PURCHASE CONTRACT

This purchase contract ("**Contract**") was concluded pursuant to Sec. 2079 *et seq*. of the Act No. 89/2012 Coll., Civil Code ("**Civil Code**"), on the day, month and year stated below by and between:

(1) **Fyzikální ústav AV ČR, v.v.i.**
(Institute of Physics of the Czech Academy of Sciences, public research institution)
with its registered office at: Na Slovance 2, Praha 8, ZIP 182 21
registration No.: 68378271
enrolled in the Register of public research institutions kept by MEYS
represented by: RNDr. Michael Prouza, PhD. – director

("**Client**"); and

(2) **DELONG INSTRUMENTS a.s.**
with its registered office at: Palackého třída 3019/153b, Královo Pole, 612 00 Brno
registration No.: 46903879
enrolled in the commercial register kept by Regional Court in Brno, item B 3738
represented by: Ing. Tomáš Papírek, Board member

("**Supplier**").

(The Client and the Supplier are hereinafter jointly referred to as "**Parties**" and individually as "**Party**".)

WHEREAS

(A) The Client is a public contracting authority and the beneficiary of grants of the Ministry of Education, Youth and Sports of the Czech Republic for different projects aimed on building and further development of the international research laser facility ELI Beamlines ("**Projects**"), within the Operational Programme Research, Development and Education (hereinafter the "**Operational Program**").

(B) For the successful realization of the Projects, it is necessary to purchase the Objects of Purchase (as defined below) in accordance with the Act No. 134/2016 Coll., on public procurement, as amended, and with binding rules of the Operational Program.

(C) The Supplier's bid for the public contract titled "*L2 and L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control Systems [TP21_046],*" whose purpose was to procure the Objects of Purchase (hereinafter the "**Bid**" and "**Public Contract**"), was selected by the Client as the most suitable. Relevant parts of the Bid describing the Objects of Purchase (as defined below) and some other

related aspects of performing this Contract form Annex 5 (*Supplier's Bid*) to this Contract.

IT WAS AGREED AS FOLLOWS:

1. **BASIC PROVISIONS**

1.1 Under this Contract, the Supplier shall:

- Design, manufacture, test, transport to, and install in ELI-Beamlines, the integrated system of the vacuum chambers for the L2 grating compressor and the L2 beam injector, the internal structures of the chambers including the optomechanical mounts, and the full vacuum and motion controls ("**L2 Compressor**"), and
- Design, manufacture, test, transport to, and install in ELI-Beamlines, the integrated system of the vacuum chambers of the L4PW grating compressor and the L4PW beam injector, the internal chassis of the compressors including the optomechanical mounts and integrated vacuum and motion controls ("**L4PW Compressor**"),

  (the L2 Compressor and the L4PW Compressor are hereinafter each of them also referred to as "**Object of Purchase**" and together as "**Objects of Purchase**"),

as specified in this Contract, mainly in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*), Annex 2 (*Detailed Technical Specifications of the Compressors*), Annex 3 (*Verification Control Document*) and Annex 5 (*Supplier´s Bid*) to this Contract and shall transfer to the Client ownership right to the Objects of Purchase,

and the Client shall take over the Objects of Purchase and shall pay the Supplier the Purchase Price (as defined below),

all under the terms and conditions stipulated herein.

1.2 The following contractual call in options are hereby agreed by the Parties:

a) Optional design and manufacture of the tubing for interconnection of the L2 injector with the L2 distribution in accordance with this Contract and all its Annexes including Annex 1 (*Summary of Deliverables, Time Schedule and Payments*) (hereinafter "**Option 1**");

b) Optional design and manufacture of the tubing for interconnection of the L4PW injector with the L4PW distribution in accordance with this Contract and all its Annexes including Annex 1 (*Summary of Deliverables, Time Schedule and Payments*) (hereinafter "**Option 2**");

c) Optional design and manufacture of the L2 mid-IR periscope chamber and of its internal supporting structures in accordance with this Contract and all its Annexes including Annex 1 (*Summary of Deliverables, Time Schedule and Payments*) (hereinafter "**Option 3**");

d) Optional design, manufacture and installation of beam polarization switch optomechanical mounts in the L4PW compressor in accordance with this Contract and all its Annexes including Annex 1 (*Summary of Deliverables, Time Schedule and Payments*) (hereinafter "**Option 4**");

(all options are referred to hereinafter together as the "**Options**"),

(except for the Art. 8 hereof any provisions of this Contract applicable on the Objects of Purchase apply on the performance of the Options (if activated) and results of the performance of the Options by the Supplier similarly).

1.3 If for the fulfilment of the requirements of the Client under this Contract or for the proper operation of the Objects of Purchase are necessary other deliveries and activities not expressly mentioned in this Contract, the Supplier shall procure such deliveries or shall carry out such activities at its own expense without any effect on the Purchase Price.

1.4 During the performance of this Contract, the Client is entitled to further specify or clarify the requirements stipulated in Annex 2 (*Detailed Technical Specification of the Compressors*). Such further requirements can be requested by the Client no later than one month before the scheduled completion of the D2A Deliverable for the L2 Compressor, of the D2B Deliverable for the L4PW Compressor of the D3 Deliverable for the optomechanical mounts of the L2 and L4PW Compressors. These further requirements shall be binding for the Supplier. Under this provision, the Client is not entitled to substantially change the existing requirements stipulated in Annex 2 (*Detailed Technical Specifications of the Compressors*). Should any request for change result in increase of the Purchase Price, such request is binding for the Supplier only if the Purchase Price modification is agreed between the Parties and such modification complies with Act No. 134/2016 Coll., on public procurement, and with binding rules of the Operational Program.

1.5 The Objects of Purchase and their components and parts shall be new (i.e. not remanufactured).

1.6 The following activities:

- Design of integration of the vacuum and optomechanical systems with the ELI-Beamlines facility,
- Design, manufacture, and vacuum cleaning of the optomechanical mounts and their electrical cabling,
- Integration of all instrumentation with the vacuum and motion electronic control systems,
- Installation, testing and performance verification at ELI-Beamlines of the optomechanical mounts including electrical cabling

must not be performed by a subcontractor.

1.7 The Supplier shall perform this Contract in Deliverables defined in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*).

2. **SUPPLIER'S DUTIES**

2.1 The Objects of Purchase shall comply with all technical specifications and performance requirements stipulated in Annex 2 (*Detailed Technical Specifications of the Compressors*). The Objects of Purchase and/or their subsystems shall meet valid safety, technical and quality Czech and EU standards.

2.2 During the performance of this Contract the Supplier proceeds independently, unless hereunder stated otherwise. If the Supplier receives instructions from the Client, the Supplier shall follow such instructions unless those contradict to the applicable law or this Contract. Should the Supplier find out or should it have found out by exercising professional care that the instructions are inappropriate or contradicting valid law, Czech or EU standards or contradict to this Contract, the Supplier must notify the Client.

3. **CLIENT´S CONFIDENTIAL INFORMATION**

3.1 For the purposes of the detailed design and manufacture of the Objects of Purchase, the Client may provide to the Contractor conceptual drawings, 3D models, schemes and other materials related to the Objects of Purchase, which are of confidential nature and which will be labelled as "Confidential and Proprietary" ("**Client's Confidential Information**"). The Supplier acknowledges that the Client's Confidential Information is of proprietary and confidential nature and that such information might be protected under laws that cover industrial or other intellectual property or trade secrets and that disclosure of such information may cause damage or other harm to the Client and/or other third persons. The Supplier may use the Client's Confidential Information solely for the purposes of the fulfilment of this Contract, i.e. for the manufacture and delivery of the Objects of Purchase to the Client.

3.2 The Supplier shall ensure that Client's Confidential Information will be accessed only by persons (e.g. employees and/or subcontractors) that need such access for the fulfilment of this Contract. The Supplier shall take all reasonable steps to ensure that the Client's Confidential Information will not be accessed by any unauthorized person and/or or third party.

3.3 Should the Supplier breach any of his duties stipulated in this Article 3, the Client is entitled to charge him with contractual penalty in the amount of 4 000 EUR for each case of such breach.

4. **DESIGN AND MANUFACTURE OF THE OBJECTS OF PURCHASE**

4.1 The detailed engineering drawings developed by the Supplier in the Deliverables D2A, D2B and D3 must comply with the requirements of this Contract and shall be approved by the Client prior to proceeding to elaboration of the production (manufacture) drawings. If the Client suggests modifications to these drawings, the Supplier shall incorporate such modifications or shall explain in writing the reason for refusing to incorporate them.

4.2 The Supplier must act in such a way that this Contract is performed in time and in due manner.

5. **LICENCE OF THE SUPPLIER**

5.1 If any part of the Objects of Purchase forms an object protected by intellectual property rights laws and/or forms related know-how, the Supplier grants to the Client a right to use such part of the Object of Purchase, including related documentation ("**Supplier's Proprietary Information**") in the original or modified version ("**Licence**") for the purposes listed in Art. 5.3.

5.2 The License is granted:

a) royalty free worldwide;

b) for the period of validity of the rights to each of the licensed intellectual property objects, which applies adequately to the related know-how.

5.3 The Licence comprises the right to use the Objects of Purchase for research and development activities within operation of the International Laser Research Facility ELI Beamlines including necessary modifications to the Objects of Purchase including software and limited handover of necessary documentation upon signature of a non-disclosure agreement to third parties for the purposes of operation, servicing and further development of the Objects of Purchase.

5.4 This granted License also includes the Supplier's permission to the Client to modify and/or alter and/or otherwise change any part of the Supplier's Proprietary Information; either by itself or with assistance of any third party. This permission shall apply *mutatis mutandis* to the Client's entitlement to combine and/or merge any part of the Supplier's Proprietary Information with any other work; either by itself or with assistance of any third party.

5.5 The Client is entitled to transfer/ assign the License on any third party if the ownership or operation of the International Laser Research Facility ELI Beamlines passes on such third party. In such case, the Client shall inform the Supplier within undue delay thereabout. The Client is entitled to grant wholly or partially the License to any third party (sublicense) if the right to use the Objects of Purchase is granted to such third party.

5.6 The Client is not required to use the Licence, unless the maintaining of the right depends on the exercise thereof.

5.7 The Supplier hereby represents and warrants to the Client that:

a) It is entitled to use and enforce all intellectual property rights to the Supplier's Proprietary Information, in order to be ensured that the Client may use the Supplier's Proprietary Information properly and without any interference; and

b) It is entitled to grant the License to the Client in the extent specified in this Contract.

5.8 If the Licence is endangered or infringed, the Client shall inform the Supplier accordingly without undue delay after ascertaining this fact. The Supplier shall provide the Client with cooperation to ensure the legal protection of the Licence. The Supplier shall give the Client consent to enforce the industrial property rights and/or related know-how rights covered by the License.

6. MONITORING AND IMPLEMENTATION OF THE INSPECTION PLAN

6.1 The Supplier undertakes to enable the Client exercising inspections of the performance of this Contract. For this purpose, the Supplier shall provide the Client with all information regarding the status of the design and manufacture of the Objects of Purchase at the request of the Client, anytime during performance of this Contract.

6.2 The Supplier shall provide to the Client all cooperation, assistance and information that the Client needs for the purposes of full evaluation of the status of the design or manufacture of the Objects of Purchase.

6.3 If the Client, especially during an inspection, ascertains any breach of the Supplier's duties under this Contract, the Client shall notify in written the Supplier of such breaches. The Supplier has to respond to such notification and suggest, in an appropriate detail, remedying the deficiencies, within fourteen (14) calendar days, unless the Parties agree otherwise.

6.4 Each Party shall invite the other Party to attend a meeting in writing at least 14 calendar days in advance. The Parties may replace, upon mutual agreement, meetings in person by other forms of communication, as long as they agree on such in advance. Each Party shall bear its expenditures related to their participation in meetings at the other Party's facility; however, costs which would arise due to an error, faulty performance or a breach of contractual provisions of the Parties shall be borne by that Party which caused it.

6.5 The Supplier shall follow the Quality and Verification Plan addressing all requirement items stated in Annex 3 (*Verification Control Document*) and shall invite the Client at least 14 calendar days in advance to participate in all relevant activities of this Plan.

6.6 In fulfillment of Deliverables D1, D2A, D2B and D3, where early agreement on specific design features as described in Annex I (*Summary of Deliverables, Time Schedule and Payments*), and/or where guidance by the Client may be needed for proper execution of the works, the Supplier will contact the Client with a written technical query, which the Client shall respond in 14 calendar days. If the Client does not respond within 14 calendar days, the Supplier is entitled to choose the technical solution he considers most appropriate.

6.7 If the Client does not participate in an inspection and/or verification activity according to Annex 3 (*Verification Control Document*) at the date communicated in accordance with Art. 6.5, the Supplier is not entitled to carry out respective activities in absence of the Client. However, in such a case the Supplier is not in delay with delivery of the corresponding Deliverable and subsequent Deliverables with proven dependency on the

corresponding Deliverable and delivery periods of such Deliverables shall extend by the time of the Client´s delay, unless the Parties agree otherwise.

7. **THE PLACE AND TIME OF DELIVERY**

7.1 The place of delivery shall be the International Research Laser Facility ELI-Beamlines located at Průmyslová 835, Dolní Břežany (district Prague-west), ZIP 252 41, the Czech Republic (hereinafter also "**ELI Beamlines**" or "**ELI Beamlines site**").

7.2 The Supplier shall perform individual Deliverables in terms stipulated in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*).

7.3 The Supplier shall carry out performance and verification tests of the major subsystems of the Objects of Purchase (i.e. of the compressor and injector chambers and of their internal structures, of the vacuum control systems (VCS), of the optomechanical mounts and of the motion control systems (MCS)) at his premises (factory acceptance tests), in relation with Deliverables D4, D6, and prior shipment of the respective components and subsystems in relation with Deliverables D8 to D12, and Optional Deliverables OD1 to OD4, on the dates agreed with the Client in accordance with Art. 6.5, according to Annex 3 (*Verification Control Document*).

Following delivery and installation of the major subsystems of the Objects of Purchase (i.e. of the compressor and injector chambers and of their internal structures, of the vacuum control systems (VCS), of the optomechanical mounts and of the motion control systems (MCS)), the Supplier shall carry out performance and verification tests of the installed components and subsystems at the Client' site, according to Annex 3 (*Verification Control Document*).

7.4 For the purpose of determination of individual deadlines stipulated hereby the **Commencement Day** shall be the seventh calendar day after the Contract is concluded (i.e. signed by the second of the Parties).

8. **PRICE AND PAYMENT TERMS**

8.1 The total purchase price for the Objects of Purchase excluding Options is **97 325 000,-** Czech Crowns (CZK) without value added tax ("**VAT**")("**Purchase Price**"). The Purchase Price represents the Supplier´s binding maximum price.

The prices for individual Objects of Purchase and for performing Options are stipulated in Annex 4 *(Prices)* hereto.

The Purchase Price shall be invoiced and paid upon acceptance of any Deliverable in instalments (hereinafter also "**Payments**") stated in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*). The Payment for the accepted Deliverable as stated in Annex 1 is understood to correspond to the price of the Deliverable. Where the Payment is composed from the price of both Objects of Purchase, the price of the Deliverable is understood to correspond to the sum of the contributing prices of the Objects of Purchase.

The VAT shall be imposed on top of all payments made hereunder according to valid legislation.

8.2 The Purchase Price and prices of Options cannot be exceeded.

8.3 The Purchase Price includes all costs and expenses of the Supplier related to the performance of this Contract excluding Options. The Purchase Price include especially all expenses related to the design, manufacture, assembly, factory testing, cleaning, delivery to ELI-Beamlines, installation, and on-site integral testing and performance verification of the Objects of Purchase or its parts, costs of the Licence, insurance, warranty service, development of prices of materials, development of foreign currency exchange rates, customs (if applicable) and any other costs and expenses related to the performance of this Contract excluding Options. Similar rules shall *mutatis mutandis* apply on the prices of Options.

8.4 The Purchase Price and prices of the Options may be changed only in accordance with the Act No. 134/2016 Coll., on public procurement, as amended.

8.5 If the Supplier performs the subject-matter hereof duly in line herewith without substantial breaches of the Contract and if there are no obvious reasons for doubts on continuing of the due performance hereof by the Supplier, by taking into account the overall approach of the Supplier to the Contract performance (presented particularly by due preparation for performance of follow-up activities), and if it might ease further performance hereof by the Supplier, the Client reserves the right fully on its discretion to provide the Supplier with the Purchase Price partial instalments (Payments) or any parts of them sooner than scheduled hereunder or in higher amount than stipulated by Annex No 1 hereto, Summary of Deliverables, Time Schedule and Payments (i.e. any Payments might be increased with proportional decreasing of subsequent payments). If the conditions stipulated above are met the Client is entitled to modify the payment schedule included in the Annex No 1 hereto anyhow in favour of the Supplier and to provide it with any prepayment. Similar rules apply on payments of prices of Options.

8.6 The Purchase Price instalments and prices of Options shall be paid based on tax documents – invoices, to the account of the Supplier designated in the invoice. The Purchase Price shall be paid following the payment schedule set out in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*). The prices of Options shall be paid according to Annex 1. The Supplier is entitled to issue any invoice no sooner than on the moment a Deliverable is duly completed and accepted by the Client in accordance with this Contract.

8.7 The Client shall execute payments on the basis of duly issued invoices within 30 days from their receipt. If the Supplier stipulates any shorter due period in an invoice such different due period shall not be deemed relevant and the due period stipulated herein prevails. Any invoice shall be considered to be paid for on the day when the invoiced amount is deducted from the Client's account on behalf of the Supplier's account.

The invoices shall be sent to the Client solely in the electronic form to the address efaktury@fzu.cz

8.8 Any invoice issued by the Supplier as a tax document must contain all information required by the applicable laws of the Czech Republic. The Client shall advice the Supplier on the proper contents of invoices if requested prior to invoicing.

Furthermore, invoices shall include:

a) registration number of this Contract, which the Client shall communicate to the Supplier based on Supplier's request before the issuance of the invoice,

b) registration number and a title of a grant Project in accordance with information provided by the Client,

and must comply with the double tax avoidance agreements, if applicable.

8.9 In case that the invoice does not contain the above mentioned information, the Client is entitled to return it to the Supplier during its maturity period and this shall not be considered as a default. The new maturity period shall begin from the receipt of the supplemented or corrected invoice to the Client.

Material costs development

8.10 For the raw materials and copper-based electrical cables essential for manufacture of major components of the Objects of Purchase (compressor chambers, internal tables and their support structures, structural components of the optomechanical mounts, and electrical cables for the vacuum and motion controllers), namely stainless steel, aluminium alloy(s) and copper-based cables, the Supplier is entitled to identify in its Bid specific categories (e.g. slabs of specific thickness, monolithic blocks of specific size, prefabricated plates of specific size / thickness, copper cables of specific type, etc.) that it considers most volatile (unstable in respect of the price) in the current situation on the market. For each identified category of the raw materials (stainless steel, aluminium alloy(s) and copper-based cables) the Supplier shall in such case identify in its Bid the total expected amount, necessary for fulfillment of the Objects of Purchase, and the corresponding unit price (e.g. per kg of identified metal raw-material product, per length of identified cable type, etc.).

Should the actual price of the identified categories of the raw materials or of the copper-based electrical cables at the moment of purchase for fulfilment of this Contract increase or decrease by more than 10 % with respect to their price considered in the Bid, the Supplier and the Client shall proceed in compliance with the below-stated conditions relating to price increase and price decrease.

The Supplier shall purchase raw materials in connection with Deliverables D4, D6, and D8 to D12, namely stainless steel, aluminium, and copper-based electrical cables, essential for manufacture of major components of the Objects of Purchase (compressor chambers,

internal tables and their support structures, structural components of the optomechanical mounts, and electrical cables for the vacuum and motion controllers).

The Supplier shall make all reasonable efforts to secure as low as possible price made possible by the overall behaviour of the market for designated raw materials and copper-based electric cables.

For the extent of the identified categories of stainless steel, aluminium alloy(s), and copper-based cables, as specified in the Bid, the Supplier shall inform the Client, without undue delay, on selection of the suppliers (sub-contractors) for each purchase, with justification of the selection. The justification shall be based on a competitive tender (i.e. to demonstrate that the price does not exceed the value usual at the given place and time, documented for example by quotes, or responses to request for price enquiry, from different suppliers), and shall use the criterion of the most economically advantageous tender to select the supplier (sub-contractor).

Price increase

Should the actual unit price of the identified categories of raw materials and of copper-based electric cables, as mentioned above and for the extent specified in the Bid, at the moment of purchase for fulfilment of this Contract increase by more than 10 % with respect to their price considered in the Bid, the Supplier is entitled to ask the Client for compensation of the extra costs incurred, in the amount above the price level considered in the Bid.

The Supplier must in such case document, in appropriate detail, the difference between the unit cost used in the Bid and the actual unit cost associated with procurement of these materials in connection with Deliverables D4, D6, and D8 to D12.

Should the following conditions:

a) the increased price is documented by the outputs of the competitive tender; and

b) the difference between the unit price in the Bid and the actual purchase price is consistent with the overall behaviour of the market for the respective materials in the relevant timeframe (using the indexes published by the London Metal Exchange (https://www.lme.com/);

be met, the Client shall agree with the Supplier on corresponding increase of the prices of the raw materials in this Contract.

Due to the budgetary limitations of the Client, the total permitted price increase of the raw materials and copper-based electrical cables under this clause is limited to 5 mil. CZK excl. VAT.

Should the Client have doubts regarding the cost figures of the raw materials or of the copper-based electrical cables presented by the Supplier, it is entitled to refuse any such price increase.

Price decrease

Should, based on the competitive tender, the unit price of the raw materials or of the copper-based electrical cables, as mentioned above and for the extent specified in the Bid, decrease by more than 10 % with respect to their price considered in the Bid, the Purchase Price shall be decreased by the corresponding amount (in the amount with respect to the price level considered in the Bid).

The Purchase Price shall be decreased by the financial amount saved by decreasing Payments for the corresponding Deliverables.

Joint provisions

Agreements or understandings between the Parties needed to implement the reserved changes in obligations above shall be made in written, however, they do not need to take the form of an amendment to this Contract.

9. ACCEPTANCE OF DELIVERABLES, HANDOVER OF INDIVIDUAL PARTS OF OBJECTS OF PURCHASE

9.1 Upon receiving any documents, reports or designs necessary for completion of Deliverables D1, D2A, D2B and D3, the Client shall provide the Supplier within 10 working days with his comments to the submitted documents. The Supplier shall be obliged to take the Client's comments into account, i.e. the Supplier shall accept all justified and materially correct comments and requirements for changes made by the Client. Should the Supplier consider any of the comments or requirements made by the Client as materially incorrect or unacceptable, the Supplier shall specify in writing his reasons for refusing to accept them. The Supplier will produce final documents containing all justified and materially correct comments and requirements for changes raised by the Client.

9.2 Upon duly completion of Deliverables D1, D2A, D2B, D3, D4 and D6, and of any of the Optional Deliverables OD1, OD2, OD3 and OD4 and fulfilling the requirements of the Client as set forth herein and in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*), the Client shall issue to the Supplier, without undue delay, a confirmation on the due execution of the Deliverable (the "**Deliverable Acceptance Protocol**"). Notwithstanding to it, the Client shall not be obliged to verify the correctness of all calculations and/or technical solution details during the course of the acceptance of the Deliverables relating to the detailed design, fabrication process, and on-shop testing. Acceptance of these individual Deliverables does not release the Supplier from his liability for the technical compliance and completeness of the Objects of Purchase.

9.3 On-site acceptance, and handover and takeover of individual parts of the Objects of Purchase, upon fulfilling the requirements of the Client as set forth in Annex 1 (*Summary of Deliverables, Time Schedule and Payments*), related to Deliverables D5, D7, D8, D9, D10, D11, D12 and of the Optional Deliverable OD4, shall be realized on the basis of a Deliverable Acceptance Protocol, which shall contain at least the following information:

a) identification of the Supplier, Client and subcontractors, if there are any;

b) identification of the Deliverable;

c) declaration of the Client that he received from the Supplier all technical information and documentation related to the Deliverable;

d) statement of the Client on acceptance of the Deliverable;

e) list of defects, and/or backlogs or performance deficiencies, if any;

f) date of the signature.

9.4 The Deliverable Acceptance Protocol for D5, D7, D8, D9, D10, D11, and D12, and for onsite acceptance of OD4, must contain the following annexes, which shall be provided by the Supplier:

a) list of items (accessories) handed over within the corresponding Deliverable;

b) protocols with full results of all design and/or manufacturing inspections and of performance verification testing, carried out according to Annex 3 (*Verification Control Document*);

c) drawings, 3D models, software codes and other contractually required information and documentation corresponding to the Deliverable.

9.5 In case of deficiencies (i.e. defects and/or backlogs) of the delivered subsystems related to Deliverables D5, D7, D8, D9, D10, D11, D12 and optional OD1, OD2, OD3 and OD4, mainly if the Supplier does not hand over to the Client all required documentation, or if a Deliverable does not comply with this Contract, the Client is entitled to refuse the takeover and acceptance of that Deliverable. Whenever technically possible the Supplier shall remedy the deficiencies within ten (10) working days, unless Parties agree otherwise (particularly due to the fact that period of 10 working days is technically impossible); however these periods do not imply that the Supplier is not in delay with the delivery of the respective Deliverable. The Client is entitled at his discretion (but not obliged) to take over and accept the respective Deliverable despite the above mentioned deficiencies, in particular if such deficiencies do not prevent the Client from the proper operation of the respective Object of Purchase. In such case the Parties shall list the deficiencies in the respective Deliverable Acceptance Protocol(s), including the manner and the date of their removal (remedy). If the Parties do not reach agreement regarding the date of the removal, the Supplier shall remove the deficiencies within ten (10) working days. Should the deadline of ten (10) working days be technically impossible and should the Supplier document an actually needed longer term, the Client shall agree on the documented longer term. Until the remedy of the deficiencies the Client shall be entitled to postpone the corresponding payment up to the amount corresponding to the significance of the deficiency.

9.6 Should it be necessary to modify any part of the already accepted Deliverable in order to meet any requirement stipulated herein, the Supplier undertakes to perform such modifications and accepts that the costs related thereto are included in the Purchase Price or price of the Options.

10. **THE OWNERSHIP RIGHT**

The ownership right to the subsystems of the Objects of Purchase or to the optional deliveries, corresponding to the Deliverables D5, D7, D8, D9, D10, D11, D12 and optional OD1, OD2, OD3 and OD4 (if the Options are activated), shall pass to the Client upon their handover and acceptance confirmed by the signature of the respective Deliverable Acceptance Protocol by both Parties.

11. **WARRANTY**

11.1 The Supplier provides a warranty of quality related to any already accepted and handed over part of the Objects of Purchase for the period of 24 months from execution of the Deliverable Acceptance Protocol for the respective part of the Object of Purchase, except for the parts of the Objects of Purchase for which the warranty length is specified in Annex 5 (*Supplier´s Bid)*. If on a warranty list or other document submitted by the Supplier the warranty period is of longer duration, then this longer warranty period shall have priority over the period stated in this Contract.

11.2 If any Deliverable Acceptance Protocol for D5, D7, D8, D9, D10, D11, and D12 and for any of OD1, OD2, OD3, and OD4 lists any deficiencies, the warranty period shall begin on the day on which the last deficiency was removed.

11.3 The Supplier shall remove defects for which he is responsible according hereto that occur during the warranty period free of charge and in the terms stipulated in this Contract. The Supplier shall bear all the expenses (e.g. shipments, travelling, accommodation expenses and price of equipment rental or purchase) related to removal of the defects.

11.4 If the Client ascertains a defect of an Object of Purchase during the warranty period, the Client shall notify such defect without undue delay to the Supplier. Defects may be notified on the last day of warranty period, at the latest.

11.5 The Client notifies defects in writing via e-mail. The Supplier shall accept notifications of defects on the following e-mail address: service@delong.cz. The Supplier shall confirm receipt of the notification within two working days.

11.6 In the notification, the Client shall describe the defect and the manner of removal of the defect. The Client has the right to:

a) ask for the removal of the defect by the delivery of a replacement individual part of the Object of Purchase,

b) ask for the removal of the defect by repair, or

c) ask for the adequate reduction of the price, i.e. the Purchase Price or the price of Option, particularly in case of irremovable defects.

11.7 The Supplier shall remove the defect within 21 calendar days from its notification, unless Parties agree otherwise. The Client shall agree an extended deadline for the defect removal with the Supplier if the Supplier submits evidence (e.g. subcontractors bid etc.) that the removal of the defect within 21 calendar days is impossible for objective reasons

(i.e. independent of the will of the Supplier), or if technical nature of the defect makes not possible its removal within 21 calendar days.

11.8 The Supplier shall remove the defect within terms stipulated in this Contract even if the notification of the defect is in his opinion unjustified. In such a case, the Supplier is entitled to ask for reimbursement of the costs of the removal of the defect. If Parties disagree on whether the notification of the defect is justified or not, the Client shall secure an expert opinion (by an expert also agreed by the Supplier). If the expert considers the notification to be justified, then the Supplier shall return the reimbursement amount paid to him in accordance with the second sentence of this paragraph.

11.9 Parties shall sign a protocol on the removal of the defect, which shall contain the description of the defect and the confirmation that the defect was removed. The warranty period of the relevant subsystem corresponding to the respective Deliverable shall be extended in case of defects preventing the Client from use of the corresponding Object of Purchase for intended use by the period of time that elapses between the notification of the defect and its removal.

11.10 Should the Supplier not remove the defect within the stipulated or mutually agreed term or should the Supplier refuse to remove the defect, the Client is entitled to remove the defect at his own costs and the Supplier shall reimburse these costs within 30 days after the Client's request to do so. In such a case the existing warranty remains intact.

12. REPRESENTATIONS AND WARRANTIES OF THE SUPPLIER

12.1 The Supplier represents and warrants to the Client that

a) he possesses all professional qualifications to supply the Objects of Purchase, has all the professional prerequisites necessary for the proper fulfilment of this Contract and is able to carry out activities foreseen hereunder with the due care, skill and knowledge of well-experienced experts in his particular professional field,

b) is fully authorized to perform this Contract, and

c) there are no obstacles on his side that would preclude him from the due performance of this Contract.

12.2 The Supplier is aware of the importance to the Client of the fulfilment of this Contract in terms of quality, performance and schedule. In the event of a failure by the Supplier to meet them (e.g. in case of delay with delivery of Deliverables and/or in the case if any of the Object of Purchase does not meet the performance requirements), substantial damage may arise to the Client.

13. PENALTIES

13.1 If the Supplier is in delay with the Deliverables D1, D2A, D2B, D3, D4, or D6, or with any of OD1 to OD4, for more than one month, the Supplier shall pay starting with the first

day of the second month of the delay to the Client a contractual penalty in the amount of 0.05% of the price of the respective Deliverable (excl. VAT) for every even incomplete day of delay.

13.2 If the Supplier is in delay with the Deliverables D5, or D7 to D12, the Supplier shall pay to the Client a contractual penalty in the amount of 0.05% of the Purchase Price (excl. VAT) for every even incomplete day of delay.

13.3 If the Supplier is in delay with the removal of a defect of the Objects of Purchase preventing the Client from proper operation of the respective Object of Purchase, the Supplier shall pay to the Client a contractual penalty in the amount of 0.05% of the Purchase Price (excl. VAT) for every even incomplete day of delay. In case of defects that do not prevent the Client from proper operation of the Object of Purchase the contractual penalty shall amount to 0.02% of the Purchase Price (excl. VAT) for every even incomplete day of delay.

13.4 The Supplier shall pay any of the contractual penalties charged under this Contract within thirty (30) days from the day, on which the Client enumerated its claim for the contractual penalty. The payment of contractual penalties shall not affect the right of the Client to damages in the extent in which such damages exceed the contractual penalty.

13.5 The amount of the contractual penalty for delay with completion of any of the Deliverables D1, D2A, D2B, D3, D4, or D6, or with any of OD1 to OD4, shall not exceed 5% of the price of each respective Deliverable. The total amount of contractual penalties for delay with completion of Deliverables D5 and D7 to D12 (i.e. the summed up amount of all penalties for delays with the Deliverables D5, D7, D8, D9, D10, D11 and D12) shall not exceed 5% of the Purchase Price.

13.6 Should a delay of the Supplier be caused by a documented impact of the Covid-19 pandemic on the course of performance of this Contract by the Supplier (e.g. sick workers, sub-supplies delays or failures, etc.), the contractual penalties for delay above do not apply. The Supplier shall in sufficient detail document when an obstacle occurred and how long it lasted. The penalties do not apply also in the case of such obstacle caused by Covid-19 pandemic, which could have been overcome but only with unreasonable efforts or disproportionate costs.

13.7 The Client is entitled to unilaterally set off claims arising from the contractual penalties against even yet undue claim of the Supplier for the payment of the Purchase Price or prices of Options.

14. RIGHT OF WITHDRAWAL AND VIS MAJOR

14.1 The Client is entitled to withdraw from this Contract without any penalties, if any of the following circumstances occur:

a) the Supplier breaches this Contract in a substantial manner;

b) the Supplier repeatedly fails to follow the mandatory activities listed in the Verification Control Document, stipulated in Annex 3, and/or does not allow the

Client to inspect the Supplier's premises for the purposes of ascertaining status of fulfilment of the Contract;

c) the Supplier is in delay with any contractual Deliverable stipulated in Annex 1 for a period exceeding 3 (three) calendar months, except where the delay has been caused by the Client;

d) results of the factory testing, even after third testing attempt, do not meet the requirements stipulated in Annex 2 (*Detailed technical specifications of the Compressors*);

e) the insolvency proceeding is initiated against the Supplier; or

f) the Client ascertains that the Supplier provided in its Bid submitted for the Public Contract information or documents that do not correspond to the reality and that had or could have had impact on the result of the tendering procedure for the Public Contract.

14.2 The Supplier is entitled to withdraw from this Contract in the following cases:

a) the Client breaches this Contract in a substantial manner;

b) the Client is in delay with the payment of any Deliverable for a period longer than 3 calendar months; or

c) the Client repeatedly refuses his attendance at the respective verification activities specified in the Verification Control Document, stipulated in Annex 3.

14.3 The act of withdrawal from the Contract shall become effective on the day of delivery of the notification in writing from one Party to the other with consequences of the Contract termination effective in the "ex tunc" regime, unless the Parties agree otherwise.

14.4 Circumstances precluding liability shall be deemed to have been constituted by such circumstances / obstacles which arose independently of the will of the obliged Party, and which prevent fulfilment of that Party's obligation, provided that it could not be reasonably expected that the obliged Party could overcome or avert this obstacle or its consequences, and furthermore that such Party could foresee such obstacle when it entered into the respective covenants. Liability cannot be precluded by obstacles that arose only after the obliged Party was in default with fulfilment of its obligations, or which arose in connection with its economic situation. The effects precluding liability shall be limited to the period during which the obstacles causing these effects persist.

14.5 Any particular effects or impacts on the Supplier or his performance under this Contract of the Covid-19 pandemic that meet the conditions set out above in Art. 14.4 (unless differently stated in this Art. 14.5) and that could have been overcome only with unreasonable efforts or disproportionate costs will be considered as vis major cases, despite the fact of the existence of the epidemic outbreak as of the date of conclusion of this Contract.

14.6 Should a situation occur, which a Party could reasonably consider to constitute vis major (force majeure), and which could affect fulfilment of its obligations hereunder, such Party shall immediately notify the other Party and attempt to continue in its performance hereunder in a reasonable degree. Simultaneously, such Party shall inform the other one of any and all its proposals, including alternative modes of performance, however, without the other Party's consent, the Party shall not proceed to carry out such alternative performance. If a situation constituting vis major occurs, the deadlines imposed hereunder shall be extended by the period of the duration of the said vis major.

15. CONFIDENTIALITY

Parties shall not disclose information that shall become available to them in connection with this Contract and its performance and whose disclosure could harm the other Party. Duties of the Client ensuing for the applicable legal regulations remain unaffected.

16. SOCIAL, ECOLOGICAL AND INNOVATIVE ASPECTS

The Client aims to conclude contracts with suppliers that take into account and implement the principles of social responsibility, ecological sustainability and innovation. Therefore, the Supplier shall ensure that:

a) this Contract is fulfilled only by persons that are employed in accordance with the applicable legal regulations (no illegal or child workers);

b) while performing this Contract, all applicable health and safety regulations and rules at work place are observed;

c) all persons performing this Contract are employed under fair and non-discriminatory working conditions;

d) if presented with different manners of fulfilling this Contract, the Supplier shall select the solution/process that is in accordance with the principles governing nature conservation and nature protection, ecological sustainability and ecological waste management; and

e) if presented with different manners of fulfilling this Contract, the Supplier shall select the solution/process that is the most innovative.

17. REPRESENTATIVES OF THE PARTIES

17.1 The Supplier appoints the following representative for the communication with the Client in technical matters:

Name: Ing. Tomáš Bejdák

E-mail: tomas.bejdak@delong.cz

Tel.: 549 123 506

17.2 The Client appoints the following representative for the communication with the Supplier in technical matters:

Name: Ing. Bedřich Rus, PhD.

E-mail: rus@fzu.cz

Tel.: +420-603-570-558

18. **FINAL PROVISIONS**

18.1 This Contract is governed by the laws of the Czech Republic, especially by the Civil Code.

18.2 All disputes arising out of this Contract or out of legal relations connected with this Contract shall be preferably settled by a mutual negotiation. In case that the dispute is not settled within sixty (60) days, such dispute shall be decided by courts of the Czech Republic in the procedure initiated by one of the Parties.

18.3 The Supplier takes into account that the Client is not in relation to this Contract an entrepreneur, nor the subject matter of this Contract is connected with the business activities of the Client.

18.4 The Supplier is not entitled to set off any of its claims or his debtor's claims against the Client's claims. The Supplier is not entitled to transfer its claims against the Client that arose on the basis or in connection with this Contract on third parties. The Supplier is not entitled to transfer rights and duties from this Contract or its part on third parties.

18.5 All modifications and supplements of this Contract must be in writing.

18.6 If any provision of this Contract is or becomes invalid or ineffective, then such invalidity, ineffectiveness or unenforceability shall not cause the invalidity, ineffectiveness, or unenforceability hereof as a whole and the Parties shall change this Contract in such a way that the invalid or ineffective provision is replaced by a new provision that is valid and effective and to the maximum possible extent correspond to the original invalid or ineffective provision as well as most closely reflects the intentions of the Parties at the time of conclusion hereof, to an extent permitted by the laws and regulations of the Czech Republic.

18.7 If any Party breaches any duty under this Contract and knows or should have known about such breach, it shall notify it to the other Party and shall warn such Party of possible consequences of the breach.

18.8 Integral parts of this Contract are:

Annex 1 (*Summary of Deliverables, Time Schedule and Payments*)

Annex 2 (*Detailed Technical Specifications of the Compressors*)

Requirements Specification Document (RSD) for the L2 Compressor

Requirements Specification Document (RSD) for the L4PW Compressor

Annex 3 (*Verification Control Document*)

Annex 4 (*Prices*)

Annex 5 (*Supplier's Bid*)

In case of any discrepancy between any provisions of this Contract and any provisions of its Annexes the provisions of this Contract shall prevail. In case of any discrepancy between any provisions of Annexes hereof the provisions containing conditions and specifications that are more favourable to the Client (i.e. higher technical specification values and/or more technically advanced or demanding solutions etc.) shall prevail.

18.9 This Contract shall be valid on the date of the signature of both Parties and effective on the date of its publication in the Register of contracts according to special legal regulation.

IN WITNESS WHEREOF attach Parties their signatures:

Client

Signature: _____

Name: RNDr. Michael Prouza, PhD

Position: Director

Supplier

Signature: _____

Name: Ing. Tomáš Papírek

Position: Board member

ANNEX 1

SUMMARY OF DELIVERABLES, TIME SCHEDULE AND PAYMENTS

Institute of Physics ASCR, v. v. i.
Na Slovance 2
182 21 Prague 8
Czech Republic
eli-cz@fzu.cz
www.eli-beams.eu

L2 and L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System [TP21_046]

TC ID/Revision: 00309895/A
Confidentiality: BL - Restricted for internal use
WBS code: 3.2, 3.4
PBS code: RA1.L2.L2_1.CMP, RA1.L4.CMP2

Deliverable	Description	Completion	Payment
	Commencement day (CD) = Contract signature + 7 calendar days	-	-
D1	Detailed schedule of project activities and all corresponding Quality and Verification Plans, and of work procedures	1 month	10% of L2 cost 10% of L4PW cost
D2A	Development of FZU concept design and 3D model and production of detailed engineering drawings for L2 compressor and injector chambers, and for internal optical support structures. Verification of structural performance of compressor and injector chamber by FEM simulations.	3 months	25% of L2 cost
D2B	Development of FZU concept design and 3D model and production of detailed engineering drawings for L4PW compressor and injector chambers, and for internal optical chassis. Verification of structural performance of compressor and injector chamber by FEM simulations.	5 months	25% of L4PW cost
D3	Development of FZU concept design of optomechanical mounts of L2 and L4PW compressors into detailed engineering design for production drawings	9 months	10% of L2 cost 10% of L4PW cost
D4	Manufacturing, assembly and factory testing of the L2 compressor and injector vacuum chambers	10 months	20% of L2 cost
D5	Transport and installation of the L2 compressor and injector vacuum chambers at ELI-Beamlines. Connection to the facility primary vacuum lines. L2 vacuum control system on-site integration, verification of vacuum performance of the L2 chambers.	12 months	10% of L2 cost
D6	Manufacturing, assembly and factory testing of the L4PW compressor and injector vacuum chambers.	13 months	20% of L4PW cost
D7	Transport and installation of the L4PW compressor vacuum and injector chambers at ELI-Beamlines. Connection to the facility primary vacuum lines. L4PW vacuum control system on-site integration, verification of vacuum performance of the L4PW chambers.	15 months	10% of L4PW cost
D8	Transport and installation of the L2 compressor internal optical support structures at ELI-Beamlines.	16 months	7.5% of L2 cost
D9	Transport and installation of the L4PW compressor internal optical chassis structures at ELI-Beamlines.	17 months	7.5% of L4PW cost

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D10	Delivery and installation of large electrically actuated optomechanical mounts of the L2 compressor (M2, M3, G1, G2, PM), and L4PW compressor (TM3, TOAP2, M1, G1, G2, PM1, M2, M3) and of their electric cabling.	18 months	10% of L2 cost 10% of L4PW cost
D11	Delivery and installation of L2 and L4PW compressors reference crossed hairs, manual and diagnostic optomechanical mounts, and of their electric cabling.	24 months	5% of L2 cost 5% of L4PW cost
D12	Delivery and installation of L2 and L4PW beam injectors optomechanical mounts, of their electric cabling, testing of integrated motion control system with all installed mounts in each system.	30 months	2.5% of L2 cost 2.5% of L4PW cost

Contractual options

Optional deliverable	**Description**	**Completion**	**Payment**
OD1	Design and manufacture of the tubing for interconnection of L2 injector with L2 distribution	6 months after order	Price of the Option
OD2	Design and manufacture of the tubing for interconnection of L4PW injector with L4PW distribution	6 months after order	Price of the Option
OD3	Design and manufacture of the L2 mid-IR periscope chamber and of its internal supporting structures	12 months after order	Price of the Option
OD4	Design, manufacture and installation of beam polarization switch optomechanical mounts in the L4PW compressor	12 months after order	Price of the Option

I. Contractual Deliverables description

1. Deliverable D1

Detailed schedule of project activities and all corresponding quality plans and work procedures

The supplier to whom the Public Contract will be awarded (hereinafter the "***Supplier***") shall provide a detailed schedule of all project activities; by which is meant a schedule that defines all the activities necessary to individually define, produce or procure and deliver every component within the scope of supply. All activities shall be resourced, allocated start / finish times and linked with relevant dependencies. The amount of detail should be sufficient to identify the longest path of activities through the entire program, thus providing confidence in the overall programme for Deliverables. The scheduled activities shall not be restricted to those of the Supplier but shall include all relevant activities of sub-suppliers, the Client or relevant third parties.

Also within the first month following the Commencement Day, the Supplier shall provide a draft set of Quality and Verification Plan and associated Work Procedures detailing all the work activities and processes required for the design, procurement, fabrication, assembly and test of all products to be supplied under the contract. This shall include aspects such as design review, inspection, analysis and test procedures (Verification Plan), and configuration management, material traceability, cleanliness control, welding procedures and qualifications (Quality Plan). The provided draft set of Quality and Verification Plan shall incorporate as a minimum all required activities listed in Annex 3 (*Verification Control Document*).

Completion: 1 month after Commencement Day

2. Deliverable D2

D2A: Development of FZU concept design and 3D model and production of detailed engineering drawings for L2 compressor and injector chambers, and for internal optical support structures. Verification of structural performance of compressor and injector chamber by FEM simulations.

D2B: Development of FZU concept design and 3D model and production of detailed engineering drawings for L4PW compressor and injector chambers, and for internal optical chassis. Verification of structural performance of compressor and injector chamber by FEM simulations.

a) The Supplier shall develop detailed engineering 3D models of the compressors and injectors chambers, based on the preliminary design drawings and 3D models supplied by the Client. These detailed engineering models and detailed drawings produced by the Supplier will be used in the subsequent steps (Deliverable D4 for L2 compressor and D6 for the L4PW compressor) to make production drawings and to manufacture the chambers. The purpose of the detailed engineering design is to develop the Client's preliminary design into a full model including all necessary mechanical details and to optimize the overall design with respect to the technologies, functionality, and fabrication methods that will be employed for manufacturing. The accepted detailed 3D model and the detailed engineering drawings developed in this Deliverable will be binding for the Supplier in the manufacturing phase (Deliverable D4 for L2 compressor and D6 for the L4PW compressor).

b) A part of this Deliverable D2 will be elaboration of specific details, such as:

- Hinges with double pivot arrangement and closing mechanisms of the chambers personal access side doors including bosses for screw-in lifting eyes for initial installation by overhead crane
- Positioning pins and lifting features (e.g. bosses for screw-in lifting eyes) of the end installation doors for manipulation by overhead crane
- Lifting points of the top lids for manipulation by overhead crane

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- Mounting points / bosses with precisely toleranced ø6 holes suitable for mounting a corner cube reflector for laser scanning, for precise measurements of the chambers' positions during installation
- Double O-ring arrangement for the installation doors, personal access side doors, and top lids
- Chamber support legs and floor plates allowing compressor chambers fine positioning during installation
- Double bellows isolation legs and corresponding floor plates
- Paths along the compressor and injector chambers for utilities, primary backing vacuum and electrical cables, determination of holes in the ribs for TMP backing vacuum and utilities, design of C-rails and cable trays on the chambers
- Internal vacuum cable trays on the compressors and on the beam injectors
- Internal optical tables support frame (for L2 compressor) and internal optical chassis (for L4PW compressor), optical tables including relied holes to avoid trapped air pockets
- Relief holes in the optical tables and optomechanical mounts to avoid trapped air pockets
- Mechanisms for attachment of transporting devices to the compressors and injectors for transport to their final location in the ELI-Beamlines facility, mechanisms for assembling and installation of the vacuum vessels, of the internal optical supports and tables, and of the beam injectors and other subsystems in the clean L2 and L4b laser halls (Class 7 cleanliness) of ELI-Beamlines. Design of all these mechanisms shall be coordinated with ELI-Beamlines.
- Determination of material thicknesses, configuration of stiffening ribs, flanges, weld locations and details, surface finishes and other such matters necessary to optimize for fabrication

c) The Supplier shall verify the stiffness of the developed detailed design of the compressor and injector vessels and of the internal optical supporting structures, by means of FEA (Finite Element Analysis) simulations. The acceptable limit of deformations under application of vacuum (stiffness) and vibrational criteria are included in the detailed specification of performance requirements in Annex 2 of the Tender. Analysis of the concept design made by the Client shows that the specified requirements are realistic. The calculations shall also provide evidence of the factor of safety against structural collapse of the compressor chamber under vacuum and when subjected to overpressure up to a value limited by means of a passive safety device (e.g. bursting disk). Similar, though less elaborate, calculations shall be supplied for the beam injector vacuum envelope. Results of the analysis shall be provided by Supplier to Client for review. Status of appropriate requirements to be verified by the analysis shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier), and shall be the basis for acceptance of D2A and D2B.

d) A brief technical report shall be provided by the Supplier that lists all the significant changes and enhancements between the FZU concept design and the agreed detail design. For each change there shall be a brief description of the reason for change and justification of the selected solution. This will provide a means of checking that no important features of the concept design have been inadvertently lost or corrupted.

e) The Supplier shall provide updated detailed 3D models of the compressor chambers, the beam injectors, and of the internal optical supporting structures of each chamber, with its associated components and sub-assemblies, showing the finally agreed configuration.

The provided documentation shall be reviewed by Client by means of Critical Design Review (CDR) process for the part of supply corresponding to D2, and its results will be recorded in a CDR Report. The verification of the Design shall be considered complete when the Client and the Supplier mutually agree that, on the basis of the CDR Report and on the basis of the Verification Control Document (VCD) that all corresponding requirements related to the Design were closed out and that all associated verification objectives were fully achieved. The status of the requirements verified in the Review of Design shall be tracked by the Verification Control Document (VCD), see Annex No. 3, and shall be the basis for acceptance of the Design.

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The Supplier shall further submit a timetable of individual major steps in the manufacturing process and factory testing related to D4 and D5 for the L2 compressor, and to D6 and D7 for the L4PW compressor. The Client reserves the right to witness verification and testing of the individual components and subsystems at the Supplier's premises at any of the indicated steps in the manufacturing process, and to monitor implementation of the contract.

In order to even out the extensive design effort and necessary cooperation with the Contracting Authority the Deliverable completion dates for the individual compressor systems are staggered:

Completion: D2A 3 months after Commencement Day
D2B 5 months after Commencement Day

3. Deliverable D3:

Development of FZU concept design of optomechanical mounts of L2 and L4PW compressors into detailed engineering design for production drawings

a) The Supplier shall develop detailed engineering 3D models of the optomechanical mounts of the L2 and L4PW compressors and injectors, based on the preliminary design drawings and 3D models supplied by the Client. These detailed engineering models produced by the Supplier will be used in the next steps to make production drawings and to manufacture the mounts. The purpose of the detailed engineering design is to develop the Client's preliminary design into a full model including all necessary mechanical details and to optimize the overall design with respect to the technologies, functionality, and fabrication methods that will be employed for manufacturing. The accepted detailed 3D models and the detailed engineering drawings developed in this Deliverable will be binding for the Supplier in the manufacturing phase and for Deliverables D10, D11, and D12.

b) A part of this Deliverable D3 will be elaboration of specific details, such as:

- Lifting points (e.g. lifting eyes) for installation of large mounts (especially G1, G2, and PM of the L2 compressor, and G1, G2, and PM1 of the L4PW compressor)
- Mounting points on large mounts with precisely toleranced ø6 holes suitable for mounting a corner cube reflector for laser scanning, for precise measurements of the mounts' positions during installation
- Design of the connector array on each electrically actuated mount, allowing extraction of these mounts without with removing cables between the mount and the respective vacuum electrical connector.
- Connection to the internal (vacuum) and external (on the outer compressor chamber surface) cable trays.
- Design of locating pins on the optical tables for each optomechanical mount
- Relief holes in the mounts to avoid trapped air pockets
- Determination of materials, configuration of motion elements, connections of the actuators and of positioning sensors, surface finishes and other similar matters necessary to optimize for fabrication

c) The Supplier shall verify the stiffness and vibrational properties of the developed detailed design of all large optomechanical mounts, by means of FEA (Finite Element Analysis) simulations. The acceptable limits of vibrational criteria are included in the detailed specification of performance requirements in Annex 2 to this Contract. Analysis of the concept design made by the Client shows that the specified requirements are realistic. Results of the analysis shall be provided by Supplier to Client for review. Status of appropriate requirements to be verified by the analysis shall be tracked by the Verification Control Document (VCD), see Annex No. 3.

d) A brief technical report shall be provided by the Supplier that lists all the significant changes and enhancements between the FZU concept design and the agreed detail design. For each change there shall be a brief description of the reason for change and justification of the selected solution. This will provide a means of checking that no important features of the concept design have been inadvertently lost or corrupted.

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e) The Supplier shall provide an updated detailed 3D model of all optomechanical mounts of the L2 and L4PW compressor and injector systems, showing the finally agreed configuration.

f) The Supplier shall provide final Quality and Verification Plan for all the main components and other documentation, which will be reviewed by the Client.

g) The Supplier shall develop detailed design of the Motion Control Systems (MCS) for each L2 and L4PW compressor and injector, based on the architecture block scheme provided in Annex 2 (Requirements Specification Document). The designed systems shall incorporate as minimum the control points specified in Annex 2, and may add additional control points so as to meet all other system requirements. The designed MCSs shall use the devices (hardware) supplied by the Client, as specified in Annex 2; the Supplier shall ask Client for approval of any MCSs devices and items provided by the Supplier. The designed MCSs detailed schemes and associated documentation, including list of all devices to be used, shall be submitted by Supplier to Client for review. The accepted detailed scheme and list of devices developed in this Deliverable will be binding for the Supplier in the manufacturing phase (Deliverables D10, D11, and D12).

h) The provided documentation shall be reviewed by Client by means of Critical Design Review (CDR) process and its results will be recorded in a CDR Report. The verification of the Design shall be considered complete when the Client and the Supplier mutually agree that, on the basis of the CDR Report and on the basis of the Verification Control Document (VCD) that all corresponding requirements related to the Design were closed out and that all associated verification objectives were fully achieved. The status of the requirements verified in the Review of Design shall be tracked by the Verification Control Document (VCD), see Annex No. 3, and shall be the basis for acceptance of the Design.

i) The Supplier shall further submit a timetable of individual major steps in the manufacturing process and factory testing related to the optomechanical mounts. The Client reserves the right to witness verification and testing of the individual components and subsystems at the Supplier's premises at any of the indicated steps in the manufacturing process, and to monitor implementation of the contract.

Completion: 9 months after Commencement Day

4. Deliverable D4:

Manufacturing, assembly and factory testing of the L2 compressor and injector vacuum chambers

The Supplier shall manufacture the L2 compressor and injector vacuum vessels including the doors and flanges, and all elements of interconnection of these subsystems, in line with the documentation produced within the D2A Deliverable. The Supplier shall perform inspection and testing of vacuum welds according to requirements in Annex 2 and Annex 3 to this Contract. Completion of individual major steps of the manufacturing process will be witnessed by the Client according to the Quality Plan and the Verification Control Document.

After finishing the individual phases of fabrication and cleaning, the Supplier shall install the compressor and injector chambers in Class 7 or better cleanroom at his premises, where all assembly and vacuum performance and vacuum cleanliness tests will be made. Upon assembling the individual components and sub-systems this phase shall verify key parameters of the L2 compressor and injector assemblies, namely:

- Performance of vacuum leak test using He leak detector of the assembled L2 compressor and injector chambers with doors, port covers, blank flanges and isolation valves fitted, to verify compliance with requirements in Annex 2;
- Vacuum performance and ability to achieve a pressure of 10^{-6} mbar within no more than 10 hours, and $5x10^{-7}$ mbar in time comparable to 48 hours with the supplied turbomolecular pumps;

- Stability of the L2 compressor and injector chambers structure during pump down, quantitative measurements of deformations of the vacuum chamber body, to verify compliance with requirements in Annex 2;
- Validation of the vacuum cleanliness (contaminants-free vacuum) by Residual Gas Analyzer (RGA) mass-spectrometer to demonstrate residual pressures of molecular compounds according to requirements in Annex 2.

The verification of the L2 compressor and injector assembly performance shall be made according to the Verification Plan. The results of this performance verification and testing will be a Protocol on Factory Testing of the L2 compressor and injector chambers. The verification shall be considered complete when the Client and the Supplier mutually agree that, on the basis of the VCD and of the Protocol on Factory Testing of the L2 compressor and injector chambers, all corresponding requirements were closed out and the associated verification objectives were fully achieved. The status of the requirements verified in this phase of Inspection and Testing shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D4.

Completion: 10 months after Commencement Day

5. Deliverable D5:

Transport and installation of the L2 compressor and injector vacuum chambers at ELI-Beamlines. Connection to the facility primary vacuum lines. L2 vacuum control system on-site integration, verification of vacuum performance of the L2 chambers

The Supplier shall prepare for transport of the L2 compressor and injector vacuum chambers, and all vacuum tubing necessary for connecting the chambers to the ELI-Beamlines primary vacuum circuits. The compressor and injector vessels shall be packed separately.

For the duration of their transport the vacuum chambers shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all parts shall be in multiple layers of plastic film (as sheet or bags), complying with requirements in Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the components to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D5. Offloading of the L2 compressor chamber at the ELI-Beamlines building entrance will probably require a mobile crane on hire. Other packages can be offloaded by fork lift truck. The transport of the compressor from the ELI-Beamlines entrance through the building right up to the point of fixing down at the operational location in the L2 hall will be carried out by the Client, under Supplier's supervision. Transport through the Laser Building will involve the use of a goods lift to transition between floors and in order to fit in the lift the maximum dimensions of the chamber body (in its transport configuration) must not exceed 5.5 m (length) x 5.1 m (width) x 3 m (height) and its weight must not exceed 10 tons. Movement through corridors and rooms will require wheels, or rollers fitted to a suitable support structure, whose design will be within the scope of the Supplier.

Upon transport of the components to the L2 hall of ELI-Beamlines, to the point of fixing, the Supplier shall fine position and bolt the compressor and injector to the floor plates, under Client's supervision. The device (laser tracker) for accurate position measurements will be provided by the Client.

The L2 compressor and injector chambers shall be positioned in the L2 hall, with respect to the local coordinate system, with a tolerance of +/- 1 mm. This positioning will be referenced to patterns centered on the flanges of the input and output laser beam windows of the chamber.

An electric overhead travelling crane with a capacity of 5 tons is installed in the L2 laser hall above the area where the compressor will be installed will be available for D5 activities. However, no reliance shall be placed on using this crane for fine positioning of the L2 compressor chamber.

The Supplier shall connect the compressor and injector chambers to the ELI-Beamlines primary vacuum circuits, and shall install all cooling water piping on the compressor and injector, connecting to the L2 hall cooling water circuit distribution point (manifold) as described in Annex 2. The Supplier shall install all compressed dry air (CDA) piping and its connection(s) to the CDA L2 hall manifold. The compressor and injector chambers will be pumped down. A vacuum performance corresponding to that reported in the D4, Protocol on Factory Testing of the L2 compressor and injector chambers, shall be demonstrated.

The Supplier shall install and integrate the L2 compressor vacuum control system (VCS). Details of this procedure will be the subject of agreement between the Client and the Supplier.

All required performance verification and testing associated with installation of the compressor and injector chambers shall be made according to the Verification Plan. The results of this performance verification and testing will be a Protocol on Installation of the L2 compressor and injector chambers and their integration in the L2 hall of the ELI-Beamlines facility. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D5.

Note: Upon completion of D5 activities, an enclosure of Cleanliness Class 5 will be installed around the L2 compressor chamber to reduce the risk of internal contamination during the subsequent operations, especially for installation of the internal optical table and optomechanical equipment and their integration and alignment. This enclosure will be designed, procured and installed by the Client.

Completion: 12 months after Commencement Day

6. Deliverable D6:

Manufacturing, assembly and factory testing of the L4PW compressor and injector vacuum chambers

The Supplier shall manufacture the L4PW compressor and injector vacuum vessels including the doors and flanges, and all elements of interconnection of these subsystems, in line with the documentation produced within the D2B Deliverable. The Supplier shall perform inspection and testing of vacuum welds according to requirements in Annex 2 to this Contract. Completion of individual major steps of the manufacturing process will be witnessed by the Client according to the Quality Plan and the Verification Control Document.

After finishing the individual phases of fabrication and cleaning, the Supplier shall install the compressor and injector chambers in Class 7 or better cleanroom at his premises, where all assembly and vacuum performance and vacuum cleanliness tests will be made. Upon assembling the individual components and sub-systems this phase shall verify key parameters of the L4PW compressor and injector assemblies, namely:

- Performance of vacuum leak test using He leak detector of the assembled L4PW compressor and injector chambers with doors, port covers, blank flanges and isolation valves fitted, to verify compliance with requirements in Annex 2;
- Vacuum performance and ability to achieve a pressure of 10^{-6} mbar within no more than 12 hours, and $5x10^{-7}$ mbar in time comparable to 64 hours with the supplied turbomolecular pumps;
- Stability of the L4PW compressor and injector chambers structure during pump down, quantitative measurements of deformations of the vacuum chamber body, to verify compliance with requirements in Annex 2;
- Validation of the vacuum cleanliness (contaminants-free vacuum) by Residual Gas Analyzer (RGA) mass-spectrometer to demonstrate residual pressures of molecular compounds according to requirements in Annex 2.

The verification of the L4PW compressor and injector assembly performance shall be made according to the Verification Plan. The results of this performance verification and testing will be a Protocol on Factory Testing of the L4PW compressor and injector chambers. The verification shall be considered complete when the Client and the Supplier mutually agree that, on the basis of the VCD and of the Protocol on Factory Testing of the L4PW

compressor and injector chambers, all corresponding requirements were closed out and the associated verification objectives were fully achieved. The status of the requirements verified in this phase of Inspection and Testing shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D6.

Completion: 13 months and after Commencement Day

7. Deliverable D7:

Transport and installation of the L4PW compressor vacuum and injector chambers at ELI-Beamlines. Connection to the facility primary vacuum lines. L4PW vacuum control system on-site integration, verification of vacuum performance of the L4PW chambers.

The Supplier shall prepare for transport of the L4PW compressor and injector vacuum chambers, and all vacuum tubing necessary for connecting the chambers to the ELI-Beamlines primary vacuum circuits. The compressor and injector vessels shall be packed separately.

For the duration of their transport the vacuum chambers shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all parts shall be in multiple layers of plastic film (as sheet or bags), complying with requirements in Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the components to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D7. Offloading of the L4PW compressor chamber at the ELI-Beamlines building entrance will probably require a mobile crane on hire. Other packages can be offloaded by fork lift truck. The transport of the compressor from the ELI-Beamlines entrance through the building right up to the point of fixing down at the operational location in the L4b hall will be carried out by the Client, under Supplier's supervision. Transport through the Laser Building will involve the use of a goods lift to transition between floors and in order to fit in the lift the maximum dimensions of the chamber body (in its transport configuration) must not exceed 5.5 m (length) x 5.1 m (width) x 3 m (height) and its weight must not exceed 10 tons. Movement through corridors and rooms will require wheels, or rollers fitted to a suitable support structure, whose design will be within the scope of the Supplier.

Upon transport of the components to the L4b hall of ELI-Beamlines, to the point of fixing, the Supplier shall fine position and bolt the compressor and injector to the floor plates, under Client's supervision. The device (laser tracker) for accurate position measurements will be provided by the Client.

The L4PW compressor and injector chambers shall be positioned in the L4b hall, with respect to the local coordinate system, with a tolerance of +/- 1 mm. This positioning will be referenced to patterns centered on the flanges of the input and output laser beam windows of the chamber.

An electric overhead travelling crane with a capacity of 1 ton is installed in the L4b laser hall above the area where the compressor will be installed will be available for D7 activities. However, no reliance shall be placed on using this crane for fine positioning of the L4PW compressor and injector chambers.

The Supplier shall connect the compressor and injector chambers to the ELI-Beamlines primary vacuum circuits, and shall install all cooling water piping on the compressor and injector, connecting to the L4b hall cooling water circuit distribution point (manifold) as described in Annex 2. The Supplier shall install all compressed dry air (CDA) piping and its connection(s) to the CDA L4b hall manifold. The compressor and injector chambers will be pumped down. A vacuum performance corresponding to that reported in the D6, Protocol on Factory Testing of the L4PW compressor and injector chambers, shall be demonstrated.

The Supplier shall install and integrate the L4PW compressor vacuum control system (VCS). Details of this procedure will be the subject of agreement between the Client and the Supplier.

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All required performance verification and testing associated with installation of the compressor and injector chambers shall be made according to the Verification Plan. The results of this performance verification and testing will be a Protocol on Installation of the L4PW compressor and injector chambers and their integration in the L4b hall of the ELI-Beamlines facility. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D7.

Note: Upon completion of D7 activities, an enclosure of Cleanliness Class 5 will be installed around the L4PW compressor chamber to reduce the risk of internal contamination during the subsequent operations, especially for installation of the internal chassis and optomechanical equipment and their integration and alignment. This enclosure will be designed, procured and installed by the Client.

Completion: 15 months after Commencement Day

8. Deliverable D8:

Transport and installation of the L2 compressor internal optical support structures at ELI-Beamlines

The Supplier shall prepare for transport of the L2 compressor internal optical support structure, of the compressor and injector optical tables, and of the double-bellows optical structures supporting posts. Each of these components shall be packed separately.

For the duration of its transport the parts shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all parts shall be in multiple layers of plastic film (as sheet or bags), complying with requirements of Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the components to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D8. Offloading of the components at the ELI-Beamlines building entrance will be made by fork lift truck. The transport of the components from the ELI-Beamlines entrance through the building to the L2 hall will be carried out by the Client, under Supplier's supervision.

The Supplier shall install the compressor optical table supports double-bellows posts on the floor plates and shall position them with respect to the L2 hall coordinate system; the device (laser tracker) for accurate position measurements will be provided by the Client. The Supplier shall also install the double-bellows support posts on the injector chassis for the injector optical tables.

The Supplier shall install into the L2 compressor the optical support structure and shall ensure its proper integration with the support posts and with the compressor chamber. The Supplier shall subsequently install all segments of the optical table to the compressor, and shall install the optical tables to the injector. The Supplier shall verify alignment of the installed optical tables with respect to the L2 hall coordinate system, using the laser tracker provided by the Client. Details of this procedure shall be the subject of agreement between the Client and the Supplier.

An electric overhead travelling crane with a capacity of 5 tons is installed in the L2 laser hall above the area of the compressor and injector, which can be used for D8 activities. However, the Supplier shall be responsible for avoiding particle contamination of the compressor interior and of the optical tables if using this crane.

All required activities and verification testing associated with installation of the internal optical supporting structures of the L2 compressor and injector shall be made according to the Verification Plan. The results of this verification and testing will be a Protocol on Installation of the L2 compressor and injector internal optical support structures and their integration with the L2 compressor and injector chambers. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D8.

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Completion: 16 months after Commencement Day

9. Deliverable D9:

Transport and installation of the L4PW compressor internal optical chassis structures at ELI-Beamlines

The Supplier shall prepare for transport components of the L4PW compressor internal optical chassis, of the compressor and injector optical tables, and of the double-bellows optical structures supporting posts. Each of these components shall be packed separately.

For the duration of its transport the parts shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all parts shall be in multiple layers of plastic film (as sheet or bags), complying with requirements of Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the components to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D9. Offloading of the components at the ELI-Beamlines building entrance will be made by fork lift truck. The transport of the components from the ELI-Beamlines entrance through the building to the L4b hall will be carried out by the Client, under Supplier's supervision.

The Supplier shall install the compressor optical table supports double-bellows posts on the floor plates and shall position them with respect to the L4b hall coordinate system; the device (laser tracker) for accurate position measurements will be provided by the Client. The Supplier shall also install the double-bellows support posts on the L4PW injector chassis, suspended on the wall, for the injector optical table.

The Supplier shall install into the L4PW compressor the optical chassis and shall ensure its proper integration with the support posts and with the compressor chamber. The Supplier shall subsequently install all optical tables to the chassis, and shall install the optical table to the injector. The Supplier shall verify alignment of the installed optical tables with respect to the L4b hall coordinate system, using the laser tracker provided by the Client. Details of this procedure shall be the subject of agreement between the Client and the Supplier.

An electric overhead travelling crane with a capacity of 1 tons is installed in the L4b laser hall above the area of the compressor, which can be used for D9 activities. However, the Supplier shall be responsible for avoiding particle contamination of the compressor interior and of the optical chassis and tables if using this crane.

All required activities and verification testing associated with installation of the internal optical supporting structures of the L4PW compressor and injector shall be made according to the Verification Plan. The results of this verification and testing will be a Protocol on Installation of the L4PW compressor and injector internal optical support structures and their integration with the L4PW compressor and injector chambers. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D9.

Completion: 17 months after Commencement Day

10. Deliverable D10:

Delivery and installation of large electrically actuated optomechanical mounts of the L2 compressor (M2, M3, G1, G2, PM), and L4PW compressor (TM3, TOAP2, M1, G1, G2, PM1, M2, M3) and of their electric cabling

The Supplier shall prepare for transport of the M2, M3, G1, G2, and PM mounts of the L2 compressor, and the TM3, TOAP2, M1, G1, G2, PM1, M2, and M3 mounts of the L4PW compressor. Each mount shall be packed separately.

For the duration of their transport the mounts shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all mounts shall be in multiple layers of plastic film (as sheet or bags) and shall comply with the respective requirements stated in Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the mounts to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D10. Offloading of the mounts at the ELI-Beamlines building entrance will be made by fork lift truck.

On the ELI-Beamlines site, the mounts and other delivered components will be unpacked by Supplier in Class 5 cleanroom tent built around each compressor, and will be inspected for absence of any damage due to transport, according to Annex 3, Verification Control Document (VCD).

The Supplier shall install the respective mounts and their electric cabling into the L2 and L4PW compressors. Positioning of the mounts on the optical tables shall be made using the designed and manufactured locating pins.

All required tests associated with on-site verification of the delivered optomechanical mounts shall be identified in the Verification Plan. The results of this deliverable will be a Protocol on Delivery of the optomechanical mounts to the ELI-Beamlines facility. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D10.

Completion: 18 months after Commencement Day

11. Deliverable D11:

Delivery and installation of L2 and L4PW compressors reference crossed hairs, manual and diagnostic optomechanical mounts, and of their electric cabling.

The Supplier shall prepare for transport of the motorized reference crossed hair mounts of the L2 and L4PW compressors, and all remaining optomechanical mounts including mounts with manual actuators and the small diagnostic mounts for both compressors. Each mount shall be packed separately.

For the duration of their transport the mounts shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all mounts shall be in multiple layers of plastic film (as sheet or bags) and shall comply with the respective requirements stated in Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the mounts to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D11. Offloading of the mounts at the ELI-Beamlines building entrance will be made by fork lift truck.

On the ELI-Beamlines site, the mounts and other delivered components will be unpacked by Supplier in Class 5 cleanroom tent built around each compressor, and will be inspected for absence of any damage due to transport, according to Annex 3, Verification Control Document (VCD).

The Supplier shall install the delivered mounts and their electric cabling into the L2 and L4PW compressors. Positioning of the mounts on the optical tables shall be made using the designed and manufactured locating pins.

The Supplier shall install and integrate the L2 and L4PW compressor motion control systems (MCS). Details of this procedure will be the subject of agreement between the Client and the Supplier.

All required tests associated with on-site verification of the delivered optomechanical mounts shall be identified in the Verification Plan. The result of this deliverable will be a Protocol on Delivery of the optomechanical mounts to the ELI-Beamlines facility. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D11.

Completion: 24 months after Commencement Day

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12. Deliverable D12:

Delivery and installation of L2 and L4PW beam injectors optomechanical mounts, of their electric cabling, testing of integrated motion control system with all installed mounts in each system.

The Supplier shall prepare for transport of the optomechanical mounts of the L2 and L4PW beam injectors and of their cabling. Each mount shall be packed separately.

For the duration of their transport the mounts shall be hermetically sealed under dry air or nitrogen. The initial wrapping of all mounts shall be in multiple layers of plastic film (as sheet or bags) and shall comply with the respective requirements stated in Annex 2. This clean conditions wrapping will be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

The Supplier will transport the mounts to the ELI-Beamlines facility and will remain responsible for them (with appropriate insurance cover) until acceptance of D12. Offloading of the mounts at the ELI-Beamlines building entrance will be made by fork lift truck.

On the ELI-Beamlines site, the mounts and other delivered components will be unpacked by Supplier in Class 5 cleanroom tent built around each injector, and will be inspected for absence of any damage due to transport, according to Annex 3, Verification Control Document (VCD).

The Supplier shall install the delivered mounts and their electric cabling into the L2 and L4PW injectors. Positioning of the mounts on the optical tables shall be made using the designed and manufactured locating pins.

The Supplier shall test functioning of the complete optomechanical assembly of both L2 and L4PW compressor and injector with the motion control system (MCS).

All required tests associated with on-site verification of the delivered injectors' mounts and of integral operation of the both L2 and L4PW optomechanical systems shall be identified in the Verification Plan. The results of this deliverable will be a Protocol on Integrated Operation of the L2 and L4PW optomechanical mounts at the ELI-Beamlines facility. The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier) and shall be the basis for acceptance of D12.

Completion: 30 months after Commencement Day

II. Contractual options

Contractual Option OD1:

Design and manufacture of the tubing for interconnection of L2 injector with L2 distribution

As part of this Optional Deliverable the Supplier shall develop detailed engineering drawings of the DN400 tubing for connecting the L2 beam injector with the first chamber of the L2 beam distribution system located in the basement of the ELI-Beamlines laser building. The design shall include elements for suspension of the tubing on the wall(s) of the floor penetration between the L2 hall and the below-located E2 hall, and shall be aligned with the penetration cover and floors partitioning elements; details will be provided by Client upon activating this option.

The developed engineering drawings will be approved by the Client.

The Supplier shall manufacture the tubing in line with the approved documentation, and shall clean it in line with the requirements on vacuum cleaning in Annex 2. The Supplier shall verify vacuum performance and vacuum cleanliness of the tubing, according to the respective requirements in Annex 2. The results of this performance verification and testing will be a Protocol on Factory Testing of the vacuum tubing for interconnection of L2 injector with L2 distribution.

The Supplier shall pack the vacuum tubing, according to requirements of Annex 2, and shall deliver it to ELI-Beamlines.

The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, and shall be the basis for acceptance of the Contractual Option 1.

The Client is entitled to activate this Optional Deliverable 1 with a written request no later than on month 18 from the Commencement Day. The Supplier is entitled to invoice the Client with the price of OD1 after its completion (i.e. upon acceptance of OD1).

Completion: 6 months after OD1 activation

Contractual Option OD2:

Design and manufacture of the tubing for interconnection of L4PW injector with L4PW distribution

As part of this Optional Deliverable the Supplier shall develop detailed engineering drawings of the DN400 tubing for connecting the L4PW beam injector with the first chamber of the L4PW beam distribution system located in the basement of the ELI-Beamlines laser building. The design shall include elements for suspension of the tubing on the wall(s) of the floor penetration between the L4b hall and the below-located L4c hall, and shall be aligned with the penetration cover and floors partitioning elements; details will be provided by Client upon activating this option.

The developed engineering drawings will be approved by the Client.

The Supplier shall manufacture the tubing in line with the approved documentation, and shall clean it in line with the requirements on vacuum cleaning in Annex 2. The Supplier shall verify vacuum performance and vacuum cleanliness of the tubing, according to the respective requirements in Annex 2. The results of this performance verification and testing will be a Protocol on Factory Testing of the vacuum tubing for interconnection of L4PW injector with L4PW distribution.

The Supplier shall pack the vacuum tubing, according to requirements of Annex 2, and shall deliver it to ELI-Beamlines.

The status of requirements verified in this phase shall be tracked by the Verification Control Document (VCD), see Annex No. 3, and shall be the basis for acceptance of the Contractual Option 2.

The Client is entitled to activate this Optional Deliverable 2 with a written request no later than on month 18 from the Commencement Day. The Supplier is entitled to invoice the Client with the price of OD2 after its completion (i.e. upon acceptance of OD2).

Completion: 6 months after OD2 activation

Contractual Option OD3:

Design and manufacture of the L2 mid-IR periscope chamber and of its internal supporting structures

Within this Optional Deliverable the Supplier shall develop detailed engineering drawings of the L2 mid-IR periscope vacuum chamber ("pyramid"), of its internal optical chassis, and of the supporting chassis. Upon approval of the developed detailed design the Supplier shall manufacture, clean and assemble components of the chamber and of its internal supporting structure, and shall perform its vacuum, structural stability, and vacuum cleanliness testing.

a) The Supplier shall develop detailed engineering 3D model of all periscope structures, based on the preliminary design drawings and 3D models supplied by the Client. The accepted detailed 3D model and the detailed engineering drawings developed in this Deliverable will be binding for the Supplier in the manufacturing phase.

b) A part of the detailed engineering design will be elaboration of specific details, such as:

- Lifting features (e.g. bosses for screw-in lifting eyes) for the vacuum chamber and for the internal optical chassis
- Mounting points / bosses with precisely toleranced ø6 holes suitable for mounting a corner cube reflector for laser scanning, for precise measurements of the chamber position during installation
- Double O-ring arrangement for large flanges of the vacuum chamber (if needed)
- Chamber support chassis and its floor plates
- Internal optical chassis with relief holes to avoid trapped air pockets
- Internal structure chassis and its floor plates
- Double bellows isolation legs
- Paths along the compressor and injector chambers for utilities, primary backing vacuum and electrical cables, determination of holes in the ribs for TMP backing vacuum and utilities, design of C-rails and cable trays on the chambers
- Determination of material thicknesses, configuration of stiffening ribs, flanges, weld locations and details, surface finishes and other such matters necessary to optimize for fabrication

c) The Supplier shall verify the stiffness of the developed detailed design of the chamber and of the internal optical supporting structure, by means of FEA (Finite Element Analysis) simulations. The acceptable limit of deformations of the chamber under application of vacuum (stiffness) and for proper frequencies of the internal optical supporting structure comply with the respective requirements for the L2 compressor in Annex 2. The calculations shall also provide evidence of the factor of safety against structural collapse of the periscope chamber under vacuum and when subjected to overpressure up to a value limited by means of a passive safety device (e.g. bursting disk). Results of the analysis shall be provided by Supplier to Client for review. Status of appropriate requirements to be verified by the analysis shall be tracked by the Verification Control Document (VCD), see Annex No. 3, Section 2 (Verification Requirements for Supplier), and shall be the basis for acceptance of Contractual Option 3.

The Supplier shall manufacture the L2 mid-IR periscope chamber and its internal supporting structures, in line with the developed documentation. The Supplier shall perform inspection and testing of vacuum welds according to requirements in Annex 2 to this Contract. Completion of individual major steps of the manufacturing process will be witnessed by the Client according to the Quality Plan.

After finishing the individual phases of fabrication and cleaning, the Supplier shall install the L2 mid-IR periscope chamber with its chassis in Class 7 or better cleanroom at his premises, where all assembly and vacuum performance and vacuum cleanliness tests will be made. Upon assembling the individual components and sub-systems this phase shall verify key parameters, namely:

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- Performance of vacuum leak test using He leak detector of the assembled chamber with ports and blank flanges, to verify compliance with requirements in Annex 2;
- Stability of the periscope chamber structure during pump down, quantitative measurements of deformations of the vacuum chamber body, to verify compliance with requirements in Annex 2;
- Validation of the vacuum cleanliness (contaminants-free vacuum) by Residual Gas Analyzer (RGA) mass-spectrometer to demonstrate residual pressures of molecular compounds according to requirements in Annex 2.

Upon completion of the testing the Supplier shall pack the L2 mid-IR periscope for transport, complying with the same requirements and procedures as for the L2 compressor and injector.

The Supplier shall transport all components of the L2 mid-IR periscope chamber and of its internal supporting structures to ELI-Beamlines.

The Client is entitled to activate this Optional Deliverable 3 with a written request anytime during the duration of the basic scope of the contract, i.e. up to and including month 30 from the Commencement Day. The Supplier is entitled to invoice the Client with the price of OD3 after its completion (i.e. upon acceptance of OD3).

Completion: 12 months after OD3 activation

Contractual Option OD4:

Design, manufacture and installation of beam polarization switch optomechanical mounts in the L4PW compressor

Within this Optional Deliverable the Supplier shall develop detailed engineering design of the L4PW beam polarization switch consisting of two additional vacuum optomechanical mounts and of their supporting structure. Upon approval of the developed detailed design the Supplier shall manufacture, clean and assemble in Class 5 components of the mounts, shall verify proper functioning of the actuates motion axes, shall deliver the mounts to ELI-Beamlines, and shall install to mounts to the L4PW compressor, including their integration with the L4PW motion control system (MCS).

The detailed engineering 3D model and drawings, based on the preliminary design drawings and 3D models supplied by the Client, shall be approved by the Client. The documentation produced by the Supplier will be used in the next steps to make production drawings and to manufacture the mounts. The purpose of the detailed engineering design is to develop the Client's preliminary design into a full model including all necessary mechanical details and to optimize the overall design with respect to the technologies, functionality, and fabrication methods that will be employed for manufacturing. The accepted detailed 3D models and the detailed engineering drawings will be binding for the Supplier in the manufacturing phase.

Upon manufacture, the Supplier shall clean and assemble the mounts and other components of the polarization switch in his premises and shall perform testing of functionality of the mounts. Same requirements as those specified in Annex 2 for the L4PW compressor mounts shall be applied. The Supplier shall pack the mounts and shall transport them to ELI-Beamlines. Supplier shall subsequently install the mounts into the L4PW compressor and shall integrate them with the L4PW motion control system. Details of this procedure will be the subject of agreement between the Client and the Supplier.

The Client is entitled to activate this Optional Deliverable 4 with a written request anytime during the duration of the basic scope of the contract, i.e. up to and including month 30 from the Commencement Day. The Supplier is entitled to invoice the Client with the price of OD4 after its completion (i.e. upon acceptance of OD4).

Completion: 12 months after OD4 activation

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ANNEX 2

DETAILED TECHNICAL SPECIFICATIONS OF THE COMPRESSORS

Requirements Specification Document (RSD) for the L2 Compressor

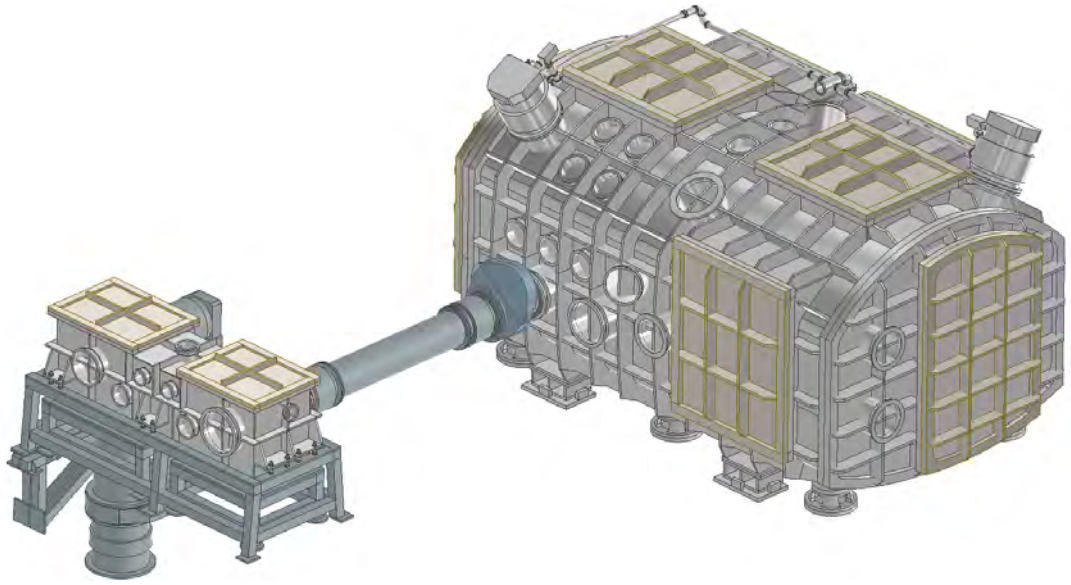
Requirements Specification Document (RSD) for the L4PW Compressor

Confidentiality Level	*BL - Restricted for internal use*	**TC ID / Revision**	00309243/C
Document Status	*Document Released*	**Document No.**	N/A
OBS code	*912*		
PBS code	RA1.L2.L2_1.CMP		
Project branch	*Engineering & Scientific documents (E&S)*		
Document Type	*Specification (SP)*		

[RSD product category C]

L2 Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System

TP21_046



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3				C

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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints on a product related to the RA1 programme of the ELI Beamlines project. This can lead to the identification of product interfaces with the ELI Beamlines science-based technology and ELI Beamlines building facility. This RSD also acts as the parent document for technical requirements that are addressed in lower level design description documents (see section 1.12).

The RSD contains all the technical requirements: functional and manufacturing design, manufacture, cleaning, packaging and transportation, as well as safety and quality, requirements for the following product (tender number: TP21_046): **L2 Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System** ("**Compressor**" in further text).

This RSD is comprised of a descriptive text that explains the purpose, function and arrangement of the Compressor to be supplied and is supported by further sections that provide a summary of requirements and technical details of material that comprises the scope of supply under the contract; all materials shall be compliant with the specified details. The Compressor is registered in the PBS database under the following PBS code: RA1.L2.L2_1.CMP.

No laser optics (mirrors, gratings, windows, etc.) are required to be supplied under this contract.

On multiple places this document mentions also the L4PW laser pulse compressor as many elements and subsystems of the L2 compressor are identical to the L4PW compressor. The technical description of the L4PW compressor system ("L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System") is in the document No. 00309478/C.

1.2. Scope of Work - Overall view of the Compressor and Injector assembly

The scope of work includes detailed design, manufacture, testing, transport to, and installation in ELI-Beamlines, of the integrated system of the vacuum chambers for the L2 grating compressor and the L2 beam injector, of the internal structures of the chambers including the optomechanical mounts, and of the full vacuum and motion controls. The supply contains all blank flanges and fittings required to seal the chambers.

The compressor chamber, see Figure 1, is designed as an externally ribbed structure in the shape of thick asymmetric cylindrical lens truncated on its sides. The upper and lower parts of the chamber are formed in shape by circular sections with radius 1,500 mm and 3,000 mm, respectively. The internal space has the net length 3,660 mm and width 2,200 mm. The maximum width and height of the internal space are respectively 2,200 mm and 1,800 mm (the internal structure with optical table when mounted reduce the clear height to 1,450 mm). At both ends, the chamber is equipped with large end installation doors with shape corresponding to the chamber section. These end doors can be removed by overhead crane to obtain unobstructed access to the chamber interior for the purpose of insertion and assembling of the internal optical table. Each installation door is further equipped with smaller hinged door allowing extensive access to the compressor optics, providing maximum clearance 1600 (h) x 1000 (w) mm^2 on the East side and 1600 (h) x 985 (w) mm^2 on the West side. Other three rectangular hinged doors at the chamber body (two on the North side and one on the South side) allow extensive access for laser personnel to the compressor gratings and adjacent optics, each providing clear opening 1,250 (h) x 1,000 (w) mm^2. There are also two rectangular top lids / hatches on the top of the chamber body, each witch clear opening 850 x 1,000 mm^2. These lids can be used e.g. for accessing chamber interior by the overhead crane to assist installation of the internal optical table. The lids will be equipped with lifting features (e.g. bosses for screw-in lifting eyes) to enable its handling by overhead crane.

The compressor chamber total height, including the top lids, is 2,265 mm, fitting with very large margin the ELI-Beamlines cargo elevator (3 m clear height) for initial transport from the cargo ramp to the L2 hall.

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All optomechanical units with optical components are mounted on an optical table located within the vacuum chamber and supported by an optimized structural support frame in the form of an inverted wing. The table is mechanically de-coupled from the vacuum vessel by a bellows structure.

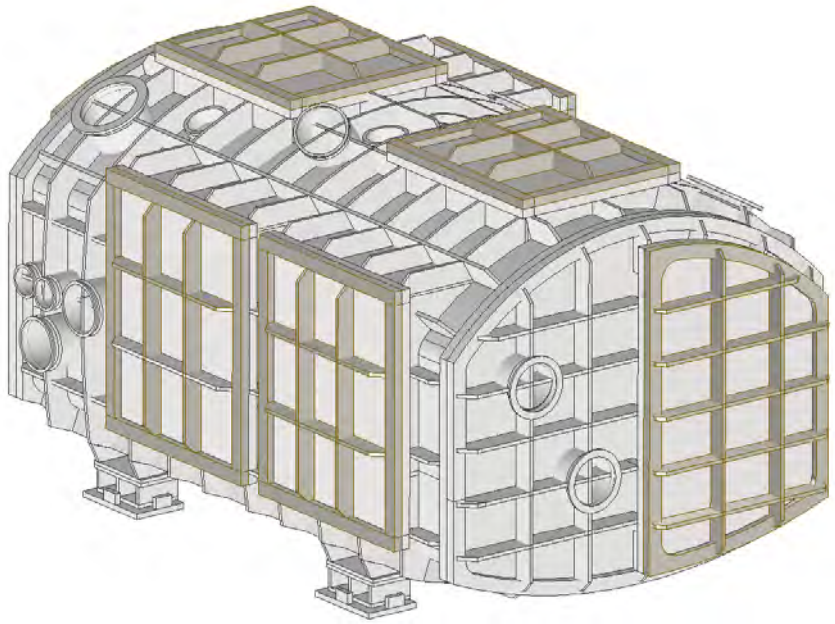

Figure 1: Compressor vacuum chamber seen from the North-West with respect to its position in the L2 laser hall of the ELI-Beamlines facility.

The injector vacuum chamber, see Figure 2, has a form of an externally ribbed cuboid with dimensions 2,120 (l) x 670 (w) x 610 (h) mm^3. The chamber is equipped with two top lids witch clear opening 680 (l) x 550 (w) mm^2 (East lid) and 750 (l) x 550 (w) mm^2 (West lid). Internal optomechanical structures in the injector are mounted on two internal tables supported by independent chassis; the tables are mechanically de-coupled from the injector chamber.

The laser beam exiting the injector is routed to the basement floor of the ELI-Beamlines building. The West part of the injector sits above the floor penetration connecting the L2 laser hall with the basement, on a supporting structure mounted in the penetration. This supporting structure inside the floor penetration will be provided by ELI-Beamlines.

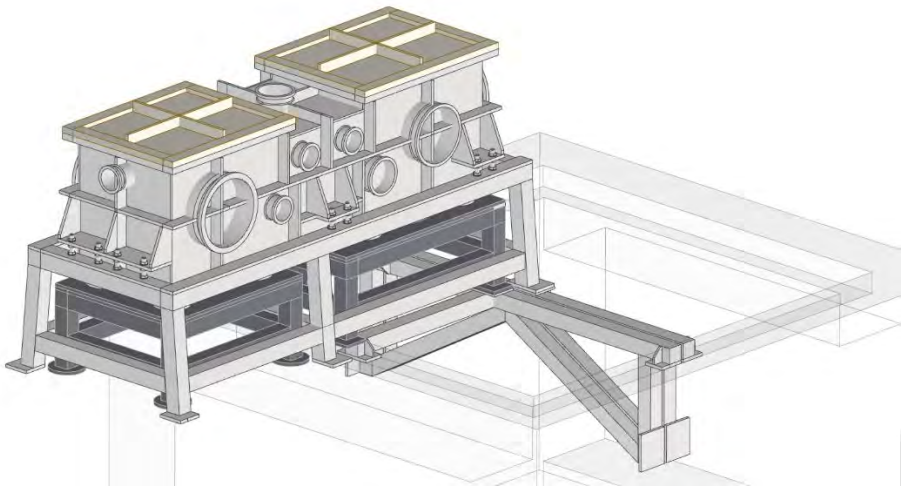

Figure 2: Injector vacuum chamber seen from North-East with respect to its position in the L2 laser hall of the ELI-Beamlines facility (chassis supporting the internal optical tables are indicated in dark grey).

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The compressor and injector vacuum chambers, including all their ports, shall be made from stainless steel class 1.4307 (equivalent to ČSN 17249, equivalent to AISI 304L), or equivalent. Good manufacturing practices for stainless steel welding shall be followed.

The nominal wall thickness of the compressor chamber and of the installation doors ID1 and ID2 in the CA design is 15 mm; the thickness of the hinged personal doors PD1 to PD5 and of the top lids TL1 and TL2 is 10 mm. The wall thickness of the injector chamber is 10 mm, as well as the thickness of its top lids. These thicknesses are based on FEM simulations and structural optimization carried out by CA, showing that deformations under the vacuum pressure differential do not exceed 1 mm anywhere on the compressor and injector chambers. The Supplier is not allowed to change substantially the structure of the ribs provided in the CA design, however can make local modifications of the ribs and adjust their thicknesses, based on optimisation study and on results of the Supplier's FEM simulations. The modified design shall provide structural stability resulting in deformations of walls less than 1 mm when the chambers are pumped down from atmospheric pressure.

1.3. Internal Optical Tables

1.3.1. Compressor

All optomechanical mounts of the compressor and of the injector will be supported by internal optical tables which are mechanically isolated from the chamber vessels by means of a double bellows structure.

The internal optical table of the compressor, see Figure 3, has total size of 3,560 x 2,100 mm^2 and is mounted on a massive support frame in the form of an inverted wing sitting on six massive support posts (legs) equipped by double bellows. The support frame shall be manufactured from one single block of cast aluminium free of internal stress and free of any defects and/or inhomogeneities.

The material of the support structure and of the optical tables segments shall be aluminium alloy EN AW 5083 (equivalent to ČSN 42 4415, equivalent to ANSI AA5083), or equivalent.

The table consists of individual segments with thickness of 40 mm, which shall be machined with an array of tapped mounting holes compatible with threads M6 on a 25 mm square grid, as indicated in the drawings. In the CA design the optical table consists of six segments (considering manufacture and installation aspects), but the Supplier is allowed to reduce number of these segments and/or modify the form of individual segments. If such modification of the segments' size and/or shape is made, it shall be accompanied by corresponding modification of the support structure.

The table assembly including the support frame and the support posts have been optimized by CA with respect to stiffness and vibration characteristics (first resonance frequency above 100 Hz); the Supplier shall repeat the FEM simulations for the manufacturing drawings, accounting for masses of the optomechanical mounts.

The optical table segments shall be made from high-flatness prefabricated panels.

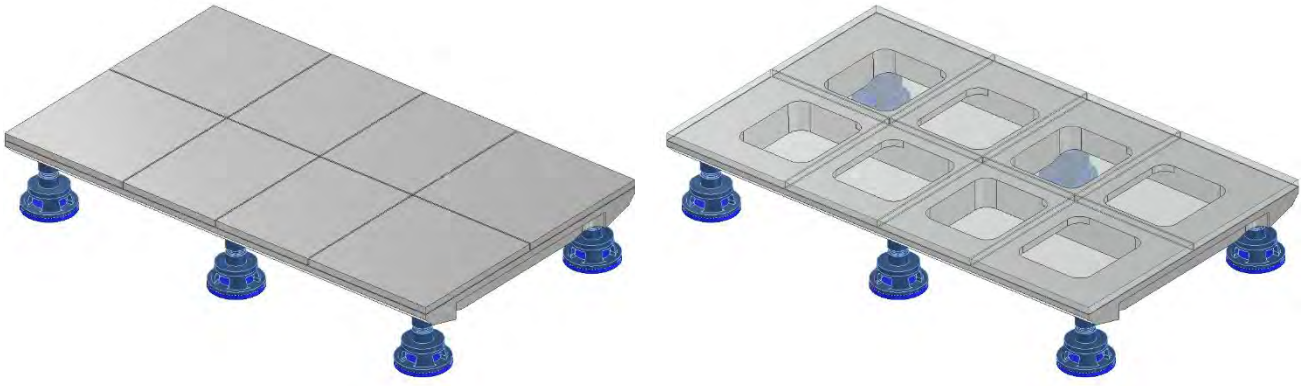

Figure 3: Compressor internal optical table integrated with the support frame (the structure is shown on the right) and with the six support posts (legs). The support posts are equipped with a double bellows structure, not indicated here.

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The supports posts (legs) will be mounted on stainless-steel floor plates which will be bonded to the structural floor with absolute vertical accuracy better than +/-0.1 mm. The supports are therefore not equipped by any fine height setting. The floor plates will be installed by CA.

The Supplier shall develop the CA conceptual design of the optical table, support structure, and supports (legs) equipped with double bellows into manufacturing design. The design shall, as for all other components inside the vacuum vessel, avoid any trapped volumes of air, *e.g.,* the mounting holes will be tapped right through.

1.3.2. Injector

The internal optical structure of the injector consists of two optical tables with sizes of 620 x 500 mm^2 (East table) and 700 x 500 mm^2 (West table). The tables have thickness of 40 mm and are directly supported by isolation legs (props).

As for the compressor, the material of the injector optical tables shall be aluminium alloy EN AW 5083 (equivalent to ČSN 42 4415, equivalent to ANSI AA5083), or equivalent. The tables shall be made from high-flatness prefabricated panels, cast and free of any defects and/or inhomogeneities.

The Supplier shall optimize the supporting chassis and shall perform the FEM simulations to demonstrate the vibration characteristics with the first resonance frequency above 100 Hz.

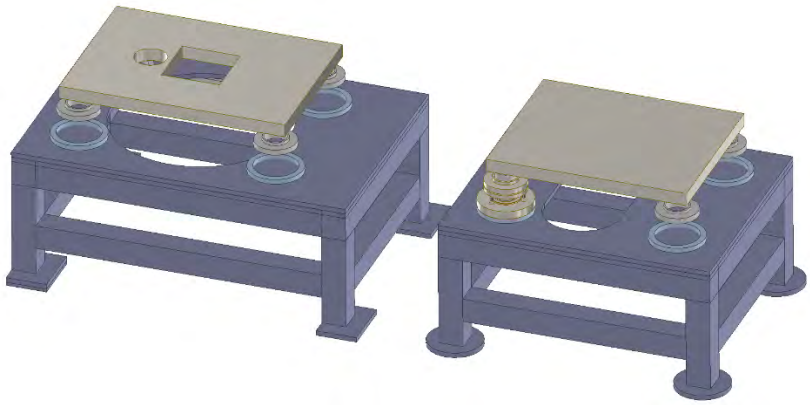

Figure 4: Injector internal optical tables sitting on separate supporting chassis (view from South-East); only one of the prop supports connecting the tables with the chassis is indicated. The props are equipped with a double bellows structure (not indicated here), similar to that used for the compressor but smaller in size.

Design of the internal optical table isolation supports (legs) is illustrated in Figure 5. The structure consists of double bellows providing full isolation of the force on the flange used for the leg, arising from pressure difference between outer atmospheric pressure and the chamber vacuum. The outer atmospheric pressure acting on the flange is transferred by the rod-shaped independent beams to the chamber body and the force acting on the support leg is zero.

This system of double-bellows based supporting props of internal optical tables for vacuum structures was pioneered by CA in 1999-2000 and has since proven to give excellent performance in a number of systems, with no detectable displacements of the optical components with respect to pump down.

[vypuštěno]

Figure 5: Concept of the isolation legs using double bellows system (illustration). The double bellows fully remove the force arising from the atmospheric pressure (vacuum pressure differential) on the flange cross-section, as the force is fully transmitted on the vessel by means of the cylindrical beams.

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1.4. Compressor Vacuum Flange Schedule

All circular flanges (except custom flanges as specified below) with diameter larger or equal to 50 mm shall be dimensioned according to ISO 1609 (2014 revision), or equivalent, corresponding to ISO-K or ISO-F implementation. All flanges smaller than 50 mm shall be dimensioned according to ISO 2861 (Second edition 2020-02), or equivalent.

All circular flanges in the list below will be sealed by simple fluoroelastomer O-rings. The doors and top lids shall be sealed by double O-ring assembly with pumped interspace.

The table below describes the intent for using these ports. For works vacuum testing by the supplier all flanges except those used for pumping and for vacuum gauges are required to be blanked by corresponding vacuum flanges. For delivery of the chamber to ELI-Beamlines all flanges shall be blanked.

The alignment of the flanges on the body of the chamber is in some places critical and elsewhere less critical. **Table 1** gives the permitted tolerance for individual tolerance grades applicable to all circular flanges of the compressor and injector chambers, as specified in **Table 2** and

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Table 3.

Table 1: Circular Flange Tolerance Grade.

Flange Tolerance Grade	Tolerance Specification
A	Co-axial tolerance of ±1 mm or better and angular tolerance of ±0.5 degrees or better with respect to their ideal axis
B	Co-axial tolerance of ±3 mm or better and angular tolerance of ±2.0 degrees or better with respect to their ideal axis
C	Normal manufacturing tolerance

Location of all flanges on the compressor and injector chamber body are shown respectively in Figure 6 and Figure 7.

All doors and top lids (ID1, ID2, PD1 to PD4, TL1 and TL2) are vacuum sealed by using a double fluoroelastomer O-ring seal arrangement minimizing effective gas load due to O-ring permeation, with the space between the O-rings actively pumped to ~10^{-2} mbar by the L2 laser hall backing vacuum circuit. The O-rings shall be located in the door flange and the interspace pumping shall be performed from the chamber flange, i.e. opening the doors shall not require disassembling of any vacuum tubes or bellows. The O-rings shall be retained in the grooves during the door opening. Detail design of the double O-ring assembly and arrangement of corresponding small flanges and tubes (inner diameter 12 mm) serving to active pumping of the space between the two O-rings shall be optimized by the Supplier during preparation of manufacturing drawings.

Small flanges for pumping O-ring interspaces are not included in the below flange schedule.

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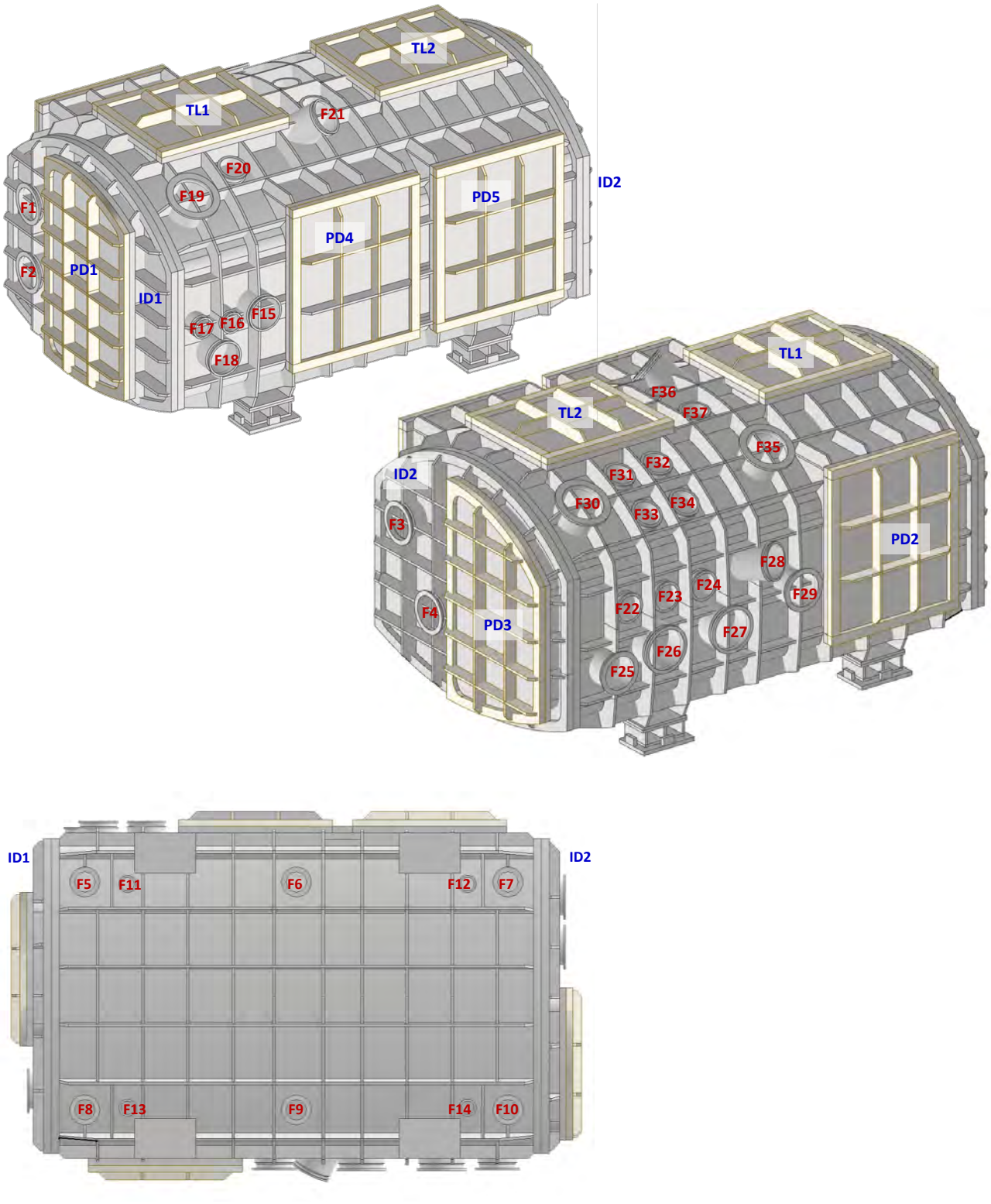

Figure 6: Doors, top lids, and circular flanges on the compressor chamber: views from North-East (above) and from South-West (middle), and view of the chamber underside (below).

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Table 2: Positions and specifications of compressor chamber vacuum flanges.

Type	Flange	Size	Position / Purpose	Note	Tolerance
-	ID1	Chamber section shape, 2350 (w) x 1950 (h) mm outer size, clear opening 2200 (w) x 1800 (h), 15 mm thickness, ribbed	Installation Door 1, East side of the chamber Installation of the internal optical table	Sealed by double O-ring assembly with pumped interspace Installed by L2 hall overhead crane, fitted with threads for lifting eyes	N.A.
-	ID2	Chamber section shape, 2350 (w) x 1950 (h) mm outer size, clear opening 2200 (w) x 1800 (h), 15 mm thickness, ribbed	Installation Door 2, West side of the chamber Installation of the internal optical table	Idem ID1	N.A.
-	PD1	At the top and bottom scaled chamber section shape, outer size 1750 (h) x 1150 (w) mm, providing clear opening 1600 (h) x 1000 (w) mm, 15 mm thickness, ribbed	Personnel Door 1, on ID1, for access to diagnostic beam optics and to input optics	Sealed by double O-ring assembly with pumped interspace Opening by hinge (double hinge arrangement to avoid O-rings crushing); fitted with threads for lifting eyes for initial installation by overhead crane	N.A.
-	PD2	Rectangular shape, outer size 1400 (h) x 1150 (w) mm, providing clear opening 1250 (h) x 1000 (w) mm, 15 mm thickness, ribbed	Personnel Door 2, South side of the chamber, access to grating 1	Idem PD1	N.A.
-	PD3	At the top and bottom scaled chamber section shape, outer size 1750 (h) x 1135 (w) mm, providing clear opening 1600 (h) x 985 (w) mm, 15 mm thickness, ribbed	Personnel Door 3, on ID2, for access to diagnostic beam optics and to input optics	Idem PD1	N.A.
-	PD4	Rectangular shape, outer size 1400 (h) x 1150 (w) mm, providing clear opening 1250 (h) x 1000 (w) mm, 15 mm thickness, ribbed	Personnel Door 4, North side of the chamber, access to grating 2	Idem PD1	N.A.
-	PD5	Rectangular shape, outer size 1400 (h) x 1150 (w) mm, providing clear opening 1250 (h) x 1000 (w) mm, 15 mm thickness, ribbed	Personnel Door 5, North side of the chamber, access to periscope mirror	Idem PD1	N.A.

Type	Flange	Size	Position / Purpose	Note	Tolerance
-	TL1	Rectangular shape, outer size 1150 (l) x 1000 (w) mm, providing clear opening 1000 (h) x 850 (w) mm, 15 mm thickness, ribbed	Top Lid 1 (hatch) for crane access to East part of compressor interior for optical table installation	Sealed by double O-ring assembly with pumped interspace	N.A.
-	TL2	Rectangular shape, outer size 1150 (l) x 1000 (w) mm, providing clear opening 1000 (h) x 850 (w) mm, 15 mm thickness, ribbed	Top Lid 2 (hatch) for crane access to West part of compressor interior for optical table installation	Idem TL1	N.A.
V	F1	DN250 ISO-F *	On ID1, spare flange for future upgrades	Will be blanked in current phase	B
V	F2	DN250 ISO-F *	Idem VF1	Idem VF1	B
V	F3	DN250 ISO-F *	On ID2, spare flange for future upgrades	Will be blanked in current phase	B
V	F4	DN250 ISO-F *	Idem VF3	Idem VF3	B
M	F5	153-mm-diam custom flange	On chamber underside, for connection of bellows isolation of the internal optical table	Tapped holes for connection with the isolation bellows, see Drawing Package. Initially closed by blank flange.	A
M	F6	153-mm-diam custom flange	Idem F5	Idem F5	A
M	F7	153-mm-diam custom flange	Idem F5	Idem F5	A
M	F8	153-mm-diam custom flange	Idem F5	Idem F5	A
M	F9	153-mm-diam custom flange	Idem F5	Idem F5	A
M	F10	153-mm-diam custom flange	Idem F5	Idem F5	A
V	F11	DN100 ISO K *	On chamber North underside, for connection to primary vacuum	Initially closed by blank flange	B
V	F12	DN100 ISO K *	On chamber North underside, for alternative connection to primary vacuum	Initially closed by blank flange	B
V	F13	DN100 ISO K *	On chamber South underside, for chamber venting	Initially closed by blank flange	B
V	F14	DN100 ISO K *	On chamber South underside, for manual chamber venting	Initially closed by blank flange	B

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Type	Flange	Size	Position / Purpose	Note	Tolerance
O	F15	DN250 ISO K *	On chamber North side, entry of the uncompressed laser beam	Will be equipped with AR-coated optical window	A
O	F16	DN160 ISO K *	On chamber North side, output of the 0^{th} order beam	Will be equipped with AR-coated optical window	A
O	F17	DN160 ISO-K *	On chamber North side, output of the Temporal and Spatial Diagnostic Beams (TBD and SDB)	DN160 with 2 subsidiary flanges DN50, equipped with AR coated optical windows	A
E	F18	DN250 ISO K *	On chamber North side, available for feedthroughs of electrical cables	Will be blanked	B
V	F19	DN320 ISO F *	On chamber North side, near top of the chamber, for TMP	Will be equipped by TMP 4000 l/s	B
V	F20	DN200 ISO K *	Near top of the chamber, for plasma cleaning	Initially closed by blank flange	C
O	F21	DN250 ISO K *	Near top of the chamber, viewport for inspection of the 1st grating	Initially closed by blank flange, later will be equipped by viewing port	B
E	F22	DN200 ISO K *	On chamber South side, for feedthroughs of electrical cables from optomechanical mounts	Will be equipped by cable feedthroughs	B
E	F23	DN200 ISO K *	Idem F22	Idem F22	B
E	F24	DN200 ISO K *	Idem F22	Idem F22	B
V	F25	DN250 ISO K *	On chamber South side, near top of the chamber, for vacuum gauges and vent outlet valve	Will be equipped by a flange with up to 4x reductions	B
O	F26	DN320 ISO F *	On chamber South side, exit of the compressed laser beam from the compressor	Fitted with the block of magnetic inserter of the beam dump mirror / pendulum DN320 HV valve	A
O	F27	DN320 ISO F *	On chamber South side, for alternative exit of the compressed beam	Closed by blank flange	A
O	F28	DN250 ISO K *	For visual inspection of the 2nd grating	Initially closed by blank flange, later will be equipped by viewing port	B
E	F29	DN250 ISO K *	On chamber South side, for feedthroughs of electrical cables from optomechanical mounts	Will be equipped by cable feedthroughs	B
V	F30	DN320 ISO F *	On chamber South side, near top of the chamber, for TMP	Will be equipped by TMP 4000 l/s	B

* or equivalent solution

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Type	Flange	Size	Position / Purpose	Note	Tolerance
V	F31	DN200 ISO K *	On chamber South side, near top of the chamber, for overpressure safety burst disk	Initially closed by blank flange	B
V	F32	DN200 ISO K *	On chamber South side, near top of the chamber, for vacuum mass spectrometer (RGA)	Initially closed by blank flange	B
V	F33	DN200 ISO K *	On chamber South side, near top of the chamber, for plasma cleaning	Initially closed by blank flange	B
V	F34	DN200 ISO K *	Idem F33	Idem F33	B
-	F35	DN320 ISO F *	On chamber South side, near top of the chamber, spare for alternative use	Will be blanked	B
O	F36	DN200 ISO K *	Near top of the chamber, for illumination of chamber interior	Initially closed by blank flange	B
O	F37	DN200 ISO K *	Idem F36	Idem F36	B

* or equivalent technical solution

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1.5. Injector Vacuum Flange Schedule

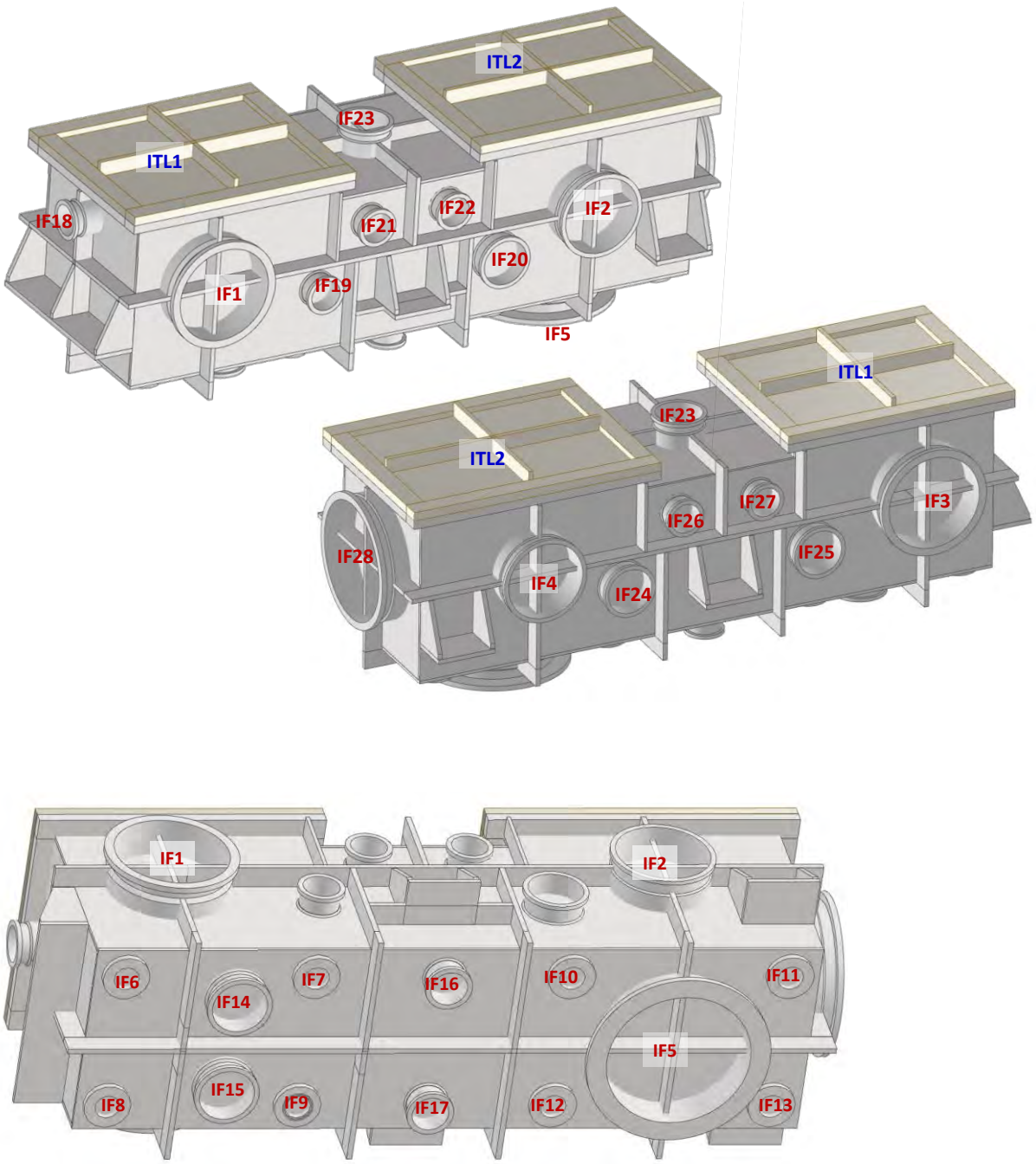

Figure 7: Top Lids and circular flanges on the injector chamber: views from North-East (above) and from South-West (middle), and view of the chamber underside (below).

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Table 3: Positions and specifications of injector chamber vacuum flanges.

Type	Flange	Size	Position / Purpose	Note	Tolerance
-	ITL1	Rectangular shape, outer size 800 (l) x 670 (w) mm, providing clear opening 680 (l) x 550 (w) mm, 10 mm thickness, ribbed	Injector Top Lid 1 for installation of the East optomechanical table of the injector and for access to the optomechanics	Sealed by double O-ring assembly with pumped interspace	N.A.
-	ITL2	Rectangular shape, outer size 870 (l) x 670 (w) mm, providing clear opening 750 (h) x 550 (w) mm, 10 mm thickness, ribbed	Injector Top Lid 2 for installation of the West optomechanical table of the injector and for access to the optomechanics	Idem ITL1	N.A.
O	IF1	DN320 ISO-K *	On injector North side, entry of the main laser beam	Initially closed by blank flange	A
V	IF2	DN250 ISO-F *	On injector North side, for connection of TMP	Will be equipped by TMP 3000 l/s	B
O	IF3	DN320 ISO-K *	On injector South side, for alternative connection of laser beam dump	Will be blanked in current phase	B
O	IF4	DN320 ISO-F *	On injector South side, for inspection of the injection mirrors	Will be blanked in current phase	B
O	IF5	DN400 ISO-F *	Output of the main and MID-IR laser beams to the L2 beam distribution	Initially closed by blank flange	A
M	IF6	70-mm-diam custom flange	On injector underside, for connection of bellows isolation of the internal optical table 1 (East)	Tapped holes for connection with the isolation bellows, see Drawing Package. Initially closed by blank flange.	A
M	IF7	70-mm-diam custom flange	Idem IF6	Idem IF6	A
M	IF8	70-mm-diam custom flange	Idem IF6	Idem IF6	A
M	IF9	70-mm-diam custom flange	Idem IF6	Idem IF6	A
M	IF10	70-mm-diam custom flange	On injector underside, for connection of bellows isolation of the internal optical table 2 (West)	Tapped holes for connection with the isolation bellows, see Drawing Package. Initially closed by blank flange.	A
M	IF11	70-mm-diam custom flange	Idem IF10	Idem IF10	A
M	IF12	70-mm-diam custom flange	Idem IF10	Idem IF10	A

* or equivalent solution

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Type	Flange	Size	Position / Purpose	Note	Tolerance
M	IF13	70-mm-diam custom flange	Idem IF10	Idem IF10	A
V	IF14	DN150 ISO-K *	On injector underside, for alternative connection to primary vacuum	Will be blanked in current phase	B
-	IF15	DN150 ISO-K *	On injector underside, for alternative use	Will be blanked	B
V	IF16	DN100 ISO-K *	On injector underside, for automated venting	Initially closed by blank flange	B
V	IF17	DN100 ISO-K *	On injector underside, for manual venting	Initially closed by blank flange	B
O	IF18	DN100 ISO-K *	On injector East side, entry of the MID-IR laser beam	Will be blanked in current phase	B
V	IF19	DN100 ISO-K *	On injector North side, for connection to primary rough vacuum	Will be connected via DN100 soft-start valve to the primary rough vacuum circuit	B
V	IF20	DN160 ISO-K *	On injector North side, for vacuum mass spectrometer (RGA)	Initially closed by blank flange	B
V	IF21	DN100 ISO-K *	On injector North side, for vacuum gauges	Initially closed by blank flange	B
V	IF22	DN100 ISO-K *	On injector North side, for vacuum gauges	Initially closed by blank flange	B
V	IF23	DN160 ISO-K *	On injector top side, for vacuum plasma cleaning	Initially closed by blank flange	B
E	IF24	DN160 ISO-K *	On injector South side, available for feedthroughs of electrical cables	Initially closed by blank flange	B
E	IF25	DN160 ISO-K *	On injector South side, available for feedthroughs of electrical cables	Initially closed by blank flange	B
V	IF26	DN100 ISO-K *	On injector South side, for overpressure safety burst disk	Initially closed by blank flange	B
-	IF27	DN100 ISO-K *	On injector South side, spare	Will be blanked in current phase	B
O	IF28	DN400 ISO-K *	On injector West side, for pointing diagnostics of the main laser beam and for diagnostics of MID-IR laser beam	Initially closed by blank flange	A

* or equivalent technical solution

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1.6. Compressor and injector vacuum system, connection to the central primary vacuum circuit

The compressor and injector chambers are designed to provide vacuum conditions of 10^{-7} mbar.

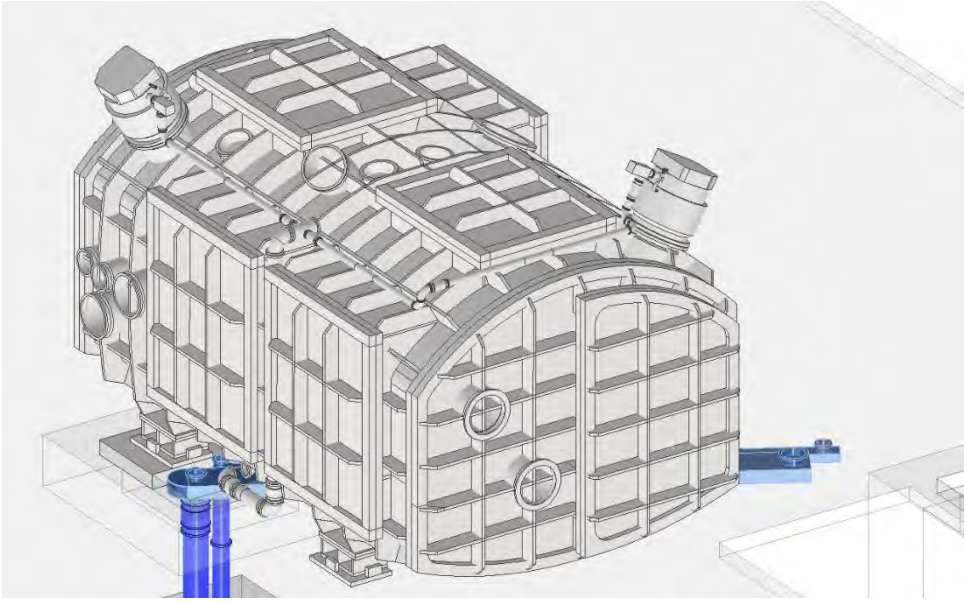
The chambers will use circular vacuum flanges, sealed by fluoroelastomer O-rings. The large access ports, i.e. installation doors ID1 and ID2, personal doors D1 to D5, and top lids on top of the chamber and of the injector, will use a double O-ring (fluoroelastomer) seal arrangement. While the conceptual design developed by ELI-Beamlines takes into account the double O-ring arrangement by providing sufficient area on the flanges of the large ports, its detailed design shall be elaborated by the Supplier.

Pumping of the compressor chamber to roughing vacuum (10^{-2} mbar) will be made using the facility primary vacuum system of ELI-Beamlines. This consists of stainless steel tubing (DN160 ISO-K) which emerges in the L2 hall through the floor penetration close to the North-East side of the compressor. A separate circuit, brought to the L2 laser hall by DN100 ISO-K tubing parallel with the roughing line, is provided for maintaining backing vacuum (10^{-2} mbar) for turbomolecular pumps (TMP). The primary vacuum circuits provide approximately 10^{-2} mbar pressure and are pumped by dry pumps.

Two TMP units with a pumping speed ~4,000 l/s (minimum 3800 l/s for Nitrogen) each are sitting on flanges in the upper part of the compressor chamber. The flanges assigned to the TMP shall be able to withstand the torque [kNm] prescribed by the TMP manufacturer in the event of a crash of the pump. The TMPs are included in the basic scope of the contract. The Supplier shall also develop a detailed design of the backing vacuum distribution to the TMPs, based on the conceptual design provided by CA.

Connection of the primary vacuum circuits of the compressor to the central primary vacuum system of ELI-Beamlines is shown in **Figure 8**. The primary vacuum provided by the lines emerging from the floor penetration will be distributed to the compressor and injector chamber by rectangular ducts (240x80 mm for the roughing line and 100x50 mm for the backing line) sitting in the floor channel. The conceptual design of the compressor and injector, developed by CA, takes fully into account details of connection of the compressor and injector to the floor vacuum ducts.

The primary vacuum tubing including the floor ducts will be provided and implemented by ELI-Beamlines.



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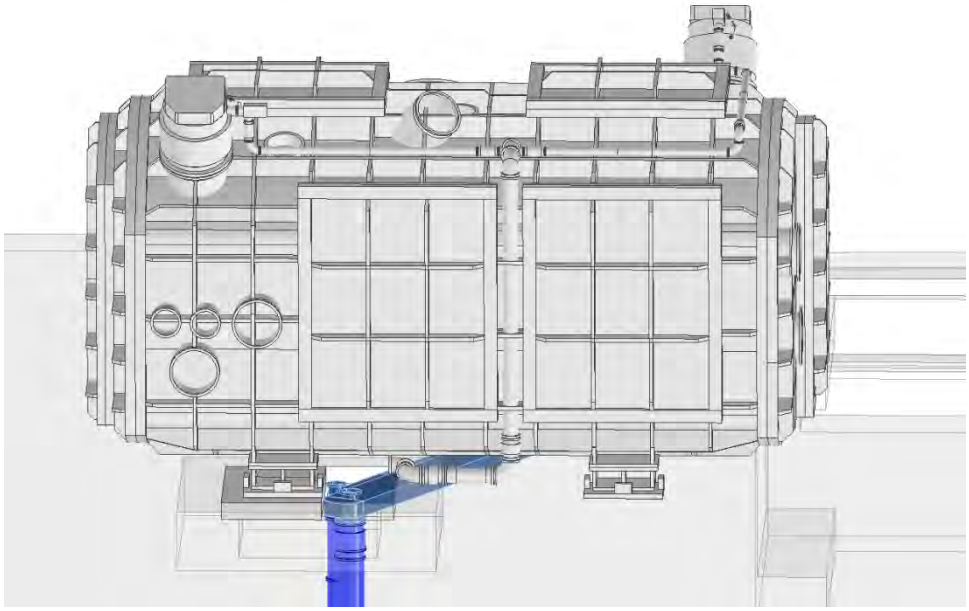

Figure 8: Layout of connection of the compressor chamber to primary vacuum circuits provided centrally by the facility (blue: arrival of the facility vacuum tubing through the floor penetration, deep blue: primary vacuum supply lines to the compressor and injector by rectangular floor tubes). All tubing indicated in colour will be provided and installed by ELI-Beamlines.

The injector vacuum pumping is separate from the compressor pumping system. The injector is pumped to roughing vacuum using the same primary vacuum line as the compressor. Pumping to ultra-high vacuum is made by one TMP unit with a pumping speed ~3,000 l/s (minimum 2,600 l/s for Nitrogen) sitting on the north side of the injector chamber.

The turbomolecular pumps shall be water cooled and all elements of the cooling circuit and tube fittings shall be stainless steel. The water cooling tubing will be brought by ELI-Beamlines to an agreed distribution point (manifold) in the vicinity of the compressor.

The compressor and the injector are interconnected by a tube with inner diameter 318 mm, equipped with a pendulum valve of the size corresponding to diameter of the vacuum tube.

A block scheme of the vacuum circuit of the compressor chamber is shown in Figure 9. All elements except those indicated below are included in the basic scope of the contract. All valves and other components used shall be compatible with vacuum level 10^{-7} mbar or better.

The supplied large pendulum valves, between the compressor and injector, and at the output of the injector, shall be with guaranteed functionality of at least 200,000 cycles until first service.

The scheme also involves the associated segment of the ELI-Beamlines primary vacuum, which are provided by ELI-Beamlines and are controlled by the L2 ELI-Beamlines facility vacuum controls.

The compressor and injector can be fully isolated from the adjacent vacuum systems by valves. The valve at the output of the injector, constituting a critical interface between the L2 laser and the downstream L2 beam delivery system to the experimental halls, is a safety gate valve (SGV) which is an important element of the compressor system machine safety.

The compressor and injectors will be equipped by a redundant set of vacuum gauges; the sensors array involves precise atmospheric gauges to provide accurate information on pressure during venting of the chambers by the clean dry air (CDA) facility circuit.

The vacuum cleanliness in the compressor will be monitored by a COTS residual gas analyser (RGA) compact quadrupole mass spectrometer.

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The upstream valves at the plasma cleaning devices serve to isolate the chamber and temporary remove the cleaning device.

Elements which will be provided by ELI-Beamlines and which are not included in the basic scope of the contract:

- All active vacuum gauges
- Plasma cleaning devices and their upstream valves
- Overpressure safety burst disks
- Clean gas filters and ceramic filters

The L2 cryo chamber, indicated in Figure 9, and all associated devices including are not within the scope of the contract, however space for control channels for these elements, as indicated in Figure 10, shall be reserved in the vacuum control cabinet.

The structure of the MID-IR laser injector tower includes contractual option of the delivery. No vacuum controls for this MID-IR injector are required within the scope of this contract.

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Figure 9: Block scheme of the L2 200 TW compressor and L2 beam injector vacuum system

[vypuštěno]

1.7. Cable trays and layout of the compressor / injector in the L2 laser hall of ELI-Beamlines

The Supplier shall develop conceptual design, including location, of both external and internal cable trays.

The internal (vacuum) cable trays will serve to arrange cables from the motorized actuators of the individual optomechanics to the vacuum feedthroughs (see Sections 1.4 and 0). The cable trays should be preferentially attached along the optical table and/or its support structure. The trays shall be accessible and their design shall avoid any cavities and/or trapped volumes of air.

The external cable trays will serve to arrange the cables of motorized actuators from the feedthroughs (see Sections 1.4 and 0) to the control rack. These external trays will also serve to arrange control and feedback-signal cables of the individual vacuum elements (valves, gauges, TMPs, etc.), and to distribute pressure clean dry air (CDA) for the vacuum valve actuators.

The Supplier shall provide the Compressor control cabinets, which will be installed in the South-West corner of the L2 hall of ELI-Beamlines, and shall pull all cables and CDA tubing between the Supplier's distribution manifold and the controlled devices.

Figure 10: Schematic layout of the floor channel in the L2 hall of ELI-Beamlines, for leading the control cables between the compressor/injector and the control cabinets. The floor channels and their covers will be made by ELI-Beamlines.

[vypuštěno]

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1.8. Vacuum Control System

The Supplier shall deliver to the Contracting Authority (CA) a separate and independent Vacuum Control System (VCS) for the L2 200 TW Pulse Compressor System and for the L4 PW Pulse Compressor System. The systems will not be co-located after installation.

Each VCS shall consist of one floor-standing control cabinet with all necessary electronics, breakouts, connecting cables, cable trays, tubing and fittings for all specified vacuum components, sufficient to meet all performance and functional requirements.

Each VCS shall include support for all items in the indicated scope of work and support for all required interfaces to CA control and facility services, according to their detailed interface specifications.

The CA can provide on request a variety of vacuum and control system hardware components from the Supplied Devices list to the Supplier (see Annex 10) for use in the delivered systems, at zero cost, up to a specified maximum quantity. A precise scope of supply, bill of materials and lead-time shall be negotiated soon after project kick-off.

The Supplier shall create production wiring diagrams following industry-standard format and notation, covering every terminal block, wire, pipe and tube, including all in-cabinet and field wiring. Final as-built drawings shall be provided to the CA in pdf format as part of delivery. An A3 copy shall be placed in a document pocket mounted on the inside surface of the control cabinet door.

For this particular system, all Controller, FPGA and GUI software will be provided by the CA. The software will be provided to the Supplier no more than 6 weeks after the Supplier delivers the final production drawings and a controller I/O signal list. To ensure software functionality, the supplier shall use only items compatible with items provided by CA (see the Supplied Devices list). All items and devices to be delivered by the Supplier shall be explicitly approved by the CA.

The software will require configuration (e.g., state machine specification) and setting of parameters (e.g., pressure thresholds). The CA will provide training on the use of the software, but the Supplier shall remain responsible for ensuring the configuration settings are appropriate to meet performance and functional requirements of the vacuum system. If any missing features or software bugs are identified, these should be handled via the CA's software change control process. The software provided is being used currently for six other complex multi-chamber vacuum systems at the CA's facility and is proven-in-use. Source code can be provided on request (the CA will provide this code in LabVIEW 2019 SP1 format).

The Supplier shall carry out a Factory Acceptance Test (FAT) on each VCS prior to delivery, the test plan and results of which shall be provided in the Factory Test Report (see chapter 9.2). Once fully installed, a final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA. The Supplier shall be responsible for resolving any defects arising from these tests and qualifications. The software provided by the CA shall be used for all tests. The CA shall be permitted to witness any test.

Figure 11: Overview of the vacuum control systems and the required interfaces to CA services and systems
[vypuštěno]

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1.9. Optomechanical mounts

Figure 12 shows the optomechanical structures of the compressor, including high-precision optical mounts to be supplied within the present contract. The required parameters for the individual optomechanical mounts are in Table 4.

In the compressor there are three main (large) assemblies G1, G2 and PM in the compressor to position the diffraction gratings and the periscope mirror. There are in total 10 optomechanical mounts corresponding to the full size laser beam: 8 mounts for positioning plane mirrors (M1 to M6, D-M1, D-M2), one mount for an off-axis parabola (OAP1), and one mount for a lens (D-L1). The assembly further involves mounts of small diagnostic mirrors (diameter 50.8 mm) and four retractable crossed hairs. A part of the compressor optomechanical assembly is also a pneumatically actuated mount for the rotatable beam dump mirror (MBD); this unit is in a separate block sitting attached to the output flange F26 (see Sections 1.4 and 0).

Figure 12: Schematic layout of the compressor optomechanical mounts and of the positioning units, top view (to scale).
[vypuštěno]

In the injector, see Figure 13, there are two mirrors IM1 and IM2 to direct the compressor output beam through the floor penetration down vertically to the E2 basement experimental hall. Additionally a small MID-IR laser beam (wavelength 2.2 µm, beam diameter 38 mm), produced by an auxiliary L2 laser chain, enters the injector from the East side, and is sent down by mirror 2IM3 to the E2 hall, to co-propagate with the main beam.

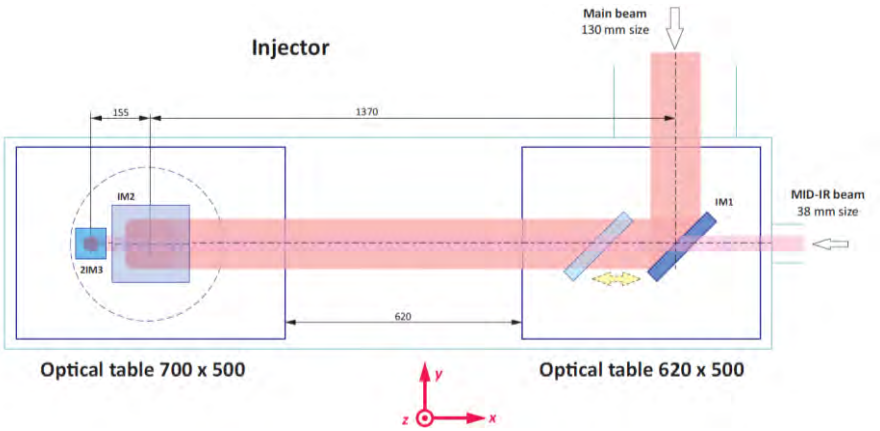

Figure 13: Schematic layout of the injector optomechanical mounts and of the positioning units, top view (to scale).

Whenever indicated in Table 4 the axes shall be equipped by encoders providing absolute position readout. The encoders shall provide this absolute position capability even after encoder switch on, without homing of the movement. While the individual parameters in Table 4 are binding the Supplier is entitled to select appropriate type of vacuum-compatible electrical actuator for each mount / axis. If needed, CA can provide Newport VHRU and/or LTA vacuum actuators including position encoders but the Supplier shall provide full integration of these elements into the optomechanics and into the control system.

Table 4: Optomechanical mounts in the compressor and injector, and requirements for parameters of individual motion axes (resolution = one incremental step of the actuator or graduation of fine adjustment scale for micrometric screw, accuracy = absolute position knowledge by encoder readout where applicable, bidirectional repeatability for motions without encoder).

No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
1	M1	Plane mirror	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-

No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
2	M2	Plane mirror	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
3	M3	Plane mirror	*y* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
4	G1	Grating 1 (350x380x80)	pitch	±0.25°	Stepper	1 µrad	2 µrad	Y
			yaw	±0.5°	Stepper	1 µrad	2 µrad	Y
			roll	±0.25°	Stepper	1 µrad	2 µrad	Y
5	G2	Grating 2 (800x380x80)	linear along green ray	±300 mm	Stepper	5 µm	10 µm	Y
			pitch	±0.25°	Stepper	1 µrad	2 µrad	Y
			yaw	±0.5°	Stepper	1 µrad	2 µrad	Y
			roll	±0.25°	Stepper	1 µrad	2 µrad	Y
6	PM1	Periscope mirror	yaw	±0.5°	Stepper	1 µrad	2 µrad	Y
			roll	±0.5°	Stepper	1 µrad	2 µrad	Y
			pitch (one mirror)	±0.5°	Manual	N.A.	N.A.	-
			linear along green ray	±300 mm	Stepper	5 µm	10 µm	Y
7	M4	Plane mirror	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
8	M5	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
9	M6	Plane mirror	*y* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
10	OAP1	Off-axis parabola	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			y - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
			roll	±0.5°	Manual	N.A.	N.A.	-
11	OAP2	Off-axis parabola (small)	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			y - linear	±5 mm	Manual	N.A.	N.A.	-
			z - linear	±5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
			roll	±0.5°	Manual	N.A.	N.A.	-
12	D-M1	Plane mirror / 0th order	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
12	D-M2	Plane mirror / 0th order	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-

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No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
			yaw	±0.5°	Manual	N.A.	N.A.	-
12	D-L1	Lens for 0th order	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
15	XH1	Crossed hair 1	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
16	XH2	Crossed hair 2	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
17	XH3	Crossed hair 3	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
18	XH4	Crossed hair 4	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
19	IM1	Injector mirror 1	*x - linear* **	*200 mm*	*Stepper*	*5 µm*	*10 µm*	*Y*
			y - linear	±12.5 mm	Stepper	5 µm	10 µm	Y
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
20	IM2	Injector mirror 2	x - linear	±12.5 mm	Stepper	5 µm	10 µm	Y
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
21	2IM3	MID-IR (2.2 µm) injector mirror 3	pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-

* ….. precision end switches shall be used for crossed hair motions
** … designed for future implementation, not implemented in present phase

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22	TDM1	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
23	TDM2	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
24	TDM3s	Spherical mirror f=2684	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
25	TDM4	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
26	TDM5	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
27	TDM6	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
28	TDM7s	Spherical mirror f=2684	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
29	TDM8	Plane mirror	pitch yaw	±0.5° ±0.5°	Stepper Stepper	5 µrad 5 µrad	10 µrad 10 µrad	- -
30	SDM1	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
31	SDM2s	Spherical mirror f=2115	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
32	SDM3	Plane mirror	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
33	SDM4s	Spherical mirror f=2115	pitch yaw	±0.5° ±0.5°	Manual Manual	N.A. N.A.	N.A. N.A.	- -
34	SDM5	Plane mirror	pitch yaw	±0.5° ±0.5°	Stepper Stepper	5 µrad 5 µrad	10 µrad 10 µrad	- -

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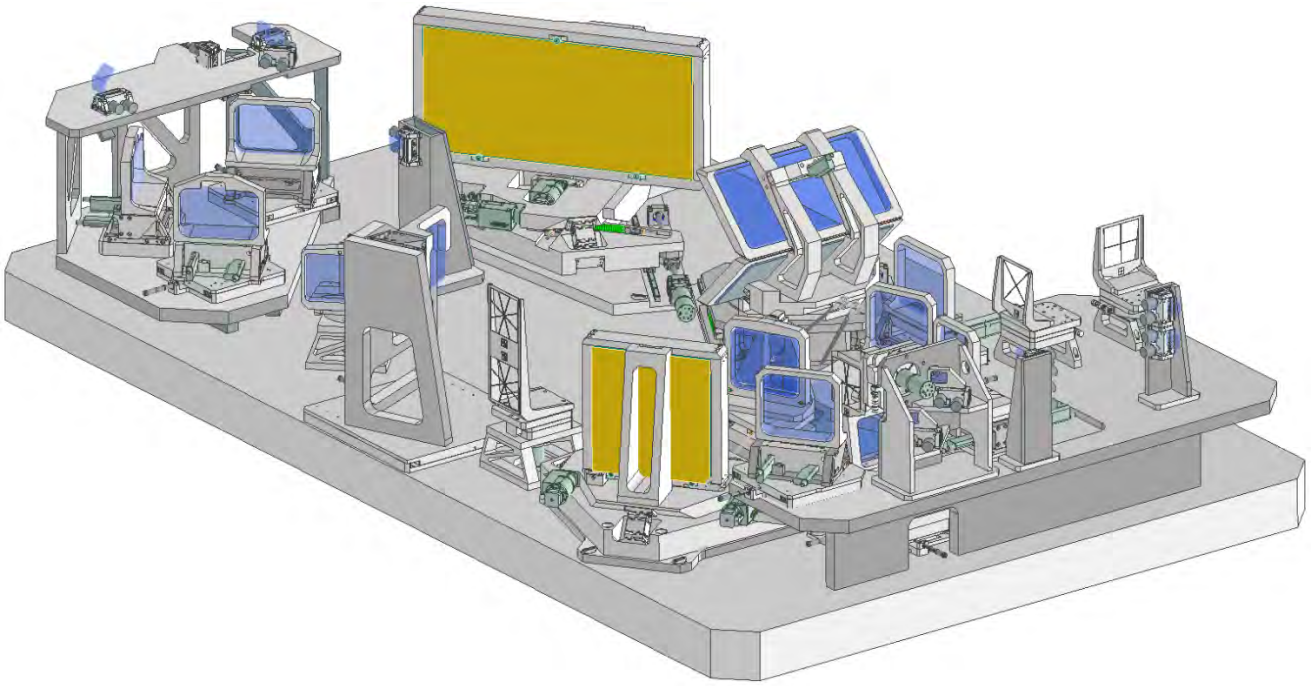

Figure 14: Advanced conceptual design of the compressor optomechanics, developed by CA (G1 and G2 represented in yellow). The supporting optical table is modelled schematically as one continuous block.

Based on the advanced conceptual design of the optomechanical assembly and of the individual mounts, developed by CA (see Figure 14 and Figure 15), the Supplier shall produce detailed engineering design including full integration of actuators, position encoders, end switches, and vacuum cabling for motorized actuators.

The Supplier shall use exclusively UHV-compatible materials in the final design of the mounts. Except aluminium alloy EN 5083 and stainless steel 304L (1.4307), all materials employed in the final design shall be submitted to Client for approval.

In order to assist initial positioning the large mounts shall be equipped with at least three precisely toleranced Ø6 mm holes (or bosses with Ø6 mm holes) suitable for mounting a corner cube reflector for laser scanning. Appropriate position of these holes and/or bosses will be agreed with CA during the detailed design process.

For large mounts (especially G1, G2 and PM) which, due to their weight, cannot be inserted into the compressor manually, the Supplier shall design an appropriate insertion / extraction device.

Positioning of the large mounts during installation shall be aided by position pins appropriately located on the optical table, serving as spatial fiducials in the x-y plane.

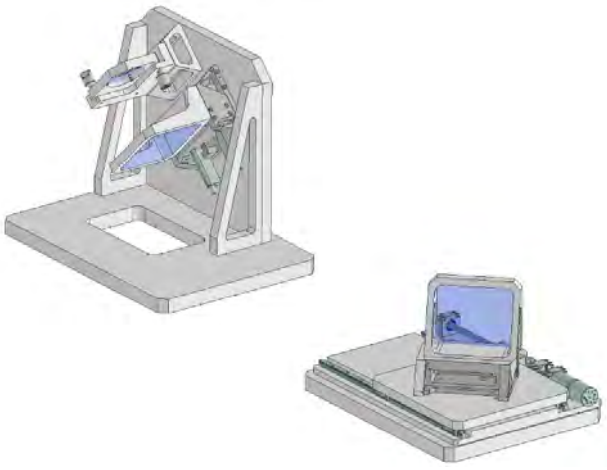

Figure 15: Advanced conceptual design of the injector optomechanics.

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1.10. Motion control system

The Supplier shall deliver to the Contracting Authority (CA) a separate and independent Motion Control System (MCS) for the L2 200 TW Pulse Compressor System and for the L4 PW Pulse Compressor System. The systems will not be co-located after installation.

Each MCS shall consist of 1 or 2 floor-standing control cabinets with all necessary electronics, motor drives, connecting cables, cable trays, and vacuum feedthroughs for all specified motorized axes, sufficient to meet all performance and functional requirements.

Each MCS shall include support for all items in the indicated scope of work and support for all required interfaces to CA control and facility services, according to their detailed interface specifications.

For these systems an initial template software project will be provided by the CA. The software will be provided to the Supplier no more than 6 weeks after the Supplier delivers final production drawings and a controller I/O signal list. The software will include all source code. It will be in a format compatible with LabVIEW 2019 SP1 and support compilation for all Linux, Windows and PharLap based target types. To ensure software functionality, the supplier shall use only items compatible with items provided by CA (see the Supplied Devices list). All items and devices to be delivered by the Supplier shall be explicitly approved by the CA.

The software will require configuration and possibly additions. The CA will provide training on the use of the software, but the Supplier shall remain responsible for ensuring the configuration and any upgrades meet performance and functional requirements. If any missing features or software bugs are identified with the core libraries delivered by the CA, these should be handled via the CA's software change control process.

The Supplier shall carry out a Factory Acceptance Test (FAT) on each MCS prior to delivery, the test plan and results of which shall be provided in the Factory Test Report (see chapter 9.2). Once fully installed, a final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA. The Supplier shall be responsible for resolving any defects arising from these tests and qualifications. The software provided by the CA shall be used for all tests. The CA shall be permitted to witness any test.

Figure 16: Overview of the motion control systems and the required interfaces to CA services and systems
[vypuštěno]

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1.11. Terms, Definitions and Abbreviations

For the purpose of this document, the following abbreviated terms are applied:

Abbreviation	Meaning
A	Analysis (as a verification method)
AC	Alternating current
AMU	Atomic Mass Unit
APG	Accuracy Capacitance Vacuum Gauge
API	Application Programming Interface
AR	Anti-Reflection
BDM	Beam Dump Mirror
BiSS-C	Bidirectional interface for Serial/Synchronous (communications protocol)
CA	Contracting Authority (Institute of Physics CAS, FZU in Czech)
CDA	Compressed Dry Air
CGF	Clean Gas Filter
floating COM	Floating common (ground)
COTS	Commercial off-the-shelf (product)
DC	Direct Current
DIN rail	Widely used metal rail for mounting
DN	Diameter Nominal (for vacuum flanges)
DRW	Drawing
ELI	Extreme Light Infrastructure
EMI	Electromagnetic interference
EMP	Electromagnetic pulse
FEM	Finite Element Method
FPGA	Field Programmable Gate Array
FTR	Factory Test Report
FWHM	Full width at half maximum (spec. of the width of a spectrum curve)
GUI	Graphical User Interface
HV	High Vacuum
I	Inspection (as a verification method)
IQ	Integration Qualification
ISO	International Organization for Standardization
ISO-F	Type of vacuum flanges
ISO-KF	Type of vacuum flanges
L2	Identification code of hall
LCW	Low Conductivity Water
LOTO	Lock-Out Tag-Out
MBD	Mirror beam dump
MCB	Miniature Circuit Breaker

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Abbreviation	Meaning
MCS	Motion Control System
MID-IR	Mid infra red (laser)
MSS	Machine Safety System
MVV	Manual Vacuum venting Valves
N/A	Not Applicable
NCR	Nonconformity Report
NVR	Non-Volatile Residue
OAP	Off-axis parabola
OQ	Operational Qualification
PC	Personal Computer
PBS	Project Breakdown Structure
PE	Polyester
PLe	Performance level (in Safety systems area)
PTFE	Polytetrafluoroethylene
RA1	Research activity 1
RGA	Residual Gas Analyser
RSD	Requirements Specification Document
RTD	Resistance Temperature Detector
SEM	Secondary Electron Multiplier
SDB	Spatial Diagnostic Beam
SDM	Spatial Diagnostic Mirror
SGV	Safety Gate Valve
SIR	on-Site Inspection Report
T	Test (as a verification method)
TBD	Temporal beam diagnostic
TDM	Temporal Diagnostic Mirror
TMP	Turbomolecular Pump
UHP	Ultra High Purity (gas filter)
UHV	Ultra High Vacuum
VCD	Verification Control Document
VCS	Vacuum Control System
VR	Verification Report
WRG	Wide Range Vacuum Gauge

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1.12. Reference Documents

Number of document	Title of Document/ File
RD-01	RD-01_Drawing package for_L2_Comp_RSD_TC0030924
RD-02	ELI Directive 20 – TCID 00272188

Detailed list of documentation included within **RD-01 archive**:

Drawing No (for the RSD purpose)	Filename	File format
DRW-01	L2_Injector_chamber.pdf	PDF
DRW-02	L2_Compressor_Optical_table.pdf	PDF
DRW-03	L2_Compressor_MID-IR_Pyramid.pdf	PDF
DRW-04	L2_Compressor_chamber.pdf	PDF
DRW-05	L2_Comp_X-H3_ds.pdf	PDF
DRW-06	L2_Comp_periscope_ds.pdf	PDF
DRW-07	L2_Comp_OAP1_ds.pdf	PDF
DRW-08	L2_Comp_G2_ds.pdf	PDF
DRW-09	L2_Comp_G1_ds.pdf	PDF
DRW-010	L2_Comp_flexi_stage_2_ds.pdf	PDF
DRW-011	L2_Comp_flexi_stage_1.pdf	PDF
DRW-012	L2_Comp_D-M1_ds.pdf	PDF
DRW-013	L2_Comp_Beam_Dump_Shutter.pdf	PDF
DRW-014	_L2_Compressor_Assembly.pdf	PDF

An overview of the **RD-01** reference drawing related to the L2 Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System is shown in section 12.

1.13. References to standards

If this document includes references to standards or standardized/ standardizing technical documents the CA allows/permits also another equal solution to be offered. If the Supplier offers another equal solution the CA shall not reject its bid, once the supplier by appropriate means in the bid proves that the offered supplies, services or works meet in an equivalent manner all the contractual requirements including references to standards or technical documents.

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2. Requirements

Following sections of this specification provide a summary of the contractual requirements. The total scope of the contract also comprises all the requirements stated or implied in the foregoing text, whether or not included in the summaries. Some requirements related to the Vacuum Control System (VCS) and Motion Control System (MCS) mention, in parallel with the L2 compressor system, also L4PW compressor. The reason is that the L4PW compressor system is procured jointly with the L2 compressor system, and requirements to VCS and MCS are in general identical although differing in specific details as mentioned.

2.1. Layout and optomechanical configuration design

REQ-032782/A **R1-1**

The Compressor and Injector chambers shall be detail designed and manufactured according to the requirements described herein and **RD-01** assembly drawings (see Section 1.12).

Verification method: R - Review of design, T – Test, I – Inspection

REQ-032784/A **R1-2**

The detailed design shall include full coordination with the interfaces of adjacent systems, especially turbomolecular pumps, vacuum gauges, coolants cooling water, CDA (compressed dry air) etc., and with the ELI-Beamlines building, according to information supplied by CA.

Verification method: R - Review of design

REQ-032785/A **R1-3**

The Supplier shall develop design of both internal (vacuum) and external paths (on the outer surface of the chambers) of electrical cables for active vacuum elements and for motorized actuators, based on description of purpose of the vacuum flanges in Sections 1.4 and 1.5. The Supplier shall subsequently elaborate design of corresponding cable trays and mounting C-rails.

Verification method: R - Review of design

REQ-032786/A **R1-4**

The turbomolecular pumps (TMPs) shall be water cooled; stainless-steel piping of the cooling water to the pumps shall be part of the Compressor and Injector chambers detailed design and supply.

Verification method: R - Review of design

REQ-032787/A **R1-5**

The Supplier shall design paths (on the outer surface of the chambers) for the primary backing vacuum for TMPs, based on CA conceptual design, and for cooling water and compressed dry air (CDA), based on description of purpose of the vacuum flanges in Sections 1.4 and 0. Both the backing vacuum tubing and the utilities shall be lead through holes in the chambers reinforcing ribs. The Supplier shall subsequently produce design of corresponding cable trays and mounting C-rails.

Verification method: R - Review of design

REQ-032788/A **R1-6**

The Supplier shall dimension the vacuum flanges assigned to turbomolecular pumps to be able to withstand the torque [kNm] prescribed by the TMP manufacturer in the event of a crash of the pump.

Verification method: R - Review of design

REQ-032789/A **R1-7**

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The Supplier shall develop detail design of double O-ring arrangement for doors and top lids, with interspace pumping performed from the chamber flange.

Verification method: R - Review of design

REQ-032790/A **R1-8**

The Supplier shall develop design of door hinges with double pivot arrangement to avoid crushing the O-rings when closing the door.

Verification method: R - Review of design, T - Test

REQ-032791/A **R1-9**

The Chamber detailed design shall make all necessary allowance for transport of the chamber to its working location. This shall include provision of designated lifting points and jacking points and positions to support the chamber on rollers for lateral movement. The lid shall also be equipped with lifting features (e.g. bosses for screw-in lifting eyes) to enable its handling by overhead crane.

Verification method: R - Review of design, I – Inspection

REQ-032792/A **R1-10**

The Compressor and Injector chambers shall be designed and manufactured for vacuum level of 10^{-7} mbar or better.

Verification method: R – Review of design, T – Test

REQ-032793/A **R1-11**

The Supplier shall perform FEM analysis of the final design of the Compressor and Injector chambers to demonstrate structural stability resulting in deformations of walls less than 1 mm upon pump down from atmospheric pressure.

Verification method: R – Review of design, A – analysis,

REQ-032794/A **R1-12**

The outer side of the Compressor and Injector chambers shall be equipped with mounting points consisting of a boss for a corner cube reflector for laser surveying. The position of these features shall be coordinated with CA during the design phase.

Verification method: R - Review of design, I – Inspection

REQ-032795/A **R1-13**

The manufacturing design and the selection of all components inside the vacuum envelope of the Compressor and Injection chambers shall follow best practice to avoid any trapped volumes of air, e.g. the mounting holes shall not be blind tapped.

Verification method: R – Review of design

REQ-032796/A **R1-14**

The internal optical table and support frame shall be mechanically de-coupled from the vacuum vessel by means of double bellows so that the support posts of the internal optical table can be bolted directly to the laser hall floor, on accurately positioned / levelled stainless-steel floor plates. These floor plates will be installed by CA.

Verification method: R – Review of design

REQ-032797/A **R1-15**

The Supplier shall design and supply a self-contained mechanical handling system to allow the internal optical table, mounted on its support frame, to be installed horizontally into the Compressor chamber through the opening of installation-door ID1 and/or ID2. The handling system can use the L2 laser hall overhead crane (load capacity 5 tons) for assistance. The system shall be compatible with a Class 100 (ISO 5, or equivalent) clean room environment.

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Verification method: R – Review of design

REQ-032798/A **R1-16**

The nominal position and orientation of the optical components and optomechanical mounts shall be as in the 3D model. The required extent of movements shall be as in Table 4.

NOTE: The 3D model will be provided to the Supplier after the contract signature.

Verification method: R – Review of design, T - Test

REQ-032799/A **R1-17**

The optomechanical mounts shall be attachable to the optical table and shall be able to be pre-positioned (without engaging the actuators) with precision better than ±1 mm.

NOTE: The 3D model will be provided to the Supplier after the contract signature.

Verification method: R – Review of design, T – Test

REQ-032800/A **R1-18**

The optical table shall be equipped with positioning pins providing a spatial fiducial for the large optomechanical mounts during their installation / pre-positioning.

Verification method: R – Review of design, I - Inspection

REQ-032801/A **R1-19**

The gratings and mirrors shall be mounted in frames separable from the positioning parts of the optomechanical mounts, in line with the conceptual design provided by CA.

Verification method: R – Review of design, I - Inspection

REQ-032802/A **R1-20**

The design of the frames of the gratings and large mirror shall include a 3-point fitting scheme, which shall not produce deformations across the entire mirror surface higher than 100 nm.

Verification method: R – Review of design

REQ-032803/A **R1-21**

The detailed design of optomechanical mounts G1, G2 and PM shall incorporate detachable lifting eyes for manipulation by a lifting device during installation.

Verification method: R – Review of design

REQ-032958/A **R1-22**

The manufacturing drawings and detailed 3D models for manufacture shall be approved by CA.

Verification method: R - Review of design

2.2. Optomechanical systems manufacture and testing

REQ-032806/A **R2-1**

Only new materials and equipment shall be used for the entire scope of supply.

Verification method: I – Inspection

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2.2.1. Raw material requirements

REQ-032807/A **R2-2**

The Compressor chamber body and the Injector chamber body shall be manufactured from stainless steel.

Verification method: R - Review

REQ-032808/A **R2-3**

The support frame of the internal optical tables shall be manufactured as monolithic block from homogeneous cast aluminium alloy, without internal stress, free of residual cavities.

Verification method: I – Inspection, T - Test

REQ-032809/A **R2-4**

The Supplier shall provide **Certificate of Origin** specifying manufacturer, composition of the alloy and details of the cast process, for the raw material of the support frame, optical table, and blanks for the large optomechanical mounts (G1, G2, PM, M1 to M6, OAP1, D-M1, D-M2, and D-L1).

Verification method: R – Review

REQ-032810/A **R2-5**

The internal optical table top shall be comprised of a stress relieved cast aluminium slab made from high-flatness (equal or better than 0.3 mm /1000 mm) prefabricated panels. The surface quality of the panels shall be compatible with the required vacuum 10^{-7} mbar. No surface machining of the panels is allowed (other than the M6 mounting holes and access ports).

Verification method: I – Inspection, T - Test

REQ-032811/A **R2-6**

The principal material of the optomechanical mounts shall be aluminium alloy, without internal stress, free of residual cavities.

Verification method: R – Review

2.2.2. Manufacture and machining requirements

REQ-032813/A **R2-7**

All welds on the Compressor and Injector vacuum chambers shall be visually inspected, and the **protocol** for each chamber shall be issued.

Verification method: R – Review

REQ-032814/A **R2-8**

All testable vacuum welds on the Compressor and Injector vacuum chambers shall be inspected by ultrasonic probe, and **protocol** for each chamber shall be issued.

Verification method: R – Review, T - Test

REQ-032815/A **R2-9**

All inner vacuum surfaces of the chambers shall have roughness Ra=0.8 µm or better (i.e. smaller). If grinding is used to achieve this finish, the following rules shall apply:

- prior the grinding the cleaning procedure involving degreasing, rinsing and drying, described in Section 4.1 - REQ-032925/A - **R4-2**, shall be used;
- the grinding process shall not involve any abrasive paste or abrasive medium that can embed into the surface.

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*NOTE: the cleaning procedure described in Section 4.1 - REQ-032925/A - **R4-2** can be complemented, before grinding, by laser cleaning. Details shall be approved in writing by the CA before such procedure is applied.*

Verification method: I – Inspection, T - Test

REQ-032816/A **R2-10**

All vacuum flanges shall have Tolerance Grades specified in Table 2 and Table 3.

Verification method: R - Review, T- Test, I – Inspection

REQ-032817/A **R2-11**

The outer surface of the Compressor and Injector chambers shall be glass bead blasted.

Verification method: I - Inspection

REQ-032818/A **R2-12**

The optical table shall be machined with an array of M6 tapped mounting holes on a 25 mm square grid over the entire surface.

Verification method: I – Inspection, T - Test

REQ-032819/A **R2-13**

All mounting holes of the optical table shall be drilled right through and parallel tapped from the top face to a depth of at least 20 mm.

Verification method: I – Inspection, T – Test

REQ-032820/A **R2-14**

All outer surfaces of the optical table support frame shall be machined resulting in surface quality of Ra 0.8 µm or better.

Verification method: I – Inspection, T - Test

REQ-032821/A **R2-15**

All edges of the optical table support frame shall be machine chamfered by 0.5x45°, unless stated otherwise on the corresponding manufacturing drawings.

Verification method: T - Test

REQ-032822/A **R2-16**

The surface of all parts of the optical table support frame shall be milled.

NOTE: Grinding, polishing, sand blasting or any other surface treatment is not allowed.

Verification method: I – Inspection

REQ-032823/A **R2-17**

No parts of the optical table support frame and of the table shall exhibit any visible surface defects, such as scratches, digs, bumps (from clamping in the manufacturing process), *etc.*

Verification method: I – Inspection

REQ-032824/A **R2-18**

All threads shall be cut tapped.

NOTE: It is not allowed to make threads by forming.

Verification method: I – Inspection

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2.2.3. Assembling and testing

REQ-032825/A **R2-19**

The Supplier shall check all major dimensions of the manufactured Compressor and Injector chambers, as defined in the manufacturing drawings approved by the CA (see also Section 9.4). The result shall be provided in the form of the **Factory Test Report** (see Section 9.2).

Verification method: R – Review, T – Test

REQ-032826/A **R2-20**

The Supplier shall verify all dimensions of the manufactured pieces of the supporting frames and optical tables, defined in the manufacturing drawings. The results of tests shall be submitted in the form of **test protocols** (see Section 9.2).

Verification method: R – Review, T – test

REQ-032827/A **R2-21**

After final cleaning (see Sections 4.1 and 4.2) the Supplier shall assemble the Compressor and Injector chambers in ISO 7, or equivalent (or better cleanliness class) cleanroom and shall vacuum test the assembled chambers with blank flanges, bolting and O-rings, which shall be part of the supply.

Verification method: R – Review, T – Test

REQ-032828/A **R2-22**

The Supplier shall perform vacuum leak test using a helium leak detector. The measured single leak rate of any flange shall be less than $1x10^{-8}$ mbar·l/sec. The total leakage rate of each chamber shall be $1x10^{-4}$ mbar·l/sec or less. The results shall be provided in the form of the **Factory Test Report** (see Section 9.2).

NOTE: It is recommended that single flange test (helium spray) is performed according to ČSN EN 1779, method A.3, and the test of total leakage according to ČSN EN 1779, method D.2.

Verification method: R – Review

REQ-032829/A **R2-23**

The Supplier shall test the evacuated Compressor and Injector chambers for deformations due to the atmospheric pressure differential. The measured deformations shall not exceed 1 mm at any location. The result shall be provided in the form of the **Factory Test Report** (see Section 9.2).

Verification method: R – Review

REQ-032830/A **R2-24**

All optomechanical mounts shall be cleaned (see Section 4 Vacuum cleaning, Cleanliness verification and Packaging Requirements) and tested with the Motion Control System (MCS) at the Supplier's works prior to acceptance for transport to ELI-Beamlines.

Verification method: R – Review

REQ-032831/A **R2-25**

The Supplier shall allow CA supervising the activities related to testing of deformation of the vacuum chambers and of the performance verification of the optomechanical mounts.

NOTE: Any acts of supervision shall not mean that CA assumes any liability for the compliance of results of these activities with the contract.

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3. Control systems requirements

3.1. Vacuum Control System (VCS) Requirements

REQ-032832/A **R3-1**

The Supplier shall deliver one VCS for the L2 200 TW Compressor system and a second independent VCS for the L4 1 PW Compressor system. The systems will not be co-located and shall not share any components or interfaces.

Verification method: R – Review, I – Inspection, T-test

REQ-032833/A **R3-2**

The Supplier shall carry out a Factory Test (FTR) on each VCS prior to delivery, the test plan and results of which shall be provided in the Factory Test Report (see Section 9.2). Once fully installed, a final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA. The Supplier shall be responsible for resolving any defects arising from these tests and qualifications. The software provided by the CA shall be used for all tests. The CA shall be permitted to witness any test.

Verification method: T-test

3.1.1. Networking and serial devices

REQ-032834/A **R3-3**

The Supplier shall use one or more FPGA Controllers, containing a LabVIEW-programmable FPGA, to implement the vacuum state machine control logic, and a real-time operating system to implement high-level device communication and control interfaces. Each controller shall have two separate network ports. Suitable controllers can be provided by the CA on request.

NOTE: No external server hardware will be provided for real-time software integration. The RMC-8354, supplied in previous projects by the CA, has been discontinued.

Verification method: R – Review, I – Inspection

REQ-032835/A **R3-4**

Each VCS shall have two separate networks; Integration and Devices. The Supplier shall configure all networked components to have fixed IPv4 addresses within the specified ranges and shall provide a list of the assigned addresses:

- L2 200 TW Compressor: Integration: 10.68.1.13*x*/24 ($0 \le x \le 9$); Devices: 10.69.1.13*x*/24 ($0 \le x \le 9$).
- L4 1 PW Compressor: Integration: 10.76.1.16*x*/24 ($0 \le x \le 9$); Devices: 192.168.1.16*x*/24 ($0 \le x \le 9$).

The Devices network shall contain all instruments and serial device servers. The Integration network shall be used to connect external control system services such as databases and graphical user interfaces to FPGA Controllers. One port from each FPGA Controller shall be connected to the Device network and one port to the Integration network, with the same final byte used for each address.

Verification method: R – Review, I – Inspection

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REQ-032836/A **R3-5**

An Operator PC connected to the Integration Network will be provided for final acceptance at the CA site. The Supplier shall not supply any PCs or additional computing hardware other than the FPGA Controllers; these shall be sufficient for full operation of the final system.

Verification method: R – Review, I – Inspection, T - Test

REQ-032837/A **R3-6**

A local DIN rail mount Devices Network Switch shall be used to provide local Devices connections. The CA can provide a suitable switch to the Supplier on request.

Verification method: R – Review, I – Inspection

REQ-032838/A **R3-7**

Residual gas analysers (RGAs) shall have an external low-level control interface (including an emission interlock to stop operation on loss of vacuum) connected directly (via relays) to FPGA Controller I/O modules, and an additional Ethernet data connection connected to the Devices Network switch.

Verification method: R – Review, I – Inspection, T - Test

REQ-032839/A **R3-8**

TMPs shall have an external low-level control interface connected directly (via relays) to FPGA Controller I/O modules, and an additional serial RS-485 data connection only for 'read-only' monitoring purposes. All serial devices shall be connected to a Serial Device Server, connected via Ethernet to the Local Device Network Switch. A suitable Serial Device Server can be provided by the CA on request.

Verification method: R – Review, I – Inspection, T - Test

REQ-032840/A **R3-9**

The Supplier shall provide DIN-rail mount patch panel terminals with the delivered control cabinet. The CA will prepare CAT7 metallic network cables to the location of each VCS cabinet prior to final on-site installation. These shall be terminated in these terminals. One terminal shall be provided for the device network, and one terminal for each integration network device.

Verification method: R – Review, I – Inspection

3.1.2. Power and lock-out-tag-out

A single three-phase 400 VAC, 32 A rated connection will be provided by the CA to power the control cabinet of each VCS, to be connected internally via DIN-rail mounted screw terminals. On-site connection of power at the CA facility will be carried out by CA Electrical Department personnel.

REQ-032848/A **R3-10**

The Supplier shall be responsible for powering all internal and external devices from this supply, including all pumps (TMPs). Each separate pump and DC power supply should have an individual Miniature Circuit Breaker (MCB) of appropriate type and rating. Additional filtering and surge protection may be necessary, according to good practice for typical laboratory and industrial environments.

NOTE: The installation location for this particular system is not subject to levels of EMI or EMP beyond those found in common industrial environments.

Verification method: R – Review, I – Inspection

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REQ-032850/A **R3-11**

All mains voltage terminals within the cabinet shall be protected with a touch-proof cover and clearly labelled with standard warning symbols and labels in both Czech and English language. Electrical revision (inspection) of all completed cabinets shall be provided by the Supplier in accordance with the binding Czech standards.

Verification method: R – Review, I – Inspection

REQ-032851/A **R3-12**

Each VCS shall include a Lock-Out, Tag-Out (LOTO) trapped key isolation switch. This switch shall disable power to all active vacuum devices, including all pumps and valve solenoids, when the key is removed. Sensors such as gauges and valve position switches should remain powered. A pressure release valve to deactivate the pneumatic actuation line should also be included and powered by the LOTO DC supply.

Verification method: R – Review, I – Inspection, T - Test

REQ-032852/A **R3-13**

The LOTO trapped key switch shall be mounted on the VCS control cabinet front panel. Additional cabinet front-panel controls, such as a controlled stop button and pilot indicators for basic state indication, are optional. A front-panel touch panel PC or display is not required.

NOTE: it is not feasible to fully enter the vacuum chamber in this design. Use of an additional mechanical interlocks on the chamber access doors is not required.

Verification method: I – Inspection

REQ-032853/A **R3-14**

The trapped key shall use a uniquely assigned key code to avoid duplication of keys:

- L2 200 TW Compressor: starting with ‘S’ (i.e., Sa)
- L4 1 PW Compressor: starting with ‘P’ (i.e., Pa) .

Verification method: R – Review, I – Inspection

REQ-032854/A **R3-15**

The LOTO trapped-key switch shall be trapped via a powered solenoid and the key only released once the main compressor chamber is fully vented, all pumps stopped and valves in a safe state for personnel access.

Verification method: R – Review, I – Inspection, T- Test

3.1.3. Water Cooling

REQ-032855/A **R3-16**

The Supplier shall ensure compatibility with the provided interface.

NOTE: At both the L4 1 PW Compressor and L2 200 TW Compressor installation sites the CA will provide a single dedicated on-site Low Conductivity Water (LCW) supply and return connection from the laser cooling distribution manifold to an agreed interface point near to the compressor chamber in 0.5 inch stainless steel press-fitted tubing with a nominal supply pressure of 4 bar, temperature 16 C and a maximum flow of 20 l/min.

Verification method: R – Review, I – Inspection

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REQ-032856/A **R3-17**

The Supplier shall be responsible for 'last mile' distribution of cooling water from the CA provided interface point to all pumps and devices requiring it and for installation of sensors (e.g., flow switches) to allow the VCS to verify cooling water.

REQ-032857/A **R3-18**

Manual flow regulating and shutoff valves shall be provided for each cooled device. Additional draining and venting valves should also be considered in order to allow efficient removal and replacement of individual cooled devices.

Verification method: R – Review, I – Inspection

REQ-032858 /A **R3-19**

The Supplier shall ensure that the risk of cooling water leaks is as low as reasonably practicable. Where possible all tubing and fittings shall be stainless steel and rated for a large overpressure (>20 bar). Where possible all joints shall be swaged or crimped. If threaded joints are unavoidable, they shall be sealed with a specifically designed compound: (e.g., Anaerobic Sealant – mixture of Polyglycol dioctanoate 18268-70-7, 10 - 20 %, Acetic acid ethenyl ester, homopolymer 9003-20-7. 10 - 20 %, Lauryl methacrylate 142-90-5, 5 - 10 %, Ethene, homopolymer 9002-88-4, 1 - 5 %, Ethene, tetrafluoro-, homopolymer 9002-84-0, 1 - 5 %, Vinyl acetal polymers, butyrals 63148-65-2, 1 - 5 %, Tetradecyl methacrylate 2549-53-3, 1 – 5 %, Silica, amorphous, fumed, crystal-free 112945-52-5, 1 - 5 %, 1-Acetyl-2-phenylhydrazine 114-83-0, 0.1 – 1 %, Hexadecyl methacrylate 2495-27-4, 0.1 – 1 %, Cumene hydroperoxide 80-15-9, 0.1 - 1 %, N,N'-Ethane-1,2-diylbis(12- hydroxyoctadecan-1-amide) 123-26-2, 0.1 – 1%; or equivalent).

PTFE tape or natural fibre cord should not be used for sealing. Tubing should be sized so that at nominal flow the velocity, v is $1 < v < 2$ m/s.

Verification method: R – Review, T - Test

REQ-032859/A **R3-20**

A flow switch or sensor shall be provided on the return line of each cooled device, set to a threshold at least 25% higher than the device minimum cooling requirement and connected directly (via relays) to FPGA Controller I/O modules.

Verification method: R – Review, I – Inspection, T- Test

REQ-032860/A **R3-21**

All tubes and pipes shall be labelled with directional flow arrows and the contained fluid designation. All tubing and piping shall be properly mounted and supported at intervals of no more than 30 cm when routed over any vacuum chamber surface.

Verification method: R – Review, I – Inspection

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3.1.4. Pneumatics, CDA and venting

REQ-032861/A **R3-22**

At both the L4 1 PW Compressor and L2 200 TW Compressor installation sites the CA will provide a single dedicated Clean Dry Air (CDA) supply in 3/8 inch UHP stainless steel Swagelok-style tubing with an adjustable pressure up to 6 bar, maximum flow up to 500 l/min and purity class of 1:1:1 according to ISO 8573.1. The Supplier shall ensure compatibility with the provided interface.

Verification method: R – Review, I – Inspection

REQ-032862/A **R3-23**

The Supplier shall be responsible for distribution, monitoring and 'last mile' tubing to all in-scope devices requiring compressed air, either for actuation or as a high-purity venting/purging source.

Verification method: R – Review, I – Inspection

REQ-032863/A **R3-24**

All tubing, fittings and sensors on CDA line(s) used for chamber venting shall be suitable for Ultra High Purity (UHP) use, free of hydrocarbon contamination and precision cleaned using the same care as components in-vacuum.

NOTE: Components on the valve actuation line do not need to take special measures for purity, but back-streaming from the valve actuation supply into CDA shall be prevented.

Verification method: R – Review, I – Inspection

REQ-032864/A **R3-25**

UHP Clean Gas Filters (CGF) shall be added at all venting locations (both for CDA and room air). Suitable filters can be provided by the CA on demand. For CDA venting, all valves used shall be rated for vacuum-tight seal against the nominal 5 bar supply pressure.

Verification method: R – Review, I – Inspection, T - Test

REQ-032865/A **R3-26**

For venting with CDA, an outlet valve fitted with a check valve of cracking pressure <= 30 mbar shall be installed. The valve should be opened by the VCS when the pressure approaches atmosphere as measured by a precise atmospheric range gauge.

Verification method: R – Review, I – Inspection, T - Test

REQ-032866/A **R3-27**

Chambers with a volume more than one cubic meter shall be individually fitted with a burst disk rated for rupture at < 500 mbar overpressure. The CA can provide suitable burst disks on request.

Verification method: R – Review, I – Inspection

REQ-032867/A **R3-28**

All manual vacuum venting valves (MVV) shall be monitored with position switches connected directly (via relays) to FPGA Controller I/O modules. A passive manometer shall be fitted to each volume in a location close to the manual venting valve, for pressure indication in the event of VCS power failure. The Supplier shall provide the calibration certificate for every passive manometer.

Verification method: R – Review, I – Inspection, T - Test

REQ-032868/A **R3-29**

Manual shutoff and venting valves shall be provided on each branch to allow for removal of devices without venting the entire pneumatic system.

Verification method: I – Inspection

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REQ-032869/A **R3-30**

All tubes and pipes shall be labelled with directional flow arrows and the contained fluid designation (e.g., CDA Actuation, CDA Venting). Tubing and piping shall be properly mounted and supported at intervals of no more than 30 cm when routed over any vacuum chamber surface.

Verification method: I – Inspection

REQ-032870/A **R3-31**

Pneumatically controlled safety elements (See Section 3.1.6) shall use the recommended control valve (see reference drawings) or one of equivalent safety rating and design. The CA can supply a suitable control valve on request.

Verification method: I – Inspection

3.1.5. Vacuum Devices and Cabling

REQ-032871/A **R3-32**

All VCS control electronics and power supplies shall be mounted in one control cabinet (per compressor system) of depth 0.4m, height 2m and max width 1.2m. Cabinets shall be fitted onto a 200mm plinth.

NOTE: The cabinet should be mechanically compatible with the Rittal VX series for which the CA carries spare parts and accessories. A suitable cabinet can be provided by the CA on request.

Verification method: I – Inspection

REQ-032872/A **R3-33**

Control cabinets shall be mounted in the following locations:

- L2 200 TW Compressor: Along the south west wall of the L2 laser hall
- L4 1 PW Compressor: Along the south east wall of the L4 laser hall

All cabling between the chambers and the VCS cabinet shall be via floor channels (provided by the CA) and via metal cable trays on the vacuum vessels (these shall be provided by the Supplier). Cable installation is in Supplier scope.

Verification method: I – Inspection

REQ-032873/A **R3-34**

All sections of cable and tube exceeding 50 cm in length shall be supported by clamps and/or cable ladders, or routed in closed metal cable trays.

Verification method: I – Inspection

REQ-032874/A **R3-35**

All external (field) cables shall be shielded and cable shields should be terminated at both ends.

NOTE: No special measures for interfacing devices need to be taken against EMP for this particular system.

Verification method: I – Inspection

REQ-032875/A **R3-36**

Supplier shall follow ELI Directive 20 (00272188/A – see RD-02) for wire colours and labelling. All wires and terminal blocks shall be labelled.

NOTE: The CA can provide printed labels on request if the Supplier provides a precise list of label types and text entries, in Excel format, within a 4 week lead-time.

Verification method: I – Inspection

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REQ-032876/A **R3-37**

Active devices shall be labelled according to their control point code (e.g., VV244).

NOTE 1: Codes for all devices can be provided by the CA on request.

NOTE 2: Codes for the L2 compressor usually start at 240. Codes for the L4 compressor usually start at 420.

Verification method: I – Inspection

REQ-032877/A **R3-38**

Sensors and valve solenoids shall use separate DC supplies and hence separate breakouts are recommended. Simple field devices, such as gauges and valves, shall be connected to a passive local breakout or connection box.

NOTE: A commercial, off-the shelf breakout solution should be used. The CA can provide suitable breakout connection box on request. The connector type for field devices should be M12 where possible.

Verification method: I – Inspection

REQ-032878/A **R3-39**

Magnetic proximity sensors (IL) shall be fitted to all chamber access doors and positioned to give a positive signal only when doors are fully closed and seals properly compressed.

Verification method: I – Inspection, T - Test

3.1.6. Safety Systems Interfaces – Personnel Safety

REQ-032879/A **R3-40**

The Supplier shall precisely follow the provided implementation diagrams for safety-critical design elements to ensure the system operates in accordance with CA safety requirements.

NOTE: The main safety-critical VCS element is the Safety Gate Valve (SGV) located on the injector output (L2 design), or compressor output (L4 design). These provide a light-tight barrier to prevent laser and prompt ionizing radiation in the receiving experimental halls.

Verification method: R – Review, I – Inspection, T - Test

REQ-032880/A **R3-41**

SGVs shall not be fitted with built-in electro pneumatic valves. Instead, a 3/2 control valve with safe exhausting function rated to PLe (Cat 4, ISO 13849-2, or equivalent) shall be used to ensure it closes reliably on loss of permission from the personnel safety systems.

NOTE: SGVs are pendulum type with spring return to close on loss of pressure. They require a single compressed air inlet to open. If the compressed air fails to vent properly it can lead to loss of the close-on-demand safety function, potentially leading to accidental exposure to ionizing radiation, irreversible injury and death

Verification method: R – Review, I – Inspection, T- Test

REQ-032881/A **R3-42**

Direct feedback monitoring of gate valve and control valve position to the CA's safety systems shall be provided using the interface shown.

NOTE: Valve position feedback will be relayed by the safety systems back to the VCS Controller. For testing, this interface may be simulated via a temporary loopback

Verification method: R – Review, I – Inspection, T- Test

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REQ-032882/A **R3-43**

The air supply to the control valve shall be fitted with a regulator with overpressure relief, and port 3 of the valve shall fitted with a silencer type as recommended in the control valve manual.

NOTE: There is no need for additional pressure monitoring by the safety systems, nor for any specific pressure buffering in this system, as the safety function requires only safe exhausting rather than safe reversal (as would be the case for a double-acting pneumatic safety element).

Verification method: I – Inspection

REQ-032883/A **R3-44**

Stainless steel solid tube and swaged fittings shall be used for the pneumatic connections between the safety control valve and the gate valve.

Verification method: I – Inspection

3.1.7. Safety Systems Interfaces – Machine Safety System (MSS)

REQ-032884/A **R3-45**

The Supplier shall provide a machine safety vacuum state signalling interface for each VCS as specified in the implementation drawings (see drawings package RD-01). The specified digital inputs and digital outputs shall be connected directly (via relays) to FPGA Controller I/O modules.

Verification method: R – Review, I – Inspection, T - Test

REQ-032885/A **R3-46**

If more than one controller is required for the system, the MSS inputs and outputs shall be assigned to the controller responsible for the relevant section, as shown in the example. VCS devices, sensors and actuators shall be assigned to the controller having the appropriate MSS inputs and outputs for their vacuum section.

NOTE: The FPGA software logic (provided by the CA) will ensure that the functional requirements of this interface are met. The Supplier only needs to implement the interface wiring to the Controller(s) and provide the specified terminals for external wiring.

Verification method: I – Inspection

REQ-032886/A **R3-47**

The Supplier shall consider using a relay type with a mechanical override function to allow the permissive input signals to be easily simulated for testing without the external MSS connected.

Verification method: R – Review

REQ-032887/A **R3-48**

In the L2 200 TW Compressor system, the Cryogenic chamber (CRYO) is not in the baseline scope for installation, however all controls including the specified machine safety vacuum state signalling interface shall be implemented by the Supplier in preparation.

Verification method: I – Inspection

3.2. Motion Control System (MCS) Requirements

REQ-032888/A **R3-49**

The Supplier shall deliver one MCS for the L2 200 TW Compressor system and a second independent MCS for the L4 1 PW Compressor system. The systems will not be co-located and shall not share any components or interfaces

Verification method: R – Review, I – Inspection, FAT - Factory Acceptance Test, SAT - Site Acceptance Test (Integration Qualification (IQ) and Operational Qualification (OQ))

3.2.1. Motion axis functionality

REQ-032889/A **R3-50**

The Supplier shall ensure that the MCS for each compressor system provides the specified control points and motion axes (as a minimum) over the specified ranges and within the required precision and accuracy (see drawings package – RD-01). The accuracy requirement (*i.e.,* repeatability) shall be satisfied after the following sequence: enabling the drive, moving an arbitrary number of steps, disabling the drive, re-enabling the drive after an arbitrary time delay, moving in the opposite direction the same number of steps. Enabling and disabling motor drives shall not result in movement greater than the required precision for that axis.

NOTE: For axes with encoders, the accuracy refers to the closed-loop performance.

Verification method: I – Inspection, T - Test

REQ-032890/A **R3-51**

It shall be possible to lock the position of all manually adjustable axes after adjustment (*e.g.,* via a locking screw).

Verification method: I – Inspection, T - Test

REQ-032891/A **R3-52**

It shall be possible to adjust all mechanically adjustable actuators *in situ,* even with all optics and optomechanics installed, without entering the chamber (other than arms and upper body).

Verification method: I – Inspection, T - Test

3.2.2. Networking and serial devices

REQ-032892/A **R3-53**

To implement each MCS the Supplier shall use one 'Master' FPGA Controller having both LabVIEW-programmable FPGA and a real-time operating system, and any number of 'Slave' FPGA Controllers having LabVIEW-programmable FPGAs. The master controller shall have two separate network ports.

NOTE: Suitable controllers can be provided by the CA on request.

Verification method: I – Inspection

REQ-032893/A **R3-54**

Each MCS shall have two separate networks; Integration and Devices. The Supplier shall configure all networked components to have fixed IPv4 addresses within the specified ranges and shall provide a list of the assigned addresses:

- L2 200 TW Compressor: Integration: 10.68.1.14x/24 ($0 \leq x \leq 9$); Devices: 10.69.1.14x/24 ($0 \leq x \leq 9$).
- L4 1 PW Compressor: Integration: 10.76.1.18x/24 ($0 \leq x \leq 9$); Devices: 192.168.1.18x/24 ($0 \leq x \leq 9$).

The Devices network shall contain all instruments and serial device servers. The Integration network shall be used to connect external control system services such as databases and graphical user interfaces to FPGA Controllers. One port from the master FPGA Controller shall be connected to the Device network and one port to the Integration network, with the same final byte used for each address. Slave controllers shall be connected only to the Device network.

Verification method: R – Review, I – Inspection

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REQ-032894/A **R3-55**

The Supplier shall not supply any PCs or additional computing hardware other than the FPGA Controllers; these shall be sufficient for full operation of the final system.

NOTE: An Operator PC connected to the Integration Network will be provided for final acceptance at the CA site for each compressor system.

Verification method: T - Test

REQ-032895/A **R3-56**

A local DIN rail mount network switch shall be used to provide for local Device network connections. *NOTE: The CA can provide a suitable switch to the Supplier on request.*

Verification method: I – Inspection

REQ-032896/A **R3-57**

All motor drives shall support configuration over a serial (RS-485) interface. This interface shall be used for configuration only (*e.g.,* to set current limits or micro-stepping). Configuration shall be done via software running on the FPGA Controller's real-time processor. All axis configuration parameters shall be stored in the MySQL Configuration Database, accessed via the API given in the provided software template. Control of motor drive shall be via step (pulse) and direction 24V digital signals directly from FPGA controller I/O modules. The same model of motor drive shall be used for all stepper motor axes.

Verification method: R – Review, I – Inspection

REQ-032897/A **R3-58**

In each MCS, motor drive serial interfaces shall be connected in a 'daisy chain' configuration and connected to a Serial Device Server, connected via Ethernet to the Local Device Network Switch.

NOTE: A suitable Serial Device Server can be provided by the CA on request.

Verification method: I – Inspection, T - Test

REQ-032898/A **R3-59**

The Supplier shall provide DIN-rail mount patch panel terminals with the delivered control cabinet. The CA will prepare CAT7 metallic network cables to the location of each VCS cabinet prior to final on-site installation. These shall be terminated in these terminals. One connection shall be provided for the device layer network switch, and one connection for each integration device.

Verification method: R – Review, I – Inspection

3.2.3. Power

A single three-phase 400 VAC, 32 A rated connection will be provided by the CA to power the control cabinet of each VCS, to be connected internally via DIN-rail mounted screw terminals. On-site connection of power at the CA facility will be carried out by CA Electrical Department personnel. DC power distribution between MCS cabinets is within Supplier scope.

REQ-032900/A **R3-60**

The Supplier shall be responsible for powering all internal and external devices from this supply. Each separate DC power supply should have an individual Miniature Circuit Breaker (MCB) of appropriate type and rating.

NOTE: Additional filtering and surge protection may be necessary, according to good practice for typical laboratory and industrial environments.

Verification method: I – Inspection

REQ-032901/A **R3-61**

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All mains voltage terminals within the cabinet shall be protected with a touch-proof cover and clearly labelled with standard warning symbols and labels in both Czech and English language. **Electrical revision** (inspection) of all completed MCS cabinets shall be provided by the Supplier in accordance with Czech standards.

Verification method: R – Review, I – Inspection

REQ-032902/A **R3-62**

Motor drives and sensors (such as limit switches) shall be powered from separate DC supplies.

NOTE 1: DC supplies for sensors should be isolated from ground (floating COM).

NOTE 2: DC suppliers should be monitored for failure by the FPGA Controller

Verification method: I – Inspection

3.2.4. Actuators and Cabling

REQ-032903/A **R3-63**

All MCS control electronics and power supplies shall be mounted one or two control cabinets per compressor system, of depth 0.4m, height 2m and max width 1.2m. Cabinets shall be fitted onto a 200mm plinth.

NOTE: Cabinets should be mechanically compatible with the Rittal VX series for which the CA carries spare parts and accessories. Suitable cabinets can be provided by the CA on request.

Verification method: I – Inspection

REQ-032904/A **R3-64**

MCS Control cabinets shall be mounted in the following locations and bayed adjacent to the VCS cabinet for the same system:

- L2 200 TW Compressor: Along the south west wall of the L2 laser hall
- L4 1 PW Compressor: Along the south east wall of the L4 laser hall

All cabling between the chambers and the cabinet shall be via floor channels (provided by CA) and via metal cable trays on the vacuum vessels (these shall be provided by the Supplier). Cable installation is in Supplier scope.

Verification method: R – Review, I – Inspection

REQ-032905/A **R3-65**

In-air cables shall be shielded and cable shields shall be terminated at both ends. The Supplier may combine multiple devices into one vacuum feedthrough and connecting cable, but measures against crosstalk shall be taken (e.g., use of individually shielded twisted pairs).

NOTE 1: Cables with individually shielded twisted pairs should be used.

NOTE 2: The CA prefers standard density D-sub vacuum feedthroughs, but the Supplier may select any suitable connector type.

Verification method: R – Review, I – Inspection

REQ-032906/A **R3-66**

Supplier shall follow ELI Directive 20 (00272188/A – see RD-02) for wire colours and labelling. All wires, terminal blocks and cable feedthroughs shall be labelled, including those in vacuum. Precision cleaned stainless steel tags may be used to label vacuum cables.

NOTE: The CA can provide printed labels on request if the Supplier provides a precise list of label types and text entries, in Excel format, within a 4 week lead-time.

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Verification method: R – Review, I – Inspection

REQ-032907/A **R3-67**

Data-producing devices shall be labelled according to their control point code (e.g., MTR208).

NOTE: Codes for all devices can be provided by the CA on request.

Verification method: I – Inspection

REQ-032908/A **R3-68**

Standard axes shall be fitted with a reliable, normally closed mechanical limit switch at each end of the safe travel range. Insertion/retraction axes (XH1-XH4, PNA) shall be fitted with mechanically repeatable (+/- 10 um or better), normally open position switches for each position. All switches shall be suitable for 24V signal logic. Hall Effect or optocoupler based limit switches shall not be used on any axes.

Verification method: I – Inspection, T - Test

REQ-032909/A **R3-69**

Encoders shall be absolute position type with an interface based on the BiSS-C protocol and connected directly to the same FPGA controller as the associated axis motor control.

NOTE: The Supplier may choose to add additional encoders to reach the required repeatability requirements on certain axes, and any axis may be converted to closed-loop if required.

Verification method: R – Review, I – Inspection

REQ-032910/A **R3-70**

Temperature sensors shall be of accuracy class A or better, connected in a 4-wire configuration, connected directly via FPGA Controller I/O modules. The Supplier shall provide calibration certificate for the sensors.

NOTE: The Supplier should consider adding sensors on any stepper motors where overheating in vacuum is a concern.

Verification method: R – Review, I – Inspection

REQ-032911/A **R3-71**

If the Supplier adds any new control points they shall inform the CA in a timely manner so that the correct CP codes may be provided for documentation, labelling and database configuration.

Verification method: R – Review, I – Inspection

3.2.5. Safety Systems Interfaces – Personnel Safety

REQ-032912/A **R3-72**

The Supplier shall precisely follow the provided implementation diagrams for safety-critical design elements to ensure the system operates in accordance with CA safety requirements.

NOTE: The main safety-critical MCS element in each compressor system is the beam dump mirror inserter. This directs the laser beam to a beam dump (or calorimeter) and helps mitigate hazards such as striking a closed gate valve. It forms part of the beam fate safety system.

Verification method: R – Review, I – Inspection, T – Test

REQ-032913/A **R3-73**

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The Beam Dump Mirror Inserter in each system shall be connected to a pneumatic actuator for insertion and retraction, as shown in the drawings package (see RD-01). The total time to insert the beam dump on loss of permission shall be < 5 seconds. Speed control valves, shock absorbers or other measures should be used on the actuator to minimize vibration from insertion and extraction operations.

Verification method: R – Review, I – Inspection, T - Test

REQ-032914/A **R3-74**

A 5/2 control valve with safe reversal function rated to PLe (Cat 4, ISO 13849-2, or equivalent) shall be used to ensure it inserts reliably on loss of permission from the safety systems. A small pneumatic buffer fed via a check valve with a volume at least twice that of the pneumatic actuator should be installed to maintain sufficient pressure to insert the beam dump mirror in the event of a loss of supply.

NOTE 1: A suitable control valve can be provided by the CA on request.

NOTE 2: No specific pressure monitoring or pressure switches are required for this system

NOTE 3: The pneumatic supply branch for the BDMs is the same actuation line used for VCS valves

Verification method: R – Review, I – Inspection, T- Test

REQ-032915/A **R3-75**

A commercial magnetically coupled vacuum motion feedthrough is recommended to bring the pneumatic movement into vacuum. Direct monitoring of the inserted and retracted positions in vacuum using normally open mechanical switches shall be provided and connected directly to CA safety systems.

NOTE: Position feedback will be relayed by the safety systems back to the MCS Controller. The MCS controller may also monitor the position of the pneumatic actuator, if desired. For testing, a temporary loopback connection should be used.

Verification method: R – Review, I – Inspection

REQ-032916/A **R3-76**

The air supply to the control valve shall be fitted with a regulator with overpressure relief, and ports 3 and 5 of the valve fitted with a silencer as recommended in the control valve manual.

Verification method: I – Inspection

REQ-032917/A **R3-77**

Stainless steel solid tube and swaged fittings shall be used for the pneumatic connections between the safety control valve and the actuator.

Verification method: I – Inspection

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3.2.6. Safety Systems Interfaces – Machine Safety System (MSS)

REQ-032918/A **R3-78**

The Supplier shall provide a machine safety signalling interface for each compressor system as specified in the implementation drawings (see drawings package RD-01). The specified digital inputs and digital outputs shall be connected directly (via relays) to FPGA Controller I/O modules.

Verification method: R – Review, I – Inspection, T - Test

REQ-032919/A **R3-79**

The MSS input permissive shall directly enable the motor drives for the relevant axes via an external dry contact closure.

Axes marked as LP ENABLE in the requirements table shall not be enabled unless the LOW POWER PERMISSIVE is given.

Those marked as HP ENABLE in the requirements table shall not be enabled unless the HIGH POWER PERMISSIVE is given.

Verification method: R – Review, I – Inspection, T - Test

REQ-032920/A **R3-80**

The MSS input signals shall be split (*e.g.,* by parallel connected relays) and a copy connected to each controller so that the permissive status may be read by the FPGA.

Verification method: I – Inspection, T - Test

REQ-032921/A **R3-81**

For each MCS the MSS safe output signal shall be combined by series connected relays from each controller so that each controller independently confirms it is safe for high power laser operation.

Verification method: I – Inspection, T - Test

REQ-032922/A **R3-82**

Each controller shall only output a positive SAFE FOR HIGH POWER signal when the following conditions are met for all axes connected to that controller:

1) All movement has completed and drives have been disabled by the controller.
2) All Alignment Crosshairs are in the fully retracted position as detected by their NC position switch.
3) The Beam Dump Mirror is in a fixed state (either fully open or fully closed as detected by its NC position switches).
4) All temperature sensors are within the configured nominal band.

Verification method: R – Review, I – Inspection, T - Test

REQ-032923/A **R3-83**

The Supplier shall consider using a relay type with a mechanical override function to allow the permissive input signals to be simulated for testing without the external MSS connected.

Verification method: R – Review

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4. Cleaning and cleanliness verification, packaging requirements

4.1. Compressor and Injector vacuum chambers

REQ-032924/A **R4-1**

Before final treatment on inner vacuum surfaces of each chamber, especially if grinding is used for surface finish, the Supplier shall invite CA to perform inspection of the surface cleanliness.

Verification method: I – Inspection

REQ-032925/A **R4-2**

All finished stainless steel parts of the chambers shall be degreased by thorough cleaning with high pressure hot water jet (>120 bar), using appropriate high-performance detergent (e.g. 2% solution of General Purpose Cleaner/Degreaser mixture of Sodium Tripolyphosphate - 3 - < 5%, Modified Polyether Anionic Surfactant - 1 - < 3%, Non-ionic surfactant 1 - < 3%; pH >11; (5 - 15% - Non-Ionic Surfactants, 1 - 5% - Phosphates, 1 - 5% - Anionic Surfactants) or equivalent), at a temperature between 70°C and 75°C, for no less than 5 minutes /m2. The water jet strokes shall form a cross pattern on the cleaned surface. Subsequently, the parts shall be immediately, without letting the surface to dry, rinsed with hot demineralised water with at least 75°C.

The previous step, i.e. thorough cleaning with high-pressure water with appropriate high-performance detergent, followed by rinsing in demineralised water without letting the surface to dry, shall be repeated.

Subsequently, the parts shall be dried by clean, dry pressurized gas (*e.g.,* nitrogen) in a way not leaving traces of residues from water drops.

NOTE: It is not allowed to use wipes wetted with isopropanol or acetone after completion of the above procedure.

NOTE: Spraying or flushing of parts of vacuum surfaces by ultraclean acetone (<5ppm evaporation residue) is allowed, provided it does not come into contact with any plastic parts such as squirt bottles or O-rings.

NOTE: Dry wiping of smooth surfaces with polyester wipes to minimize particle contamination is allowed.

NOTE: Use of specific degreasing solution shall be approved in writing by CA. The CA also permits another equivalent cleaning procedure to be offered, however this shall be approved in writing by the CA.

NOTE: A possible additional step may involve cleaning by laser or by manual electro-polishing with 10% solution of H_3PO_4. If any of these techniques is used, detailed steps of the procedure shall be agreed in writing with CA.

Verification method: R – Review, I – Inspection

REQ-032926/A **R4-3**

All O-rings shall be vacuum baked at temperature of 120°C for 24 hours prior to use. After the bake-out, the O-rings shall not come in contact with isopropyl alcohol or any grease.

Verification method: I – Inspection

REQ-032927/A **R4-4**

The Supplier shall perform mass-spectrometer RGA (Residual Gas Analyzer) test on each chamber. The RGA shall have a range of at least 200 AMU (Atomic Mass Unit) and shall contain Secondary Electron Multiplier (SEM). The chambers shall be pumped by a dry vacuum pump and a turbomolecular pump to a pressure of 10^{-6} mbar for at least 12 hours before activating the RGA. The

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RGA filament shall be on for at least 4 hours before recording the final scan. The resulting RGA spectrum shall conform to the following criteria:

a) all peaks above AMU 45 shall be lower than 1/100 of AMU 44;
b) the AMU 45 peak shall be lower than 1/10 of AMU 44.

Verification method: R – Review, T – Test, I - Inspection

REQ-032928/A **R4-5**

The Supplier shall invite CA to inspect the vacuum cleanliness of the chamber in ISO 7, or equivalent, (or better cleanliness class) cleanroom before starting the packaging these components for transport. The results of the inspection shall be recorded in the form of the Compressor and Injector Chambers Vacuum Cleanliness Inspection Report.

Verification method: I – Inspection

4.2. Internal optical table and optomechanical mounts

REQ-032929/A **R4-6**

All finished aluminium alloy parts of the internal optical tables and optomechanical mounts shall be degreased by thorough cleaning with high pressure hot water jet (>120 bar), using appropriate high-performance detergent (e.g. 2% solution of General Purpose Cleaner/Degreaser mixture of Sodium Tripolyphosphate - 3 - < 5%, Modified Polyether Anionic Surfactant - 1 - < 3%, Non-ionic surfactant 1 - < 3%; pH >11; (5 - 15% - Non-Ionic Surfactants, 1 - 5% - Phosphates, 1 - 5% - Anionic Surfactants) or equivalent), at a temperature between 70°C and 75°C, for no less than 5 minutes /m2. The water jet strokes shall form a cross pattern on the cleaned surface. Subsequently, the parts shall be immediately, without letting the surface to dry, rinsed with hot demineralised water with at least 75°C.

The previous step, i.e. thorough cleaning with high-pressure water with appropriate high-performance detergent, followed by rinsing in demineralised water without letting the surface to dry, shall be repeated.

Alternatively, the optical table support frame and the optical table panels can be degreased by immersing in hot bath with high-performance detergent (e.g. 2% solution of General Purpose Cleaner/Degreaser mixture of Sodium Tripolyphosphate - 3 - < 5%, Modified Polyether Anionic Surfactant - 1 - < 3%, Non-ionic surfactant 1 - < 3%; pH >11; (5 - 15% - Non-Ionic Surfactants, 1 - 5% - Phosphates, 1 - 5% - Anionic Surfactants) or equivalent.

Subsequently, the parts shall be dried by clean dry pressurized gas (e.g. nitrogen) in a way not leaving traces of residues from water drops.

NOTE: It is not allowed to use wipes wetted with isopropanol or acetone after completion of the above procedure.

NOTE: Spraying or flushing of parts of vacuum surfaces by ultraclean acetone (<5ppm evaporation residue) is allowed, provided it does not come into contact with any plastic parts including squirt bottles or O-rings.

NOTE: Dry wiping of smooth surfaces with polyester wipes to minimize particle contamination is allowed.

NOTE1: Use of specific degreasing solution shall be approved in writing by CA. The CA also permits another equivalent cleaning procedure to be offered, however this shall be approved in writing by the CA.

NOTE2: The cleaning of the aluminium alloy parts may, if necessary, involve an additional step consisting in cleaning with 10% solution of phosphoric acid (H3PO4) applied with e.g. polyester (PE) wipes. Within less than 40 seconds the acid has to be removed by clean PE wipes. Immediately after,

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the walls shall be neutralized by 5% solution of analytical purity sodium bicarbonate (NaHCO3); after approximately 2 minutes the sodium bicarbonate shall be removed by clean PE wipes.

After processing the components with the phosphoric acid and sodium bicarbonate, the component has to be rinsed by demineralised water. The rinsing shall be made by low pressure jet (spray).

Verification method: R – Review, I - Inspection

REQ-032930/A **R4-7**

Best practice shall be followed in cleaning individual parts of the optomechanical mounts. The cleaning procedure shall follow the same steps as used for cleaning the optical table support frame and the optical table panels (see REQ-032929/A - **R4-6**). The Client reserves the right to test any part of the mounts before or during the final assembly, and/or to perform his own cleanliness test of the assembled mounts.

Verification method: R – Review, I - Inspection

REQ-032931/A **R4-8**

The Supplier shall invite CA to inspect the vacuum cleanliness of the component of the optical table support frame and of the optical table panels in ISO 7, or equivalent, (or better cleanliness class) cleanroom before starting the packaging these components for transport. The results of the inspection shall be recorded in the form of the Vacuum Cleanliness Inspection Report.

Verification method: I – Inspection

4.3. Packaging

REQ-032932/A **R4-9**

The Supplier shall invite CA to inspect vacuum cleanliness of the chambers, of the optical table support frame, of the optical table panels, and of the optomechanical mounts, placed in ISO 7, or equivalent, (or better cleanliness class) cleanroom, before starting the packaging of these components for transport. The results of the inspection shall be recorded in the form of the Vacuum Cleanliness Inspection Report.

Verification method: I – Inspection

REQ-032933/A **R4-10**

The Compressor and Injector chambers shall be prepared for transport with the top lids and doors fitted and all circular flanges sealed by metal blanks cleaned to the same standard as the chamber itself.

Verification method: I - Inspection

REQ-032934/A **R4-11**

The vacuum chambers, the internal support frames, and the optical table panels shall be packed separately for transport.

Verification method: I – Inspection

REQ-032935/A **R4-12**

The cleaned chambers, optical table support frames, optical tables panels and optomechanical mounts shall be wrapped in two layers of ultra-low outgassing polyethylene film (as sheet or bags) with thickness of at least 100 µm, with NVR (non-volatile residue) better than 0.15 µg/cm^2 and very low particle generation. Alternatively, UHV compatible aluminium foil approved by CA can be used. The clean conditions wrapping shall be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

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NOTE: CA can recommend to the Supplier appropriate low-outgassing polyethylene-based foils brands if required.

Verification method: R – Review, I – Inspection

REQ-032936/A **R4-13**

Each individual transported component shall be within the limitations of the 10 tonne limit freight elevator of ELI-Beamlines, with net size of the cargo space 5.5(l) x 5.1 (w) x 3 (h) m.

Verification method: R - Review, I – Inspection

5. Transportation Requirements

REQ-032937/A **R5-1**

The supplier shall transport the completed and tested components to the ELI Beamlines site

NOTE: The bid price will be considered by the CA as the final price, including transportation costs and insurance.

Verification method: R – Review, I - Inspection

REQ-032938/A **R5-2**

The transportation procedure shall be reviewed and agreed by the CA.

Verification method: R - Review

REQ-032939/A **R5-3**

The Supplier shall allow supervision by the CA of the activities related to the transportation.

NOTE: Any acts of supervision shall not mean that the CA assumes any liability for the results of these activities.

Verification method: R - Review

REQ-032940/A **R5-4**

The flanges of the chamber shall remain sealed during transport.

Verification method: R - Review, I – Inspection

6. Final on-site transportation, installation and Integration

REQ-032942/A **R6-1**

The Supplier shall transport and install the components to the ELI-Beamlines facility right up to the point of fixing down at the operational location in the ELI-Beamlines Laser Building.

Verification method: R - Review, I – Inspection

REQ-032943/A **R6-2**

Transport through the Laser Building will involve the use of a goods lift to transition between floors and in order to fit in the lift the maximum dimensions of the chamber body (in its transport configuration) shall not exceed 5.5 x 5.1x 3 (height) m^3 and its weight shall not exceed 10 tons.

Verification method: R - Review, I – Inspection

REQ-032944/A **R6-3**

Movement through corridors and rooms will require wheels, rollers or air skates fitted to a suitable support structure, whose design and supply shall be within the scope of the Supplier, as shall be any floor surface protection or load spreading sheets.

Verification method: R - Review, I – Inspection

REQ-032945/A **R6-4**

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All transport and installation activities at the ELI-Beamlines facility shall be pre-planned in advance by means of a written Installation Method Statement that shall be reviewed and agreed with the Client's officer in charge of such work. Transport and installation activities shall be undertaken strictly in accordance with the agreed Method Statement and subject to Client's overall control.
Verification method: R - Review, I – Inspection

REQ-032946/A **R6-5**

The Supplier shall fully install and integrate the components on-site at the operational location in the ELI-Beamlines Laser Building.
Verification method: FD - Functional Demonstration

7. Safety Requirements

REQ-032947/A **R7-1**

The Supplier shall supply a **Declaration of Conformity** for each product type if the appropriate legislation determines the Supplier's obligation to have a Declaration of Conformity for the purposes of a Device sale in the Czech Republic. In such a case the Declaration of Conformity shall comply with:

- Act No. 90/2016 Coll., as amended
  Including implementing legal acts, especially the Czech Government regulation No 176/2008 Coll., on technical requirements on machinery (implementing the EU Acts 2006/42/ES, 2009/127/ES, 2012/32/EU)
- Act No. 22/1997 Coll., as amended
  Including implementing legal acts, especially the Czech Government regulation No 118/2016 Coll., on the conformity assessment of electrical equipment designed for use within certain voltage limits (implementing the EU Act 2014/35/EU)
- OR the equivalent legal regulation of another EU member state so that the conditions for the sale of the product in the Czech Republic are met.

NOTE: The compliance with these obligations will be demonstrated by the (EU) Declaration of conformity, other relevant documents and the CE marking if required by the relevant regulations. If a delivered product is not required to undergo conformity assessment according to specific legislation, the supplier declares, in written form, by concluding the contract that the product complies with the general safety requirement of EU Directive 2001/95/EC on general product safety and that the Supplier duly complies with their obligations under this Regulation.

REQ-033233/A **R7-2**

Wherever applicable, the supplier shall provide technical documentation prepared in accordance with ČSN EN 1012-2+A1:2010 (Compressors and vacuum pumps – Safety requirements – Part 2: Vacuum pumps) – or with any equivalent act/ norm of another EU member state. Based on this documentation Assessment of Conformity according to Government Regulation No. 176/2008 Coll., on technical requirements for machinery, to implement Act No. 22/1997 Coll., will be issued by the CA.

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8. Quality requirements

8.1. Documentation and data control

REQ-032948/A **R8-1**

The Supplier shall supply the following relevant manufacturing documents:

- all manufacturing design, 3D model and design supporting documentation approved by the CA (see REQ-032954/A – R9-4);
- all "requests for deviation/waiver from requirements described herein" approved by the CA (see REQ-032950/A – R8-4).
- full technical documentation on the delivered Product regarding the following procedures:
- transport, handling, storage, disassembling and cleaning;
- safe operation, maintenance and disposal procedures;
- description of cable wires or connector pins (if relevant);
- list of spare parts, specialized tools, equipment and materials for proper maintenance or repair (if relevant);
- user manual for the software or libraries and for communication protocols (if relevant);

Verification method: R – Review, I - Inspection

REQ-032949/A **R8-2**

The Supplier shall use following data formats:

- *.JPG, *.PNG, *.TIFF, *.PDF/A, *.HTML
- CAD 2D: *.dwg
- CAD 3D: *.stp; *.ste; *.step or other 3D CAD formats agreed with the CA
- text processors *.doc, *.docx, OpenDocument Format
- spreadsheet processors *.xls, *.xlsx, OpenDocument Format
- presentations *.ppt, *.pptx; OpenDocument Format

Verification method: Not To Be Tracked within VCD

REQ-032950/A **R8-3**

Documentation (e.g. reports, protocols, certificates, instructions, manuals, etc.) shall be supplied in PDF format and hardcopy.

Verification method: Not To Be Tracked within VCD

8.2. Nonconformity control system

REQ-032950/A **R8-4**

The Supplier shall establish and maintain a nonconformity control system compatible with ČSN EN ISO 9001 (or equivalent, e.g. EN ISO 9001).

Verification method: Not To Be Tracked within VCD

9. Verification requirements for the Supplier

The verification process will be performed mostly by the Supplier. The VCD draft provided by the CA will specify exactly what is required to be verified by whom as well as the CA proposal how.

The VCD serves for the gradual recording of executed verifications by the Supplier during the Contract realization. The records usually consist of the date (time) when the verification was executed, by whom, the result (OK/NOK) and usually also reference to the related document as evidence of the result of verification.

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9.1. Verification Control Document (VCD)

The CA requires that the Supplier will use the VCD document provided by the CA. Supplier can extend and adapt the VCD document for better reflection to the real condition and fulfilment of the basic purpose of the VCD – to document and demonstrate the verification of fulfilment of CA requirements

REQ-032960/A **R9-1**

The Supplier shall gradually execute the verification as required within this RSD as well as within the VCD draft provided by CA and record the results in to the VCD.

NOTE: Phases of delivery are called Deliverables in the Purchase contract.

Verification method: R – Review

REQ-032963 /A **R9-2**

The verification approach shall be defined by the Supplier in the **VCD** prior to its implementation.

NOTE: In the VCD, the Supplier shall describe HOW and WHEN each of the technical requirements is to be verified.
NOTE: Guidelines for VCD preparation will be provided by the CA (see RD-03; section 1.12).

Verification method: R – review

9.2. Documentation and reporting from the tests

REQ-032952/A **R9-3**

The verification reports shall be submitted to the CA for the review as agreed with the CA after corresponding verification activity completion, within the time frame agreed with the CA in the VCD.
NOTE: Verification activity can be design review, test (FTR or SAT), analysis (e.g. FEM) or inspection (SIR, see REQ-032964/A - R9-4 and REQ-032965/A - R9-5).
Verification method: Not To Be Tracked within VCD

REQ-032964/A **R9-4**

The results of the tests shall be documented in the appropriate Factory Test Report (**FTR**) and on-Site Acceptance Test (**SAT**) and tracked in the VCD (see chapter 9.1).
Verification method: R – Review

REQ-032965/A **R9-5**

The results of the inspection shall be documented in the appropriate on-Site Inspection Report (further "**SIR**") and the results of the analysis shall be documented in the appropriate Analysis Report and tracked in the VCD (see chapter 9.1).
Verification method: R – Review

9.3. Verification methods

REQ-032966/A

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R9-6

The verification process shall be accomplished by the Supplier through one or more of the following verification methods recommended by the CA:

1. Test – verification that consists of measuring product performance and functions under controlled conditions, as close as possible to real operation. The Test protocols with test results or the complete Test report usually serve as the documented evidence (Test – T), e.g.:
   a. Test at the Supplier (documented in the FTR);
   b. Test at the CA (documented in the SAT);
   c. Functional Demonstration at the Supplier or at the CA but always with CA attendance (Functional Demonstration – FD);

NOTE: The CA can also ask for valid calibration certificates (protocols) of used measuring instruments or similar documentation.

2. Review – verification that the Documentation meets the requirements or the Documentation demonstrate the fulfilment of the requirements (Review – R).
3. Inspection – visual check or evaluation of physical characteristics of the subject whether meet the requirements (Inspection – I).
4. Analysis - performing of theoretical or empirical evaluations of meeting the requirements by using defined methods (Analysis - A).

Verification method: Not To Be Tracked within VCD

9.4. Phasing of the delivery

This chapter is intended to briefly summarize basic milestones of the Contract delivery. These milestones represent gates (checkpoints) where the quality of the delivery is to be evaluated.

Delivery shall not proceed past these gates unless their satisfactory accomplishment is approved by the CA.

Delivery lifecycle shall contain at least the following phases (**quality gates**):

- Qualification of Design;
- Manufacturing;
- Delivery and Installation;
- Acceptance (performed by the CA).

9.4.1. Qualification of Design

This chapter describes summary of what has to be provided by the Supplier in terms of documentation (detailed engineering documentation including technical documentation and design supporting documentation) before starting the manufacturing.

Output of this phase is **Final set of detailed engineering documentation, approved by the CA**.

REQ-032953/A **R9-7**

Before completion of the Qualification of Design phase the Supplier shall provide following information that shall be agreed by the CA:

- structure and content of the Test protocols, Analysis reports, Review reports etc. (if applicable);
- structure and content of the VCD if it was modified by the Supplier.

NOTE: Phases of delivery are called Deliverables in the Purchase contract.

Verification method: R - Review.

REQ-032954/A **R9-8**

Before completion of the Qualification of Design phase the Supplier and the CA shall agree on:

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- final detailed engineering drawings provided by the Supplier;
- detailed procedures related to the testing, cleaning and packaging during Manufacturing phase;
- common nonconformity control system (see REQ--032950/A – **R8-4**).

NOTE: Phases of delivery are called Deliverables in the Purchase contract.

Verification method: R - Review.

9.4.2. Manufacturing

The goal is to demonstrate that all the manufactured and delivered parts of the contract meet all requirements specified herein.

Output of this phase is the **Verified all manufactured parts of the contract**.

REQ-032955/A **R9-9**

The results of the Manufacturing phase of verification shall be recorded by the Supplier in the appropriate FTR and overall results (including review of documentation/reports and inspection of all the manufactured and delivered parts) shall be recorded in the VCD (see chapter 9.1). *NOTE: Phases of delivery are called Deliverables in the Purchase contract.*

Verification method: R – Review

9.4.3. Delivery and Installation

The goal is to demonstrate that the delivered and installed Compressor meet all requirements specified herein.

Output of this phase is the **Verified delivered and installed final product**.

REQ-032971/A **R9-10**

The results of the verification of the delivered and installed Compressor shall be recorded by the Supplier in the appropriate SAT (see REQ-032964/A - R9-4) and SIR (see REQ-032964/A - R9-4) and overall results shall be recorded in the VCD (see chapters 9.1).

Verification method: R - review

REQ-032972/A **R9-11**

The final issue of the VCD shall be submitted to the CA after the approval of the last report before delivery.

Verification method: R – Review

9.5. Acceptance

Acceptance will be carried out by the CA upon completion of each Phase of delivery. In case of successful acceptance phase the CA will provide to the Supplier signed acceptance protocol for each Phase of delivery. In case of unsuccessful acceptance stage the CA will provide to the Supplier Nonconformity Report (NCR) and process in accordance with REQ-032950/A – **R8-4** shall be applied.

The final acceptance will be executed by the CA by verifying all criteria stated in REQ-032955/A – **R9-12**

The Acceptance phase shall demonstrate the following:

- The final product(s) has (have) been successfully verified and this process has been documented in an appropriate way;
- All detected nonconformities have been solved in accordance with REQ-032950/A – **R8-4**;

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- The final product(s) is (are) free of fabrication errors, is (are) not damaged during transport and is (are) ready for the intended operational use.
- The final product(s) is (are) fully installed and the final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA.

REQ-032955/A **R9-12**

The Acceptance phase shall demonstrate the following:

- All finished parts of the contract have been successfully verified by the Supplier and the results of this process have been documented in VCD (The completed VCD is submitted);
- All previous Phases of delivery were accepted by CA and confirmed by the related Acceptance protocol (All the Acceptance protocols are submitted);
- All detected nonconformities have been solved in accordance with REQ-032950/A – **R8-4**;

Verification method: Not To Be Tracked within VCD (Final CA verification)

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10. ANNEX: Supplied Devices List

The following items may be supplied by the CA free of charge for use by the Supplier in the delivered systems. Unused parts must be returned.

Part Name	Typical Part Number(s)	Max. quantity
FPGA Controller	NI cRIO-9057 (Master), NI 9149 (Slave)	4 (Master) 6 (Slave)
Device Network Switch	Moxa EDS-G516E-4GSFP	4
Serial Device Server	Moxa Nport IA5450AI	6
Control Cabinet	Rittal VX 8204.000	6
Breakout	Weidmuller SAI-8-MMS 5P M12	20
3/2 Safety Control Valve	Festo VOFA-L26-T32C-M-G14-1C1-APP	2
5/2 Safety Control Valve	Festo VOFA-L26-T52-M-G14-1C1-APP	2
APG Pirani/Piezo Vacuum Gauge	MKS 910-22034	7
APG High Accuracy Capacitance Vacuum Gauge	Pfeiffer PT R24 601	5
WRG Pirani/Cold Cathode Wide Range Vacuum Gauge	Leybold PTR90N	7
Clean Gas Filter	SMC SFC102-03	14
UHP Ceramic Filter for CDA	Swagelok SS-SCF3-VR4-P-600	4
Overpressure Burst Disc	Allectra 461-PBD-ISO63-ULPP	4
UHP Manual Needle Valve	Swagelok SS-4MG-VCR	2
High Load Short Travel Actuator	Newport VHRU	16
Compact Short Travel Actuator	Newport LTA	16

The CA reserves the right to substitute any supplied part with an alternative of similar performance and functionality

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11. ANNEX: Control System Drawings

11.1. Key to Control System Drawings

[vypuštěno]

11.2. VCS Control Point Diagram – L2 200 TW Compressor

[vypuštěno]

11.3. VCS Control Point Diagram – L4 PW Compressor

[vypuštěno]

11.4. VCS Network and Serial Example (General)

[vypuštěno]

11.5. VCS Power and LOTO Example (General)

[vypuštěno]

11.6. Water cooling Example (General)

[vypuštěno]

11.7. Clean Dry Air and Pneumatics Distribution Example (General)

[vypuštěno]

11.8. VCS Devices and Cabling Example (General)

[vypuštěno]

11.9. VCS Personnel Safety (applicable to both compressor systems)

[vypuštěno]

11.10. VCS Machine Safety – L2 200 TW Compressor

[vypuštěno]

11.11. VCS Machine Safety – L4 PW Compressor

[vypuštěno]

11.12. MCS Control Point Diagram – L2 200 TW Compressor

[vypuštěno]

11.13. MCS Control Point Diagram – L2 200 TW Compressor

[vypuštěno]

11.14. MCS Network and Serial Example (General)

[vypuštěno]

11.15. MCS Actuator and Cabling Example (General)

[vypuštěno]

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11.16. MCS Personnel Safety (Applicable to both compressor systems)

[vypuštěno]

11.17. MCS Machine Safety (Applicable to both compressor systems)

[vypuštěno]

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12. ANNEX: Drawings in RAR archive file

RD-01_Drawing package for_L2_Comp_RSD_TC00309243.rar

Includes

- Assembly of the L2 compressor and beam injector with adjacent systems (_L2_Compressor_Assembly.pdf)
- L2 compressor chamber (L2_Compressor_chamber.pdf)
- L2 injector (L2_Injector_chamber.pdf)
- L2 compressor optical table (L2_Compressor_Optical_table.pdf)
- L2 pyramid tower of MID-IR beam (L2_Compressor_MID-IR_Pyramid.pdf)
- G1 grating optomechanical mount (L2_Comp_G1_ds.pdf)
- G2 grating optomechanical mount (L2_Comp_G2_ds.pdf)
- PM periscope mirror mount (L2_Comp_periscope_ds.pdf)
- Flexure joint pitch-yaw mount for large mirrors (L2_Comp_flexi_stage_1.pdf)
- OAP1 optomechanical mount (L2_Comp_OAP1_ds.pdf)
- D-M1 optomechanical mount (L2_Comp_D-M1_ds.pdf)
- Flexure joint pitch-yaw mount for small diagnostic mirrors (L2_Comp_flexi_stage_2_ds.pdf)
- XM3 double crossed hair rotation mount (L2_Comp_X-H3_ds.pdf)
- Pneumatically actuated flipping mirror for beam dump (L2_Comp_Beam_Dump_Shutter.pdf)

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DIR 20
ELI name convention and addressing for electrical components

Keywords

Conductor, cabinet, UID

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Table of Content

1. Purpose

This directive sets standards for name convention, addressing and type of electrical components, cabinets, IT racks, conductors and similar devices used in ELI Beamlines.

2. Scope

This document is valid for all ELI Beamlines employees for installations in laser and experimental halls.

This document does not directly deal with mains installation (230/400V) as this is described by general electrical standards [1, 2].

This directive is not valid for cabinets installed prior to release of this directive and for those in scope of facility that follow general electrical standards [1, 2].

3. Glossary of Abbreviations and Terms

Abbr.	Term	Explanation
-	ELI Beamlines employees	Employees of Fyzikální ústav AV ČR, v.v.i., organizationally assigned to section 9 – ELI Beamlines
UID	Unique identification number	A unique identification code for all electrical devices in laser and experimental halls.

4. Related documents

[1]. ČSN 332130:2014, ed.3 Low-voltage electrical installations – Internal electric distribution lines

[2]. ČSN 332000:2009, ed. 2 Low-voltage electrical installations

[3]. ČSN EN 60445:2017, ed. 5 Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors

5. Naming convention

5.1. Components abbreviations

All components in cabinets have unique abbreviations and follow the convention below:

- A = PLCs
- D = DIN rails
- F = Fuses
- FA = Circuit breakers for mains (230/400V)
- FLT = Filters for mains (230/400V)
- FV = Surge protectors for mains (230/400V)
- G = Power supplies
- KA = Relays
- KM = Contactors
- R = Cabinets
- SPD = Signal surge protectors for low voltage (up to 50V)

- UPS = Uninterruptible power supplies
- X = Connection terminals

5.2. UIDs marking

The UID marking is preferably used for cabinets, PLCs and UPSs. The UID is generated according to the key **ABnn** where **A** stands for abbreviation (Chapter 5.1) /function of the device (Chapter 5.3.1 for PLCs), **B** stands for the system prefix defined in table (**Table 1**) and **nn** is a serial number in the system – examples:

- R801 – cabinet number 01 in experimental hall E3
- IOH501 – IOH is a function of PLC, 5 means that it is related to BT and 01 that it is the first PLC in the system
- RIO403 – RIO is a function of PLC, 4 means that it is related to L4 and 03 that it is the third PLC in the system

Table 1: System prefixes for generating UID

System	L1	L2	L3	L4	BT	E1	E2	E3	E4	E5	Plant rooms
System prefixes	1	2	3	4	5	6	7	8	9	10	11

Other components inside cabinets that have some parameters have also a unique UID created using the same convention. Examples of such components: SDS and NSW.

5.3. Numbering systems for components

5.3.1. PLCs

PLC itself is marked by its label (UID) that typically starts with its function IOH, RIO, CRIO, PLC, etc. This label is directly attached to the device and it not used during addressing.

PLCs cards are marked **nAm**, where **n** is a serial number of PLC in a cabinet and **m** is a serial number of a card. The exception is the first power supply card that is an integral part of PLC.

For B&R components, this first power supply card is marked by **nA.PS**. The **m** = 1, 2, etc. is used for rest of the cards including further power supply cards.

Additionally, when PLC contains network module next to the cards, this network module is marked **nA.BC** or **.HB**. If there is more such modules then a serial number is added from left to right (example for first PLC in the cabinet - 1A.BC1, 1A.BC2, etc.). The network inputs of such modules if they do not have original marking are marked IF1, IF2, etc. (used only during addressing, not marked on the device itself). Example of such PLC, type from company B&R – **Figure 1**.

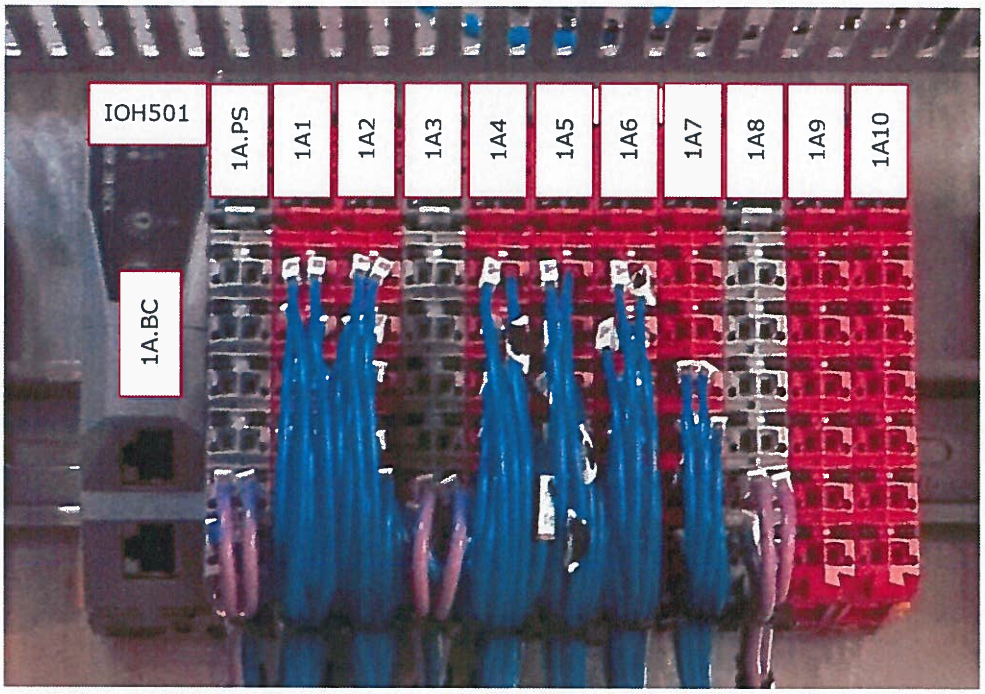

Figure 1: PLC IOH501 type B&R with 1 network module and 3 power supply cards

Other examples of PLCs, type from company PILZ – **Figure 2** and type from company NI – **Figure 3**. (**1A.***, * depends on exact marking on the device, e.g. 1A.X1).

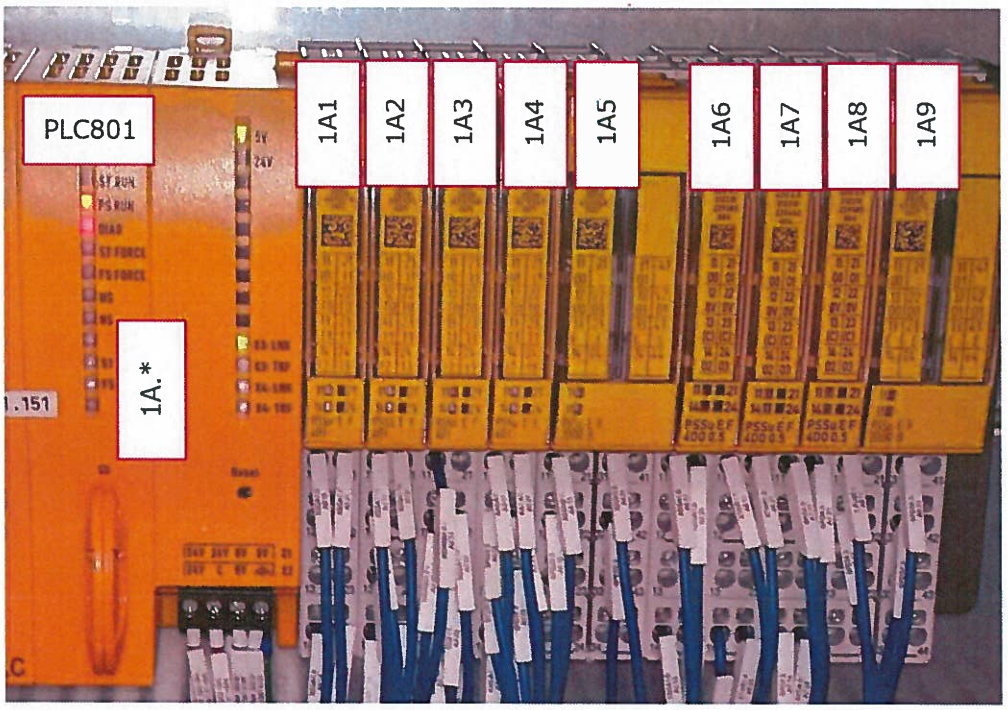

Figure 2: PLC801 type PILZ

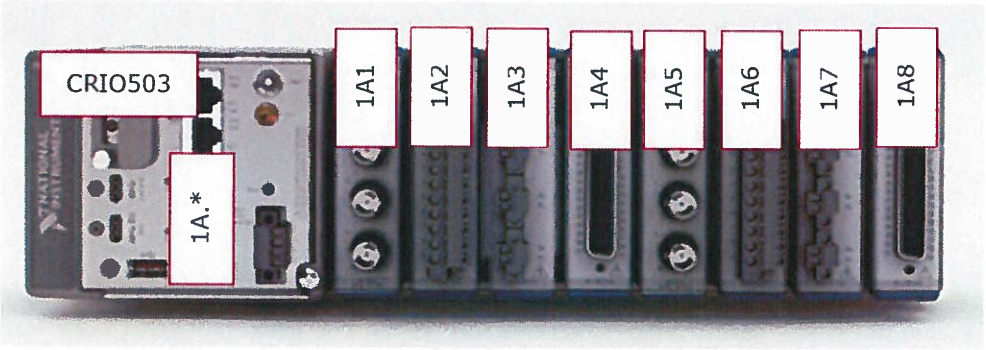

Figure 3: PLC CRIO503 type NI

5.3.2. Connection terminals

The function name of the connection terminal is preferable added after the marking X – examples: XSACB, XDPWR.G52_24V, XDPWR.G52_COM, XTEMP, XTMPS, XSCON, etc. When it is not required to add the specific function name these connection terminals are marked X1, X2 … Xn (n is a serial number in the cabinet).

When more of the same connection terminals are in the cabinet, then a serial number is added after the marking.

Inside a cabinet, it is possible to mark connection terminals by labels with or without DIN rail number, which they are mounted on – **Figure 4**. Both variants are allowed.

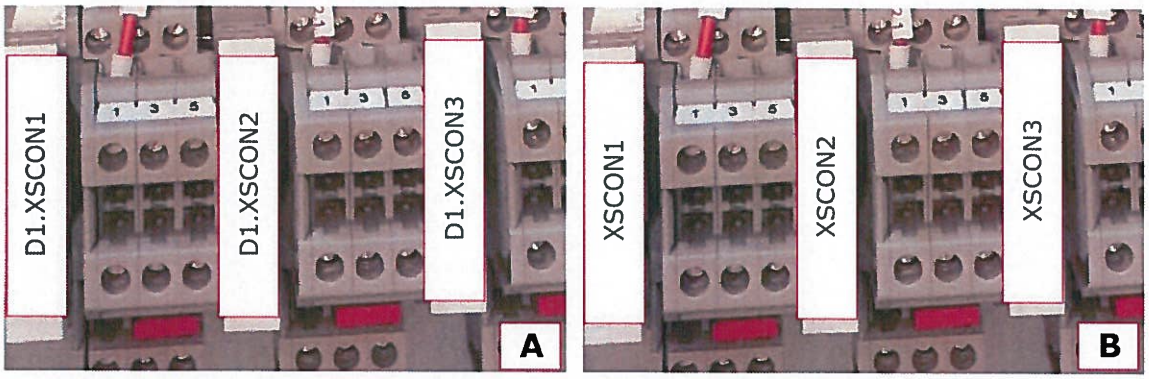

Figure 4: 3 connection terminals XSCON on DIN rail D1 and two possible ways of marking – A) marking with DIN rail nr. B) marking without DIN rail nr.

5.3.3. Filters, Power supplies, Circuit breakers and Surge protectors connected to mains (230V/400V)

Components - circuit breakers (FA), power supplies (G), filters (FLT) and surge protectors (FV) connected to mains (230/400V) are numbered by the convention below to indicate which branches are powered based on various **laser states** (scenarios)

- Numbering G/FA/FLT/FV101-199 for no emission laser state (scenario)
- Numbering G/FA/FLT/FV201-299 for low power laser state (scenario)

- Numbering G/FA/FLT/FV301-399 for high power laser state (scenario)
- Numbering G/FA/FLT/FV501-599 for powered by UPS laser state (scenario)

Designer can choose additional system (e.g. 401-499) for components operated in other laser states (scenarios) if he considers it as useful or better arranged. In that case, he must create a note describing his system on the electrical drawing.

Other components that refer to neither above-mentioned options have a serial number set by a designer; see the example of cabinet with UPS - **Figure 5**.

```
FA5 - FV5  ┐- FA51   - UPS501 ┐- FA511  - FLT511  - G511
           |                  |- FA512  - FLT512  - G512
           |                  |- FA513  - FLT513  - G513
           |                  |- FA514  - FLT514  - G514
           |                  └ FA515  - FLT515  - G515
           |
           └ FA52   -  KM1   ┐- FA521  - FLT521  - G521
                             |- FA522  - FLT522
                             |- FA523  - FLT523
                             |- FA524  - FLT524
                             |- FA525  - FLT525
                             |- FA526  - FLT526
                             └ FA527  - FLT527
```

Figure 5: Part of circuit with UPS

5.3.4. DIN rails

DIN rails are marked D1, D2 ... Dn (n is a serial number in a cabinet) in direction from up to down and subsequently from the left to right – **Figure 6**.

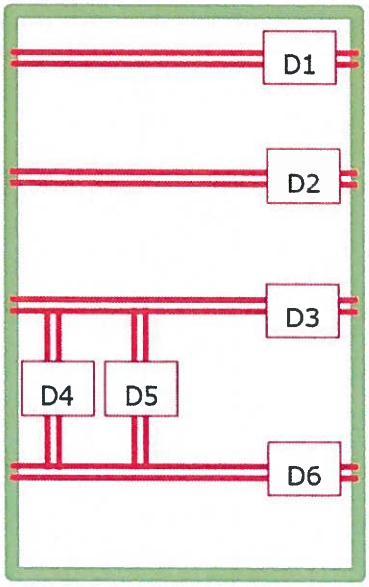

Figure 6: Example of cabinet with DIN rails

5.3.5. Relays, SPDs, Contactors and Fuses

These components are marked according to the convention that all components have a serial number starting from 1:

- Relays are numbered KA1, KA2 ... KAn (n is a serial number in a cabinet).
- Contactors are numbered KM1, KM2 ... KMn (n is a serial number in a cabinet).
- SPDs are numbered SPD1, SPD2 ... SPDn (n is a serial number in a cabinet).
- Fuses are numbered F1, F2 ... Fn (n is a serial number in a cabinet).

5.4. Addressing

Conductors between components in cabinets are marked according the convention defined in **Table 2**.

Table 2: Addressing convention

Conductor start			Conductor end		
Start Address	separator	End Address	End Address	separator	Start Address
Dn.Qn.x	:	Dm.Qm.y	Dm.Qm.y	:	Dn.Qn.x

Dn.Qn.x : Dm.Qm.y

- **Dn** – DIN rail with serial number **n** at conductor start
- **Dm** – DIN rail with serial number **m** at conductor end
- **Qn** – component **Q** with serial number **n** and pin **x** at conductor start
- **Qm** – component **Q** with serial number **m** and pin **y** at conductor end
- The marking is mirrored on each end
- If the conductor comes from different cabinet, the cabinets UIDs are added before both numbers RO.Dn.Qn.x : RP.Dm.Qm.y (RO is the UID of the first cabinet and RP is the UID of the second cabinet).
- Examples:
  - D1.1A1.11:D1.2A3.1
  - D1.XTEMP1.8:D2.KA1.1
  - R510.D1.1A1.5:R513.D7.KA127.A1
  - D10.XSACB13.20:D3.XDPWR.G51_24V
  - D6.KA57.A1:D1.2A.X2.3

5.4.1. Printed labels

Conductors are preferably marked by printed plastic labels from the printing machine Weidmüller Printjet ADVANCED. The manual for this device is attached, see [AP02]. Experiment Control Systems dpt. is responsible for production of these printed labels

and define the suitable type of labels for components/conductors (examples of labels are on **Figure 7**).

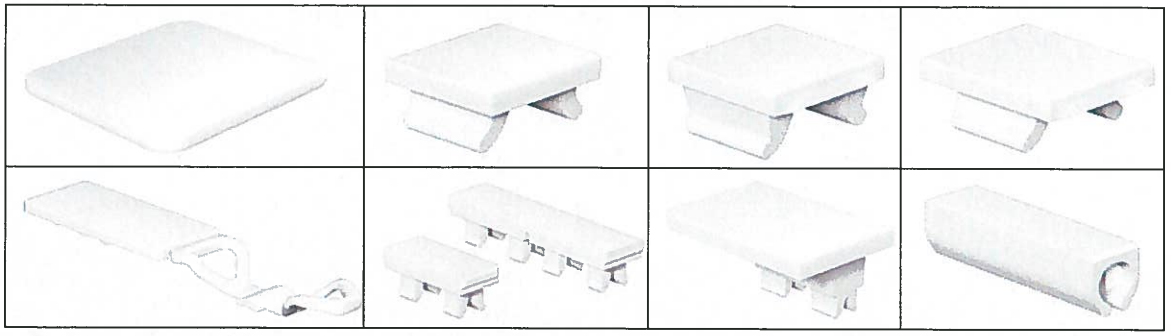

Figure 7: Types of labels for Weidmüller Printjet ADVANCED

Printed labels are placed as close as possible to conductor terminals (must be still easily readable). The marking is printed on two lines, example on **Figure 8** and **Figure 9**.

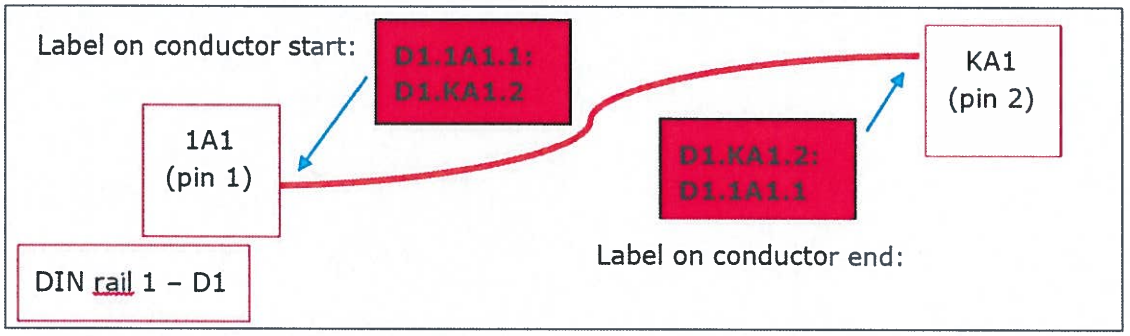

Figure 8: General scheme of printed labels from the printing machine Weidmüller

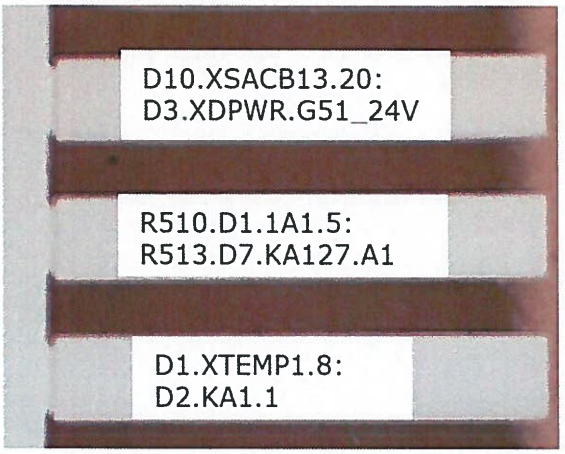

Figure 9: Example of printed labels from the printing machine Weidmüller

In case of additional changes/reworks in fieldworks or lack of space for two lines, it might be necessary to use shrink/sleeve tubes labels from the mobile printing device Brother that prints complete addressing label on only one line. These labels are placed again as close as possible to conductor terminals. On vertical components as relays

and connection terminals the labels are placed on upper side from right direction and on down side from left direction, example on **Figure 10**.

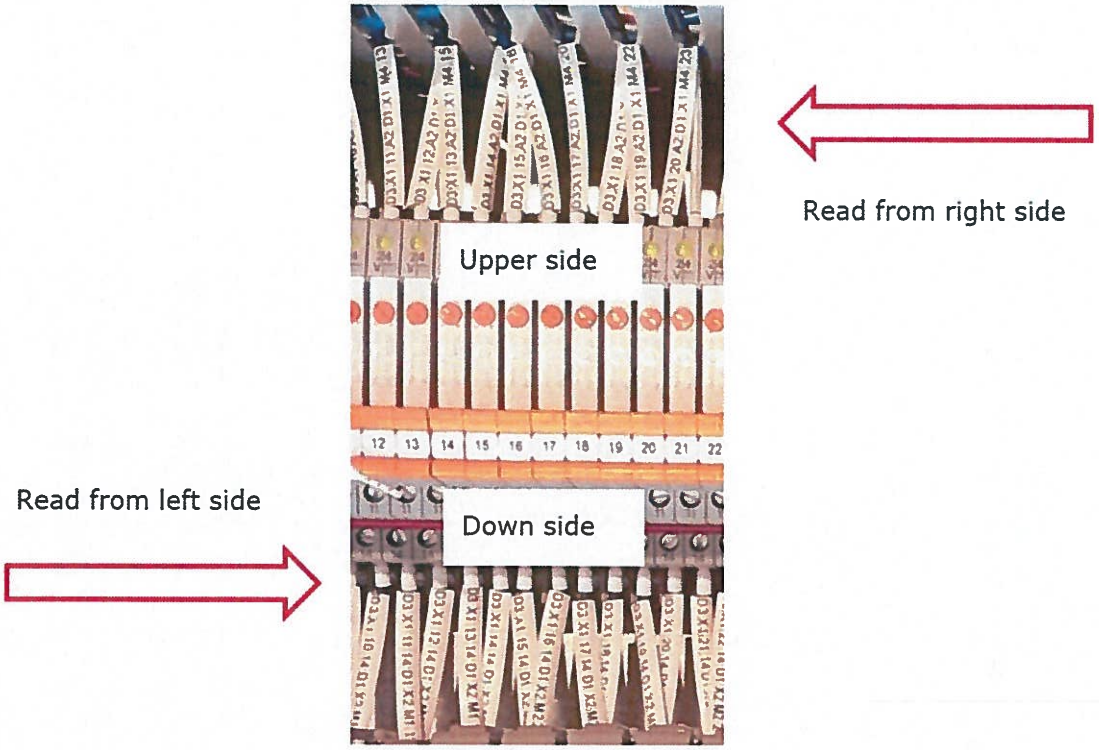

Figure 10: Example of shrink/sleeve tubes labels from the device Brother

6. Conductors requirements

Conductors for cabinets and IT racks are divided into these three main categories:

- Signal conductors (providing just information in 24V logic) + analogue conductors
- Power conductors permanently energized with low voltage (up to 50V)
- Power conductor – mains (230/400V)

The conductors colours are defined by this directive (mentioned RAL values are only informative). The cross sections are only recommended.

6.1. Signal conductors (providing just information in 24V logic) + analogue conductors

These conductors have different requirements than power conductors. The conductors have to be stranded, with crimped ferrule on both ends.

- General digital signals
  - Colour – **White** (e.g. RAL 9010)
  - Cross section – 0.50 mm^2
- Personnel Safety signals
  - Colour – **Yellow** (e.g. RAL 1021)
  - Cross section – 0.50 mm^2

- Machine Safety signals
  - Colour – **Orange** (e.g. RAL 2003)
  - Cross section – 0.50 mm^2
- Analogue signals
  - Colour – **Violet** (e.g. RAL 4005)
  - Cross section – 0.50 mm^2

6.2. Power conductors permanently energized with low voltage (up to 50V)

The cross section of conductors for low voltage (up to 50V) is selected by a designer and the cross section corresponds to relevant current flow. The conductors have to be stranded, with crimped ferrule on both ends.

- Positive Voltage
  - Colour – **Red** – (e.g. RAL 3000)
  - Cross section – 0.50 / 0.75 / 1.50 mm^2
- Negative Voltage
  - Colour – **Dark Blue** – (e.g. RAL 5002)
  - Cross section – 0.50 / 0.75 / 1.50 mm^2

6.3. Power conductors – mains (230/400V)

The conductors for mains (230/400 V) follow standard [3].

7. Database

- The Database of UID is shared at http://laser-interface.eli-beams.eu/.
- It serves for generating UID.
- The administration of the Database is the responsibility of the Laser dpt.
- The Database manual is attached, see [AP01].

8. Attachments

[AP01] Laser Interfaces Database Tutorial
[AP02] Manual PrintJet ADVANCED

Confidentiality Level	*BL - Restricted for internal use*	**TC ID / Revision**	00309478/C
Document Status	*Document Released*	**Document No.**	N/A
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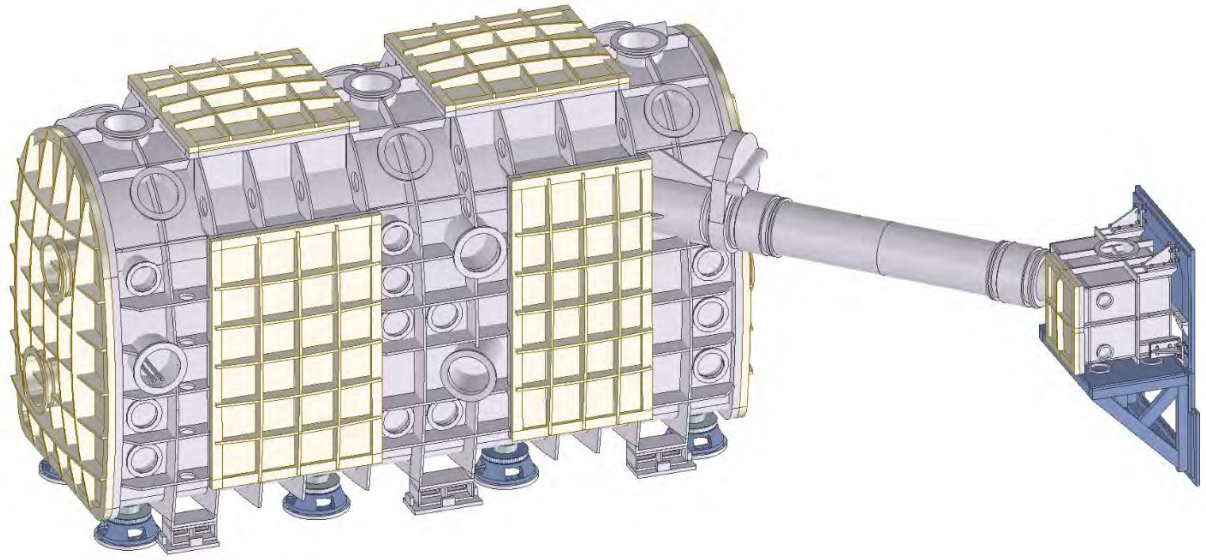
PBS code	RA1.L4.CMP2		
Project branch	*Engineering & Scientific documents (E&S)*		
Document Type	*Specification (SP)*		

[RSD product category C]

L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System

TP21_046



Keywords

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Revision History / Change Log

Change No.	*Made by*	*Date*	*Change description, Pages, Chapters*	*TC rev.*
1	B. Rus, J. Naylon	6.08.2021	RSD draft creation	A
2	J. Adamec	13.08.2021	Preparation for Review	B
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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints on a product related to the RA1 programme of the ELI Beamlines project. This can lead to the identification of product interfaces with the ELI Beamlines science-based technology and ELI Beamlines building facility. This RSD also acts as the parent document for technical requirements that are addressed in lower level design description documents (see section 1.12).

The RSD contains all the technical requirements: functional and manufacturing design, manufacture, cleaning, packaging and transportation, as well as safety and quality, requirements for the following product (tender number: TP21_046): **L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System** ("**Compressor**" in further text).

This RSD is comprised of a descriptive text that explains the purpose, function and arrangement of the Compressor to be supplied and is supported by further sections that provide a summary of requirements and technical details of material that comprises the scope of supply under the contract; all materials shall be compliant with the specified details. The Compressor is registered in the PBS database under the following PBS code: RA1.L4.CMP2.

No laser optics (mirrors, gratings, windows, etc.) are required to be supplied under this contract.

On multiple places this document mentions also the L2 laser pulse compressor as many elements and subsystems of the L4PW compressor are identical to the L2 compressor. The technical description of the L2 compressor system ("L2 Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System") is in the document No. 00309243/C.

1.2. Scope of Work - Overall view of the Compressor and Injector assembly

The scope of work includes detailed design, manufacture, testing, transport to, and installation in ELI-Beamlines, of the integrated system of the vacuum chambers of the L4PW grating compressor and of the L4PW beam injector, of the internal chassis of the compressors including the optomechanical mounts, and of integrated vacuum and motion controls. The supply contains all blank flanges and fittings required to seal the chambers.

The compressor chamber, see Figure 1, is designed as an externally ribbed structure with the overall envelope given by the compressor optical arrangement. The upper part of the chamber is semi-circular in shape with radius 850 mm and the sides are shaped as circular segments with radius 5,000 mm, for reasons of structural integrity with respect to vacuum pressure differential. The lower part of the chamber is flat with ribs forming typical pressure vessel dished head shape.

The internal space has the net length 5,000 mm and maximum width 1,855 mm (the net width near bottom of the chamber is 1,500 mm). The maximum height of the internal space is 2,640 mm.

The outer dimensions of the compressor chamber (without the doors and top lids mounted) are 5,000 (l) x 2,200 (w) x 2,955 (h) mm^3. The chamber can thus be transported in upright position by the ELI-Beamlines cargo elevator, simplifying works connected to chamber transport through ELI-Beamlines building and installation.

At both ends, the chamber is equipped with large end installation doors with shape corresponding to the chamber section. These end doors can be removed by L4b hall overhead crane to obtain unobstructed access to the chamber interior for the purpose of insertion and assembling of the internal optical chassis. Fours

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rectangular hinged doors at the chamber body (two on the North side and two on the South side) allow required access for laser personnel to the compressor gratings and mirrors. The doors on the North side provide clear opening 2,000 (h) x 950 (w) mm^2 and 1,900 (h) x 1,195 (w) mm^2. The doors on the South side provide clear opening 2,000 (h) x 1,300 (w) mm^2 and 1,900 (h) x 1,100 (w) mm^2.

There are also two rectangular top lids / hatches on the top of the chamber body, with clear opening 1,305 (l) x 1,170 (w) mm^2 (West lid) and 1,200 (l) x 1,170 (w) mm^2 (East lid). These lids are essential for accessing chamber interior by the overhead crane to assist installation of the internal optical chassis to inside the compressor chamber. The lids will be equipped with lifting features (e.g. bosses for screw-in lifting eyes) to enable its handling by L4b hall overhead crane.

All optomechanical units with optical components are mounted on an optical chassis located within the vacuum chamber. The chassis is mechanically de-coupled from the vacuum vessel by a bellows structure.

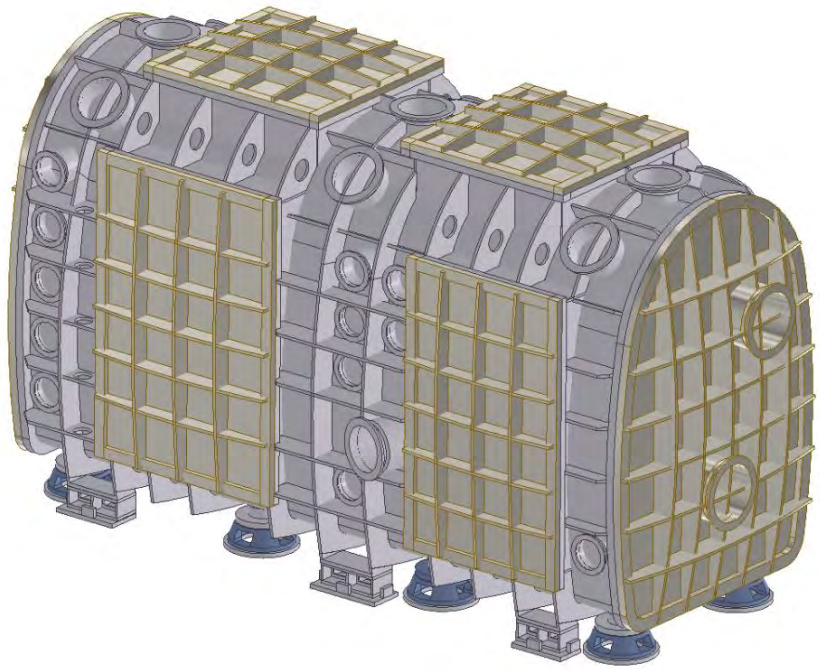

Figure 1: L4PW compressor vacuum chamber seen from the South-East with respect to its position in the L4b laser hall of the ELI-Beamlines facility.

The injector vacuum chamber, see Figure 2, has a form of externally ribbed near-cube with internal dimensions 800 (l) x 630 (w) x 600 (h) mm^3. The chamber is suspended on the structural wall of the L4b hall. It is equipped on the East side with one access hinged door providing clear opening 500 (w) x 600 (h) mm^2. The internal optomechanics is mounted on internal table supported by independent suspended chassis. The table with dimensions 740 (l) x 570 (w) x 40 (t) mm^3 is mechanically de-coupled from the injector chamber by supports equipped with isolating bellows.

The laser beam exiting the injector is routed to the L4c basement floor of the ELI-Beamlines building, toward the L4PW beam distribution system.

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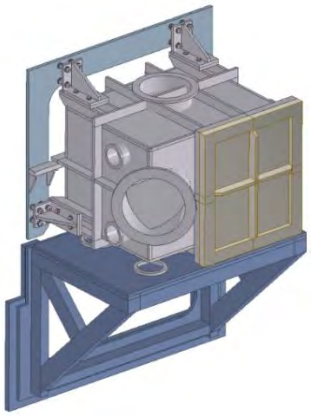

Figure 2: Injector vacuum chamber seen from North-East with respect to its position in the L2 laser hall of the ELI-Beamlines facility (chassis supporting the internal optical tables are indicated in dark grey).

The compressor and injector vacuum chambers, including all their ports, shall be made from stainless steel class 1.4307 (equivalent to ČSN 17249, equivalent to AISI 304L), or equivalent. Good manufacturing practices for stainless steel welding shall be followed.

The nominal wall thickness of the compressor chamber, of the installation doors, personnel doors and top lids in the CA design is 15 mm. This thickness and the structure of the reinforcing ribs are based on FEM simulations and extensive structural optimization carried out by CA, showing that deformations under the vacuum pressure differential do not exceed 1.2 mm anywhere on the compressor and injector chambers. The Supplier is not allowed to change substantially the structure of the ribs provided in the CA design, however can make local modifications of the ribs and adjust their thicknesses, based on optimisation study and on results of the Supplier's FEM simulations. The modified design shall provide structural stability resulting in deformations of walls less than 1.2 mm when the chambers are pumped down from atmospheric pressure.

1.3. Internal Optomechanical Structures

The internal structures of the compressor and injector shall provide ultra-high-stability environment for both the main and beam / pulse diagnostics optical elements of the system.

1.3.1. Compressor Optomechanical Chassis

All optomechanical mounts of the compressor will be supported by internal optical chassis which is mechanically isolated from the chamber vessel by means of a double bellows structure. The chassis provides environment for optomechanical mounts on two floors (decks) as required by the optical layout of the compressor.

The structure of the internal chassis, see Figure 3, has total size of 4,880 (l) x 1,550 (w) mm^2; its highest part has size of 1,490 mm. The basis of the chassis is formed by a massive support frame with total thickness of 190 mm. The frame is sitting on eight massive support posts (legs) equipped by double bellows.

The support frame shall be manufactured from one single block of cast aluminium free of internal stress and free of any defects and/or inhomogeneities. Other parts of the chassis shall also be manufactured each from one single block of cast aluminium free of internal stress and free of any defects and/or inhomogeneities.

The material of the chassis and of the optical tables segments shall be aluminium alloy EN AW 5083 (equivalent to ČSN 42 4415, equivalent to ANSI AA5083), or equivalent.

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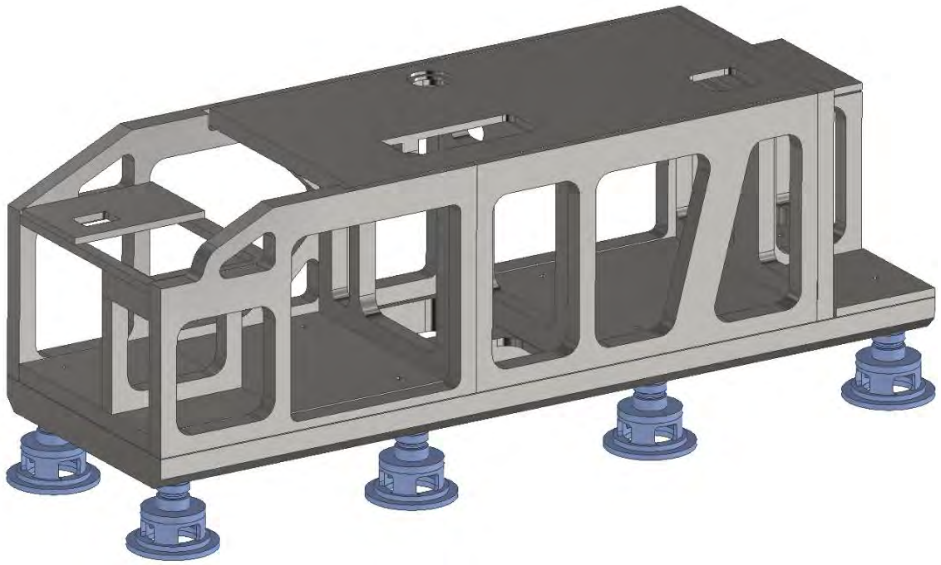
The optomechanical mounts will be sitting on optical tables, consisting of segments with thickness of 50 mm (lower floor) and 40 mm (upper floor). These segments shall be made from high-flatness prefabricated panels and shall be machined with an array of M6-compatible tapped mounting holes on a 25 mm square grid, as indicated in the drawings.

The chassis assembly including the support frame and the support posts have been extensively optimized by CA with respect to stiffness and vibration characteristics (first resonance frequency well above 50 Hz). The Supplier shall repeat the FEM simulations for the final manufacturing design, accounting for masses of the optomechanical mounts and for details of elements joining the individual parts of the chassis (bolts, etc.).



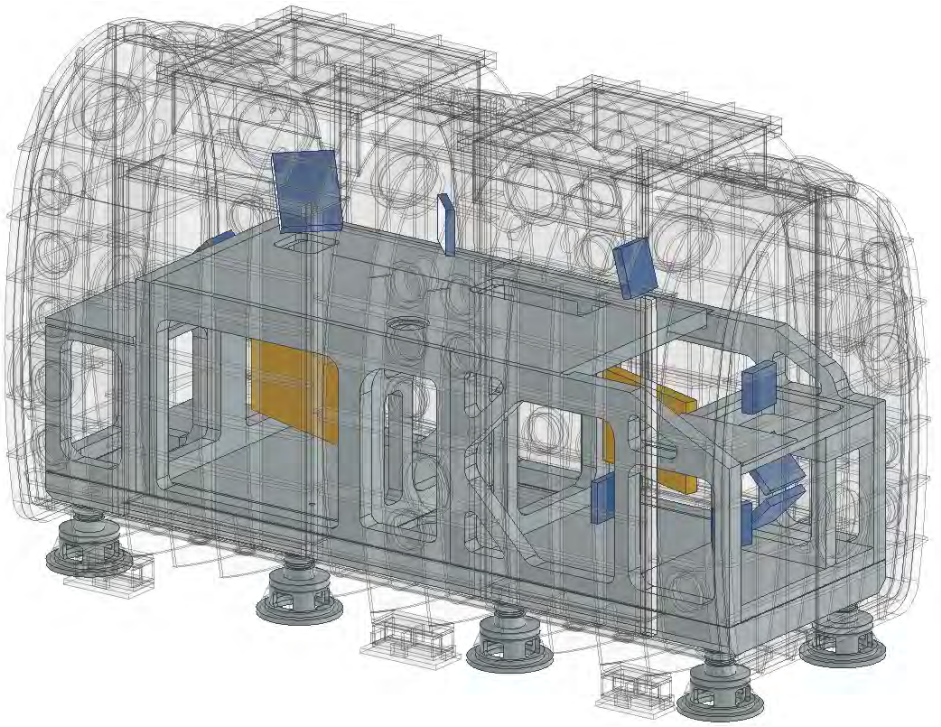


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Figure 3: Compressor internal optical chassis with eight support posts (upper picture); the supports are equipped with a double bellows structure, not indicated here. Structure of the chassis within the compressor vessel with gratings, indicated in yellow, and main mirrors (lower picture).

The supports posts (legs) will be mounted on stainless-steel floor plates which will be bonded to the structural floor with absolute vertical accuracy better than +/-0.1 mm. The supports are therefore not equipped by any fine height setting. The floor plates will be installed by CA.

The Supplier shall develop the CA conceptual design of the optical chassis, support structure, and supports (legs) equipped with double bellows into a manufacturing design. The design shall, as for all other components inside the vacuum vessel, avoid any trapped volumes of air; *e.g.*, the mounting holes will be tapped right through.

1.3.2. Injector Internal Optical Table

The internal optical structure of the injector consists of an optical table with size of 740 x 570 mm^2. The table has thickness of 40 mm and is directly supported by isolation bellows legs mounted on a supporting suspended chassis (frame).

The bellows legs are of identical design as for the injector of the L2 laser.

The material of the injector optical table shall be aluminium alloy EN AW 5083 (equivalent to ČSN 42 4415, equivalent to ANSI AA5083), or equivalent. The table shall be made from a high-flatness prefabricated panel, cast and free of free of any defects and/or inhomogeneities.

The supporting suspended chassis shall be made from stainless-steel 1.4307 (equivalent to ČSN 17249, equivalent to AISI 304L), or equivalent. The chassis will be mounted on accurately positioned (with precision better than +/-0.2 mm in each direction) wall plates which will be bonded to the structural wall. The wall plates will be designed and installed by CA; the Supplier shall coordinate design of the chassis with the CA wall plates design.

The Supplier shall optimize the supporting chassis and shall perform the FEM simulations to demonstrate the vibration characteristics with the first resonance frequency above 100 Hz.

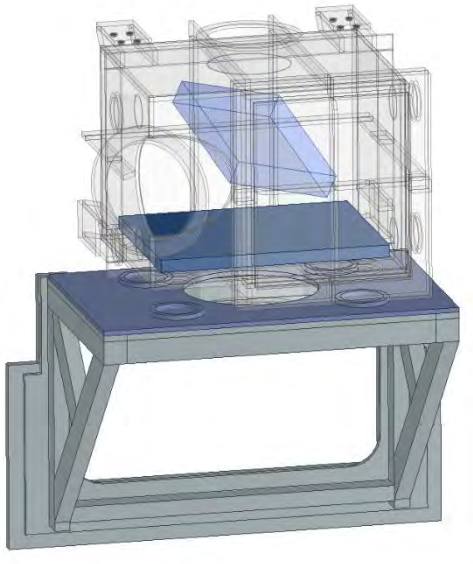

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Figure 4: Injector internal optical table sitting on separate supporting suspended chassis (view from South-East). The isolating supports are equipped with a double bellows structure (not indicated here), of identical design as those in the L2 beam injector.

Generic design of the internal optical table isolation supports (legs) is illustrated in Figure 5. The structure consists of double bellows providing full isolation of the force on the flange used for the leg, arising from pressure difference between outer atmospheric pressure and the chamber vacuum. The outer atmospheric pressure acting on the flange is transferred by the rod-shaped independent beams to the chamber body and the force acting on the support leg is zero.

This system of double-bellows based supporting props of internal optical tables for vacuum structures was pioneered by FZU in 1999-2000 and has since proven to give excellent performance in a number of systems, with no detectable displacements of the optical components with respect to pump down.

[vypuštěno]

Figure 5: Concept of the isolation legs using double bellows system (illustration). The double bellows fully remove the force arising from the atmospheric pressure (vacuum pressure differential) on the flange cross-section, as the force is fully transmitted on the vessel by means of the cylindrical beams.

1.4. Compressor Vacuum Flange Schedule

All circular flanges (except custom flanges as specified below) with diameter larger or equal to 50 mm shall be dimensioned according to ISO 1609 (2014 revision), or equivalent, corresponding to ISO-K or ISO-F implementation. All flanges smaller than 50 mm shall be dimensioned according to ISO 2860 (Second edition 2020-02), or equivalent.

All circular flanges in the list below will be sealed by simple fluoroelastomer O-rings. The doors and top lids shall be sealed by double O-ring assembly with pumped interspace.

The table below describes the intent for using these ports. For works vacuum testing by the supplier all flanges except those used for pumping and for vacuum gauges are required to be blanked by corresponding ISO blank flanges. For delivery of the chamber to ELI-Beamlines all flanges will be blanked.

The alignment of the flanges on the body of the chamber is in some places critical and elsewhere not critical. **Table 1** gives the permitted tolerance for individual tolerance grades applicable to all circular flanges of the compressor and injector chambers, as specified in **Table 2** and **Table 3.**

Flange Tolerance Grade	Tolerance Specification
A	Co-axial tolerance of ±1 mm or better and angular tolerance of ±0.5 degrees or better with respect to their ideal axis
B	Co-axial tolerance of ±3 mm or better and angular tolerance of ±2.0 degrees or better with respect to their ideal axis
C	Normal manufacturing tolerance (in accordance with ISO 2768-mK, or equivalent)

Table 1: ISO Circular Flange Tolerance Grade.

Location of all flanges on the compressor and injector chamber body are shown respectively in Figure 6 and Figure 7.

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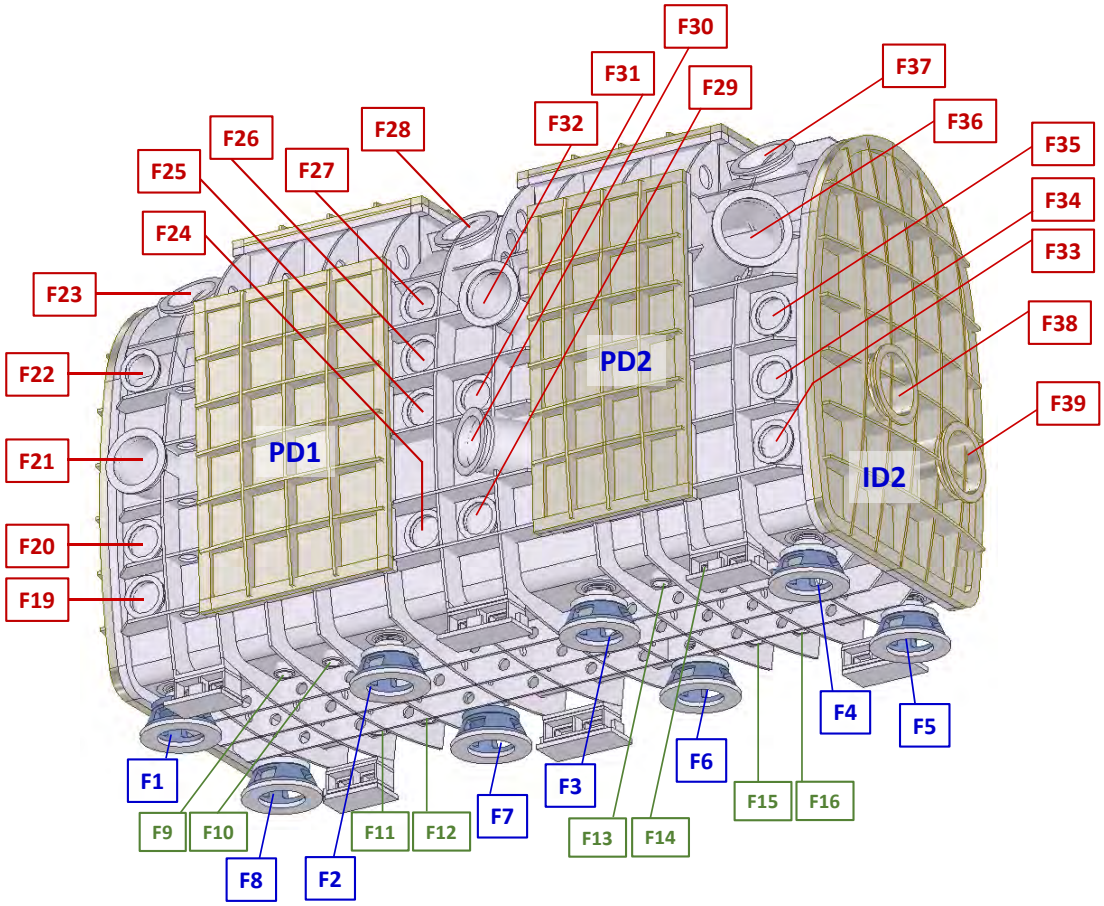
All doors and top lids (ID1, ID2, PD1 to PD4, TL1 and TL2) are vacuum sealed by using a double fluoroelastomer O-ring seal arrangement minimizing effective gas load due to O-ring permeation, with the space between the O-rings actively pumped to ~10^{-2} mbar by the L4b laser hall backing vacuum circuit. The O-rings shall be located in the door flange and the interspace pumping shall be performed from the chamber flange, *i.e.,* opening the doors shall not require disassembling of any vacuum tubes or bellows. The O-rings shall be retained in the grooves during the door opening. Detail design of the double O-ring assembly and arrangement of corresponding flanges (DN10 ISO-KF) and tubes (inner diameter 12 mm) serving to active pumping of the space between the two O-rings shall be optimized by the Supplier during preparation of manufacturing drawings.

Small flanges DN10 ISO-KF for pumping O-ring interspaces are not included in the below flange schedule.

The upstream valves at the plasma cleaning devices (Evactron) serve to isolate the chamber and temporary remove the device.



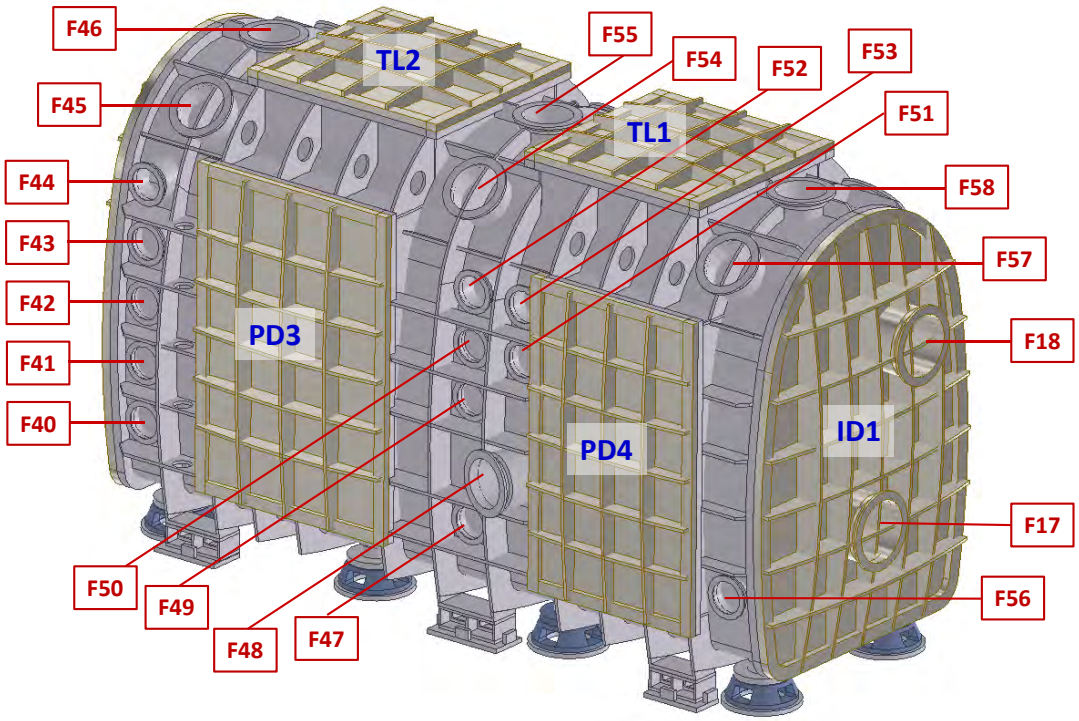


Figure 6: Injector Top Lids and circular ISO flanges on the compressor chamber: views from North-East (above) and from South-West (middle), and view of the chamber underside (below).

Table 2 Positions and specifications of compressor chamber vacuum flanges.

Type	Flange	Size	Position / Purpose	Note	Tolerance
-	ID1	Chamber section shape, 2040 (w) x 2820 (h) mm outer size, clear opening 1860 (w) x 2640 (h), 15 mm thickness, ribbed	Installation Door 1, East side of the chamber Installation of the internal optical table	Sealed by double O-ring assembly with pumped interspace Installed by L4b hall overhead crane, fitted with threads for lifting eyes	N.A.
-	ID2	Chamber section shape, 2040 (w) x 2820 (h) mm outer size, clear opening 1860 (w) x 2640 (h), 15 mm thickness, ribbed	Installation Door 2, West side of the chamber Installation of the internal optical table	Idem ID1	N.A.
-	PD1	Rectangular shape, outer size 2060 (h) x 1355 (w) mm, providing clear opening 1900 (h) x 1195 (w) mm, 15 mm thickness, ribbed	Personnel Door 1, North side of the chamber, for access to grating G1 and to input beam optics	Sealed by double O-ring assembly with pumped interspace Opening by hinge (double hinge arrangement to avoid O-rings crushing); fitted with threads for lifting eyes for initial installation by overhead crane	N.A.

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Type	Flange	Size	Position / Purpose	Note	Tolerance
-	PD2	Rectangular shape, outer size 2160 (h) x 1115 (w) mm, providing clear opening 2000 (h) x 955 (w) mm, 15 mm thickness, ribbed	Personnel Door 2, North side of the chamber, for access to compressed beam output mirrors	Idem PD1	N.A.
-	PD3	Rectangular shape, outer size 2160 (h) x 1460 (w) mm, providing clear opening 2000 (h) x 1300 (w) mm, 15 mm thickness, ribbed	Personal Door 3, South side of the chamber, for access to diagnostic beam optics and to 0^{th} order optics	Idem PD1	N.A.
-	PD4	Rectangular shape, outer size 2060 (h) x 1265 (w) mm, providing clear opening 2000 (h) x 1105 (w) mm, 15 mm thickness, ribbed	Personal Door 2, South side of the chamber, access to grating G2	Idem PD1	N.A.
-	TL1	Rectangular shape, outer size 1360 (l) x 1330 (w) mm, providing clear opening 1200 (h) x 1170 (w) mm, 15 mm thickness, ribbed	Top Lid 1 (hatch) for crane access to East part of compressor interior for optical table installation	Sealed by double O-ring assembly with pumped interspace Fitted with threads for lifting eyes for manipulation by overhead crane	N.A.
-	TL2	Rectangular shape, outer size 1465 (l) x 1330 (w) mm, providing clear opening 1305 (h) x 1170 (w) mm, 15 mm thickness, ribbed	Top Lid 2 (hatch) for crane access to West part of compressor interior for optical table installation	Idem TL1	N.A.
M	F1	213-mm-diam custom flange	On chamber underside, for connection of bellows isolation of the internal optical table	Tapped holes for connection with the isolation bellows, see Drawing Package. Initially closed by blank flange	B
M	F2	213-mm-diam custom flange	Idem F1	Idem F1	B
M	F3	213-mm-diam custom flange	Idem F1	Idem F1	B
M	F4	213-mm-diam custom flange	Idem F1	Idem F1	B
M	F5	213-mm-diam custom flange	Idem F1	Idem F1	A
M	F6	213-mm-diam custom flange	Idem F1	Idem F1	A
M	F7	213-mm-diam custom flange	Idem F1	Idem F1	A

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Type	Flange	Size	Position / Purpose	Note	Tolerance
M	F8	213-mm-diam custom flange	Idem F1	Idem F1	A
V	F9	DN100 ISO-K *	On chamber underside, for connection #1 to L4b roughing vacuum circuit	Initially closed by blank flange	C
V	F10	DN100 ISO-K *	On chamber underside, for connection #2 to L4b roughing vacuum circuit	Initially closed by blank flange	C
V	F11	DN100 ISO-K *	On chamber underside, alternative for connection #1 to L4b roughing vacuum circuit	Initially closed by blank flange	C
V	F12	DN100 ISO-K *	On chamber underside, alternative for connection #2 to L4b roughing vacuum circuit	Initially closed by blank flange	C
V	F13	DN100 ISO-K *	On chamber underside, for automated venting	Initially closed by blank flange	C
V	F14	DN100 ISO-K *	On chamber underside, for manual venting	Initially closed by blank flange	C
V	F15	DN100 ISO-K *	On chamber underside, alternative for automated venting	Initially closed by blank flange	C

* or equivalent solution

V	F16	DN100 ISO-K *	On chamber underside, alternative for manual venting	Initially closed by blank flange	C
-	F17	DN400 ISO K *	On ID1, spare flange for future upgrades	Will be blanked in current phase	B
O	F18	DN400 ISO K *	On ID1, alternative exit of diagnostic beam, spare flange	Idem F9	B
E	F19	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (PM1)	Will be equipped by cable feedthroughs	C
E	F20	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (PM1)	Will be equipped by cable feedthroughs	C
O	F21	DN320 ISO F *	On chamber North side, for output of Temporal and Spatial Diagnostic Beams (TDB, SDB) and of the 0^{th} order diagnostics	DN320 with 2 subsidiary flanges DN50 and one DN80, equipped with AR coated optical windows	B
V	F22	DN200 ISO K *	On chamber North side, for overpressure safety burst disk	Initially closed by blank flange	C

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Type	Flange	Size	Position / Purpose	Note	Tolerance
V	F23	DN320 ISO F *	Near top of chamber North side, for TMP	Will be equipped by TMP 4000 l/s	B
E	F24	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (G1)	Will be equipped by cable feedthroughs	C
E	F25	DN200 ISO-K *	On chamber North side, for feedthroughs od electrical cables (XH3/4)	Will be equipped by cable feedthroughs	C
E	F26	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (TOAP2)	Will be equipped by cable feedthroughs	C
E	F27	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (XH1 / XH2 / TM3)	Will be equipped by cable feedthroughs	C
-	F28	DN320 ISO K *	Near top of chamber North side, contingency	Will be blanked in current phase	B
E	F29	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (G1)	Will be equipped by cable feedthroughs	C
		* or equivalent solution			
O	F30	DN320 ISO K *	On chamber North side, for observation / visual inspection of grating G2	Initially closed by blank flange, later will be equipped by viewing port	B
E	F31	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (TM3)	Will be equipped by cable feedthroughs	C
O	F32	DN320 ISO F *	On chamber North side, for entry of the uncompressed beam	Will be connected to vacuum tube of beam telescope, blanked in the initial phase	B
E	F33	DN200 ISO K *	On chamber North side, available for feedthroughs of electrical cables	Initially closed by blank flange	C
E	F34	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (XH5)	Will be equipped by cable feedthroughs	C
E	F35	DN200 ISO K *	On chamber North side, for feedthroughs of electrical cables (M3)	Will be equipped by cable feedthroughs	C
O	F36	DN400 ISO K *	On chamber North-West upper edge, for output of compressed beam	Fitted with the block of magnetic rotational inserter of the beam dump mirror and pendulum DN400 valve	A

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Type	Flange	Size	Position / Purpose	Note	Tolerance
E	F37	DN320 ISO F *	On chamber North side, for feedthroughs of electrical cables for future polarization switch	Will be equipped by cable feedthroughs	B
-	F38	DN400 ISO K *	On ID2, spare flange for future upgrades	Will be blanked in current phase	B
O	F39	DN400 ISO K *	On ID2, alternative output of 0^{th} order, spare flange for future upgrades	Idem F30	B
E	F40	DN200 ISO K *	On chamber South side, for feedthroughs of electrical cables (G2)	Will be equipped by cable feedthroughs	C
E	F41	DN200 ISO K *	On chamber South side, for feedthroughs of electrical cables (G2)	Will be equipped by cable feedthroughs	C
V	F42	DN200 ISO K *	On chamber South side, for vacuum gauges	Will be equipped by a flange with 2x reductions	C
V	F43	DN200 ISO K *	On chamber South side, for vacuum gauges	Will be equipped by a flange with 2x reductions	C
		* or equivalent solution			
V	F44	DN200 ISO K *	On chamber South side, for vacuum mass spectrometer (RGA)	Initially closed by blank flange	C
V	F45	DN320 ISO F *	Near top of chamber South side, for TMP	Will be equipped by TMP 4000 l/s	B
O	F46	DN320 ISO-K *	On top of the chamber on West side, for illumination of chamber interior	Will be equipped by viewport	B
E	F47	DN200 ISO K *	On chamber South side, available for feedthroughs of electrical cables	Initially closed by blank flange	C
O	F48	DN320 ISO-F *	On chamber South side, for observation / visual inspection of grating G1	Initially closed by blank flange, later will be equipped by viewing port	B
V	F49	DN200 ISO-K *	For plasma cleaning device	Initially closed by blank flange	C
E	F50	DN200 ISO K	On chamber South side, available for feedthroughs of electrical cables	Initially closed by blank flange	C

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Type	Flange	Size	Position / Purpose	Note	Tolerance
E	F51	DN200 ISO K *	On chamber South side, available for feedthroughs of electrical cables	Initially closed by blank flange	C
V	F52	DN200 ISO-K *	On chamber South side, alternative for plasma cleaning device (mirrors on chassis top floor)	Initially closed by blank flange	C
E	F53	DN200 ISO K *	On chamber South side, available for feedthroughs of electrical cables	Initially closed by blank flange	C
V	F54	DN320 ISO-F *	Near top of chamber South side, contingency for additional TMP	Will be blanked in current phase	B
O	F55	DN320 ISO-K *	On top in the middle of chamber, for illumination of chamber interior	Will be equipped by viewport	B
E	F56	DN200 ISO K *	On chamber South side, for feedthroughs of electrical cables (SDM / TDM final mirrors)	Will be equipped by cable feedthroughs	C

* or equivalent solution

V	F57	DN320 ISO-F *	Near top of chamber South side, alternative for plasma cleaning device	Will be blanked in current phase	B
O	F58	DN320 ISO-K *	On top of the chamber on East side, for illumination of chamber interior	Will be equipped by viewport	B

* or equivalent technical solution

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1.5. Injector Vacuum Flange Schedule

The injector installation door IAD1 is vacuum sealed by using a double fluoroelastomer O-ring seal arrangement, with the space between the O-rings actively pumped to ~10^{-2} mbar by the L4c laser hall backing vacuum circuit (connected to and controlled by the adjoining VCS system, not in the scope of supply). As for the compressor, the O-rings shall be located in the door flange and the interspace pumping shall be performed from the chamber flange, *i.e.*, opening the door shall not require disassembling of any vacuum tubes or bellows. The O-rings shall be retained in the grooves during the door opening. As for the compressor, the detail design of the double O-ring assembly and arrangement of corresponding flange (DN10 ISO-KF) and tube (inner diameter 12 mm) serving to active pumping of the space between the two O-rings shall be optimized by the Supplier during preparation of manufacturing drawings.

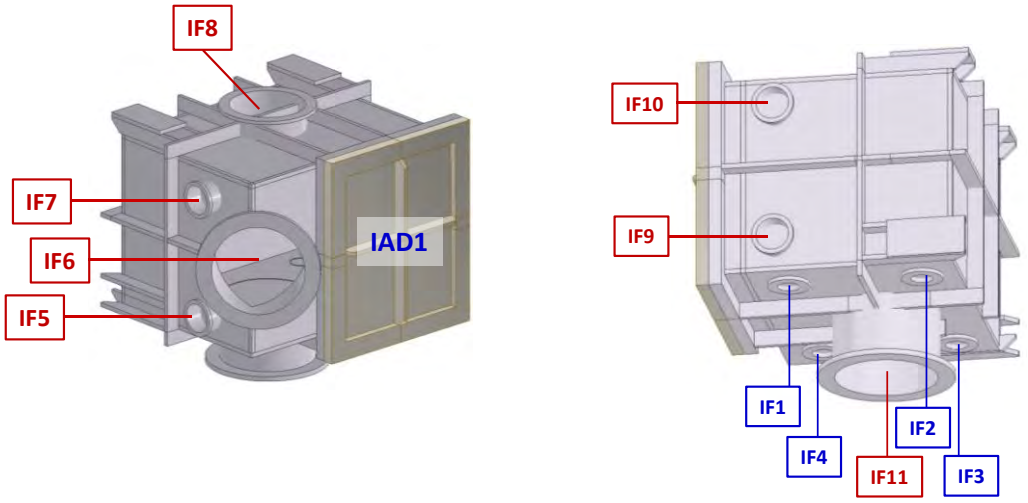

Figure 7: Door and circular ISO flanges on the injector chamber: views from South-East (left) and from North-West (right) showing also the chamber underside.

Table 3: Positions and specifications of injector chamber vacuum flanges.

Type	Flange	Size	Position / Purpose	Note	Tolerance
-	IAD1	Rectangular shape, outer size 630 (w) x 730 (h) mm, providing clear opening 500 (l) x 600 (h) mm, 15 mm thickness, ribbed	Injector Access Door 1 for installation of the optomechanical table and for access to the optomechanics	Sealed by double O-ring assembly with pumped interspace	N.A.
M	IF1	70-mm-diam custom flange	On injector underside, for connection of bellows isolation of the internal optical table	Tapped holes for connection with the isolation bellows (same type as for L2 Injector), see Drawing Package. Initially closed by blank flange.	A

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Type	Flange	Size	Position / Purpose	Note	Tolerance
M	IF2	70-mm-diam custom flange	Idem IF1	Idem IF1	A
M	IF3	70-mm-diam custom flange	Idem IF1	Idem IF1	A
M	IF4	70-mm-diam custom flange	Idem IF1	Idem IF1	A
V	IF5	DN100 ISO-K *	On Injector South side, for vacuum gauges	Will be equipped by a flange with 2x reductions	C
O	IF6	DN320 ISO-F *	On injector South-East edge, for entry of the PW laser beam from	Initially closed by blank flange	A
V	IF7	DN100 ISO-K *	On injector South side, for vacuum gauge and burst disk	Will be equipped by a flange with 2x reductions	C
V	IF8	DN250 ISO-F *	On injector top side, for connection of TMP	Will be equipped by TMP 3000 l/s	B
V	IF9	DN100 ISO-K *	On injector North side, for plasma cleaning device	Will be blanked in current phase	C
V	IF10	DN100 ISO-K *	On injector North side, for RGA	Will be blanked in current phase	C
O	IF11	DN400 ISO-F *	On injector underside, for output of the PW laser beam	Initially closed by blank flange	A

* or equivalent technical solution

1.6. Compressor and injector vacuum system, connection to the central primary vacuum circuit

The compressor and injector chambers are designed to provide vacuum conditions of 10^{-7} mbar.

The chambers will use vacuum flanges of the DN ISO standard, or equivalent, sealed by fluoroelastomer O-rings. The large access ports, i.e. installation doors ID1 and ID2, personal doors PD1 to PD4, and top lids TL1 and TL2 of the chamber, and the injector access door IAD1, will use a double O-ring (fluoroelastomer) seal arrangement. While the conceptual design developed by ELI-Beamlines takes into account the double O-ring arrangement by providing sufficient area on the flanges of the large ports, its detailed design shall be elaborated by the Supplier.

Pumping of the compressor chamber to roughing vacuum (10^{-2} mbar) will be made using the facility primary vacuum system of ELI-Beamlines. This consists of stainless steel tubing (DN160) which is run close to the floor under the tables of the L4 laser. The primary vacuum circuit in the L4b hall provides approximately 10^{-2} mbar pressure and is pumped by dry pump. A separate circuit, led by DN80 tubing running parallel with the roughing line, is provided for maintaining backing vacuum (10^{-2} mbar) for turbomolecular pumps (TMP).

Two TMP units with a pumping speed ~4,000 l/s (minimum 3800 l/s) each are sitting on DN320 flanges in the upper part of the compressor chamber. TMP supply is included in the basic scope of the contract. The

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Supplier shall also develop a detailed design of the backing vacuum distribution to the TMPs, based on the conceptual design provided by CA.

Connection of the primary vacuum circuits of the compressor to the L4b primary vacuum lines of ELI-Beamlines is shown in Figure 8 and Figure 9. The primary vacuum is brought to under the compressor chamber by rectangular ducts (200x60 mm for the roughing line and 100x60 mm for the backing line) sitting in the floor channel. The conceptual design of the compressor, developed by CA, takes fully into account details of connection of the compressor and injector to the floor vacuum ducts. The main vacuum valves on the roughing and backing lines are sitting at the entrance of the floor ducts, under the L4 optical table.

The primary vacuum tubing including the floor ducts will be provided and implemented by ELI-Beamlines.

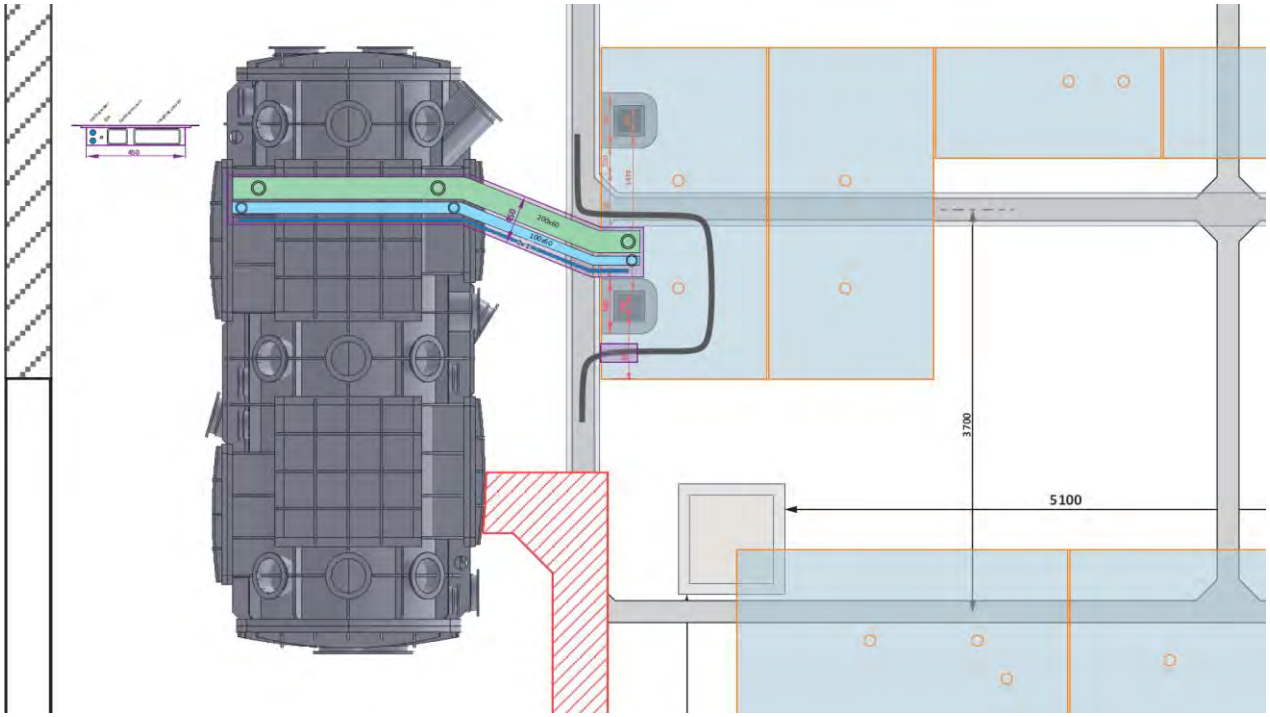

Figure 8: Layout of connection of the compressor chamber to L4b primary vacuum circuits (green: floor duct of the roughing vacuum, blue: floor duct of the backing vacuum). The ducts (rectangular floor tubes) will be provided and installed by ELI-Beamlines.

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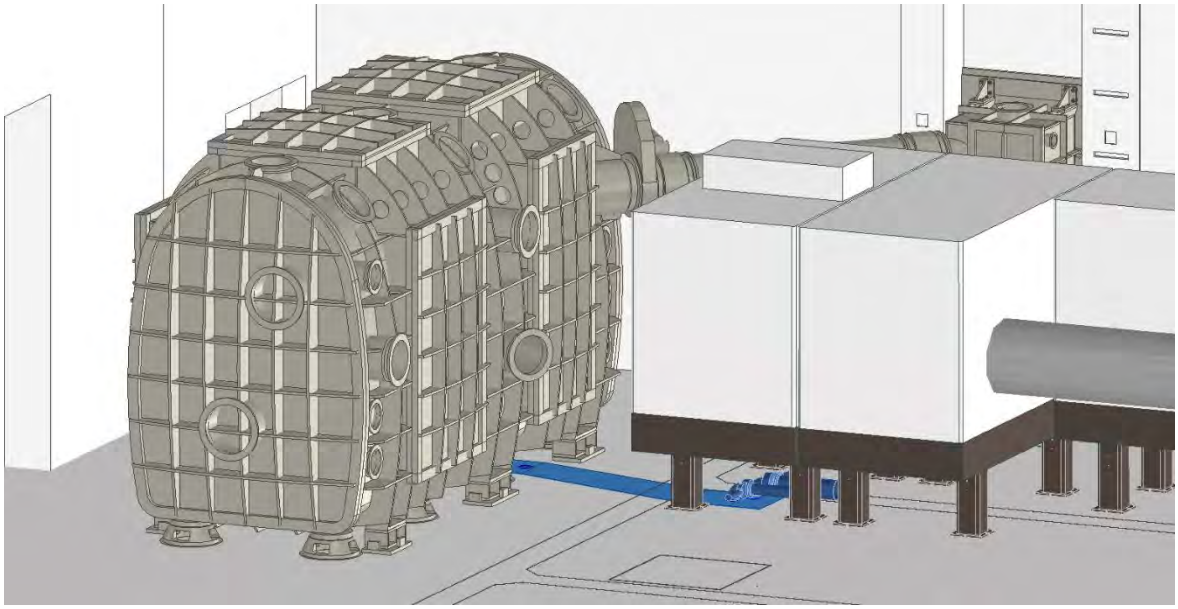

Figure 9: Schematic 3D design of the vacuum rectangular floor ducts and their connection to the L4b primary vacuum tubing running under the laser table.

The injector vacuum pumping will be provided by downstream L4PW beam distribution system, except the O-ring interspace pumping of the access door which will be made by the L4b backing circuit. The injector design provides the possibility to install a TMP on it (flange DN320 on top of the injector) if needed in future.

The compressor and the injector are interconnected by a DN400 tube equipped with a pendulum valve DN400 at the output of the injector. This valve constitutes a critical interface between the L4PW compressor and the downstream L4PW beam delivery system to the experimental halls, is a safety gate valve (SGV) which is an important element of the compressor system machine safety.

A block scheme of the vacuum circuit of the compressor chamber is shown in Figure 10. All elements except those indicated below are included in the basic scope of the contract. All valves and other components used shall be compatible with vacuum level 10^{-7} mbar or better.

The supplied large pendulum valves, between the compressor and injector, and at the output of the injector, shall be with guaranteed functionality of at least 200,000 cycles until first service.

The scheme also involves the associated segment of the ELI-Beamlines primary vacuum, which are provided by ELI-Beamlines and are controlled by the L4b ELI-Beamlines facility vacuum controls.

The compressor will be equipped by a redundant set of vacuum gauges, involving a precise atmospheric gauge to provide accurate information on pressure during venting of the chambers by the clean dry air (CDA) facility circuit.

The vacuum cleanliness in the compressor will be monitored by a COTS residual gas analyser (RGA) compact quadrupole mass spectrometer.

The upstream valves at the plasma cleaning devices serve to isolate the chamber and allow temporary removal of the cleaning device.

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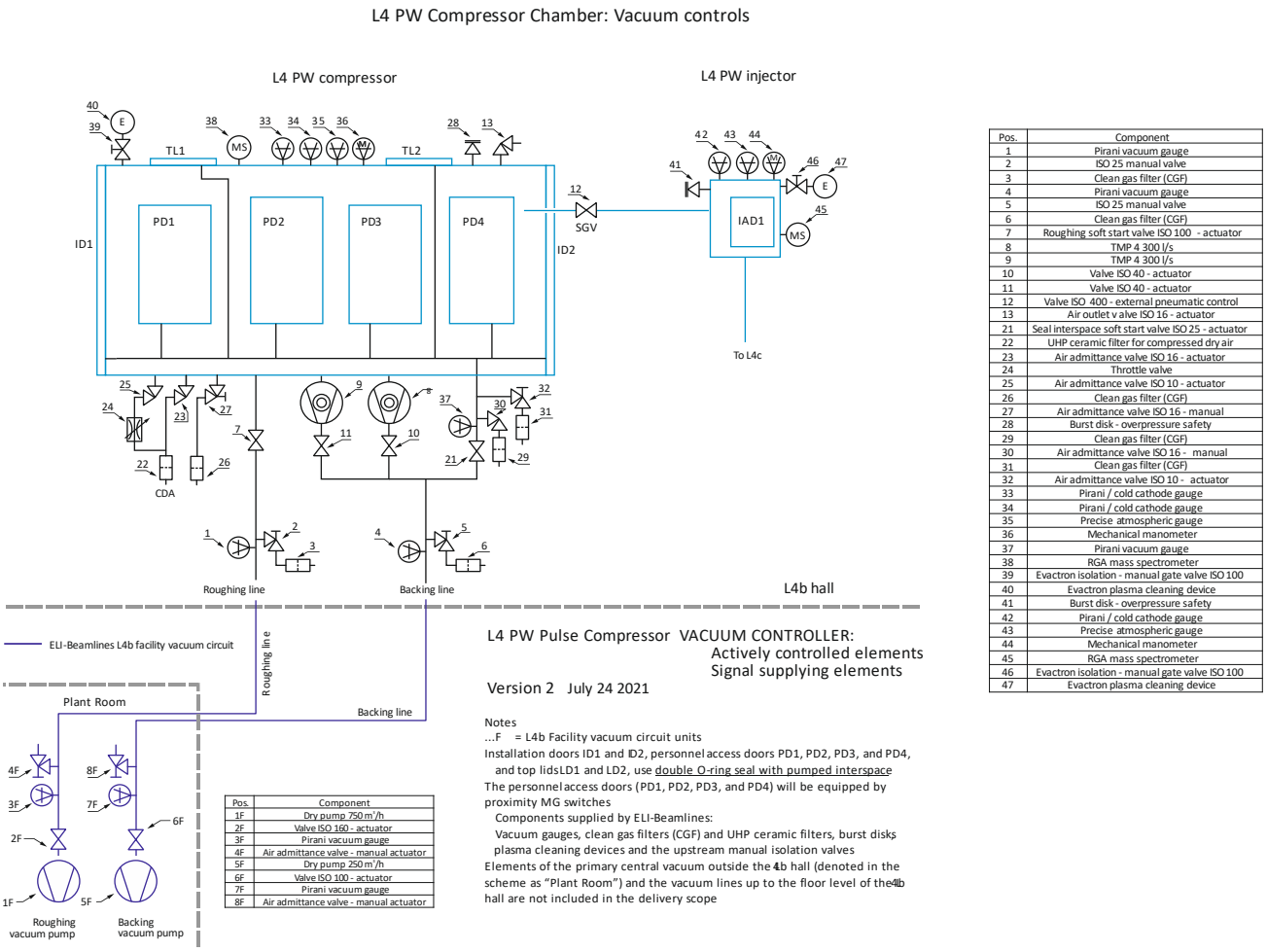
Elements which will be provided by ELI-Beamlines and which are not included in the basic scope of the contract:

- All active vacuum gauges
- Plasma cleaning devices and their upstream valves
- Overpressure safety burst disks
- Clean gas filters and ceramic filters



Pos.	Component
1F	Dry pump 750 m³/h
2F	Valve ISO 160 - actuator
3F	Pirani vacuum gauge
4F	Air admittance valve - manual actuator
5F	Dry pump 250 m³/h
6F	Valve ISO 100 - actuator
7F	Pirani vacuum gauge
8F	Air admittance valve - manual actuator

Pos.	Component
1	Pirani vacuum gauge
2	ISO 25 manual valve
3	Clean gas filter (CGF)
4	Pirani vacuum gauge
5	ISO 25 manual valve
6	Clean gas filter (CGF)
7	Roughing soft start valve ISO 100 - actuator
8	TMP 4 300 l/s
9	TMP 4 300 l/s
10	Valve ISO 40 - actuator
11	Valve ISO 40 - actuator
12	Valve ISO 400 - external pneumatic control
13	Air outlet v alve ISO 16 - actuator
21	Seal interspace soft start valve ISO 25 - actuator
22	UHP ceramic filter for compressed dry air
23	Air admittance valve ISO 16 - actuator
24	Throttle valve
25	Air admittance valve ISO 10 - actuator
26	Clean gas filter (CGF)
27	Air admittance valve ISO 16 - manual
28	Burst disk - overpressure safety
29	Clean gas filter (CGF)
30	Air admittance valve ISO 16 - manual
31	Clean gas filter (CGF)
32	Air admittance valve ISO 10 - actuator
33	Pirani / cold cathode gauge
34	Pirani / cold cathode gauge
35	Precise atmospheric gauge
36	Mechanical manometer
37	Pirani vacuum gauge
38	RGA mass spectrometer
39	Evactron isolation - manual gate valve ISO 100
40	Evactron plasma cleaning device
41	Burst disk - overpressure safety
42	Pirani / cold cathode gauge
43	Precise atmospheric gauge
44	Mechanical manometer
45	RGA mass spectrometer
46	Evactron isolation - manual gate valve ISO 100
47	Evactron plasma cleaning device

Figure 10: Block scheme of the L4PW compressor and L4PW beam injector vacuum circuit.

1.7. Cable trays and layout of the compressor / injector in the L4b laser hall of ELI-Beamlines

The Supplier shall develop conceptual design, including location, of both external and internal cable trays.

The internal (vacuum) cable trays will serve to arrange cables from the motorized actuators of the individual optomechanics to the vacuum feedthroughs (see Sections 1.4 and 1.5). The cable trays should be preferentially attached along structures of the optical chassis and/or its support structure. The trays shall be accessible and their design shall avoid any cavities and/or trapped volumes of air.

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The external cable trays will serve to arrange the cables of motorized actuators from the feedthroughs (see Sections 1.4 and 1.5) to the control rack. These external trays will also serve to arrange control and feedback-signal cables of the individual vacuum elements (valves, gauges, TMPs, etc.), and to distribute pressure clean dry air (CDA) for the vacuum valve actuators.

The Supplier shall provide the Compressor control cabinets, which will be installed in the South-East corner of the L4b hall of ELI-Beamlines, see Figure 11, and shall pull all cables and CDA tubing between the Supplier's distribution manifold and the controlled devices.

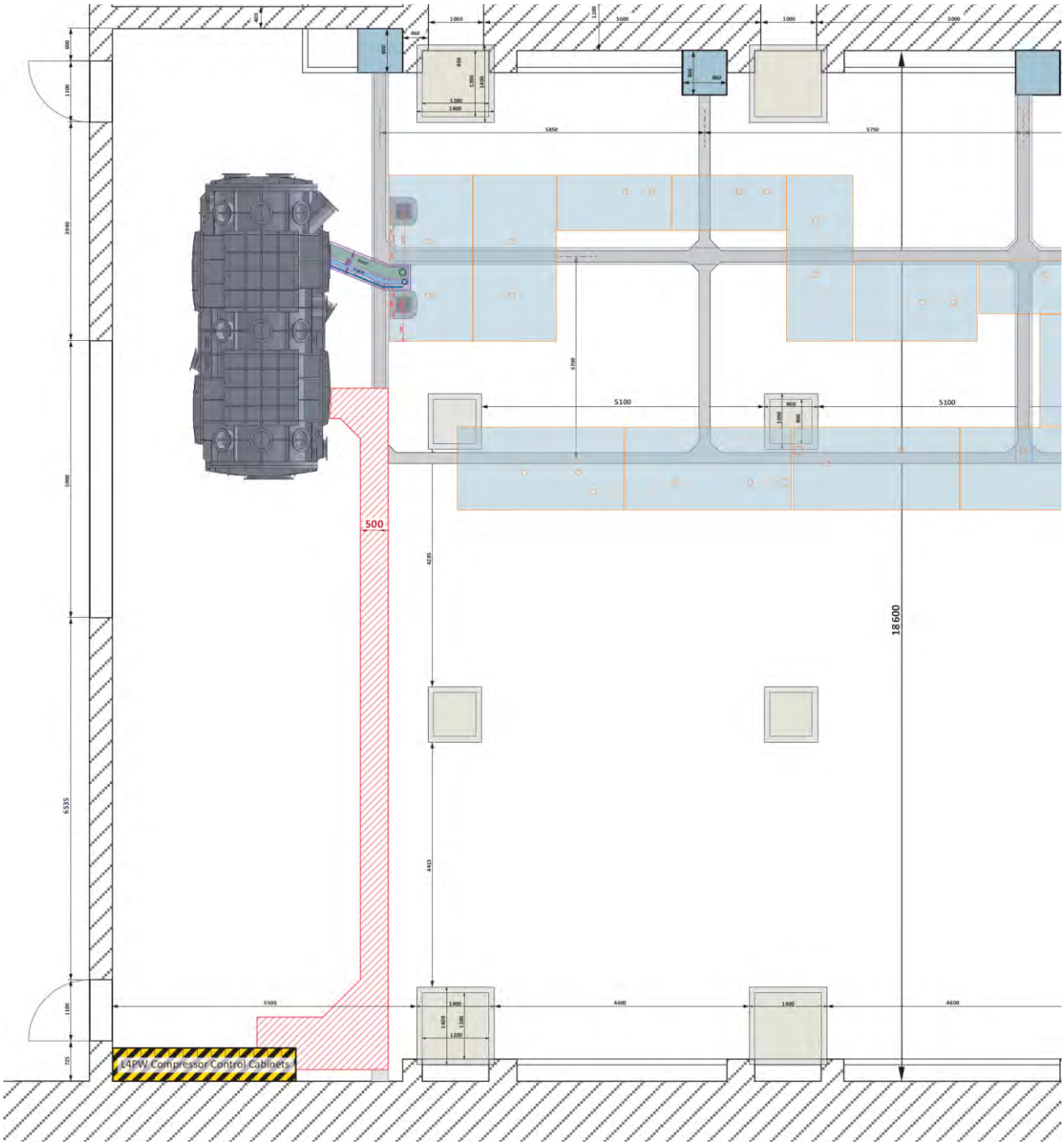

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Figure 11: Schematic layout of the floor channel (in hatched red) in the L4b hall of ELI-Beamlines, for leading the electrical cables between the compressor / injector and the control cabinets. The floor channel and its covers will be made by ELI-Beamlines.

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1.8. Vacuum Control System

The Supplier shall deliver to the Contracting Authority (CA) a separate and independent Vacuum Control System (VCS) for the L2 200 TW Pulse Compressor System and for the L4 PW Pulse Compressor System. The systems will not be co-located after installation.

Each VCS shall consist of one floor-standing control cabinet with all necessary electronics, breakouts, connecting cables, cable trays, tubing and fittings for all specified vacuum components, sufficient to meet all performance and functional requirements.

Each VCS shall include support for all items in the indicated scope of work and support for all required interfaces to CA control and facility services, according to their detailed interface specifications.

The CA can provide on request a variety of vacuum and control system hardware components from the Approved Devices list to the Supplier (see Annex 10) for use in the delivered systems, at zero cost, up to a specified maximum quantity. A precise scope of supply, bill of materials and lead-time shall be negotiated soon after project kick-off.

The Supplier shall create production wiring diagrams following industry-standard format and notation, covering every terminal block, wire, pipe and tube, including all in-cabinet and field wiring. Final as-built drawings shall be provided to the CA in pdf format as part of delivery. An A3 copy shall be placed in a document pocket mounted on the inside surface of the control cabinet door.

For this particular system, all Controller, FPGA and GUI software will be provided by the CA. The software shall be provided to the Supplier no more than 6 weeks after the Supplier delivers the final production drawings and a controller I/O signal list. To ensure software functionality, the supplier shall use only items from the Approved Devices list or an alternative explicitly approved by the CA.

The software will require configuration (e.g., state machine specification) and setting of parameters (e.g., pressure thresholds). The CA will provide training on the use of the software, but the Supplier shall remain responsible for ensuring the configuration settings are appropriate to meet performance and functional requirements of the vacuum system. If any missing features or software bugs are identified, these should be handled via the CA's software change control process. The software provided is being used currently for six other complex multi-chamber vacuum systems at the CA's facility and is proven-in-use. Source code (written in LabVIEW 2019 SP1) can be provided on request.

The Supplier shall carry out a Factory Acceptance Test (FAT) on each VCS prior to delivery, the test plan and results of which shall be provided in the Factory Test Report (see chapter 9.2). Once fully installed, a final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA. The Supplier shall be responsible for resolving any defects arising from these tests and qualifications. The software provided by the CA shall be used for all tests. The CA shall be permitted to witness any test.

[vypuštěno]

Figure 12: Overview of the vacuum control systems and the required interfaces to CA services and systems

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1.9. Optomechanical mounts

Figure 13 shows optical layout of the compressor and injector assembly, corresponding to high-precision mounts to be supplied within the present contract. The required parameters for the individual optomechanical mounts are specified in Table 4.

The initial two optical elements serve to direct (telescope mirror TM3) and collimate (telescope off-axis parabola TOAP2) the diverging L4 laser beam to the compressor clear aperture 200x200 mm (TM1, TM2 and TOAP1 are outside the compressor in the laser system and their mounts are not part of the supply).

The largest positioning units correspond to the diffraction gratings G1 and G2. The other positioning units are similar or identical (though equipped with larger mirror frames) to the optomechanical positioning units in the L2 compressor.

[vypuštěno]

Figure 13: Schematic optical / optomechanical layout of the L4PW compressor and injector, top and side views (to scale).

The assembly also involves mounts of small diagnostic mirrors (size 50.8 x 50.8 mm) and four retractable crossed hairs. A part of the compressor optomechanical assembly is also a pneumatically actuated mount for the rotatable beam dump mirror (MBD); this unit is in a separate block sitting attached to the output flange F36 (see Sections 1.4 and 1.5).

The injector contains one plane mirror IM1 to direct the compressor output beam through the floor penetration vertically down to the L4c basement hall, where the beam will enter the L4PW distribution system. The IM1 positioning unit corresponds to the standard positioning units used in the L2 compressor.

Whenever indicated in Table 4 the axes shall be equipped by encoders making it possible absolute position knowledge by the encoder readout. The encoders shall provide this absolute position capability even after encoder switch on, without homing of the movement. While the individual parameters in Table 4 are binding the Supplier is entitled to select appropriate type of vacuum-compatible electrical actuator for each mount / axis. If needed, CA can provide Newport VHRU and/or LTA vacuum actuators including position encoders but the Supplier shall provide full integration of these elements into the optomechanics and into the control system.

Table 4: Optomechanical mounts in the L4PWcompressor and injector, and requirements for parameters of individual motion axes (resolution = one incremental step of the actuator or graduation of fine adjustment scale for micrometric screw, accuracy = absolute position knowledge by encoder readout where applicable, bidirectional repeatability for motions without encoder).

No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
1	MT3	Plane mirror	y - linear	±12.5 mm	Stepper	5 µrad	10 µrad	Y
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
2	TOAP2	Telescope off-axis parabola	x - linear	±12.5 mm	Manual	N.A.	N.A.	Y
			y - linear	±12.5 mm	Manual	N.A.	N.A.	Y

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No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
			roll	±0.5°	Stepper	5 µrad	10 µrad	-
3	M1	Plane mirror	x - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
4	G1	Grating 1 (750x530x100)	pitch	±0.25°	Stepper	1 µrad	2 µrad	Y
			yaw	±0.5°	Stepper	1 µrad	2 µrad	Y
			roll	±0.25°	Stepper	1 µrad	2 µrad	Y
5	G2	Grating 2 (950x530x100)	linear along green ray	±100 mm	Stepper	5 µm	10 µm	Y
			pitch	±0.25°	Stepper	1 µrad	2 µrad	Y
			yaw	±0.5°	Stepper	1 µrad	2 µrad	Y
			roll	±0.25°	Stepper	1 µrad	2 µrad	Y
6	PM1	Periscope mirror	yaw	±0.5°	Stepper	1 µrad	2 µrad	Y
			roll	±0.5°	Stepper	1 µrad	2 µrad	Y
			pitch (one mirror)	±0.5°	Manual	N.A.	N.A.	-
			y - linear	±25 mm	Manual	N.A.	N.A.	-
7	M2	Plane mirror	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
8	M3	Output plane mirror	*x-y (diagonal)* - linear	300 mm	Stepper	±5 µm	±10 µm	Y
			pitch	±0.5°	Stepper	±5 µrad	±10 µrad	Y
			yaw	±0.5°	Stepper	±5 µrad	±10 µrad	Y
9	PM2	Periscope mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
			pitch (one mirror)	±0.5°	Manual	N.A.	N.A.	-
10	OAP1	Off-axis parabola	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			y - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
			roll	±0.5°	Manual	N.A.	N.A.	-
11	OAP2	Off-axis parabola (small)	*x* - linear	±5 mm	Manual	N.A.	N.A.	-
			y - linear	±5 mm	Manual	N.A.	N.A.	-
			z - linear	±2.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-

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No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
			roll	±0.5°	Manual	N.A.	N.A.	-
12	D-M1	Plane mirror / 0th order	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
13	D-L1	Lens of 0th order telescope	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
14	D-M2	Plane mirror / 0th order	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
15	D-M3	Plane mirror / 0th order	*z* - linear	±5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
16	D-L2	Lens of 0th order telescope	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
17	D-M4	Plane mirror / 0th order	*x* - linear	±12.5 mm	Manual	N.A.	N.A.	-
			pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
18	XH1	Crossed hair 1	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
19	XH2	Crossed hair 2	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
20	XH3/4	Crossed hairs 3&4 (joined)	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *
21	XH5	Crossed hair 5	rotation (vert. axis)	90°	Stepper	N.A.	N.A.	- *

* ..... precision end switches shall be used for crossed hair motions

22	IM1	Injector mirror 1	pitch	±0.5°	Stepper	5 µrad	10 µrad	-
			yaw	±0.5°	Stepper	5 µrad	10 µrad	-
23	SDM1	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
24	SDM2s	Spherical mirror f=2610 mm	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
25	SDM3	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
26	SDM4	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-

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No	Name	Type	Motion axis	Range	Actuator	Resolution	Accuracy	Position encoder
27	SDM5s	Spherical mirror f=2610 mm	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
28	SDM6	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
29	SDM7	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
30	TDM1	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
31	TDM2	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
32	TDM3	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
33	TDM4	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
34	TDM5s	Spherical mirror f= 2585 mm	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
35	TDM6	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
36	TDM7	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
37	TDM8s	Spherical mirror f= 2585 mm	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
38	TDM9	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-
39	TDM10	Plane mirror	pitch	±0.5°	Manual	N.A.	N.A.	-
			yaw	±0.5°	Manual	N.A.	N.A.	-

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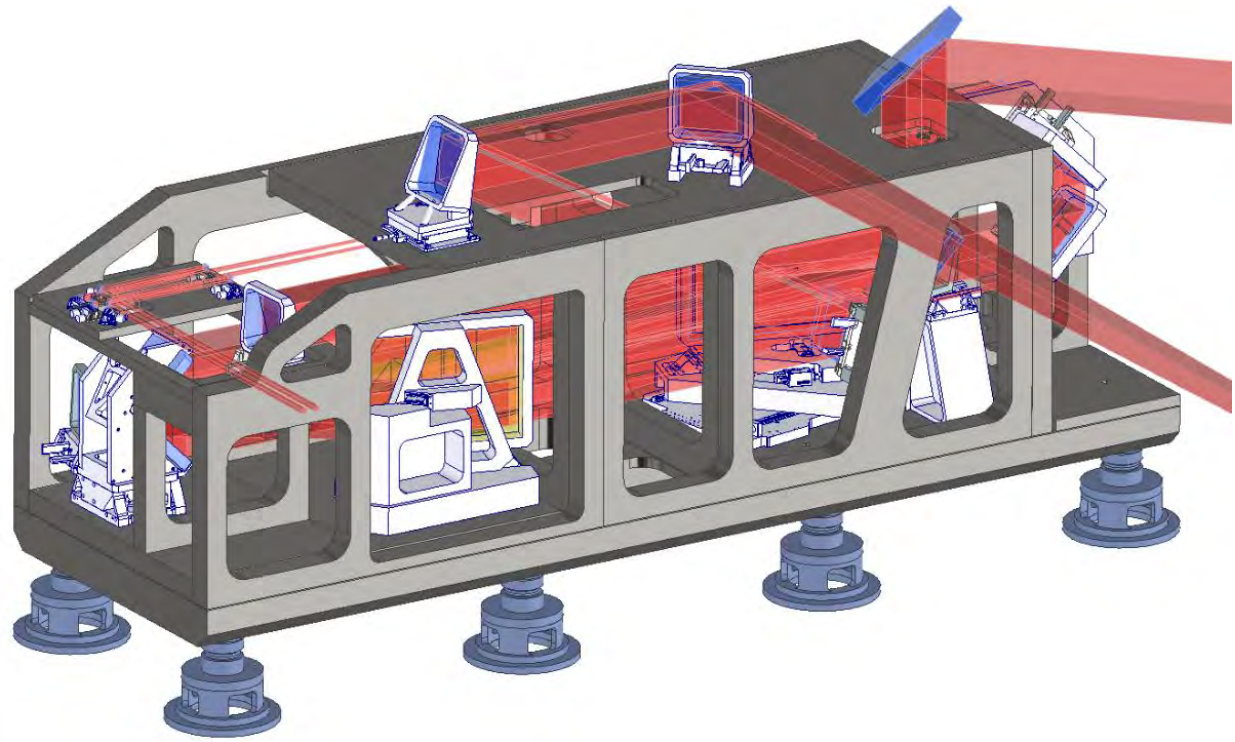

Figure 14: Advanced conceptual design of the compressor optomechanics, developed by CA (G1 and G2 are represented in yellow). Except G1 and G2 the positioning units are based on flexure-joint stages of the same type as those employed in the L2 compressor.

Based on the advanced conceptual design of the optomechanical assembly and of the individual mounts, developed by CA (see Figure 14), the Supplier shall produce detailed engineering design including full integration of actuators, position encoders, end switches, and vacuum cabling for motorized actuators.

The Supplier shall use exclusively UHV-compatible materials in the final design of the mounts. Except aluminium alloy EN AW 5083 and stainless steel 304L (1.4307), all materials employed in the final design shall be submitted to Client for approval.

In order to assist initial positioning the large mounts shall be equipped with at least three precisely toleranced Ø6 mm holes (or bosses with Ø6 mm holes) suitable for mounting a corner cube reflector for laser scanning. Appropriate position of these holes and/or bosses will be agreed with CA during the detailed design process.

For large mounts (especially G1 and G2) which, due to their weight, cannot be inserted into the compressor manually, the Supplier shall design an appropriate insertion / extraction device.

Positioning of the large mounts during installation shall be aided by position pins appropriately located on the optical table, serving as spatial fiducials in the x-y plane.

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1.10. Motion control system

The Supplier shall deliver to the Contracting Authority (CA) a separate and independent Motion Control System (MCS) for the L2 200 TW Pulse Compressor System and for the L4 PW Pulse Compressor System. The systems will not be co-located after installation.

Each MCS shall consist of 1 or 2 floor-standing control cabinets with all necessary electronics, motor drives, connecting cables, cable trays, and vacuum feedthroughs for all specified motorized axes, sufficient to meet all performance and functional requirements.

Each MCS shall include support for all items in the indicated scope of work and support for all required interfaces to CA control and facility services, according to their detailed interface specifications.

For these systems an initial template software project will be provided by the CA. The software shall be provided to the Supplier no more than 6 weeks after the Supplier delivers final production drawings and a controller I/O signal list. The software shall be provided in LabVIEW 2019 SP1 and include all source code. To ensure software functionality, the supplier shall use only items from the Approved Devices list or alternatives explicitly approved by the CA

The software will require configuration and possibly additions. The CA will provide training on the use of the software, but the Supplier shall remain responsible for ensuring the configuration and any upgrades meet performance and functional requirements. If any missing features or software bugs are identified with the core libraries delivered by the CA, these should be handled via the CA's software change control process

The Supplier shall carry out a Factory Acceptance Test (FAT) on each MCS prior to delivery, the test plan and results of which shall be provided in the Factory Test Report (see chapter 9.2). Once fully installed, a final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA. The Supplier shall be responsible for resolving any defects arising from these tests and qualifications. The software provided by the CA shall be used for all tests. The CA shall be permitted to witness any test

[vypuštěno]

Figure 15: Overview of the motion control systems and the required interfaces to CA services and systems

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1.11. Terms, Definitions and Abbreviations

For the purpose of this document, the following abbreviated terms are applied:

Abbreviation	Meaning
A	Analysis (as a verification method)
AC	Alternating current
AMU	Atomic Mass Unit
APG	Accuracy Capacitance Vacuum Gauge
API	Application Programming Interface
AR	Anti-Reflection
BDM	Beam Dump Mirror
BiSS-C	Bidirectional interface for Serial/Synchronous (communications protocol)
CA	Contracting Authority (Institute of Physics AV CR, v. v. i., FZU in Czech)
CDA	Compressed Dry Air
CGF	Clean Gas Filter
floating COM	Floating common (ground)
COTS	Commercial off-the-shelf (product)
DC	Direct Current
DIN rail	Widely used metal rail for mounting
DN	Diameter Nominal (for vacuum flanges)
DRW	Drawing
ELI	Extreme Light Infrastructure
EMI	Electromagnetic interference
EMP	Electromagnetic pulse
FEM	Finite Element Method
FPGA	Field Programmable Gate Array
FTR	Factory Test Report
FWHM	Full width at half maximum (spec. of the width of a spectrum curve)
FZU	Fyzikální ústav (Institute of Physics – Contracting Authority)
GUI	Graphical User Interface
HV	High Vacuum
I	Inspection (as a verification method)
IQ	Integration Qualification
ISO	International Organization for Standardization
ISO-F	Type of vacuum flanges
ISO-KF	Type of vacuum flanges
L4b	Identification code of hall
LCW	Low Conductivity Water

Abbreviation	Meaning
LOTO	Lock-Out Tag-Out
MBD	Mirror beam dump
MCB	Miniature Circuit Breaker
MCS	Motion Control System
MID-IR	Mid infra red (laser)
MSS	Machine Safety System
MVV	Manual Vacuum venting Valves
N/A	Not Applicable
NCR	Nonconformity Report
NVR	Non-Volatile Residue
OAP	Off-axis parabola
OQ	Operational Qualification
PC	Personal Computer
PBS	Project Breakdown Structure
PE	Polyester
PLe	Performance level (in Safety systems area)
PTFE	Polytetrafluoroethylene
RA1	Research activity 1
RGA	Residual Gas Analyser
RSD	Requirements Specification Document
RTD	Resistance Temperature Detector
SEM	Secondary Electron Multiplier
SDB	Spatial Diagnostic Beam
SDM	Spatial Diagnostic Mirror
SGV	Safety Gate Valve
SIR	on-Site Inspection Report
T	Test (as a verification method)
TBD	Temporal beam diagnostic
TDM	Temporal Diagnostic Mirror
TMP	Turbomolecular Pump
UHP	Ultra High Purity (gas filter)
UHV	Ultra High Vacuum
VCD	Verification Control Document
VCS	Vacuum Control System
VR	Verification Report
WRG	Wide Range Vacuum Gauge

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Abbreviation	Meaning
FAT	Factory acceptance test

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1.12. Reference Documents

Number of document	Title of Document/ File
RD-01	RD-01_Drawing package for_L4_Comp_RSD_TC00309478
RD-02	ELI Directive 20 – TCID 00272188

Detailed list of documentation included within **RD-01 archive**:

Drawing No	Filename	File format
DRW-01	Assembly of the L4PW compressor and beam injector with adjacent system	PDF
DRW-02	L4PW compressor chamber	PDF
DRW-03	L4PW injector chamber	PDF
DRW-04	L4PW compressor optical chassis	PDF
DRW-05	L4PW injector chamber	PDF
DRW-06	L4PW G1 grating optomechanical mount	PDF
DRW-07	L4PW G2 grating optomechanical mount	PDF
DRW-08	L4PW periscope mirror mount	PDF
DRW-09	Flexure joint pitch-yaw mount for large mirrors	PDF
DRW-010	L4PW M1 mirror mount	PDF
DRW-011	L4PW M2 mirror mount	PDF
DRW-012	L4PW M3 mirror mount	PDF
DRW-013	Flexure joint pitch-yaw mount for small diagnostic mirrors	PDF
DRW-014	XM3 double crossed hair rotation mount	PDF
DRW-015	Pneumatically actuated flipping mirror for beam dump	PDF
DRW-016	L4PW Beam polarization switch assembly	PDF

An overview of the **RD-01** reference drawing related to the L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control System is shown in section 12.

1.13. References to standards

If this document includes references to standards or standardized/ standardizing technical documents the CA allows/permits also another equal solution to be offered. If a supplier offers another equal solution the CA shall not reject its bid, once the supplier by appropriate means in the bid proves that the offered supplies, services or works meet in an equivalent manner all the contractual requirements including references to standards or technical documents.

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2. Requirements

Following sections of this specification provide a summary of the contractual requirements. The total scope of the contract also comprises all the requirements stated or implied in the foregoing text, whether or not included in the summaries.
Some requirements related to the Vacuum Control System (VCS) and Motion Control System (MCS) mention, in parallel with the L4PW compressor system, also L2 compressor. The reason is that both compressors are expected to be procured jointly, and requirements to VCS and MCS are in general identical although differing in specific details as mentioned.

2.1. Layout and optomechanical configuration design

REQ-033016/A **R1-1**
The Compressor and Injector chambers shall be detail designed and manufactured according to the requirements described herein and **RD-01** assembly drawings (see Section 1.12).
Verification method: R - Review of design, T – Test, I – Inspection

REQ-033017/A **R1-2**
The detailed design shall include full coordination with the interfaces of adjacent systems, especially turbomolecular pumps, vacuum gauges, coolants cooling water, CDA (compressed dry air) etc., and with the ELI-Beamlines building, according to information supplied by CA.
Verification method: R - Review of design

REQ-033018/A **R1-3**
The Supplier shall develop design of both internal (vacuum) and external paths (on the outer surface of the chambers) of electrical cables for active vacuum elements and for motorized actuators, based on description of purpose of the vacuum flanges in Sections 1.4 and 1.5. The Supplier shall subsequently elaborate design of corresponding cable trays and mounting C-rails.
Verification method: R - Review of design

REQ-033019/A **R1-4**
The turbomolecular pumps (TMPs) shall be water cooled; stainless-steel piping of the cooling water to the pumps shall be part of the Compressor and Injector chambers detailed design and supply.
Verification method: R - Review of design

REQ-033020/A **R1-5**
The Supplier shall design paths (on the outer surface of the chambers) for the primary backing vacuum for TMPs, based on CA conceptual design, and for cooling water and compressed dry air (CDA), based on description of purpose of the vacuum flanges in Sections 1.4 and 1.5. Both the backing vacuum tubing and the utilities shall be lead through holes in the chambers reinforcing ribs. The Supplier shall subsequently produce design of corresponding cable trays and mounting C-rails.
Verification method: R - Review of design

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REQ-033021/A **R1-6**

The Supplier shall dimension the vacuum flanges assigned to turbomolecular pumps to be able to withstand the torque [kNm] prescribed by the TMP manufacturer in the event of a crash of the pump.

Verification method: R - Review of design

REQ-033022/A **R1-7**

The Supplier shall develop detail design of double O-ring arrangement for doors and top lids, with interspace pumping performed from the chamber flange.

Verification method: R - Review of design

REQ-033023/A **R1-8**

The Supplier shall develop design of door hinges with double pivot arrangement to avoid crushing the O-rings when closing the door.

Verification method: R - Review of design, T - Test

REQ-033024/A **R1-9**

The Chamber detailed design shall make all necessary allowance for transport of the chamber to its working location. This shall include provision of designated lifting points and jacking points and positions to support the chamber on rollers for lateral movement. The lid shall also be equipped with lifting features (e.g. bosses for screw-in lifting eyes) to enable its handling by overhead crane.

Verification method: R - Review of design, I – Inspection

REQ-033025/A **R1-10**

The Compressor and Injector chambers shall be designed and manufactured for vacuum level of 10^{-7} mbar or better.

Verification method: R – Review of design, T – Test

REQ-033026/A **R1-11**

The Supplier shall perform FEM analysis of the final design of the Compressor and Injector chambers to demonstrate structural stability resulting in deformations of walls less than 1.2 mm (targeted value should be 1 mm) upon pump down from atmospheric pressure.

Verification method: R – Review of design, T – Test

REQ-033027/A **R1-12**

The outer side of the Compressor and Injector chambers shall be equipped with mounting points consisting of boss for a corner cube reflector for laser scanning. The position of these features shall be coordinated with CA during the design phase.

Verification method: R - Review of design, I – Inspection

REQ-033028/A **R1-13**

The manufacturing design and the selection of all components inside the vacuum envelope of the Compressor and Injection chambers shall follow best practice to avoid any trapped volumes of air, e.g. the mounting holes shall not be blind tapped.

Verification method: R – Review of design

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REQ-033029/A **R1-14**

The internal optical table and support frame shall be mechanically de-coupled from the vacuum vessel by means of double bellows so that the support posts of the internal optical table can be bolted directly to the laser hall floor, on accurately positioned / levelled stainless-steel floor plates. These floor plates will be installed by CA.

Verification method: R – Review of design

REQ-033030/A **R1-15**

The Supplier shall design and supply a self-contained mechanical handling system to allow the internal optical table, mounted on its support frame, to be installed horizontally into the Compressor chamber through the opening of installation-door ID1 and/or ID2. The handling system can use the L4b laser hall overhead crane (load capacity 1 ton) for assistance. The system shall be compatible with a Class 100 (ISO 5) clean room environment.

Verification method: R – Review of design

REQ-033031/A **R1-16**

The nominal position and orientation of the optical components and optomechanical mounts shall be as in the 3D model. The required extent of movements shall be as in Table 4.

NOTE: The 3D model will be provided to the Supplier after the contract signature.

Verification method: R – Review of design, T - Test

REQ-033032/A **R1-17**

The optomechanical mounts shall be attachable to the optical table and shall be able to be pre-positioned (without engaging the actuators) with precision better than ±1 mm.

NOTE: The 3D model will be provided to the Supplier after the contract signature.

Verification method: R – Review of design, T – Test

REQ-033033/A **R1-18**

The optical table shall be equipped with positioning pins providing spatial fiducial for the large optomechanical mounts during their installation / pre-positioning.

Verification method: R – Review of design, T - Test

REQ-033034/A **R1-19**

The gratings and mirrors shall be mounted in frames separable from the positioning parts of the optomechanical mounts, in line with the conceptual design provided by CA.

Verification method: R – Review of design

REQ-033035/A **R1-20**

The design of the frames of the gratings and large mirror shall include a 3-point fitting scheme, which shall not produce deformations across the entire mirror surface higher than 100 nm.

Verification method: R – Review of design

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REQ-033036/A **R1-21**

The detailed design of optomechanical mounts G1 and G2 shall incorporate detachable lifting eyes for manipulation by a lifting device during installation.

Verification method: R – Review of design

REQ-033037/A **R1-22**

The manufacturing drawings and detailed 3D models for manufacture shall be approved by CA.

Verification method: R - Review of design

2.2. Optomechanical systems manufacture and testing

REQ-033038/A **R2-1**

Only new materials and equipment with manufacturer's full warranty shall be used for the entire scope of supply.

Verification method: R – Review of design, I – Inspection

2.2.1. Raw material requirements

REQ-033056/A **R2-2**

The Compressor chamber body and the Injector chamber body shall be manufactured from stainless steel EN 1.4307 (equivalent to ČSN 17249, equivalent to AISI 304L), or equivalent.

Verification method: R - Review of design

REQ-033057/A **R2-3**

The support frame and other parts of the compressor internal optical chassis shall be manufactured as monolithic block from homogeneous cast aluminium alloy EN AW 5083 (equivalent to ČSN 42 4415, equivalent to ANSI AA5083), or equivalent, without internal stress, free of residual cavities.

Verification method: R – Review of design, I – Inspection

REQ-033058/A **R2-4**

The Supplier shall provide Certificate of Origin specifying manufacturer, composition of the alloy and details of the cast process, for the raw material of the support frame, optical table, and blanks for the large optomechanical mounts (G1 and G2).

Verification method: R – Review of design, I – Inspection

REQ-033059/A **R2-5**

The internal optical tables shall be comprised of a stress relieved cast aluminium slab made from high-flatness (equal or better than 0.3 mm /1000 mm) prefabricated panels. The surface quality of the panels shall be compatible with the required vacuum 10^{-7} mbar. No surface machining of the panels is allowed (other than the M6 mounting holes and access ports).

Verification method: R - Review of design, I – Inspection

REQ-033060/A **R2-6**

The principal material of the optomechanical mounts shall be aluminium EN AW 5083 (equivalent to ČSN 42 4415, equivalent to ANSI AA5083), or equivalent.

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Verification method: R – Review of design

2.2.2. Manufacture and machining requirements

REQ-033063/A **R2-7**

All welds on the Compressor and Injector vacuum chambers shall be visually inspected. All internal welds shall be examined by PT (Penetration Testing), and protocol for each chamber shall be issued.

Verification method: R – Review of design, I – Inspection

REQ-033064/A **R2-8**

All testable vacuum welds on the Compressor and Injector vacuum chambers shall be inspected by ultrasonic probe, and protocol for each chamber shall be issued.

Verification method: R – Review of design, I – Inspection

REQ-033065/A **R2-9**

All inner vacuum surfaces of the chambers shall have roughness Ra=0.8 µm or better (i.e. smaller). If grinding is used to achieve this finish, the following rules shall apply:

- prior the grinding the cleaning procedure involving degreasing, rinsing and drying, described in Section 4.1 - REQ-033167/A - **R4-2** shall be used;
- the grinding process shall not involve any abrasive paste or abrasive medium that can embed into the surface.

NOTE: the cleaning procedure described in Section 4.1 - REQ-033167/A - **R4-2** *can be complemented, before grinding, by laser cleaning. Details shall be approved in writing by the CA before such procedure is applied.*

Verification method: R - Review of design, I – Inspection

REQ-033066/A **R2-10**

All circular vacuum flanges, including ISO, or equivalent, flanges and custom flanges, shall have Tolerance Grades specified in Table 2 and Table 3.

Verification method: R - Review of design, T- Test, I – Inspection

REQ-033067/A **R2-11**

The outer surface of the Compressor and Injector chambers shall be glass bead blasted.

Verification method: R – Review of design, I - Inspection

REQ-033068/A **R2-12**

The optical table shall be machined with an array of M6 tapped mounting holes on a 25 mm square grid over the entire surface.

Verification method: R - Review of design, I – Inspection

REQ-033069/A **R2-13**

All mounting holes of the optical table shall be drilled right through and parallel tapped from the top face to a depth of at least 20 mm.

Verification method: R - Review of design, I – Inspection

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REQ-033070/A **R2-14**

All outer surfaces of the optical table support frame shall be machined resulting in surface quality of Ra 0.8 µm or better.

Verification method: I – Inspection, T - Test

REQ-033071/A **R2-15**

All edges of the optical table support frame shall be machine chamfered by 0.5x45°, unless stated otherwise on the corresponding manufacturing drawings.

Verification method: I – Inspection

REQ-033072/A **R2-16**

The surface of all parts of the optical table support frame shall be milled.

NOTE: Grinding, polishing, sand blasting or any other surface treatment is not allowed.

Verification method: I – Inspection

REQ-033073/A **R2-17**

No parts of the optical table support frame and of the table shall exhibit any visible surface defects, such as scratches, digs, bumps (from clamping in the manufacturing process), etc.

Verification method: I – Inspection

REQ-033074/A **R2-18**

All threads shall be cut tapped.

NOTE: It is not allowed making threads by forming.

Verification method: I – Inspection

2.2.3. Assembling and testing

REQ-033076/A **R2-19**

The Supplier shall check all major dimensions of the manufactured Compressor and Injector chambers, as defined in the manufacturing drawings approved by the CA (see also section **Chyba! Nenalezen zdroj odkazů.**). The result shall be provided in the form o f the Factory Test Report (see section 9.2).

Verification method: R – Review, T – Test

REQ-033077/A **R2-20**

The Supplier shall verify all dimensions of the manufactured pieces of the supporting frames and optical tables, defined in the manufacturing drawings. The results of tests shall be submitted in the form of test protocols (see section 9.2).

Verification method: R – Review, T – test

REQ-033078/A **R2-21**

After final cleaning (see R4-2) the Supplier shall assemble the Compressor and Injector chambers in ISO7, or equivalent, (or better cleanliness class) cleanroom and shall vacuum test the assembled chambers with blank flanges, bolting and O-rings which shall be part of the supply.

Verification method: R – Review, T – Test

REQ-033079/A **R2-22**

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The Supplier shall perform vacuum leak test using a helium leak detector. The measured single leak rate of any flange shall be less than $1x10^{-8}$ mbar·l/sec. The total leakage rate of each chamber shall be $1x10^{-4}$ mbar·l/sec or less. The results shall be provided in the form of the **Factory Test Report** (see section 9.2).

NOTE: It is recommended that the single flange test (helium spray) is performed according to ČSN EN 1779, method A.3, and the test of total leakage according to ČSN EN 1779, method D.2.

Verification method: R – Review

REQ-033080/A **R2-23**

The Supplier shall test the evacuated Compressor and Injector chambers for deformations due to the atmospheric pressure differential. The measured deformations shall not exceed 1.2 mm at any location. The result shall be provided in the form of the Factory Test Report (see section 9.2).

Verification method: R – Review, T – Test

REQ-033081/A **R2-24**

All optomechanical mounts shall be cleaned (see Section 4 Vacuum cleaning, Cleanliness verification and Packaging Requirements) and tested with the Motion Control System (MCS) at the Supplier's works prior to acceptance for transport to ELI-Beamlines.

Verification method: T – Test

REQ-033082/A **R2-25**

The Supplier shall allow CA supervising the activities of related to testing of deformation of the vacuum chambers and of the performance verification of the optomechanical mounts.

NOTE: Any acts of supervision shall not mean that CA assumes additional liability of any kind exceeding its liabilities according to the contract.

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3. Control systems requirements

3.1. Vacuum Control System (VCS) Requirements

REQ-033083/A **R3-1**

The Supplier shall deliver one VCS for the L2 200 TW Compressor system and a second independent VCS for the L4 1 PW Compressor system. The systems will not be co-located and must not share any components or interfaces

Verification method: R – Review, I – Inspection

REQ-033084/A **R3-2**

The Supplier shall carry out a Factory Acceptance Test (FAT) on each VCS prior to delivery, the test plan and results of which shall be provided in the Factory Test Report (see section 9.2). Once fully installed, a final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA. The Supplier shall be responsible for resolving any defects arising from these tests and qualifications. The software provided by the CA shall be used for all tests. The CA shall be permitted to witness any test.

Verification method: T-test, I - Inspection

3.1.1. Networking and serial devices

REQ-033085/A **R3-3**

The Supplier shall use one or more FPGA Controllers, containing a LabVIEW-programmable FPGA, to implement the vacuum state machine control logic, and a real-time operating system to implement high-level device communication and control interfaces. Each controller shall have two separate network ports. Suitable controllers can be provided by the CA on request

NOTE: No external server hardware will be provided for real-time software integration. The RMC-8354, used in previous projects by the CA, has been discontinued

Verification method: R – Review, I – Inspection

REQ-033086/A **R3-4**

Each VCS shall have two separate networks; Integration and Devices. The Supplier shall configure all networked components to have fixed IPv4 addresses within the specified ranges and shall provide a list of the assigned addresses:

- L2 200 TW Compressor: Integration: 10.6**8**.1.13*x*/24 ($0 \leq x \leq 9$); Devices: 10.6**9**.1.13*x*/24 ($0 \leq x \leq 9$).
- L4 1 PW Compressor: Integration: 10.76.1.16*x*/24 ($0 \leq x \leq 9$); Devices: 192.168.1.16*x*/24 ($0 \leq x \leq 9$).

The Devices network shall contain all instruments and serial device servers. The Integration network shall be used to connect external control system services such as databases and graphical user interfaces to FPGA Controllers. One port from each FPGA Controller shall be connected to the Device network and one port to the Integration network, with the same final byte used for each address

Verification method: R – Review, I – Inspection

REQ-033087/A **R3-5**

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An Operator PC connected to the Integration Network shall be provided for final acceptance at the CA site. The supplier must not supply any PCs or additional computing hardware other than the FPGA Controllers; these shall be sufficient for full operation of the final system

Verification method: R – Review, I – Inspection, T - Test

REQ-033088/A **R3-6**

A local DIN rail mount Devices Network Switch should be used to provide local Devices connections. The CA can provide a suitable switch to the Supplier on request

Verification method: R – Review, I – Inspection

REQ-033089/A **R3-7**

Residual gas analysers (RGAs) shall have an external low-level control interface (including an emission interlock to stop operation on loss of vacuum) connected directly (via relays) to FPGA Controller I/O modules, and an additional Ethernet data connection connected to the Devices Network switch

Verification method: R – Review, I – Inspection, T - Test

REQ-033090/A **R3-8**

TMPs shall have an external low-level control interface connected directly (via relays) to FPGA Controller I/O modules, and an additional serial RS-485 data connection only for 'read-only' monitoring purposes. All serial devices shall be connected to a Serial Device Server, connected via Ethernet to the Local Device Network Switch. A suitable Serial Device Server can be provided by the CA on request.

Verification method: R – Review, I – Inspection, T - Test

REQ-033091/A **R3-9**

The Supplier shall provide DIN-rail mount patch panel terminals with the delivered control cabinet. The CA will prepare CAT7 metallic network cables to the location of each VCS cabinet prior to final on-site installation. These shall be terminated in these terminals. One connection shall be provided for the device layer network switch, and one connection for each integration device.

Verification method: R – Review, I – Inspection

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3.1.2. Power and lock-out-tag-out

A single three-phase 400 VAC, 32 A rated connection shall be provided by the CA to power the control cabinet of each VCS, to be connected internally via DIN-rail mounted screw terminals. On-site connection of power at the CA facility shall be carried out by CA Electrical Department personnel

REQ-033092/A **R3-10**

The Supplier shall be responsible for powering all internal and external devices from this supply, including all pumps (TMPs). Each separate pump and DC power supply should have an individual Miniature Circuit Breaker (MCB) of appropriate type and rating. Additional filtering and surge protection may be necessary, according to good practice for typical laboratory and industrial environments

NOTE: The installation location for this particular system is not subject to levels of EMI or EMP beyond those found in common industrial environments

Verification method: R – Review, I – Inspection

REQ-033093/A **R3-11**

All mains voltage terminals within the cabinet shall be protected with a touch-proof cover and clearly labelled with standard warning symbols and labels in both Czech and English language. Electrical revision (inspection) of all completed cabinets shall be provided by the Supplier in accordance with Czech standards

Verification method: R – Review, I – Inspection

REQ-033094/A **R3-12**

Each VCS shall include a Lock-Out, Tag-Out (LOTO) trapped key isolation switch. This switch shall disable power to all active vacuum devices, including all pumps and valve solenoids, when the key is removed. Sensors such as gauges and valve position switches should remain powered. A pressure release valve to deactivate the pneumatic actuation line should also be included and powered by the LOTO DC supply

Verification method: R – Review, I – Inspection, T - Test

REQ-033095/A **R3-13**

The LOTO trapped key switch shall be mounted on the VCS control cabinet front panel. Additional cabinet front-panel controls, such as a controlled stop button and pilot indicators for basic state indication, are optional. A front-panel touch panel PC or display is not required.

NOTE: it is not feasible to fully enter the vacuum chamber in this design. Use of an additional mechanical interlocks on the chamber access doors is not required

Verification method: R – Review, I – Inspection

REQ-033096/A **R3-14**

The trapped key shall use a uniquely assigned key code to avoid duplication of keys:

- L2 200 TW Compressor: starting with ‘S’ (i.e., Sa)
- L4 1 PW Compressor: starting with ‘P’ (i.e., Pa)

Verification method: R – Review, I – Inspection

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REQ-033097/A **R3-15**

The LOTO trapped-key switch shall be trapped via a powered solenoid and the key only released once the main compressor chamber is fully vented, all pumps stopped and valves in a safe state for personnel access

Verification method: R – Review, I – Inspection, T- Test

3.1.3. Water Cooling

REQ-033098/A **R3-16**

The Supplier shall ensure compatibility with the provided interface.

NOTE: At both the L4 1 PW Compressor and L2 200 TW Compressor installation sites the CA will provide a single dedicated on-site Low Conductivity Water (LCW) supply and return connection from the laser cooling distribution manifold to an agreed interface point near to the compressor chamber in 0.5 inch stainless steel press-fitted tubing with a nominal supply pressure of 4 bar, temperature 16 C and a maximum flow of 20 l/min.

Verification method: R – Review, I – Inspection

REQ-033099/A **R3-17**

The Supplier shall be responsible for 'last mile' distribution of cooling water from the CA provided interface point to all pumps and devices requiring it and for installation of sensors (e.g., flow switches) to allow the VCS to verify cooling water

Verification method: R – Review, I – Inspection

REQ-033100/A **R3-18**

Manual flow regulating and shutoff valves shall be provided for each cooled device. Additional draining and venting valves should also be considered in order to allow efficient removal and replacement of individual cooled devices

Verification method: R – Review, I – Inspection

REQ-033101 /A **R3-19**

The Suppler shall ensure that the risk of cooling water leaks is as low as reasonably practicable. Where possible all tubing and fittings shall be stainless steel and rated for a large overpressure (>20 bar). Where possible all joints shall be swaged or crimped. If threaded joints are unavoidable, they shall be sealed with a specifically designed compound (e.g., Anaerobic Sealant – mixture of Polyglycol dioctanoate 18268-70-7, 10 - 20 %, Acetic acid ethenyl ester, homopolymer 9003-20-7. 10 - 20 %, Lauryl methacrylate 142-90-5, 5 - 10 %, Ethene, homopolymer 9002-88-4, 1 - 5 %, Ethene, tetrafluoro-, homopolymer 9002-84-0, 1 - 5 %, Vinyl acetal polymers, butyrals 63148-65-2, 1 - 5 %, Tetradecyl methacrylate 2549-53-3, 1 – 5 %, Silica, amorphous, fumed, crystal-free 112945-52-5, 1 - 5 %, 1-Acetyl-2-phenylhydrazine 114-83-0, 0.1 – 1 %, Hexadecyl methacrylate 2495-27-4, 0.1 – 1 %, Cumene hydroperoxide 80-15-9, 0.1 - 1 %, N,N'-Ethane-1,2-diylbis(12- hydroxyoctadecan-1-amide) 123-26-2, 0.1 – 1%; or equivalent). PTFE tape or natural fibre cord should not be used for sealing. Tubing should be sized so that at nominal flow the velocity, v is $1 < v < 2$ m/s

Verification method: R – Review, I – Inspection

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REQ-033102/A **R3-20**

A flow switch or sensor shall be provided on the return line of each cooled device, set to a threshold at least 25% higher than the device minimum cooling requirement and connected directly (via relays) to FPGA Controller I/O modules

Verification method: R – Review, I – Inspection, T- Test

REQ-033103/A **R3-21**

All tubes and pipes shall be labelled with directional flow arrows and the contained fluid designation. All tubing and piping shall be properly mounted and supported at intervals of no more than 30 cm when routed over any vacuum chamber surface

Verification method: R – Review, I – Inspection

3.1.4. Pneumatics, CDA and venting

REQ-033104/A **R3-22**

At both the L4 1 PW Compressor and L2 200 TW Compressor installation sites the CA will provide a single dedicated Clean Dry Air (CDA) supply in 3/8 inch UHP stainless steel Swagelok-style tubing with an adjustable pressure up to 6 bar, maximum flow up to 500 l/min and purity class of 1:1:1 according to ISO 8573.1. The Supplier shall ensure compatibility with the provided interface.

Verification method: R – Review, I – Inspection

REQ-033105/A **R3-23**

The Supplier shall be responsible for distribution, monitoring and 'last mile' tubing to all in-scope devices requiring compressed air, either for actuation or as a high-purity venting/purging source.

Verification method: R – Review, I – Inspection

REQ-033106/A **R3-24**

All tubing, fittings and sensors on CDA line(s) used for chamber venting shall be suitable for Ultra High Purity (UHP) use, free of hydrocarbon contamination and precision cleaned using the same care as components in-vacuum.

NOTE: Components on the valve actuation line do not need to take special measures for purity, but back-streaming from the valve actuation supply into CDA shall be prevented

Verification method: R – Review, I – Inspection

REQ-033107/A **R3-25**

UHP Clean Gas Filters (CGF) shall be added at all venting locations (both for CDA and room air). Suitable filters can be provided by the CA on demand. For CDA venting, all valves used shall be rated for vacuum-tight seal against the nominal 5 bar supply pressure

Verification method: R – Review, I – Inspection, T – Test

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REQ-033108/A **R3-26**

For venting with CDA, an outlet valve fitted with a check valve of cracking pressure <= 30 mbar shall be installed. The valve shall be opened by the VCS when the pressure approaches atmosphere as measured by a precise atmospheric range gauge

Verification method: R – Review, I – Inspection, T - Test

REQ-033109/A **R3-27**

Chambers with a volume more than one cubic meter shall be individually fitted with a burst disk rated for rupture at < 500 mbar overpressure. The CA can provide suitable burst disks on request.

Verification method: R – Review, I – Inspection

REQ-033110/A **R3-28**

All manual vacuum venting valves (MVV) shall be monitored with position switches connected directly (via relays) to FPGA Controller I/O modules. A passive manometer shall be fitted to each volume in a location close to the manual venting valve, for pressure indication in the event of VCS power failure. The Supplier shall provide the **Calibration certificate** for every passive manometer.

Verification method: R – Review, I – Inspection, T - Test

REQ-033111/A **R3-29**

Manual shutoff and venting valves shall be provided on each branch to allow for removal of devices without venting the entire pneumatic system

Verification method: R – Review, I – Inspection

REQ-033112/A **R3-30**

All tubes and pipes shall be labelled with directional flow arrows and the contained fluid designation (e.g., CDA Actuation, CDA Venting). Tubing and piping shall be properly mounted and supported at intervals of no more than 30 cm when routed over any vacuum chamber surface.

Verification method: R – Review, I – Inspection

REQ-033113/A **R3-31**

Pneumatically controlled safety elements (See Section 3.1.6) shall use the recommended control valve (see reference drawings) or one of equivalent safety rating and design. The CA can supply a suitable control valve on request.

Verification method: R – Review, I – Inspection

3.1.5. Vacuum Devices and Cabling

REQ-033114/A **R3-32**

All VCS control electronics and power supplies shall be mounted in one control cabinet (per compressor system) of depth 0.4m, height 2m and max width 1.2m. The cabinet should be mechanically compatible with the Rittal VX series for which the CA carries spare parts and accessories. Cabinets shall be fitted onto a 200mm plinth. A suitable cabinet can be provided by the CA on request

Verification method: R – Review, I – Inspection

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REQ-033115/A **R3-33**

Control cabinets shall be mounted in the following locations:

- L2 200 TW Compressor: Along the south west wall of the L2 laser hall
- L4 1 PW Compressor: Along the south east wall of the L4 laser hall

All cabling between the chambers and the VCS cabinet shall be via floor channels (provided by CA) and via metal cable trays on the vacuum vessels (these shall be provided by the Supplier). Cable installation is in Supplier scope.

Verification method: R – Review, I – Inspection

REQ-033116/A **R3-34**

All sections of cable and tube exceeding 50 cm in length shall be supported by clamps and/or cable ladders, or routed in closed metal cable trays

Verification method: R – Review, I – Inspection

REQ-033117/A **R3-35**

All external (field) cables shall be shielded and cable shields should be terminated at both ends

NOTE: No special measures for interfacing devices need to be taken against EMP for this particular system.

Verification method: R – Review, I – Inspection

REQ-033118/A **R3-36**

Supplier shall follow ELI Directive 20 (00272188/A) (see RD-02) for wire colours and labelling. All wires and terminal blocks shall be labelled. The CA can provide printed labels on request if the Supplier provides a precise list of label types and text entries, in Excel format, within a 4 week lead-time

Verification method: R – Review, I – Inspection

REQ-033119/A **R3-37**

Active devices shall be labelled according to their control point code (e.g., VV244). Codes for all devices can be provided by the CA on request.

NOTE: Codes for the L2 compressor usually start at 240. Codes for the L4 compressor usually start at 420

Verification method: R – Review, I – Inspection

REQ-033120/A **R3-38**

Simple field devices, such as gauges and valves, shall be connected to a passive local breakout or connection box. A commercial, off-the shelf breakout solution shall be used. The CA can provide suitable breakout connection box on request. The connector type for field devices should be M12 where possible. Sensors and valve solenoids shall use separate DC supplies and hence separate breakouts are recommended.

Verification method: R – Review, I – Inspection

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REQ-033121/A **R3-39**

Magnetic proximity sensors (IL) shall be fitted to all chamber access doors and positioned to give a positive signal only when doors are fully closed and seals properly compressed

Verification method: R – Review, I – Inspection, T - Test

3.1.6. Safety Systems Interfaces – Personnel Safety

REQ-033122/A **R3-40**

The Supplier shall precisely follow the provided implementation diagrams for safety-critical design elements to ensure the system operates in accordance with CA safety requirements

NOTE: The main safety-critical VCS element is the Safety Gate Valve (SGV) located on the injector output (L2 design), or compressor output (L4 design). These provide a light-tight barrier to prevent laser and prompt ionizing radiation in the receiving experimental halls

Verification method: R – Review, I – Inspection, T - Test

REQ-033123/A **R3-41**

SGVs shall not be fitted with built-in electropneumatic valves. Instead, a 3/2 control valve with safe exhausting function rated to PLe (Cat 4, ISO 13849-2, or equivalent) shall be used to ensure it closes reliably on loss of permission from the personnel safety systems.

NOTE: SGVs are pendulum type with spring return to close on loss of pressure. They require a single compressed air inlet to open. If the compressed air fails to vent properly it can lead to loss of the close-on-demand safety function, potentially leading to accidental exposure to ionizing radiation, irreversible injury and death

Verification method: R – Review, I – Inspection, T- Test

REQ-033124/A **R3-42**

Direct feedback monitoring of gate valve and control valve position to the CA's safety systems shall be provided using the interface shown.

NOTE: Valve position feedback shall be relayed by the safety systems back to the VCS Controller. For testing, this interface may be simulated via a temporary loopback

Verification method: R – Review, I – Inspection, T- Test

REQ-033125/A **R3-43**

The air supply to the control valve shall be fitted with a regulator with overpressure relief, and port 3 of the valve shall fitted with a silencer type as recommended in the control valve manual

NOTE: There is no need for additional pressure monitoring by the safety systems, nor for any specific pressure buffering in this system, as the safety function requires only safe exhausting rather than safe reversal (as would be the case for a double-acting pneumatic safety element)

Verification method: R – Review, I – Inspection

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REQ-033126/A **R3-44**

Stainless steel solid tube and swaged fittings shall be used for the pneumatic connections between the safety control valve and the gate valve

Verification method: R – Review, I – Inspection

3.1.7. Safety Systems Interfaces – Machine Safety System (MSS)

REQ-033127/A **R3-45**

The Supplier shall provide a machine safety vacuum state signalling interface for each VCS as specified in the implementation drawings (see drawings package RD-01). The specified digital inputs and digital outputs shall be connected directly (via relays) to FPGA Controller I/O modules

Verification method: R – Review, I – Inspection, T - Test

REQ-033128/A **R3-46**

If more than one controller is required for the system, the MSS inputs and outputs shall be assigned to the controller responsible for the relevant section, as shown in the example. VCS devices, sensors and actuators shall be assigned to the controller having the appropriate MSS inputs and outputs for their vacuum section

NOTE: The FPGA software logic (provided by the CA) shall ensure that the functional requirements of this interface are met. The Supplier only needs to implement the interface wiring to the Controller(s) and provide the specified terminals for external wiring

Verification method: R – Review, I – Inspection, T - Test

REQ-033129/A **R3-47**

The supplier shall consider using a relay type with a mechanical override function to allow the permissive input signals to be easily simulated for testing without the external MSS connected

Verification method: R – Review

REQ-033130/A **R3-48**

In the L2 200 TW Compressor system, the Cryogenic chamber (CRYO) is not in the baseline scope for installation, however all controls including the specified machine safety vacuum state signalling interface shall be implemented by the supplier in preparation

Verification method: R – Review, I – Inspection

3.2. Motion Control System (MCS) Requirements

REQ-033131/A **R3-49**

The Supplier shall deliver one MCS for the L2 200 TW Compressor system and a second independent MCS for the L4 1 PW Compressor system. The systems will not be co-located and shall not share any components or interfaces

Verification method: R – Review, I – Inspection, T - Test

3.2.1. Motion axis functionality

REQ-033132/A **R3-50**

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The Supplier shall ensure that the MCS for each compressor system provides the specified control points and motion axes (as a minimum) over the specified ranges and within the required precision and accuracy (see drawings package). The accuracy requirement (*i.e.,* repeatability) shall be satisfied after the following sequence: enabling the drive, moving an arbitrary number of steps, disabling the drive, re-enabling the drive after an arbitrary time delay, moving in the opposite direction the same number of steps. Enabling and disabling motor drives must not result in movement greater than the required precision for that axis.

NOTE: For axes with encoders, the accuracy refers to the closed-loop performance

Verification method: R – Review, I – Inspection

REQ-033133/A **R3-51**

It shall be possible to lock the position of all manually adjustable axes after adjustment (*e.g.,* via a locking screw)

Verification method: R – Review, I – Inspection

REQ-033134/A **R3-52**

It shall be possible to adjust all mechanically adjustable actuators *in situ,* even with all optics and optomechanics installed, without entering the chamber (other than arms and upper body)

Verification method: R – Review, I – Inspection

3.2.2. Networking and serial devices

REQ-033135/A **R3-53**

To implement each MCS the Supplier shall use one 'Master' FPGA Controller having both LabVIEW-programmable FPGA and a real-time operating system, and any number of 'Slave' FPGA Controllers having LabVIEW-programmable FPGAs. The master controller shall have two separate network ports. Suitable controllers can be provided by the CA on request.

Verification method: R – Review, I – Inspection

REQ-033136/A **R3-54**

Each MCS shall have two separate networks; Integration and Devices. The Supplier shall configure all networked components to have fixed IPv4 addresses within the specified ranges and shall provide a list of the assigned addresses:

- L2 200 TW Compressor: Integration: 10.68.1.14x/24 ($0 \leq x \leq 9$); Devices: 10.69.1.14x/24 ($0 \leq x \leq 9$).
- L4 1 PW Compressor: Integration: 10.76.1.18x/24 ($0 \leq x \leq 9$); Devices: 192.168.1.18x/24 ($0 \leq x \leq 9$).

The Devices network shall contain all instruments and serial device servers. The Integration network shall be used to connect external control system services such as databases and graphical user interfaces to FPGA Controllers. One port from the master FPGA Controller shall be connected to the Device network and one port to the Integration network, with the same final byte used for each address. Slave controllers shall be connected only to the Device network.

Verification method: R – Review, I – Inspection

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REQ-033137/A **R3-55**

The supplier shall not supply any PCs or additional computing hardware other than the FPGA Controllers; these shall be sufficient for full operation of the final system.

NOTE: An Operator PC connected to the Integration Network shall be provided for final acceptance at the CA site for each compressor system.

Verification method: R – Review, I – Inspection

REQ-033138/A **R3-56**

A local DIN rail mount network switch shall be used to provide for local Device network connections. The CA can provide a suitable switch to the Supplier on request

Verification method: R – Review, I – Inspection

REQ-033139/A **R3-57**

All motor drives shall support configuration over a serial (RS-485) interface. This interface shall be used for configuration only (*e.g.,* to set current limits or micro-stepping). Configuration shall be done via software running on the FPGA Controller's real-time processor. All axis configuration parameters shall be stored in the MySQL Configuration Database, accessed via the API given in the provided software template. Control of motor drive shall be via step (pulse) and direction 24V digital signals directly from FPGA controller I/O modules. The same model of motor drive shall be used for all stepper motor axes.

Verification method: R – Review, I – Inspection

REQ-033140/A **R3-58**

In each MCS, motor drive serial interfaces should be connected in a 'daisy chain' configuration and connected to a Serial Device Server, connected via Ethernet to the Local Device Network Switch. A suitable Serial Device Server can be provided by the CA on request.

Verification method: R – Review, I – Inspection

REQ-033141/A **R3-59**

The Supplier shall provide DIN-rail mount patch panel terminals with the delivered control cabinet. The CA will prepare CAT7 metallic network cables to the location of each VCS cabinet prior to final on-site installation. These shall be terminated in these terminals. One connection shall be provided for the device layer network switch, and one connection for each integration device.

Verification method: R – Review, I – Inspection

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3.2.3. Power

A single three-phase 400 VAC, 32 A rated connection shall be provided by the CA to one cabinet in each MCS system, to be connected internally via DIN-rail mounted screw terminals. On-site connection of power at the CA facility shall be carried out by CA Electrical Department personnel. DC power distribution between MCS cabinets is within Supplier scope

REQ-033142/A **R3-60**
The Supplier shall be responsible for powering all internal and external devices from this supply. Each separate DC power supply should have an individual Miniature Circuit Breaker (MCB) of appropriate type and rating. Additional filtering and surge protection may be necessary, according to good practice for typical laboratory and industrial environments

Verification method: R – Review, I – Inspection

REQ-033143/A **R3-61**
All mains voltage terminals within the cabinet shall be protected with a touch-proof cover and clearly labelled with standard warning symbols and labels in both Czech and English language. Electrical revision (inspection) of all completed MCS cabinets shall be provided by the Supplier in accordance with Czech standards

Verification method: R – Review, I – Inspection

REQ-033144/A **R3-62**
Motor drives and sensors (such as limit switches) shall be powered from separate DC supplies.

NOTE 1: DC supplies for sensors should be isolated from ground (floating COM).

NOTE 2: DC suppliers should be monitored for failure by the FPGA Controller

Verification method: R – Review, I – Inspection

3.2.4. Actuators and Cabling

REQ-033145/A **R3-63**
All MCS control electronics and power supplies shall be mounted one or two control cabinets per compressor system, of depth 0.4m, height 2m and max width 1.2m. Cabinets shall be fitted onto a 200mm plinth.

NOTE: Cabinets should be mechanically compatible with the Rittal VX series for which the CA carries spare parts and accessories. Suitable cabinets can be provided by the CA on request

Verification method: R – Review, I – Inspection

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REQ-033146/A **R3-64**

MCS Control cabinets shall be mounted in the following locations and bayed adjacent to the VCS cabinet for the same system

- L2 200 TW Compressor: Along the south west wall of the L2 laser hall
- L4 1 PW Compressor: Along the south east wall of the L4 laser hall

All cabling between the chambers and the cabinet shall be via floor channels (provided by CA) and via metal cable trays on the vacuum vessels (these shall be provided by the Supplier). Cable installation is in Supplier scope

Verification method: R – Review, I – Inspection

REQ-033147/A **R3-65**

In-air cables shall be shielded and cable shields shall be terminated at both ends. The Supplier may combine multiple devices into one vacuum feedthrough and connecting cable, but measures against crosstalk shall be taken (*e.g.,* use of individually shielded twisted pairs)

NOTE 1: Cables with individually shielded twisted pairs should be used.

NOTE 2: CA prefers standard density D-sub vacuum feedthroughs, but the Supplier may select any suitable connector type

Verification method: R – Review, I – Inspection

REQ-033148/A **R3-66**

Supplier shall follow ELI Directive 20 (00272188/ A – see RD-02) for wire colours and labelling. All wires, terminal blocks and cable feedthroughs shall be labelled, including those in vacuum. Precision cleaned stainless steel tags may be used to label vacuum cables

NOTE: The CA can provide printed labels on request if the Supplier provides a precise list of label types and text entries, in Excel format, within a 4 week lead-time.

Verification method: R – Review, I – Inspection

REQ-033149/A **R3-67**

Data-producing devices shall be labelled according to their control point code (e.g., MTR208).

NOTE: Codes for all devices can be provided by the CA on request.

Verification method: R – Review, I – Inspection

REQ-033150/A **R3-68**

Standard axes shall be fitted with a reliable, normally closed mechanical limit switch at each end of the safe travel range. Insertion/retraction axes (XH1-XH4, PNA) shall be fitted with mechanically repeatable (+/- 10 um or better), normally open position switches for each position. All switches shall be suitable for 24V signal logic. Hall Effect or optocoupler based limit switches must not be used on any axes

Verification method: R – Review, I – Inspection

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REQ-033151/A **R3-69**

Encoders shall be absolute position type with an interface based on the BiSS-C protocol and connected directly to the same FPGA controller as the associated axis motor control.

NOTE: The supplier may choose to add additional encoders to reach the required repeatability requirements on certain axes, and any axis may be converted to closed-loop if required

Verification method: R – Review, I – Inspection

REQ-033152/A **R3-70**

Temperature sensors shall be platinum RTD 100 of accuracy class A or better, connected in a 4-wire configuration, connected directly via FPGA Controller I/O modules. The Supplier shall provide **Calibration certificate** for the sensors.

NOTE: The Supplier should consider adding sensors on any stepper motors where overheating in vacuum is a concern.

Verification method: R – Review, I – Inspection

REQ-033153/A **R3-71**

If the Supplier adds any new control points they shall inform the CA in a timely manner so that the correct CP codes may be provided for documentation, labelling and database configuration

Verification method: R – Review, I – Inspection

3.2.5. Safety Systems Interfaces – Personnel Safety

REQ-033154/A **R3-72**

The Supplier shall precisely follow the provided implementation diagrams for safety-critical design elements to ensure the system operates in accordance with CA safety requirements

NOTE: The main safety-critical MCS element in each compressor system is the beam dump mirror inserter. This directs the laser beam to a beam dump (or calorimeter) and helps mitigate hazards such as striking a closed gate valve. It forms part of the beam fate safety system

Verification method: R – Review, I – Inspection, T – Test

REQ-033155/A **R3-73**

The Beam Dump Mirror Inserter in each system shall be connected to a pneumatic actuator for insertion and retraction, as shown in the drawings package RD-01. The total time to insert the beam dump on loss of permission shall be < 5 seconds. Speed control valves, shock absorbers or other measures should be used on the actuator to minimize vibration from insertion and extraction operations

Verification method: R – Review, I – Inspection, T – Test

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REQ-033156/A **R3-74**

A 5/2 control valve with safe reversal function rated to PLe (Cat 4, ISO 13849-2, or equivalent) shall be used to ensure it inserts reliably on loss of permission from the safety systems. A small pneumatic buffer fed via a check valve with a volume at least twice that of the pneumatic actuator should be installed to maintain sufficient pressure to insert the beam dump mirror in the event of a loss of supply.

NOTE 1: A suitable control valve can be provided by the CA on request.

NOTE 2: No specific pressure monitoring or pressure switches are required for this system

NOTE 3: The pneumatic supply branch for the BDMs is the same actuation line used for VCS valves

Verification method: R – Review, I – Inspection, T- Test

REQ-033157/A **R3-75**

A commercial magnetically coupled vacuum motion feedthrough is recommended to bring the pneumatic movement into vacuum. Direct monitoring of the inserted and retracted positions in vacuum using normally open mechanical switches shall be provided and connected directly to CA safety systems

NOTE: Position feedback shall be relayed by the safety systems back to the MCS Controller. The MCS controller may also monitor the position of the pneumatic actuator, if desired. For testing, a temporary loopback connection should be used

Verification method: R – Review, I – Inspection

REQ-033158/A **R3-76**

The air supply to the control valve shall be fitted with a regulator with overpressure relief, and ports 3 and 5 of the valve fitted with a silencer as recommended in the control valve manual

Verification method: R – Review, I – Inspection

REQ-033159/A **R3-77**

Stainless steel solid tube and swaged fittings shall be used for the pneumatic connections between the safety control valve and the actuator

Verification method: R – Review, I – Inspection

3.2.6. Safety Systems Interfaces – Machine Safety System (MSS)

REQ-033160/A **R3-78**

The Supplier shall provide a machine safety signalling interface for each compressor system as specified in the implementation drawings (see drawings package). The specified digital inputs and digital outputs shall be connected directly (via relays) to FPGA Controller I/O modules

Verification method: R – Review, I – Inspection, T – Test

REQ-033161/A **R3-79**

The MSS input permissives shall directly enable the motor drives for the relevant axes via an external dry contact closure.

Axes marked as LP ENABLE in the requirements table must not be enabled unless the LOW POWER PERMISSIVE is given.

Those marked as HP ENABLE in the requirements table must not be enabled unless the HIGH POWER PERMISSIVE is given

Verification method: R – Review, I – Inspection, T - Test

REQ-033162/A **R3-80**

The MSS input signals shall be split (*e.g.,* by parallel connected relays) and a copy connected to each controller so that the permissive status may be read by the FPGA

Verification method: R – Review, I – Inspection, T - Test

REQ-033163/A **R3-81**

For each MCS the MSS safe output signal shall be combined by series connected relays from each controller so that each controller independently confirms it is safe for high power laser operation

Verification method: R – Review, I – Inspection, T - Test

REQ-033164/A **R3-82**

Each controller shall only output a positive SAFE FOR HIGH POWER signal when the following conditions are met for all axes connected to that controller:

1) All movement has completed and drives have been disabled by the controller
2) All Alignment Crosshairs are in the fully retracted position as detected by their NC position switch
3) The Beam Dump Mirror is in a fixed state (either fully open or fully closed as detected by its NC position switches)
4) All temperature sensors are within the configured nominal band

Verification method: R – Review, I – Inspection, T - Test

REQ-033165/A **R3-83**

The supplier shall consider using a relay type with a mechanical override function to allow the permissive input signals to be simulated for testing without the external MSS connected

Verification method: R – Review

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4. Cleaning and cleanliness verification, packaging requirements

4.1. Compressor and Injector vacuum chambers

REQ-033166/A **R4-1**

Before final treatment on inner vacuum surfaces of each chamber, especially if grinding is used for surface finish, the Supplier shall invite CA to perform inspection of the surface cleanliness.

Verification method: I – Inspection

REQ-033167/A **R4-2**

All finished stainless steel parts of the chambers shall be degreased by thorough cleaning with high pressure hot water jet (>120 bar), using appropriate high-performance detergent (e.g. 2% solution of General Purpose Cleaner/Degreaser - mixture of Sodium Tripolyphosphate - 3 - < 5%, Modified Polyether Anionic Surfactant - 1 - < 3%, Non-ionic surfactant 1 - < 3%; pH >11; (5 - 15% - Non-Ionic Surfactants, 1 - 5% - Phosphates, 1 - 5% - Anionic Surfactants) or equivalent), at a temperature between 70°C and 75°C, for no less than 5 minutes /m^2. The water jet strokes shall form a cross pattern on the cleaned surface. Subsequently, the parts shall be immediately, without letting the surface to dry, rinsed with hot demineralised water with at least 75°C.

The previous step, i.e. thorough cleaning with high-pressure water with appropriate high-performance detergent, followed by rinsing in demineralised water without letting the surface to dry, shall be repeated.

Subsequently, the parts shall be dried by clean pressure gas (e.g. nitrogen) in a way not leaving traces of residues from water drops.

NOTE: It is not allowed to use wipes wetted with isopropanol or acetone after completion of the above procedure.

NOTE: Spraying or flushing of parts of vacuum surfaces by ultraclean acetone (<5ppm evaporation residue) is allowed, provided it does not come into contact with any plastic parts such as squirt bottles or O-rings.

NOTE: Dry wiping of smooth surfaces with polyester wipes to minimize particle contamination is allowed.

NOTE: Use of specific degreasing solution shall be approved in writing by CA. The CA also permits another equivalent cleaning procedure to be offered, however this shall be approved in writing by the CA.

NOTE: A possible additional step may involve cleaning by laser or by manual electro-polishing with 10% solution of H_3PO_4. If any of these techniques is used, detailed steps of the procedure shall be agreed in writing with CA.

Verification method: R – Review, I – Inspection

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REQ-033168/A **R4-3**

All O-rings shall be vacuum baked at temperature of 120°C for 24 hours prior to use. After the bake-out, the O-rings shall not come in contact with isopropyl alcohol or any grease.

Verification method: I – Inspection

REQ-033169/A **R4-4**

The Supplier shall perform mass-spectrometer RGA (Residual Gas Analyzer) test on each chamber. The RGA shall have a range of at least 200 AMU (Atomic Mass Unit) and shall contain Secondary Electron Multiplier (SEM). The chambers shall be pumped by a dry vacuum pump and a turbomolecular pump to a pressure of 10^{-6} mbar for at least 12 hours before activating the RGA. The RGA filament shall be on for at least 4 hours before recording the final scan. The resulting RGA spectrum shall conform to the following criteria:

a) all peaks above AMU 45 shall be lower than 1/100 of AMU 44;
b) the AMU 45 peak shall be lower than 1/10 of AMU 44.

Verification method: R – Review, T – Test, I - Inspection

REQ-033170/A **R4-5**

The Supplier shall invite CA to inspect the vacuum cleanliness of the chambers in ISO 7, or equivalent, (or better cleanliness class) cleanroom before starting the packaging these components for transport. The results of the inspection shall be recorded in the form of the Compressor and Injector Chambers Vacuum Cleanliness Inspection Report.

Verification method: I – Inspection

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4.2. Internal chassis, tables and optomechanical mounts

REQ-033171/A **R4-6**

The compressor internal chassis and the optical table panels shall be degreased by thorough cleaning with high pressure hot water jet (>120 bar), using appropriate high-performance detergent (e.g. 2% solution of General Purpose Cleaner/Degreaser - mixture of Sodium Tripolyphosphate - 3 - < 5%, Modified Polyether Anionic Surfactant - 1 - < 3%, Non-ionic surfactant 1 - < 3%; pH >11; (5 - 15% - Non-Ionic Surfactants, 1 - 5% - Phosphates, 1 - 5% - Anionic Surfactants) or equivalent), at a temperature between 70°C and 75°C, for no less than 5 minutes /m^2. The water jet strokes shall form a cross pattern on the cleaned surface. Subsequently, the parts shall be immediately, without letting the surface to dry, rinsed with hot demineralised water with at least 75°C.

The previous step, i.e. thorough cleaning with high-pressure water with appropriate high-performance detergent, followed by rinsing in demineralised water without letting the surface to dry, shall be repeated.

Alternatively, the optical table support frame and the optical table panels can be degreased by immersing in hot bath with high-performance detergent (e.g. 2% solution of General Purpose Cleaner/Degreaser - mixture of Sodium Tripolyphosphate - 3 - < 5%, Modified Polyether Anionic Surfactant - 1 - < 3%, Non-ionic surfactant 1 - < 3%; pH >11; (5 - 15% - Non-Ionic Surfactants, 1 - 5% - Phosphates, 1 - 5% - Anionic Surfactants) or equivalent),.

Subsequently, the parts shall be dried by clean pressure gas (e.g. nitrogen) in a way not leaving traces of residues from water drops.

NOTE: It is not allowed to use wipes wetted with isopropanol or acetone after completion of the above procedure.

NOTE: Spraying or flushing of parts of vacuum surfaces by ultraclean acetone (<5ppm evaporation residue) is allowed, provided it does not come into contact with any plastic parts including squirt bottles or O-rings.

NOTE: Dry wiping of smooth surfaces with polyester wipes to minimize particle contamination is allowed.

NOTE1: Use of specific degreasing solution shall be approved in writing by CA. The CA also permits another equivalent cleaning procedure to be offered, however this shall be approved in writing by the CA.

NOTE2: The cleaning of the aluminium alloy parts may, if necessary, involve an additional step consisting in cleaning with 10% solution of phosphoric acid (H_3PO_4) applied with e.g. polyester (PE) wipes. Within less than 40 seconds the acid has to be removed by clean PE wipes. Immediately after, the walls shall be neutralized by 5% solution of analytical purity sodium bicarbonate ($NaHCO_3$); after approximately 2 minutes the sodium bicarbonate shall be removed by clean PE wipes.

After processing the components with the phosphoric acid and sodium bicarbonate, the component has to be rinsed by demineralised water. The rinsing shall be made by low pressure jet (spray).

Verification method: R – Review, I - Inspection

REQ-033172/A **R4-7**

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Best practice shall be followed in cleaning individual parts of the optomechanical mounts. The cleaning procedure shall follow the same steps as used for cleaning the optical table support frame and the optical table panels (see REQ-033171/A - **R4-6**). The Client reserves the right to test any part of the mounts before or during the final assembly, and/or to perform his own cleanliness test of the assembled mounts.

Verification method: R – Review, I - Inspection

REQ-033173/A **R4-8**

The Supplier shall invite CA to inspect the vacuum cleanliness of the components of the chassis and of the optical table panels in ISO 7, or equivalent, (or better cleanliness class) cleanroom before starting the packaging these components for transport. The results of the inspection shall be recorded in the form of the Vacuum Cleanliness Inspection Report.

Verification method: I – Inspection

4.3. Packaging

REQ-033174/A **R4-9**

The Supplier shall invite CA to inspect vacuum cleanliness of the chambers, of the compressor internal chassis, of the optical table panels, and of the optomechanical mounts, placed in ISO 7, or equivalent, (or better cleanliness class) cleanroom, before starting the packaging of these components for transport. The results of the inspection shall be recorded in the form of the Vacuum Cleanliness Inspection Report.

Verification method: I – Inspection

REQ-033175/A **R4-10**

The Compressor chamber shall be prepared for transport with the top lids and doors sealed by metal blanks cleaned to the same standard as the chamber itself. The doors and top lids shall be packed separately.

Verification method: I – Inspection

REQ-033176/A **R4-11**

The Injector chambers shall be prepared for transport with the access door fitted and all circular flanges sealed by metal blanks cleaned to the same standard as the chamber itself.

Verification method: I - Inspection

REQ-033177/A **R4-12**

The vacuum chambers, the internal chassis, and the optical table panels shall be packed separately for transport.

Verification method: I – Inspection

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REQ-033178/A **R4-13**

The cleaned chambers, internal chassis, optical tables and optomechanical mounts shall be wrapped in two layers of ultra-low outgassing polyethylene film (as sheet or bags) with thickness of at least 100 µm, with NVR (non-volatile residue) better than 0.15 µg/cm^2 and very low particle generation. Alternatively, UHV compatible aluminium foil approved by CA can be used. The clean conditions wrapping shall be further enclosed in robust outer packaging and transport crates as necessary for protection and handling during shipping to the ELI-Beamlines site.

NOTE: CA can recommend to the Supplier appropriate low-outgassing polyethylene-based foils brands if required.

Verification method: R – Review, I – Inspection

REQ-033179/A **R4-14**

Each individual transported component shall be within the limitations of the 10 tonne limit freight elevator of ELI-Beamlines, with net size of the cargo space 5.5(l) x 5.1 (w) x 3 (h) m.

Verification method: R - Review, I – Inspection

5. Transportation Requirements

REQ-033180/A **R5-1**

The supplier shall transport the completed and tested components to the ELI Beamlines site

NOTE: The bid price will be considered by the CA as the final price, including transportation costs and insurance.

Verification method: R – Review, I - Inspection

REQ-033181/A **R5-2**

The transportation procedure shall be reviewed and agreed by the CA.

Verification method: R - Review

REQ-033182/A **R5-3**

The Supplier shall allow supervision by the CA of the activities related to the transportation.

NOTE: Any acts of supervision shall not mean that the CA assumes additional liability of any kind exceeding its liabilities according to the contract.

Verification method: R - Review

REQ-033183/A **R5-4**

The flanges of the chamber shall remain sealed during transport.

Verification method: R - Review, I – Inspection

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6. Final on-site transportation, installation and Integration

REQ-033185/A **R6-1**

The Supplier shall transport and install the components to the ELI-Beamlines facility right up to the point of fixing down at the operational location in the ELI-Beamlines Laser Building.

Verification method: R - Review, I – Inspection

REQ-033186/A **R6-2**

Transport through the Laser Building will involve the use of a goods lift to transition between floors and in order to fit in the lift the maximum dimensions of the chamber body (in its transport configuration) shall not exceed 5.5 x 5.1x2.98 m3 and its weight shall not exceed 10 tons.

Verification method: R - Review, I – Inspection

REQ-033187/A **R6-3**

Movement through corridors and rooms will require wheels, rollers or air skates fitted to a suitable support structure, whose design and supply shall be within the scope of the Supplier, as shall be any floor surface protection or load spreading sheets.

Verification method: R - Review, I – Inspection

REQ-033188/A **R6-4**

All transport and installation activities at the ELI-Beamlines facility shall be pre-planned in advance by means of a written Installation Method Statement that shall be reviewed and agreed with the Client's officer in charge of such work. Transport and installation activities shall be undertaken strictly in accordance with the agreed Method Statement and subject to Client's overall control.

Verification method: R - Review, I – Inspection

REQ-033189/A **R6-5**

The Supplier shall fully install and integrate the components on-site at the operational location in the ELI-Beamlines Laser Building.

Verification method: FD - Functional Demonstration

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7. Safety Requirements

REQ-033191/A **R7-1**

The Supplier shall supply a **Declaration of Conformity** for each product type if the appropriate legislation determines the Supplier's obligation to have a Declaration of Conformity for the purposes of a Device sale in the Czech Republic. In such a case the Declaration of Conformity shall comply with:

- Act No. 90/2016 Coll., as amended
- Act No. 22/1997 Coll., as amended
- The equivalent legal regulation of another EU member state so that the conditions for the sale of the product in the Czech Republic are met, and/or
- the relevant EU/EC regulation

NOTE: The compliance with these obligations will be demonstrated by the (EU) Declaration of conformity, other relevant documents and the CE marking if required by the relevant regulations. If a delivered product is not required to assess conformity according to specific legislation, the supplier declares, in written form, by concluding the contract that the product complies with the general safety requirement of EU Directive 2001/95/EC on general product safety and that the Supplier duly complies their obligations under this Regulation.

Verification method: R – Review

8. Quality requirements

8.1. Documentation and data control

REQ-033192/A **R8-1**

The Supplier shall supply the following relevant manufacturing documents:

- all manufacturing design, 3D model and design supporting documentation approved by the CA (see REQ-033199/A – **R9-4**);
- all "requests for deviation/waiver from requirements described herein" approved by the CA (see REQ-033195/A – **R8-4**).
- full technical documentation on the delivered Product () regarding the following procedures:
- transport, handling, storage, disassembling and cleaning;
- safe operation, maintenance and disposal procedures;
- description of cable wires or connector pins (if relevant);
- list of spare parts, specialized tools, equipment and materials for proper maintenance or repair (if relevant);
- user manual for the software or libraries and for communication protocols (if relevant);

Verification method: R – Review, I - Inspection

REQ-033193/A **R8-2**

The Supplier shall use following data formats:

- *.JPG, *.PNG, *.TIFF, *.PDF/A, *.HTML
- CAD 2D: *.dwg
- CAD 3D: *.stp; *.ste; *.step or other 3D CAD formats agreed with the CA
- text processors *.doc, *.docx, OpenDocument Format

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- spreadsheet processors *.xls, *.xlsx, OpenDocument Format
- presentations *.ppt, *.pptx; OpenDocument Format

Verification method: Not To Be Tracked within VCD

REQ-033194/A **R8-3**

Documentation (e.g. reports, protocols, certificates, instructions, manuals, etc.) shall be supplied in PDF format and hardcopy.

Verification method: Not To Be Tracked within VCD

8.2. Nonconformity control system

REQ-033195/A **R8-4**

The Supplier shall establish and maintain a nonconformity control system compatible with ČSN EN ISO 9001 (or equivalent, e.g. EN ISO 9001).

Verification method: Not To Be Tracked within VCD

9. Verification requirements for the Supplier

The verification process will be performed mostly by the Supplier. The VCD draft provided by the CA will specify exactly what is required to be verified by whom as well as the CA proposal how.

The VCD serves for the gradual recording of executed verifications by the Supplier during the Contract realization. The records usually consist of the date (time) when the verification was executed, by whom, the result (OK/NOK) and usually also reference to the related document as evidence of the result of verification.

9.1. Verification Control Document (VCD)

The CA requires that the Supplier will use the VCD document provided by the CA. The Supplier can extend and adapt the VCD document for better reflection to the real condition and fulfillment of the basic purpose of the VCD – to document and demonstrate the verification of fulfillment of the CA requirements.

REQ-033196/A **R9-1**

The Supplier shall gradually execute the verification as required within this RSD as well as within the VCD draft provided by the CA and record the results into the VCD.

*NOTE: In the **VCD**, the Supplier shall describe **HOW** and **WHEN** each of the technical requirements is to be verified.*

NOTE: Guidelines for VCD preparation will be provided by the CA (see RD-03; section 1.12).

Verification method: R – Review

REQ-033197/A **R9-2**

The verification approach shall be defined by the Supplier in the **VCD** prior to its implementation.

Verification method: R – review

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9.2. Documentation and reporting

REQ-033198/A **R9-3**

The verification reports shall be submitted to the CA for the review as agreed with the CA after corresponding verification activity completion, within the time frame agreed with the CA in the VCD.

NOTE: Verification activity can be design review, test (FTR or SAT), analysis (e.g. FEM) or inspection (SIR, see REQ-033199/A - R9-4 and REQ-033200/A - R9-5).

Verification method: Not To Be Tracked within VCD

REQ-033199/A **R9-4**

The results of the tests shall be documented in the appropriate Factory Test Report (**FTR**) and on-Site Acceptance Test (**SAT**) and tracked in the VCD (see chapter 9.1).

Verification method: R – Review

REQ-033200/A **R9-5**

The results of the inspection shall be documented in the appropriate on-Site Inspection Report (further "**SIR**") and the results of the analysis shall be documented in the appropriate Analysis Report and tracked in the VCD (see chapter 9.1).

Verification method: R - Review

9.3. Recommended verification methods

REQ-033210/A **R9-6**

The verification process shall be accomplished by the Supplier through one or more of the following verification methods recommended by the CA:

1. Test – verification that consists of measuring product performance and functions under controlled conditions, as close as possible to real operation. The Test protocols with test results or the complete Test report usually serve as the documented evidence (Test – T), e.g.:
   a. Test at the Supplier (documented in the FTR);
   b. Test at the CA (documented in the SAT);
   c. Functional Demonstration at the Supplier or at the CA but always with CA attendance (Functional Demonstration – FD);

NOTE: The CA can also ask for valid calibration certificates (protocols) of used measuring instruments or similar documentation.

2. Review – verification that the Documentation meets the requirements or the Documentation demonstrate the fulfilment of the requirements (Review – R).
3. Inspection – visual check or evaluation of physical characteristics of the subject whether meet the requirements (Inspection – I).
4. Analysis - performing of theoretical or empirical evaluations of meeting the requirements by using defined methods (Analysis - A).

Verification method: Not To Be Tracked within VCD

9.4. Phasing of the delivery

This chapter is intended to briefly summarize basic milestones of the Contract delivery. These milestones represent gates (checkpoints) where the quality of the delivery is to be evaluated.

Delivery shall not proceed past these gates unless their satisfactory accomplishment is approved by the CA.

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Delivery lifecycle shall contain at least the following phases (**quality gates**):

- Qualification of Design;
- Manufacturing;
- Delivery and Installation;
- Acceptance (performed by the CA).

9.4.1. Qualification of Design

This chapter describes summary of what has to be provided by the Supplier in terms of documentation (detailed engineering documentation including technical documentation, manufacturing drawings and design supporting documentation) before starting the manufacturing.

Output of this phase is the **Final set of detailed engineering documentation, approved by the CA**.

REQ-033202/A **R9-7**

Before completion of the Qualification of Design phase the Supplier shall provide the following information that shall be agreed by the CA:

- structure and content of the Test reports or protocols, Analysis reports, Review reports etc. (if applicable);
- structure and content of the VCD if it was modified by the Supplier.

NOTE: Phases of delivery are called Deliverables in the Purchase contract.

Verification method: R - Review.

REQ-033203/A **R9-8**

Before completion of the Qualification of Design phase the Supplier and the CA shall agree on:

- final detailed engineering drawings provided by the Supplier;
- detailed procedures related to the testing, cleaning and packaging during the Manufacturing phase;
- common nonconformity control system (see REQ-033195/A – **R8-4**).

NOTE: Phases of delivery are called Deliverables in the Purchase contract.

Verification method: R - Review.

9.4.2. Manufacturing

The goal is to demonstrate that all the manufactured parts of the contract meet the specified technical requirements (RSD) of the CA.

Output of this phase is the **Verified all manufactured parts of the contract**.

REQ-033204/A **R9-9**

The results of the Manufacturing phase of verification shall be recorded by the Supplier in the appropriate FTR and overall results (including review of documentation/reports and inspection of all the manufactured and delivered parts) shall be recorded in the VCD (see chapter 9.1).

NOTE: Phases of delivery are called Deliverables in the Purchase contract.

Verification method: R – Review

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9.4.3. Delivery and Installation

The goal is to demonstrate that the delivered and installed Compressor meet all requirements specified herein.

Output of this phase is the **Verified delivered and installed the final product**.

REQ-033205/A **R9-10**

The results of the verification of the delivered and installed Compressor shall be recorded by the Supplier in the appropriate SAT (see REQ-033199/A - R9-4) and SIR (see REQ-033199/A - R9-4) and overall results shall be recorded in the VCD (see chapters 9.1).

Verification method: R - review

REQ-033206/A **R9-11**

The final issue of the VCD shall be submitted to the CA after the approval of the last report after delivery and installation.

Verification method: R – Review

9.5. Acceptance

Acceptance will be carried out by the CA upon completion of each Phase of delivery. In case of successful acceptance phase, the CA will provide to the Supplier signed acceptance protocol for each Phase of delivery. In case of unsuccessful acceptance phase, the CA will provide to the Supplier Nonconformity Report (NCR) and process in accordance with REQ-033195/A – **R8-4** shall be applied.

The final acceptance will be executed by the CA by verifying all criteria stated in REQ-033207/A – **R9-12**

The Acceptance phase shall demonstrate the following:

- The final product(s) has (have) been successfully verified and this process has been documented in an appropriate way;
- All detected nonconformities have been solved in accordance with REQ-033195/A – **R8-4**;
- The final product(s) is (are) free of fabrication errors, is (are) not damaged during transport and is (are) ready for the intended operational use.
- The final product(s) is (are) fully installed and the final on-site Integration Qualification (IQ) and Operational Qualification (OQ), shall be performed in cooperation with the CA.

REQ-033207/A **R9-12**

The Acceptance phase shall demonstrate the following:

- All finished parts of the contract have been successfully verified by the Supplier and the overall results of this process have been documented in VCD (The completed VCD is submitted);
- All previous Phases of delivery were accepted by CA and confirmed by the related Acceptance protocol (All the Acceptance protocols are submitted);
- All detected nonconformities have been solved in accordance with REQ-033195/A – **R8-4**;

Verification method: Not To Be Tracked within VCD (Final CA verification)

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10. ANNEX: Supplied Devices List

The following items may be supplied by the CA for use by the Supplier in the delivered systems. Unused parts must be returned.

Part Name	Typical Part Number(s)	Max. quantity
FPGA Controller	NI cRIO-9057 (Master), NI 9149 (Slave)	4 (Master) 6 (Slave)
Device Network Switch	Moxa EDS-G516E-4GSFP	4
Serial Device Server	Moxa Nport IA5450AI	6
Control Cabinet	Rittal VX 8204.000	6
Breakout	Weidmuller SAI-8-MMS 5P M12	20
3/2 Safety Control Valve	Festo VOFA-L26-T32C-M-G14-1C1-APP	2
5/2 Safety Control Valve	Festo VOFA-L26-T52-M-G14-1C1-APP	2
APG Pirani/Piezo Vacuum Gauge	MKS 910-22034	7
APG High Accuracy Capacitance Vacuum Gauge	Pfeiffer PT R24 601	5
WRG Pirani/Cold Cathode Wide Range Vacuum Gauge	Leybold PTR90N	7
Clean Gas Filter	SMC SFC102-03	14
UHP Ceramic Filter for CDA	Swagelok SS-SCF3-VR4-P-600	4
Overpressure Burst Disc	Allectra 461-PBD-ISO63-ULPP	4
UHP Manual Needle Valve	Swagelok SS-4MG-VCR	2
High Load Short Travel Actuator	Newport VHRU	16
Compact Short Travel Actuator	Newport LTA	16

The CA reserves the right to substitute any supplied part with an alternative of similar performance and functionality

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11. ANNEX: Control System Drawings

11.1. Key to Control System Drawings

[vypuštěno]

11.2. VCS Control Point Diagram – L4 PW Compressor

[vypuštěno]

11.3. VCS Network and Serial Example (General)

[vypuštěno]

11.4. VCS Power and LOTO Example (General)

[vypuštěno]

11.5. Water cooling Example (General)

[vypuštěno]

11.6. Clean Dry Air and Pneumatics Distribution Example (General)

[vypuštěno]

11.7. VCS Devices and Cabling Example (General)

[vypuštěno]

11.8. VCS Personnel Safety (applicable to both compressor systems)

[vypuštěno]

11.9. VCS Machine Safety – L4 PW Compressor

[vypuštěno]

11.10. MCS Control Point Diagram – L4 1 PW Compressor

[vypuštěno]

11.11. MCS Network and Serial Example (General)

[vypuštěno]

11.12. MCS Actuator and Cabling Example (General)

[vypuštěno]

11.13. MCS Personnel Safety (Applicable to both compressor systems)

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11.14. MCS Machine Safety (Applicable to both compressor systems)

[vypuštěno]

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12. ANNEX: Drawings

RD-01_Drawing package for_L4_Comp

- Assembly of the L4PW compressor and beam injector with adjacent system (Assembly_L4PW_compressor_and_injector.pdf)
- L4PW compressor chamber (L4PW_Compressor_chamber_V5_12Feb2021.pdf)
- L4PW injector chamber (L4PW_Injector_chamber_2021-07-23.pdf)
- L4PW compressor optical chassis (L4PW_Compressor_optical_chassis.pdf)
- L4PW injector chamber (L4PW_Injector_chamber_2021-07-23.pdf)
- L4PW G1 grating optomechanical mount (L4PW_G1_grating_mount.pdf)
- L4PW G2 grating optomechanical mount (L4PW_G2_grating_mount.pdf)
- L4PW periscope mirror mount (L4PW_Periscope_mount.pdf)
- Flexure joint pitch-yaw mount for large mirrors
- L4PW M1 mirror mount (L4PW_M1_mirror_mount.pdf)
- L4PW M2 mirror mount (L4PW_M2_mirror_mount.pdf)
- L4PW M3 mirror mount (L4PW_M3_and_Polarization_switch_mounts.pdf)
- Flexure joint pitch-yaw mount for small diagnostic mirrors (Flexure_joint_pitch_yaw_mount_small_diagnostics.pdf)
- XM3 double crossed hair rotation mount (XM3_double_crossed_hair.pdf)
- Pneumatically actuated flipping mirror for beam dump (Pneumatically_actuated_shutter_flipping_mirror.pdf)

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ANNEX 3

VERIFICATION CONTROL DOCUMENT

ANNEX NO. 3

VERIFICATION CONTROL DOCUMENT

L2 and L4PW Compressor and Beam Injector Integrated Vacuum, Optomechanical and Electronic Control Systems

Confidentiality:	*BL - Restricted for internal use*	**TC ID/Revision**:	00309915/A
WBS code:	3.2 – L2 system, 3.4 – L4 system	**PBS code**:	*RA1.L2.L2_1.CMP, RA1.L4.CMP2*
Doc Status:	*DocReleased*	**Doc Type**:	*Specification (SP)*
Project Branch:	*Engineering & Scientific documents (E&S)*		

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1. Quality Requirements for Supplier

1.1. General Quality Requirements

N°	TC N°		Requirement	Verification by
QR1-01	REQ-022310	A	The Supplier shall identify a Quality Manager for the project, responsible for implementing and performing management and other Quality disciplines and functions.	R - review
QR1-02	REQ-022311	A	If the Supplier delegates the quality assurance tasks to other organization it shall be done in a documented and controlled way monitored by the Supplier.	Not To Be Tracked within VCD
QR1-03	REQ-022312	A	The Supplier shall prepare, maintain and implement a Quality Plan for the product development and manufacturing to ensure that the product quality is in compliance with intended use and in conformity with requirements. *NOTE: The Client reserves the right to provide basic requirements for the Quality Plan.*	R - review
QR1-04	REQ-022313	A	The Quality Plan shall be submitted according to provisions of Annex 1.	R - review

1.2. Nonconformity Control System

N°	TC N°		Requirement	Verification by
QR1-05	REQ-022314	A	The Supplier shall establish and maintain a nonconformity control system compatible with ČSN EN ISO 9001 (equivalent to EN ISO 9001).	Not To Be Tracked within VCD

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1.3. Documentation and data control

N°	TC N°		Requirement	Verification by
QR1-06	REQ-022315	A	The Supplier shall supply the following relevant manufacturing documents: • Full technical documentation (including manufacturing drawings) • Breakdown list as built • Handling, installation and maintenance manuals • All approved "requests for deviation/waiver" (see REQ-022314; QR1-05).	I – inspection
QR1-07	REQ-022316	A	All documentation shall be supplied in both hardcopy and PDF/A.	I – inspection
QR1-08	REQ-022317	A	The Supplier shall provide the following types of technical documentation: • Final 3D model (if available) • Final 2D drawings.	R - review
QR1-09	REQ-022318	A	The Supplier shall use the following data formats: • *.JPG, *.PNG, *.PDF/A, *.HTML • CAD 2D: *.dwg • CAD 3D: *.stp; *.ste; *.step, *.x_t; *.x_b, or other 3D CAD formats agreed with the Client • Text processors *.doc, *.docx, OpenDocument Format • Spreadsheet processors *.xls, *.xlsx, OpenDocument Format • Presentations *.ppt, *.pptx; OpenDocument Format.	Not To Be Tracked within VCD

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2. Verification Requirements for Supplier

2.1. General requirements

N°	TC N°		Requirement	Verification by
QR2-01	REQ-022319	A	The verification process shall be managed by the Supplier and shall proceed according to the Verification Plan (VP), see provisions of Annex 1. The verification process shall include the following activities: 1. **Verification planning** (see section 2.3 below) 2. **Verification execution and reporting** (see section 2.4 below) 3. **Verification control and close-out** (see sections 2.5 and 2.6 below).	Not To Be Tracked within VCD
QR2-02	REQ-022320	A	The Supplier shall assign clear responsibility for the implementation of the verification process including the activities defined in QR2-01 (REQ-022319).	R - review

2.2. Verification Documentation

N°	TC N°		Requirement	Verification by
QR2-03	REQ-022335	A	The Supplier shall establish and maintain the system of verification process documentation.	Not To Be Tracked within VCD
QR2-04	REQ-022336	A	Verification documentation shall consist of following basic types of documents: • **VP, Verification Plan** (see section 2.3) • **Verification Reports** including: CDR Report, Tests, Inspection and Analyses reports (see section 2.4) • **VCD, Verification Control Document** (see section 2.5).	Not To Be Tracked within VCD
QR2-05	REQ-022337	A	The verification report shall be submitted to the Client for the review as agreed with the Client after corresponding verification activity completion, within the time frame agreed with the Client. *NOTE: Verification activity can be design review and analysis during the development, test and inspection of the final System.*	R - review

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2.3. Verification Planning

N°	TC N°		Requirement	Verification by
QR2-06	REQ-022321	A	The Supplier shall define the verification approach in a Verification Plan (VP) for approval by the Client prior to implementation.	Not To Be Tracked within VCD
QR2-07	REQ-022322	A	The Verification Plan (VP) shall describe **HOW** and **WHEN** each of the technical requirements will be verified: *NOTE 1: The Client reserves the right to provide binding guidelines for establishing the VP, within 15 working days from the Commencement Day of the contract.* *NOTE 2: Guidelines for VP preparation can be provided by the Client.*	R – review

2.4. Verification execution

N°	TC N°		Requirement	Verification by
QR2-08	REQ-022323	A	The verification execution process shall consist of following stages according to the phasing of the contract execution: • **Critical design review (CDR**); • **Verification of all components of the System** (testing and inspection at Supplier's site)**;** • **Acceptance by the Client at customer site**. *NOTE 1: The CDR is intended to verify that the design meets corresponding requirements (could be accepted) and/or identify required corrective actions needed to accept the design and start manufacturing phase of the contract.* *NOTE 2: Verification of all elements of the System is executed at the end of each corresponding manufacturing phase by inspection and tests. The purpose of this verification is checking the product readiness for shipment to the Client.* *NOTE 3: In the acceptance stage the verification shall demonstrate that the product meets the specifications (see Annex 2 of the Contract) and that it is free of fabrication defects and is ready for the intended operational use.*	Not To Be Tracked within VCD
QR2-09	REQ-022324	A	Acceptance shall be carried out on final hardware and software. *NOTE 1: Output of this verification stage is Verified System.* *NOTE 2: The results of acceptance stage shall be recorded by the Client within VCD (see section 2.6).*	Not To Be Tracked within VCD

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QR2-10	REQ-022325	A	Verification shall be accomplished by the Supplier through one or several of the following methods: 1. **Review of design**; Verification by Review (**R**) shall consist of using official project documentation (e.g. design and technical documentation, numerical analysis reports, engineering drawings, manuals and operation documentation) that unambiguously shows that the requirement is met. 2. **Inspection**; Verification by Inspection (**I**) shall consist of visual examination of the manufactured and/or assembled product. 3. **Test** (including functional demonstration); Verification by Test (**T**) shall consist of quantitatively measuring performance of the product and of its functions in a defined operating regime. 4. **Analysis**; Verification by Analysis (**A**) shall consist of performing numerical or empirical performance evaluation of the product using a technique defined in the VP (see QR2-06; REQ-022321).	Not To Be Tracked within VCD
QR2-11	REQ-022326	A	The results of a review of design shall be documented in the Critical Design Review Report (**CDRR**) and tracked in the VCD. *NOTE: The Client can provide to the Supplier the template of CDRR.*	R – review
QR2-12	REQ-022330	A	The results of a review of analysis shall be documented in the appropriate Analysis Report (**AR**) and tracked in the VCD.	R – review
QR2-13	REQ-022327	A	The results of the inspection shall be documented in the appropriate Inspection Report (**IR**) and tracked in the VCD.	R – review
QR2-14	REQ-022328	A	The results of the test shall be documented in the appropriate Test Report (**TR**) and tracked in the VCD.	R – review
QR2-15	REQ-022329	A	The parts of the VCD related to the Design of the System shall be accepted by the Client before manufacturing of the System starts.	Not To Be Tracked within VCD

2.5. Verification Control Document (VCD)

The Verification Control Document (VCD) lists the requirements to be verified with the selected methods at the defined levels. The VCD is a living document and provides traceability during contract phases (design, manufacturing, testing and deployment) how each requirement is planned to be verified and is actually verified.

The VCD represents a formal tool of communication between the Supplier and the Client (formal record, reporting tool).

N°	TC N°		Requirement	Verification by
QR2-16	REQ-022338	A	The Supplier shall provide the first version of the Verification Control Document (VCD) as a part of the D1 Deliverable. *NOTE: Binding guidelines for VCD preparation will be provided by the Client within 15 working days from the Commencement Day of the contract.*	R - review

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2.6. Verification close out

Acceptance will be carried out on the final System after delivery and installation.

In case of successful acceptance phase the Client shall provide to the Supplier signed acceptance protocol. In case of unsuccessful acceptance phase the Client shall provide to the Supplier Nonconformity Report (NCR) and process in accordance with QR1-05 (see REQ-022314) shall be applied.

N°	TC N°		Requirement	Verification by
QR2-17	REQ-022421/A	A	Upon delivery of the System components in appropriate and undamaged packaging, the Client shall provide to the Supplier with Handover/takeover protocol.	Not To Be Tracked within VCD
QR2-18	REQ-022332	A	The verification process shall be considered complete for a given project phase (contractual Deliverables) when the Client approves all corresponding items in the VCD by confirming that: 1. All specified requirements for a given project phase (contractual Deliverable) have successfully been verified by the Supplier and results of this verification process has been approved by the Client; 2. All detected nonconformities have been solved in accordance with QR1-05 (REQ-022314); 3. Documented evidence is recorded in the VCD. *NOTE: In the acceptance phase, the verification of the final System and required documentation will be carried out and tracked by the Client in the final version of the VCD within 4 weeks after the issuing of the latest Handover/takeover protocol (D9).*	Not To Be Tracked within VCD

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3. Quality & Verification Plan

The table in Section 3.2 below summarizes the compulsory Quality and Verification activities of design, manufacturing, testing and delivery. These activities must be included in the detailed Quality and Verification Plan developed by the Supplier.

3.1 Abbreviations

Abbreviation	Meaning	Note
I	Inspection	As verification methods; Further details see QR2-10 (REQ-022325)
RoD	Review of Design	
T	Test	
A	Analysis	
FD	Functional Demonstration	
R	Review	Relevant official project documents for a given activity shall be reviewed, and a review report issued, by a responsible person at the Client.
H	Hold point	Progress shall not be made to the next sequenced activity until the Requirements of the Hold Point Activity have been met
W	Witness point	The activity shall be witnessed in person with appropriate advance notice having been given.
QR	Quality Report	All items from the Quality Plan, see QR1-03 (REQ-022312), corresponding to the given activity, must be documented
AR	Analysis Report	Documented results of corresponding verification activities shall be submitted to the Client (see section 2.4)
IR	Inspection Report	
TR	Test Report	
n/a	not applicable	
CDR	Critical Design Review	Details see in QR2-08 (REQ-022323)
CDRR	CDR Report	Details see in QR2-11 (REQ-022326)
VP	Verification Plan	Details see in section 2.3
VCD	Verification Control Document	Details see QR2-16 (REQ-022338)
ELI-BL	ELI-Beamlines	-

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3.2 List of compulsory Quality and Verification activities

Seq. No	Activity	Input Requirement / Specifications	Place	Quality process		Verification process		Contractor		ELI-BL	
				Input	Output	Input	Output	Quality	Verification	Quality	Verification
1	Detailed project schedule, detailed engineering design (Deliverables D1, D2A, D2B, D3)										
1.1	Contract kick-off and planning meeting	Kick off meeting agenda	ELI-BL or Contractor	n/a	Minutes	n/a	n/a	R	n/a	R	n/a
1.2	Design of specific components, drawings and schemes	Detailed concept design and 3D models, detailed engineering drawings for components and subsystems	ELI-BL or Contractor	Engineering drawings and schemes	Critical Design Review Report (CDRR), QR (Quality Report)	Engineering drawings and schemes	CDRR VP VCD (Annex 3 of the Contract)	n/a	RoD	H	RoD
1.3	Design of utilities distribution and integration with facility	Detailed technical specifications (Annex 2 of the contract)	ELI-BL or Contractor	Engineering drawings and schemes	Critical Design Review Report (CDRR)	Engineering drawings and schemes	CDRR	n/a	RoD	H	RoD
1.4	Review of the contractor qualifications and procedures before launching fabrication	Contractor qualifications and procedures	Contractor	Contractor qualifications and procedures	Inspection report	n/a	n/a	n/a	n/a	W	I
1.5	Failure Mode and Effect Analysis (FMEA)	Detailed technical specifications (Annex 2 of the contract)	ELI-BL or Contractor	Detailed technical specifications	Analysis Report (AR)	n/a	n/a	AR/H	A	R	RoD
1.6	Vacuum control system (VCS) state machine design specifications	Detailed technical specifications (Annex 2 of the contract)	ELI-BL or Contractor	Design documentation	RoD report	Design documentation	RoD report	H	RoD	R	RoD
1.7	Motion Control System (MCS) configuration specifications	Detailed technical specifications (Annex 2 of the contract)	ELI-BL or Contractor	Design documentation	RoD report	Design documentation	RoD report	H	RoD	R	RoD
1.8	VCS and MCS software component design	Detailed technical specifications (Annex 2 of the contract)	ELI-BL or Contractor	Design documentation	RoD report	Design documentation	RoD report	H	RoD	R	RoD

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Seq. No	Activity	Input Requirement / Specifications	Place	Quality process		Verification process		Contractor		ELI-BL	
				Input	Output	Input	Output	Quality	Verification	Quality	Verification
2	**Factory testing and performance verification at the Supplier (Deliverables D4, D6, D8, D9, D10, D11, and D12)**										
2.1	Welding coordination tasks and responsibilities	ČSN EN ISO 14731 * (equivalent to EN ISO 14731 *)	Contractor	ČSN EN ISO 14731 * (equivalent to EN ISO 14731 *)	Certificates	n/a	n/a	H	I	R	I
2.2	Welding personnel qualifications	ČSN EN ISO 9606 *, ČSN EN ISO 14732 * or relevant (equivalents to EN ISO 9606*, EN ISO 14732 *)	Contractor	ČSN EN ISO 9606 *, ČSN EN ISO 14732 * or relevant (equivalents to EN ISO 9606*, EN ISO 14732 *)	Certificates	n/a	n/a	H	I	R	I
2.3	Inspection of the new material and components, traceability	Raw material certificates and contractor traceability procedures	Contractor	Raw material certificates and contractor traceability procedures	Certificates and procedures	n/a	n/a	H	I	R	I
2.4	Welding inspection	Production drawings (D2A and D2B Deliverables), welding procedures, welding sequence plan	Contractor	Production drawings, welding procedures, welding sequence plan	Inspection report	n/a	n/a	H	n/a	W	n/a
2.5	NDT inspection of the vacuum chambers	NDT procedures	Contractor	NDT procedures	Inspection report	NDT specifications	Test / Inspection report	H	T, I	R	R, I
2.5a	Visual inspection 100% EN ISO 17637 *	ČSN EN ISO 5817 * (equivalent to EN ISO 5817 *), evaluation group B	Contractor	Criteria according to ČSN EN ISO 5817 * (equivalent to EN ISO 5817 *), evaluation group B, product to be verified	Inspection report	Criteria according to ČSN EN ISO 5817 * (equivalent to EN ISO 5817 *), evaluation group B, product to be verified	Inspection report	H	I	W	R, I
2.5b	Surface crack test /PT/ of all load bearing parts and vacuum welds EN ISO 17637 *	ČSN EN ISO 23277 * (equivalent to EN ISO 23277 *), evaluation group 1	Contractor	Criteria according to ČSN EN ISO 23277 * (equivalent to EN ISO 23277 *), evaluation group 1, product to be verified	Inspection report	Test specifications	Test / Inspection report	H	T, I	W	R, I

** Regarding the referred standards or standardized/ standardizing technical documents the Client allows also another equivalent solution to be offered.*

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Seq. No	Activity	Input Requirement / Specifications	Place	Quality process		Verification process		Contractor		ELI-BL	
				Input	Output	Input	Output	Quality	Verification	Quality	Verification
2.6	Vacuum control systems (VCS) offline testing of sequences and failure mode handling	Vacuum control systems state machine design specification	Contractor	Vacuum control system state machine design specification	Quality report	Test specifications	Test report	H	T	W	R, I
2.7	Machine Safety and Personnel Safety Interlock systems simulated interface functional testing	Control system design specifications	Contractor	Vacuum control system state machine design specification	Quality report	Test specifications	Test report	H	T	W	R, I
2.8	Optomechanical motion control systems (MCS) basic functional demonstration	Motion control systems design specification	Contractor	Motion control system design specification	Quality report	FD specifications	Inspection report	H	FD, I	W	I, I
2.9	Inspection of the finished chamber structure including visual inspection, surface and dimensional control	Production drawings Detailed Technical Specifications (Annex 2 of the Contract)	Contractor	Production drawings, Detailed Technical Specifications	Inspection control report	Production drawings, Detailed Technical Specifications	Inspection and dimensional control report	H	T, I	W	R, I
2.10	Measurement of deformations of the vacuum chambers walls upon pump down	Production drawings Detailed Technical Specifications (Annex 2 of the Contract)	Contractor	Production drawings, Detailed Technical Specifications	Quality report	Test specifications	Test report	H	T, I	W	R, I
2.11	Inspection of the cleaned vacuum chambers, vacuum leak and vacuum cleanliness tests	Manufacturing requirements including the cleaning procedure Vacuum test requirements	Contractor	Manufacturing requirements including cleaning procedure Vacuum test requirements	Quality report	Manufacturing requirements including cleaning procedure Vacuum test requirements	Test report	H	T, I	W	R, I
2.12	Acceptance of each of the vacuum chambers vacuum tested	Detailed technical specifications (Annex 2 of the contract)	Contractor	Detailed technical specs (Annex 2 of the contract)	Inspection and Test report	Detailed technical specs (Annex 2 of the contract)	Test report	H	T, I	W	R, I
2.13	Inspection of the optical support chassis assembly and cleanliness inspection	Production drawings Cleaning procedures	Contractor	Production drawings, Cleaning procedures	Inspection control report	Production drawings, Cleaning procedures	Inspection control report	H	T, I	W	R, I

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Seq. No	Activity	Input Requirement / Specifications	Place	Quality process		Verification process		Contractor		ELI-BL	
				Input	Output	Input	Output	Quality	Verification	Quality	Verification
2.14	Verification of mechanical functioning of optomechanical mounts	Production drawings, Detailed technical specifications (Annex 2 of the contract)	Contractor	Production drawings, Detailed technical specifications (Annex 2 of the contract)	Quality report	Detailed technical specs (Annex 2 of the contract)	Test report	H	T, I	W	R, I
2.15	Verification of operation of optomechanical mounts with electrical actuators	Production drawings, Detailed technical specifications (Annex 2 of the contract)	Contractor	Production drawings, Detailed technical specifications (Annex 2 of the contract)	Quality report	Detailed technical specs (Annex 2 of the contract)	Test report	H	T, I	W	R, I

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Seq. No	Activity	Input Requirement / Specifications	Place	Quality process		Verification process		Contractor		ELI-BL	
				Input	Output	Input	Output	Quality	Verification	Quality	Verification
3	**Delivery, installation and performance verification at ELI-Beamlines (Deliverables D5, D7, D8, D9, D10, D11, and D12)**										
3.1	Packaging for transport	Packaging for transport	Part list Shipping specifications	Contractor	Part list Shipping specifications	Shipping list	n/a	n/a	H	I	W
3.2	Shipping and reception at ELI-Beamlines	Shipping and reception specifications	ELI-BL	Shipping and reception specifications	Reception report	n/a	n/a	W	I	H	I
3.3	Unpacking and inspection	Unpacking and storage specifications Manual / specifications for installation	ELI-BL	Unpacking and storage specifications Manual /specifications for installation	Reception report	n/a	n/a	n/a	n/aI	H	I
3.4	Acceptance of each of the vacuum chambers connected to ELI primary vacuum and utilities	Detailed technical specifications (Annex 2 of the contract) Installation procedure	ELI-BL	Detailed technical specifications (Annex 2 of the contract) Installation procedure	Installation report	Installation procedure	Test report	n/a	n/a	H	T

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Seq. No	Activity	Input Requirement / Specifications	Place	Quality process		Verification process		Contractor		ELI-BL	
				Input	Output	Input	Output	Quality	Verification	Quality	Verification
3.5	Acceptance of each of the optical support chassis installed in vacuum chamber, assembled with double bellows, and vacuum tested	Installation procedure Detailed technical specifications (Annex 2 of the contract) Vacuum cleanliness specifications	ELI-BL	Installation procedure Detailed technical specifications (Annex 2 of the contract) Vacuum cleanliness specifications	Acceptance certificate	Installation procedure	Installation and Test report	n/a	n/a	H	T
3.6	Verification of operation of Vacuum Control System (VCS) for each compressor and injector, including pump sequences testing	Detailed technical specifications (Annex 2 of the contract) Manufacturing documentation	ELI-BL	Detailed technical specifications (Annex 2 of the contract) Manufacturing documentation	Test report	Detailed technical specifications (Annex 2 of the contract)	Test report	n/a	n/a	H	T
3.7	Installation of optomechanical mounts into each compressor	Installation procedure Detailed technical specifications (Annex 2 of the contract)	ELI-BL	Installation procedure Detailed technical specifications (Annex 2 of the contract)	Installation report	Detailed technical specifications (Annex 2 of the contract)	Installation report	n/a	n/a	H	T
3.8	Installation of optomechanical mounts into each injector	Installation procedure Detailed technical specifications (Annex 2 of the contract)	ELI-BL	Installation procedure Detailed technical specifications (Annex 2 of the contract)	Installation report	Detailed technical specifications (Annex 2 of the contract)	Installation report	n/a	n/a	H	T
3.9	Verification of optomechanical mounts operation with Motion Control System (MCS)	Detailed technical specifications (Annex 2 of the contract) Manufacturing documentation	ELI-BL	Detailed technical specifications (Annex 2 of the contract) Manufacturing documentation	Test report	Detailed technical specifications (Annex 2 of the contract)	Inspection and Test report	n/a	n/a	H	T

Note: Regarding the referred standards or standardized/ standardizing technical documents throughout this document, the Client allows also another equivalent solution to be offered.

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ANNEX 4

PRICES

Item No.	Item	Price CZK excl. VAT per item
1a	**Price of the L2 Compressor** (the full scope of the L2 Compressor as statetd by the Purchase contract: the design, manufacture, testing, transport to, and installation in ELI-Beamlines, the integrated of system of the vacuum chambers for the L2 grating compressor and of the L2 beam injector, of the internal structures of the chambers including the optomechanical mounts and of the full vacuum and motion controls)	**45 889 000,00**
1b	**Price of the L4PW Compressor** (the full scope of the L4PW Compressor as statetd by the Purchase contract: the design, manufacture, testing, transport to, and installation in ELI-Beamlines, of the integrated system of the vacuum chambers of the L4PW grating compressor and of the L4PW beam injector, of the internal chassis of the compressors including the optomechanical mounts and of integrated vacuum and motion controls	**51 436 000,00**
1	**Purchase Price according to art. 8.1 of the Purchase contract** *(i.e. the price for the Objects of Purchase - the L2 Compressor and the L4PW Compressor - without Options)*	**97 325 000,00**
2	**Option 1: Optional design and manufacture of the tubing for interconnection of L2 injector with L2 distribution**	**159 000,00**
3	**Option 2: Optional design and manufacture of the tubing for interconnection of L4PW injector with L4PW distribution**	**194 000,00**
4	**Option 3: Optional design and manufacture of the L2 mid-IR periscope chamber and of its internal supporting structures**	**2 145 000,00**
5	**Option 4: Optional design, manufacture and installation of beam polarization switch optomechanical mounts in the L4PW compressor**	**669 000,00**
Total Bid Price excl. VAT CZK		**100 492 000,00**

ANNEX 5

SUPPLIER'S BID

A) Warranty periods

The Supplier provides a warranty of quality:

- on the turbomolecular pumps (remaining warranty) for the period of 36 months;
- on the Vacuum Control System and on the Motion Control System of the Objects of Purchase for the period of 36 months;
- on the optomechanical mounts of the Objects of Purchase for the period of 36 months.

B) Qualification prerequisites

The Supplier shall carry out assembly and testing works hereunder in the cleanroom spaces described within the Bid as follows:

The economic operator hereby declares that it has available a cleanroom space of Class 7 or better with minimal dimensions 8 m x 5 m x 3 m (height)
Brief description of the cleanroom space:
ISO Class 7 cleanroom space in DELONG INSTRUMENTS own premises, with 200 m^2 floor surface, with dimension 18 x 12 m, and with height 3,5 m For testing of large vacuum units and/or large optomechanical assemblies 

The economic operator hereby declares that it has available a cleanroom space of Class 5 or better with minimum surface 20 m^2 for assembling and testing of optomechanical units required in this procurement
Brief description of the cleanroom space:
ISO Class 5 cleanroom space in DELONG INSTRUMENTS own premises, floor surface 50 m^2, with surface dimensions 10 x 5 m For assembling and testing of optomechanical units

The Supplier shall use the following persons it identified within its Bid for performing this Contract while carrying out all the relevant activities hereunder:

Team member position		
Senior Optomechanical Designer	**Name**:	Ing. Tomáš Bejdák
Junior Optomechanical Designer	**Name**:	Ing. Miroslav Florián
Junior Optomechanical Designer	**Name**:	Ing. Lukáš Chmela
Junior Optomechanical Designer	**Name**:	Ing. Michal Andrys
Senior Electronic Engineer	**Name**:	Ing. Jan Robotka
Junior Electronic Engineer	**Name**:	Ing. Petr Dobiáš

Junior Electronic Engineer	**Name**:	Ing. Jan Novotný
Welding Coordination Supervisor	**Name**:	Petr Vítek
Qualified Welder	**Name**:	Jan Landkamr
Qualified Welder	**Name**:	Ondřej Šindelář

The Supplier is allowed to use another cleanroom spaces or another persons only if it proves that such spaces or persons meet the requirements for cleanroom spaces or team members stated in the procurement documentation issued for the purposes of the Public Contract award.