



PURCHASE CONTRACT

This purchase contract ("**Contract**") was concluded pursuant to section 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) **Institute of Physics of the Academy of Sciences of the Czech Republic, a public research institution,**

with its registered office at: Na Slovance 2, Praha 8, PSČ: 182 21,

registration no.: 68378271,

represented by: RNDr. Michael Prouza, Ph.D., director

("Buyer"); and

- (2) **Lastronics Jena GmbH**

with its registered office at: Moritz-von-Rohr-Straße 9, 07745 Jena, Germany

registration no.: Jena HRB 504004, ID 19604077

represented by: Dr. Thomas Töpfer

enrolled in the commercial register kept by Amtsgericht Jena (District Court)

("Seller").

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

WHEREAS

- (A) The Buyer is a public contracting authority and the beneficiary of public grants for projects within the Operational Programme Research, Development and Education.
- (B) For the successful realization of 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, and Rules for the Selection of Suppliers within the Operational Programme Research, Development and Education.
- (C) The Seller wishes to provide the Objects of Purchase to the Buyer for consideration.
- (D) The Seller's bid for the public procurement entitled "*High Power Laser Diodes TP2O_030 II.*", whose purpose was to procure the Objects of Purchase ("**Public Procurement**"), was selected by the Buyer as the most suitable.

IT WAS AGREED AS FOLLOWS:



1. BASIC PROVISIONS

- 1.1 Under this Contract the Seller shall hand over to the Buyer 2 pieces of diode modules (including all accessories) that are described in Annex 1 (*Technical Specification*) to this Contract in the quality described therein (“**Objects of Purchase**”) and shall transfer to the Buyer ownership right to the Objects of Purchase, and the Buyer shall take over the Objects of Purchase and shall pay the Seller the Purchase Price (as defined below), all under the terms and conditions stipulated in this Contract.
- 1.2 Under this Contract the Seller shall also:
- a) carry out factory acceptance tests (REQ-030060/A);
 - b) verify that Objects of Purchase meet all requirements stipulated in this Contract;
 - c) transport the Objects of Purchase to the place of delivery under the conditions stipulated in Annex 1 (*Technical Specification*);
 - d) to elaborate and hand over to the Buyer operational and maintenance manuals of the Objects of Purchase in the extent specified in Annex 1 (*Technical Specification*) or other documents which are necessary for the proper takeover and use of the Objects of Purchase in Czech or English language;
 - e) carry out other activities specified in Annex 1 (*Technical Specification*); and
 - f) cooperate with the Buyer during the performance of this Contract
- (“**Related Activities**”).

2. THE PLACE OF DELIVERY

The place of delivery is at the address: Fyzikální ústav AV ČR v.v.i/ELI beamlines, Průmyslová 836, post code 252 41, Dolní Břežany, Czech Republic.

3. THE TIME OF DELIVERY

- 3.1 The Seller shall deliver the Objects of Purchase within 10 months from the effectiveness of this Contract. The Buyer is entitled to postpone the time of delivery by 1 months, if the premises at the place of delivery are not due to construction reasons prepared for acceptance of the Object of Purchase.

The Buyer shall extend the time of delivery at the request of the Seller, if the Seller is not able to fulfill this Contract due to circumstances that the Seller had no control over and such circumstances were hard to anticipate and are hard to overcome (e.g. covid-19 measures). In order for the Buyer to extend the time of delivery, the Seller must prove to the Buyer that such circumstances happened and explain how it adversely impacted the Seller. In case of doubts, the Buyer may also ask the Seller to support its claims with an adequate evidence. The Buyer shall extend the time of delivery by the period



corresponding to the time that is necessary for obstacles to disappear or to be overcome by the Seller.

4. **THE OWNERSHIP RIGHT**

The ownership right to the Objects of Purchase shall be transferred to the Buyer upon the acceptance of the Objects of Purchase by the Buyer.

5. **DESIGN**

- 5.1 The Parties are aware that the Seller has to design the Objects of Purchase in such a way that the requirements of this Contract are met. The Seller shall submit the final version of design of the Objects of Purchase to the Buyer for approval. The Buyer approves of the design within 3 weeks if the requirements of this Contract are met. The Buyer is entitled to comment on the design and propose some modifications. The Seller shall either incorporate such modifications (if these are in compliance with the requirements of this Contract) or shall explain why it refuses to do so. By approving the design the Buyer does not take responsibility for any potential flaws of the design which would result in the defects and deficiencies of the Objects of Purchase, i.e. the Seller is solely responsible that the requirements imposed on the Objects of Purchase under this Contract are met.

6. **PRICE AND PAYMENT TERMS**

- 6.1 The purchase price for the Objects of Purchase is **284.400,-** EUR (“**Purchase Price**”) without value added tax (“**VAT**”). VAT will be paid in accordance with the applicable legal regulations.
- 6.2 The Purchase Price cannot be exceeded and includes all costs and expenses of the Seller related to the performance of this Contract. The Purchase Price includes, among others, all expenses related to the handover and acceptance of the Objects of Purchase and execution of Related Activities, costs of copyright, insurance, customs, warranty service and any other costs and expenses connected with the performance of this Contract.
- 6.3 The Purchase Price for the Objects of Purchase shall be paid in EUR on the basis of a tax document – invoice, to the account of the Seller designated in the invoice.
- 6.4 The Purchase Price shall be paid in the following matter:
- a) 40% of the Purchase Price shall be paid after the Buyer approves of the design of the Objects of Purchase;
 - b) 20% of the Purchase Price shall be paid after successful factory acceptance tests;
 - c) 40% of the Purchase Price shall be paid after the acceptance of the Objects of Purchase by the Buyer.
- 6.5 The Buyer shall realize payments on the basis of duly issued invoices within 30 days from their receipt (maturity period). The invoice shall be considered to be paid for on the day



when the invoiced amount is deducted from the Buyer's account on behalf of the Seller's account. To avoid any doubts Parties declare that if on the invoice is stated a maturity period that is shorter than 30 days, then such maturity period may be disregarded by the Buyer.

6.6 The invoice issued by the Seller as a tax document must contain all information required by the applicable laws of the Czech Republic. Invoices issued by the Seller in accordance with this Contract shall contain in particular following information:

- a) name and registered office of the Buyer,
- b) tax identification number of the Buyer,
- c) name and registered office of the Seller,
- d) tax identification number of the Seller,
- e) registration number of the tax document,
- f) scope of the performance (including the reference to this Contract),
- g) the date of the issue of the tax document,
- h) the date of the fulfilment of the Contract,
- i) Purchase Price,
- j) registration number of this Contract, which the Buyer shall communicate to the Seller based on Seller's request prior to the issuance of the invoice,
- k) declaration that the performance of the Contract is for the purposes of a specific project (the number and the title of the project shall be communicated to the Seller based on Seller's request prior to the issuance of the invoice).

6.7 The Buyer prefers electronic invoicing on the following address: efaktury@fzu.cz.

6.8 In case that the invoice shall not contain the above mentioned information, the Buyer is entitled to return it to the Seller 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 Buyer.

7. **SELLER'S DUTIES**

7.1 The Seller shall ensure that the Objects of Purchase and Related Activities are in compliance with this Contract including all its annexes and applicable legal (e.g. safety), technical and quality norms.

7.2 During the performance of this Contract the Seller proceeds independently. If the Seller receives instructions from the Buyer, the Seller shall follow such instructions unless these are against the law or in contradiction to this Contract. If the Seller finds out or should



have found out if professional care was exercised that the instructions are for any reason inappropriate or illegal or in contradiction to this Contract, then the Seller must notify the Buyer.

- 7.3 All things necessary for the performance of this Contract shall procure the Seller, unless this Contract stipulates otherwise.
- 7.4 The Seller is aware that the Buyer does not have at its disposal premises for the storage of packaging and, therefore, shall not store packaging of the Objects of Purchase. The absence of original packaging cannot be an excuse for refusal of elimination of defects of the Objects of Purchase.

8. **HANDOVER AND ACCEPTANCE OF THE OBJECTS OF PURCHASE**

- 8.1 The Objects of Purchase shall be delivered to the place of delivery and handed over to the Buyer within the time stipulated in this Contract.
- 8.2 If the Seller fails to duly carry out all Related Activities or if the Objects of Purchase do not meet requirements of this Contract, the Buyer is entitled to refuse the acceptance of the Objects of Purchase. In such a case the Seller shall remedy the deficiencies within ten (10) working days, unless Parties agree otherwise. The Buyer is entitled (but not obliged) to accept the Objects of Purchase despite the above mentioned deficiencies, in particular if such deficiencies do not prevent the Buyer in the proper operation of the Objects of Purchase. In such a case the Buyer shall notify the deficiencies to the Seller. The Seller shall remove the deficiencies within ten (10) working days, unless Parties (due to the nature of deficiencies) agree otherwise.

9. **WARRANTY**

- 9.1 The Seller shall provide a warranty of quality of the Objects of Purchase for the period of 24 months. If on the warranty list or other document is the warranty period of longer duration, then this longer warranty period shall have priority over the period stated in this Contract.
- 9.2 The warranty period shall begin on the day of the acceptance of the Objects of Purchase by the Buyer.
- 9.3 The Seller shall remove defects that occur during the warranty period free of charge and in the terms stipulated in this Contract.
- 9.4 If the Buyer ascertains a defect of the Objects of Purchase during the warranty period, the Buyer shall notify such defect without undue delay to the Seller. Defects may be notified on the last day of warranty period, at the latest.
- 9.5 The Buyer notifies defects in writing via e-mail. The Seller shall accept notifications of defects on the following e-mail address: ragnar.boedefeld@lastronics.com. The Seller shall confirm within 24 hours from the receipt of the notification.



- 9.6 In the notification the Buyer shall describe the defect and the manner of removal of the defect. The Buyer has the right to:
- a) ask for the removal of the defect by the delivery of new Objects of Purchase or its individual parts, or
 - b) ask for the removal of the defect by repair, or
 - c) ask for the reasonable reduction of the Purchase Price.

The choice among the above mentioned rights belongs to the Buyer. The Buyer shall take into account the recommendation of the Seller.

- 9.7 The Seller shall remove the defect within 10 working days from its notification, unless Parties agree otherwise due to the nature of the defect or special circumstances of the case.
- 9.8 Parties shall execute 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 shall be extended by a period of time that elapses between the notification of the defect until its removal.
- 9.9 In case that the Seller does not remove the defect within stipulated time or if the Seller refuses to remove the defect, then the Buyer is entitled to remove the defect at his own costs and the Seller shall reimburse these costs within 10 days after the Buyer's request to do so.
- 9.10 The warranty does not cover defects caused by unprofessional manipulation or by the failure to follow Seller's instructions for the operation and maintenance of the Objects of Purchase.

10. **PENALTIES**

- 10.1 If the Seller is in delay with the delivery of the Objects of Purchase to the place of delivery, it shall pay to the Buyer a contractual penalty in the amount of 0,05% of the Purchase Price for every (even commenced) day of delay.
- 10.2 If the Seller is in delay with the removal of the defect, the Seller shall pay to the Buyer a contractual penalty in the amount of 0,05% of the Purchase Price for every (even commenced) day of delay.
- 10.3 The Seller shall pay contractual penalties within fifteen (15) days from the day, on which the Buyer enumerated its claims. The payment of contractual penalties shall not affect the right of the Buyer to damages even to the extent to which such damages exceeds the contractual penalty.
- 10.4 The total amount of contractual penalties imposed on the Seller shall not exceed 7% of the Purchase Price.



10.5 The Buyer is entitled to unilaterally set off claims arising from the contractual penalties against the claim of the Seller for the payment of the Purchase Price.

11. **RIGHT OF WITHDRAWAL**

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

- a) the Seller shall be in delay with the fulfilment of this Contract and such delay lasts more than 4 weeks;
- b) the insolvency proceeding is initiated against the Seller; or
- c) the Buyer ascertains that the Seller provided in its bid for the Public Procurement 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, which preceded the conclusion of this Contract.

12. **SPECIAL PROVISIONS**

By signing this Contract, the Seller becomes a person that must cooperate during the finance control within the meaning of Section 2 letter e) of the act no. 320/2001 Coll., on finance control in the public administration, and shall provide to the Directing Body of the Operational Programme Research, Development and Education or other control bodies access to all parts of the bid, Contract or other documents that are related to the legal relationship formed by this Contract. This duty also covers documents that are subject to the protection in accordance with other acts (business secrets, secret information, etc.) provided that control bodies fulfil requirements stipulated by these acts. The Seller shall secure that all its subcontractors are also obliged to cooperate with control bodies in the above stipulated extent. The possibility of effective control must be preserved until the year 2033.

13. **FINAL PROVISIONS**

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

13.2 The terms and conditions of this Contract represent the whole agreement between the Parties regarding the subject matter of this Contract and any prior or oral agreements have been either consolidated into this Contract or are disregarded by the Parties.

13.3 Parties acknowledge that this Contract shall be published in the Register of Contracts in accordance with the Act no. 340/2015 Coll., on the Register of Contracts.

13.4 All disputes arising out of this Contract or out of legal relations connected with this Contract shall be preferable 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.



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- 13.5 The Seller is not entitled to set off any of its claims or his debtor's claims against the Buyer's claims. The Seller is not entitled to transfer its claims against Buyer that arose on the basis or in connection with this Contract on third parties. The Seller is not entitled to transfer rights and duties from this Contract or its part on third parties.
- 13.6 All modifications and supplements of this Contract must be in writing.
- 13.7 If any of provisions of this Contract are invalid or ineffective, the Parties are bound to change this Contract is 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.
- 13.8 This Contract is executed in four (4) counterparts and every Party shall receive two (2) counterparts.
- 13.9 An integral part of this Contract is Annex 1 (*Technical Specification*) including all its annexes. If Annex 1 (*Technical Specification*) uses the term "Contracting Authority", it means Buyer and if it uses the term "Supplier", it means Seller.
- 13.10 This Contract shall be valid on the date of the signature of both Parties and effective on the day, on which it is published in the Register of Contracts.

IN WITNESS WHEREOF attach Parties their handwritten signatures:

Buyer

Signature: _____

Name: RNDr. Michael Prouza, Ph.D.,

Position: director

Date:

Seller

Signature: _____

Name: Dr. Thomas Töpfer

Position: CEO

Date:



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ANNEX 1

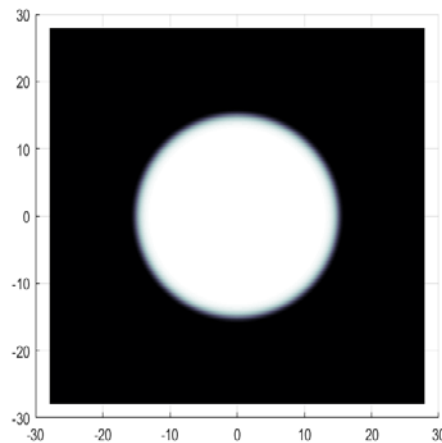
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RSD product category B

High Power Laser Diodes

TP20_030 II.



Keywords

Laser, Diode

	Position	Name
Responsible person	Senior Researcher / Laser 2	Jonathan Tyler Green
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<i>Reviewed By</i>			
<i>Name (Reviewer)</i>	<i>Position</i>	<i>Date</i>	<i>Signature</i>
Bedřich Rus	Scientific Coordinator of Laser Technology (RP1)	<i>Informed (RSD category B)</i>	
Daniel Kramer	Chief Optical Designer	<i>Informed (RSD category B)</i>	
Ladislav Půst	Manager Installation of Technology	<i>Informed (RSD category B)</i>	
Luboš Nims	Head of Electrical Engineering	<i>Informed (RSD category B)</i>	
Pavel Bakule	Team Leader Scientific L1&BT	<i>Informed (RSD category B)</i>	
Veronika Olšovcová	Safety Team Manager	<i>Informed (RSD category B)</i>	
Viktor Fedosov	SE & Planning Group Leader; Quality Manager	<i>Informed (RSD category B)</i>	

<i>Approved by</i>			
<i>Name (Approver)</i>	<i>Position</i>	<i>Date</i>	<i>Signature</i>
Bedřich Rus	Scientific Coordinator of Laser Technology (RP1)		

<i>Revision History / Change Log</i>				
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3	J.T.Green, A.Kuzmenko	15.06.2020	RSD update - version for approval by the author	C
4	A.Kuzmenko	17.06.2020	Released version of the RSD	D

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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints for the selection of a two high energy, high average power-pump diode modules which are to be delivered to ELI Beamlines. These diodes will be used within the scope of the DUHA project.

1.2. Scope

This RSD contains all of the technical requirements: functional, performance and design, delivery, safety and quality requirements for the following product (tender number: TP20_030): **High Power Laser Diodes** (further "**Diodes**").

The diodes will be located in the L2 laser hall and will drive the main pump laser for the AMOS beamline within the scope of the DUHA project. The products are registered in the PBS database under the following PBS codes: RA1.L2.L2_1.PL.PL1.MPA.LH.7.PL2 and RA1.L2.L2_1.PL.PL1.MPA.LH.7.PL1.

These products are **Category B products** according to the ELI Beamlines RSD categories. The category B is an Off-the-shelf Product with customization (e.g., product performance, dimensions and etc.) that does not require any design modifications of the product. All verification activities performed by a supplier shall be executed in accordance with the supplier's plan of outgoing inspection and tests. The verification of all specified parameters listed in this RSD shall be undertaken by the supplier before delivery to the ELI Beamlines facility and all items shall be furnished with a verification protocol and a declaration of conformity, to reflect their proper characteristics. Furthermore, all items may be subject to testing and verification upon delivery to the ELI Beamlines facility by qualified personnel. All non-conformances (if any) must be addressed by the supplier in a timely manner.

1.3. Terms, Definitions and Abbreviations

For the purpose of this document, the following abbreviations apply:

Abbreviation	Meaning
BNC	Bayonet Neill-Concelman coaxial connector
CA	Contracting Authority (Institute of Physics AV CR, v. v. i.)
CDA	Clean dry air
ELI	Extreme Light Infrastructure
FWHM	Full Width Half Maximum
HR	High Reflectivity
HTTP	HyperText Transfer Protocol: a specific web application protocol
JSON	JavaScript Object Notation: a specific open standard for data objects text representation
LXI	LAN (Local Area Network) eXtensions for Instrumentation: a specific open standard for text-based instrument control over a

Abbreviation	Meaning
	network
Modbus	Modicon bus: a specific serial communications protocol
OPC UA	OLE (Object Linking and Embedding) for Process Control, Unified Architecture: a specific machine-machine communication protocol
PLC	Programmable Logic Controller: a specific type of industrial ruggedized digital computer
REST API	Representational State Transfer, Application Programming Interface: a specific web service architectural style
RMS	Root Mean Square
RSD	Requirements Specification Document
SCPI	Standard Commands for Programmable Instruments: a specific open standard for text based instrument control
TCP/IP	Transmission Control Protocol/Internet Protocol: a specific network communication protocol
TTL	Transistor–Transistor Logic
V DC	Volts, Direct Current
XML	Extensible Markup Language: a specific open standard for document markup

1.4. Reference documents

Number of document	Title of Document/ File
RD-01	00273560-A_3.2_ES_VCD_High Power Laser Diodes_TP20_030

1.5. 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 the requirements including references to standards or technical documents.

2. Functional, Performance and Design requirements

2.1. General requirements for the Diodes

REQ-029997/A

The **Diodes** shall meet the general requirements defined in Table 1.

Verification method: R – review, T - test

REQ-029998/A

The performance and stability parameters of **Diodes** specified in Table 1 shall be satisfied for the following ambient environmental conditions and lab infrastructure:

- 1) Room temperature 20 °C, stability ± 0.5 °C, Humidity 50 %;
- 2) Facility water provided to chillers: 16 °C, inlet pressure max. 5 bar on input, differential pressure between input and output: 1.5 bar;
- 3) Clean dry air (CDA) purity: Class 1:1:1 to ČSN ISO 8573-1:2013 (equivalent to ISO 8573-1:2010), pressure adjustable up to 6 bar, flow adjustable to 100 l/min (preferred interface is Swagelok compression fitting or G1/4 female parallel thread).

NOTE: Regarding the referred to standard/s the CA allows/permits also another equal solution to be offered.

Verification method: R – review

REQ-030000/A

Spectral, spatial, temporal characteristics and stability as defined in Table 1 shall be satisfied simultaneously over the full range of required repetition rates and pulse durations specified in Table 1 unless otherwise specified.

NOTE 1: The plateau of the beam profile (referred to in subsequent specifications) is defined as a circle, concentric with the center of the profile, and a diameter equal to the width of the central region of the profile cross section containing 85 % of the cross sectional area. The cross section is to be taken at the minimum width of the profile. See Figure 1 for clarification.

NOTE 2: The parameters in Table 1 are taken to be after the final optical element of the diode modules.

Verification method: R – review

Table 1: Technical Parameters of laser diode modules

#	Parameter	Required value (description)
1.1	Repetition rate (Hz)	1 - 50, tunable Nominal rep rate: 50 Hz
1.2	Pulsed Peak Power (kW)	≥ 37 (33 nominal)
1.3	Pulse Duration (ms)	0.6 – 0.8 tunable
1.4	Central Wavelength (wavelength above and below which 50% of the total energy is contained) for average output powers between 500 W and 1000 W, λ_0 (nm)	Between 938.5 and 939.5
1.5	Maximum drift over 6 h in central wavelength after warm up for fixed duty cycle and pulse energy (nm)	± 0.5
1.6	Bandwidth	> 30 % of total energy contained with ± 1 nm of λ_0 > 70 % of total energy contained within -3.5 nm and +2.5 nm of λ_0
1.7	Central Wavelength tunability via bias current or cooling water temperature (nm)	> 1 nm
1.8	Polarization	Vertical with respect to optical table plane, 90 % polarization extinction ratio
1.9	Distance to working plane from final optical element of the diode module (can be changed in agreement with CA based on diode module dimensions) (mm)	> 600 ± 20
1.10	Profile shape in working plane	Circular, octagonal, or hexagonal top hat, super-Gaussian
1.11	FWHM diameter or distance between parallel sides of an octagon/hexagon (mm)	30 ± 1
1.12	Slope of spatial profile sides $\frac{\Delta r_{90\% - 10\%}}{\text{FWHM}}$	< 5 %
1.13	Plateau homogeneity as percentage of plateau intensity (peak to valley)	5 %
1.14	Beam height above table (mm)	150 ± 1
1.15	Temporal Pulse shape (integrated over spatial profile)	Flat
1.16	Rise/fall times of pulses (10% - 90% peak intensity)	< 60 μs
1.17	Pulse to pulse energy stability for 10 000 pulses (peak to valley with respect to the average of all pulses)	< 2 %
1.18	Long term average power stability (6 hour) measured with thermal power meter or shot to shot meter with 3 s moving average (peak to valley)	< 3 %

#	Parameter	Required value (description)
1.19	Variation of instantaneous output power within the temporal plateau of the pulse at maximum output pulse duration and nominal output peak power	< 3 %
1.20	Spatial deviation of profile centroid position in target plane over 8h	< 0.5 mm

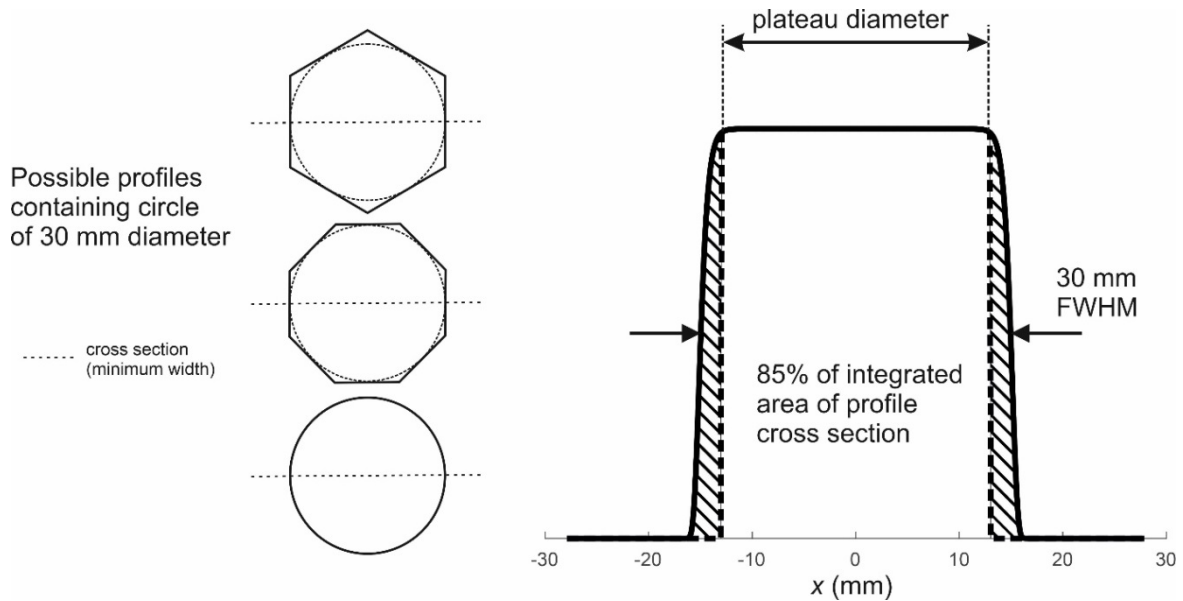


Figure 1: The desired spatial profile is a circular, octagonal, or hexagonal super-Gaussian. The plateau is the area defined in terms of the integrated area of the cross section at minimum width to maintain a consistent definition for various shapes of profile. The diameter of the plateau is taken to be the width of the region containing 85% of the cross sectional area of the profile. The slope is considered between 10% and 90% of the average intensity of the plateau. The FWHM is taken at the width at 50% the average intensity of the plateau.

REQ-030001/A

At reduced repetition rates (20 Hz and below) the diodes shall be able to operate at least the nominal output peak power (33 kW) and longer pulse duration (up to 1.5 ms).

Verification method: T - test

REQ-030002/A

The full divergence angle in a region extending ± 15 mm around the target plane in both horizontal and vertical direction shall be no more than 7 degrees. The divergence angle is given by the change of the beam width over distance, with the beam width defined as that containing 95 % of the total energy. In the bid, the Supplier shall provide calculated intensity distributions for 1) the near field beam profile in the target plane, 2) near field ± 15 mm away from the target plane, 3) far field.

Verification method: R – review

REQ-030003/A

The sources may be exposed to on-axis optical feedback both at the pump wavelength and at 1030 nm. 1) The diodes shall be tolerant of optical feedback at the operation wavelength (940 nm) of up to 10% of the maximum output power without degradation of performance. 2) The diodes shall tolerate feedback in the form of a collimated 1030 nm laser beam with a circular profile, 30 mm in diameter, with a pulse duration down to 1 ns and pulse energy up to 20 mJ.

NOTE: To achieve this, the exit windows of the diode modules should have HR coatings ($R > 99\%$) at $1030 \text{ nm} \pm 2 \text{ nm}$, and should be tilted by at least one degree relative to the optical axis.

Verification method: R – review

REQ-030004/A

At least one alignment beam ($< 5 \text{ mW}$) with an output wavelength between 910 nm and 940 nm shall be installed to aid laser alignment. The path of the alignment beam shall be centered on the optical axis or consist of two beams which are symmetrical about the optical axis and intersect at the target plane.

Verification method: R – review, T - test

2.2. Mechanical requirements and constraints

REQ-030005/A

The laser diode modules shall be placed on the optical table and shall fit in the area indicated by the dashed boxes, which is shown in the layout of the amplifier (see Figure 2).

NOTE 1: The layout is symmetric, and the dimensions indicated on the right side apply to the left as well. The target plane of the diodes is in the center of the circular head shown in the Figure 2, 244 mm from the second dichroic turning mirror.

NOTE 2: If required, the first mirror after the diode module can be moved in the directions indicated by the purple arrows to ensure the working plane and target plane of the laser intersect.

Verification method: R – review

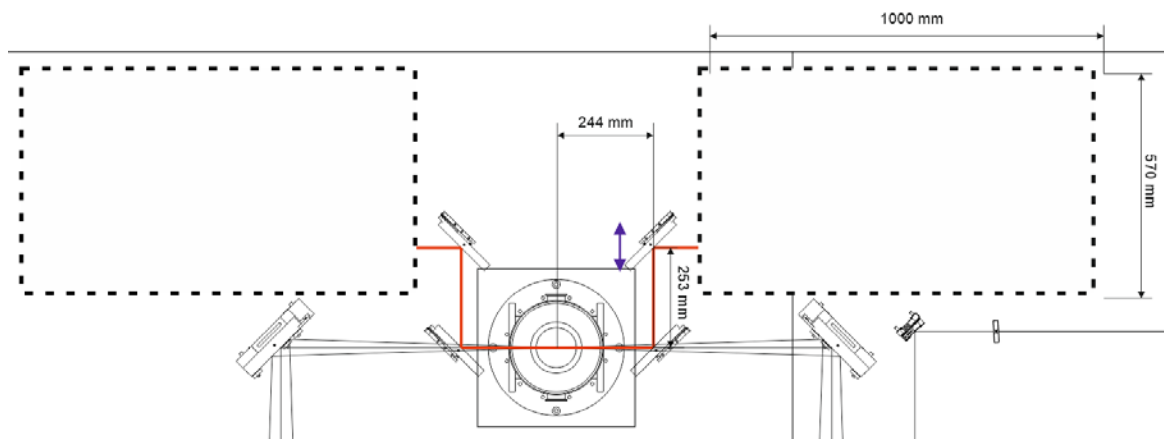


Figure 2: Amplifier head layout. Layout is symmetric and diodes should fit within the dashed areas shown. The position of the first mirror after the diode module can be adjusted in the direction of the purple arrows if necessary.

REQ-030006/A

The modules shall be mounted on suitable posts which can be rigidly clamped to the table. All materials required for clamping the modules to the table shall be provided.

Verification method: R – review

REQ-030007/A

Suitable cables or conductors with minimal length carrying the pulsed diode current shall be easily connected/disconnected, unless the sources and the pulsed power supplies form an integrated unit that does not need to be disassembled for transport. The layout of supporting electronics for pulsed power supplies shall be agreed upon with the CA. All cables shall be shielded to reduce electromagnetic emissions. Cable lengths from any rack mounted power supplies to the diode drivers shall be at most 13 m in length.

Verification method: R – review

REQ-030008/A

The modules shall be water-cooled (no fans are permitted on the modules). The temperature of the internal module cooling water shall not be outside the range of 19 °C to 32 °C.

Verification method: R – review

REQ-030009/A

If additional equipment (e.g., pulsers) will be mounted underneath the optical table, the maximum total heat dissipation into air under the table shall be less than 200 W per module. Water cooling should be used to reduce the air heat load of all under-table equipment to a minimum.

Verification method: R – review

REQ-030010/A

Any additional equipment (e.g., power supplies) not mounted on or under the optical table shall be mounted in standard 19 inch equipment racks and shall consume no more than 20 U per module (Racks will be provided by the Client). The maximum total heat dissipation into the air inside the racks shall be less than 500 W per module.

NOTE: Water cooling should be used to reduce the air heat load of this equipment. The cable distance between these racks and the optical table is 13 meters.

Verification method: R – review

REQ-030011/A

Microchannel water cooling shall be avoided, i.e. all cooling channels and tubing shall be ¼ in diameter or larger.

Verification method: R – review

REQ-030012/A

The chillers used for water cooling of the diodes, power supplies and pulsers shall be identical commercially available off-the-shelf 19-inch rack mount water-water with ± 0.1 K accuracy control, cooling capacity at least 2300 W (4.5 l/min, 3 bar), and an external interlock. The chillers shall be no more than 9U in height, no more than 640 mm deep and no more than 60 kg weight. The chillers must not have an external filter. The chillers must have front-panel filling and draining, a separate front-panel fill level sight-tube, and a front-panel status display with manual control including shutoff. The chillers must have an RS485 serial remote control interface and must be compatible with the CA's LabVIEW-based control system, the CA's external water supply and the CA's interlock system. Within two weeks from the signature of this Contract, the Supplier shall communicate to the CA, what specific product intends to use to fulfil the requirements mentioned above. The Supplier may proceed with the manufacturing of the diode module only after such product is approved by the CA. The CA shall approve of the specific product only after the Supplier demonstrates to the CA that all the relevant requirements are met.

Verification method: R – review

REQ-030013/A

Suitable, certified lifting points for simple installation shall be provided.

Verification method: R – review

REQ-030014/A

The modules, comprised of diode emitters and all required optics, shall be assembled in a single mechanical unit in a way which ensures the long term stability of the optics alignment. This alignment shall be preserved during shipping and handling.
NOTE: External elements may be used as long as they fit within the allotted space, fulfill all applicable optical requirements enumerated in this document, and are alignment free after installation.

Verification method: R – review

REQ-030015/A

All connections between the module and rack mounted support systems shall be clearly labelled and straightforward to connect and disconnect.

2.3. Diagnostics and Control interface

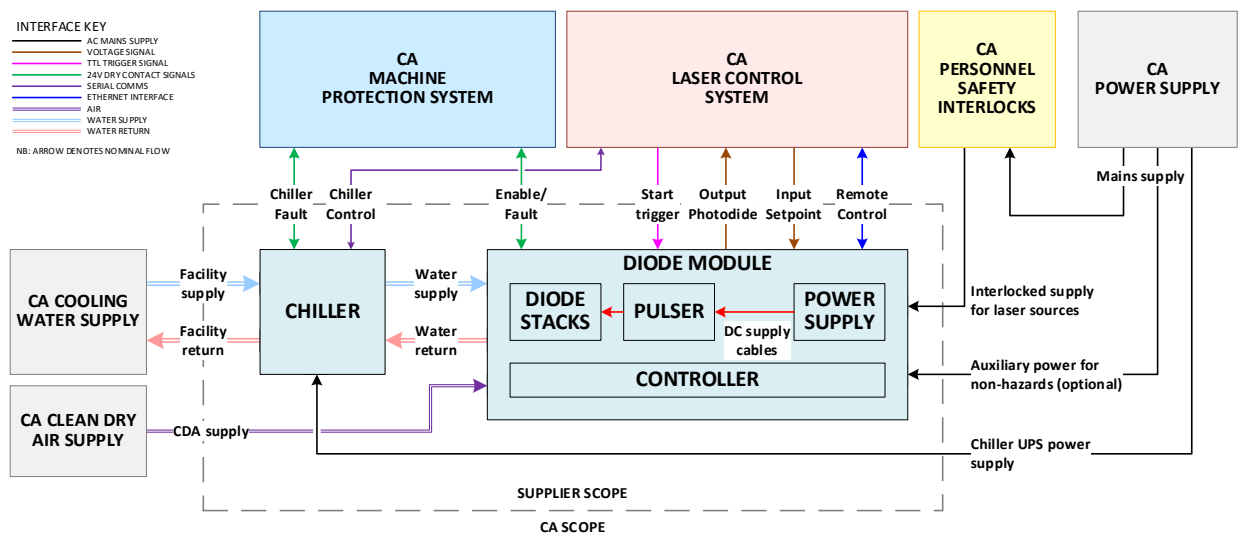


Figure 3: System integration block diagram with interfaces and scope definition

2.3.1. Preferred implementation

If the specified in this section models for the Pulsar, Power Supply and Controller are used by the Supplier to implement the diode module, the CA will then provide reasonable assistance regarding the configuration and programming in LabVIEW of these devices, based on mutually agreed requirements.

REQ-030016/A

The Pulsar used in the diode module shall be a commercially available off-the-shelf single 19-inch rack-mount device no more than 2U high with water-cooling and safety interlock, front-panel key enable and E-stop push button, and front-panel display with manual control option. It must have an Ethernet control interface and must

be compatible with the CA's LabVIEW-based control system. Within two weeks from the signature of this Contract, the Supplier shall communicate to the CA, what specific product intends to use to fulfil the requirements mentioned above. The Supplier may proceed with the manufacturing of the diode module only after such product is approved by the CA. The CA shall approve of the specific product only after the Supplier demonstrates to the CA that all the relevant requirements are met.

Verification method: R – review

REQ-030017/A

The Power Supply used in the diode module shall be a commercially available off-the-shelf single 19-inch rack-mount device no more than 4U high with water-cooling and safety interlock, front-panel start and stop buttons, and a front-panel display with manual control option that can be disabled if remote control is used. It must have an Ethernet control interface and must be compatible with the CA's LabVIEW-based control system. Within two weeks from the signature of this Contract, the Supplier shall communicate to the CA, what specific product intends to use to fulfil the requirements mentioned above. The Supplier may proceed with the manufacturing of the diode module only after such product is approved by the CA. The CA shall approve of the specific product only after the Supplier demonstrates to the CA that all the relevant requirements are met.

Verification method: R – review

REQ-030018/A

The Controller shall perform all functions necessary for normal operation of the diode module that are not otherwise provided by other specifically labelled devices in Figure 3. The Controller shall be a commercially available off-the-shelf embedded controller with a real-time operating system and must include reliable FPGA-based processing of critical analog and digital signals. The Controller must have an Ethernet control interface and must be compatible with the CA's LabVIEW-based control system. Within two weeks from the signature of this Contract, the Supplier shall communicate to the CA, what specific product intends to use to fulfil the requirements mentioned above. The Supplier may proceed with the manufacturing of the diode module only after such product is approved by the CA. The CA shall approve of the specific product only after the Supplier demonstrates to the CA that all the relevant requirements are met.

Verification method: R – review

2.3.2. Output Photodiode

REQ-030019/A

A dedicated photodiode for (temporal) monitoring of the instantaneous emitted power shall be installed. The analog output of the photodiode shall be accessible with a standard 50 Ohm BNC or SMA electrical connector and provide a time resolution of at least 1 μ s. A calibration curve converting photodiode voltage to laser output peak power shall be provided to the CA in the Documentation.

Verification method: R – review

2.3.3. Triggering

REQ-030020/A

Each diode module shall have a START trigger input compatible with TTL logic level signals with 50 Ohm BNC connector. The trigger input shall be optically coupled for galvanic isolation. A rising edge on this trigger input shall cause the diodes to output a laser pulse of the pre-configured length (see Table 3), with the pulse leading edge aligned to this trigger with RMS jitter no more than 10 ns.

Verification method: R – review

REQ-030021/A

Diode modules shall support triggering at any repetition rate from single-shot to 50 Hz. Diodes shall be physically incapable of outputting a laser pulse at a higher repetition rate than 50 Hz, or less than 20 ms after a previously emitted pulse, regardless of any applied trigger.

Verification method: R – review

REQ-030022/A

Diode modules shall not be damaged in the event of spurious triggering occurring at any repetition rate or by the sudden absence of one or more triggers at any repetition rate.

Verification method: R – review

REQ-030023/A

When the diode modules are not externally triggered, it shall be impossible by design for a laser pulse to be output (i.e., it must not be possible to accidentally set a self-triggered or CW mode or for the modules to startup up in such a mode due to a fault).

Verification method: R – review

REQ-030024/A

Regardless of any configuration settings on the pulse length, it shall be impossible to emit a pulse longer than 2 ms under any conditions (i.e., physical limitation, not software setting).

Verification method: R – review

2.3.4. Controls interface to chillers

REQ-030025/A

The Supplier shall ensure that no electronic interfaces between the chillers and the diode modules are necessary for full operation of the diode modules.

NOTE: The chillers providing cooling water to the diode modules are out of scope of the diode module control system. The CA will monitor all required chillers and will be responsible for ensuring that the Machine Protection Enable (see chapter 2.3.7) input to the diodes is open-contact in the event that a fault with the chillers is detected.

Verification method: R – review

2.3.5. Fast amplitude control input control

REQ-030026/A

When changing the SETPOINT of the Module, either by an analog input (optional) or via the remote control input, the response time (10-90 %) of the output peak power to an arbitrary step change in this control shall be < 20 ms, with a settling time < 60 ms to an error of < 3 %. When changing via the remote control input, these times are taken to be from the time of arrival of the command packet.

NOTE: It is assumed that this input directly or indirectly modulates the set-point of an internal closed-loop controller regulating the diode current in response to the output peak power, as measured with the internal monitoring photodiode. Closed-loop regulation of the diode current without reference to the optical output is also permitted, as long as all other requirements are satisfied.

Verification method: R – review

REQ-030027/A

The relationship between the SETPOINT input voltage and the laser output peak power shall be given by a measured reference curve that shall be provided to the CA as part of the documentation, to an accuracy < 10% and repeatability < 3% over 6 hours. This accuracy shall be maintained for at least 24 months from delivery or 1 billion shots (whichever is sooner).

NOTE: The scaling curve should be fixed and not change if the Peak Power Limit (see Table 3) is changed.

Verification method: R – review

REQ-030028/A

Regardless of the value of this input, it shall not be possible to output a pulse with power greater than the configured Peak Power Limit (Table 3).

Verification method: R – review, T - test

REQ-030029/A

Diode modules shall not be damaged by the application of any voltage from -30 to +30 V DC to this analog input or by any arbitrary instantaneous change of the applied voltage to any value within this range.

Verification method: R – review

2.3.6. Automation and Remote Control Interface

REQ-030030/A

The diode modules shall be able to start up, initialize, operate, shutdown, and otherwise fulfil all requirements of this document, without requiring any direct manual user interaction (except for essential safety mechanisms, i.e., key switches and E-stops).

Verification method: R – review

REQ-030031/A

All necessary operations required to use the laser diode modules to their full capacity shall be performed via the Remote Control Interface. No HMIs, GUIs, touch panels, push buttons, control PCs, laptops, displays or similar are permitted to be required in order to use the diode modules to their full capacity.

Verification method: R – review

REQ-030032/A

Each diode module shall be provided with its own Remote Control Interface. This interface shall allow the CA's control system to monitor key system Status Variables (Table 2), set key Configuration Parameters (Table 3) and allow it to start and shut down the laser diode modules remotely.

Verification method: R – review

REQ-030033/A

The Remote Control Interface shall be Ethernet and use one of the following communications protocols/standards, in order of preference: LXI (TCP/IP), OPC UA (HTTP), REST API (HTTP), Modbus

TCP/IP or ASCII-based string commands over TCP/IP or UDP. Commands and responses shall be formatted as human-readable strings (e.g., SCPI, JSON, XML). Alternative communication protocols shall be explicitly approved by the CA.

Verification method: R – review

REQ-030034/A

Full documentation on the entire list of supported commands and responses from the device over the Remote Control Interface shall be provided to the CA, including any additional to those listed in (Table 2) and (Table 3).

Verification method: R – review

REQ-030035/A

Status Variables (Table 2) shall be measured by the electronic controller and their values shall be updated and made available over the Remote Control Interface at the specified minimum update rate. Unless otherwise specified, all physical parameters reported shall be accurately calibrated and within < 10% error of the real physical value when in an operational regime.

Verification method: R – review

REQ-030036/A

If the Status Variables (Table 2) include an error code or error readout, a list of the possible error codes, their description and suggested remedial measures shall be provided to the CA in the Documentation.

Verification method: R – review

REQ-030037/A

Any Configuration Parameter (Table 3) shall be possible to read back on demand via the Remote Control Interface.

Verification method: R – review

REQ-030038/A

All Configuration Parameters (Table 3) shall be permanently retained and restored automatically in the event of a power cycle, with the exception of the Alignment Beam and Output Enable parameters, which shall default to off/disabled on restoration of power.

Verification method: R – review

REQ-030039/A

All Configuration Parameters (Table 3) shall be impossible to set to a value that is outside of the achievable range or to a value that could cause damage to the diode modules.

Verification method: R – review

Table 2: Required Status Variables for readout via the Remote Control Interface

Category	Name	Description	Min. update rate	Format
Photodiodes	Output monitor	Optical peak power of the diode module output pulse	10 Hz	Scalar numeric, with conversion to calibrated Watts peak
	Back reflection monitor	Optical peak power of the last back reflection measurement	10 Hz	Scalar numeric, with conversion to calibrated Watts peak
Temperature	Inlet cooling water		1 Hz	Celsius, scalar numeric
	Outlet cooling water		1 Hz	Celsius, scalar numeric
	Diode block(s)	From sensor(s) in direct contact with the diode emitters	1 Hz	Celsius, scalar numeric
Enclosure environment	Dew point	e.g., readout from a thin-film polymer dew point sensor	0.5 Hz	Celsius, scalar numeric
	Air temperature		0.5 Hz	Celsius, scalar numeric
Cooling circuit	Outlet flow switch		10 Hz	Good/Bad status
General	Overall health status	Overall system health (or health of each system component independently)	10 Hz	Good/Bad status, optional error code/description
	Operational mode	One of a limited set of operational modes, e.g., Standby, Warmup, Ready, Error	1 Hz	Short string from a finite, known set

Table 3: Required Configuration Parameters to be set via the Remote Control Interface

Name	Description	Format
Peak Power Limit	Configurable upper limit for the output pulse peak power (regardless of analog SETPOINT control value)	Calibrated Watts peak
Pulse Length	Configurable pulse length	FWHM in microseconds,
Alignment Mode	Set the laser output to a power level suitable for alignment and manipulation of downstream optics (energy level will be decided in consultation with CA)	Binary on/off
Output Enable	Enable or disable the emission of the main output beam	Binary enable/disable

2.3.7. Machine Protection

REQ-030040/A

The Diodes shall have internal detection and protection against, or be inherently resistant to sustaining damage from, the following failure modes:

1. Loss of cooling water flow or pressure;
2. Cooling water excess pressure;
3. Overheating or thermal runaway of diode stacks;
4. Condensation of water vapor in the housing;
5. Excessive humidity in the housing;
6. Leakage of cooling water into the housing;
7. Sudden loss of external power on any supply;
8. Sudden loss of any external control signal or interface;
9. Overvoltage or overcurrent of internal power supply;
10. Short-circuit or open-circuit fault of a diode stack;
11. Back reflections up to 10 %;
12. Random failure of electronic controller.

Verification method: R – review

REQ-030041/A

The Diodes shall include a Machine Protection Enable input. An externally provided closed contact (suitable for 24 V DC signals) shall be required at all times for the Diodes to operate. Opening these external contacts shall cause the Diodes to stop operating within 10 ms of the open-circuit event. The preferred connector types for this interface are DSUB-9 female or M12 female.

NOTE: The CA will ensure that failures of externally provided services, such as cooling water or dry air, result in open-contact of this input.

Verification method: T - test

REQ-030042/A

The Diodes shall include a Machine Protection Fault output (or multiple outputs for every individual device). Internal dry contacts or a 24 V DC signal output shall be provided that are closed in normal operation and opened in the event of any detected internal fault, failure or off-normal condition.

NOTE: The preferred connector types for this interface are DSUB-9 or M12. The connector may be shared with the Enable input or it may be separate.

Verification method: T - test

2.3.8. Laser Safety

REQ-030043/A

The Supplier shall provide the CA with all necessary information about the Diodes to ensure the compliance of the fully integrated laser system with these standards.

NOTE: The Diodes should be supplied as an 'OEM component.' The CA has the responsibility to implement a laser safety interlock for use of the Diodes in the CA's laboratory in accordance with IEC 60825.

Verification method: R – review

REQ-030044/A

It shall be physically impossible for the Diodes to emit laser radiation in the absence of mains power.

NOTE: The CA intends to satisfy laser interlock requirements by directly disconnecting the mains power to the Diodes.

Verification method: R – review

REQ-030045/A

Sudden disconnection and restoration of the interlocked mains power to the diode power supplies shall not result in damage.

Note: An auxiliary non-interlocked mains supply may be provided to maintain power to electronic controllers and ancillary devices that do not produce a laser hazard. The chillers will also be provided with a dedicated mains power connection which will be UPS-backed. This requirement does not apply to either of these power supplies.

Verification method: T - test

REQ-030048/A

Each diodes module shall be able to operate with input power supply up to a maximum of eight single phase 230 V AC (50 Hz), 16 A circuits and/or up to two three phase 400 V AC (50 Hz), 32 A circuits, in accordance with Czech Republic national standards.

NOTE 1: Each circuit may be of interlocked or auxiliary type as specified by the Supplier in order to meet all laser safety requirements above.

NOTE 2: Each circuit is fitted with a circuit breaker.

NOTE 3: The Supplier should not provide their own mains power distribution as part of the delivery.

Verification method: R – review

3. Delivery requirements

REQ-030049/A

The transportation to the final destination shall be conducted by the Supplier.

NOTE 1: The bid price will be considered by the CA as the final price, including transportation cost.

NOTE 2: The Diodes will be installed by the CA. The Supplier will provide all necessary documentation detailing procedures for safe and proper installation (see REQ-030051/A).

REQ-030067/A

The Diodes shall be cleaned and packaged in a way to comply with the clean environment of class 7 according to ČSN EN ISO 14644 (equivalent to EN ISO 14644) on best effort basis.

NOTE: Regarding the referred to standard/s the CA allows/permits also another equal solution to be offered.

Verification method: R – review

4. Safety Requirements

REQ-030050/A

The Supplier shall supply a Declaration of Conformity or any other equivalent document legally recognized and accepted in the Czech Republic for each product type if the appropriate legislation determines the Supplier's obligation to have a Declaration of Conformity (or the equivalent document) for the purposes of a Product sale in the Czech Republic to fulfil the requirements of 2001/95/EC directive or applicable Czech law.

5. Quality Requirements

5.1. General Quality Requirements

REQ-030051/A

The Supplier shall provide Instructions for use (Product User Manual) as part of the delivered Product. The Manual shall include the instructions and descriptions regarding the following procedures:

- transport, handling and storage;
- installation and cleaning to fulfill the required cleanliness level of clean environment (see REQ-030067/A);
- safe operation and maintenance procedures.

Verification method: R – review

REQ-030052/A

The Supplier shall provide a declaration of conformity with technical requirements defined by the product RSD and ensure completeness of the products.

Verification method: R – review

REQ-030053/A

The Supplier shall provide verification protocols outlining the results of tests executed for each optical **Diode Modules** before their delivery at ELI Beamlines premises to confirm specification conformity (see REQ-030060/A).

NOTE: The content of the verification protocols shall be agreed with the CA.

Verification method: R – review

REQ-030054/A

The Supplier shall establish and maintain a nonconformity control system compatible with ČSN EN ISO 9001 (equivalent to EN ISO 9001).

5.2. Specific Quality requirements

REQ-030055/A

In case of a warranty repair of the **Diodes** by the Supplier, the Supplier shall redo necessary parts of the verification procedure (see chapter 6). The results of this process shall be provided to the CA.

REQ-030056/A

All the documents shall contain strictly the units which are used to define the requirements in the chapter 2.

Verification method: R - review

REQ-030057/A

All tests and alignments of the **Diodes** shall be performed with the measuring instruments with valid metrological confirmation.

NOTE: The CA can request the Supplier to provide the valid Calibration Certificates.

6. Verification requirements for the Supplier

The verification process will be performed by the Supplier to demonstrate that the **Diodes** meet the specified requirements of the CA.

6.1. General requirements

REQ-030058/A

The Supplier shall assign clear responsibility for the implementation of the verification process including the following activities:

1. **Verification planning** (via VCD, see chapter 6.2.2);
 2. **Verification execution and reporting** (see chapters 6.2.1 and 6.2.2);
 3. **Verification control and close-out** (see chapter 6.3).
-

Verification method: R – review

REQ-030059/A

The verification process shall be accomplished by the Supplier through one or more of the following verification methods:

1. **Review**; Verification via Review (**R**) shall consist of using approved records (examples of such approved records are design documents and reports, technical descriptions, and engineering drawings, manuals and accompanying operation documentation) or evidence that unambiguously shows that the requirement is met.

2. **Test** (including functional demonstration); Verification via Test (**T**) shall consist of measuring product performance and functions under realistic operating conditions. When the test objectives include the demonstration of qualitative operational performance (functional demonstration), the execution shall be observed and results recorded.

6.2. Verification documentation

6.2.1. General requirements

REQ-030060/A

The test report (protocol of the measurement) shall be submitted to the CA for the review after corresponding verification activity completion.

NOTE 1: The accuracy of measuring process shall be included in the test reports.

NOTE 2: The analysis of data derived from testing shall be an integral part of the test and the results included in the test report.

Verification method: R – review

REQ-030061/A

The results of the test and the review of documentation shall be tracked in the VCD (see chapter 6.2.2).

Verification method: R – review

6.2.2. Verification Control Document (VCD)

The Verification Control Document (VCD) shall list the selected method(s) of verification, overall verification result (pass/fail) and reference to the relevant report, where necessary for each requirement. The VCD is a living (versioned) document and provides an overview of the mutually agreed Verification methods during the contract execution and overview of the verification results at the contract end to support the acceptance of the Diodes. The **VCD** represents a formal tool of communication between the Supplier and the CA (formal record, reporting tool). The **VCD** will be provided by the CA and it can be accommodated to the Supplier's needs.

REQ-030062/A

The Supplier shall provide a Verification Control Document (**VCD**) in coordination with and having approval from the CA.

*NOTE 1: Guidelines for VCD preparation will be provided by the CA (see **RD-01**; section 1.4).*

NOTE 2: The form of VCD will be agreed between the CA and the Supplier based on the best commercial praxis used by the Supplier.

Verification method: R - review

REQ-030063/A

The verification approach shall be defined by the Supplier in the **VCD** prior to its implementation.

Verification method: R - review

REQ-030064/A

In the **VCD**, the Supplier shall describe **HOW** and **WHEN** each of the technical requirements is to be verified.

Verification method: R – review

REQ-030065/A

The final issue of the VCD shall be submitted to the CA after completion of the final verification of the **Diodes** and approval of the last test report (see chapter 6.3).

Verification method: R – review

6.3. Acceptance

Acceptance will be carried by the CA after delivery and successfully passing acceptance tests. Upon delivery of the Diodes in the appropriate and undamaged packaging, the CA shall provide to the Supplier with a Handover/takeover protocol.

The basis for acceptance will be completed VCD summarizing the overall verification results together with relevant documentation supporting the verification (i.e. test protocols, declaration of conformity, Product User Manual, etc.).

In case of successful acceptance phase, the CA will provide to the Supplier signed acceptance protocol. In case of unsuccessful acceptance, the CA will provide to the Supplier a Nonconformity Report (NCR) and the Supplier will be obliged to address the nonconformance.

REQ-030066/A

The Acceptance phase shall demonstrate the following:

1. The delivered Diodes have been successfully verified by the Supplier's outgoing check and the results of this process have been documented properly through test protocols (see section 6.2.1) and VCD (see section 6.2.2);
2. All detected nonconformities have been solved in accordance with REQ-030054/A;
3. The Diodes are free of fabrication errors and are ready for the intended operational use.

NOTE: In the acceptance phase, the verification of the Diodes and required documentation will be carried out by the CA within 7 weeks after the issuing of the latest Handover/takeover protocol.
