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, PhD., director

("**Buyer**"); and

(2) **OptiXs, s.r.o.**

with its registered office at: Křivoklátská 37, 199 00 Praha 9

registration no.: 02016770

represented by: Ing. Martin Klečka, CEO

("**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 a grant of the Ministry of Education, Youth and Sports of the Czech Republic for the project „Pokročilý výzkum s využitím fotonů a částic vytvořených vysoce intenzivními lasery (Advanced Research Using High Intensity Laser Produced Photons and Particles)", reg. number: CZ.02.1.01/0.0/0.0/16_019/0000789 ("**Project**"), within the Operational Programme Research, Development and Education.

(B) For the successful realization of the Project it is necessary to purchase the Object of Purchase (as defined below) in accordance with the Act no. 134/2016 Coll., on Public Procurement, and the Rules for the Selection of Suppliers within the Operational Programme Research, Development and Education.

(C) The Seller wishes to provide the Object of Purchase to the Buyer for consideration.

(D) The Seller's bid for the public contract entitled "**Fs Optical Amplifiers – individual lot B Delivery of Fs Amplifier B** (the "**Public Contract**") 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 manufacture, deliver to the Place of Delivery, install, verify and hand over to the Buyer a device as specified in Annex 1 (*Technical Specification*) and Annex 2 (*Seller´s Bid*) to this Contract, including related services, in the quality and with the properties described therein ("**Object of Purchase**") and shall transfer to the Buyer ownership right to the Object of Purchase, and the Buyer shall take over the Object of Purchase and shall pay the Seller the Purchase Price (as defined below), all under the terms and conditions stipulated in this Contract.

If it becomes necessary or proper in the course of the Object of Purchase manufacturing to deviate from the Annex 2 (*Seller´s Bid*) such deviation will be subject to previous written approval by the Buyer. The Buyer will not refuse the approval if well substantiated reasons are presented by the Seller. No such deviation might lead to a price increase without an amendment hereto concluded in line with applicable law.

1.2 The Seller promises to the Buyer that if for the fulfillment of the requirements of the Buyer under this Contract or the proper operation of the Object of Purchase are necessary other deliveries and activities not mentioned in this Contract, the Seller shall procure such deliveries or shall carry out such activities at its own expense without any effect on the Purchase Price.

1.3 The Object of Purchase (all of its parts) shall be new (not previously used).

2. **THE PLACE OF DELIVERY**

The place of delivery ("**Place of Delivery"**) is at the address: ELI beamlines facility at the adress Průmyslová 836, post code 252 41, Dolní Břežany, Czech Republic or any other address in Dolní Břežany, Czech Republic, which the Buyer communicated to the Seller prior to the delivery of the Object of Purchase.

3. **THE TIME OF DELIVERY**

3.1 The Seller shall finish performance of this Contract (i.e. including installation and final verification of the Object of Purchase) within 6 months from the conclusion of this Contract. The Seller is entitled to deliver the Object of Purchase earlier, if the Buyer agrees to it.

3.2 The Buyer is entitled to postpone the final installation and verification of the Object of Purchase by up to 3 months, if there are serious reasons for it on the side of the Buyer (mainly non-readiness of premises or inavailability of any resources needed for the installation). In such a case the Buyer is obliged to inform the Seller on the postponement at latest 1 month before expiration of the delivery deadline. The Seller shall in such case deliver the Object of Purchase within the delivery deadline of 6 months to the Place of Delivery but install it only after the Buyer requests them to do so. The

Seller is not entitled to charge the Buyer with any extra costs in the case of postponed installation if the Buyer complies with all the rules included in this article.

The Seller shall carry out installation and verification of the Object of Purchase in accordance with Annex 1 (*Technical Specification*) within 1 month from the request to do so by the Buyer in the case of postponed installation.

4. THE OWNERSHIP RIGHT

The ownership right to the Object of Purchase shall be transferred to the Buyer upon the signature of the acceptance protocol by both Parties.

5. PRICE AND PAYMENT TERMS

5.1 The purchase price for the Object of Purchase is **209 450 USD** ("**Purchase Price**") without value added tax ("**VAT**"). VAT will be paid in accordance with the applicable legal regulations.

5.2 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 manufacture, transport, handover of the Object of Purchase and execution of related services, costs related to any intellectual property rights, insurance, customs, warranty service and any other costs and expenses neccessary for the due performance of this Contract.

5.3 The Purchase Price for the Object of Purchase shall be paid in USD on the basis of a tax documents – invoices, to the account of the Seller designated in the invoice. The Purchase Price shall be paid in the following instalments:

a) 30% of the Purchase Price shall be paid after the Seller submits to the Buyer an overall design document of the Object of Purchase which shall include at least overall specific hardware design including all subcomponents (e.g. amplifier, out of devices beam routings, telescopes, photodiode etc.) and synchronizing trigger signal connections; the design document shall not be subject to Buyer´s approval but the Buyer is entitled to make any comments that should be dealt with in line with art. 6.2 hereof.

b) 65% of the Purchase Price shall be paid after the delivery of the Object of Purchase to the Place of Delivery;

c) 5% of the Purchase Price shall be paid after the signature of the acceptance protocol (i.e. after installation and verification). The copy of the acceptance protocol must be attached to the invoice.

5.4 The Buyer shall realize payments on the basis of duly issued invoices within 30 days from their receipt. If the Seller stipulates any shorter due period of the invoiced amount in the invoice such different due period shall not be deemed relevant and the due period stipulated herein applies.

Any invoice shall be deliver only in the electronic form to the email address: efaktury@fzu.cz

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.

5.5 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 before the issuance of the invoice,

k) declaration that the performance of the Contract is for the purposes of the project „Pokročilý výzkum s využitím fotonů a částic vytvořených vysoce intenzivními lasery (Advanced Research Using High Intensity Laser Produced Photons and Particles)", reg. number: CZ.02.1.01/0.0/0.0/16_019/0000789,

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

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

6. SELLER'S DUTIES

6.1 The Seller shall ensure that the Object of Purchase is in compliance with this Contract including all its annexes and applicable legal (e.g. safety), technical and quality norms.

6.2 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.

6.3 All things necessary for the performance of this Contract shall procure the Seller, unless this Contract stipulates otherwise.

7. HANDOVER AND ACCEPTANCE OF THE OBJECT OF PURCHASE

7.1 The Buyer shall confirm the delivery of the Object of Purchase to the Place of Delivery by signing a handover protocol/ delivery note.

7.2 Acceptance of the Object of Purchase shall be realized on the basis of an acceptance protocol under the terms stipulated in Annex 1 (*Technical Specification*) hereto.

7.3 If the Object of Purchase does not meet requirements of this Contract, the Buyer is entitled to refuse the acceptance of the Object 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 Object of Purchase despite the above mentioned deficiencies, in particular if such deficiencies do not prevent the Buyer from the proper operation of the Object of Purchase. In such a case the Seller and the Buyer shall list the deficiencies in the acceptance protocol, including the manner and the date of their removal (remedy). If the Parties do not reach agreement in the acceptance protocol regarding the date of the removal, the Seller shall remove the deficiencies within ten (10) working days.

8. WARRANTY

8.1 The Seller provides a warranty of quality of the Object of Purchase for the period of 12 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.

8.2 The warranty period shall begin on the day of the signature of the acceptance protocol by both Parties. If the acceptance protocol lists any deficiencies, the warranty period shall begin on the day, which follows the day, in which the last deficiency was removed.

8.3 The Seller shall remove defects that occur during the warranty period free of charge and in the terms stipulated in this Contract.

8.4 If the Buyer ascertains a defect of the Object 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.

8.5 The Buyer notifies defects in writing via e-mail. The Seller shall accept notifications of defects on the following e-mail address: servis@optixs.cz. The Seller shall confirm within 24 hours from the receipt of the notification.

8.6 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 Object of Purchase or its individual parts, or

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

c) ask for the adequate reduction of the Purchase Price.

The choice among the above mentioned rights belongs to the Buyer. However, the Buyer is not entitled to request delivery of the new Object of Purchase in case of removable defects that do not occur repeatedly. The Buyer is also entitled to withdraw from this Contract, if by delivering the Object of Purchase with defects this Contract is substantially breached.

8.7 The Seller shall remove the defect within 30 days from its notification, unless Parties agree otherwise.

8.8 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 if the Buyer is prevented from using the Object of Pucrahse for its intended use.

8.9 In case that the Seller does not remove the defect within stipulated time or if the Seller refuses to remove a defect for which they are responsible, 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.

8.10 The warranty does not cover defects caused by unprofessional manipulation or by the failure to follow Seller's instructions for the operation and maintanence of the Object of Purchase.

9. PENALTIES

9.1 If the Seller is in delay with timely finalization of performance of the Contract in accordance with art. 3.1 and 3.2 hereof, the Seller shall pay to the Buyer a contractual penalty in the amount of 0.15% of the Purchase Price (excl. VAT) for every even incomplete day of delay.

9.2 If the Seller is in delay with the removal of a defect, the Seller shall pay to the Buyer a contractual penalty in the amount of 0,05% of the Purchase Price (excl. VAT) for every even incomplete day of delay.

9.3 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 in the extent in which such damages exceed the contractual penalty.

9.4 Total amount of the contractual penalty that the Buyer is entitled to claim according to art. 9.1 hereof shall not exceed 5 % of the Purchase Price (excl. VAT). Total amount of the contractual penalty that the Buyer is entitled to claim according to art. 9.2 hereof shall not exceed 3 % of the Purchase Price (excl. VAT).

9.5 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.

9.6 Parties exclude the Section 2050 of the Civil Code.

10. RIGHT OF WITHDRAWAL

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

a) the Seller is in delay with the fulfilment of this Contract and such delay lasts more than 4 weeks;

b) The Object of Purchase during testing at the Buyer's premises does not fulfil the requirements stipulated in this Contract, in particular in Annex 1 (*Technical Specification*) and the deficiencies cannot be remedied;

c) the insolvency proceeding is initiated against the Seller; or

d) 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.

11. 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 acces 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 2027.

12. FINAL PROVISIONS

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

12.2 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.

12.3 The Seller bears the risk of changed circumstances within the meaning of Section 1765 of the Civil Code.

12.4 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.

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

12.6 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.

12.7 This Contract is executed in four (4) counterparts and every Party shall receive two (2) counterparts.

12.8 An integral part of this Contract are Annex 1 (*Technical Specification*) and Annex 2 (*Seller´s Bid*). If Annex 1 (*Technical Specification*) uses the term "Contracting Authority" or "contracting authority" it means Buyer. If Annex 1 (*Technical Specification*) uses the term "Supplier" or "supplier" it means Seller.

12.9 This Contract shall be valid on the date of the signature of both Parties and effective upon publication in the register of contracts according to applicable law.

/SIGNATURES FOLLOW ON THE NEXT PAGE/

IN WITNESS WHEREOF attach Parties their handwritten signatures:

Buyer

Signature:
Name: RNDr. Michael Prouza, PhD.
Position: director

Seller

Signature: _____
Name: Ing. Martin Klečka
Position: CEO

ANNEX 1

TECHNICAL SPECIFICATION

Confidentiality Level	*BL - Restricted for internal use*	**TC ID / Revision**	*00190411/C*
Document Status	*Document Released*	**Document No.**	*N/A*
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Document Type	*Specification (SP)*		

[RSD product category B]

Fs optical amplifiers

Amplifier "B"

TP18_730

Keywords

N/A

	Position	**Name**
Responsible person	Researcher RA4	Miroslav Kloz
Prepared by	Researcher RA4	Miroslav Kloz

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Reviewed By			
Name (Reviewer)	Position	Date	Signature
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Ladislav Půst	Manager installation of technology	NOTICE (RSD product category B)	
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Pavel Bakule	Deputy RP1 Leader	NOTICE (RSD product category B)	
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Tomáš Laštovička	Team Leader BIS	NOTICE (RSD product category B)	
Veronika Olšovcová	Safety coordinator	NOTICE (RSD product category B)	
Viktor Fedosov	SE & Planning group leader; Quality Manager	NOTICE (RSD product category B)	

Approved by			
Name (Approver)	Position	Date	Signature
Georg Korn	Science and Technology Manager, Scientific coordinator of RP2-6	17.08.2018	

Revision History / Change Log				
Change No.	Made by	Date	Change description, Pages, Chapters	TC rev.
1	M. Kloz	17.07.2018	RSD draft creation	A
2	M. Kloz, A. Kuzmenko	08.08.2018	RSD update, version for internal review	B
3	A. Kuzmenko	17.08.2018	RSD update, final version for approval	C

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Table of Content

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1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints for the 1 kHz fs laser amplifier designed planned to supplement experiments conducted on existing laser systems. The amplifier is expected to have at least 40 fs pulse duration or shorter, central wavelength around 800 nm, 1 kHz repletion frequency and output at least 7 mJ or higher. The amplifier must achieve these parameters after being seeded by our already existing **80 MHz Ti-Sapphire optical oscillators Vitara-S (Coherent)**.

1.2. Scope

This RSD contains all of the top level functional, performance and design, transportation and installation, safety, quality and verification requirements for the following product *(PBS code: TP18_730)*: ***Fs optical amplifier*** (further **"Amplifier B"**).

The Amplifier is an integral part of the standalone E1 experimental spectroscopy station and is intended for use in the E1 experimental hall at the ELI Beamlines facility. The product is registered in the PBS software under the following PBS codes: E.E1.OPP.LAS.2.

This product is a **product Category B** according to the ELI Beamlines RSD categories. Category B is an Off-the-shelf Product with customization (e.g., product performance) that does not require substantial design modifications to the product. All verification activities performing 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 will be undertaken by the Supplier before delivery to the ELI Beamlines facility and the Amplifier shall be furnished with a verification protocol and a declaration of conformity, to reflect its proper characteristics. Furthermore, the Amplifier will be subject to testing and verification upon delivery and installation at the ELI Beamlines facility. All nonconformities (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
$1/e^2$	distance between the two points on the marginal distribution that are $1/e^2 = 0.135$ times the maximum value
CA	Contracting Authority (Institute of Physics AV CR, v. v. i.)
E1	Experimental hall number 1
ELI	Extreme Light Infrastructure
FD	Functional Demonstration (as a verification method)
FWHM	Full Width at Half Maximum

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Abbreviation	Meaning
ICD	Interface Control Document
ID	Identification
L x W	Length x Width
M^2	Beam quality factor
NCR	Nonconformity Report
R	Review (as a verification method)
RA4	Research activity 4
RMS	Root Mean Square
RSD	Requirements Specification Document
T	Test (as a verification method)
VCD	Verification Control Document

1.4. Reference documents

Number of document	Title of Document/ File
RD-01	*00163567-B_1.2_Q_M_Guide_for_Instructions_for_Use_Ver-9_EN_fully_signed.pdf*

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. General Requirements

REQ-024097/A

The Supplier shall deliver:

- fs amplifier system (**Amplifier B**);
- Software for the Laser operation;
- Product User Manuals;
- Installation, verification (including testing) and user-training at the ELI premises.

Verification method: I - inspection

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3. Functional, Performance and Design Requirements

3.1. General System Requirements

REQ-024098/A

The **Amplifier B** shall be movable between experimental locations. Disassemble at old location and assemble (including adjustment) at new location within the same building shall not take more than 3 working days.

Verification method: R – review

REQ-024099/A

Dimension of the **Amplifier B** shall not exceed 1.5 m x 0.85 m (L x W) footprint at 50 cm maximal height.
NOTE: Additional supporting equipment such as power sources or chillers may occupy extra space in case they do not require optical table for its operation.

Verification method: R – review, T - test

REQ-024100/A

Power consumption of the **Amplifier B** in stabilized operation mode shall not exceed 5 kW.

Verification method: T - test

REQ-024101/A

When turned on from a steady state (chillers in constant operation), the **Amplifier B** shall reach full operational stability in less than 1 hour.

Verification method: T - test

REQ-024102/A

The **Amplifier B** shall include personal protection interlock (including remote interlock connector and key or digital key operated master control) and basic machine safety interlocks to prevent damage to the major components of the system.

Verification method: R - review

REQ-024103/A

The **Amplifier B** shall be able to operate from maximum of ten 230 V/50 Hz 1-phase sockets with 10 A circuit breaker with overcurrent delay of 2 sec.
NOTE: Requirement for multiple independent phases for optimal running is allowed provided information what devices require independent phase is clearly defined.

Verification method: R – review

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3.2. "Amplifier B" performance requirements

REQ-024104/A

The **Amplifier B** shall produce optical pulses with characteristics defined in the Table 1 below.

Verification method: T - test

Description of parameter	Value
Central wavelength (+- 5 nm)	800 ±5 nm
Pulse duration (FWHM)	< 40 fs
Pulse energy	≥ 7 mJ
Repetition rate	1 kHz
Beam diameter (1/e2)	Any between 11 ± 1 mm
Beam pointing stability	< 5 µrad RMS at full beam diameter
Spatial mode	$M^2 < 1.25$
Polarization	Linear (horizontal, 1:100)
Pulse to pulse energy stability	< 0.5 % RMS
Long term pulse energy stability	< 1 % over 48h
Contrast	Better than 1000:1 pre pulse and 100:1 post-pulse within 1 ns interval
80 MHz clock	Self-generated from seeding input or provided by BNC
1 KHz clock	Externally triggerable

Table 1: Output characteristics of optical pulses of the **Amplifier B**.

REQ-024105/A

The parameters above (see Table 2) shall be achievable after the **Amplifier B** is seeded by the 90 mW seed pulse train from the Vitara–S 80 MHz oscillator (Coherent) with spectrum as in the Figure 1 below.

Verification method: T – test

REQ-024106/A

The **Amplifier B** shall be triggerable by the externally provided 1 kHz TTL signal from the "master amplifier" (provided by the CA) in such a way that amplifies the nearest seeding pulse arriving after the kHz trigger (see chapter 3.3 for details).

Verification method: FD - functional demonstration

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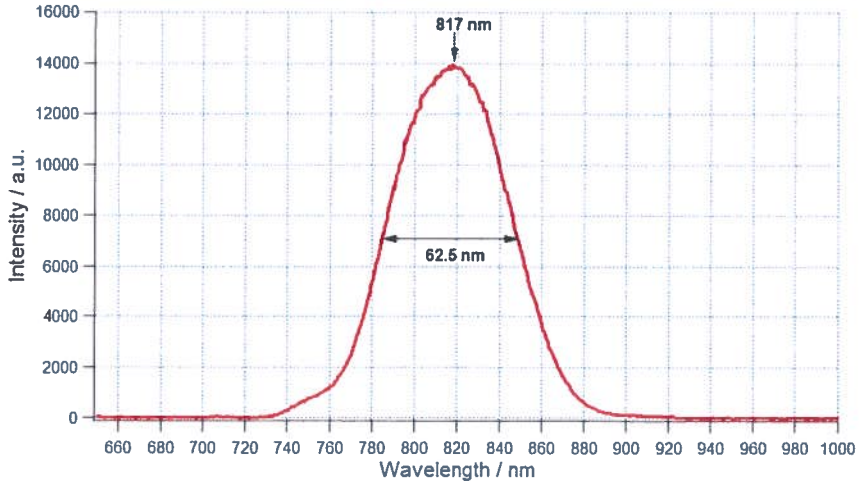

Figure 1: Emission spectrum.

3.3. Synchronization parameters

REQ-024107/A

The **Amplifier B** shall be capable of a synchronized operation as a "slave" laser to the "master" 1 kHz amplified with whom it will share the oscillator (80 MHz) and the 1 kHz TTL trigger signal (generated form 80 MHz by divider) provided with a tunable delay. The slave amplifier shall receive its 80 MHz clock from the photodiode placed after the optical delay line (see Figure 2 below). The compatible photodiode together with its power source shall be provided by the Supplier.

Verification method: T - test

REQ-024108/A

When the "master" amplifier will provide its 1 kHz clock to the "slave" amplifier with an electronic delay, the mutual delay of "master" and "slave" amplifiers shall change accordingly, however at fixed parameters it shall stay constant with shot-to-shot jitter below 50 fs and 1 hour drift below 10 ps.

Verification method: T - test

REQ-024109/A

Operation in accordance with points REQ-024107/A and REQ-024108/A shall be possible in configuration where an optical delay line is placed into the seeding part to the "slave" amplifier. In this configuration a continuous delay of the lasers from 0 – 1 ms shall be achievable by combination of synchronized optical and electronic delay.
NOTE: This is visualized in the Figure 2 below.

Verification method: T - test

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REQ-024110/A

Solution for the REQ-024109/A shall be proposed by the Supplier. That means, how to correctly combine 80 MHz clock, 1 kHz clock with electronic 0-1 ms electronic delays, and optical delays 0 - 13 ns of the seed pulses in order to guarantee safe windowless delay setting of the slave laser without alteration of output pulse parameters.

Verification method: R - review

REQ-024111/A

Alteration (setting) of electronic delay between amplifiers shall not take more than 1 second when the devices (delay generators) are correctly interfaced.

Verification method: T - test

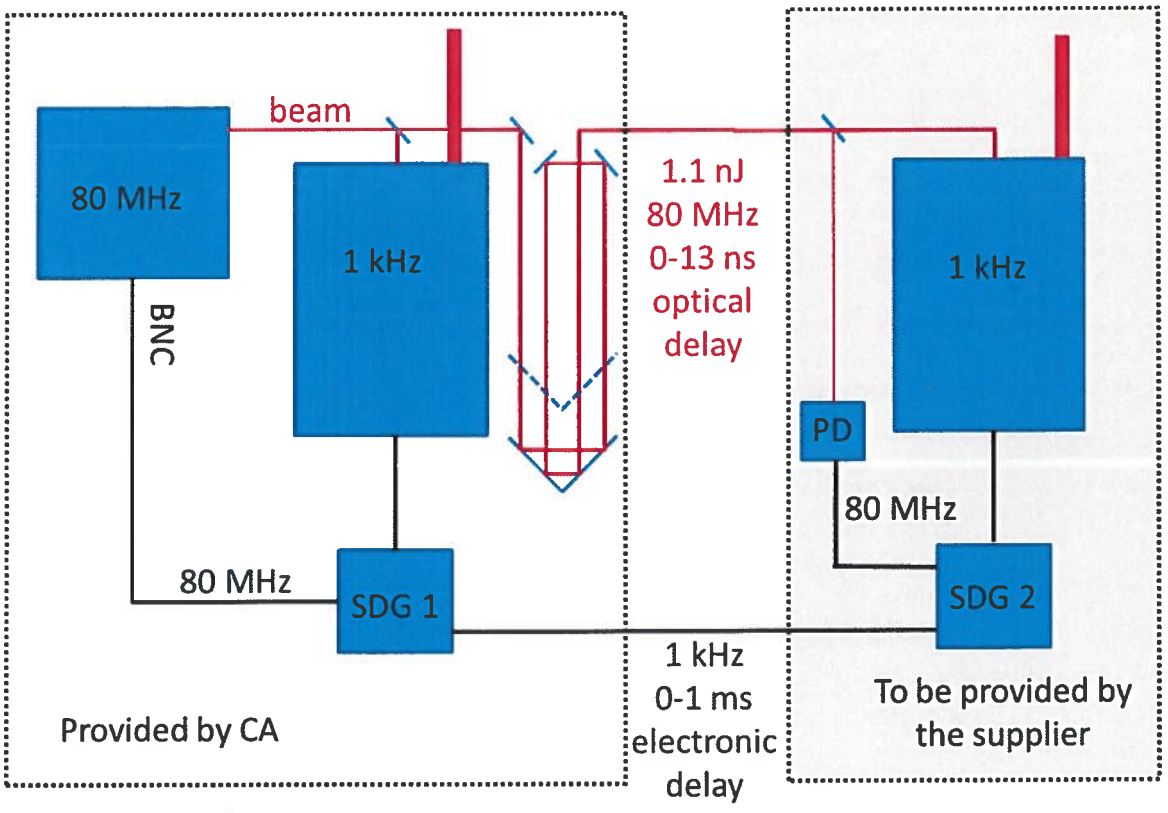

Figure 2: Scheme of synchronized operation of Amplifiers.

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3.4. Control system and Electronics

REQ-024112/A

Any control interfaces shall be equipped with an Ethernet port that will allow communication with the ELI Beamline computer. The communication shall be performed on a standard protocol, which can be implemented on the Linux based control system.
NOTE: The Supplier shall assist with the integration of the instrument into the ELI Beamline network and software environment.

Verification method: R - review

REQ-024113/A

The Supplier shall provide to the CA the Interface Control Document (ICD) which shall include at least the following information:

- Description of the data exchange format and protocol for exchange;
- General description of the interface;
- Dependencies regarding the interfaces where appropriate;
- Estimated size and frequency of data exchange;
- Description of implemented security.

Verification method: R - review

4. Transportation and Installation requirements

4.1. General requirements

REQ-024114/A

The transportation to the final destination at the ELI Beamlines premises, the installation and final verification of the **Amplifier B** shall be conducted by the Supplier.
NOTE: The bid price will be considered by the CA as the final price, including both transportation and installation costs.

Verification method: R – review, I - inspection

REQ-024115/A

The **Amplifier B** and its components shall be delivered in protective package preventing damage and contamination. The **Amplifier B** and its components shall be cleaned and packaged in compliance with the cleanliness of class 7 according to ČSN EN ISO 14644 (or equivalent, e.g. EN ISO 14644) or cleaner.
NOTE 1: If the Supplier cannot fulfill class 7 cleanliness requirements, the Supplier shall clean devices without decreasing the devices' performance and to avoid contamination of clean spaces of the CA.

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NOTE 2: Regarding the referred to standard/s or standardized/ standardizing technical documents the CA allows/permits also another equal solution to be offered.

Verification method: R – review, I - inspection

REQ-024116/A

The transportation and installation procedures shall be discussed and can be reviewed by the CA's installation officer.

Verification method: R – review

REQ-024117/A

The Supplier shall allow the CA to supervise the activities related to the transportation and installation of the **Amplifier B**.
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: I - inspection

REQ-024118/A

All participants to the installations shall undertake a lecture by the CA regarding safety, cleanliness, protection of the environment and working methods before starting their activities on the premises.
NOTE: The content of the lecture will be adequate to the working area and the work activities expected.

Verification method: R – review

REQ-024119/A

The Supplier shall ensure that activities at the ELI Beamlines premises and the installation of the **Amplifier B** will be performed without contaminating the place of installation unnecessarily. The premises include rooms with normal cleanliness and cleanrooms of class 7 according to ČSN EN ISO 14644 (or equivalent, e.g. EN ISO 14644).

Verification method: I - inspection

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5. Safety Requirements

5.1. General requirements

REQ-024120/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.

Verification method: R – review, I - inspection

6. Quality Requirements

6.1. General Quality Requirements

REQ-024121/A

The Supplier shall provide Instructions for use (Product User Manual) as part of the delivered Product. The Instructions for use shall be written in accordance with standard ČSN EN 82079-1 (or equivalent, e.g. EN 82079-1) and shall include the instructions and descriptions regarding the following:

- transport, handling and storage;
- installation, alignment and cleaning;
- user manual for the software, SDKs and/or for communication protocol;
- safe operation and maintenance procedures.

*NOTE 1: As an alternative to standard ČSN EN 82079-1 (or equivalent, e.g. EN 82079-1) an internal ELI "Instructions for use" methodology can be used (see **RD-01**; chapter 1.4) which will be provided to the Supplier upon request.*

NOTE 2: Regarding the referred to standard/s or standardized/ standardizing technical documents the CA allows/permits also another equal solution to be offered.

Verification method: R - review, I - inspection

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REQ-024122/A

The Supplier shall provide information on execution of outgoing check of the Product. At least this information shall comprise declaration about execution of outgoing check and declaration of conformity with technical requirements defined by the product RSD and completeness of the Product.

Verification method: I - inspection

REQ-024123/A

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

6.2. Specific Quality requirements

REQ-024124/A

In case of a warranty repair of the **Amplifier B** by the Supplier, the Supplier shall redo necessary parts of the verification procedure (see chapter 7). The results of this process shall be provided to the CA.

Verification method: Not To Be Tracked within VCD

REQ-024125/A

All the documents shall contain strictly the units which are used to define the requirements in the chapter 3.

Verification method: R - review

REQ-024126/A

All tests and alignments of the **Amplifier B** shall be performed with the measuring instruments with valid metrological confirmation.
NOTE: The CA can request the Supplier to provide the valid Calibration Certificates.

Verification method: Not To Be Tracked within VCD

REQ-024127/A

The Supplier shall provide basic training at ELI premises on how to operate the **Amplifier B**. This training shall take place during the acceptance phase (see chapter 7.3).
NOTE: Minimal duration of the training shall be 1 working day with possibility for further training via VTC (e.g. by Skype) or another convenient way.

Verification method: Not To Be Tracked within VCD

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7. Verification requirements for the Supplier

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

7.1. General requirements

REQ-024128/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 7.2.2);
2. **Verification execution and reporting** (see chapters 7.2.1 and 7.2.2);
3. **Verification control and close-out** (see chapter 7.3).

Verification method: R – review

REQ-024129/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. **Inspection**; Verification via Inspection **(I)** shall consist of visual examination of the manufactured and/or assembled product, i.e. its physical characteristics proving that the specific requirements have been met.
3. **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.

Verification method: Not To Be Tracked within VCD

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7.2. Verification documentation

7.2.1. General requirements

REQ-024130/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-024131/A

The results of the test, functional demonstration, inspection and the review of documentation shall be tracked in the VCD (see chapter 7.2.2).

Verification method: R – review

7.2.2. Verification Control Document (VCD)

The Verification Control Document (**VCD**) lists the requirements to be verified with the selected methods at the specified time (see REQ-024133/A) of contract delivery phases.

The VCD is a living document which shall be used throughout the entire Contract delivery and its phases. The VCD provides traceability during contract delivery phases (Manufacturing, Delivery and Installation, Acceptance, etc.). 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 Supplier's needs.

REQ-024132/A

The Supplier shall provide a **Verification Control Document** (further "**VCD**") for the reviews as agreed with the CA.
NOTE 1: Guidelines for VCD preparation will be provided by the CA.
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-024133/A

In the VCD the Supplier shall specify **HOW** and **WHEN** each requirement is planned to be verified.

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Verification method: R – review

REQ-024134/A

The final issue of the VCD shall be submitted to the CA after completion of the final verification of the **Amplifier B** and approval of the last test report (see chapter 7.3).

Verification method: R – review

REQ-024135/A

The Supplier shall make available to the CA for consultation the VCD's supporting documentation in addition to the reports.

Verification method: Not To Be Tracked within VCD

7.3. Acceptance

Acceptance will be carried out by the CA upon installation and final verification of the **Amplifier B** at ELI Beamlines premises. The basis for acceptance will be completed VCD summarizing the overall verification results together with relevant documentation supporting the verification (i.e. test reports, Instructions for use and etc.).

The Acceptance phase shall demonstrate following:

- Final (installed) **Amplifier B** has been successfully verified and this process has been documented in an appropriate way through test report (see chapter 7.2.1) and VCD (see chapter 7.2.2);
- All detected nonconformities have been solved in accordance with REQ-024123/A;
- Final **Amplifier B** is free of fabrication errors and is ready for the intended operational use.

In case of successful acceptance phase the CA will provide to the Supplier signed acceptance protocol. In case of unsuccessful acceptance stage the CA will provide to the Supplier Nonconformity Report (NCR) and process in accordance with REQ-024123/A shall be applied.

REQ-024136/A

Acceptance shall be carried out on the final hardware and software after **Amplifier B** installation at ELI premises.

Verification method: R – review

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REQ-024137/A

Acceptance shall be complete when the **Amplifier B** complies with all specifications verified by the Supplier's outgoing check (see REQ-024122/A) and after successful passing acceptance tests including functional demonstration.
NOTE 1: Supplier's outgoing check shall be carried out prior to delivery.
*NOTE 2: The final verification shall be carried out by the Supplier after the **Amplifier B** installation at ELI Beamlines premises within 8 weeks upon the issuing of the Handover/takeover protocol.*

Verification method: R – review

REQ-024138/A

The results of final verification process (see REQ-024137/A) shall be documented by the Supplier in the test reports and overall results shall be recorded in the VCD.

Verification method: R – review

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ANNEX 2

SELLER´S BID

Femtosecond Optical Amplifier

Technical description:

The subject of delivery would be 1 kHz fs laser amplifier Astrella. The amplifier will have at least 40 fs pulse duration or shorter, central wavelength around 800 nm, 1 kHz repetition frequency and output at least 7 mJ or higher. The amplifiers will achieve these parameters after being seeded by 80 MHz Ti-Sapphire optical oscillators Vitara-S (Coherent).

The list of delivered parts would be :

- Astrella-USP-1K, one box femtosecond amplifier systems with integrated pump lasers, stretcher and compressor. Oscillator is not part of delivery.
- Controllers and power supplies for all units
- Chiller for complete laser cooling
- Fast optical detector system for optical synchronization with SDG unit, incl. stands
- All necessary hardware like as cables, power supplies
- Software for the laser operation
- Product user manual in English
- Test protocol from factory
- Installation, verification (including testing) at the ELI premises
- User training at the ELI premises
- Shipment and insurance

We will provide the complete system including all the components required for the operation of the system. Installation and user training will take approx. 3 days.

Technical parameters:

Femtosecond optical amplifier according part B.

General system requirements	Offered value
The Amplifier B shall be movable between experimental locations. Disassemble at old location and assemble (including adjustment) at new location within the same building shall not take more than 3 working days.	YES, it will be movable between experimental locations, disassemble at old location and assemble at new location will not take more than 3 working days.
Dimension of the Amplifier B shall not exceed 1.5 m x 0.85 m (L x W) footprint at 50 cm maximal height.	YES, the dimensions are 1417 x 793 mm footprint, height is 262 mm.
Power consumption of the Amplifier B in stabilized operation mode shall not exceed 5 kW.	YES, power consumption of amplifier is around 3 kW and will not exceed 5 kW.
When turned on from steady state (chillers in	YES, amplifier will reach full

constant operation), the Amplifier B shall reach full operational stability in less than 1 hour.	operational stability in less than 1 hour.
The Amplifier B shall include personal protection interlock (including remote interlock connector and key or digital key operated master control) and basic machine safety interlocks to prevent damage to the major components of the system.	YES, personal protection interlock and basic machine safety interlocks are part of the system.
The Amplifier B shall be able to operate from maximum of ten 230 V/50 Hz 1-phase sockets with 10 A circuit breaker with overcurrent delay of 2 sec.	YES, laser system requires 10 A / 230 VAC sockets only. The laser chiller will be good to plug in separated phase circuit.
Amplifier B performance requirements	
Central wavelength 800 ± 5 nm	YES, 800 nm
Pulse duration (FWHM) < 40 fs	YES, < 35 fs
Pulse energy ≥ 7 mJ	YES, ≥ 7 mJ
Repetition rate 1 kHz	YES, 1 kHz
Beam diameter at 1/e2 any between 11 ± 1 mm	YES, nominal value 11 mm
Beam pointing stability < 5 µrad RMS at full beam diameter	YES, < 5 urad RMS value measured under stable environmental conditions after warm-up time and over one hour.
Spatial mode M^2 < 1.25	YES, < 1,25
Polarization linear (horizontal, 1:100)	YES, linear horizontal 1:100
Pulse to pulse energy stability < 0.5 % RMS	YES, < 0,5% RMS
Long term pulse energy stability < 1 % over 48 h	YES, < 1 % over 48 hod
Pre-pulse contrast better than 1000:1 within 1 ns interval	YES, > 1000:1, Defined as the ratio between peak intensity of output pulse to peak intensity of any pre-pulse that occurs within 1 ns interval before the output pulse
Post-pulse contrast better than 100:1 within 1 ns interval	YES, > 100:1, Defined as the ratio between peak intensity of output pulse to peak intensity of any post-pulse that occurs within 1 ns interval after the output pulse.
80 MHz clock - self generated from seeding input or provided by BNC	YES, 80 MHz clock signal is Ok for operation
1 kHz clock, externally triggerable	YES, 1 kHz clock, externally triggerable
The parameters above must be achievable after the Amplifier B is seeded by the 90 mW seed	YES, all parameters above will be achievable with seeding power of 90

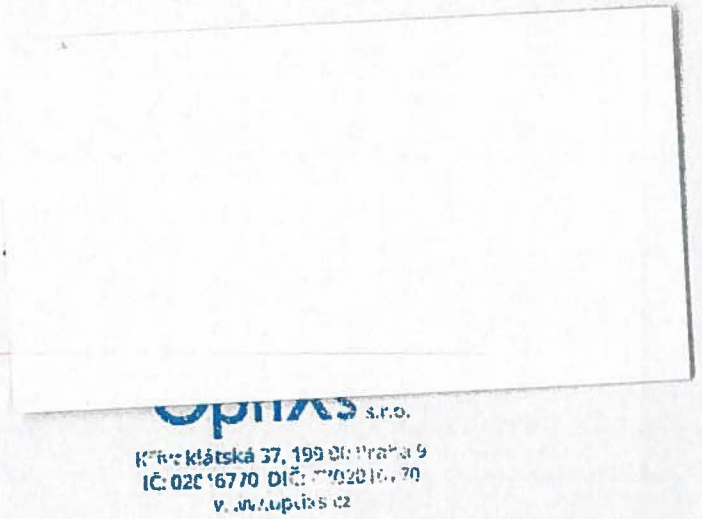
pulse train from the Vitara–S 80 MHz oscillator (Coherent) with spectrum as in the figure 1 in documentation.	mW from Vitara-S 80 MHz with defined spectrum in figure 1.
The Amplifier B shall be triggerable by the externally provided 1 kHz TTL signal from the "master amplifier" (provided by the CA) in such a way that amplifies the nearest seeding pulse arriving after the kHz trigger	YES, it is triggerable via its control SDG unit
Synchronization parameters	
The amplifier B shall be capable of a synchronized operation as a "slave" laser to the "master" 1 kHz amplified with whom it will share the oscillator (80MHz) and the 1 kHz TTL trigger signal (generated from 80 MHz by divider) provided with a tunable delay. The slave amplifier shall receive its 80 MHz clock from the photodiode placed after the optical delay line (figure 2 in documentation). The compatible photodiode together with its power source shall be provided by the Supplier.	YES, operation as a slave laser with triggering from 1 kHz and 80 MHz is possible. The compatible photodiode together with its power source will be part of delivery.
When the "master" amplifier will provide its 1 kHz clock to the "slave" amplifier with an electronic delay, the mutual delay of "master" and "slave" amplifiers shall change accordingly, however at fixed parameters it must stay constant with shot-to-shot jitter below 50 fs and 1 hour drift below 10 ps.	YES
Operation in accordance with above points shall be possible in configuration where an optical delay line is placed into the seeding part to the "slave" amplifier. In this configuration a continuous delay of the lasers from 0 – 1 ms must be achievable by combination of synchronized optical and electronic delay.	YES
Solution for the operation in point above shall be proposed by the Supplier. That means, how to correctly combine 80 MHz clock, 1 kHz clock with electronic 0-1 ms electronic delays, and optical delays 0 - 13 ns of the seed pulses in order to guarantee save windowless delay setting of the slave laser without alteration of output pulse parameters.	YES, this solution will be proposed by laser supplier.
Alteration (setting) of electronic delay between amplifiers shall not take more than 1 second when the devices (delay generators) are	YES

correctly interfaced.	
Control system and electronics	
Any control interfaces shall be equipped with an Ethernet port that will allow communication with the ELI Beamline computer. The communication shall be performed on a standard protocol, which can be implemented on the Linux based control system.	YES, control laptops are equipped with Ethernet ports
The Supplier shall provide to the CA the Interface Control Document (ICD) which shall include at least the following information: • Description of the data exchange format and protocol for exchange; • General description of the interface; • Dependencies regarding the interfaces where appropriate; • Estimated size and frequency of data exchange; • Description of implemented security.	YES, it is described in the manual
Transportation and Installation requirements	
The transportation to the final destination at the ELI Beamlines premises, the installation and the final verification of the Amplifier B shall be conducted by the Supplier.	YES
The amplifier B and its components shall be delivered in protective package preventing damage and contamination. The Amplifier B and its components shall be cleaned and packaged in compliance with cleanliness of class 7 according to ČSN EN ISO 14644 or cleaner.	YES
The transportation and installation procedures shall be discussed and can be reviewed by the CA's installation officers.	YES
The Supplier shall allow the CA to supervise the activities related to the transportation and installation of the Amplifier B.	YES
All participants to the installations shall undertake a lecture by the CA regarding safety, cleanliness, protection of the environment and working methods before starting their activities on the premises.	YES
The Supplier shall ensure that their activities at the ELI beamlines premises and the installation of the Amplifier B will be performed without	YES

contaminating the place of installation unnecessarily. The premises include rooms with normal cleanliness and cleanrooms of class 7 according to ČSN EN ISO 14644.	
Safety Requirements	
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.	YES

Details and parameters are mentioned in attached specs sheet.

Prague, 19.10.2018



List of attachement :

Price quote
Astrella datasheet
Astrella brochure

Astrella

Ultrafast Ti:Sapphire Amplifier

Astrella is a next-generation, ultrafast, kHz amplifier that is the first to combine industry-leading performance and industrialized durability.

Manufactured to Coherent's rigorous standards using advanced stress-testing techniques, the one-box Astrella system enables a wide range of demanding scientific applications and operating conditions, offering higher productivity and lower data acquisition costs. Delivering high (up to >7 mJ/pulse) energy, either <35 fs or <100 fs pulse widths, and excellent beam quality (M^2 <1.25), Astrella is ideal for ultrafast spectroscopy, THz studies, femtosecond micromachining, etc.

With unmatched performance, reliability and affordability, Astrella stands at the forefront of the industrial revolution in ultrafast science.

FEATURES

- One-box, industrialized platform
- HASS* verified for quality and reliability
- >5 mJ or >7 mJ, <35 fs or <100 fs pulses
- High performance STAR regen amplifier (water-only cooling)
- Hands-free Vitara oscillator
- Revolution pump laser for performance overhead
- Sealed stretcher/compressor section with advanced dispersion management for clean, short pulses
- Thermally-stabilized sub-systems for long term stability

APPLICATIONS

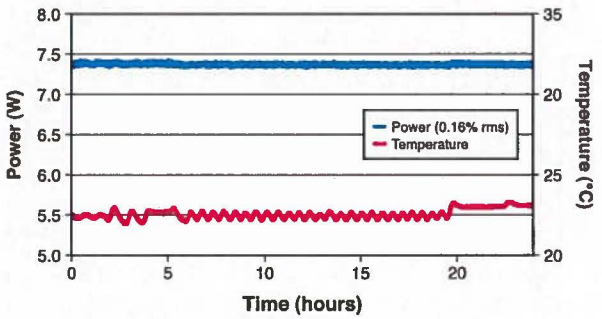
- Time-resolved Spectroscopy
- Multidimensional Spectroscopy
- THz Spectroscopy
- fs Micromachining
- Surface SFG/SHG
- Stimulated Raman Scattering

COHERENT.

SPECIFICATIONS	Astrella-1K-USP	Astrella-1K-F
Center Wavelength[2] (nm) (nominal)	795 to 805	780 to 820
Repetition Rate (kHz)	1	1
Pulse Duration[3] (fs) (FWHM)	<35	<100
Contrast Ratio[4]		
Pre-pulse	>1000:1	>1000:1
Post-pulse	>100:1	>100:1
Power Stability[5,6] (rms)	<0.5	<0.5
Beam Pointing Stability[5,6] (µrad) (rms)	<10	<10
Beam Diameter (mm) ($1/e^2$) (nominal)	11	11
Spatial Mode	TEM_{00}, M^2 <1.25	TEM_{00}, M^2 <1.25
Polarization	Linear, horizontal	Linear, horizontal
Energy per Pulse (mJ)	>7.0 , >5.0	>7.0 , >5.0
Pump Laser	REVOLUTION-65, REVOLUTION-50	REVOLUTION-65, REVOLUTION-50
Seed Laser	Vitara-S, Vitara-T, or Vitara-T-HP	Vitara-S, Vitara-T, or Vitara-T-HP

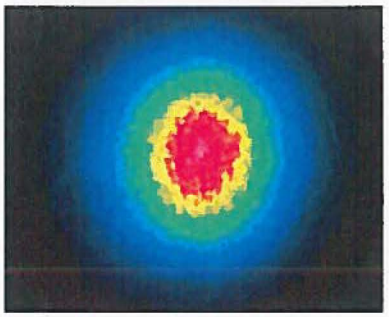
1 Specifications apply at 800 nm
2 Factory set, must be specified when ordered and will be optimized prior to shipment
3 A Gaussian pulse shape de-convolution factor (0.7) is used to determine the pulse width from an autocorrelation signal measured by a Coherent SSA (Single-Shot Autocorrelator)
4 Contrast ratio is defined as the ratio between the peak intensity of the output pulse to the peak intensity of any other pulse that occurs greater than 1 ns before or after the output pulse
5 Under stable environmental conditions after system warm-up
6 Over 24 hrs

Astrella Power and Pulse Width Stability

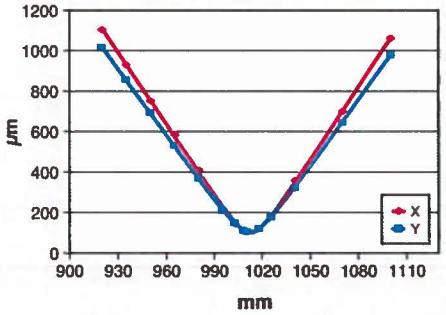


SUPERIOR MODE QUALITY

Typical Near Field Mode Quality



M^2 (x = 1.18, y = 1.14)



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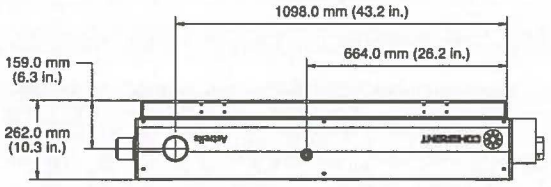
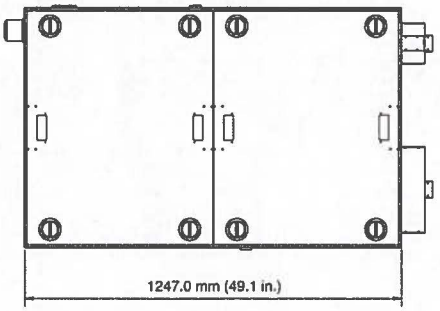
MECHANICAL SPECIFICATIONS

Astrella

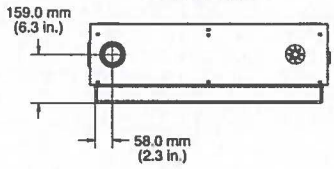
Right Side View



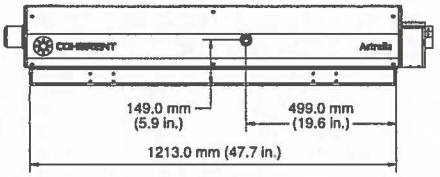
Top View



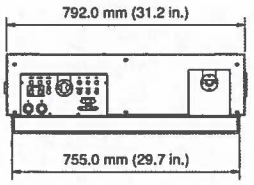
Front View



Left Side View



Rear View



COHERENT.

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tech sales@Coherent.com **www.Coherent.com**

>12.5GHz Photodetectors

EOT's >12.5GHz Photodetectors contain PIN photodiodes that utilize the photovoltaic effect to convert optical power into an electrical current. When terminated into 50Ω into an oscilloscope, the pulsewidth of a laser can be measured. When terminated into 50Ω into a spectrum analyzer, the frequency response of a laser can be measured. EOT's >12.5GHz Photodetectors come with their own internal bias supply consisting of long-life lithium cells. Plugging a coaxial cable into the photodetector's SMA output connector and terminating into 50Ω at the oscilloscope or spectrum analyzer is all that is required for operation.

Applications:

- Monitoring the output of Q-switched lasers
- Monitoring the output of mode-locked lasers
- Monitoring the output of externally modulated CW lasers
- Time domain and frequency response measurements

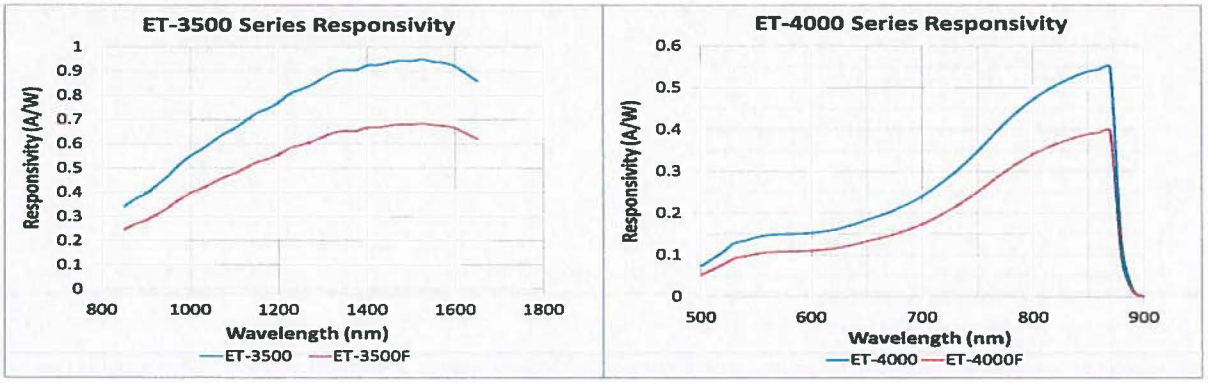
Features:

- >12.5GHz GaAs and InGaAs Photodetectors can be ordered with optional wall plug-in power supply

Specifications[a,b]:

Part No. (Model)	120-10058-0001 (ET-3500)	120-10068-0001 (ET-3500F)	120-10071-0001 (ET-4000)	120-10081-0001 (ET-4000F)
Detector Material	InGaAs	InGaAs	GaAs	GaAs
Rise Time/Fall Time	<25ps/<25ps	<25ps/<25ps	<30ps/<30ps	<30ps/<30ps
Responsivity[c]	>0.90A/W at 1300nm	>0.65A/W at 1300nm	0.53A/W at 830nm	0.38A/W at 830nm
Power Supply	6VDC	6VDC	3VDC	3VDC
Bandwidth	>15GHz	>15GHz	>12.5GHz	>12.5GHz
Active Area Diameter	32µm	32µm	60µm	60µm
Dark Current	<3nA	<3nA	<0.5nA	<0.5nA
Acceptance Angle (1/2 angle)	15°	N/A	15°	N/A
Noise Equivalent Power[d]	20pW/√Hz at 1300nm	28pW/√Hz at 1300nm	35pW/√Hz at 830nm	45pW/√Hz at 830nm
Maximum Linear Rating CW	10mW	10mW	10mW	10mW
Mounting (Tapped Holes)	8-32 or M4	8-32 or M4	8-32 or M4	8-32 or M4
Output Connector	SMA	SMA	SMA	SMA
Fiber Optic Connection[e]	N/A	FC/UPC, SMF28e	N/A	FC/UPC, SMF28e

[a] Product specifications are subject to change.
[b] All specifications apply for a 50Ω termination unless otherwise noted.
[c] Photodetectors have an internal 50Ω termination. Responsivity data applicable to diode only. Detector output should be determined based on 1/2 the responsivity of that shown on graph.
[d] Noise Equivalent Power (NEP) is determined via open circuit output.
[e] Multi-mode fiber available. May limit bandwidth.
Note: All products are RoHS compliant.



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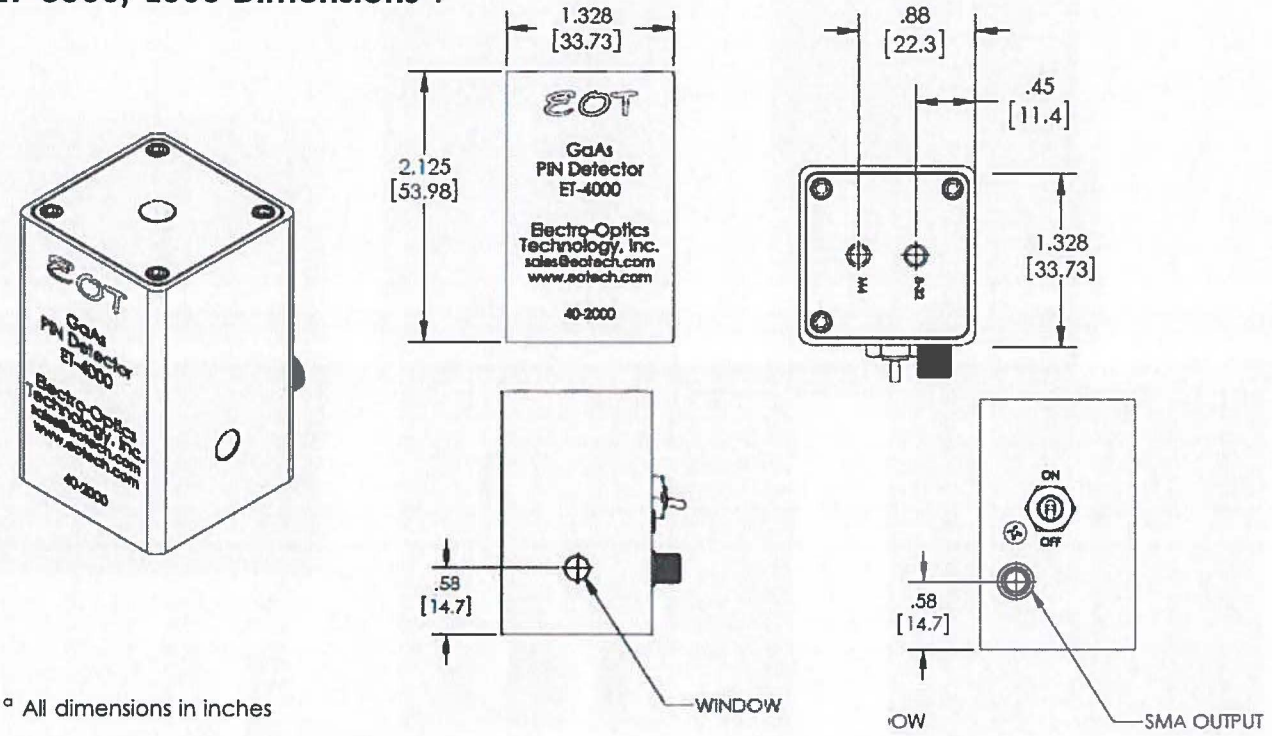
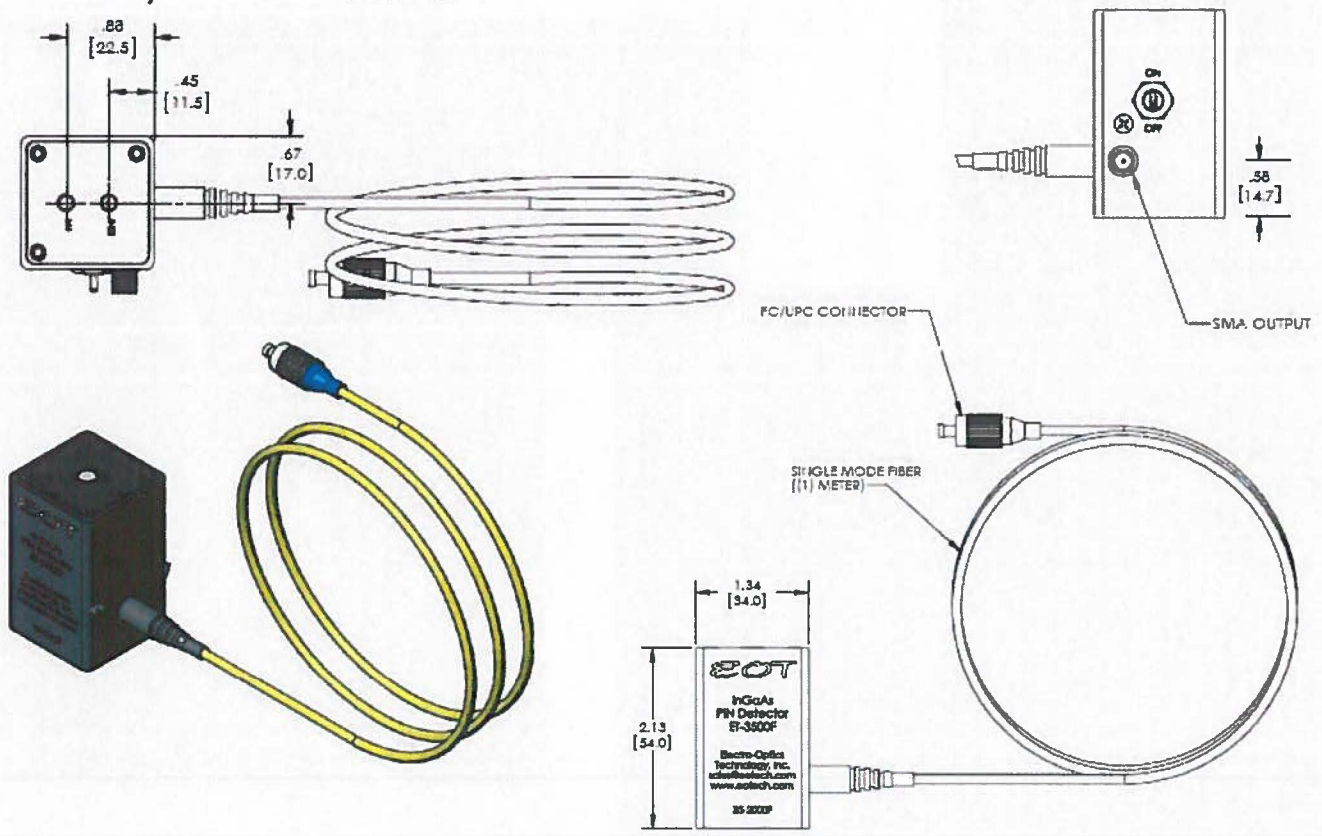
ET-3500, 4000 Dimensions[a]:



[a] All dimensions in inches

ET-3500F, 4000F Dimensions[a]:



[a] All dimensions in inches