

Annex 3 to Tender Documentation

Technical specifications and commercial terms „High Energy, High Repetition Rate Diode-Pumped Laser Scalable to multi-100-J level in a Single Beam“

This Annex 3 forms also an Annex to the Contract for Work, which provides the contextual framework for its interpretation, especially with reference to Article II section 6, letter a).

High Energy, High Repetition Rate Diode-Pumped Laser Scalable to multi-100-J level in a Single Beam

The subject of this Tender is design, construction, testing and delivery of laser-diode pumped laser amplifier technology capable to provide large energy in a single beam. The potential of this technology will be demonstrated by a 10 J / 10 Hz system. Operation and performance of this demonstrator is essential for the Client in planning of works connected with implementation of beamlines based on the technology of 100 J and multi-100-J repetition rate lasers.

Article I: Technical Specifications

A-I.i Architecture

The system must be based upon laser-diode-pumped Ytterbium doped YAG (ceramic or crystal) architecture suitable for multipass amplification of nanosecond laser pulses. The proposed solution must feature conceptual simplicity, versatility, and robustness in regard to the control of ASE (Amplified Spontaneous Emission).

A-I.ii Single pulse parameters

Energy	10 J
Pulse duration	2-10 ns (adjustment capability)
Repetition rate	10 Hz
Output energy stability	better than +/- 3% rms over 100 pulses
Wall-plug efficiency	>5 % (electrical input to pump laser / laser output)
Beam quality	5x diffraction limit or better for operation at 10 Hz

The design must be compatible with temporal pulse shaping capability for the generation of output pulse profiles suitable for pumping optical parametric broadband amplifiers (OPCPA). Any and each Deliverable described below must be in full compliance with any binding standards applicable in the Czech Republic, Republic of Hungary, Romania and the European Union.

A-I.iii Multi-pulse parameters

In addition to the single pulse parameters identified above in Annex 3 Article A-I.ii, the laser amplifier head must run for a total of 10,000 pulses at 10 Hz without sustaining damage of any of its optical components.

A-I.iv Scalability

The system must be aperture scalable to energies of 100 J and 500 J in a single beam, with all other parameters identical to those mentioned above in Article A-I.ii. The scaled amplifier must have the same overall geometry as the 10 J system developed and delivered within this Contract. The scaled amplifier must also employ the same principle of thermal management of the active medium as the 10 J system developed and delivered within this Contract.

A-I.v Heat extraction system

The system of heat extraction from the laser amplifier head must employ easily available, non-toxic, coolant medium. The Supplier shall perform the demonstration of performance of the system using his own cooling circuit. Integration of the delivered laser amplifier head into the ELI-Beamlines facility will be made using a cooling circuit provided by the Client.

Article II: Contract Deliverables**A-II.i Deliverable D1 Conceptual design report**

Produce a conceptual design of a laser-diode-pumped Ytterbium doped YAG (ceramic or crystal) laser amplifier architecture suitable for operation at 10 Hz and scalable to a system output of at least 500 J with pulse durations in the 2-10 ns range in line with technical specifications in Annex 3 Article A-I above.

A-II.ii Deliverable D2 Detailed engineering design report

Produce a detailed engineering design of a 10 J / 10 Hz laser amplifier head based upon the concept design described in Annex 3 Article II.i above. The design must include preliminary parameters of the cooling medium setting initial requirements on parameters of the external cooling circuit.

A-II.iii Deliverable D3 Construction of 10 J laser amplifier head

Construct and commission at the Contractor's normal place of business a 10 J 10 Hz laser-diode-pumped Ytterbium doped YAG (ceramic or crystal) laser amplifier head according to the detailed design developed under Annex 3 Article II.ii above.

A-II.iv Deliverable D4 10 J laser amplifier head demonstration

Perform systematic tests and measurements of the performance of the 10 J 10 Hz laser head. Demonstrate the operation of the 10 J laser amplifier head to the Client and produce a performance report including a comparison of performance against the Client's specification in Annex 3 Article I.ii above. A part of the delivery will be a full set of parameters of the cooling system to be supplied by the external cooling circuit at the Client's facility.

In the case of schedule delays or significant departure of the actual performance of the laser head from the Client's specification in Annex 3 Article I.ii above (in the case the Client chooses to accept Deliverable D4 despite such departure), financial penalties and/or Price discount will be imposed upon the Contractor as specified in Annex 3 Article IV below.

A-II.v Deliverable D5 100 J – 500 J schematic design report

Produce schematic engineering designs of 100 J and 500 J 10 Hz laser amplifier heads including schematic designs of all major system components including the laser gain media, optical pumping arrangement and energy extraction system.

The designs will take due note of the actual performance of the laser amplifier head according to Annex 3 Article II.iv above.

Provide estimates of the cost of production and advice on the installation of such systems within the ELI-Beamlines facility.

The scope of work undertaken under this deliverable includes calculations, modeling and measurements of the prototype system as may be necessary to give a high level of confidence that the concept is scalable to energies up to 500 J in a single beam.

A-II.vi Deliverable D6 Delivery of laser amplifier head to Client

Following the demonstration of the performance of the 10 J (or lower if accepted by the Client within Deliverable D4) 10 Hz laser amplifier head, the Contractor will ship the laser amplifier head and associated

components as specified in Annex 3 Article A-II.vii to the Client's normal place of business. The Contractor will arrange appropriate transit insurance for the equipment.

A-II.vii Equipment to be delivered to the Client

The equipment to be supplied to the Client in respect of Deliverable D6 comprises:

- a) Diode laser pumping system including the laser diodes, power supplies & control system
- b) 10 J (or lower if accepted by the Client within Deliverable D4) laser amplifier head assembly
- c) Optics including dichroic pump mirrors and associated optical mounts; amplifier head windows and laser gain slabs

Note: The cooling system for the laser amplifier head is excluded from the Contract, see above Article A-II.v.

A-II.viii Acceptance of the delivered equipment

Upon delivery of the equipment specified in Article A-II.vii to the Client the Contractor will provide its activation and will demonstrate the following functionality:

- a) Operation of the diode laser pumping system running with parameters identical to those achieved in the operation of the demonstrator in 10 J (or lower if accepted by the Client within Deliverable D4) 10 Hz regime in Delivery D4
- b) Vacuum operation of the assembled laser amplifier head equipped with windows
- c) Alignment of implemented optics (dichroic pump mirrors and associated optical mounts, laser gain slabs, amplifier head windows) and verification that the aligned optics is free of optical damage

A-II.ix Assistance to integration of the equipment into the Client's system

The Contractor will provide advice and/or assistance (including out of warranty service) to the Client in integration of the accepted equipment with the cooling loop and with Client's lasers systems, up to a maximum of ten man-days provided at the Client's normal place of business.

Article III: Delivery Schedule

The deadlines for the delivery of the Deliverables are set forth as a number of months after the date of signing of the Contract for Work (hereinafter "x months post contract") as follows.

Deliverable D1	Conceptual design report	3 months post contract
Deliverable D2	Detailed engineering design report	6 months post contract
Deliverable D3	Construction of 10 J laser amplifier head	9 months post contract
Deliverable D4	10 J laser amplifier head demonstration	10 months post contract
Deliverable D5	100 J – 500 J schematic design report	12 months post contract
Deliverable D6	Delivery of laser amplifier to Client	15 months post contract

Article IV Penalty Schedule

A-IV.i Delay Penalty

The penalty schedule for the individual Deliverables as specified in Article III reflects the importance of Deliverable D4 and D5 for timely execution of the ELI-Beamlines Project.

Should the Contractor be in delay with any of the Deliverables D1 to D6 the following contractual penalties shall apply:

Deliverable D1	0.02% of the Price for each day of the delay
Deliverable D2	0.02% of the Price for each day of delivery the delay
Deliverable D3	0.02% of the Price for each day of the delay
Deliverable D4	0.2% of the Price for each day of the delay
Deliverable D5	0.2% of the Price for each day of the delay
Deliverable D6	0.1% of the Price for each day of the delay

In case of simultaneous delay with more Deliverables, the contractual penalties as specified above are to be added up.

A-IV.ii Price Discount

In the case the Client chooses to accept the Deliverable D4 despite the fact that the Energy criterion set forth in Art. A-I.ii is not met, the following Price discount will apply:

- a) 5% of the Contract Price if energy output is less than 10 J;
- b) 10% of the Contract Price if energy output is less than 7.5 J.

Article V: Warranty

A-v.i Diode laser pump

Remaining manufacturer's warranty on diode laser pumping system, power supplies and control system will be passed to the Client on delivery of the laser head to the Client; the remaining duration of the warranty passed to the Client shall be at least 10 months.

A-v.ii 10 J laser amplifier head assembly

The laser amplifier head assembly will be warranted against poor design, poor workmanship and poor materials for a period of 1 year. This warranty will commence on delivery of the laser head to the Client.

A-v.iii Optics

The Contractor can elect between providing warranty for the optical components, comprising the dichroic pump mirrors, amplifier head windows and laser gain slabs, for a period of 1 year, or supplying a complete spare set of optics for use by the Client, on delivery of the laser head and comprised within the price.