LaserFusion Project School on
ICF Related Laser and Plasma Sources and Technology

13th July – 23rd July 2026 – ELI Beamlines conference hall

LaserFusion education - training
ERASMUS+ KA220-HED-13A477C3
Erasmus+ Enriching lives, opening minds.
Co-funded by the European Union
Innovative Education & Training in Laser Inertial Fusion Energy
https://laserfusion.hmu.gr

Day	Week 1
Mon 13 Jul	16:30 Arrival & registration 17:30 Welcome party
Tue 14 Jul	09:30 Welcome **09:40 Evaluation test** 10:25 Coffee break **10:45 L1a: Laser safety** 11:45 Short break **11:55 L1b: Radiation safety** **12:40 S0: Join Future at ELI** 12:50 Lunch **13:50–17:00 A1/A2/A3**
Wed 15 Jul	08:30 Breakfast **09:00 S1: Laser oscillators** 10:00 Short break **10:10 L2a: High energy lasers** 10:55 Coffee break **11:15 S2: High rep. las. accel.** 12:15 Short break **12:25 L2b: ICF principles** 13:10 Lunch **14:10–17:25 A4/A5/A6**
Thu 16 Jul	08:30 Breakfast **09:00 S3: Laser acceleration** 10:00 Short break **10:10 L3: Petawatt lasers** 10:55 Coffee break **11:15 L3: Petawatt lasers** 12:00 Short break **12:10 S4: Radiotherapy** 13:10 Lunch **14:10–17:30 A1/A2/A3**
Fri 17 Jul	**09:30 L4: Optics damage** 10:15 Short break **10:25 L4: Optics damage** 11:10 Coffee break **11:30 S5: Plasma diagnostics** 12:30 Lunch **13:30 O1: Facility tour**
Sat 18 Jul	**10:00 O2: Student presentations** 12:20 Lunch 14:30 Laser game
Sun 19 Jul	10:00 Prague city tour, free afternoon

Day	Week 2
Mon 20 Jul	**09:30 L5: Beam smoothing** 10:15 Coffee break **10:35 L6a: Temporal diagnostics** 11:20 Short break **11:30 L6b: Spatial properties** 12:15 Group photo 12:30 Lunch **13:30 L7: Beam delivery** 14:15 Short break **14:25 L7: Beam delivery** 15:10 Coffee break **15:30 S6: Experiments ELI**
Tue 21 Jul	**09:30 L8: CPA / OPCPA** 10:15 Short break **10:25 L8: CPA / OPCPA** 11:10 Coffee break **11:30 L9: EMP** 12:15 Short break **12:25 L9: EMP** 13:10 Lunch **14:10 L10: Vacuum tech** 14:55 Coffee break **15:15 L11a: Cryo targets**
Wed 22 Jul	**09:30 L11b: Foam targets** 10:15 Coffee break **10:35 L12: ICF plasma probing** 11:20 Short break **11:30 S7: Magnetized plasmas** 12:30 Lunch **13:30 Final test** 18:00 Farewell party
Thu 23 Jul	09:30 Learning conclusions, departure

Hands-on activities:

- **A1.** Fourier optics and its application in high power lasers
- **A2.** ELI Beamlines – Intro and overview
- **A3.** User Application Writing
- **A4.** Laser Beam Handling and Optical Alignment
- **A5.** 3D printing and target analysis
- **A6.** Hands-on Optical Spectroscopy

Other activities:

- **O1.** Facility tour
- **O2.** Student presentations (presentations about activities A4, A5 and A6, student's own research)

Lectures:

- **L1.** Safety
  - a. Vaclav Sobr - Laser
  - b. Veronika Olsovcova - Radiation safety at high-power laser facility
- **L2.** ICF Basics
  - a. Bedrich Rus - High energy laser systems
  - b. Ondrej Klimo - Principles and milestones of inertial confinement fusion
- **L3.** Stepan Vyhlidka - Petawatt class laser systems and their scaling towards higher repetition rates and better power efficiency
- **L4.** Daniel Kramer - Optics damage and coatings
- **L5.** David Blackman - Laser beam smoothing techniques
- **L6.** Laser beam characteristics
  - a. Davorin Peceli - Temporal characteristics and diagnostics of laser beams
  - b. Jakub Novak - Spatial properties of laser beams: From near field to far field
- **L7.** Petr Zimmermann - Laser beam handling and delivery to experimental stations
- **L8.** Tyler Green - Chirped pulse amplification (CPA / OPCPA)
- **L9.** Michael Ehret - Laser-generated EMP, not just a problem
- **L10.** Lukas Brabec - Vacuum technologies for high-power laser systems
- **L11.** Targets
  - a. Timofej Chagovets - Cryogenic and liquid targets for laser driven secondary emission
  - b. Tibor Teplicky - Target technology: two-photon polymerization printing
- **L12.** Uddhab Chaulagain - Probing of ICF plasmas with electron and photon beams

Seminars:

- **S0.** Andrea Fürst (ELI ERIC, ELI Beamlines) - Join the Future of Laser Science at ELI
- **S1.** Ioannis Fitilis (Hellenic Mediterranean University) - Fundamentals of Laser Oscillators and Resonators
- **S2.** Luca Volpe (Universidad Politécnica de Madrid) - Charged particle beams and plasmas generated by ultra-short ultra-intense laser pulses at high repetition rate
- **S3.** Chris Murphy (University of York) - Introduction to laser-based electron acceleration and extreme applications
- **S4.** Luca Labate (Consiglio Nazionale delle Ricerche) - Novel approaches to radiotherapy using laser-driven electron accelerators and perspectives for new modalities using high rep rate lasers
- **S5.** Sebastien LE PAPE (Institut Polytechnique de Paris) - Plasma diagnostics for inertial fusion energy
- **S6.** Singh Raj Laxmi (ELI ERIC, ELI Beamlines) – Laser Plasma Interactions at ELI Beamlines
- **S7.** Mathieu Bailly-Grandvaux (Université de Bordeaux) - HED magnetized plasmas and laser-driven magnetized ICF

A1 Fourier optics and its application in high power lasers

This tutorial introduces Fourier optics as a tool in laser design for preserving beam quality and enabling precise control over the spatial profile. We will explore how spatial profiles evolve as the beam propagates, the relation between near-field and far-field (the spatial profile at the focus), and how we can shape the beam using spatial filtering. The activity consists of a presentation followed by a laboratory class, where we will construct our own beam shaper setup.

A4 Laser Beam Handling and Optical Alignment

Participants will gain hands-on experience with laser beam alignment on an optical table. They will build and align a 4f telescope, including both beam-expanding and beam-reducing configurations, while exploring the constraints imposed by the available optical space and the distances between object and image planes. The activity will also introduce spatial filtering as a practical beam-conditioning technique. Finally, participants will assemble and align a simple interferometer, gaining practical experience with optical interference and precision alignment.

A5 3D printing and target analysis

This hands-on practical activity will allow the participants to use 3D printing based on MSLA / resin technology to fabricate holders for targets and samples and learn how to use X-ray transmission spectroscopy to determine the thickness of thin foil targets or density of very low density (foam) targets for laser fusion.

A6 Hands-on Optical Spectroscopy

Participants will work with a simple spectrograph station and based on the available information, calculate its properties and light diffraction output. Grating and prism spectrograph differences will be also discussed, together with usual applications of spectrographs.

S1 Fundamentals of Laser Oscillators and Resonators

This seminar introduces the basic principles of laser oscillators, including stimulated emission, population inversion, optical gain, and the conditions required for laser oscillation. It also discusses the role of the optical resonator in providing feedback, selecting resonant modes, and sustaining laser action. The seminar is intended as a refresher on the subject for the participants.

S2 Recent Advances in Ion stopping power in WDM and pump and probe experiments driven by ultra-fast High Repetition Rate PW Lasers

Ion stopping in dense plasmas remains a fundamental yet not fully understood topic in modern physics. It plays a central role in Inertial Confinement Fusion (ICF), where target self-heating by alpha particles triggers ignition and sustains thermonuclear burn propagation. The phenomenon is even more critical in target-heating schemes that employ ion beams as the primary energy drivers, such as heavy-ion fusion and ion-driven fast ignition. Beyond fusion, ion stopping is also of fundamental importance in high-energy-density physics for the generation, diagnosis, and characterization of Warm Dense Matter (WDM), as well as in a wide range of astrophysical applications.

A recent experiment [Malko2022], performed at the Centro de Láseres Pulsados (CLPU) in Salamanca using the petawatt-class VEGA laser, has demonstrated the unique capabilities of ultra-short, high-intensity laser systems for dedicated studies of ion stopping power in dense plasmas.

The experimental platform simultaneously generates ultra-short laser-driven proton bursts [Volpe2024] and isochorically heated plasmas, providing well-controlled conditions for time-resolved stopping power measurements in warm dense matter. This unique configuration opens the way to a new class of ultrafast pump–probe experiments in plasma physics, laboratory astrophysics, and laser-driven particle acceleration. The same platform also offers exciting opportunities for applications in inertial fusion, materials science, biology, and medicine.

This presentation will review the underlying physical mechanisms, summarize recent experimental achievements, and discuss future perspectives enabled by next-generation high repetition-rate laser facilities, advanced plasma diagnostics, and laser-driven particle sources.

References:

[Volpe2024] L. Volpe et al., A Platform for Ultra-Fast Proton Probing of Matter in Extreme Conditions, Sensors 24 (16), 5254 (2024).

[Malko2022] S. Malko et al., Proton stopping measurements at low velocity in warm dense carbon, Nature Communications (2022).

S3 Introduction to laser-based electron acceleration and extreme applications

In the last 20 years, advances in laser technology have allowed compact plasma accelerators to develop at a rapid pace. Laser wakefield acceleration (LWFA) is one such accelerator approach which has demonstrated the capability to accelerate electrons to GeV levels in a few centimetres. Combining this advance with ever-increasing laser power, also allows strong fields to be studied in a way which was not possible before. This seminar will introduce the concept of LWFA and show how understanding of strong field QED - including antimatter creation - might be achieved through these compact accelerators.

L3 Petawatt class laser systems and their scaling towards higher repetition rates and better power efficiency

In this lecture, we will examine the design of petawatt-class systems like L3 HAPLS and L4 ATON. We will focus on how diode pumping replaces flashlamps to overcome thermal limits, boost wall-plug efficiency and increase repetition rate. Additionally, we will discuss the technical challenges of their further scaling.

L4 Optics Damage and Coatings

We will discuss the damage mechanisms and test procedures for long and short pulses. Simulations. Laser induced contamination and mitigation strategies. Coating types and resulting optics properties will be highlighted.

L5 Laser beam smoothing techniques

Students are introduced to the idea of laser-plasma instabilities and how we try to avoid these on the laser side of the interaction. This includes well developed methods such as random phase plates and high frequency conversion, as well as more novel approaches such as broad bandwidth lasers.

L6b Spatial Properties of Laser Beams: From Near Field to Far Field

This lecture introduces the fundamental spatial properties of laser beams, bridging the concepts of geometrical optics and physical optics with a practical focus on laser systems. It begins with the basic principles of ray optics and imaging, followed by an introduction to optical aberrations, their measurement, and practical strategies for minimizing their impact in simple optical systems. Participants will then learn how laser beam propagation evolves from the near field to the far field, including the roles of diffraction, wavefront curvature, beam quality, and Gaussian beam parameters.

The course emphasizes an intuitive understanding of the underlying principles, helping participants quickly identify and interpret common phenomena encountered in the laser laboratory.

L10 Vacuum Technologies for High-Power Laser Systems

The lecture will introduce the fundamental principles of vacuum technologies used in modern research infrastructures such as ELI Beamlines. The presentation will focus on the methods used to achieve high vacuum conditions, including the different types of vacuum pumps, vacuum measurement techniques, and procedures for testing vacuum quality. In addition, the basic principles and considerations involved in the design of vacuum systems will be discussed.

L11b Target technology: two-photon polymerization printing

This lecture introduces the complete workflow of fabricating laser targets using two-photon polymerization (2PP) printing at ELI Beamlines. Starting from the initial experimental requirements and CAD design, participants will follow the process through fabrication, quality inspection, and final target assembly, illustrating how an experimental idea is transformed into a ready-to-use target.