eurizon
European network
for developing new horizons for RIs

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Document information

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1	25.10.2023	Chris Baird, Rob Clarke, Magali Garcia, Daniela Stozno, Ramona Landgraf	

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1. Introduction

WP6 "High-power lasers: Technology development for future multi-PW laser facilities" has the following objectives

- Develop new optics and metrology technologies as key technological foundations for future multiPW (peta watt) laser facilities
- Use relativistic plasma mirrors as light condensers to approach the Schwinger limit
- Design a spatio-temporal diagnostics device for ultrashort & ultraintense laser pulses at multi-PW laser facilities with low repetition rates
- Train researchers and engineers in intense laser science, metrology and applications

Task 6.3 deals with "Training and scientific exchange", under joint responsibility of Laserlab-Europe AISBL and ELI-ERIC. In particular, Laserlab-Europe provides a platform for dedicated knowledge sharing and training on the topics of intense laser pulse propagation, pulse contrast enhancement, and pulse metrology. This is realized through a series of events in which these relevant topics are discussed among the partners in conjunction with leading experts from Laserlab-Europe and external internationally renowned instructors. The regularity of these training events provides a sustainable laser science forum in which knowledge and state-of-the-art results are shared and best practices are developed.

The training events had been conceived as on-site trainings with hands-on sessions in partner labs, and the Covid-19-related restrictions on travels and meetings in presence made it necessary to postpone the planned trainings. After the end of the pandemic, and following an online training event in 2021, training events on site have started in summer 2022 (see deliverables D6.1 and D6.3). During the last year of the project, two training events in person have been held.

2. CLF training weeks for high-power laser experiments, 4th – 15th September & 11th – 22nd September 2023

Description of the Course

The CLF Training Weeks is a course designed to teach PhD students and early career researchers the fundamentals of conducting experiments using high-power laser systems, such as the CLF-based Vulcan and Gemini, as well as other such facilities around the world. We aim to provide students with the technical skills and knowledge required to conduct cutting-edge research.

Each course runs for two weeks, and students are taught in groups of 6. The course consists of a series of practical modules, which teach students a range of skills such as optical alignment, diagnostic setup and calibration, experimental best practice, and data analysis techniques. We also cover critical safety procedures to enable students to work safely with class 4 lasers, high-pressure gases, and vacuum systems, all of which are commonly encountered during high-power laser experiments.

The target audience for the CLF Training Weeks is students near the start of their PhD (i.e. 1st / 2nd year), however we offer training to those at any stage of their PhD, and to early stage postdoctoral

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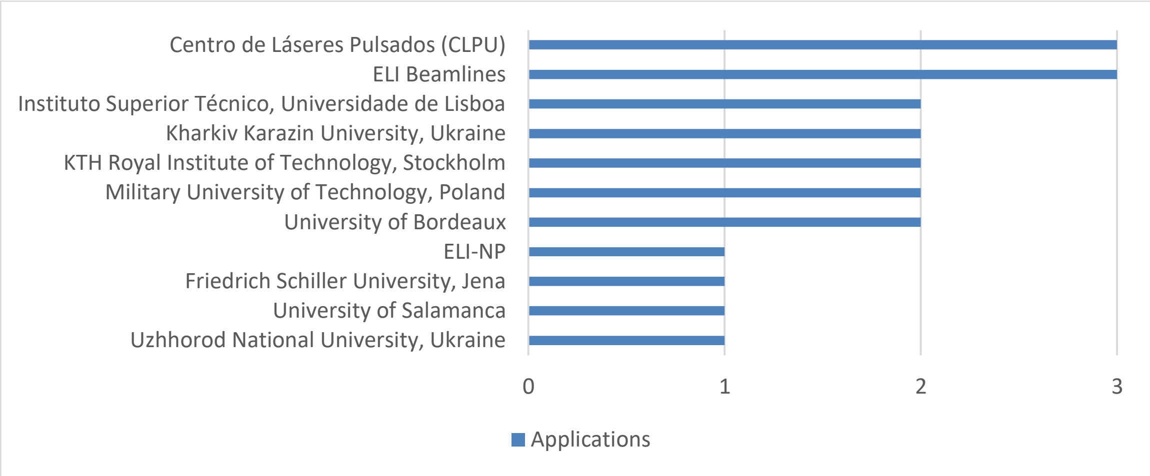
researchers who require it. The 2023 edition of the course has been organised on behalf of the project EURIZON and Laserlab-Europe.

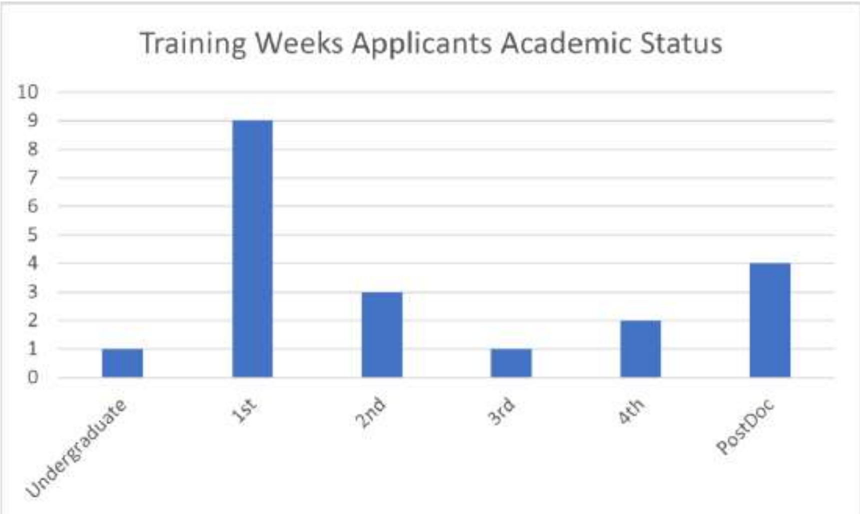
Institutions Represented in 2023

This year we had 20 applications for training from the following institutions:



Applicant Statistics

Only the institution and academic status of the applicants was recorded. The plurality of applications came from 1st year PhD students (9). The distribution of academic status is shown below.



Selection Criteria

Applicants are required to be part of a PhD programme, or an early career postdoctoral researcher in a field of laser physics relevant to the course content. The aim of the course was to reach applicants from as many laser institutes/research infrastructures as possible. At the request of the funding institution, students from Ukraine were given priority.

Where more than two applications were received from the same institution, places were given to those we determined would benefit most from the training i.e., those early in their PhD with little-to-no prior experimental experience. Further applicants were placed on a reserve list.

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Participants

Twelve participants were chosen from the applications, representing the following institutions:

- Centro de Láseres Pulsados (CLPU) | 2 (both 1st yr)
- ELI-NP | 1 (1st yr)
- ELI Beamlines | 1 (Postdoc.)
- Instituto Superior Técnico | 1 (4th yr)
- KTH Royal Institute of Technology, Stockholm | 1 (1st yr)
- University of Bordeaux | 1 (1st yr)
- University of Salamanca | 1 (1st yr)
- Friedrich Schiller University, Jena | 1 (4th yr)
- Uzhhorod National University, Ukraine | 1 (Postdoc.)
- Kharkiv Karazin University, Ukraine | 2 (4th yr undergrad, 2nd yr phd)

Unfortunately, two of the students from Ukraine withdrew their applications at short notice (one cited issues obtaining a visa in time). Due to the short notice, it was not possible to fill remaining slots. Therefore, there were 10 participants in total.

Gender

Of the 20 applicants, 14 were male and 6 female. The selected applicants were 7 male and 5 female. Unfortunately, the two Ukrainian students who could not attend were female. There was therefore a total of 3 female and 7 male participants.

Sessions

Upon arrival, students are introduced the scientific output and impact of the CLF by the facility director, Prof. John Collier.

Lectures

The course starts with a safety briefing, followed by a lecture on optics used in high power laser experiments. This lecture is designed to extend the students' existing knowledge of optics from university into a more experimental context. Key topics include, focussing properties of optical elements, optical materials and coatings, aberrations, and nonlinear effects, all of which are important considerations in any experiment involving lasers.

This is followed by a series of motivating lectures on the scientific applications, and some of the key challenges, associated with high repetition-rate laser facilities:

- EPAC Science – Dr. Dan Symes (Senior Beamline Scientist, CLF)
    - Explores the promising scientific applications of high rep-rate facilities such as EPAC, such as compact particle acceleration schemes, ultra-high-brightness X-ray sources, and high-resolution imaging.
- Automation and Intelligent Control Systems – Dr. Stephen Dann (Data Management Technical Lead, CLF) & Dr. Matt Streeter (QUB)
    - Discusses the necessity of automation high rep-rate laser experiments and gives an overview of various techniques for real-time data analysis at scale.
- Detectors – Dr. Chris Armstrong (Senior Detector Scientist, CLF)
    - Explores the capabilities and limitations of diagnostic detectors and showcases ongoing developments in this area.

Practical Sessions

Students are given hands-on training in a variety of techniques which are essential for conducting successful experiments. The practical sessions were conducted in one of several lab spaces within the

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facility. The general format is an introductory demonstration by a CLF staff member, followed by a series of problem-solving tasks to be completed by the students. Each session is prepared and tested prior to the start of the course to ensure the students attain the maximum benefit.

The focus of the course is a short experimental practical in one of our target areas, Gemini TA2, where the students participate in a short, but realistic experimental campaign to optimise an X-ray source produced from a laser interaction with copper. The experiment was designed at the CLF and gives the students the opportunity to guide the experimental process, ultimately collecting sets of data from various diagnostics which they can analyse during the data analysis sessions.

The practical sessions for this year were as follows:

Optics handling	Teaches the correct approach for handling large and delicate optics in order to prevent damage, as well as techniques for inspecting and cleaning optical elements.
Optics & Optomechanics	Students learn the basic techniques of optical alignment, including how to build rudimentary imaging systems using optical components.
Parabola Optimisation	Principles of alignment and optimisation of parabolic mirrors used to focus lasers to high intensity.
Adaptive Optics	Measurement and mitigation of wavefront aberrations. Adaptive optics are used to reduce aberrations and improve focal spot quality.
Beam Timing	Techniques used to temporally overlap laser pulses to femtosecond precision.
Particle and X-ray diagnostics	Students learn about the types of diagnostics used to detect particle and X-ray emission, as well as techniques for calibration and analysis.
Simulations and High-Performance Computing	An overview of the simulation techniques used to complement experimental campaigns. Students are also introduced to high-performance computing using our on-site computing cluster, SCARF.
Experimental Practical	Students spend two days in one of our laser target areas and learn how to set up an experiment and collect data at high-repetition rate. The students conduct a basic laser-solid experiment to produce hard X-rays from copper tape.
Data Analysis Techniques	A three-day workshop on basic analysis techniques using Python, during which the students analyse the data collected from their experiment.

Final Presentation

On the final day of the course, the students give a short presentation on the results of their experiment to an audience comprised of CLF staff. Following the presentation there is a question-and-answer session to allow further discussion of the results.

Student Feedback

Students are encouraged to give feedback on the course, both in person and via an online feedback form which asks students to give ratings on various aspects of the course, on a scale of 1 (very negative) to 6 (very positive).

Only a small number of responses to the form have been received so far, but all have rated the course either 5 or 6 on the scale.

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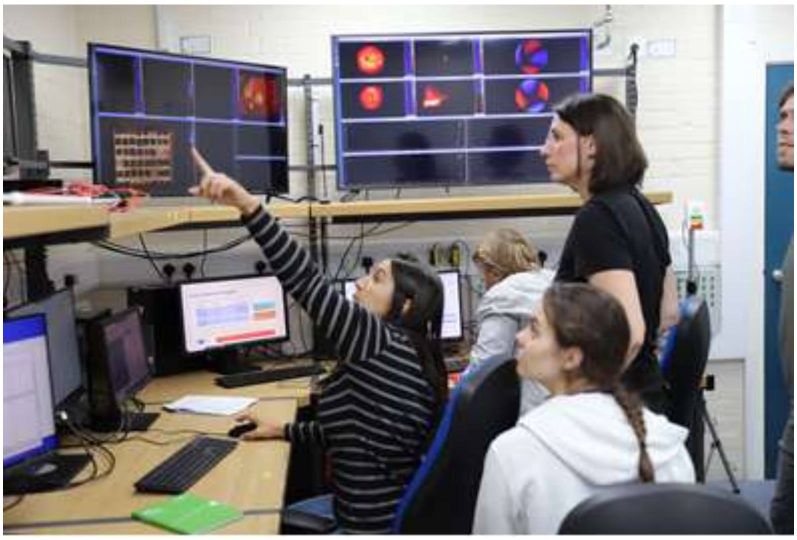
The students have also provided comments on improvements which could be made to the course in future. As in previous years, we take all feedback into account to deliver the best possible experience for the students.

Impressions

Selection of images from the course



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3. Training Course on Intense Lasers, 16-20 October 2023, Talence (Bordeaux), France

Description of the course

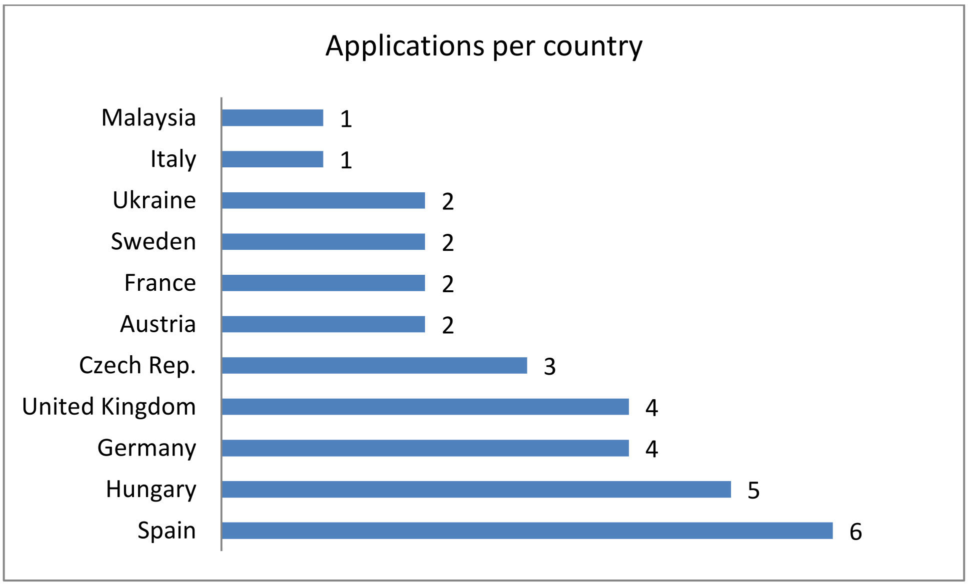
The PYLA training center provides training courses in the field of lasers, optics and photonics since 2005. Located within the Institute of Optics of Aquitaine, the PYLA training center has premises entirely dedicated to the organization of training courses for professionals, including 500sqm of labwork facilities.

This 5-day training course on intense lasers provides participants with the necessary skills to design and efficiently use intense laser systems. The course addresses the theoretical background as well as practice and lab work including computation and simulations, covering laser architecture; laser sources (oscillators); amplification, beam handling and focusing; non-linear optics: frequency conversion and laser tenability; laser diagnostics and beam management; and labs-simulations and codes. The course consists of 12 sessions of tutorials or lab works by more than ten expert trainers in the field.

Applications

Attendance is limited to 12 participants. A call for applications was published on the webpages of Laserlab-Europe and EURIZON and distributed through several email distribution lists. Applications from scientists in Ukraine were encouraged.

In total, 32 candidates from all over Europe applied, of which 25 male and 7 female.



Participants

Applicants were selected according to their level of training with respect to the contents of the course to allow successful participation in the high-level course. In addition, the aim was to include applicants from different institutions. Therefore, in case of more than one application from the same institution, only one applicant was selected. Applicants from Ukraine were given priority, if their profile matched at least the basic required level of training. Further applicants were put on a reserve list.

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Twelve participants were chosen from the applications, representing the following institutions:

- Centro de Láseres Pulsados (CLPU), Spain | 1
- ELI-ALPS, Hungary | 1
- Institut Optique, France | 1
- AWE / Orion, UK | 1
- INFN, Italy | 1
- Lund University, Sweden | 1
- HiLASE, Czech Republic | 1
- Friedrich Schiller University, Germany | 1
- CLF, UK | 2
- ICFO, Spain | 1
- TU Graz, Austria | 1

Three female and nine male applicants were selected. Unfortunately, the selected applicant from Ukraine withdrew his application so that the remaining place had to be filled at short notice.

For the second applicant from Ukraine, other training options in bilateral collaboration are under discussion.

Training course instructors

The training course instructors and coaches for the hands-on sessions are experts from universities, laboratories and partner companies, mainly in the Bordeaux area.

Courses

- Prof. Eric Cormier, LP2N Laboratoire Photonique, Numérique et Nanosciences
- Elodie Boursier, CEA
- Jean-Christophe Delagnes, CELIA UMR5107 CEA – CNRS – Univ. Bordeaux
- Catherine Le Blanc, LULI, Ecole Polytechnique, Palaiseau
- Antoine Courjaud, Amplitude
- Sébastien Montant, CEA
- Guillaume Beaugrand, Imagine Optics

Labwork and Tutorials

- Guillaume Machinet, Valerian Freysz, Yanis Kabir ALPhANOV
- Frédéric Burgy, Lionel Canioni, Hussein Toffaili, Paolo Paris, University of Bordeaux
- Fabien Verdes, Femto Easy
- Geoffrey Gallé, SourceLab
- Guillaume Beaugrand, Imagine Optics

Student Feedback

In their feedback, the participants unanimously appreciated the quality and high standard of the course regarding topics, the state-of-the-art experience of the experts, as well as the good ratio of theory and practice.

Two statements are cited as examples:

- So useful to see immediately in the lab the theory heard in class, that re-inforce the knowledge acquisition.
- The chance to see inside lasers/amplifiers that are normally closed!

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Schedule – Sessions

LASER INTENSES TRAINING COURSE, 16 Oct; - 20 Oct. 2023, Talence
PYLA TRAINING CENTER– Bordeaux France

SCHEDULE

	Monday 16/10/2023		Tuesday 17/10/2023		Wednesday 18/10/2023
	LASER ARCHITECTURE		NON LINEAR OPTICS		LASER SOURCE (OSCILLATORS)
09:00	**WELCOME 9h00 - 9h15** **LASER BEAMS - 9h15 - 10h45** **Physical quantities** - Wavelength - Power, Energy, Fluence, Intensity, Brightness - Peak power, average power **Linear propagation**: - Complex electric field - Time-frequency duality - Spatial modes - Beam quality M^2, wavefront	09:00	**BASICS OF NON LINEAR OPTICS 9h00 - 10h00** Concept and definition - conservation laws, phase matching, $\chi 2$,$\chi 3$ **NON LINEAR OPTICS APPLICATION 10h00-10h45** Frequency conversion and parametric sources Crystal with $\chi 2$	09:00	**9h00 – 11h00** **OSCILLATOR PRINCIPLES** Laser operation: CW, Q-switch, mode-locking (active, passive) Cavities and gain mediua (3 et 4 levels) Optical pumping (Laser de pompe, diodes lasers) **FEMTOSECOND SOLID-STATE OSCILLATORS** Gain media for modelocking Modelocked sources (Picoseconde Femtoseconde, Non linearisés/dispersion, performances/state of the art)
10:45	BREAK - 10h45 - 11h00	10:45	BREAK - 10h45 - 11h00	11:00	BREAK - 11h - 11h15
11:00	**LASER ARCHITECTURE - 11h00 - 12h30** **Hih intensity lasers** Components: Oscillator, pulse picker, amplifiers, compressor, beam shaping, ... Specific architectures (ns, ps, fs, CPA, OPA) **Related issues:** Damage , Thermal, Propagation (Linear, Non-lineaire, Kerr/Brillouin/Raman), ...		**NON LINEAR PROPAGATION - 11h00 - 12h30** Impact in the spectral/temporal domain Impact in the spatial domain Self focusing, SPM, SRS, AM-FM, SBS, cascaded processes,, B- integral, ...		AMPLIFICATION **SOLID STATE AMPLIFICATION - 11h15 - 12h30** Optical Pumping, Single and multipass amplifier (IllustrationNd:glass)
12:30	LUNCH 12h30 - 13h30	12:30	LUNCH 12h30 - 13h30	12:30	LUNCH 12h30 - 13h30
13:30	**LABWORKS 13h30 - 17h00** **Rotation - 4 groups 3 Pers., 50' /TP** Fibre injection, Helium - Neon Cavity, VR Alignement / telescope / parabola, Basic metrology (Power, energy, spectrum)	13:30	**LABWORKS 13h30 - 17h00** **Rotation - 4 groups 3 Pers., 50' /TP** Frequency doubling, Raman. , S-pulse HR, super continuum, SNLO, designing and selecting non-linear cristal for frequency conversion, OPA, OPO, SPM, dispersion, solitons in fibres (Fiberdesk, GNLSE code Python)	13:30	**AMPLIFICATION (suite) - 13h30 - 15h30** Regenerative amplifier (Illustration with Ti :Sapph) Chirped pulse amplification Constraints **+ TUTORIAL** BREAK - 15h30 - 15h45 **FIBER OSCILLATORS 15h45 - 17h00** Waveguide and fibers , gain media femto secondes fiber Oscillators
17:30	Feedback and round table	17:30	Feedback and round table	17:30	Feedback and round table

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LASER INTENSES TRAINING COURSE, 16 Oct; - 20 Oct. 2023, Talence
PYLA TRAINING CENTER– Bordeaux France

SCHEDULE

	Thursday 19/10/2023
	AMPLIFICATION (continuation)
09:00	**FIBER AMPLIFIERS - 9h00 - 10h00** Er, Yb, Quasi 2 ou quasi 3 level Design, geometry Specific constraints Performances / State of the art
10:00	BREAK - 10h00-10h15
11:00	**CONSTRAINTS - 10h15 - 11h45** Gain managment Damage Birefringence Environment Thermal issues Contrast (ASE, prepulse)
12:00	**TUTORIAL 11h45 - 12h30**
12:30	LUNCH 12h30 - 13h30
13:30	**LABWORKS 13h30 - 17h00** **Rotation - 4 groups 3 Pers., 50' /TP** Neodyme:Glass Oscillator,Regen, S-Pulse, Fiber laser kit, Fiber amplifier
17:30	Feedback and round table

	Friday 20/10/2023
	LASER DIAGNOSTICS ET BEAM SHAPING
09:00	**DIAGNOSTICS - 9h00 - 10h00** Energy, power, spectrum Temporal characterization (Autoco, FROG, SPIDER,...) Spatial characterization, wavefront measurement (HASO, ...) M2, Strehl ratio, Encircled energy
10:00	**TEMPORAL AND SPECTRAL SHAPING - 10h - 11h00** Amplitude and phase Dazzler, SLM and zero dispersion line
11:00	BREAK 11h00-11h15
	SPATIAL CONTROL - 11h15-12h00 Measurements Correction and protection techniques
12:00	**TUTORIAL 12h - 12h45** Influence of the spectral phase on the pulse duration and diagnostics simulation (TF, autoco, FROG and SPIDER traces)
12:45	LUNCH 12h45- 13h30
13:30	**LABWORKS 13h30 - 17h00** **Rotation - 4 groups 3 Pers., 50' /TP** Temporal measurement: commercial Autoco, FROG, Manual autoco, Spatial control and measure, Spatio-temporal measurement
17:30	Feedback and round table/Evaluation

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