Joint ELI Workshop on Advanced Technologies 2024 – session reports

Eva Klimešová, Science with coherent XUV sources

The “Science with coherent XUV sources” workshop gathered scientists working on high-harmonic sources and their applications mainly in AMO sciences. External speakers presented topics such as chiral dynamics in molecules, ultrafast processes in liquid jets and photodynamics in laser-irradiated molecules. In the technical talks, several instruments were presented: the HHG beamline and MAC end-station at ELI Beamlines; and the gas high-repetition rate HHG beamline, the MIR-driven HHG beamline and polarimetry experiments at ELI ALPS. Moreover, a user-oriented code for calculations of HHG process was discussed.

The topics for round-table discussion included non-linear XUV studies, XUV pump / XUV probe investigations, XUV polarization studies, and the position of HHG sources with respect to XFELs

A general feedback to UWAT:

The workshop was nice and fruitful, it allowed discussions with (potential) users. But the date of the workshop 28th June was not convenient, as it was the last day of the school year.

Subhendu Kahaly, Generation and applications of ultrashort structures light

The topic is an exciting new direction where there has been lots of interest and research activity recently. With this in mind we organized the session to push for advanced technology at ELI. There were four speakers invited to present complementary directions. The session was very successful. The interest on the topic was evidenced by the large attendance to the session and a sample of the the advancement in the field was well captured by the presentations.

Marco Picardo presented the latest advancements made in IST (Lisbon) through meta optics intelligent design, that can benefit ultrashort pulse spatio-temporal shaping. In the presentation he showed experimental implementation of a small prototype. Then Igor Adnriyash summarized the ENSTA, Ecole Polytechnique approaches of utilising structured light in the high intensity regime to optimize wake field acceleration structures to improve laser acceleration of electrons. It would improve ELI capability to test such approaches and utilize them to offer optimized secondary sources to the user community. Mihail Cernaianu presented the recent experimental results from ELI NP side, where they implemented structured ligh configurations at high intensity on solid targets for ion acceleration purposes. The final presentation was made by Jorge Viera, where he demonstrated how state of the art 3D PIC simulations incorporating enhanced data visualization can unravel intricacies of structured light interaction in laser plasma domain. He showed that such virtual experiments, that they undertook in IST (Lisbon) are essential to interprete secondary radiations coming from structured laser interaction with plasma at high intensities.

Lorenzo Giuffrida, Secondary Sources for Cultural Heritage and Space Radiation

The ELI User Workshop on Advanced Technologies, titled "Secondary Sources for Cultural Heritage and Space Radiation," was held at ELI Beamlines on June 28, 2024. The primary objective of the workshop was to facilitate contact between ELI ERIC representatives working on laser-driven particle generation (ions, electrons, neutrons, and gamma rays) and communities engaged in the fields of cultural heritage and space radiation.

The key message from all invited speakers was their keen interest in the capacity of ELI ERIC instruments to generate different types of radiation, including mixed fields. For cultural heritage, the opportunity to investigate samples using neutrons, electrons, gamma rays, and protons is particularly welcomed. This is due to the significant advantage offered by the simultaneous generation of these particles during the same laser-target interaction, which could pave the way for new research directions. Furthermore, the ability to operate lasers at a high repetition rate is crucial for enhancing the statistical robustness of measurements, thereby solidifying experimental results.

Techniques such as Particle Induced X-ray Emission (PIXE), Energy Dispersive X-ray Spectroscopy (EDXS), X-ray Fluorescence Spectroscopy (XRF), Activation Analysis with Protons and Neutrons (PAA, NAA), and Radiography have been revitalized using laser-driven secondary sources. These can serve as complementary techniques to those employing conventional accelerators.

Within the domain of space applications, the situation is more complex. While mixed fields are commonly experienced in space, space agencies require radiation hardness tests for single particle types. Furthermore, radiation hardness requirements are the same regardless of the type of space application. For example, the European Space Agency requires radiation hardness tests for proton and ion fields even if a satellite is designed to be sent to an area where the dominant radiation is represented by electrons. The community that studies radiation hardness for space applications is eager for access to proton and ion beams; therefore, the possibility of accessing these beams at ELI is particularly enticing. The interest in using electron beams for radiation hardness studies was also discussed.

In addition to the space electronics domain, other potential space applications could benefit from ELI's capabilities, such as astrochemistry, particularly regarding the icy mantles of the interstellar medium in plasma environments. This would involve using radiation (including Terahertz, XUV, ions, and electrons) generated through laser-matter interaction, encompassing mixed radiation fields. The potential for simulating meteoritic impacts using high-energy, high-repetition-rate laser pulses was also mentioned.

Sergey Bulanov, Electron-Photon Collision Platforms at ELI

Collisions of high-energy electrons with a strong electromagnetic wave, being one of the central problems of classical and quantum electrodynamics, have attracted attention since the works of J. J. Thomson and A. H. Compton. The laser facilities currently in operation and being put into operation make it possible to accelerate electrons to ultra-relativistic energies and to achieve the focused laser radiation with unprecedented intensities, which makes it possible to enter regimes where the interaction of electrons with photons will occur in the regimes of strong-field quantum electrodynamics. Theoretical and experimental study of these regimes using the lasers available at ELI-BL and ELI-NP will open the way to research on fundamental scientific problems, as well as to the development of novel high-brightness sources in the X-ray and gamma-ray ranges.

The session "Electron-Photon Collision Platforms at ELI" featured 5 talks from speakers from ELI-BL, ELI-NP, and user groups from the US, Japan, and UK. About 30 participants attended in

person and 5 attended virtually. Each of the talks presented in the session raised up active discussion.

The session was opened with a talk by J. Grittani, who gave an overview of the ELBA setup at ELI-BL, demonstrating readiness to conduct experiments on the collision of the LWFA accelerated electron beams with the focused high-power laser pulse.

M. Kando from KPSI-QST (Japan) discussed an approach towards generating an ultra-intense electromagnetic field using the concept of a relativistic flying mirror. M. Kando presented theoretical and experimental results obtained at KPSI-QST and spoke about the plans of the KPSI-QST scientific group to participate in the ELI user program. In addition, he demonstrated the latest results obtained in Japan on generating electromagnetic radiation using a compact XFEL based on the use of laser-accelerated electron beams.

A.G.R. Thomas from the University of Michigan (USA) gave a report on the fundamentals of laser-electron collision physics. The main focus is on the signatures of the constant field approximation and the monochromatic wave model used to describe nonlinear Compton scattering that can be realized in the interaction of a multi-petawatt laser with ultrarelativistic electrons.

In the talk “High field electrodynamics with ultraintense lasers and electrons” by S. Ataman (ELI-NP) who is the coordinator of the theory group at NP and he will focus on high field electrodynamics with ultraintense lasers and electrons. S. Ataman spoke on basic QED physics which can be experimentally observed with the multi-petawatt laser interaction with high energy charged particles.

E. Gerstmayr’s talk was on the ongoing experiment of their team at NP on Compton backscattering in which he described the setup, parameters and technical details of the joint ELI-NP and Queen’s University of Belfast experiments

Stefan Weber, 10-PW Laser Plasma Platforms

The topic of this meeting were the 10 PW laser facilities, which are either operational (SIOM, ELI-NP) or about to go online (ELI-BL).

Dr. Doria from ELI-NP provided very interesting insight into the commissioning phase of multi-PW operation. This was extremely useful for ELI-Beamlines for our own upcoming commissioning phase and all the experimental and technological difficulties we will be facing. A collaboration with ELI-NP during the commissioning of the L4 ATON laser will be useful.

Prof. Wang from SIOM showed interesting results using OAM beams for PW-class lasers. This topic is attracting a lot of attention in the community. The fabrication of corresponding optical elements is still a challenge and possible future interaction with them might be useful for fundamental research with multi-PW lasers.

Dr. Condamine provided an overview of the upcoming L4 commissioning phase in E3, and in particular, designed an interesting way on how to measure the contrast of L4f at full power using the existing VISAR setup in P3.

Finally, Dr. Gamiz from IST in Lisbon presented an interesting proposal for direct laser acceleration of electrons using the L4 laser. This could be a possible high-level commissioning experiment as gas-jets are employed, rather than solid targets. However, at present this is on the conceptual level and needs to be transitioned to the design of an actual experiment.

Overall this small workshop was useful and it should be considered to repeat it in future user conferences of ELI-ERIC.

Peter Dombi, Ultrafast Techniques in Material and Surface Studies

The session of Ultrafast Techniques in Material and Surface Studies was very well attended with some 25 participants following the 3 talks. Prof. Martin Aeschlimann from the University of Kaiserslautern gave an excellent overview in ultrafast surface science experiments, putting ELI instrumentation into a broader perspective. Dr. László Óvári from ELI ALPS introduced important technical details of the unique NanoESCA endstation of the facility and described some of the first static and time-resolved experiments performed in Szeged. Finally, Dr. Zsuzsanna Pápa introduced additional ultrafast techniques in time-resolved nanoscience including ultrafast ellipsometry and scanning near-field microscopy (SNOM).

Timofej Chagovets, Advances in high rep-rate target technology

Compact laser-driven sources have a broad spectrum of applications in fields such as radiobiology, medical research, and material science. However, achieving sufficient average flux and meeting the demands of high repetition rate systems necessitates the advancement of target systems, optics, and diagnostics. The development and validation of new target systems often require extensive research and development, with multiple techniques typically combined for the fabrication of a single target type. This meeting focused on the development of target systems and their specific applications.

Enam Chowdhury from Ohio State University provided an overview of liquid target systems and their applications in fundamental laser-matter interaction studies. Fabien Souris from CEA Grenoble's Low Temperature Systems Department detailed the operation of a unique tunable hydrogen target system, enabling the use of PW-level laser systems at repetition rates up to 10 Hz. Nina Gamaiunova from ELI BL presented the latest advancements in high repetition target systems, both liquid and cryogenic, and their integration with kHz laser systems. Florian Condamine from ELI BL showcased a tape-drive target system commissioned for both burst and single-shot operation modes.

The round table discussion explored the potential applications of these systems in various experiments and the future development trajectories of existing technologies