Swiss Society for Photon Science

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Dear readers,

It is my pleasure to present the third newsletter of the SSPh with a focus on ELI (**E**xtreme **L**ight **I**nfrastructure). As many of you know ELI is a European Infrastructure Development with an emphasis on laser based photon sources producing either extremely short and/or extremely intense photon pulses. Recently, ELI has been starting to accept user proposals for some of its beamlines and the article should provide you with all the information required to decide whether ELI can assist you in tackling your scientific problems. For further information feel free to contact the authors.

With great pleasure I also congratulate SSPh member Ursula Keller for being awarded the Swiss Science Prize Marcel Benoist, one of the most prestigious science prizes in Switzerland. Over the past 30 years as a professor in physics at ETHZ, Ursula Keller has been a pioneer in ultrafast science and technology. She invented the SESAM, pushed spectroscopy to the attosecond regime, and demonstrated the world`s most precise clock, the attoclock. There will be several opportunities this fall to celebrate Ursula's achievements. For now, please join me in expressing our gratitude for what she has accomplished!

With that I conclude by thanking all of you for your continuous support of the SSPh, we try our best to make SSPh a useful and valuable instrument of the Swiss photon science community.

Thomas Feurer – President SSPh

Research in the SSPh community

The Extreme Light Infrastructure: Multi-disciplinary Science and Research Applications of Ultra-intense and Ultra-short Laser Pulses

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Abstract

The Extreme Light Infrastructure (ELI) is the premier research center for scientists to access the most advanced and intense lasers in the world. Established in 2021, ELI ERIC is an international user organisation for multi-disciplinary research using extreme intensity and ultra-short laser pulses [1]. The ELI Beamlines Facility in the Czech Republic and ELI ALPS in Hungary are complementary, providing access for experiments in physics, chemistry, radiography, fusion, environment, materials sciences, nanotechnologies, biology and biochemistry [2]. The talk details their status and the first ELI Call for Users [3], including the ELI Nuclear Physics Facility being built in Romania. Sources, instruments and the proposal process will be presented.

Introduction

The Extreme Light Infrastructure (ELI ERIC) is the world's largest and most advanced high-power laser research infrastructure. As an international user facility dedicated to multi-disciplinary science and research applications of ultra-intense and ultra-short laser pulses, ELI provides access to world-class high-power, high-repetition-rate laser systems and enables cutting-edge research in physical, chemical, materials, and medical sciences, as well as breakthrough technological innovations. The ELI ERIC operates as a single multi-site organisation with two complementary facilities specialised in different fields of research with extreme light: ELI Beamlines in Dolní Břežany (Czech Republic) and ELI ALPS in Szeged (Hungary). The forthcoming third facility ELI Nuclear Physics in Măgurele (Romania) is expected to join the ERIC in the future.

The European Research Infrastructure Consortium (ERIC) is a unique legal entity, formed by an EU regulation specifically for scientific infrastructures, and exists as a pan-European intergovernmental organisation with full legal personality in all EU member states. ERICs are participated by EU states and allow the possibility of countries and organisations outside the EU to join. An ERIC is able to establish its own Procurement Rules which provides the freedom to adapt to the specific requirements of each infrastructure. ERICs are also exempt from VAT and excise duty and offer legal flexibility and mobility for staff. [1] As Europe's first large-scale research infrastructure located in Central Europe, ELI was recognised by the European Strategy Forum on Research Infrastructures (ESFRI) as a strategic priority for Europe and included on the ESFRI Roadmap as a Landmark project.

The main mission of ELI ERIC is making the ELI ERIC Facilities available to the scientific community as a single international organisation, with unified governance and management. The two host countries Czech Republic and Hungary are joined by Italy and Lithuania as founding members, while Germany and Bulgaria are founding observers.

ELI's ultra-high-power ultra-short pulsed lasers with focused intensities and average powers at the edge of laser technology will open new frontiers in fundamental science. As the first infrastructure dedicated to the fundamental study of laser-matter interaction in the ultra-relativistic regime, the scientific research at ELI will challenge the vacuum critical field, as well as provide a new avenue to ultrafast attosecond studies of laser-matter interaction. [1]

Integration and Joint User Programme

The ELI Facilities are being made incrementally available to ELI ERIC for users, while being operated by the ELI Host Organisations. The integration of the ELI Facilities to ELI ERIC is being realised by the implementation of a joint management system translates governance policies to operative processes and procedures. The ELI ERIC Facilities gradually adopt the same processes and rules into their organisational structures and eventually transfer the responsibilities to ELI ERIC. The integration activities are being developed and facilitated as part of the Horizon 2020 Project IMPULSE.

The ELI Facilities are open to scientists from the European Research Area and around the world. Access to the ELI Facilities is competitive, international, and open to users from within and outside the Members countries. There are three modes of access:

- Excellence-Based Access – Scientific evaluation of proposals by and international peer-review panels composed of qualified scientists (Open Data)
- Mission-Based Access – Thematic areas of research granted on the basis of specific scientific missions pursuing clearly defined challenges (Open Data)
- Proprietary Access – Paid access for industrial or other users, (Results retained by the user)

Scientific Data is one of the most valuable results for ELI ERIC and aims to contribute to sharing and dissemination of knowledge across the European Research Area. Results of publicly-supported research should in principle be made publicly available. The ELI ERIC aims to preserve and manage Data according to the 'FAIR' principles, meaning that Data shall be Findable, Accessible, Interoperable and organised in Reusable datasets. Data shall be managed according to processes and standards having regard, among others, to security, quality control, data tracking and documentation.

The first Joint ELI Call for Users was launched in June 2022. The Call invites scientists from Europe and worldwide to submit proposals for experiments to be performed at the ELI facilities. The focus of this Call is on instruments with demonstrated readiness and reliability and most extensive operational experience. Proposals will be peer-reviewed and access granted based on scientific excellence. First experiments are expected to be performed in Autumn 2022. This Call includes all three of the ELI Facilities, thanks to a close collaboration between ELI ERIC and the "Horia Hulubei" National Institute of Physics and Nuclear Engineering (IFIN-HH), and the support of the Horizon 2020 Project IMPULSE.

The second Call is expected to be launched in early 2023. [3]

ELI ERIC Facilities

The ELI ERIC consist of two facilities, ELI ALPS and ELI Beamlines, each with a specific focus in high-power, high-repetition-rate lasers. A third ELI facility, ELI Nuclear Physics, is expected to join the ELI ERIC in the near future. The ELI Facilities will provide a collection of the most powerful and shortest-pulsed laser systems currently available. The scientists coming to ELI will be able to do multidisciplinary studies relevant for both fundamental and applied research.

ELI Attosecond Light Pulse Source (ELI ALPS) in Szeged, Hungary, provides laser and secondary light and particle sources in the form of ultrashort bursts with high repetition rates. Energetic coherent light pulses of few optical cycles are available from terahertz (10^{12} Hz) to X-ray (10^{18} - 10^{19} Hz) frequency range. ELI ALPS is dedicated to study extremely fast dynamics by taking snapshots in the attosecond scale of the electron dynamics in atoms, molecules, plasmas and solids. The parallel existence of these secondary sources and state- of-the-art lasers - including a PW-class laser within the same facility, offers unique time-resolved investigation possibilities for both non-relativistic and relativistic interaction of light with all four phases of matter. ELI ALPS will also pursue research with ultrahigh intensity lasers.

ELI ALPS is a leading research facility in ultrafast physical processes as well as a world-class centre for generating outstanding biological, chemical, medical and materials science results.

- Development of attosecond light sources and measurement techniques
- Radiobiological applications
- Energy research: solar cells, artificial
- photosynthesis, transmutation of used nuclear fuels
- High-peak-power photonics
- Information technology, materials science and nanoscience
- Particle acceleration with few cycle laser pulses

ELI ALPS offers five main types of laser systems with additional end stations and state of the art spectroscopy instrumentation, plus three dedicated nanofabrication, chemical and biological labs.

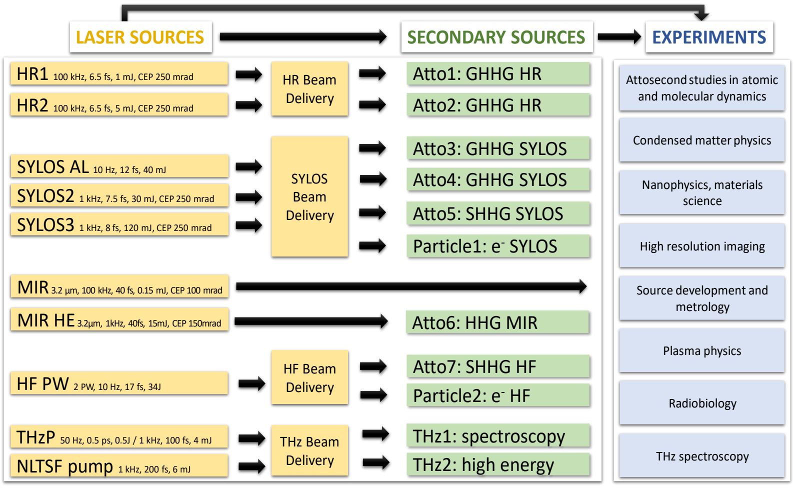

Fig. 1: ELI ALPS Main Laser Systems

The *SYLOS2* (1kHz/30mJ/7fs) and SYLOS Alignment (10Hz/ 40mJ/ 12fs) lasers are operational and serving the development of four beamlines. Upgrades were implemented to improve the beam quality for the beamlines, such as spatial filtering and a new beam expander. Post-compression was achieved down to 3.7 fs with more than 10 mJ output energy. The SYLOS3 laser (1kHz/ 120mJ/ 8fs) is in development in Vilnius. The SYLOS-driven Long Gas High-Harmonic Generation (GHHG) beamline is being commissioned, using 20 m focusing in combination with a single gas cell of variable length (36-70 cm) is fully assembled. The SYLOS-driven Compact GHHG beamline is fully assembled. The XUV pulses are generated and characterised with respect to pulse energy (µJ level), spatial beam profile, photon spectrum (up to 150 eV energies) and temporal properties. An end-station, hosting back-focusing multilayer mirrors for wavelength selection and focusing in combination with a bi-polar Time-of-Flight spectrometer, is commissioned.

The fiber-based *High-repetition Rate Laser (HR1)* (100kHz /1mJ/ < 7fs) serves GHHG beamline developments and user experiments, and it includes carrier-envelope phase (CEP) stabilisation. The HR2 system with 5 mJ pulse energy is in development. The two HR Laser-driven GHHG attosecond beamlines produce attosecond pulse trains for XUV – IR pump- probe measurements, in the gas or condensed phase. The beamlines are continuously upgraded and optimised. Currently ~166 as APTs in the 30-70 eV photon energy range with up to 75 pJ energy are delivered on target, an outstanding result at 100 kHz operation. One beamline incorporates a time-delay compensated monochromator for selecting different XUV spectral widths, down to 50 meV, while preserving the few-femtosecond duration of the XUV pulses. Commissioning experiments have included all-optical control of the high harmonic spectral peak positions. The beamlines are equipped with special experimental stations, like a VMI end-station and a reaction microscope end-station available for XUV – IR pump- probe measurements in the gas phase, as well as a NanoESCA end-station for surface science.

The *Mid-Infrared Laser (MIR)* is dedicated to drive strong-field interaction experiments in solids and gases at 100 kHz repetition rate, allowing for unprecedented amount of data for proper statistical analysis of low- yield processes driven by 3.2 µm CEP stable few-cycle pulses. After several years of continuous user operation, the MIR laser (100kHz/ 3.2µm/ < 40fs) has gone through extensive maintenance. A back-up oscillator was commissioned to reduce laser downtime.

The *Nonlinear Terahertz (THz) Spectroscopy Facility (NLTSF)* enables time-resolved studies using a strong THz pulse to initiate changes in the sample and a weaker THz pulse to probe them. User-inspired measurement capabilities were implemented to combine optical pump or probe pulses with the THz pulses. A broad temperature range from 6 K to 800 K is available for the sample by an integrated compact cryocooler-heater unit. Scientific topics span a broad range from solid-state physics and exotic materials, to in vivo biological specimens. A dual architecture THz pump laser serves the high energy THz beamline with an Yb and Ti:Sa probe arms to sub-10fs synchronization. The development and installation of the High Energy-THz (HE-THz) source was completed by the University of Pécs. Single-cycle THz pulses with up to 1 mJ energy were demonstrated from this source.

The *High-Field Peta-Watt* laser is in commissioning, demonstrating promising results already with an uncompressed 22J pulse energy at 10Hz. The sampled beam was compressed to 23.6 fs. The Beam transport towards the High Shielded Target Area (HTA) has been assembled and the PW compressor is already in position. The HTA will house the ePW and PW Surface HHG plasma beamlines, as well as a multipurpose high field physics end- station. It will accommodate user experiments centred on relativistic intensity laser- plasma interactions in gas, liquid and solid targets, nanometer-scale foils and nano-photonic targets.

ELI Beamlines located in Dolní Břežany (near Prague), Czech Republic, focuses on the development of short-pulse secondary sources of radiation and particles, and on their multidisciplinary applications in molecular, biomedical and materials sciences, physics of dense plasmas, warm dense matter, and laboratory astrophysics. In addition, the facility will utilise its high- power, high-repetition-rate lasers for high-field physics experiments investigating exotic plasma physics, and nonlinear Quantum Electrodynamic effects. In addition to basic research and development in the field of lasers, ELI Beamlines deals with research in materials sciences, electronics and engineering.

- Material Science
- Biomolecular Applications
- X-ray Sources Driven by Ultrashort Laser Pulses
- Plasma and High-field Physics
- Particle Acceleration

ELI Beamlines offers four main laser systems. Several of the main laser beamlines are operational and are being expanded and upgraded to reach their full performance and maximum availability.

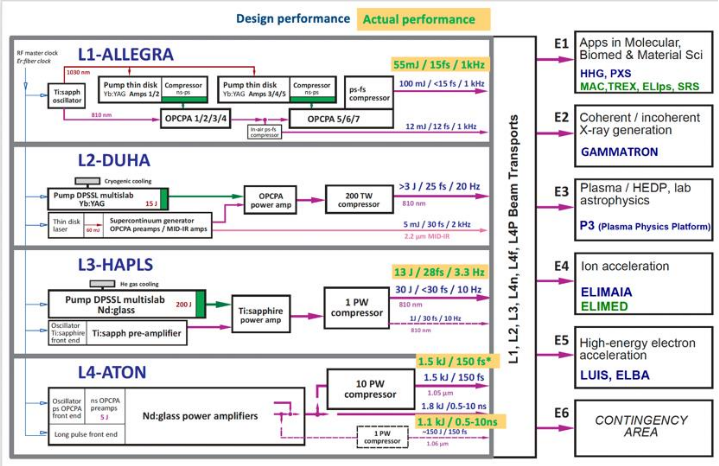

Fig.2: ELI Beamlines Main Laser Systems

The *L1 Allegra/F-Synch Laser System* is being developed in house by the ELI Beamlines laser team. The laser system is designed to generate <20 fs pulses with energy exceeding 100 mJ per pulse at a high repetition rate (1 kHz). The concept of the laser is based entirely on amplification of frequency chirped picosecond pulses in an optical parametric chirped pulse amplification (OPCPA) chain consisting of a total of seven amplifiers. The OPCPA amplifier stages are pumped by precisely synchronised picosecond pulses generated by state-of-the-art thin-disk-based Yb:YAG laser systems. The L1 Allegra laser beam is being sent to E1 experimental hall. It drives X-ray sources that are subsequently used for multidisciplinary physics experiments. In particular, ultrafast dynamics of various samples is probed by sub-picosecond pulses of hard X-rays generated by plasma X-ray source and femtosecond pulses of XUV or soft X-rays generated as high-order harmonics of the laser pulse. [9]

The *L2-DUHA Laser* (Dual-beam Ultra-fast High energy OPCPA Amplifier) is designed to provide 100 TW-level pulses at a high repetition rate (50 Hz) at 820 nm, falling between L1-Allegra and L3-HAPLS in terms of peak power. The main role of L2-DUHA laser is driving laser-driven wakefield acceleration, where higher average power is desired and PW-level intensities aren't necessarily required. L2-DUHA is the newest of the laser systems and is currently under development at ELI with expected completion in the first half of 2024.L2-DUHA is novel in that it is entirely based on DPSSL-pumped OPCPA. This is a departure from conventional Ti:Sapphire pumped by flashlamp pumped Nd-lasers and offers advantages in terms of average power handling and contrast. In addition to the 100 TW output, the L2-DUHA laser has a synchronized 5 mJ, 30 fs, 2.2 µm auxiliary output centered at 2 kHz. The large range of output wavelengths is what gives the laser its name, as "duha" is Czech for "rainbow."

The high-energy performance of the *L3-HAPLS (High repetition rate Advanced Petawatt Laser System)* became fully operational for experimental stations in hall E3 and E4. The L3-HAPLS laser relies on semiconductor excitation using diodes, and enables continuous operation at 1 PW with a repetition rate of 10 Hz. The pump laser is based on Nd doped glass, the beam of which is converted into a second harmonic (wavelength 527 nm) and used to excite the Ti:sapphire power amplifier, designed for a generation of pulses with an energy of up to 45 J (with a central wavelength of 810 nm). The generated pulses are compressed in a vacuum lattice compressor to a length of <30 fs. The laser beam at the compressor output has a size of 214x214 mm. The L3-HAPLS laser was developed at Lawrence Livermore National Laboratory with the active participation of the laser team, which was responsible for the construction of selected subsystems, in particular the output compressor of PW pulses.

The *L4-ATON laser (the highest energy and the highest peak optical performance at ELI Beamlines)* is completing commissioning. The main subsystems of the laser are the Optical Parametric Chirped Pulse Amplification (OPCPA) preamplifier chain, capable of generating pulses with energy up to 5 J and two large neodymium-doped glass-based amplifiers with optical apertures of 18 and 30 cm, providing output energy exceeding 1.5 kJ at a wavelength of 1.06 µm. These amplifiers use innovative liquid cooling technology, allowing full-energy shots up to once per minute. The L4-ATON laser system was developed in collaboration with a consortium of companies National Energetics and EKSPLA. A combination of two types of neodymium-doped laser glasses in power amplifiers, enables an output >1.5 kJ pulses with a spectral width of >13 nm, allowing them to be compressed to 150 fs and generate a peak power of 10 PW. The output pulses are compressed in an 8-meter vacuum compressor using diffraction grids with dimensions of 850x700 mm. The size of the laser beam in the compressor is 620x620 mm. In 2021, the construction of the optical beam transfer system from the laser output to the compressor was completed. In addition to the generation of compressed 150 fs pulses, the L4-ATON laser is able to provide kJ nanosecond pulses with adjustable length (in the range of 0.2 – 10 ns) and adjustable time profile (in the step of 125 ps) for experiments focused on laboratory astrophysics, hot density matter research, thermonuclear fusion issues, etc. The L4 ATON laser pulses will be routed to E3, E4 and E5 experimental halls, where they will be used, for example, for the laser-matter interaction research or particle acceleration.

Available Instruments in the Joint Call for Users

The *High Repetition rate laser system-based Gas High-order Harmonic Generation (HR GHHG Gas)* beamline for Gas targets attosecond beamline of ELI ALPS is driven by the 100 kHz high average-power HR-1 laser system and produces attosecond pulse trains (APTs) for XUV – IR pump-probe measurements on gas-phase targets [4]. Different spectral ranges and fluxes can be provided utilizing different rare gas targets. The beamline is under continuous upgrade and optimisation, currently providing up to 50 pJ, ~166 as long XUV APTs on target in the 30-70 eV photon energy range at 100 kHz repetition rate [5]. The schematic optical layout is given in Fig. 3 . The beamline is equipped with an electron time-of-flight (TOF) spectrometer, which serves as the primary tool for temporally characterizing the XUV pulses via RABBITT, positioned in "Target area 1". In "Target area 2", a Reaction Microscope end-station will be positioned for the 1st User Call. For flux and spectral characterisation of the XUV, a photodiode and a flat-field spectrometer are continuously available.

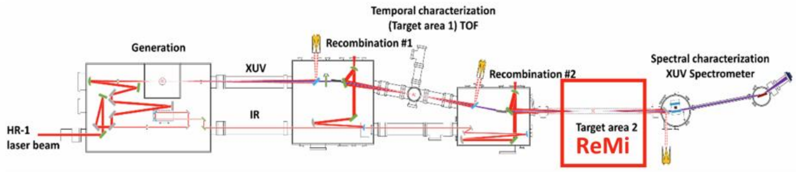

Fig. 3 The schematic optical layout of HR GHHG Gas - REMI-ES

The *Mid-Infrared laser system (MIR system)* has been delivering 140 µJ, 4-cycle pulses centred at 3.2 µm at 100 kHz repetition rate with < 1% RMS stability over 8+ hours of operation per day since November 2017 (Fig. 4). The system has unique <100 mrad CEP stability together with precise CEP control during experiments [6]. As a result of recent developments, a post-compressed output is also available, providing 70 µJ pulses in sub-2-cycle durations.

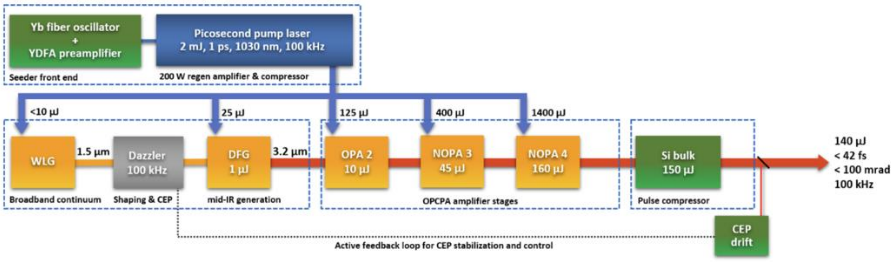

Fig. 4: Schematic layout of the MIR system

The *NanoESCA* endstation (Fig. 5) is a state-of-the-art powerful tool to study the electronic structure of surfaces and the condensed phase. Our aim for the near future is to conduct NIR pump - XUV probe measurements in order to reveal surface dynamics, like ultrafast processes in topological insulators, ultrafast magnetism, electron transfer processes, band structure evolution, etc. Although the connection of laser sources to the NanoESCA is not yet ready, we can accept proposals relying on the internal cw light sources of NanoESCA allowing for cutting edge static measurements. The system consists of a Preparation Chamber and an Analysis Chamber. [7,8]

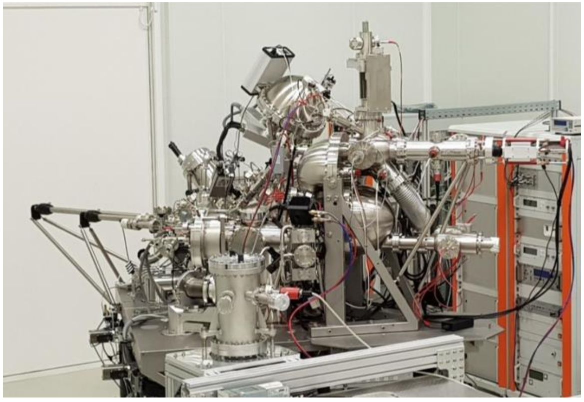

Fig. 5: The NanoESCA Endstation at the ELI ALPS

The *Nonlinear Terahertz Spectroscopy Facility (NLTSF)* consists of two main units: (i) a multi-mJ femtosecond pump laser and (ii) the THz pump—THz probe (TP2) system [Fig. 6]. TP2 enables time-resolved studies of THz-induced phenomena by using a strong THz pulse to initiate changes in the sample and a weaker THz pulse to detect these. Additional measurement capabilities enable to use optical pump or probe pulses in combination with THz pulses. A broad temperature range from 6 K to 800 K will be available for the sample.

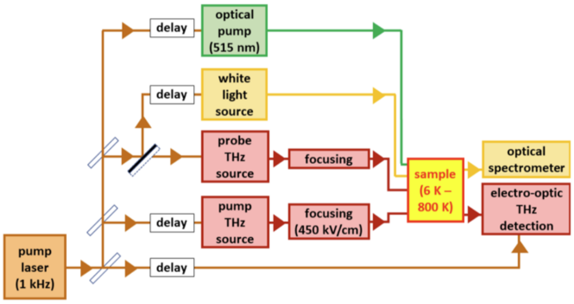

Fig. 6: Block scheme of the Nonlinear THz Spectrocopy Facility (NLTSF)

Femtosecond Stimulated Raman Scattering and transient optical absorption (FSRS & TA) is an experiment that allows monitoring Raman vibration spectra of molecules with sub-ps time resolution. When used with reactions that can be triggered, ideally photo-triggered, it is powerful tool to follow reaction dynamics and structural changes with high time resolution and high acquisition speed. [10, 11, 12, 13, 14]

On the *MAC and HHG, station for AMO science and Coherent Diffractive Imaging*, HHG source development possible experiments which can be performed include: Pump-probe experiments using HHG and auxiliary beams with available detectors and sample delivery systems and CDI experiments with a monochromatized HHG beam. The HHG source is also available for applications on source development. To discuss the feasibility of a project you have in mind, please contact the corresponding contact persons. The MAC station and the HHG source are operated using the L1 Allegra laser or alternatively the Coherent Legend Duo Elite, details are available in a dedicated document. Fig.7. [15, 16, 17]

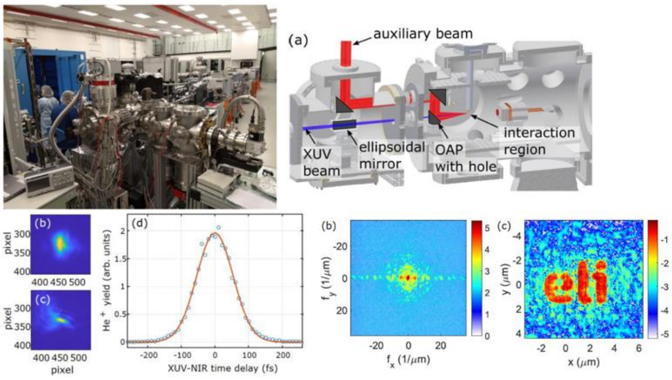

Fig. 7: (Top left) The MAC end station with cryo-cooled cluster source during operation in the E1 experimental hall. (Top right) Set up for pump-probe experiments in the MAC chamber. (Bottom left) IR/LUX overlap imaged with the in-line microscope and in He gas. (Bottom right) Single harmonic diffraction patter and reconstructed image of the ELI logo.

trELIps: Time resolved spectroscopic ellipsometry, the femtosecond pump-probe ellipsometer measures the polarization response of planar samples which allows the calculation of the optical constants of the material in an excited state and during the time evolution of these states. It is a PR-S-CR-AR ellipsometer. For transparent-double-side-polished samples, ellipsometry in transmission can be measured. Transient absorption and transient reflection spectroscopic measurements are also possible. [18]

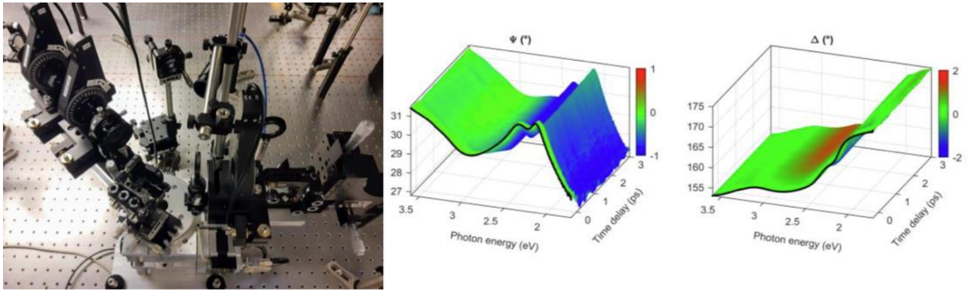

Fig. 8: (Left) Setup for pump-probe spectroscopic ellipsometry in operation in the E1 experimental hall. (Right) Results of the pump-probe spectroscopic ellipsometry measurements.

TREX: X-ray diffraction, scattering and spectroscopy experiments is the experimental station for X-ray science offers a modular area for Plasma X-ray source development as well as diffraction and spectroscopy experiment. The following type of pulsed and CW sources are available:

- Cu tape X-ray source (pulsed), 8 keV Cu-Ka radiation / Bremsstrahlung
- Water jet X-ray source (pulsed), Bremsstrahlung
- Sealed tube CW source with Cu anode and Montel optic, 8 keV Cu-Ka radiation / Bremsstrahlung
- Sealed tube CW source with Mo anode and polycapillary optic, 17.5 keV Mo-Ka radiation / Bremsstrahlung

The diffraction station is equipped with an Eulerian Cradle diffractometer (STOE). Main detector is a single photon counting hybrid pixel detector (model Eiger X 1M from Dectris). Cryo cooling is available by a cryo stream cooler from Oxford Cryosystems.

The station for X-ray spectroscopy uses a von Hamos geometry with several different crystals available. Main detector is an Andor Newton X-ray CCD camera with an elevated front illuminated, deep-depletion chip for greater photon acceptance angle.

Experienced members of the scientific community are invited to submit applications related to source and instrument development as well as early experiments. The TREX/PXS station is operated using the L1 Allegra laser or alternatively the Coherent Legend Duo Elite, details are available in a dedicated document.[19, 20]

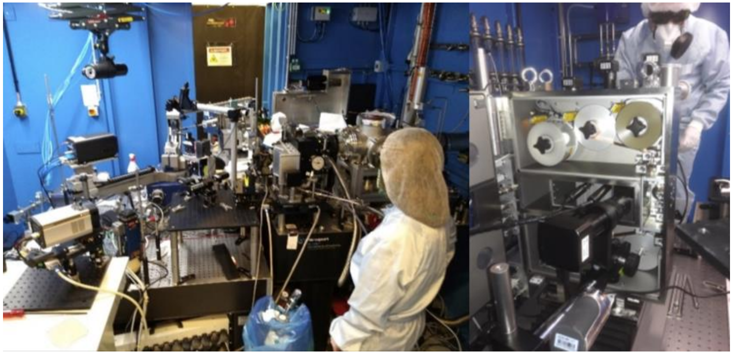

Fig. 9: (Left) Hard X-ray experimental station including the pulsed Cu tape and water jet sources, complementary sealed tube sources (Cu and Mo anodes), diffractometer and von Hamos spectrometer for absorption/emission spectroscopy. (Right) Cu tape Plasma X-ray source.

References

[1] Statutes of the Extreme Light Infrastructure ERIC (2021/C 230/01) (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2021.230.01.0001.01.ENG)

[2] ELI Whitebook – Extreme Light Infrastructure; Science and Technology with Ultra-Intense Lasers (https://eli-laser.eu/media/1019/eli-whitebook.pdf) DOI- 10.13140/2.1.1227.0889

[3] Extreme Light Infrastructure - Call for Users (https://eli-laser.eu/news/extreme-light-infrastructure-call-for-users/)

[4] Peng Ye et al., J. Phys. B: At. Mol. Opt. Phys. 53 154004 (2020). https://doi.org/10.1088/1361-6455/ab92bf

[5] Peng Ye et al., "High-flux 100-kHz attosecond pulse source driven by a high average power annular laser beam", submitted to Ultrafast Science, available on arXiv (2021). https://doi.org/10.34133/2022/9823783

[6] N. Thiré, R. Maksimenka, B. Kiss, C. Ferchaud, T. Pinoteau, H. Jousselin, S. Jarosch, P. Bizouard, V. Di Pietro, E. Cormier, K. Osvay and N. Forget, "Highly-stable, 15 W, few-cycle, 65 mrad CEP-

noise mid-IR OPCPA for statistical physics", Optics Express 26(21), 26907-26915 (2018) https://doi.org/10.1364/OE.26.026907

[7] M. Escher et al., J. Phys.: Condens. Matter 17 (2005) S1329 https://doi.org/10.1088/0953-8984/17/16/004

[8] D. Vasilyev et al., J. Electron Spectr. Relat. Phenom. 199 (2015) 10

[9] Optics Express, Vol. 22, Issue 24, pp. 30281–30286 (2014)

[10] Structural dynamics upon photoexcitation-induced charge transfer in a dicopper (i)-disulfide complex, M Naumova, et al., Physical Chemistry Chemical Physics 20 6274-6286 (2018)

[11] Comparative ultrafast spectroscopy and structural analysis of OCP1 and OCP2 from Tolypothrix, V. Kuznetsova, et al., Biochimica et Biophysica Acta (BBA) - Bioenergetics Volume 1861, Issue 2, 1 February 2020, 148120 (2020)

[12] Femtosecond-to-nanosecond dynamics of flavin mononucleotide monitored by stimulated Raman spectroscopy and simulations, P. C. Andrikopoulos, et al., Physical Chemistry Chemical Physics: PCCP, 29 Jan 2020, 22(12):6538-6552 (2020)

[13] Time-Resolved Femtosecond Stimulated Raman Spectra and DFT Anharmonic Vibrational Analysis of an Electronically Excited Rhenium Photosensitizer, M. Pižl, et al., Journal of Physical Chemistry A, 2020 Feb 20; 124(7):1253-1265 (2020)

[14] 2.4-Å structure of the double-ring Gemmatimonas phototrophica photosystem Science Advances, 16 Feb 2022, Vol 8, Issue 7, DOI: 10.1126/sciadv.abk3139 Pu Qian, et al.

[15] A Multipurpose End-Station for Atomic, Molecular and Optical Sciences and Coherent Diffractive Imaging at ELI Beamlines Eur. Phys. J. Spec. Top. 1-12 (2021) https://doi.org/10.1140/epjs/s11734-021-00192-z E. Klimešová, et al.

[16] Plasma channel formation in NIR laser-irradiated carrier gas from an aerosol nanoparticle injector Sci Rep 9, 8851, https://doi.org/10.1038/s41598-019-45120-3 (2019) E. Klimešová, et al.

[17] Nanoparticle-assisted acceleration of laser-irradiated low-density He ions Physical Review A 104 (6), L061101 (2021) Eva Klimešová, et al.

[18] Femtosecond laser studies of the Single Event Effects in Low Gain Avalanche Detectors and PINs at ELI Beamlines, Nuclear Inst. and Methods in Physics Research, A (under review) Gordana Lastovicka-Medina, et al.

[19] First experiments with a water-jet plasma X-ray source driven by the in-house developed L1 Allegra laser at ELI-Beamlines, Journal of Synchrotron Radiation, Volume 28, Part 6, pages 1778-1785 (2021), A. Zymaková, et al.

[20] Implementation of a crossed-slit system for fast alignment of sealed polycapillary X-ray optics, Journal of Synchrotron Radiation 27 (6), 1730-1733, Anna Zymaková, et al.

News from the SSPh

Prof. Ursula Keller received the Swiss Science Prize Marcel Benoist

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Prof. Ursula Keller, member of the SSPh, received the Swiss Science Prize Marcel Benoist, one of the most significant science prizes in Switzerland. As former director of the NCCR MUST, she became a member of the Swiss Society for Photon Science. Ursula Keller is an experimental physicist working at ETHZ. In her nearly 30 years of applied and basic research, she shifted the boundaries of ultrafast laser physics in the attosecond range. A breakthrough was her idea to use semiconductors and developing the SESAM (Semiconductor Saturable Absorber Mirror) technology, which allows materials to be transformed with lasers without overheating the respective materials. The principle of SESAM is used in cutting materials, in optical communication, in the production of smartphones or in medicine. The world`s most precise clock, the attoclock, was also invented by Ursula Keller and today enables the measurement of fundamental processes of quantum mechanics. The SSPh congratulates Prof. Keller to her outstanding achievement.

International Conference MUST2022 – Final meeting and closing event of the NCCR MUST

From June 7 to June 10, 2022 the International Conference on Molecular Ultrafast Science and Technology took place in Grindelwald. Over 170 national and international scientists participated in this conference which was at the same time the closing event of the NCCR MUST. The general scientific driver of the NCCR MUST was to understand how matter changes its structure and charge distribution, how quanta of energy are being transported on a microscopic and ultrafast scale, and how this relates to function. Over the last 12 years the NCCR MUST has shaped the scientific landscape in these many different fields of photon science in Switzerland and beyond.

Opening by Natalie Banerji (University of Bern) and closing by Jeremy Richardson (ETHZ).

The closing remarks by Jeremy Richardson summarized not only the conference itself, but also the last 12 years of our research; *covering a wide range of topics and ultrafast processes on timescales of attoseconds and femtoseconds using THz, IR, Raman, visible, UV and extreme UV through to soft and hard X-rays spectroscopy. Study objects were single atoms, small organic molecules, large organometallics, proteins, liquids, ionic liquids, liquid crystals and macromolecular crystals, metals, insulators, perovskites, metallic carbides and nitrides and maybe even superconductors. Molecules are studied in the gas-phase, in clusters, in microcrystals, in hydrogen-bonded complexes, in solution, in liquid jets, on oxide or graphite surfaces or even in living animals. Also theoretical developments from* *phenomenological models fit to experiment to first-principles electronic-structure calculations, exact solutions of the Schrödinger equation, path integrals, surface hopping and improvements to it, classical mechanics and machine learning were part of the NCCR MUST and its research. The conference was truly a nice way to celebrate the end of 12 exciting years of the NCCR MUST together with our guests from Austria, Czech Republic, Hungary, India, Israel, Italy, Lithuania, The Netherlands, Poland, Sweden, Spain, UK, USA and (at least via zoom) China.*

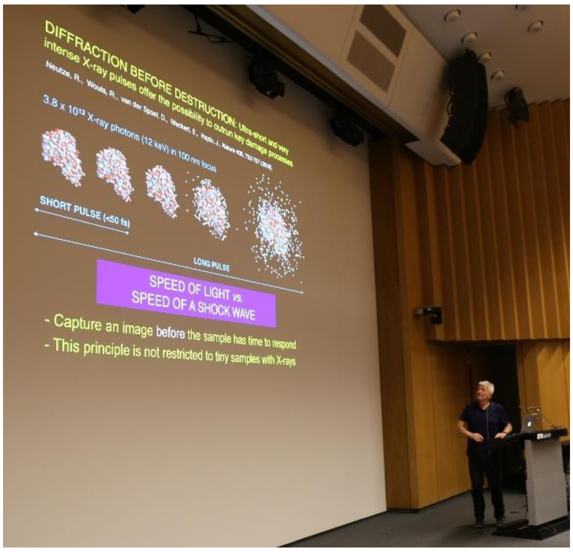
Impressions of the MUST2022 conference with key notes, discussions, exchange and networking (pictures by Ursula Keller).

The conference ended with the thank-you to Ursula Keller and Thomas Feurer who led this amazing network and dedicated themselves to the success of the NCCR MUST over the past 12 years and the reminder, that the Swiss Society for Photon Science will be the future of photon science in Switzerland. The full speech is available here and a summary of the NCCR MUST, its achievements in terms of science, education and outreach, can be found on the website of the SSPh.

First SSPh talk combined with the Assembly Meeting in Zürich on August 23rd

The 2022 General Assembly of the SSPh took place on August 23rd at ETH Zürich. This was the first SSPh General Assembly in person, despite being our third yearly meeting already!

The General Assembly was embedded in the first SSPh talk. We were thrilled to host Prof. Janos Hajdu, from Uppsala University and the European Light Infrastructure (ELI), who gave a presentation about "Diffraction before destruction". The talk and discussion provided a wonderful perspective about the booming field of high-resolution imaging of individual biological molecules using ultrashort and highly intense pulses of x-ray light, which Prof. Hajdu pioneered concomitant with the advent of x-ray free electron lasers. Thank you again to Prof. Hajdu for accepting our invitation!



Prof. Janos Hajdu giving a presentation about "Diffraction before destruction" (picture by Elsa Abreu)

The General Assembly followed. In addition to the usual discussions of SSPh affairs, led by SSPh president Prof. Thomas Feurer, the meeting included a presentation of the LEAPS initiative by representative Dr. Luc Patthey. The goal was to introduce the mission and goals of LEAPS (League of European Accelerator-based Photon Sources) to the members of the SSPh.

The morning program ended with an apéro, the perfect opportunity to network with other members of the SSPh. We look forward to seeing each other again (latest) next year!

Powers of Ten makes school: 10^{HOCH}. Dimensionen zwischen Urknall und Verglühen. Eine Reise in die Zeit

2015 the NCCR MUST published the book "A Journey into Time in Powers of Ten" in which scientists presented their research in timescales from 10^{-16}, the electron motion in molecules, to 10^{18}, the formation of the Milky Way. Even then, the idea arose to have a high school designing the book once again, which was finally implemented by the Gymnasium Lerbermatt (Bern). In the end, over 300 high school students created the book „*10^{HOCH}. Dimensionen zwischen Urknall und Verglühen. Eine Reise in die Zeit*“. With their animations and films they show us their understanding of time and with the texts they wrote they give us a glimpse into their world. They show the time from a "young" perspective and shed a different light on it. 28 contributions could be published in the book and many more can be assessed via our website.

The fact that a whole school got involved in our project exceeded all our expectations. We thank all students and teachers for the unique and wonderful implementation of our idea of a journey into time. We celebrated the book publication with a "thank-you" event at the Gymnasium Lerbermatt and participation in the "Nacht der Forschung" at the University of Bern.