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Development of pan-European Extreme Light Infrastructure

Extreme-Light-Infrastructure (ELI) is aimed at establishment of an international research infrastructure that will use the most intense light pulses in the world for the benefit of a large variety of scientific disciplines. More than 40 research and academic institutions from 13 European countries have been involved since 2007 in the Preparatory Phase of ELI (ELI-PP) with the aim to bring the project to the level of scientific, technical, legal, organisational and financial maturity.

By the middle of the next decade, the ELI project aims to build, commission and open to users the most powerful laser ever which will open the way to a totally new branch of optics – ultrarelativistic optics – giving rise to new avenues of research in particle physics, nuclear physics, astrophysics and cosmology. The European Strategy Forum on Research Infrastructures (ESFRI) recognised this exceptional ambition by including ELI on its Roadmap of 44 large-scale research infrastructure projects and in 2007, as part of the 7th Framework Programme, the European Commission financed the Preparatory Phase of this project.

Scientific fields of study of ELI and its applications

Unique in the world, it aims to provide scientists with the most powerful lasers that have hitherto existed. Using extreme laser intensities, exceeding the peak power of current most powerful lasers by two orders of magnitude, ELI aims to realize a long standing ambition of physicists to be able to break down vacuum into elementary particles and anti-particles. The ultra short time span of these pulses will enable extremely fleeting movements and reactions measured in attoseconds (10^{-18} s) or even shorter timescales to be observed in real time. Unique instruments will deliver high-quality synchronized sources of photons and particles which will find applications in the medical field, biology and materials science. In general, ELI should expand explosively the horizons of light and matter physics much influencing on European and the global science.

Afer the Preparatory Phase

From the very beginning of this project it was clear that implementation of ELI represents a tremendous scientific and technological challenge which requires pan-European endeavour due to diversity and complexity of the planned facility. It was decided that the purposes of ELI will be best served by implementing it as a distributed infrastructure placed under the single governance of a European Research Infrastructure Consortium (ERIC). The four main ELI pillars have been identified and four different facilities will represent them: Czech Republic, Hungary and Romania will host beamline, attosecond and photonuclear pillars respectively while the location of the fourth – ultra-high intensity – pillar is still to be determined. Development of technologies, necessary for building all four facilities, will be carried out through coordinated and complementary programmes with ongoing national prototyping initiatives playing a significant role. In order to implement ELI on time, to budget and to specifications, a precise assessment of the human resources and expertise available in Europe will be needed.

Lithuanian laser science for ELI

Vilnius University Quantum Electronics Department (QED) and Laser Research Center (LRC) is one of the participating institutions in this project and it brings two key scientific expertise aspects – optical parametric chirped pulse amplification (OPCPA) technique and metrology of optical components. Optical parametric amplification of chirped pulses was demonstrated for the first time at Vilnius University QED/LRC in 1992 by prof. A.P. Piskarskas and co-workers and nowadays this technique, essential for the generation of ultra-high intensity pulses, is widely used either separately or in conjunction with laser amplifiers. Despite tremendous progress since the first demonstration and already impressive numerous experimental achievements, OPCPA still has to be elevated to previously unattainable highs. QED/LRC continuous developments in this field will contribute to the collective efforts targeted at overcoming main bottlenecks on a way to record breaking light powers. Another important aspect is optical metrology and this activity is pursued by a group of optical material diagnostics at QED/LRC which investigates in detail the behavior of laser components at extreme intensities. This is a key issue for high-intensity lasers, such as ELI, since every optical element has to withstand incident intense light and it is as important to preserve costly optical components as to develop more durable ones which would allow reaching even higher intensities. QED/LRC is developing new techniques for real-time monitoring of critical components for damage prevention. Concurrently, a test station for characterization of various optical components is being established which allows to collect and analyze valuable data needed for production of novel and more durable components. Finally, it is believed that QED/LRC could become a perfect place for training future ELI employees in the field of nonlinear optics, optical parametric amplification and optical metrology.

Front-end of high-power OPCPA laser system prototype located at Vilnius University Quantum Electronics Department

The above mentioned scientific expertise could only emerge because Vilnius University QED/LRC has been an active player in the laser field for over 40 years. The first experiments on picosecond lasers and optical parametric amplifiers (OPA) were started in Vilnius University in 1969 and further research activity involved application of OPAs in ultrafast spectroscopy as well as various topics of nonlinear optics. Perhaps the most celebrated achievements of Lithuanian laser science are the development of powerful and broadly tunable picosecond and femtosecond OPAs and, particularly, the invention of OPCPA technique back in 1992. This technique will undoubtedly be at the core of most high intensity lasers, including those at ELI pillars. Vilnius University QED/LRC have successfully contributed to FP6 projects LASERLAB-EUROPE, ATLAS, NOVIGLAS and STELLA in the past and is continuing this international collaborative experience in FP7 projects such as ELI-PP, LASERLAB-EUROPE II and MesMesh. Current topics of research cover a broad scope of laser science, ranging from femtosecond nonlinear optics and laser femtotechnology to biomedical applications of lasers. Helped by recent national initiatives, laser technology group started to work on the development of high-average power and high-pulse energy lasers. The average power (laser pulse repetition rate) or peak power could be increased by employing the originally at QED/LRC demonstrated concept of coherent combining of multiple pump beams. The lasers developed here will comprise a front end of a new national laser facility NAGLIS to be constructed until 2013, which will hopefully provide a useful ground for testing scientific and technologic ideas on a smaller scale, before adopting them in the pan-European infrastructure.

QED/LRC team is very optimistic and enthusiastic, because the use of OPCPA might actually enable ELI to reach the originally conceived goals and hopes to participate constructively in addressing the scientific and technological challenges that will arise in the implementation of ELI ideas.

More information

Further information about ELI-PP and on the participating organizations can be accessed at:
http://www.extreme-light-infrastructure.eu .
Websites for ELI:
attosecond pillar - http://www.eli-hungary.hu/index_EN.html
beamlines pillar - http://www.eli-beams.eu/
photonuclear pillar - http://www.eli-np.ro

- ELI-PP has received € 6 million from the European Commission for the Preparatory Phase of the project.
- Starting in November 2007, the participating institutions had 36 months to define the technical, legal, and financial aspects of the project until the end of ELI-PP.
- Currently more than 40 laboratories in 13 different countries of the European Union are involved in various ELI-PP activities. Several non-European countries might also participate in the future.