The ELI-Nuclear Physics Project

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Abstract. The Extreme Light Infrastructure - Nuclear Physics facility (ELI-NP) to be constructed in Bucharest-Magurele will be one of the three pillars of ELI and will consist of two components: a very high intensity laser beam and a very intense (\(10^{13}\) \(\gamma\)/s), brilliant \(\gamma\) beam, 0.1% bandwidth, with \(E_\gamma = 19\) MeV. ELI-NP will allow either combined experiments between the high-power laser and the \(\gamma\) beam or stand-alone experiments. This facility will create a new European laboratory with a broad range of science covering frontier fundamental physics, new nuclear physics and astrophysics as well as applications. A review of the Project and the Status of its implementation will be presented.

Keywords: Photonuclear Reaction, Laser-matter interaction

1. The ELI European Project

Initiated in 2005, the Extreme-Light-Infrastructure (ELI) will be an European research infrastructure that will use new and emerging laser technologies to generate the most intense light pulses in the world. Fully open to external users, it will be dedicated to the fundamental study and societal applications of laser-matter interaction in a new and unsurpassed regime of laser intensity: the ultra-relativistic regime. Identified by the European Strategy Forum on Research Infrastructures (ESFRI) as one of the top priority projects of research infrastructure for Europe, ELI has been brought to legal, organisational, financial and scientific maturity thanks to a 36-month Preparatory Phase (ELI-PP) FP7 project launched in November 2007 which involved nearly 40 research and academic institutions from 13 EU Member States. A major outcome of this work consisted in defining the scientific scope of ELI. The final report of the Scientific Advisory Committee, issued in May 2009, identified four main branches of research and applications:

- High Energy Beam Science: development and usage of dedicated beam lines with ultra short pulses of high energy radiation and particles reaching almost the speed of light
- Attosecond Laser Science: temporal investigation of electron dynamics in atoms, molecules, plasmas and solids at attosecond scale (10-18 sec., i.e. a billionth of a billionth of a second)
- Photonuclear Physics: nuclear physics methods to study laser-target interactions, new nuclear spectroscopy, new photonuclear physics, etc.
- Ultra High Field Science: investigation of laser-matter interaction in an energy range where relativistic laws could stop to be valid

In October 2009, the Steering Committee of the ELI-PP Consortium gave the mandate to the Czech Republic, Hungary and Romania to jointly implement ELI through the construction of three specialised research facilities dedicated to the first three scientific fields listed above: Beam Science near Prague, Attosecond Laser Science in Szeged and Photonuclear Physics in Bucharest-Magurele. The fourth “pillar” will be implemented later on through the upgrade of one of the three initial facilities or the construction of a fourth facility. ELI is the only facility on the ESFRI Roadmap proposed for construction in new EU member States (at the exception of some pan-European virtual facility nodes).

The three host countries intend to use Structural Funds for the project’s implementation between 2011 - 2016.

The ELI facilities will form a unique infrastructure placed under the governance of a European Research Infrastructure Consortium (ERIC), a new legal structure specifically designed for infrastructures of the kind of ELI. This entity is expected to benefit from contributions from a large number of ELI-Preparatory Phase Partners. The location of the first three ELI facilities in new Member States represents a significant development in favour of a better balance in the distribution of Research Infrastructures in Europe. It should be noted that each of the individual pillars will have its own specific research, technology and construction characteristics and will not depend on the others to be successfully delivered.

With the likely involvement of major countries such as France, Germany, or the United Kingdom, apart from the three host countries, the ELI-ERIC will be a genuine international facility, which represents an unprecedented development in the field of laser science. The ELI-ERIC will be the legal entity coordinating the operation of the infrastructure, setting major strategies (research, IPR, training, access policy) and selecting users. Access will be delivered in collaboration with the local entities owning the facilities.

2. The ELI Nuclear Physics (ELI-NP) Project

The Romanian pillar, ELI-Nuclear Physics will be dedicated to nuclear physics studies of the laser-matter interaction and to photonuclear physics. According to the ‘White Book for ELI-NP’ (available on project web-site http://www.eli-np.ro), elaborated by more than 100 scientists from 30 research institutions from Europe, United States and Japan, the ELI Nuclear Physics facility (ELI-NP) will consist of two components:

- A very high intensity laser, where two 10 PW Apollon-type lasers are coherently added to intensities of $10^{23}-10^{24}$ W/cm² or electrical fields of $10^{15}$ V/m
- A very intense (10¹⁵ $\gamma$/s), brilliant $\gamma$ beam, 0.1% bandwidth, with $E_{\gamma}$ up to 20 MeV, which is obtained by incoherent Compton back scattering of a laser light off a very brilliant, intense, electron beam produced by a warm LINAC ($E_e$ up to 720 MeV).

ELI-NP will allow either combined experiments between the high-power laser and the $\gamma$ beam or stand-alone experiments. ELI-NP will open up new research areas for laser, nuclear, astrophysics and fundamental research. The ultrahigh power and intensity of pulses will produce electric fields...
so strong that they may alter and sense the texture of the vacuum itself. The extremely performing gamma beam will allow the photonuclear reactions to become a powerful tool in nuclear structure studies. A very broad range of applications will be also studied, such as: industrial tomography and gamma radiography, surface characterization using positrons sources, medical imaging, radiation and proton cancer therapy. A very special class of applications will be based on photonuclear reactions produced by the very performing gamma-beam, namely the nuclear materials and radioactive waste management and new pharmaceutical radioisotopes.

A multitude of the experiments is already proposed and the experimental area is designed in a modular way to accommodate the planned experiments with a maximum of flexibility.

3. **Conclusion**

A new major infrastructure in nuclear physics is planned to be built in Bucharest-Magurele, Romania, namely ELI-NP, part of a larger European project. The ground breaking for ELI-NP should start as early as 2011 and the operation will start in 2016-2017. A very broad range of physics cases are targeted within ELI-NP, covering many facets of photonuclear reactions, but also astrophysics and fundamental physics. Moreover, various perspectives for applications ranging from medicine to material science, life science and radioactive materials management are envisaged to be studied.

4. **Acknowledgement**

The contribution of more than 100 people to the development of this project and to ELI-NP White Book is acknowledged.