Laser systems and laser-driven sources of X-rays and accelerated particles at ELI Beamlines

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We will be giving an overview on the development of the “ELI-beamline facility” being currently implemented and opened as a user facility within the Extreme Light Infrastructure (ELI) project based on the European ESFRI (European Strategy Forum on Research Infrastructures) process.

ELI-Beamlines will be the high-energy, repetition-rate laser pillar of the ELI (Extreme Light Infrastructure) project. The main objective of the ELI-Beamlines facility is the delivery of ultra-intense high-energy pulses for high field experiments and the generation and applications of high-brightness X-ray sources and accelerated particles. The high power laser systems currently prepared and used for the generation of higher repetition rate sources of x-rays and particles are L1 (Allegra) a 1 kHz diode pumped laser produced sub-20fs OPCPA system and the L3 (HAPLS) a 10 Hz, 1 PW (30fs) laser using as the active medium Ti:sapphire with new gas cooled diode pumped Nd doped Glass pump laser. The lasers will be able to provide focused intensities attaining $>10^{18}$-10^{21} Wcm^{-2} suitable for generation of x-rays and particles (electrons and ions). We will discuss the infrastructure concerning the availability of experimental areas, including secondary sources of particles and x-rays in the wavelength range between 20 eV-100 keV and few Mev and their practical implementation at the ELI-Beamline user facility. The sources are either based on direct interaction of the laser beams with gaseous targets (high order harmonics) or will first accelerate electrons which then will interact with laser produced wigglers (Betatron radiation) or directly injected into undulators (laser driven LUX or later X-FEL). The direct interaction (collision) of laser accelerated electrons with the intense focused laser again will lead to short pulse high energy radiation via Compton or Thomson scattering for different applications opening also the route to fundamental physics investigations in high intensity interaction due to the 4 γ^2 Lorentz boost of the intensity seen by high energy (GeV- $\gamma^2 > 10^6$) electrons.

The L4 Aton laser system is designed to generate an extremely high and unprecedented peak power of 10 PW (Petawatt) during pulse duration of about 130 fs that will allow accessing the intensities of the order of 10^{23} Wcm^{-2}. The uncompressed energy can reach almost 2 kJ with a shot rate of 1/min, which is a major step in the field of kJ-class lasers. The architecture is based on direct compression of a broadband beam amplified by a combination of different Nd:glass slabs. The L4 Aton laser system can operate in two main modes: In the first one all the energy can be used to generate a power of 10 PW in a single beam. By-pass of the compressor is possible in order to use the chirped nanosecond (ns) beam directly. In the second mode the main amplifier can deliver almost 2 kJ in a narrowband ns beam with variable temporal shaping seeded by a separate front end. At the same time, the broadband front end can seed the first main amplifier and thus provide a 200 J-class PW pulse. It will be the main driver for plasma physics and high-energy density physics experiments within the plasma physics platform (P3).