Form B1_EN - Project Summary

Programme / Sub-programme / Module	5/5.1/ELI-RO
Project type	RDI
ELI-NP thematic	RA35/IV.1 Laser-plasma interaction and laser driven radiation generation – experiments, theoretical models and simulations 5.2.2; RA35/II.1 Radiation Reaction Physics: Classical and Quantum 5.3.3
Project title / Acronym	Simulations of Ultra-High Intensity Laser Pulse Interaction with Solid Targets **/ SIMULATE**
Project duration	2 years and 2.5 months (26.5 months)

PROJECT SUMMARY

(Times New Roman 11; 1.15 pt. spacing, max. 1 page)

Compact accelerated ion beam obtained from ultra-high intensity laser pulses interaction with different kind of targets is more efficient than the ion beams accelerated classical. This accelerated ion beams will be used to produce very neutron-rich heavy nuclei for the first time by cascade fission-fusion reaction mechanism which is one of the main area of the scientific case of ELI-NP. The goal of the project is to continue the previous work of the project leader from the others ELI-NP projects on the ultra-high laser ion acceleration simulations, as well as to form young researchers in this field and creating a long-term partnership which targets the use of partner's cluster and the creation of new modules in the codes used for the calculations.

In order to achieve our purpose we will consider in our Particle-in-Cell (PIC) simulations several known regimes as target normal sheath acceleration (TNSA), radiation pressure acceleration (RPA), Coulomb explosion and synchronized acceleration by slow light. We will perform PIC simulations for the ultra-short laser pulses with intensities higher than 10^{22} W/cm^2 in interaction with different targets: flat-top microcones coated everywhere inside with nanometers spheres; foam and thin foil in front or on back; three-layer stack target with two densities; multi-layer foils with varying low densities; nanotargets. We expect to find the appropriate target and laser parameters to obtain ions accelerated from hundreds MeV/u to GeV/u and narrow energy band, high flux and small divergent ion beam.

In order to reach the highest fields for experiments planned at multi-PW facilities such as ELI, one needs tightly focusing of the laser pulses as low as possible. When temporal and spatial extensions of the pulse are comparable with the wavelength of the pulse, the experiments using such pulses are regarded as performed in the lambda cubed regime (λ^3) or wavelength cubed regime. The effects expected in such experiments depend on the spatial and temporal extension of the huge electric fields generated by tightly-focused laser pulses. To establish the appropriate ultra-short laser beam parameters in terms of f number and pulse duration, numerical computation of laser pulse propagation is needed. Thus, the electromagnetic field distribution in the vicinity of the focus will be investigated in the case of each target geometry using FULLWAVE, a package of the commercial software RSoft which solves the Maxwell equations using the finite difference time domain (FDTD) method. Basing on this technique, we will complement and extend the results concerning the electromagnetic field structure for ultra-short pulses below the actual spatial and temporal limits, using a numerical approach.

Another fundamental scientific area at ELI-NP is the electron-positron pairs production which represent one of the strog-field QED effects at the intensities of 10^{24} W/cm^2 envisioned at ELI-NP.

We will perform PIC simulations for high and low density double-layer targets with various thickness for converting laser energy into gamma-ray energy and then to create cascades of electron-positron pairs based on multiphoton Breit-Wheeler process. Our aim is to find the proper target and laser parameters to have the most efficient pairs production rate.