Numerical investigation of the influence of the magnetic field on the hot electron flux generated at laser irradiation of a disc-coil target

J. Domanski[1], J. Badziak[1], Z. Rusiniak[1], O. Renner[2,3,4], R. Dudzak[3,2], T. Chodukowski[1], J. Dostal[2,3], M. Krupka[2,3], S. Singh[2,3], M. Ehret[5], P. Gajdos[2], A. Zaras-Szydłowska[1], M. Szymanski[1], J. Krasa[3], T. Burian[3,2], S. Jelinek[2,3], G. Kocourkova[3], D. Batani[6], K. Batani[1], J. Santos[6], C. Vlachos[6], V. Ospina-Bohórquez[6], L. Volpe[5], L. Juha[3], M. Krus[2], S. Agarwal[3] and T. Pisarczyk[1]

[1] *Institute of Plasma Physics and Laser Microfusion, Warsaw, Poland*
[2] *Institute of Plasma Physics, CAS, 182 00 Prague, Czech Republic*
[3] *Institute of Physics, CAS, 182 21 Prague, Czech Republic*
[4] *ELI Beamlines Center, Institute of Physics, CAS, 252 41 Dolni Brezany, Czech Republic*
[5] *C.L.P.U. (Centro de Láseres Pulsados), Salamanca, Spain*
[6] *Univ. Bordeaux, CNRS, CEA, CELIA, UMR 5107, F-33405, Talence, France*

1. Introduction

Laser-driven generators of quasi-static, strong magnetic fields are considered to be a useful tool for generating and studying magnetized plasma, in particular for astrophysics and inertial fusion research [1-3]. One such generator uses a disc-coil (DC) target in which a disc of high-Z material coupled to a coil is irradiated by an intense laser beam [4]. In a recent experiment at the PALS laser facility, it was shown that the DC scheme provides a possibility to generate magnetic fields exceeding 5T with a laser driver energy of ~ 0.5 kJ [4]. Such magnetic fields appear to be sufficient to create a highly magnetized plasma and/or to modify the properties of the charged particle fluxes emitted from the plasma.

In this paper we present selected results of numerical studies of the magnetic field influence on the hot electron (HE) flux produced in the DC target. Our investigation is related to the PALS experiment in which the laser pulse interacted with a DC target composed of a Cu disk connected to a single-turn coil [4]. To examine the effect of the magnetic field on the flux of hot electrons generated in the DC scheme, full 3D particle-in-cell (PIC) simulations were performed using the adapted EPOCH code [5].

2. Numerical procedure

There are two main challenges in the discussed simulations: reconstruction of the electromagnetic (EM) fields generated by the coil and simulations of their effect on particle propagation.

In order to include the coil EM fields to the simulation, the artificial currents were placed in the simulation box at positions of the real coil configuration. These currents were constant throughout the simulation and equal to 4.1kA which correspond to the magnetic field measured inside the coil using the Faraday effect in the TGG crystal [4]. The simulations of the particle propagation started after the stabilization of the EM fields associated with the coil. The coil with the 1mm diameter was situated 0.8mm from the target (see Fig.1).

The HE propagation is substantially affected by electromagnetic fields generated by fluxes of charged particles and by interaction between the electron beam and the charged target. In order to reconstruct adequately these fields, our simulations include hot and "thermal electrons" as well as protons and copper ions. The initial positions and velocities of particles were derived from the Monte Carlo method based on the angular distributions of particle energy. The HE distribution was determined from multi-channel spectrometer measurements for the case without the coil (magnetic field) [4]. In order to predict the distribution of "thermal electrons",