Gamma photon and electron-positron production on the PETAL laser facility

F. Brun[1], X. Davoine[2], P. E. Masson-Laborde[2], N. Iwata[3], Y. Sentoku[3], D. Raffestin[1], E. d'Humières[1], and X. Ribeyre[1]

[1]Centre Lasers Intenses et Applications, Univ. Bordeaux-CNRS-CEA, UMR 5107 Talence 33405, France
[2]CEA DAM DIF F-91297 Arpagon, France
[3]Institute of Laser Engineering, Osaka University, 2-6 Yamadaoka, Suita, Osaka 565-0871, Japan

We have performed theoretical and numerical studies of an experiment performed with the high intensity laser PETAL. The experiments were done for the commissioning of the PETAL laser with a laser energy of about 400 J, an intensity of 8.10^{19} W.cm^{-2} and a pulse duration (FWHM) of 600 fs on solid targets [1]. We were interested in the production of high energy photons generated during this commissioning. The experimental shots were conducted on a tungsten target with a thicknes of 2 mm. The high energy photons diagnostic used for the experiment was a hard X-ray spectrometer with a stack of filters and Image Plates. The high energy photons were produced mainly from the bremsstrahlung process for relativistic electrons accelerated inside a plasma generated on the front side of the target [2]. To model this experiment we have used a simulation chain including hydrodynamic, Particle In Cell and Monte Carlo simulations. We can simulate the pre-plasma generated at the front of the target by the PETAL laser prepulse, the acceleration of the electrons inside the plasma and the generation of MeV range photons from these electrons. We also have simulated the response of the detector impacted by the high energetic photon beam with a Monte Carlo simulation. All this work allowed us to compare the photon spectra given by the simulation with the experimental measurements, getting good agreement and in consequence validate our simulations chain. Our study did not stop on the photon spectra analysis, we investigated positron production. Indeed, if high energy photons are generated inside the solid target some positron/electron pairs may be produced from the Bethe-Heitler process [3]. We therefore quantified the positron production achievable with the PETAL laser facility. To conclude our study we investigated the possibility to create electron and positron pairs by the linear Breit-Wheeler process using PETAL [4].

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