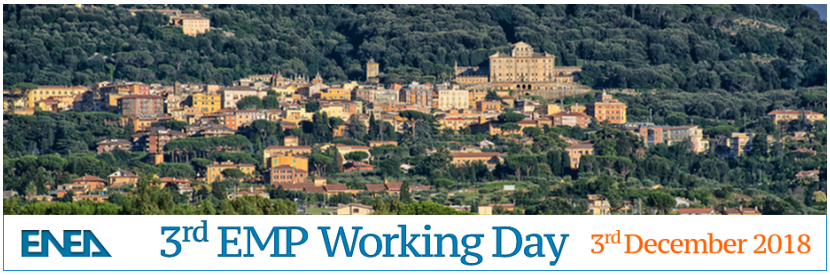

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EMP mitigation on the LMJ-PETAL facility

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The interaction of a Petawatt laser with a flat target can produce intense electric field [1] which may exceed 1 MV/m. Such a field leads to equipment failures, may damage diagnostics and produce spurious signals in detectors. As part of the PETAL project, we have studied the EMP generation mechanisms. A 3D, multi-physics, simulation chain has been developed. An EMP diagnostic has also been developed and set up inside the LMJ experimental chamber. Mitigation devices have been developed and tested on different campaigns, in several facilities, at low and high laser energy, in order to prepare the first PETAL experiments.

A mechanism of the EMP generation has been identified [2, 3]. The proof of concept of this scheme is a major scientific breakthrough which has allowed us to develop a multi-physics simulation chain. The simulation is performed in four subsequent steps with a suite of numerical codes. First, the effect of the laser pre-pulse on the solid target is simulated with a hydrodynamic code developed at CEA/DIF. Second, the main laser-plasma interaction is simulated with a particle-in-cell (PIC) code developed at CEA/DIF. The electrons are propagated inside the target by a Monte-Carlo code. Finally the escape of electrons from the target and their propagation to the laser chamber is simulated by another PIC code developed at CEA/CESTA. This simulation chain has been validated on different experimental campaigns. Magnetic field measurements have been compared to numerical results.

New target holders have been designed by numerical simulations. They are composed of a glass capillary with inside resistive gel. One end of this capillary is fixed to the target and the other end is fixed on a conducting cylinder surrounded by a magnetic material which operates as an inductance. The goal of this new holder is to mitigate the discharge current produced and to limit the generation of the electromagnetic radiation. These devices have been tested, first, at low laser energy (0.1 J), than, at higher energy (80 J) on the POPCORN campaign at the LULI2000 facility and finally on the first PETAL experiments up to 400 J. For these last campaigns, the results show a very good agreement on the radiated magnetic field between the simulations and the measurements. As expected, the new target holder with integrated mitigation device, reduce the radiated electromagnetic field by a factor greater than 3 on the frequency bandwidth of interest. The next step will be to validate the performances of this new target holder at higher laser energy closed to 1 kJ.

[1] “Analysis of EMP measurements in the NIF’s chamber”, Brown et al., EPJ 59 (2013).
[2] “Target charging in short-pulse-laser experiments”, Dubois et al., Phys. Rev. E 89 (2014).
[3] “Physics of giant EMP generation in short-pulse laser experiments”, Poyé et al., Phys. Rev. E 91, (2015).

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