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High-sensitivity tens-of-MeV ion diagnostics by a large-area diamond detector for time-of-flight schemes in petawatt high-repetition-rate laser experiments

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The effective ion diagnostics in high-repetition-rate experiments with laser pulses at petawatt regimes and with high focal intensity, is one of the task of primary importance for the full exploiting of the potential of recent and future high performance laser facilities. It is a complex task, especially when high sensitivity is required where instead high levels of Electromagnetic Pulses (EMPs) in the radiofrequency-microwave regime are classically produced in these experiments, that remarkably worsen the signal-to-noise ratio of the detected signals.

A prototype of a new polycrystalline diamond sensor with a large area (15 mm × 15 mm) and 150 μm thickness has been designed and developed [1]. Because of the specific detector design, having high rejection to possible EMPs [3] and the large detector area, it promises high sensitivity and, thanks to the fast temporal response, also high energy resolution when used in Time-Of-Flight (TOF) schemes [2]. Especially at the highest ion energies, this is one of the great advantages with respect to Thomson Spectrometry. Preliminary successfully tests of this diagnostics were performed in hundred-terawatt laser regimes for ions up to a few MeV [1]. Here we describe the results of tests on the diagnostics performed for the characterization of tens-of-MeV protons accelerated by laser-matter interactions at Petawatt (~30 J energy, ~30 fs pulses, ~10^{21} W/cm^2 intensity) regimes and at high-repetition rates, performed with the Vega 3 Laser facility at CLPU on solid targets. The design and optimization of this detector and the advanced TOF methodology used allowed to obtain signals with high signal-to-noise ratio and high dynamic range even in these very challenging experimental environments, where the interaction of high-intensity laser pulses with matter leaded to effective ion acceleration, but also to the generation of strong EMPs with intensities that can generally reach the MV/m order, and that are known to be serious issues for the fielded diagnostic systems [3].

References

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