Surface parallel electron acceleration using ultra-intense sub-picosecond pulses

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Introduction

In the experiment P090, we investigated the generation of highly collimated target surface electron (TSE) beams with high electron energy and small divergence angle [1,2] from the interaction of a Cu bulk target irradiated by an ultra-intense laser pulse at PHELIX, with the objective to generate high-energy Gamma rays for backlighting of HIHEX targets up to 300 µm Pb.

Experiment

The first experiments in Jan. 2014 were carried out by working at the fundamental wavelength of 1053 nm with a peak power of around 200 TW. The s–polarized laser beam with a duration of τ^0 = 500 fs was focused by an f=1.5m off-axis paraboloidal mirror at a grazing incidence angle onto a Cu bulk target. An additional pre-pulse with adjustable intensity from 0 to 1×10^{-6} was applied 2.8 ns in advance of the main pulse. A schematic picture of the experimental setup is shown in Figure 1. Also, 1% leakage of the main beam was frequency-doubled and applied as a probe beam to monitor the pre-plasma scale and density.

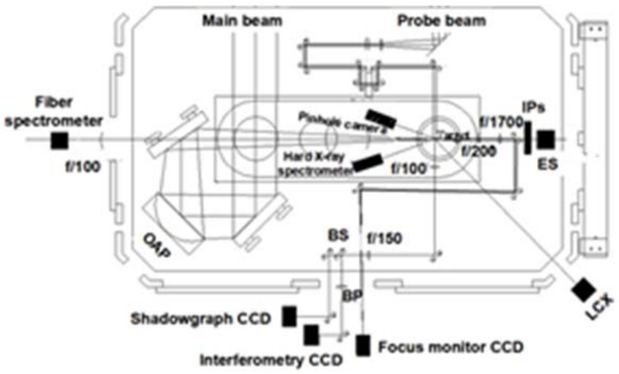

Figure 1: Experiment setup.

We investigated the pre-pulse dependence on the TSE generation. An optimized intensity ratio of the pre-pulse is essential to achieve an effective under-dense pre-plasma. In experiment, the intensity ratio of the pre-pulse was adjustable from $1\times10^{+2}$ to 1×10^{-6} which was 2.8 ns in advance of the main beam, while the consequent pre-plasma density and scale were simultaneously monitored. At the optimized ratio between pre-pulse and main pulse intensities of around 5×10^{-6}, well concentrated and intense TSE electron jets with low divergence were observed at a laser incident angle of 72o, as shown in Figure 2 (a). The divergence of the TSE electron jet was measured to be around 1o (FWHM). By a rough calculation, the energy range of the TSE bunches is around 5 MeV. In the case without pre-pulse, the electron beam becomes divergent and weak, as shown in Figure 2 (b). During the short beam time (5 days), we found that the pre-plasma condition is crucial to generate a high quality TSE Beam.

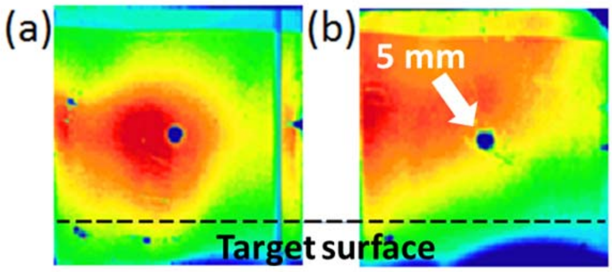

Figure 2: Spatial angular distribution of the TSE beam in the case (a) with the pre-pulse intensity ratio of 5×10^{-6} and (b) without pre-pulse. The hole has a 5 mm diameter. The color-coding shows the relative exposure of an image-plate detector (blue-lowest/red-highest)

Prospects

In the next step, we applied for a longer beam time (10 days) at PHELIX in Jun. 2015, which will provide us another opportunity to continue the experiments above and to deepen our understanding of surface electron acceleration.

References

[1] J. Y. Mao, L. M. Chen, X. L. Ge *et al.*, Phys. Rev. E**85**, 025401 (R) (2012).
[2] J. Y, Mao, L. M. Chen, K. Huang *et al.*, Appl. Phys. Lett., accepted. (2015)

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