Generation of GeV-electron beams from laser-plasma interactions

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Laser-plasma produced by ultraintense femtosecond laser pulses is an emerging particle acceleration technology which promises a revolutionary impact in the field of high-energy particle accelerators. In the so-called laser wakefield acceleration scheme, the ponderomotive force of an ultrashort high-intensity laser pulse excites a longitudinal plasma wave or bubble in a way similar to the generation of a wake wave behind a boat as it propagates on the water's surface. Electric fields inside the plasma bubble can be several orders of magnitude higher than those available in conventional RF-based particle accelerator facilities which are limited by material breakdown. Therefore, if an electron bunch is properly phase-locked with the bubble's acceleration field, it can gain relativistic energies within an extremely short distance [1]. In contrary to the emerging trend of using capillary discharges for guiding the laser pulses over long distances in order to achieve GeV electron beam energies, here in this talk, we show results that demonstrate the first generation of stable and reproducible sub-GeV (Fig. 1) and GeV (Fig. 2) electron beams from a few-millimeters long plasma channels produced by self-guided laser pulses in gas jet targets [2]. Supported by three-dimensional simulations, our experimental results show the highest acceleration gradients produced so far. Simulations showed the possibility for achieving higher electron beam energies by minimizing the plasma bubble elongation. In this way, new generation of ultra-compact all-optical multi-GeV electron beam accelerators and their applications in science, medicine and technology will be possible in the future.

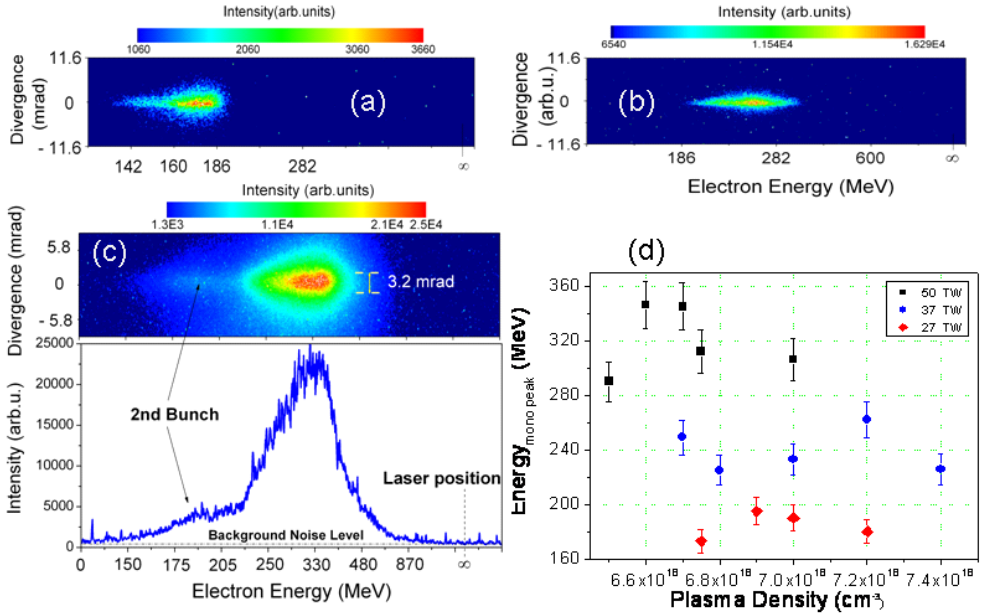

Fig.1. Stable Multi-hundred MeV electron beams generated from laser-driven plasma accelerator at APRI.

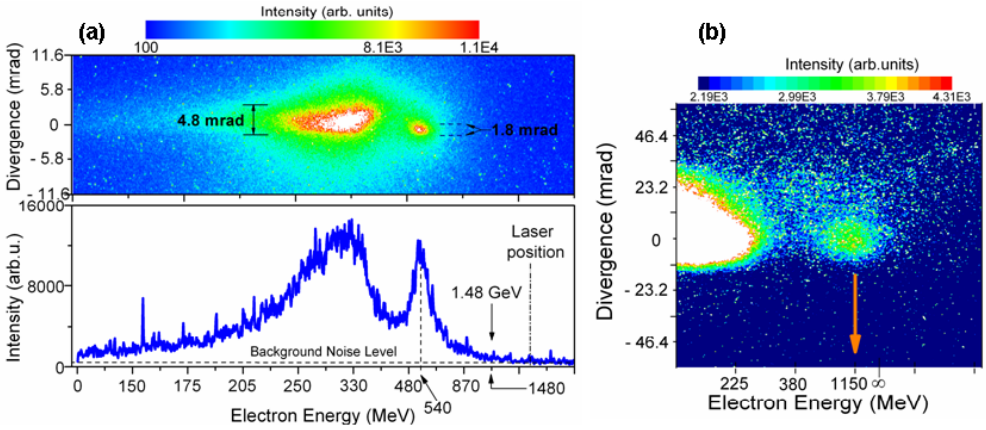

Fig.2. GeV electron beams generated from laser-driven plasma accelerator at APRI.

References

[1] N. M. Hafz, I. W. Choi, J. H. Sung, H. T. Kim, K.-H. Hong, T. M. Jeong, and T. J. Yu, V. Kulagin and H. Suk, Y.-C. Noh, D.-K. Ko, and J. Lee, "Dependence of the electron beam parameters on the stability of laser propagation in a laser wakefield accelerator" Applied Physics Letters **90,** 151501 (2007).

[2] N. M. Hafz et al., Nature Photonics (Re-submitted on May.25.2008).