DEMONSTRATED EFFICIENT LASER-DRIVEN ION BEAMS WITH NARROW ENERGY SPREAD USING GIANT SELF-GENERATED PLASMA FIELDS

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Table-top laser-plasma ion accelerators seldom achieve narrow energy spreads, and never without serious compromises in efficiency, particle yield, etc. until now. Using massive computer simulations of relativistic laser-plasma interactions, we identify a self-organizing scheme that exploits persisting self-generated plasma electric (~TV/m) and magnetic (~10^4 Tesla) fields to reduce the ion energy spread after the laser exits the plasma. This way the ion acceleration can be separated from the energy spread reduction. Consistent with the scheme, we experimentally demonstrate aluminum and carbon ion beams with narrow spectral peaks at energies up to 310 MeV and 220 MeV, respectively, with high conversion efficiency (~5%). These ion beams have a very low transverse emittance, and are therefore amenable to focusing without a serious loss in particle count. The experimental results, which are the focus of this presentation, are achieved at the LANL Trident facility with 0.12 PW, high-contrast, Gaussian laser pulses 0.65 ps in duration that irradiate planar foils up to 250 nm thick. The ion spectral peak energy empirically scales with laser intensity (I) as $I^{0.5\text{-}0.7}$. These results [1] pave the way for next generation compact accelerators suitable for applications. For example, a 400 MeV carbon-ion beam with narrow energy spread has been identified as suitable for fast ignition (FI) [2]. Our results, obtained with existing laser and target fabrication technology, are not only directly relevant to FI, but also indicate that the actual ion-beam parameters necessary for FI are well within the capability of PW-class lasers.

[1] S. Palaniyappan, et al., under review for Nature (2015)
[2] J.C. Fernández, et al., *Fast ignition with laser-driven proton and ion beams.* Nuclear Fusion, **54**(5), 054006 (2014)