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Efficient quasi-monoenergetic ion beams up to 18 MeV/nucleon via self-generated plasma fields in relativistic laser plasmas SASI PALANIYAPPAN, CHENGKUN HUANG, DONALD GAUTIER, CHRISTOPHER HAMILTON, MIGUEL SANTIAGO, Los Alamos National Lab, CHRISTIAN KREUZER, Ludwig-Maximilian-University, RAHUL SHAH, JUAN FERNANDEZ, Los Alamos National Lab, LOS ALAMOS NATIONAL LABORATORY TEAM, LUDWIG-MAXIMILIAN-UNIVERSITY TEAM — Table-top laser-plasma ion accelerators seldom achieve narrow energy spreads, and never without serious compromises in efficiency, particle yield, etc. Using massive computer simulations, we identify a self-organizing scheme that exploits persisting self-generated plasma electric ($\sim$ TV/m) and magnetic ($\sim 10^4$ Tesla) fields to reduce the ion energy spread after the laser exits the plasma – separating the ion acceleration 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 (11.5 MeV/nucleon) and 220 MeV (18.3 MeV/nucleon), respectively, with high conversion efficiency ($\sim$ 5%, i.e., 4J out of 80J laser). This is achieved with 0.12 PW high-contrast Gaussian laser pulses irradiating planar foils with optimal thicknesses of up to 250 nm that scale with laser intensity. When increasing the focused laser intensity fourfold (by reducing the focusing optic f/number twofold), the spectral-peak energy increases twofold. These results pave the way for next generation compact accelerators suitable for applications. For example, 400 MeV (33.3 MeV/nucleon) carbon-ion beam with narrow energy spread required for ion fast ignition could be generated using PW-class lasers.

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