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Sub 1% energy spread and sub 5 micron emittance, high current electron beams with energies up to 26 GeV with a transformer ratio of greater than 2.

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Next-generation free-electron laser-based coherent light sources and future particle colliders at the energy frontier demand high brightness, high energy electron beams that must have a sub-one percent energy spread and low emittance. Realizing such beams in practice using an ultrahigh gradient plasma accelerator remains a vexing challenge. Here we report the results of a Plasma Wakefield Accelerator campaign, at the newly commissioned FACET-II facility at SLAC National Accelerator Laboratory, that self-generates a much lower-emittance trailing bunch with energies of up to 26 GeV and sub-1% energy spread and less than 5 micron normalized transverse emittance by utilizing a novel yet simple plasma platform that utilizes down ramp self-injection in the wake followed by acceleration in a >1 m long plasma wake created in a lower density hydrogen gas. During the wakefield acceleration process the much of the charge in the 10 GeV drive is fully energy depleted while the injected bunch containing up to 25 pC charge is accelerated from rest to more than twice the initial energy of the drive beam. This places a lower bound on the transformer ratio of greater than 2.6. PIC simulations indicate that the nonlinear wake was underloaded and that there is room for

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