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External Injection experiment: first accelerated beam

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In recent studies on LWFA staging and external injection-acceleration in PWFA only a very small fraction (from below 0.1% to few percent) of the injected charge (the coupling efficiency) was accelerated. For future colliders where beam energy will need to be boosted using multiple stages, the coupling efficiency per stage must approach 100%. Here we report the first demonstration of external injection from a high-brightness RF photogun based conventional linear accelerator (LINAC) into a LWFA and subsequent acceleration without any significant loss of charge or degradation of quality. Stable 31-MeV, 20-fC electron beams from the LINAC were velocity bunched to the length of ~ 13 fs (r.m.s.) in the high-gradient photocathode RF gun and then external injected into the linear wakefield excited by the 8TW, 40 fs laser. The experimental results show that nearly all the electrons can be mono-energetically accelerated with average gradient ~ 300 MV/m. This is achieved by properly shaping and matching the beam into the dedicatedly designed plasma structure. High capture efficiency of external injection has also been systematically validated by 3D PIC simulations. This is an important step towards realizing a high throughput, multi-stage high energy hybrid conventional-plasma accelerator.

Primary author: HUA, Jianfei (Tsinghua University)

Co-authors: Mr WU, Yipeng (Tsinghua University); Mr ZHOU, Zheng (Tsinghua University); Mr LIU, Shuang (Tsinghua University); Mr PENG, Bo (Tsinghua University); Mr FANG, Yu (Tsinghua University); Mr ZHANG, Jie (Tsinghua University); Dr NIE, Zan (University of California Los Angeles); Prof. PAI, Chih-Hao (Tsinghua University); Prof. DU, Yingchao (Tsinghua University); Prof. LU, Wei (Tsinghua University of Beijing, China); Prof. MORI, Warren Bicknell (University of California Los Angeles); Prof. JOSHI, Chan (University of California Los Angeles)

Presenter: HUA, Jianfei (Tsinghua University)

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