Overview of the latest experimental advances in electron and positron beam-driven plasma accelerators

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To unlock the mysteries of the subatomic world, physicists use the world’s most powerful microscopes — particle colliders. But as we push the resolving power of these microscopes — the particle energy — even higher, conventional accelerator techniques are attaining their limits and new concepts are emerging. Whereas the electric field of conventional accelerators is limited by the breakdown of the metallic radio-frequency (RF) cavity that contains the electromagnetic field, a plasma is a ionized medium and is therefore already broken down, with ions and free electrons. In a plasma wakefield accelerator (PWFA), a charge-density plasma wave is excited by an ultra-relativistic bunch of charged particles, with accelerating fields exceeding the gigaelectronvolt-per-meter and good energy efficiencies. These beam-driven plasma accelerators therefore hold out the promise of more compact, more affordable and higher-energy particle accelerators. They are increasingly considered as a mean to push the energy frontier of particle physics even higher.

The field of beam-driven plasma acceleration has recently seen a rapid experimental progress, in particular with the last few years of running of the FACET facility at SLAC. I will present an overview of the latest key experimental results for plasma acceleration of both the electron and its antimatter counterpart, the positron. For electrons, the acceleration of a distinct bunch was achieved with high energy efficiency. Very high fields in a beam-ionized high-ionization-potential gas were also generated, unveiling important physical processes such as particle beam self-focusing. The more challenging problematic of positron acceleration will be discussed, and the progress made in positron PWFA and in the use of hollow plasma channels will be presented.