Controlled acceleration of GeV electron beams in an all-optical plasma waveguide

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Laser-plasma accelerators are a promising alternative to conventional accelerators thanks to their 1000 times greater accelerating fields. However, to reach high energies, the electrons require to experience these fields on large distances, which involves overcoming laser diffraction. A solution is to guide the pulse that drives the wakefield thanks to the use of plasma channel waveguides. These were first produced using electrical discharges in a capillary tube [1], it allowed to reach GeV level electron beams for the first time in 2006, but this method has some drawbacks such as potential laser damage to the capillary tube or lack of control during the injection process.

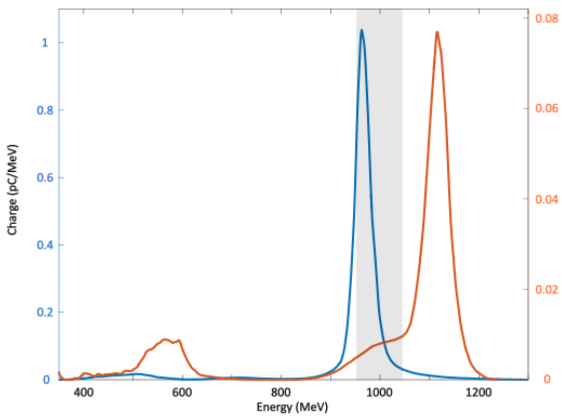

Figure 1: Two examples of angularly-integrated spectra.

These issues are addressed in the all-optical technique that is reported here as the plasma channel is shaped with a reflective mirror called axiparabola. This device produces a focal line that generates a plasma channel which will be used as the waveguide after expanding in the ambient gas [2, 3]. As the plasma channel is field-ionized, this means it can be shaped in order to control the injection process. This technique therefore allows the production of electron beams that are simultaneously high quality and high energy.

This proof-of-concept experiment allowed to produce well-peaked spectra down to 2% energy spread with a 70% efficiency [4]. This setup has also shown its efficiency on petawatt installations since it recently allowed to accelerate electrons up to 2.5 GeV on the Apollon laser facility.

References

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