



Contribution ID: 71

Type: poster

Concept of the long wakefield accelerator based on the tunnel gas ionization by the electric field from a dense electron bunch

Monday, September 25, 2017 7:30 PM (1 hour)

The train of charged particle bunches is an effective driver for a plasma-based accelerator, but the amplitude of the excited wakefield strongly depends on the uniformity of plasma, in other words, the type of plasma source. For the train with N bunches relative uniformity must be better than $1/N$, thus, the more bunches are in a beam, the higher are the requirements on plasma. One of the prospective ways to obtain the high uniformity of plasma is the full ionization of the initially uniform gas using powerful laser pulse. For example, this method forms the basis of the AWAKE experiment at CERN.

On the other hand, the laser pulse starts diverging after a long distance, it influences the radius of plasma column as well as the ionization degree and limits the possible length of the accelerator. This work considers charged particle bunches as the alternative to the laser pulse. Being charged, the bunch is able to be focused either by the external quadrupole magnets or the plasma itself and allows to increase the possible length of the accelerator significantly.

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Session Classification: Wine and Poster Session 1(WG1-WG2-WG3-WG8)

Track Classification: WG8 - Advanced and novel accelerators for High Energy Physics