Contribution ID: **168** Type: **poster**

Investigation of the self-modulation seeding by a short electron bunch within a long proton bunch

Monday, 25 September 2017 19:30 (1 hour)

The AWAKE Experiment at CERN is world's first proton-driven plasma wakefield accelerator aiming for acceleration of externally injected electrons in gradients up to the GeV/m scale.
The 12 cm long proton bunch from CERN's Super Proton Synchotron propagates through a 10-m long laser induced plasma channel and is split into a train of microbunches on the order of the plasma wavelength by its electromagnetic interaction with the plasma by the self-modulation instability (SMI), a transverse plasma instability. According to simulations, this instability does not significantly grow over a meter scale and is therefore seeded by having an ionizing laser pulse co-propagating at the centre of the proton bunch.
We present calculations and simulations for a different concept of SMI by electron injection. The timing between laser and protons is shifted, so that the whole protons bunch propagates through a preformed plasma. The proton beam current is modulated by the external injection of a short electron bunch in the centre of the proton beam. The resulting sharp rise of the total current in the electron bunch drives large wakefields that seed the growth of the SMI. This seeding technique will also be tested experimentally.

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

Track Classification: WG1 - Electron Beams from Plasmas