Contribution ID: **37** Type: **talk**

Electron acceleration in beam-loaded and beam-dominated laser wakefields

Tuesday, 17 September 2019 16:20 (20 minutes)

We report on the generation of quasi-monochromatic electron beams with up to 1.2 nC beam charge, 18 pC/MeV spectral charge density and less than 1 mrad rms divergence using shock-front injection in a 100-TW-class laser wakefield accelerator. Due to the high charge density, beam loading clearly affects both the final energy and the spectral shape of the beams themselves. We explain these effects using quasi-3D particle-in-cell simulations and provide estimates for the longitudinal phase-space distribution in the weakly and strongly loaded cases. Additionally, we measure the influence of beam-loading on witness bunches, which are created via a colliding pulse injection or a modification of the shock-front. In a last experiment, we send the electron beams into a second gas target. We observe that the energy gain of the witness in this stage is dependent on the first beam's charge, which demonstrates plasma wakefield acceleration in a driver-witness configuration.

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Session Classification: WG1 - Plasma acceleration physics I

Track Classification: WG1 - Electron beams from plasmas