The E332 experiment at FACET-II: harnessing beam-plasma interaction for solid-density electron beams and extremely dense gamma-ray pulses

A. Matheron[1] and the E332 collaboration*

[1] *LOA, Palaiseau, France,* [2] *SLAC National Accelerator Laboratory, Menlo Park, USA,*
[3] *CEA, Saclay, France,* [4] *Max-Planck-Institut für Kernphysik, Heidelberg, Germany,*
[5] *University of California, Los Angeles, USA,* [6] *University of Colorado Boulder, Boulder, USA,*
[7] *University of Oslo, Oslo, Norway,* [8] *Stone Brook University, New York, USA*

When an electron beam impinges onto an overdense plasma, the beam self fields are reflected at the plasma surface which can result in a strong focusing effect for the beam. Passing through multiple thin plasma layers of solid density may allow to self-focus bunches with beam densities reaching the density of a solid, and generate collimated gamma rays with sub-micrometer source sizes and conversion efficiencies exceeding 10 % [Sampath *et al.*, PRL 126, 064801 (2021)]. The relative simplicity, unique properties, and high efficiency of this gamma-ray source open up new opportunities for both applied and fundamental research including laserless investigations of strong-field QED processes with a single electron beam [Matheron *et al.*, arXiv:2209.14280].

The possibility offered by this plasma-based scheme to self-focus high-energy beams and generate extremely dense gamma-ray beams calls for an experimental demonstration. This is the purpose of the E332 experiment at the SLAC National Accelerator Laboratory where this mechanism can be studied with unprecedented electron beam parameters available with the FACET-II accelerator facility. During the beam-plasma interaction, the beam is focused each time it passes through a vacuum-plasma boundary leading to an increase of beam final divergence, a shift of the waist and a smaller beam size. We present the latest experimental results by looking at the modified beam parameters after the interaction of the 10-GeV electron beam with a specifically-designed multifoil target that acts as multiple thin plasma layers. We furthermore report on simulations of realistic electron beam and plasma configurations for FACET-II that give rise to focusing of electron bunches that we compare to the experimental data.

*Full list of E332 Collaborators: E. Adli[7], I. Andriyash[1], R. Ariniello[2], J. Cary[6], S. Corde[1], X. Davoine[3], C. Doss[6], H. Ekerfelt[2], C. Emma[2], J. Faure[3], F. Fiuza[2], E. Gerstmayr[2], S. Gessner[2], M. F. Gilljohann[2], L. Gremillet[3], M. Hogan[2], K. Hunt-Stone[6], C. Joshi[5], C. Keitel[4], A. Knetsch[1], O. Kononenko[1], V. Lee[6], M. Litos[6], Y. Mankovska[1], A. Marinelli[2], K. Marsh[5], S. Montefiori[4], W. Mori[5], N. Nambu[5], Z. Nie[5], B. O'Shea[2], S. Passalidis[3], J. Peterson[2], A. Sampath[4], P. San Miguel Claveria[1], D. Storey[2], M. Tamburini[4], N. Vafaei-Najafabadi[8], Y. Wu[5], X. Xu[2], V. Yakimenko[2], J. Yan[8], V. Zakharova[1], C. Zhang[5]