

Emittance measurements and transport for the BELLA center free electron laser

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The success of many laser plasma accelerator (LPA) based applications, such as a compact x-ray free electron laser (FEL), relies on the ability to produce electron beams with excellent 6D brightness, where brightness is defined as the ratio of charge to the product of the three normalized emittances. As such, parametric studies of the emittance of LPA generated electron beams are essential. Profiting from a stable and tunable LPA setup, combined with a carefully designed single-shot emittance diagnostic, we present a direct comparison of charge dependent emittance measurements of electron beams generated by two different injection mechanisms: ionization injection and shock induced density down-ramp injection. Notably, the measurements reveal that ionization injection results in significantly higher emittance. With the down-ramp injection configuration, emittances less than 1 micron at spectral charge densities up to ~ 2 pC/MeV were measured. These measurements are discussed in the greater context of the BELLA Center FEL project which aims to demonstrate FEL amplification using the 4 meter VISA undulator. Various aspects of this project, including transport design, FEL simulation and the development of a novel electromagnetic chicane for longitudinal bunch decompression are discussed in detail.