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Optimizing down-ramp injection to generate stable and tunable electron bunches for an LPA driven FEL

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The mission to achieve free electron lasing using electron bunches generated from an LPA source calls not only for exceptionally high quality and stability in electron beam properties, but also tunability of the laser-plasma interaction and therefore the particle beam parameters. As an alternative to self-trapping, utilizing a density down-ramp in the gas jet density profile has gained a lot of attention to realize this goal. At the BELLA Center HTU system, we use a 100 Terawatt Ti:Sa laser system capable of producing 40 fs pulses with 4 J energy that are subsequently focused into a helium gas jet set up for down-ramp injection. We will present detailed analysis of the jet parameters as well as positioning of the blade, coupled to investigations of the consequential plasma density profiles that allow us to achieve precise control over the properties of the electron bunches and operate our source with high energy stability and charge over hundreds of shots. For example, the optimum separation of the blade from the jet orifice and laser focus was studied in great detail, revealing dramatic improvements in down-ramp sharpness.

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