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Ultra-short pulses and low jitter for time-resolved experiments at the SRF photoinjector of SEALAB

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In the last years, the visualization of structural dynamics, which take place on time scales as short as few femtoseconds has been complemented by pump-probe techniques that employ relativistic electrons as probes, e.g. ultrafast electron diffraction (UED). These applications demand not only extreme beam quality in 6-D phase space such as few nanometer transverse emittances and femtosecond bunch lengths, but also equivalent beam stability. Although these utmost requirements have been demonstrated by a compact setup with a high-gradient electron gun with state-of-the-art laser technologies, this approach is fundamentally restricted by its nature for compressing the electron bunches in a short distance by a ballistic bunching method while also suppressing the time-of-flight jitter of the electrons. Here, we propose a new methodology that pushes the limit of timing jitter and bunch compression simultaneously beyond the state-of-the-art by utilizing consecutive RF cavities. This accelerator layout already exists for energy recovery linear accelerator demonstrators such as SEALAB in Helmholtz-Zentrum Berlin. Furthermore, the superconducting nature of the RF cavities in the beam-line is capable of providing MHz repetition rates, which are out of reach for most conventional high-gradient electron guns. Hence, the proposed accelerator layout offers a new scientific case for similar ERL demonstrators without significant modifications, while providing enhanced signal to noise performance when compared to other purpose-built UED accelerators.

Summary

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