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Sub-femtosecond resolution electro-optical arrival-time measurement of relativistic electron bunches in a free-electron laser

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SwissFEL is a normal conducting linear accelerator driving two separate free-electron laser (FEL) lines –one for soft and one for hard x-rays. We report jitter and correlation measurements of two electro-optical Bunch Arrival-Time Monitors (BAMs), which use directly the pulses from a mode-locked laser oscillator. The arrival-time is encoded in the amplitude of one single reference laser pulse in a fiber coupled Mach-Zehnder modulator driven by a fast RF-transient from a button pick-up. Using the modulation slope and the laser amplitude jitter, we demonstrate <1 femtosecond resolution at 200 pC bunch charges for the BAM with a 16 mm pick-up beam pipe diameter and <10 fs at 10 pC for the BAM with 8 mm pick-up beam pipe diameter. We also report a jitter correlation measurement of two independent BAMs over 1 min at 100 Hz machine repetition rate as well as a similar correlation measurement of one single BAM station with 8 mm pick-up beam pipe diameter and having two identical high resolution channels. The measured correlations are as low as 1.3 fs rms resulting in sub-femtosecond resolution of the optical detection scheme.

Footnotes

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