Ultra-fast arrival time feedback using BACCA at FLASH.

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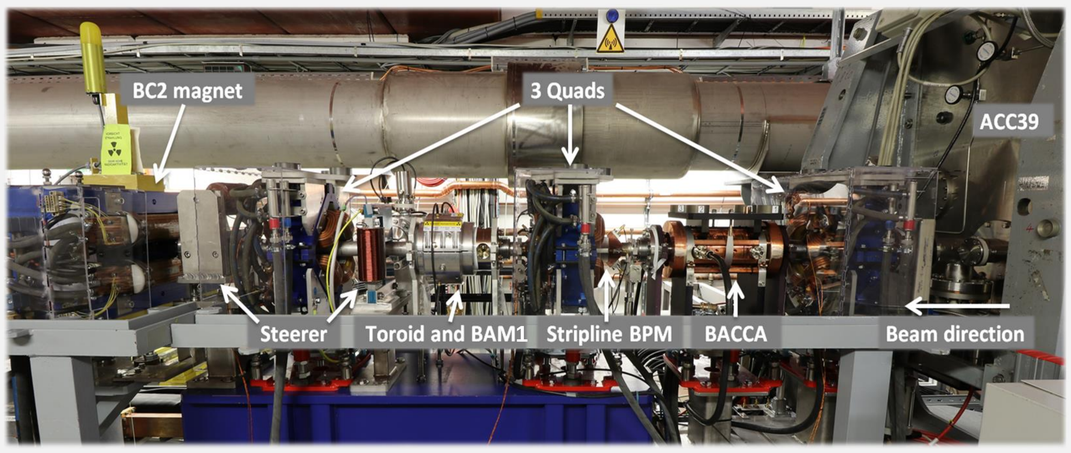
Poster ID: 42

Abstract

The longitudinal intra-bunch train beam-based feedback is used to correct arrival time fluctuations of the electron bunches at the free-electron laser in Hamburg (FLASH). The arrival time information is measured by a bunch arrival time monitor (BAM). The novel bunch arrival corrector cavity (BACCA) has been successfully commissioned and characterized. BACCA is a normal conducting RF cavity, located prior to the first bunch compressor, and acts as ultra-fast energy corrector. Due to the energy dependent path length through the magnetic chicane of the bunch compressor the cavity is used to stabilize the bunch arrival time. This fast energy corrector cavity acts together with the superconducting RF cavities for larger corrections in an intra-train beam-based feedback system. First measurements at FLASH show arrival time stabilities towards 5 fs (rms).

BACCA – Bunch Arrival Corrector CAvity

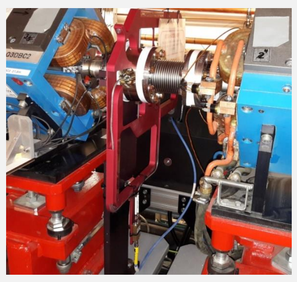
- Normal conducting RF cavity
- Four cell cavity
- Installed in front of the bunch compressor BC2
- 2.9972 GHz operating frequency
- Energy modulation range ±50 keV
- Feedback loop latency < 700 ns
- 1 kW amplifier



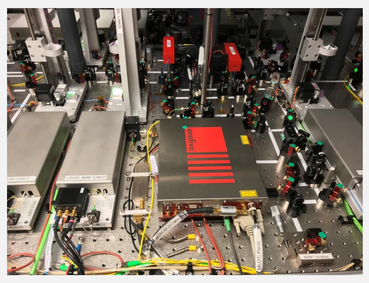
S. Pfeiffer et all, Status Update of the Fast Energy Corrector Cavity at FLASH, 29th International Linear Accelerator Conference, 2018

Bunch arrival time monitor (BAM)

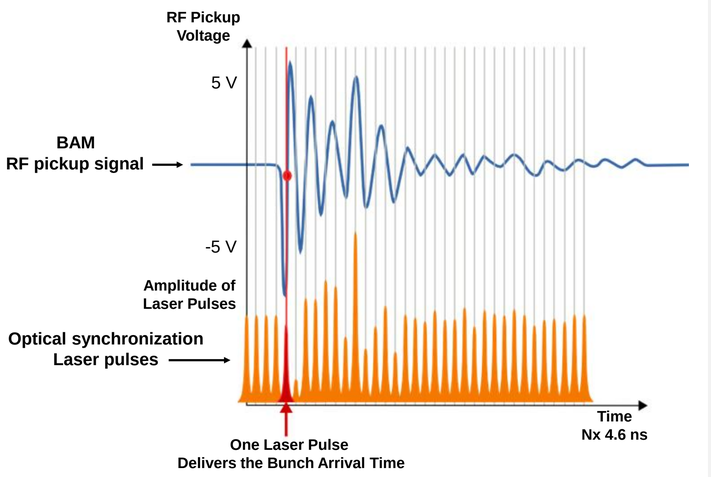
- Optical synchronization system – latest European XFEL design based on PM fibers
- New designed BAM RF pickups (Bandwidth of 40 GHz)
- Resolution of the arrival time measurement < 10 fs
- The measured arrival time $t_{Arrival}$ is used for the intra-train beam-based feedback



RF frontend on the beamline

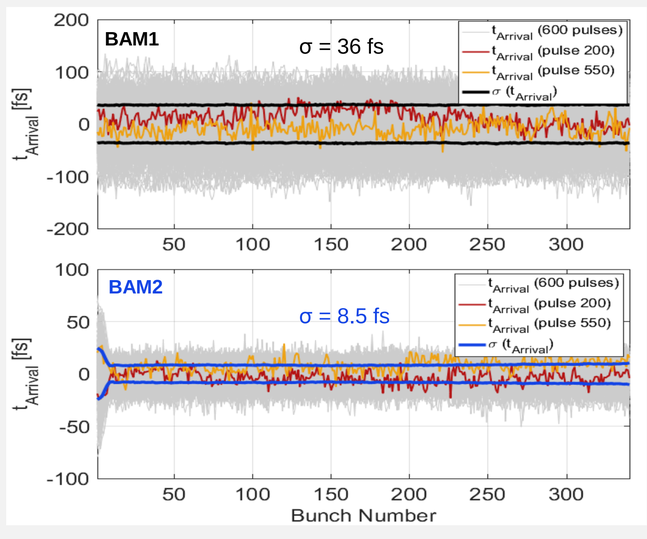


Optical table of the synchronization system



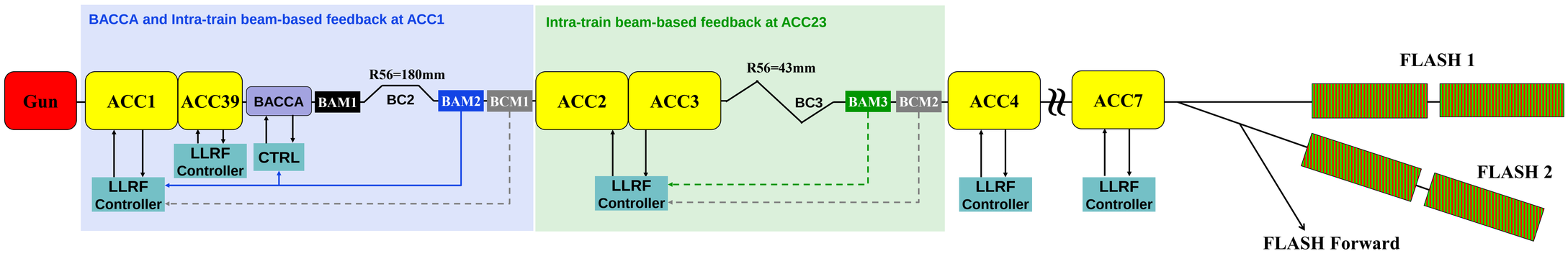
Result: mean–free arrival time

- Intra-train beam-based feedback at ACC1 and BACCA
- Arrival time jitter of 8.5 fs (rms) after BC2 (BAM2)



S. Pfeiffer et all, Longitudinal Intra-Train Beam-Based Feedback at FLASH, FEL19, 2019

Intra-train beam-based feedback at FLASH



Conclusion

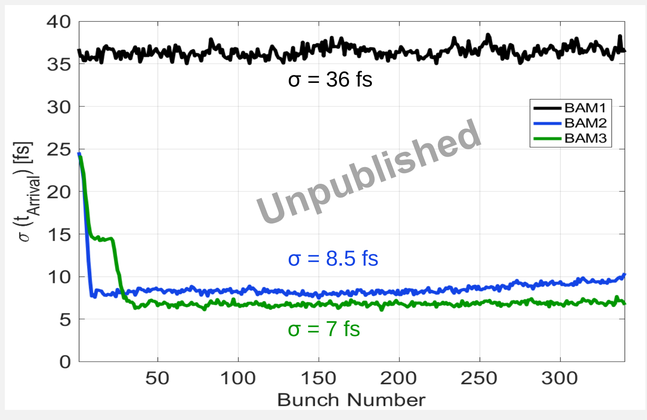
- Using beam based measurements for the feedback system increases the arrival time stability significantly
- Arrival time stability of 8.5 fs (rms) after the first bunch compressor (BC2)
- Reaches steady state value after 10 µs (10 bunches with a repetition rate of 1 MHz)

Outlook

- Additional intra-train beam based feedback loop for the regulation of ACC23
- Integration of additional beam information for the feedback loop, e.g. measurements of the bunch compression monitors (BCM1 and BCM2)
- Finding the optimal closed loop bandwidth and gain for ACC1 and BACCA

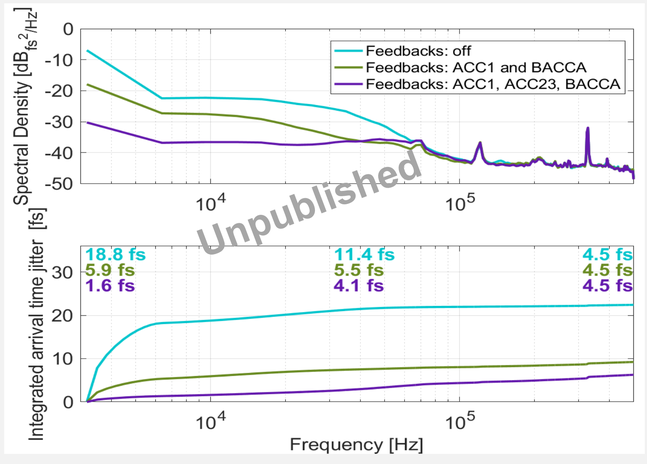
Arrival time stability from BAM1 to BAM3, (600 pulses)

- Activated intra-train beam-based feedback at ACC1, ACC23 and BACCA
- Arrival time jitter of 7 fs (rms) after BC3 (BAM3)



Different feedback modes: spectra and integrated arrival time jitter

- The feedbacks affect the arrival time in the frequency range up to ~70 kHz (with the used controller settings)



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