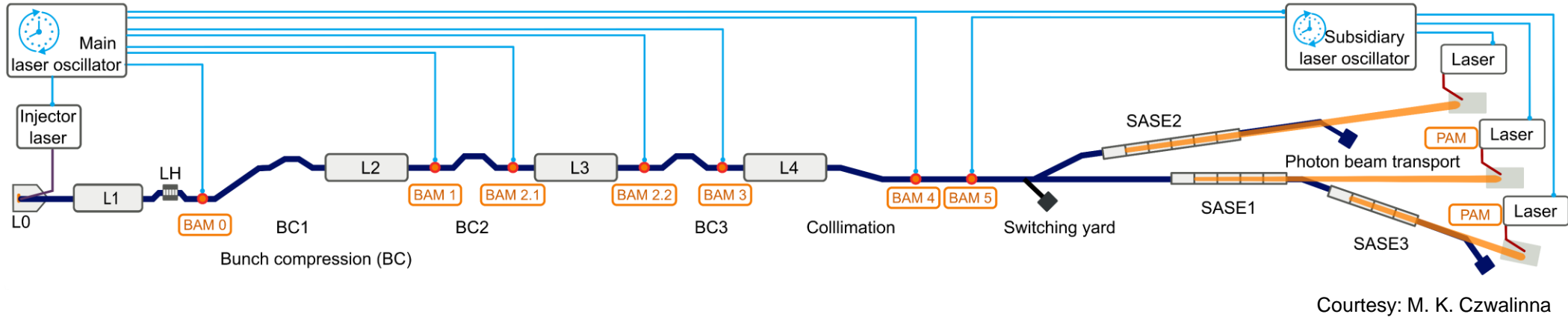


Bunch arrival stability at the European XFEL

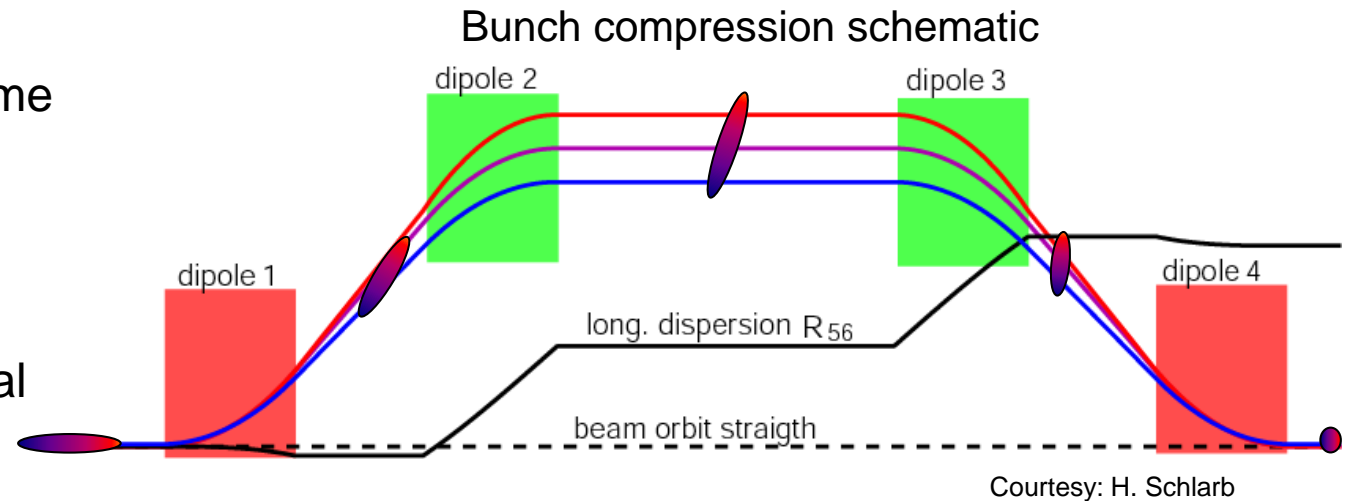
MT ARD ST3 Meeting 2021 in Hamburg

Björn Lautenschlager on behalf of MSK - DESY
Hamburg, 29.09.2021

Overview European XFEL

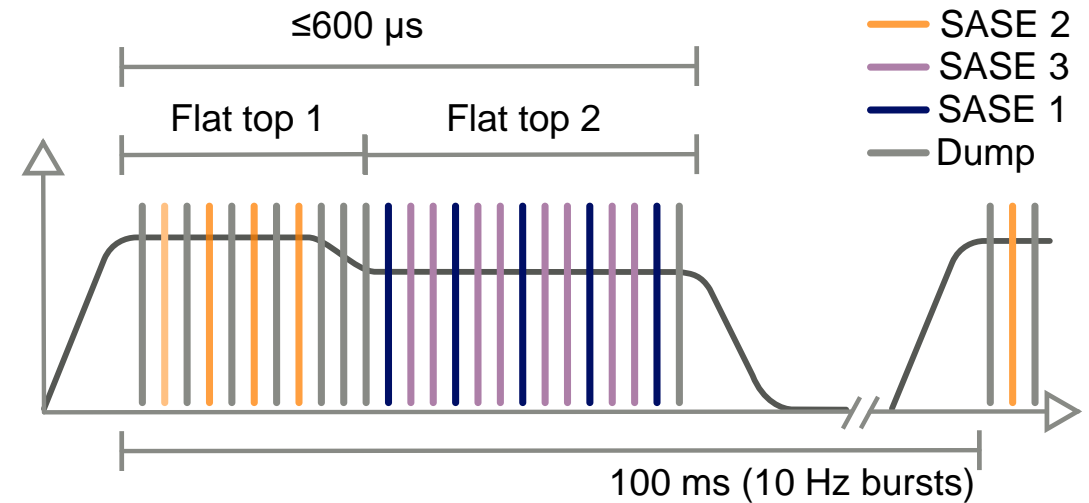


- 10 Hz burst mode, Up to 4.5 MHz bunch repetition rate within a burst, up to 17.5 GeV total energy
- Pump-probe experiments need stable arrival time
- Optical synchronization system
- Three bunch compression chicanes
- Energy adjustment before the chicane => arrival time change after the chicane



Low-level radio frequency (LLRF) system and bunch arrival time monitor (BAM)

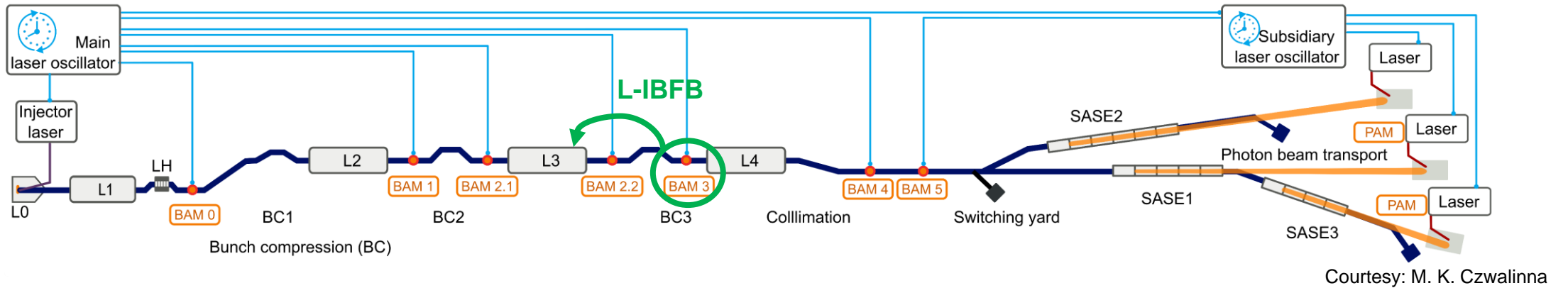
- LLRF: Control of the RF-field of the accelerator modules, Amplitude A and Phase φ
- Calculates drive signal for high power provided by the klystron
- Three different parts
 - Filling, Flat-tops, Decay
- Different controller types like, multi-input multi-output or learning feedforward controller



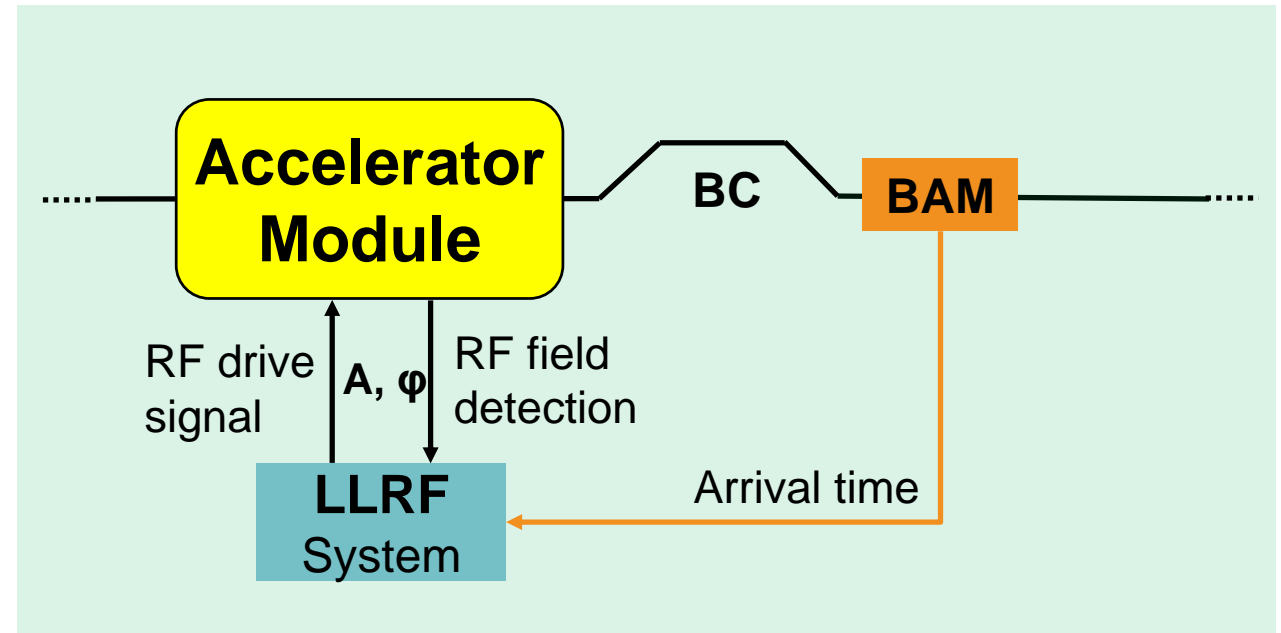
Courtesy: M. K. Czwalińska

- BAM: measurement of the relative arrival time of each bunch in a bunch-train
- Reference is provided by the laser pulses of the optical synchronisation system
- Measured arrival time is used for the beam-based feedback to improve the jitter

Longitudinal intra bunch-train feedback (L-IBFB)

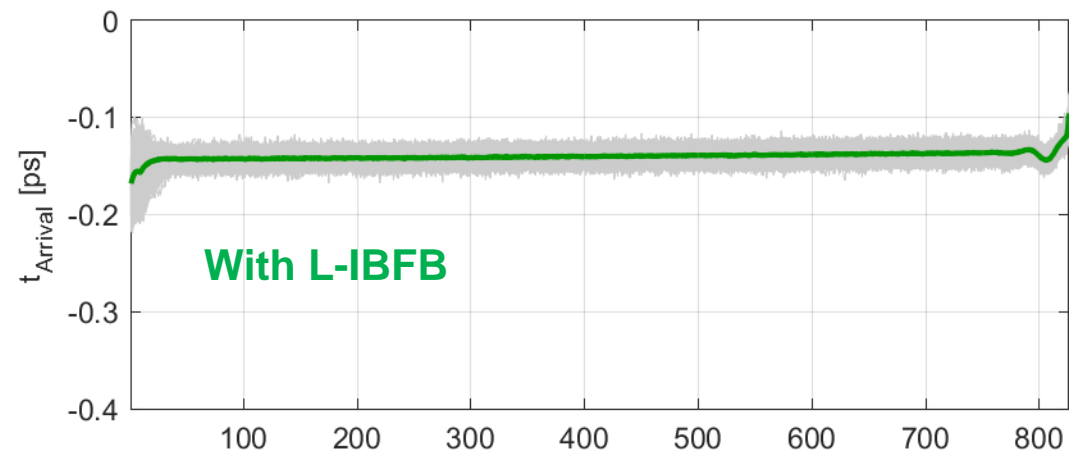
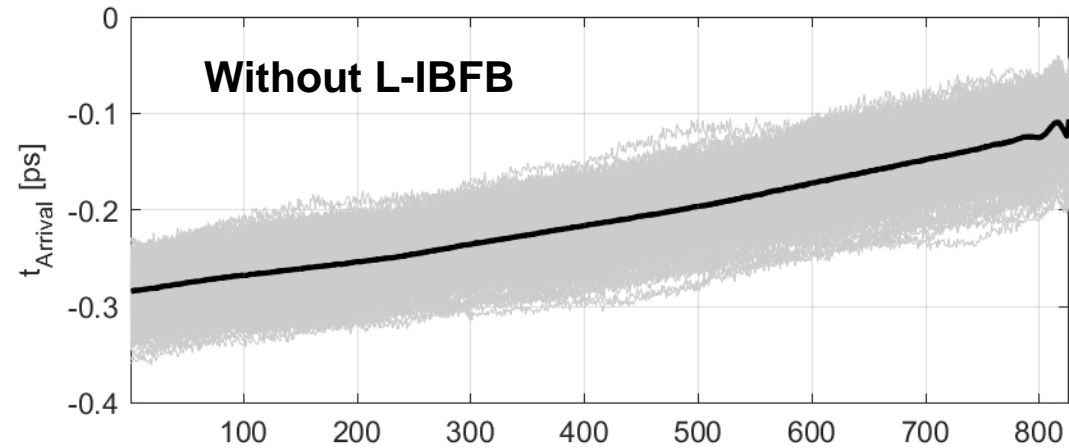


- The measured arrival time is sent to LLRF system
- LLRF system uses combination of field error and beam error
- Energy adjustment in front of the chicane results in arrival time changes after the chicane
- L-IBFB loop around BC3



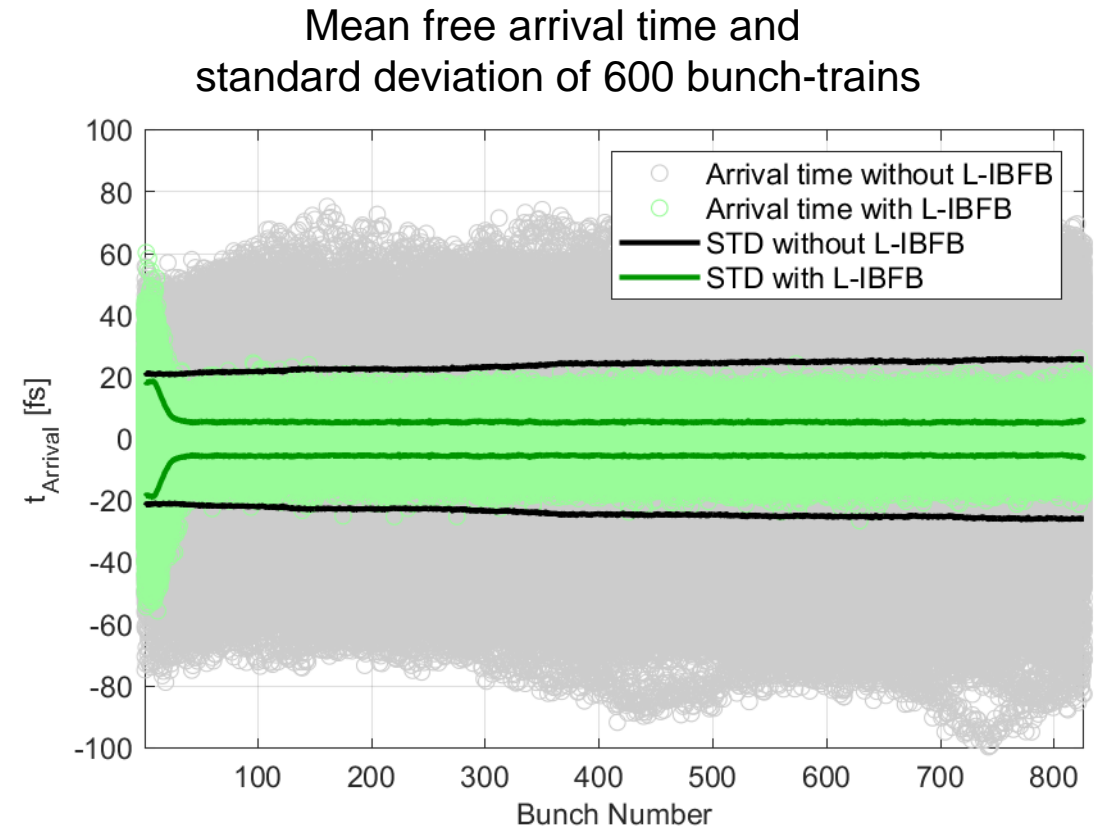
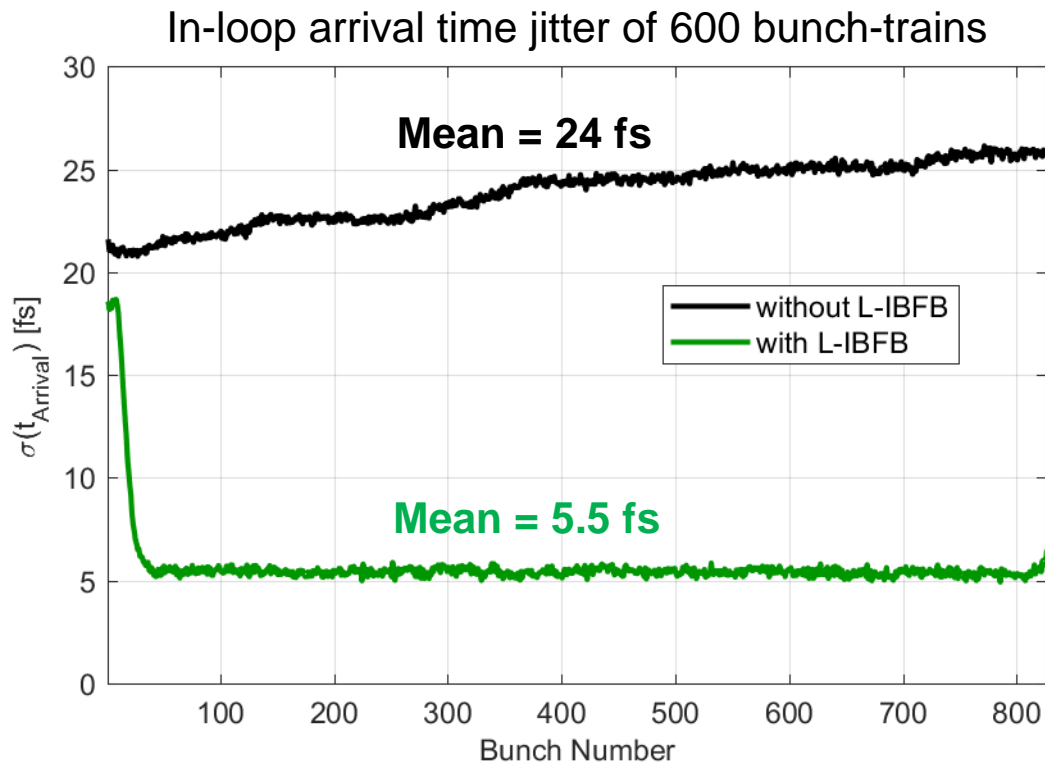
Arrival time stability: measurement results

- Measured arrival time along the bunch-train (more than 800 bunches)
- 600 bunch-trains
- Measurements with BAM3 after the last bunch compressor
- Bunch-to-bunch repetition rate 2.25 MHz
- Bunch charge 0.25 nC
- Measurements taken in parallel to SASE delivery



Arrival time stability: measurement results

- L-IBFB pushes the in-loop arrival time jitter from 24 fs down to 5.5 fs
- Reaches steady state value after 25 bunches



Summary and outlook

- Longitudinal intra bunch-train feedback pushes the arrival time jitter down to 5.5 fs (rms)
- Factor of 4.4 compared to the jitter without the FB
- Data taken during SASE delivery
- L-IBFB is used for first experiments with stable operation over days
- Integration of the compression signal into the L-IBFB
- Confirm the measurements with an out of loop photon arrival time monitor (PAM) using a bunch charge of 0.25 nC
- Establish the L-IBFB also for the first flat top.
- Improve the automation for setting up the L-IBFB

Thank you for you attention

Contact

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