PAUL SCHERRER INSTITUT

PSI

Cezary Sydlo :: Timing and Synchronization :: Paul Scherrer Institute

Timing and synchronization status and objectives

Third SwissFEL Performance Workshop , 27. January 2021

Responsibility of “Timing and Synchronization”

- 2998.8 MHz Master Oscillator + 10 MHz Rubidium Reference
- Harmonic Extraction **(spare in preparation)**
- 7x analog Laserlocks, **2x more this year** (ATHOS &HERO) + **new development**
- 4x Aramis BAMs: 2x with and 2x without stabilized links
- 2x Athos BAMs: prepared, but on hold
- 2x “experimental” RF-stabilized pulsed optical links (for BAMs)
- 4x 2856 MHz + 1x 2998.8MHz amplifiers
- 36x CW-Links (Tx + Rx, 2856 MHz & 2998.8MHz), **4x more this year**
- 28x C-band doublers
- 142.8MHz mixed (fibers and cables) reference distribution (1x Tx + 8x Rx)
- Plus supportive installations (WAGO, I2C etc.), > 270 (soft-) IOCs

- Optical cross-correlators upcoming (shared work with “Elektronenquellenlaser ”)

Current team situation

- ~~Stephan Hunziker (left 2018)~~
- Vladimir Arsov
- ~~Florian Büchi (left December 2019)~~
- ~~Markus Heiniger (left April 2020)~~
- ~~Maik Kaiser (long absence, situation unclear)~~
- Uwe Kolb (temporary contract)
- ~~Albert Romann (passed away)~~
- ~~Miroslav Dach (left of April)~~

- Cezary Sydlo (since May 2019)
- Chris Deutschendorf (since January 2020)
- Maciej Patro (since January 2021 with Controls: Tadej Humar)
- Nicola Berger (will start May 2021)
- **One more offered position, difficult to fill**

- **Substantial help from Martin Paraliev (Group: ”HF Systeme 1”)**

Mid-term Roadmap

- MO upgrade (announced 2nd SF Performance Workshop) done: less jitter
  - Biggest bottlenecks
    - Current analog laser sync (for Gun&Experiment lasers, OMO and for BAMs)
- Next steps
  - Digital laser sync by 2022? (with CW-Link as reference) => **low jitter**
    (too much person power necessary for maintenance/operation)
    - Development of custom pulsed optical links => **low-drift**
    - Development of optical cross-correlation => **"zero-drift"**
  - BAM reference upgrade for SINLH01-DBAM010 & S10BC01-DBAM070
    - Less **jitter and drift** between machine and BAM
  - Rework BAMs for new custom pulsed optical links (polarization maintaining fiber)

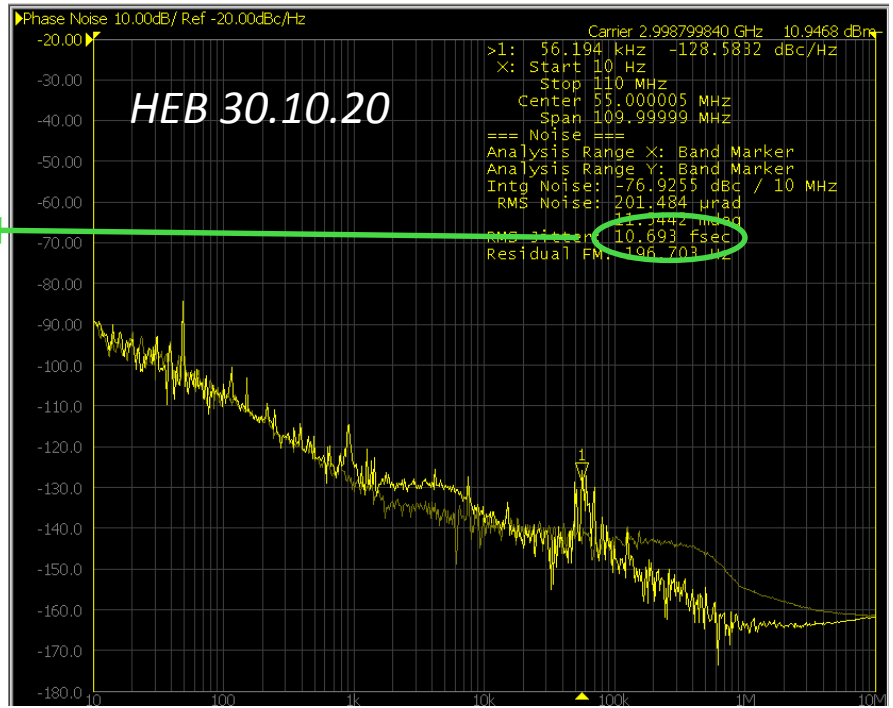
- Continuous task: Operation, Maintenance & Installations,
  cleanup of IOCs, documentation, etc.

Generation of ultra-stable reference signals

- Master Oscillator (announced Jan 2020)
- Also Harmonic extraction box exchange
- Was 23 fs RMS (10Hz-10MHz)
- Now 10.7 fs since Oct 2020 shutdown
- Becomes difficult to measure!

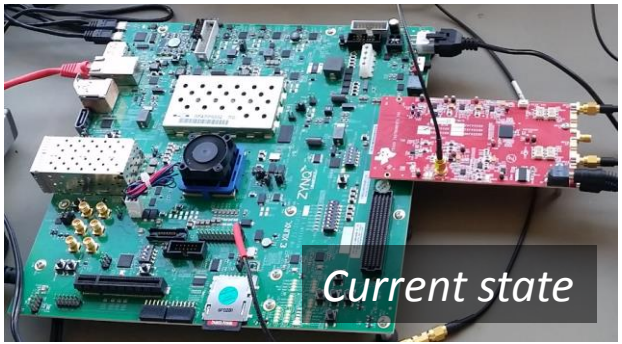
- Users see added jitter in distribution
  - CW-Links ca. 4-5 fs
  - Vector mod. for laser sync ca. 8 fs

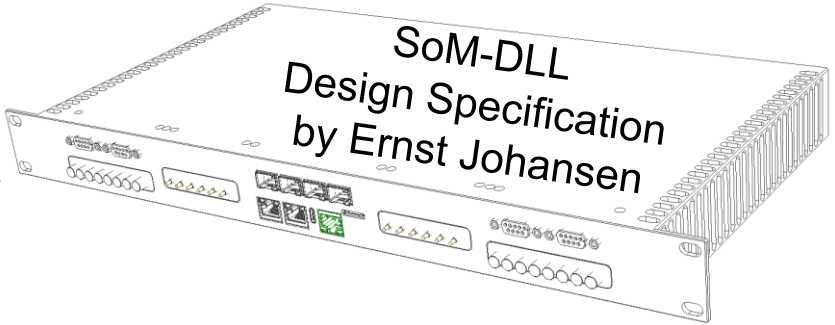
  → ~ 15 fs RMS max. (absolute)



Thanks to Vladimir Arsov, Chris Deutschendorf and Martin Paraliev

Digital Laser synchronization





- First FW tests proved 1fs RMS in-loop
- Still a long way to go …
  - In-depth system optimization
  - Hardware design
  - Firmware development

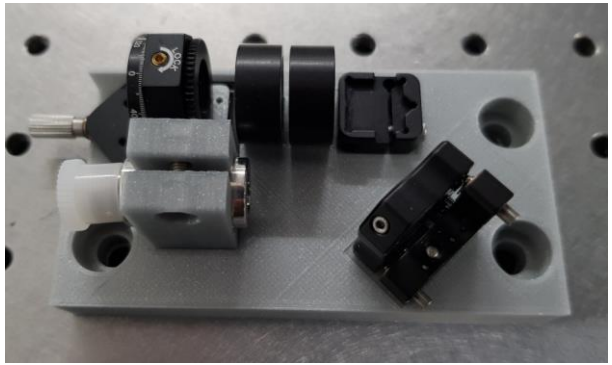
Project application passed bureaucracy

- Digital frontend (1HE) concept nearly done
- RF/analog frontend (1HE?) concept pending
- All (known) issues addressed
- 1st prototype scheduled for Q3/2021

Thanks to Martin Paraliev, Goran Marinkovic, Oliver Bründel, Waldemar Koprek and Ernst Johansen

Pulsed optical reference distribution

- Started own development
  - All-optical lock (sub-fs distribution)
  - Improved version of Eu-XFEL design



  - Deployment needs a overall revision
    major rework of OSFA/SK.023

Thanks to Florian Büchi

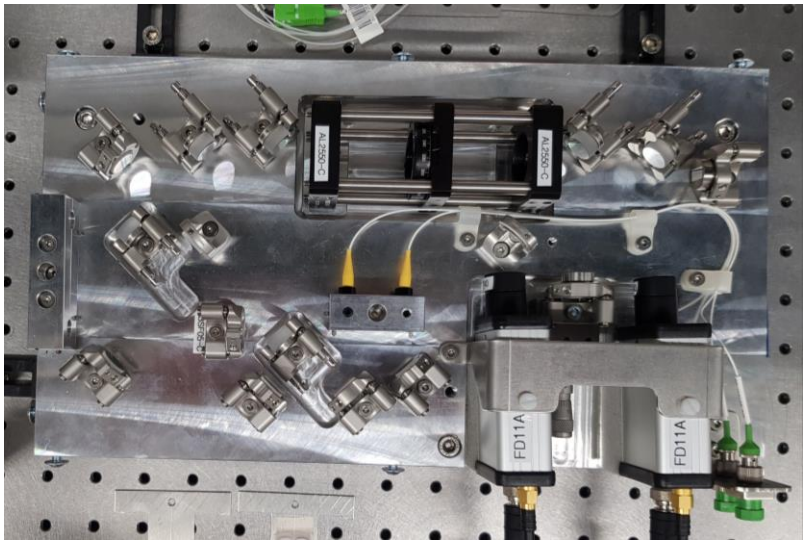
- Delayed, needs more person power
  - Colleague left PSI
- Task for new coworker (starts May 2021)

- Will be continued after ATHOS commissioning of laser sync

- Already started:
  - Assessment of components
    - Delay stage
    - Fiber components
- Still a lot of work to do

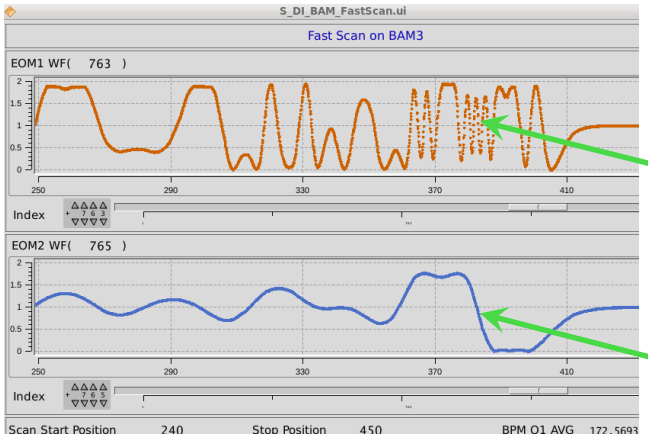
Laser arrival time monitors (LAMs)

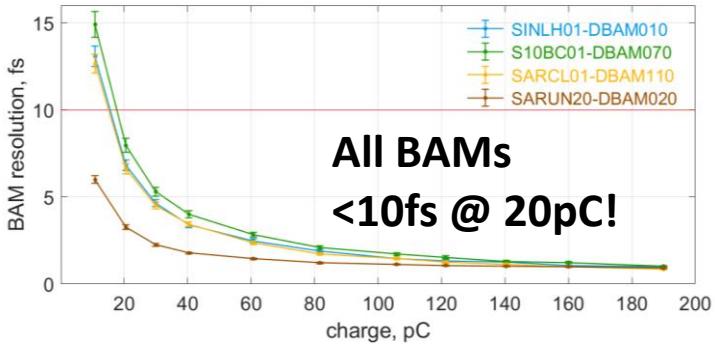
- Optical cross-correlator development
  - «One size fits all» design
  - Addressed issues observed at Eu-XFEL
  - In cooperation with FHNW
  - Two prototype available at PSI from bachelor thesis of M. Schädler
  - Delayed, needs more person power



Thanks to Alexandre Trisorio, Carlo Vicario, Andreas Dax, Vladimir Arsov
Prof. Dr. Bojan Resan (FHNW) and Michel Schädler

Bunch Arrival Monitor





Nov.19 removed 40GHz RF limiters → Improvement

- Typical : **~ 0.7 fs .. ~ 1.7 fs @ 200 pC**
- SARUN20-DBAM020: **~6 fs @ 10 pC**
- **Highest resolution ever reported**

Difficulties:

- Complex signal, multiple zero-crossings
  - Solution Aug.20: use of the 2nd EOM (including EPICS alarm and validity)

- Still high jitter ~30 fs RMS: machine vs. BAM
  - Assumption: 2nd (analog) laser sync and 2nd OMO contribute the most
  - Solution: Deduce everything from OMO1 Work in progress

Thanks to Vladimir Arsov

Outlook

- Many very heterogeneous systems, limited person-power
- Several different clients that rely on these systems

Focus 2021

- Athos and HERO laser sync
- Athos RF stations
- Digital laser lock development
- Developments of pulsed optical links and BAM upgrades

Good planning & communication needed

- Number of clients significantly increases, especially lasers
- User requirements increase
- Needs planning well in advance

Wir schaffen Wissen – heute für morgen

My thanks go to all of you

- Fruitful discussions
- Enjoyable cooperation