Overview of SLS 2.0 Diagnostics  (minus BPMs)
New Electronics Platform
Upgrade of motion controls & camera servers
New design and/or new monitor

Beam size monitor

Beam loss monitors

Filling Pattern Monitor

Streak Camera

Screens
ICTs
WCM
FCP

Screens
SRM
ICTs

NPCT

MPCT

Beam size monitor

System Requirements
Technical Design Finalization

2019

2020-2021

2021-2022

2022-2023

2023-2024

Commissioning
Installation
Controls integration
Pre-beam commissioning

Testing final products
Purchasing
Construction

Prototyping
Testing at SLS
Revisions
## Requirements

<table>
<thead>
<tr>
<th>Device</th>
<th>Motivation</th>
<th>Requirements</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Monitor (Bergoz NPCT)</td>
<td>Storage Ring Current, Transmission Efficiency and Lifetime</td>
<td>0-400mA to 0.1mA</td>
<td>In-flange NPCT, NEP</td>
</tr>
<tr>
<td>Injection &amp; Extracted Charge (Bergoz MPCT)</td>
<td>Optimizing injection into Booster</td>
<td>0-300pC to 1%</td>
<td>SLS solution OK, NEP</td>
</tr>
<tr>
<td>Charge Monitors (ICT)</td>
<td>Optimization of transmission to &lt;5%</td>
<td>0-400pC to 1%</td>
<td>Turbo ICT, NEP</td>
</tr>
<tr>
<td>Filing Pattern Monitor</td>
<td>Synchronization of the injection chain to refill any electron bucket, to keep desired storage ring filling pattern</td>
<td>Sufficient bandwidth &amp; gain to resolve single electron buckets</td>
<td>SLS solution OK, NEP</td>
</tr>
<tr>
<td>Screen Monitors</td>
<td>Resolve expected smallest 40µm in BTR</td>
<td>&lt;15µm/pixel, higher sensitivity (&lt;1 pC)</td>
<td>Re-design required</td>
</tr>
<tr>
<td>Beam Size Monitors</td>
<td>Coupling and emittance measurements, stability diagnostics</td>
<td>Sensitive to low currents, high dynamic range and rep rate, measure 5µm</td>
<td>SLS π-pol monitor OK, Pin-hole insufficient</td>
</tr>
<tr>
<td>Streak Camera (dual sweep synchroscan)</td>
<td>See jitter inside bunch train</td>
<td>2ps resolution every 100 or 1000 turns</td>
<td>New with gated photocathode</td>
</tr>
<tr>
<td>Loss Monitors</td>
<td>Protecting and positioning beam within IDs Scraper optimization</td>
<td>To be defined</td>
<td>SwissFEL solution or Commercial</td>
</tr>
</tbody>
</table>
Heatload/Radiation damage on vacuum windows of beam size monitors (replacement every 18mo)
Kicker magnet power supply introduces noise on standard ICTs
Streak camera: Photocathode damage, MCP aging
Analog cameras >> Firewire cameras >> Area scan detectors
Loss of old camera server >> Lost X-ray pin-hole monitor
Replacement of electronic modules: end of lifetime, no/few backups, long past industry standards
Resource sharing with other projects (SITF, SwissFEL, HIPA, Proscan)
Our latest processing platforms are already several years old (e.g. IFC1210 developed in 2011 for SwissFEL)
SLS hardware (VME crate, CPU and I/O cards) already facing operational/availability issues
VMEbus speed: far behind today’s technology, bottleneck, reducing it to housing with power supply

We need to act!

What bus-standard we should use?

- Technology trend: shifting from parallel bus arch to switched serial interconnects
- uTCA risks: complex, lack of PSI-internal know-how, fragile and small market
- CPCI-Serial:
  - Very good future perspective
  - Based on widespread PCIe and Ethernet technologies
  - PSI-internal know-how available

Thanks to AEK division for slides and info
Study phase: Finished!
HW selection & ordering: Done!
Practical evaluation: To be started soon

Planned pre-project:
- Evaluate typical control system app (Linux, EPICS, I/O, timing)
- Define Backplane, FE concept, FPGA platform(?)
- Work out migration concept for future

9-slot cPCI-Serial crate (ELMA)
02G025A00, Intel Xeon D-1539 (MEN)
SC5430D FESTIVAL Intel Xeon E3 (ELMA/EKF)
Multi-function I/O
Timing EVR, PSI Stock
Strategy for new systems:

- If commercial components are available, use CompactPCI-Serial bus-platform
  - Reduces dependency on internal resources
  - Rapid development cycle when requirements are known ahead of time
- Custom solutions only if commercial solutions fall short (e.g., SLS 2.0 BPM based on DBPM3)

New platform will be used for the following diagnostics devices:

- Current Monitors (2x)
- Charge Monitors (5x)
- Filling Pattern Monitor (1x)
• Keep in tunnel to avoid disruption
• APD bias control, EVR, IOC → new hardware platform
• Higher BW ADC + Migrate from s/w to f/w → Faster processing → increased stability, reduced injection time
Beam Size measurement at SLS 2.0

Synchrotron Light for Coupling and Emittance Determination

Smallest beam measured with $\pi$-polarization (at 364nm) = $3.6 \pm 0.6\,\mu m$

For SLS 2.0, using visible / UV SR from LGB bending magnets for $\pi$-polarization (vertical) and interferometric method (horizontal)

- Re-use components from existing beam size monitors
- Can extend existing beamline hutch to include streak camera
Screen monitor for BTR

**SLS**
Telescopic arrangement of lenses
Optical resolution: 26µm
Ce:YAG, OTR

**SwissFEL**
Follows the Scheimpflug imaging principle
Optical resolution: 8µm
Dependency on charge due to Ce:YAG behavior
Screen monitor for BTR

- Entire screen can be observed without depth-of-field issues by
- Detector is tilted by 14° for 1:1 imaging to avoid astigmatism
- Observation of beam profile according to Snell’s law
- Beams smaller than scintillator thickness can be imaged

<table>
<thead>
<tr>
<th>Scintillator</th>
<th>Observed rms beam image size [μm]</th>
<th>Light yield relative to OTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>YAG</td>
<td>16.4</td>
<td>252</td>
</tr>
<tr>
<td>CRY019</td>
<td>23.4</td>
<td>102</td>
</tr>
<tr>
<td>Diamond</td>
<td>106.6</td>
<td>1.9</td>
</tr>
<tr>
<td>CHROMOX</td>
<td>252.2</td>
<td>432</td>
</tr>
<tr>
<td>OTR (for comparison)</td>
<td>15.8</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Published in Physical Review Special Topics - Accelerators and Beams 18, 082802 (2015)
Loss Monitors: From FEL or not from FEL?

The SwissFEL way:

• Loss tracking due to:
  - Insertion of screens, collimators, slits
  - Beam alignment
  - Wire insertions

• Two types of loss monitors:
  - Scintillator based, for localized losses (BLM)
  - Optical fiber for tracking loss positions along the machine (LLM)
Analog front-end & digital backend developed at PSI
Cost reduction: using same readout chain for all
Common firmware and software solutions

ARAMIS + ATHOS = 29 Systems
Loss Monitors: Signal processing

MPS Algorithm:

\[
\frac{1}{2K} \left( \text{avg}_n \cdot (K - 1) + S_n \right)
\]

- \(S_n\): sum of PMT pulse from single bunch loss
- \(\text{avg}_n\): previously calculated sum
- \(K\): factor for weighted average (filter length)

- Once generated Alarm remains active until condition is no longer fulfilled
- Calculations performed at 100Hz, independent of beam repetition rate
Loss Monitors: Rate reduction

Dynamic change of beam repetition rate

- No need for rep rate reduction
- Possible EPS integration for ID safety
- Based on VME standard
  > migration to NEP > resources?!!
• Libera BLM vs SwissFEL BLM system testing at SLS
• Screen resolution improvement
• Technical Design of beam size monitors
• Turbo ICT testing in BTR
• Based on the new electronics platform, diagnostic device readout prototyping and testing at SLS
Thanks to everybody involved in the SLS 2.0 project & Thank you for your time and attention.

Your feedback and experience is important to us.
Solution: Grounded shielding + 2m long double shielded SMA cables (K02252D) + wrapped 4 turns around 10x 4c65 Ferrite cores (170nH)

Still ambient noise seen