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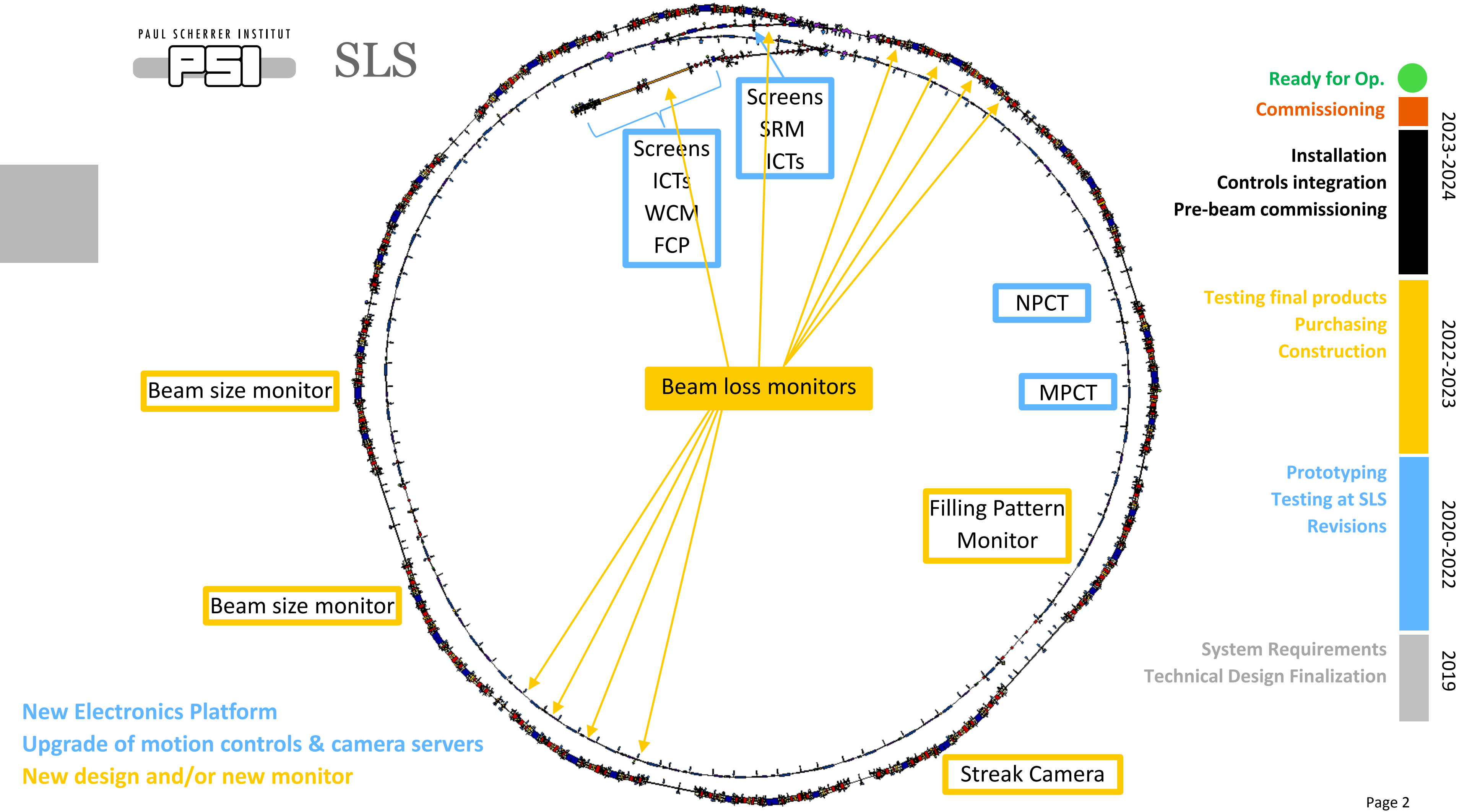
Cigdem Ozkan Loch :: Electron Beam Instrumentation :: Paul Scherrer Institute

Overview of SLS 2.0 Diagnostics (minus BPMs)

DEELS 2019, ESRF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PSI
SLS
Screens
SRM
ICTs
Screens
ICTs
WCM
FCP
NPCT
Beam size monitor
Beam loss monitors
MPCT
Filling Pattern Monitor
Beam size monitor
Streak Camera
New Electronics Platform
Upgrade of motion controls & camera servers
New design and/or new monitor
Ready for Op.
Commissioning
Installation
Controls integration
Pre-beam commissioning
2023-2024
Testing final products
Purchasing
Construction
2022-2023
Prototyping
Testing at SLS
Revisions
2020-2022
System Requirements
Technical Design Finalization
2019

Requirements

Device	Motivation	Requirements	Solution
Current Monitor (Bergoz NPCT)	Storage Ring Current, Transmission Efficiency and Lifetime	0-400mA to 0.1mA	In-flange NPCT, NEP
Injection & Extracted Charge (Bergoz MPCT)	Optimizing injection into Booster	0-300pC to 1%	SLS solution OK, NEP
Charge Monitors (ICT)	Optimization of transmission to <5%	0-400pC to 1%	Turbo ICT, NEP
Filing Pattern Monitor	Synchronization of the injection chain to refill any electron bucket, to keep desired storage ring filling pattern	Sufficient bandwidth & gain to resolve single electron buckets	SLS solution OK, NEP
Screen Monitors	Resolve expected smallest 40µm in BTR	<15µm/pixel, higher sensitivity (<1 pC)	Re-design required
Beam Size Monitors	Coupling and emittance measurements, stability diagnostics	Sensitive to low currents, high dynamic range and rep rate, measure 5µm	SLS π-pol monitor OK Pin-hole insufficient
Streak Camera (dual sweep synchroscan)	See jitter inside bunch train	2ps resolution every 100 or 1000 turns	New with gated photocathode
Loss Monitors	Protecting and positioning beam within IDs Scraper optimization Sensitive for lifetime Low charge on-axis injection	To be defined	SwissFEL solution or Commercial

20 years

- 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)

New Electronics Platform: Why??

- 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

Electronics Upgrade: Status and plans

- ✓ 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

Thanks to AEK division for slides and info

Electronics Upgrade: Strategy

Strategy for new systems:

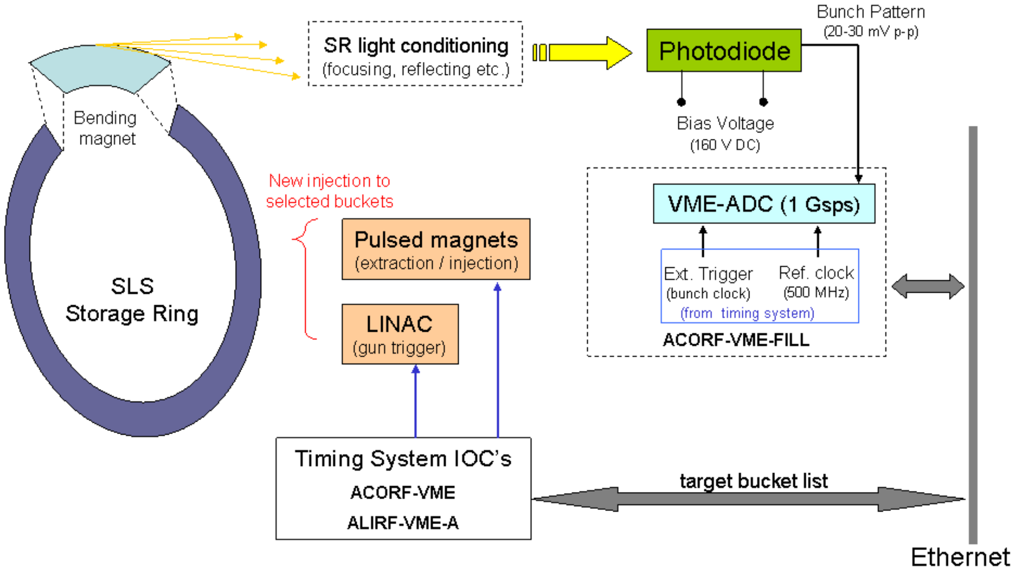
- If commercial components are avaiable, use **CompactPCI-Serial** bus-platform
  - Reduces dependency on internal resources
  - Rapid development cycle when requirements are known ahead of time
- Custom solutions only if commercial solutions fall short (eg, SLS 2.0 BPM based on DBPM3)

New platform will be used for the following diagnostics devices:

- **Current Monitors (2x)**
- **Charge Monitors (5x)**
- **Filling Pattern Monitor (1x)**

Thanks to AEK division for slides and info

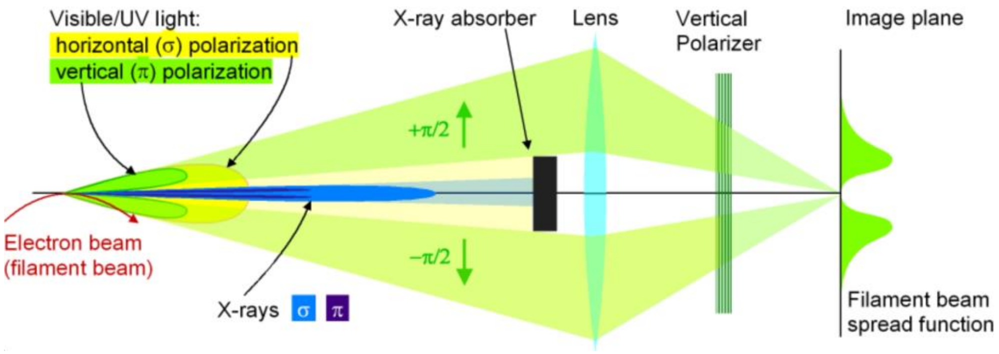
Filling Pattern Monitor

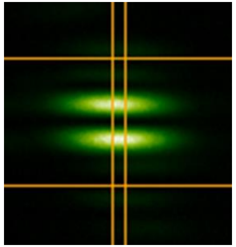


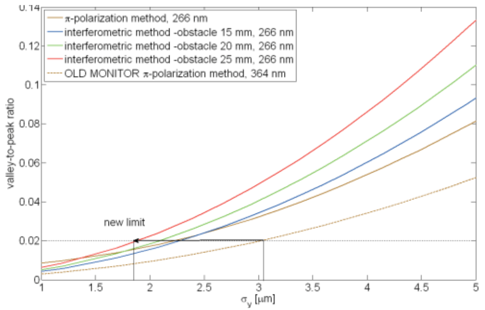
- Keep in tunnel to avoid disruption
- APD bias control, EVR, IOC → new hardware platform
- Higher BW ADC + Migrate from s/w to f/w → Faster processing → increased stability, reduced injection time

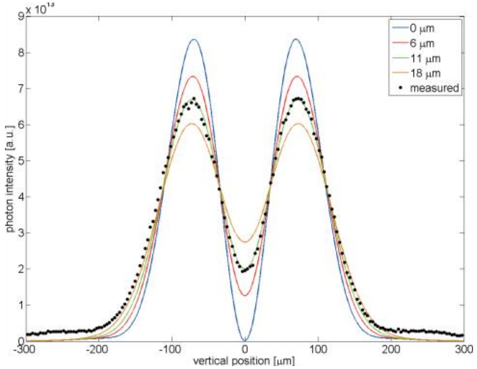
Beam Size measurement at SLS 2.0

Synchrotron Light for Coupling and Emittance Determination









Smallest beam measured with π-polarization (at 364nm) = **3.6±0.6um**

> For SLS 2.0, using visible / UV SR from LGB bending magnets for **π-polarization** (vertical) and **interferometric method** (horizontal)

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

Published in Conf. Proc. C130512 (2013) pp.MOPWA041

Screen monitor for BTR

SLS

Telescopic arrangement of lenses

Optical resolution: 26µm

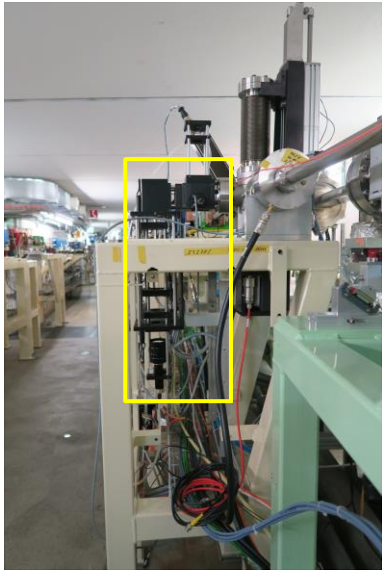
Ce:YAG, OTR

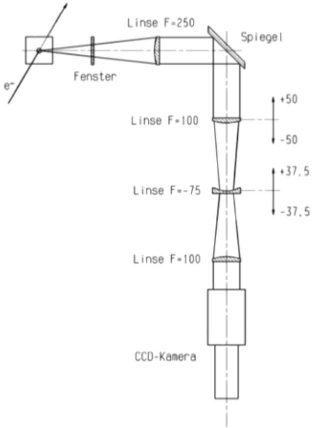
SwissFEL

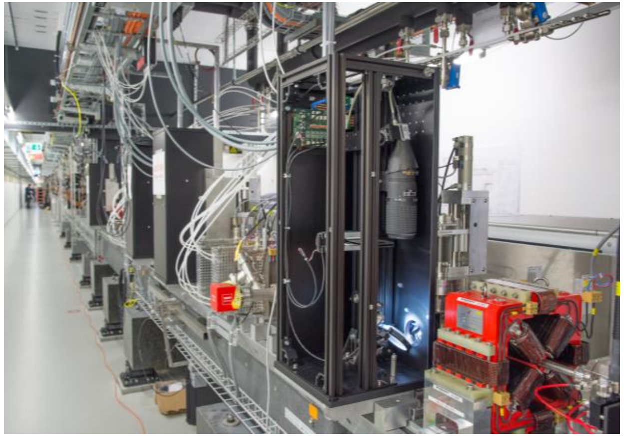
Follows the Scheimpflug imaging principle

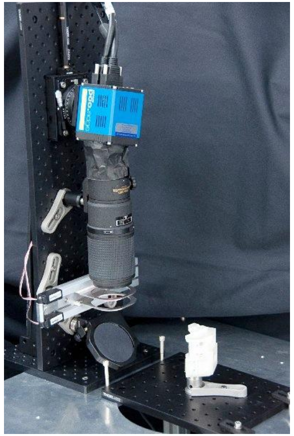
Optical resolution: 8µm

Dependency on charge due to Ce:YAG behavior





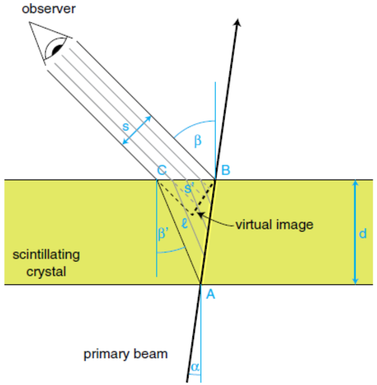




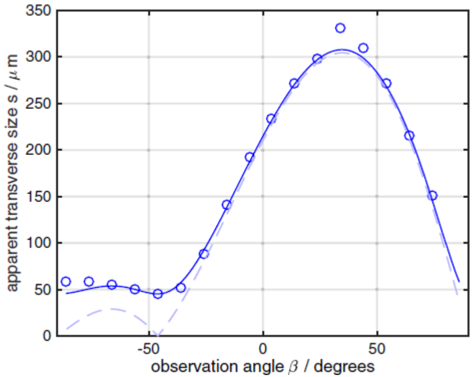
Screen monitor for BTR

- 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

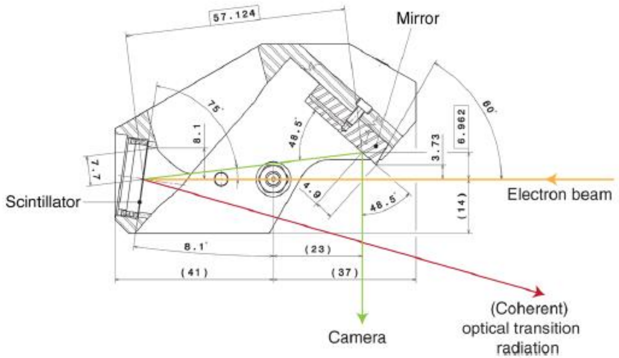
Scintillator	Observed rms beam image size [μm]	Light yield relative to OTR
YAG	16.4	252
CRY019	23.4	102
Diamond	106.6	1.9
CHROMOX	252.2	432
OTR (for comparison)	15.8	1



Snell-Descartes



Experimental verification of angle dependency



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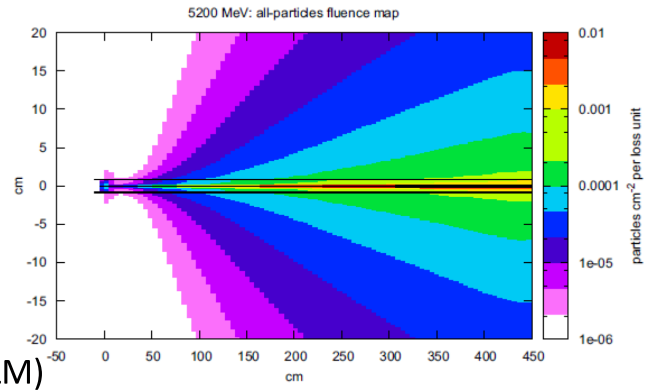
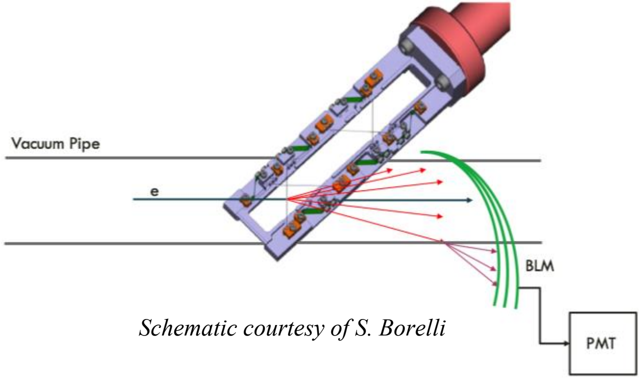
Loss Monitors: From FEL or not from FEL?

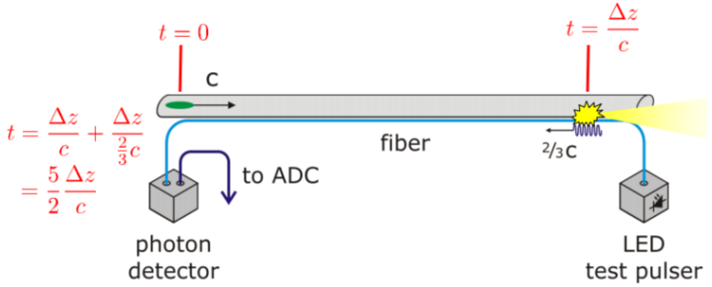
The SwissFEL way:

- 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)



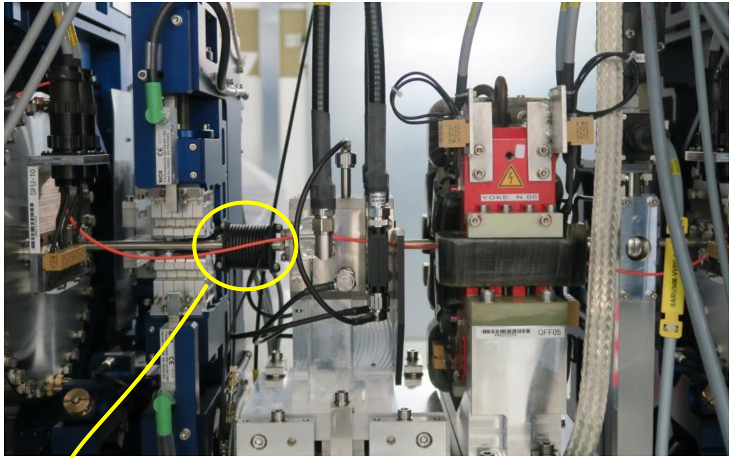


Schematic courtesy of S. Borelli



Schematic courtesy of L. Froehlich

Loss Monitors: DAQ System Overview

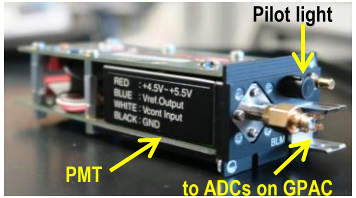


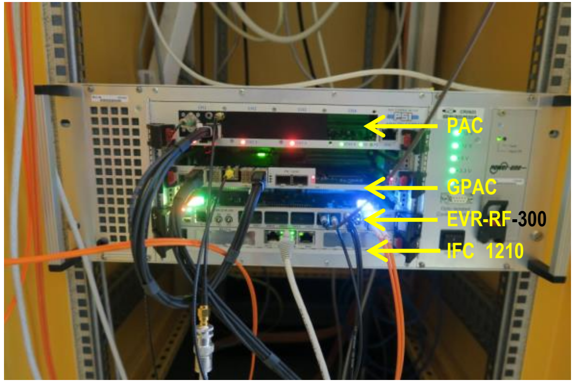
Analog front-end & digital backend developed at PSI

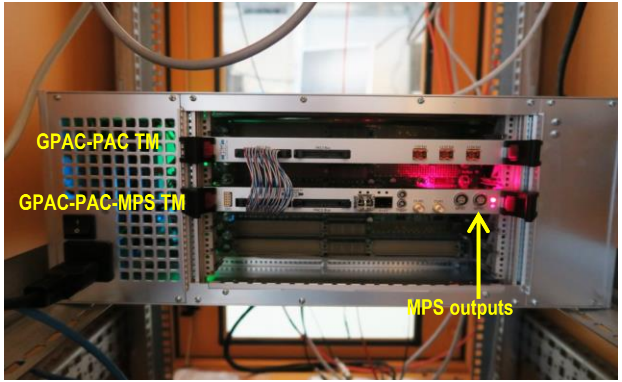
Cost reduction: using same readout chain for all

Common firmware and software solutions

ARAMIS + ATHOS = 29 Systems

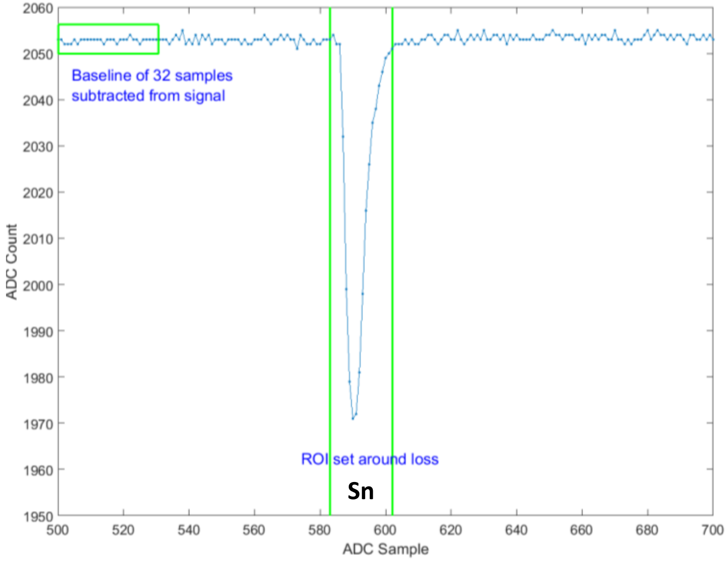




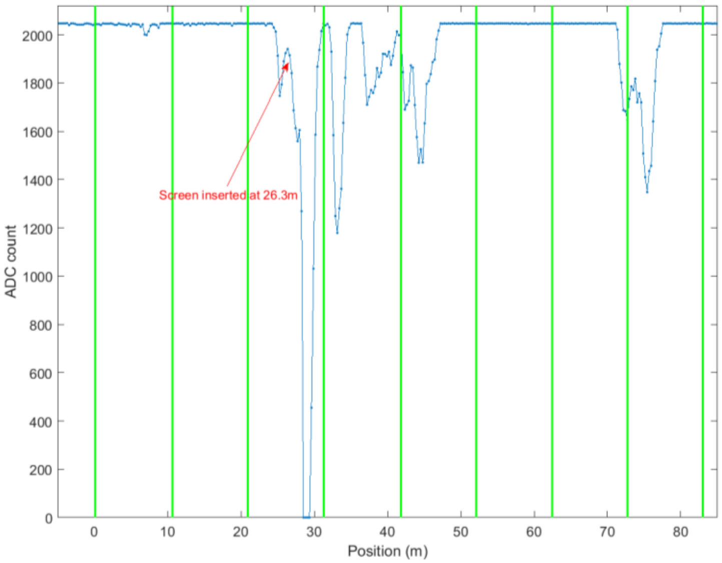


Loss Monitors: Signal processing

Beam loss monitor



Longitudinal loss monitor



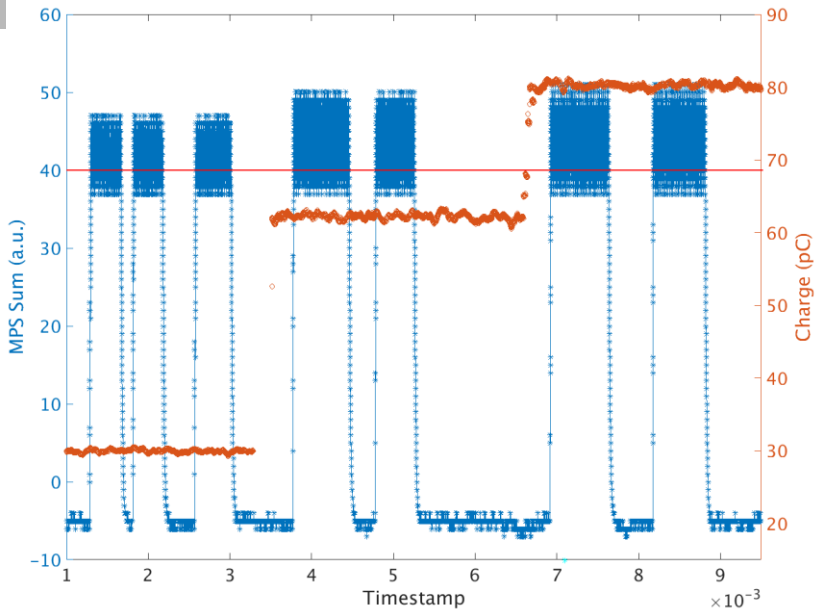
MPS Algorithm: $$\frac{1}{2K}\left(avg_n \cdot (K-1) + S_n\right)$$

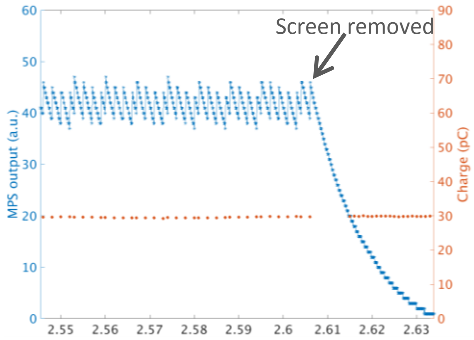
S_n: sum of PMT pulse from single bunch loss
avg_n: previously calculated sum
K: factor for weighted average (filter length)

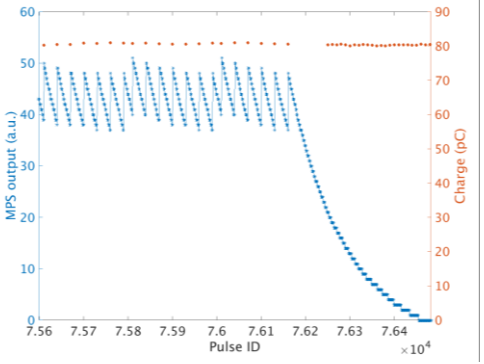
- Once generated Alarm remains active until condition is no longer fulfilled
- Calculations performed at 100Hz, independent of beam repetition rate

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?!!

In preparation of SLS 2.0

- 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

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Wir schaffen Wissen – heute für morgen

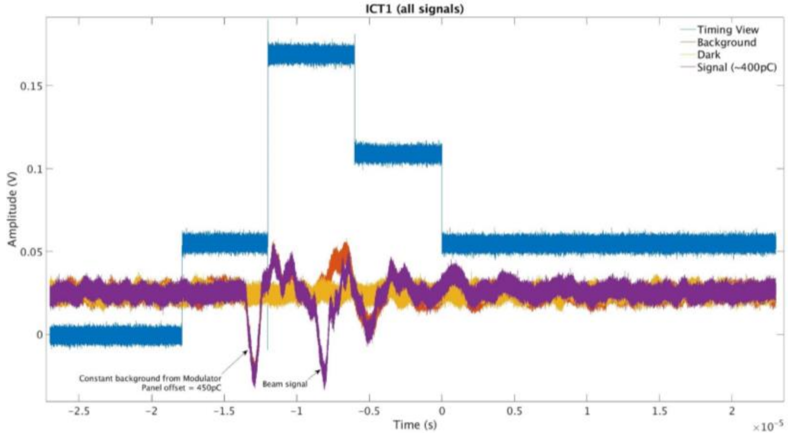
Thanks to everybody involved in the SLS 2.0 project

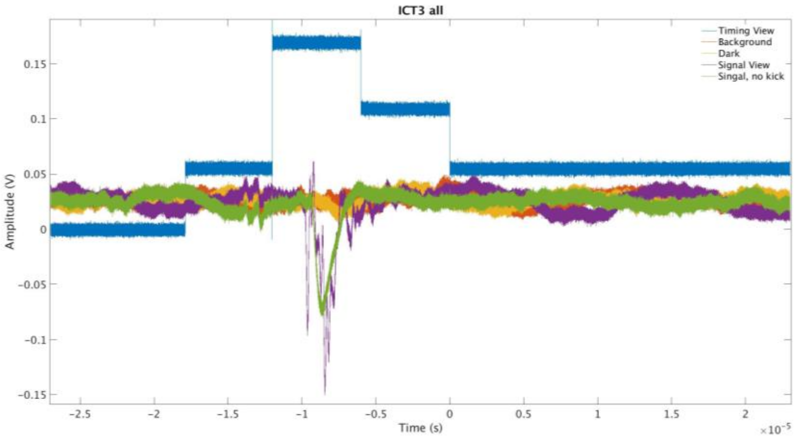
&

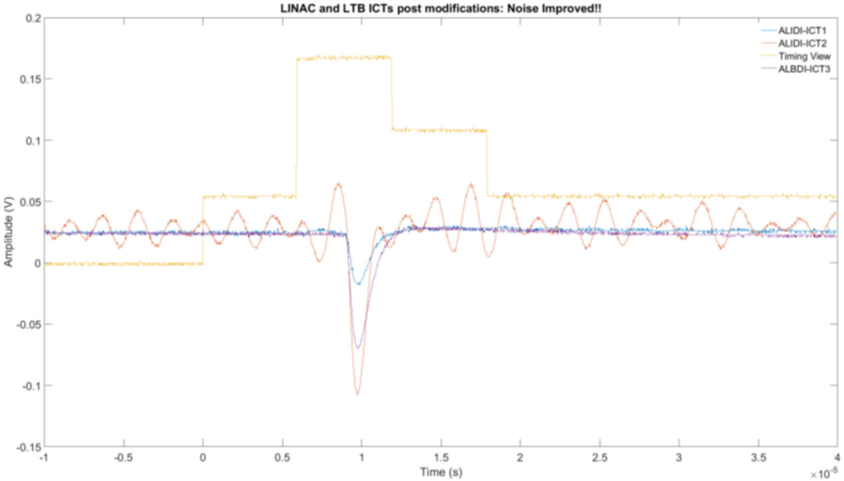
Thank you for your time and attention.

Your feedback and experience is important to us.

Noise on ICTs







Solution: Grounded shielding + 2m long double shielded SMA cables (K02252D) + wrapped 4 turns around 10x 4c65 Ferrite cores (170nH)

>>>>>>>>>> Still ambient noise seen

Turbo ICT