PAUL SCHERRER INSTITUT

PSI

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International Beam Instrumentation Conference

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CMOS based Beam Loss Monitor at SLS

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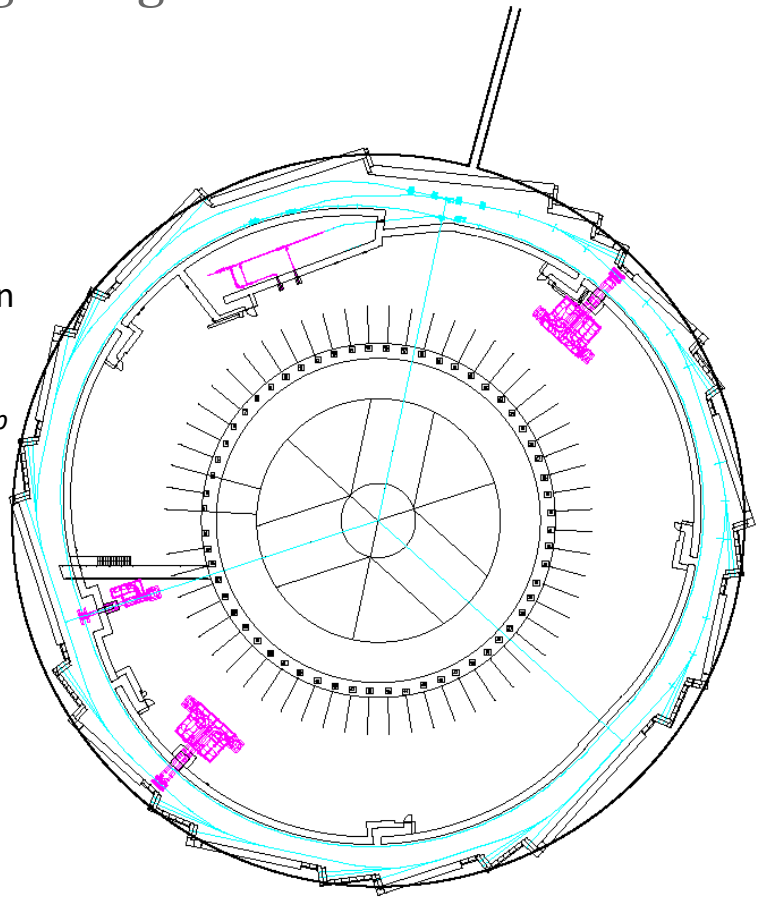
Requirements

- From the booster extraction point, down the storage ring injection straight and around the storage ring
- Detect low charge on-axis injection losses
- Provide loss patterns around the storage ring
- Loss measurements to determine beam lifetime and injection efficiency
  - Slow losses:
    Usually confined to hot spots (collimators, scraper, …). Depend on the beam size and population of the buckets. Time scale of the order of seconds.
  - Fast losses:
    Related to accidental effects or events such as injection or beam dump. These losses can be distributed all around the machine. Time scale of the order of the single bunch or single turn.
- Protection of Insertion Devices
- Possibility of [software] interface to machine interlocks

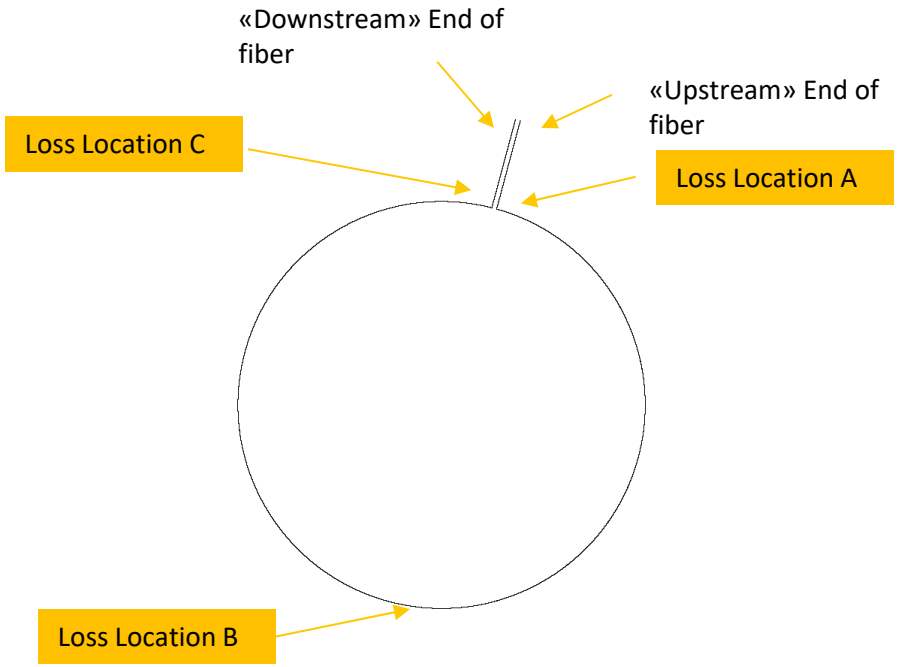
Long fiber around the Storage Ring

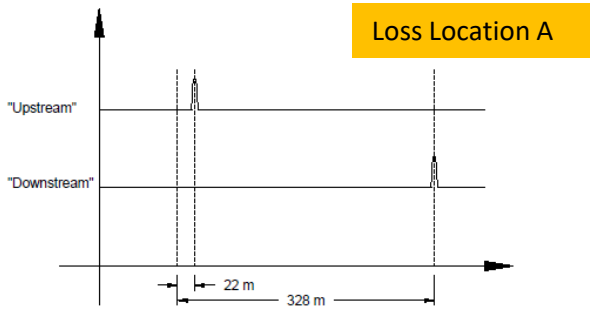
- ACAD drawing of the ring, with symbolic circle (frying pan shape) representing the 350m length of fiber optic
- Straight lines representing the two ends of the fiber which are brought out of the tunnel to the measurement location

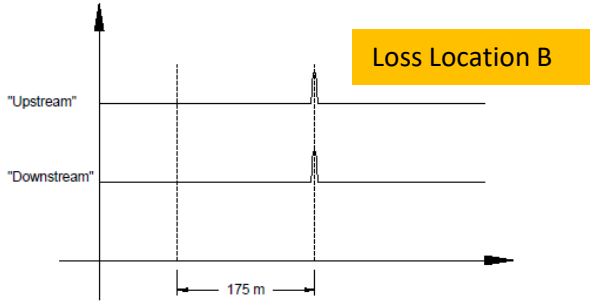


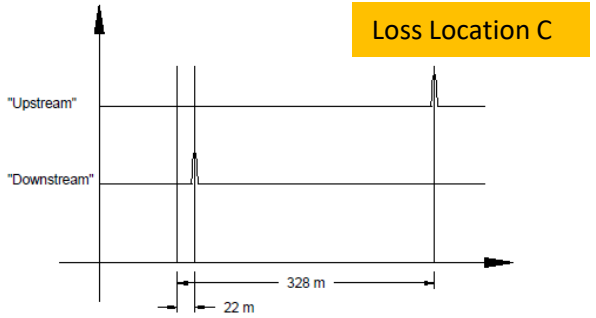
Thanks to Chris Gough for his collaboration and generosity, and Jonas Kallestrup for losing the beam on demand.

The principle



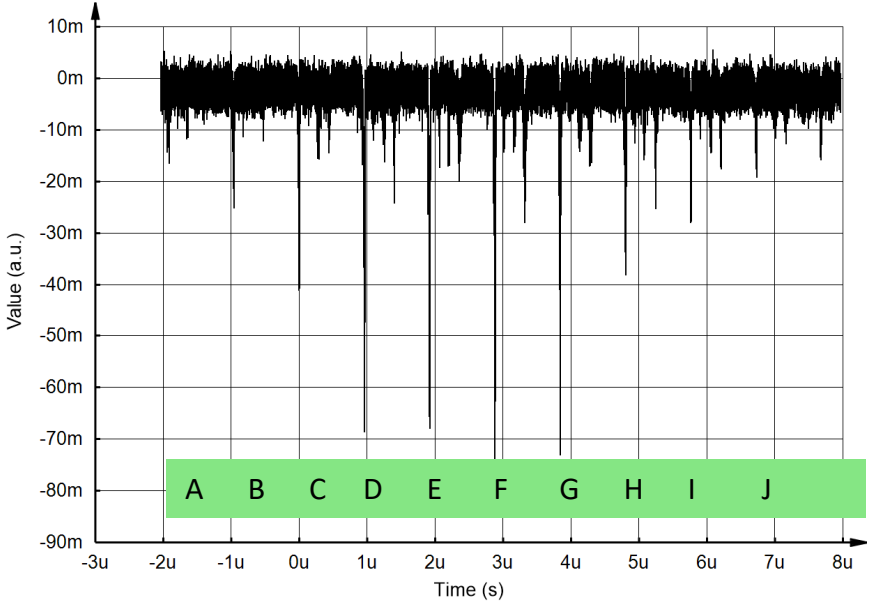




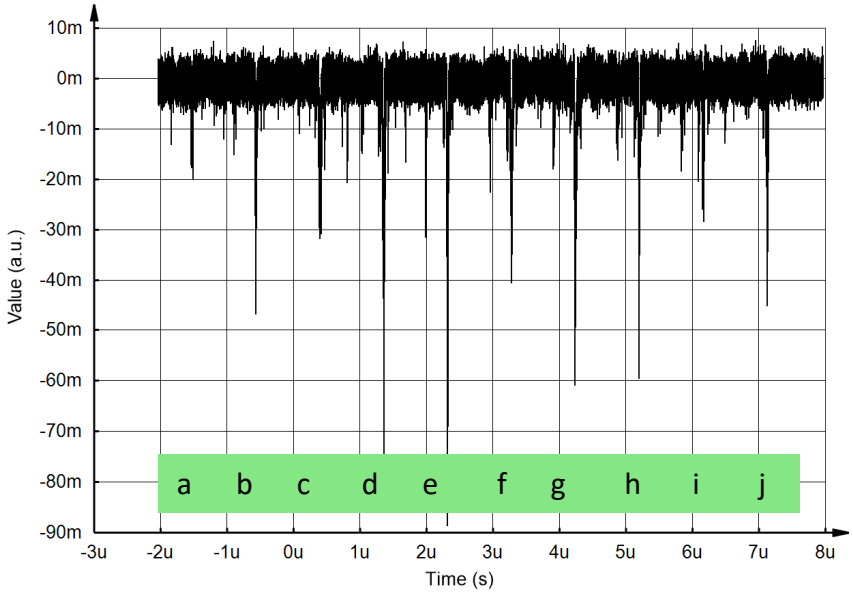


Loss of almost single bunch using RF phase inversion for beam dump

Downstream photon signal from fiber

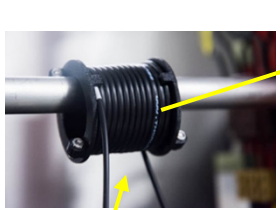


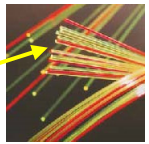
Upstream photon signal from fiber

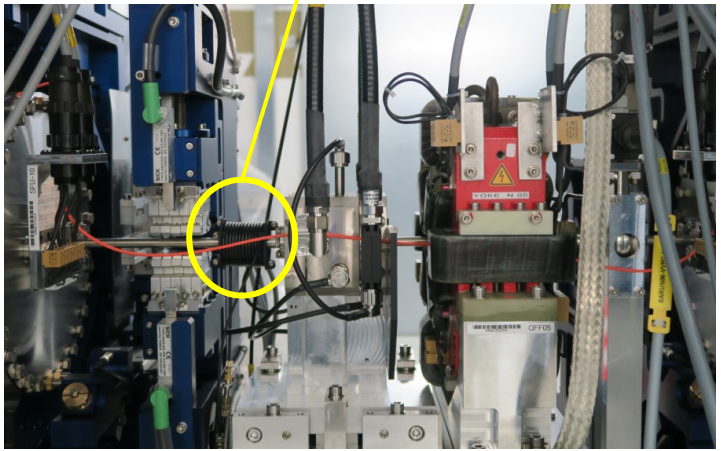


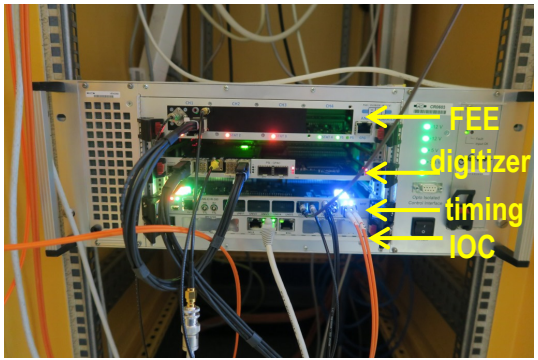
Surprise ! Reproducible single location of loss…but where?

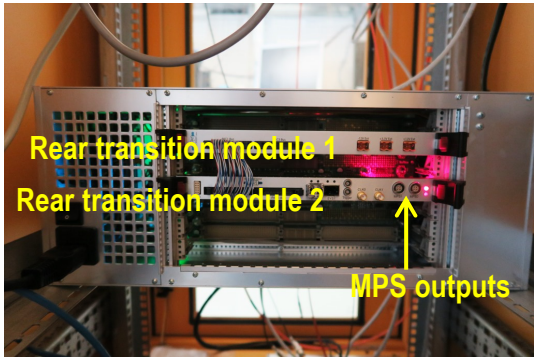
Loss Monitors for the SwissFEL

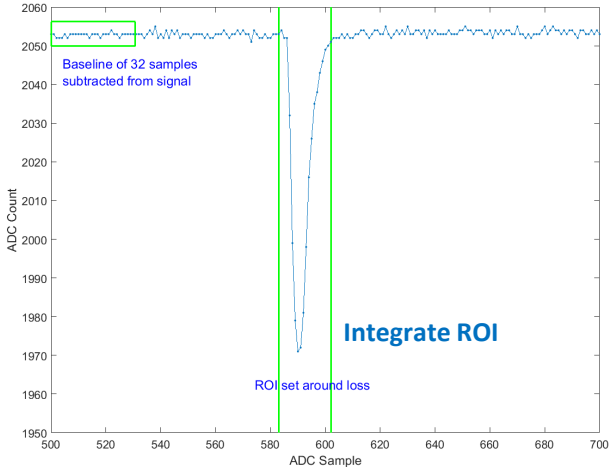


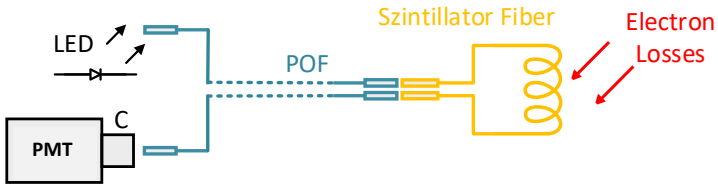










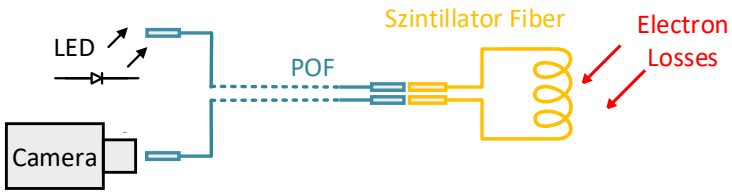


- Connects to machine protection system
- Calculations performed at 100Hz, independent of beam repetition rate

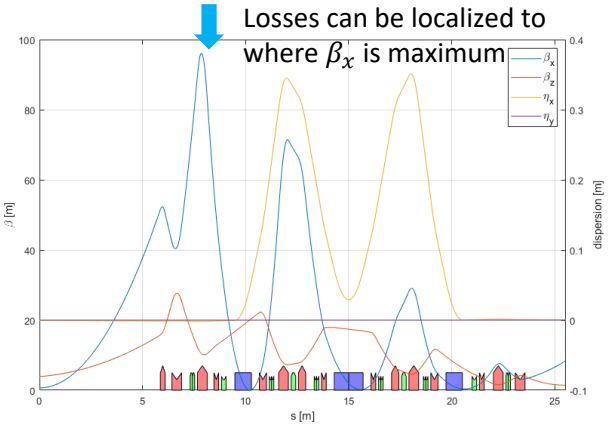
Phys. Rev. Accel. Beams 23, 102804

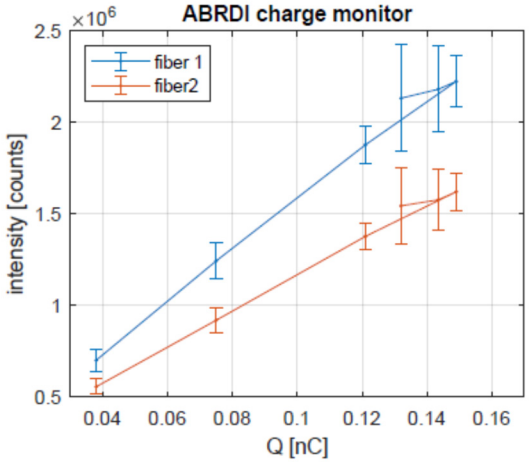
At SLS … with a CMOS camera

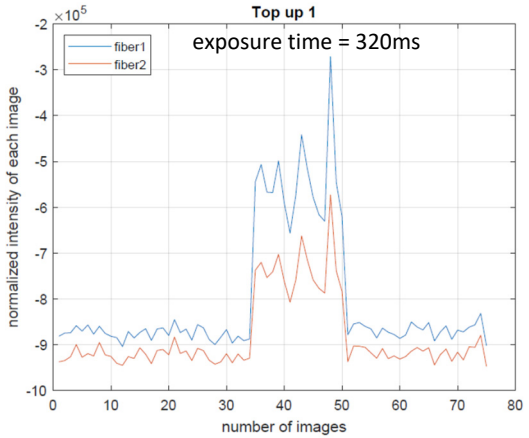
Proof of principle

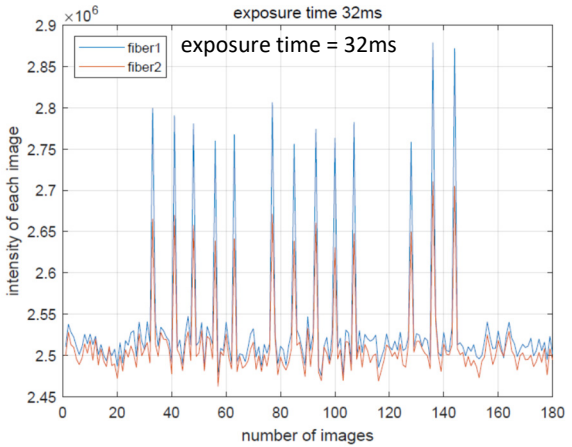


Cannot detect turn-by-turn losses

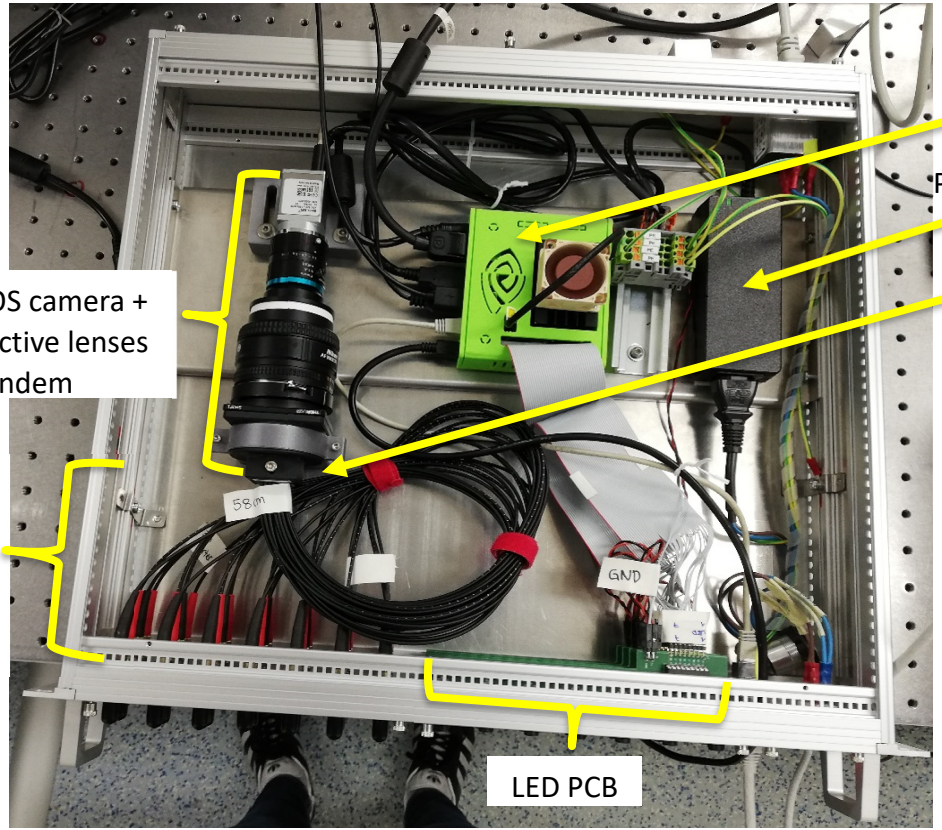


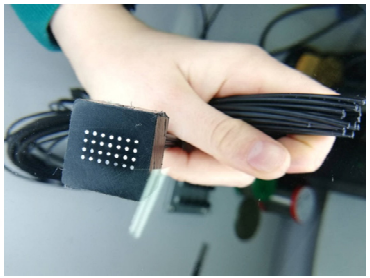






CMOS based Beam Loss Monitor





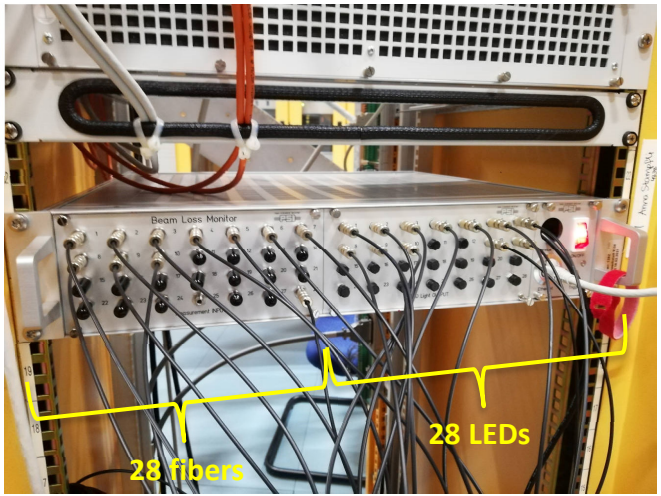
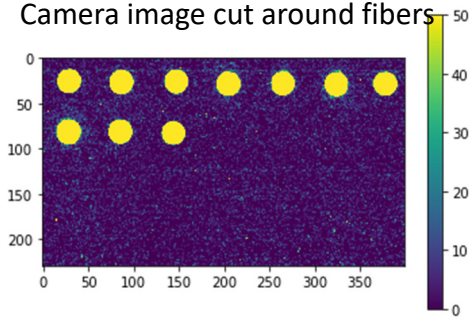


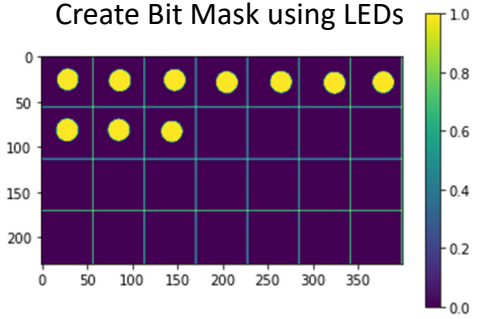
Image Processing Step by Step

Camera image cut around fibers



x

Create Bit Mask using LEDs



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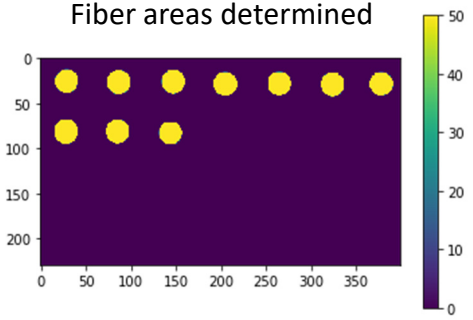
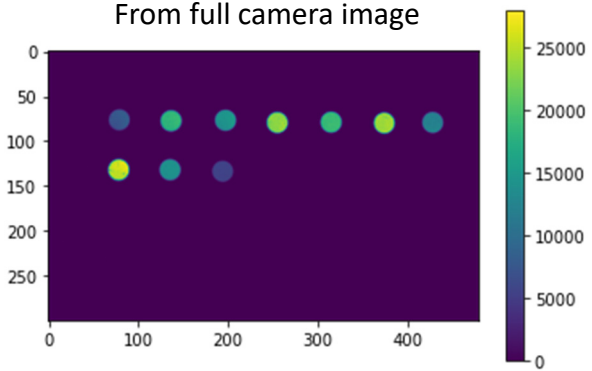
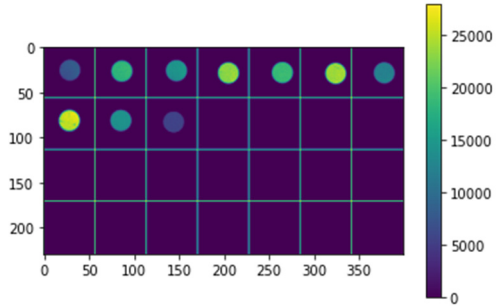
Fiber areas determined



From full camera image

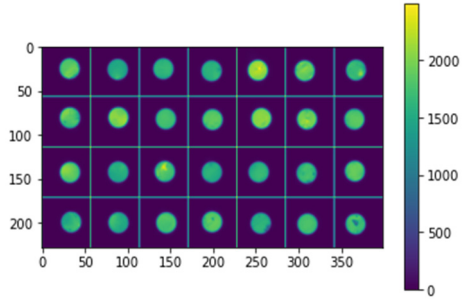


To loss values from each fiber

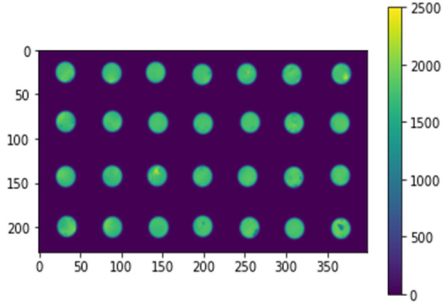


- Image divided into equal ROIs around fibers
- ROIs summed for tracking loss intensity

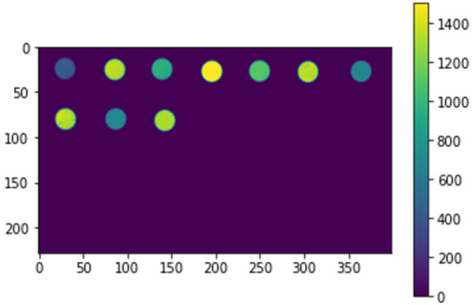
Calibration



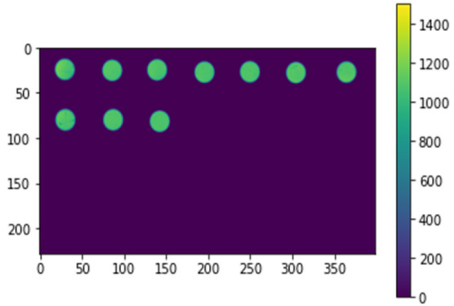
All LEDs ON (with calibration fiber)



LEDs normalized to average LED intensity



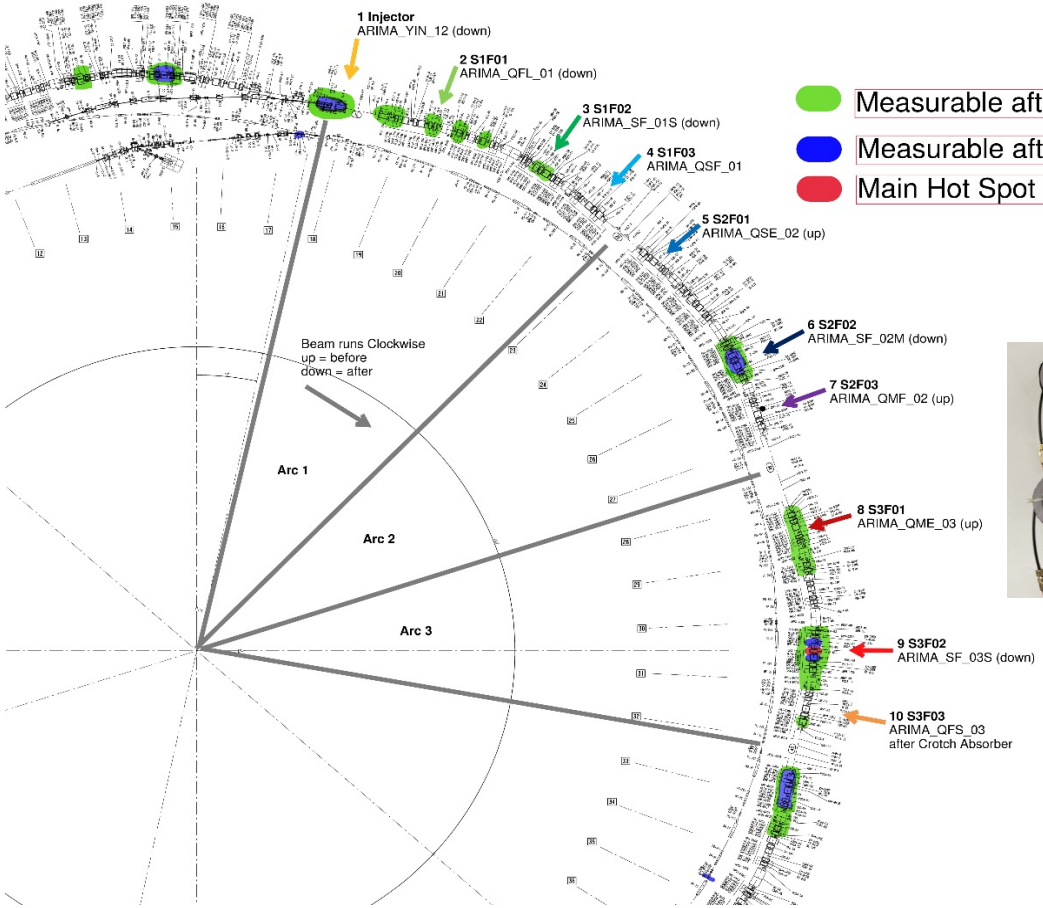
LED through (POF + Scintillator) fiber



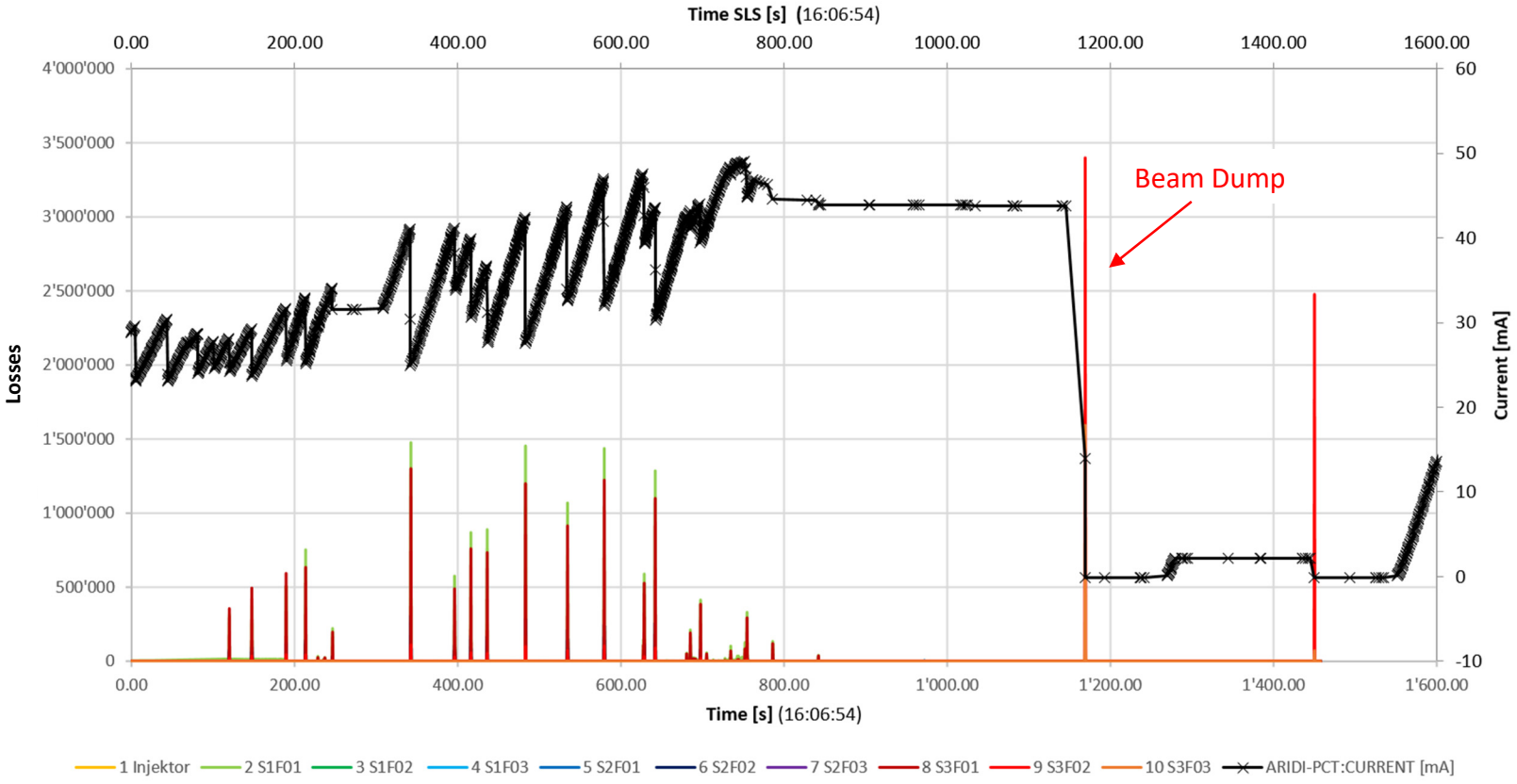
Fiber responses normalized to average fiber intensity

Ready for Beam

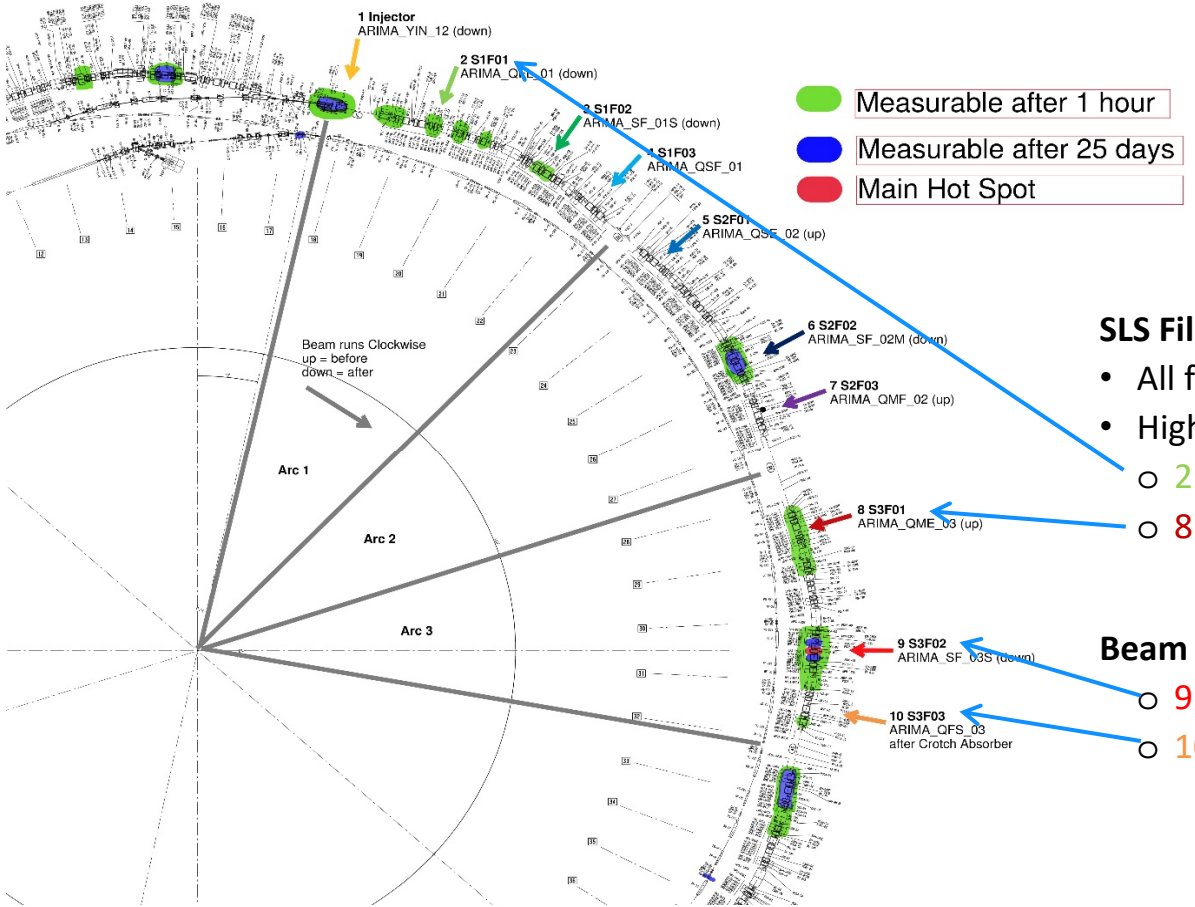
Position of the scintillator coils in SLS



Problems filling the SLS Storage Ring



Hotspot located



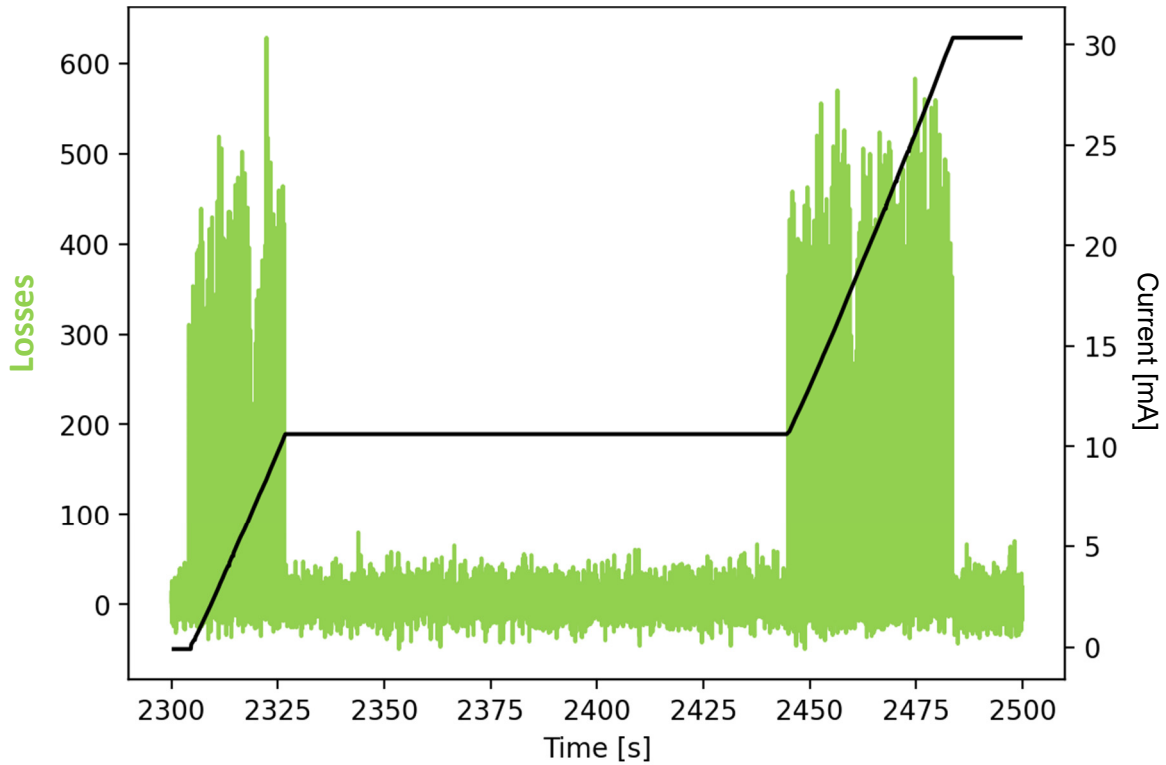
SLS Filling:

- All fibers detect losses
- Highest Losses seen by
  - 2 S1F01
  - 8 S3F01

Beam Dump:

- 9 S3F02 → Main Hot Spot
- 10 S3F03

Injection losses on S1F01: Filling the SLS



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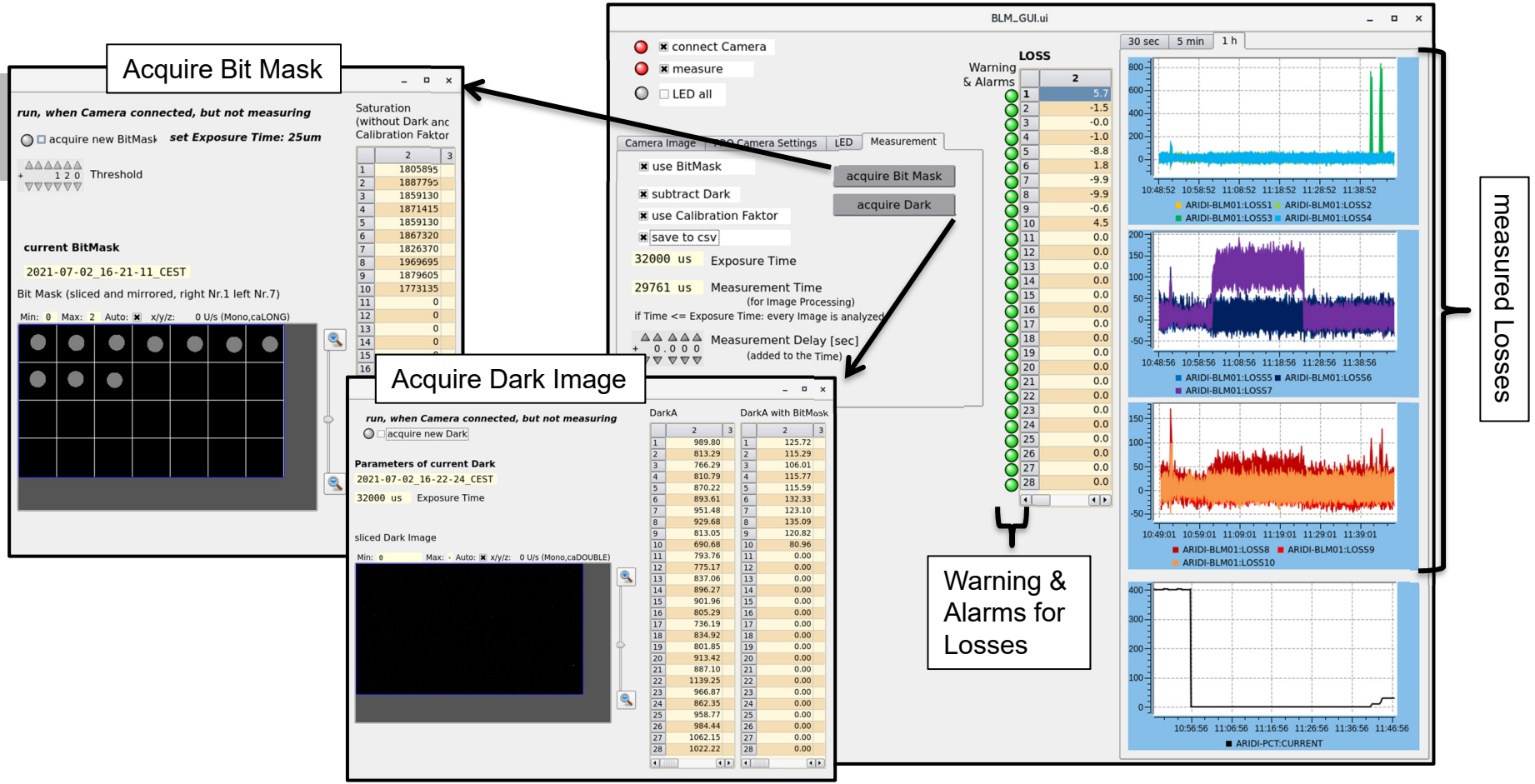
EPICS Integration and GUI



Summary

- CMOS based BLM is good for surveillance of slow losses
- Can also be used in the Booster-to-Ring transfer line
- Not for turn-by-turn loss detection
- System is inexpensive (~3250CHF/box = ~117CHF/channel, fibers included)

➢ To be tested in SLS at the Undulator exit for sensitivity and further improvement

➢ Cover the entire SLS with these loss monitors for further exploration

Wir schaffen Wissen – heute für morgen

Many, many thanks to

- Jonas Kallestrup
- Anik Stark
- Markus Baldinger
- Renata Krempaska
- Michael Boege
- Chris Gough