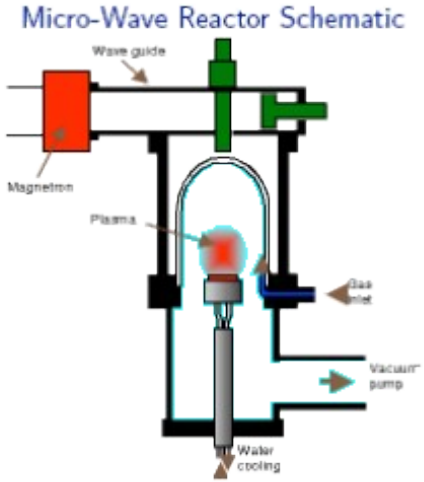
Diamond BLM status update

J. Kral for the BE-BI-BL

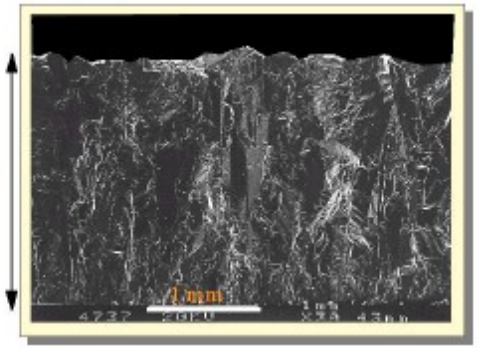
Diamond detectors

- Solid state ionization chamber (~cm^2)
- Linear response to losses
- Ideal for high dose environments
- Poly-crystal or single crystal (pCVD, scCVD)



Surface

Side

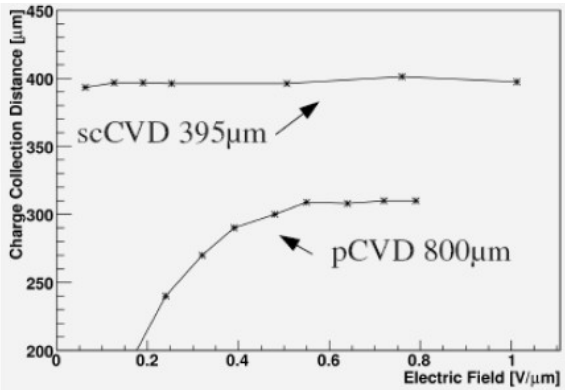


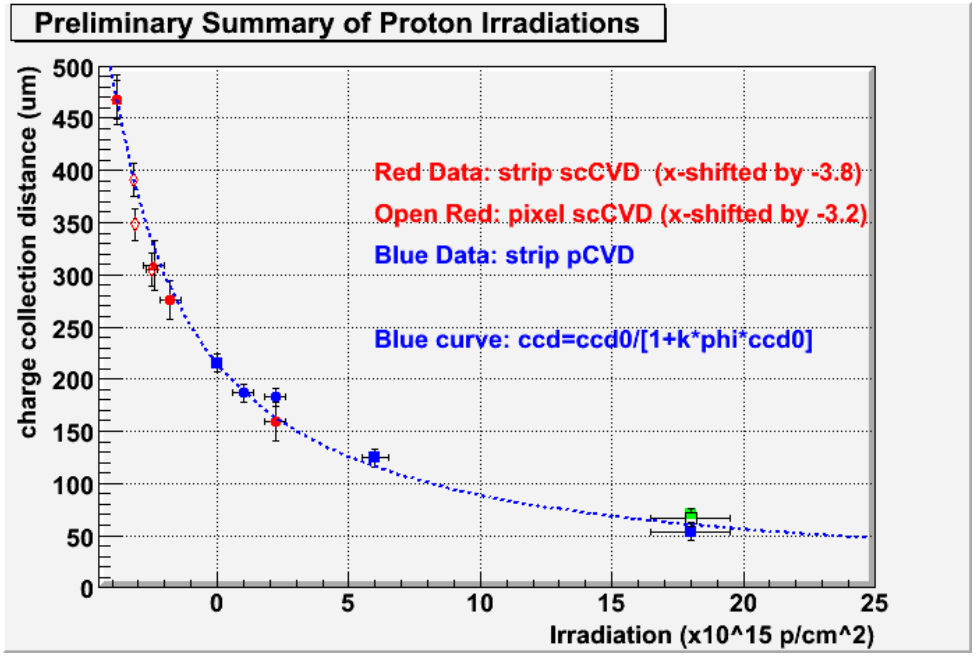
High dynamic range	10^8	
High breakdown field	10^7 [V/cm]	
High charge mobility	e: 1900; h: 2300 [cm^2/Vs]	Fast
Intrinsic resistivity	> 10^{11} [Ω cm]	Low leakage
Dielectric constant	5.7	Low capacitance
Displacement energy	43 [eV/atom]	Radiation hard
Thermal conductivity	~2000 [W/m K]	Good conductor
Energy to create pair	13 [eV]	Lower signal
Average signal	3602 [e_0/μm]	

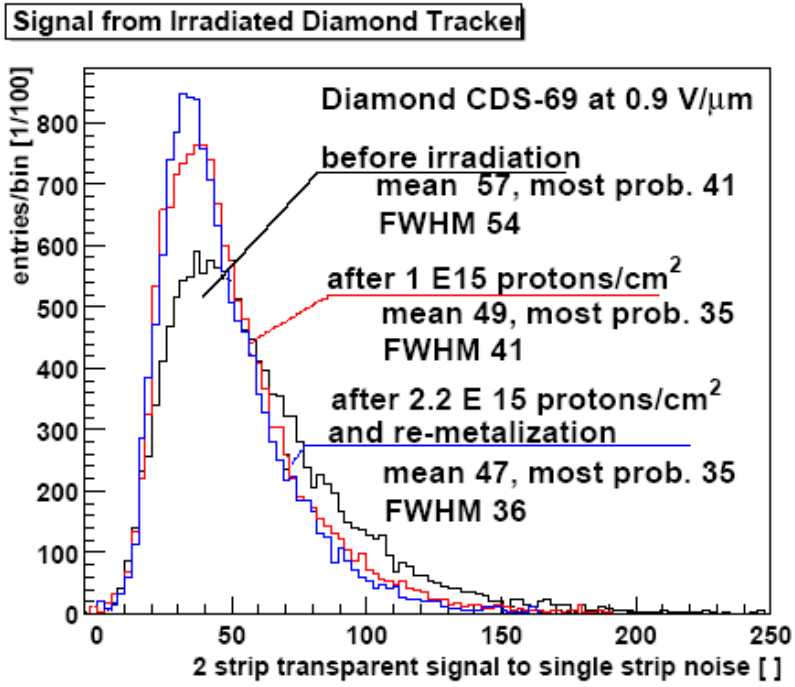
M. Mikuz ICHEP 2012

Radiation damage

- Charge collection distance $CCD = \frac{\langle Q_{col} \rangle}{36 \frac{e_0}{\mu m}} \simeq mfp_e + mfp_h$
- Efficiency $\epsilon = CCD / t$
- Traps at edges of crystals
  - Homogenization with irradiation
- Polarization







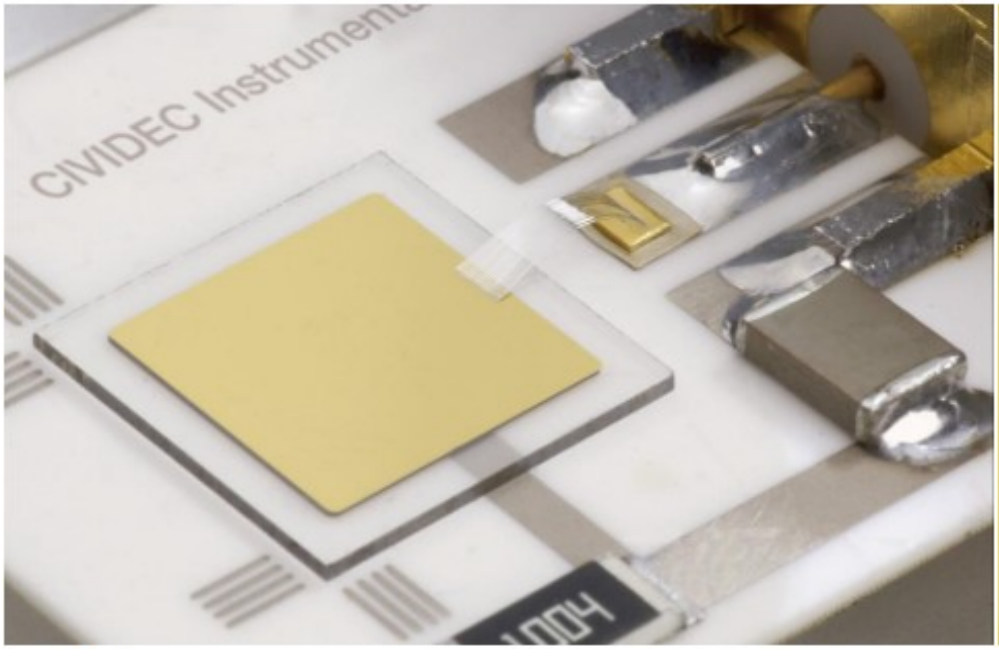
Detectors

- Commercial product

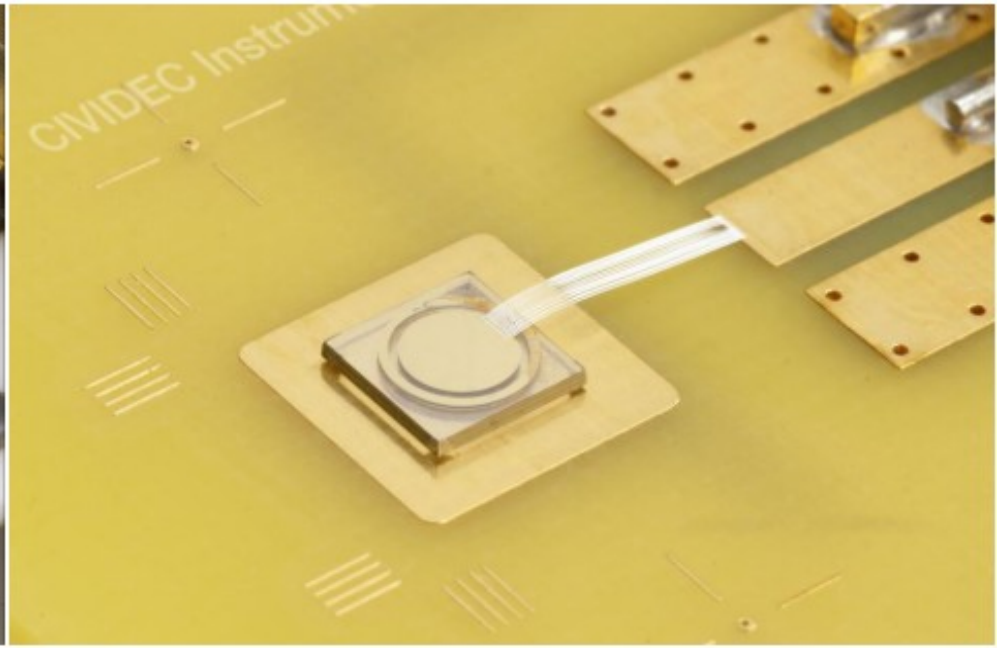
Diamond Substrate:

pCVD = 10 mm x 10 mm
sCVD = 5 mm x 5 mm

Thickness = 500 um



pCVD

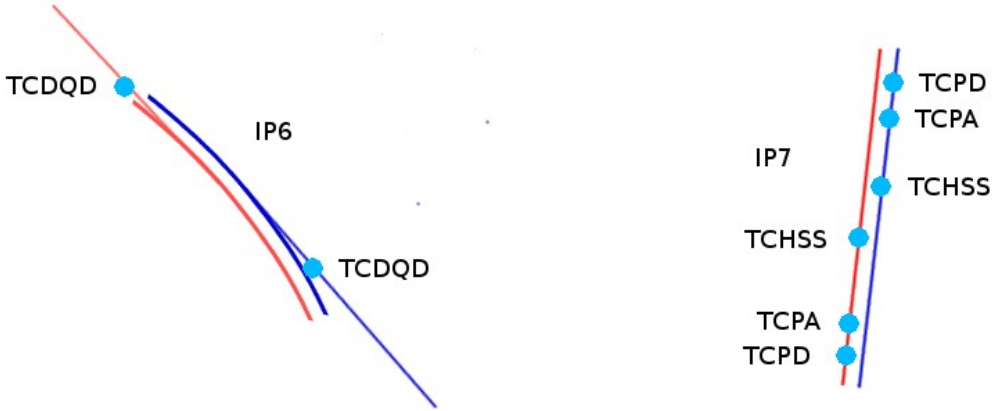


sCVD

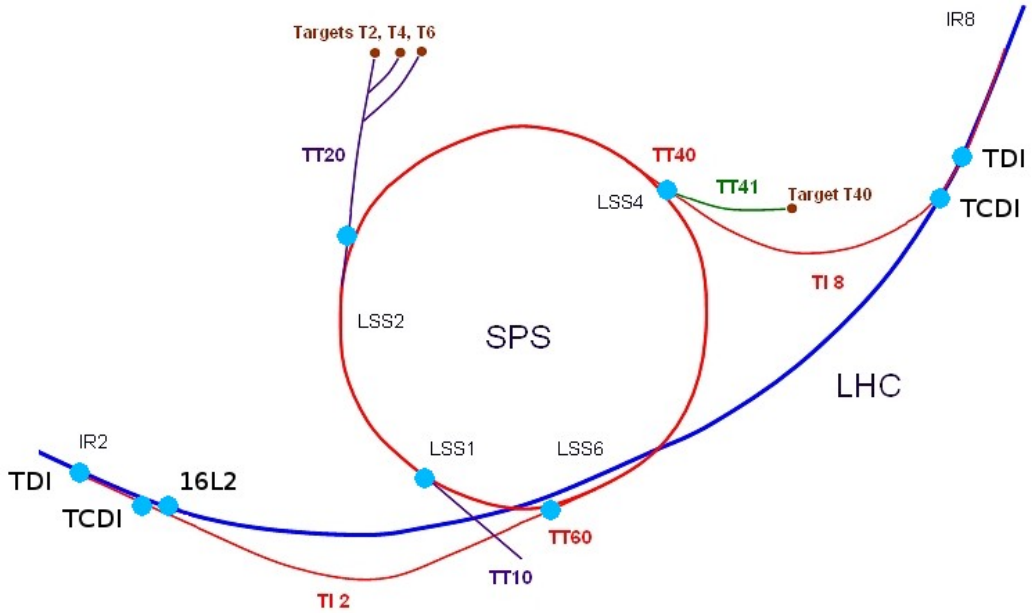
Cividec

LHC and SPS installation

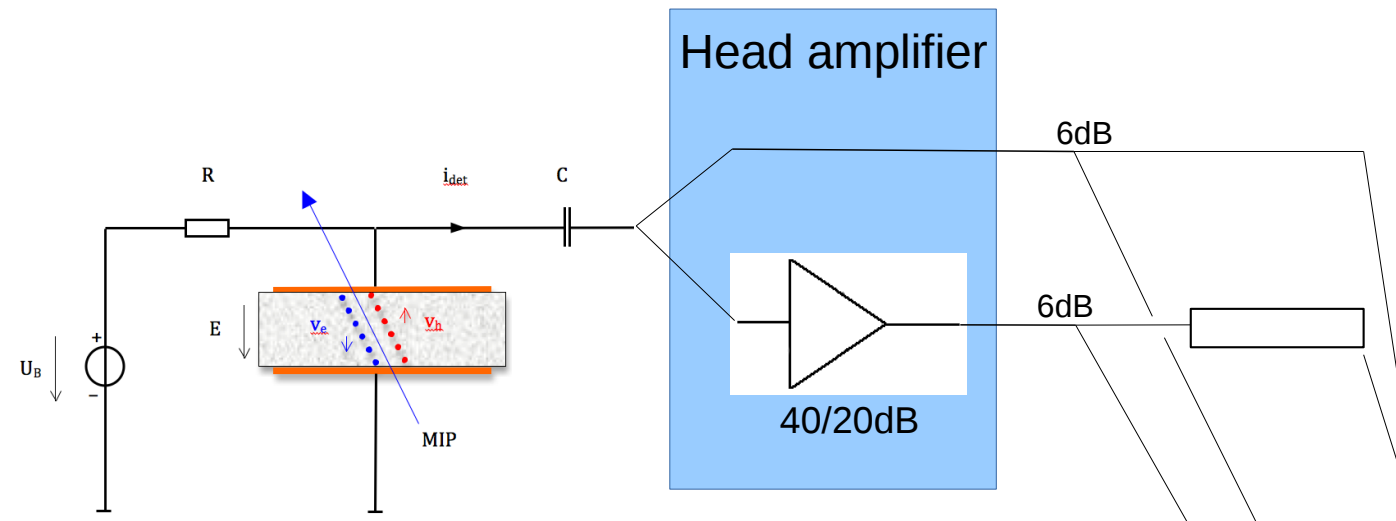
- Next to injection/extraction and primary collimators
- 19 in LHC+SPS
  - 2 cryo BLMs
  - 14 with VFC readout
    - 15 after TS2

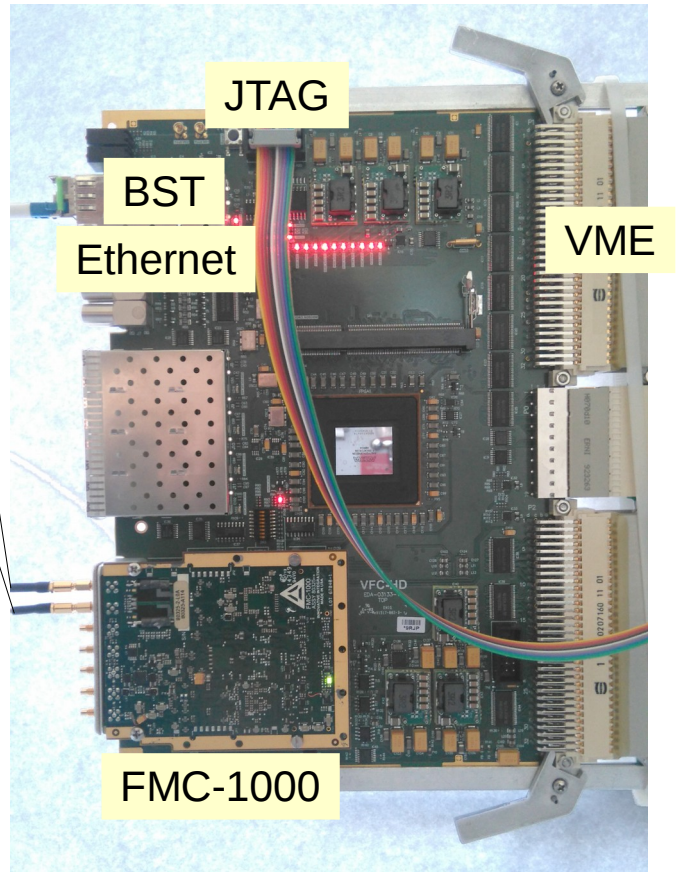


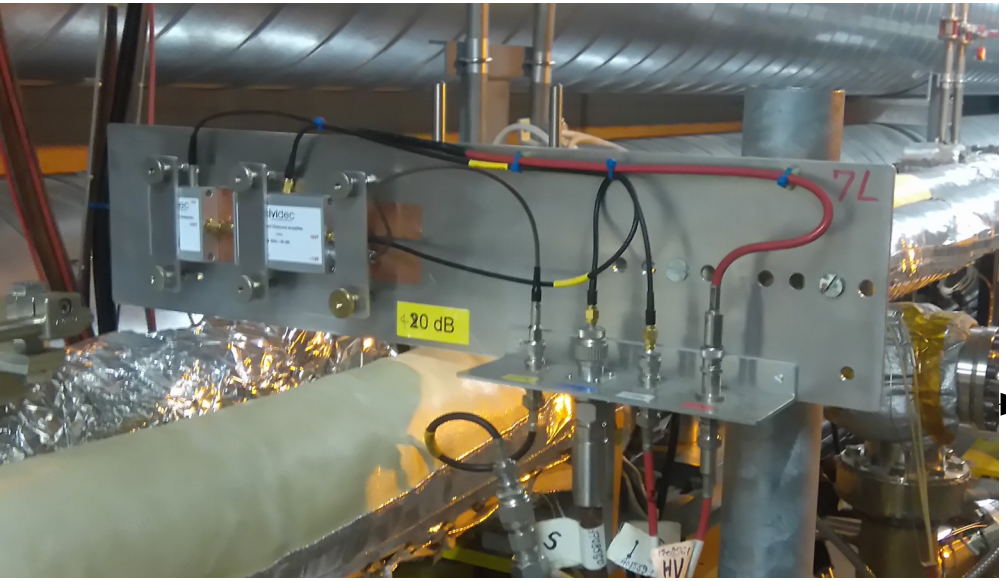
- 17 in PS
- 8 in booster after LS2



Hardware





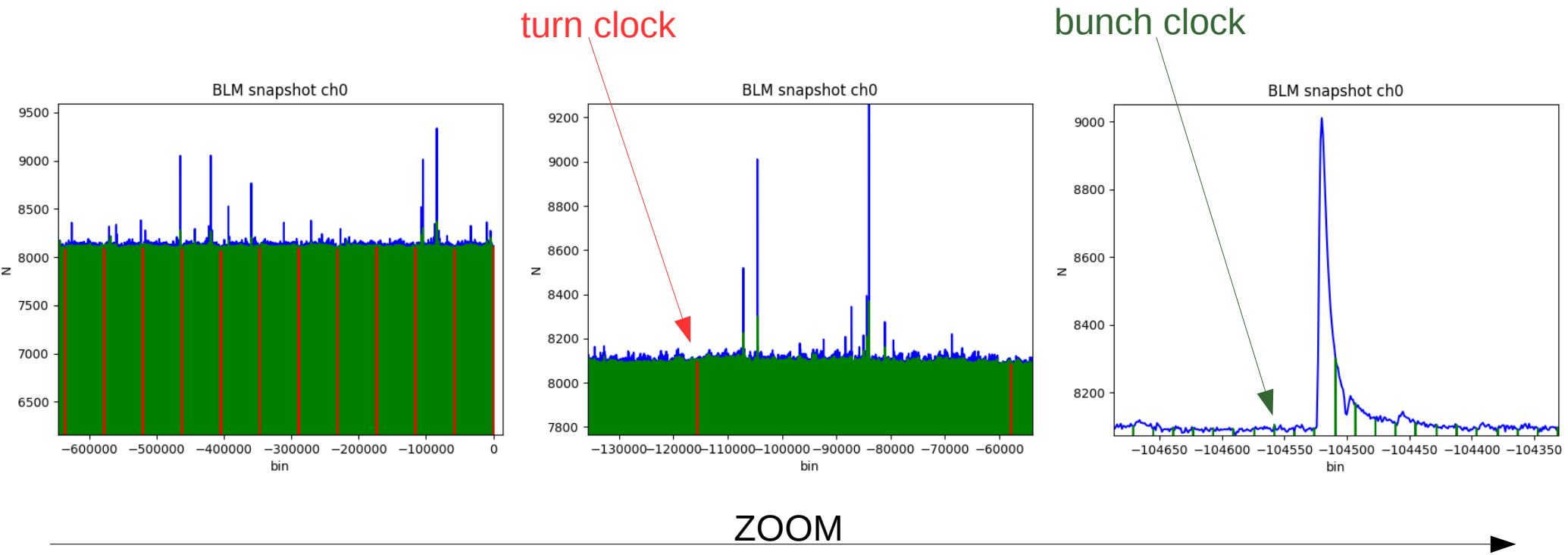


Scope

Signal

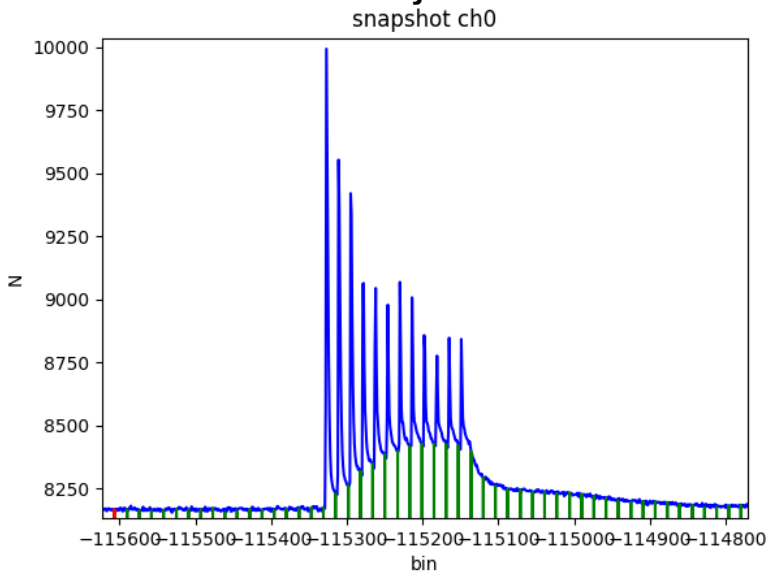
- Main advantage of diamonds: bunch by bunch resolution

Signal example: usual stable beams losses

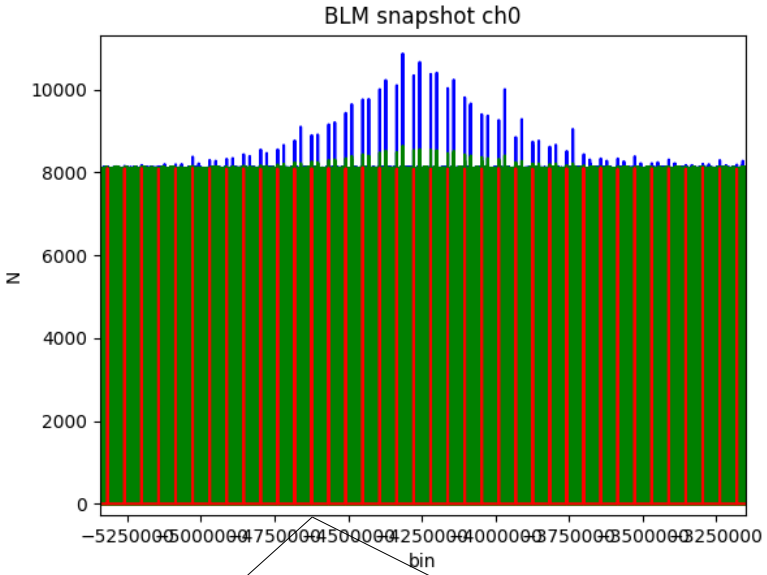


Signal 2

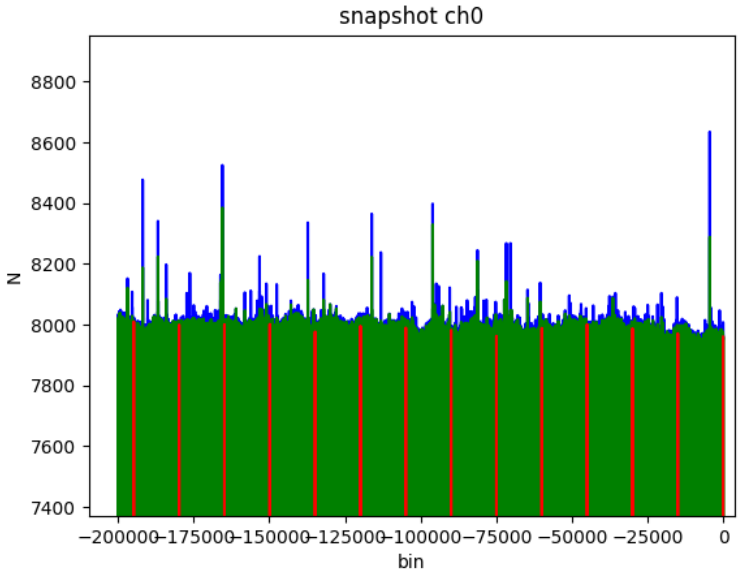
LHC B1 injection TDI

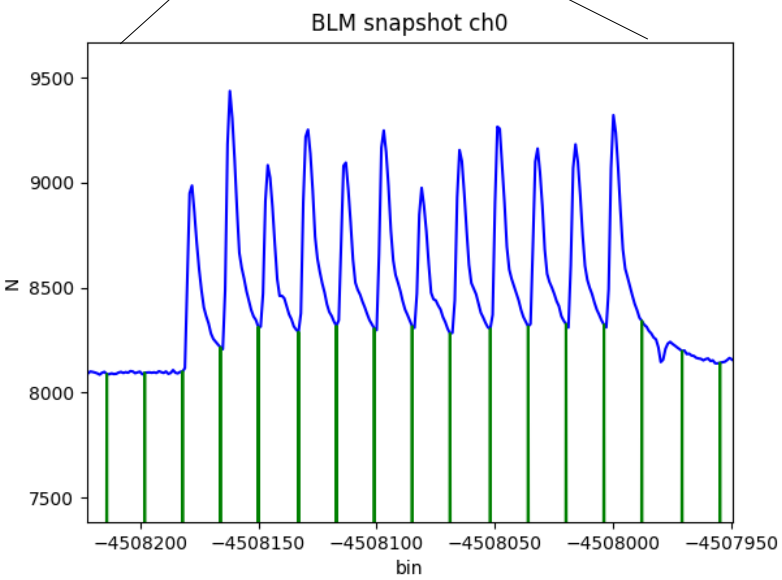


LHC UFO TCPA



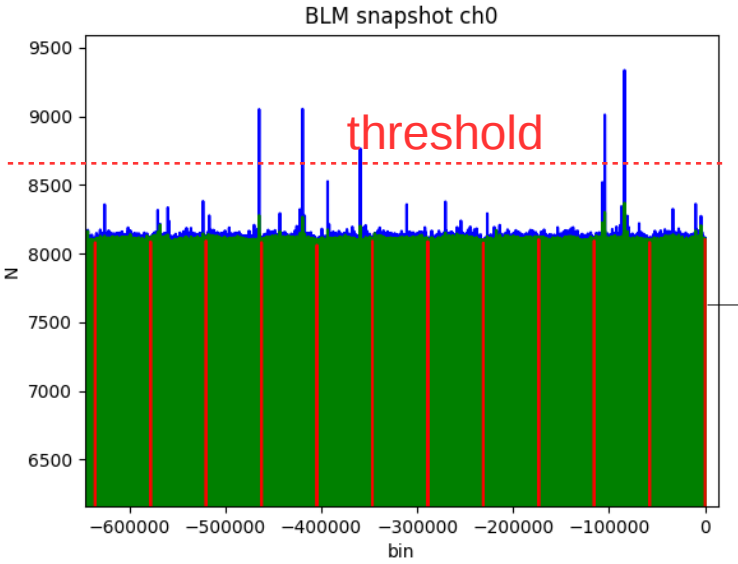
SPS NA extraction

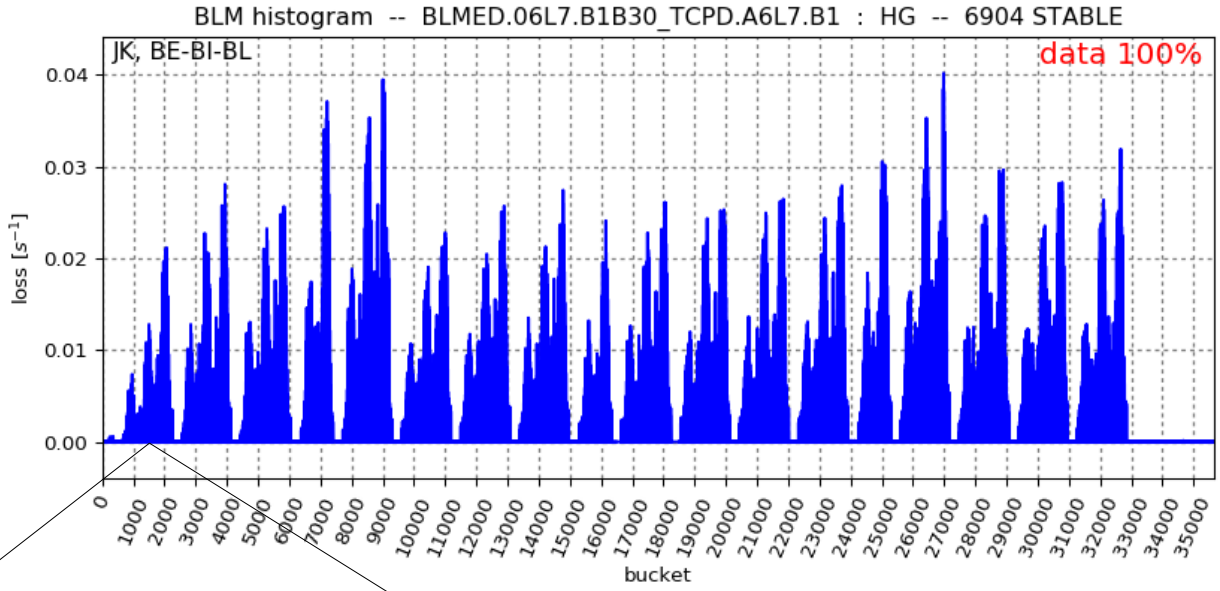


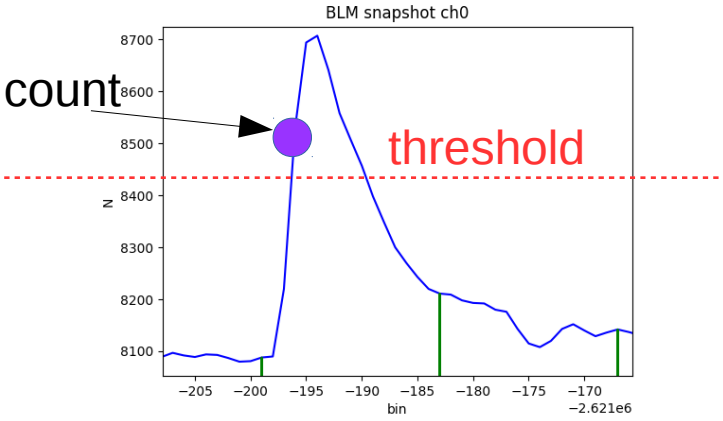


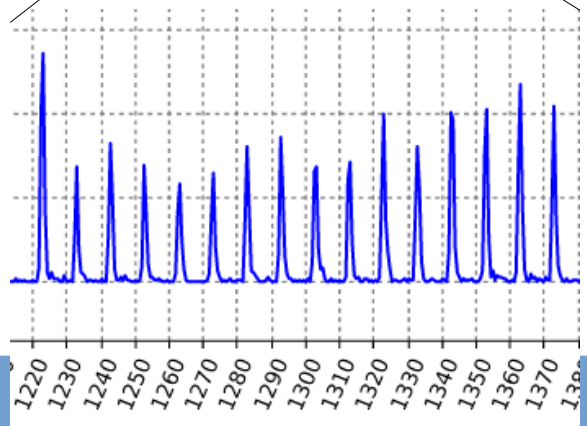
Loss histogram

- Count each cross of a threshold
  - 1s readout (configurable), 16-bit counters



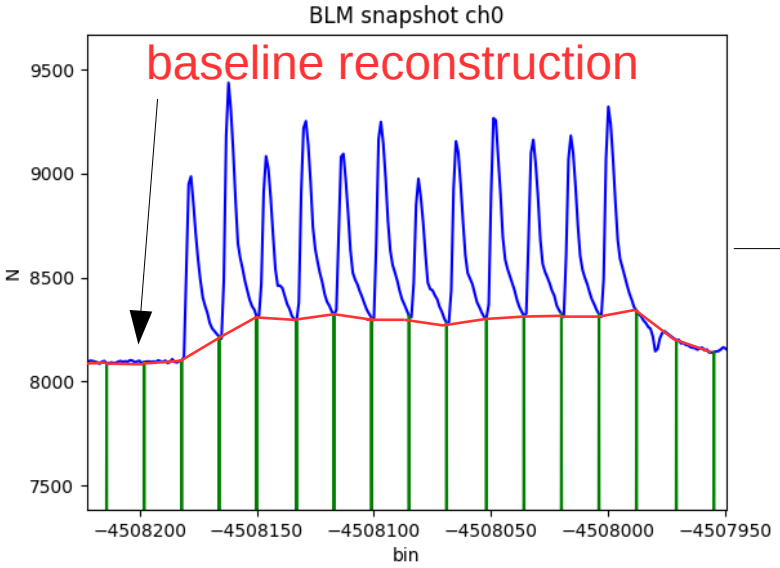


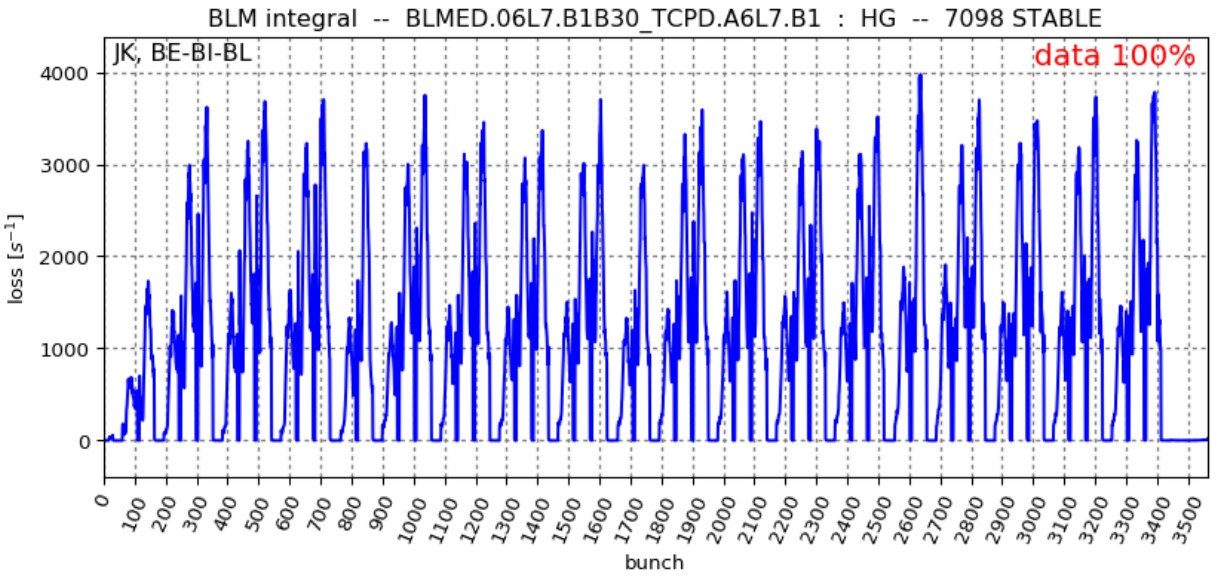




Loss integral

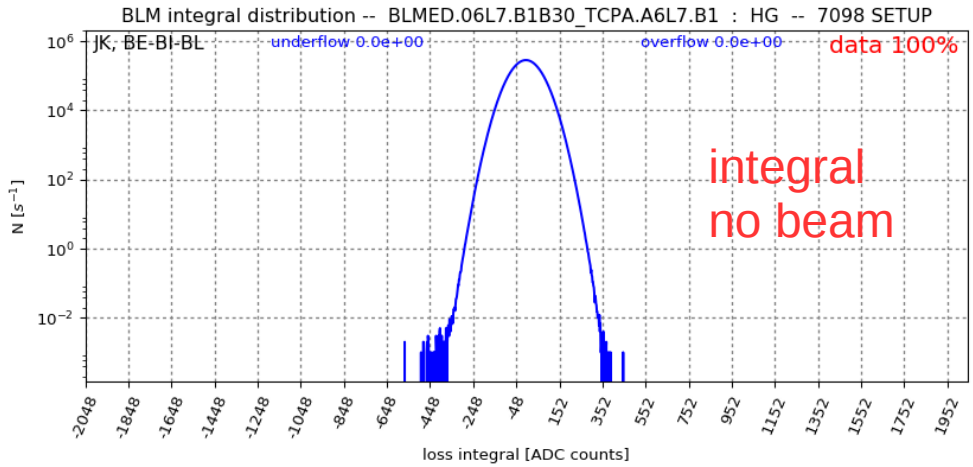
- Integrate loss magnitudes on per bunch bases
  - First iteration of the algorithm
  - 1s readout (configurable)

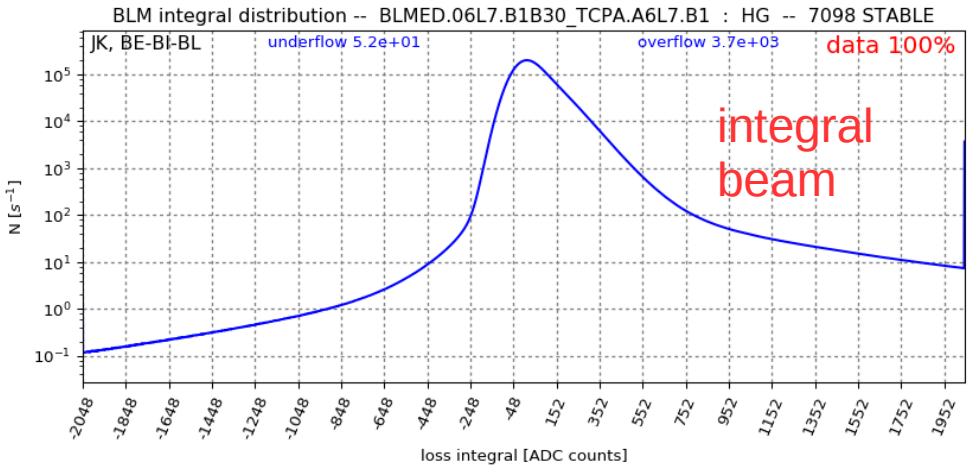


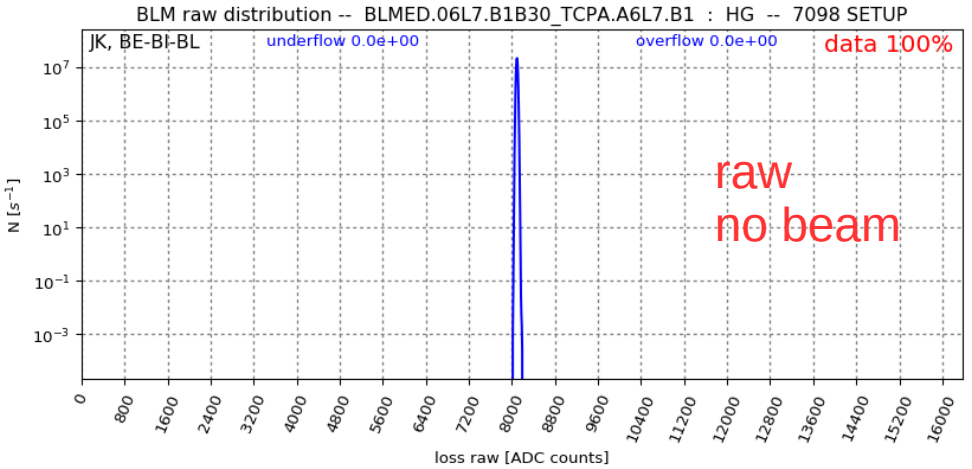


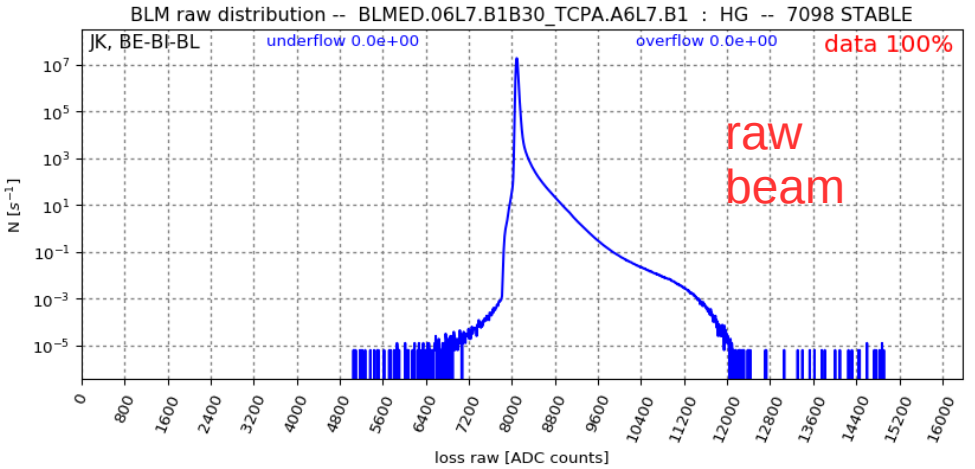
Loss distributions

- Construct distributions of RAW data amplitudes and integrated losses
  - 1s readout (configurable)



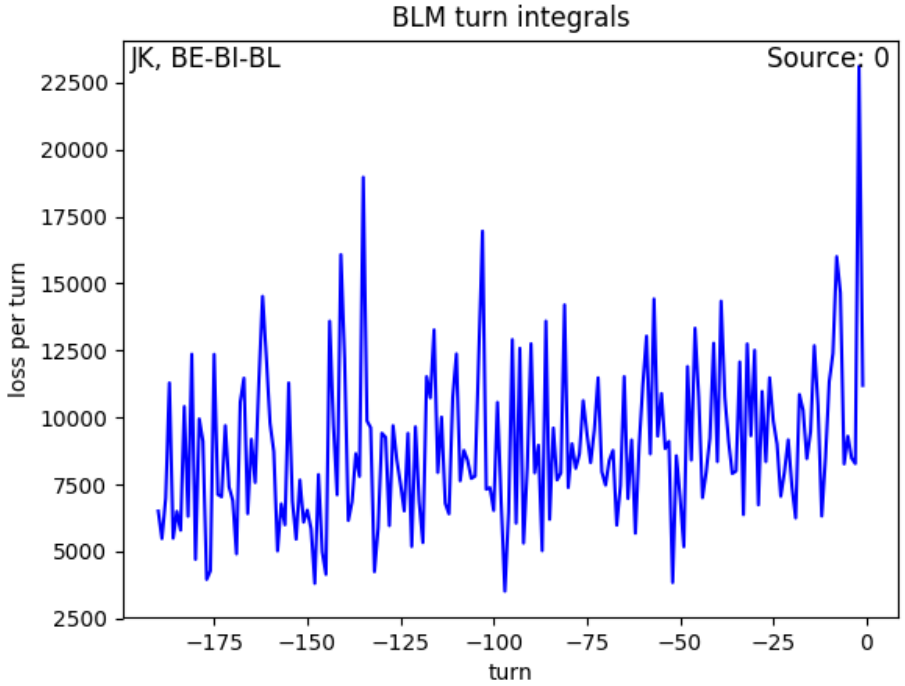




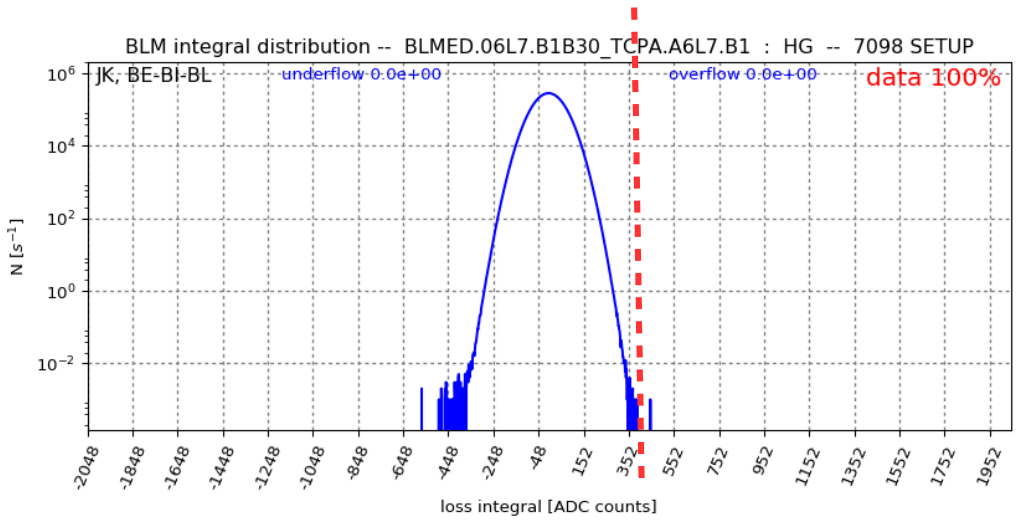


Per turn loss integral

- Construct turn-by-turn loss integral by summing single bunch losses within a turn
  - Noise suppression with a threshold
  - Configurable to selected bunch instead of turn



Noise suppression threshold

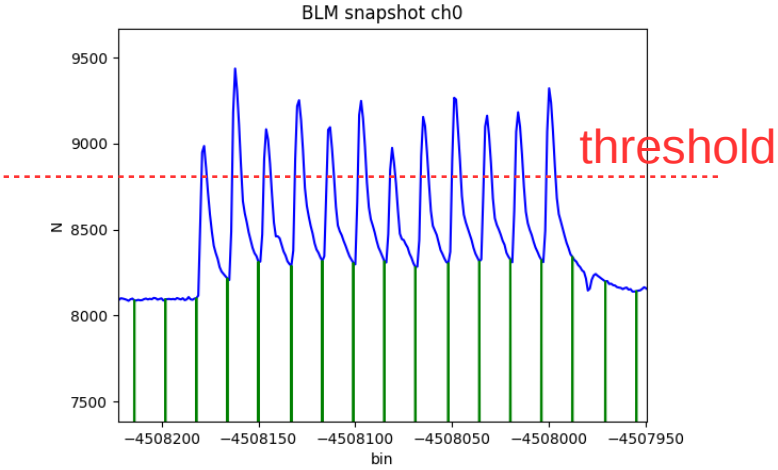


Snapshot

- Capture up to 413 ms (826 ms new VFC batch) of raw ADC data per channel
  - BST and external (CTRp) timing triggers
  - Internal trigger
    - Raw amplitudes
    - Loss integrals bunch/turn
    - Advanced triggering schemes
    - Selectable by BST beam mode
  - Pre or post-trigger
- ~ 3 min readout over VME of the complete buffer
  - Subset readout possible
- Rate reduction (average, summing) by factors up to 2^5

UFO hunting

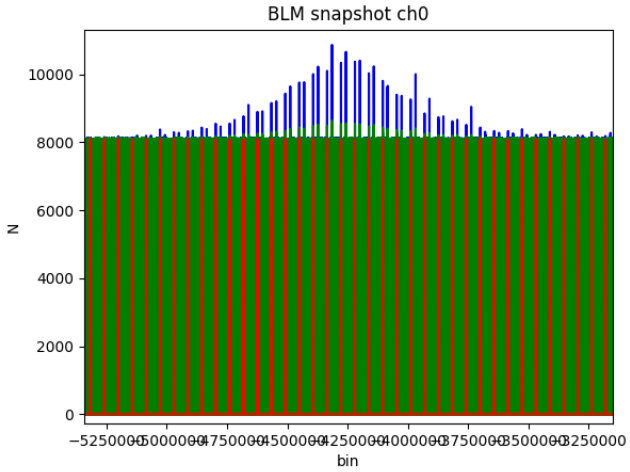
- Trigger on UFO



→ Detect > N raw data peaks above threshold withing turn

- Apply 5 ms window requiring activity in the window only, not longer, to limit triggers on ramp, adjust, squeeze

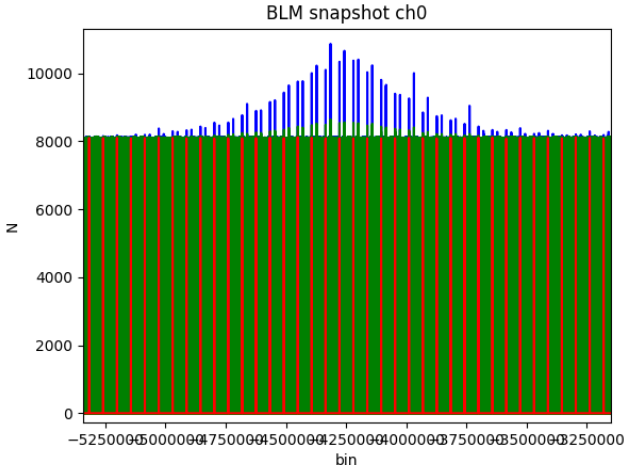
Björn Lindstrom



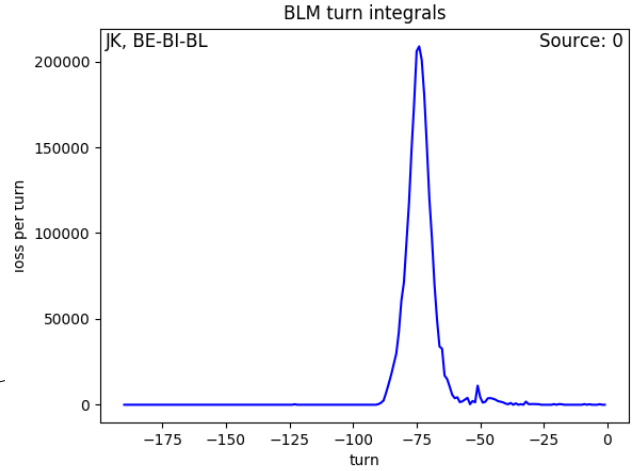
→ Detect > N integrals above threshold within turn

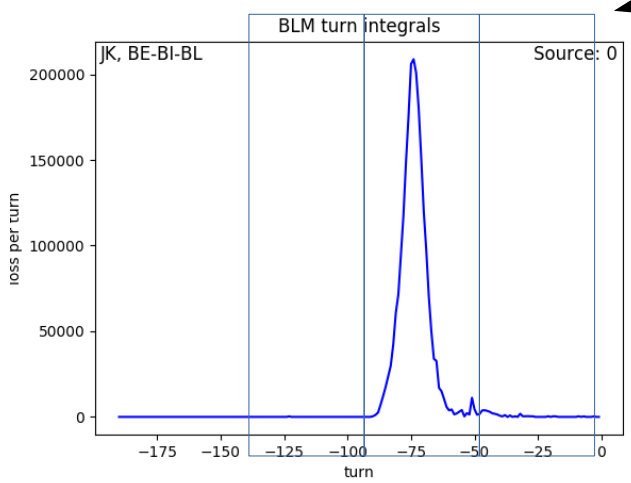
Advanced UFO hunting

- Trigger better
- Use the macroscopic UFO loss Gaussian-like shape



Compute per turn loss integral





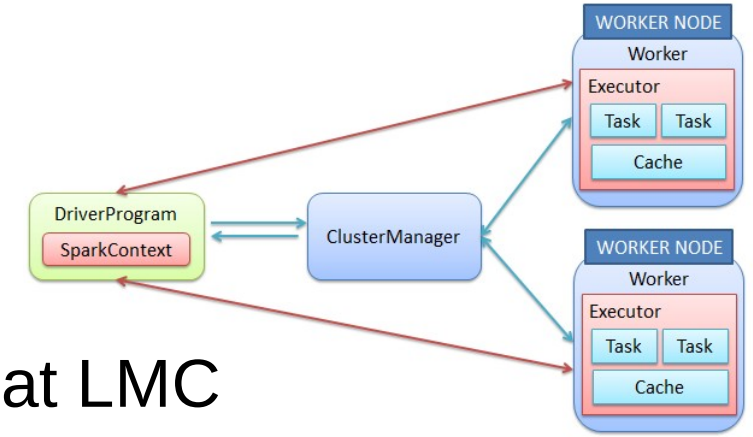
- Take 3 consecutive 5 ms blocks and check for total sum of the middle one being high while the two adjacent are low
- STABLE per turn losses differ by order of magnitude from fill to fill, working on relative (adaptive) threshold

Archival

- LHC & SPS Injections/extractions to post-mortem
- LHC ring (P7) data archive to NXCALS
  - Running private ingestion code
    - Python @ crate → TCP/IP stream → private Java ingestion server with CMW layer → NXCALS
    - Very useful for early development stages
  - We have knowledge of the NXCALS code/machinery and working example in BI now
  - Switching to FESA soon
    - NXCALS subscribes to property, saves on publication
    - Private ingestion designed FESA compatible → seamless switch

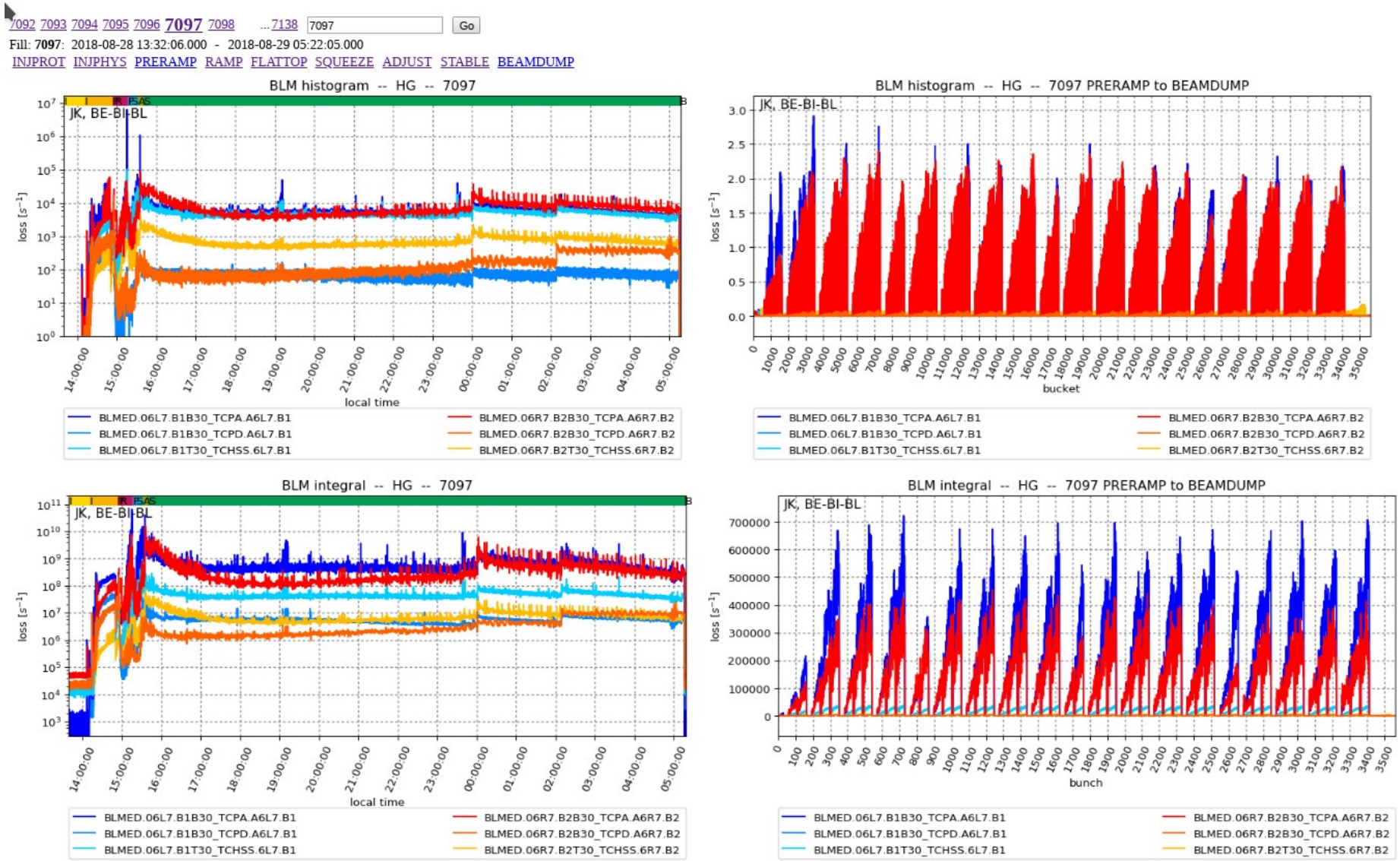
Extraction from NXCALS

- NXCALS saves data into compressed daily files per CMW property
  - **Large** file if running many devices or archiving big data
  - NXCALS loads the file to a node, uncompresses, runs user code (takes time)
- Run data aggregation and pre-analysis on the hadoop cluster to avoid large data transfers and memory limits
  - Submit Spark Yarn client task from local PC to cluster, wait completion, pull results
- Running Java
  - Python for Spark does support only limited user defined functions
- Diamonds given as good example at LMC



Monitoring

- http://dblm.web.cern.ch



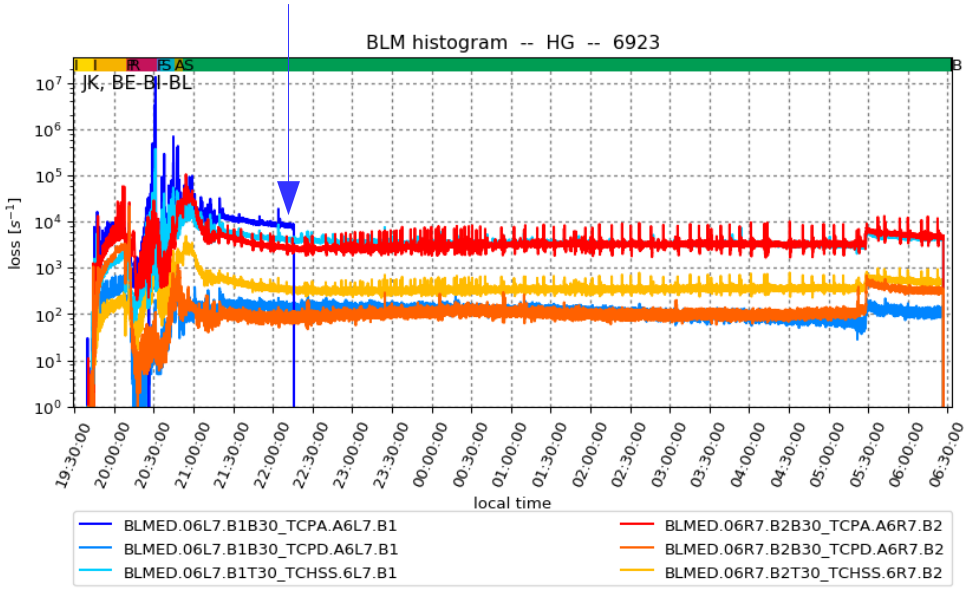
Diamond BLM Wiki

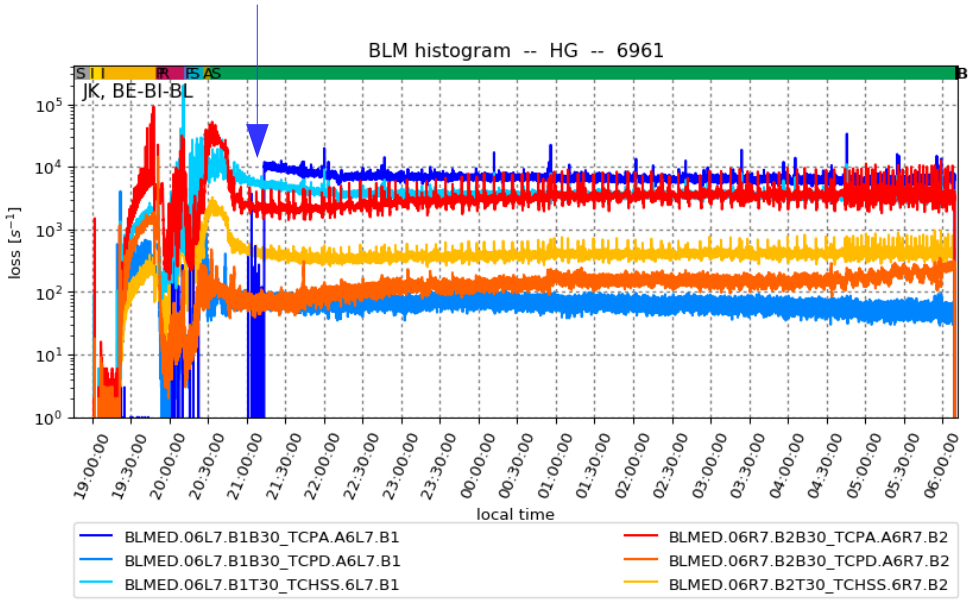
- Wiki for analysts
  - https://wikis.cern.ch/display/BEBI/BLM+Diamonds+Data+Analysis

- Wiki for NXCALS data injection and extraction
  - https://wikis.cern.ch/display/BEBI/NXCALS+How+to

Problems

- TCPA diamond died twice out of which reanimated once





- Various channels dead, noisy or showing double peaks (reflections?)
- Loop currents in setups with amplified and non-amplified channel connected
- Investigation ongoing

What is next

- TS2
  - Swap 16L2 diamond to VFC readout
  - Install VFCs + FMC-1000 at P2,8,6 if available
  - Improve shape based UFO trigger
  - FESA on the way (Manuel)
  - Display for the operators on the way (Belen)
- Before LS2
  - In depth signal checks for all channels
    - Note details problems, gather enough raw data
    - Fix after shutdown
- Calibration???

NXCALS for BI

- NXCALS team might profit from input on what we will need the system to digest and deliver
- For example:
  - FESA properties with thousands of devices. Such daily file might easily run out of node memory during decompression
    - Different sorting mechanism?
      - Can also provide better use of the cluster parallelism
      - Will we access short (hours) or long (days) time frames?
  - Data from yesterday are no available while the daily file compression is running
    - In contact with Jakub Wozniak for this
  - pyspark does not support complex user defined functions

Conclusion

- Installed diamonds are being read out by VFCs and data is being archived
- VFC readout offers
  - Better resolution than ROSY
  - Flexibility
  - Provides more measurements
- Diamond functionality already useful for beam studies
- NXCALS knowledge obtained