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Jiri Kral

Diamond Beam Loss Monitors at CERN Accelerators

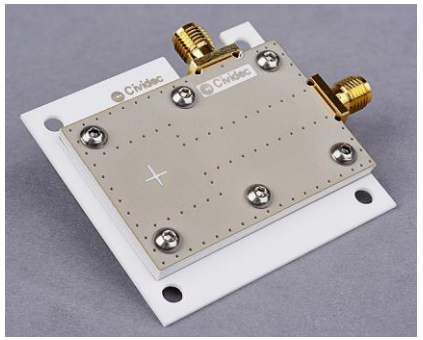
for

CERN, BE-BI-BL
ČVUT, FJFI

Hardware

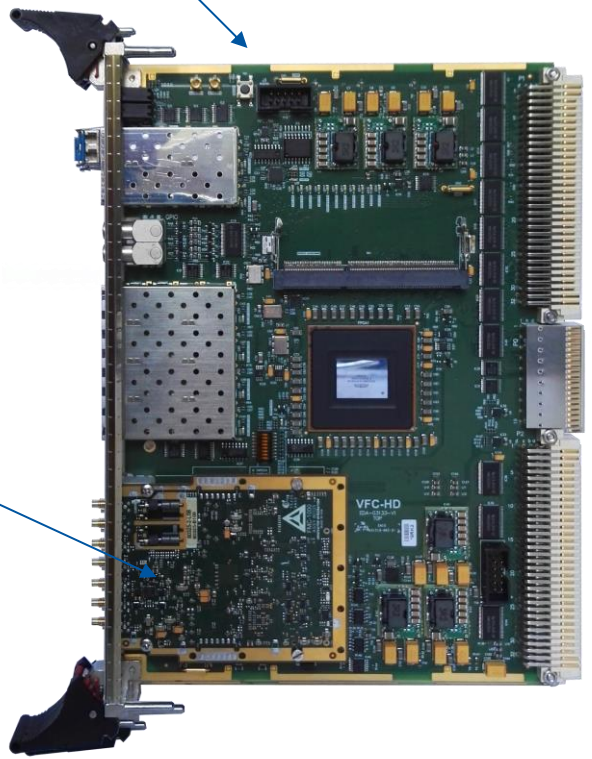
- Cividec pCVD
  - 500 µm thickness, 10x10 mm surface
  - 1 V / µm
  - One installation with 200 µm thickness

- Cividec sCVD
  - Cryogenic Beam Loss Monitors
  - 500 µm thickness, 4.5x4.5 mm surface
  - Ceramic PCB, isolated ground



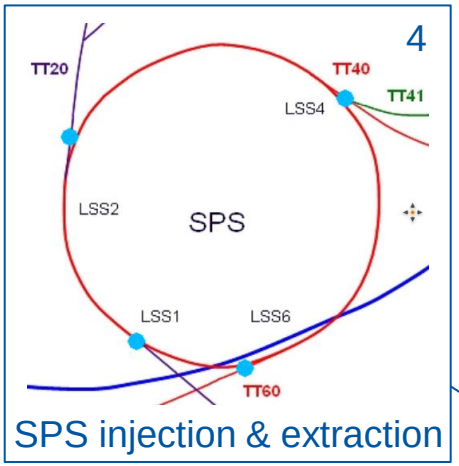
Readout

- In-house standard VME carrier (VFC-HD)
  - Arria V FPGA
  - Machine timing
  - 8 Gb DDR3
- Innovative FMC-1000
  - 2 channel 14-bit ADC
  - Operated at 650 Msps

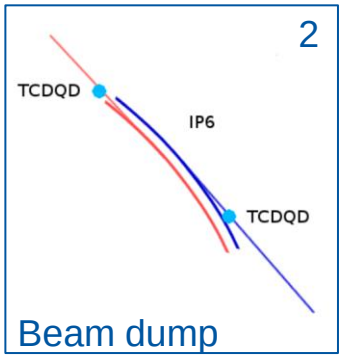


Installations

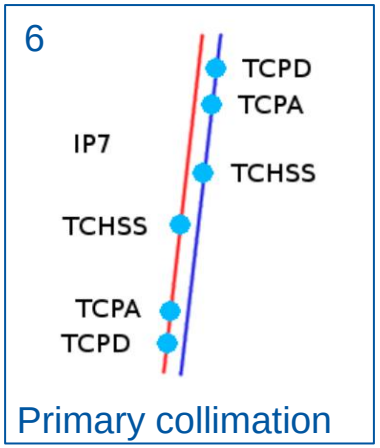
Observing collimators



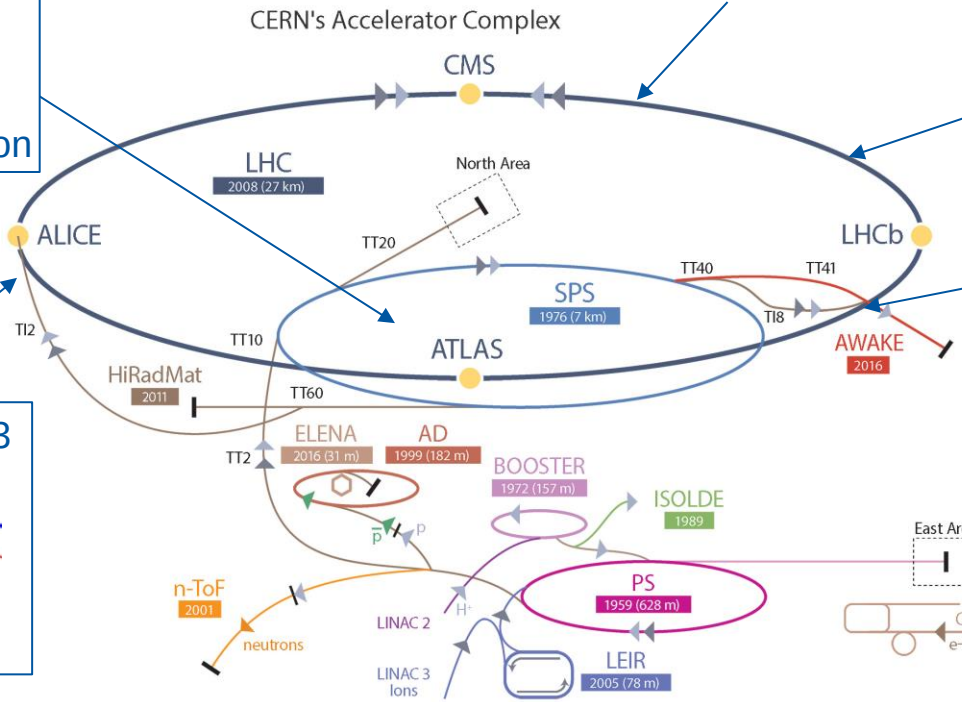
SPS injection & extraction

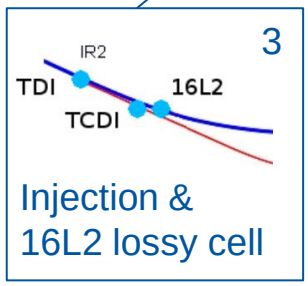


Beam dump

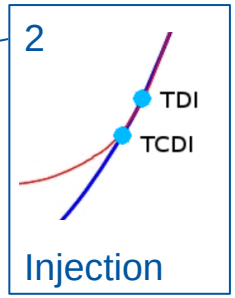


Primary collimation





Injection & 16L2 lossy cell

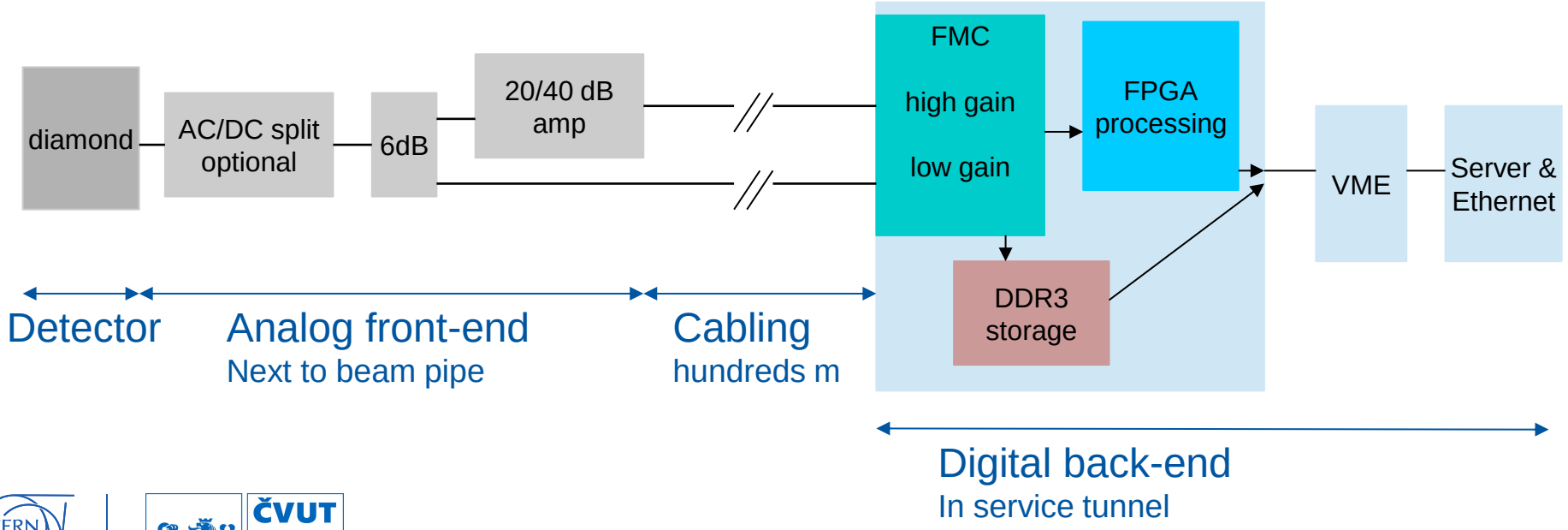


Injection

p (proton) ion neutrons p̄ (antiproton) electron proton/antiproton conversion

Chain

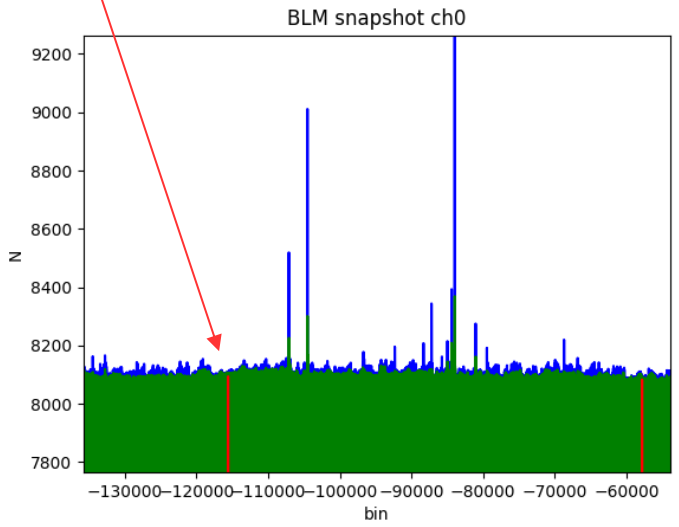
Observed collimator



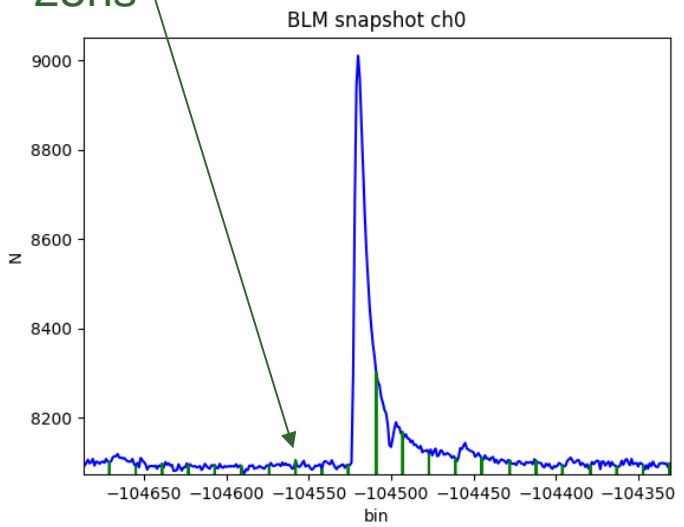
Signal

- Main purpose is to deliver on-line per-bunch (25 ns) beam loss data at points with large losses (collimators)

turn clock

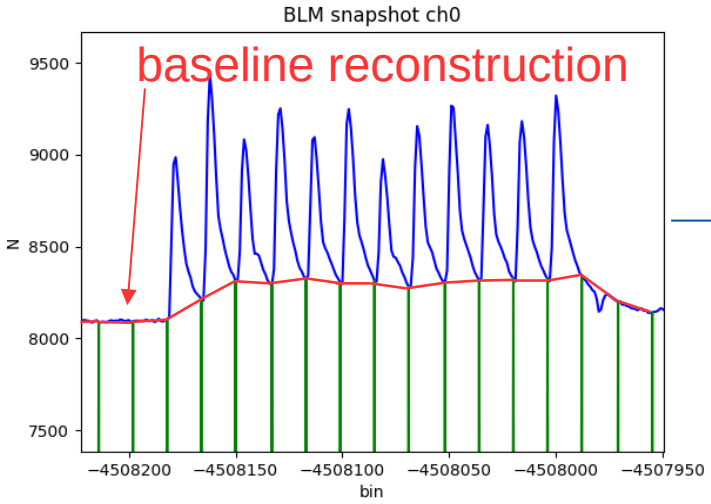


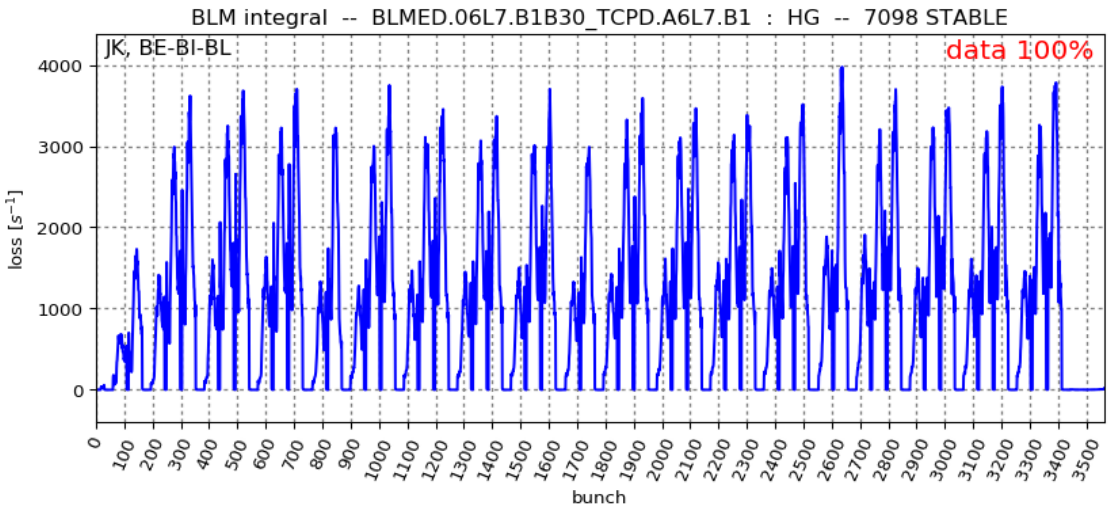
bunch clock
~25ns



Measurements - integral

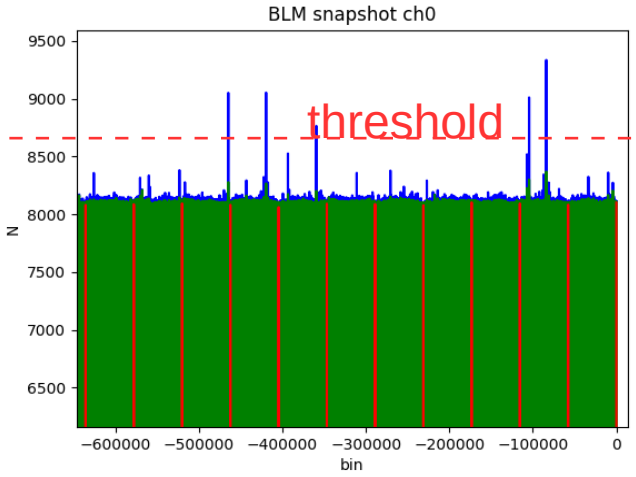
- Loss integration
  - 1 s refresh rate, per-bunch (25ns) array
  - Linear per-bunch baseline interpolation

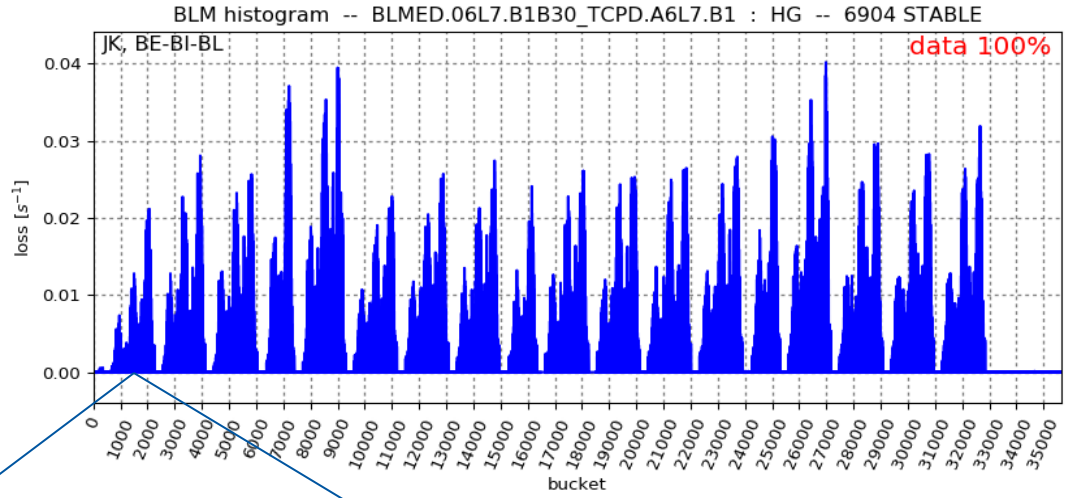


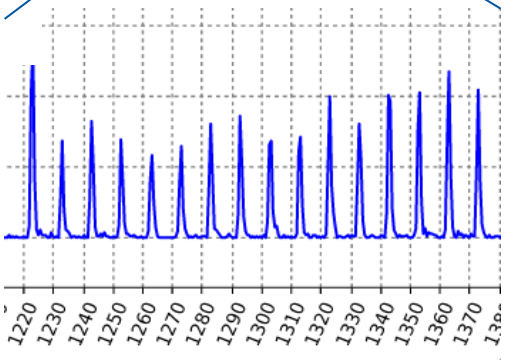


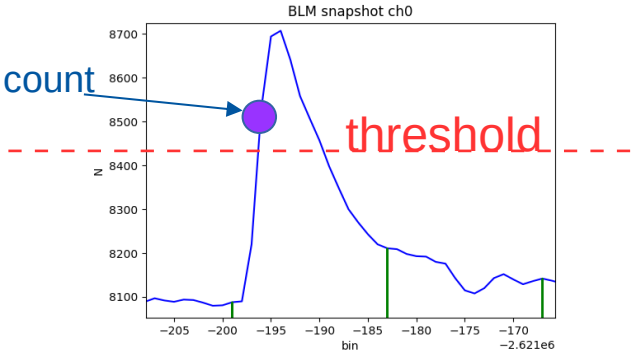
Measurements - counter

- Counter with 1.54 ns time bins
  - No constant fraction yet



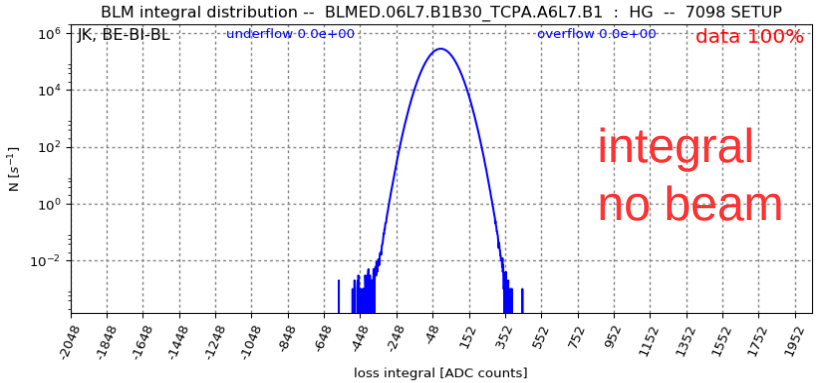


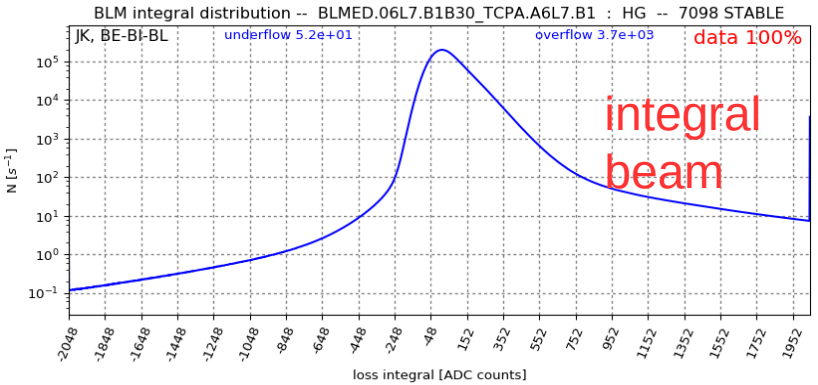


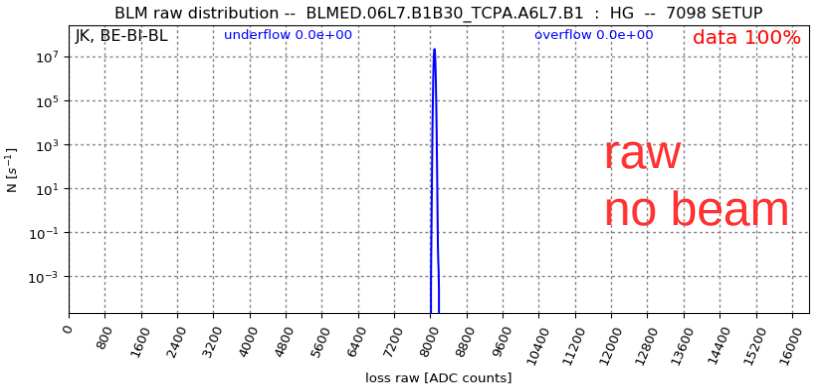


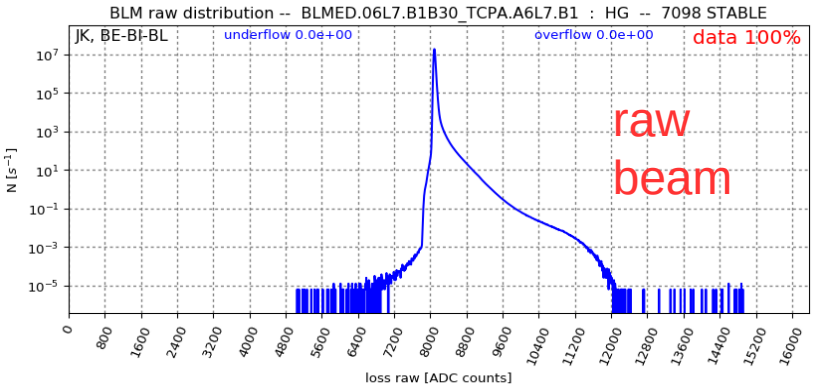
Measurements - distributions

- Characterization of the system
- Spectrum of losses



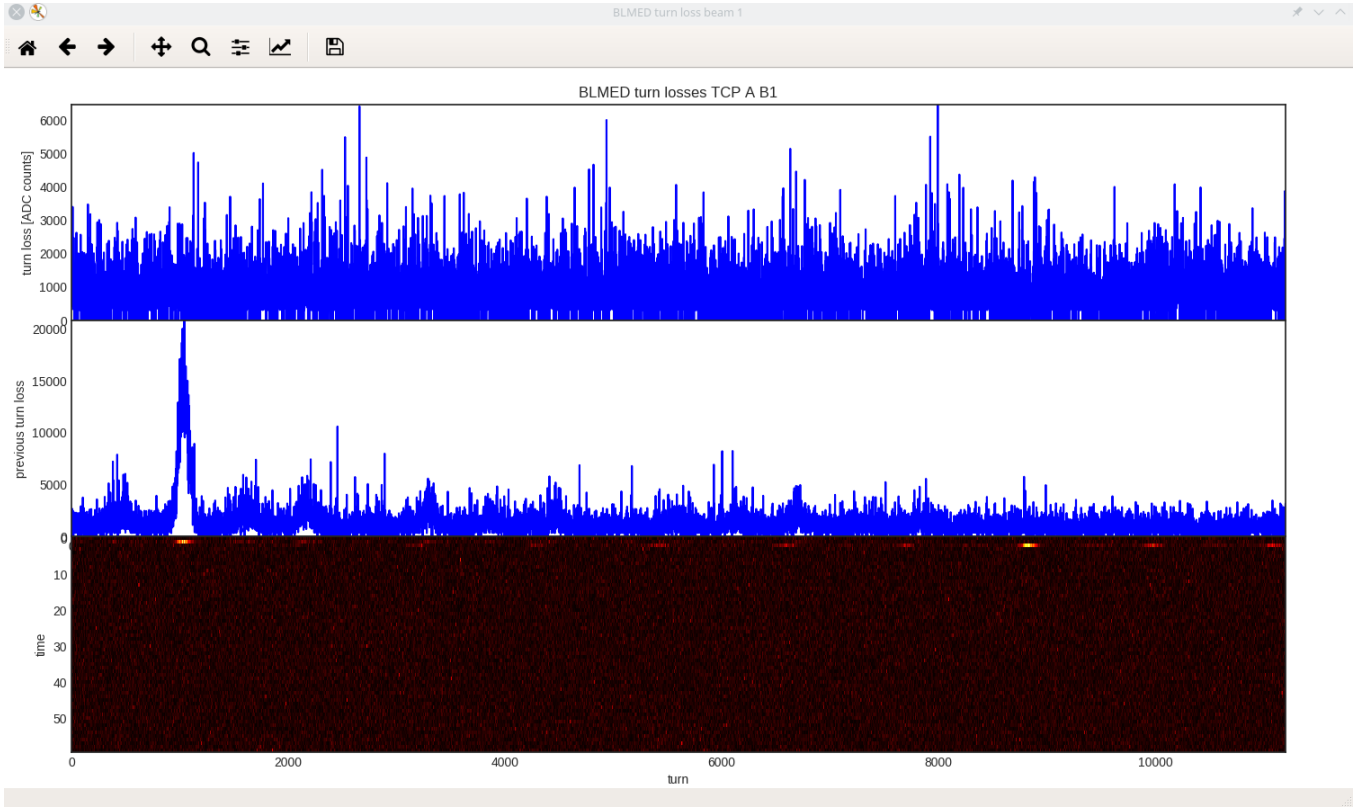






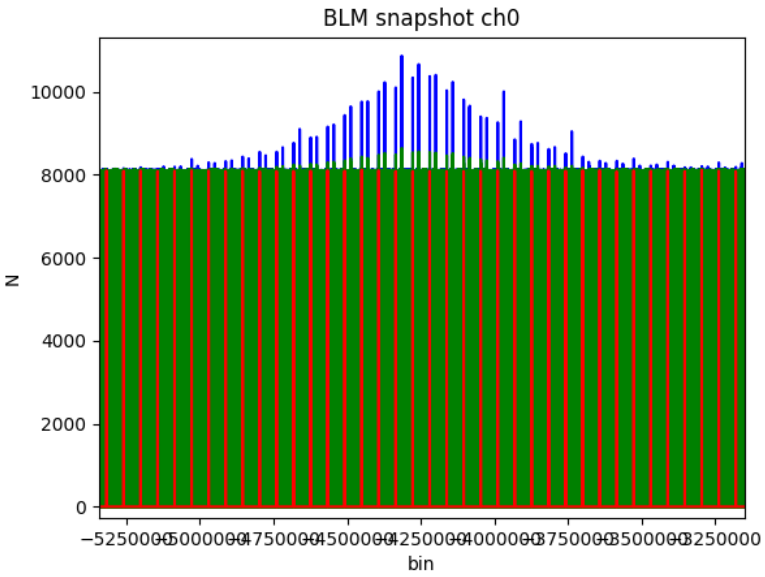
Measurements – per-turn loss

- Per-turn loss
  - FFTs, operators, fast event studies



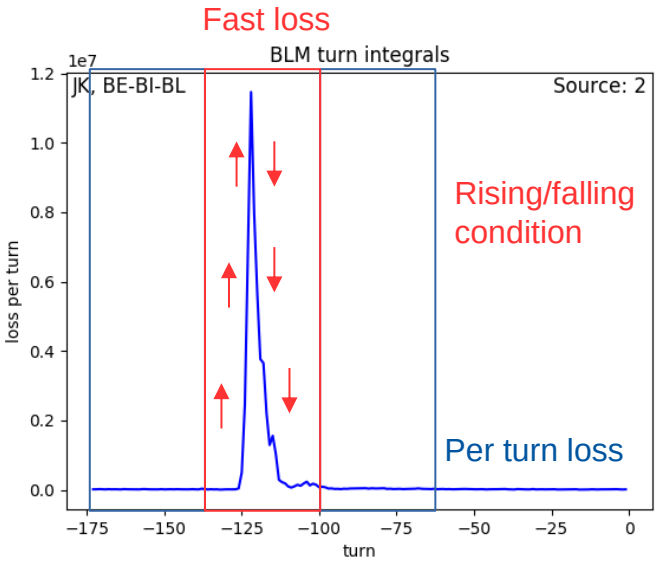
Measurements - snapshot

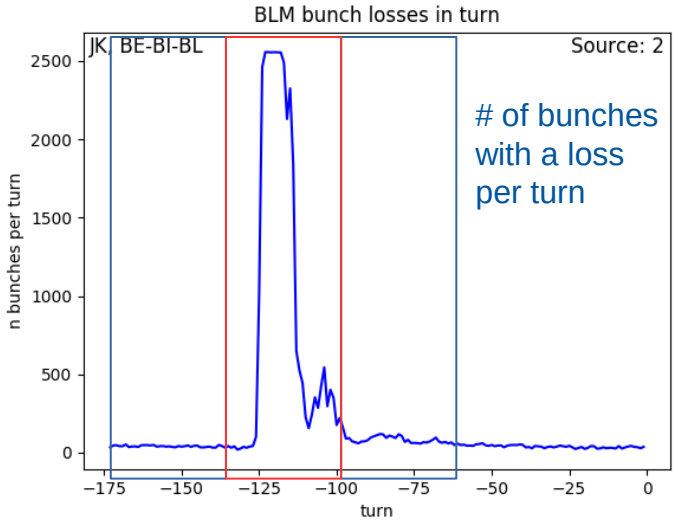
- 800 ms of raw ADC data dumped in the DDR3
- Trigger sources
  - External cable for beam dump
  - Internal shape based trigger



Internal trigger

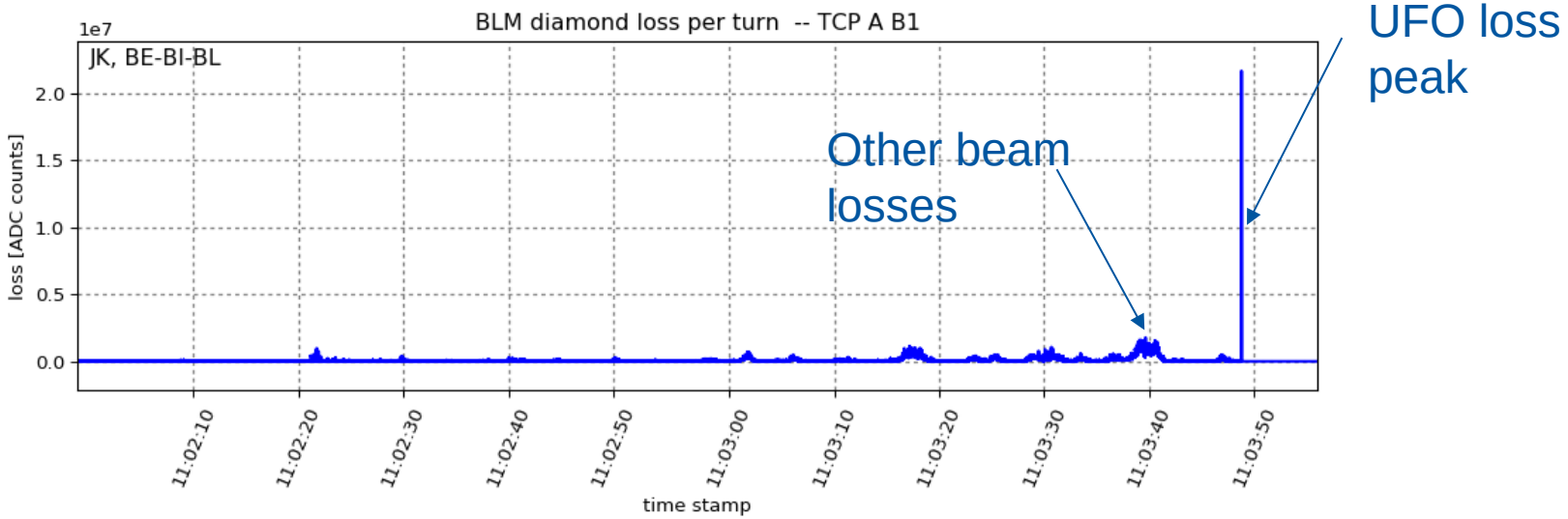
- Signal shape of per-turn losses
- Number of bunches with a loss
- Rejection of collimator movement / injection losses





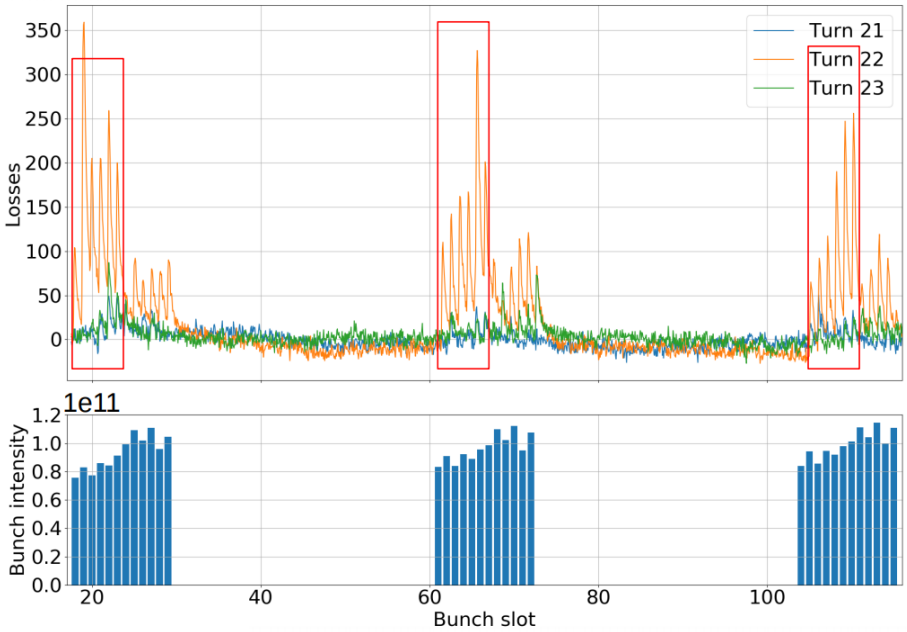
Studies - UFOs

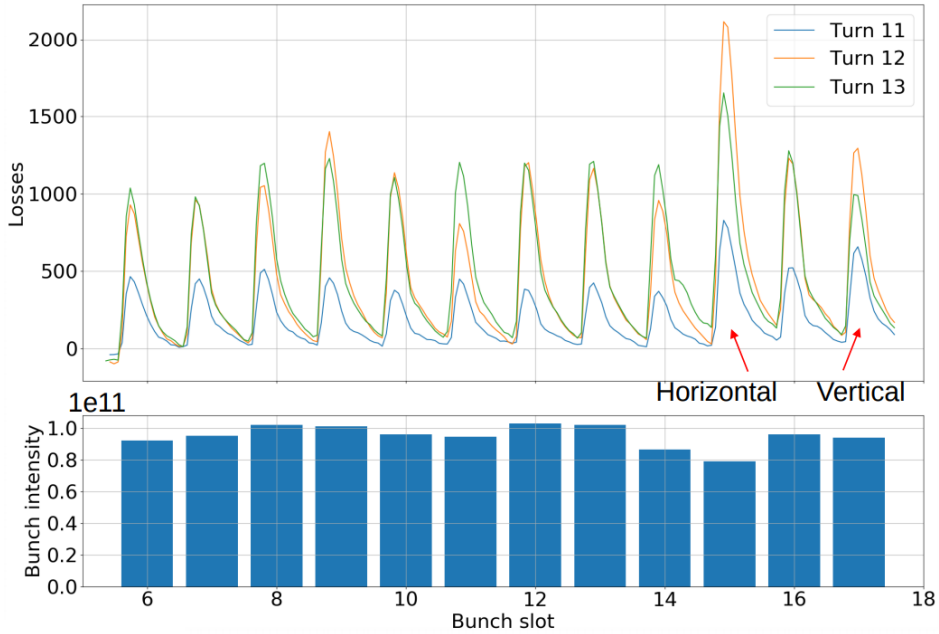
- Falling objects in LHC
  - UFOs have had a significant impact on LHC availability on run 1 and beginning of run 2
  - Source, release mechanism, dynamics, conditioning mechanism are not sufficiently understood



Studies - UFOs

- Dataset obtained in 2018
  - Exploited in physics run and in machine development
  - UFO detection with triggered diamonds is a good tool





M. Väänänen, A. Gorzawski, B. Lindström, J. Kral

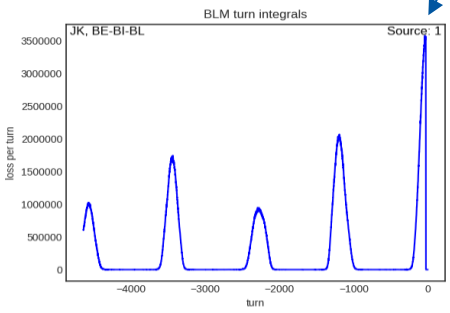
Studies - ~10 Hz oscillations

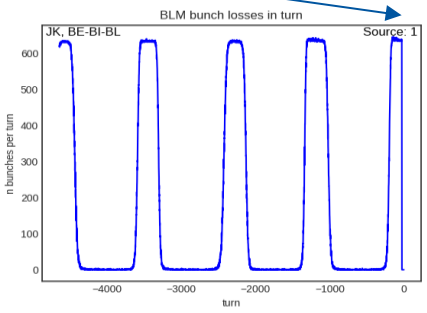
- Unknown origin, studies in progress

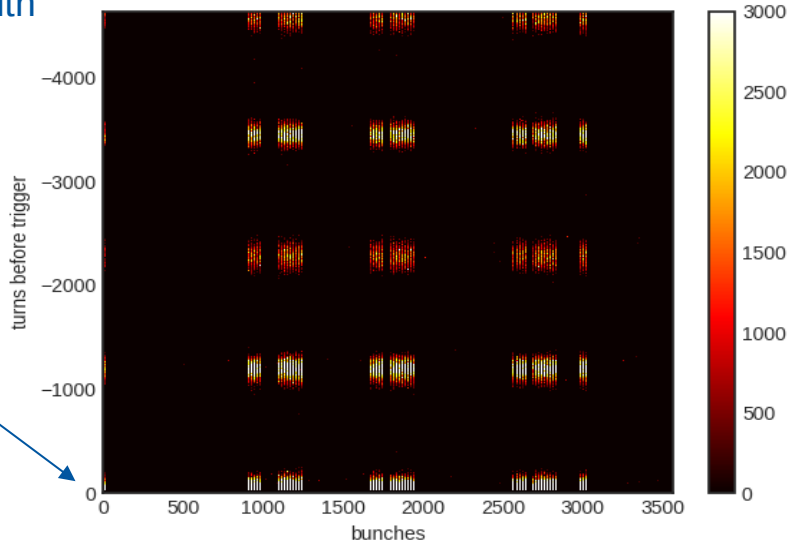
Protection dump

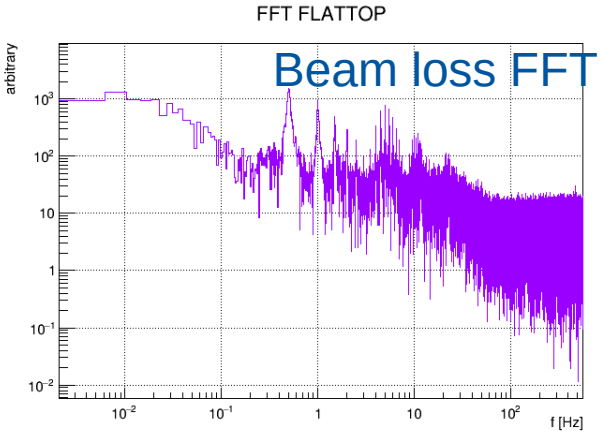
Per-turn loss

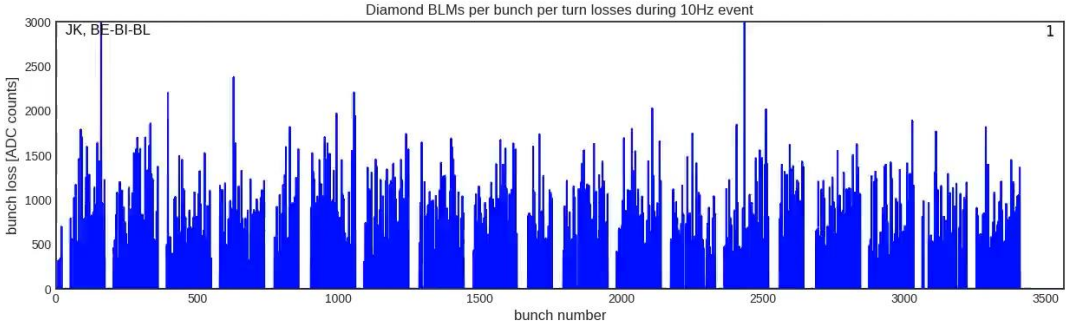
# of bunches with a loss per turn





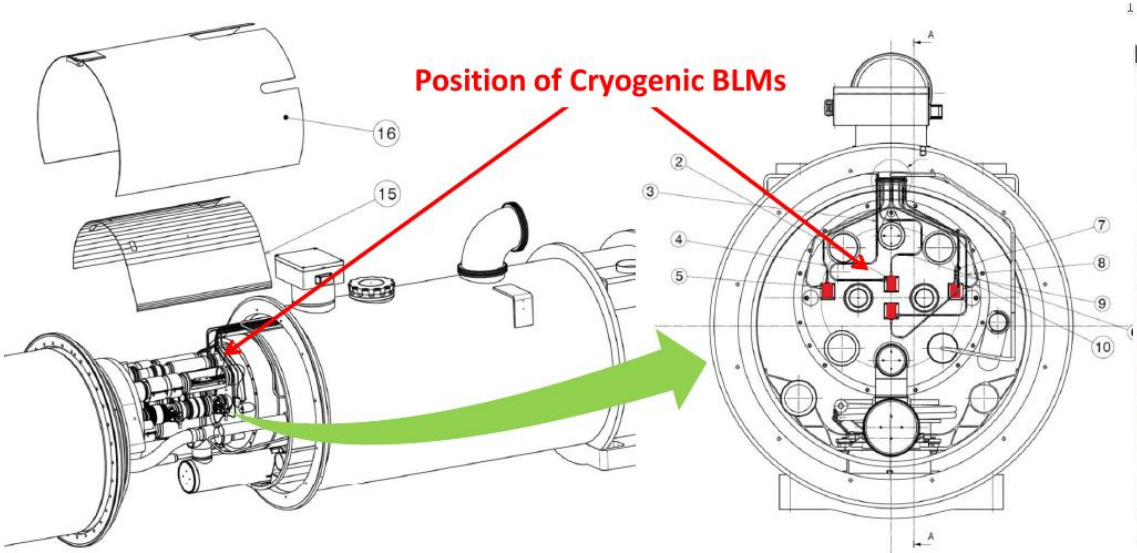


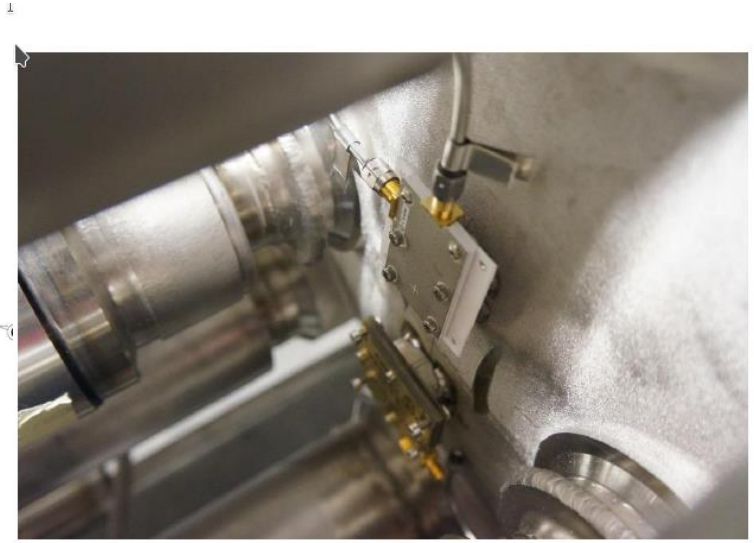




Cryogenic Diamond BLMs

- Installed inside cold mass of LHC submerged in liquid He
  - Operation in 2 T magnetic field, 1.9 K temperature
  - Resistance to a fast pressure rise from 1.1 to 20 bar

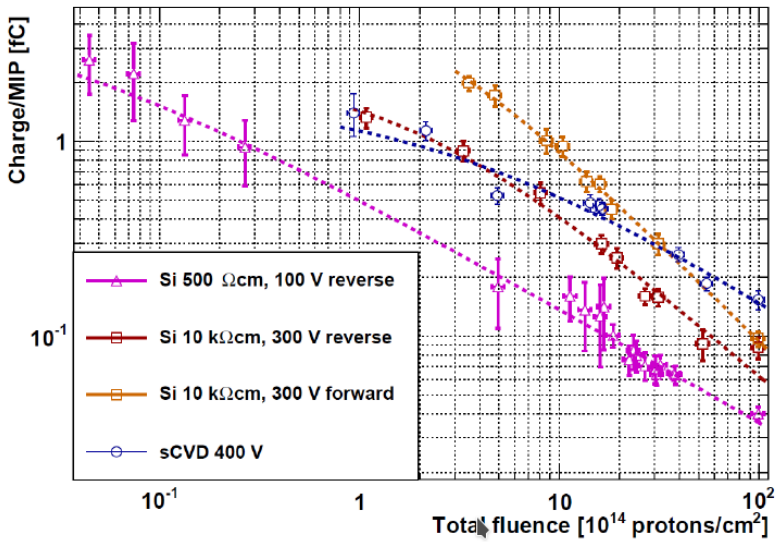


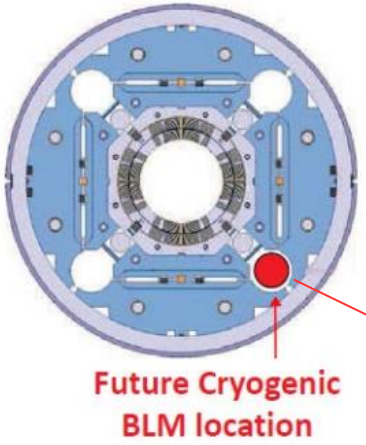


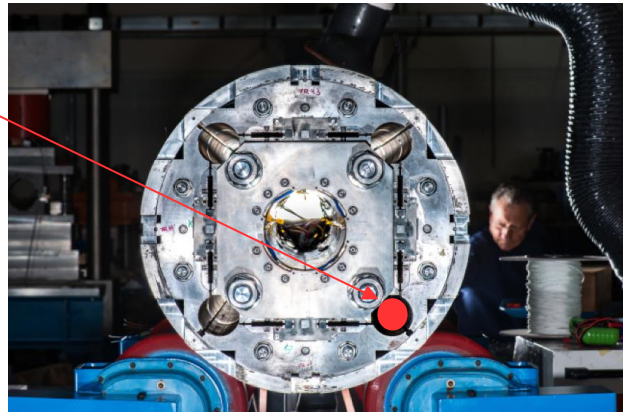
M. Bartosik, C. Zamantzas

HL-LHC upgrade

- Increase luminosity by factor of 3
  - Monitoring of insertion triplets before ATLAS and CMS
  - No access once installed, 20 MGy in 20 years
  - Sensitivity degradation twice lower than that of silicon



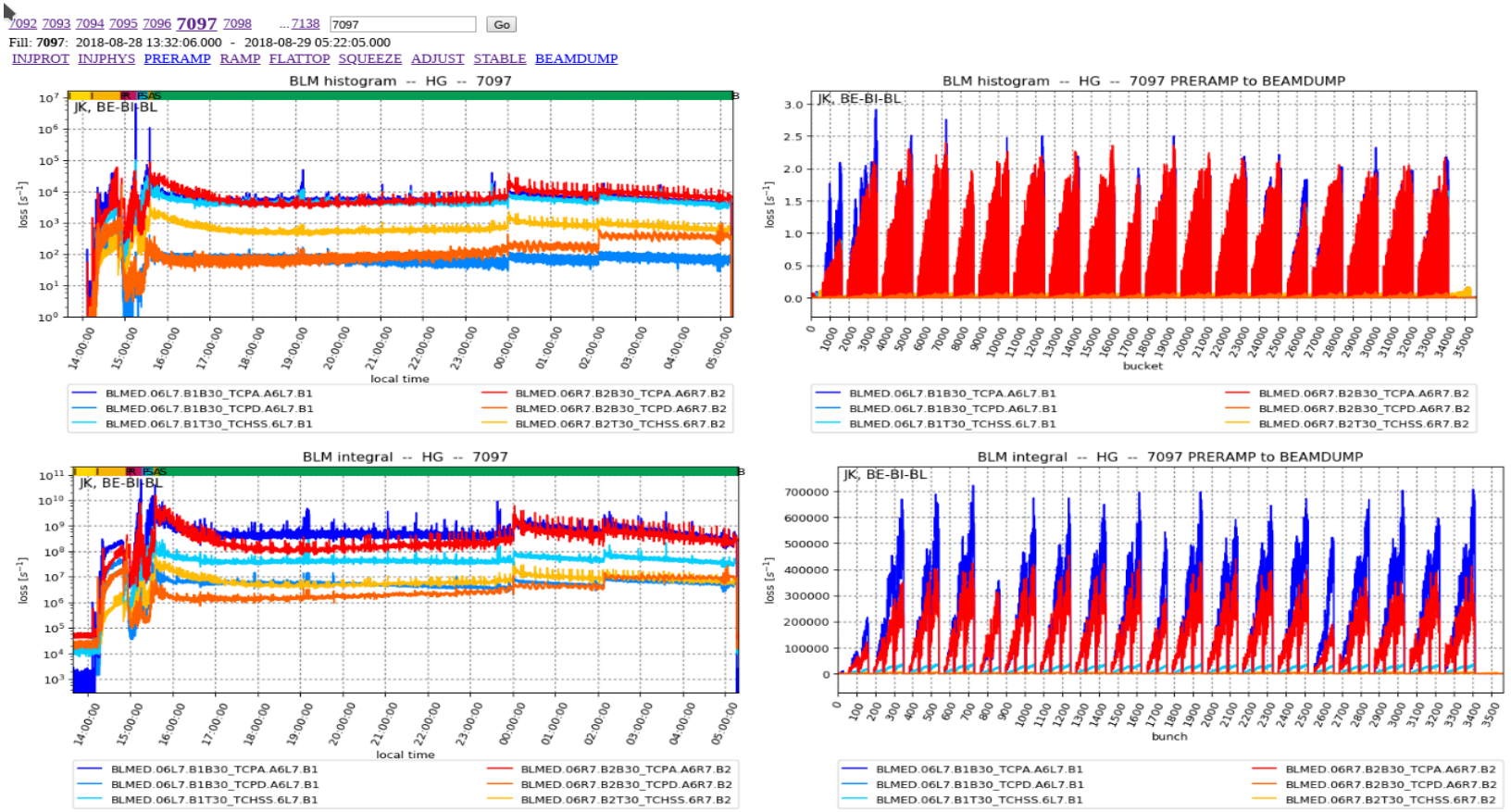




C. Zamantzas

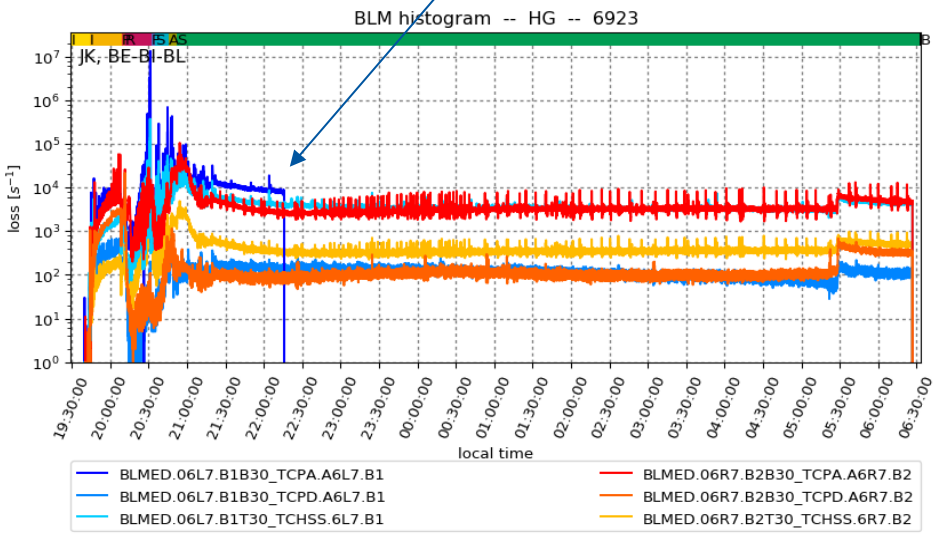
Monitoring

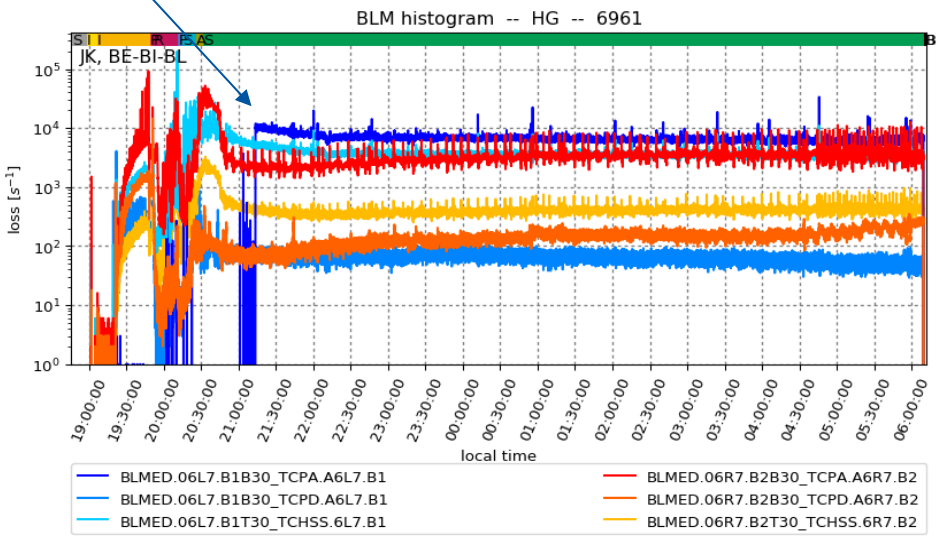
- Web based monitor



Issues encountered so far

- Ground loops at the very long cables (hundreds of meters)
- Sudden death and resurrection





Summary

- Diamond Beam Loss Monitors proved to be functional loss detection system
  - Provides unprecedented granularity
- Issues in analog chain to be addressed
- Rough calibration during LHC long shutdown
- More diamonds will be installed
  - Many years of good collaboration with Cividec
- System operational for LHC re-start in 2021