New Beam Loss Monitor Systems For SOLEIL

DEELS

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ESRF, Grenoble

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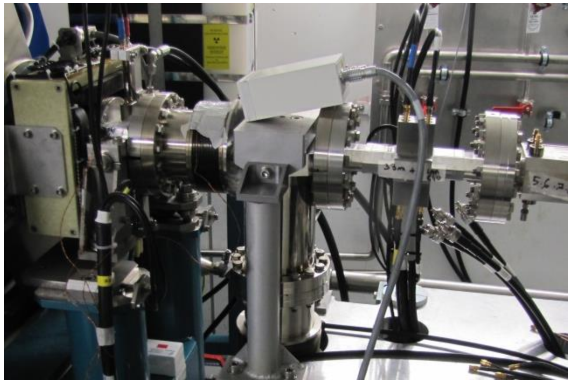
Loss Monitoring

- Present beam loss monitor system:
  - Coincidence pin diodes
    - Insensitive (by conception) to SR
    - Small angle of detection
    - Counting mode only
    - Slow losses only



- Objective for the upgrade of the beam loss monitor system:
  - Slow and fast losses
  - Improve (-> reduce) the directivity
  - Synchronized measurements
  - Relative calibration between monitors is needed
    - The new beam loss monitor system will be used by the radioprotection group to validate their simulation tools.
    - Objective: have less that 10% dispersion in detectors sensitivity.
- Status:
  - Preliminary tests conducted last year
  - Assembly and calibration of 20 modules
  - Installation on 2 cells and first measurements

Detector

- Re-use of the ESRF design:
  - EJ-200 plastic scintillator 100 mm rod:
    - Rise time: 0.9 ns
    - Decay time: 2.1 ns
  - Compact photosensor (Hamamatsu H10721-110):
    - PMT
    - High voltage power supply
    - Rise-time: 0.6 ns
  - Housed in a Al section

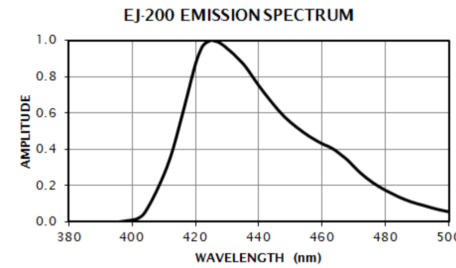
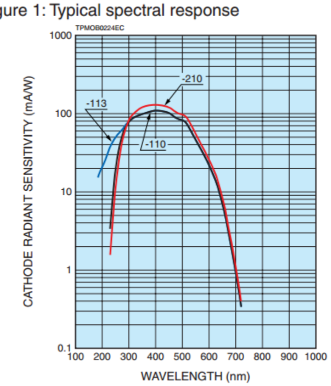
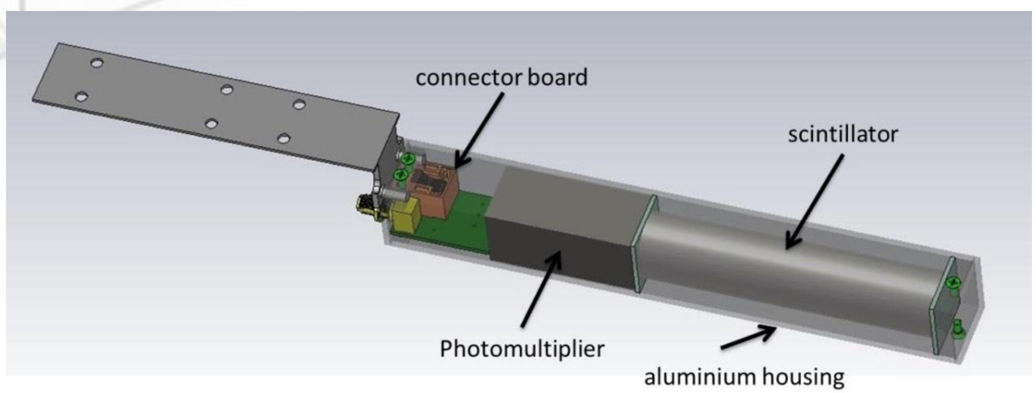


Figure 1: Typical spectral response





Electronics

- Libera BLM
  - 4x125 MHz digitizers (14 bits)
  - Several configurable data rates
    - Triggered (ADC, TbT, averaged…)
    - Continuous flow
    - Counting mode
    - Postmortem
  - Power-supplies for the detectors

- Relative calibration:
  - Can be compensated by the electronics:
    - Detector sensitivity compensation (scintillator yield and photomodule sensitivity)
    - Variable photomodule gain compensation
    - Variable attenuation compensation

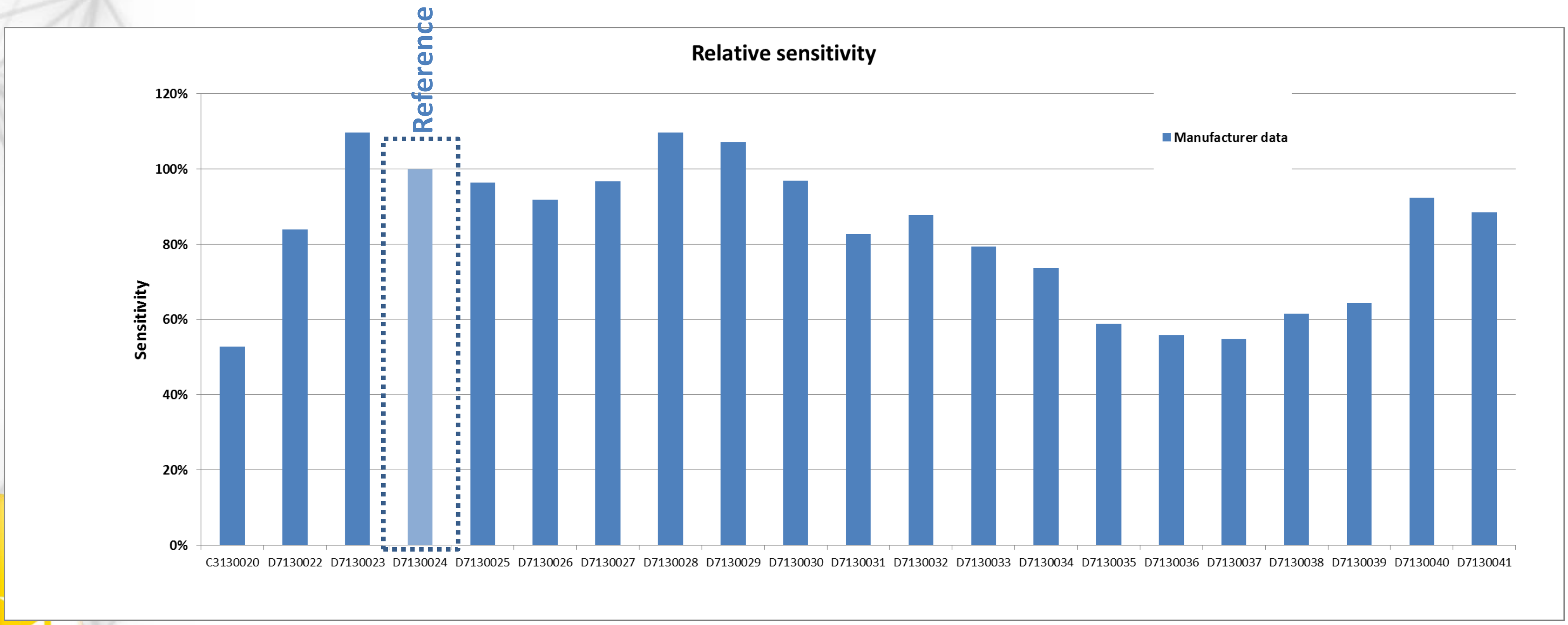
Acal = Araw x BLDCalib x G x AT

Where:

Acal	calibrated amplitude
Araw	raw amplitude (no correction)
BLDCalib	BLDCalib ... It is a calibration constant specific to each channel and the PMT.
G	It is a relative gain factor that depends on the setting of the gain control voltage.
AT	It corrects for the 10^(Att/20)

Source: Libera BLM user guide

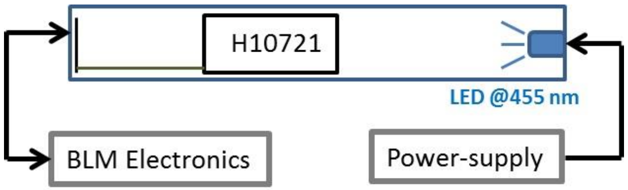
- Diode based sensitivity measurement:
  - High dispersion modules sensitivity: up to 50 % for the same reference.

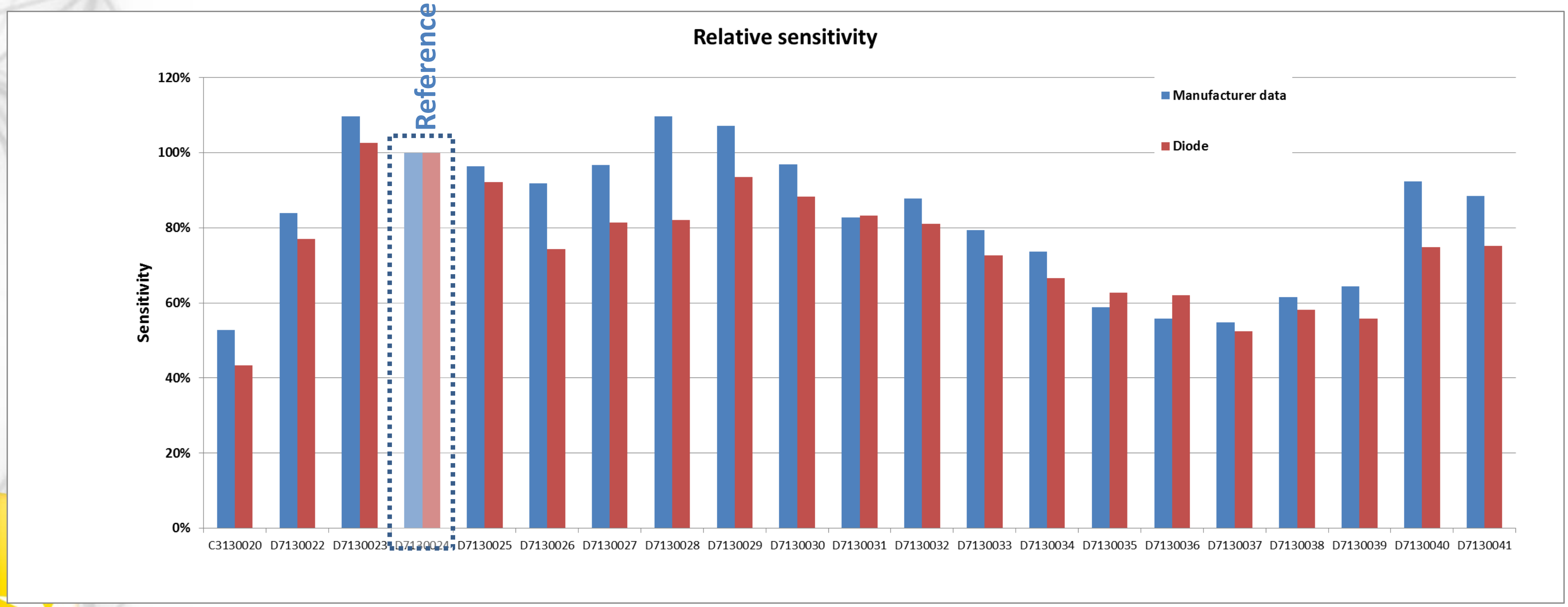


Photomodule sensitivity provided by the manufacturer at delivery

BLM Calibration

- Diode based sensitivity measurement:
  - Photomodule sensitivity
  - High dispersion between modules

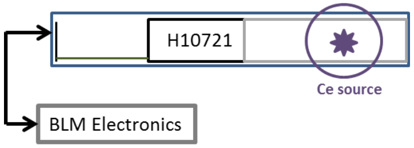


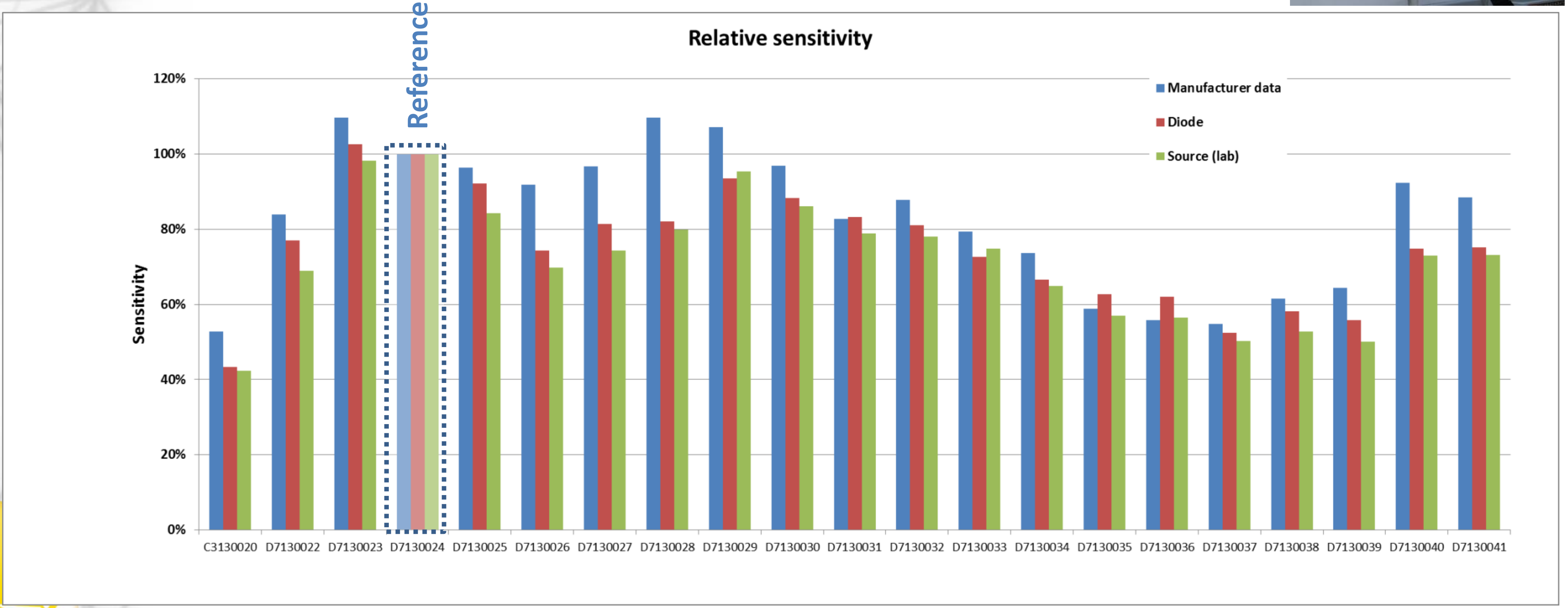


Photomodule sensitivity comparison (manufacturer data vs SOLEIL lab)

BLM Calibration

- Cesium source based sensitivity measurement:
  - 3D-printed support adapted to BLM housing
  - Lab measurement
    - Same Libera BLM module and channel used for all sensors
    - Includes scintillator response (see next slides).

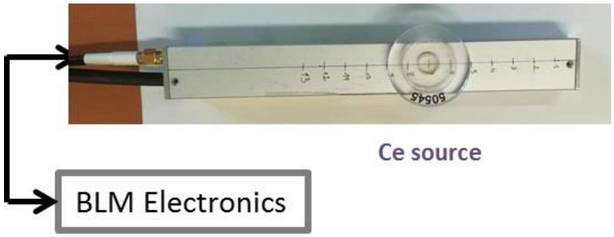


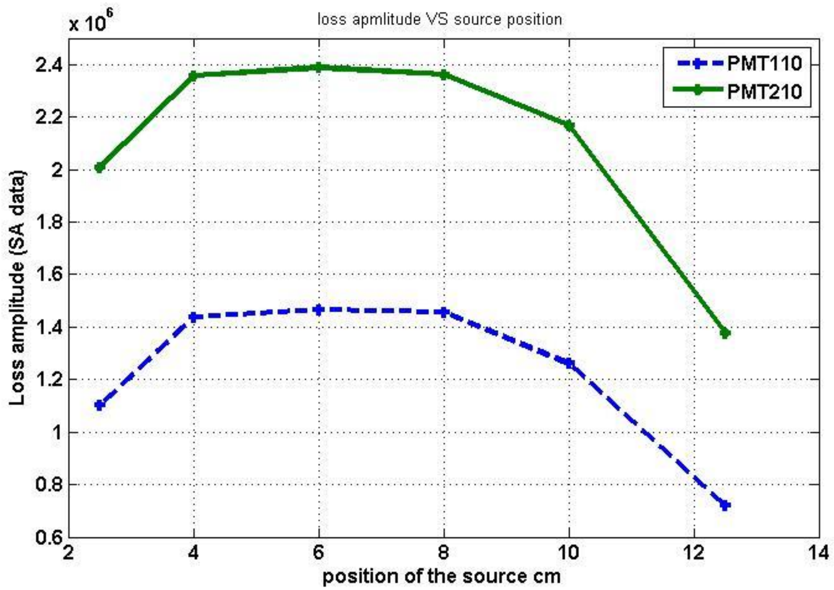


Photomodule sensitivity comparison (manufacturer data vs SOLEIL lab)

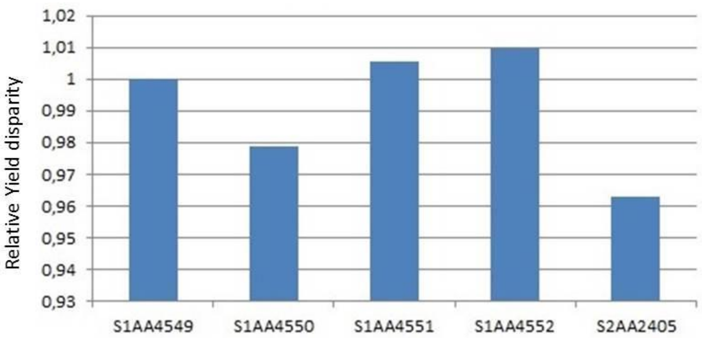
Scintillator sensitivity

- Dependence to source position:
  - To minimize the scintillation amplitude dependence to source position, this one must be placed in the middle region of the rod.



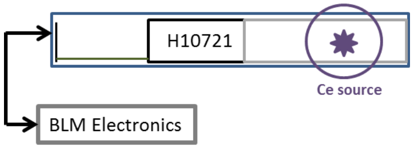


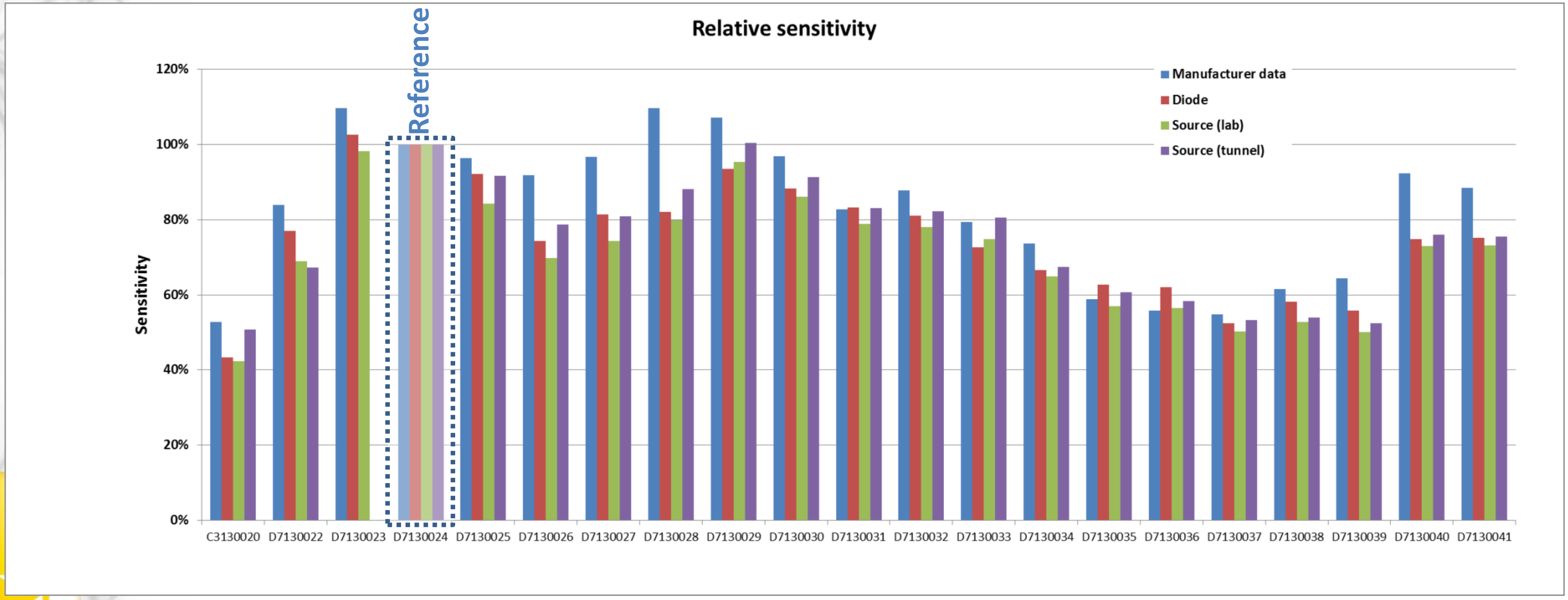
- Sensitivity dispersion between scintillators
  - Measured on 5 units with same electronics and photosensor.
  - Relative dispersion is below 5 %
  - Since the pair photosensor/scintillator is not supposed to be separated it has been decided to calibrate the pair together.



BLM Calibration

- Cesium source based sensitivity measurement:
  - 3D-printed support adapted to BLM housing
  - Tunnel measurement
    - Includes cabling
    - Includes electronics, after offsets compensation (see next slides)
- Very good (<10%) reproducibility of the sensitivity measurements done in-house
  - Compensation applied based on the measurement performed with Cs source in the tunnel
    - Includes all components.
    - Possibility to repeat the measurement periodically

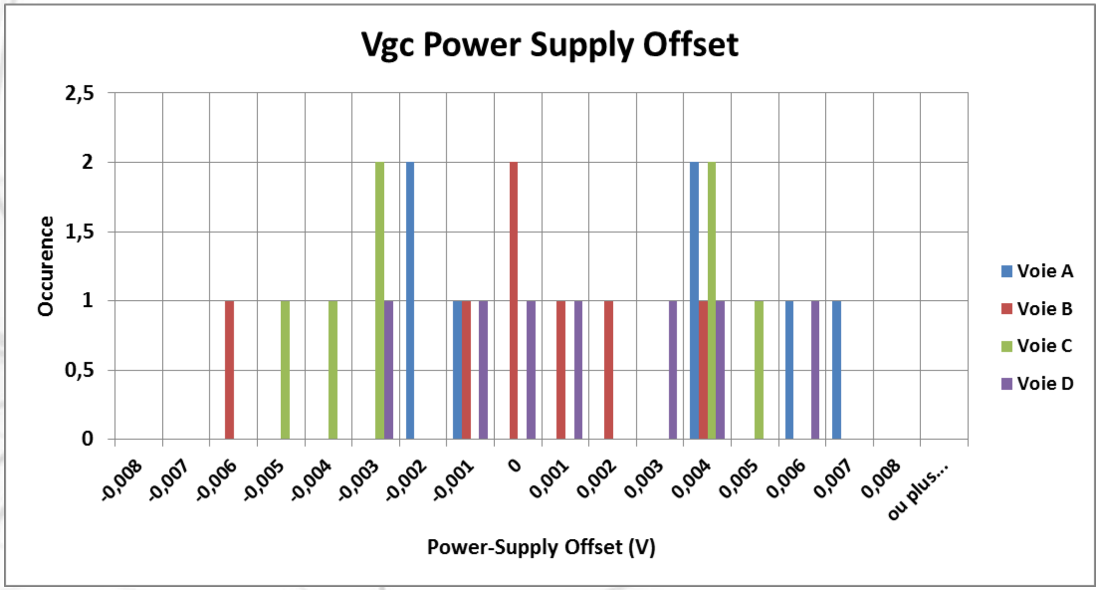




Photomodule sensitivity comparison (manufacturer data vs SOLEIL lab)

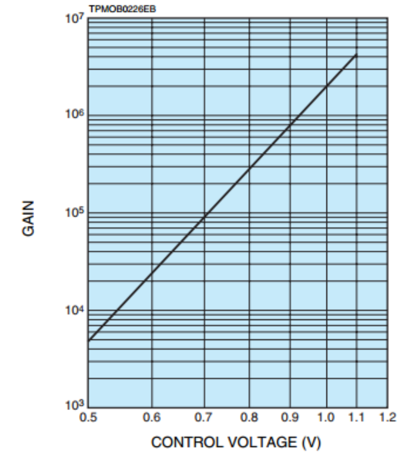
Electronics calibration

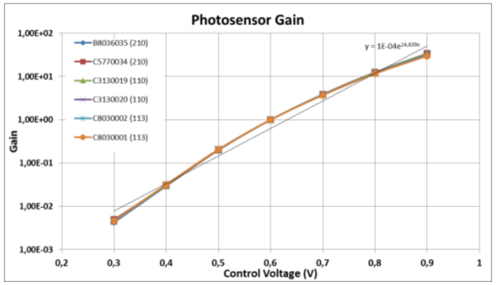
- Gain power-supply offset:
  - Constant whatever the required voltage
  - Photomodule gain is very sensitive to it!



Libera BLM Vgc power-supply offset distribution (28 channels)

Figure 4: Typical gain





Gain vs Vgc voltage

A difference of 13 mV between 2 channels creates a 20% variation on the applied gain value.
-> Calibrate each module with its own electronics ->to be redone at each permutation (maintenance)
or
-> Compensate for this offset -> measured in the lab and corrected by the high-level application

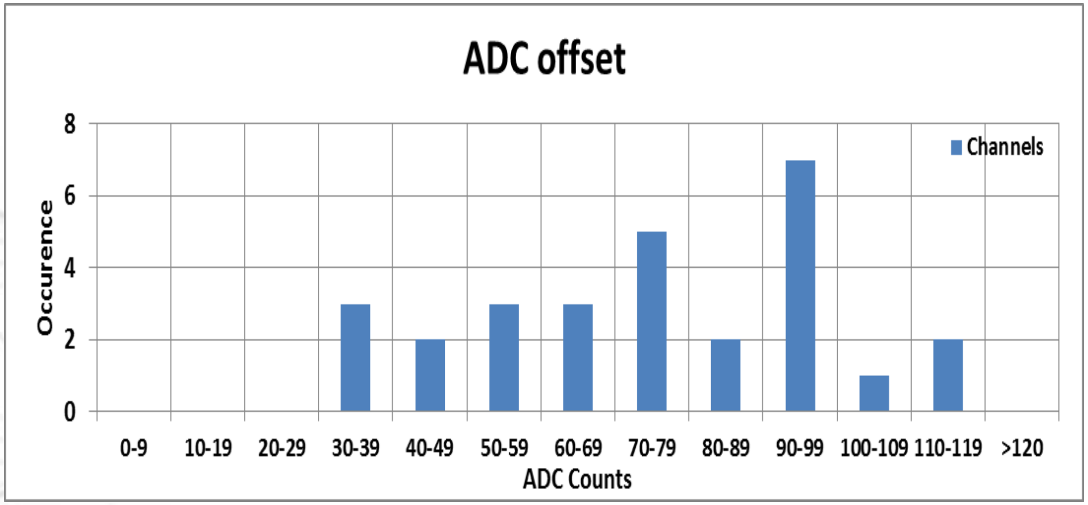
Hopefully, we have in the electronics a discrete gain compensation table without interpolation between points

Acal = Araw x BLDCalib x G x AT

Vgc ref	0.00	0.30	0.40	0.50	0.60	0.70	0.80	0.90
G	NaN	334.5	33.25	4.97	1	0.26	0.0825	0.0313

Electronics Calibration

- ADC offset:
  - Measured with 50 ohms termination at the channel inputs
  - Compensated by the electronics

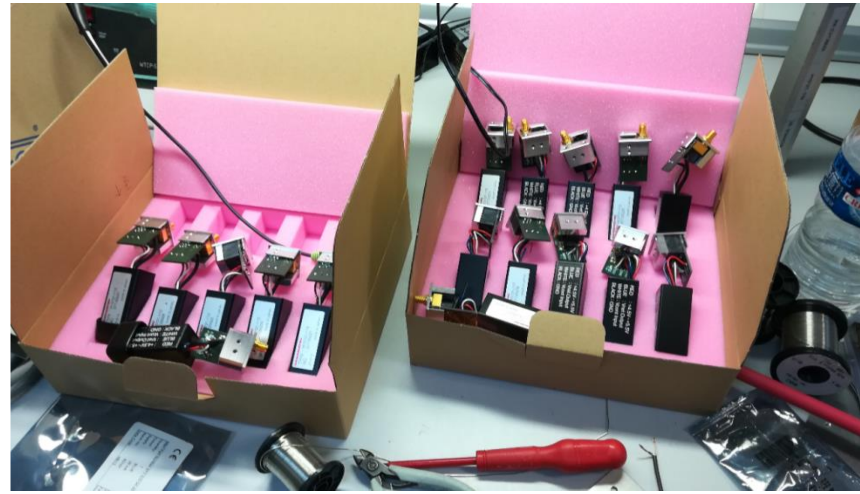


Libera BLM ADC offset distribution (28 channels)

Installation

- Assembly:
  - Individual pieces produced externally
  - Assembly/soldering done in-house

Scintillators and first assembled BLM



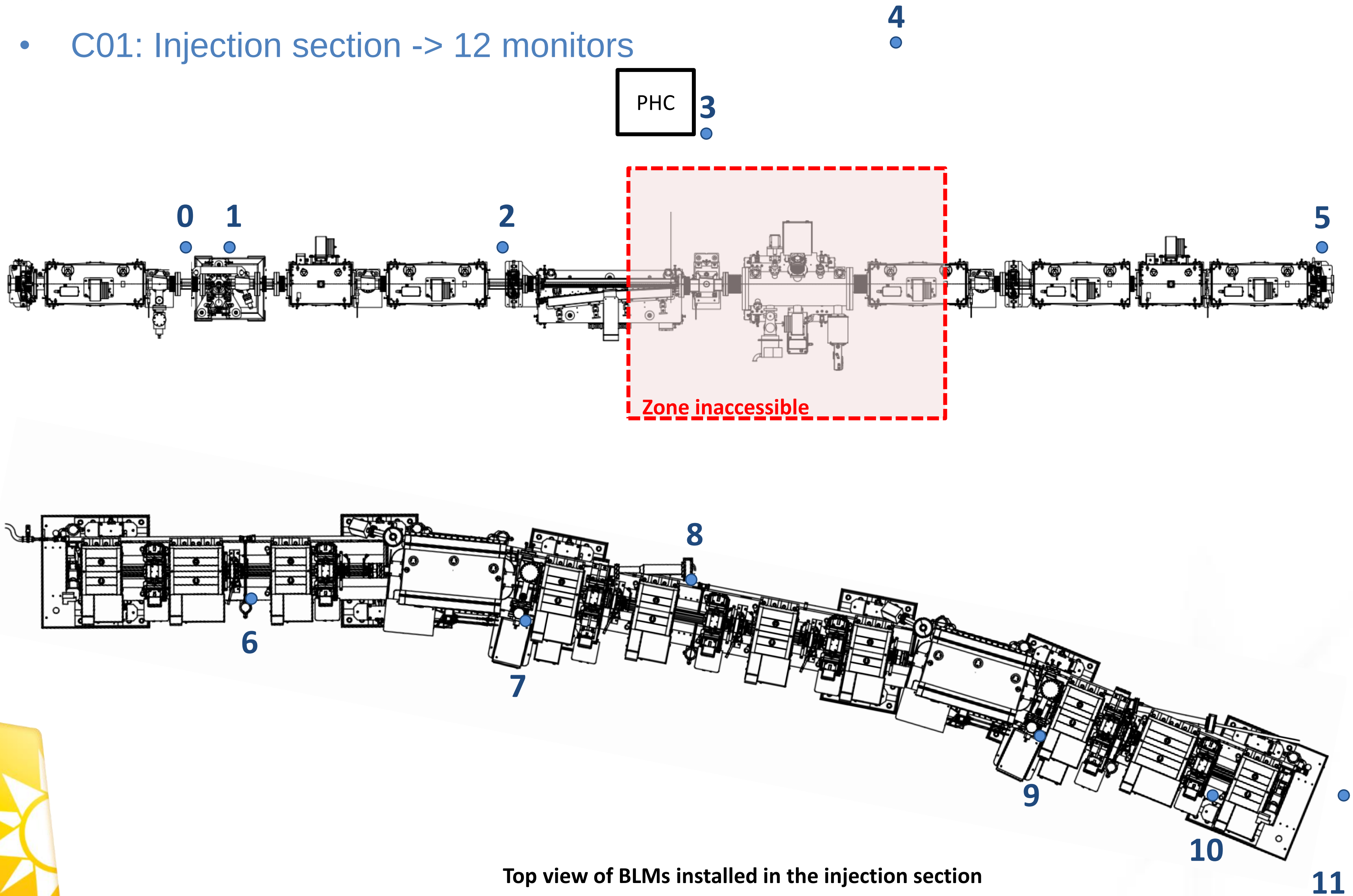
Photomodules soldered to their connector board

- Shieding
  - 3mm thick lead shielding
  - Damping of synchrotron radiation

3 mm lead shielding

Installation

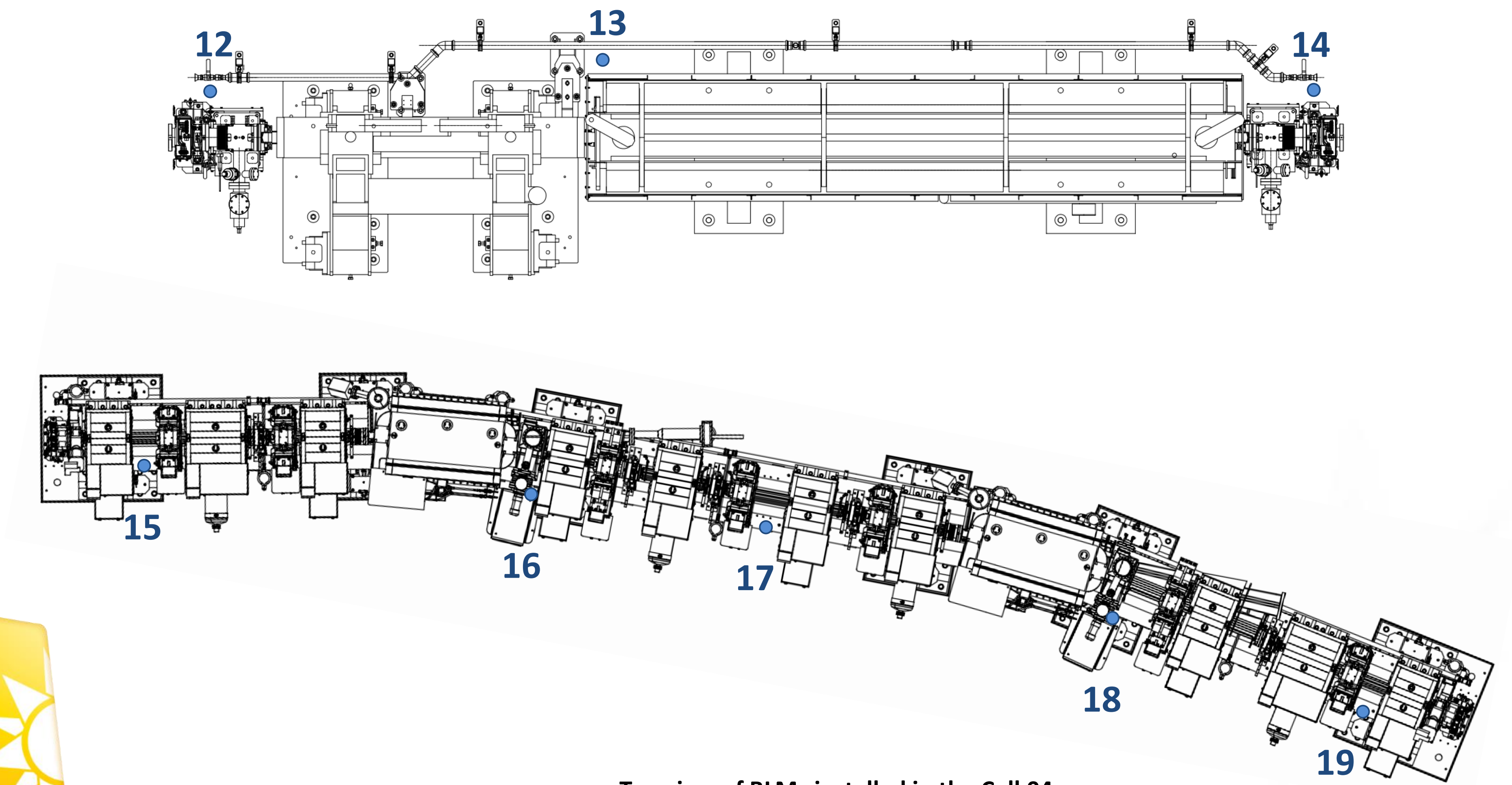
- C01: Injection section -> 12 monitors



Top view of BLMs installed in the injection section

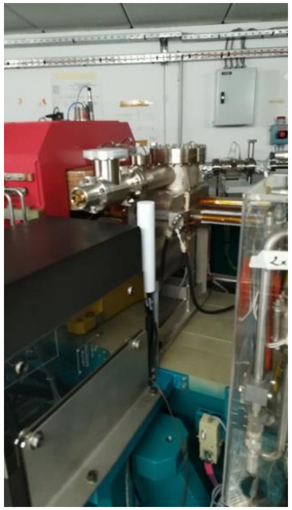
Installation

- C04: standard section -> 8 monitors



Top view of BLMs installed in the Cell 04

Installation



Just after dipole

Arc location

Upstream
straight section

Downstream
straight section

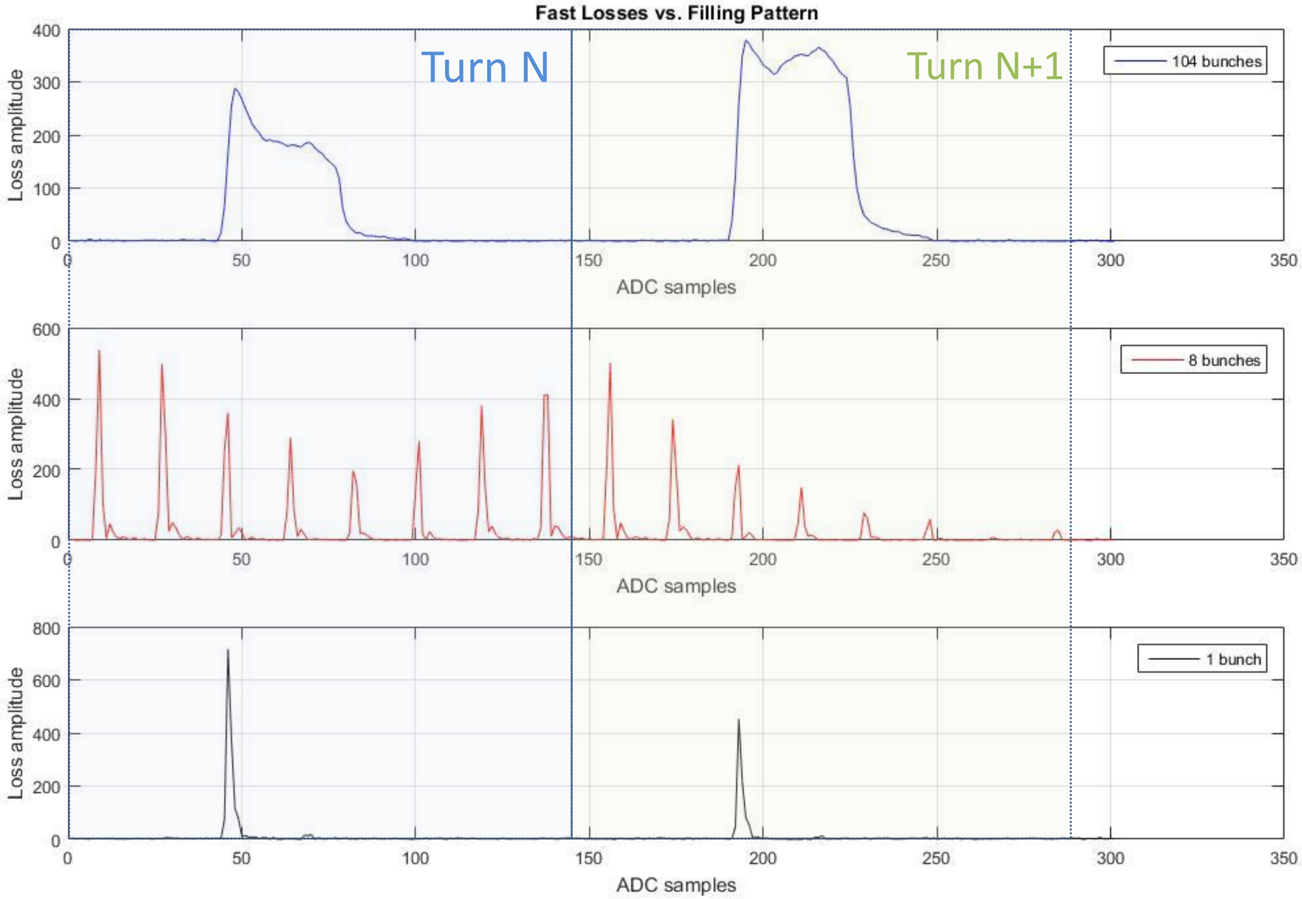
Between undulators
Middle of a straight section

Upstream septum

Upstream and in front
of vertical scraper

In front of horizontal
internal scraper

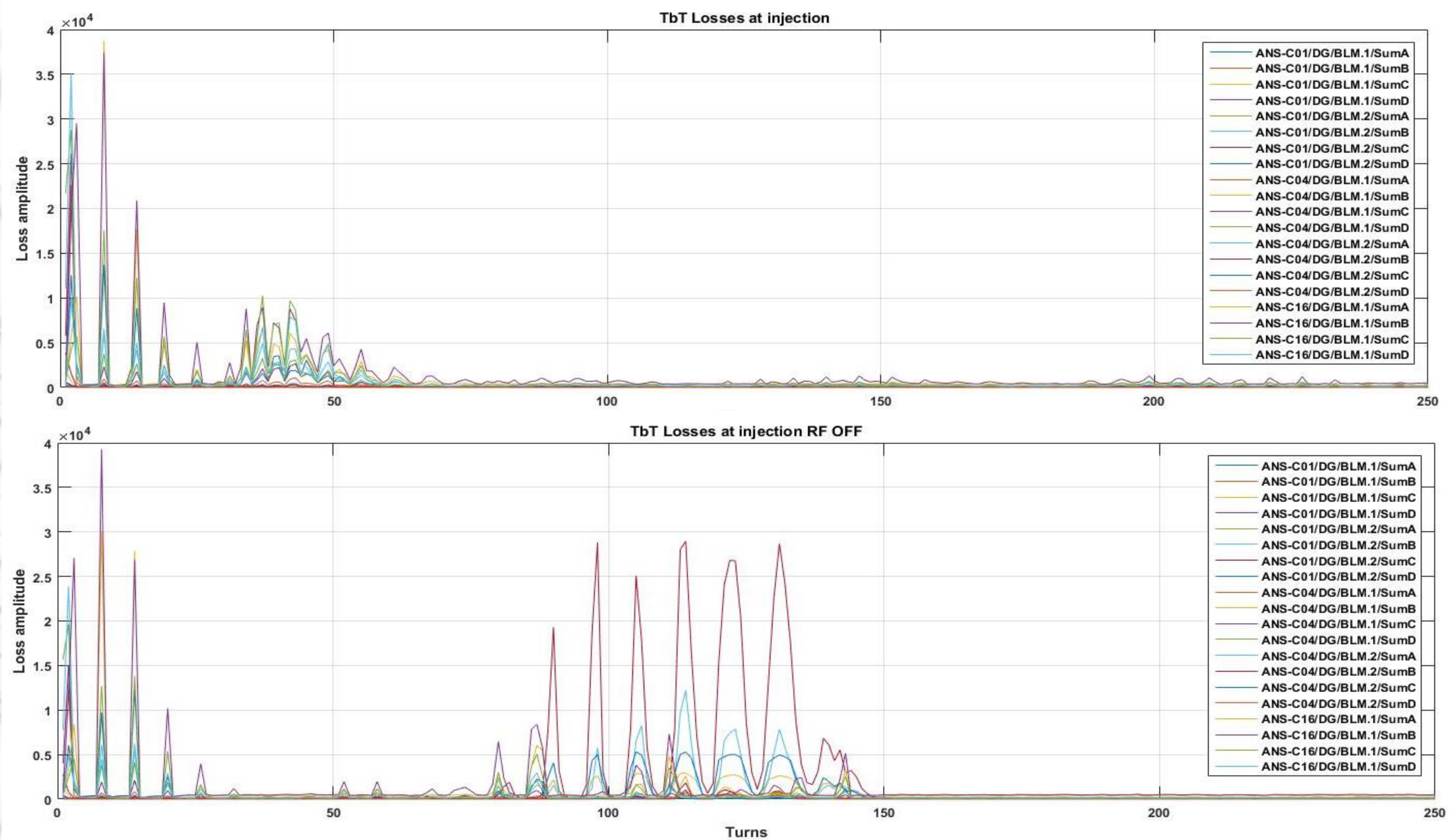
- Fast Losses:
  - Stored beam, scraper slightly inserted, vertical excitation



Losses measurement (ADC data) for 104 consecutive bunches (top), 8 bunches (middle) and single bunch (bottom). Records on BLM 1 in front of the vertical scraper.

Beam Measurements

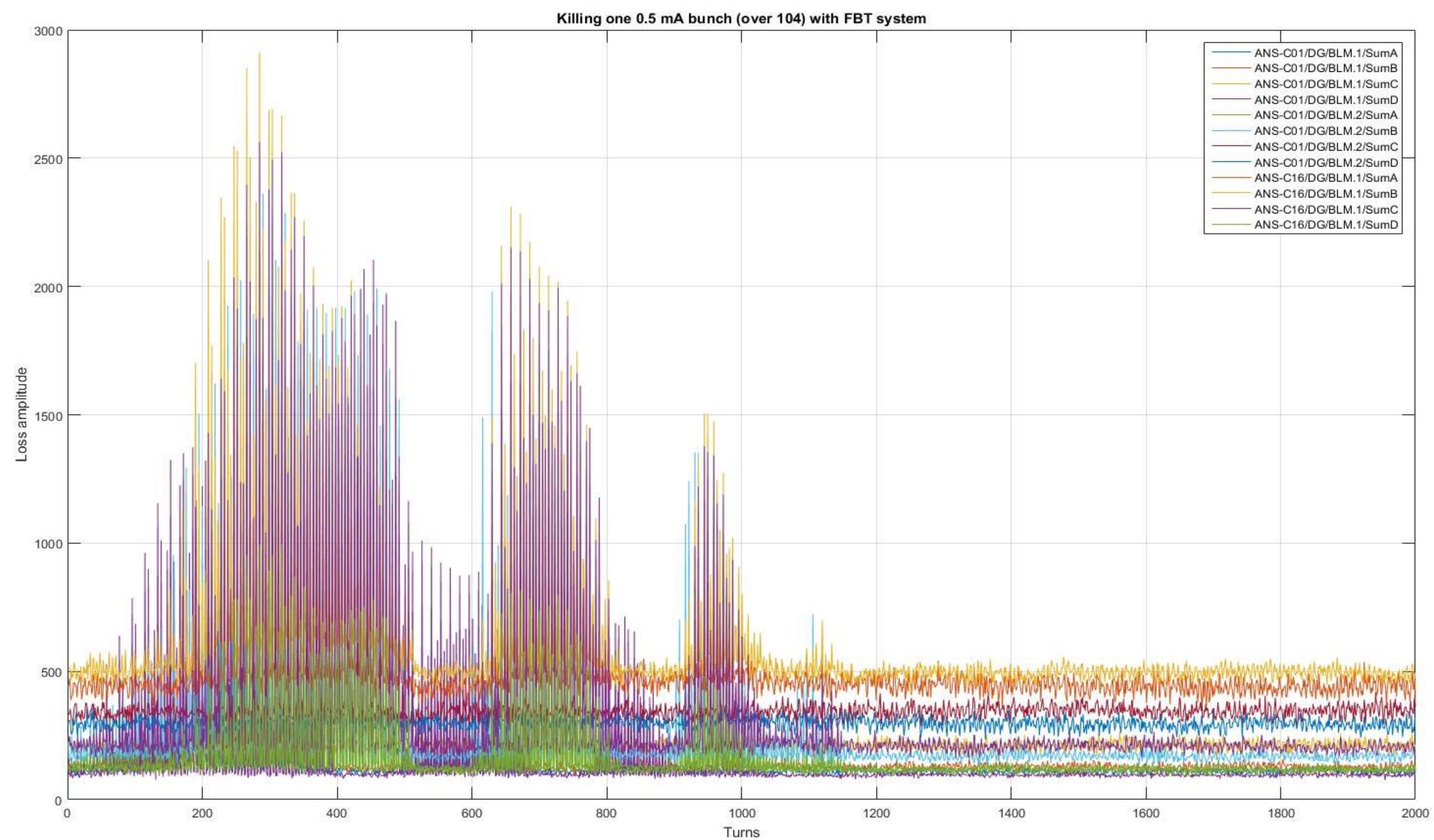
- Fast Losses:
  - Turn by turn losses at injection



Turn by turn losses measurement on the 20 detectors when injecting with RF switched ON (top) and OFF (bottom).

Beam Measurements

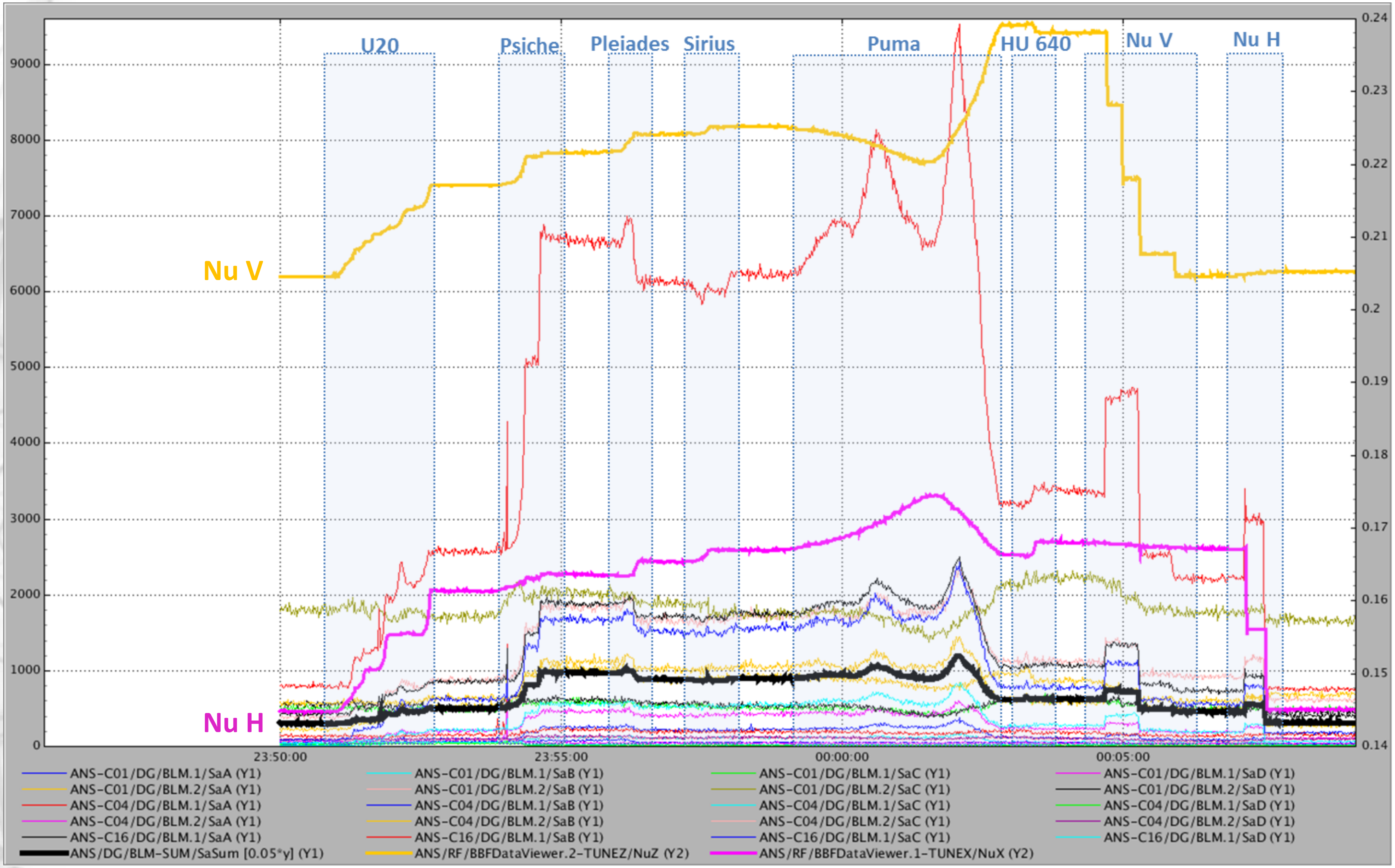
- Fast Losses:
  - Killing one (over 104) bunch with BbB feedback system



Turn by turn losses measurement on the 12 detectors of cell 01 when killing one over 104 bunches.

Beam Measurements

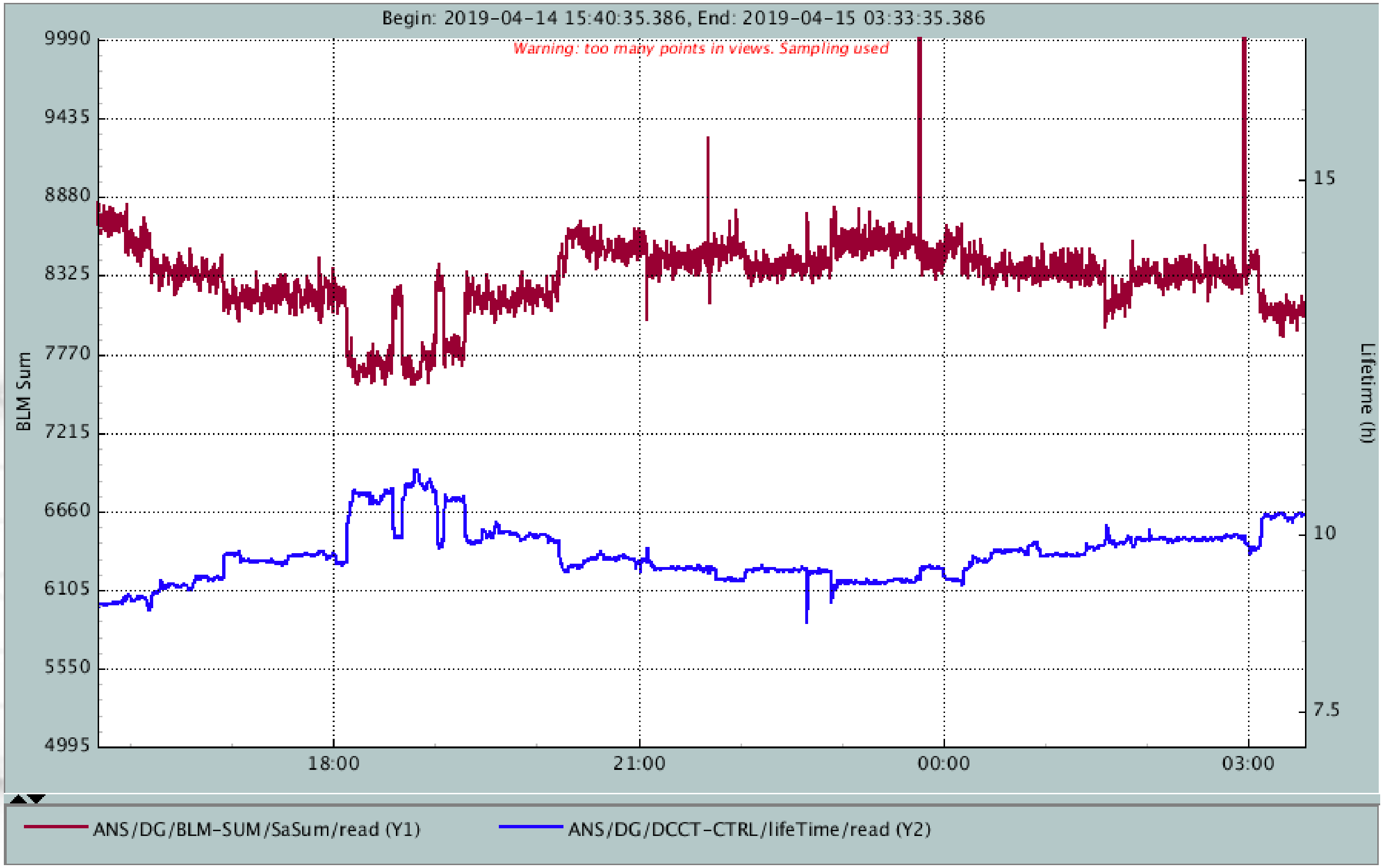
- Slow Losses: tune shift and IDs



Slow acquisition losses measurement on the 20 detectors when closing or switching ON insertion devices at 500 mA.

Beam Measurements

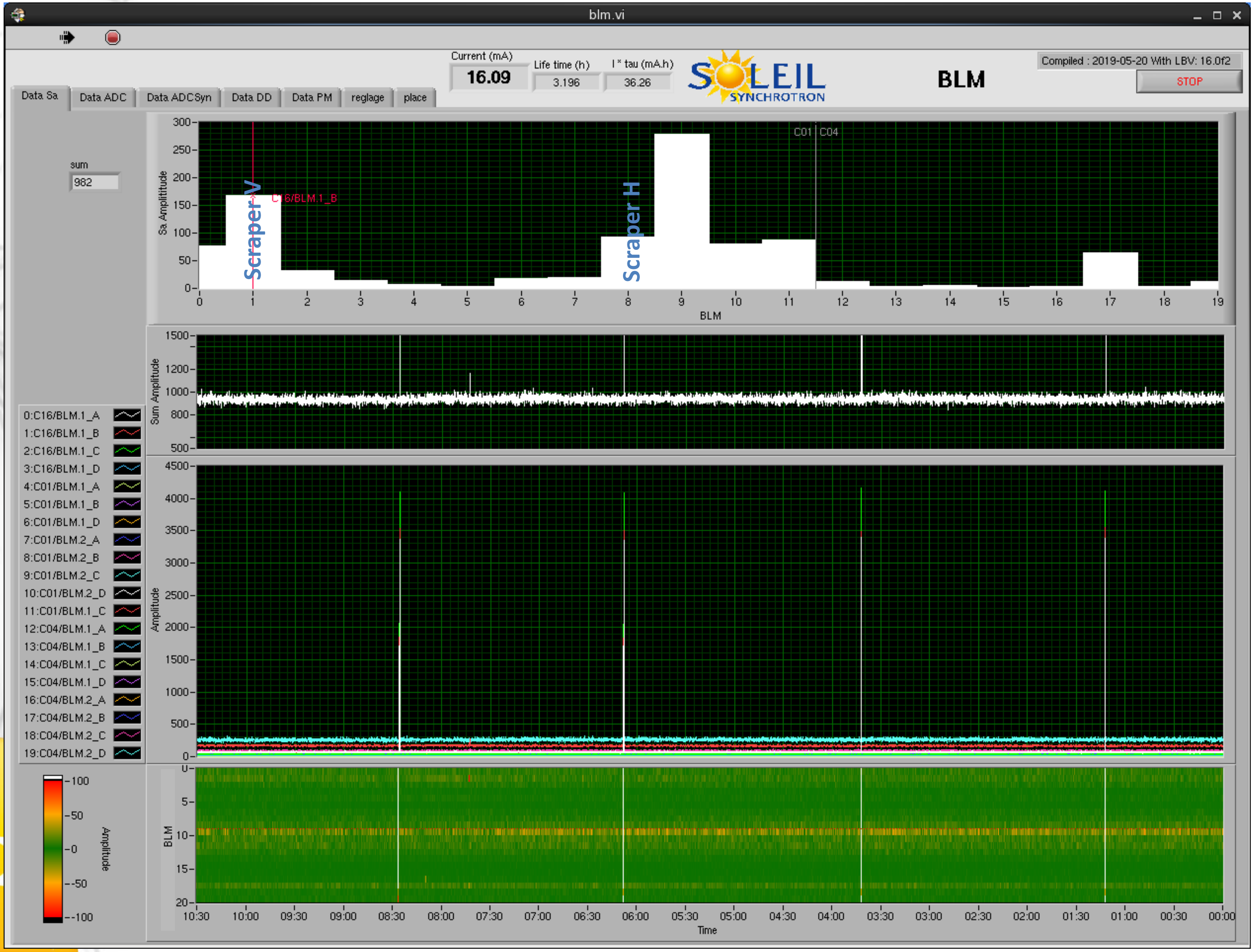
- Slow Losses: Correlation with lifetime



Correlation between lifetime and losses (sum of the 20 BLMs)

Beam Measurements

- Daily operation: high level interface



Current loss value (SA)

10 minutes history of the sum of the 20 BLMs

10 minutes history of the 20 BLMs

10 minutes histogram of the 20 BLMs

Conclusion

- 20 monitors mounted and installed on 2 cells of the storage ring
- Calibration based on diode and Cs source methods are in good agreement
  - Compensation based on calibration with Cs source placed on detector in the tunnel:
    - Take into account all parts from scintillator to electronics
    - Easy to reproduce (typically every 2 years) to check possible evolutions (ageing, radiation damages…)
  - Electronics gain power supply offset has to be compensated
- Radioprotection group will start to use those detectors to cross check their radiation codes.
- Full storage ring to be equipped by the end of the year:
  - 4 BLMs per cells