New Beam Loss Monitors for SOLEIL

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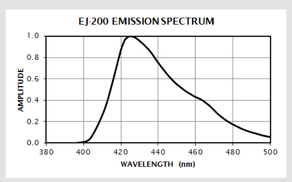
Abstract

SOLEIL has recently upgraded its Beam Loss Monitor (BLM) system from pin-diode detectors to plastic scintillators associated with photosensor modules [1]. This new kind of monitor, associated to its dedicated electronics, is able to measure slow or fast losses. Monitors have been carefully calibrated with a Cesium source, and installed at systematic locations on the storage ring to provide reliable loss amplitude comparison between them. SOLEIL storage ring is now equipped with 80 BLMs. Installation setup, calibration procedure and resulting measurements will be presented.

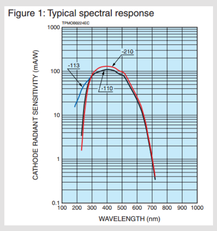
DESCRIPTION OF THE NEW BLM SYSTEM

- Scintillator
  - 100 mm plastic (EJ-200) rod.
- Photosensor
  - Compact Hamamatsu H10721 photo-module including PMT and high voltage source.
- Acquisition board (Libera BLM)
  - 4 x 125 MS/s channels /unit.
  - Gain and power supply voltage sources.

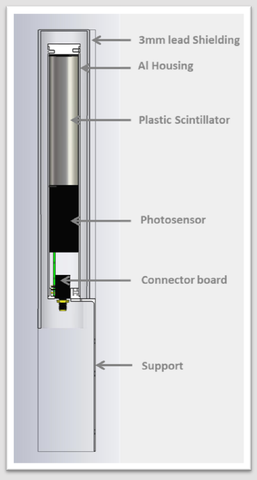
Libera BLM Electronics



Scintillator with its emission spectrum



Photosensor and its spectral response

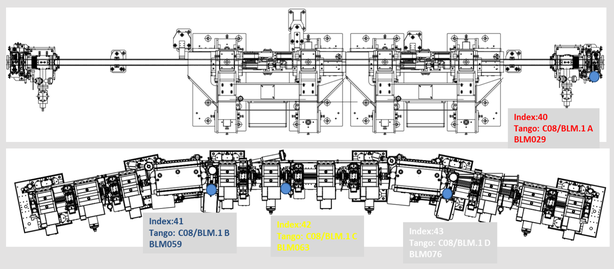


Detector integration

SYSTEMATIC LOCATION

BLM have been installed on the storage ring using systematic locations:
- Downstream each straight section
- Downstream each bending magnet
- In the middle of the arcs

Additional detectors are installed in the injection section and close to the scrapers



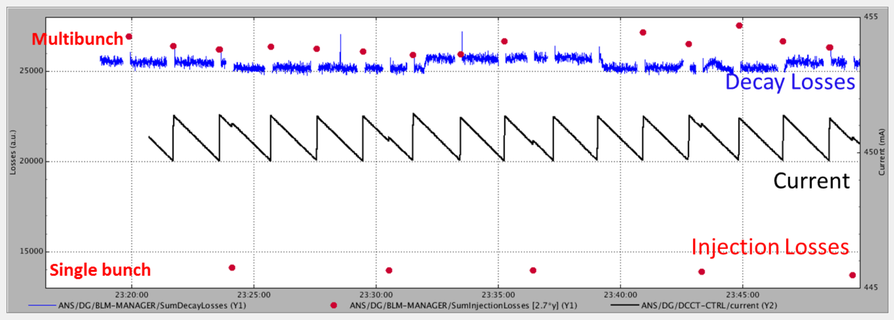
Example of installation of the BLMs in a standard cell

MEASUREMENTS WITH BEAM

Partial Loss Detection:

Sudden partial losses that may be hardly visible by eye on the DCCT (top, red) are perfectly detected and localized by the BLMs (Sum of the losses on all BLMs in blue).

BLM Management



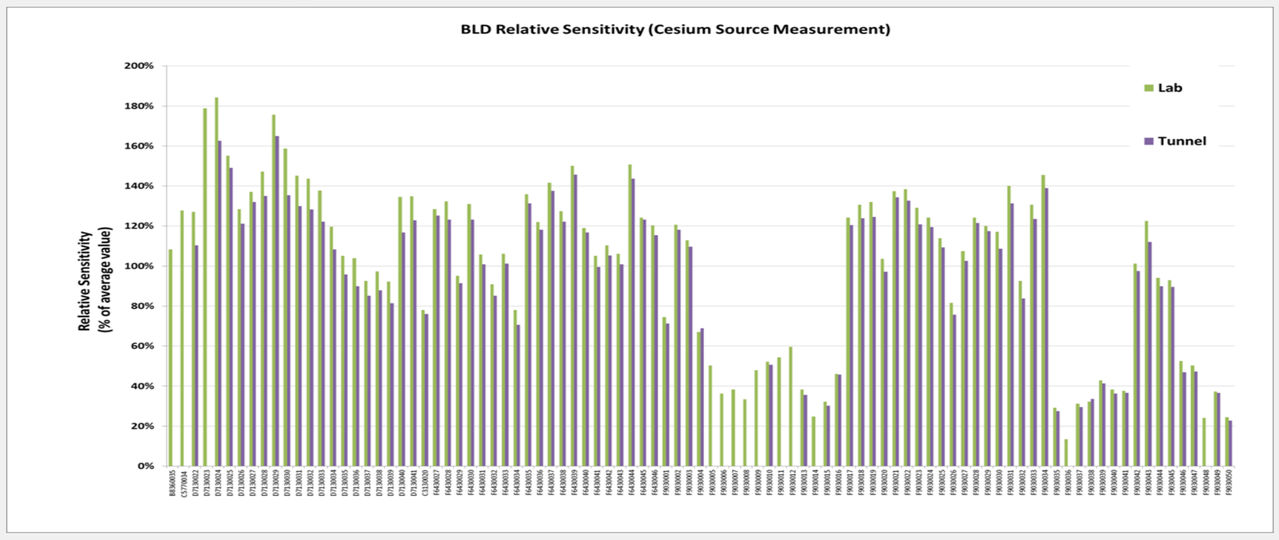
BLMs configuration is automatically switched between decay losses mode (blue) and injection losses mode (red) before and after each injection in top-up mode

RELATIVE CALIBRATION

- **Objective after calibration : < 10 % difference in detectors sensitivities.**
- Raw sensitivities of the Beam Loss Detectors (BLD) have been measured with a **cesium source** in the lab and in the tunnel. Periodic campaigns are foreseen to survey BLD ageing effects.
- Electronics errors (power supplies, attenuators) have been measured in the lab before installation.

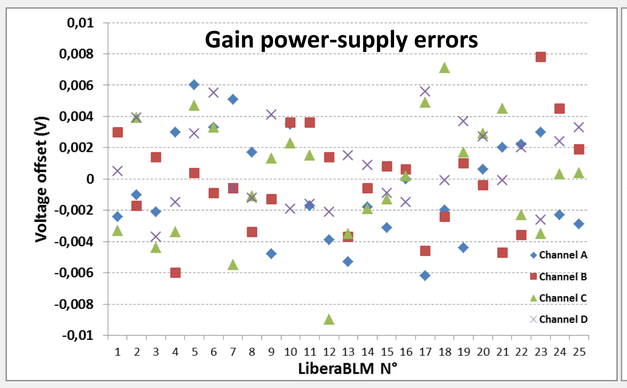
Cesium source calibration

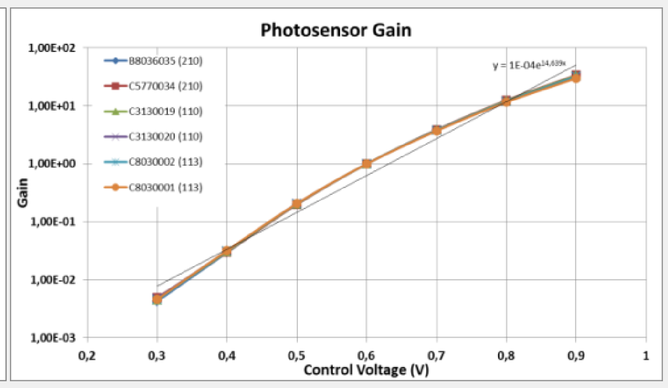
Detector Sensitivity:



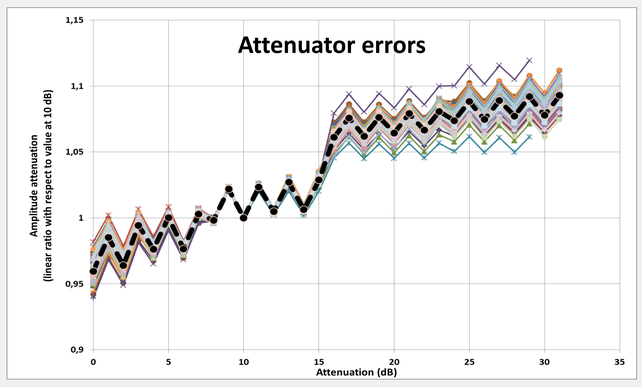
Relative sensitivity of the Beam Loss Detectors (scintillators + photosensor) measured with the cesium source in the lab. (green) and after their installation in the tunnel (purple).

Electronics Errors:





Power-supply error distribution (left). Maximum difference between 2 channels is 17 mV , inducing a ~28 % variation on the applied gain coming from the photosensor response (right). This offset is compensated by the high level application controlling BLM gains.



LiberaBLM modules provide attenuation stage with 31 dB range. Those attenuators present an error that has been measured for all channels and averaged (black curve). The pattern is very similar for all channels, leading to an error of maximum 15 % in amplitude. It will be compensated in a future release of the software by introducing a lookup table mechanism.

BLD sensitivity as well as **attenuation** and **gain compensation** are done in the electronics to provide relatively calibrated measurements.

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)

CONCLUSION

80 new Beam Loss Monitors have been installed and are now in operation on SOLEIL storage ring. Big effort has been put on their relative calibration with the objective to reach less than 10 % variation in their sensitivity (after correction). Combined with systematic placement on the storage ring, one can compare loss amplitudes at two different locations on the storage ring.

High level application are still under development but the detectors are already very useful for the operation. Those measurement will be used by the radioprotection group in order to cross check their radiation codes in the preparation of the SOLEIL upgrade.

[1] L. Torino et al. “New Beam Loss Detector System For EBS-ERSF”, IBIC2018, Shanghai

ACKNOWLEDGEMENTS

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