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New Beam Loss Monitors for SOLEIL

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Abstract

SOLEIL is currently upgrading its Beam Loss Monitor (BLM) system from pin-diode detectors to plastic scintillators associated with photosensor modules. This new kind of monitor, associated to its dedicated electronics, can be used to record slow or fast losses. Monitors have been calibrated with a diode and with a cesium source. Both methods are compared. After preliminary tests, a first set of 20 new BLMs have been installed on 2 cells of the storage ring. Installation setup, calibration procedure and first measurements are presented.

MOTIVATION

Replacement of the 36 coincidence PIN diodes on the storage ring:

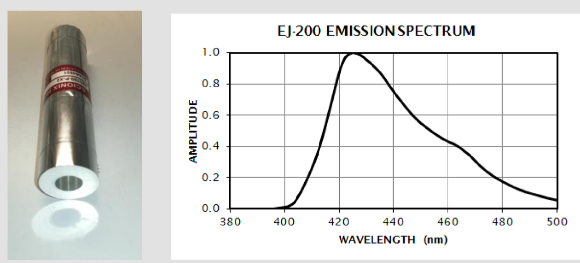
- **Slow losses only**
- **Small angle of detection**

The new system should provide:

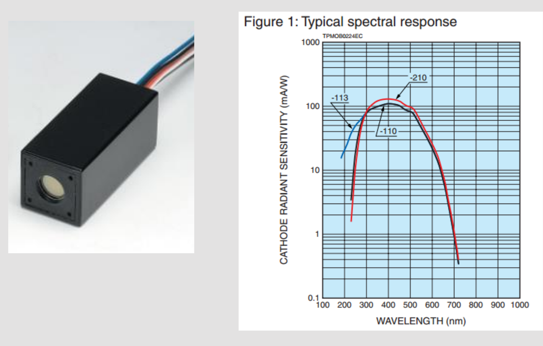
- **Good (<10% error) relative calibration between detectors to allow a comparison of the losses around the machine.**
- **Possibility to provide slow and fast losses with the same detector.**
- **Postmortem functionality**

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.

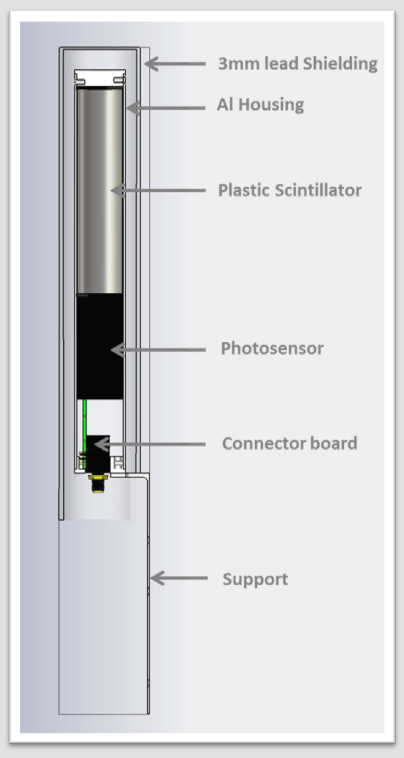


Scintillator with its emission spectrum



Photosensor and its spectral response

Libera BLM Electronics



Detector integration

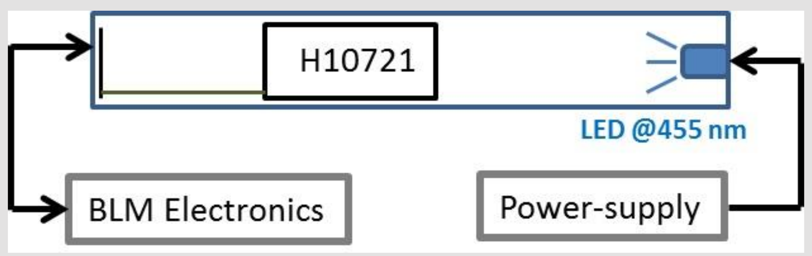
CALIBRATION METHODS

- **LED (diode) and cesium source based calibration methods have been performed and compared with photosensor manufacturer data.**
- **If some discrepancies have been found with sensitivity manufacturer data, our three measurements (LED in lab, cesium source in lab and cesium source in the tunnel) gives very good reproducibility with less that 10% variations.**
- **Sensitivity results from cesium source measurement in the tunnel are used to calculate sensitivity compensation factor.**
- **Sensitivity (BLDCalib) as well as attenuation (AT) and gain (G) compensation are done in the electronics to provide relatively calibrated measurements.**

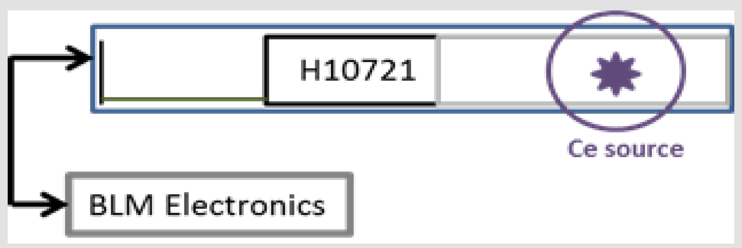
Acal = Araw x BLDCalib x G x AT

Where:

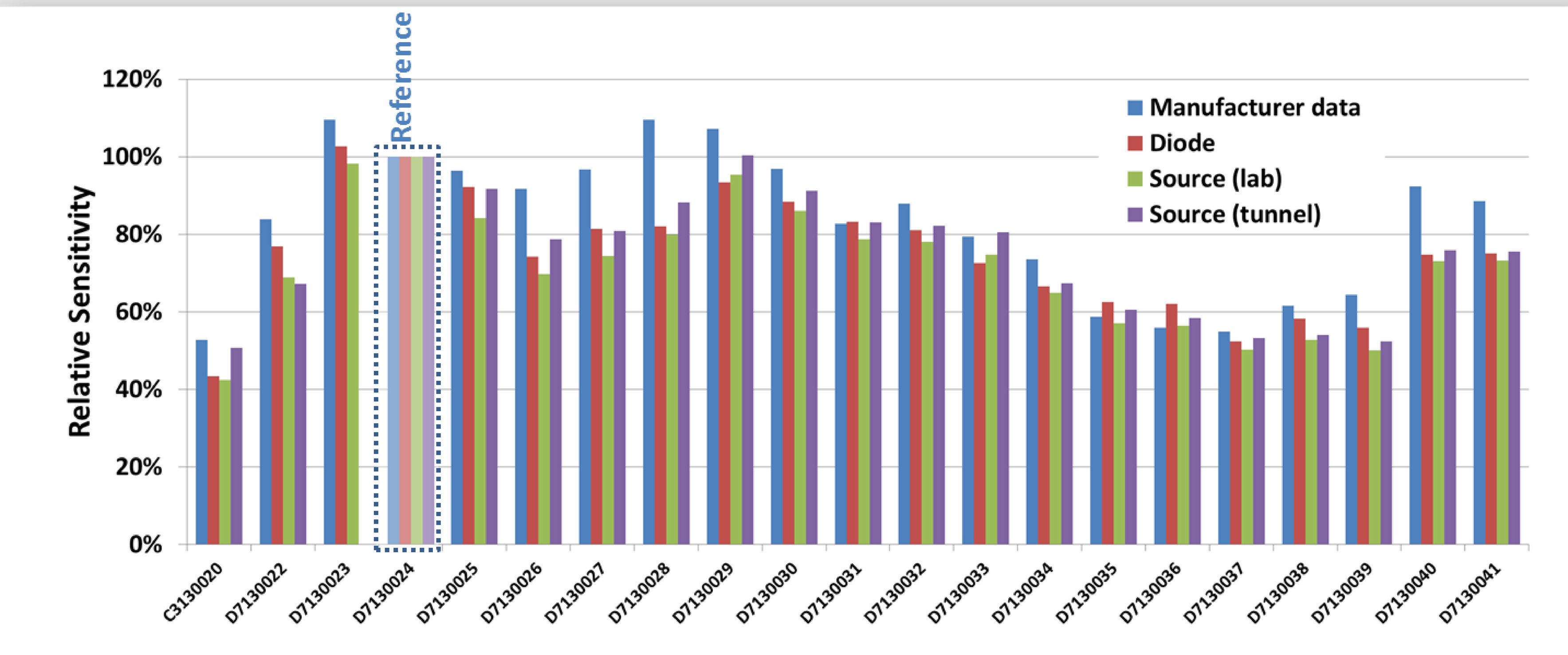
Acal	calibrated amplitude
Araw	raw amplitude (no correction)
BLDCalib	BLDCalib ... It is a calibration constant specific to each channel and the PMT.
G	It is a relative gain factor that depends on the setting of the gain control voltage.
AT	It corrects for the 10^(Att/20)



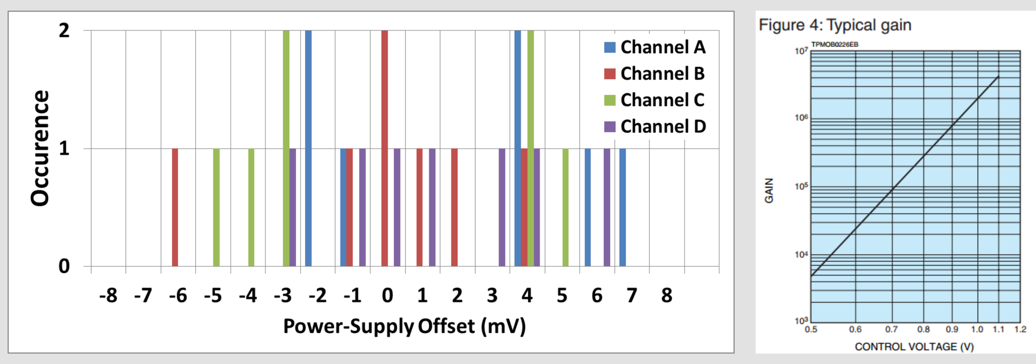
Setup for the calibration with a LED.



Setup for the calibration with a cesium source.



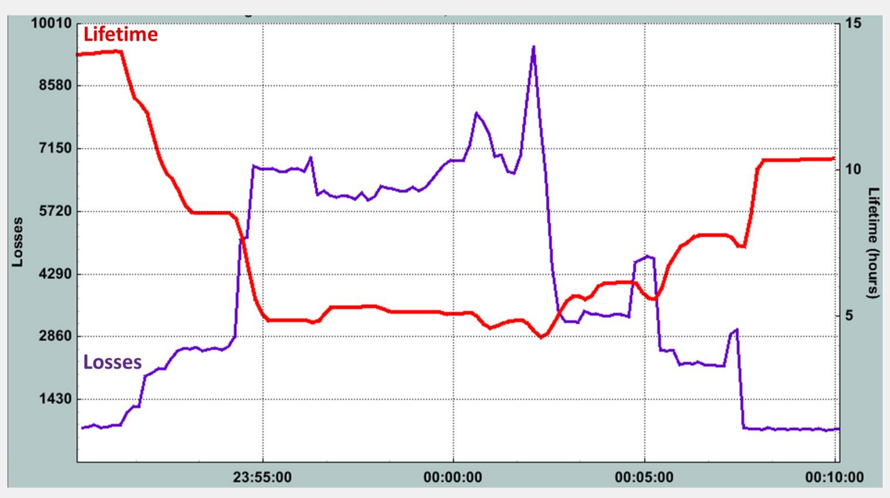
Relative sensitivity of the scintillators with their photosensor measured with the cesium source in the laboratory, in the tunnel and compared to the diode method and manufacturer data. Unit D7130024 is used as reference.



PM power-supply offset distribution. Maximum difference between 2 channels is 13 mV (left) inducing a 20 % variation on the applied gain coming from the photosensor response (right). This offset is compensated by the high level application controlling BLM gains.

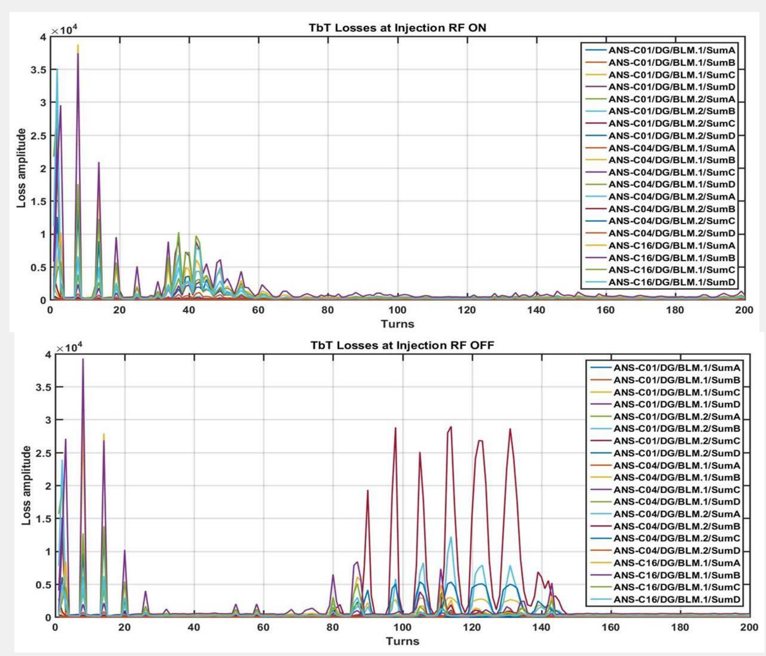
MEASUREMENTS WITH BEAM

Slow (~10 Hz) measurements

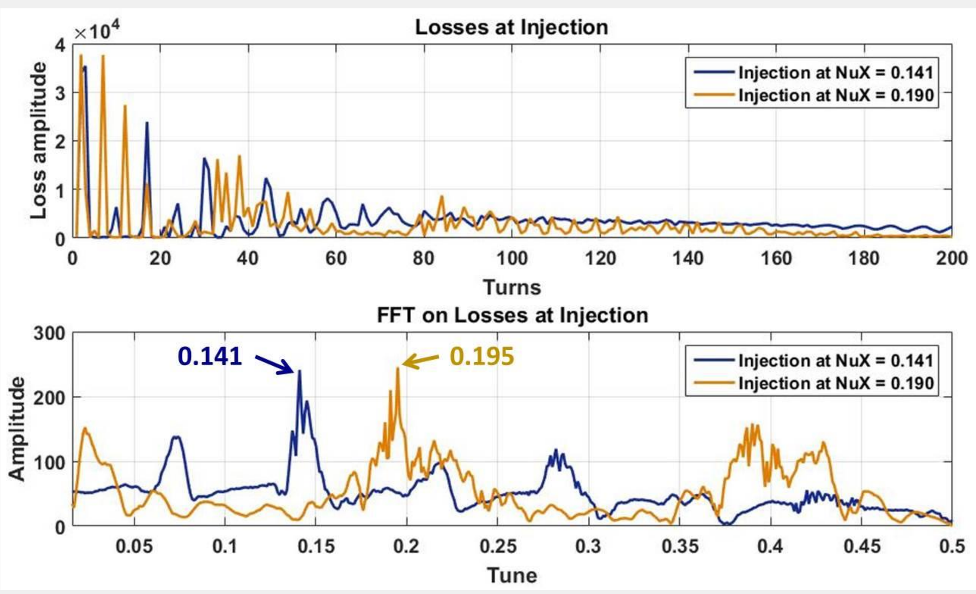


Correlation between loss measurement (purple) in slow (high impedance) mode and the beam lifetime (red) while moving one after the other the different IDs of the storage ring.

Fast (turn by turn) measurements



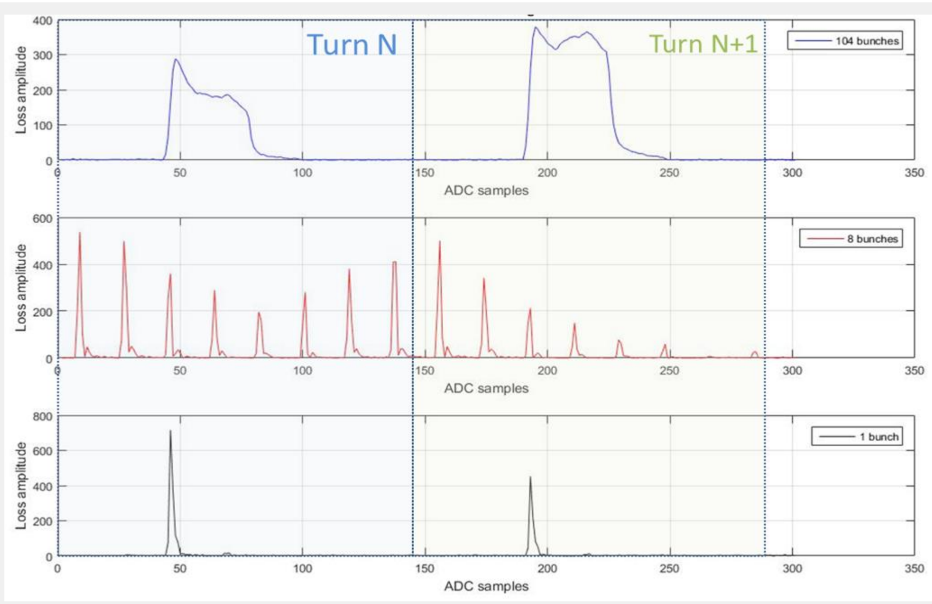
Losses measurement (turn by turn data) at injection with RF ON (top) and OFF (bottom).



Turn by turn losses at injection for horizontal tune set at 0.141 (blue) and 0.190 (orange). Taking the Fourier transform of the losses gives a maximum at the horizontal tune of the machine.

Fast (ADC) measurements

Losses measurement (ADC data) for 104 consecutive bunches (top), 8 bunches (middle) and single bunch (bottom) recorded on the BLM located in front of the vertical scraper for two consecutive turns.
With a temporal resolution of ~8 ns (limited by ADC sampling rate at 125 MHz), the new BLM system is not able to resolve bunch by bunch losses (2.4 ns spacing). Nevertheless, we can clearly correlate the losses signal to the filling pattern of the storage ring.



SUMMARY

A new BLM system, based on plastic scintillators coupled with photosensors, has been installed on two cells of SOLEIL storage ring. Two different calibration methods (with a LED or with a cesium source) have been used and their results compared to the manufacturer data. Both methods are in good agreement and the cesium source based calibration will be used as reference and repeated periodically to survey monitors ageing.

Compared to the current loss monitoring system in operation at SOLEIL, this new BLM system shows better sensitivity, lower directivity (by design) and enables measures of slow as well as fast losses (with a temporal resolution of few bunches). The next step will be the deployment of additional BLMs in all the other cells of the storage ring (4 monitors/cell in average).

ACKNOWLEDGEMENTS

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