Libera

First results of a development project for a complete Beam Loss Monitoring system

Peter Leban, May 28, 2015

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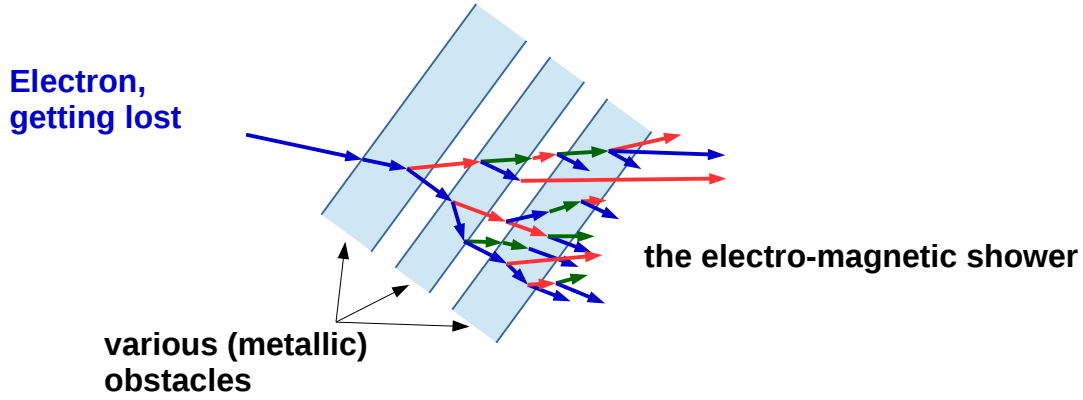
Beam loss

Particle is considered lost if it doesn't follow design trajectory and interacts with matter.

Loss can be:

- **Intentional: anything put in the beam trajectory on purpose**
- **Unintentional but regular: instabilities, beam size, halo scraping, residual gas scattering**
- **Unintentional and irregular: usually makes damage**

Courtesy of A.Zhukov, ORNL



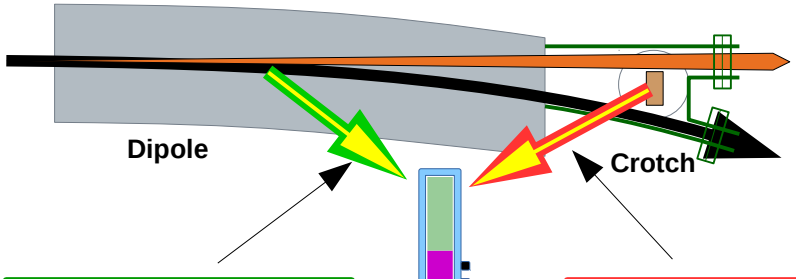
Detectors

Ionization chamber

PIN diodes

Diamond detectors

Scintillator + Photo Multiplier Tube (PMT)



The GOOD signal for a BLD

e-m shower of energetic particles, resulting from an electron crashing on the inside of Dipole chamber

Signal to be avoided

Back-scattered particles, resulting from synchrotron light hitting the absorber

Courtesy of K.Scheidt, ESRF

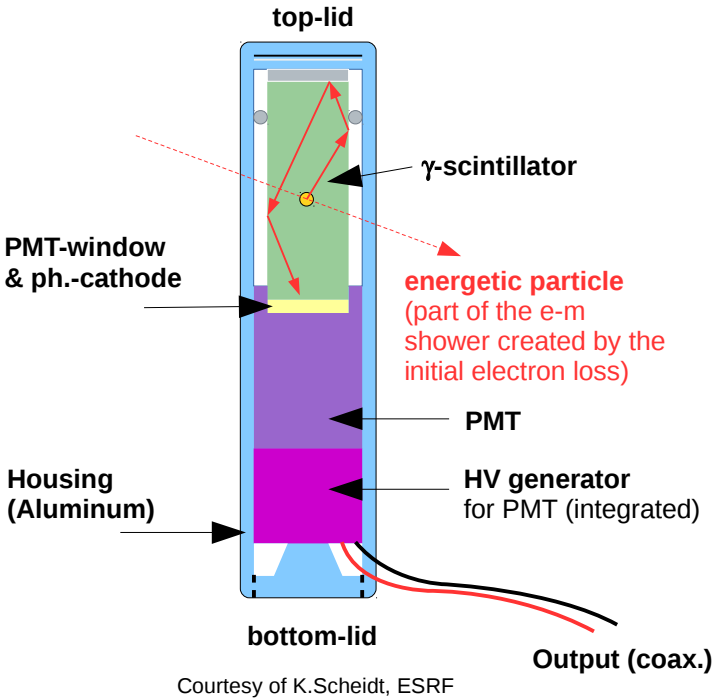
Compact detector at ESRF

Length: from 25 cm

Integrated PMT (Hamamatsu)

Optional Lead shield to stop the X-Rays

Compact and robust design



Courtesy of K.Scheidt, ESRF

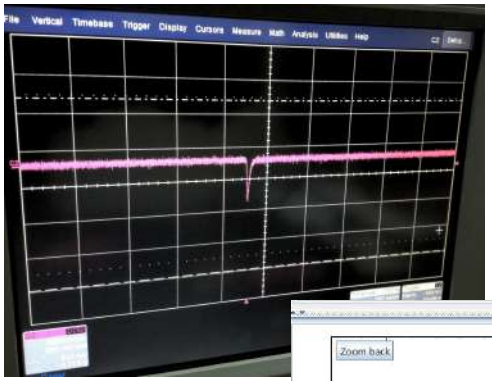
Existing electronics

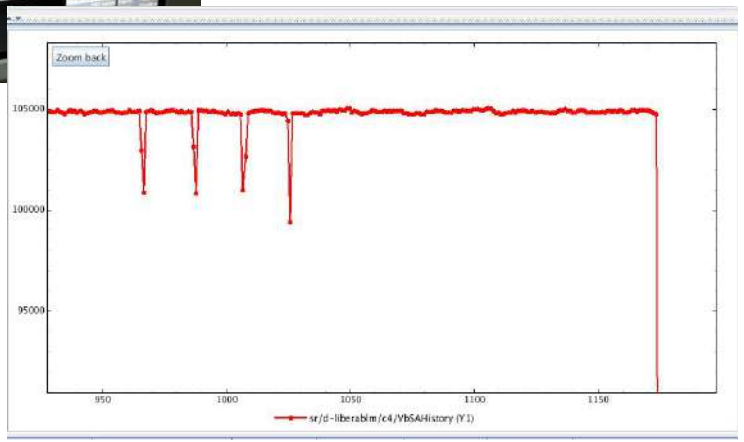
Oscilloscope

… various digitizers (fast, slow)

Other laboratory and industrial solutions

+ Libera BLM prototype (in 2011)





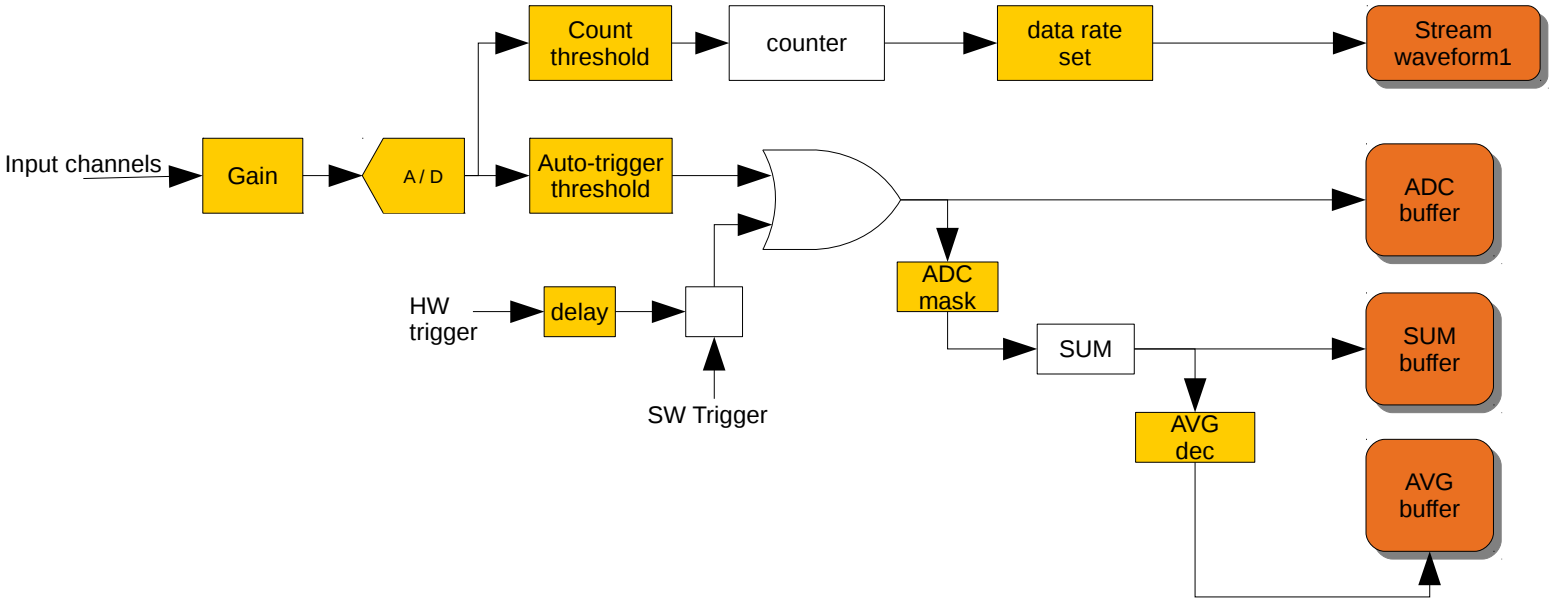
Proposed electronics

Count mode is not able to evaluate fast and big losses. More details about the loss is required.

New electronics should have at least these properties:

- Selectable input impedance: *(50 Ω or 1 MΩ)*
- Configurable input gain: *(±30 mV to ±1 V)*
- Fast time resolution: *(125 MHz 14-bit sampling)*
- Configurable processing for immediate results
- Built-in power supply for PMT and gain control

Processing scheme



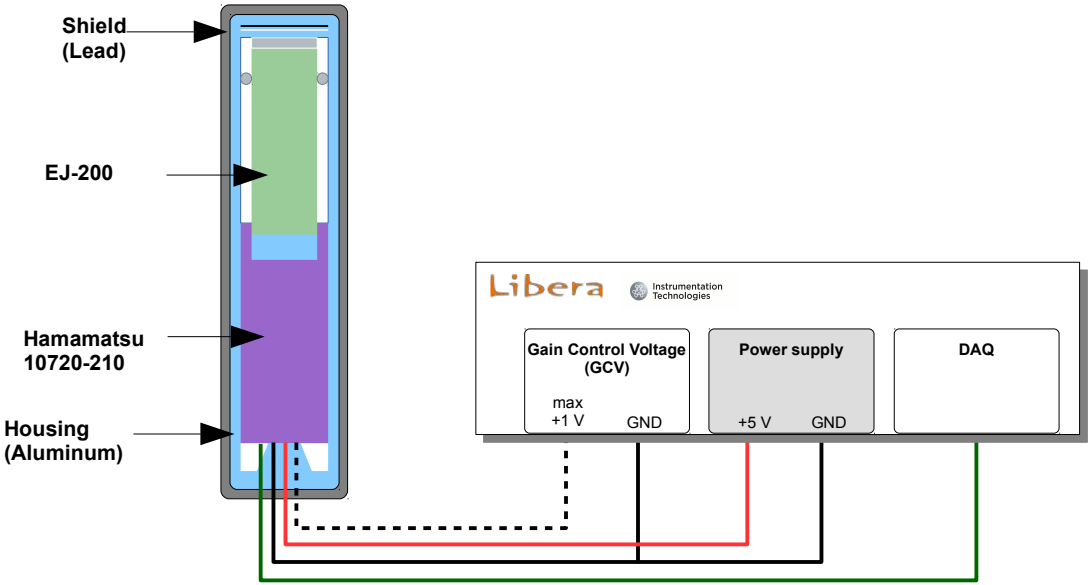
Processing scheme – details

Data path	Sampling rate (S/s)	Buffer size
ADC	f_{ADC}	16 M
SUM	$\frac{f_{ADC}}{SUM\_DEC}$	8 M
AVG	$\frac{f_{ADC}}{(SUM\_DEC * AVG\_DEC)}$	8 M
Stream	Selectable interval	/

$$\text{SUM amplitude} = \sum_{i=1}^{ADC\_MASK} x_i$$

$$\text{AVG amplitude} = \frac{1}{AVG\_DEC} \sum_{j=1}^{AVG\_DEC} SUM\_amplitude_j$$

The system



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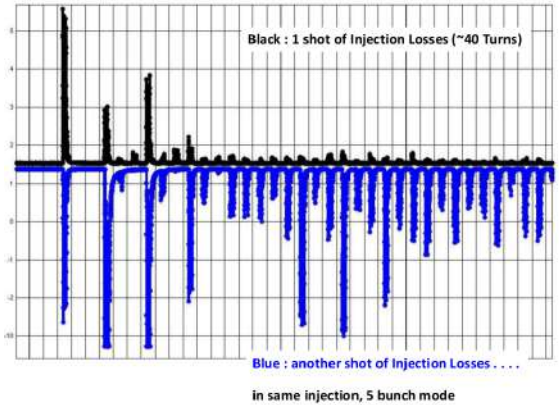
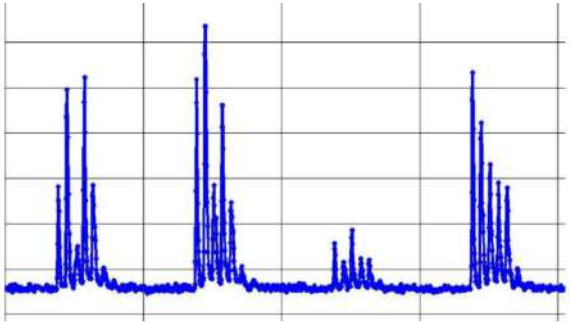
Results at ESRF (1)

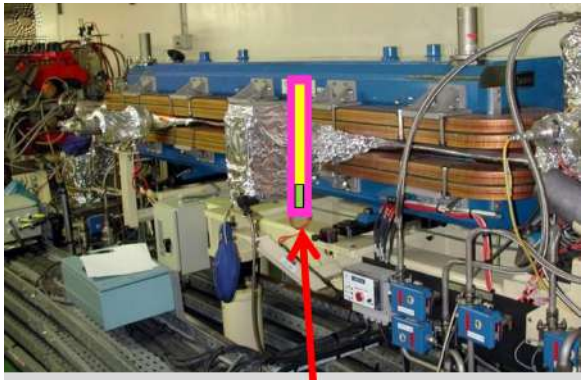
Fast and big losses at injection



Turn-by-turn, shot-to-shot



Bunch-to-bunch, turn-by-turn

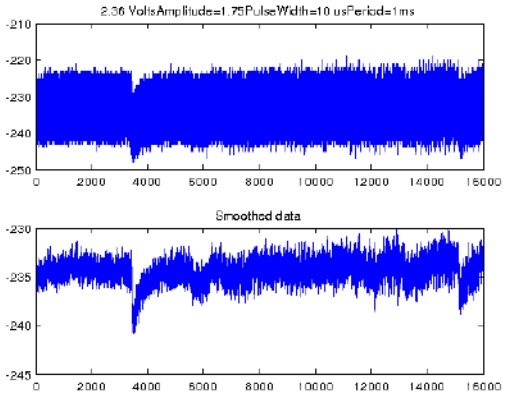


Installation behind the dipole

Courtesy of K.Scheidt, ESRF

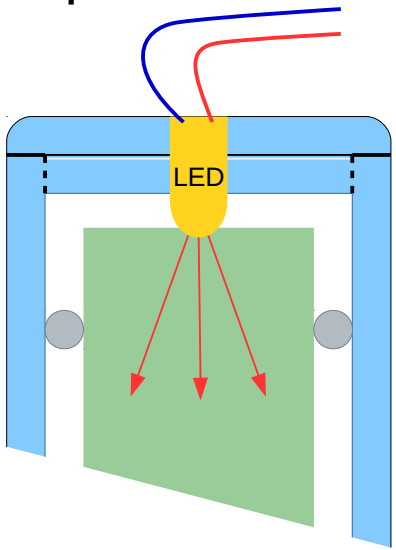
Results at ESRF (2)

Test with LED diode & pulse generator

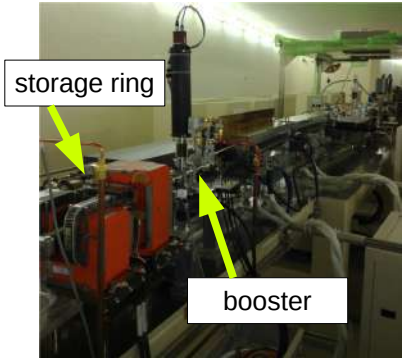


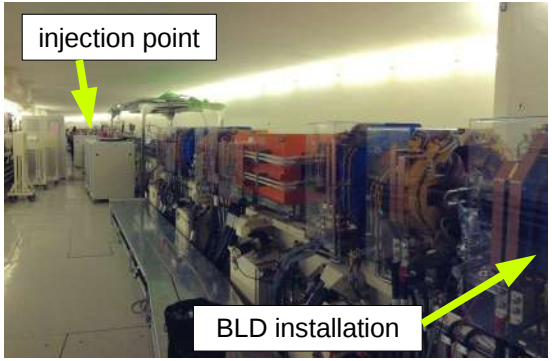
»Single-photon detection«

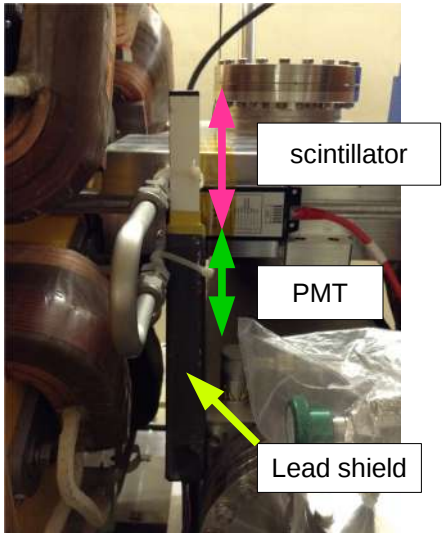
top-lid with LED



Results at TPS (1)







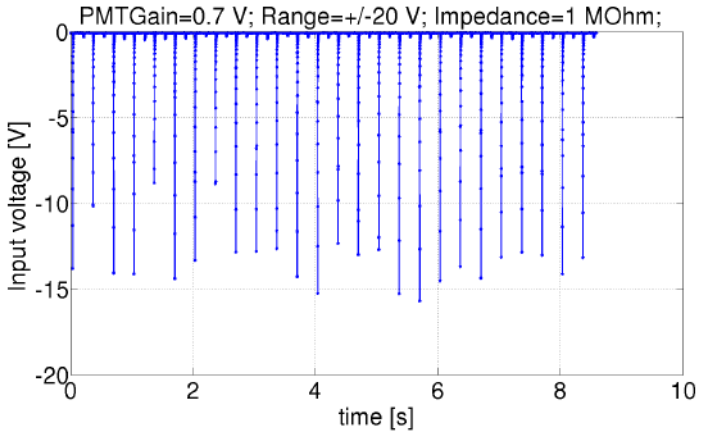
If Lead shield protects only the PMT, higher sensitivity to losses is expected.

Results at TPS (2)

Not synchronized with injection trigger. Input impedance set to High-Z.

3 injections per second are clearly visible, they show big losses but not in fast time resolution (due to High Z).

High averaging is used (65536)



3 injections per second

Conclusion

Libera BLM electronics will ship-out November 2015.

Detectors are offered optionally. Hamamatsu 10721 + EJ-200 scintillator are default choice.

Default processing scheme can be improved / edited by users.

Requests from other laboratories for higher sampling rates and postmortem capability

Many thanks to Kees Scheidt for thorough explanations, continuous support and beam tests.