Progress with various studies & applications of Beam Loss monitoring in EBS

ESRF, DIAG group, E. Buratin

Outline

1) The **ESRF complex** & the **Beam Loss Detectors** (BLDs)

2) **Slow Losses** in the **EBS machine**

3) **Injection Losses** in the **EBS machine**

4) BLDs signals vs **other diagnostics** in the EBS machine

5) **Injection Losses** in the **Booster**

6) **Conclusions**

1)The ESRF complex

EBS parameters in User-mode:

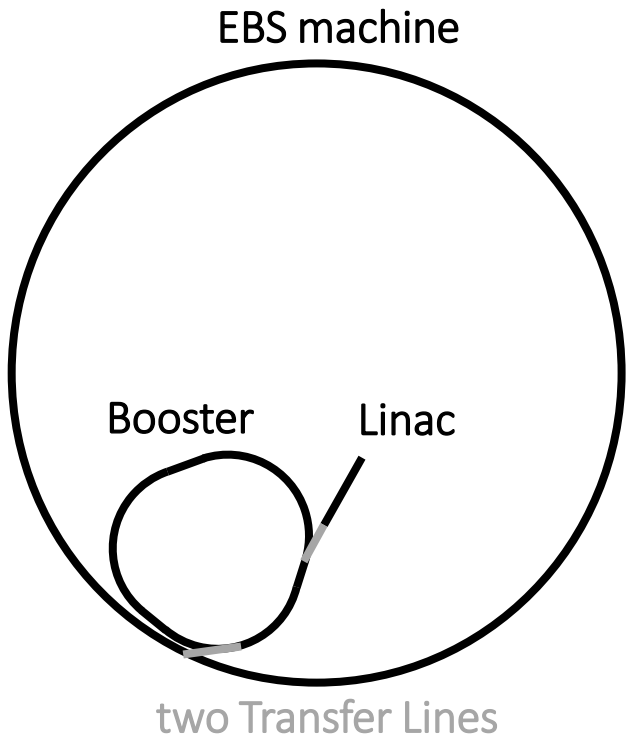
- Circumference = 844 m
- Beam energy = 6 GeV
- Beam current = 200 mA
- Typical lifetime = 20h

➡
- $3.5 \cdot 10^{12}$ electrons
- $4.9 \cdot 10^{7}$ lost electrons/second

At injection:

- 0.5 mA/shot
- 80% injection efficiency

➡
- $1.8 \cdot 10^{9}$ lost electrons in around 2-3 ms



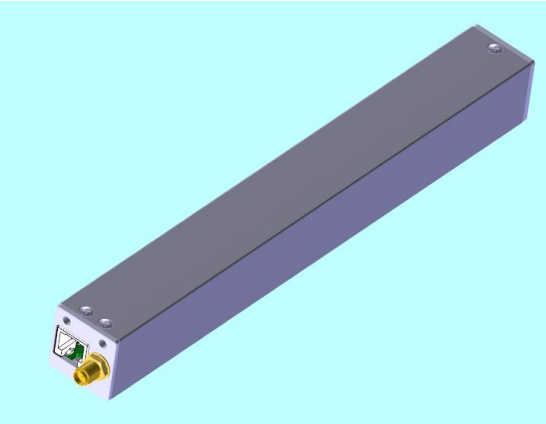
1) The Beam Loss Detector (BLD)

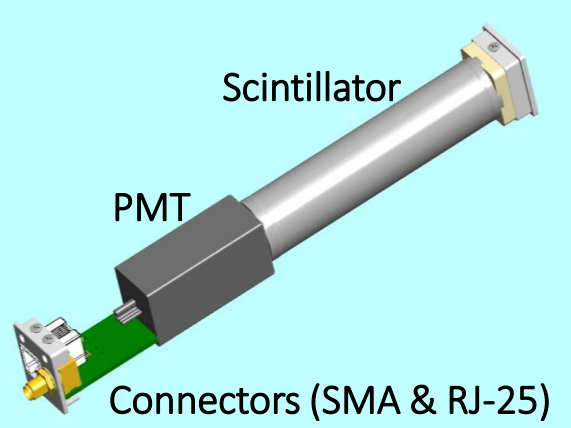
- 128 BLDs in the EBS machine + 4 additional BLDs near the RF cavities
- 4 BLDs in the Transfer Line TL2
- 8 BLDs in the Booster

➡ We have 144 Beam Loss Detectors (BLDs) with a 3-mm lead shielding to stop Synchrotron Radiation to measure electron losses only

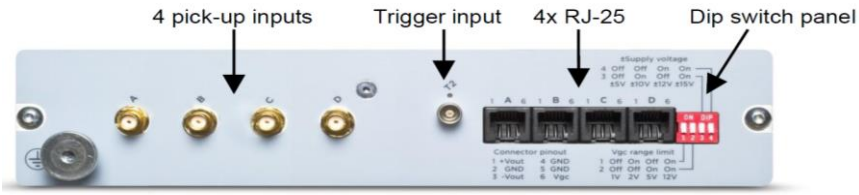
We can use them in:

- Slow mode (1 MΩ termination) during the **User-mode**
- Fast mode (50 Ω termination) during the **injections**





Beam Loss Monitor (BLM)

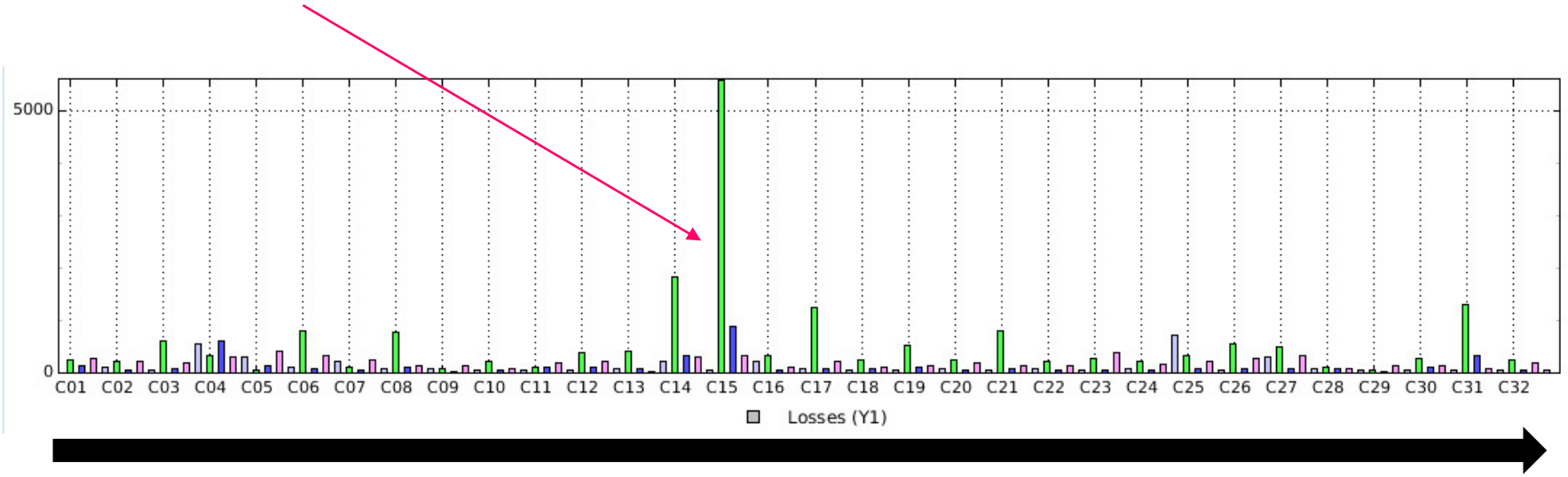


2) Slow Losses in the EBS

During User-mode

The distribution of the slow losses is shown for a 4-bunch user-mode. The filling pattern and the gaps of the Insertion Devices (IDs) influence the loss distribution.

In this case, ID15 has the smaller gap, therefore the higher losses.

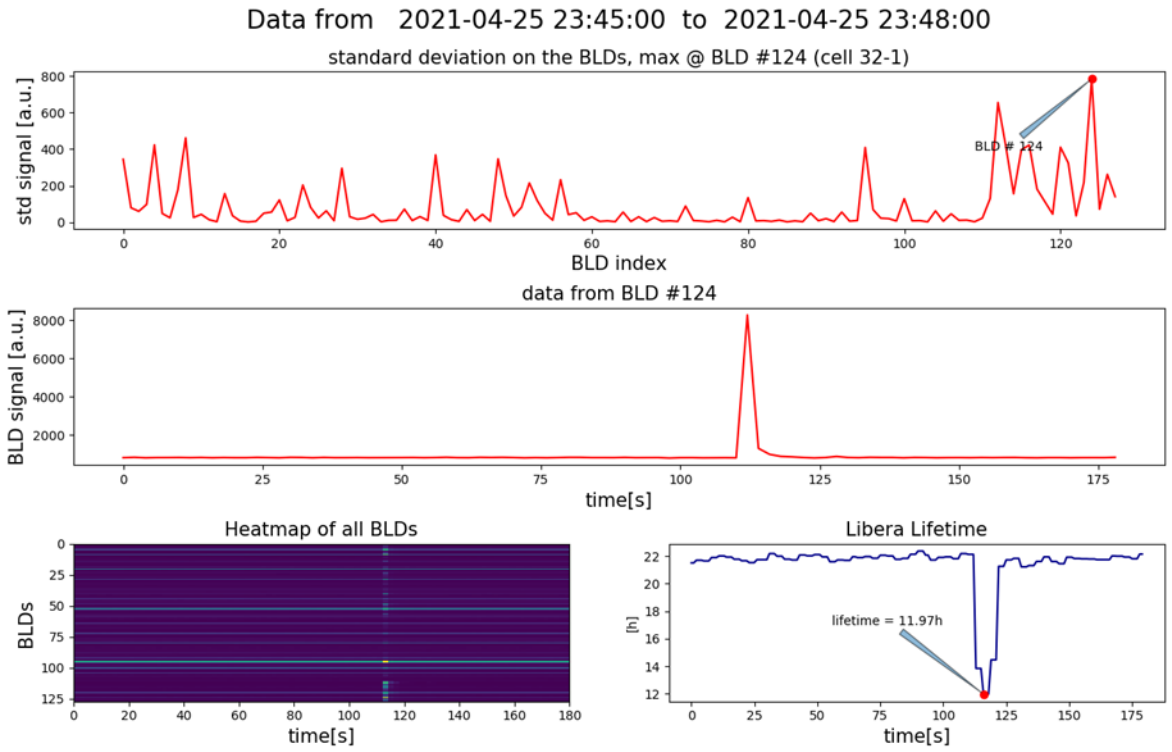


32 cells along the ring, each cell has 4 BLDs

2) Slow Losses in the EBS

During User-mode

Lifetime accidents can occur. We see **beam losses** and vacuum degradation along the ring.



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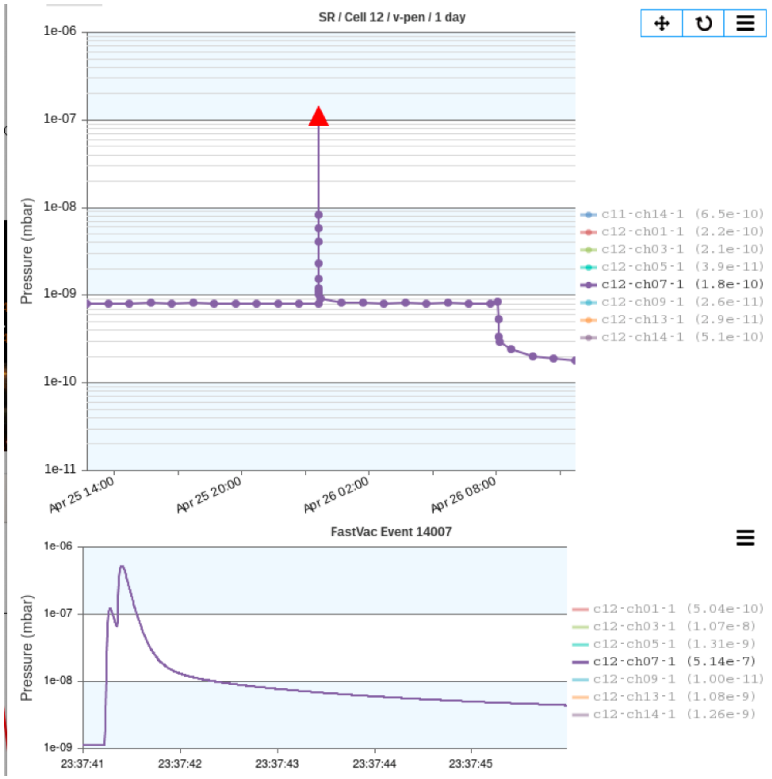
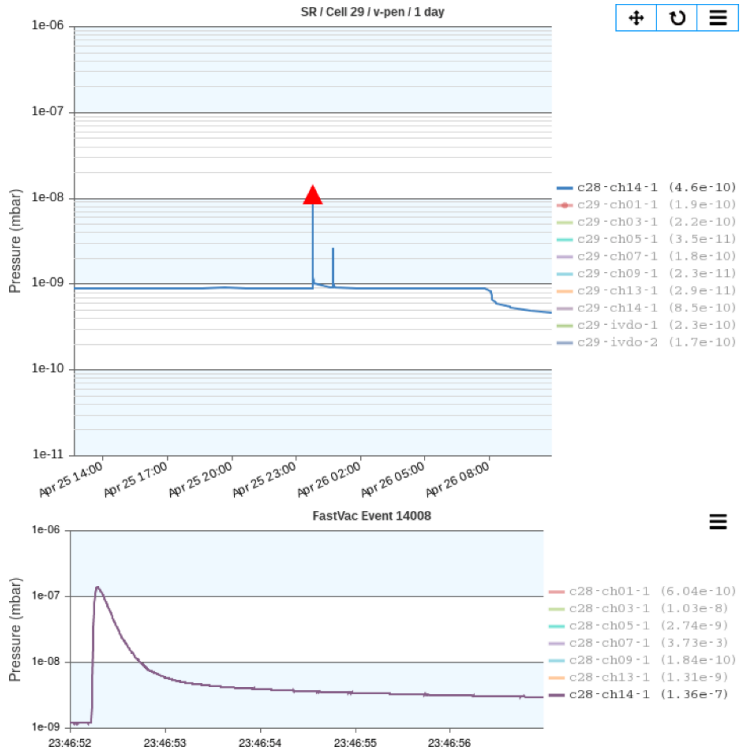
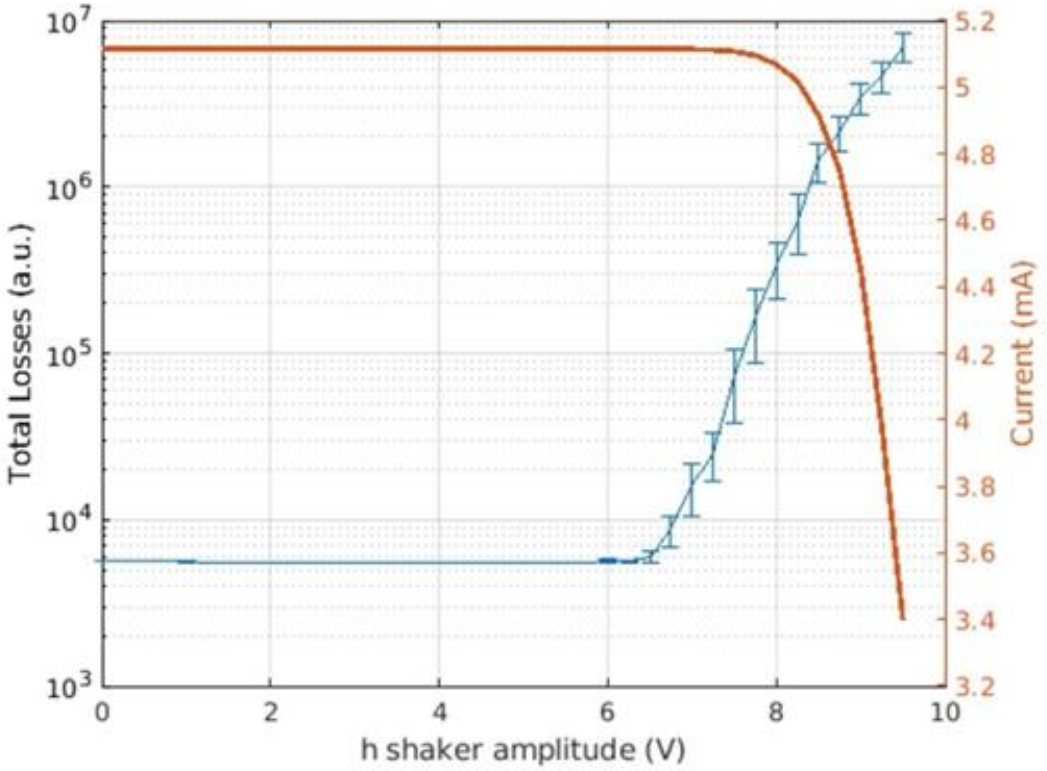




2) Slow Losses in the EBS

During Machine-Dedicated-Time

BLDs are particularly useful for machine studies and optimizations.
Losses distribution as a function of the **horizontal shaker**, with a 5 mA beam and no aperture limitations (scrapers, collimators, IDs open),

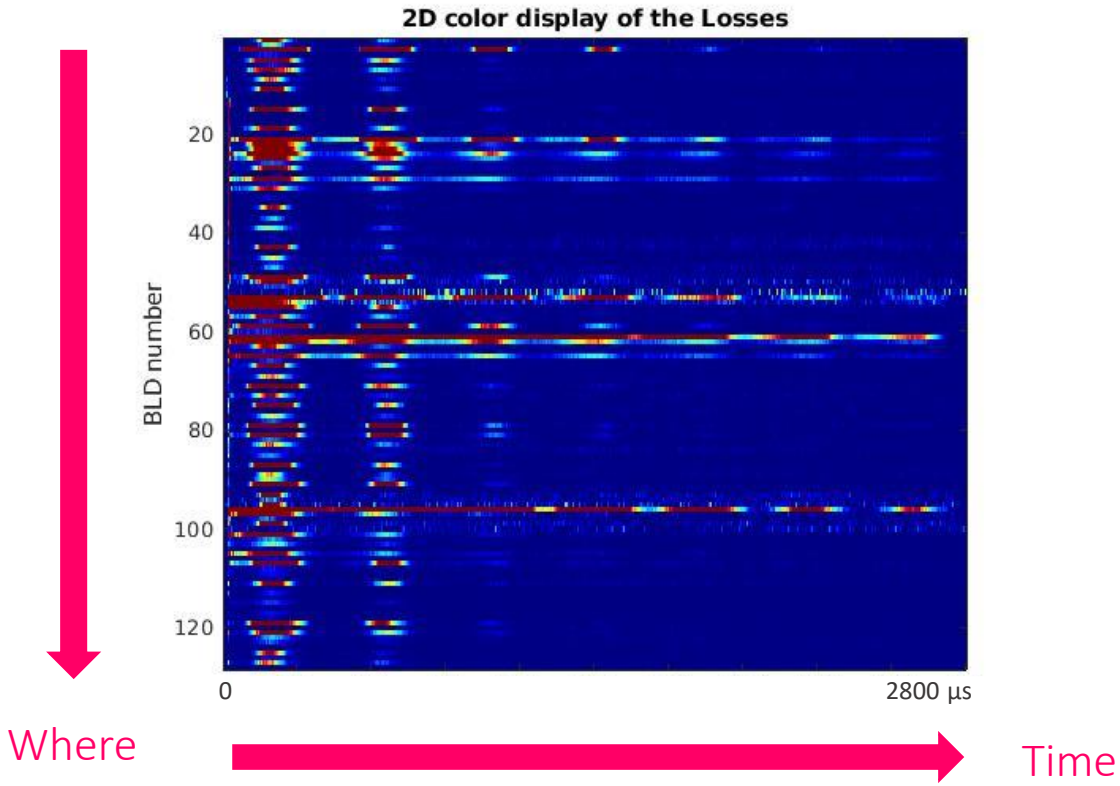


MDT study performed by the Beam Dynamics colleagues (N. Carmignani, S. Liuzzo, L. Hoummi, P. Raimondi)

3) Injection Losses in the EBS

128 signals around the machine

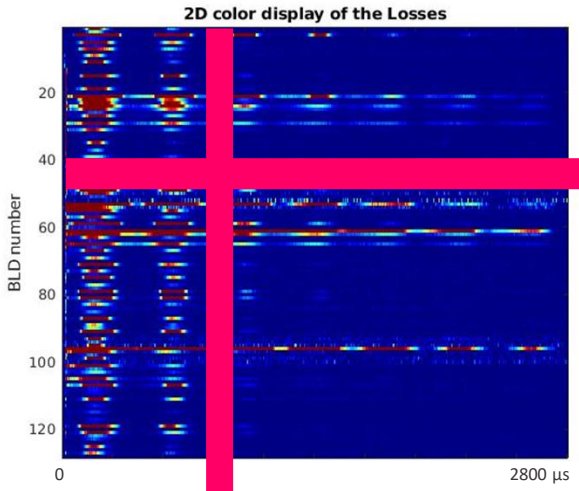
At injection, the **fast mode** (50 Ω termination) gives two essential informations: where the losses occur and the time domain.

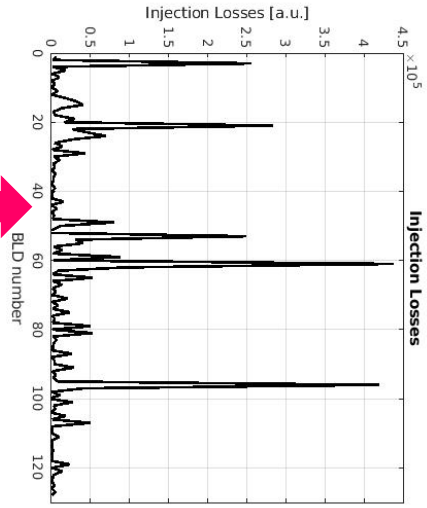


3) Injection Losses in the EBS

128 signals around the machine

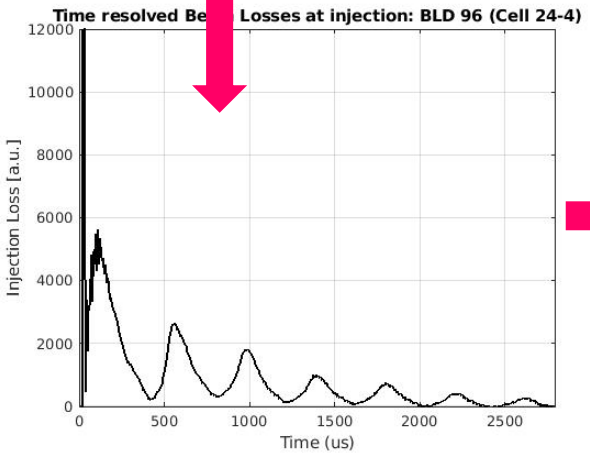
2D color map: space and time distribution





Injection Losses: integral of each BLD in time

Time resolved Beam Losses: evolution of the losses in time



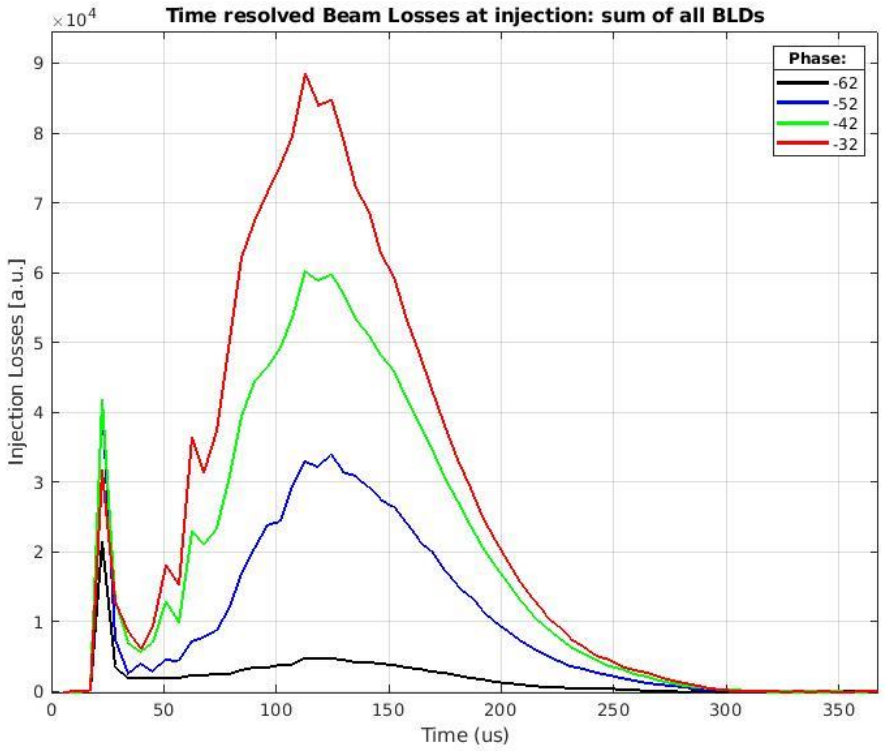
Total Injection loss: a representative value of the total losses in space and time

3) Injection Losses in the EBS

Time resolved Beam Losses

As a function of the phase of the Booster with respect to EBS:

- When we degrade the optimum phase, the losses increase



4) BLDs vs other diagnostics

Total Injection Losses (BLDs) vs Lost Current (Transfer Efficiency System)

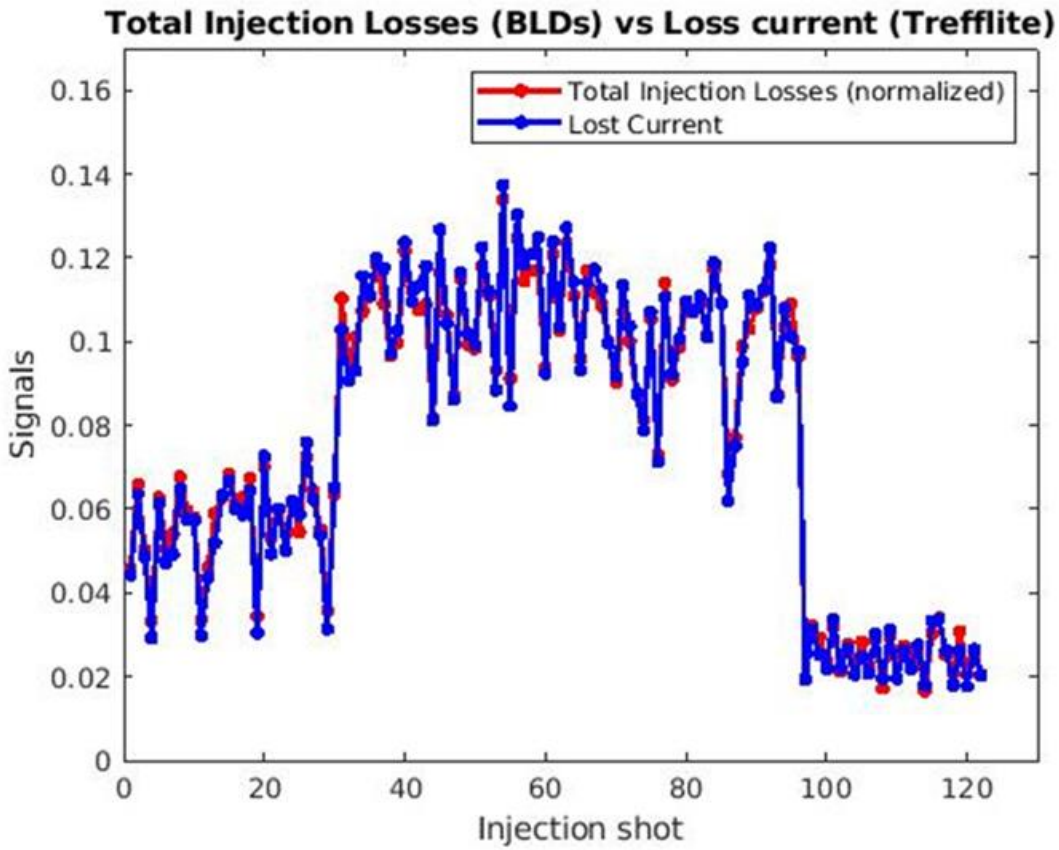
Excellent correlation between **Lost Current** measured with the Transfer Efficiency System and **Losses** (BLDs) recorded by two totally different systems.

$$I_{lost} = I_{extracted}(1 - \eta)$$

Lost current during injection

Extracted current from the Booster

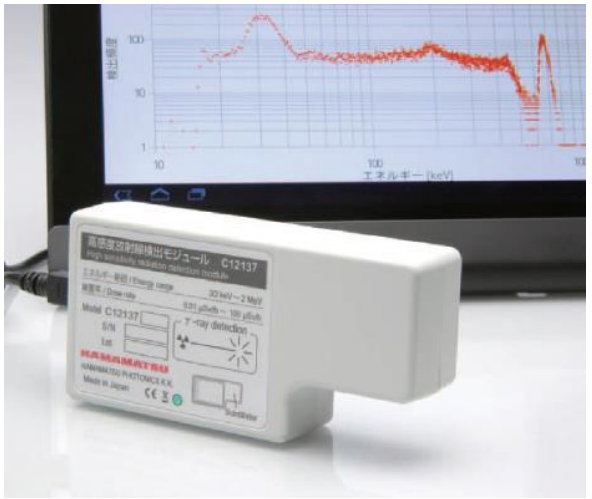
Injection efficiency



4) BLDs vs other diagnostics

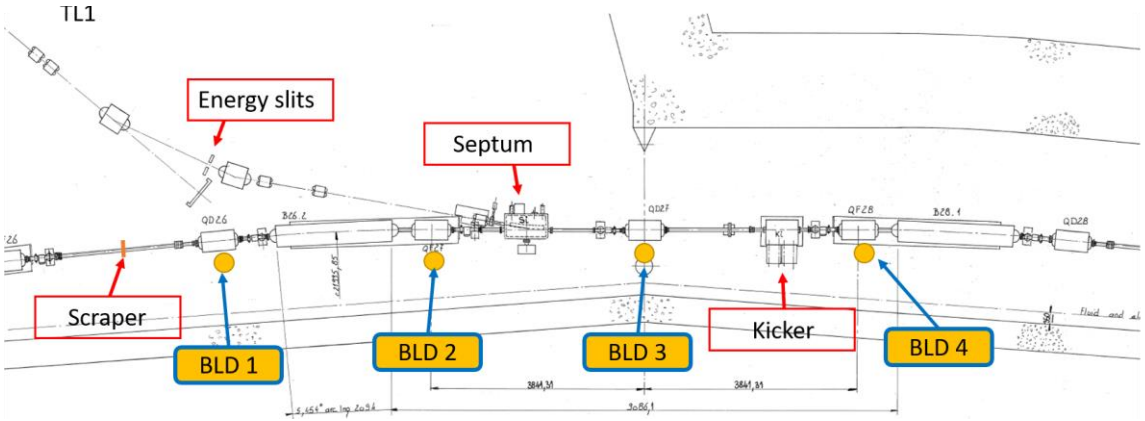
Total Injection Losses (BLDs) vs Energy Spectrum of the Losses (Radiation Detector)

- The lead-shielded BLDs see only the **electron losses**.
- The Radiation Detector (Hamamatsu – c12137) measures the **energy spectrum** of the hitting radiation. The energy spectrum is linked to several phenomena, such as **Synchrotron Radiation**, **multipactoring on the RF cavities**, **electron loss**, etc.
- Analysis are on-going, the preliminary results are promising.



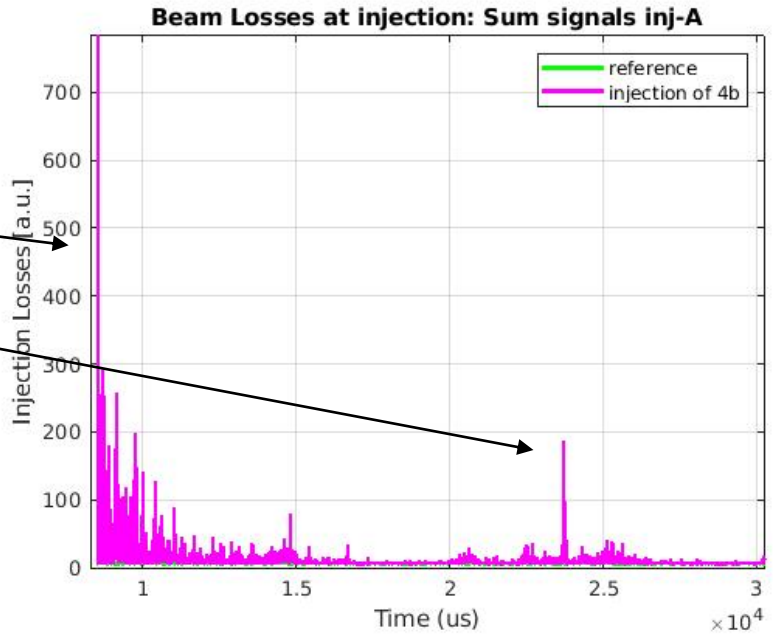
5) Injection Losses in the Booster

4 BLDs in the **injection** section of the Booster



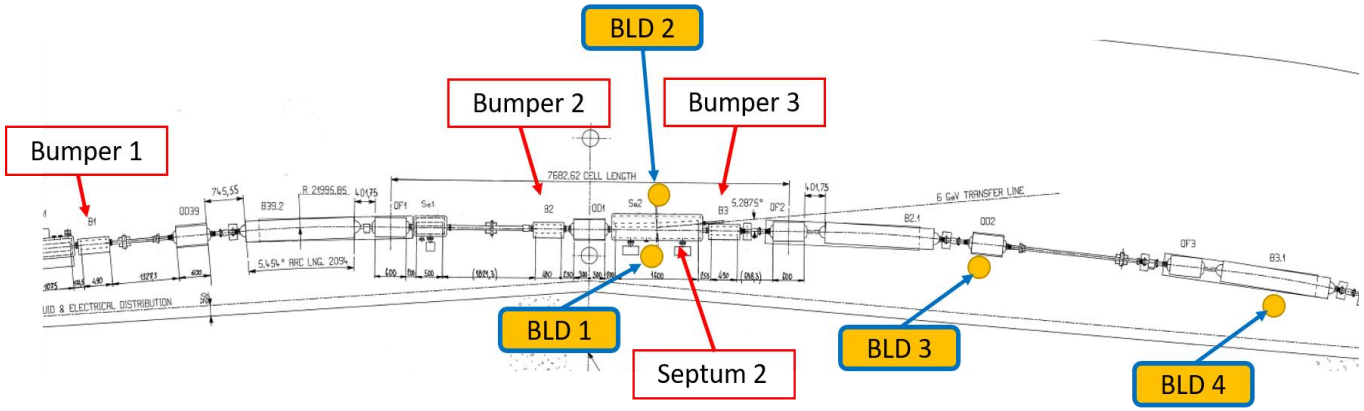
The losses in the injection zone:

- **Injection process** (8.5 ms)
- **Bunch cleaning** using the scraper (20-26 ms) that provides high bunch purity between bunches



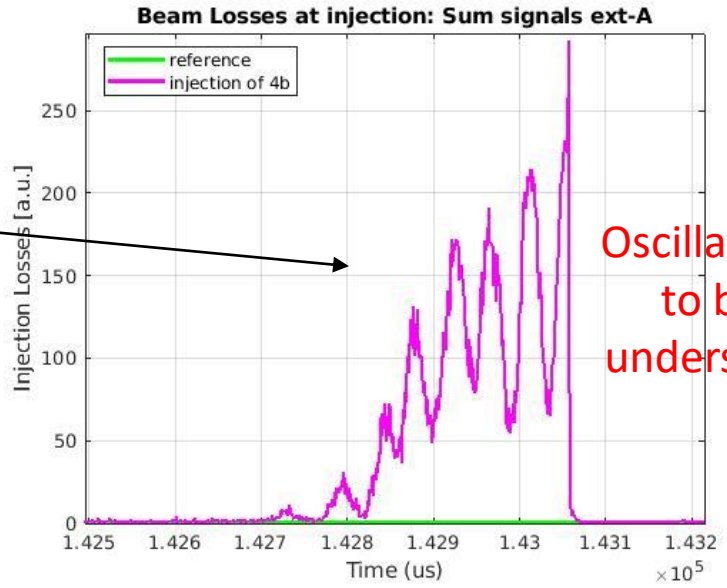
5) Injection Losses in the Booster

4 additional BLDs in the **extraction** section of the Booster



The losses in the extraction zone:

- **Extraction process** into the EBS machine (around 143 ms)



Oscillations to be understood

6) Conclusions

At ESRF, 144 BLDs are now configured in a more optimum manner in the EBS complex.

They have been **more intensively & systematically used** to show their strong potential in understanding the nature, **distribution and amplitude of the beam losses**.

The **time-resolved injection losses** are now available. Their results **agree well with other diagnostics**.

The BLM system is a **useful** tool during the **commissioning of a new ring**, **the User-mode operation** and **for specific accelerator studies**. They are an essential diagnostics in a modern light source.