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# NEW APPLICATIONS AND STUDIES WITH THE ESRF BEAM LOSS MONITORING AT INJECTION

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ESRF The European Synchrotron

ESRF-EBS Extremely Brilliant Source

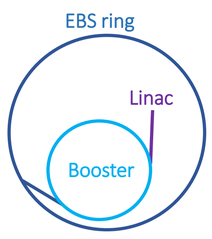
**Abstract**

More than one year after the commissioning of the ESRF's new Extremely Brilliant Source (EBS), the Beam Loss Detectors (BLDs) are continuing to be used for extensive applications and studies, notably at injection. A total of 144 BLDs and 36 associated Libera Beam Loss Monitors (BLMs) are distributed in the EBS ring and the Booster. These BLDs allow to measure slow losses during user-mode operation and fast losses at injection, with a sub-orbit-turn time resolution. In this paper these fast beam loss dynamics are presented at injection for different lattice parameters, collimator-settings and beam conditions. We will also show the excellent correlation with results obtained from the injection efficiency diagnostic and the bunch length acquired with the Streak Camera.

## 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:**

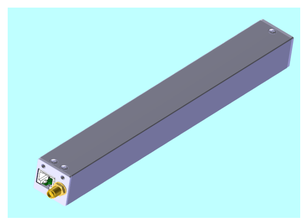
- 0.5 mA/shot
- 80% injection efficiency
- $1.8 \cdot 10^{9}$ lost electrons in around 2-3 ms

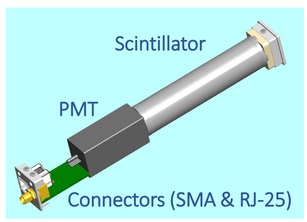
## The Beam Loss Detectors (BLDs)

- 128 BLDs in the EBS machine
- 8 additional BLDs for dedicated studies
- 8 BLDs in the Booster
- a 3-mm lead shielding to stop Synchrotron Radiation and to measure electron losses only

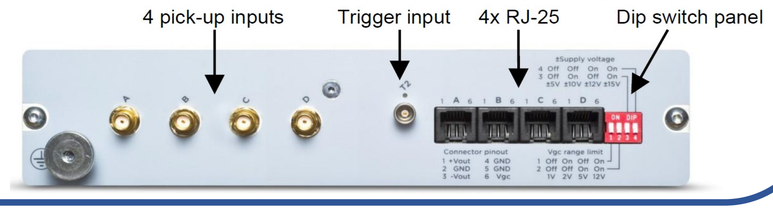
We can use them in:

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



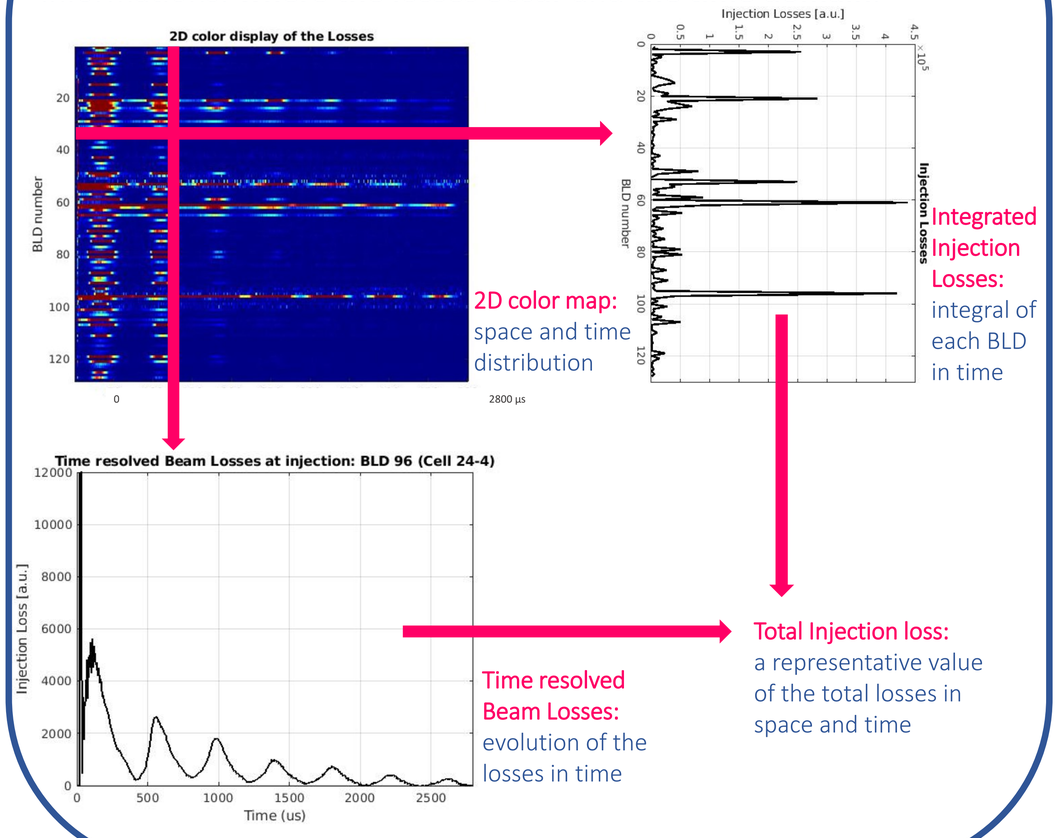



### The Beam Loss Monitor (BLM)




## Injection Losses in EBS

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




2D color map: space and time distribution

Integrated Injection Losses: integral of each BLD in time

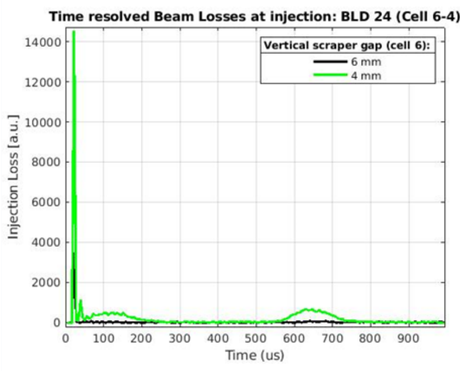
Time resolved Beam Losses: evolution of the losses in time

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

## Machine parameter optimization

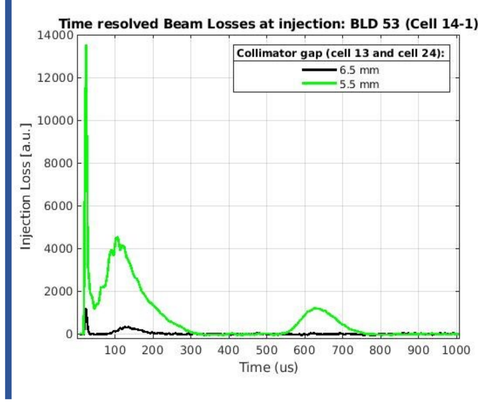
### Loss evolution as a function of the vertical scraper aperture

- The smaller the vertical aperture, the stronger the losses after the scraper.



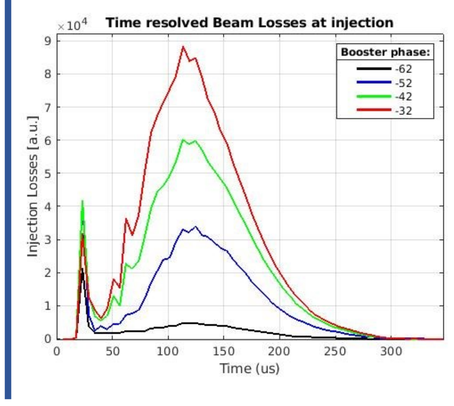

### Loss evolution as a function of the collimator aperture

- The losses drastically change below a 6 mm gap.




### Study as a function of the phase of the Booster with respect to EBS:

- When we degrade the optimum phase, the losses increase.




Therefore, the BLDs fast losses can be an extremely useful measurement to help improving the performance of the injection process.

## BLDs vs other diagnostics

### BLDs vs Streak Camera

The injected bunch length (measured with the Streak Camera) is influenced by several parameters.

The time evolution of the **bunch length oscillates** after injection for few milliseconds.

The oscillations have 0.4 ms periodicity, as the BLDs show on the time-resolved beam losses (see above).




### BLDs vs Transfer Efficiency System

The Transfer Efficiency System measures both the current in the Booster (B) and the added current in the EBS (E).

Next to monitoring the injection efficiency (the division of E with B), it can also calculate the **Lost Injected Current**, which is simply B-E.

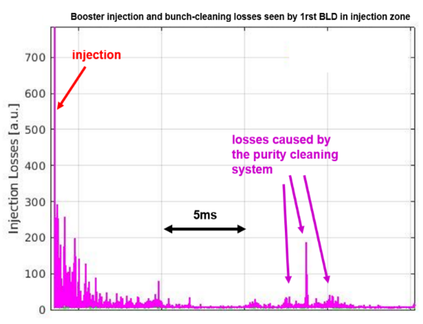
The **Total Injection losses** measured with the BLDs agree with the Transfer Efficiency System.



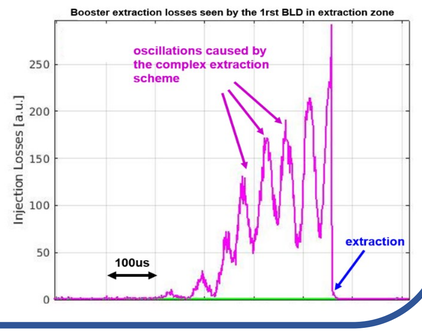

## Injection and extracted losses in the Booster

4 BLDs are positioned in the **injection zone**. At injection, two events are visible on this BLD:

the **injection process** and the **bunch cleaning** (15 ms after the injection). This cleaning system uses a scraper to remove electrons from RF-buckets that must be fully empty for experimental requirements.




4 additional BLDs are positioned in the **extraction zone.** Strong losses are visible during the Booster **extraction process**. They starts at about 400 us before extraction, with oscillatory behaviour caused by the complex extraction scheme involving 3 slow bumpers, one pulse septum magnet and one fast extraction kicker. New tests and studies are planned.




## Conclusions

At ESRF, the BLDs have been intensively and systematically used in EBS, especially at injection. The time-resolved injection losses can be used to **optimize the machine** during the Machine Dedicated Time (MDTs). These fast losses **agree well with other diagnostics**, such as the Transfer Efficiency System and the Streak Camera. In the Booster, the BLDs can **identify the injection**, the **bunch cleaning** and the **extraction processes**.