The European Synchrotron

Beam Instrumentation Performances through the ESRF-EBS Commissioning

Laura Torino
On behalf of ESRF diagnostics group

International Beam Instrumentation Conference
14-18 September 2020, Remote

Extremely Brilliant Source – EBS

The aim of EBS is to increase the source **brilliance** and the **coherent fraction**
→ **Hybrid Multi-Bend Achromat Lattice**

Requests:

- Reduce the horizontal equilibrium emittance from 4 nm to 140 pm
- Maintain the existing beamlines
- Preserve the time structure operation and a multi-bunch current of 200 mA
- Keep the present injector complex and reuse existing hardware
- Limit the downtime for installation and commissioning to less than 18 months

J. Biasci et al. Synchrotron Radiation News, vol. 27, Iss. 6, 2014

P. Raimondi, THPPA3, IPAC'17

L. Torino et Al, MOAO03, IBIC'19

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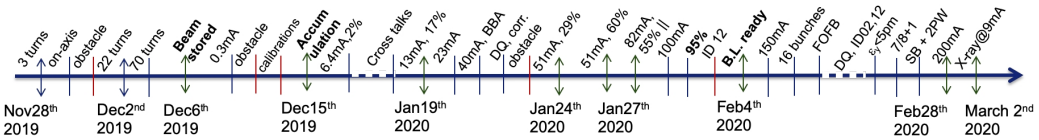
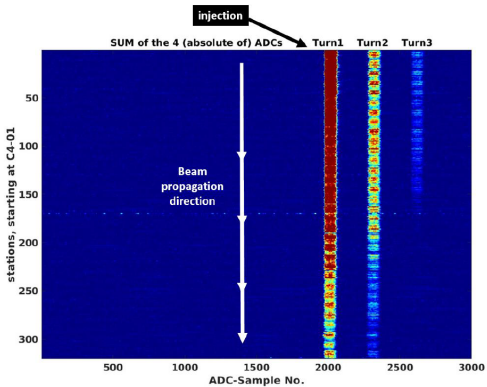
EBS Commissioning Time-Line



- Nov. 28th: First injection
  - 3 turns!
  - On-axis injection
  - Orbit and tune measurement show evidence of problems with the magnets calibration and cross talk
  - Evidence of an obstacle in cell 23



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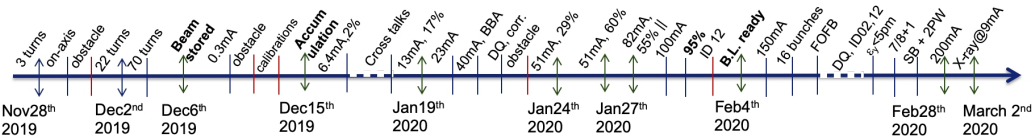
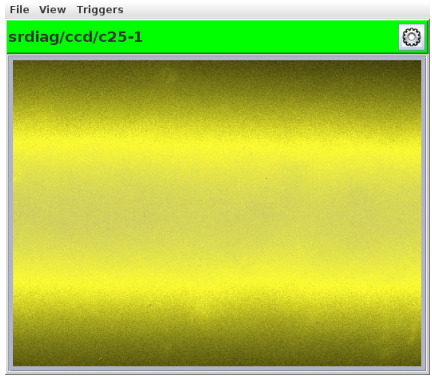


- Nov. 28th: First injection
- Dec. 5th: Beam Stored!
  - Steering implementation using BPMs and correctors
  - First synchrotron light observed
  - Second obstacle found in cell 8
  - Off-axis injection achieved



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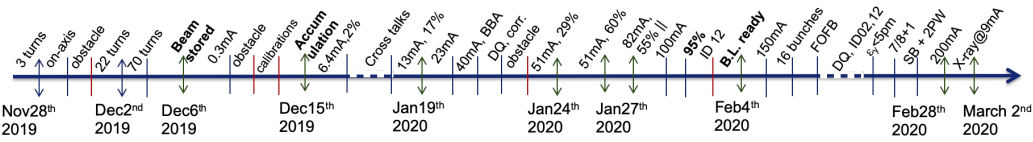
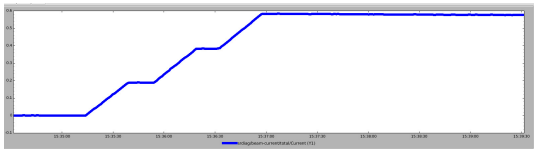


- Nov. 28th: First injection
- Dec. 5th: Beam Stored!
- Dec. 15th: Accumulation!
  - Linear optics optimization
  - Injection optimization... Injection efficiency still quite low



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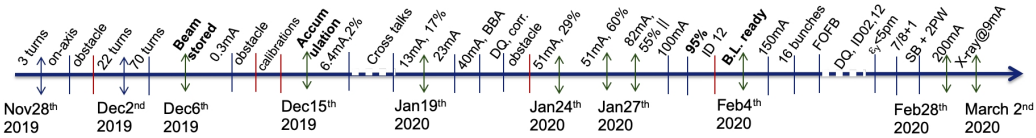
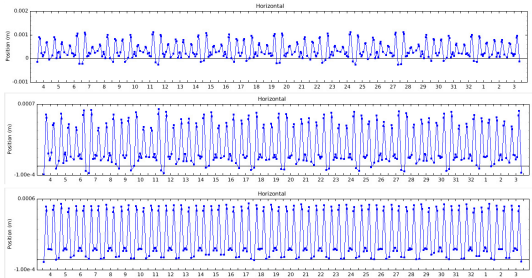


- Nov. 28th: First injection
- Dec. 5th: Beam Stored!
- Dec. 15th: Accumulation!
- Dec. 17th - Jan. 17th: Post-Shutdown
  - Dynamic aperture studies
  - Non-linear optics optimization
  - Beam Based Alignment
  - Third obstacle found in cell 5



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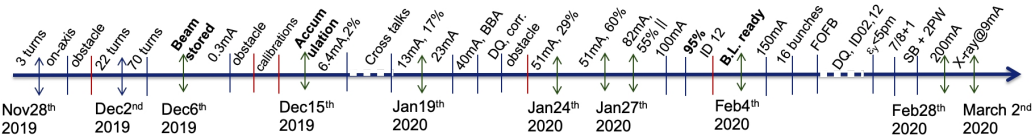
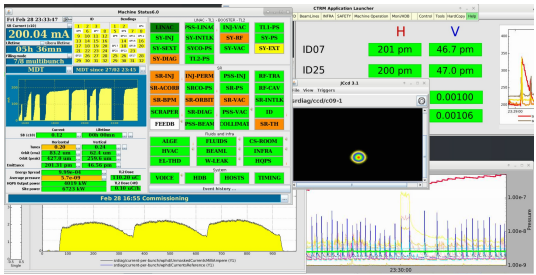
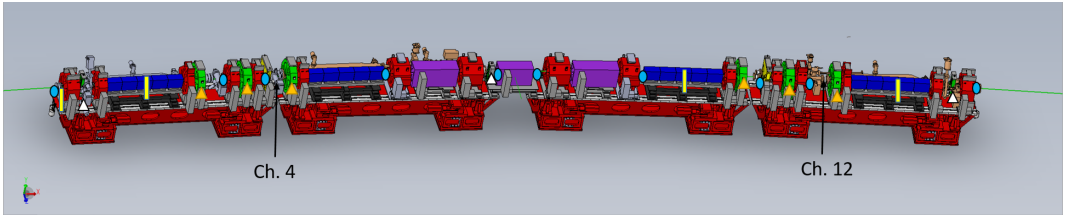


- Nov. 28th: First injection
- Dec. 5th: Beam Stored!
- Dec. 15th: Accumulation!
- Dec. 17th - Jan. 17th: Post-Shutdown
- Mar. 2nd: User-mode parameters!
  - 200 mA
  - 95% Injection efficiency
  - 150/10 pm H&V l emittance
  - Feedback on...



EBS Beam Instrumentation



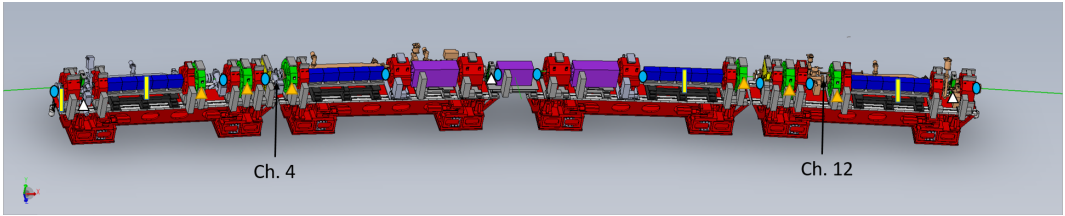
Quantity	Component
320	BPMs
5	Striplines
9	Correctors
3	Special BPM blocks
6	CTs
128	BLDs
5	Emittance Monitors
1	Bunch Purity Monitor
1	Visible light beamline

BLD
BPM
Slow Correctors
Fast Correctors

Ch. 4: Emittance monitor extraction/ Visible light extraction

Ch. 12: Emittance monitor extraction/ Shakers/ Striplines/CTs

EBS Beam Instrumentation



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BPM
Slow Correctors
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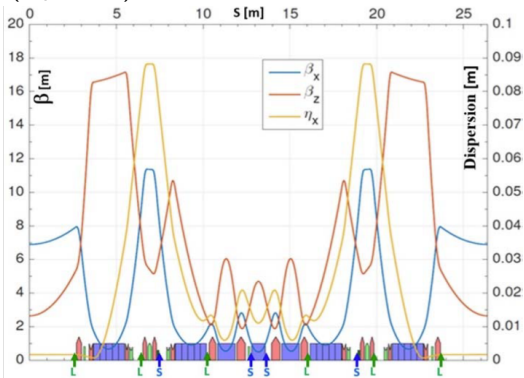
Ch. 4: Emittance monitor extraction/ Visible light extraction

Ch. 12: Emittance monitor extraction/ Shakers/ Striplines/CTs

Beam Position Monitors @ EBS

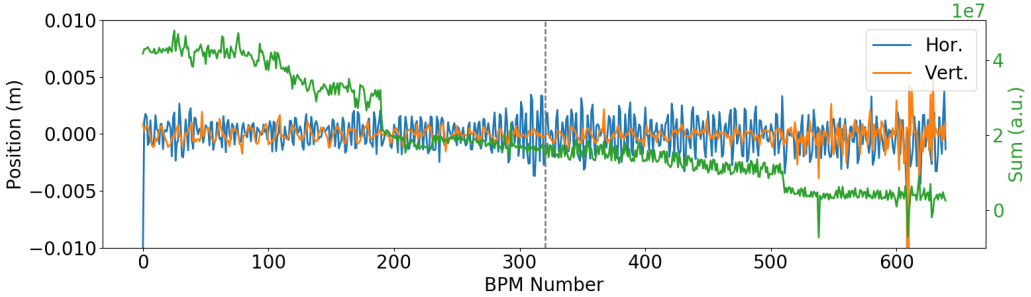
- 320 BPMs (10 per cell)
  - 192 with Libera-Brilliance electronics (6 per cells) → Slow/Fast Orbit Feedback
  - 128 with Libera Spark electronics (4 per cell) → Slow Orbit Feedback

K.B. Scheidt, TUPB02, IBIC'18



Data-streams, and buffers with identically synchronized sampling-rates

BPMs – First Turns – TBT



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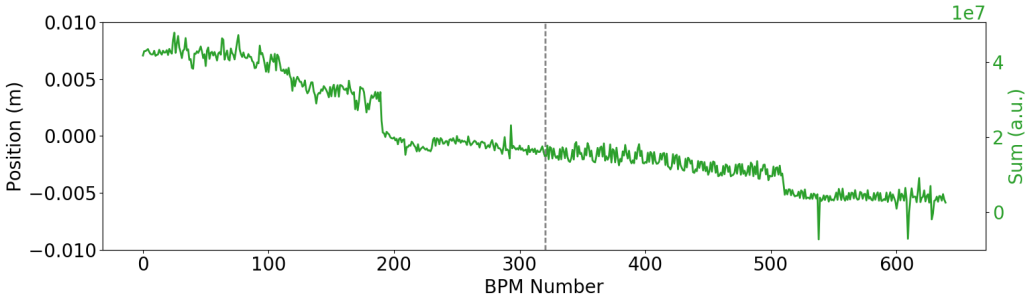
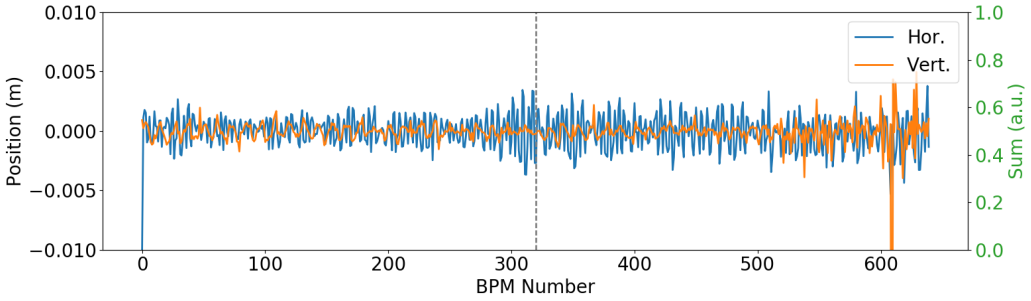


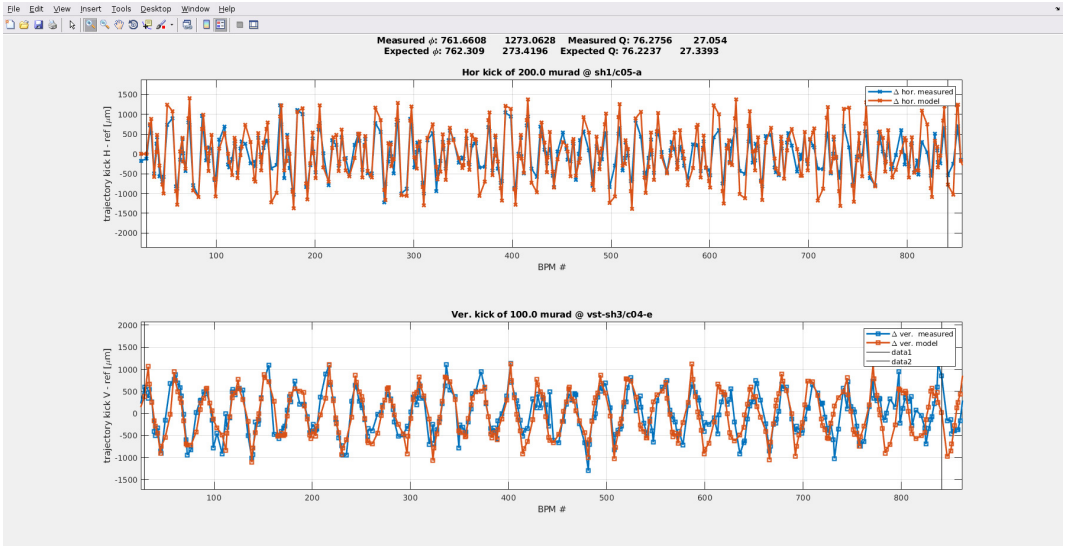
- Sum data to see the progression of the beam along the machine
  - Number of turns
  - Signal proportional to current → check injected current
  - Sudden signal drop → spot obstacles

BPMs – First Turns – TBT

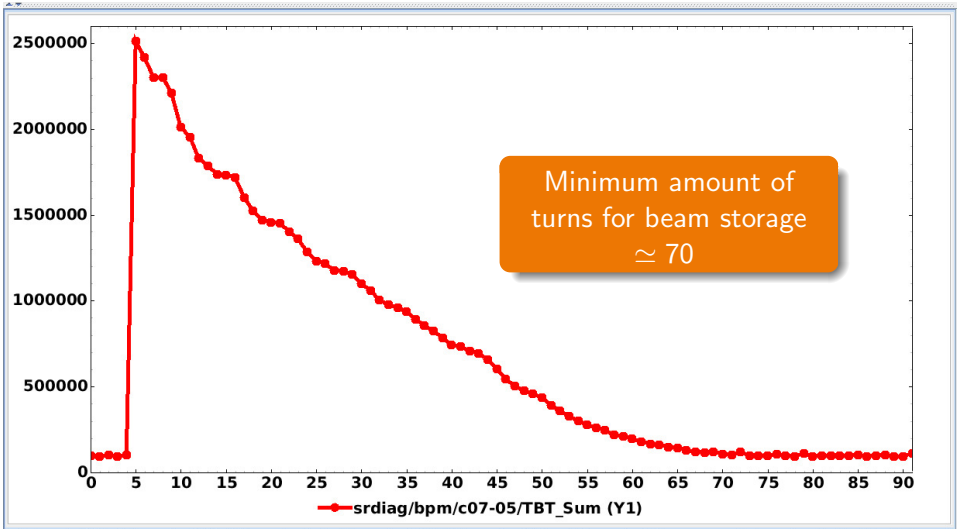


- Sum data to see the progression of the beam along the machine
- Orbit used to correct the lattice
  - TBT orbit measurement @ less then 1 mA injected
  - High excursion → polynomials used to calculated the position
  - Integer tune measurements

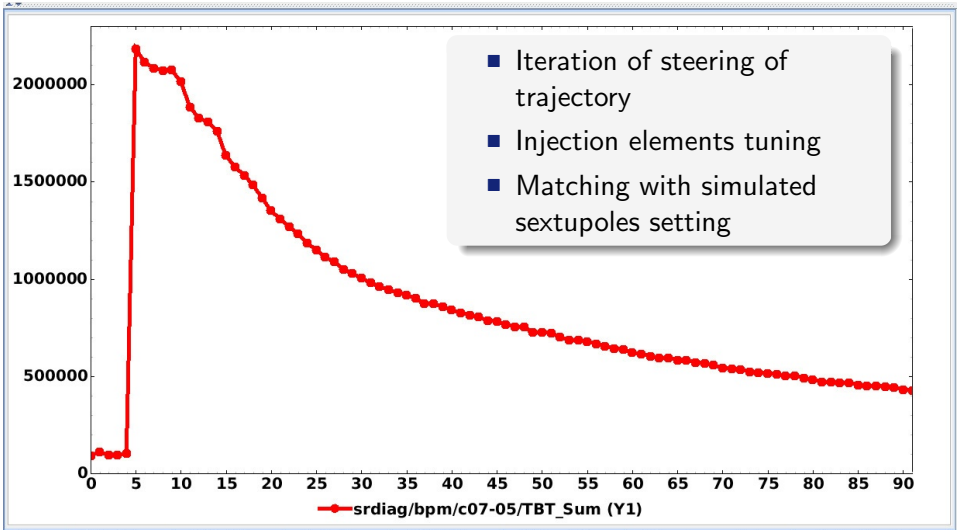
BPMs – First Turns – TBT



BPMs – RF capture – TBT

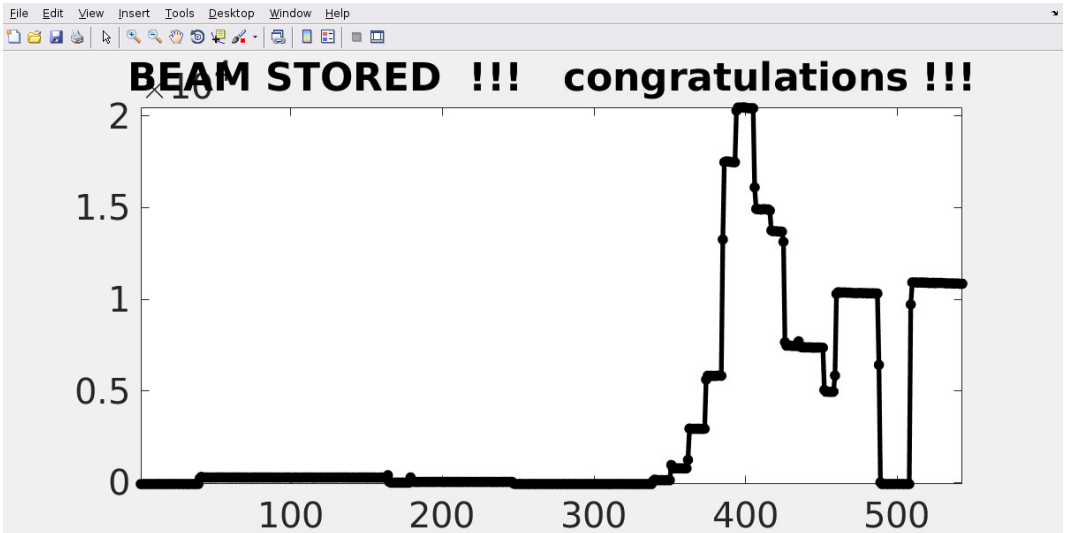


BPMs – RF capture – TBT



- Iteration of steering of trajectory
- Injection elements tuning
- Matching with simulated sextupoles setting

BPMs – Beam Stored – SA



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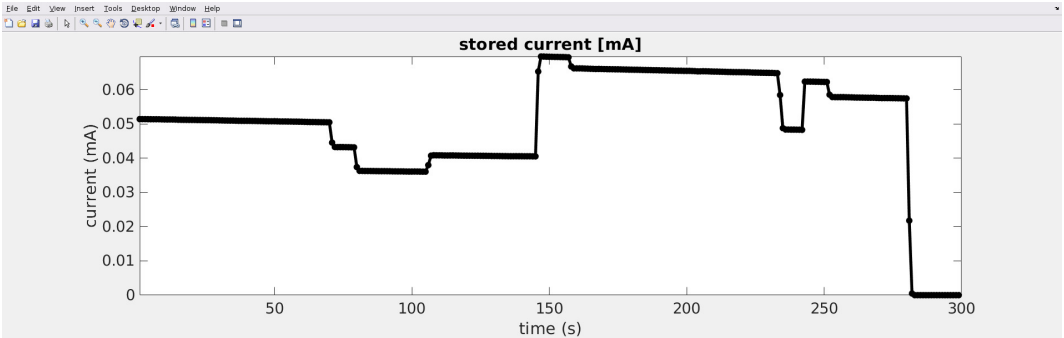

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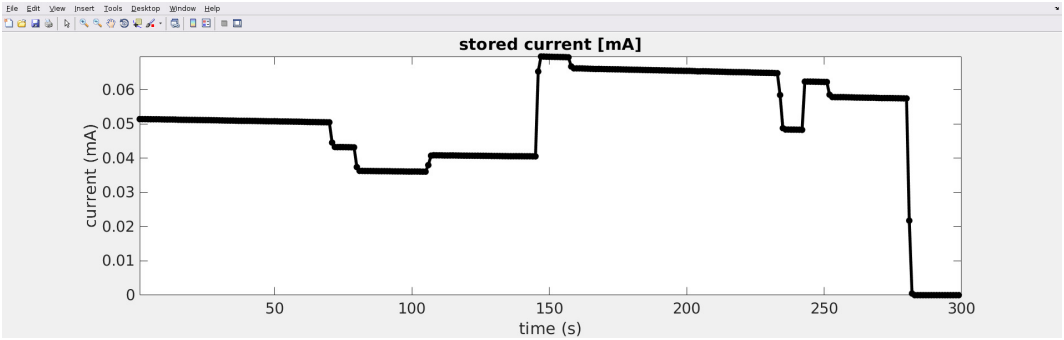
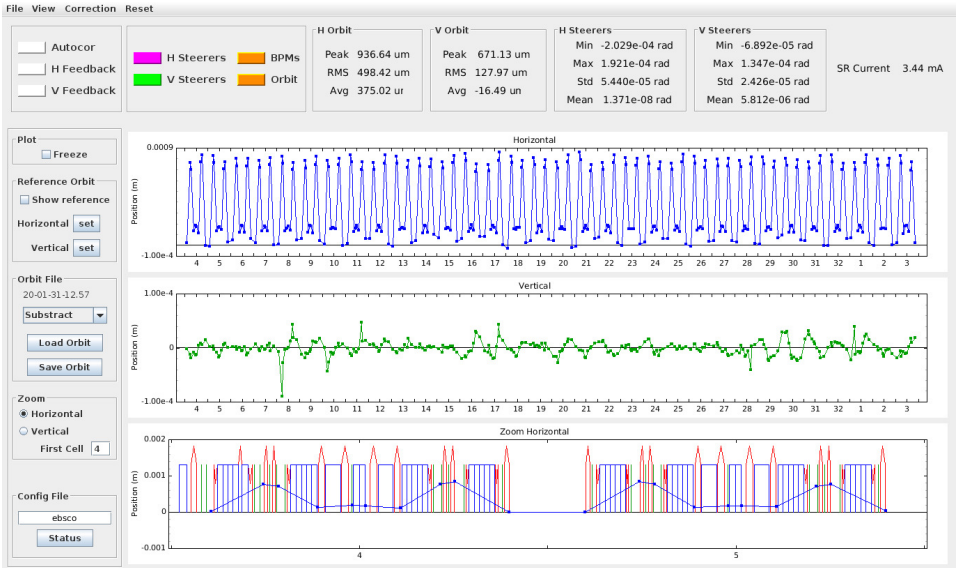
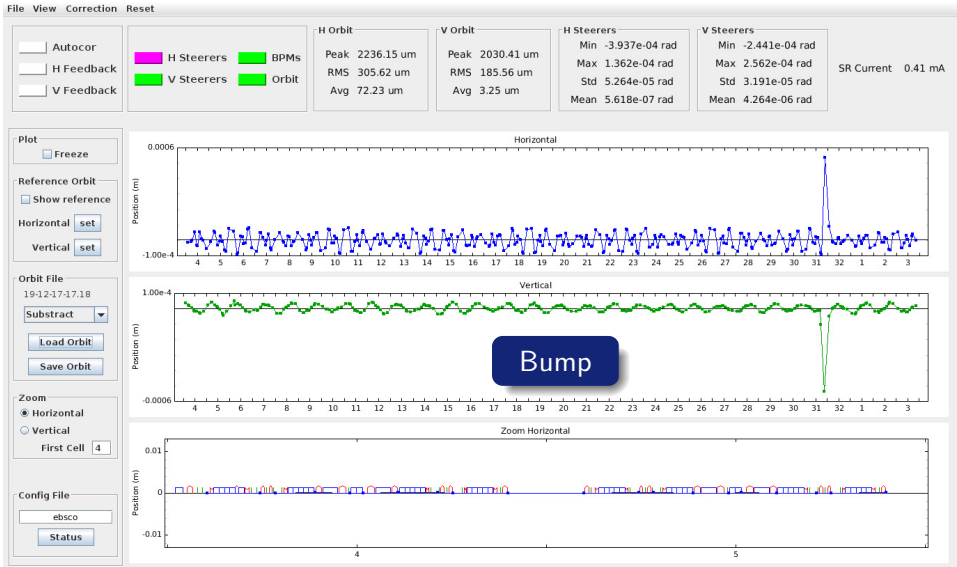


Once the beam was stored it was possible to use the BPMS in a more standard way...

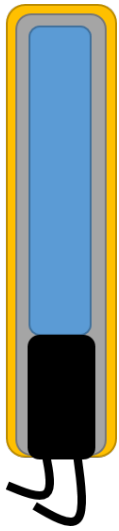
BPMs – Orbit Measurements – SA



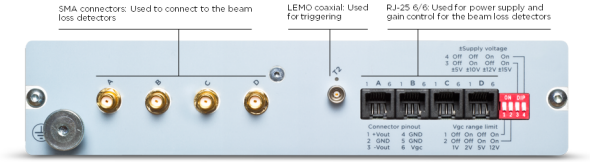
BPMs – Orbit Measurements – SA



Beam Loss Monitor @ EBS



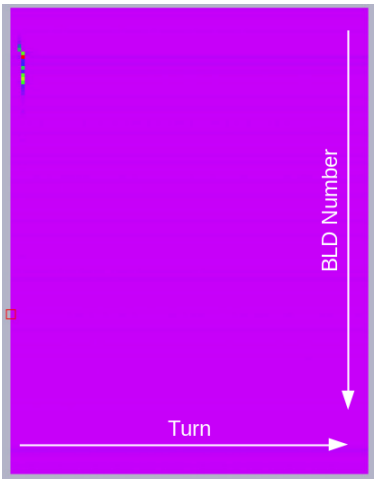
- 128 BLDs PMT+Scintillator+Lead shielding
- Power/Readout electronics Libera-BLM
- 4 BLDs per BLM (32)
- Independent gain and attenuation settings
- Relative calibrated losses
- Capability for almost BbB and full TbT losses measurements



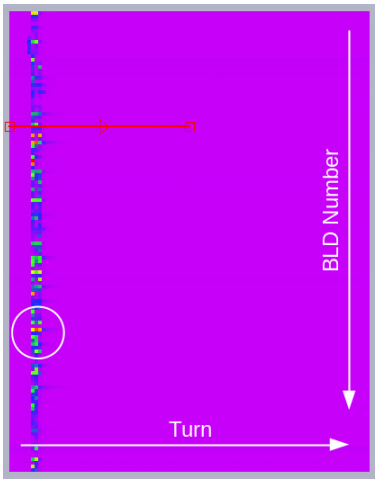
L. Torino, et al., WEOB01, IBIC'18

BLM – First Turns – TBT

First Injection – Screen in

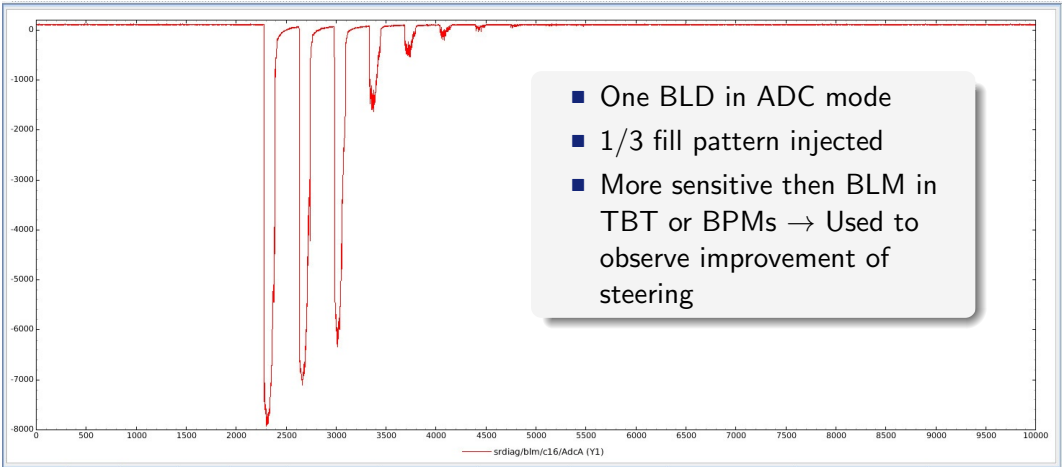


Second Injection – Screen out



BLM – First Turns – ADC

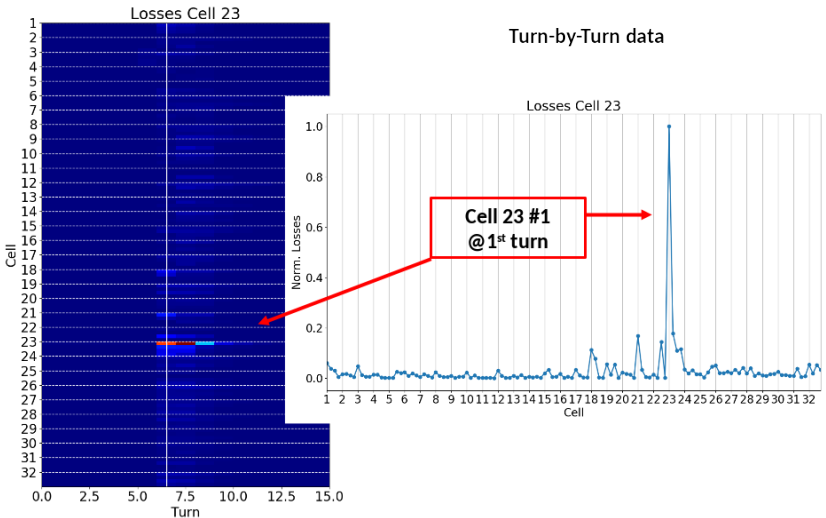
ADC: 352 samples = 1 Turn



- One BLD in ADC mode
- 1/3 fill pattern injected
- More sensitive then BLM in TBT or BPMs → Used to observe improvement of steering

BLM – Obstacles Detection 1/3 – TBT

Obstacle 1: ID chamber Cell 23



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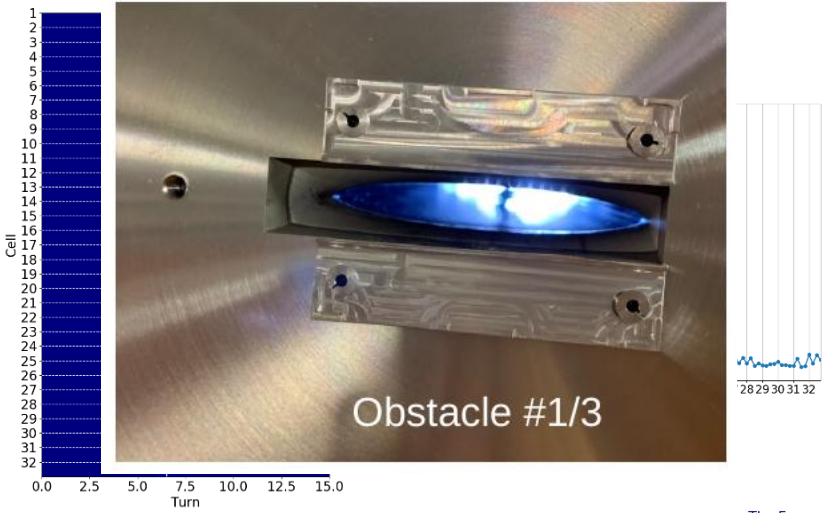
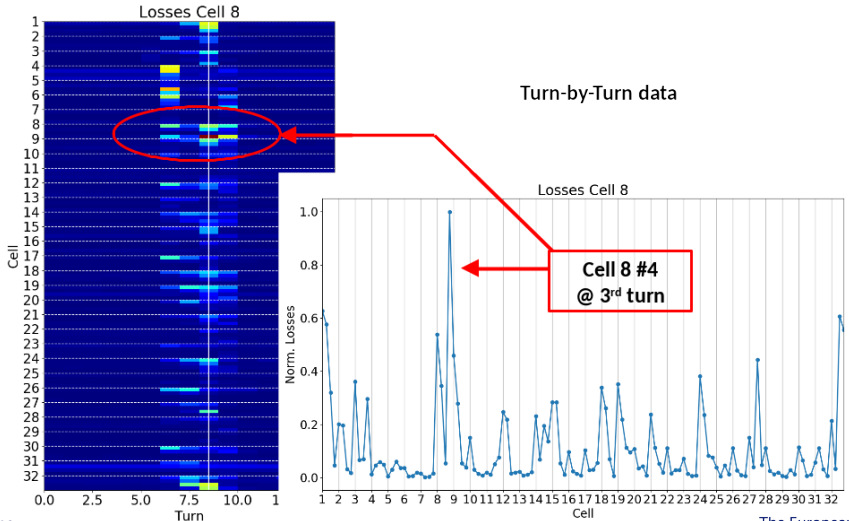


BLM – Obstacles Detection 2/3 – TBT

Obstacle 2: Chamber 10 Cell 8



BLM – Obstacles Detection 2/3 – TBT

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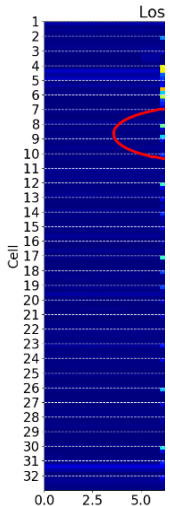
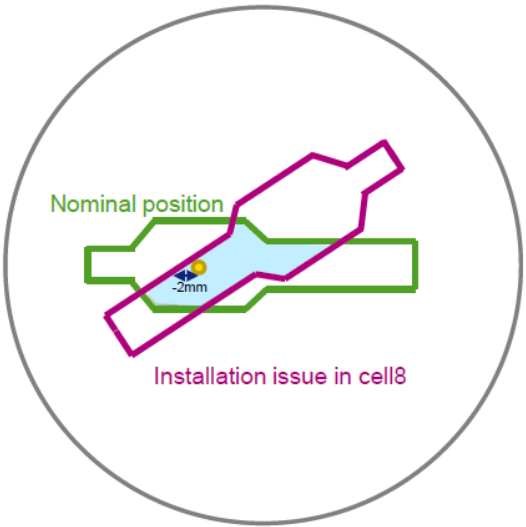
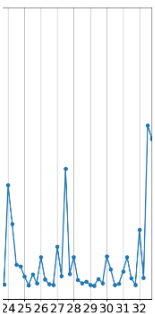
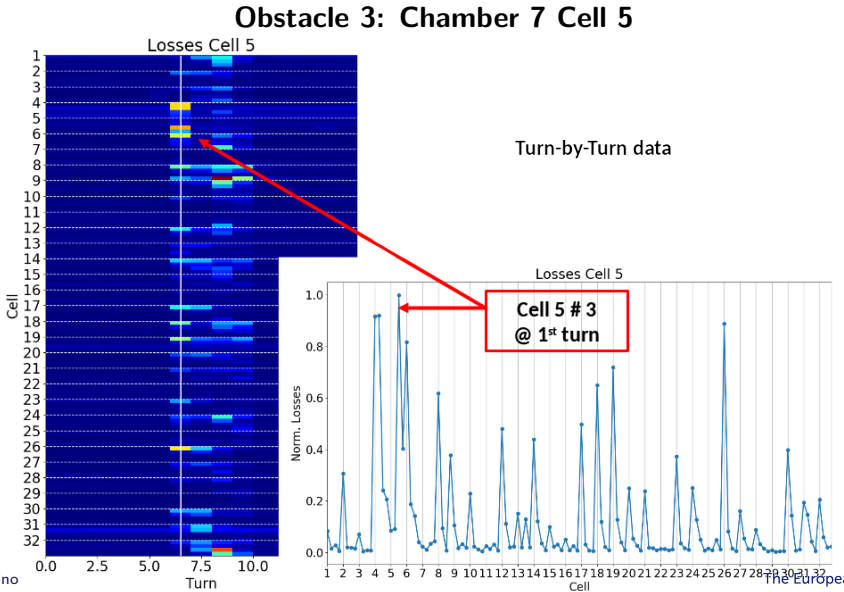




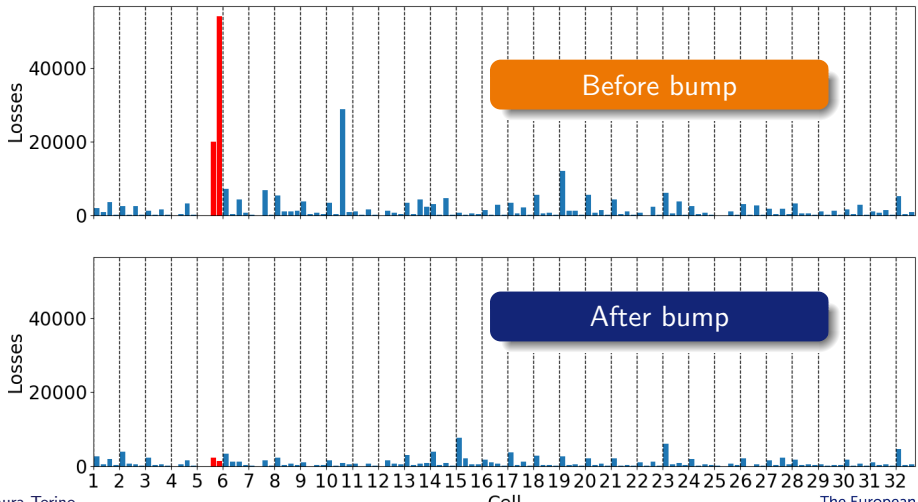


BLM – Obstacles Detection 3/3 – TBT/SA

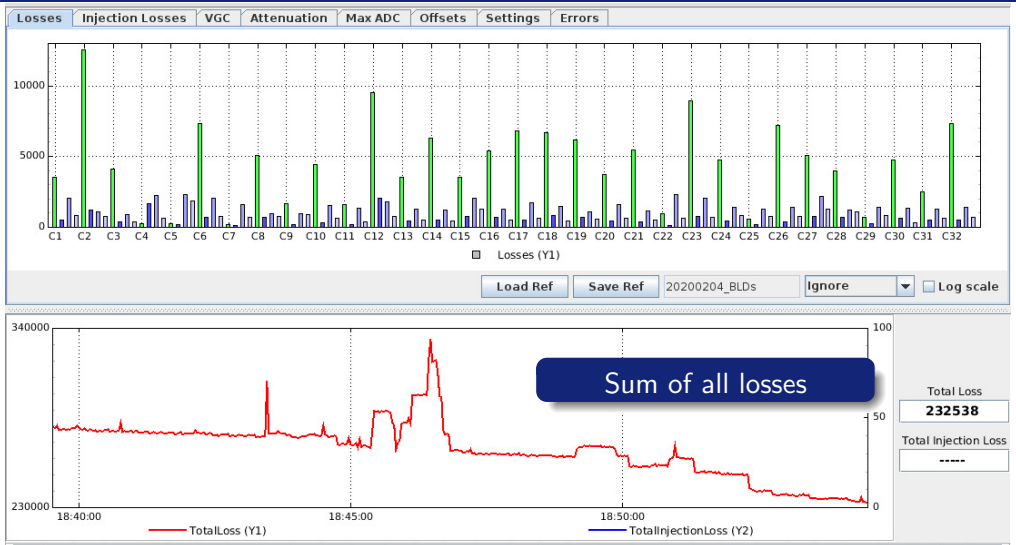


BLM – Obstacles Detection 3/3 – TBT/SA

Obstacle 3: Chamber 7 Cell 5 – SA data

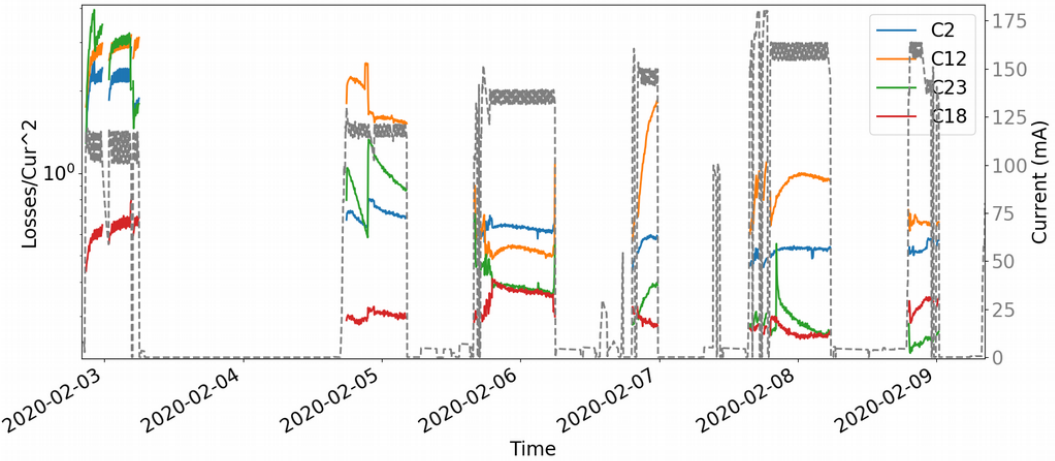


BLM – Machine Optimization – SA



BLM – Machine Conditioning – SA

Check losses at straight section versus current to verify the conditioning
→ Losses/Current^2 stays constant at fixed temperature



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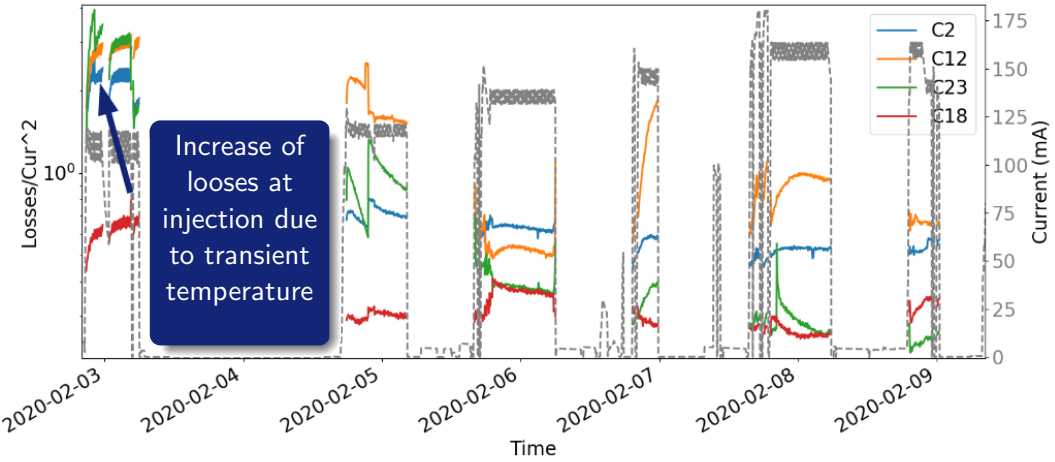

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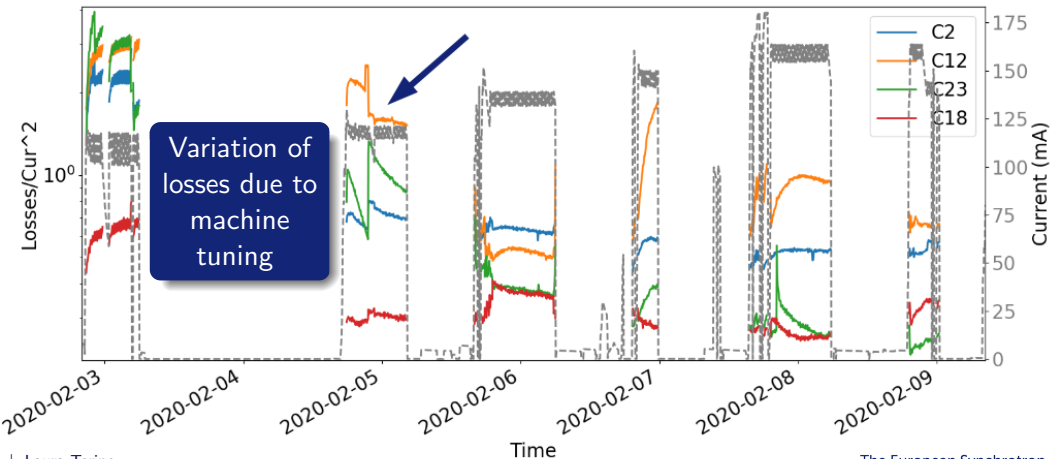

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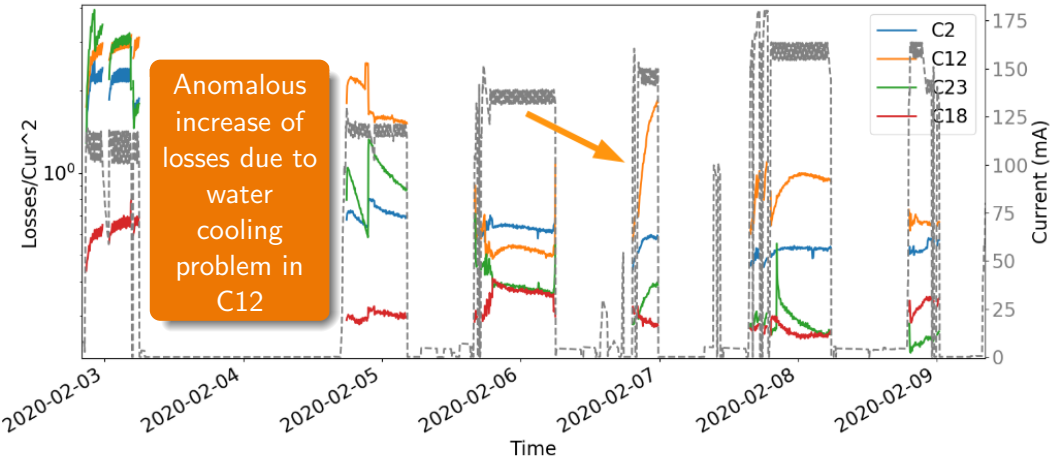

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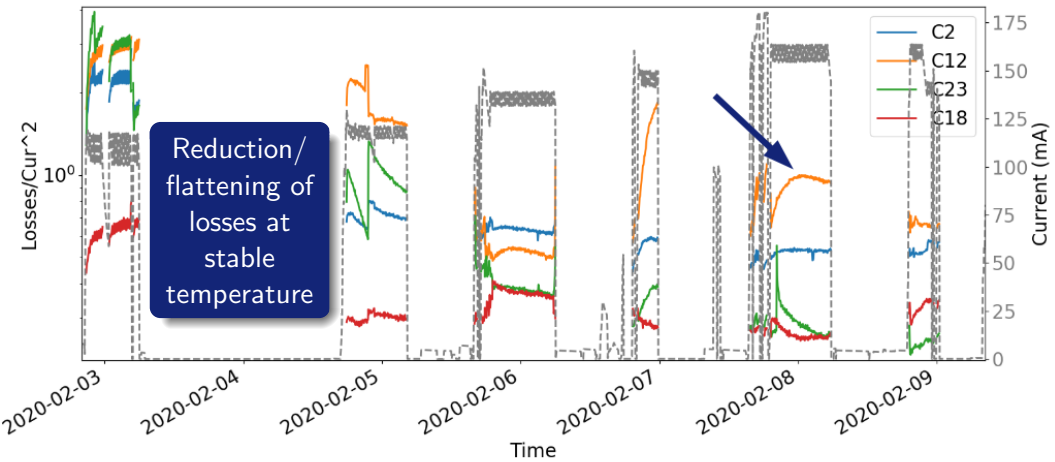
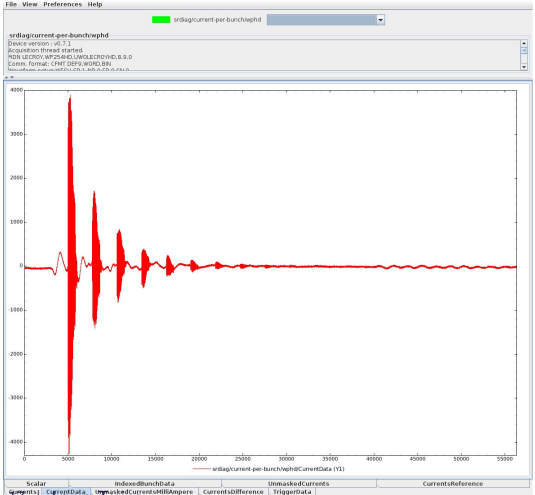


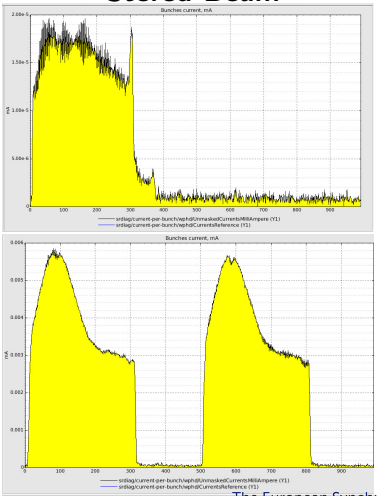
Fill Pattern Measurement

Stripline + Oscilloscope (12 bit dynamic range)

First Turns



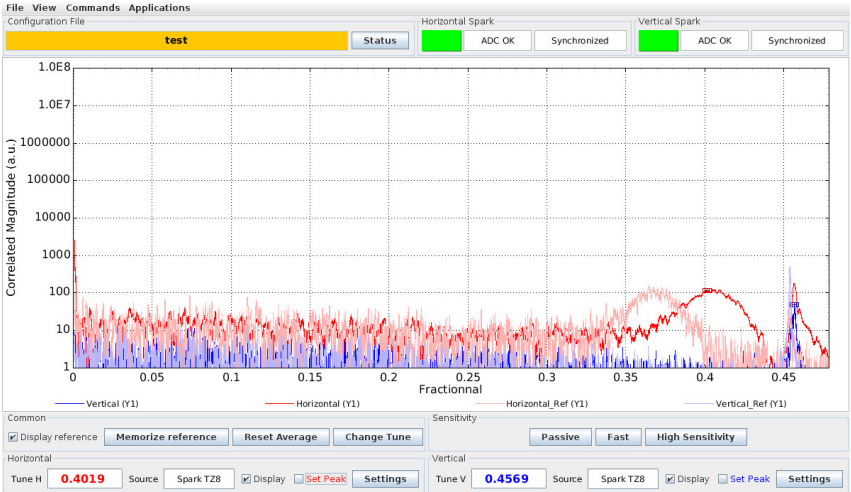
Stored Beam



Tune Monitor

4 BPM buttons + Libera Spark + Shaker

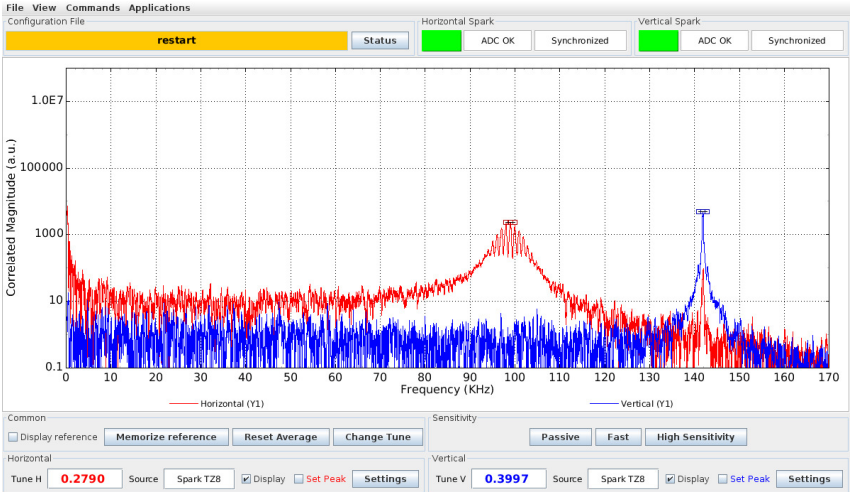
16 µA



Tune Monitor

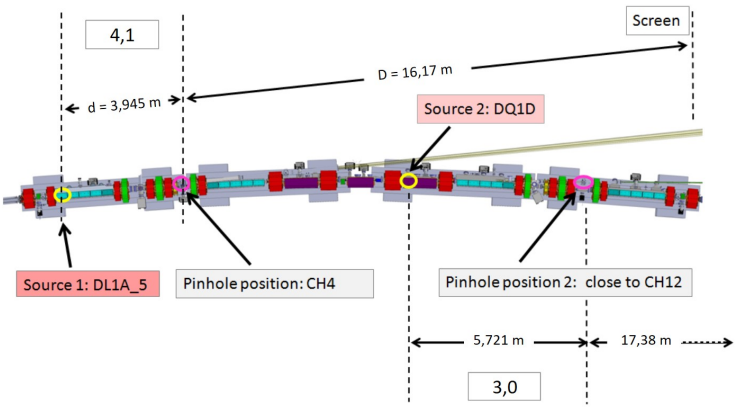
4 BPM buttons + Libera Spark + Shaker

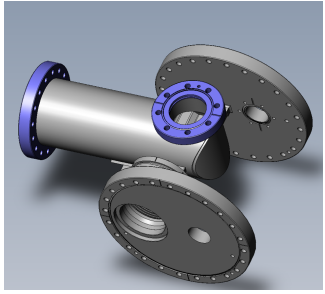
50 µA



Emittance Monitor

5 x-rays ports available for **emittance** and **energy spread** measurements. Each of this port will be equipped with a **pinhole**.



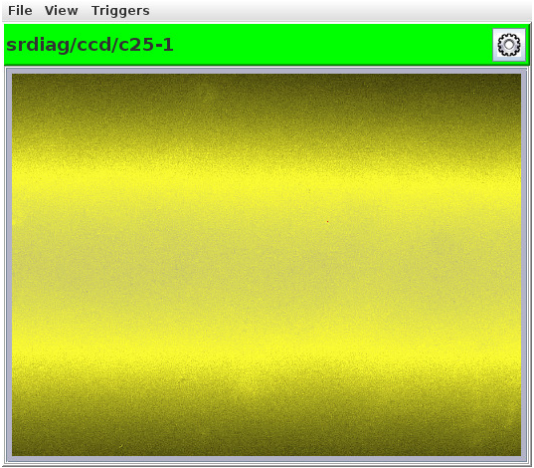


DL1A_5 vacuum chamber modified to locate the pinhole

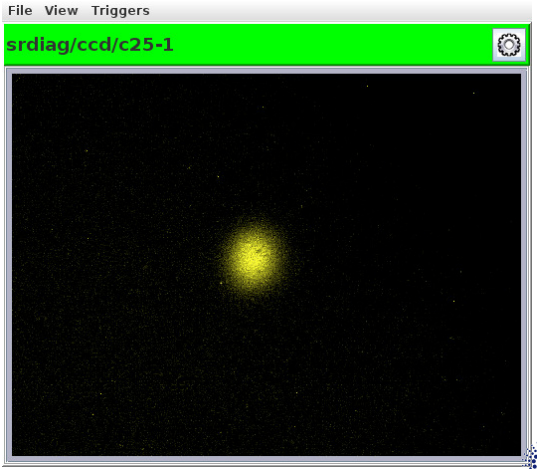
Emittance – Stored Beam

First synchrotron light observed as soon as the beam was stored!

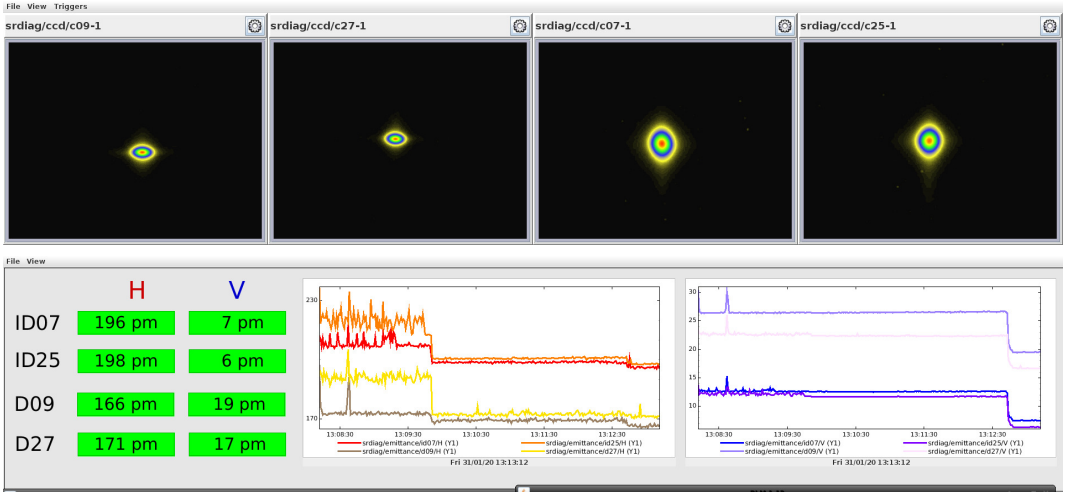
No Pinhole



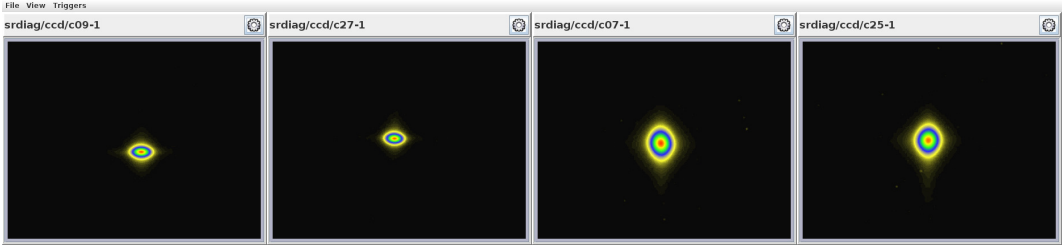
Pinhole

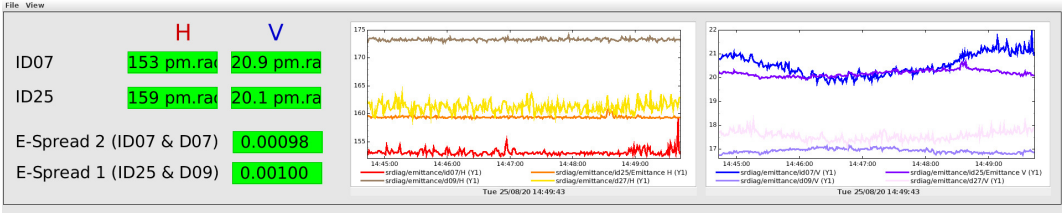


Emittance – Machine Optimization



Emittance – Machine Optimization

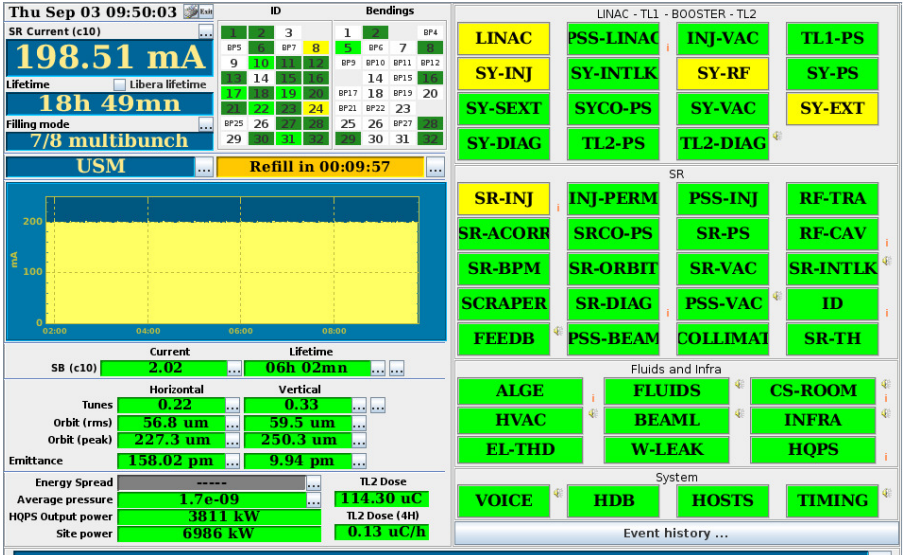




Overview

Part of the success of such a quick and efficient commissioning is related with the **reliability** of the beam instrumentation.
Most of the subsystems were already **installed and commissioned on the old machine** and were ready to be used since the first injection.

Overview


Thu Sep 03 09:50:03
SR Current (c10)
198.51 mA
Lifetime
Libera lifetime
18h 49mn
Filling mode
7/8 multibunch
ID
Bendings
USM
Refill in 00:09:57
200
100
0
mA
02:00
04:00
06:00
08:00
Current
Lifetime
SB (c10)
2.02
06h 02mn
Horizontal
Vertical
Tunes
0.22
0.33
Orbit (rms)
56.8 um
59.5 um
Orbit (peak)
227.3 um
250.3 um
Emittance
158.02 pm
9.94 pm
Energy Spread

Average pressure
1.7e-09
HQPS Output power
3811 kW
Site power
6986 kW
TL2 Dose
114.30 uC
TL2 Dose (4H)
0.13 uC/h
LINAC - TL1 - BOOSTER - TL2
LINAC
PSS-LINAC
INJ-VAC
TL1-PS
SY-INJ
SY-INTLK
SY-RF
SY-PS
SY-SEXT
SYCO-PS
SY-VAC
SY-EXT
SY-DIAG
TL2-PS
TL2-DIAG
SR
SR-INJ
INJ-PERM
PSS-INJ
RF-TRA
SR-ACORR
SRCO-PS
SR-PS
RF-CAV
SR-BPM
SR-ORBIT
SR-VAC
SR-INTLK
SCRAPER
SR-DIAG
PSS-VAC
ID
FEEDB
PSS-BEAM
COLLIMAT
SR-TH
Fluids and Infra
ALGE
FLUIDS
CS-ROOM
HVAC
BEAML
INFRA
EL-THD
W-LEAK
HQPS
System
VOICE
HDB
HOSTS
TIMING
Event history ...
Sep 3 09:40 Delivery:Next Refill at 10:00;