Status and plans for LHC Diamond BLMs

Oliver Stein TE-MPE-PE

Thanks to:
D. Wollmann, R. Schmidt, A. Verweij, V. Raginel (TE-MPE-PE)
B. Dehning, E. Effinger, S. Sousa, et al. (BE-BI-BL)
L. Jensen, S. Bart Pedersen, et al. (BE-BI-SW)
F. Burkart, W. Bartmann, et al. (TE-ABT-BTP)
C. Buhl Sørensen, M. Bursy

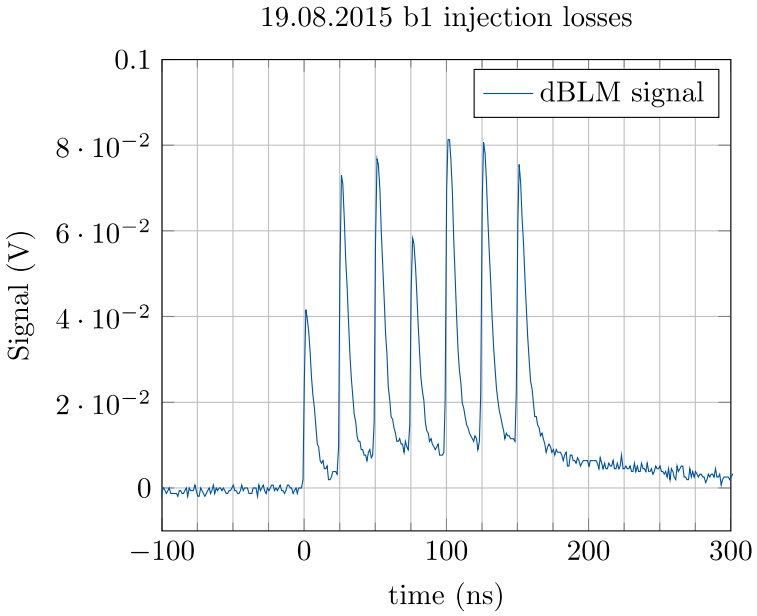
dBLMs for fast loss measurements @LHC.

Goal: Better understanding of fast losses for improving the machine protection.

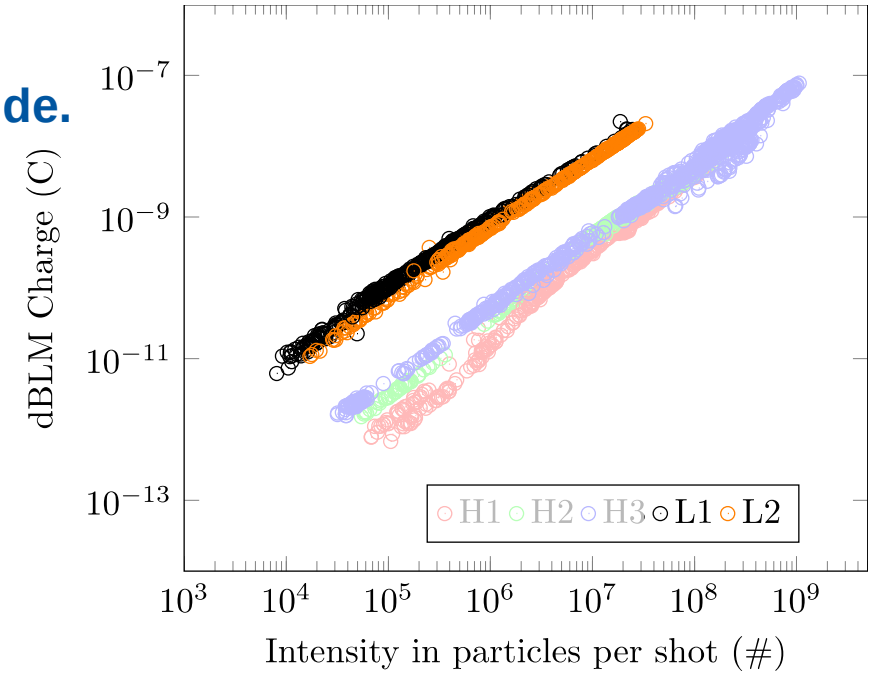
- Time structure
- Loss amplitude

dBLMs provide ns-time resolution.

Dynamic range 3-4 ord. of magnitude.



Response measurements of LHC type dBLMs.



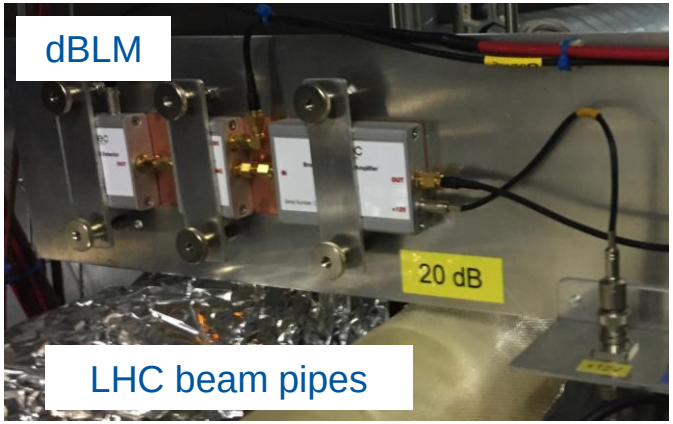
O. Stein et al., 'Response of Polycrystalline Diamond particle Detectors Measured with a High Intensity Electron Beam', in Proceedings IPAC15, 2015

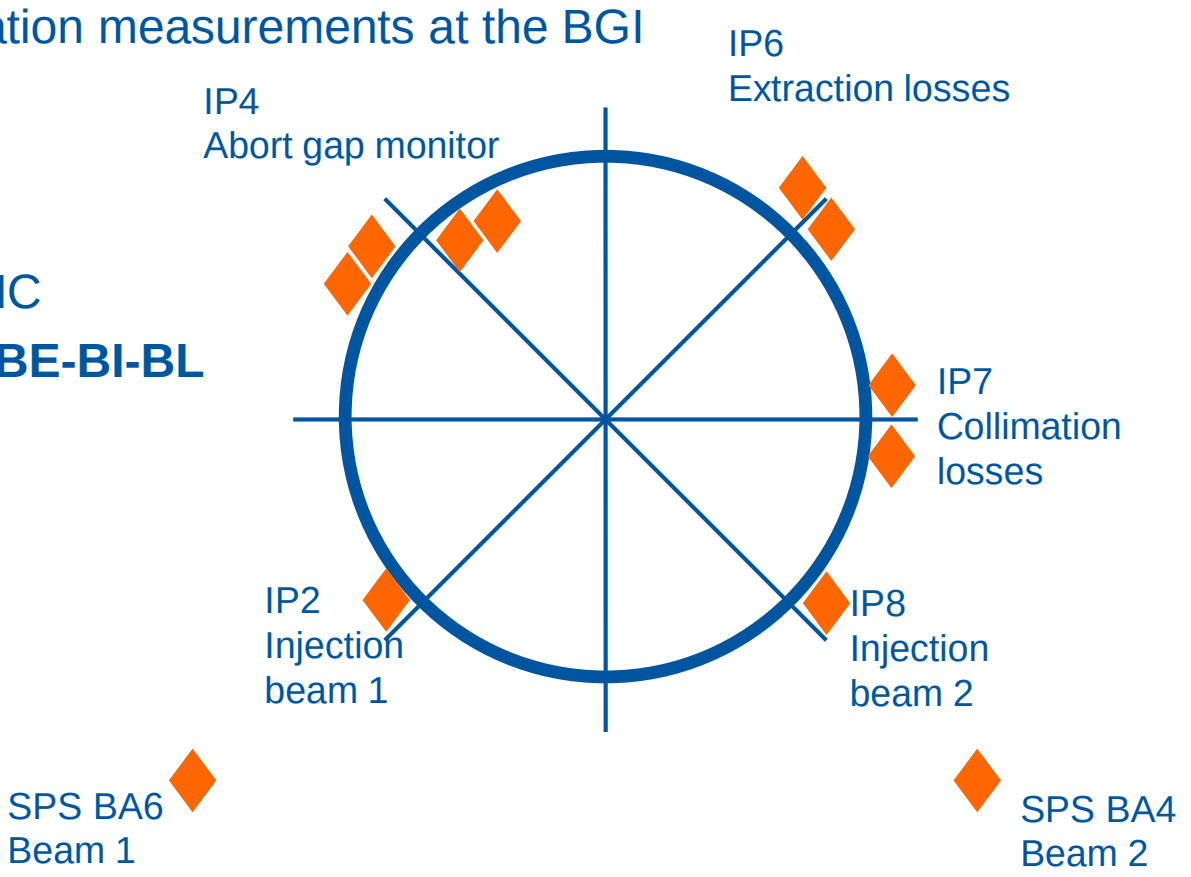
dBLMs@LHC and SPS.

12 dBLMs installed at the LHC and SPS.

- 2 IP2/IP8 injection losses
- 4 IP4 abort gap population measurements at the BGI
- 2 IP6 loss signatures during beam dump
- 2 IP7 global losses
- 2 SPS extraction to LHC

Close collaboration with BE-BI-BL (Bernd Dehning et al.)

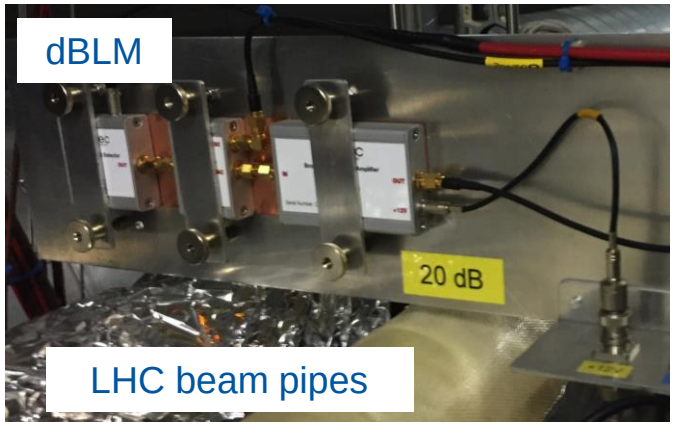


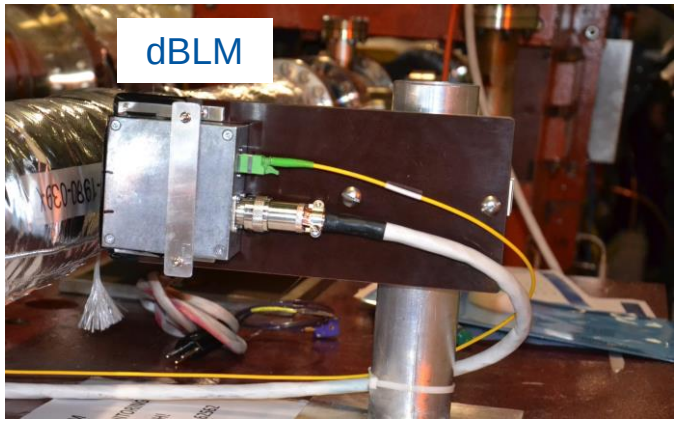


Detector front-end.

2 Types of dBLMs installed.

- pCVD 500µm diamond detector, CIVIDEC (IP2, IP6, IP7, IP8, SPS)
- sCVD 500µm diamond detector, CMS (IP4)





Front end:
Detector, AC/DC-Splitter, Amp.
Cables:
det. HV, ck50 Signal,
BNC DC, 12 V amp.

Front end:
Detector, shaper, amp., opto coupler
Cables:
multiwire, fibre

Detector DAQs.

2 DAQ system types installed.

- Scope, Lecroy waverunner 4 ch. operational (IP2, IP6, IP7, IP8, SPS)
  - IP2 and IP8: 1, CH1 no amp./att., CH2 –40 dB attenuation
  - IP6: CH2 beam 1 +20 dB amp., CH4 beam 2 +20dB amp.
  - IP7: CH1 beam 1 +40 dB amp., CH2 beam 2 +40dB amp.
- ROSY CIVIDEC, Scope and “Histogram” experimental (IP4, IP7)
  - IP4 1(2) ROSY, Histogram unit for counting beam gas interactions
  - IP7 2 ROSY, Histogram unit for counting global losses at the primary collimators
    Scope function recording time loss signal for PM events

Timing and data handling.

Scopes:

Timing/trigger

IP2/IP8 and IP7 beam1:

LHC BOBR card provides triggers

Pre-injection pulses → CH4

Post Mortem pulse → EXT.

IP6 trigger on signal.

Data Handling:

Manual data transfer.

Script based file conversion and analysis.

ROSY:

Timing/trigger

IP4/IP7:

LHC turn clock (“Histograms”)

Multiple triggers planned (Scope)

Data Handling:

Data storage on BI server.

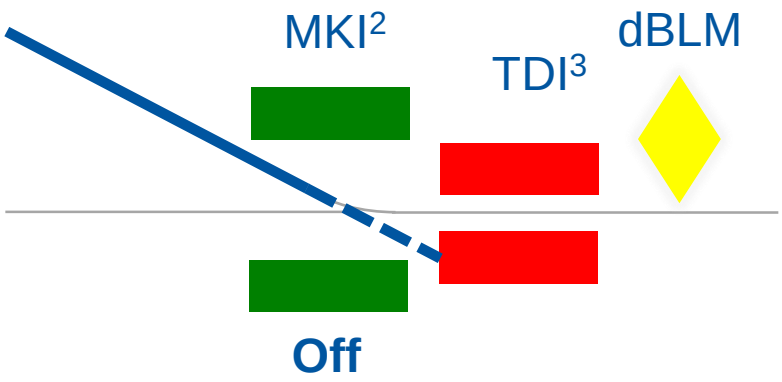
Manual (script) analysis.

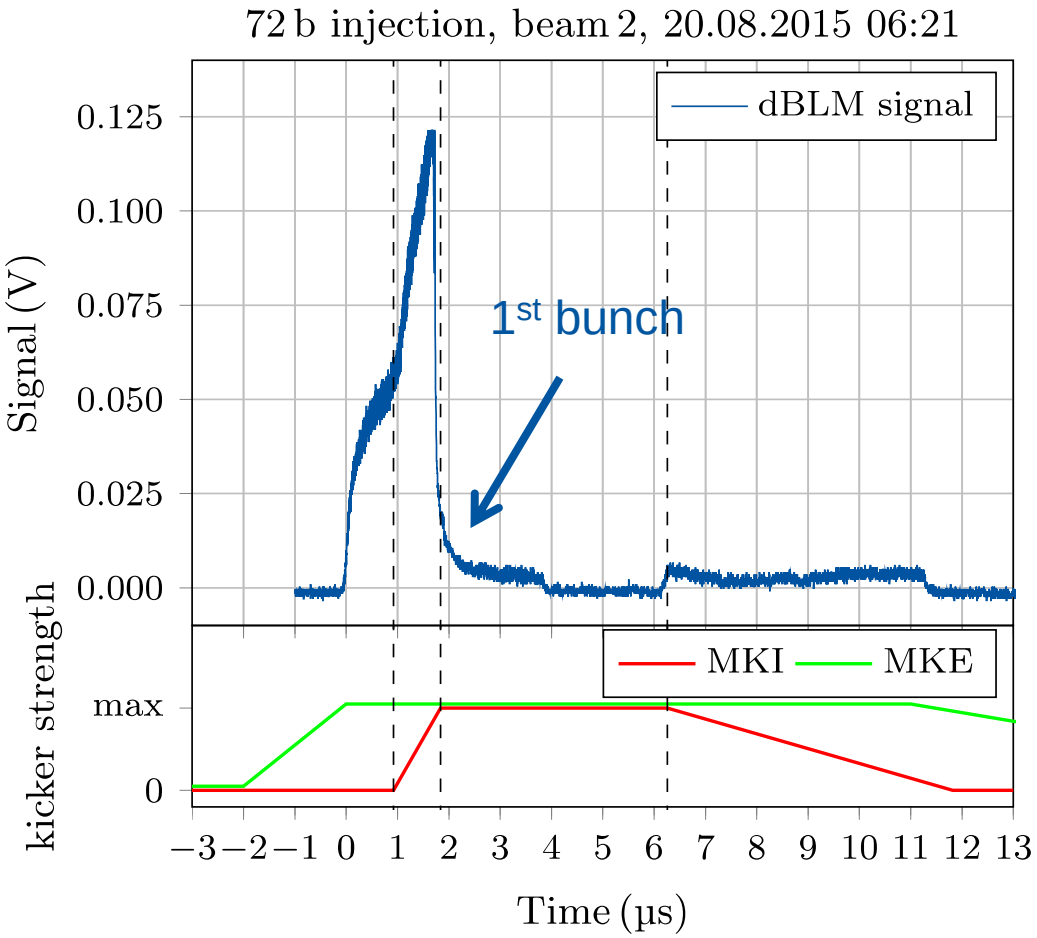
Measurements and Results

First time ns-res injection loss measurements!

- **Signature dominated by re-captured beam (SPS) losses.**
- Bunch train losses can be identified. 1st b beginning at the kicker flat top.
- Loss pattern can be correlated with kicker time constants.

Beam from SPS, MKE[1] ON



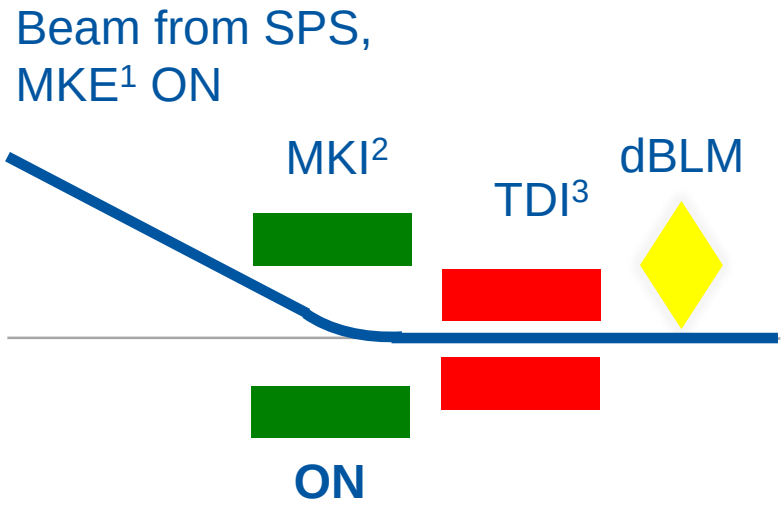


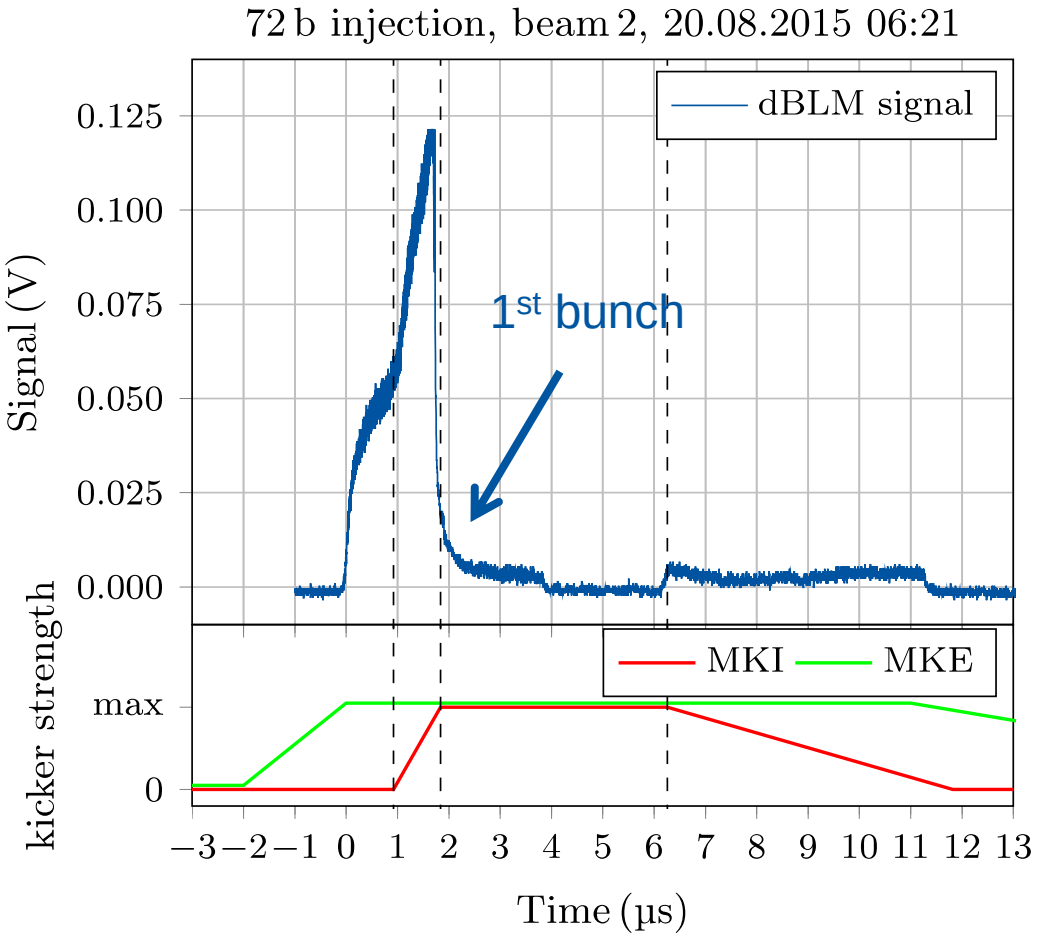
1 SPS extraction kicker
2 LHC injection kicker
3 LHC injection beam stopper

Special thanks to: F. Burkart and W. Bartmann, et al.

First time ns-res injection loss measurements!

- **Signature dominated by re-captured beam (SPS) losses.**
- Bunch train losses can be identified. 1st b beginning at the kicker flat top.
- Loss pattern can be correlated with kicker time constants.

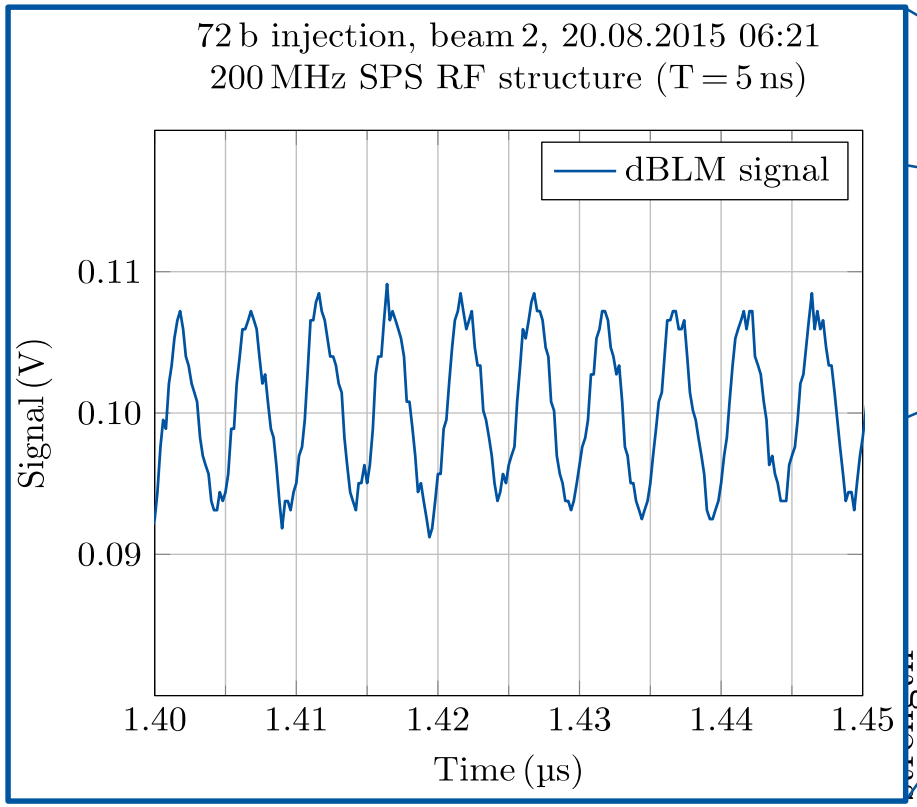


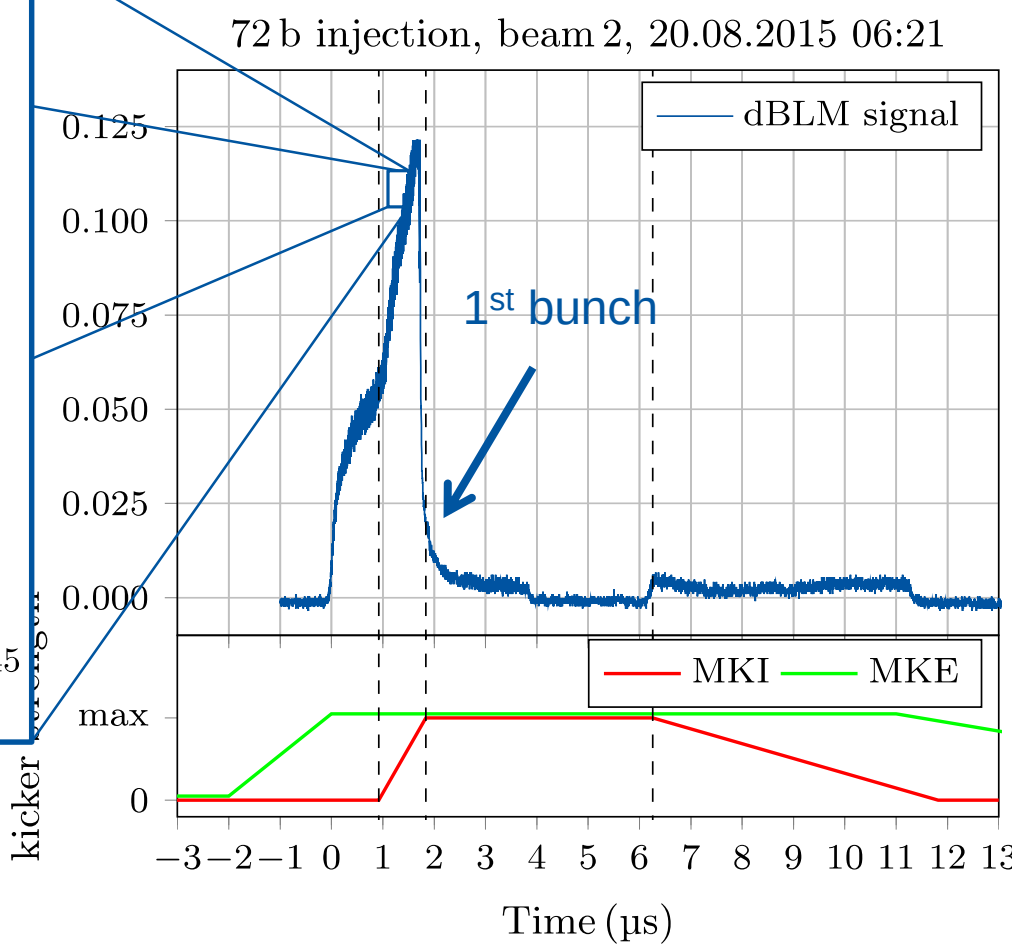


1 SPS extraction kicker
2 LHC injection kicker
3 LHC injection beam stopper

Special thanks to: F. Burkart and W. Bartmann, et al.

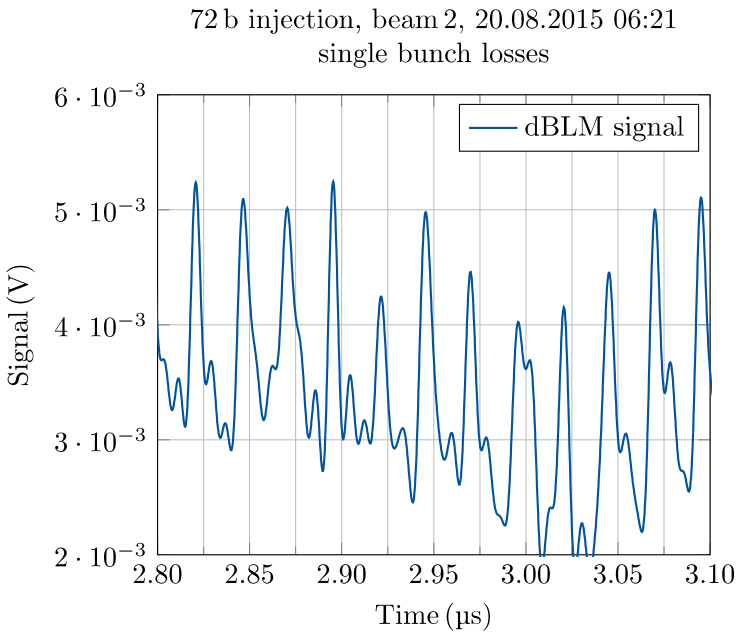
Re-captured beam (SPS) losses, 200 MHz RF.



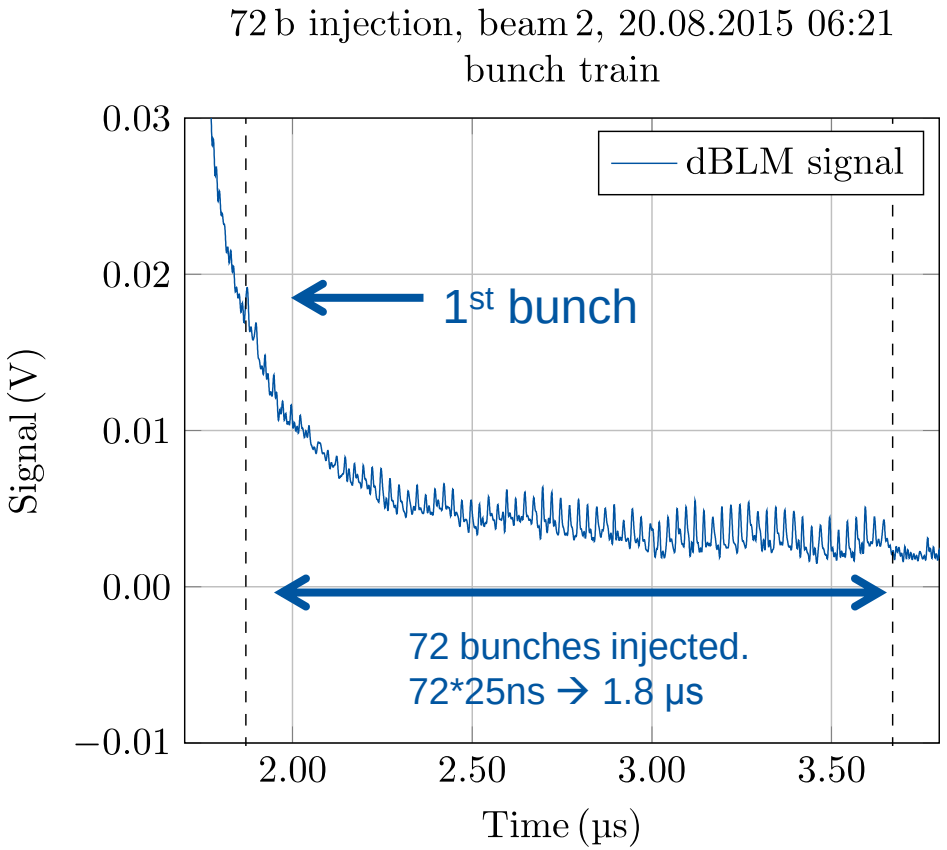


Injection loss signature beam 2, 72 bunches.

- Losses dominated by re-captured beam from the SPS.
- **Bunch train losses can be identified.**
  1st b beginning of the kicker flat top.



Low pass filter applied to bunch loss data.

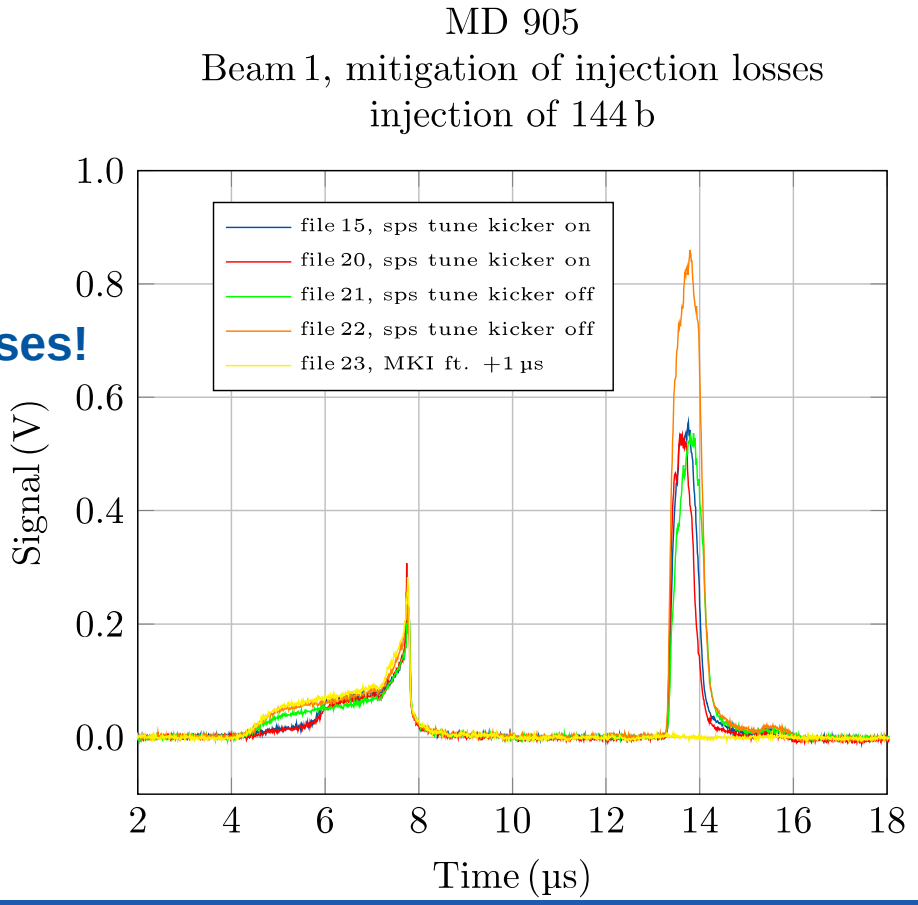


Injection loss mitigation

- Improving the safe machine operation the injection losses need to be reduced. 88% of the dump threshold were reached during normal 144b injection.

- Dedicated MD:
  - Used the SPS tune kicker for cleaning the recaptured beam.
    → **Cleaning reduces the injection losses!**
  - Increased the MKI flat top by +1µs.
    → **Second loss signature vanishes!**

dBLM measurements highly valuable for injection quality checks!



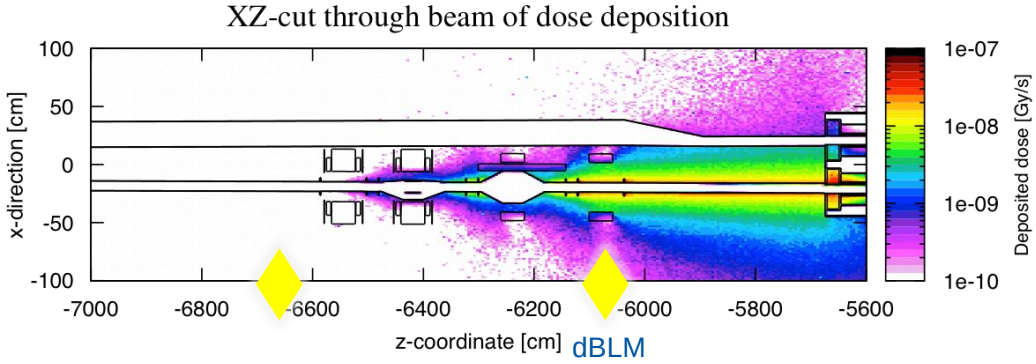
Special thanks to: F. Burkart and W. Bartmann, et al.

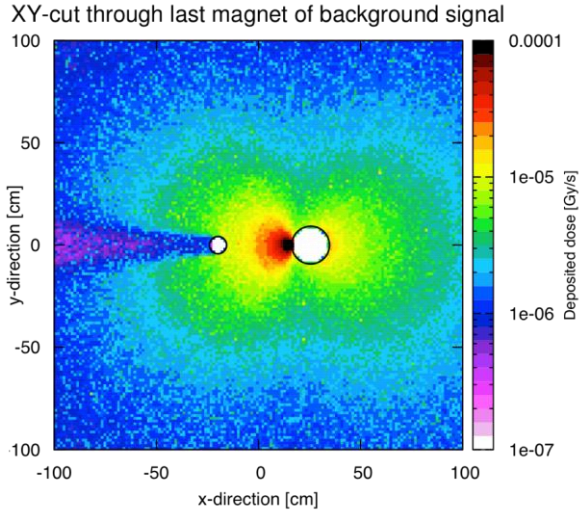
Monitoring the abort gap population with dBLMs.

Proof of principle:

Calculation of the abort gap population by measuring the secondary shower particles from beam gas interactions in the BGI in point 4.

Optimization of detector positions with FLUKA simulations.
Calculations of interaction and detection rates.





Feb. 2015 installation of 4 (2 per beam) sCVD dBLMs at the BGIs in point 4.

1st dBLM for beam gas interaction downstream of BGI

2nd dBLM for background measurements upstream of BGI

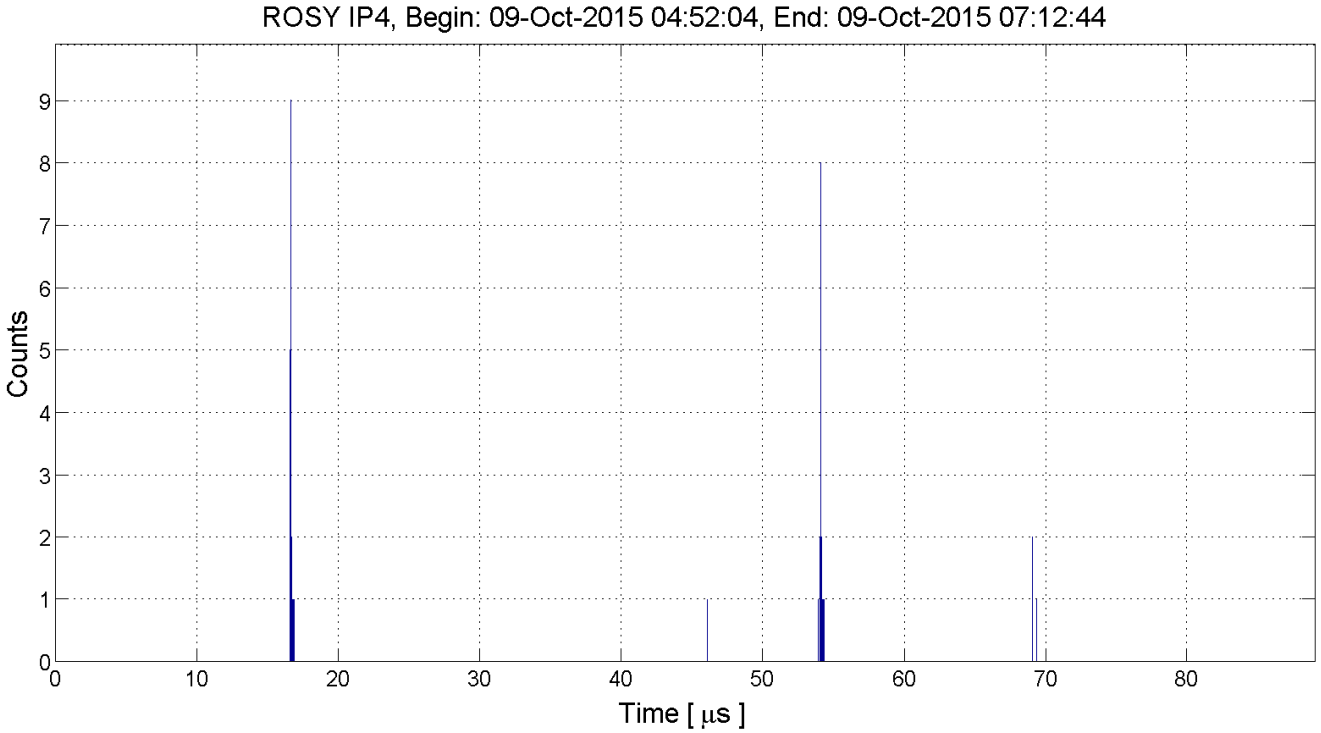
DAQ: CIVIDEC ROSY “Histogram” unit.

O. Stein et al., ’Feasibility Study of Monitoring the CERN-LHC Abort Gap with Diamond based Particle Detectors’, in Proceedings IPAC15, 2015

Special thanks to: C. Buhl Sørensen

First measurements with dBLM setup in IP4.

- ROSY readout FESA-class developed with BE-BI-SW (S. B. Pedersen)
- First test measurements in summer 2015.
- Measurement during floating MDs, **MD:456** and MD:292, 08.10.2015.
- **Two single nominal bunches can be clearly identified.**



Special thanks to: M. Bursy

First measurements with dBLM setup in IP4.

Bunch signal ~ 70 bins (100ns) instead of ~ 3-4 bins (6ns)

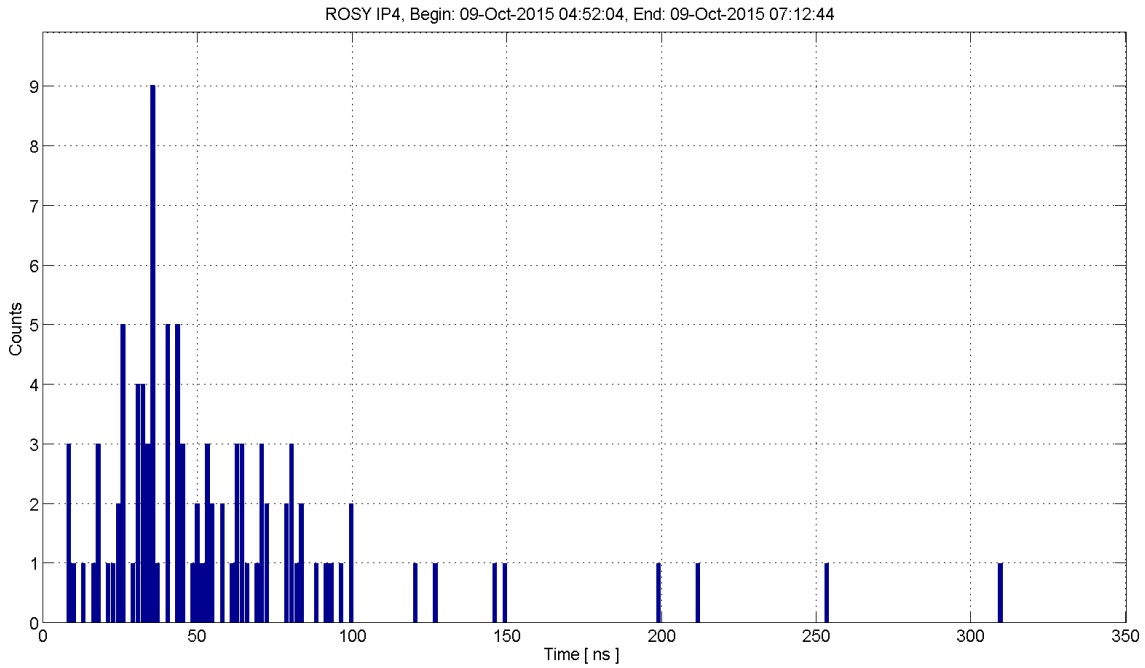
→ Time jitter.

Count rate 70 x lower than expected (2 hours integration).

Possible explanations:

- Ionization of neon gas reduces gas pressure.
- Geometric effects.
- Detector efficiencies.

Further DAQ tests needed.

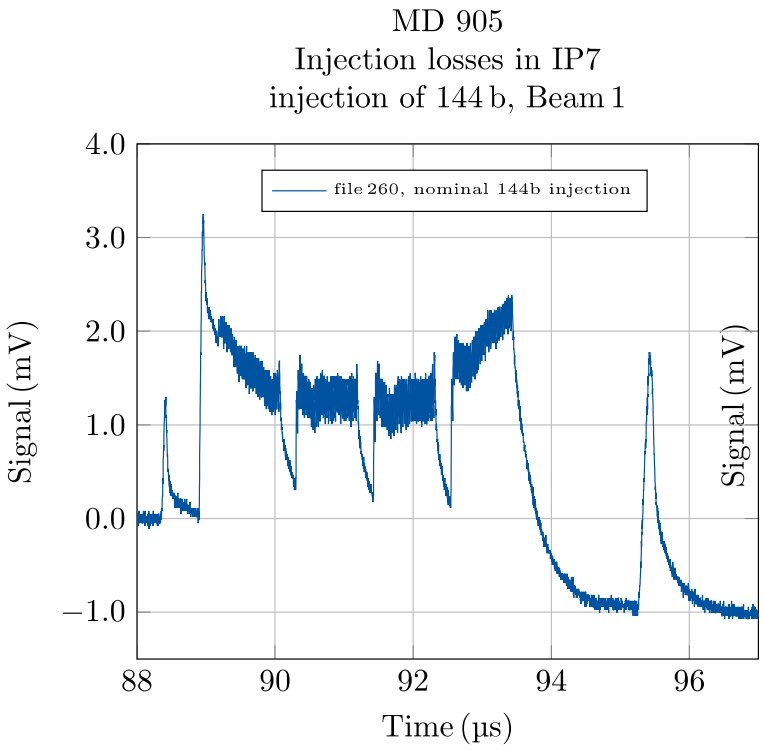


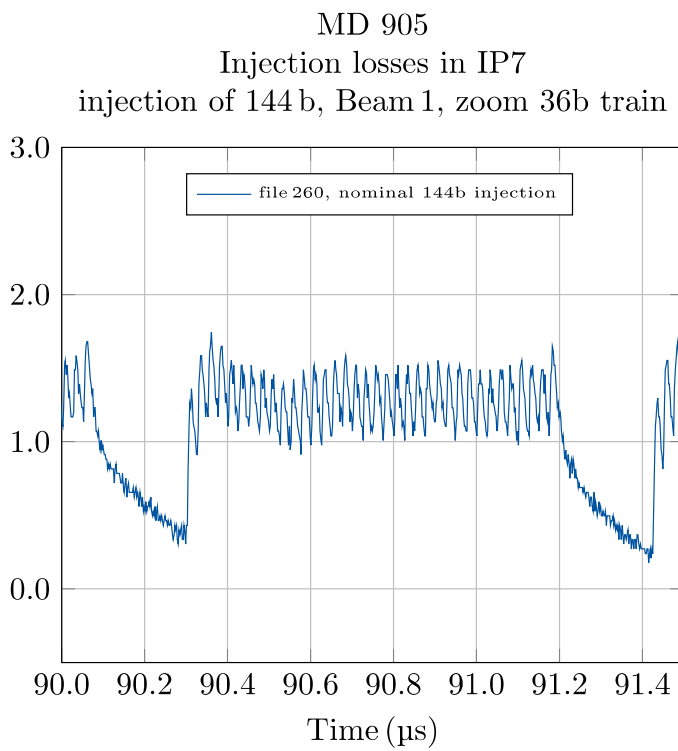
Special thanks to: M. Bursy

IP7: Further use cases for dBLMs

Measurements in IP7 (close to the TCP*)

- Injection oscillations
- *Planned: Continuous measurements (histograms ROSY)*
- Dump losses
- Instabilities
- UFOs



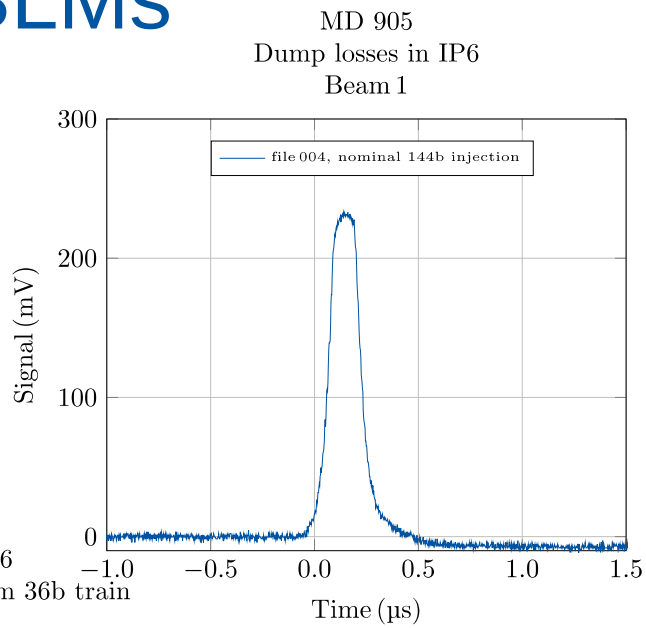


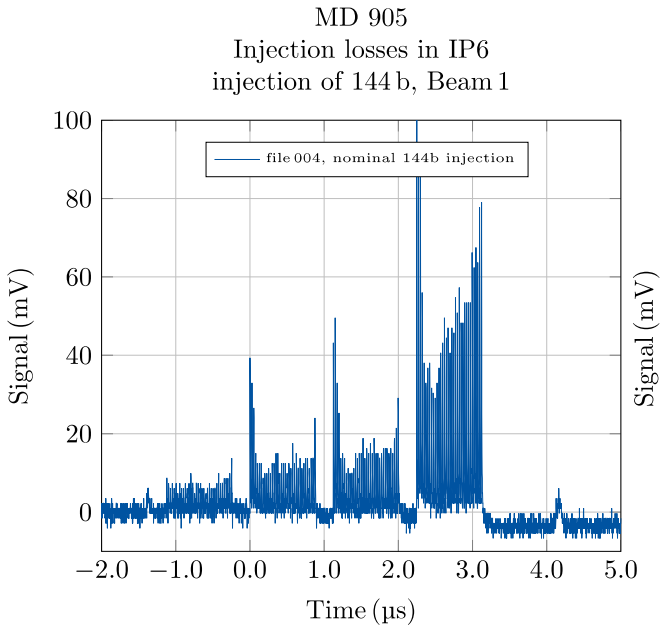
*Primary collimator

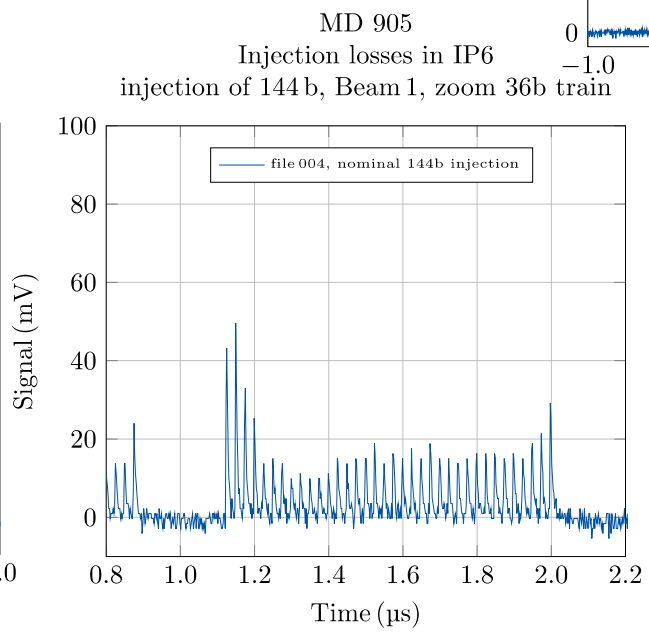
IP6: Further use cases for dBLMs

Measurements in IP6 (close to the TCDQ*)

- **Dump losses**
  - **Asynchronous beam dump**
- Injection oscillations







* Absorber block protecting downstream components from extraction losses

Required updates for dBLMs

To allow an automatic data recording

- Rosy fesa-class tests with dedicated test stand
  - Histogram unit
  - Scope function
- Automated data transfer and analysis
  - Intermediate:

    Script based data transfer and pre-analysis
  - Final:

    Fesa-class for Lecroy scopes and Rosy

    Include dBLM data into logging data base and Post Mortem

Required improvements

- LHC timing for IP6, IP7 (beam 2) and SPS dBLMs
- Signal cascades in IP2, IP6, IP7, IP8

Due to scope limitations new DAQ card development by BI.

Summary

- 12 dBLMs installed at LHC and SPS providing ns-time resolution over 3-4 orders of magnitude.
- 2 dBLM types installed, sCVD (CMS) and pCVD (Cividec).
- 2 DAQ installed, Lecroy scopes (operational) and Cividec Rosys (experimental).
- LHC timing information allows triggering on events (injection and PM).
- **dBLM measurements at LHC:**
  - **Injection losses and injection oscillations**
  - **Abort gap monitor studies**
  - **Dump losses (Async. beam dump)**
  - **UFOs**
  - **Instabilities**
- Necessary upgrades before fully operational:
  - Timing for IP6,IP7, BA4 and BA6, fesa-classes for scopes and Rosys, implementation into logging data bases and Post Mortem, signal cascades.

Thank you for your attention!

www.cern.ch