Study of the signal linearity and response, calibration, saturation, and comparison of different types of beam loss monitors (BLM) at HiRadMat

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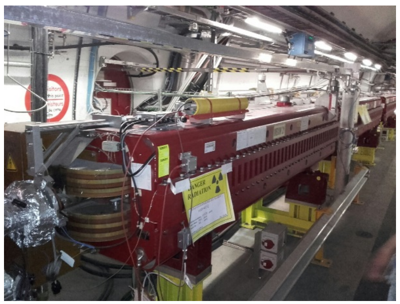
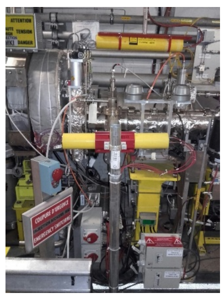
Scientific overview

- An unprecedented amount of energy is stored in the circulating beams of LHC and other accelerators. **The loss of even a very small fraction of a beam may induce a quench in the superconducting magnets or cause physical damage to machine components.** A fast (one turn) loss of 3 · 10−9 and a constant loss of 3 · 10−12 times the nominal beam intensity can quench a dipole magnet. A fast loss of 3 · 10−6 times nominal beam intensity can damage a magnet.
- **To comply with these requirements several different types of detectors**, such as the Ionization Chambers, currently the main beam loss detectors at LHC, ESS, GSI, the little ionization chambers (LIC), and the proportional chambers have been designed and produced aiming at highly reliable operation with a large dynamic range. For example, the sudden increase of losses in the half-cell 16L2 presented a major machine limitation during 2017 with 67 dumps induced.

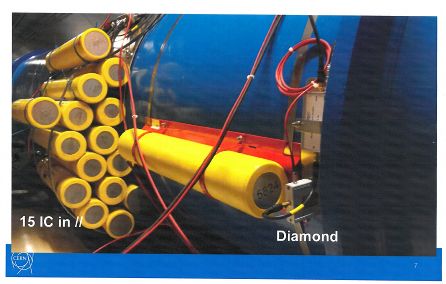
Beam Loss Monitors at CERN, ESS, GSI

At the beginning of Run 2, BLM LHC system had 3929 monitors
with 3518 Ionization Chambers (IC), 108 LIC and 191 SEM (and 1 FIC)





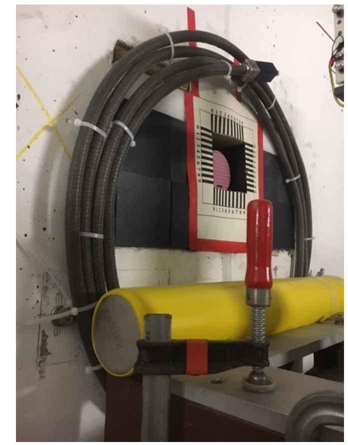
BLM 16L2



LINAC 2 had 5 IC
LINAC 4 installed 24 IC
~100 ICs are in PS

BLM PSB system had 32 installed IC and 32FIC.

GSI



ESS

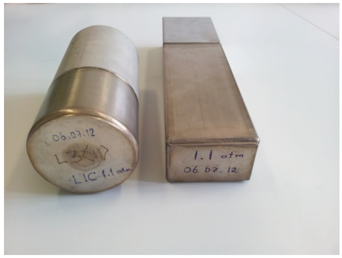
Project opportunity/interest

EUROPEAN SPALLATION SOURCE

- The functionality, stability, calibration, and saturation tests of BLM detectors at HRM are proposed for validating and characterizing fully those detectors.
- **This kind of test is unique in HiRadMat from many reasons**: the beam parameters in wide range, the beam diagnostics, the cables and fibers availability with required grounding, last but not least to have the experts around to get quick feedback from the test and very importance of having such a facility available in future.
- We, in ESS, consider the different places as Germany's centers, USA sites to BLM tests but HRM is most acceptable for BLM study mainly due to beam required parameters.
- **BLM19 & BLM2 experiments have been using HiRadMat since 2012.**

HRM tests of BLM

HRM19-BLM2
B. Dehning, E. Effinger, V. Grishin.
2015

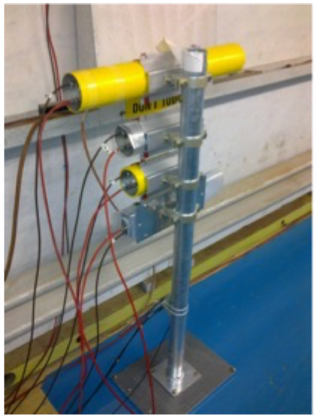



Motivation

Response of Beam Loss Monitors in high radiation conditions.

•- LIC have been designed to reduce the sensitivity with respect to LHC IC (LHC injection area installation)

•- FIC have been designed for geometry considerations (PCB installation)

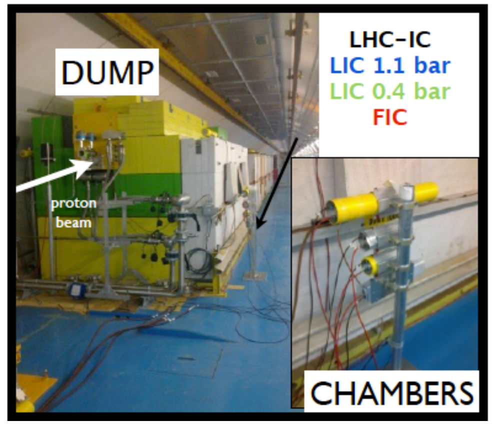
HRM04-BLM

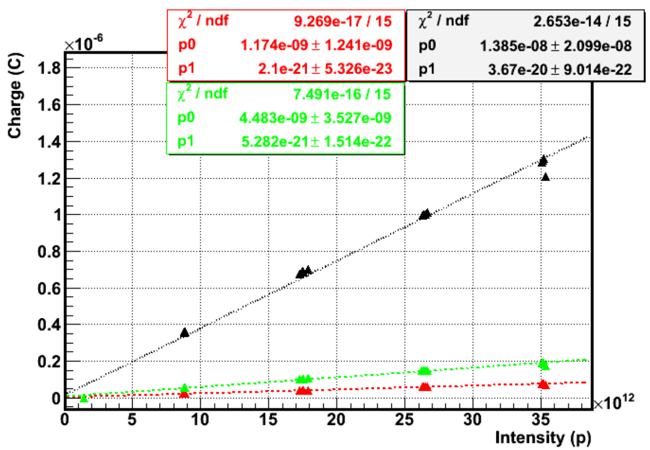
Study of the response of ionization chambers in HiRadMat

E. Nebot, B. Dehning, E. Effinger,V. Grishin.
Acknowledgments: N.Charitonidis.
2012

Detector performance for Set up in 2012- 2016

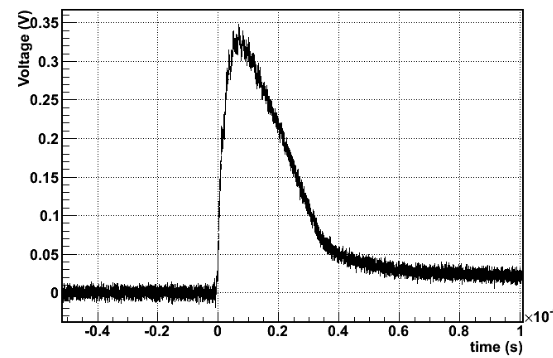
- Response to 1 ns pulsed (mixed radiation field. Protons onto dump)
- Raise time/FWHM ~40/200 ns
- Total (ion) charge collected in 300us
- Response linear with intensity

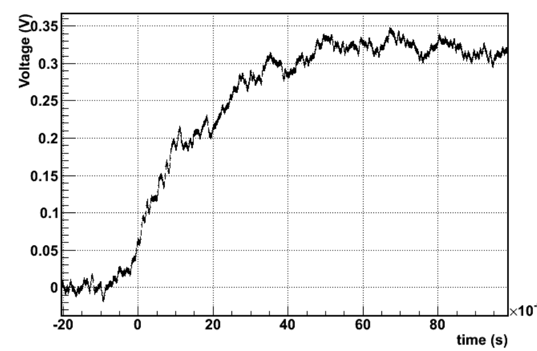




plot of the integrated charge (over 40 us), **Sep 2015** at HRM
black = IC, green = FIC, red =LIC

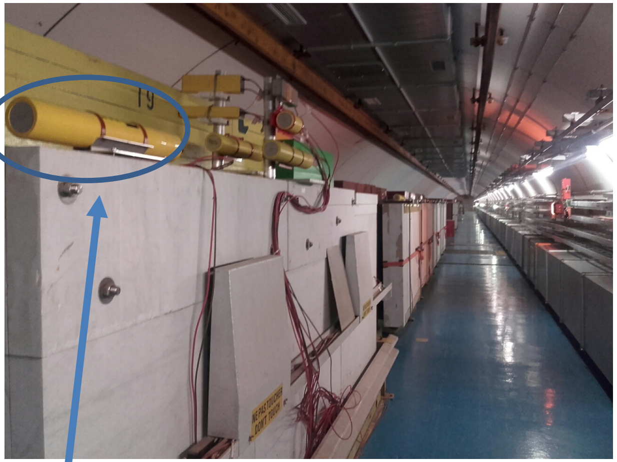
Electron induced signal





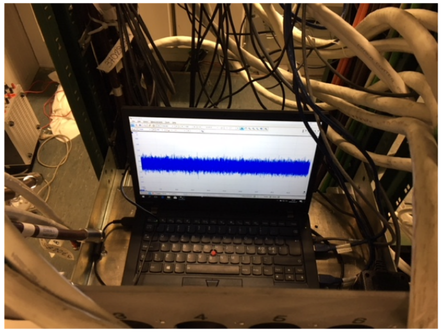
Courtesy E.Nebot

Set up in 2017-2018



TT66.BLM.660518LOSS_EXTR1 next to the last BTV on the beamline (just before the beam exit window)
TT66.BLM.660523LOSS_EXTR1 next to table B (where your experiment is installed)
TT66.BLM.660526LOSS_EXTR1 next to table C (most downstream table)

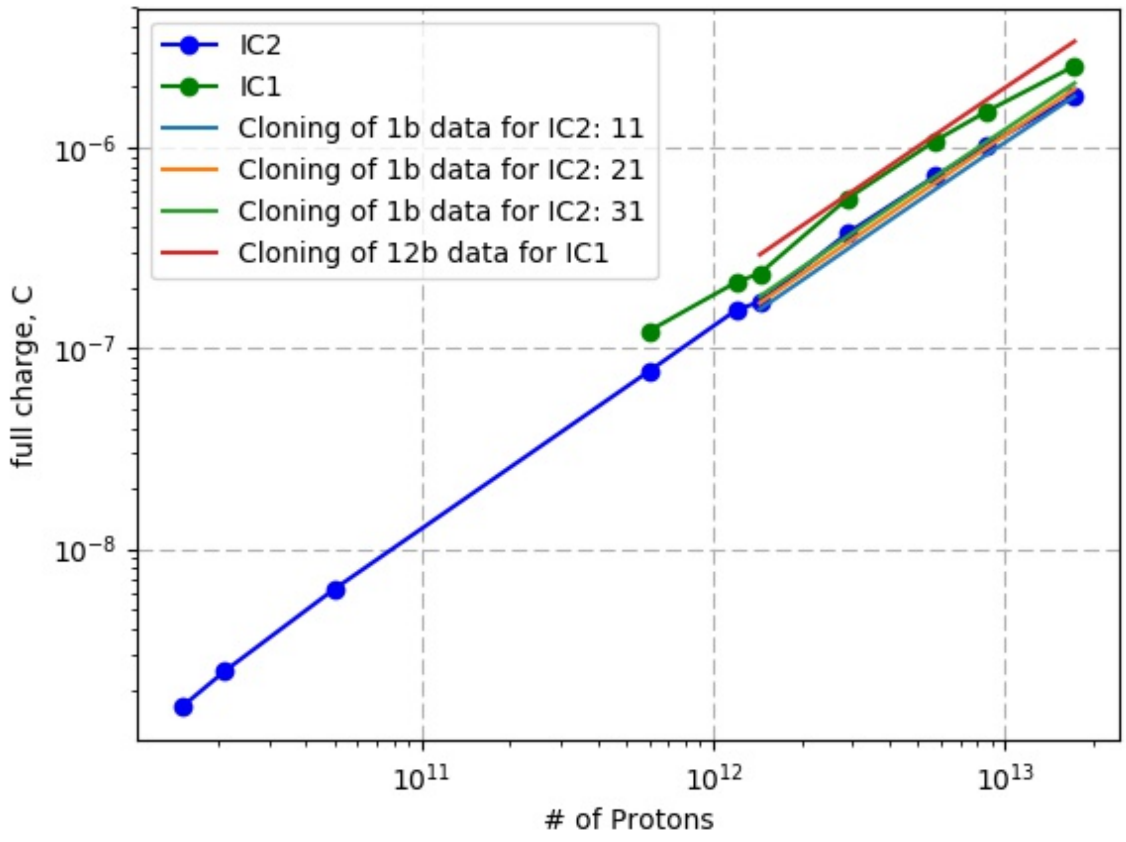
Length of cables



DAQ for BLM2@&HRM

2 USB Pico scopes connected to a PC and Ethernet, running automated acquisition on the scopes and sending data.

Full charge fron flux: IC1-ic17, IC2-ic08



Continuation of study of the signal linearity and response, calibration, saturation, comparison of different types of BLM detectors.

- **The LHC type of Ionization Chambers,** IC08 and IC17, were tested in 2017-2018 and will need to continue to be tested in 2020-2022 to check the aging of IC and comparison with Run 2 data. This is highly important for evaluating the requirement of beyond 20 years of operation in the LHC and HL-LHC environment as well as evaluating the ceramics used in the production of the IC17 batch.
- **The LIC (Little ionization chamber)** type with IC ceramics was tested for the first time in 2017-2018. Based on the very promising results of this test we are following with a second pre-series production of these type of detectors. Those make use of different ceramics than the LICs currently installed at LHC.
- To support the investigations of the 16L2 limitation and anticipate other possible similar future problems, we have produced a new type **proportional chambers**, which would be preferable to be tested first at HRM together with the standard detectors. This new type of detectors has the same outside geometry but the sensitivity is 10-100 times higher in comparison to the existing detectors.

Set up

IC2008/IC2017/IC202X

PC vers IC2008/IC2017).

LICic2020/LIC(LHC type)

Proportional Chambers

- This detector should provide 100-1000 times (depending on the applied bias voltage) higher sensitivity to the LHC type IC.
- The parallel plates are replaced with a single wire and the gas from Nitrogen with a mix of Argon & CO2.
- it is a drop-in replacement to the standard detectors and should avoid the need of the complex bundle installations such those done in 16L2 and 31L2.

Courtesy to Christos Zamantzas, 07/05/2019

BLM test features

- In 2015 and 2016, the BLM detectors were positioned at the side of the dump. In 2017, all detectors were moved at top of the dump. Based on the experience of 2017-2018, the proposal for 2020-2022 will be to continue to optimize the system and the position of the detectors to ascertain a full range of values, including ions and electrons.

- From RP's point of view, the monitors could be removed easily from the area with minimal activity, since there is no significant activation for this parasitic experiment.
- The detectors connect with copper cables within the area of the HiRadMat tables and provide a direct link to the HiRadMat Control Room in BA7. Therefore, there is no need for a patch panel (especially since the monitors have low current and are not grounded).

- It would be possible and of great value to operate in the shadow of other HRM experiments for the majority of the run. Only for one type of validation, it would be necessary dedicated time for which we do not expect to be more than once or twice per year. The desirable beam parameters are from a single bunch with different intensity for the calibration up to 144 (or 288, if that becomes available) bunches for saturation tests.

- It's the very important that the teams, which will participate in BLM &HRM tests consists from different groups and countries: CERN BE-BI-BL section (Christos Zamantzas , Section Leader), ESS ERIC , Lund, Sweden, BD section (Viatcheslav Grishin, Detector Project Leader), IHEP Protvino, Russia, BI lab (Andrey Koshelev, BI lab Leader)

The beam pulse list

The beam pulse list:

A) <u>Calibration:</u>
1, 12 bunches x pulses 0.5e11

B) <u>High intensity:</u>
1.2e11 ppb

- pulses with 12 nominal bunches
- pulses with 24 nominal bunches
- pulses with 48 nominal bunches
- pulses with 72 nominal bunches
- pulses with 144 nominal bunches
- Pulses with 288 nominal bunches

ARIES-CERN-HiRadMat

Thanks to

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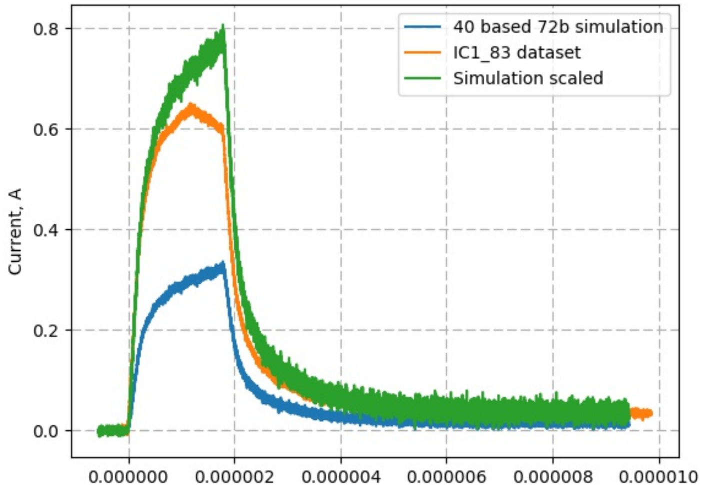
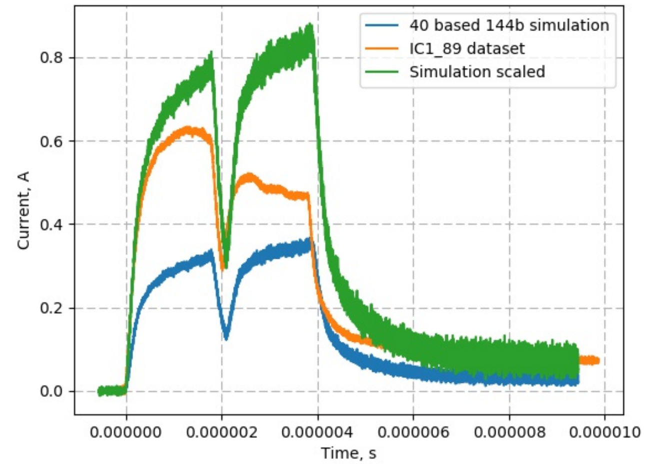
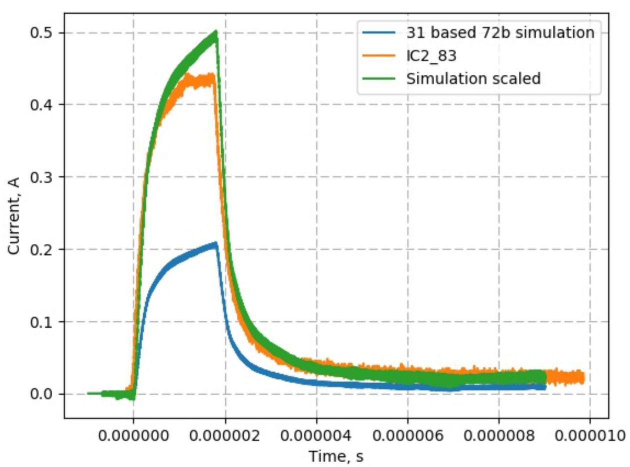
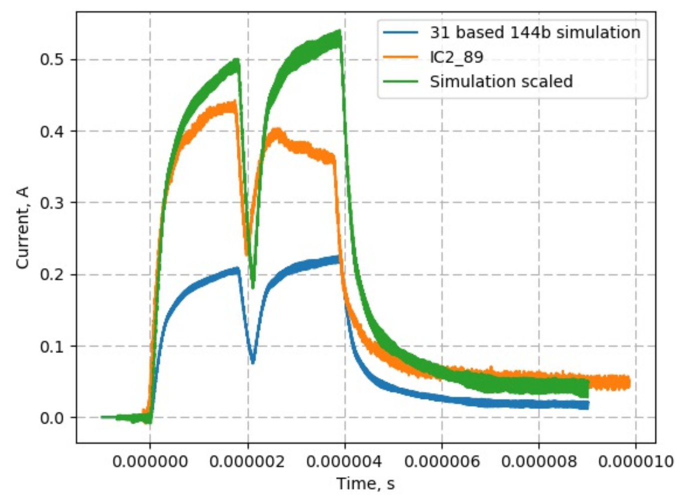
Thanks to
Eduardo Nebot Del Busto
Tatiana Medvedeva
Ion Savu

IC1-icBLM17; IC2-icBLM08 (saturation)

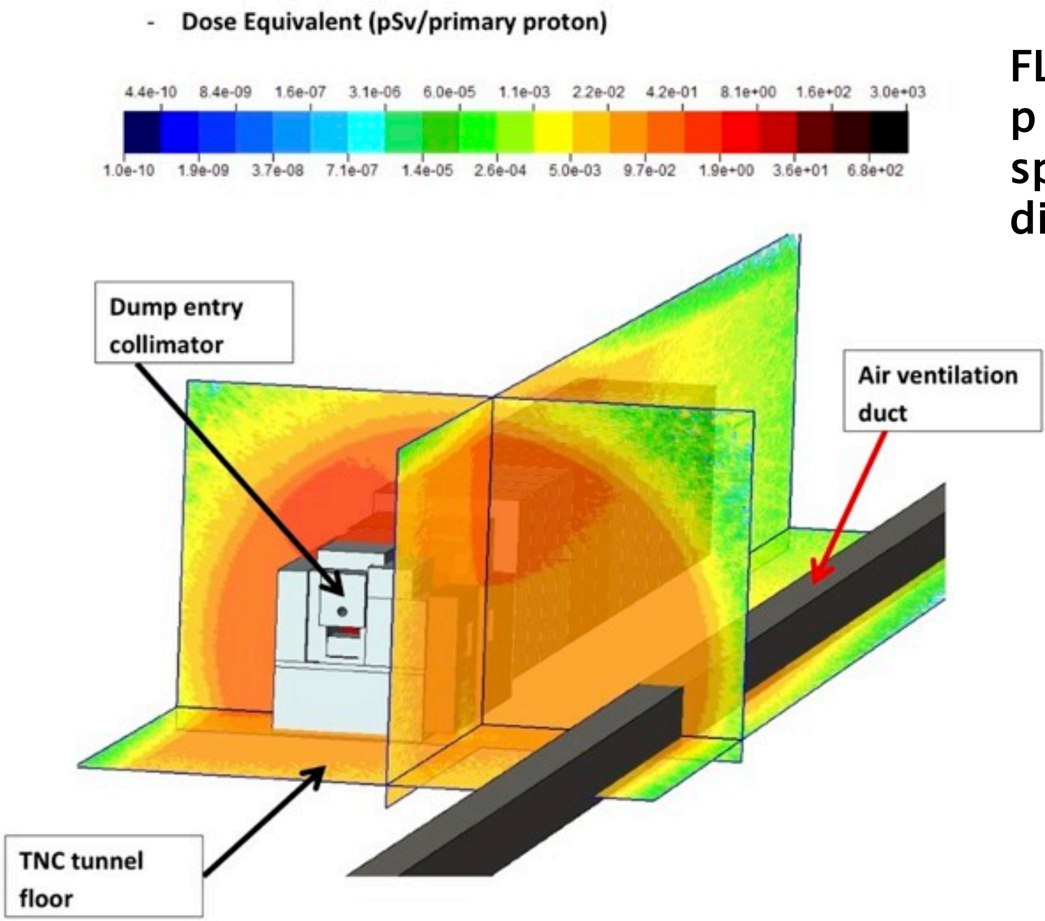








Simulation



FLUKA (Nikos Charitonidis) 450 GeV p beam
spot size ~2mm
directly hitting beam dump