BLM55:Detector response test of various BLM detectors types.

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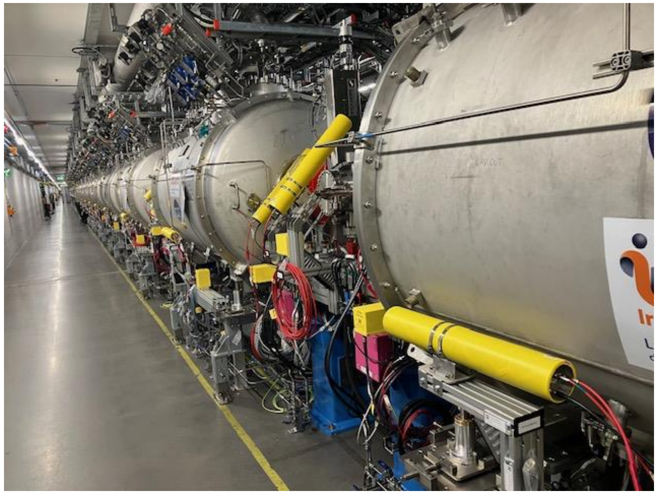
02.12.2024 User Day 2024

Beam Loss Monitoring System

The beam loss monitoring system must protect the machine components from damage, prevent the superconducting magnets from quenching, be sensitive to different level of losses in different accelerator locations, should limit the losses to a level which ensures hands-on-maintenance or intervention. From another side, the BLM system should be sensitive enough to enable machine fine tuning and machine studies with help of BLM signals. From 2005 more than 6000 various types of beam loss monitors have produced for most of high energy accelerators in world. Currently a new CERN production campaign is ongoing with the aim to deliver 1000 units in 2026.

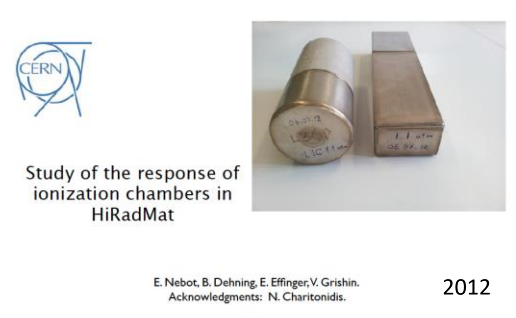
- **Ionization chambers (IC)- the main beam loss detector** type; three different productions: IC-2004, IC-2016 (for ESS, CERN,GSI), IC-2024.

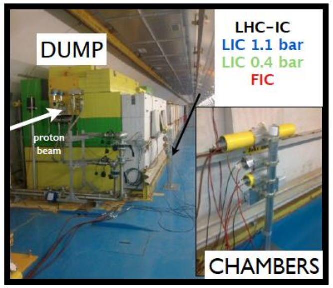


- **Little ionization chambers (LIC)** – were designed to reduce the sensitivity with respect to IC. LIC, installed in LHC have with SEM ceramic insulators. LIC prototypes with IC ceramics disks have been succesfully tested at HRM. Currently new LICs , which considering as a detector for HL-LHC, is under production at CERN.

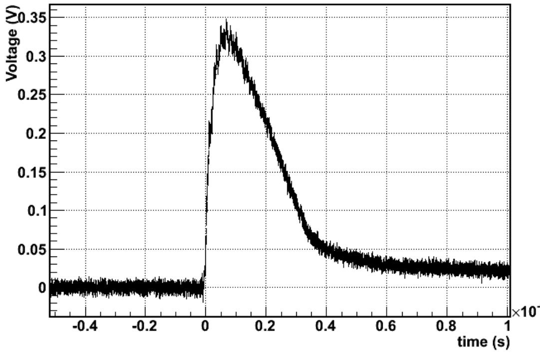
All BLMs (except SEM) have been tested at HRM for validation and characterisation purposes since 2012.

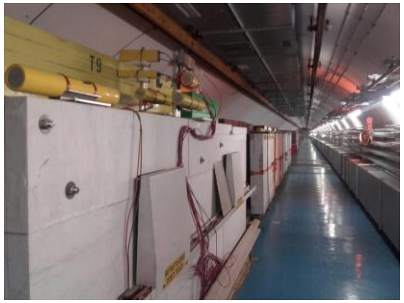
BLM2 & 19 & 55 at HiRadMat

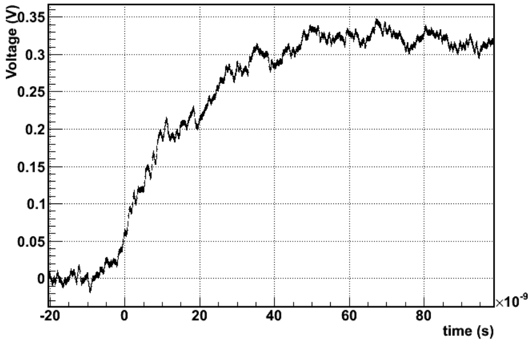


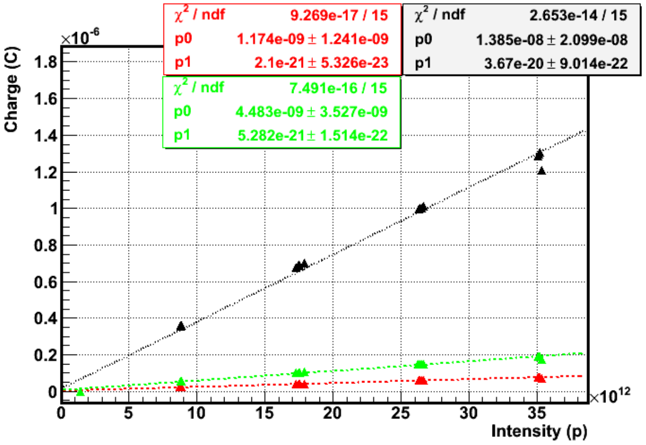


Electron induced signal









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

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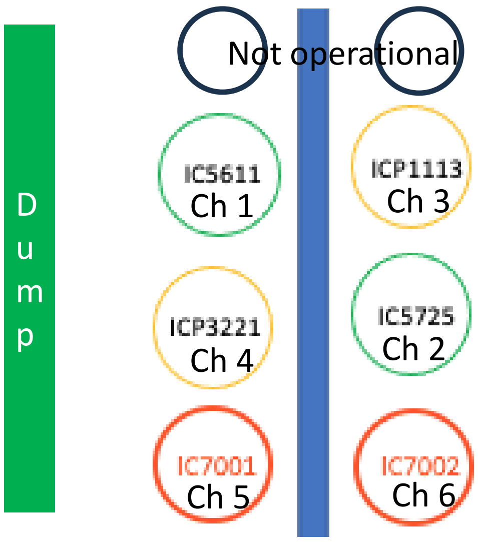
Set-up and goals of 2024

- ***Cross checks, comparisons IC-2004, IC-2016 , IC-2024***
- ***Calibration/saturation of IC-2016, IC-2024***
- ***Signal time evolution (drift time) for IC2016***
- ***New type of Little Ionization Chambers (LIC2024)***



Ch1 & Ch2 – type IC2016
CH3 & CH4 – type IC2004
CH5 : first prototype IC2024
CH6: second prototype IC2024

Set-up for July beam test , 2024

Set-up for August beam test , 2024

Scope ch.	Position	BLM	Name
2	G	New IC	HCBLM_I001-CR006005
3	E	New LIC	HCBLM_L001-CR001002
4	C	New IC	HCBLM_I001-CR006003
5	D	IC	IC7001
6	H	IC	IC7002
8	A	LIC	HCBLM_L001-CR001001

A	|	E
B	|	F
C	|	G
D	|	H

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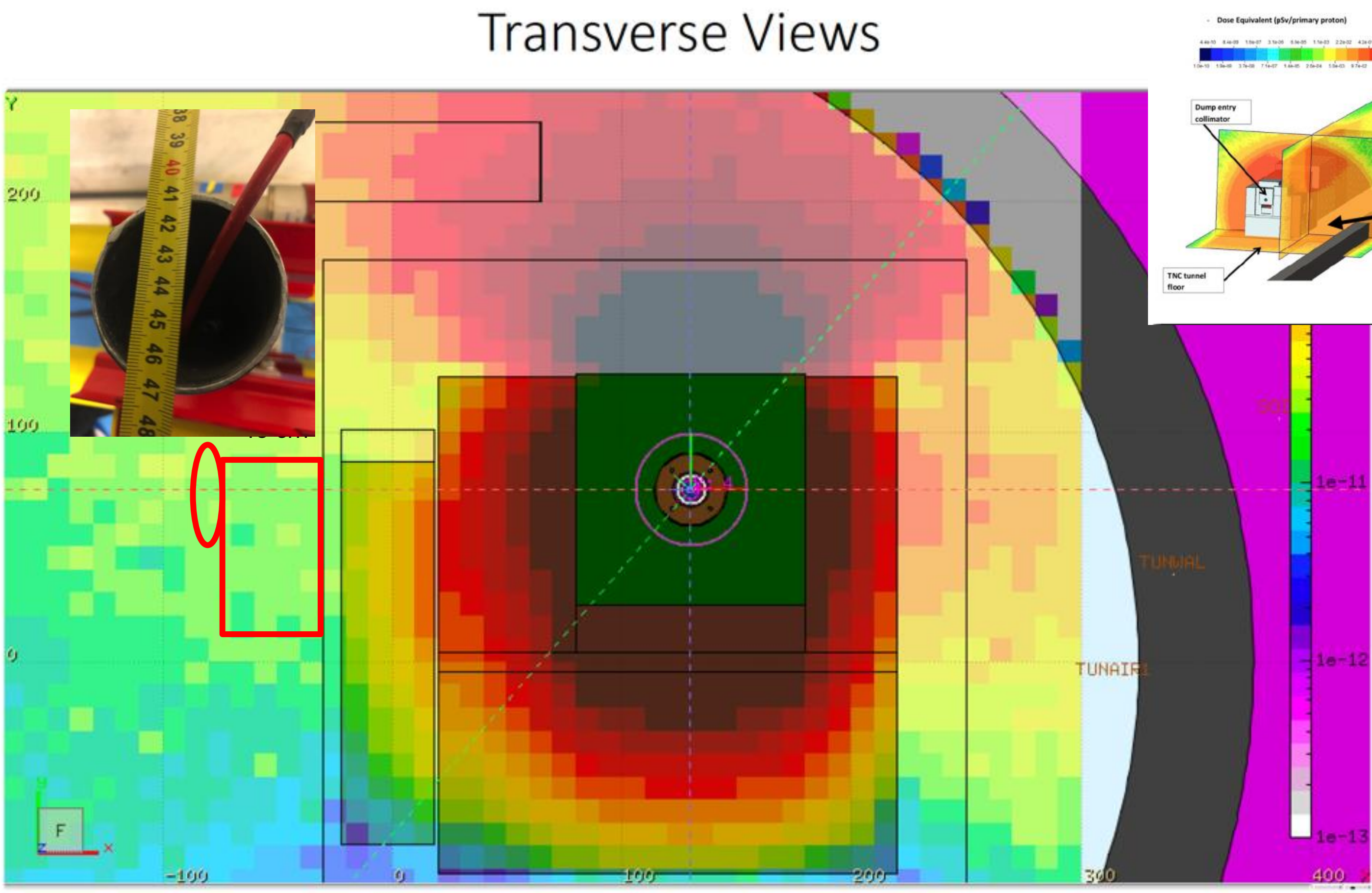
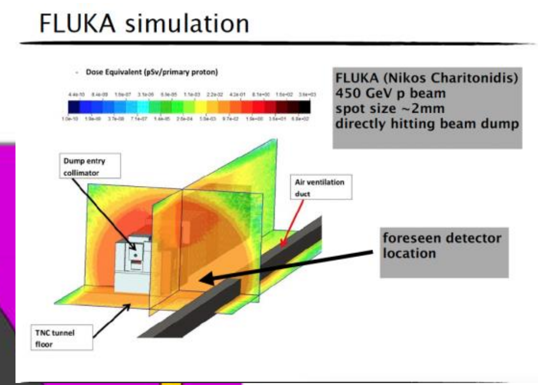
2021 simulation (J.Hunt, L.Esposito)
2012 simulation (N. Charitonidis)

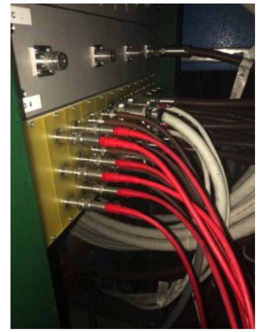


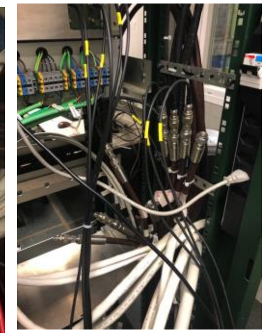


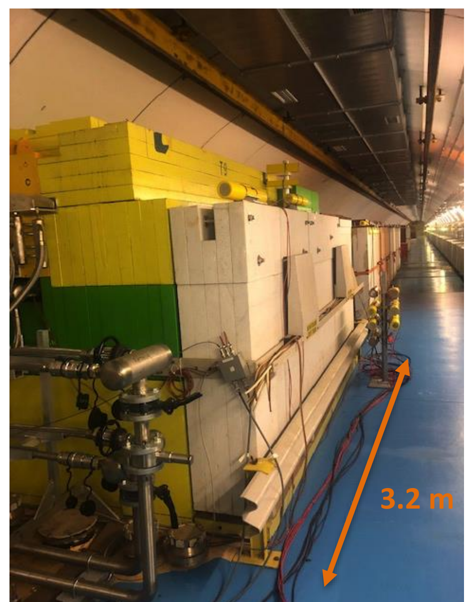
- At 3.2 -3.3 m and height ~80 cm approximately uniform, homogeneous dose in beam direction
- At detector locations the dose approximately independent of the vertical position (within statistical error)

BLM experimental setup at HiRadMat

- Detectors connected from the area of HiRadMat side of dump to the HiRadMat Control Room in BA7.
- Due to low detector current
  – Detector signal cables connected through only one patch panel
  – Signal connection not grounded.
- DAQ:
  – Signal waveforms acquired with a scope (Tektronix, MSO58LP), ~3-6 waveforms per pulse/bunch







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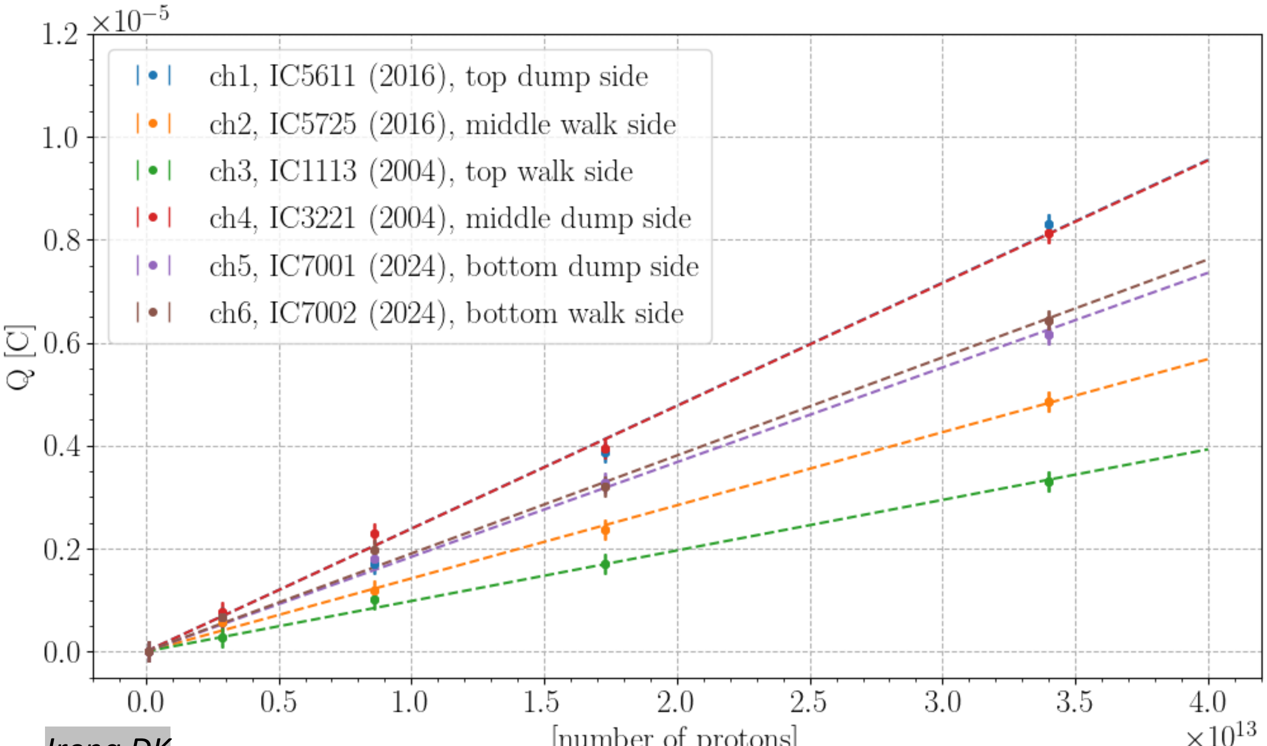
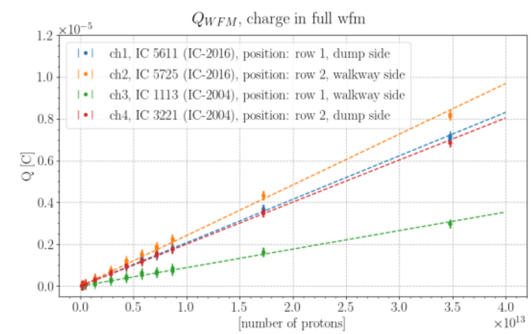
Charge vs intensity, July 2024

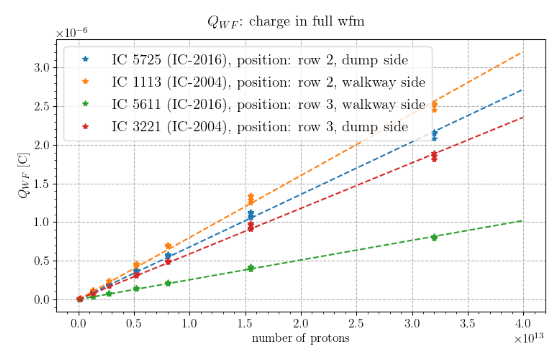


Irena DK

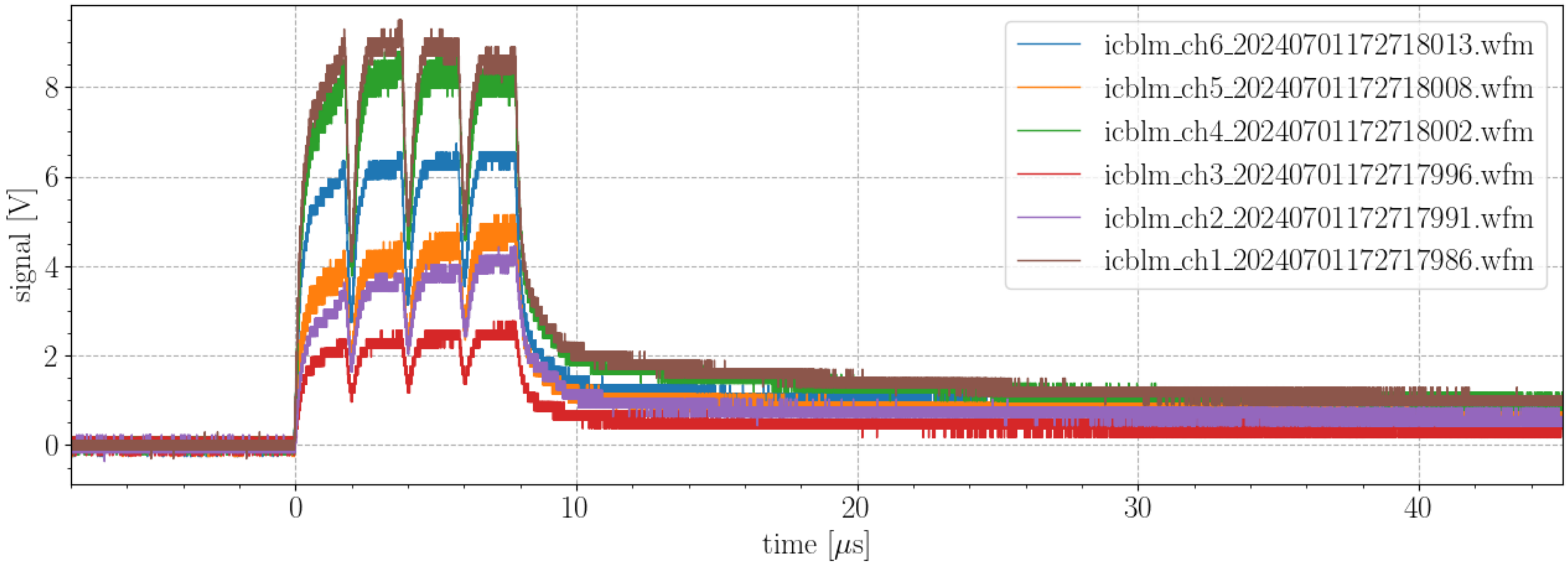
2023



2022

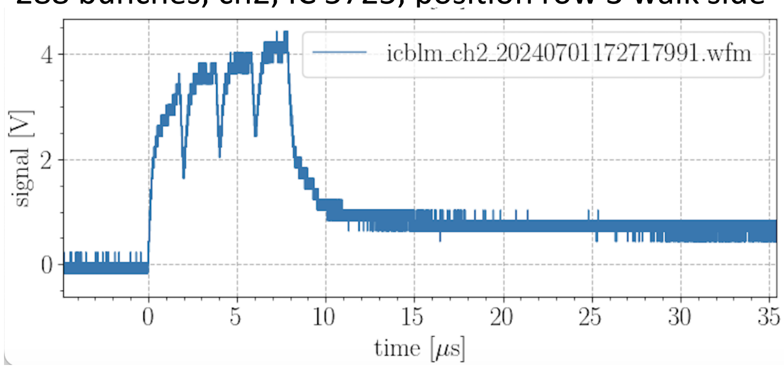


Saturation

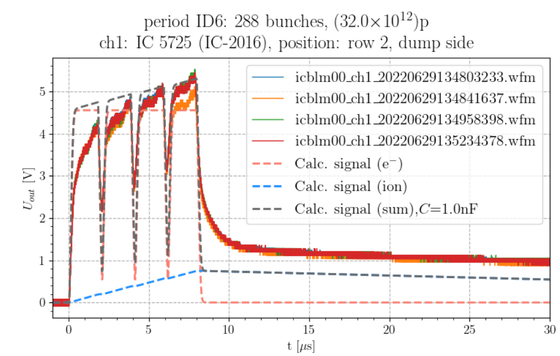


2024

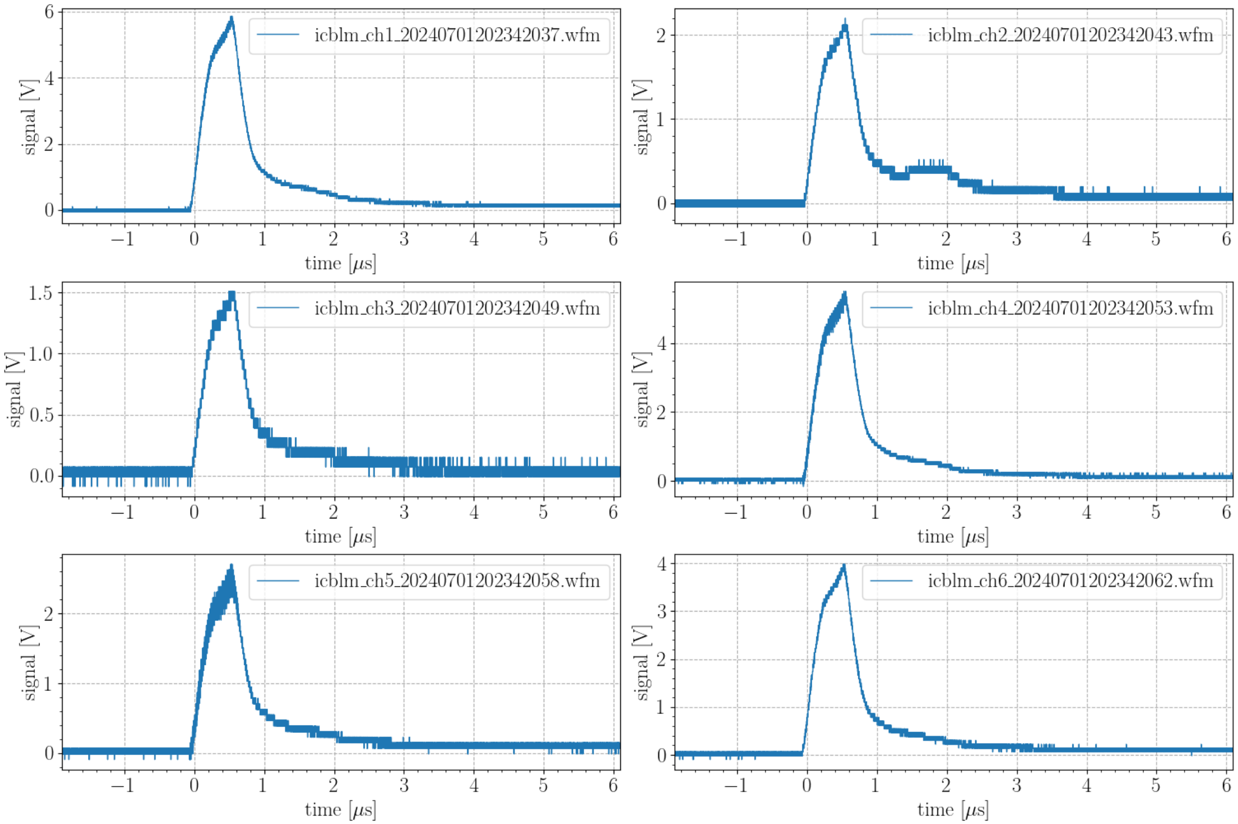
288 bunches, ch2, IC 5725, position row 3 walk side

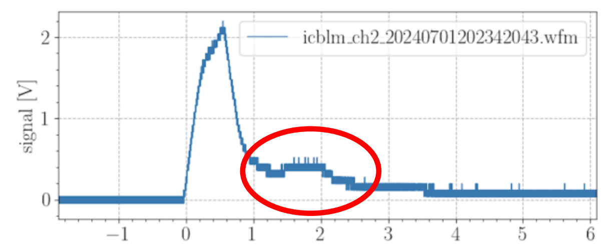


2022



24 bunches





24 bunch, ch2, IC 5725, position row 3 walk side

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Compare 2024 & 2023 results:

- Ch3 (IC2004) shows about the same result (a bit higher this year)
- Ch1 (IC2016) and Ch4 (IC2004) are like last year close, and again a bit higher this year
  - A bit higher this year - sounds reasonable, as we have now 1ms integration instead of 80us
- Just Ch2 (IC2016) seems to be substantially lower - perhaps connected to that reflection at around 1.8us from the signal start, it's visible for all periods with number of bunches up to including 24 bunches, for more bunches it disappears as the proton trains/bunches become longer then 1.8us
- The 24 bunch data for the full drift time : drift ends around 100us on ch1(IC2016), >150us for ch3(IC2004), no end for ch2, ch4, ch6, ch5 (IC2016, IC2004, IC2024, IC2024).

Summary

- Results indicate similar detector performance for all ICs
- However, detector-to-detector performance variations potentially larger for IC-2016 than IC-2004, IC-2024 but should take into account the detector location (for 2025 proposal)
- IC preliminary results for integrated total charge is over 300 μs but should test by LHC daq , exclude the scope possible contribution (for 2025 proposal)
- New LICs need more time and more efforts to test/design/simulation/new prototype production

Acknowledgements

•We especially thank to HiRadMat team, P. Simon, N.Charitonidis , A.Goillot, P.Alexaki and SPS control team

Last Publications:

- *IBIC23, V.Grishin, I.Dolenc Kittelmann(ESS), A.Lenevall, C.Zamatzas, E.Effinger, W.Vigano (CERN), "Detector response studies of the ESS ionization chambers"*
- *TAC, September 5, 2024, I. Dolenc Kittelmann, "ESS BLM status and test plans"*

•This project has receiving funding from the Horizon Europe EC funded EURO-LABS project under Grant Agreement No. 101057511

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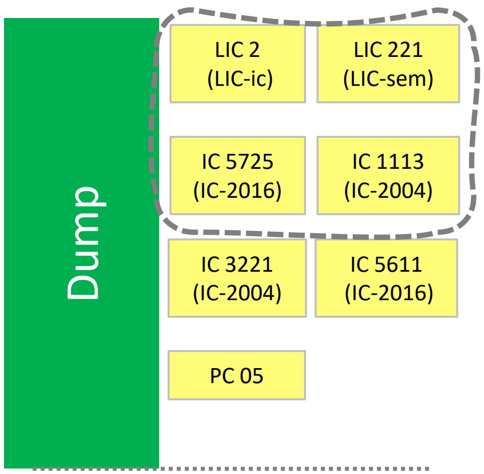
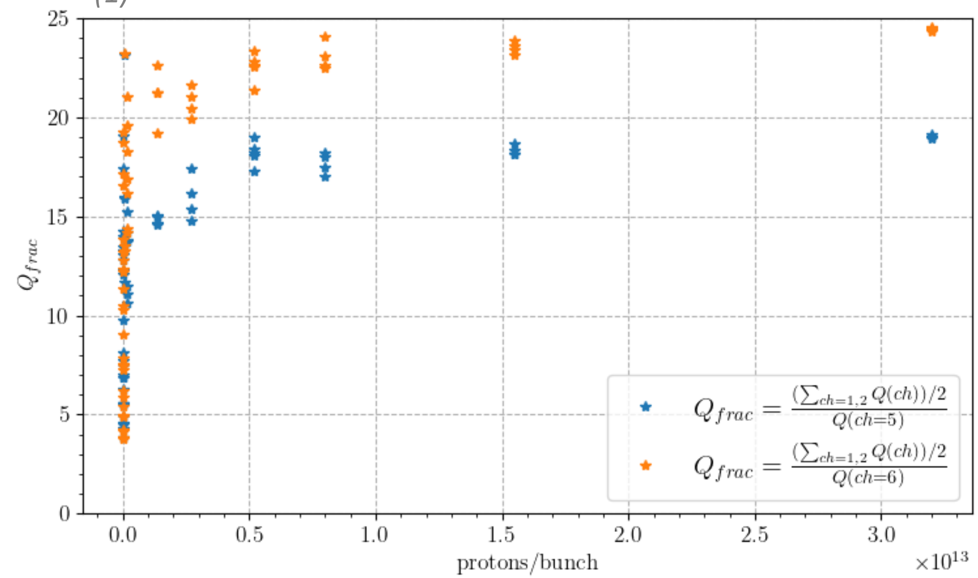
LIC-ic 2022 results and summary for 2025 production

- Expected ration of charge between IC and LIC:
  - $Q_{IC}/Q_{LIC\text{-}ic}$ ~ 20 and
  - $Q_{IC}/Q_{LIC\text{-}sem}$ ~ 12
- Measured ratio values:
  - At higher intensities as expected ~20/12
  - Larger discrepancies at lower intensities due to issue LIC sensitivity



Measured IC/LIC ration, calculated as comparison of LIC detector charge to the average of charge from 2 IC detectors placed directly below.
Blue = LIC-sem
Orange = LIC-ic

(1)



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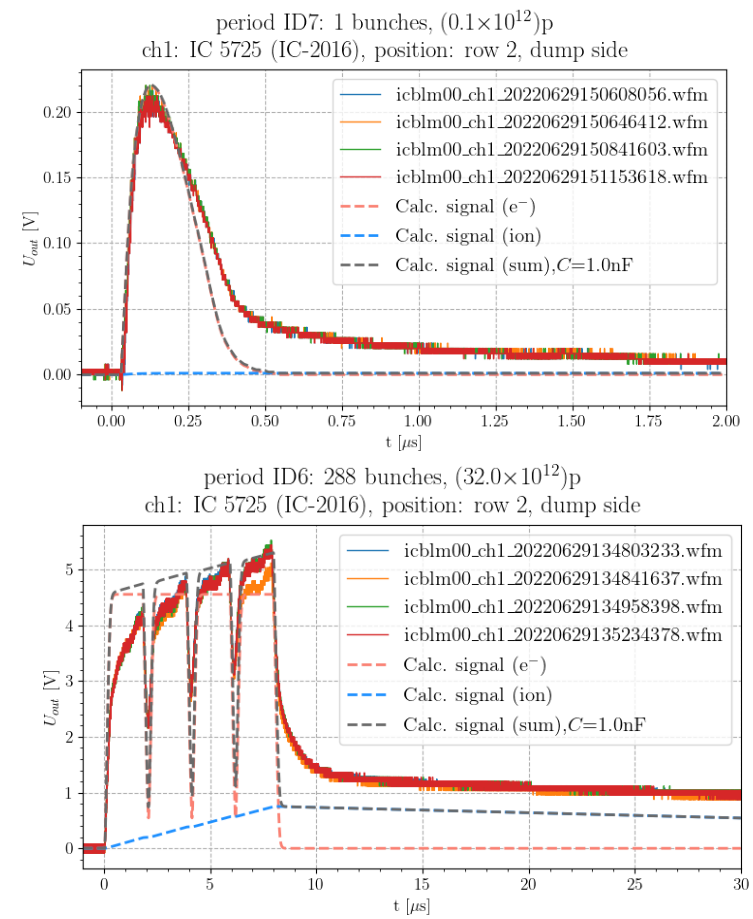
IC results 2022: signal

- Signal shape rather different than what is expected for a parallel plate geometry, assuming $^{+}N_2$ and e^- drift:
  - –Less linear for ion drift part
  - –Increased contribution from ions

Irena DK

Measured and calculated (dashed lines) signal for 1 (top) and 288 (bottom) bunches assuming e^- and $+N_2$ drift times from literature:



Measured average signal for 1 (right) and 288 (left) bunches – ion drift zoomed in: