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Charged particles fluences distribution measured by LHCb RMS: status and plans for upgrade

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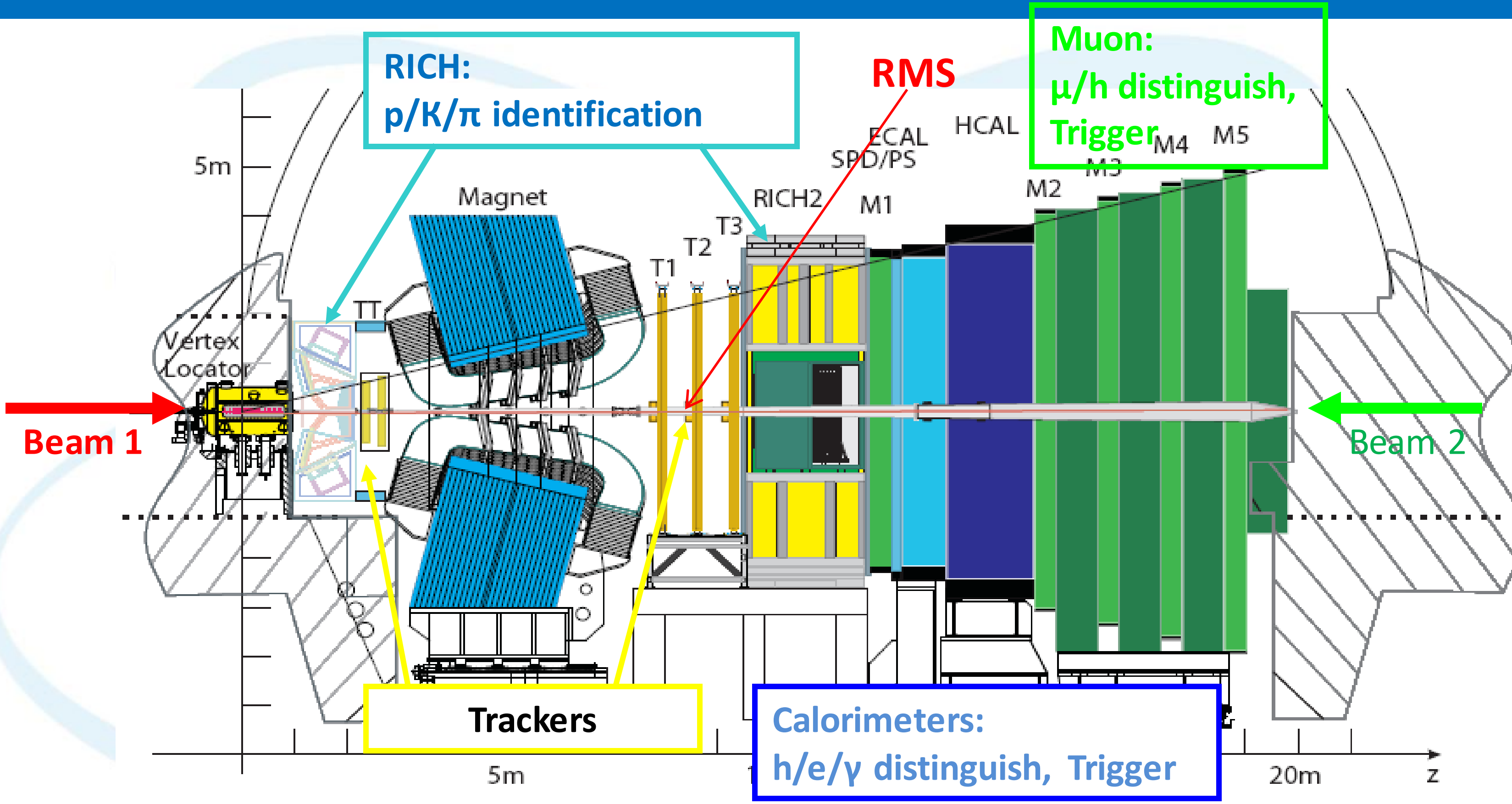
Introduction: LHCb



LHCb – forward spectrometer, located at LHC.

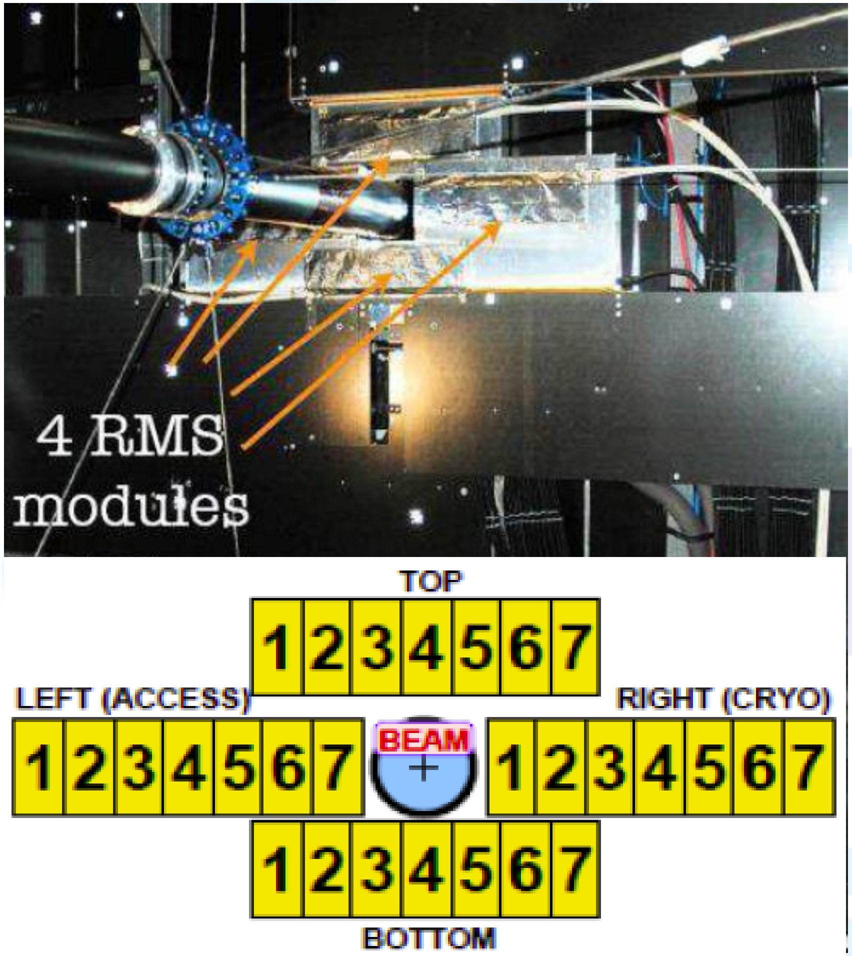
Proton-proton interaction at **$\sqrt{s}$ = 14 TeV, L = 2×10^{32} cm^{-2}s^{-1}**, **ν=1, μ=0.699**

2012: 8 TeV, 2-4×10^{32} cm^{-2}s^{-1}, ν=2.6, μ=1.8, 50ns b.c., 1262 c.b.

2015: 13 TeV, 2-3×10^{32} cm^{-2}s^{-1}, ν=1.6, μ=1.1, 25ns b.c., 1536 c.b.

Goal: CP violation and rare decays of B-mesons.

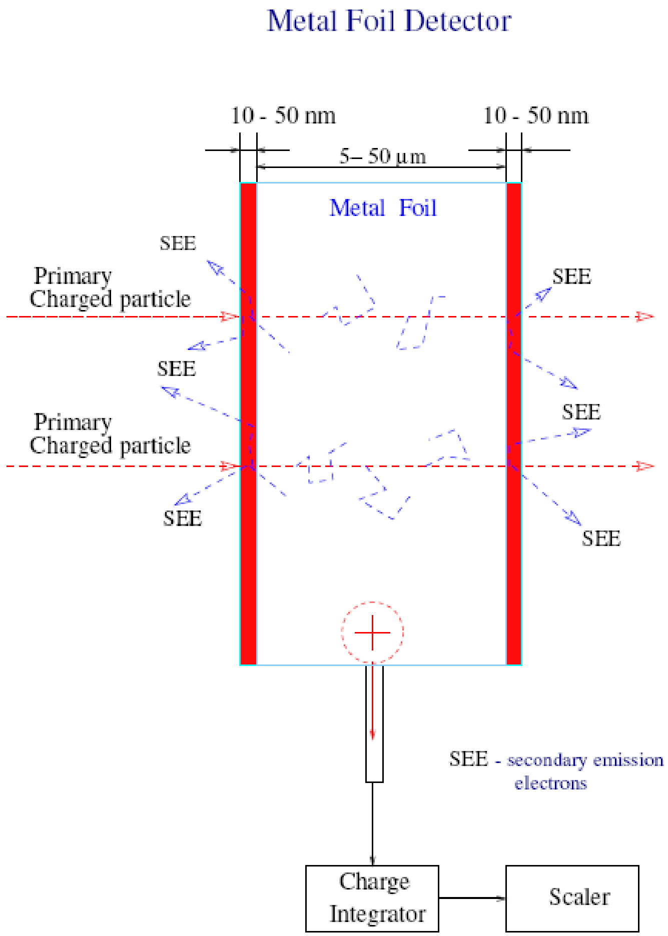
Introduction: RMS



- The RMS is based on the Metal Foil Detector technology developed in Kiev
- The RMS (detection part) comprises 4 Boxes (access, cryo, top, bottom) fixed at the IT-2 station
- 7 MFD sensors
  (110x75 mm^2) in each
- Dimensions of sensors are close to Inner Tracker ones
- Main function: to monitor radiation load on Silicon Tracker sensors

Introduction: MFD

- MFD is a metal foil connected to the **sensitive Charge Integrator** (ChI)
- Principle of operation – **Second Electron Emission** from metal foil surface (**10-50 nm**) caused by projectile charge particles
- Positive charge created in metal foil is integrated by Charge Integrator - converted into a frequency, measured by a scaler



Introduction: RMS

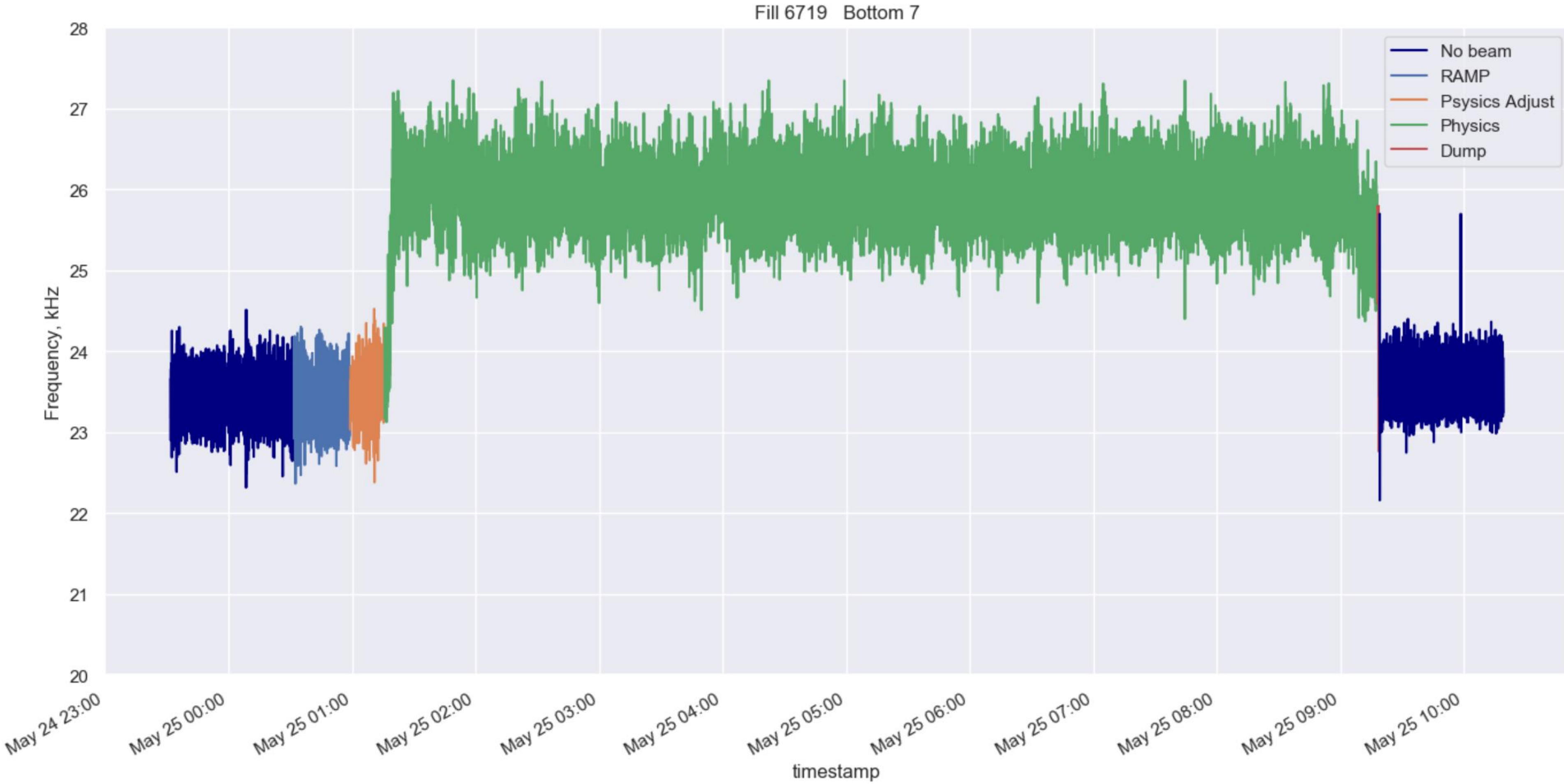
- The calibrating current at the input of the charge integrators is set to 250 pA, determines a baseline of 25 kHz for output frequency (10 fC – 1 count).

- One count in the charge integrator is generated by ~ 10^3–10^4 charged particles hitting sensor per second (depending upon their charge, energy etc.):
  - Linear response – up to 1,2 MHz output frequency.

- **RMS allows to monitor the luminosity by 2 orders exceeding the LHCb nominal one.**

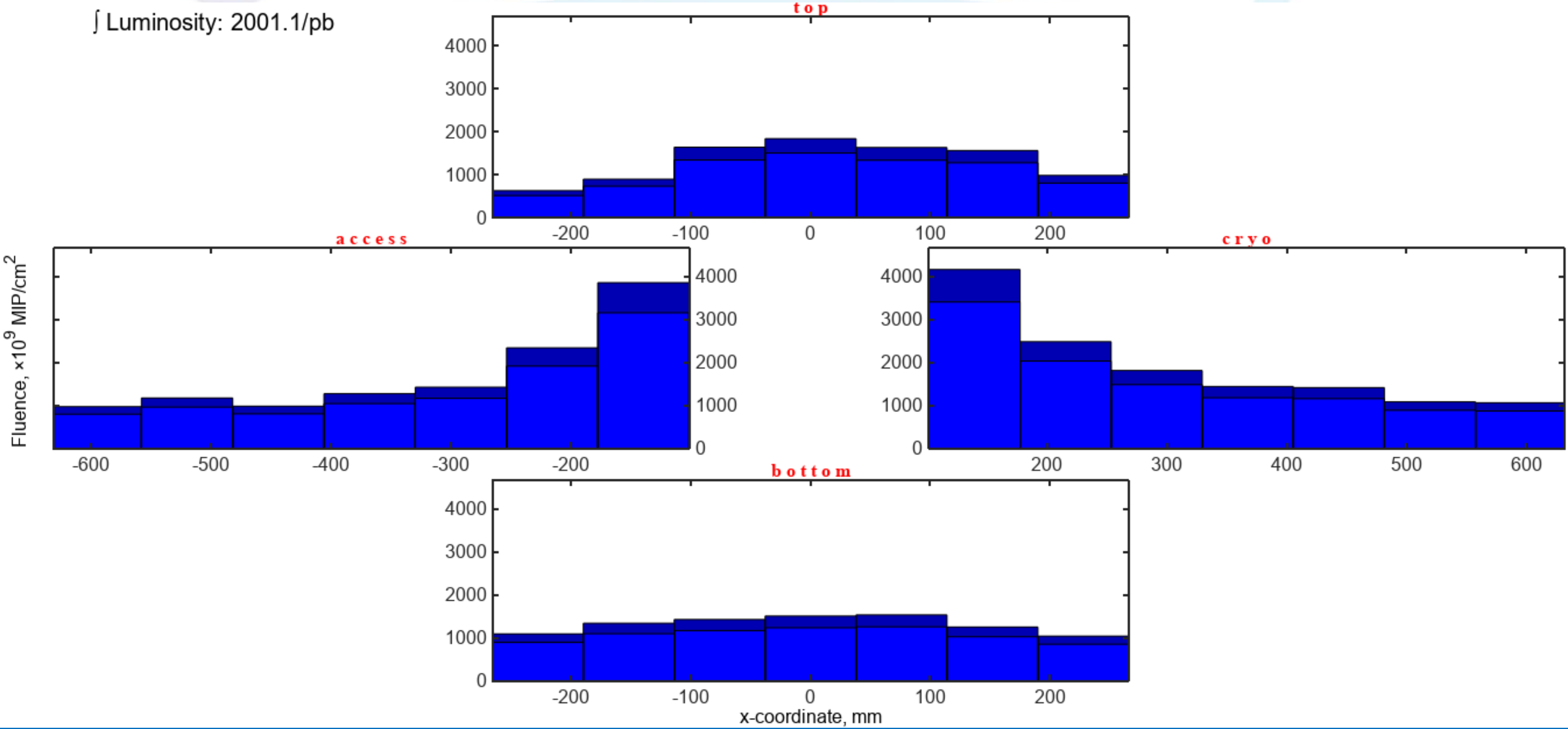
RMS response on pp collisions in 2018

Fill 6719: duration **~8 h**; **2332/2556@25ns** c.b.;
av. inst. Lumi **$4.38*10^{32}$ $cm^{-1}s^{-1}$**; ev. μ = **1.08**; delivered int. Lumi **~12/pb**



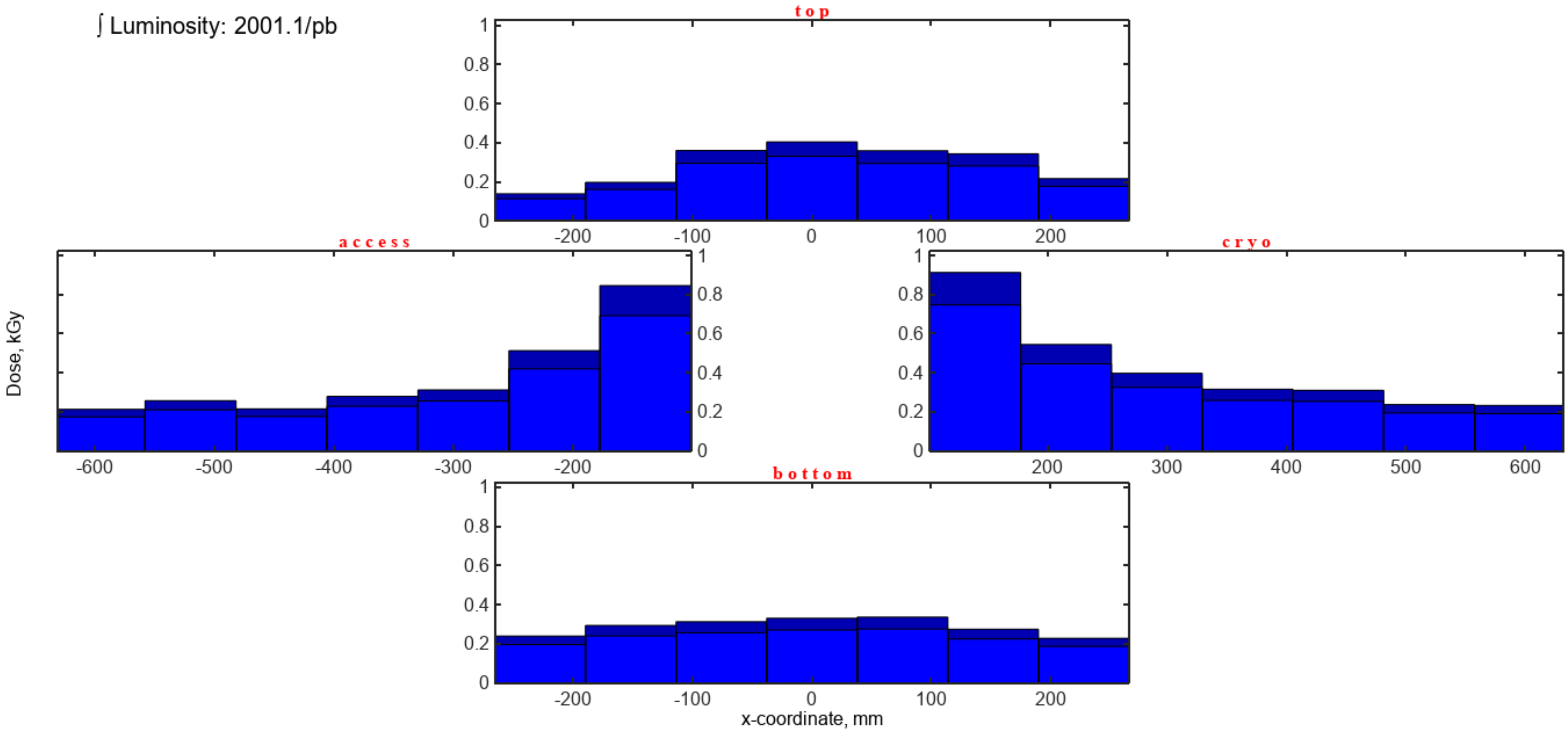
Fluence distribution over IT-2 Si-sensors in 2017

- In 2018 LHC delivered about 2 fb^{-1} to the LHCb.
- **Fluence[MIP/cm^2] = $\sum_i(\mathrm{Rate}_{PHYS}(i) - \mathrm{BaseLine}_{NOBEAM})\cdot\Delta t_i\cdot 2500/\mathrm{SensorArea}$**
- This corresponds upto **$3.8\cdot10^{12}$ MIP/cm^2** over Si-sensors of IT-2 station.
- That level of fluences (~10^{13}–10^{14} MIP/sensor near beampipe) can cause a **type inversion** in some Si-sensors (Should be checked with CCE, leakage currents and bias voltages).



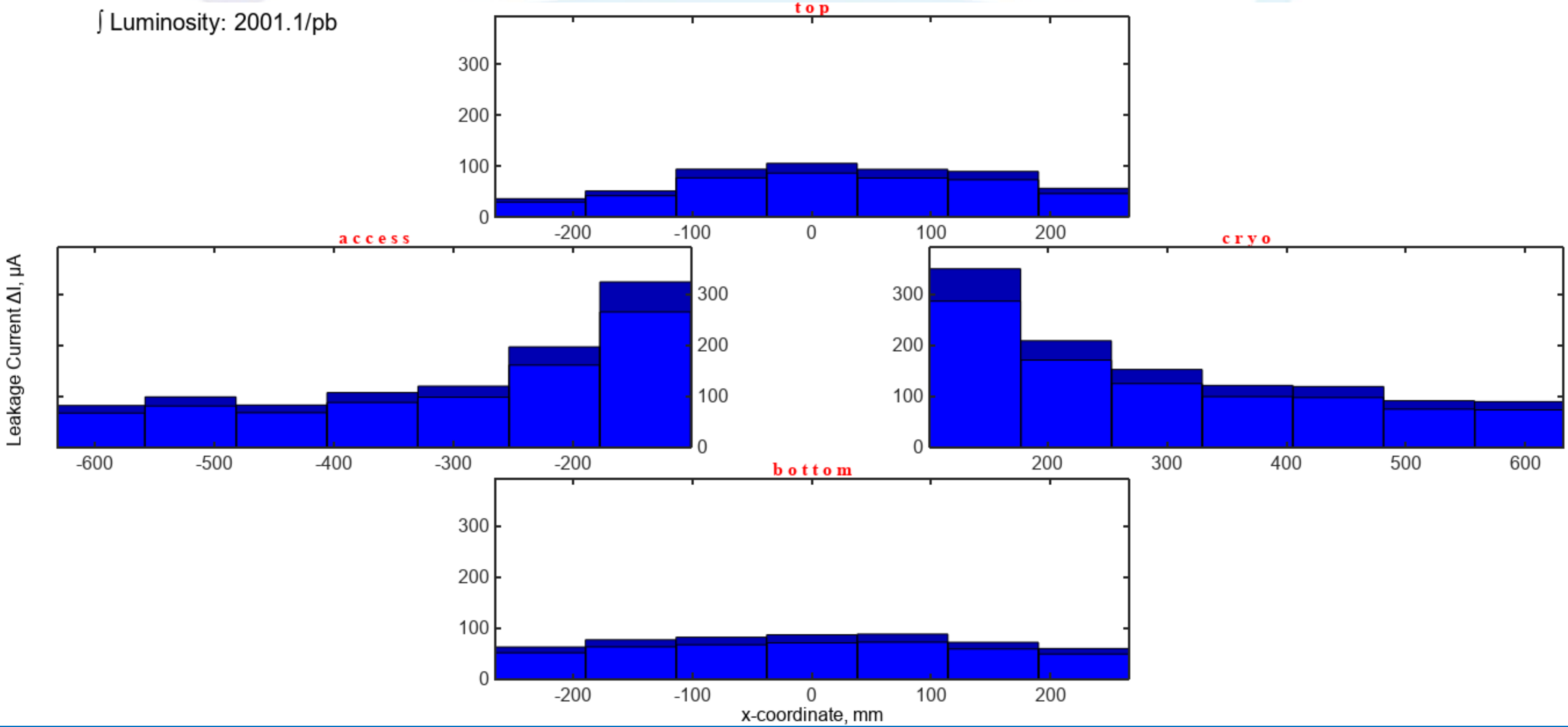
Dose distribution over ST-sensors

- Si-sensors of IT-2 have absorbed **0.15–0.8 kGy** this year



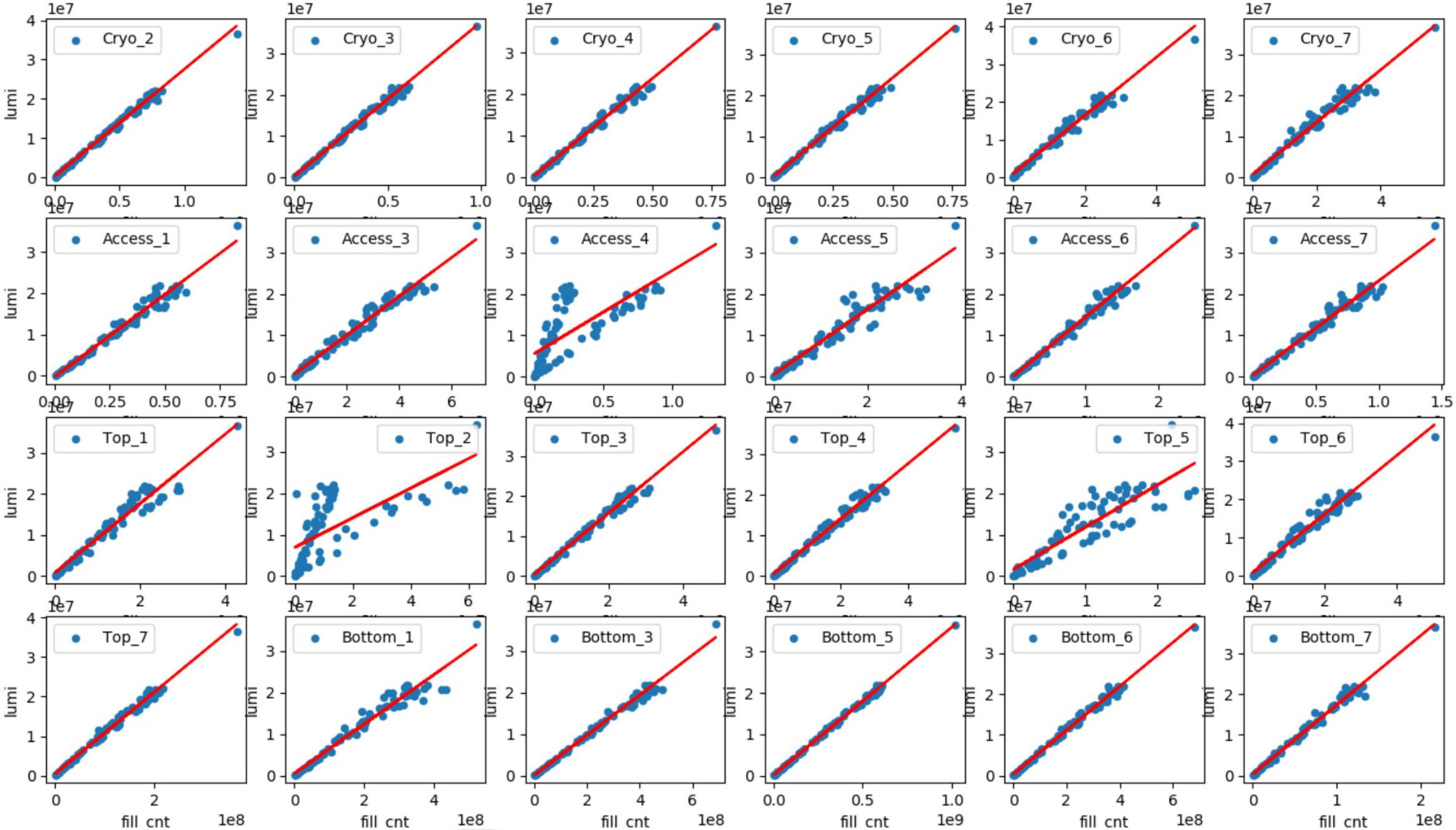
Leakage Currents distribution over IT2-sensors

- **$\Delta I = \alpha \times V \times f$**, where **$\alpha = 1.7\times10^{17}$ A/cm** (for 20°C), **V** – volume of the Si-sensors, **f** – fluence in 1MeV Neutron Equivalent per cm^2.
- Leakage Currents through Si-sensors of IT-2 have increased by **40–300 μA** depending on sensor size and position.



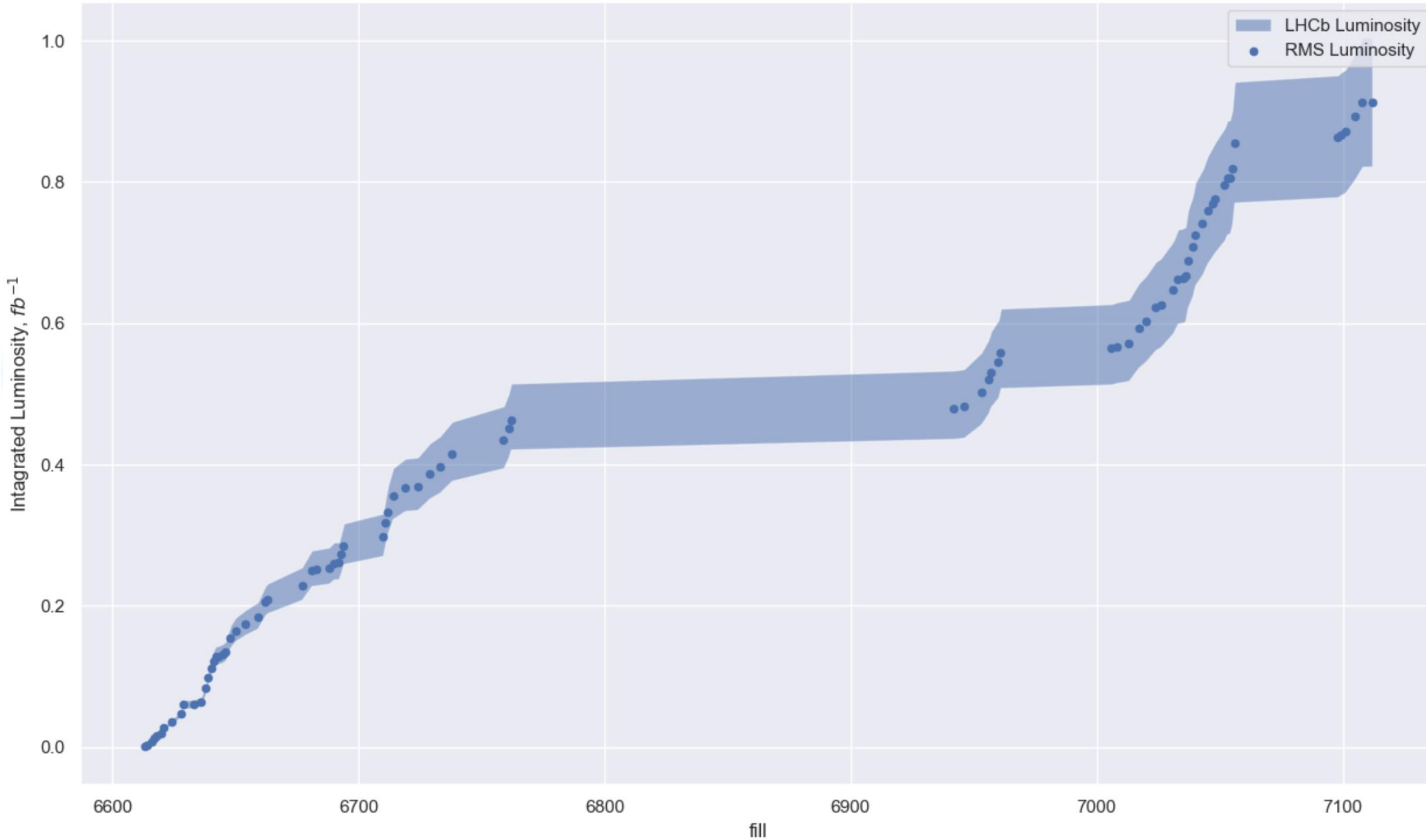
Luminosity Measurements

- This allow to extrapolate RMS data (fluences) on "non-detected by RMS" fills.

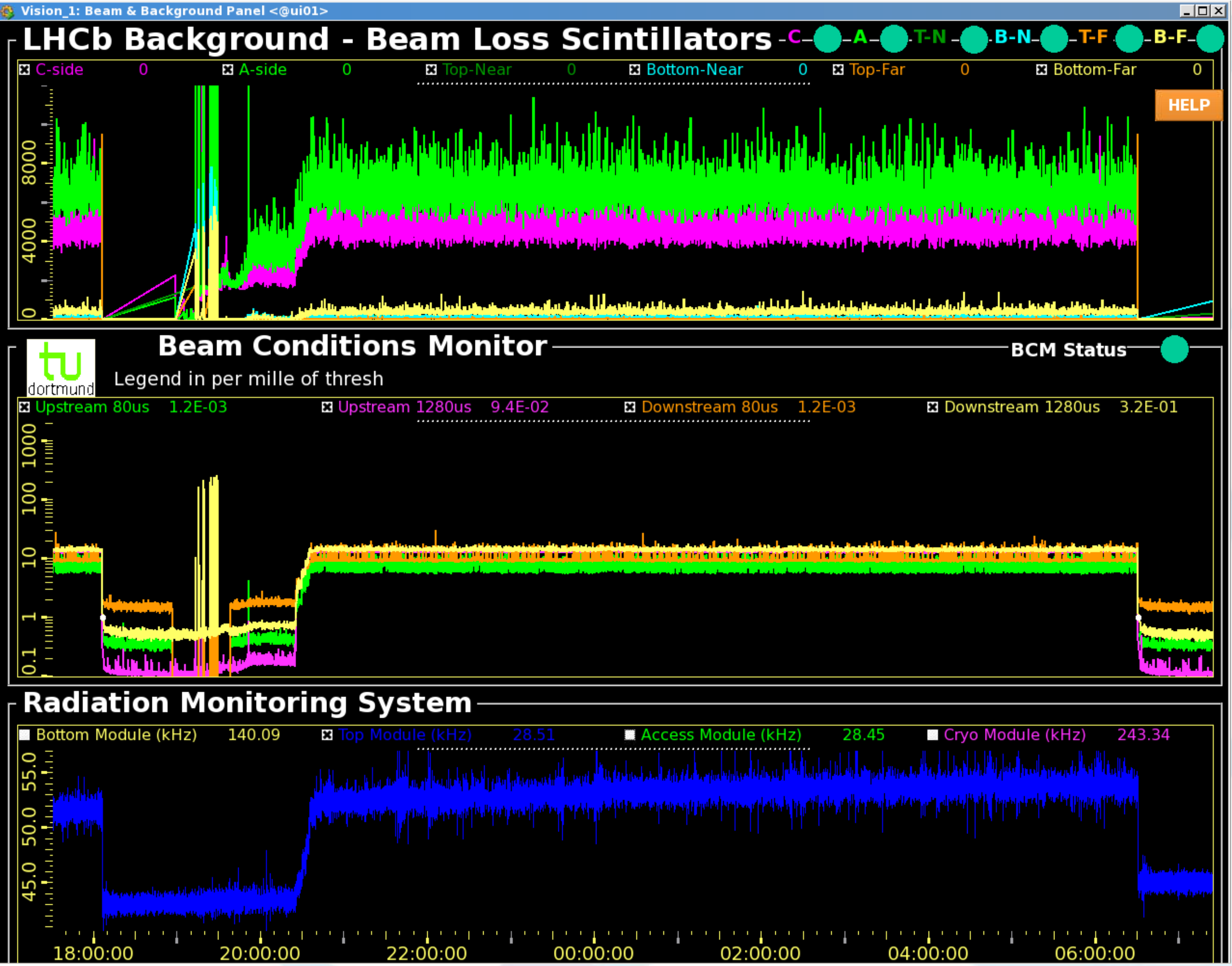


Luminosity Measurement

Evolution of the Delivered Luminosity at LHCb measured by RMS in comparison with LHCb data.



Beam and Background control tool



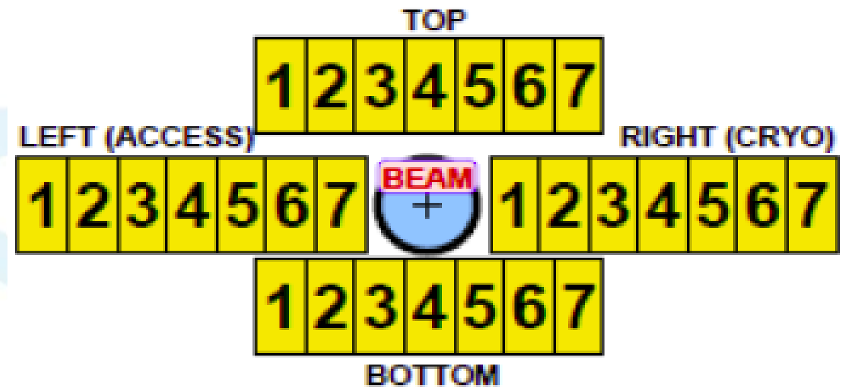
RMS together with **BLS** and **BCM** is displayed at **Beam & Background Panel** in the **Control Room**.

This panel is very essential during beam injection to prevent radiation damage of the detectors.

Asymmetries measurements

$A = (I_1 - I_2)/(I_1 + I_2)$

- First preliminary results with asymmetries.
- Charged particle fluences asymmetry measured by RMS can allows monitoring of beam position (less then 1 mm) and IT-2 stations moving (due to magnet polarity changes) additional to BCAMs which is needed for better alignment.



Plans for RMS upgrade for Run3

Works on Upgrade of RMS for Run3 in progress:

- RMS based on MFD technology can be useful for Upstream or SciFi Trackers as radiation loads measuring tools
- Also, RMS can be used as Radiation background and Lumi measurements.
- The design of Upgraded RMS depends on it application and location: it is possible to produce MFD sensors of various sizes and shapes and use several types of front-end readout electronics (ASIC Beetle or NIM Charge Integrators developed in KINR).

Conclusions

- RMS characteristics allows to measure charged particles fluences over IT Si-sensors
- RMS is used as Beam and Background Tools to monitor Radiation Background – very important during beam injection to avoid radiation damages.
- RMS is able to measure Integrated Luminosity.

Thank You for attention!

Asymmetry measurements