technische universität
dortmund

FSP LHCb
Erforschung von
Universum und Materie

LHCb beam monitoring and safety systems

Holger Stevens
on behalf of the LHCb collaboration

ICHEP
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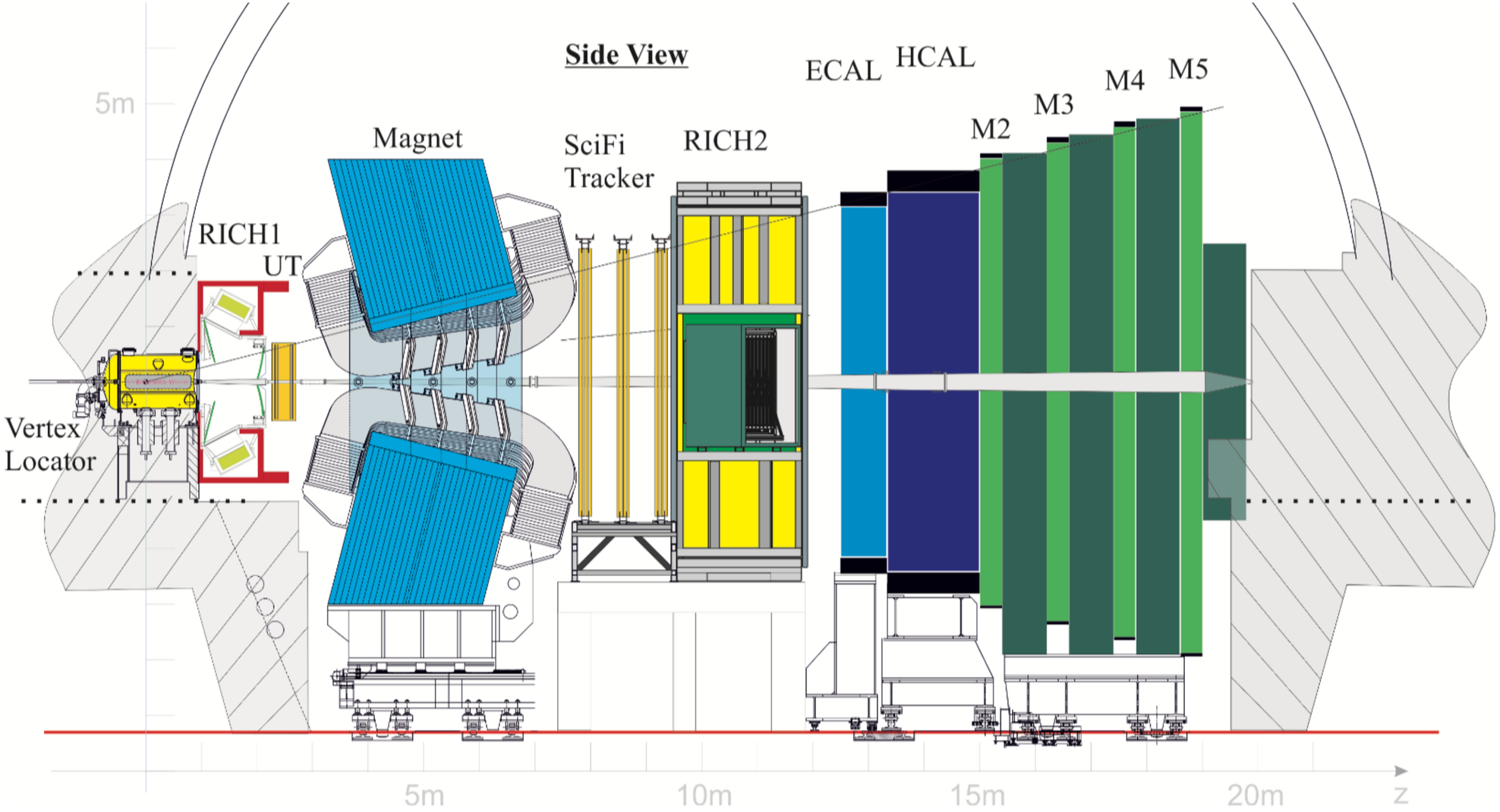
Radiation Monitoring

- Normal accelerator background depends on:
  - filling scheme
  - proton number
  - bunch length
- Background can reduce data quality
- Component damage possible

The LHCb Detector

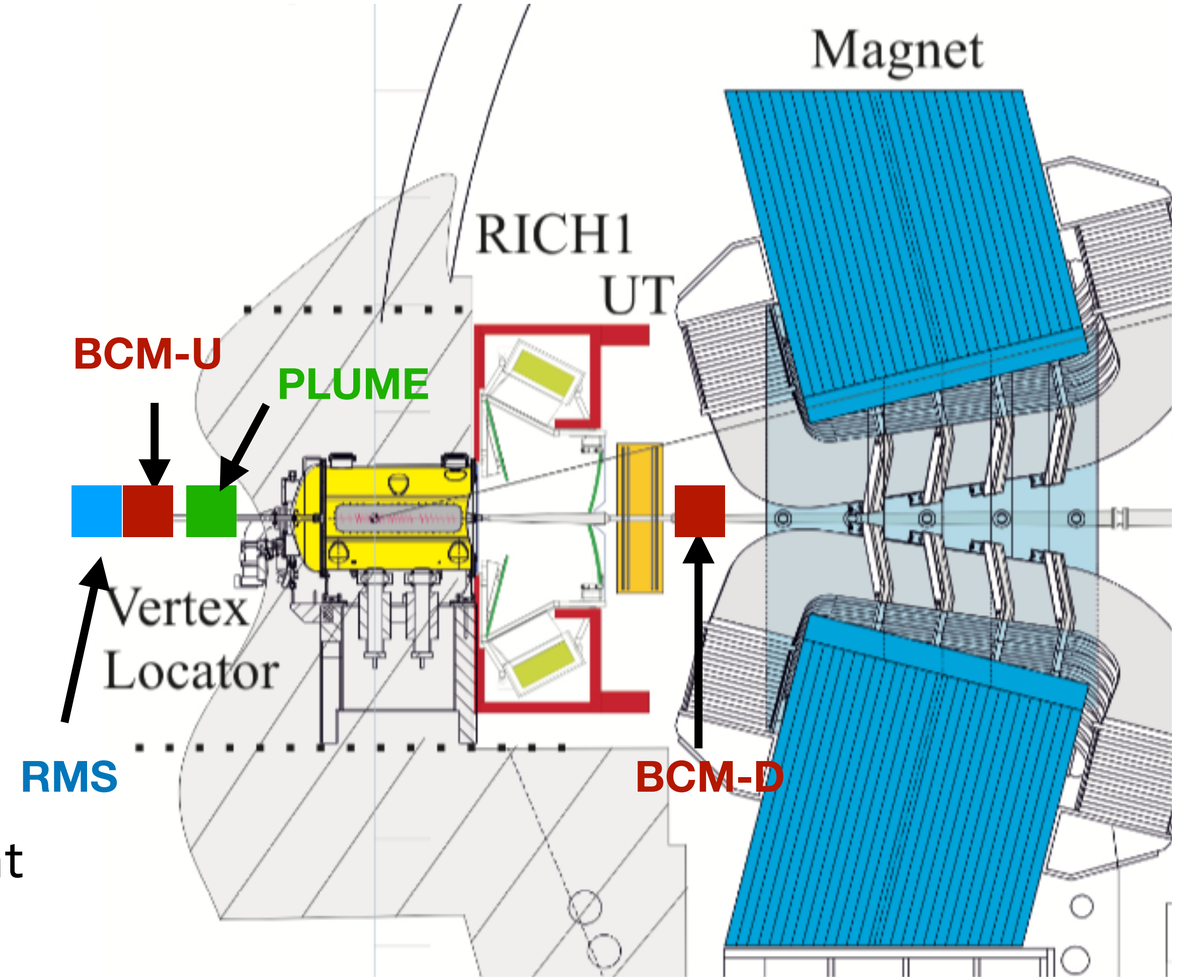


Conditions in Run 3 + 4

- Luminosity 2 * $10^{33}cm^{-2}s^{-1}$
- Integrated luminosity 50 fb^{-1} (~10 y)
- Full software trigger
- Trigger-less 40 MHz Detector readout
- Reduced VELO-beam distance
  - 5.1mm radial distance (8.2mm before)

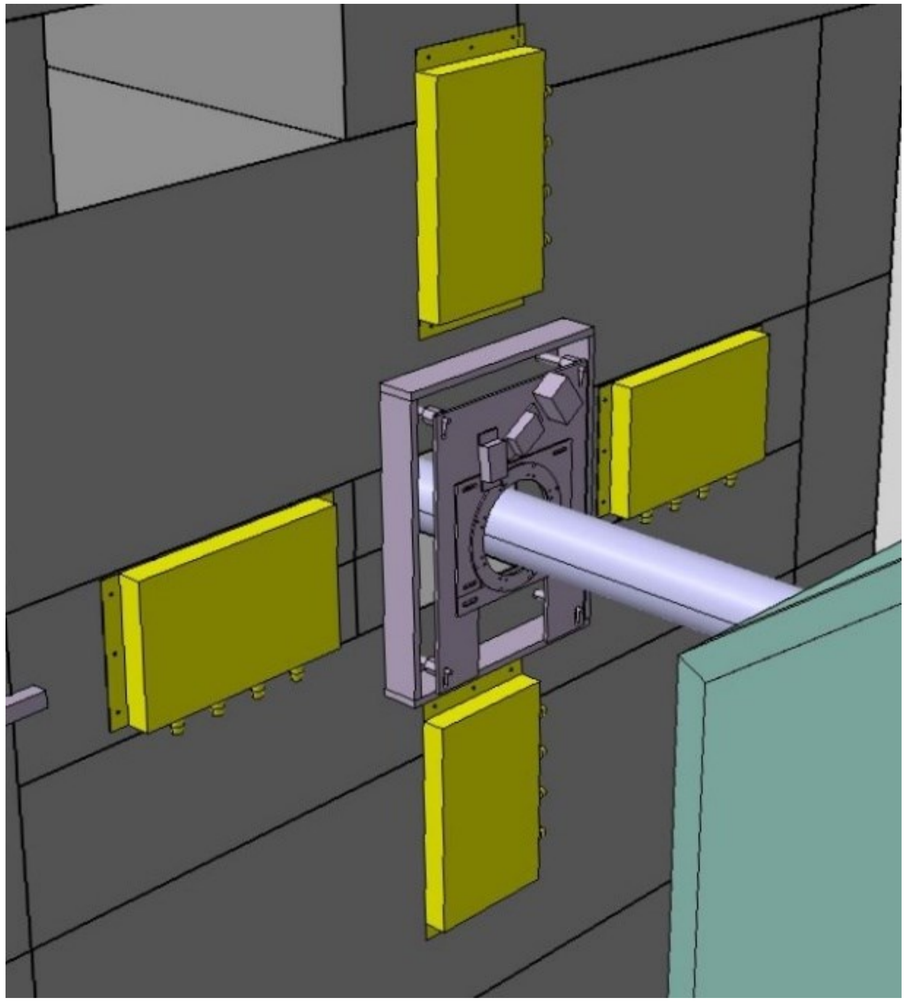
Monitoring system positions

- Radiation Monitoring System (RMS)
  - Shielding wall
- Beam Conditions Monitor (BCM)
  - Upstream next to RMS
  - Downstream in front of the magnet
- PLUME
  - Details in „Luminosity at LHCb in Run 3“ today 15:50
  - Poster : Probe for Luminosity Measurement at LHCb



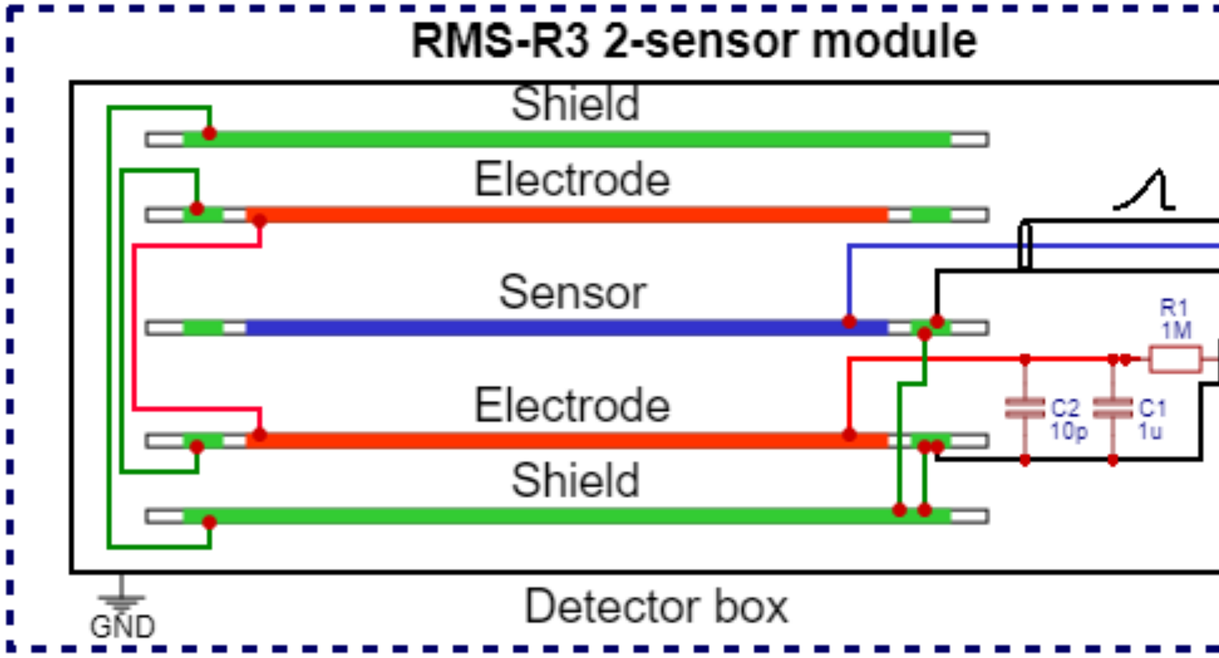
RMS-R3

- 4 Modules symmetrically around beam-pipe
- Backward acceptance of 7-14 degrees
- Relative beam interaction rate
- Interaction Point shifts ->Flux asymmetries
- Background conditions monitoring



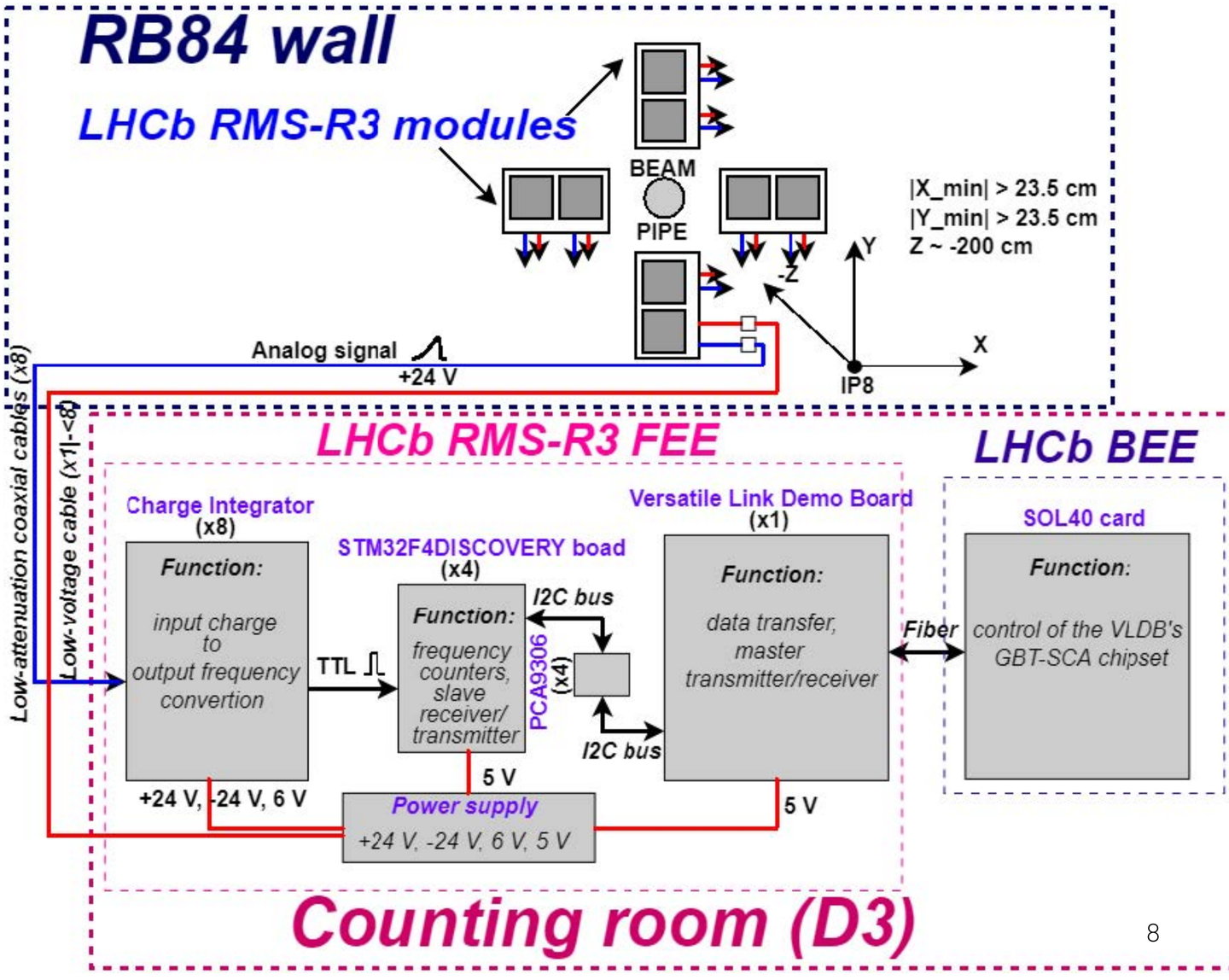
RMS module

- Metal foil detector (MFD) with 5 Layer
- Sensor layer 50 µm copper
- Bias voltage 24 V
- Secondary electron emission -> positive charge in foil
- Dynamic range from 10^3 - 10^9 MIP/sec
- Channel noise and resolution < 1%

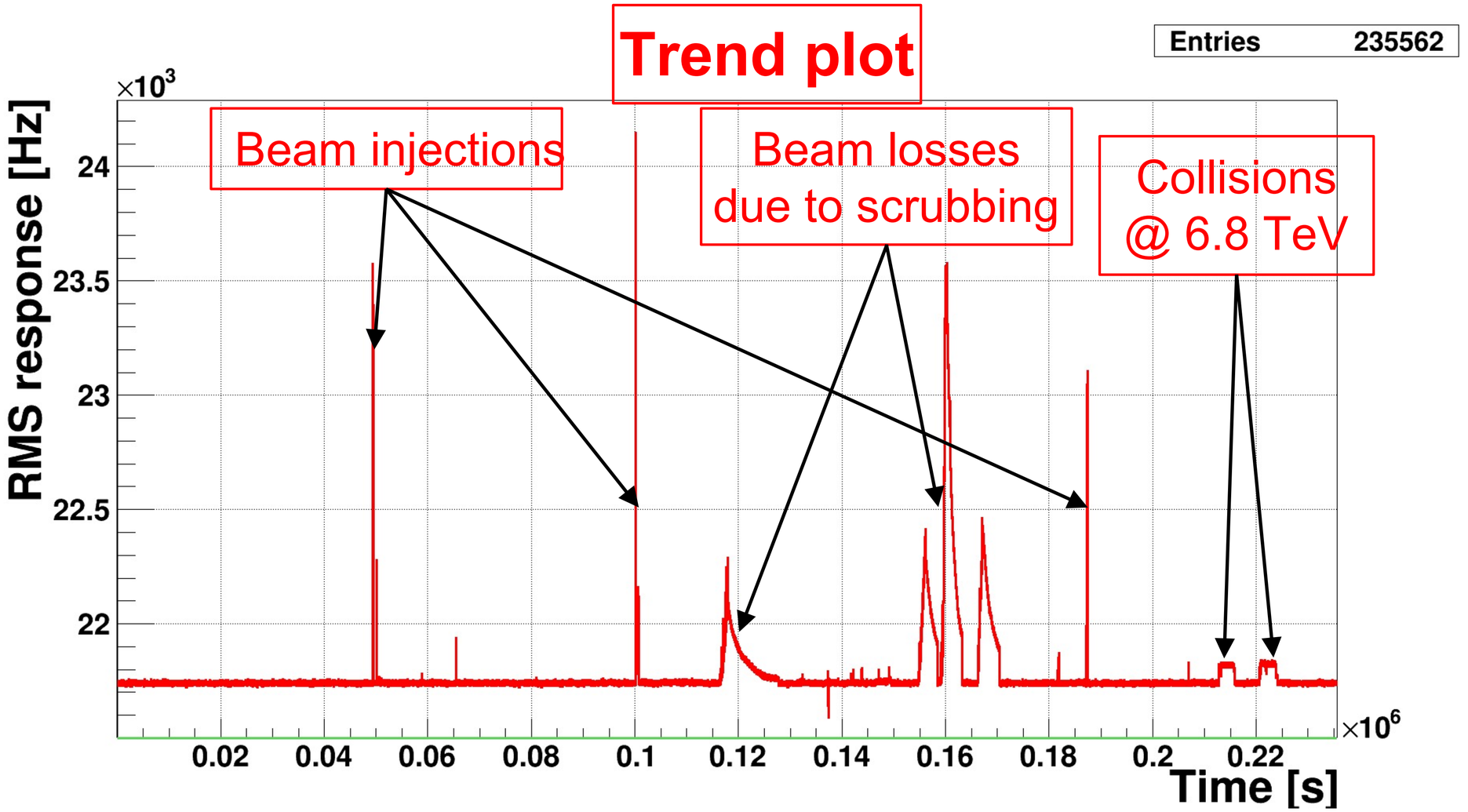


RMS data chain

- Integration time 1 s
- Current frequency converter
- Frequency counter
- Interface to LHCb via SOL40

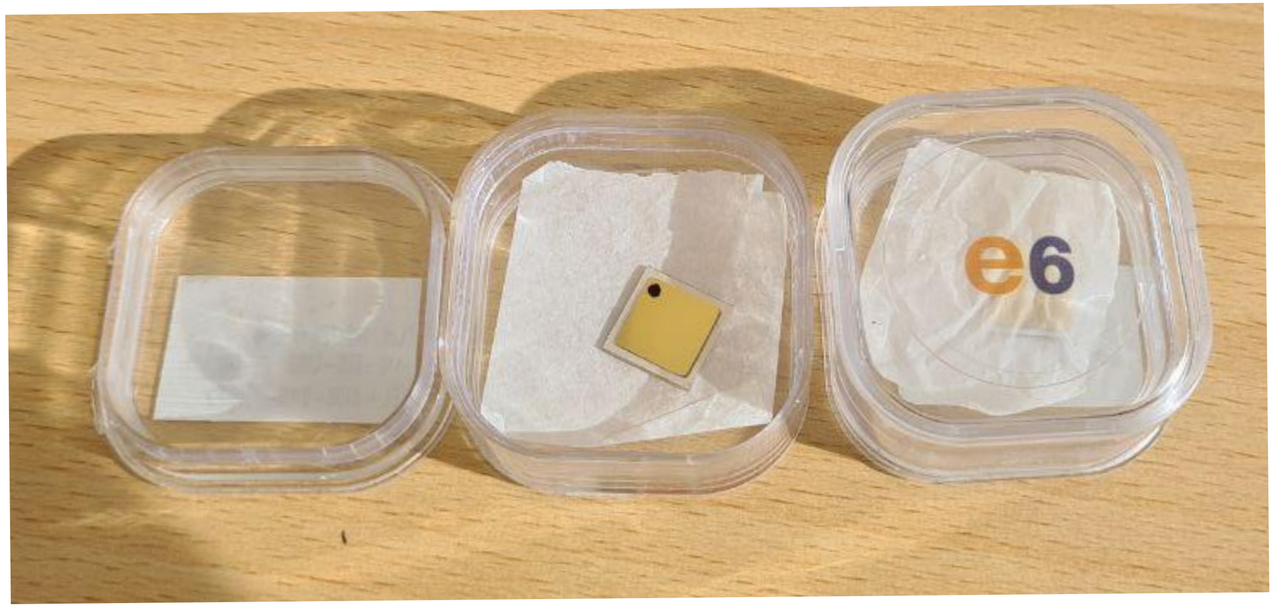


First RMS run 3 data



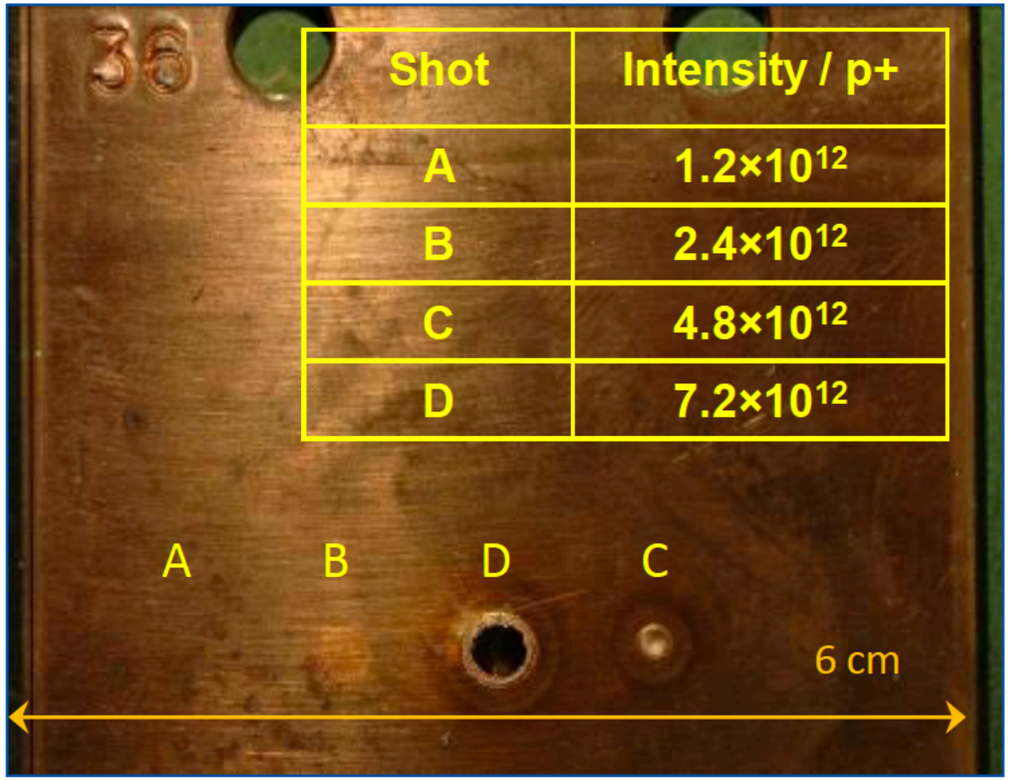
BCM

- 8 Diamond sensors per station
  - Synthetic and poly-crystalline
  - 10 mm * 10 mm and 0.5 mm thick
  - Steamed titanium-gold contacts
- Bias voltage = 200 V
- Custom made support structures



BCM motivation

- LHC beam 2 injection in front of LHCb
  - Large beam-shape
  - Most imprecise condition
- VELO in vacuum
  - Stable beam condition -> sensors are moved closer to the beam
  - Sensor 5.1 mm, RF-foil 3.5 mm
  - BCM interlock signal needed

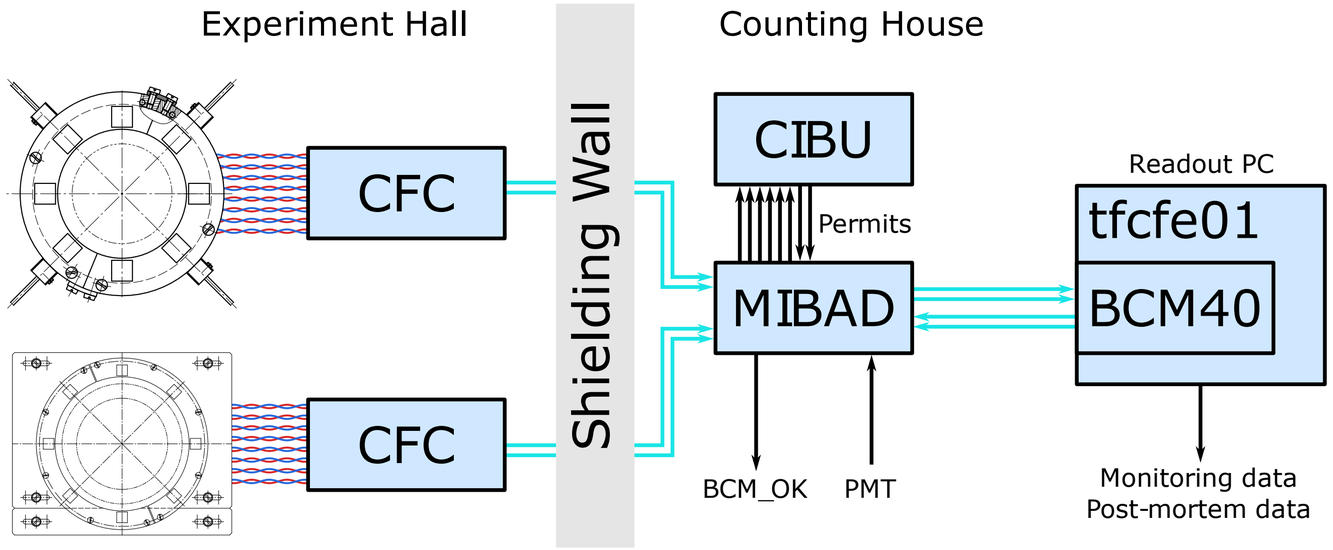


SPS 450 GeV beam

Cern accelerator school 2021

Signal processing

- Current integration via CFC card
  - Time window = 40 µs
  - Data sent via optical link
- Beam permit in non-radiative area
- Signal threshold comparison on custom FPGA, Aria V



BCM beam-dump logic

Current Measurements every 40 µs

Short range abort (~1 LHC turn)

Apply threshold for each diamond and frame

Threshold passed for two consecutive measurements ?

In three neighbouring diamonds?

Long range abort (~14 LHC turn)

Sum current per diamond over 32 measurements

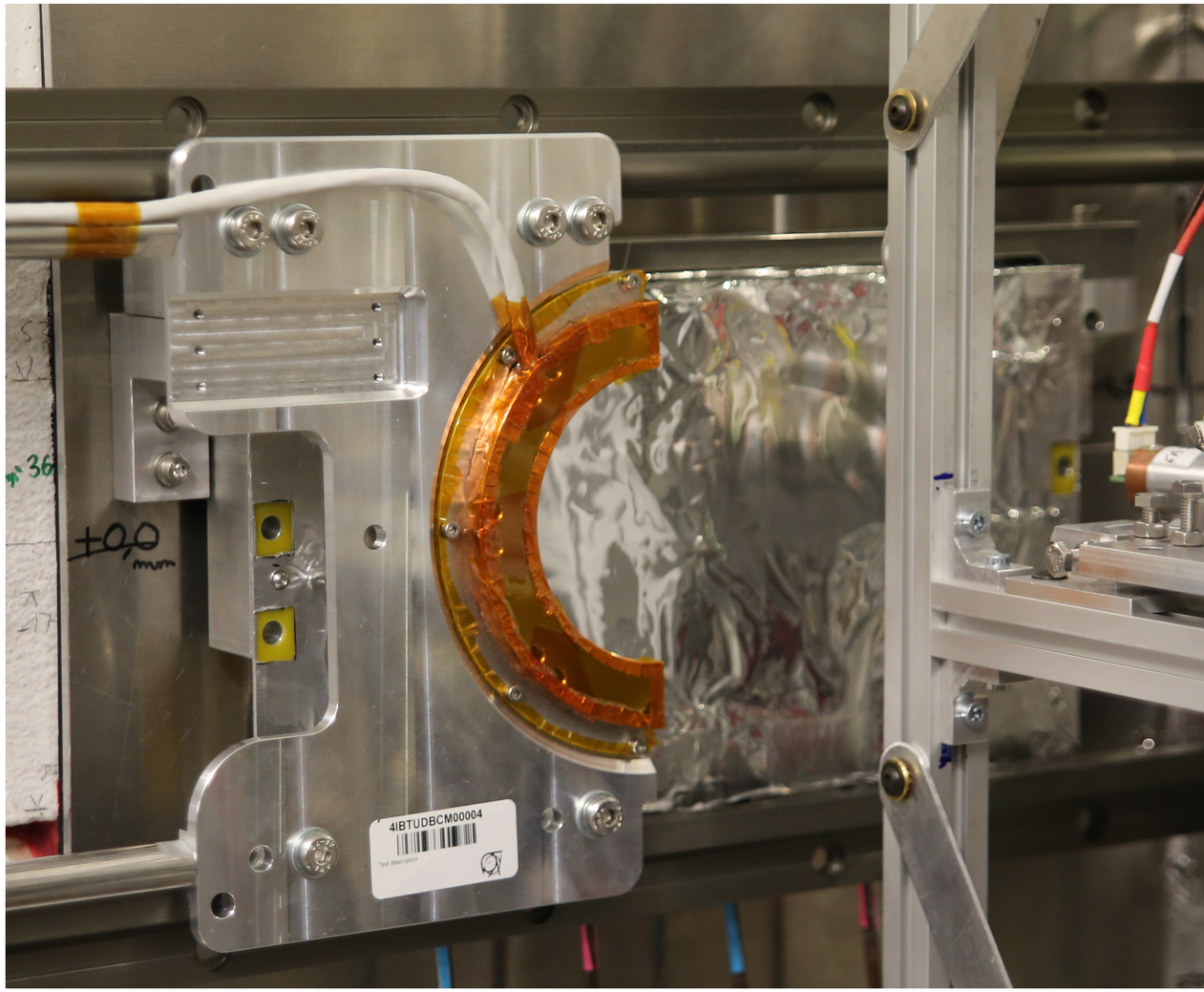
Sum diamonds in each station (excluding 2 largest and 1 smallest)

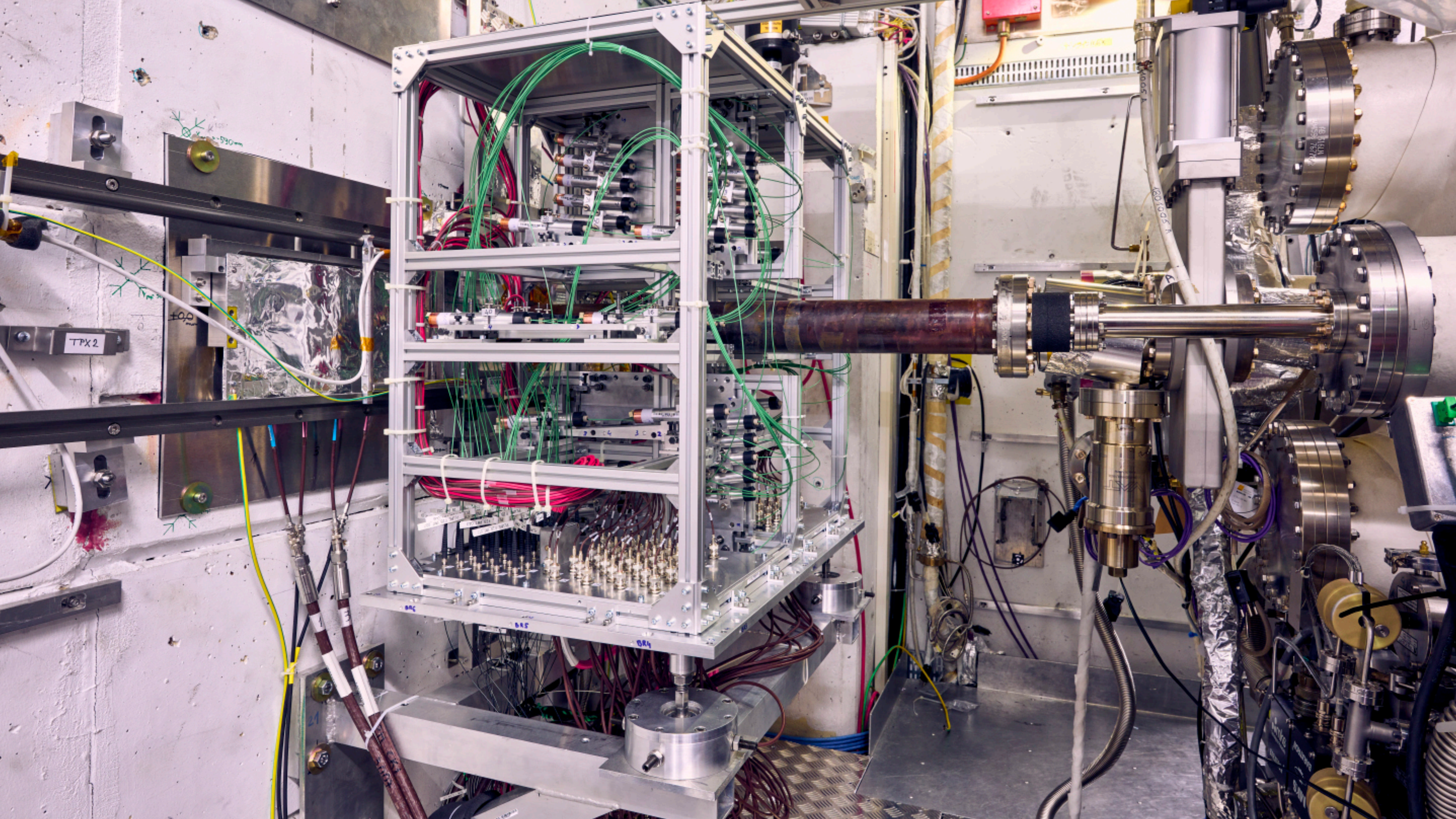
Apply threshold

Beam dump via LHC interface

BCM-U

- Limited space
- Sliding doors with half ring
- Most activated area at LHCb
- Quick replacement, in case of damage




TPX2

BCM-D

- Mounted around beryllium beam-pipe
- Support ring made of Tekapeek
  - Radiation hard
  - Low material budget
- Station and cable Kapton shielded

Conclusion

- RMS and BCM ready for RUN 3
- Successful data taking during
  - Beam test
  - Scrubbing / loss maps
  - First 13.8 TeV collisions