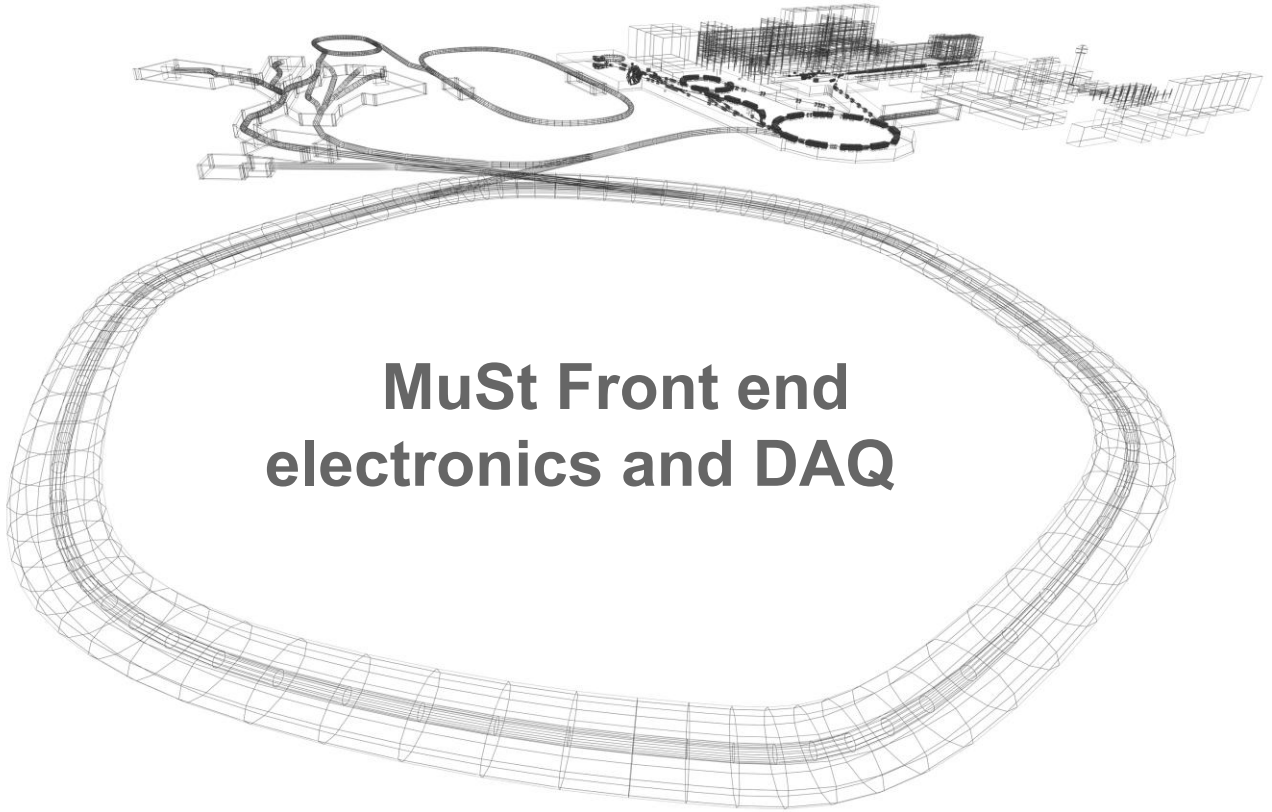


MuSt Front end electronics and DAQ

Outline

I. **LHCb straw-tube Outer Tracker FEE**

II. **FEE developments at GSI**

III. **mCBM beamtime 2025**

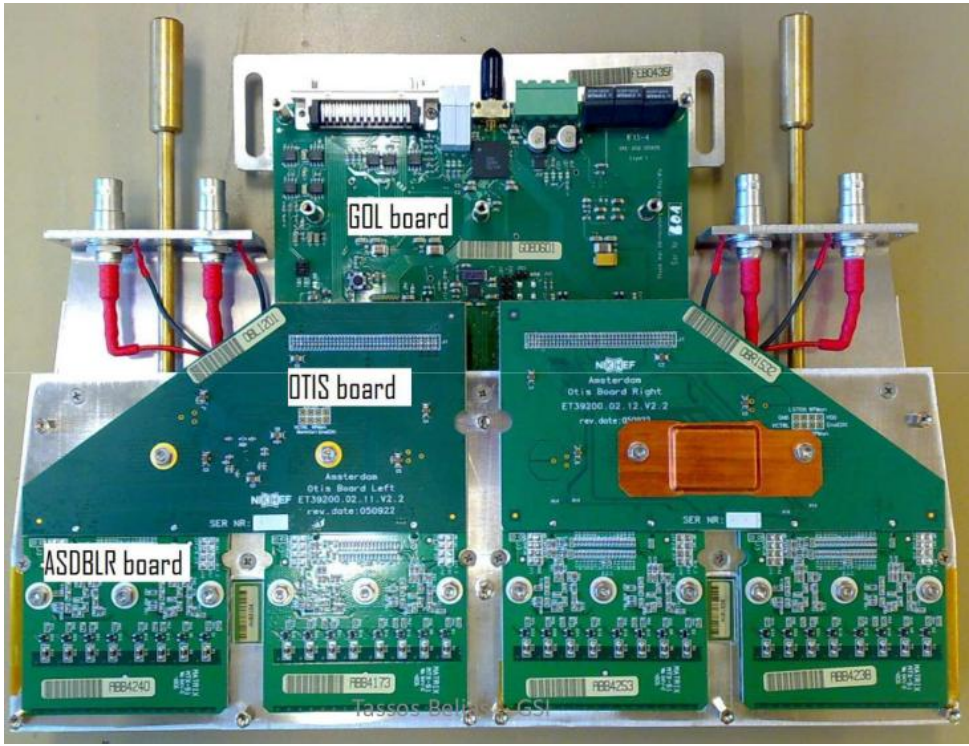
- Setup
- Data Analysis

IV. **Muon Straws for CBM**

- FEE Module
- The DOGMA DAQ
- MuSt infrastructure

Outer Tracker FEE Boards of LHCb

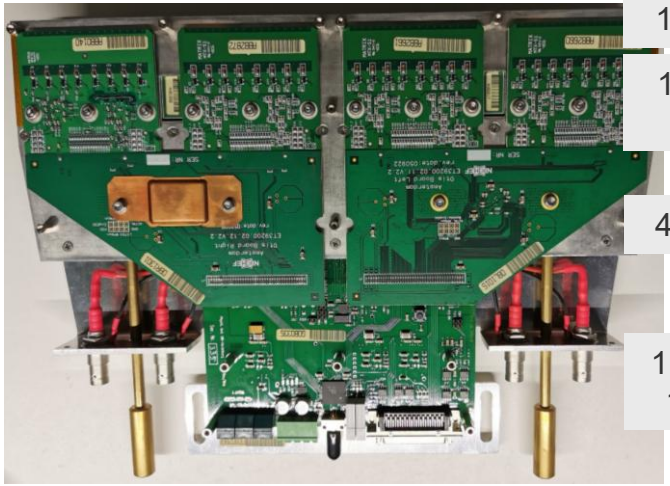
- **GOL/Auxiliary board** (1) that reads out the OTIS boards of a Front End box. The GOL serializes the time information and sends it to the off-detector electronics through an optical link.
- **OTIS boards** (4) for time measurement, that each take the output of two ASDBLR boards. The OTIS board has a 32 channel TDC-chip that digitizes the hit signal time wrt the LHC Bunch Crossing.
- ***ASDBLR* boards** (8) with ASICs connect to the HV boards to amplify the signals received from these. A board contains two ASDBLR ASICs, that is two 8-channel *A*mplifier-*S*haper-*D*iscriminator with ion-tail cancellation and *B*ase*L*ine *R*estoration. (Designed for ATLAS TRT Readout)
- **High Voltage boards** (4) (hidden behind the aluminium chassis) plug into a module's feed-through board. Distribute HV to 128 anode wires and pass the straw signals to the ASICs.



FEE Box boards on one side & another set of same boards on the other side.

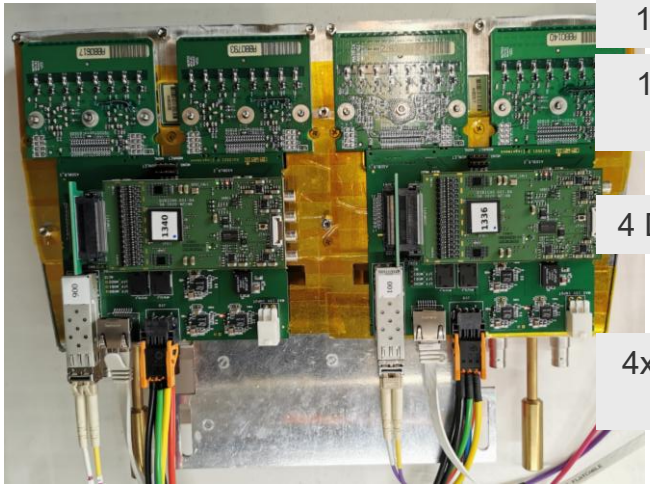
Front-End Electronics Development at GSI

LHCb straw-tube OT Readout



- 128 ch input
- 16 ASDBLR ASICs
- 4 OTIS TDC
- 1 optical link, 1.28 Gbit/s

PaSta @ mCBM Readout

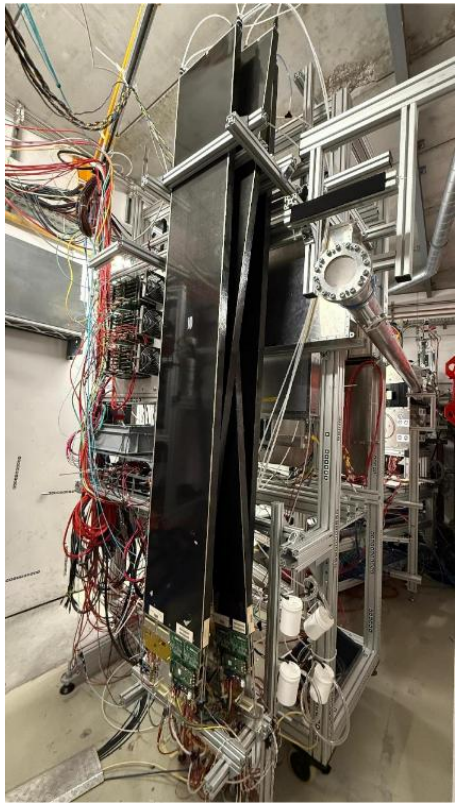


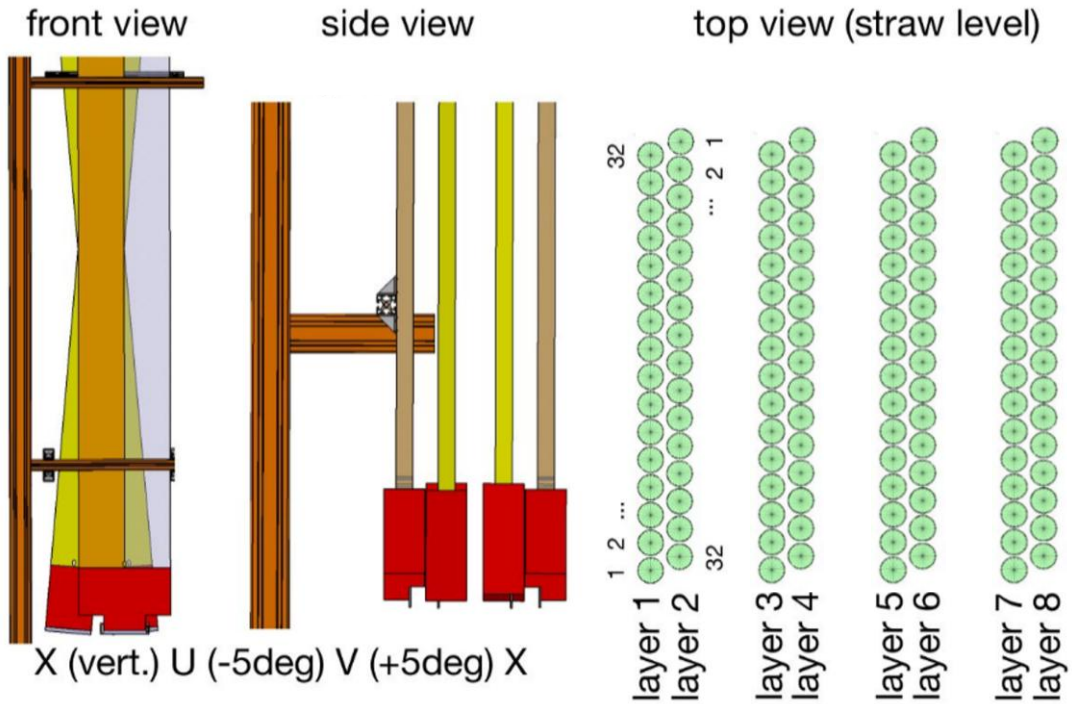
- 128 ch input
- 16 ASDBLR ASICs
- 4 DiRICH TDC
- 4x optical link, 1 Gbit/s

- Goal: reuse ASICs and replace TDCs by already existing ecosystem at GSI
- Interface board developed at GSI
- Integrated into well-known and used TRBnet DAQ system

Straw-tube Modules Setup in mCBM

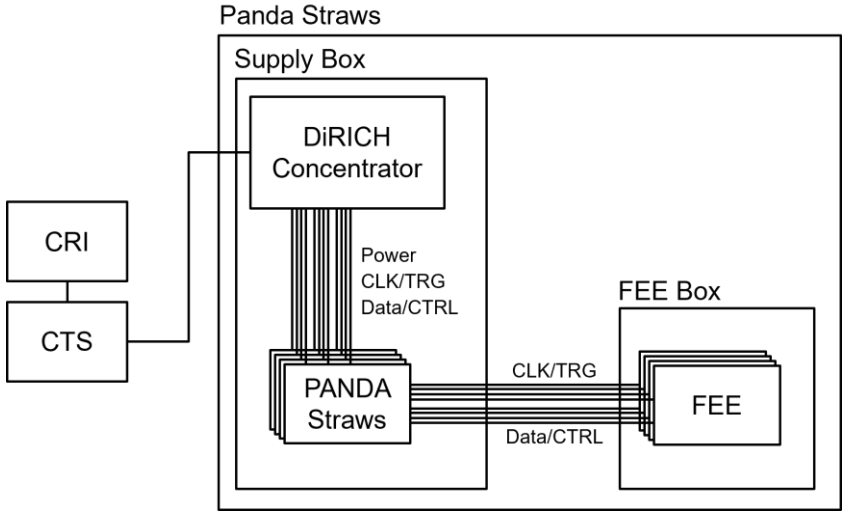
S. Koch (GSI) and
R. Karabowicz (GSI)





Some layers not fully read out due to FEE issues and shortage on replacements

Straw-tube Modules Setup in mCBM



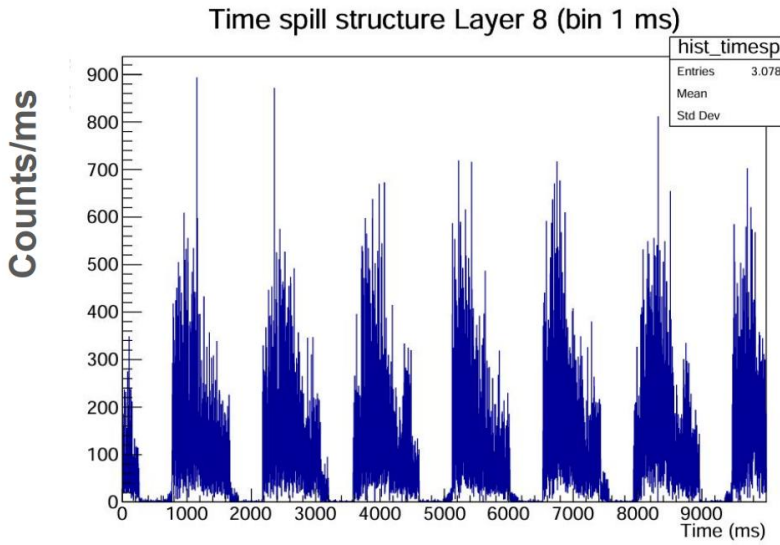
- Participation in mCBM beamtime 2025
  - 4 Modules → 8 layers
- LV distribution board for FEE
- Incorporation into RICH readout chain
  Use of DiRICH Backplane with interface solution (thanks to M. Traxler!)
- Gaining experience
  Multiple HV and threshold settings
- Online data unpacking and observation
  (B. Sobol)

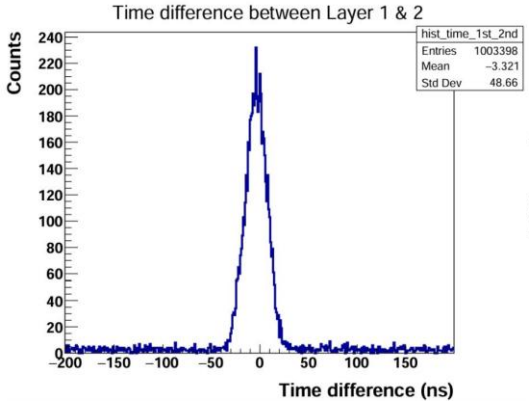
→ Successfull first implementation in CBM ecosystem via TRBnet

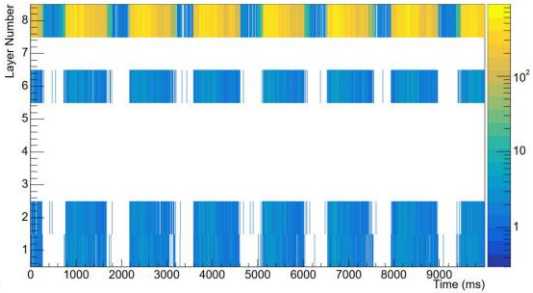
Data Analysis – First Results

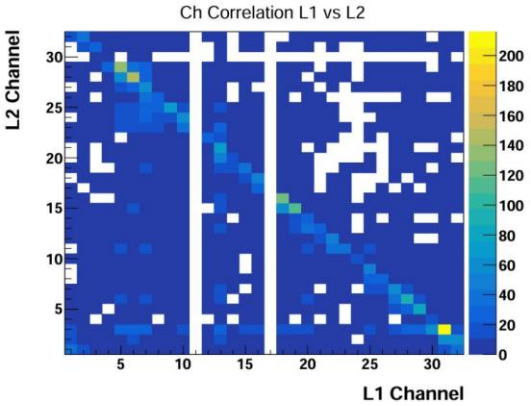
Preliminary results

Beam Setup:
$^{56}Fe(26+)+^{28}Ni$; ~ 1.0 x 10^7 /spill; HV = 1500 V





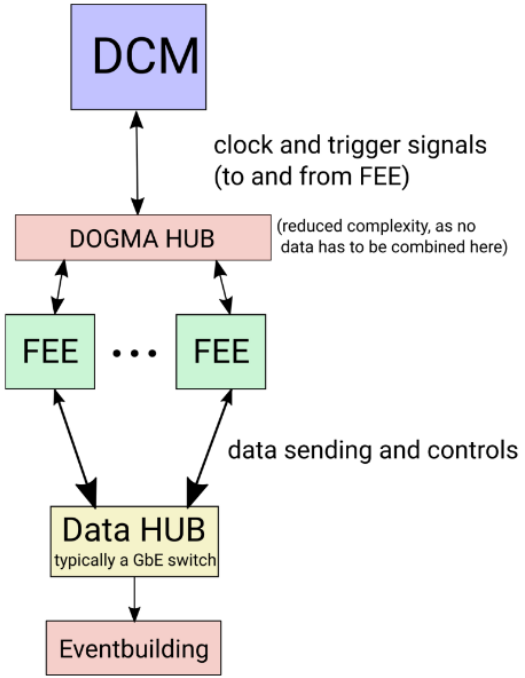




S. Chattopadhay (VECC, Kolkata)

DOGMA DAQ – System Architecture

- DCM
  - Provides and distributes system CLK and TRG
- DOGMA Hub
  - Up to 1:30 fan-out and can be cascaded
- FEE
  - One Doglink and one GbE link for data transport and „slow control“
- Data Hub
  - Commercial network switches (1G/10G Ethernet)
- Eventbuilding with DABC



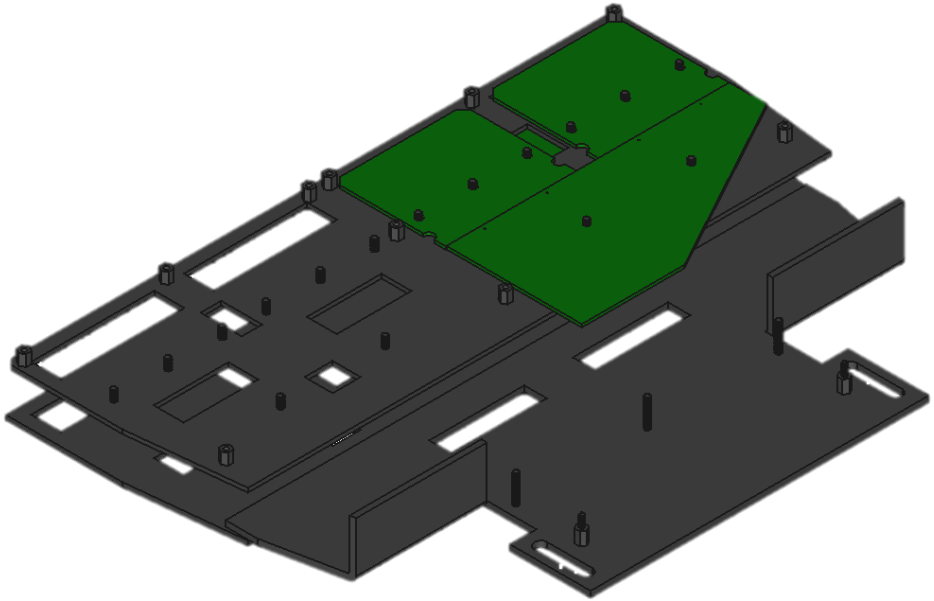
FEE Box in MuSt - Interface Board Redesign

ASDBLR and HV Boards

Reused from LHCb Outer Tracker

New Interface Board

- Geometry constrained by module layout
  Board shape must fit tight constraints by FEE module
- Optimised for Dogma ecosystem
  Signal routing, powering for ASDBLR, test pulse circuit, ASIC thresholds
- Preproduction series
  Designed for validation in a realistic detector environment

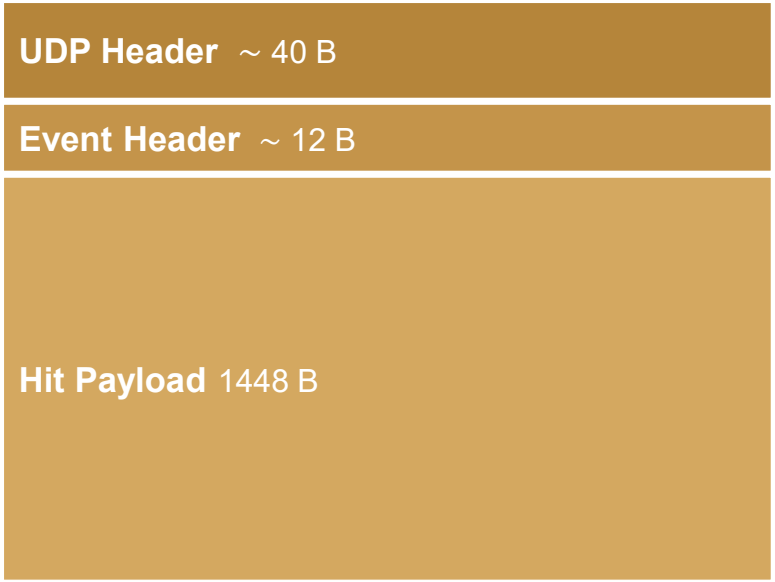


128-ch FEE module CAD model

DOGMA DAQ – Data

Event packet structure

1500 Byte total



1 Hit = rising edge (3 B) + falling edge (3 B)

Key data parameters

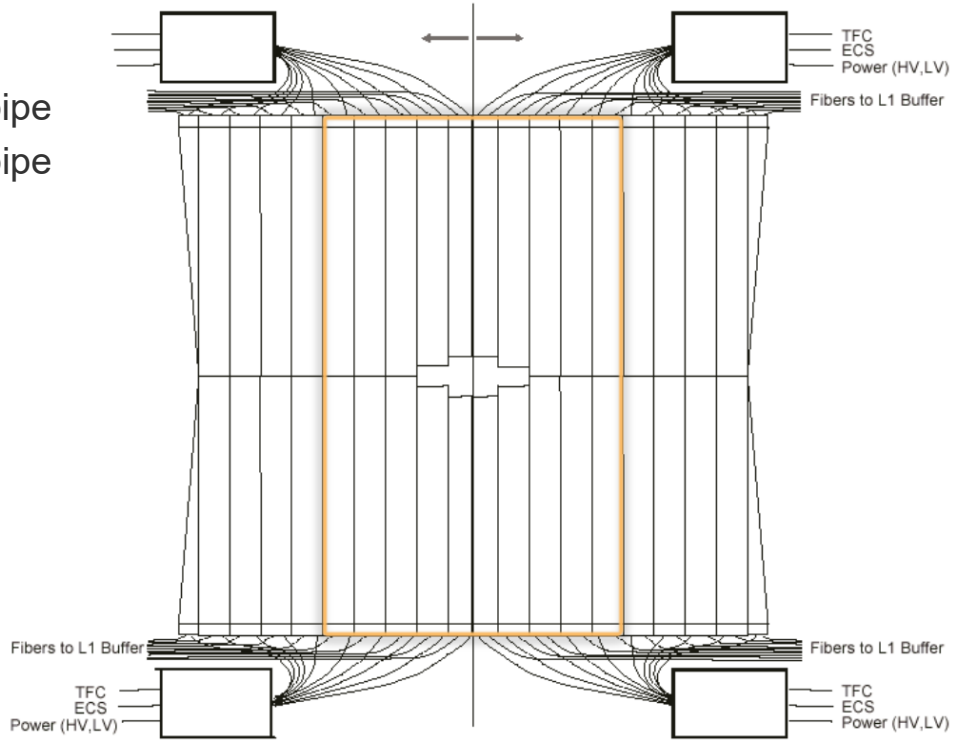
Packet size	**1500 B**
Channels / TDC	**32**
Bytes / hit	**6 B**
Hits / packet	**241**
Packet overhead	**52 B (3.5%)**

- Possibility to only record rising edge
- MuSt – required bandwidth: work in progress

MuSt Scale

- Organized in 4 quadrants
  - Station 3: 20 (18) DOGs left (right) of beampipe
  - Station 4: 24 (22) DOGs left (right) of beampipe
- 12 C-Frames (consisting of 2 layers)
  - **48 DCM**
  - **1008 Dogma boards** total
  - **2016 optical fiber pairs**
- Low voltage supply
  using existing infrastructure:
  individual ±5V supply per quadrant
- 24 commercial ethernet switches
  placed either on C-frames or in a rack
  below the upstream platform

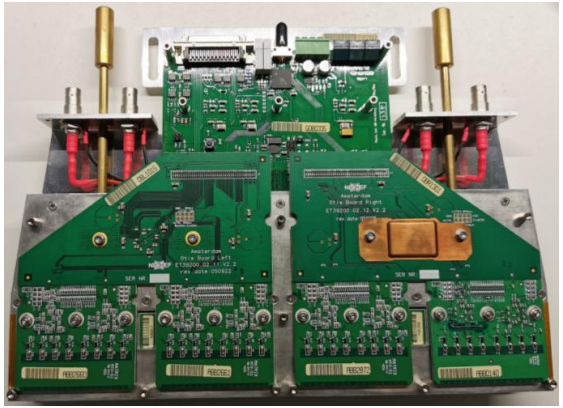
In color the MuSt case



LHCb-Note 2005-025

Readout Evolution – From LHCb to CBM

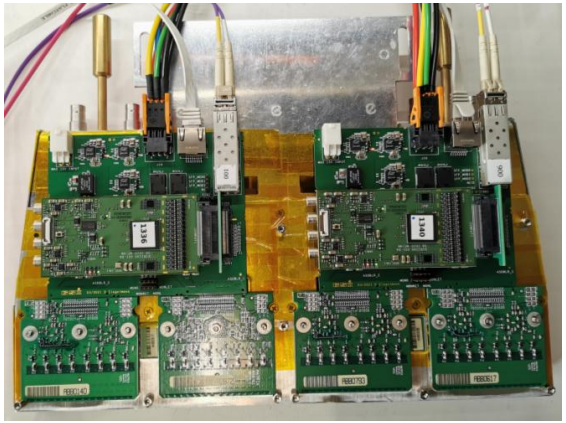
LHCb Outer Tracker Readout



GOL/AUX board

OTIS (TDC) board

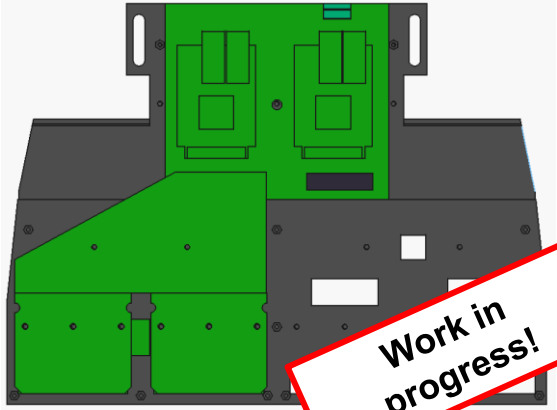
PaSta @ mCBM Readout



DiRICH (TDC) board [TRBnet]

Interface board
> TRBnet link, power, clock in

MuSt @ CBM Readout



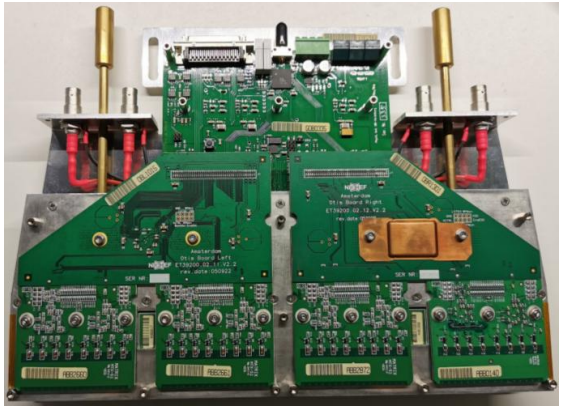
DOGMA link / combiner board
> Optical links + power / cntrl

DOG (TDC) board [DOGMA]

Interface board
> Signal routing + ASDBLR test pulse circuit

Readout Evolution – From LHCb to CBM

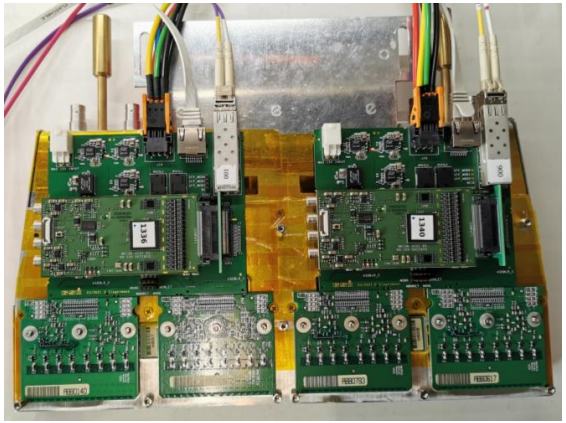
LHCb Outer Tracker Readout



GOL/AUX board

OTIS (TDC) board

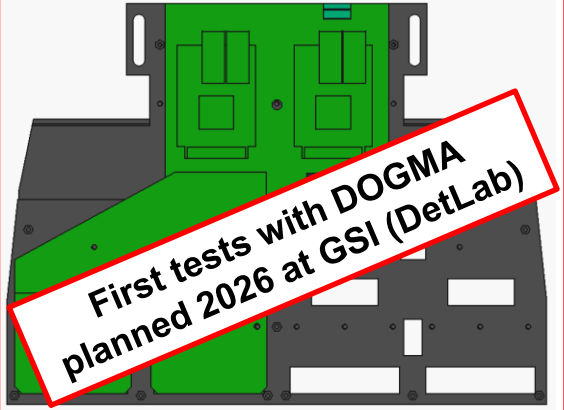
PaSta @ mCBM Readout



DiRICH (TDC) board [TRBnet]

Interface board
> TRBnet link, power, clock in

MuSt @ CBM Readout



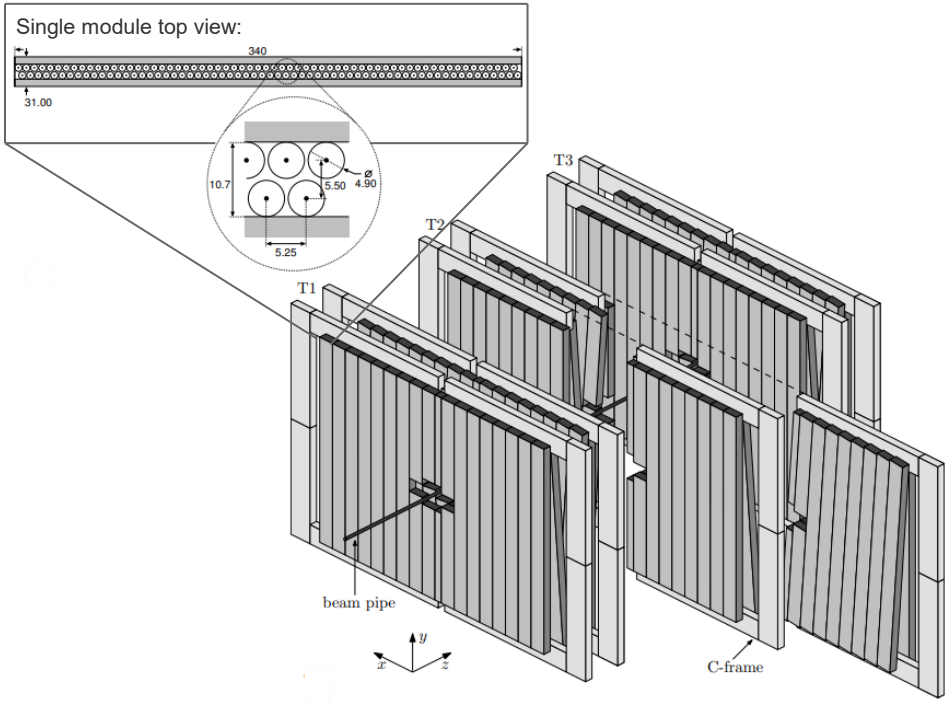
DOGMA link / combiner board
> Optical links + power / cntrl

DOG (TDC) board [DOGMA]

Interface board
> Signal routing + ASDBLR test pulse circuit

Backup

The straw-tube Outer Tracker



arXiv:1708.00819

Straw-tube Outer Tracker brief specs

Straw tube

- Diameter, length: 5 mm, 2.4 m
- Anode wire: 25 µm at 1550 V
- Gas mix: Ar/CO2/O2 (75%/23.5%/1.5%)

Module

- Independent upper and lower parts
- Each part has 2 staggered layers of 64 tubes
- Single sided readout
- Front-end electronics each end of module

Whole detector

- 53,760 straw tubes, 216 modules, 432 FEE
- Area coverage: 5 x 6 m² x 12 planes

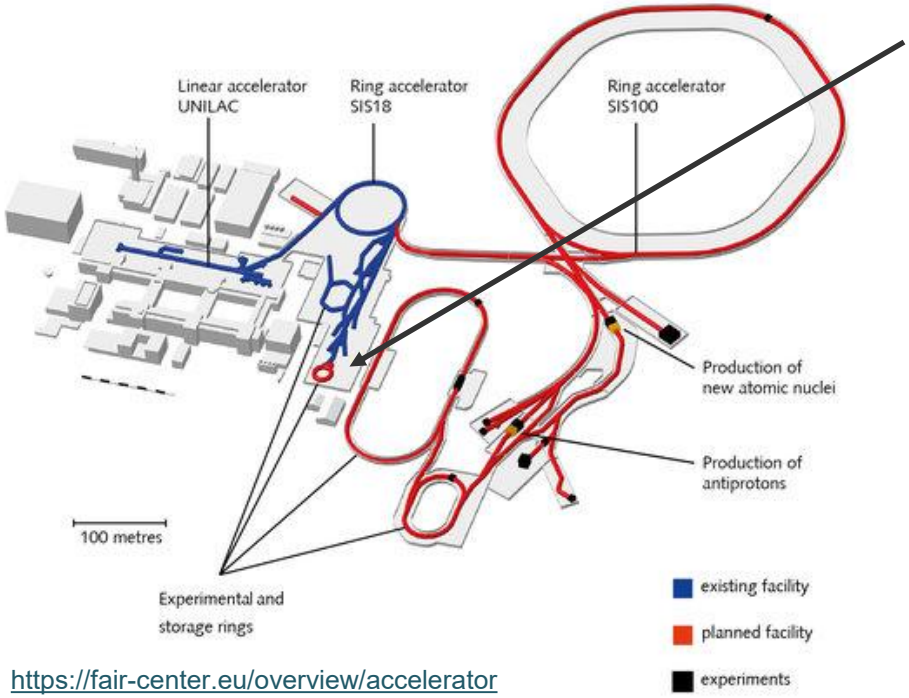
Performance at LHCb Run 1&2 (2011-13, 2015-16)

- ε ~98%, σ ~170 µm
- dp/p ~ 0.4% (2-100 GeV tracks)

mCBM Beamtime 2025

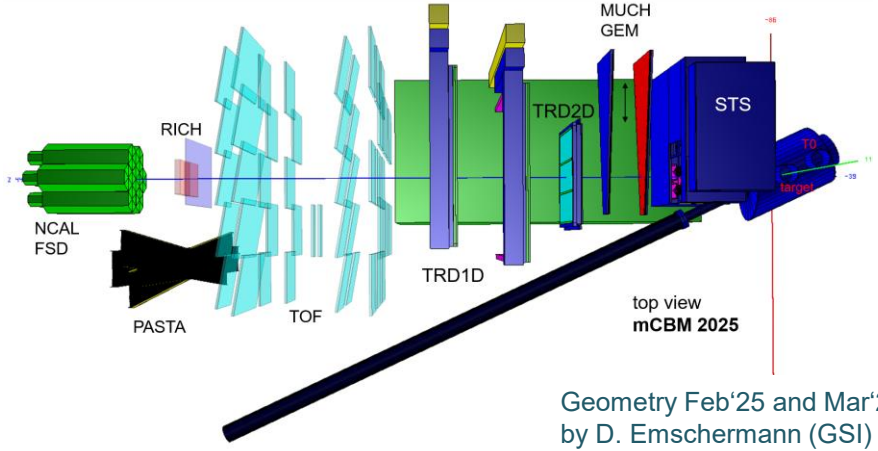
- February 2025 (4 days)
  - ^{47}Ag(45+)+^{47}Ag @ 1.58 AGeV, Intensity: 1.0×10^7-3.0×10^7
  - ^{47}Ag(45+)+^{47}Ag @ 1.23 AGeV, Intensity: 1.5×10^7
- March 2025 (3 days)
  - ^{79}Au(69+)+^{79}Au @ 1.23 AGeV, Intensity: 1×10^7-2×10^7
- May 2025 (5 days)
  - ^{56}Fe(26+)+^{28}Ni @ 1.7 AGeV, Intensity: 1×10^7-2×10^7
  - ^{209}Bi(68+)+^{79}Au @ 1.1 AGeV, Intensity: 1×10^7-10×10^8

GSI/FAIR – mCBM Cave Overview



https://fair-center.eu/overview/accelerator

mCBM @ SIS18

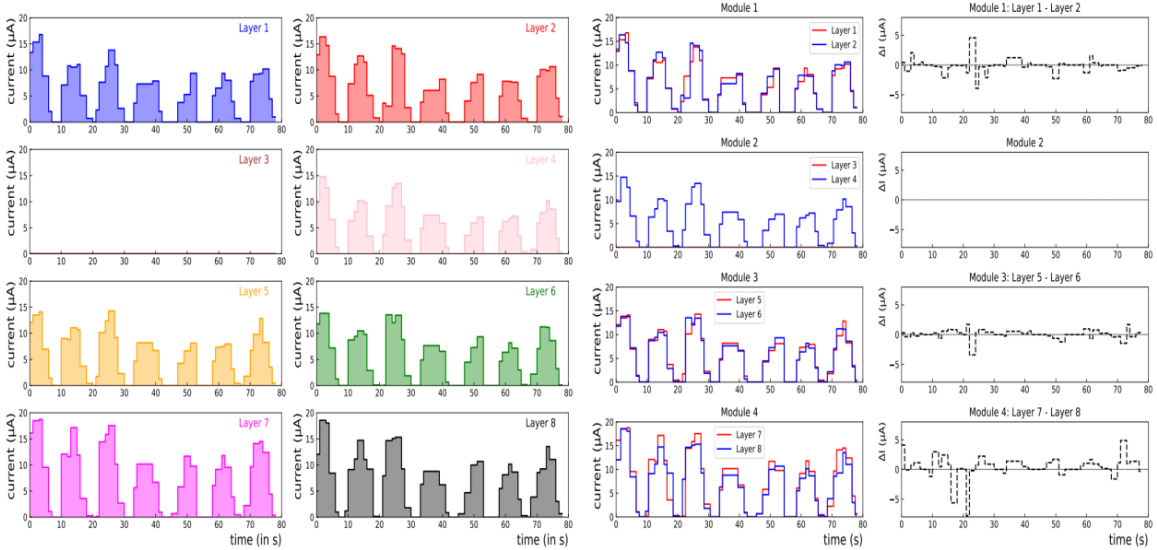


Geometry Feb'25 and Mar'25
by D. Emschermann (GSI)

PaSta Data Analysis

Preliminary results

HV – current analysis May‘25



Saikat et al.

Beam Setup:
$^{209}Bi(68+)+^{79}Au$; ~3.0 x 10^7 /spill ; HV = 1500 V