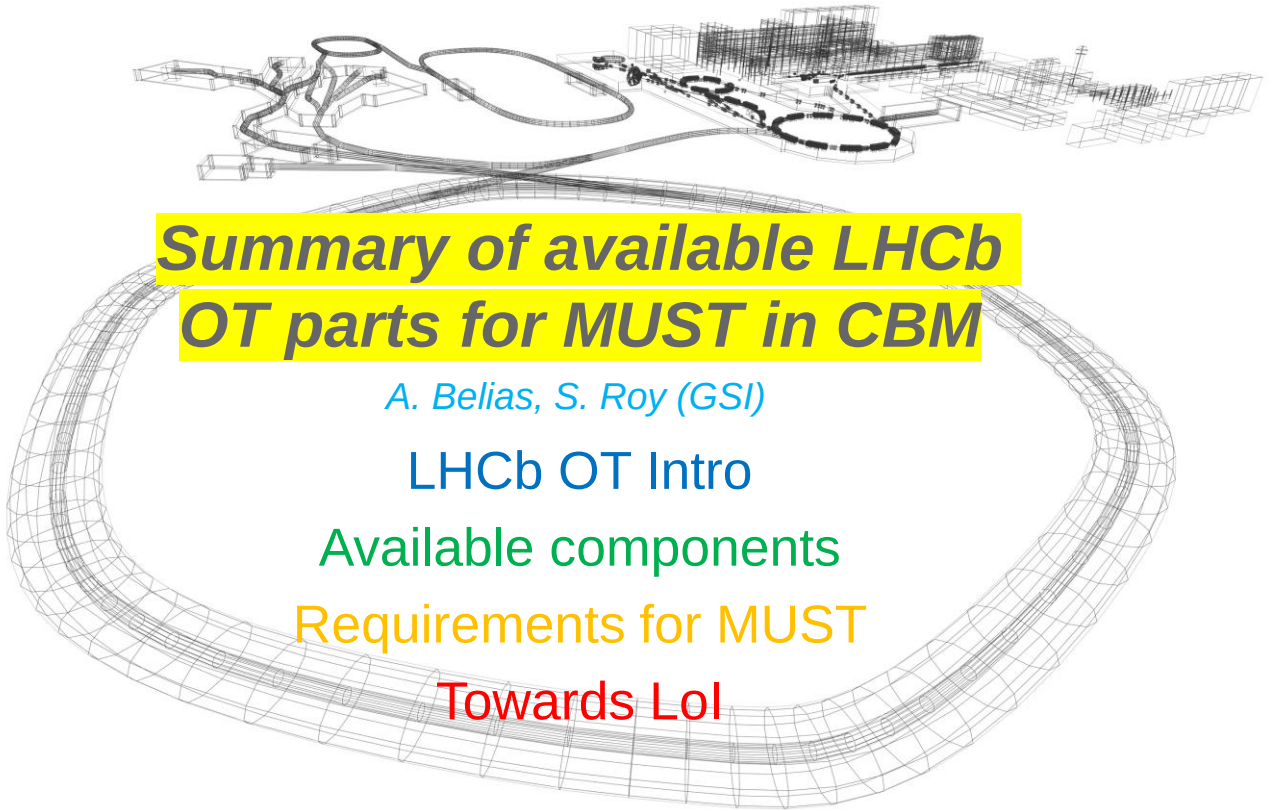


# Summary of available LHCb OT parts for MUST in CBM

*A. Belias, S. Roy (GSI)*

LHCb OT Intro

Available components

Requirements for MUST

Towards LoI

# LHCb Outer Tracker – Straw tube detector

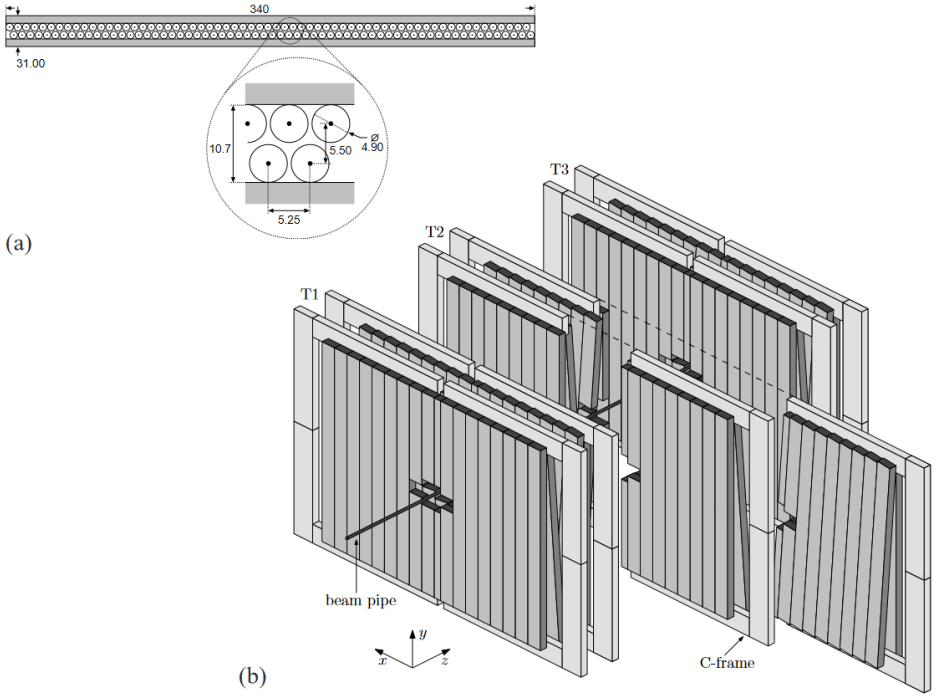
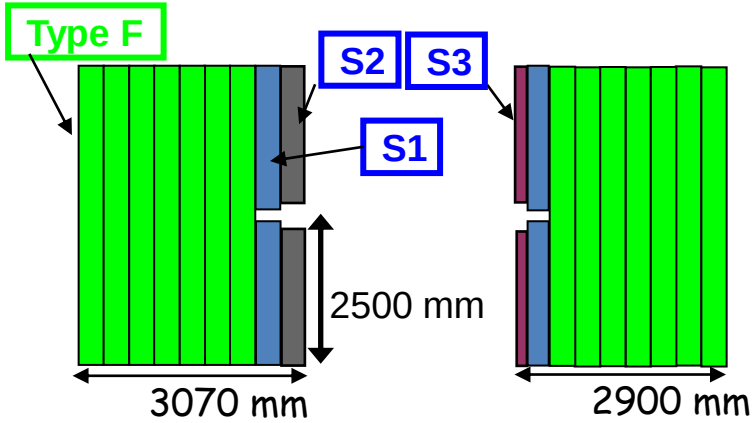



**Figure 1**. (a) Module cross section. (b) Arrangement of OT straw-tube modules in layers and stations.

N Tuning 2014 JINST 9 C01040

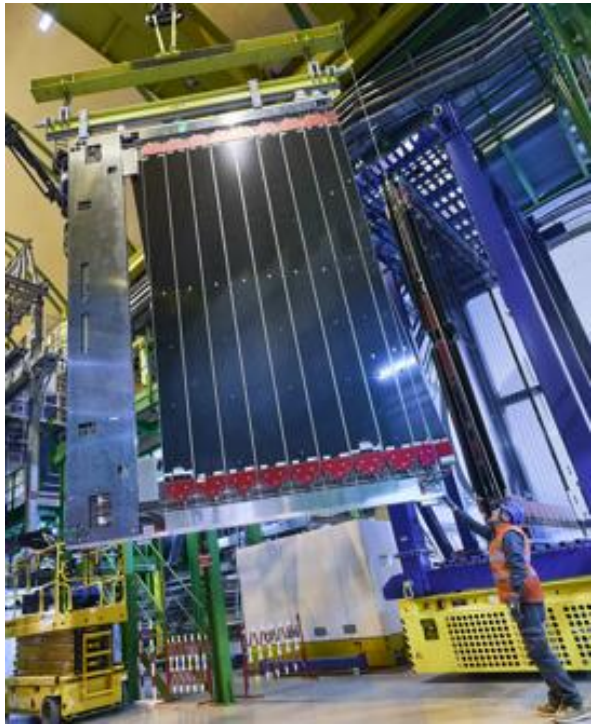



LHCb Outer Tracker consists of 3 stations T1, T2, T3

- Station contains
  - 4 layers of modules with orientation $0^0$,$+5^0$,$-5^0$,$0^0$
  - attached to 4 support frames (C-frames), two per side of the beam pipe
- Layer contains modules of straw tubes:
  - 14 type F ; cover 5 m (2 x 2.5 m) without gap
  - 4 type S ; cover < 5 m (2 x 2.3-2.4 m) with gap around beam pipe

# PANDA receives the whole LHCb Outer Tracker - straw tube detector

LHCb/CERN donated the formidable Outer Tracker straw tube detector to PANDA at GSI/FAIR.



One of 12 frames, 6x4 $m^2$, with 4352 straws in 18 modules. (Photo courtesy: LHCb)

**Outer Tracker brief specs**

Straw tube
- Diameter, length: 5 mm, 2.4 m
- Anode wire: 25µm at 1550 V
- Gas mix: $Ar/CO_2/O_2$

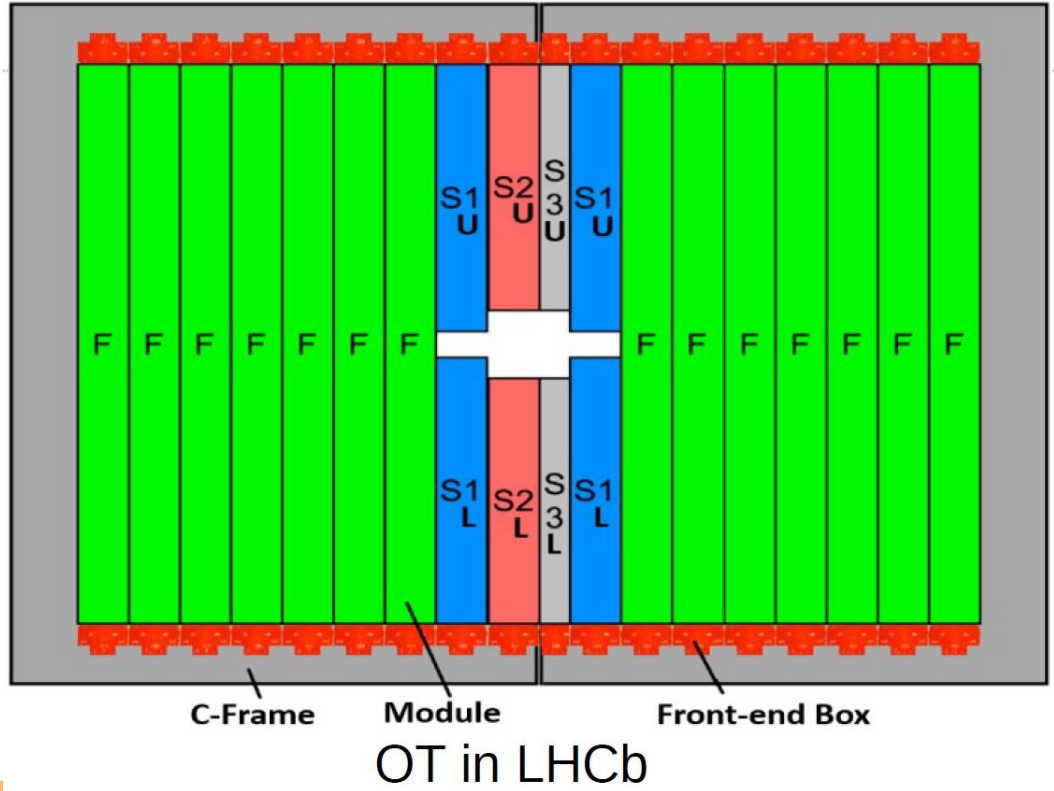
Module
- Two staggered layers of 64 straw tubes
- Independent upper and lower sides
- Front-end electronics (FEE) each side

**Whole Detector Available @GSI**
- **53,760 straw tubes, 216 modules, 432 FEE**
- **ready mounted on 12 C-frames**
- **all placed in dedicated transport frame**
- **Active area coverage: (5x6)$m^2$ x12 planes**
- **Mechanic envelope: (6x8)$m^2$ (per 2 planes)**

Performance (LHCb operations, Run 1&2)
- $\varepsilon \approx 98\%$, $\sigma \approx 170$ µm
- $\delta p/p \approx 0.4\%$ (2-100 GeV tracks)


Whole OT in transport frame, 7x5.5x3.5 $m^3$, 24t, arrival at GSI, Aug. 25, '23. (Photo courtesy: GSI)

# LHCb Outer Tracker Straws –
## Available components: Detector Modules



OT in LHCb

### LHCb Outer Tracker straw tube brief specs

**Tube elements**

- Diameter$_{(i)}$, length: 4.9mm, 2.4m
- Anode wire: 25µm at 1550 V
- Gas: Ar/$CO_2$/$O_2$ (70/28.5/1.5)
- Two staggered layers of 64 tubes (few 32 tubes, half width)

**Module**

- Enclosure (5m) has straw tubes in upper and lower parts
- Two staggered layers of 64(32) tubes in each part
- Singe sided and independent readout of each part
- Module type S; can be separated into U and L parts
- Module type F; cannot be separated (staggered in y)

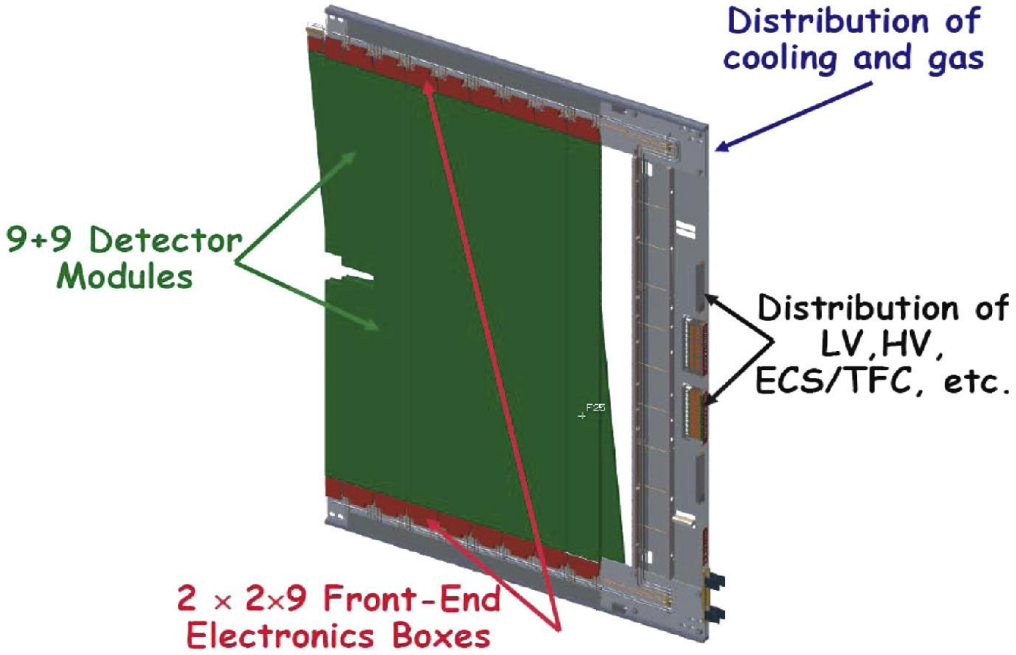
**Whole Detector Available @GSI**

- **Modules: 216**
- **F-type: 168 , S-type: 48 (or 96 separate U & L parts)**
- **FEE boxes with electronics: 432 for 53,760 straw tubes**
- **C-Frames: 12, mechanics & operations per 2x9 modules**
- **Active area coverage: (5 x 6)m$^2$ x12 planes**
- **Mechanic envelope: 6 x 8 m$^2$ (per 2 planes)**

**Performance at LHCb (Run1&2)**

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

# LHCb Outer Tracker Straws –
## Available components: C-frames




C-frame: usable unit with mechanics and distribution lines ready ( 1/12 of whole OT )

**C-frame – Support & operations carrier**

- safe mechanical stability
- positioning of modules
- integrated service conduits
- connection manifolds

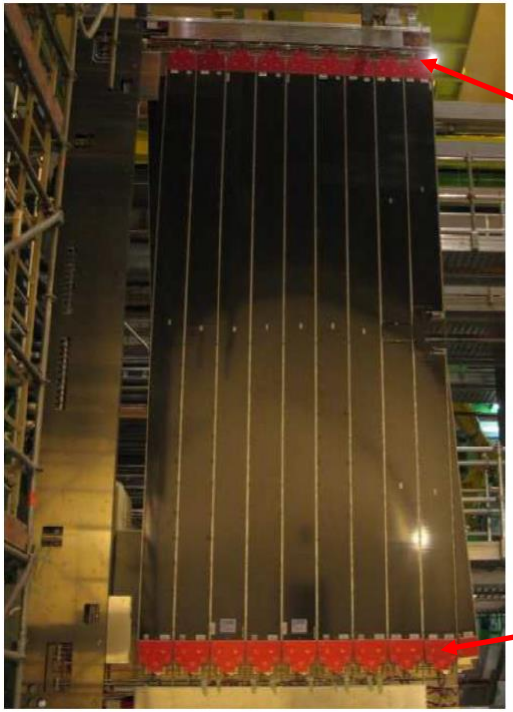
**All 12 C-frames available**

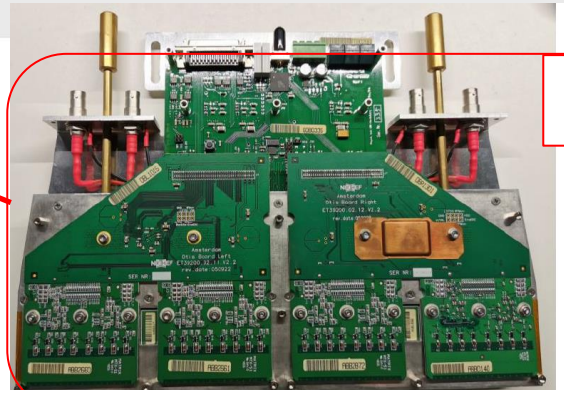
Each C-frame has

- 2x9 detector modules
- 4x9 FEE boxes
- LV and HV distribution cables
- Gas, cooling water distribution pipes
- Fibers – DAQ
- Cables – Slow Control

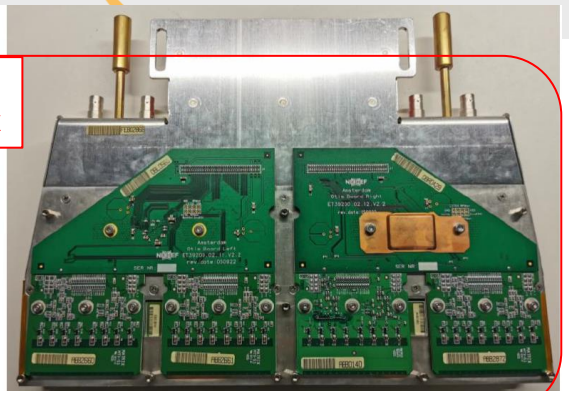
# LHCb Outer Tracker Straws –

## Available components: Front-End Electronics I





Upper FEE-Box

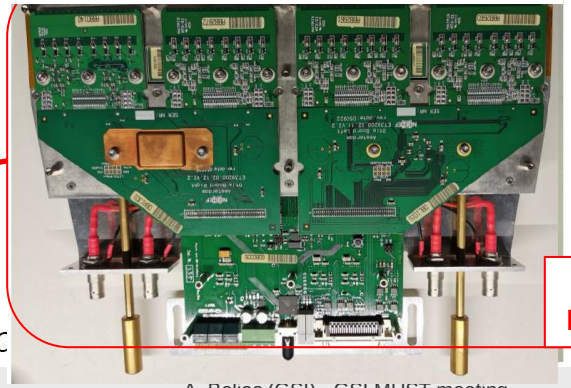


Upper Front - 1st mono-layer 64 straws

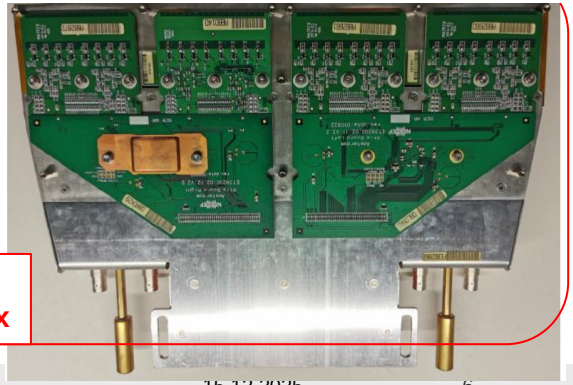
Upper Back – 2nd mono-layer 64 straws

Lower Front - 1st mono-layer 64 straws

Lower Back – 2nd mono-layer 64 straws



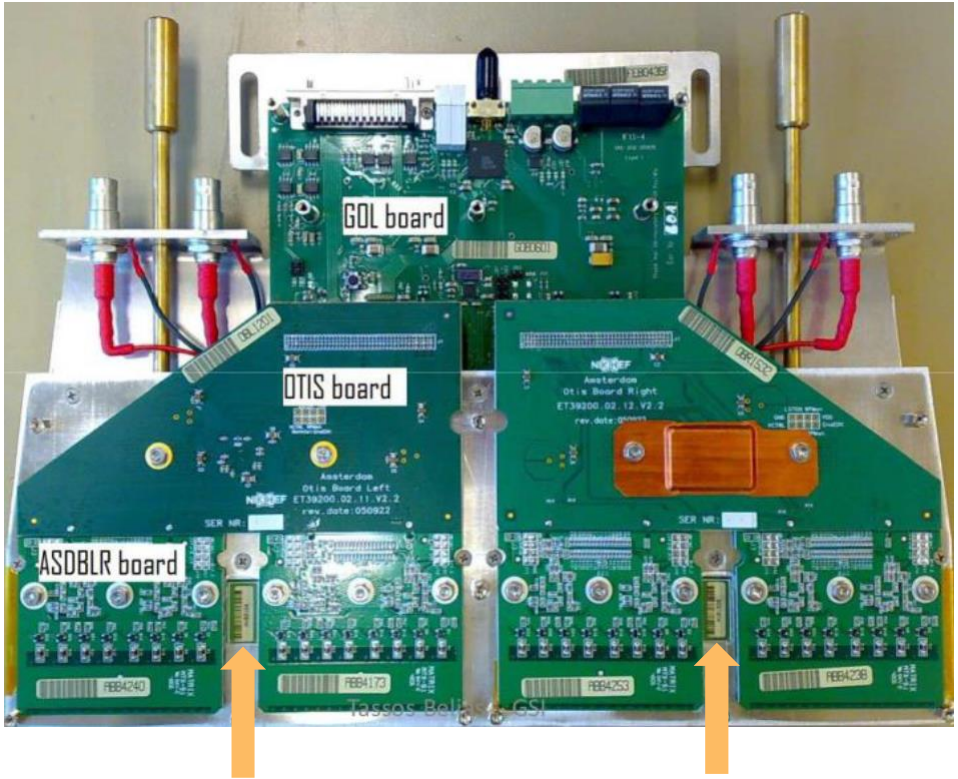
Lower FEE-Box



(middle), FEE Box open (right) (Photos courtesy: LHC

# LHCb Outer Tracker Straws –
## Available components: Front-End Electronics II

- GOL (1 board)
  - Transfer of data of 128 channels (+headers) via optical fiber at 1.6Gb/s
- OTIS time-to-digital converter (4 boards)
  - 25ns LHC bunch clock into 64 TDC bins
  - incorporate up to three BX drift time
- ASDBLR amplifier (8 boards)
  - discriminate signal against threshold
  - high speed through elimination of long ion tail by shaping and baseline restoring of signal dead time ~20ns
  - low noise through differential logic swing
  - low threshold =► *good efficiency & resolution*
- HV circuit board (4 boards)
  - 330 pF capacitors decouple signal from HV
  - embedded capacitors reduce leakage currents



# LHCb Outer Tracker Straws –

## Available components: HV Supply systems


LHCb OT actual HV units
and modules are at GSI.

Two mainframes
CAEN SY1527LC
and eight HV units
CAEN A18338PLC
and a cable junction-box.

These units were used
for the whole OT.

# LHCb Outer Tracker Straws – Hardware for MUST

| | LHCb OT - Available | MUST needs.. | Requirements / Attention |
|---|---|---|---|
| **Detectors** | Modules on C-frames | ~55% of modules | Cover around CBM beam pipe |
| Mechanics | C-frames | C-frames (2 stations, 6 layers/station) | Fit in MUCH & absorbers |
| Stations & platform | Not available,<br>not available | Stations: Frames to hold C-frames<br>Platform: Carry stations & absorbers | Integrate MUCH mechanics incl. absorbers |
| Gas system | Not available | Gas system as in LHCb/CERN | Similar specs as LHCb/CERN |
| **On-detector** distribution | Gas, HV, LV, Controls are part of C-frames | C-frames | Connections to off-detector supplies via patch panels |
| HV & Straw signals-digits | Boards in FEE Box | ~55% of available boards | |
| TDC / DAQ | LHCb native | GSI Readout DOGMA & adapt to CBM | Fit within FEE Box, stay within power budget |
| LV, Controls | Prototype board | New design for GSI Readout DOGMA | |
| **Off-detector** LV, Controls | HV as used in LHCb<br>Not available | HV of LHCb<br>LV supplies, controls system to CBM | Racks, cables & connectors<br>LV PSUs, patch panels,<br>DAQ racks, fibers&connectors |
| DAQ | Prototype system | Interface system CBM DAQ to DOGMA | |

# LHCb Outer Tracker Straws – Towards MUST LoI

## MUST Detector Realization Plan for CBM (Target: 2030)

*Work Package Summary, Resources, Tasks, and Timelines*

### Overview

This document summarizes the major work packages (WPs), associated tasks, challenges, responsibilities, and timelines for realizing the MUST detector as part of the CBM experiment. The MUST detector is based on the LHCb Outer Tracker (OT) technology [1, 2, 3, 4, 5, 6, 7, 8, 9] and will be integrated into the MUCH platform of CBM. Each WP contributes to a key phase in design, acceptance, integration, software development, and commissioning.

1



| WP | Description |
|---|---|
| 1 | Detector components and services |
| 1.1 | C-frames with straw modules (LHCb) |
| 1.2 | Straw modules with electronics box (LHCb) |
| 1.3 | On-detector services (LV) |
| 1.4 | On-detector services (HV) |
| 1.5 | MUST Gas system |
| 1.6 | On-detector services (Cooling) |
| 2 | Mechanics |
| 2.1 | Revisit C-frame module assembly for MUST |
| 2.2 | Integration of C-frames to Stations for MUST |
| 2.3 | Mechanical integration of MUST in MUCH |
| 3 | FEE, DAQ, DCS |
| 3.1 | Analogue readout (LHCb ASICs) |
| 3.2 | Digital readout DiRICH (with interface) |
| 3.3 | Digital readout DOGMA (with interface) |
| 3.4 | DAQ and integration to CBM [DOGMA] |
| 3.5 | DCS and integration to CBM |
| 4 | Detector tests |
| 4.1 | Dismounting of C-frames and modules |
| 4.2 | Testing of individual modules with electronics box (LHCb) |
| 4.3 | Detector data analysis & Quality Assurance(QA) |
| 4.4 | Acceptance tests of MUST modules |
| 5 | MUST software integration in CBMROOT |
| 5.1 | Simulation Framework |
| 5.2 | Performance evaluation |
| 5.3 | Computing and data analysis |
| 6 | Installation, Commissioning and Monitoring |
| 6.1 | Planning of LV, HV infrastructure in CBM |
| 6.2 | Reassessment of optical backbone in CBM |
| 6.3 | Monitoring/control software |
| 6.4 | Alignment & Calibration in CBM |

2

First view of MUST with LHCb OT