# TWEPP 2024 Topical Workshop on Electronics for Particle Physics

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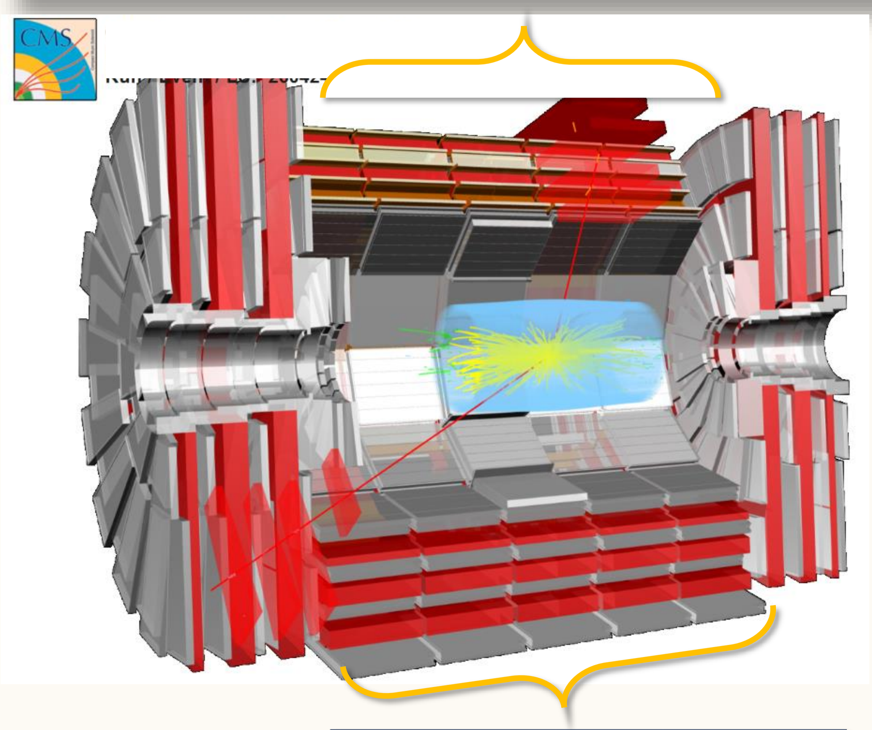
# Upgrade of the CMS Drift Tube Electronics for the High Luminosity-LHC

Ignacio Redondo on behalf of the CMS Collaboration, CIEMAT, Madrid – SPAIN -- redondo@cern.ch



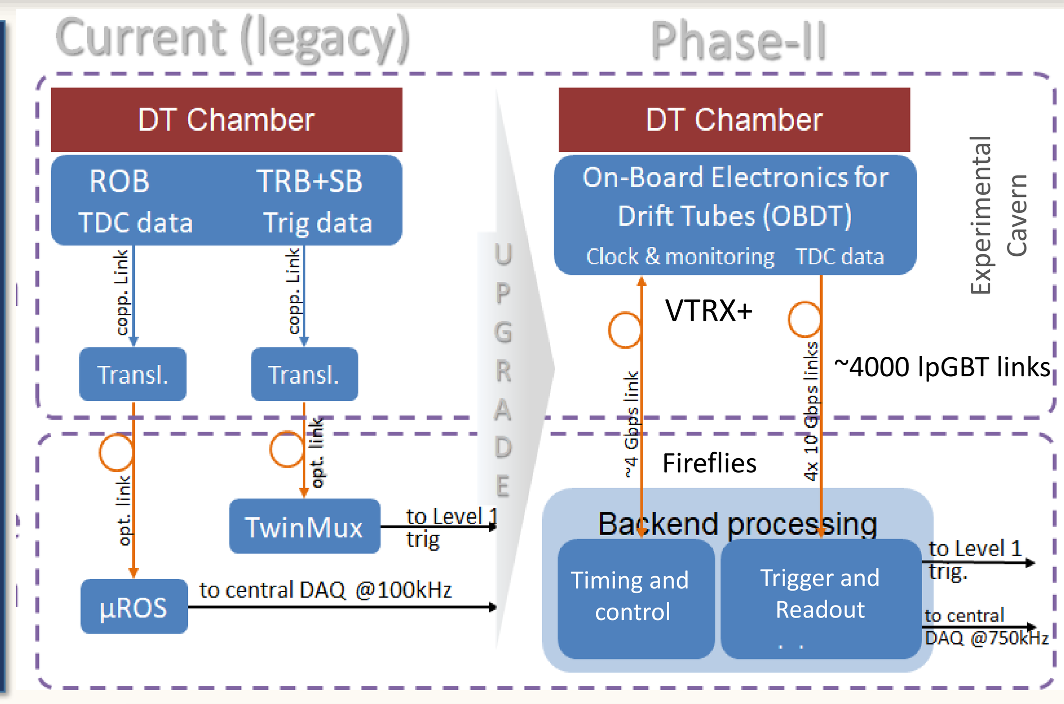
Muon Barrel DT

## Motivation

- L1 readout limit at 300 KHz for present readout boards
- Obsolescence of present electronics
- Ease maintenance: 2 different boards vs. up to 17 different boards now
- Reduce power consumption
- Move trigger primitives' logic to a radiation-free environment

## Upgrade Overview

- **New architecture**: Full streaming of all time digitized data (hits@0.8 ns) in an asynchronous way to backend where tracks are reconstructed [1]
- **Replace Minicrates**: Aluminum structures attached to the DT chambers embedding DT on-detector electronics
- **New backend.** Two types: "Timing and Control" and "Trigger and Readout"




New streaming readout architecture

Image of the OBDT-ϕ pre-production board

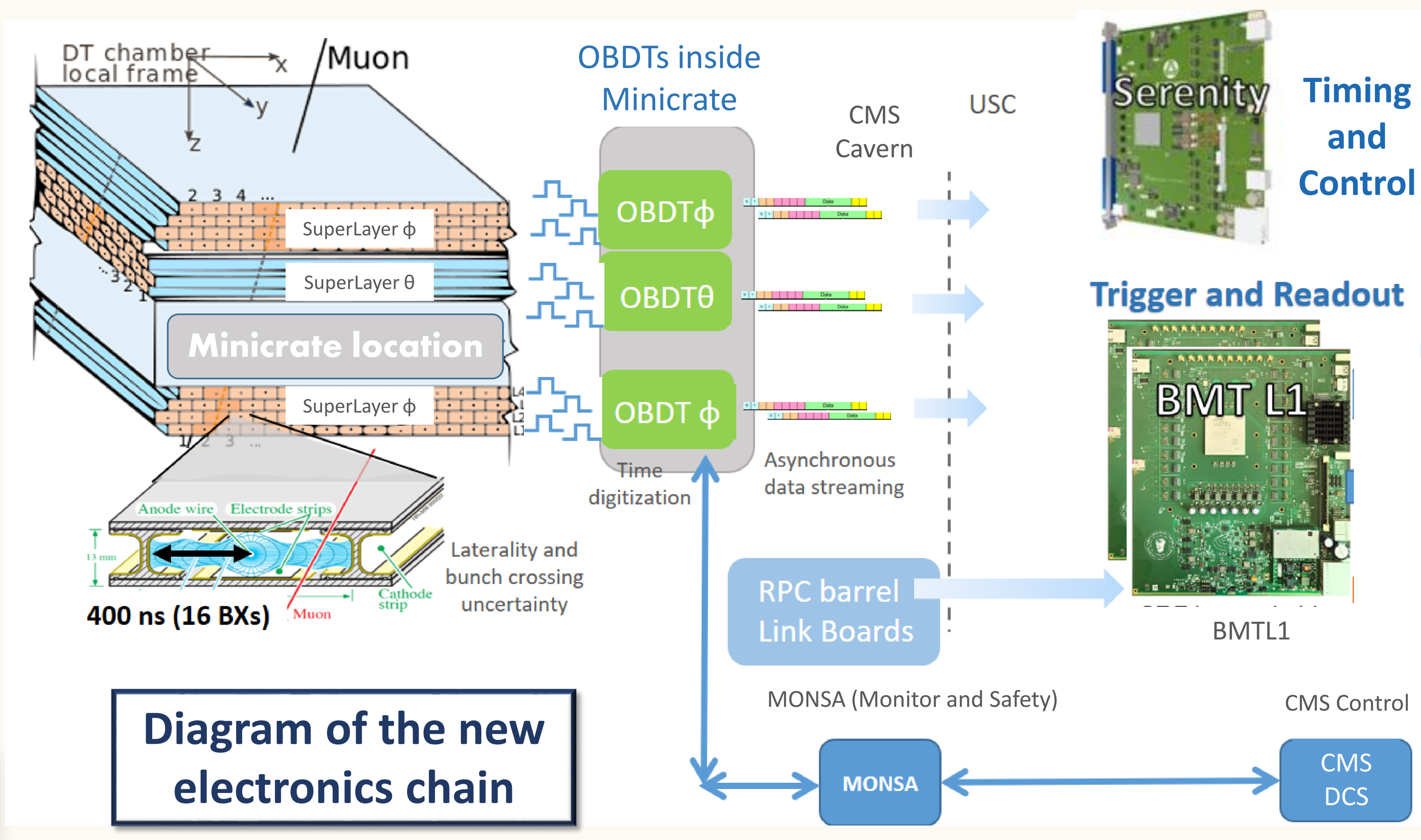



Diagram of the new electronics chain

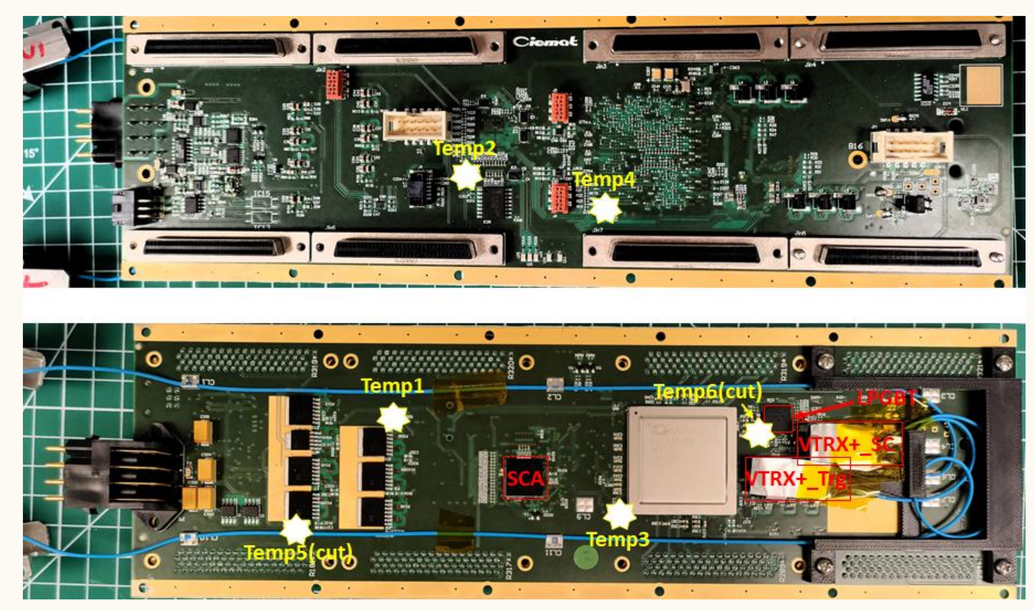



Image of the OBDT-θ pre-production board with the VTRX+ assembled

# The new electronics

## OBDT-ϕ board

- **Time digitization** of 240 channels in the ϕ SuperLayers
- Input cables substitution by higher performance shielded pairs cables
- 14 layers, 280x90 mm
- Halogen-free material EMC EM-890K

## OBDTs

- **Microsemi PolarFire** MPF300T-1FCG1152E FPGA
- On board safety system : temperature, voltage, current
- Power consumption ~ 10W
- 2 x RX @5 Gb/s
- 6 x TX @10.24 Gb/s
- Tested under radiation up to 100 Gy: CHARM, Legnaro

## OBDT-θ board

- **Time digitization** of 228 channels, it uses legacy connectors since θ view SuperLayers (SL) is not accessible
- 14 layers, 280x90 mm
- Halogen-free material "Panasonic Megtron 6"
- Water leak detection system

## Timing & control backend

- System for the distribution of LHC clock and fast timing commands
- Configuration and monitoring of the OBDTs status
- 10 **Serenity ATCA boards**

## Monsa safety system

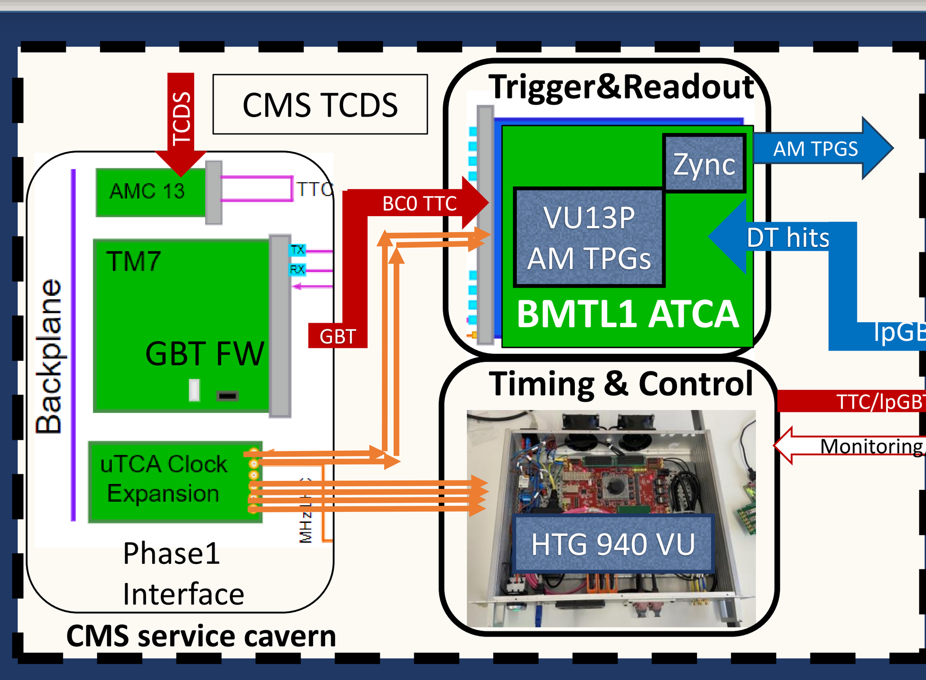
- Automatic hardware interlock for OBDT alarms
- Monitoring of OBDT status
- Connection to CMS DT DCS (Detector Control System)

## Trigger & Readout backend

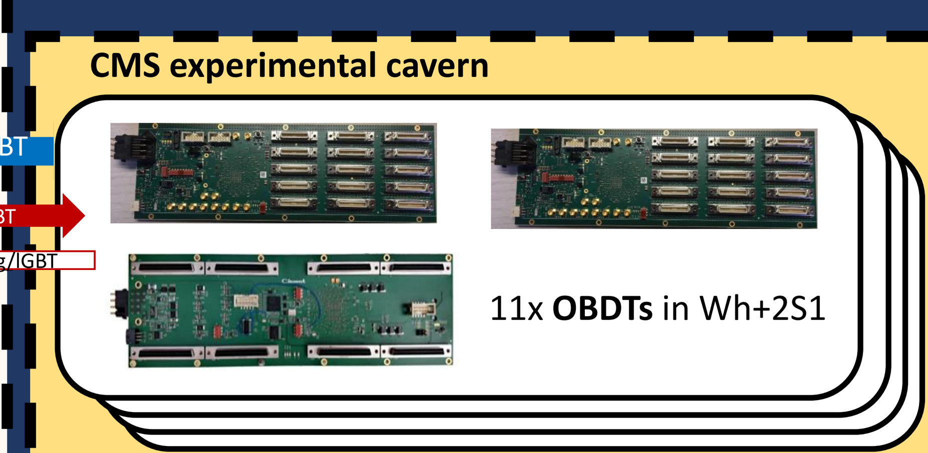
- Trigger primitive generation by **Analytical Method (AM)**[2] algo
- Exploits maximum chamber resolution, bringing the hardware trigger close to offline performance capabilities.
- Readout of DT and RPC (Resistive Plate Chambers)
- 42 **BMTL1 ATCA boards** [3], porting VU13P, distributed in 2 layers

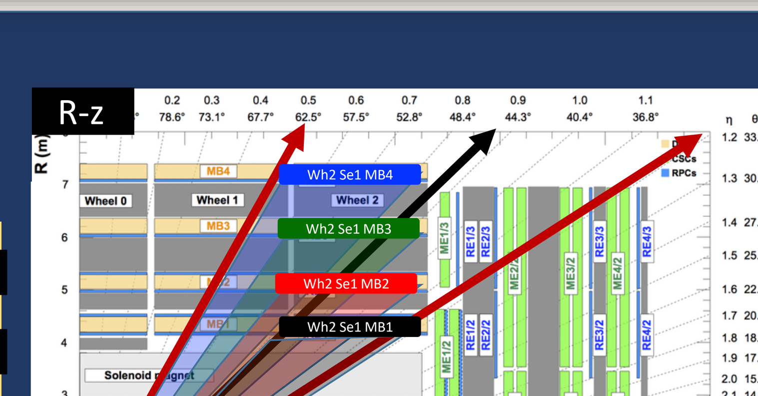
## Slice Test Integration in CMS

- LHC Clock distributed to backend boards via copper (SMA) from uTCA backend using custom boards
- TTC signals: (BC0,OC0,L1A…) received by BMTL1 optically from TM7 via GBT payload and via SMA to the Timing & Slow Control backend
- No trigger is applied, all DT hits are streamed to the BMTL1 board and collected asynchronously with its generated AM[2] trigger primitives sampling internal memories of the BMTL1 board.




## The Sector1 Slice Test

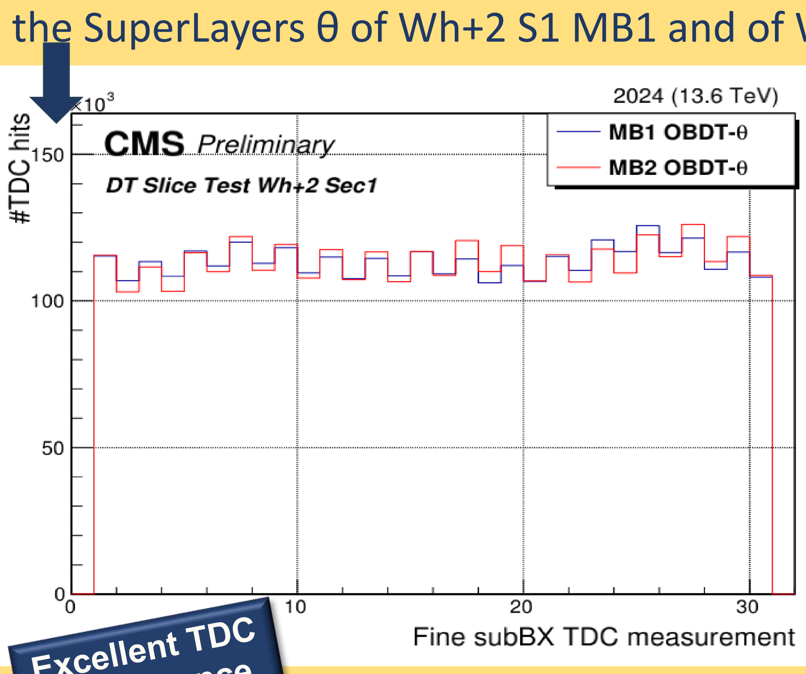


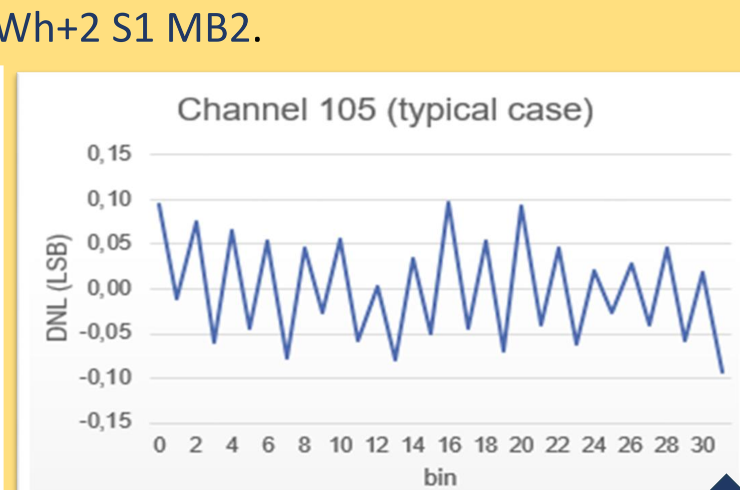



**Sector 1 Slice Test:** 11 OBDTs reading 4 DT chambers in Wh+2 Sector 1 since 2023

## OBDT-θ TDC Differential Non-Linearity

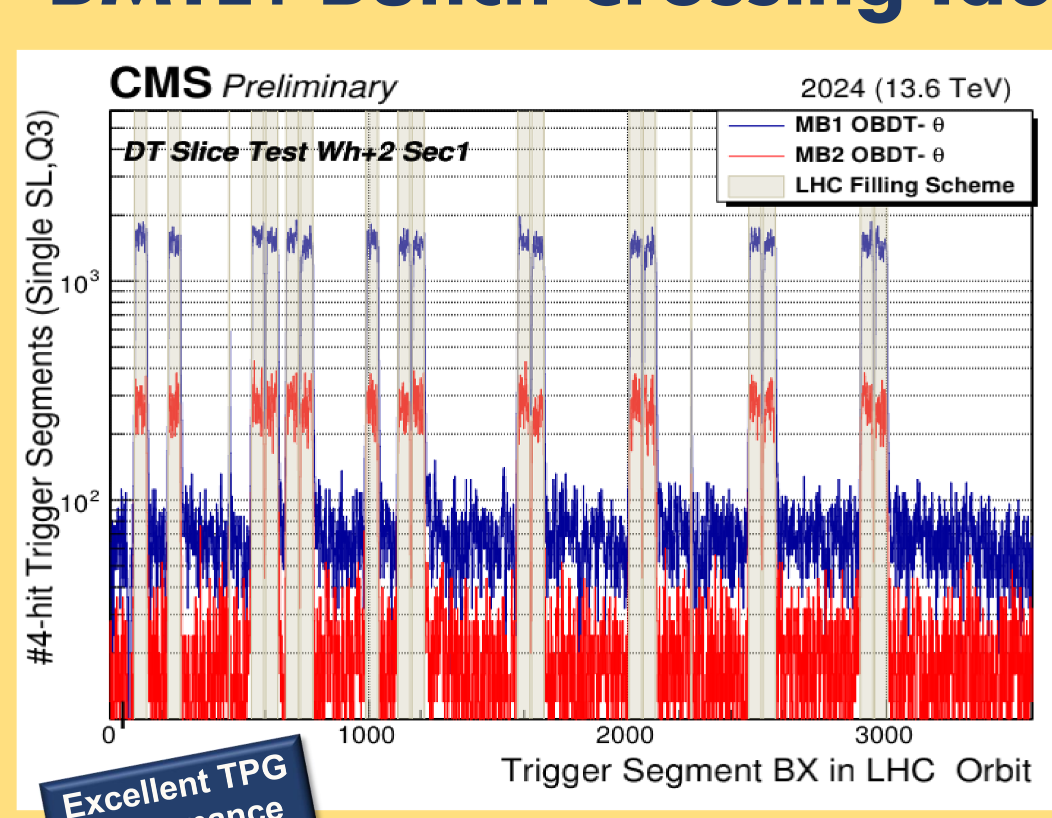
Distribución of the Fine, subBX (BX=Bunch Crossing), time measurement of the TDC hits recorded by the OBDT-θ boards digitalizing DT tube signal pulses coming from the SuperLayers θ of Wh+2 S1 MB1 and of Wh+2 S1 MB2.




Lab measurements: Typical channel DNL structure showing the non perfect duty cycle of the clock.

## BMTL1 Bunch Crossing Identification in Collisions




- Disitribution of the BX measurement of the 4-hit trigger primitives (TPGs) coming from the SuperLayers θ of MB1 (blue line) and MB2 (red line) as reconstructed by the AM algorithm[2] running in the BMTL1 prototype[3].
- The structure of the colliding beams is well reconstructed.
- Due to the large background level, the inhomogeneous B field and the large track angle with respect to the wire, the θ SuperLayers of Wh+2 MB1 are the most challenging enviroment in the DT acceptance

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References: [1] CMS Collaboration, "The Phase-2 Upgrade of the CMS Muon Detectors", CERN-LHCC-2017-012 ; CMS-TDR-016. 2017. https://cds.cern.ch/record/2283189?ln=es CMS Collaboration, "The Phase-2 Upgrade of the CMS Level-1 Trigger Technical Design Report", CERN-LHCC-2020-001 https://cds.cern.ch/record/2714892?ln=es [2] 10.1016/j.nima.2023.168103 [3] JINST 18 (2023) 02, C02039

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