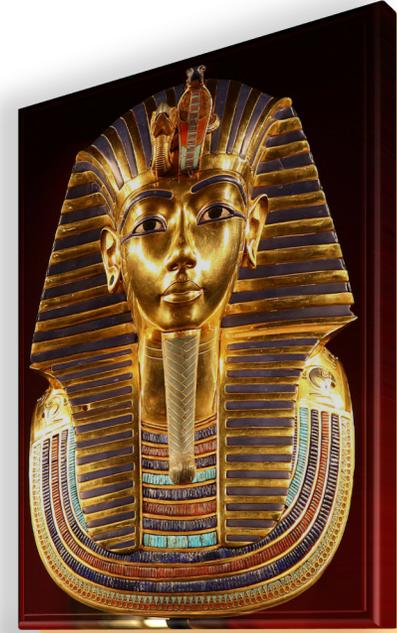


HO trigger link project

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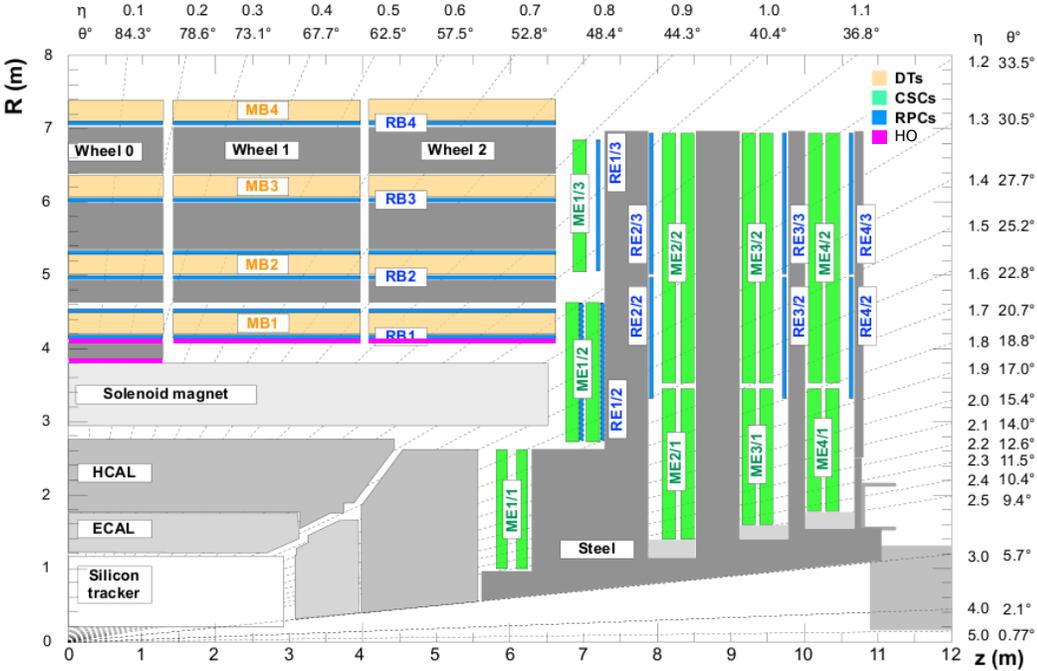


Introduction

Novel Trigger Bits from HO for Muon and HCAL

Motivations

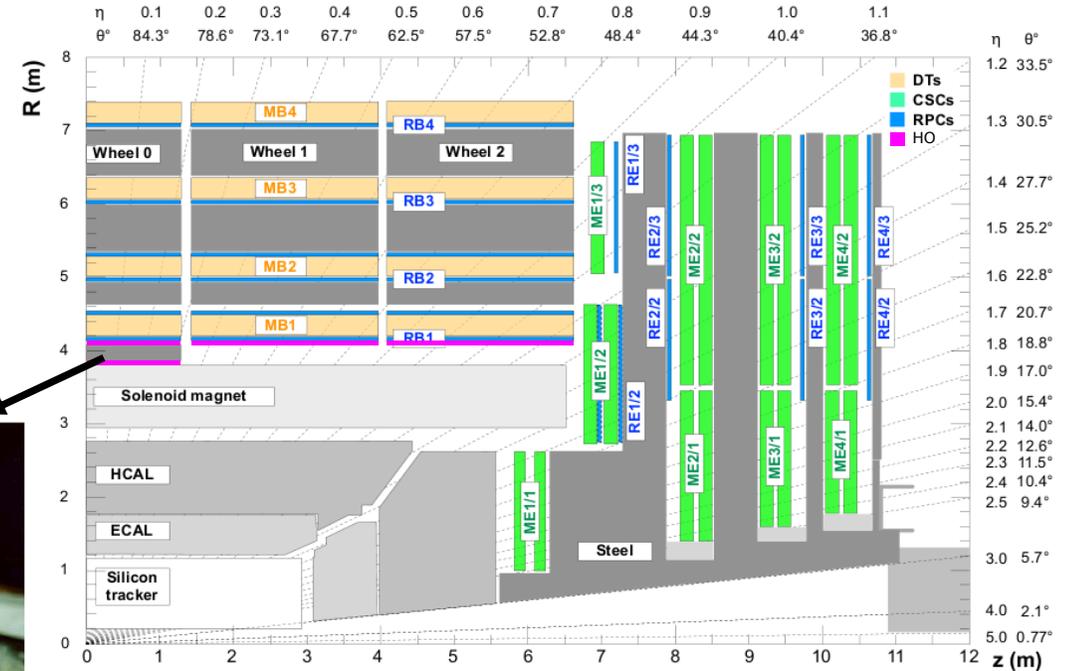
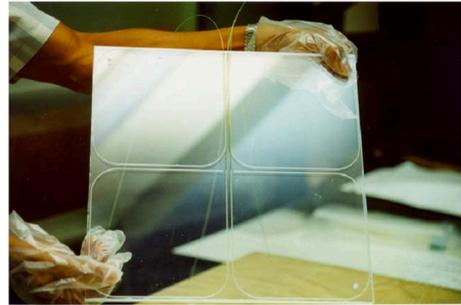
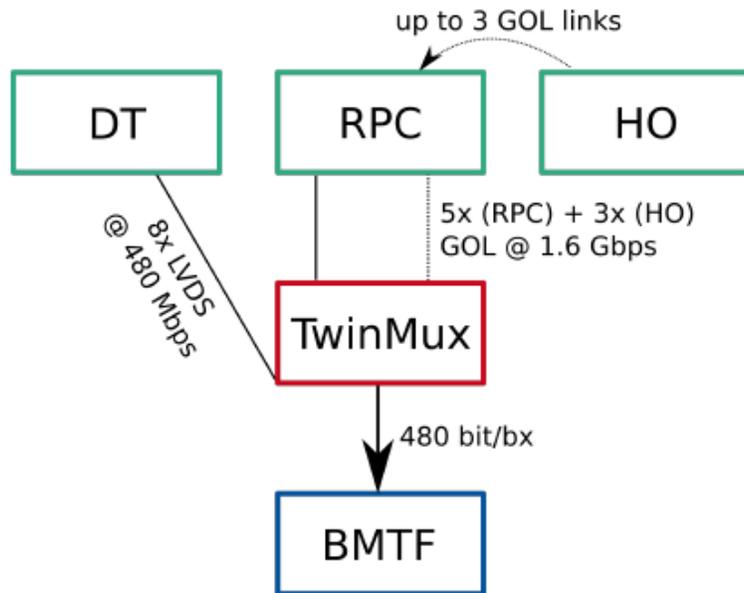
- In the Barrel region HCAL is supported with a “tail catcher” to detect punch through and to improve the detection of the jets with high hadronic activity
 - Hadronic Outer Calorimeter (HO)
- placed just outside the magnet cryostat
- Represents an additional layer of plastic scintillator



Novel Trigger Bits from HO for Muon and HCAL

Motivations

- HO is MIP detector and because of its intermediate location between the HCAL and muon detectors, a link was established to send the HO bits to the level-1 muon trigger
- A data concentrator board (TwinMux) is combining this information to be sent to the trigger

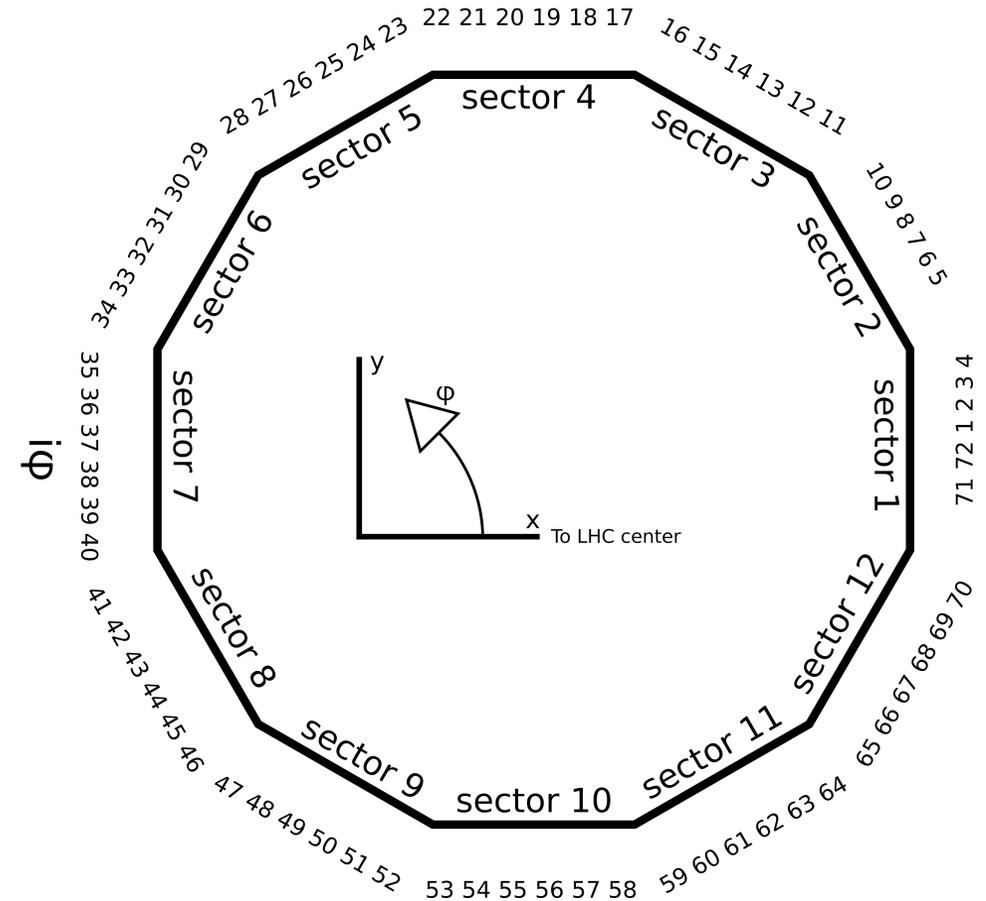
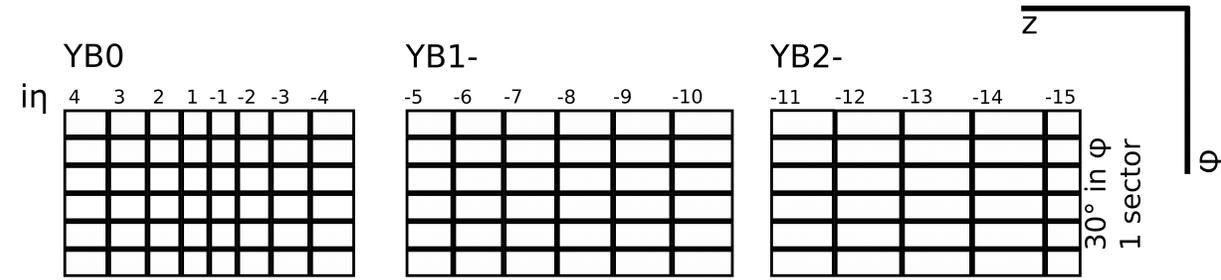


- The HO tile size: $45\text{ cm} \times 45\text{ cm}$ which covers 0.087×0.087 in $\eta \times \phi$
- Overall HO consists of 12 sector in ϕ each of $\phi = 30^\circ$ and 5 rings in η , covering $|\eta| < 1.262$

HO design

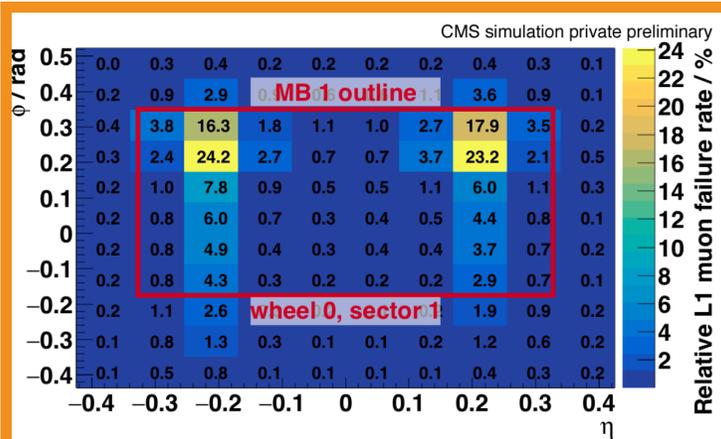
HO geometry

- Every HO sector is consisting of 6 tiles in the direction of ϕ and 30 tiles in the direction of η
- Tile numbering in η starts at the central barrel, starts at 1 and increases until the 15th in the right direction and vice versa in the other direction it starts at -1 and decreases until -15th
- The position of any tile is determined by tile number in η and ϕ in the local HO coordinates, i.e $i\eta$ & $i\phi$



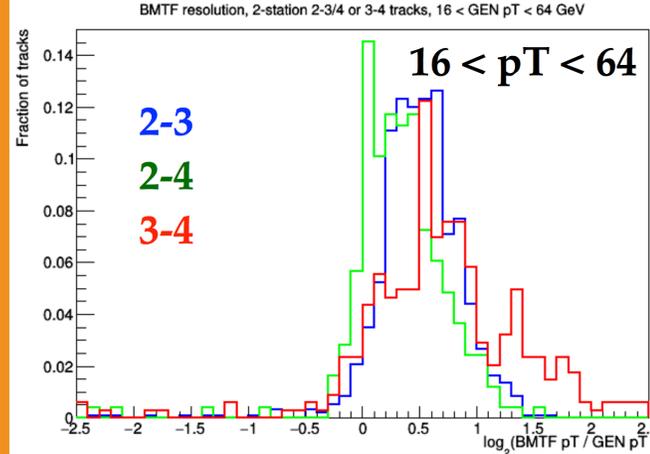
HO Support for L1 Muon Trigger

Past activity



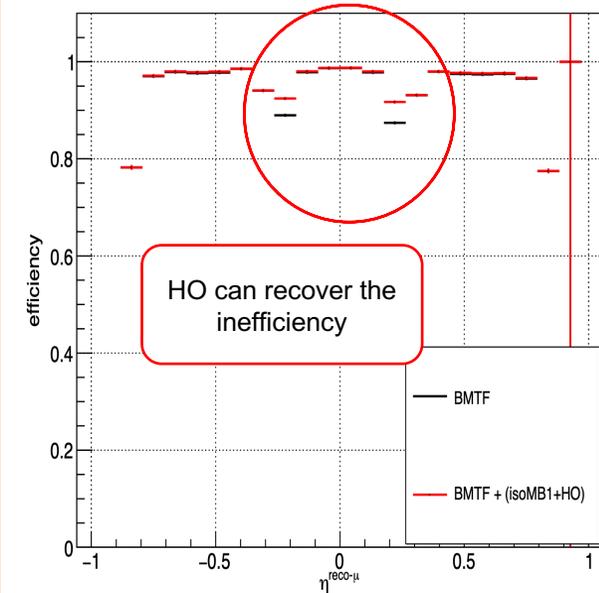
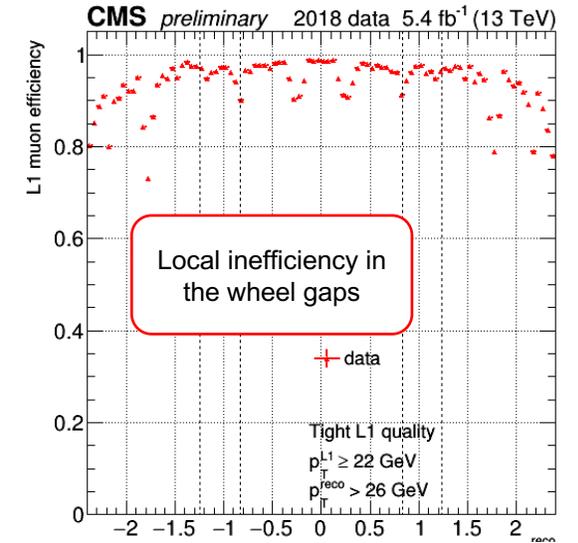
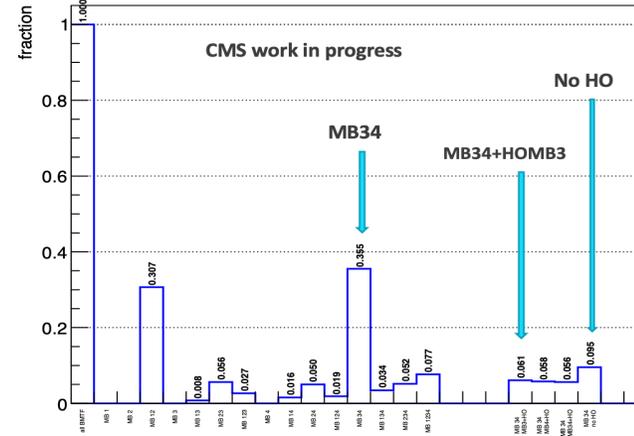
DT failure scenarios

- Muon system suffers from radiation damage especially in the MB1
- HO can recover in case of single or multi cell failure



Inefficiency in the p_T resolution due to fake contributions

HO can reject fakes and reduce the trigger rate by 15%

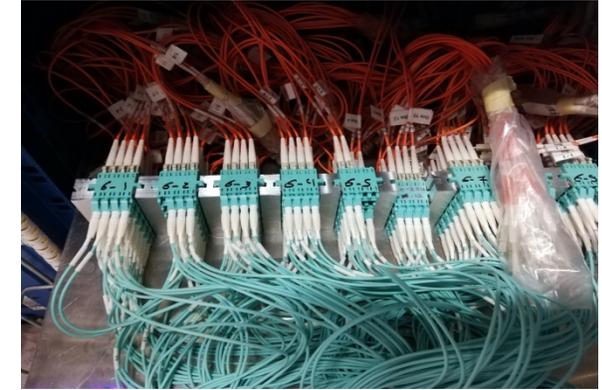
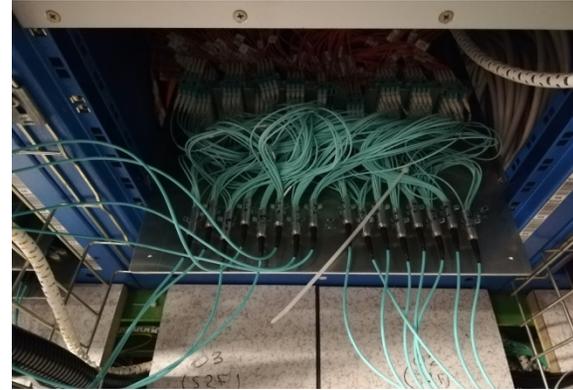


All studies documented in the Detector Note:
CMS DN-2017/053

HO Upgrade to μ TCA

Main parts installed and tested

- HCAL is moving from VME to μ TCA. The Outer Hadron Calorimeter (HO) is upgraded to the new standard by DESY during LS2.
- A link to the Muon Trigger system had been established, studied and summarized in an internal CMS detector note (DN-17-053)
- The μ TCA upgrade is necessary to keep this link functional since the MUON Trigger is upgrading its electronics, as well
- The new, complex patch panel for fiber routing
- Electronic and logic mapping were developed, used to readout all the channels and link them with the physical position in (η, ϕ)



4 new designed patch panels, one for each HO quarter

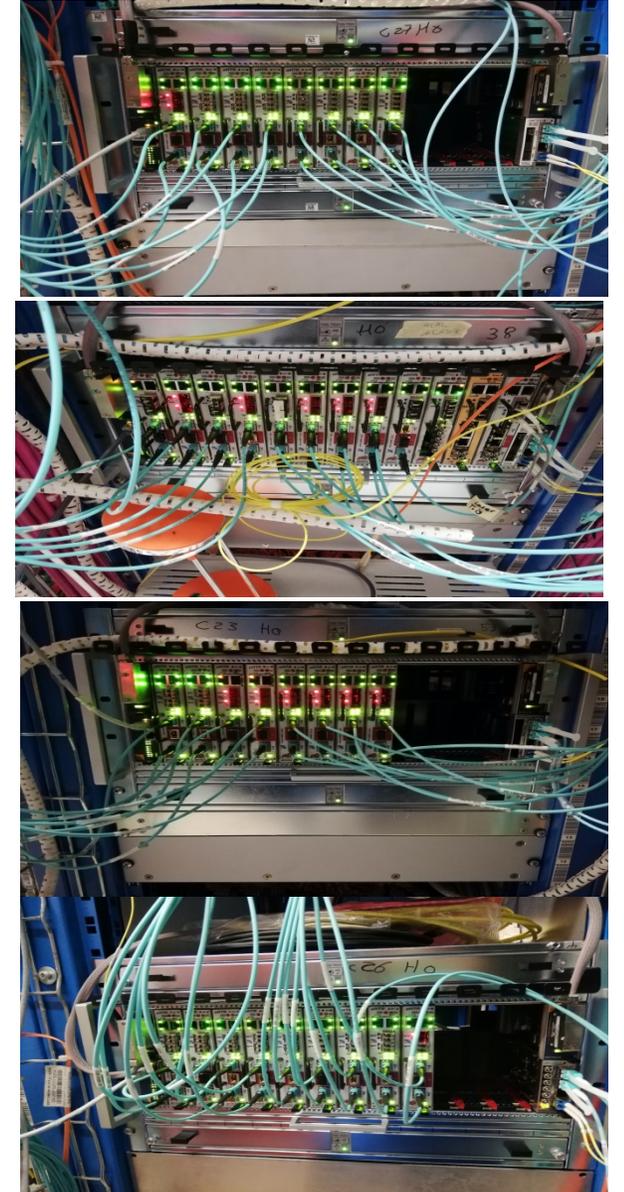
HO Hardware Status

Main parts installed and tested

First light in the new HO fibers seen in September 2019

- HO is fully migrated to μ TCA (4 crates, one per HO Quarter)
- HO has in total 2268 signal channel (+77 for calibration)
 - **All connected and tested**
- The trigger link to Muon has been **connected**
- The ethernet for communication and control
 - **Commissioned and tested**
- DAQ link for data acquisition
 - **Commissioned and tested**
- Timing and Control for synchronization
 - **Commissioned and tested**

We participated in a Weekly Global Run with the full system and everything looks fine!



4 crates, one for each HO quarter, filled with μ HTR boards

HO in HCAL and L1 muon trigger

Plans

Further Studies for triggers with HO:

- With the new electronics not only one bit can be transmitted, but with small modifications two bits and with more modifications even 4 bits
→ the definition of trigger bits does not need to be restricted to a muon (MIP) detection, but also calorimeter properties can be addressed
- The Phase I Upgrade for the HCAL with the new readout electronics foresees several new feature bits
Presently studies are ongoing for HB, HE and HF (with EPR) looking at profiting from the new depth segmentation, timing information, single isolated muons, rejecting pile-up
- We will join this effort and study the opportunities to complement the feature bits with trigger from HO

Thank you

شكراً

Danke