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



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

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







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HO design

From CMS geometry to HO

- The barrel part of the CMS detector is consisting of 5 co-centric wheels in the direction of η , so HO
- Usually call the wheel YB
- The YB numbering is 0 for central wheel and ±1, ± 2 for the other 4 wheels
- HO has 2 layers in the YB0 and only one layer in the other wheels
- The motivation for that was because hadronic jets are stronger in the central wheel than others
- In the direction of ϕ HO has 12 sectors numbered from 1 to 12, each sector covers 30°



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 cooridanates, i.e iη & iφ



HO Support for L1 Muon Trigger



HO electronics

HO frontend



HO electronics

HO backend – VME-based

- The old backend electronics were based on VME standard cards called HCAL Trigger Readouts (HTRs)
- The VME is open standard that includes mechanical, electrical and protocol sections
- A data transfer protocol that is relatively easy to implement
- Due to limitation in payload and bandwidth, only one bit of information could be sent to the twinmux from HO
- The bit 1 ins the presence of MIP in one of the HO tiles and 0 when not
- The entire HCAL detector is now moved to new standard uTCA and will no longer support VME soon





Ho data BX-1	0x6	windex	valid bit	BCn	MIP	MIP	MIP MIP	MIP	MIM MIM	MIP	MIP	MIP	MIP MIP	MIP	MIP	MIP	MIP valid bit	BCn	MIP	MIP	MIP	MIP		MIP	MIN MIN	MIP	MIP	MIP	MIP	MID						
HO data BX=0	0x6	windex	valid bit	BCn	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	dIM	MIP	MIP	MIP valid bit	BCn	MIP	MIP	MIP	MIP	MIP	NIIF AAID						
HO data BX+1	0x6	windex	valid bit	BCn	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP valid bit	BCn	MIP	MIP	MIP	MIP	MIM	MIP	MIN MIN	MIP	MIP	MIP	MIP	NIIF AAID

HO Upgrade to µTCA

Main parts installed and tested

- HCAL is moving from VME to µTCA. 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 µTCA 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 µTCA (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

