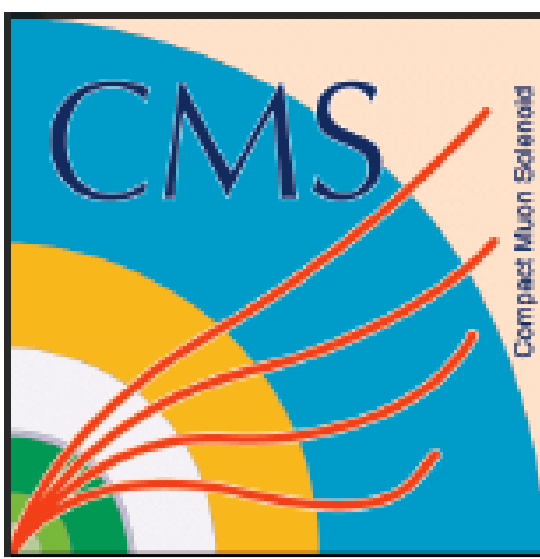


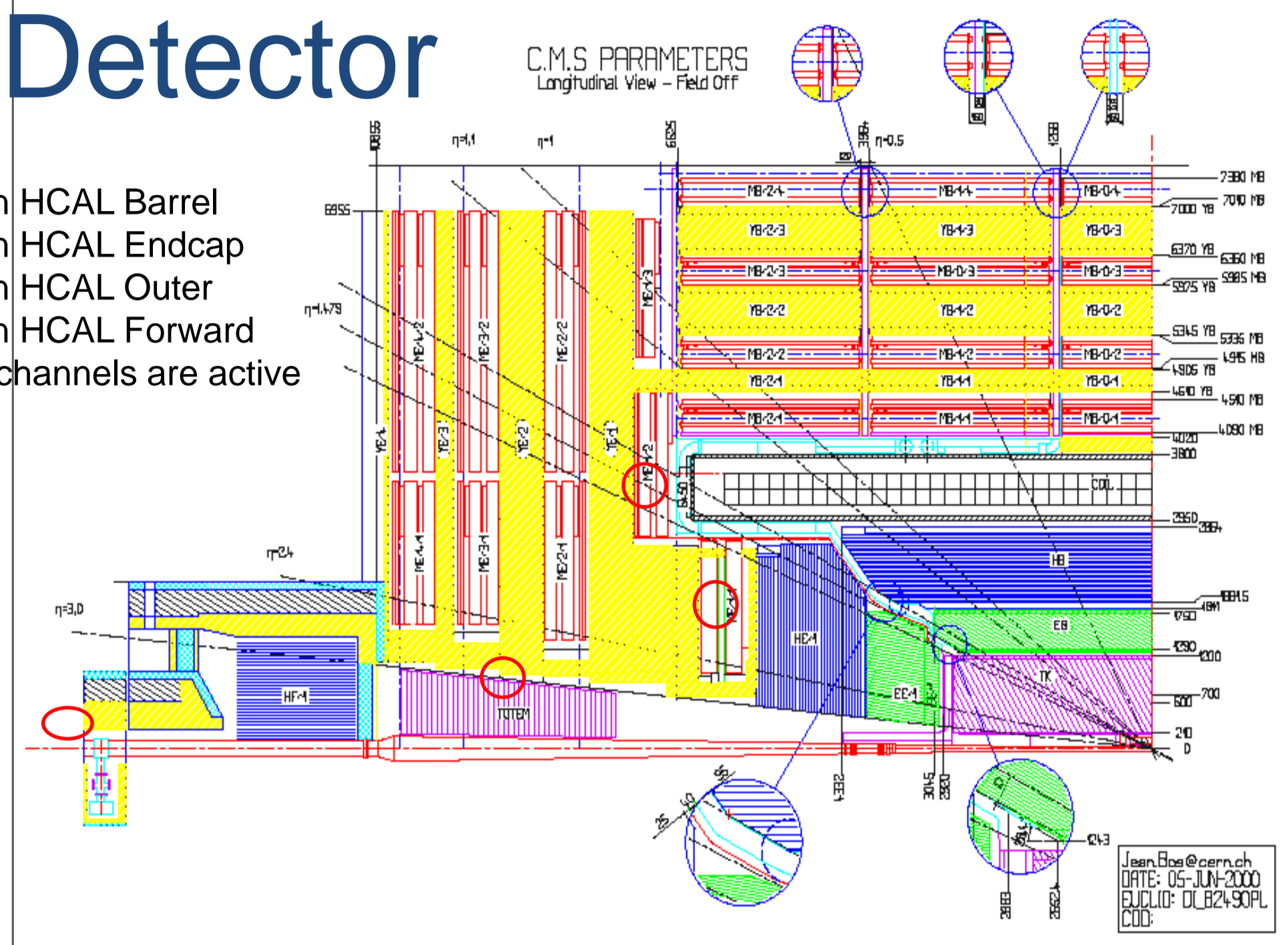
Commissioning and Performance of the CMS Hadronic Calorimeters in pp Collisions at a Center of Mass Energy of 7 TeV at the Large Hadron Collider

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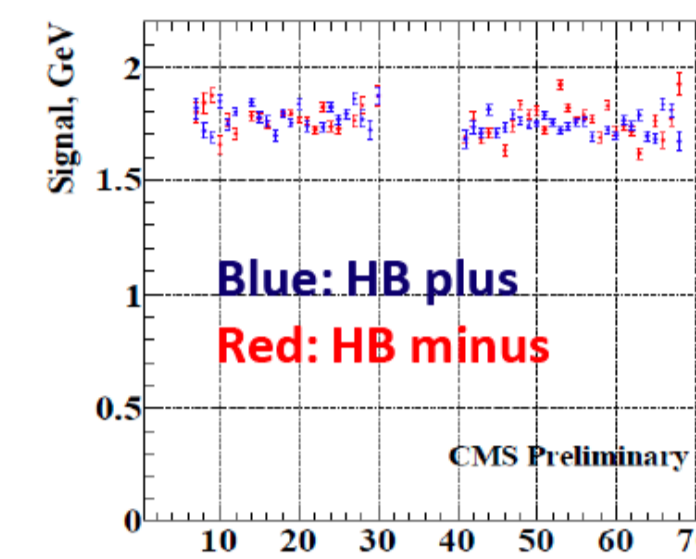
CMS Detector

2592 channels in HCAL Barrel
2592 channels in HCAL Endcap
1728 channels in HCAL Outer
1728 channels in HCAL Forward
99.2% of HCAL channels are active

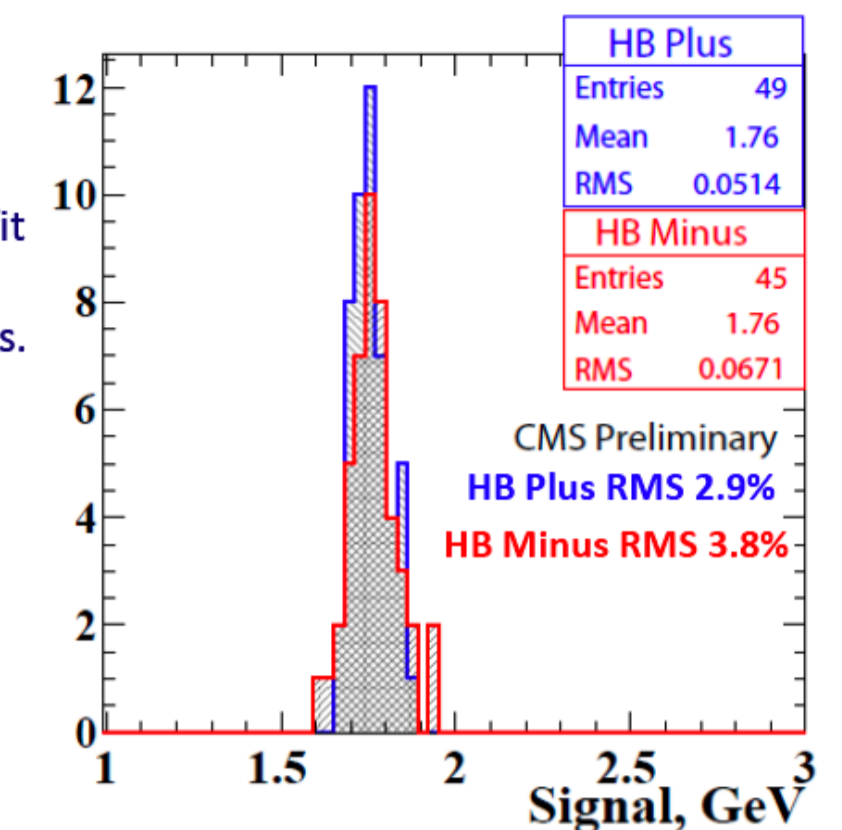


HCAL Response to Cosmics

- Uses tracker tracks – propagation to the inner and outer radius of the HCAL barrel
- 45 M cosmic triggers $B=3.8\text{ T}$
- $P_{\mu} = 5\text{--}100\text{ GeV}/c$
- Fit error < 3%
- Path length correction applied
- Signal is normalized to the response at one particular momentum value (25 GeV/c) using a fit to dE/dX vs. P_{μ} from data.
- Gaps in the plot due to lack of horizontal muons.



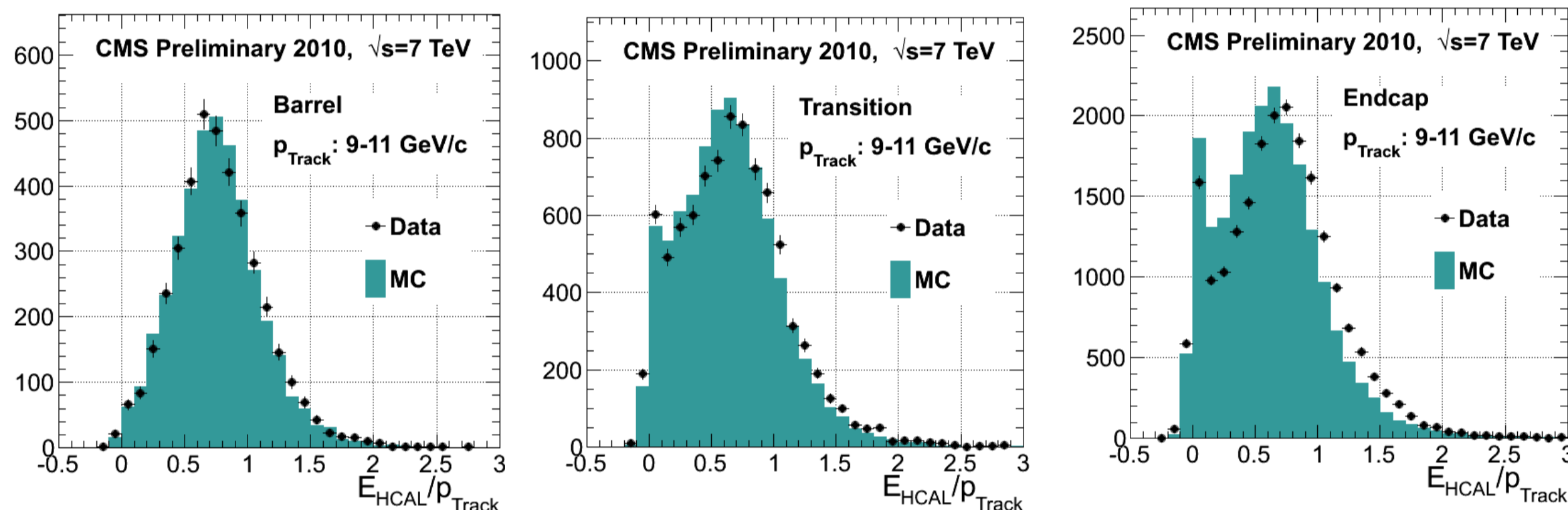
- Muon response as a function of $i\phi$
- $i\phi$ -sectors having replaced readout modules are excluded from the plots



Mean response for HB+/HB- is in good agreement

HCAL Response Shape

Barrel: $|\eta| < 1.1$
Transition region: $1.1 < |\eta| < 1.7$
Endcap: $1.7 < |\eta| < 2.2$

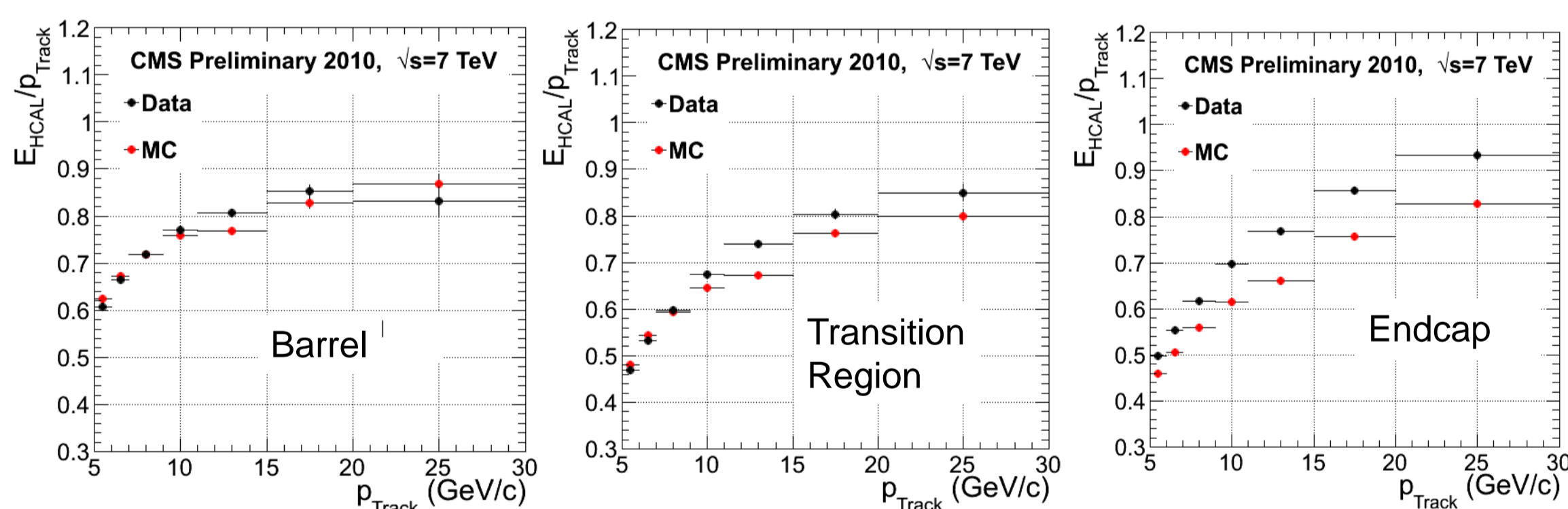


The HCAL response for well isolated tracks, non-interacting in Tracker and ECAL, with a momentum between 9 and 11 GeV/c for three different regions of HCAL.

The data is compared with the Geant4 based MC simulation of minimum bias events.

HCAL Mean Response vs Track Momentum

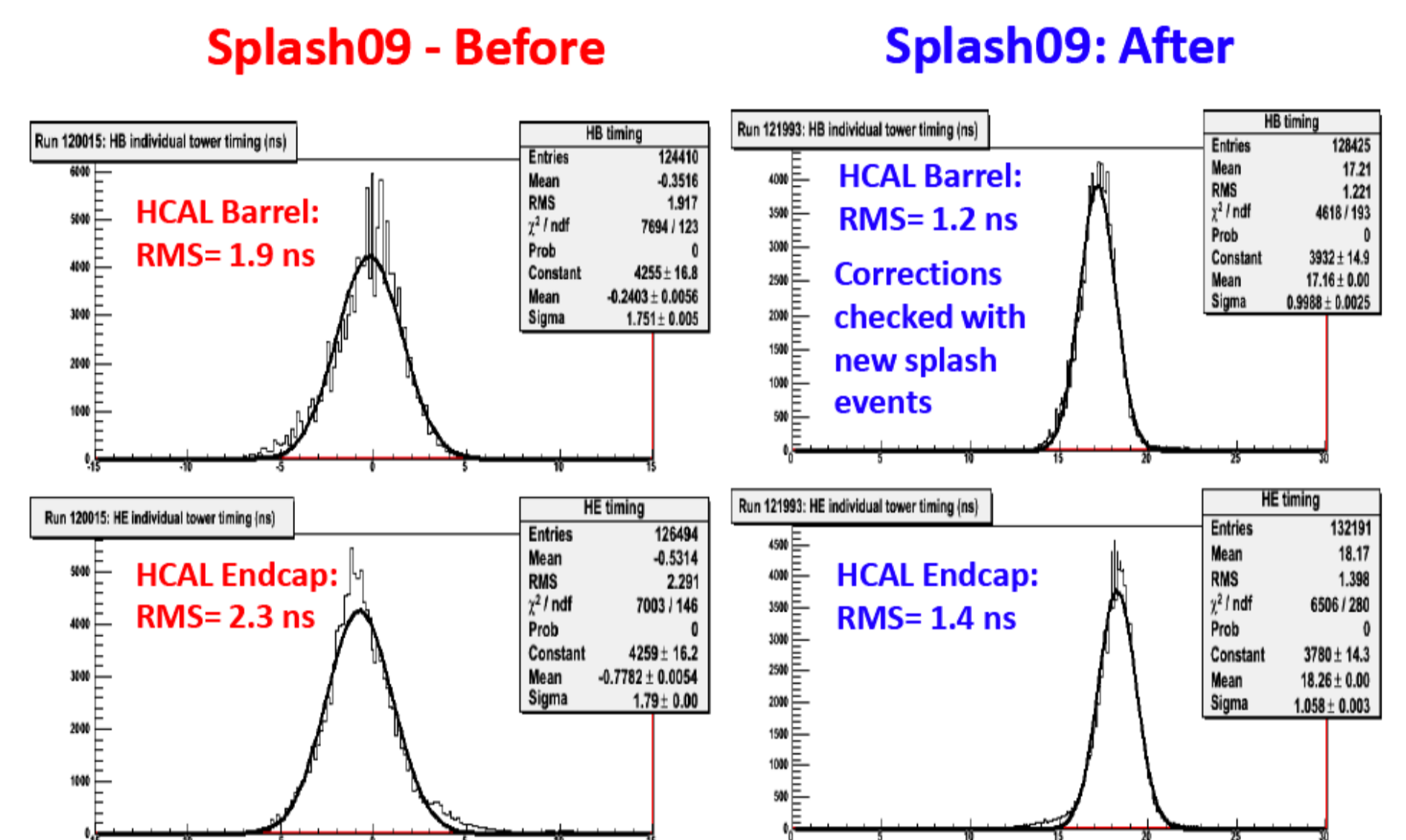
Barrel: $|\eta| < 1.1$
Transition region: $1.1 < |\eta| < 1.7$
Endcap: $1.7 < |\eta| < 2.2$



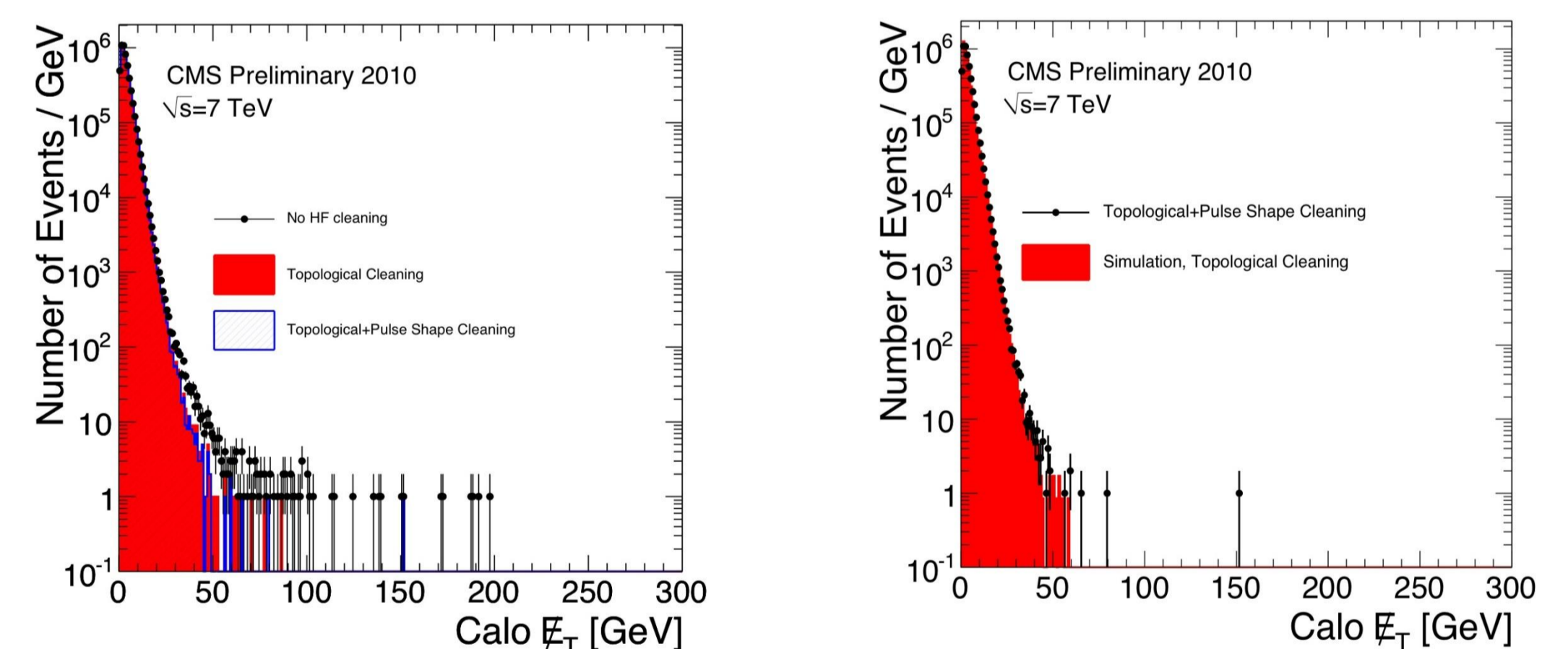
The measured mean response as a function of the track momentum in three different regions of the hadron calorimeter.

The full calibration will use tracks with a momentum of ~50 GeV and will require ~10 pb⁻¹ of data in order to get sufficient statistics.

HCAL Synchronization with Splash Events



HF PMT Hit Filters: Performance on the MET

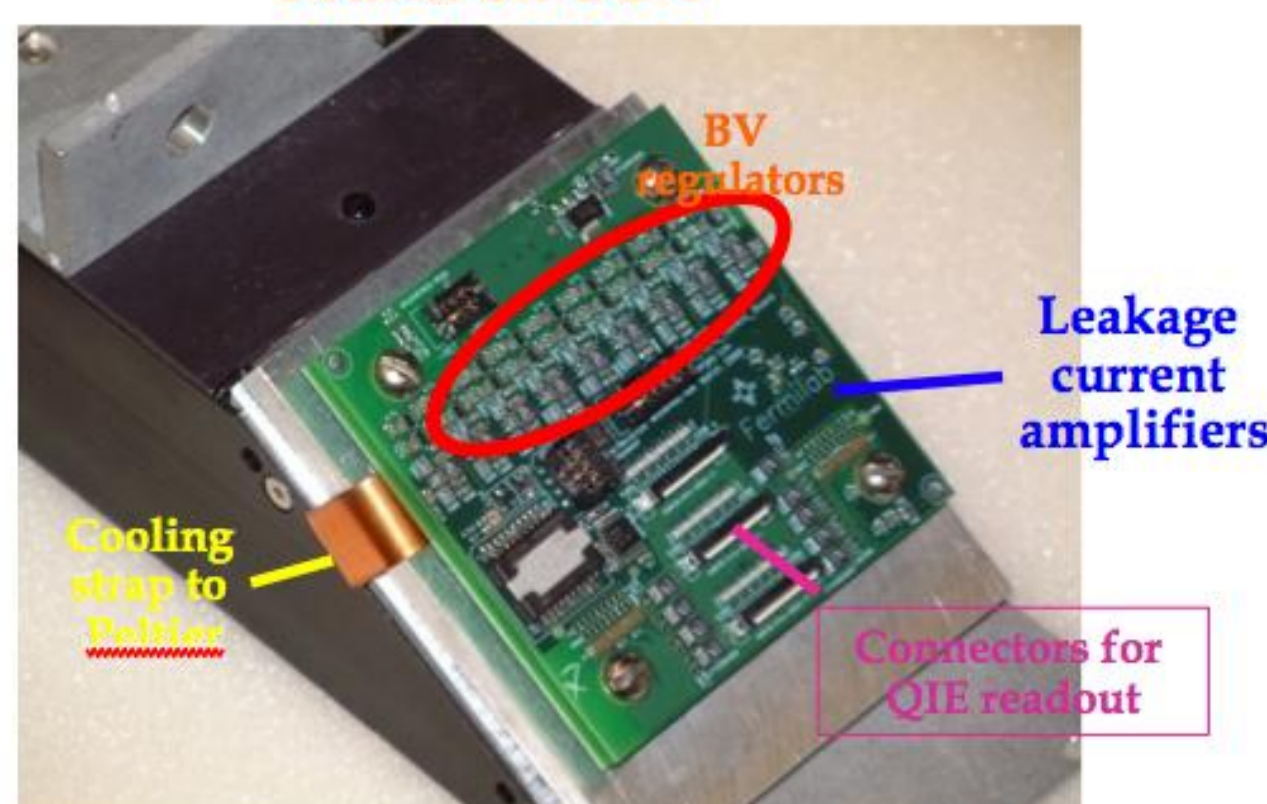


Calorimetric Missing Transverse Energy before and after the HF PMT hit cleaning using the topological and pulse shape PMT hit noise filters (left) and comparison of the cleaned spectrum with the MC G4-based CMS simulation (right). All other calorimetry noise removal algorithms are applied prior to the HF PMT cleaning.

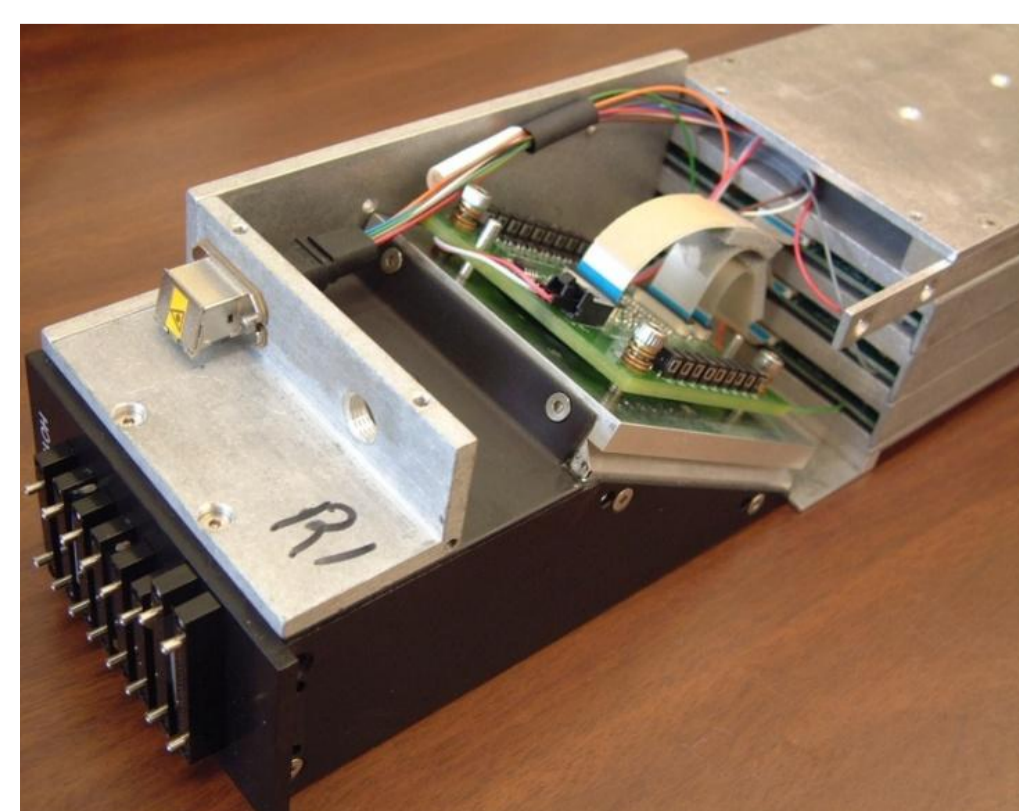
HO SIPM Upgrade

144 SIPMs installed into CMS in April 2009 and now operating. 36 Zecotek 15K/mm² 3X3mm, 108 Hamamatsu 400/mm² 3X3mm. 2000 SiPMs will be installed during 2011 shutdown.

Control and Mounting boards on ODU



HCAL Optical Decoder Unit



SIPM response for muons in CMS

