First results from SiPM+QIE11 readout in CMS for pp collisions

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Hadronic Calorimeter Upgrade

The CMS hadronic endcap (HE) is a sampling calorimeter with alternating layers of brass absorber and plastic scintillator tiles. The scintillation light is collected by wave-length shifting fibers, and in the original detector fed onto hybrid photodiodes (HPDs), and read out by Charge Integrator and Encoder 8 (QIE8) cards.

During the 2016-2017 year-end technical stop, one readout box (HEP17) was upgraded to use silicon photomultipliers (SiPM) and QIE11. The full endcap is being upgraded over the 2017-2018 YETS, with the barrel following in LS2.

Upgrade Motivation

As the plastic scintillator accumulates radiation damage, the energy response decreases. This signal loss is monitored with a laser system for layer 1 (right) and layer 7.

The SiPMs mitigate this signal loss with three times higher photon detection efficiency. The also remove the high-amplitude noise and response drifts of the HPDs themselves.

The QIE11 chips have a nonlinear 8-bit ADC with 17-bit dynamic range and (new!) embedded TDC with 500 ps resolution.

SiPM+QIE11 Performance

Selected measurements of SiPM characteristics with 2017 data:

- SiPM dark current with integrated luminosity exposure, observe linear correlation (top left).
- In situ signal pulse shape measurement, exploiting TDC information from QIE11 readout (top right).
- Greatly reduced high-energy noise readout noise (right).

HEP17 performed as expected during 2017, and pilot installation experience has been invaluable for on-going full upgrade of HE.

References


HE energy distribution during cosmic running. HPD (black) exhibit two types of noise absent in HEP17 (red).