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High Precision, Low Disturbance Calibration of the High Voltage System of the CMS Barrel Electromagnetic Calorimeter

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The CMS Electromagnetic Calorimeter utilizes scintillating lead tungstate crystals, with avalanche photodiodes (APD) as photo-detectors in the barrel part. 1224 HV channels bias groups of 50 APD pairs, each at a voltage of about 380V. The APD gain dependence on the voltage is 3%/V. A stability of better than 60 mV is needed to have negligible impact on the calorimeter energy resolution. Until 2015 manual calibrations were performed yearly. A new calibration system was deployed recently, which satisfies the requirement of low disturbance and high precision. The system is discussed in detail and first operational experience is presented.

Summary

The CMS Electromagnetic Calorimeter (ECAL) utilizes about 76000 lead tungstate (PbWO) scintillating crystals, the light from which is detected by Avalanche Photodiodes (APDs) in the central “barrel” region.
The APDs were produced by Hamamatsu in collaboration with the CMS Experiment.
Two APDs are glued on each crystal and are operated at gain 50 with a bias voltage of about 380 V.
The High Voltage (HV) system consists of 1224 channels biasing each 50 APD pairs.

The requirement of the HV system to have an impact on the energy resolution of less than 0.2\% translates into a needed voltage stability of better than 60 mV per month. All the HV boards were qualified prior installation and satisfy this requirement. Variations on a time scale longer than a month can be corrected for by the detector calibration with physics events.

The HV system utilizes CAEN A1520PE boards, located in the CMS service cavern and connected to the APDs via 120˜m long cables.
The HV channels use sense wires to correct for HV changes at the load.

In order to avoid inducing noise on the calorimeter signal measurement, the HV system was not equipped with a continuous monitoring system, but periodic monitoring and calibration campaigns are performed.

Until 2015 this operation was done manually, un-cabling the system in the service cavern and calibrating one by one all the HV boards with a precision multimeter.
Due to the long time required to perform this operation, and to reduce mechanical stress on the hardware, the HV calibration was done once per year during the LHC winter shutdown.

A new calibration system was deployed at the end of 2015. It
consists of mechanical switches, that can connect the high voltage
cables to the CMS detector or to the calibration system, guaranteeing
that no additional noise is introduced.
Calibration cables draw the bias to a precision multimeter through a set of multiplexers.
The calibration program cycles through all the channels allowing both
to measure the voltage and to recalibrate the channels one by one if
needed. The new HV calibration system is discussed in detail, along with first operational experiences.

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