Progress on the SIPM Upgrade of the CMS Outer Hadron Calorimeter (HO)

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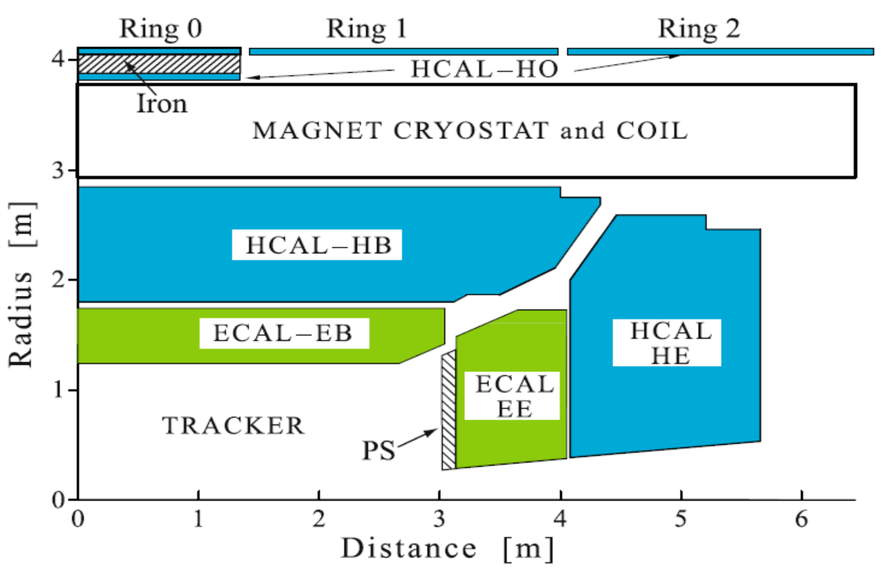
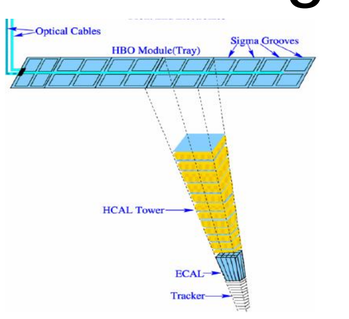
CMS Hadron Calorimeter



HO Design



"Tail catcher" for the barrel calorimeter.

- Correct missing E_T and jets particularly in Ring 0.
- Useful for muon identification.
- HO is in projective towers that match the inner calorimeter.
- Made of scintillator/wavelengthshifting fiber.

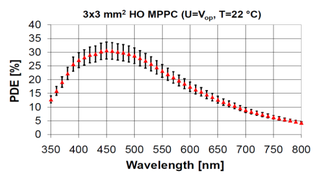
SIPM Choice

Important requirements were
- Rad. tolerance to 5E11 neutrons (>100 KeV) /cm**2
- Dynamic range sufficient for HO (2500 pes)
- Pulse recovery time
- Leakage current
- Photon detection efficiency
- Temperature dependence of gain
- Source capacitance

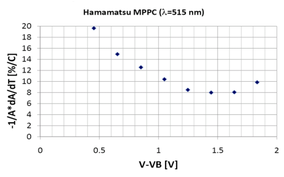
- 2200 + spares Hamamatsu 3X3 mm 50 micron MPPCs are in the system

Simulated Neutron field in CMS. E >100KeV

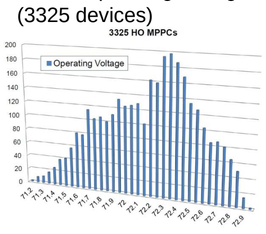
MPPC PDE vs. wavelength



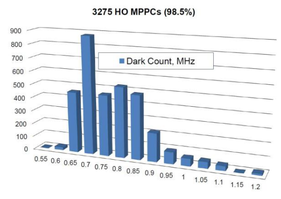
MPPC
Gain dependence vs temperature



MPPC Operating Voltage (3325 devices)

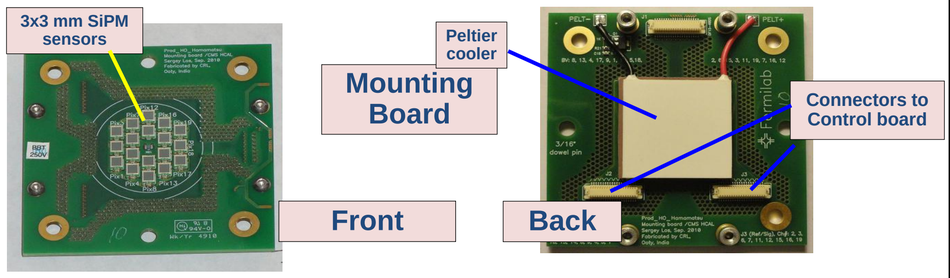


MPPC Dark Count (3375 devices)



System Design

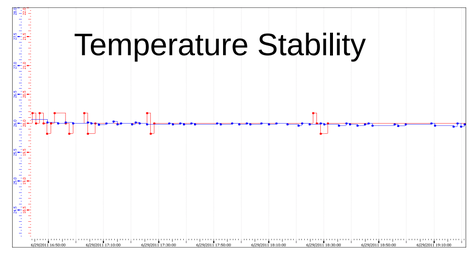
Design criteria were for a "drop-in" replacement of the HPDs with the SIPM system.
The system has
- Local temperature sensing and stabilization (Peltier and software feedback correction voltage)
- Hardware under-temperature protection
- Leakage current measurement
- Bias voltage generation (CW from LV volt supply)



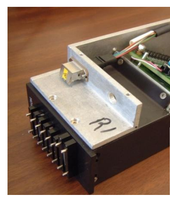
"Mounting Board" has 18 SIPM array (match HPD) and Peltier on back side

Control Board Parameter	Hamamatsu 3x3 mm
Maximum DAC set BV	100 V
BV resolution	25 mV
BV current limit (per diode)	100 uA
Maximum measurable leakage current	40 uA
Leakage current resolution	10 nA
Diode grounding resistor	4.99 kOhm
Temperature resolution	0.018 C

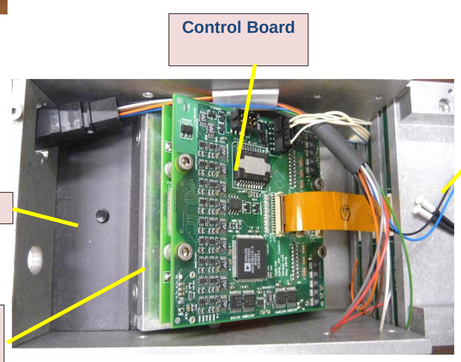
Control Board Major Design Parameters



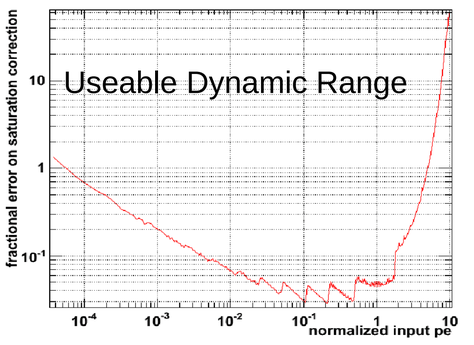
Temperature response to transient. Stable to least count (0.02 C)



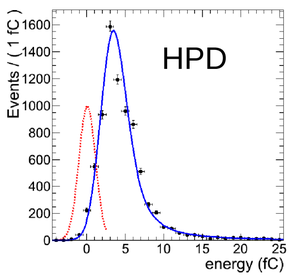
HCAL readout Module

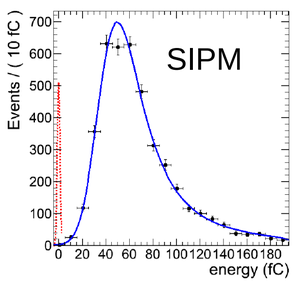


Simulated fractional error vs number pe's per micro-pixel. Includes ADC binning. Useable to ~5000 pe's

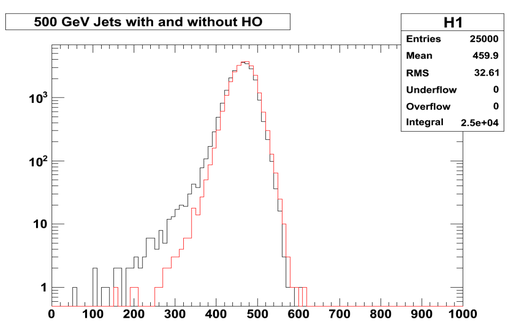


Performance





Minimum ionizing tracks in HO for HPDs, left, and SIPMs, right. Pedestals are shown in red. S/N for SIPM is > 20/1



Simulated Jet response for 500 GeV Jets. Curves are with/without HO energy added to Jet. HO makes important improvement to missing E_T

Status and Schedule

CMS made an initial installation during the spring of 2009, replacing ~10% of the HO HPD's. This initial trial has been successful.

All components of the HO SIPM replacement (2200 SIPMs, 160 SIPM Mounting Boards, 160 Control Boards) have been built and tested. An extended burn-in of the electronics is ongoing at CERN and will be complete by the end of 2012.

The full HO SIPM system will be installed during the LHC LS1 shutdown in 2013.