CMS Calorimeters

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CMS Calorimeters

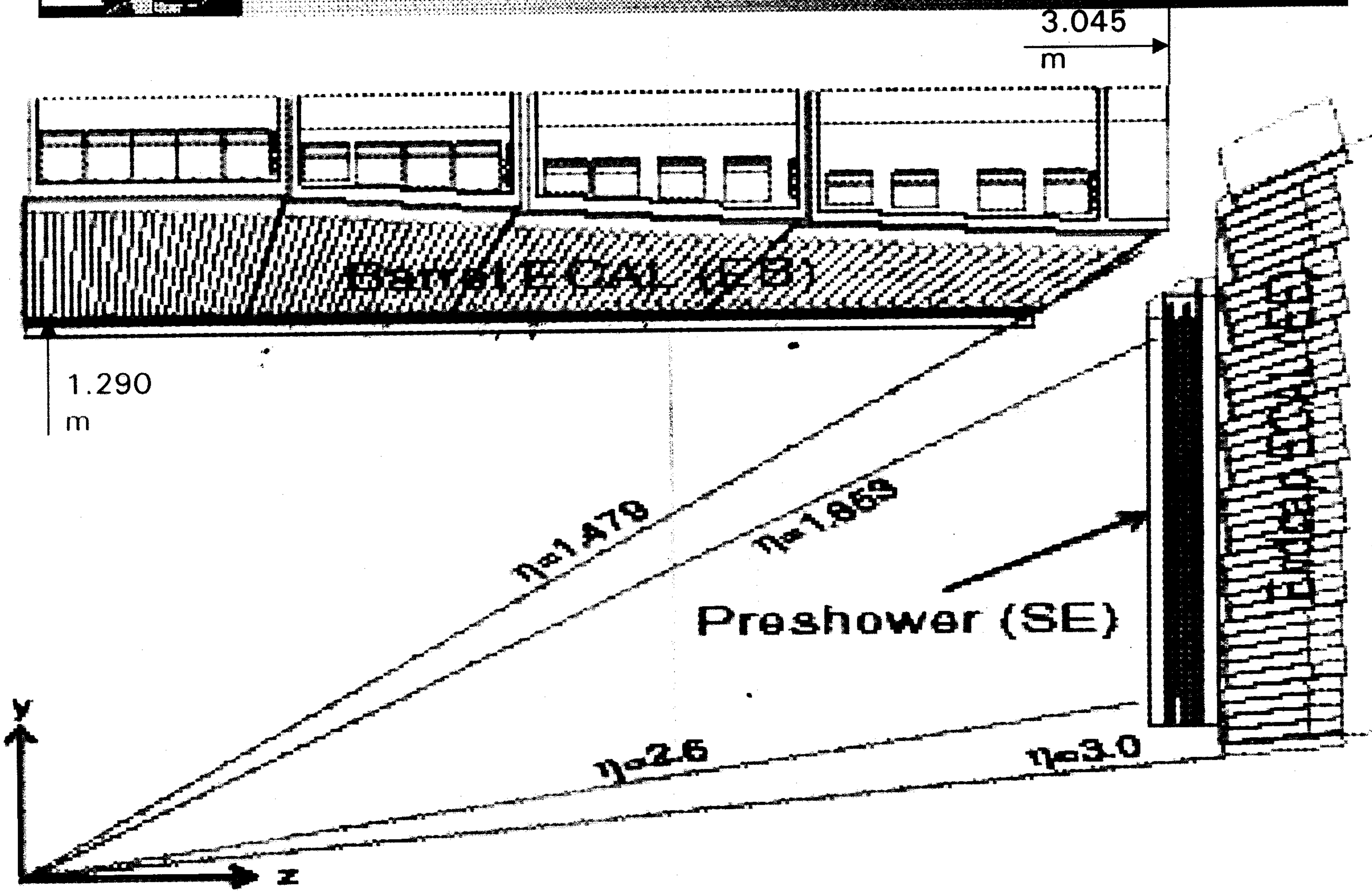
CMS has a Crystal calorimeter consisting of Lead Tungstate crystals to detect electrons and gammas.

The Crystal calorimeter is inserted into a Hadron calorimeter consisting of scintillator tiles with WLS readout fiber inserted into slots of Brass absorbers all located in the 4 Tesla field of CMS. The hadron calorimeter consists of Barrel (HB), Endcap (HE) and forward calorimeters (HF). In the barrel region an extra layer of scintillator is inserted into the muon absorber to form an Outer Calorimeter (HO). It detects late starting showers and also serves as a "tailcatcher" for regular hadronic showers.

CMS ECAL

- The CMS calorimeter for photon and electron detection consists of about 100,000 Lead Tungstate crystals. Each crystal is read out by 2 APD's.
- The Crystal Calorimeter has a goal of 0.5% stochastic term for its resolution. (for 10 GeV to 20 GeV)
- Radiation damage to the crystals and the APD's has been of major concern but apparently both problems have been solved recently.

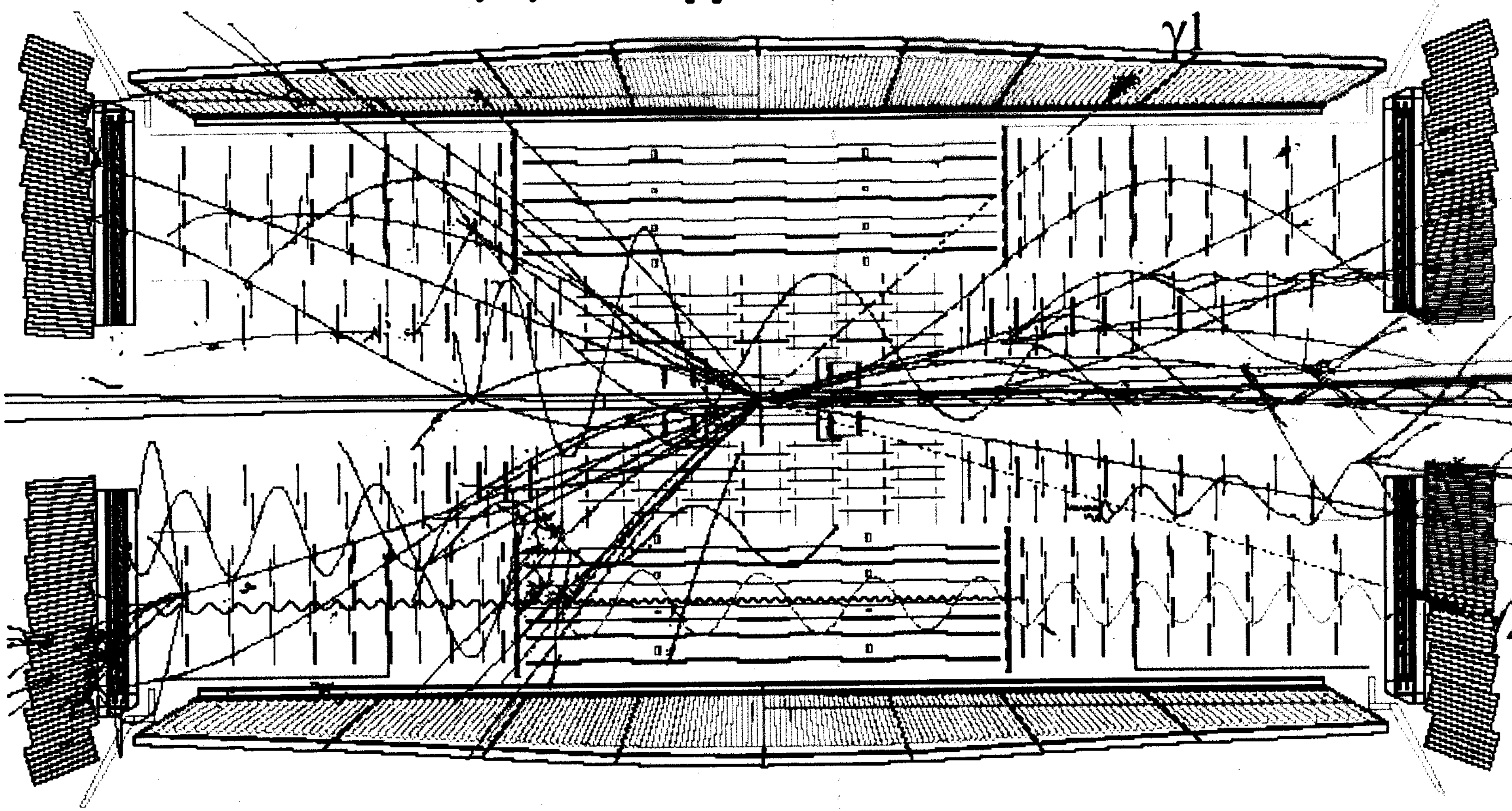
ECAL



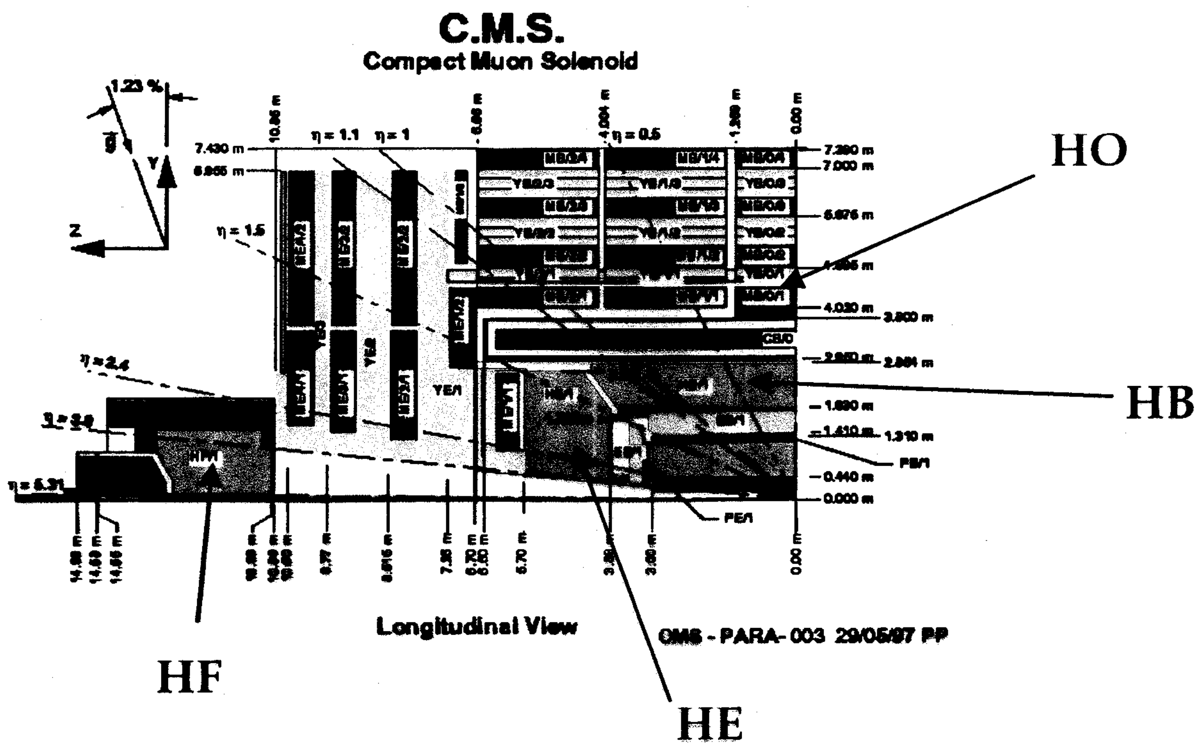
3.045 m
Barrel ECAL (EB)
1.290 m
η=1.479
η=1.653
Preshower (SE)
Endcap ECAL (EE)
η=2.6
η=3.0
y
z

Higgs event into two Photons

H -> $\gamma\gamma$, M_H = 100 GeV

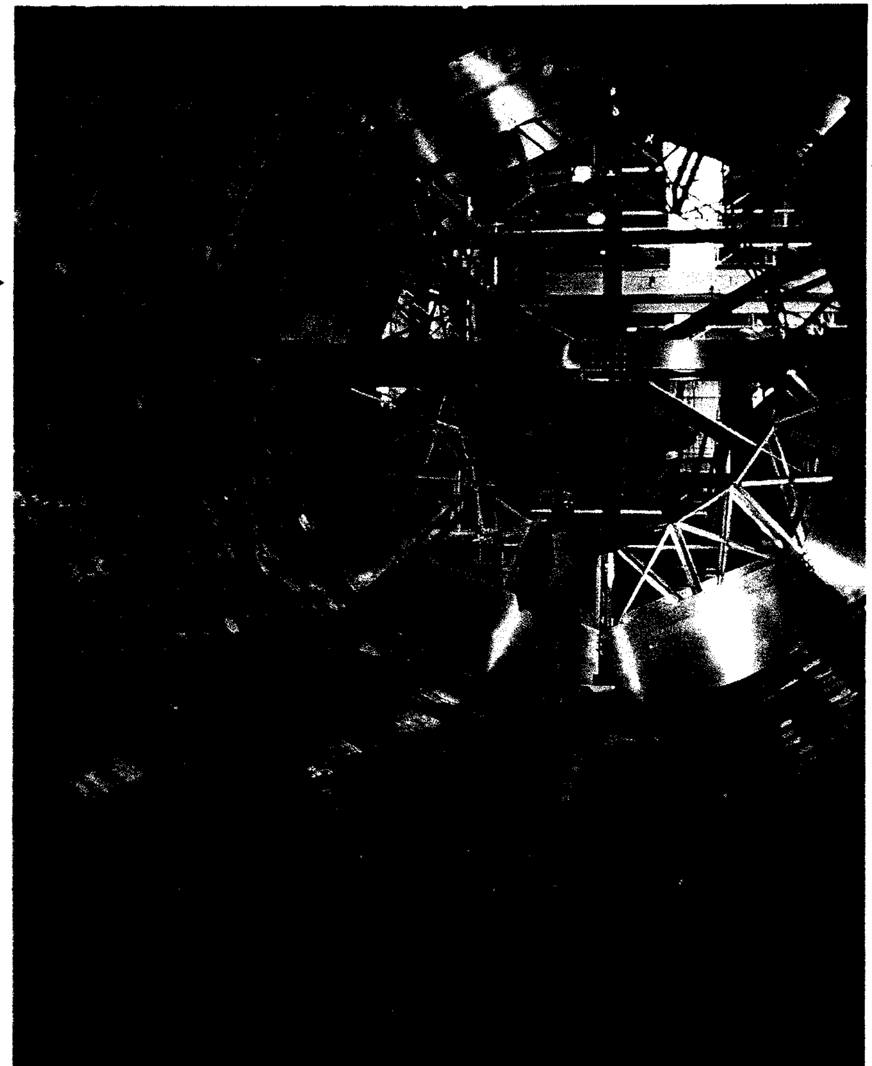


HCAL System Overview



Interior of cryostat

Rail support →



Interior of vacuum vessel for superconducting magnet.

The HBs rest on the rail.

Readout Boxes (RBX's)

US CMS is responsible for the Readout Boxes (RBX's) for all HCAL subsystems (HB,HO,HE,HF)

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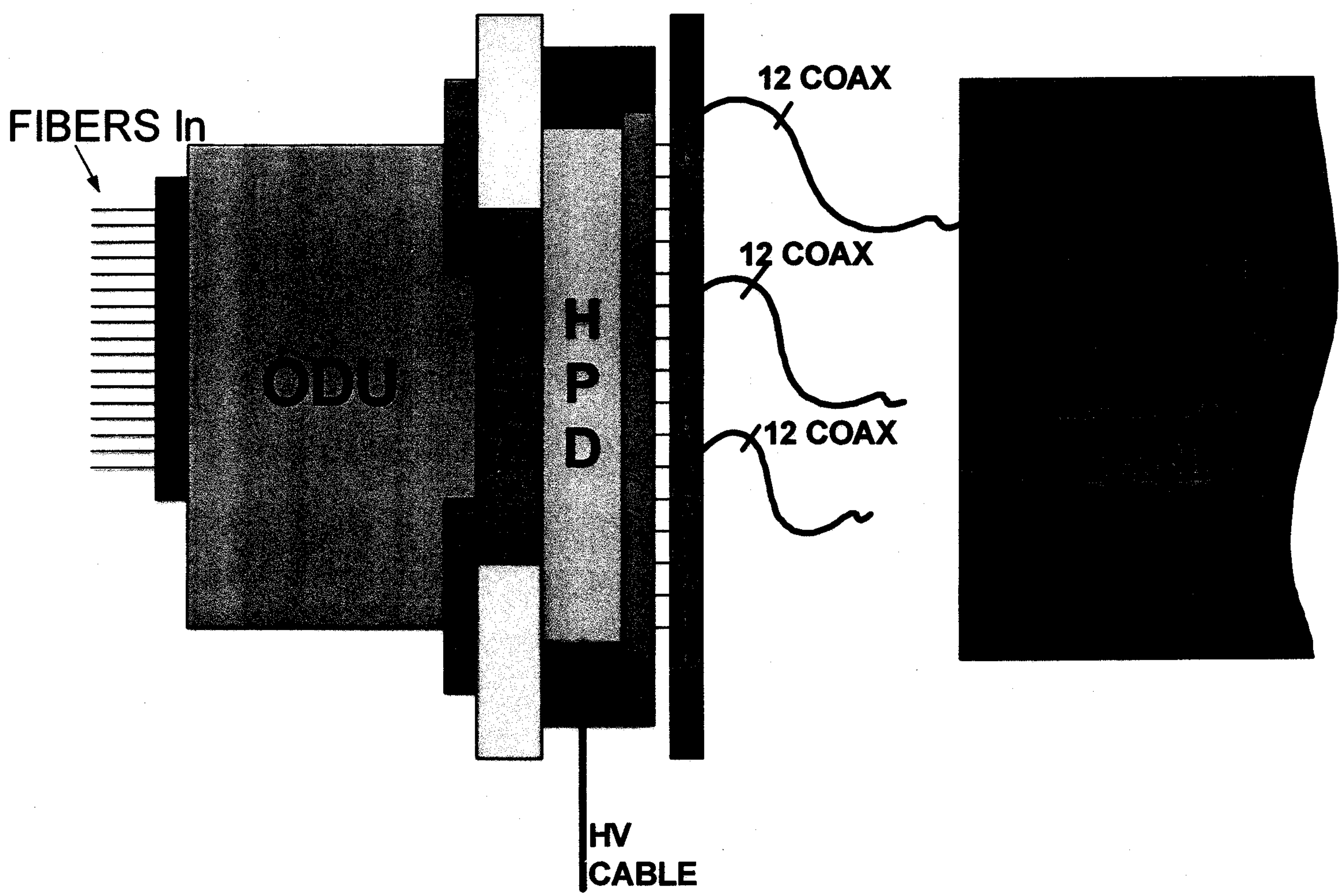
The light signals from the scintillator tile layers are summed optically in the Boxes to form Calorimeter towers.

A new design now exists for HB and HE RBX's that is modular and can co-exist with the services surrounding HE and HB. The box shell contains a backplane and a cooling circuit. HPD RM's (Readout Modules) containing a 19-channel or a 73-channel HPD and its corresponding ODU (Optical Decoder Unit) are plugged into the box. It also contains a Calibration Unit and a Clock & Control Module (CCM) as well as HV/LV plug-ins.

Readout Module Overview

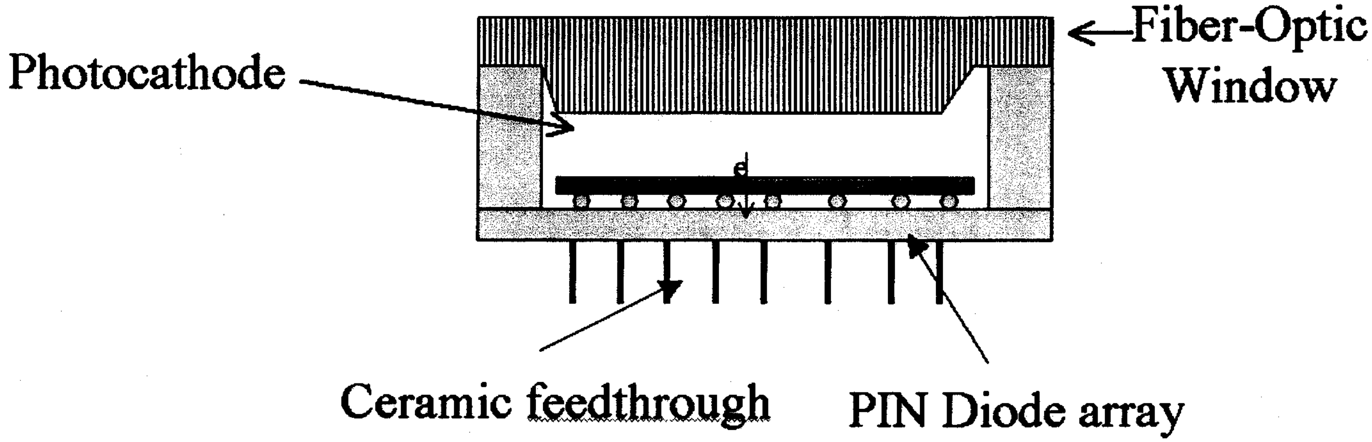


Photodetectors

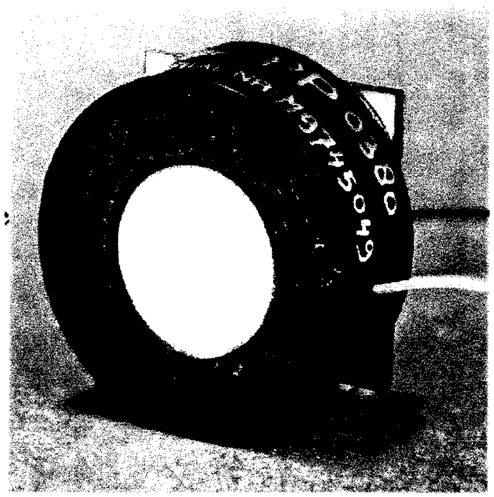
The photodetectors for the optical readout of HB, HE and HO are DEP Hybrid Photodetectors (HPD's) with either 19 or 73 pixel readout. They reside in the Readout Boxes, aligned with the 4T magnetic field. The H1 signals are directed to the 73 pixel HPD's, while the H2 signals are routed to the 19 pixel HPD's. Towers with multiple readouts may be processed by either tube type. We are studying the necessity of an independent H1 readout. Eliminating it could realize savings of about $1 million and add time contingency to the project.

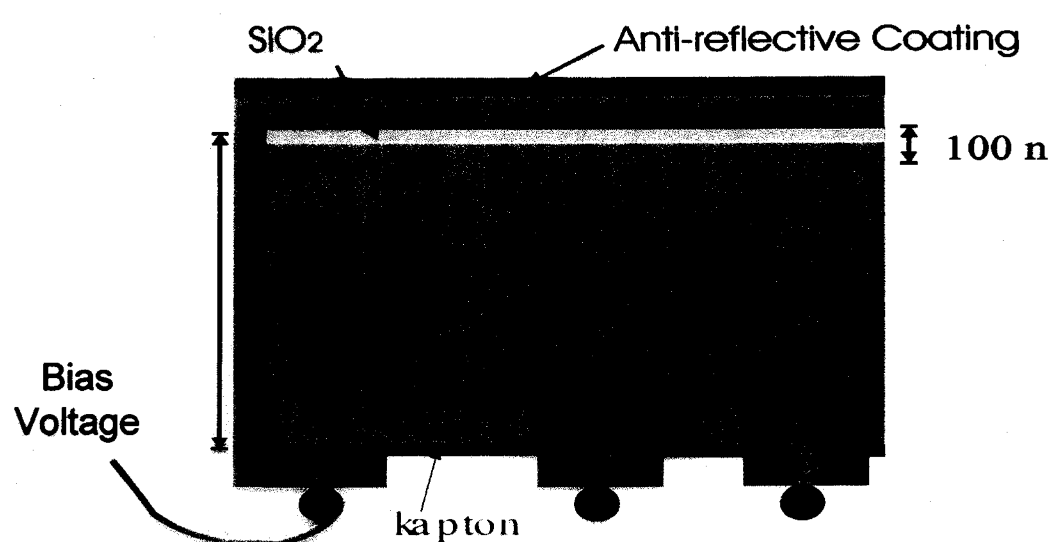
High Frequency cross-talk was observed in '99 as were a number of HV problems. These have been solved, one step taken being the aluminization of the diodes. This step contributed to optical cross talk (real photon back scattering) which had to be reduced by 1/4 wavelength coating. We have discovered no new problems and pre-production prototypes will be ready by Fall '01.

HPD



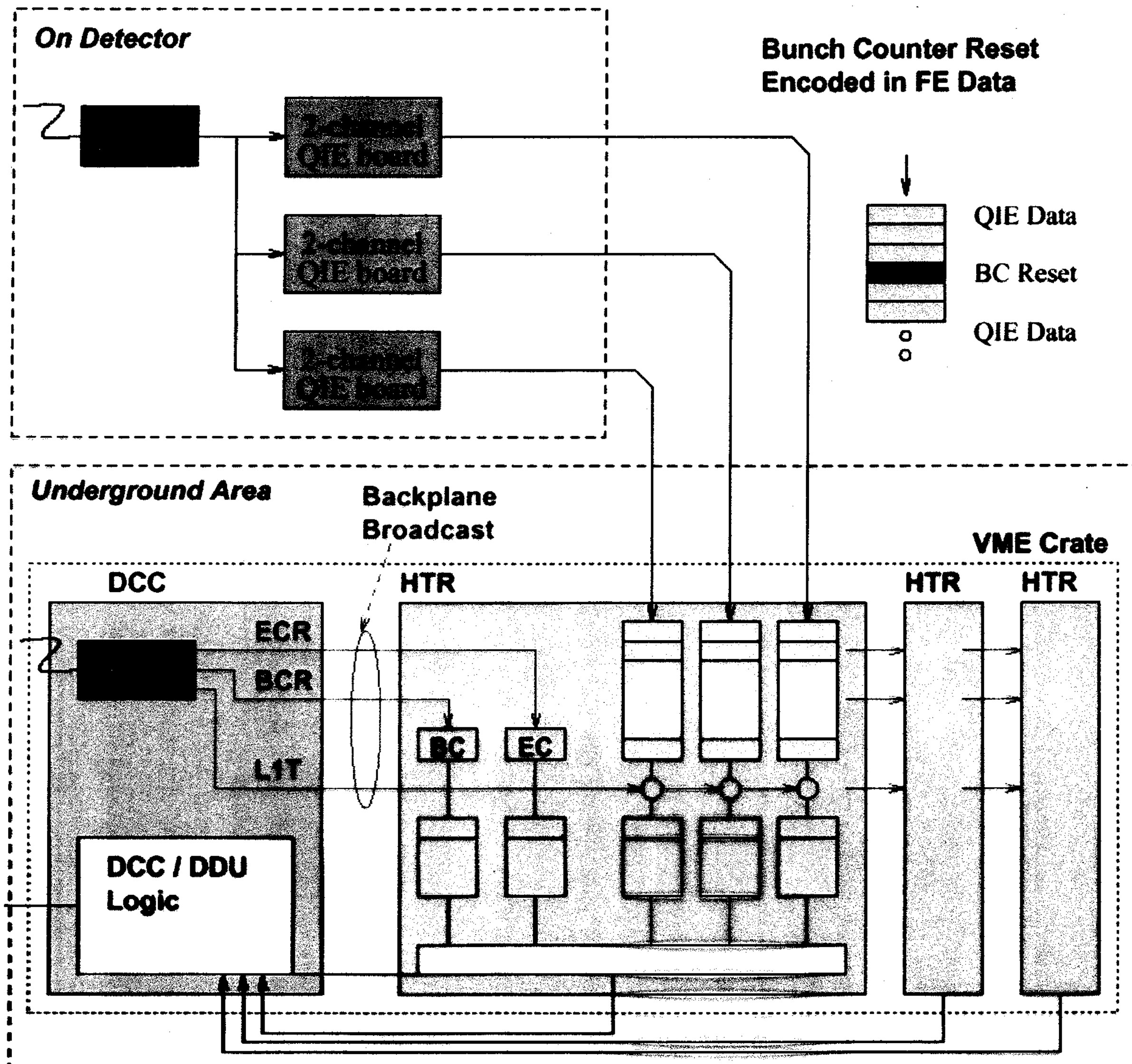
Photocathode
Fiber-Optic Window
d
Ceramic feedthrough
PIN Diode array





Diode Structure
SIO2
Anti-reflective Coating
100 n
Bias Voltage
kapton

HCAL Electronics Overview



Front End Electronics

The front end electronics design now consists of a modified KTeV QIE chip with an on-board flash ADC on the same ASIC followed by a Channel Control ASIC (CCA).

The digitized output signals are transmitted over optical links to the CMS Counting Room. Three (or two) ADC channels per link will be transmitted over the CMS rad-hard CERN solution to the counting house.

The ASIC project no longer defines our CRITICAL PATH. We expect to complete these ASICs by August of 2002.

Calibration System

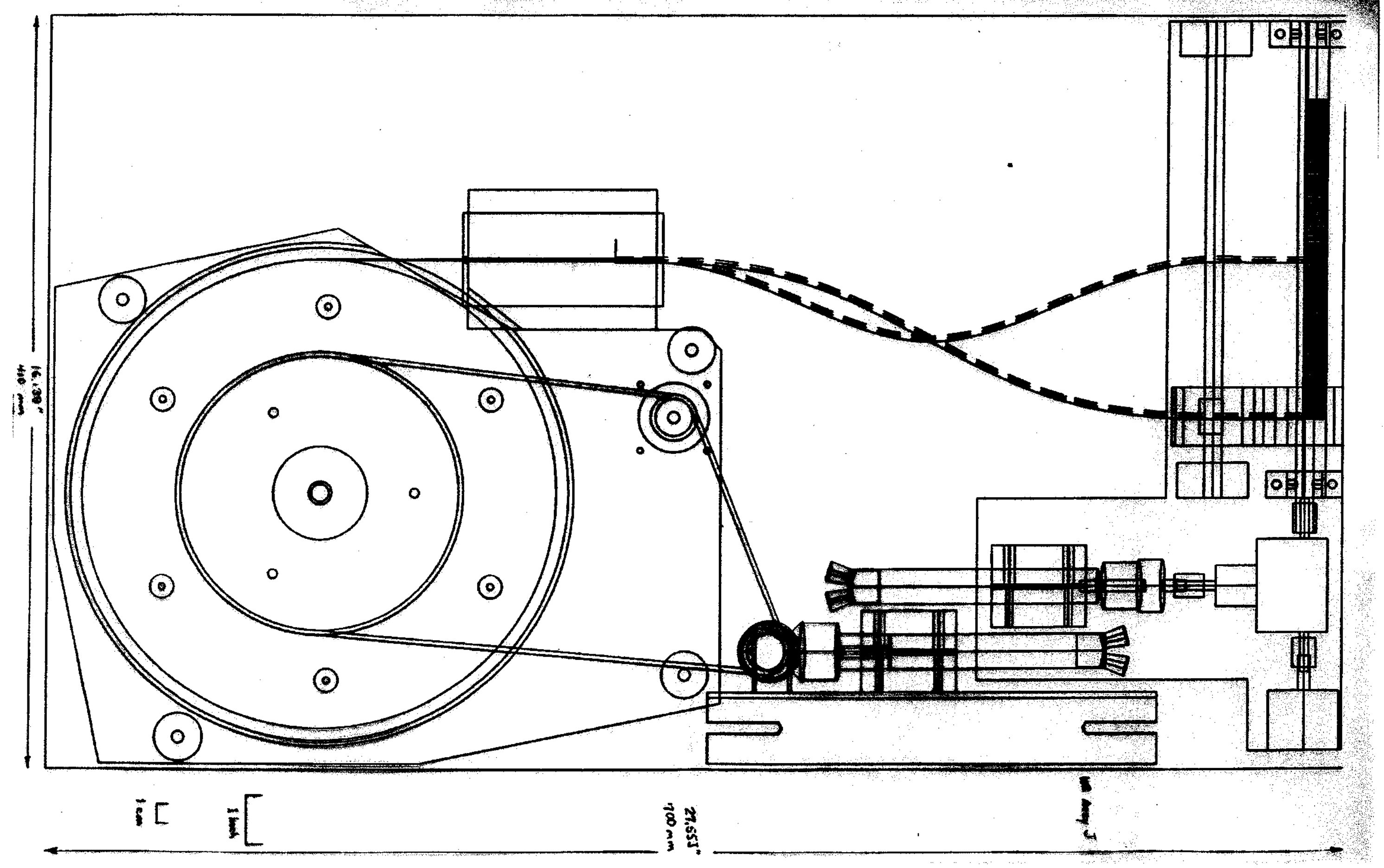
The Calibration system consists of:

- Radioactive source system (primary and absolute calibration of all megatiles)
- Laser system (stability monitoring and timing system for all megatiles)
- LED's (stand alone system)

QA/QC stations have also been manufactured to ensure megatile uniformity

All calibration systems could be finished by end of '01 for installation at CERN on time and on budget.

HCAL SOURCE CALIBRATION



Schematic layout of HB Air-Motor Source Driver

Envelope is 410 mm x 700 mm

Forward Calorimeter (HF)

The forward calorimeter (HF) is essential for Missing Energy determination as well as for tagging Higgs production

HF is also an optical device, but a Cherenkov light device, sitting in a very high radiation environment. The Cherenkov light is produced and transmitted via quartz fibers to photomulitpliers. The entire electronics and calibration chain for HF is similar/identical to that of HB.

B Field Effect

B Field perpendicular to the scintillator planes (Endcap configuration) increases the light yield of scintillator by approximately 5% to 6%

B Field parallel to scintillator (Barrel configuration) affects the electromagnetic shower development and hence the scintillator response to hadron shower development.

- The effect is due to the change in path length of low momentum electrons (between 1 MeV and 10 MeV) traversing the scintillator layer
- To set the scale, the radius of electron trajectory in a 3 Tesla field increases by 1mm for each 1MeV of energy
- This effect is strongly dependant on the distance of the scintillator package from the walls of the absorber -- the further the scintillator the smaller the effect (since the number of "high" energy electrons falls of very quickly)
- Scintillator will be mounted in gaps as far away from absorber as possible using thin brass springs (minimizing response dependence on energy)

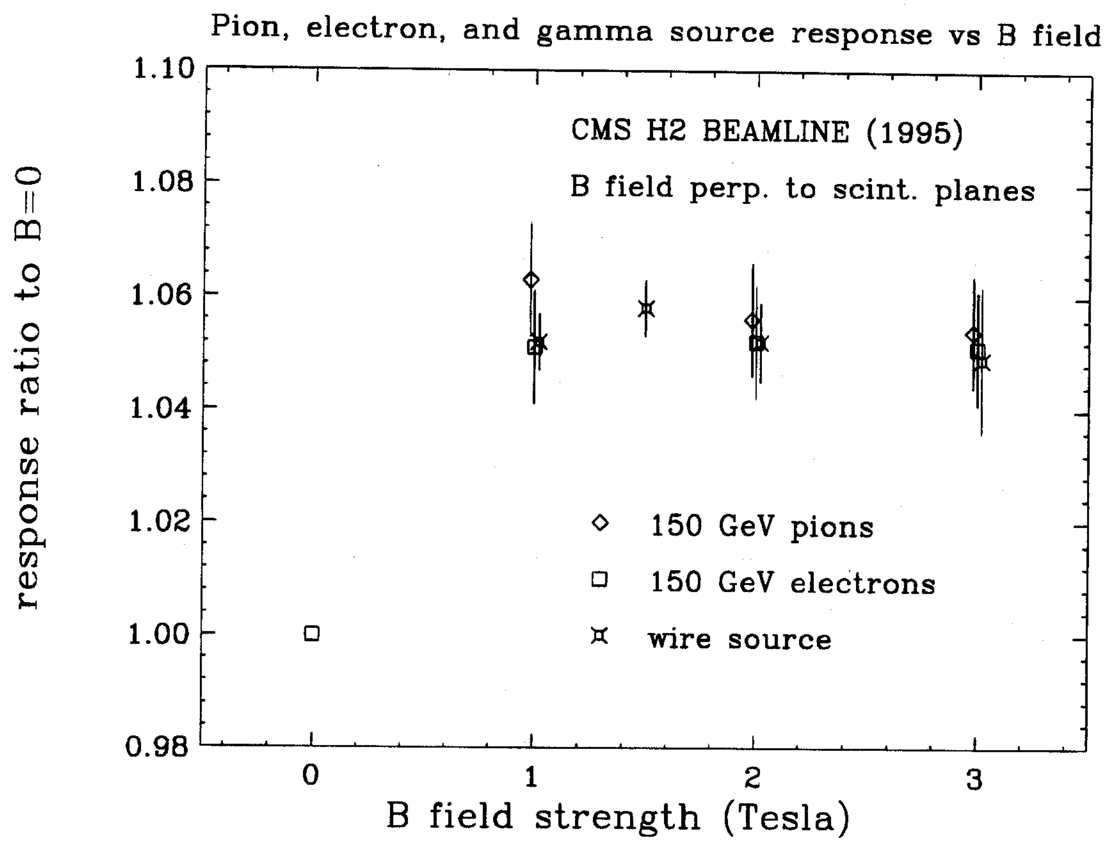


Fig. 4. Effect of a B field on the average energy response of the tile/fiber calorimeter to pions, electrons for H2(1995) data, and a calibration source. Here the B field lines are perpendicular to the scintillator plates (endcap configuration). In this configuration, the only effect is scintillator brightening with B field, which is the same for muons. hadrons. electrons and gamma rays from a radioactive source.