



Stability studies of the prototype Monitoring System for CMS-ECAL

①The CMS-ECAL②The Monitoring System③Results of Tests Beam

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CMS		The CMS	-ECAL		
ETA=1.473	TETA=1.766 EJA=2.5 5.7 deg			Tesla along Z a	xis
Parameter	Barrel	Endcaps	Lead Tungstate Crystals		
Coverage	η < 1.48	1.48< η <3.0			
R inner, outer [mm]	1238, 1750	316, 1711			
Z inner, outer [mm]	0, ±3045	±3170, ±3900	Density [g/cm3]	8.28	
			Radiation length [cm]	0.89	compactness
Crystals			Interaction length [cm]	22.4	1.14
Dimensions [mm]	21.8x21.8x230	29.6x29.6x210	Mohere radius [cm]	2.19	granularity
Depth [X ₀]	25.8	23	Intrinsic light yield [7/MeV]	80	gain (APD+VPT)
Off pointing	3 deg.	3 deg.	Temperature coeff. [%/C]	-2	cooling system
Numbers	(100	15(2)	Pofractive index [@ 450 nm]	22	light over action
	61200	15032	Kenacuve muex [@ 450 mm]	2.3	iight extraction
Weight [t]	61200 67.4	15632	Ken active index [@ 450 init]	2.0	nght extraction
Weight [t]	61200 67.4	15052 18.2	Light decay times [ns]	5(39%), 15(60%), 100(1%)
Weight [t] Modularity	61200 67.4 36 SuperModules	15032 18.2 4 Dees	Light decay times [ns] Radiation hardness [%]	2.3 5(39%), 15(60% 3), 100(1%) monitoring system

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• Goals :

•
$$\frac{\sigma(E)}{E} = \frac{3\%}{\sqrt{E}} \oplus 0.5\% \oplus \frac{200MeV}{E}$$

• H $\longrightarrow \gamma\gamma$ $m_{\rm H} < 150 \ {\rm GeV/c^2}$

- Two steps :
 - Pre-calibration
 - Calibration with physics events at LHC
- But ...
 - dLY(crystal)/dT, dM(apd)/dT, dM(apd)/dV
 - and ...





- From Pre-calibration to LHC :
 - Control ECAL stability for several months/years
- ECAL calibration at low luminosity will take long time (40 days)
 - PbWO₄ optical transmission depends on the irradiation dose

• Need to measure crystal transmission continuously to follow damage/recovery during LHC cycles







The Monitoring System (picture-1)





The Monitoring System (picture-2)





The Monitoring System (picture-3)







The Monitoring System (picture-4)





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- Light injection on each crystal by group of 850 (1/2 SM)
 - Laser (3 λ) : Equivalent Energy from 0 to 1.3 TeV (2% steps)
 - 3 levels of light distribution :
 - → Optical switch (1/2 SM selection, 3 to 88) 1/2 SM or 1/4 Dee –
 - → Level-2 fan-out (module distribution, 1 to 5)
 - → Level-1 fan-out (crystal distribution, 1 to 200)

Laser light monitoring

- Monitoring at the laser level
- Monitoring at level-2 fan-out
- Monitoring at level-1 fan-out
 - → Dedicated electronic line
- ♦ Full calorimeter measurement every ~ 1 hour
 - Use of LHC gaps (3 μs every 89 $\mu s)$
 - 20 mn measurement per wave length

Real time processing





- ♦ Goals
 - Validate calibration procedure (May-June, this report)
 - → From pre-calibration to calibration
 - → Monitoring procedure for irradiation/recovery control
 - Validate technical choices on crystals, electronics, etc... (July-August)
- Description of 2000 test beam
 - 30 crystals (3 alveolae) with final sub-module mechanics
 - Monitoring system with final set-up
 - Only green laser installed
 - Electronic test-pulse available on APD electronic line
- Same matrix followed during 2 months
 - Calibration / Irradiation sequences
 - Long term stability without beam
 - Power cut-off



Monitoring of irradiation process







Transportation of calibration coefficients



50 120 GeV/c ♦ Residual calibration coefficients after O 😑 channel 11 channel 12 0. May/June 00 testbeam compensation O 🔮 channel 13 intercalibration coeff 80'1 Stability of the 30 channel response compensated and transported during a 55 days period of runs through: · an Irradiation of crystals (channel 13 and 24) a 28 days period of monitoring · a 4 hours power cut off May/June 00 testbeam events 40 ID 100 120 GeV Entries 424 shift to nominal Mean 1.000 < 0.4% with 70% efficiency RMS 0.3875E-02 IRRADIATION channel 13 and 24 **READIATION** channel 13 and 24 < 0.5% with 83% efficiency < 0.6% with 90% efficiency channel 13 and 30 all sets of Calibration < 0.7% with 93% efficiency and all the channels 1.06 20 superimposed 10 **HADIATION** 1 11 1 0.98 0.985 0.99 0.995 1.005 1.01 1.015 1.02 1 intercalibrated response 1.04 30 52 events ID 101 50 GeV Entries 299 shift to nominal 1.000 Mean < 0.4% with 70% efficiency RMS 0.4334E-02 20 < 0.5% with 78% efficiency monitoring period 1.02 < 0.6% with 83% efficiency all sets of Calibration (28 days) < 0.7% with 86% efficiency 15 and all the channels superimposed 10 5 50 20 30 40 60 time (days) 0 1.01 1.015 1.02 0.98 0.985 0.99 0.995 1 1.005 power cut off intercalibrated response (4 hours)

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- Understanding of calibration procedure is going on
 - Able to keep inter-calibration coefficients in 0.4 % (σ) over two months
 - Can recover calibration coefficients after power cuts
- Next steps
 - Study replacement of electronic test pulse by infra-red laser (~800 nm)
 - 400 crystal module to be tested in 07/2001
 - → Pre-calibration debugging
 - First Super-Module 04/2002
 - → Finalization of pre-calibration method
 - Start of pre-calibration mid 2002
 - \rightarrow 1 SM/week