## **D The CMS ECAL Very Front End Electronics: Production and Tests**



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C. Biino<sup>4</sup>, C. Combaret<sup>3</sup>, M. Dejardin<sup>2</sup>, L. Djambazov<sup>1</sup>, M. Dröge<sup>1</sup>, M. Hansen<sup>2</sup>, W. Lustermann<sup>1</sup>, E. Menichetti<sup>4</sup>, <u>A. Nardulli<sup>1</sup></u>, J. Nash<sup>2</sup>, M. Nervo<sup>4</sup>, M. Obertino<sup>4</sup>, N. Pastrone<sup>4</sup>

1. Eidgenoessische Technische Hochschule, ETH Zurich, Switzerland

- 2. European Organization for Nuclear Research, CERN, Switzerland
- 3. IPN, IN2P3/CNRS and Université Claude Bernard, Lyon, France
  - 4. Instituto Nazionale di Fisica Nucleare, INFN Torino, Italy
- **1.** Overview of the ECAL electronics
- 2. Very Front End card (VFE)
- **3.** The VFE production schedule
- 4. Test program of the VFE
- 5. **Power On test, Burn In and the Calibration test**
- 6. First Super Module: results of the pre production
- 7. Conclusions



## **ECAL: system overview**



#### **ECAL BARREL**

36 Super-modules for EB
61200 crystals with APD's
1700 crystals per Supermodule
340 VFE per SM
12240 VFE in total
68 Trigger Towers

#### ECAL ENDCAP

4 Dee's for EE 14648 crystals with VPT's 734 VFE per Dee 2936 VFE in total 3662 crystals per Dee 156 Supercrystals per Dee



#### A. Nardulli, ETH Zurich





## **Very Front End Electronics**



#### Five read out channels per VFE

#### Multi Gain Pre Amplifier (MGPA) has:

Gain ranges of 1, 6 and 12. Full scale signal 60 pC LVDS output signal to match ADC Linearity +/- 0.1 %



#### Quad Channel ADC (AD41240) has:

12 bit, 40 MS/s Digital logic selects the highest unsaturated gain

#### The LVDS\_RX Buffer:

adapts the LVDS output of the AD41240 to the single ended inputs of the FE board

## All chips designed in 0.25 micron CMOS technology and radiation hard.

Chip	N chips per VFE	+2.5 V analog Current (mA).	+2.5 V digital Current (mA).	Sum 5 Channels (A)
MGPA	5	240		1.20
AD41240	5	104	90	0.97
Buffer	5		24	0.12





## **The Very Front End card**



VFE also contains a DCU (Detector Control Unit) chip for the measurement of the APD leakage currents and the crystal temperature





The guard ring keeps the housing at the GND potential



## The Test program



#### The production test program is the following:

- 1. Automatic Optical Inspection (AOI) of the card done by the manufacturer.
- 2. Power-On test, including limited functional testing by the manufacturer; the required test setup is provided by the ECAL collaboration (ETHZ)
- 3. Burn-in test for three days at IN2P3 Lyon.
- 4. Calibration of the characteristics of each gain of each individual channel by measuring the gain, the pedestal, the noise and the linearity. Calibration of the leakage currents and temperature measurements.
- The production of the VFE cards started in summer 2004 with a pre-series of 420 pieces. This is followed by the production of 12000 pieces, about 2000 pieces/ month, for the ECAL Barrel.



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РОТВ

#### A. Nardulli, ETH Zurich

 $R_s = 0.033 \Omega$ 

5 times: R\_I\_leak 1 times: R T sens





## **1. Power On test**



	2.5V analog	2.5V digital	2.5V buffer	total
Average current in A	1.724	0.439	0.121	2.285
Standard deviation in A	0.007	0.007	0.005	0.007

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## 2. Burn In Test





C. Combaret IN2P3Lyon

10 lines of 15 VFE boards on the front and on the back

- A burn in period of 3 days is proposed, at an elevated ambient temperature of 60°C +/- 1°C:
- Burn-in will start with 50 cards from the pre-serie in order to accumulate statistics and confirm whether the burn-in period is appropriate.
- T is measured in several points of the rack.
- VFEs are powered with 2.5 V and the clock is provided
- Current is monitored through shunt resistor.

Temperature regulation: heating and cooling

Control and PC interface via RS232

Power Supply 3x 2.5V/200A



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## **3. Calibration Test**



Steps of the test are:

- Varying a charge pulse injection over the full dynamic range and get the response in ADC counts (5x 14 bit).
- Testing the temperature read out channel of the crystal.
- Simulating the leakage current of the APDs.
- Verifying the communication with the chips via the I2C bus.
- Measure the pedestal and noise in three different gains.

For the pre-production the set up was not fully operational so the first 420 cards were only functional tested.



## Temperature and leakage current results



Temperature read out channel of the crystal: a digital potentiometer changes its value to simulate a temperature variation on the crystals.

Leakage current of APD: the test board generates a current, through a DAC and a V to I converter to simulate a variation of the leakage current of the photo-detectors for the 5 channels of the VFE.

The Detector Control Unit (DCU) chip on the VFE reads the data of temperature and leakage current and sends them to the data acquisition system.









### Linearity









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## **Results from the pre-production**





The test injects 30 samples of charge per each gain per each channel in the VFE. The charge varies between 0 and full-scale in gain 1

#### On 420 VFE delivered:

- 3 failed power on test
- 35 failed the functional test:
- > 12 failed in CH. X GAIN Y
- ➢ 4 failed in ALL CH.
- 15 failed the temperature measurement
- 4 were damaged on connectors during test and installation
- → The functional test will be included in the Power On test



- 1. The production of 16000 cards is started with the fabrication of 420 cards of the pre-series in August
- 2. The test set up has been successfully developed and built:
  - Power On test already powerful and it has still to be integrated with a functional test, in order to identify the majority of the failures directly at the manufacturer.
  - A pre-series of 50 VFE cards will burn in first half of October.
  - Calibration test has to be finalized, it has been improved a lot in the last 2 months.
- 3. 7% of cards failed the tests ... NEXT STEP IS TO INVESTIGATE ON THE FAILURES !
- 4. Performance of the cards in a Super-module very good with noise in the highest gain around 1.2 ADC counts and stable pedestal.



## Personal notes



Each of them has the noise measured for 27 trigger towers. The parameters from the gaussian fit are G1 mean= 0.5332 + -0.0014 sigma=0.0338 + -0.0014 G6 mean=0.7248 + -0.0014 sigma=0.0366 + -0.0014 G12 mean=1.091 + -0.002 sigma=0.048 + -0.002

The sigma of the 3 distributions is: 0.36+/-0.04 ADCcounts for Gain 12

0.30+/-0.05 ADCcounts for Gain 6 0.25+/-0.03 ADCcounts for Gain 1

# **Test Beam preliminary results**

A full Trigger Tower (25 channels) with 5 VFE,1 FE board and 1 LVR board was tested with beam at PSI with 10^9 p/cm^2/s for 2 hours:

- Data after irradiation OK
- Power consumption didn't change (consistent for this technology)
- Baseline moves from 200 to 600 ADC counts after 2h irradiation, normal for this high radiation dose, and anyway it can be adjusted via a DAC in the MGPA chips

More information on the VFE behavior under irradiation we will have after the test beam of 1700 channels (a complete Super Module) in October.