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Final calibration results of CMS electromagnetic calorimeter photodetectors

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Abstract

The Compact Muon Solenoid is one of two generic detectors currently being constructed for the Large Hadron Collider at CERN foreseen to begin data taking in 2007. The electromagnetic calorimeter consists of a barrel and endcaps. These are made of $PbWO_4$ scintillating crystals. In the barrel, the scintillation signal is read out by Hamamatsu avalanche photodiodes, connected in parallel in a structure called a "capsule". Each of the 61,200 channels must be equipped with a capsule, the reliability of which must be assured since they will be inaccessible during the life of the experiment. The capsule production is now finished. We present the final calibration and performance statistics.

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Keywords: LHC; Electromagnetic calorimeter; Calibration; Avalanche photodiodes

1. Introduction

The definitive production run of Hamamatsu Photonics avalanche photodiodes (APD) for the CMS ECAL, numbering more than 140,000 and having a capacitance of between 75 and 80 pF, began in 2001 and ended in 2004.

A quality assurance/control facility has been established at CERN (in bat. 27) by collaborators from the University of Minnesota, Northeastern University and PSI in order to verify Hamamatsu measurements on the APDs and in particular the bias voltage at gain 50.

2. Capsule creation

The Hamamatsu production of APDs meeting the CMS technical specifications are grouped into a number of pairs corresponding to that required for an ECAL high-voltage module (50 capsules). These are sent to IPN Lyon, where the pairs are mounted into "capsules", each of which will ultimately be glued onto a $PbWO_4$ crystal.

A capsule consists of the pair of APD's, a molded receptacle, foam, a length of kapton with connector, and, on one of every ten, a radiation-hard temperature sensor (thermistor 100k3960dp3 from BetaTHERM). The temperature sensors are calibrated by Laboratoire Leprince-Ringuet (Fig. 1). There are twenty-two different types of capsules, corresponding to the thirteen possible lengths of kapton (dictated by the capsule's position in η in the calorimeter) convoluted with the presence or not of a temperature sensor on capsules associated with nine of the lengths (Fig. 2).

The capsules are calibrated on an automatic test bench (Fig. 3) [1].

The bench measures gain curve in DC mode: gain vs. bias voltage; it obtains low-frequency noise measurements at different gains (50, 70 and 150) as well as high-frequency noise measurement and it records a pulse response (capsule + charge preamplifier), giving then rise time and fall time values.

The production goal was to obtain at least 100 good capsules per day (i.e. 200 APDs per day). It has been fulfilled. The 100% validation and characterization of the capsules at this point is of extreme importance,

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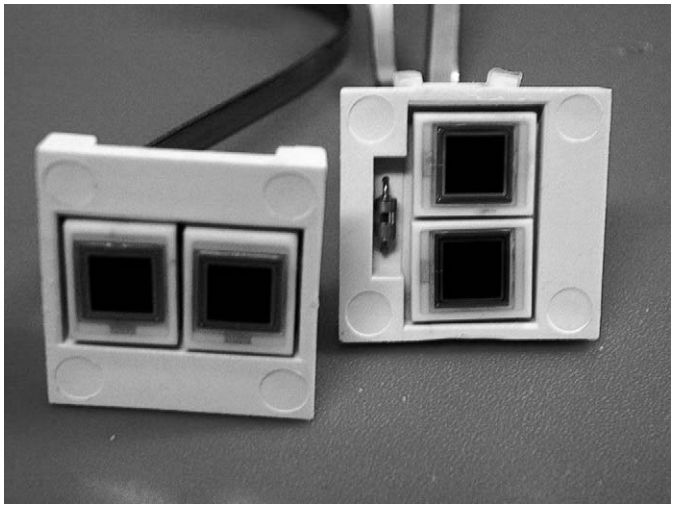

Fig. 1. Closeup of capsules from the APD side. Right one with temperature sensor.

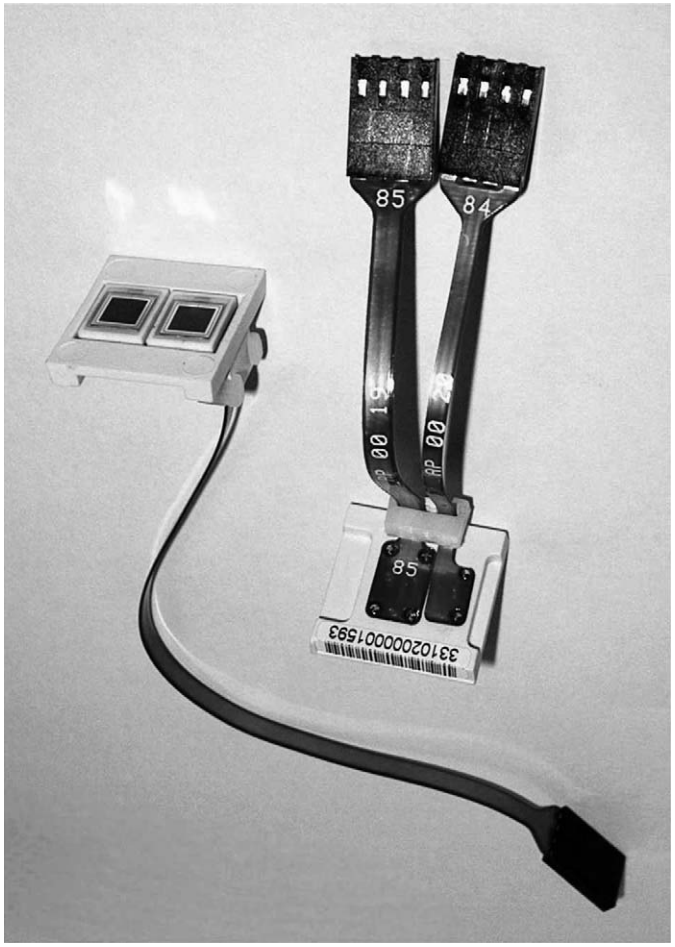

Fig. 2. Two types of capsules, one with temperature sensor (second kapton needed) and the other without.

since accessing them becomes difficult once they are glued to crystals, and impossible after supermodule installation.

Fig. 3. The CMS ECAL photodetection capsule test bench.

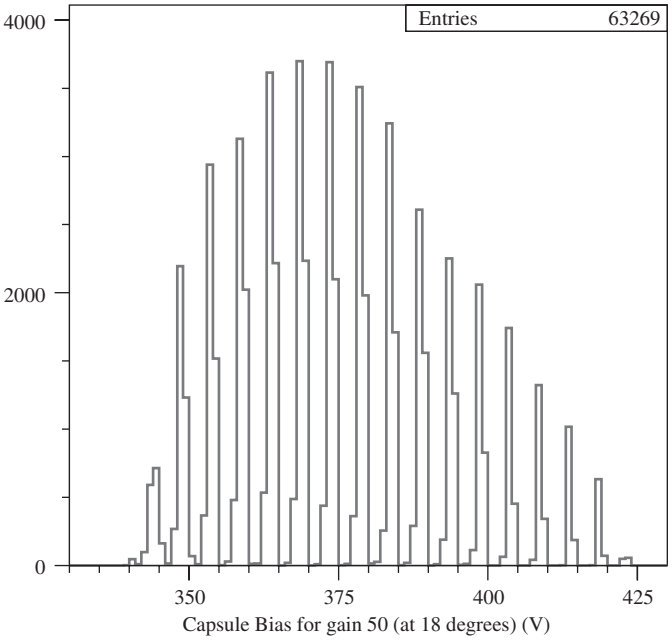

Fig. 4. Distribution of the bias voltage for gain 50.

3. Rejection criteria

The measured and calculated quantities are transferred automatically and in real time to the CRISTAL [2] database, with which one can obtain an acceptance/rejection decision for the capsule, based on the following criteria:

First, temperature measurements must lie within a predetermined interval ($18 \pm 1\,^{\circ}\mathrm{C}$).

- The values of V_{bias} (at gain 50) for a lot of capsules must lie within a predetermined interval of 5 V.
- The value I_{dark} (at gain 50) must lie below a predefined maximum value