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The intercalibration of the CMS electromagnetic calorimeter at the test beam

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Abstract

During summer 2006, 9 supermodules of the CMS electromagnetic calorimeter (ECAL) have been exposed to an electron beam at the CERN SPS north area facility. Each supermodule contains 1700 crystals. The intercalibration coefficients of the different channels have been measured for each supermodule. The reproducibility of the intercalibration has been tested by measuring a supermodule twice. The intercalibration coefficients obtained in the electron beam have also been compared with those obtained with cosmic ray muons.

Introduction

The CMS (Compact Muon Solenoid) [CERN/LHCC 94-38] is one of the two multi-purpose experiments that will take data at the LHC proton-proton collider. It consists of a silicon central tracking device surrounded by the electromagnetic and hadron calorimetry (all immersed in a 4 T magnetic field) and by a muon detector in the return yoke. The electromagnetic calorimeter (ECAL) [CERN/LHCC 97-33] consists of 75,568 $PbWO_4$ scintillating crystals covering the pseudo-rapidity (η) range from -3.0 to 3.0 by means of a barrel part ($0 < |\eta| < 1.48$) and two endcaps ($1.48 < |\eta| < 3$). The ECAL is composed by 36 supermodules (each containing 1700 crystals arranged in four modules) in the barrel and in 4 dees (each consisting of 3662 crystals) in the end-caps. Crystals in the barrel are read out by Avalanche PhotoDiodes (APD), while in the endcaps the scintillating light is detected by Vacuum Photo Triodes (VPT). Each channel shows a response different from the others, mostly because of the spread in the crystal light yield ($\simeq$13%) in the barrel and because of the spread of the VPT gain ($\simeq$25%) in the endcaps.

To fully exploit its physics reach, in particular in the benchmark channel H$\rightarrow \gamma\gamma$, the intercalibration of ECAL must be controlled at the level of 0.5% at high energies. To make the ECAL effective from the beginning of the data taking, precalibration is important. For this purpose, various procedures have been envisaged, among which the exposure of ECAL supermodules to electron beams of different energies.

1 Test Beam Electrons pre-calibration

The test took place at CERN during summer 2006 in a beam of electrons of well defined energy (dp/p $<$ 0.1%).

Each crystal received the electron beam in a geometrical configuration mimicking the CMS geometry so that the electrons were incident from the direction, with respect to the crystals, of the nominal interaction point in the CMS detector. The beam was set to the energies of 120 GeV and 90 GeV, allowing the study of systematic effects due to the energy on the pre-calibration. The data taking procedure aimed at recording at least 3,000 events with the beam impinging on each crystal. The impact position of the particles on the crystals was measured by a set of scintillating fibers arrays placed upstream along the beam. The data taking was performed and controlled by means of the final tools designed for CMS, as well as the processing of the data and the reconstruction of the particles' energy [Eur. Phys. J. C 46, s1.23-s1.35 (2006)].

The intercalibration technique applied is based on the energy deposited in a crystal. The pre-calibration is calculated by equalizing the maximal response of each crystal to a reference value. The statistical accuracy has been studied on independent sub-samples as the sigma of the difference distribution between two sets of coefficients, calculated with different datasets (figure 1), while the reproducibility of the technique was tested by repeating the calibration procedure at one month interval on the same supermodule (figure 2).
The intercalibration coefficients obtained have been used as a reference for other pre-calibration techniques, namely the intercalibration with cosmic rays [A. Ghezzi, HCP2007 contribution] and the one obtained by using measures of the crystals optical properties.

Conclusions

Nine supermodules of the CMS ECAL barrel have been successfully intercalibrated on the test beam in summer 2006, measuring the intercalibration coefficients with a precision and reproducibility better than 0.3 %.

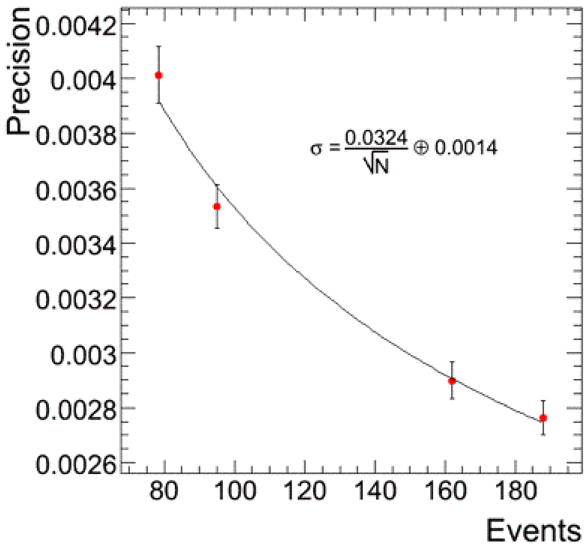

Figure 1: statistical precision of the intercalibration, calculated using independent sub-samples of the total dataset, with the number of events surviving the selections.

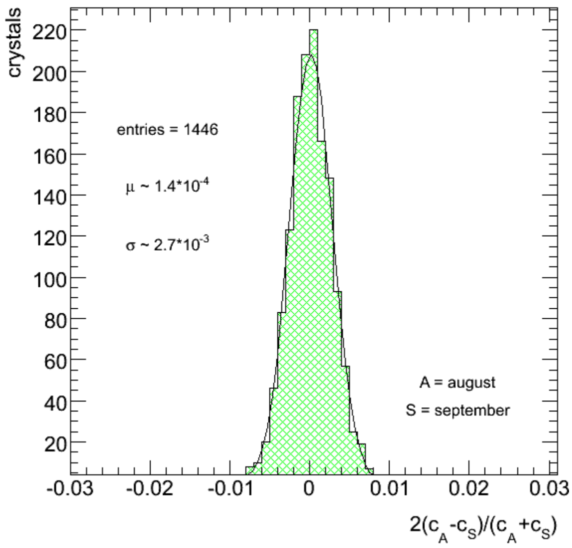

Figure 2: reproducibility of the intercalibration, calculating by measuring twice at one month interval.