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The Compact Muon Solenoid Experiment

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CMS Tracker Commissioning using cosmic muon data

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Abstract

Many physics channels, and in particular events containing top quarks, produce b jets in the final state which need to be distinguished from more copious backgrounds containing only light flavored jets. Tagging of b-jets, mainly relies upon relatively distinct properties of b-hadrons such as large proper lifetime, large mass, decays to final states with high charged track multiplicities. Precise spatial reconstruction close to the interaction point and efficient track reconstruction are key ingredients for all b-tagging algorithms. These rely on stable, low noise, low occupancy and highly efficient tracking detectors. This is a short review of the results of the studies on the CMS tracker performances carried out with cosmics at the CERN Tracker Integration Facility from march to july 2007, in order to show how this performance is in line with the requirement of the CMS community for a good b-tagging.

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1 Introduction

In past experiments b-tagging played an important role in the measurement of the branching ratio for the decay $Z \to b\bar{b}$ [1], as well as in the discovery of the top quark through $t \to bW$ decay at TeVatron [2]. The algorithms generally used for b-tagging rely on large beauty hadron lifetimes ($c\tau$ 450 μm), which provide some information for b-jet identification. Lifetime information can be extracted using different methods, based primarily on the track impact parameters and on the capability of the detector to identify individual secondary vertices, which are the clearest evidence of a long-lived hadron decay. These methods need a powerful microvertex detector as well as large vertex and track reconstruction efficiencies and good experimental resolution on the track parameters.

The tracking system of the CMS experiment at the Large Hadron Collider (LHC) is designed to provide a precise and efficient measurement of the trajectories of charged particles emerging from LHC collisions as well as a precise reconstruction of secondary vertices.

The CMS Silicon Strip Tracker (SST) [3, 4] has a high granularity, with more than 10 million channels organized into 15,148 detector modules. With about 200 m^2 of active silicon area the SST is the largest silicon strip tracker ever built for a high energy physics experiment. It surrounds the LHC beam interaction point and has a length of 5.8m and a diameter of 2.5m.

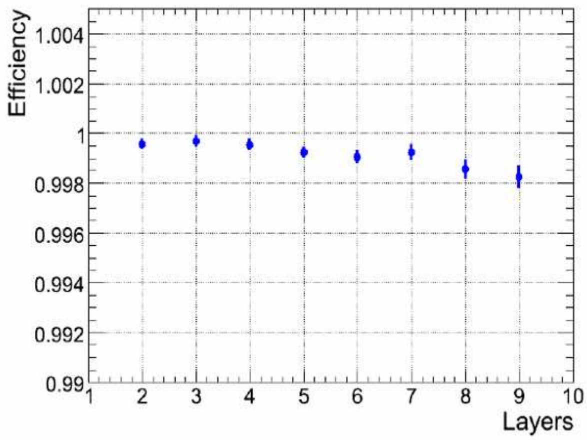

Figure 1: Hit reconstruction efficiency in eight of the ten layers of the barrel

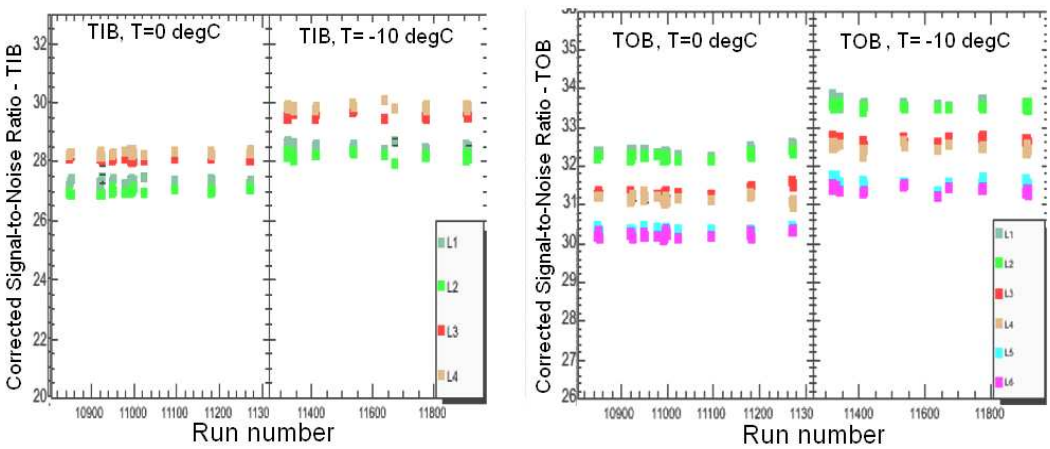

Figure 2: Stability of the cluster signal-to-noise ratio for TIB (Tracker Inner Barrel) and TOB (Tracker Outer Barrel), corrected for the angle of the tracks, at two different temperatures: 0^oC and -10^oC

2 Data taking at Tracker Integration Facility and analysis results

Approximately 15% of the SST was used to take cosmic ray data at five operating temperatures (15, 10, -1, -10 and -15 ^{o}C) from March to July 2007. During this period, data were readout of various parts of the SST in different combinations.

Almost 4.5 million cosmic events were recorded and used to evaluate detector performance. These studies included noise evaluation, determination of hit reconstruction efficiencies, detector stability studies and optimization of tracker reconstruction, cosmic tracking and alignment algorithms.

The results of the analysis of these data demonstrate that the detector performs better than specifications. The key results are summarized below:

- Less than 0.3% dead or noisy strips;
- An overall hit reconstruction efficiency of 99.8%. The breakdown of the hit reconstruction efficiency for eight of the ten layers of the barrel is shown in figure 1. Layer 1 and 10 were used tag the track
- A signal-to-noise ratio larger than 25 in peak readout mode. Figure 2 shows the cluster signal-to-noise ratio for TIB and TOB at two different temperatures as a function of run number and hence, time. The values plotted are the Most Probable Value obtained from fitting signal-to-noise distributions with a Landau function. Noise and signal-to-noise results show excellent performance and very stable behavior. The signal-to-noise ratio moreover increases in time, thanks both to lowering the temperature, and to the optimization of the electronics readout parameters.

In conclusion, the results of the studies performed using data taken at the Tracker Integration Facility show that the SST performs better than specifications.

References

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