

## COMMISSIONING OF THE CMS EXPERIMENT WITH COSMIC RAYS

## Performance of CMS muon reconstruction in cosmic-ray events

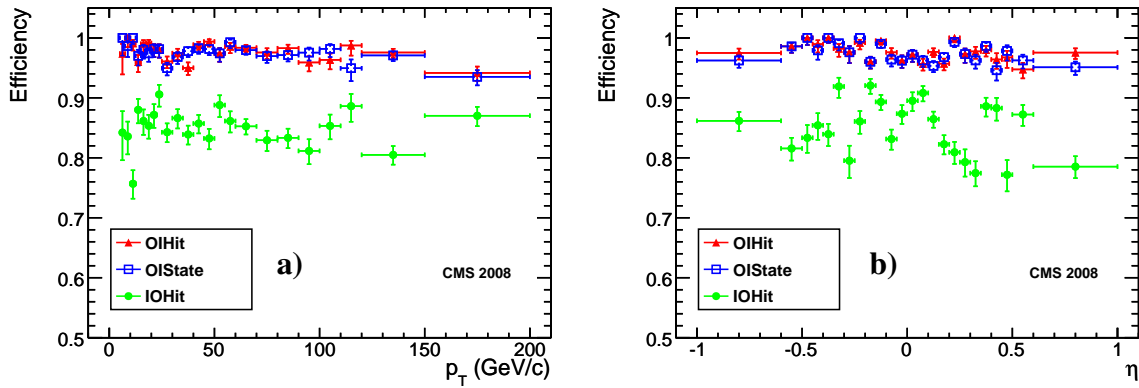
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### CMS Collaboration

**ABSTRACT:** The performance of muon reconstruction in CMS is evaluated using a large data sample of cosmic-ray muons recorded in 2008. Efficiencies of various high-level trigger, identification, and reconstruction algorithms have been measured for a broad range of muon momenta, and were found to be in good agreement with expectations from Monte Carlo simulation. The relative momentum resolution for muons crossing the barrel part of the detector is better than 1% at 10 GeV/ $c$  and is about 8% at 500 GeV/ $c$ , the latter being only a factor of two worse than expected with ideal alignment conditions. Muon charge misassignment ranges from less than 0.01% at 10 GeV/ $c$  to about 1% at 500 GeV/ $c$ .

**KEYWORDS:** Muon spectrometers; Large detector systems for particle and astroparticle physics

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**Figure 23.** Reconstruction efficiency for Level-3 muons as a function of a)  $p_T$  and b)  $\eta$  of the Level-2 muon for three algorithms: IOHit (circles), OIHit (triangles), OIState (squares). Error bars represent statistical uncertainties only.

low  $p_T$  values and of about 8% at  $p_T \sim 0.5$  TeV/c has been obtained with the initial CRAFT-based alignment of the tracker and the muon chambers. Charge misassignment has been measured to be less than 0.01% at 10 GeV/c and about 1% at 0.5 TeV/c.

The analysis of cosmic-ray muons from CRAFT has provided detailed insight into the performance of the CMS muon reconstruction algorithms. The experience gained is valuable in the preparation for data from LHC collisions, where reconstruction and identification of muons will be crucial to achieve the physics goals of the CMS collaboration.

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## References

- [1] CMS collaboration, *The CMS experiment at the CERN LHC*, 2008 *JINST* **3** S08004.
- [2] L. Evans and P. Bryant eds., *LHC Machine*, 2008 *JINST* **3** S08001.

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