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Definition and performance of muon physics object at CMS

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The performance of muon reconstruction and identification in CMS has been studied on data collected in pp collisions at $\sqrt{s}$ = 7 TeV and 8 TeV at the LHC. We present measurements of muon reconstruction and trigger efficiencies, fake rates, and momentum scale and resolution.

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1. Introduction

The Compact Muon Solenoid (CMS) [1] is a general-purpose detector at the Large Hadron Collider (LHC). Its physics program ranges from standard model presision measurements to Higgs and new physics searches. Muons are a distinctive signature for many of these processes. Thus CMS was designed for muon detection on a large momentum range, from few GeV up to the TeV scale. We present measurements of muon reconstruction and trigger efficiencies, misidentification rate, and momentum scale and resolution [2].

2. Muon Reconstruction and Identification

In the standard CMS reconstruction for pp collisions, tracks are first reconstructed independently in the inner silicon tracker (*tracker tracks*) and in the muon spectrometer (*standalone-muon tracks*), using a Kalman-filter technique. Starting from these tracks, two algorithms are used. In the *global muon* reconstruction, standalone and tracker tracks are extrapolated onto a common surface, taking into account the magnetic field and the expected energy loss and multiple scattering in the detector material, their parameters are compared, and if a matching pair of tracks is found, their hits are fitted to form a combined (*global*) track. In the *tracker muon* reconstruction, all tracker tracks are extrapolated to the muon system and matched to segments reconstructed in muon detectors.

We study the performance of two basic muon identification algorithms: the *soft muon* selection, which requires the candidate to be a tracker muon with tight requirements on the matched muon segment; and the *tight muon* selection, which requires the candidate to be both a global and a tracker muon, with stringent selections on the tracks' χ^2, hit multiplicity, and transverse impact parameter. Figure 1 shows the distribution of muon transverse momentum p_T, multiplied by the muon charge q, for an inclusive sample of soft muons collected with a zero-bias trigger (*left*), and the p_T spectrum of tight muons collected with a single-muon trigger with p_T threshold of 15 GeV/c (*right*). Data from 2010 LHC run at 7 TeV centre-of-mass energy are compared with simulations of multi-jet, quarkonia, W and Z bosons, non-resonant Drell–Yan, and top-pair production. The data agree with the predictions within 10% or better.

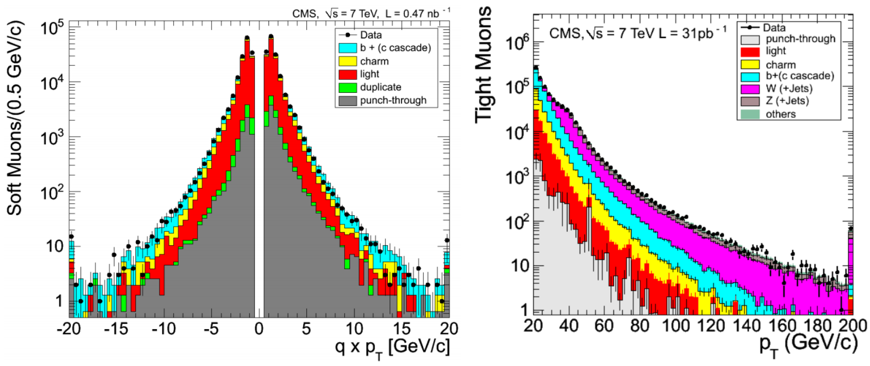

Figure 1: Data-simulation comparison, with data from 2010 LHC run at 7 TeV centre-of-mass energy. Left: charge × p_T spectrum of soft muons collected with a zero-bias trigger. Right: p_T spectrum of tight muons collected with a single-muon trigger with p_T threshold of 15 GeV/c.

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3. Efficiency and Misidentification

Muon identification and trigger efficiencies are measured with the tag-and-probe technique, using muons from selected Z decays in data and simulation [2]. Figure 2 shows the efficiency versus muon pseudorapity η at 8 TeV of the tight muon selection (*left*) and of a single-muon trigger with p_T threshold of 40 GeV/c with respect to tightly-selected muons (*right*). Tight muon efficiency is generally above 95% in the muon spectrometer barrel ($|\eta| < 1.2$) and 92% in the endcaps ($1.2 < |\eta| < 2.4$), and is reproduced in simulation to within 1%. Some data-simulation discrepancies in the trigger efficiency are due to the continuous evolution of triggers during the data taking, and are corrected with scale factors in physics analyses.

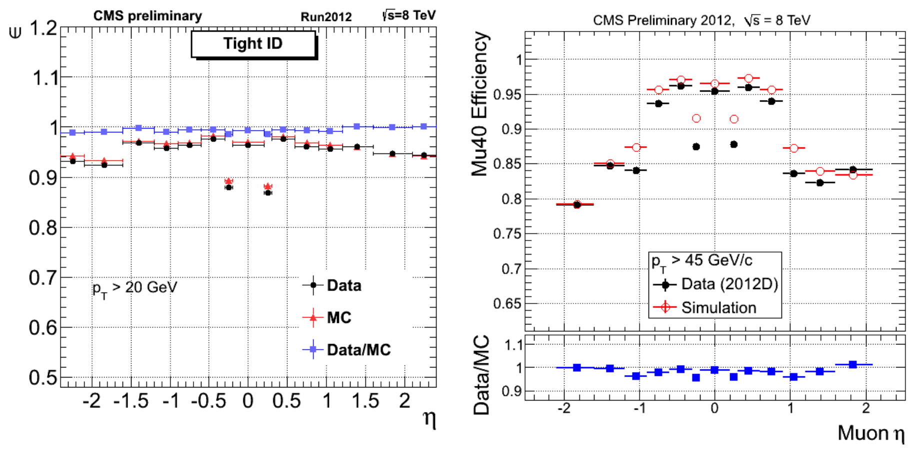

Figure 2: Efficiency of tight muon selection (*left*) and single-muon trigger with $p_T > 40$ GeV/c (*left*) versus muon η, in selected $Z \to \mu\mu$ events in 8 TeV data (*black*) and simulation (*red*), and their ratio (*blue*).

Using the tag-and-probe method with decays $\phi \to \pi\pi$, $\Lambda \to p\pi$, and $K_S \to \phi\phi$, hadron-to-muon misidentification rates are measured for pions, kaons, and protons, and found to be lower than 1% for the soft-muon selection, and lower than 0.1% for the tight muon selection.

4. Muon Momentum Scale and Resolution

The momentum scale and resolution of muons are studied using different approaches. For p_T values up to 100 GeV/c, methods exploiting the J/ψ and Z mass resonances are used. The average bias in the muon momentum scale was measured with a precision of better than 0.2% and was found to be consistent with zero. The relative p_T resolution is 1.3–2.0% for muons in the barrel and better than 6% in the endcaps. For muons with p_T higher than 100 GeV/c, the resolution is measured with cosmic rays in the barrel region, and is found to be better than 10% up to 1 TeV for global and tracker muons, and better than 6% for specific high-p_T recostruction algorithms [2].

References

[1] CMS Collaboration, *JINST* **3** (2008) S08004.

[2] CMS Collaboration, *JINST* **7** (2012) P10002.