Low-Mass Di-muons in CMS

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The reconstruction of low-mass di-muon signaures at CMS with data collected at 7.0 TeV c.m.s. energy, corresponding to 15 nb^{-1} are presented here. The work flow includes muon selection, reconstruction, quality cuts and performance capabilities are presented here for early CMS data.

1. Introduction

Low-mass di-muon distributions are used as a calibration tool for the CMS detector. We present results in muon identification, efficiency and resolution from extensive analysis on cosmic-ray muons and 900 GeV c.m.s. energy collisions. In section 2 we present the workflow of muon identification with the current performance of muon identification being discussed in section 3. In section 4 we present early CMS results on the opposite-sign di-muon spectrum around the known J/ψ resonance.

2. Muon Identification and Reconstruction

Muon identification is done via two complementary algorithms. The first method is based on tracker tracks and are referred to as *tracker* muons; this involves matching tracker tracks to segments in the muon system.

The second method relies on muon tracks that are reconstructed using the muon system called *stand alone* muons. Hits from *stand alone* muons are merged with hits from the tracker track and refit to produce a *global* muon. Tracker muons are much more efficient at finding muons with lower transverse momentum but at the cost of an increased acceptance for decays-in-flight from charged pions and kaons.

3. Performance of Muon Reconstruction

For both *tracker* and *global* muons, quality analysis objects are selected using low-level distributions with typical cuts on the normalized χ^2 and the number of hits. While muon reconstruction was vetted with cosmic runs, CMS tracking was studied with 900 GeV c.m.s. energy data; Figure 1[4] shows some low-level tracking distributions. In Figure 2[8] we show the comparison between data and Monte Carlo for the $p_T$distributions of tracker and global muons; there is good agreement between data and Monte Carlo.

The performance of CMS muon reconstruction was heavily vetted on cosmic data prior to LHC collisions. Cosmic-ray studies led to an understanding of global muon reconstruction that yielded a precision measurement of the cosmic muon charge asymmetry ratio (see Figure 3) [6] employing a technique where cosmic muons are treated as di-muons that are split at the muon's point of closest approach to the center of CMS. The half-sum of key track parameters are used to complete the measurement and the half-difference is used to estimate the resolution. In Figure 4[5] we show the resolution for muons using tracker tracks, global tracks, and specialized muon reconstruction algorithms for high-$p_T$muons.

4. Di-Muons

Muons are symmetrically selected based on the number of tracker hits, vertex probability and χ^2 with a loose cut on impact parameter to reject cosmics. Opposite-signed muon pairs including tracker and global muons are formed and the invariant mass of these pairs is reconstructed and presented in Figure 5[7] on the range of $[2.6, 3.5]$ GeV/c^2. The uncorrected J/ψ is fit with a Crystal Ball signal shape with a flat background.

The fit parameters yield $M_0 = 3.092 \pm 0.001$ (stat) GeV/c^2 and $\sigma = 42.7 \pm 1.5$ (stat) MeV/c^2

with a fit $\chi^2/ndf = 1.1$. Under the peak extending 2.5σ from M_0 there are 1230 ± 47 signal events with a signal-to-background ratio of 5.4. The muon momentum scale has yet to be corrected.

5. Conclusions

Muon identification and reconstruction has been heavily vetted with CMS cosmic-ray data. Early di-muon resonances already show promising results in the region of the J/ψ. Work is ongoing to correct the momentum scale and improve the muon resolution.

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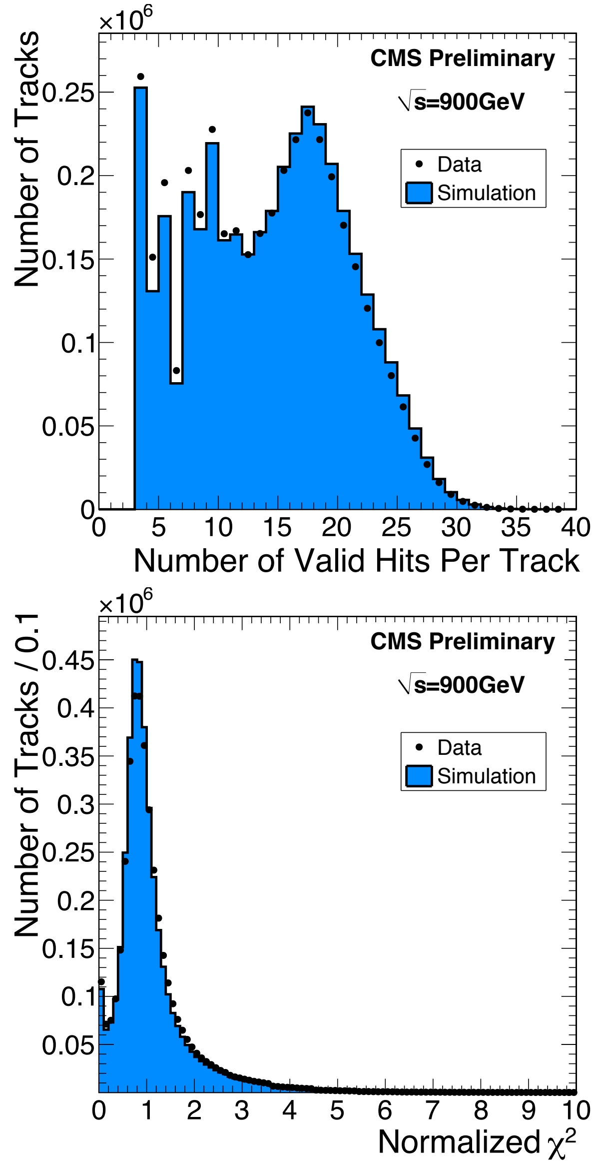

Figure 1. Representative low-level quality track distributions showing the number of tracker hits in a tracker track and the normalized χ^2 of the tracker track fits taken with 900 GeV c.m.s. energy.

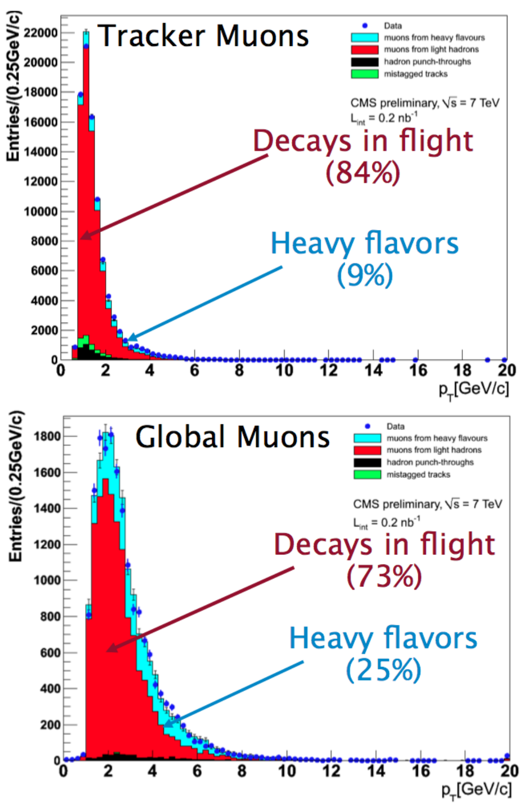

Figure 2. Comparisons between data and MC for the $p_T$distributions for global and tracker muons for 0.2 nb^{-1} integrated luminosity. Tracker muons are more efficient at low-$p_T$but the sample has a higher fraction of decays-in-flight.

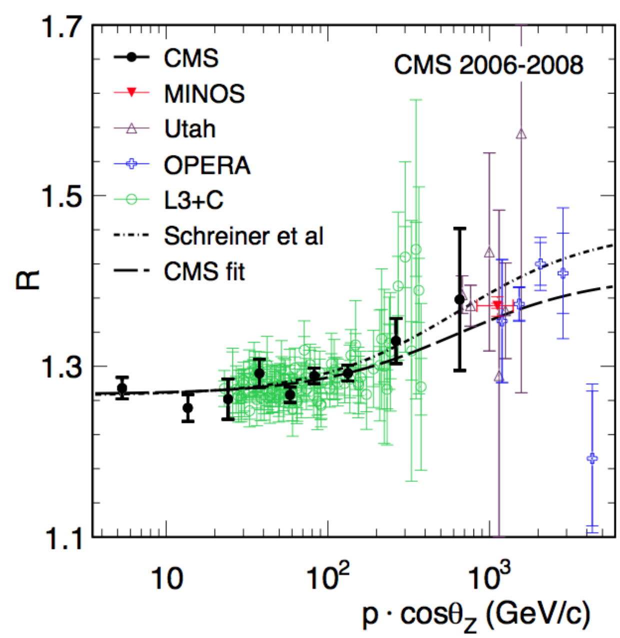

Figure 3. The CMS result for the muon charge asymmetry ratio as a function of the vertical component of the muon momentum, together with some previous measurements and a fit of the pion-kaon model to the CMS data.

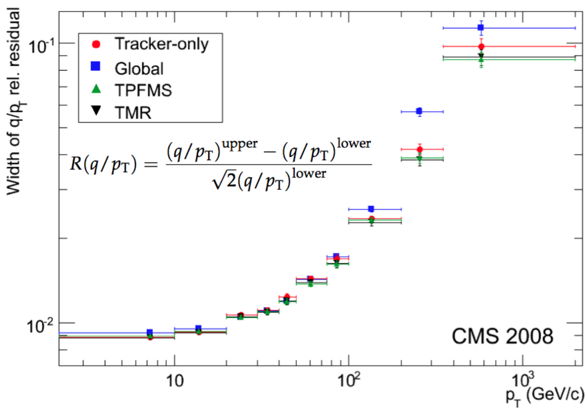

Figure 4. Widths of Gaussian fits to the distributions of the normalized residuals, $P(q/p_T)$, for various muon reconstruction algorithms, as a function of $p_T$of the reference track.

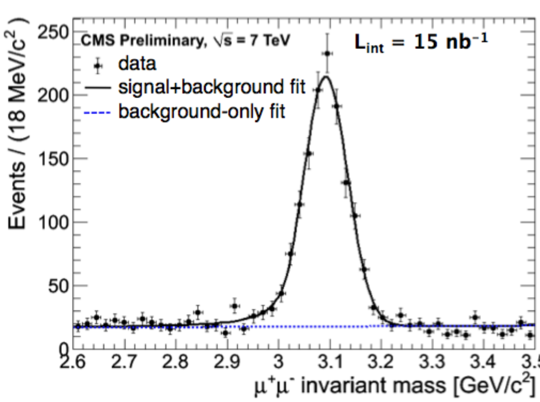

Figure 5. Uncorrected opposite-sign di-muon invariant mass distribution. Fit with a crystal ball signal shape on a flat background.