MUON STUDIES AT CMS

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Detection and reconstruction of muons is one of the most important goal of the detectors at LHC. In the first part of this paper, the CMS muon system is described. Then, the muon reconstruction performance, measured with the cosmic-ray sample collected during the data-taking exercise performed in 2008, is presented. Finally, the first J/ψ candidate in di-muon final states collected in CMS is described.

1 CMS Muon System

The Compact Muon Solenoid [1] (CMS) is a general purpose detector designed to optimize the discovery potential of the LHC collider.

Final states with muons are a signature for important processes produced in CMS. Goal of the CMS muon system is muon identification, momentum measurement and trigger. The muon system is the outermost detector in CMS (Fig.1). It consists of three independent subsystems: the Drift Tubes (DT), the Cathode Strips Chambers (CSC) and the Resistive Plate Chambers (RPC).

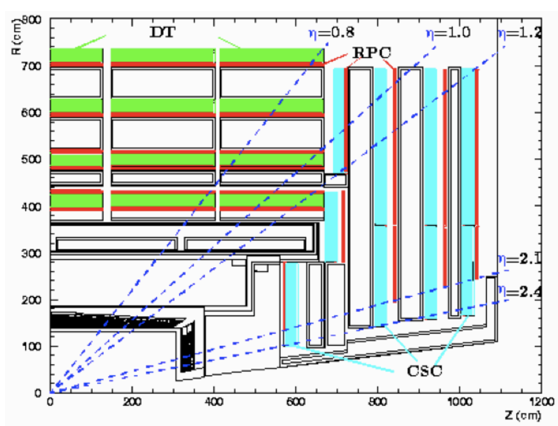

Figure 1: CMS Muon System.

1.1 Drift Tubes

In the barrel region, where the neutron-induced background is small and the muon rate is low, the Drift Tubes technology has been chosen. The detector is composed by four stations forming concentric cylinders around a beam line. The DT chambers are 250, for a total of 172000 sensitive wires. The pseudorapidity coverage is $|\eta| < 1.2$.

DT performances have been extensively tested during the commissioning of the apparatus using cosmic-rays [2] [3]. The resolution of single reconstructed hits is on the order of 260 μm in all chambers, while the muon position within one station can be measured with a precision of about 100 μm. The local reconstruction efficiency is measured to be about 99% in all chambers. The overall local trigger efficiency, when the proper time of arriving muon is taking into account, is 97% for any trigger quality.

1.2 Cathode Strip Chambers

The endcap region is characterized by a large and varying magnetic field, and by a higher particle rate: cathode strip chambers are used. CSC are composed by trapezoidal chambers mounted on eight stations (four in each endcap). There are 468 chambers in total. The pseudorapidity coverage is $0.9 < |\eta| < 2.4$.

CSC performance have been measured with cosmic-rays [5]: the efficiencies for local charged track triggers, for hit and for segments reconstruction are above 99%. The fraction of noisy or dead channels is less then 1%. The spatial resolution for local muon reconstruction varies from 47 μm to 243 μm .

1.3 Resistive Plate Chambers

To improve the muon trigger efficiency, a complementary trigger system, consisting of resistive plate chambers, have been placed both in the barrel and in the endcap region. RPC have a fast time response ($\sigma_t \sim 2$ ns) and the pseudorapidity coverage is $|\eta| < 1.6$. There are a total of 6 layer of RPC in the barrel and a plane in each of the first 3 stations of the endcap.

More than 98% of the channels were operational during the cosmic-ray data taking exercise with typical detection efficiency of 90% [6].

2 Muon Reconstruction Performance

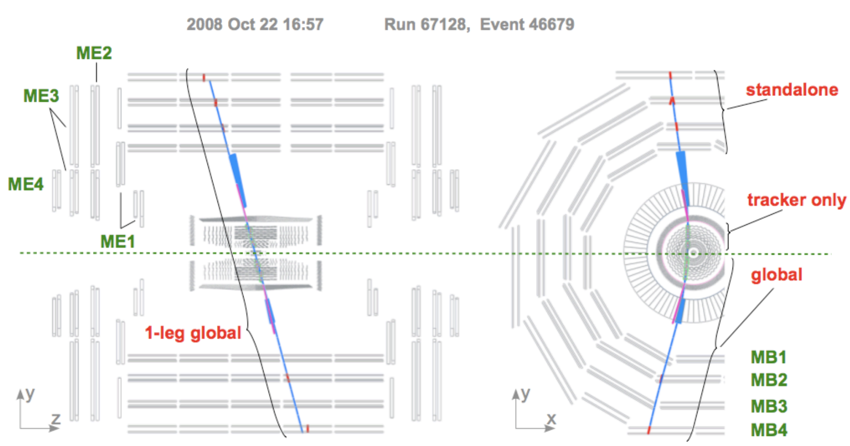

Figure 2: Event display of a cosmic muon crossing CMS.

The performance of muon reconstruction in CMS has been widely tested with the data sample of cosmic muons [7]. Fig. 2 shows, as an example, the event display of a cosmic muon crossing the whole CMS detector: muons tracks can be reconstructed using informations from the muon system only (*standalone muons*), from the tracker system only (*tracker tracks*) or from all CMS (*global muons*).

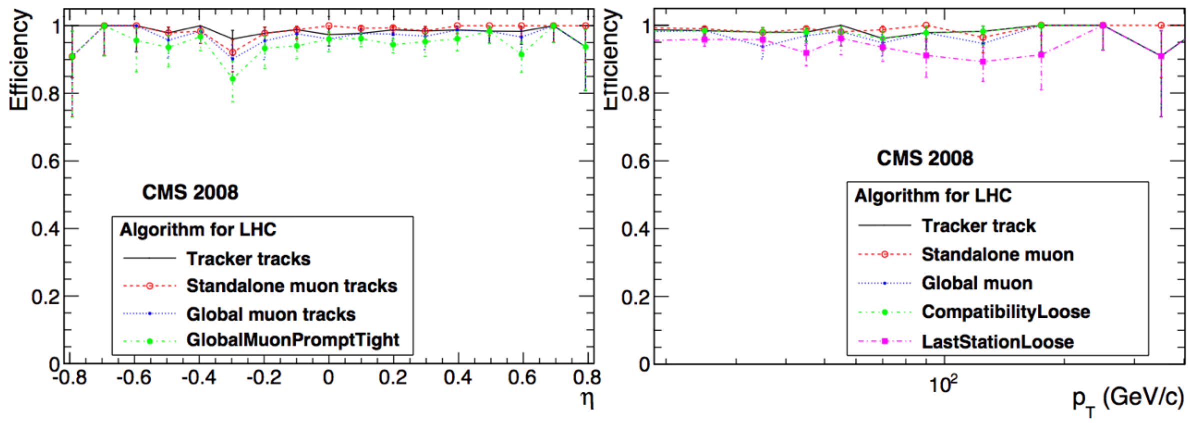

Figure 3: Muon reconstruction efficiency as a function of η (left) and p_T (right).

Cosmic-ray events have been used to measure the muon reconstruction efficiency: events with a good-quality muon reconstructed in one hemisphere have been selected and the corresponding track in the other hemisphere were searched in the region of $|\Delta\phi| < 0.3$ and $|\Delta\eta| < 0.3$ around the direction of the reference global-muon track. To be sure that all the detector is traversed, only global-muon with $p_T > 10$ GeV/c at the point of closest approach to the beam line have been considered. Fig 3 show the measured muon reconstruction efficiency for the standard LHC-like algorithms (a detailed description of the algorithms can be found in Ref. [4]).

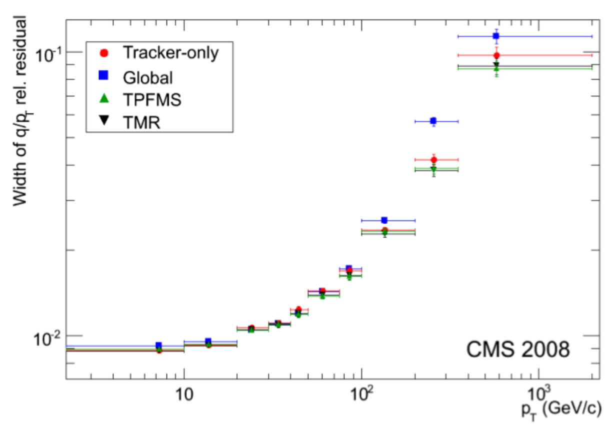

Figure 4: Widths of Gaussian fits to the distribution of the relative residuals for various muon reconstruction algorithm, as a function of p_T of the reference track.

The muon momentum resolution can be measured by the width of the distribution of the relative residuals, R(q/p_T):

$$R(q/p_T) = \frac{(q/p_T)^{upper} - (q/p_T)^{lower}}{\sqrt{2}(q/p_T)^{lower}} \tag{1}$$

where $(q/p_T)^{upper}$ and $(q/p_T)^{lower}$ are the ratios of the charge sign to the transverse momentum for muon tracks in the upper and lower detector halves, respectively. Figure 4 shows the muon momentum resolution as a function of the p_T: below 200 GeV/c the contribution of muon detector hits is low; for high p_T the resolution will improve once that a better detector alignment will be in place.

3 Dimuons in CMS at 900 and 2360 GeV

At the end of 2009, about 12 μb^{-1} of integrated luminosity has been collected by the CMS detector with a centre of mass energy of 900 GeV and 2360 GeV. A selection, searching for final states with 2 muons, has been applied: an event (Fig.5) in the 3.0 - 3.2 GeV mass window (centered in the J/ψ mass peak) has been selected.

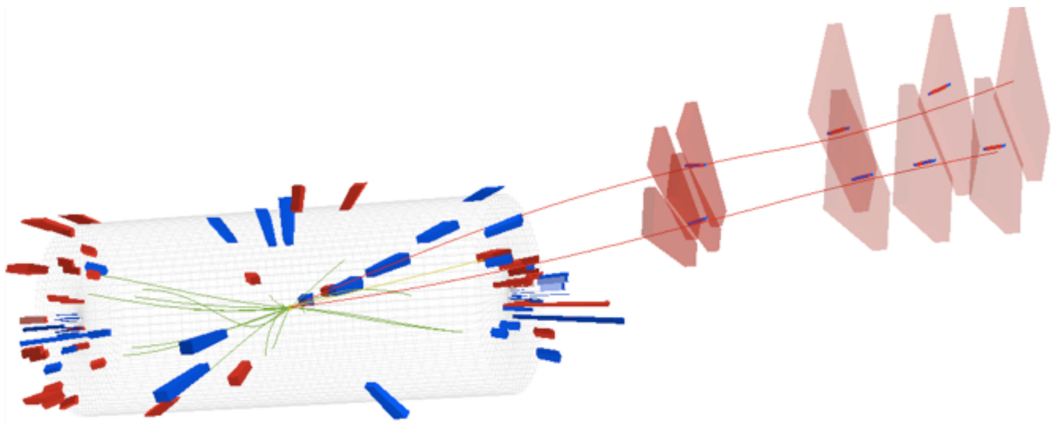

Figure 5: J/ψ candidate. Reconstructed mass: 3.04 GeV/c^2; p_T: 5.38 GeV/c; Dimuon vertex chi^2 prob.: 57%; $c\tau$: -17±81 μm

4 Conclusion

The CMS muon system, composed by three independent subsystems, has been fully commissioned in the past years. Cosmic-ray data taking allowed to evaluate the performances of the detector. The first events coming from proton-proton interaction confirm that CMS is ready for the LHC era. With the first few pb^{-1} collected, it will be possible to reconstruct the J/ψ and Υ resonances, and therefore measure the muon efficiencies and resolution at low momenta (<20 GeV/c). Already with $\sim 10\ pb^{-1}$, several thousands of $Z \rightarrow \mu\mu$ events are expected to be identified in the di-muon reconstructed mass distribution: thus it will be possible to measure muon efficiencies and resolution at high momenta (>20 GeV/c).

References

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