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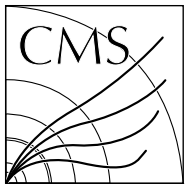

The Compact Muon Solenoid Experiment

CMS Performance Note

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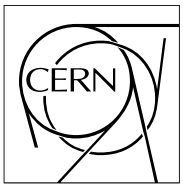


26 June 2014

Muon ID performance: low-p_T muon efficiencies

CMS Collaboration

Abstract

Muon Identification efficiencies from 2012 Data, obtained from $J/\Psi \rightarrow \mu\mu$ decays by the Tag and Probe method. They cover the range of muon $p_T < 20$ GeV.

Muon ID performance: low-pt muon efficiencies

CMS Collaboration

PPD General Meeting, 18th June 2014

Contents

- Muon Identification efficiencies from 2012 Data, obtained from J/Psi ->mumu decays by the Tag and Probe method. They cover the range of muon pt<20 GeV and |eta|<2.1.
- These results complement the muon efficiencies at pt>20 GeV, obtained from Z -> mumu decays with similar techniques, included in DP-2013/009.
- MisIdentification probabilities for pions, kaons, protons with pt>4 GeV are presented in DP-2014/018.

Muon ID: definitions

- **Loose Muon**
  - Particle identified as a muon by the Particle-Flow event reconstruction
  - Discard muon candidates which are reconstructed only on the muon detectors, without hits reconstructed on the inner tracking system.

- **Tight Muon**
  - Particle identified as a muon by the Particle-Flow event reconstruction
  - Global muon track, including hits in the inner tracking system and in the muon detectors
  - At least one muon chamber hit used in the global track fit
  - Global track fit χ^2/ndf < 10
  - Muon Inner track extrapolation matched to segments in at least two muon stations (by the Tracker Muon algorithm)
  - Hits on more than 5 layers of the inner tracking system
  - At least one pixel hit.
  - Cuts on the impact parameters in the transverse and longitudinal planes w.r.t. the primary vertex of the event :|dxy| < 0.2 cm, |dz| < 0.5 cm

General description of the reconstruction and identification algorithms in: JINST **7** (2012) P10002. Here some different cuts introduced for the 2012 run.

Muon ID: definitions (II)

- **Soft Muon:** Selection aimed at low-pt muons, with quality cuts, not using the Particle-Flow event reconstruction. The muon candidate is identified by the *Tracker-Muon* algorithm (inside-out):
  - inner tracker tracks are extrapolated and matched to segments in DT or CSC chambers. A matching is found when the distance between the extrapolated track and a muon segment is less than 3 cm or the pull is less than 4, in the local best-measured position coordinate.
  - The matching of inner tracks and muon segments is arbitrated by choosing the best geometrical matching, to resolve ambiguities and remove duplicates.

  The detailed definition is:
  - `TMOneStationLoose`: at least one segment matching in local-x position with the extrapolated track within 3cm or pull≤3
  - Track HighPurity flag [see Tracking paper: CERN-PH-EP-2014-070]
  - Hits on more than 5 layers of the inner tracking system
  - At least one pixel hit.
  - Loose cuts on the impact parameters in the transverse and longitudinal planes w.r.t. the primary vertex of the event :|dxy| < 0.3 cm, |dz| < 20 cm (compatibility with the beamspot)

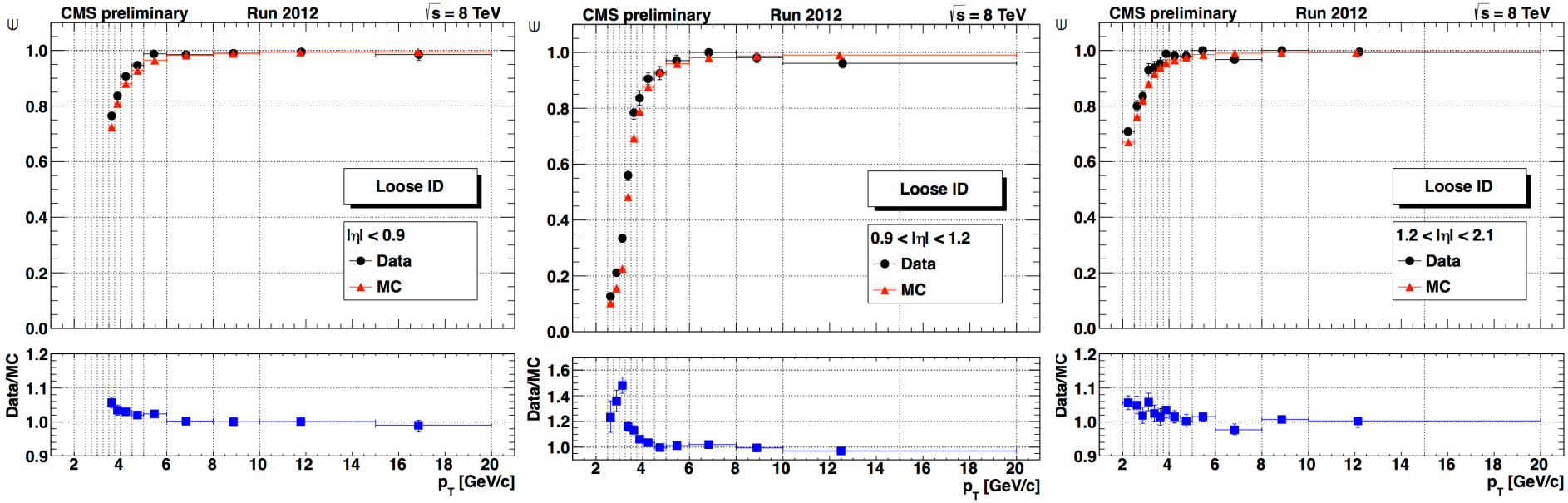
  General description of the reconstruction and identification algorithms in: JINST **7** (2012) P10002. Here some different cuts introduced for the 2012 run.

Dataset and Method

- MuOnia dataset from 2012 run (not including parked data)
- Special (prescaled) efficiency triggers for J/Psi selection to be used by the Tag and Probe method: HLT_Mu5_Track2_Jpsi and HLT_Mu7_Track7_Jpsi.
- Tag muon matched to the Mu leg of the trigger
- Probe candidate: general Track matched to the Track leg of the trigger
- Using only one efficiency trigger according to the (offline) pt of the candidate probe: pt<8 GeV or pt>8 GeV.
- Minimum separation of the two tracks, extrapolated to the first muon station, DR>0.5 to avoid correlations
- Mass window 2.9 < M < 3.3 GeV around the J/Psi mass
- Fit PDF's: Crystal-Ball function for the J/Psi signal, exponential for the background
- Systematic uncertainties related to the background subtraction, obtained from the T&P fits, are shown in the following plots together with the statistical errors.
- Additional systematics (not included in the error bars) are estimated to be below 1.5% on the Data/MC scaling factors. The absolute efficiencies (both Data and MC) have an extra bias of 0.5-0.8% (depending on the selection) due to the loose quality cuts applied in the trigger path.

Loose ID: efficiency vs pt

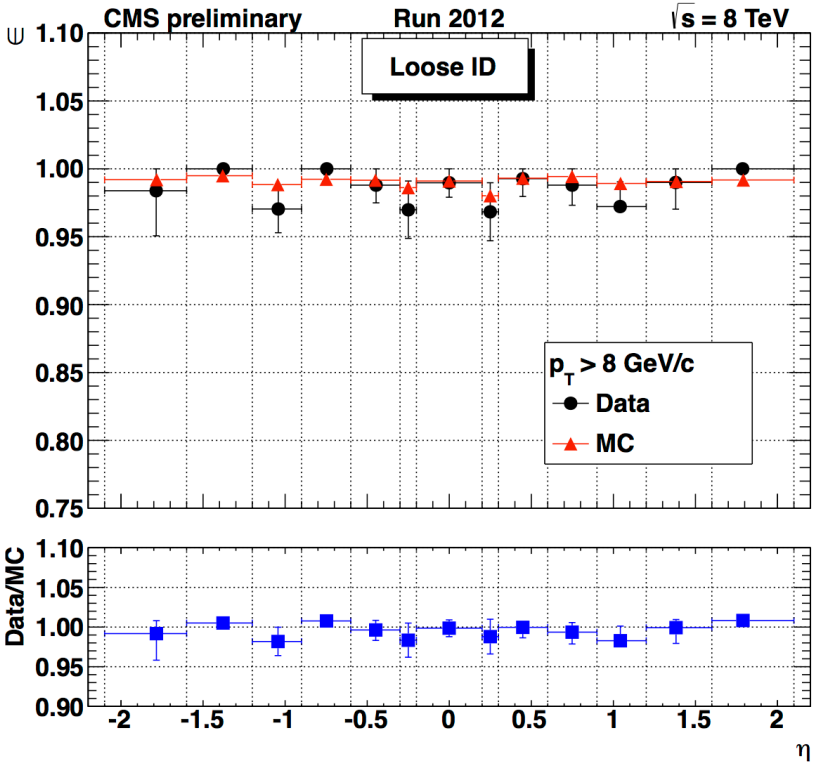
Efficiency of the Loose Muon selection as a function of muon pt in the barrel (|eta| <0.9), overlap (0.9<|eta|<1.2), endcap (1.2<|eta|<2.1) regions, for Data, MC simulation and their ratio. The errors are from the T&P fit (statistical + background subtraction).

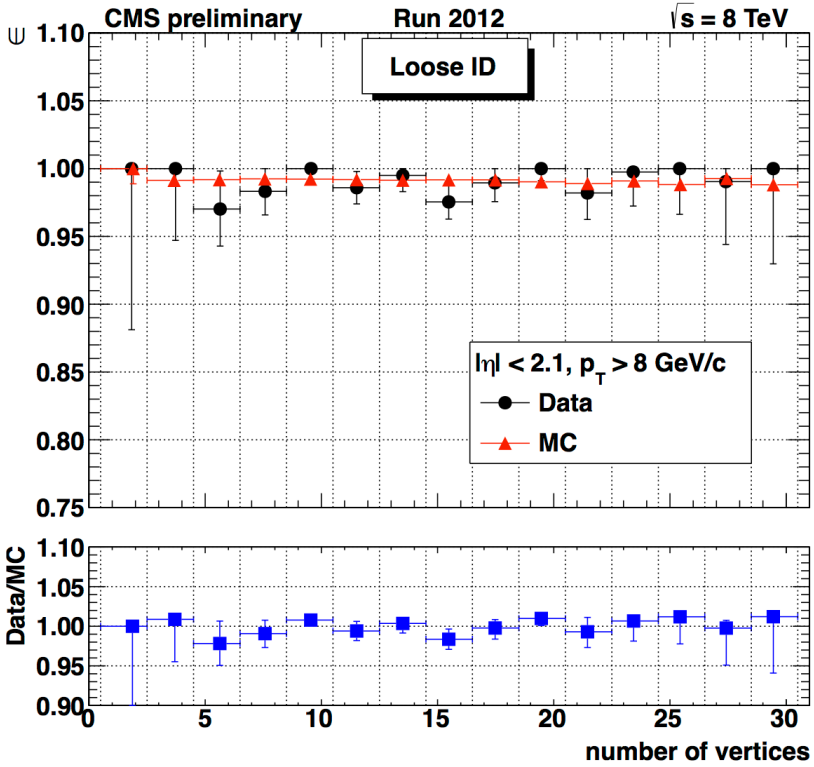


Good agreement between Data and MC within 2% in the plateau region. Discrepancies in the turn-on region arise from a small difference in the residuals and pulls of the extrapolated track w.r.t. the matched muon segments, amplified by the large variation of the efficiency throughout individual bins [more details in: JINST **7** (2012) P10002]

Loose ID: efficiency vs eta and PileUp dependence

Efficiency of the Loose Muon selection as a function of the muon pseudorapidity (left) and the number of primary vertices in the event (right) for the plateau region pt>8 GeV. The errors are from the T&P fit (statistical + background subtraction)

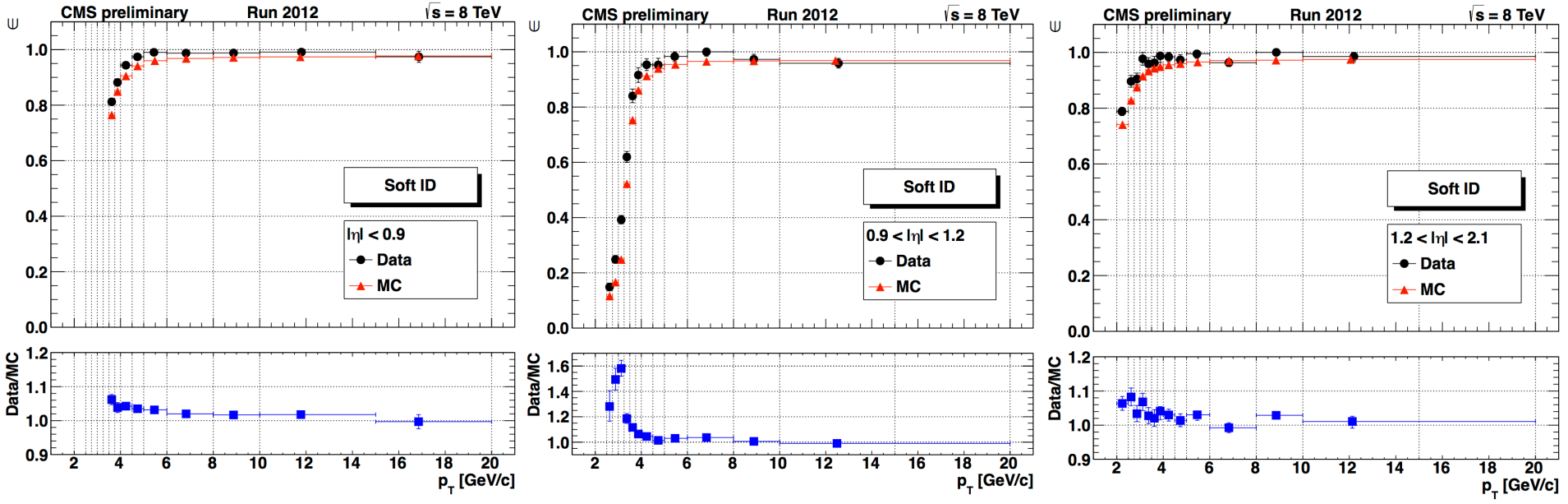




No visible dependence on pile-up

Soft ID: efficiency vs pt

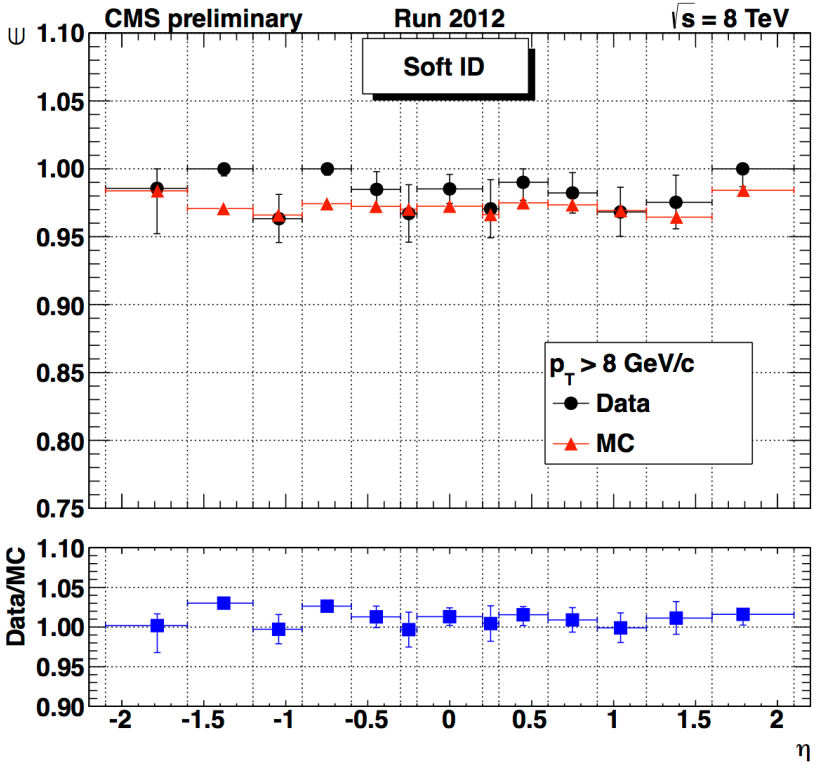
Efficiency of the Soft Muon selection as a function of muon pt in the barrel (|eta|<0.9), overlap (0.9<|eta|<1.2), endcap (1.2<|eta|<2.1) regions, for Data, MC simulation and their ratio. The errors are from the T&P fit (statistical + background subtraction).

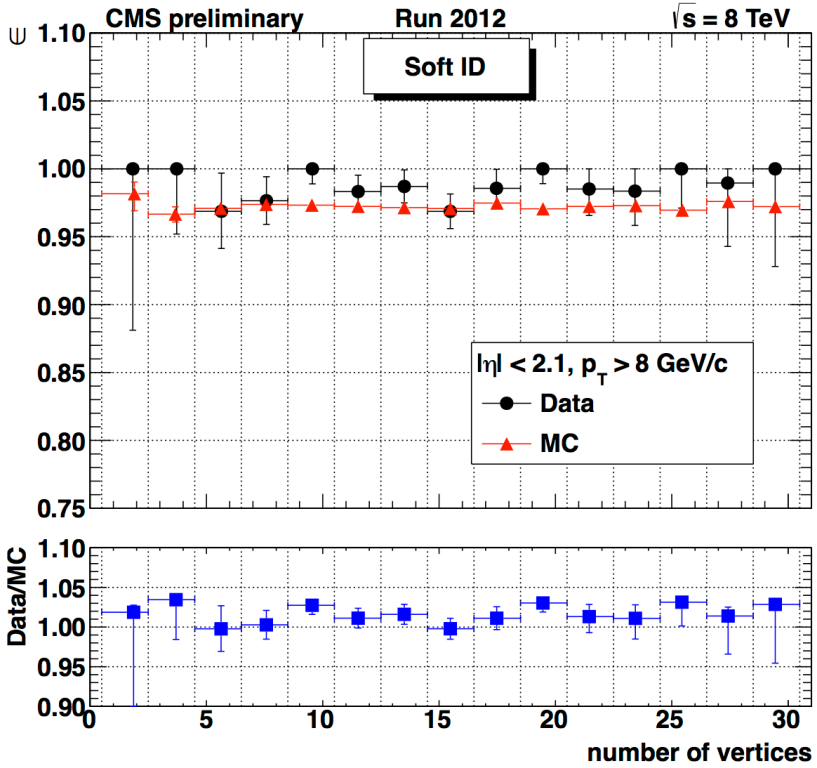


Good agreement between Data and MC within 3% in the plateau region. Discrepancies in the turn-on region arise from a small difference in the residuals and pulls of the extrapolated track w.r.t. the matched muon segments, amplified by the large variation of the efficiency throughout individual bins [more details in: JINST **7** (2012) P10002]

Soft ID: efficiency vs eta and PileUp dependence

Efficiency of the Soft Muon selection as a function of the muon pseudorapidity (left) and the number of primary vertices in the event (right) for the plateau region pt>8 GeV. The errors are from the T&P fit (statistical + background subtraction)

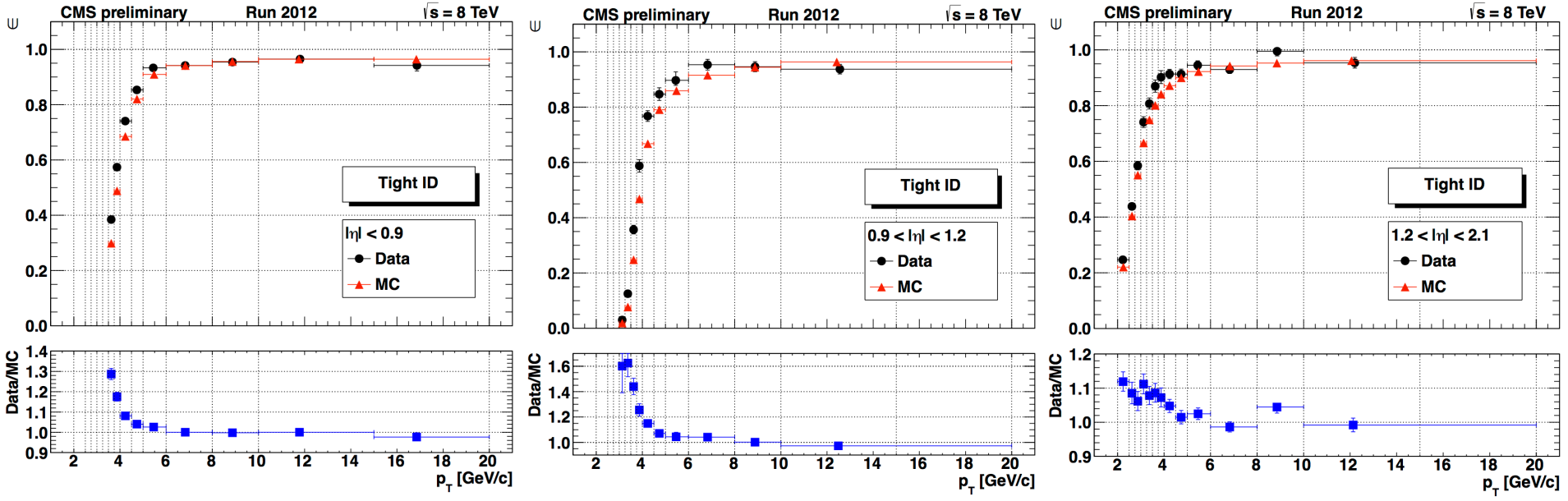




No visible dependence on pile-up

Tight ID: efficiency vs pt

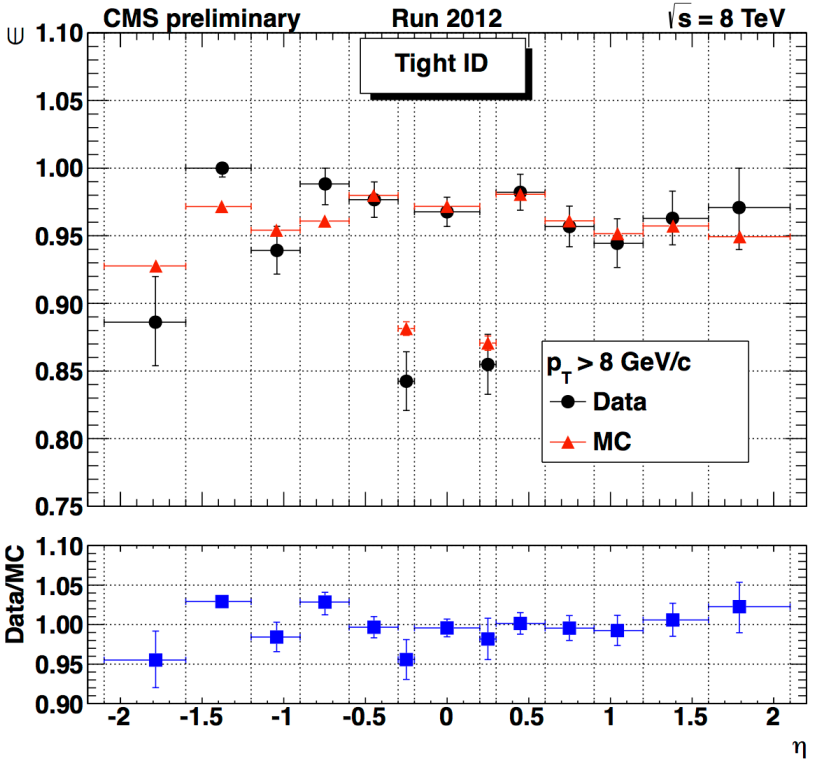
Efficiency of the Tight Muon selection as a function of muon pt in the barrel (|eta|<0.9), overlap (0.9<|eta|<1.2), endcap (1.2<|eta|<2.1) regions, for Data, MC simulation and their ratio. The errors are from the T&P fit (statistical + background subtraction).

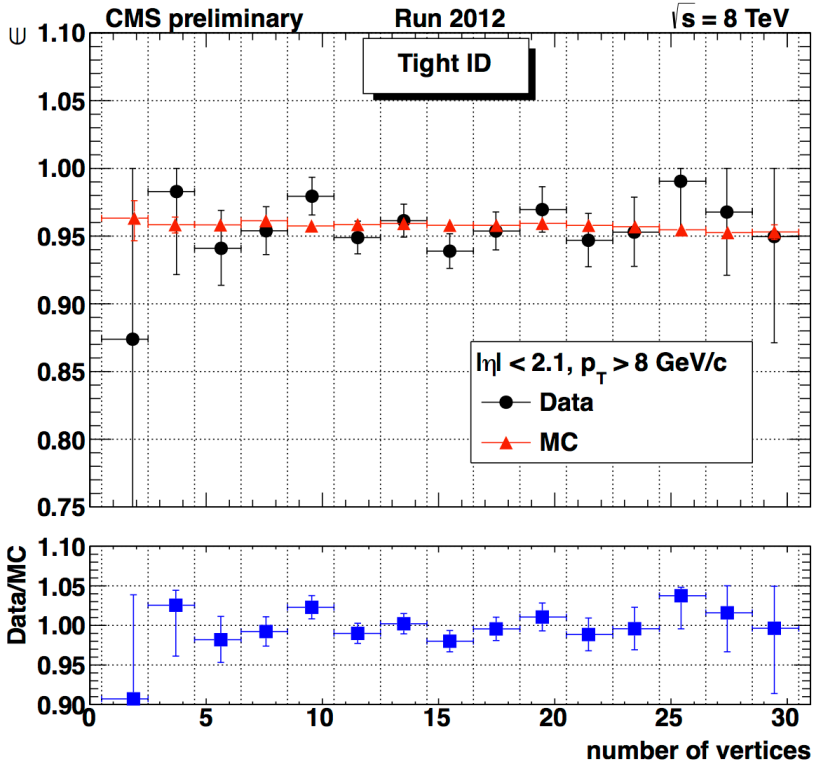


Good agreement between Data and MC within 3% in the plateau region. Discrepancies in the turn-on region arise from a small difference in the residuals and pulls of the extrapolated track w.r.t. the matched muon segments, amplified by the large variation of the efficiency throughout individual bins [more details in: JINST **7** (2012) P10002]

Tight ID: efficiency vs eta and PileUp dependence

Efficiency of the Tight Muon selection as a function of the muon pseudorapidity (left) and the number of primary vertices in the event (right) for the plateau region pt>8 GeV. The errors are from the T&P fit (statistical + background subtraction)





No visible dependence on pile-up