The 2013 European Physical Society Conference on High Energy Physics – Stockholm, Sweden, 18-24 July, 2013

Definition and performance of muon physics object at CMS

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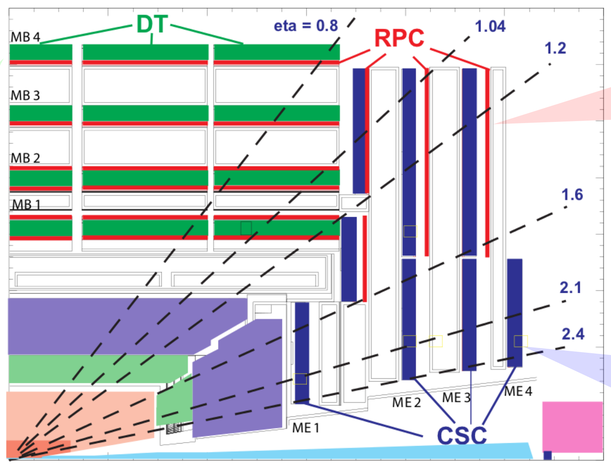
The Compact Muon Solenoid is designed for muon detection on a large momentum range, from few GeV up to the TeV scale

✓ *high identification efficiency* ✓ *good momentum and mass resolution* ✓ *fast and efficient trigger*

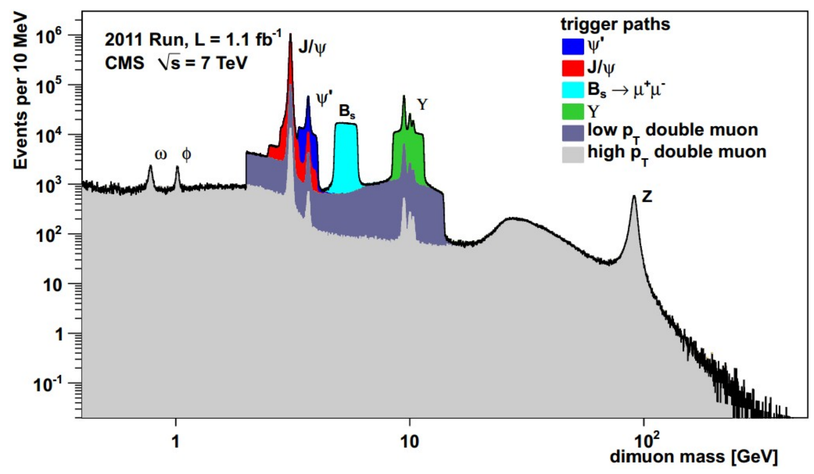
Drift Tubes (DT)
$|\eta| < 1.2$

Silicon tracker
$|\eta| < 2.5$
- Pixel: 2-3 layers
- Strip: 10-12 layers



Resistive Plate Chambers (RPC)
$|\eta| < 1.6$

Cathode Strip Chambers (CSC)
$0.9 < |\eta| < 2.4$

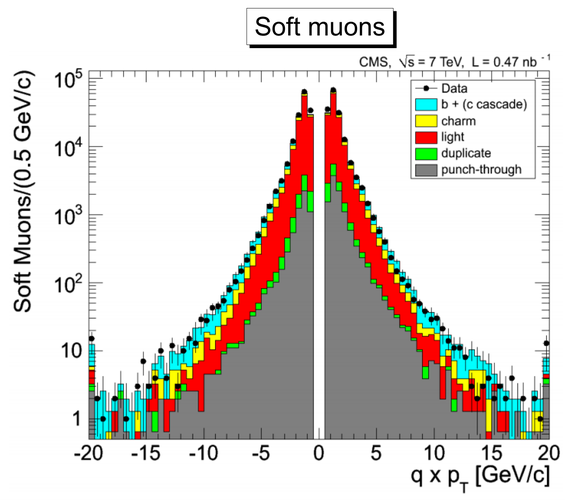


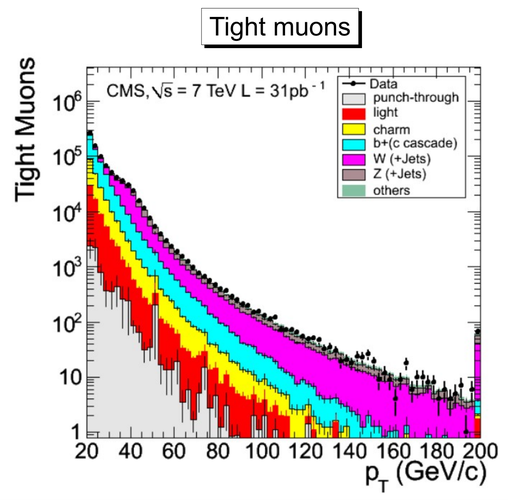
Muon identification

- **Soft muons** Tracker track matched to segments in the DT or CSC chambers
  Requirements on number of hits, track χ^2, impact parameters
  Mainly used for low-p_T muons (e.g. B-physics)
- **Tight muons** Combined fit of tracker and muon system hits and segments
  Requirements on hit and segment number, track χ^2, impact parameters
  Efficient for medium/high-p_T prompt muons (e.g. W, Z), reject decays-in-flight
- **Isolation** Sum of all particle candidates in a cone $(\Delta\varphi^2 + \Delta\eta^2)^{1/2} < 0.4$:

$$(\Sigma\, charged\ hadrons + \Sigma\, neutral\ hadrons + \Sigma\, photons) / p_T^{\mu}$$

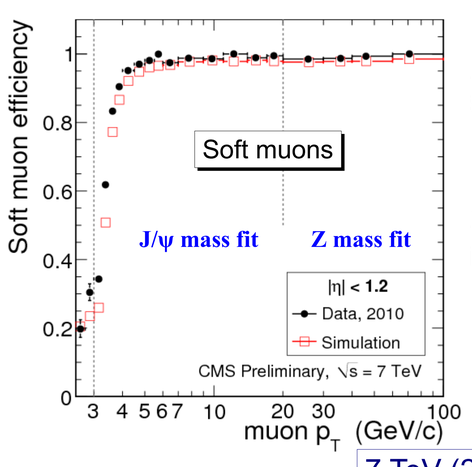
  - ► Charged hadrons are constrained to the primary interaction vertex (PV)
  - ► Neutral components are corrected using the charged hadrons from non-primary vertices inside the isolation cone, and the neutral-to-charged ratio

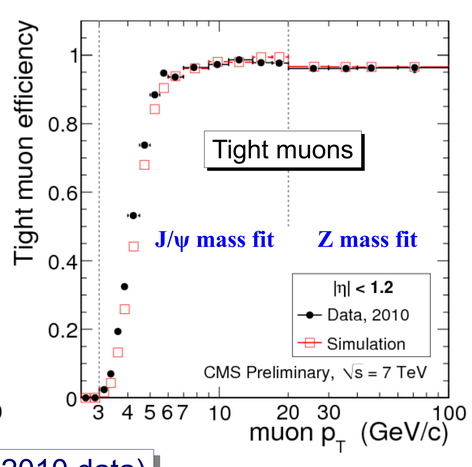




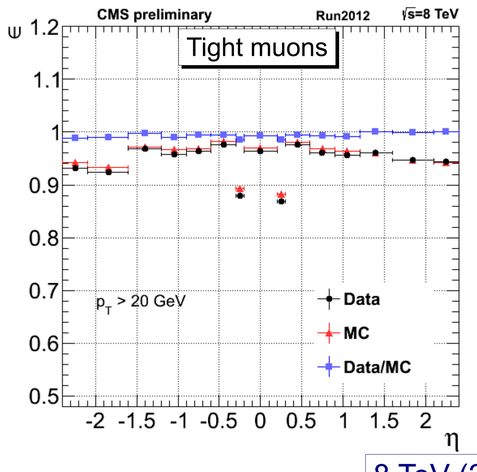
Efficiency measured with the tag-and-probe technique using J/ψ and Z resonances

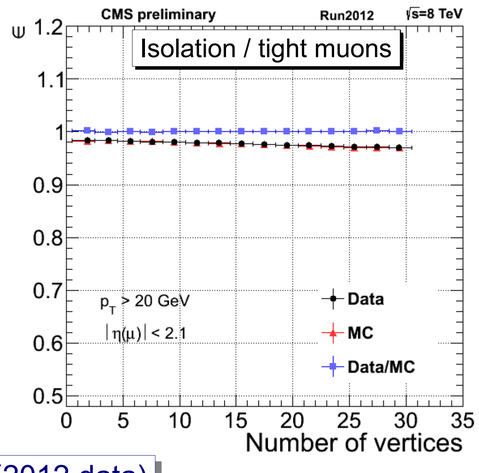
- **tag** strictly-identified muon which triggered the event
- **probe** tracker track or loosely-identified muon
- efficiency obtained fitting simultaneously the resonance mass for probes passing and failing the selection criteria





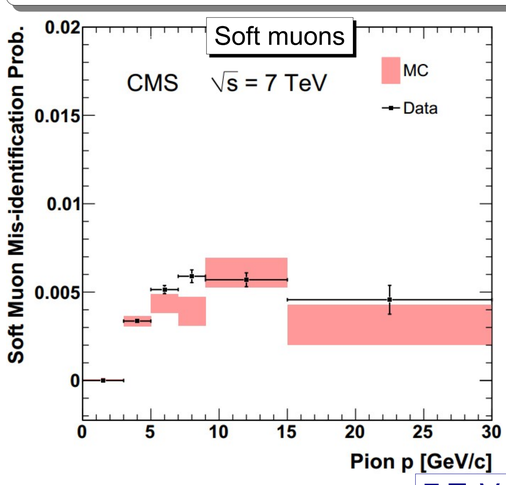
7 TeV (2010 data)

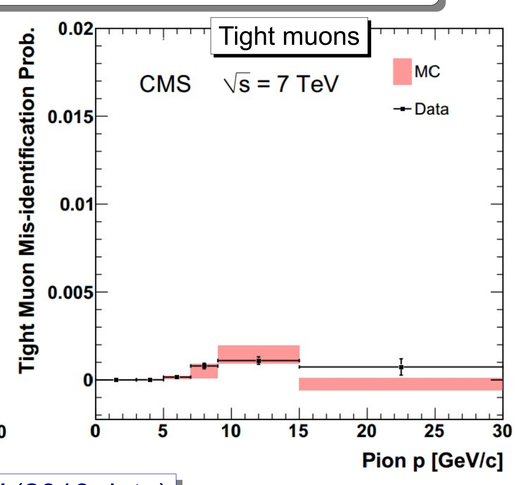




8 TeV (2012 data)

Misidentification rate of charged hadrons faking muons measured using $\phi \to \pi\pi$, $\Lambda \to p\pi$, $K_S \to \phi\phi$ decays with a hadron track identified as a muon



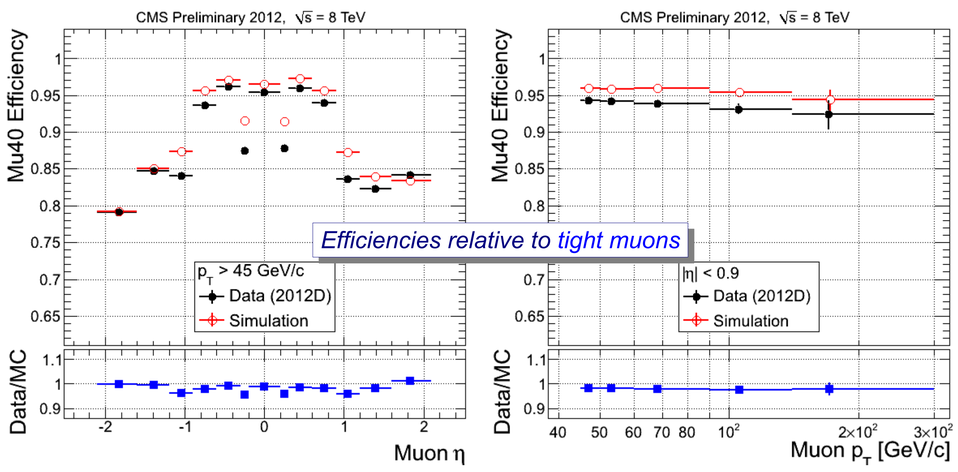


7 TeV (2010 data)

Muon triggers are composed of two main stages

- **Level-1 (L1):** hardware based, muon detectors only
- **High Level Trigger (HLT):** software based, using also tracker and calorimeters

Muon triggers can require one or more candidates, with possible additional selections: isolation, track quality requirements, dimuon mass, vertex, etc.



Mu40: trigger path requiring a single muon with $p_T > 40$ GeV/c and track quality cuts

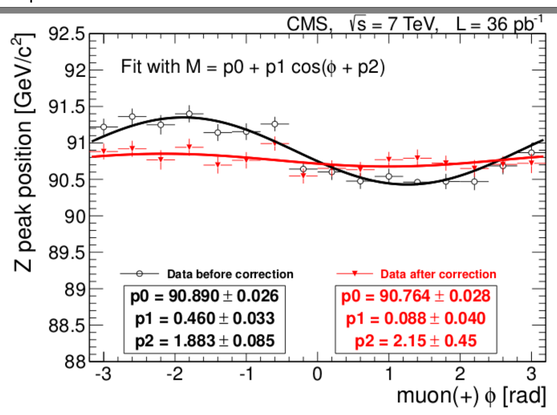
Data-MC discrepancies due to the constant evolution of triggers used during data-taking, in order to cope with changing LHC conditions, especially the increasing pile-up

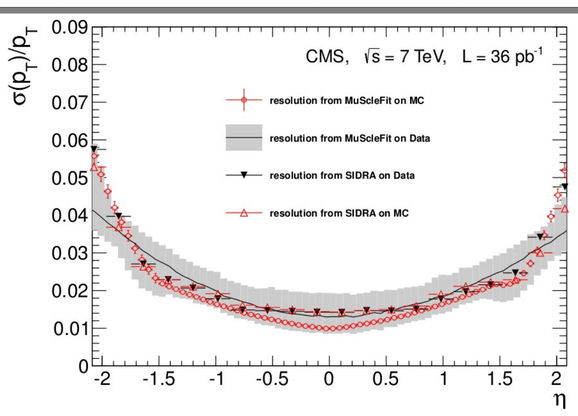
Differences are corrected with proper scale factors

Muon momentum scale sensitive to detector alignment, material, magnetic field description

- for muon $p_T < 100$ GeV/c, scale calibrated using J/ψ and Z resonances → all biases removed (< 0.2%)
- same procedure used to measure the momentum resolution: 1– 2% barrel, ~ 6% endcaps
- for higher p_T, the resolution is measured with cosmic-ray muons (barrel only): < 6% up to 1 TeV

*Z peak **before** and **after** scale calibration*





Muon p_T resolution

References

CMS Collaboration, "Performance of CMS muon reconstruction in pp collision events at √s = 7 TeV", **JINST 7** (2012) P10002 [arXiv:1206.4071]

Other CMS results with muons:
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsMUO