Performance of the Muon Identification and Isolation Efficiencies for Run II using CMS Experiment

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Abstract

The identification and isolation strategies to discriminate prompt muons from a background, and their performance with 13 TeV data collected with the CMS experiment. This poster will present main studies concerning muon performance in of the CMS muon detector and muon reconstruction with proton-proton collisions the Run II is shown.

Tag and Probe Efficiency Method

- Select the object that would fire the trigger in a way independent of the trigger itself
- Count how many times it fires the trigger
- Under the resonance peak (e.g Z, J/ψ, Υ) basically only the resonance (for example Z boson) production is expected
- Given one good lepton, use the invariant mass of dimuons (M_{ll}) constraint to identify it the result has to be corrected for combinatorial background under the Z peak (or the counting done by fitting the shapes)
- With sufficient statistics the efficiency can be evaluated in bins of p_T, η ,ϕ
- Total muon detection efficiency is defined using the different contributions of muon reconstruction, identification, isolation, and trigger to the overall efficiency: $\epsilon_{total} = \epsilon_{trk} \times \epsilon_{ID} \times \epsilon_{ISO} \times \epsilon_{trigger}$

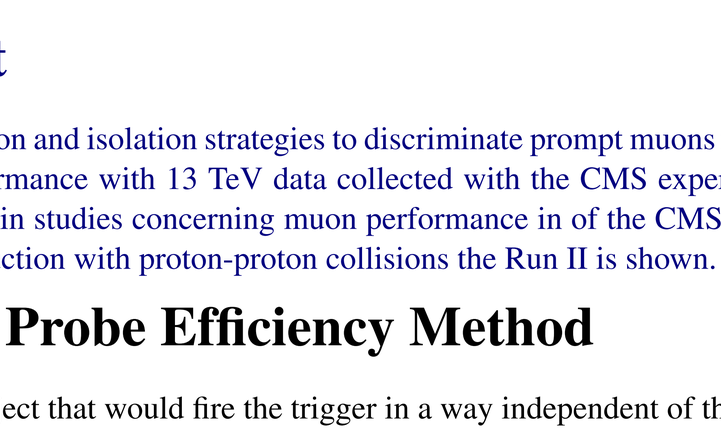
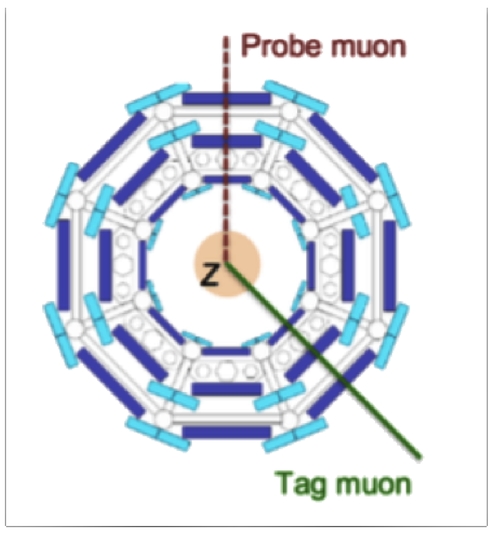


Figure 1: Dimuon invariant mass spectrum



- Tag Muon
  - Triggered by single muon trigger
  - Minimum p_T threshold applied
- Probe Muon
  - Basic object of the muon reconstruction (track)
  - Minimum p_T threshold applied
  - Inv. mass window around e.g $M(tag, probe) \approx M_Z$ for Z boson

Efficiency of the probe is the number of passing probes divided by the total number of probes.

$$\epsilon_{muon\,trk} = \frac{nb.\,of\,probes\,that\,fire\,the\,trigger}{nb.\,of\,probes}$$

for both muons might fire the trigger

$$\varepsilon_{\text{muon tr}} = \frac{2TT + TP}{2TT + TP + TF}$$

T = **T**ag
P = **P**robe that fires a trigger
F = probe that **F**ails a trigger

Event Selection Criteria and Datasets Samples

Datasets Samples

- Data Samples
  - Collision data at 13 TeV and 25 ns bunch spacing. Luminosity: 16.3 fb^{-1} (2016), 41.3 fb^{-1} (2017) and 11.8 fb^{-1} (2018)
- Monte-Carlo sample
  - Drell-Yan + Jets sample generated at LO
  - Re-weighting is applied to match the pileup distribution in data

Event Selection Criteria

The tag and probe method is used to evaluate the scale factors between data and MC that account for the several muon identifications (IDs) and isolations (ISOs) algorithms.

- Tag selection:
  - Tight muon ID with $p_T > 29.0\,GeV$
  - Rel. Comb. Isolation ($\Delta R = 0.4$) < 0.2
  - Matched with single isolation muon trigger ($p_T > 27.0\,GeV$)
- Probe selection:
  - For ID: tracks with $p_T > 10.0\,GeV$
  - For isolation: muon must pass the indicated ID requirement
- Fitting parameters
  - The invariant mass distribution for signal and background is fitted using the following functions:
  - signal: sum of two voigtians
  - background: CMSshape or exponential
- Z mass window
  - For ID: [70-130] GeV
  - For isolation: [77-130] GeV

The efficiency is computed for many working points based on quality requirements on the muon ID and ISO (more details in arXiv:1804.04528)

- Tight muon ID aims to suppress muons from decay in flight and from hadronic punch-through
- Relative muon Isolation: sum of the energy relative to the muon p_T in a geometrical cone ΔR surrounding it

Results

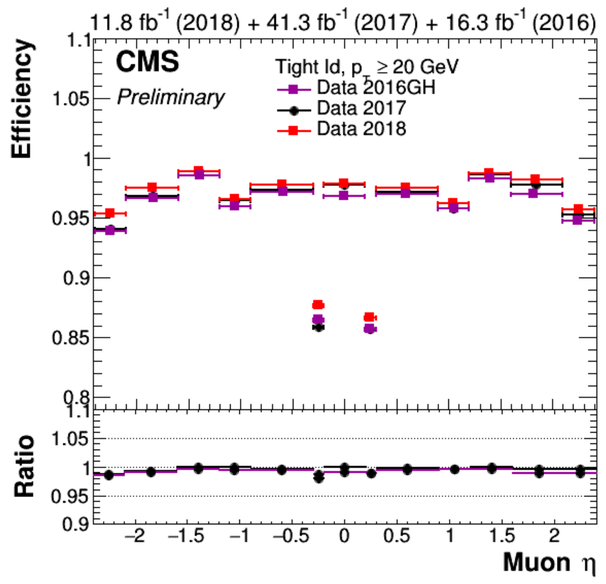


Figure 2: TightID efficiency vs η for the three run periods

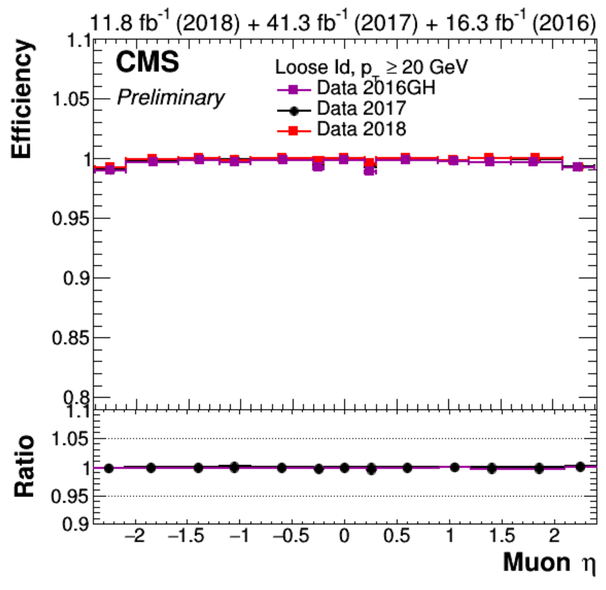


Figure 3: LooseID efficiency vs η for the three run periods

References

[1] The CMS Collaboration, "Muon identification and isolation efficiencies with2017 and 2018 data", CMS DP -2018/042, 04 July 2018.

[2] The CMS Collaboration, "Performance of the CMS muon detector and muon reconstruction with proton-proton collisions at $\sqrt{s} = 13$ TeV", JINST 13 (2018) P06015.