Tight Muon Reconstruction Efficiency

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Introduction

- Used Tag & Probe method to calculate the reconstruction efficiency of tight muon.

$$\varepsilon(\mu) = \varepsilon(\mu|\mathrm{ID})\times\varepsilon(\mathrm{ID}) \cong \varepsilon(\mu|\mathrm{ID})\times\varepsilon(\mathrm{ID}|\mathrm{MS})$$

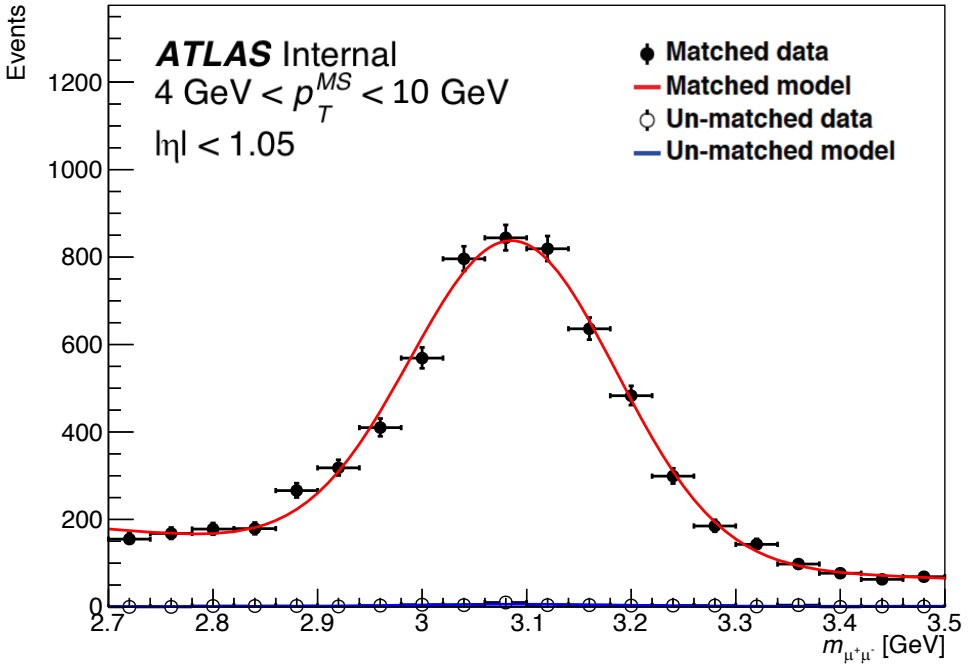
- $\varepsilon(\mu|\mathrm{ID})$ Muon Reconstruction efficiency with respect to inner detector.
- $\varepsilon(\mathrm{ID}|\mathrm{MS})$ Inner Detector efficiency with respect to muon chamber.
- Event Selection:
  - Trigger mu3 || mu8 || mu10
  - GRL
  - At least 1 primary vertex
- $\varepsilon(\mathrm{ID}|\mathrm{MS})$ match: MS track with an ID track dR < 0.2
- $\varepsilon(\mu|\mathrm{ID})$ match: ID track with a reconstructed muon dR < 0.01
- Probe tracks Selection:
  - Opposite charge with tag
  - ID tracks: Muon ID Selections (No TRT)
  - MS tracks: No Selections
- Invariant mass window
  - for data: J/ψ 2.6 -3.6 GeV
  - for mc: J/ψ 2.6 -3.6 GeV

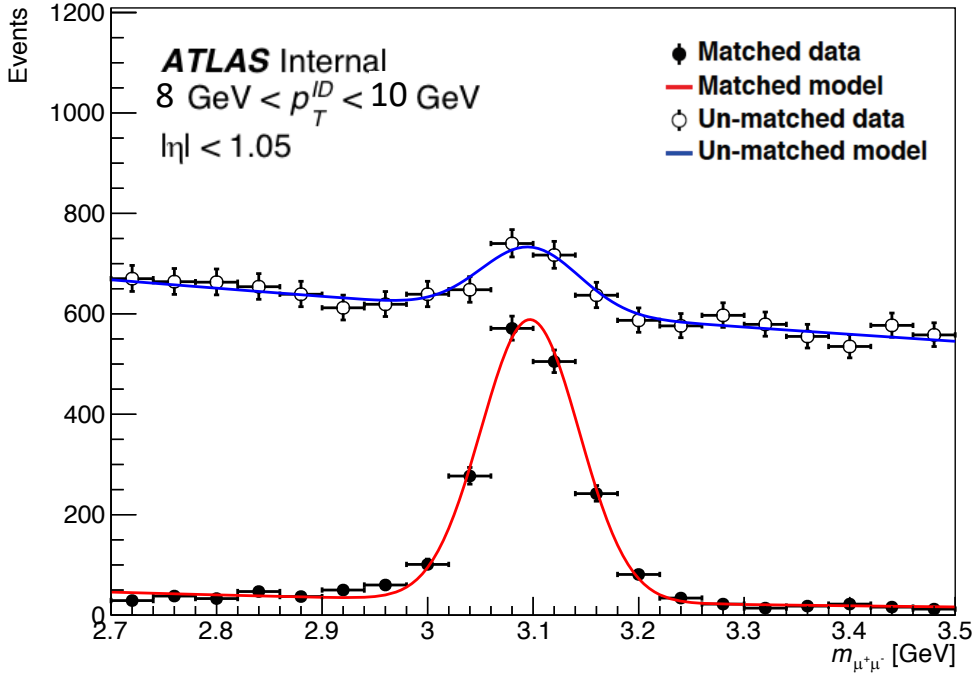
- Data: 2018 Pb-Pb Hard Probe Stream Data at 5.02 TeV
- Monte Carlo:Pythia8B with Prompt J/psi to Muons with Heavy Ion Overlay. mc16_5TeV:mc16_5TeV.300000.Pythia8BPhotospp_A14_CTEQ6L1_pp_Jpsimu2p5mu2p5.merge.AOD.e4973_d1521_r11472_r11217

Tag & Probe Fitting

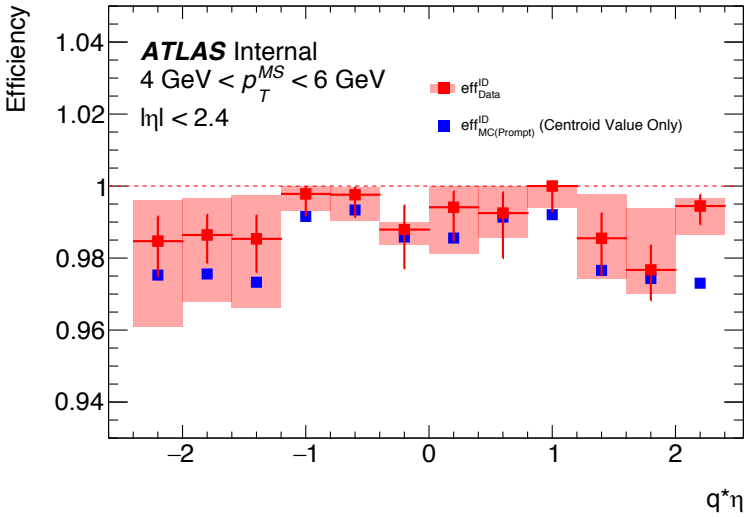
- Efficiency centroid values extraction
  - Invariant mass of matched and unmatched samples are fitted simultaneously (signal has same mean and sigma for matched and unmatched).
  - $N_{match} = N_{tot} * \varepsilon * Sig(mass) + N_{bkg1} * Bkg1(mass)$
  - $N_{unmatch} = N_{tot} * (1-\varepsilon) * Sig(mass) + N_{bkg2} * Bkg2(mass)$
  - The fitting outputs N_{tot} and ε.

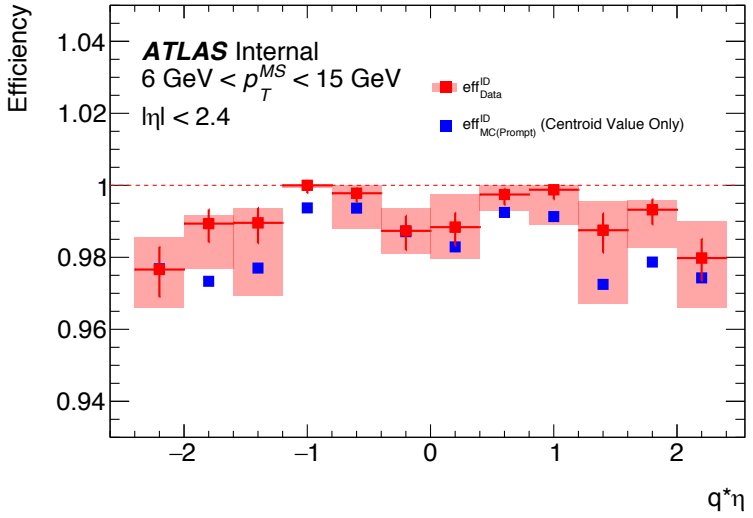
Sig(mass): Gaus
Bkg(mass): Exponential

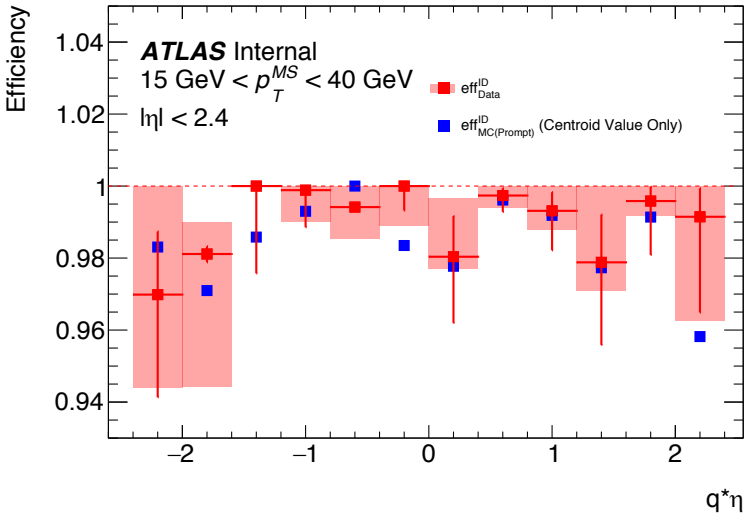


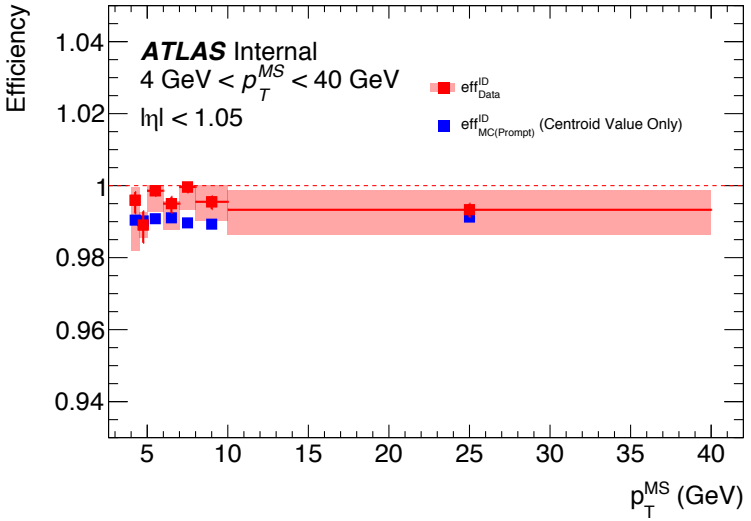


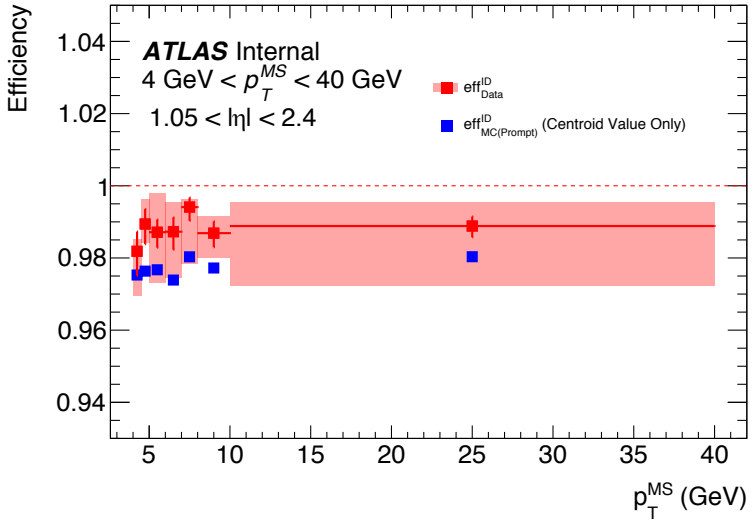
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ Nominal Values





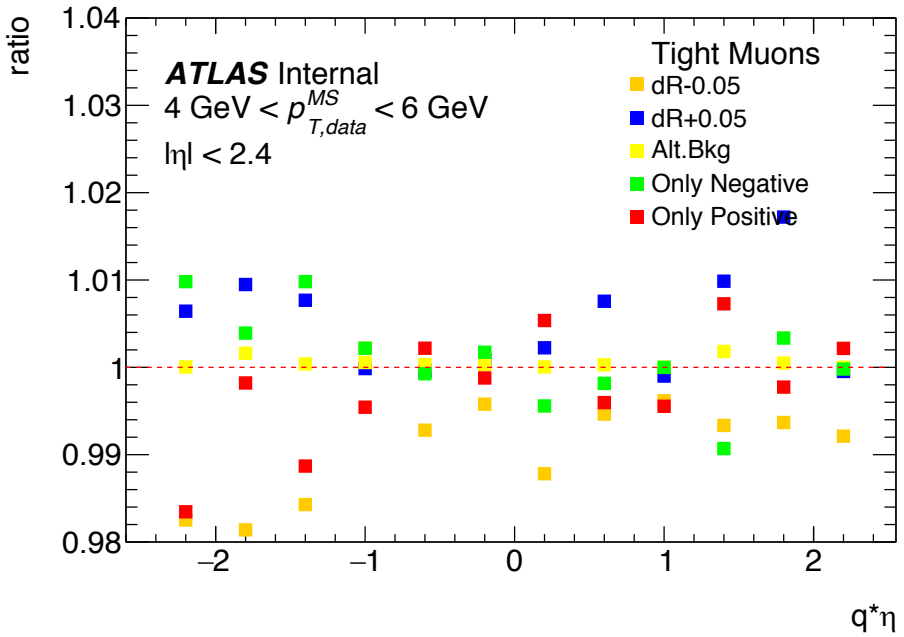


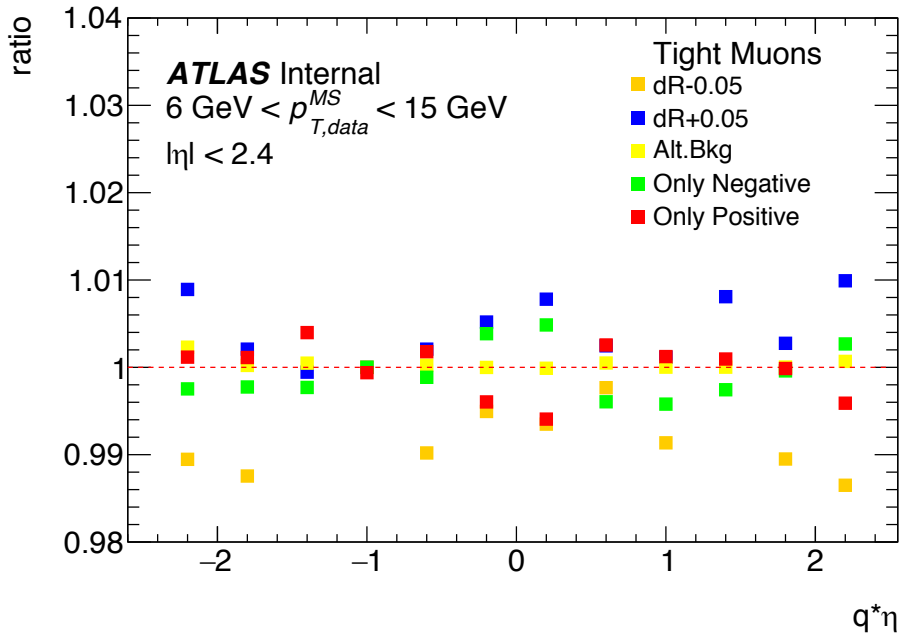


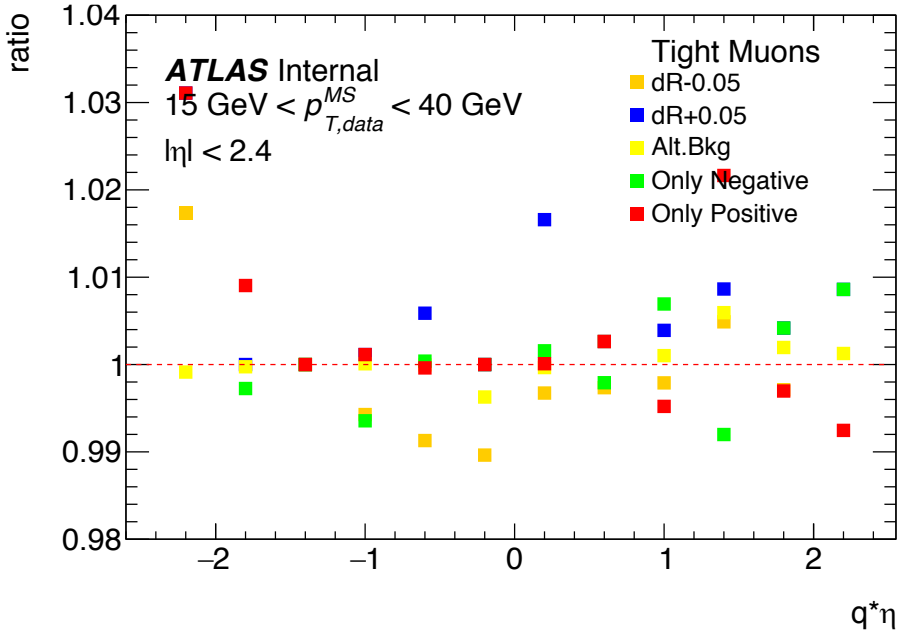


- Systematics = Sqrt(Sum($\delta(varying\ parameters)^2$))

Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs q*eta, Ratio of Variations in Parameters to Nominal Values

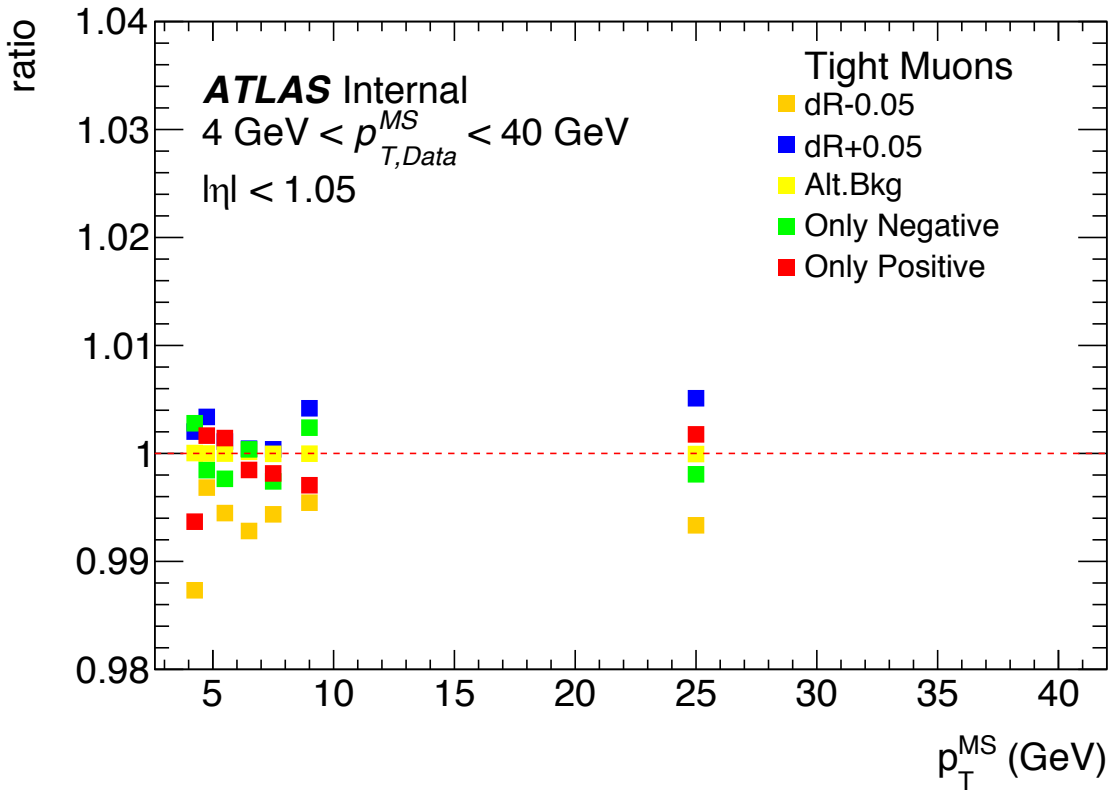


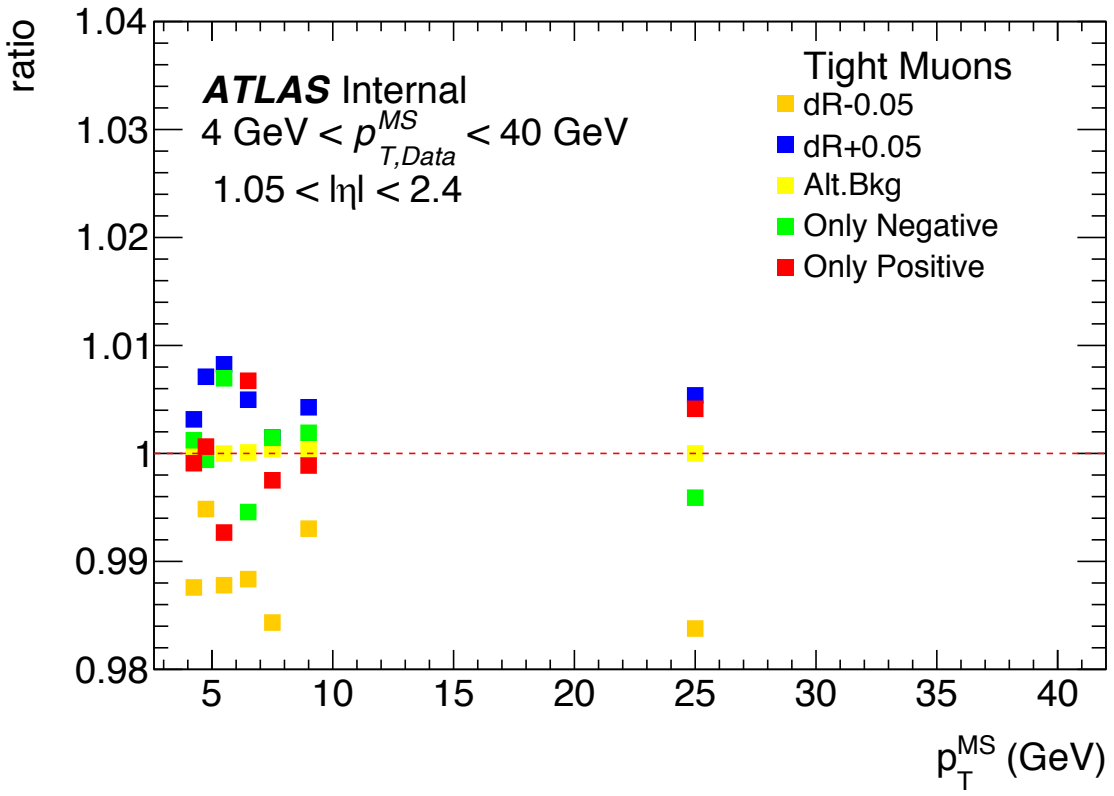




- dR +/-0.05: increase/decrease the minimum dR criteria by 0.05, nominal values are taken at dR = 0.2
- Alt. Bkg: change the background model for fitting, nominal values are taken using exponential function, alternative values are taken using Chebyshev polynomials.
- Only positive/negative: using only positively/negatively charged tracks. Nominal values use both tracks.

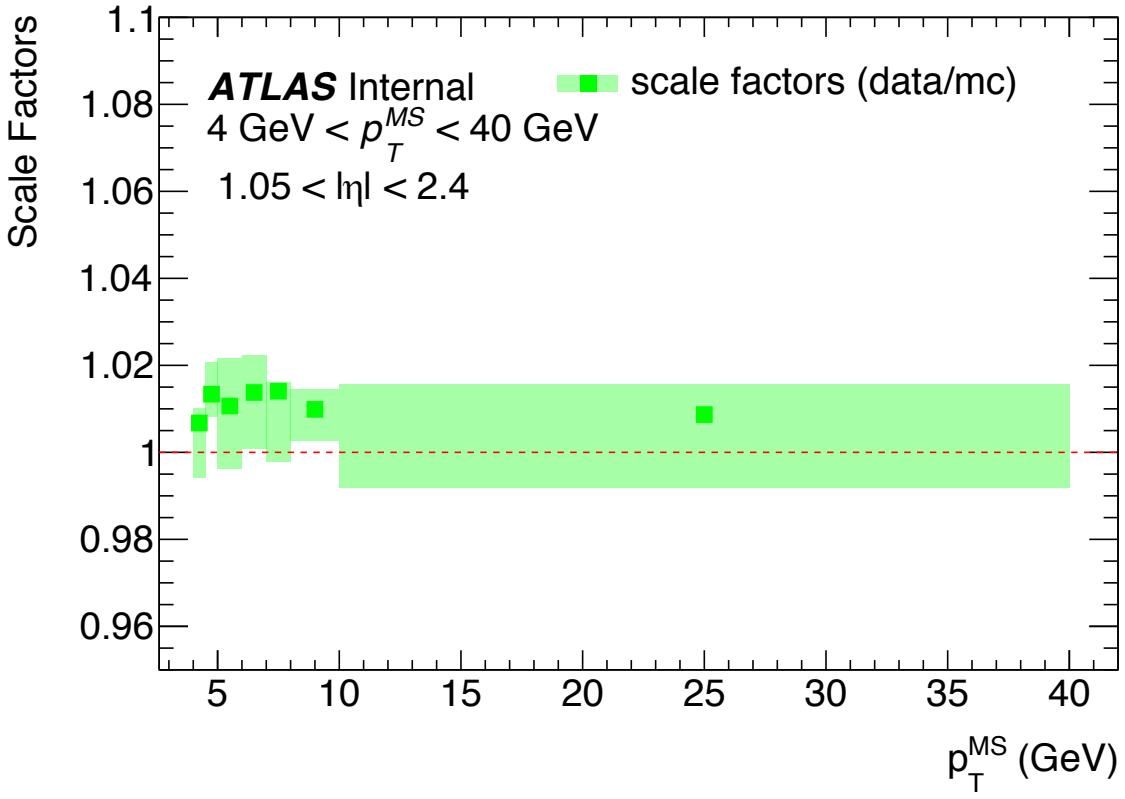
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs p_T^{MS}, Ratio of Variations in Parameters to Nominal Values

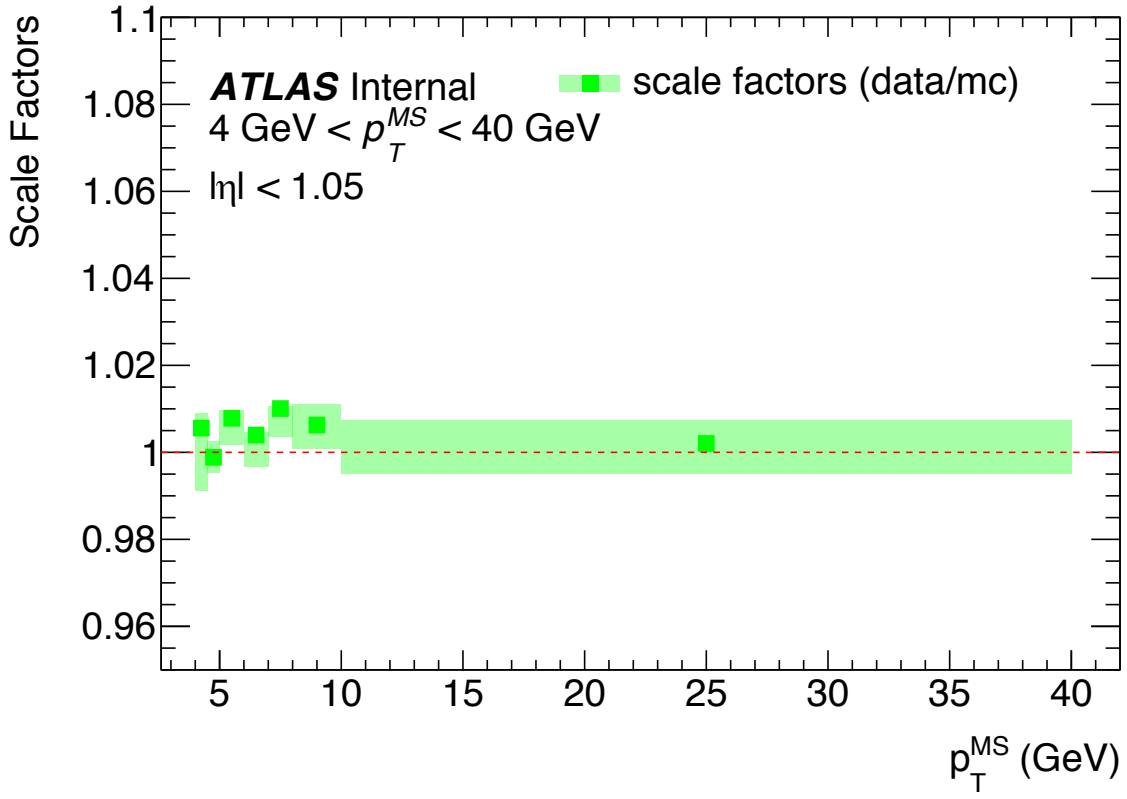




- Largest contribution to systematics come from varying dR.

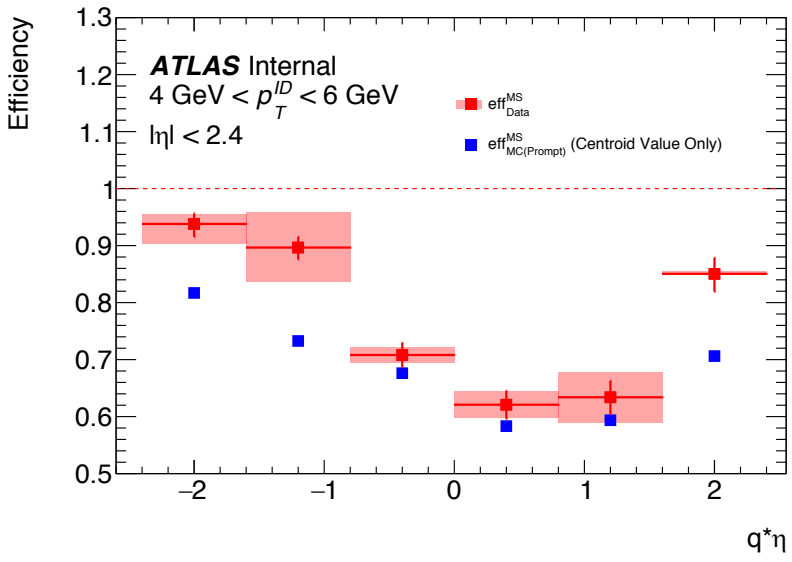
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ Scale Factors

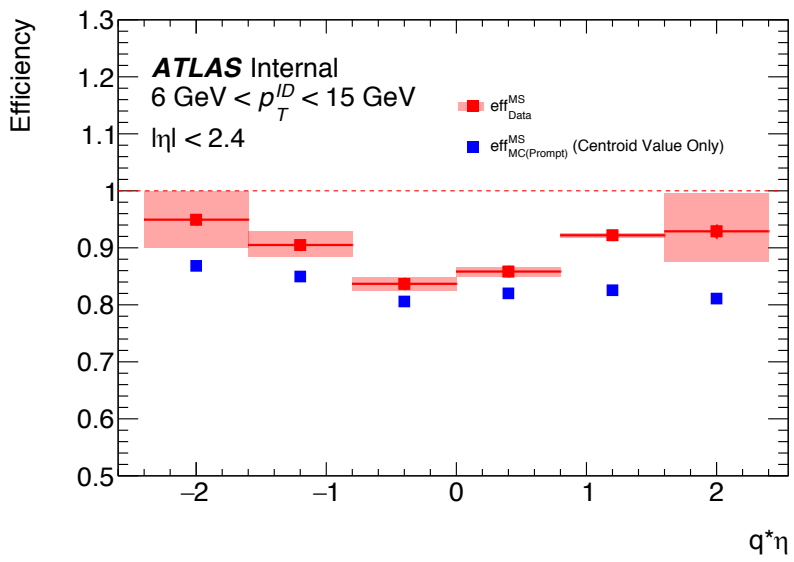


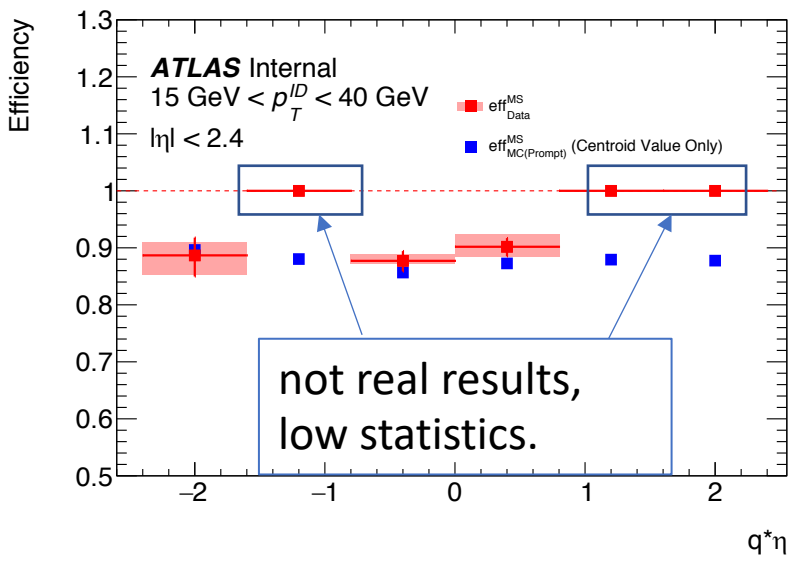


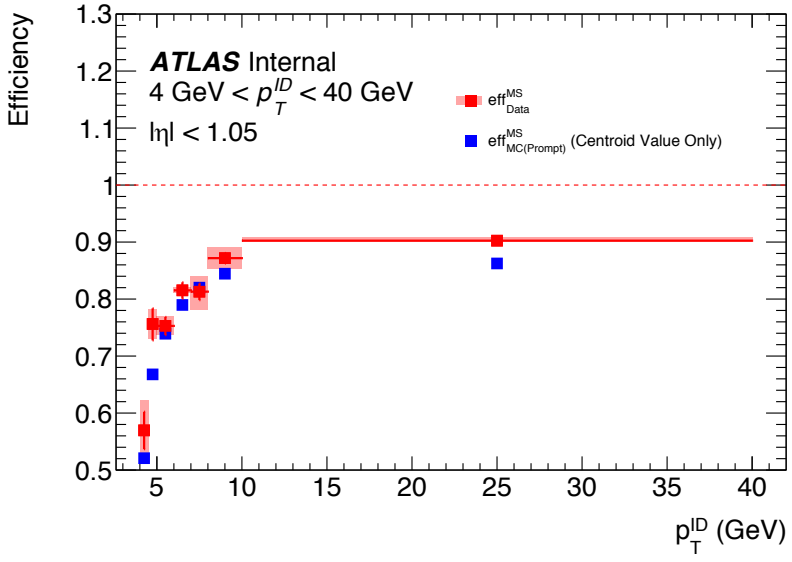
- Scale factors centroid values = Data centroid values/MC centroid values.
- Scale factor systematics = Data systematics/MC centroid values.
- Scale factors are distributed around 1.01.

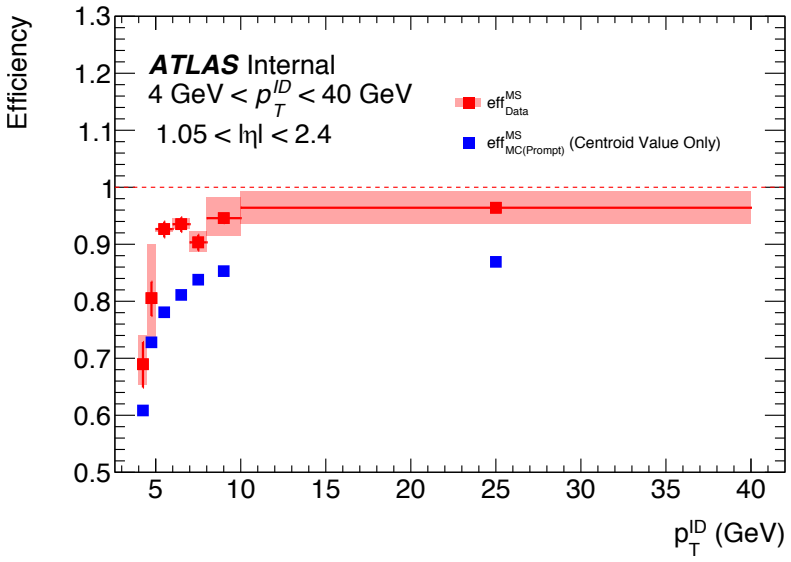
Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ Nominal Values





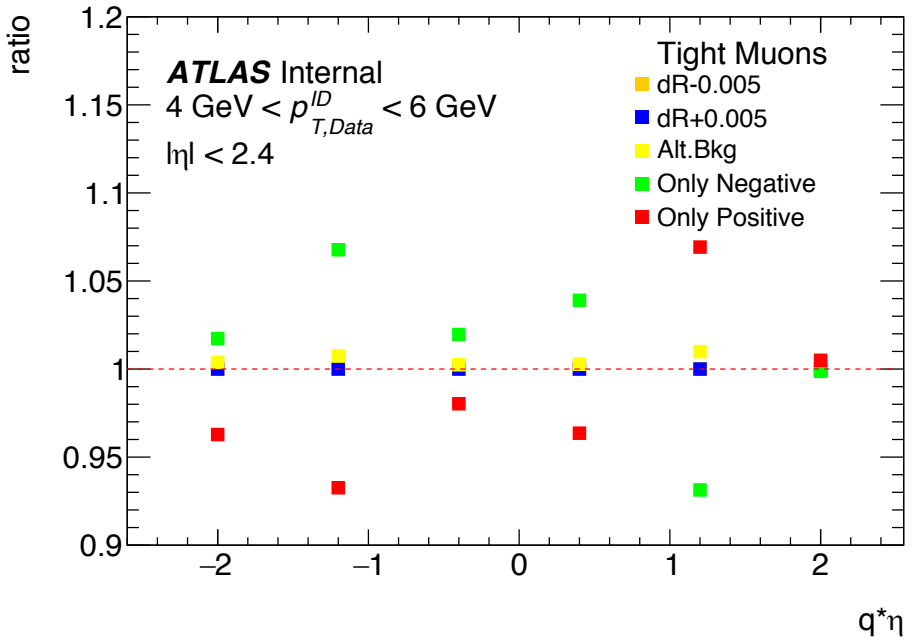


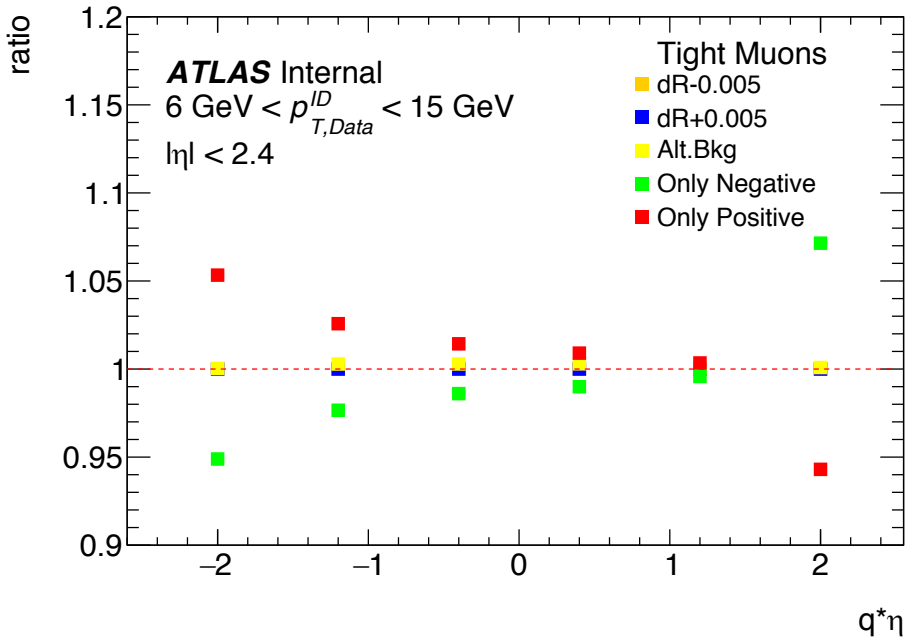


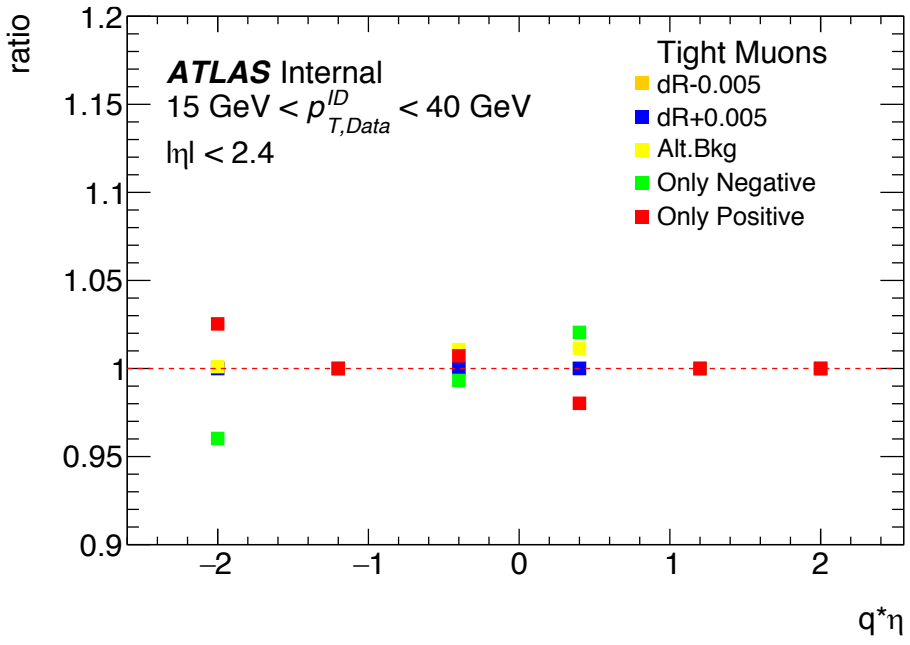


- Systematics = Sqrt(Sum($\delta(varying\ parameters)^2$))

Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ vs q*eta, Ratio of Variations in Parameters to Nominal Values







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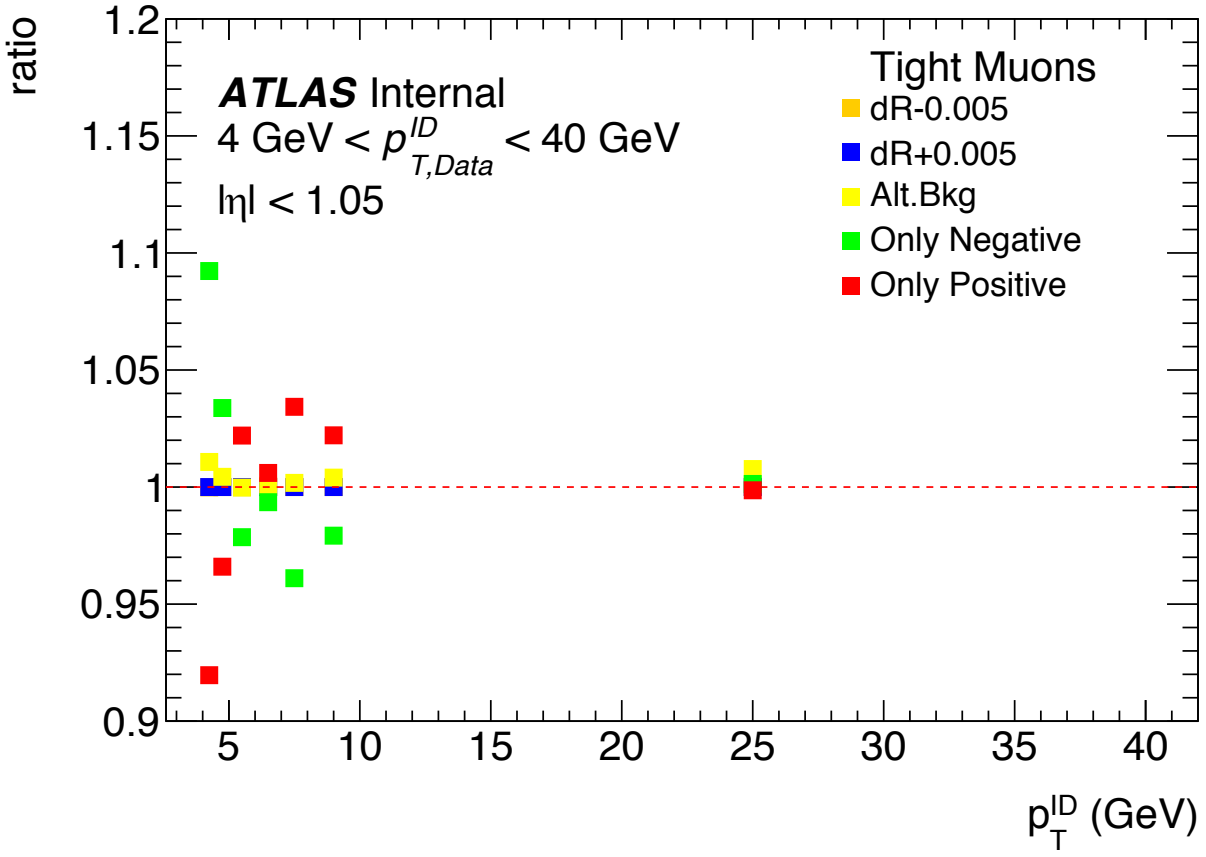
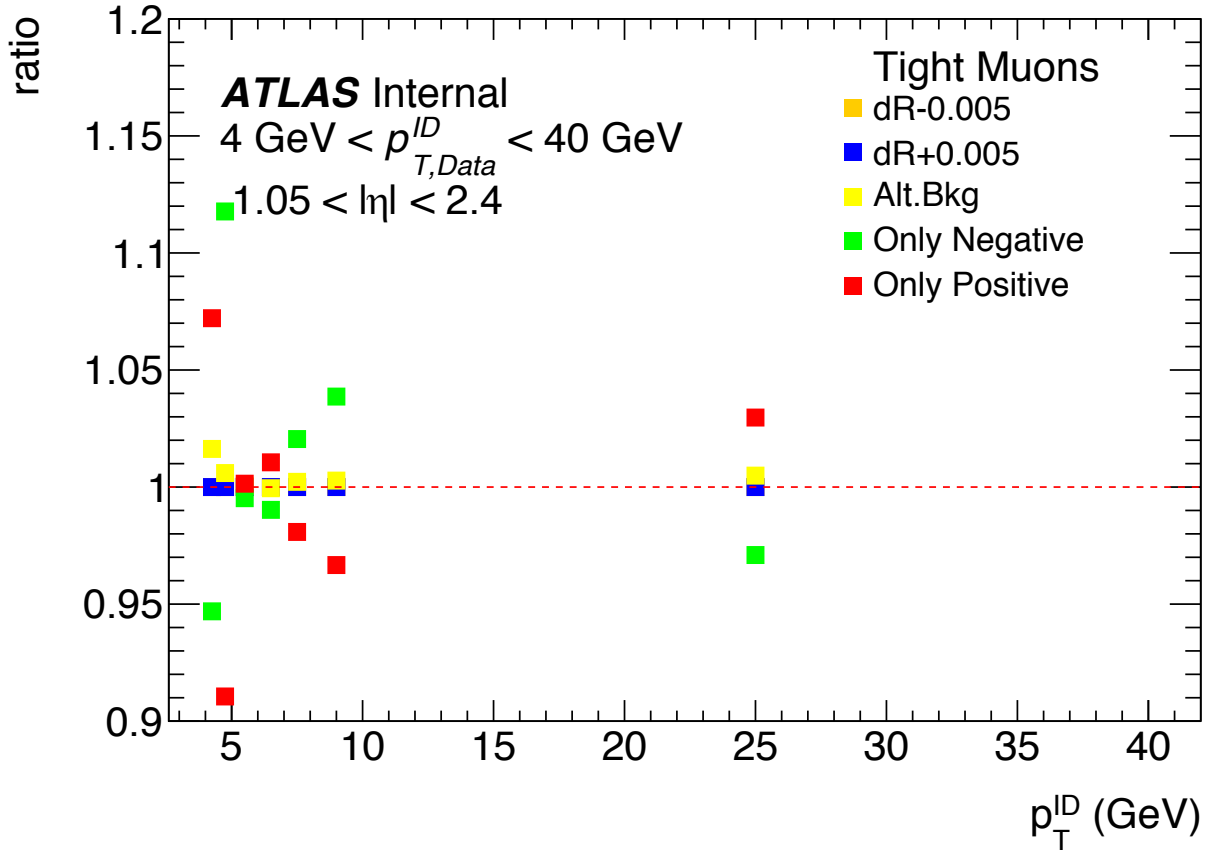
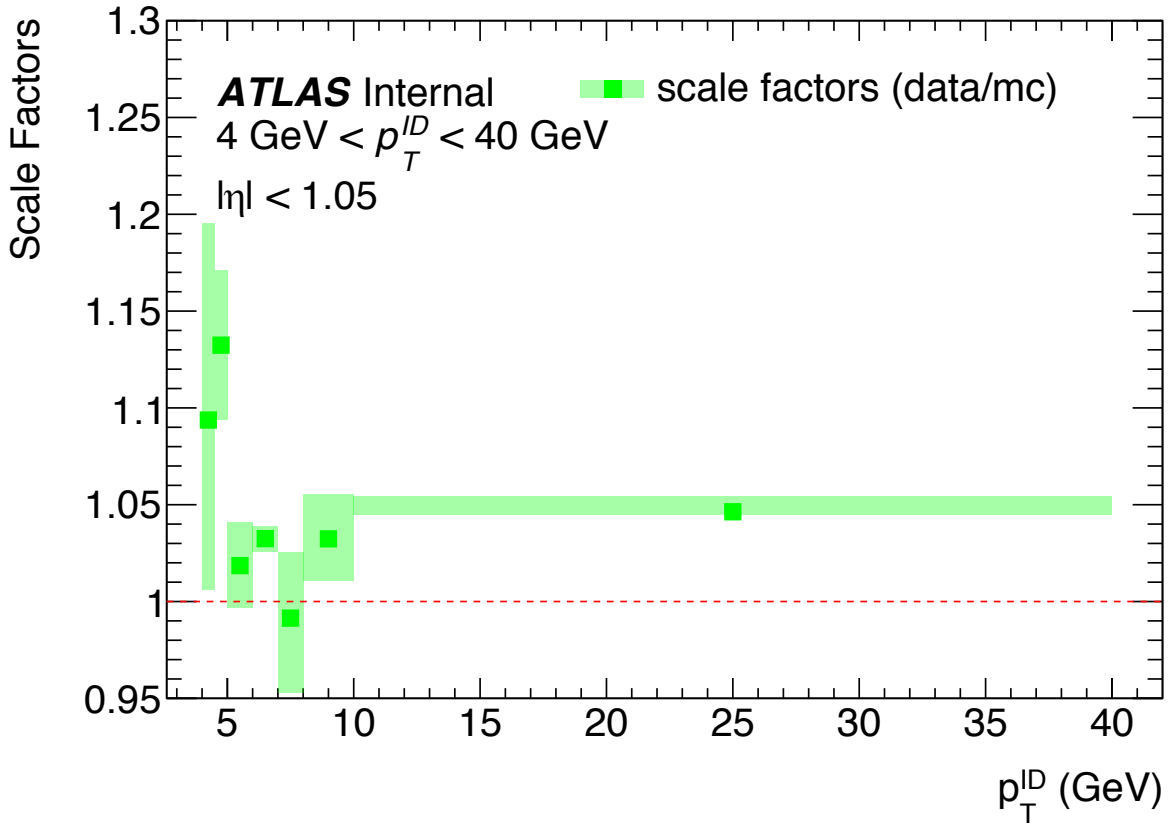
Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ vs q*eta, Ratio of Variations in Parameters to Nominal Values

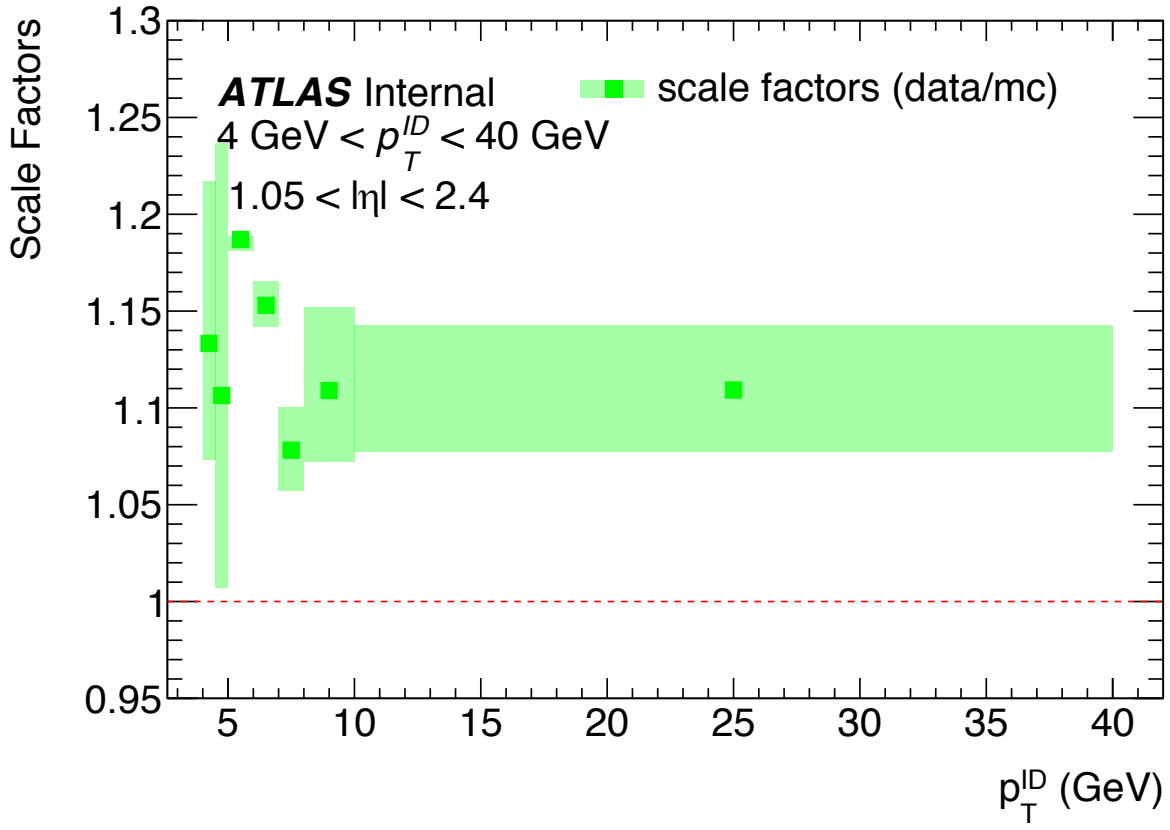




- Largest contribution to systematics come from separating charges.

Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ Scale Factors





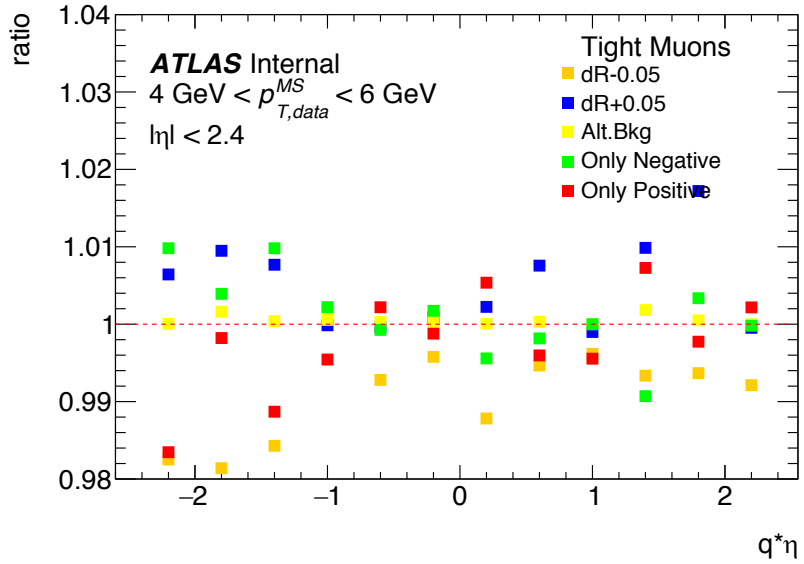
- Scale factors centroid values = Data centroid values/MC centroid values.
- Scale factor systematics = Data systematics/MC centroid values.
- Scale factors are distributed around 1.05 for barrel region, and 1.10 for end cap region.

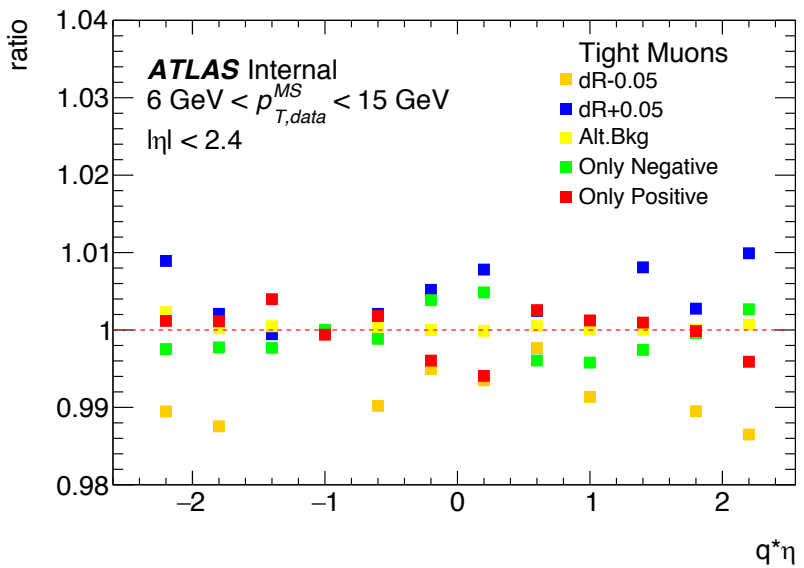
Conclusions

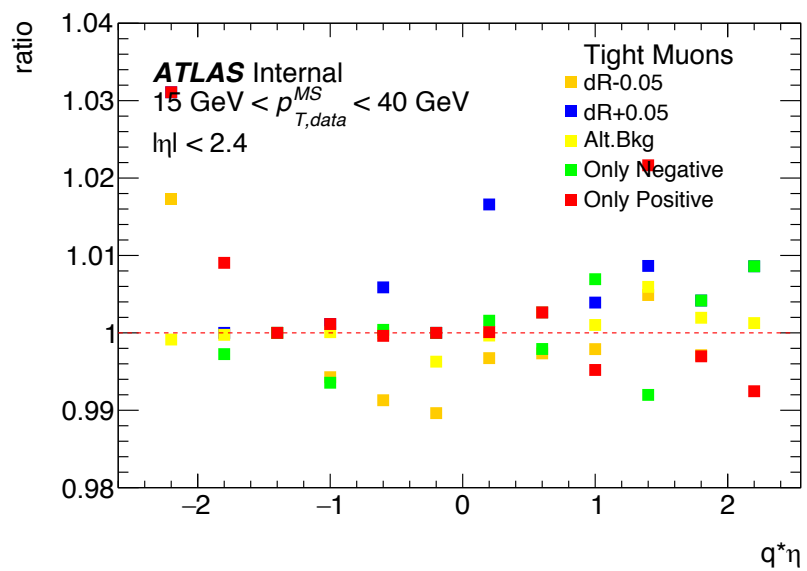
- Using 2018 Pb-Pb Hard Probe Stream Data at 5.02 TeV and Pythia8B with Prompt J/psi to Muons with Heavy Ion Overlay, scale factors are calculated for $\varepsilon(\mu|\mathrm{ID})$ and $\varepsilon(\mathrm{ID}|\mathrm{MS})$
- For both barrel region and end cap region , $\varepsilon(\mathrm{ID}|\mathrm{MS})$ has scale factors around 1.01.
- For barrel region, $\varepsilon(\mu|\mathrm{ID})$ has scale factors around 1.05, and for end cap region, $\varepsilon(\mu|\mathrm{ID})$has scale factors around 1.10.
- We plan to use these values for our b-tagging analysis.

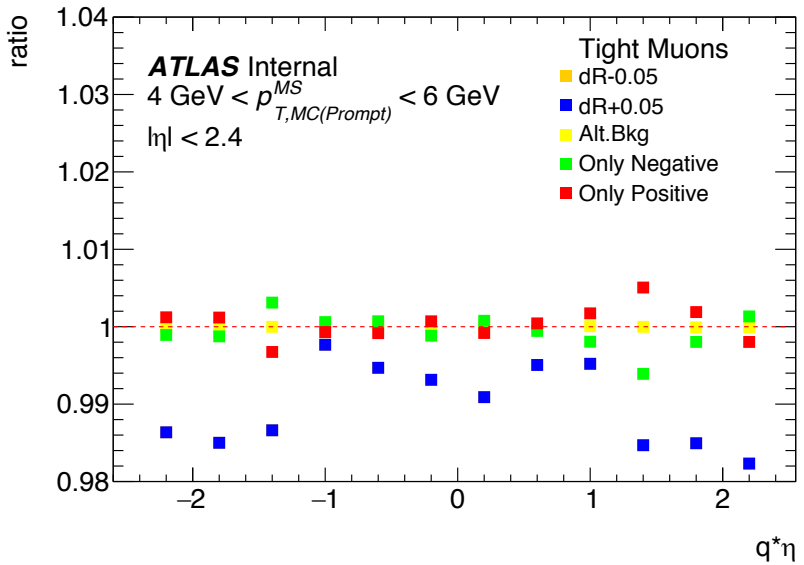
Backup

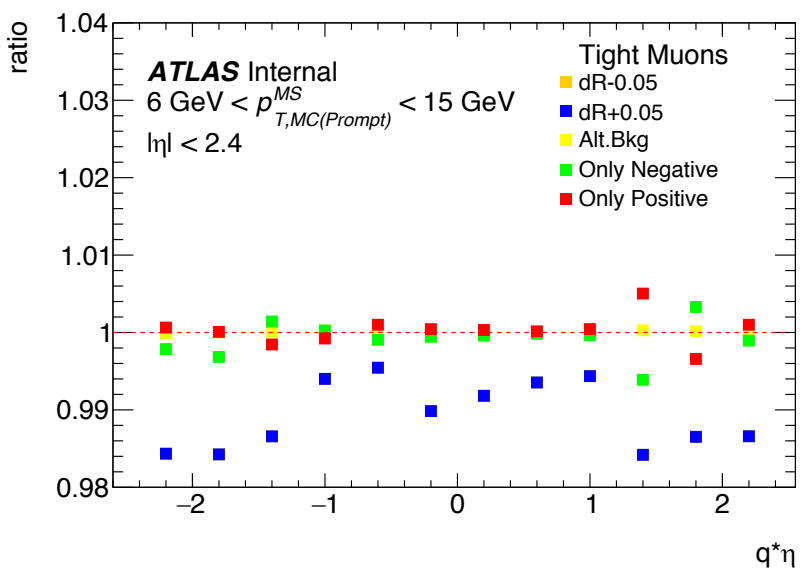
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs q*eta, Ratio of Variations in Parameters to Nominal Values

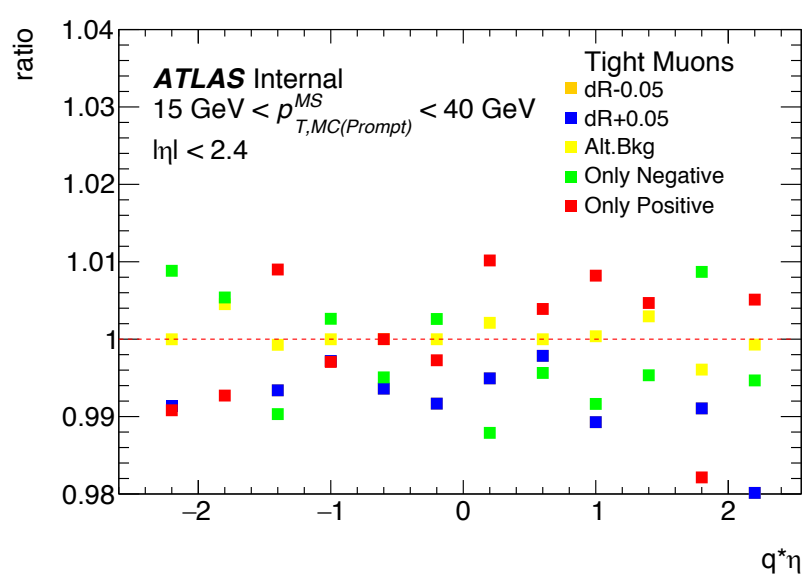




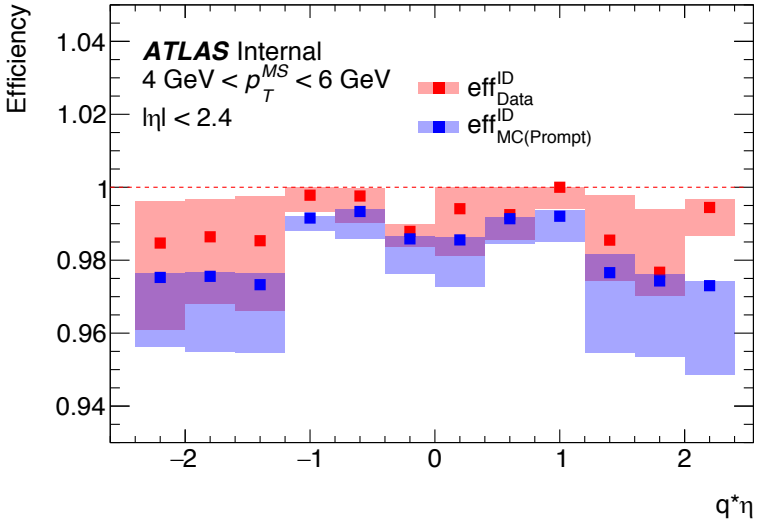


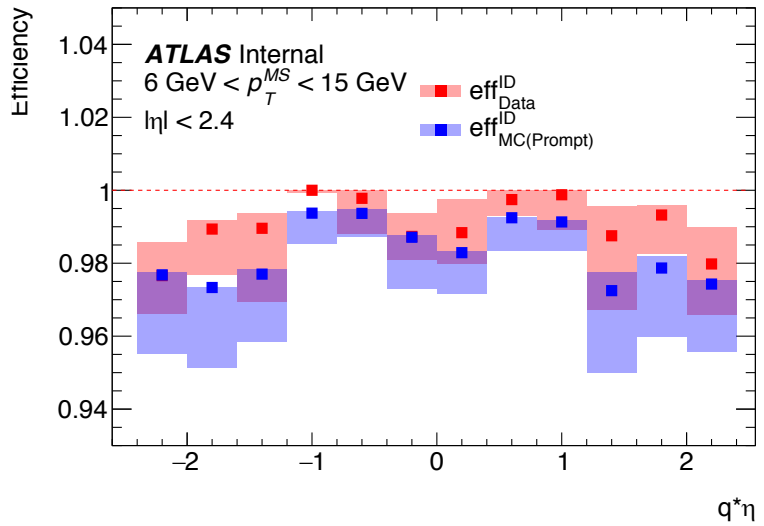


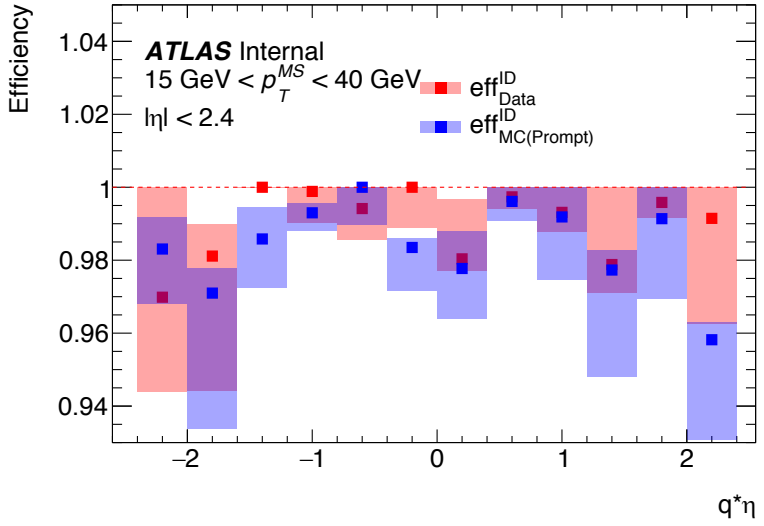


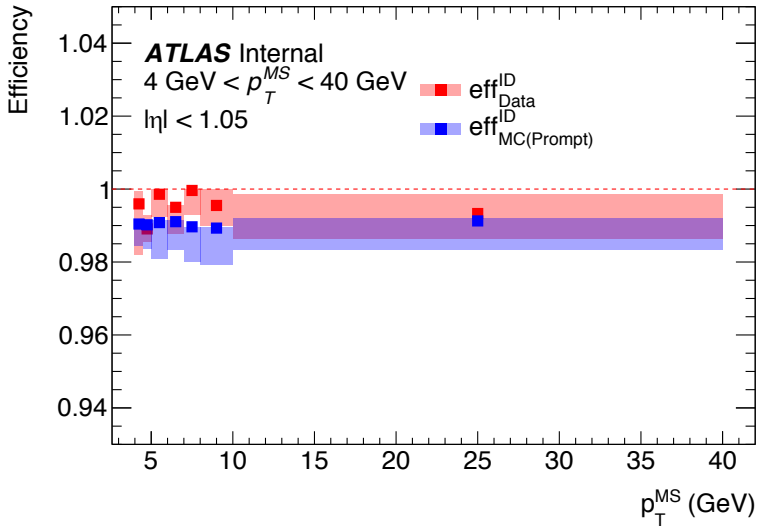


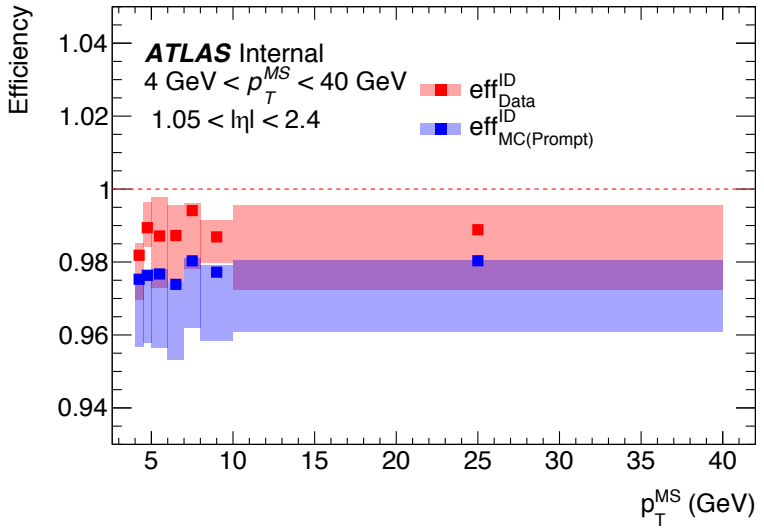
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ Nominal Values with Systematics





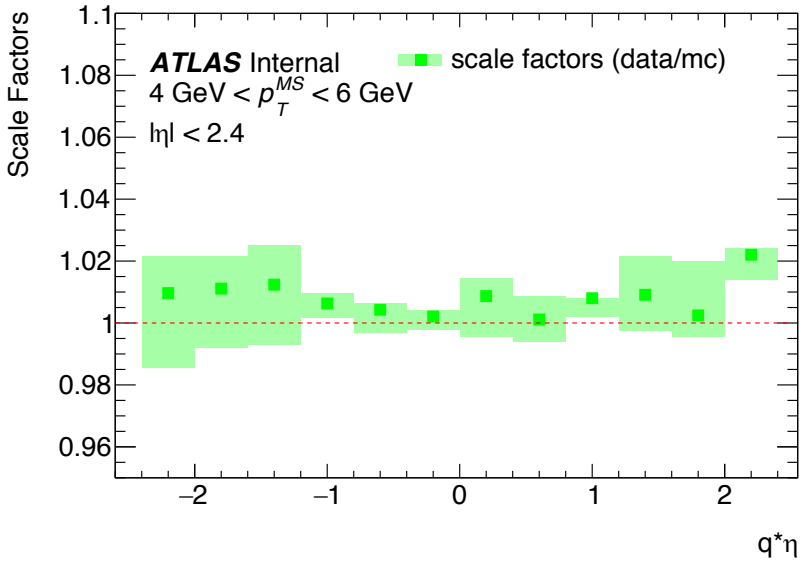


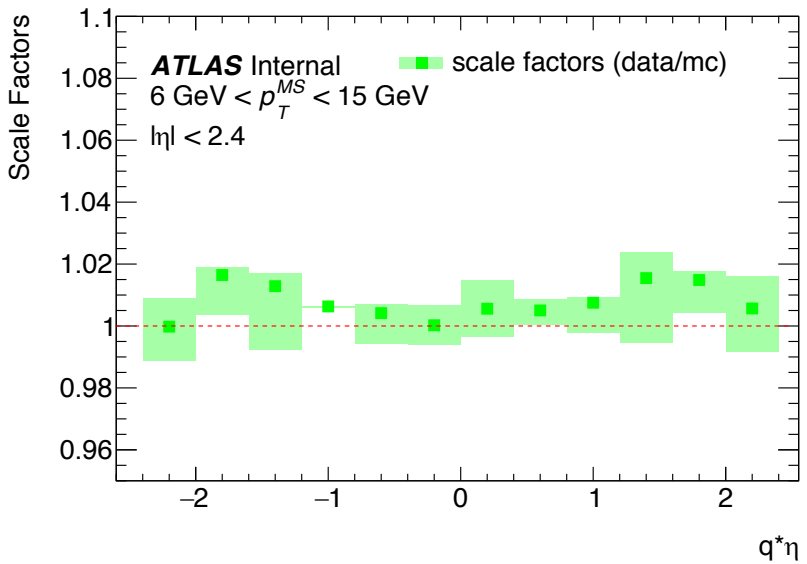


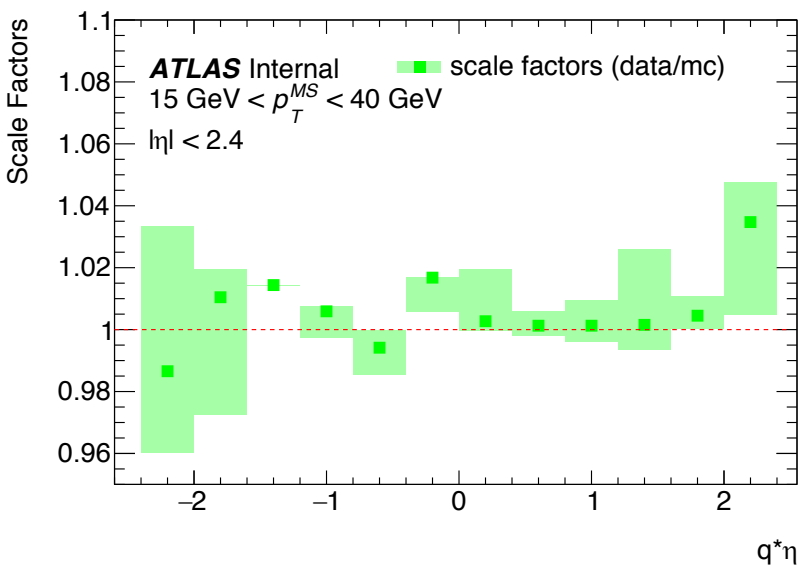


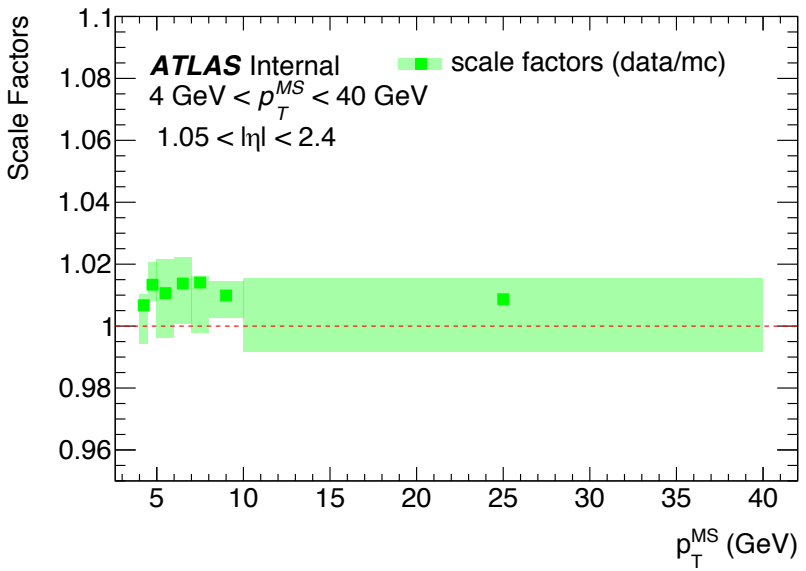
- Systematics = Sqrt(Sum($\delta(varying\ parameters)^2$))

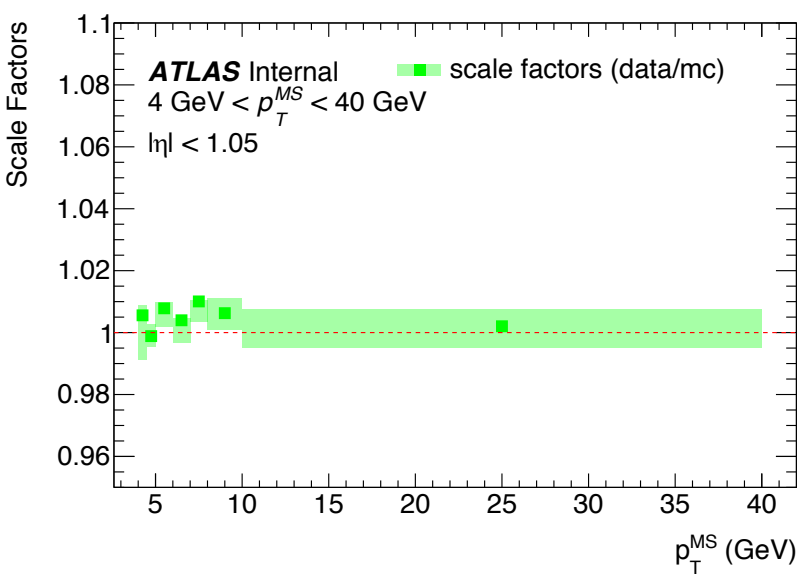
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ Scale Factors





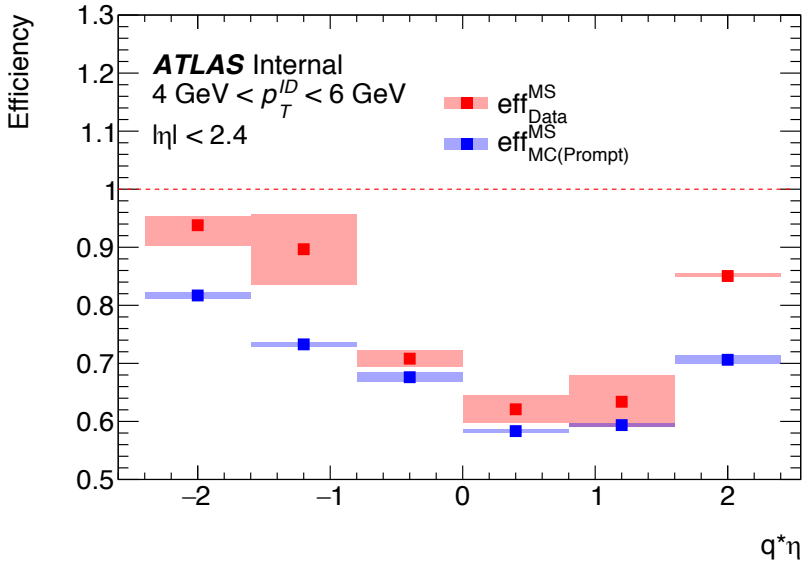


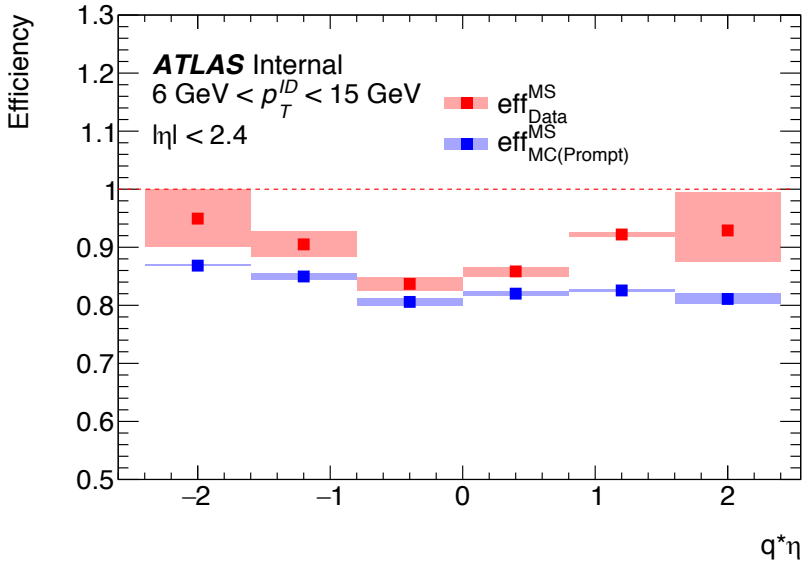


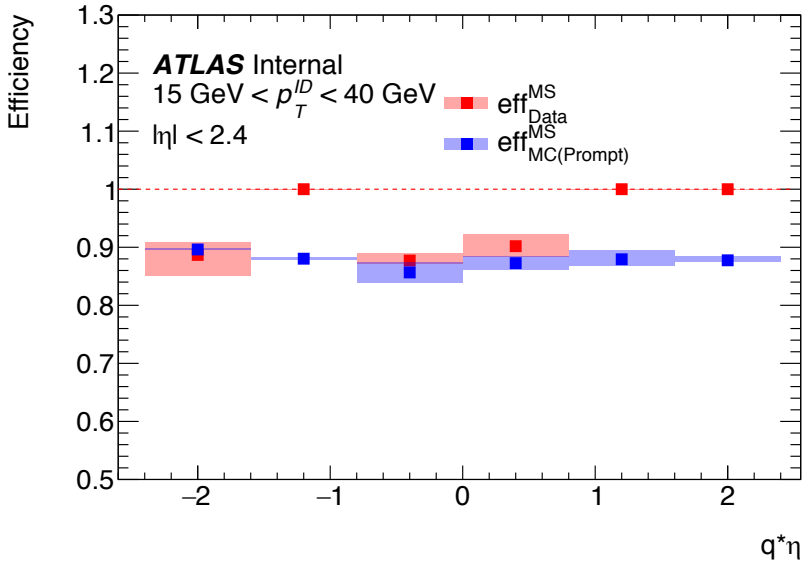


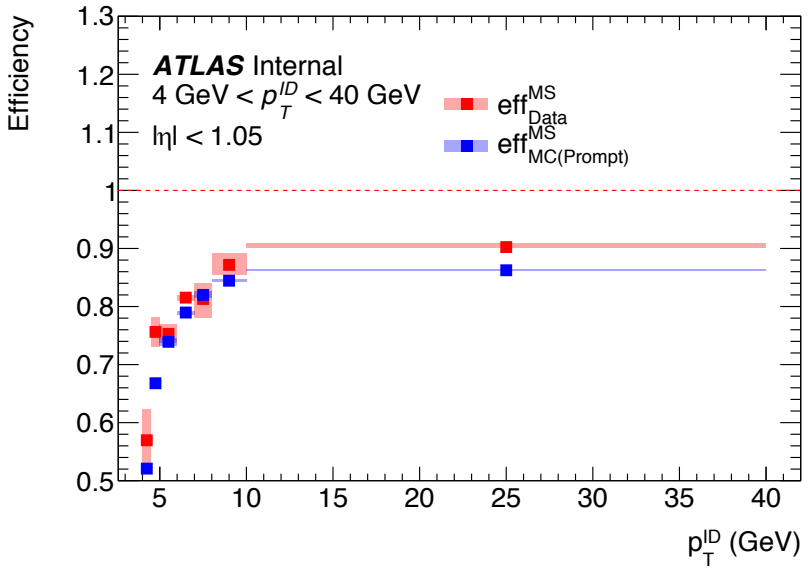
- Scale factors are distributed around 1.01.

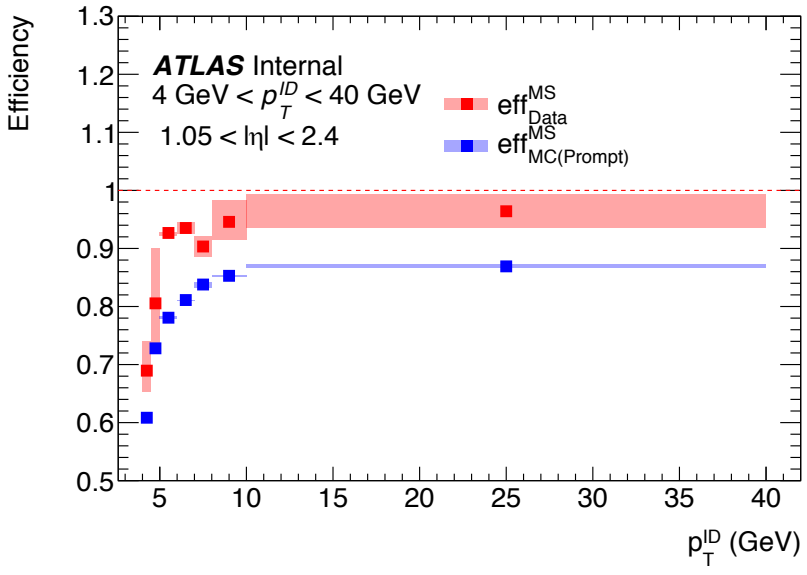
Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ Nominal Values with Systematics





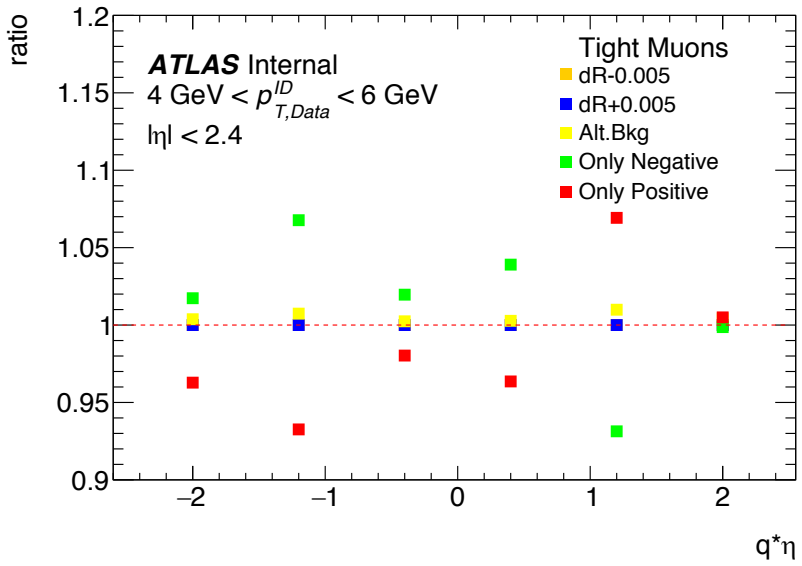


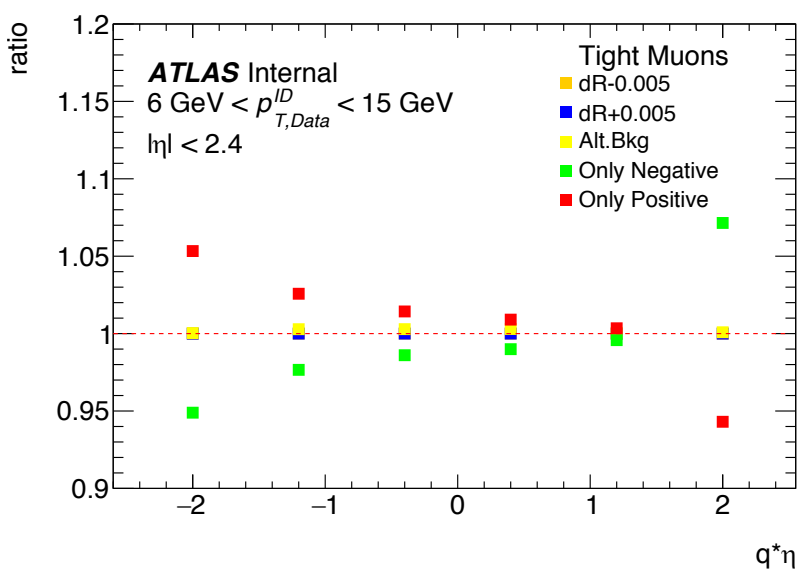


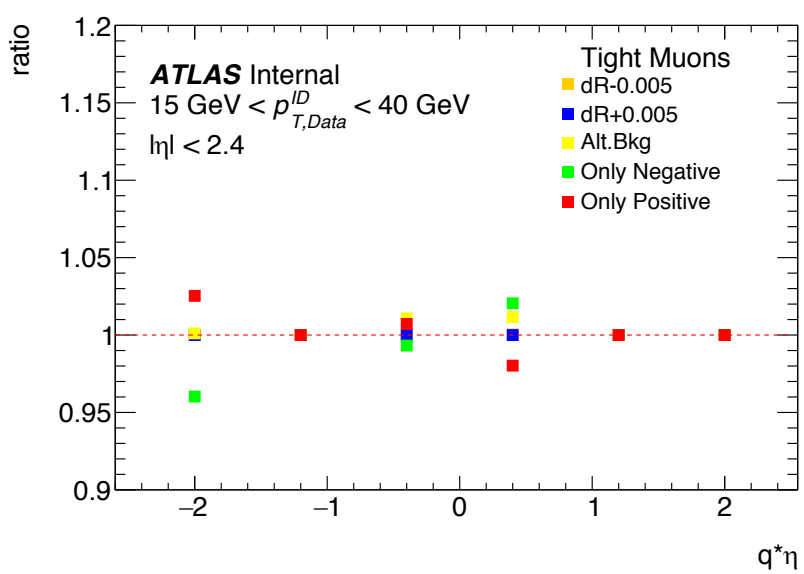


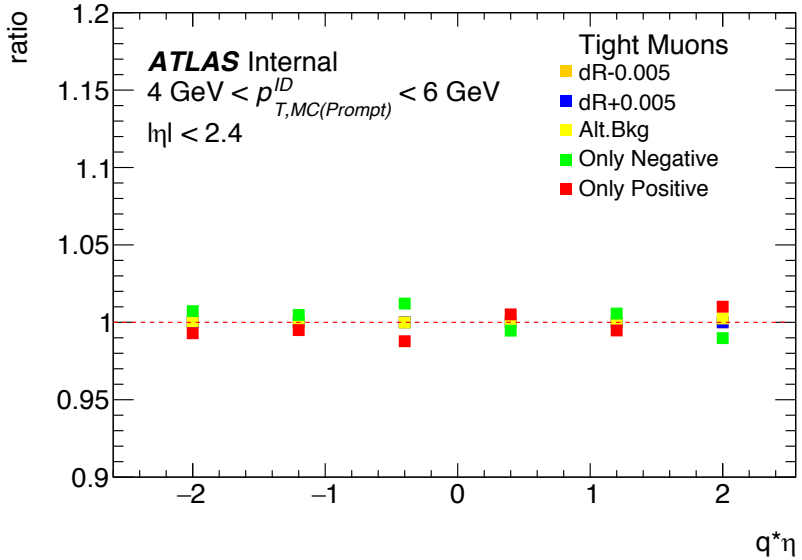
- Systematics = Sqrt(Sum($\delta(varying\ parameters)^2$))

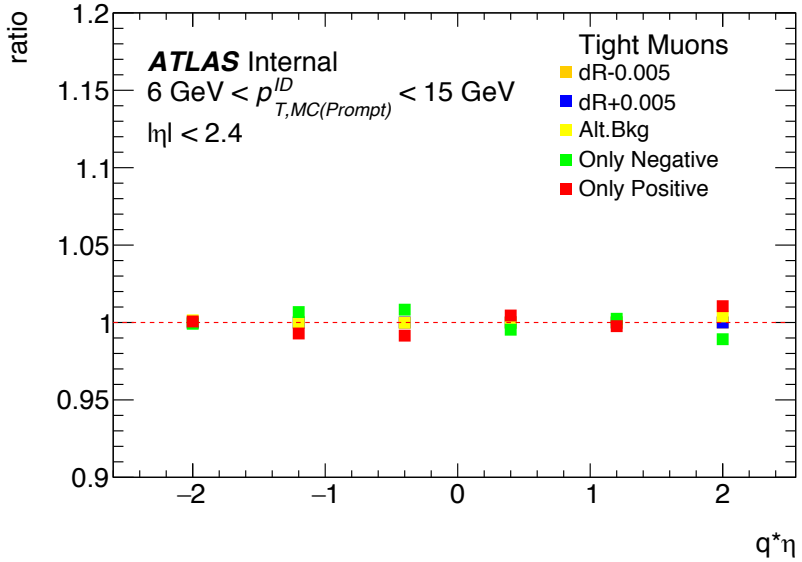
Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ vs q*eta, Ratio of Variations in Parameters to Nominal Values

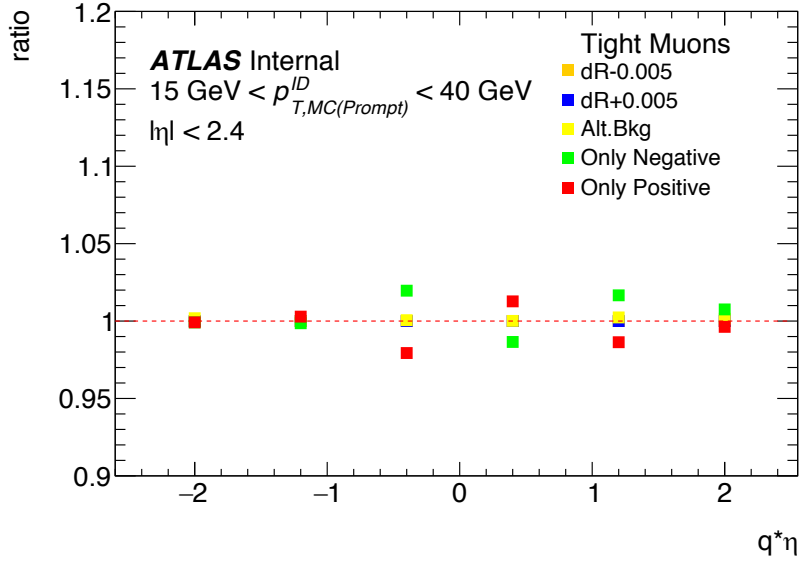




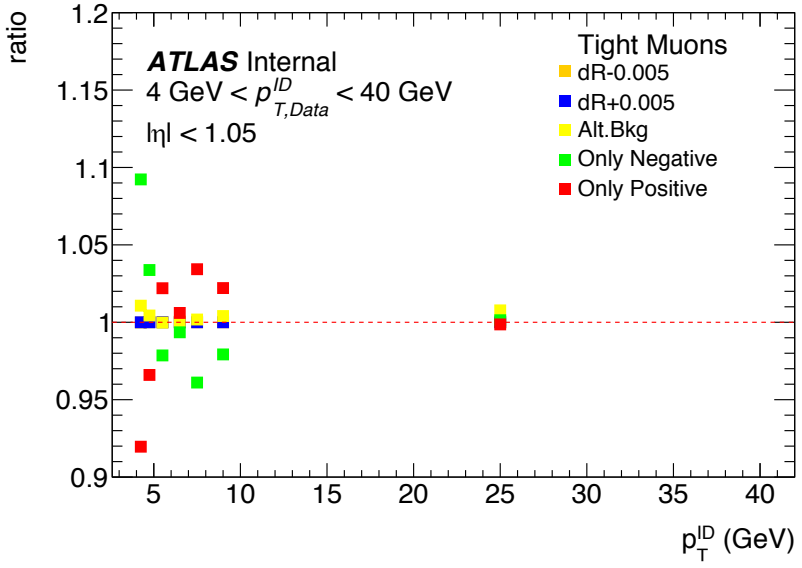


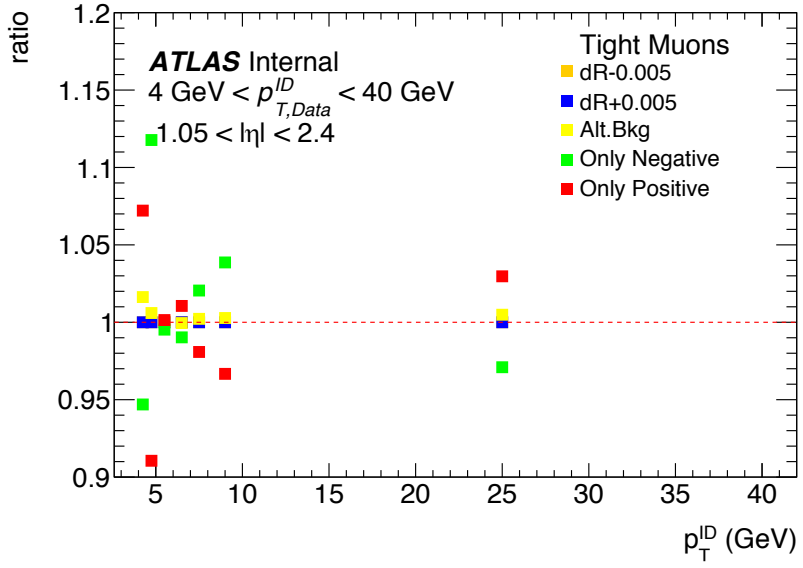


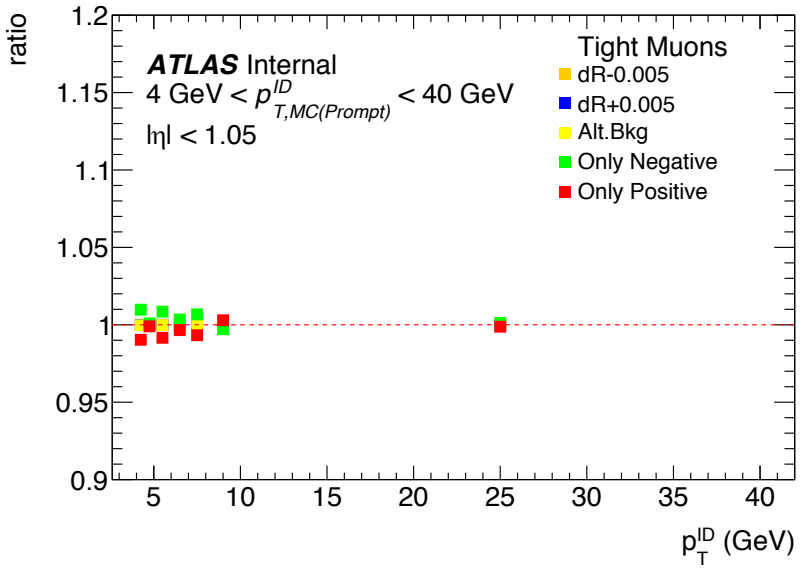


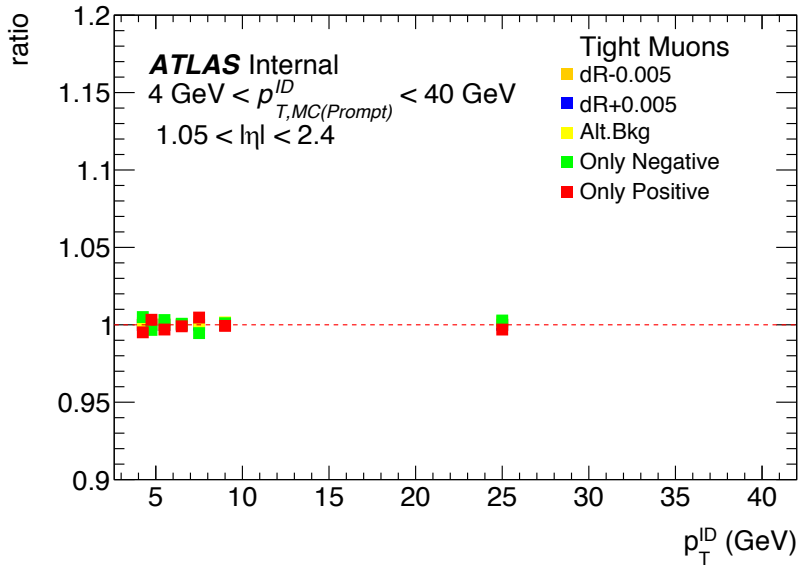


Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ vs q*eta, Ratio of Variations in Parameters to Nominal Values



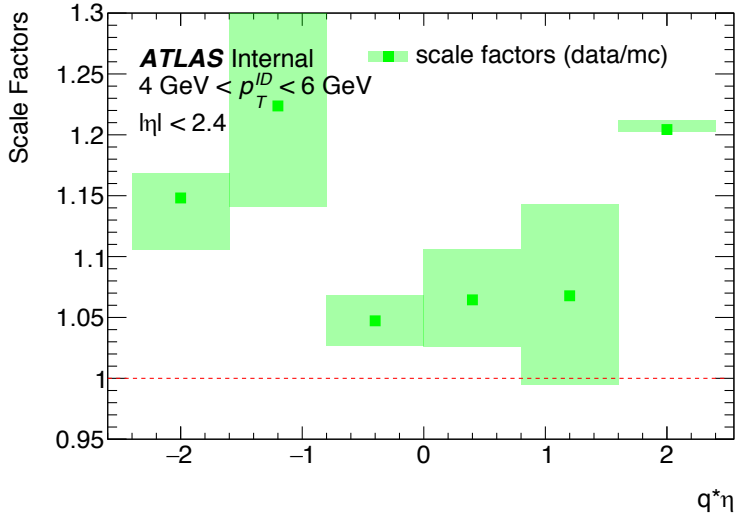


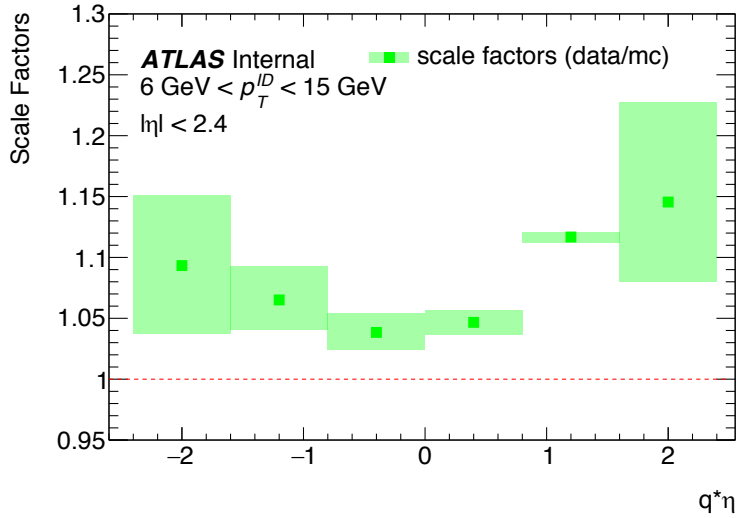


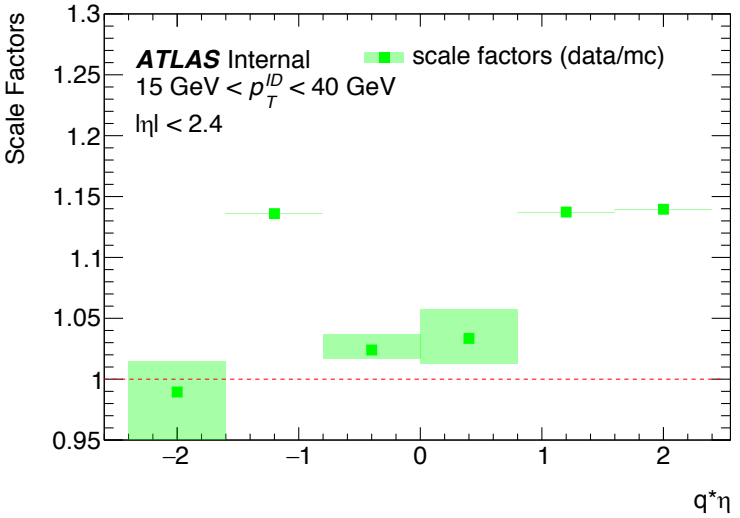


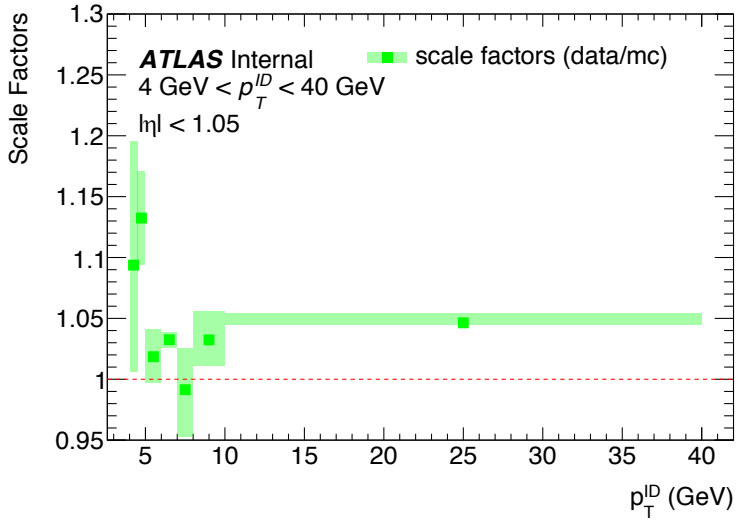
- Largest contribution to systematics come from separating charges.

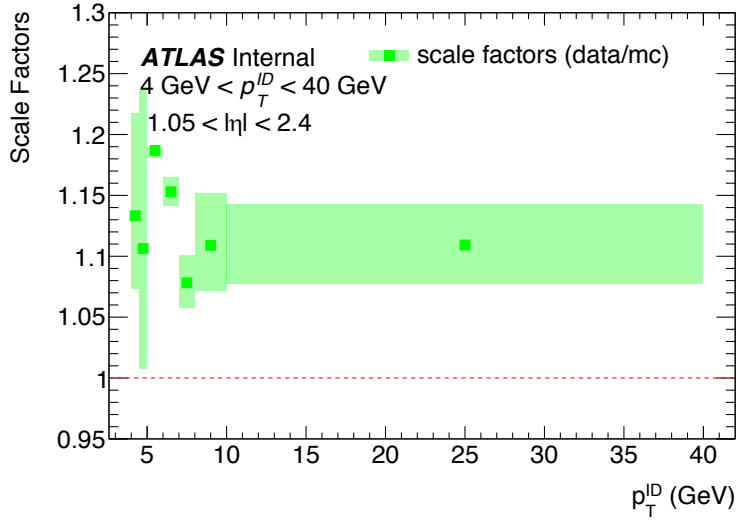
Muon reconstruction efficiency $\varepsilon(\mu|\mathrm{ID})$ Scale Factors



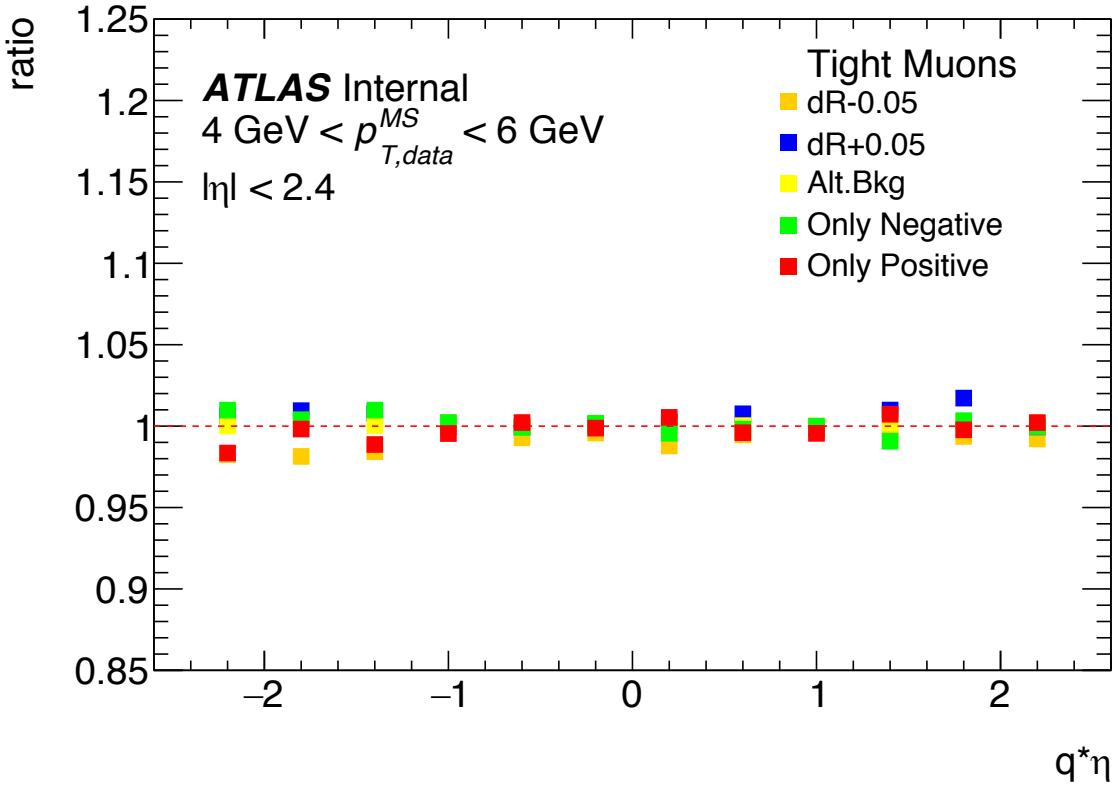


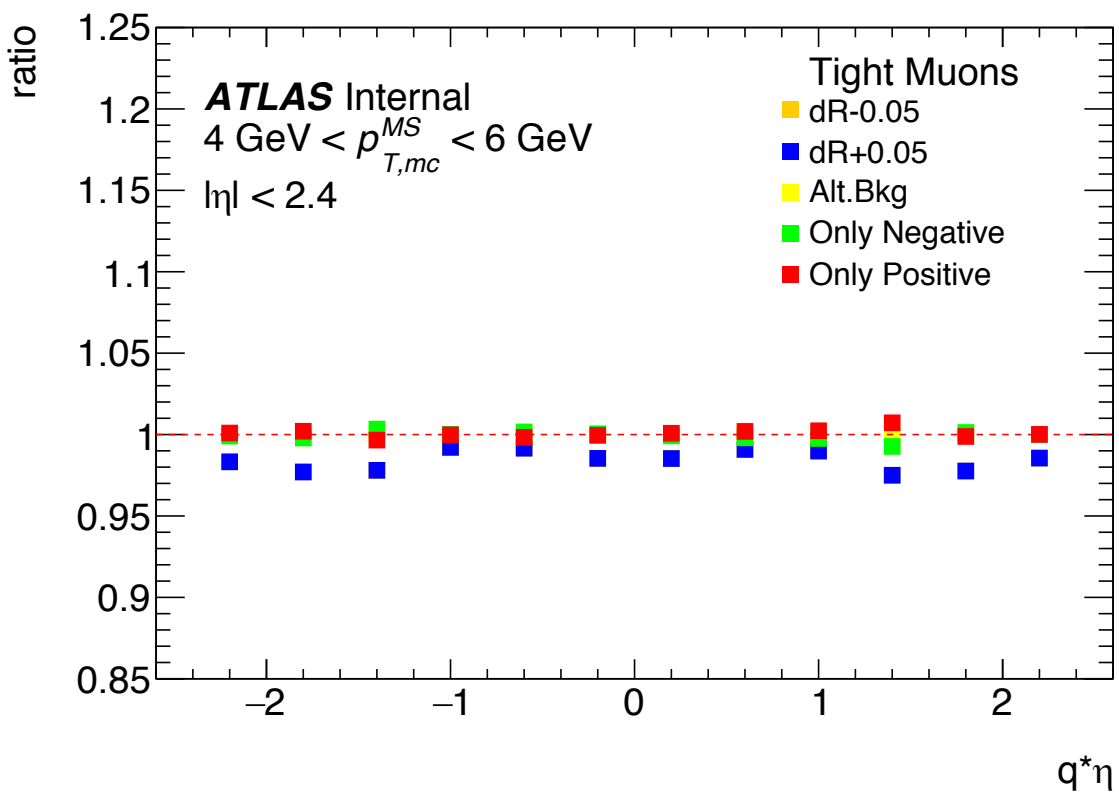






Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs q*eta, low pt regime, using MC upsilon

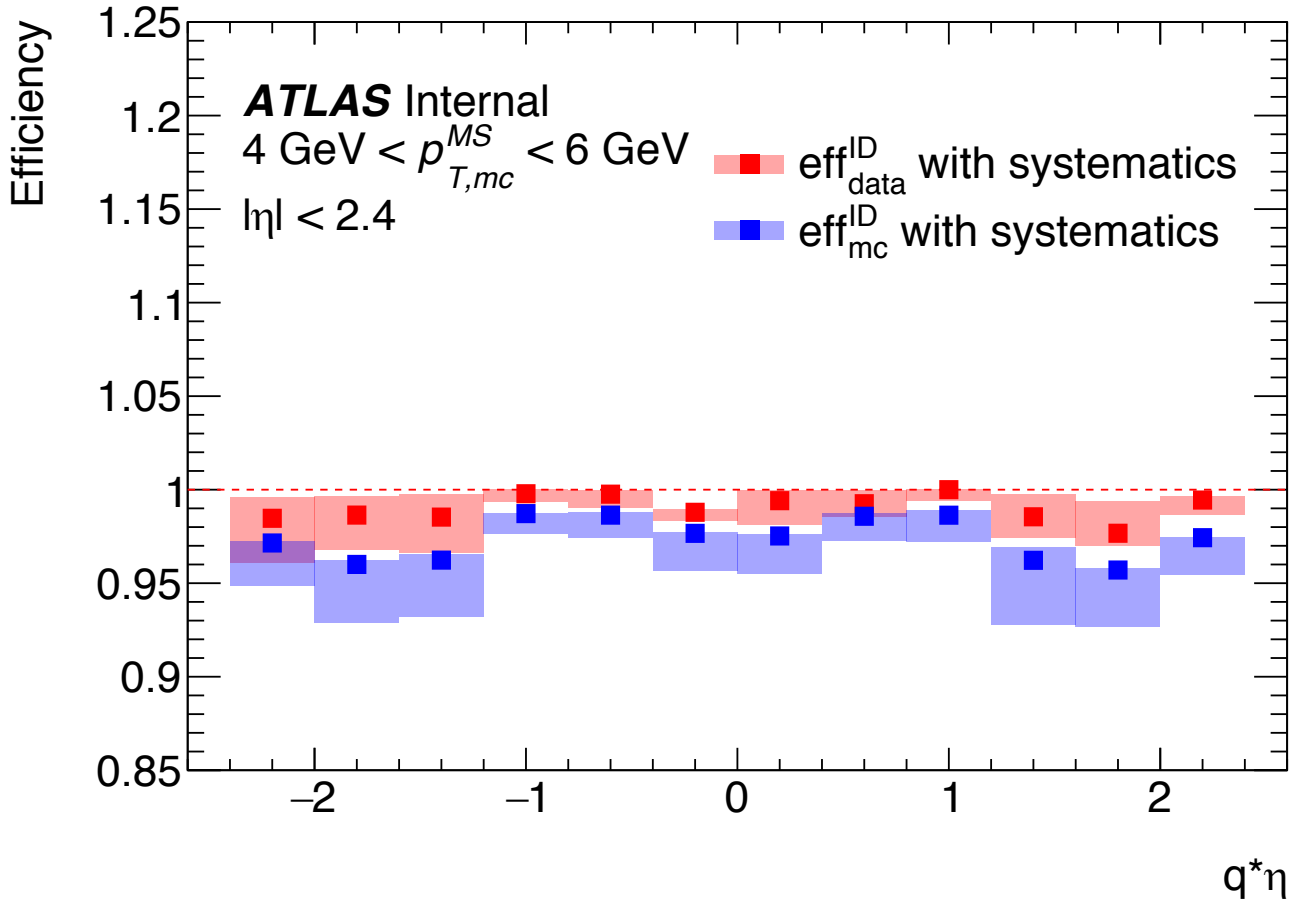




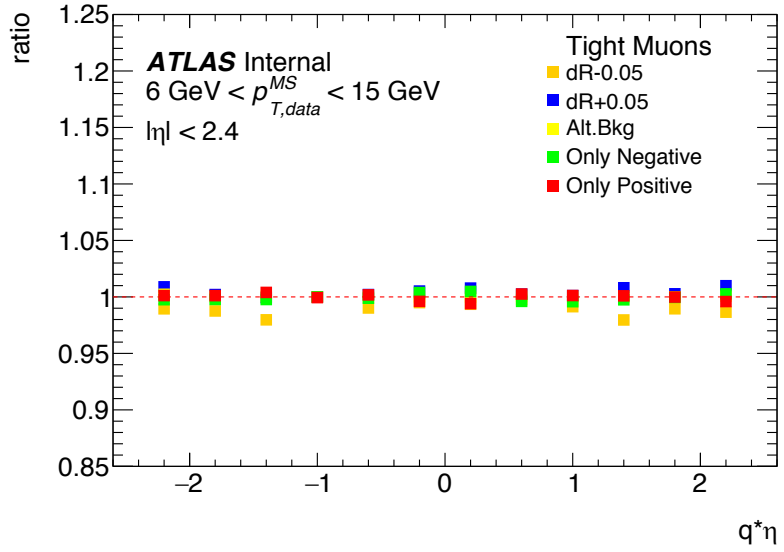
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs q*eta, low pt regime, using MC upsilon

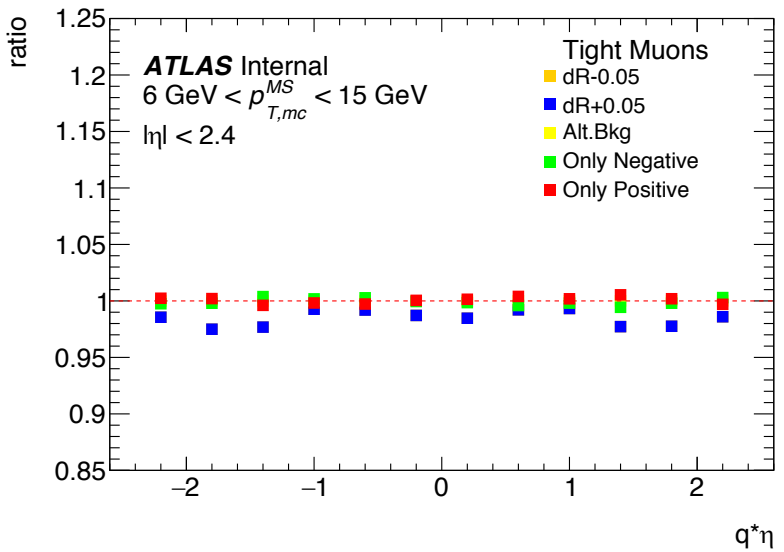
- Nominal efficiency is calculated at dR = 0.2
- Taking both positively and negatively charged tracks.
- The fitting model for background uses exponential curve
- The fitting model for signal uses gaussian curve.

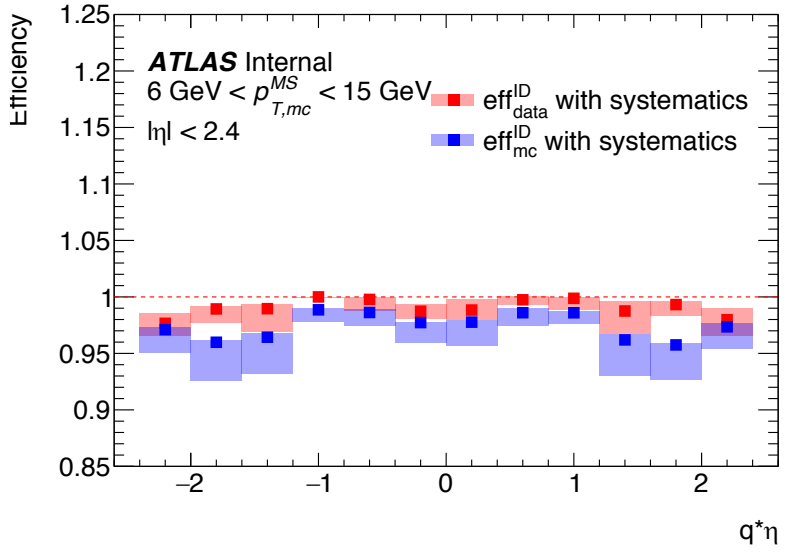
- Largest contribution to overall systematics comes from changing dR.

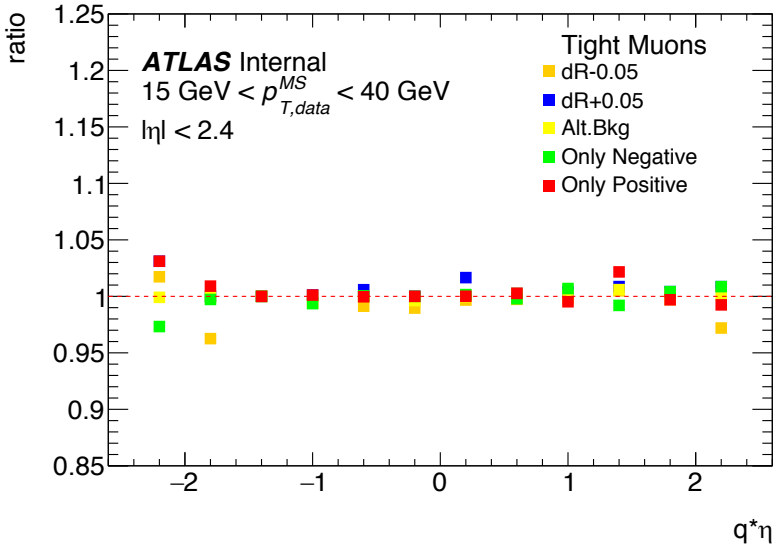


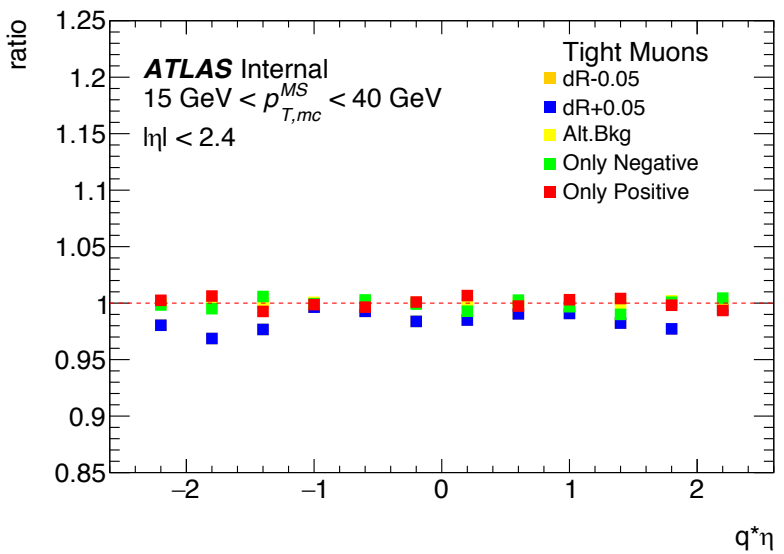
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs q*eta, middle and high pt regime, using MC upsilon

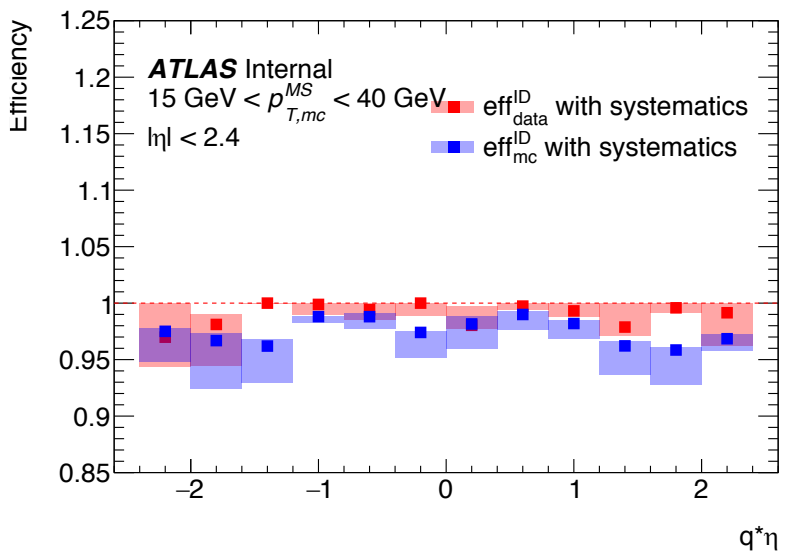




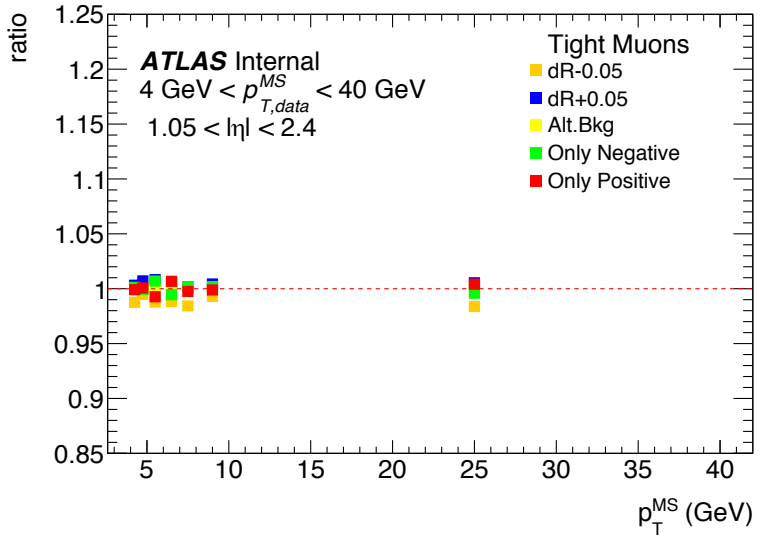


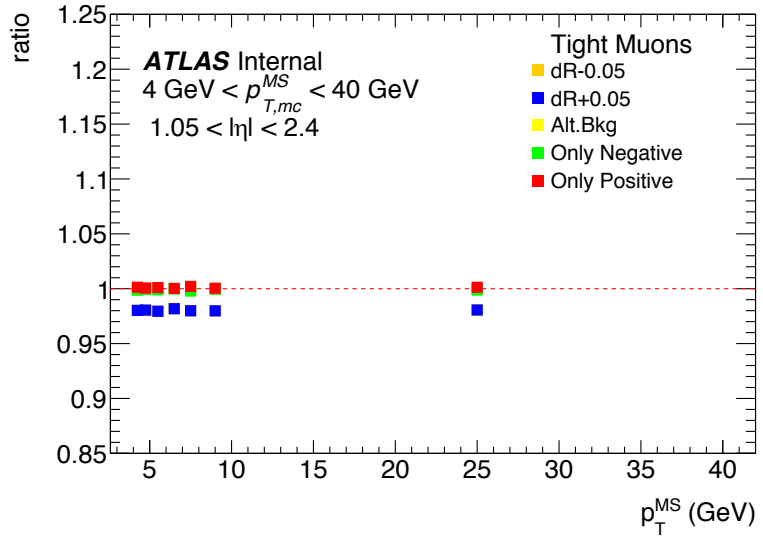


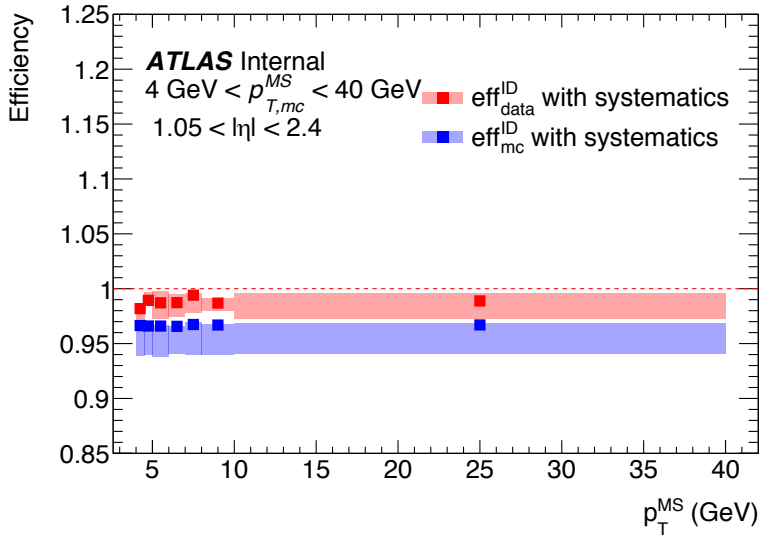


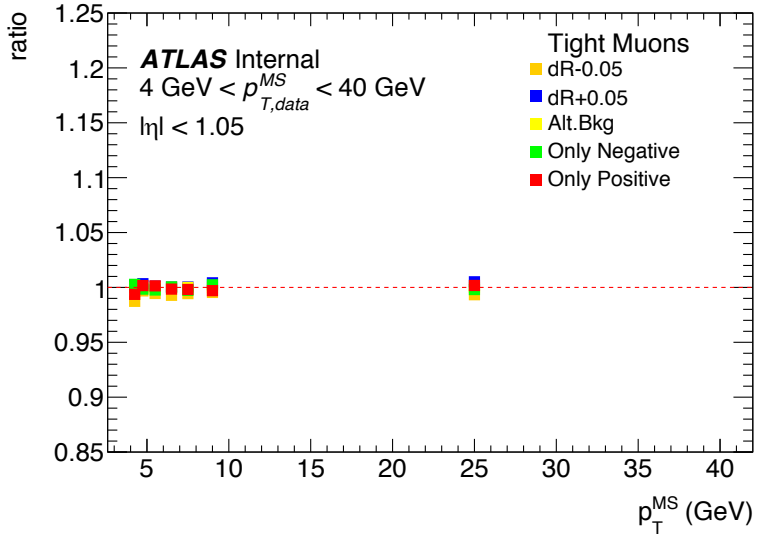


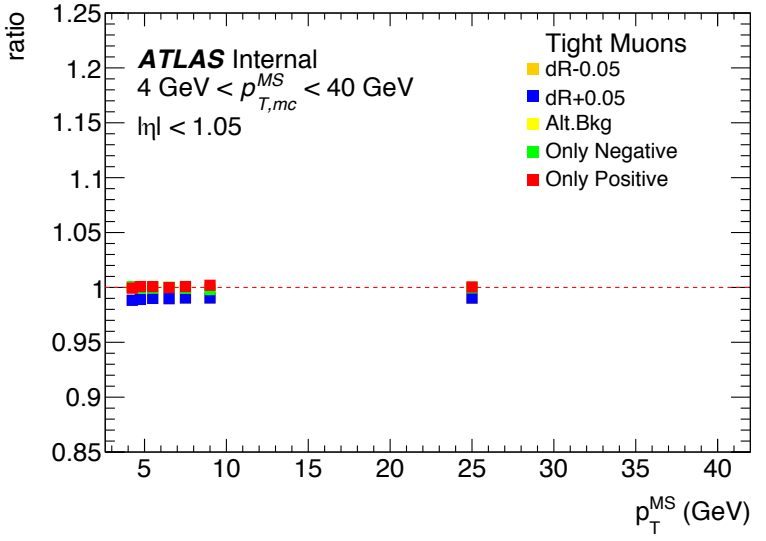
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs probe MS track momentum p_T^{MS}, using MC upsilon

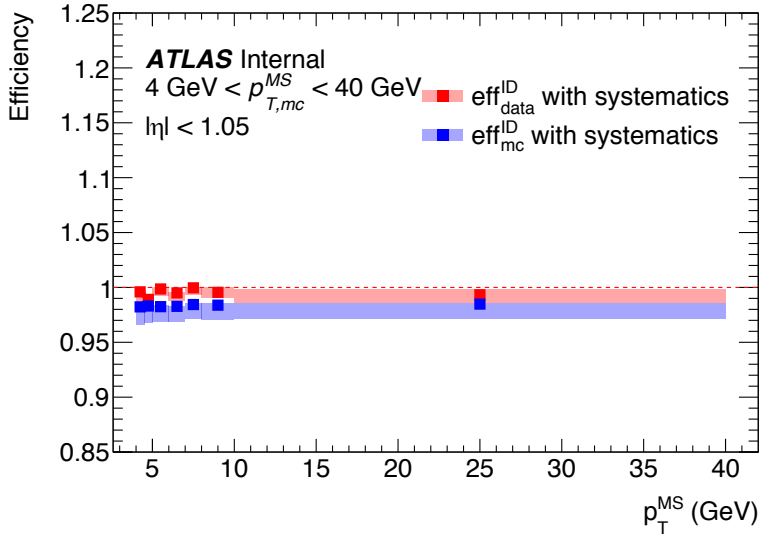




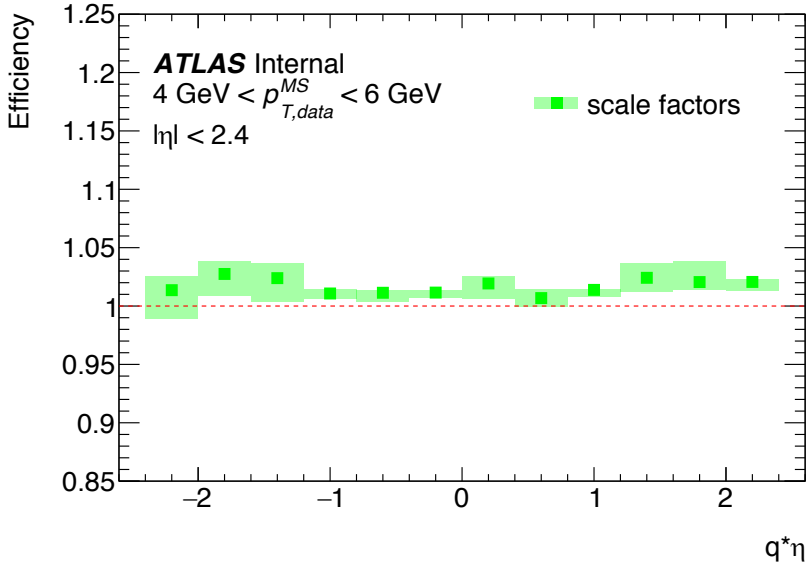


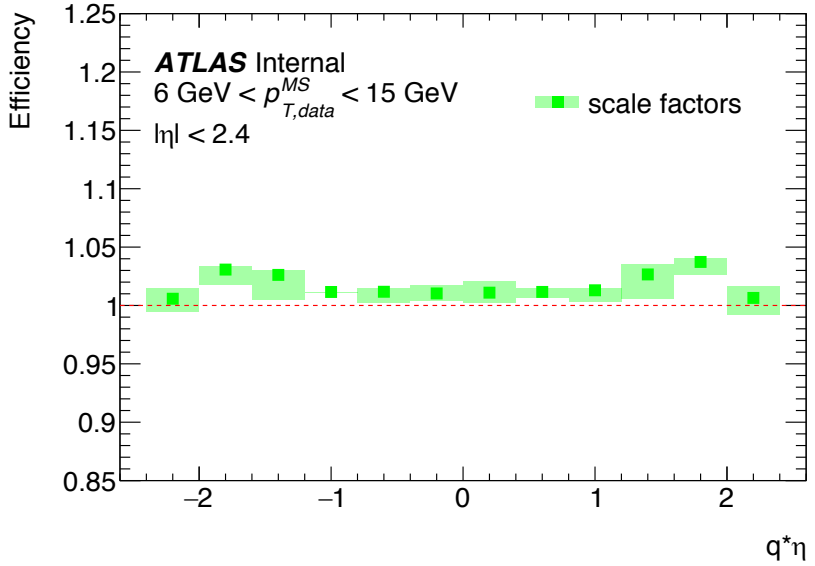


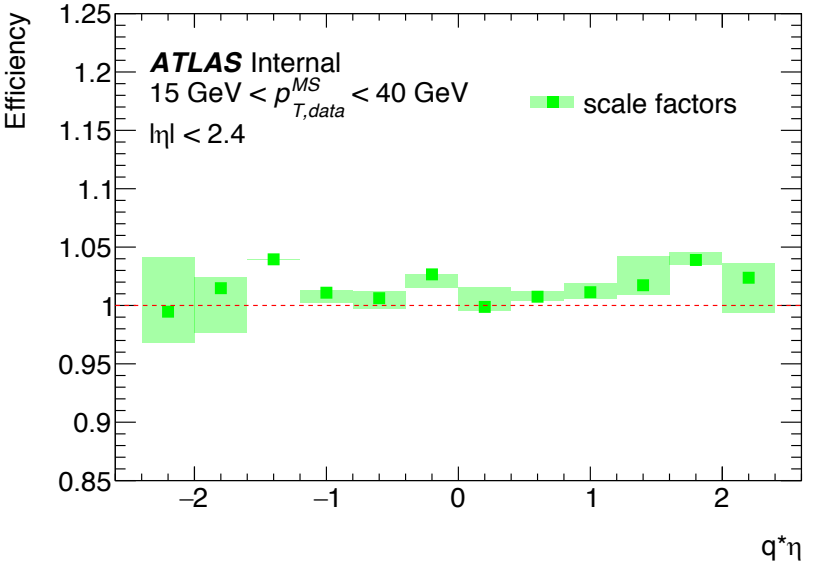


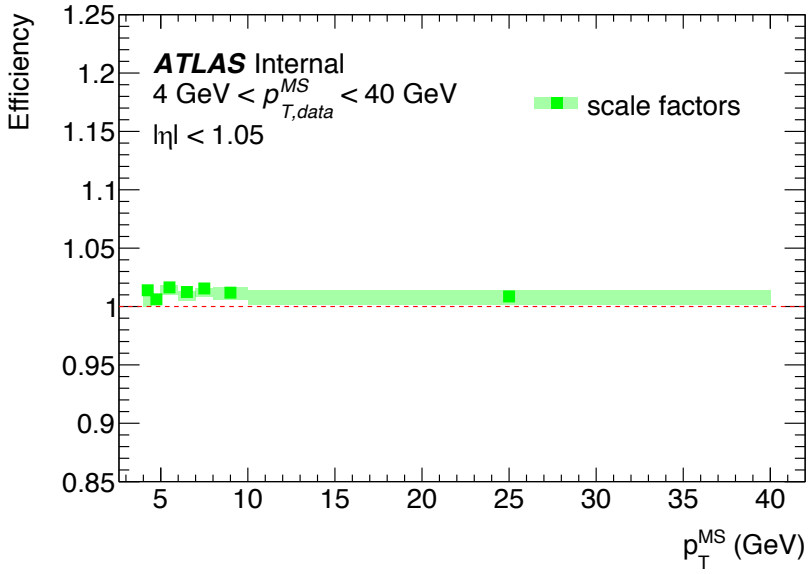


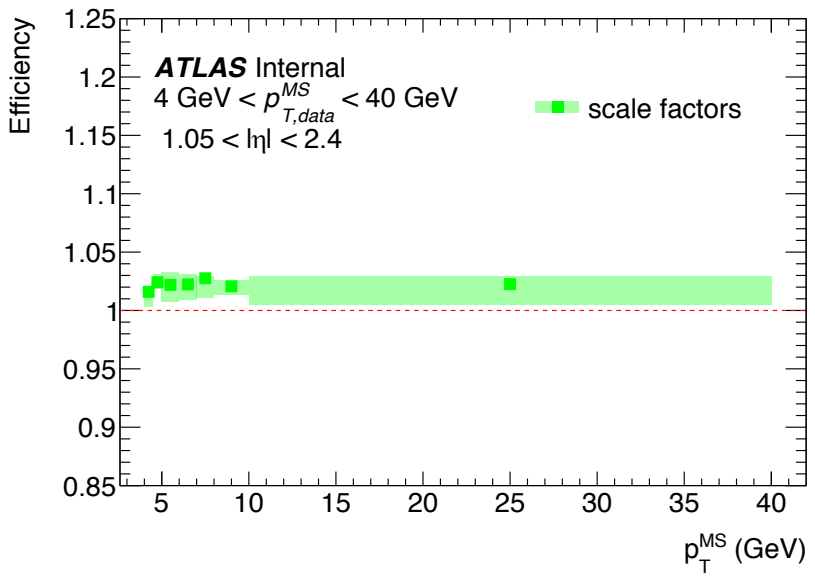
Scale factors for Inner Detector efficiency, using MC with upsilon





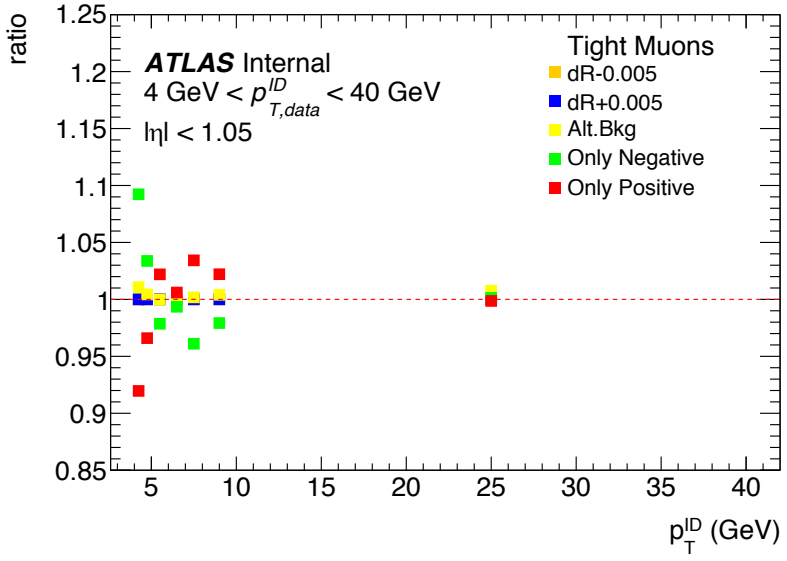


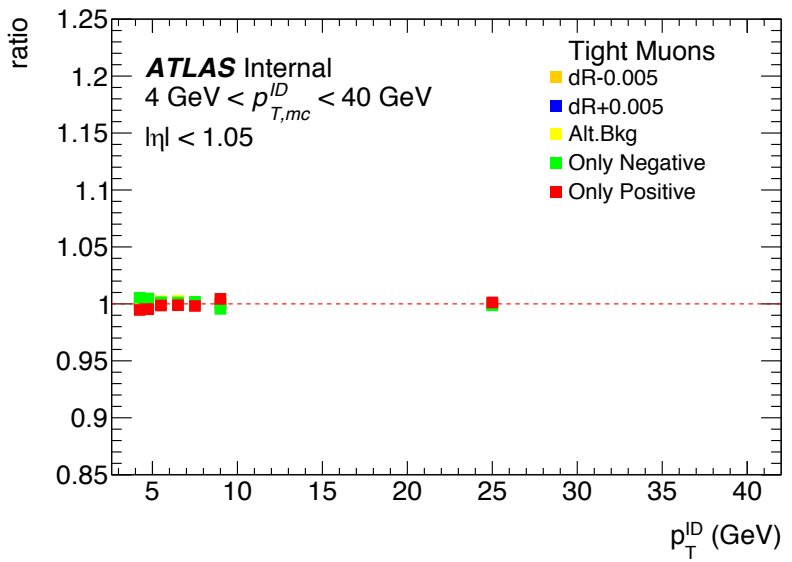


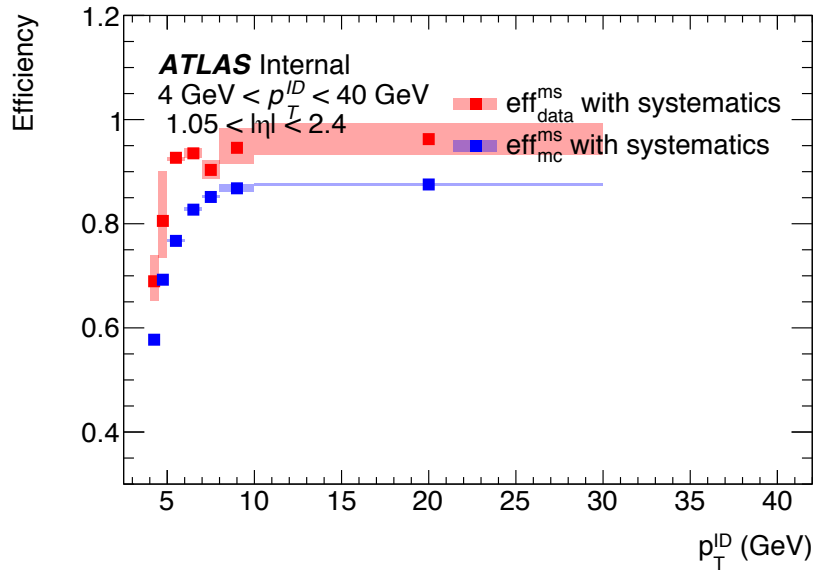


- Scale factors are mostly distributed around 1.02 for inner detector for all |eta|<2.4 and 4 GeV < pT < 40 GeV region.

Tight Muon Reconstruction Efficiency $\varepsilon(\mu|\mathrm{ID})$ vs Probe ID Track Momentum p_T^{ID} , using MC upsilon

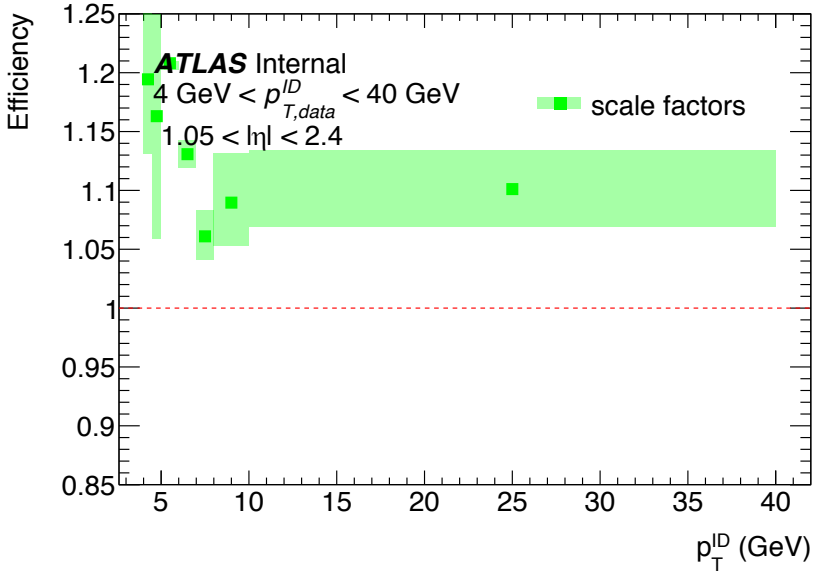




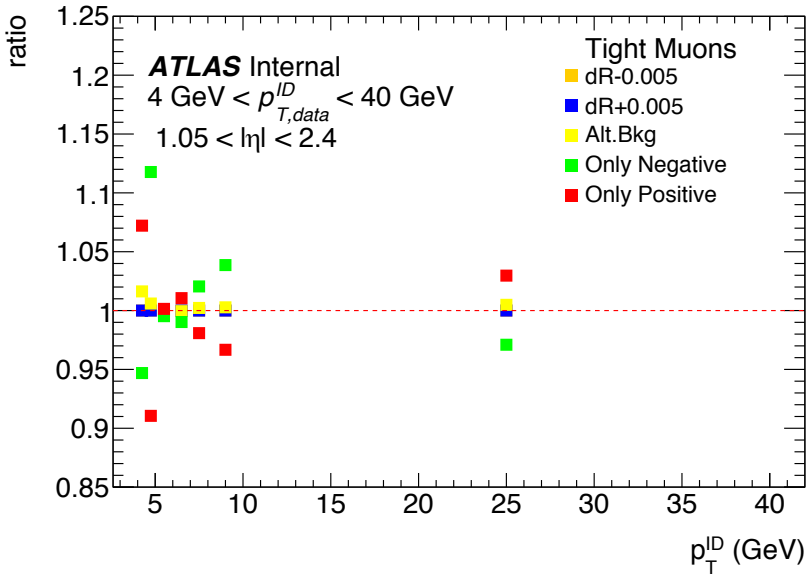


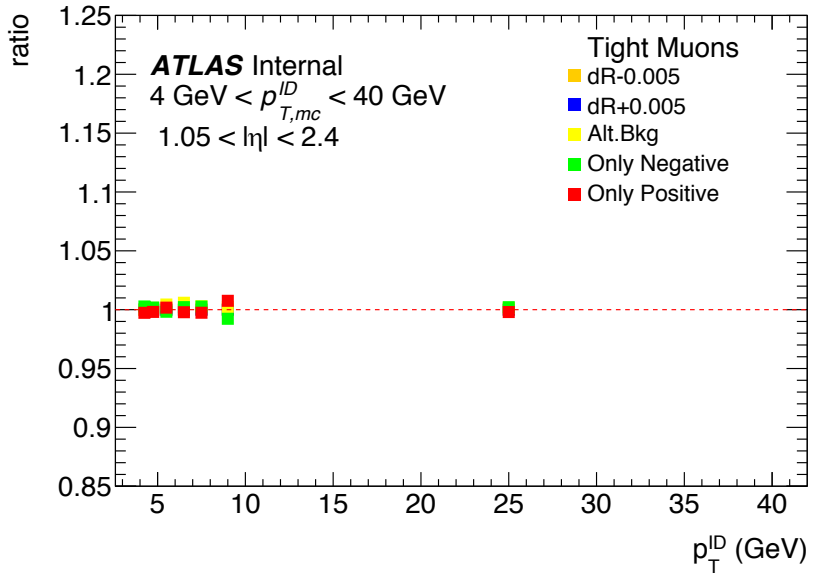
- End cap region
- Nominal efficiency is calculated at dR = 0.01
- Taking both positively and negatively charged tracks.
- The fitting model for background uses exponential curve
- The fitting model for signal uses gaussian curve.

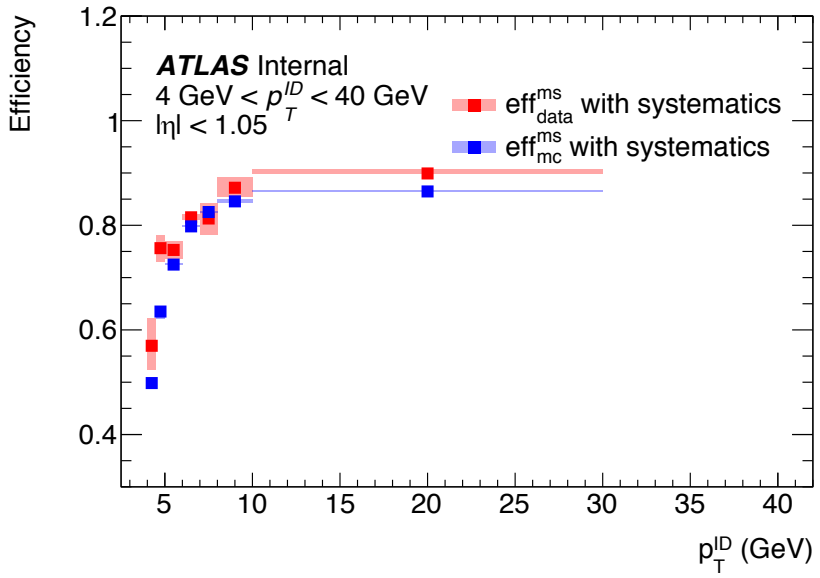
- MC has very small systematics, data has large systematics.
- Largest contribution of systematics for data comes from separating positively charged tracks from negatively charged tracks.



Tight Muon Reconstruction Efficiency $\varepsilon(\mu|\mathrm{ID})$ vs Probe ID Track Momentum p_T^{ID}, using MC upsilon

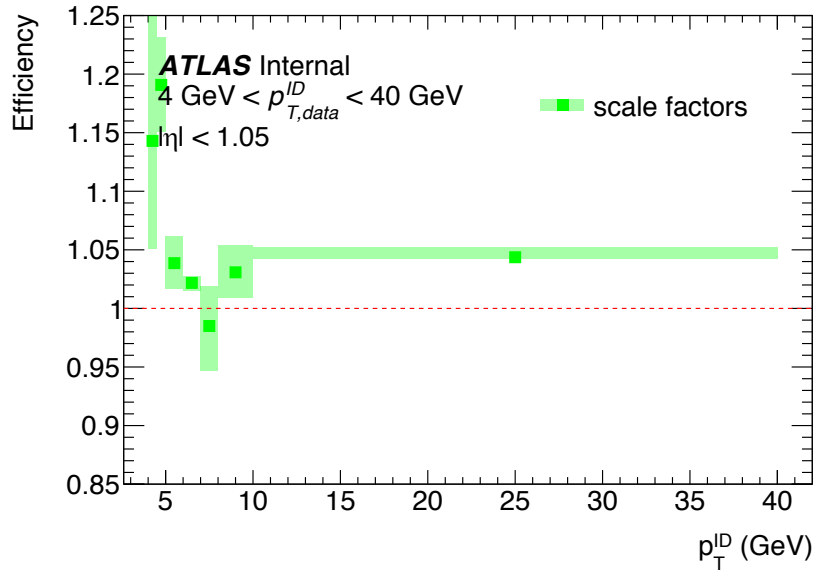




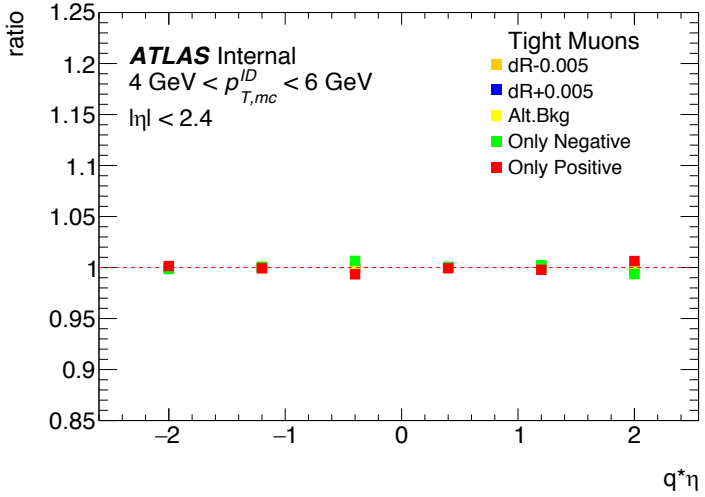


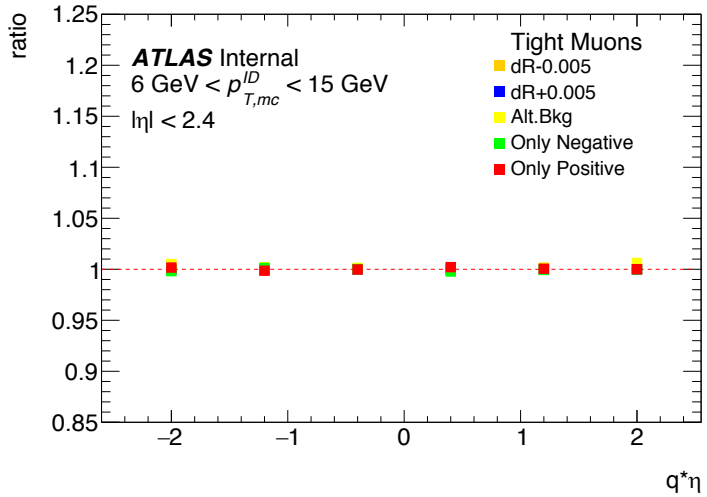
- Barrel region
- Nominal efficiency is calculated at dR = 0.01
- Taking both positively and negatively charged tracks.
- The fitting model for background uses exponential curve
- The fitting model for signal uses gaussian curve.

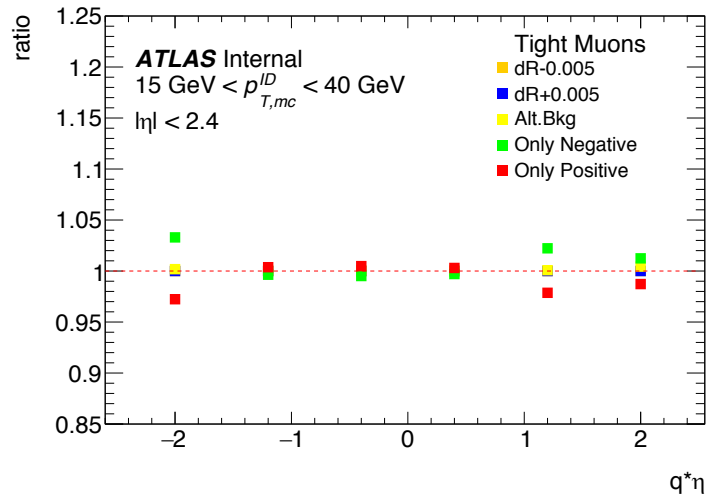
- MC has very small systematics, data has large systematics.
- Largest contribution of systematics for data comes from separating positively charged tracks from negatively charged tracks.

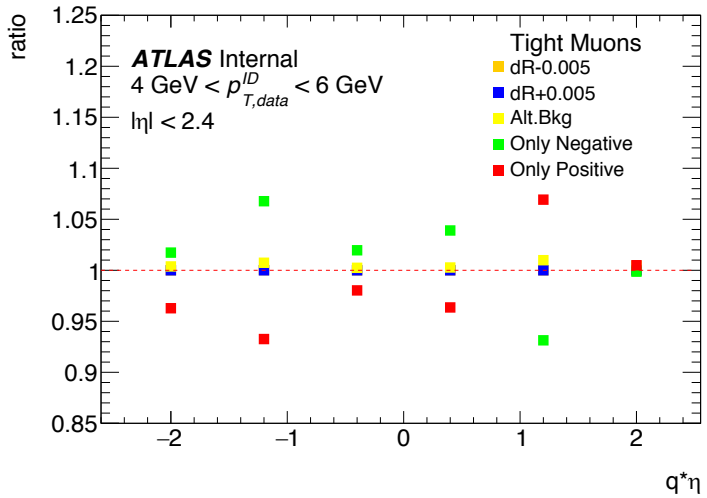


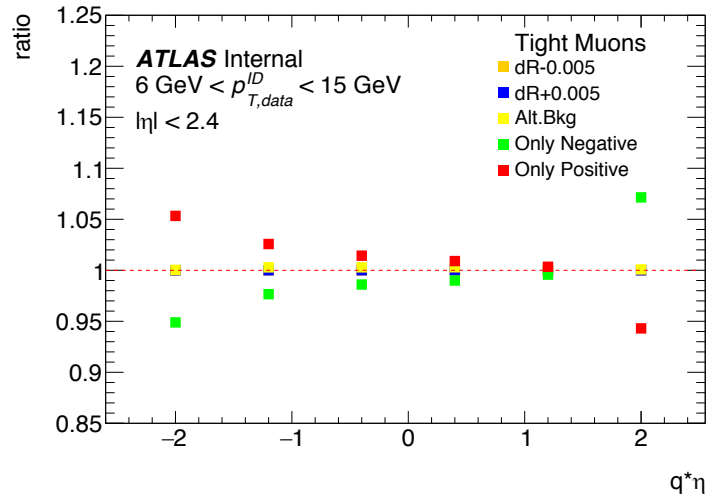
Tight Muon Reconstruction Efficiency $\varepsilon(\mu|\mathrm{ID})$ vs q*eta, using MC upsilon

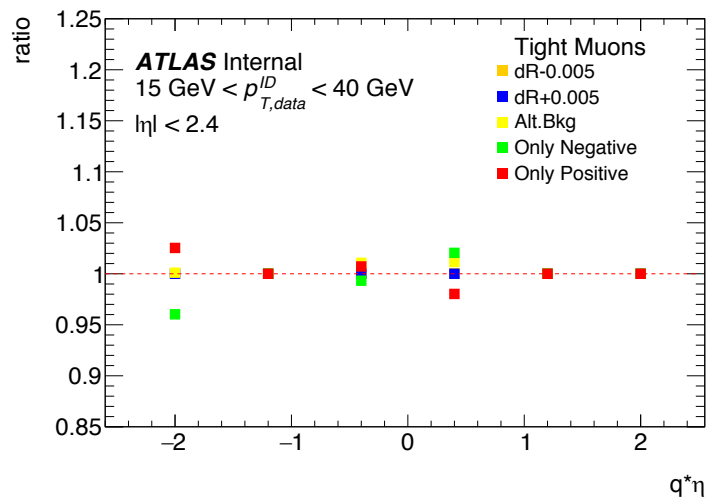






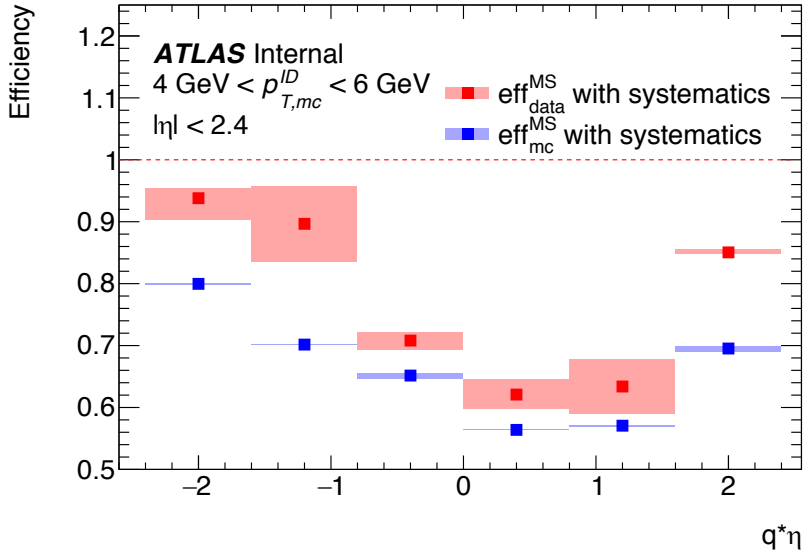


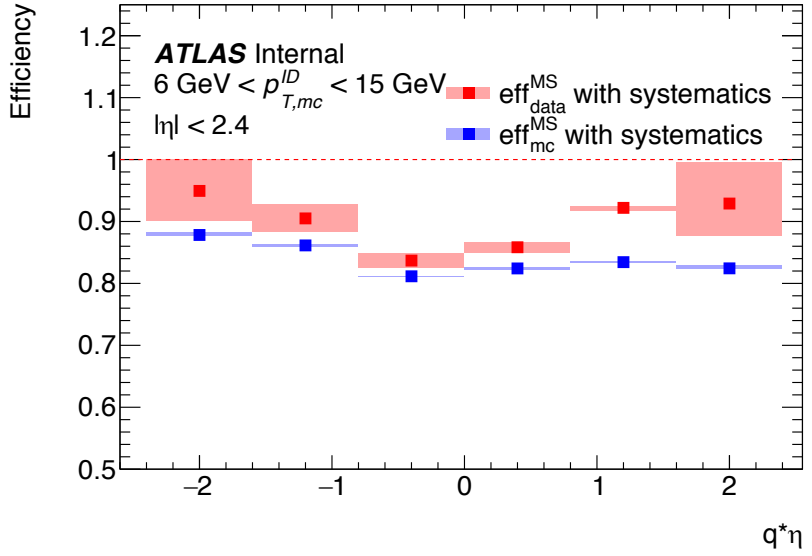


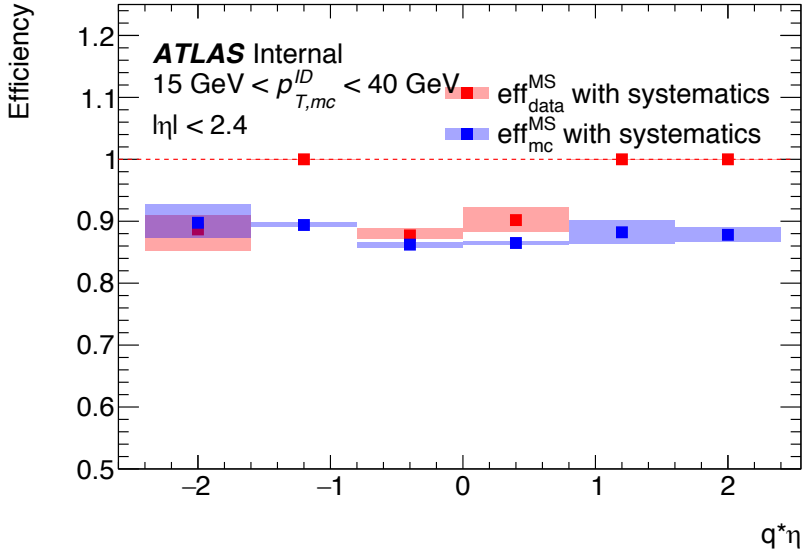


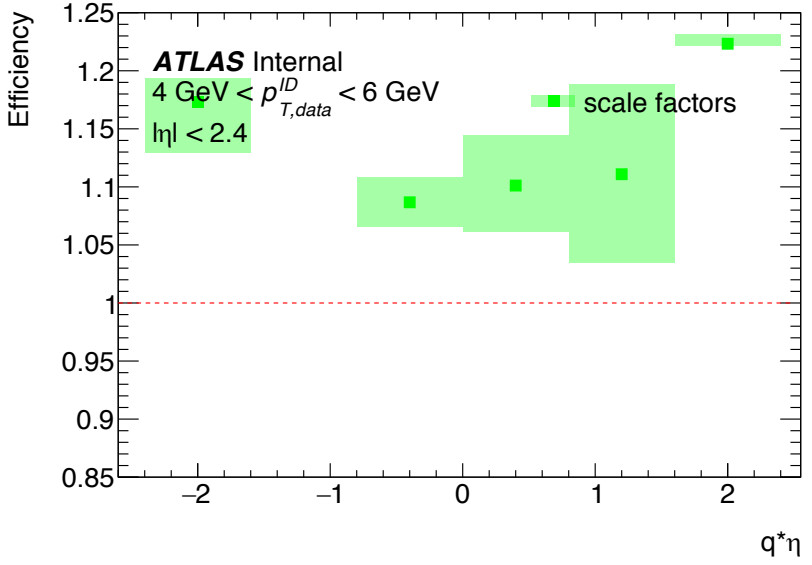
- Systematics mostly come from separating charges.
- MC have small systematics.
- I believe the fittings are reflecting the inputs honestly because the deviations from separating charges are symmetric.

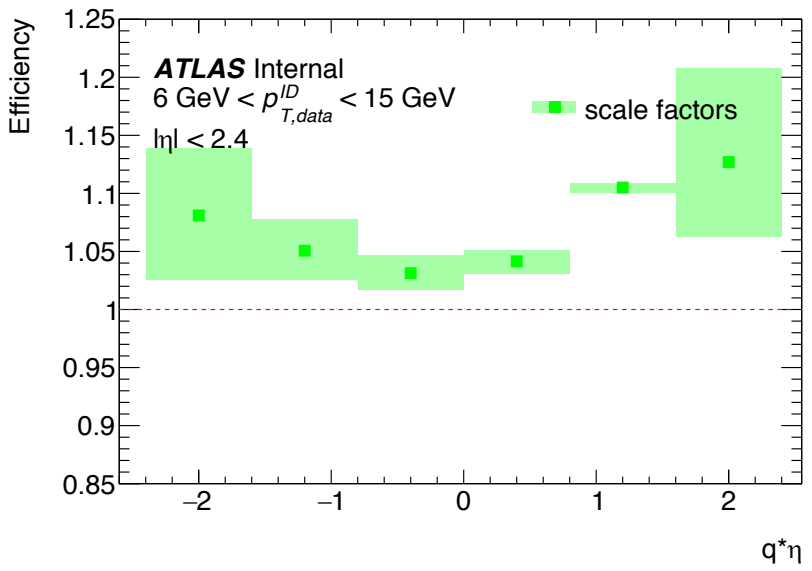
Tight Muon Reconstruction Efficiency $\varepsilon(\mu|\mathrm{ID})$ vs q*eta, using MC upsilon

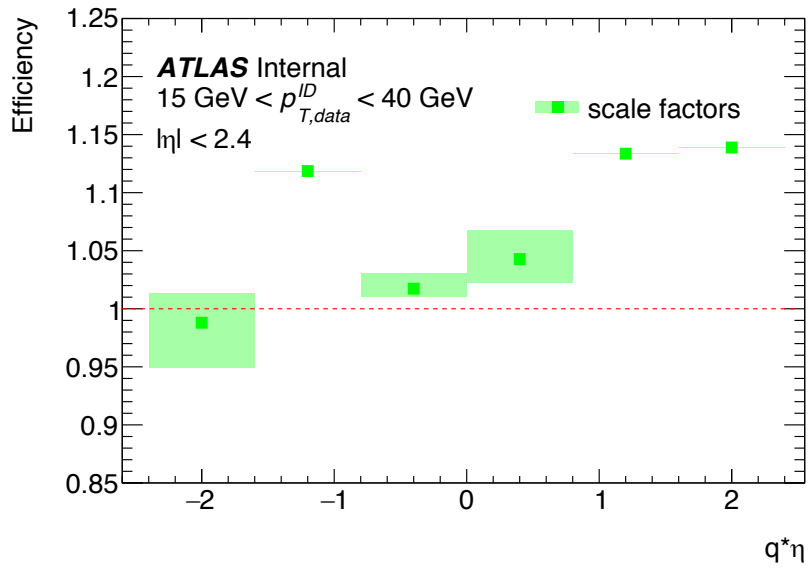






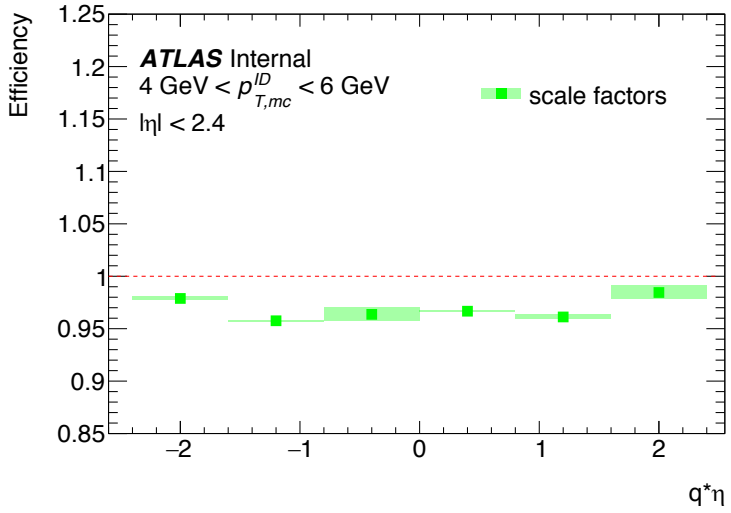


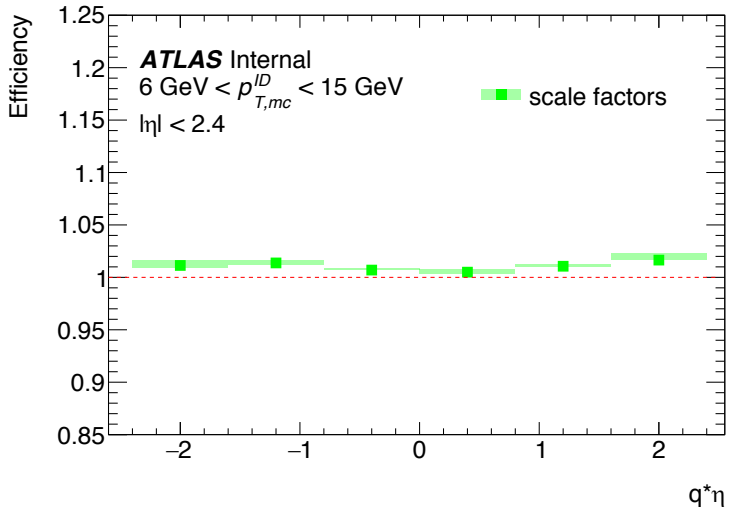


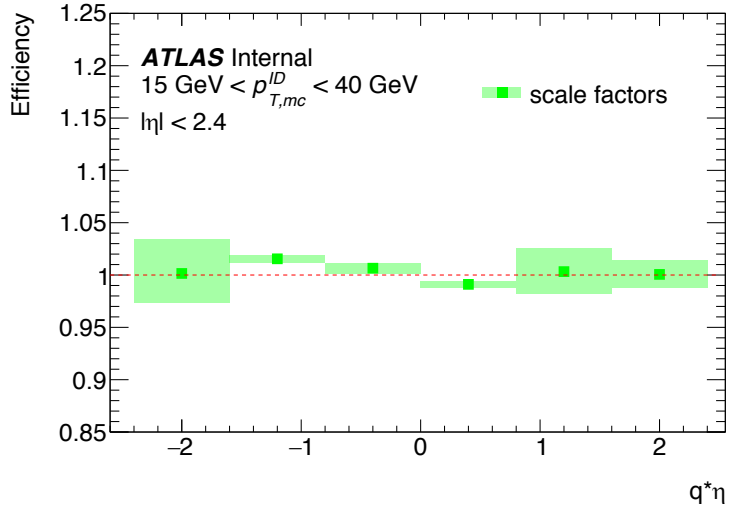


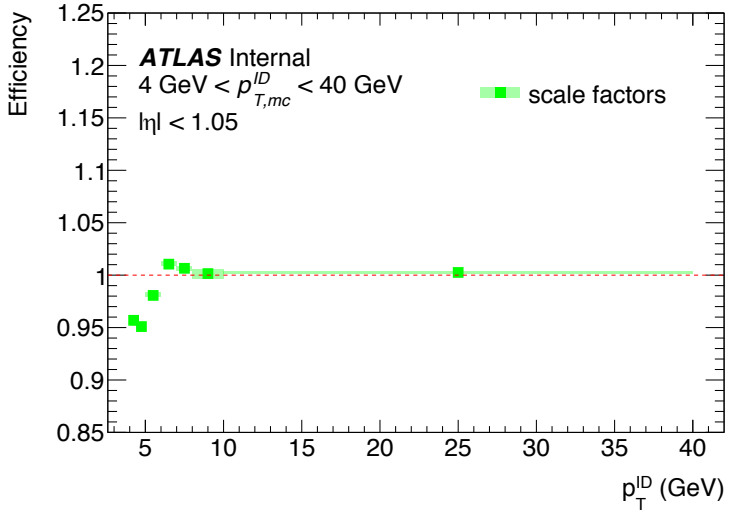
We now also have MC with J/Psi statistics, and here are some results.

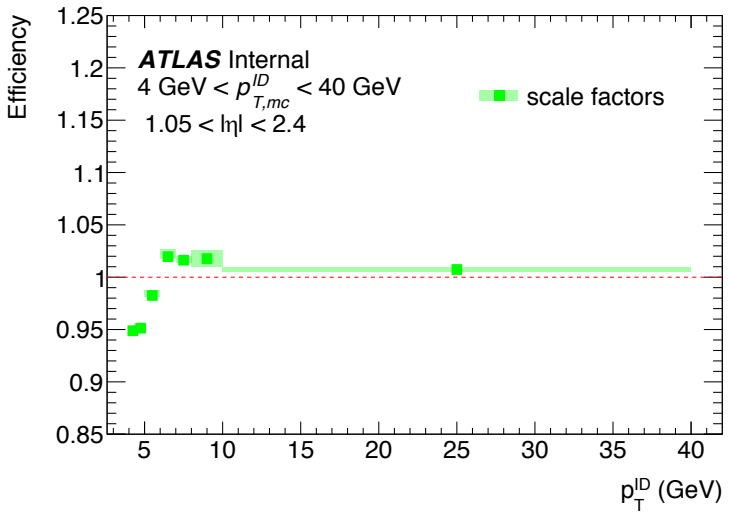
Muon reconstruction efficiency relative to ID for MC using Upsilon versus MC using J/Psi

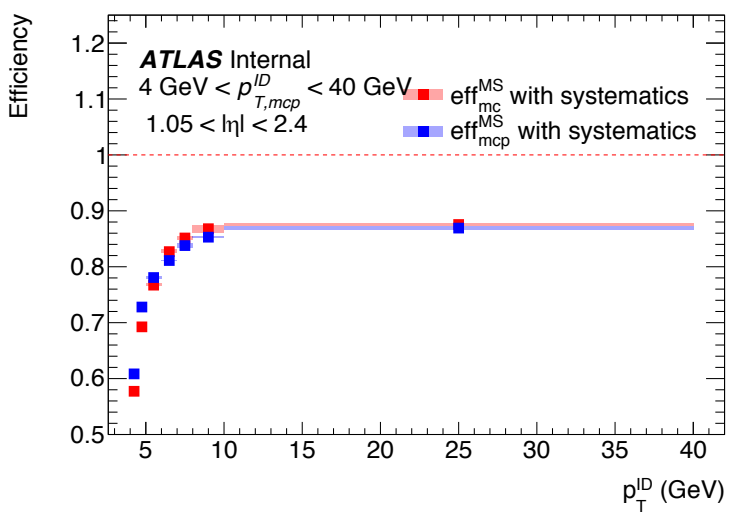






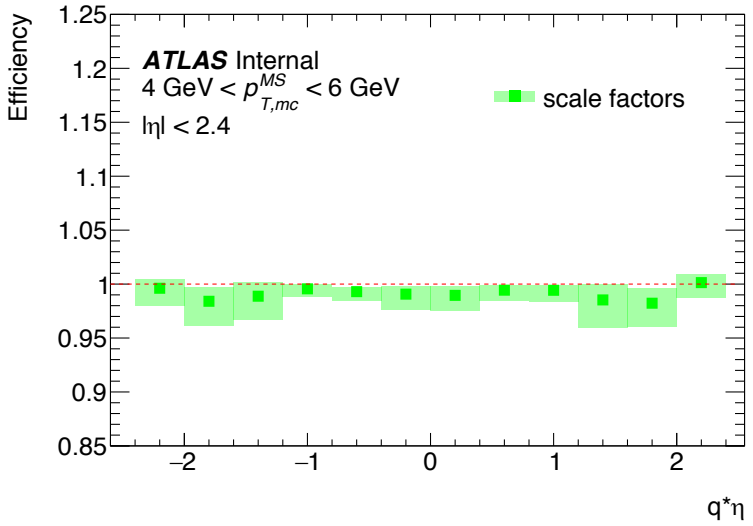


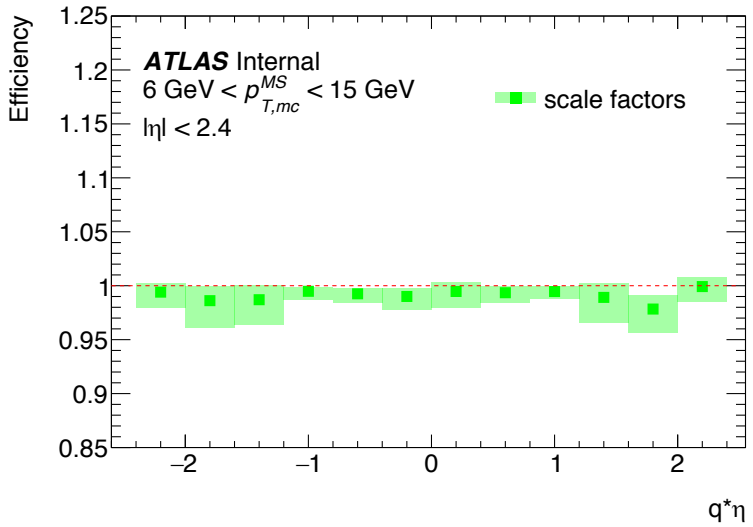


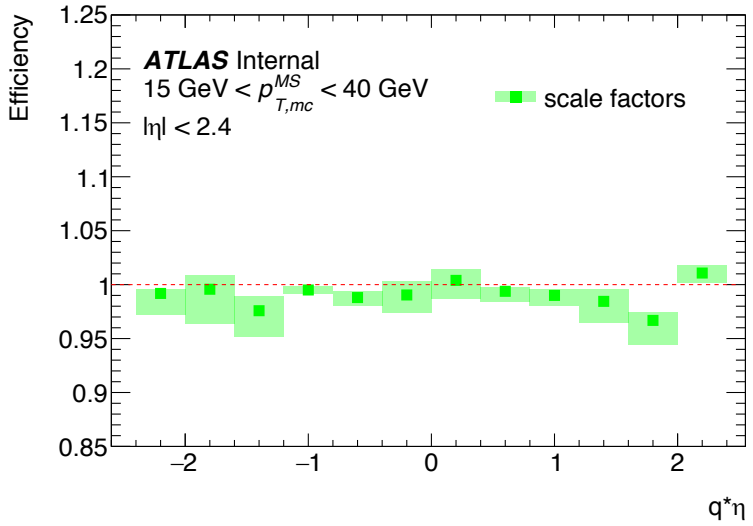


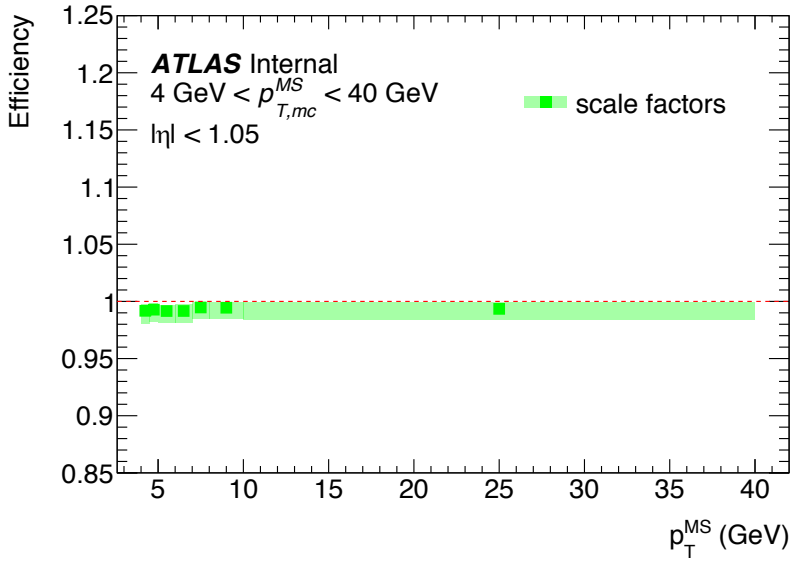
- In comparison to MC using J/Psi, MC using Upsilon invariant mass is calculated to have bigger muon reconstruction efficiency relative to ID at high pT and lower efficiency at low pT.
- Systematics largely come from separating charges.

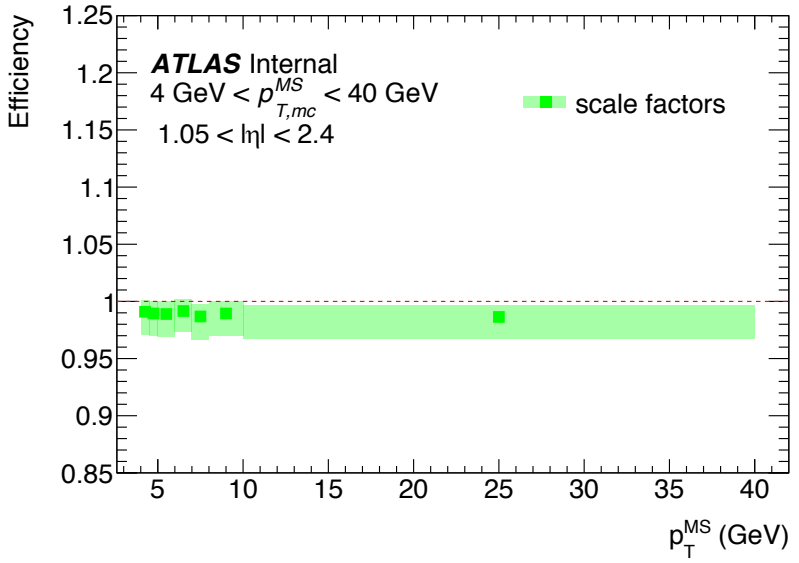
Inner Detector Efficiency $\varepsilon(\mathrm{ID}|\mathrm{MS})$ vs q*eta, MC using upsilon versus MC using J/psi





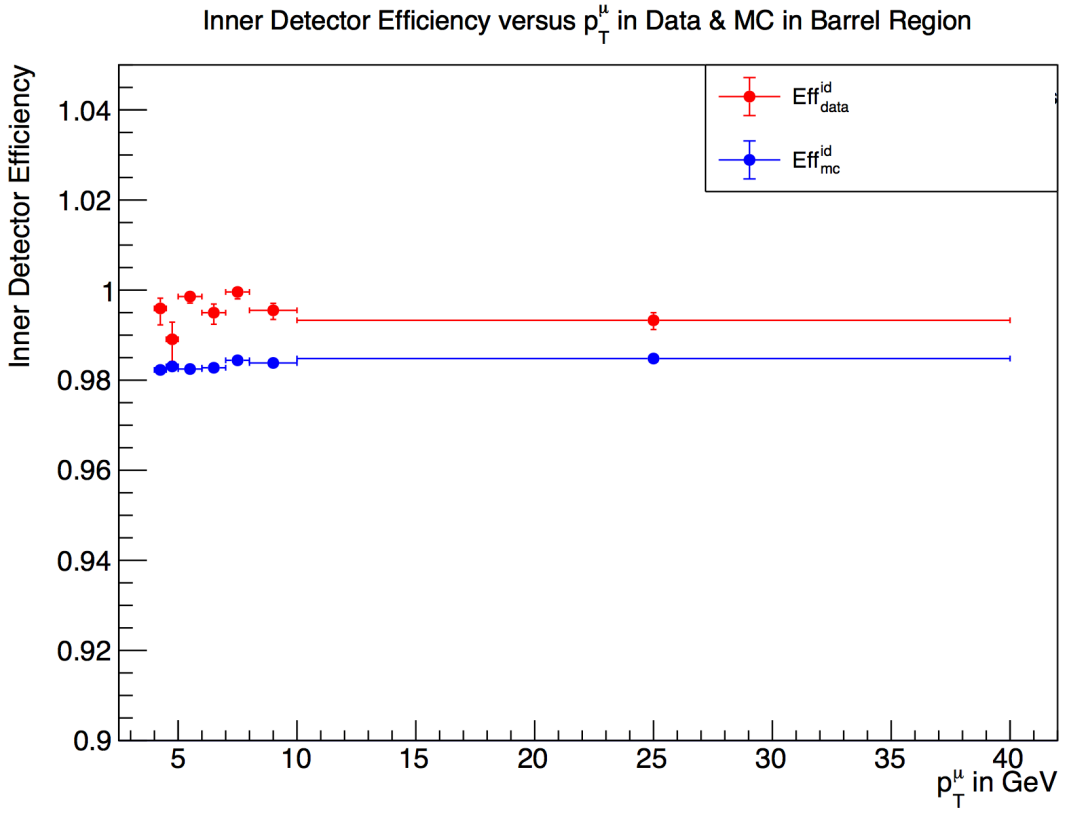


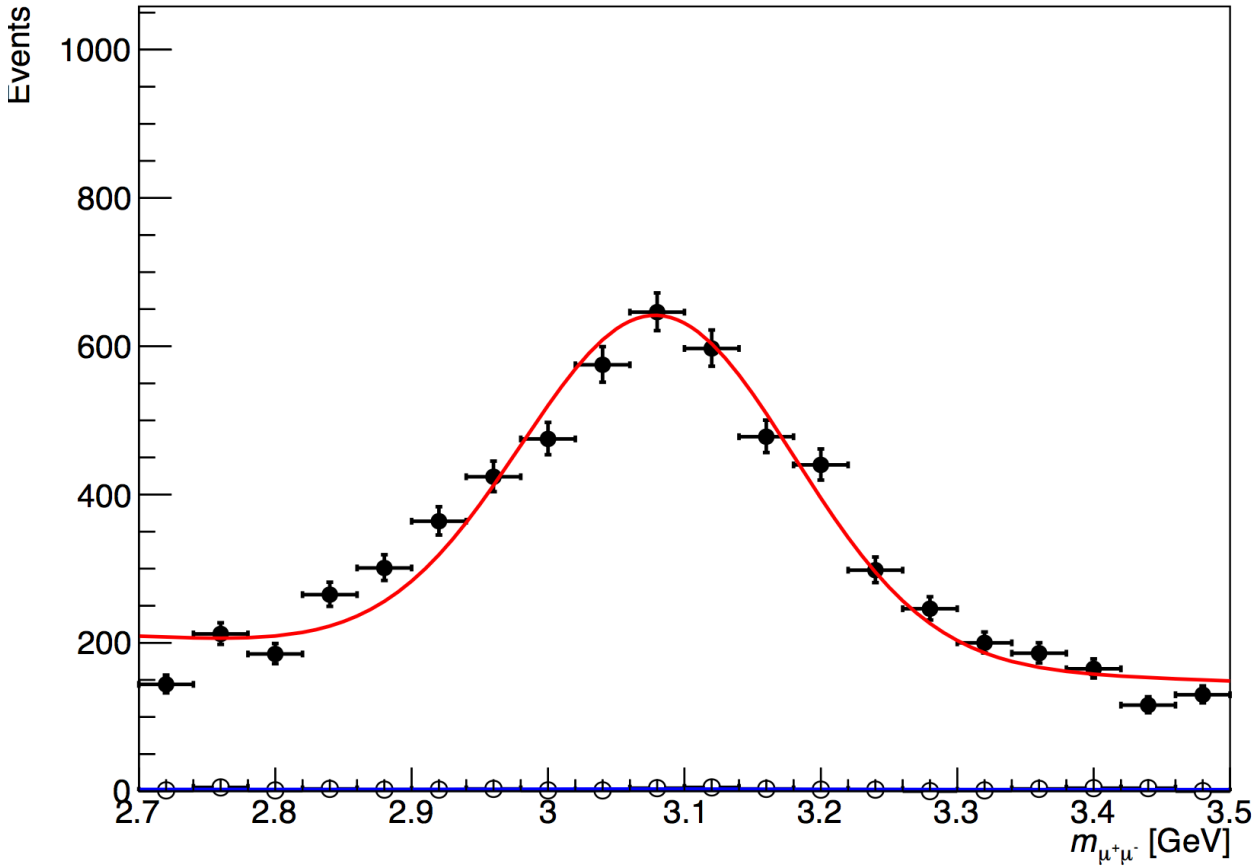




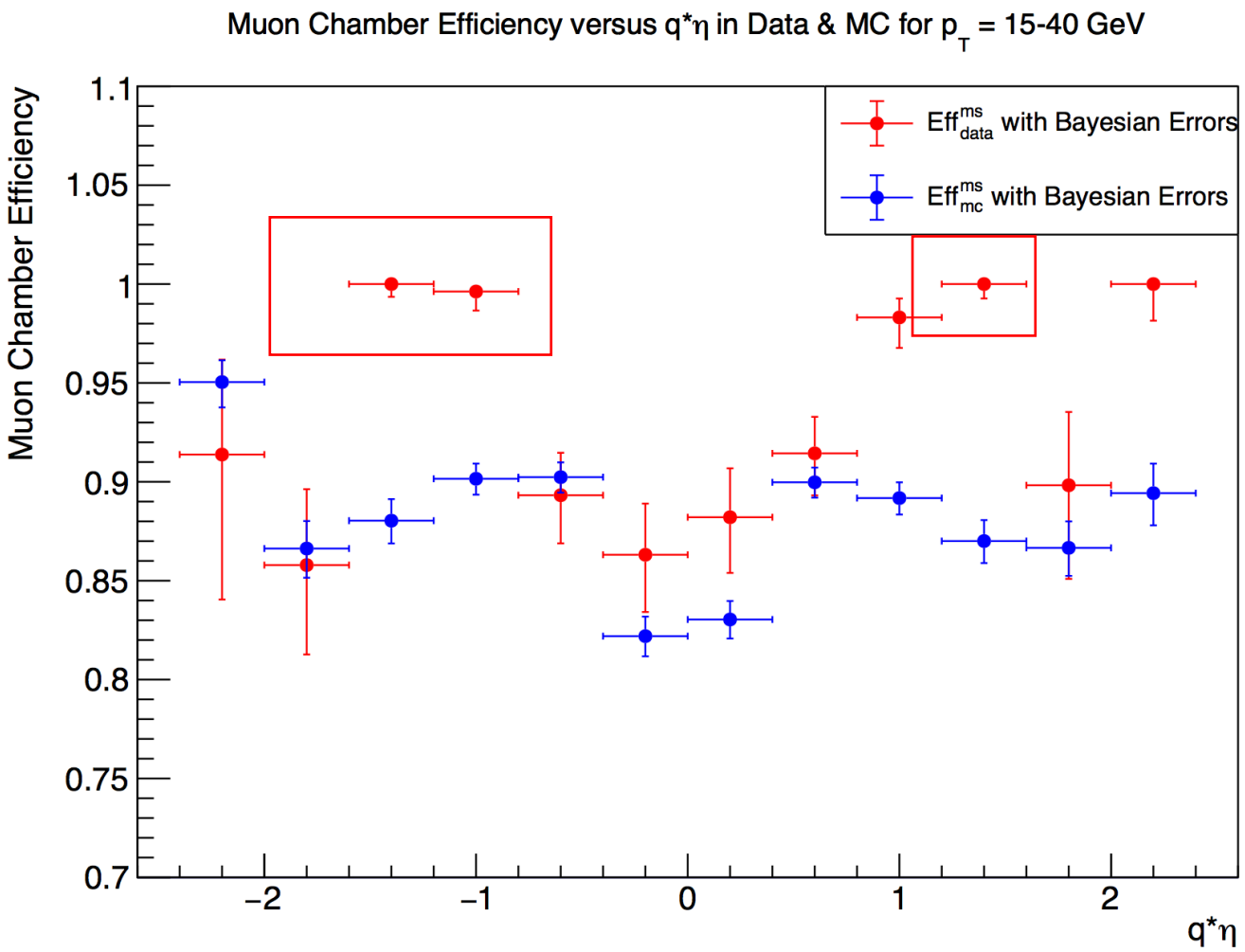
- MC using upsilon ID efficiency is about 1% lower than MC using J/psi.

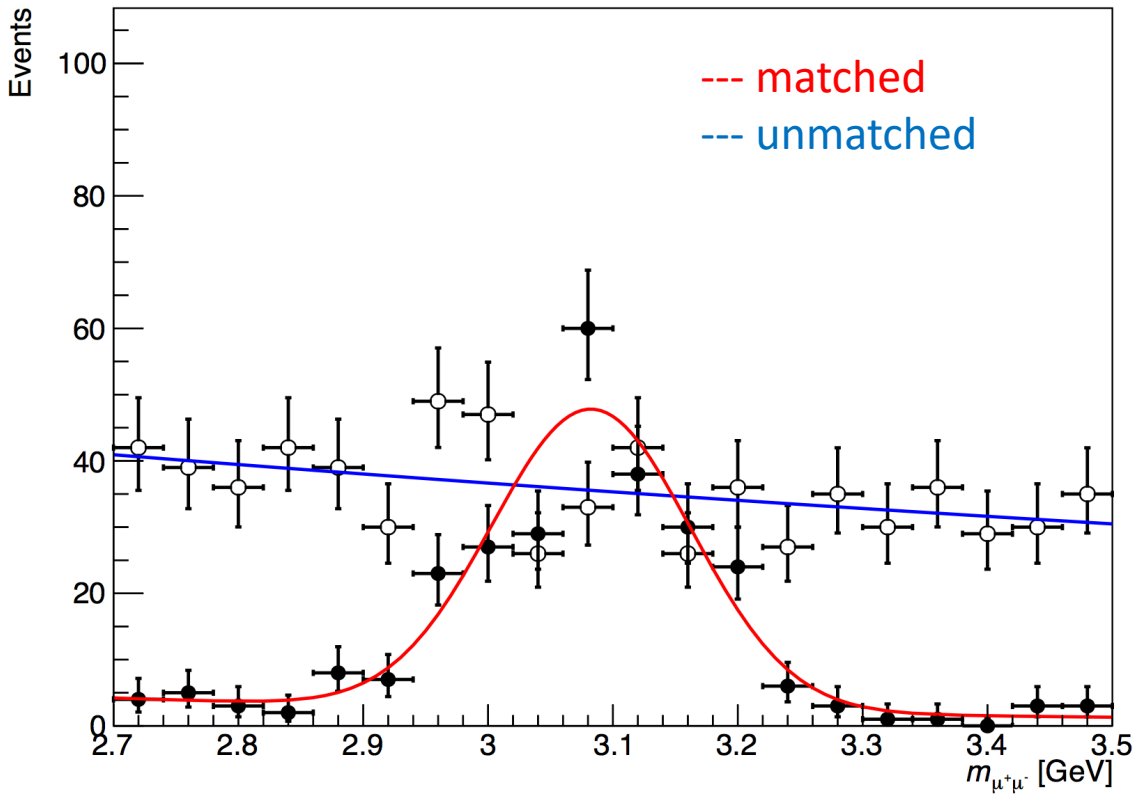
Eff_id for data in Barrel Region p_T = 6-7 GeV



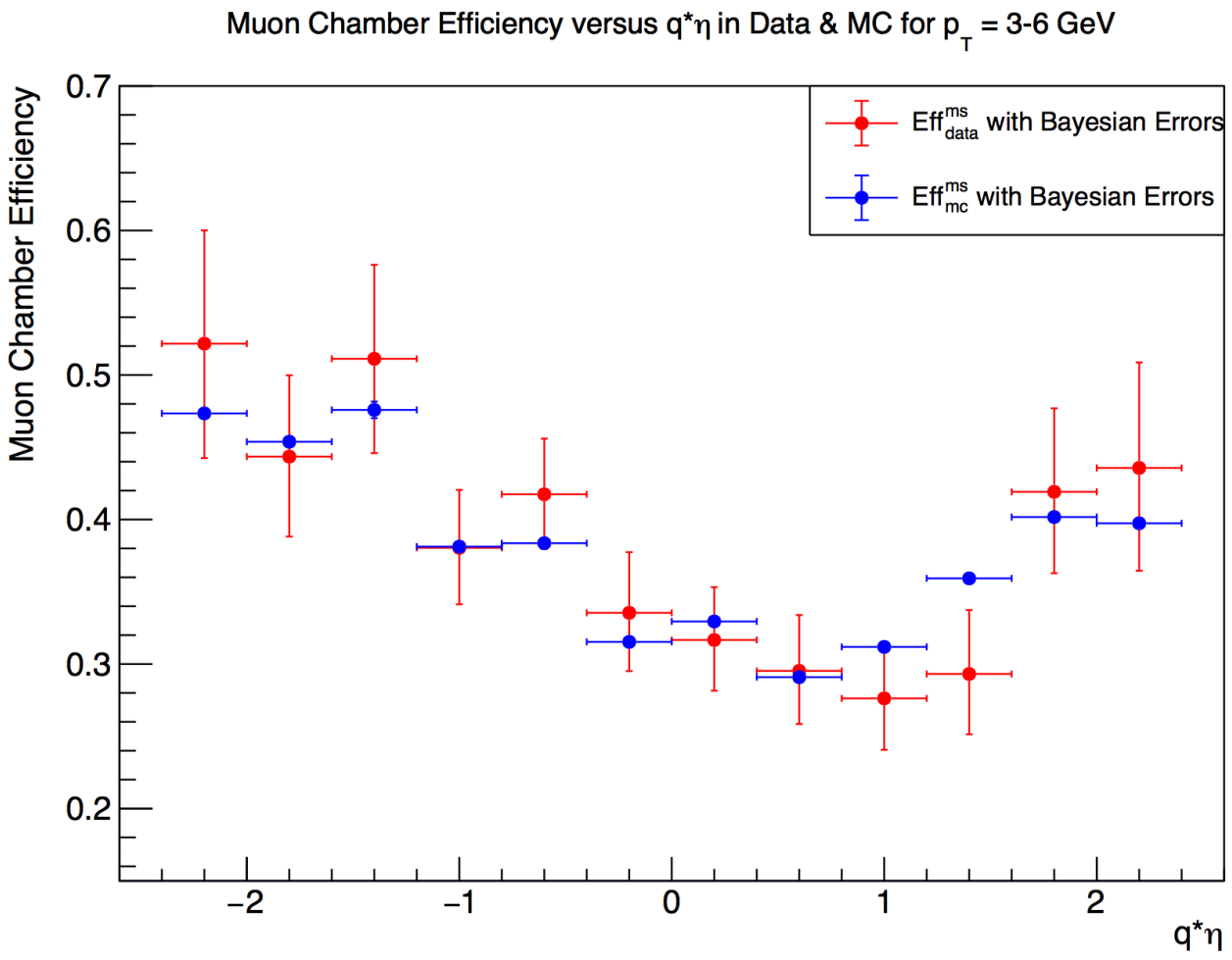


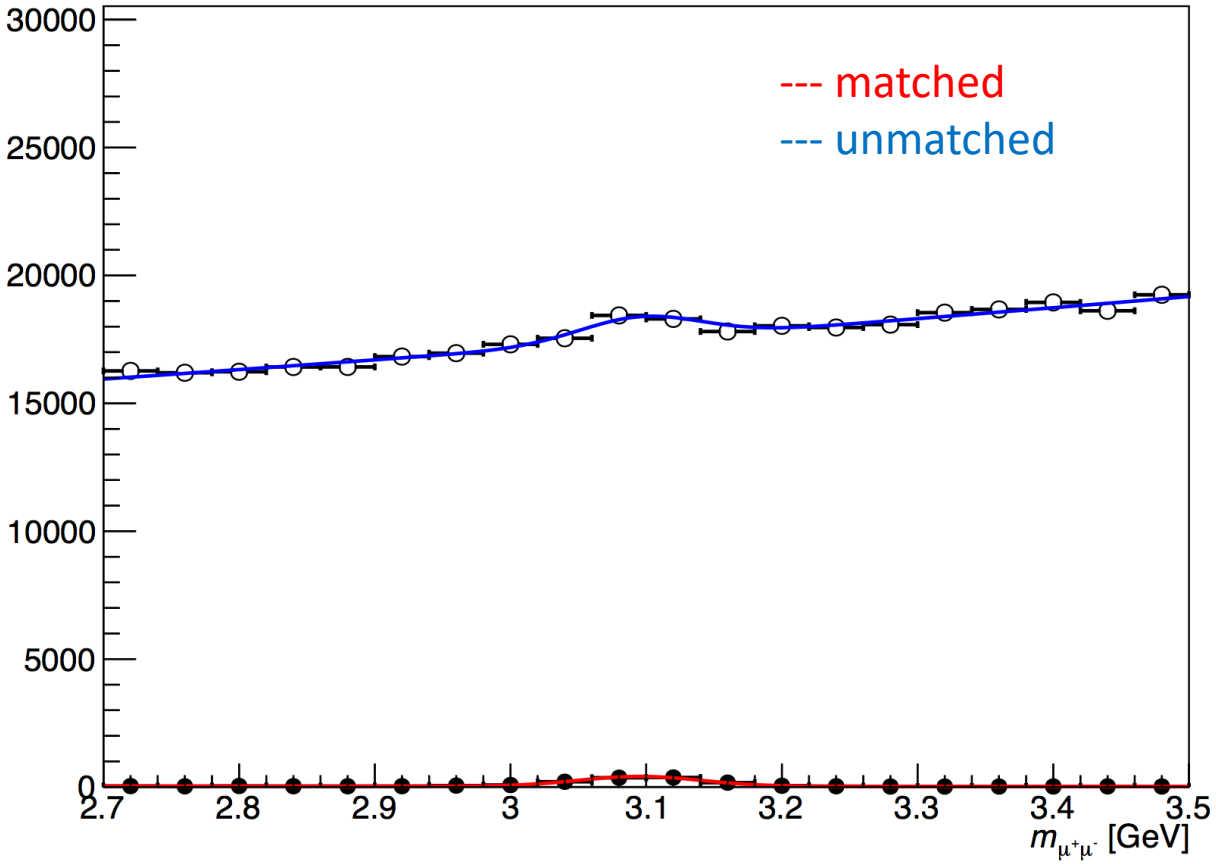
ID efficiency are in general high, signals are high comparing to the background and matched tracks are





- High pT region has very few data and some fake efficiencies are calculated.





- Low pT region has more data and data and MC go the same trend approximately.