Tight Muon Reconstruction Efficiency

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Overview

- Two methods can be used to compute reconstruction efficiency of muons of a specific quality (tight, medium, or loose, etc.).
  - Tag and probe method (see detail in slide 4-5) that approximates muon reconstruction efficiency $\varepsilon(\mu)$ using muon reconstruction efficiency with respect to inner detector $\varepsilon(\mu|\mathrm{ID})$, corrected by inner detector efficiency with respect to muon spectrometer $\varepsilon(\mathrm{ID}|\mathrm{MS})$.
    - $\varepsilon(\mu) = \varepsilon(\mu|\mathrm{ID})\times\varepsilon(\mathrm{ID}) \cong \varepsilon(\mu|\mathrm{ID})\times\varepsilon(\mathrm{ID}|\mathrm{MS})$
  - Truth match method that finds how many out of all truth muons have a reconstructed muon (of a specific quality, for example, tight or medium) located close to it in the same event.
    - Distance between truth muon and reco muon (dR) smaller than 0.2
    - This method is only applicable to MC.

- The results from the two methods do not agree for tight muon in PbPb MC (pp overlay), with the efficiency by truth match method being ~30% lower than T&P.
  - The efficiency is dependent on centrality, pT and eta, but the difference cannot be accounted by these factors.
  - The efficiency for loose and medium muons using truth match method is also low in PbPb MC.

- The results from the two methods agree within ~2% for tight muon in pp MC.
- Is there a problem with the tracks in overlay? Is there a work-around?

Plan and Progresses

- Verify that the methods work fine in pp MC
  - Tight muon efficiencies agree within ~2%. (see slide 6)
  - Will verify medium muon. (job running on the grid)
  - If both qualities of muons agree, will calculate for muon reco efficiency at data to use as a systematics. (job running the grid)
- Currently the two methods for $\varepsilon(\mu)$ do not agree in overlay, what can we do?
  - Try figure out which method gives correct answer (Either? Neither?)
  - Separate the two parts in T&P method: ($\varepsilon(\mathrm{ID}|\mathrm{MS})_{\mathrm{MC}}$ and $\varepsilon(\mu|\mathrm{ID})$)
    - A suspicion: there is a problem with ($\varepsilon(\mathrm{ID}|\mathrm{MS})_{\mathrm{MC}}$)
      - Check whether the $\varepsilon(\mathrm{ID}|\mathrm{MS})_{\mathrm{MC}}$ agrees with efficiency of ID by directly matching available ID track to truth muon. (slide 7)
    - Assuming $\varepsilon(\mathrm{ID}|\mathrm{MS})_{\mathrm{MC}}$ is the problem, a potential workaround to get $\varepsilon(\mu)$ in data (given that data has low statistics in MS):
      - Get $\varepsilon(\mu|\mathrm{ID})_{\mathrm{data}}$ (assumed to be fine)
      - Get $\varepsilon(\mu|\mathrm{ID})$ in data and $\varepsilon(\mu|\mathrm{ID})$ in MC, these are the un-corrected muon efficiency, both assumed to be fine with respect to ID, and calculate scale factor (SF)

Tag & Probe Method

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

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

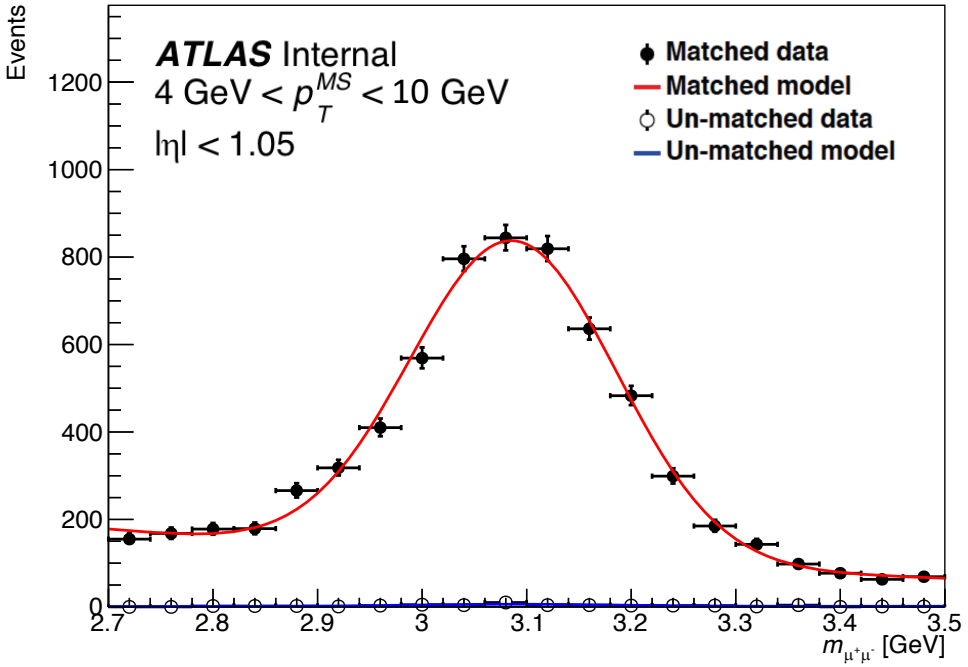
- $\varepsilon(\mu|\mathrm{ID})$ Muon Reconstruction efficiency with respect to inner detector.
- $\varepsilon(\mathrm{ID}|\mathrm{MS})$ Inner Detector efficiency with respect to muon chamber.
- Event Selection:
  - Trigger mu3 || mu8 || mu10
  - GRL
  - At least 1 primary vertex
- $\varepsilon(\mathrm{ID}|\mathrm{MS})$ 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

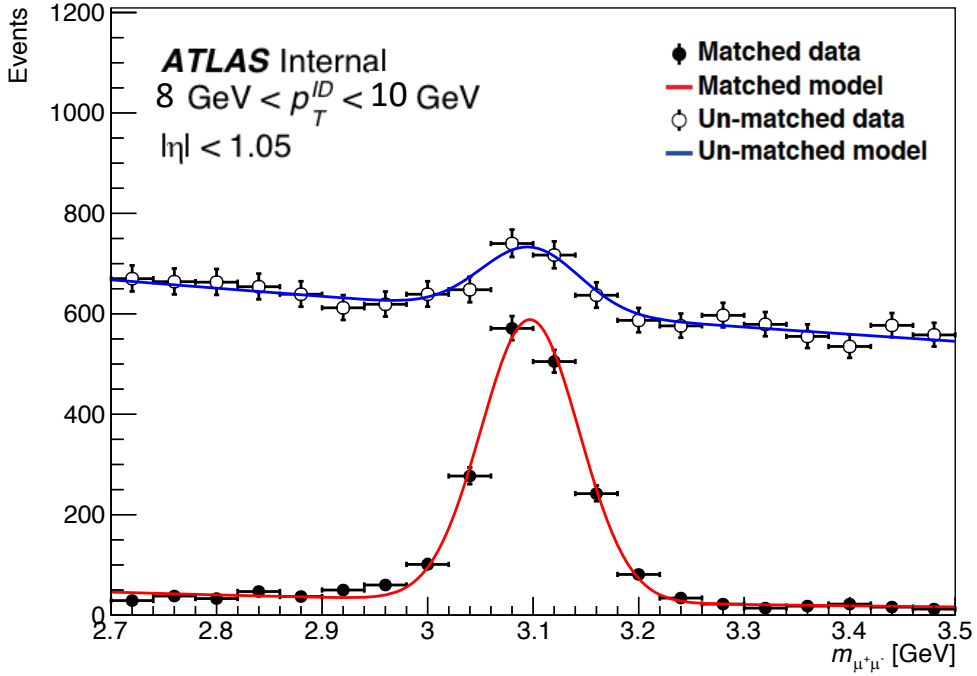
- Data: 2018 Pb-Pb Hard Probe Stream Data at 5.02 TeV
- Monte Carlo:Pythia8B with Prompt J/psi to Muons with Heavy Ion Overlay. mc16_5TeV:mc16_5TeV.300000.Pythia8BPhotospp_A14_CTEQ6L1_pp_Jpsimu2p5mu2p5.merge.AOD.e4973_d1521_r11472_r11217

Tag & Probe Fitting

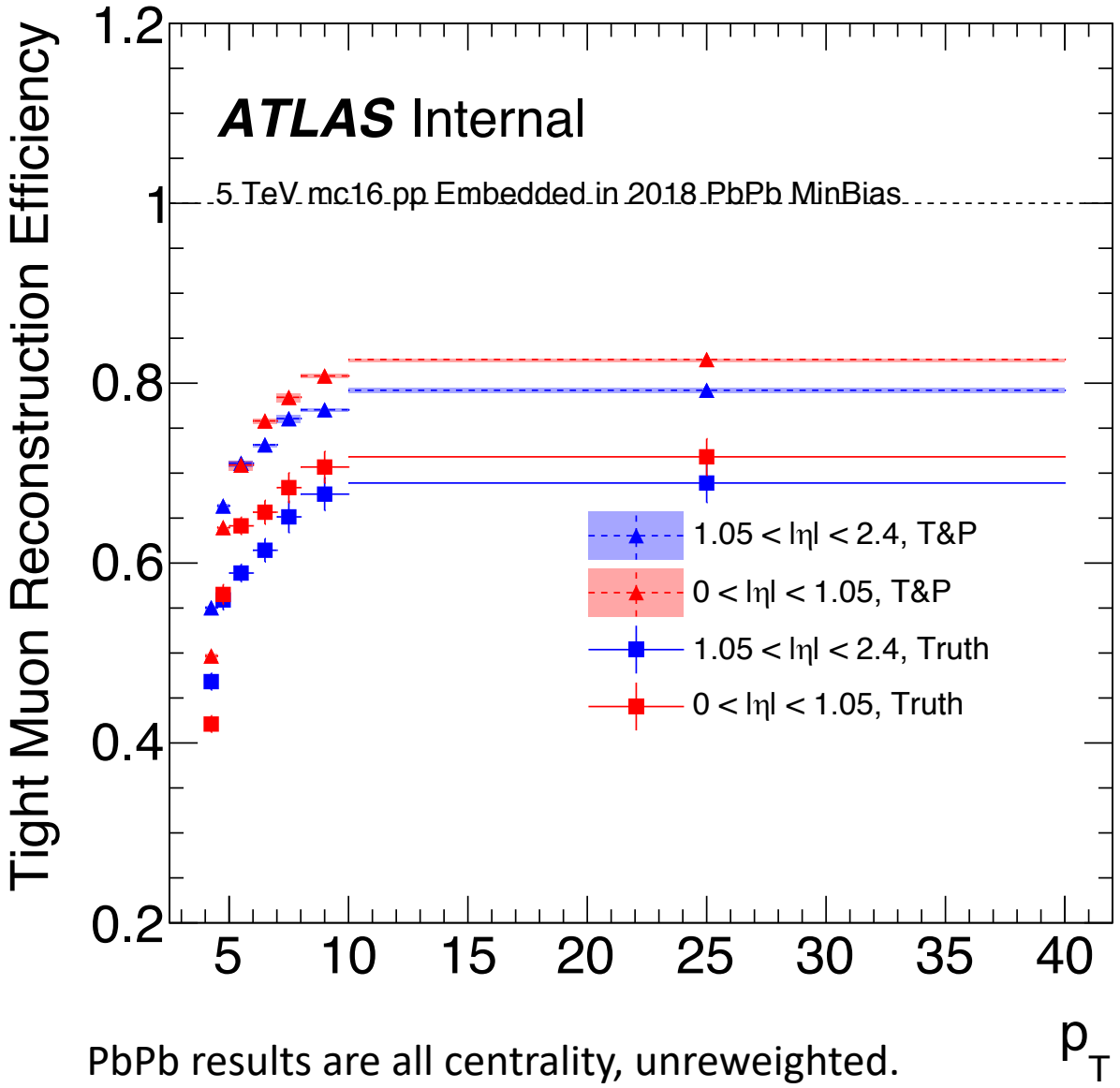
- Efficiency centroid values extraction
  - Invariant mass of matched and unmatched samples are fitted simultaneously (signal has same mean and sigma for matched and unmatched).
  - $N_{match} = N_{tot} * \varepsilon * Sig(mass) + N_{bkg1} * Bkg1(mass)$
  - $N_{unmatch} = N_{tot} * (1-\varepsilon) *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

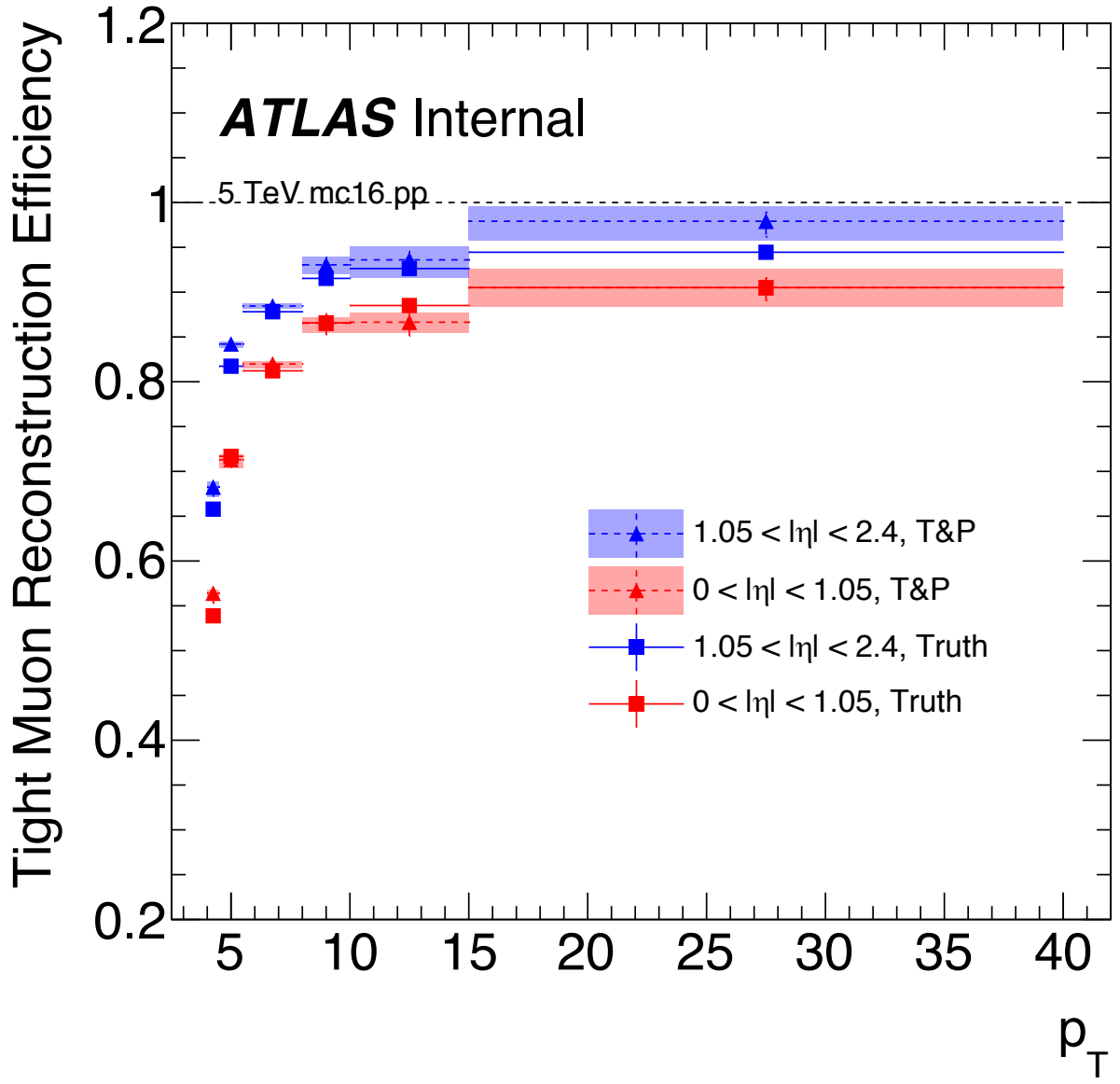
Sig(mass): Gaus
Bkg(mass): Exponential





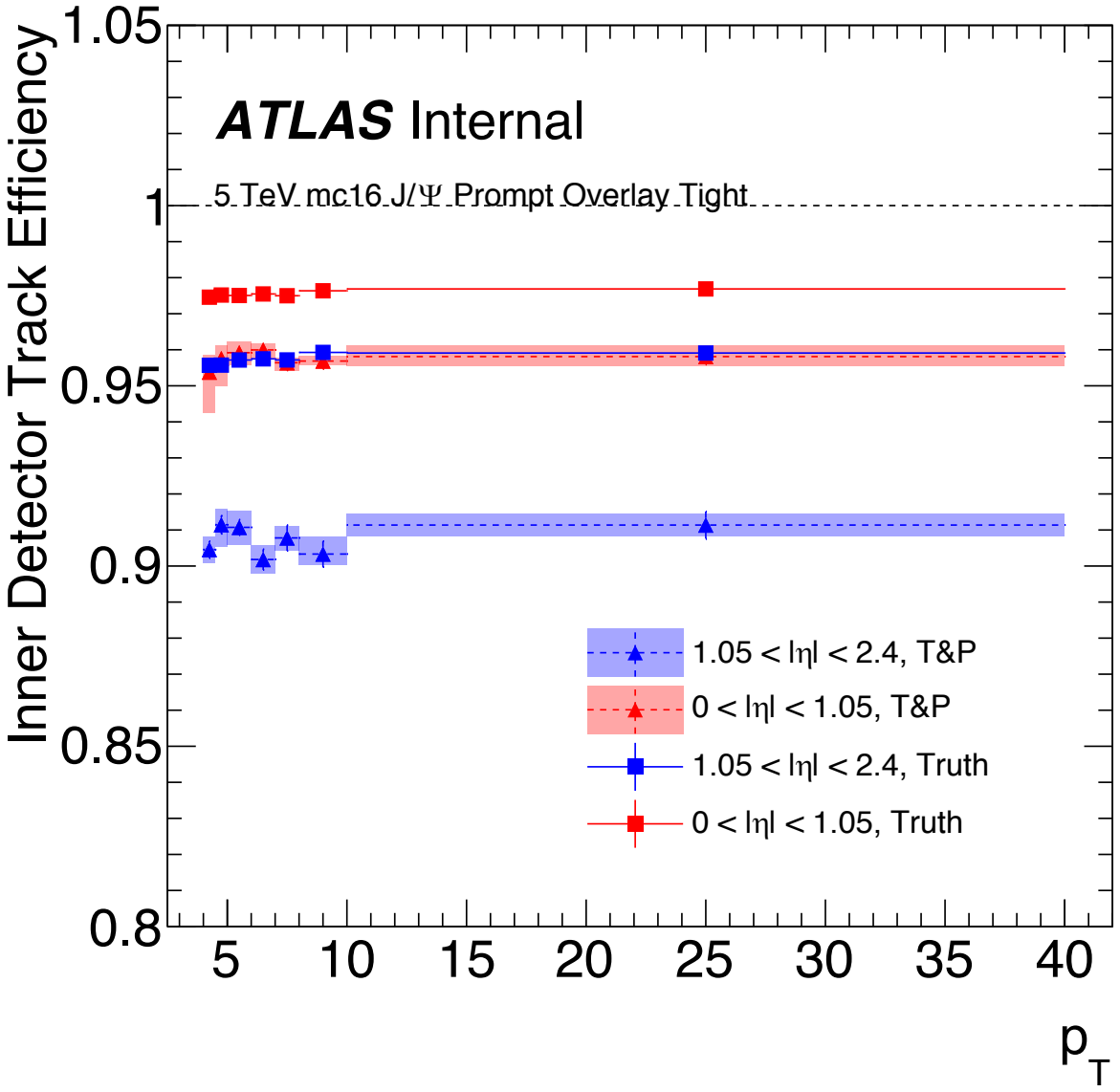
Results of Tight Muon in PbPb and pp MC

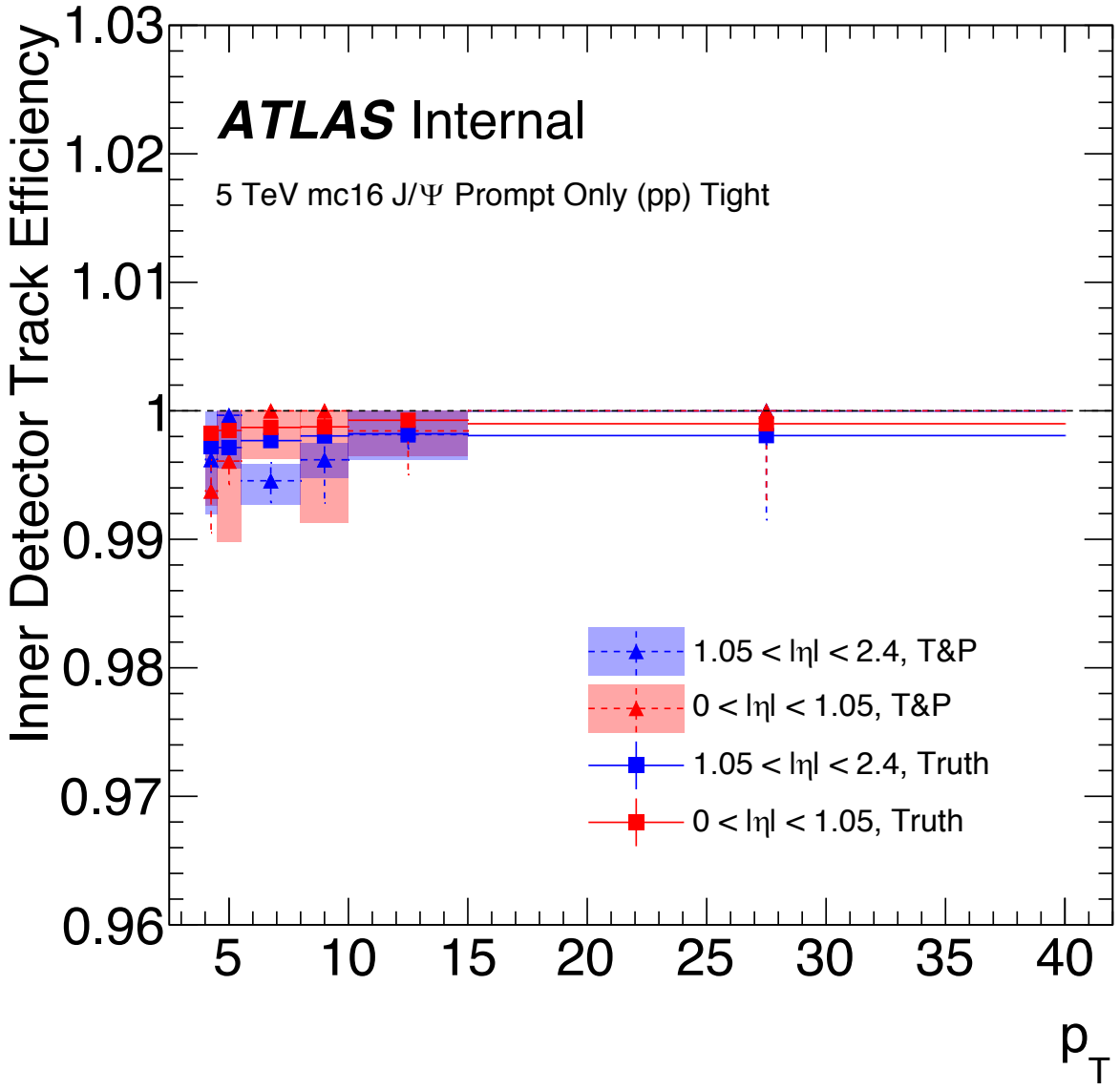




PbPb results are all centrality, unreweighted.
Reweighting needs debugging.

Results of ID Track in PbPb and pp MC

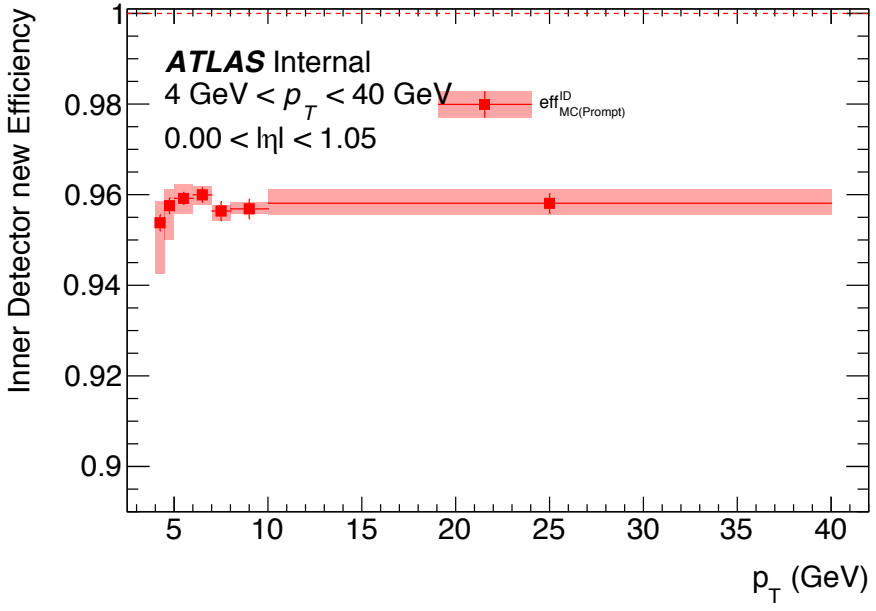


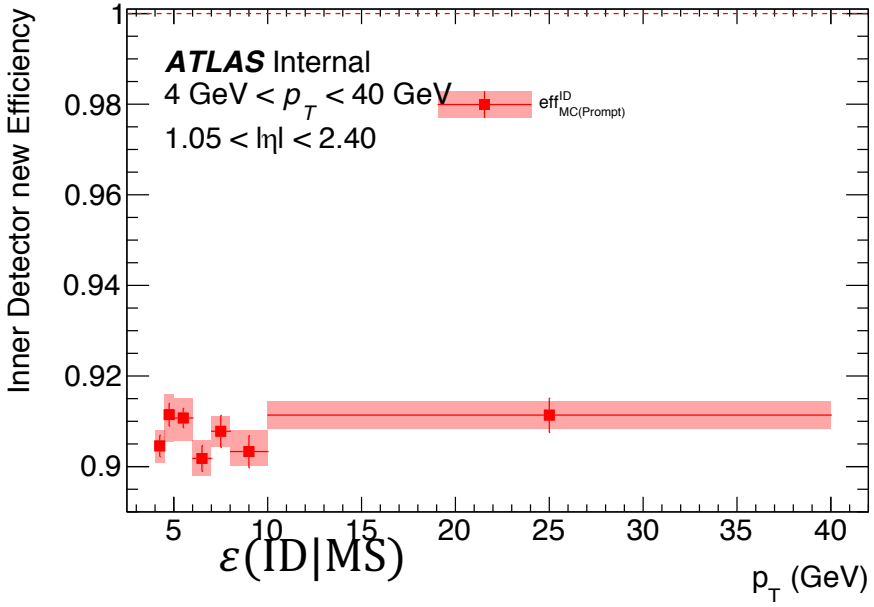


PbPb results are all centrality, unreweighted.
Reweighting needs debugging.

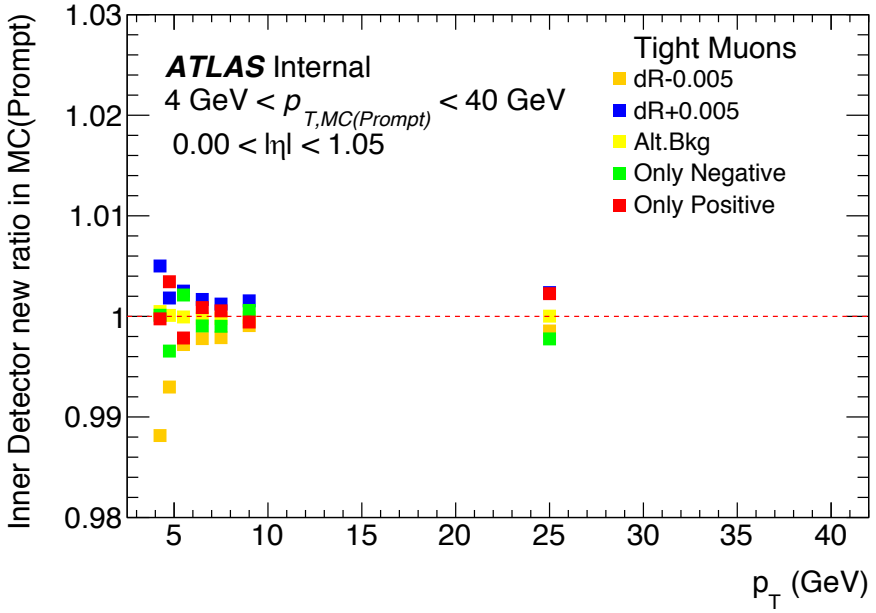
Back-up

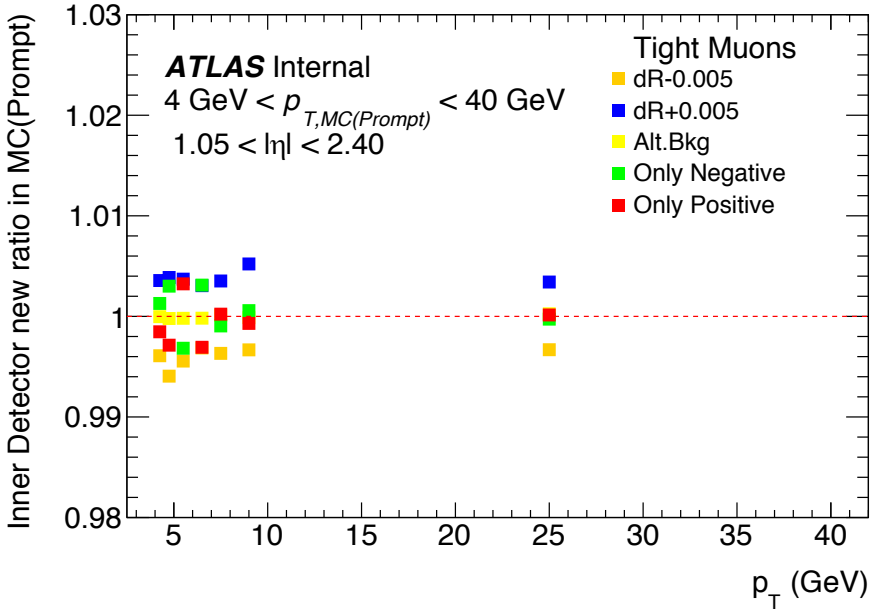
$\varepsilon(\mathrm{ID}|\mathrm{MS})$ in PbPb MC Tight Muon Using T&P (unreweighted)



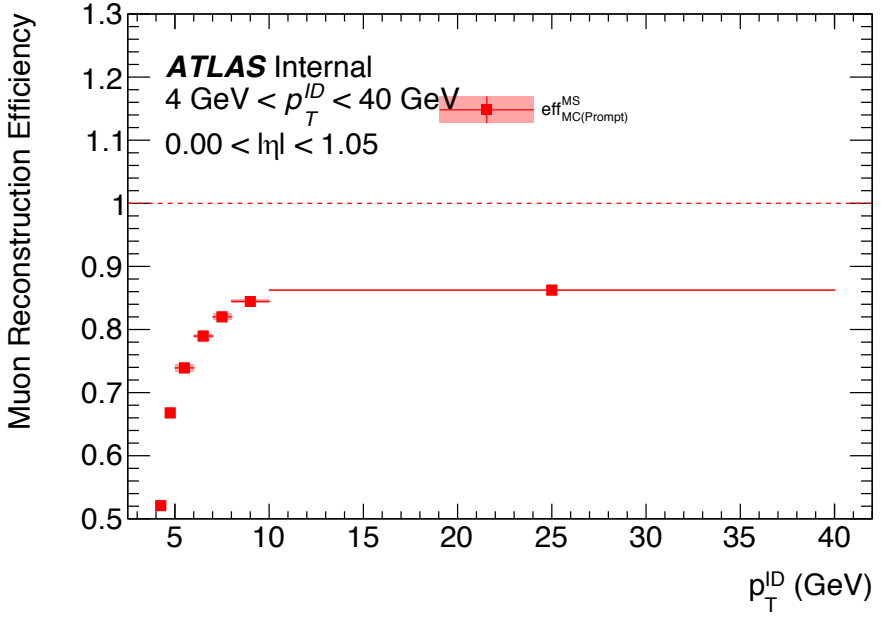


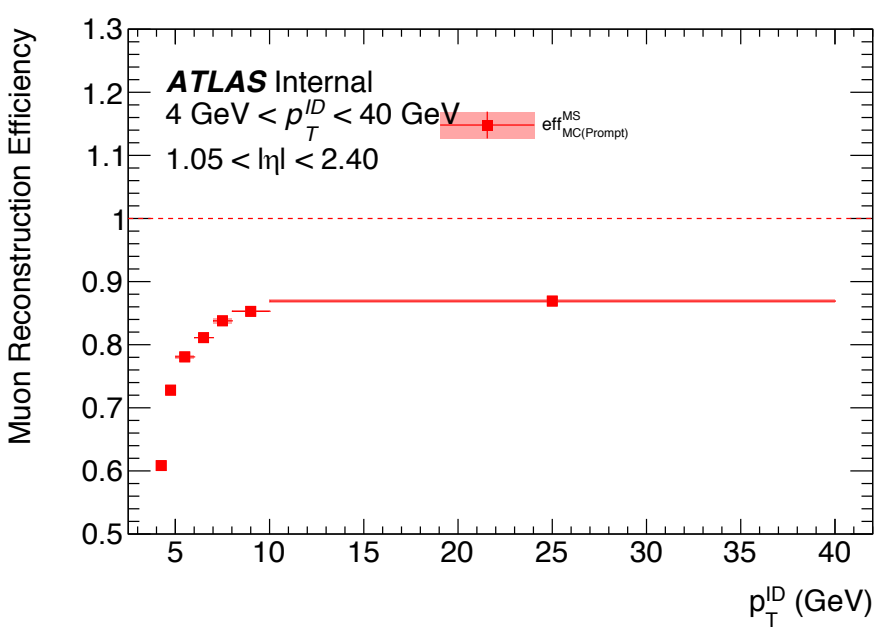
$\varepsilon(\mathrm{ID}|\mathrm{MS})$

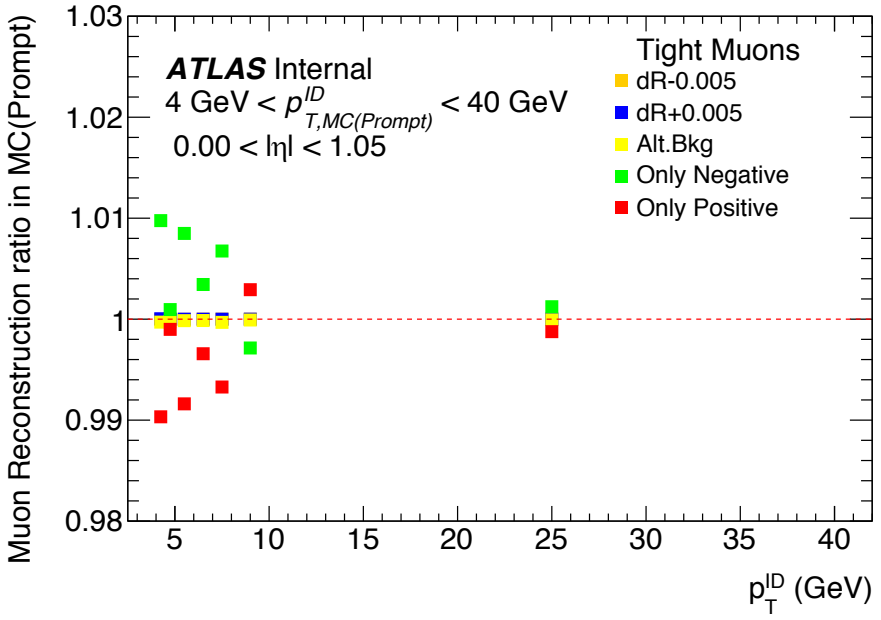


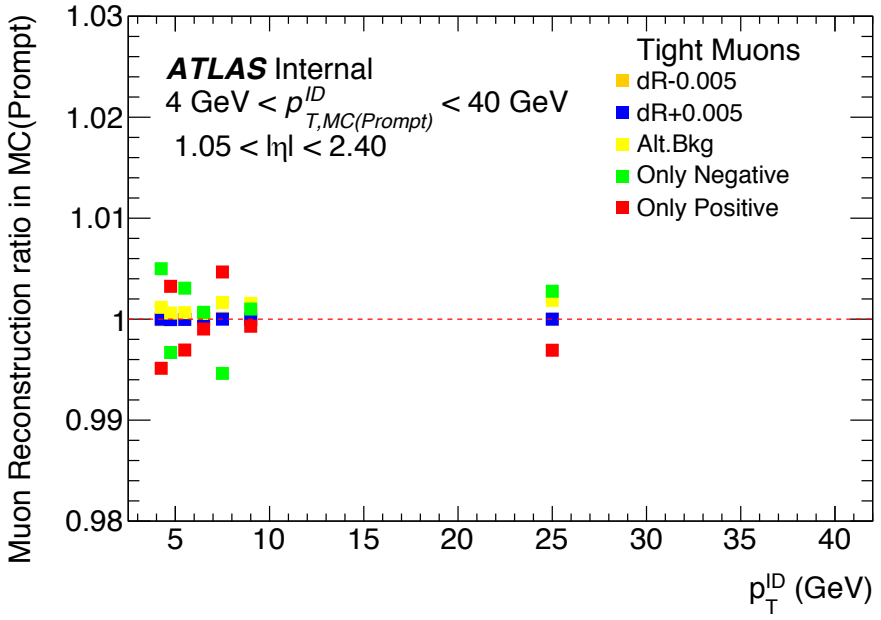


$\varepsilon(\mu|\mathrm{ID})$ in PbPb MC Tight Muon Using T&P (unreweighted)

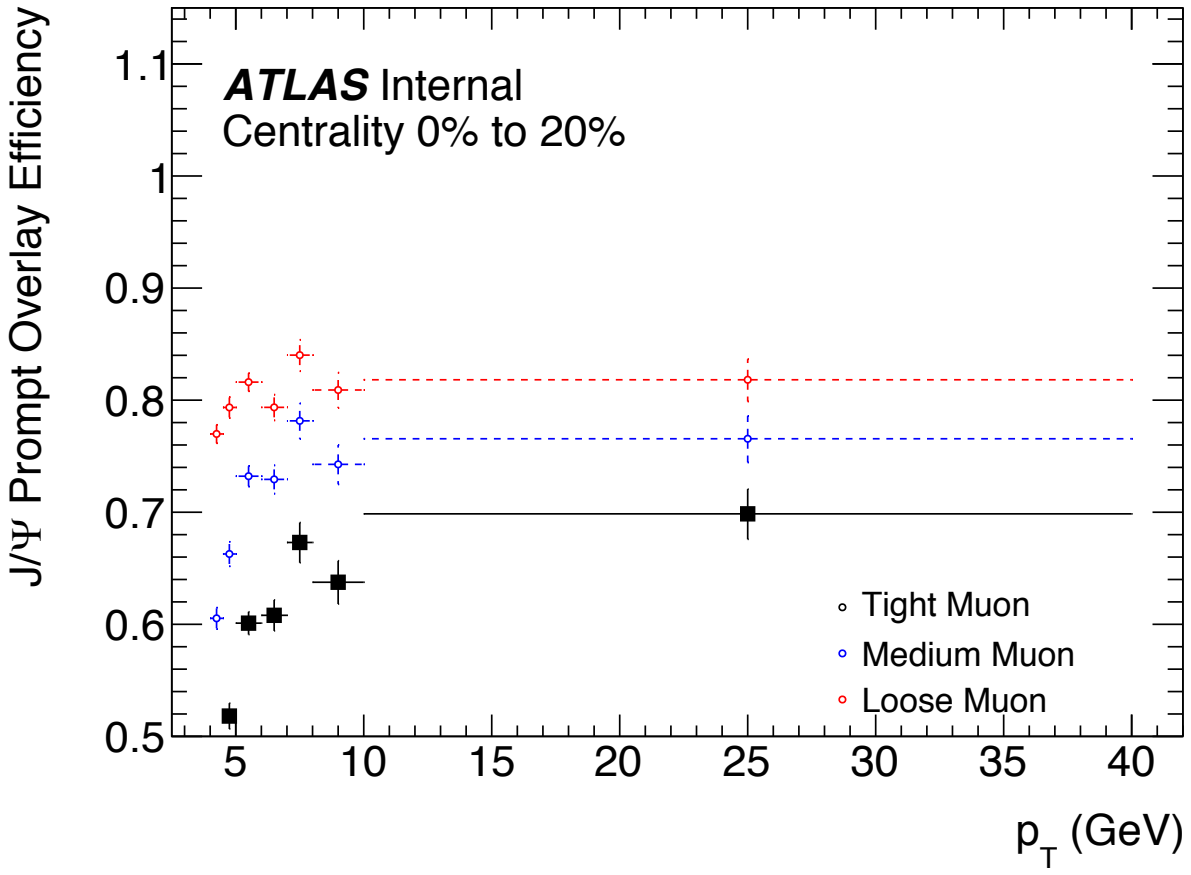


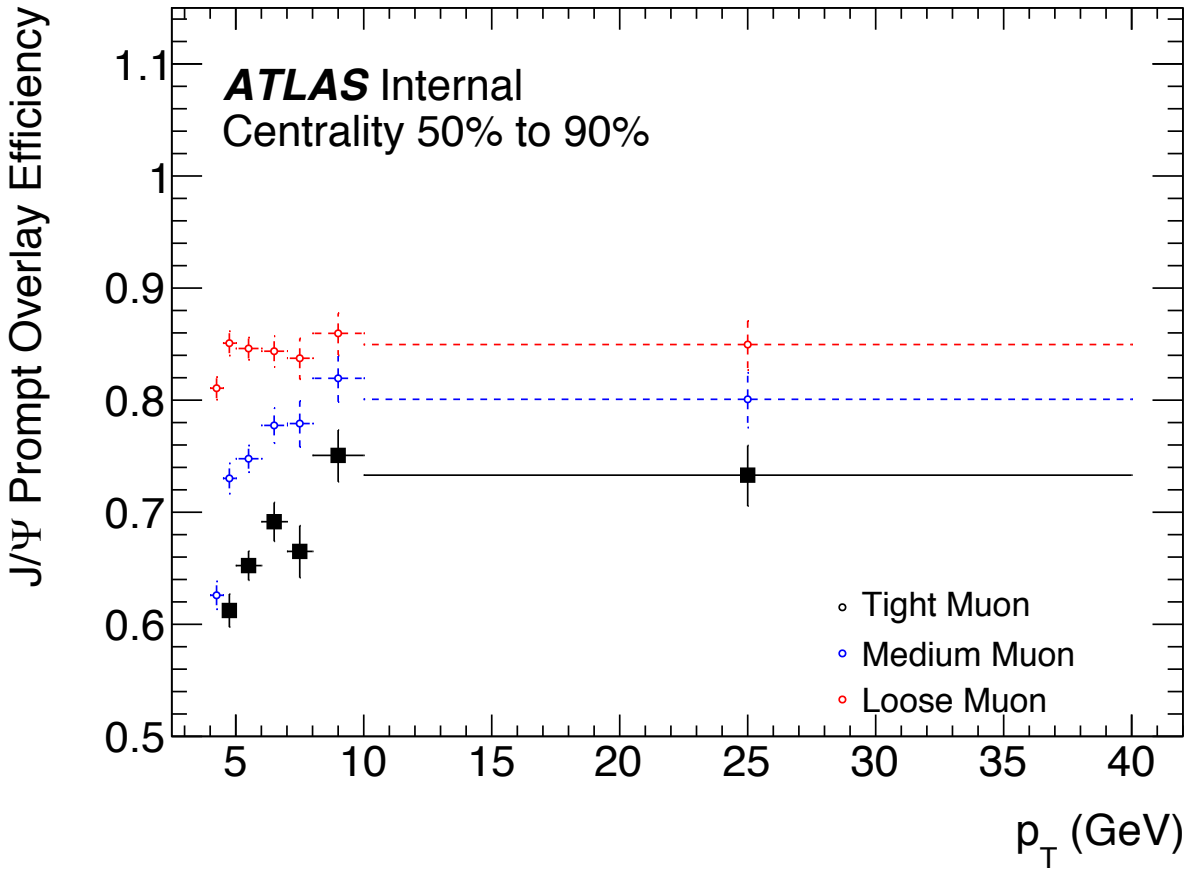






PbPb MC Tight Muon using Truth match





- Peripheral efficiency slightly better than central.
- All much lower than T&P.