Measurement of prompt and non-prompt J/ψ in pPb collisions at $\sqrt{S_{NN}}$ = 5.02 TeV

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lab meeting
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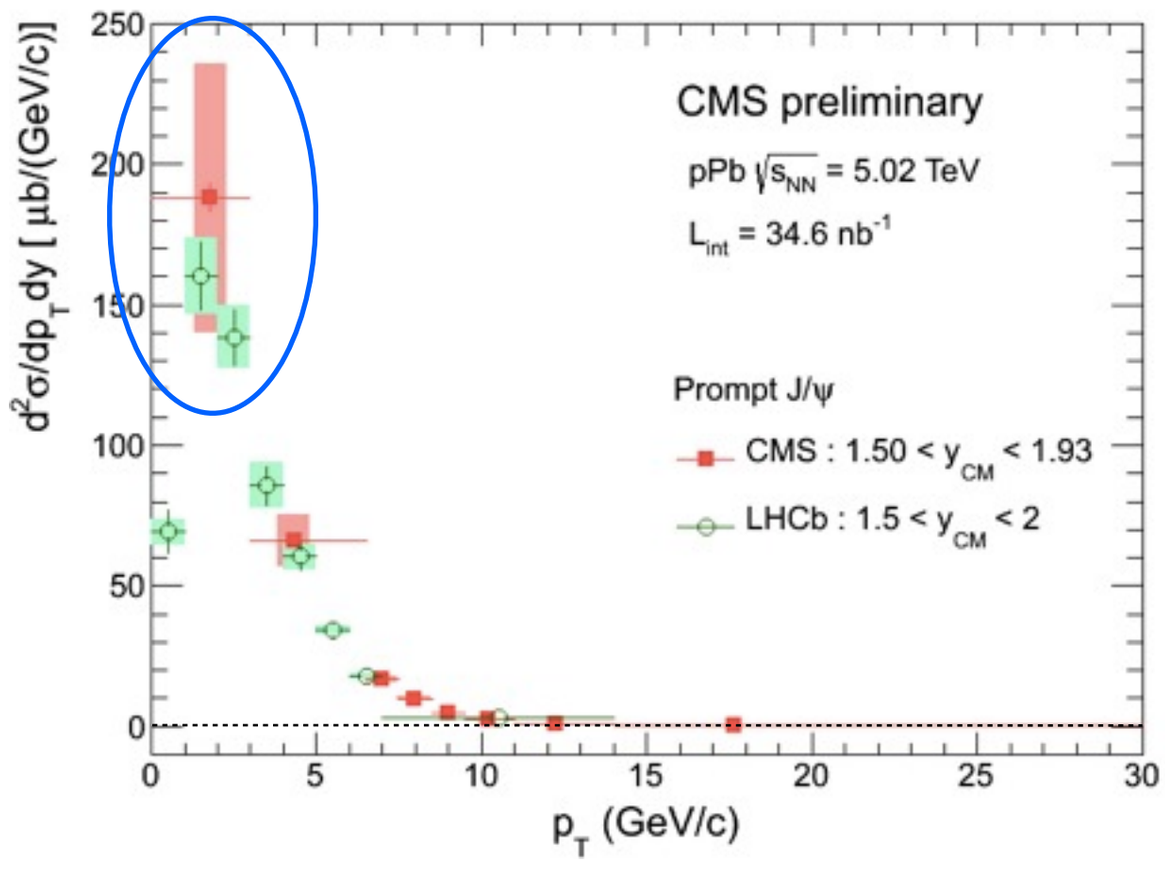
New sample

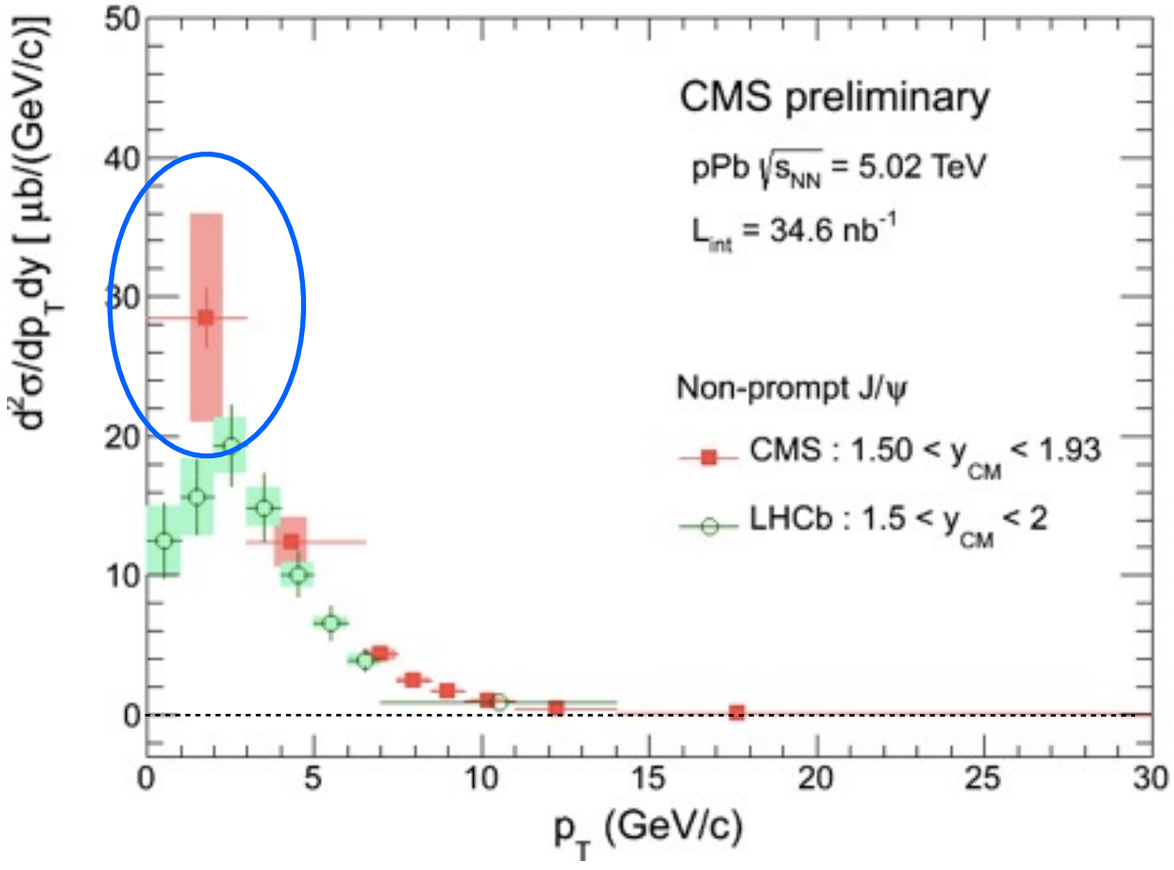
- **Double differential cross section**
  - LHCb points plotted at the center of the bin
  - Our points plotted at < p_T >

$$\frac{d^2\sigma}{dp_T dy} = \frac{N_{fit}^{J/\psi} / (A \cdot \varepsilon)}{L_{int} \times B(J/\psi \to \mu^+\mu^-) \times \Delta p_T \Delta y}$$

[Prompt]



[Non-prompt]



- **Large discrepancies at lower p_T < 3 GeV/c**
  - **acceptance or efficiency underestimated?**

New sample

- **Definition of acceptance and efficiency**
  - **Acceptance :** 1) a sample produced with the same configuration setting as the official, but MuMuGen Filter (kinematic filter for single muons) were removed.

$$\alpha = \frac{N^{dimuon}_{reconstructible,M1}(p_T, y)}{N^{dimuon}_{generated}(p_T, y)}$$

Acc. numerator(GEN)
M1 + acc.cut

  - **Efficiency :** 2) centrally produced official sample (with MuMuGen Filter).

$$\varepsilon = \frac{N^{dimuons\ reconstructed,M2,muIDcut,triggerselection}_{detectable}(p_T, y)}{N^{dimuon\ generated,M1}_{detectable}(p_T, y)}$$

Eff. denominator(GEN)
M1 + acc.cut + filter

• M1

$2.6 < m_{\mu\mu} < 3.5\ GeV/c^2$

• acceptance cut

(detectable/reconstructable)

$$-2.4 < \eta < 1.93$$

$$|\eta^{\mu}| < 1.3 \rightarrow p_T^{\mu} > 3.3\ GeV/c$$
$$1.3 < |\eta^{\mu}| < 2.2 \rightarrow p^{\mu} > 2.9\ GeV/c$$
$$2.2 < |\eta^{\mu}| < 2.4 \rightarrow p_T^{\mu} > 0.8\ GeV/c$$

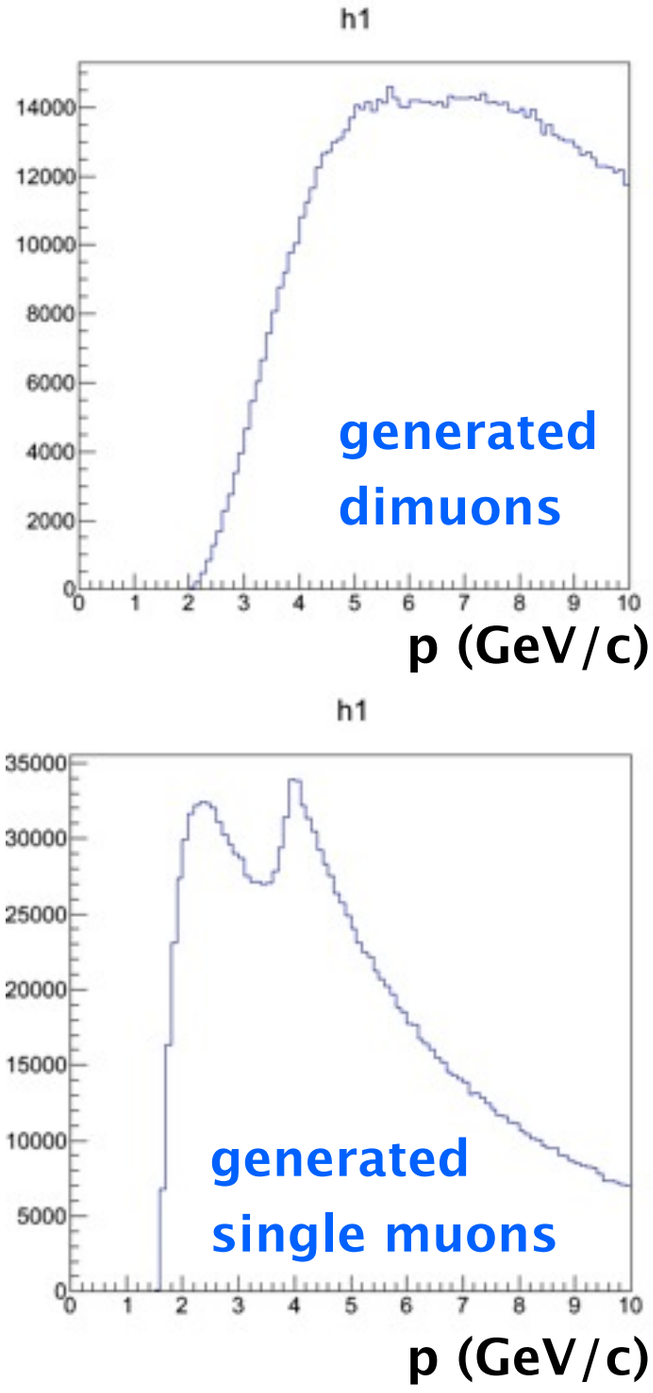
• MuMuGen filter

1) $-2.5 < \eta^{\mu} < 2.5$
2) $p^{\mu} > 2.5$
(configuration in backup)

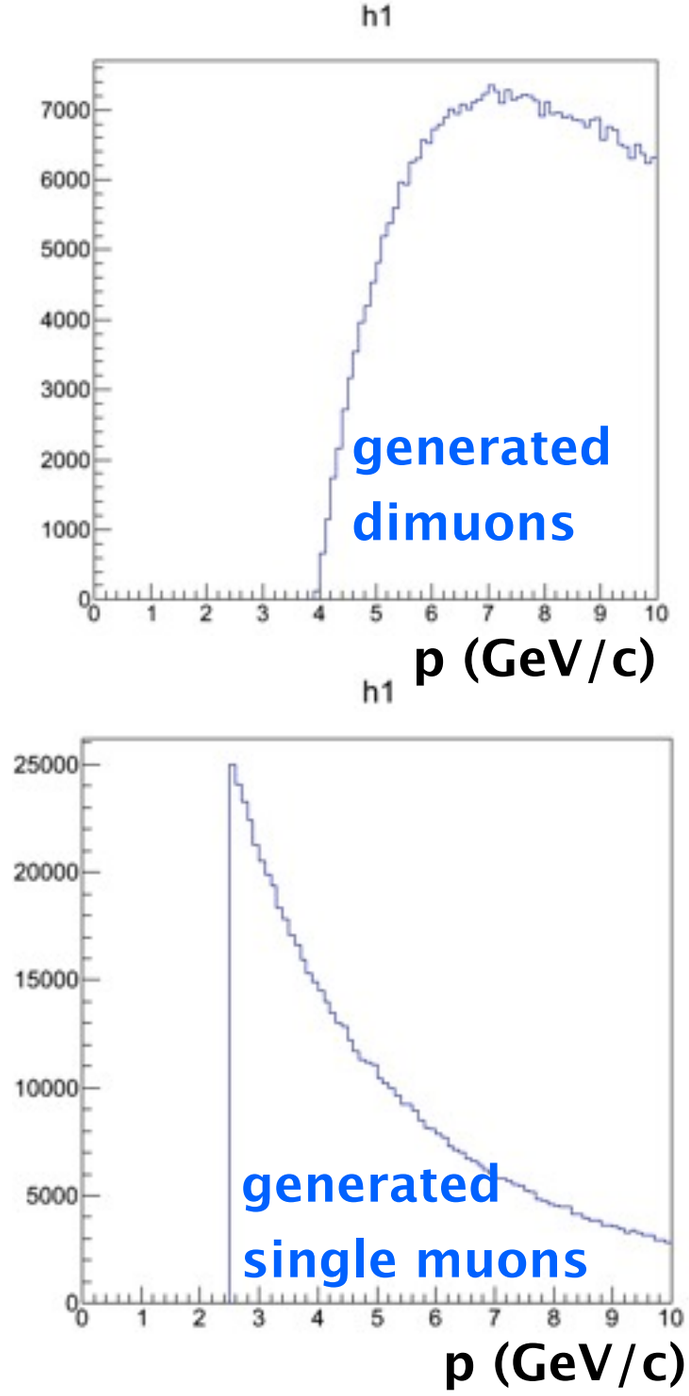
- **MuMuGen Filter should be looser than the acceptance cut, and "denominator of efficiency" should be same with "numerator of acceptance".**

New sample

- **pp boosted prompt J/psi sample**
  - Old official sample (~2M)



  - New sample with correct filter (~1M)

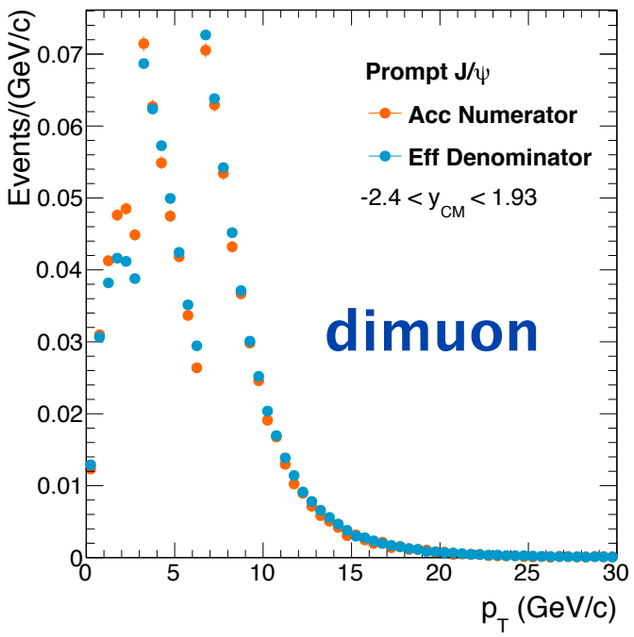


  - Filter is applied properly
  - Details are on back-up

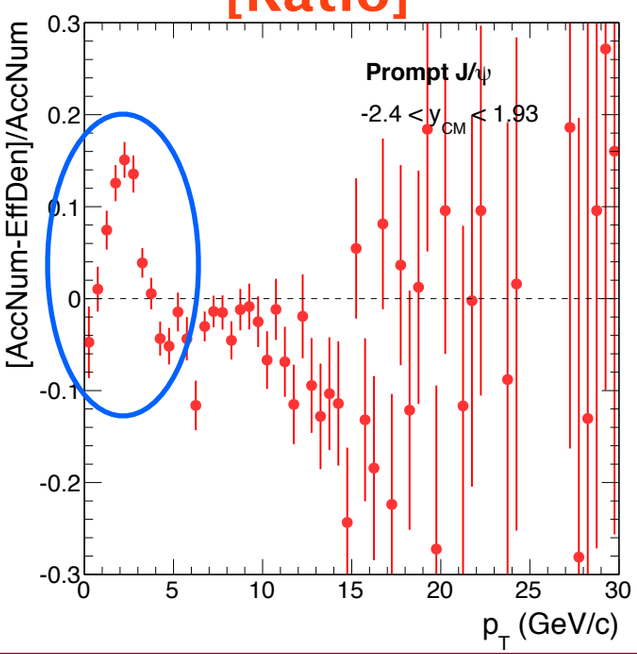
Acc. sample vs Eff. sample

Dimuons : p_T distributions

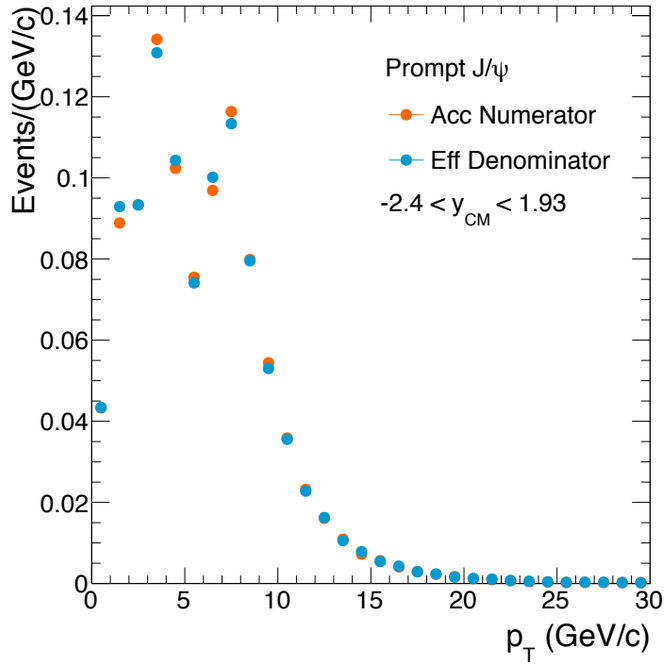
- Old official sample (~2M)

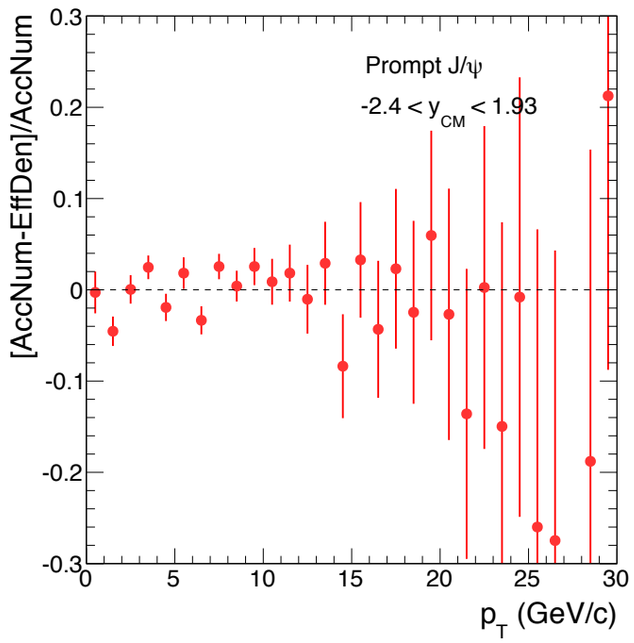


[Ratio]



- New sample with correct filter (~1M)



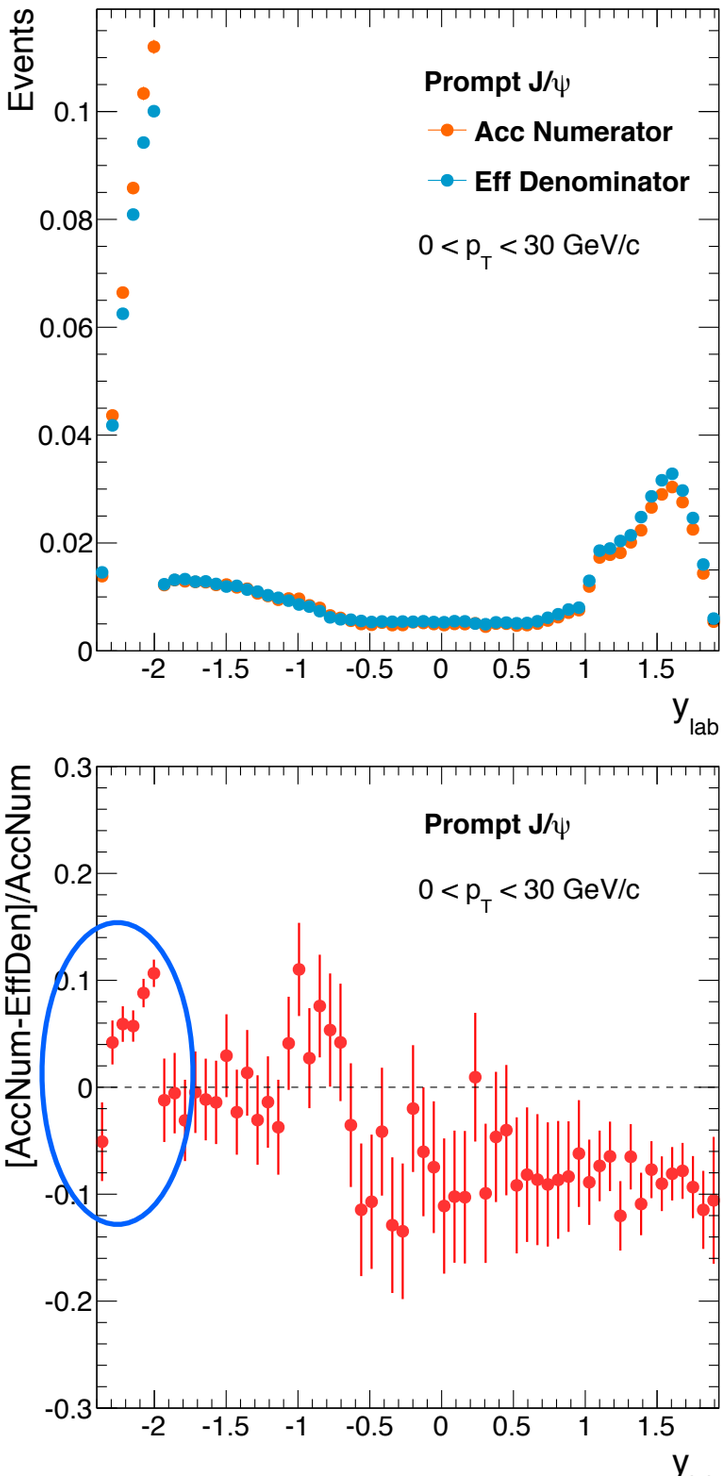


- Discrepancies removed
- Details are on back-up

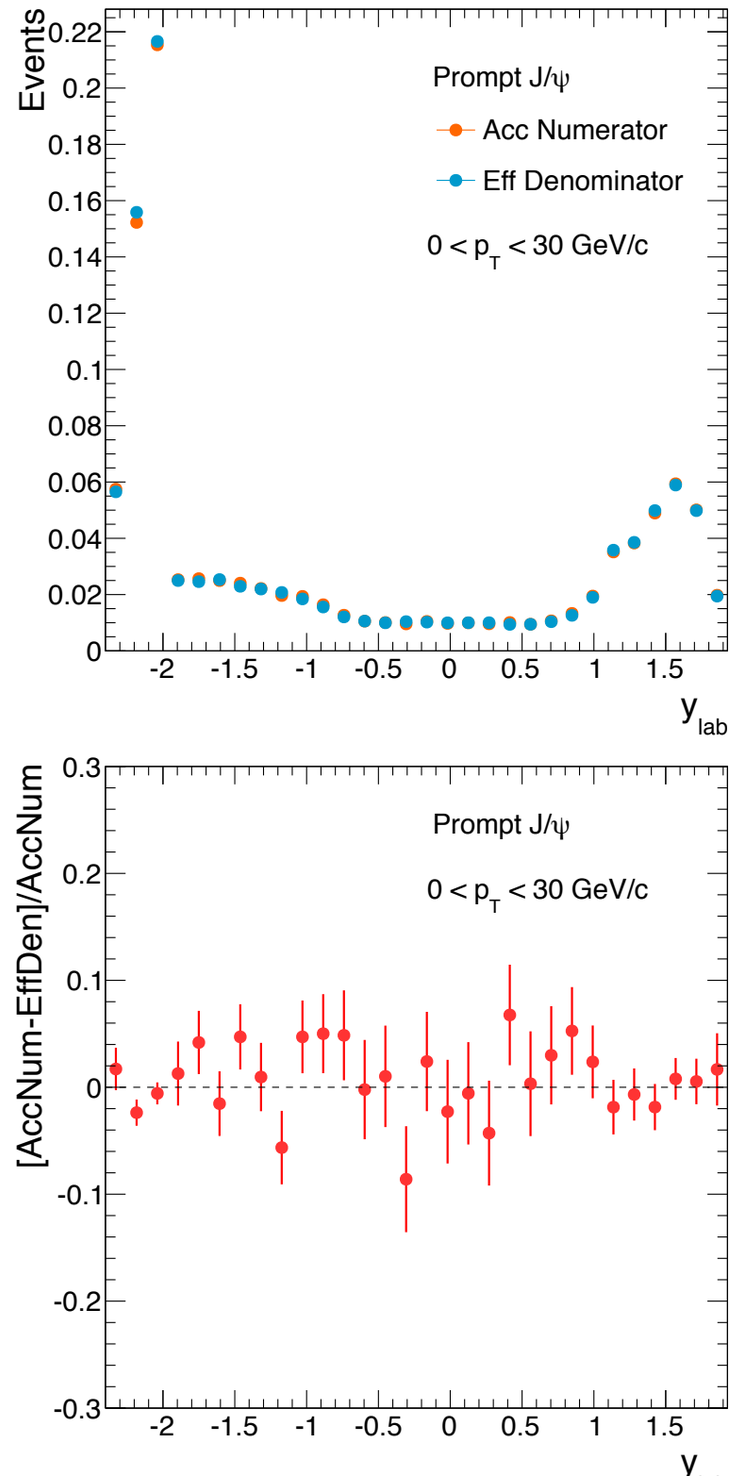
Acc. sample vs Eff. sample

Dimuons : y_{lab} distributions

- Old official sample (~2M)



- New sample with correct filter (~1M)

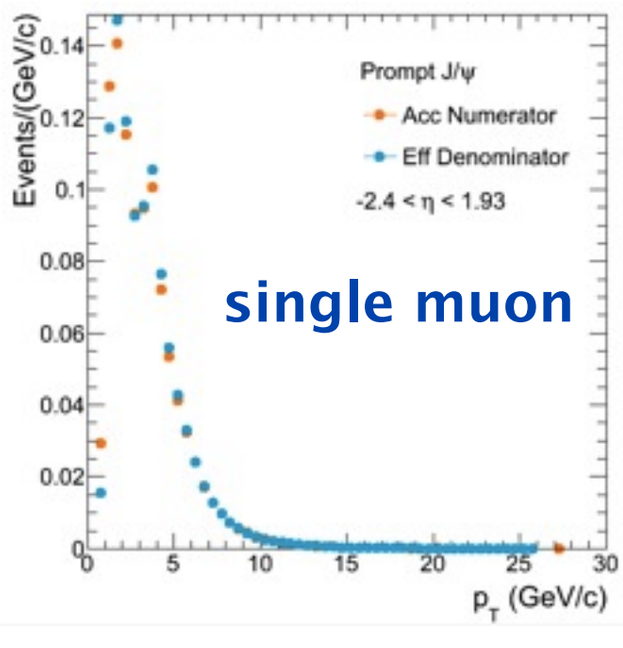


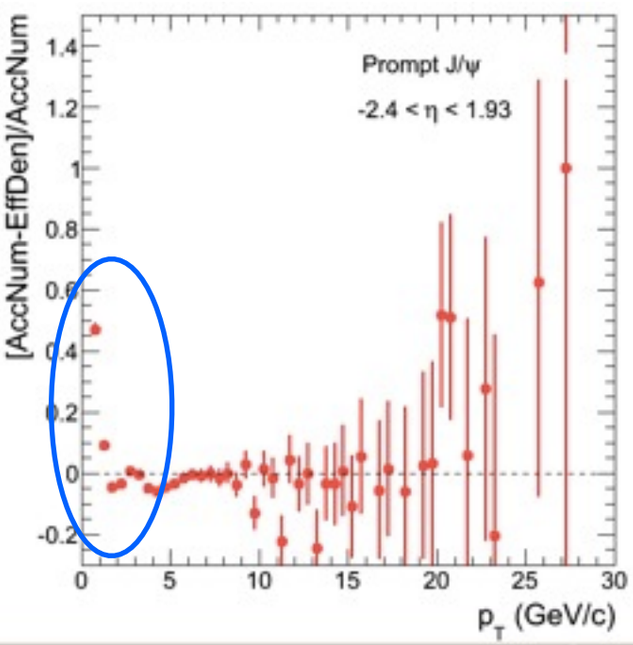
- Discrepancies removed
- Details are on back-up

Acc. sample vs Eff. sample

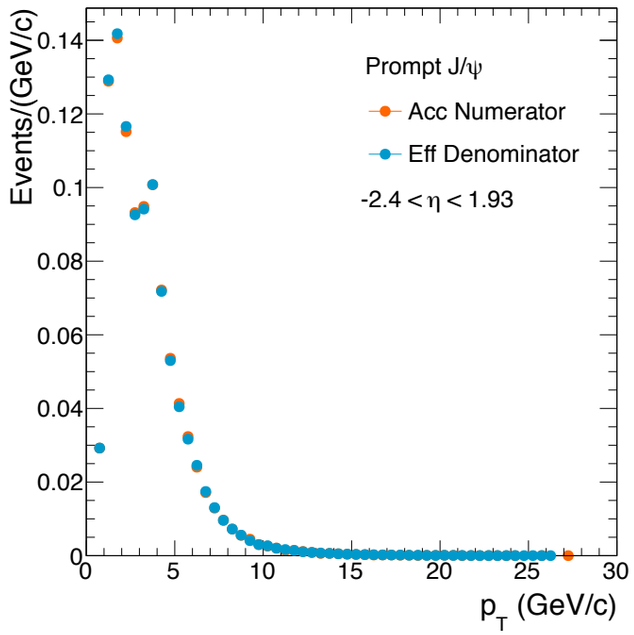
Single muons : p_T distributions

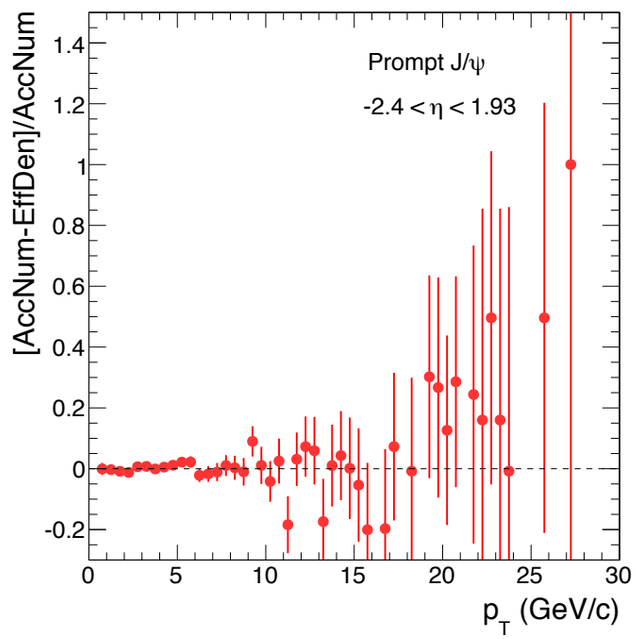
- Old official sample (~2M)





- New sample with correct filter (~1M)



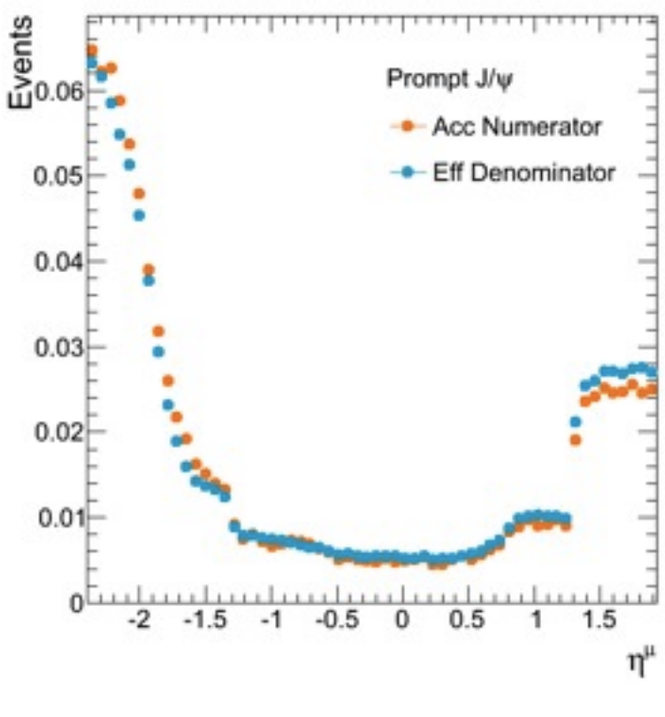


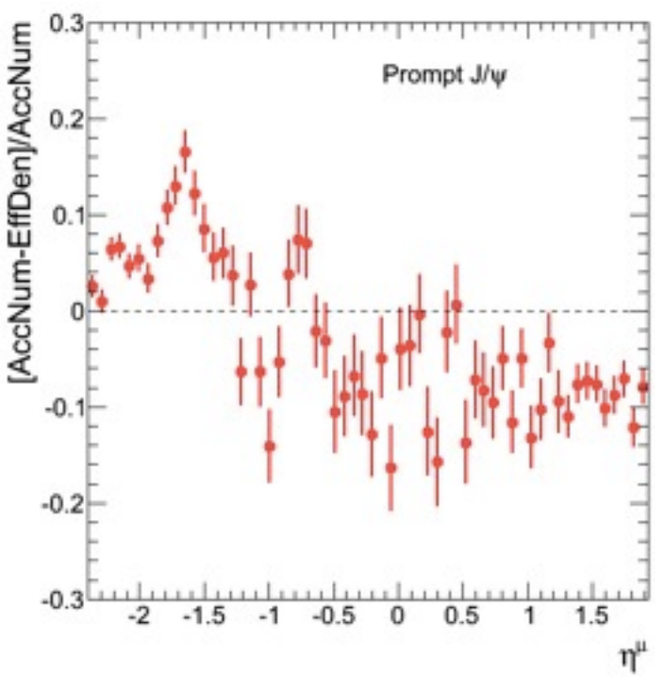
- Discrepancies removed
- Details are on back-up

Acc. sample vs Eff. sample

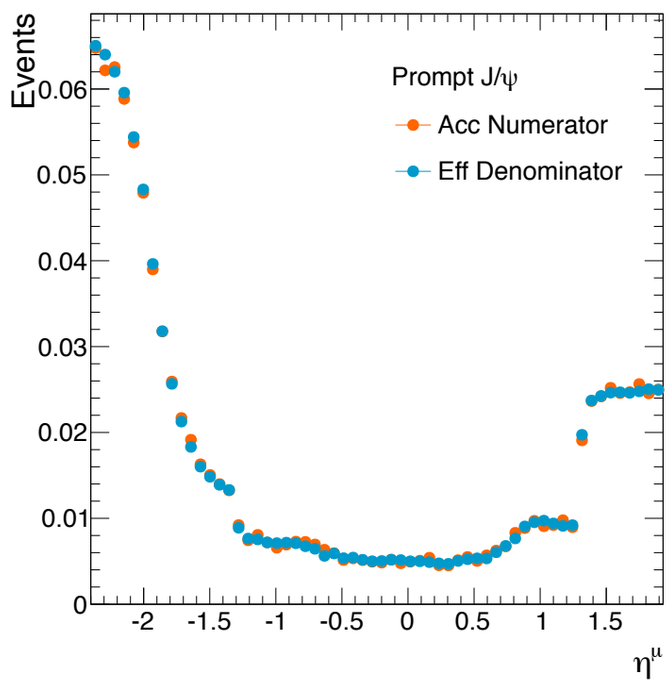
Single muons' : η_{lab} distributions

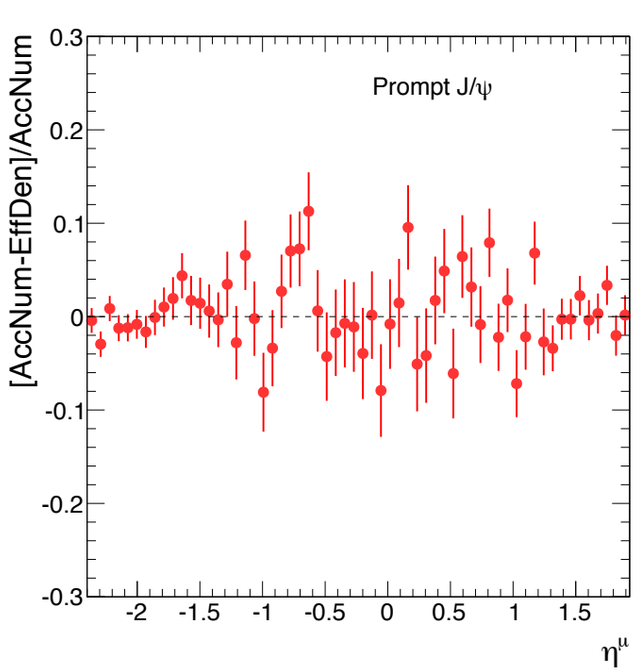
- Old official sample (~2M)





- New sample with correct filter (~1M)



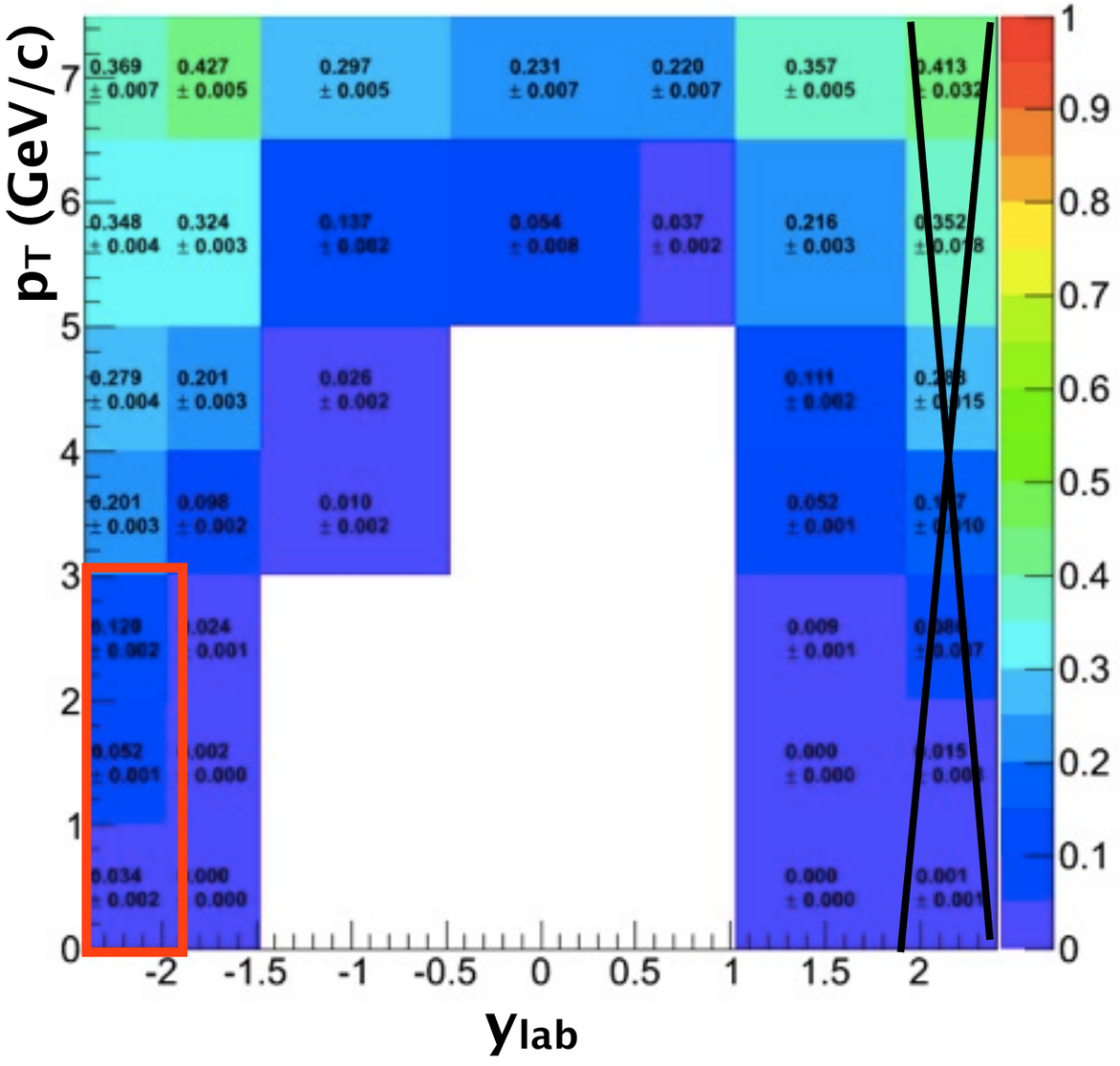


- Discrepancies removed
- Details are on back-up

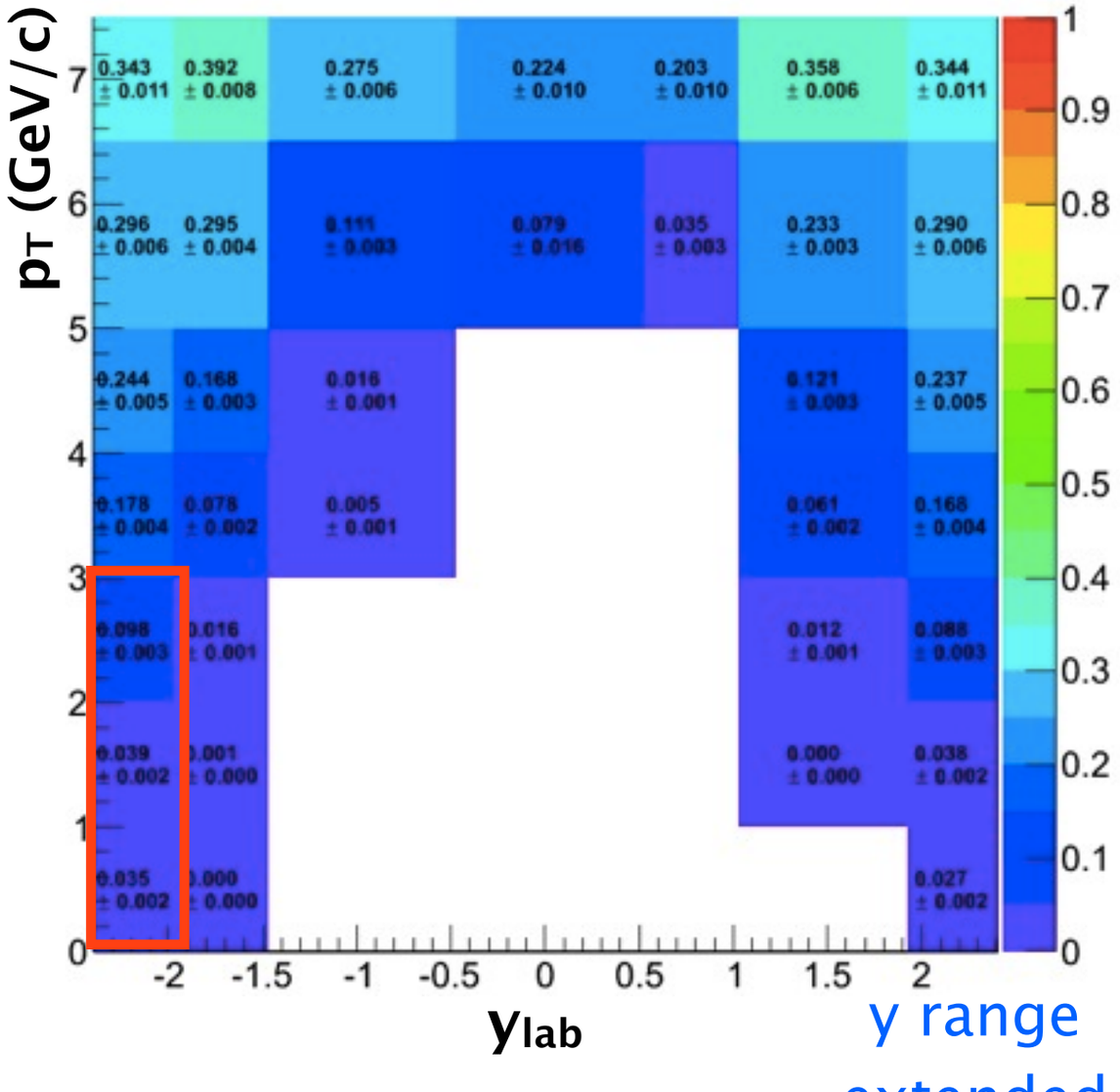
Efficiency values

Efficiency values

- Old official sample (~2M)



- New sample with correct filter (~1M)



y range extended

- Efficiency values in low p_T bins are not improved as we expected
- need to check other things
- Still, bug in MC sample is fixed, so we are going to request official production.

Plan

- **Central production : pp boosted MC sample (Songkyo)**
  - 1M events privately produced in CMSSW version 5_3_8_HI
  - checking in the new CMSSW version 5_3_19 before official request (soon)
- **private production : embedded MC sample (Yongsun)**
  - GEN-RECO is done
  - Skimming is ongoing
- **TNP study (Kisoo)**
  - working with new (private) sample
- **Fitting study (Songkyo)**
- **Acceptance systematics study (referring B analysis)**

Back up

detailed calculation

- **Example : How filter becomes tighter than acceptance cut**

$|p| = p_T * \cosh(\eta)$

  - **Before boosting**

    Let's assume a single muon with

    $\eta_{before} = 1.73$

    $p_{before} = 2.5$ GeV/c (limit of the filter cut)

    → $p_T = 0.859$ GeV/c

  - **After boosting**

    $\eta_{after} = \eta_{before} + \Delta\eta = 1.73+0.47 = 2.2$

    $p_T = 0.859$ GeV/c (invariant)

    $p_{after} = 3.65$ GeV/c

    In this η range, acceptance cut is $2.2 < |\eta^{\mu}| < 2.4 \rightarrow p_T^{\mu} > 0.8\ GeV/c$.

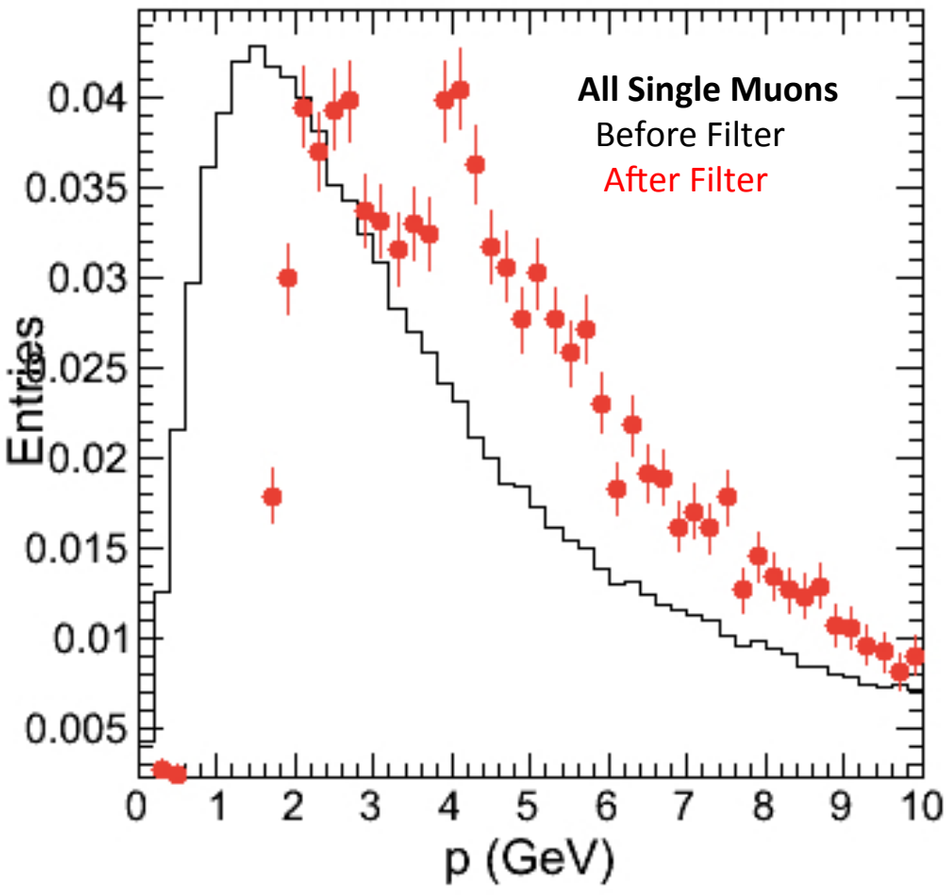
    So this muon should be accepted,

    But already rejected by filter before boosting!!

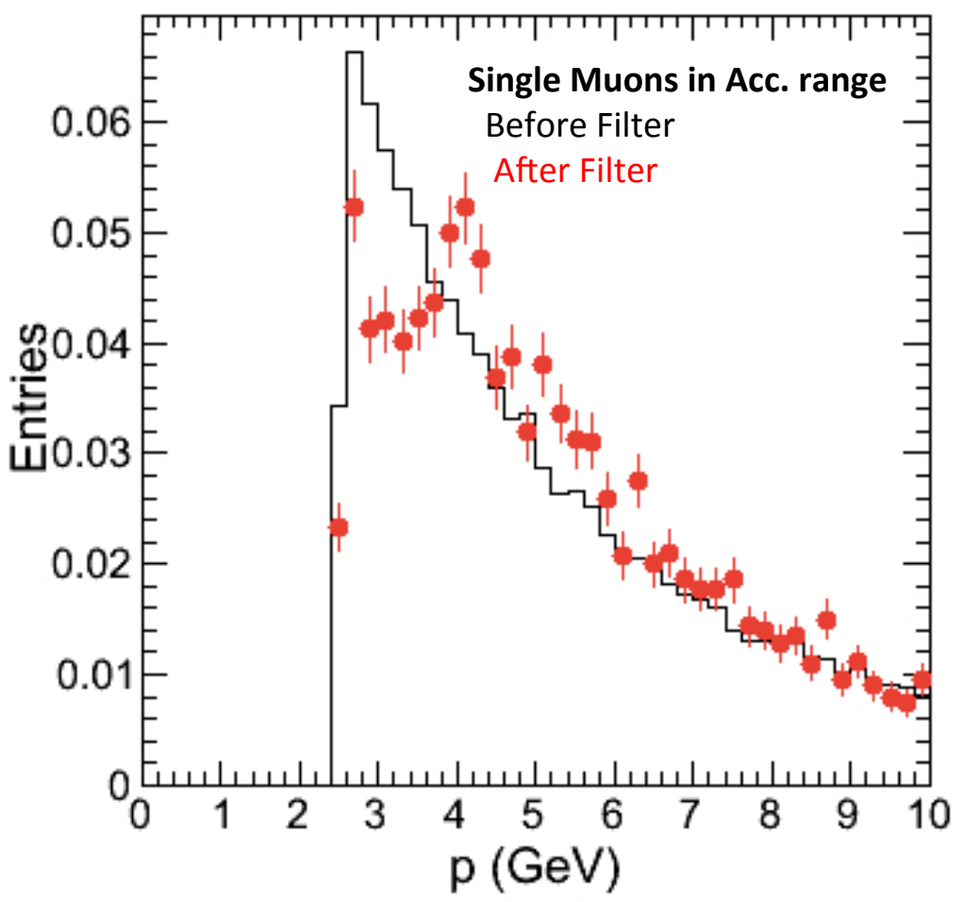
  - **This problem is only for pPb analysis where pseudo-rapidity shifts.**

two MC samples

- **single muon momentum distributions (not p_T)**
  - Produce small sample with and without MuMuGen Filter



acceptance cut



They don't agree!

- **Acceptable dimuon pairs can be lost by MuMuGen Filter (Boost order sequence)**
  - filter cuts affects muons up to p~ 4 GeV/c : detailed calculation on backup

Fix in configurtion

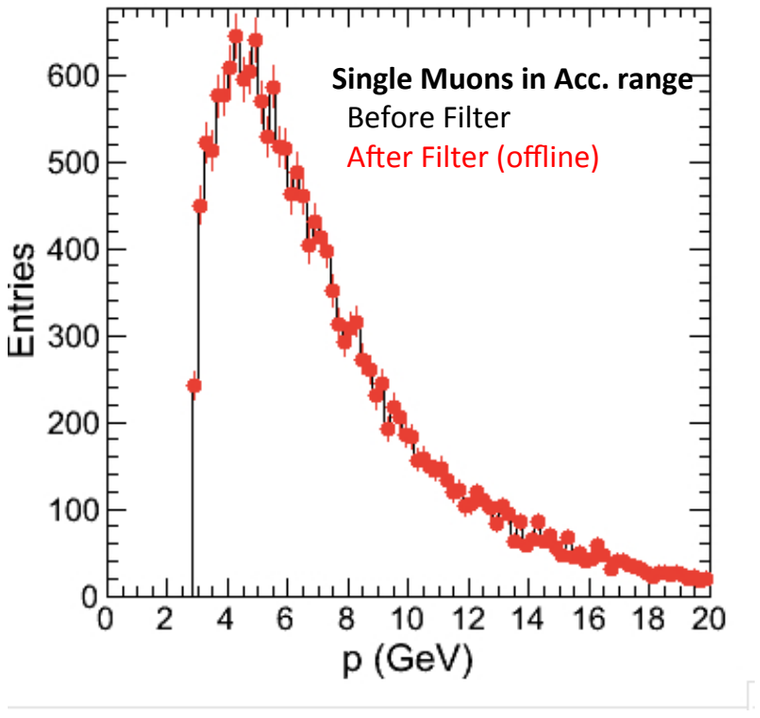
Option 1 : change the order of Filter and Boost

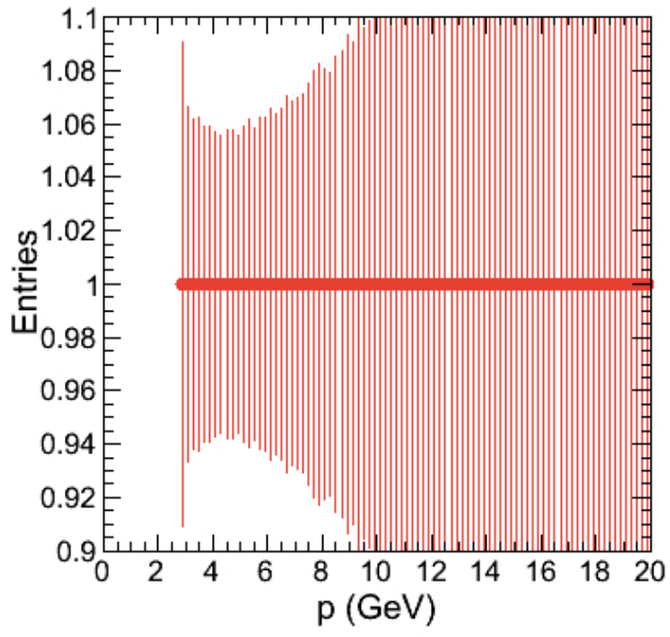
Current : generator*filter precedes all sequence

```
for path in process.paths:
    getattr(process,path)._seq = process.ProductionFilterSequence*getattr(process,path)._seq
```

After Fix : vtxSmeared located just before filter

```
process.ProductionFilterSequence =
cms.Sequence(process.generator*process.VtxSmeared*process.oniafilter*process.mumugenfilter)
```





They agree

Option 2 : Loose filter thresholds so all acceptable muons can pass

- pT > 0.8 GeV
- p > 1.5 GeV
- |eta| < 3.0

Summary & plan

- Request New MC samples
  - Configuration fragments (cfi) will be ready soon to be used for cmsDriver command

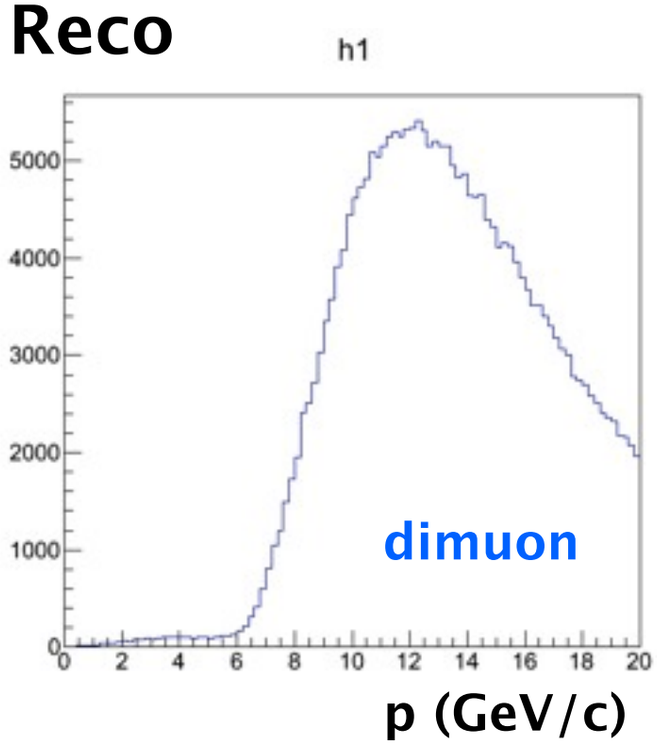
PYTHIA + HIJING embedding (8M in total)
- Prompt J/psi + Minbias HIJING (2M in pPb, 2M in Pbp)
- Non-prompt J/psi + MinBias HIJING (2M in pPB, 2M in Pbp)

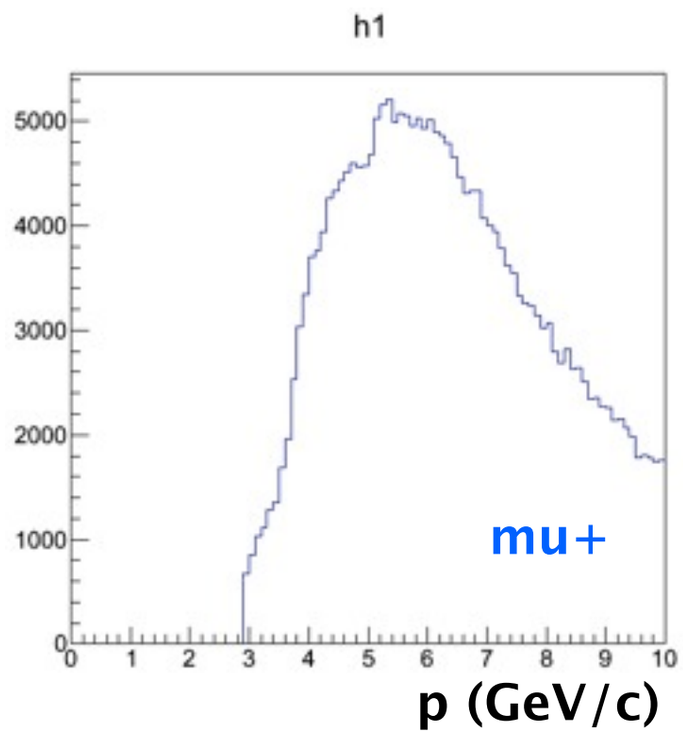
- Fitting study
  - No serious problem in the current fitting method,
    but we would like to study further and improve the quality. (next slides)
  - extend the rapidity range from to $-2.4 < y_{lab} < 1.93$ to $-2.87 < y_{CM} < 1.93$

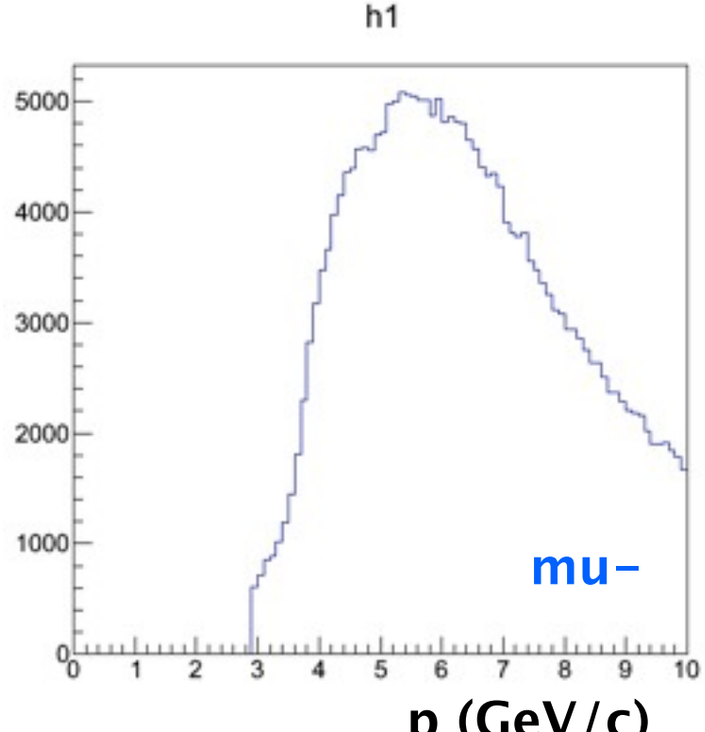
- TNP result validation
  - should be done with new MC sample
  - Cross check every step

old sample

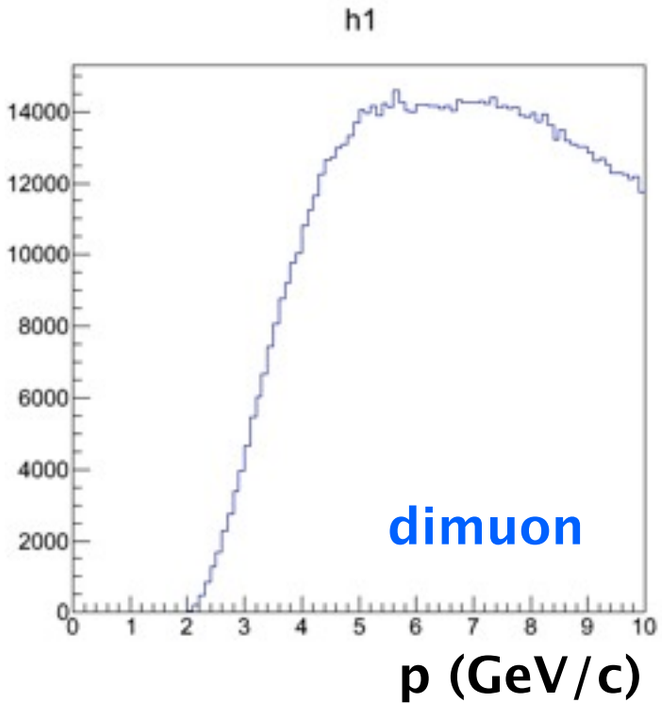
- **Reco**

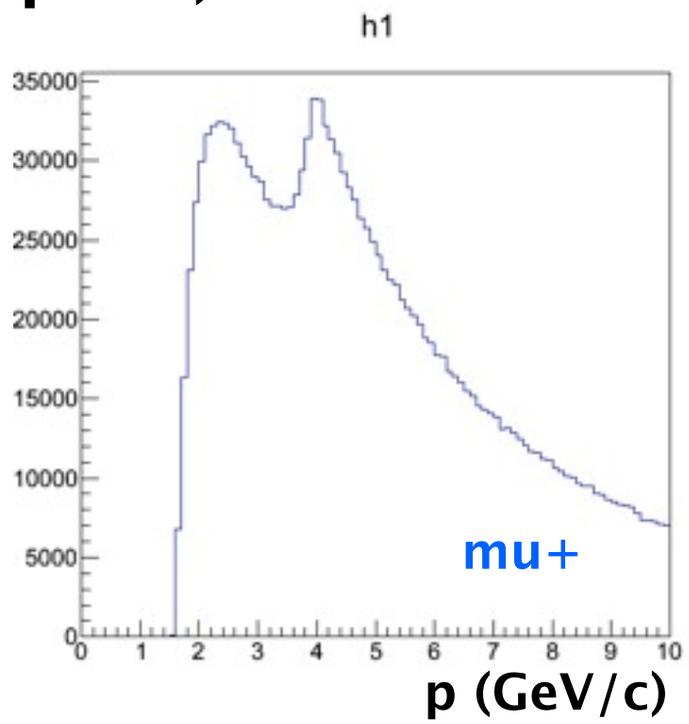


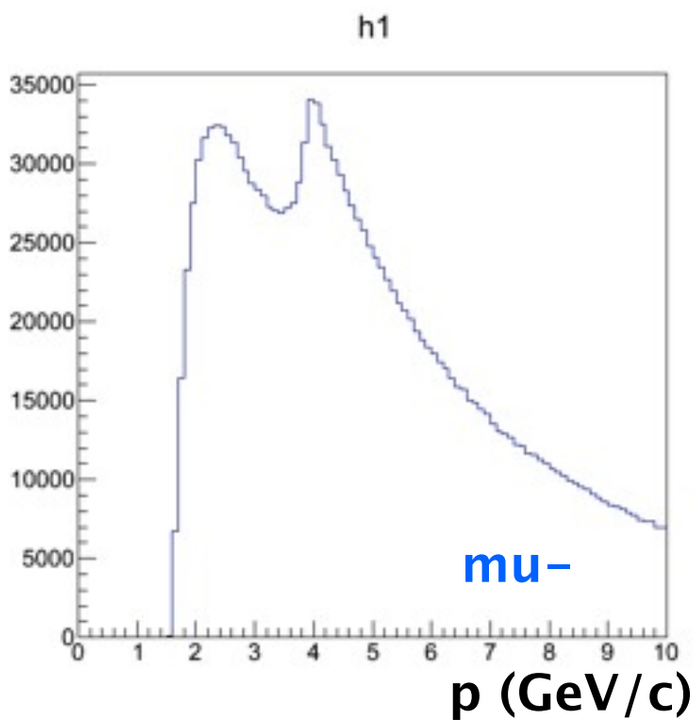




- **Gen (acc. cut NOT applied)**

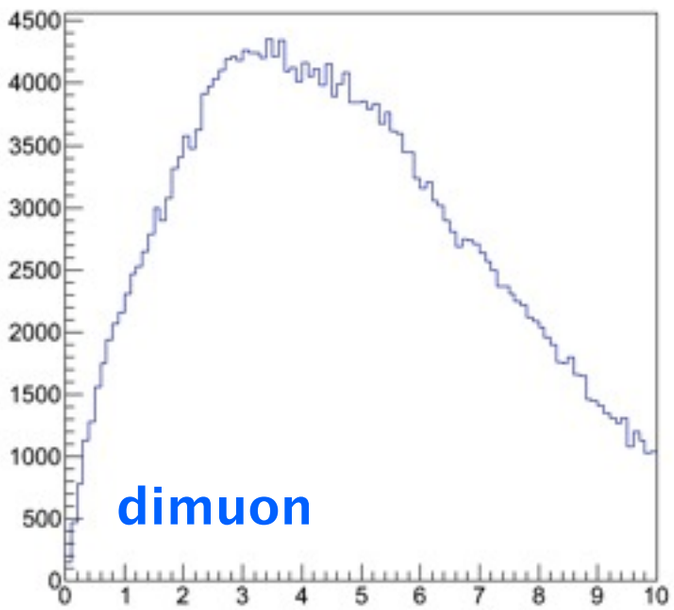


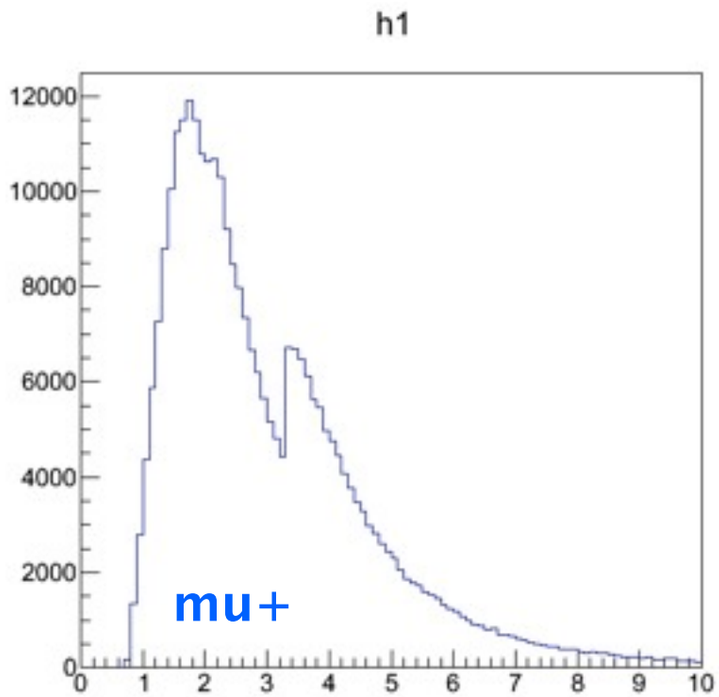


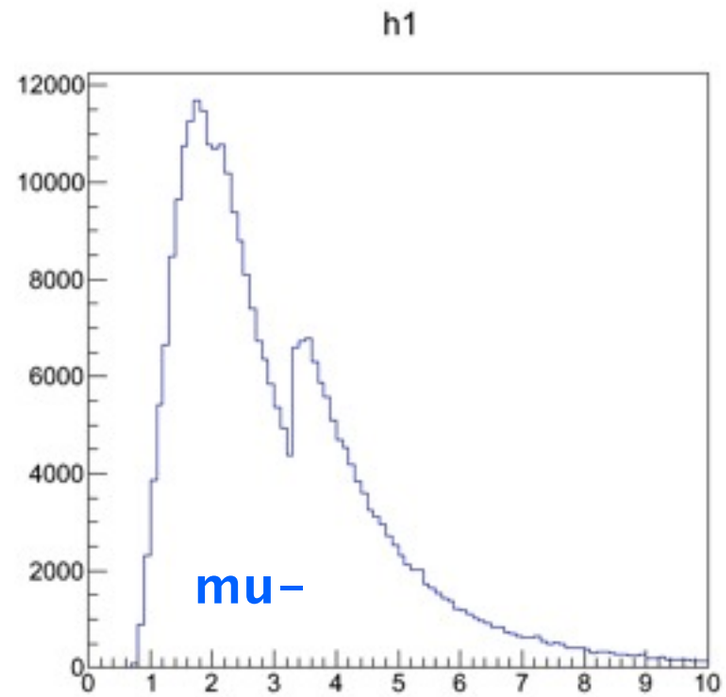


old sample

- **Reco**







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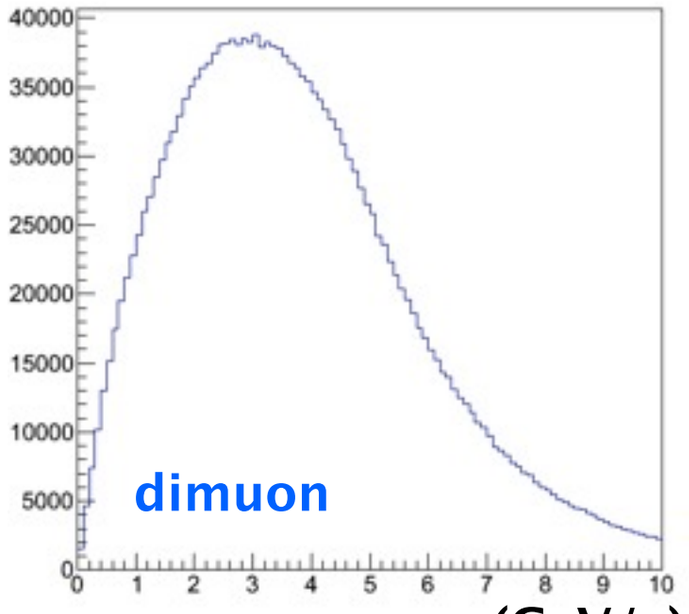
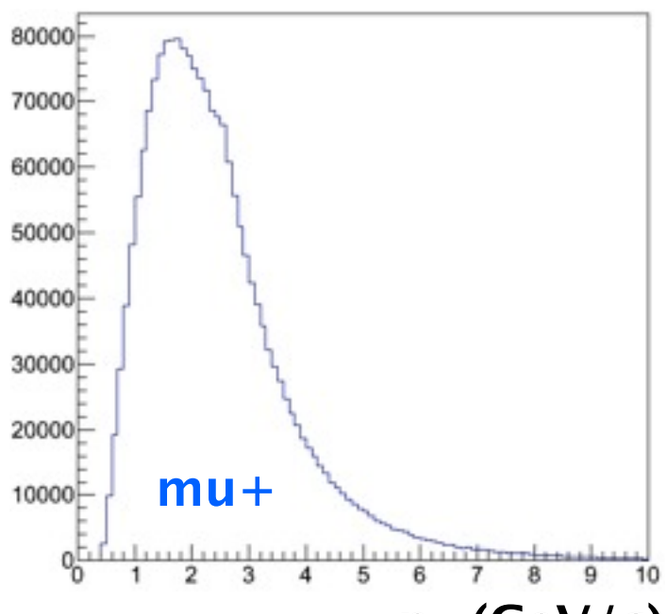
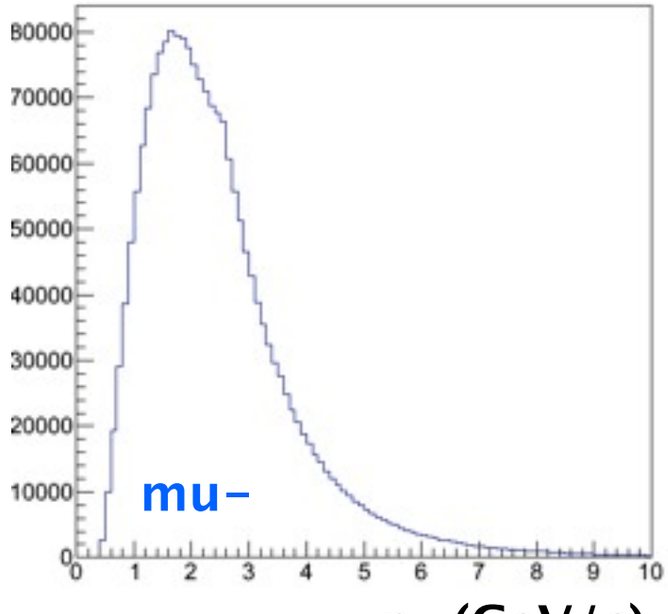
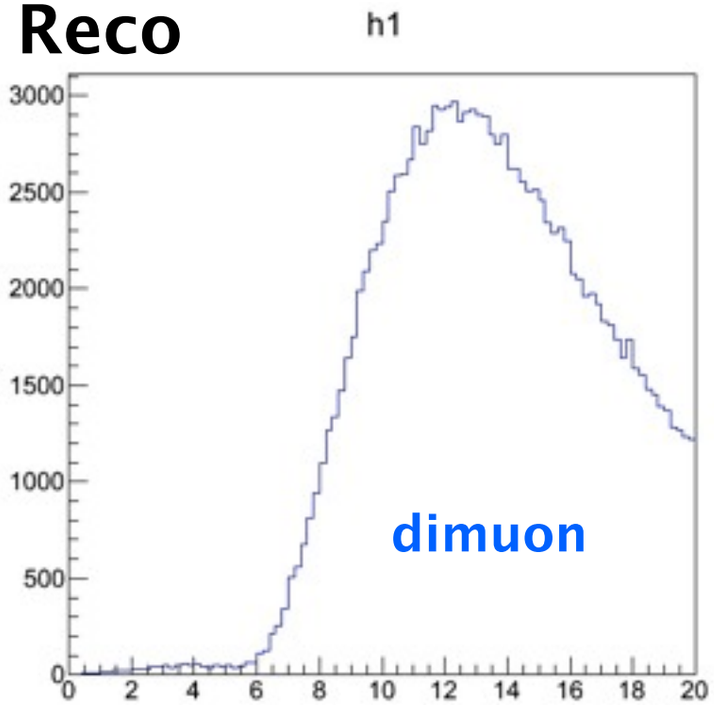


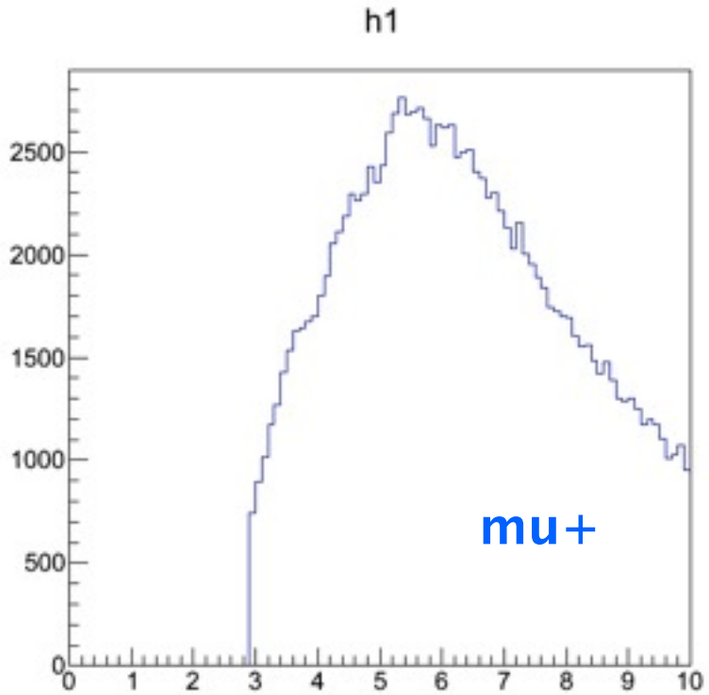


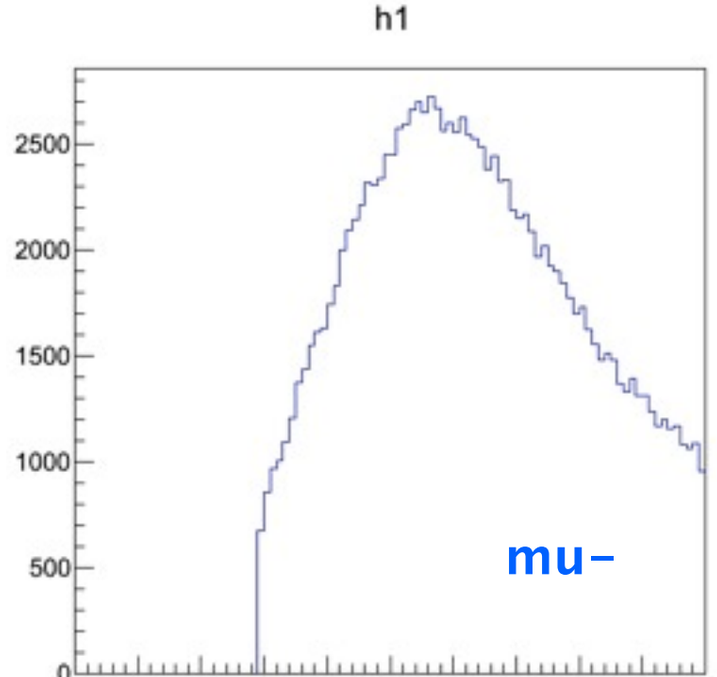


new sample

- **Reco**







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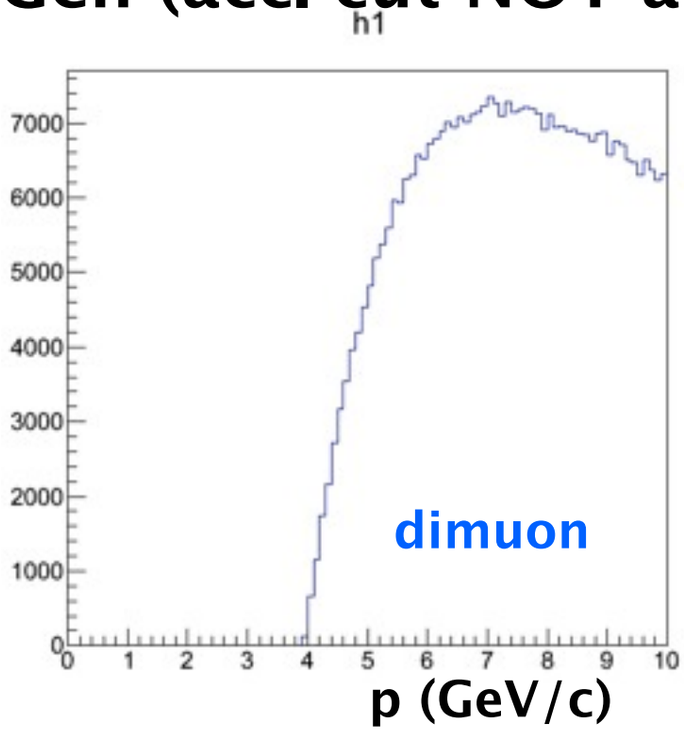

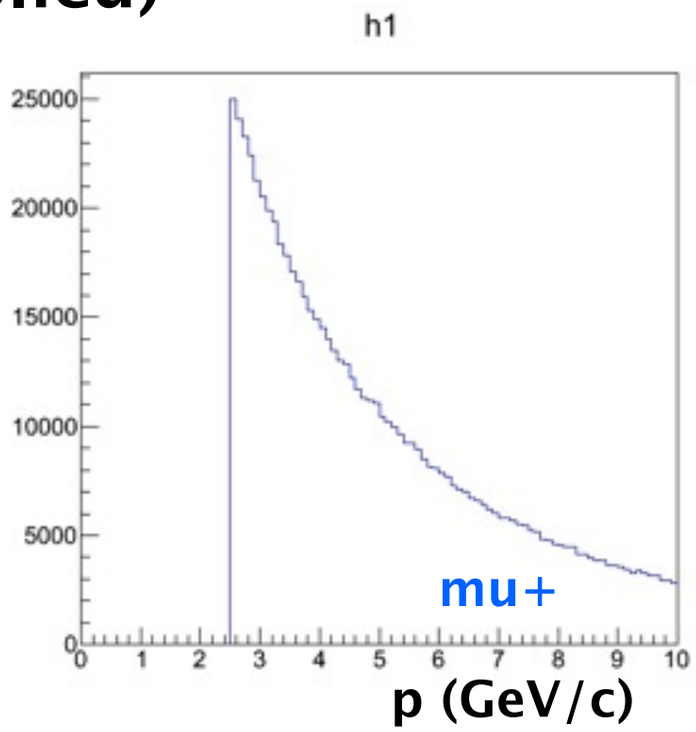

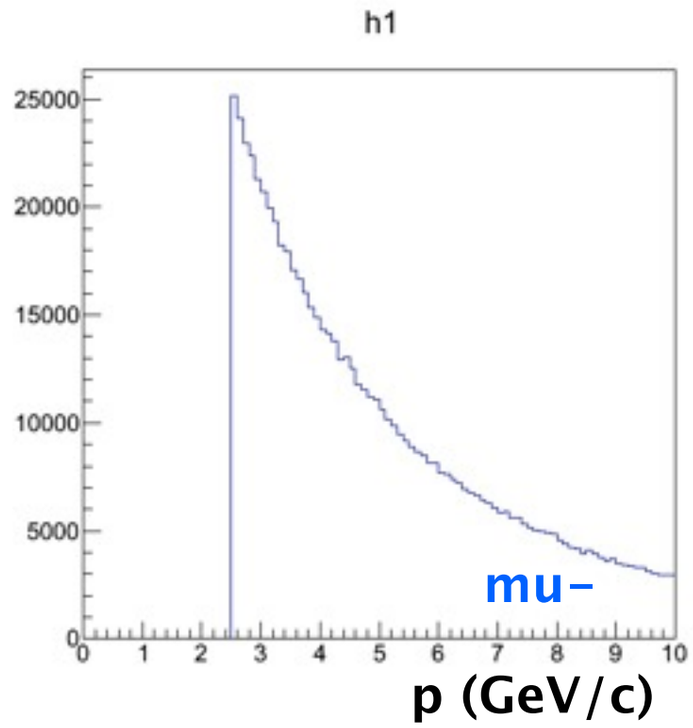

new sample

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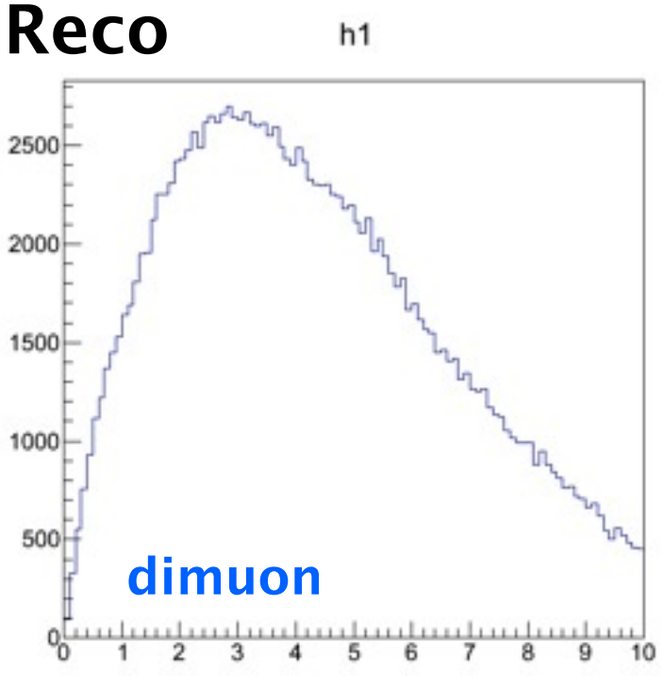
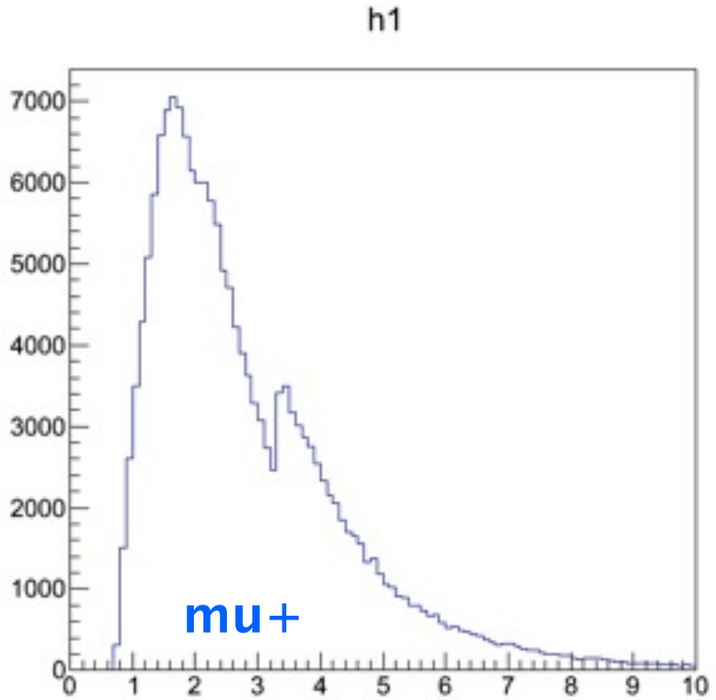
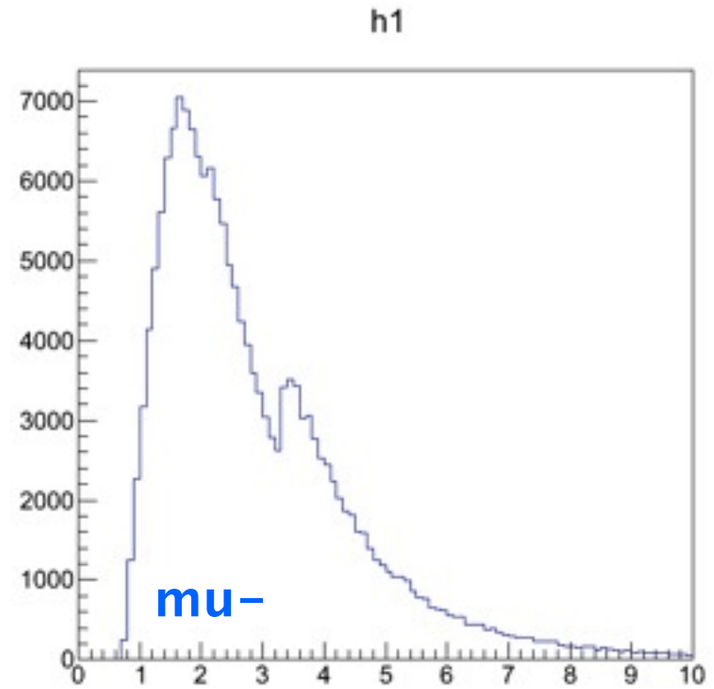
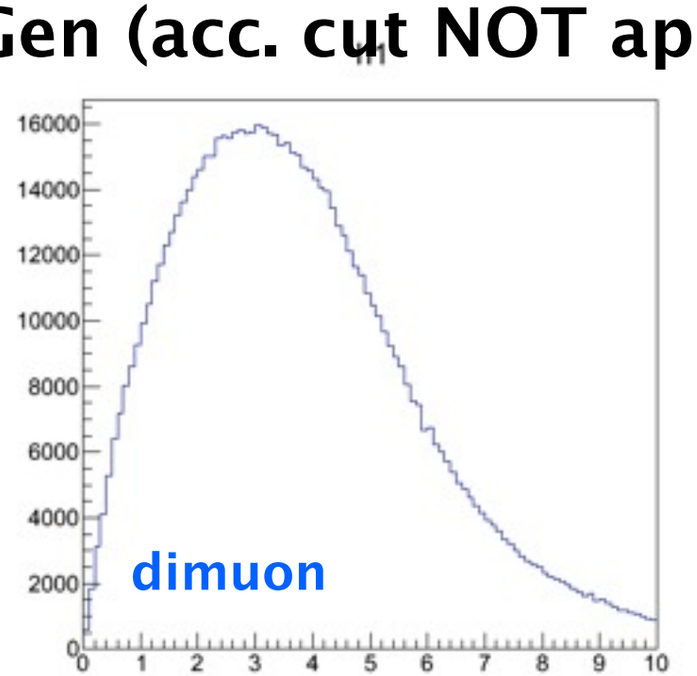
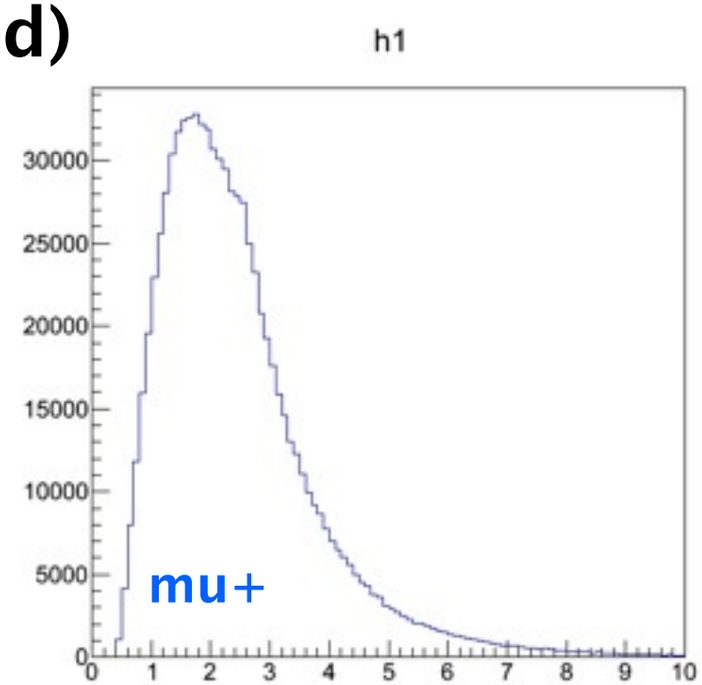


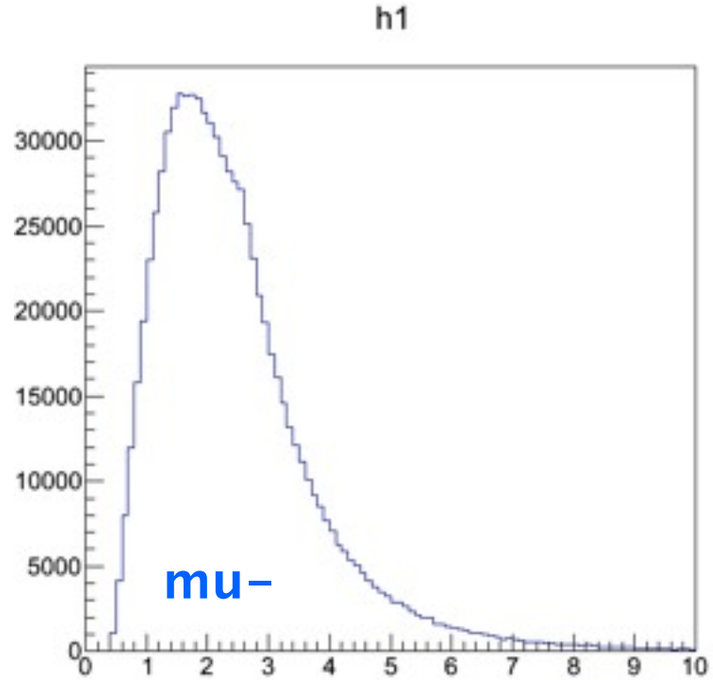




- **Gen (acc. cut NOT applied)**

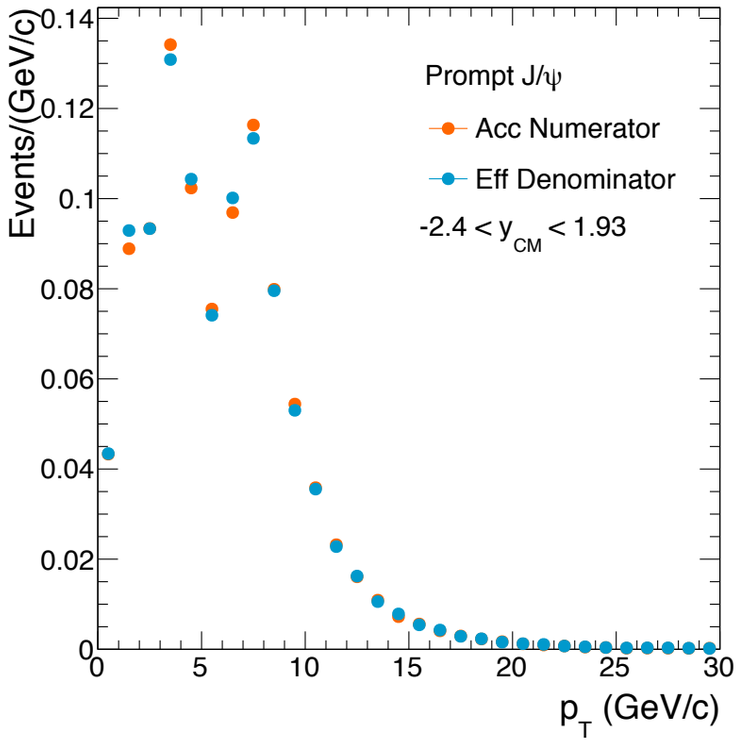


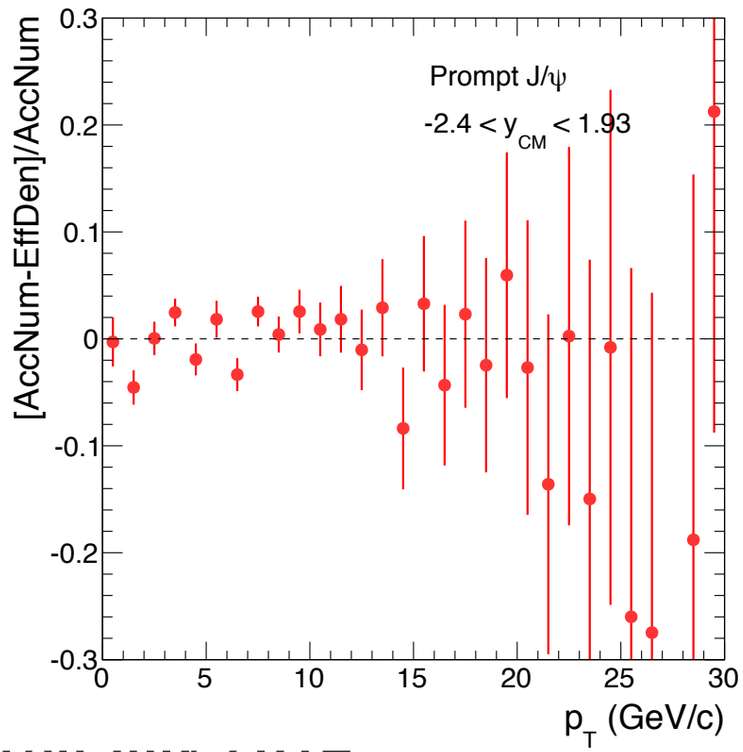




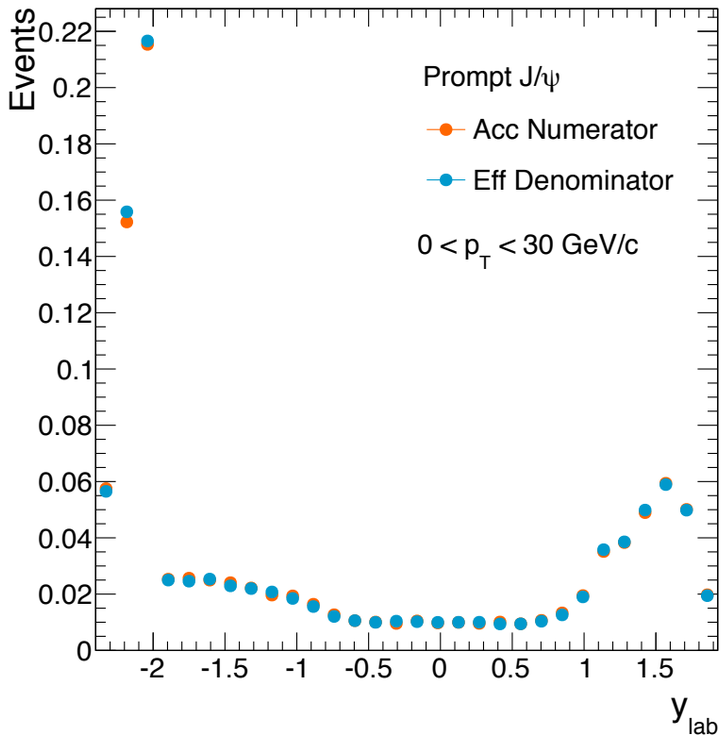
new sample

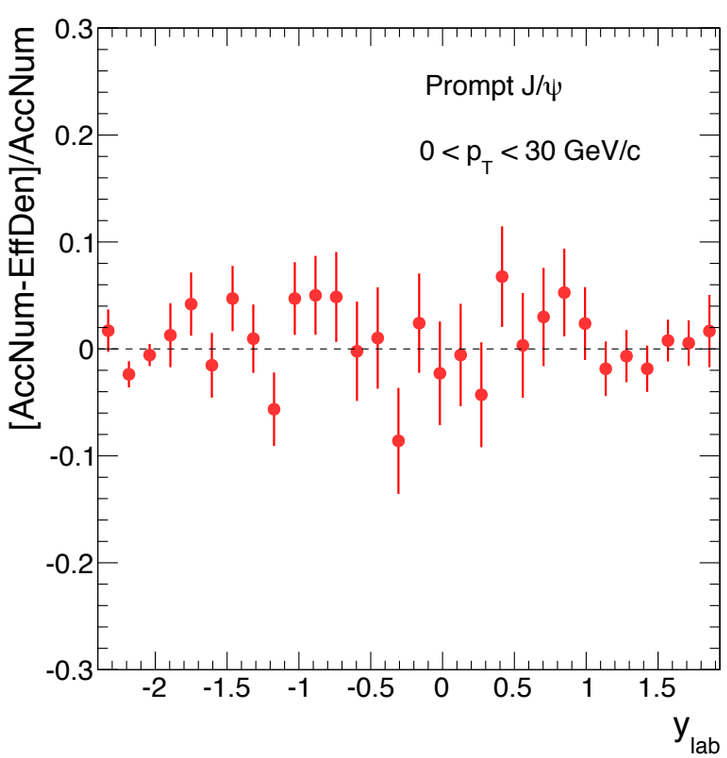
dimuon pT

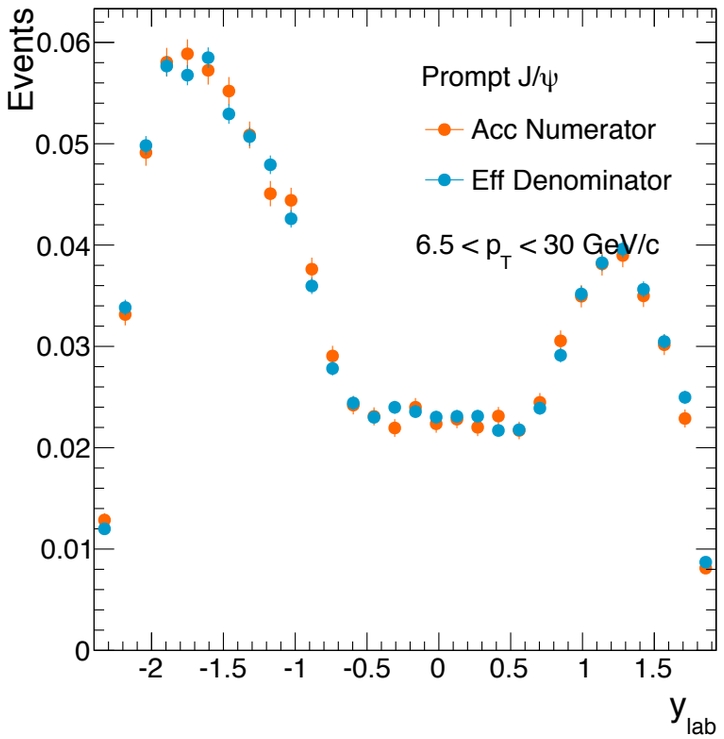


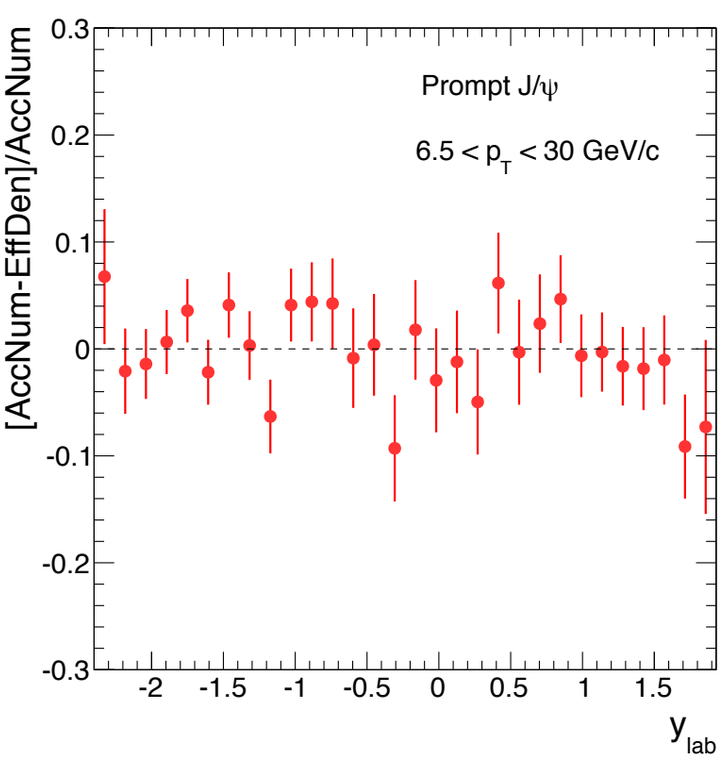


dimuon rapidity



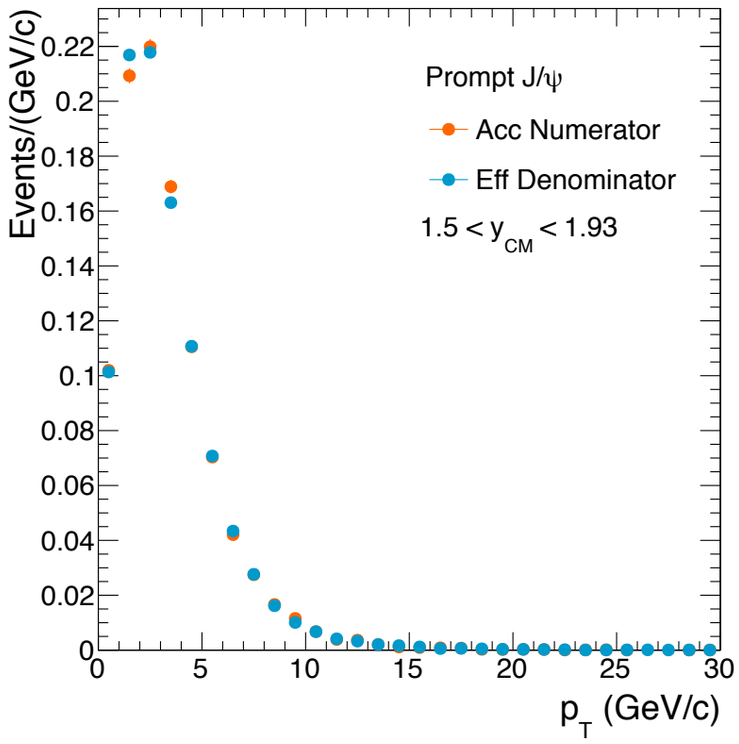


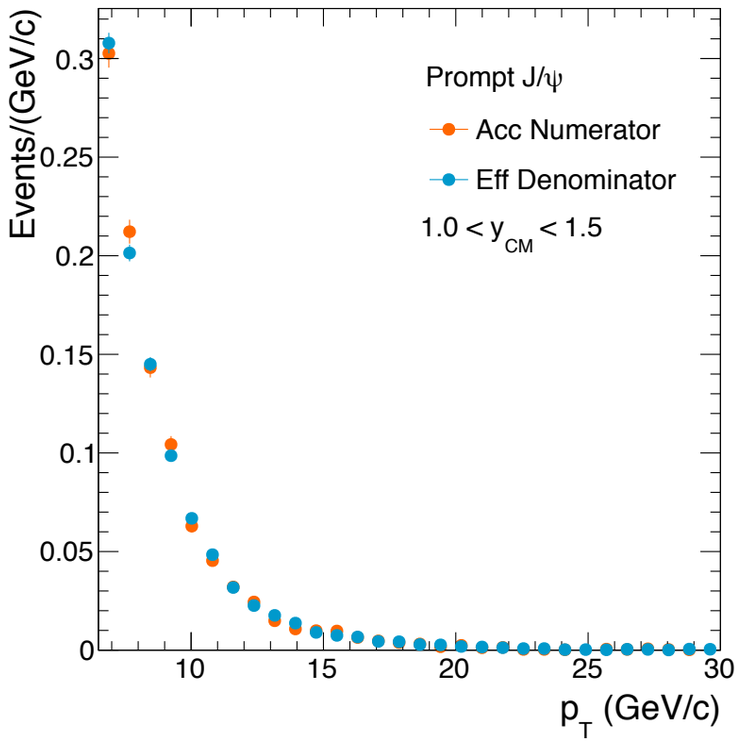


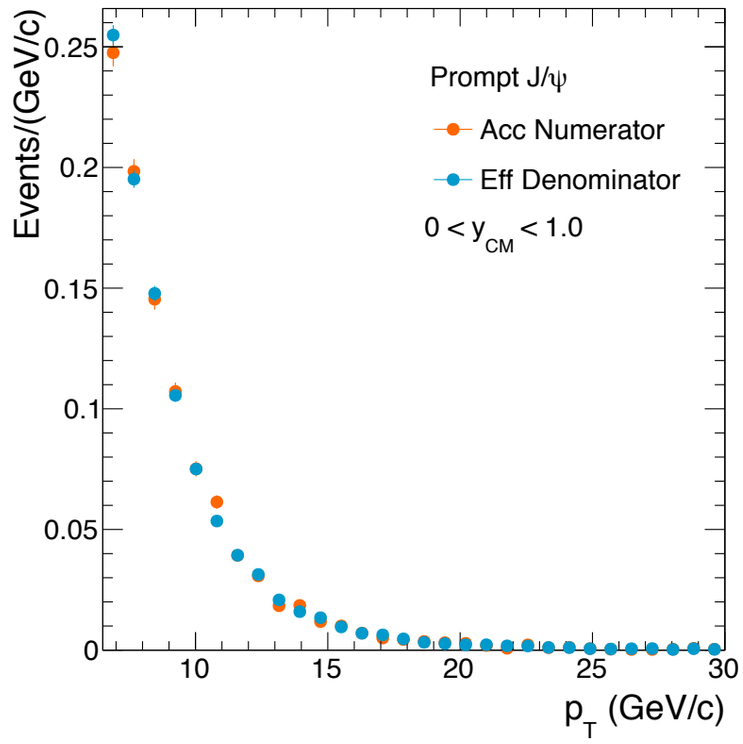


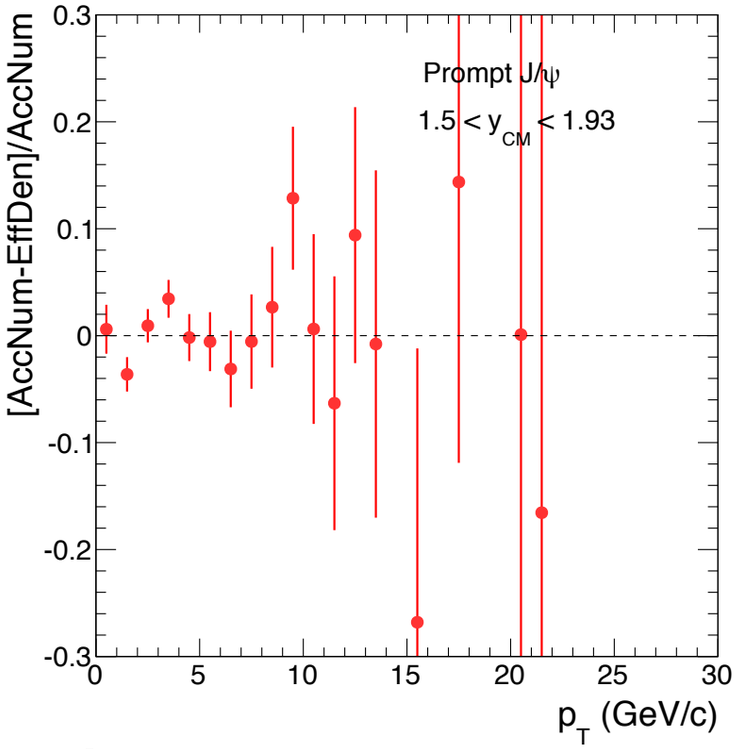
new sample

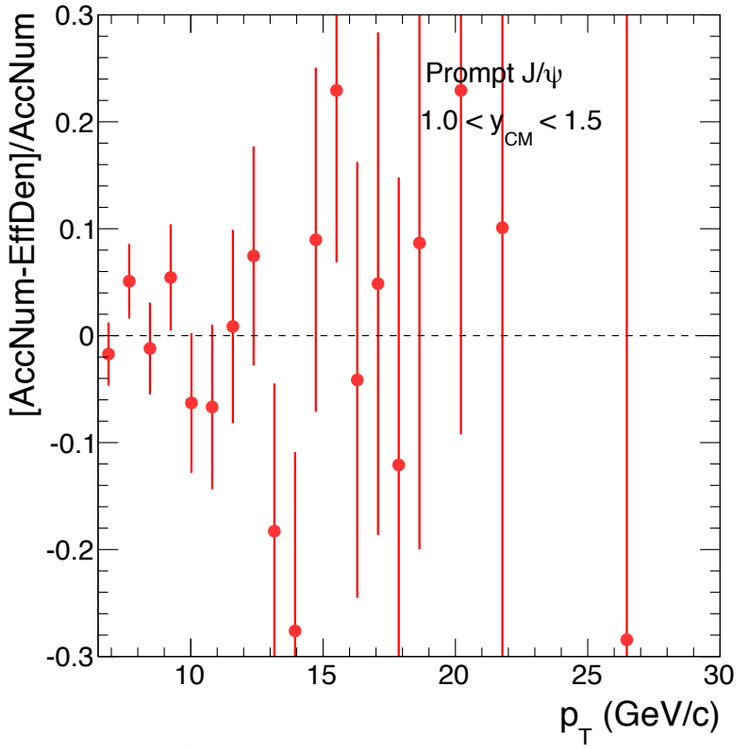
- **dimuon**

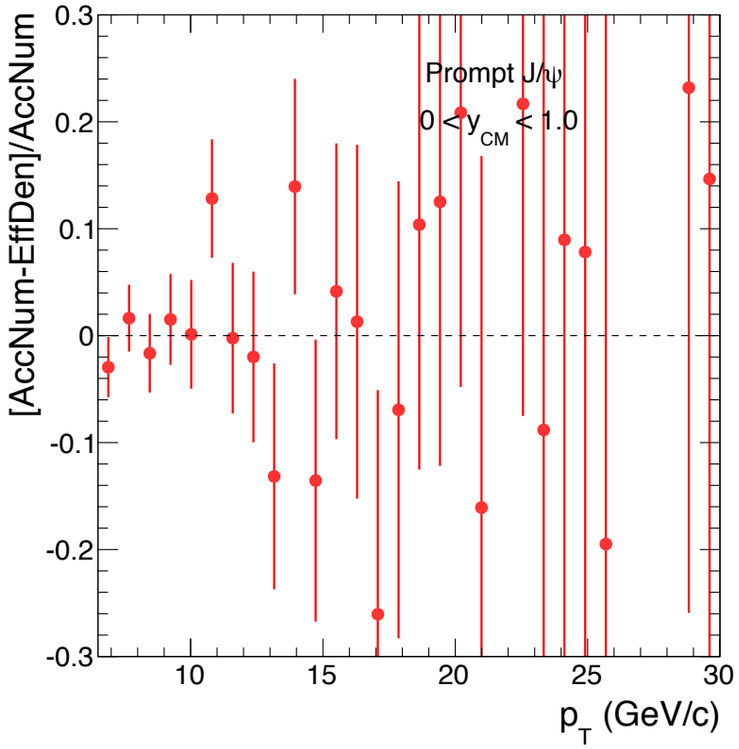






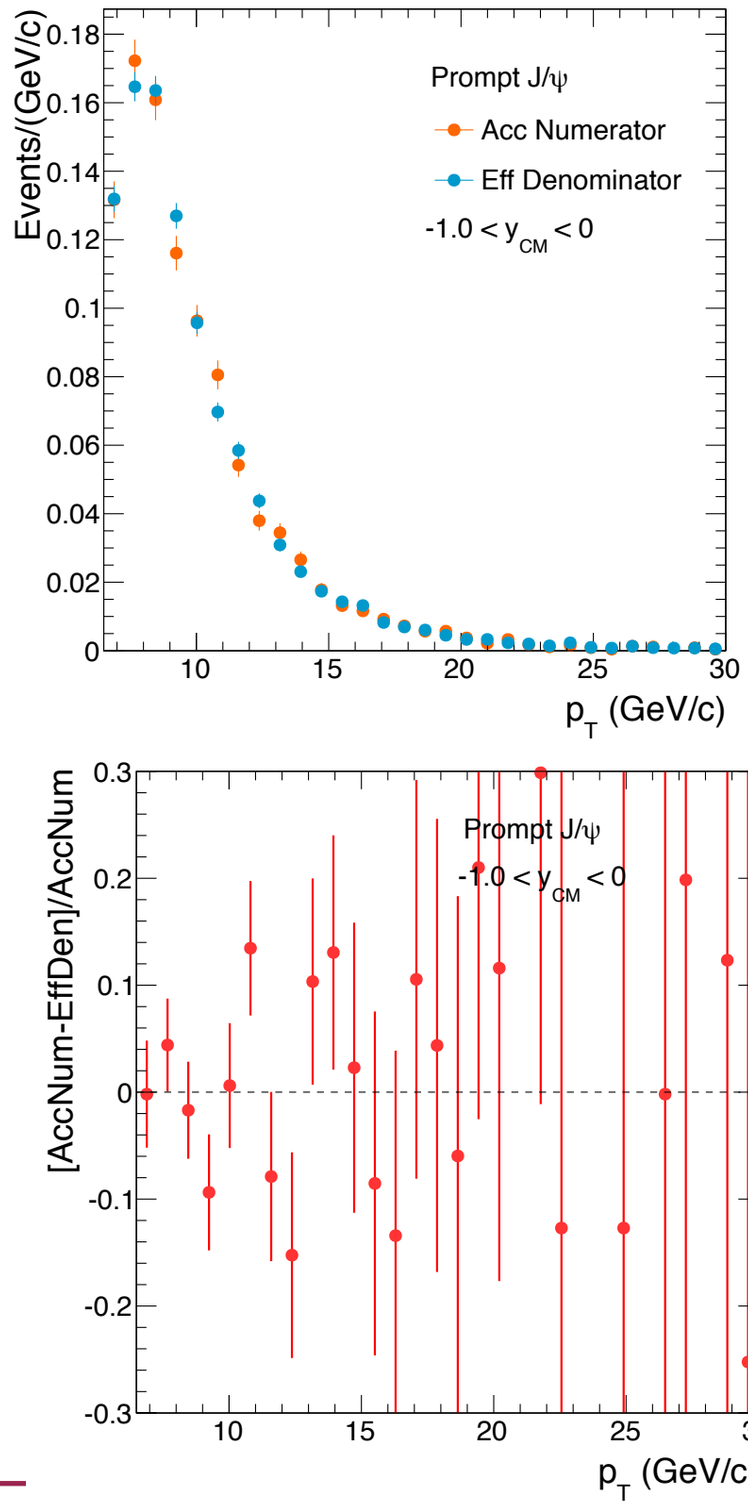


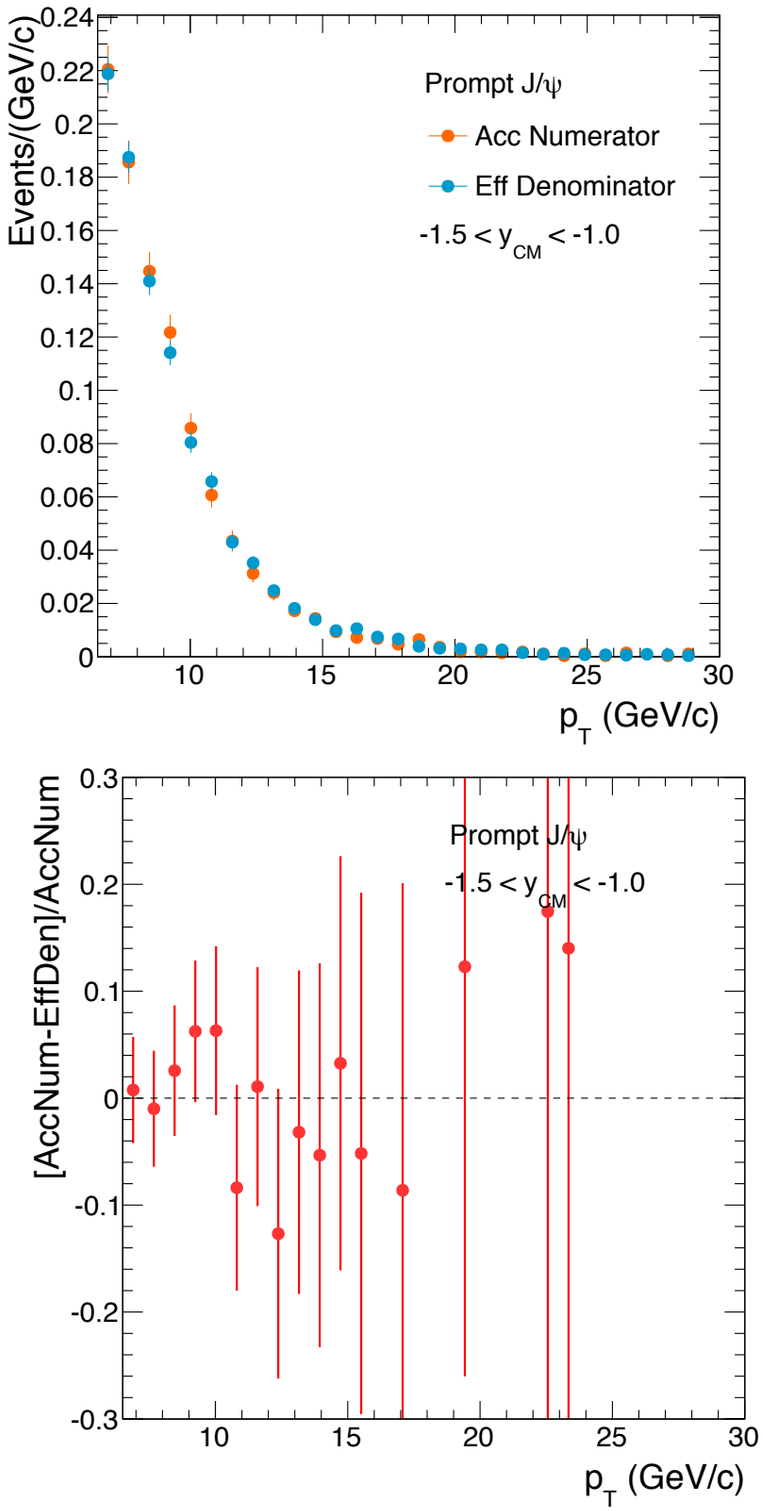


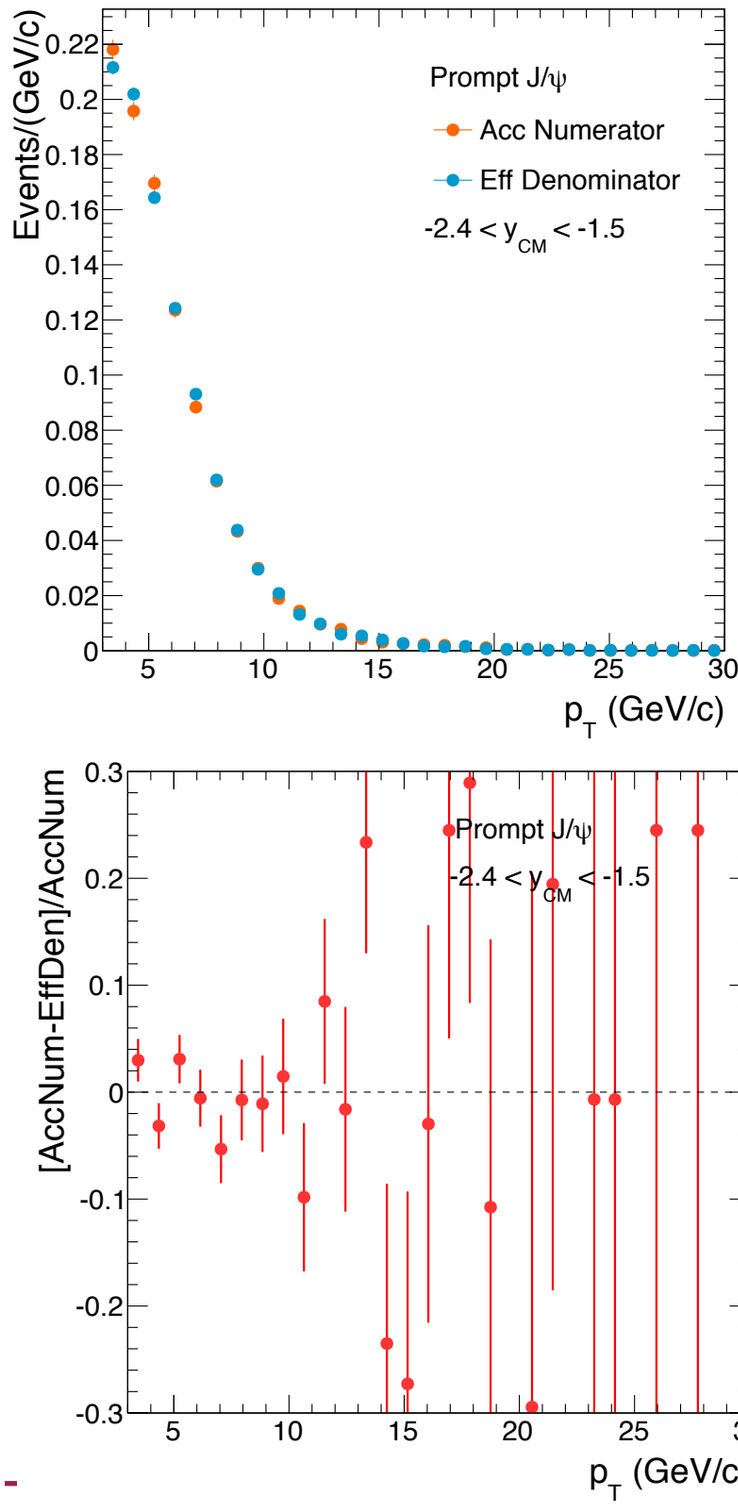


new sample

- **dimuon**

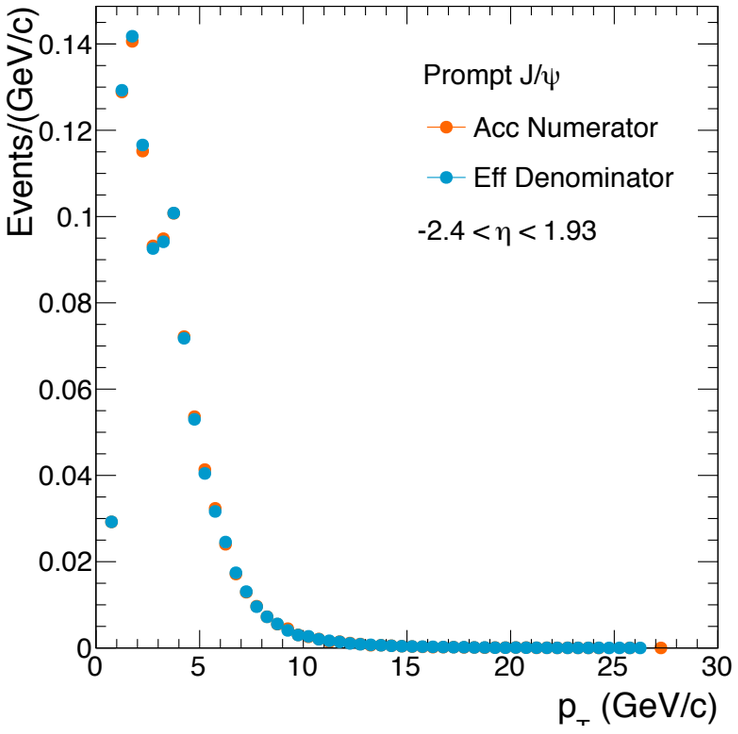


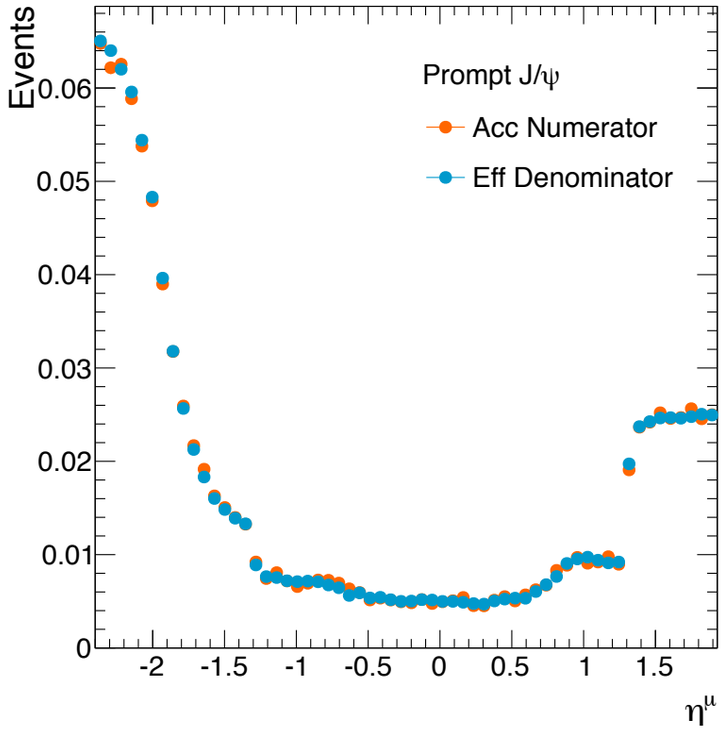


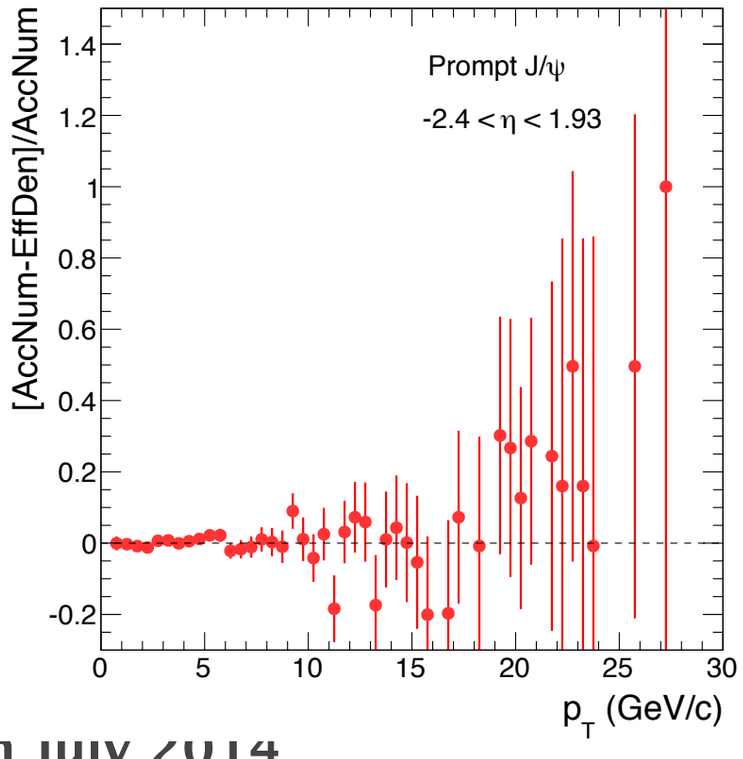


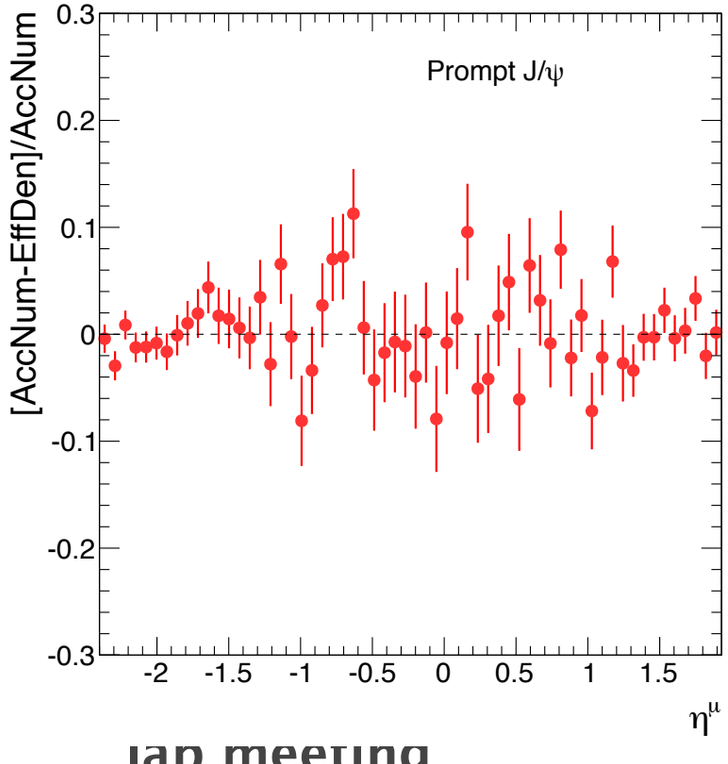
new sample

- **single muons pT & eta**



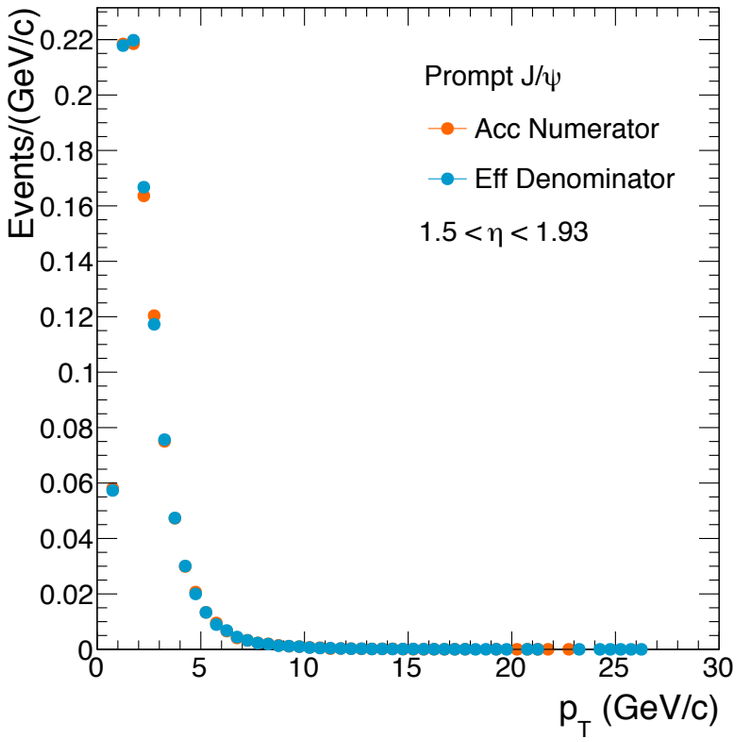


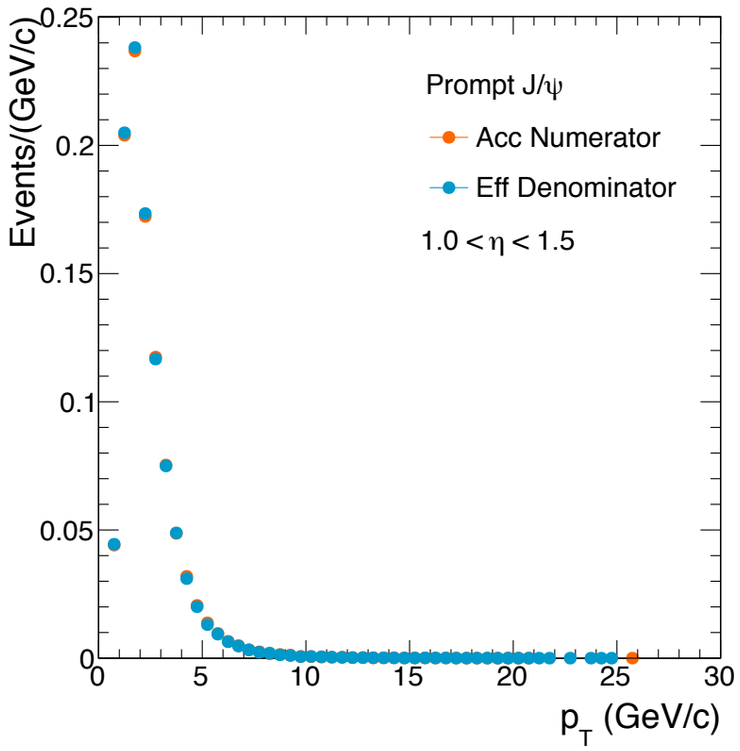


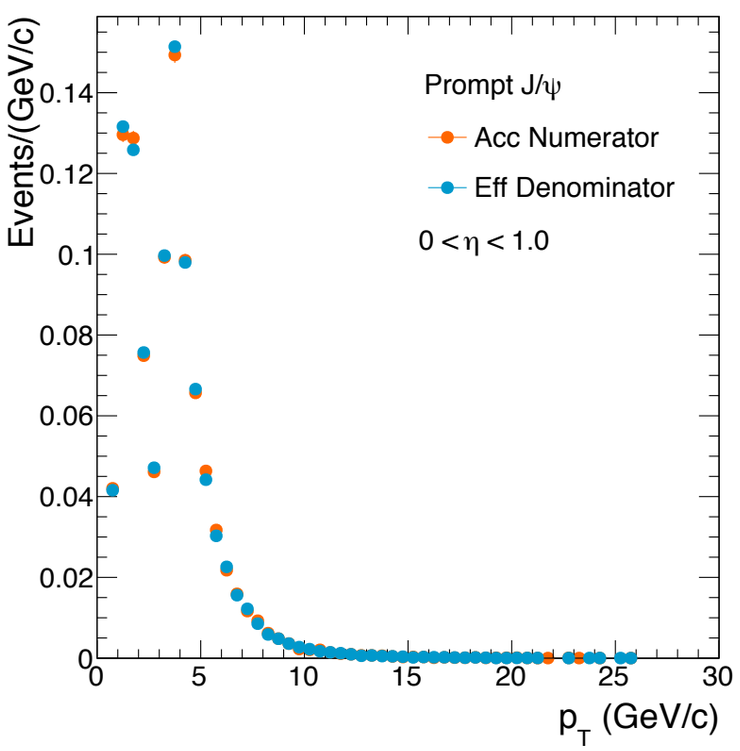


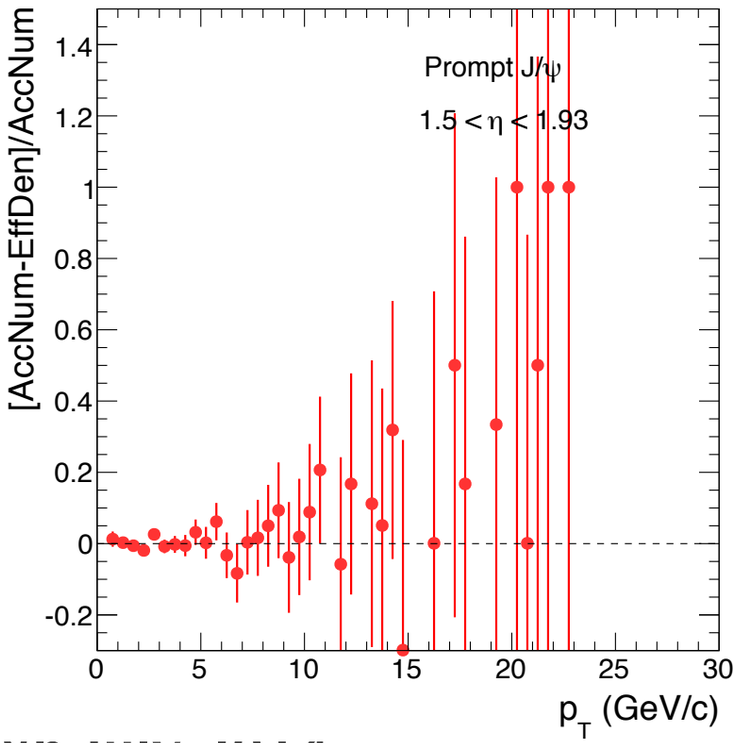
new sample

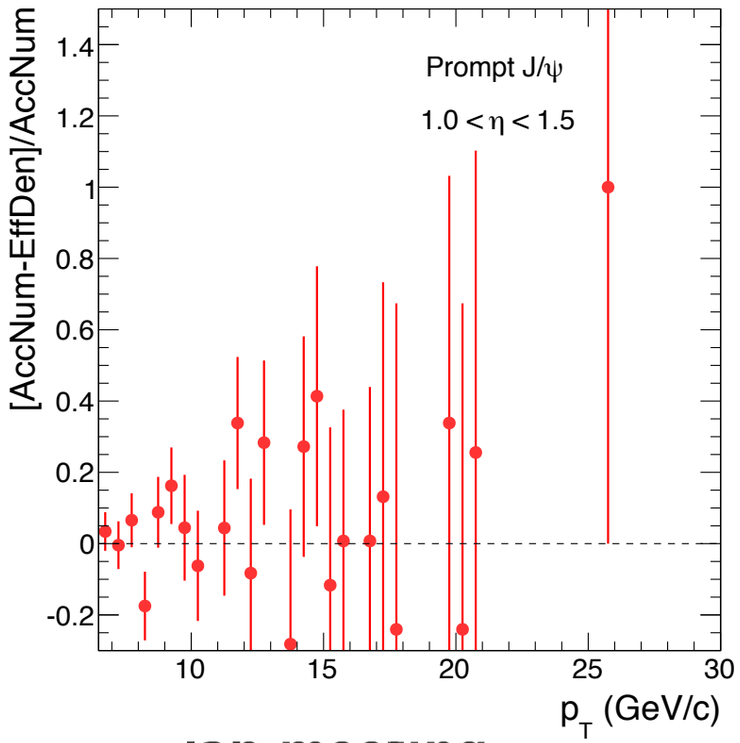
- **single muons**

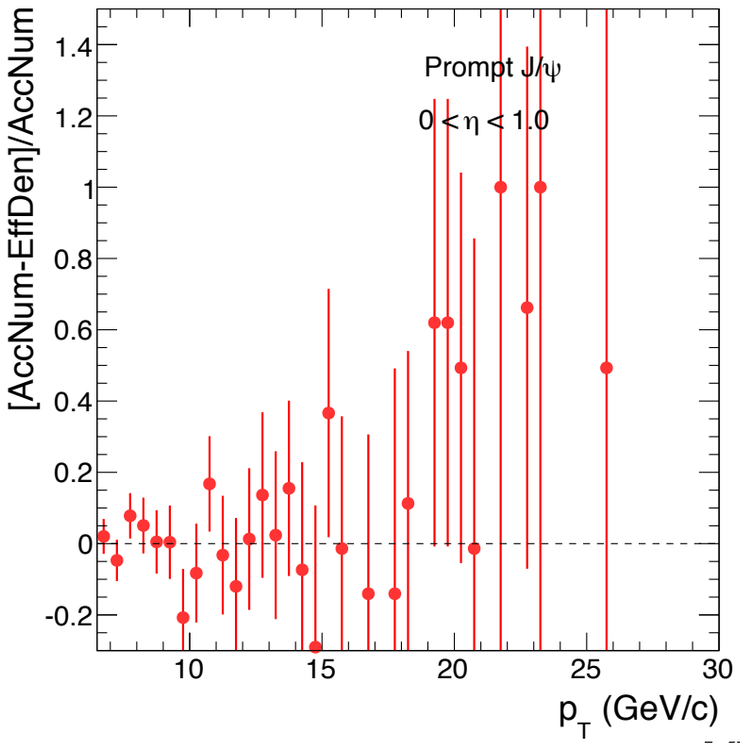






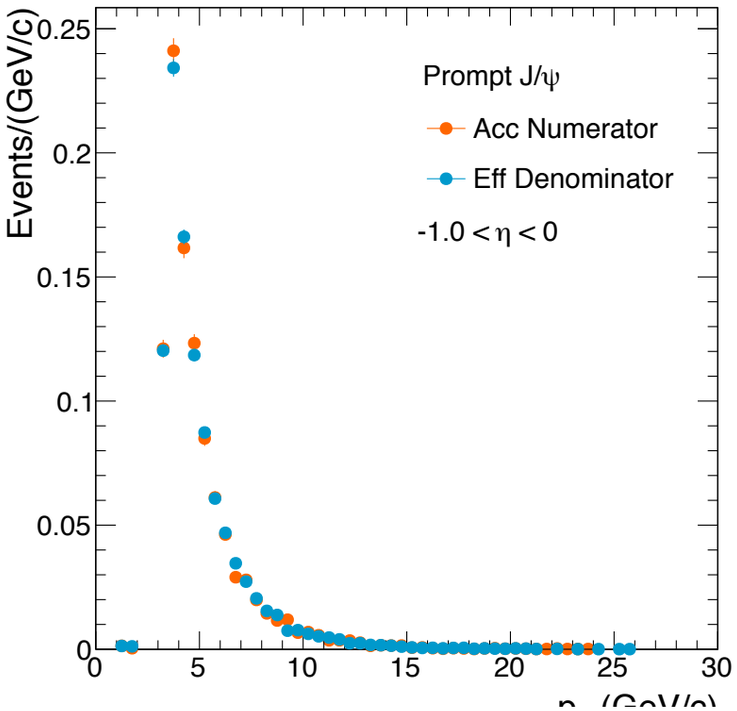


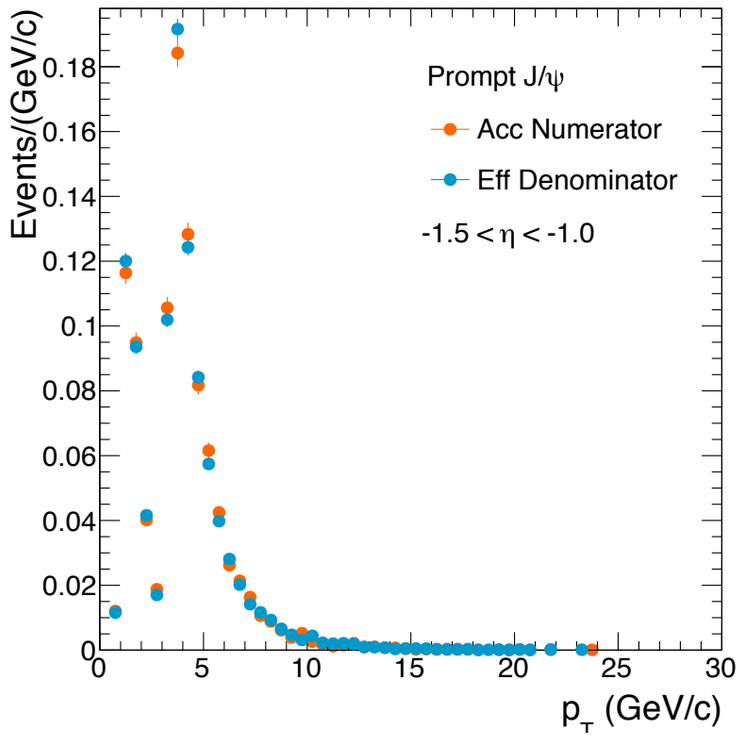


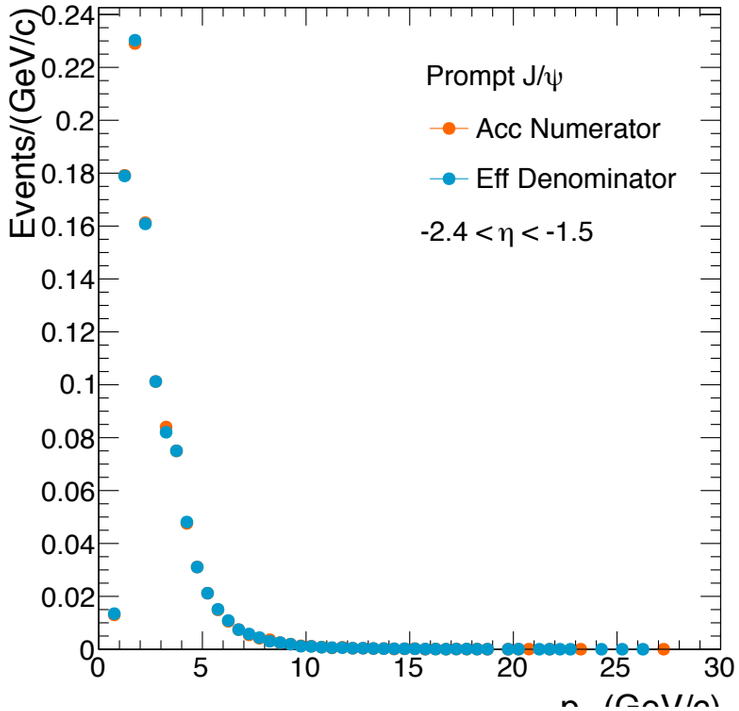


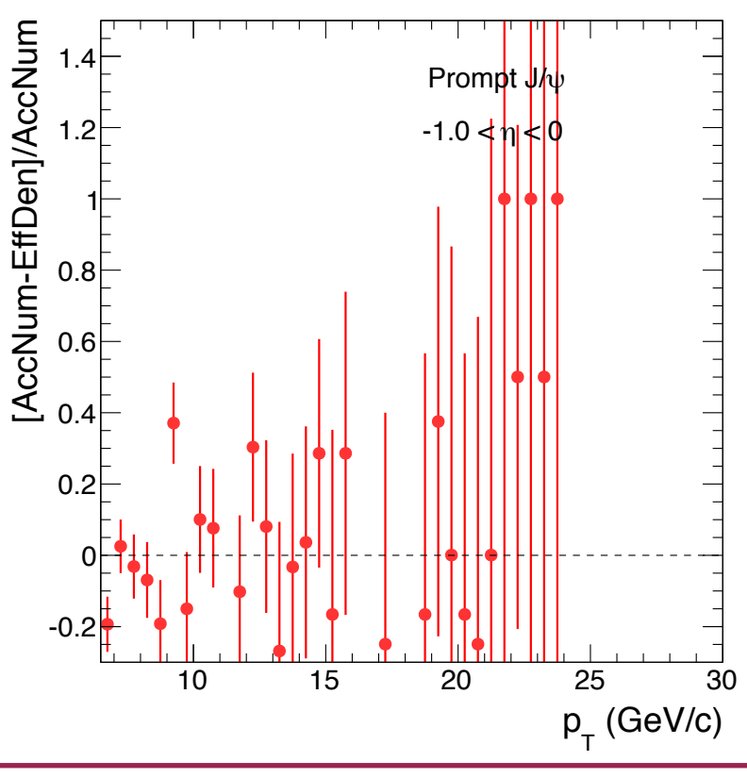
new sample

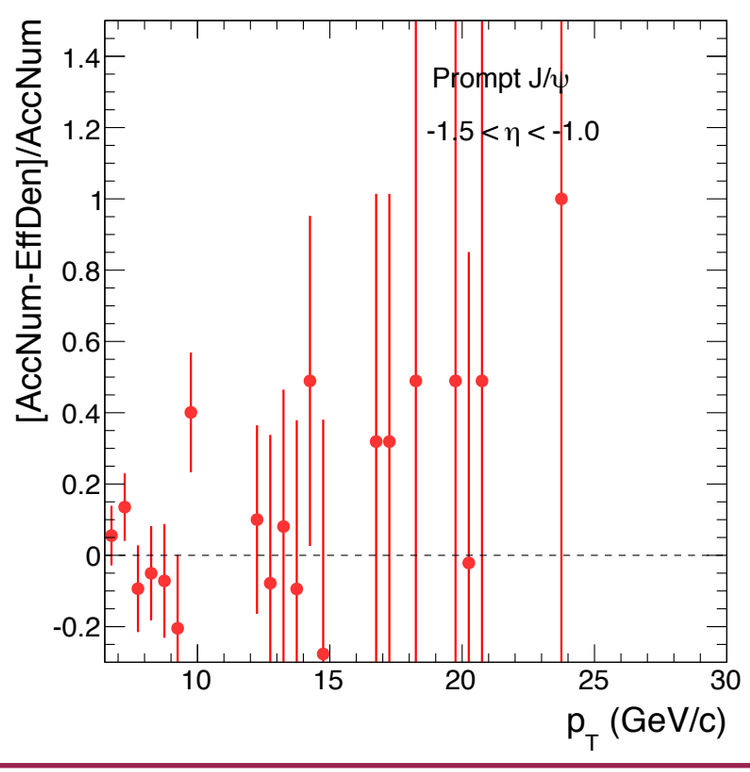
- **single muons**

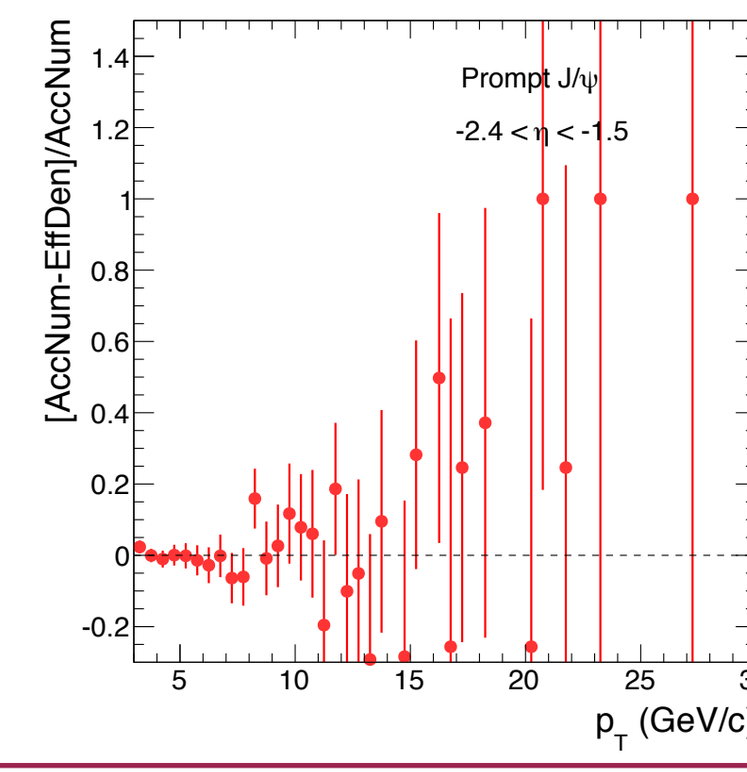






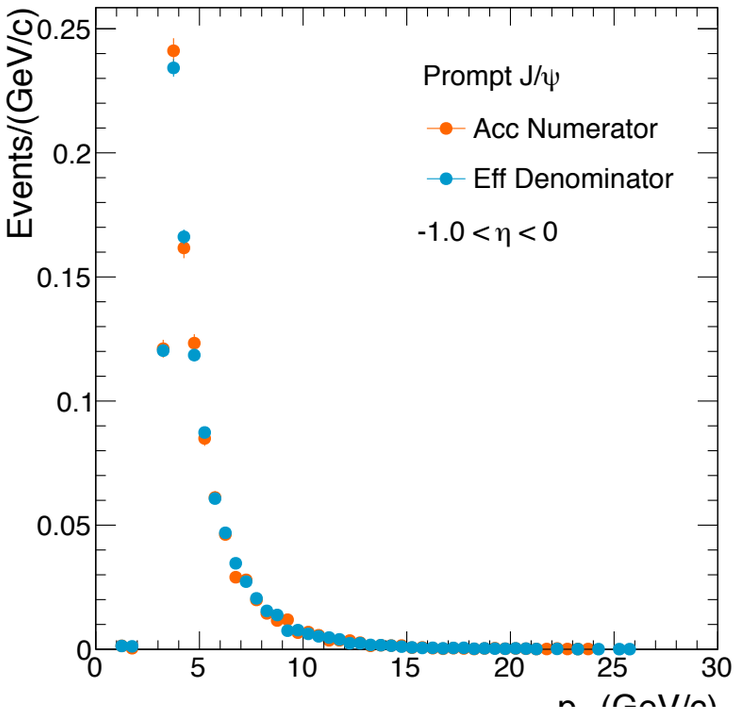


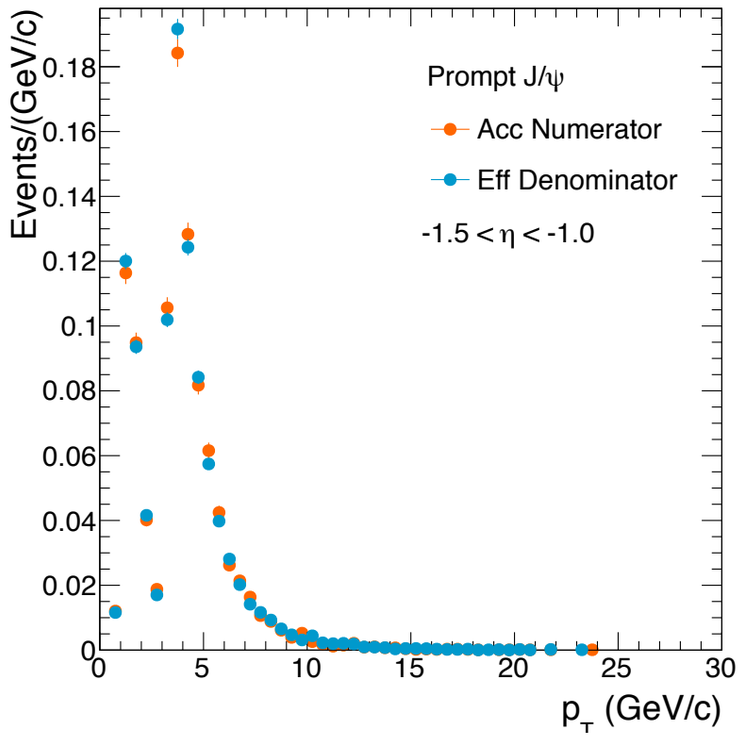


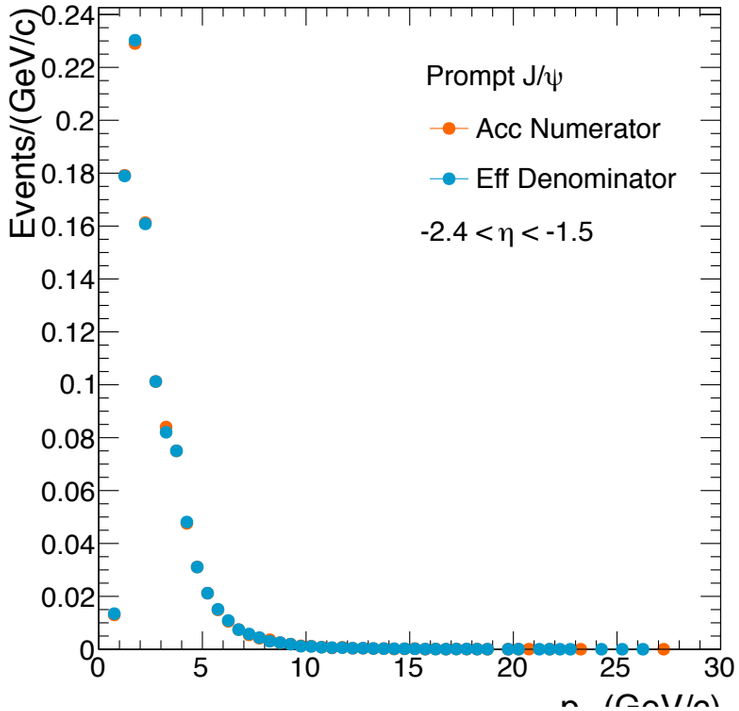


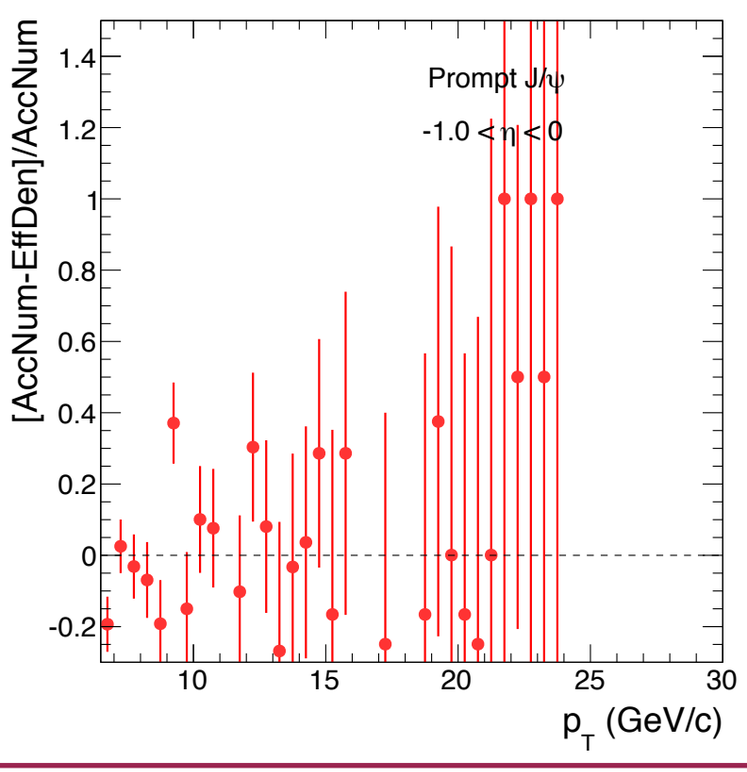
new sample

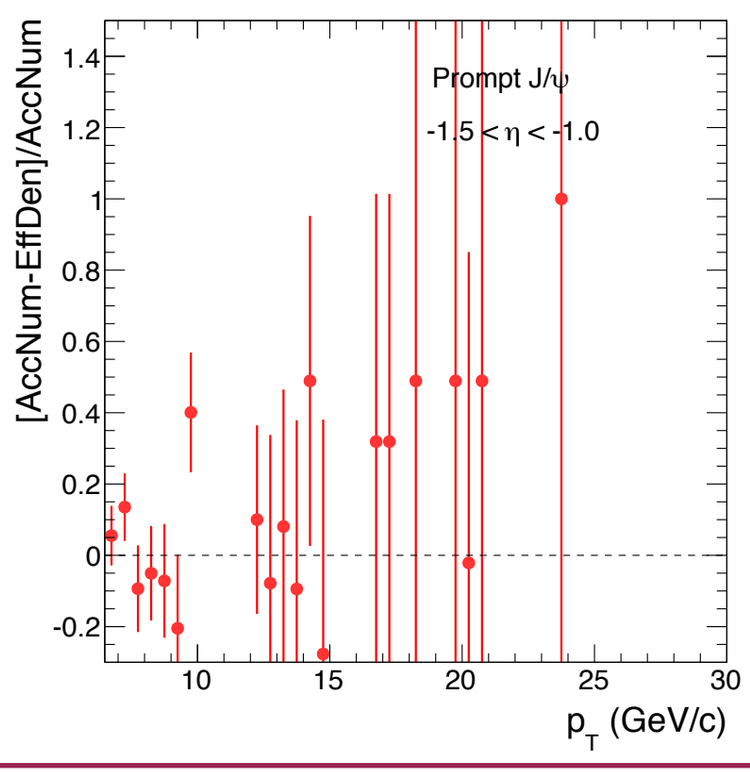
- **single muons**

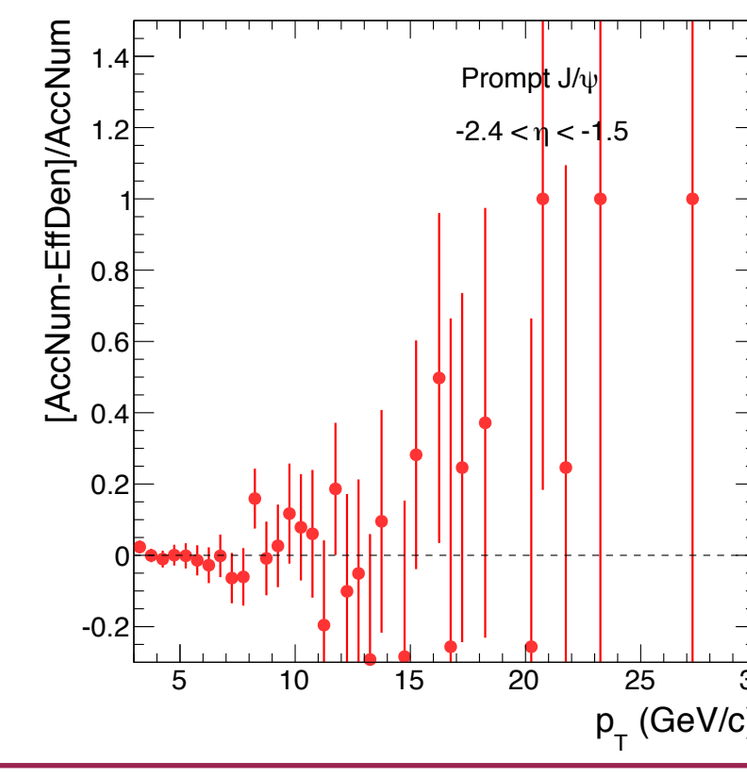






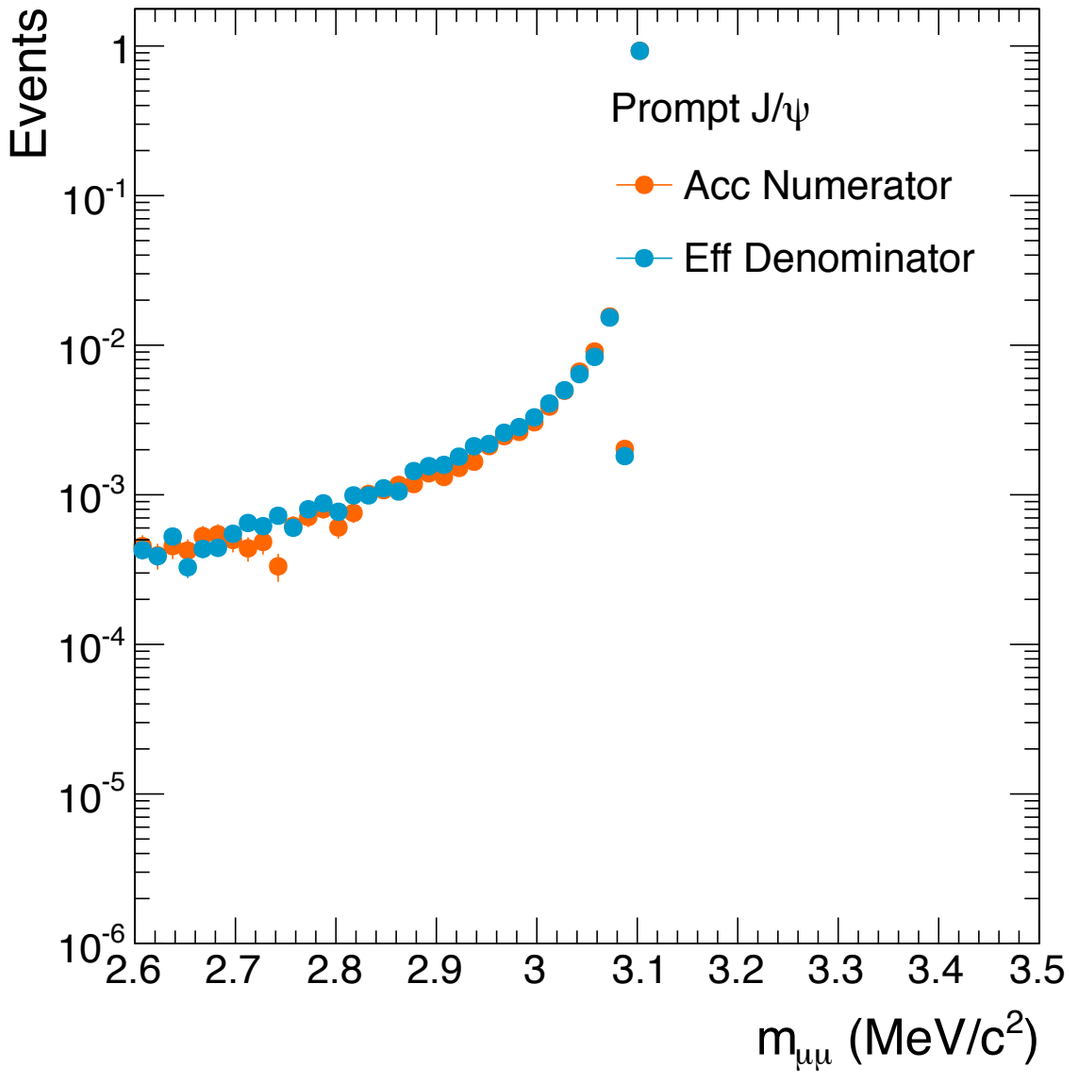


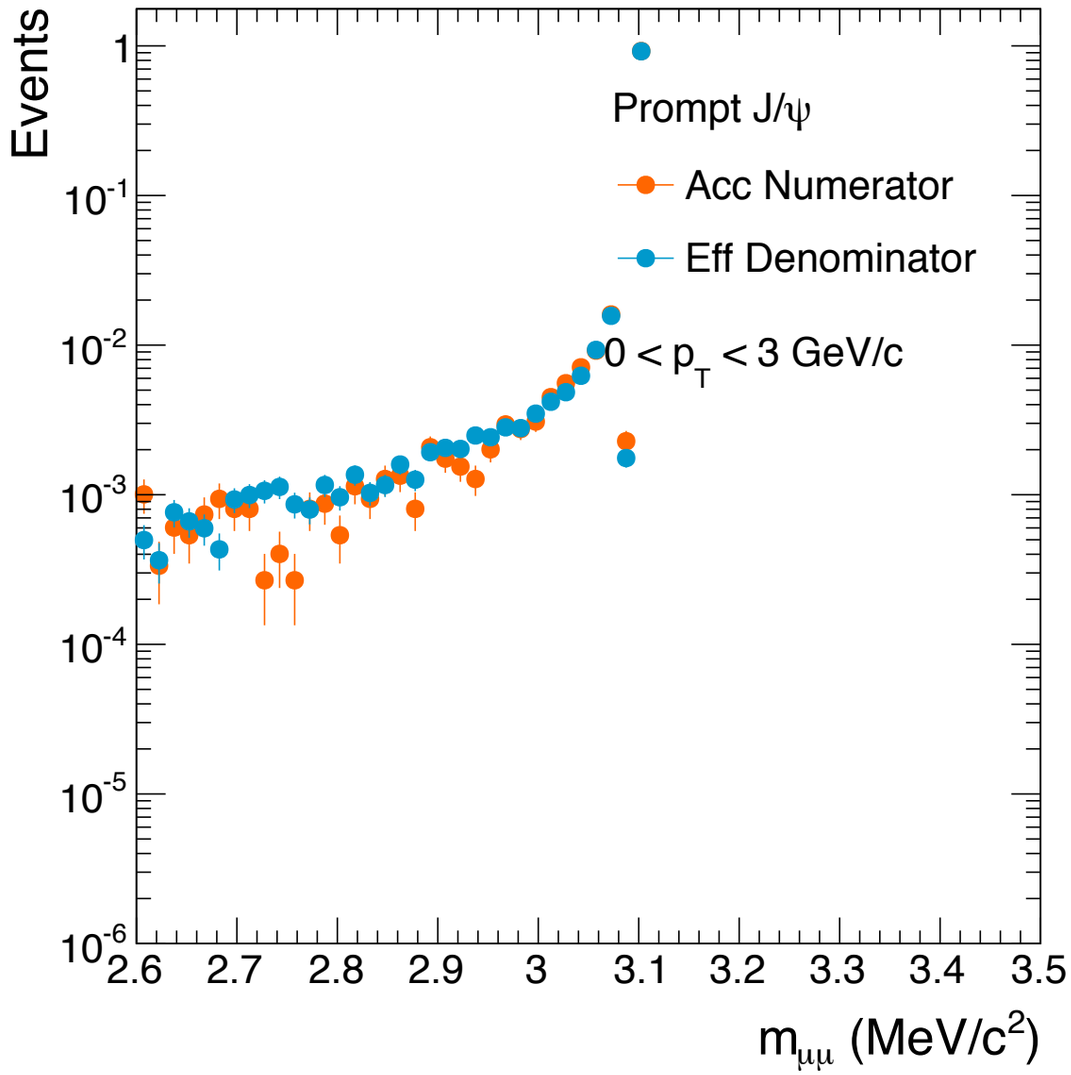




new sample

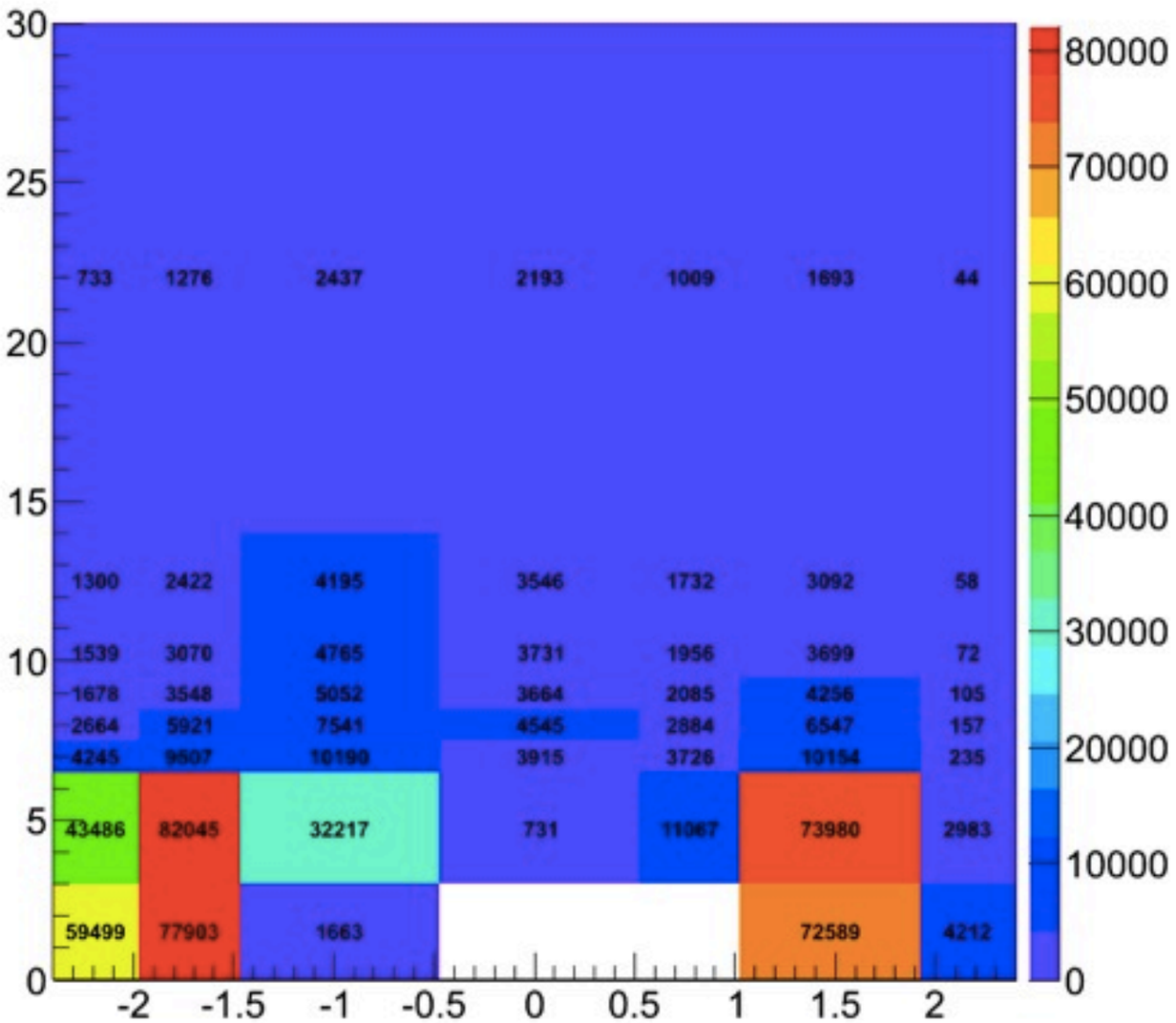
- **mass**



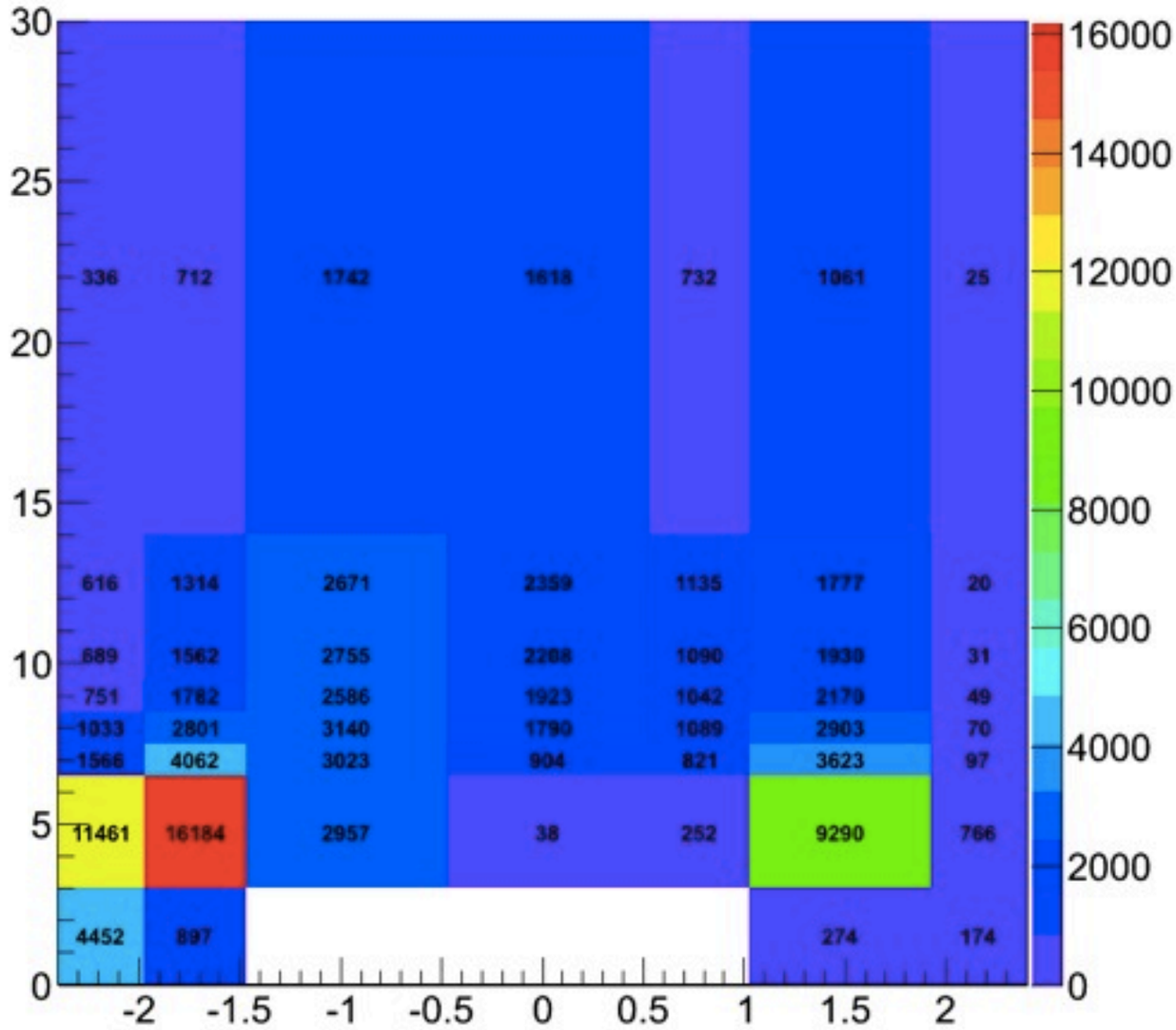


old sample

- **Eff Den**

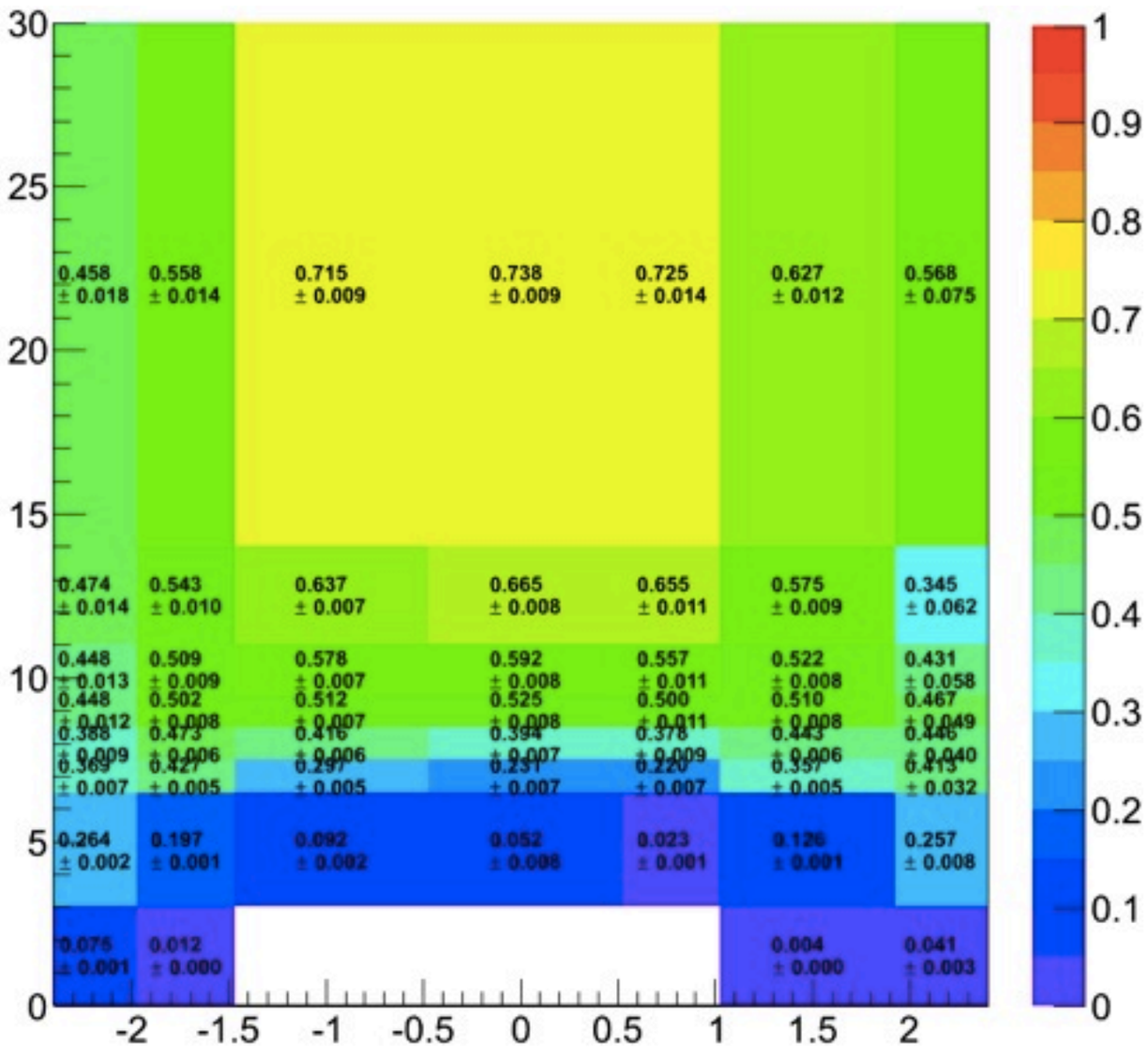


- **Eff Num**

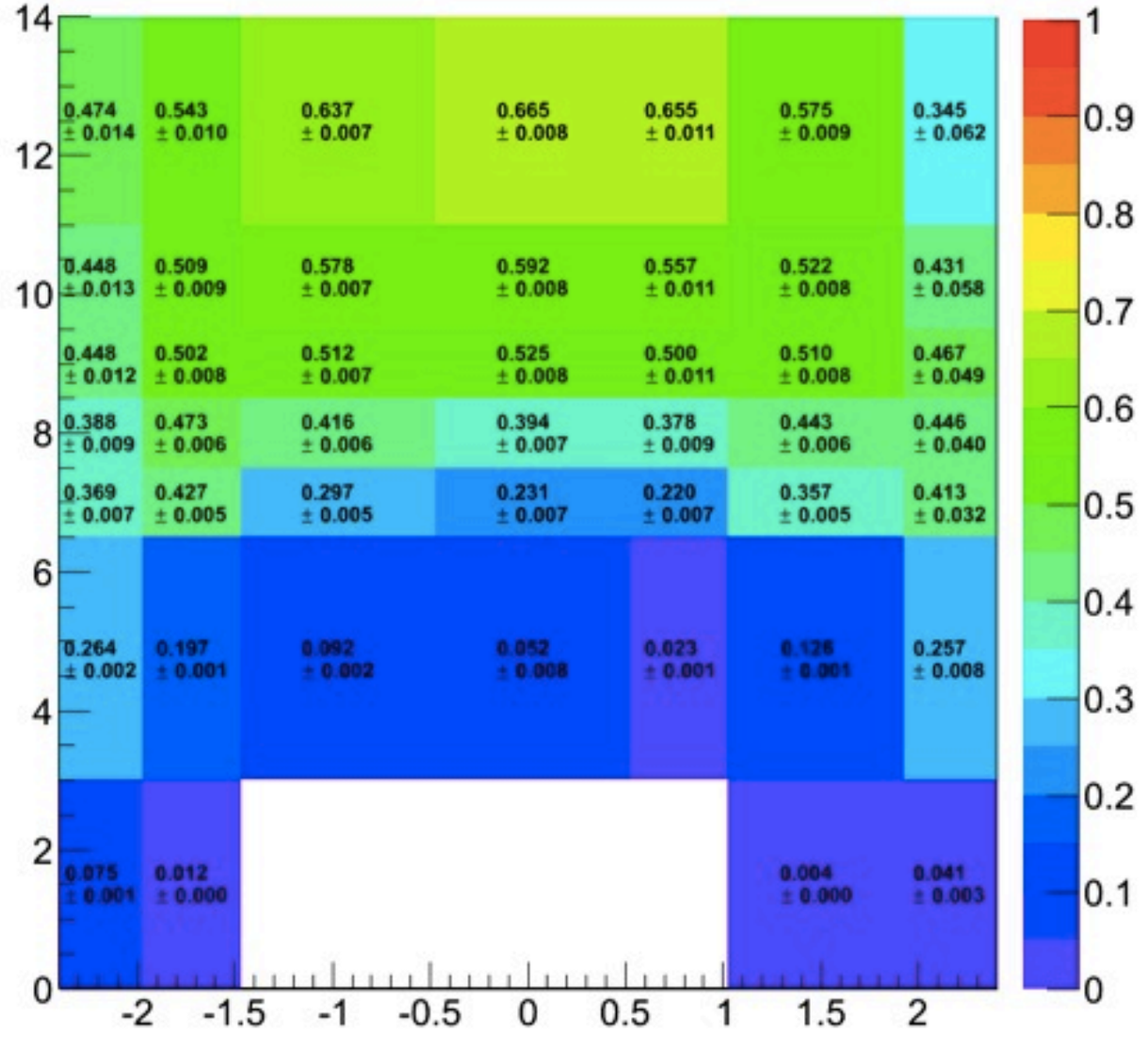


old sample

- **Efficiency**

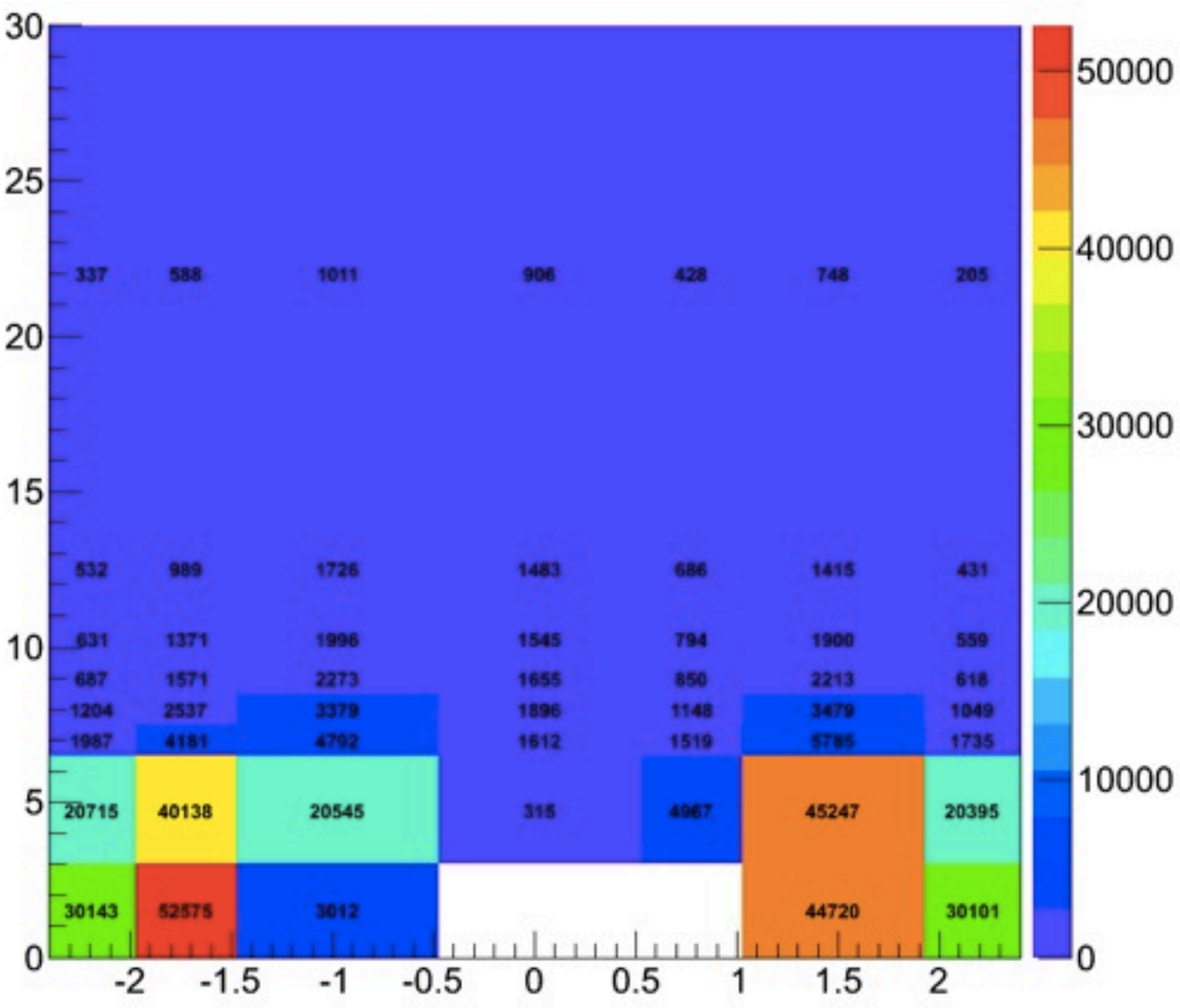


- **zoomed in**



old sample

- **Eff Den**



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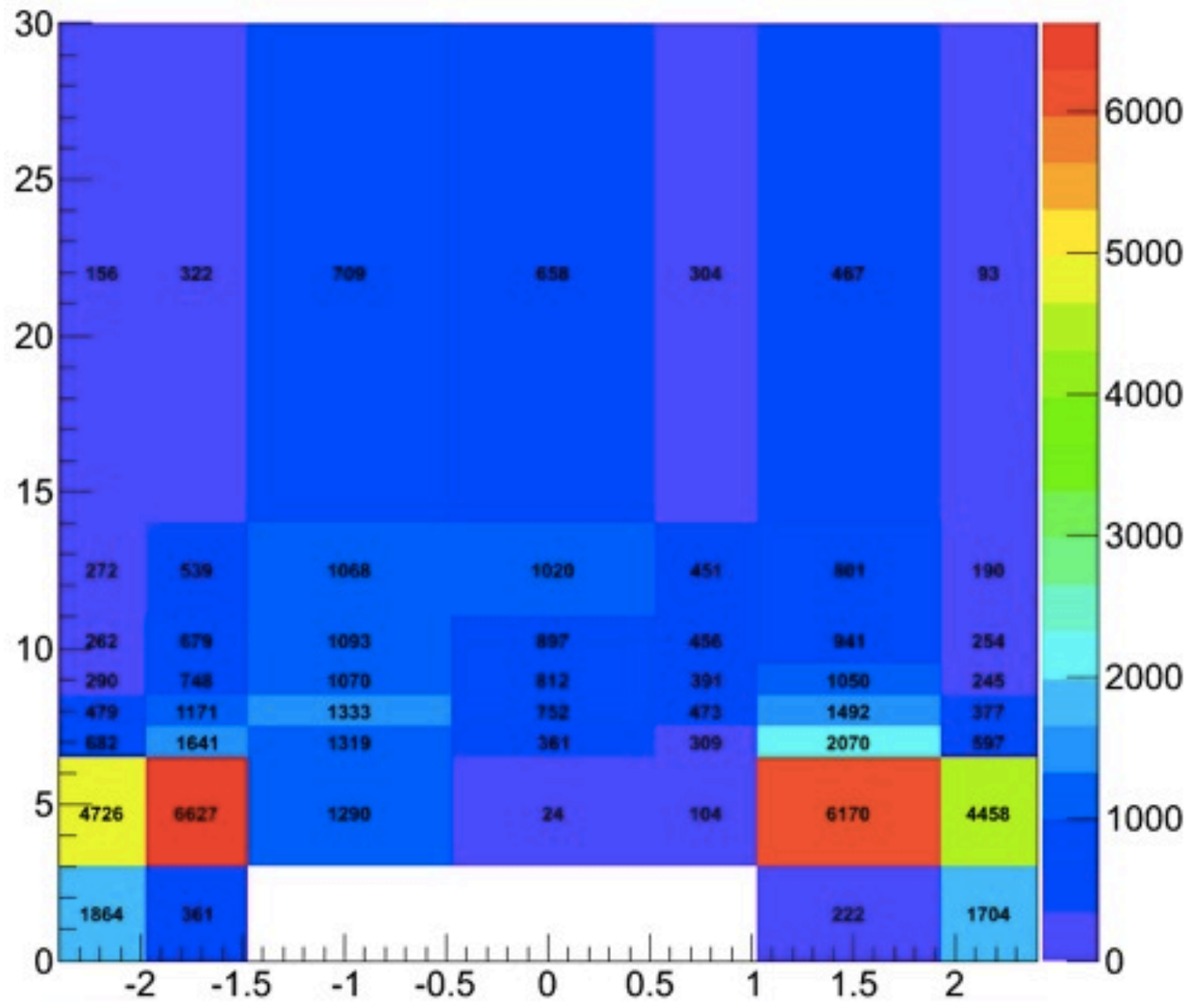
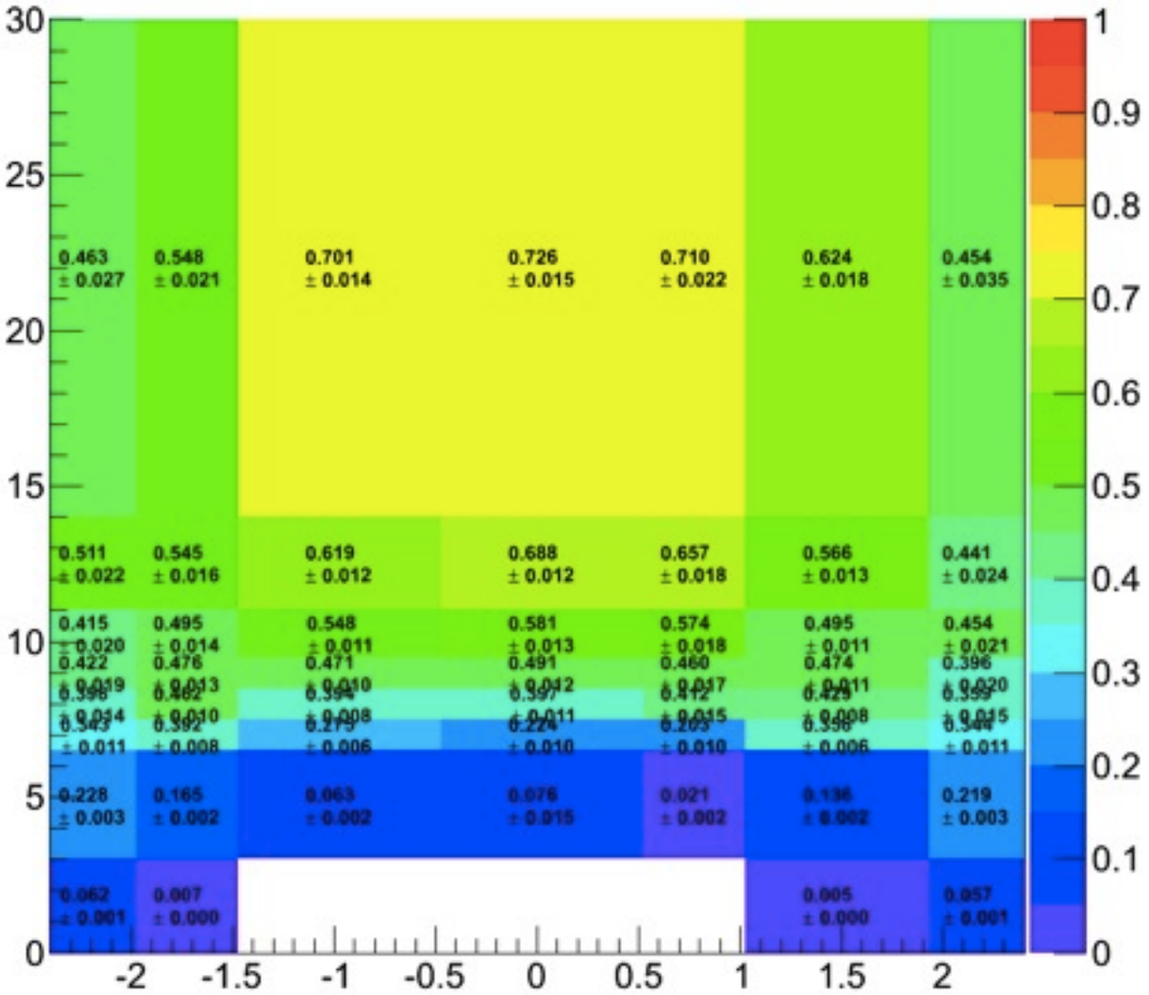


new sample

- **Efficiency**



- **zoomed in**

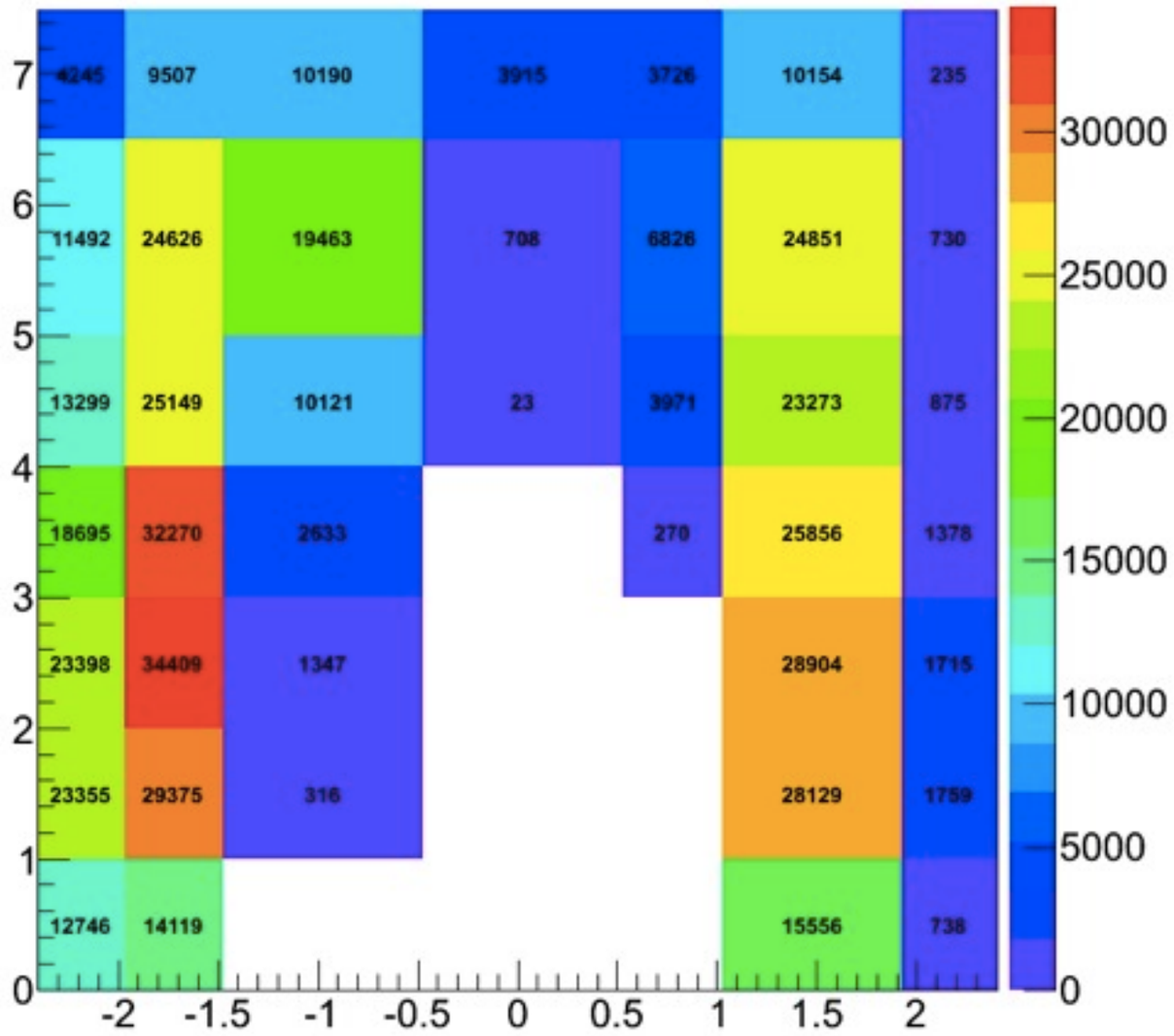
finer 2

- **old sample**

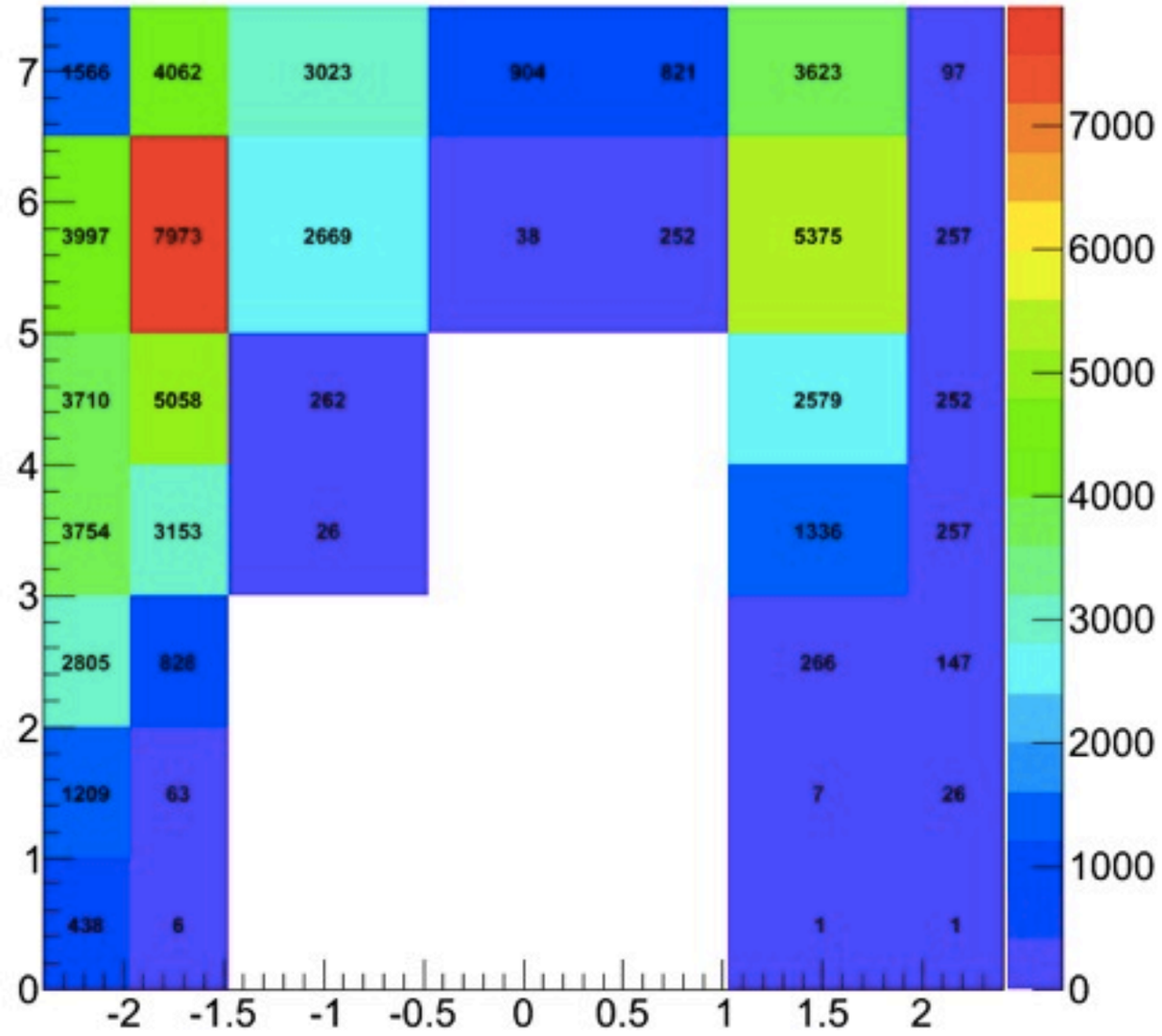
0,1,2,3,4,5,6.5 GeV/c

Entries = 8237319

- **Eff Den**

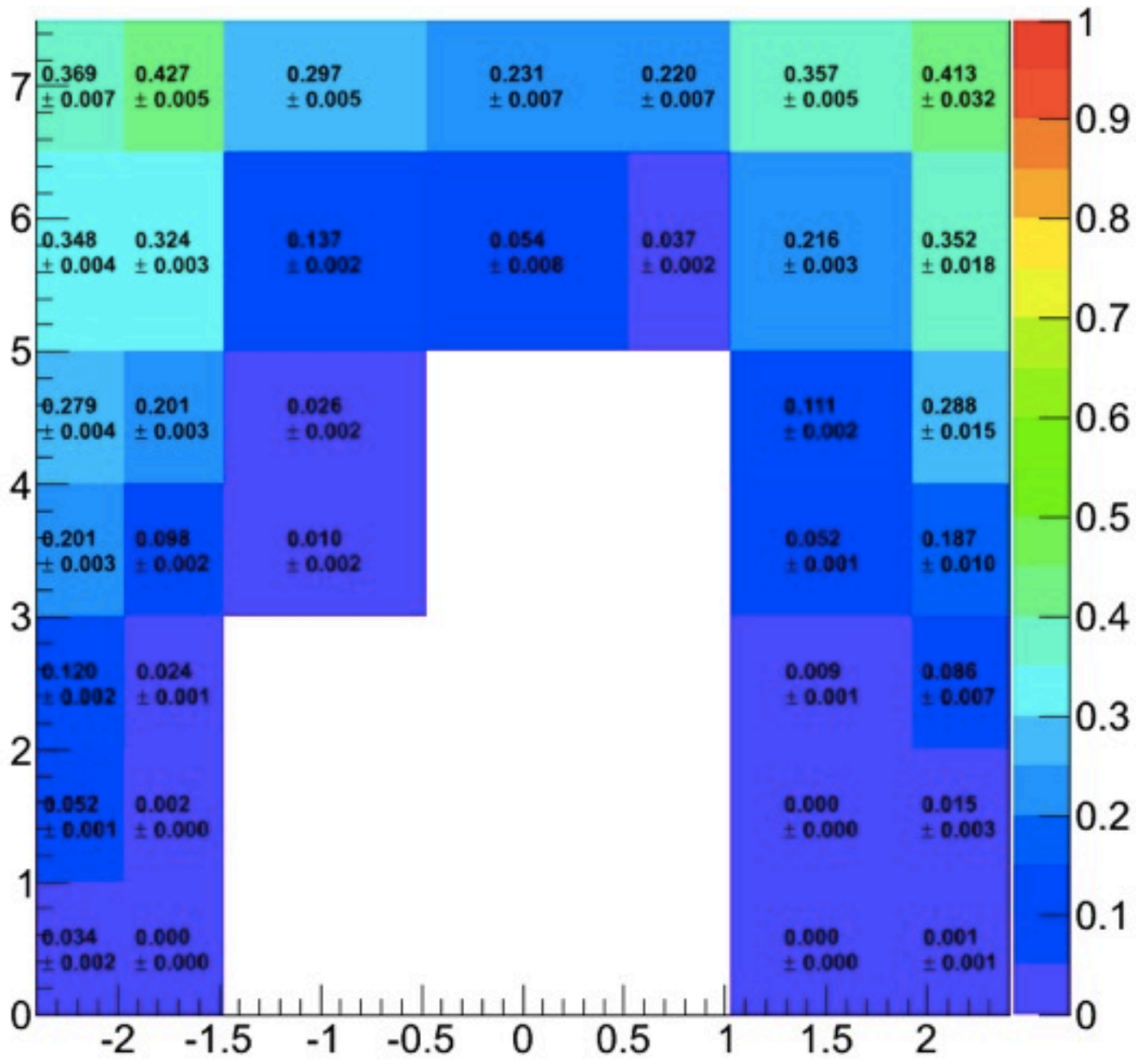


- **Eff Num**



finer 2

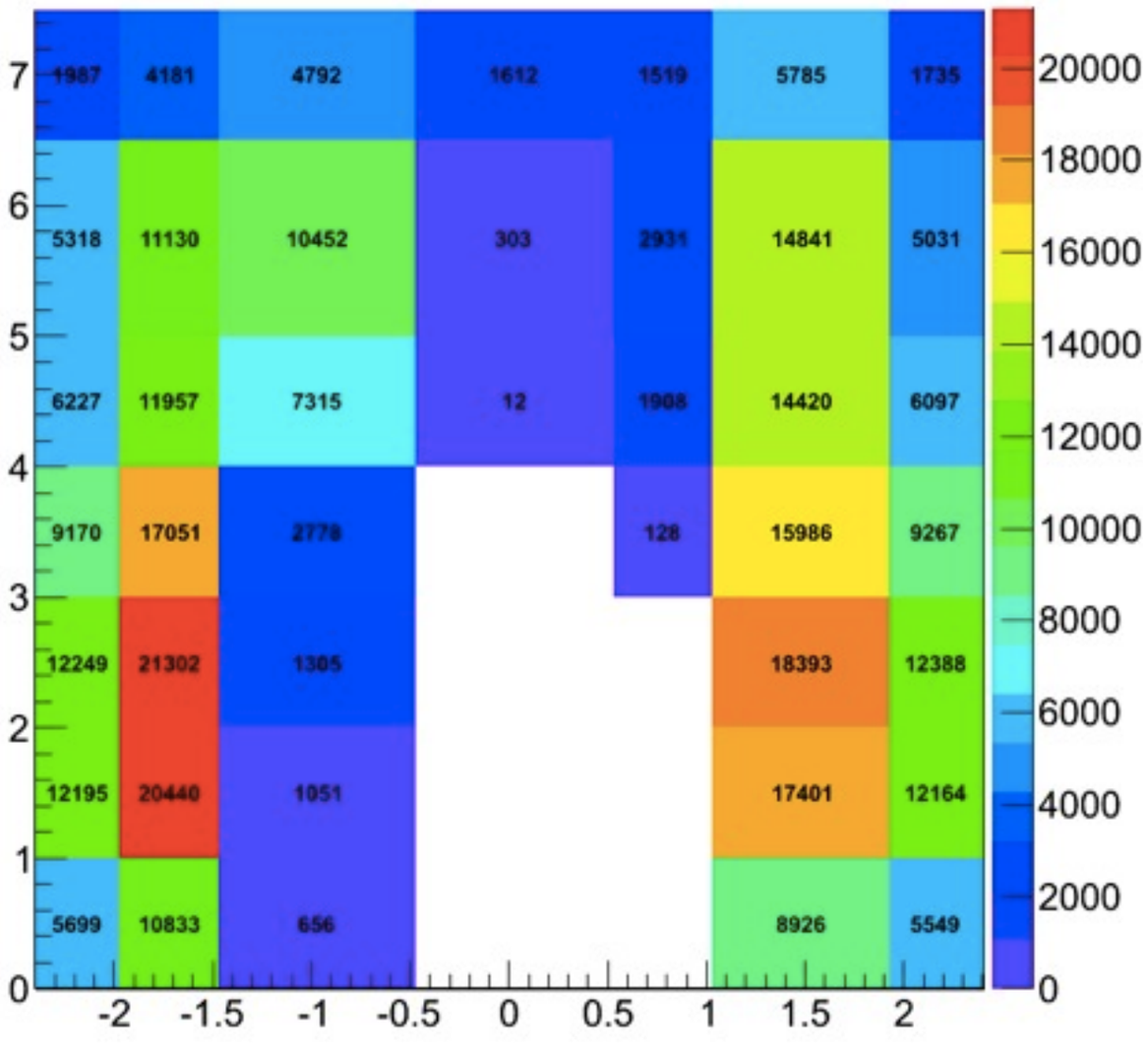
- **old sample** 0,1,2,3,4,5,6.5 GeV/c Entries = 8237319
- **Efficiency**



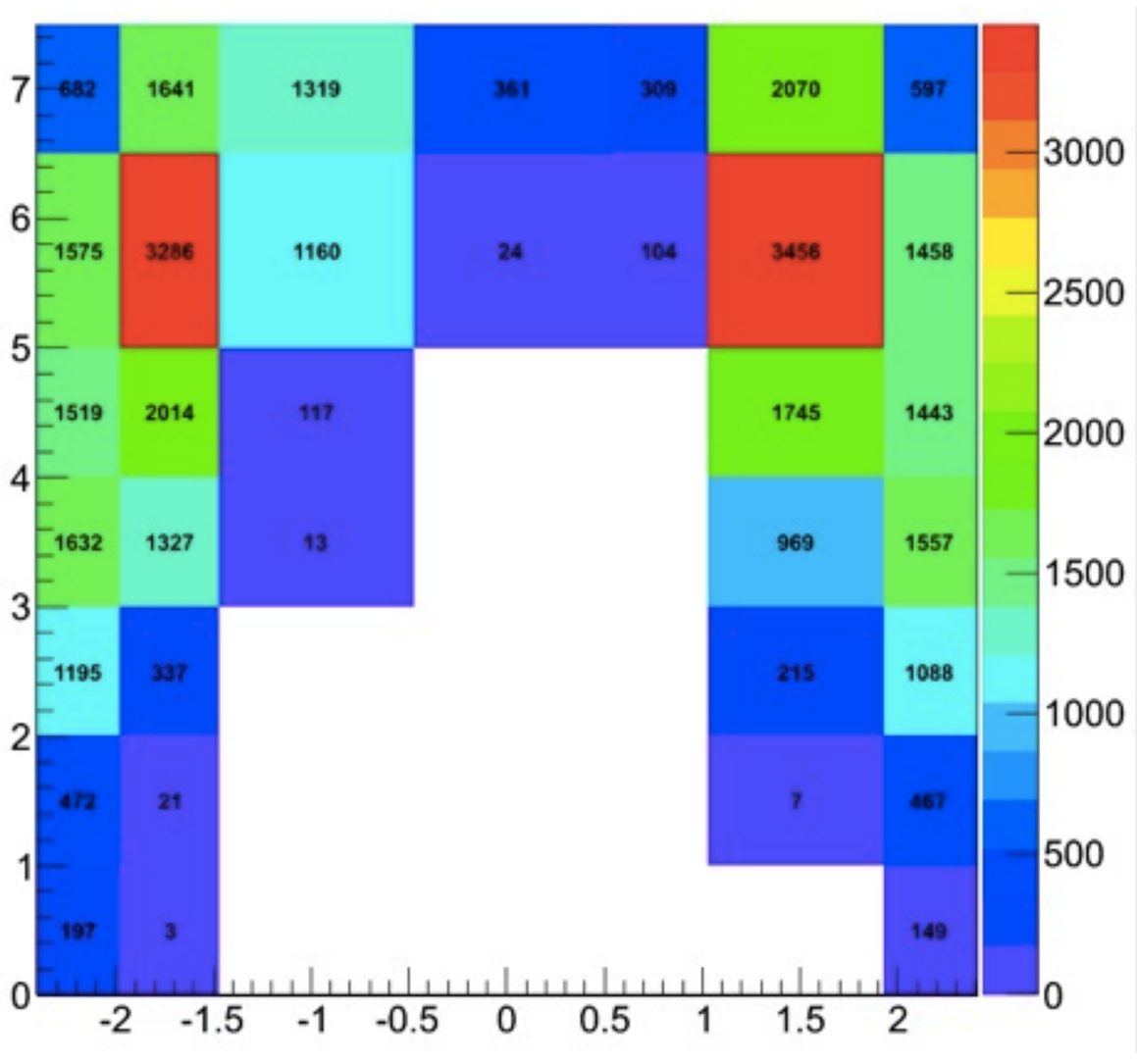
finer 2

- **New sample** 0,1,2,3,4,5,6.5 GeV/c Entries = 8237319

- **Eff Den**



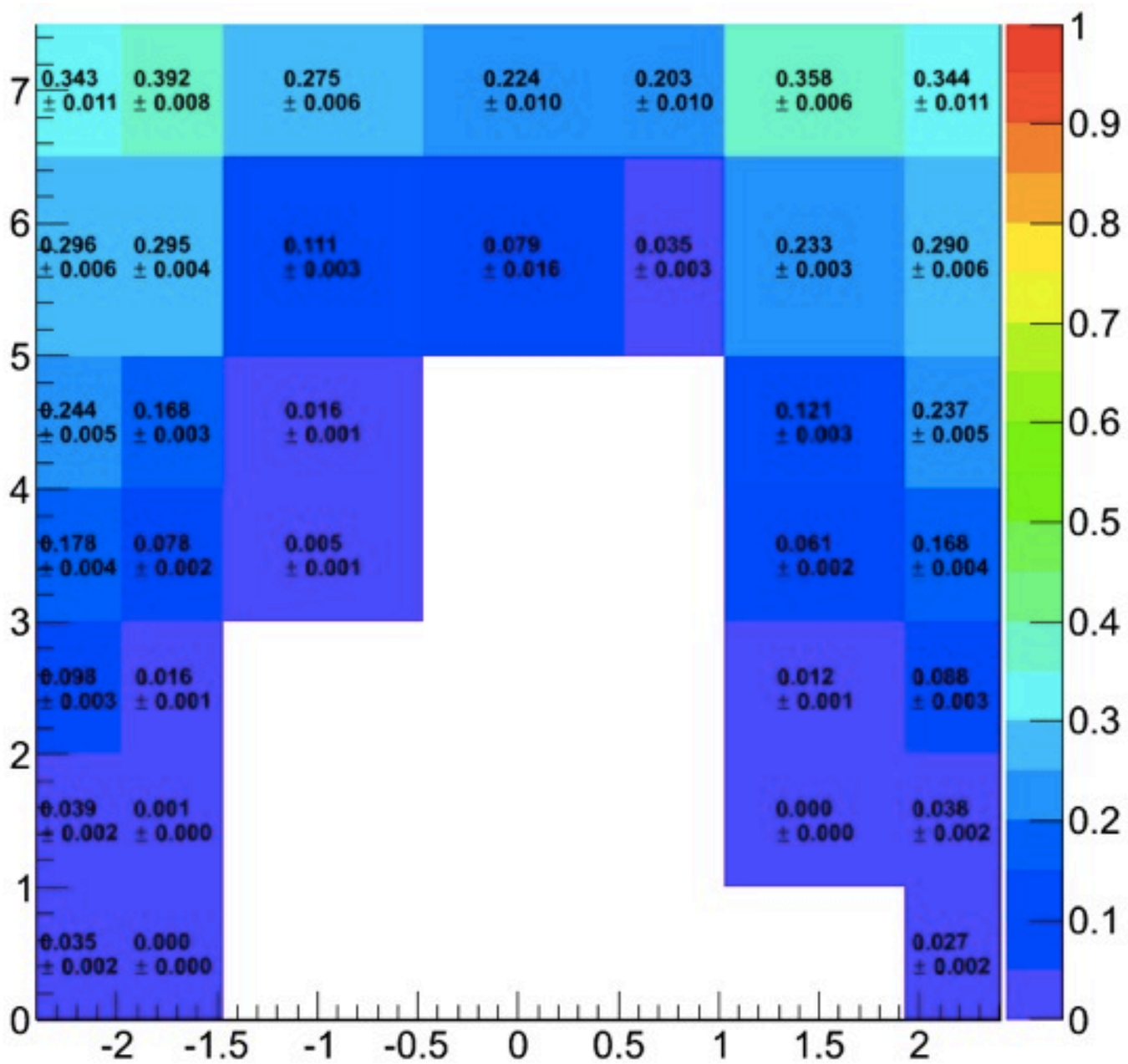
- **Eff Num**



finer 2

- **New sample** 0,1,2,3,4,5,6.5 GeV/c Entries = 8237319

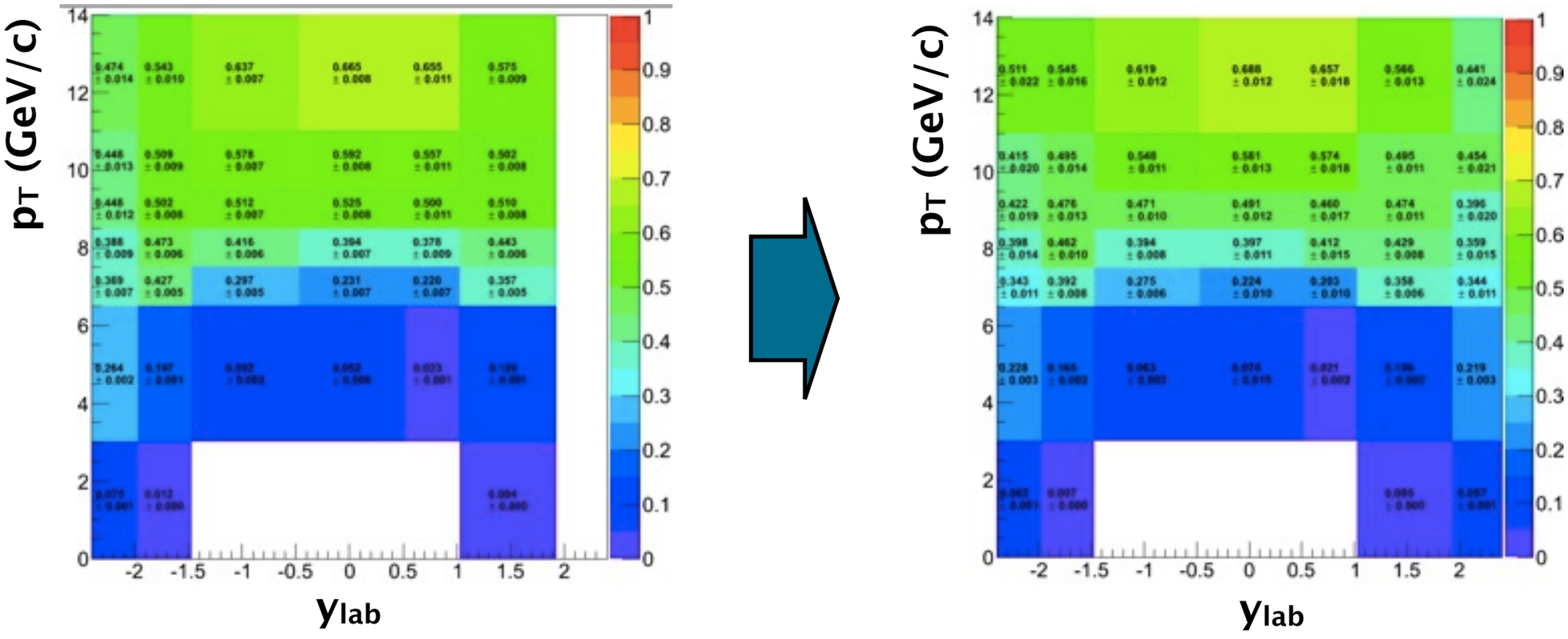
- **Efficiency**



Back up

MC production

- **pp boosted sample**
  - prompt J/psi sample is done (~1M events)
    - quick check for the efficiency values
    - No improvement at low p_T??
    - further confirmation before discussing in dilepton meeting



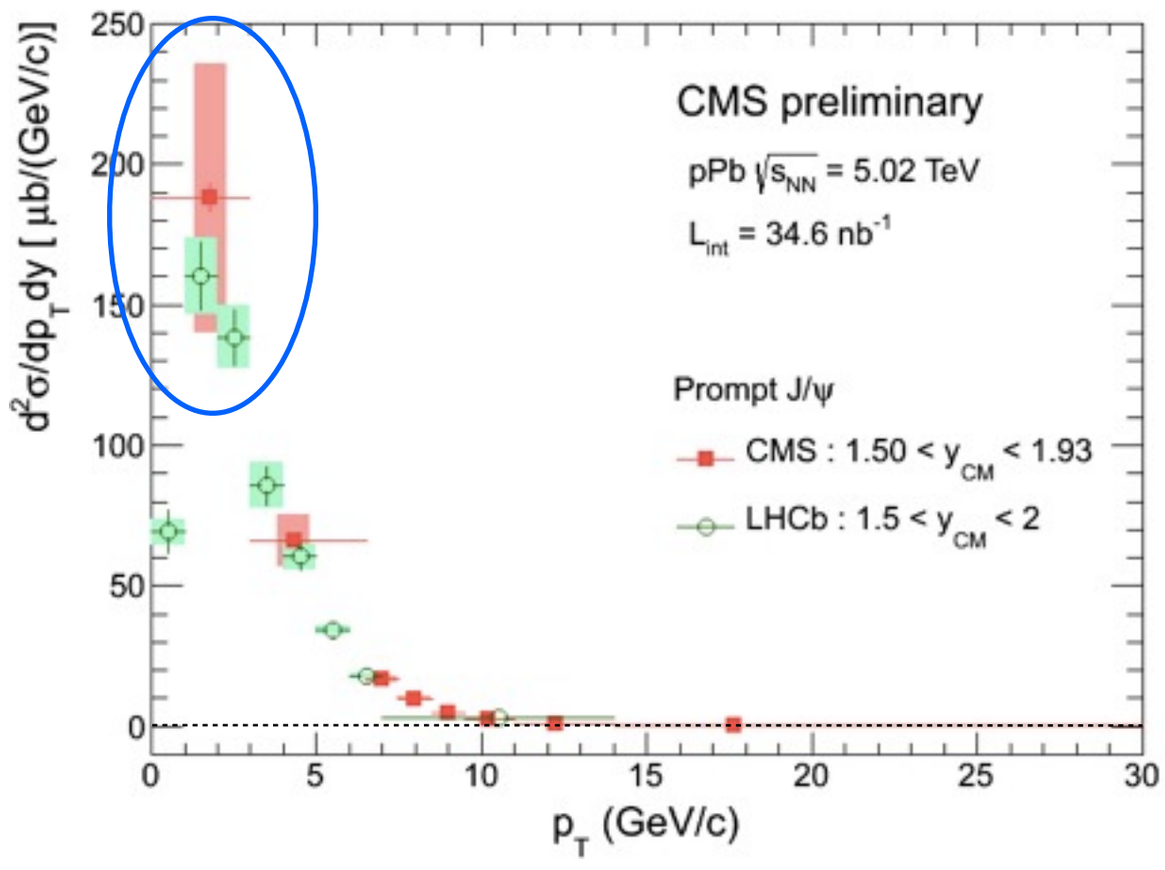
- **HIJING embedding sample**
  - Test has been done in local machine
  - fixing the minor problems when running crab job

Comparison with LHCb

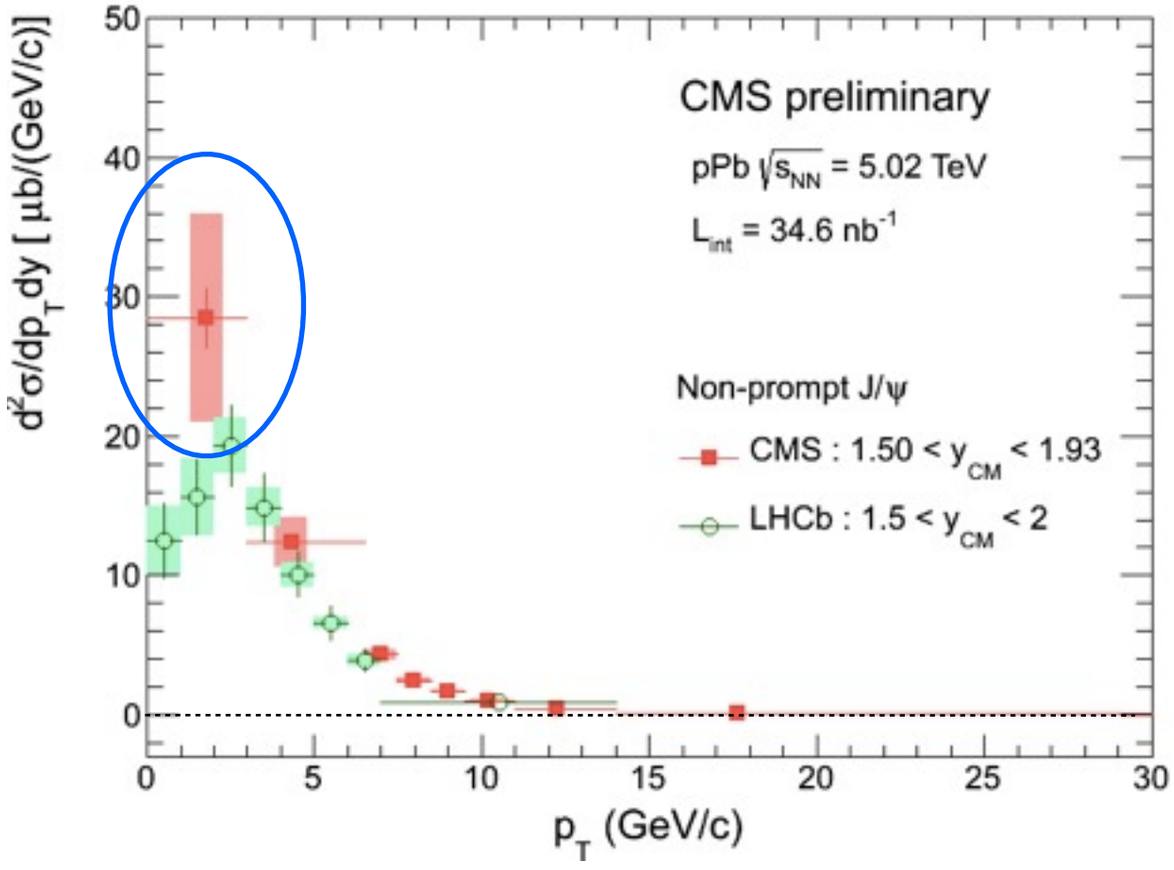
- **Double differential cross section**
  - LHCb points plotted at the center of the bin
  - Our points plotted at < p_T >

$$\frac{d^2\sigma}{dp_T dy} = \frac{N_{fit}^{J/\psi} / (A \cdot \varepsilon)}{L_{int} \times B(J/\psi \to \mu^+\mu^-) \times \Delta p_T \Delta y}$$

[Prompt]



[Non-prompt]



- **Large discrepancies at lower p_T < 3 GeV/c**
  - **acceptance or efficiency underestimated?**

two MC samples

- **Definition of acceptance and efficiency**
  - **Acceptance :** 1) a sample produced with the same configuration setting as the official, but MuMuGen Filter (kinematic filter for single muons) were removed.

$$\alpha = \frac{N^{dimuon}_{reconstructible,M1}(p_T, y)}{N^{dimuon}_{generated}(p_T, y)}$$

Acc. numerator(GEN)
M1 + acc.cut

  - **Efficiency :** 2) centrally produced official sample (with MuMuGen Filter).

$$\varepsilon = \frac{N^{dimuons\ reconstructed,M2,muIDcut,triggerselection}_{detectable}(p_T, y)}{N^{dimuon\ generated,M1}_{detectable}(p_T, y)}$$

Eff. denominator(GEN)
M1 + acc.cut + filter

- **M1**

  $2.6 < m_{\mu\mu} < 3.5\ GeV/c^2$

- **acceptance cut**

  (detectable/reconstructable)

$$-2.4 < \eta < 1.93$$

$$|\eta^\mu| < 1.3 \rightarrow p_T^\mu > 3.3\ GeV/c$$
$$1.3 < |\eta^\mu| < 2.2 \rightarrow p^\mu > 2.9\ GeV/c$$
$$2.2 < |\eta^\mu| < 2.4 \rightarrow p_T^\mu > 0.8\ GeV/c$$

- **MuMuGen filter**

  1) $-2.5 < \eta^\mu < 2.5$
  2) $p^\mu > 2.5$
  (configuration in backup)

- **MuMuGen Filter should be looser than the acceptance cut, and "denominator of efficiency" should be same with "numerator of acceptance".**