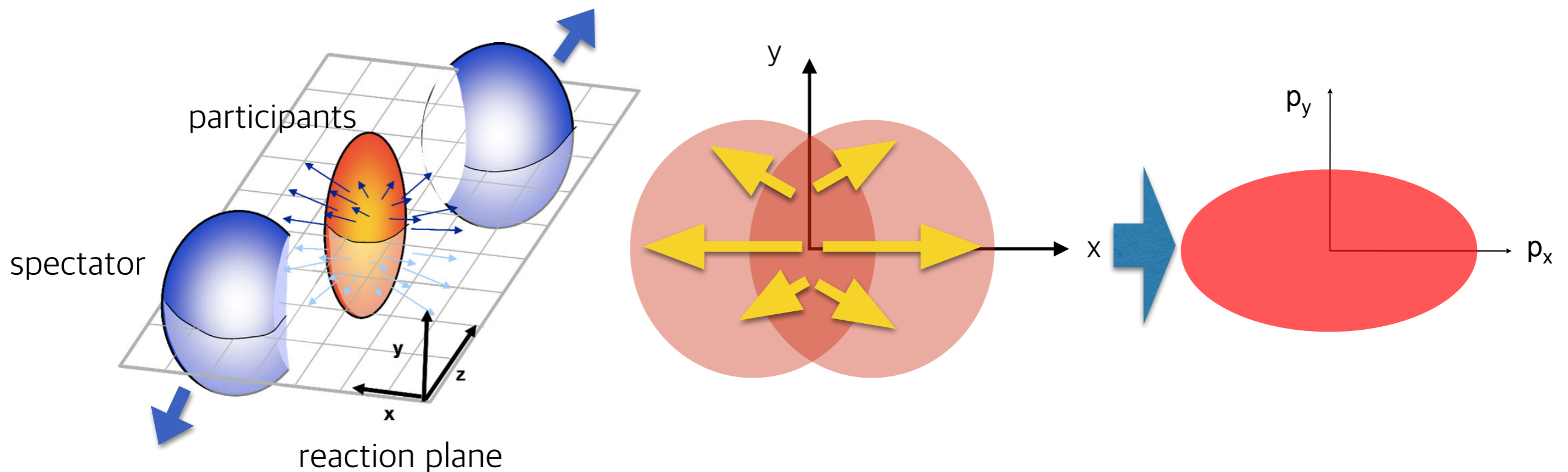


Υ -h correlation analysis in pPb at 8 TeV

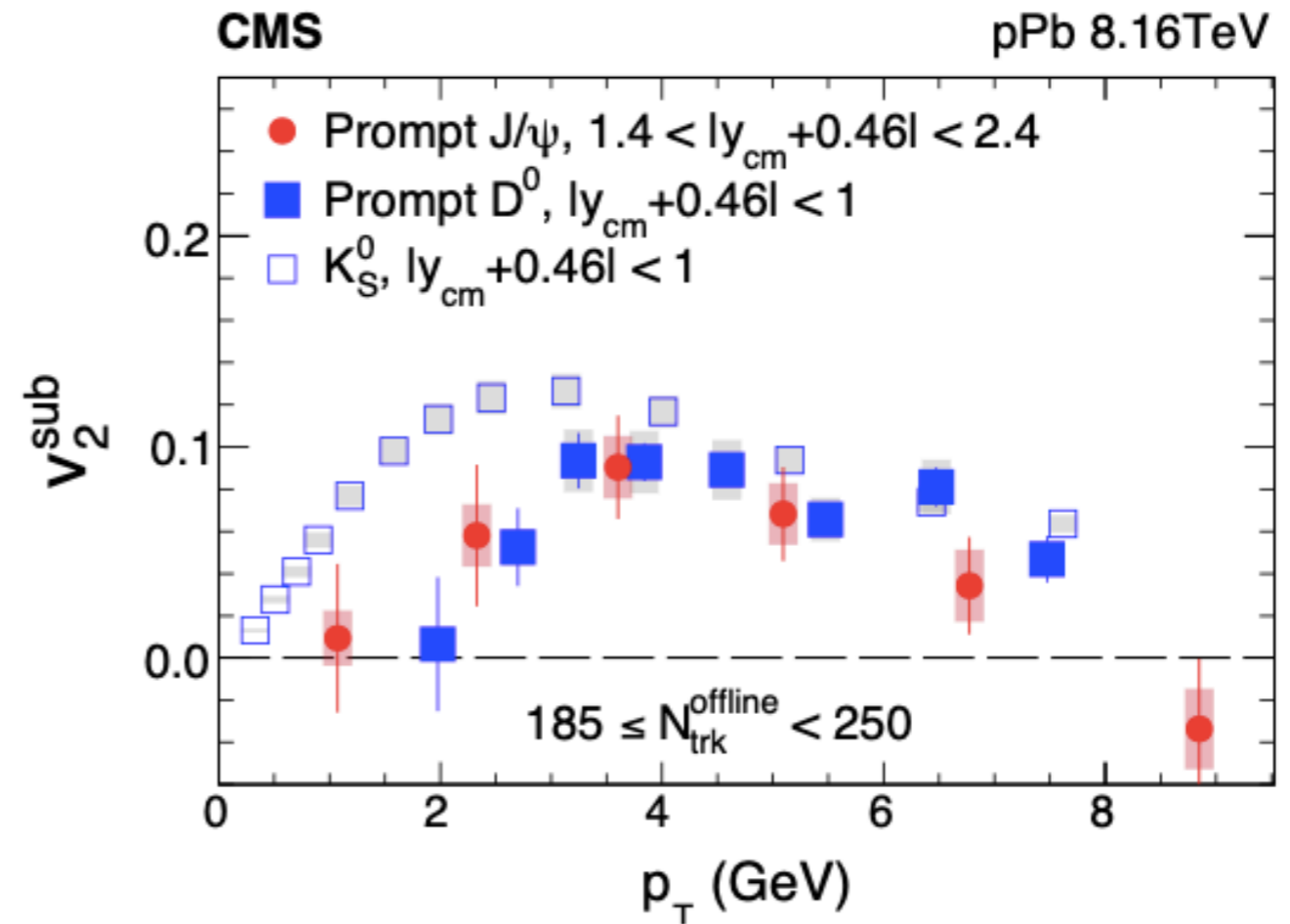
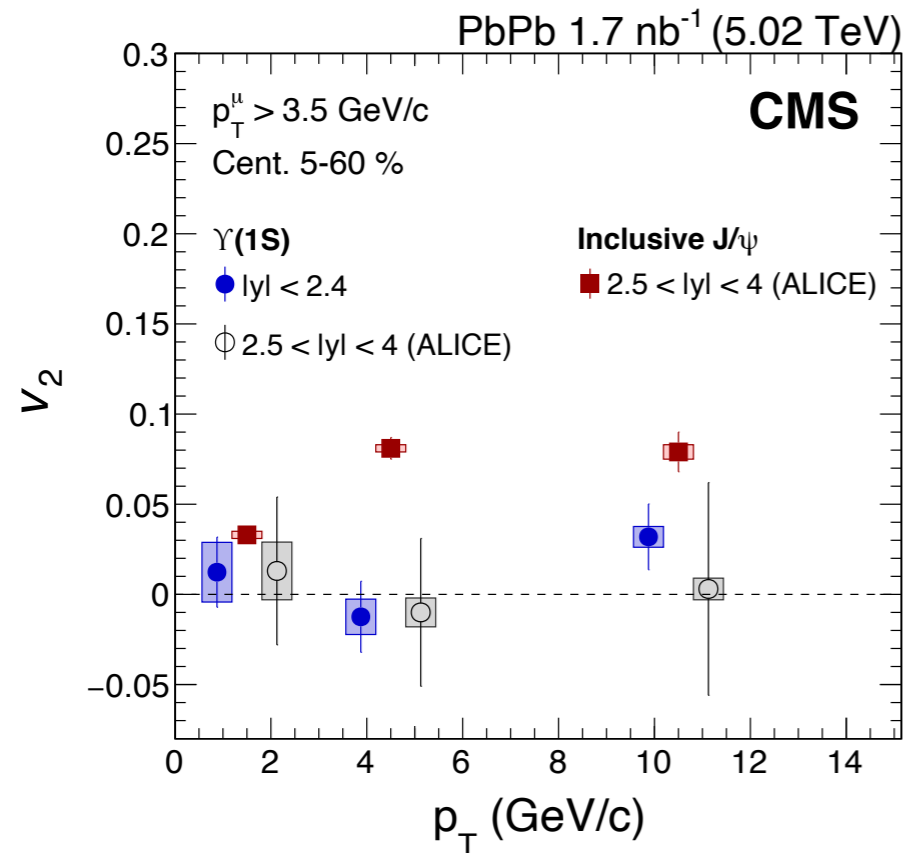
KiSoo Lee

Motivation



- Participants of the collision are distributed in an almond shape region
- Due to the length and pressure difference, spatial anisotropy converted into a momentum anisotropy
- Quarkonia are expected to carry out information on the initial state and the medium effects

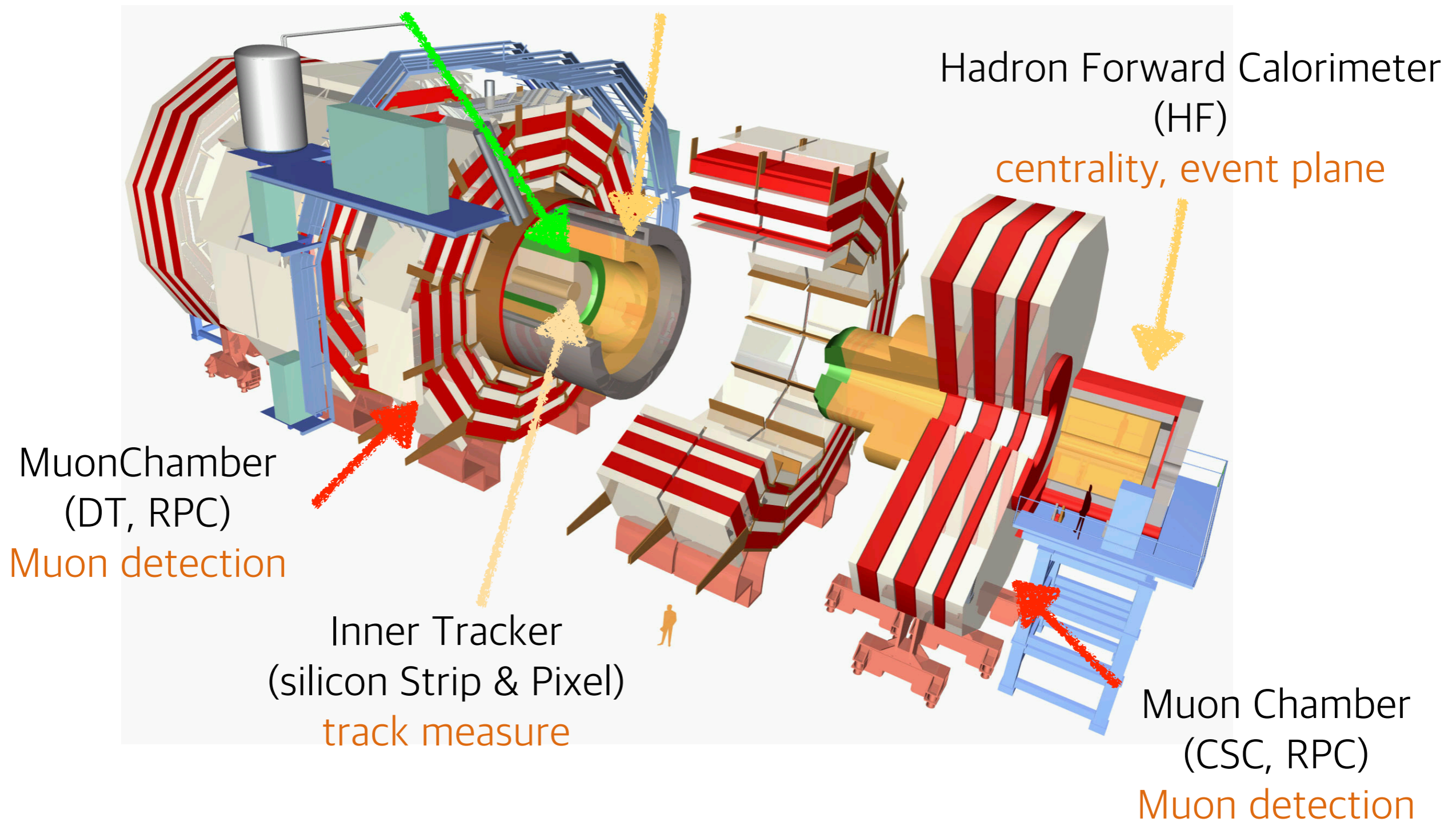
Motivation



- Zero Υv_2 in PbPb 5 TeV
- Non-zero J/ψ v_2 in pPb 8 TeV
- First study of Υv_2 in pPb
- Prove to understand small system

CMS detector

Calorimeters
(Electromagnetic & Hadron)



Correlation method

$$S(\Delta\eta, \Delta\phi) = \frac{1}{N_{\text{trig}}} \frac{d^2 N^{\text{same}}}{d\Delta\eta d\Delta\phi}$$

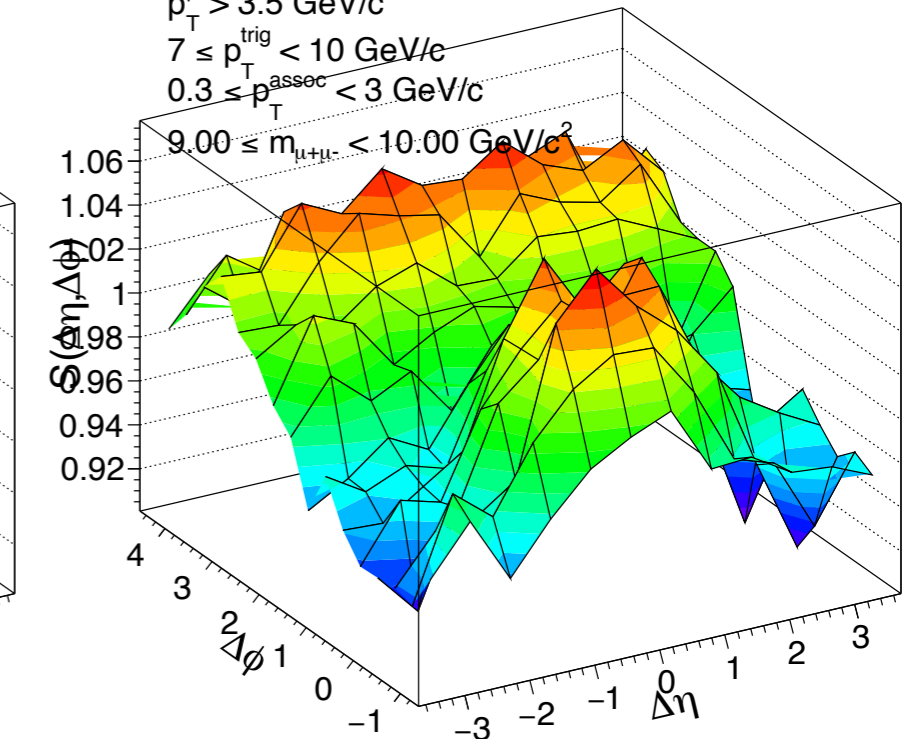
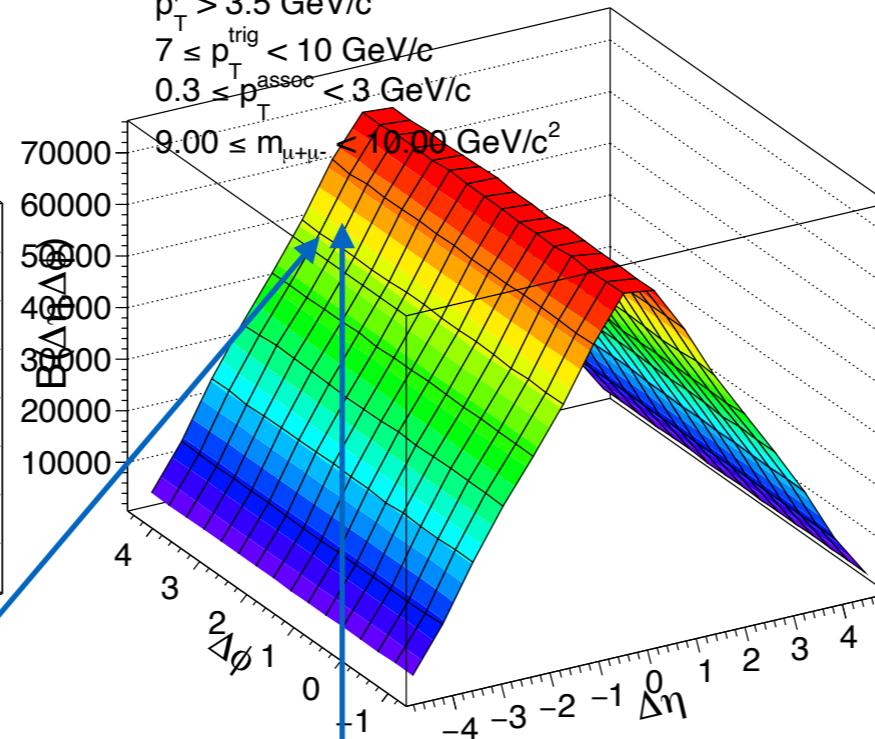
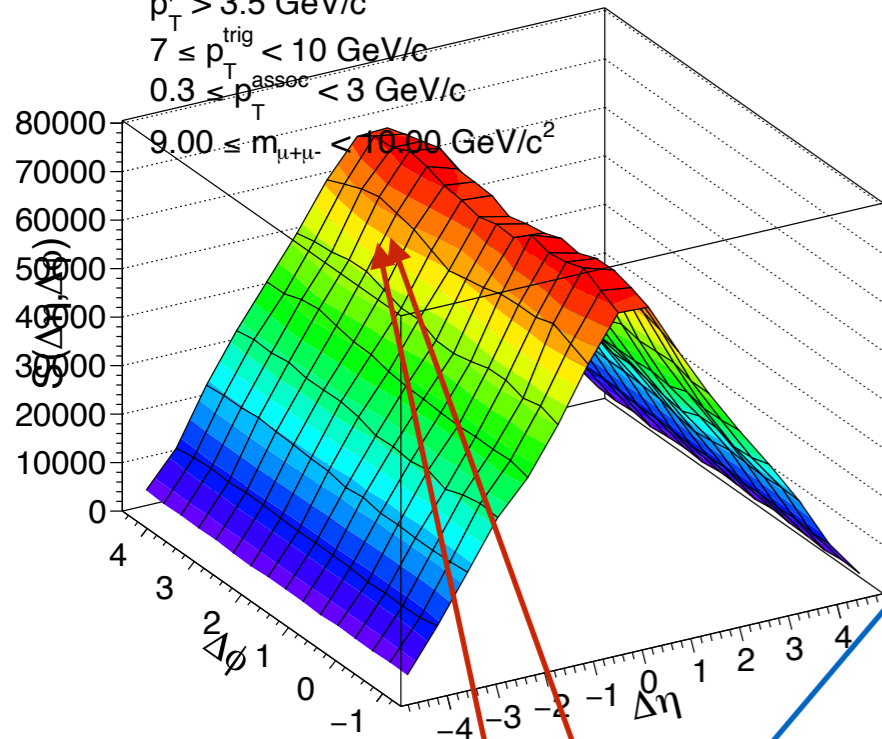
$$B(\Delta\eta, \Delta\phi) = \frac{1}{N_{\text{trig}}} \frac{d^2 N^{\text{mix}}}{d\Delta\eta d\Delta\phi}$$

$$\frac{1}{N_{\text{trig}}} \frac{d^2 N^{\text{pair}}}{d\Delta\eta d\Delta\phi} = \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}$$

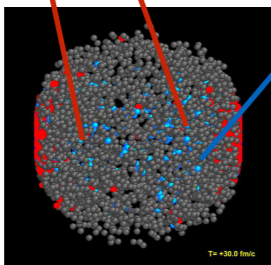
pPb $\sqrt{s} = 8.16$ TeV, $90 \leq N_{\text{trk}}^{\text{offline}} < 300$
 $p_{\text{T}}^{\mu} > 3.5$ GeV/c
 $7 \leq p_{\text{T}}^{\text{trig}} < 10$ GeV/c
 $0.3 < p_{\text{T}}^{\text{assoc}} < 3$ GeV/c
 $9.00 \leq m_{\mu+\mu-} < 10.00$ GeV/c²

pPb $\sqrt{s} = 8.16$ TeV, $90 \leq N_{\text{trk}}^{\text{offline}} < 300$
 $p_{\text{T}}^{\mu} > 3.5$ GeV/c
 $7 \leq p_{\text{T}}^{\text{trig}} < 10$ GeV/c
 $0.3 < p_{\text{T}}^{\text{assoc}} < 3$ GeV/c
 $9.00 \leq m_{\mu+\mu-} < 10.00$ GeV/c²

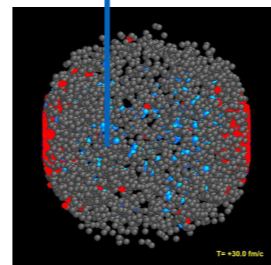
pPb $\sqrt{s} = 8.16$ TeV, $90 \leq N_{\text{trk}}^{\text{offline}} < 300$
 $p_{\text{T}}^{\mu} > 3.5$ GeV/c
 $7 \leq p_{\text{T}}^{\text{trig}} < 10$ GeV/c
 $0.3 < p_{\text{T}}^{\text{assoc}} < 3$ GeV/c
 $9.00 \leq m_{\mu+\mu-} < 10.00$ GeV/c²



Event1



Event2



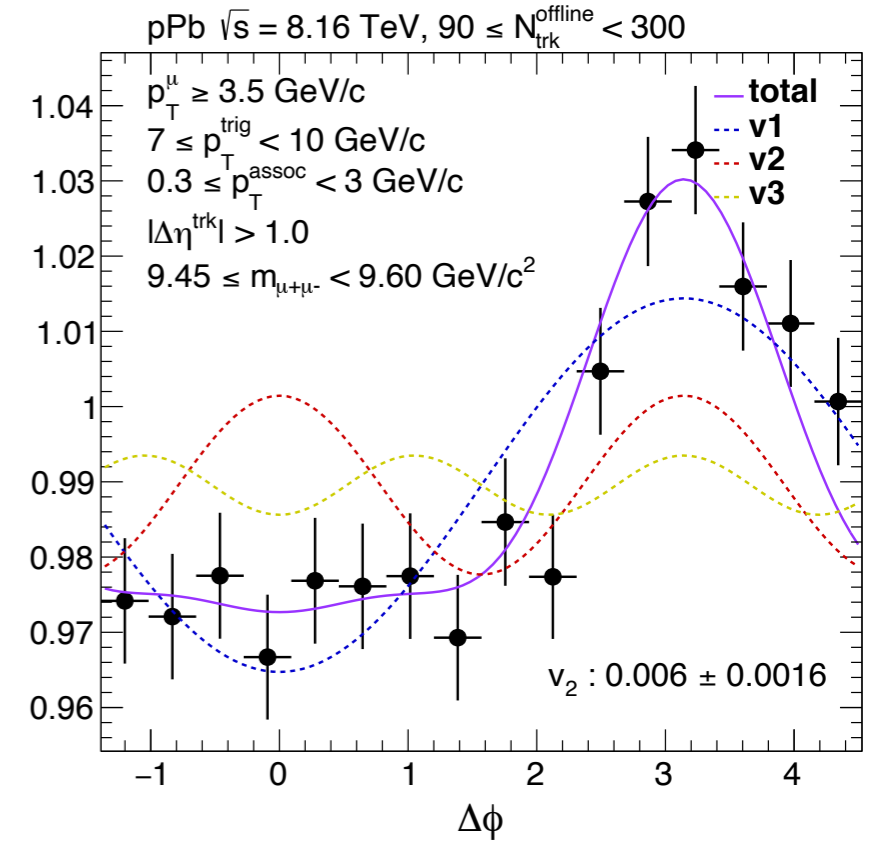
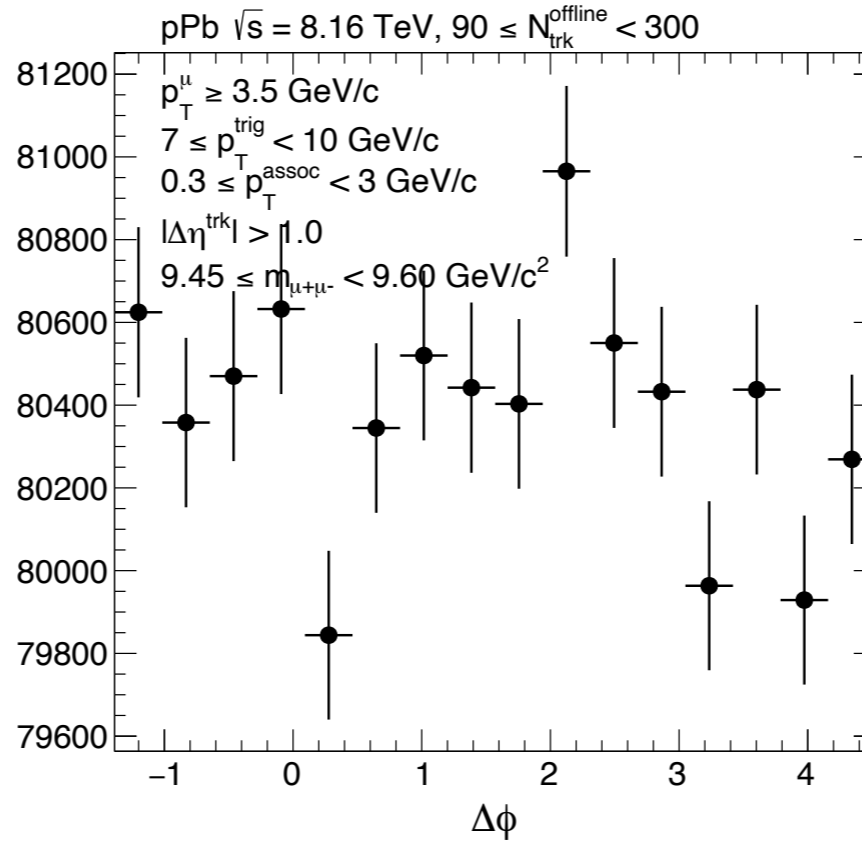
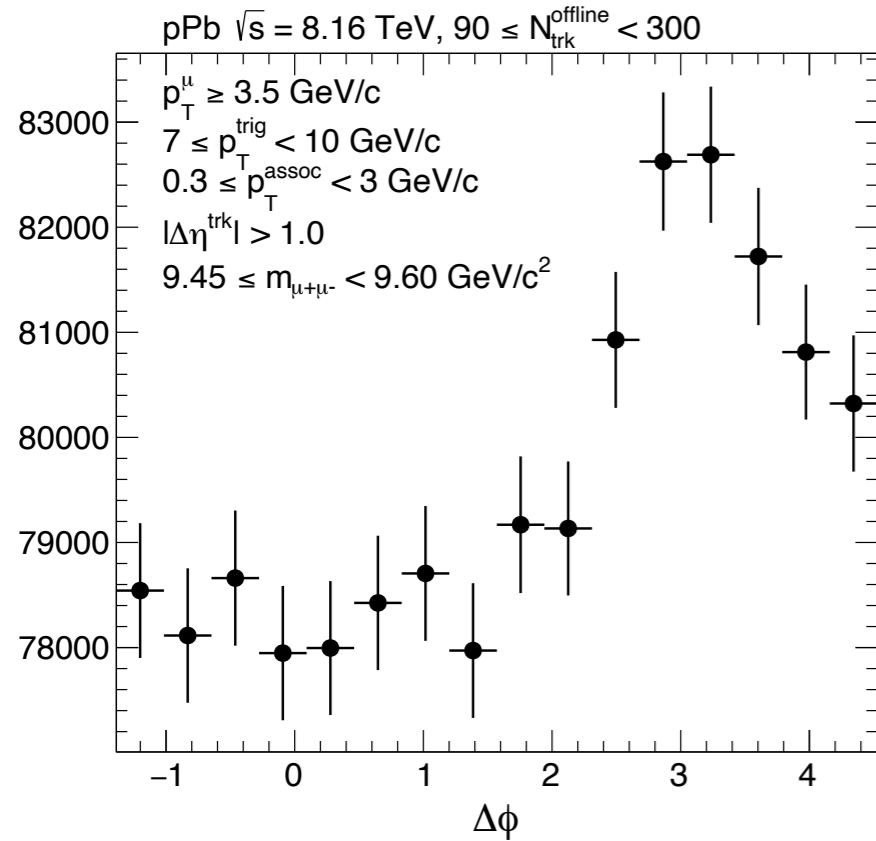
- Two-particle angular correlations in $\Delta\eta$ - $\Delta\phi$ (Υ -track)
- $0.3 < p_{\text{T}}^{\text{track}} < 3$, $90 \leq \text{multiplicity} < 300$
- $|z_{\text{vtx}}^1 - z_{\text{vtx}}^2| < 2$ cm

$d\phi$ projection

$$S(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{d^2 N^{same}}{d\Delta\eta d\Delta\phi}$$

$$B(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{d^2 N^{mix}}{d\Delta\eta d\Delta\phi}$$

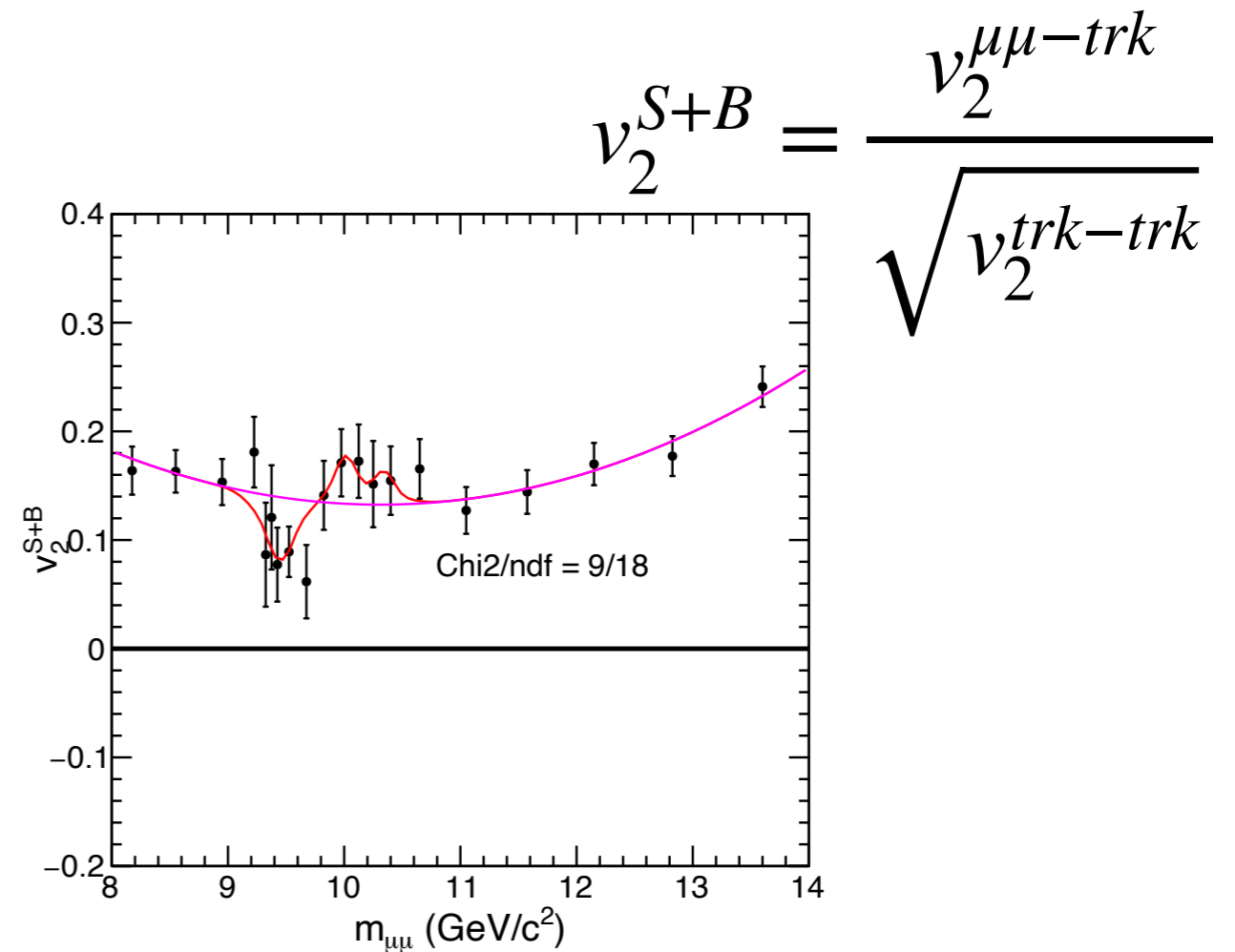
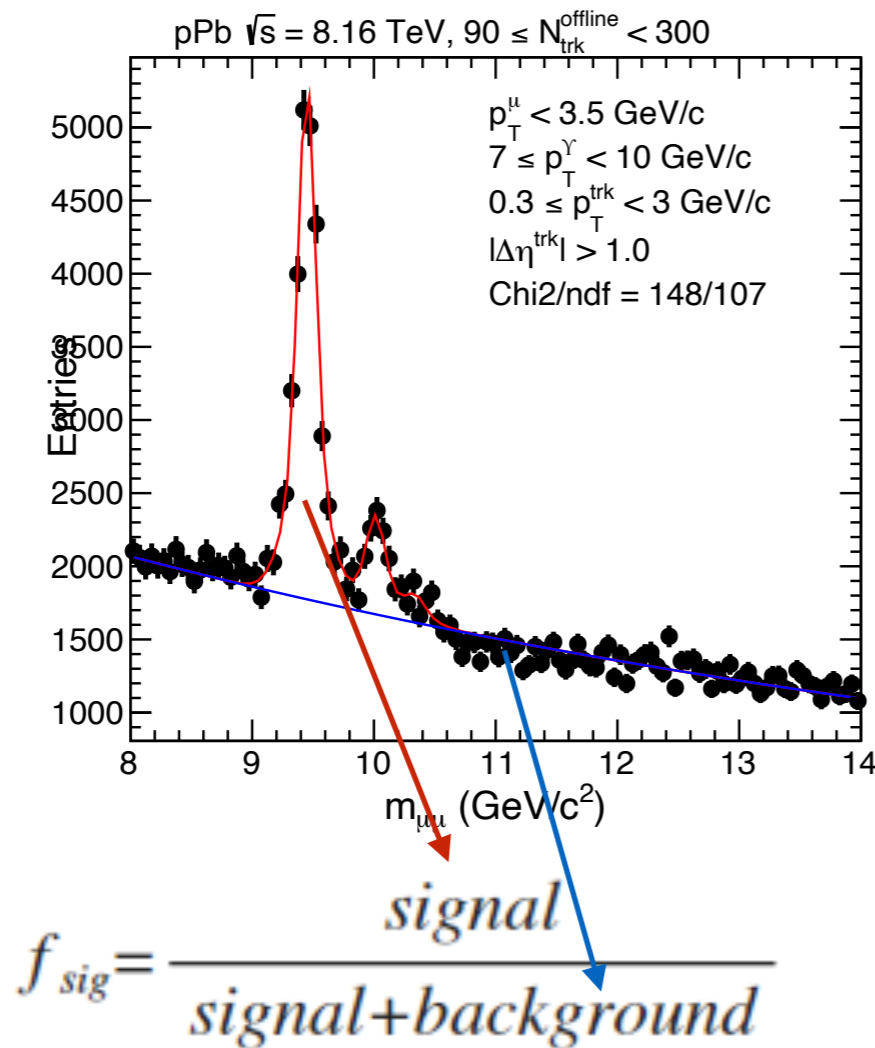
$$\frac{1}{N_{trig}} \frac{d^2 N^{pair}}{d\Delta\eta d\Delta\phi} = \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}$$



$$\frac{1}{N_{trig}} \frac{dN^{pair}}{d\Delta\phi} = \frac{N_{assoc}}{2\pi} \left\{ 1 + \sum_n 2V_{n\Delta} \cos(n\Delta\phi) \right\}$$

- $|\Delta\eta| > 1$ projected to remove jet contribution
- Ratio fitted with Fourier series

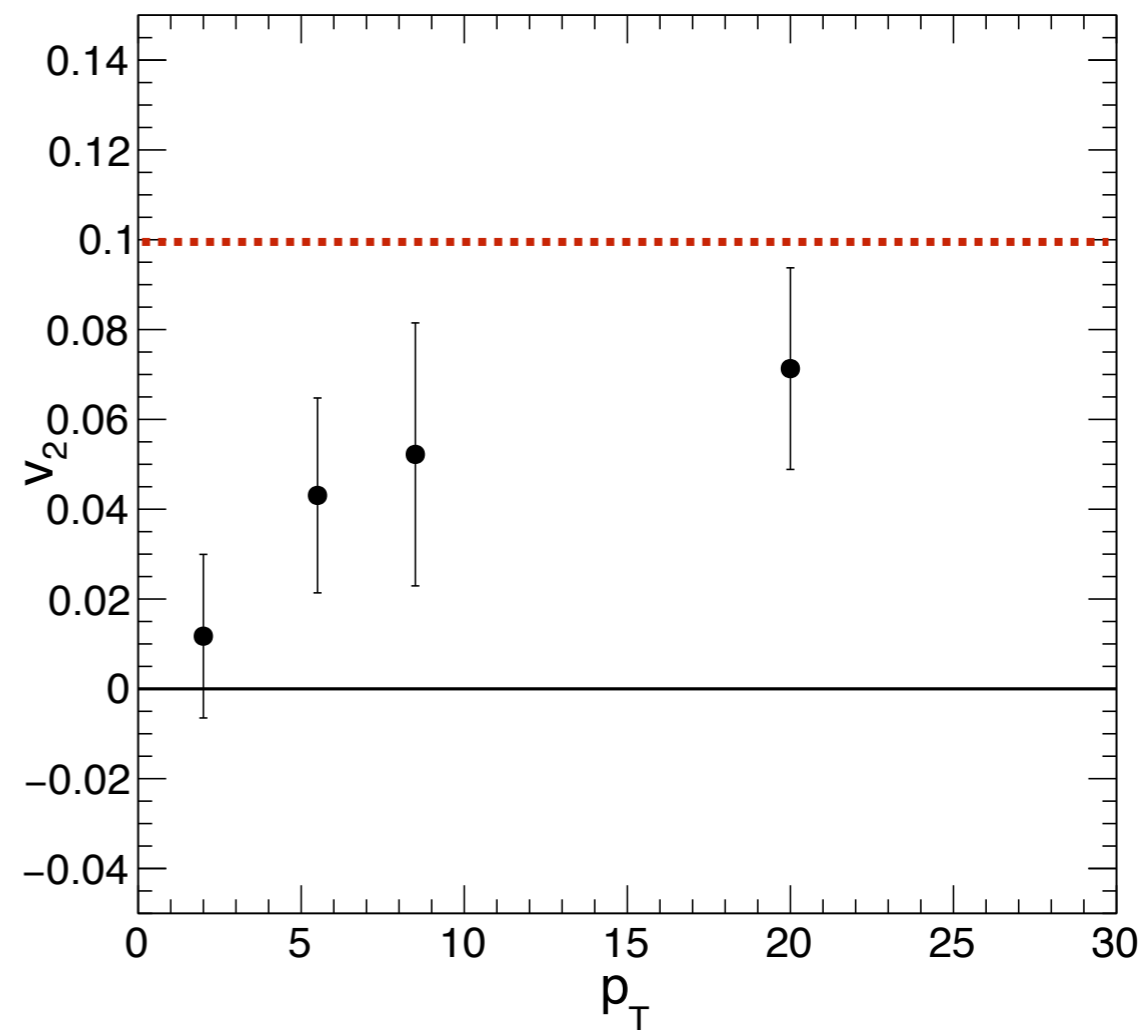
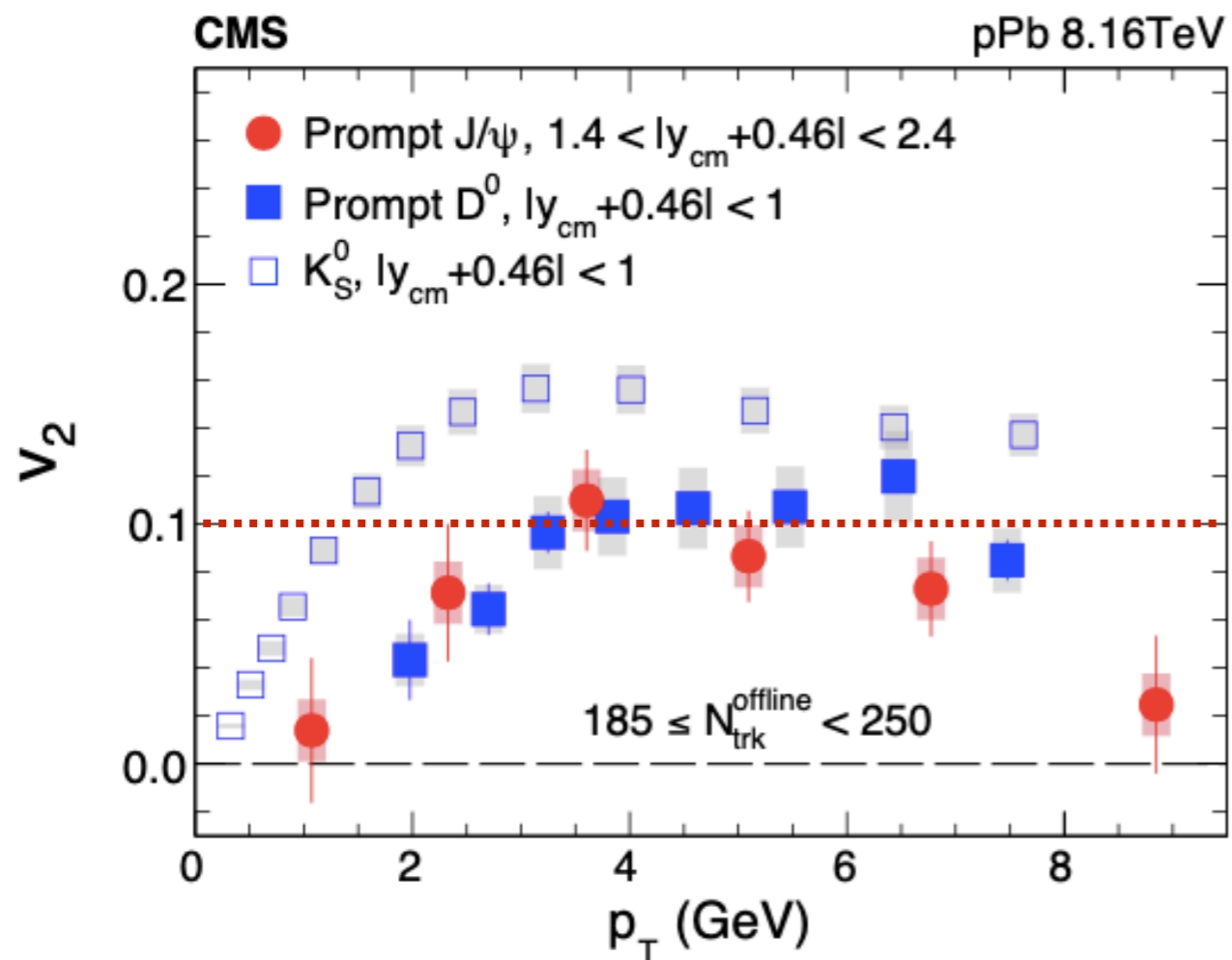
Simultaneous fitting



$$v_n^{\text{obs}} = f_{\text{sig}} v_n^{\text{sig}} + (1 - f_{\text{sig}}) v_n^{\text{bkg}}$$

- Track component should be subtracted to observe Υ v_2
- Observed v_2 is combination of signal and background di-muon v_2
- Simultaneous fitting is applied to extract signal v_2

High-multiplicity v_2



- High-multiplicity Υ v_2 is non-zero
- Lower than charm mesons

Low-multiplicity subtraction

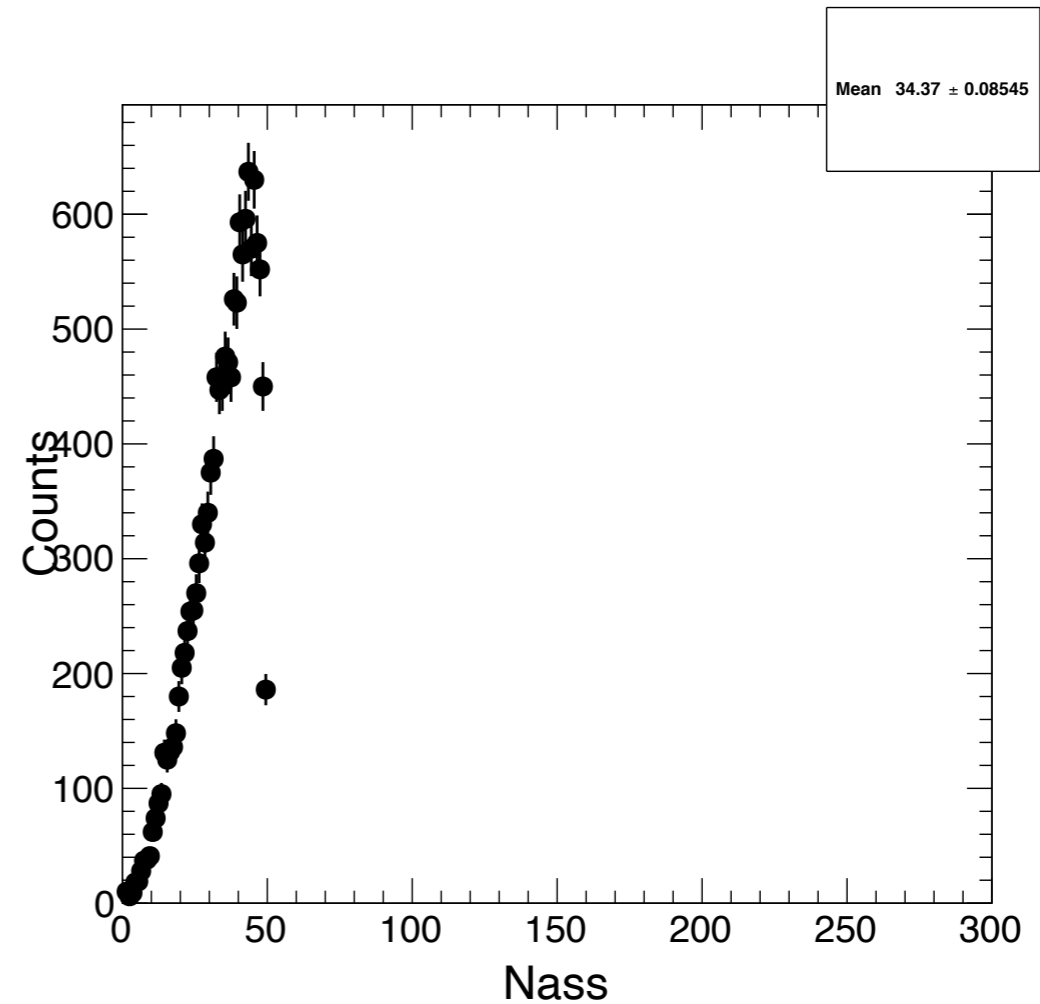
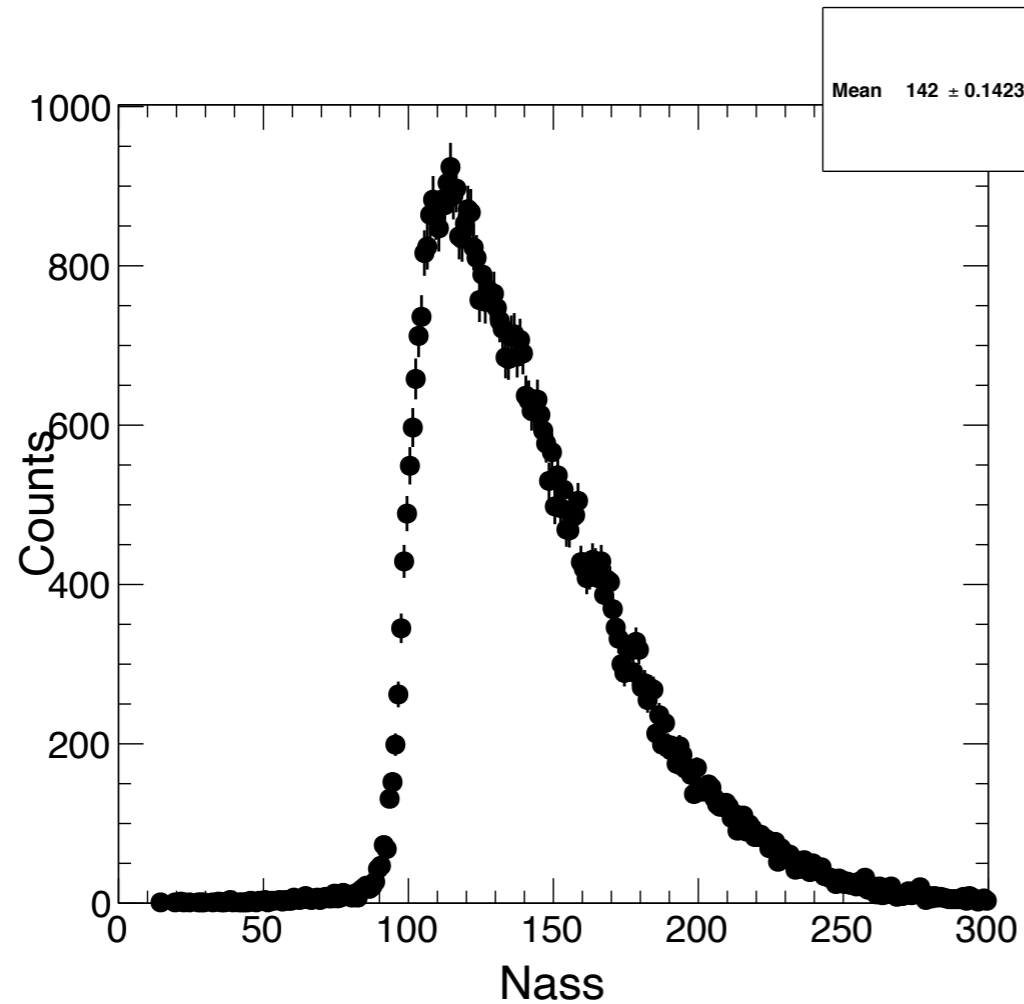
- Low-multiplicity subtraction is needed to estimate residual contribution from back-to-back jet correlation

$$\bullet v_2^{sub} = v_2(high) - v_2(low) \times \frac{N_{assoc}(low)}{N_{assoc}(high)} \times \frac{Y_{jet}(high)}{Y_{jet}(low)}$$

$$\bullet Y_{jet}^{sig} = \frac{Y_{jet}^{peak} - (1 - f)Y_{jet}^{bkg}}{f}$$

$$\bullet Y_{jet} = Y_{jet}(|\Delta\eta| < 1) - Y_{jet}(|\Delta\eta| > 2)$$

Number of associator

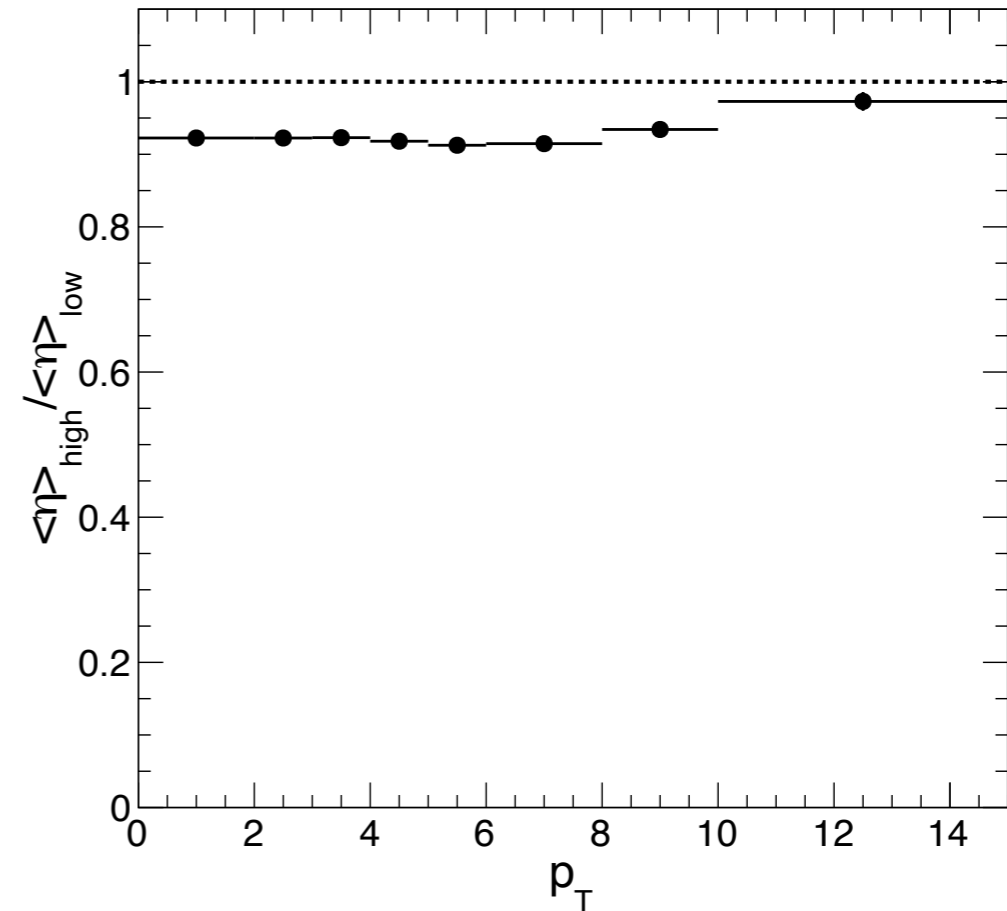
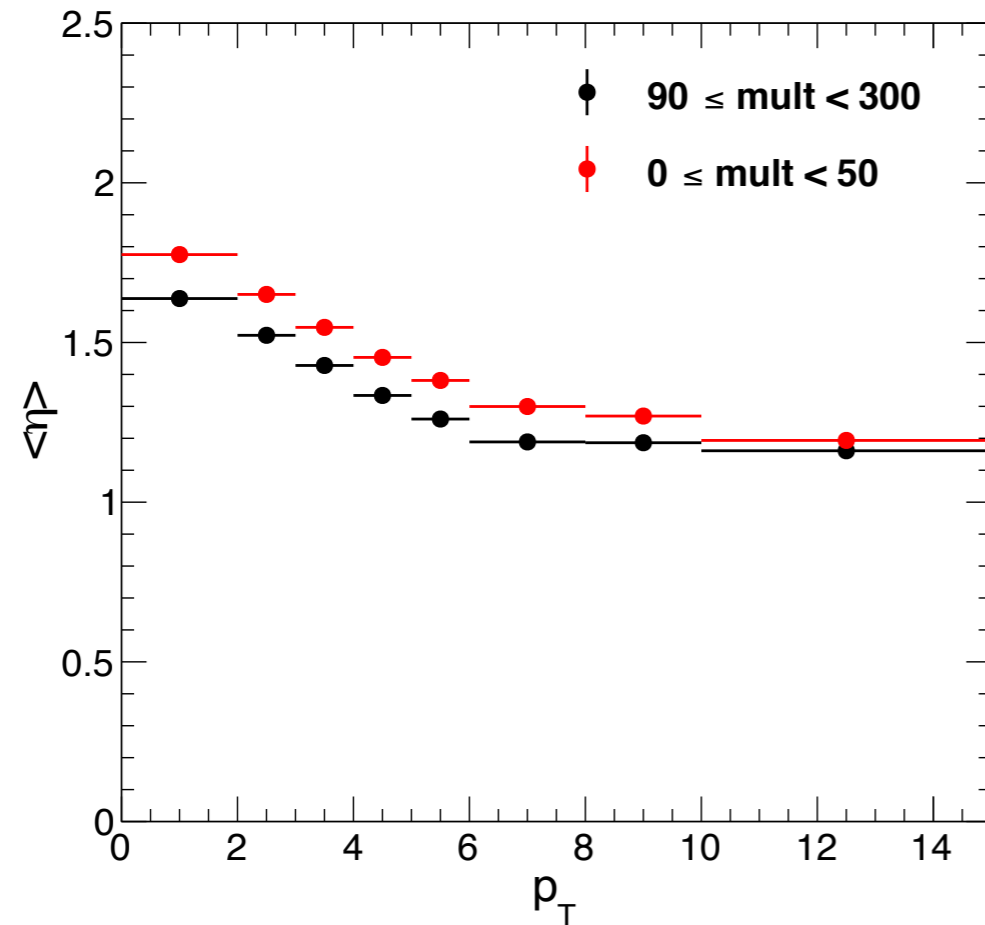


$$\bullet v_2^{sub} = v_2(high) - v_2(low) \times \frac{N_{assoc}(low)}{N_{assoc}(high)} \times \frac{Y_{jet}(high)}{Y_{jet}(low)}$$

$$\bullet Y_{jet}^{sig} = \frac{Y_{jet}^{peak} - (1 - f)Y_{jet}^{bkg}}{f}$$

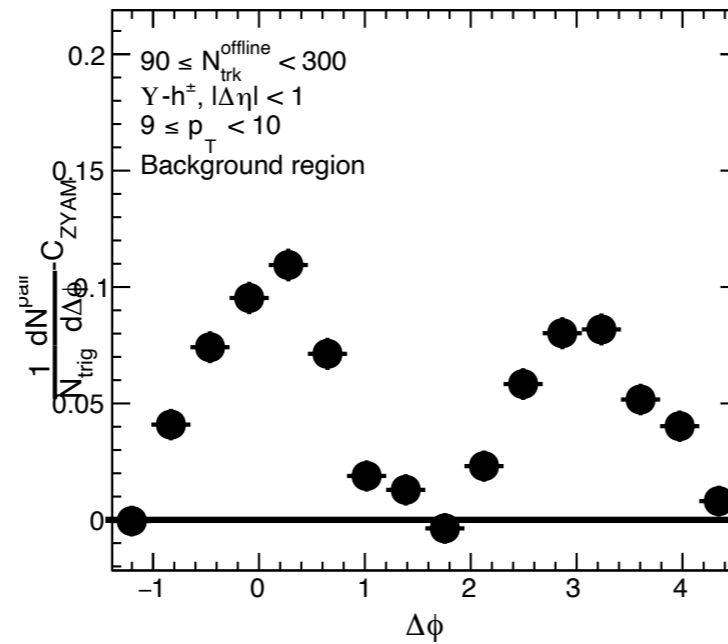
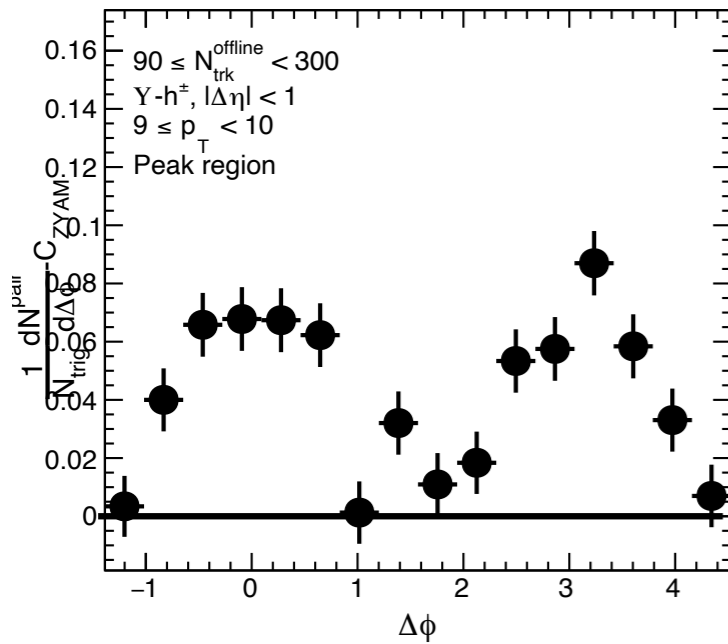
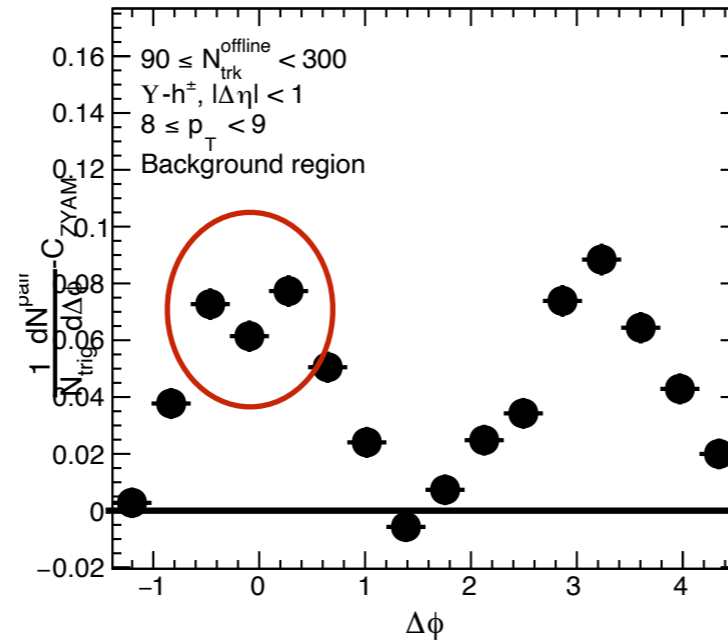
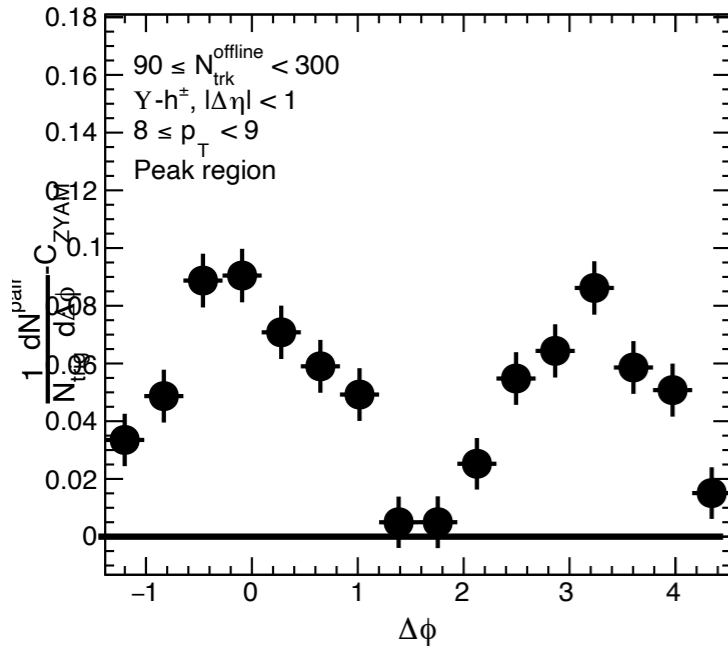
$$\bullet Y_{jet} = Y_{jet}(|\Delta\eta| < 1) - Y_{jet}(|\Delta\eta| > 2)$$

High η truncation



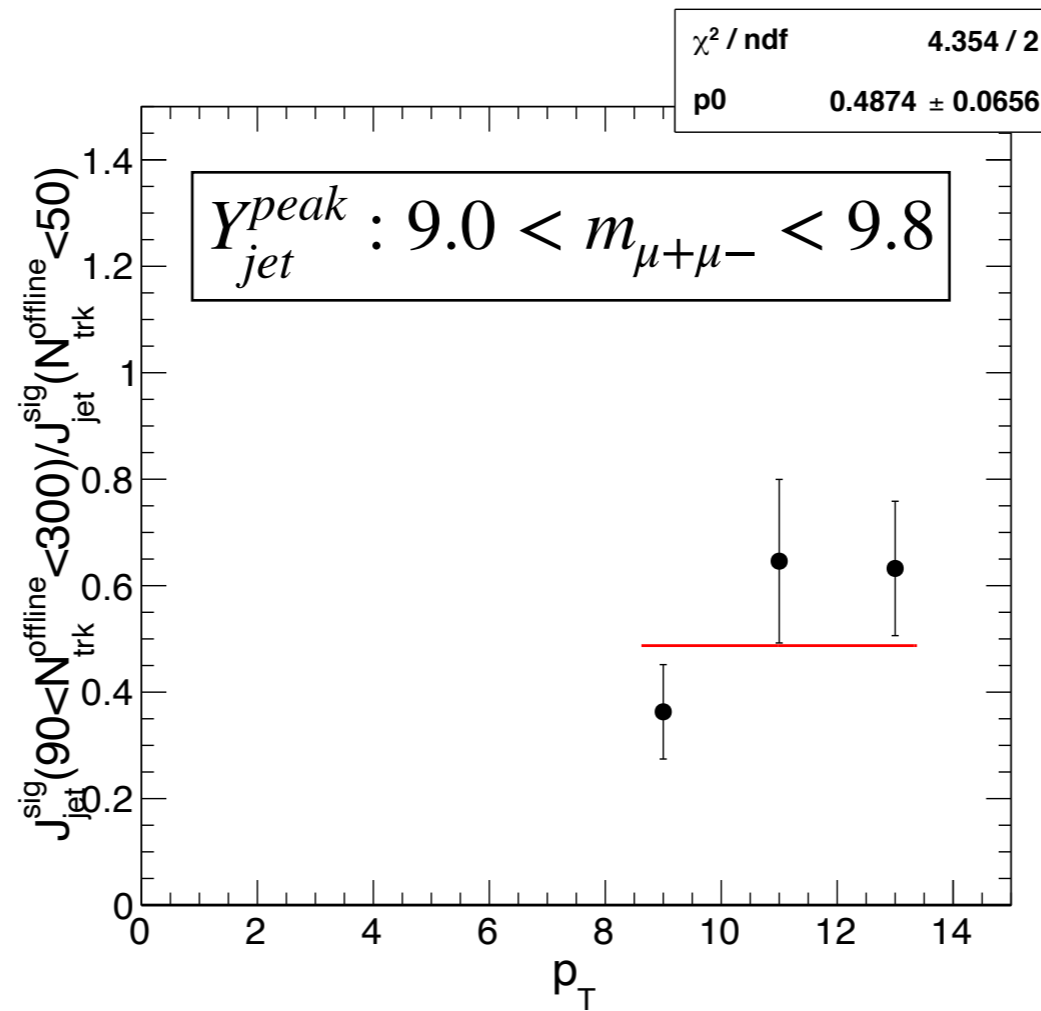
- High η di-muon lose correlate tracks due to CMS detector acceptance
- Need to consider multiplicity dependence of η distribution
- Effects from truncation are largely cancelled

Υ p_T range



- Even if the truncation is cancelled, high- p_T is used to calculate jet yield ratio
- [9, 10, 12, 15]

Yield ratio(Υ)



$$\bullet \quad Y_{jet}^{sig} = \frac{Y_{jet}^{peak} - (1 - f)Y_{jet}^{bkg}}{f}$$

- Jet yield ratio could be different for peak region range definition

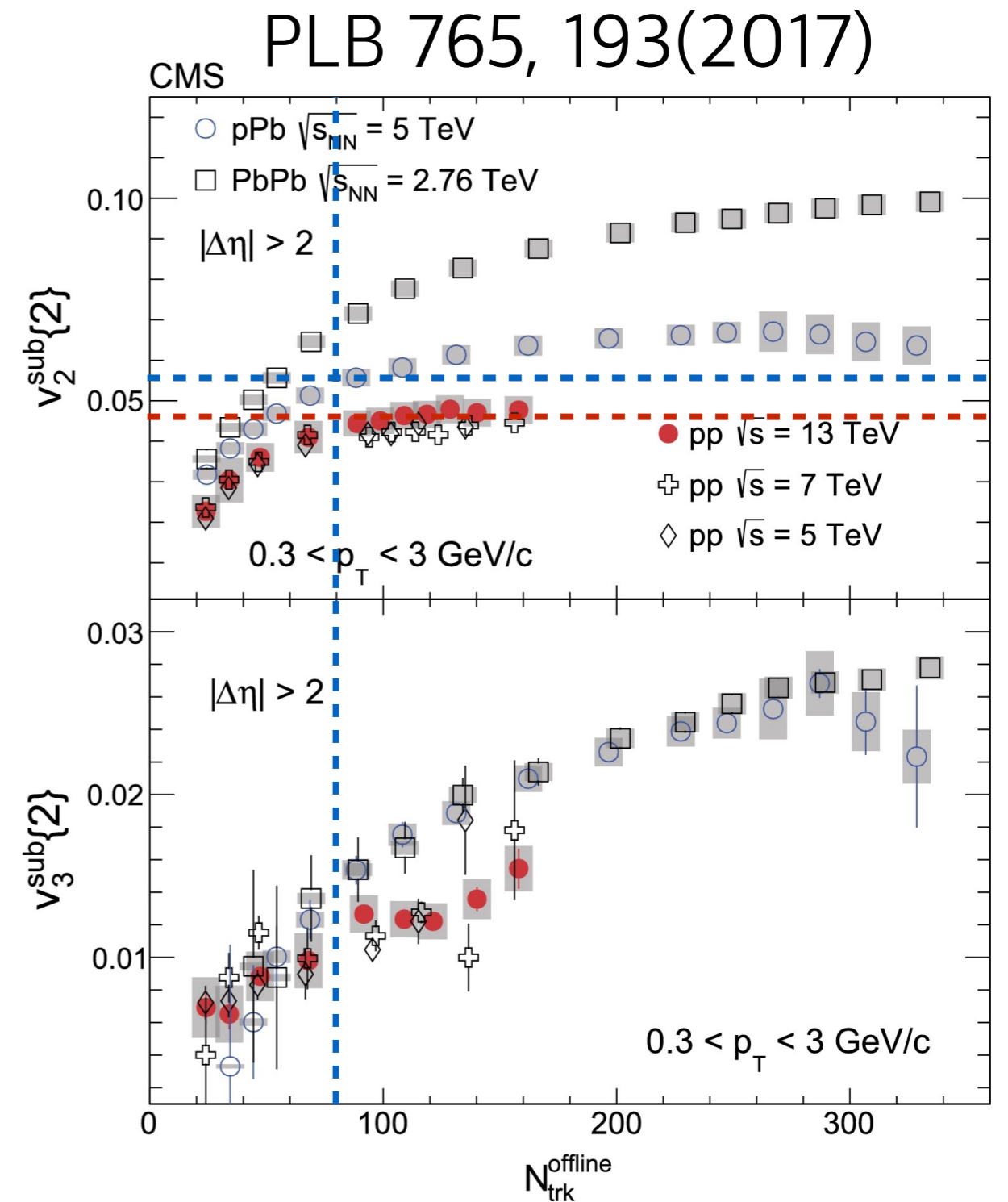
Summary

- Quarkonia are expected to carry out information on the initial state and the medium effects
- Zero Υ v_2 in PbPb 5 TeV and non-zero J/ψ v_2 in pPb 8 TeV are studied at CMS
- pPb Υ v_2 is one of important probe to understand Υ and small system
- High-multiplicity Υ v_2 is non-zero but lower than that of J/ψ
- Low-multiplicity subtraction is ongoing

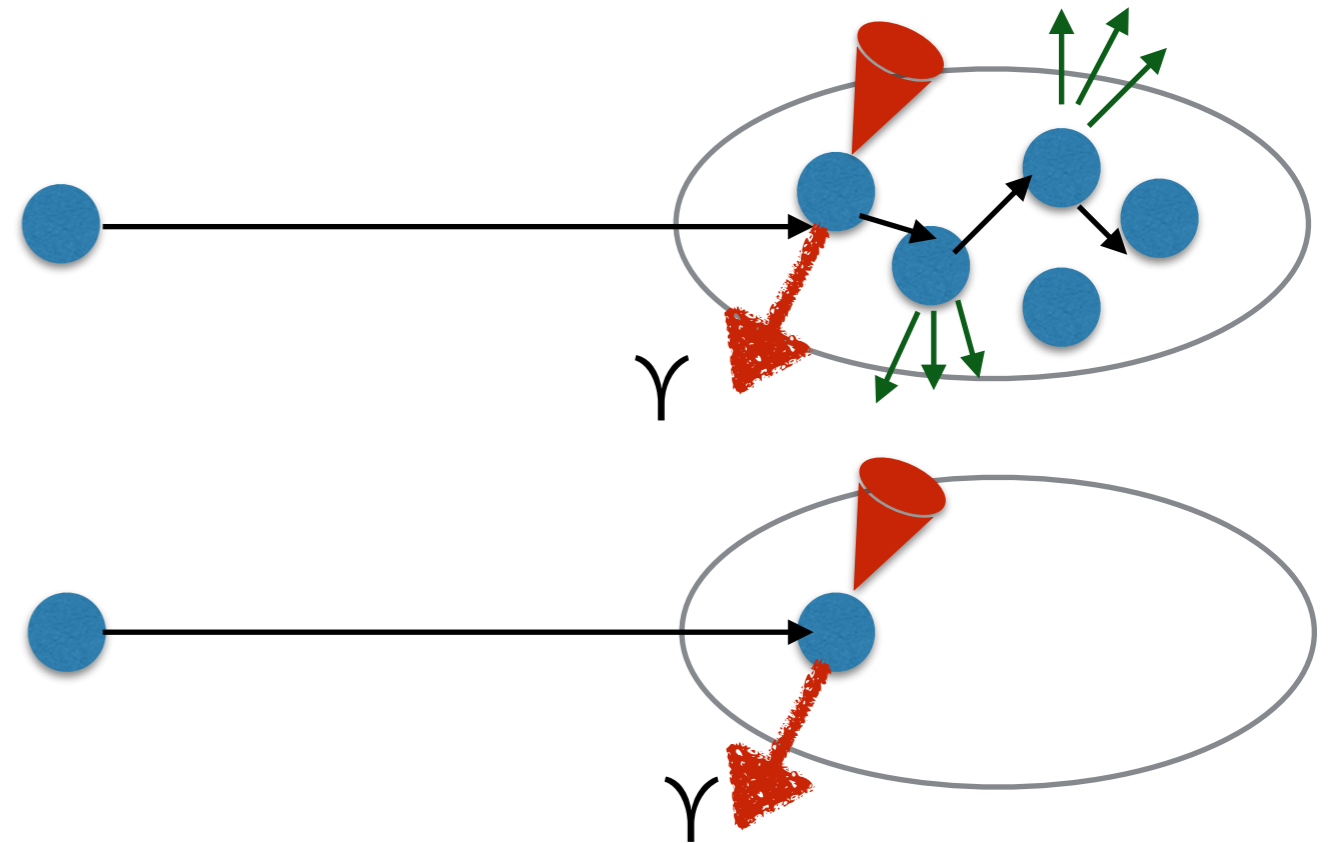
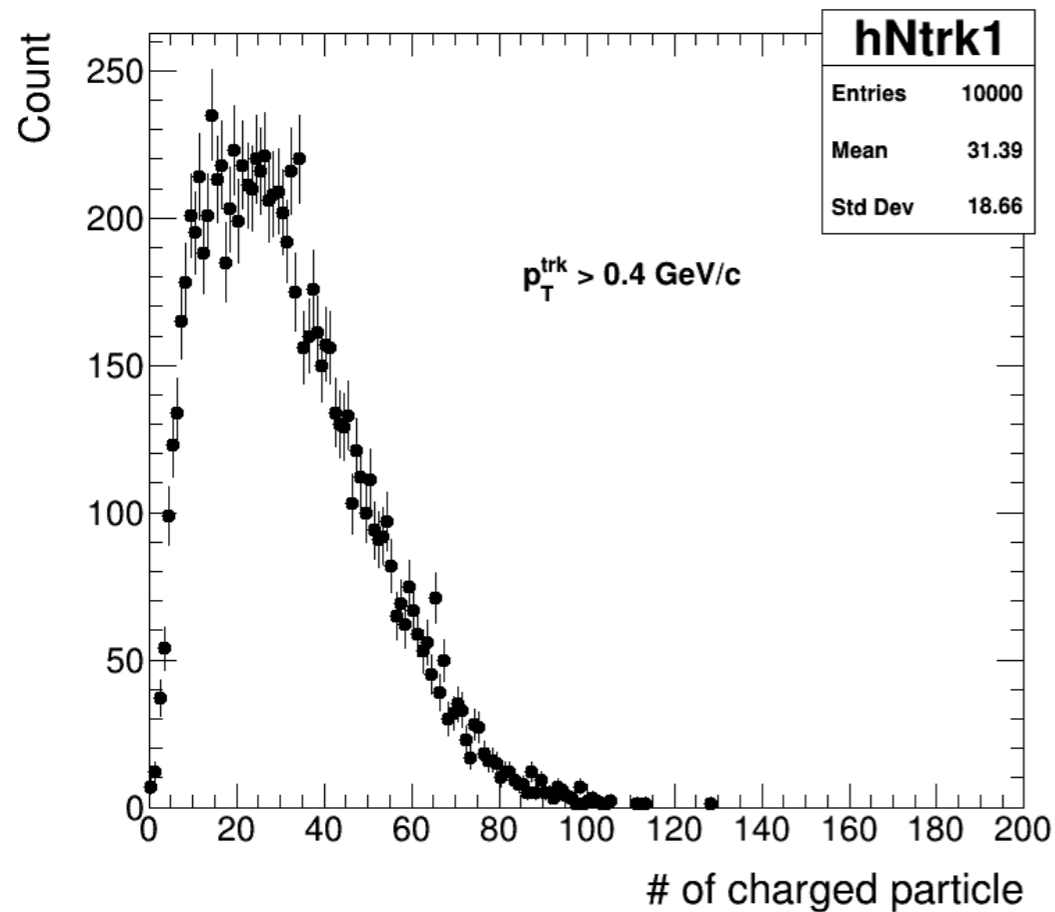
Back up

High-multiplicity

- What is high-multiplicity?
 - No clear definition
 - If there is heavy-ion like phenomena (i.e. ridge) at relatively high-multiplicity, it is high-multiplicity
- How about Υ case?
 - If v_2 is 0, can not define high-multiplicity
 - Should be defined with verified range in the previous analysis
 - Higher than 90 shows higher v_2 than pp

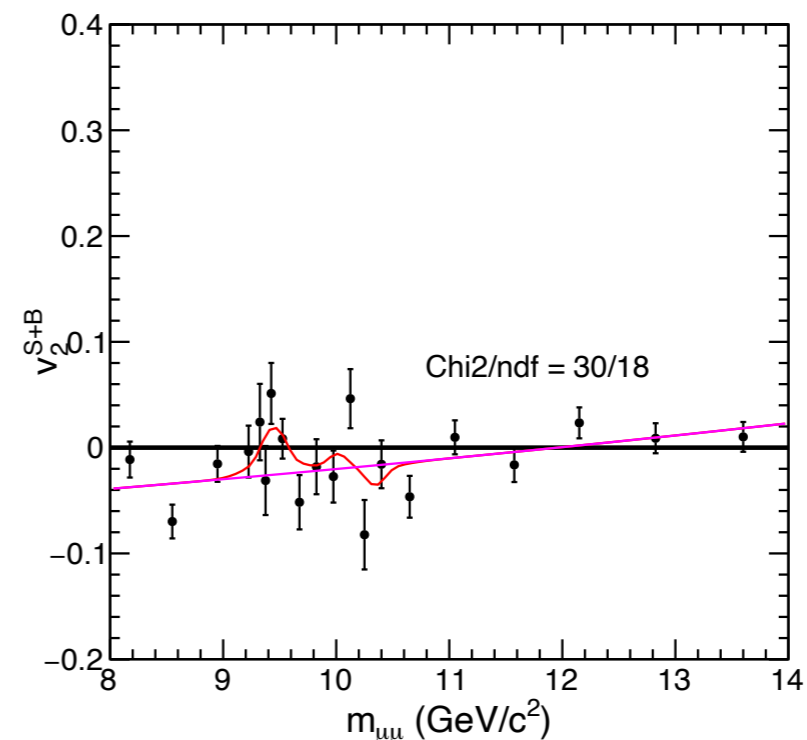
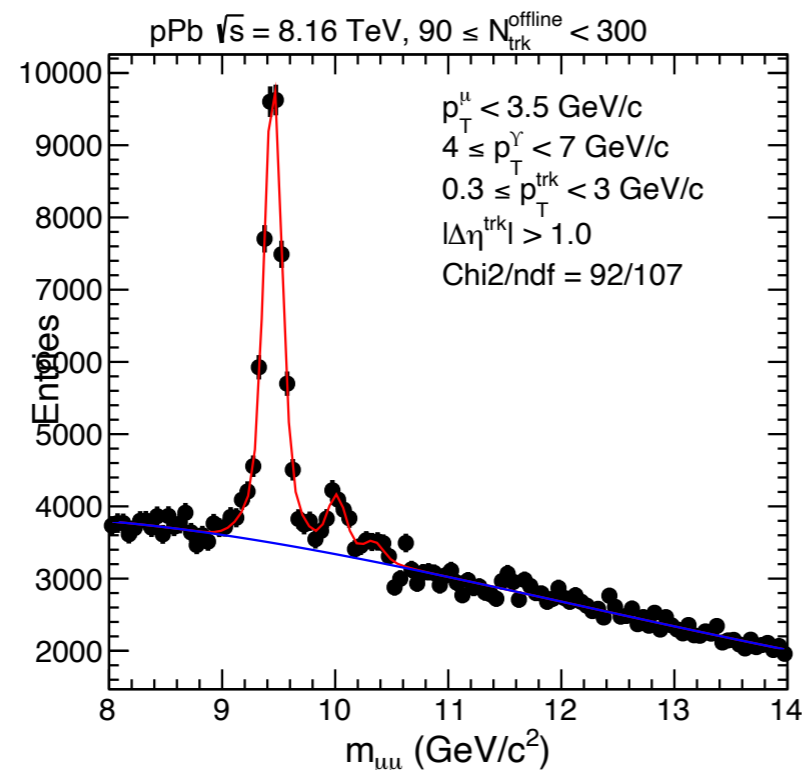
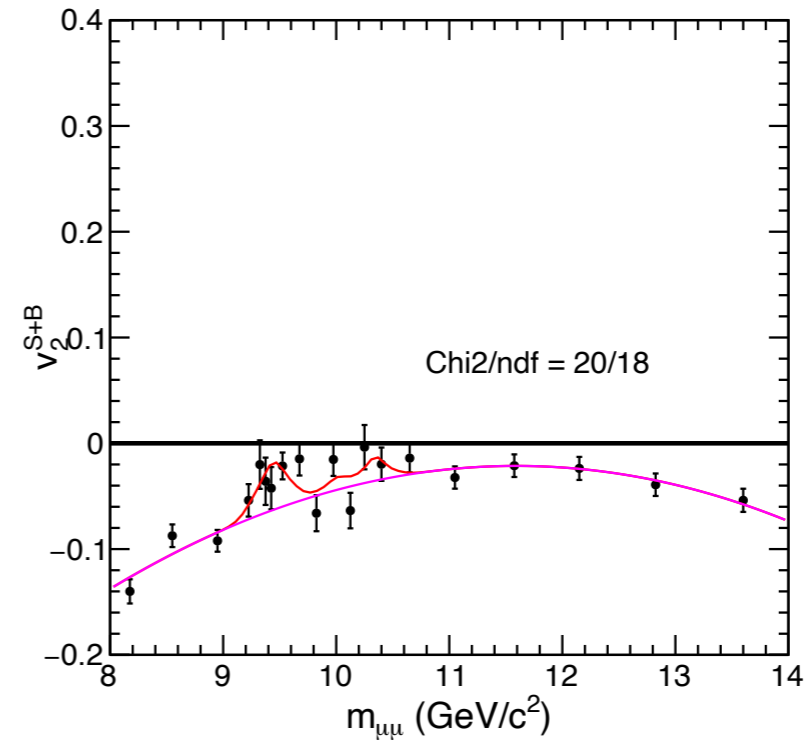
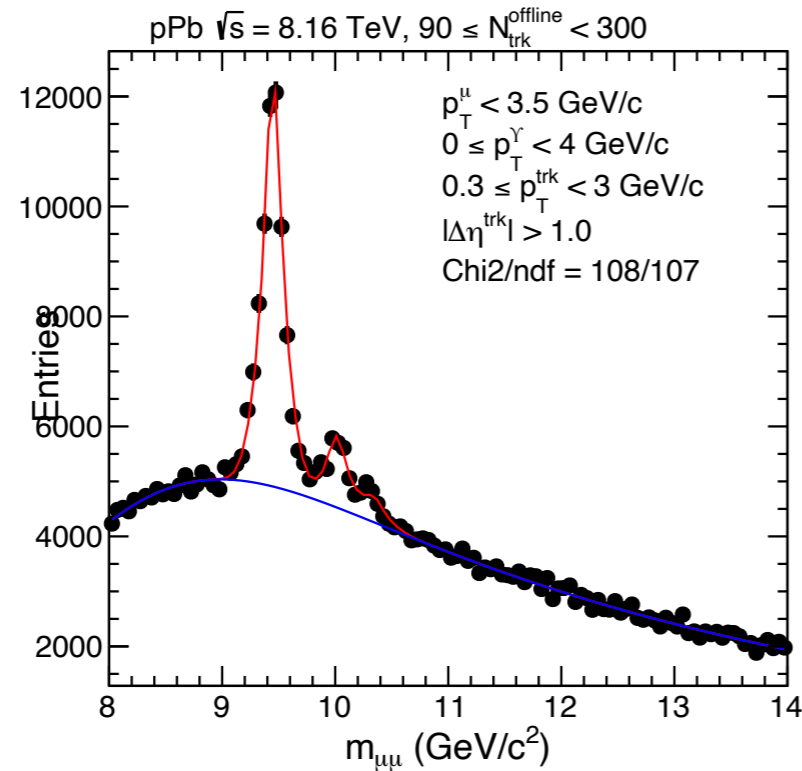


Low-multiplicity

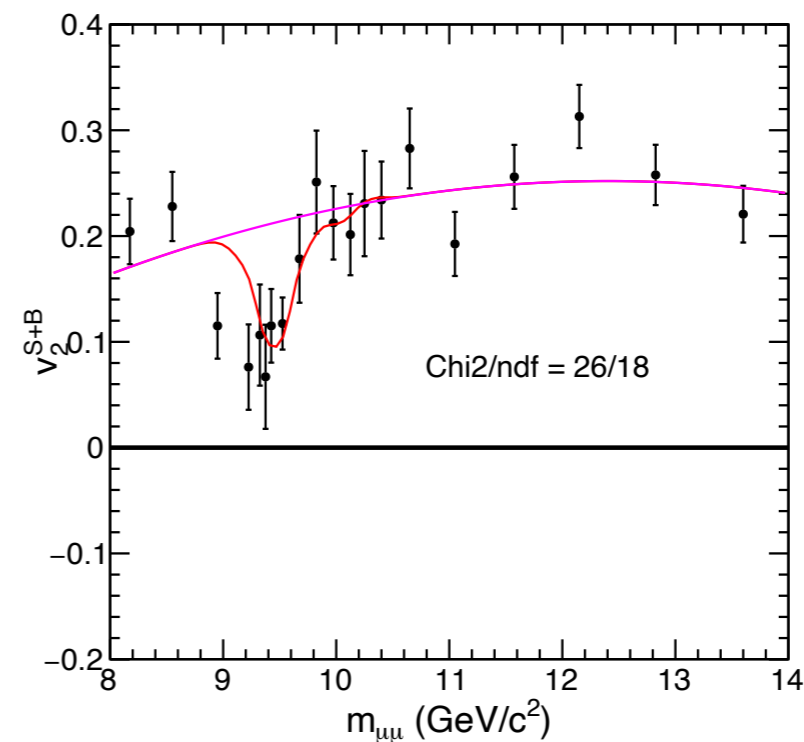
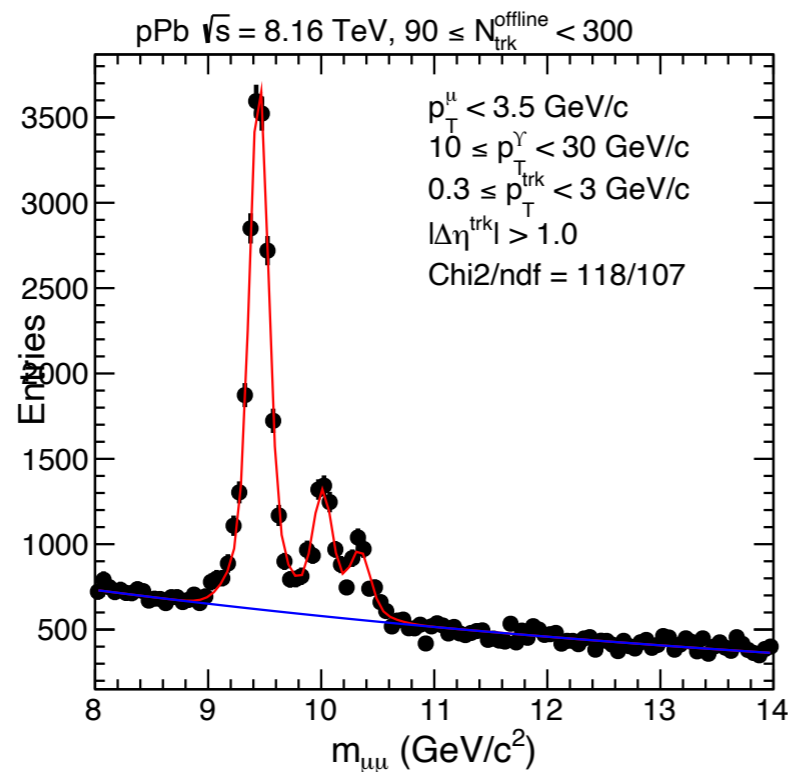
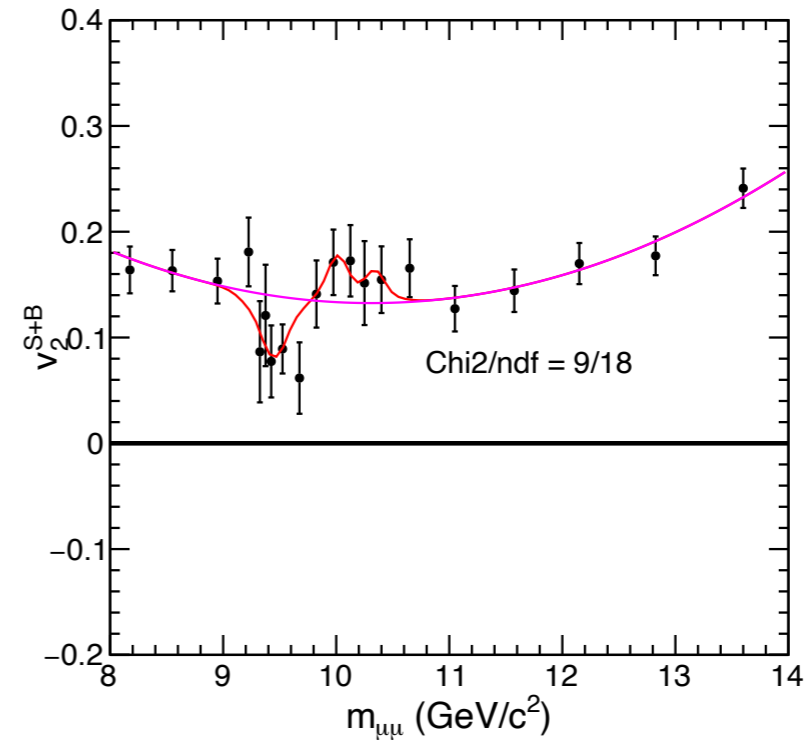
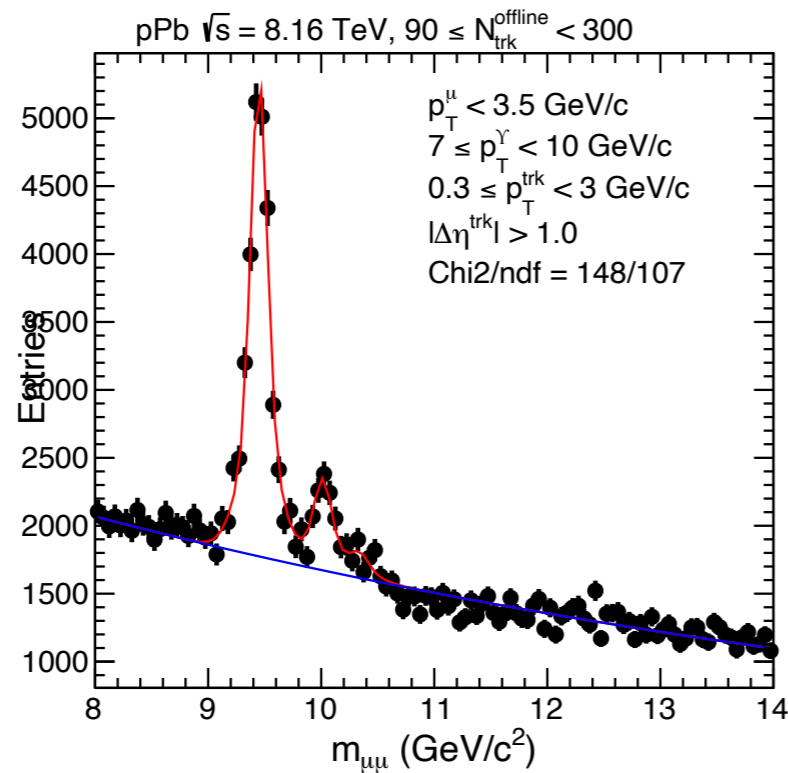


- Low-multiplicity range also need to retain enough Υ
- Low-multiplicity subtraction is needed to estimate residual contribution from back-to-back jet correlations
- $N_{\text{coll}} == 1$ is back-to-back jet correlation case
- Multiplicity 50 (31 ± 18) is tentative multiplicity range

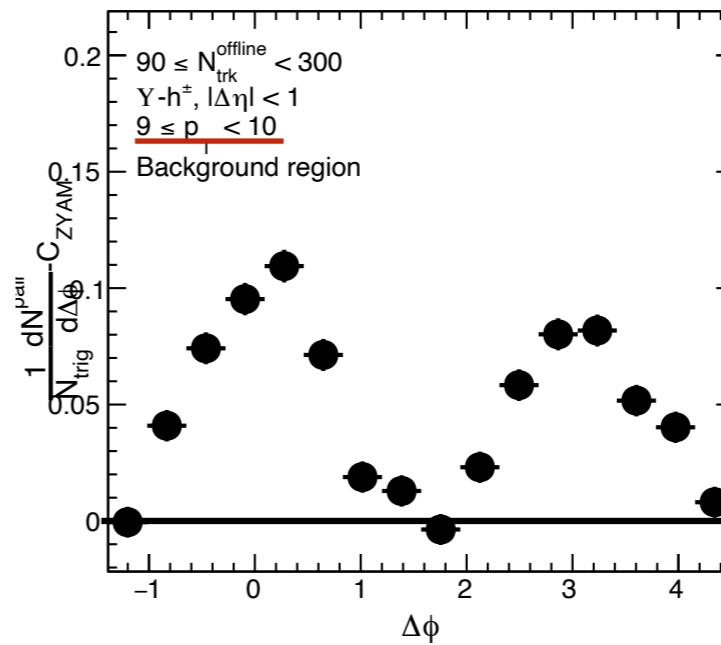
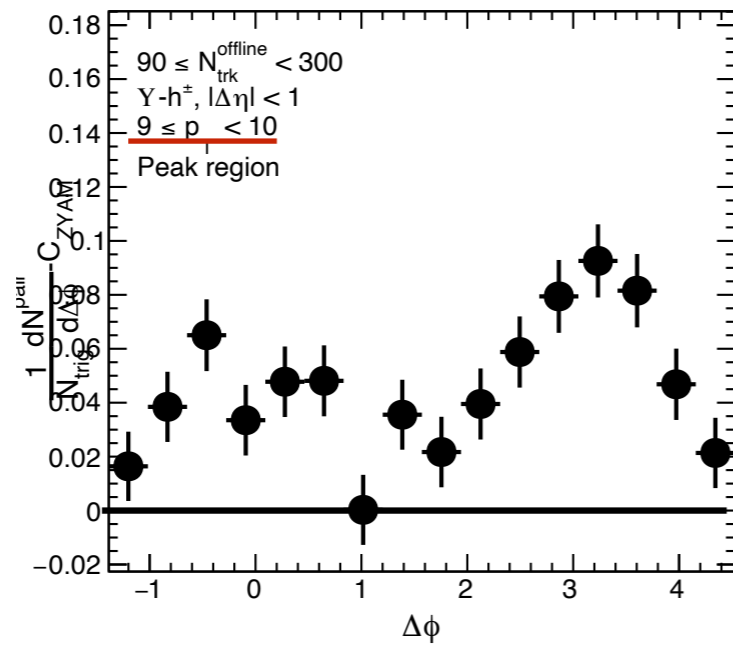
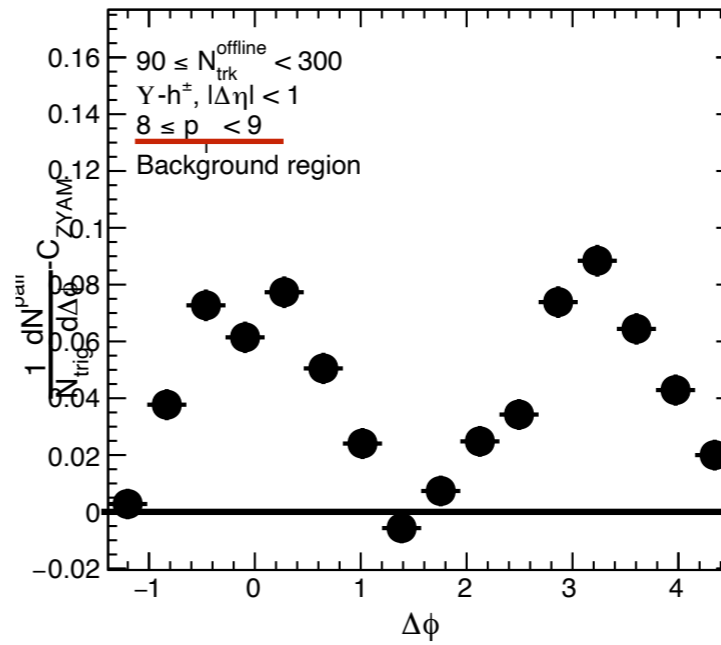
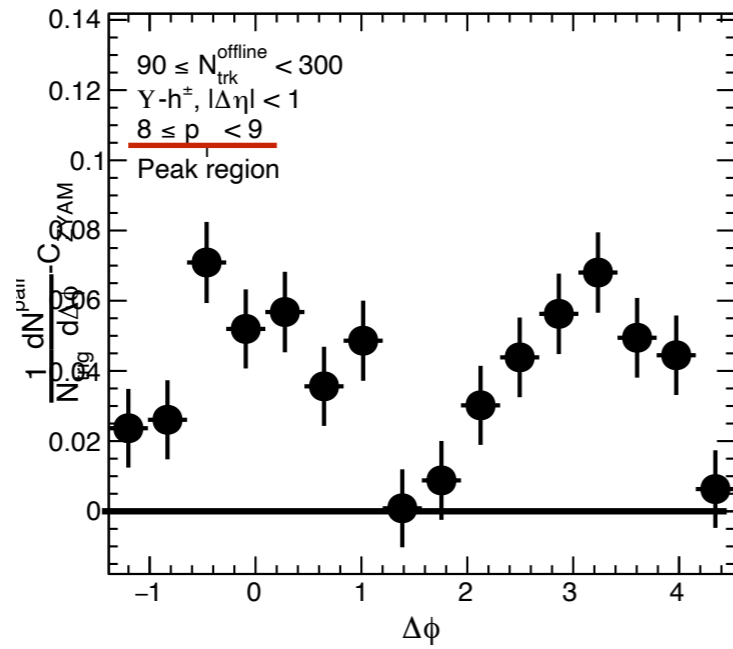
Simultaneous fitting $90 < \text{mult.} < 300$



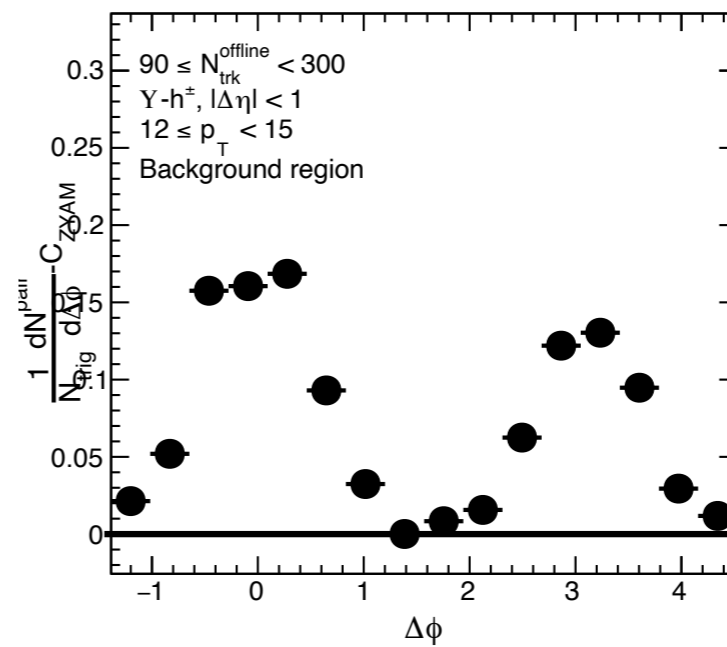
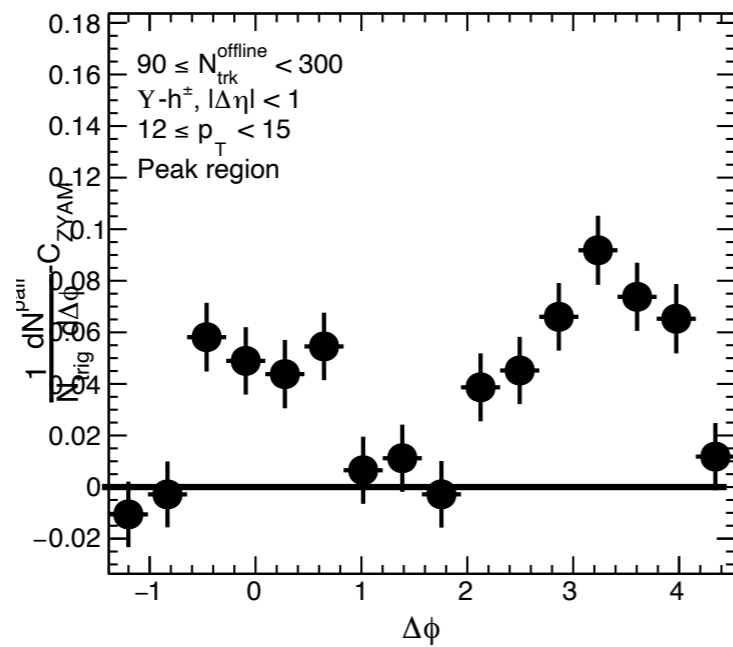
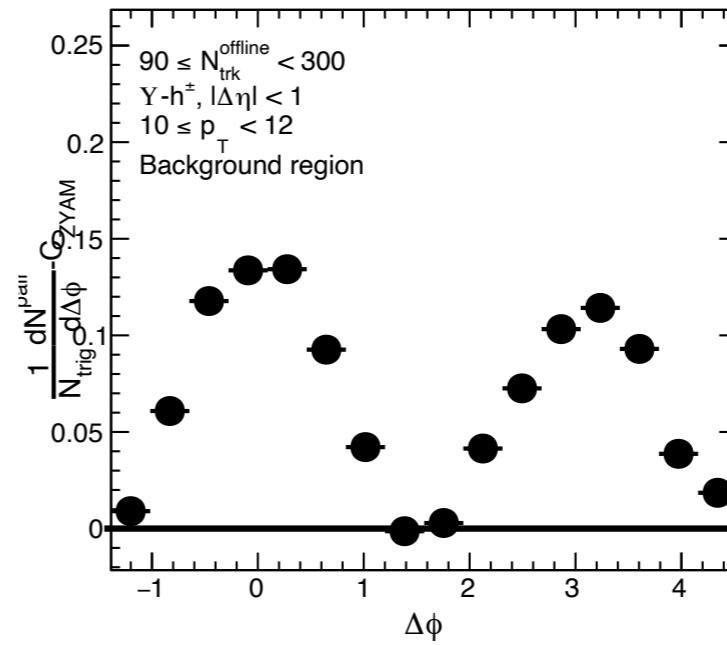
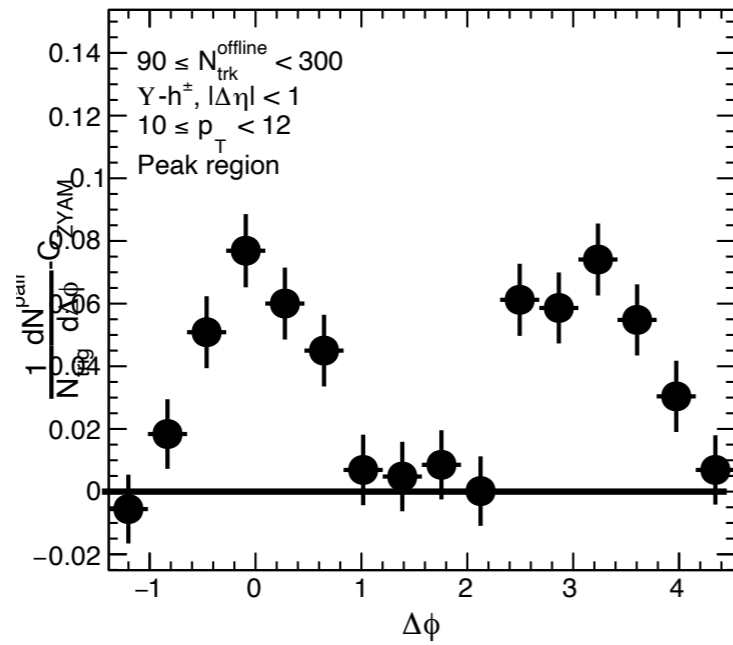
Simultaneous fitting $90 < \text{mult.} < 300$



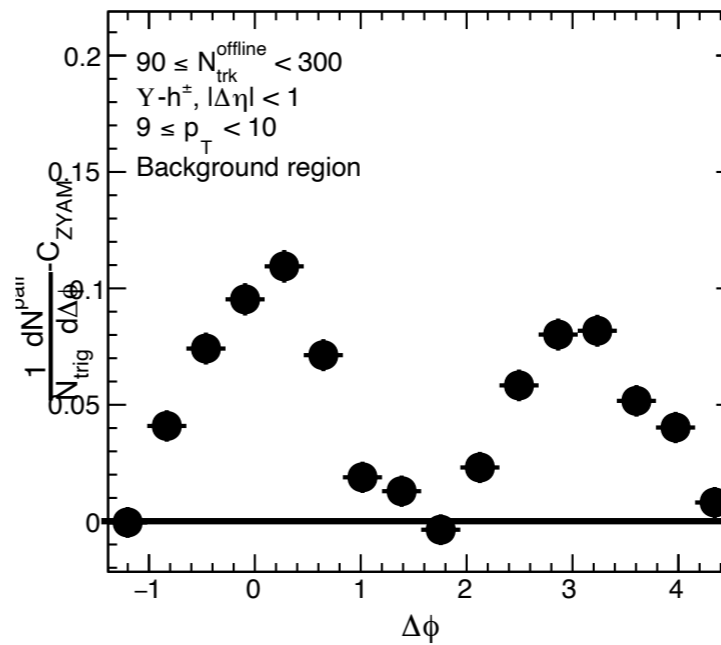
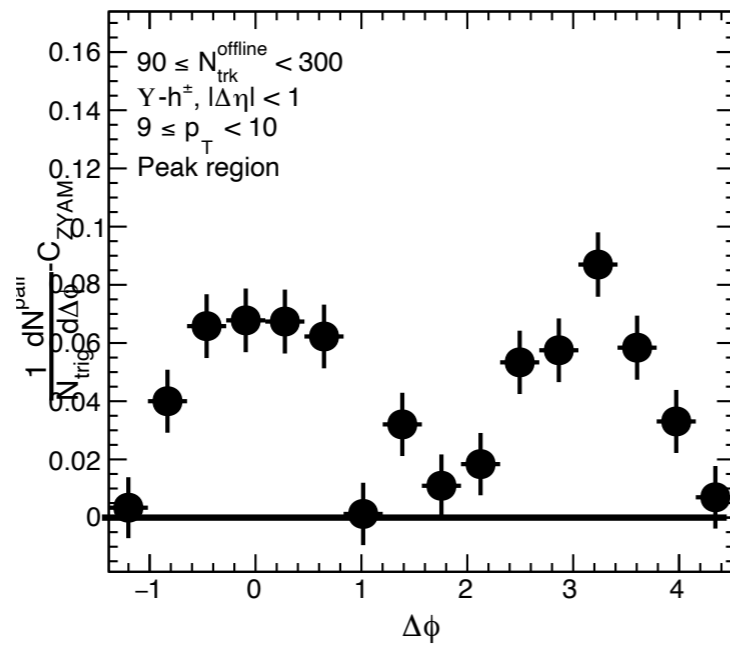
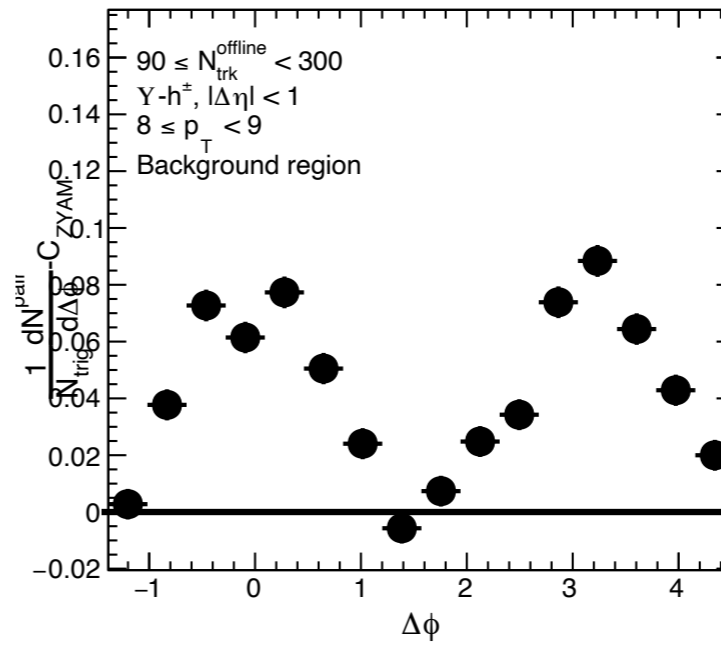
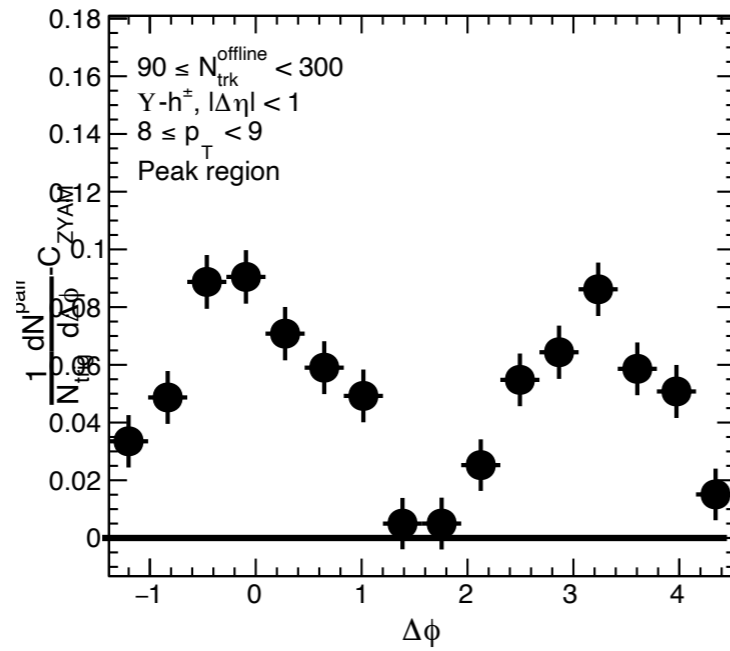
90 < mult. < 300 (9.2 < m < 9.6)



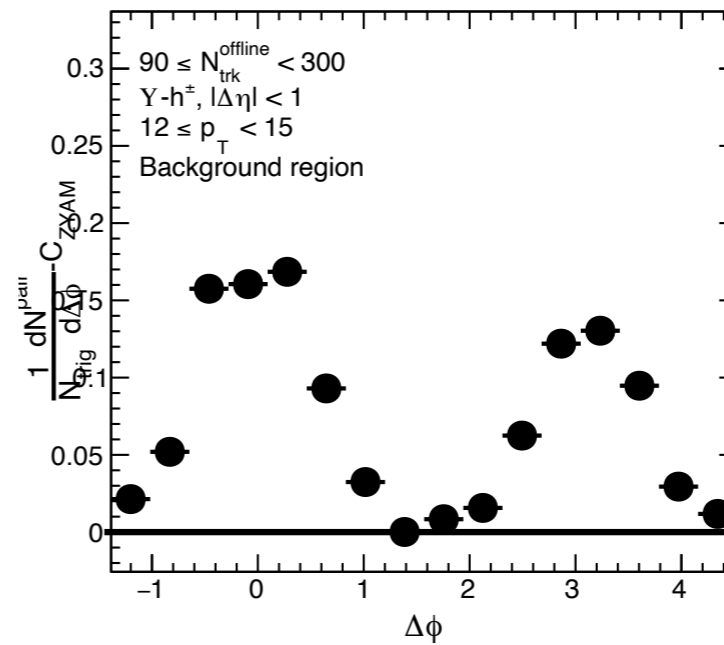
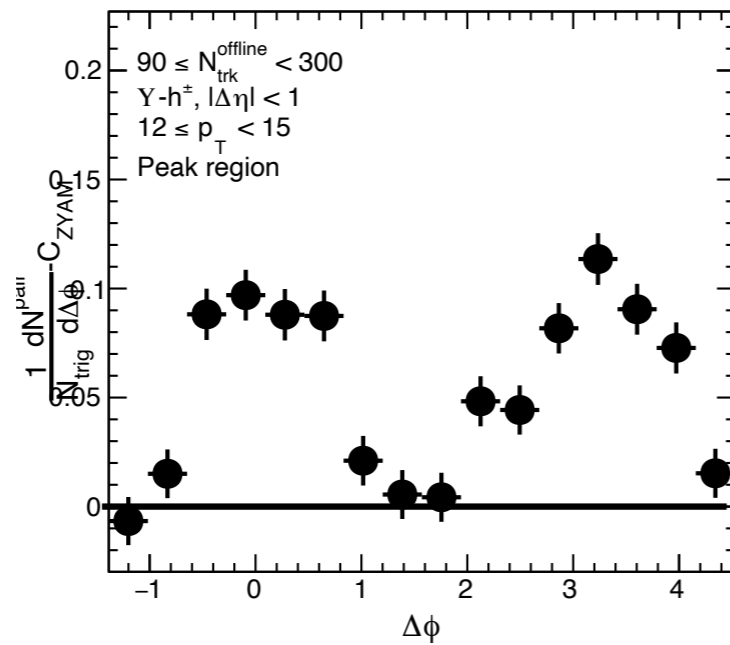
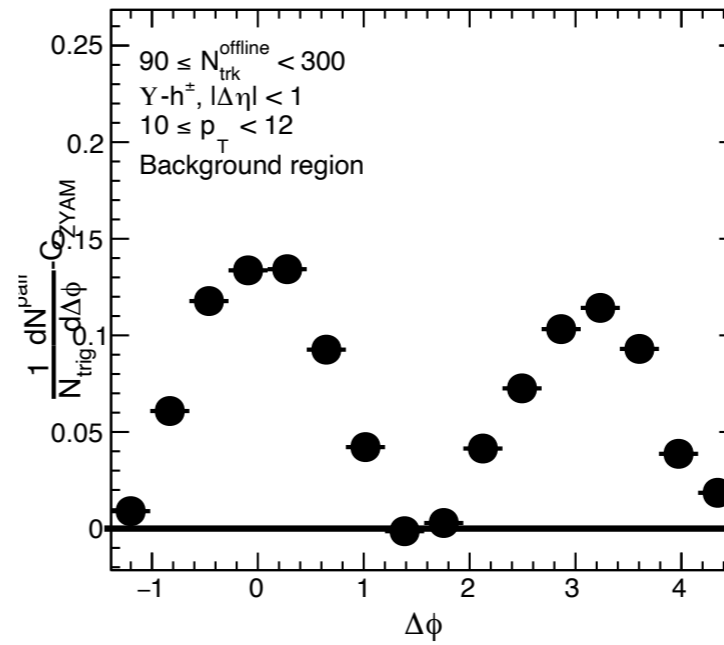
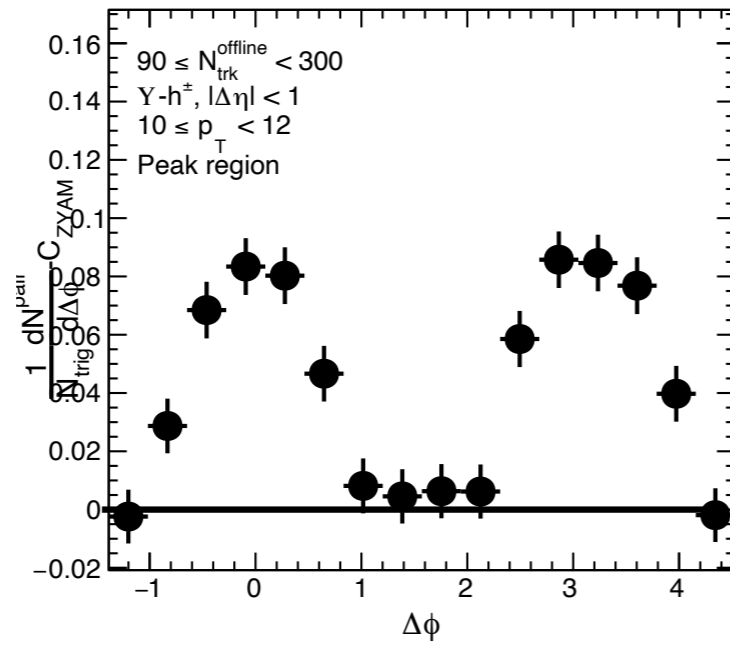
90 < mult. < 300 (9.2 < m < 9.6)



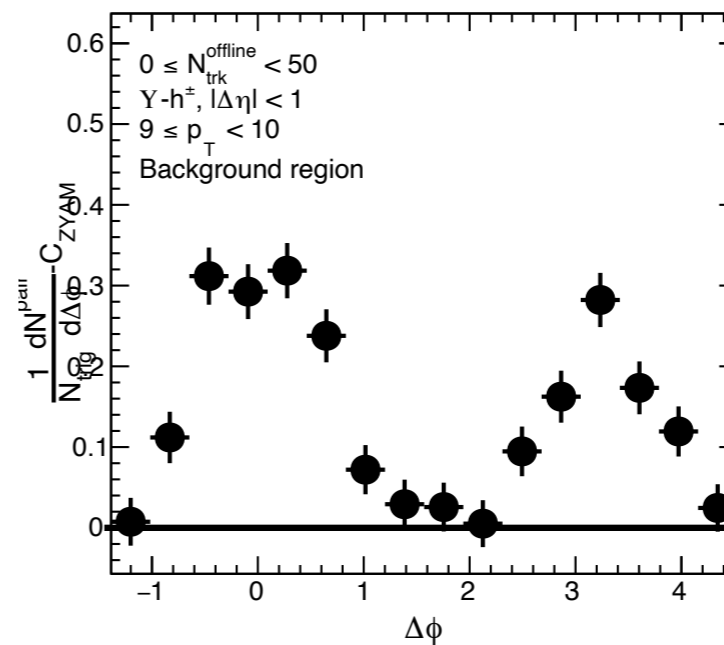
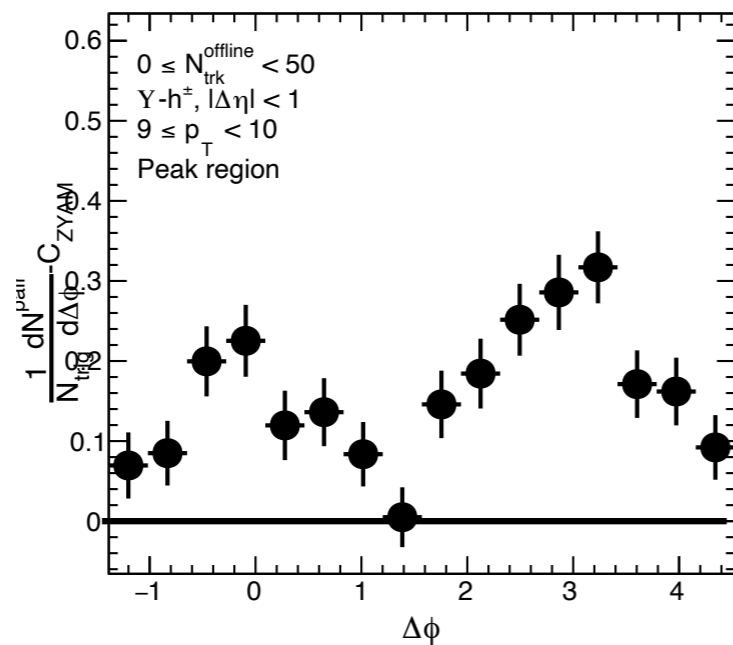
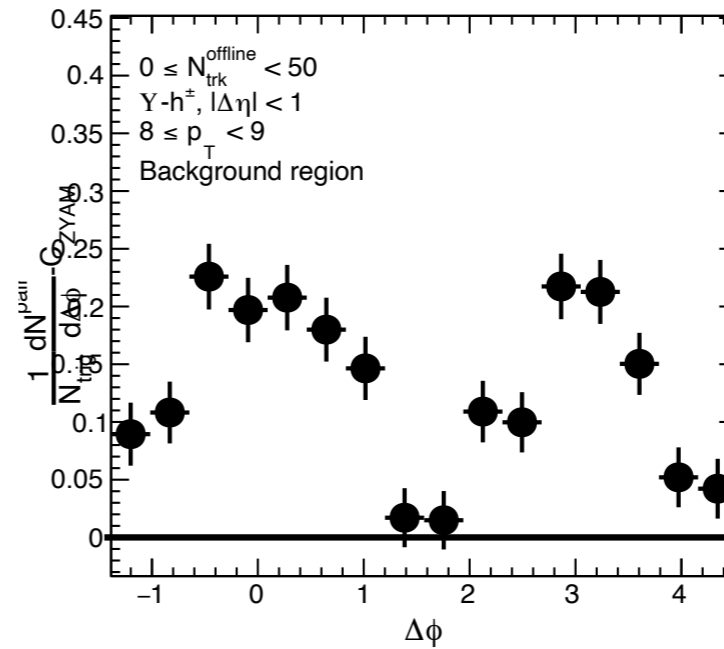
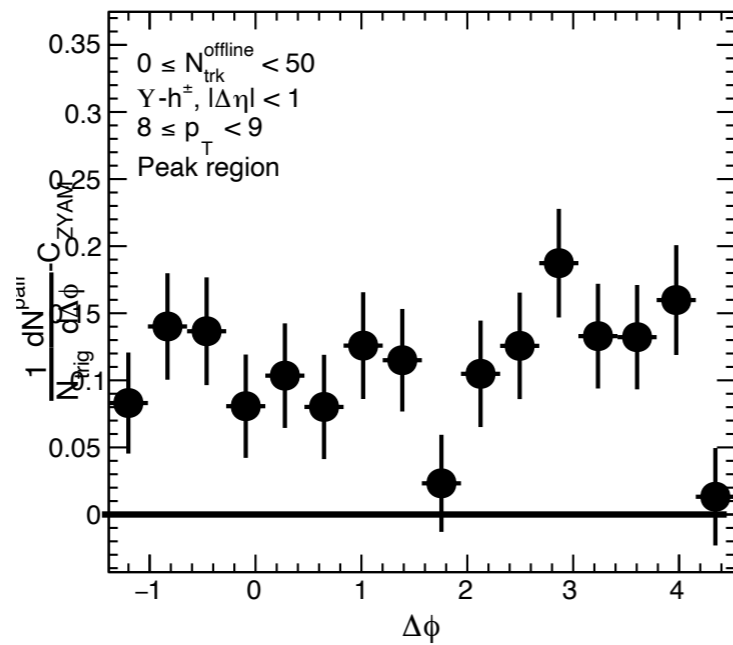
90 < mult. < 300 (9.0 < m < 9.8)



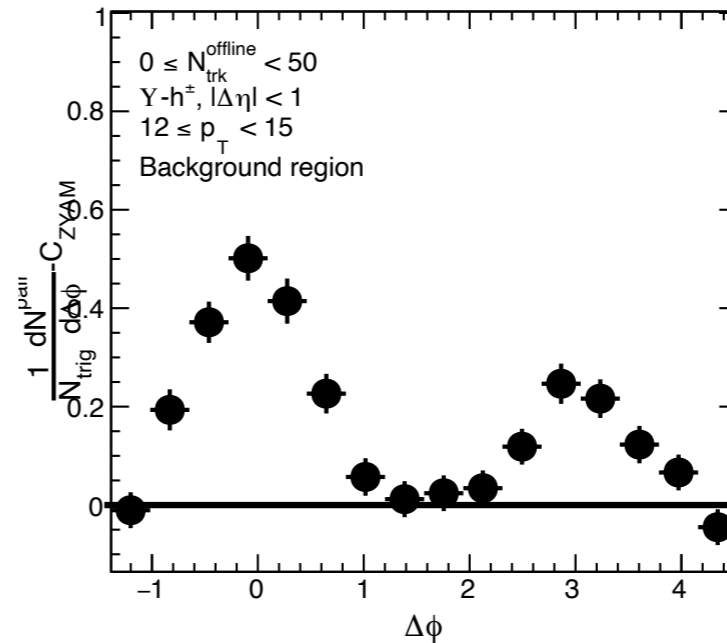
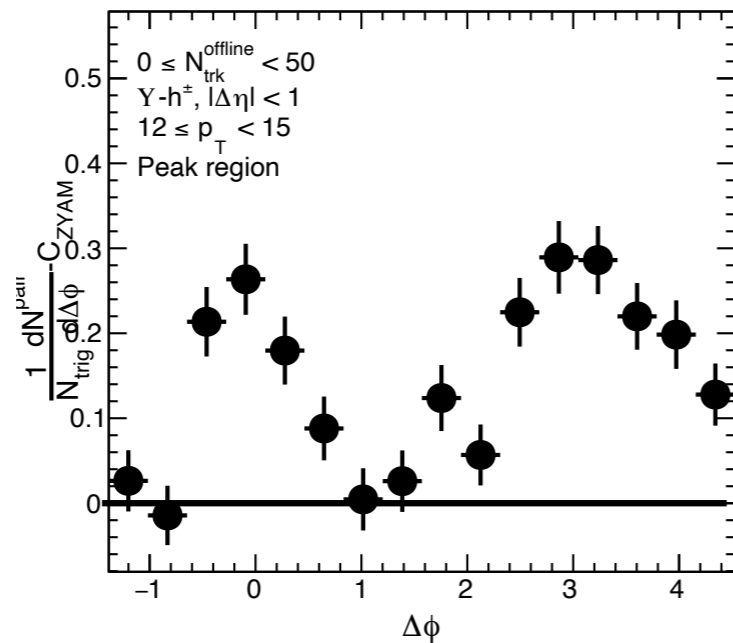
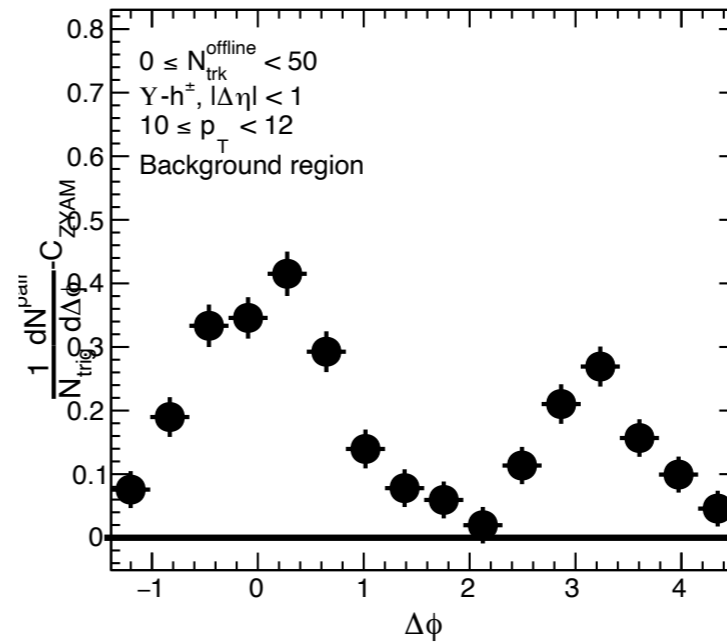
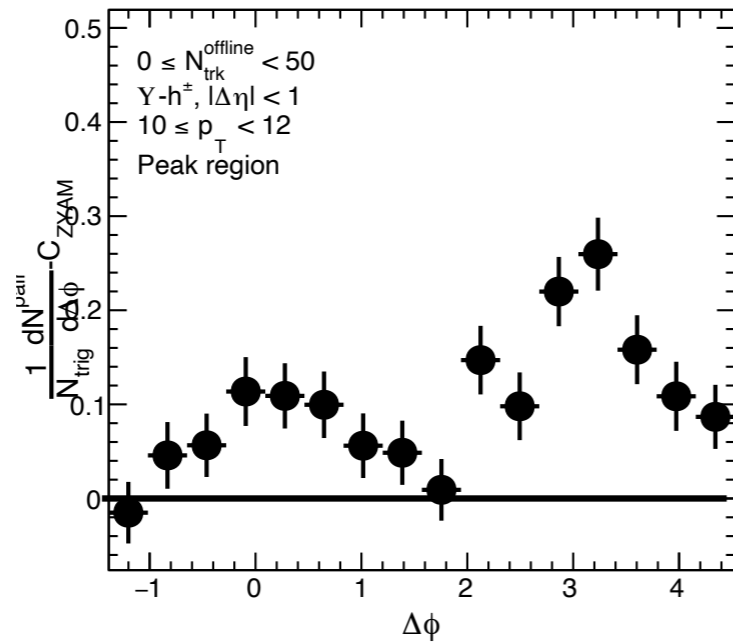
90 < mult. < 300 (9.0 < m < 9.8)



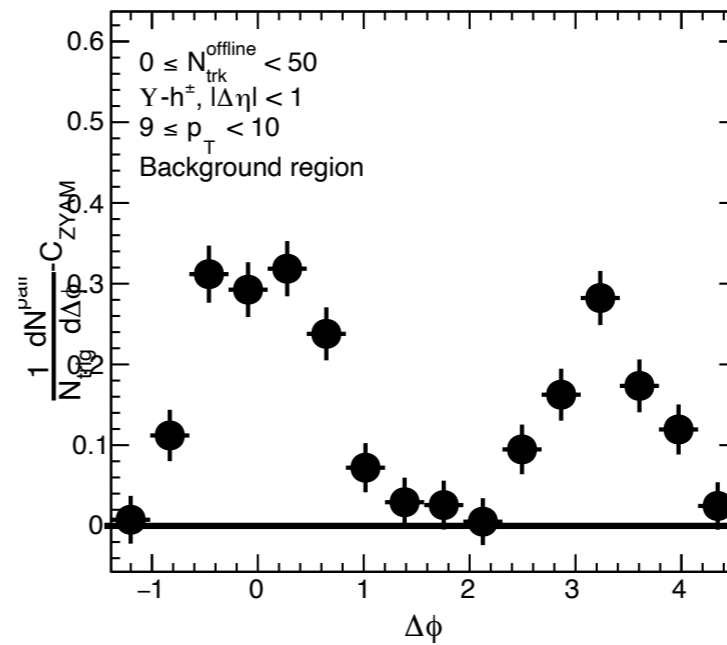
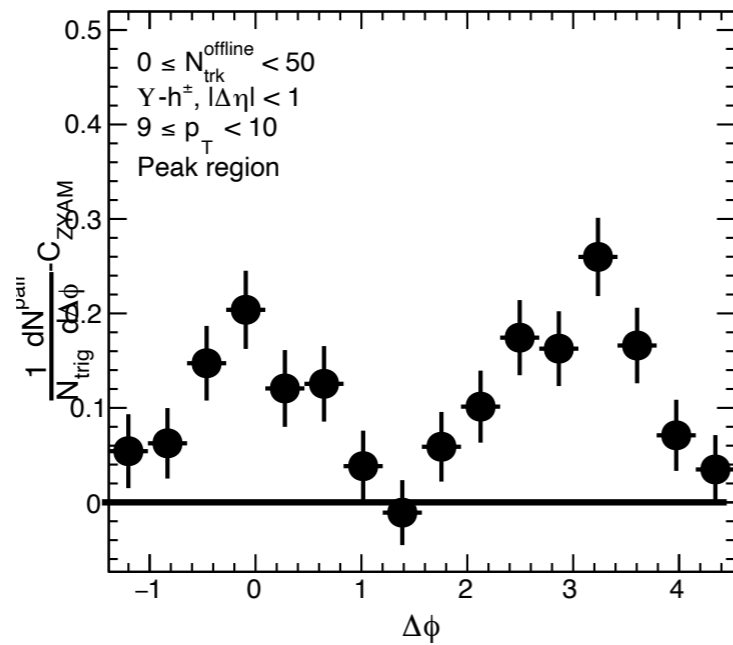
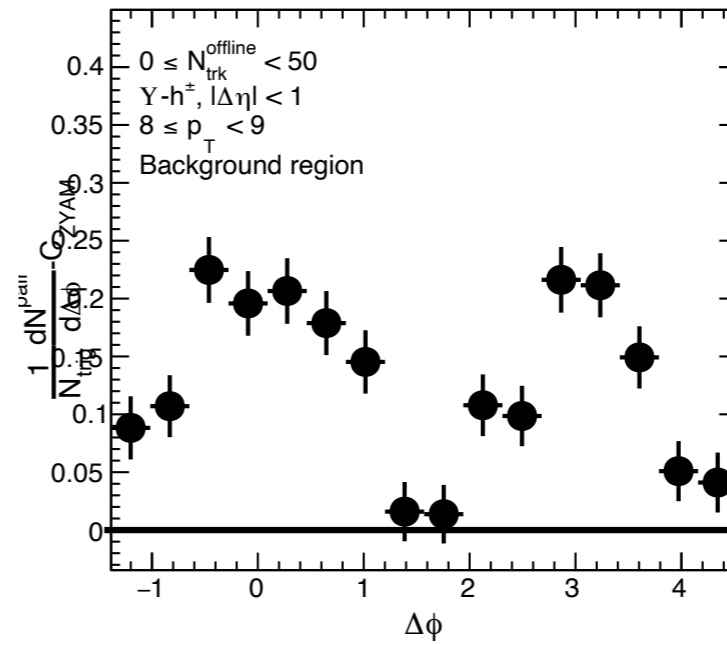
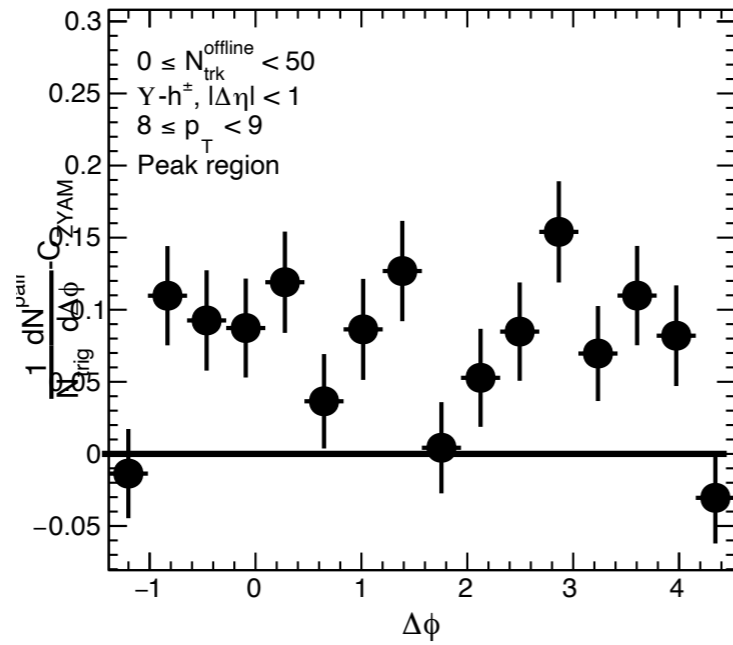
$0 < \text{mult.} < 50$ ($9.2 < m < 9.6$)



$0 < \text{mult.} < 50$ ($9.2 < m < 9.6$)



$0 < \text{mult.} < 50$ ($9.0 < m < 9.8$)



$0 < \text{mult.} < 50$ ($9.0 < m < 9.8$)

