K_s^0 and Λ v_1,v_2 in Au + Au Collisions at $\sqrt{S_{NN}}$= 3.9 GeV

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Outline

- Motivation
- Dataset and cuts
- Event QA and centrality determination
- EPD Flow Vector QA, event plane reconstruction and resolution
- K_s^0 and Λ reconstruction and flow measurements
- Summary

Dataset and Cuts

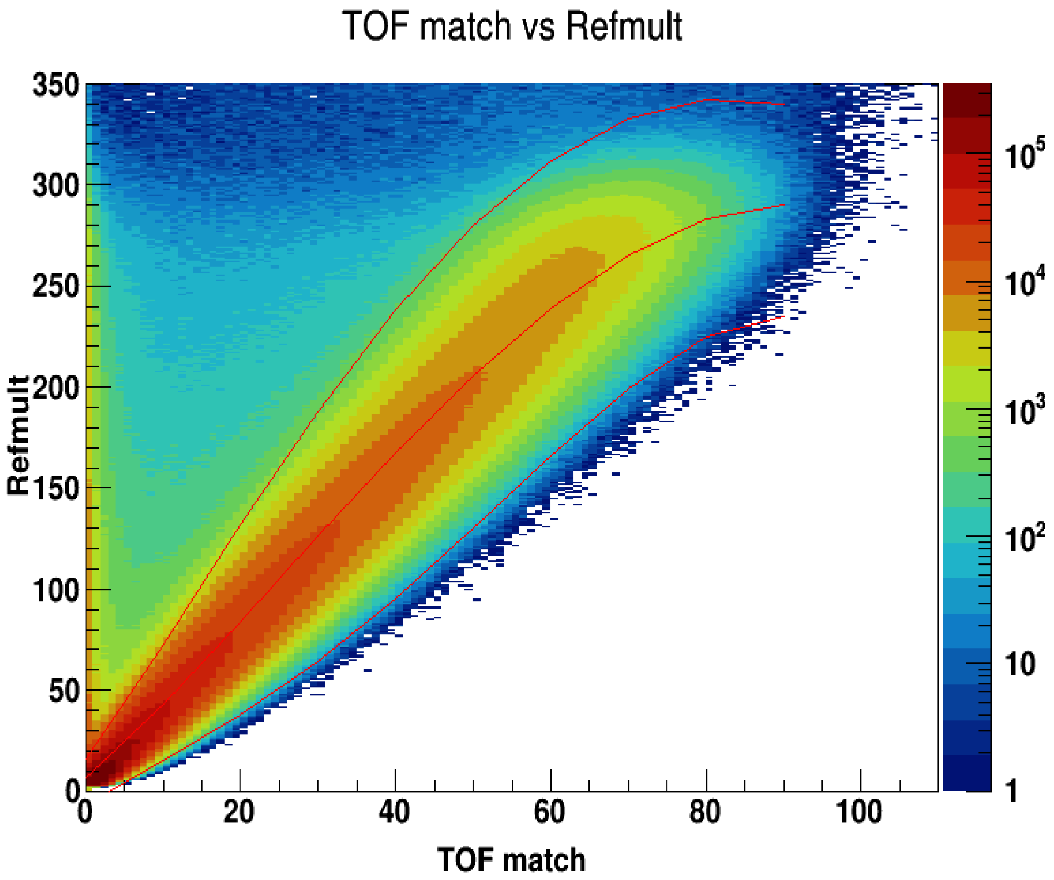
- **Dataset**

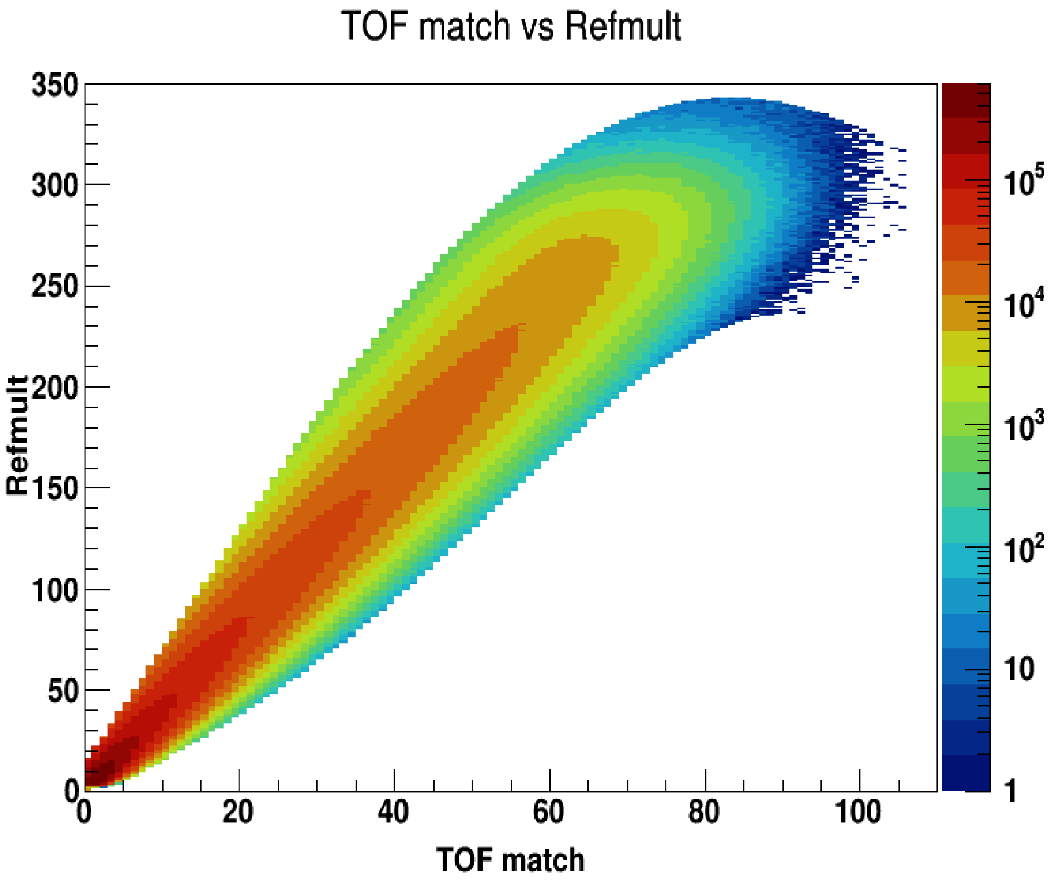
System	Number of PicoDst Files	Minibias trigger id	Run Number	Total Events	After Event Cuts
Au+Au 3.9GeV	6004	730000	21035003-21035007 21035009 21035011-21035017 21035025-21035036 21036002-21036003 21036005-21036010 21036012-21036013 (32 runs)	126.5M	126M

- **Cuts**

Event Cuts	$198 \leq Vz \leq 202$ cm		$(V_x + 0.4)^2 + (V_y + 2)^2 \leq 4\ cm^2$
Track Cuts(for EP reconstruct)	$\lvert DCA \rvert \leq 3$ cm	$N_{Hits} \geq 15$	$\frac{nhitsFit}{nhitsMax} \geq 0.52$

Event QA and Centrality



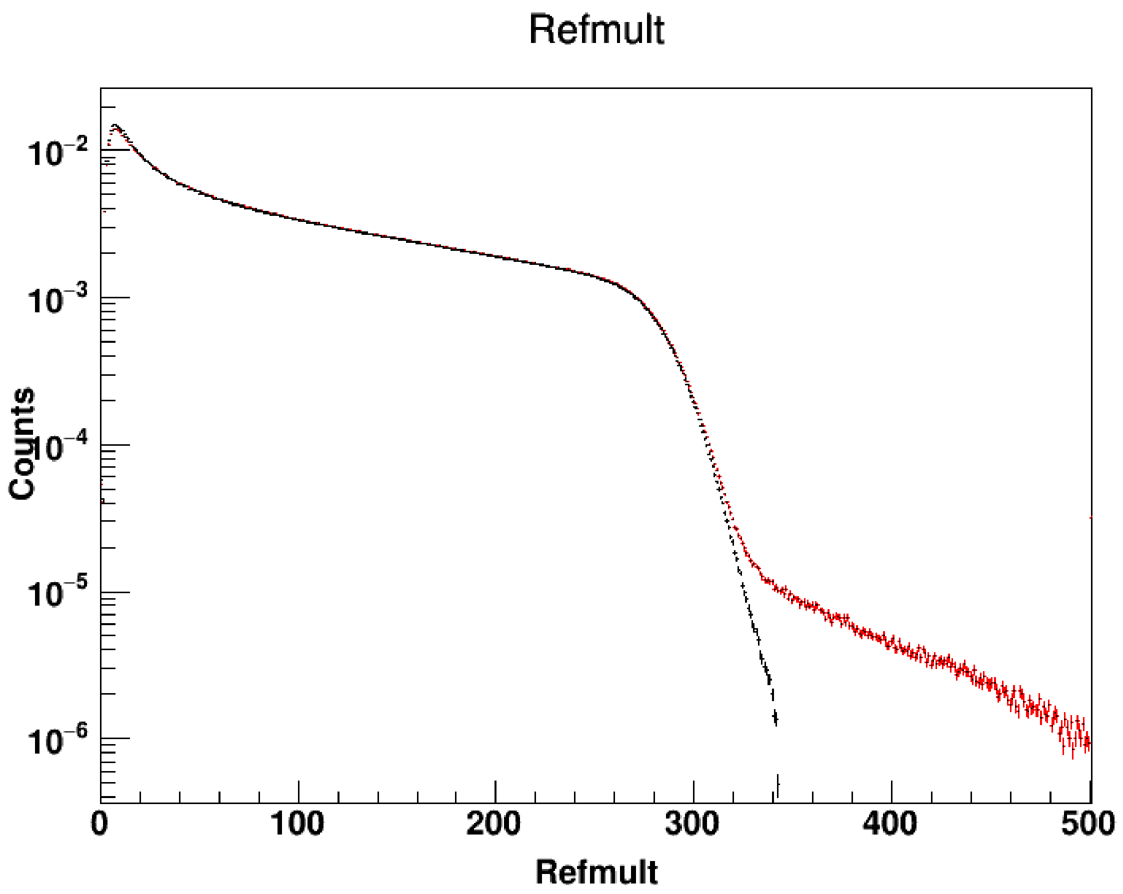


- Remove the pile-up effect by correlation of TOF_match_mult and TPC_ref_mult

The detailed study about removing the pile-up effect could be found : https://drupal.star.bnl.gov/STAR/system/files/3p9GeV_Xing%20Wu.pptx

Event QA and Centrality

- Centrality Determination



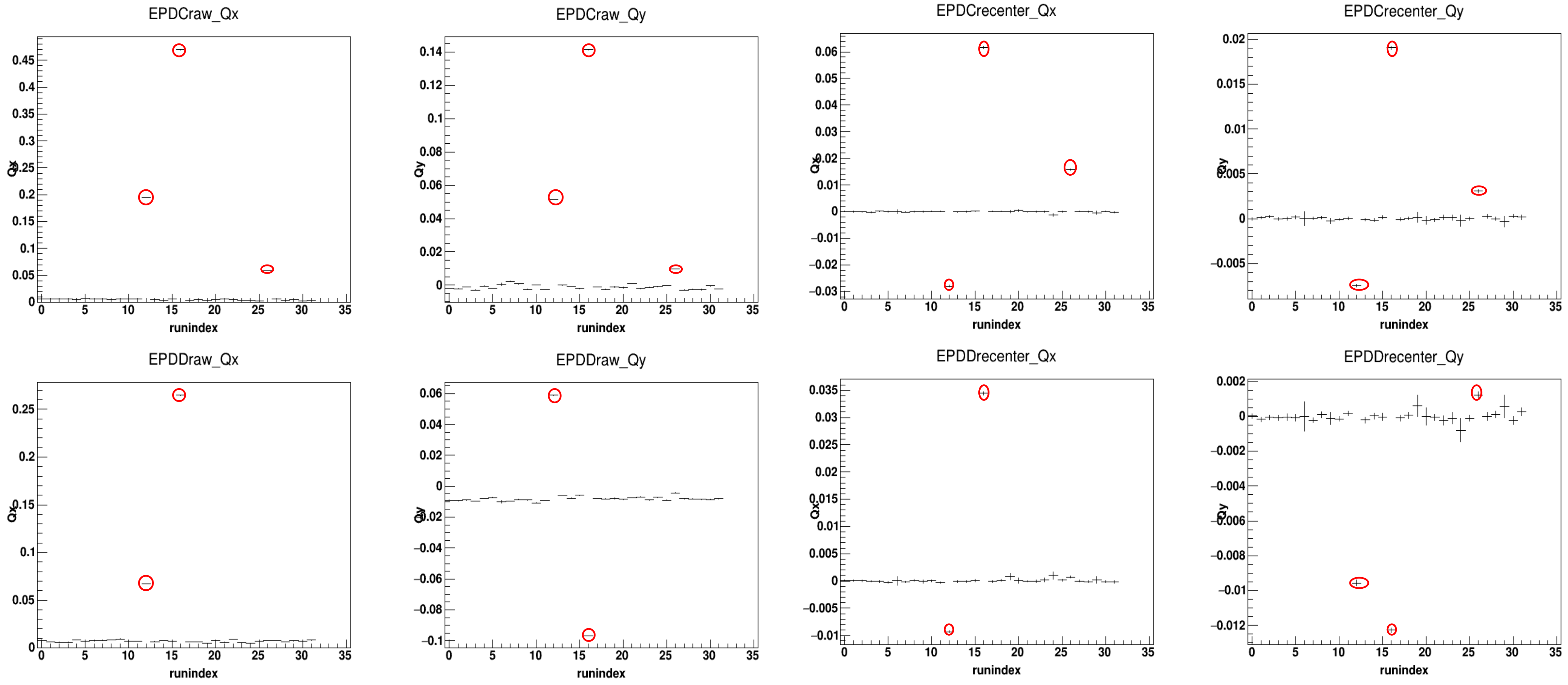
Centrality determined by the raw multiplicity distribution.

As Guoping and me did the pile-up rejection independently, the applied cut is slightly different. Thus the centrality definition is also slightly different.

Centrality	Refmult cut
70%-80%	18-29
60%-70%	30-46
50%-60%	47-66
40%-50%	67-92
30%-40%	93-124
20%-30%	125-163
10%-20%	164-212
5%-10%	213-244
0-5%	≥245

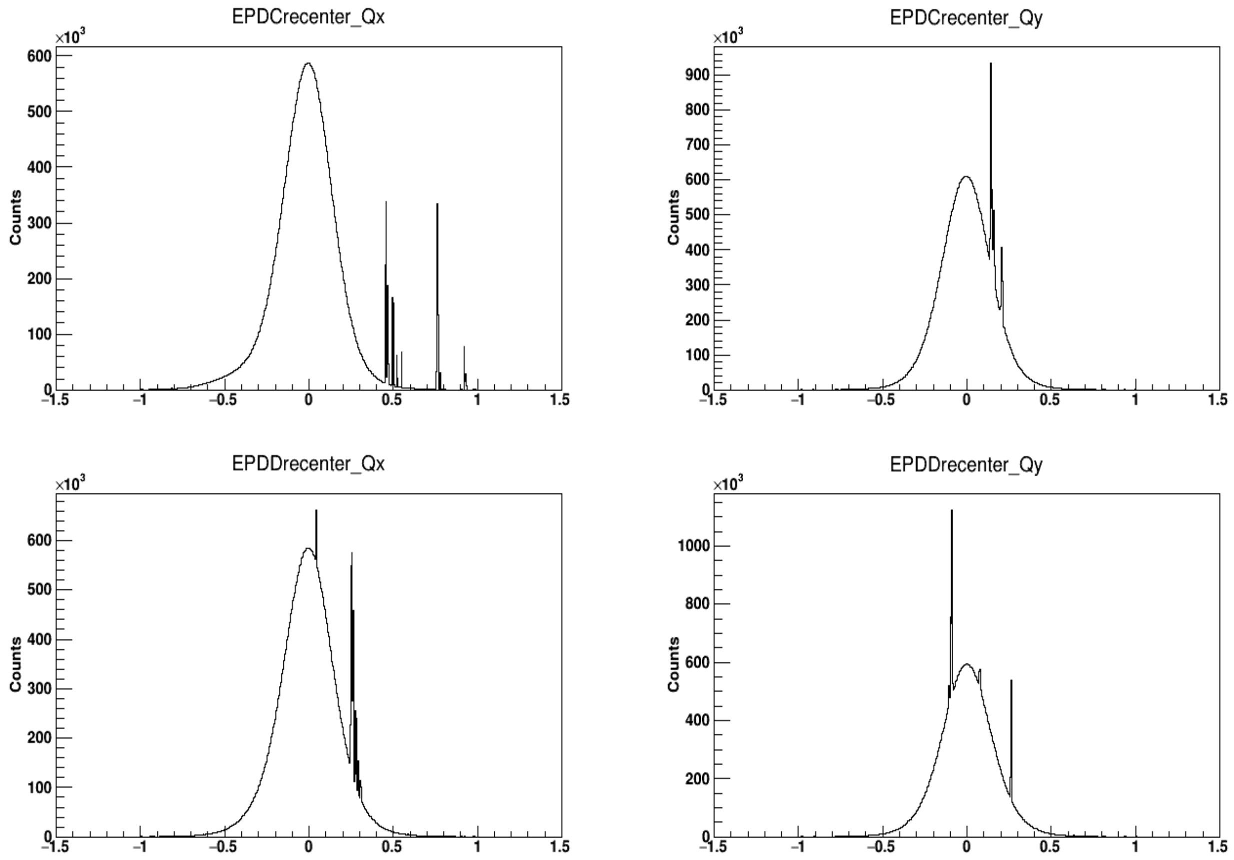
EPD Flow Vector QA

- Remove outliers in the $< Q_x >$and $< Q_y >$ distribution

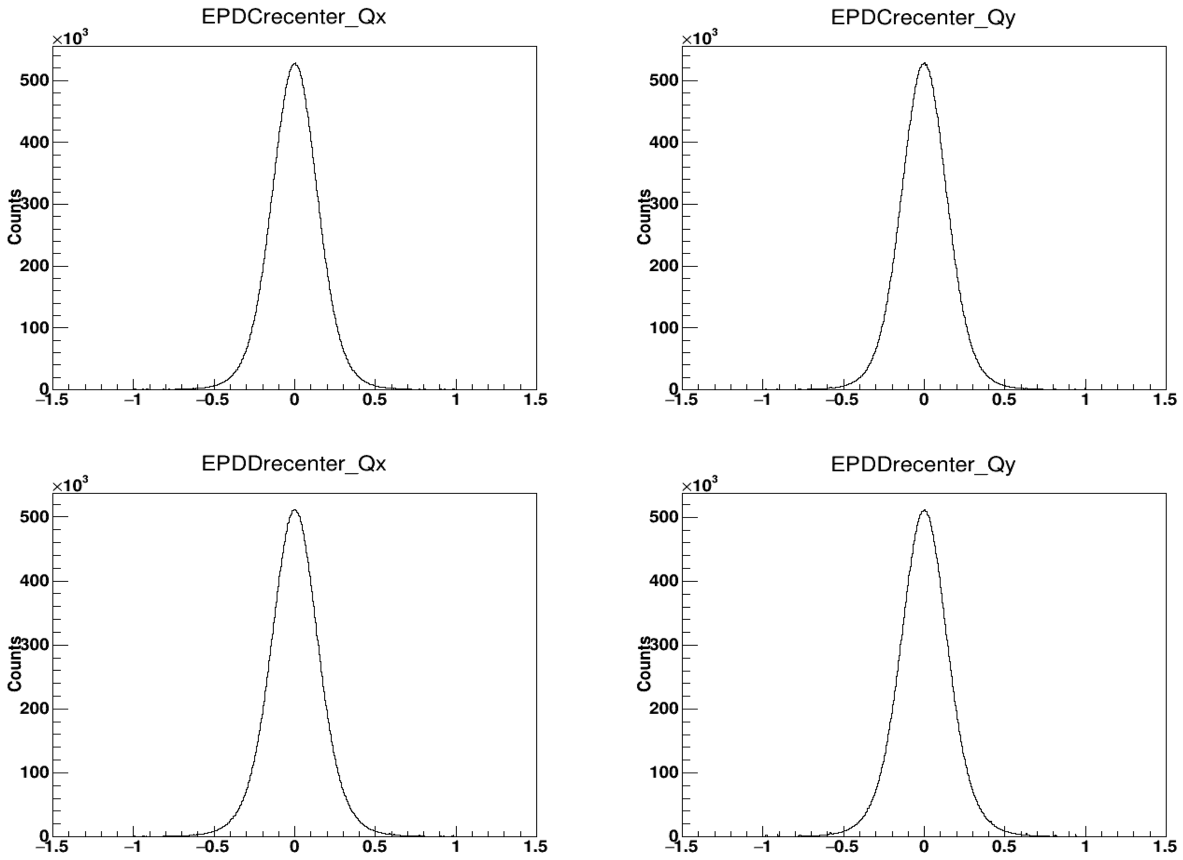


Qx/y vs run number

EPD Flow Vector QA



Before bad run selection

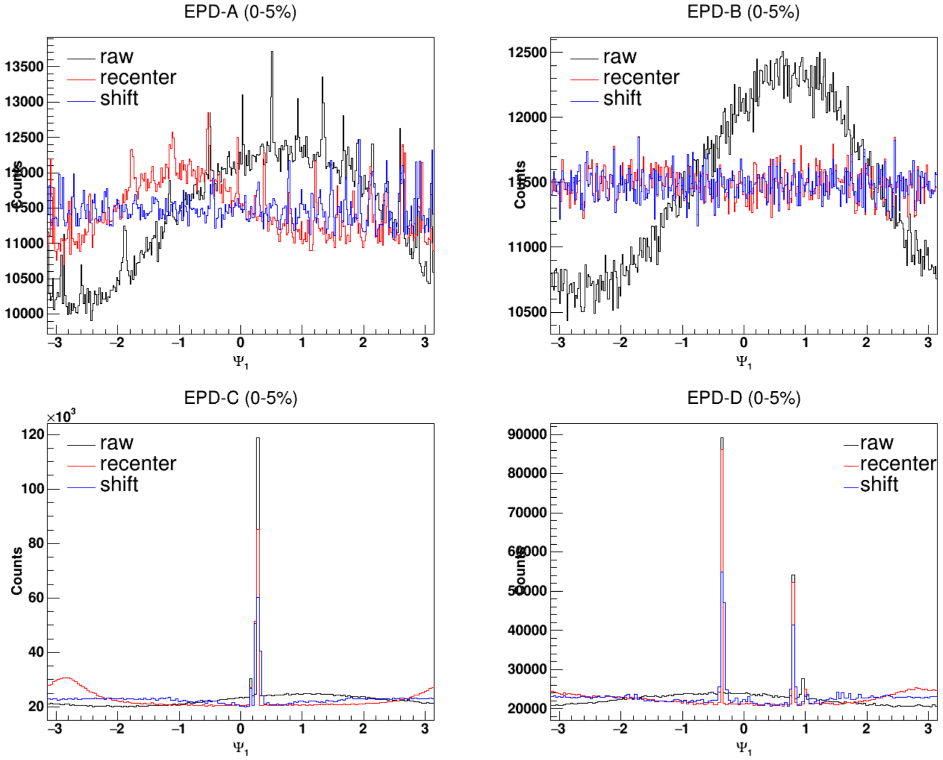


After bad run selection

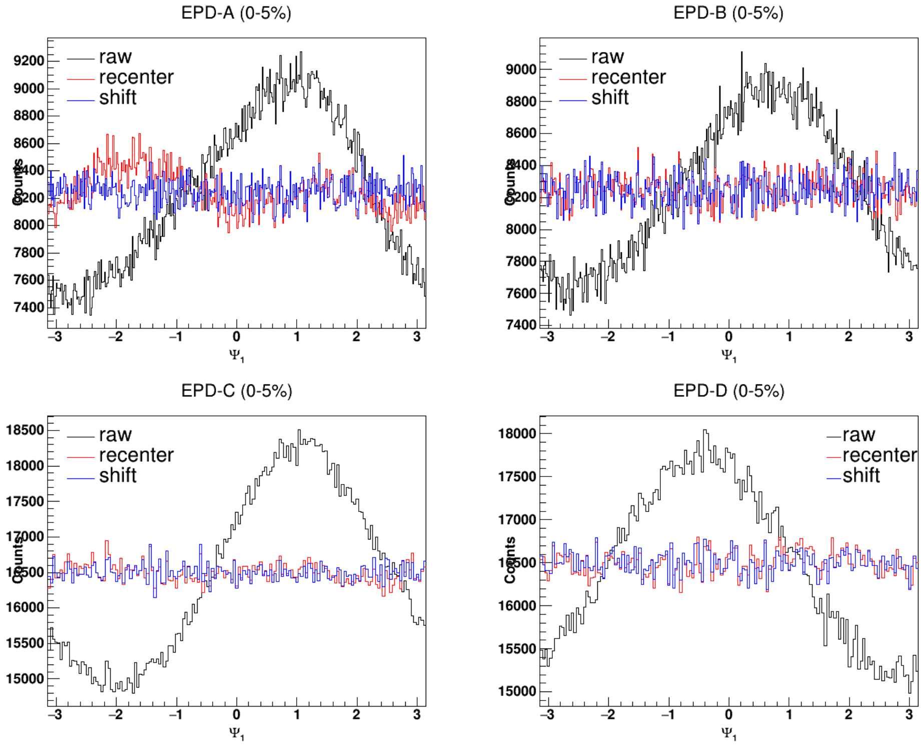
- After bad run selection, the EPD flow vector distribution becomes smooth.

EPD Event Plane Reconstruction

- EPD sub-event Ψ_1 distribution in 0-5% centrality



Before bad run selection



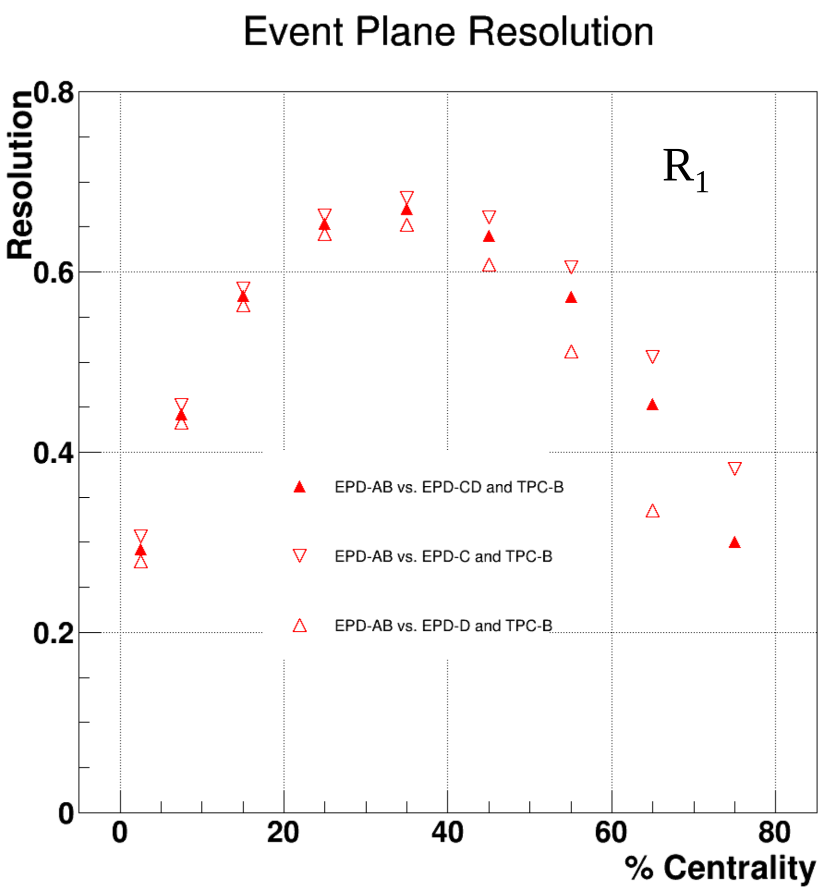
After bad run selection

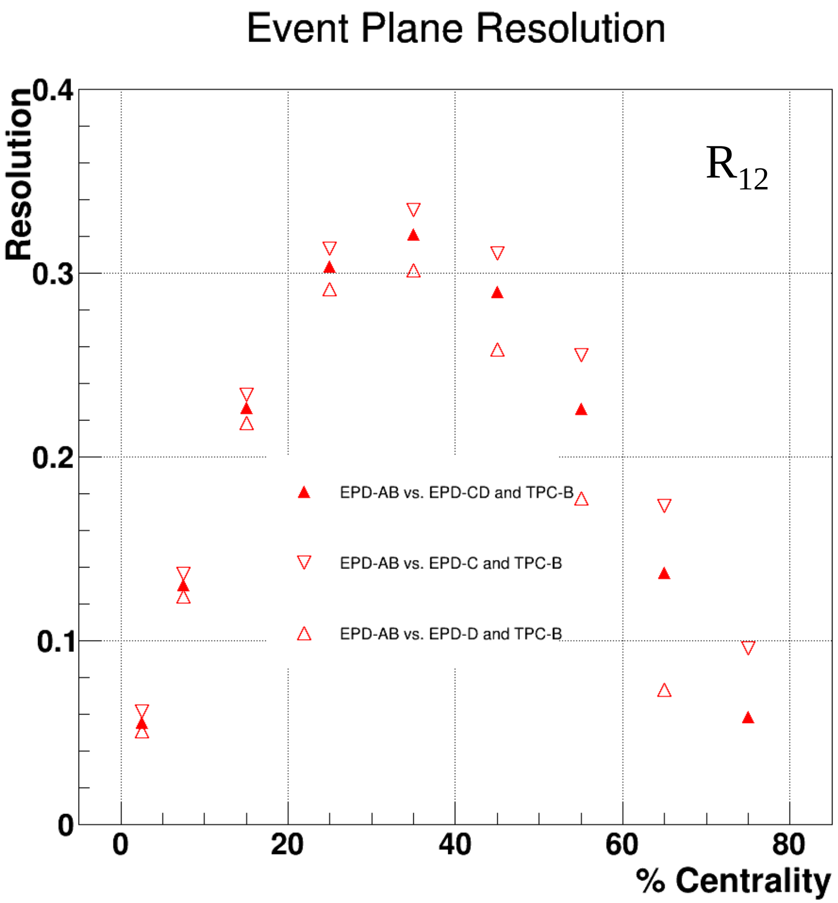
$$\vec{Q}=\begin{pmatrix}Q_y\\Q_x\end{pmatrix}=\begin{pmatrix}\sum_i \omega_i \sin(n\phi_i)\\\sum_i \omega_i \cos(n\phi_i)\end{pmatrix}\quad \Psi_n=tan^{-1}\left(\frac{\sum_i \omega_i \sin(n\phi_i)}{\sum_i \omega_i \cos(n\phi_i)}\right)/n\quad \langle Q\rangle=\begin{pmatrix}\omega_i \sin(n\phi_i)\\\omega_i \cos(n\phi_i)\end{pmatrix}\quad \vec{Q}_{rc}=\begin{pmatrix}\sum_i \omega_i \sin(n\phi_i)-\langle Q_y\rangle\\\sum_i \omega_i \cos(n\phi_i)-\langle Q_x\rangle\end{pmatrix}$$

$$\psi_{n,shift}=\sum_{k=1}^{20}\frac{1}{k}\left[-\langle\sin(nk\Psi_{n,rc})\rangle\cos(nk\Psi_{n,rc})+\langle\cos(nk\Psi_{n,rc})\rangle\sin(nk\Psi_{n,rc})\right]\quad \psi_{n,corr}=\psi_{n,rc}+\psi_{n,shift}$$

A. M. Poskanzer and S. A. Voloshin Phys. Rev. C58, 1671(1998)

Event Plane Resolution





- Use three sub-events to determine the event plane resolution

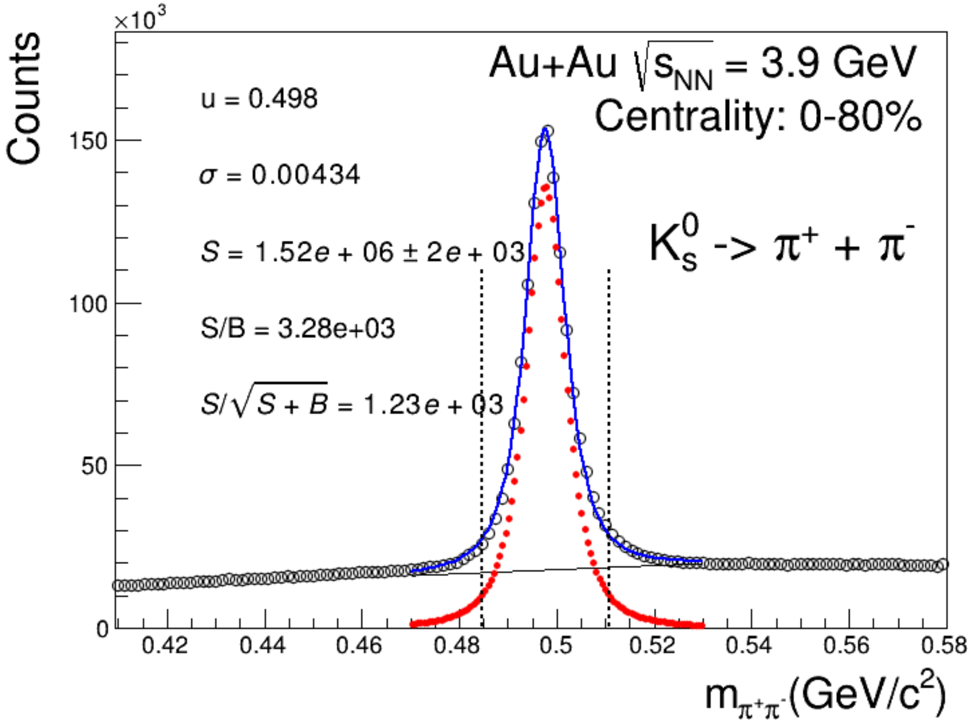
$$R_1 = \sqrt{\frac{\langle\cos(\Psi_1^a - \Psi_1^b)\rangle\langle\cos(\Psi_1^a - \Psi_1^c)\rangle}{\langle\cos(\Psi_1^b - \Psi_1^c)\rangle}}$$

$$R_1 = \frac{\sqrt{\pi}}{2\sqrt{2}}\chi_1 \exp(-\chi_1^2/4) \times [\, I_0(\chi_1^2/4) + I_1(\chi_1^2/4)]$$

$$R_{12} = \frac{\sqrt{\pi}}{2\sqrt{2}}\chi_1 \exp(-\chi_1^2/4) \times [\, I_{1/2}(\chi_1^2/4) + I_{3/2}(\chi_1^2/4)]$$

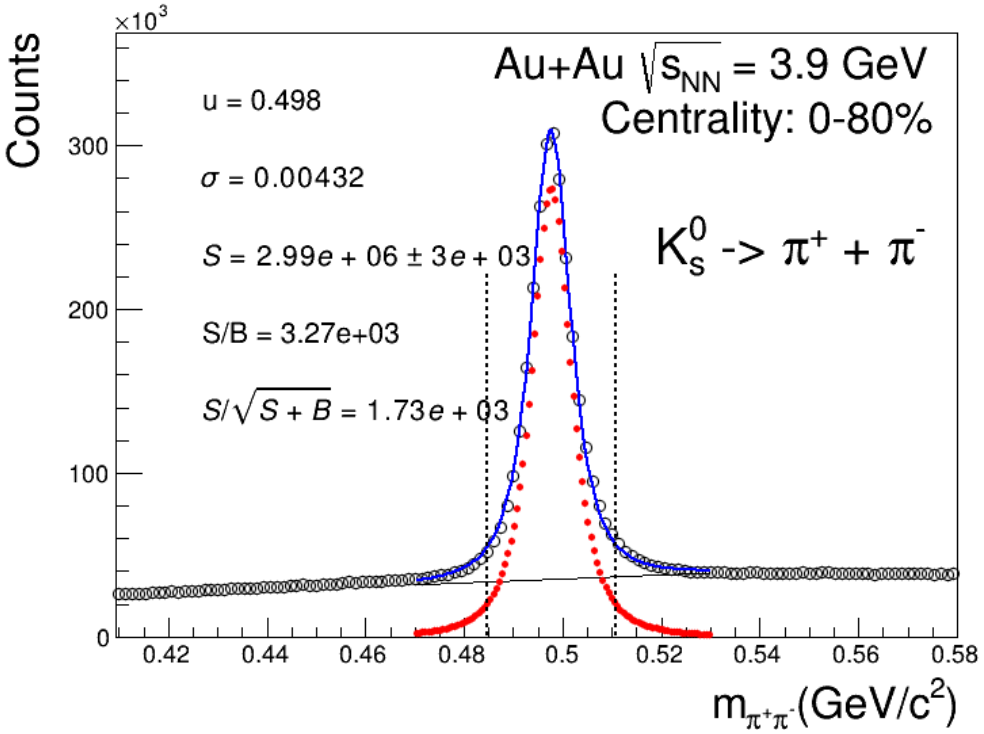
A. M. Poskanzer and S. A. Voloshin Phys. Rev. C58, 1671(1998)

K_s^0 Reconstruction



Invariant mass distribution for π^+-π^- pairs

Before considering $n\sigma_{\pi^+}$ and $n\sigma_{\pi^-}$ shift



Invariant mass distribution for π^+-π^- pairs

After considering $n\sigma_{\pi^+}$ and $n\sigma_{\pi^-}$ shift

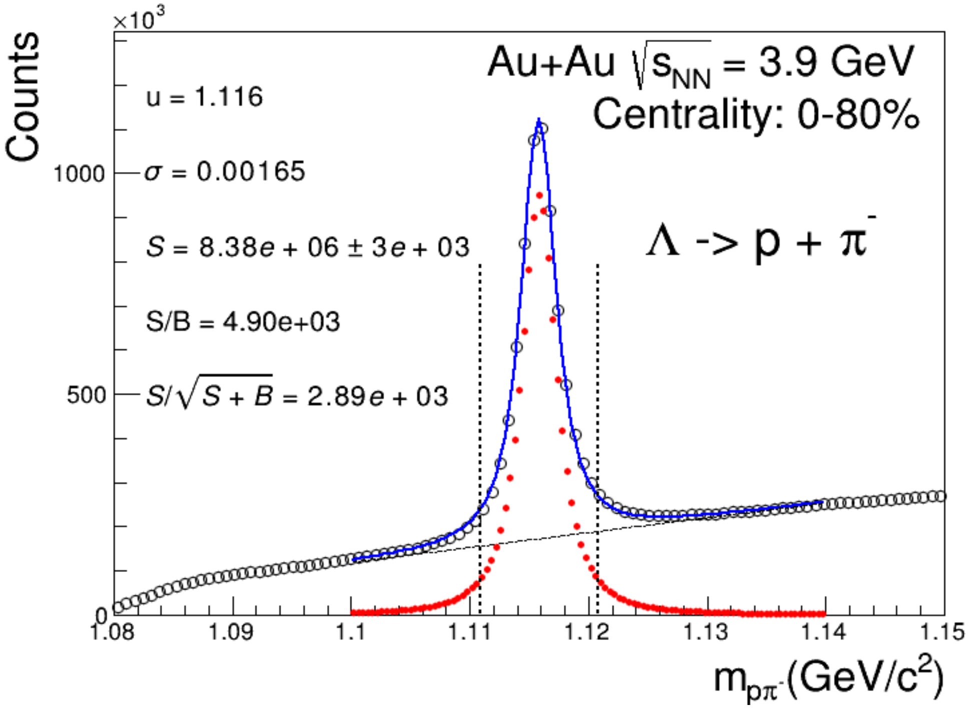
- K_s^0 are reconstructed by KF particle package

0.485GeV/c² < $m_{K_s^0}$ < 0.511 GeV/c² $\chi^2_{primary,\pi^+} > 10$

-0.06GeV²/c⁴ < $m^2_{\pi^+}$ < 0.1GeV²/c⁴ $\chi^2_{primary,\pi^-} > 10$

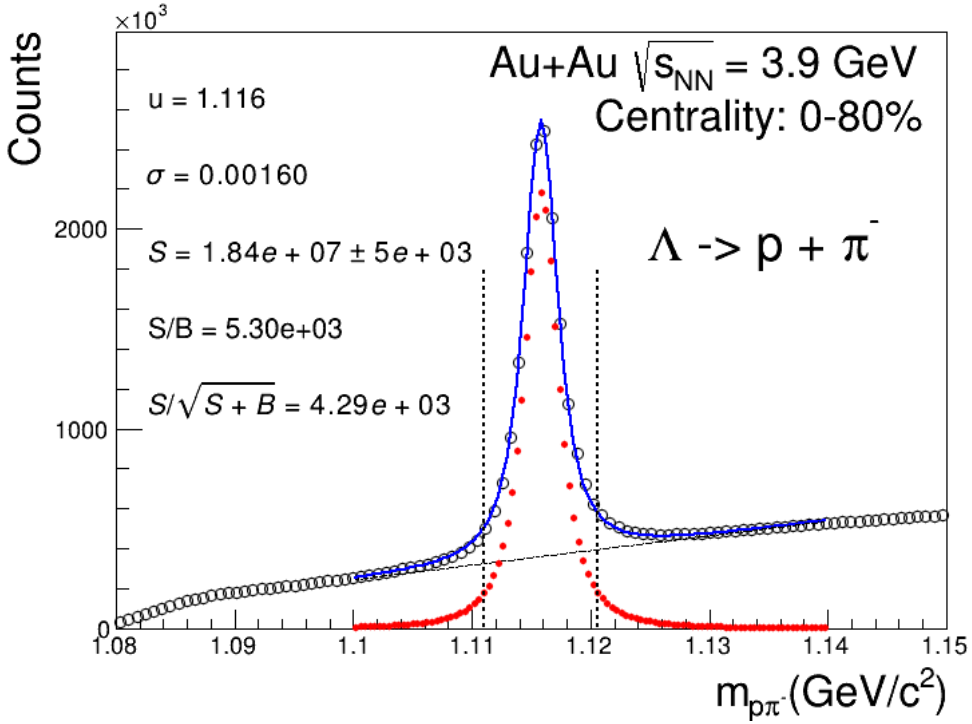
- Significance increases by a factor of 1.4

Λ Reconstruction



Invariant mass distribution for p - π^- pairs

Before considering $n\sigma_p$ and $n\sigma_{\pi^-}$ shift



Invariant mass distribution for p - π^- pairs

After considering $n\sigma_p$ and $n\sigma_{\pi^-}$ shift

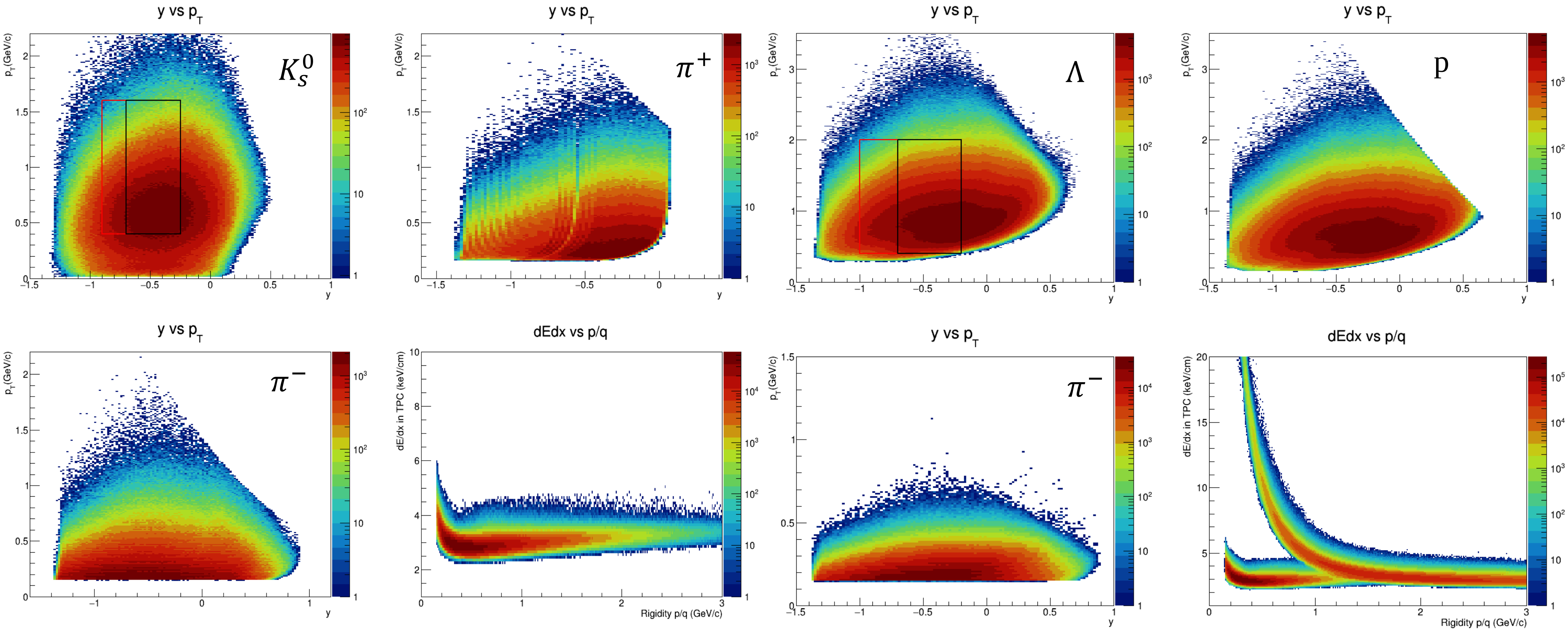
- Λ are reconstructed by KF particle package

  1.111GeV/c² $< m_\Lambda <$ 1.121 GeV/c²

  $\chi^2_{primary,p} > 5$ $\chi^2_{primary,\pi^-} > 10$

- Significance increases by a factor of 1.5

K_s^0 and Λ Acceptance



K_s^0 acceptance window

Red box: 0.4 GeV/c < p_T < 1.6 GeV/c -0.9 < y < -0.25

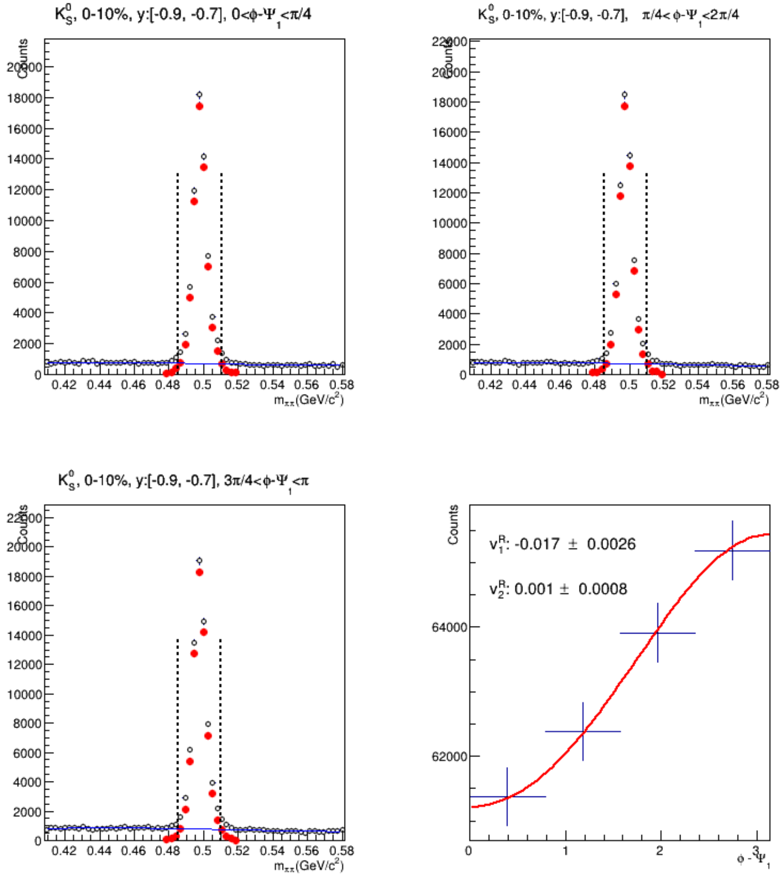
Black box: 0.4 GeV/c < p_T < 1.6 GeV/c -0.7 < y < -0.25

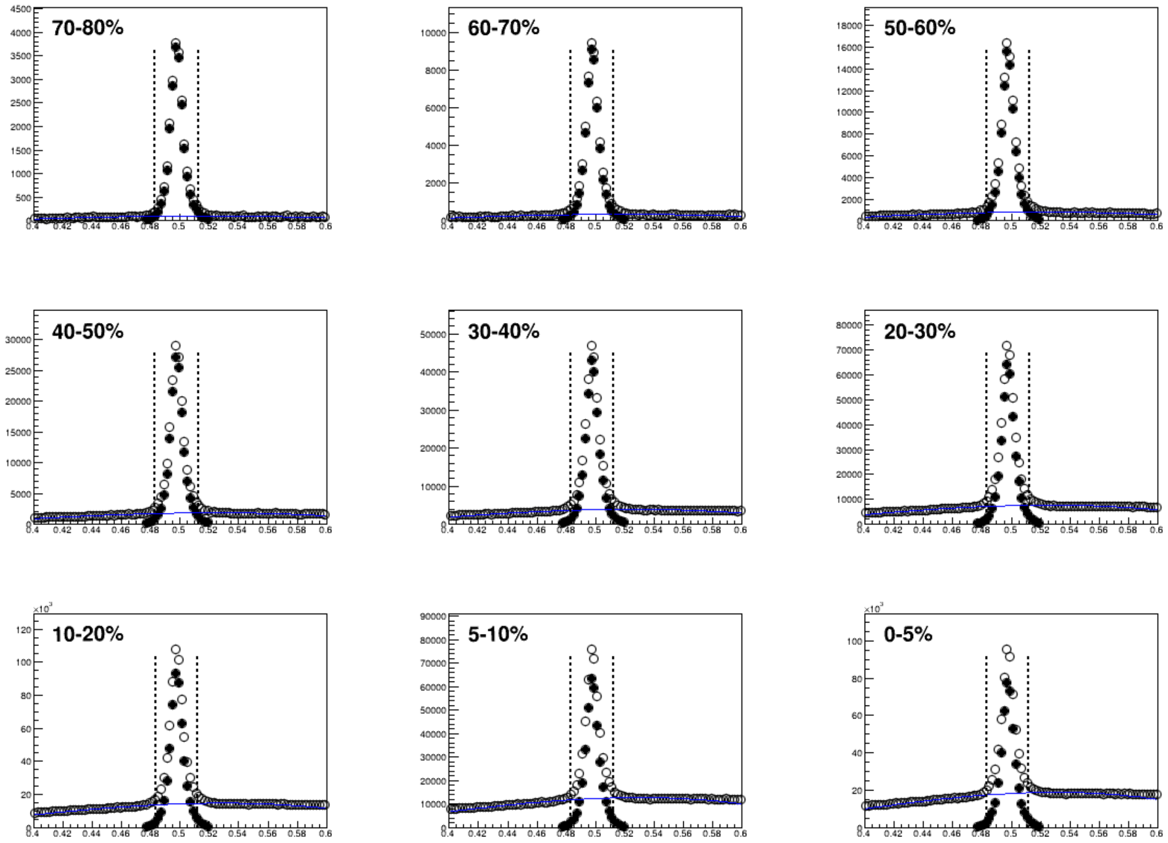
Λ acceptance window

Red box: 0.4 GeV/c < p_T < 2.0 GeV/c -1.0 < y < -0.2

Black box: 0.4 GeV/c < p_T < 2.0 GeV/c -0.7 < y < -0.2

K_s^0 v_1 Measurements





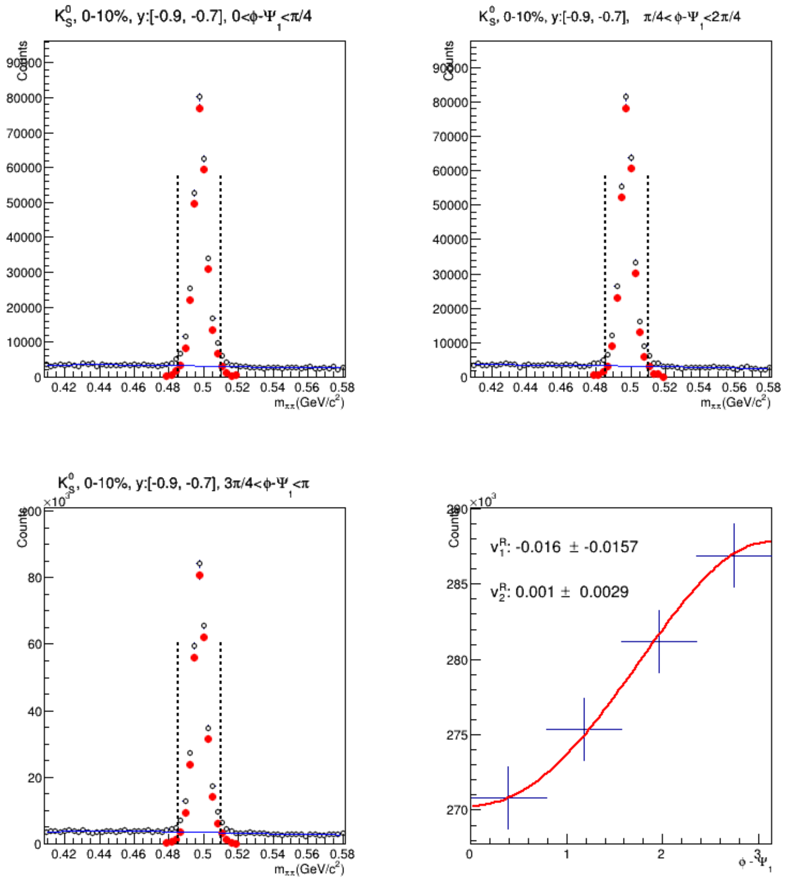
- ➢ Event plane method used to extract v_1^{obs}
- ➢ Event by event resolution correction

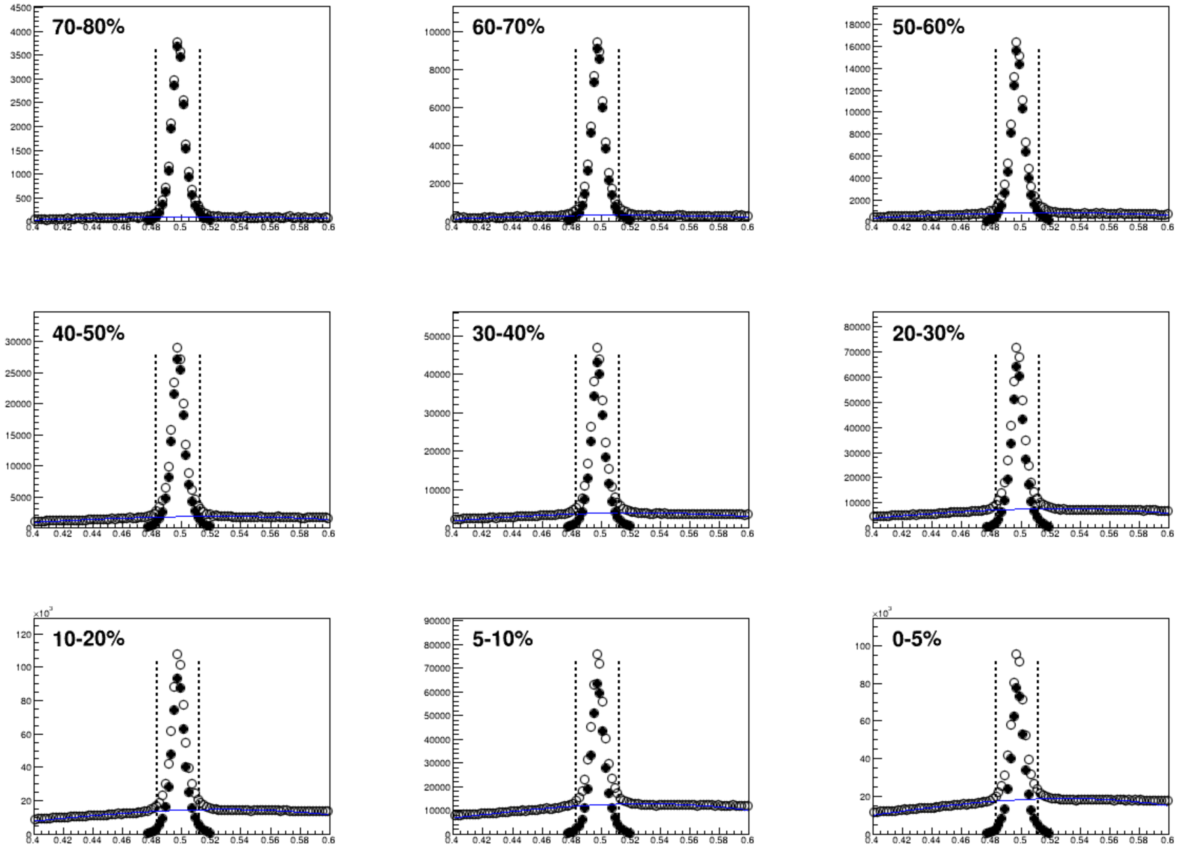
$$\frac{1}{R_1}\frac{dN}{d(\phi-\Psi_1)} = N_0\left(1 + 2v_1^{obs}\cos(\phi-\Psi_1) + 2v_2^{obs}\cos[2(\phi-\Psi_1)]\right)$$

$$\left\langle\frac{1}{R_1}\right\rangle = \frac{\sum_i N_i * \frac{1}{R_i}}{\sum_i N_i} \qquad \langle v_1\rangle = \langle v_1^{obs}\rangle\left\langle\frac{1}{R_1}\right\rangle$$

Masui, H., Schmah, A., & Poskanzer, A.M. (2016).

K_s^0 v_2 Measurements





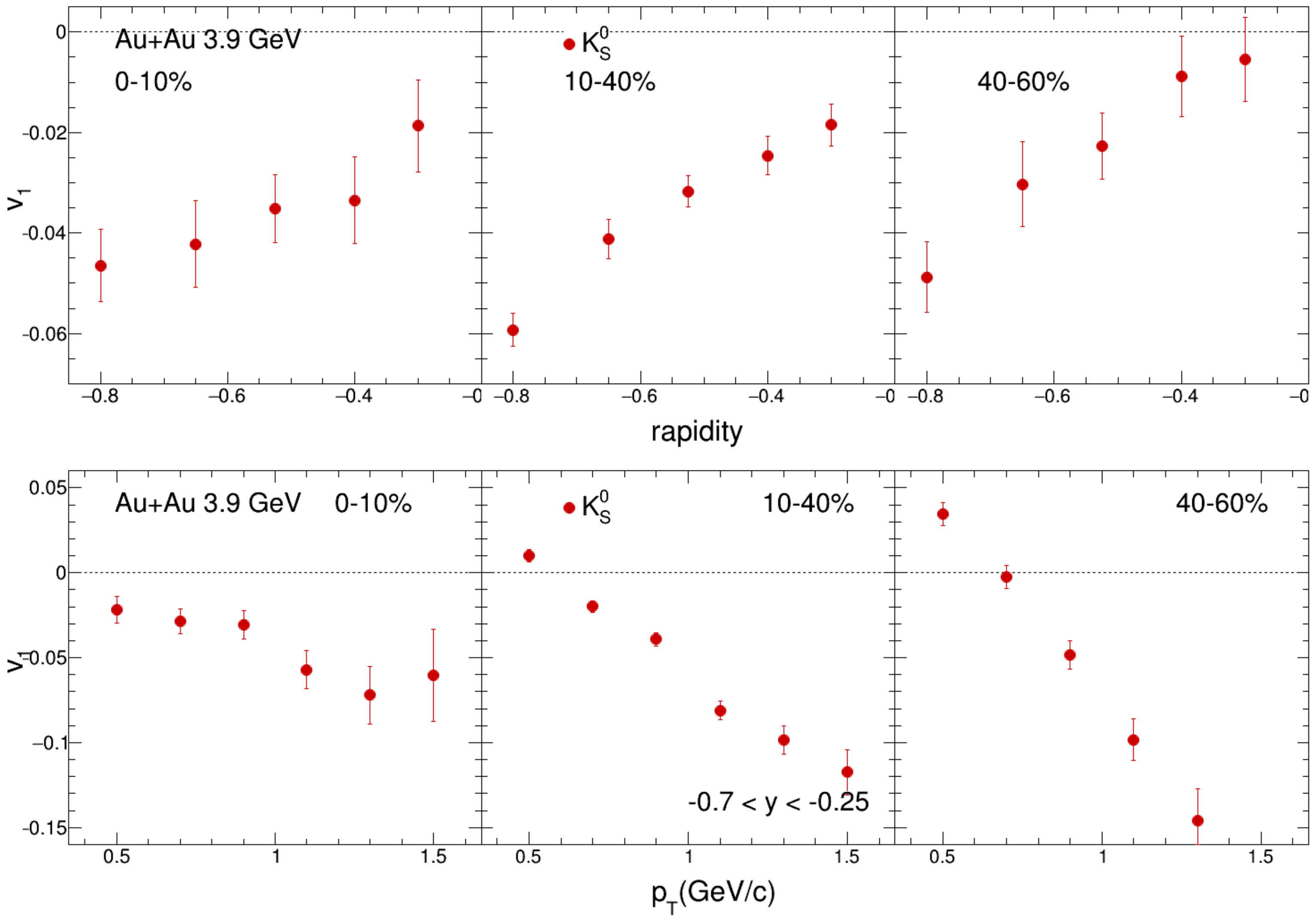
- Event plane method used to extract v_2^{obs}
- Event by event resolution correction

$$\frac{1}{R_{12}}\frac{dN}{d(\phi-\Psi_1)} = N_0\left(1 + 2v_1^{obs}\cos(\phi-\Psi_1) + 2v_2^{obs}\cos[2(\phi-\Psi_1)]\right)$$

$$\left\langle\frac{1}{R_{12}}\right\rangle = \frac{\sum_i N_i * \frac{1}{R_i}}{\sum_i N_i} \qquad \langle v_2\rangle = \langle v_2^{obs}\rangle\left\langle\frac{1}{R_{12}}\right\rangle$$

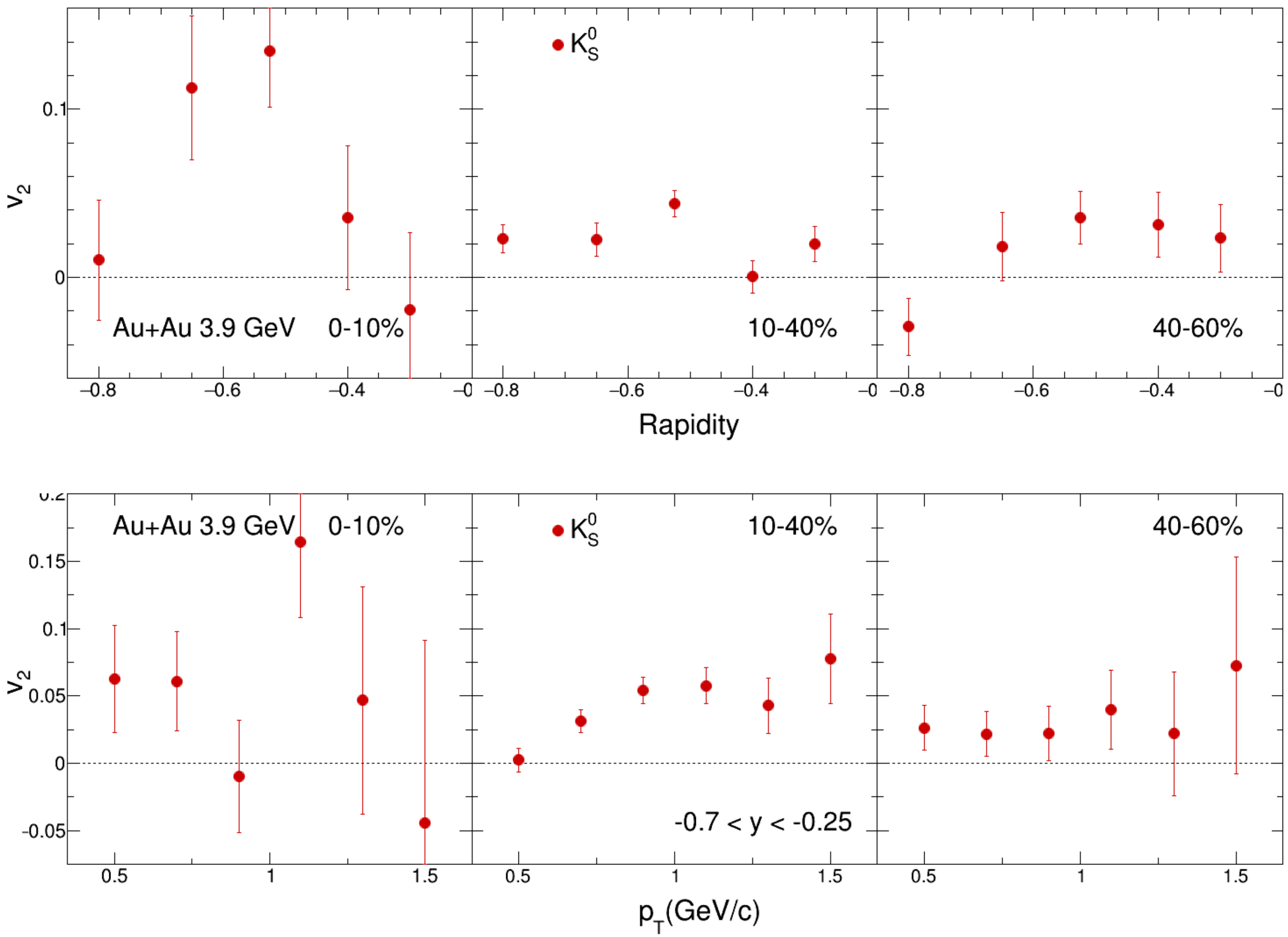
Masui, H., Schmah, A., & Poskanzer, A.M. (2016).

p_T and y Dependence of K_s^0 v_1



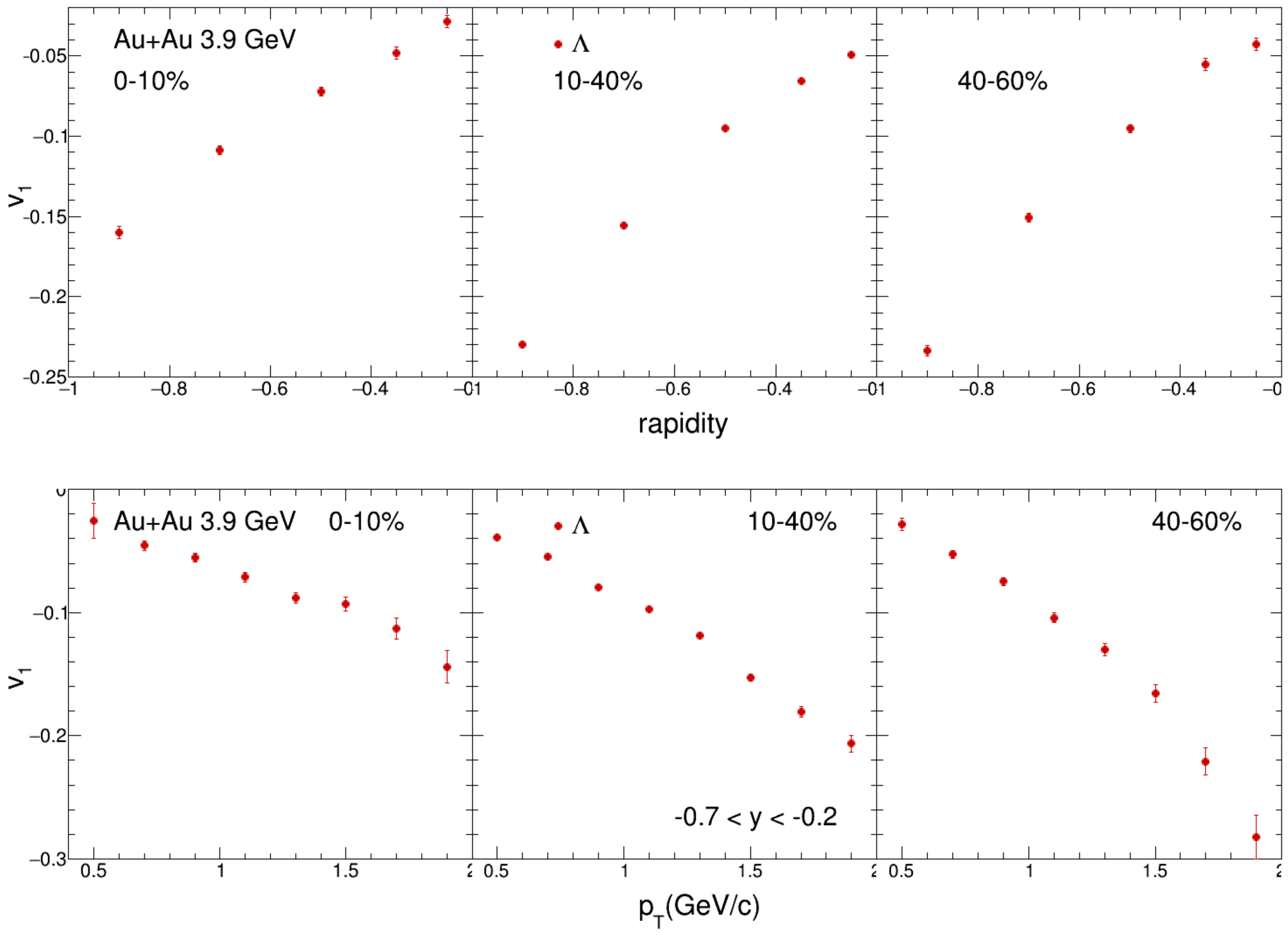
Rapidity and p_T dependence v_1 measured for three centrality bins

p_T and y Dependence of K_s^0 v_2



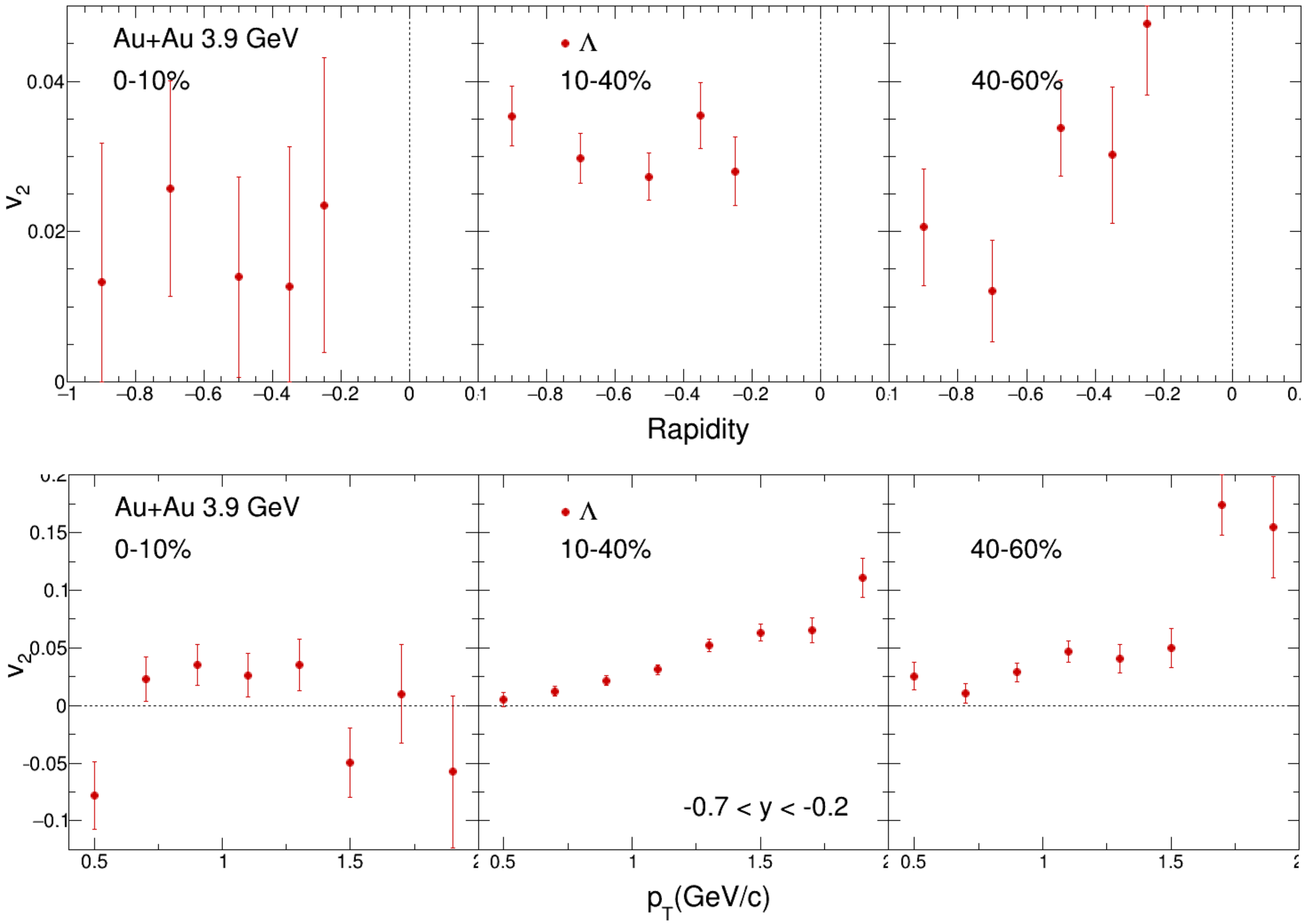
Rapidity and p_T dependence v_2 measured for three centrality bins

p_T and y Dependence of Λ v_1



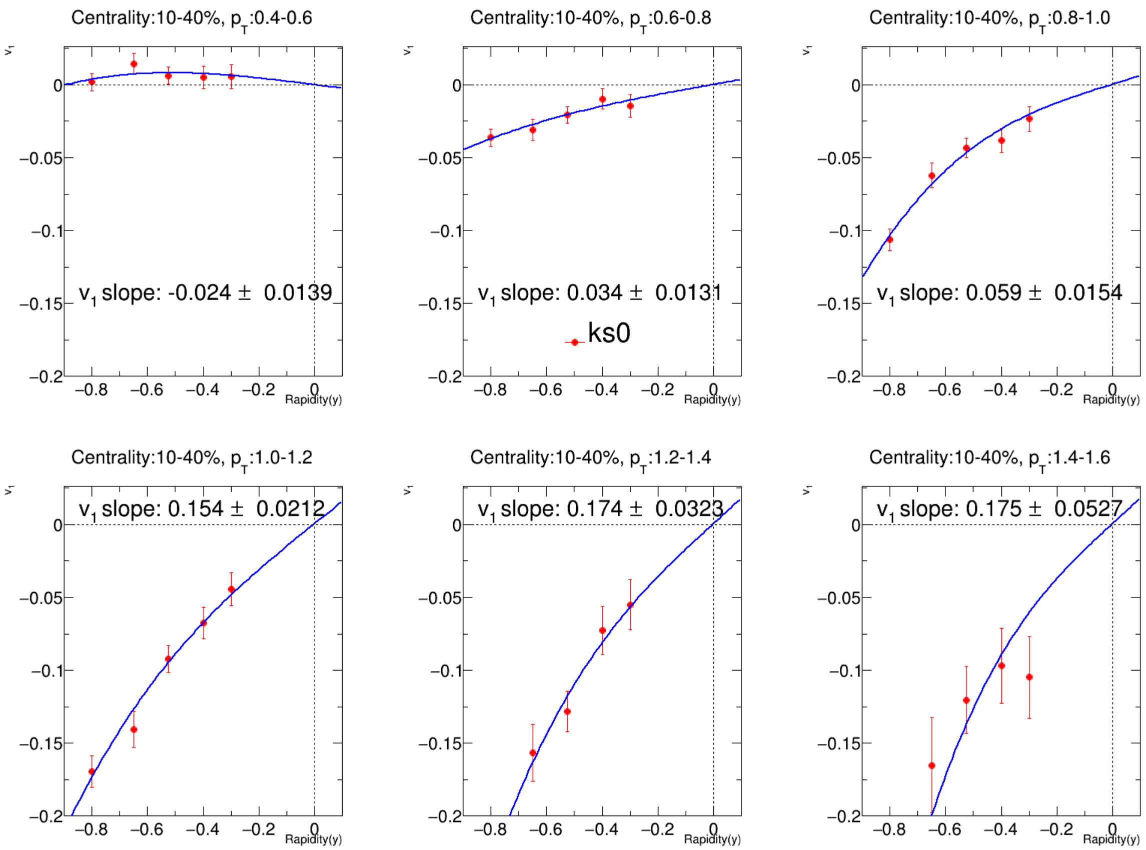
Rapidity and p_T dependence v_1 measured for three centrality bins

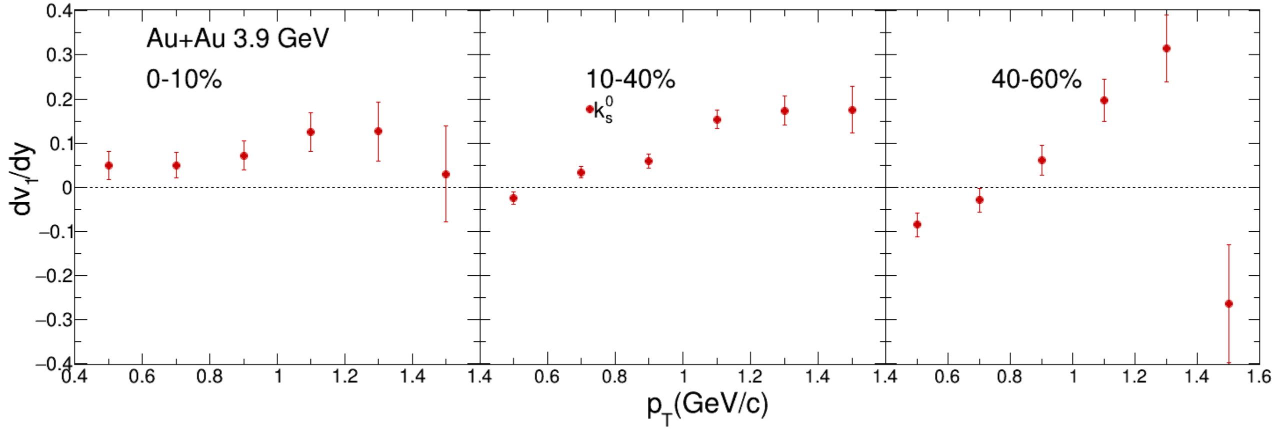
p_T and y Dependence of Λ v_2



Rapidity and p_T dependence v_2 measured for three centrality bins

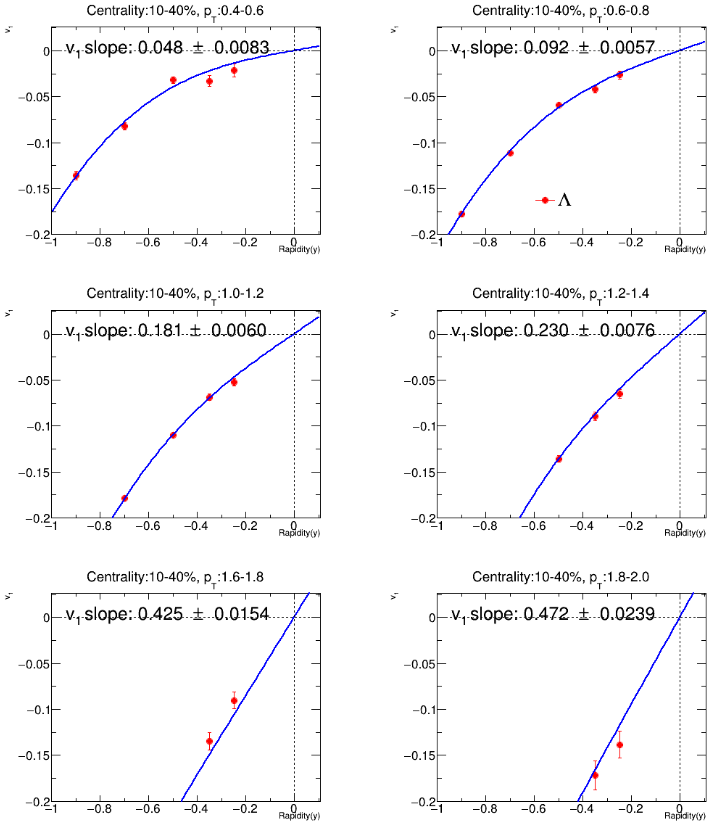
p_T Dependence of K_s^0 v_1 Slope

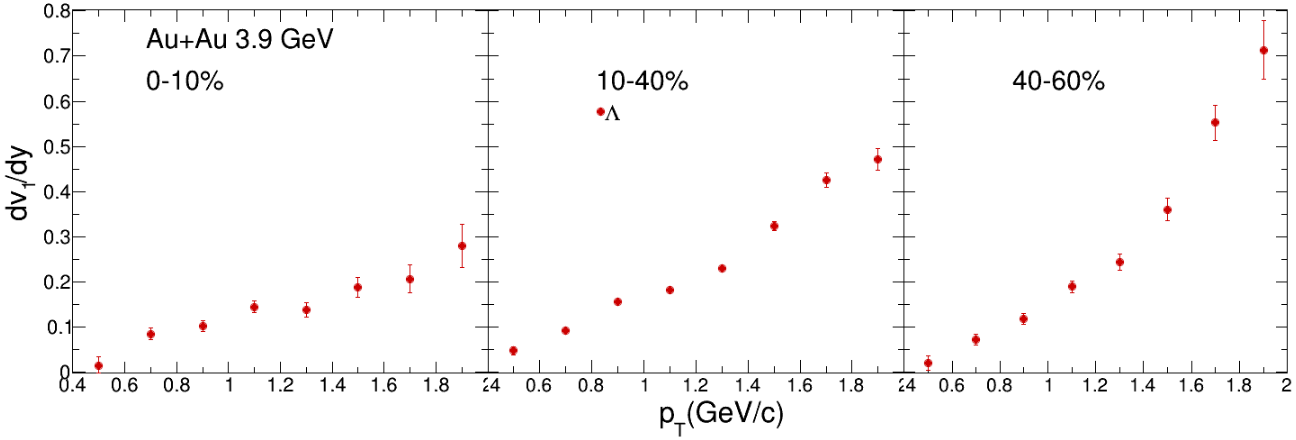




- v_1 slopes measured as a function of p_T bins
- Fit function: $y=ax+bx^3$

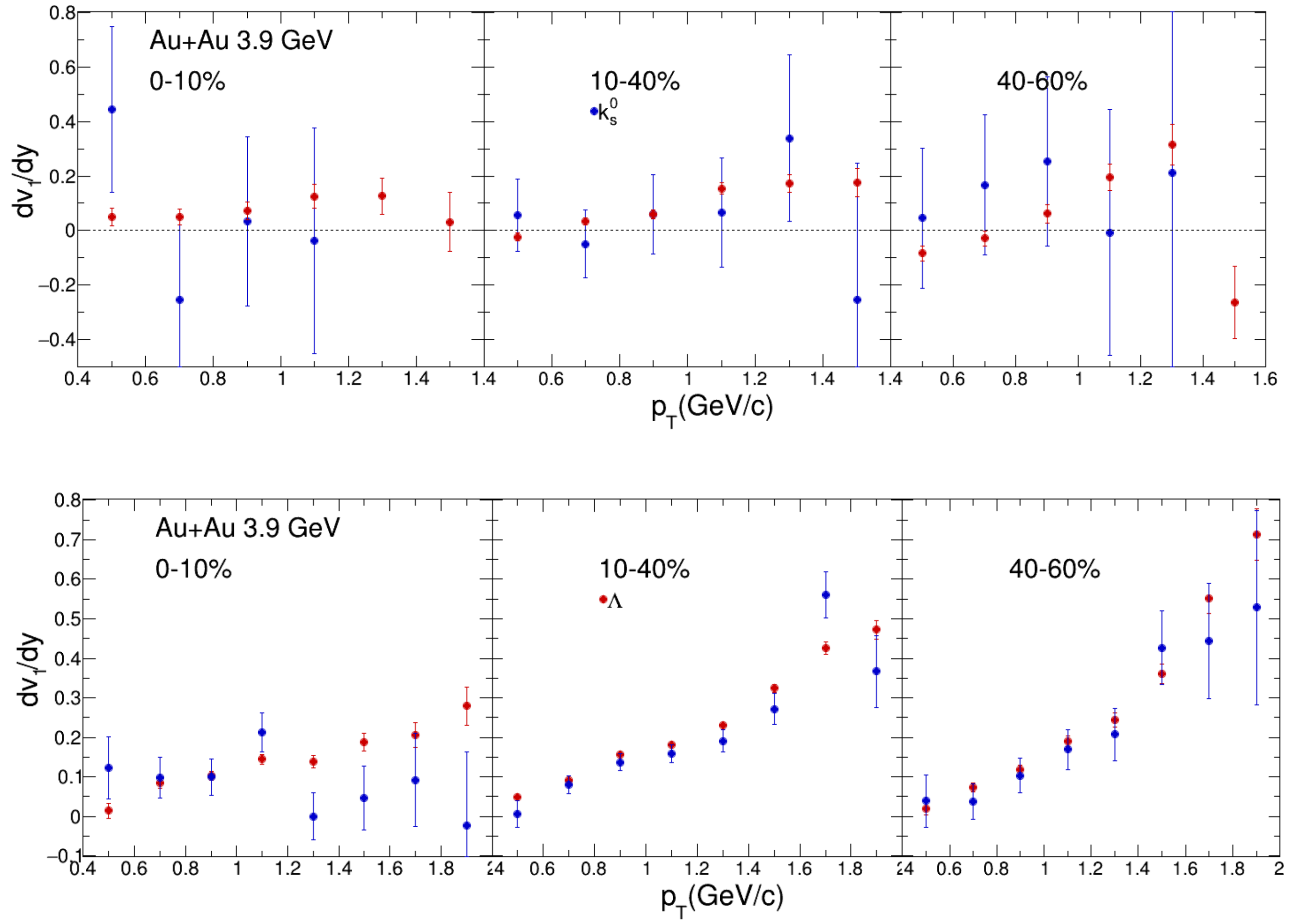
p_T Dependence of Λ v_1 Slope





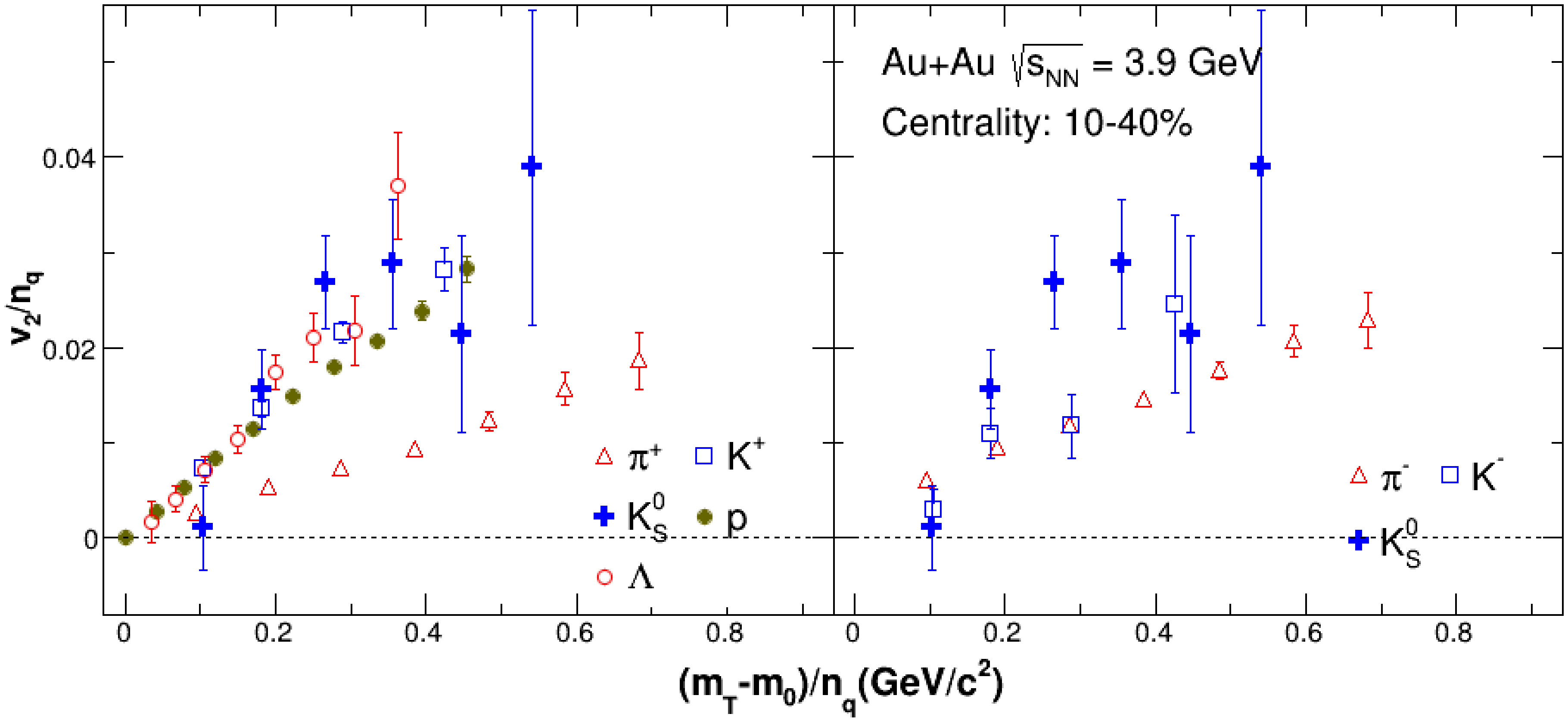
- v_1 slopes measured as a function of p_T bins
- Fit function: $y=ax+bx^3$

p_T Dependence of K_S^0 and Λ v_1 Slope



Slope extraction by different functions: $y=ax+bx^3$ (red) versus $y=ax+bx^3+c$ (blue)

NCQ Scaling



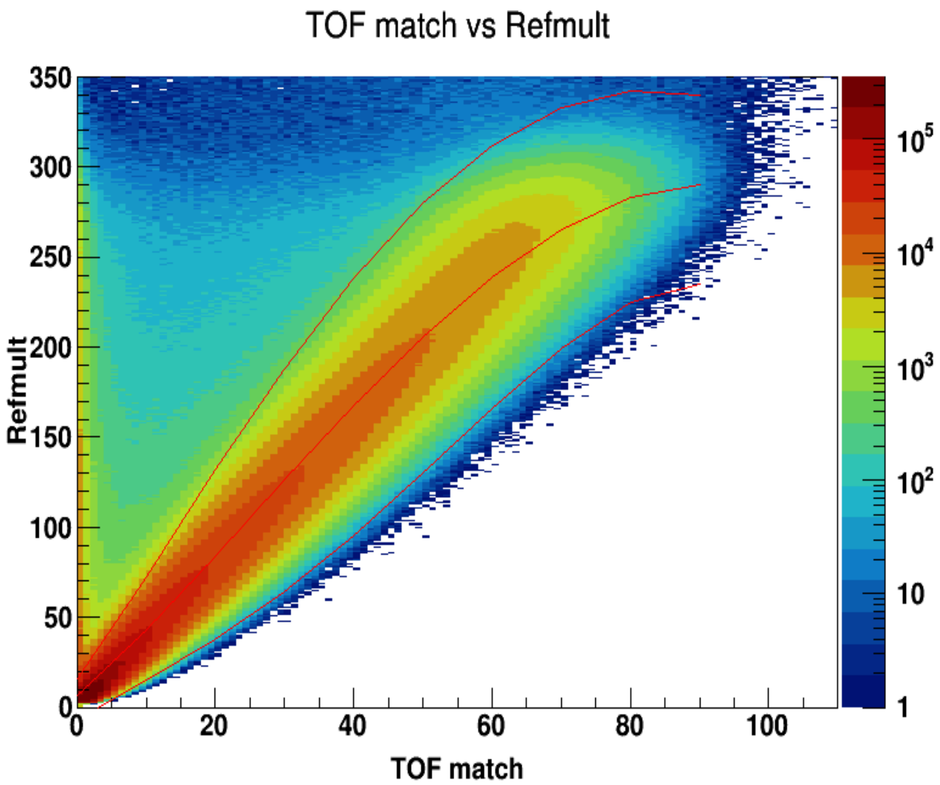
- ➢ $\pi^{\pm}$ $K^{\pm}$ p results are from Guoping
- ➢ Clear deviation of NCQ scaling at 3.9 GeV

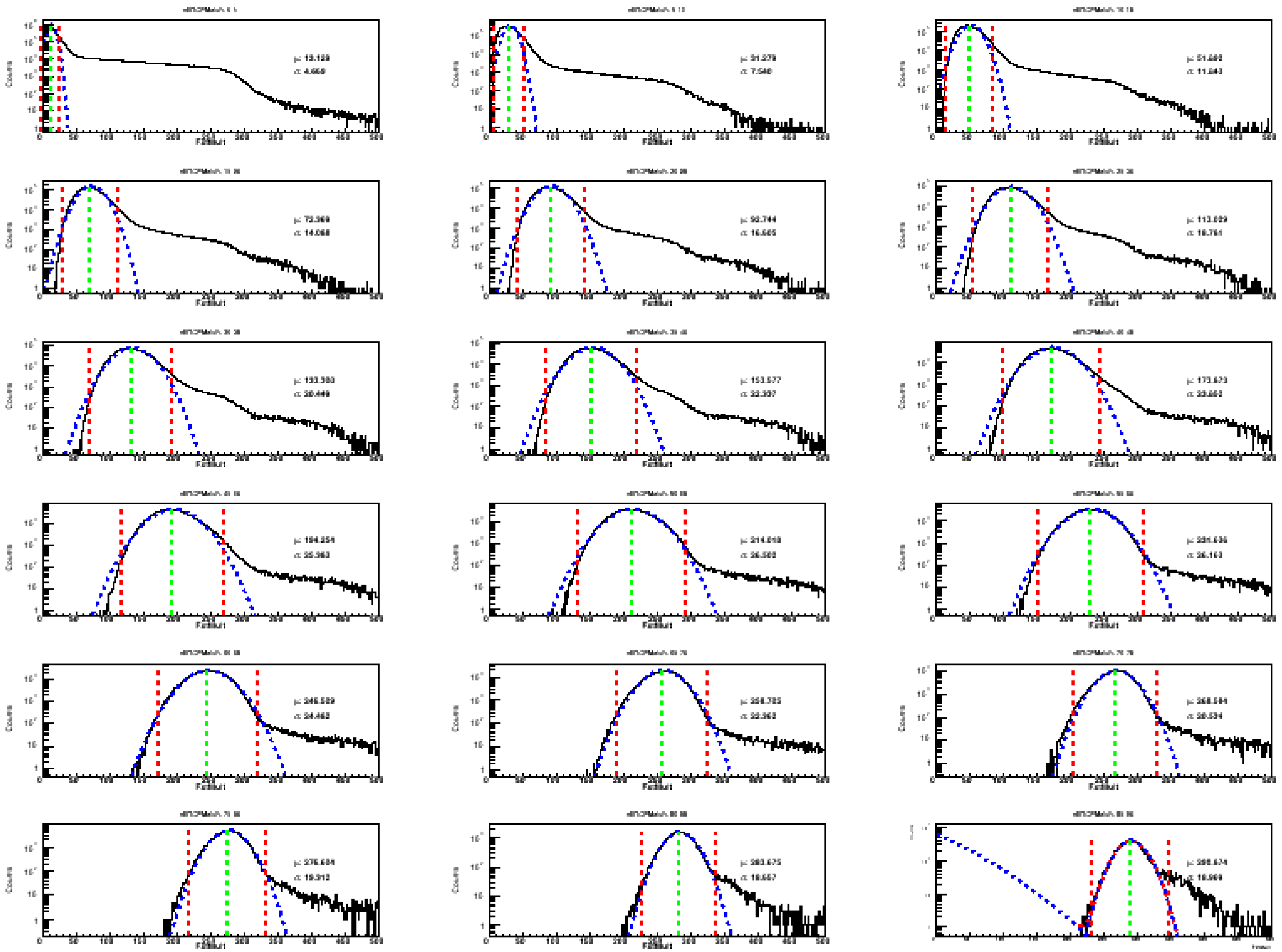
Summary

- Pile-up rejection
- Bad runs study based on EPD flow vector QA
- Event Plane from EPD
- Rapidity and p_T dependence of v_1 and v_2 measurements for K_s^0 and Λ
- NCQ scaling test

Back up

Remove the pile-up effect

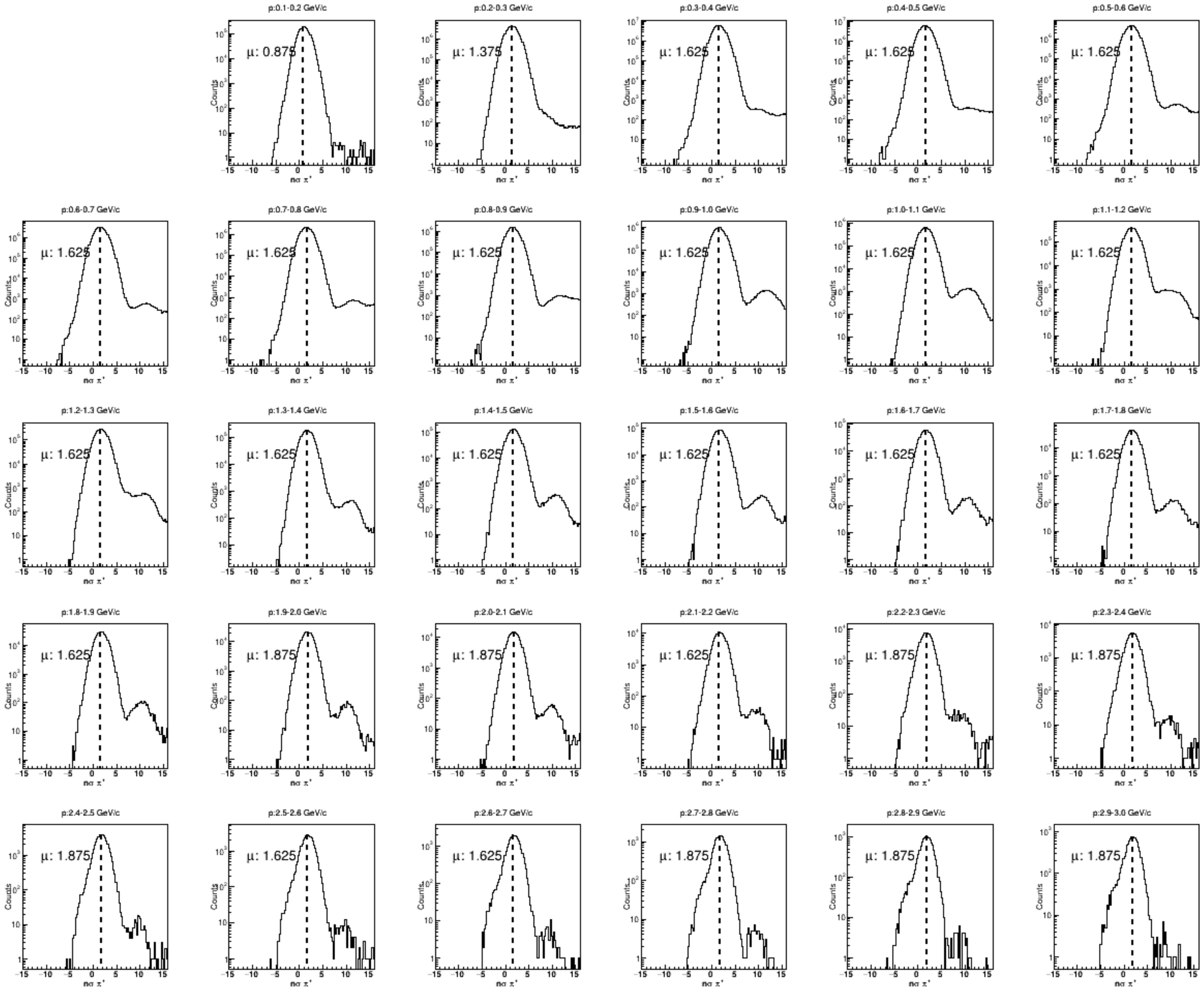




- The horizontal axis was divided into 18 bins to project to the vertical axis respectively.

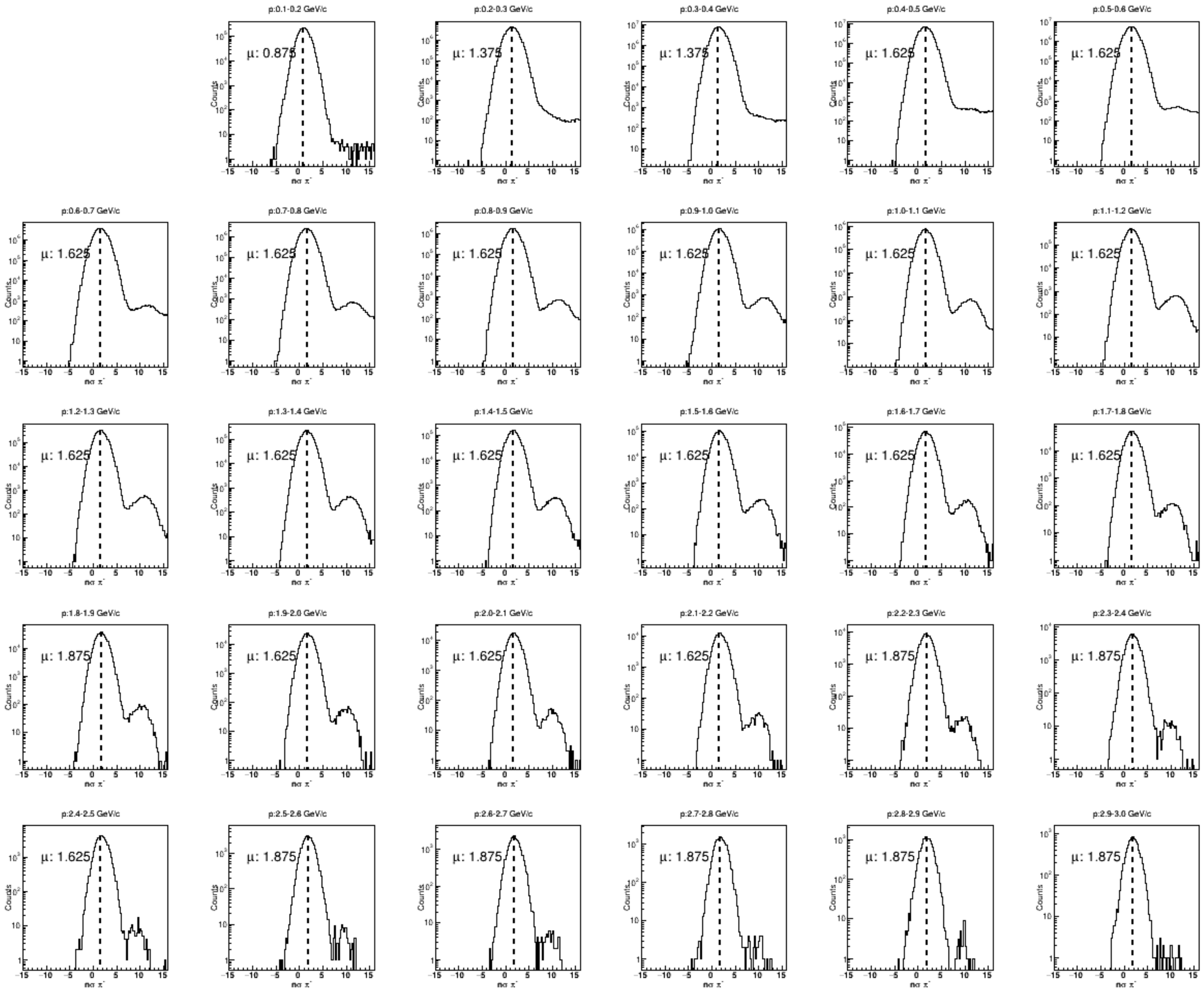
- The parameters of the red curve that remove the pile-up effect are obtained by fitting the projected picture.

The $n\sigma$ shift of each p bin π^+



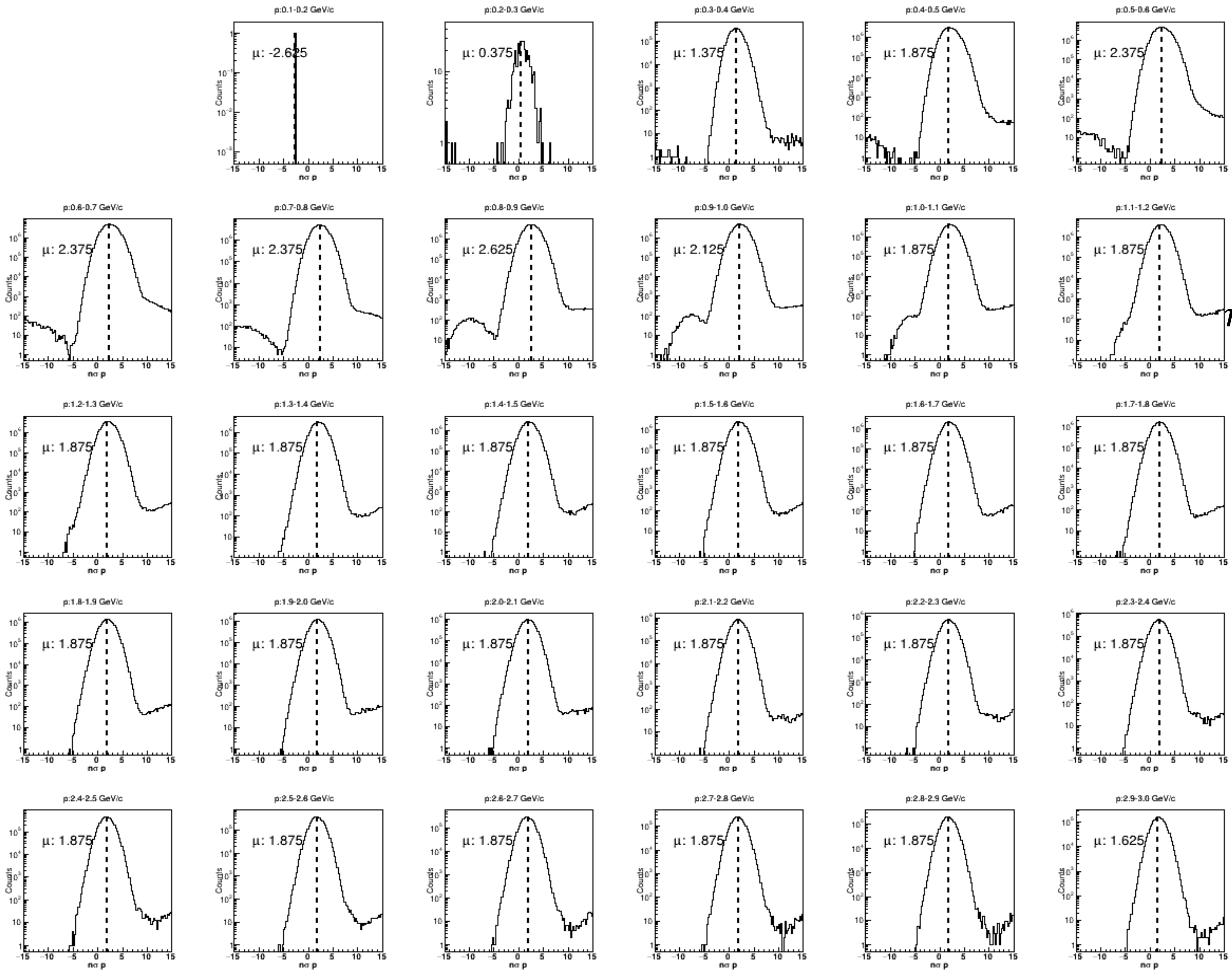
$m_{\pi}^2 = 0.019(GeV^2/c^4) \in [0.015, 0.025]\ (GeV^2/c^4)$

The $n\sigma$ shift of each p bin π^-



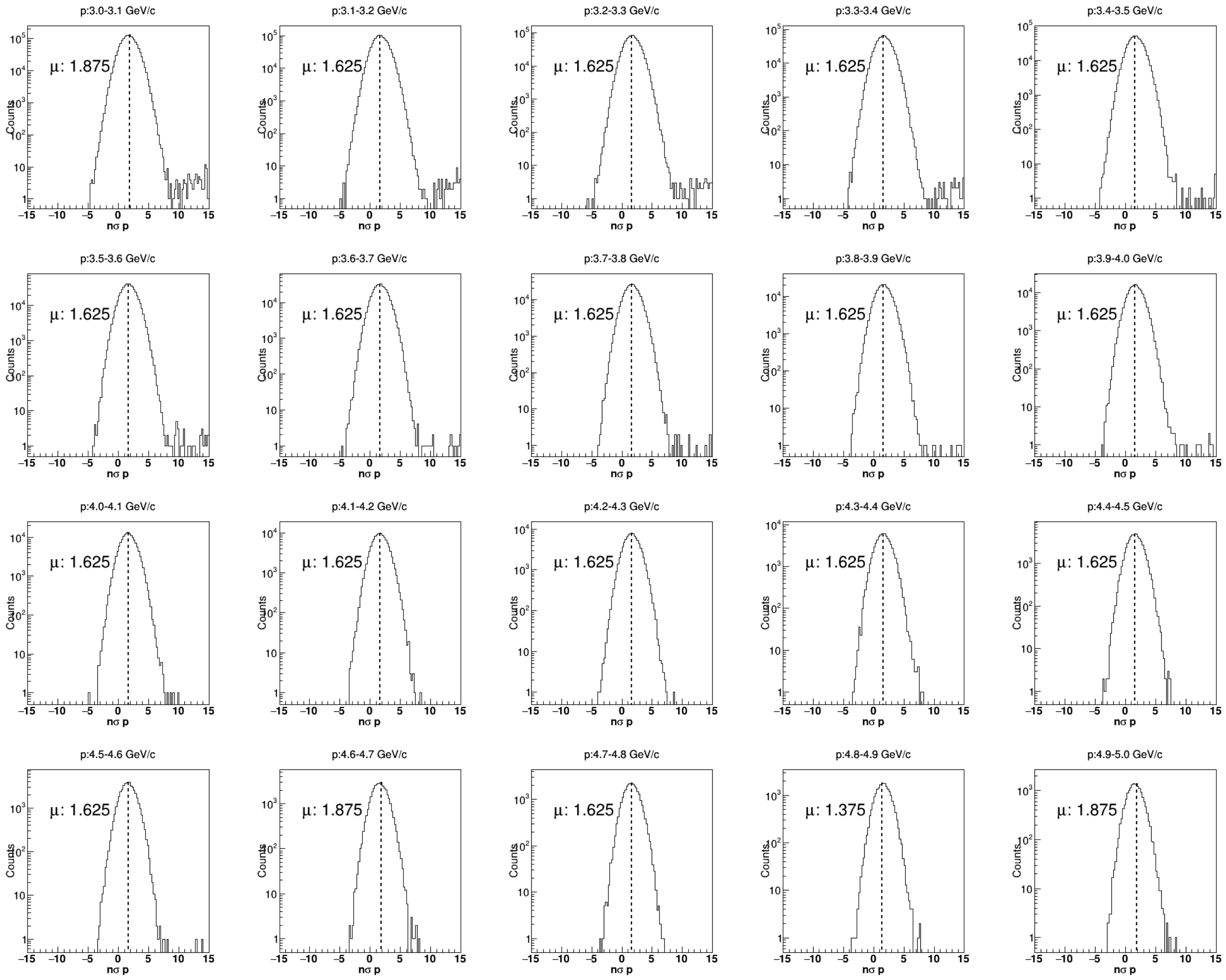
$m_\pi^2 = 0.019(GeV^2/c^4) \in [0.015,0.025]\ (GeV^2/c^4$

The $n\sigma$ shift of each p bin proton



$m_P^2 = 0.879 (GeV^2/c^4) \in [0.82, 0.96]\ (GeV^2/c^4)$

The $n\sigma$ shift of each p bin proton



$m_P^2 = 0.879 (GeV^2/c^4) \in [0.82, 0.96]\ (GeV^2/c^4)$