$\pi^{\pm}$, $K^{\pm}$ and proton v_1, v_2 in Au + Au Collisions at $\sqrt{s_{NN}}$ = 3.9 GeV

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2022-10-26

Outline

- Dataset and cuts
- EPD Flow Vector QA, pile-up rejection and centrality determination
- Event plane reconstruction and resolution
- Acceptance and PID flow results
- Summary

Dataset and Cuts

Dataset

System	Number of PicoDst Files	Minibias trigger id	Run number	Total Events	After Event cuts
Au + Au 3.9 GeV	6004	730000	21035003-21036013(2020) (32 runs)	~77.0M	~76.8M

Cuts

Events Cuts	$198 \leq V_z \leq 202$ cm	$(v_x + 0.4)^2 + (v_y + 2)^2 \leq 4$ cm^2	
Track Cuts(for EP reconstruction)	$\lvert DCA \rvert \leq 3$ cm	$N_{Hits} > 15$	$\frac{nhitsFit}{nhitsMax} \geq 0.52$

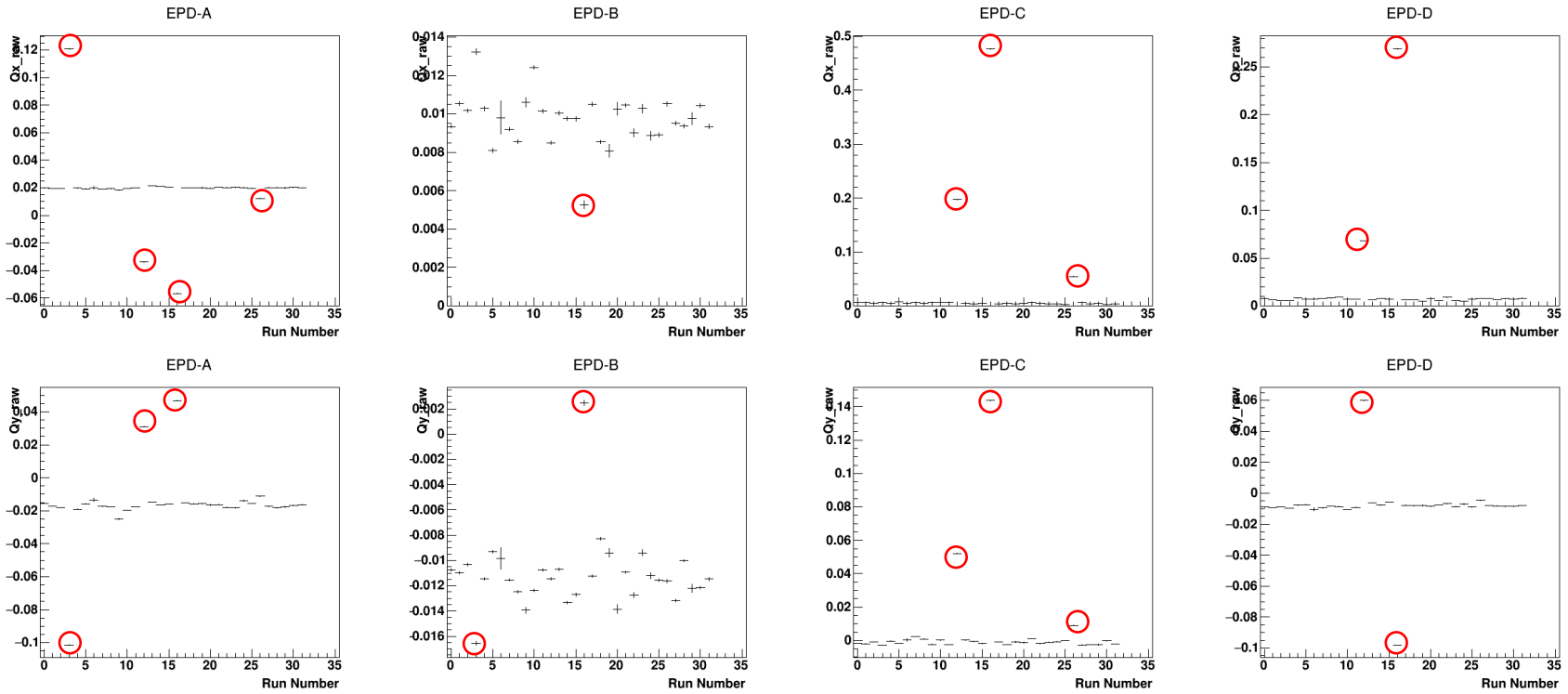
EPD Flow Vector QA

- We filled TProfiles of <Qx>/<Qy> vs run number, and found some outliers. We removed these runs.

Remove four badruns： 21035006, 21035025, 21035031, 21036007

$$Q_{x,raw} = \sum_i w_i \cos(\phi)$$

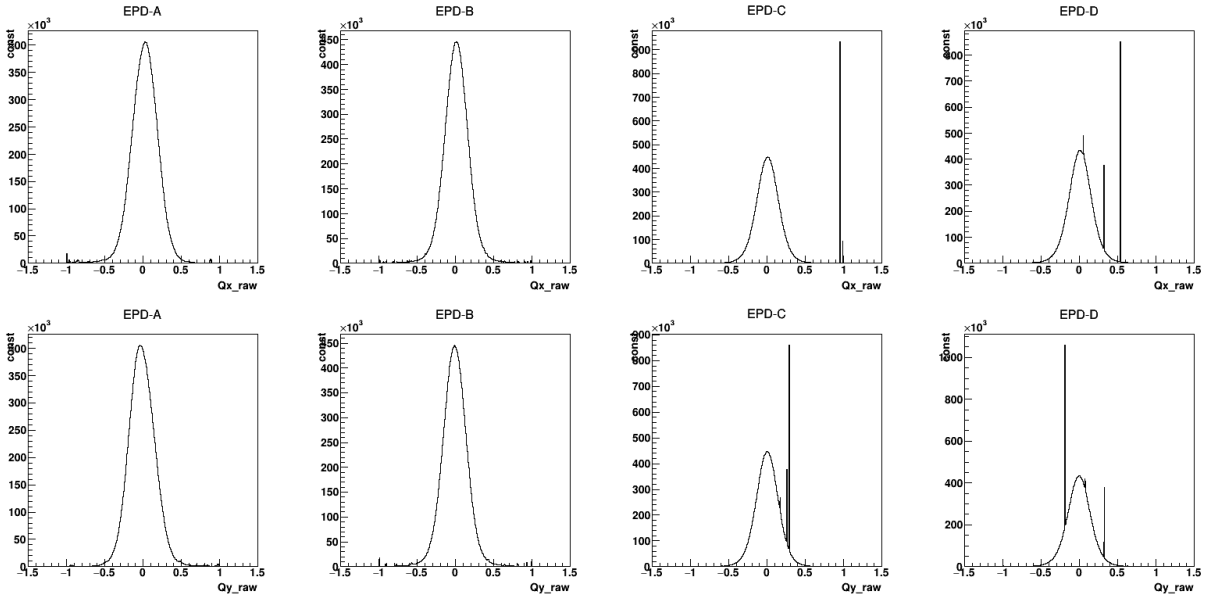
$$Q_{y,raw} = \sum_i w_i \sin(\phi)$$



<Qx>/<Qy> vs Run Number

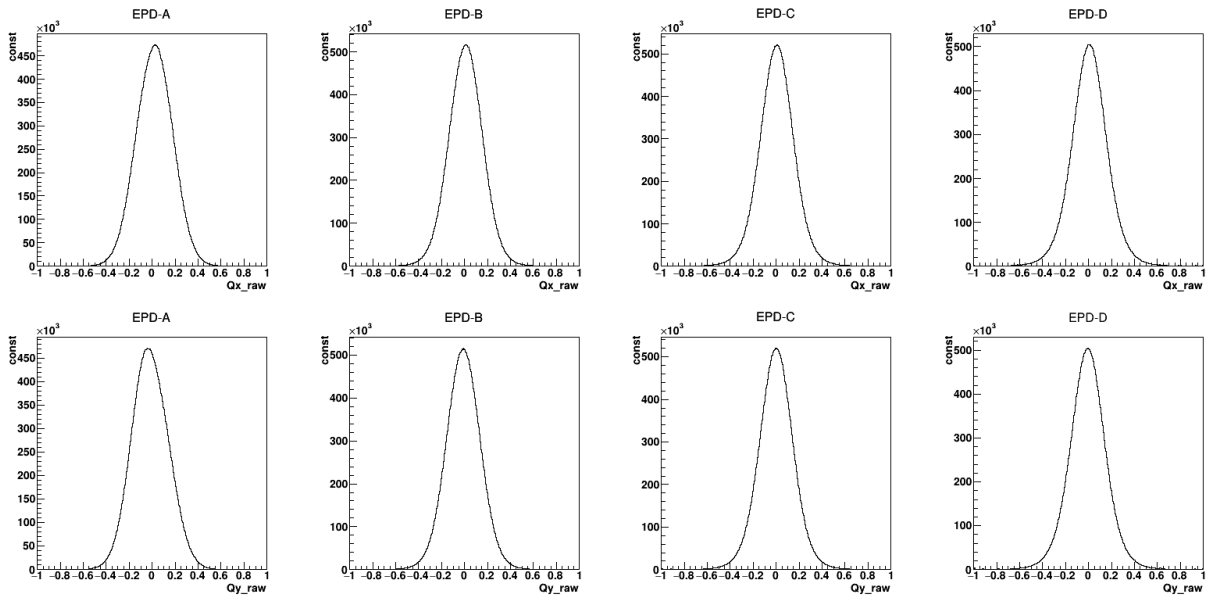
EPD Flow Vector QA

- Before we select the bad runs, there are some strange peaks in the Qx/y distributions of EPD-C and D



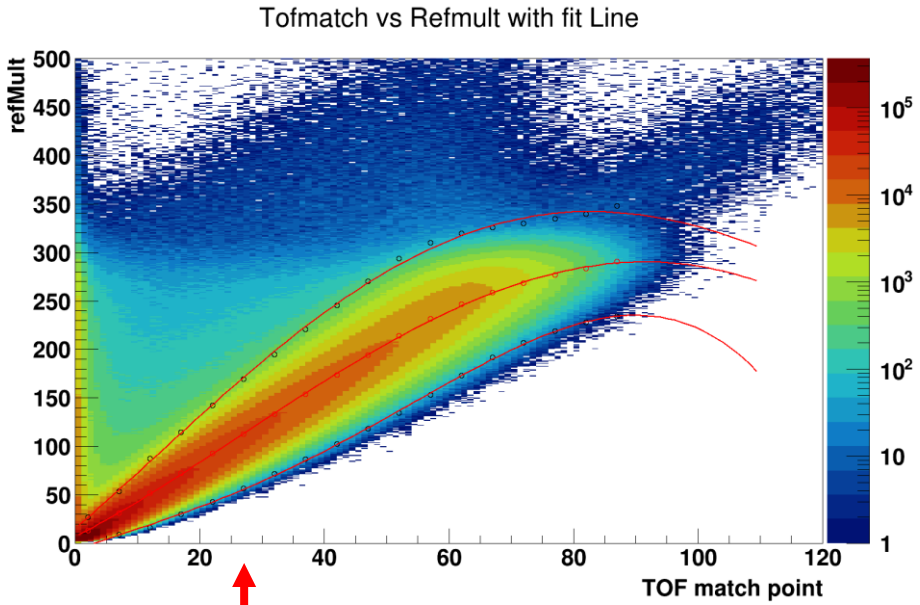
Qx/y distribution(before)

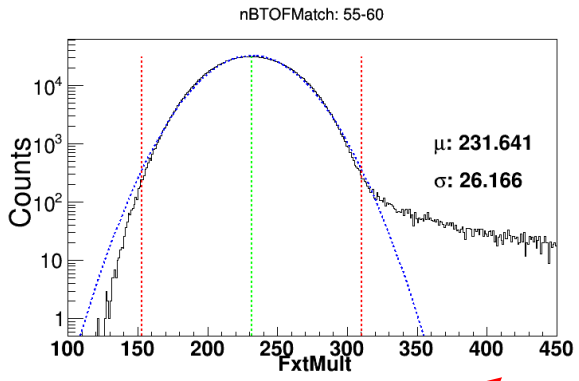
- After we removed the bad runs, the Qx/y distribution looks normal

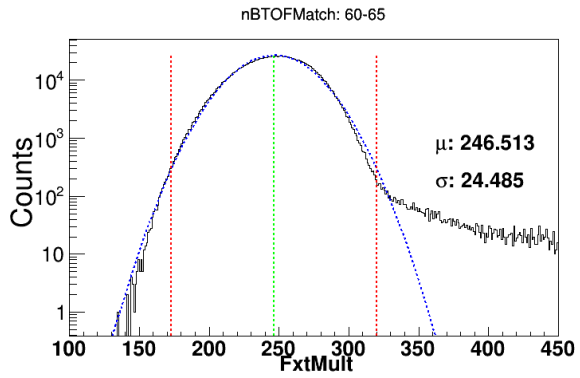


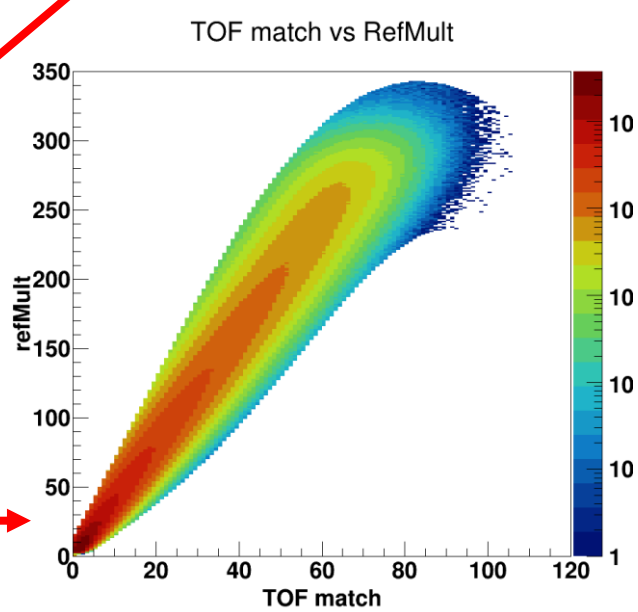
Qx/y distribution(after)

Pile-up Rejection





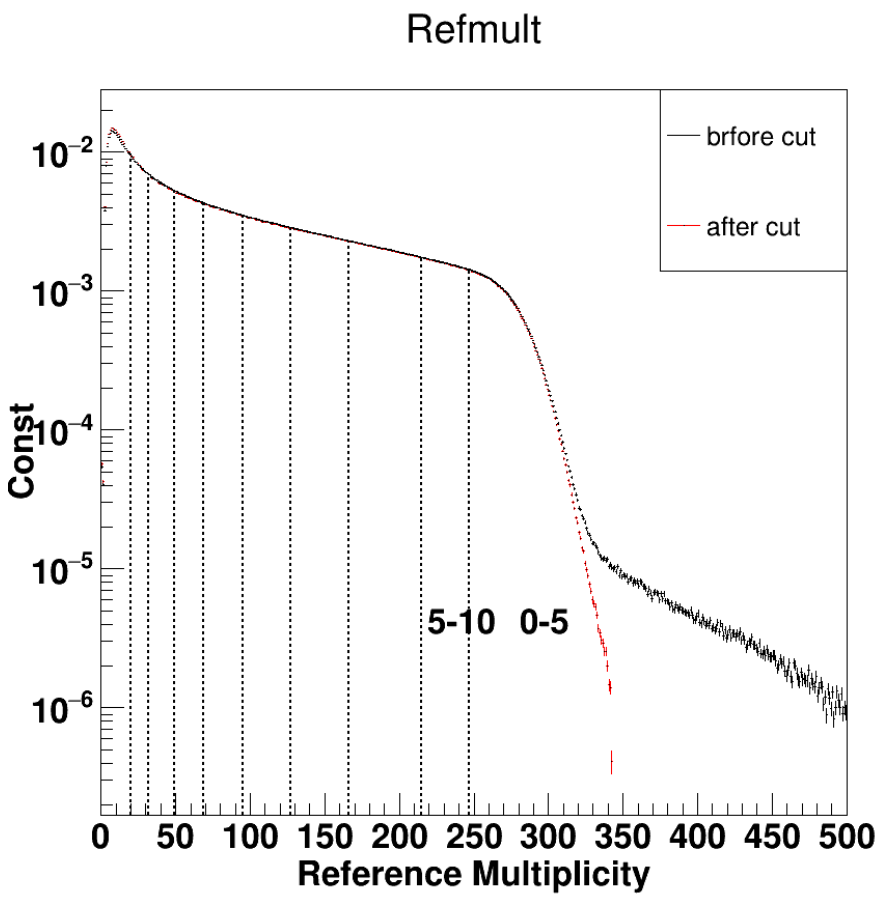




after pile-up rejection

- X-axis is divided into 18 bins, each bin is projected on the Y-axis.
- We then fitted the projected figures to obtain a group of points (3) shown in the upper left plot.
- We parametrize the 3 red curves to reject the pile-up

Centrality Determination



centrality	Refmult cut (>)
0-5%	247
5-10%	215
10-20%	166
20-30%	127
30-40%	95
40-50%	69
50-60%	49
60-70%	32
70-80%	20

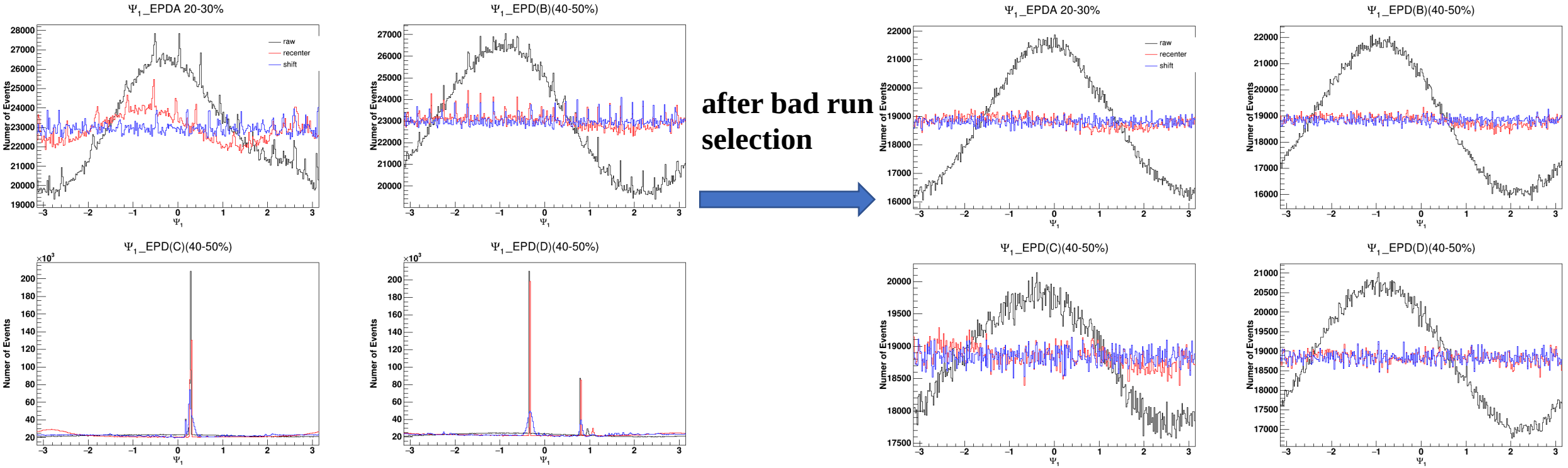
- The event centrality classes are determined by using the raw multiplicity distribution

Event Plane Reconstruction

$$Q_{x,rc} = \sum_{i}^{N} w_i \cos(\phi_i) - \langle w_i \cos(\phi_i) \rangle \qquad \Psi_{1,raw} = tan^{-1} \frac{Q_{y,raw}}{Q_{x,raw}} \qquad \Psi_{1,rc} = tan^{-1} \frac{Q_{y,rc}}{Q_{x,rc}}$$

$$Q_{y,rc} = \sum_{i}^{N} w_i \sin(\phi_i) - \langle w_i \sin(\phi_i) \rangle \qquad \Psi_{1,shift} = \sum_{i}^{N} \frac{2}{i} [-\langle \sin(i\Psi_{1,rc}) \rangle \cos(i\Psi_{1,rc}) + \langle \cos(i\Psi_{1,rc}) \rangle \sin(i\Psi_{1,rc})]$$

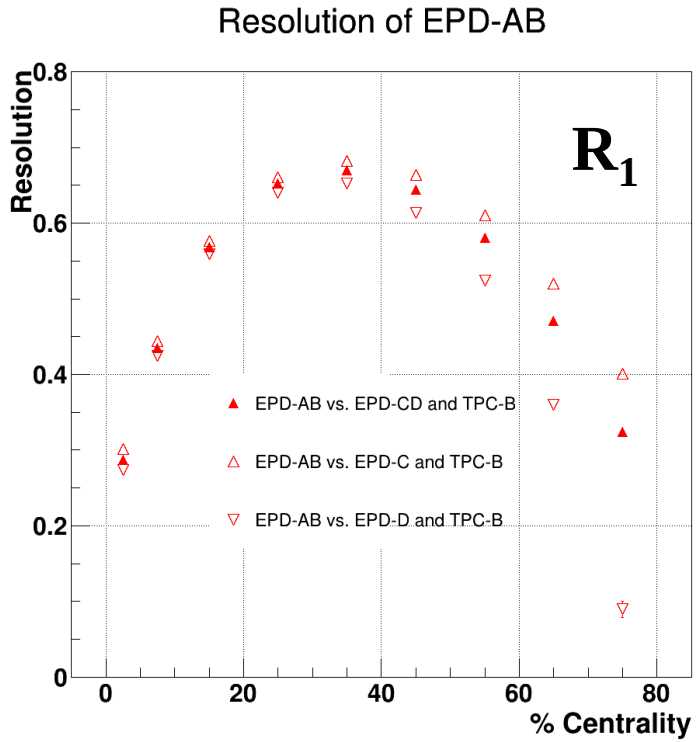
- After we removed bad runs, the strange peaks in the left plots disappear

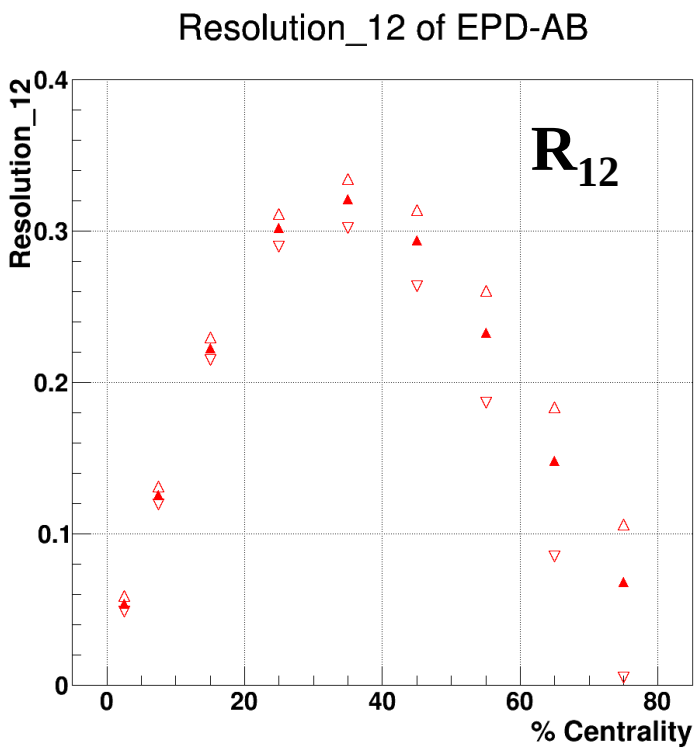


the Ψ_1 before removed bad runs

the Ψ_1 after removed bad runs

EPD Event Plane Resolution





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

$$R_1(\chi_1) = \frac{\sqrt{\pi}}{2\sqrt{2}}\chi_1 \exp\left(-\frac{{\chi_1}^2}{4}\right) * \left[I_0\left(\frac{{\chi_1}^2}{4}\right) + I_1\left(\frac{{\chi_1}^2}{4}\right)\right]$$

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

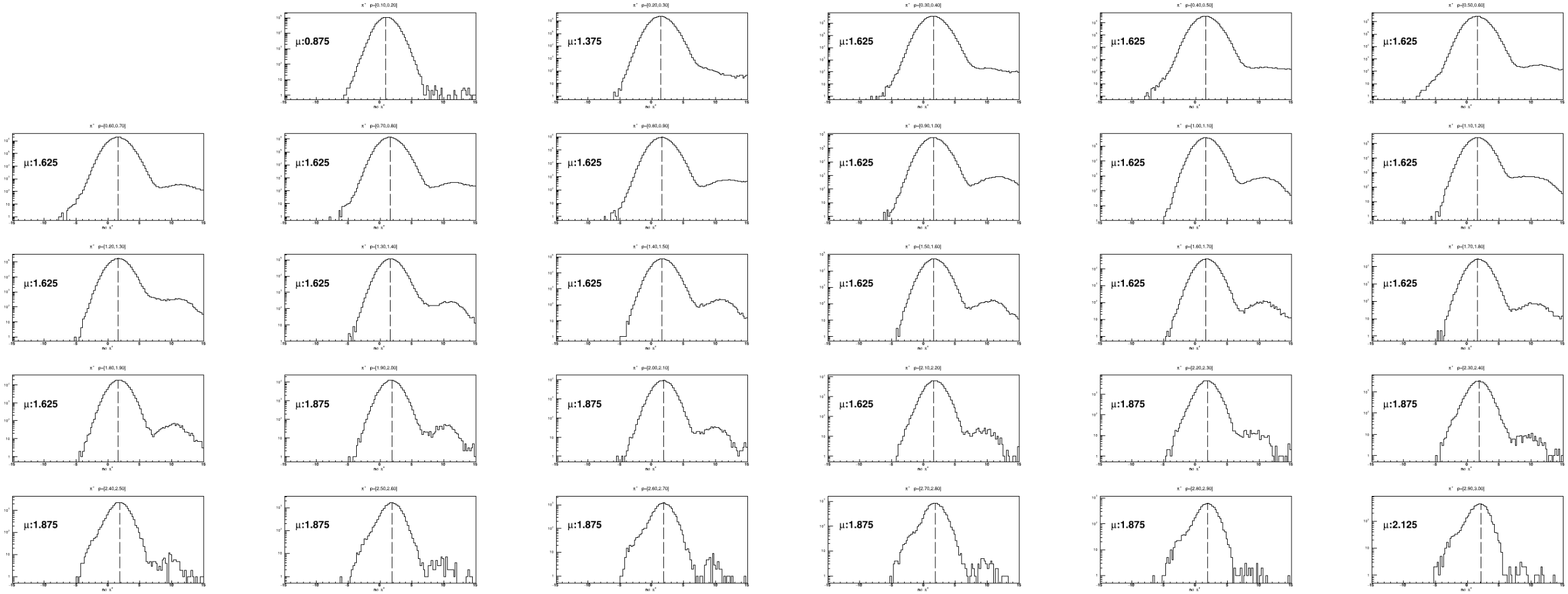
Reference: A. M. Poskanzer and S. A. Voloshin, "Methods for analyzing anisotropic flow in relativistic nuclear Phys. Rev. C 58, 1671 (1998) [nucl-ex/9805001].

- EPD-AB 1st event plane resolution as a function of centrality

The $n\sigma$ shift: π^+

1. Use tight m^2 cuts to determine the shift of $n\sigma$ as a function of p

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

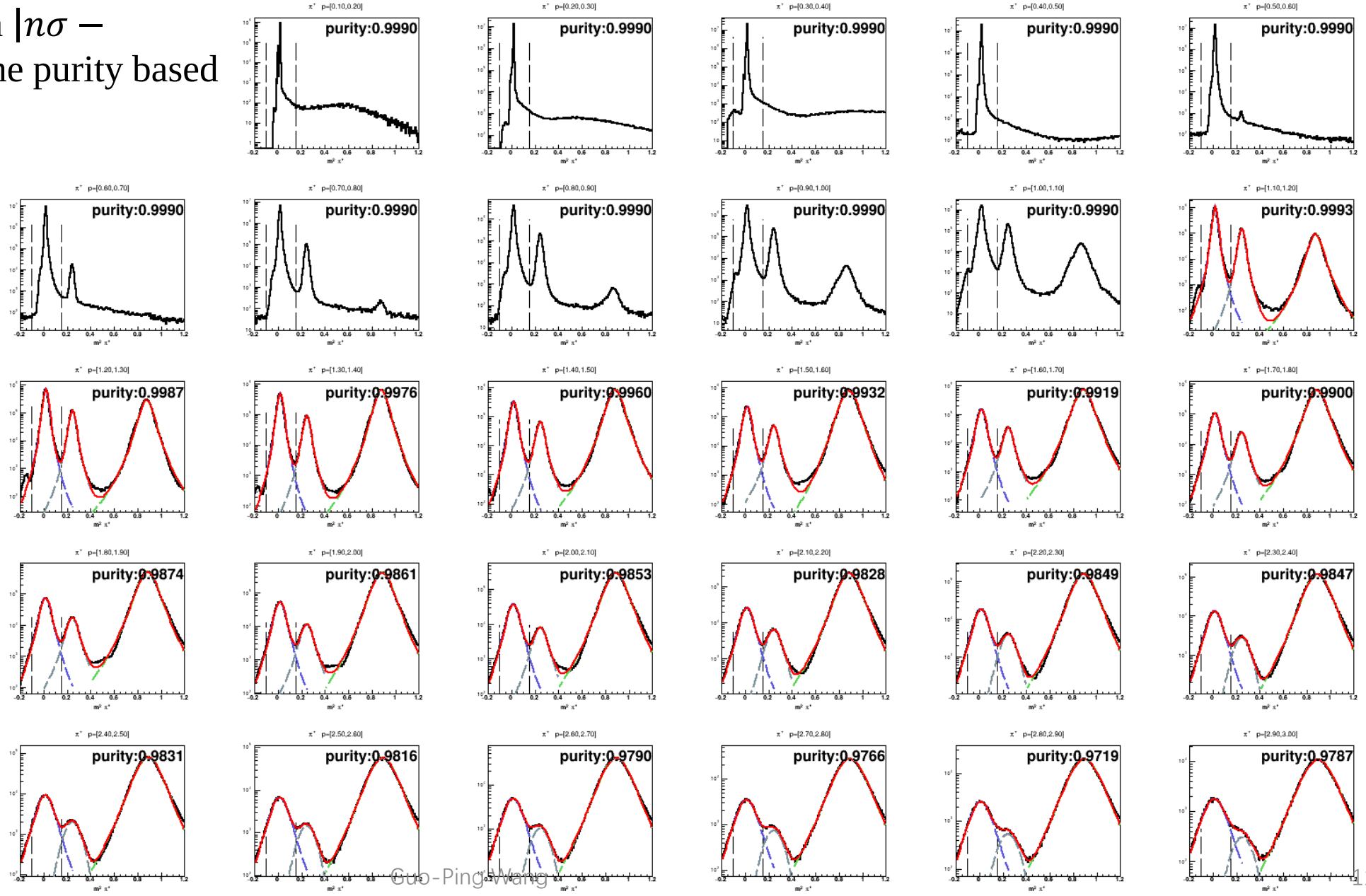


Purity of π^+

2. Get m^2 distribution with $|n\sigma - shift| < 3$ and calculate the purity based on m^2 distribution

3 Student-t function used

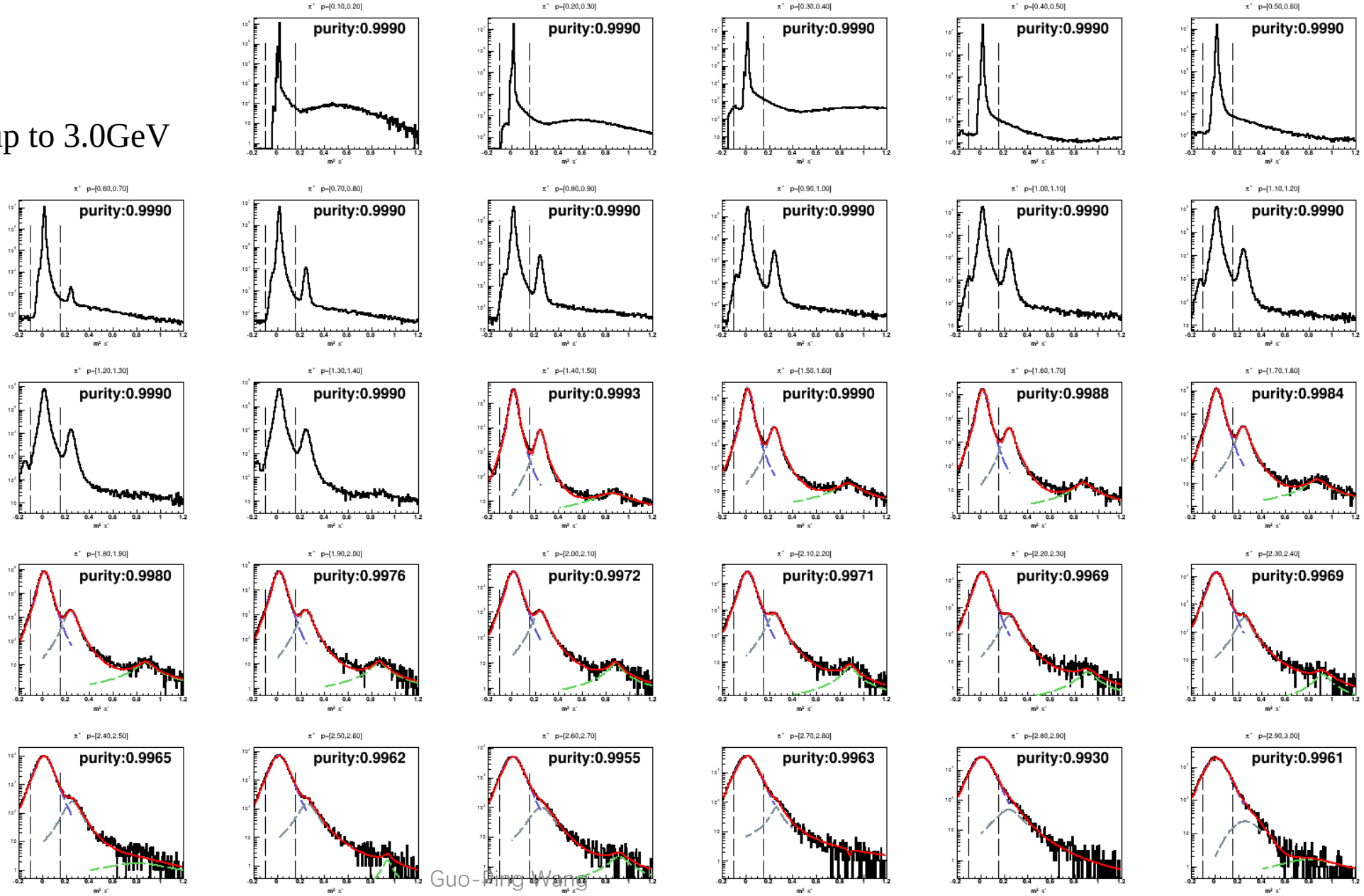
Purity can reach to 97% up to 3.0GeV



Purity of π^-

Purity can reach to 99% up to 3.0GeV

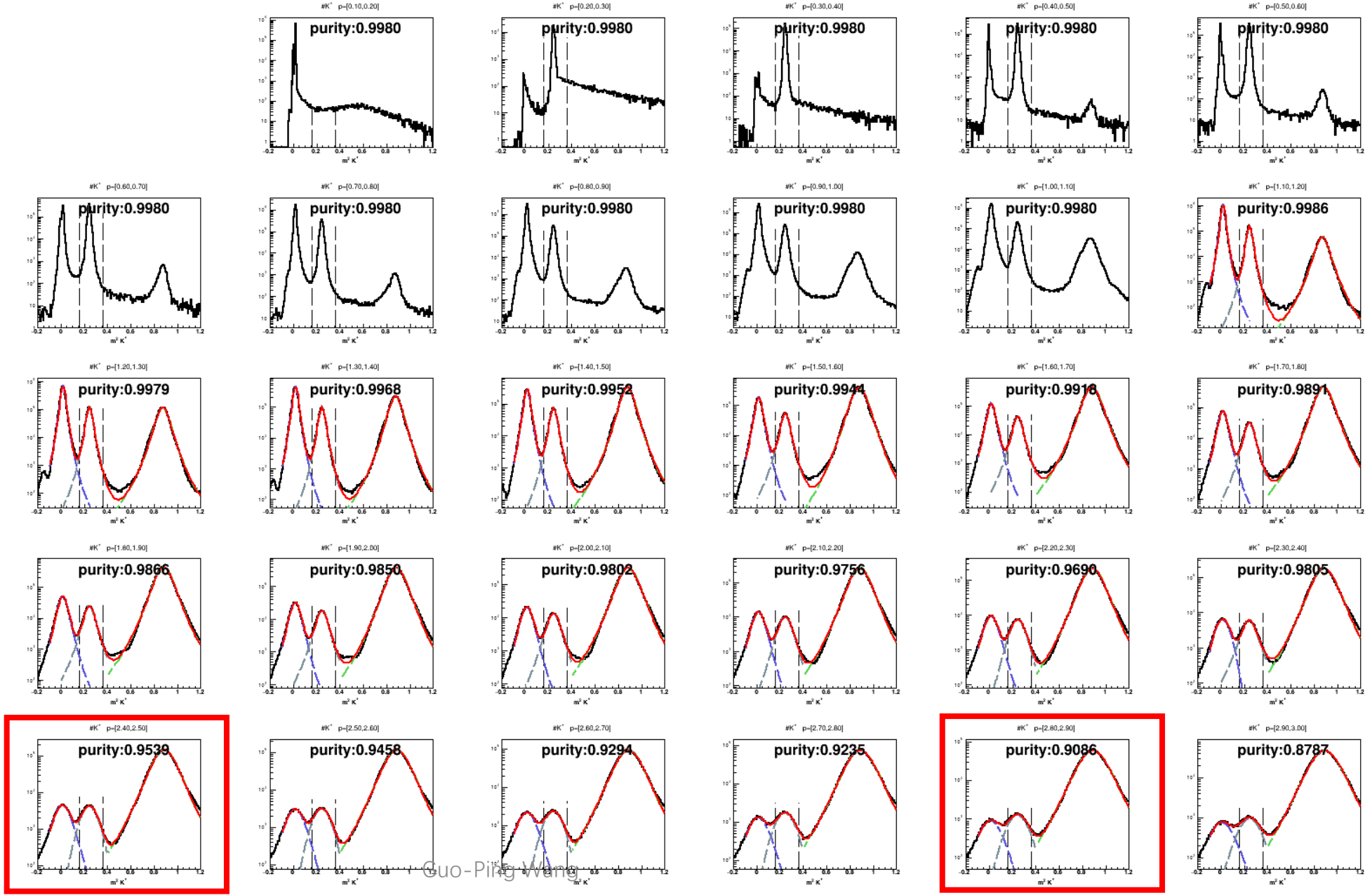
3 student-t function used



Purity of K^+

3 Student-t function used

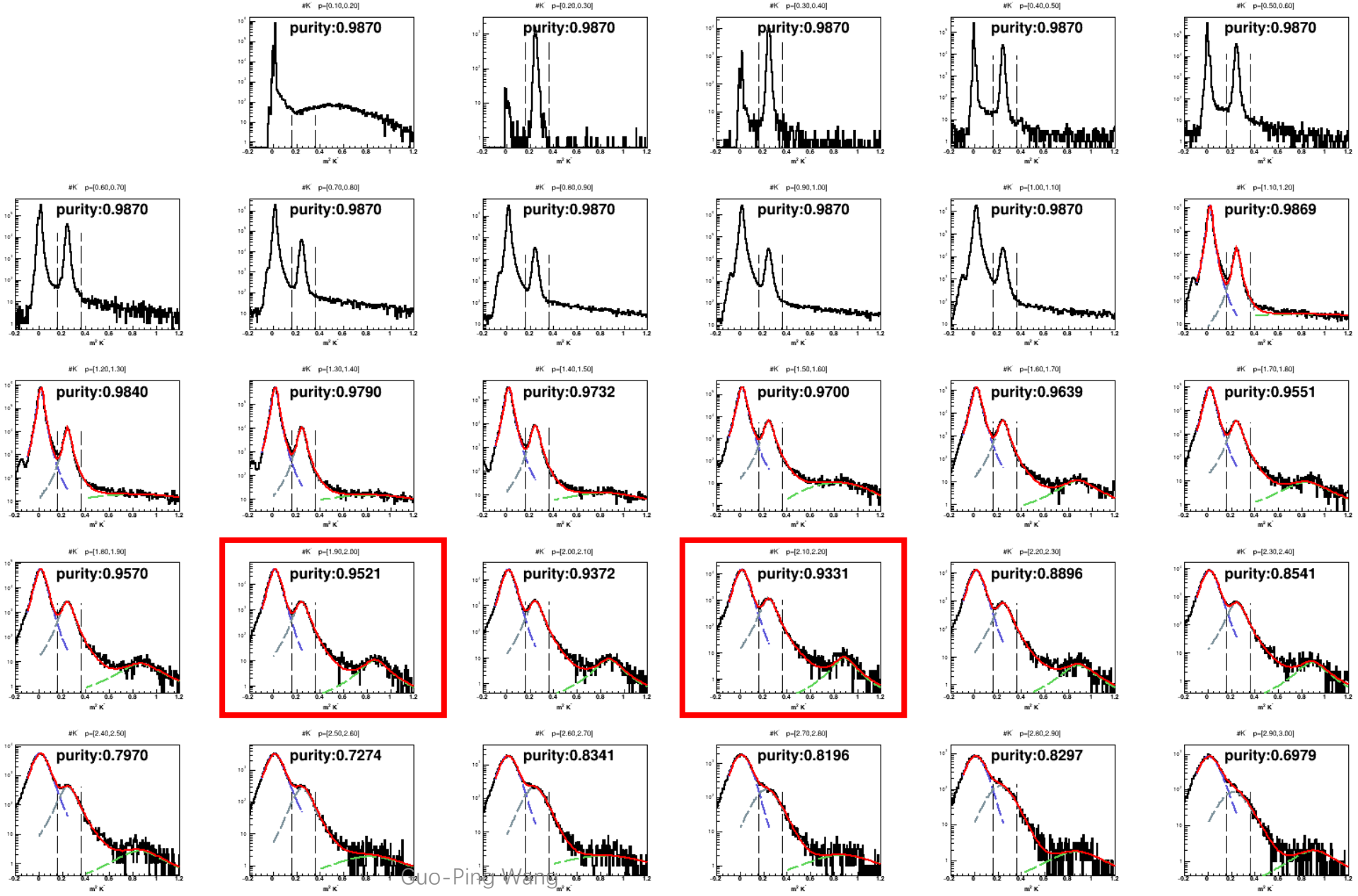
Purity:
95% up to 2.5GeV
90% up to 2.9GeV



Purity of K^-

3 Student-t function used

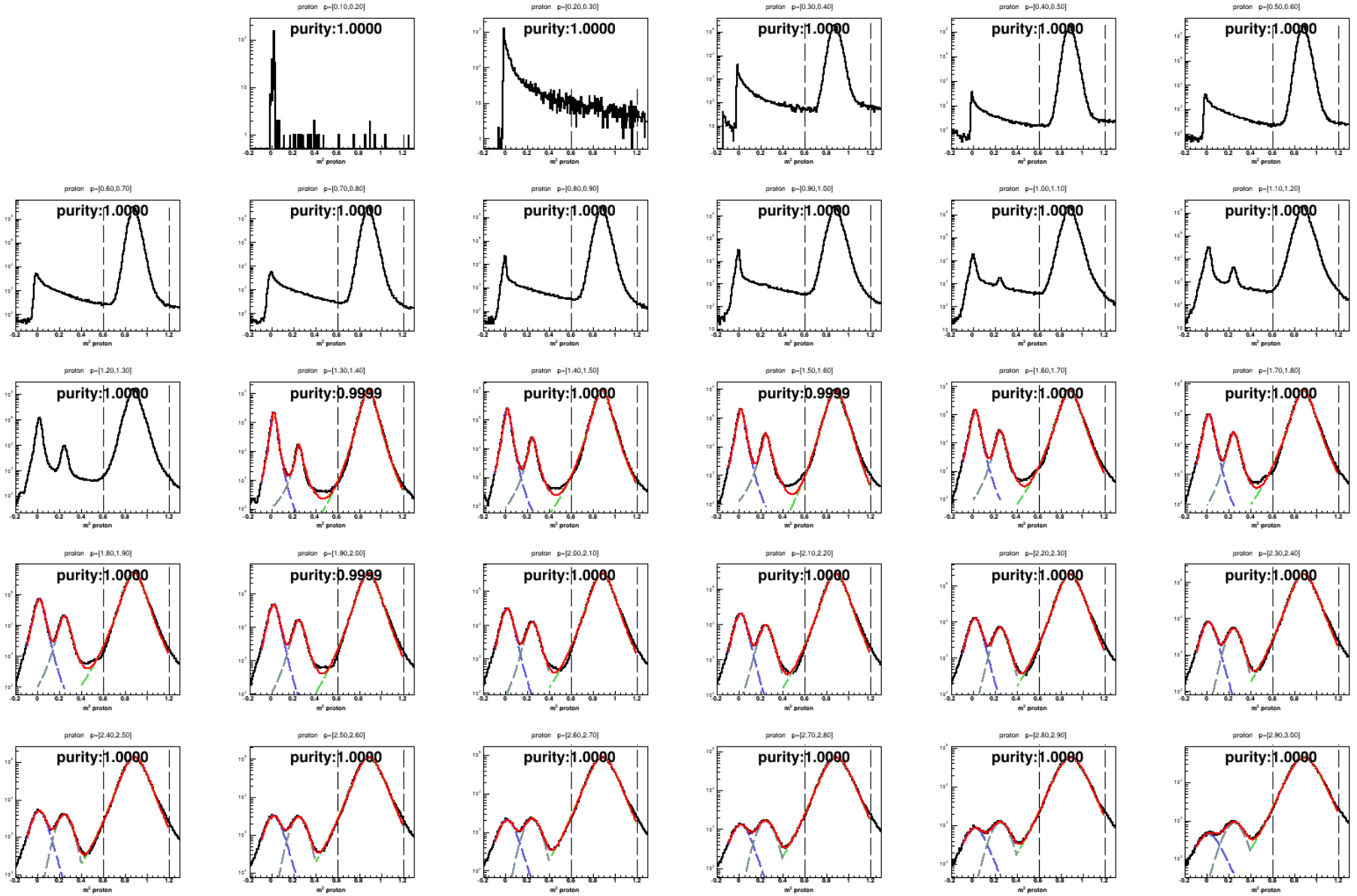
Purity:
95% up to 2.0GeV
90% up to 2.2GeV



Purity of p

0.1 < p < 3GeV

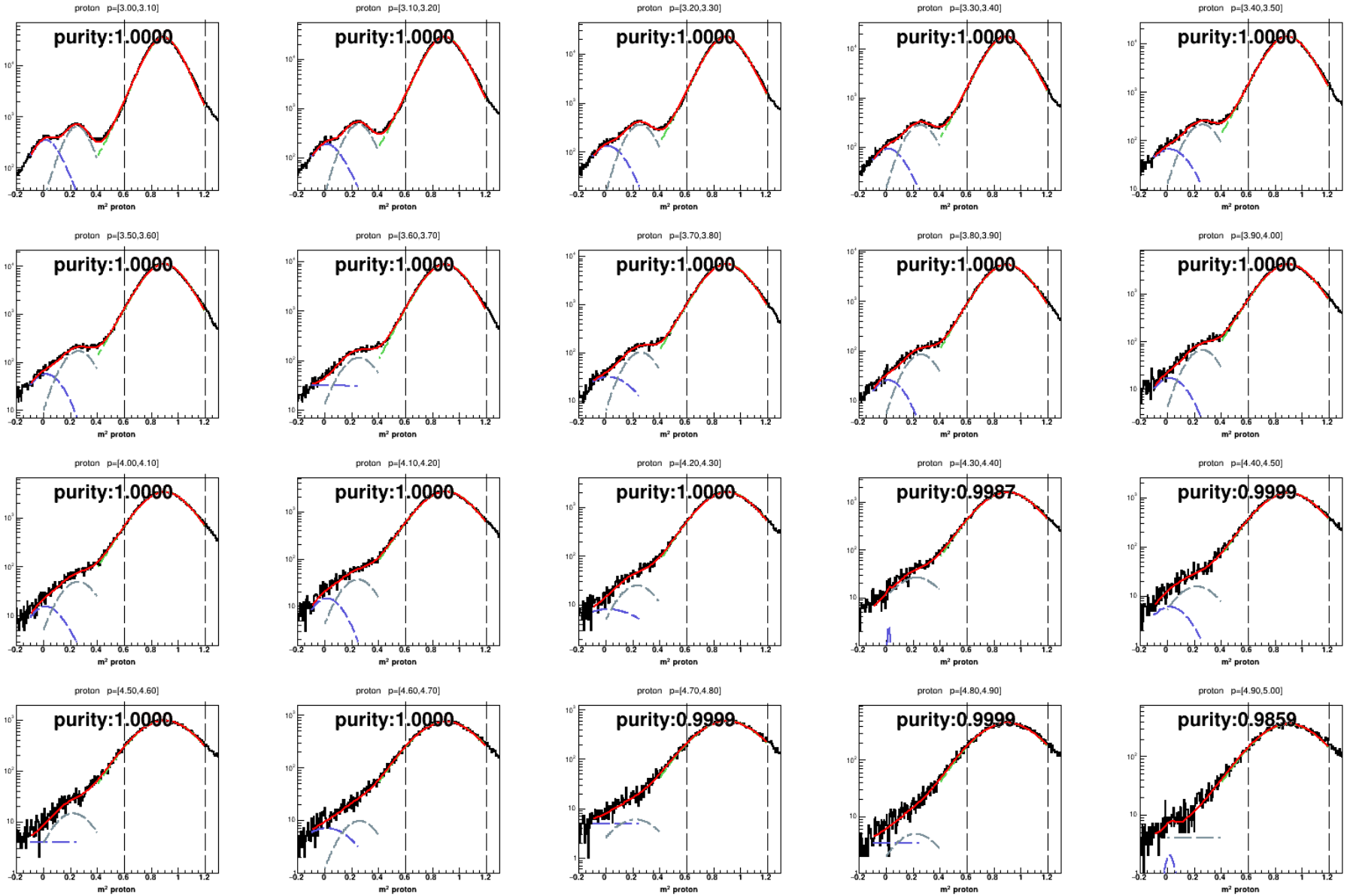
3-Student-t function used



Purity of p

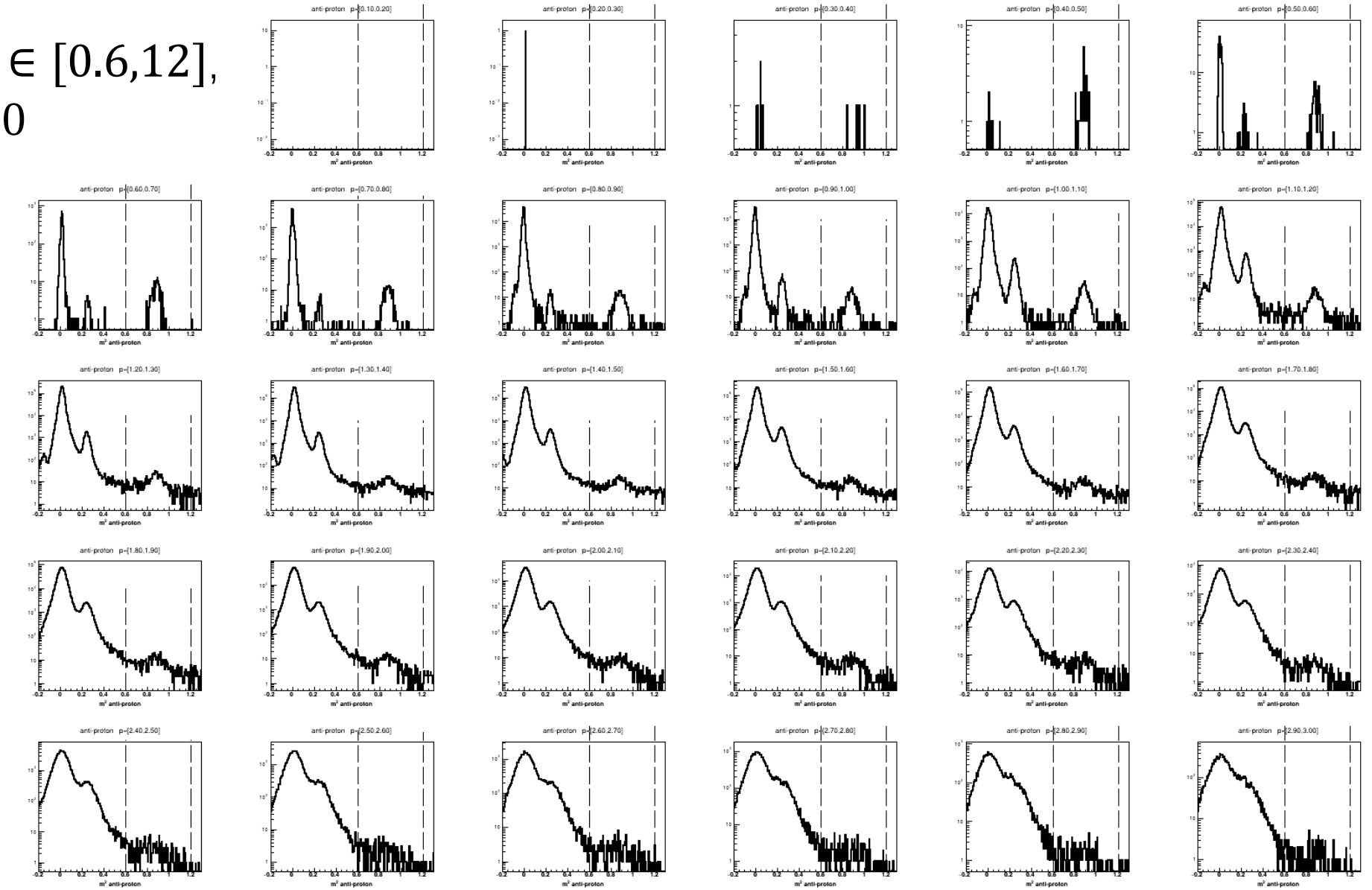
3.0 < p < 5.0GeV

Purity can reach to 98% up to 5.0GeV

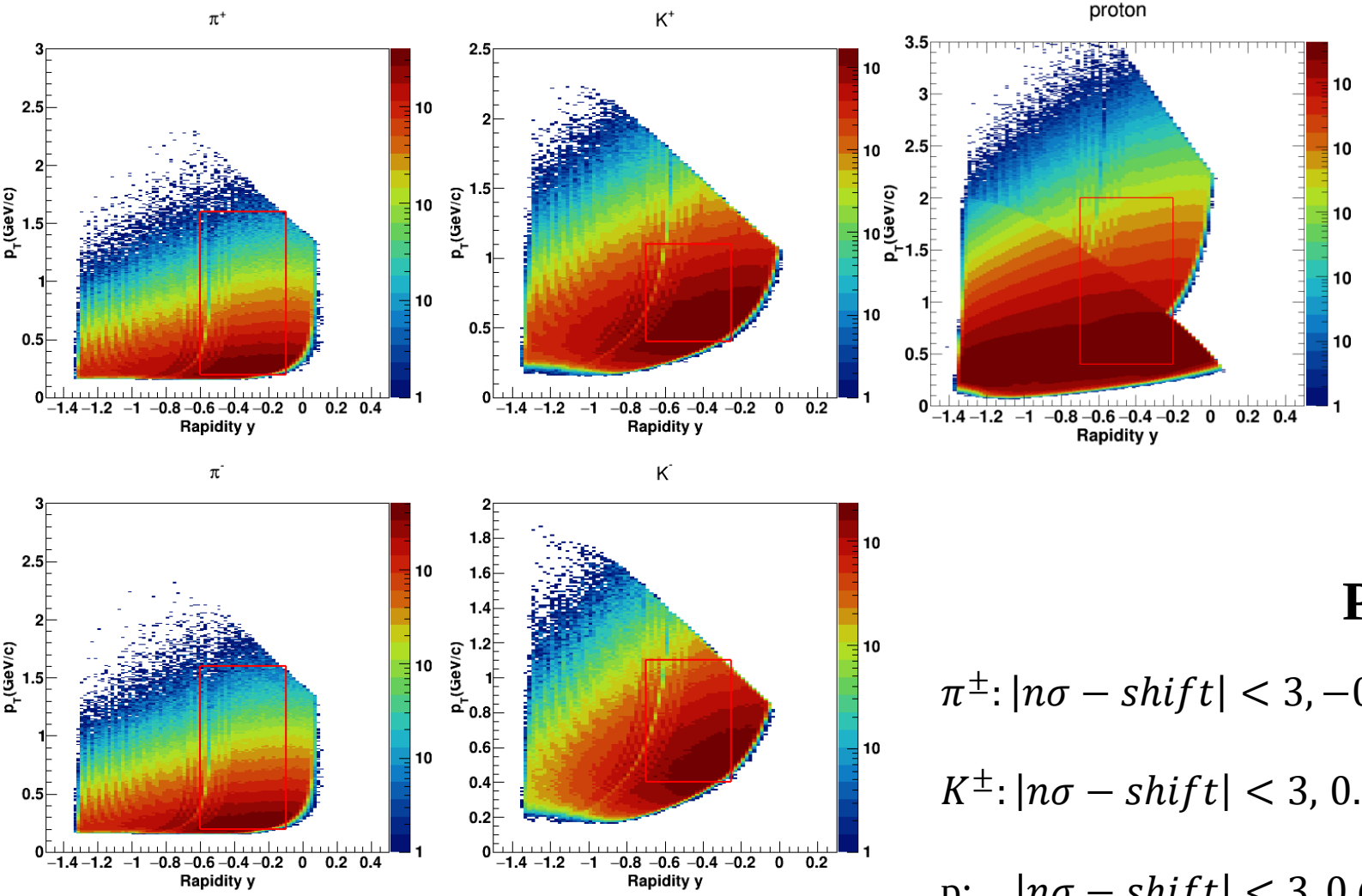


Purity of $\bar{p}$

In the range of $m_{\bar{p}}^2 \in [0.6,12]$, $\bar{p}$ yields less than 20



Acceptance



Acceptance window

- $\pi^{\pm}$: $y \in (-0.6, -0.1), Pt \in (0.2, 1.6)$ GeV/c
- $K^{\pm}$: $y \in (-0.7, -0.25), Pt \in (0.4, 1.1)$ GeV/c
- P: $y \in (-0.7, -0.2), Pt \in (0.4, 2.0)$ GeV/c

PID cuts

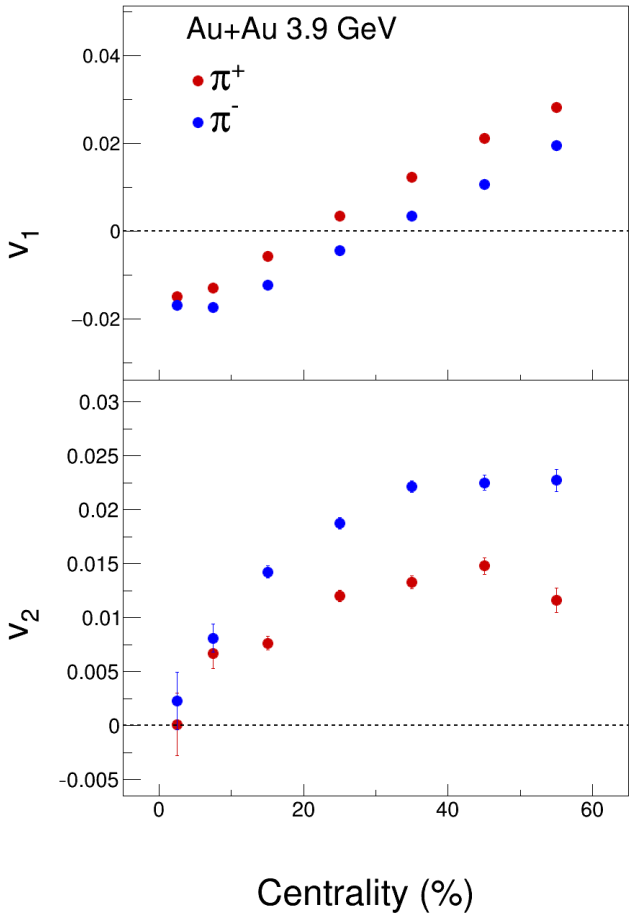
$\pi^{\pm}$: $|n\sigma - shift| < 3, -0.1 < m^2 < 0.15$ GeV^2/c^4, P < 3.0 GeV/c

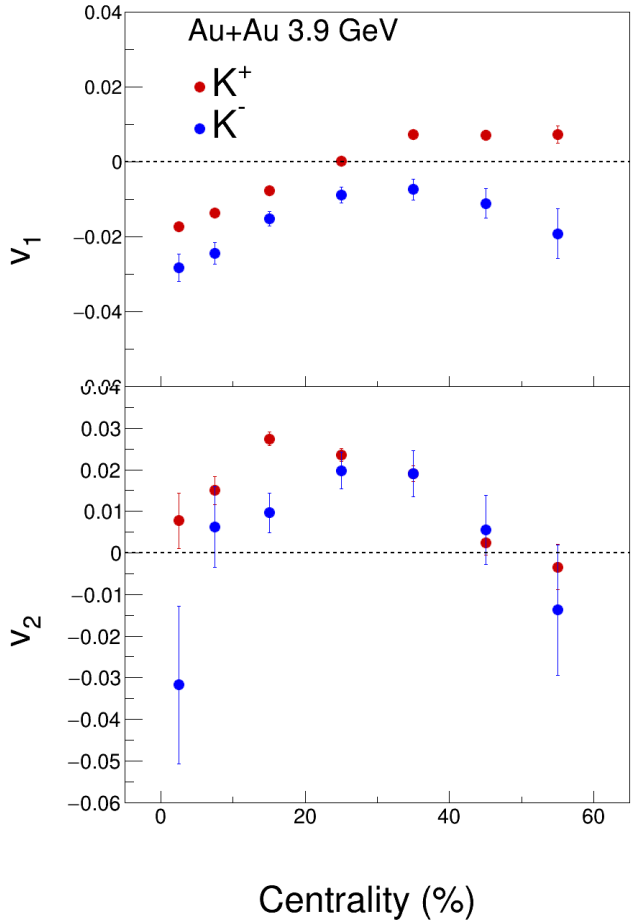
$K^{\pm}$: $|n\sigma - shift| < 3, 0.16 < m^2 < 0.36$ GeV^2/c^4, P < 2.2 GeV/c

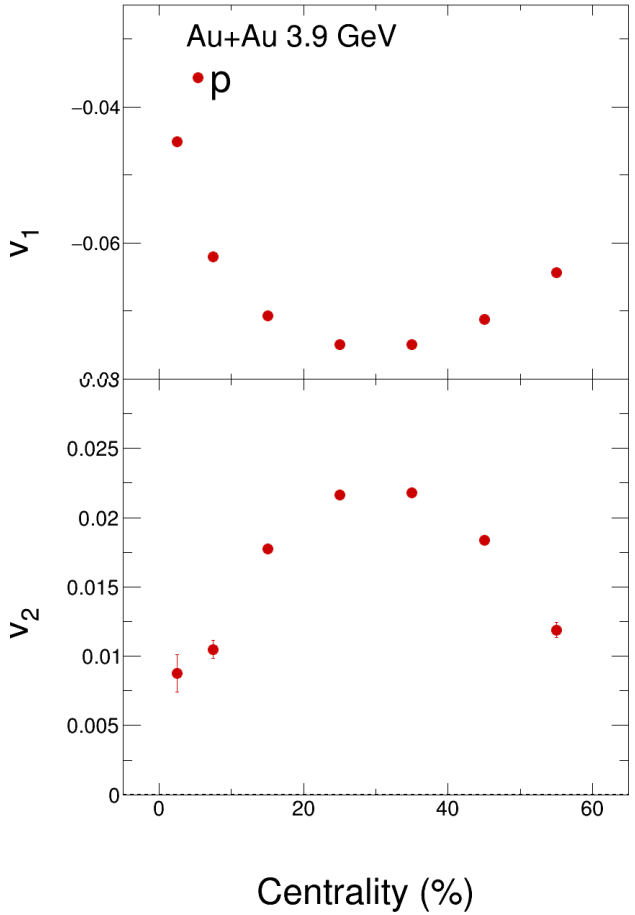
p: $|n\sigma - shift| < 3, 0.6 < m^2 < 1.2$ GeV^2/c^4, P < 5.0 GeV/c

Centrality Dependence of v_1 and v_2

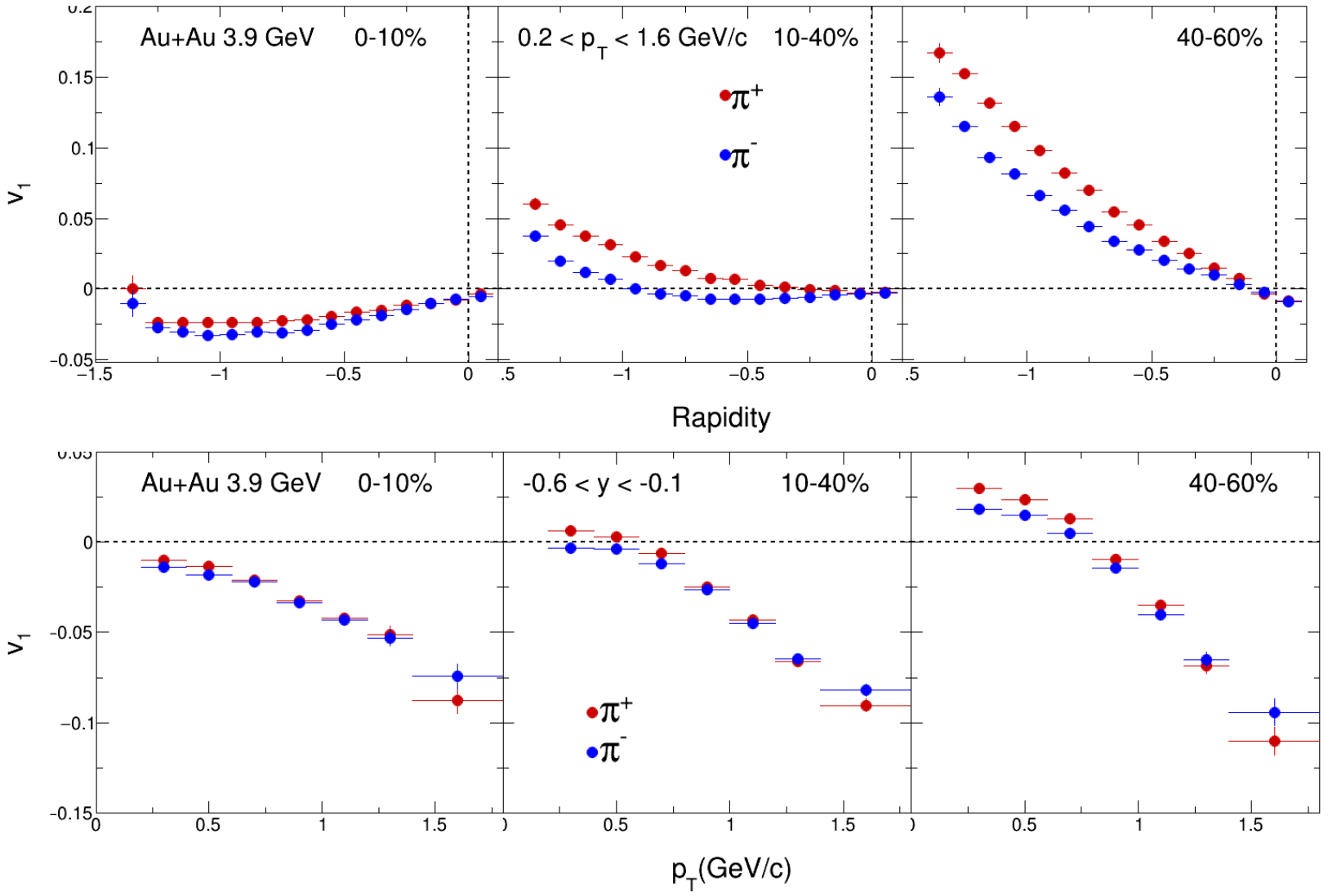
$$v_1 = \frac{v_1^{obs}}{R_1} = \frac{\langle \cos(\phi - \Psi_1) \rangle}{\langle \cos(\Psi_1 - \Psi_r) \rangle} \qquad v_2 = \frac{v_2^{obs}}{R_{12}} = \frac{\langle \cos 2(\phi - \Psi_1) \rangle}{\langle \cos 2(\Psi_1 - \Psi_r) \rangle}$$





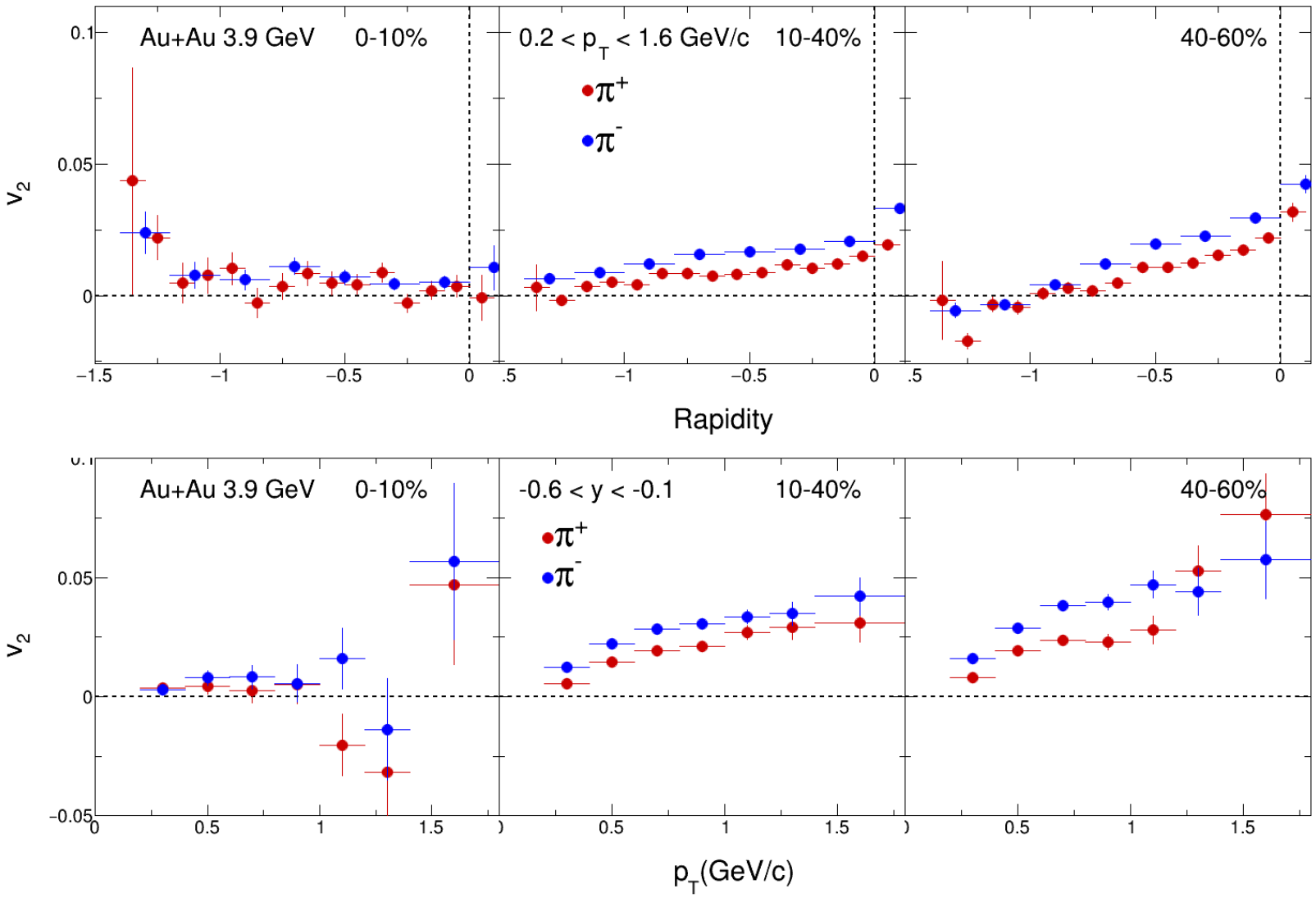


p_T and y dependence of v_1 for $\pi^{\pm}$



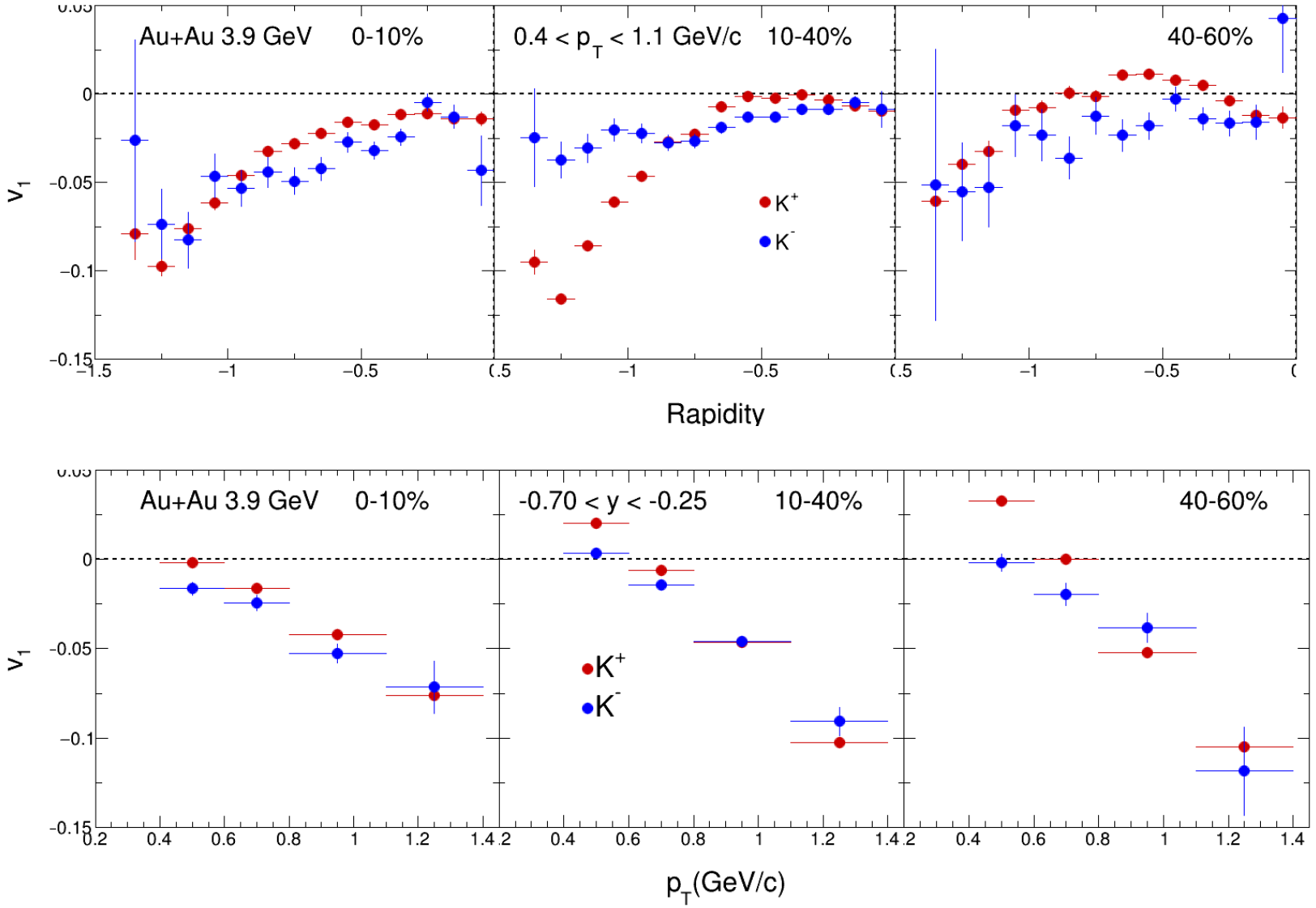
p_T and y dependence of v_1 measured in three centrality bins

p_T and y dependence of v_2 for $\pi^{\pm}$



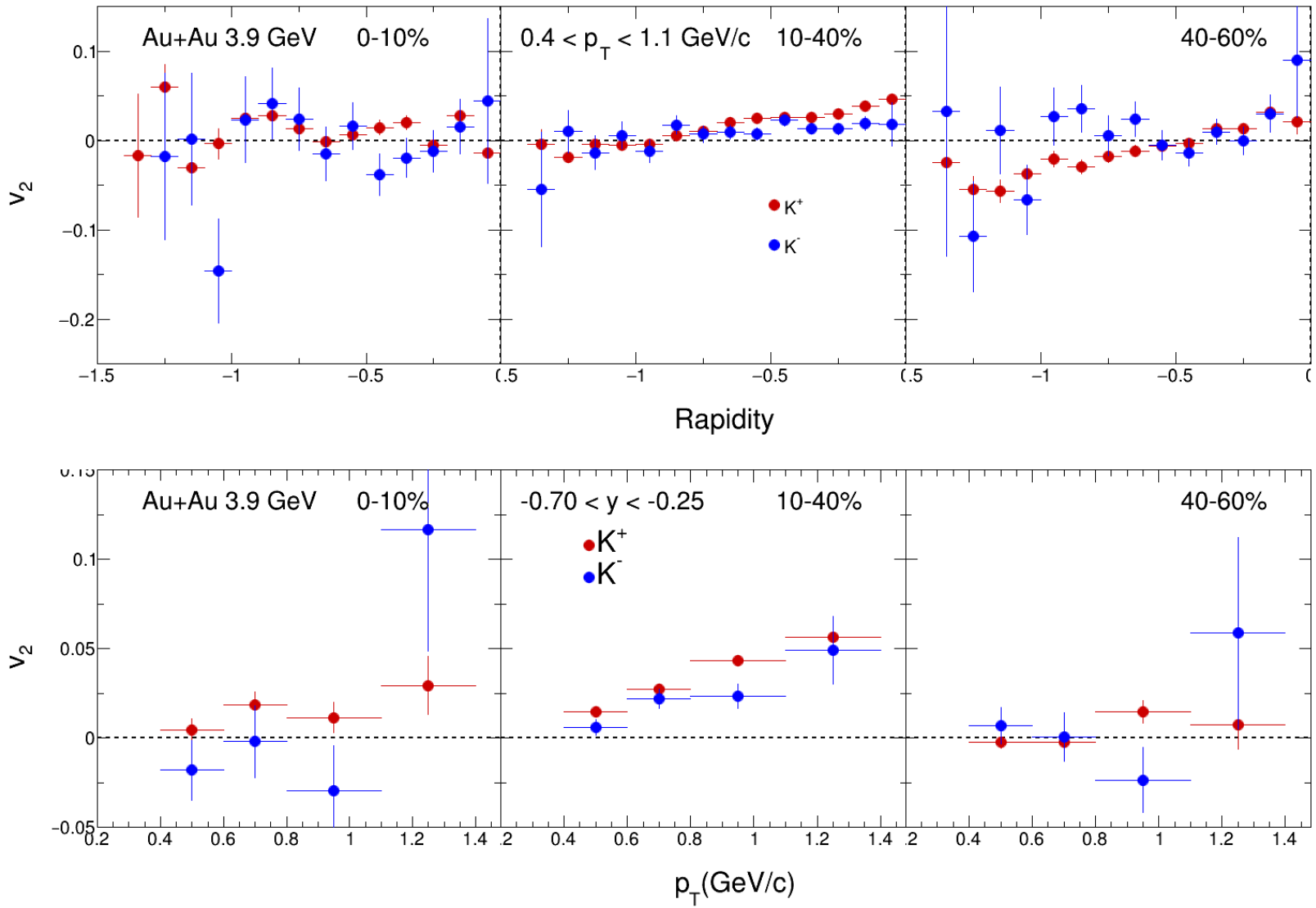
p_T and y dependence of v_2 measured in three centrality bins

p_T and y dependence of v_1 for $K^{\pm}$



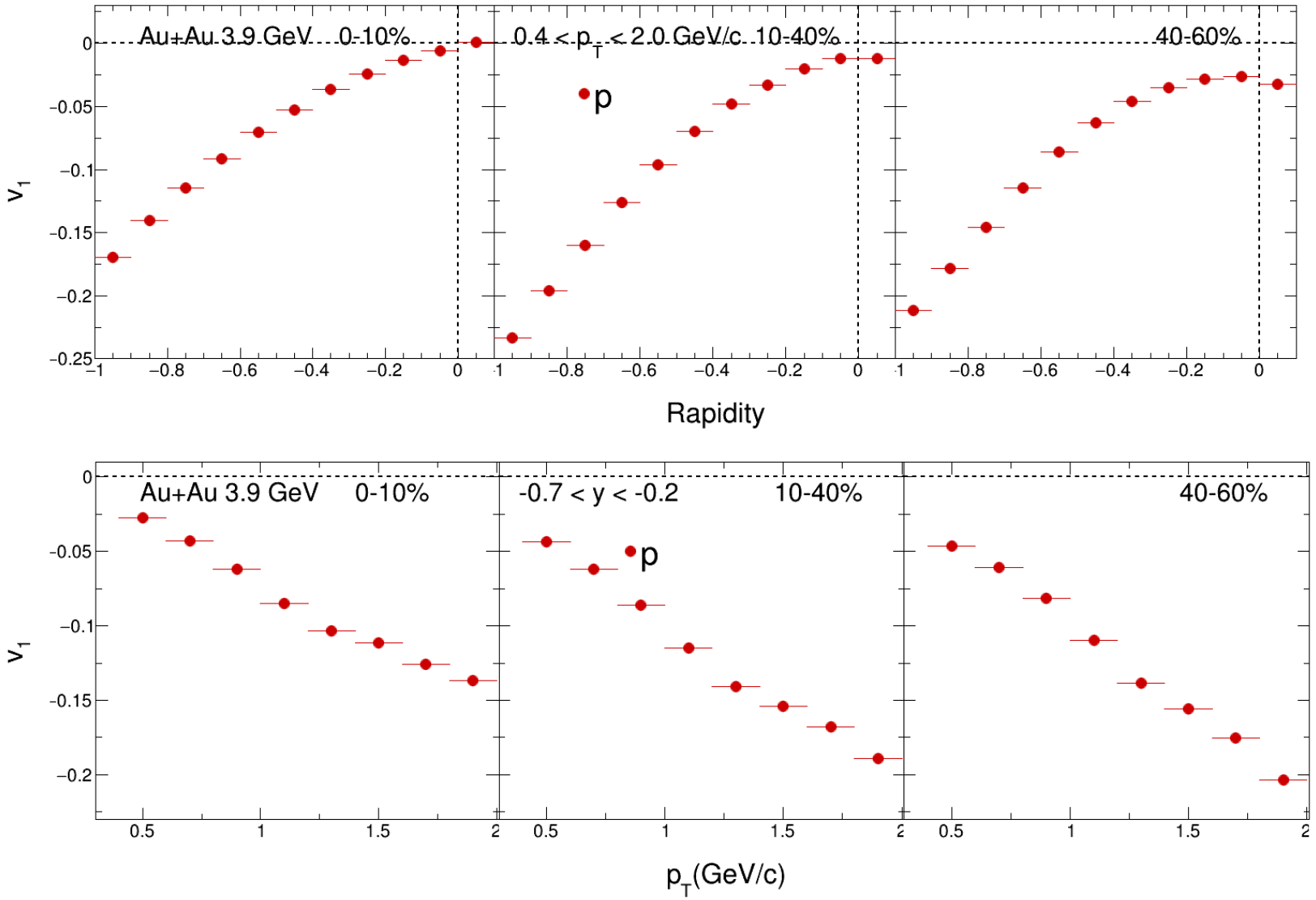
p_T and y dependence of v_1 measured in three centrality bins

p_T and y dependence of $K^{\pm}$ v_2



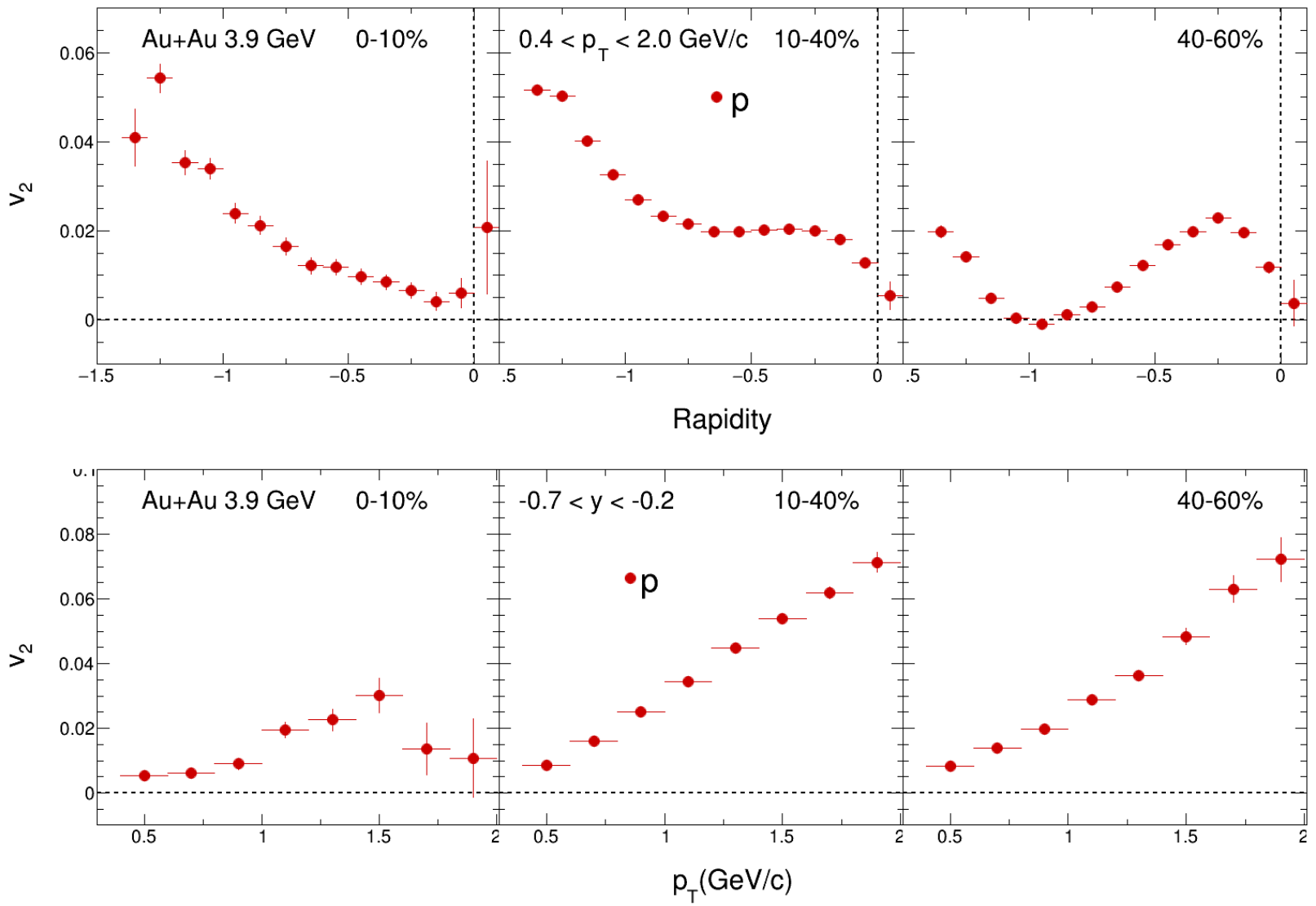
p_T and y dependence of v_2 measured in three centrality bins

p_T and y dependence of p v_1



p_T and y dependence of v_1 measured in three centrality bins

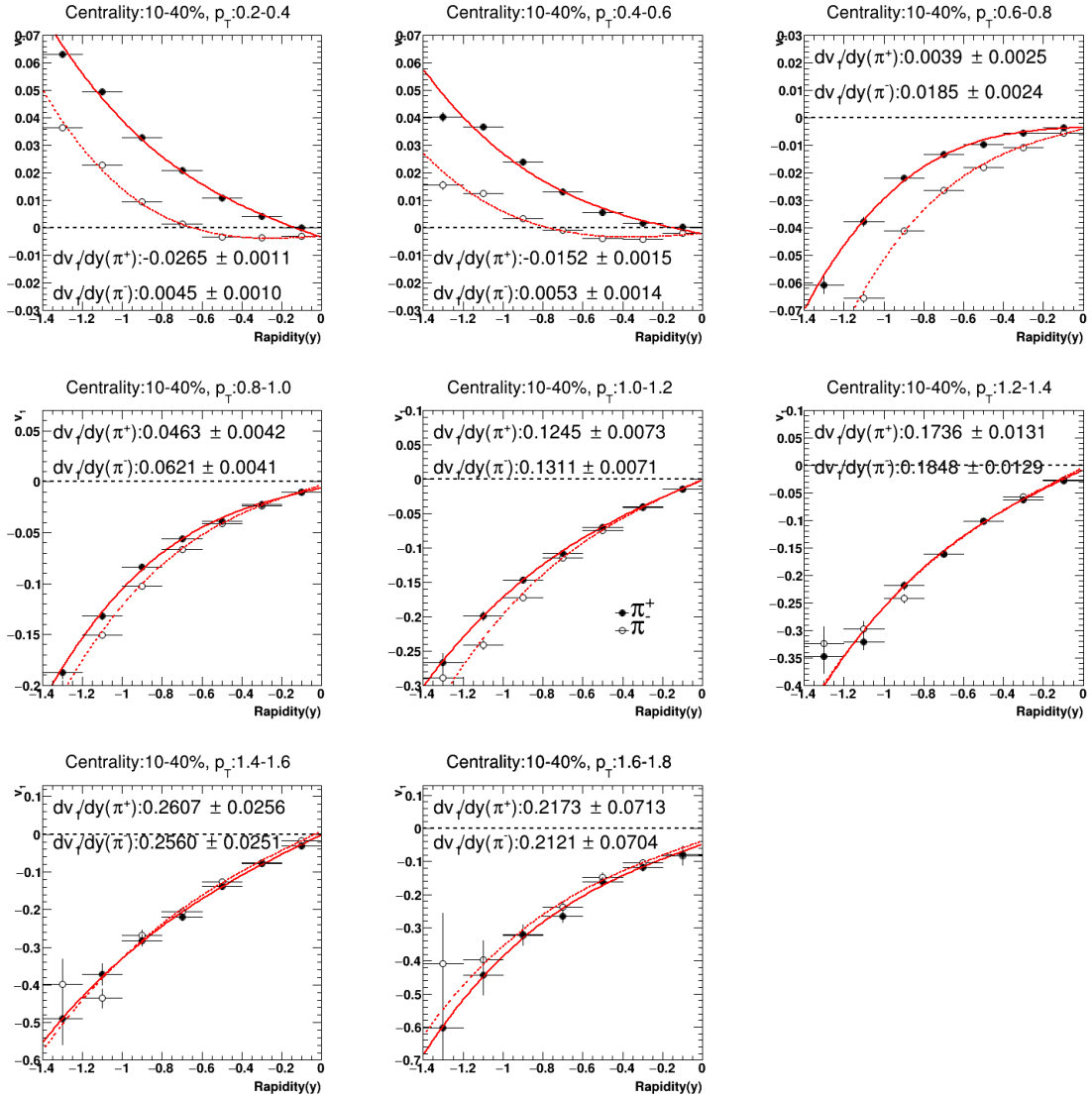
p_T and y dependence of p v_2



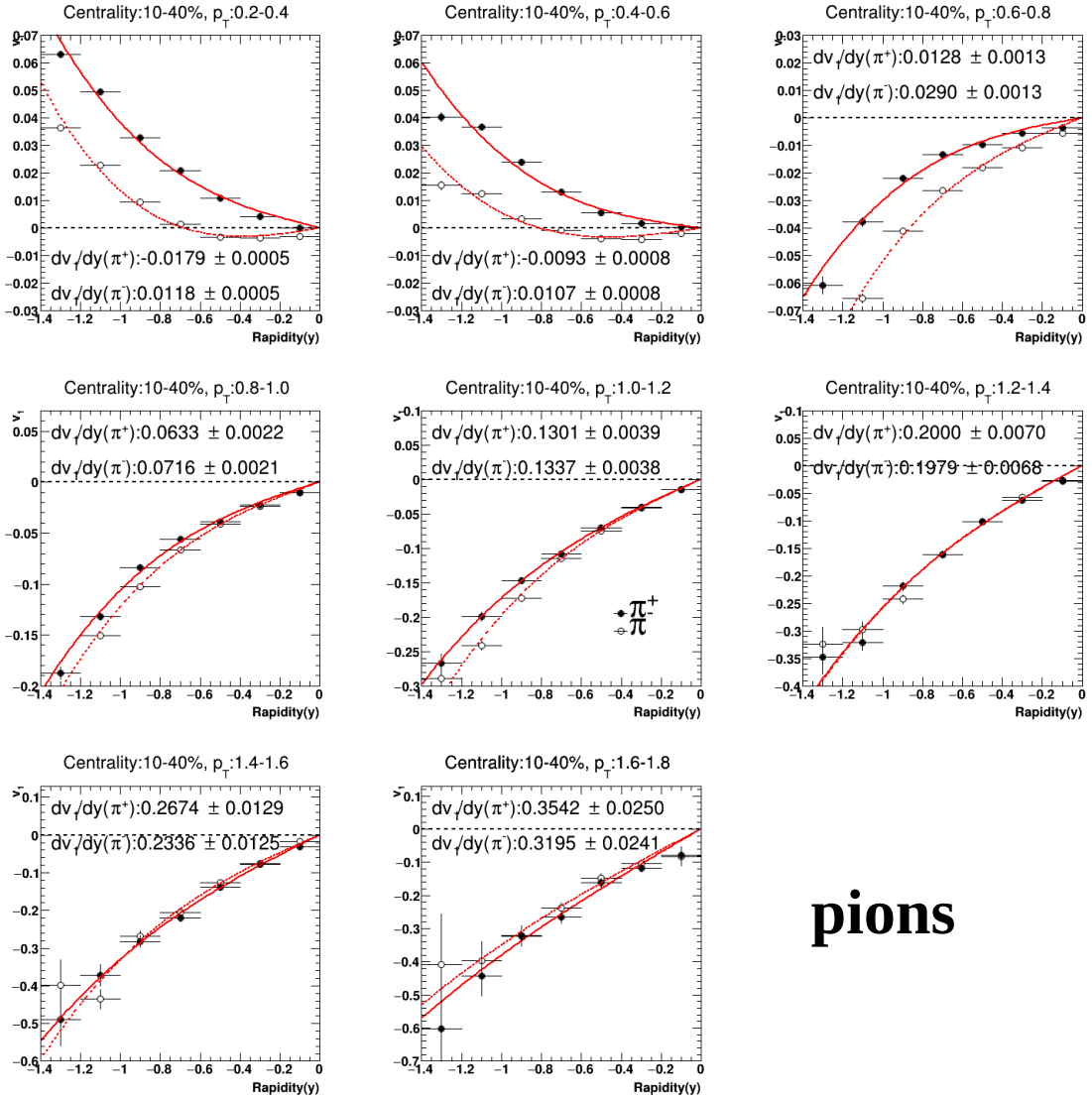
p_T and y dependence of v_2 measured in three centrality bins

p_T dependence of v_1 slope

$f(x) = ax + bx^3 + c$



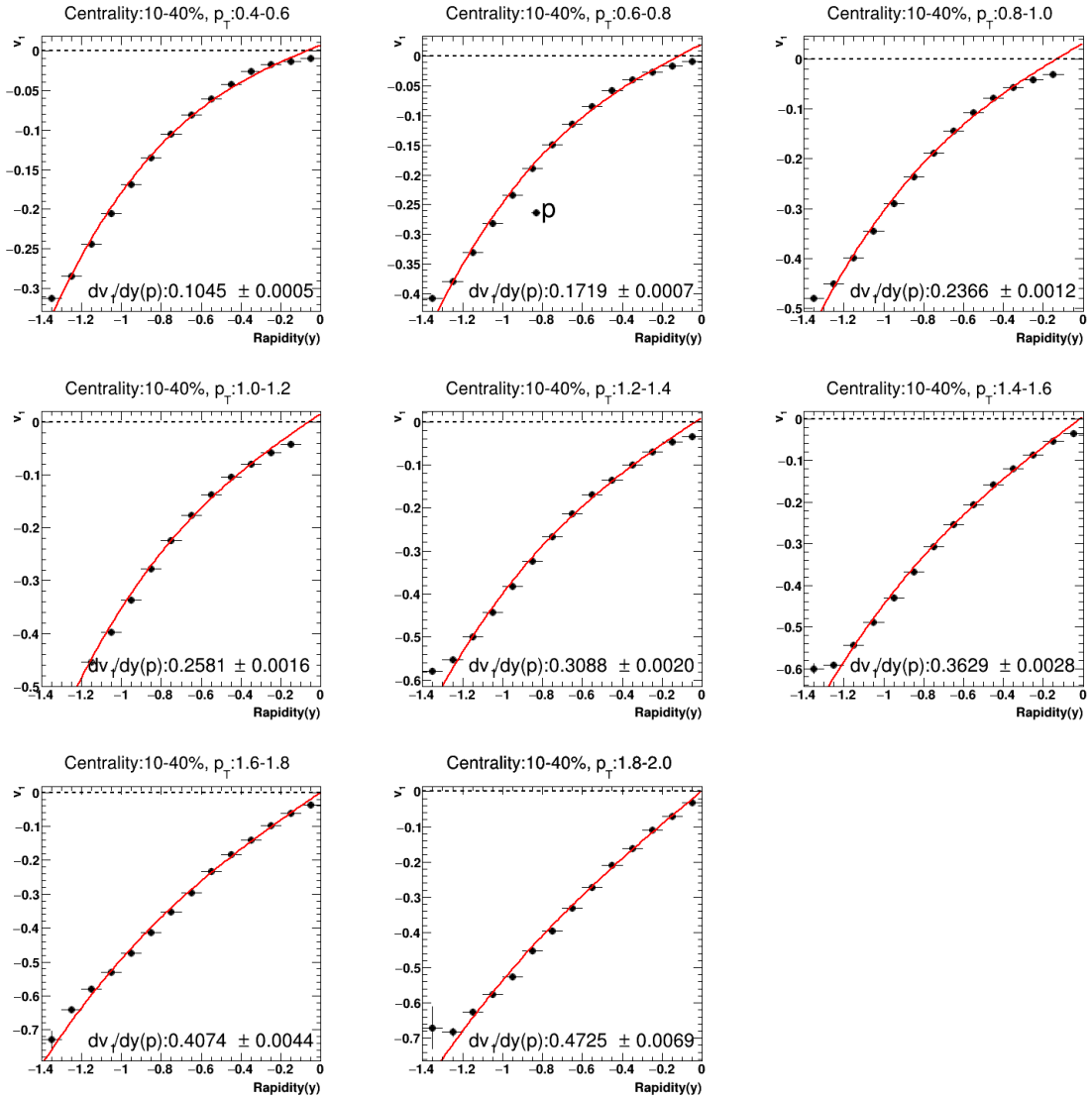
$f(x) = ax + bx^3$



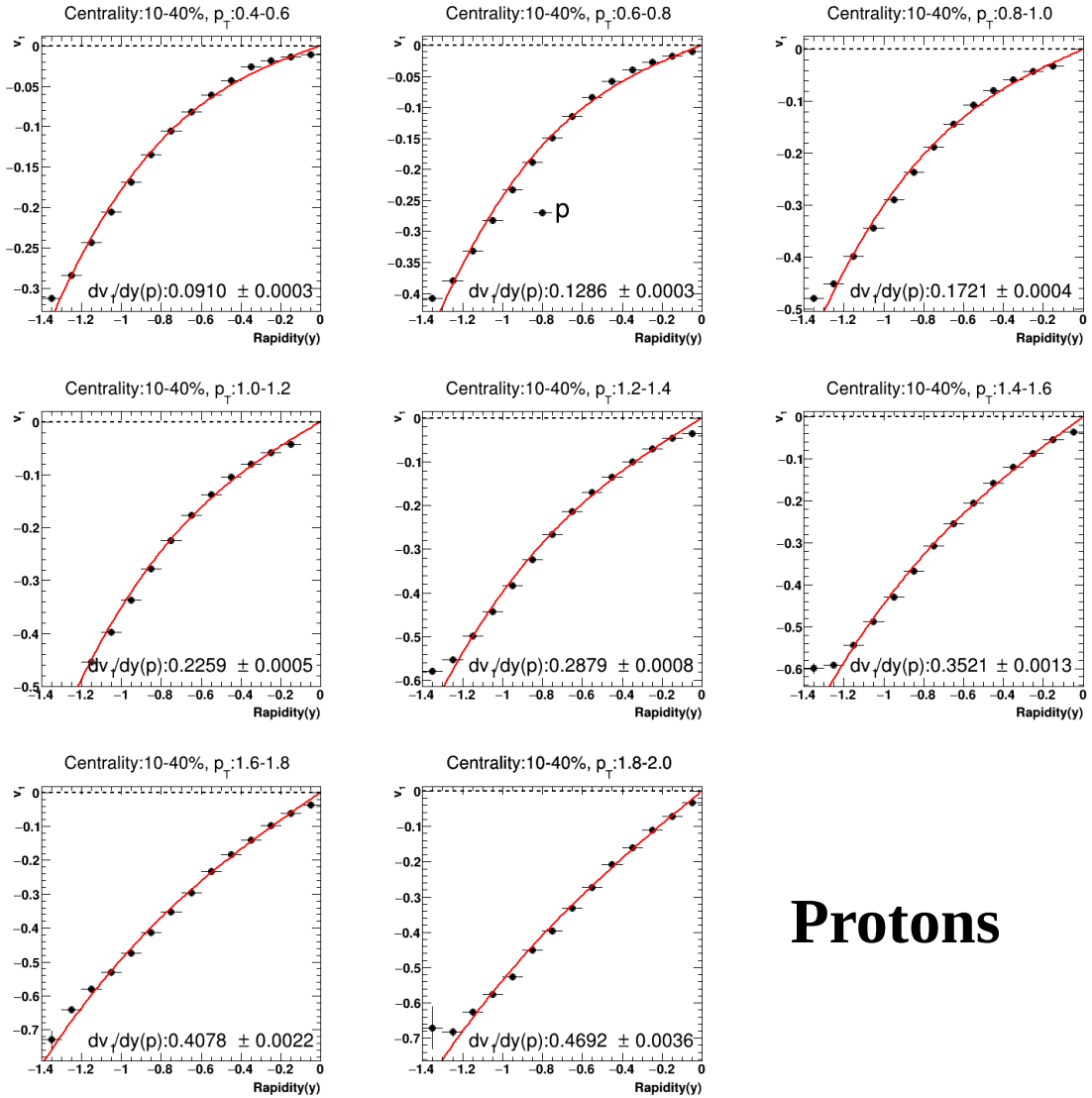
pions

p_T dependence of v_1 slope

$$f(x) = ax + bx^3 + c$$

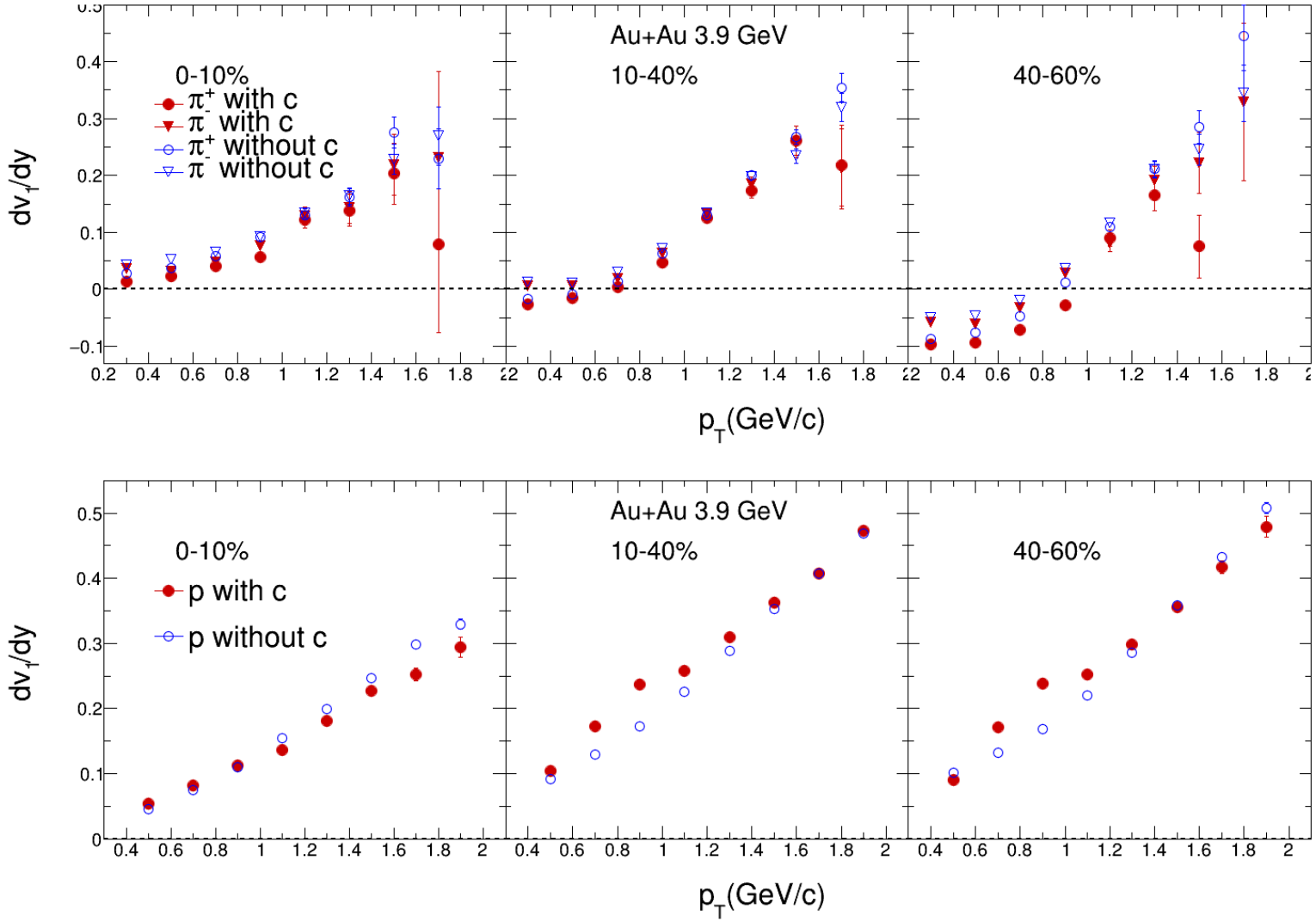


$$f(x) = ax + bx^3$$



Protons

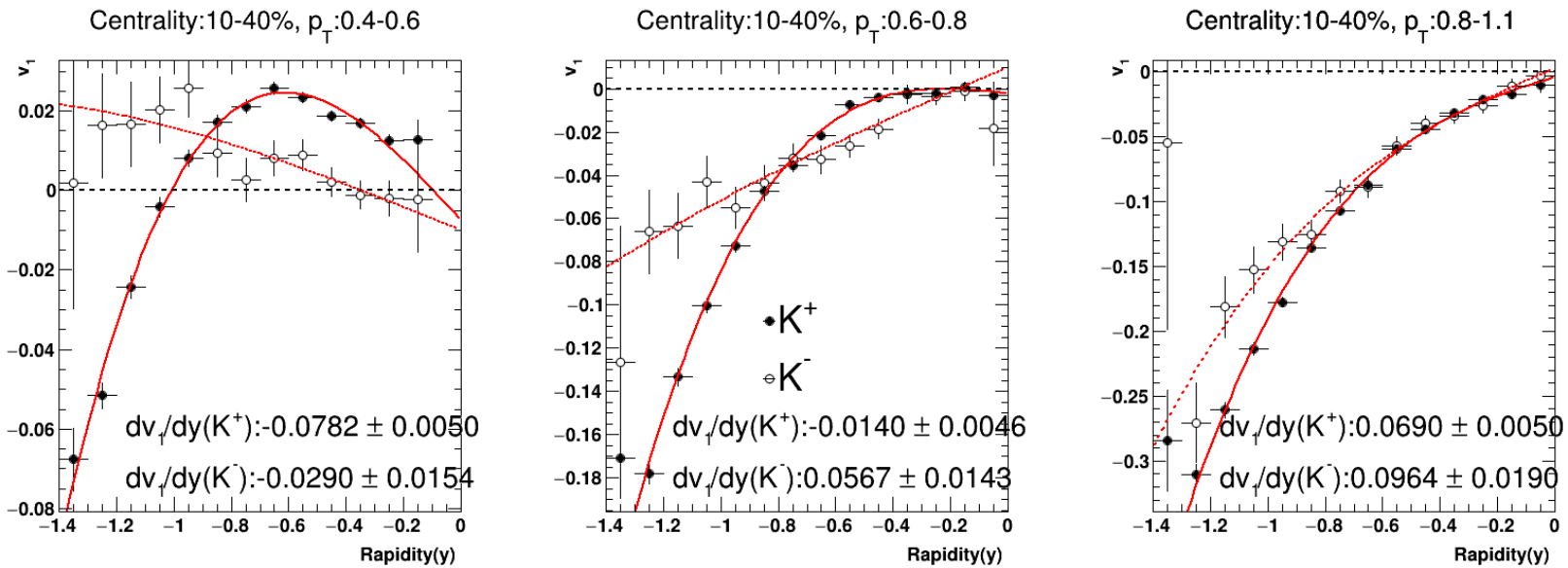
p_T dependence of v_1 slope



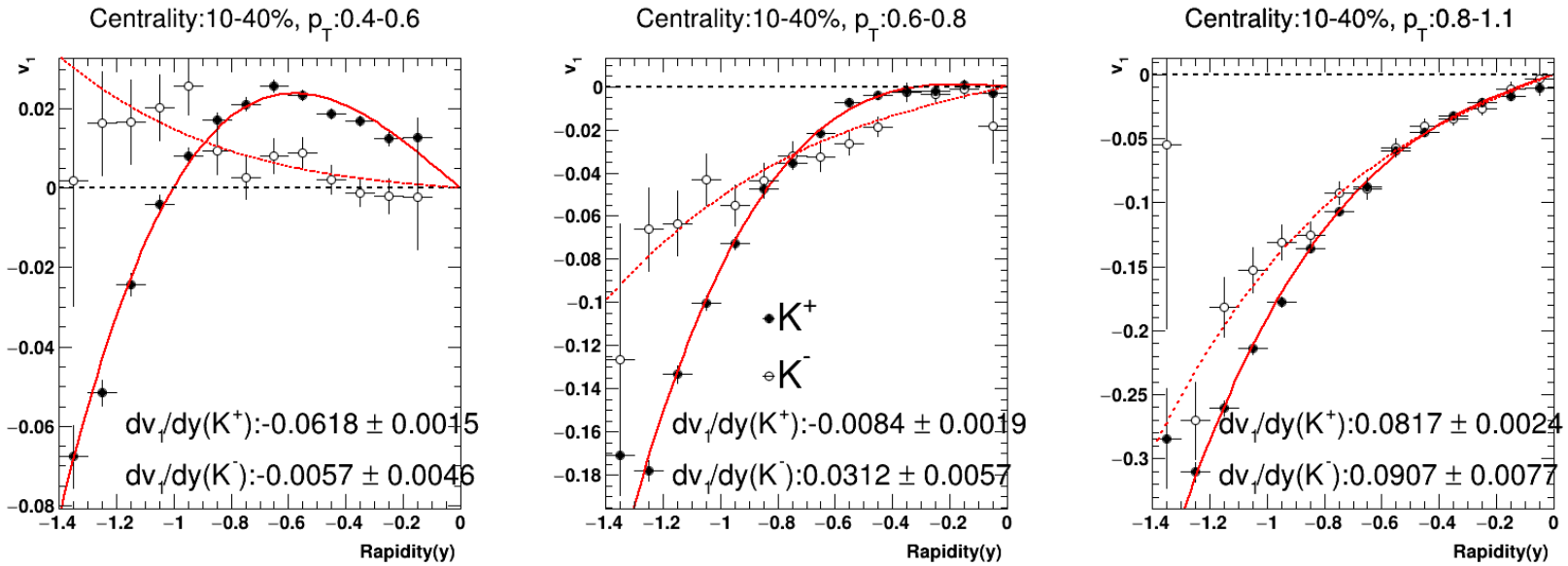
pions' and protons' v_1 slope as a function of p_T in three centrality bins

p_T dependence of v_1 slope

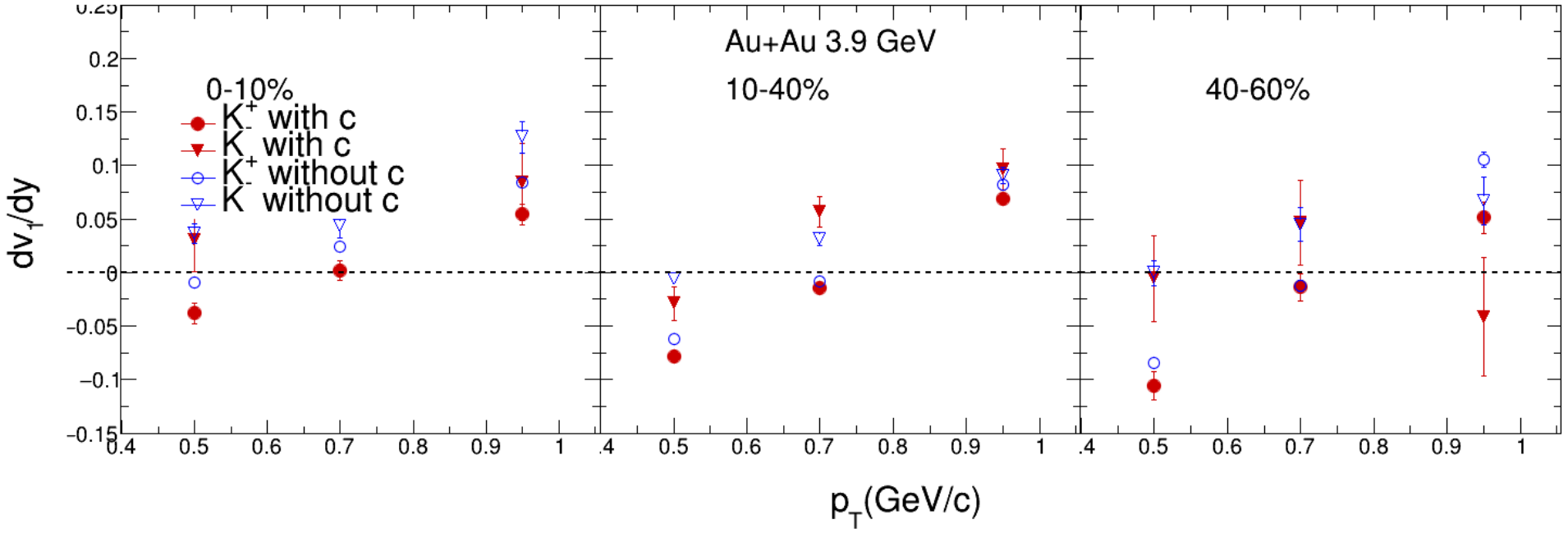
$f(x) = ax + bx^3 + c$



$f(x) = ax + bx^3$

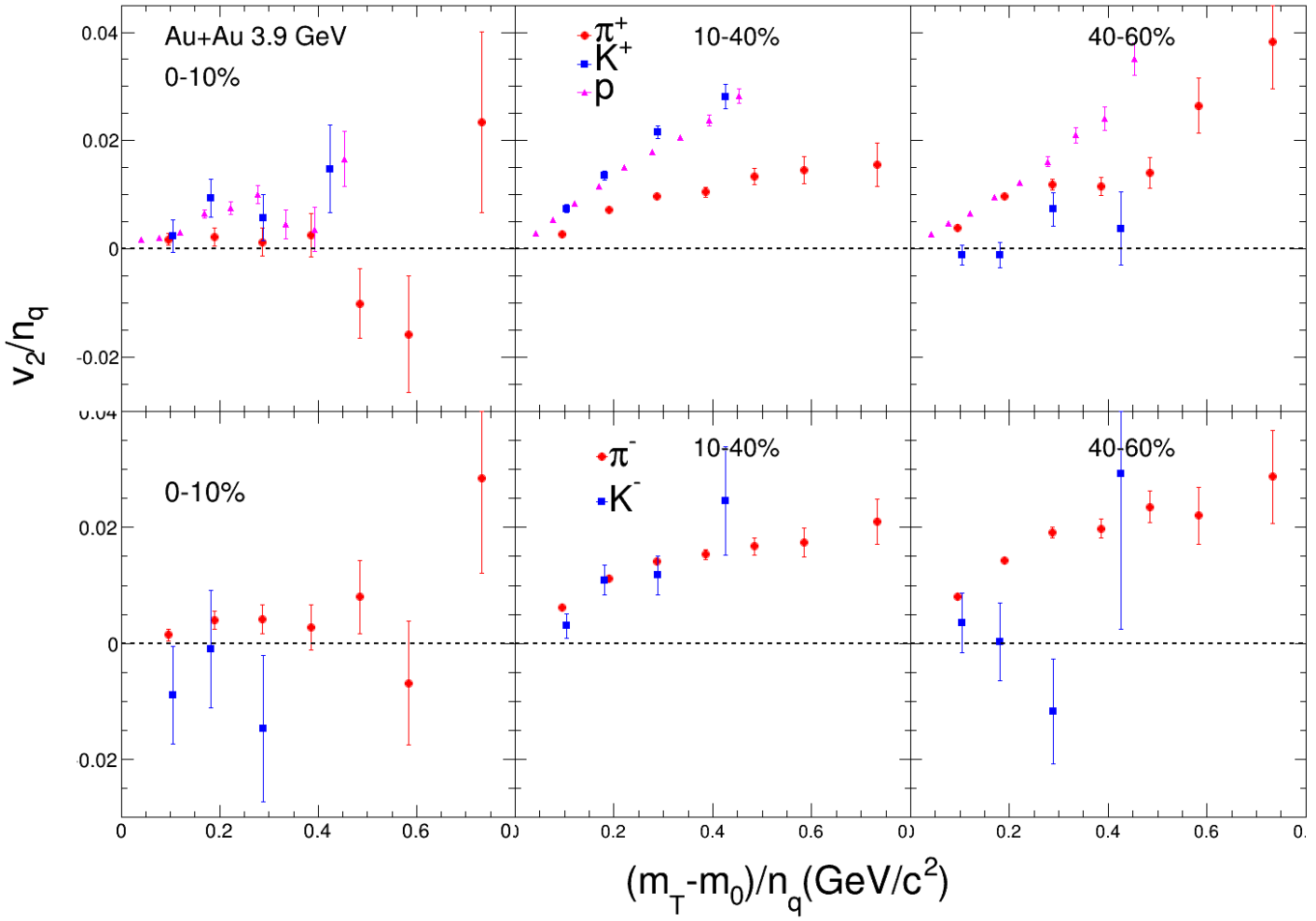


p_T dependence of v_1 slope



kaons' v_1 slope as a function of p_T in three centrality bins

NCQ scaling



The top three plots: positive charge particle ,
The bottom three plots: negative charge particle.

Summary

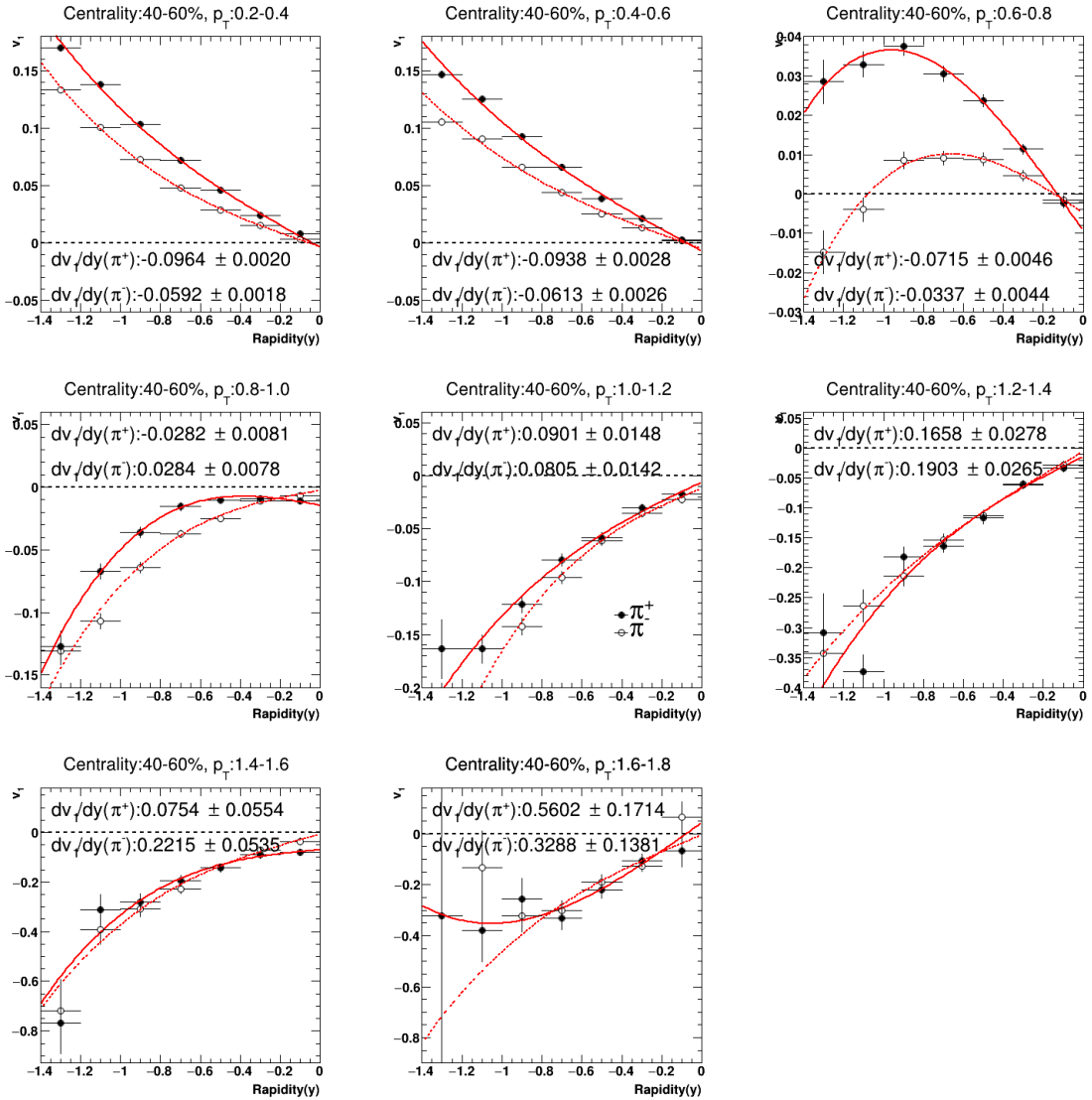
- Bad run selection based on flow vector distribution
- Pile-up removed by a 2D tofMatch and refMult cut
- EPD event plane calibration and resolution calculation
- PID selection study on $\pi^{\pm}$ $K^{\pm}$ p
- p_T and rapidity dependence of v_1 and v_2
- NCQ scaling test

Thank you

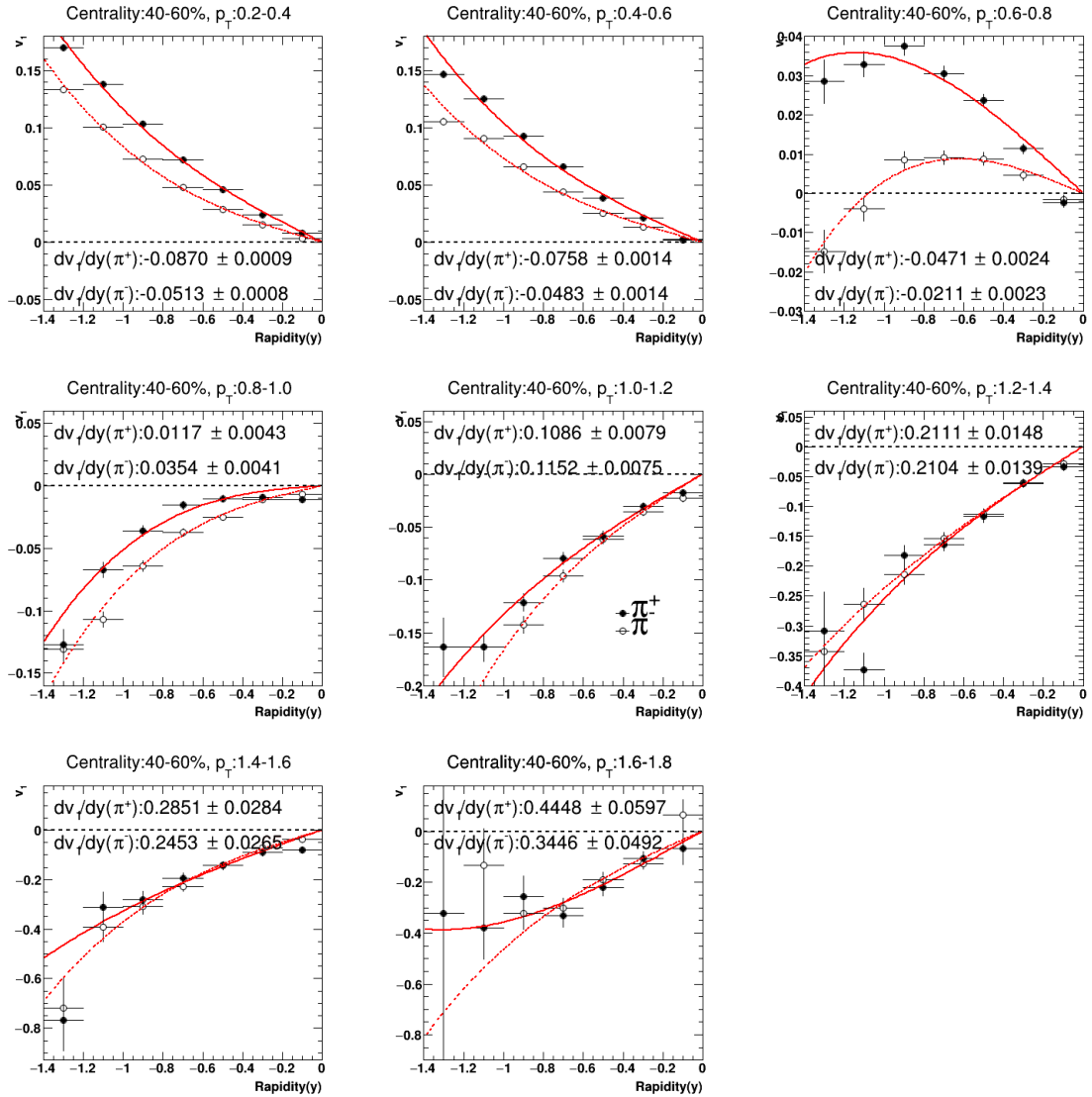
Back up

p_T dependence of v_1 slope

$$f(x) = ax + bx^3 + c$$

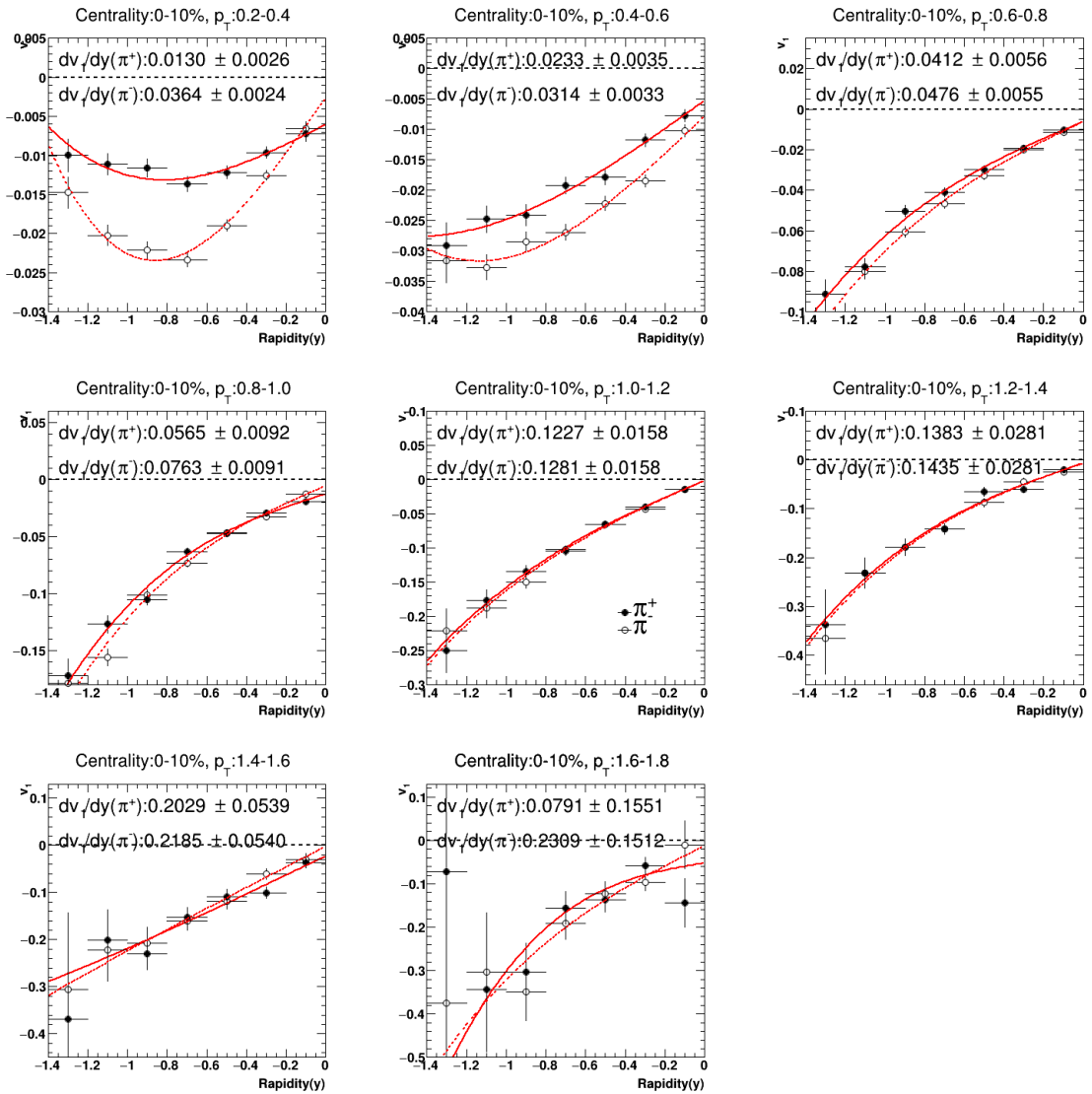


$$f(x) = ax + bx^3$$

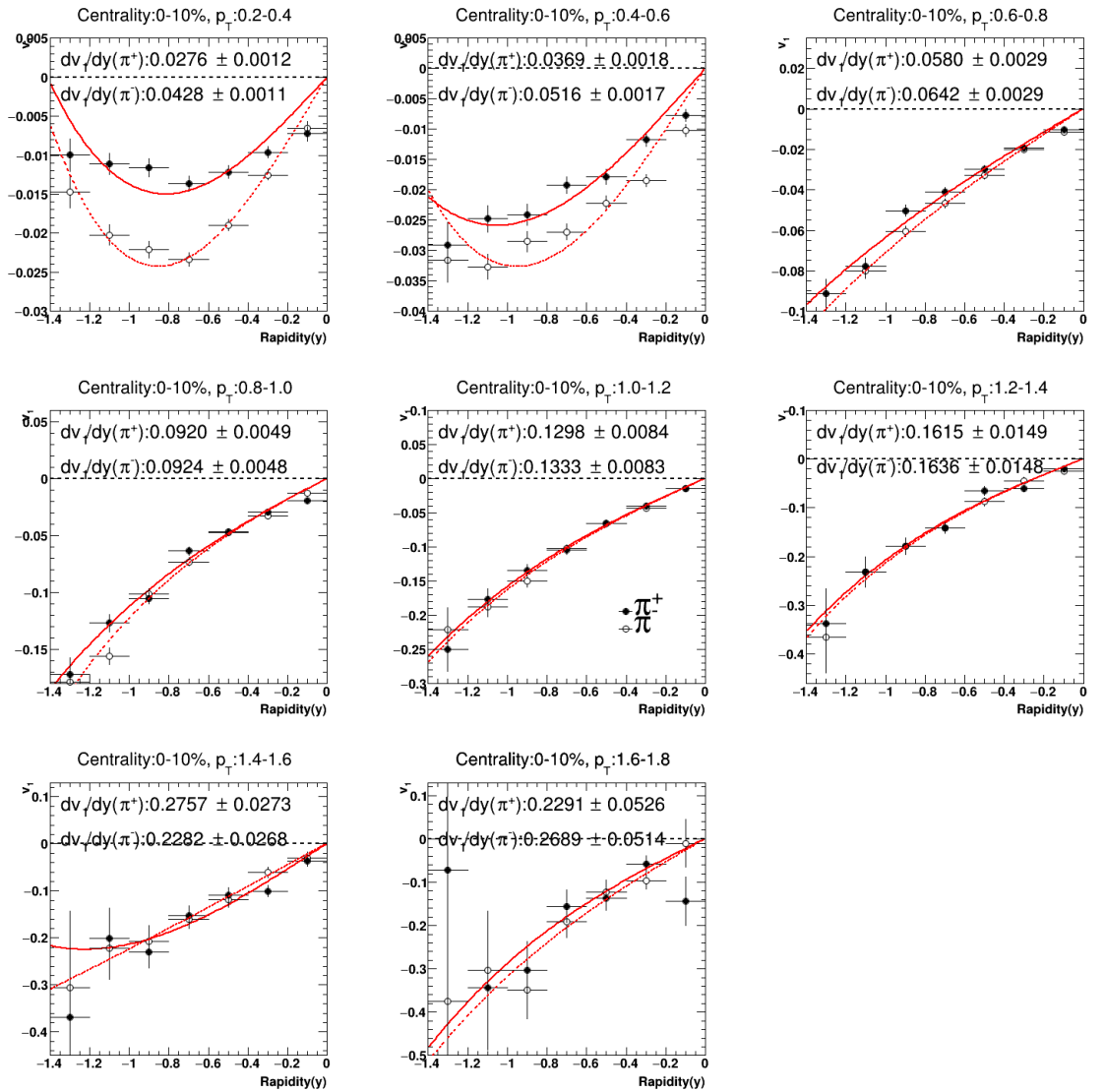


p_T dependence of v_1 slope

$$f(x) = ax + bx^3 + c$$

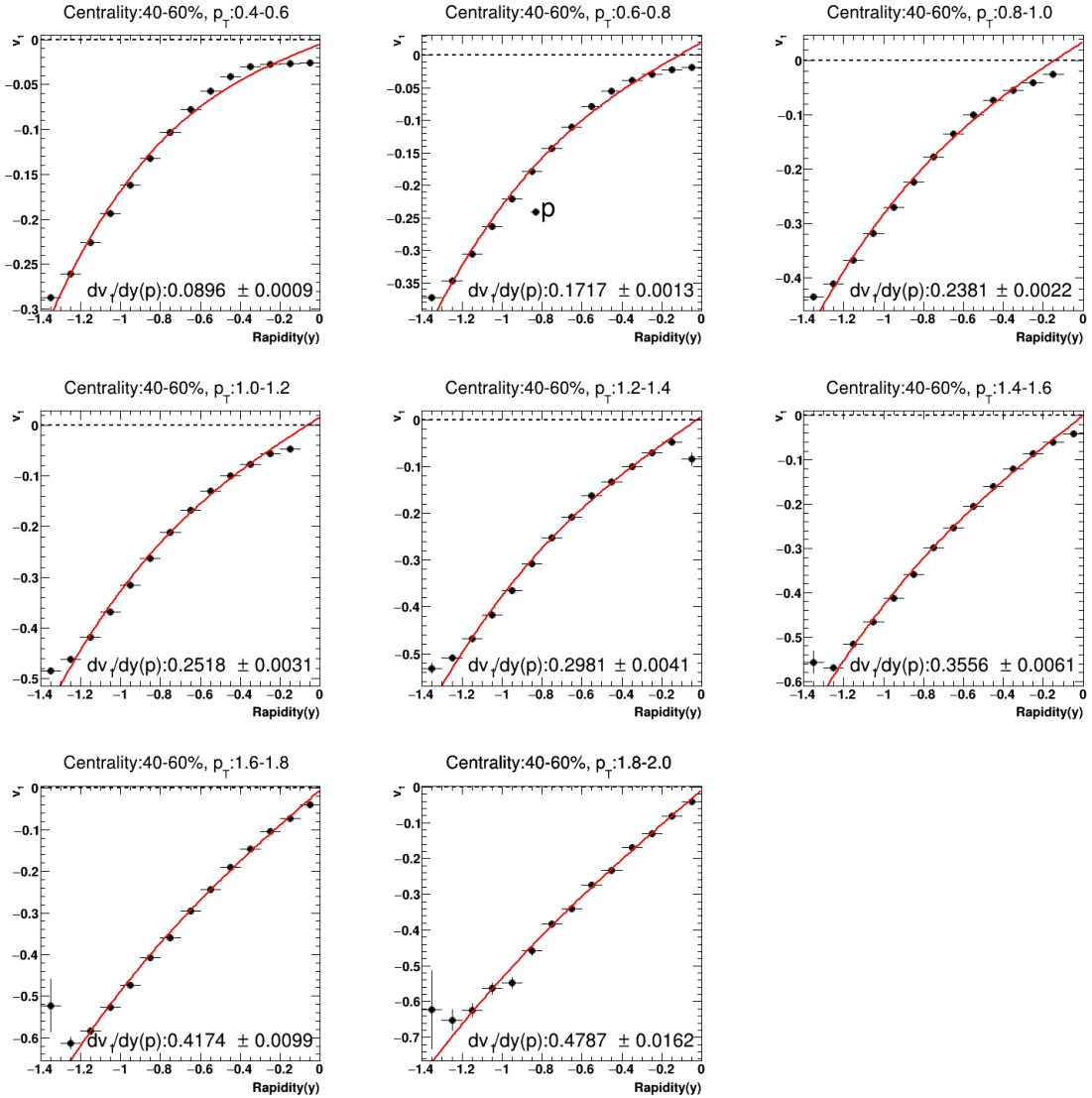


$$f(x) = ax + bx^3$$

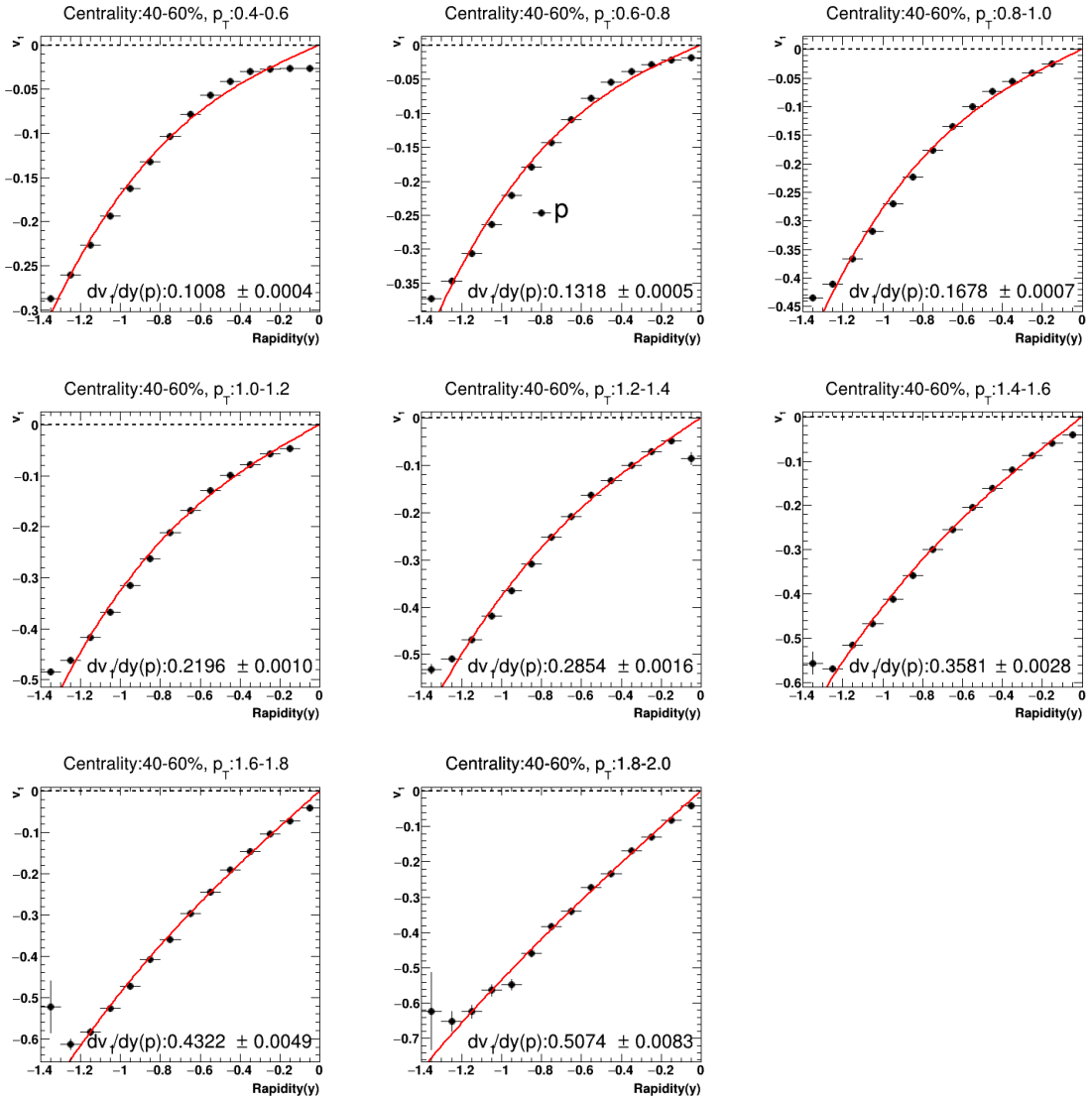


p_T dependence of v_1 slope

$$f(x) = ax + bx^3 + c$$



$$f(x) = ax + bx^3$$



p_T dependence of v_1 slope

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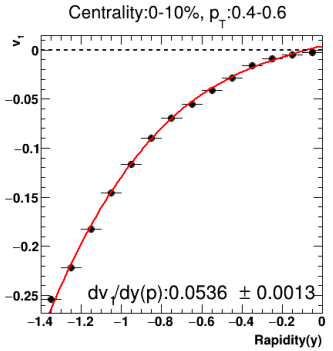

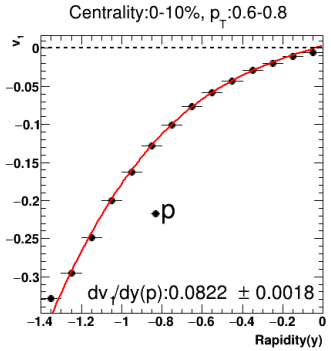

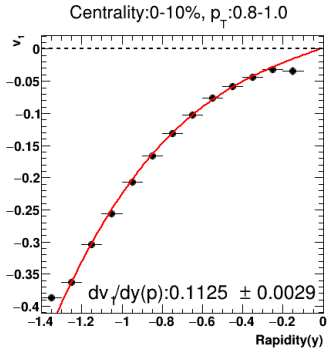

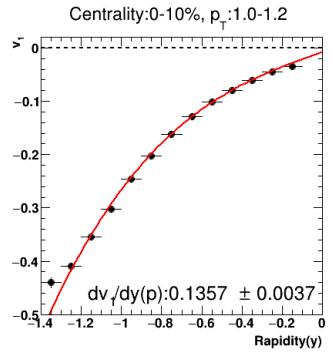

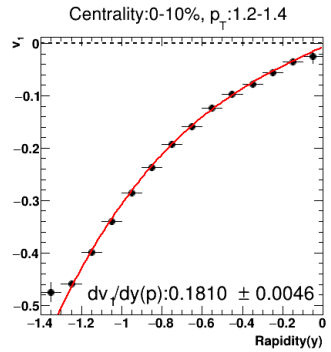

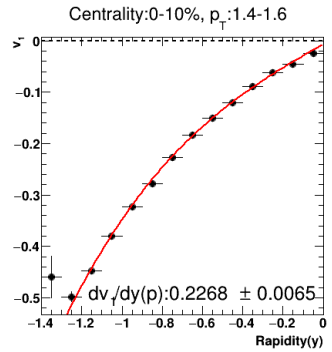

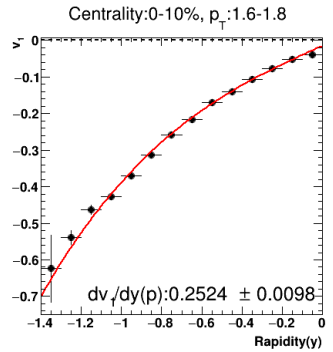

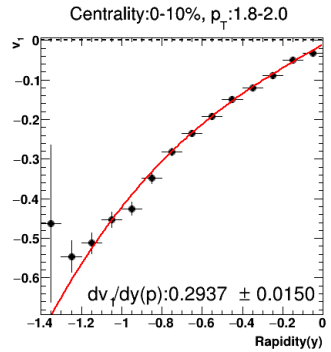

$f(x) = ax + bx^3$