Preliminary Results of reconstructed π^0 flow

Speaker: Yan Huang(黄彦)

Co-advisor: Yi Wang (王义)

MPD/ECal collaboration

Outline

- Introduction
- Measure Method
- Preliminary results of flow
  - ✓ Flow of charged particles
  - ✓ Flow of π^0
- Summary

Introduction

BROOKHAVEN NATIONAL LABORATORY *Newsroom* *Media & Communications Office*

RHIC Scientists Serve Up "Perfect" Liquid (2005)

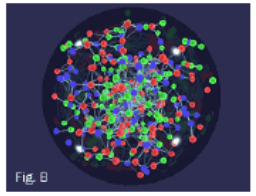
New state of matter more remarkable than predicted -- raising many new questions

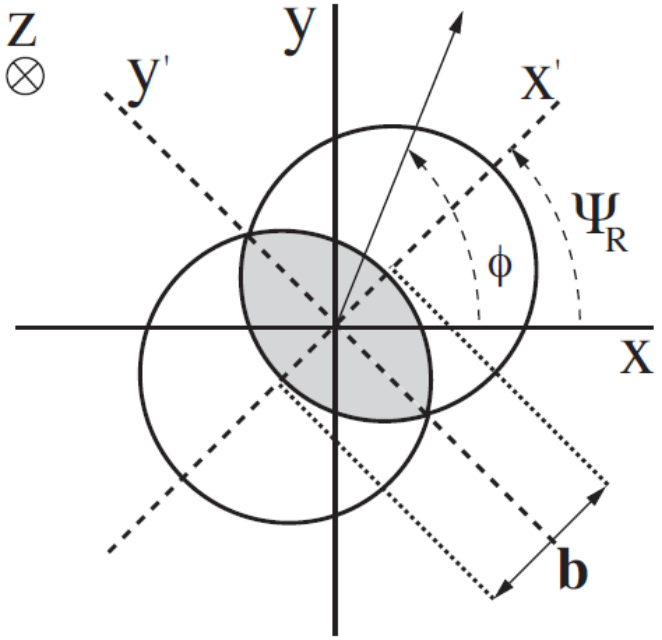
Monday, April 18, 2005

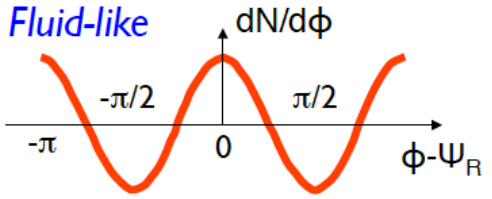
TAMPA, FL -- The four detector groups conducting research at the Relativistic Heavy Ion Collider (RHIC) -- a giant atom "smasher" located at the U.S. Department of Energy's Brookhaven National Laboratory -- say they've created a new state of hot, dense matter out of the quarks and gluons that are the basic particles of atomic nuclei, but it is a state quite different and even more remarkable than had been predicted. In peer-reviewed papers summarizing the first three years of RHIC findings, the scientists say that instead of behaving like a gas of free quarks and gluons, as was expected, the matter created in RHIC's heavy ion collisions appears to be more like a *liquid*.

Strongly coupled like a *liquid*, instead of gas

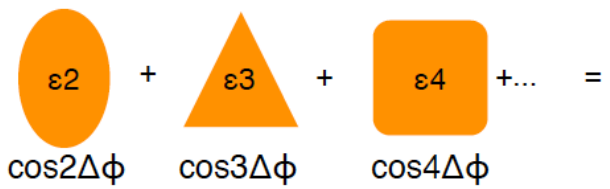
Important evidence from collectivity



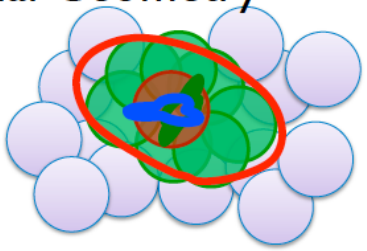




Momentum anisotropy



Initial Geometry



Reaction Plane

$$\frac{dN}{d\phi} = \frac{N}{2\pi}\left[1 + 2\sum_n v_n cosn(\phi - \Phi_n)\right]$$

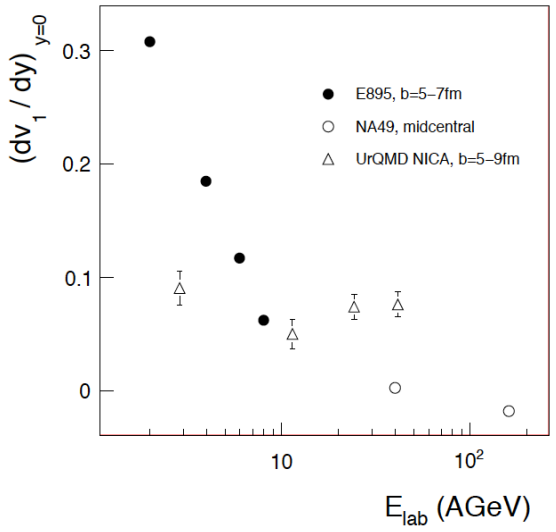
Anisotropic Flow

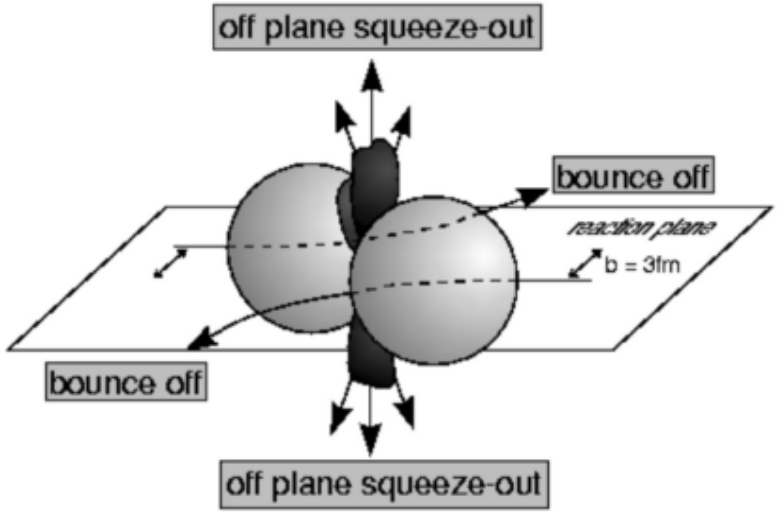
v_1: direct flow

v_2: elliptic flow

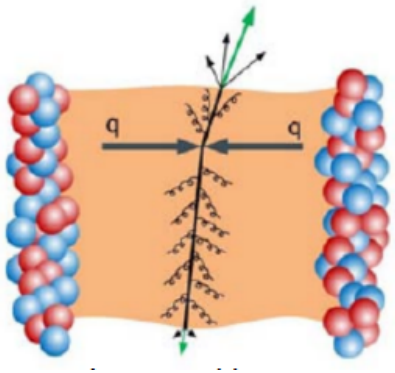
from Zhenyu Chen, QM2019

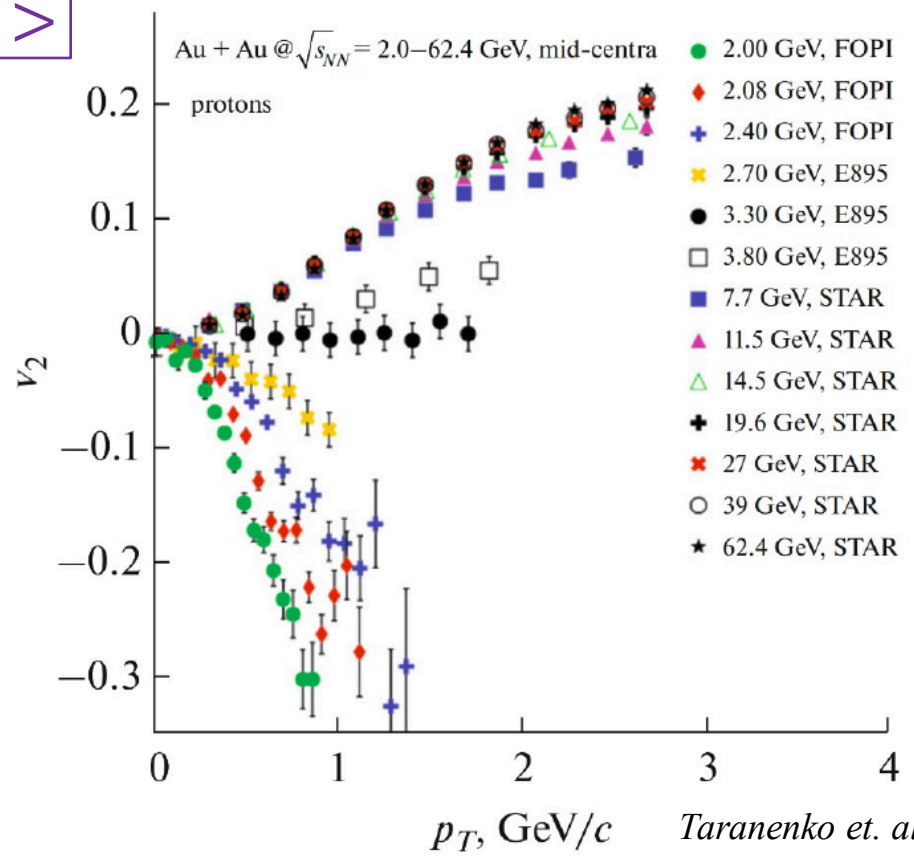
$v_1 = < \cos(\phi - \psi_R) >$

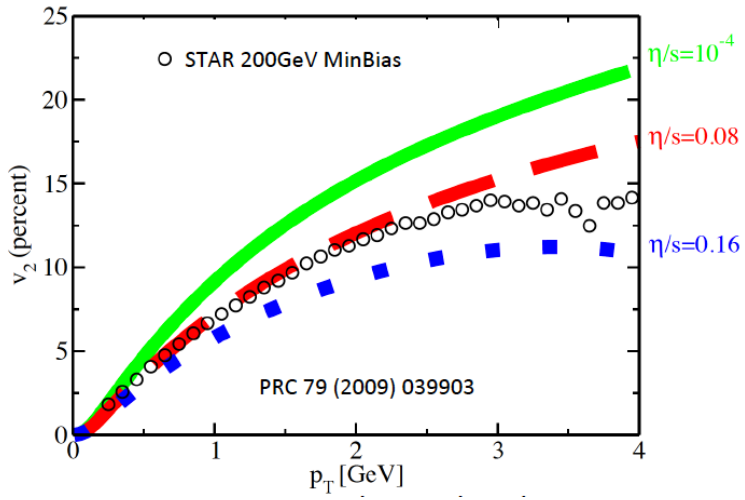




$v_2 = < \cos 2(\phi - \psi_R) >$







Taranenko et. al. Phys. Part. Nuclei 51, 309–313 (2020)

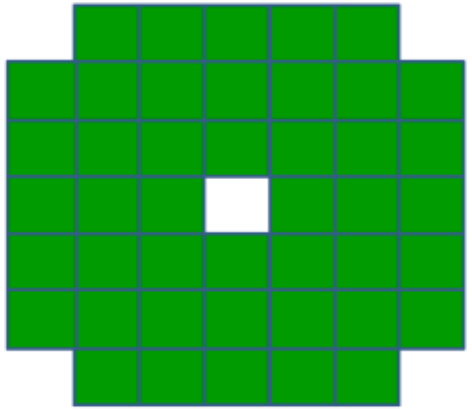
Event Plane Method

$$Q_x^m = \frac{\sum \omega_i \cos(m\varphi_i)}{\sum \omega_i}, Q_y^m = \frac{\sum \omega_i \sin(m\varphi_i)}{\sum \omega_i}$$

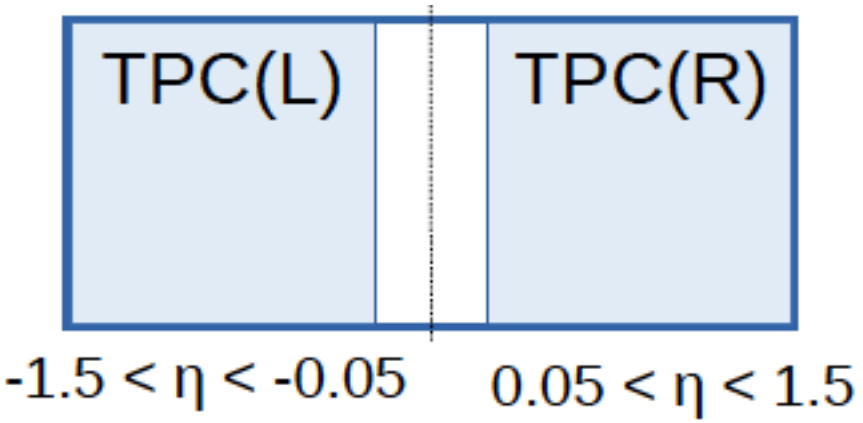
$$\Psi_m^{EP} = \frac{1}{m} \mathrm{ATan2}(Q_y^m, Q_x^m)$$

$$Res_n^2\left\{\Psi_m^{EP,L}, \Psi_m^{EP,R}\right\} = \left\langle \cos\left[n\left(\Psi_m^{EP,L} - \Psi_m^{EP,R}\right)\right]\right\rangle$$

$$v_n = \frac{\langle \cos(n(\varphi - \Psi_n^{EP}))\rangle}{Res\{\Psi_n^{EP}\}}$$



(Forward Hadron Calorimeter)



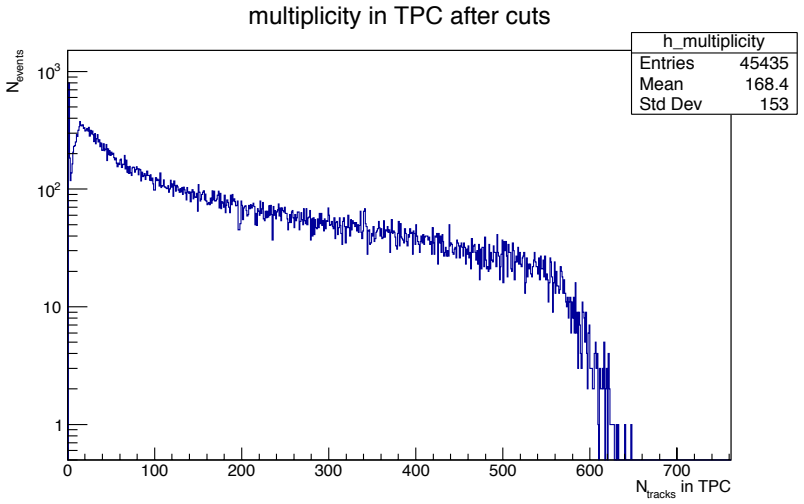
Direct cumulant method:
http://indico.oris.mephi.ru/event/181/session/2/contribution/8

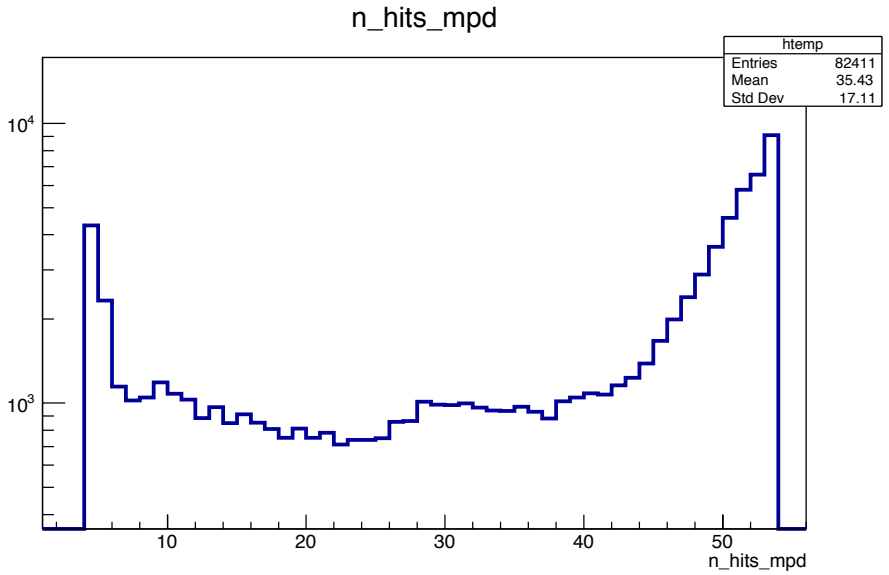
https://github.com/jinrNICA/MPD/tree/master/Flow

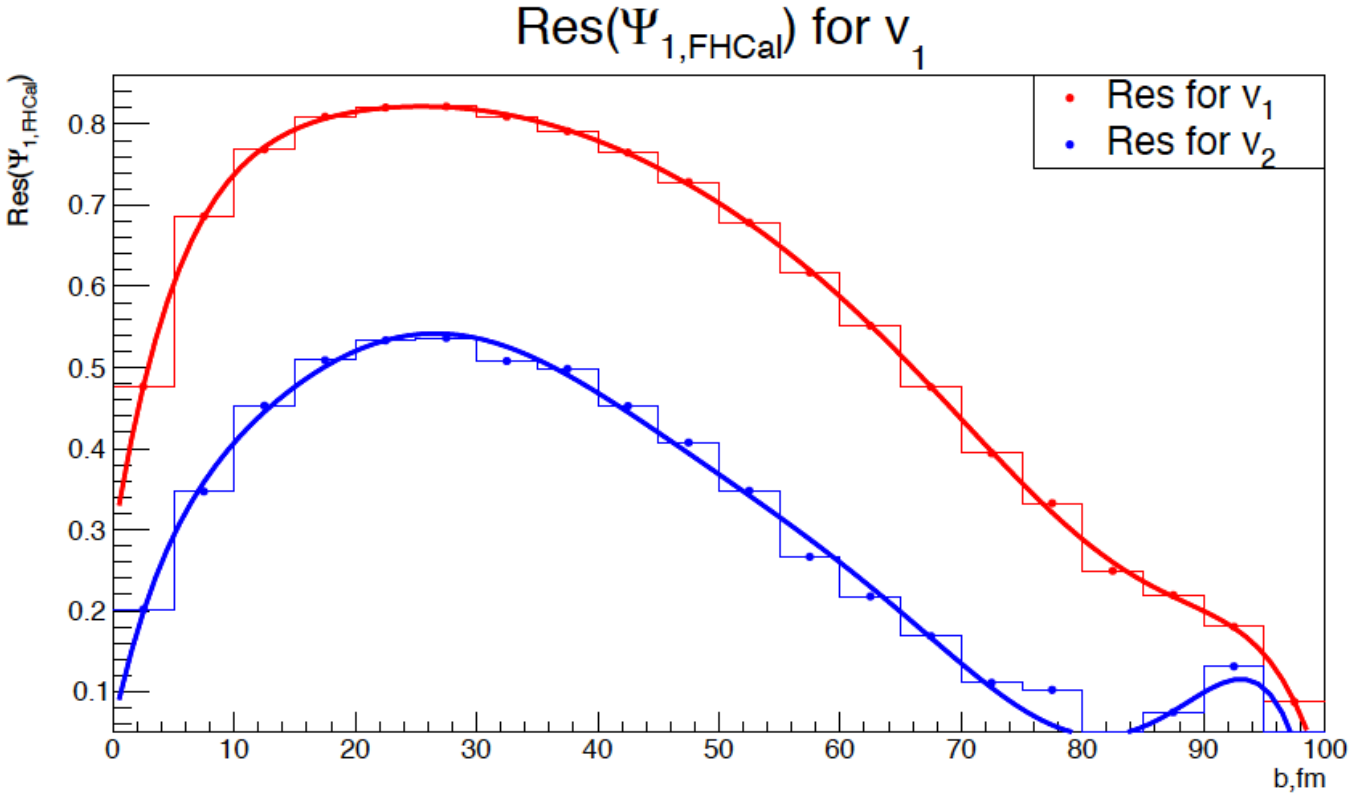
Data Set

Bi+Bi @9.46GeV
~1M Events

Track selection
- Primary Tracks(2σ DCA cut)
- N_hits>32
- 0.2<|η|<1.5

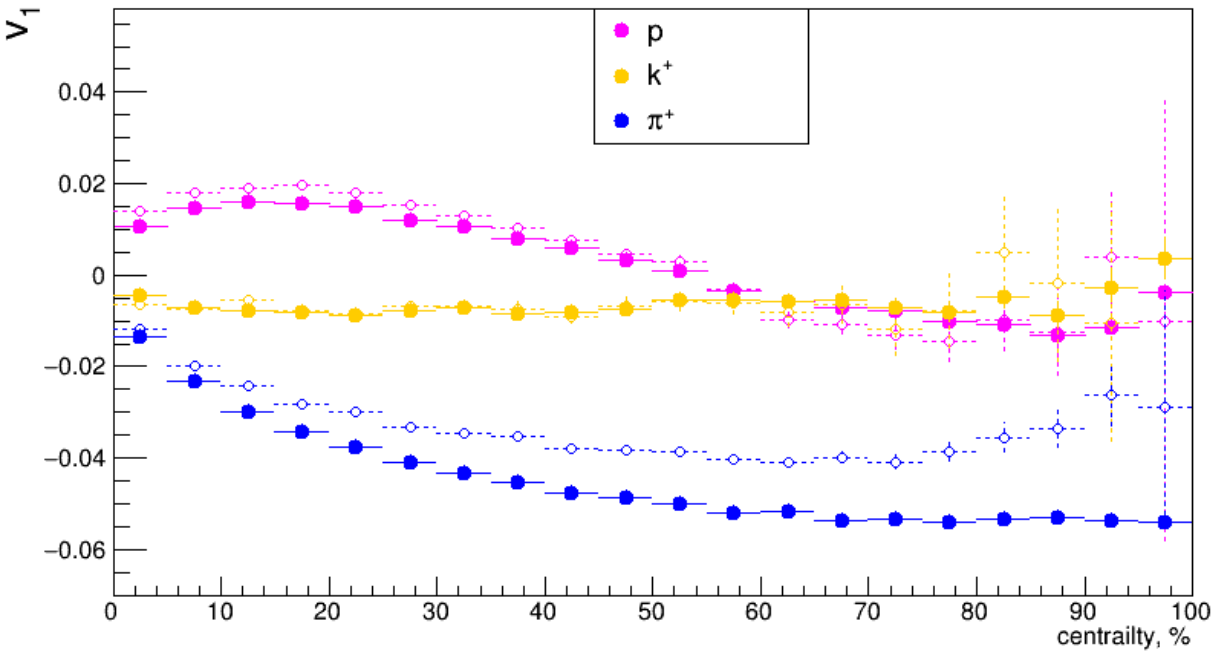


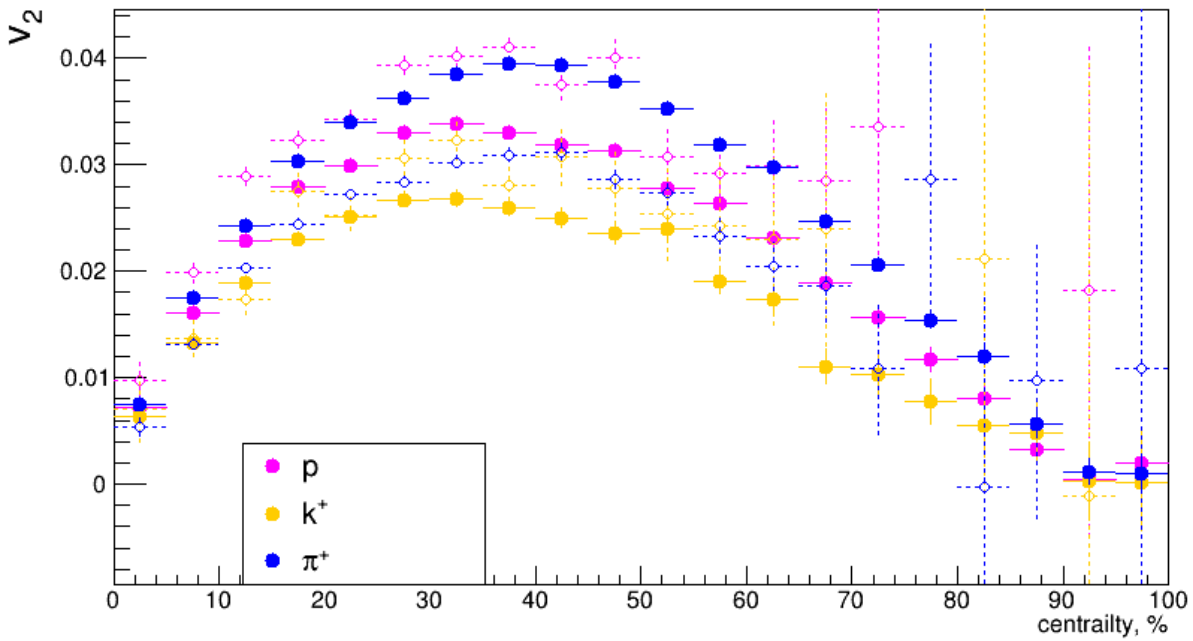




Preliminary results for charged particles

With Centrality

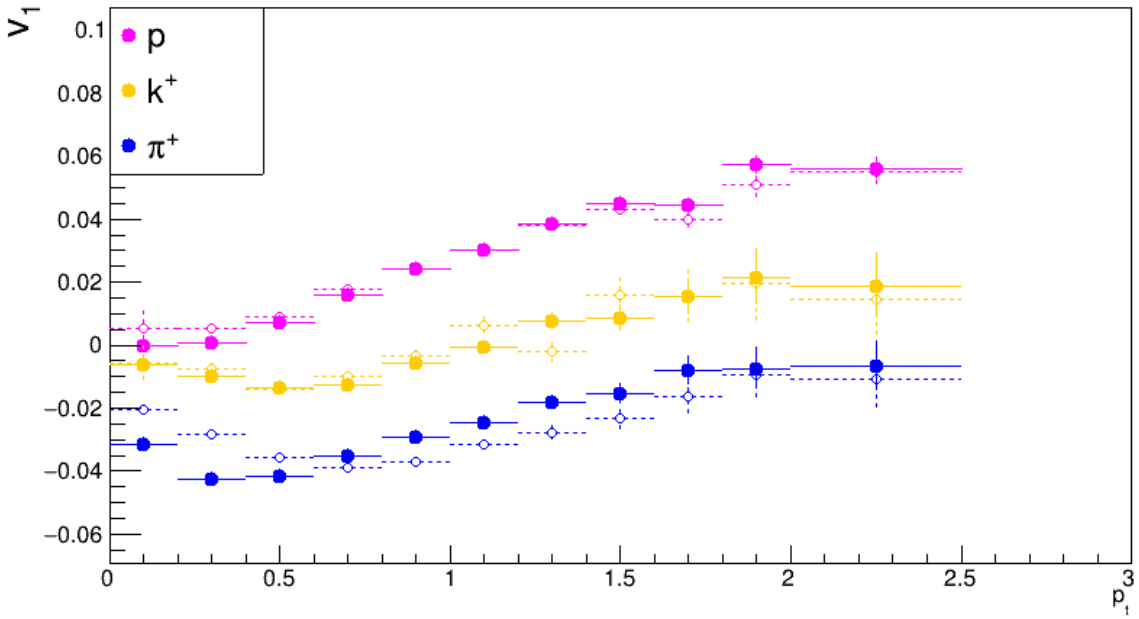


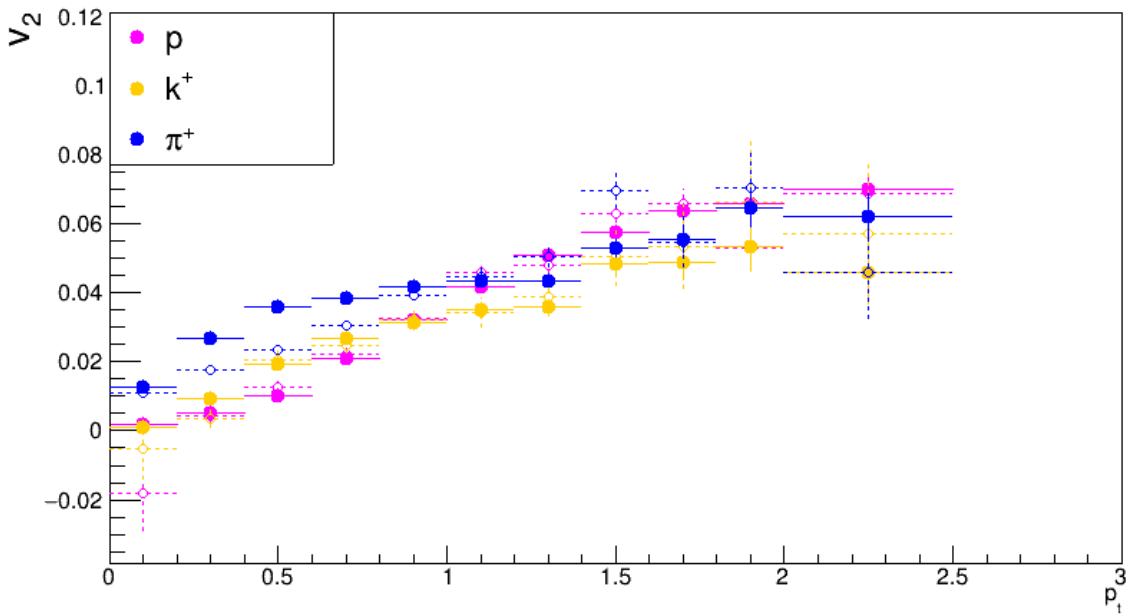


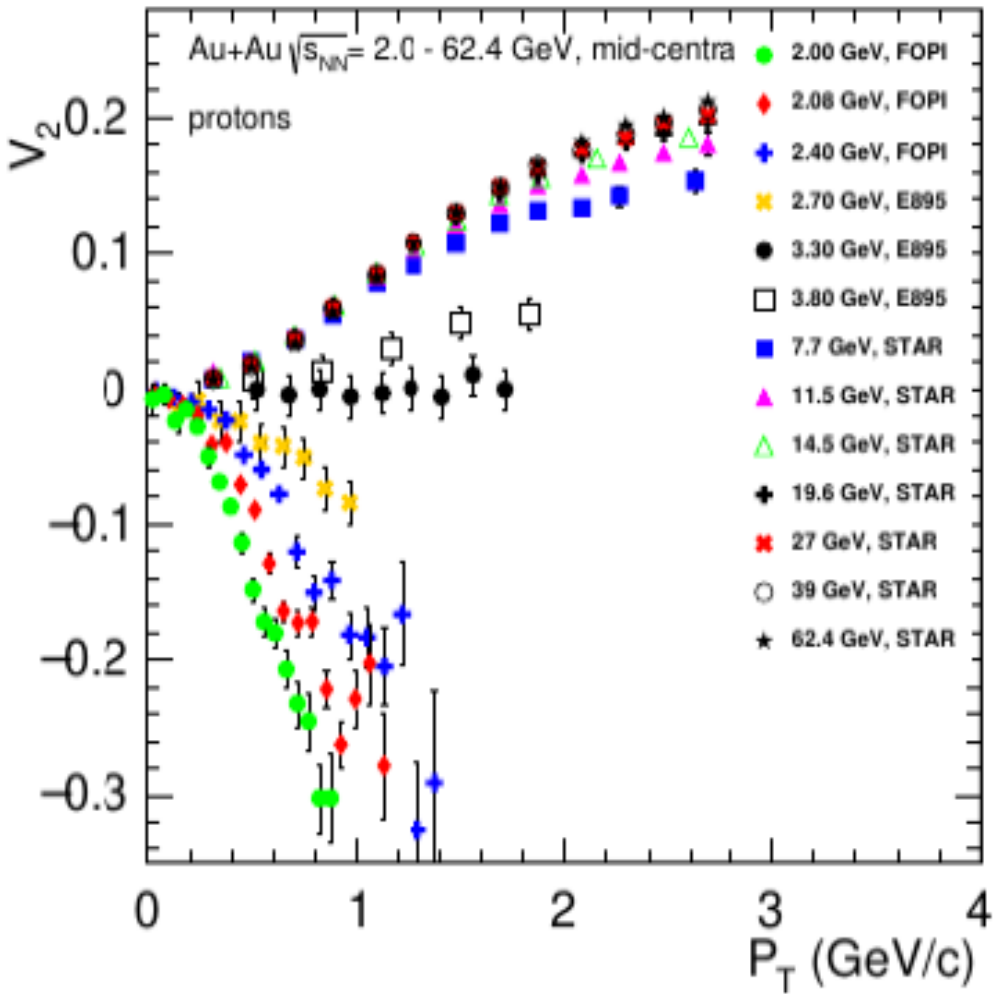
only primary tracks in MC for π^+

With Pt

10-20% centrality

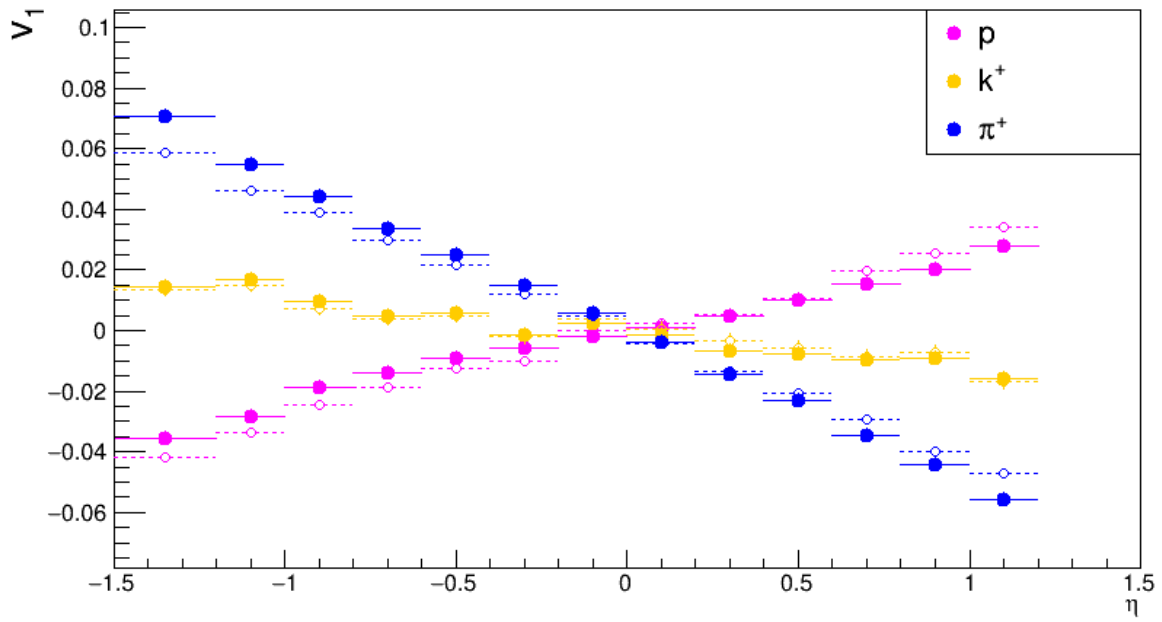


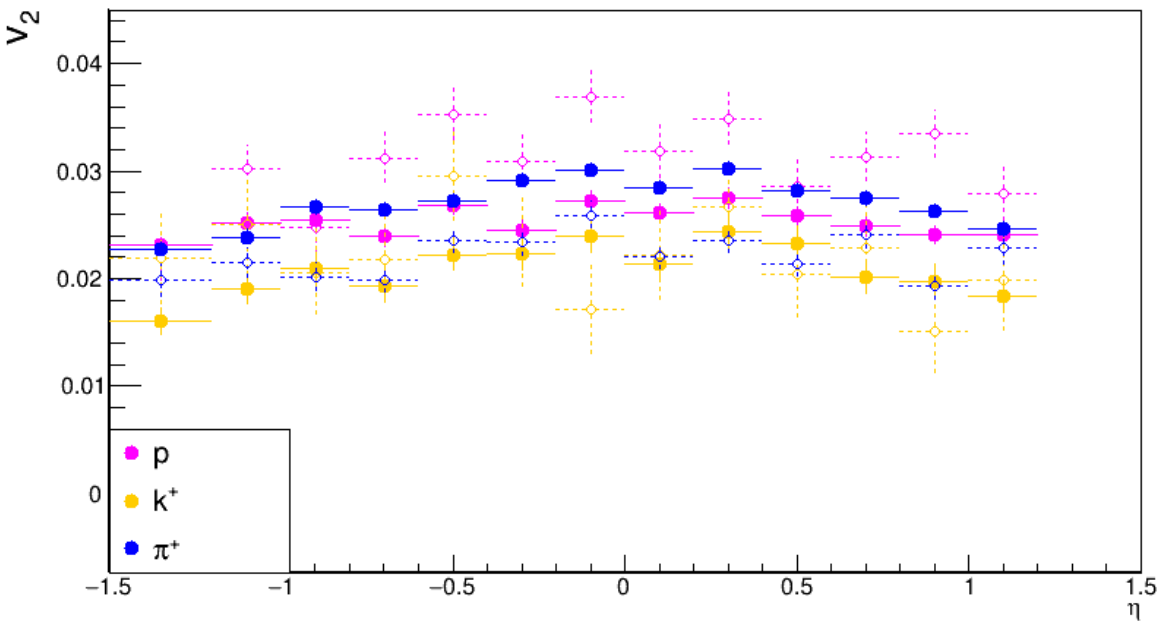


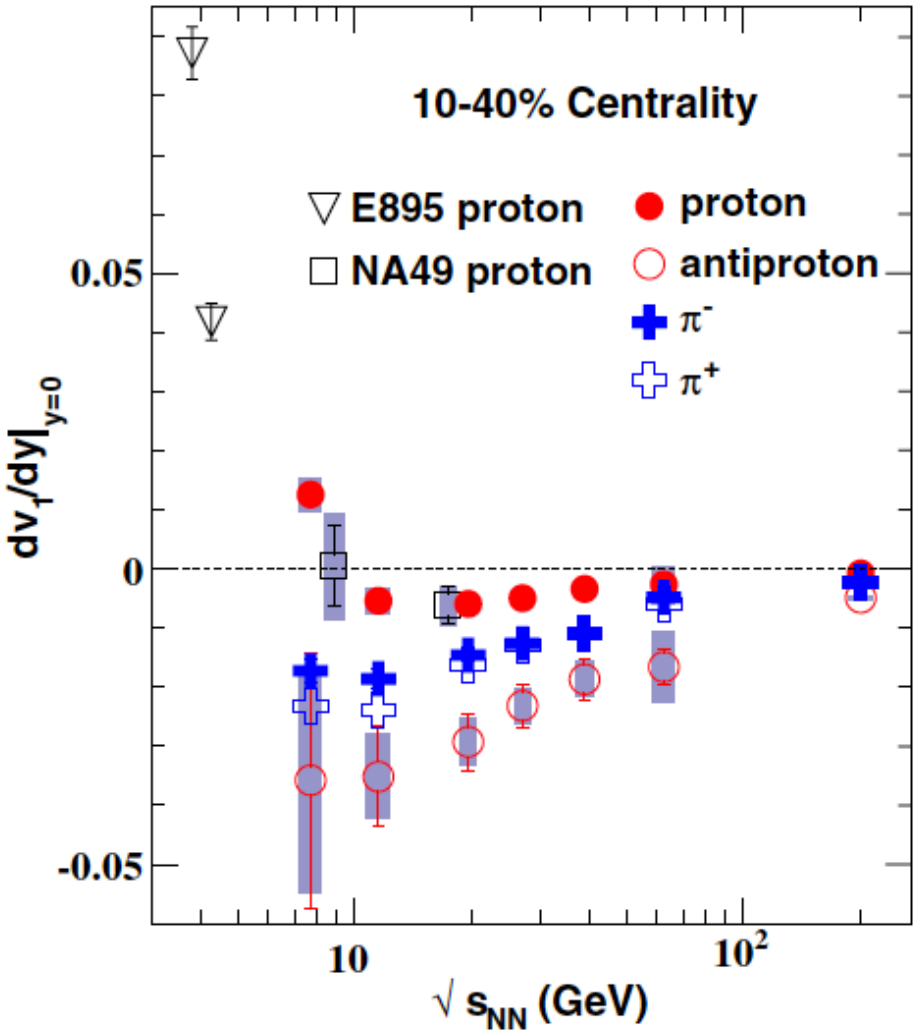


With η

10-20% centrality







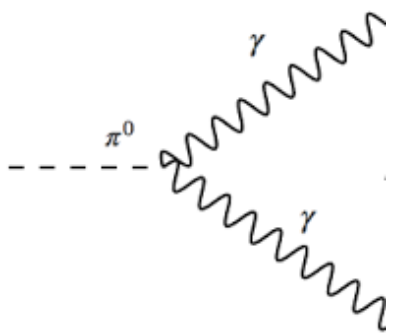
PRL 112,162301(2014)

Preliminary results for pions

π^0

$I^G(J^{PC}) = 1^-(0^{-+})$

Mass $m = 134.9770 \pm 0.0005$ MeV (S = 1.1)
$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.52 \pm 0.18) \times 10^{-17}$ s (S = 1.2)
$c\tau = 25.5$ nm



Photon selection

$E_\gamma > 200MeV$

Invariant mass reconstruction

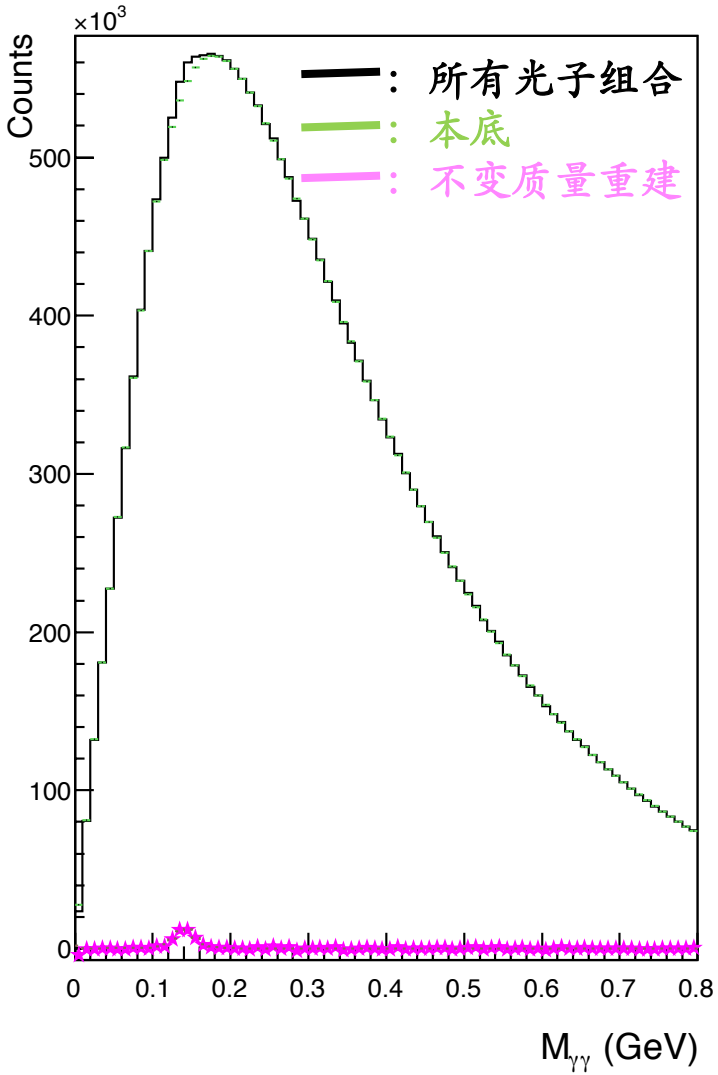
$M_{\gamma\gamma} = \sqrt{2E_{\gamma 1}E_{\gamma 2}(1-\cos(\theta_{12}))}$

Subtract the Background

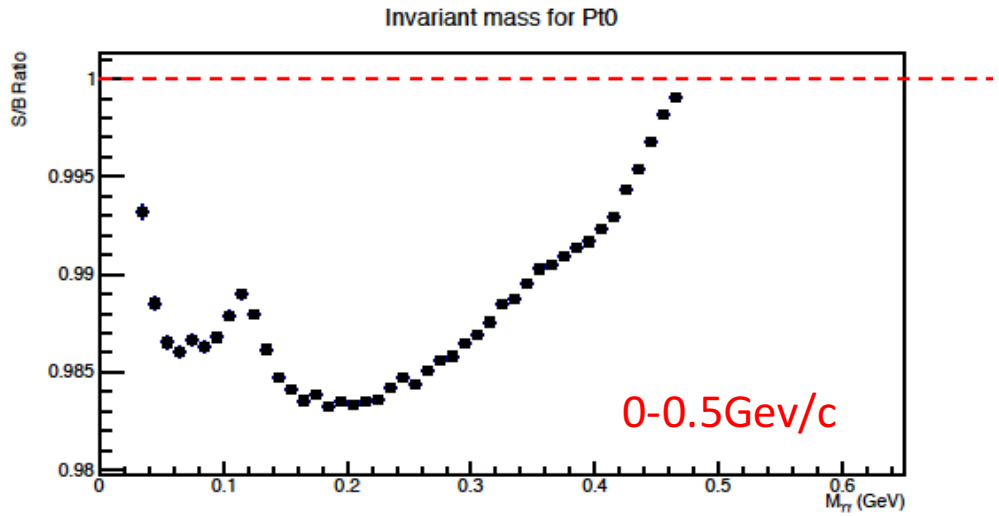
Event mixed method and scaling

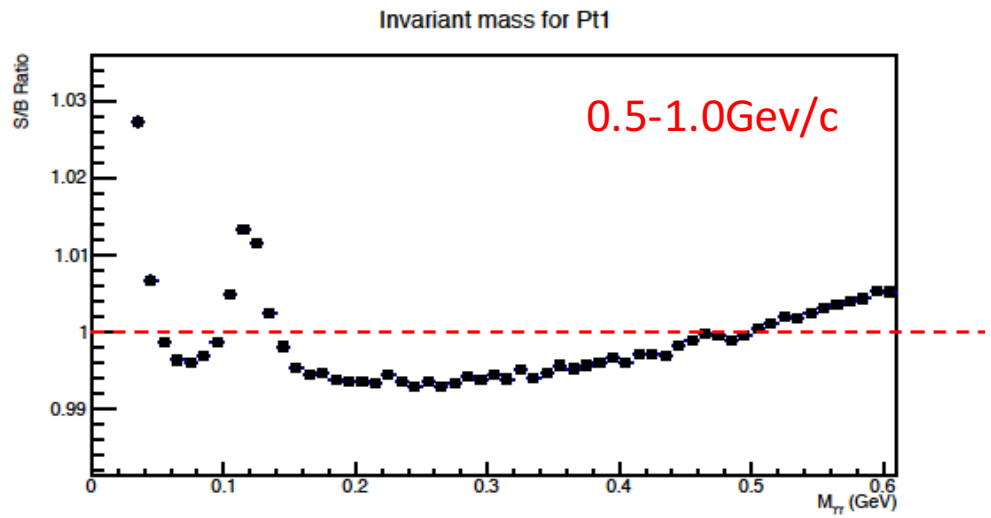
The method of pi0 reconstruction

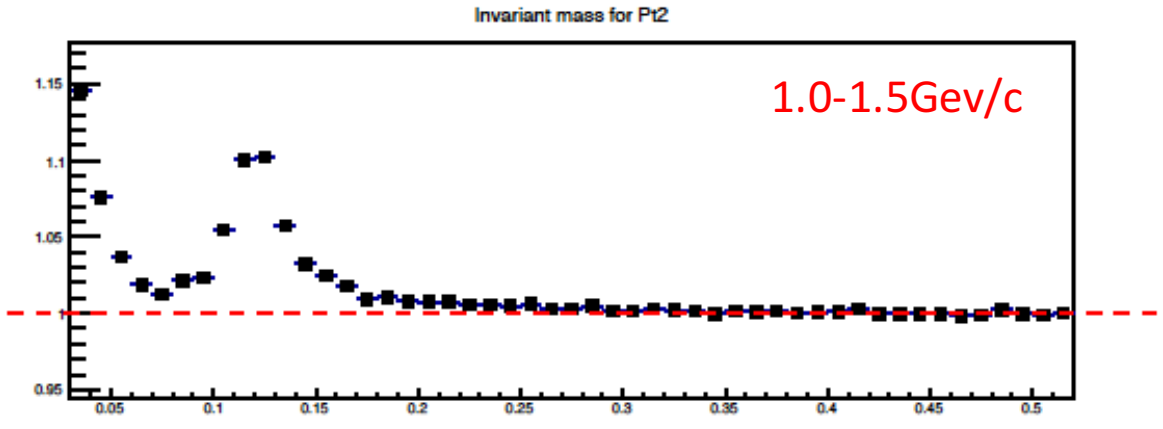
2-photon mass

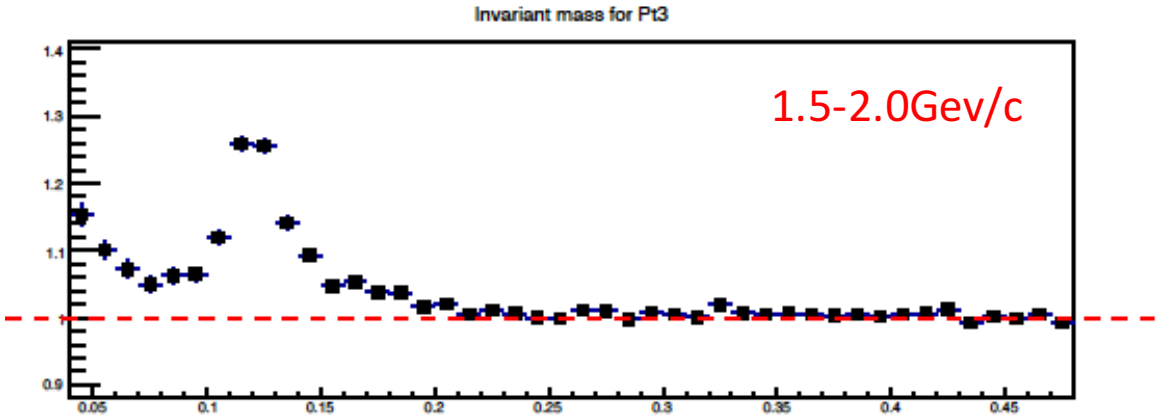


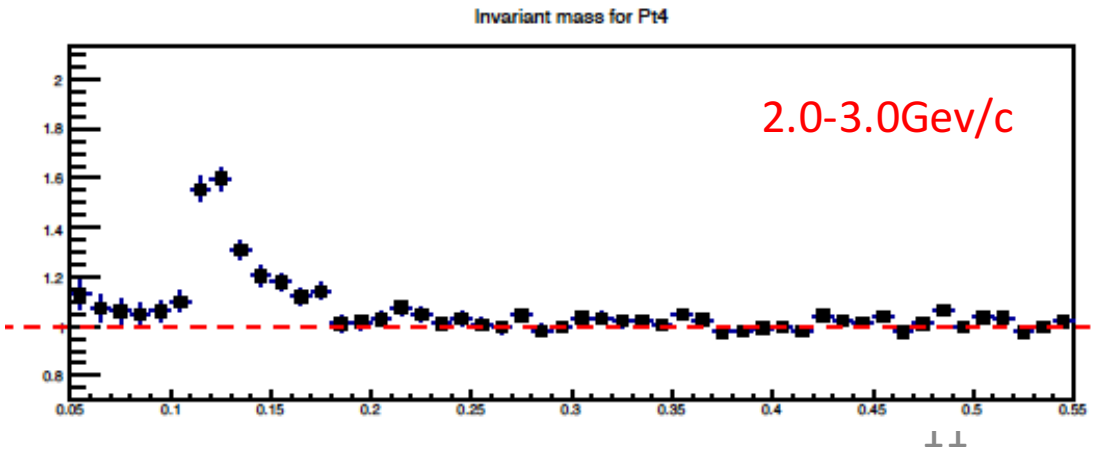
Bi+Bi @9.46GeV
75K Events





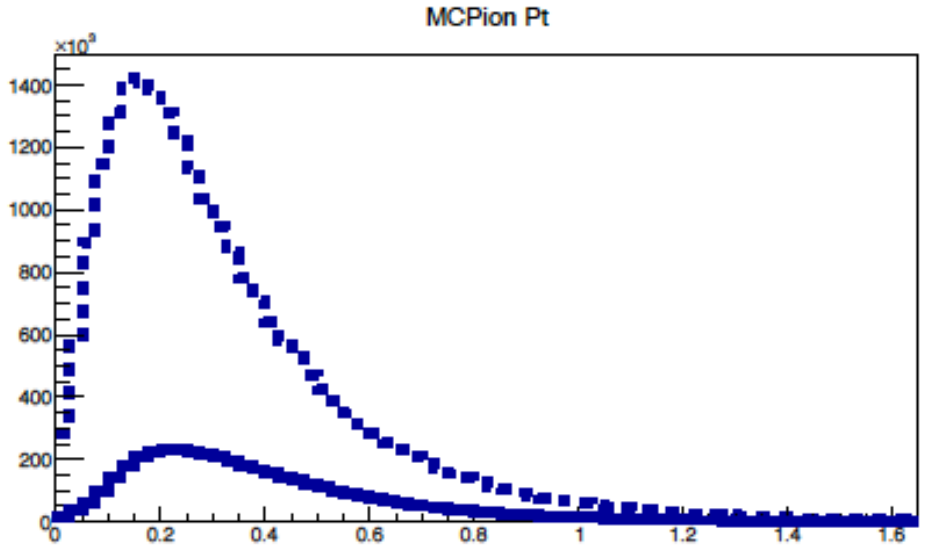


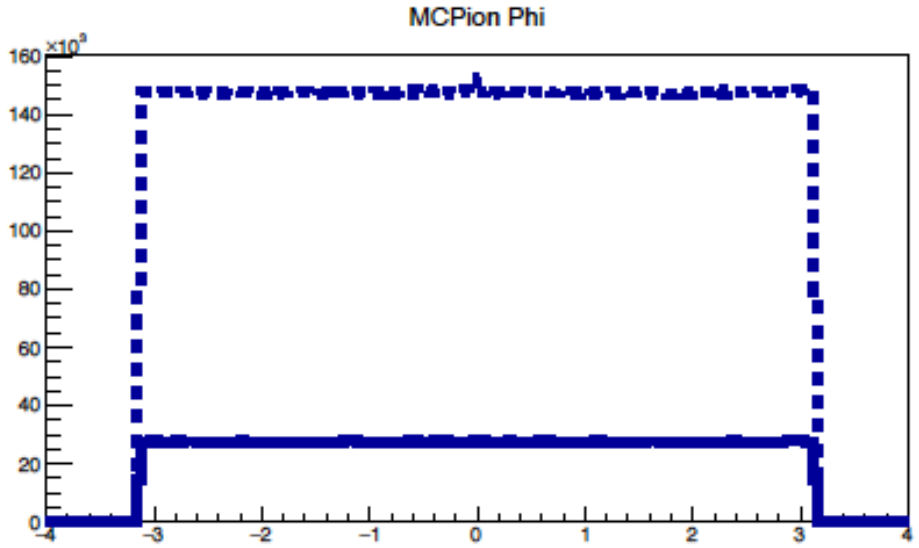


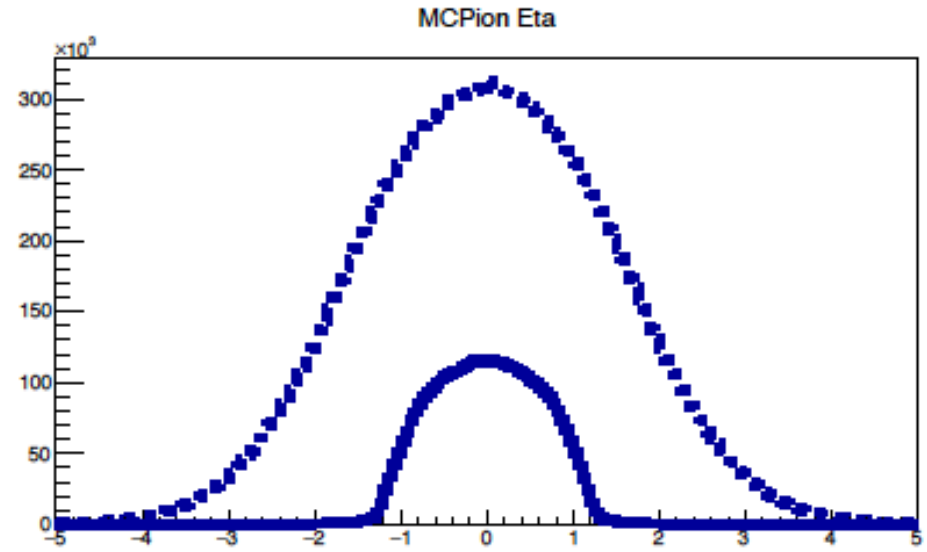


π^0 Flow

Distribution for Rec and MC

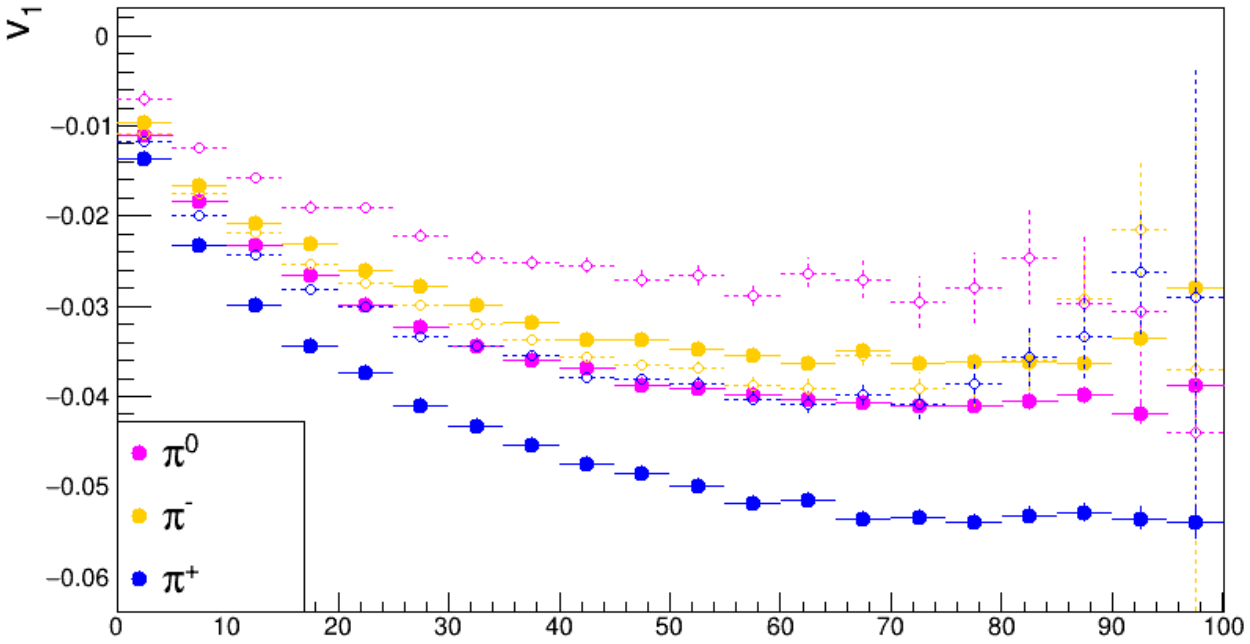


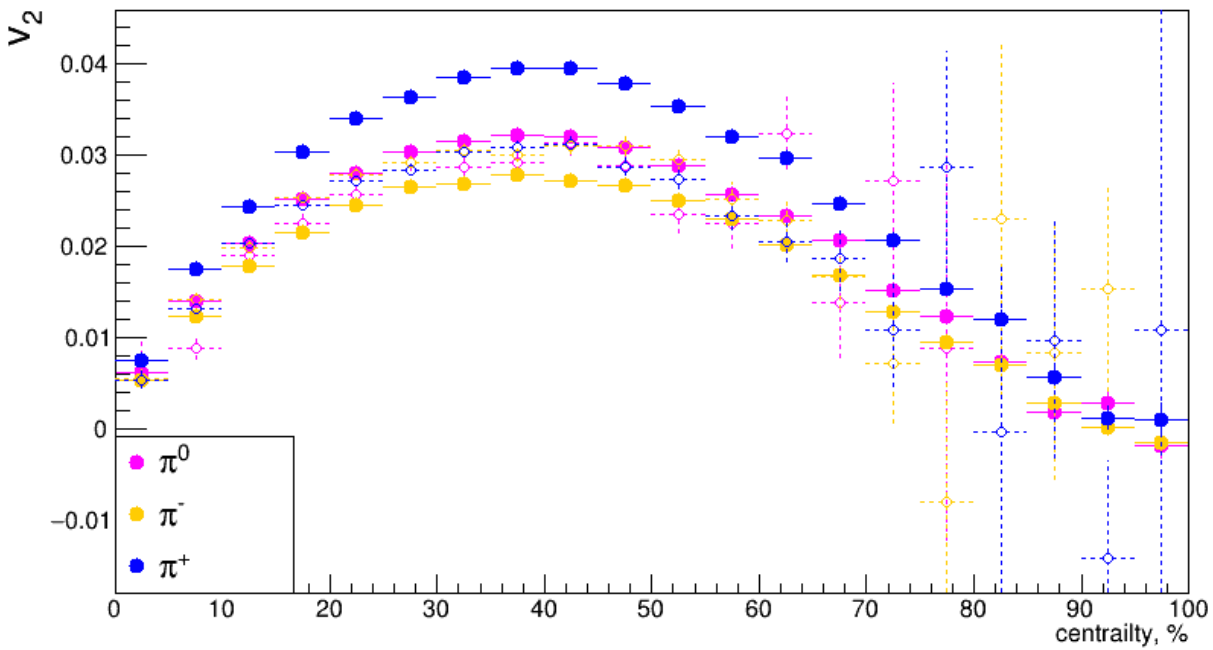




Bi+Bi @9.46GeV
0.3M Events for π^0

With Centrality

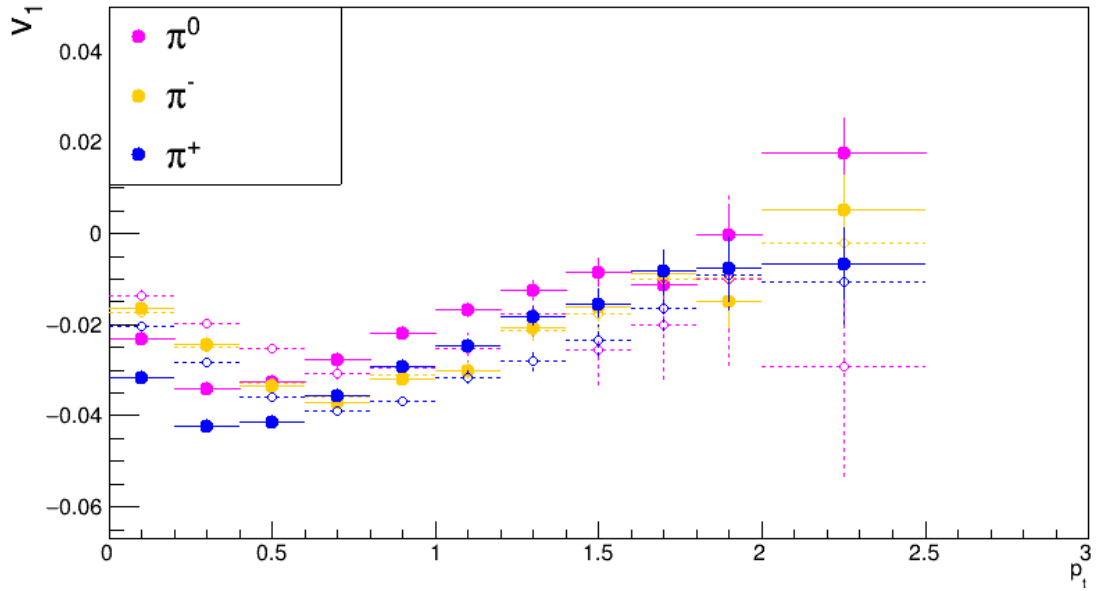


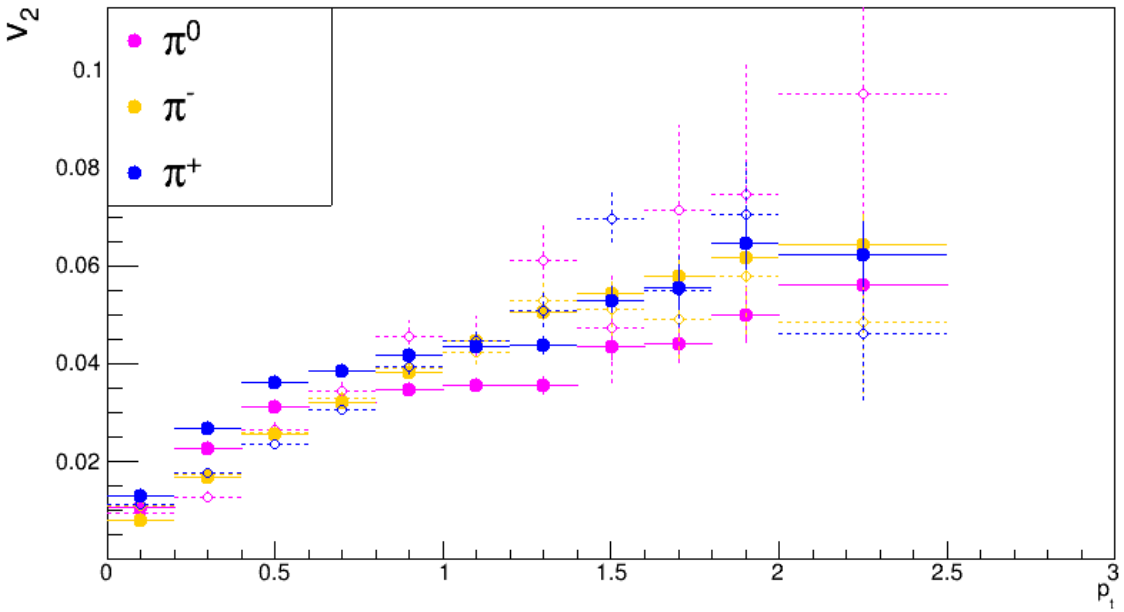


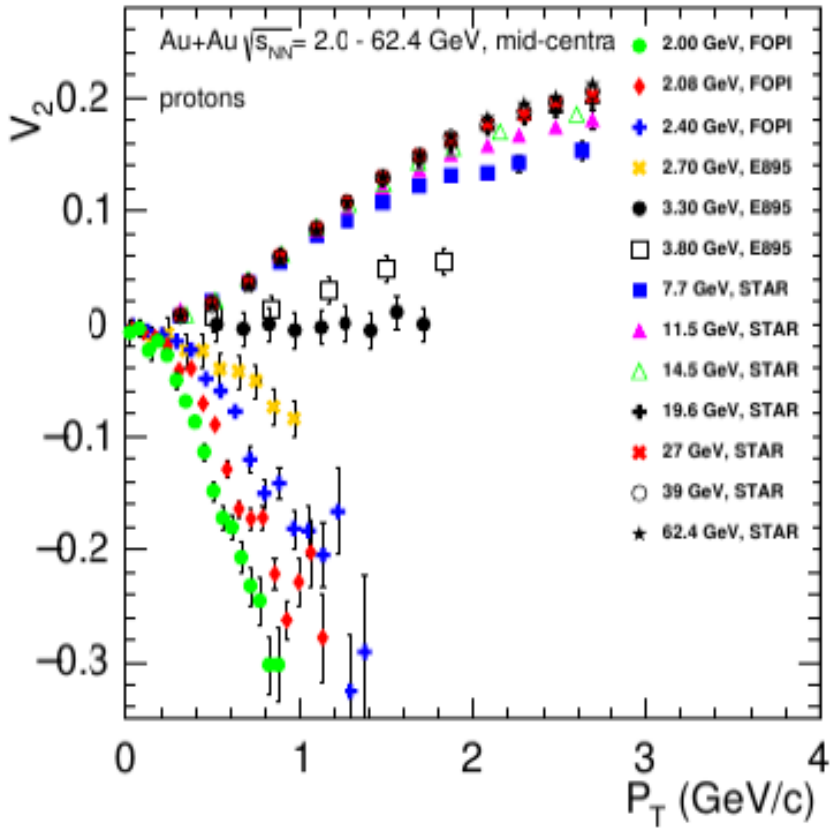
Large deviation between Rec and Mc for π^0 and π^+

With Pt

10-20% centrality

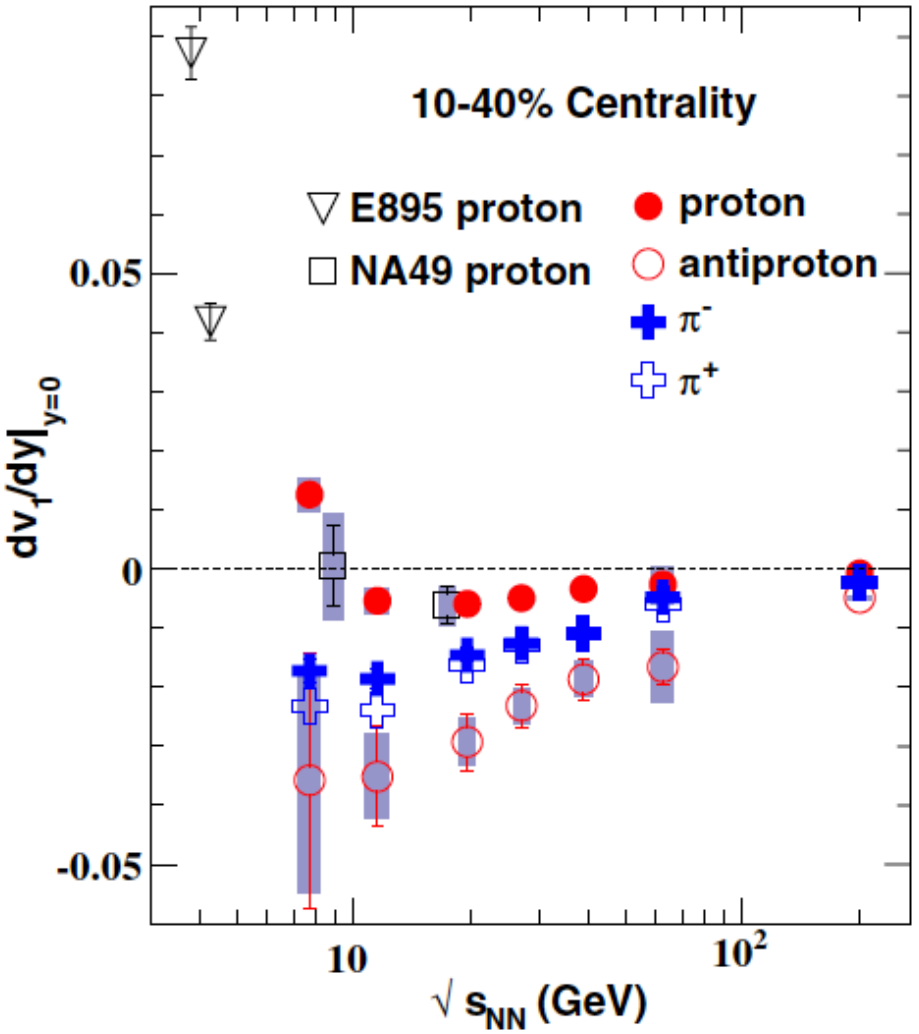






With η

10-20% centrality



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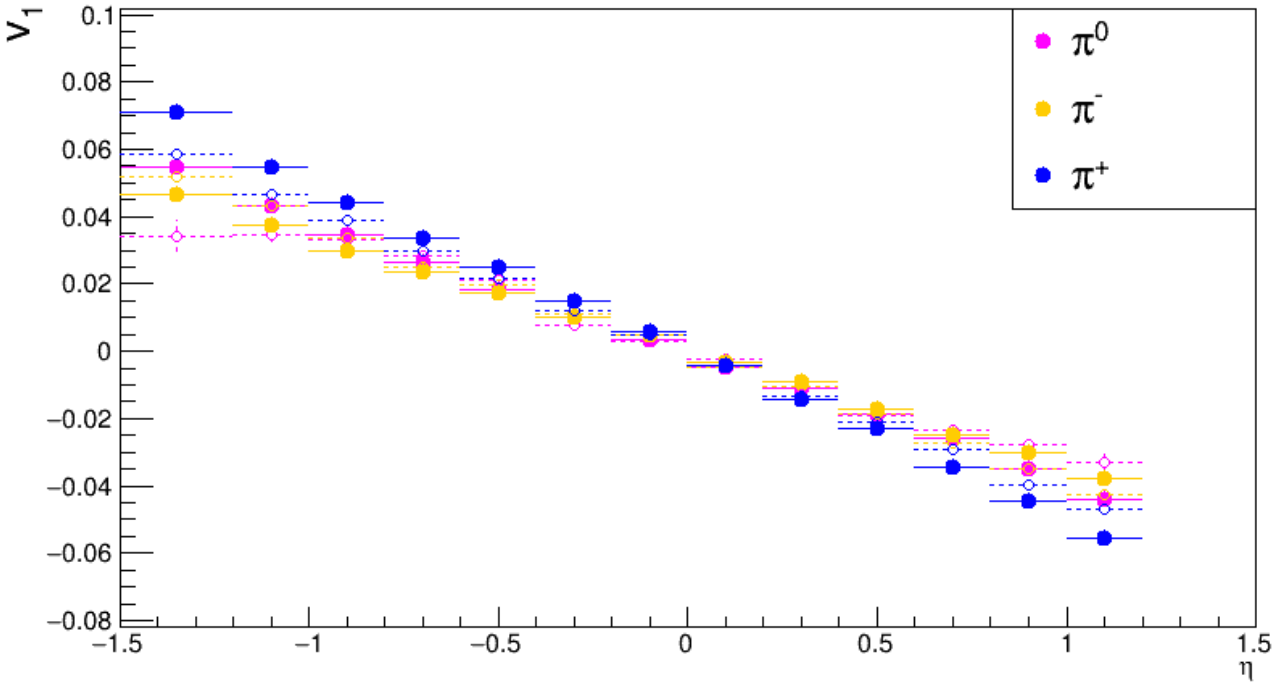
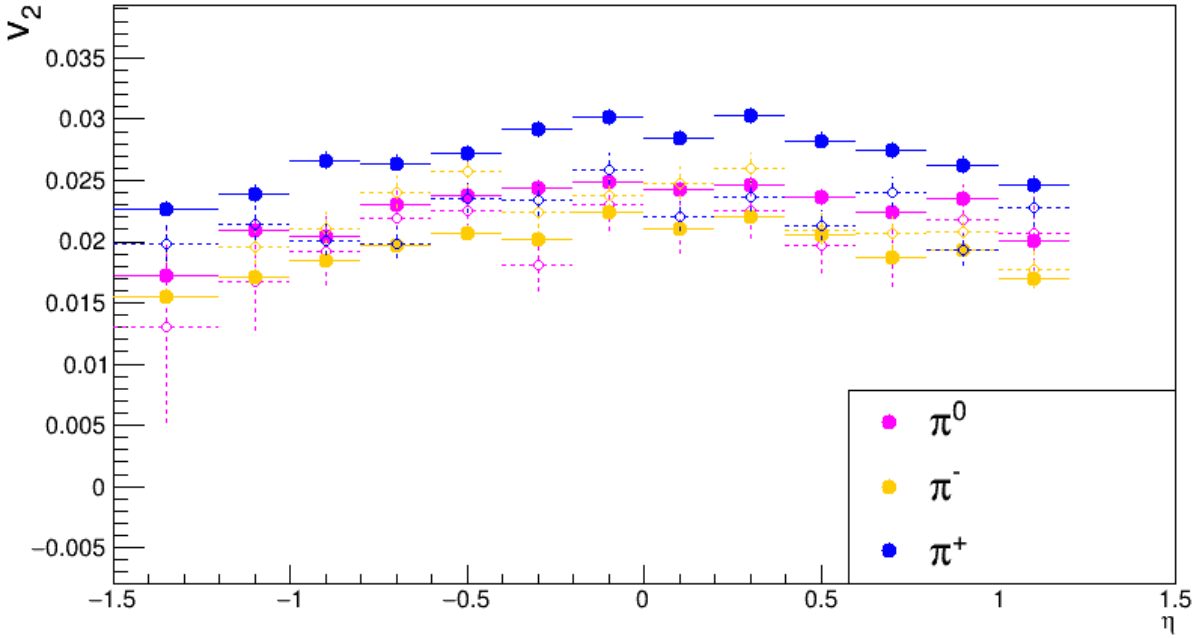
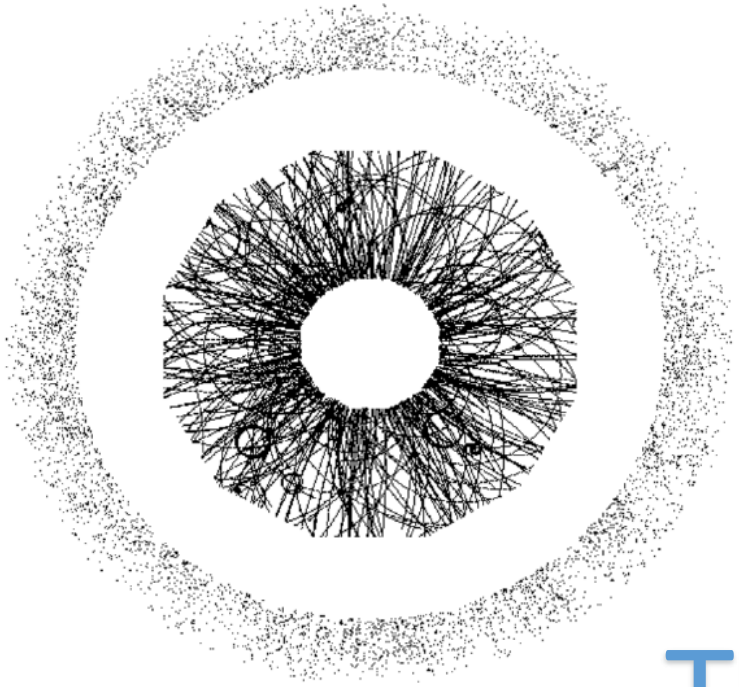




Summary

- ✓ Flow of π^0 reconstructed from ECal are calculated preliminarily.
- ✓ The functions of flow with centrality, Pt and η are achieved.



Thanks for your attention!

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             ;
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ROOT_prompt_11:1:1: error: use of undeclared identifier 'mpd'
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ROOT_prompt_12:1:1: error: use of undeclared identifier 'mpd'
mpd.Write();}
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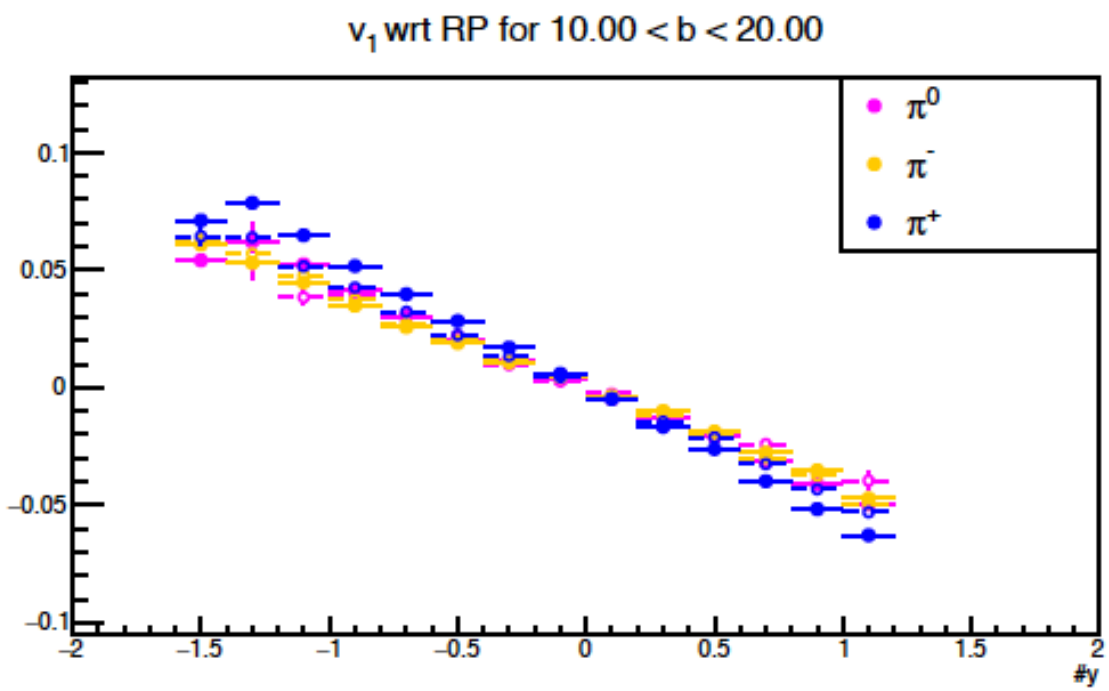
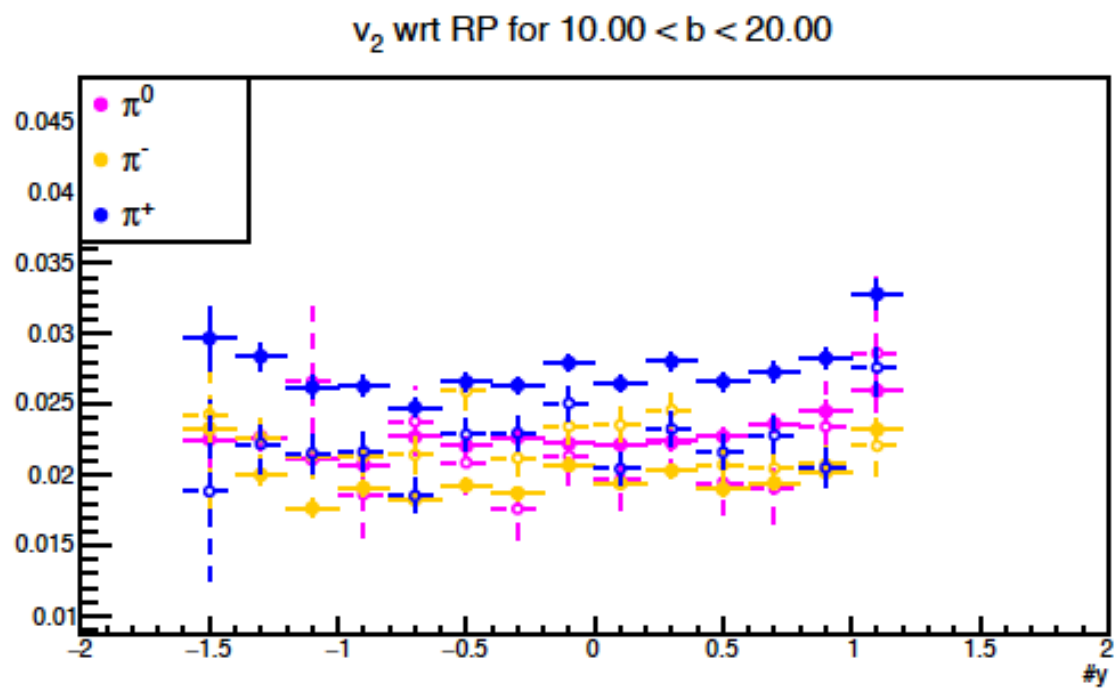
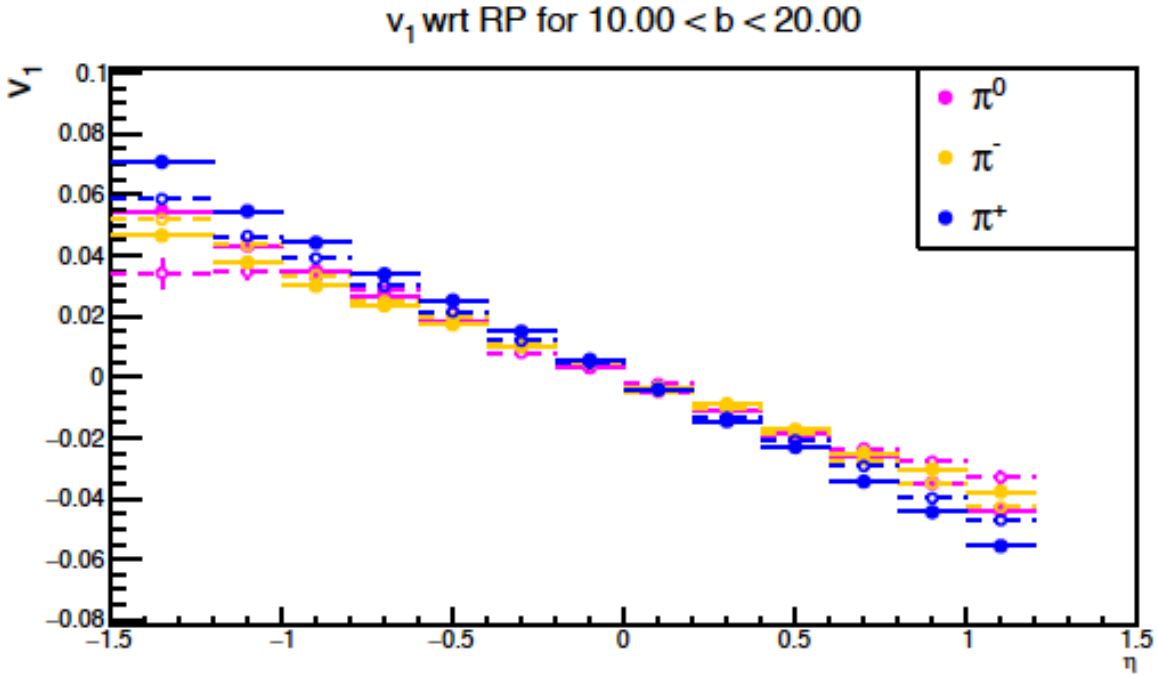
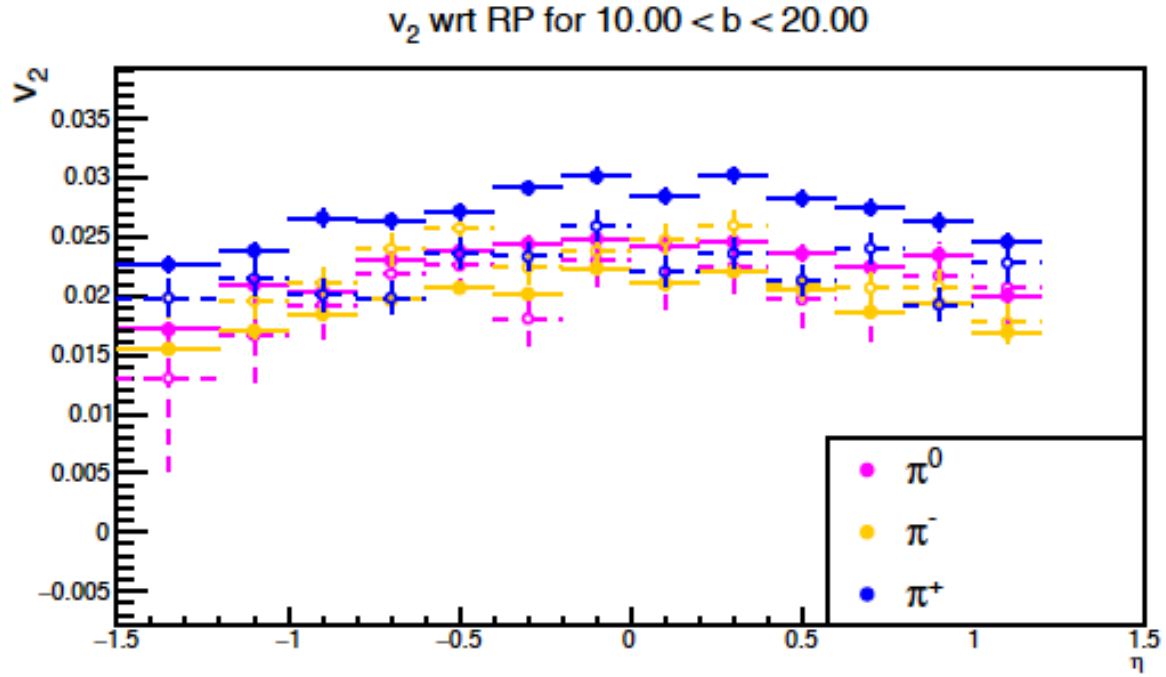
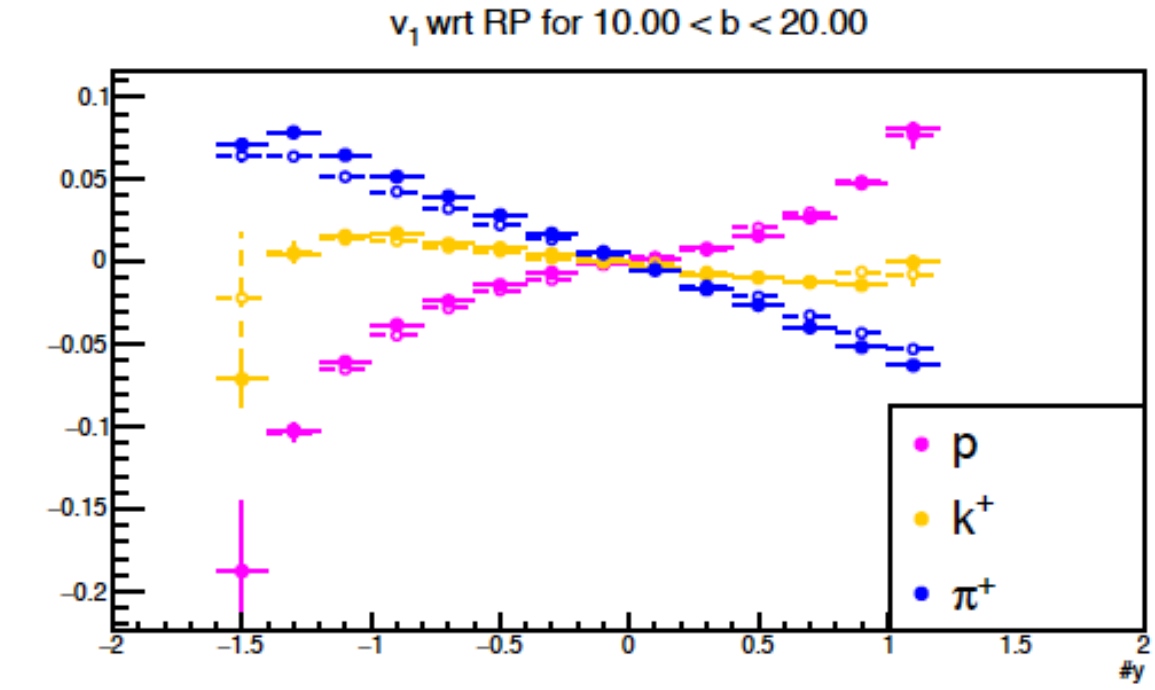
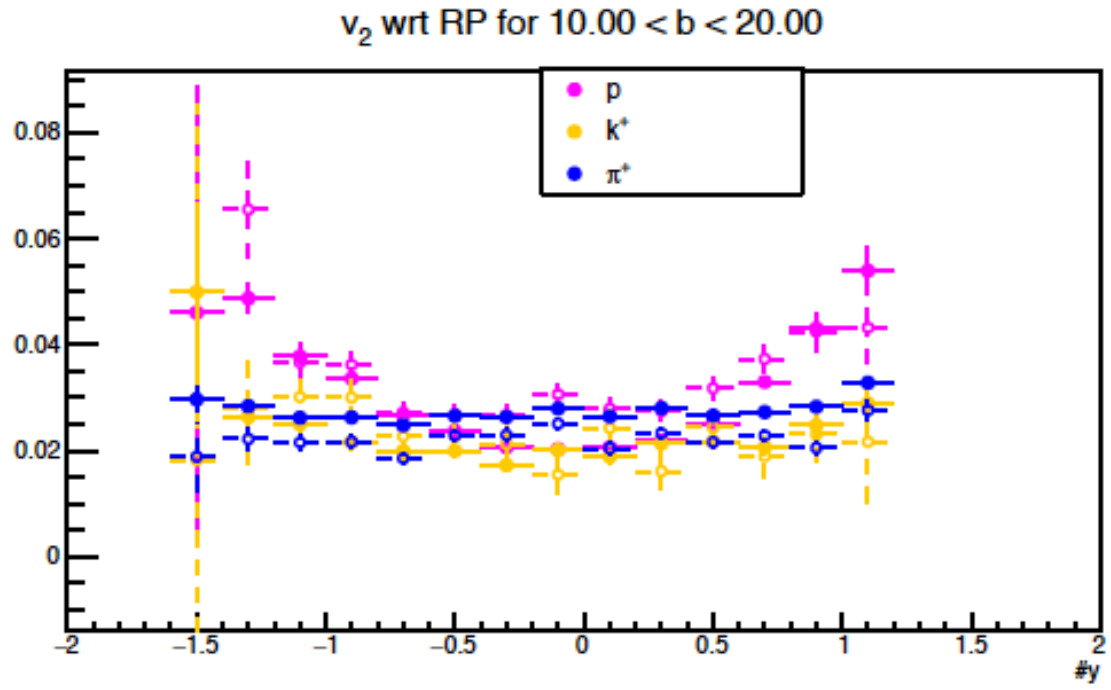

v_1 wrt RP for 10.00 < b < 20.00
π^0
π^-
π^+
#y

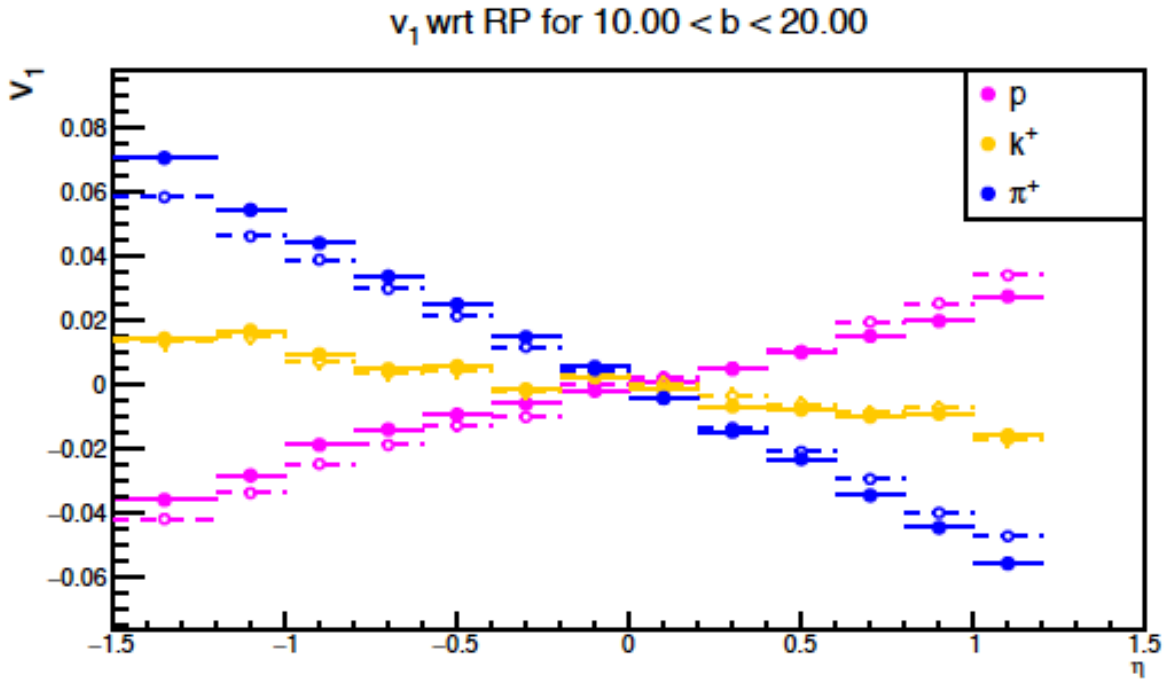

v_2 wrt RP for 10.00 < b < 20.00
π^0
π^-
π^+
#y

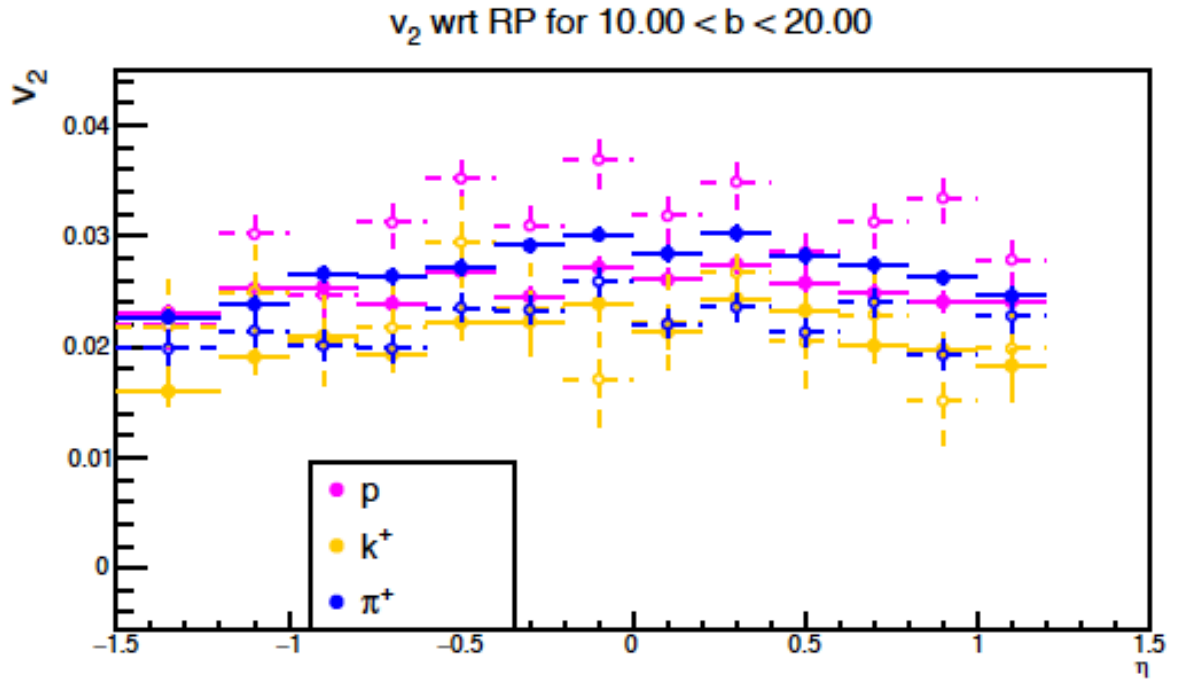

v_1 wrt RP for 10.00 < b < 20.00
v_1
π^0
π^-
π^+
η


v_2 wrt RP for 10.00 < b < 20.00
v_2
π^0
π^-
π^+
η


v_1 wrt RP for 10.00 < b < 20.00
p
k^+
π^+
#y


v_2 wrt RP for 10.00 < b < 20.00
p
k^+
π^+
#y


v_1 wrt RP for 10.00 < b < 20.00
v_1
p
k^+
π^+
η


v_2 wrt RP for 10.00 < b < 20.00
v_2
p
k^+
π^+
η