Transverse momentum dependence of v2 for identified hadrons measured in PHENIX experiment

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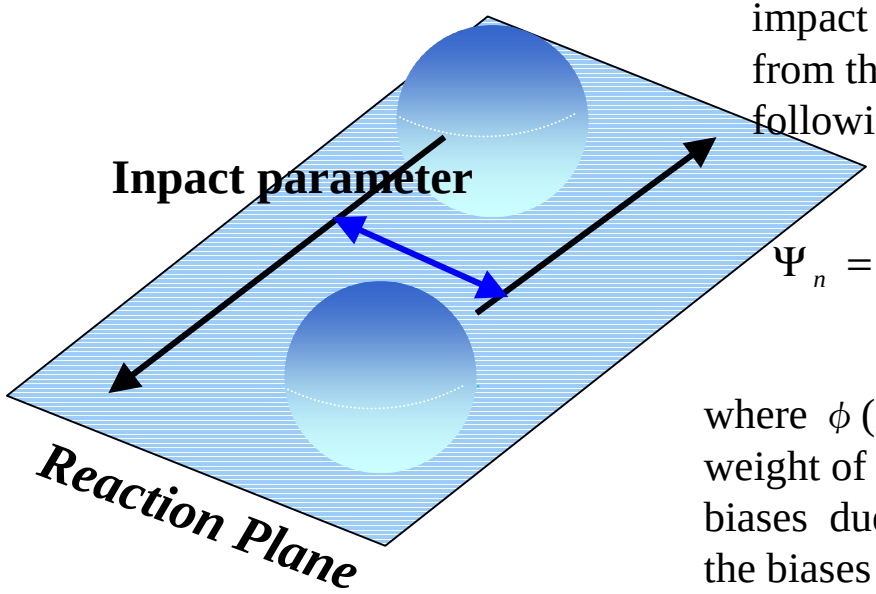
Introduction

The azimuthal event anisotropy is believed to be very sensitive to the early pressure gradient in the collision zone. Therefore it is one of the important observable that helps us to understand the early stage of unclear-nuclear collisions. The transverse momentum dependence of the anisotropy for the different particle species could possibly provide further information on how the anisotropy is developed during the collisions.

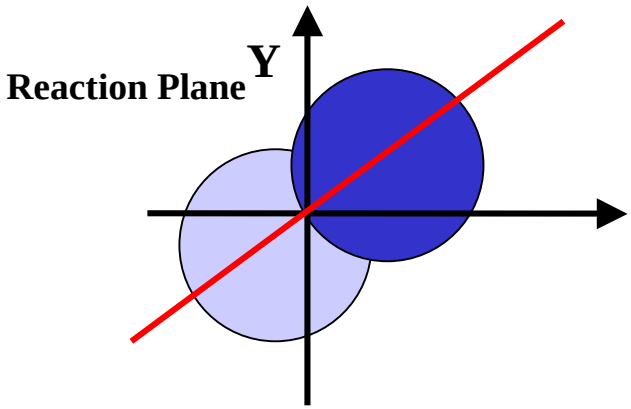
Reaction plane



Reaction plane is defined by the beam direction and the impact parameter direction . Reaction plane angle Φ(n) from the n-th harmonic of the distribution are defined by following equation :

$$\Psi_n = \left(\tan^{-1} \frac{\sum_i w_i \sin(n\phi_i)}{\sum_i w_i \cos(n\phi_i)} \right) \Big/ n \qquad (0 \le \Psi_n < 2\pi/n)$$

where ϕ (i) is the azimuhal angle of each particles and w(i) is weight of each particle. In the laboratory, reaction plane has biases due to the finite acceptance of the detector. To removed the biases of the reaction plane, “flattening method” which is one of the “shifting method ” are adopped in the analysis. Correction factor is obtained following equation:



$$n\Delta\Psi_n = \sum_n \frac{2}{i}[A_n \cos(in\Psi_n) + B_n \sin(in\Psi_n)]$$

$$A_n = -\frac{2}{i} < \sin(in\Psi_n) >, B_n = -\frac{2}{i} < \cos(in\Psi_n) >$$

where i is degree of Fourier expansion.

Method of Analysis of Azimuhal Anisotropy (reaction plane method)

"Reaction plane method" is a one of the analysis method of azimuhal anisotropy of particle emission. Azimuhal anisotropy can be evaluated with following Fourier expansion of azimuthal distribution of particles (ϕ) with respect to the reaction plane (Ψ) ;

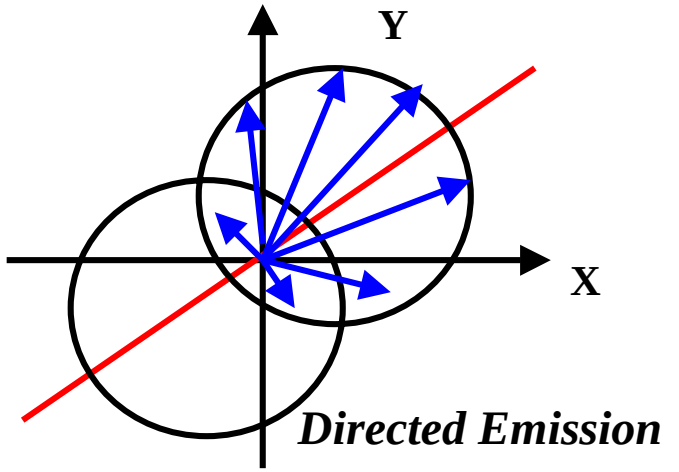
$$\frac{dN(\phi)}{d(\phi-\Psi)} = N_0\{1+\sum 2v_n \cos(\phi-\Psi)\}$$

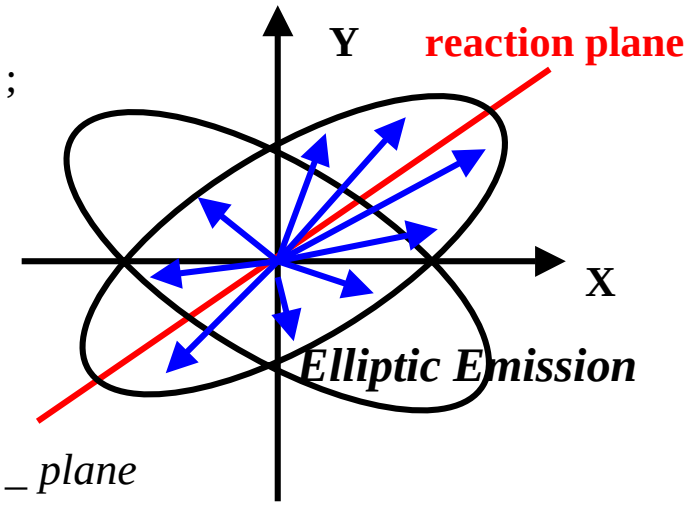
The first two harmonics are called directed and elliptic emission patterns. The coefficients v (n) is evaluated by ;

$$v_n = <\cos[n(\phi-\Psi)]>$$

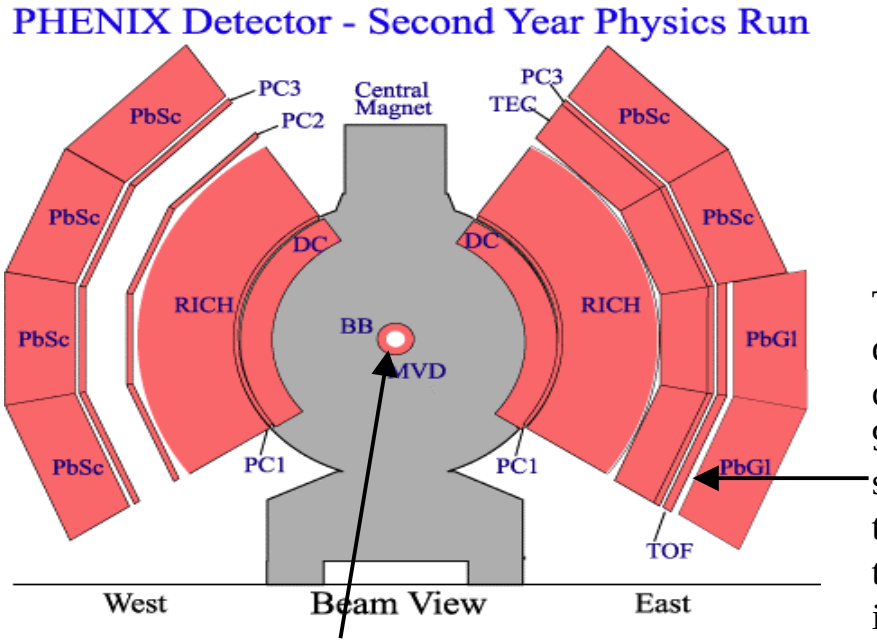
Using resolution of the reaction plane, the strength of azimuthal anisotropy is given as;

$$v_n = <\cos[n(\phi-\Psi)]> / \sigma_{reaction\_plane}$$





Detectors



<Beam-Beam-Counter>

The main purpose of BBC is to provide the start time for the Time of flight measurement, to produce a signal for the PHENIX Level-1 trigger and to Decide the collision vertex point along the beam axis. The BBC consists of two identical sets of counters installed on both sides of the beam axis (north & south) and located 144cm from the center of the collision point. Start timing resolution of the BBC has about 40 ps.

<Time-of-flight>

The TOF detector is a primary particle identification device for charged hadrons in PHENIX. The detector consist of 10 panels of TOF walls. One wall consist of 96 scintillators and 196 photo-multiplier tubes. The slat is oriented along the r- ϕ direction and provides time and longitudinal position information of particles that hit the slat. The designed time resolution of TOF is 80 ps, which corresponds to the π/K separation up to 2.4 GeV/c and K/Proton separation up to 4.0 GeV/c in 4 σ.

Data selection

<Run & Event selection>

Full field data

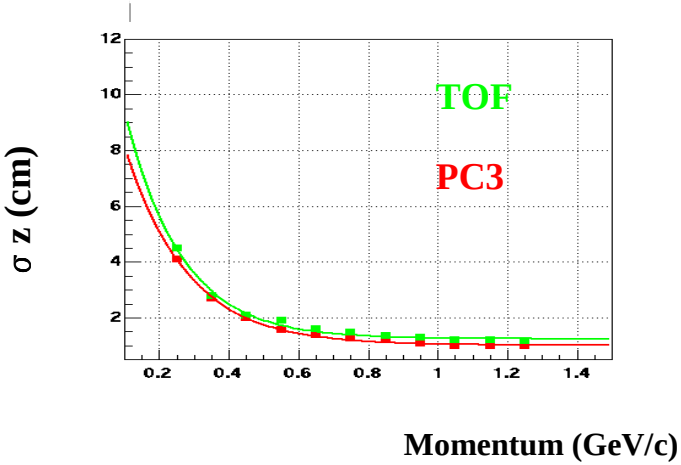
BBC zvertex < ±30.0 cm

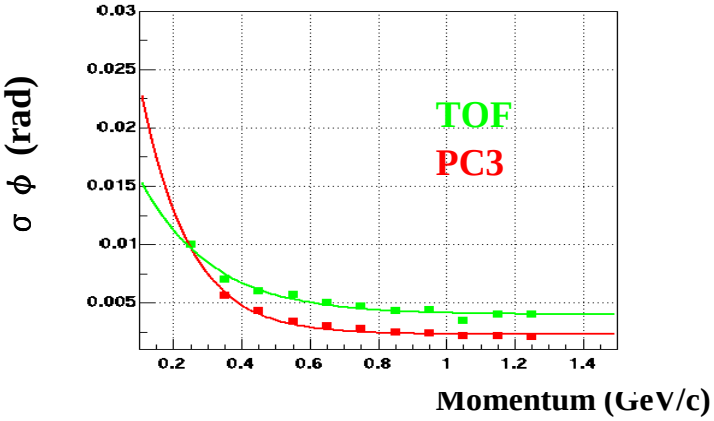
Total event using this analysis ･･･~ 10 M

<Track selection>

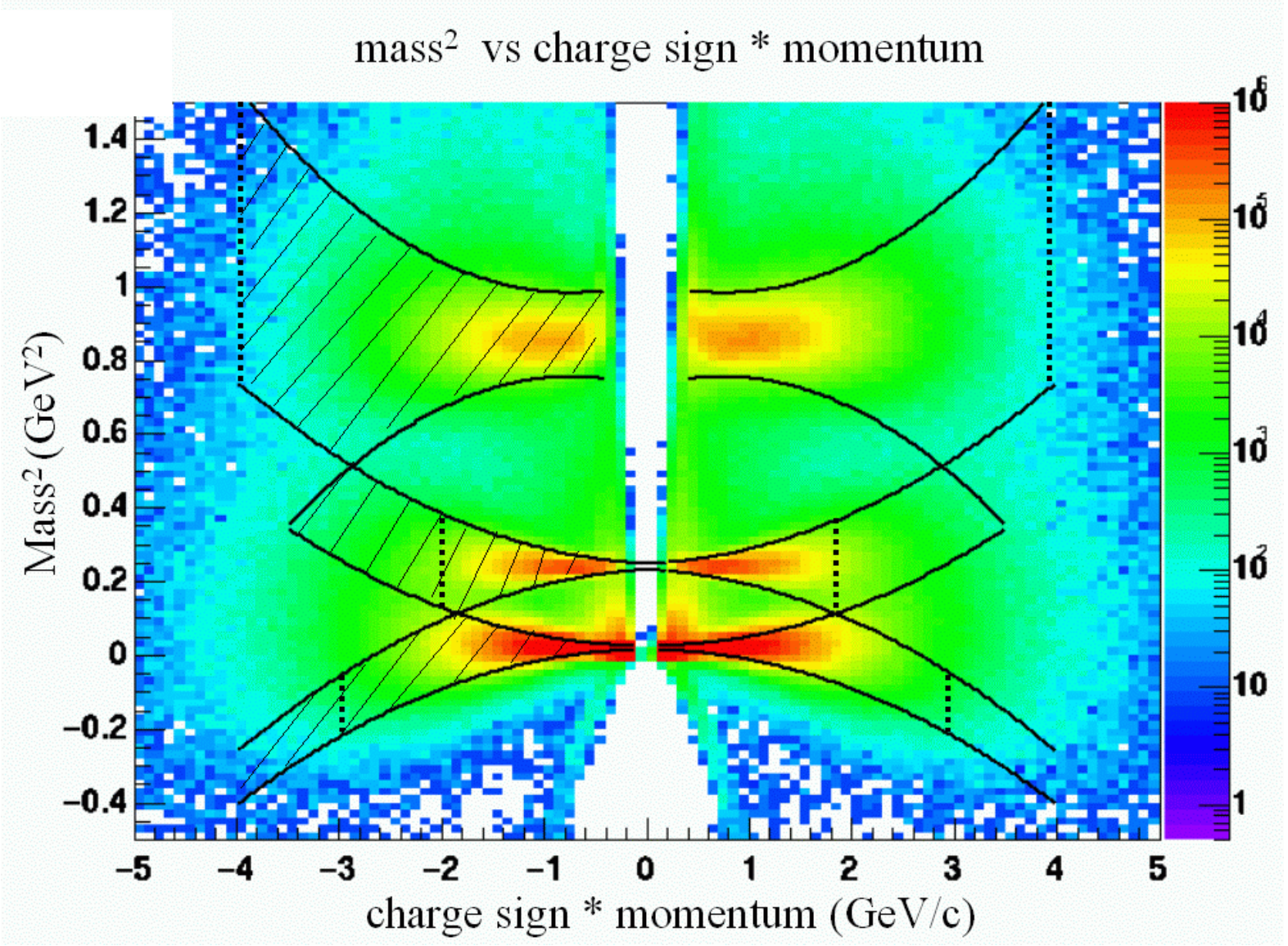
TOF･･･TOF-Track matching cut < 2 σ

PC3-Track matching cut < 2 σ

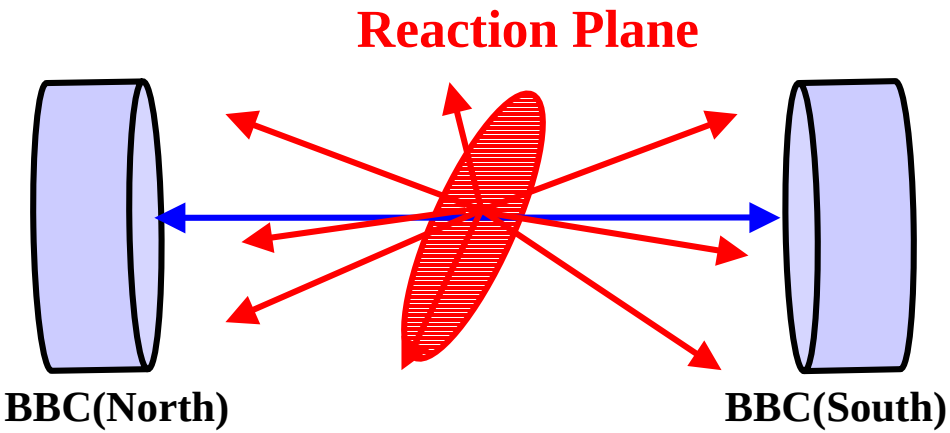




PID

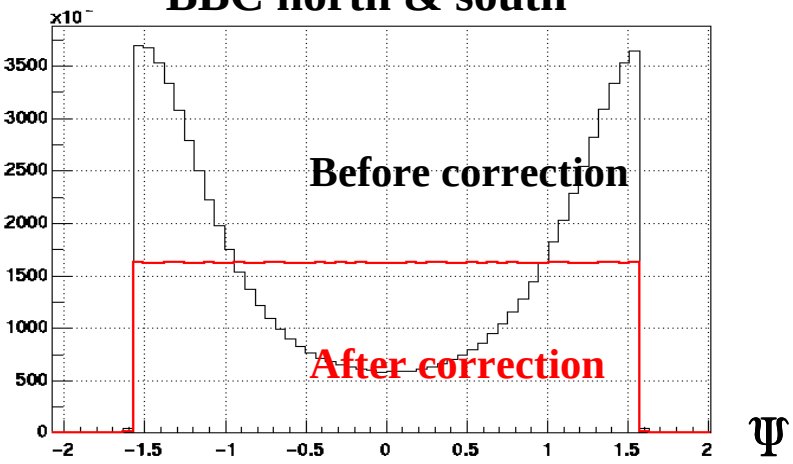

mass² vs charge sign * momentum
Mass² (GeV²)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−5
−4
−3
−2
−1
0
1
2
3
4
5
charge sign * momentum (GeV/c)
10⁶
10⁵
10⁴
10³
10²
10
1

Reaction plane determination using BBC

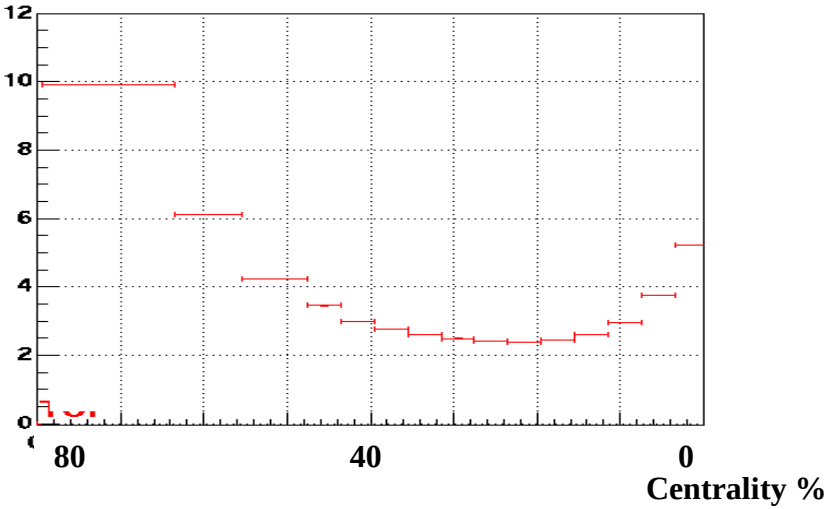


$$\Psi_n = \left(\tan^{-1} \frac{\sum_i ADC_i \sin(n\phi_i)}{\sum_i ADC_i \cos(n\phi_i)} \right) \Big/ n$$

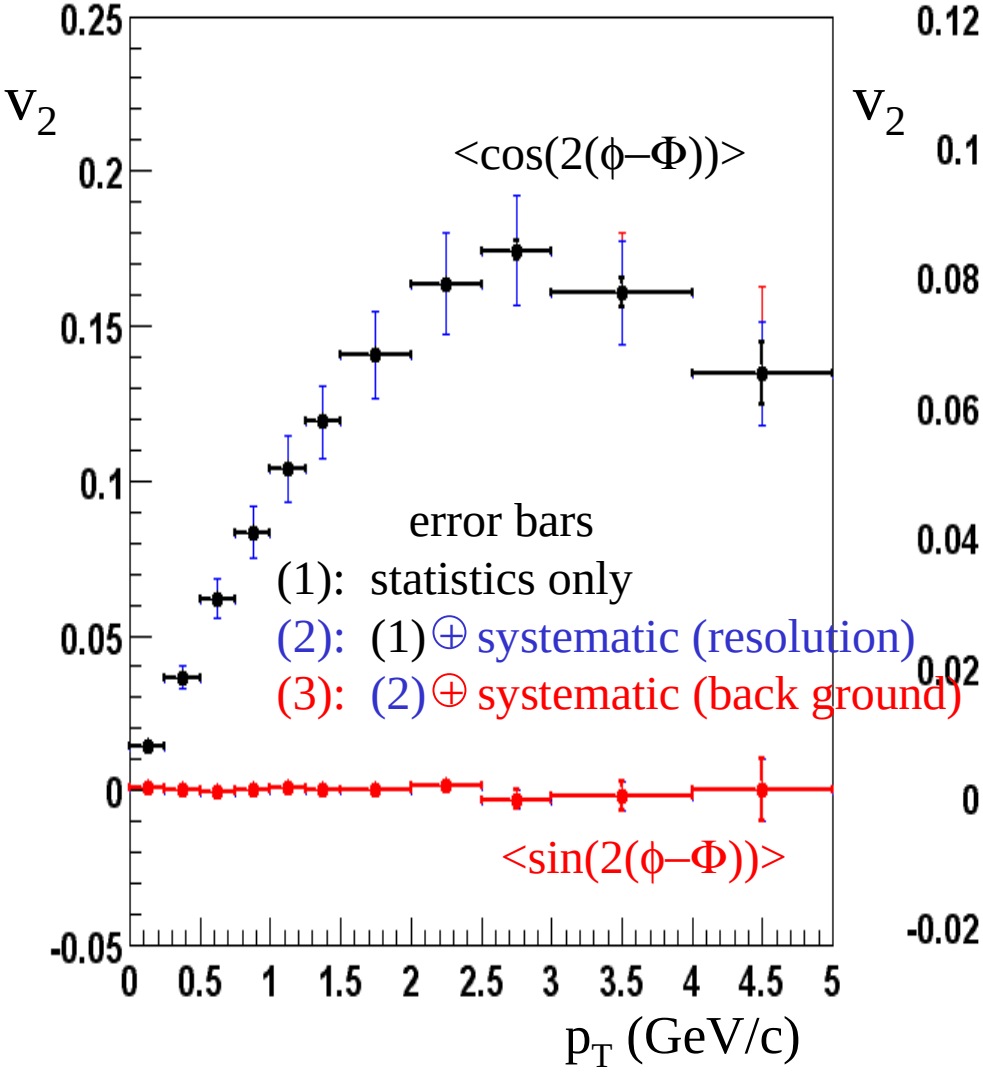
Decide Reaction plane using BBC north & south

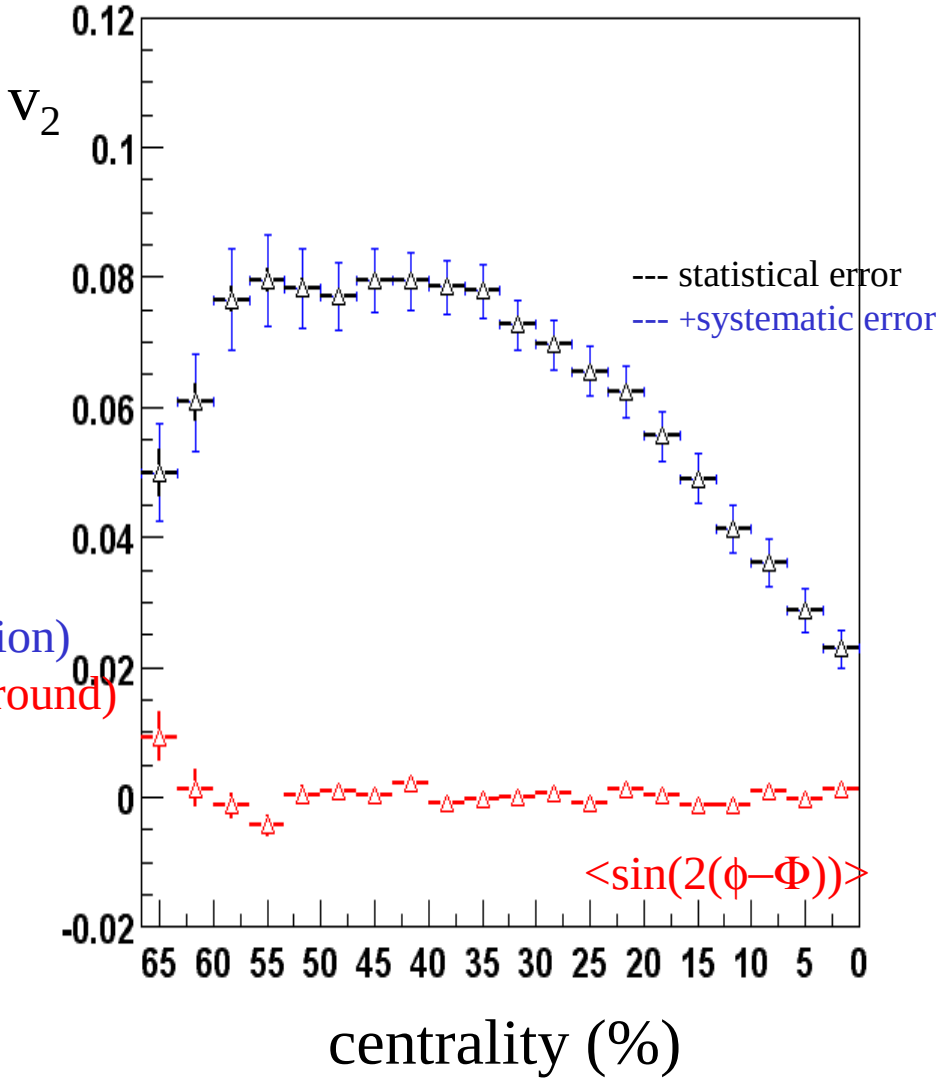


resolution

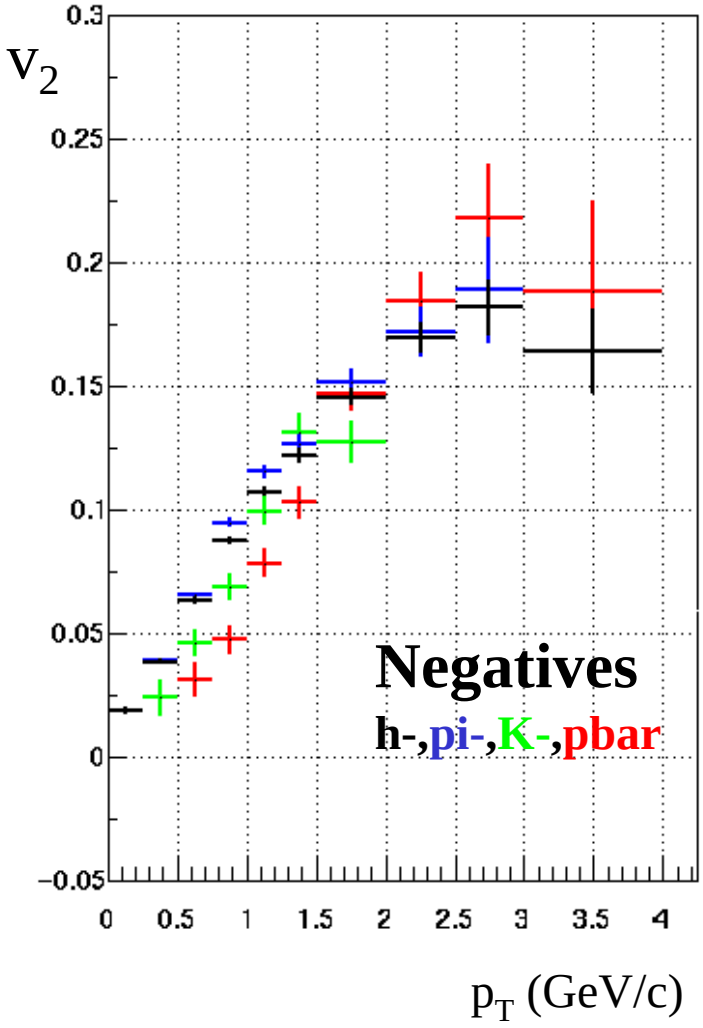


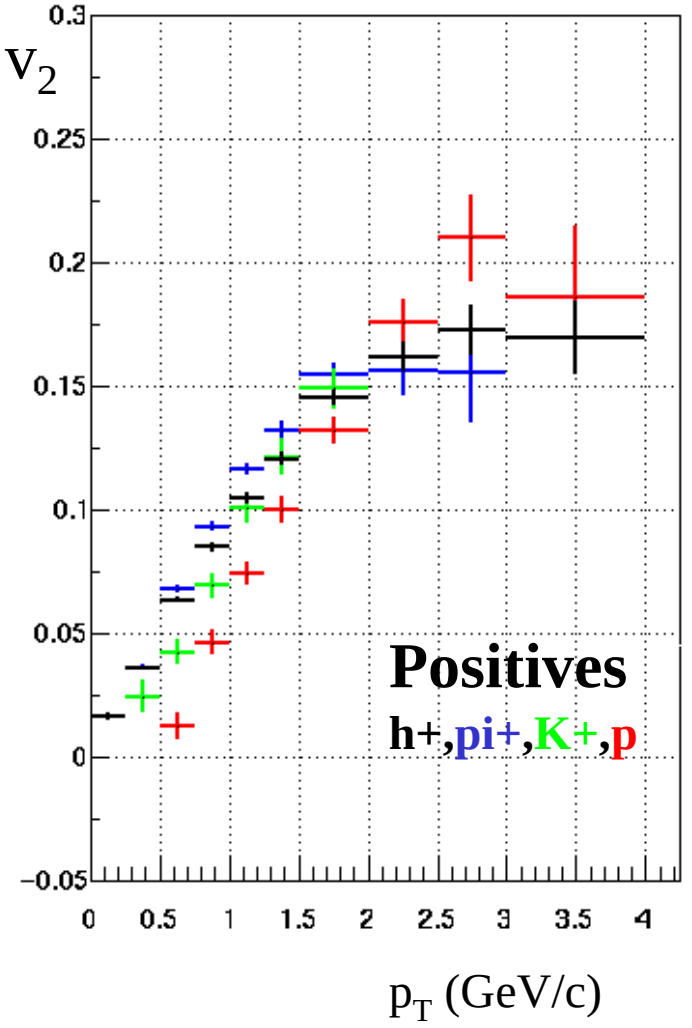
Transverse & Centrality dependence of v_2



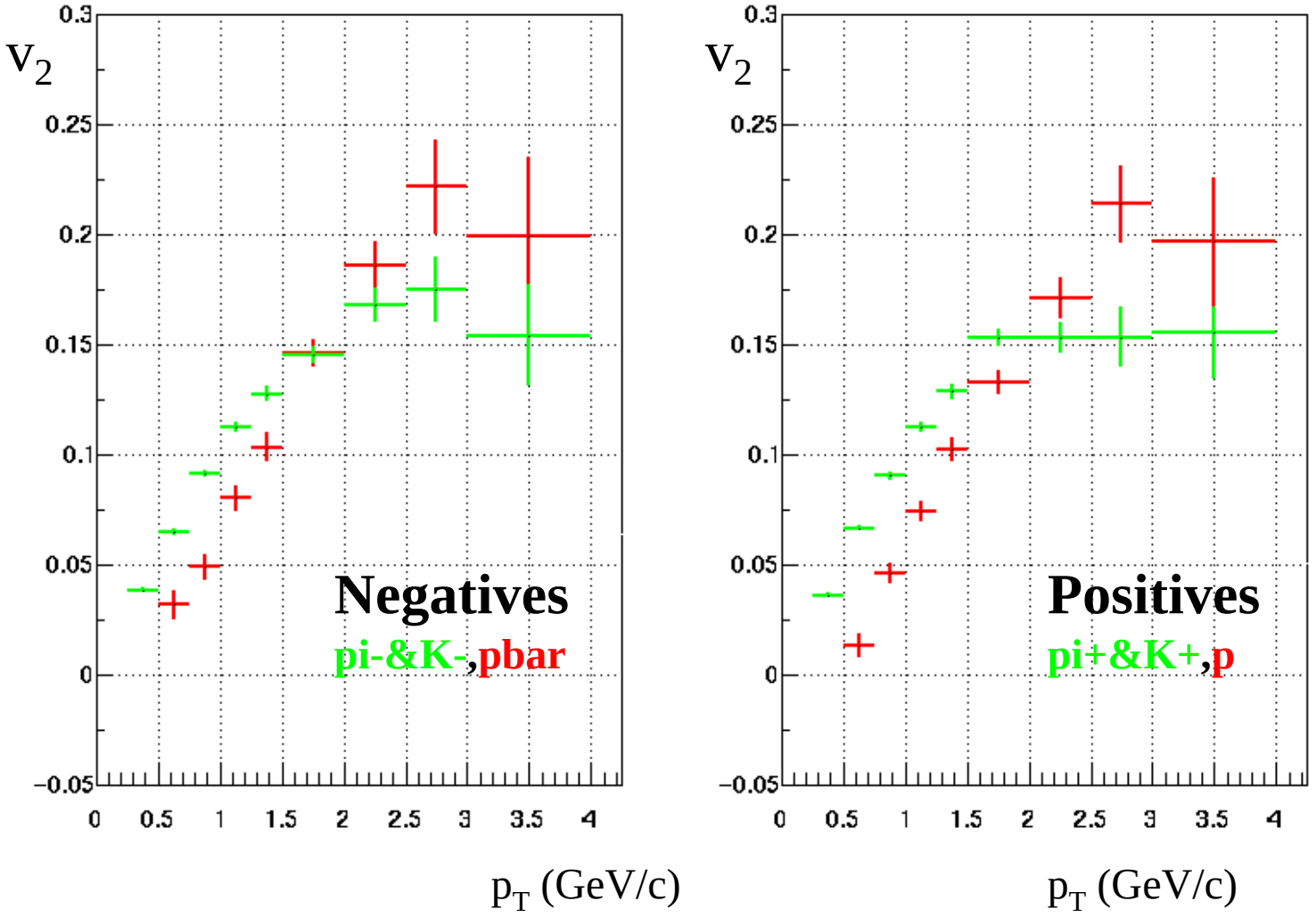


Transverse dependence of v_2 (PID)

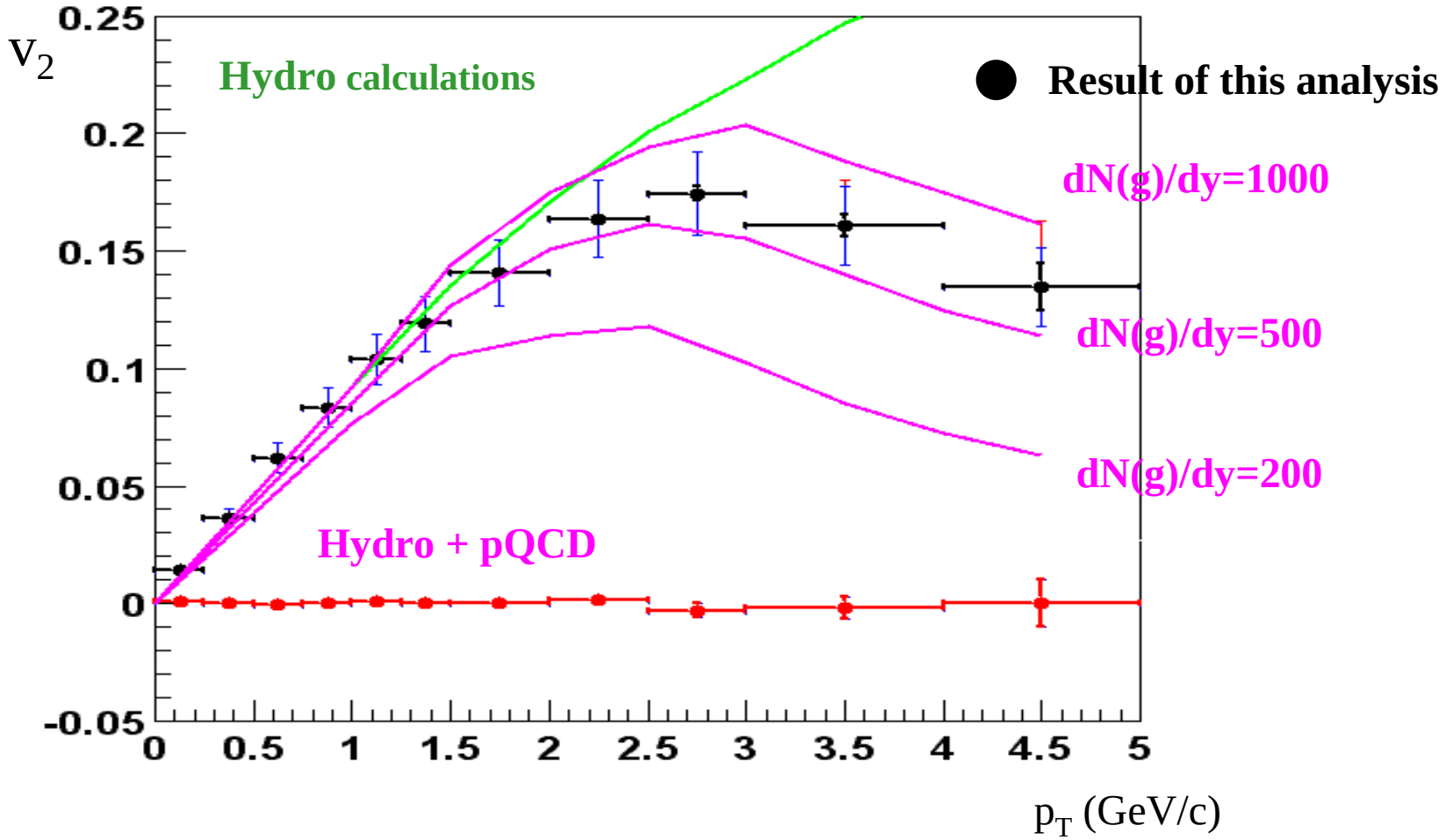




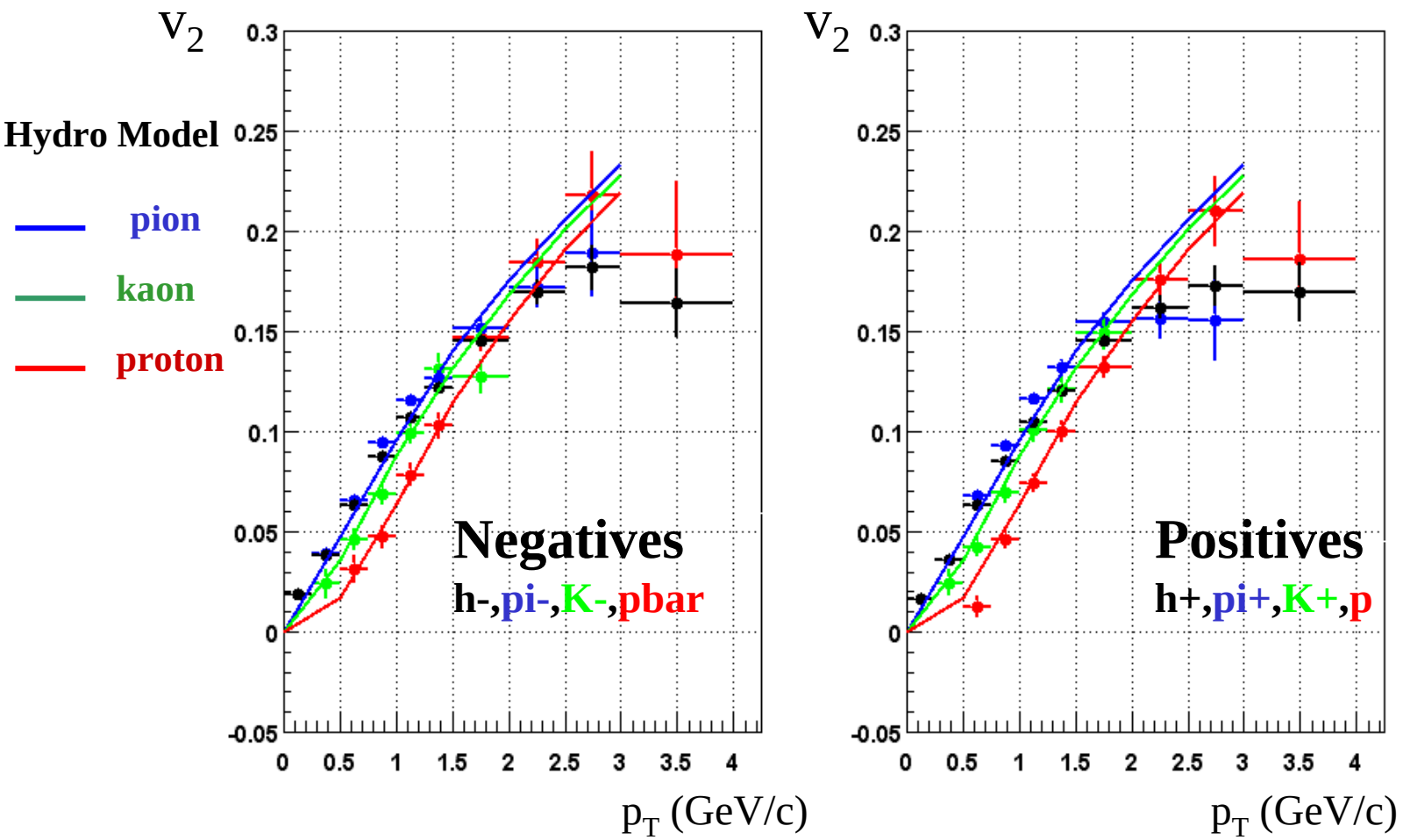
Transverse dependence of v_2 (PID)



Compare the theory(1)



Compare the theory(2)



Summary

In this study, v2 of identified particles (pi+,pi-,K+,K-,p,pbar) and Charged particle are measured as function of transverse momentum.

- Above 2.5 GeV/C the saturation of v2 is clearly seen
- Clear identified particle dependence is seen expected the Hydro model