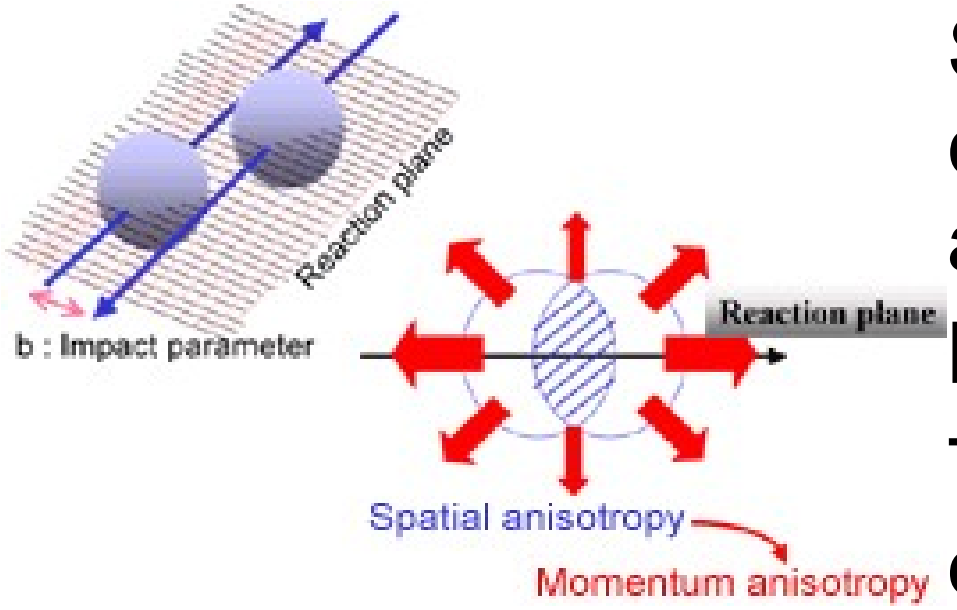
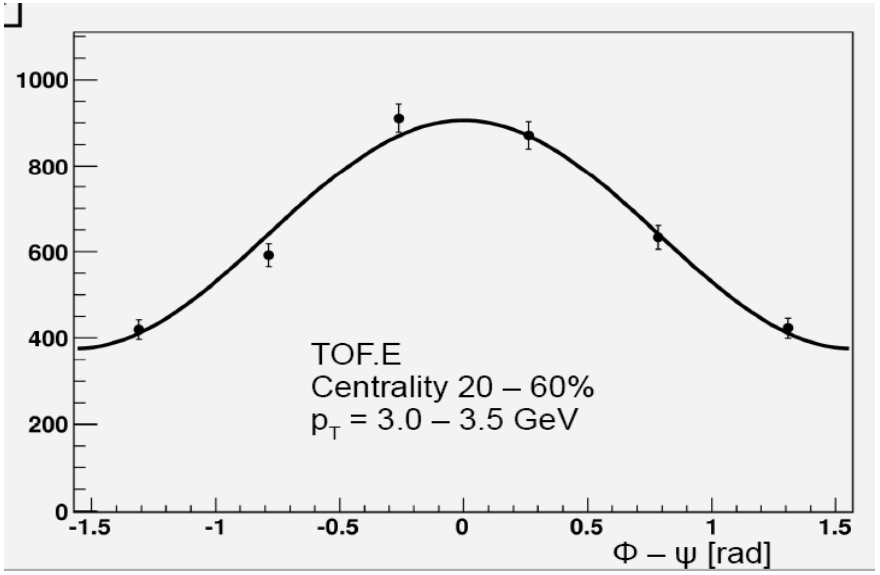
Measurement of Azimuthal Anisotropy with the New Reaction Plane Detector in the PHENIX experiment

Yoshimasa Ikeda
for the PHENIX collaboration
(University of Tsukuba)

Azimuthal anisotropy





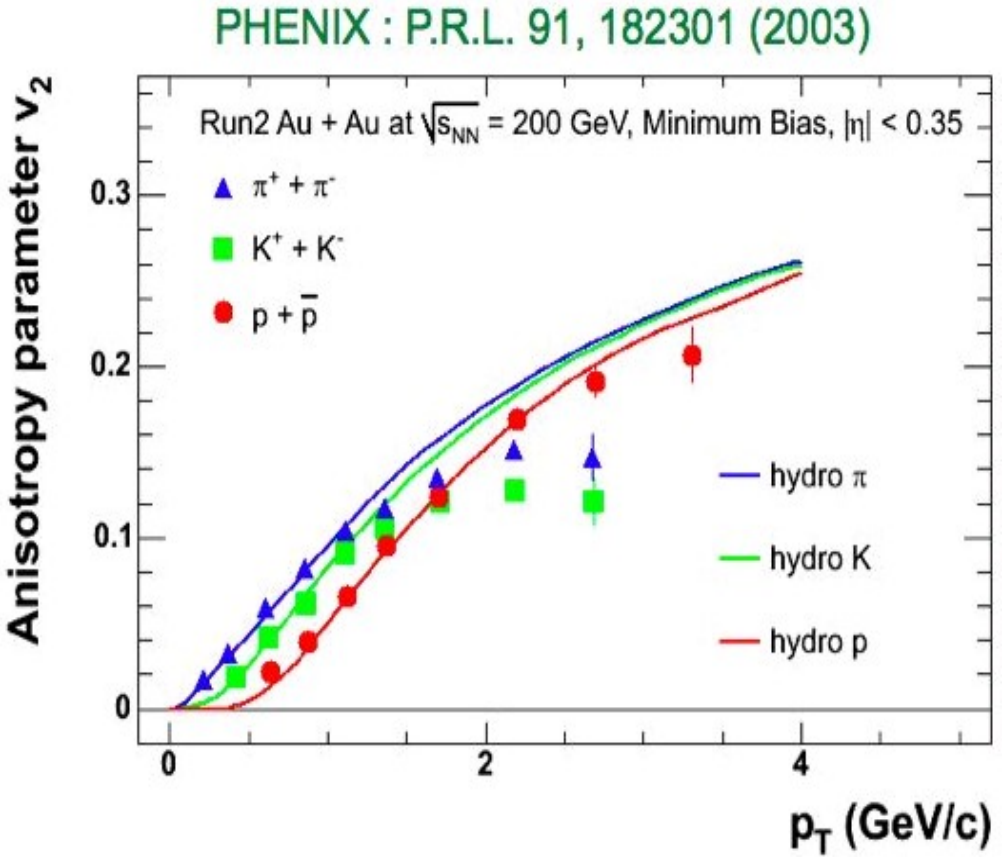
Spatial anisotropy in non-central collision provides azimuthal anisotropy of particle emission.

The large anisotropy is an evidence of the formation of a hot and dense partonic matter.

$$\frac{dN}{d\Phi} \propto 1 + 2v_2 \cos 2(\Phi - \Psi)$$

Ψ : reaction plane angle

Motivation of v_2 measurement



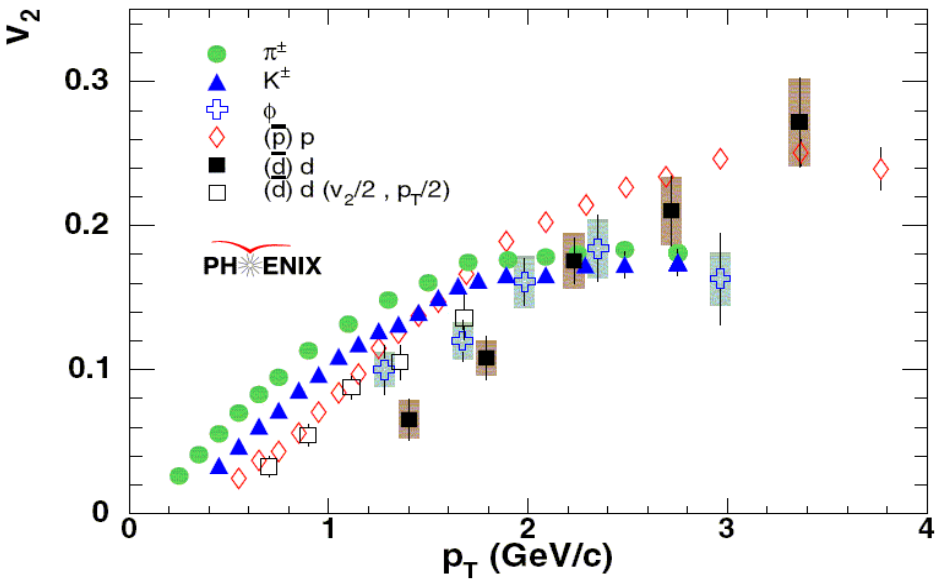
Large v_2 was observed in RHIC

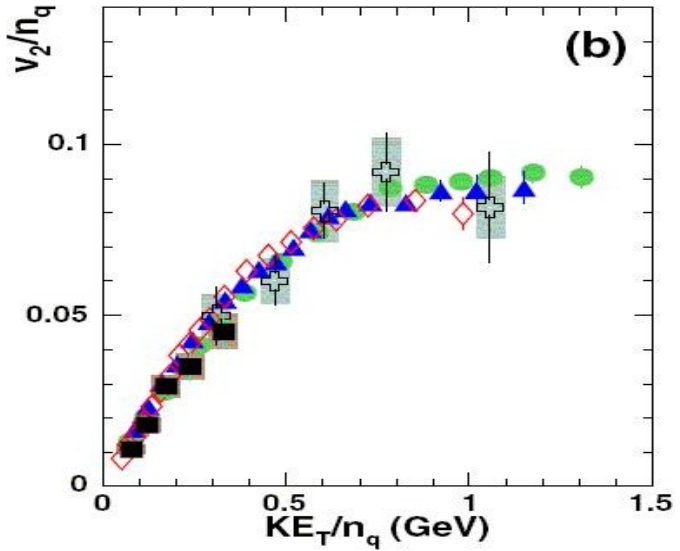
The values agreed with hydro-dynamical models

It suggests rapid thermalization and quark flow.

KE_T and quark number scaling

PHENIX. PRL. 99, 052301 (2007)

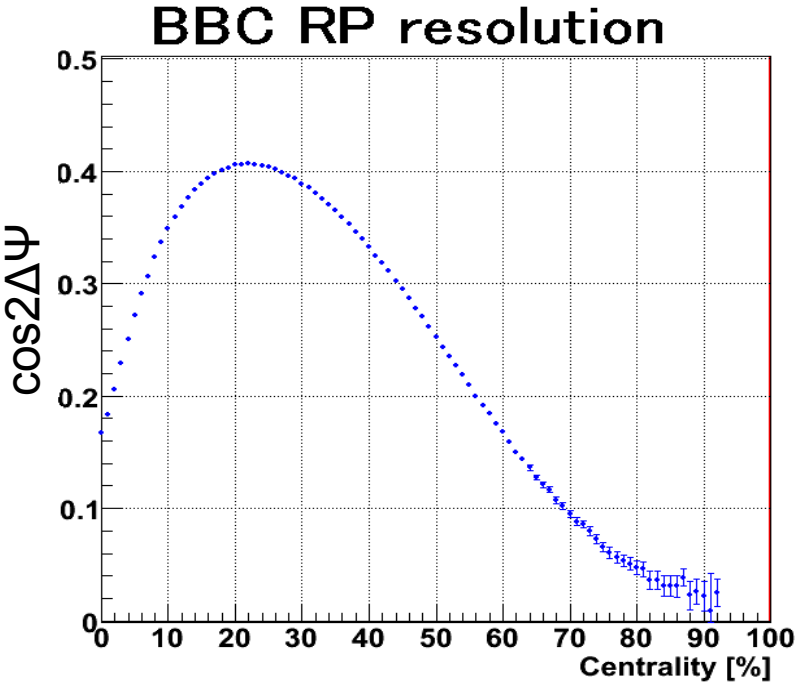




- The values of v_2 are in proportion to the number of quarks
- heavy particle shifts to high p_T
- These agree very well by KE_T/n_q scaling at low p_T range.

$$KE_T = \sqrt{(M^2 - P_T^2)} - M$$

Reaction Plane Resolution



$$v_{2\,observe} = v_{2\,real} \times \langle \cos 2(\Psi_{real} - \Psi_{observe}) \rangle$$

$$\delta v_2 \sim \frac{1}{\langle \cos 2(\Psi_{real} - \Psi_{observe}) \rangle} \times \frac{1}{\sqrt{N}}$$

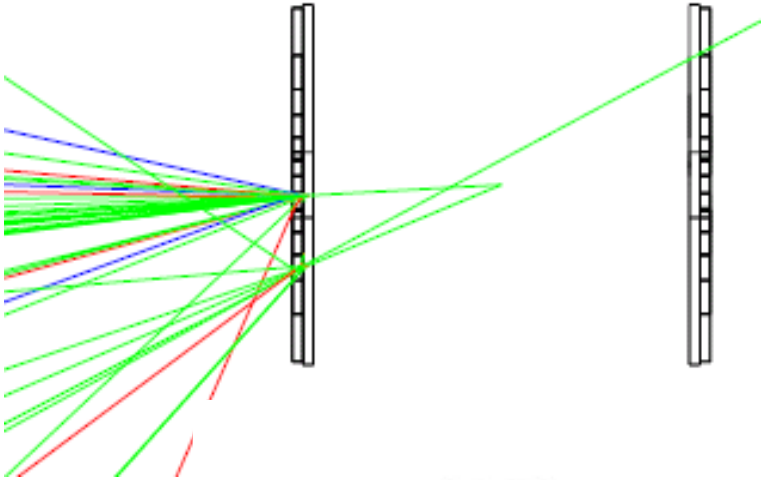
- Reaction plane resolution was ~0.4 before the introduction of the reaction plane detector.
  - The observed v_2 strength is only less than 40% of its real value.
  - statistical power less than 1/6.

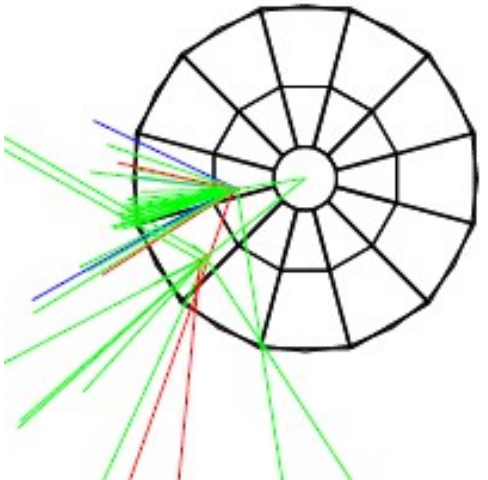
Reaction Plane Detector (RxP)

The reaction plane detector was installed just before Run7 (2007).

35cm

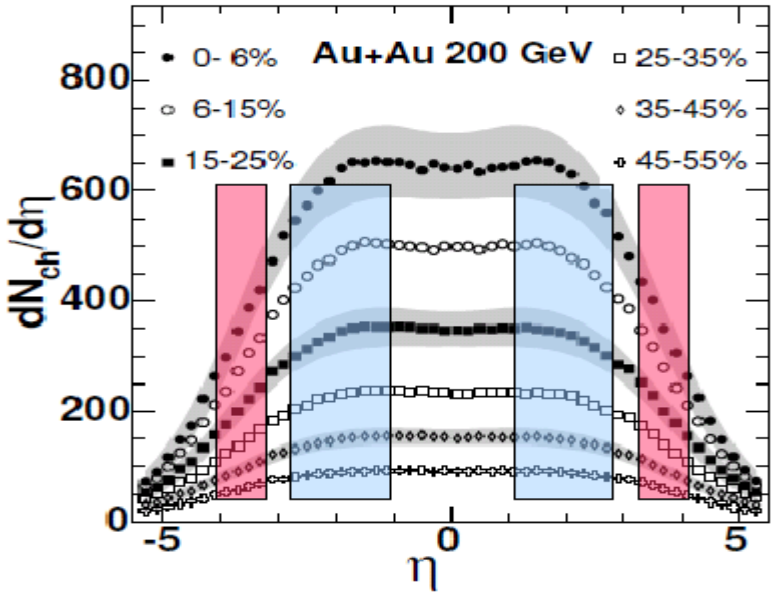
Collision piont

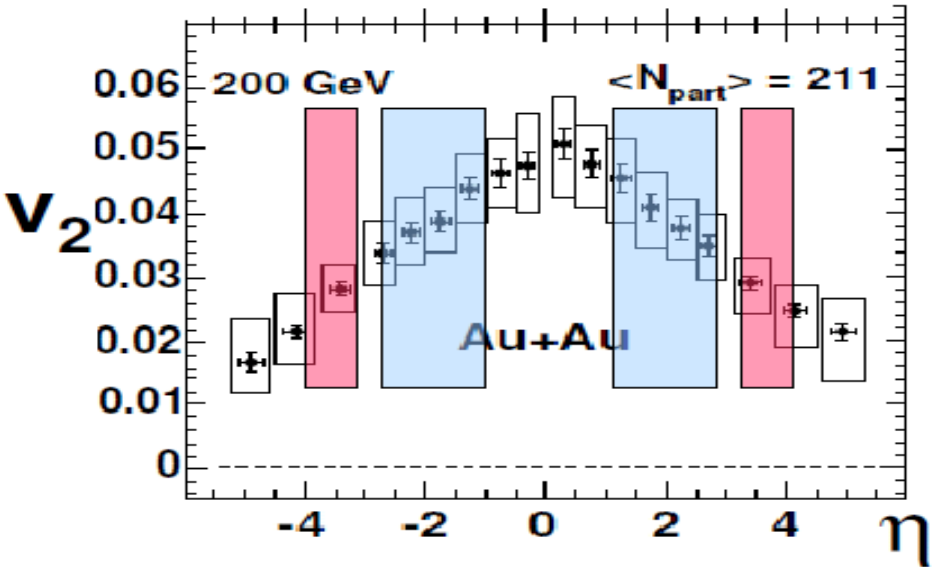




Acceptance of “RxP”

PHOBOS, PRL. 91, 052303 (2003)

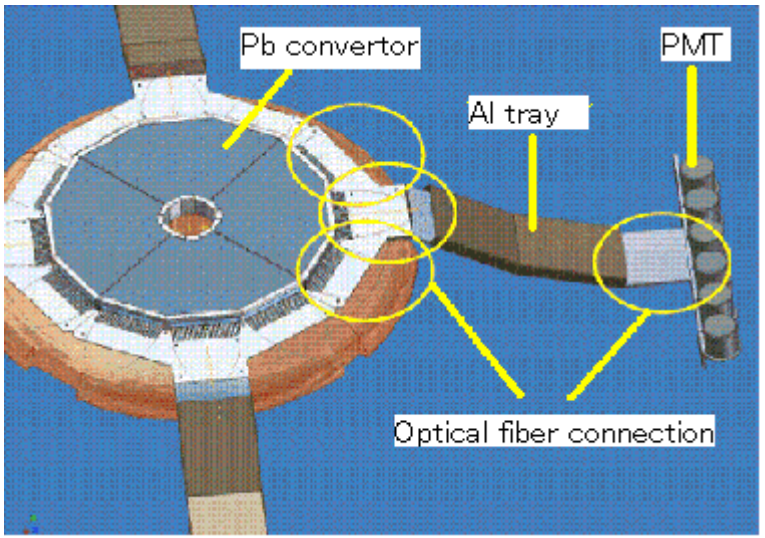




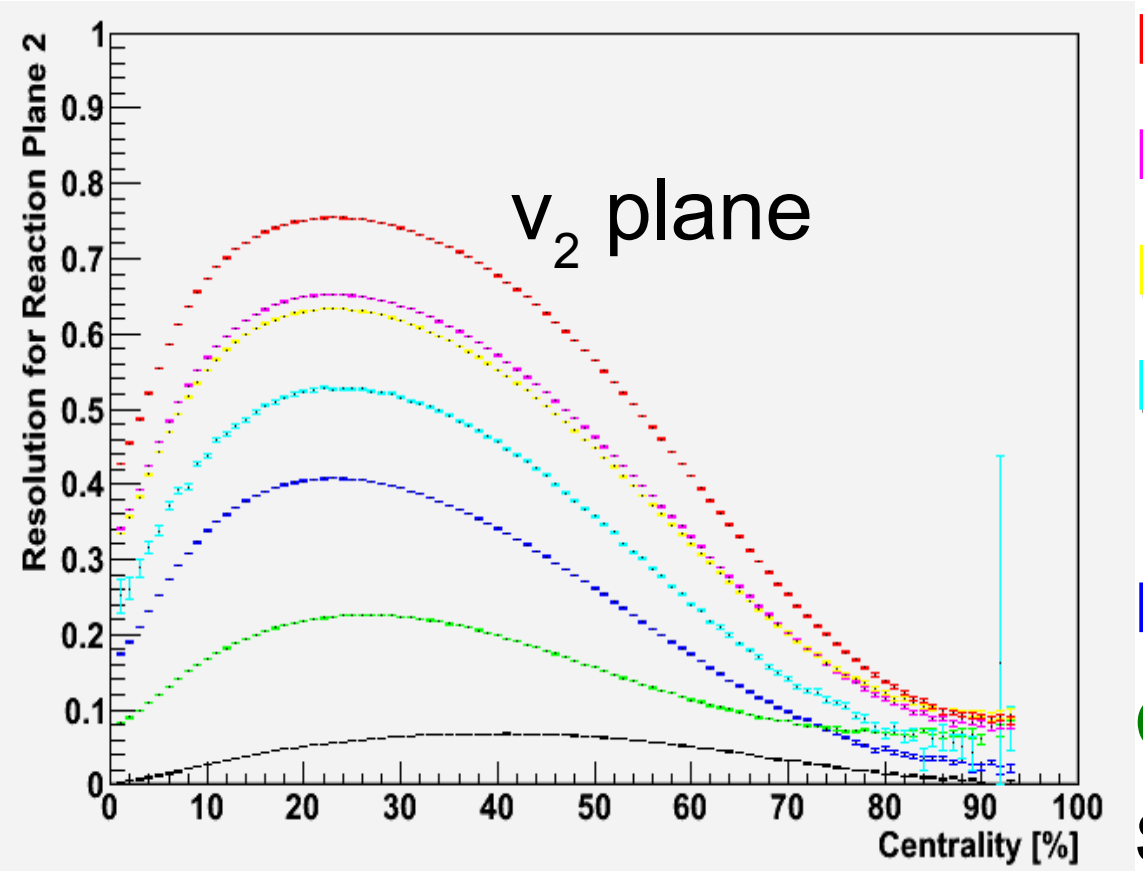
RxP measure more particles and the particles with more large v_2.

RxP : η = ±1~2.8(blue)

BBC : η = ±3.1~4(red)



New Reaction Plane Resolution



RxP |η| = 1.0 – 2.8 New!

RxPinner |η| = 1.5 – 2.8 New!

RxPouter |η| = 1.0 – 1.5 New!

MPC |η| = 3.0 – 4.0 New!

BBC |η| = 3.1 – 3.9

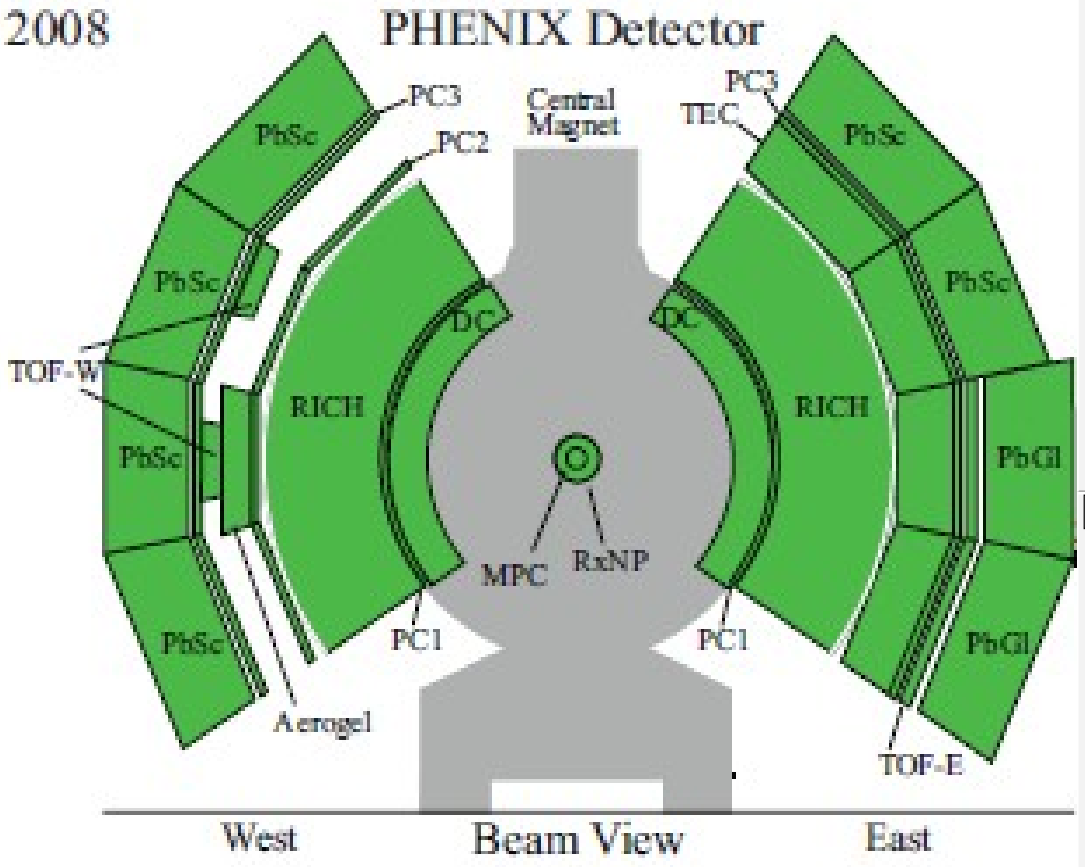
CNT |η| = 0 – 0.35

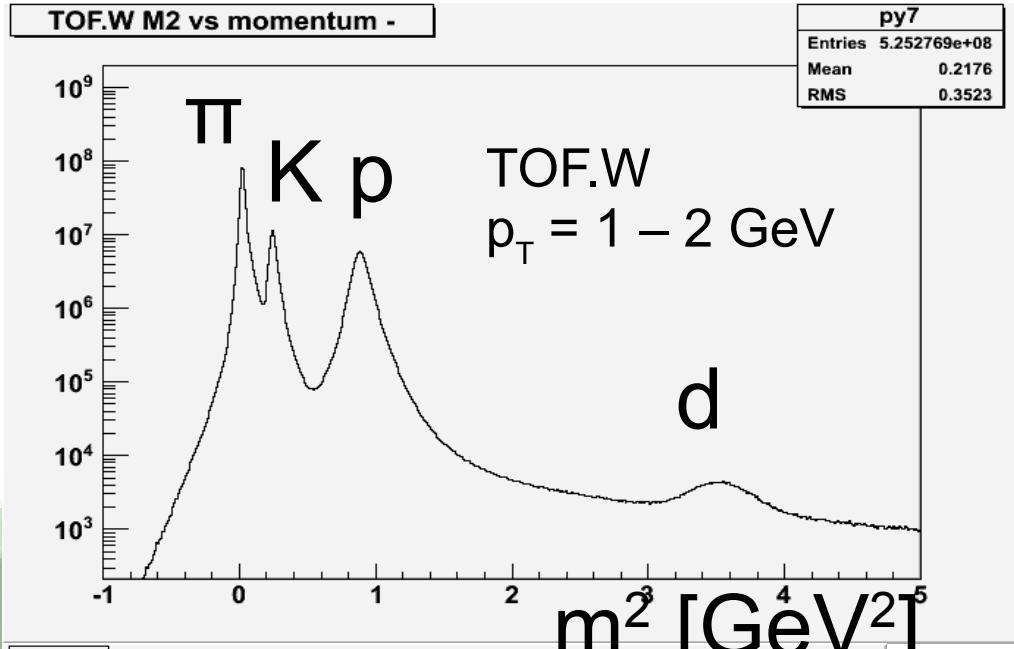
SMD |η| > 6

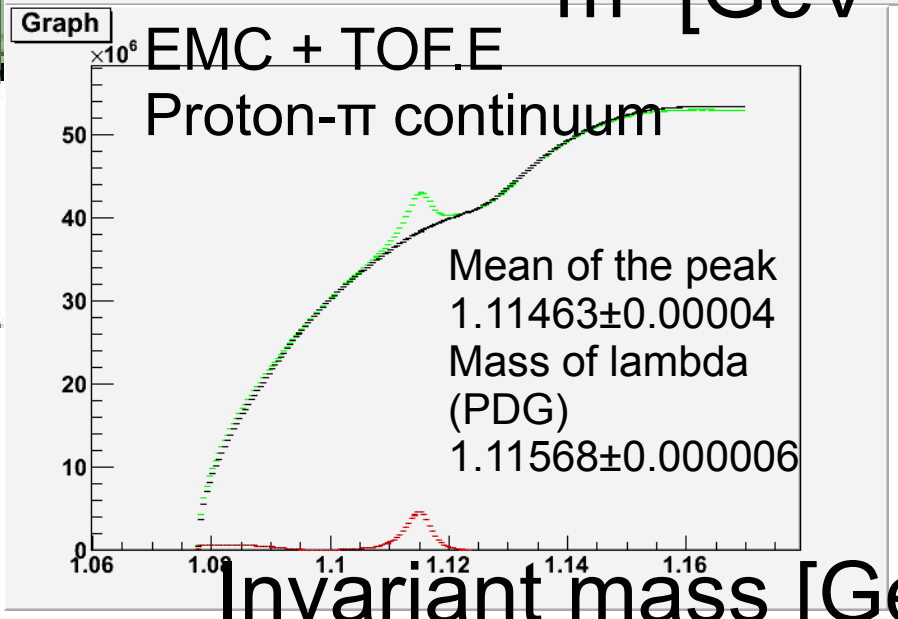
$$v_{2\,observe} = v_{2\,real} \times \langle \cos 2(\Psi_{real} - \Psi_{observe}) \rangle$$

$$\delta v_2 \sim \frac{1}{\langle \cos 2(\Psi_{real} - \Psi_{observe}) \rangle} \times \frac{1}{\sqrt{N}}$$

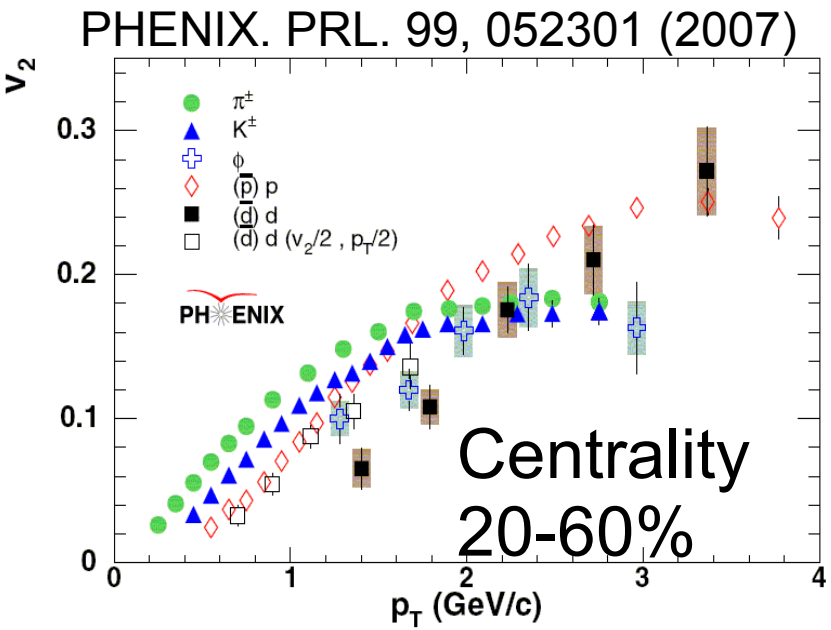
PID in PHENIX

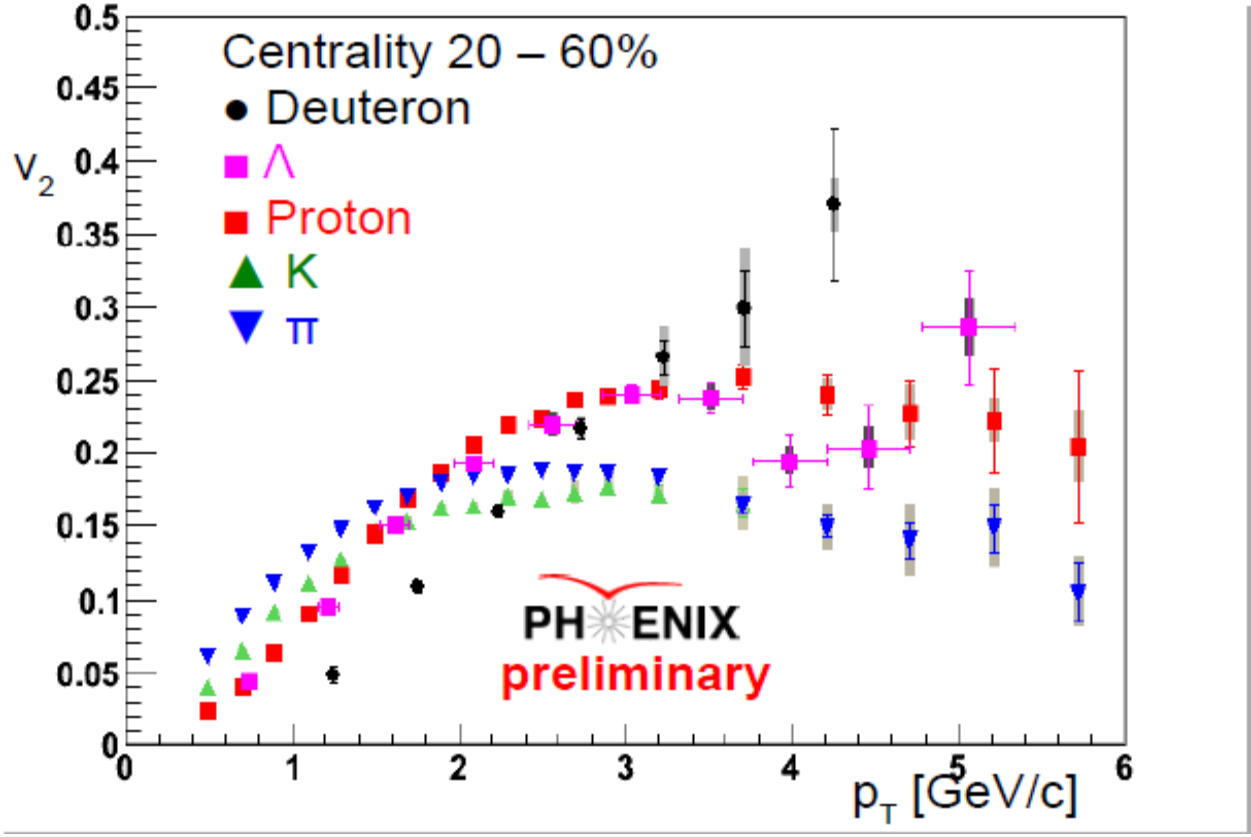






v_2 before and after





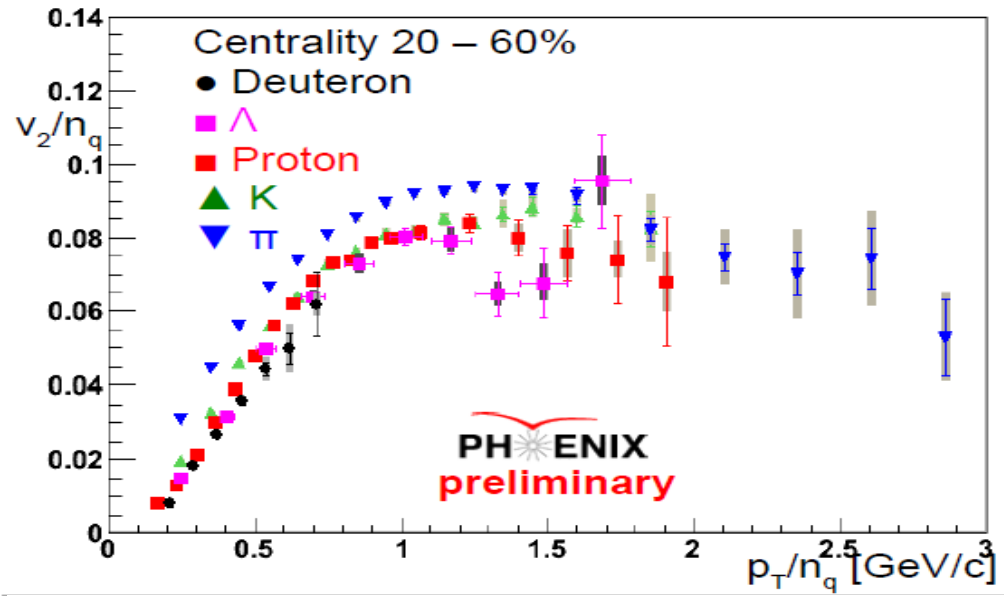
Before (Run4)

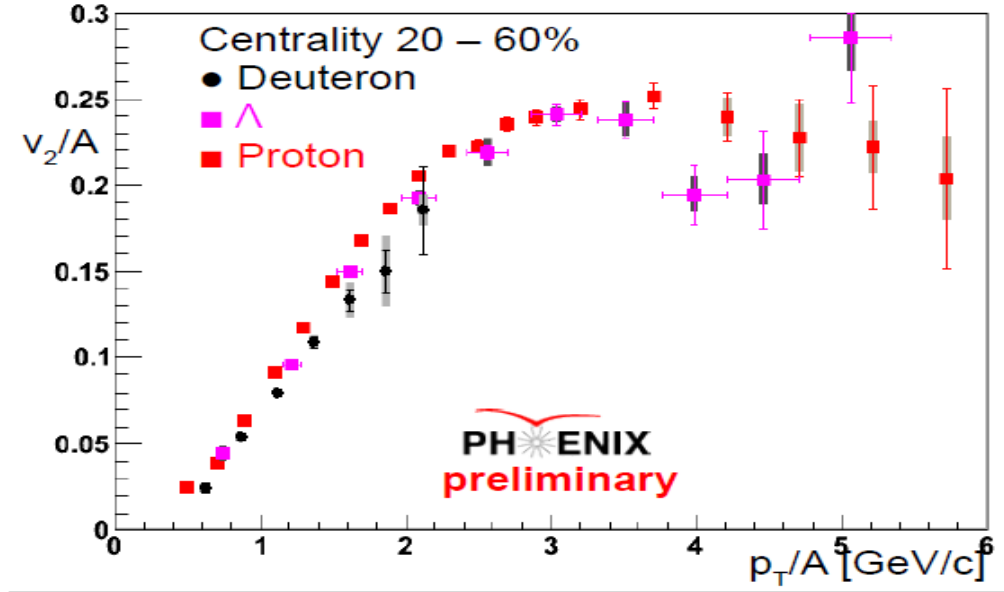
BBC RP resolution (< 0.4)
0.8 billion events

After (Run7)

Better resolution of RxP (< 0.75)
Higher statistical (3.5 billion)

Number scaling by quark or atom

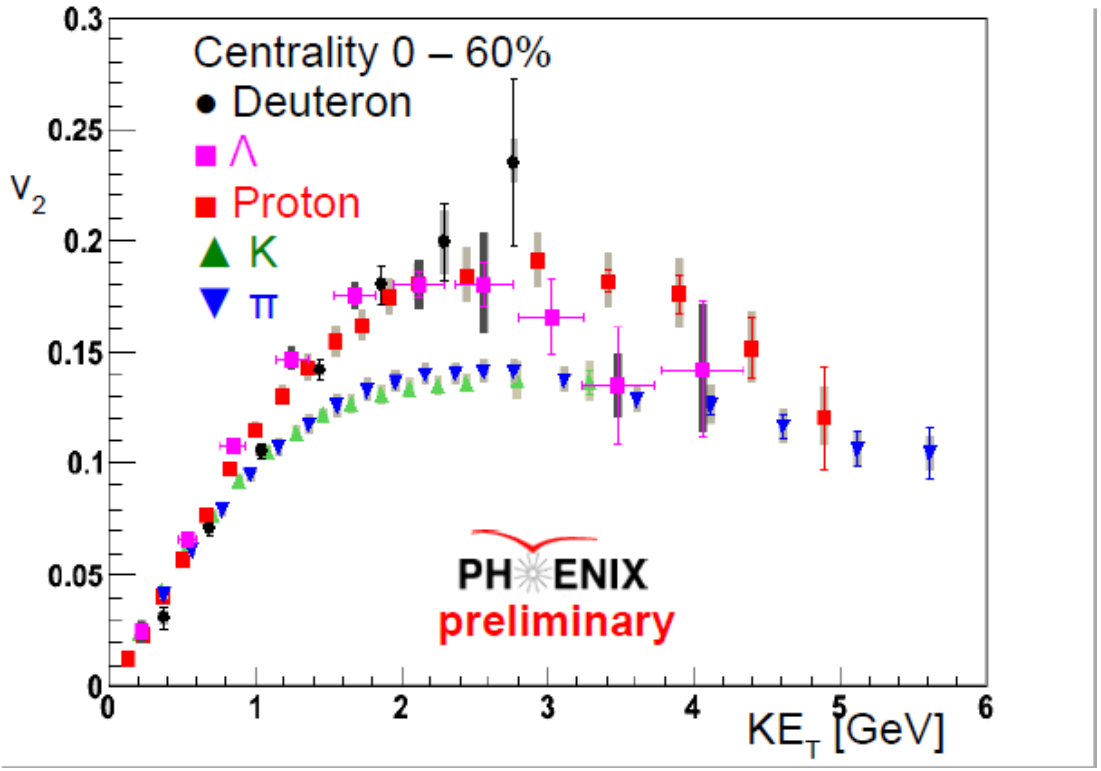




$$v_2^d \sim 2\, v_2^p, \quad p_T^d \sim 2\, p_T^p$$

- Deuteron and proton are consistent almost on the number scaling.
- It is agree that the p and n have same v_2 and final state coalescence of them.
- Deuteron peak is expected at p_T=6GeV/c.

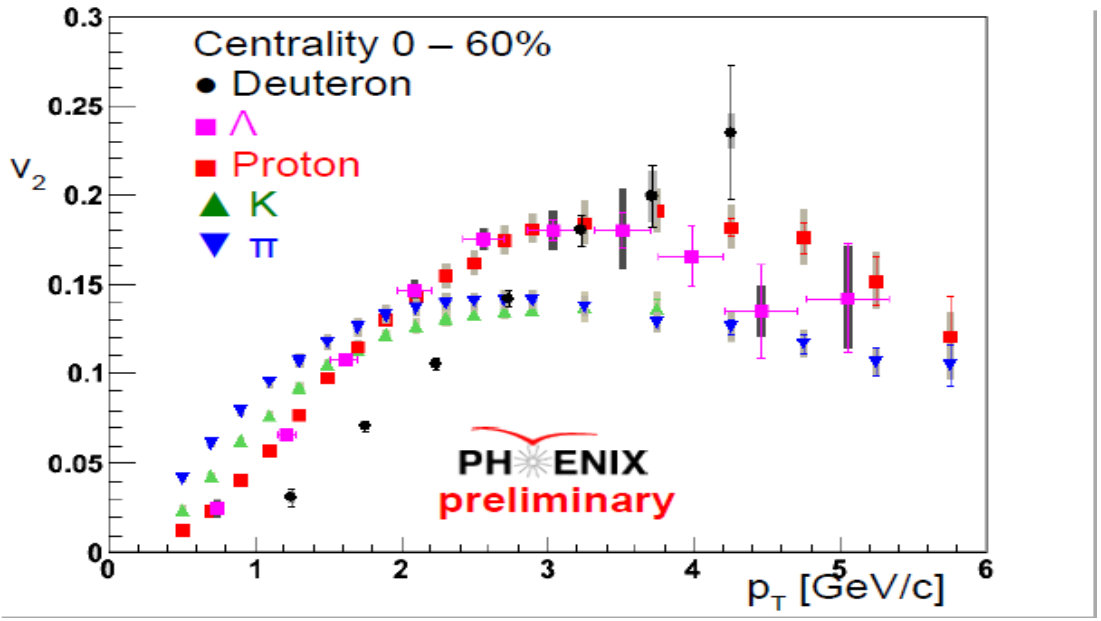
KE_T scaling

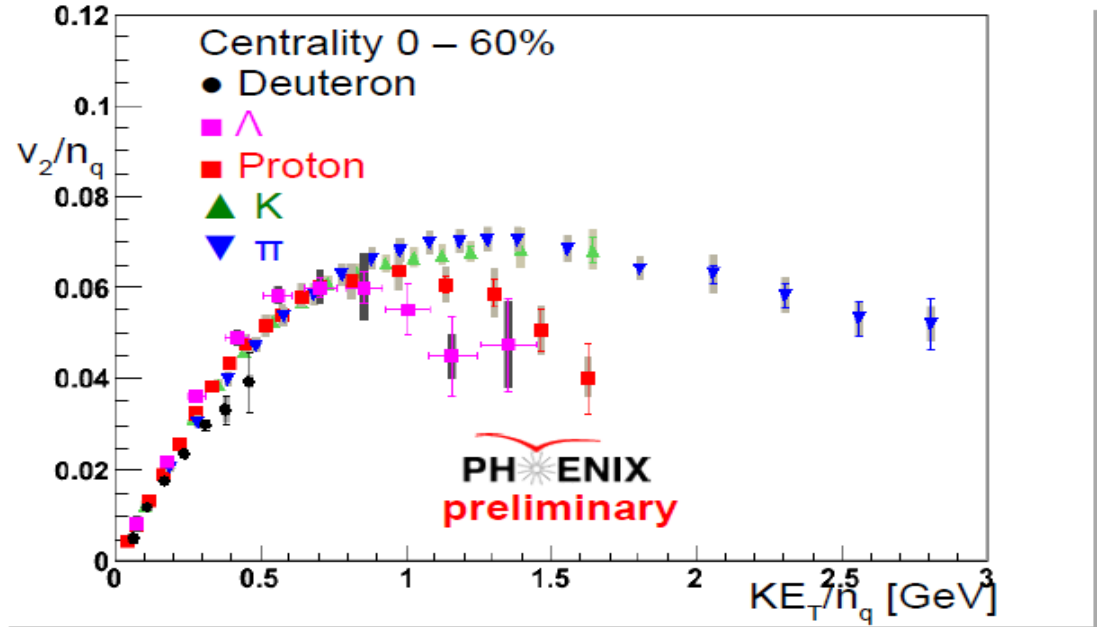


$$KE_T = \sqrt{(M^2 - P_T^2)} - M$$

- They are consistent between mesons or baryons.
- The values are decided by centrality, KE_T and quark number.
- Meson line and baryon line approach at high KE_T.

Quark number and KE_T scaling

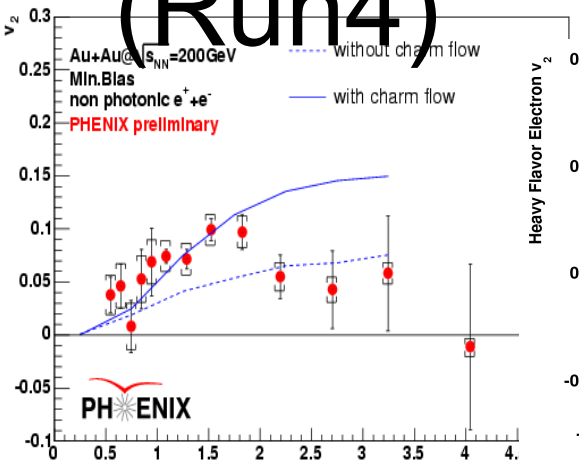




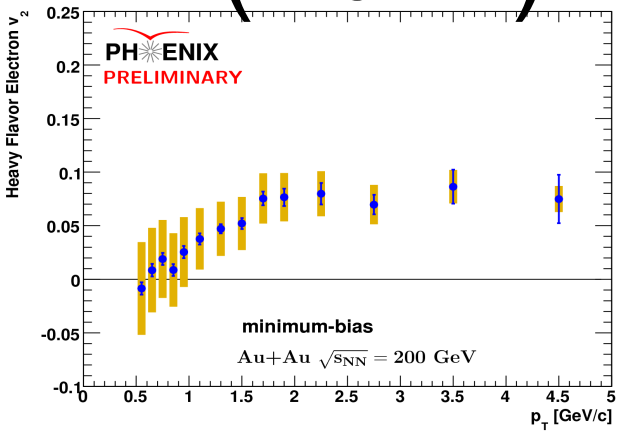
- Consistent for all particles on KE_T and quark number scaling at $KE_T/n_q<0.8$GeV.
- They approach at high p_T. (deviate on KE_T/n_q scaling)
- This indicate a change of particle and v_2 production mechanism.

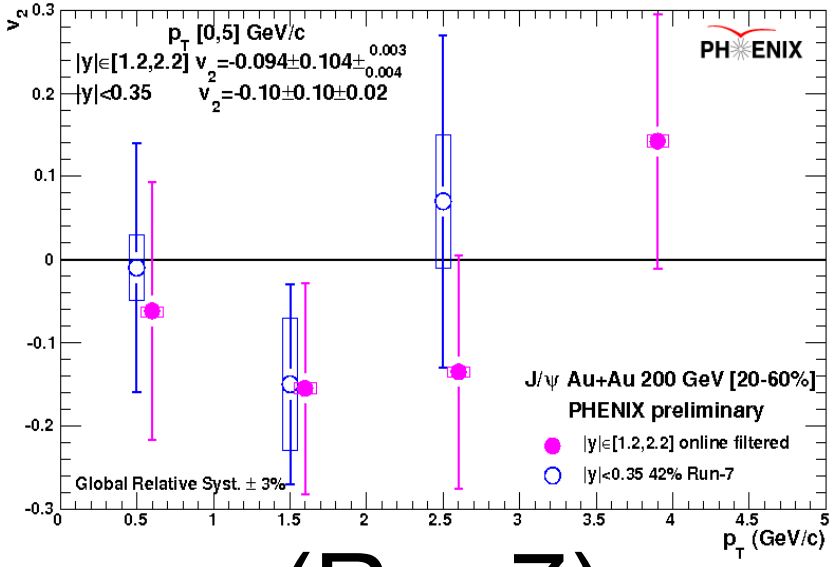
Heavy flavor and J/ψ v_2

(Run4)



(Run7)





(Run7)

- The data at low pT favor the models that include quark level elliptic flow of charm.
- It could not be judged whether J/Psi succeeds the charm flow Because the poor statistics.
- B meson decay becomes a significant source above 2.5 GeV/c.

Summary

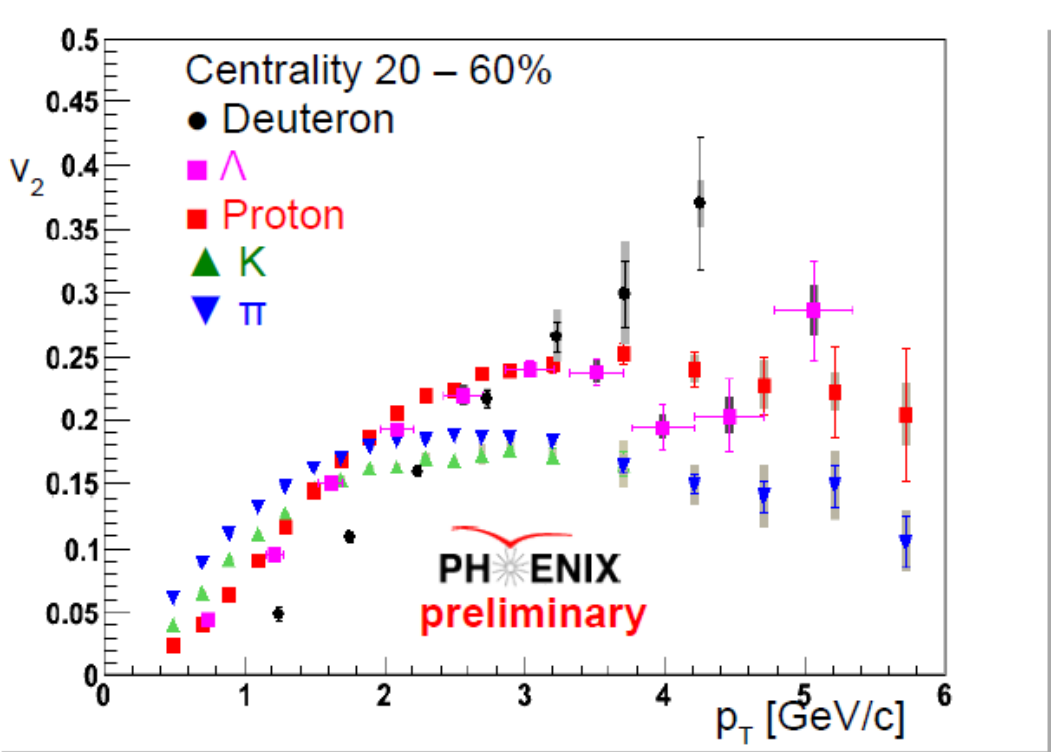
- The new reaction plane detector worked well.
  - Resolution is improved by a factor of two.
  - It means 4 times of statistic Power.
- Deuteron v_2 and p_T are double of proton.

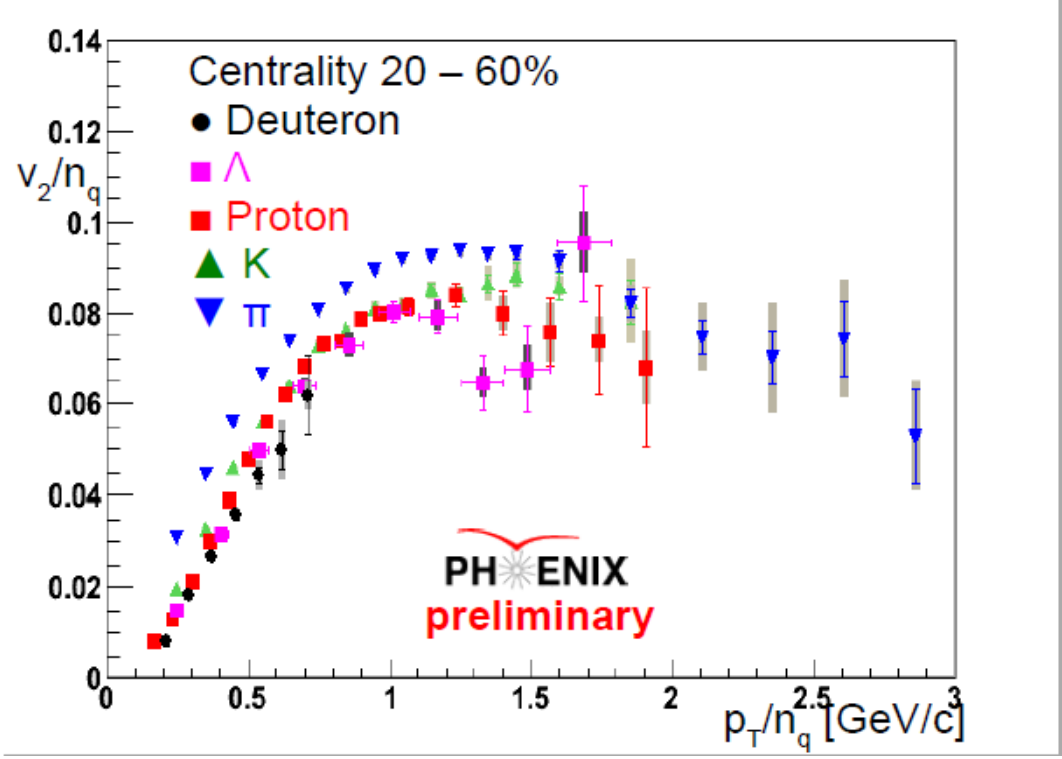
$$v_2^d \sim 2\, v_2^p$$

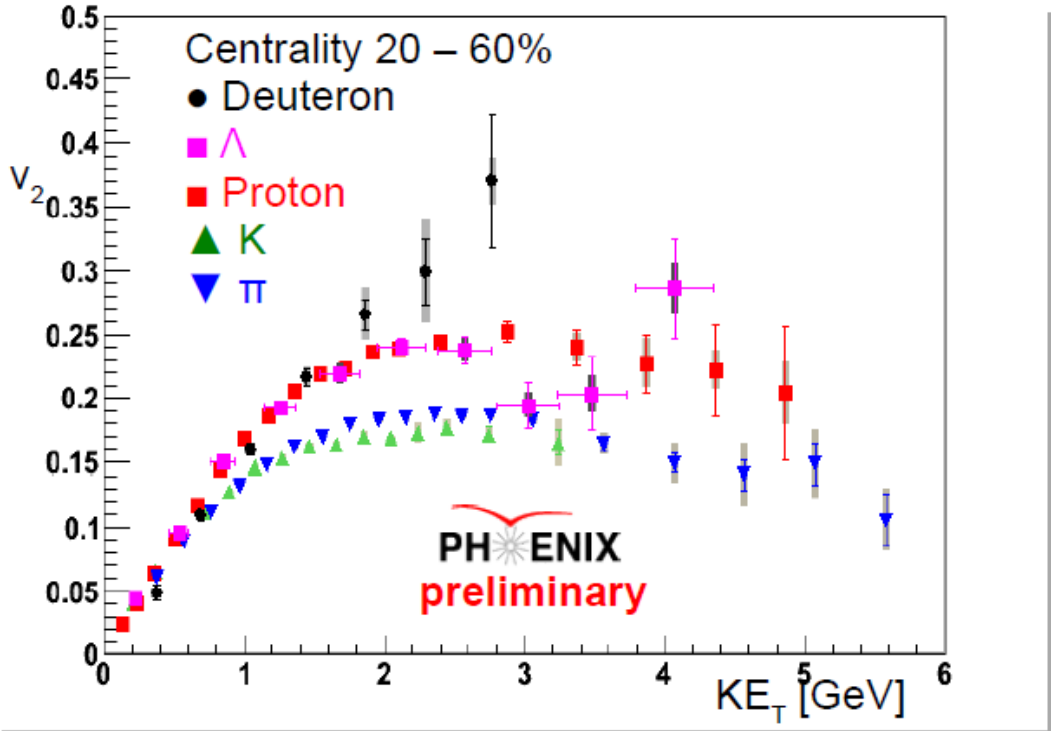
$$p_T^d \sim 2\, p_T^p$$

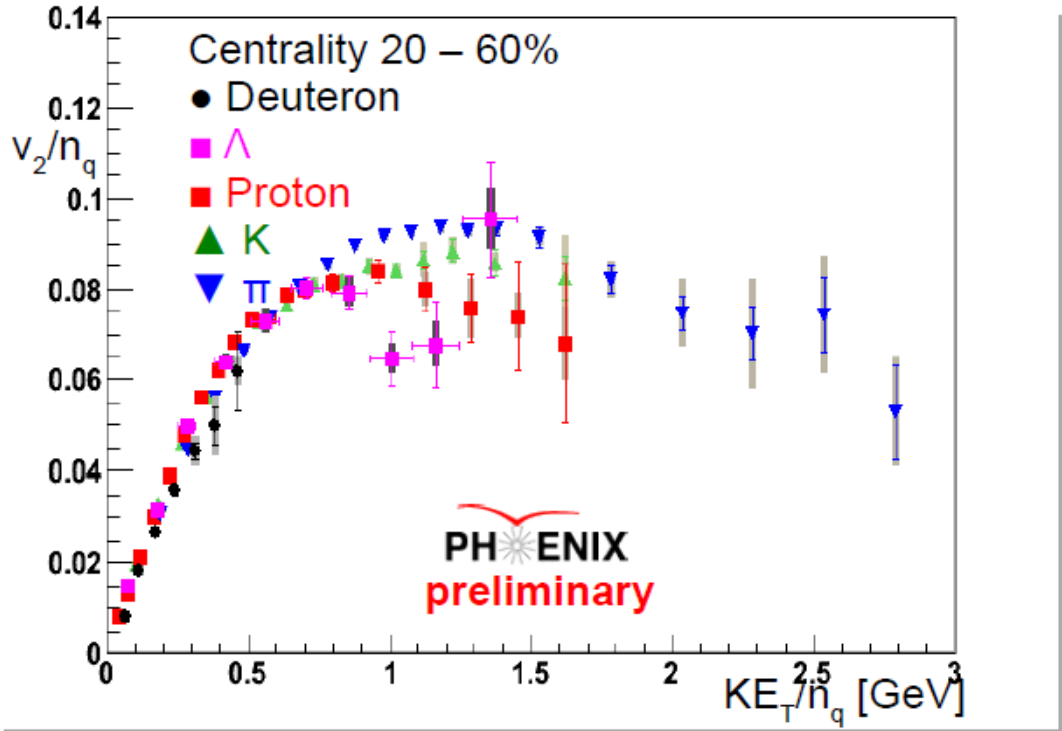
  - d and p are consistent on atom number scaling.
  - It agree the p–n coalescence in final state.
- v_2 is decided by centrality, KE_T and n_q on KE_T scaling.
  - Consistent for all particles on KE_T and n_q scaling at $KE_T < 0.8$GeV.
- v_2 have no depend on particles at high p_T range.
  - Production mechanism is different.

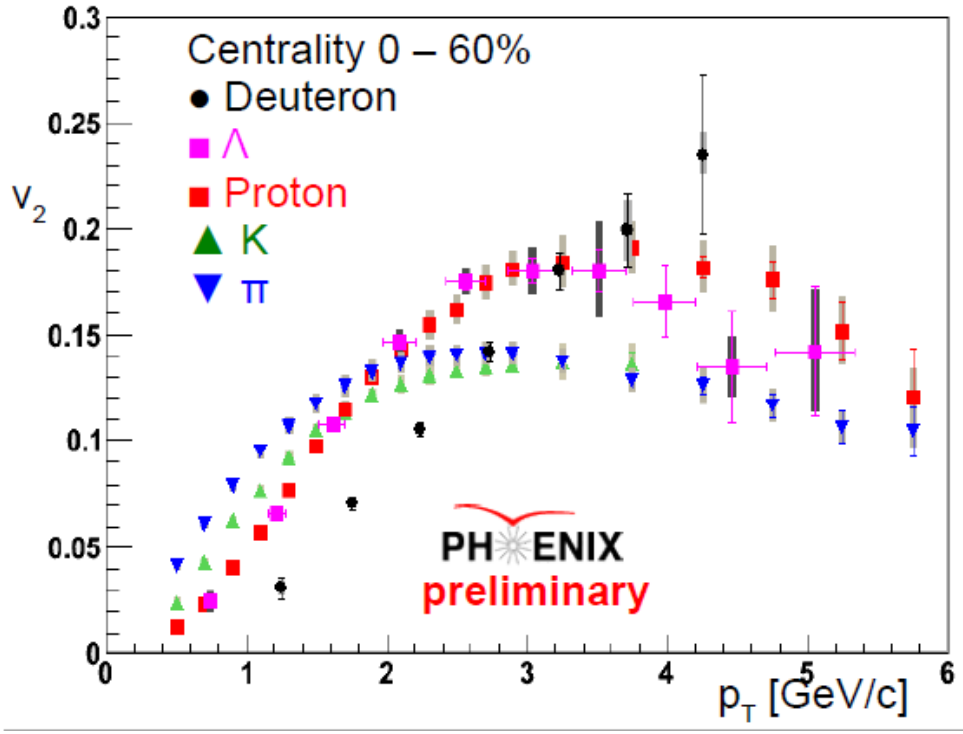
Back up

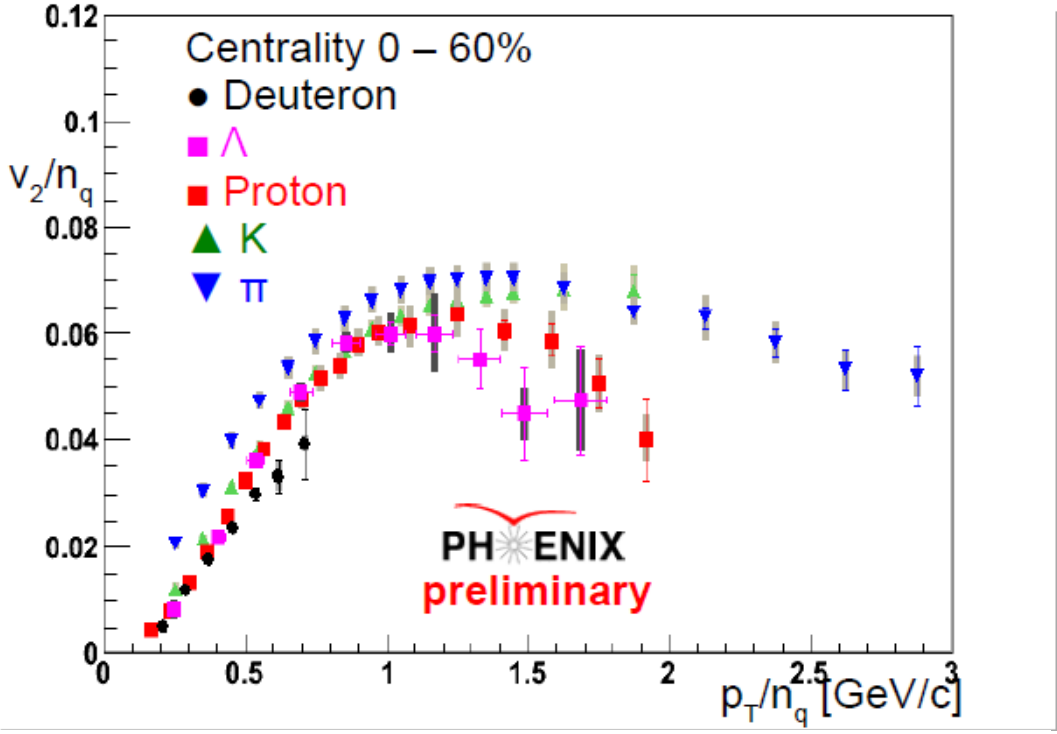

Centrality 20 – 60%
Deuteron
Λ
Proton
K
π
v_2
p_T [GeV/c]
PHENIX
preliminary

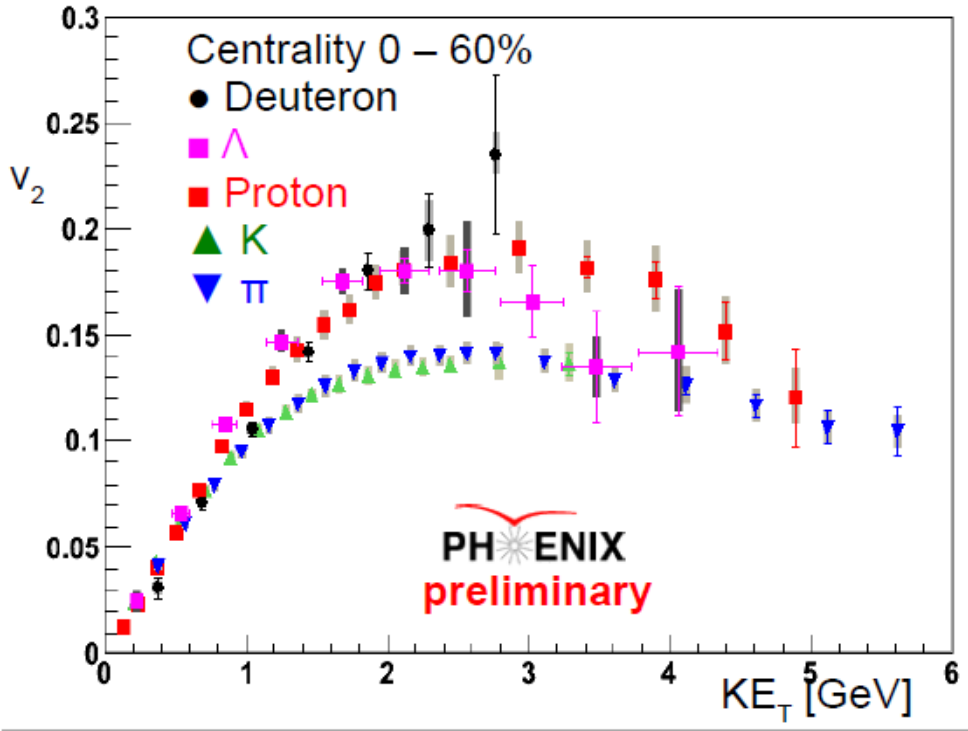

Centrality 20 – 60%
Deuteron
Λ
Proton
K
π
v_2/n_q
p_T/n_q [GeV/c]
PHENIX
preliminary


Centrality 20 – 60%
Deuteron
Λ
Proton
K
π
v_2
KE_T [GeV]
PHENIX
preliminary


Centrality 20 – 60%
Deuteron
Λ
Proton
K
π
v_2/n_q
KE_T/n_q [GeV]
PHENIX
preliminary


Centrality 0 – 60%
Deuteron
Λ
Proton
K
π
v_2
p_T [GeV/c]
PHENIX
preliminary


Centrality 0 – 60%
Deuteron
Λ
Proton
K
π
v_2/n_q
p_T/n_q [GeV/c]
PHENIX
preliminary


Centrality 0 – 60%
Deuteron
Λ
Proton
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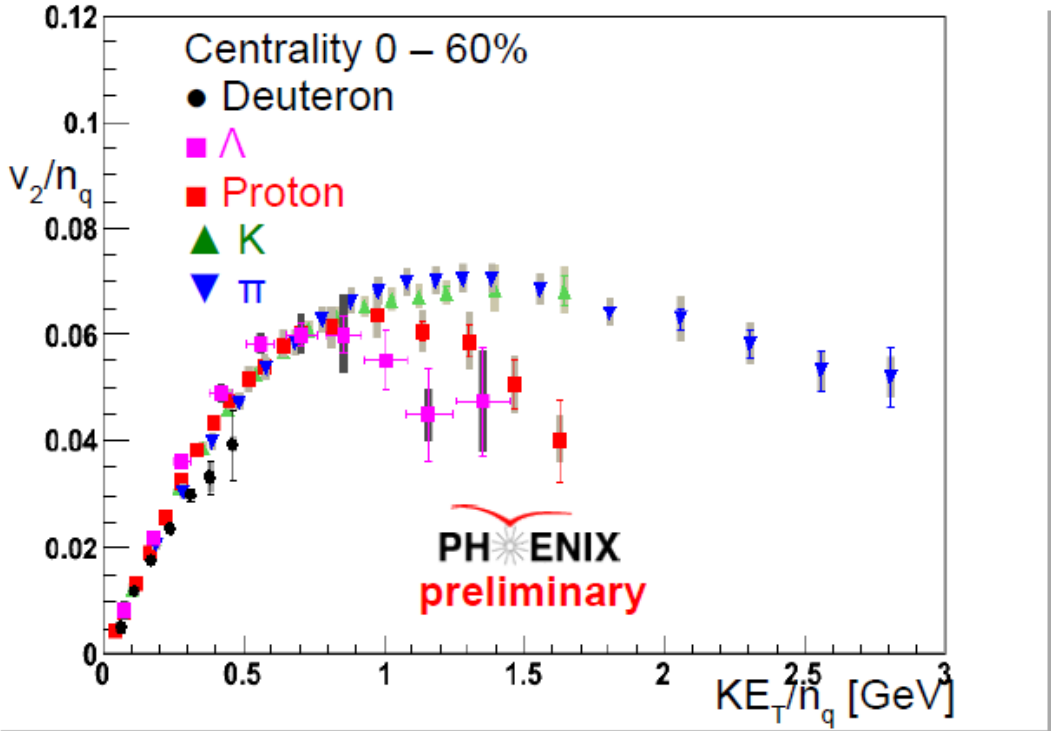
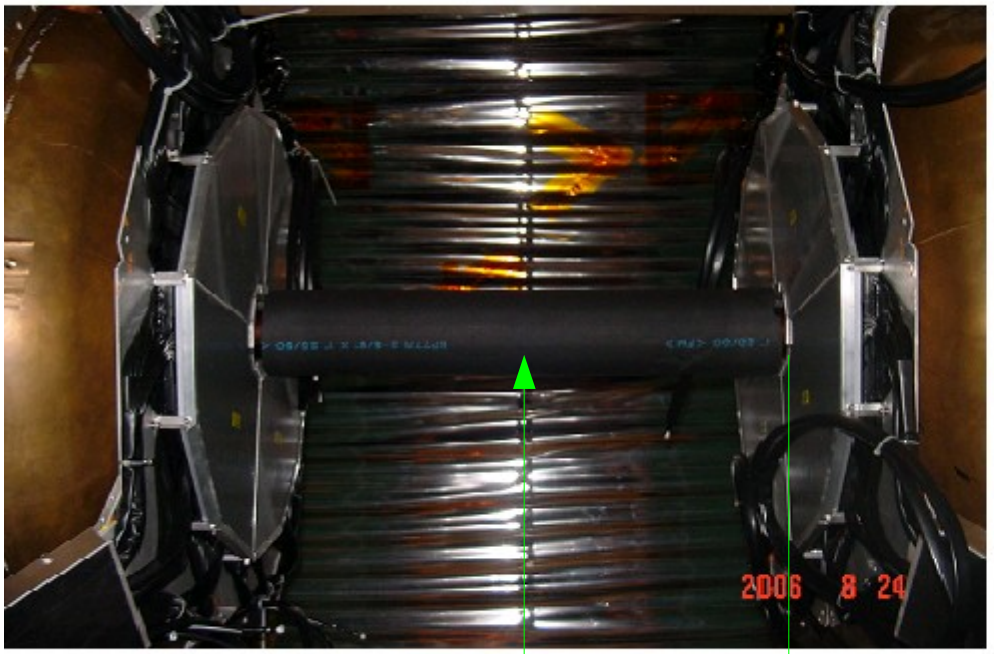
π
v_2
KE_T [GeV]
PHENIX
preliminary


Centrality 0 – 60%
Deuteron
Λ
Proton
K
π
v_2/n_q
KE_T/n_q [GeV]
PHENIX
preliminary

Reaction Plane Detector (RxP)

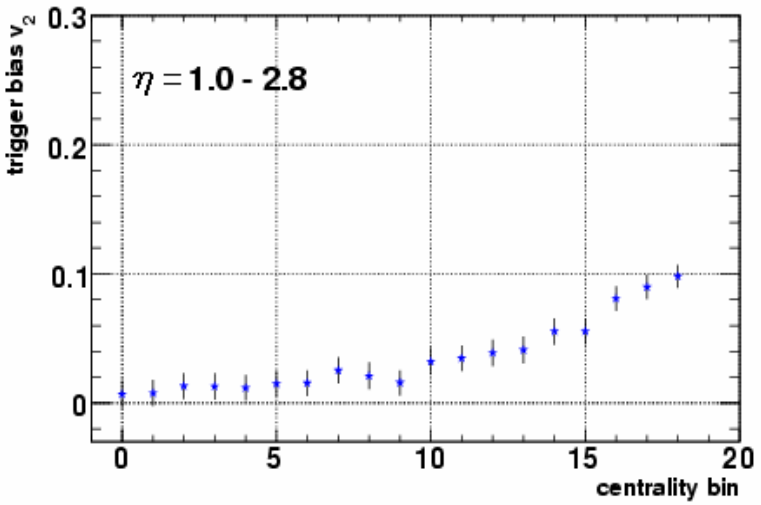
The reaction plane detector was installed just before Run7 (2007).

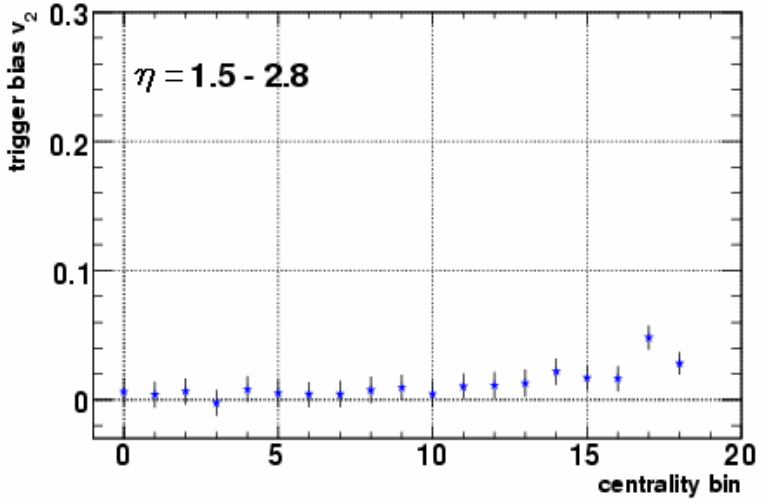


35cm

Collision piont

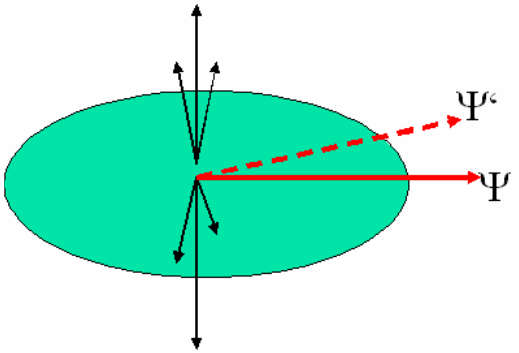
Correlation effect



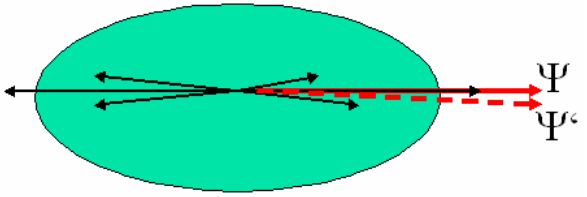


v_2 is over estimated by correlation effect.

According to HIJING+PYTHIA, the effect by jet does not have any problem with η>1.5

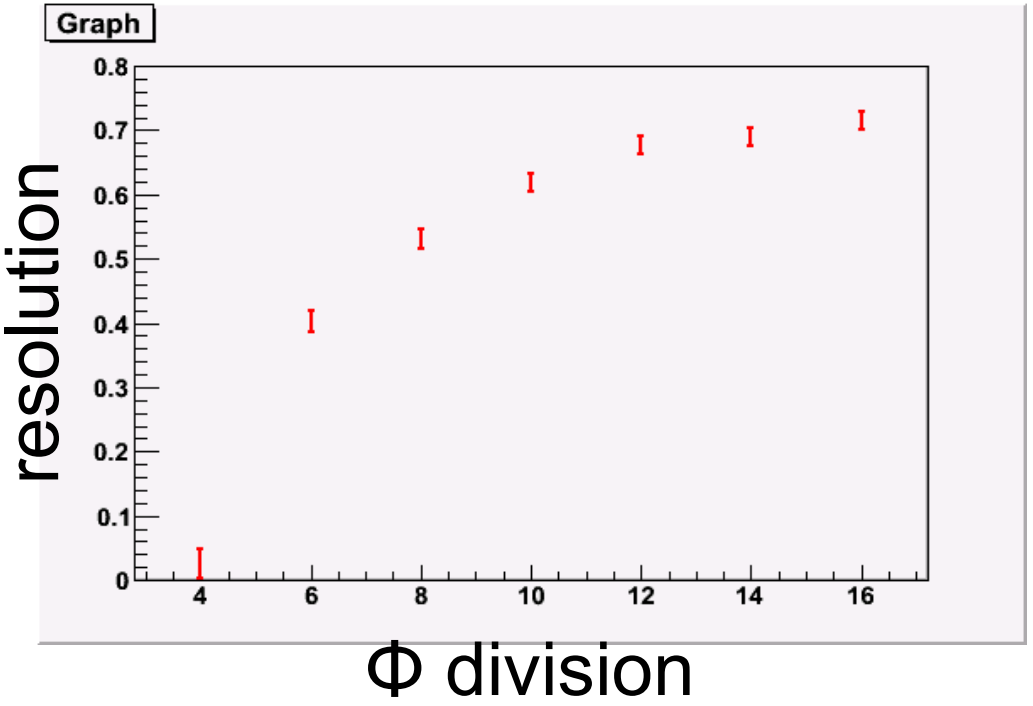


di-jet is out of plane



di-jet is in plane

Design and Geant simulation



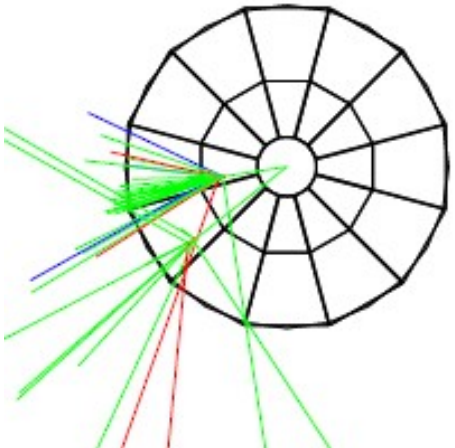
Detector parameters were optimized with Geant simulation

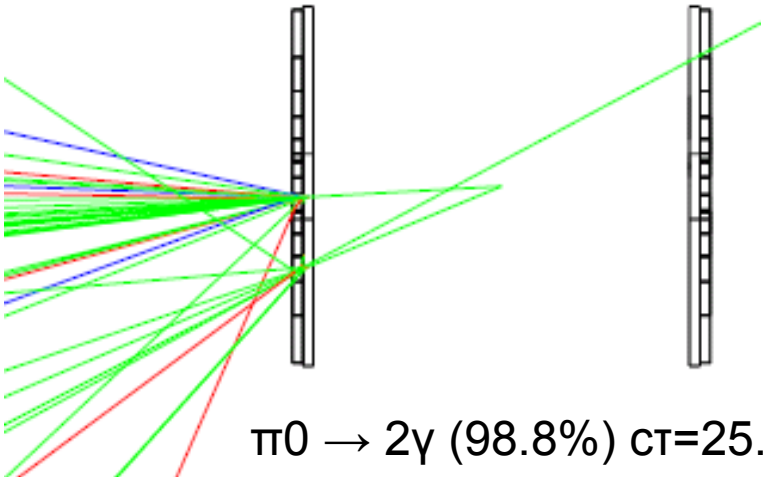
Thickness

Scintillator 2cm

Converter 2cm

Φ division into 12





π0 → 2γ (98.8%) cτ=25.1[nm]


2006 8 9
2006 8 10

Configuration of RxP