Measurement of azimuthal anisotropy and quark number scaling on AuAu200GeV at RHIC-PHENIX

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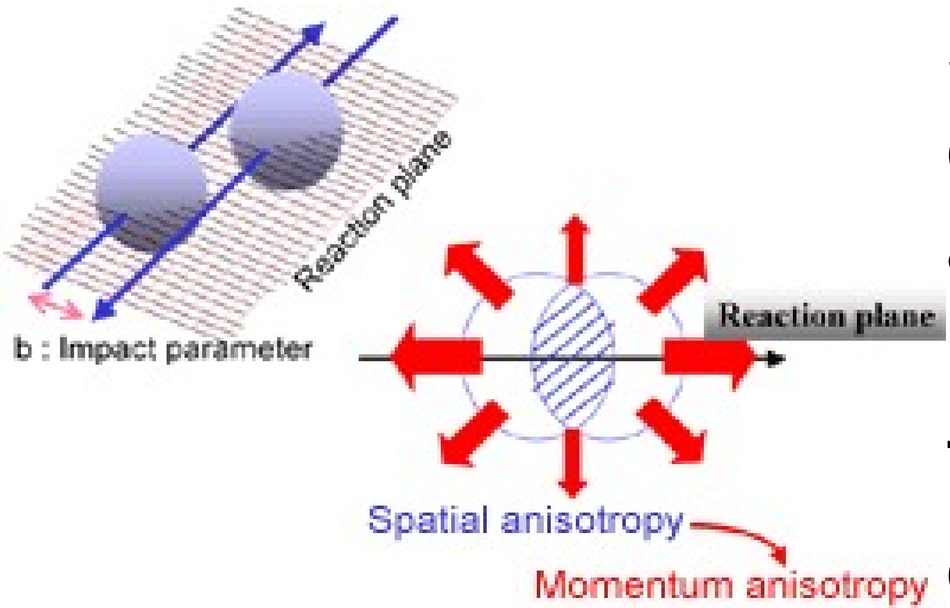
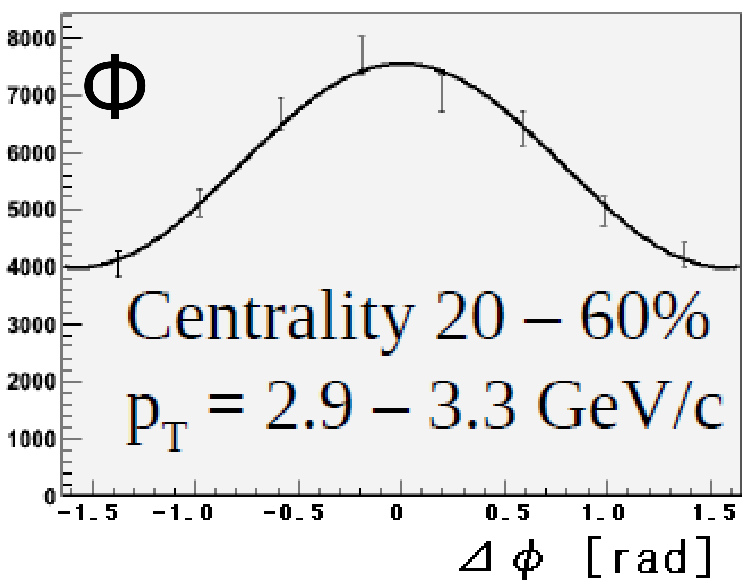
for the PHENIX collaboration
(University of Tsukuba)

Azimuthal anisotropy





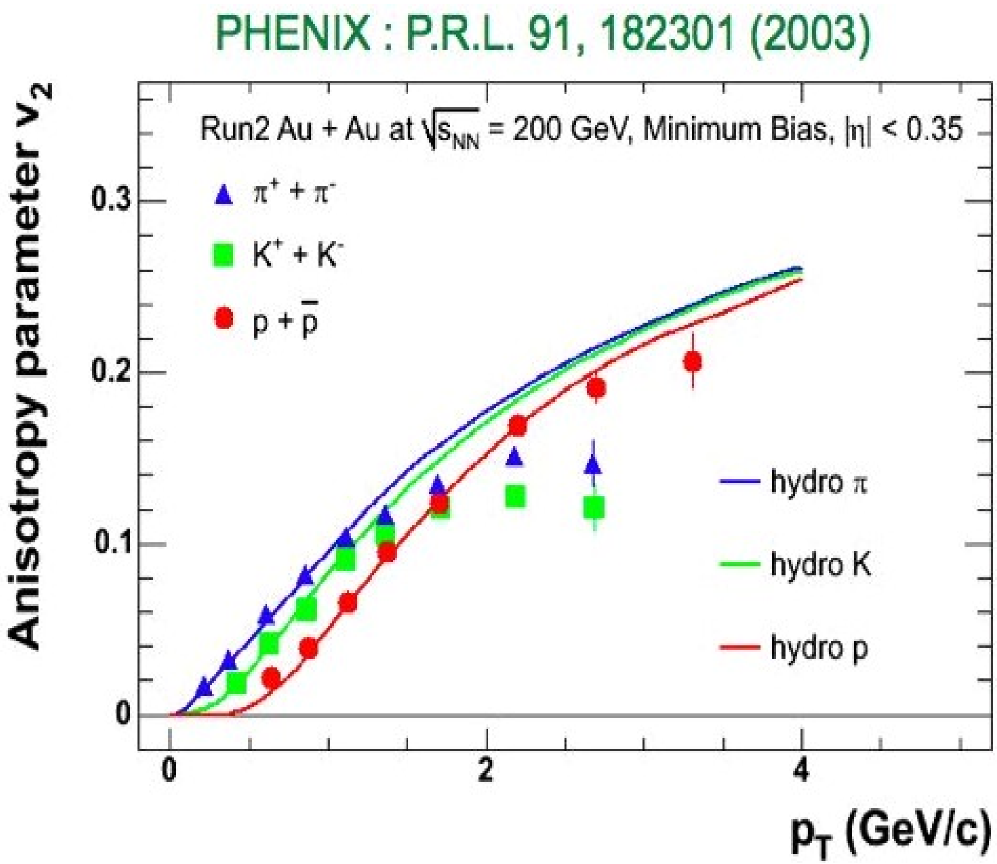
Spatial anisotropy in non-central collision provides azimuthal anisotropy of particle emission.

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

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

Ψ : reaction plane angle

Motivation of v_2 measurement



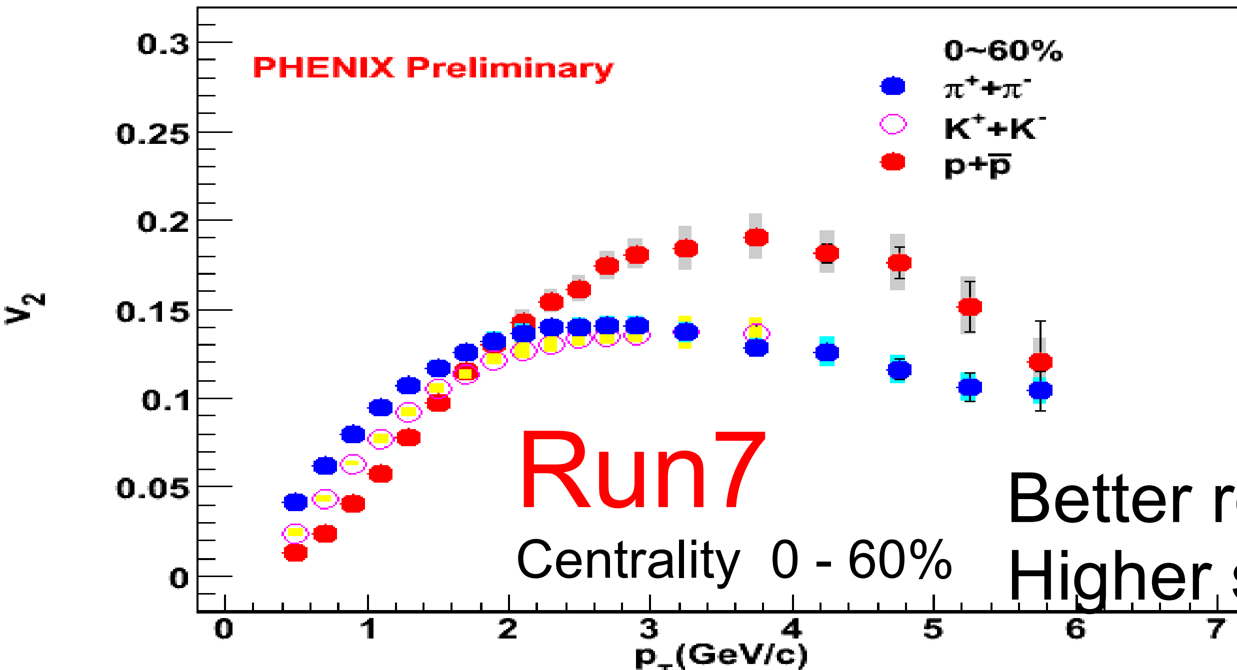
Large v_2 was observed in RHIC.

The values agreed with hydro-dynamical models.

It suggests rapid thermalization and quark flow.

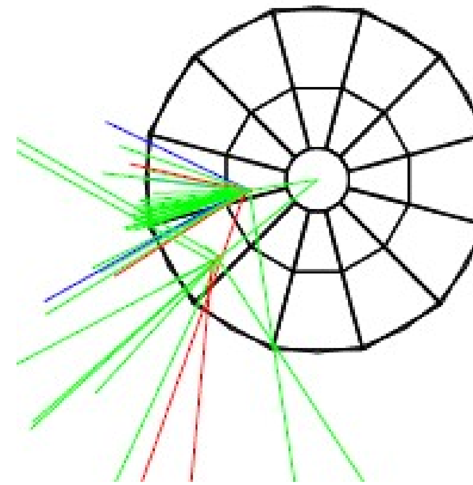
The v_2 values are different for each particle.

v_2 on PHENIX-Run7



Run7

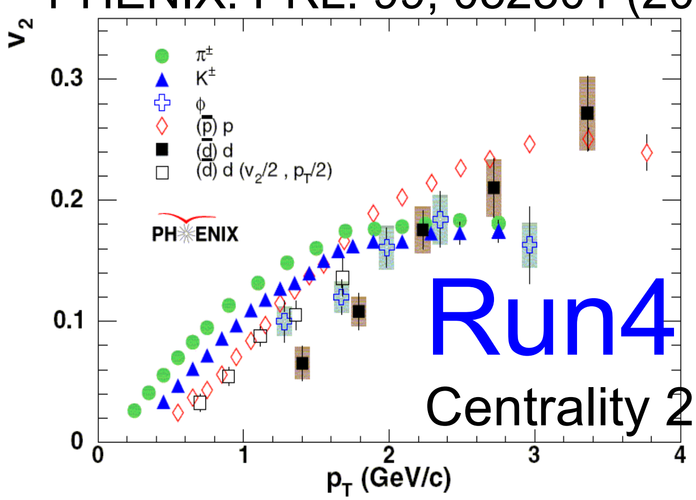
Centrality 0 - 60%



Better resolution of "**RxP**" (< 0.75)

Higher statistical (3.5 billion)

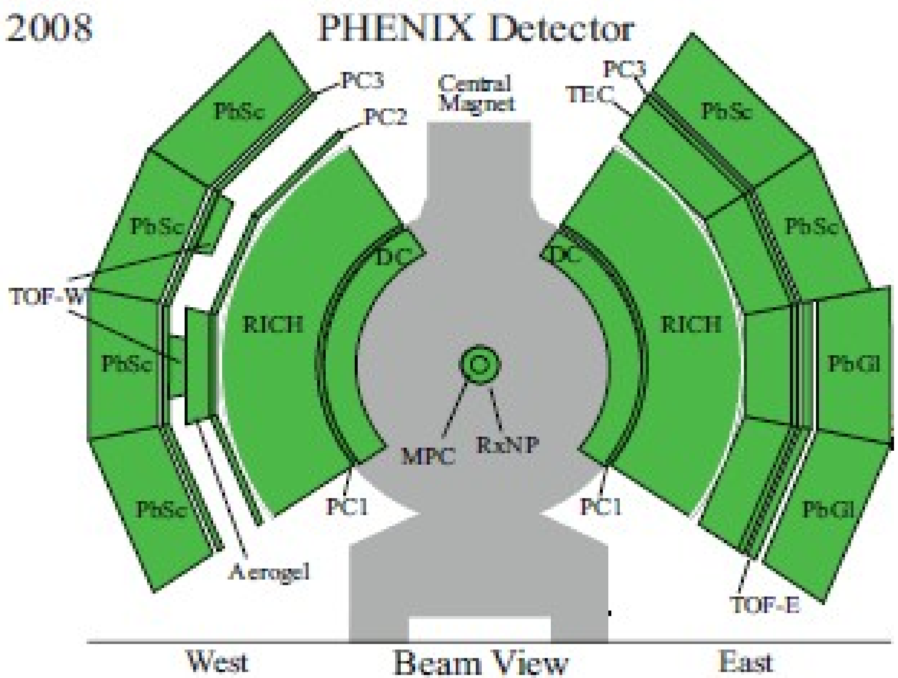
PHENIX. PRL. 99, 052301 (2007)

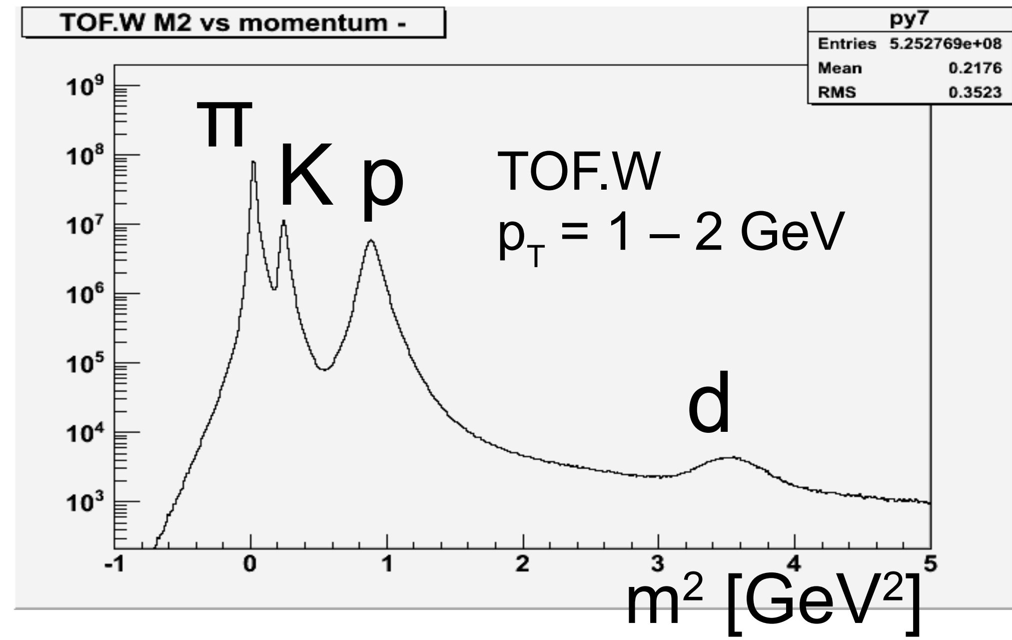


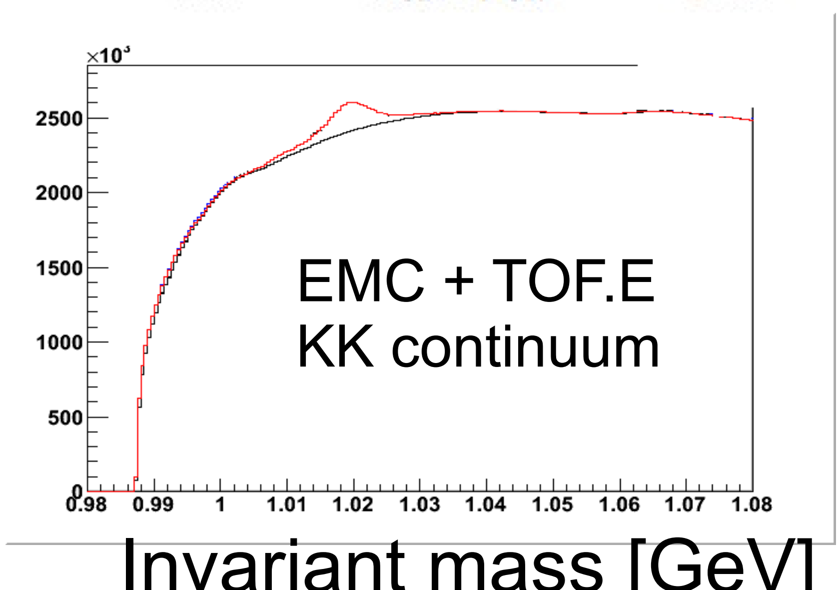
Run4

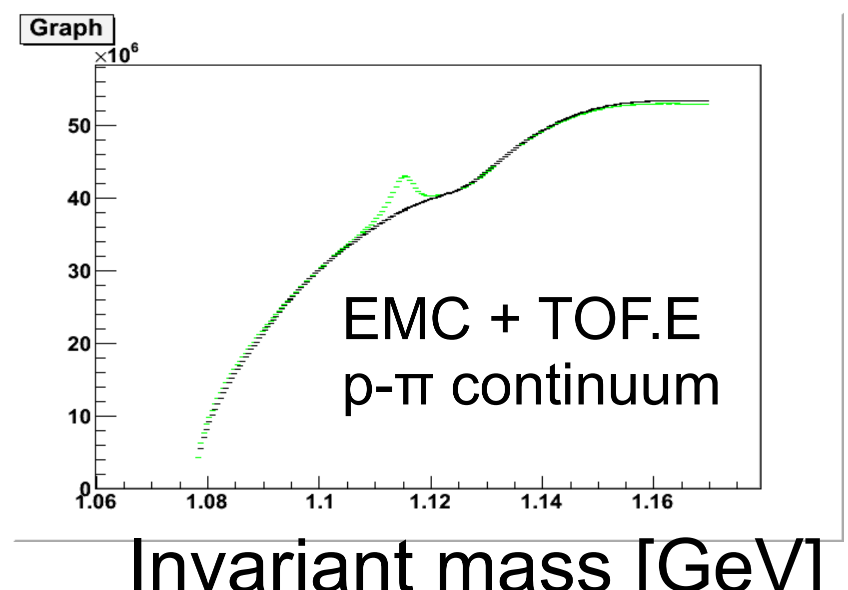
Centrality 20 - 60%

PID in PHENIX

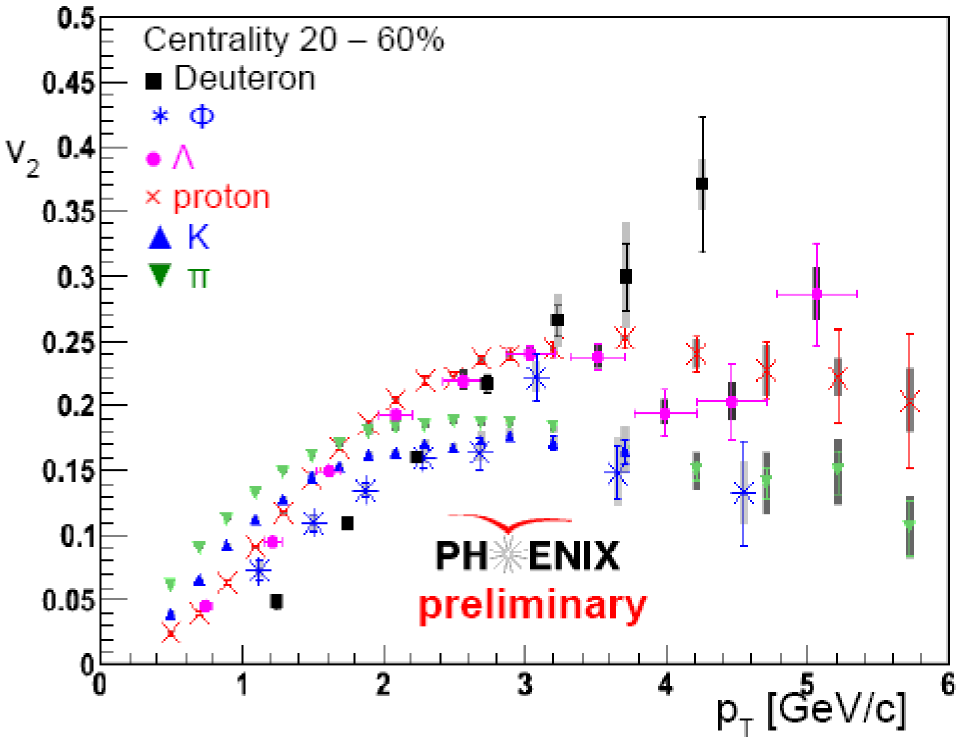






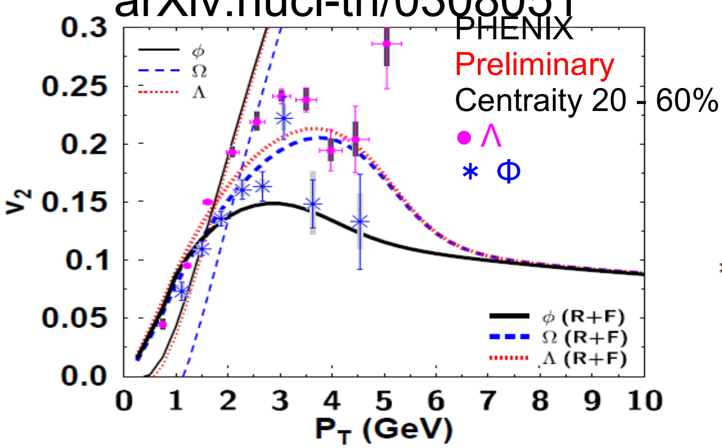


Hadron v_2 on Run7

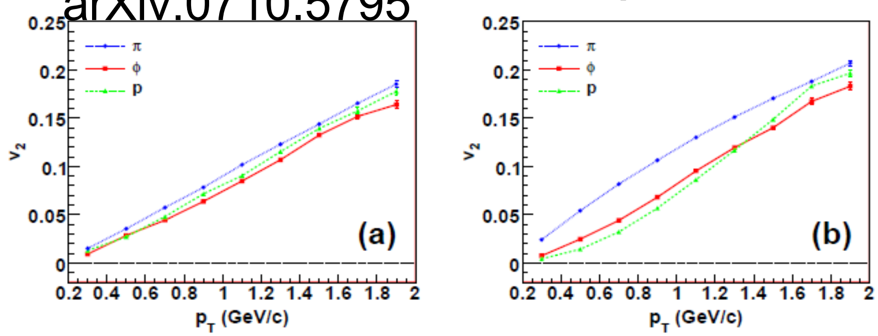


- D v_2 is higher than p v_2 at p_T> 3 GeV
- Λ v_2 is consistent to p v_2
- Φ v_2 is near to meson (π or K) rather than baryon (p or Λ) at mid-p_T range (p_T= 2 – 5 GeV).

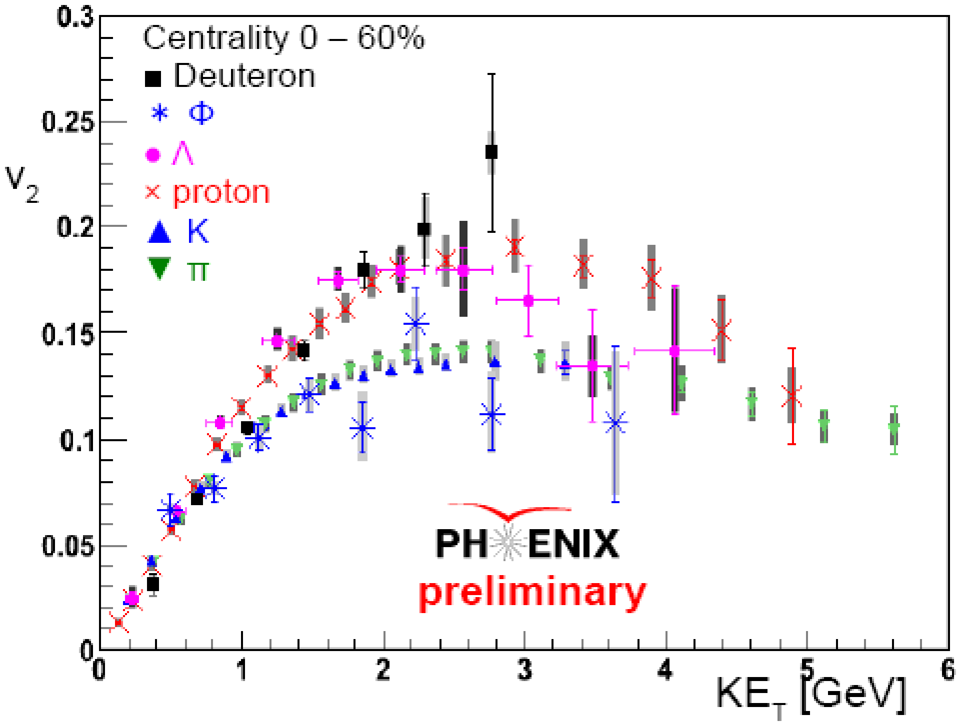
arXiv:nucl-th/0308051



arXiv:0710.5795



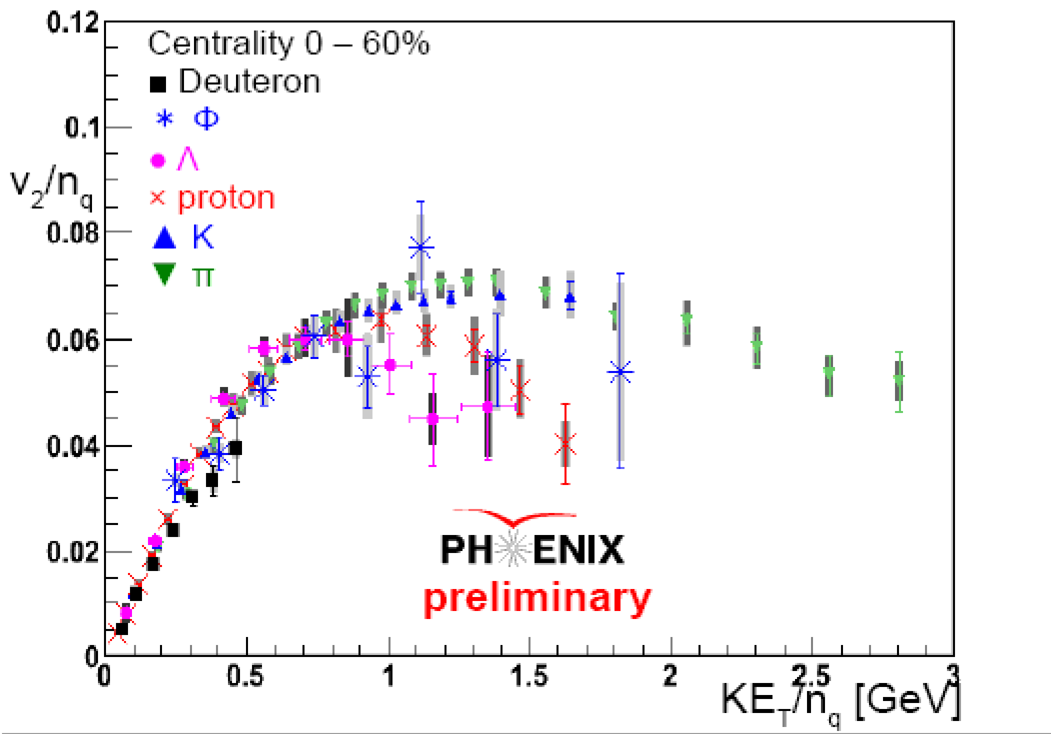
KE_T scaling



$$KE_T = M_T - M_0 = \sqrt{(M_0^2 + P_T^2)} - M_0$$

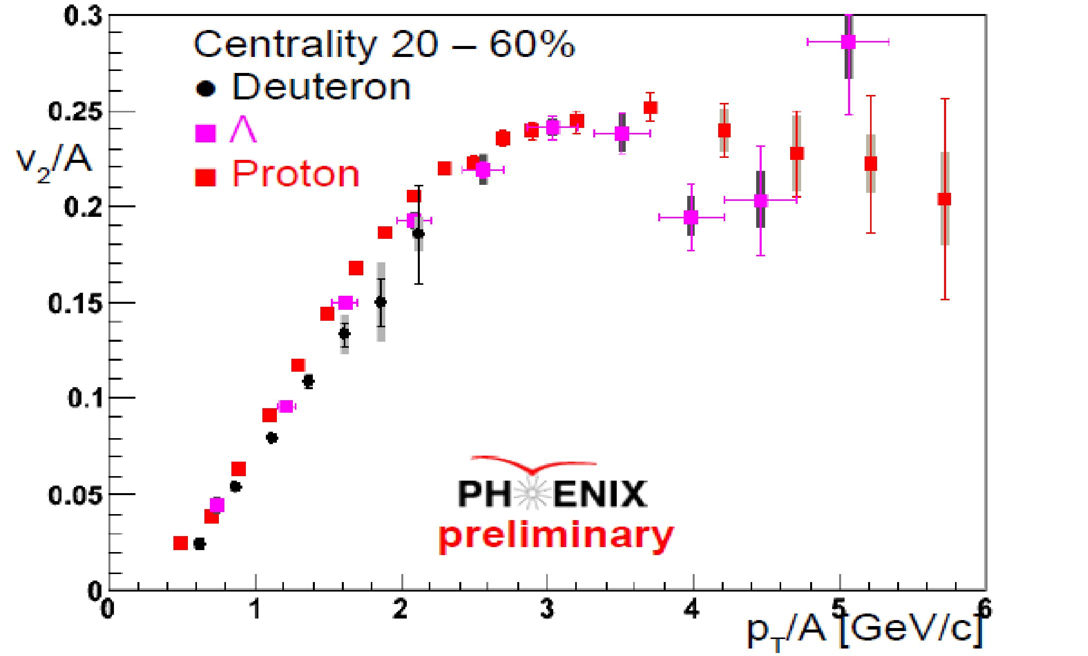
- They are consistent between mesons or baryons.
- The values are determined by centrality, KE_T and quark number.
- Meson line and baryon line approach at high KE_T.

Quark number and KE_T scaling

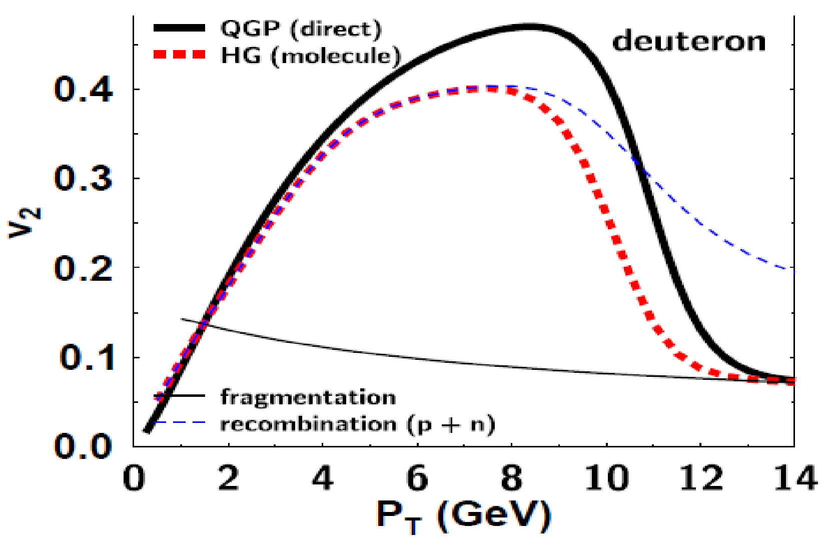


- Consistent for all particles on KE_T and quark number scaling at KE_T/n_q<0.8GeV.
- They deviate at high KE_T/n_q
- This indicate a change of particle and v_2 production mechanism.

Nucleon number scaling



arXiv:nucl-th/0312081



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

- D v_2 and p v_2 are consistent on p_T/A scaling.
- p v_2 and n v_2 are consistent.
- The peak of d v_2 is expected at p_T=6GeV/c.
- Coalescence of p-n or 6 quarks?

Summary

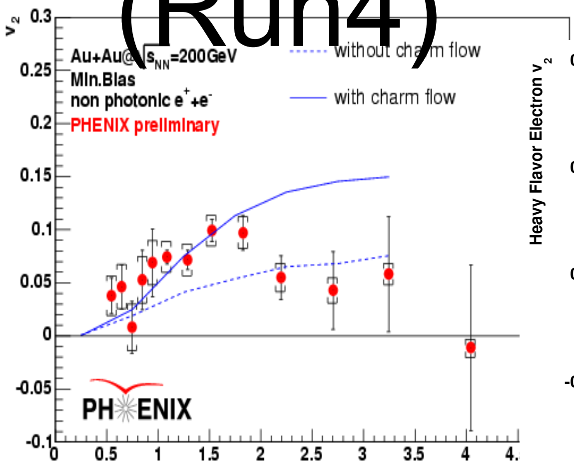
- The new reaction plane detector worked well.
  - We can see rare particles by the good resolution.
- .v_2 is depend on n_q on KE_T scaling.
  - Consistent for all particles on KE_T and n_q scaling at KE_T/n_q<0.8GeV.
  - Φ v_2 is same to other meson on KE_T.
- v_2 have no depend on the quark number at high p_T range.
  - Production mechanism is different.
- d v_2 and p v_2 are consistent on parton number scaling

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

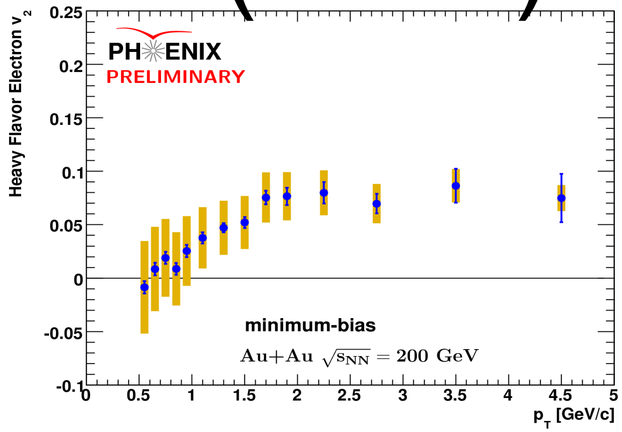
Back up

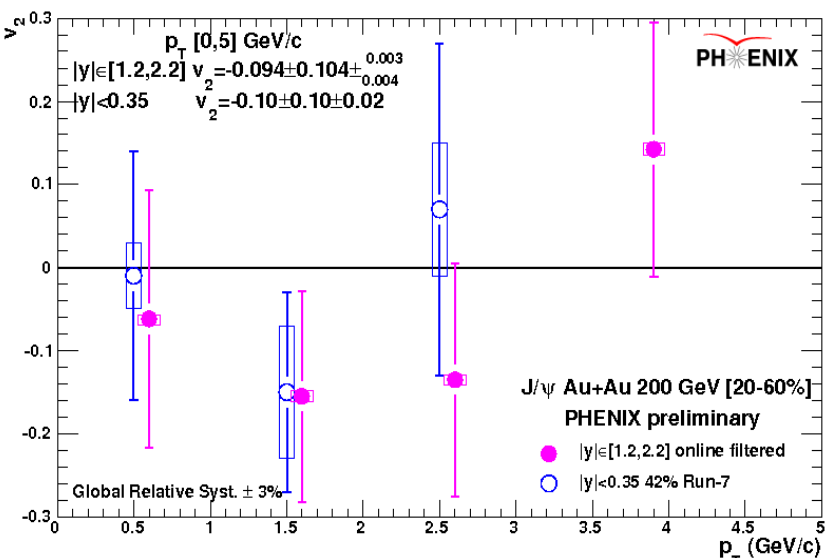
Heavy flavor and J/ψ v_2

(Run4)



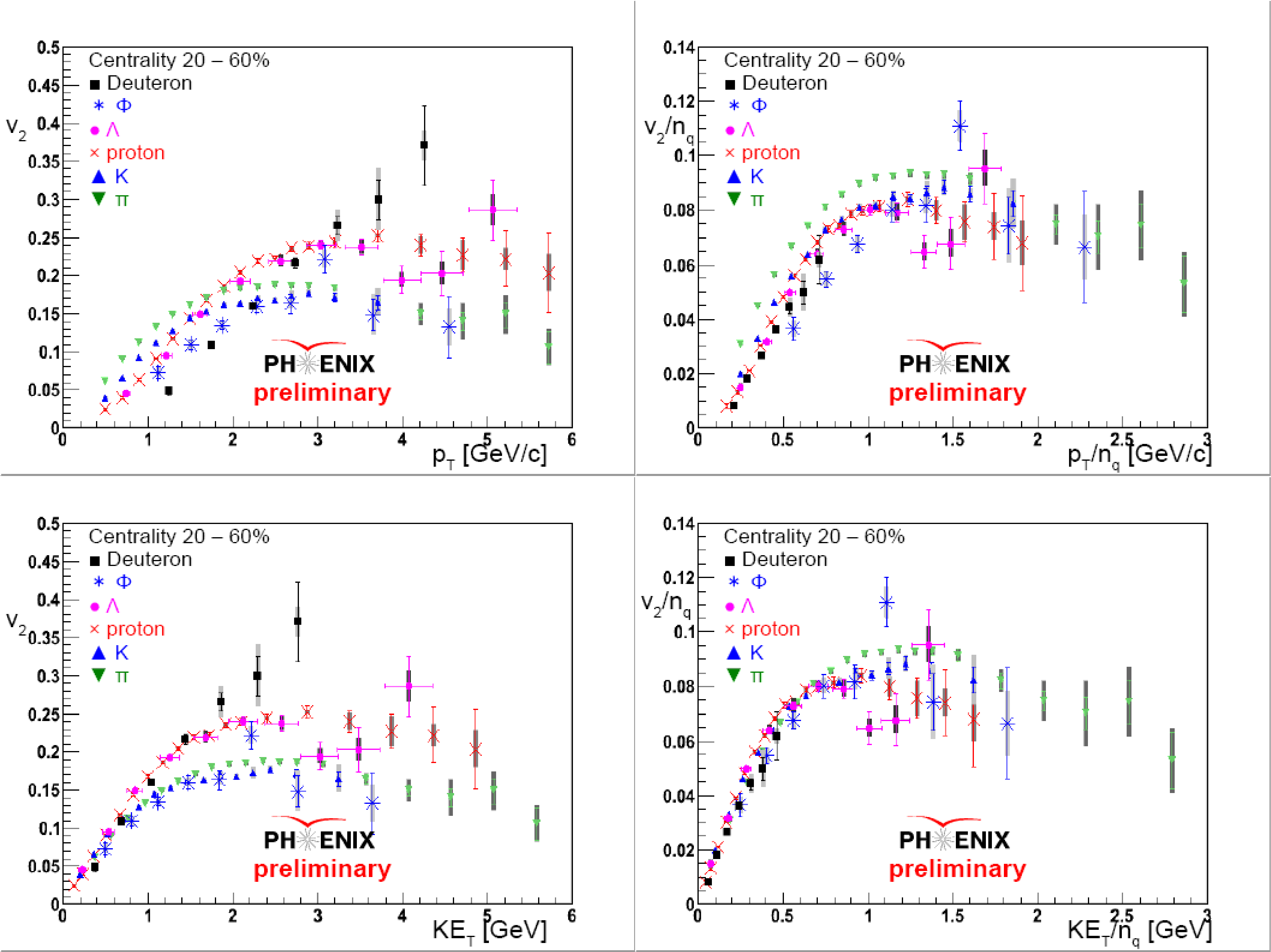
(Run7)





(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.


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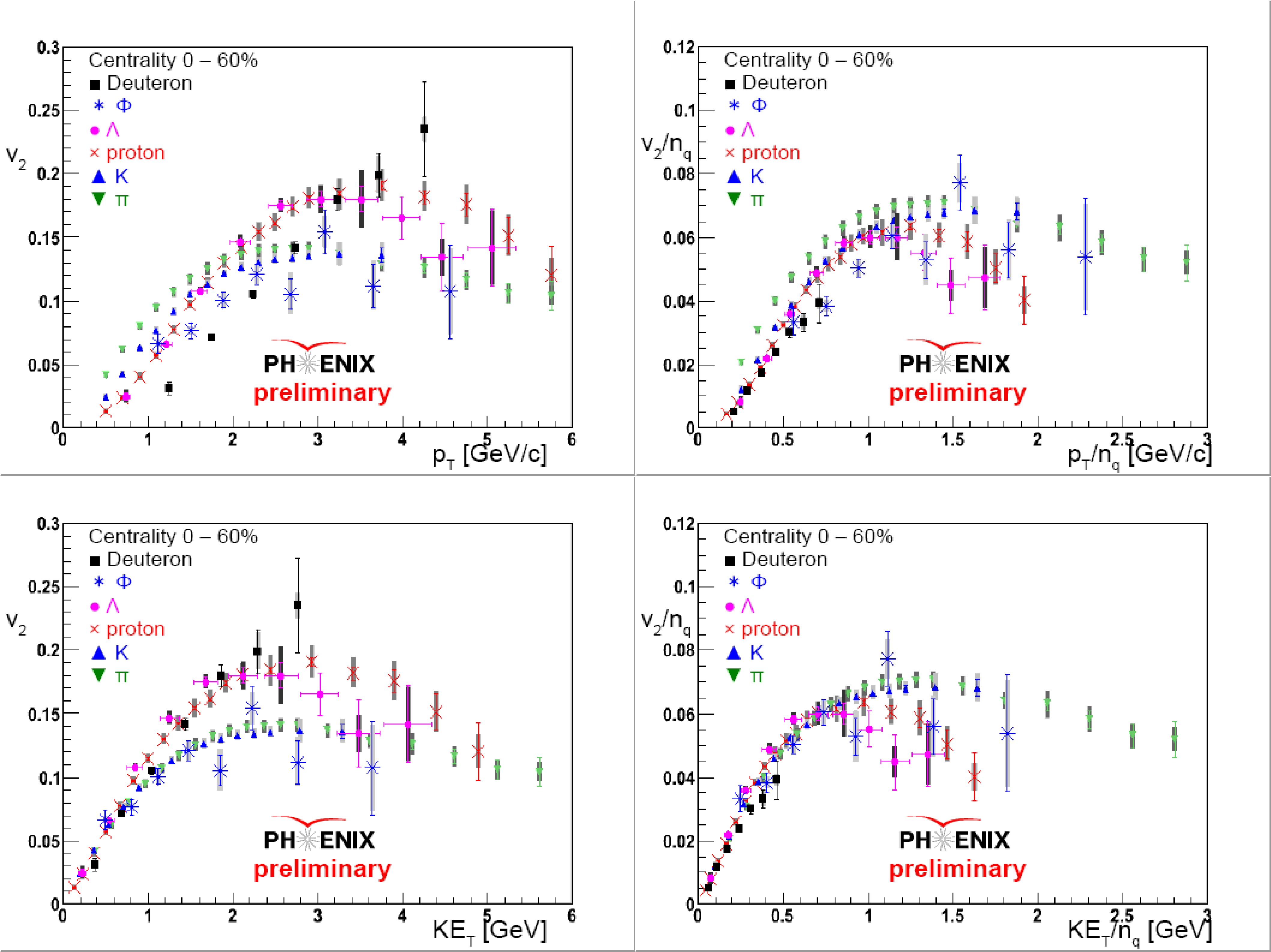
preliminary



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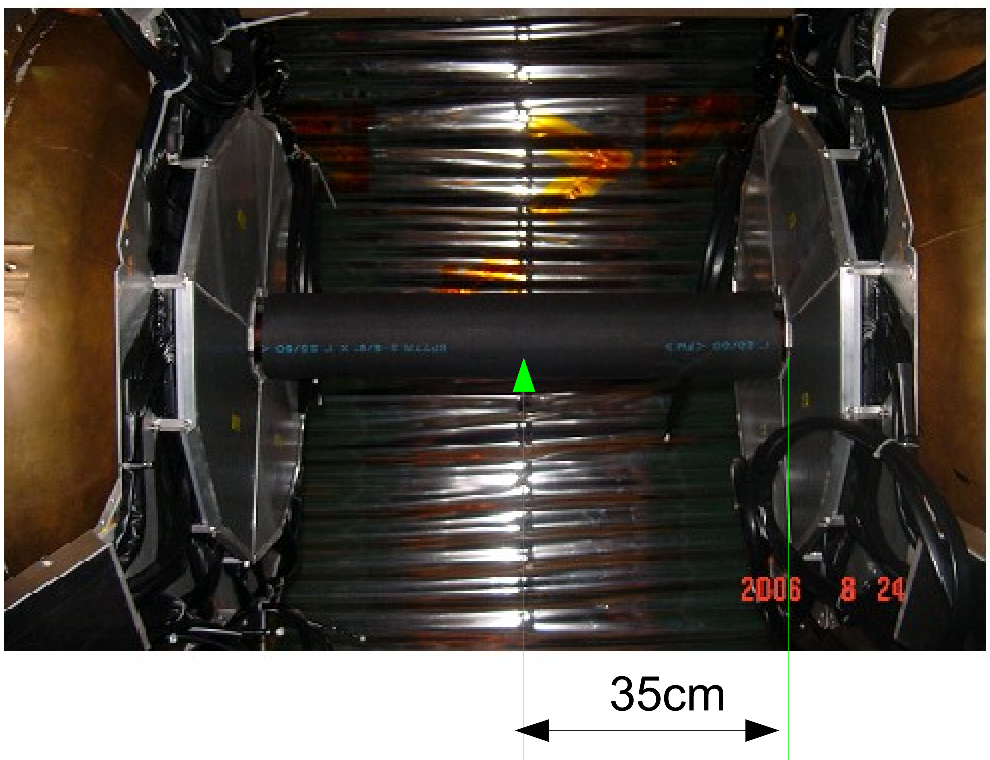
K
π
v_2/n_q
KE_T/n_q [GeV]
PHENIX
preliminary

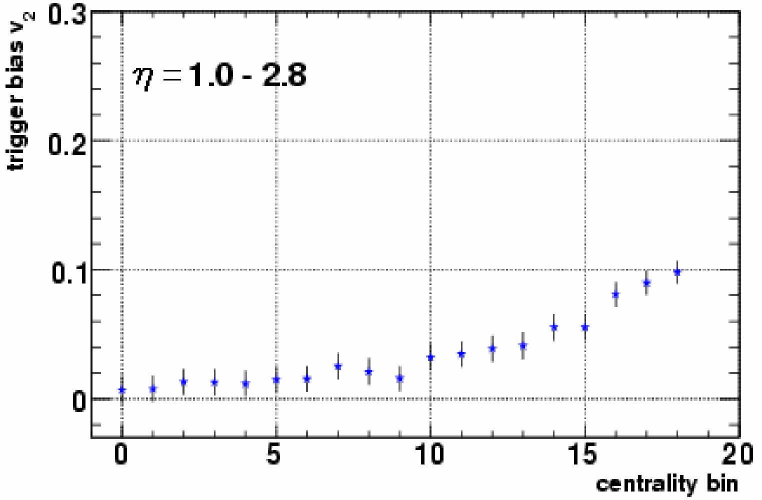
Reaction Plane Detector (RxP)

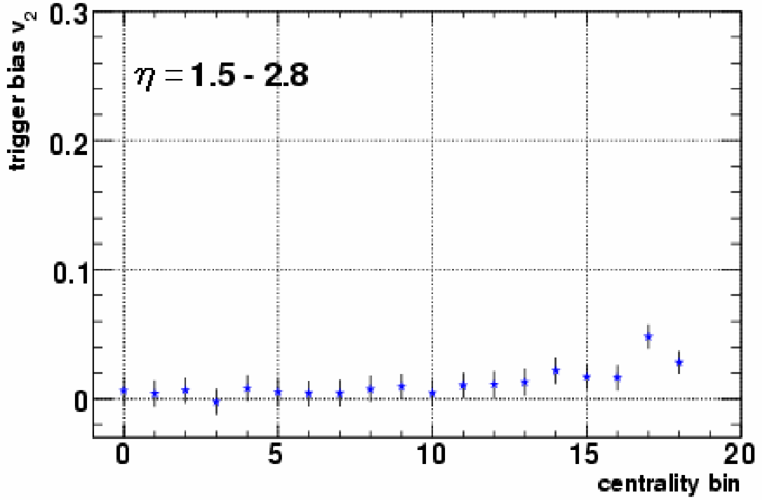
The reaction plane detector was installed just before Run7 (2007).



Collision piont

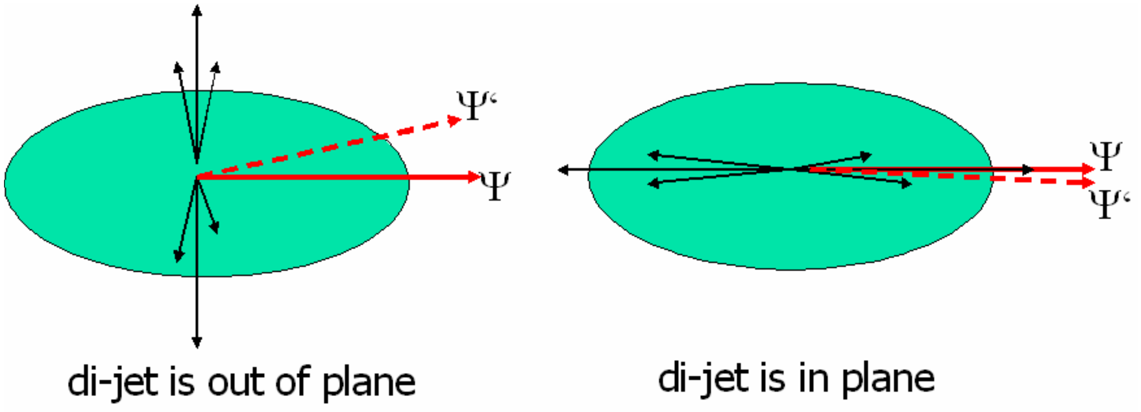
Correlation effect



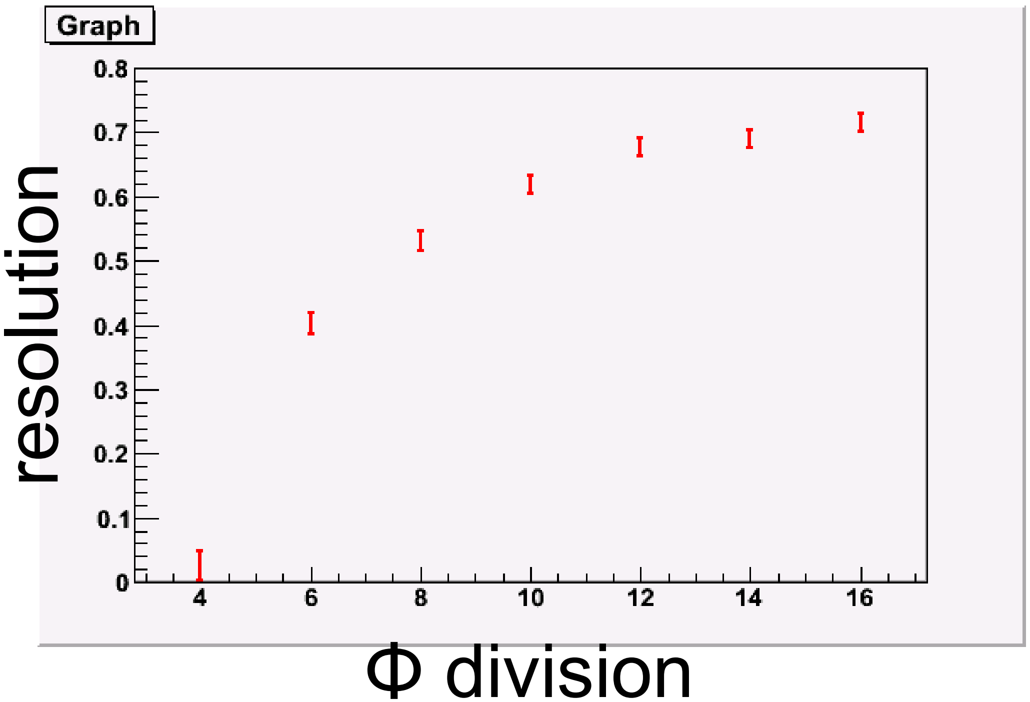


- v_2 is over estimated by correlation effect.

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



Design and Geant simulation



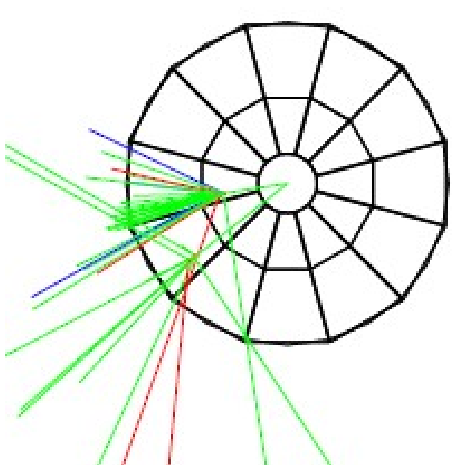
Detector parameters were optimized with Geant simulation

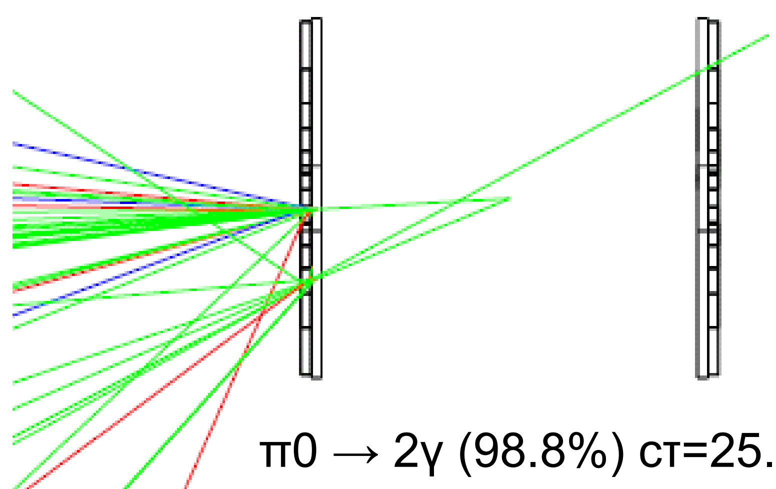
Thickness

Scintillator 2cm

Converter 2cm

Φ division into 12

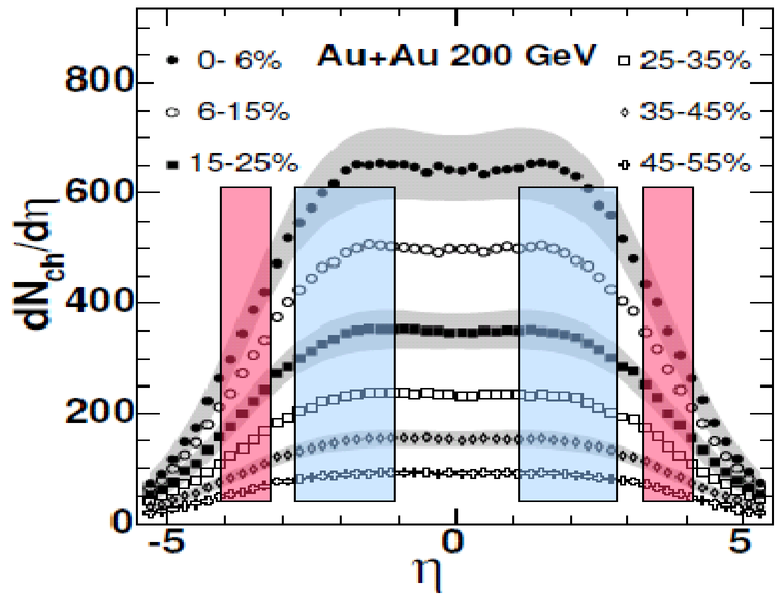


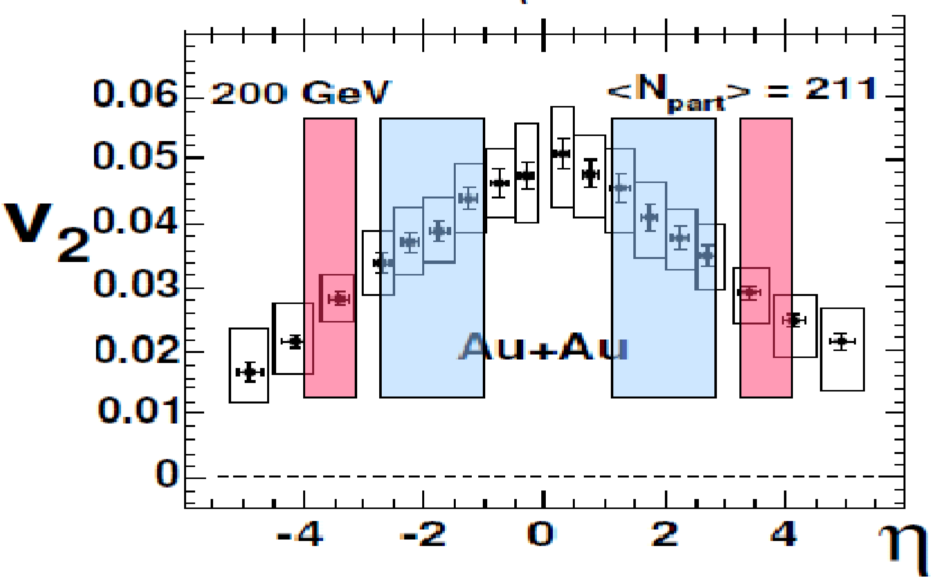


π0 → 2γ (98.8%) cτ=25.1[nm]

Acceptance of “RxP”

PHOBOS, PRL. 91, 052303 (2003)

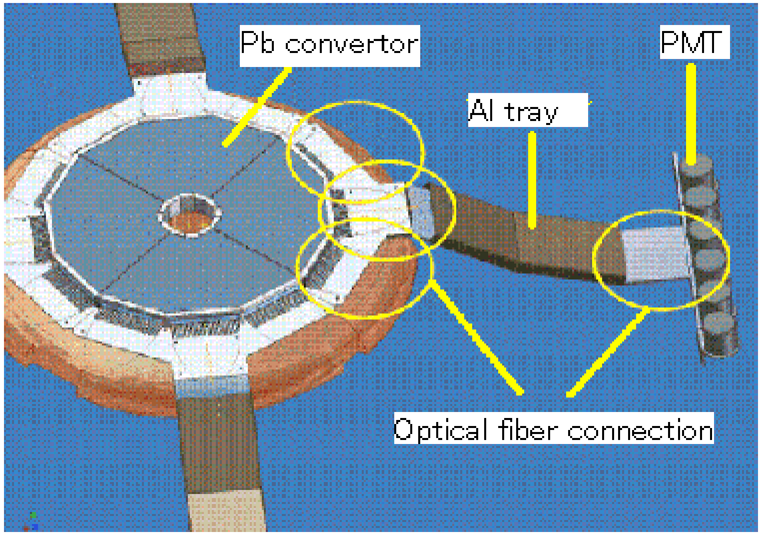


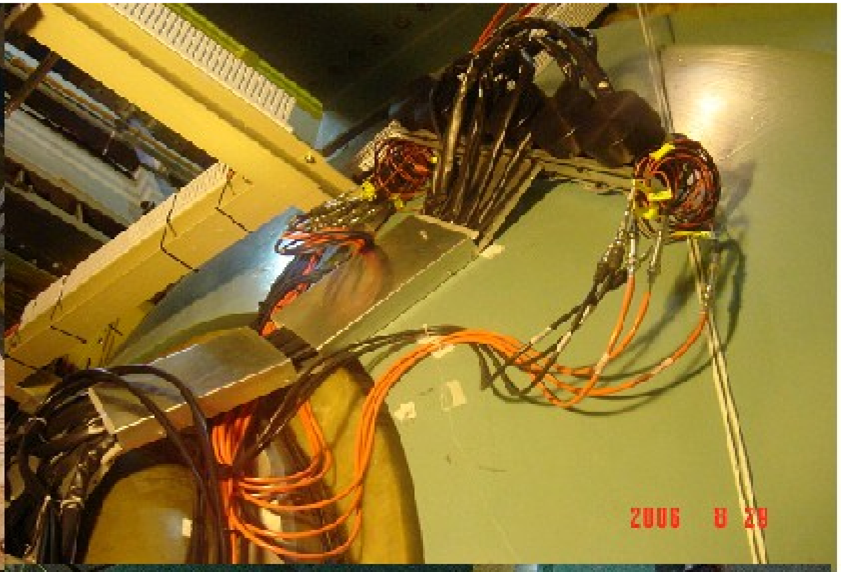


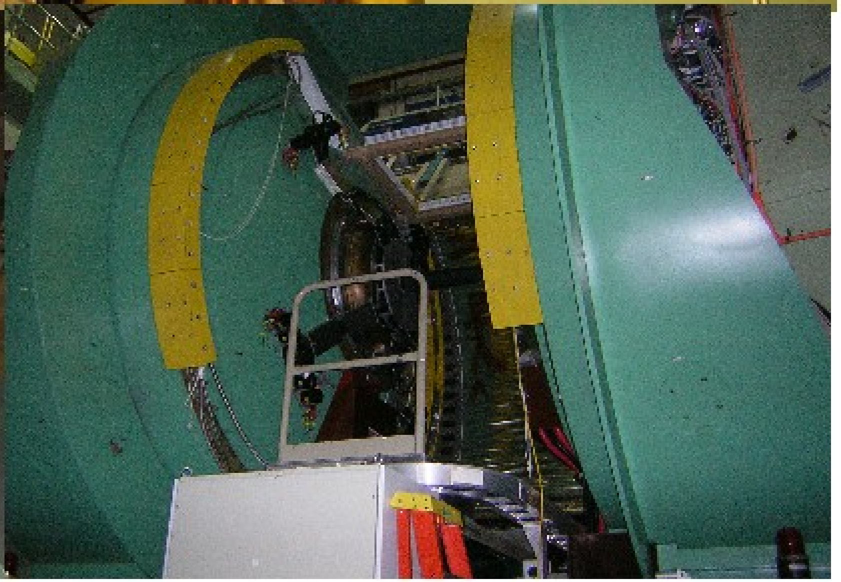
RxP measure more particles and the particles with more large v_2.

RxP : η = ±1~2.8(blue)

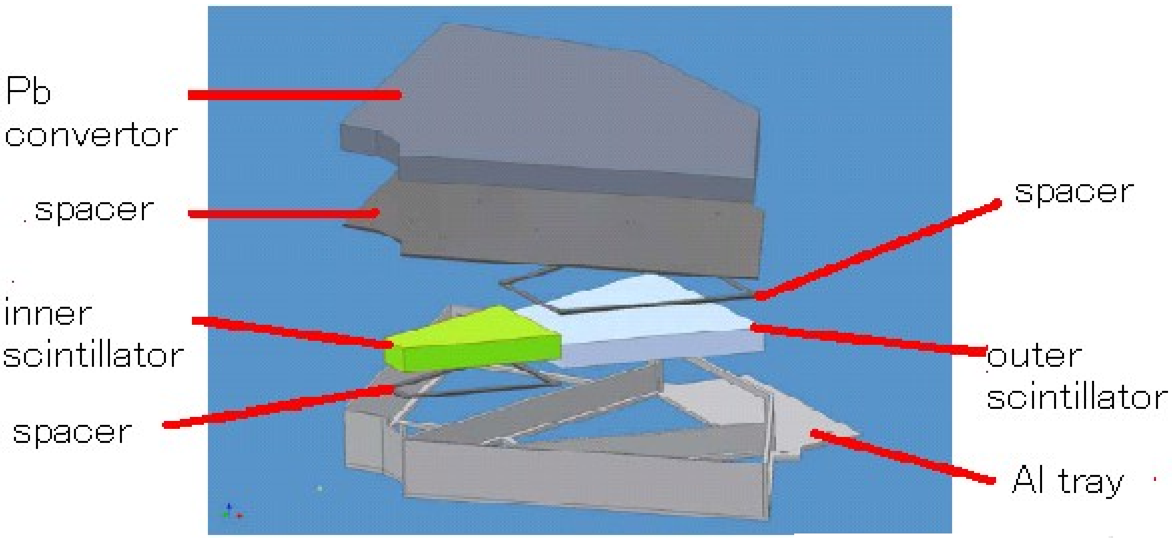
BBC : η = ±3.1~4(red)

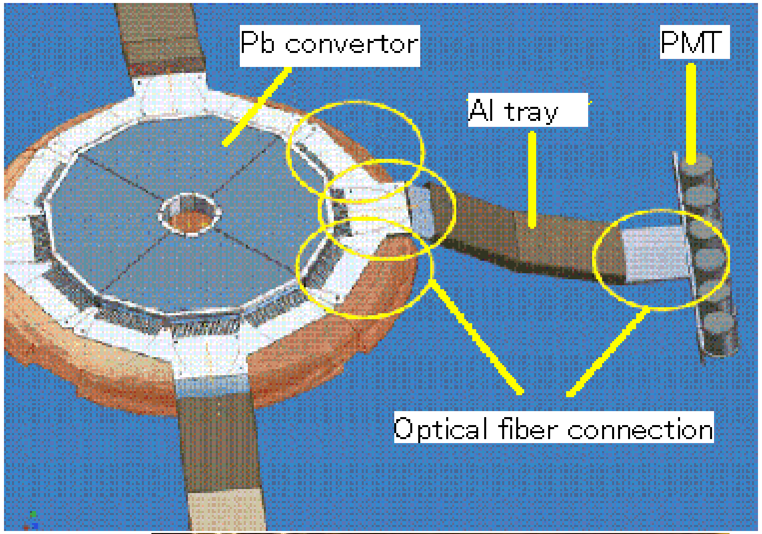


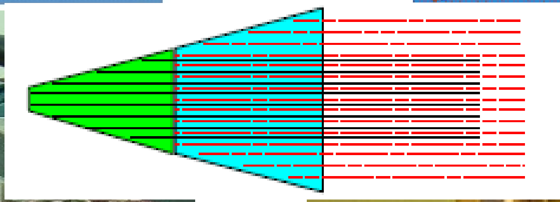

2006 8 9

2006 8 29

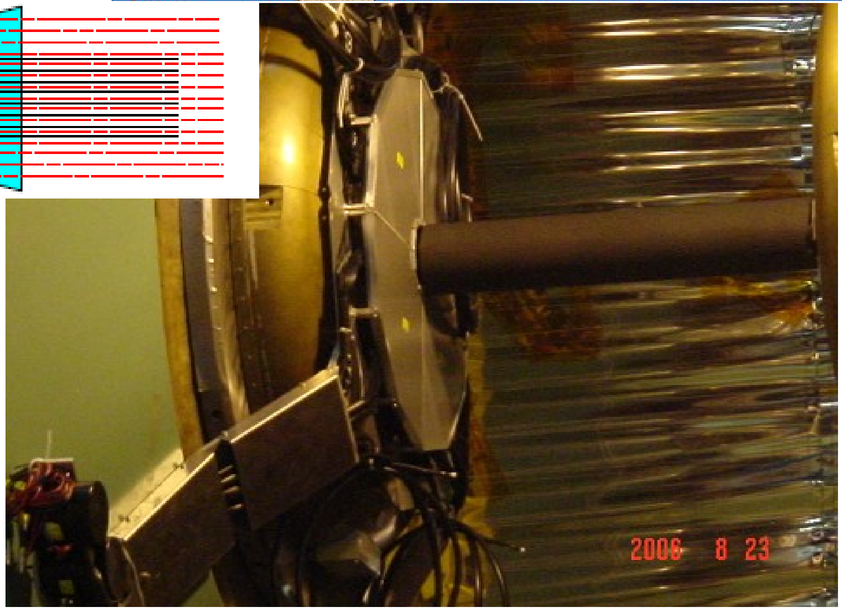
2006 8 10


Configuration of RxP







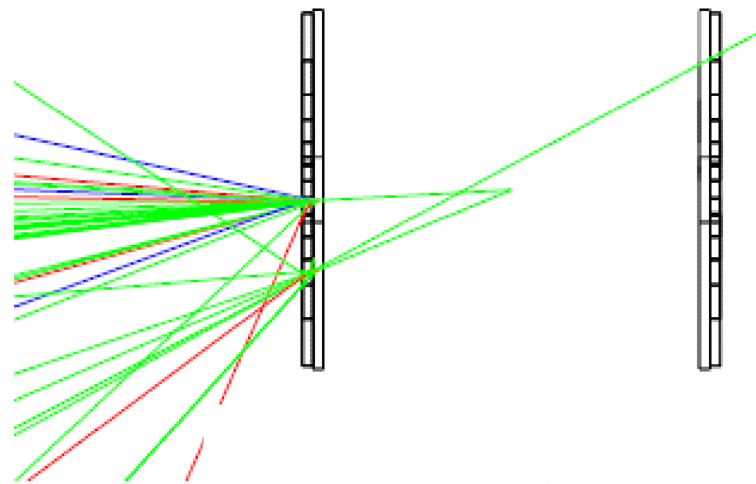


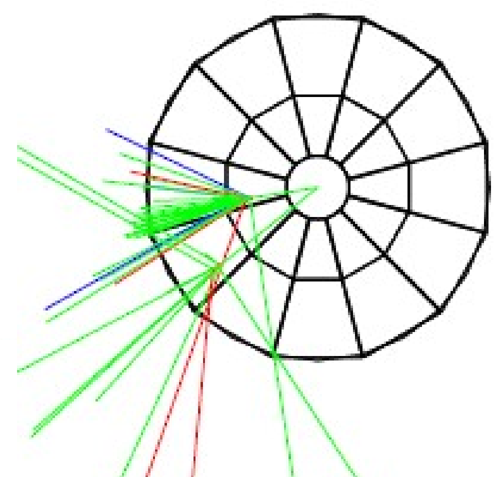
Reaction Plane Detector (RxP)

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

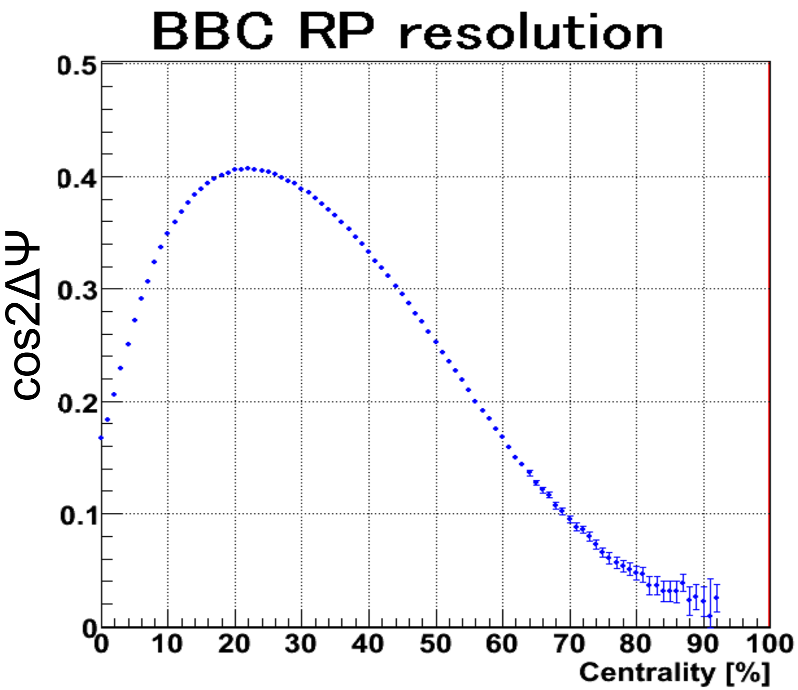
35cm

Collision piont





Reaction Plane Resolution

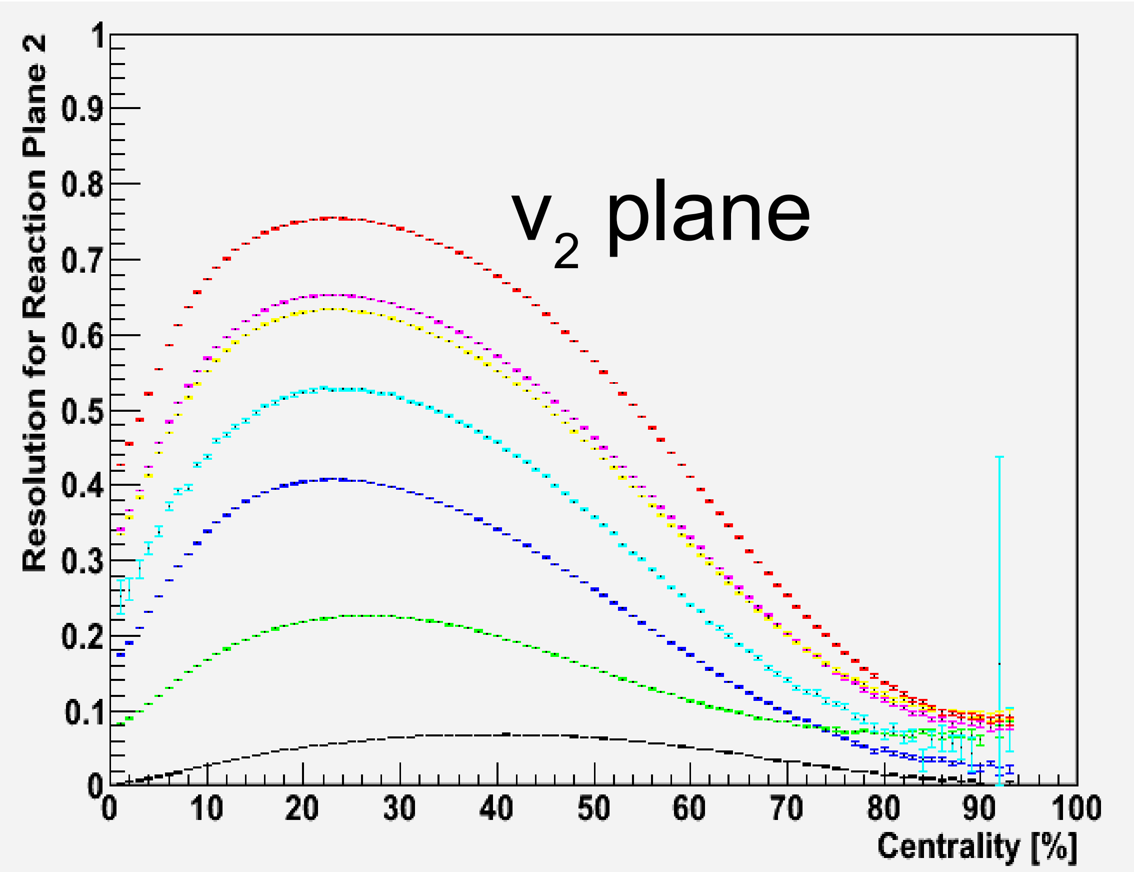


$$v_{2\,observe} = v_{2\,real} \times \langle \cos 2(\Psi_{real} - \Psi_{observe}) \rangle$$

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

- 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 Resolution on Run7



RxP $|\eta| = 1.0 - 2.8$ New!

RxPinner $|\eta| = 1.5 - 2.8$ New!

RxPouter $|\eta| = 1.0 - 1.5$ New!

MPC $|\eta| = 3.0 - 4.0$ New!

BBC $|\eta| = 3.1 - 3.9$

CNT $|\eta| = 0 - 0.35$

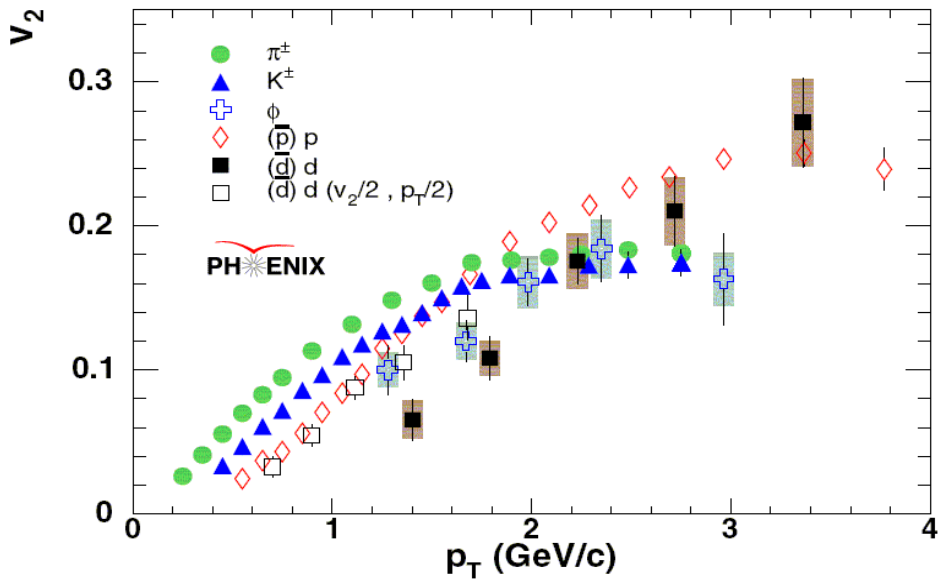
SMD $|\eta| > 6$

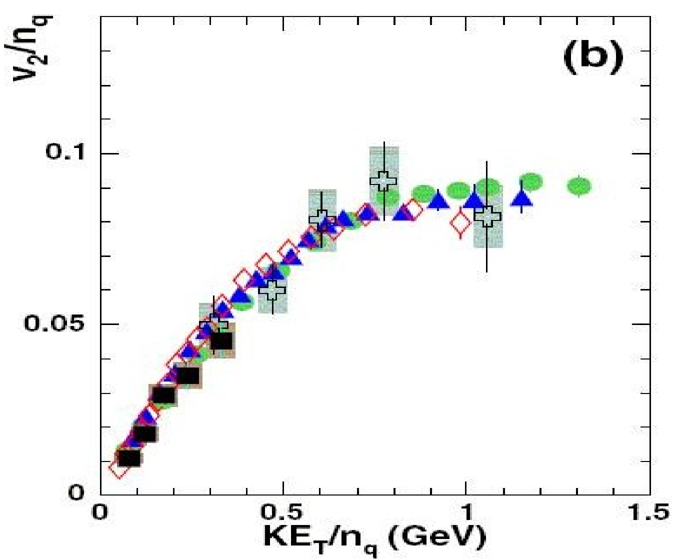
$$v_{2\,observe} = v_{2\,real} \times \langle \cos 2(\Psi_{real} - \Psi_{observe}) \rangle$$

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

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.

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