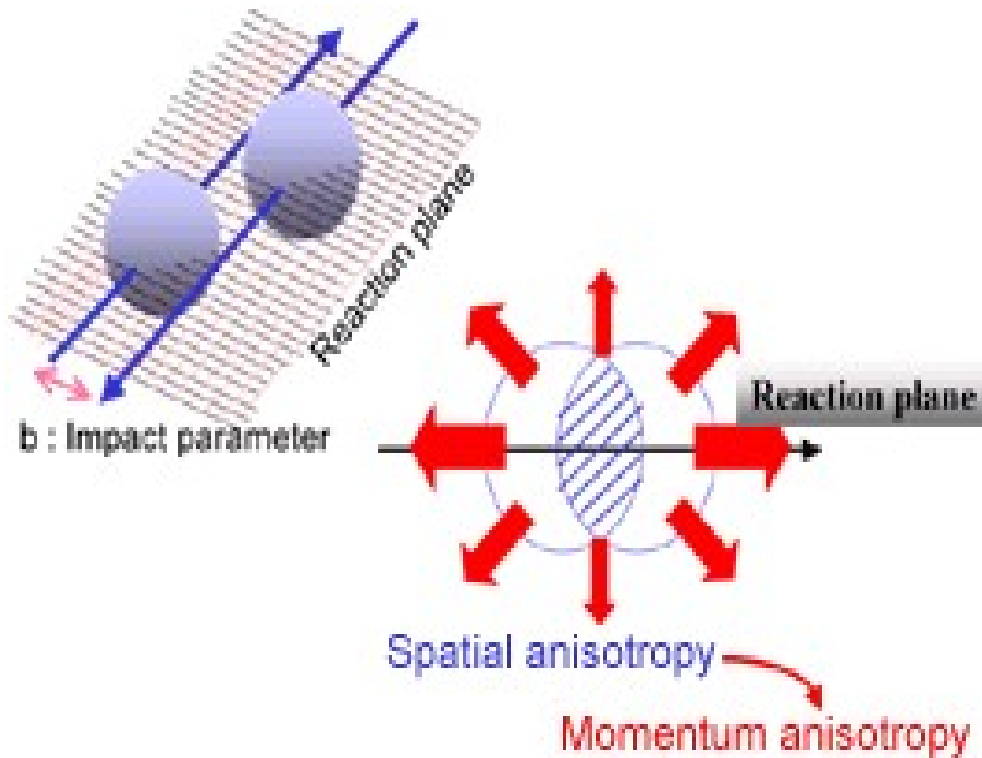


# Measurement of Azimuthal Anisotropy with the New Reaction Plane Detector in the PHENIX experiment

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(University of Tsukuba)

# Azimuthal anisotropy

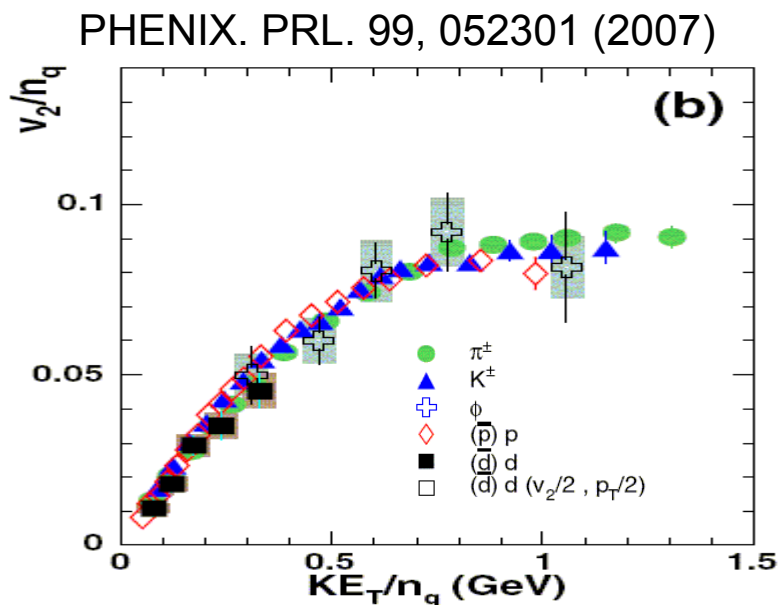
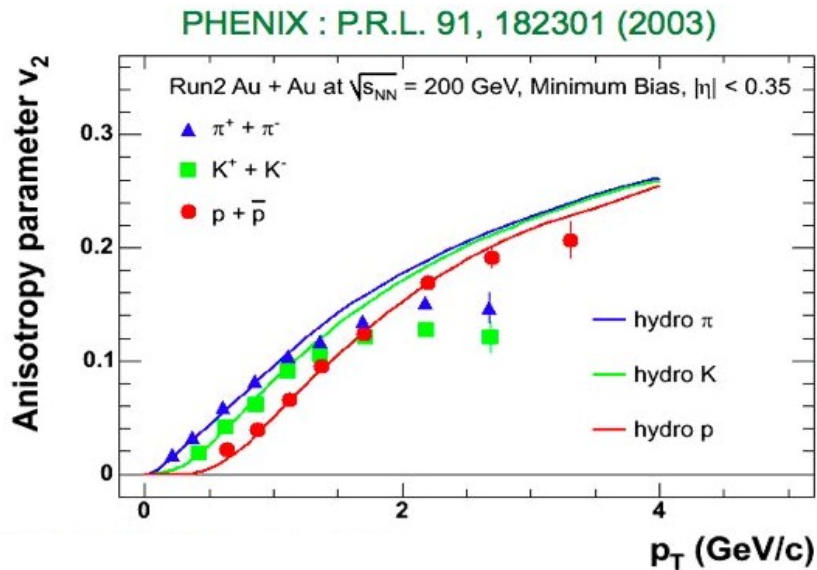


- Spatial anisotropy in non-central collision provides azimuthal anisotropy of particle emission.
- The large anisotropy is an evidence of the formation of a hot and dense partonic matter.

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

$\Psi$  : reaction plane angle

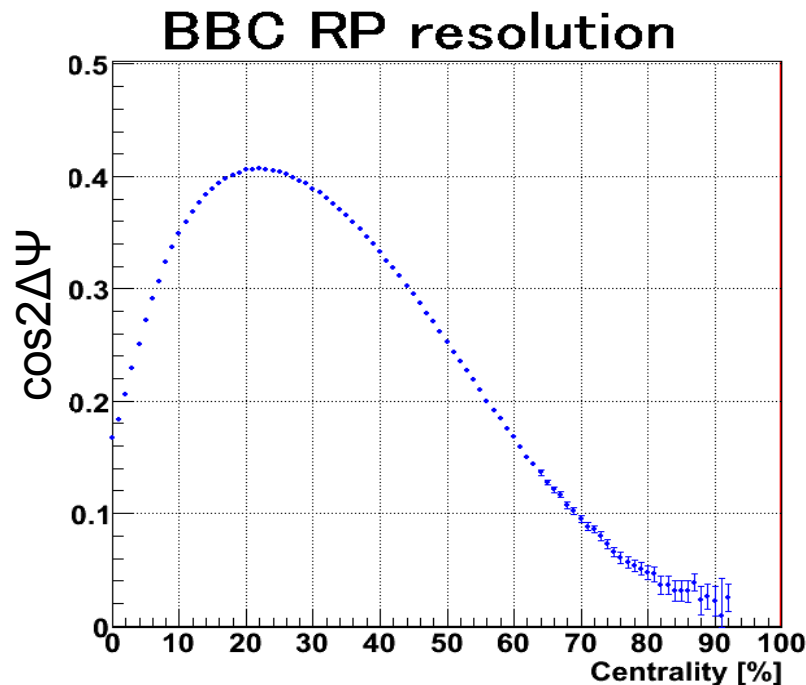
# Motivation of $v_2$ measurement



- Large  $v_2$  was observed in RHIC
- The values agreed with hydro-dynamical models
- It suggests rapid thermalization and quark flow.

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

# Reaction Plane Resolution



- Reaction plane resolution is  $\sim 0.4$  before the introduction of the reaction plane detector.

- The observed  $v_2$  strength is only less than 40% of its real value.

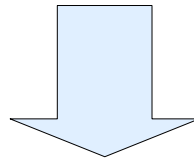
- statistical power less than 1/6.

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

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

# Motivation of new detector

- Measurement of more precise  $v_2$  is expected.
- Poor reaction plane resolution was a major limiting factor of PHENIX  $v_2$  measurement of rare probes such as open charm,  $J/\Psi$  and direct photon.

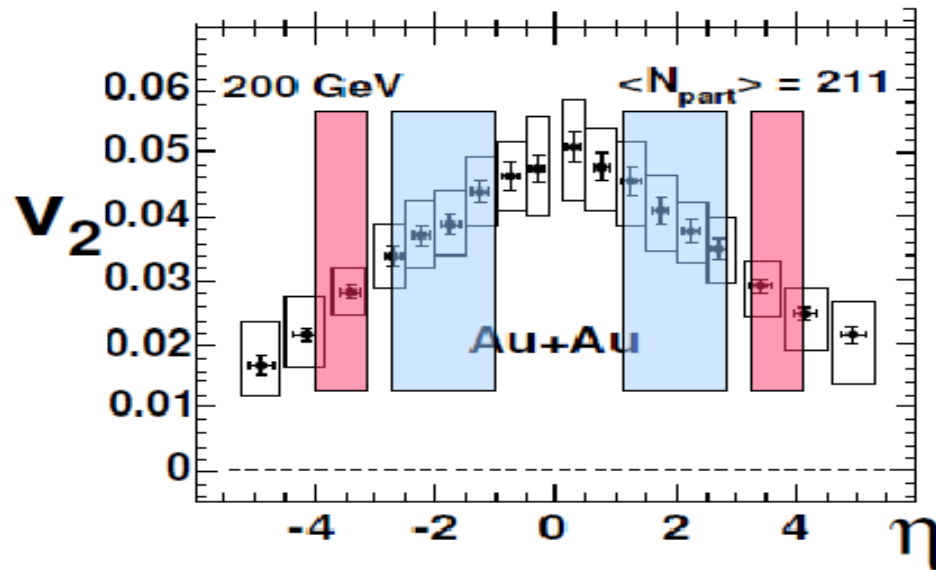
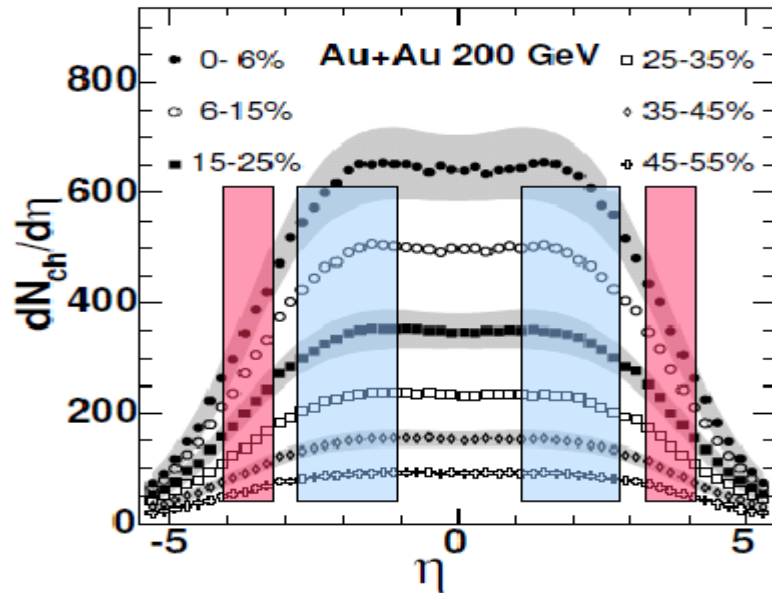


Reaction Plane Detector (RxP) has been constructed and installed to PHENIX in 2007.

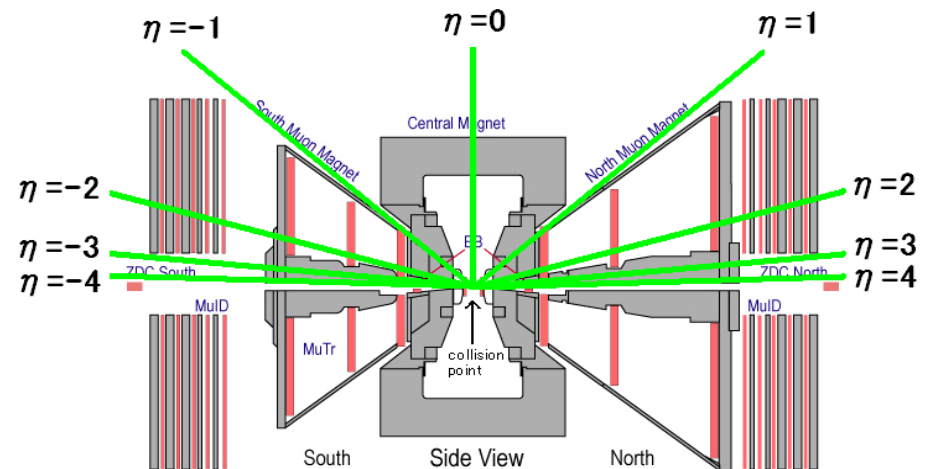
- Reaction plane resolution of  $\cos 2\Delta\psi \sim 0.7$  for minimum bias Au+Au collisions

# Acceptance of RxP

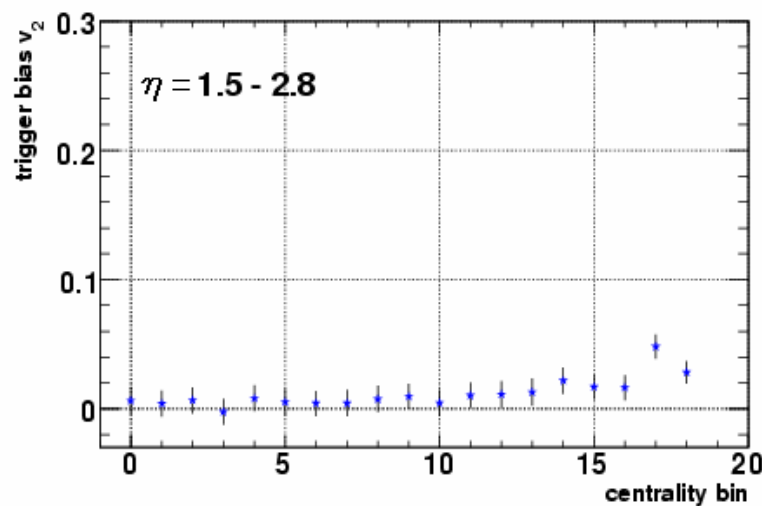
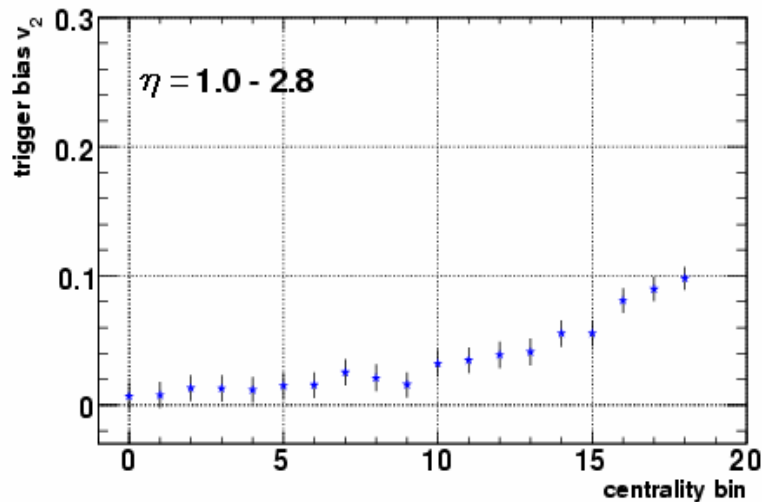
PHOBOS, PRL. 91, 052303 (2003)



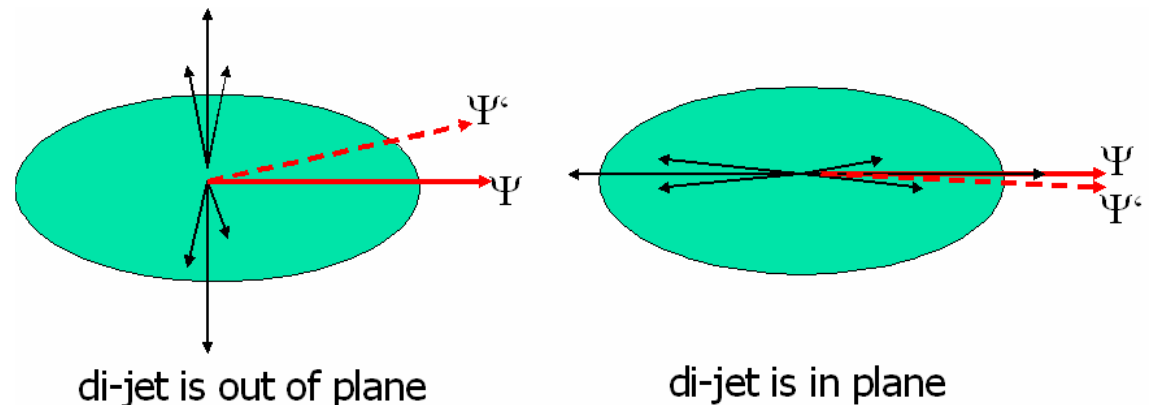
- RxP measure more particles and the particles with more large  $v_2$ .
  - RxP :  $\eta = \pm 1 \sim 2.8$  (blue)
  - BBC :  $\eta = \pm 3.1 \sim 4$  (red)



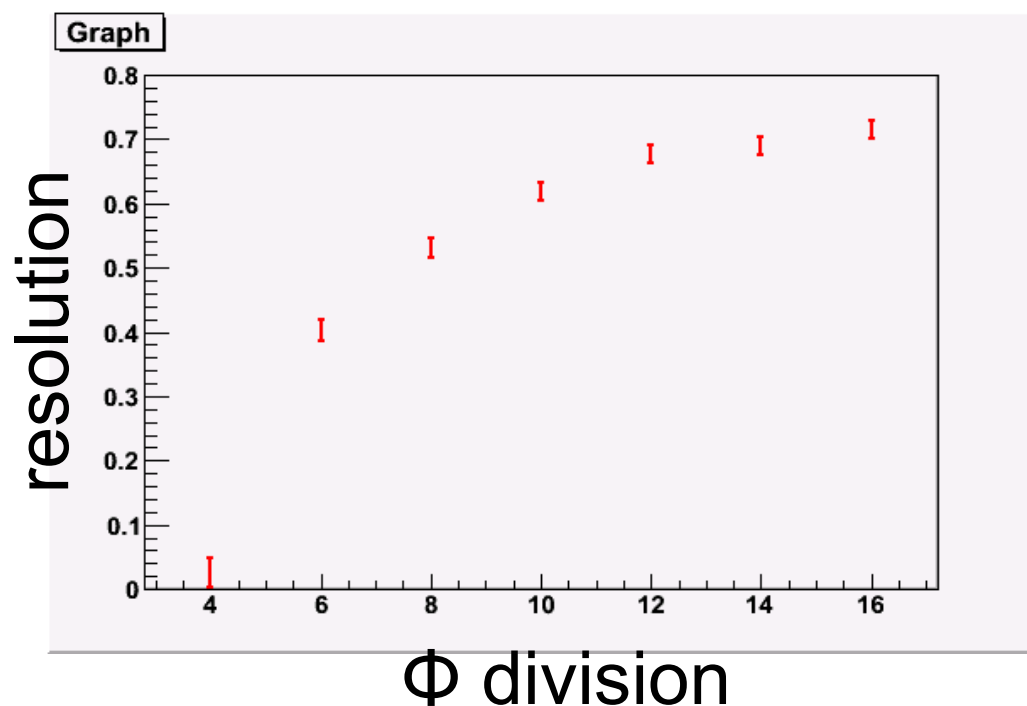
# Correlation effect



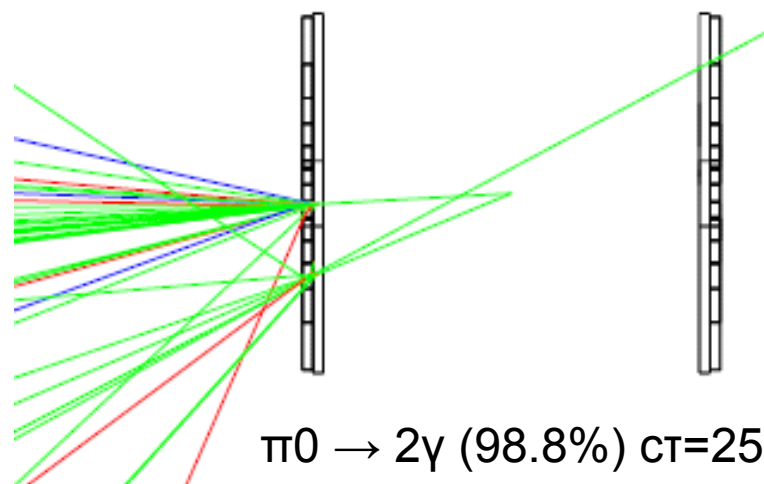
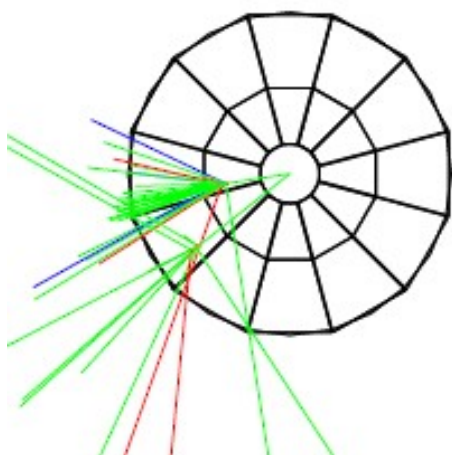
- $v_2$  is over estimated by correlation effect.
- According to HIJING+PYTHIA, the effect by jet does not have any problem with  $\eta > 1.5$



# Design and Geant simulation



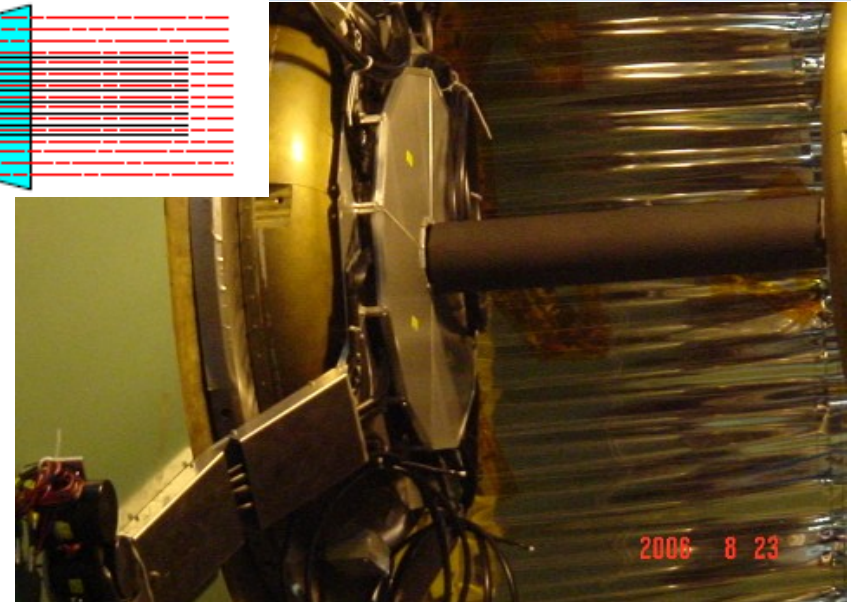
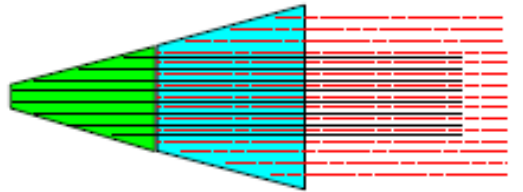
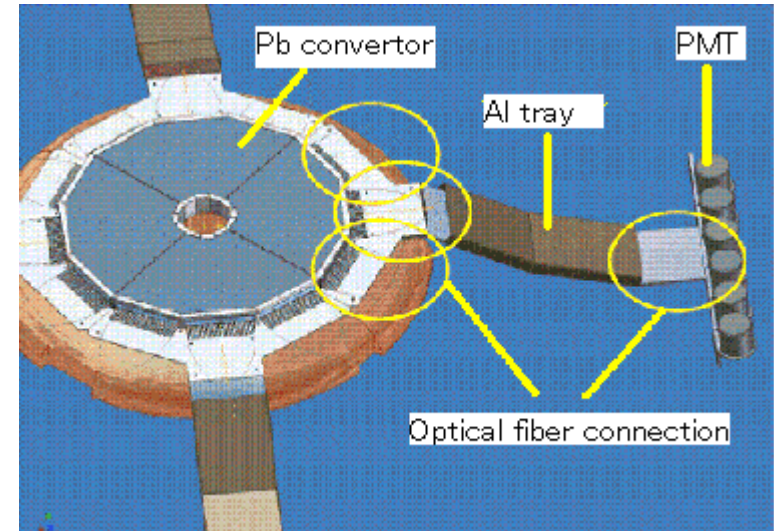
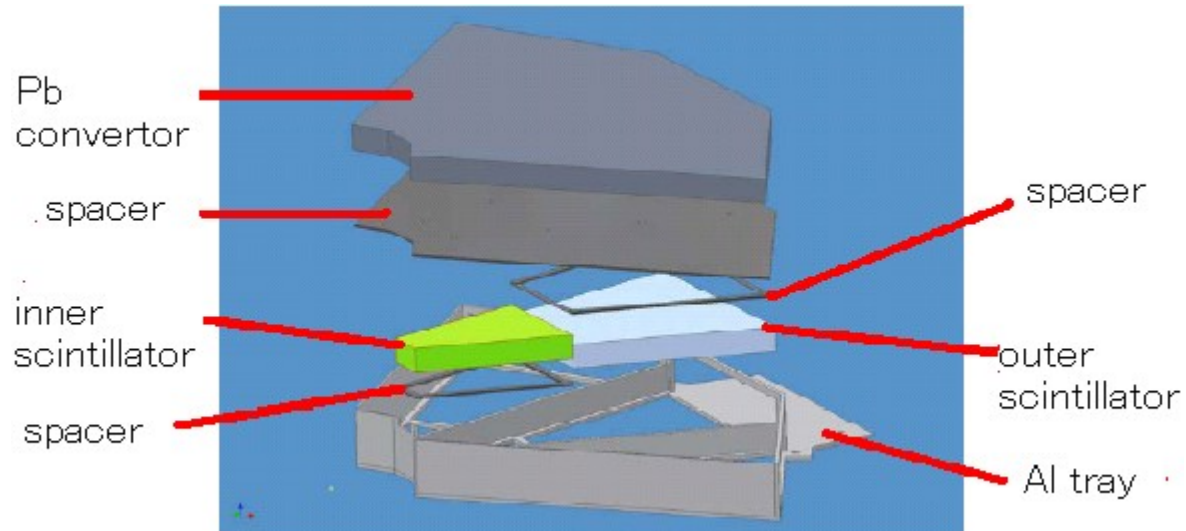
- Detector parameters were optimized with Geant simulation
- Thickness
  - Scintillator 2cm
  - Converter 2cm
- $\Phi$  division into 12



$\pi^0 \rightarrow 2\gamma$  (98.8%)  $\sigma_T=25.1[\text{nm}]$



# Configuration of RxP





# Reaction Plane Detector (RxP)

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



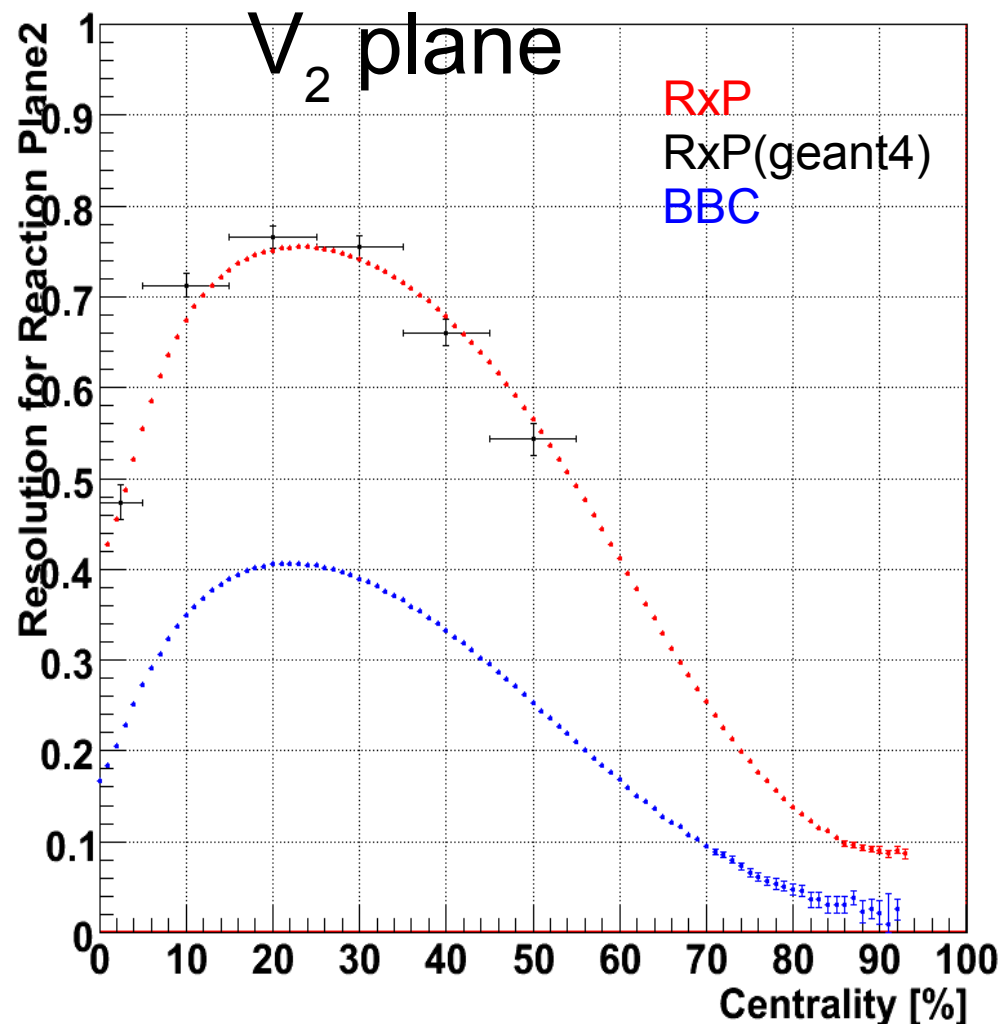
35cm

Collision point



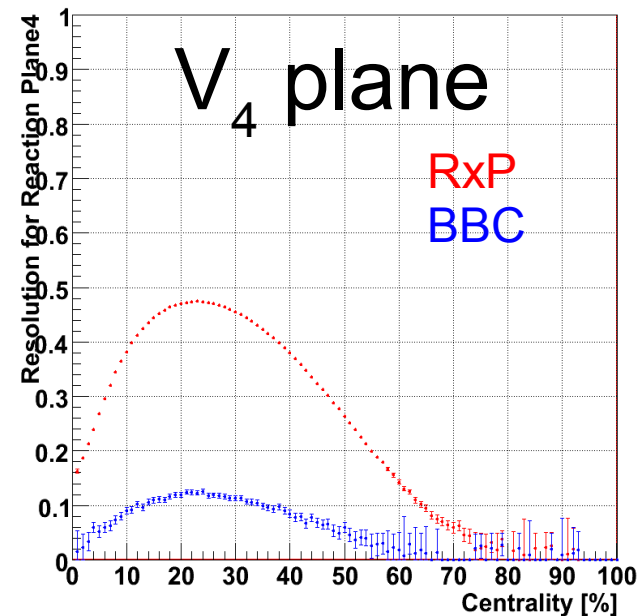
# Reaction Plane Resolution Run7

Red: RxP, Blue: BBC, Black: Simulation RxP

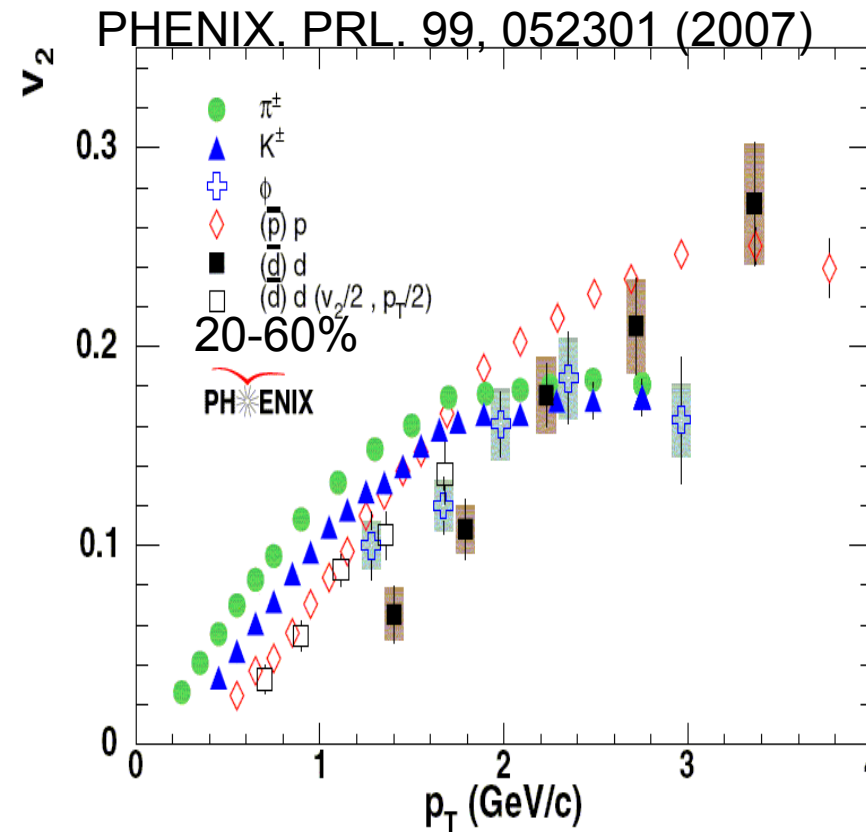


- resolution is improved by a factor of two as we expected.

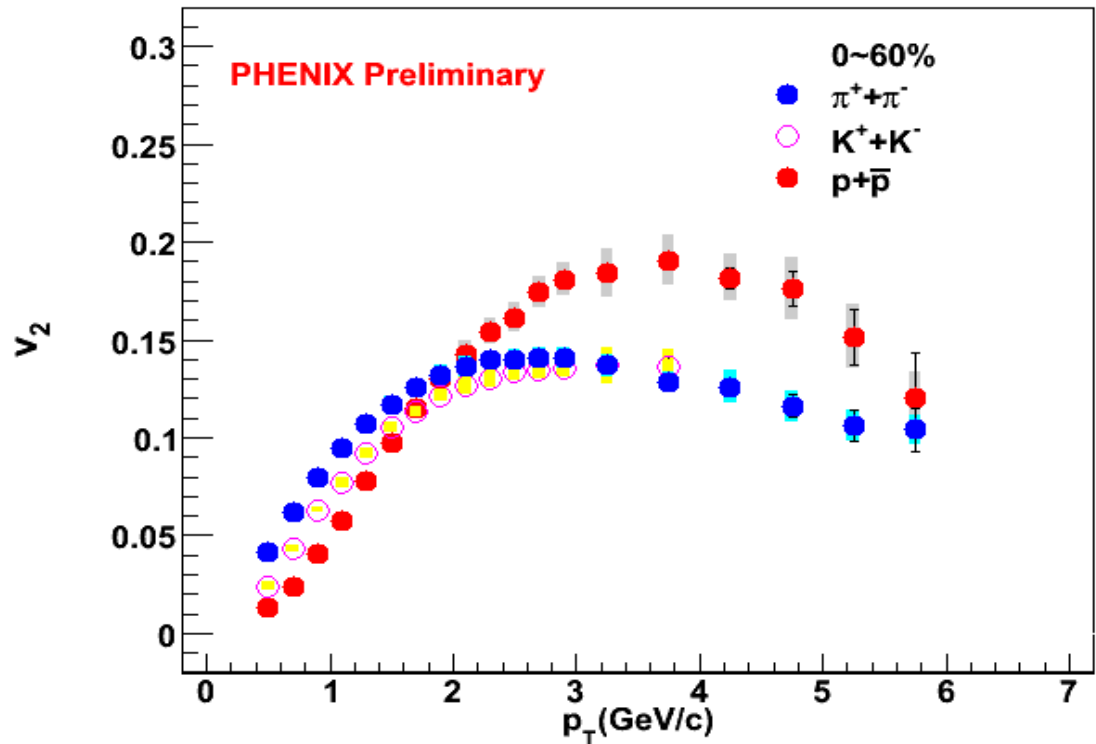
Red: RxP, Blue: BBC



# $v_2$ before and after



Before (Run4)



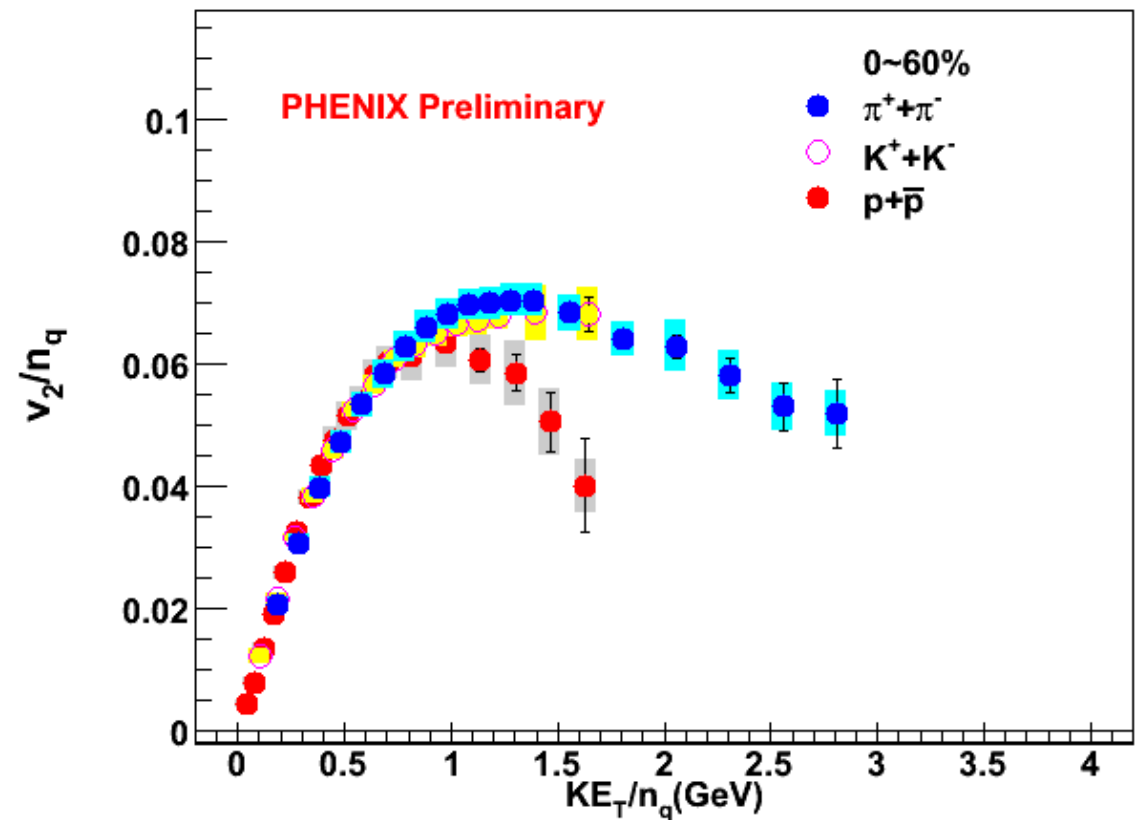
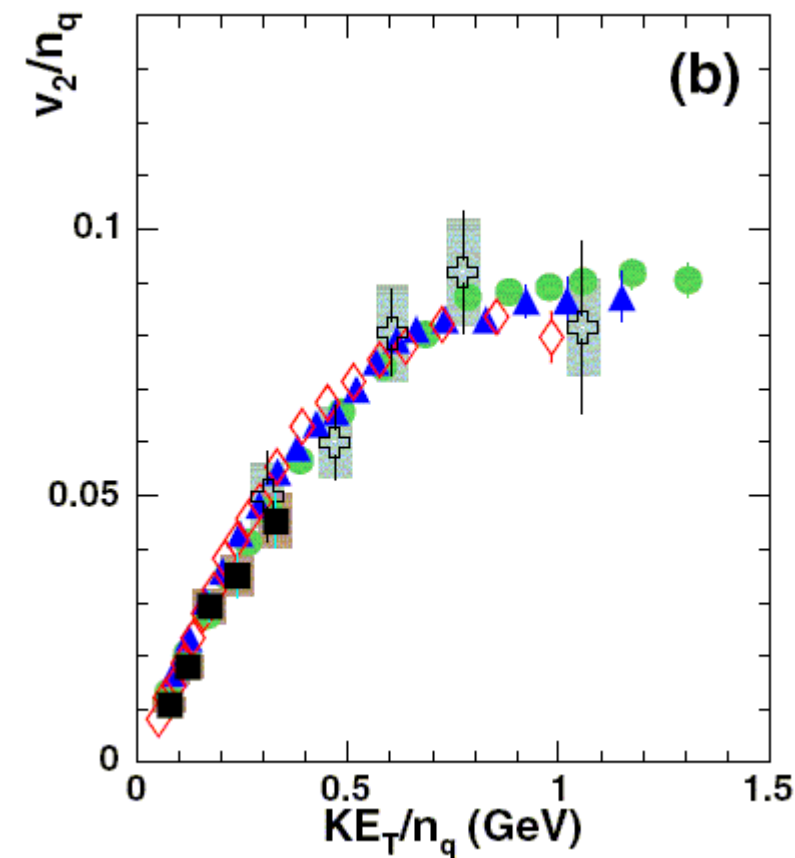
After (Run7)

Higher statistical  
Better resolution of R<sub>xP</sub>

# Quark number and $KE_T$ scaling

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

PHENIX. PRL. 99, 052301 (2007)

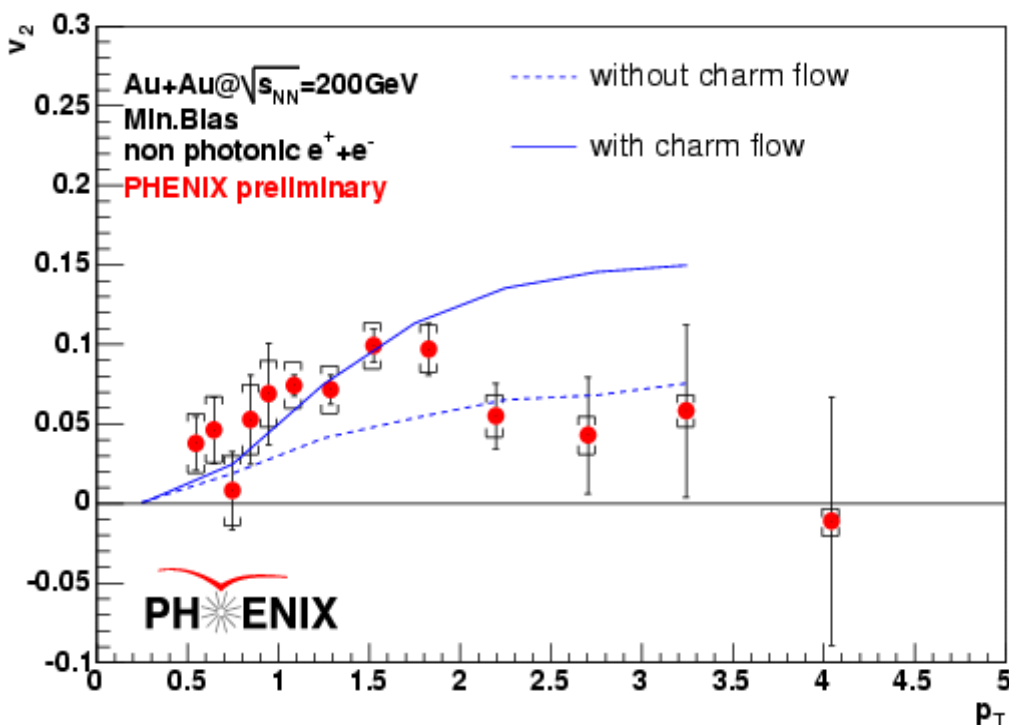


The  $v_2$  of proton and anti-proton show clear deviation from the number of quark scaling at  $KE_T/n$  1 GeV.

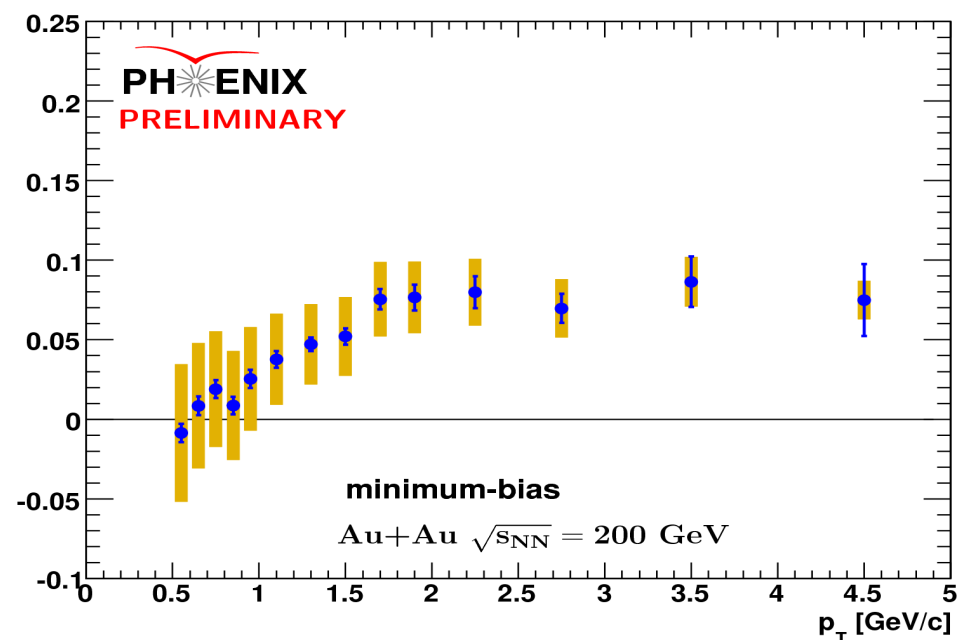
This may indicate a change of particle production mechanism.

# Heavy flavor $v_2$

- The data at low  $p_T$  favor the models that include quark level elliptic flow of charm.
- B meson decay becomes a significant source above 2.5 GeV/c

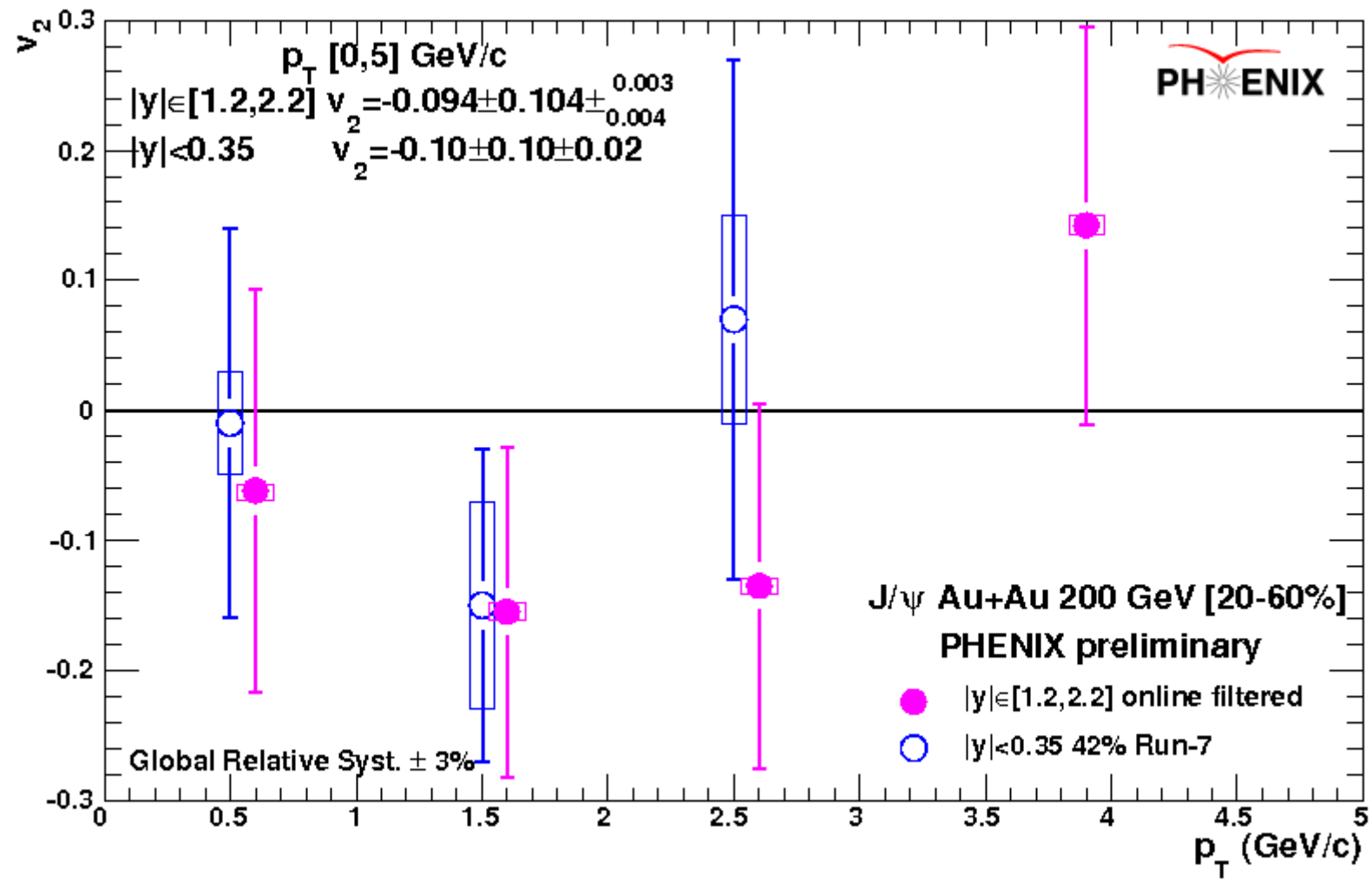


Before (Run4)



After (Run7)

# J/Psi $v_2$



# Summary

- RxP has worked very well during the PHENIX Run7 period and demonstrated the design performance.
  - resolution is improved by a factor of two ( $0.4 \Rightarrow 0.75$ )
- We are analyzing the data with RxP.
  - $\pi$ , K, Proton, single electron and  $J/\Psi$  have been measured and also preparing for the publications.
  - Please wait for Deuteron,  $\Lambda$  and  $\Phi$ .







