

Introduction

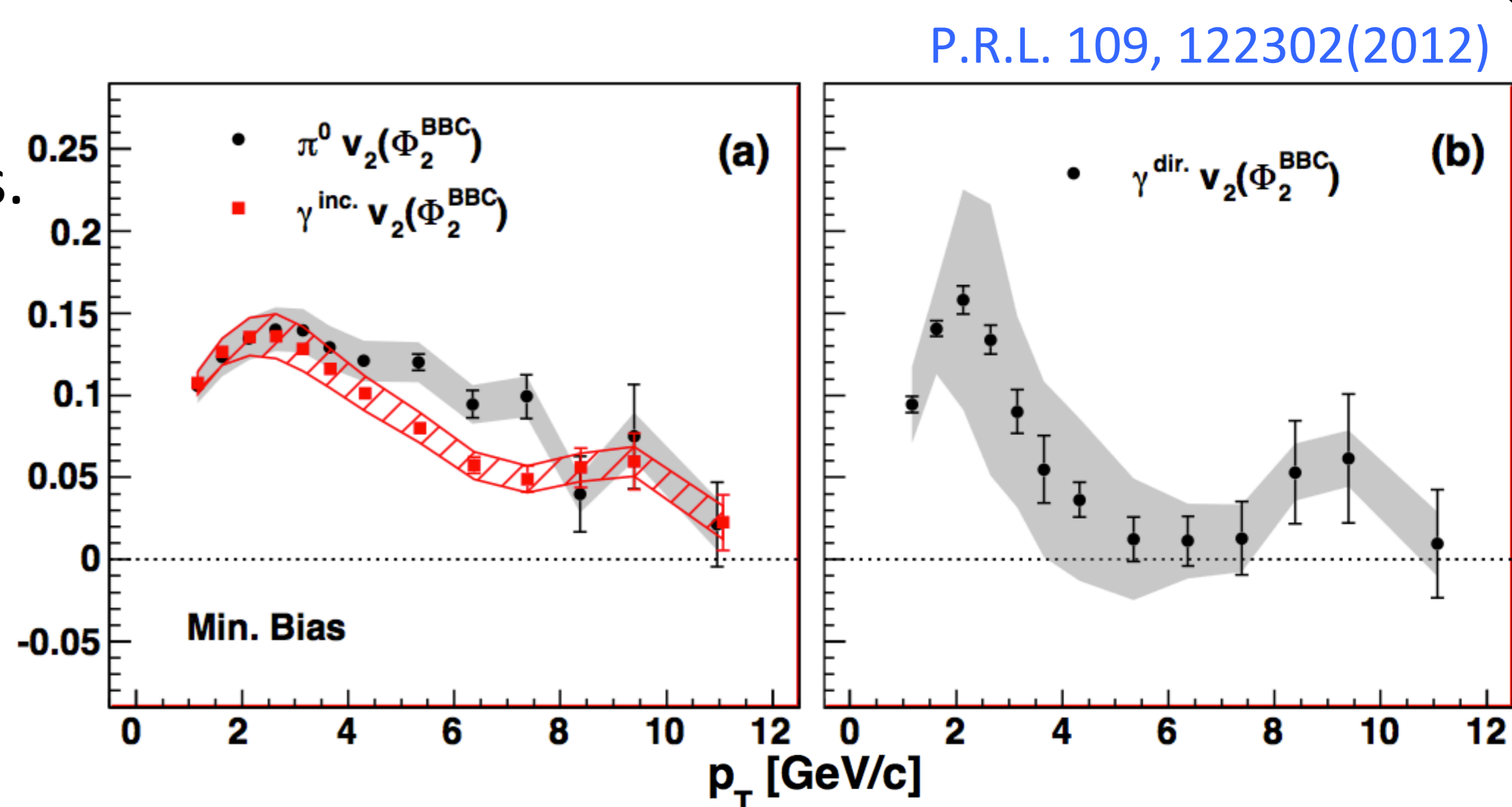
Direct photon: all photons except those coming from hadron decays.
They are powerful tools to study the QGP.

- ✓ Good probes of the early stages of collisions since they penetrate the QGP
- ✓ Created during all stages

It is found that $\gamma^{\text{dir.}}$ has as large v_2 as hadron and it has not yet understood.

How do we understand this physics?

Direct photon v_3 originated from the initial geometry fluctuation may help disentangling different sources of photons.



Analysis

Real photons are measured by EMCal.

Event Plane (Ψ_n) is estimated by Reaction Plane detector (RxN) and MPC.

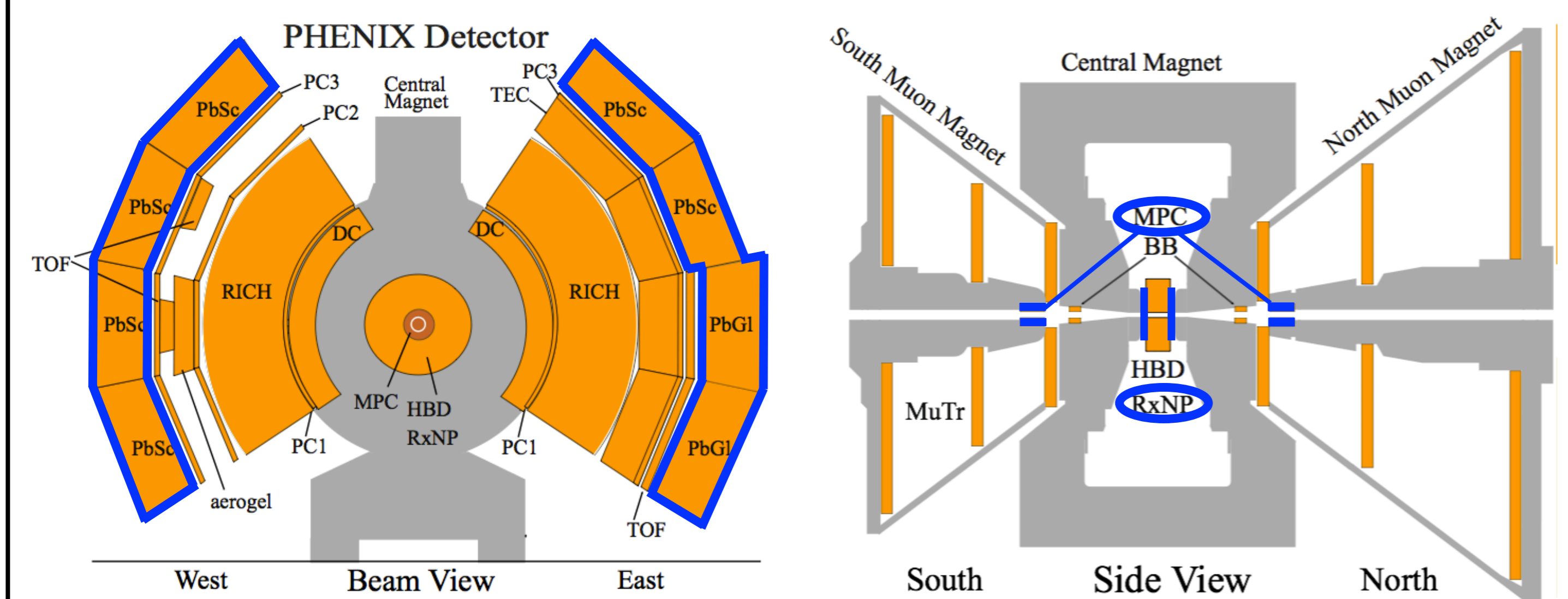
The inner and outer rings of the RxN and the MPC are located on either sides of the nominal vertex.

EMCal : $|\eta| < 0.35$

RxN(In+Out) : $1.0 < |\eta| < 2.8$

RxN(In)+MPC : $1.5 < |\eta| < 3.8$

MPC : $3.1 < |\eta| < 3.8$



Measurement & Result 1

Direct photon v_n is extracted from inclusive photon v_n , decay photon v_n , which is simulated from $\pi^0 v_n$, and R_γ .

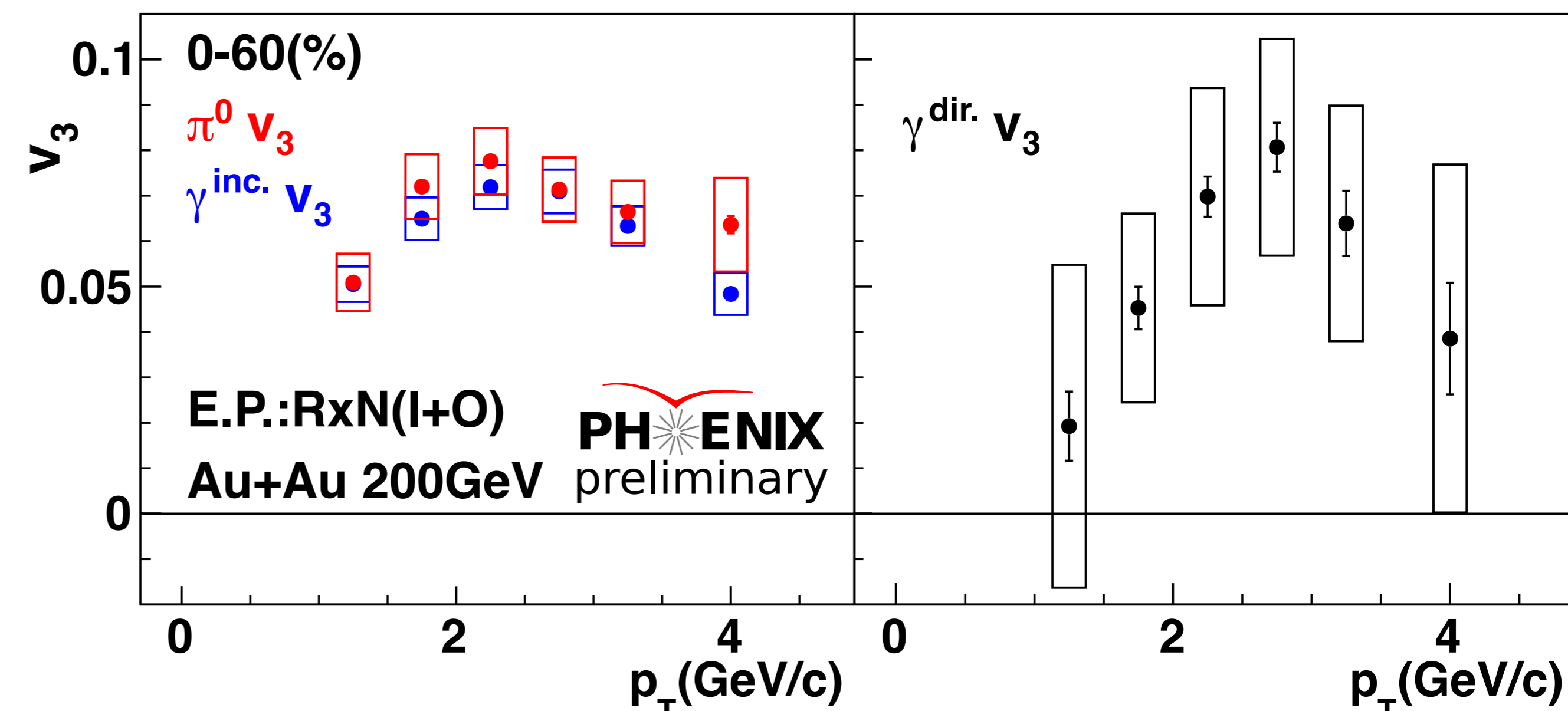
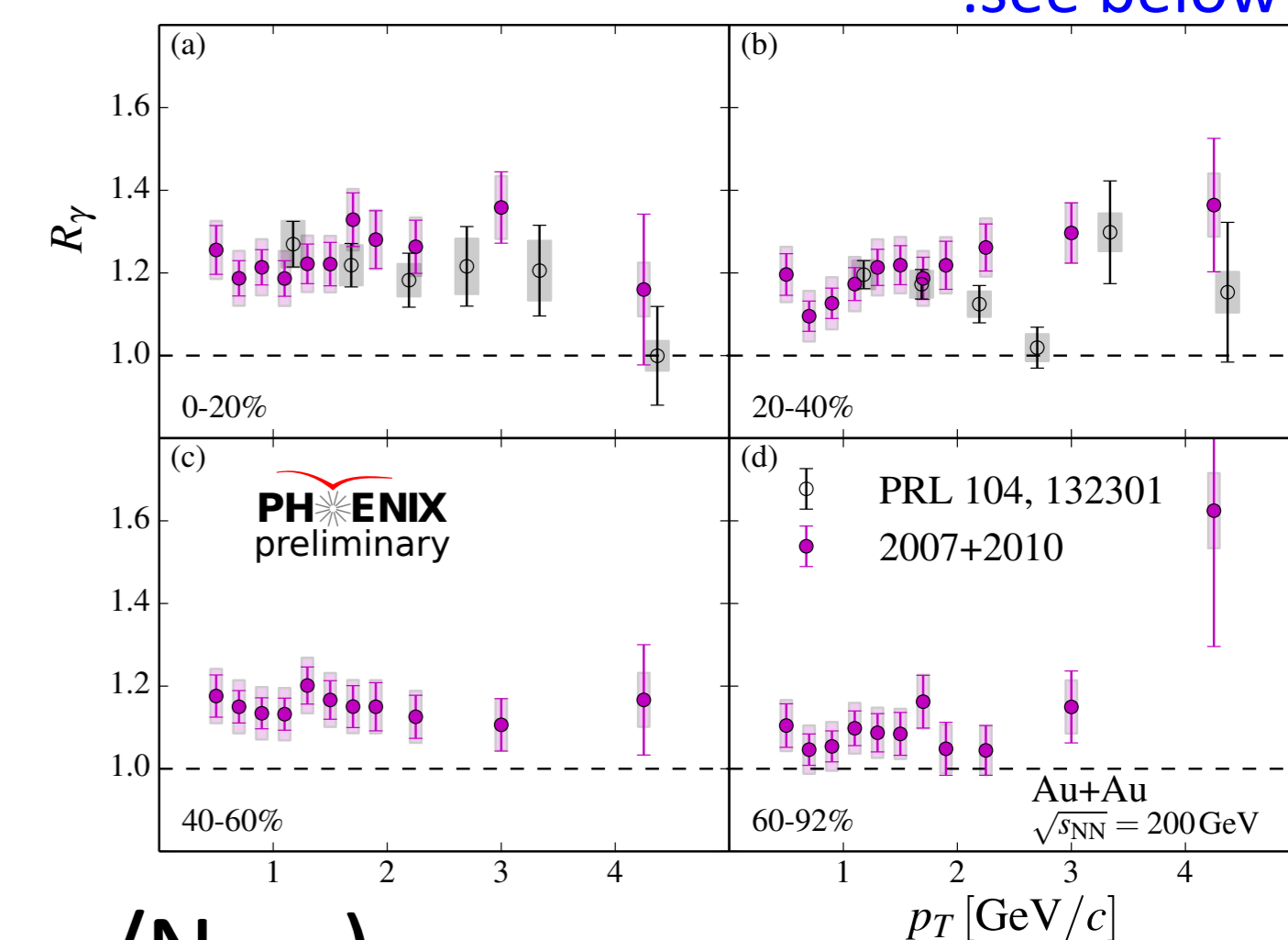
$$v_n^{\text{dir.}} = \frac{R_\gamma v_n^{\text{inc.}} - v_n^{\text{dec.}}}{R_\gamma - 1}$$

$v_n^{\text{dir.}}$: Direct photon v_n

$v_n^{\text{inc.}}$: Inclusive photon v_n

$v_n^{\text{dec.}}$: Decay photon v_n

R_γ : The excess of photon ($= N_{\text{inc.}}/N_{\text{dec.}}$)



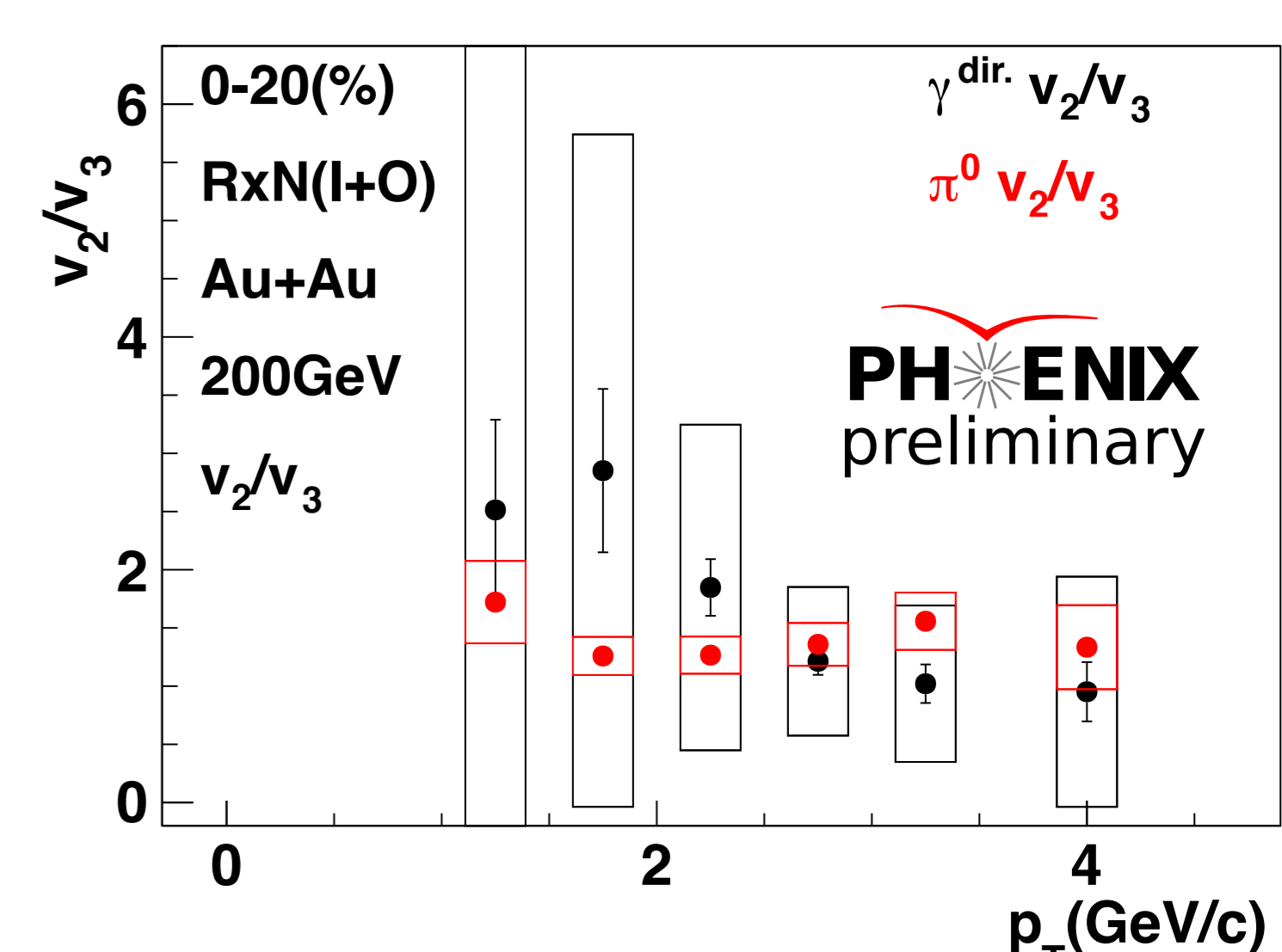
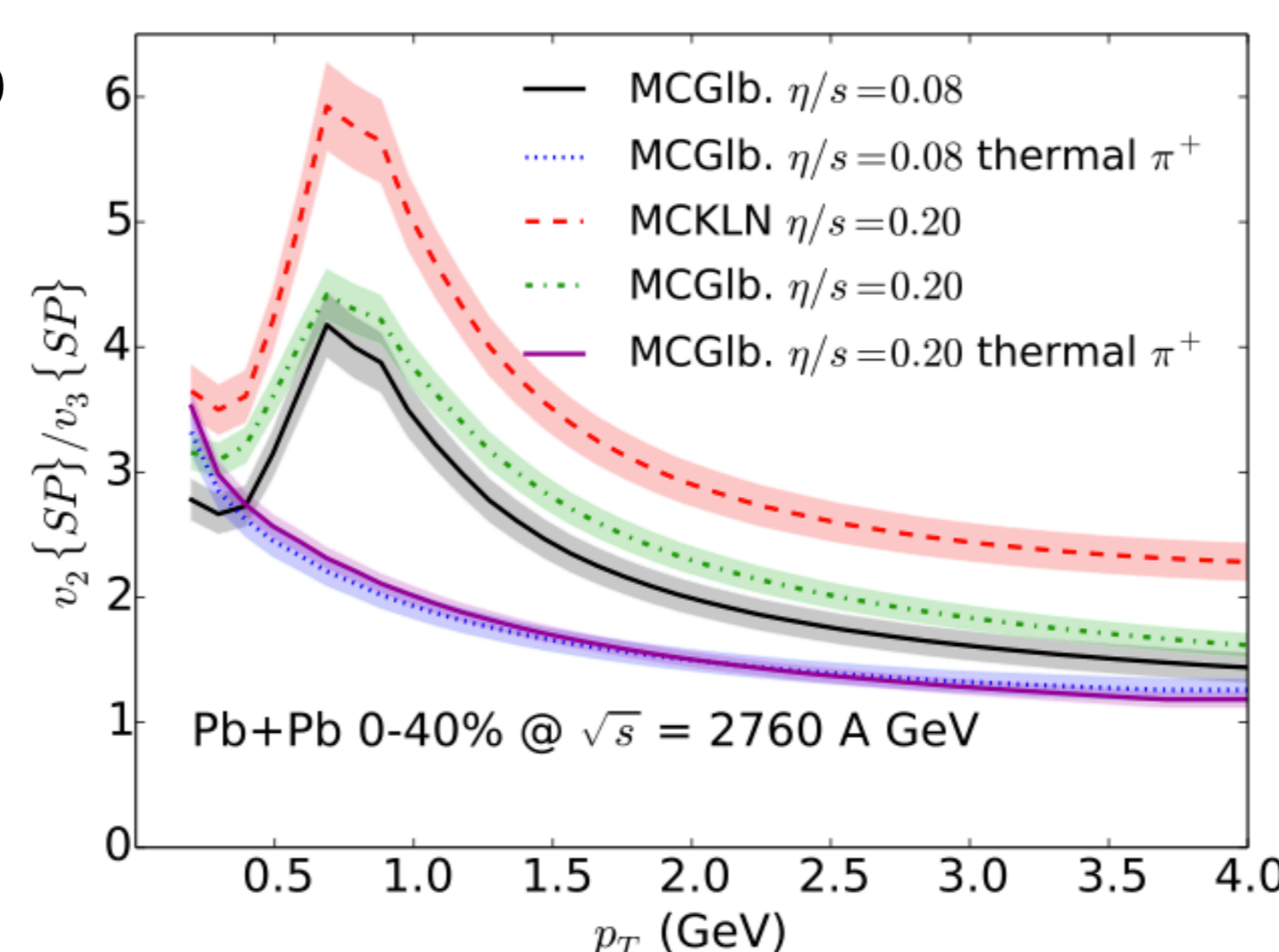
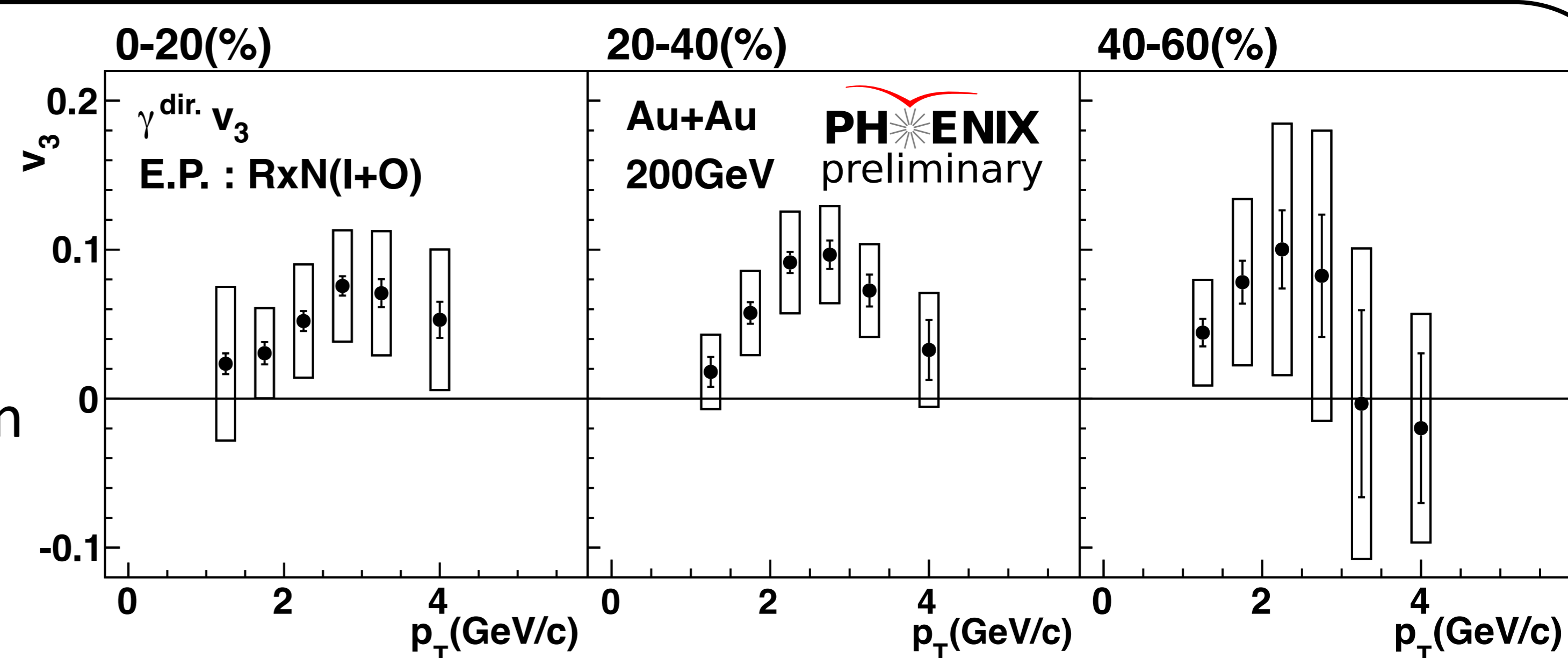
It is found that $\gamma^{\text{dir.}}$ has as large v_3 as hadron!!

Result 2 & Conclusion

- $\gamma^{\text{dir.}}$ has non-zero v_3 independent of centrality.
- Magnitude of $\gamma^{\text{dir.}} v_3$ is similar to $\pi^0 v_3$.
- This measurement could be one of the keys in understanding the production of $\gamma^{\text{dir.}}$ in heavy ion collisions.
- They are consistent within sys.error measured by conversion photon analysis. (*: see below)

Theoretical calculations indicate that the ratio of $\gamma^{\text{dir.}} v_2/v_3$ is more sensitive to η/s than hadrons and can serve as a visco ([arXv:1403.7558v1](https://arxiv.org/abs/1403.7558v1) in right figure).

The v_2/v_3 ratio from this analysis has large systematic uncertainties. The canceling of the large correlated systematic errors, which are coming from photon PID, π^0 PID, have yet to be implemented. This will be done in the next few months.



*: $\gamma^{\text{dir.}} v_n$ measurement from conversion photon shown at G-01 (Benjamin Banner)