

Azimuthal anisotropy of high- p_T direct photons

High- p_T Physics at LHC
September 2013
Grenoble, France

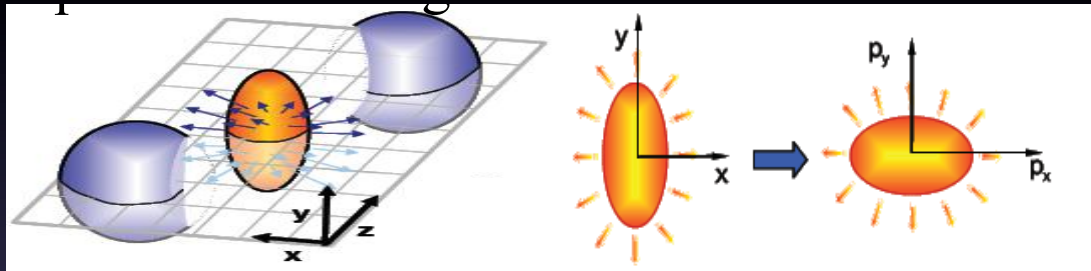
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Motivation-I

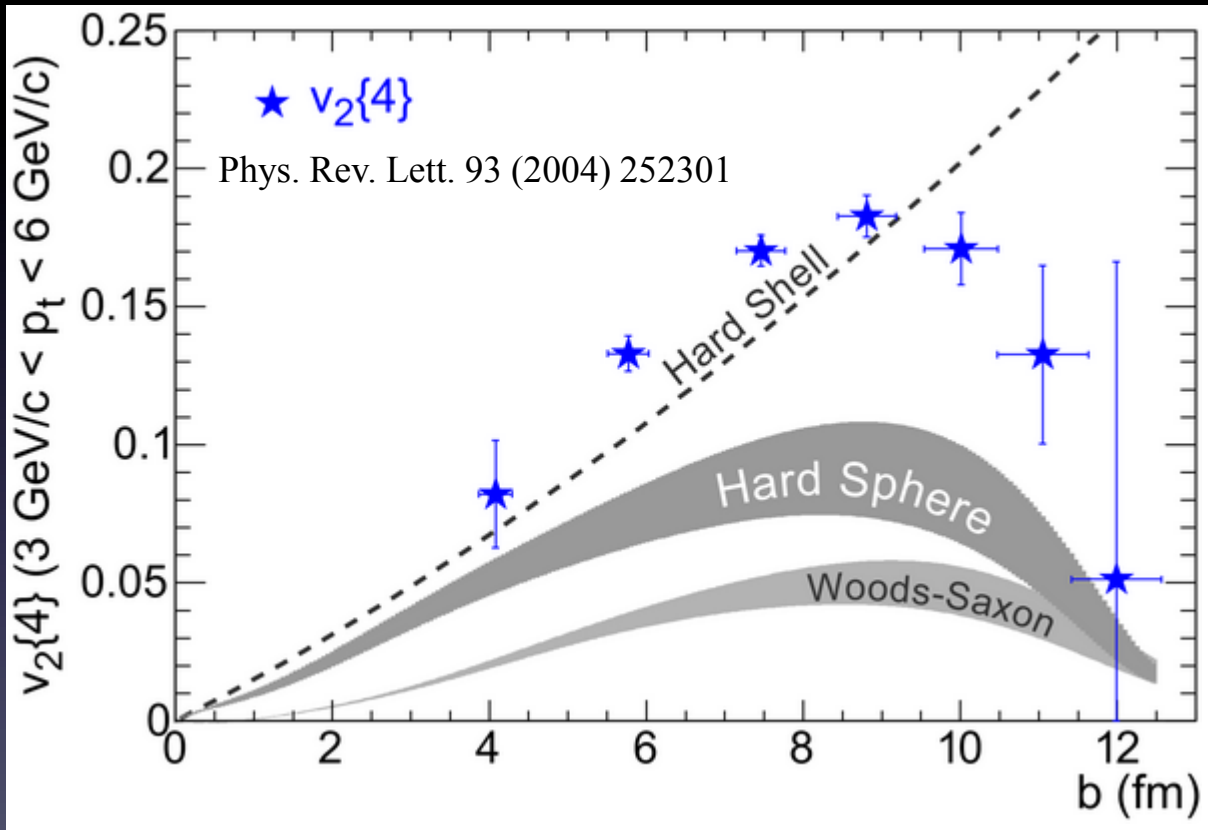
- Produced hadrons are correlated “not freely streaming”.
- Many Th. ideas and Ex. Observables investigating the underlying physics of those correlations (Φ, η, p_t).



$$dN/d\phi \propto 1 + \sum_n 2v_n \cos n(\phi - \Psi_{RP})$$

- Azimuthal correlations w.r.t. to reaction plane provide the geometrical effects on the hadron trajectory .
- At high- p_t , the azimuthal anisotropy could constrain the path length dependence of energy loss “jet quenching”

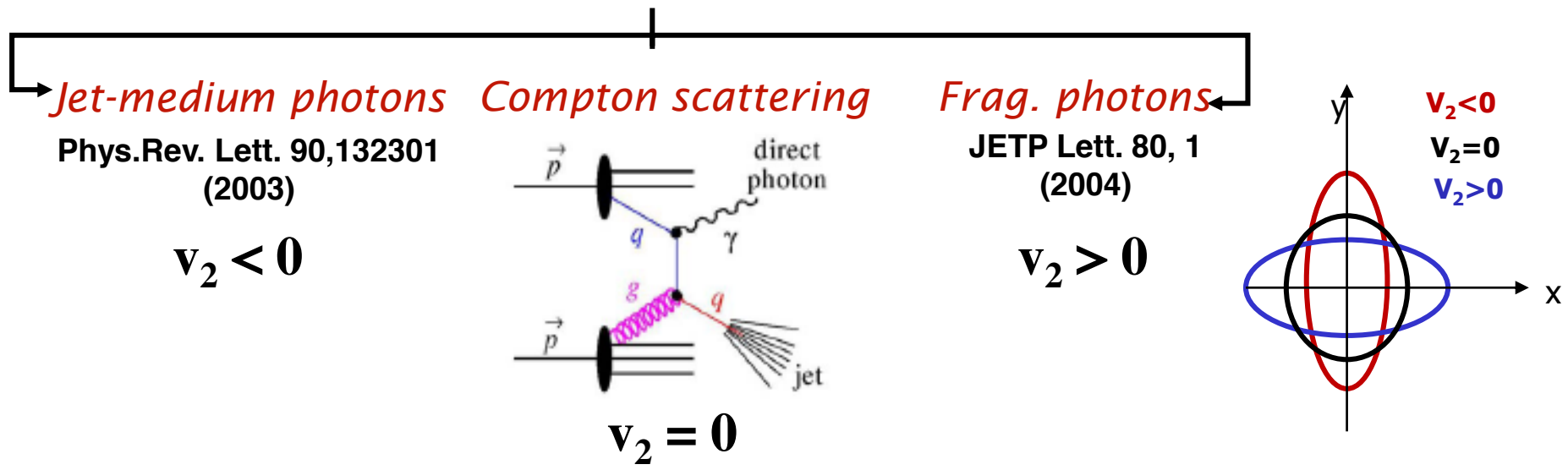
Motivation -II



- v_2 at high p_t seems to be too large for a pure “jet quenching”. Phys. Rev. C 66, 027902(200)
- EM interacting particles of high- p_t are expected to have no preferred direction w.r.t to the reaction plane, i.e. $v_2=0$

Theoretical Predictions

- According to the production mechanisms of direct photons:



- $v_2 > 0$: particles prefer shorter path "out-of-plane"
- $v_2 = 0$: no preferred direction w.r.t reaction plane
- $v_2 < 0$: particles prefer longer path "in-plane"

STAR techniques

- ⊕ Select EM neutral clusters
- ⊕ Use the transverse shower shape to select γ^{dir} free (π^0 -rich) sample and γ^{rich} sample from the neutral clusters.

$$v_2^{\gamma_{\text{rich}}} N^{\gamma_{\text{rich}}} = v_2^{\text{bg}} N^{\text{bg}} + v_2^{\gamma_{\text{dir}}} N^{\gamma_{\text{dir}}}$$

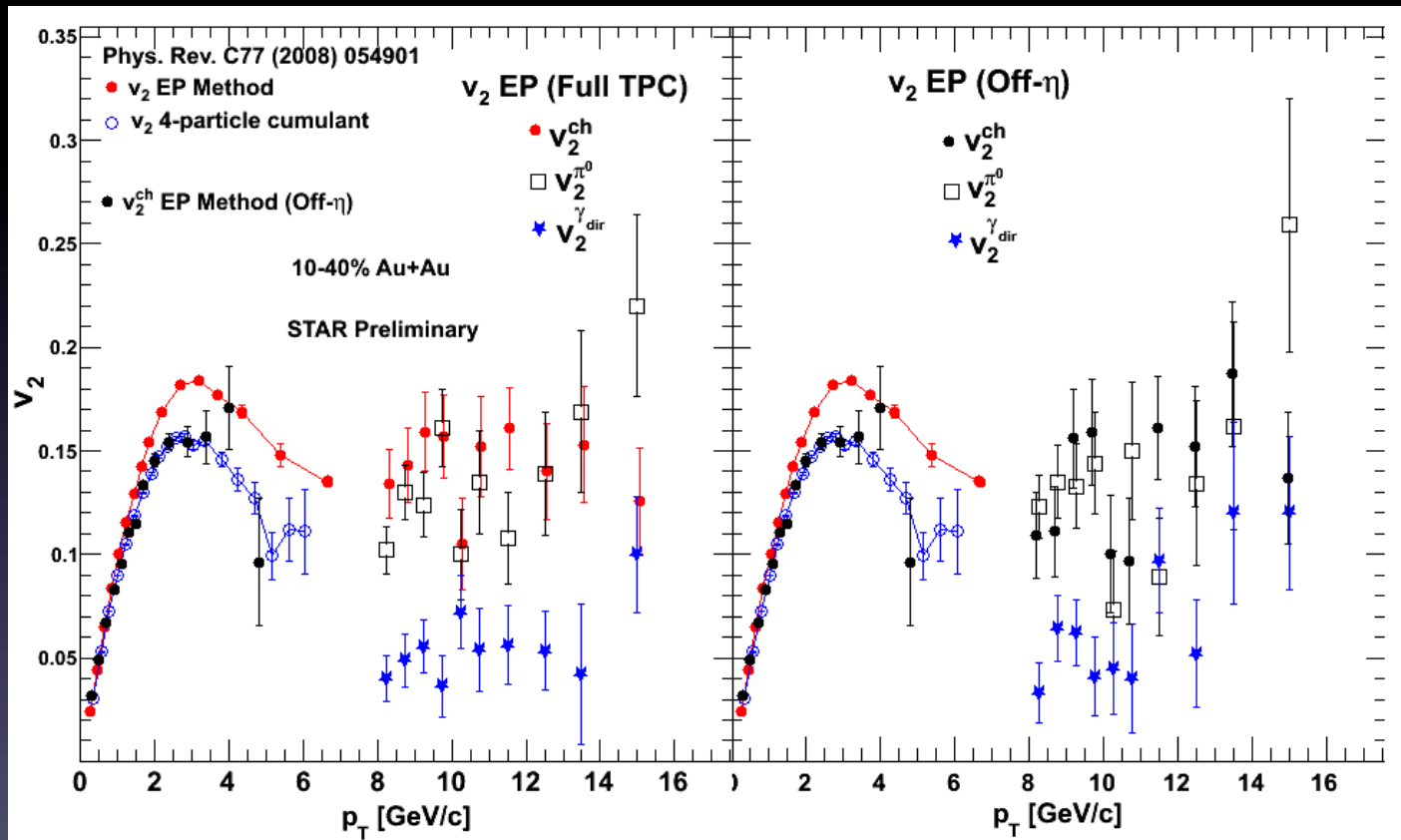
$$\mathcal{R} = \frac{N^{\text{bg}}}{N^{\gamma_{\text{rich}}}} \simeq \frac{N^{\pi^0}}{N^{\gamma_{\text{rich}}}}$$

$$v_2^{\gamma_{\text{direct}}} = \frac{v_2^{\gamma_{\text{rich}}} - v_2^{\text{bg}} \mathcal{R}}{1 - \mathcal{R}}$$

$$v_2^{\gamma_{\text{direct}}} = \frac{v_2^{\gamma_{\text{rich}}} - v_2^{\pi^0} \mathcal{R}}{1 - \mathcal{R}}$$

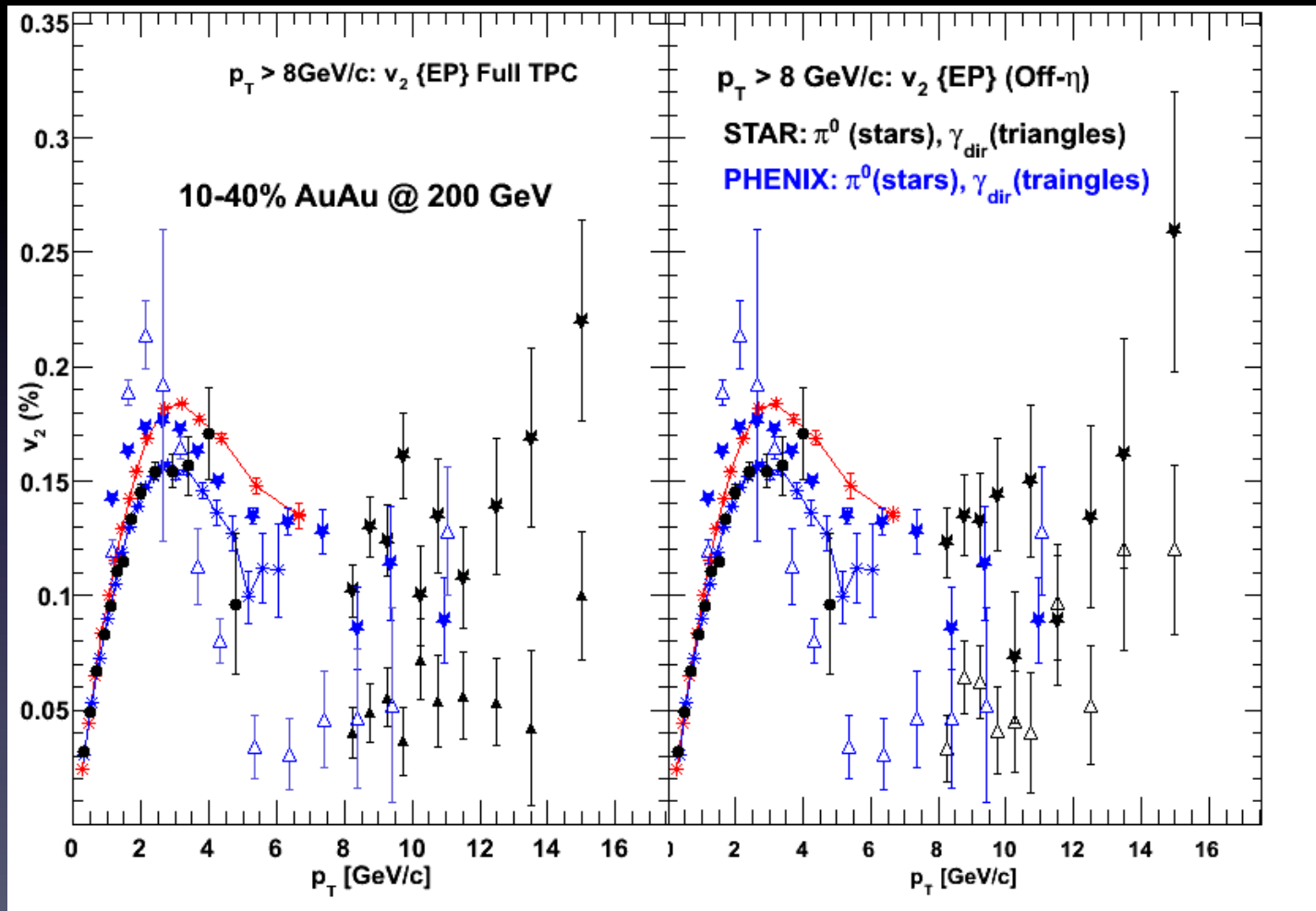


Previous Results-STAR (Run 2007)



- v_2 of direct photons is $\sim 1/3$ of pions, frag. photons contribution?!
- Not all of the measured v_2 of neutral pions at high-pt are due to the L dependence of ΔE .

Previous Results-STAR vs. PHENIX

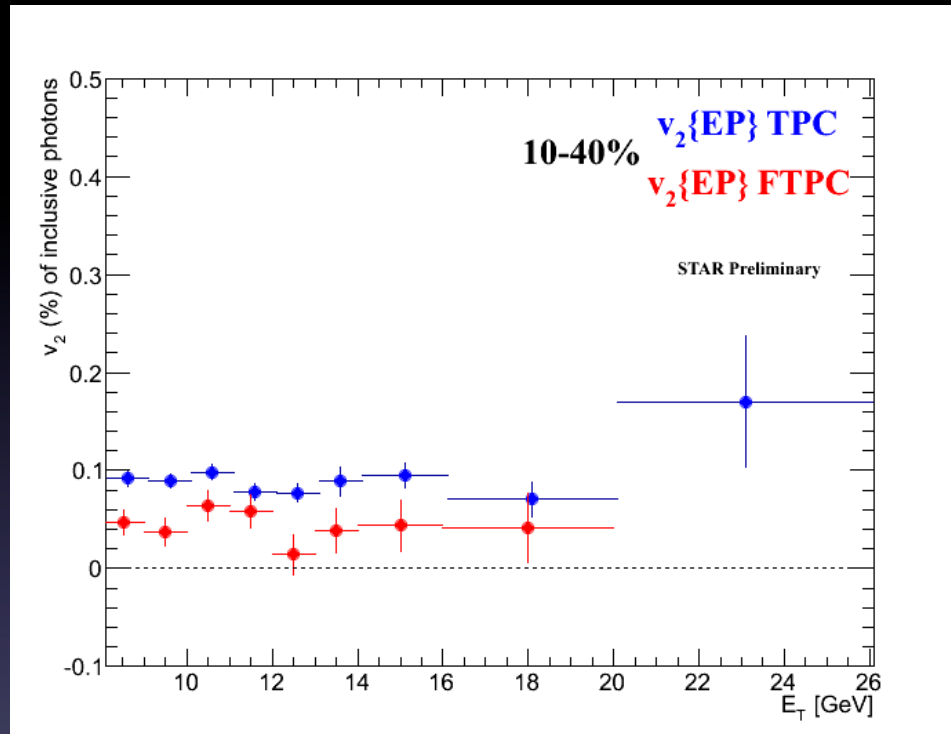


- STAR and PHENIX have similar results using different techniques

Summary of the previous results

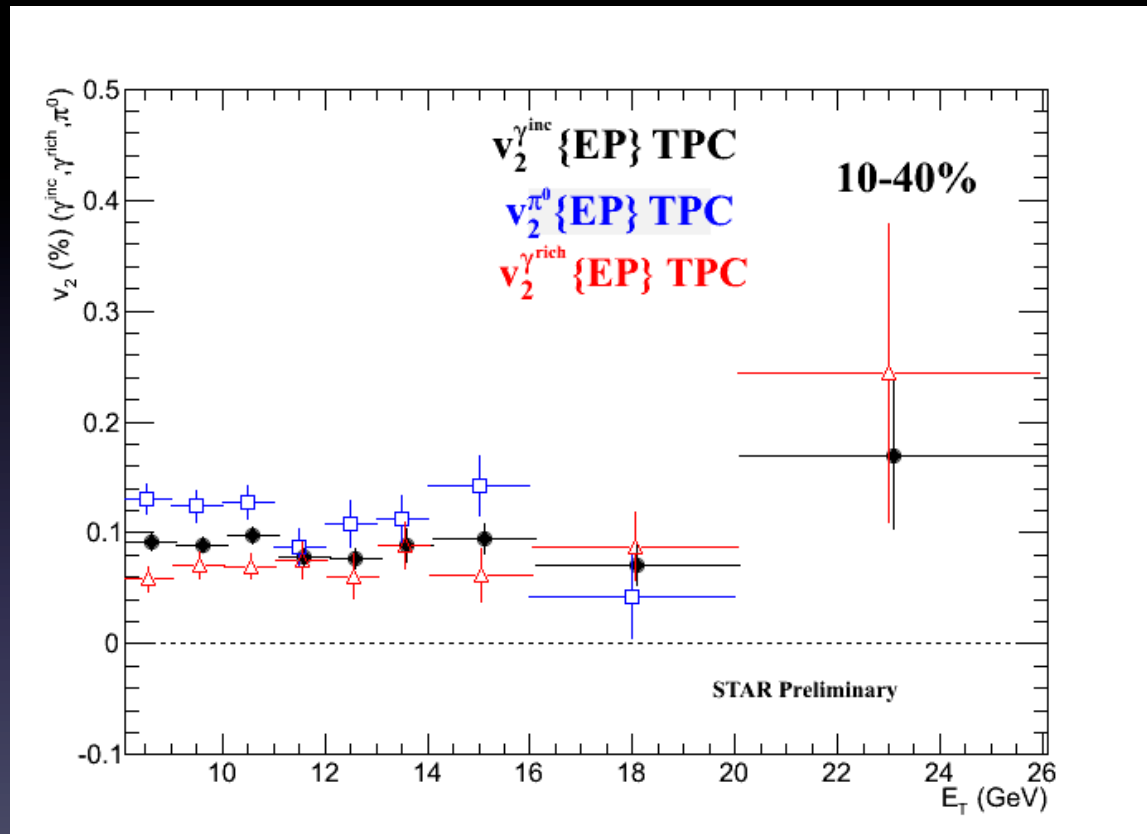
- v_2 (TPC) of direct photons at high-pt is not zero within the statistical errs (dominant source of uncertainties in Run 2007 data set)
 - Event-plane reconstruction biases “non-flow”?
 - Fragmentation photons contributions?
- More forward detectors to determine the reaction plane orientation.
 - STAR Time Projection Chambers: $1.0 < |\eta|$ for TPC and $2.5 < |\eta| < 4.0$ for FTPC

EM Neutral clusters v_2



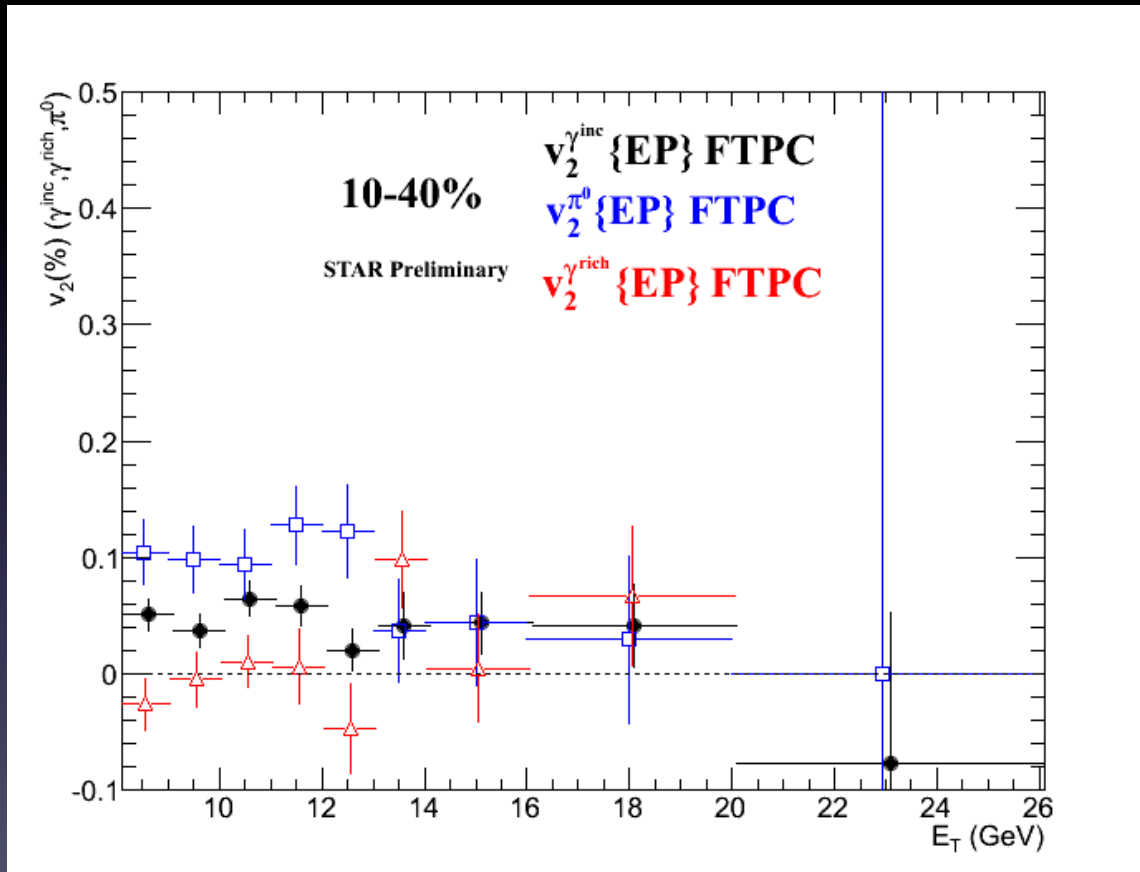
- Neutral cluster v_2 shows no strong dependence on cluster energy.
- v_2 (TPC) > v_2 (FTPC), may indicate the event-plan reconstruction biases contributions for the TPC-based measurements.
- **Is it fully eliminated at the FTPC?**

v_2 (TPC) of neutral cluster, π^0 , γ^{rich}



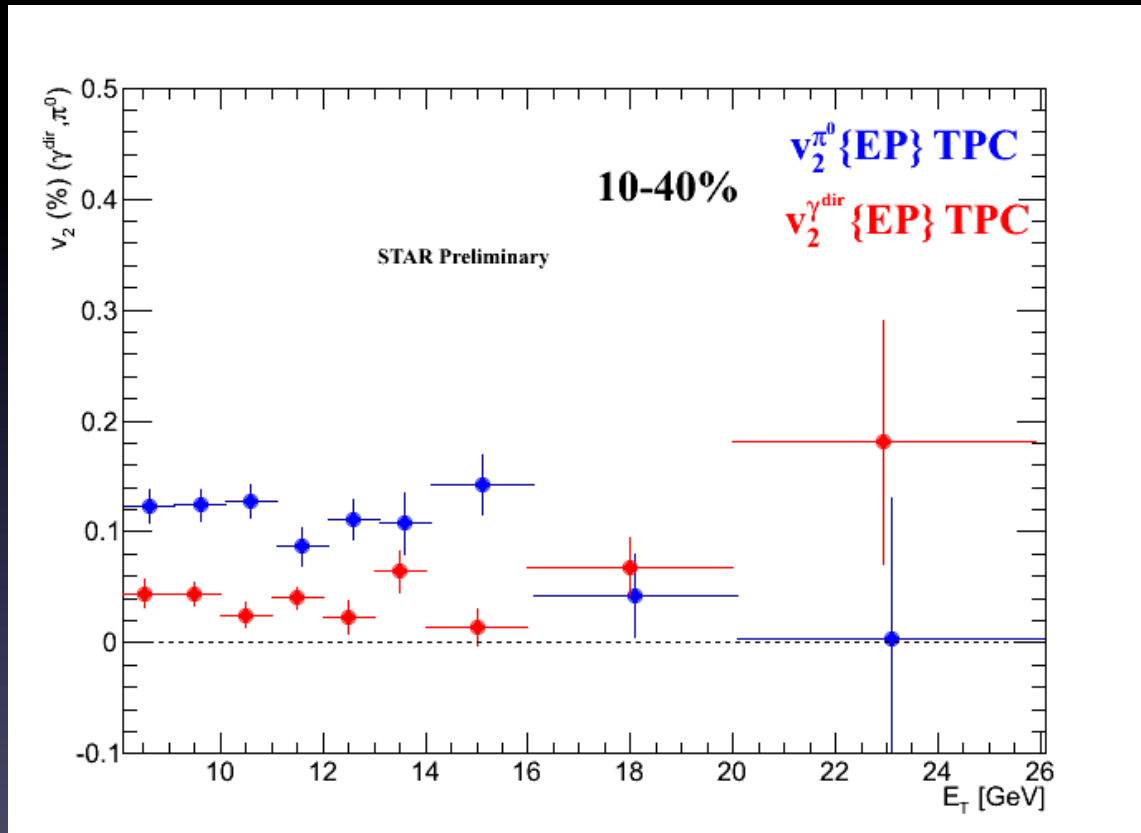
- v_2 of neutral pions is $\sim 10\% - 15\%$, agrees with the STAR previous measurements (Run 2007) and PHENIX measurements.

v_2 (FTPC) of neutral cluster, π^0 , γ^{rich}



- v_2 of neutral pions is $\sim 10\%$ and slightly smaller than measured values by TPC.

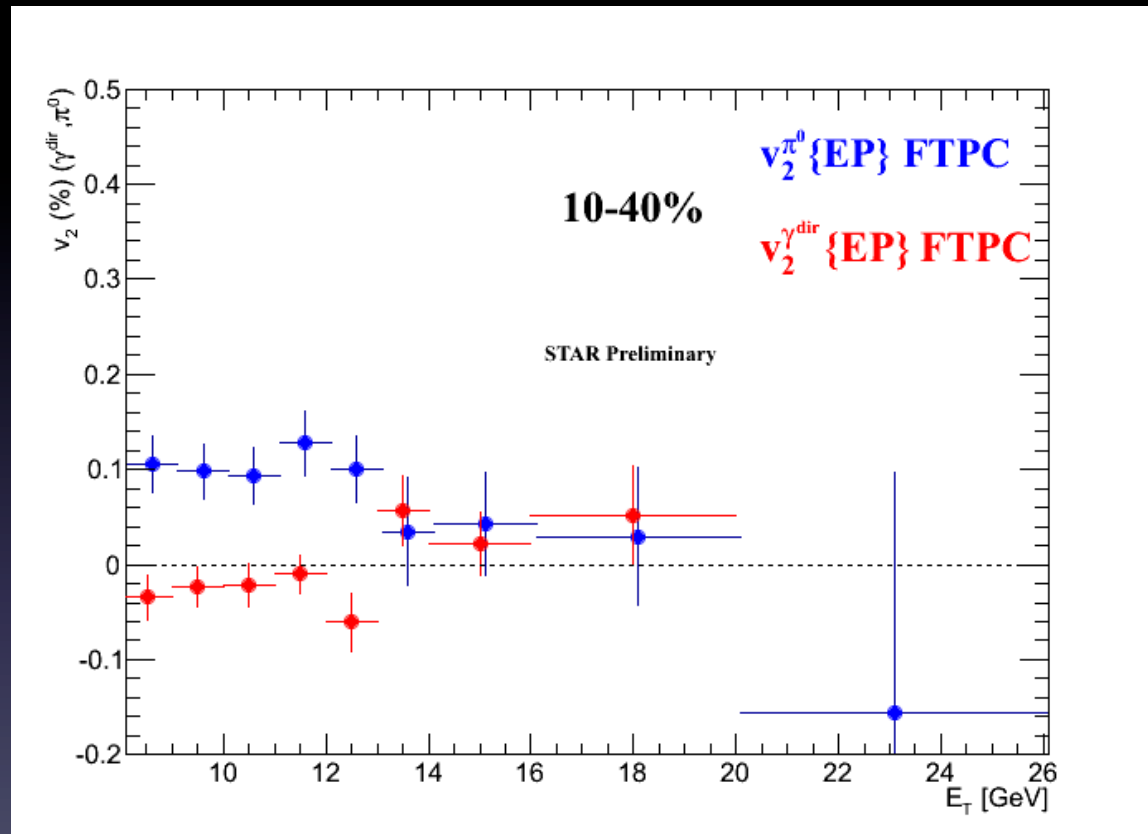
v_2 (TPC) π^0 , direct photons



Sys. errors are estimated to be 20-30% for direct photons and neutral pions

- v_2 of neutral pions and direct photons with the STAR previous measurements and PHENIX measurements.
- v_2 of direct photons is not zero (3-5%)

v_2 (FTPC) π^0 , direct photons



Sys. errors are estimated to be 20-30% for direct photons and neutral pions

- v_2 of neutral pions is $\sim 10\%$, agrees PHENIX measurements.
- v_2 of direct photons is 0%

Summary

- The pseudorapidity gap reduces the bias in the reaction plane determination and accordingly to the measured azimuthal anisotropy w.r.t reaction plane.
- First statistically significant measurements of direct photons v_2 up to 20 GeV in the field of heavy ion collisions.
- The STAR results of direct photons v_2 using the FTPC indicate the negligible remaining bias in event-plane reconstruction.
- Negligible contribution of the fragmentation photons for the direct photons.
- The v_2 of neutral pions using the FTPC is apparently due to the path length dependence of energy loss.