

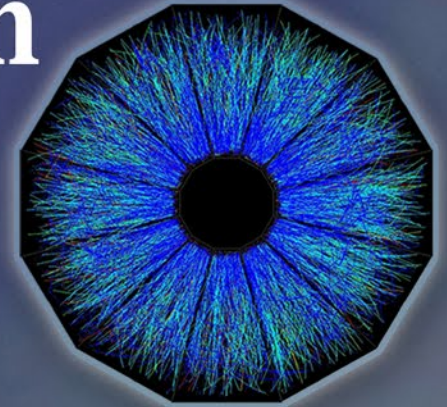
2013 STAR Collaboration

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Lawrence Berkeley National Lab

Bldg 50 - Auditorium

<http://star2013.lbl.gov>



*Direct Photon Correlation
Measurements*

Ahmed M. Hamed

University of Mississippi, Texas A&M University

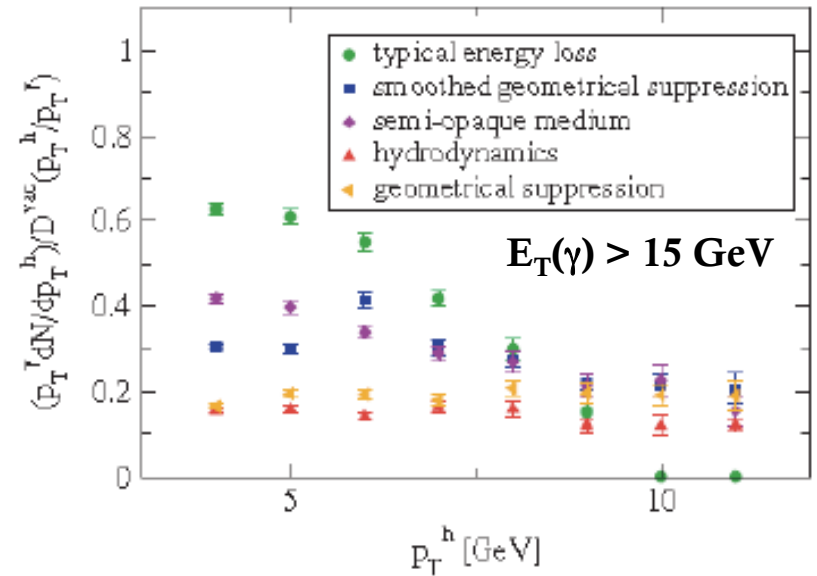
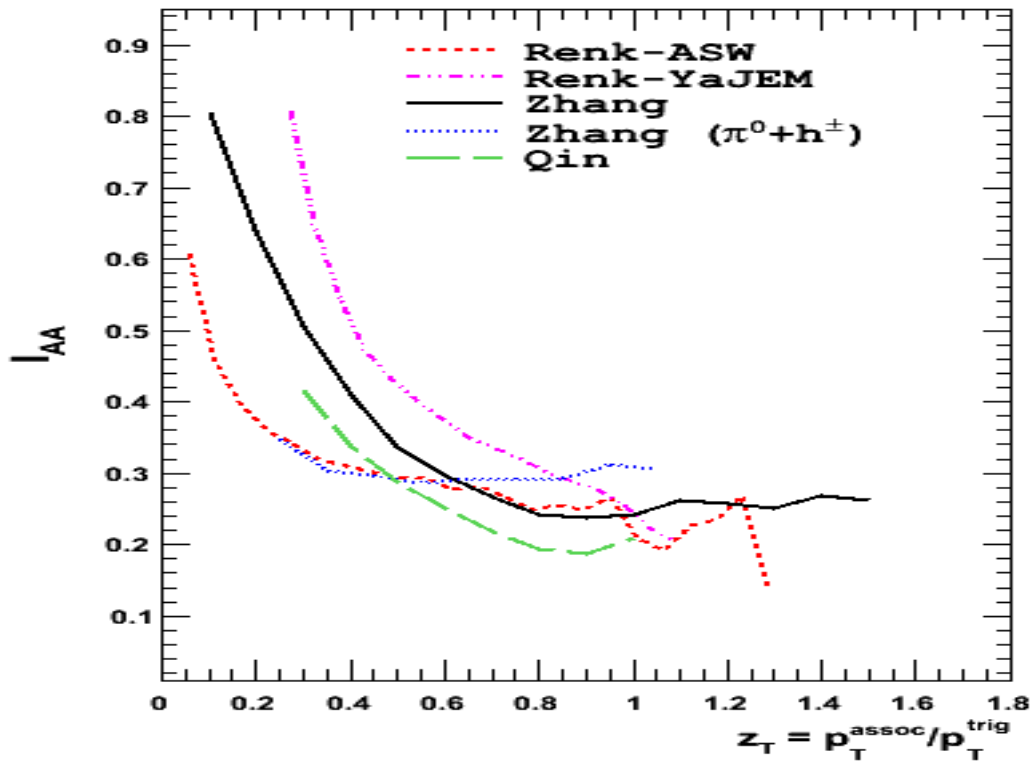
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Motivation: Parton Energy Loss

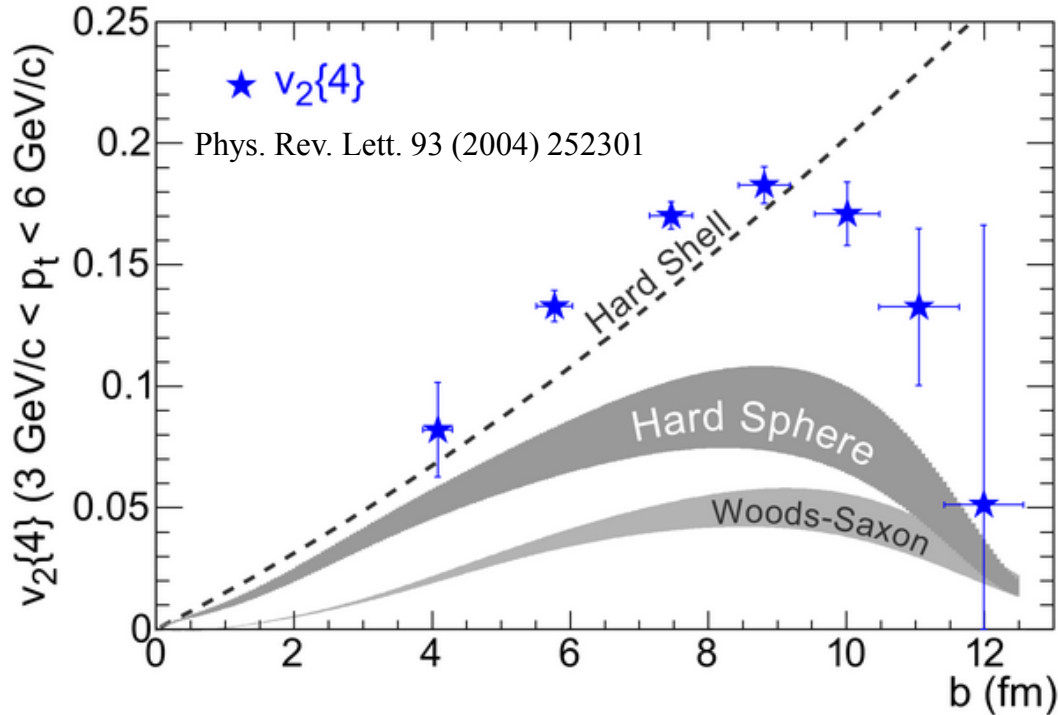
- ◆ **Parton energy loss:** parton initial energy, path length, color factor, quark flavor
- ◆ **EM interacting particles sample uniform hard scattering vertex in the med.**
- ◆ **2-partciles correlations ($\Delta\phi$):** FF of the recoiling parton from direct γ vs. π^0 :
 - Different path length “on average”
 - Different q/g compositions
 - Different parton initial energy } $\begin{array}{l} \checkmark I_{AA}(\pi^0) < I_{AA}(\gamma) \\ \checkmark I_{AA}(E_i) \end{array}$
- ◆ **Reaction plane ($\Delta\phi$):** Azimuthal anisotropy of π^0 vs. γ (reference $v_2(\gamma) = 0$)
 - path length dependence of ΔE

Theoretical Predictions- I_{AA}



- The med. effect is reflected in the FF of the recoiling partons at low z_T :
- ✓ Large p_T trigger (γ / π^0)
- ✓ Low p_T associated (flow)

Theoretical Predictions- v_2

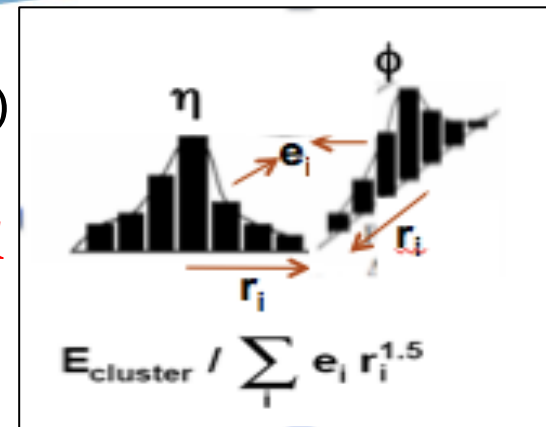


- v_2 at high p_t seems to be too large for a pure “jet quenching”. Phys. Rev. C 66, 027902(200)
- EM interacting particles of high- p_t are expected to have no preferred direction w.r.t to the reaction plane, i.e. $v_2=0$:

- ✓ $v_2 < 0$: jet-medium photons
- ✓ $v_2 = 0$: direct photons
- ✓ $v_2 < 0$: frag. photons

STAR Techniques - I_{AA}

- EM neutral cluster identifications (clustering Algo., etc.)
- EM transverse shower profile + $Z_{\gamma\gamma}$:
EM neutral energy = π^0 + other sources of EM neutral energy + γ -rich sample
- Imposing direct photon definitions: have no NS yields:



$$Y^{\gamma_{dir}+h} = \frac{(Y^{\gamma_{rich}+h} - \mathcal{R}Y^{bgd+h})}{1 - \mathcal{R}} \quad \mathcal{R} \equiv \frac{Y_{NS}^{\gamma_{rich}+h}}{Y_{NS}^{bgd+h}} = \frac{N^{bgd}}{N^{\gamma_{rich}}}$$

$$Y^{\gamma_{dir}+h} = \frac{(Y^{\gamma_{rich}+h} - \mathcal{R}Y^{\pi^0+h})}{1 - \mathcal{R}} \quad \mathcal{R} \simeq \frac{N^{\pi^0}}{N^{\gamma_{rich}}} = \frac{Y_{NS}^{\gamma_{rich}+h}}{Y_{NS}^{\pi^0+h}}$$

✓ π^0 purity, Bg assumption justifications

STAR Techniques – v_2

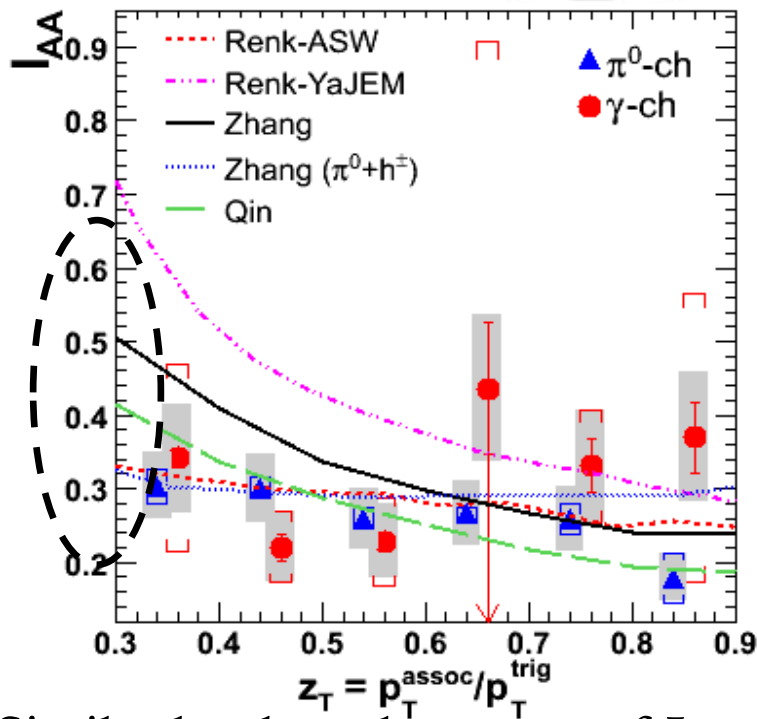
$$v_2^{\gamma_{rich}} N^{\gamma_{rich}} = v_2^{bg} N^{bg} + v_2^{\gamma_{dir}} N^{\gamma_{dir}}$$

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

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

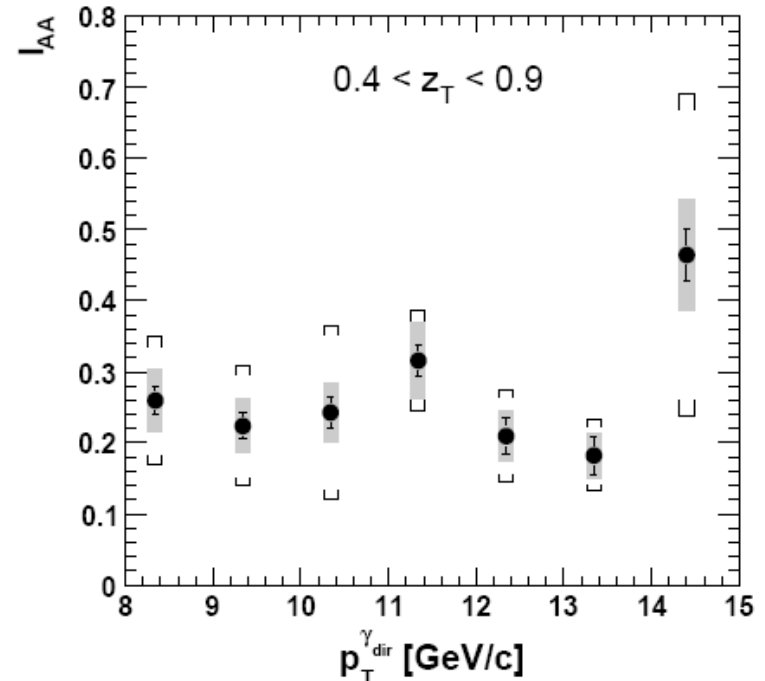
$$v_2^{\gamma_{direct}} = \frac{v_2^{\gamma_{rich}} - v_2^{\pi^0} \mathcal{R}}{1 - \mathcal{R}}$$

Previous Results- I_{AA}



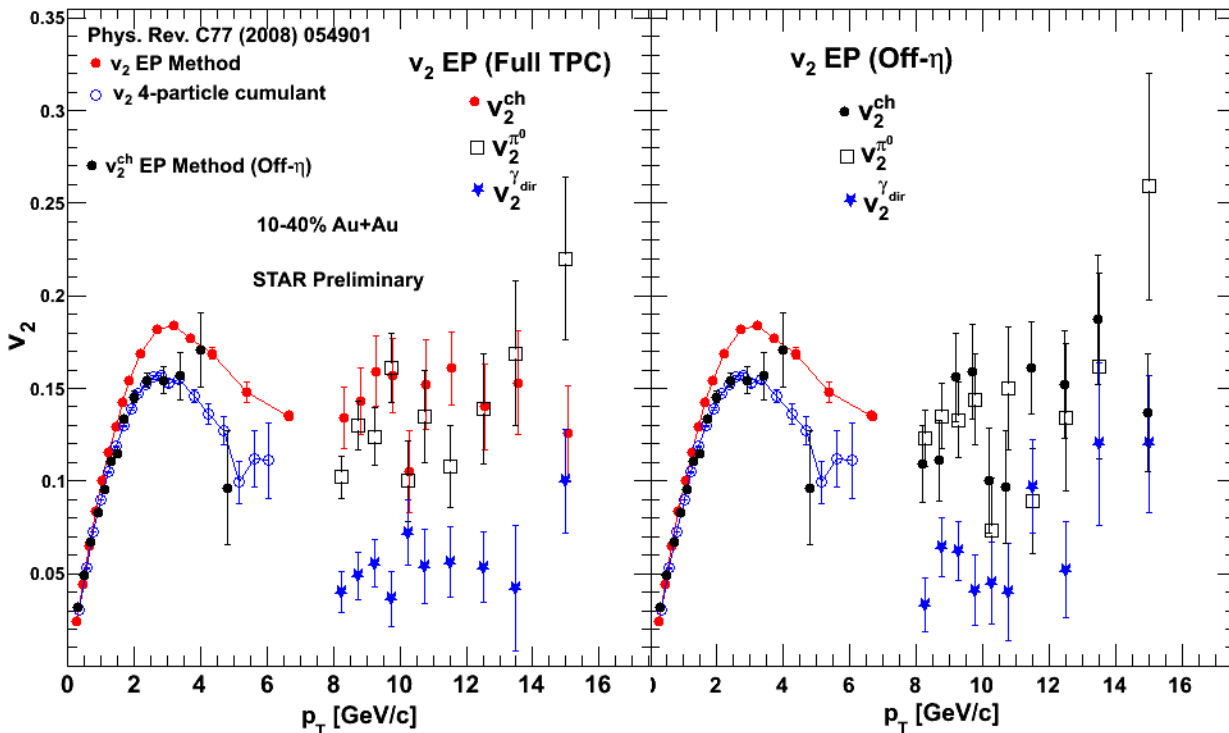
- Similar levels and patterns of I_{AA} for π^0 and direct γ as “all” models expected, need to probe low z_T

Phys. Rev. C 82, 034909 (2010)



- I_{AA} shows no strong dependence on E_i within the current uncertainties

Previous Results- v_2



➤ v_2 of direct photons at high- p_T is not zero within the statistical errors

➤ Not all the measured v_2 of pions (π^0) at high p_T are due to the L dependence of ΔE

- ✓ Event-plane reconstruction biases “non-flow”?
- ✓ Fragmentation photons contributions?

☐ More forward detectors: $1.0 < |\eta|$ for TPC and $2.5 < |\eta| < 4.0$ for FTPC

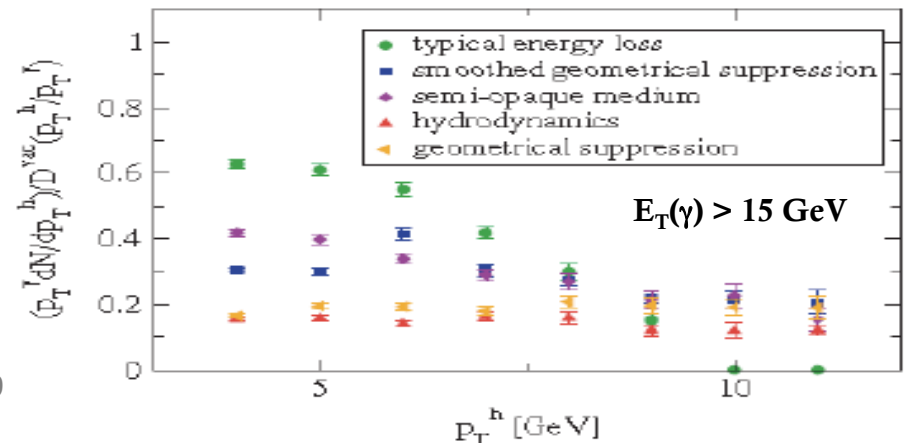
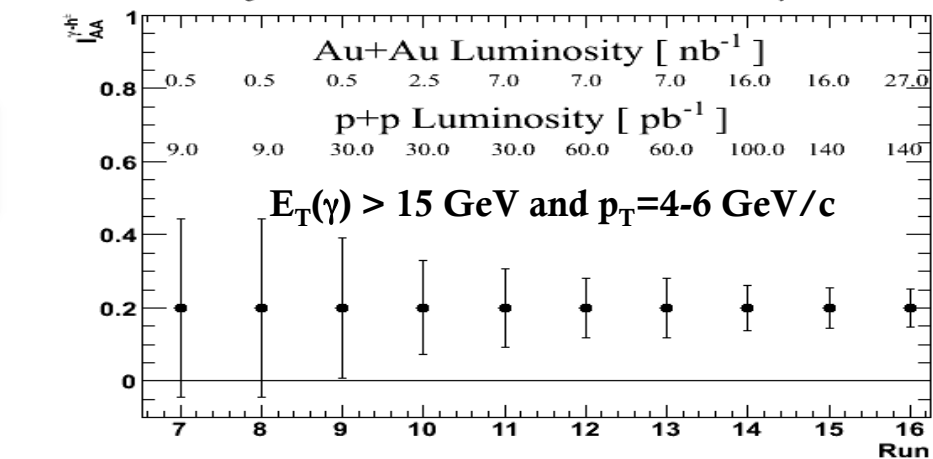
Integrated and Projected Luminosity

Table 1: Integrated and projected luminosity for γ_{dir} -triggered at $\sqrt{s}=200\text{GeV}$ for different collision systems

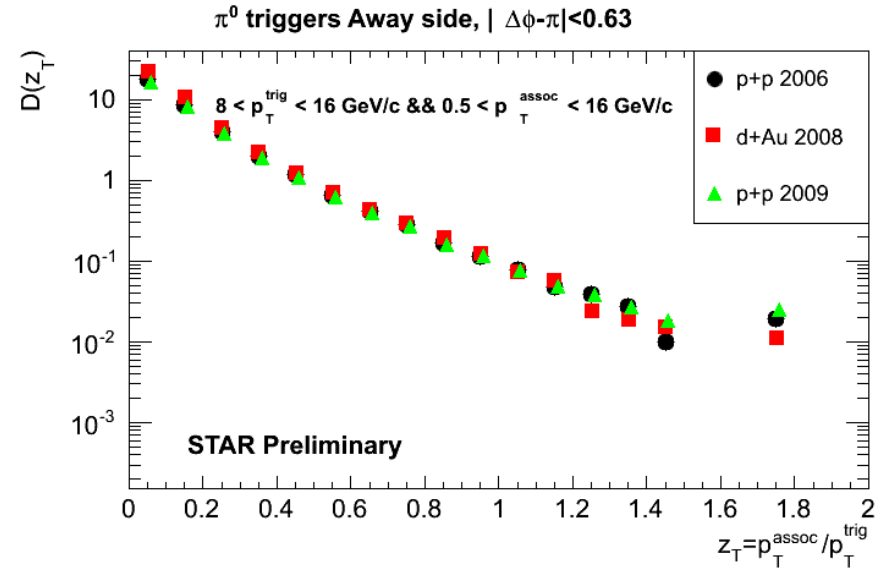
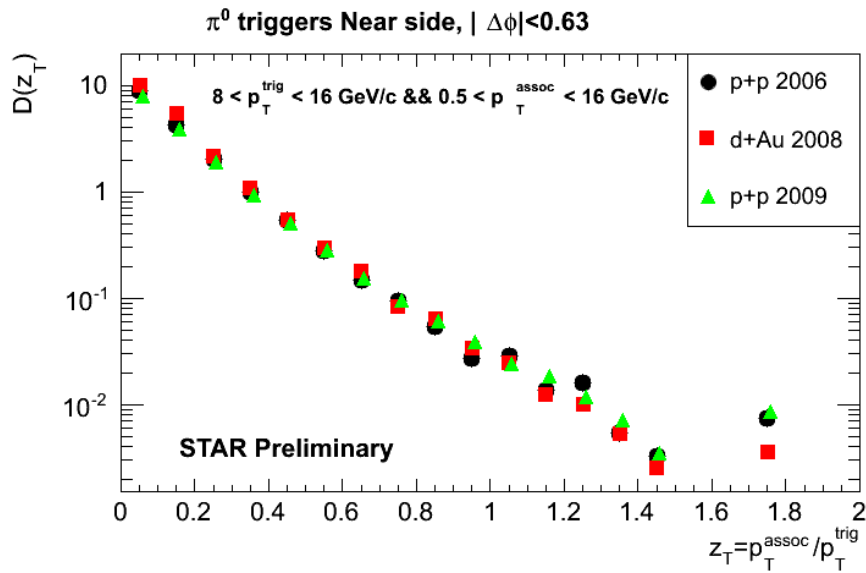
Run	System	Integrated Luminosity	Projected Luminosity	pp-equivalent
6	p+p	9 pb ⁻¹	—	9 pb ⁻¹
7	Au+Au	0.50 nb ⁻¹	—	20 pb ⁻¹
8	d+Au	34 nb ⁻¹	—	13 pb ⁻¹
9	p+p	23 pb ⁻¹	—	23 pb ⁻¹
10	Au+Au	2.0 nb ⁻¹	—	80 pb ⁻¹
11	Au+Au	1.5 nb ⁻¹	—	60 pb ⁻¹
12	p+p	25 pb ⁻¹	—	25 pb ⁻¹
	U+U	0.26 nb ⁻¹	—	—
	Cu+Au	10 nb ⁻¹	—	—
13	Au+Au	0	—	—
	p+p	0	—	—
14	Au+Au	—	9 nb ⁻¹	360 pb ⁻¹
	p+p	—	40 pb ⁻¹	40 pb ⁻¹
15	p+p	—	40 pb ⁻¹	40 pb ⁻¹
16	Au+Au	—	11 nb ⁻¹	440 pb ⁻¹

Current reconstructed data is sufficient to rule out “few” models and to reduce the v_2 “statistical” uncertainties by factor of 4.

Projection for Statistical Uncertainties for γ - hadron

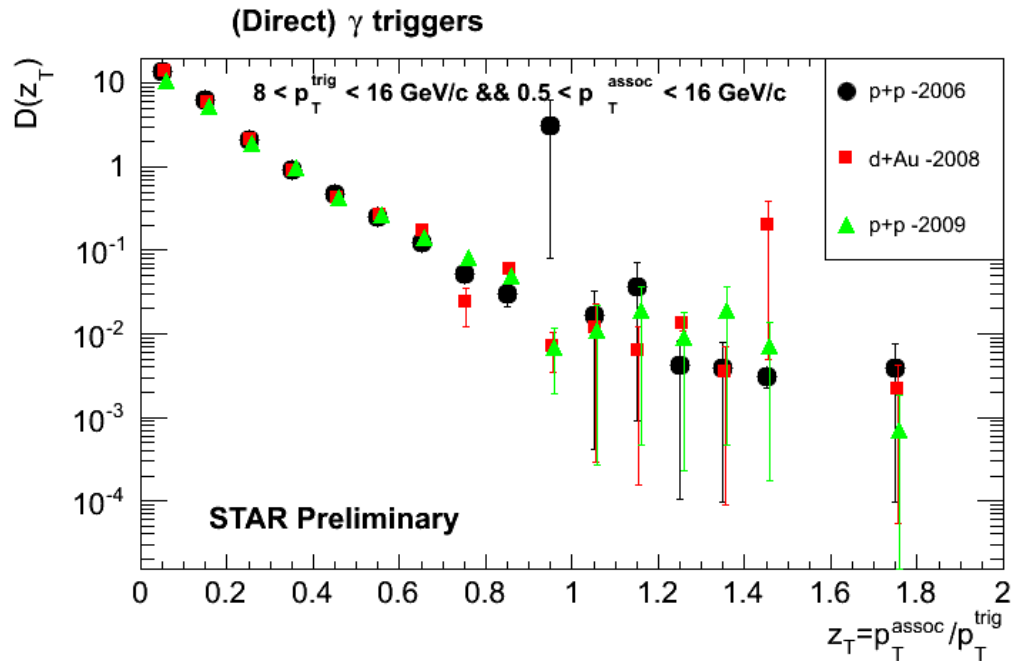


New Results I: toward I_{AA}



- The NS and AS conditional yields per π^0 from different data sets (pp2006, dAu2008, and pp2009) agree over the entire explored z_T -range (0 - 2.0).

New Results I: toward I_{AA}

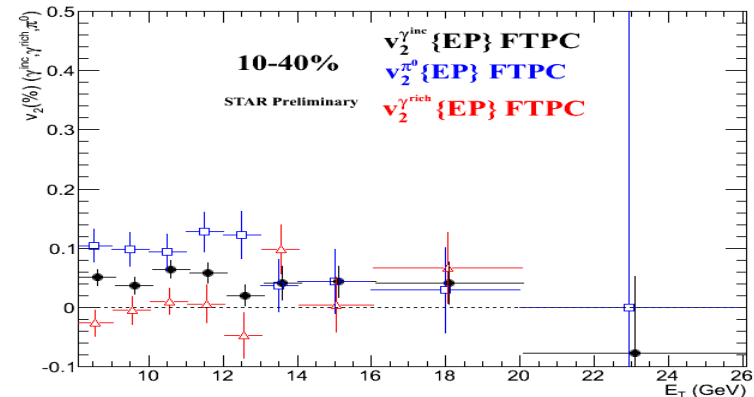
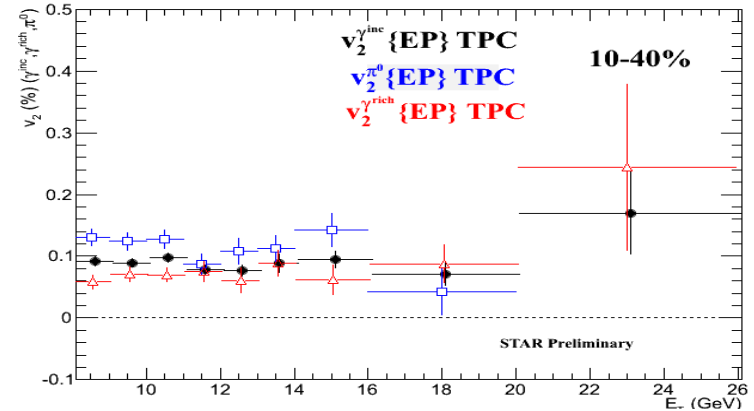
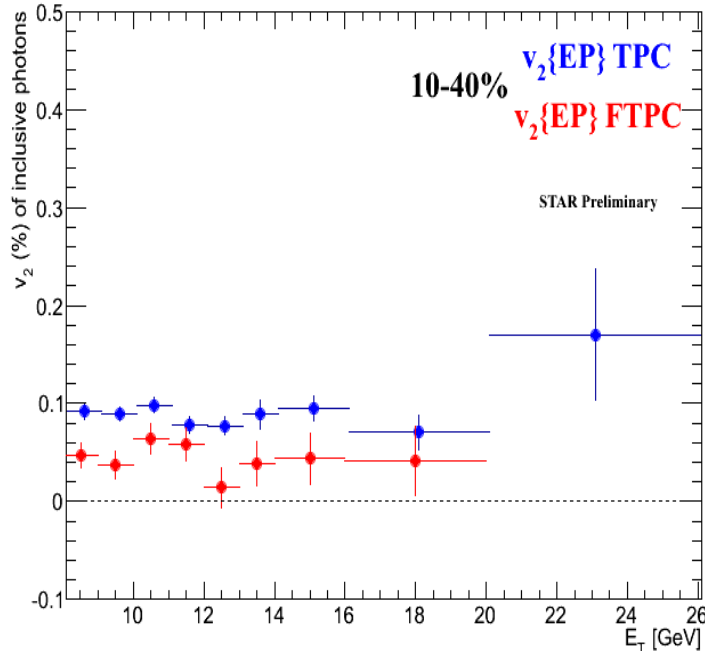


$$Y^{\gamma_{dir+h}} = \frac{(Y^{\gamma_{rich+h}} - \mathcal{R}Y^{\pi^0+h})}{1 - \mathcal{R}}$$

- The AS conditional yields per direct γ from different data sets (pp2006, dAu2008, and pp2009) agree at low z_T

New Results II: v_2 (EM neutral clusters) to $v_2(\pi^0)$ and $v_2(\gamma\text{-rich})$ [AuAu2011]

EM neutral clusters $\xrightarrow{\text{EM transverse shower cut}}$ $\pi^0, \gamma\text{-rich}$

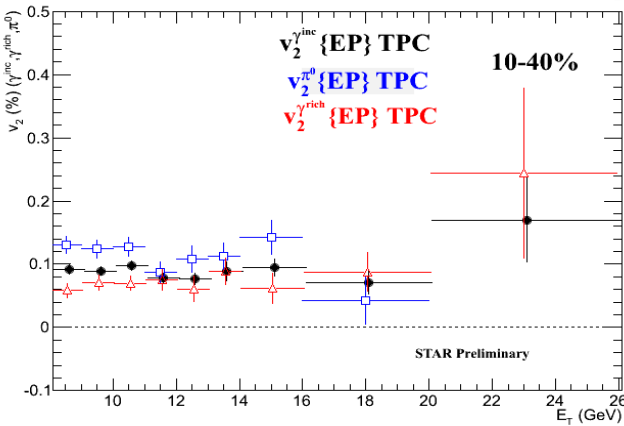


$v_2(\pi^0, \gamma\text{-rich}, \text{EM})$ (TPC) $>$ $v_2(\pi^0, \gamma\text{-rich}, \text{EM})$ (FTPC)?!

biases in reaction plane reconstructions!

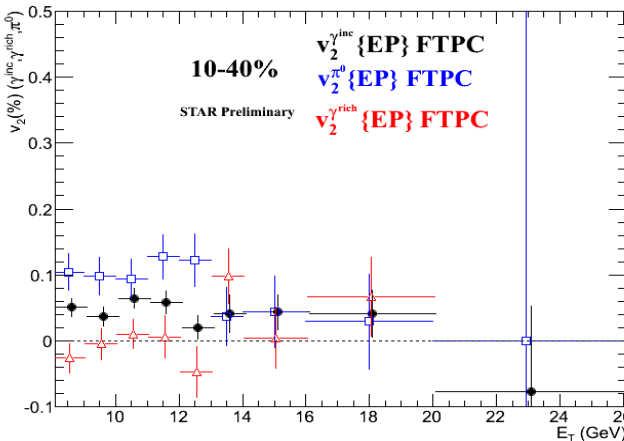
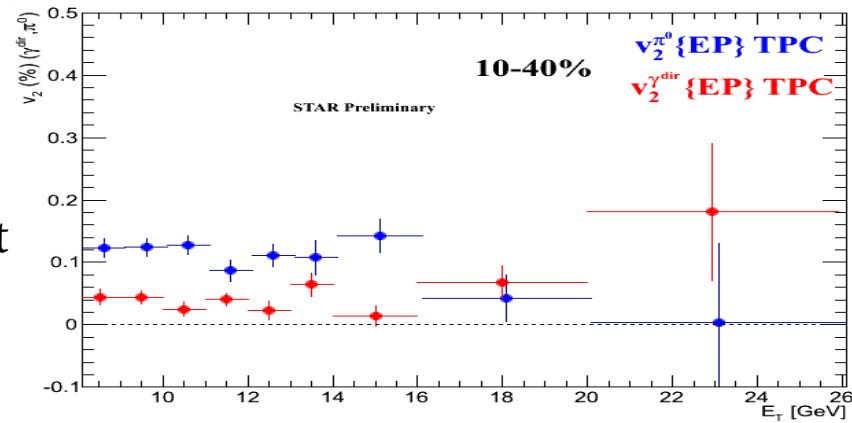
Is it fully diminished in $v_2(\text{FTPC})$?

New Results II: $v_2(\pi^0)$ and $v_2(\gamma^{\text{rich}})$ to $v_2(\gamma^{\text{dir}})$

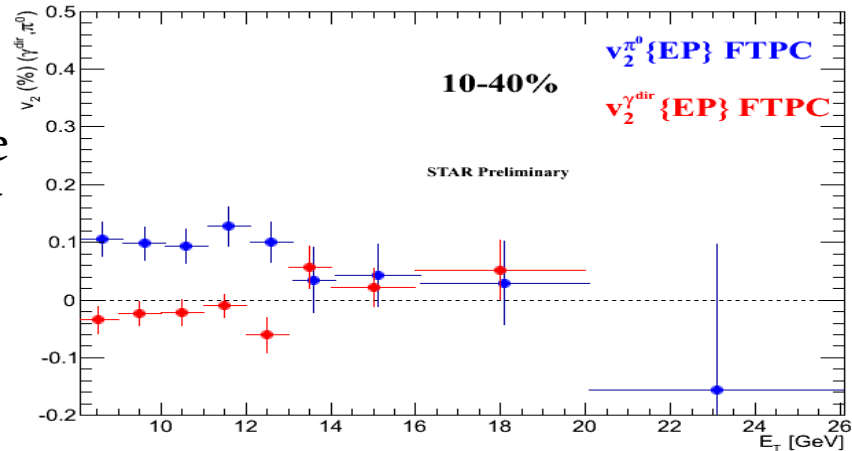


$$v_2^{\text{direct}} = \frac{v_2^{\text{rich}} - v_2^{\pi^0} \mathcal{R}}{1 - \mathcal{R}}$$

- v_2 (TPC) of direct photons is not zero (3-5%)
- v_2 (FTPC) of direct photons is zero



- v_2 of π^0 using the FTPC is apparently due to the L dependence of ΔE .



Summary - I

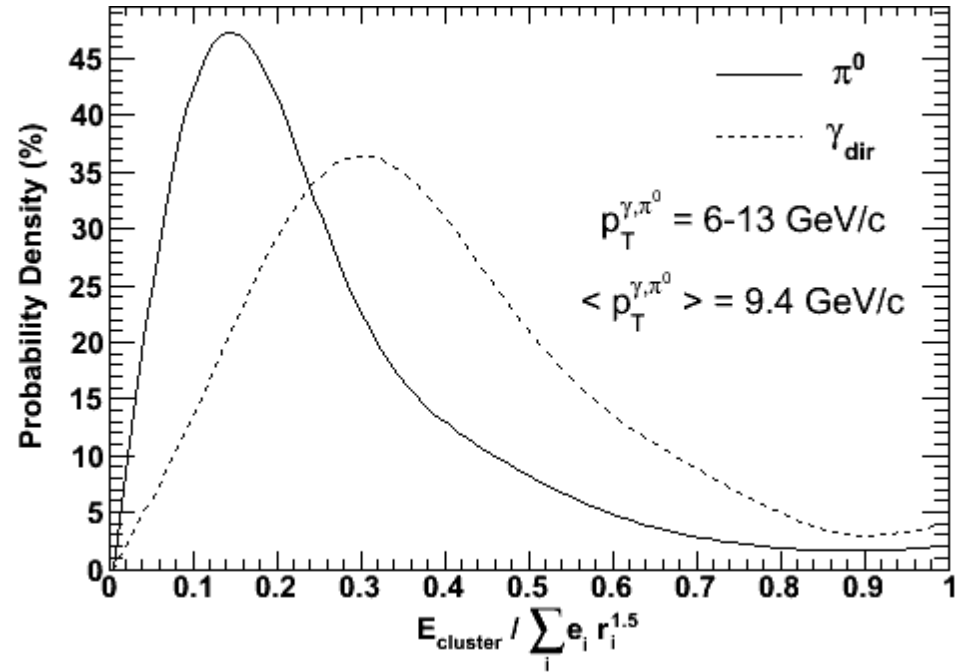
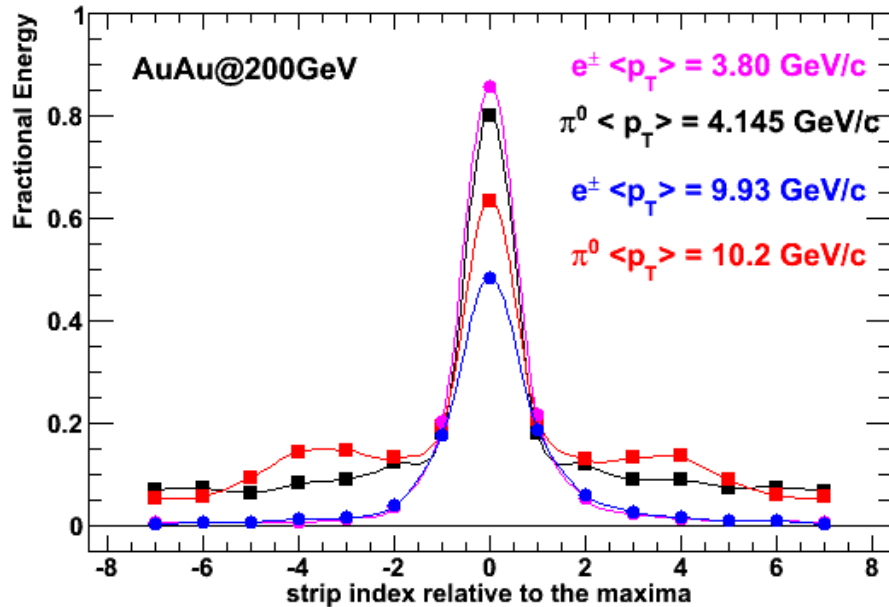
- ◆ Exploring the soft sector of the FF is necessary for the models discriminations
- ◆ The current integrated luminosity is sufficient to probe the low z_T region
- ◆ The conditional yields associated with p_0 and direct photons from different data sets (pp2006, dAu2008, pp2009) are consistent
- ◆ Studying the $D(z_T)$ at the low z_T regions in AuAu 2011+AuAu2007
- ◆ Studying the systematic errs of I_{AA} and move toward publications.

Summary - II

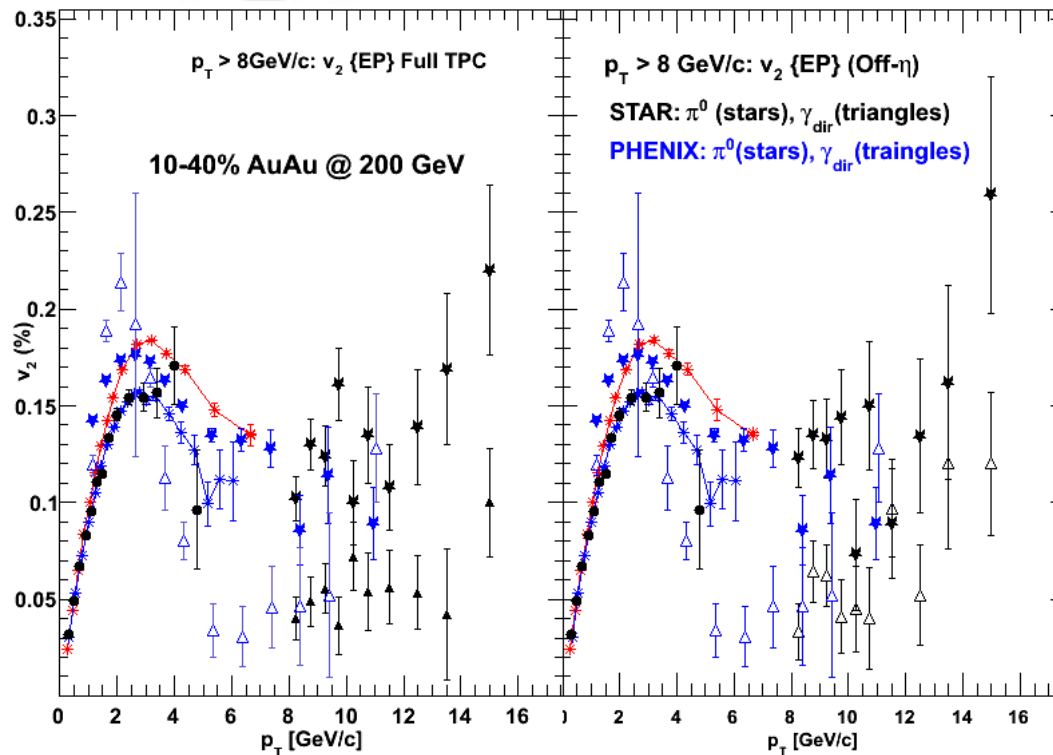
- ◆ The pseudorapidity gap reduces the bias in the reaction plane determination and accordingly to the measured azimuthal anisotropy w.r.t reaction plane.
- ◆ First statistically significant measurements of direct photons v_2 up to 20 GeV in the field of heavy ion collisions.
- ◆ The STAR results of 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.
- ◆ Studying the systematic errors and move toward publications.

Backup Slides

EM Transverse Shower Profile



Previous Results-STAR vs. PHENIX

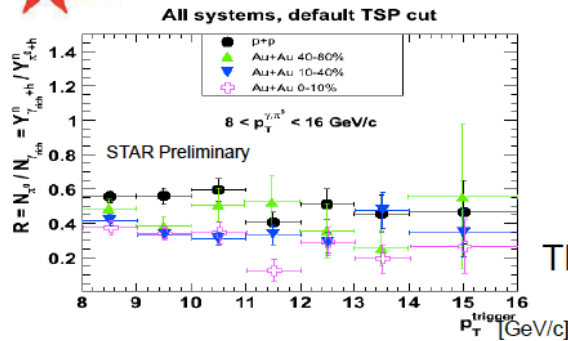


💧 STAR and PHENIX have similar results using different techniques

The Ratio R



1. R values



$$\mathcal{R} \approx \frac{N^{\pi^0}}{N^{\text{rich}}} = \frac{Y_{NS}^{\gamma_{\text{rich}}+h}}{Y_{NS}^{\pi^0+h}}$$

The level of bg in the γ_{rich} sample:
 ~55-30% from pp to central
 Au+Au, and doesn't show
 strong dependence
 neither on p_T trig
 nor on p_T assoc.

