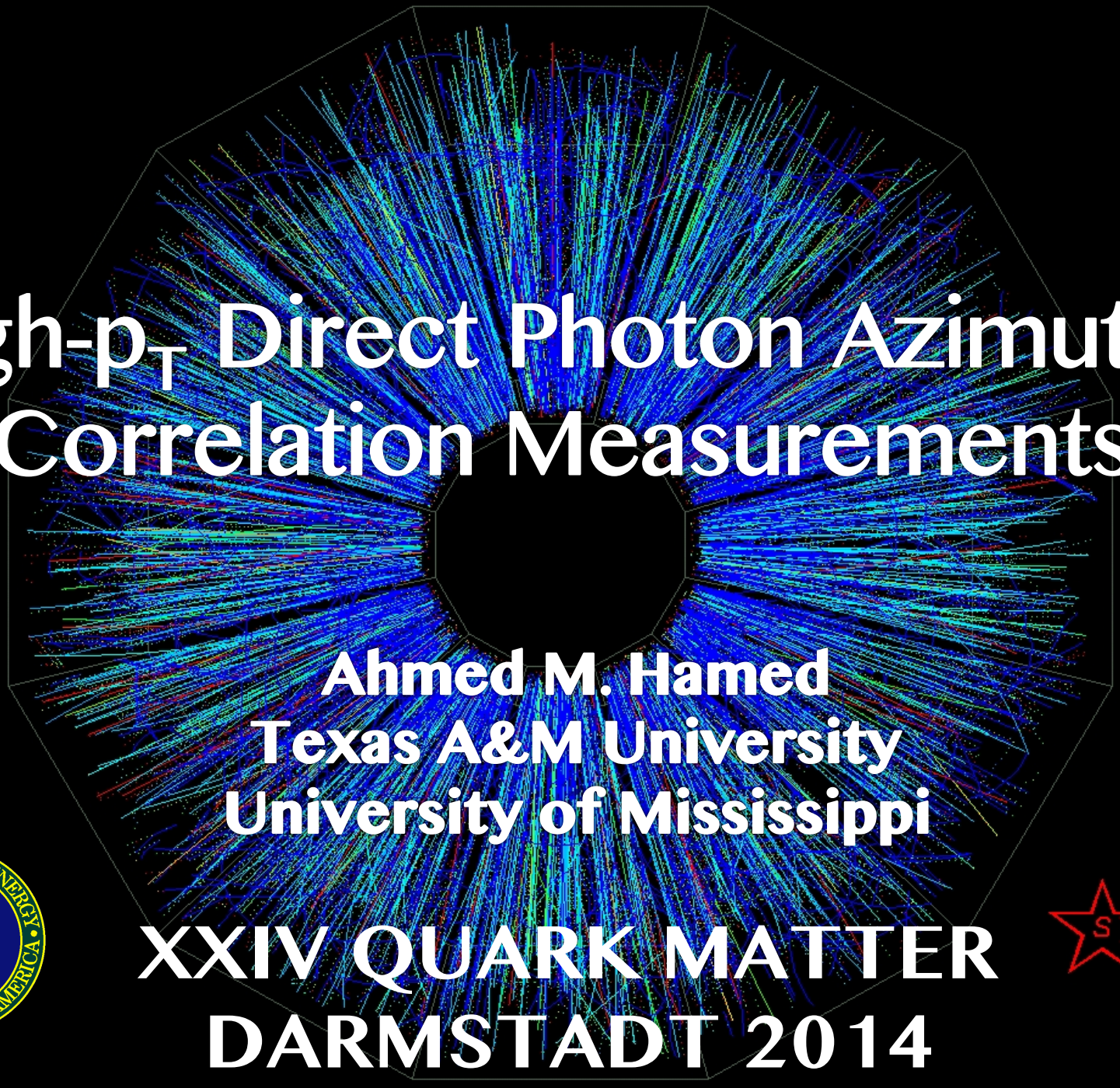

High-p_T Direct Photon Azimuthal Correlation Measurements

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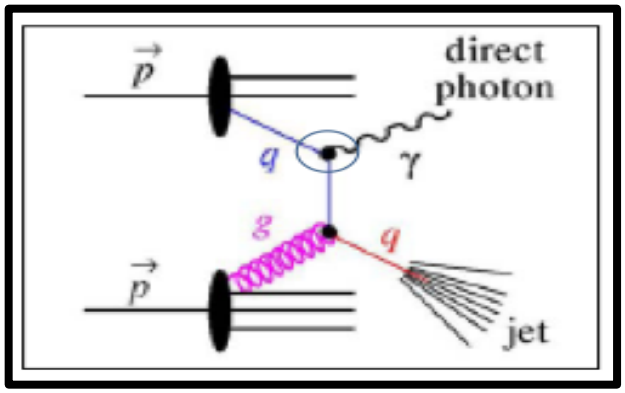
XXIV QUARK MATTER
DARMSTADT 2014

Contents

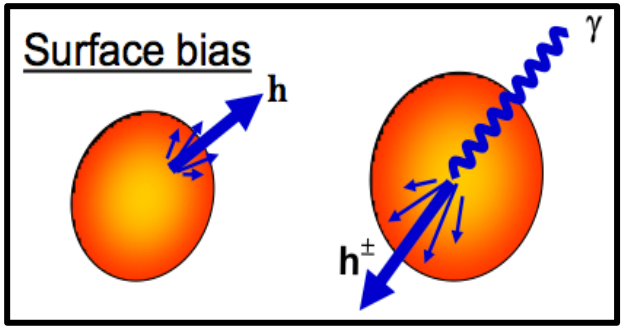
- Motivation
- Theoretical Predictions
- STAR Techniques
- Results ($\sqrt{s_{NN}}$ = 200 GeV)
- Summary and Outlook

Motivation: Parton Energy Loss in QGP

- **Energy loss:** *parton initial energy*, *path length*, *color factor*, quark flavor
- **EM interacting particles "high-p_T photons"**: uniform hard scattering vertex in the QCD medium

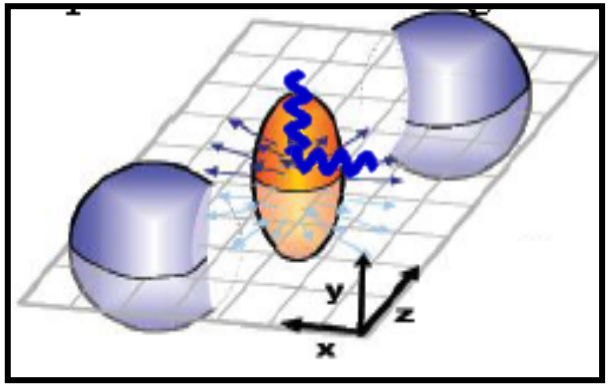


✸ **2-particles correlations ($\Delta\phi$)**:
FF of the recoiling parton from direct γ and π^0:



- **Parton initial energy "Compton-Scattering"**
- **Different path length "on average"**
- **Different q/g compositions**
  - **Observable: $I_{AA} = D_{AA}/D_{NN}$**

✸ **Reaction plane ($\Delta\phi$)**:
Azimuthal anisotropy of π^0 and γ



- **path length dependence of ΔE**
  - **Observable: $v_2(p_T) = \langle \cos(2(\phi_{pT} - \psi_{RP})) \rangle$**

Theoretical Predictions

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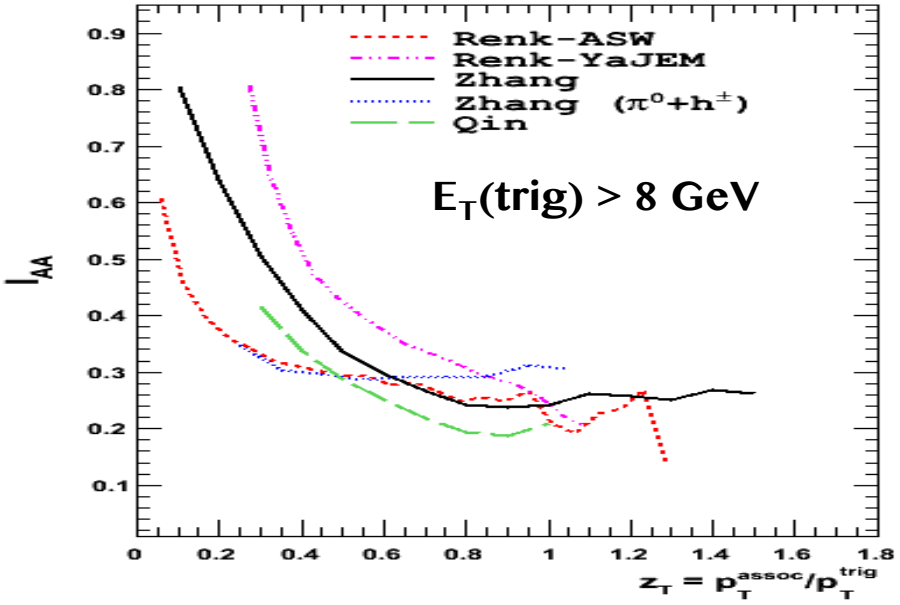
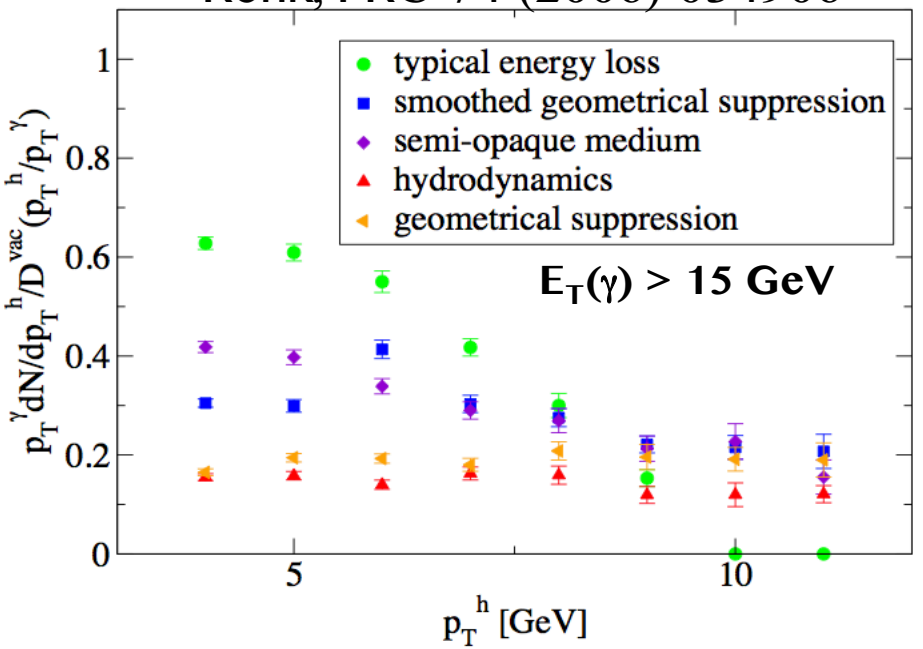


Renk, PRC 74 (2006) 034906

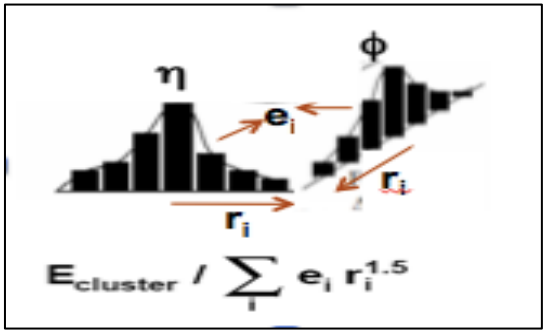


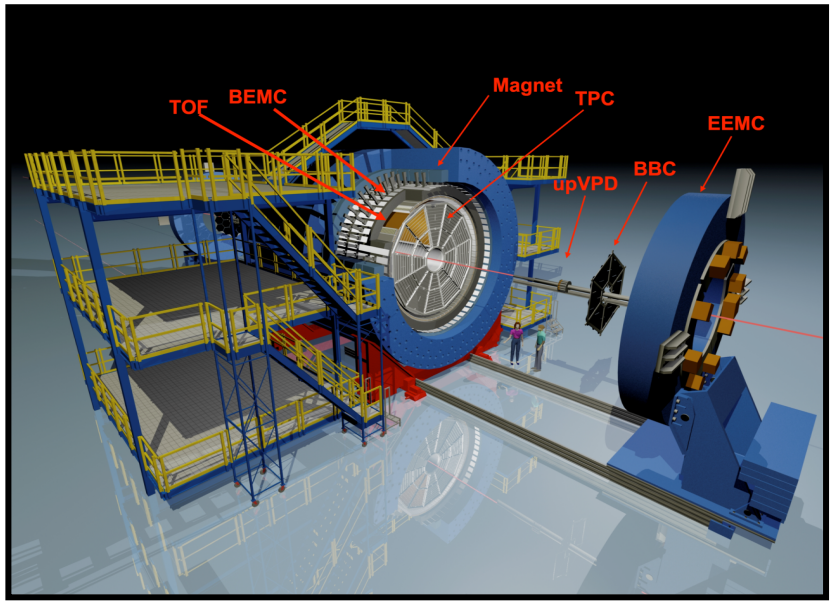
- The medium effect is reflected in the FF of the recoiling partons at low z_T: Large p_T trigger (γ / π^0) OR Low p_T associated (flow)
- Promptly produced EM-interacting particles of high-p_T are expected to have no preferred direction w.r.t to the reaction plane, i.e. $v_2 = 0$.

✓ $v_2(\gamma) < 0$: jet-medium photons "Fries et al., PRL 90, 132301 (2003)"
✓ $v_2(\gamma) = 0$: direct photons "Compton Scattering"
✓ $v_2(\gamma) > 0$: frag. photons "Zakharov, JETP Lett. 80, 1 (2004)"

STAR Techniques (high-p_T direct γ)

- EM neutral cluster identifications (clustering algo., isolation cut)





- EM transverse shower profile + $Z_{\gamma\gamma}$:
  EM neutral energy = π^0 + other sources of EM neutral energy + γ-rich sample

✓ **BEMC: $|\eta| < 1.0$, $\Delta\phi = 2\pi$**
✓ **TPC: $|\eta| < 1.0$, $\Delta\phi = 2\pi$**
✓ **FTPC: $2.5 < |\eta| < 4.0$, $\Delta\phi = 2\pi$**

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

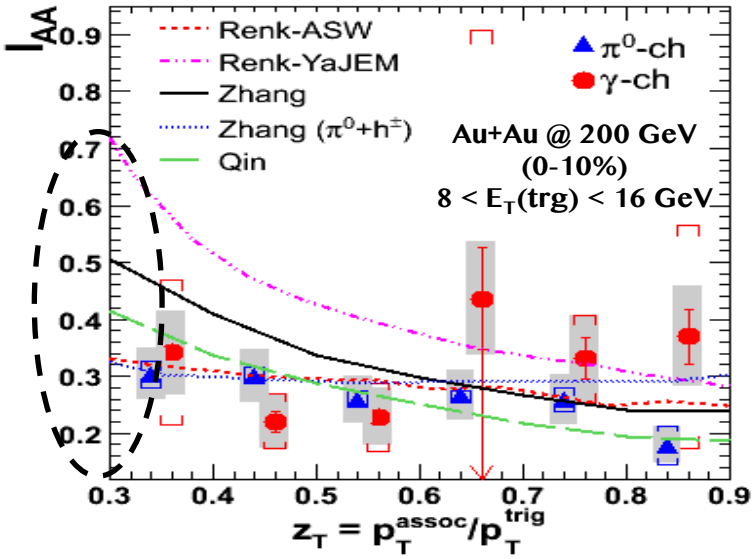
$$v_2^{\gamma_{direct}} = \frac{v_2^{\gamma_{rich}} - v_2^{\pi^0}\mathcal{R}}{1-\mathcal{R}}$$

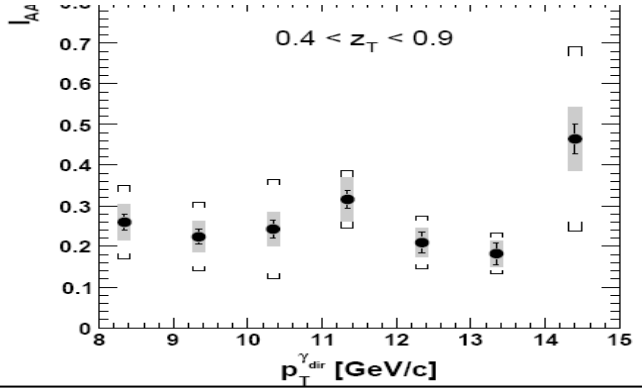
✓ π^0 purity, BG assumption justifications

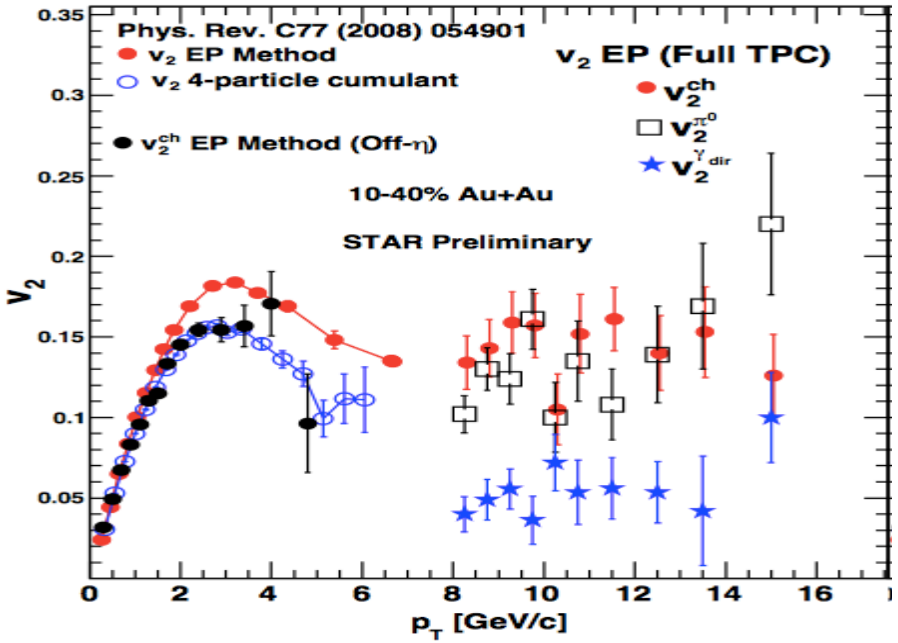
$$\mathcal{R} = \frac{N^{bg}}{N^{\gamma_{rich}}} \simeq \frac{N^{\pi^0}}{N^{\gamma_{rich}}}$$

Previous Results

STAR, PRC 82, 034909 (2010)







➢ $v_2(\gamma)$ is finite. Event-plane reconstruction biases (non-flow) and/or Frag. photons contributions?

➢ Similar levels and patterns of I_{AA} for π^0 and direct γ. I_{AA} shows no strong dependence on E_i

✓ **need to probe low z_T**

✓ **More forward detectors:**
$2.5 < |\eta| < 4.0$

Integrated and Projected Luminosity in STAR

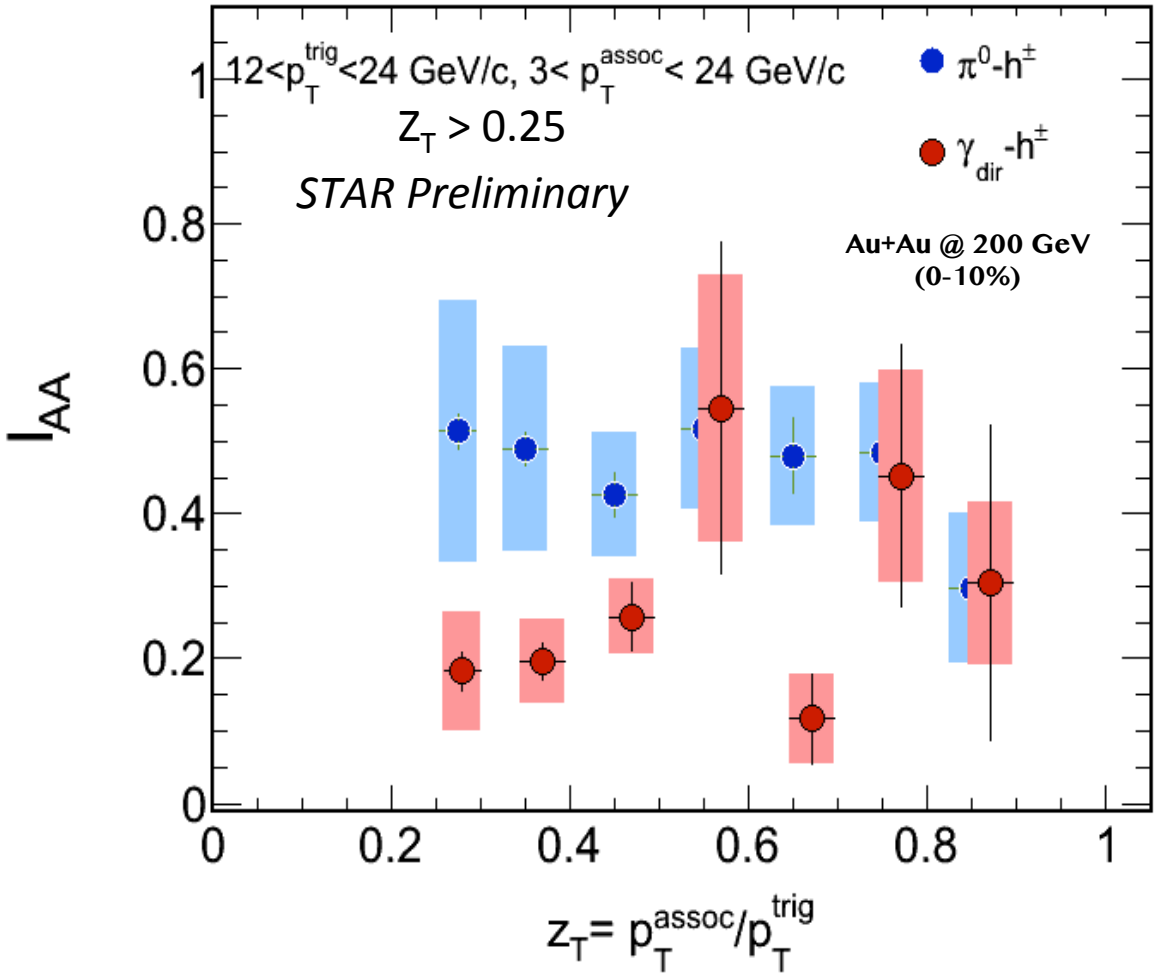
Table 1: Integrated and projected luminosity for γ_{dir}-triggered at $\sqrt{s}$=200GeV for different collision systems

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}

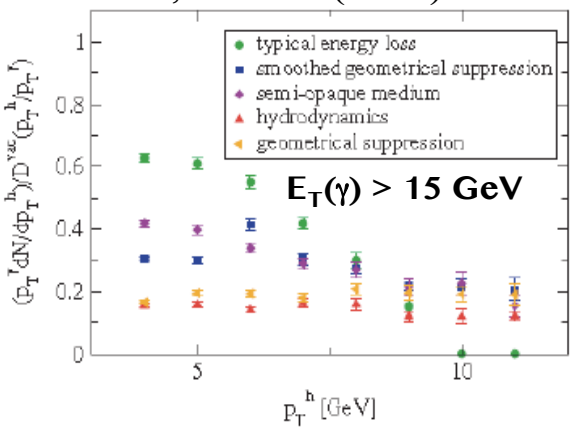
Current reconstructed data is sufficient

- To probe the low z_T region and,
- To measure the v_2 using the STAR forward detector.

Particle Correlations -- I_{AA}



Renk, PRC 74 (2006) 034906



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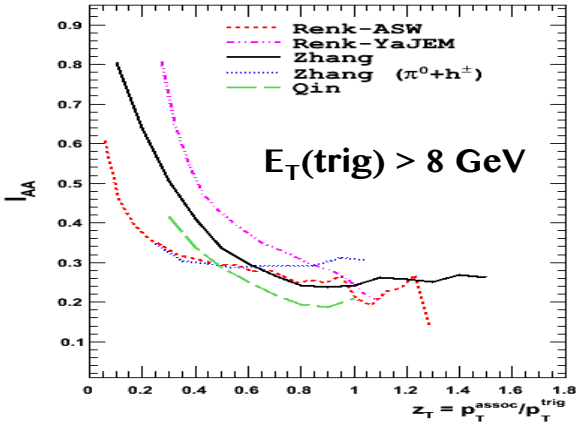
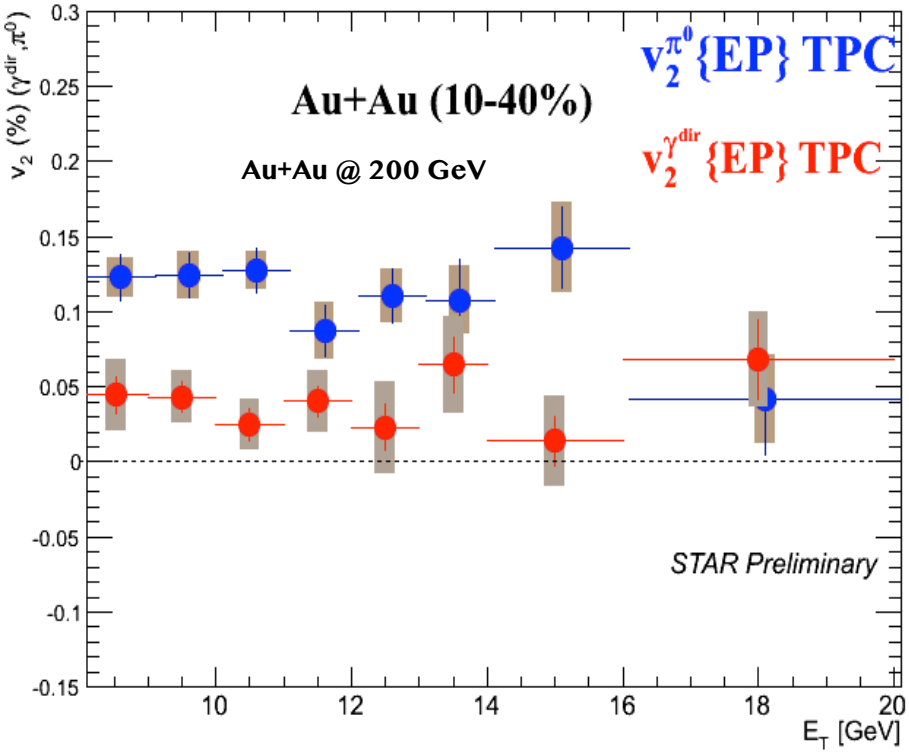


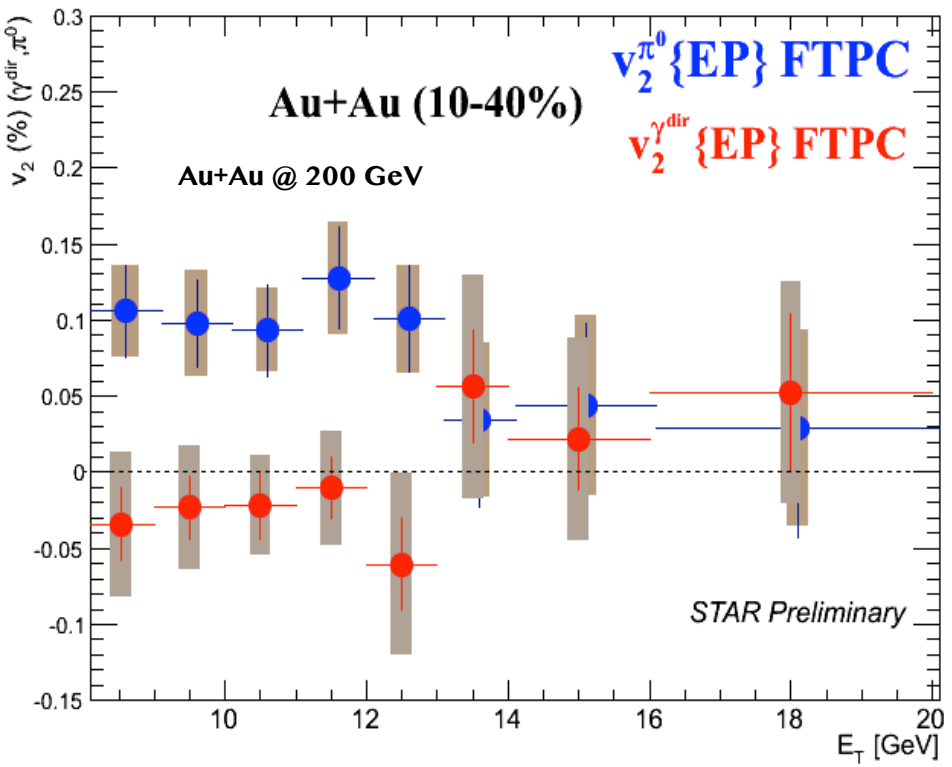
- Both I_{AA} of direct photons and π^0 are flat within current uncertainties in the measured kinematics range

Reaction-plane Correlations: v_2

✓ BEMC: $|\eta| < 1.0$, TPC: $|\eta| < 1.0$



✓ BEMC: $|\eta| < 1.0$, FTPC: $2.5 < |\eta| < 4.0$



- v_2 of direct photon is consistent with zero within the current systematic errors
- Remaining bias in reaction-plane determination is small when using forward detector
- Fragmentation photons have negligible effect on overall v_2 of direct photons

- v_2 of π^0 using the FTPC is apparently due to the path length dependence of energy loss.

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

Summary and Outlook

- STAR high-p_T direct photon azimuthal and neutral pions, correlated with charged hadrons, measurements show:

☑ The recoil parton from direct photons and π^0 observed to have constant softening in the QCD medium within the measured kinematic range (E_T(trig) =12 - 24 GeV/c and p_T(assoc) = 3 - 24 GeV/c) -- I_{AA} is flat

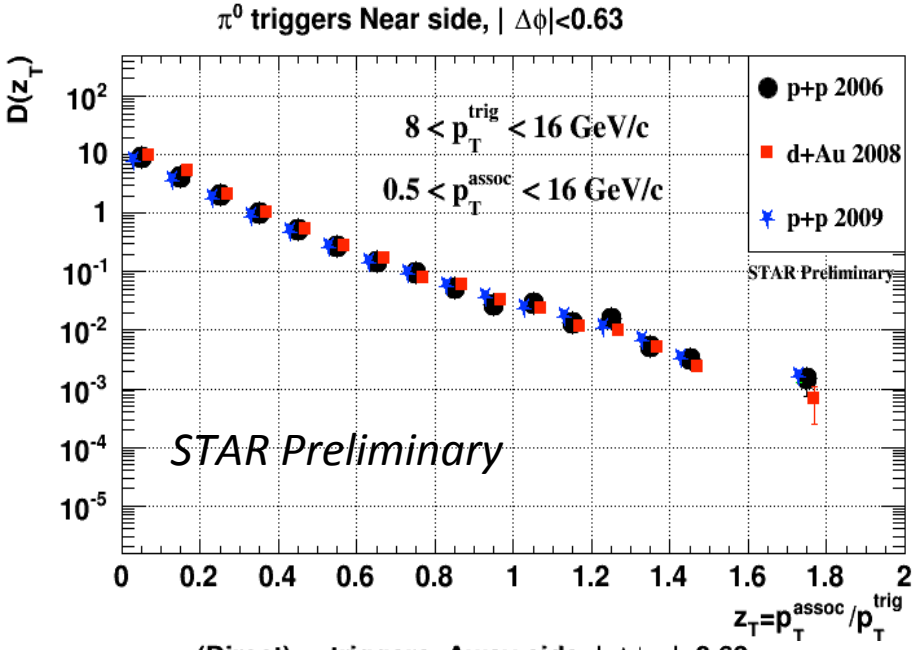
☑ The high-p_T direct photons (8-20 GeV) is azimuthally uniform distributed w.r.t reaction plane -- $v_2 = 0$

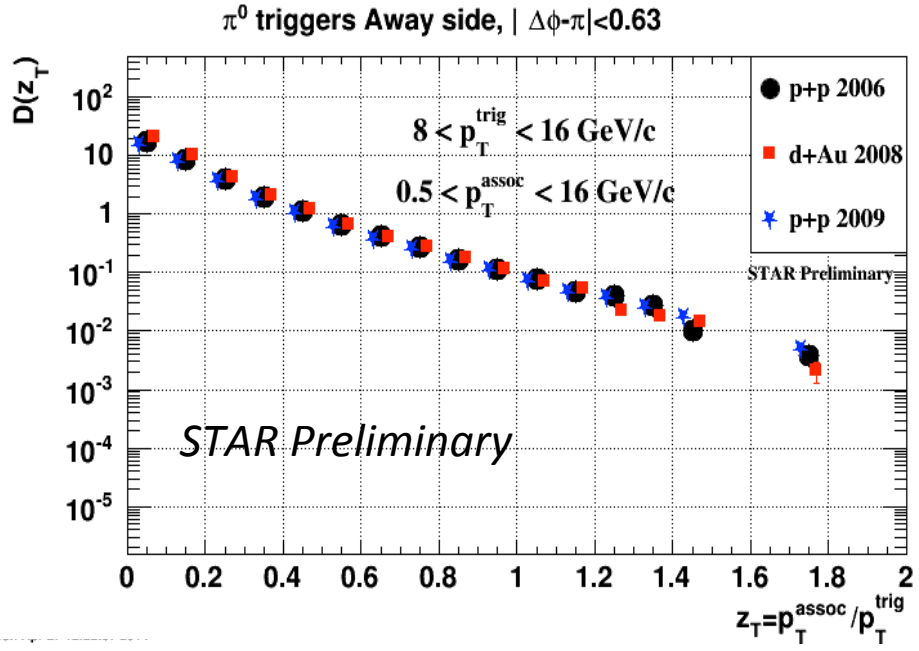
☑ More data to improve stat. and sys. errors, and explore further the low z_T region. Stay tuned!

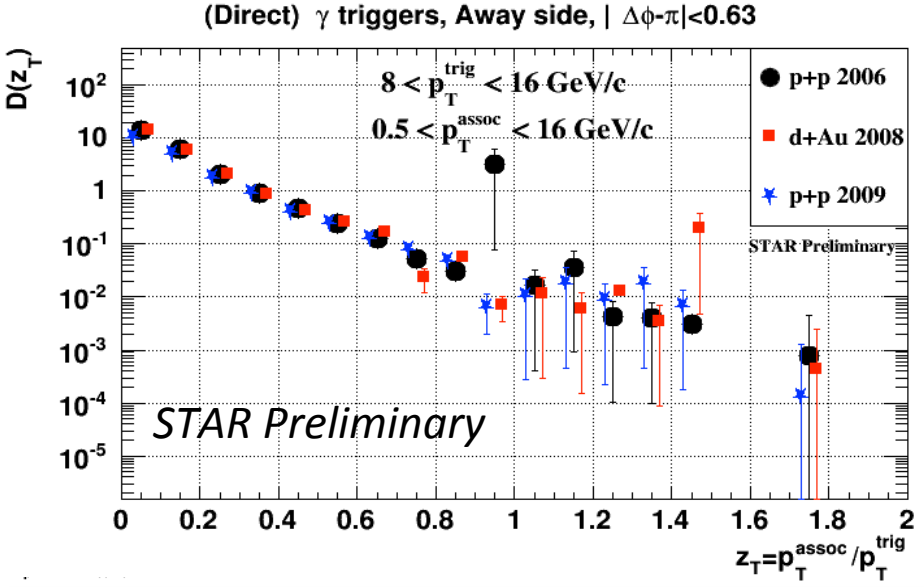

Thank you
STAR

Backup Slides

D (z_T) from different data sets I

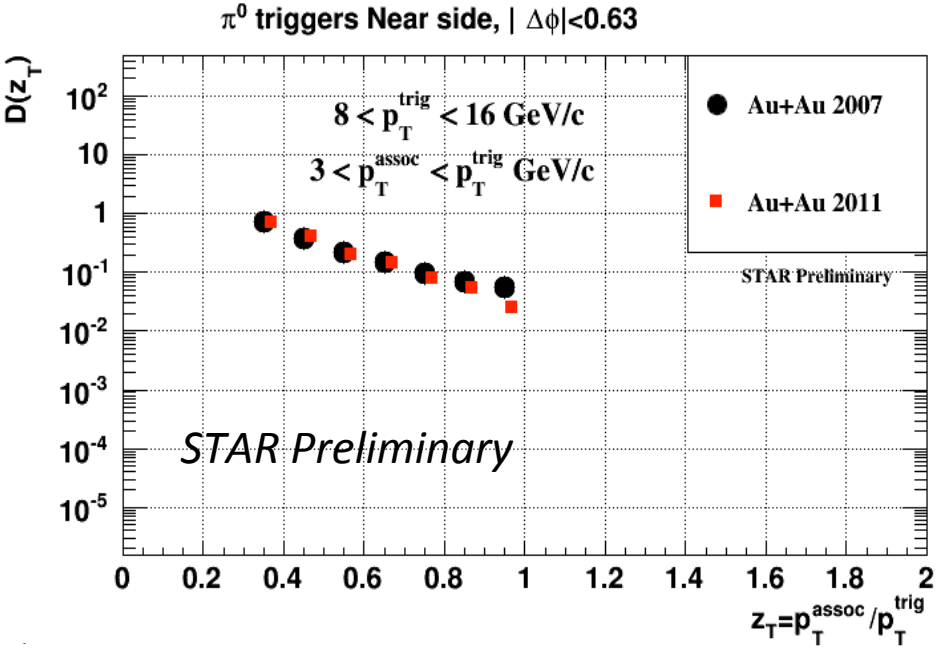


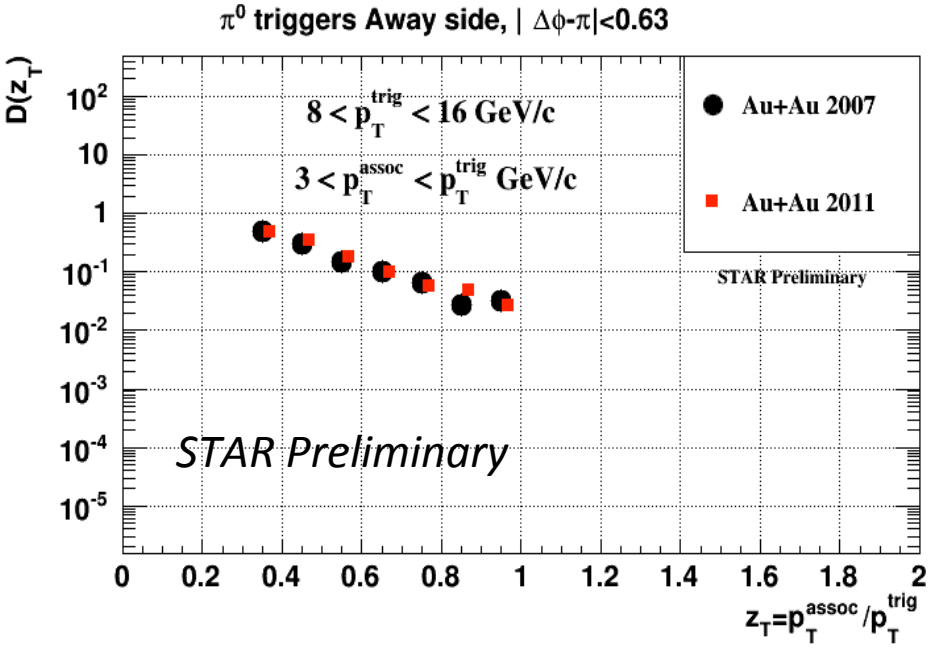


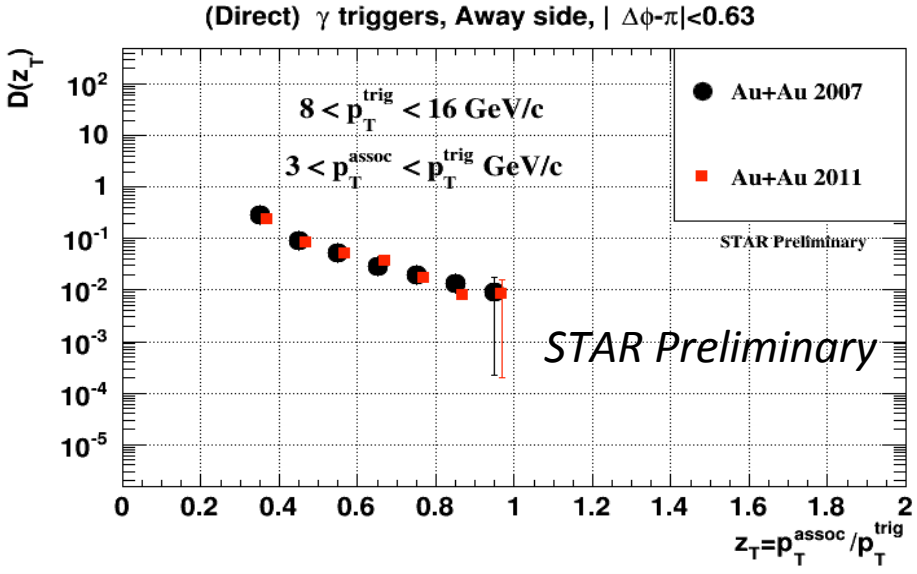


- The NS and AS conditional yields per π^0 from different data sets (pp2006, dAu2008, and pp2009) agree over the entire explored z_T-range (0 - 2.0) .
- The AS conditional yields per direct photon from different data sets (pp2006, dAu2008, and pp2009) agree over many orders of mag.

D (z_T) from different data sets III

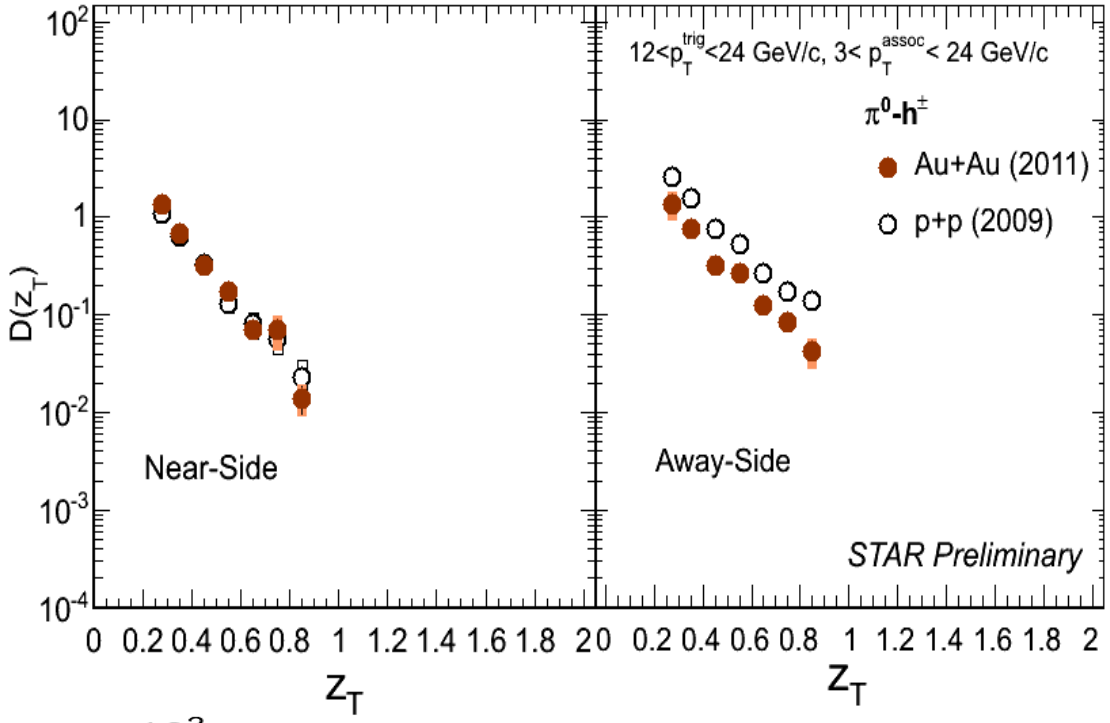


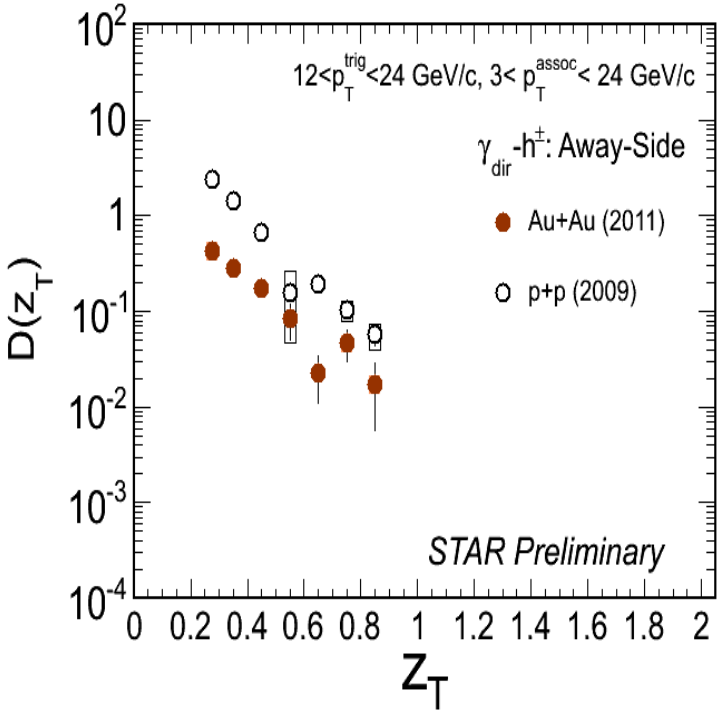


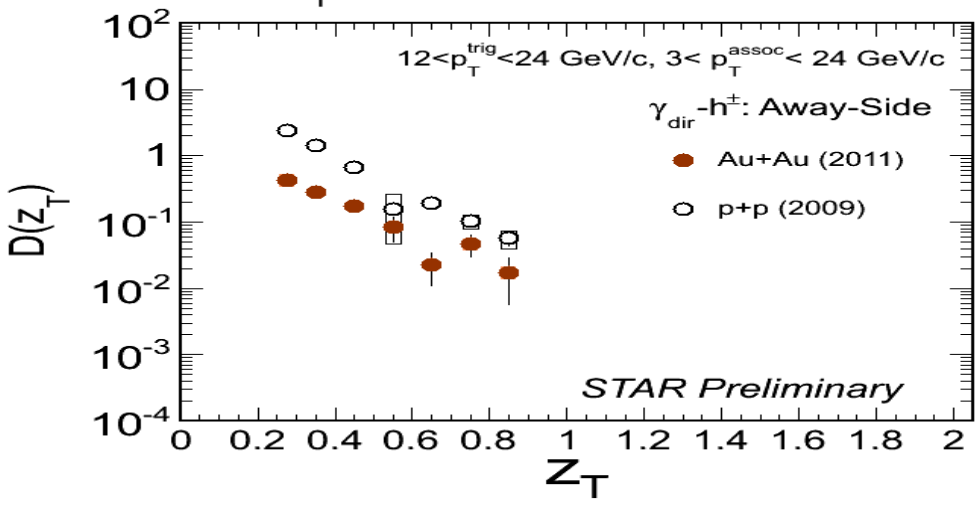


- The conditional yields per π^0 and direct γ from different data sets AuAu 2007 and AuAu 2011) agree over the entire explored z_T-range

D (z_T) from different data sets II

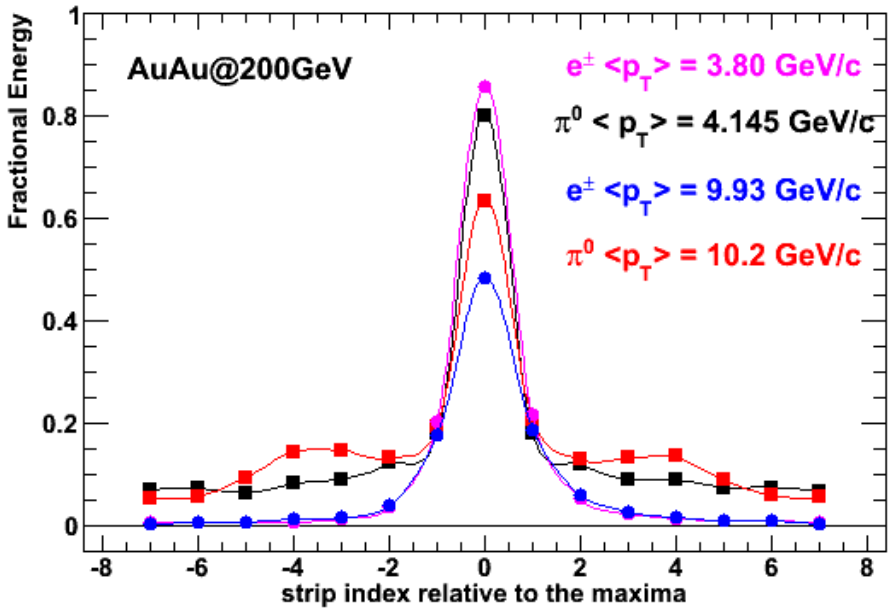


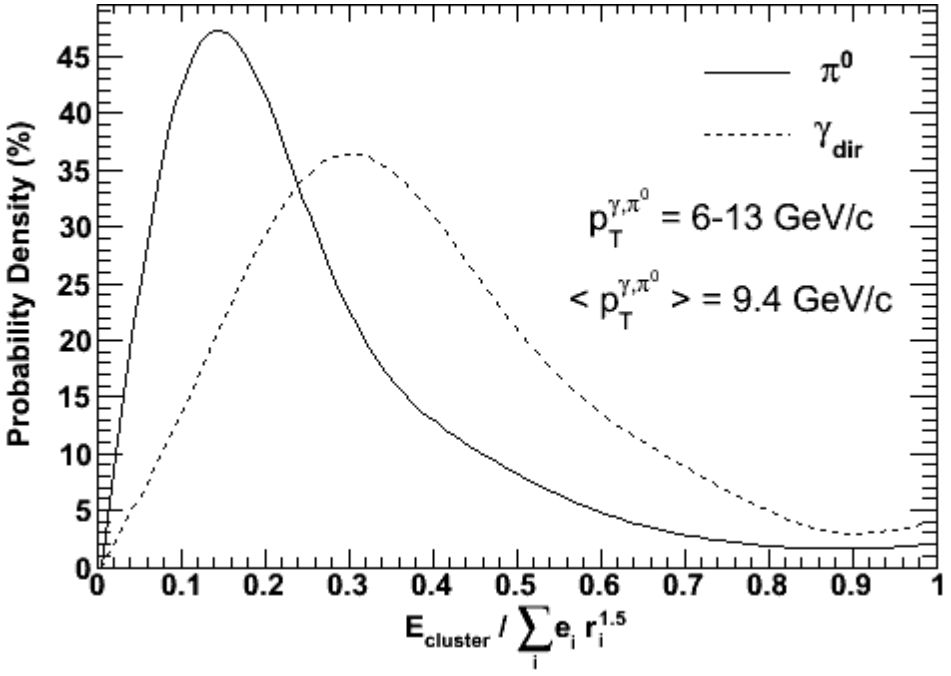




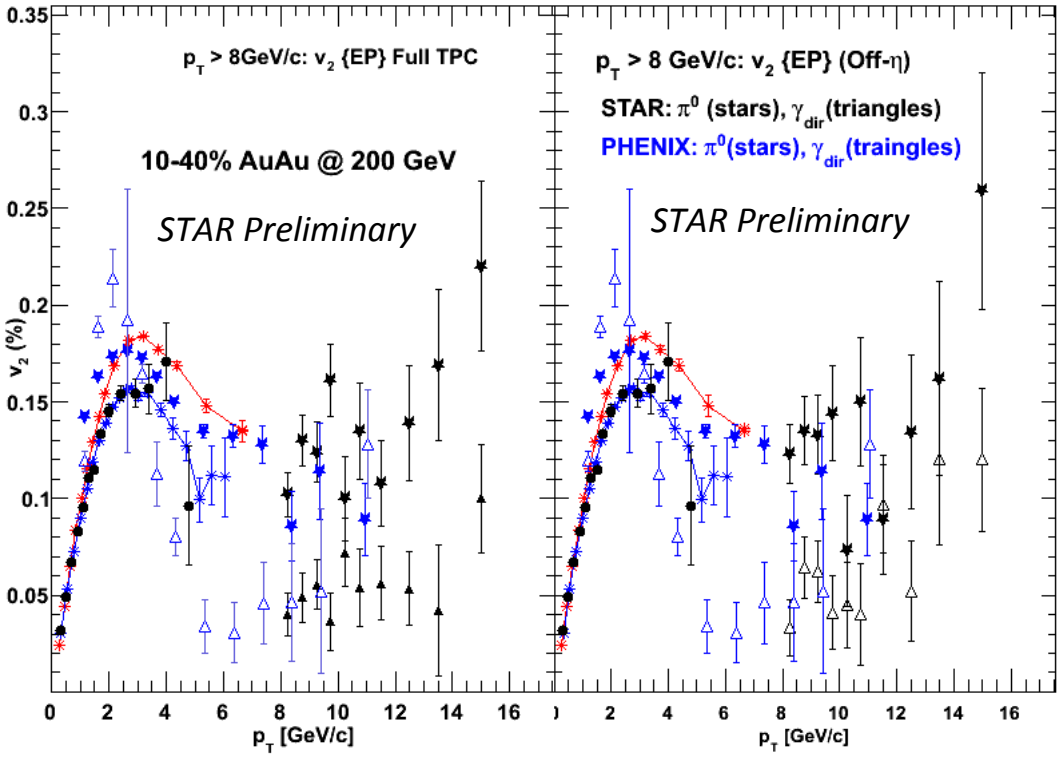
- The conditional yields per π^0 and direct γ from (AuAu 2011 and pp 2009) data shows expected trends.

EM Transverse Shower Profile





Previous Results-STAR vs. PHENIX



- STAR and PHENIX have similar results using different techniques