Photon-Hadron Correlations measured at PHENIX

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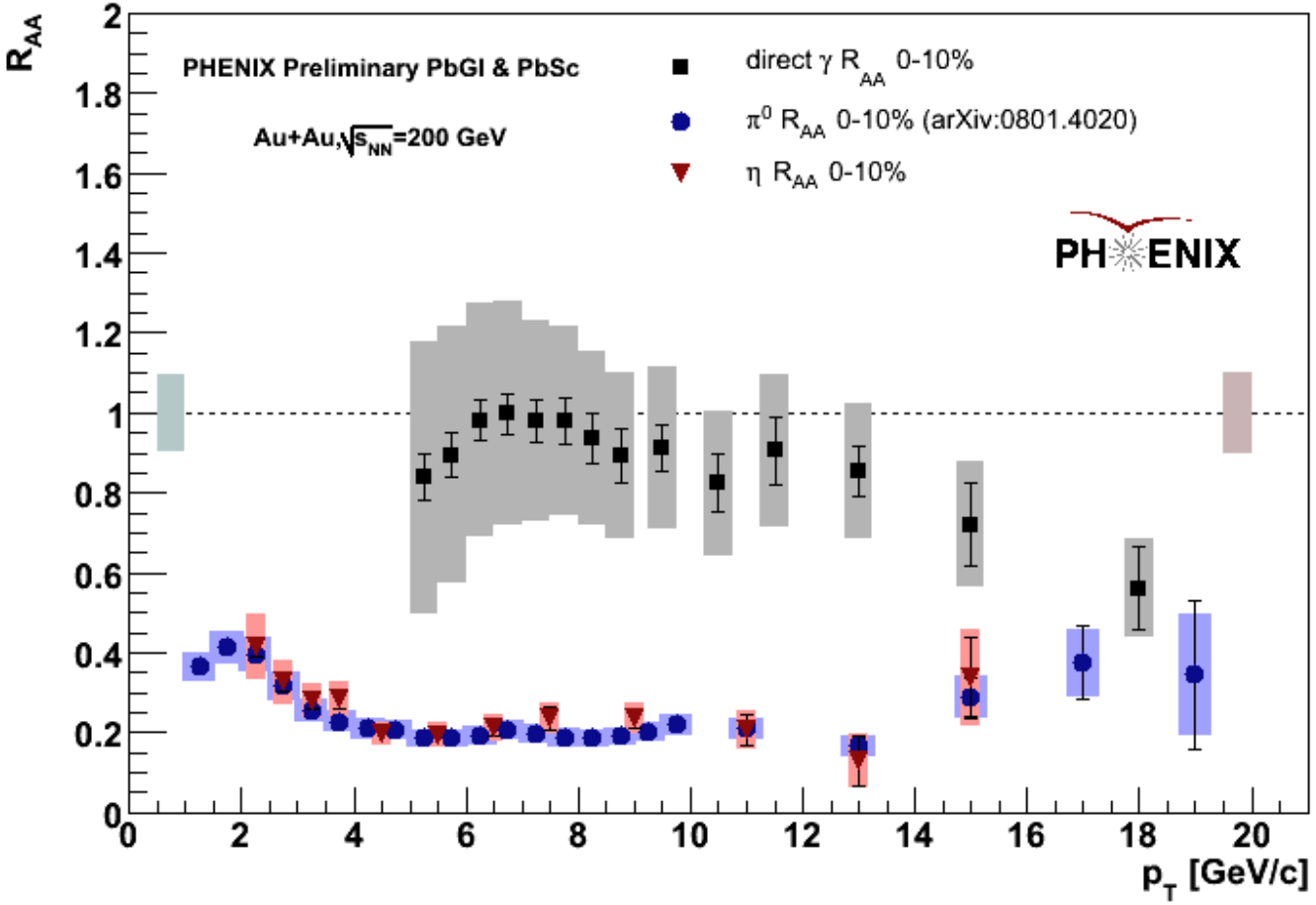
Outline

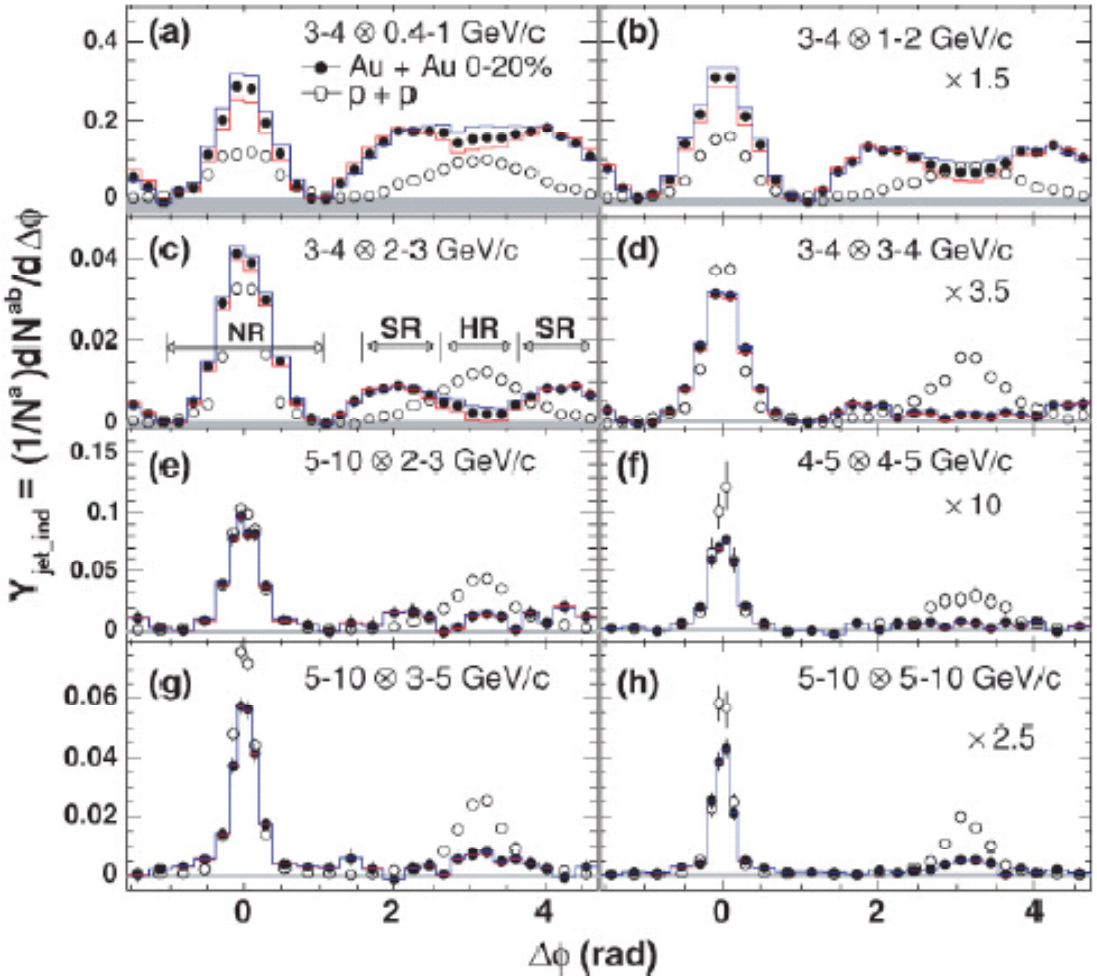
- Why γ_{dir}-h?
- Recent γ_{dir}-h results
- Another source of direct photon: fragmentation photon
- Latest result: isolated direct photons

Energy loss in the medium



- Hadrons are suppressed in the medium
- Photons are not

Jets are modified in the medium



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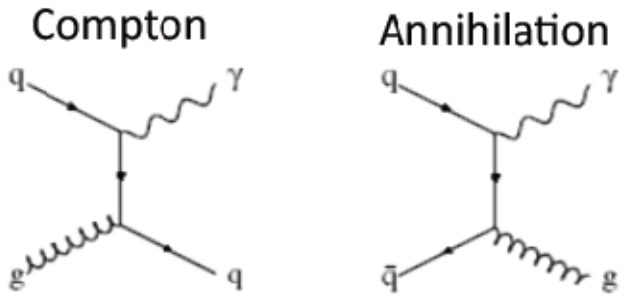
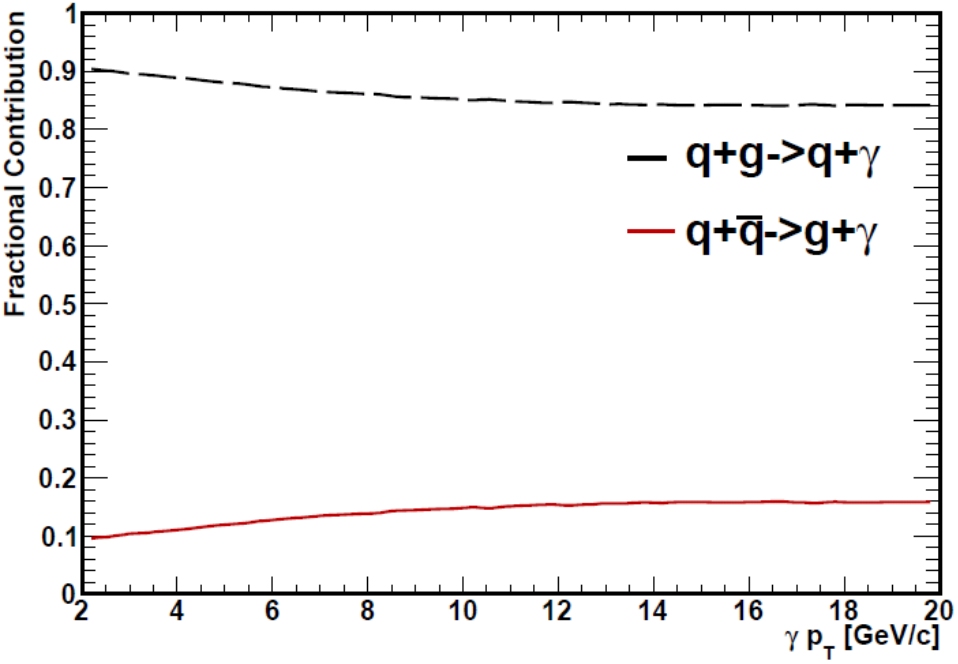
- In two particle correlations, the awayside shape is modified
- How is the energy lost in the medium?

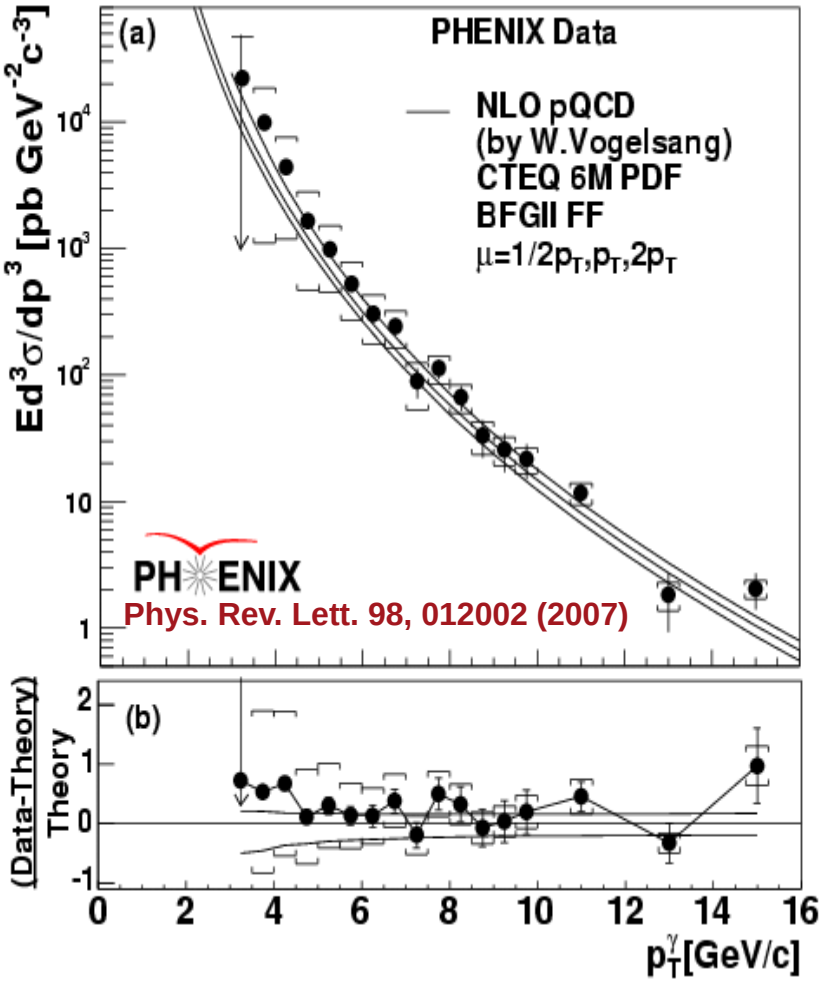
Direct photons as probes





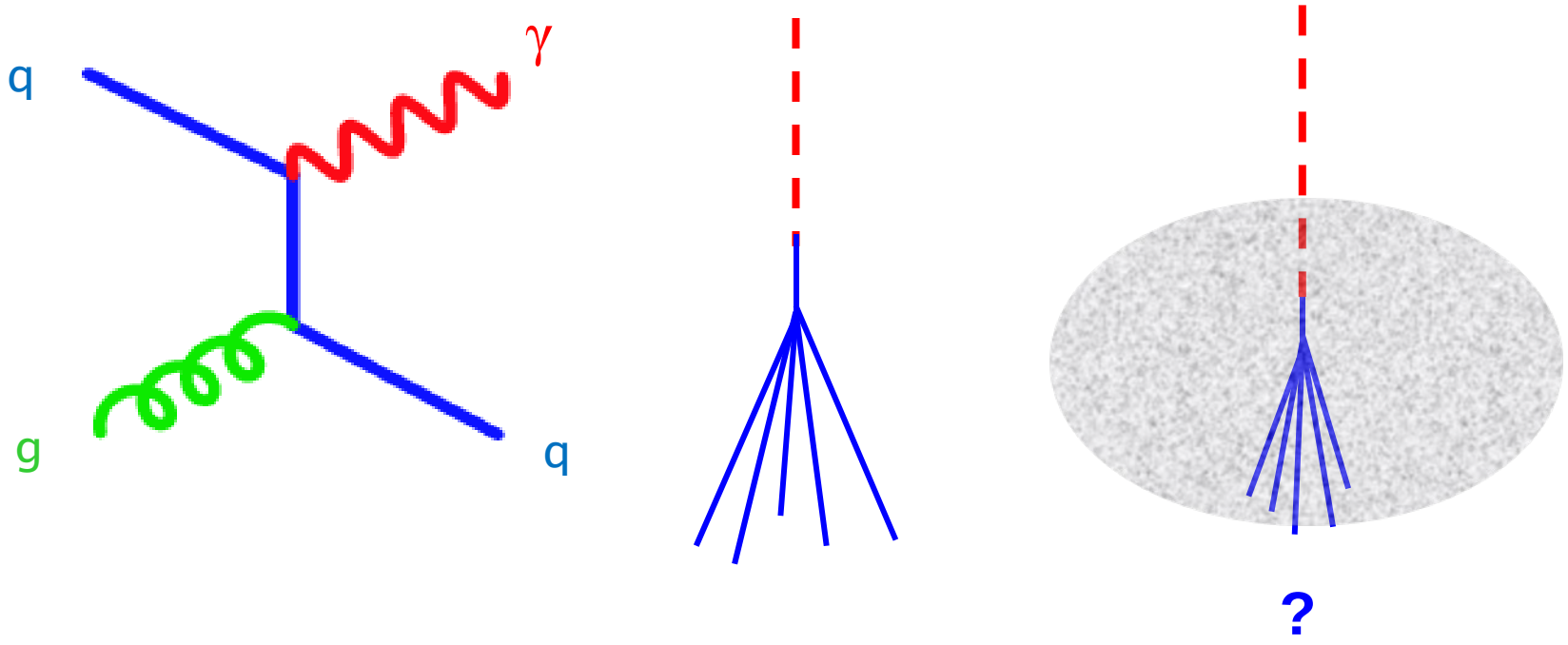
- At LO, direct photon comes from Compton scattering and quark annihilation
- most of the direct photons come from QCD Compton scattering
- $E_{photon} \sim E_{jet}$
- Photons are color neutral, and do not interact with the color medium

Direct photons in PHENIX



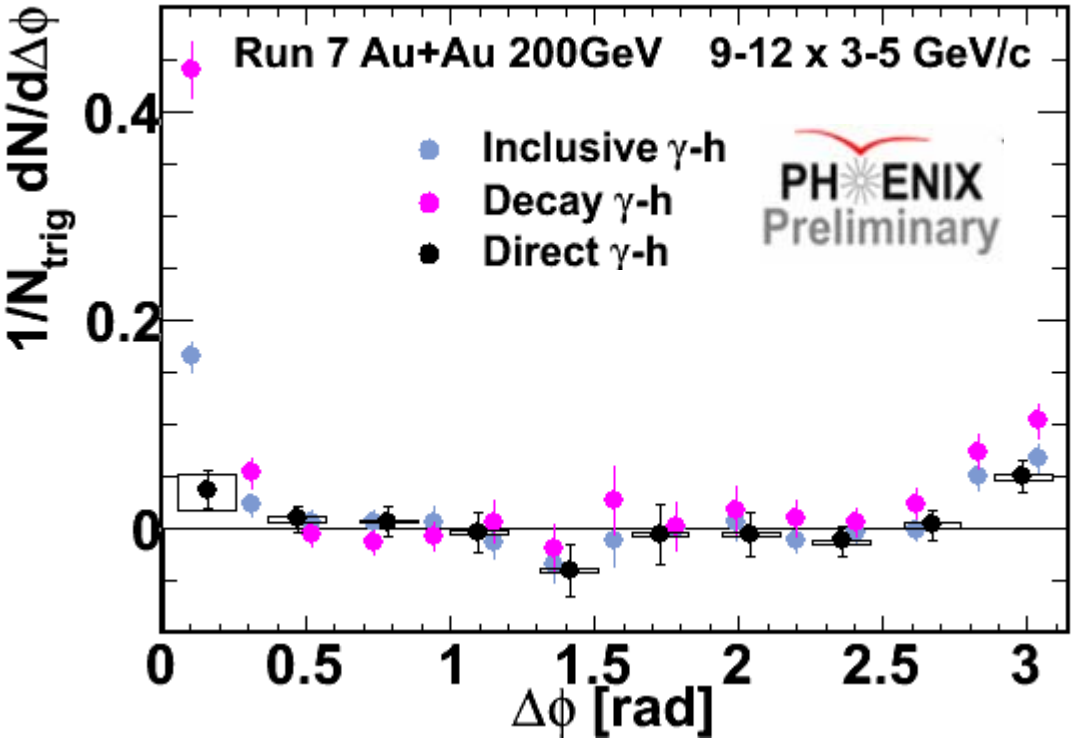
- Inclusive direct photons are measured in PHENIX
- Well described by pQCD

γ_{direct}-jet

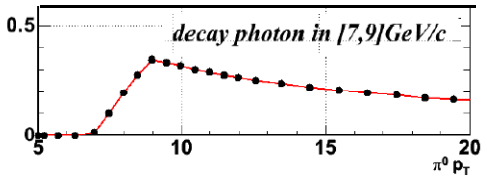


- Direct photon produced from Compton scattering
- $E_\gamma \sim E_{jet}$
- Tag the jet in the awayside, and measure the fragmentation function (FF)
- How does the FF modify when there is medium?

γ_{dir}-h $\Delta\phi$ Correlation



- Inclusive γ-h
- Decay γ-h



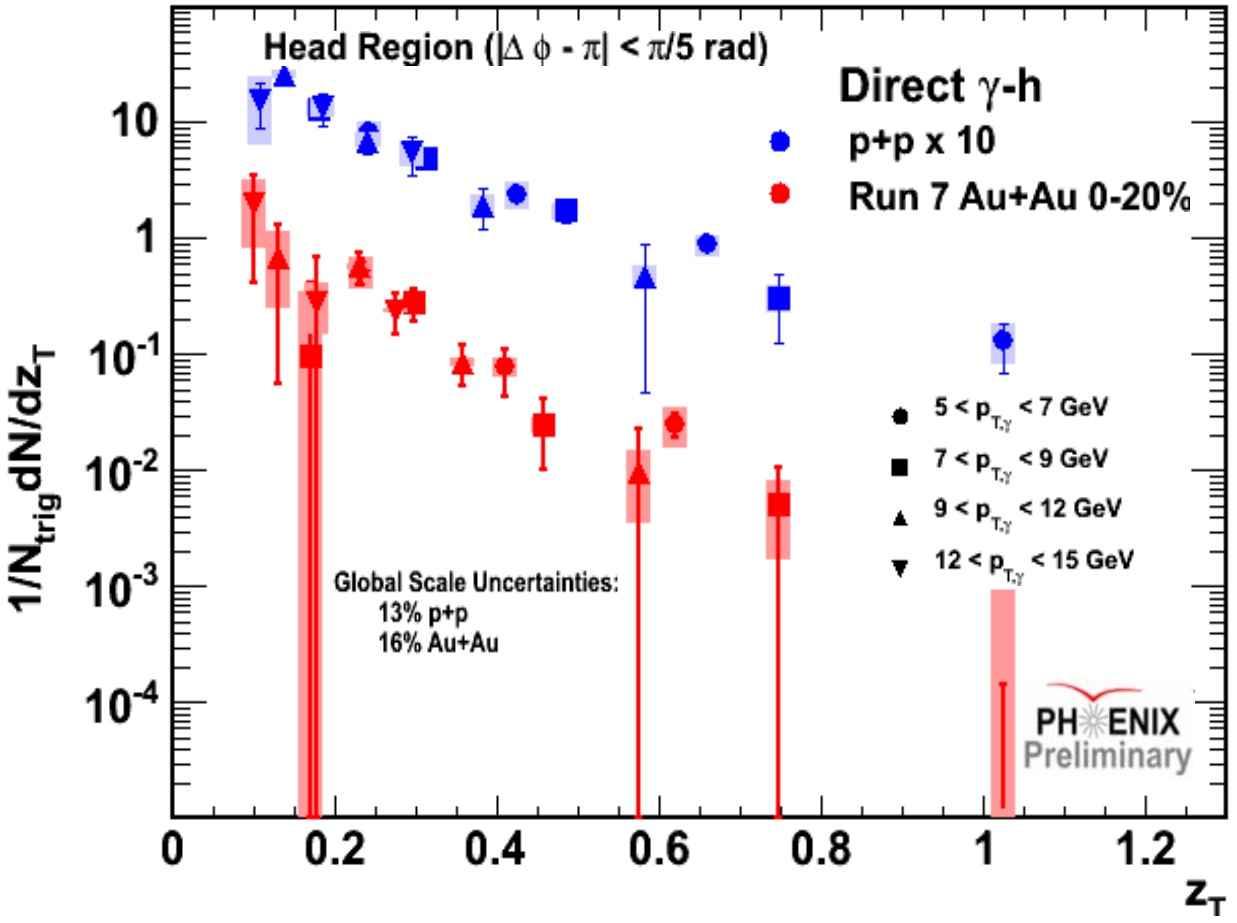
- Direct γ-h

$$Y_{direct} = \frac{R_\gamma Y_{incl} - Y_{decay}}{R_\gamma - 1}$$

Near side: little/no jet
Measure the away side yield

($R_\gamma = Y_{inc}/Y_{dec}$)

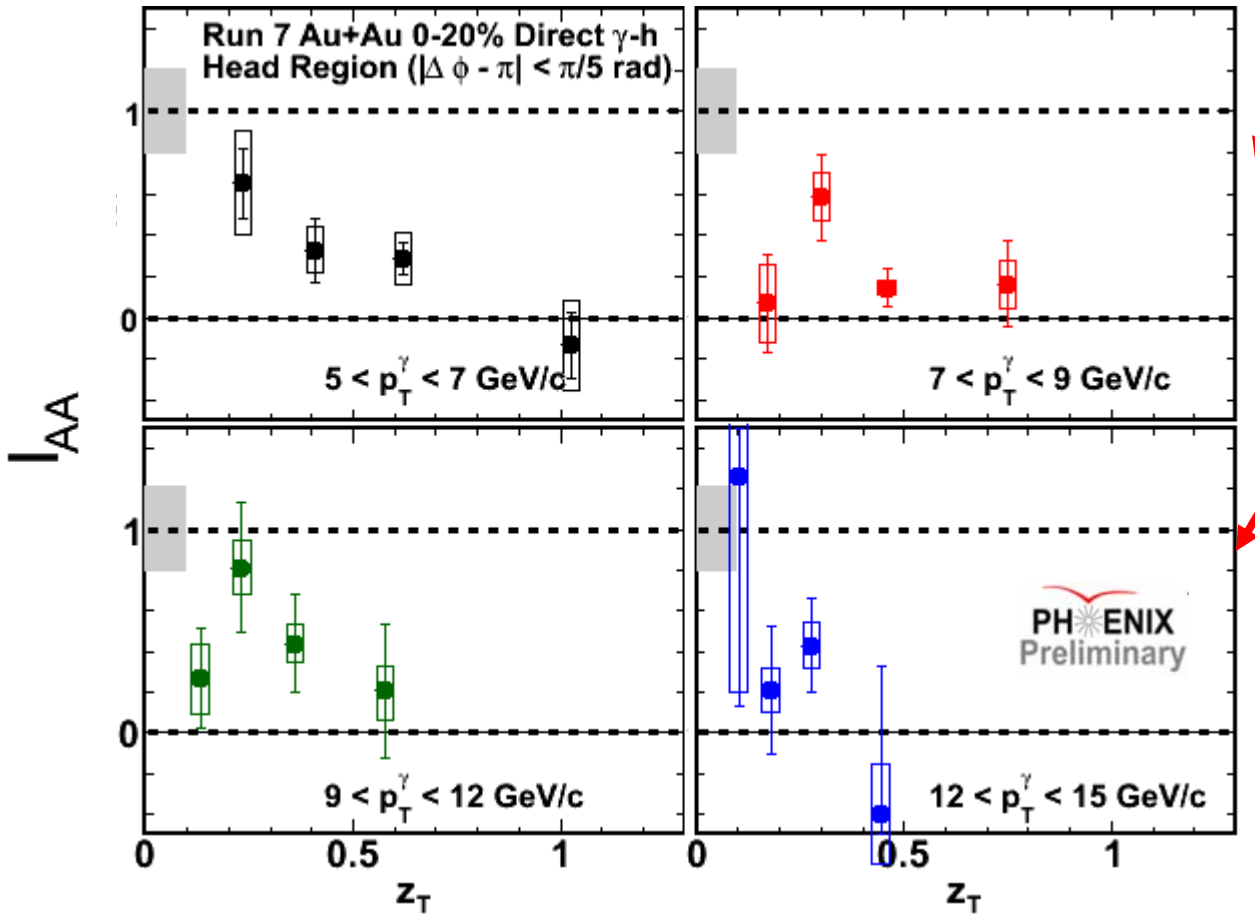
Fragmentation function in AuAu and pp



- γ $p_T \approx$ jet p_T
- $z_T = p_T^h / p_T^\gamma$

- FF: $D(z_T) = 1/N_{evt}\, dN(z_T)/dz_T$
- Is $D_{AuAu}(z_T)$ modified?

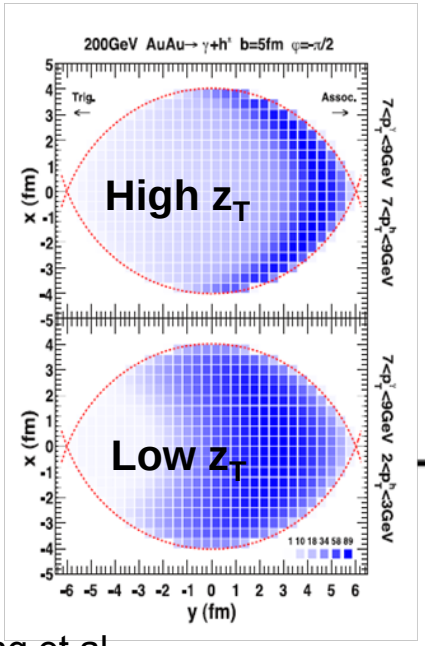
How is the FF modified in AuAu?



$I_{AA} = 1$
no modification

- $I_{AA} = D_{AuAu}(z_T)/D_{pp}(z_T)$
- Significant suppression in AuAu ($I_{AA} < 1$)

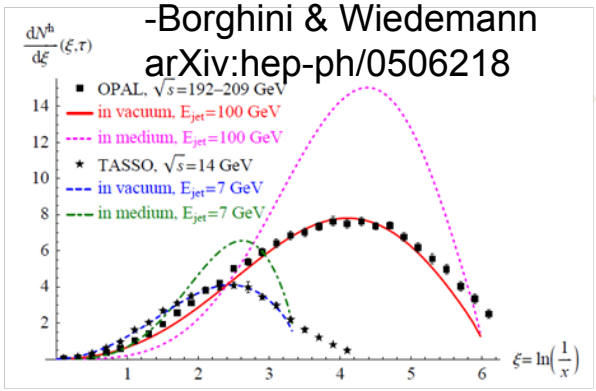
Comparison to Models



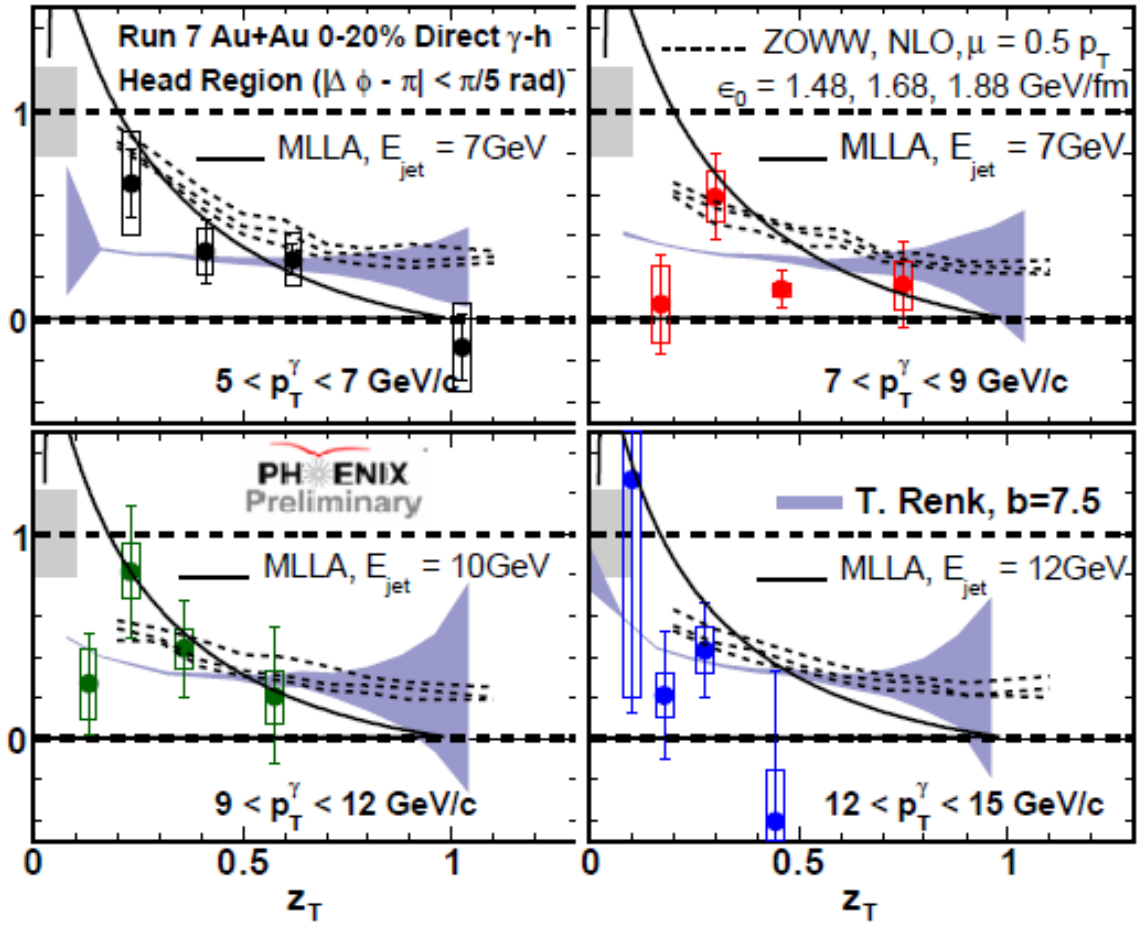
-Zhang et al,
Phys.Rev.Lett.103:032302,2009

-Renk, Phys.Rev.C80:014901,2009

-Borghini & Wiedemann
arXiv:hep-ph/0506218

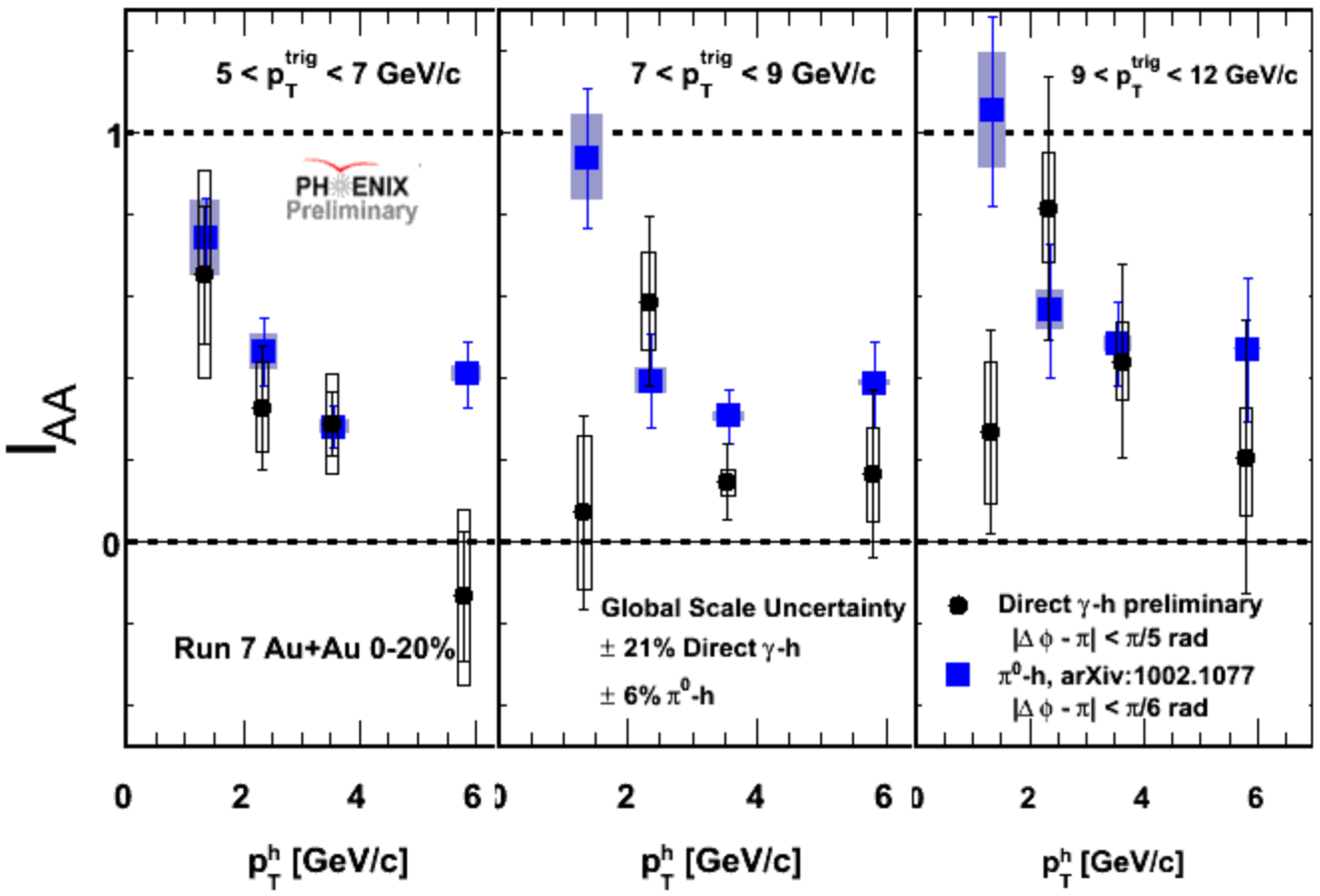


I_{AA}



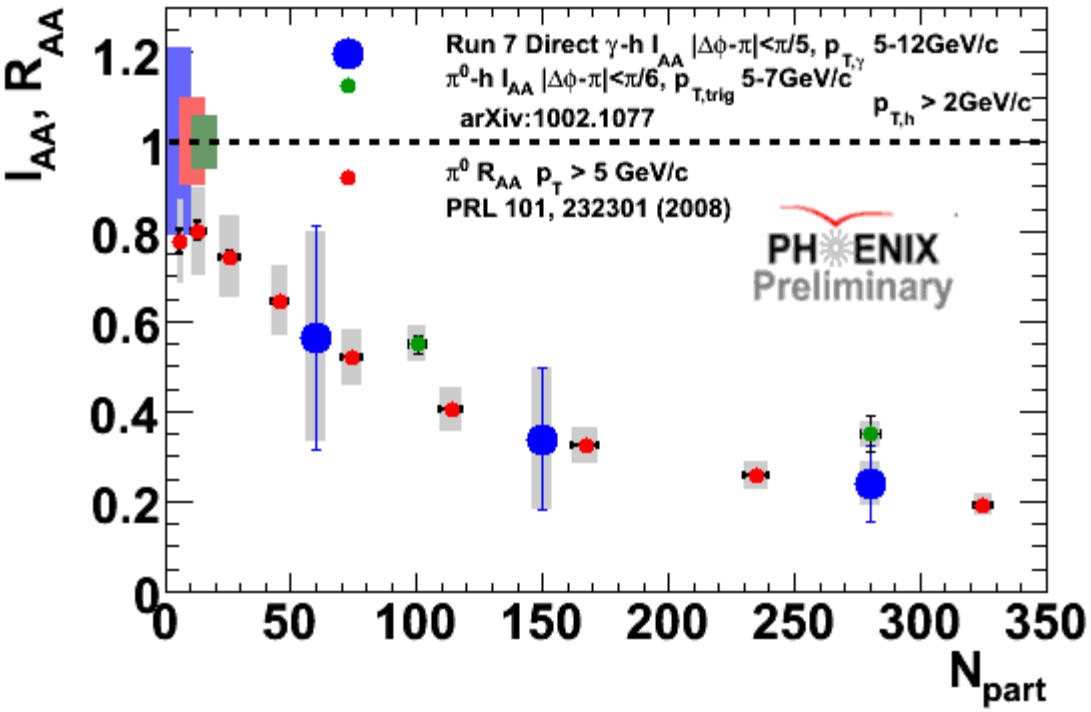
- Models describe suppression at high z_T
- Models diverge at low z_T

Compare to π^0-h

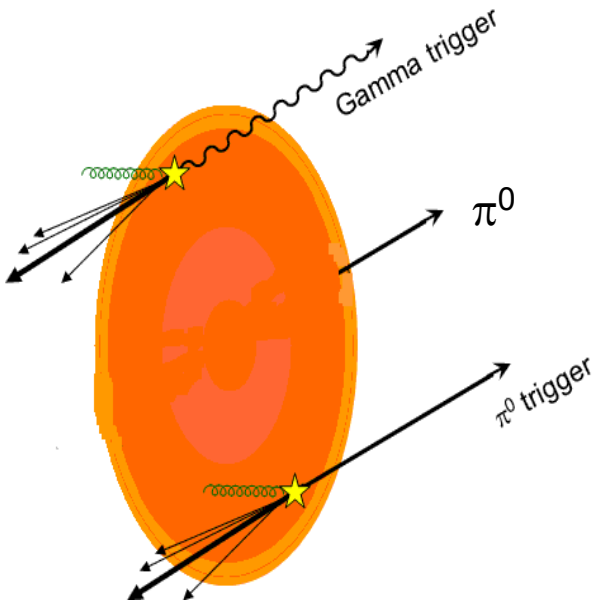


- Similar suppression in γ_{dir}-h and π^0-h at p_T^h > 2 GeV/c

Centrality Dependence



- Surface Bias?

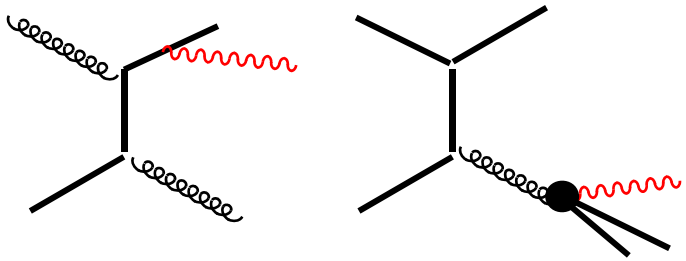


- π^0-h I_{AA} appears greater than π^0 R_{AA}
- γ_{dir}-h I_{AA} also consistent with π^0 R_{AA}

Further studies between photons and hadrons

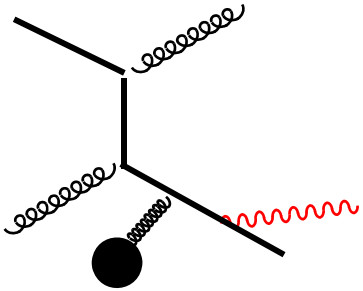
- Other source of direct photon
  - Fragmentation photon
- Improve PID of direct photon
  - Decay photon tagging + Isolation cut

Fragmentation photon



- NLO:
  - photon fragmentation
  - photon radiation

Medium induced modifications:

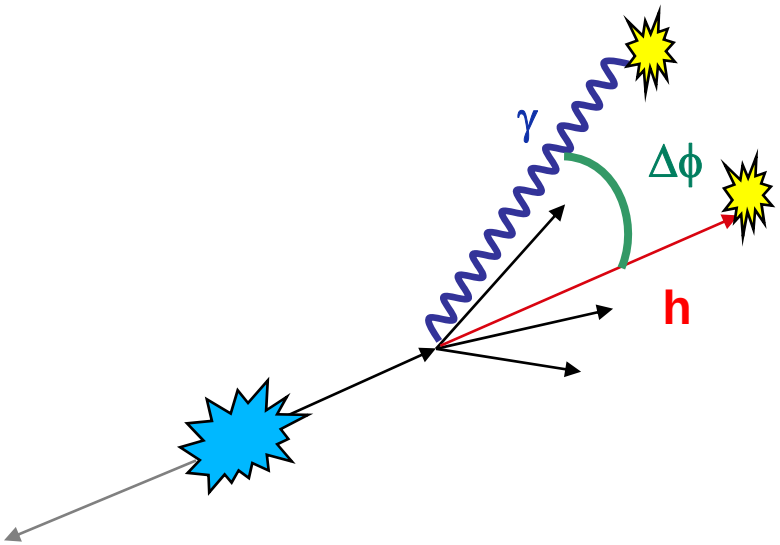


- **Occurs at NLO - modifies the fragmentation component of direct photon spectrum only**

- Fragmentation photons are sensitive to jet-medium interaction

Measuring fragmentation photon in p+p

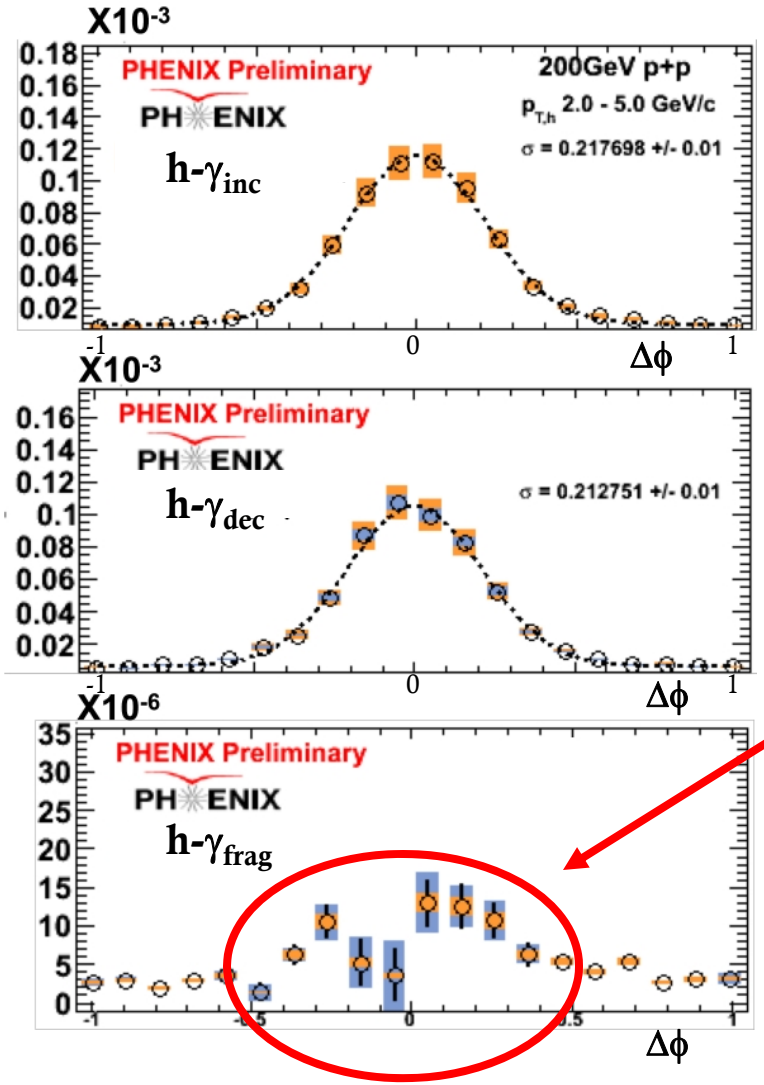
Use event mixing to correct for acceptance



$$Y_{\gamma frag}(\Delta\phi) = Y_{\gamma inc}(\Delta\phi) - Y_{\gamma dec}(\Delta\phi)$$

- Two particle $\Delta\phi$ correlation
- Using high p_T (2-5 GeV/c) charged hadron as trigger
- Photon as partner
- Tag the photon from meson decay
- Focusing on nearside ($|\Delta\phi|<\pi$) only

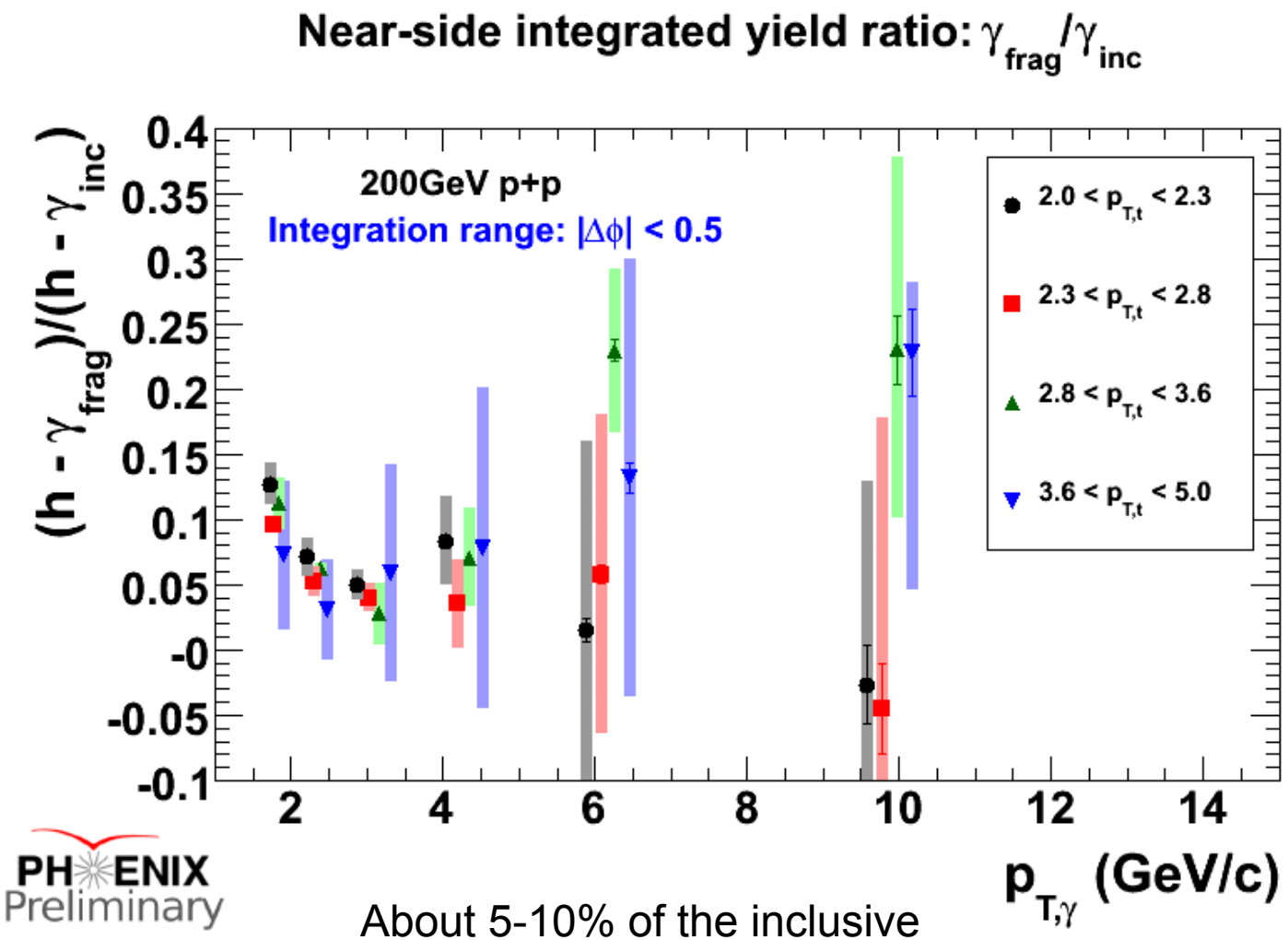
Measuring fragmentation photon



$$Y_{\gamma frag}(\Delta\phi) = Y_{\gamma inc}(\Delta\phi) - Y_{\gamma dec}(\Delta\phi)$$

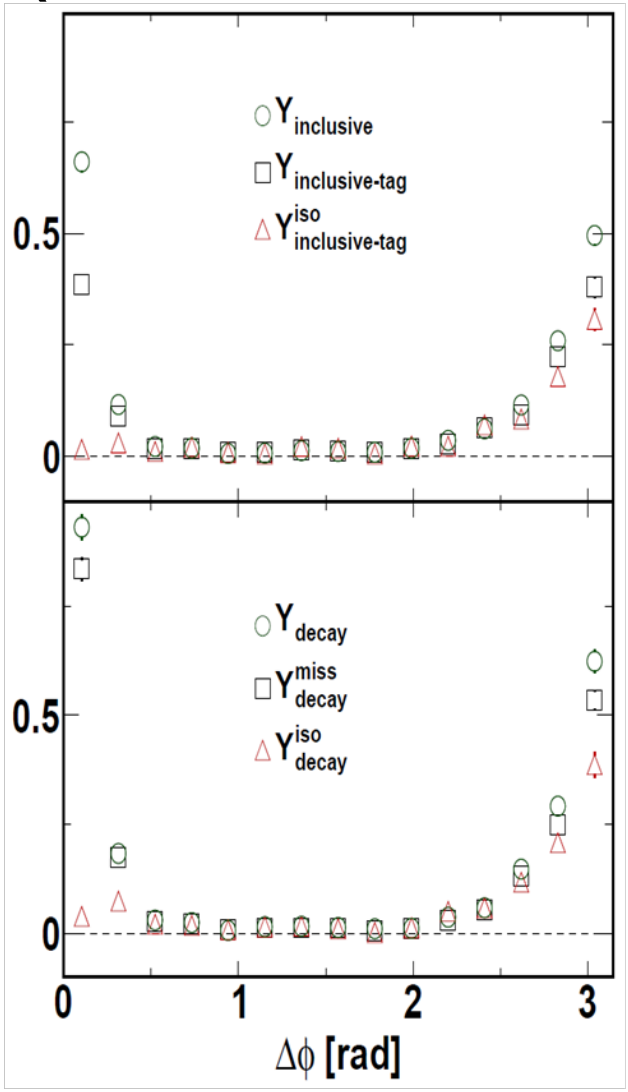
- We see fragmentation photons!

$\gamma_{frag}/\gamma_{inc}$ in p+p



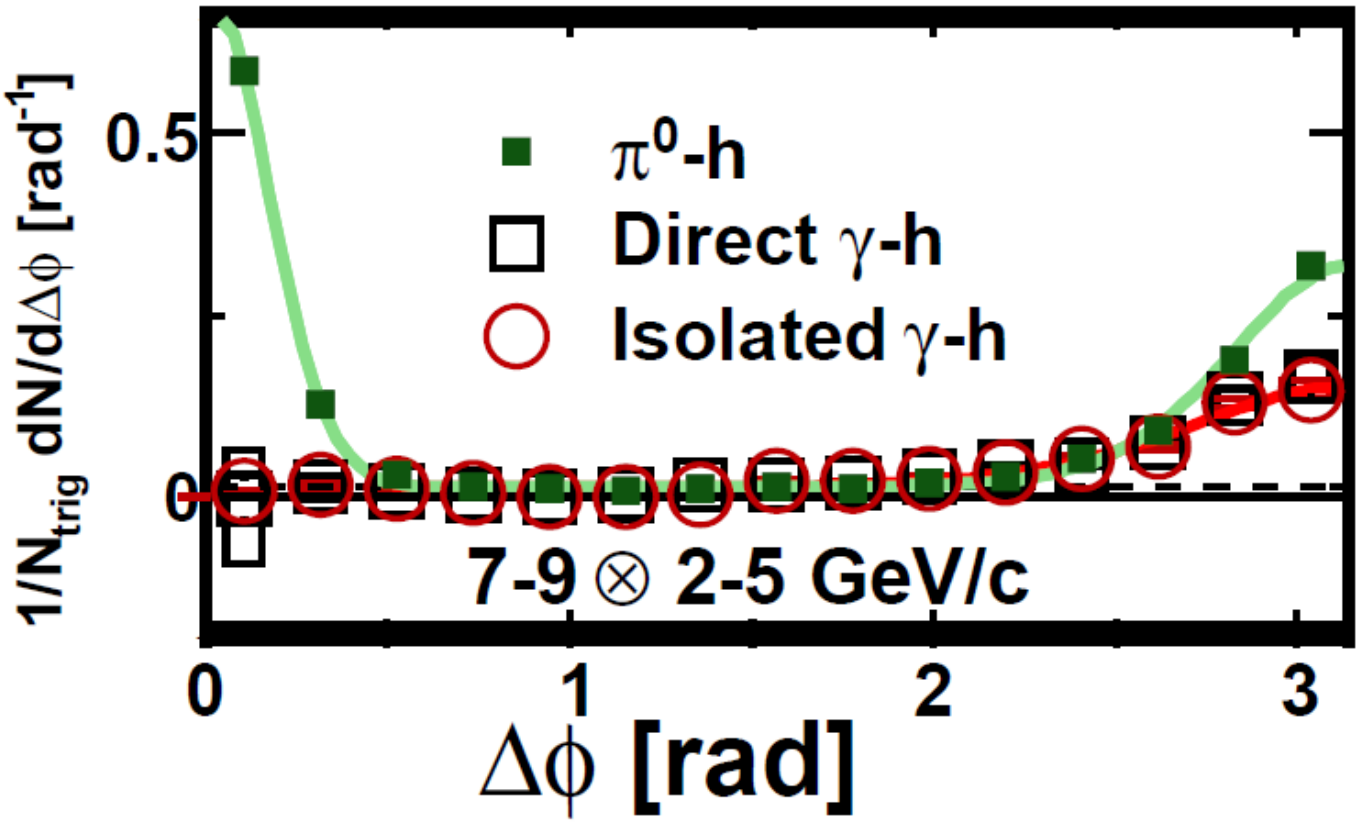
About 5-10% of the inclusive photons are from fragmentation!

Isolated direct photon (latest result!! arXiv:1006.1347)



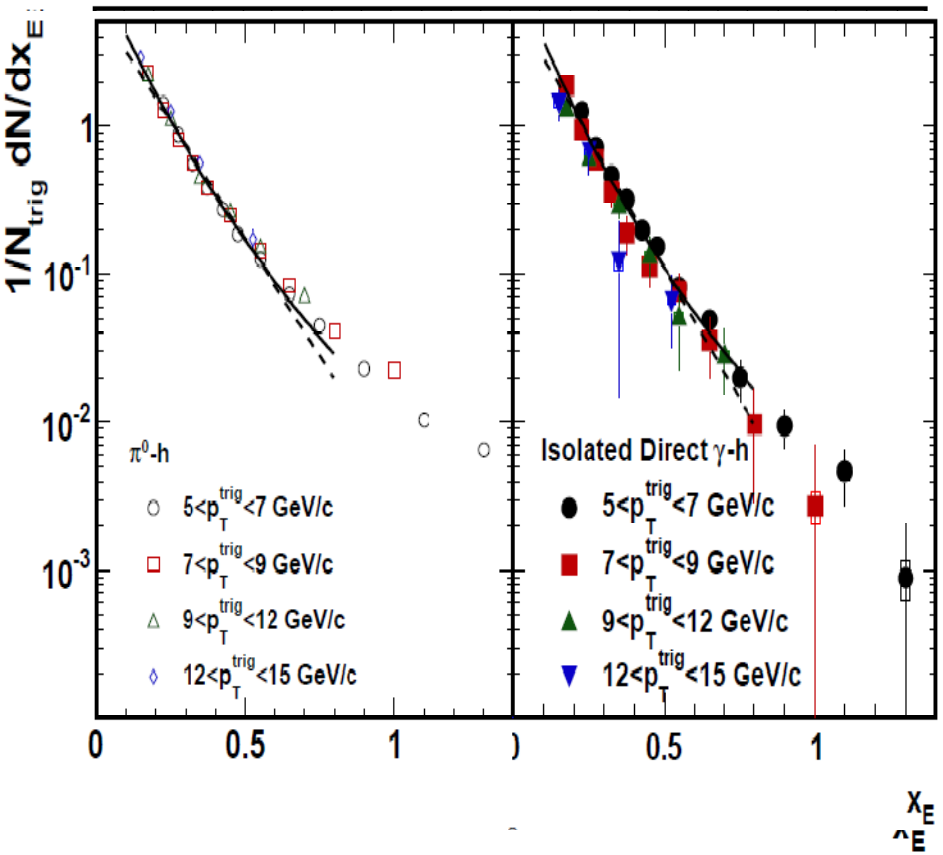
- The statistical subtraction method introduces large error
- Event-by-event direct photon ID
  - Tag the decay photon from invariant mass (π^0, η)
  - Isolation cut: (Sum of momentum of charged particles + neutral energy within cone of R = 0.3) < 10% of the photon energy
  - Reduce the contribution from fragmentation photon

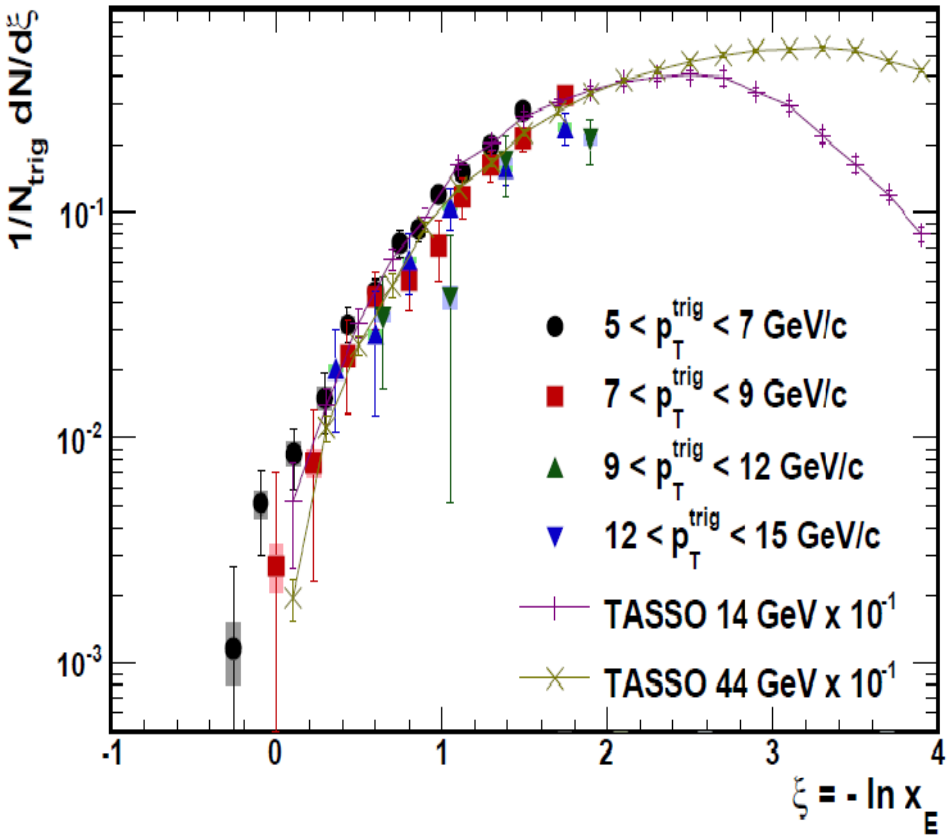
Isolated direct photon-h correlation



- Decay tagging + isolation cut reduce both statistical and systematic errors!!
- γ-h nearside yield consistent with 0
- γ-h awayside yield smaller than π^0-h

Fragmentation function of γ-h and π^0-h

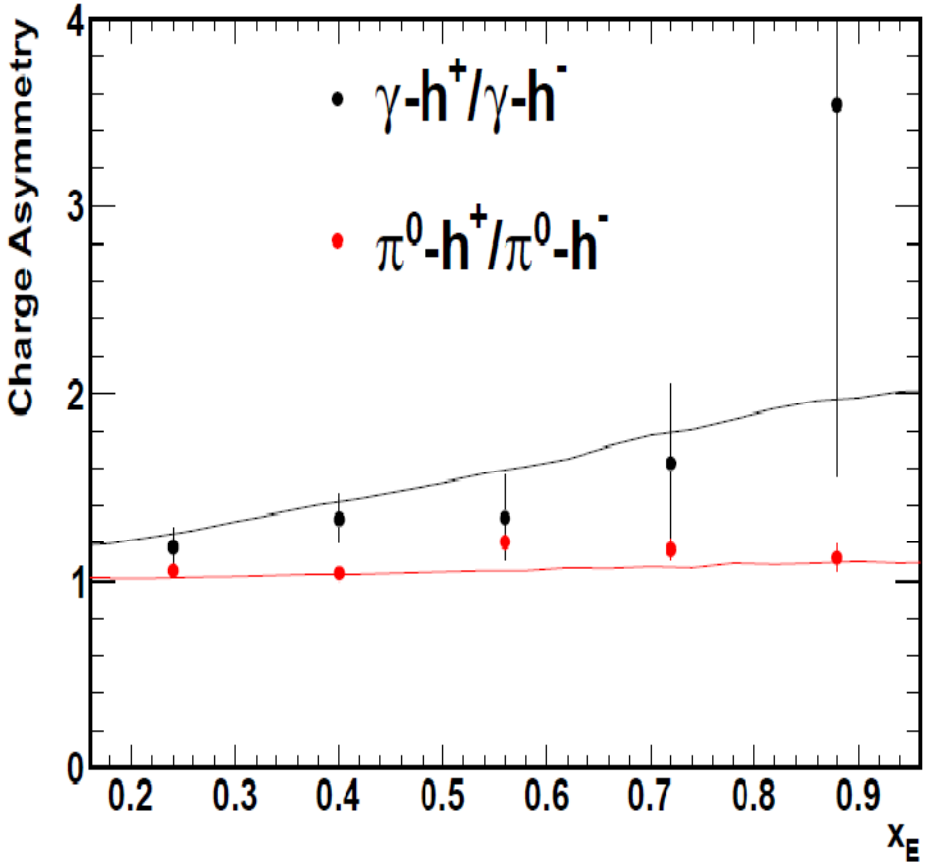




- $x_E = p_T^h/p_T^\gamma \cos(\Delta\phi)$ ~z_T
- γ-h is steeper than π^0-h!
- x_E universal scaling!

- Plot with MLLA variable $\xi = -\ln x_E$
- Good agreement with TASSO measurement (e^+e^-)
- Baseline for E-loss in AuAu

Charge asymmetry



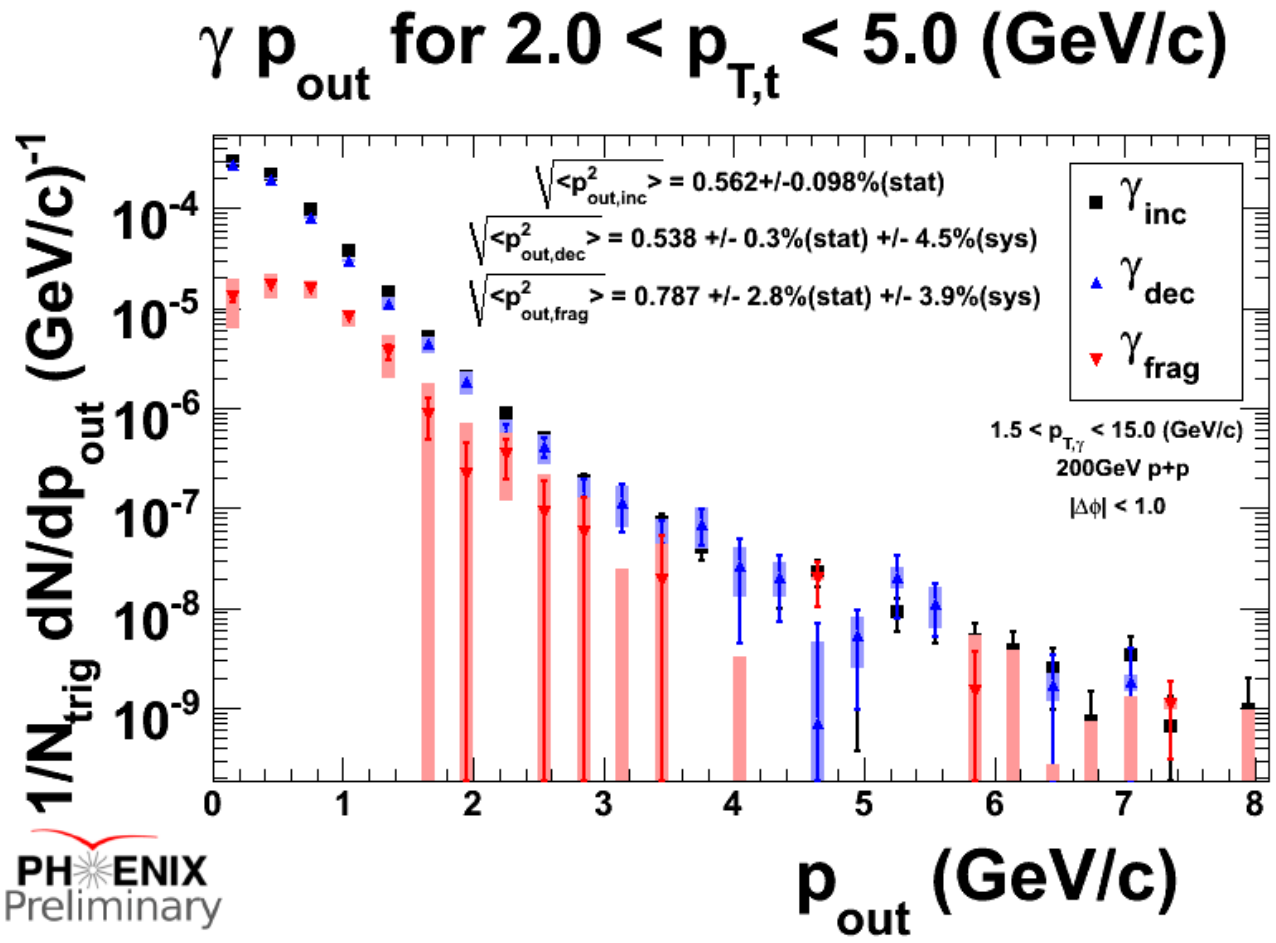
- Compton scattering dominate the direct photon production
- Charge asymmetry of valence quark (u:d = 2:1) should reflect in final state charged hadrons
- An excess of positive charge yields in γ-h!
- The recoil jet is dominated by quark fragmentation!

summary

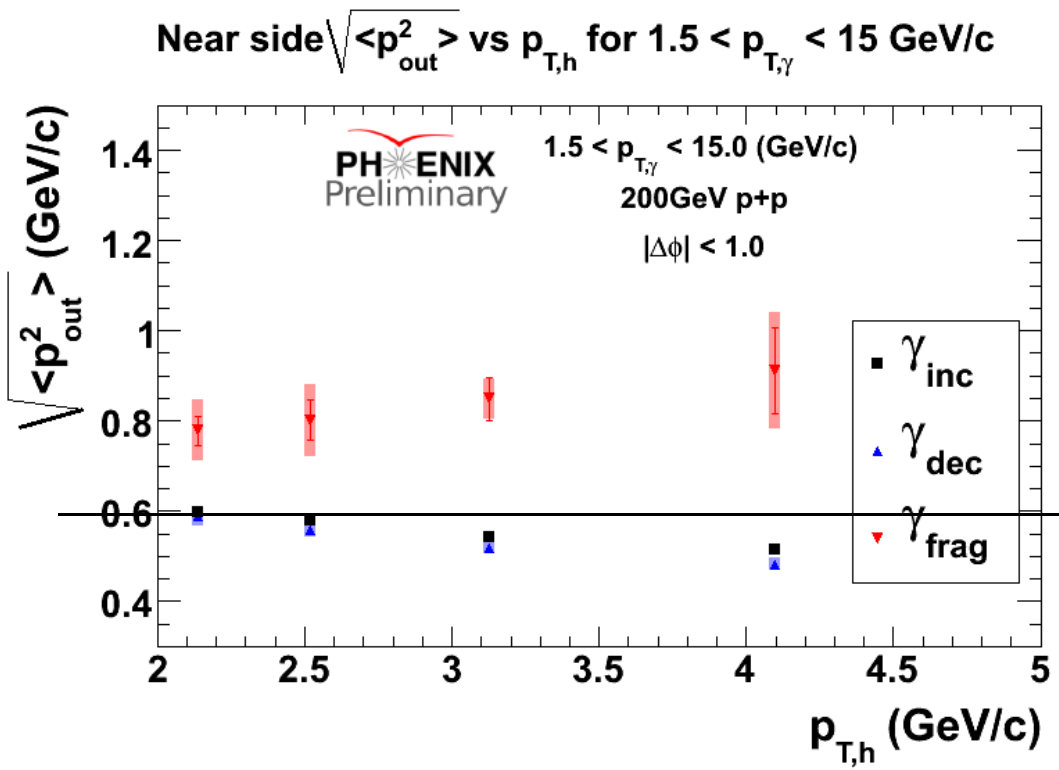
- γ-h is well measured in Au+Au and p+p
- γ-h I_{AA} consistent with R_{AA}, slightly below π^0-h I_{AA}
- Measured fragmentation photon in p+p, $\gamma_{frac}/\gamma_{inc}$ ~ 0.1
- Decay photon tagging + isolation cut significantly reduce the error bar of γ-h measurement
- The recoil jet in γ-h is dominated by quark fragmentation

Backup slides

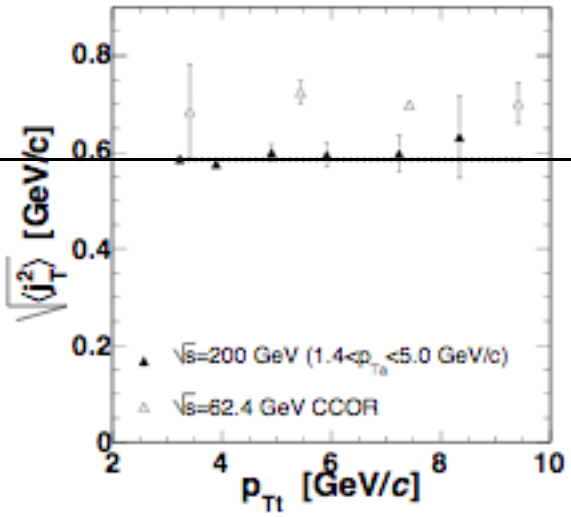
Jet property from p_{out}



h-γ_{frag} vs π^0-h



$p_{out} \sim j_{Ty,trig}$

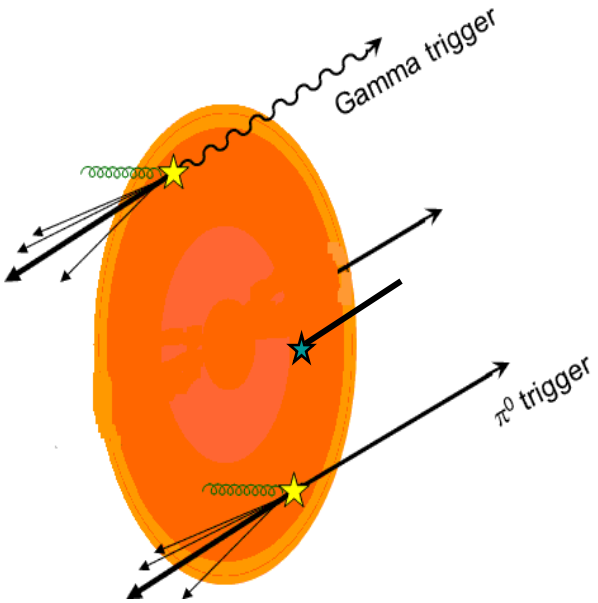


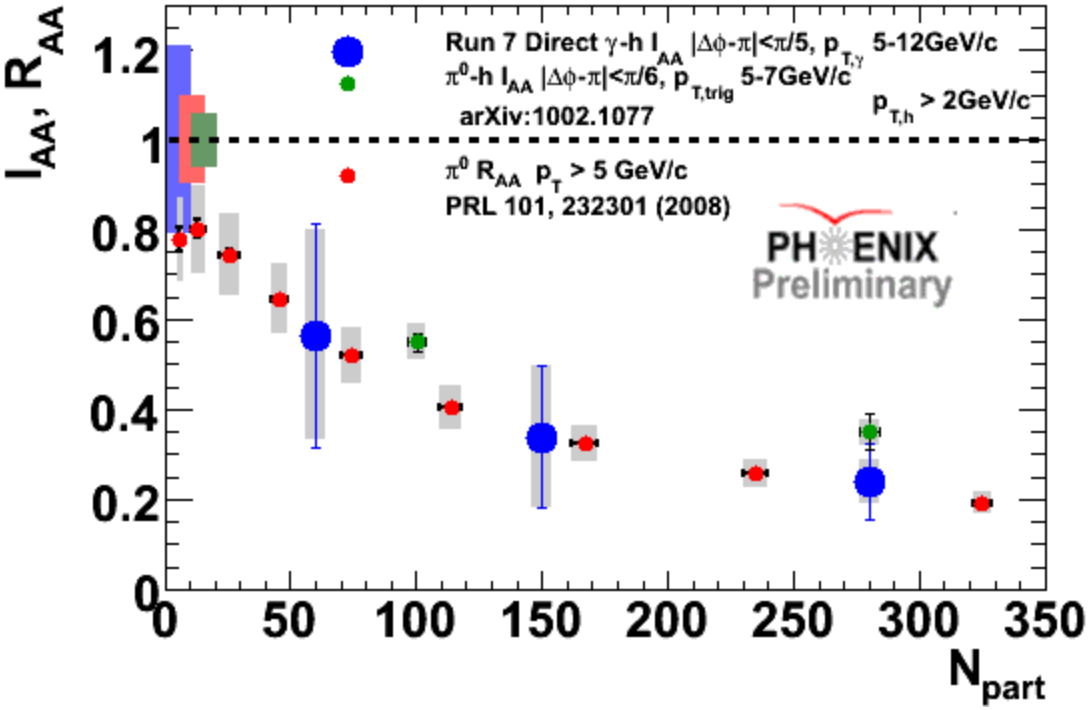
How do we measure γ_{dir}-h?

- Key formula: $Y_{direct} = \frac{R_\gamma Y_{incl} - Y_{decay}}{R_\gamma - 1}$,$R_\gamma = Y_{inc}/Y_{dec}$
- Key ingredient: inclusive γ-h, decay γ-h, R_γ

Centrality Dependence

- γ_{dir}-h I_{AA} also consistent with π^0 R_{AA}
- Surface Bias?





- π^0-h I_{AA} appears greater than π^0 R_{AA}