29TH INTERNATIONAL CONFERENCE ON ULTRARELATIVISTIC NUCLEUS - NUCLEUS COLLISIONS

APRIL 4-10, 2022

KRAKÓW, POLAND

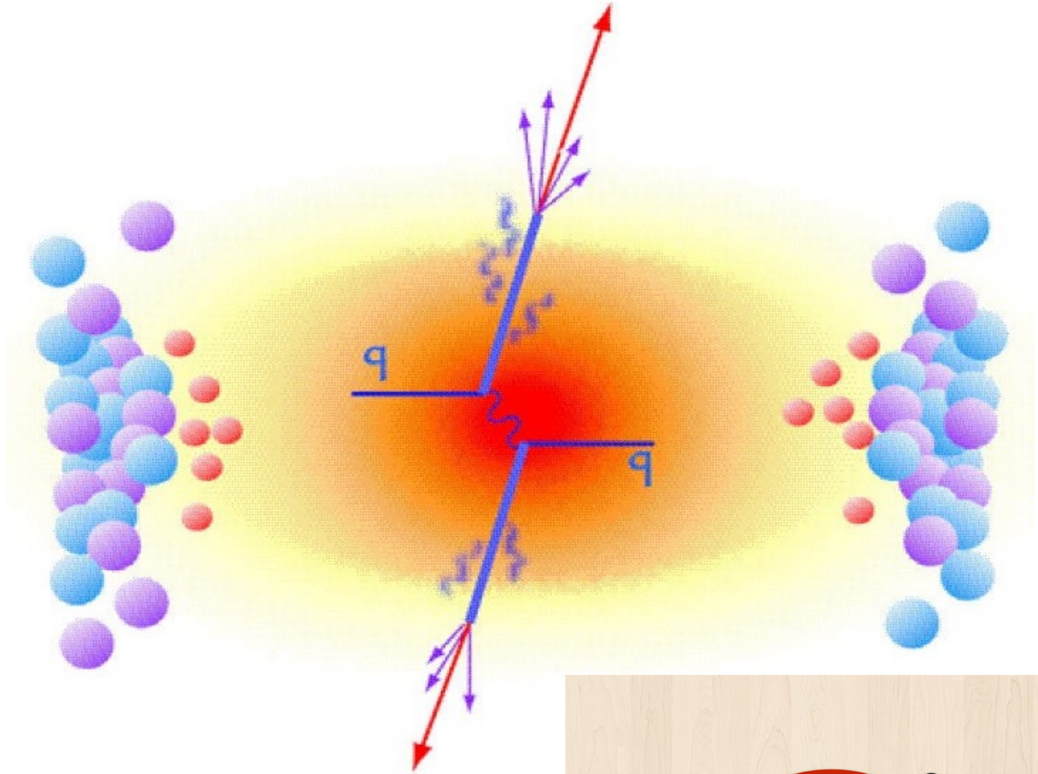
Exploring jet modification via γ-hadron and π^0-hadron correlations in Au+Au collisions at PHENIX

Megan Connors

Georgia State University

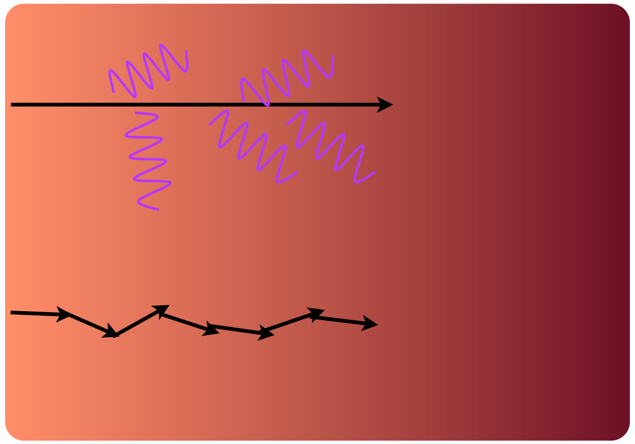
For the PHENIX Collaboration

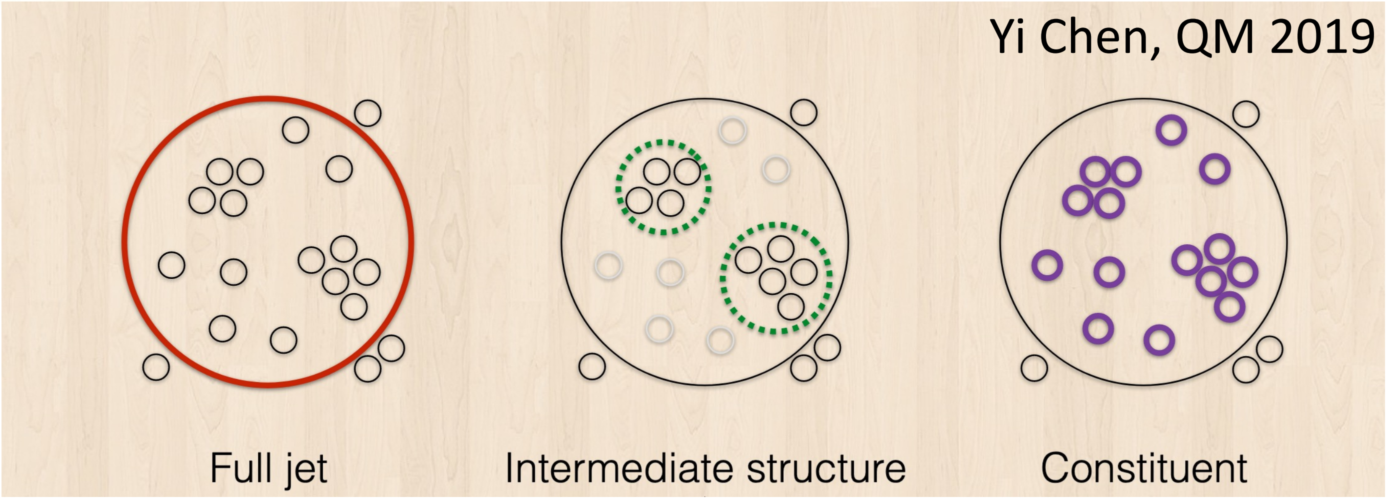
Jet modification



radiative $\rightarrow \hat{q}$

collisional $\rightarrow \hat{e}$





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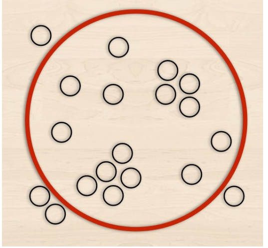
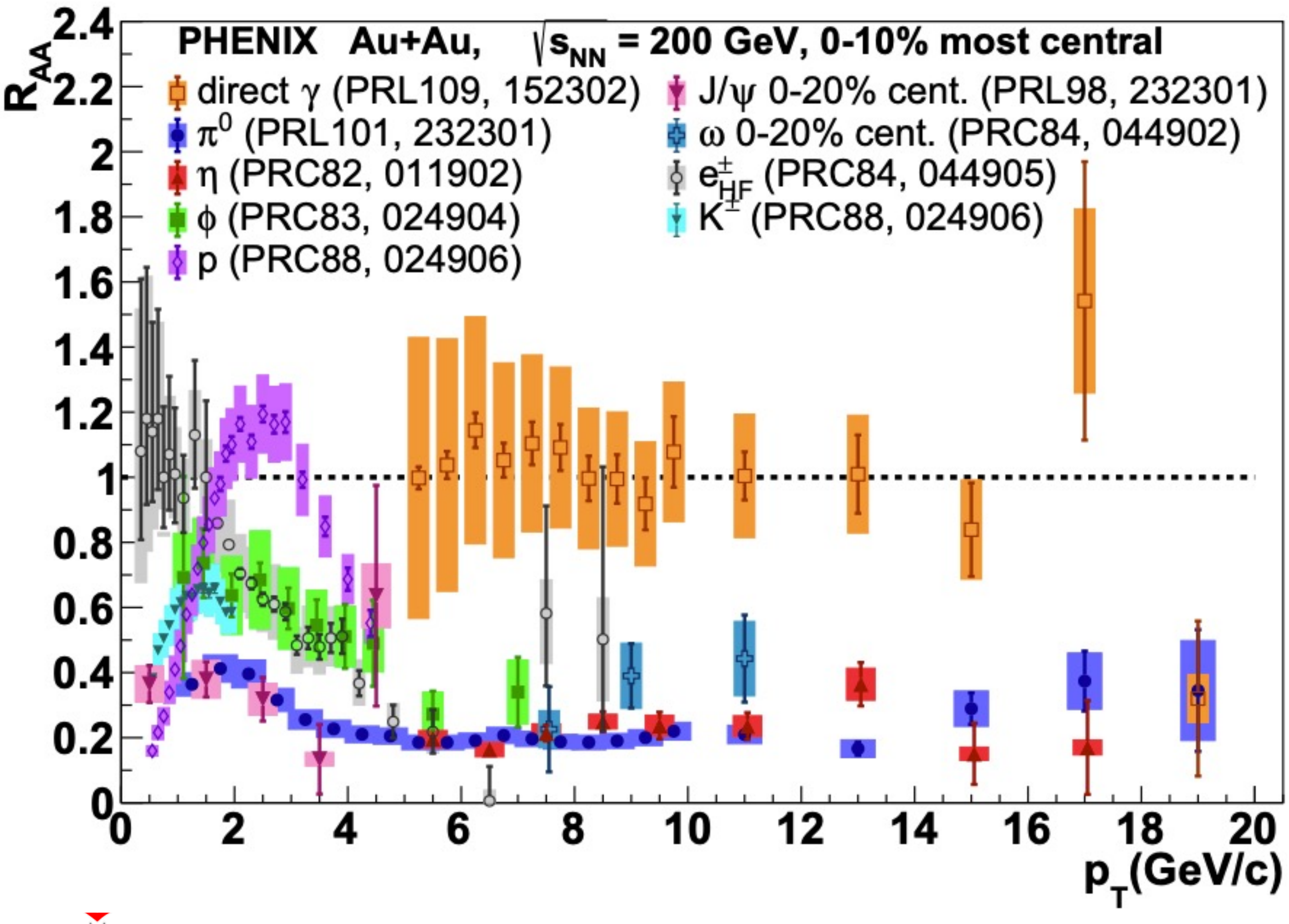
Energy loss in the QGP - I





$$R_{AA} = \frac{\sigma^{NN}}{\langle N_{Coll} \rangle} \frac{d^2N^{AA}/dp_T d\eta}{d^2\sigma_{pp}/dp_T d\eta}$$

- Suppression of high p_T hadrons in R_{AA} indicates energy loss in QGP

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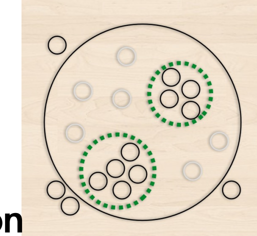
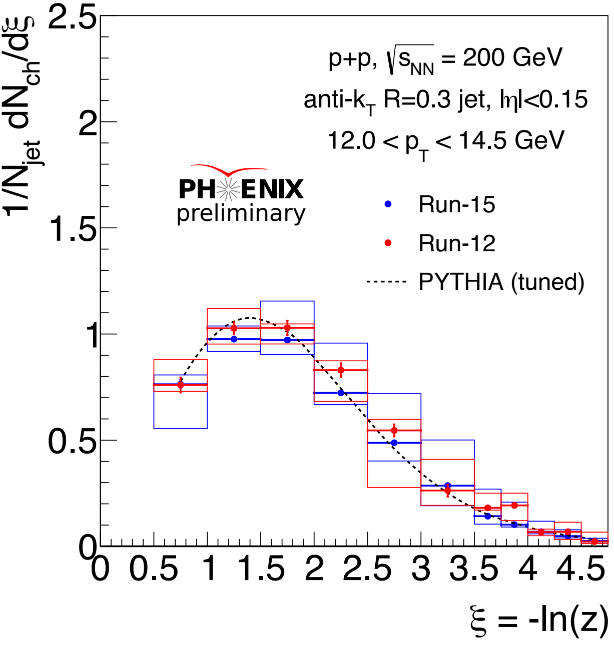
Energy loss in the QGP – II

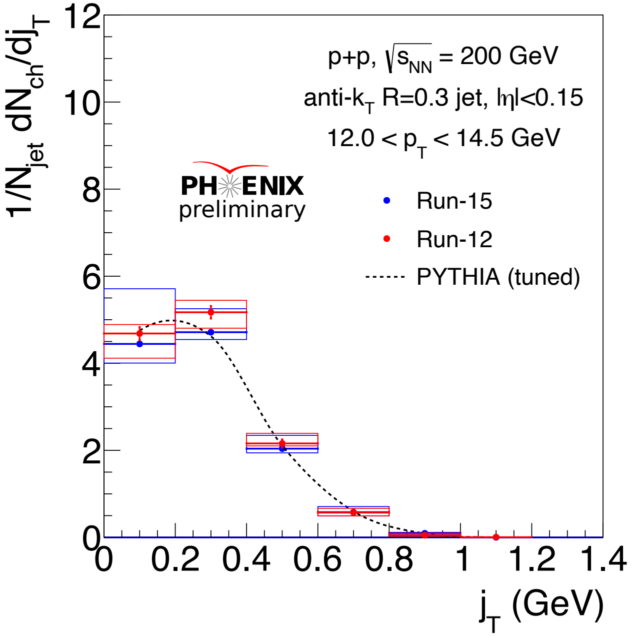


Fragmentation Function



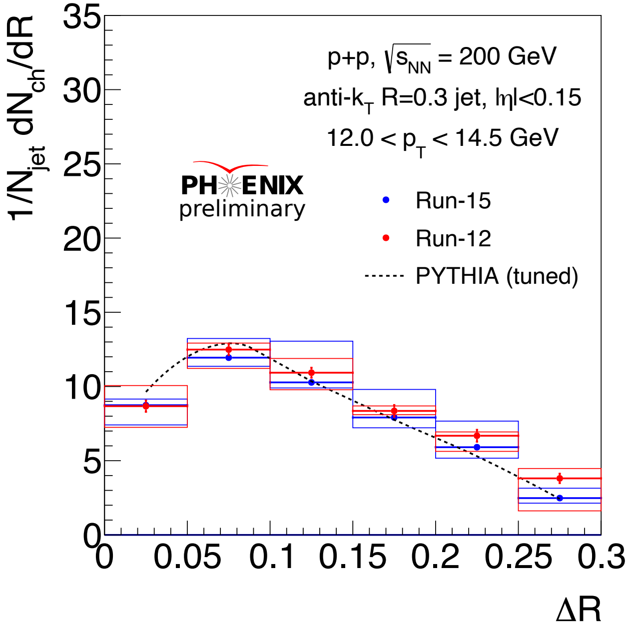
$\xi = -\ln(z) = \ln(p_{T,jet}/p_{Th})$

Transverse fragmentation



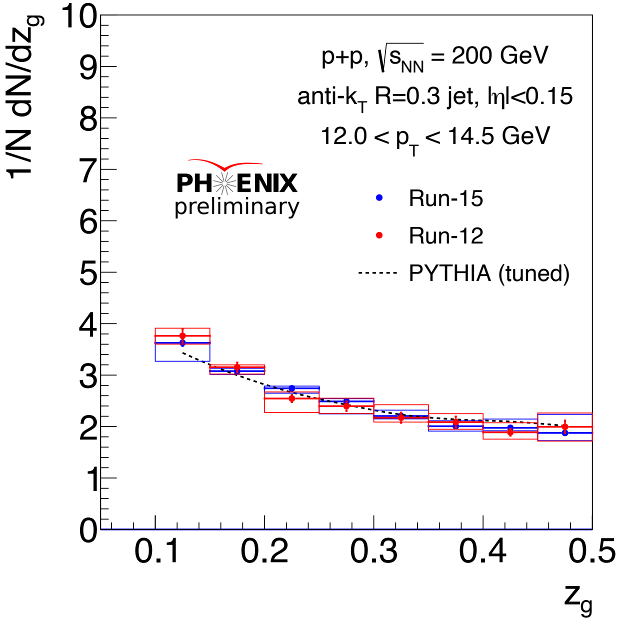
$j_T = |p_{jet} \times p_{track}| / |p_{jet}|$

Radial profile



$\Delta R = \sqrt{(\Delta\phi^2 + \Delta\eta^2)}$

Jet splitting function

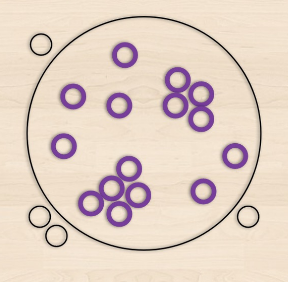


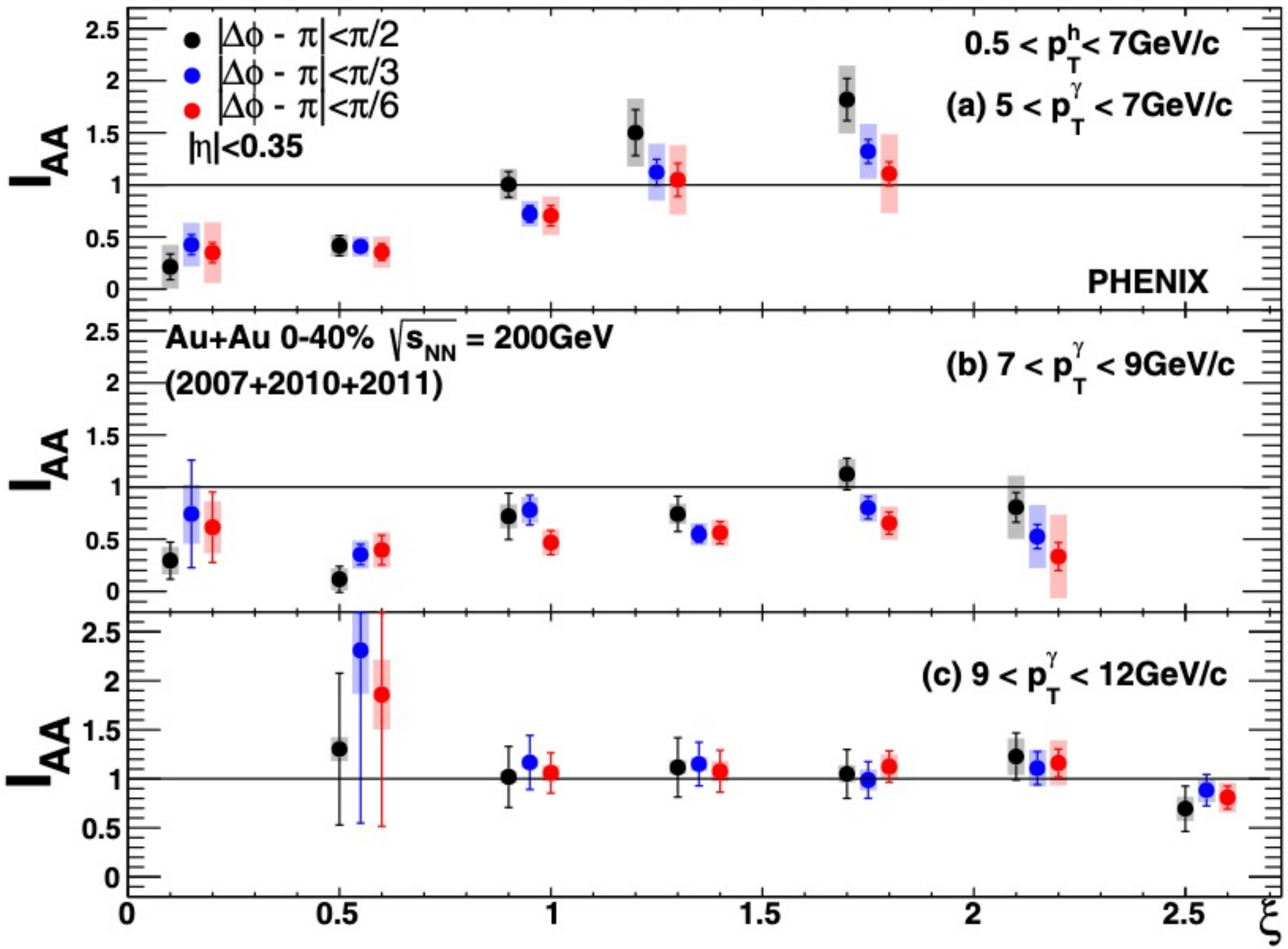
$z_g = \min(p_{T1}, p_{T2})/(p_{T1} + p_{T2})$

- PHENIX measured Jet Substructure with Reconstructed Jets in pp
- Baseline for p+A and A+A

See John Lajoie's Poster

Energy loss in the QGP - III





$I_{AA} = Y_{AA}/Y_{pp}$

- Depletion of away-side hadrons in high p_T γ–h correlations
- Angular correlations provide insight to how lost energy is redistributed
- Enhancement of low momentum particles at wider angles

PhysRevC.102.054910

$\xi = -\ln(z) = \ln(p_{T\gamma}/p_{Th})$

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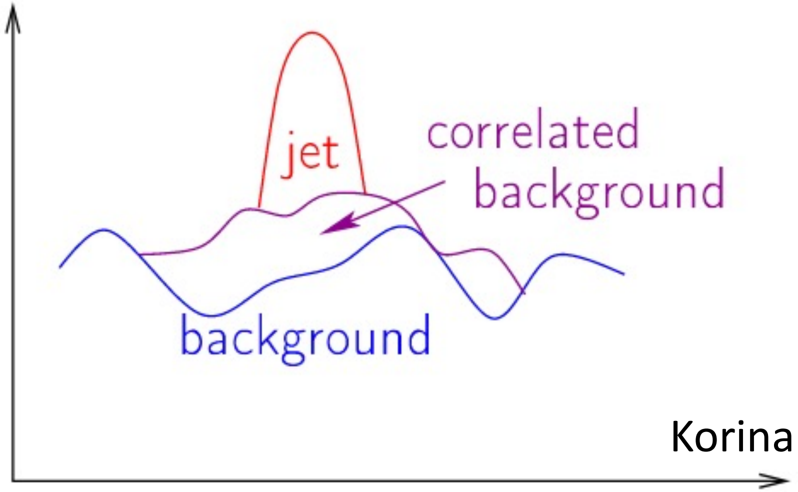
Jet Medium Interactions

- What is a jet?
  - A collimated spray defined by your algorithm
- What is a jet in the QGP?
  - Jet particles “lose” energy to the medium
  - Excited, correlated response = jet or background?
  - Medium response contains interesting physics

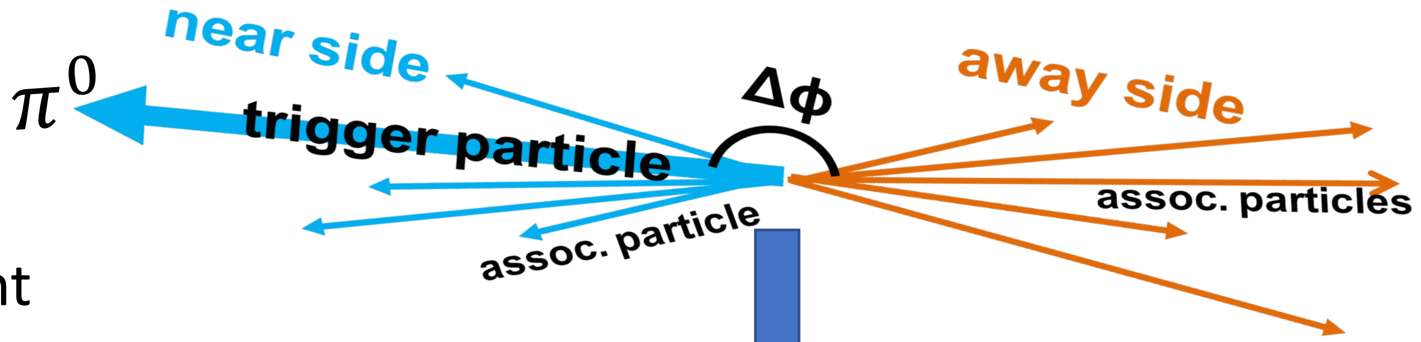


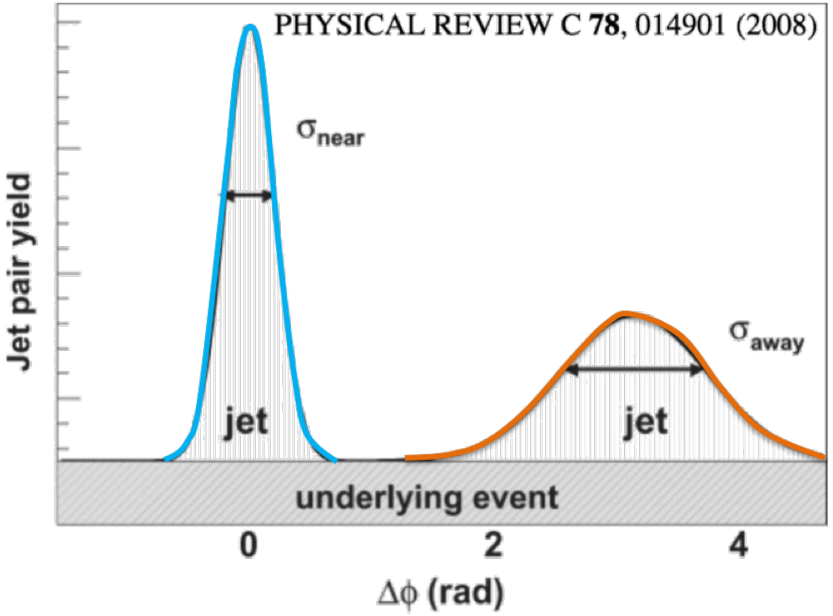
Korina Zapp

- Two particle Correlations assume jet + flow modulated background

Two Particle Correlations

- High p_T (>4 GeV/c) π^0 as trigger
  - Reconstructed with PHENIX EMCal
- Awayside jets are not biased by any jet finding algorithm or trigger requirement
- Explore lower momentum jets & fragments





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Two Particle Correlations

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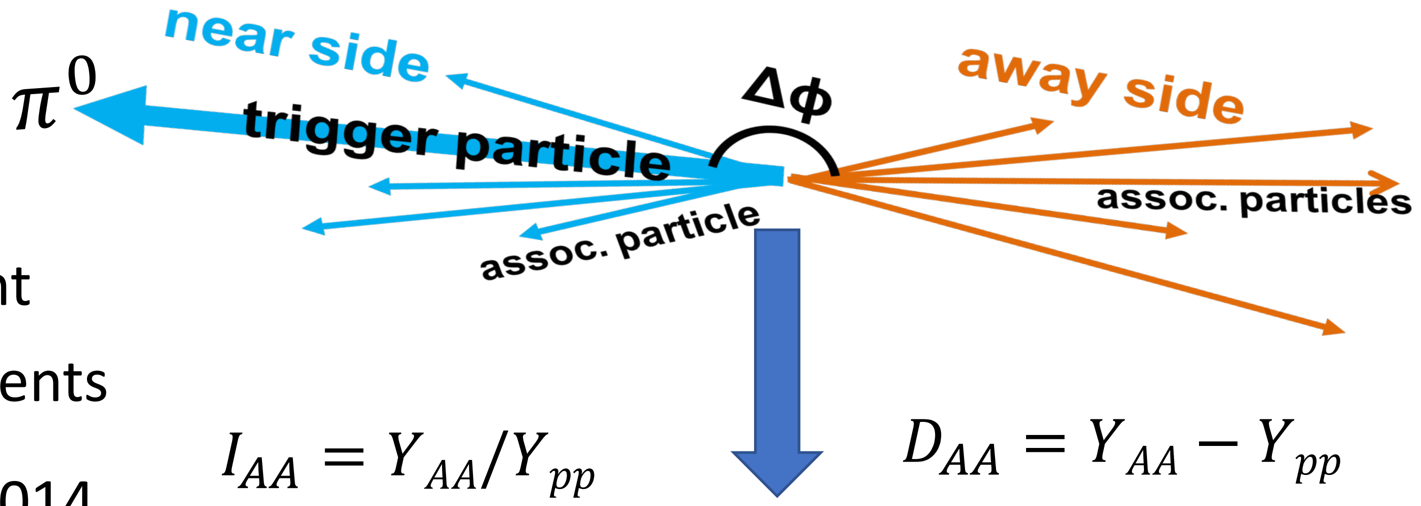
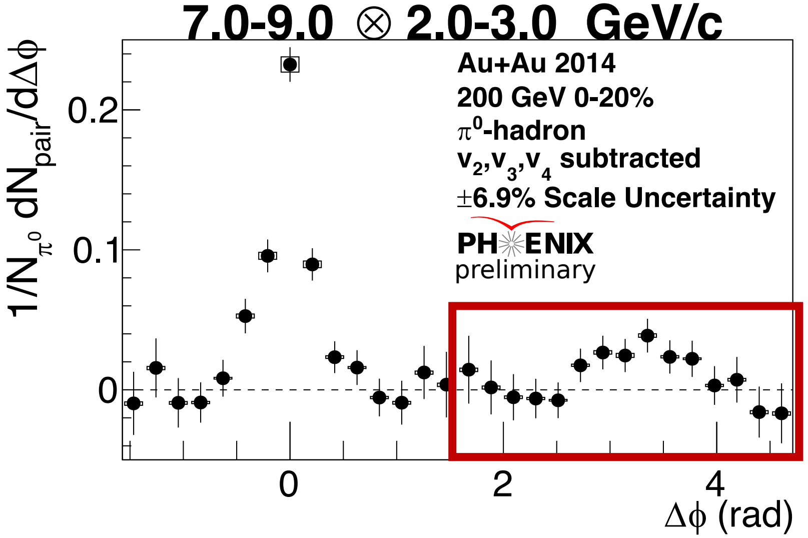
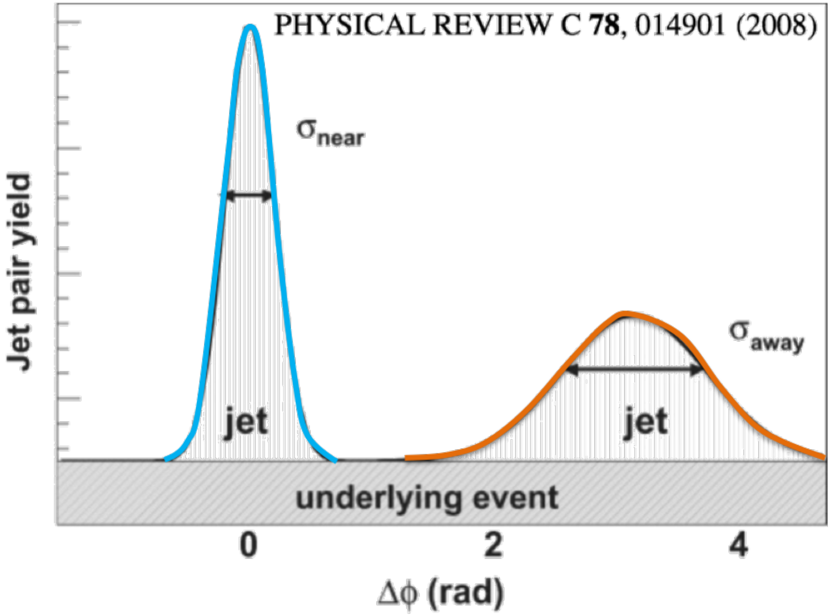


$I_{AA} = Y_{AA}/Y_{pp}$ $D_{AA} = Y_{AA} - Y_{pp}$

- Utilizing higher statistics dataset from 2014
- Subtract v_2, v_3 and v_4
- Focus on modification of awayside yield, Y
  - As a function of Δϕ
  - For various p_T bins





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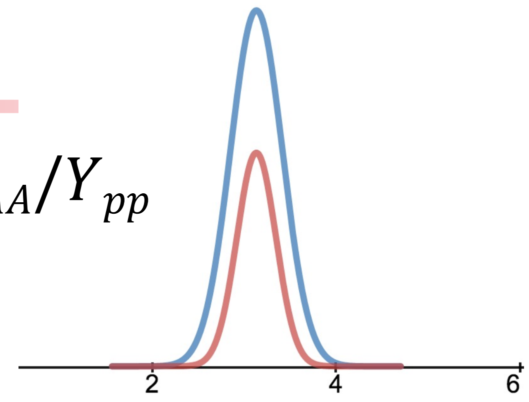
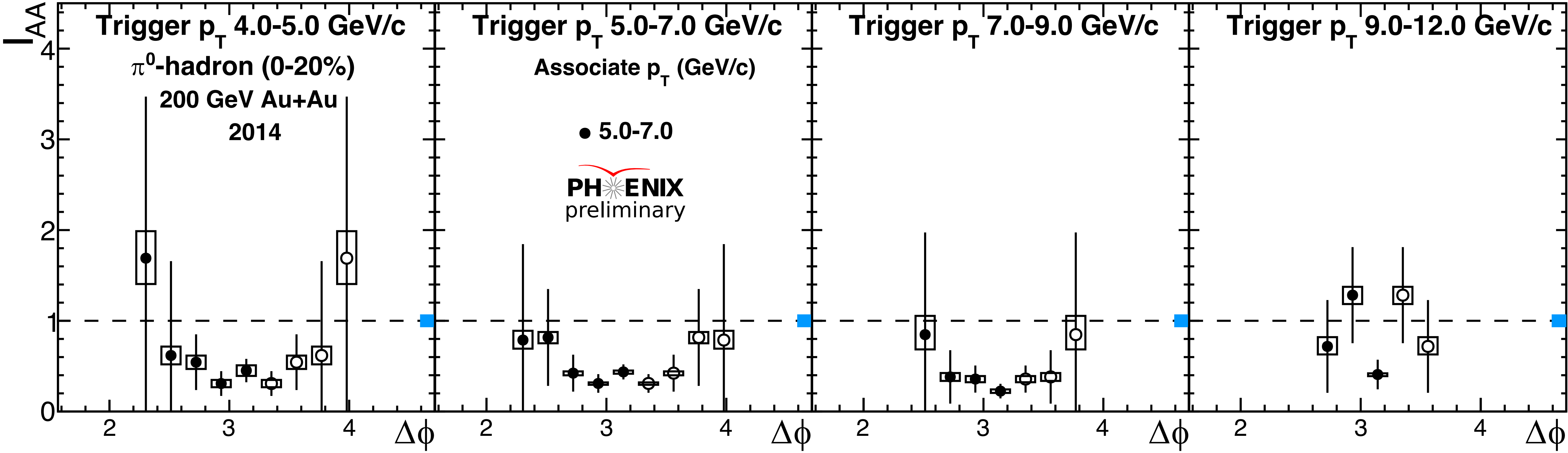
I_{AA} vs $\Delta\varphi$

$$I_{AA} = Y_{AA}/Y_{pp}$$



- Suppression of high momentum hadrons



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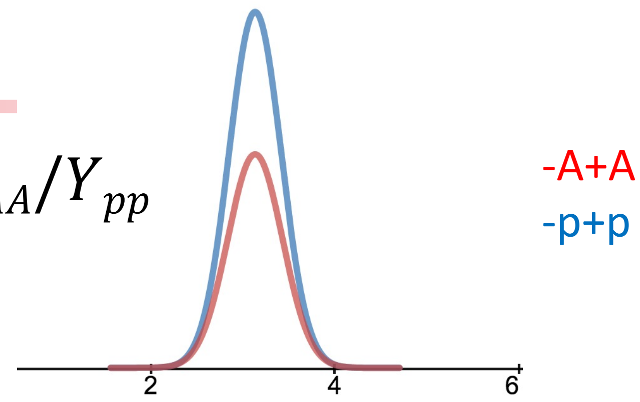

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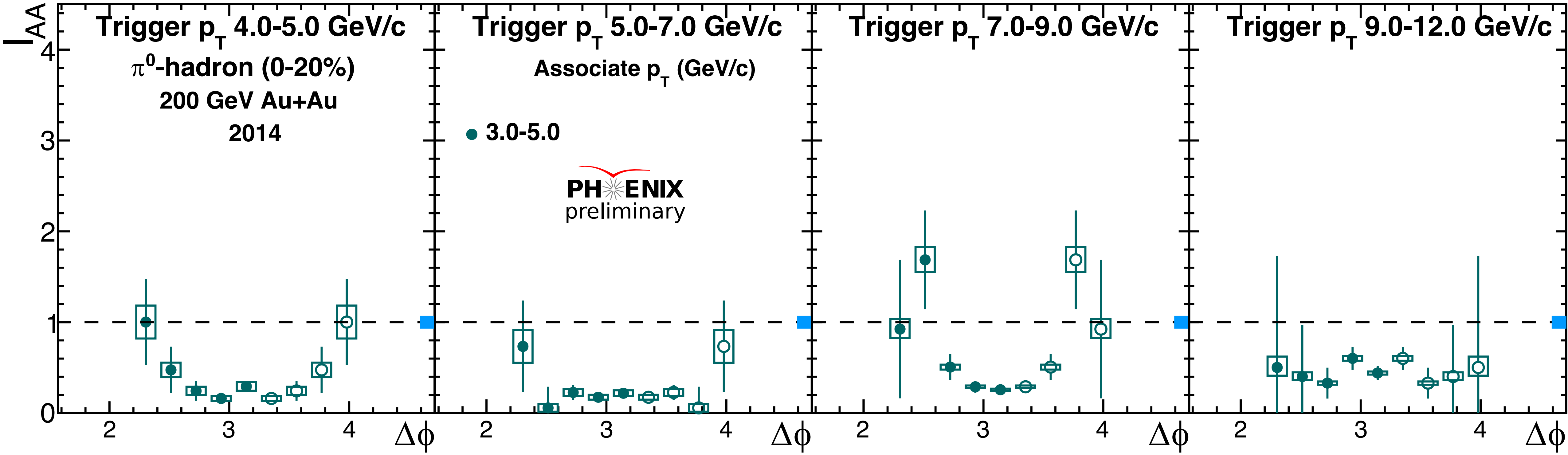

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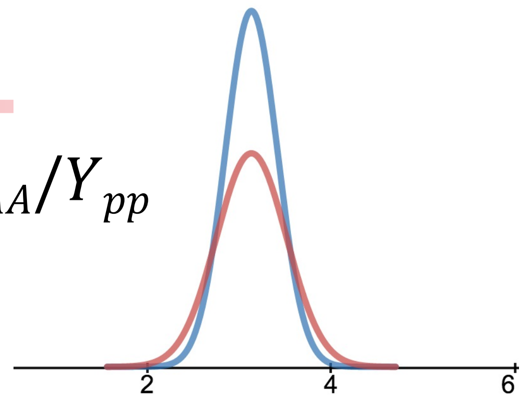
$$I_{AA} = Y_{AA}/Y_{pp}$$



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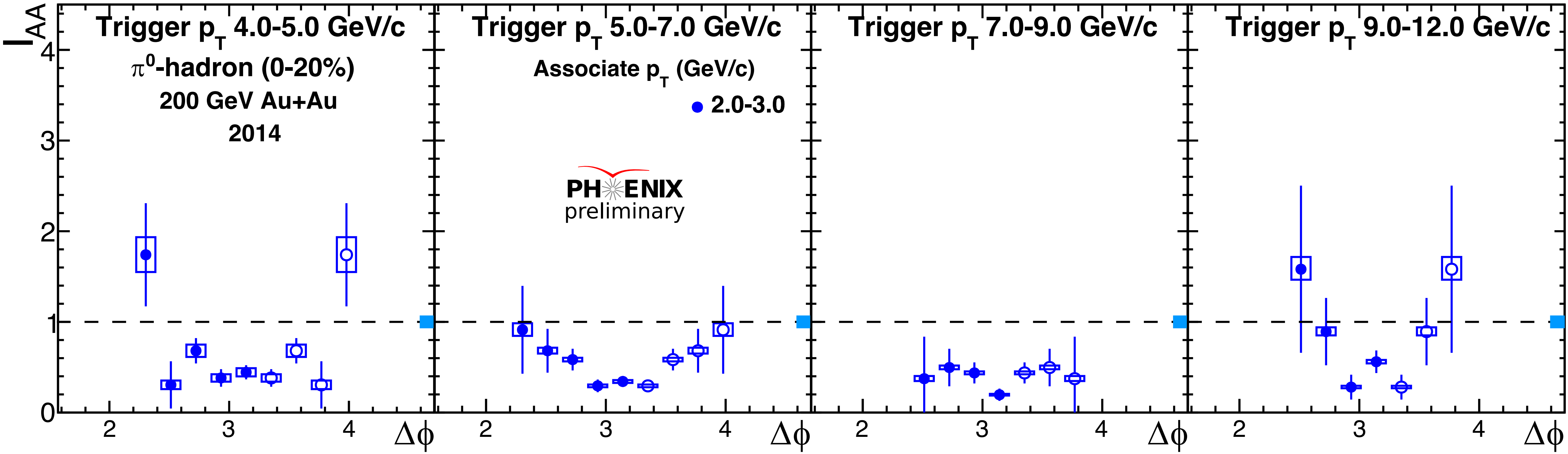
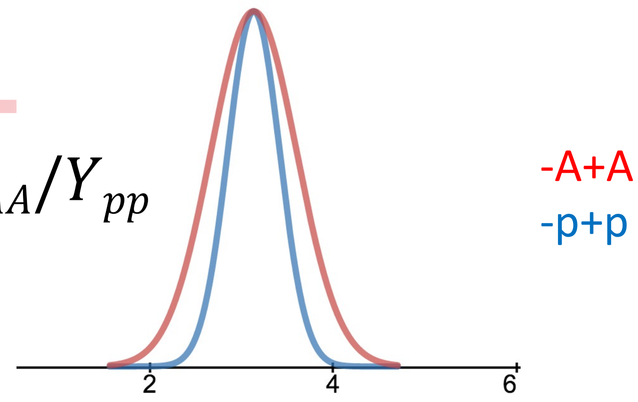


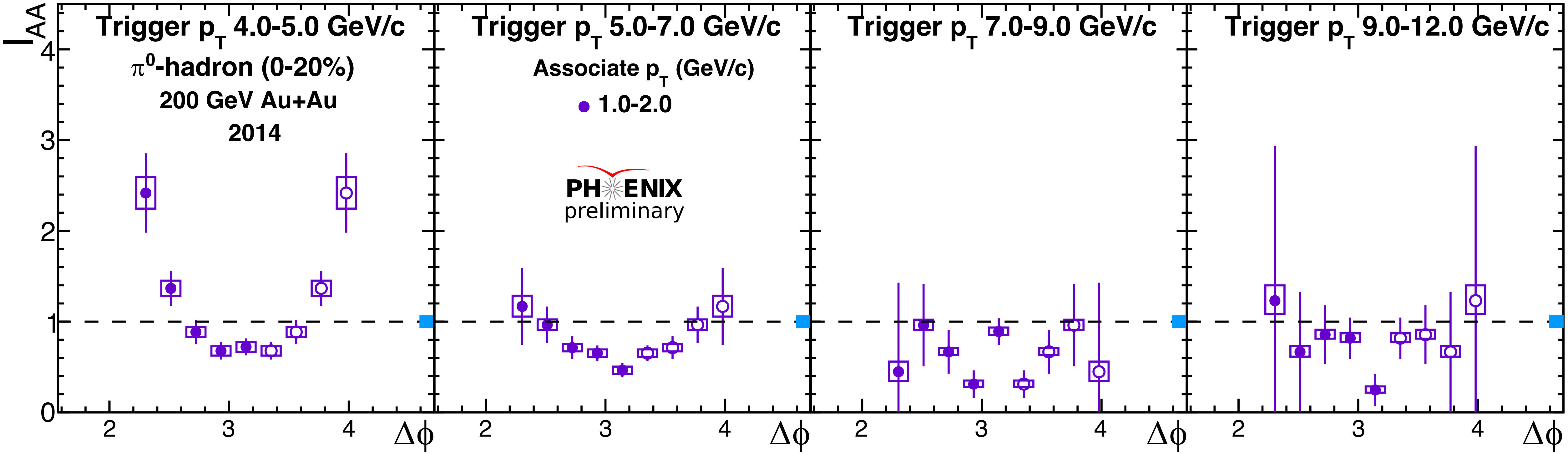
PHENIX

I_{AA} vs $\Delta\varphi$

$$I_{AA} = Y_{AA}/Y_{pp}$$

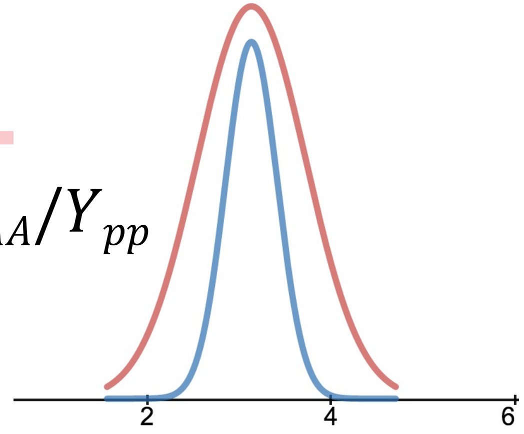


- Suppression of high momentum hadrons
- Enhancement at large angles for lower p_T hadrons

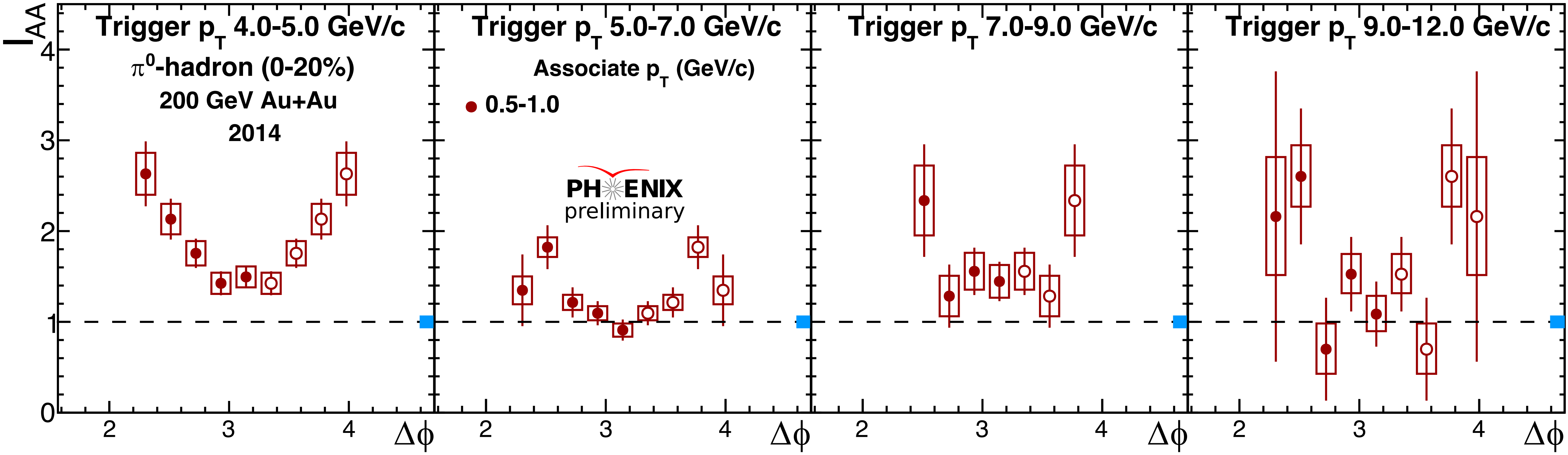


I_{AA} vs $\Delta\varphi$

$$I_{AA} = Y_{AA}/Y_{pp}$$



- Suppression of high momentum hadrons
- Enhancement most pronounced at large angles for lower p_T hadrons



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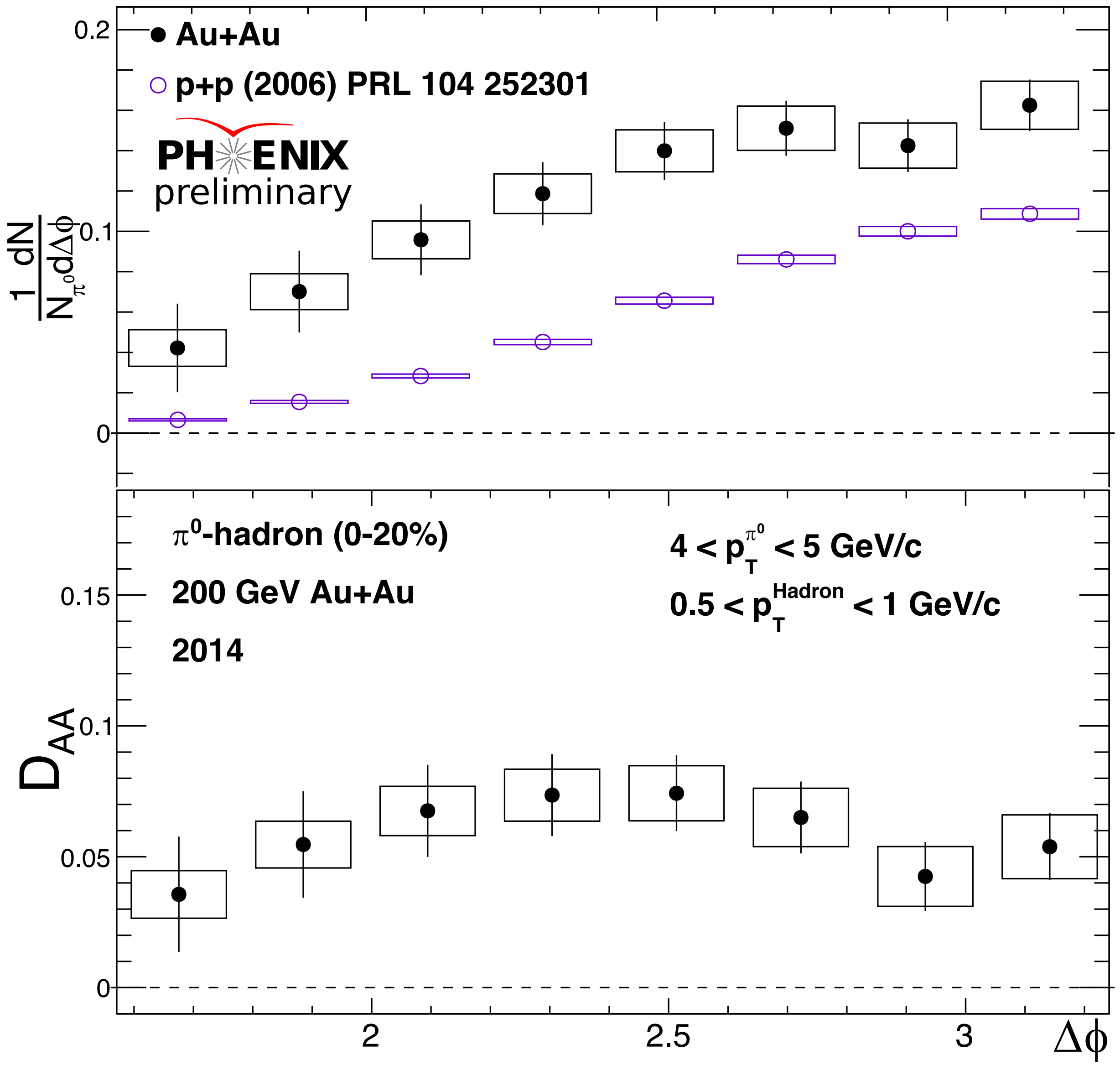
$D_{AA}\,(\Delta\varphi)$

$$D_{AA} = Y_{AA} - Y_{pp}$$

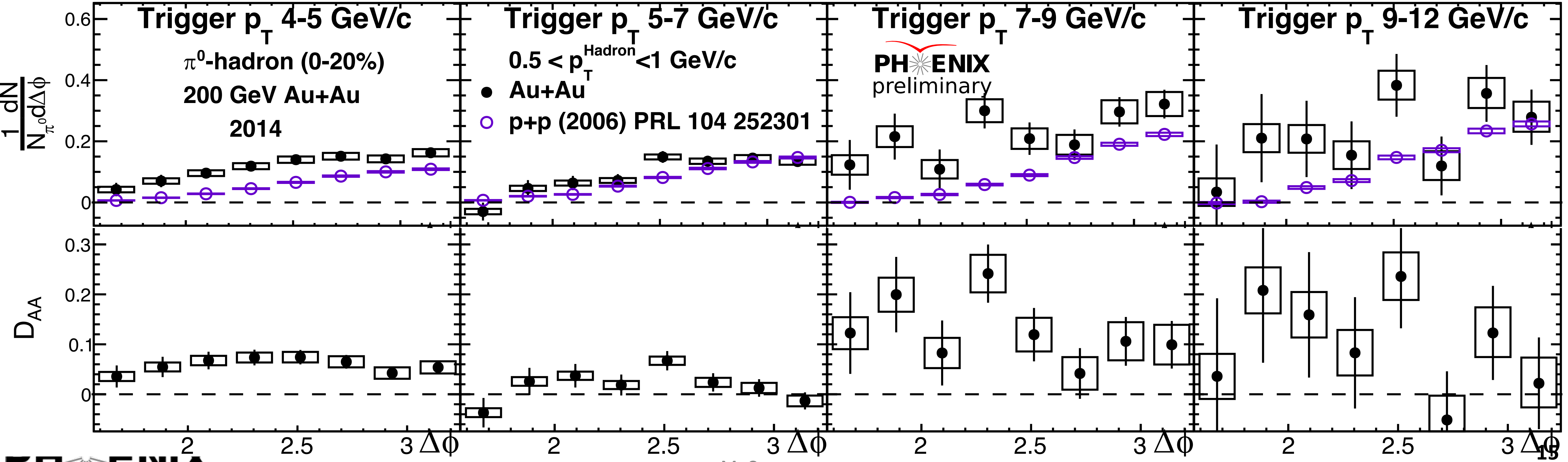
- Measure the difference in the yields instead of the ratio
- Less sensitive to yields near zero than ratio
- Enhancement: $D_{AA} > 0$
- Suppression: $D_{AA} < 0$



$D_{AA}(\Delta\varphi)$ for fixed Associated Hadron p_T

$$D_{AA} = Y_{AA} - Y_{pp}$$

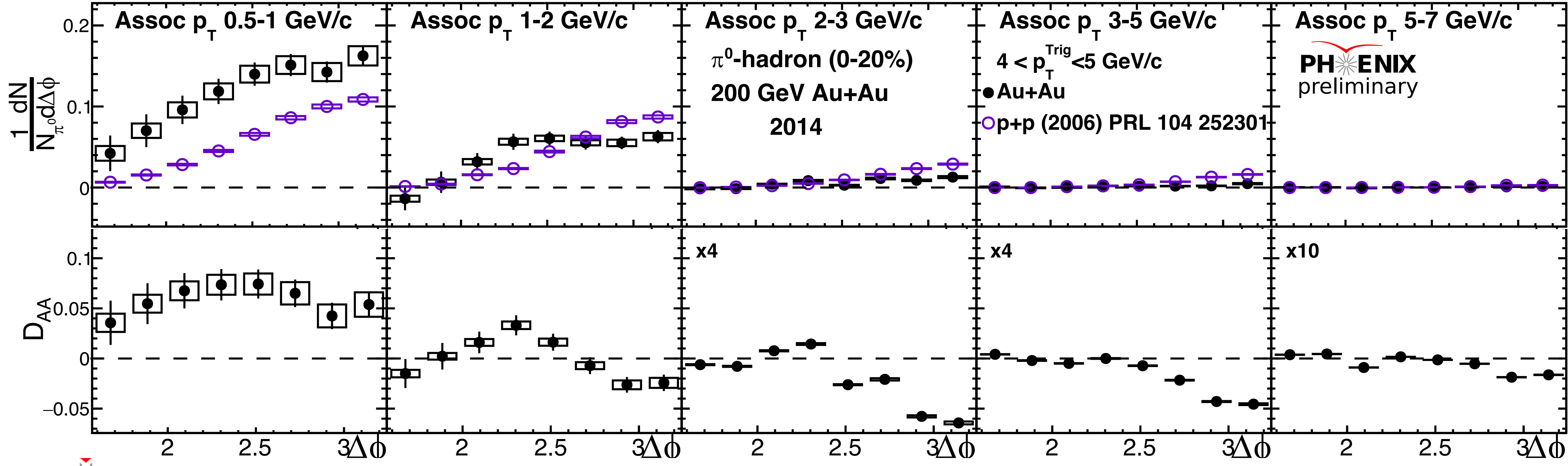
- Measure the difference in the yields instead of the ratio
- Less sensitive to yields near zero



$D_{AA}(\Delta\varphi)$ for fixed Trigger p_T

$$D_{AA} = Y_{AA} - Y_{pp}$$

- What is the dependence on hadron p_T?
- Trigger p_T: 4-5 GeV/c



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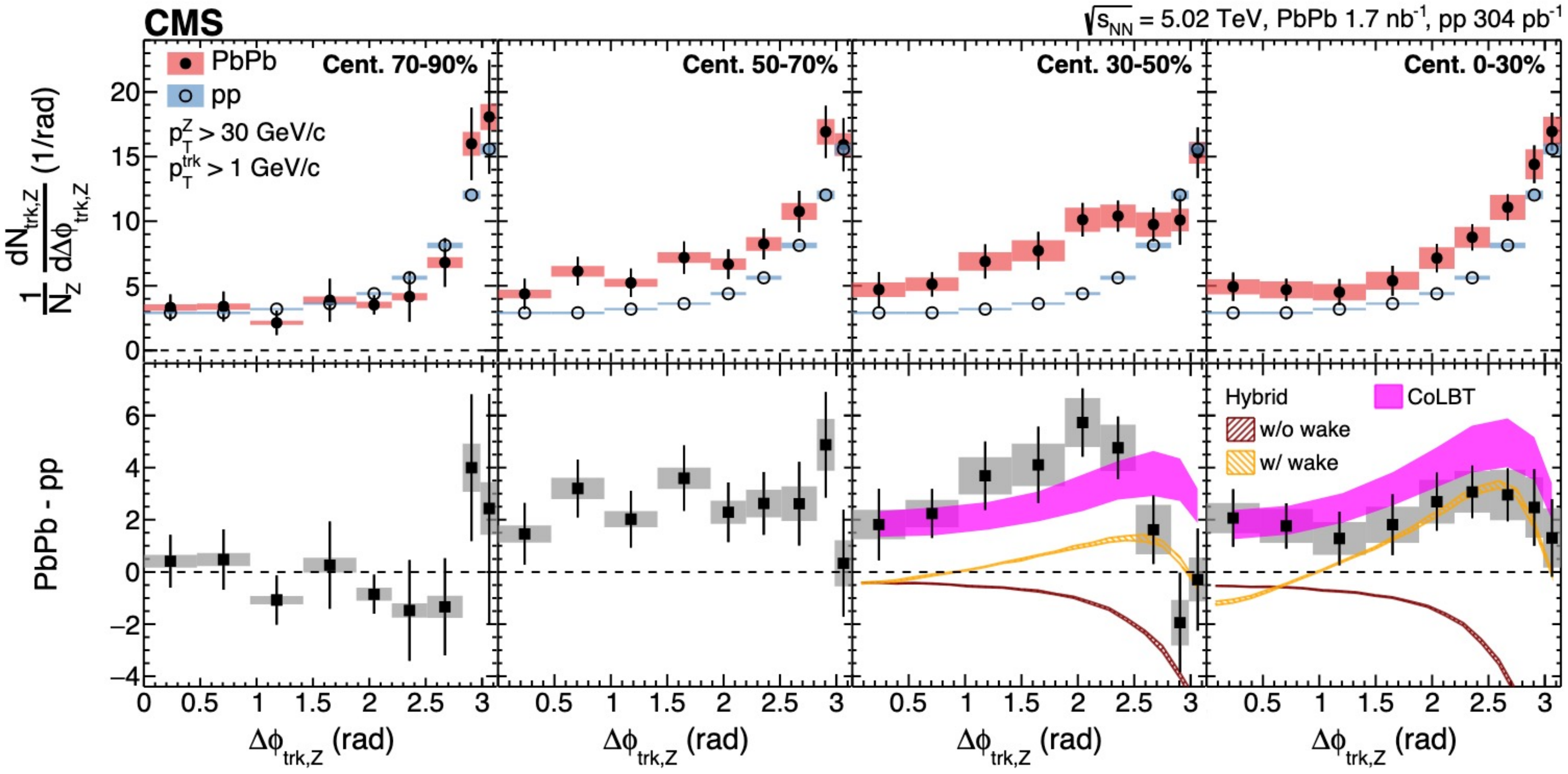
An Aside: D_{AA} ($\Delta\varphi$) from Z-track Correlations (CMS)

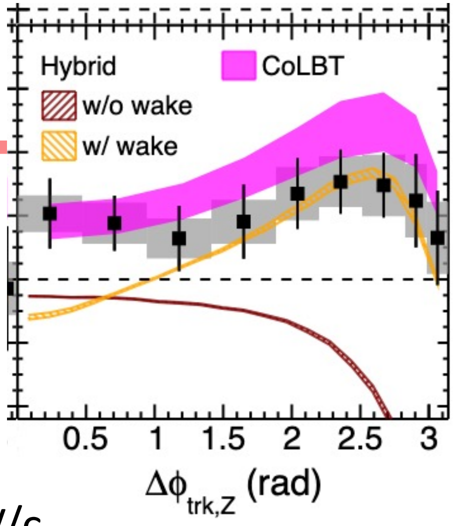
- CMS extracted D_{AA} from Z-track correlations
  - Z p_T > 30 GeV/c
  - Track p_T > 1 GeV/c
- Theory comparisons:
  - CoLBT
  - Hybrid: w/ & w/o wake
- PHENIX π^0–h:
  - What is the p_T dependence?
  - Dependence on RHIC vs LHC energies?



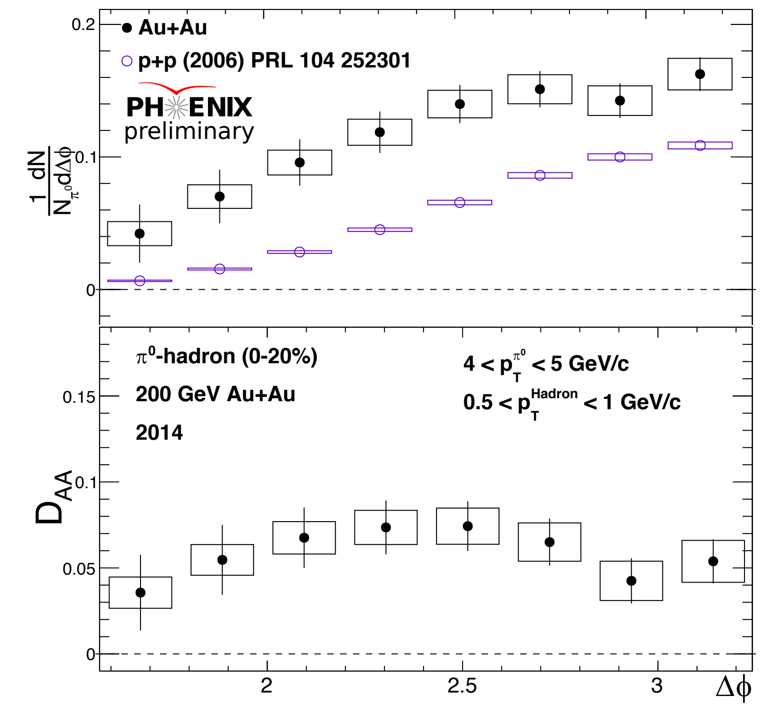
Phys. Rev. Lett. 128 (2022) 122301

Potential Implications

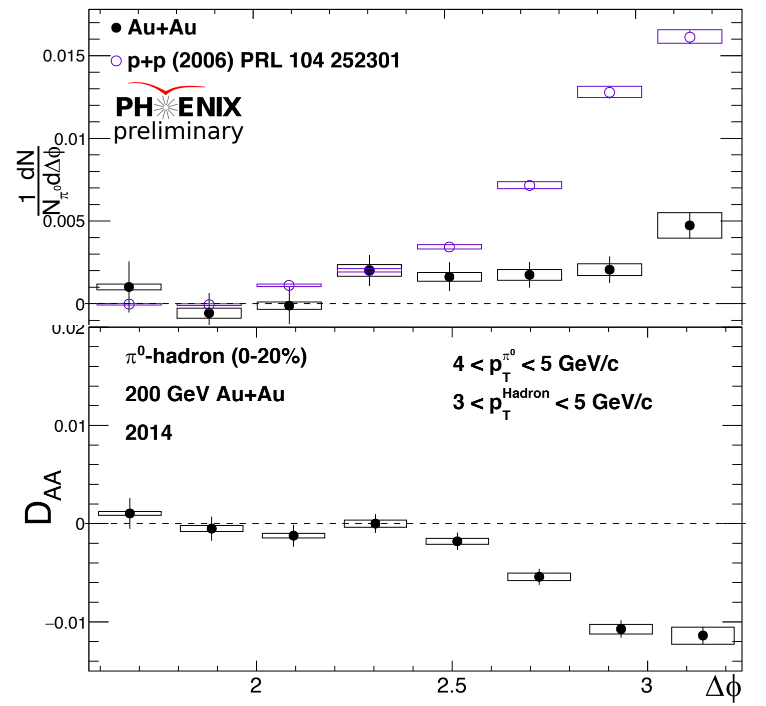
- Hybrid model shows different behavior with and without wake (medium response)
- What is the p_T dependence to this feature?
  - PHENIX π^0–h may imply wake is more relevant for low p_T hadrons



0.5 < $p_{T,h}$ < 1 GeV/c



3 < $p_{T,h}$ < 5 GeV/c



PHENIX

Potential Implications

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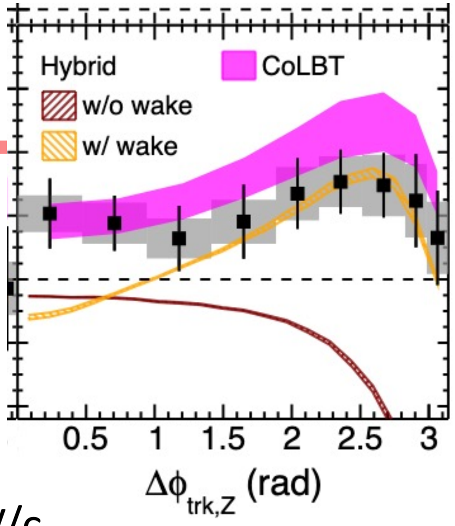
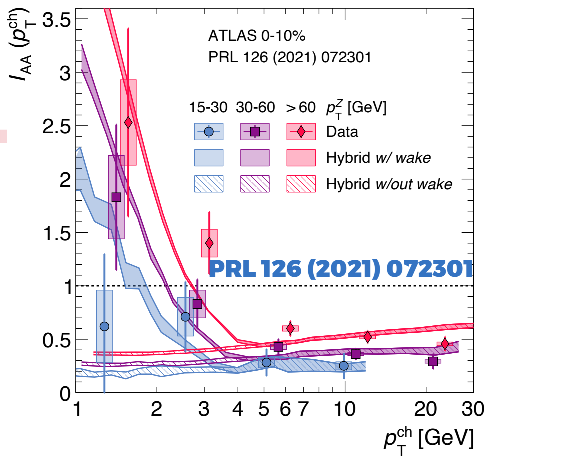
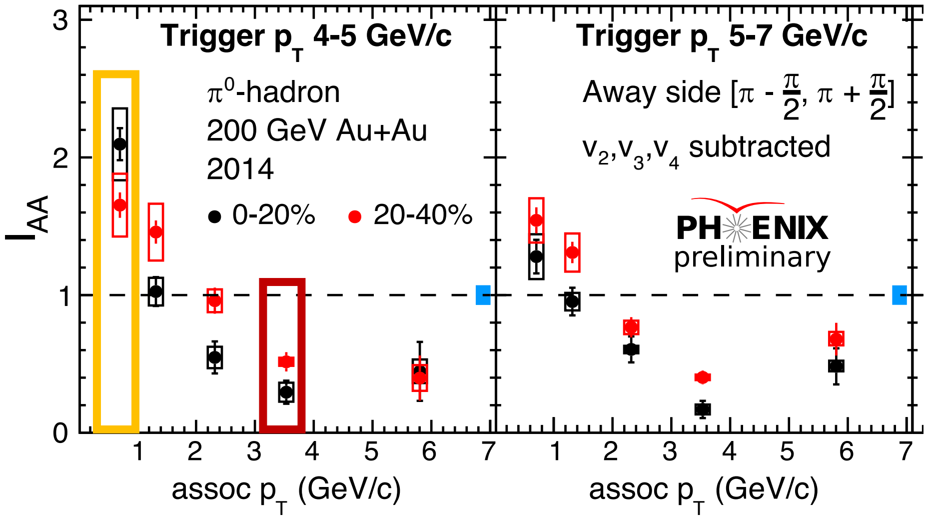
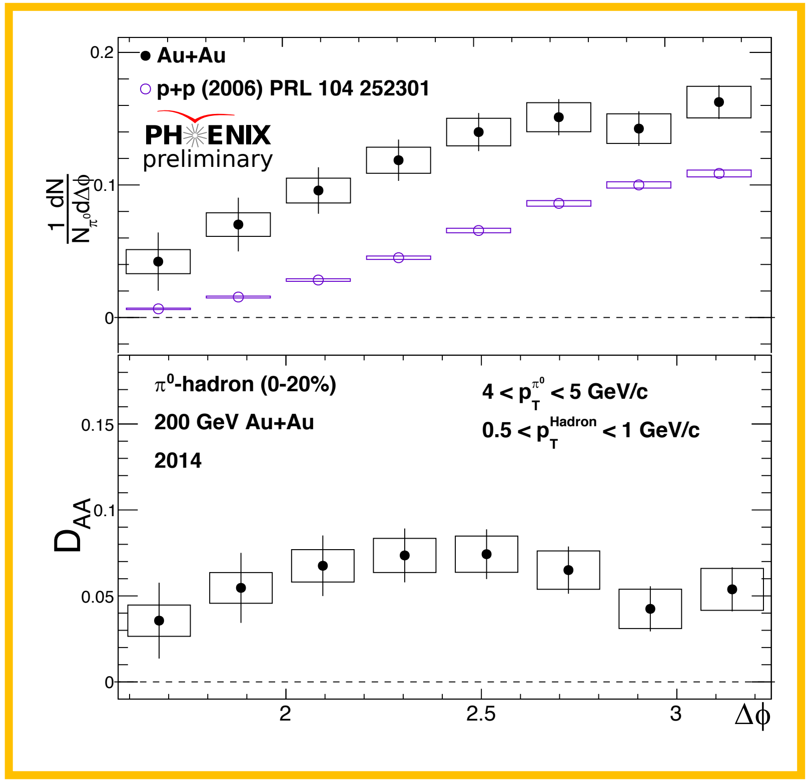


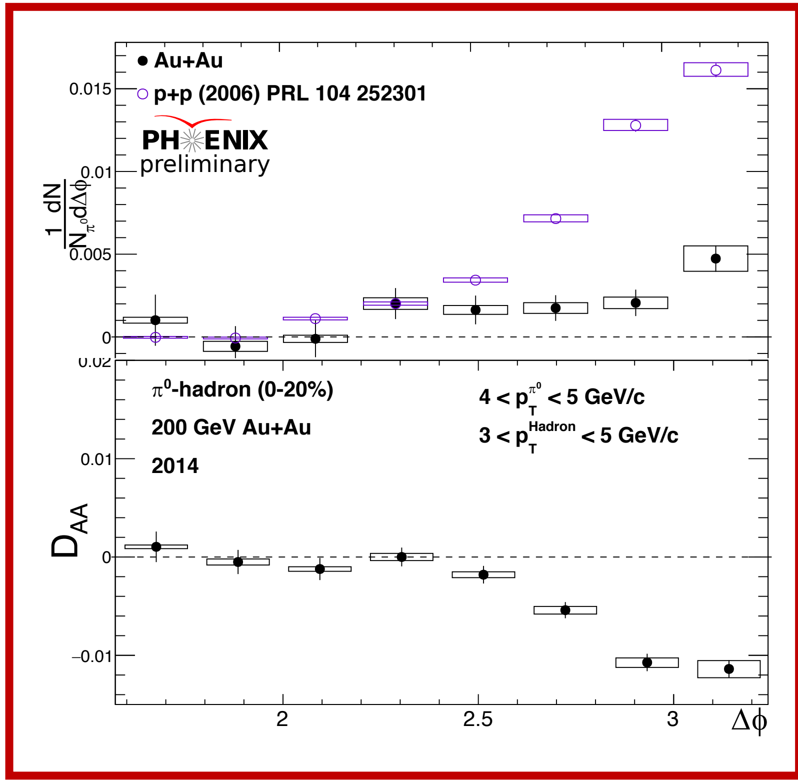




$0.5 < p_{T,h} < 1$ GeV/c



$3 < p_{T,h} < 5$ GeV/c



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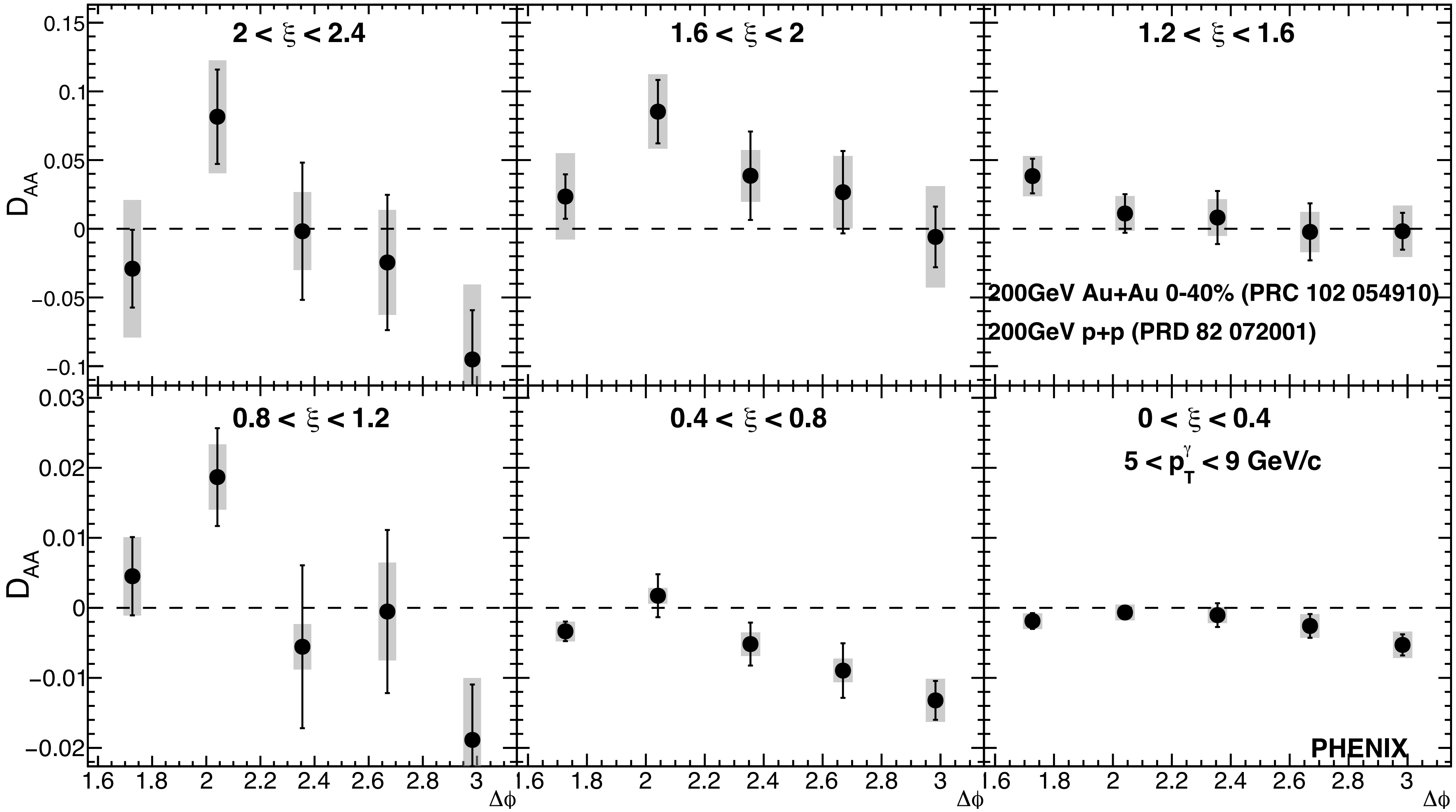
$D_{AA}(\Delta\varphi)$ from PHENIX γ-h

- From published PHENIX results for 2007 + 2010+ 2011
- Similar evolution as seen in π^0–h

$\xi = -\ln(z) = \ln(p_{T\gamma}/p_{Th})$

Low p_{Th}



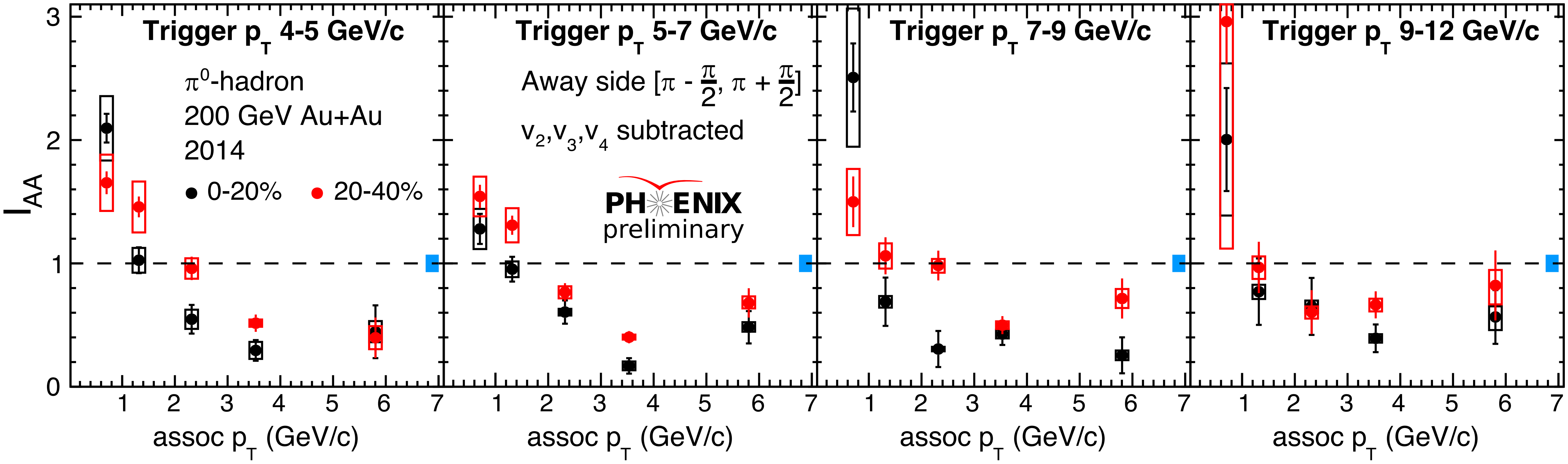
High p_{Th}

Summary

- PHENIX uses γ–h and π^0–h to probe energy loss effects including medium response
  - Latest from π^0–h 2014 Run shown
- PHENIX explores associate p_T dependence from 0.5-7 GeV/c
- I_{AA} vs $\Delta\varphi$ indicates a redistribution of low momentum hadrons to wide angles
- $D_{AA}(\Delta\varphi)$ shows a dependence on associate p_T that may be related to medium response
- Looking forward to more detailed comparisons to theory
- Still to come from PHENIX: Run 14 + 16 γ–h and Run 16 π^0–h

Backup Slides

I_{AA} vs p_{Th}



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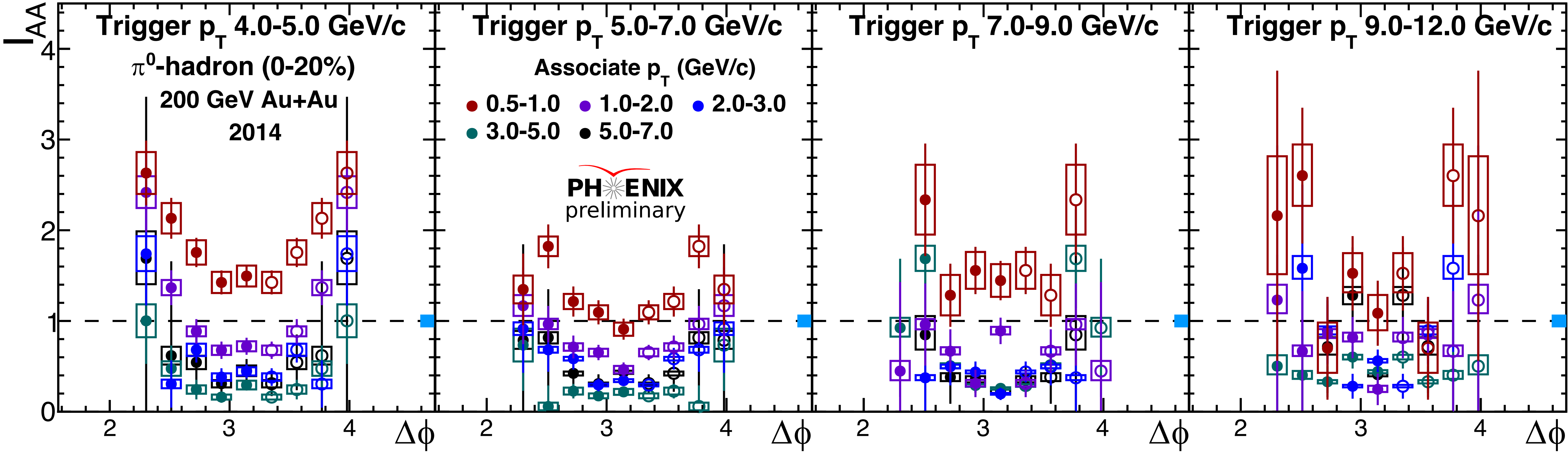
I_{AA} vs $\Delta\varphi$

$$I_{AA} = Y_{AA}/Y_{pp}$$

- Suppression of high momentum hadrons
- Enhancement most pronounced at large angles for lower p_T hadrons



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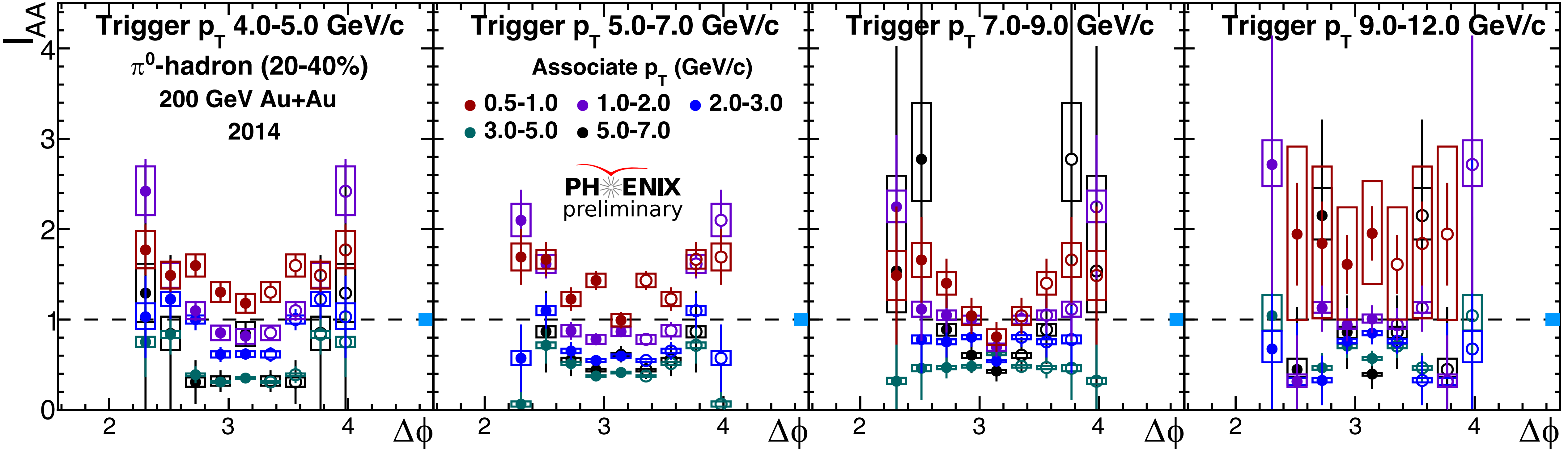
I_{AA} vs $\Delta\varphi$

$$I_{AA} = Y_{AA}/Y_{pp}$$

- 20-40% centrality
  - Suppression of high momentum hadrons
  - Enhancement most pronounced at large angles for lower p_T hadrons



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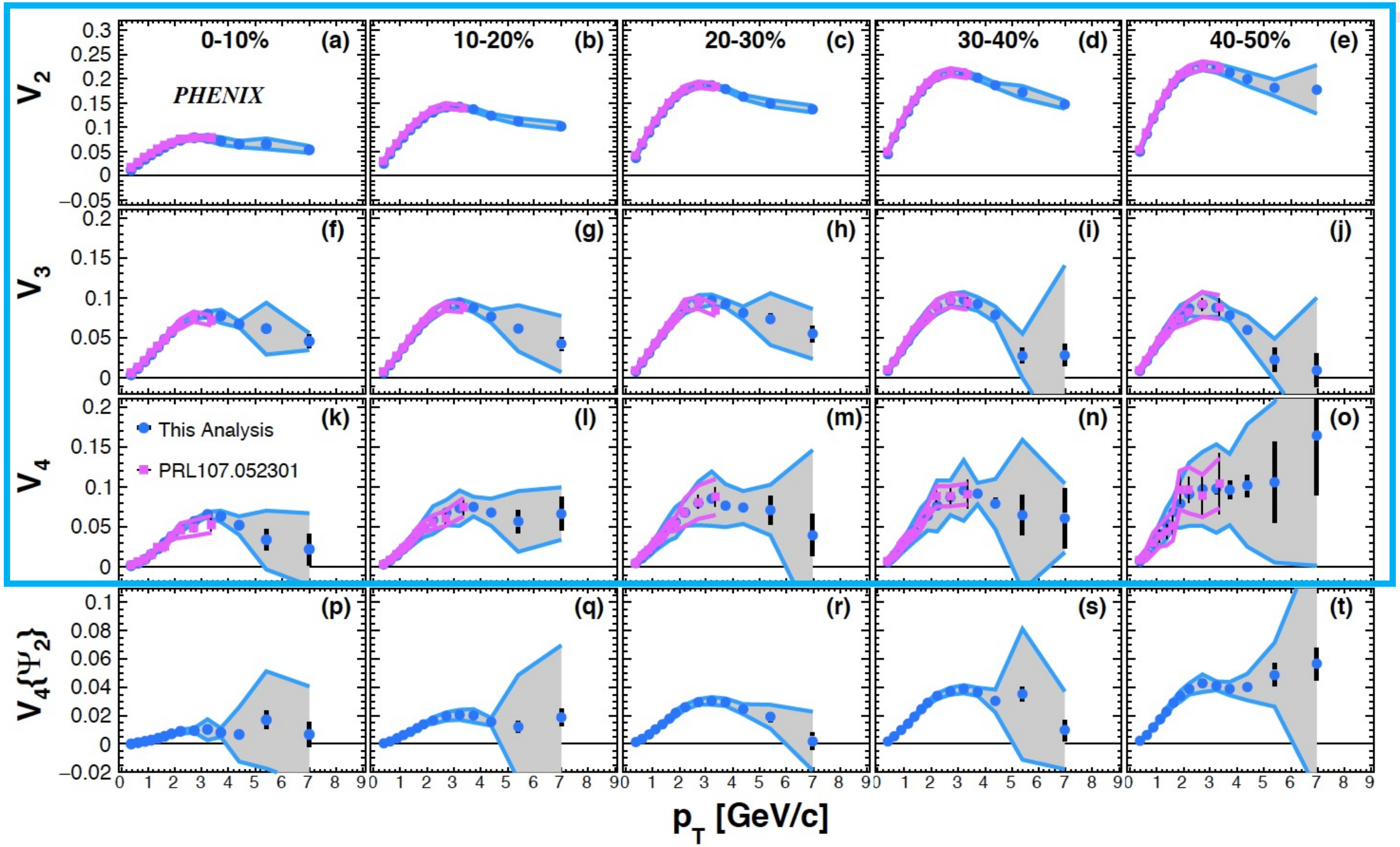
Flow Subtraction – Charged Hadron v_n

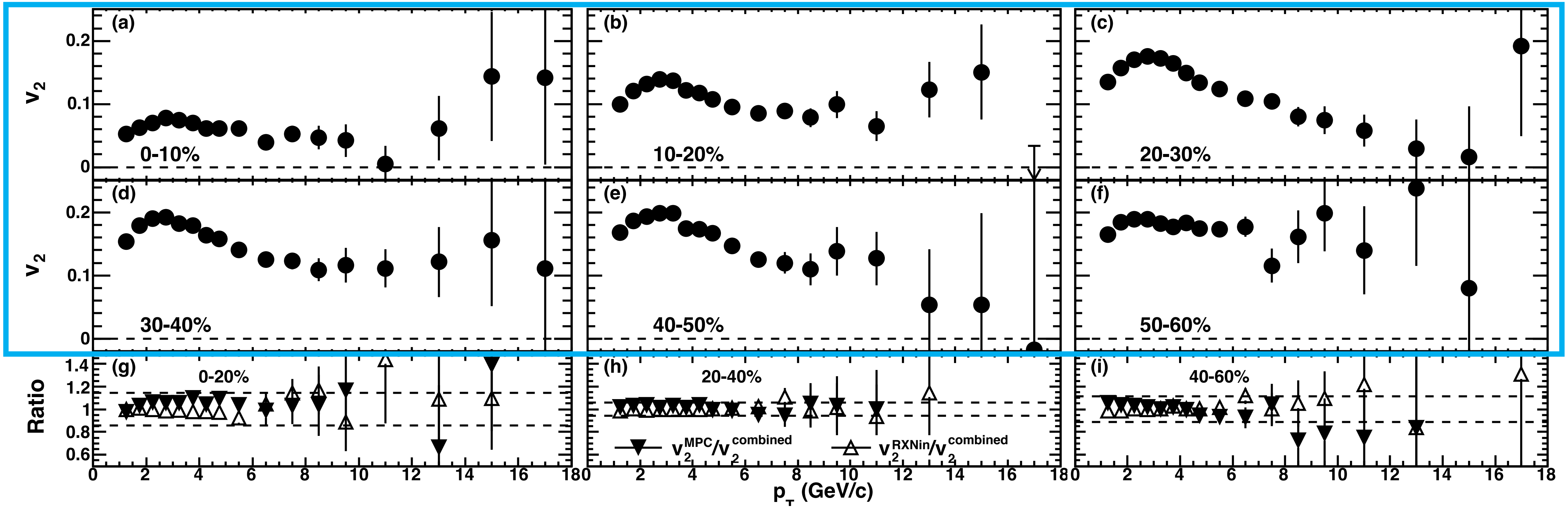


arXiv:1803.01749v1 (2007 data)

- Charged hadron v_n from PHENIX data
- Measured via event plane method

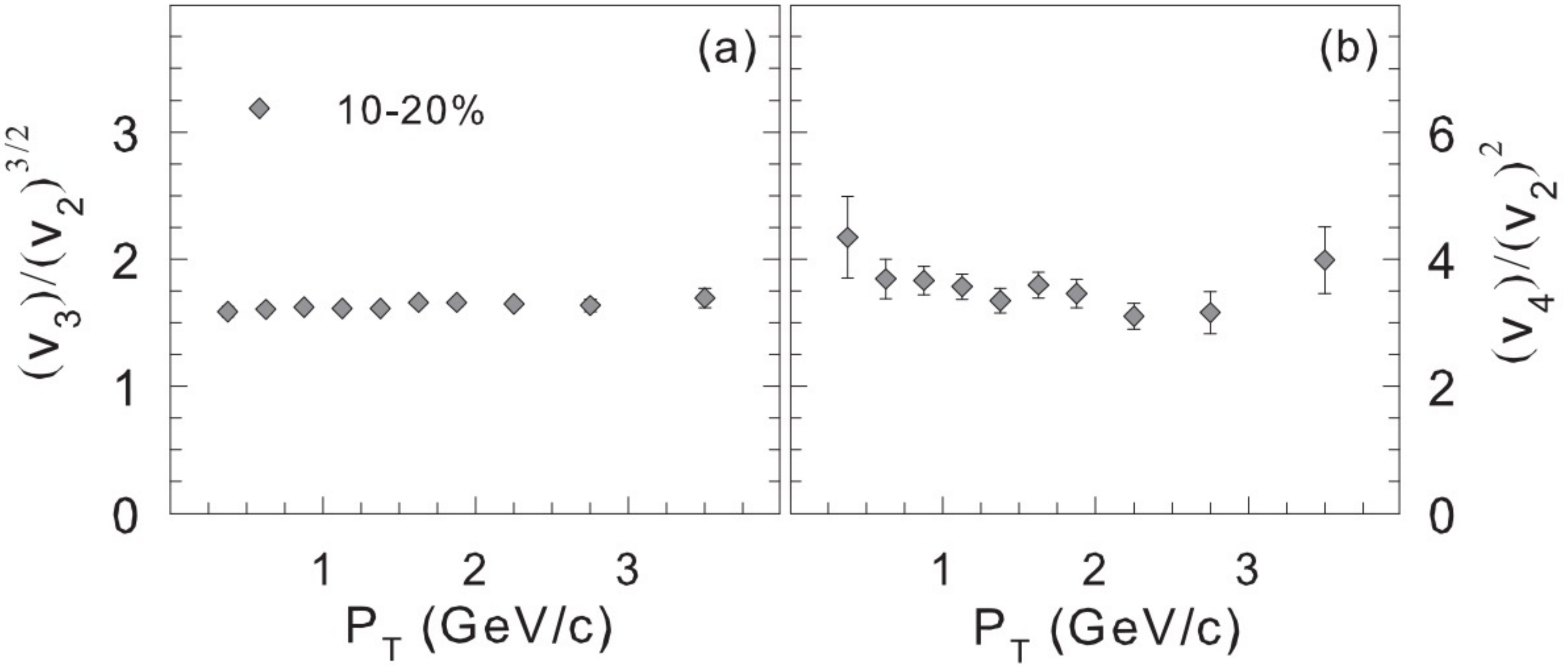
Flow Subtraction - $\pi^0 \, v_n$

PRL 105, 142301 2010 (2007 data)



- Taken from PHENIX data
- Measured via reaction plane method
- Higher order harmonics not available

Flow Subtraction – Acoustic Scaling

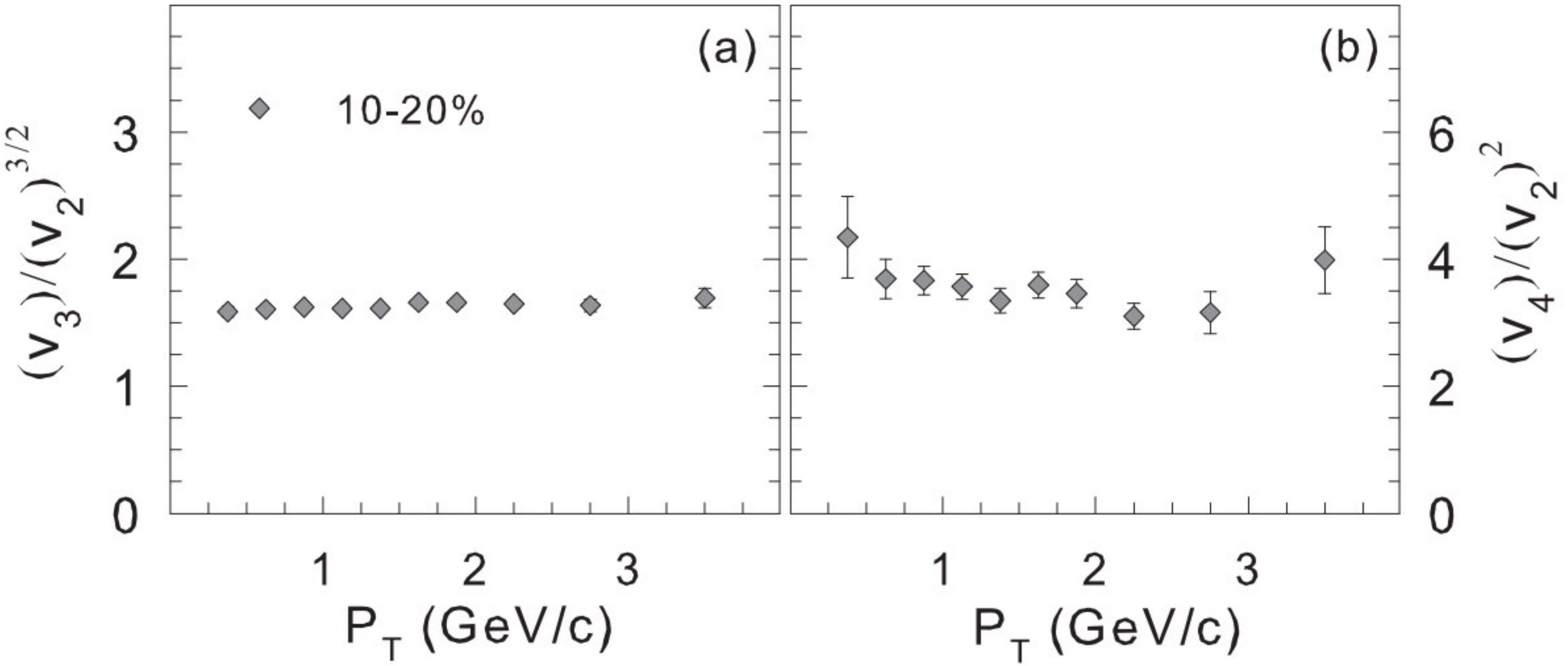


arXiv:1105.3782v2

$$g_n = \frac{v_n}{(v_2)^{n/2}}$$

- Have charged hadron v_n for $(n = 2,3,4)$ from PHENIX results
- No π^0 v_3 or v_4 measured at RHIC energies
- v_n harmonics can be scaled to one another via value g_n

Flow Subtraction – Acoustic Scaling



arXiv:1105.3782v2

$$v_n^{\pi^0} = g_n^h \left(v_2^{\pi^0}\right)^{n/2}$$

- Can calculate π^0 v_3, v_4 by scaling π^0 v_2 with charged hadron g_n