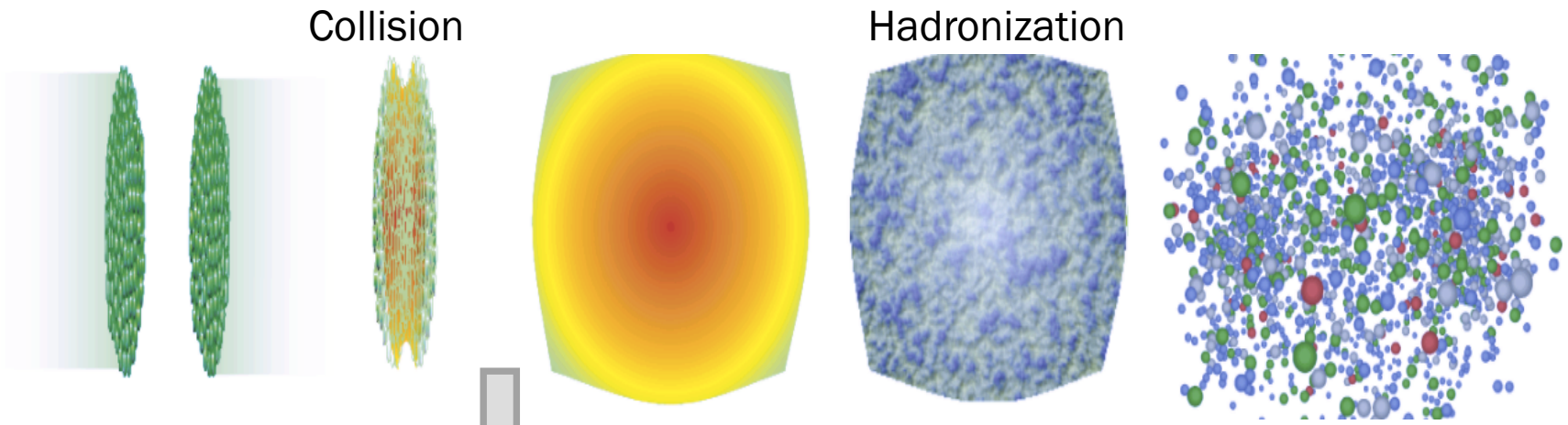
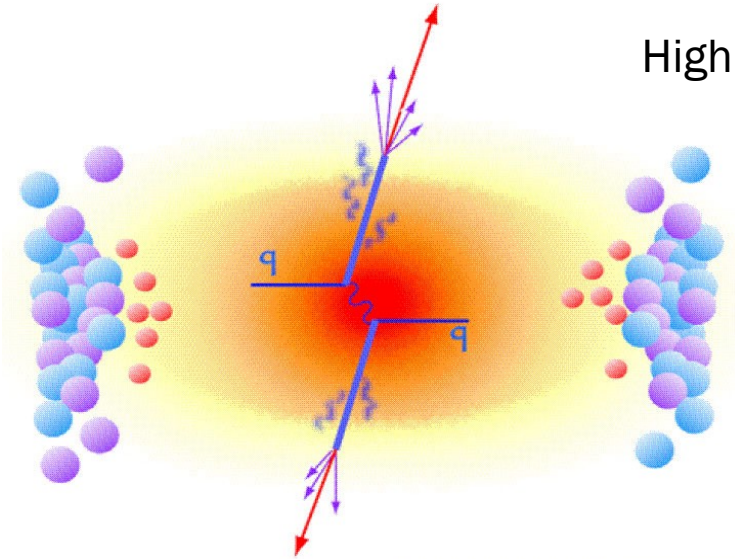
In-Medium Jet Modification Measured by PHENIX Via Two Particle Correlations and High p_T Hadrons in A+A Collisions

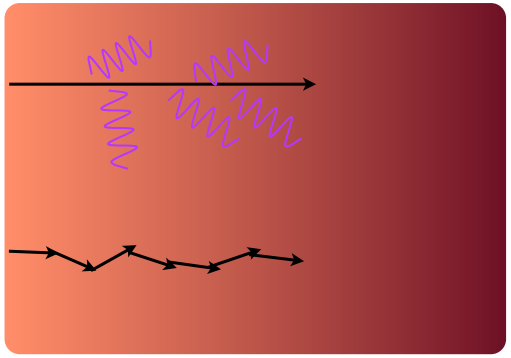
Anthony Hodges
On Behalf of
The PHENIX Collaboration
Quark Matter 2019
Wuhan, China

Energy Loss in the Quark Gluon Plasma



High momentum partons lose energy

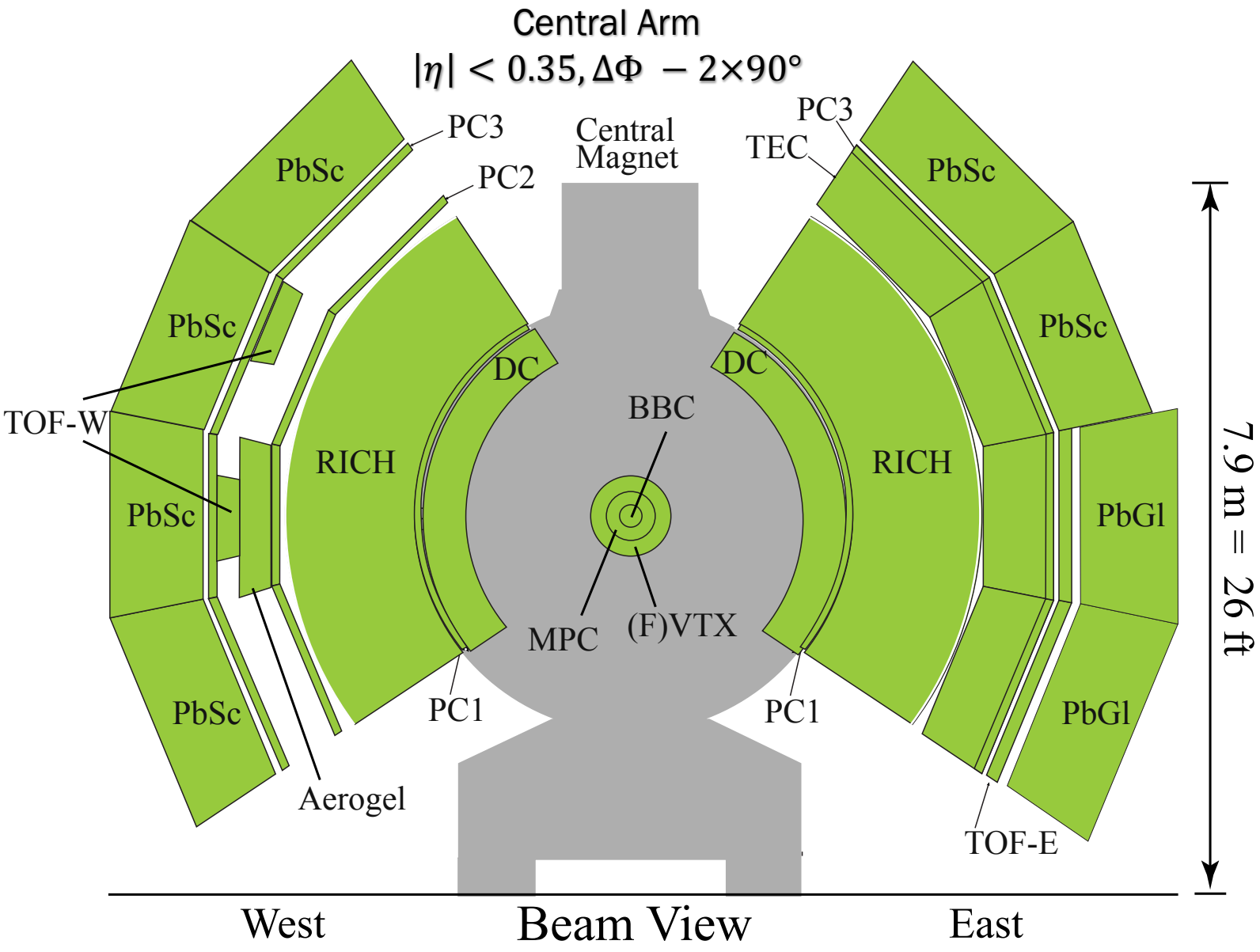




$\rightarrow \hat{q}$

$\rightarrow \hat{e}$

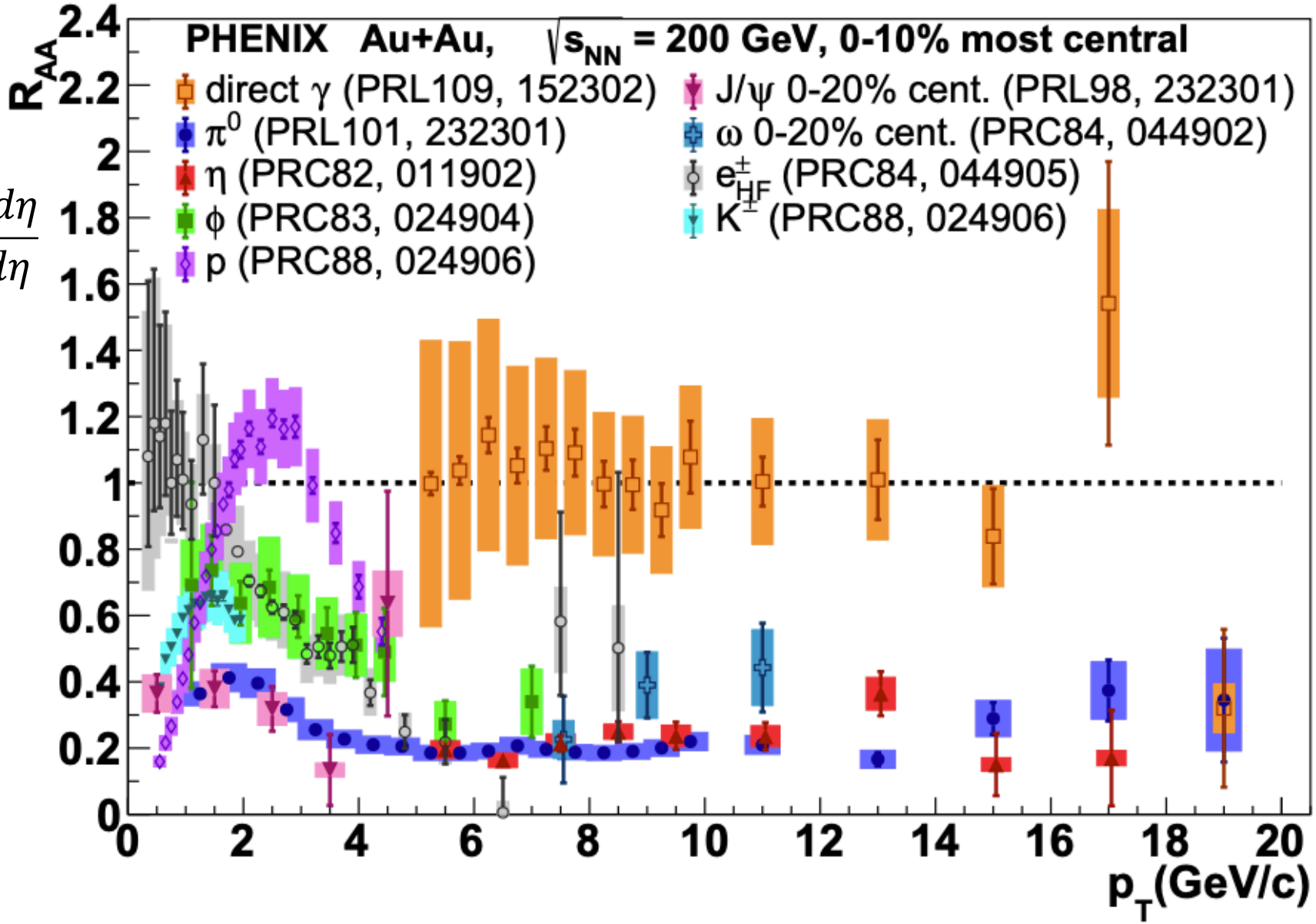
The PHENIX Detector



The Nuclear Modification Factor - R_{AA}

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

- This talk: Large Systems
  - Au+Au, U+U, Cu+Au



For small systems:
Iurii Mitrankov
Small Systems III

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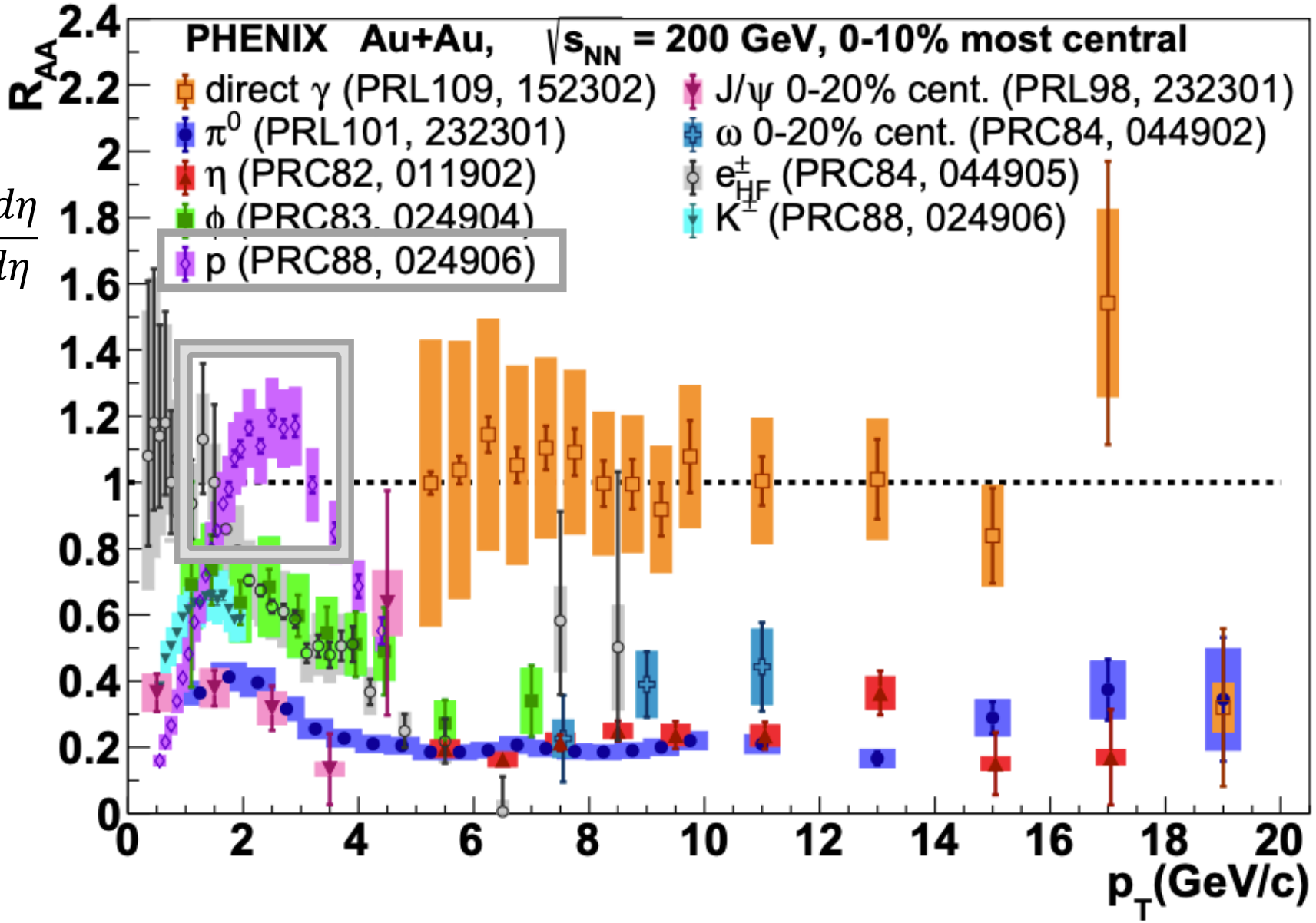

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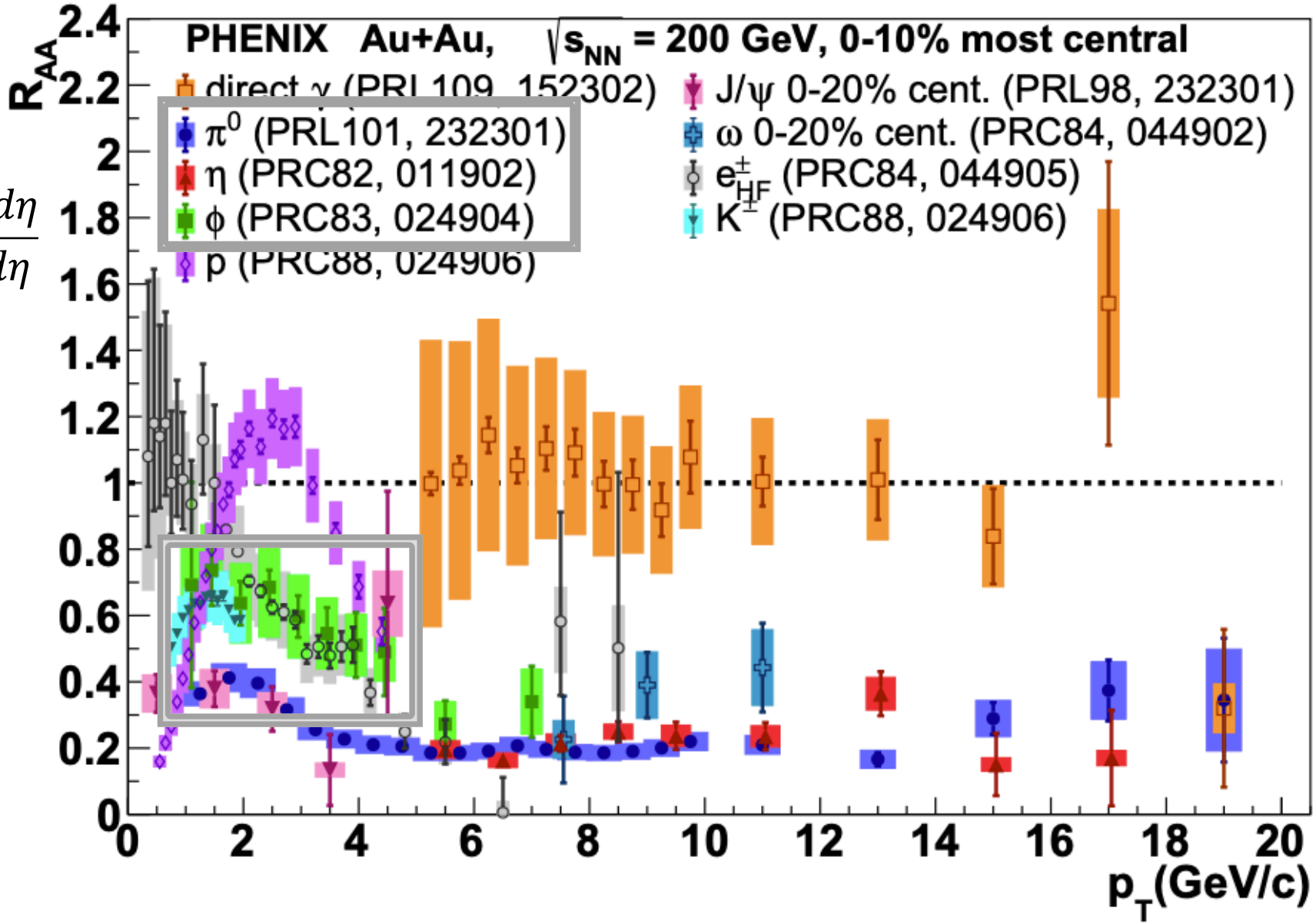

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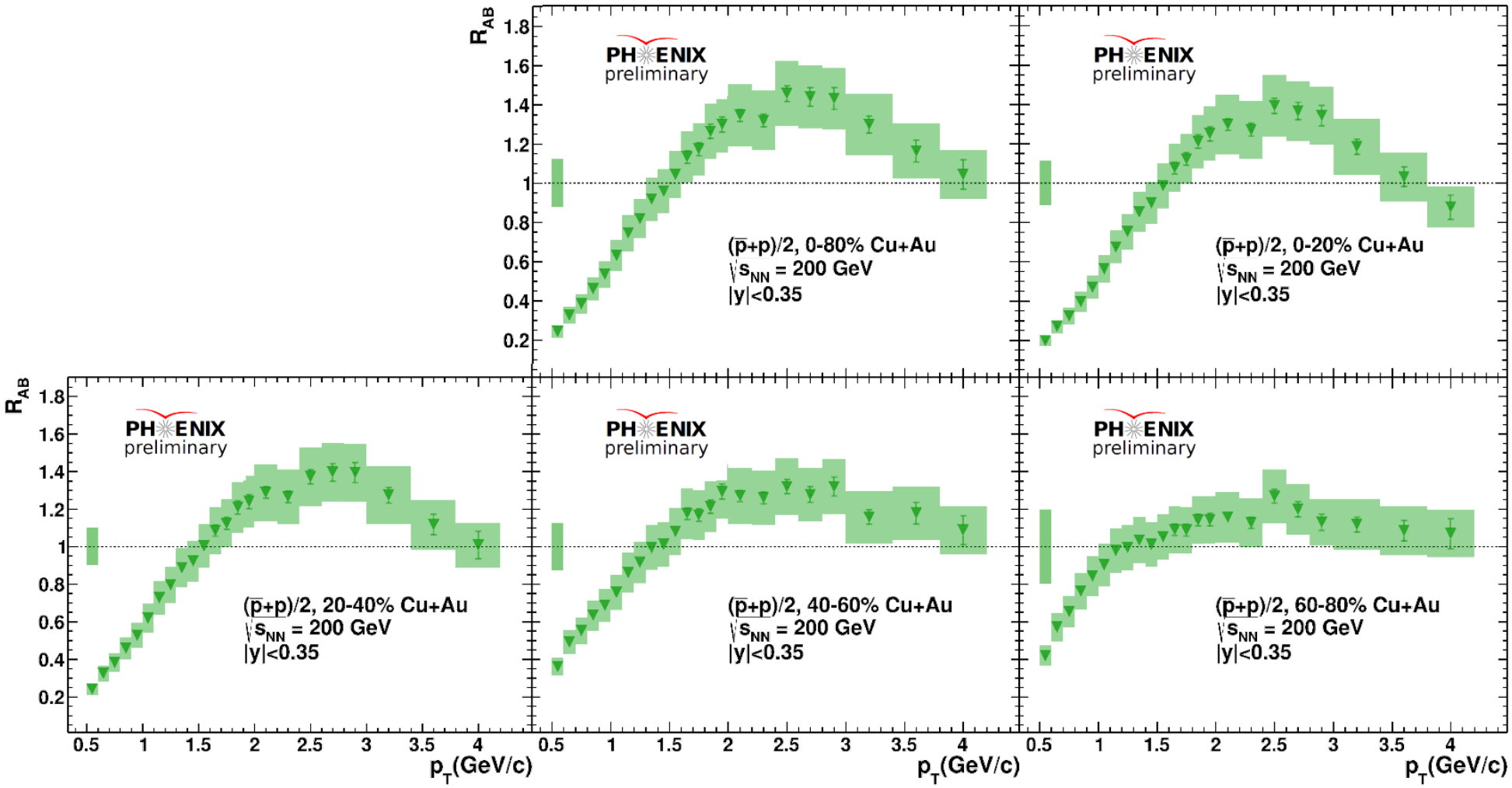
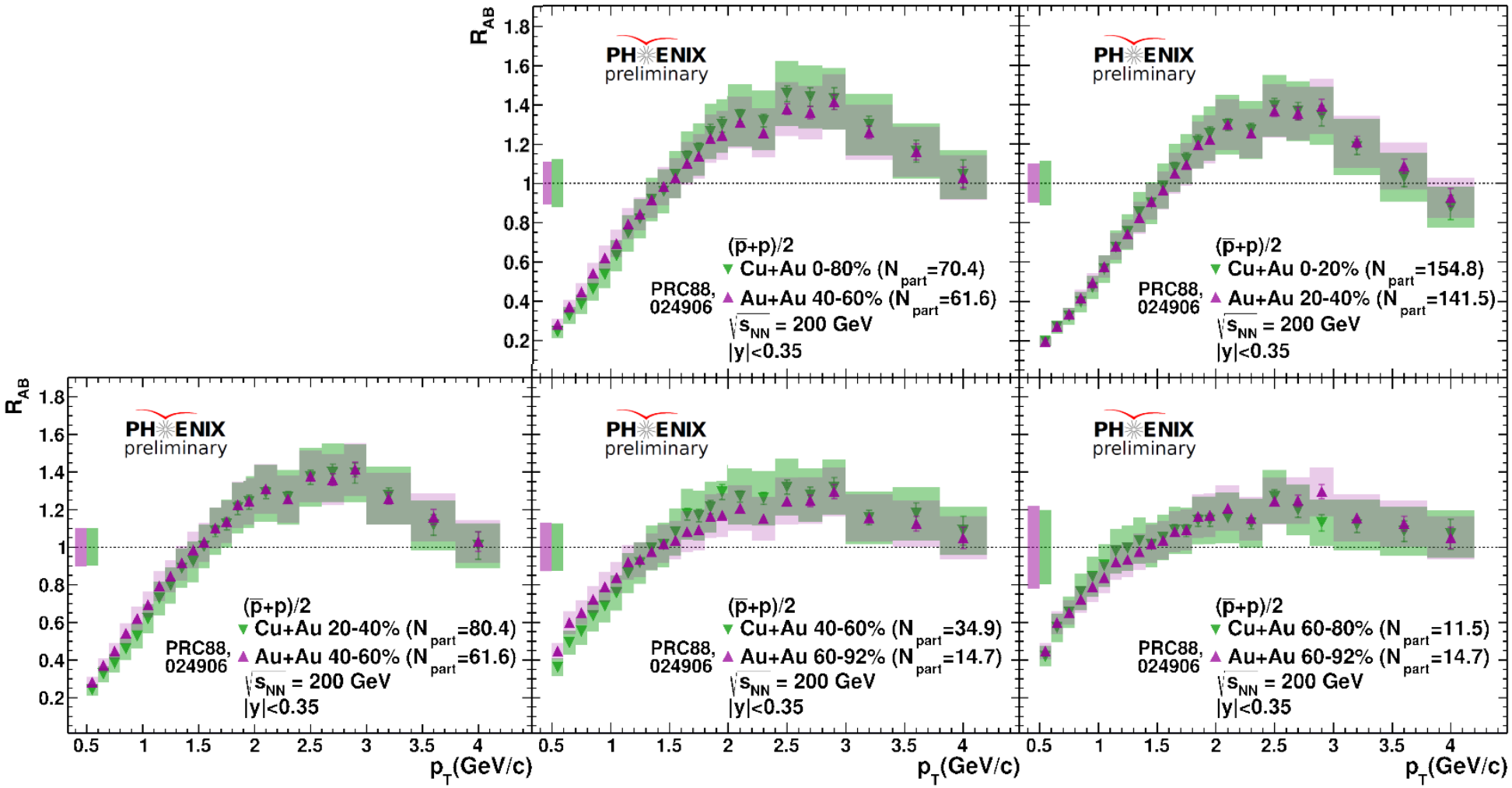
Baryon Enhancement in Cu+Au



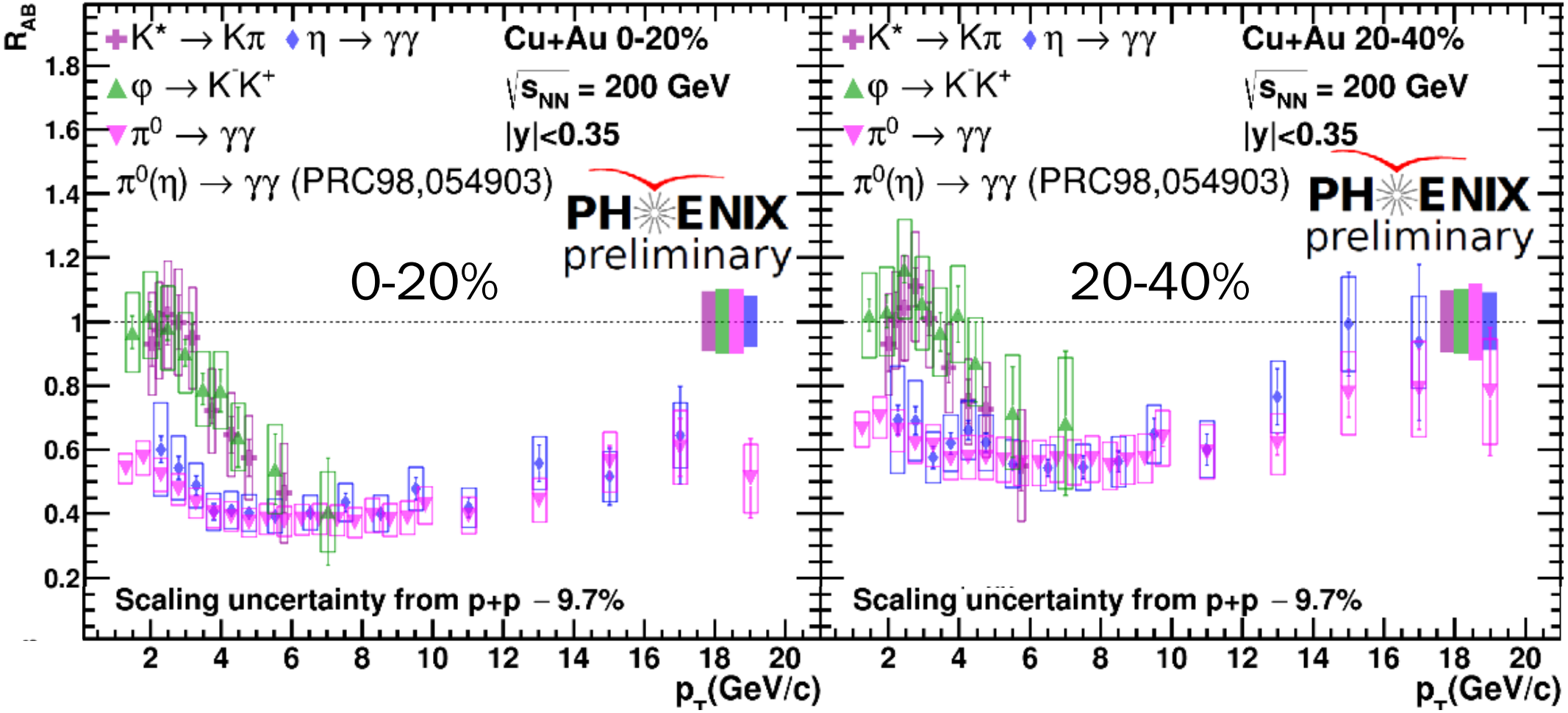
- Enhancement of $(p+\bar{p})/2$ yield at moderate p_T

Baryon Enhancement in A+A



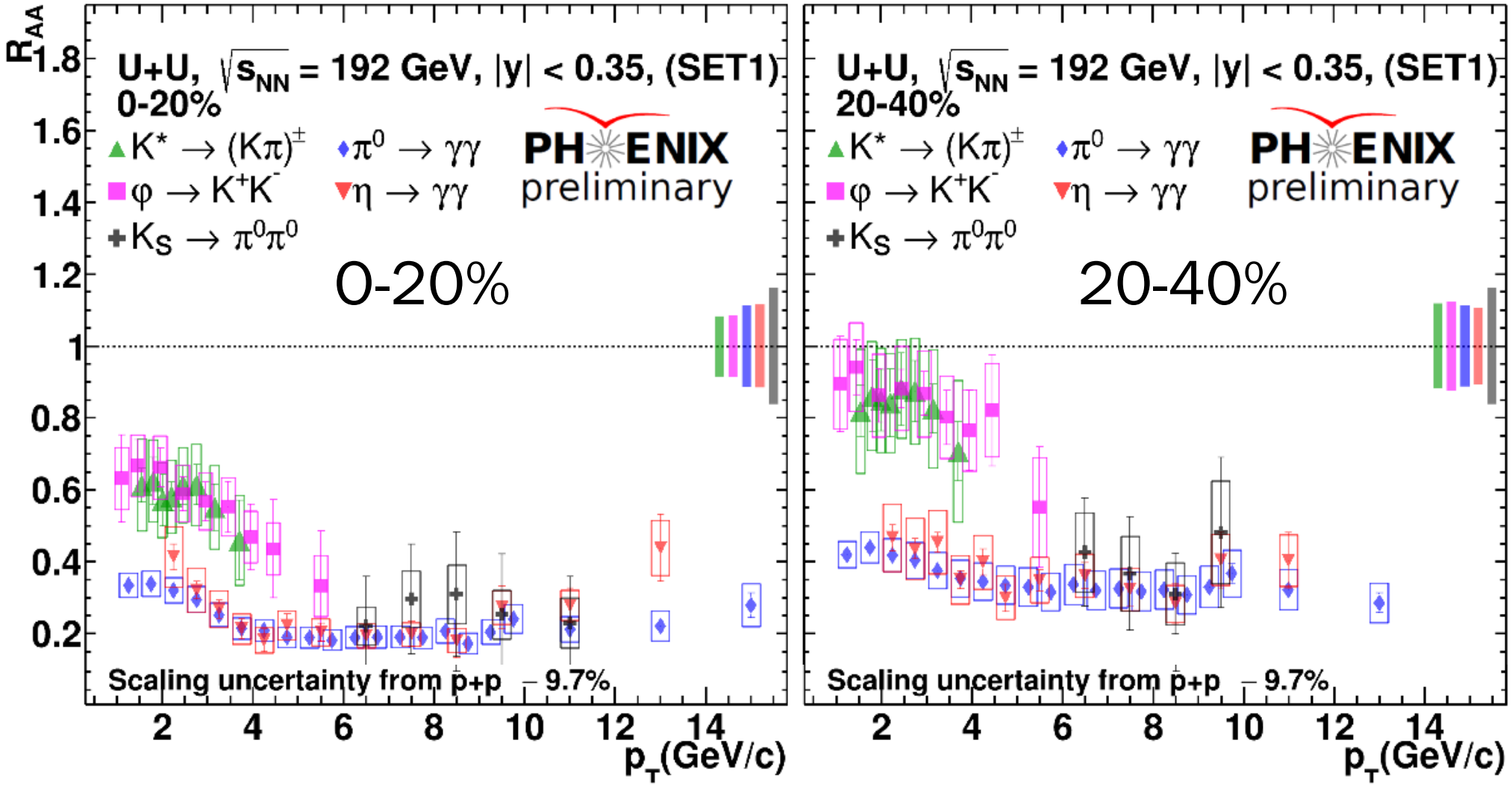
- Enhancement of $(p+\bar{p})/2$ yield at moderate p_T
- $(p+\bar{p})/2$ R_{AB} consistent across Cu+Au and Au+Au at similar N_{part}

Meson R_{AA} Cu+Au



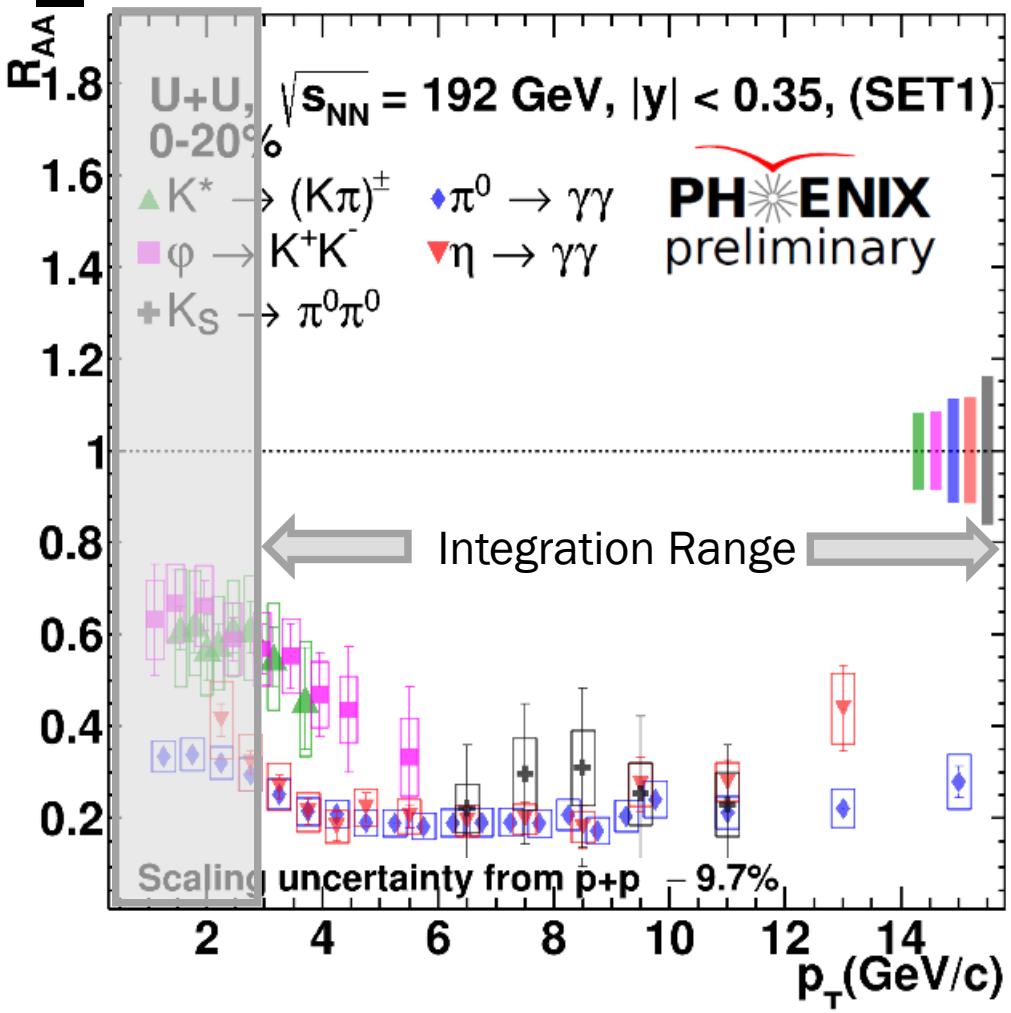
- R_{AA} for K^* and Φ meson > R_{AA} for π^0 and η at low p_T
- Difference disappears at high p_T

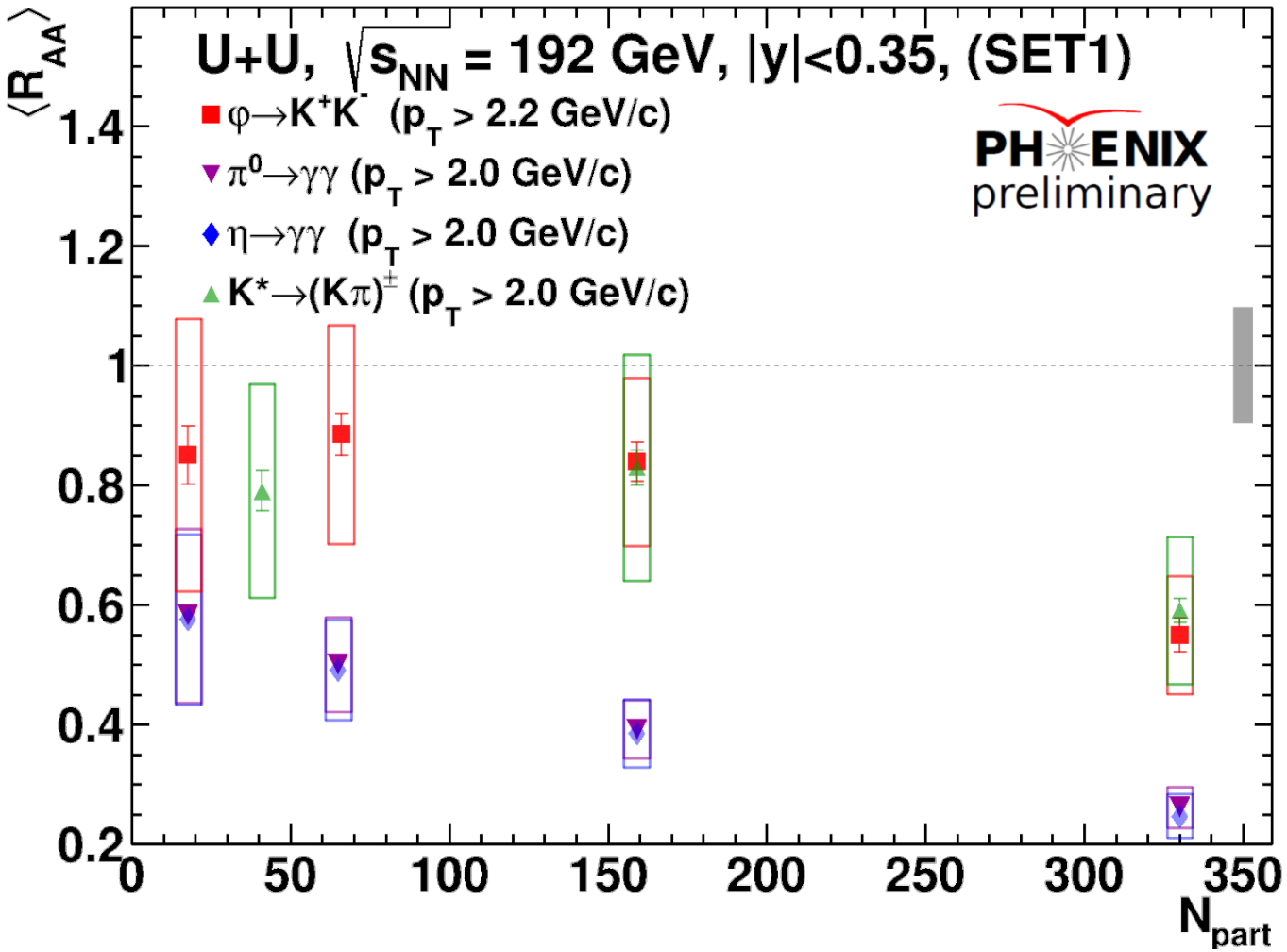
Meson R_{AA} in U+U



- Strange quark dependence also present in U+U collisions

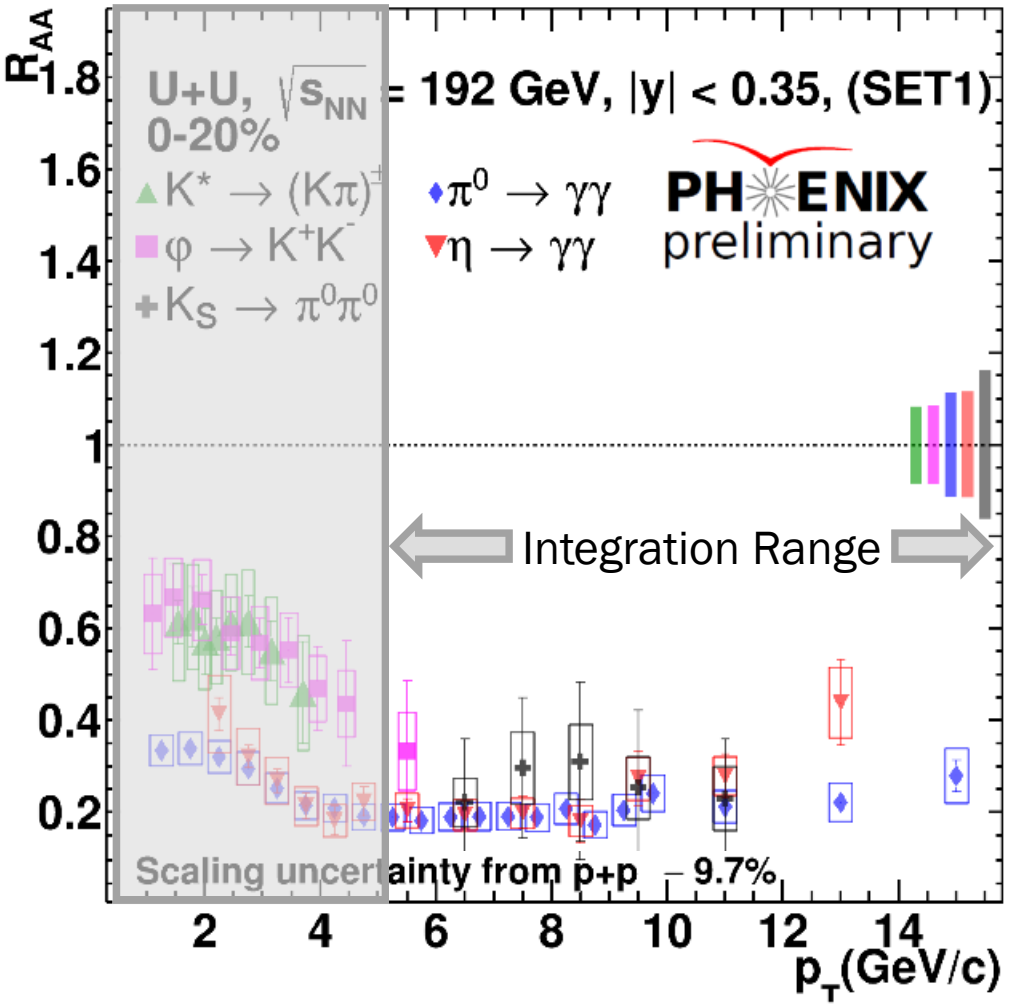
Low p_T Meson R_{AA} in U+U

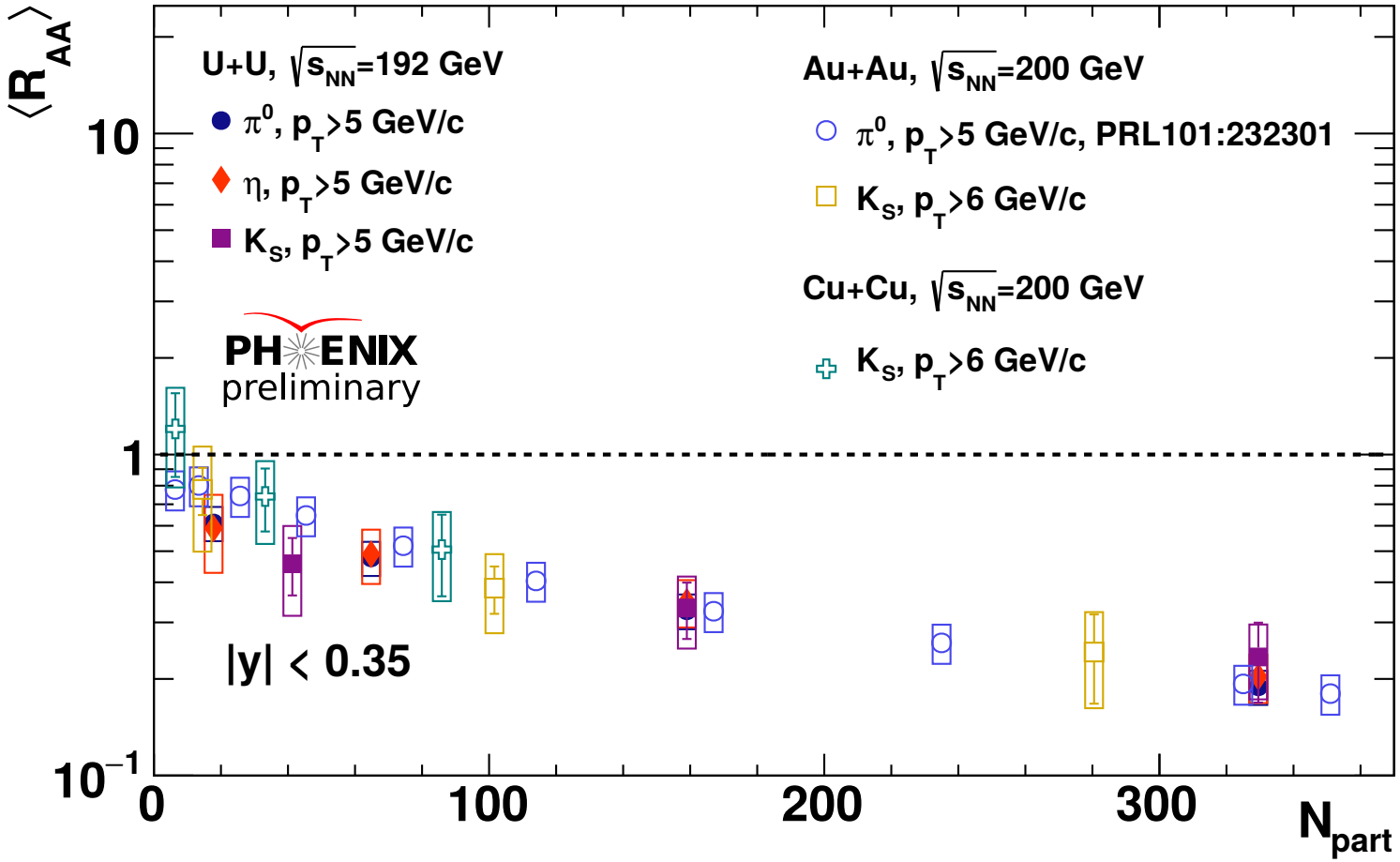




- Strange quark dependent separation seen across wide N_{Part} range

High p_T Meson R_{AA} In A+A





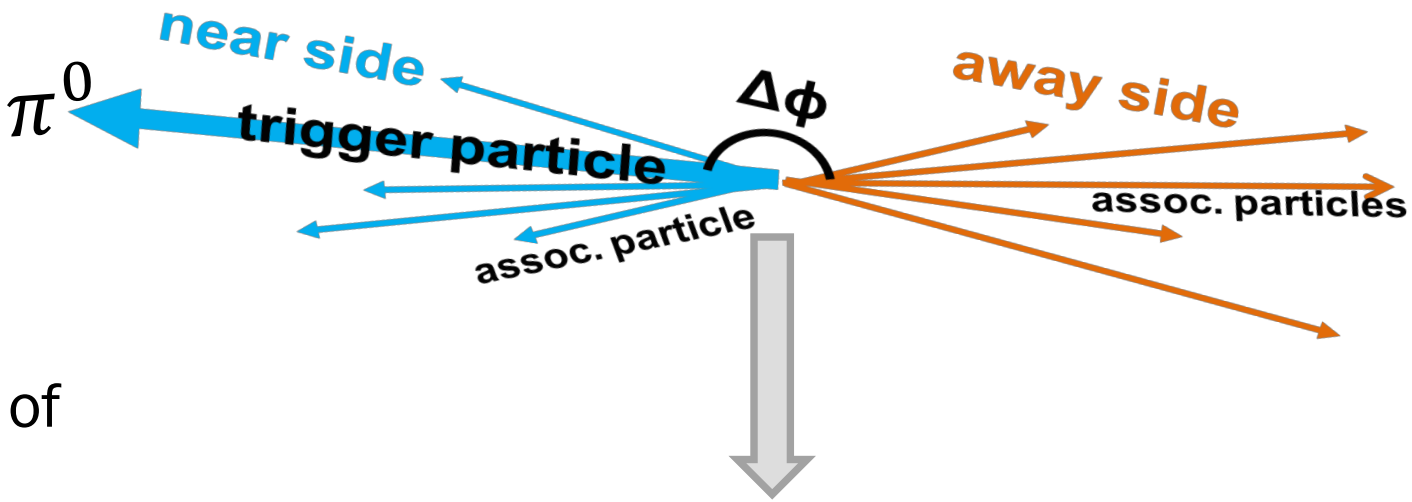
- All meson R_{AA}'s and collision systems follow similar trend
- $\langle R_{AA} \rangle$ depends on system size, not collision species!

Hadron R_{AA} Conclusions

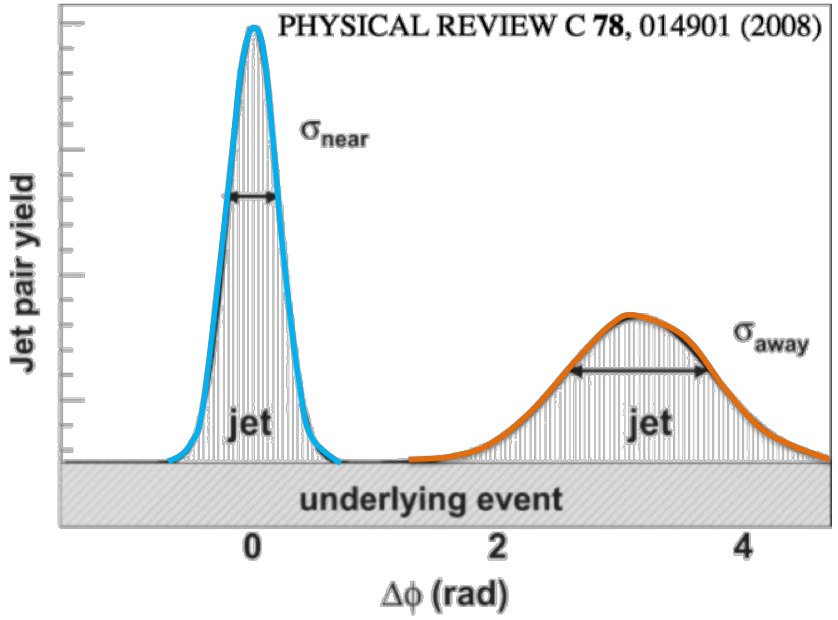
- Baryon enhancement seen in Cu+Au and Au+Au
  - Same R_{AA} at similar N_{part}
- Difference in suppression levels based on strangeness contribution to meson makeup.
- R_{AA} for all meson species converges at high p_T
- At high p_T, integrated R_{AA} behavior depends on system size, rather than collision species

Two Particle Correlations

Small systems:
Jonathan Runchey
Initial State I



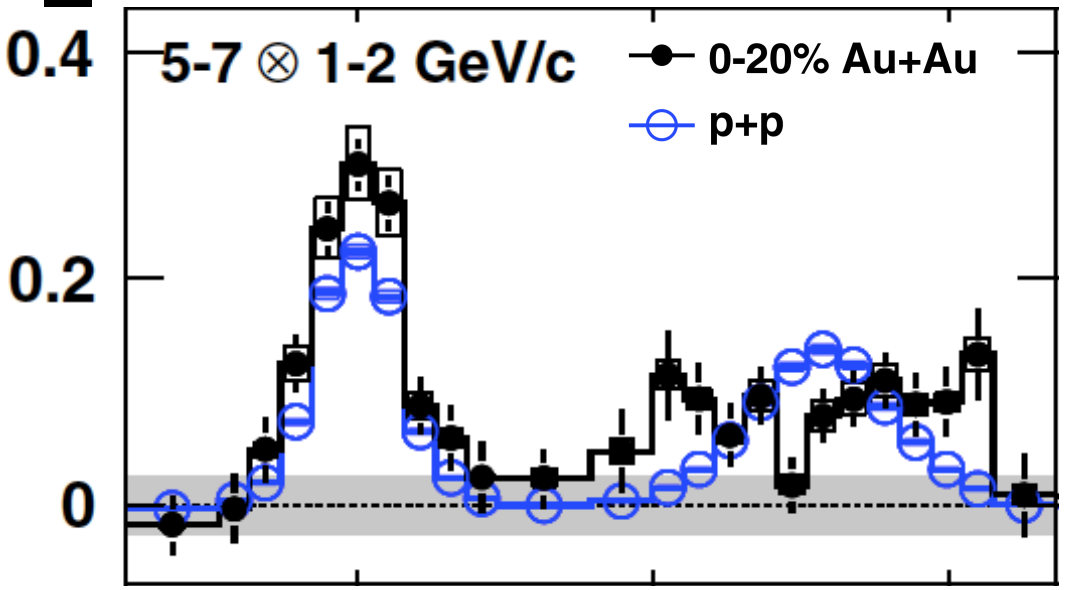
- Jet widths: $\sigma_{near}, \sigma_{away}$
  - Broadening
  - Requires careful subtraction of background flow
- $I_{AA} = \frac{Y_{AA}}{Y_{pp}}$
  - Modification of hadron yield
  - Will show as a function of p_T^h and $\Delta\phi$



Precision Extraction of Jet Width

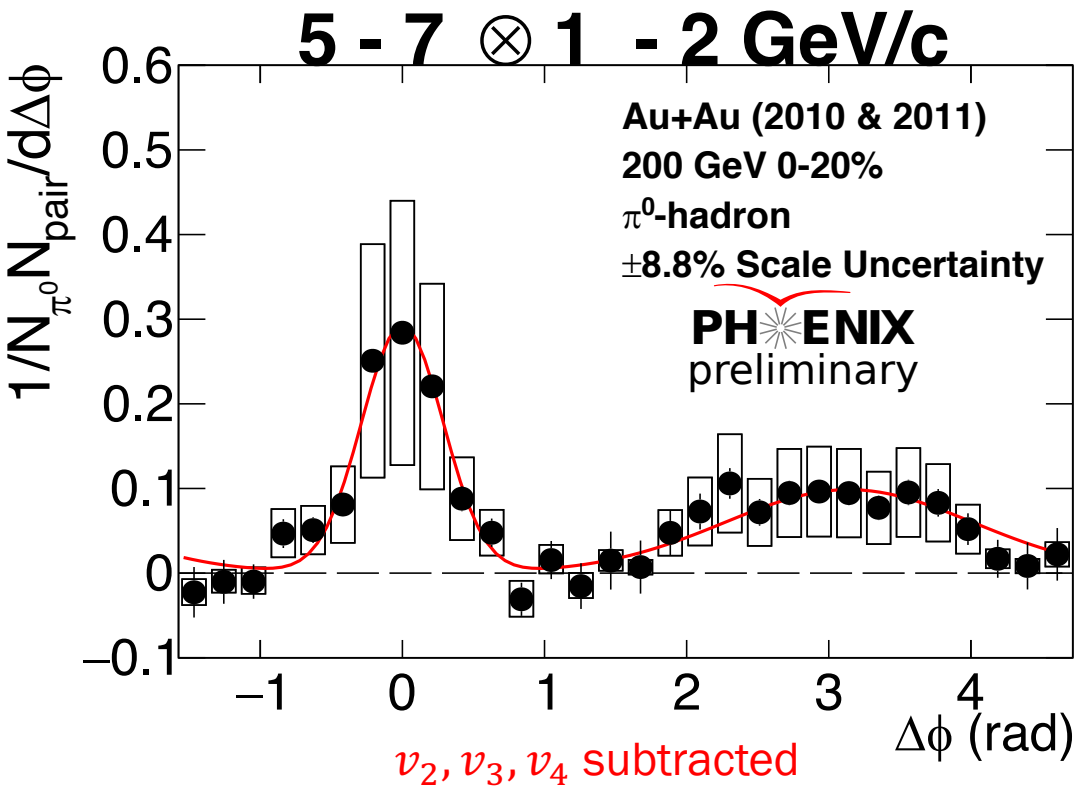
Old

PRL 104 252301 (2010)



v_3, v_4 not subtracted

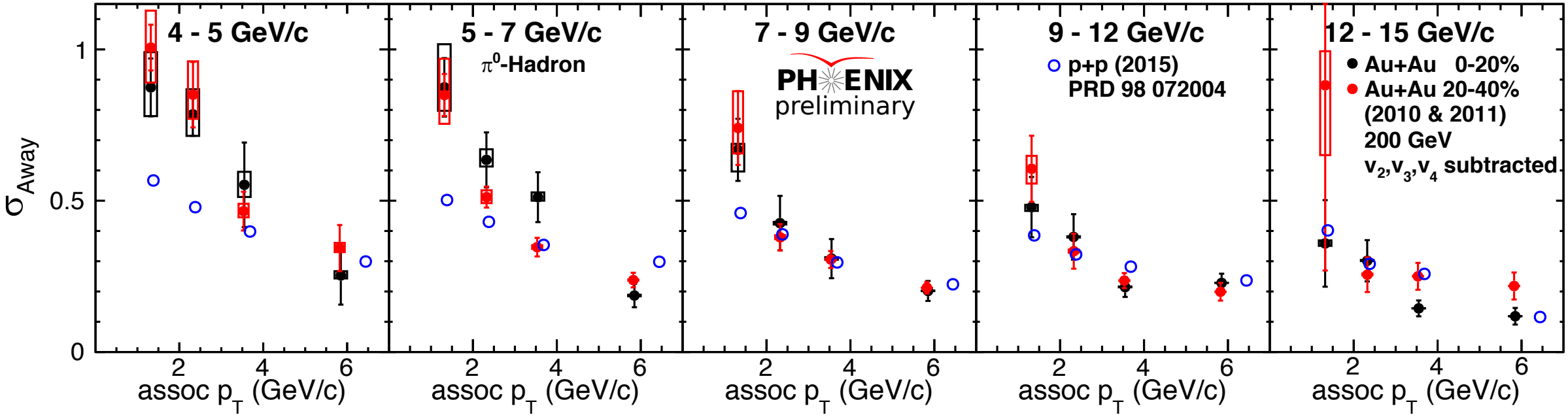
New



v_2, v_3, v_4 subtracted

- New results (right) from combined data from 2010 and 2011
- v_2 ,v_3 ,and v_4 subtracted in new results → flow contamination removed

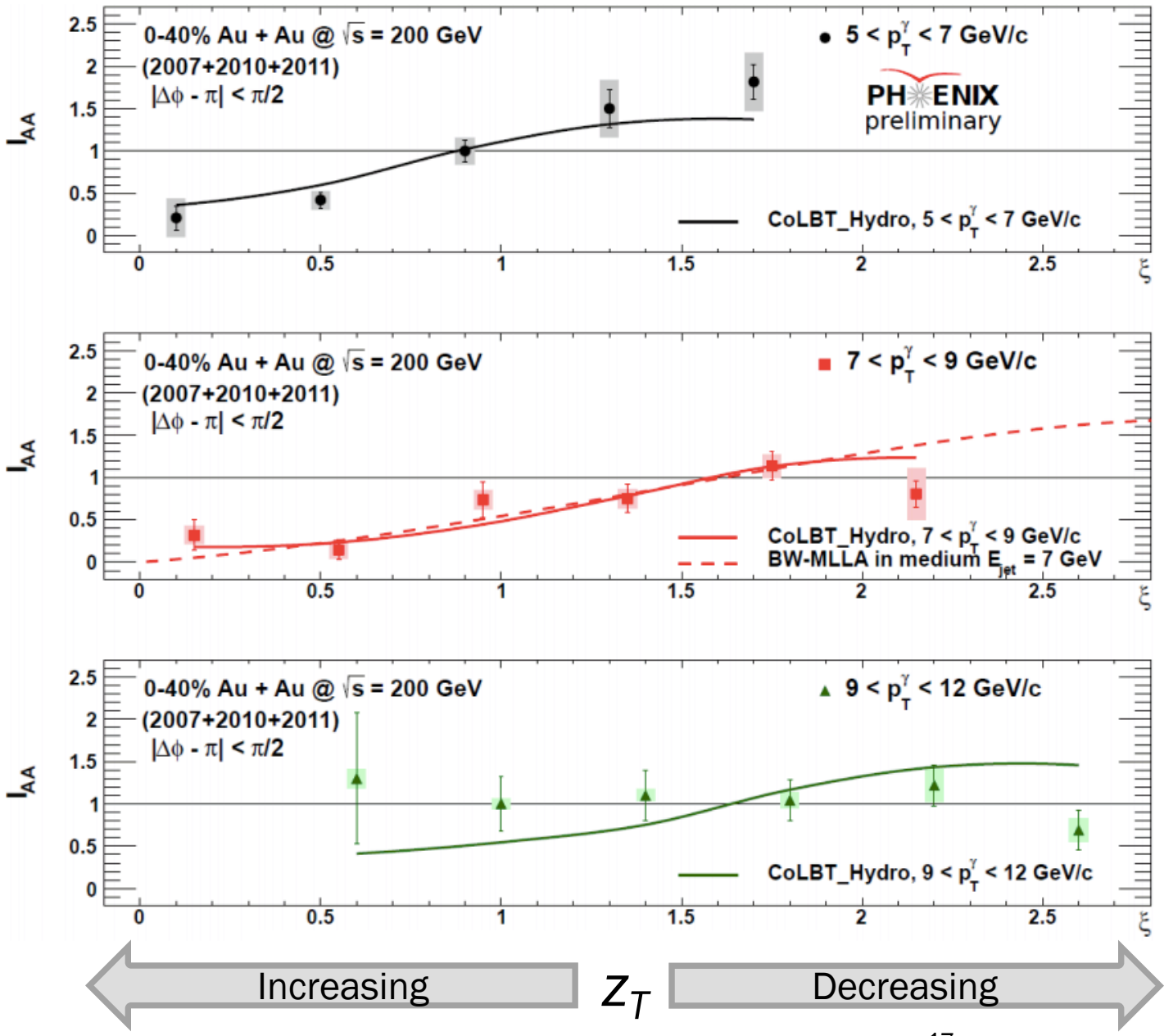
π^0-Hadron Correlations – $\sigma_{away}(p_T)$



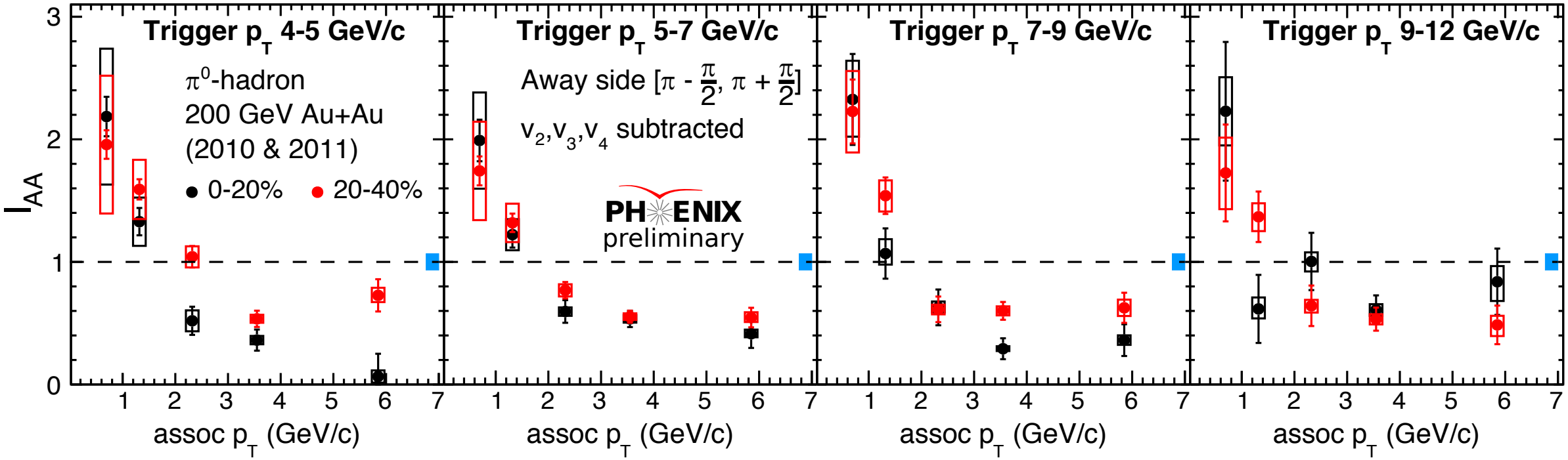
- Away side jet peaks are broader at low $p_T^{h^\pm}$
- Consistent with p+p widths at high $p_T^{h^\pm}$

Previous PHENIX Results – Direct Photon I_{AA}

- Direct photon-hadron correlations
  - Access to initial parton energy
  - Previous PHENIX result shown at right
- $\pi^0 - h$ correlations (This talk)
- Current analyses shift from $I_{AA}(\xi)$ to $I_{AA}(p_T^h)$
- $\xi = \ln\left(\frac{1}{z_T}\right)$; $z_T = p_T^h / p_T^{Trig}$



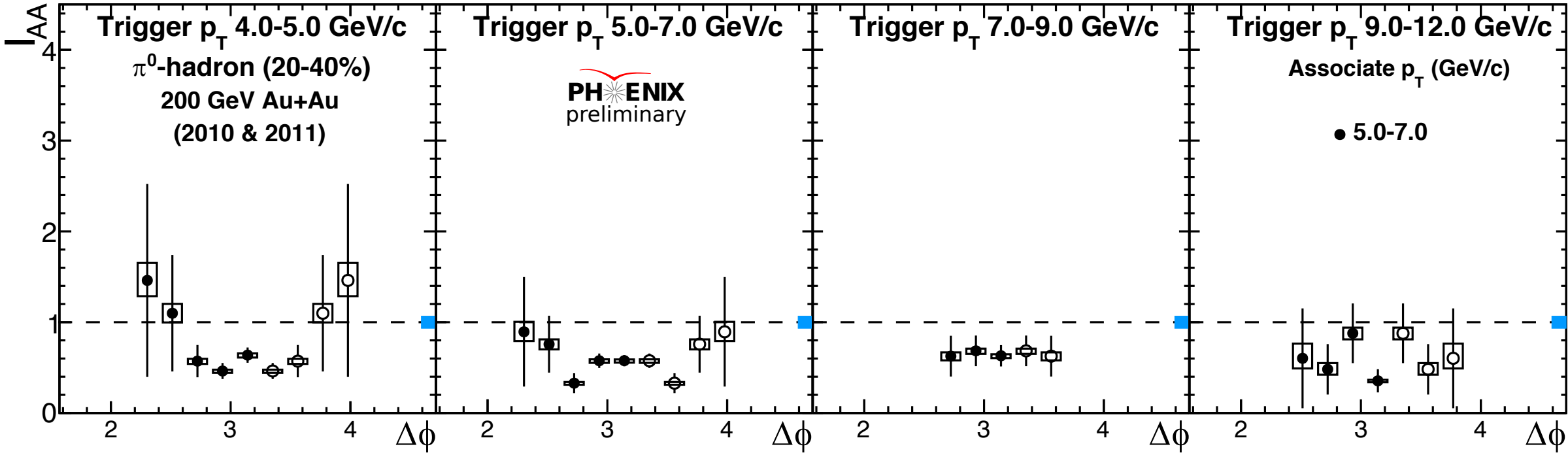
π^0-Hadron Correlations – $I_{AA}(p_T^h)$



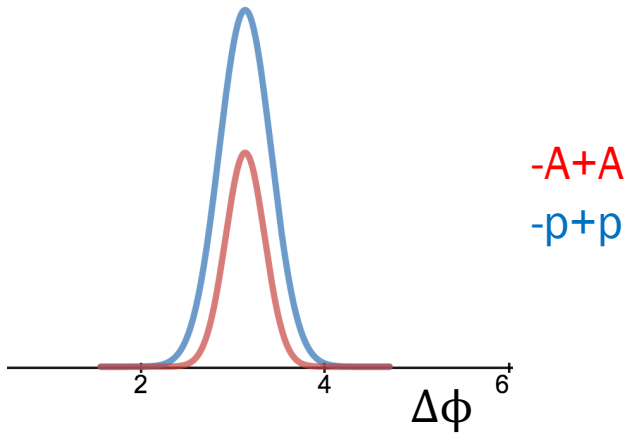
$$I_{AA} = \frac{Y_{Away}^{AA}}{Y_{Away}^{pp}}$$

- Enhancement of yield ($I_{AA} > 1$) at low associate particle momentum
- Depletion ($I_{AA} < 1$) at high associate particle momentum

π^0-Hadron Correlations – $I_{AA}(\Delta\phi)$



- Calculate ratio in yields between Au+Au jet function and p+p baseline
- Shows modification to away-side jet peak at substructure level



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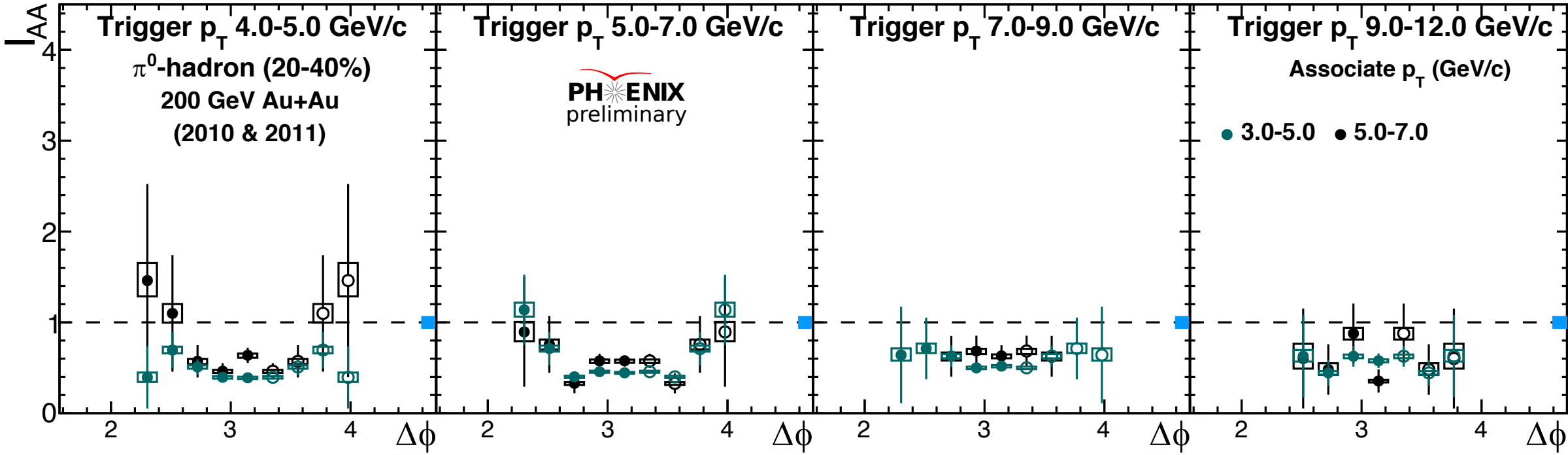

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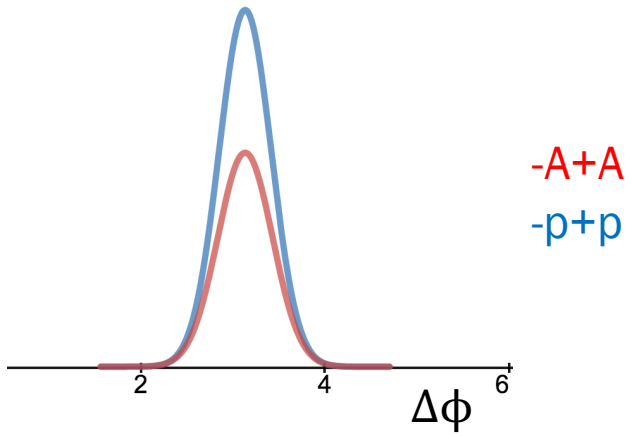

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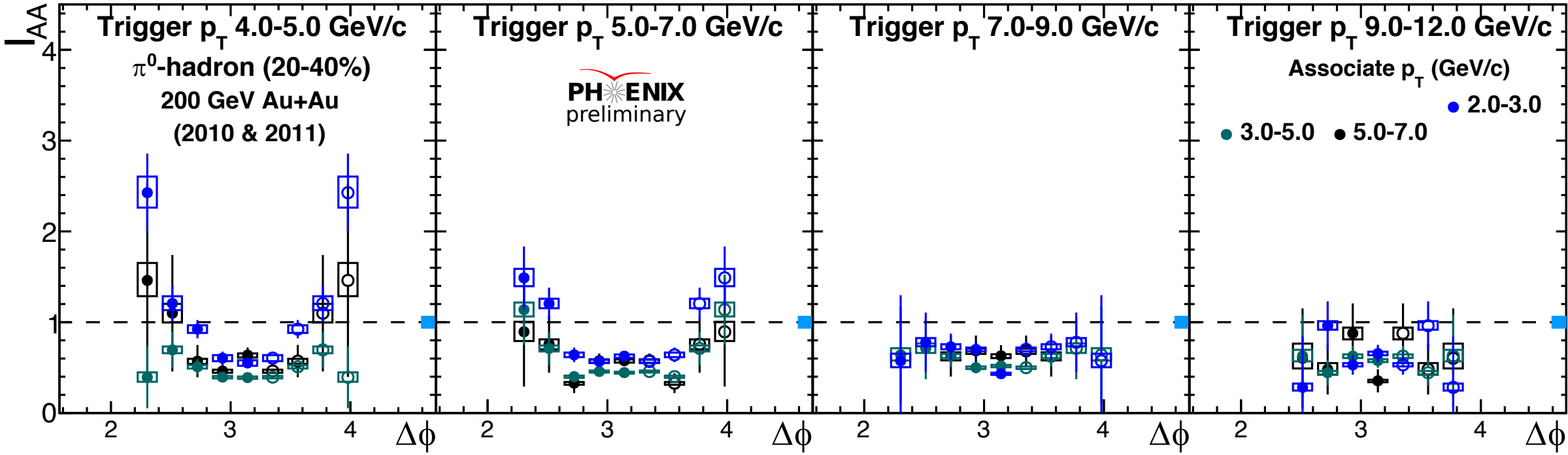
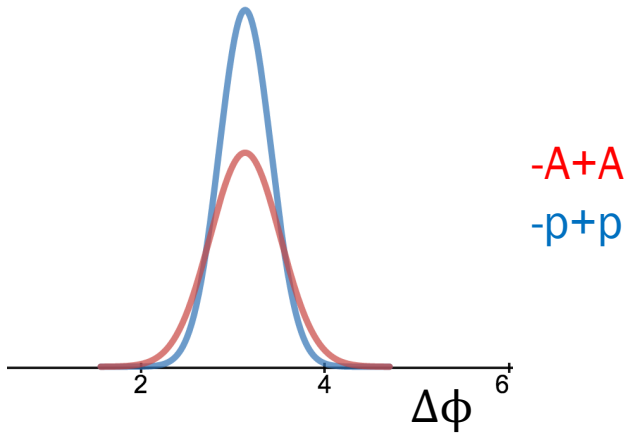


- Calculate ratio in yields between Au+Au jet function and p+p baseline
- Shows modification to away-side jet peak at substructure level
- Skirt of jet is the first to see significant enhancement



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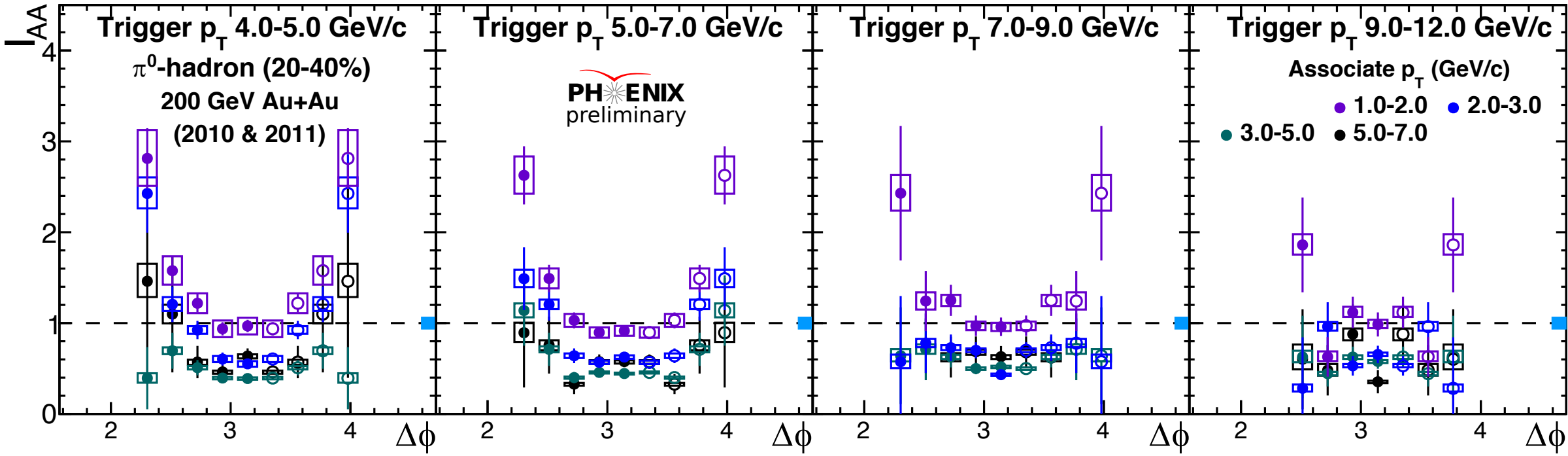

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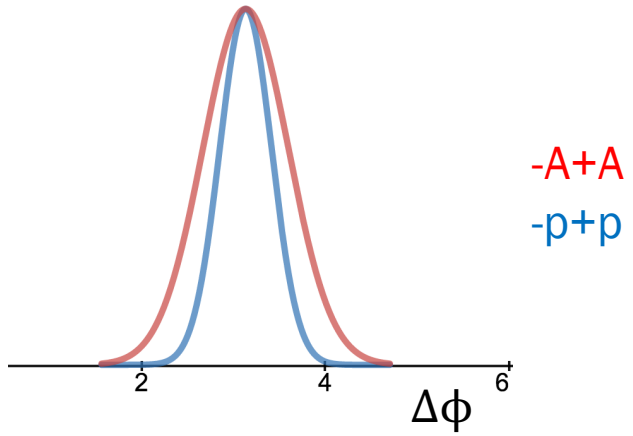

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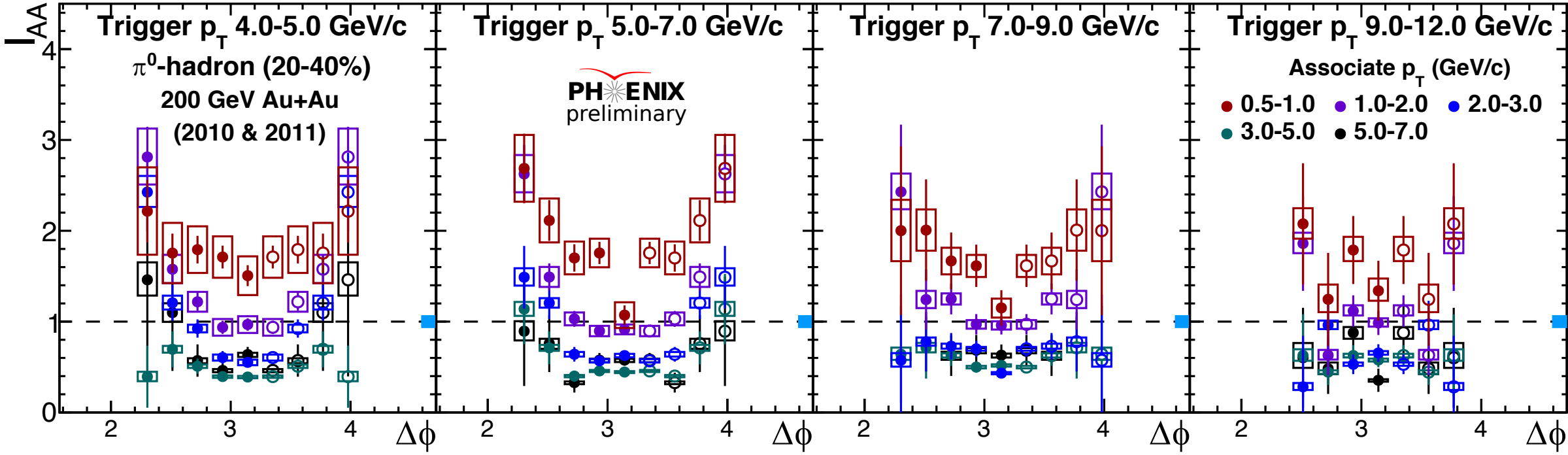
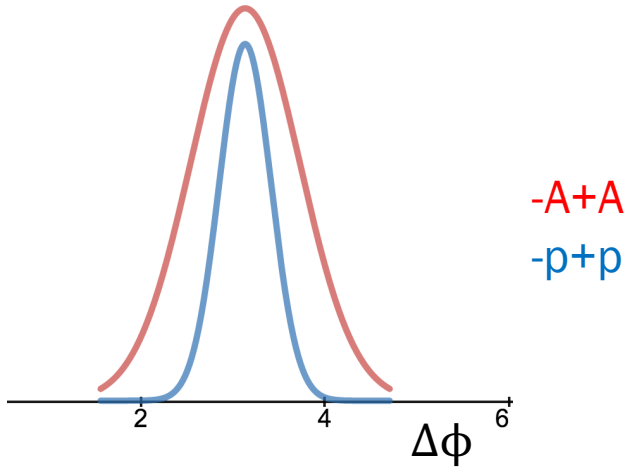
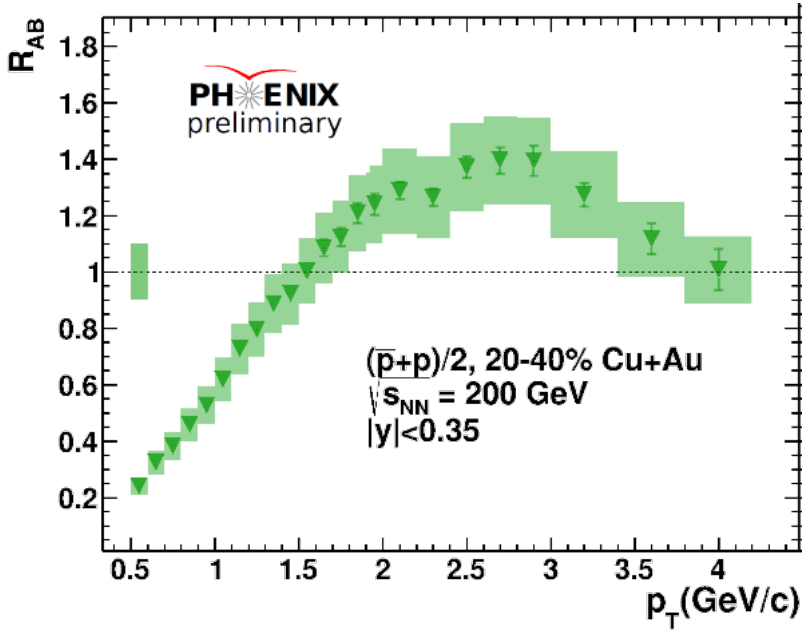


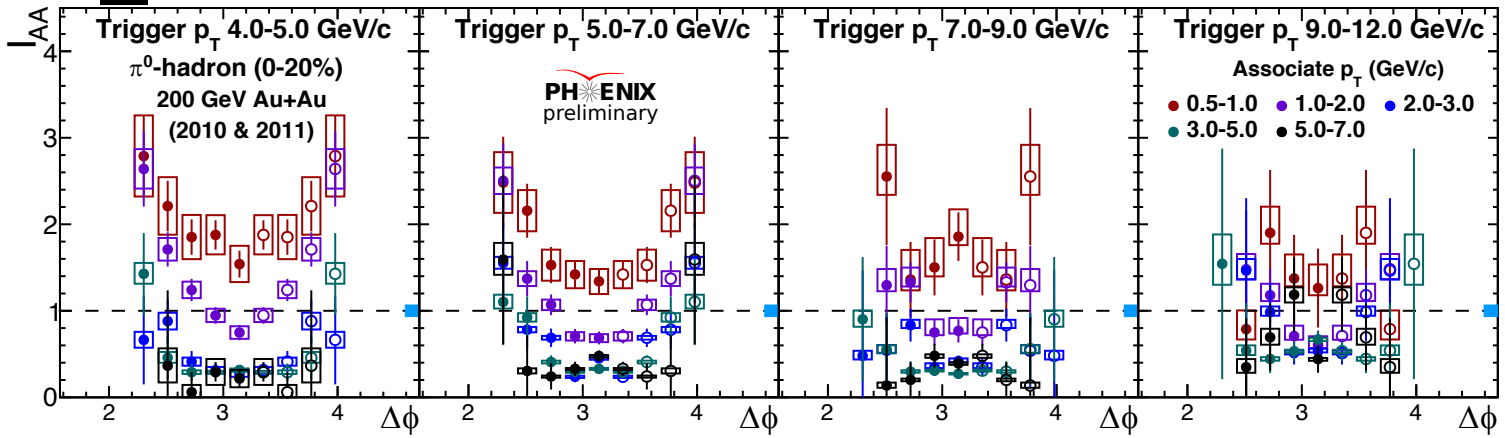
- Calculate ratio in yields between Au+Au jet function and p+p baseline
- Shows modification to away-side jet peak at substructure level
- Skirt of jet is the first to see significant enhancement
- Most intense enhancement at wide angles

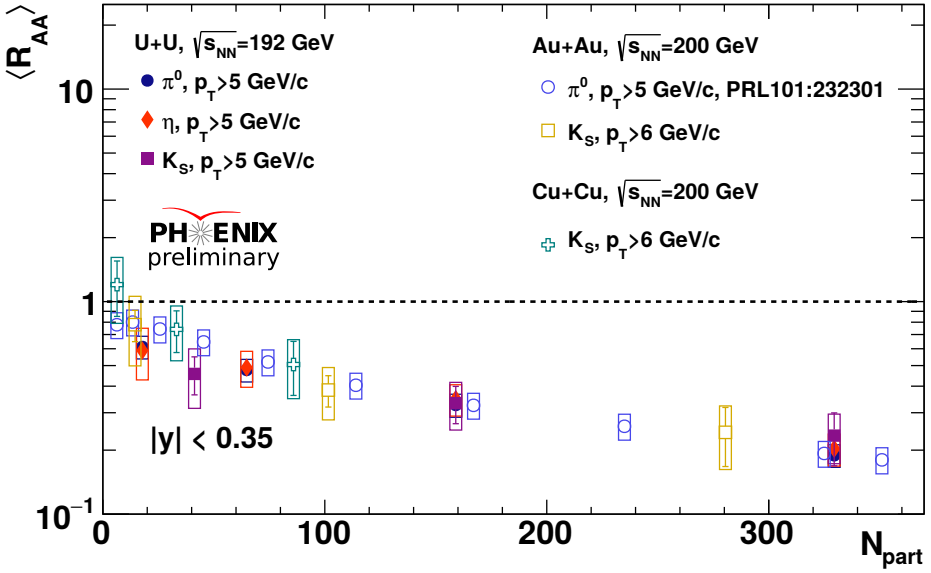


Conclusion

- Baryon enhancement in Cu+Au
- New hadron R_{AA} in Cu+Au and U+U
- System size dependence of $\langle R_{AA} \rangle$
- Away-side jet yield and shape modification consistent with energy loss via wide angle gluon radiation
- New $I_{AA}(\Delta\phi)$ probes jet modification at substructure level



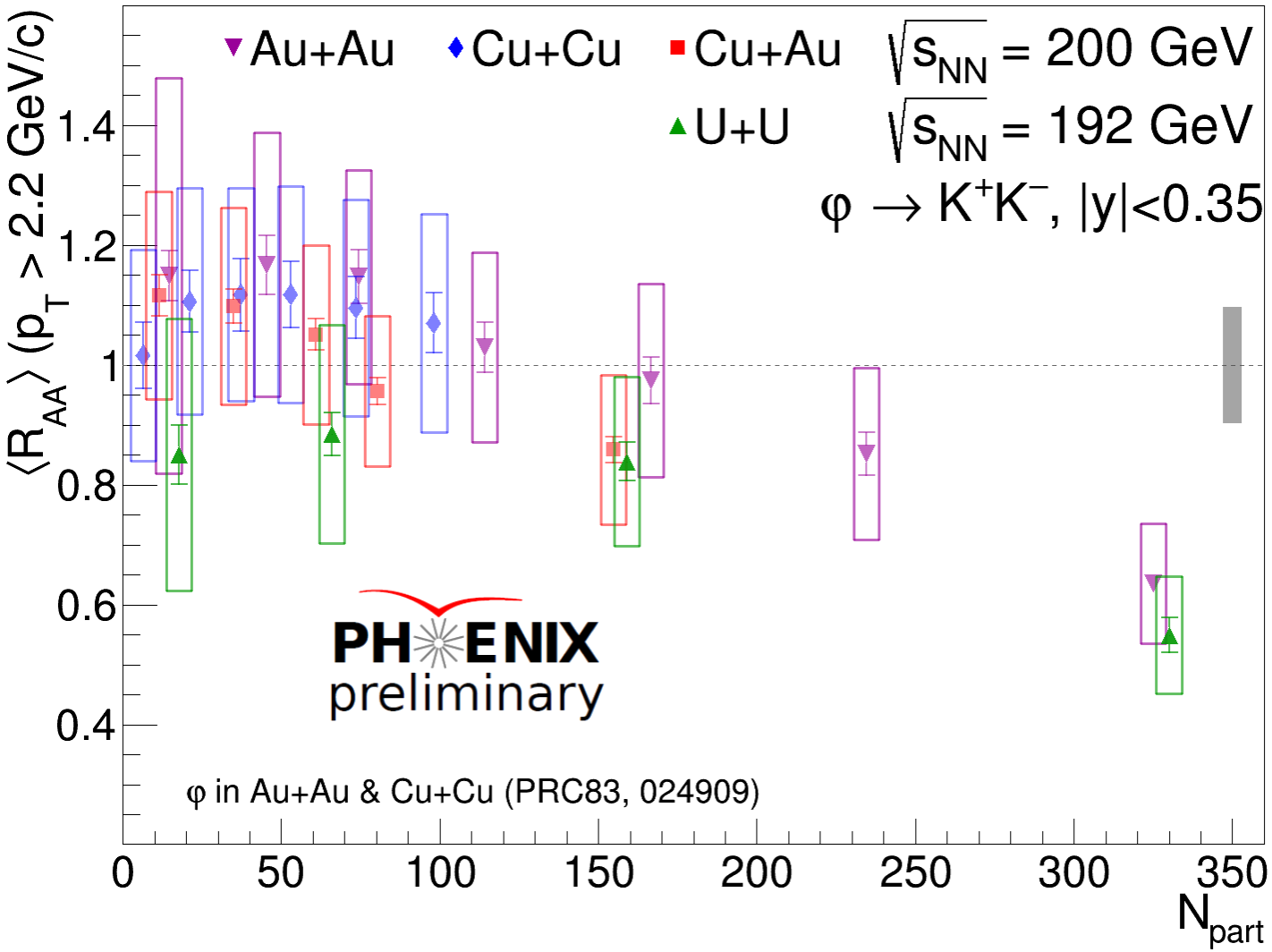




Thank you!

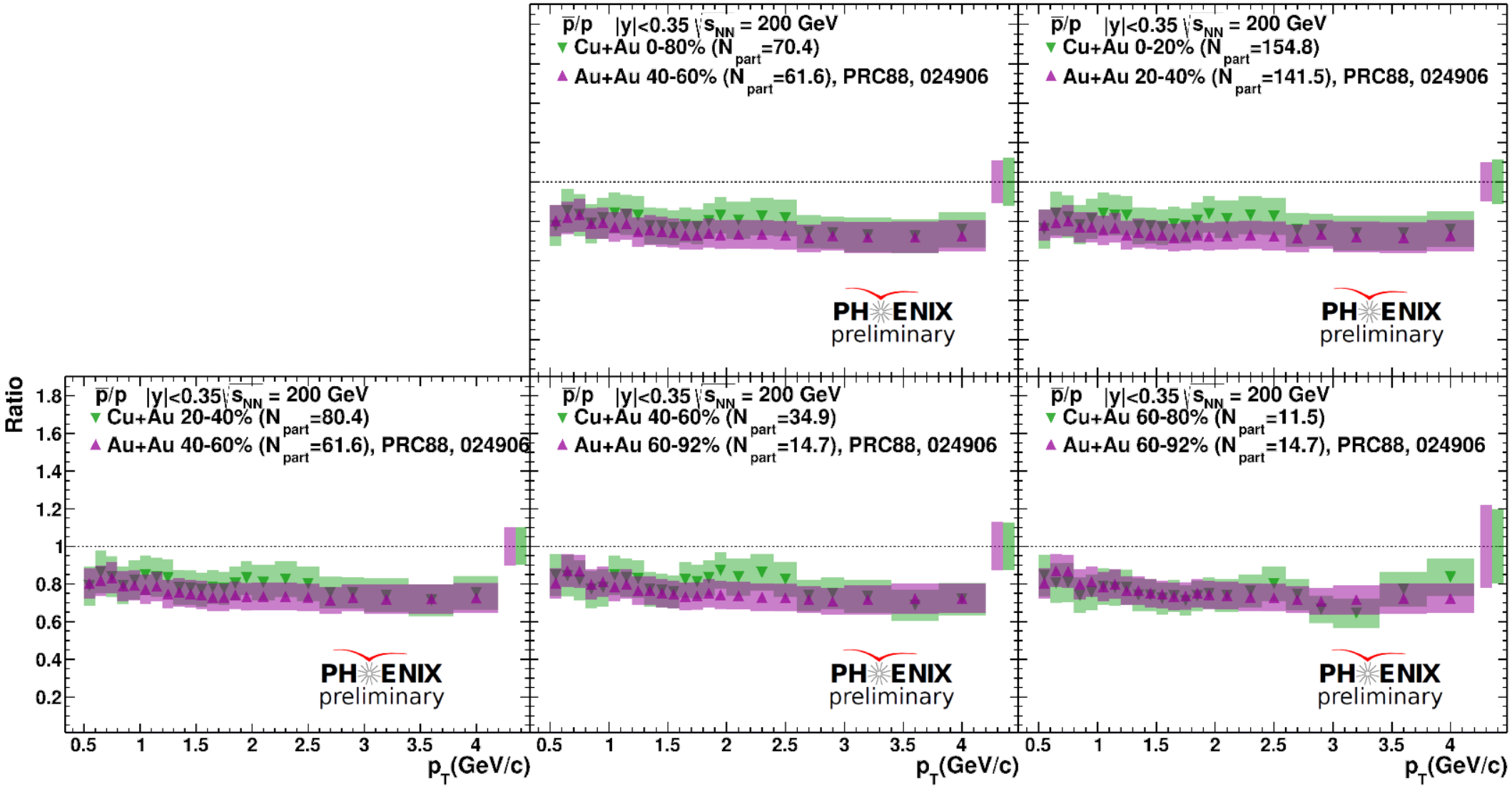
BACK UP

7 - Φ Meson R_{AA} in A+A



- Consistent R_{AA} across collision species

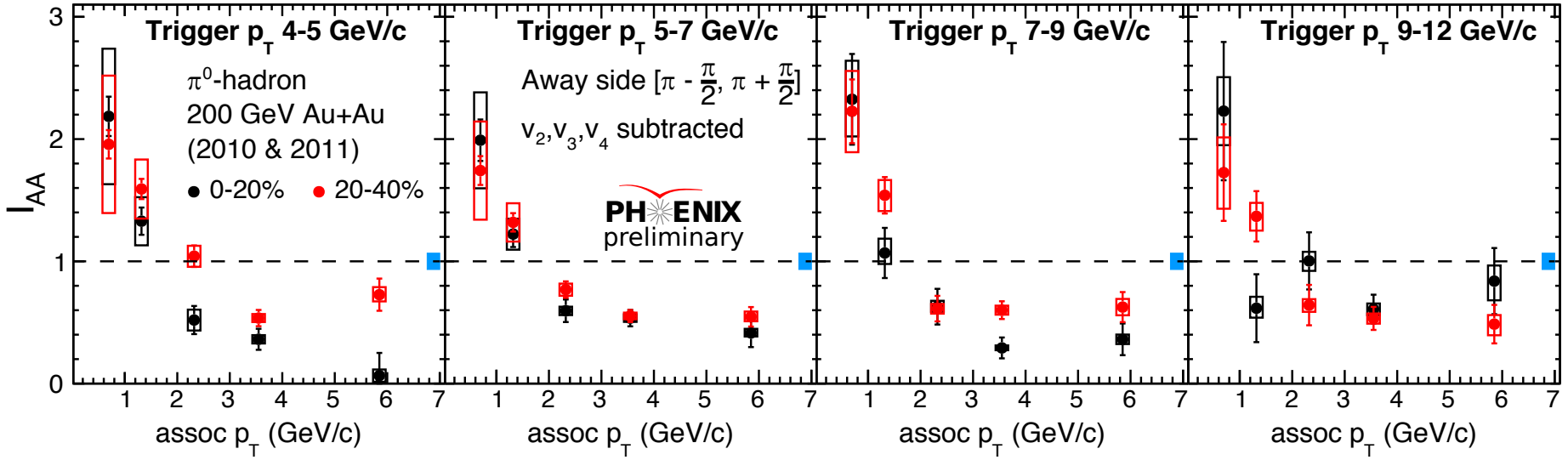
$\bar{p}/p$ Ratio in A+A

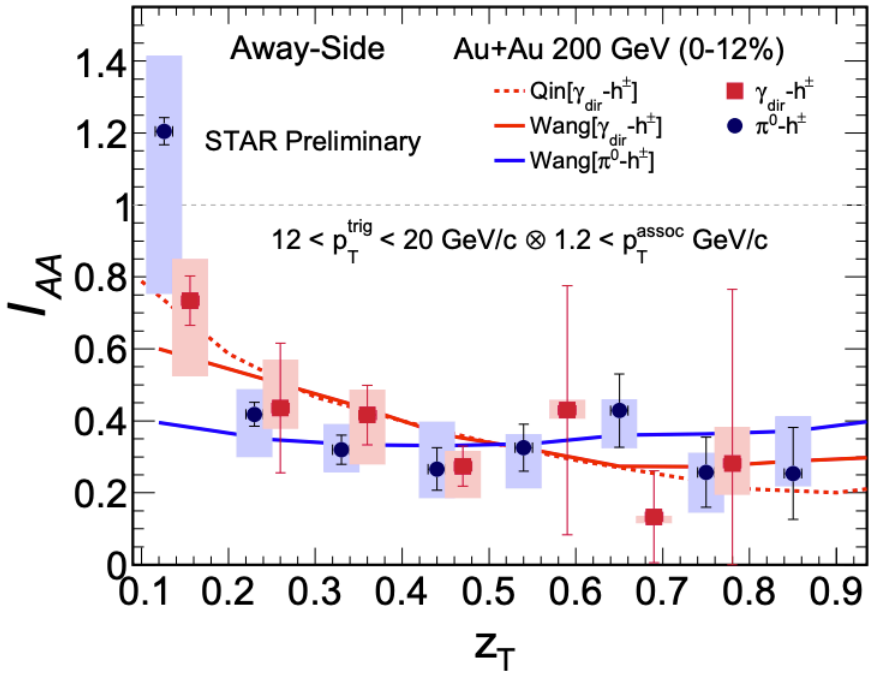


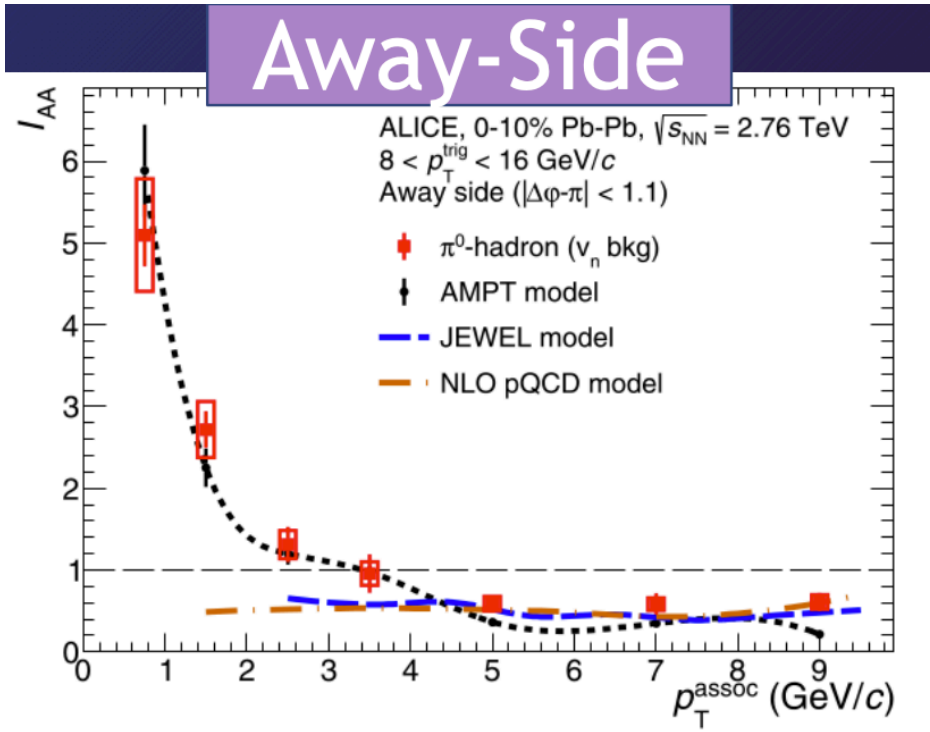
- $\bar{p}/p$ ratio consistent across Cu+Au and Au+Au

π^0-Hadron Correlations – $I_{AA}(p_T)$

- PHENIX $\pi^0 - h^{\pm}$ I_{AA} results consistence with ALICE
- STAR reports no enhancement, but lacks similar kinematic reach in its measurement to PHENIX and ALICE result







Nuclear Physics A 956 (2016) 621–624

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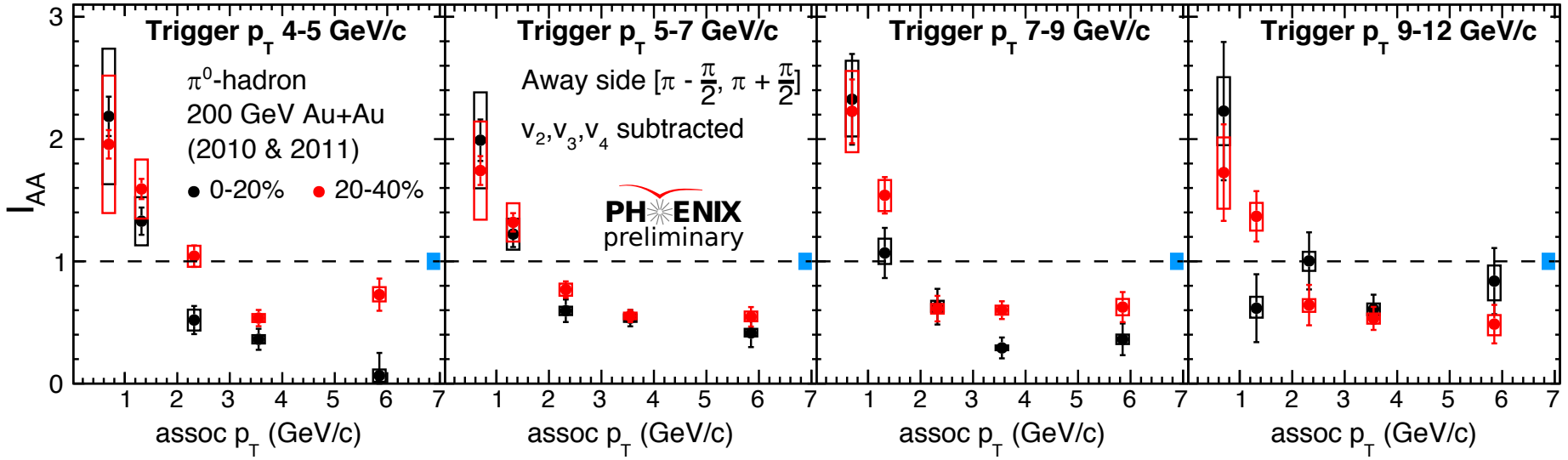

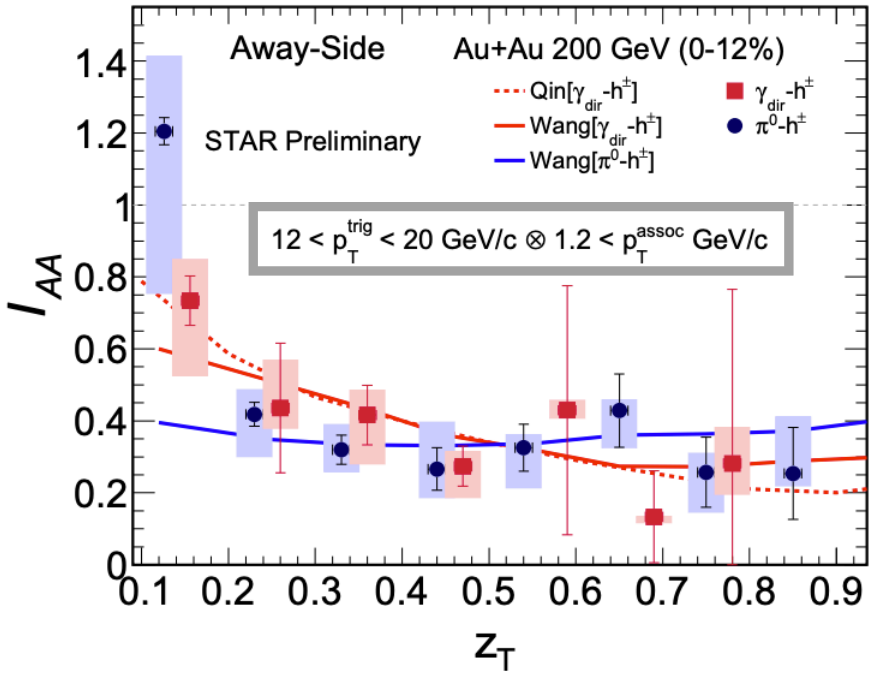

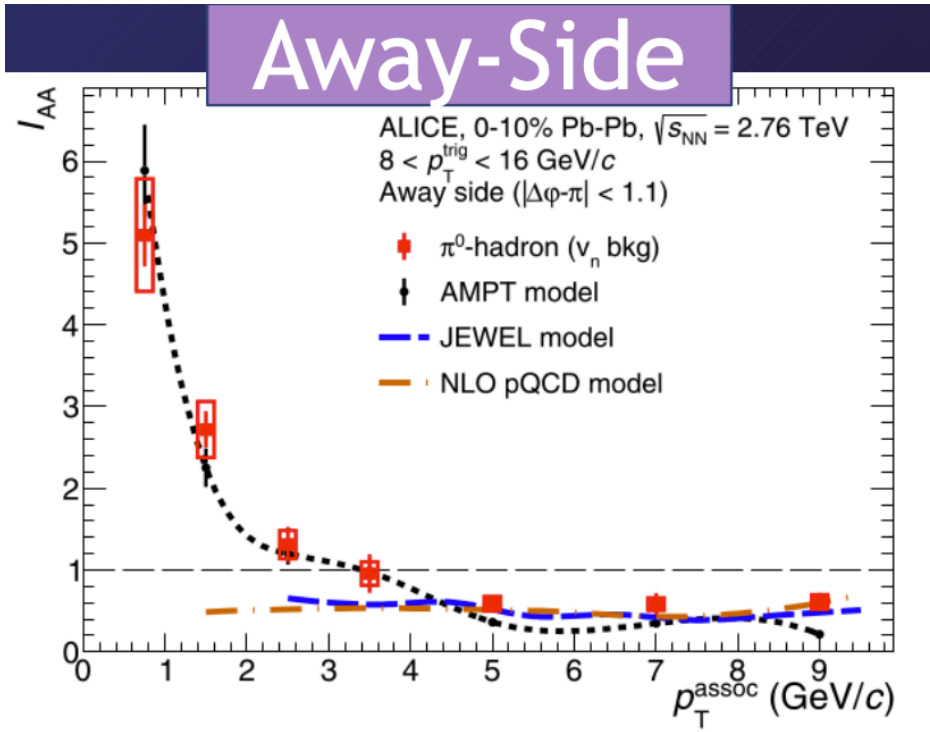

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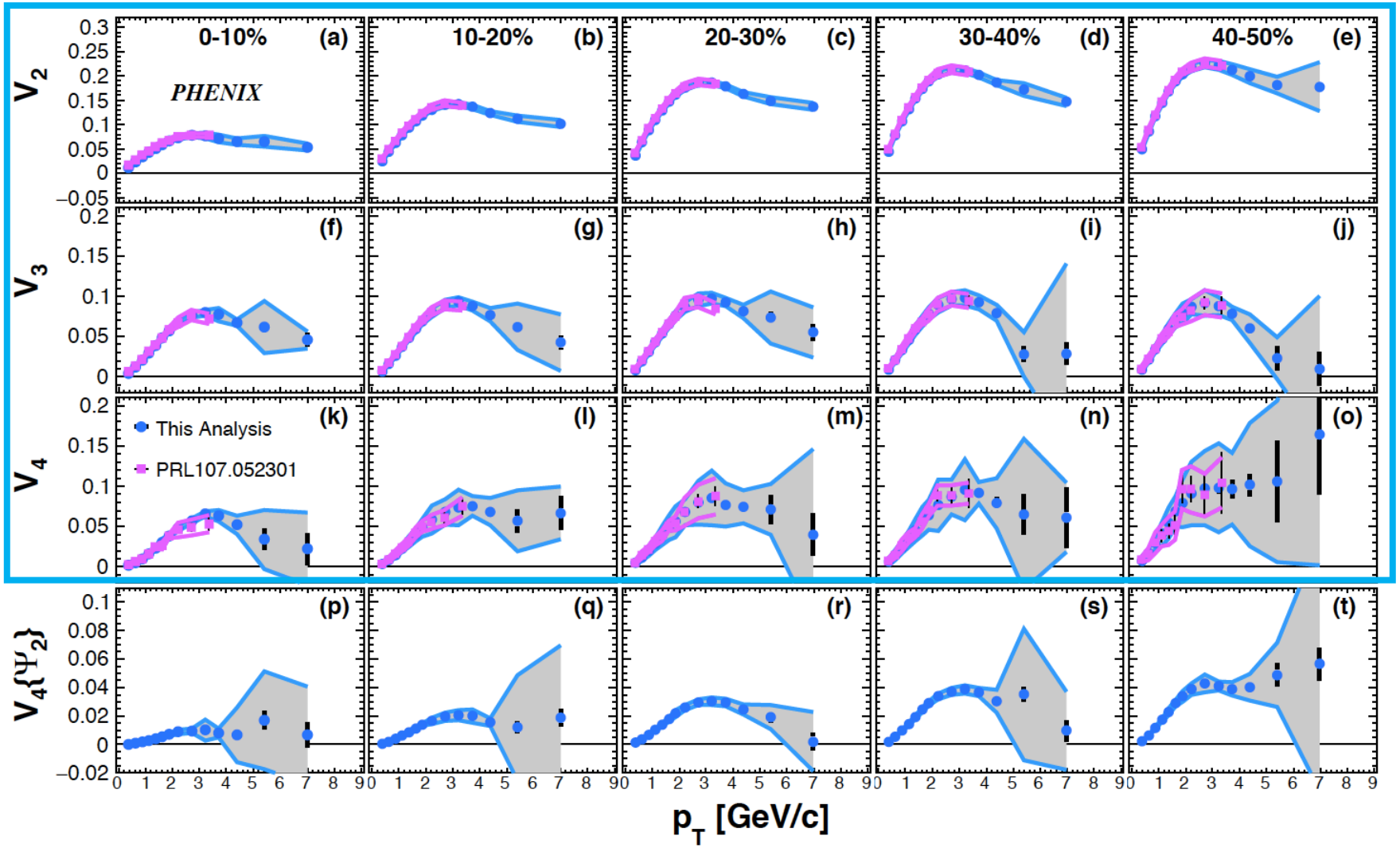
Flow Subtraction – Charged Hadron v_n

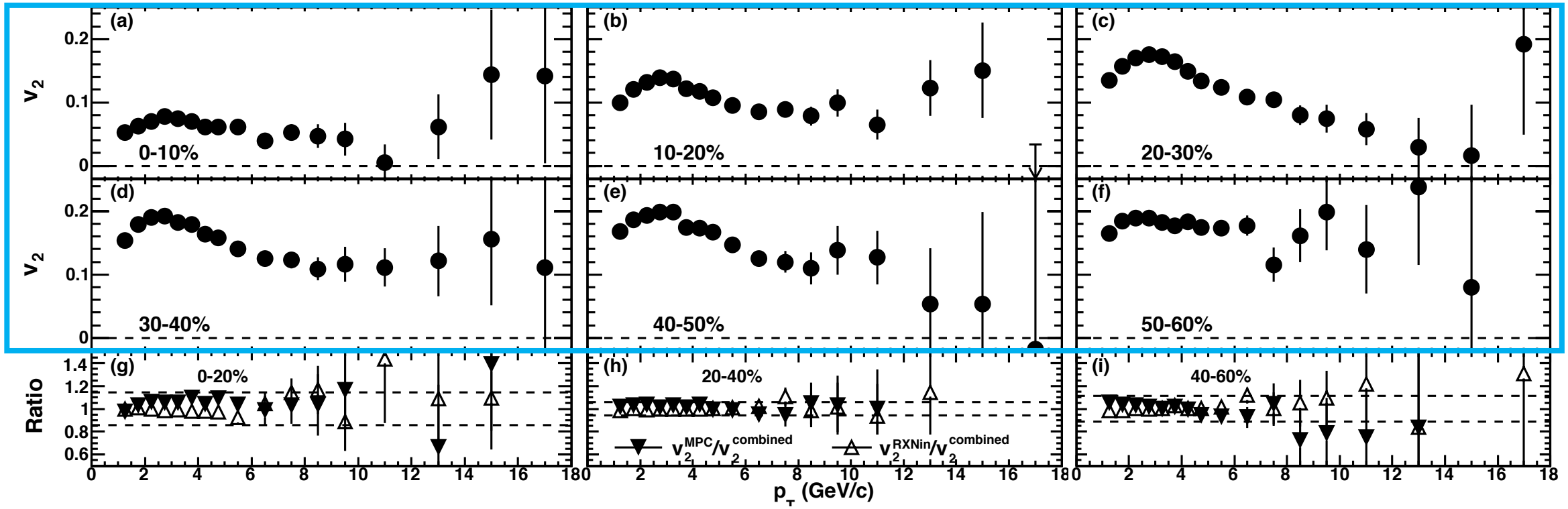


arXiv:1803.01749v1 (2007 data)

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

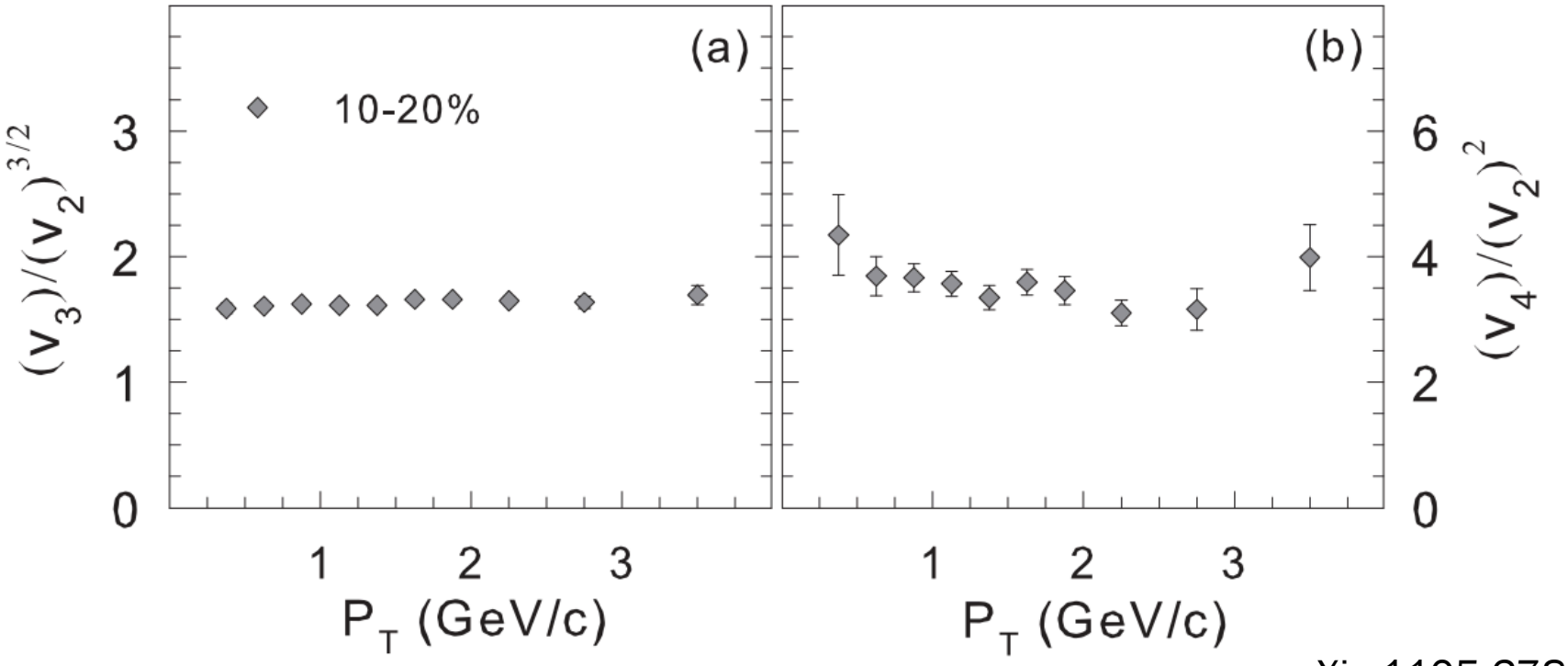
Flow Subtraction - π^0 v_n

PRL 105, 142301 2010 (2007 data)



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

Flow Subtraction – Acoustic Scaling

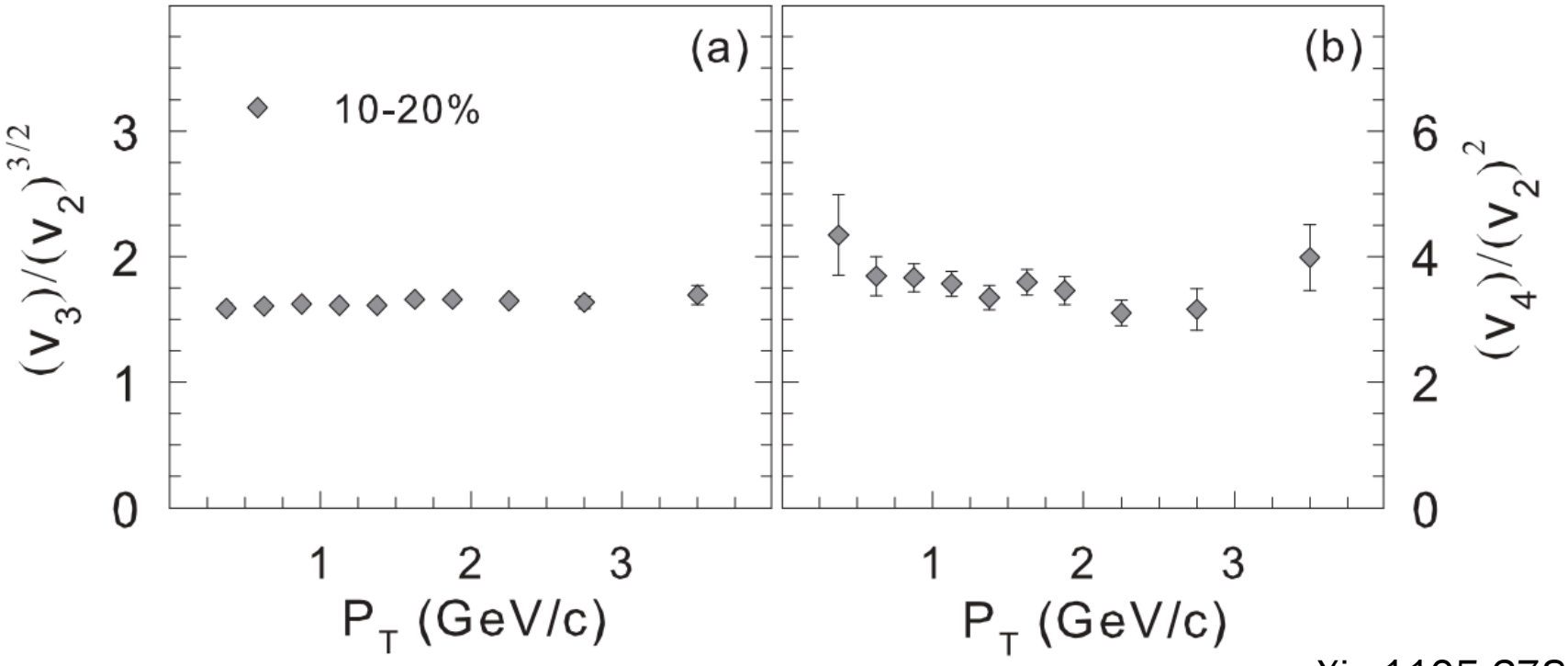


arXiv:1105.3782v2

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

- 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

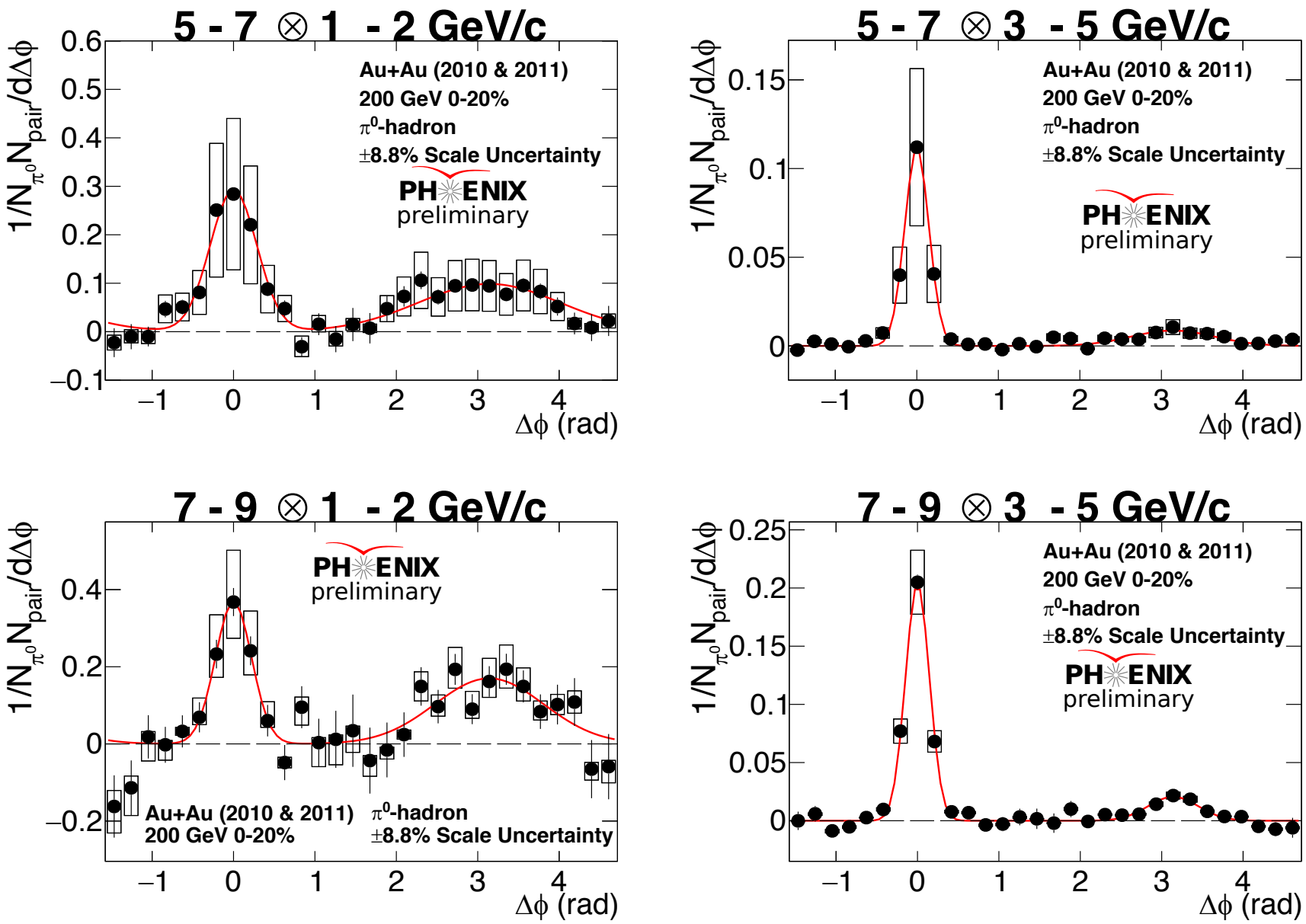


arXiv:1105.3782v2

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

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

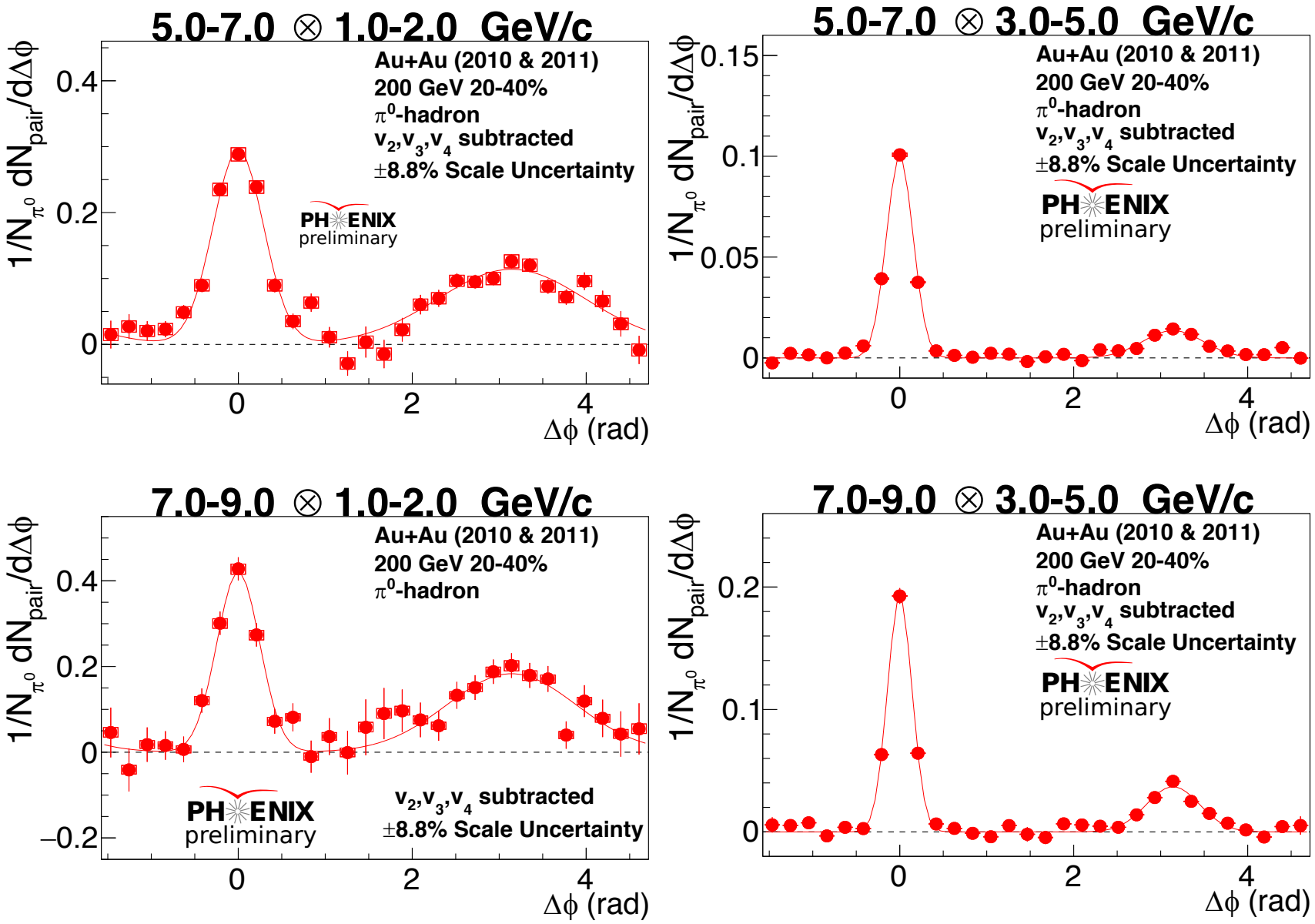
Sample Jet Functions:



0–20%

$v2, v3, v4$ subtracted

Sample Jet Functions:



20—40%

$v2, v3, v4$ subtracted