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St.Petersburg Polytechnic
University

PHENIX

Modification of hadron productions in small systems observed by PHENIX

Mitrankov Iurii

For PHENIX collaboration

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MOTIVATION

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Flow measurements →strong evidence for QGP droplets in small systems;

Talk by Seyoung Han

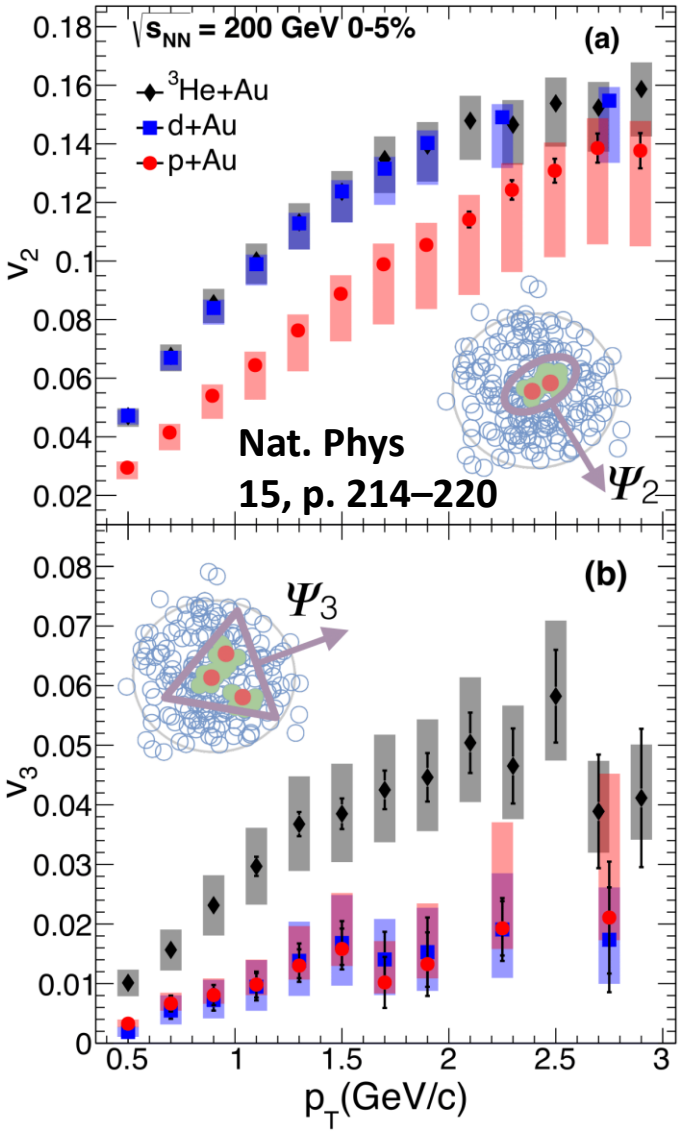
Energy loss in the plasma?

If so, it would present itself in the hadrons spectra;

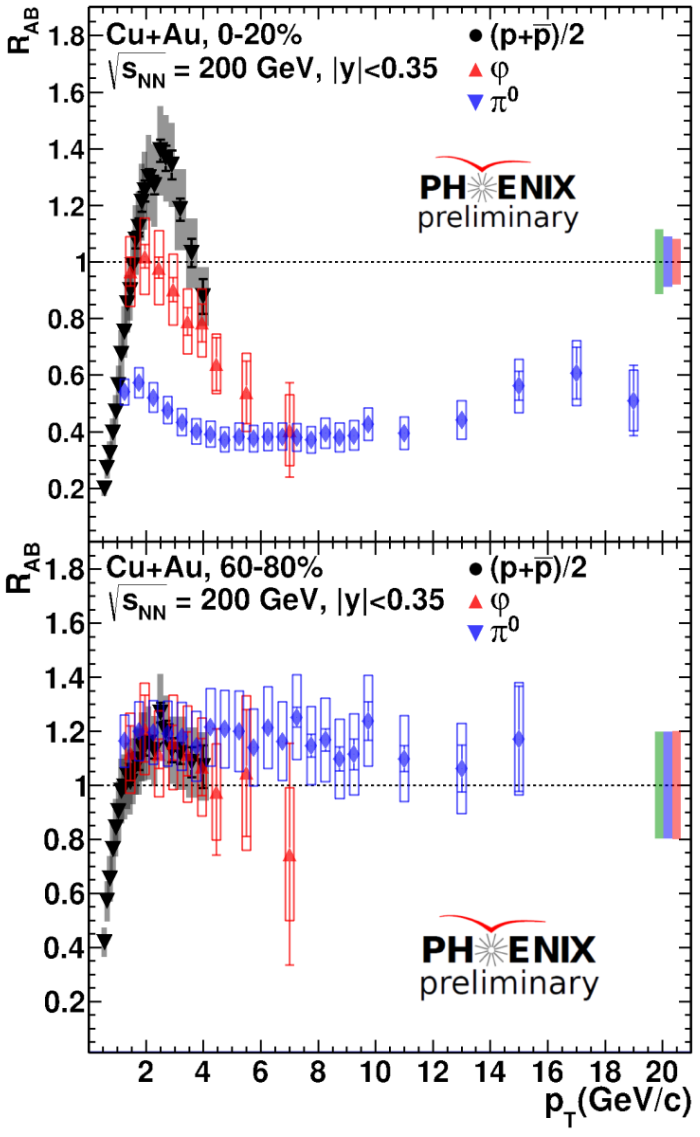
Interpreting Large systems

Talk by Anthony Hodges

Small systems



Large system



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Flow measurements →strong evidence for QGP droplets in small systems

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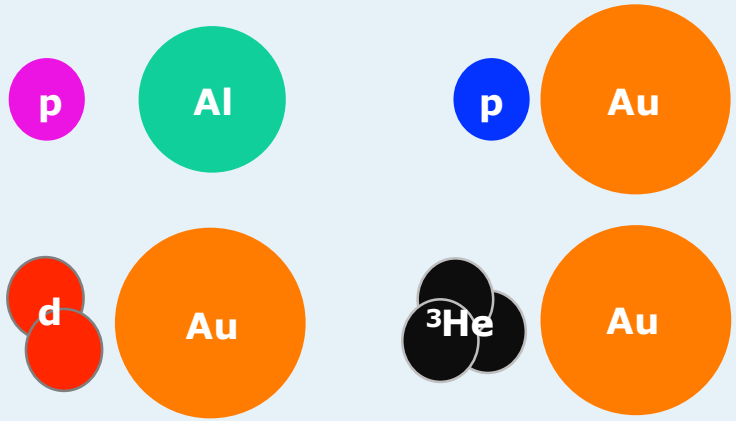
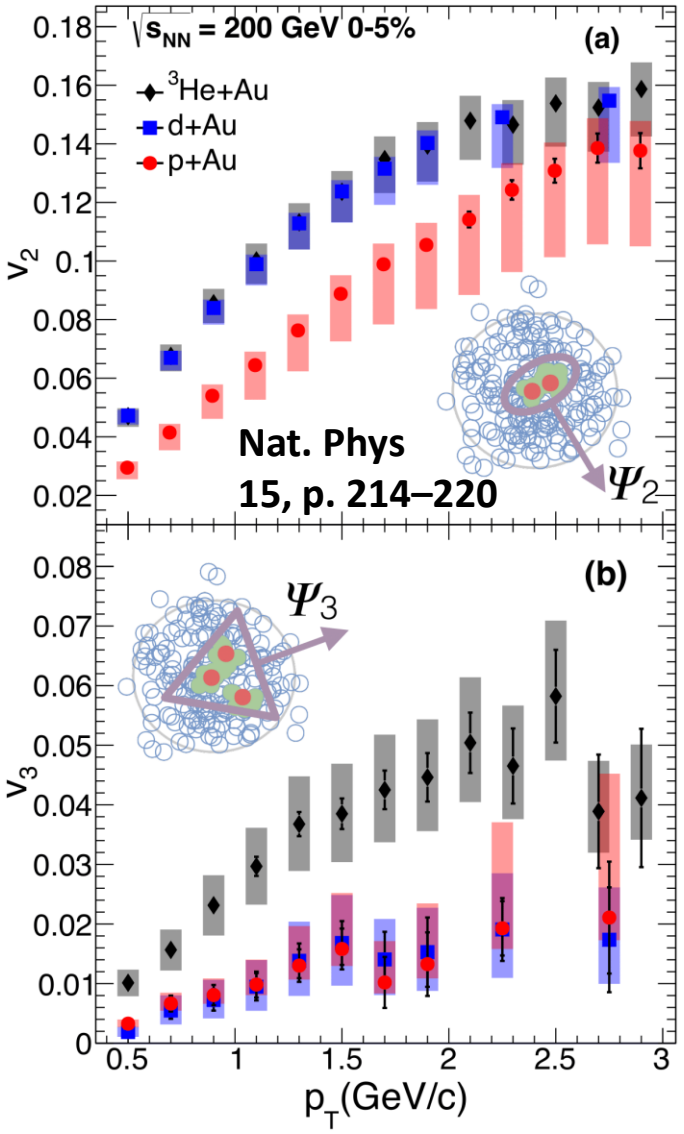
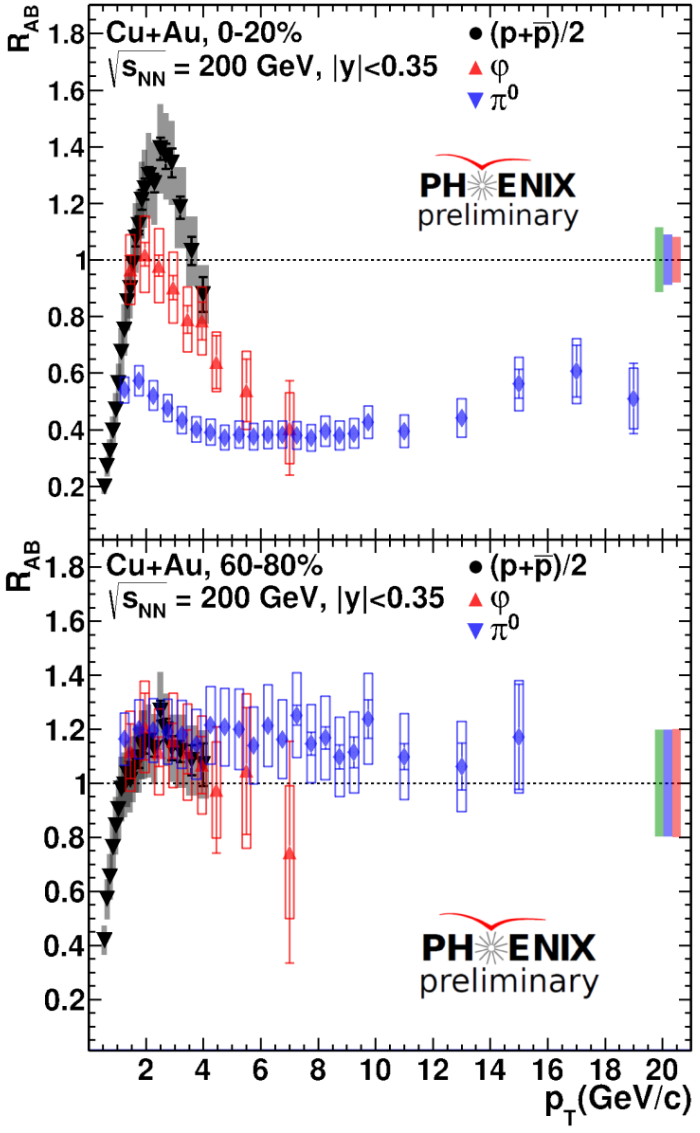
Interpreting Large systems



Small systems



Large system



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π^0 and φ R_{AB} in p+Au

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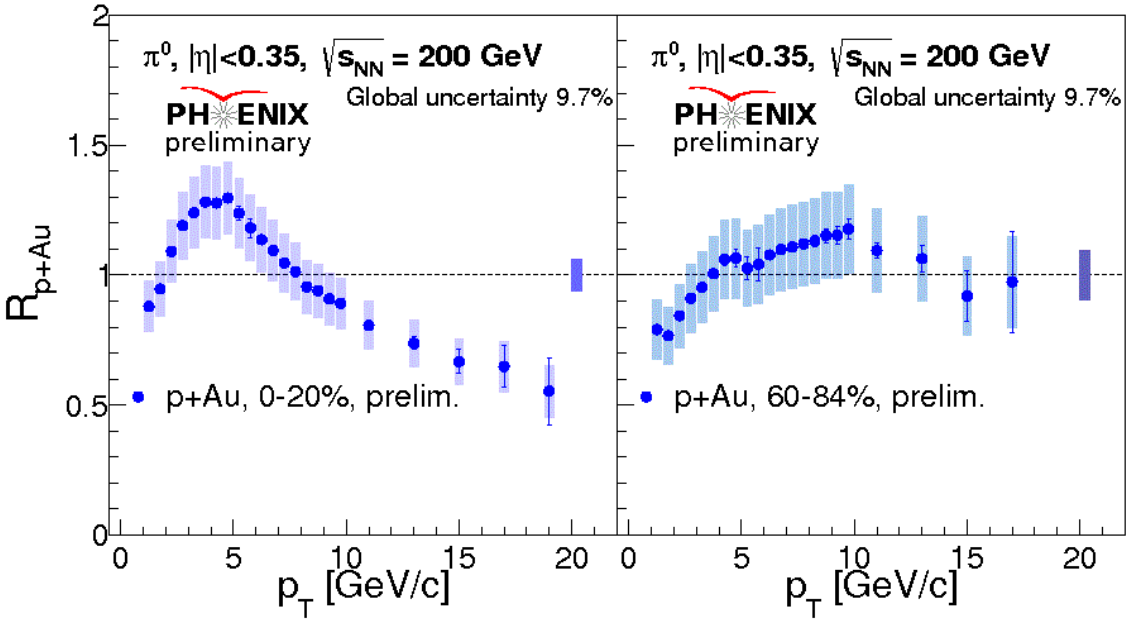

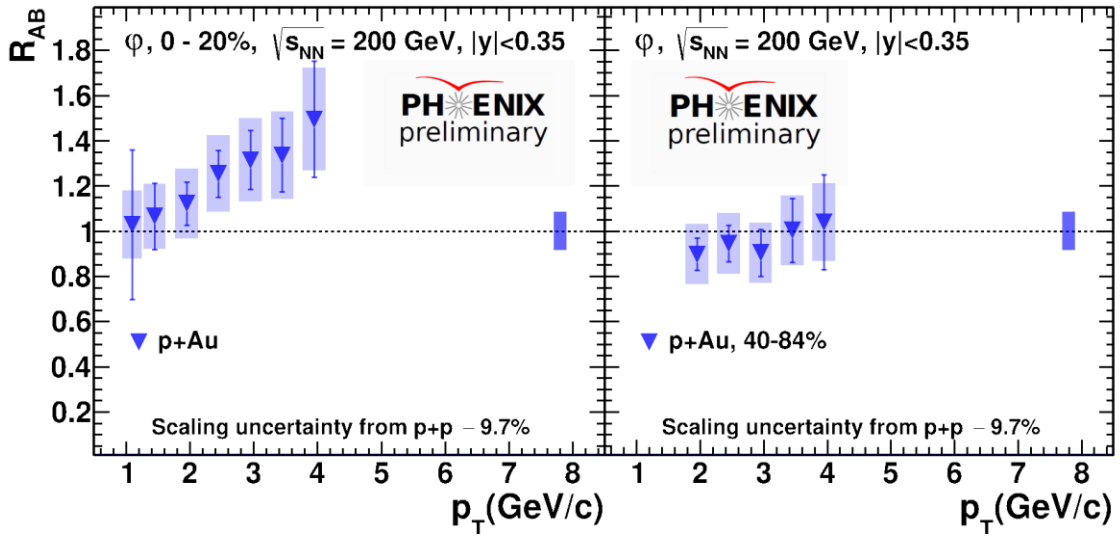

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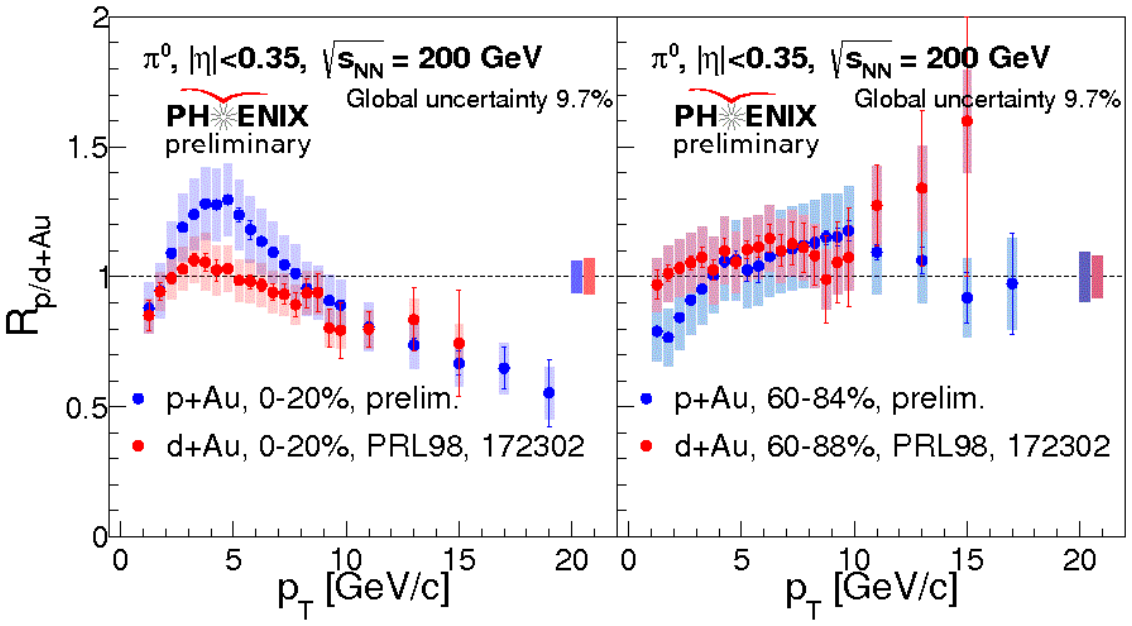
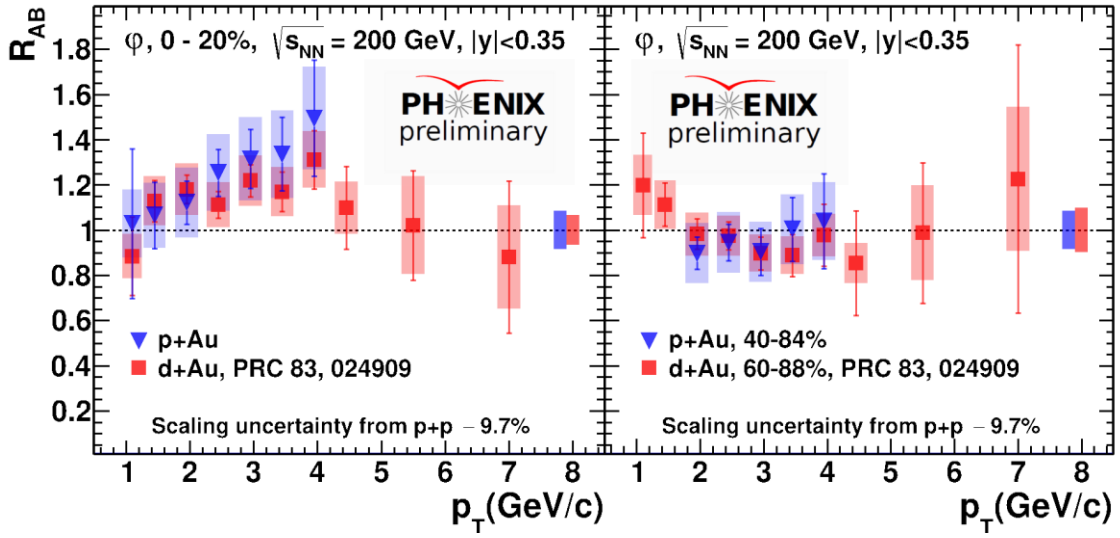
π^0 and φ R_{AB} in p+Au, d+Au

PHENIX





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π^0 and φ R_{AB} in p+Au, d+Au, ^{3}He+Au

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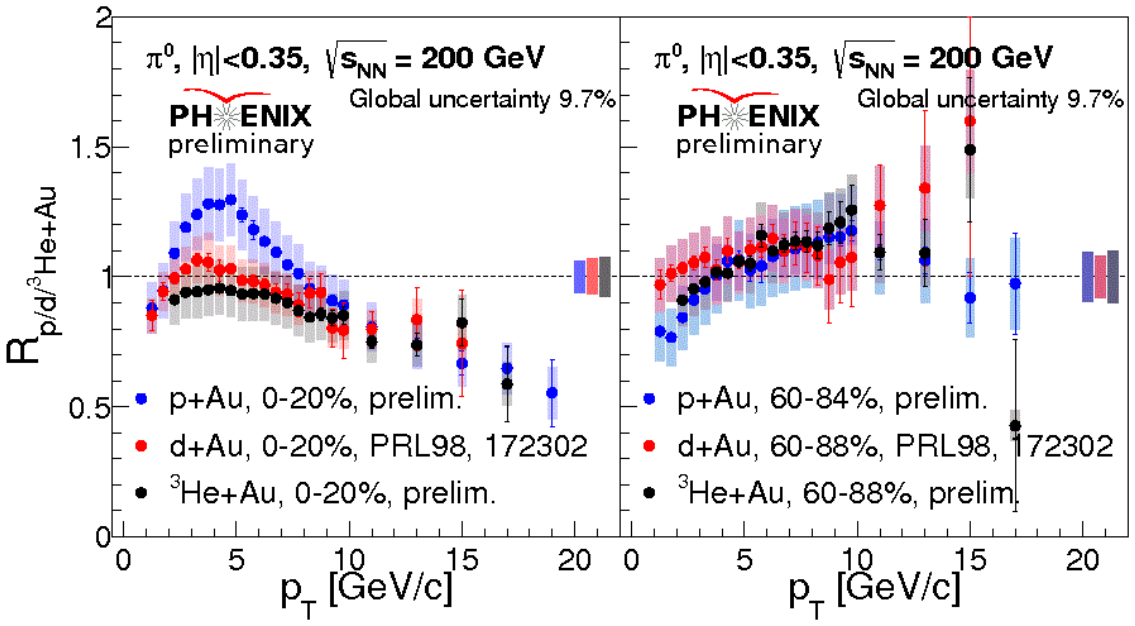
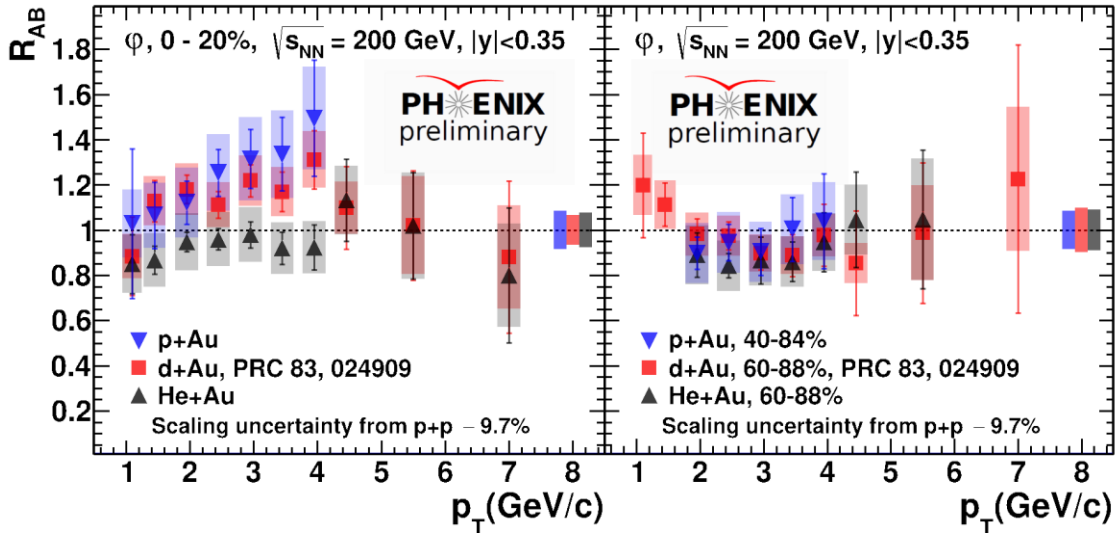
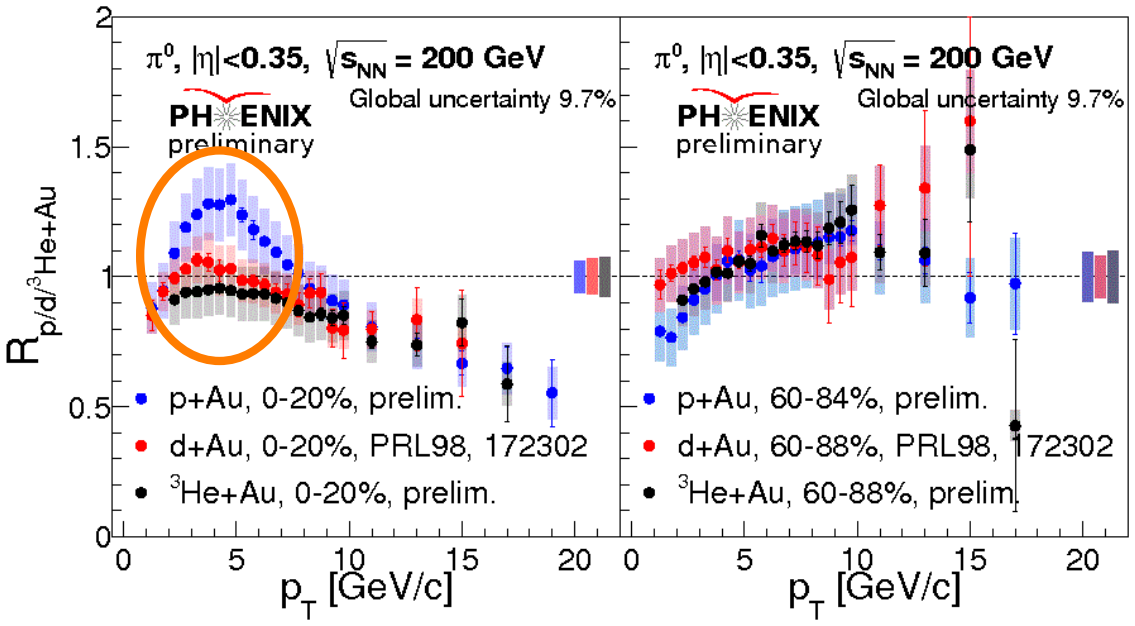
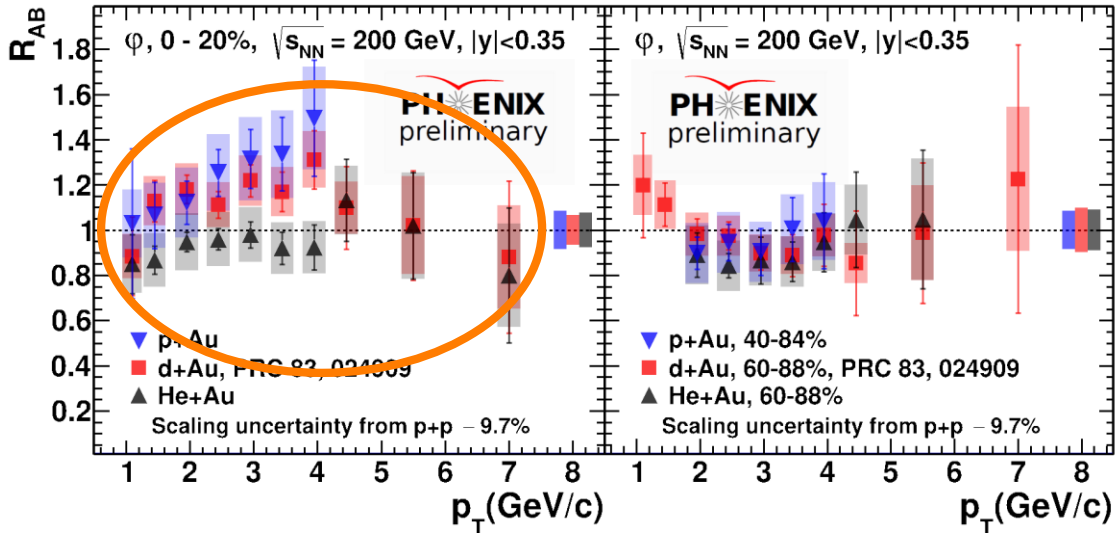




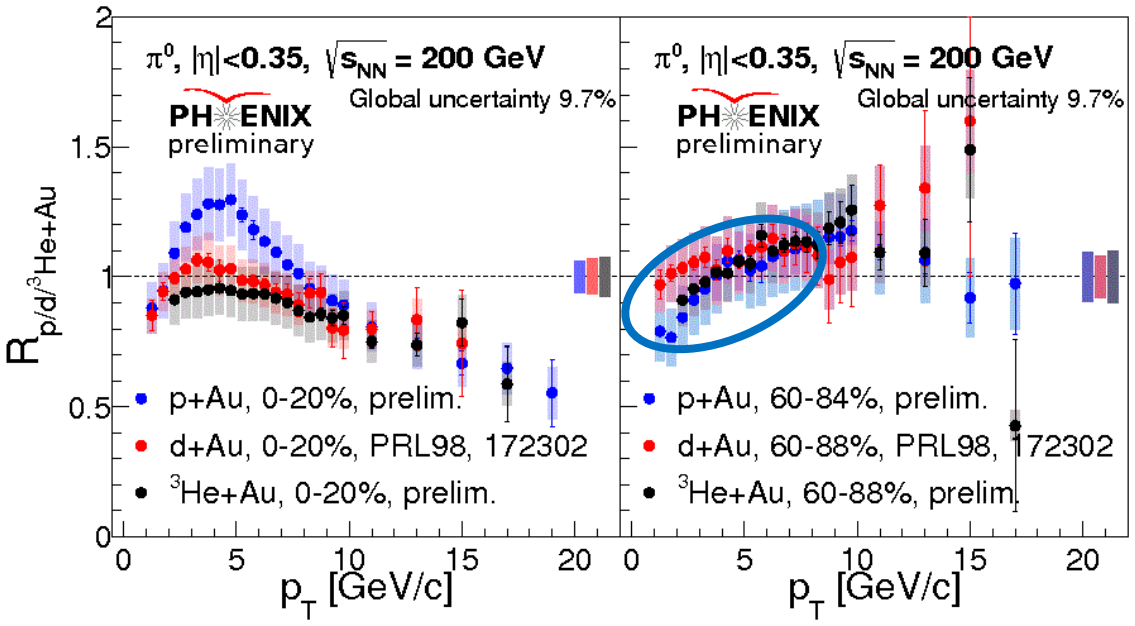


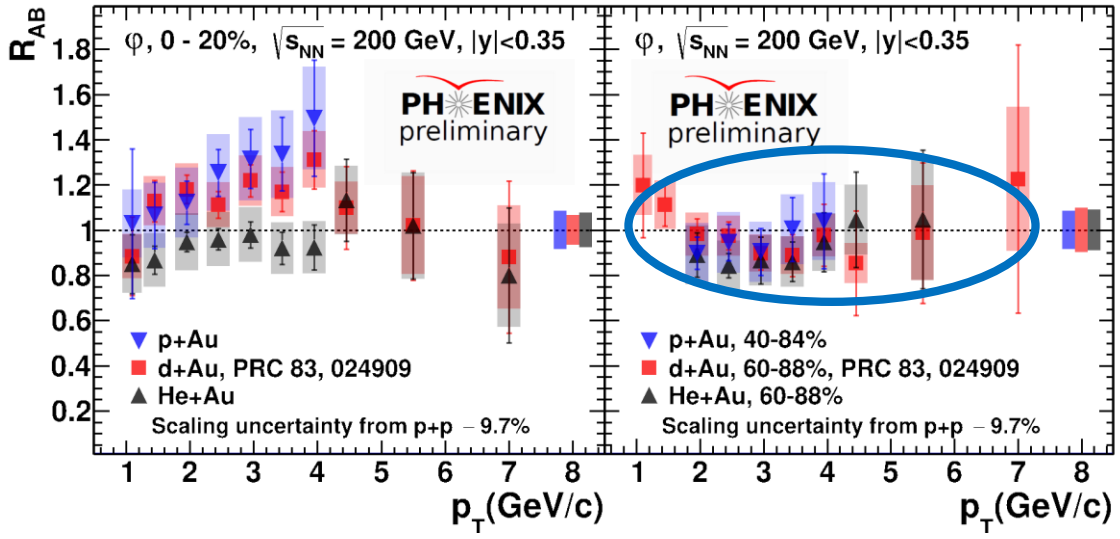


π^0 and φ R_{AB} in p+Au, d+Au, ^{3}He+Au

AT INTERMEDIATE p_T RANGE:

- Ordering $R_{pAu} > R_{dAu} > R_{HeAu}$ in 0-20%

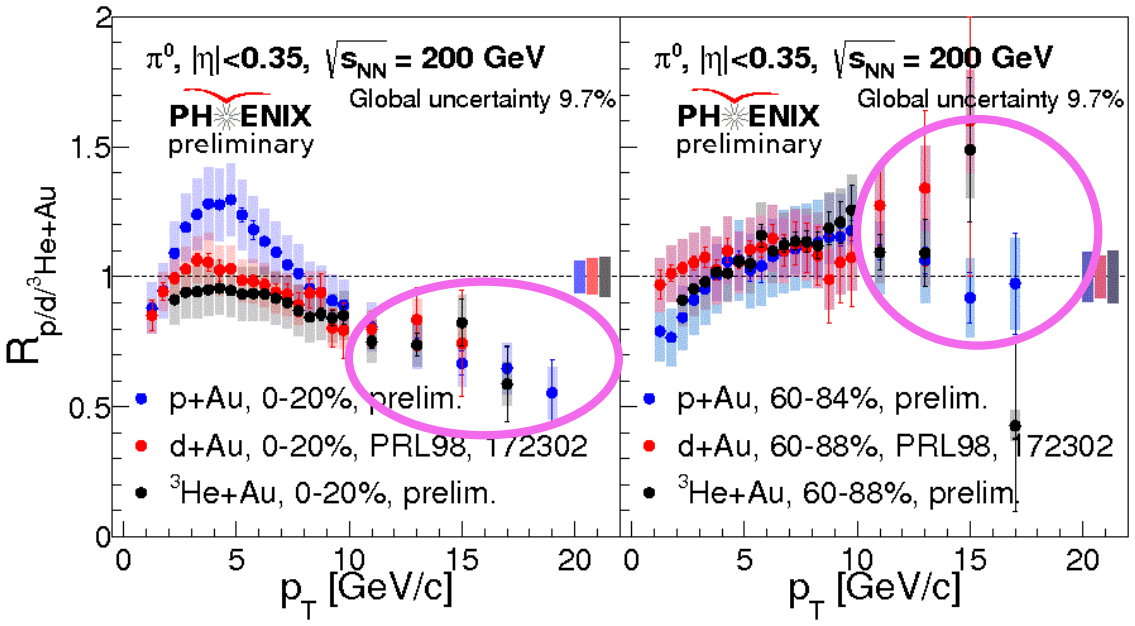


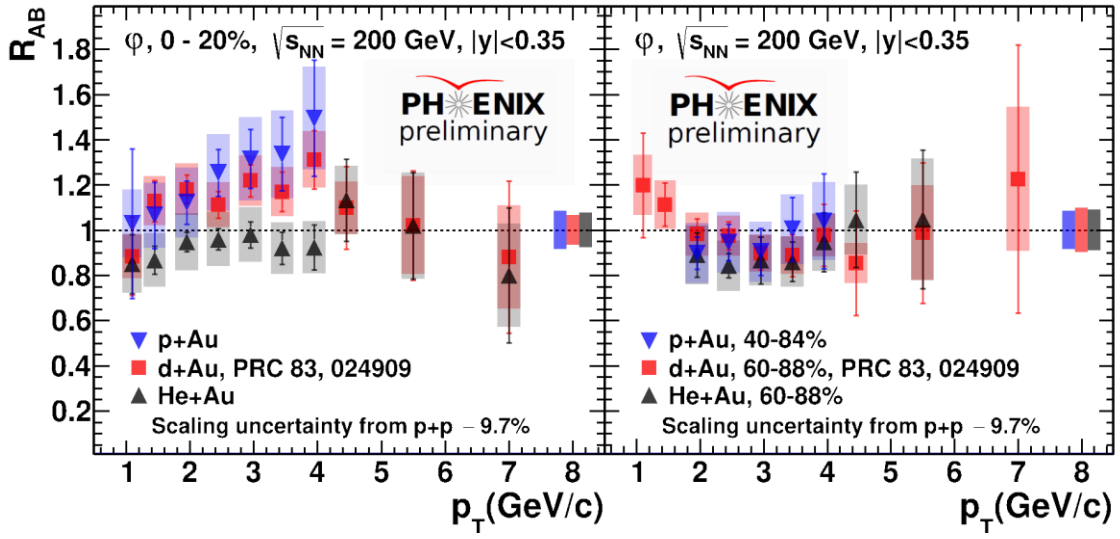


π^0 and φ R_{AB} in p+Au, d+Au, ^{3}He+Au

AT INTERMEDIATE p_T RANGE:

- Ordering $R_{pAu} > R_{dAu} > R_{HeAu}$ in 0-20%
- π^0&φ $R_{pAu} \approx R_{dAu} \approx R_{HeAu}$ in peripheral collisions





π^0 and φ R_{AB} in p+Au, d+Au, ^{3}He+Au

AT INTERMEDIATE p_T RANGE:

- Ordering $R_{pAu} > R_{dAu} > R_{HeAu}$ in 0-20%
- π^0&φ $R_{pAu} \approx R_{dAu} \approx R_{HeAu}$ in peripheral collisions

AT HIGH-p_T RANGE:

- π^0 R_{AB}'s consistent with each other at high-p_T

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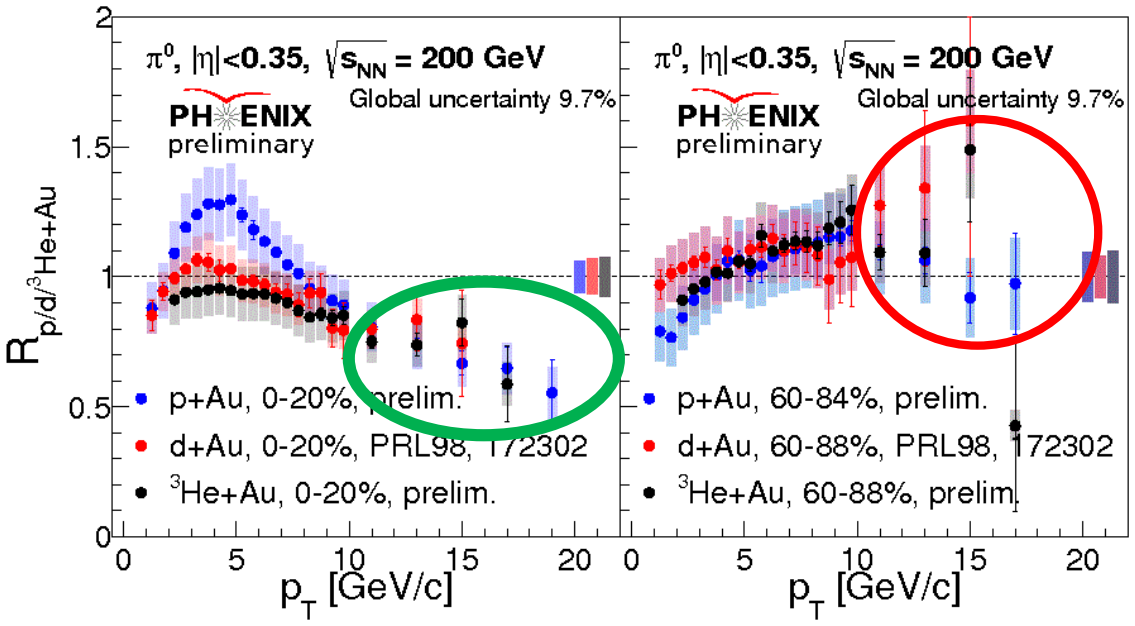
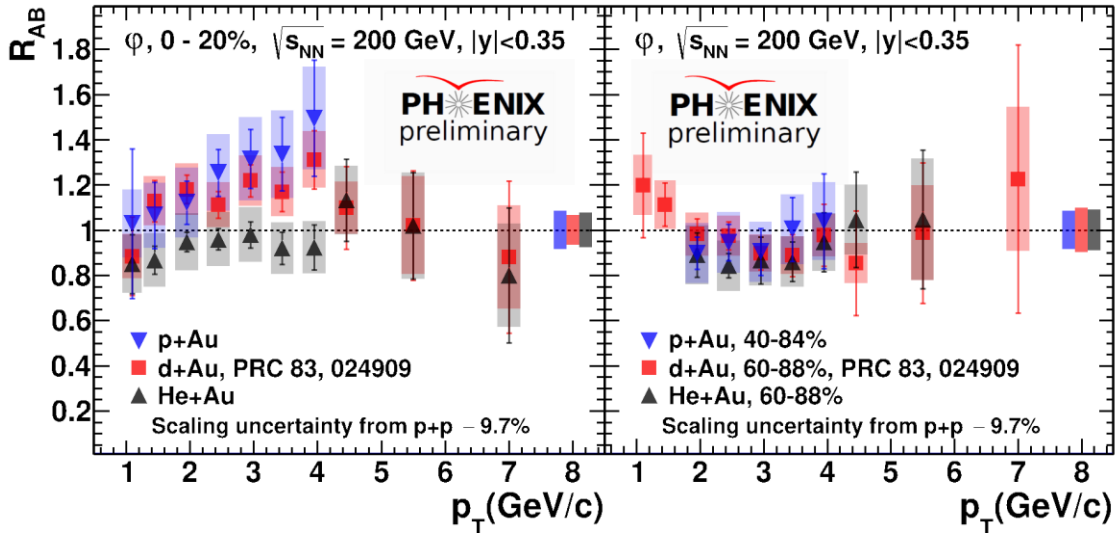
π^0 and φ R_{AB} in p+Au, d+Au, ^{3}He+Au





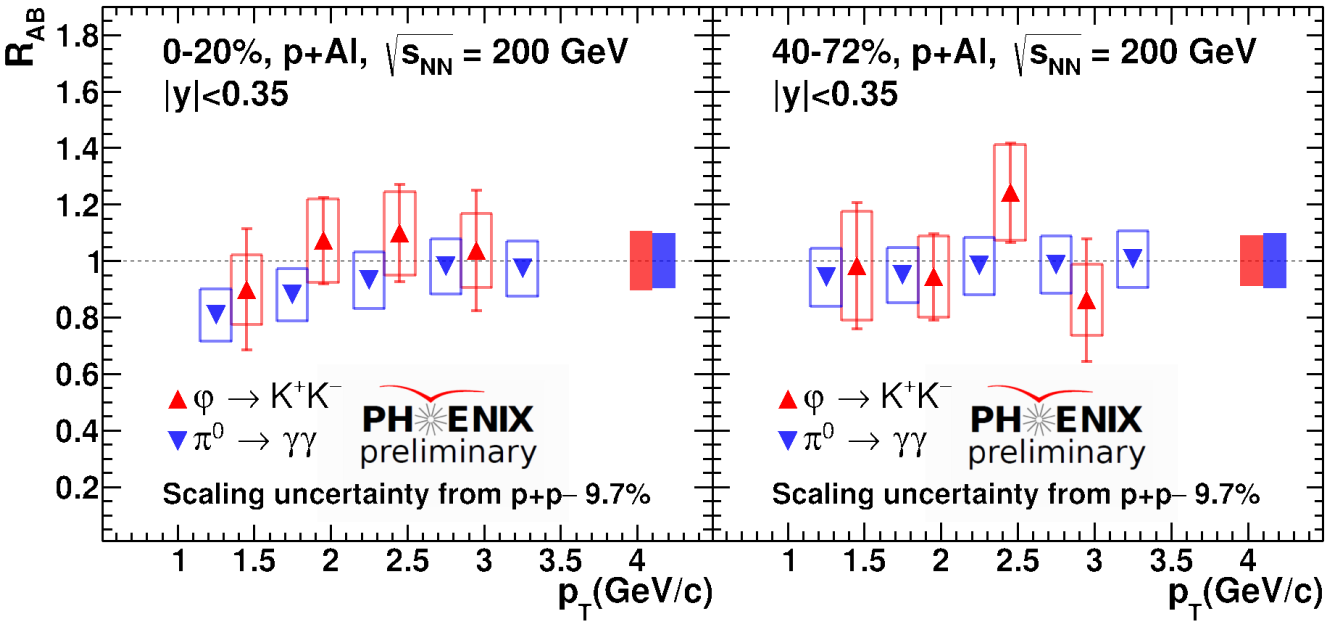
AT INTERMEDIATE p_T RANGE:

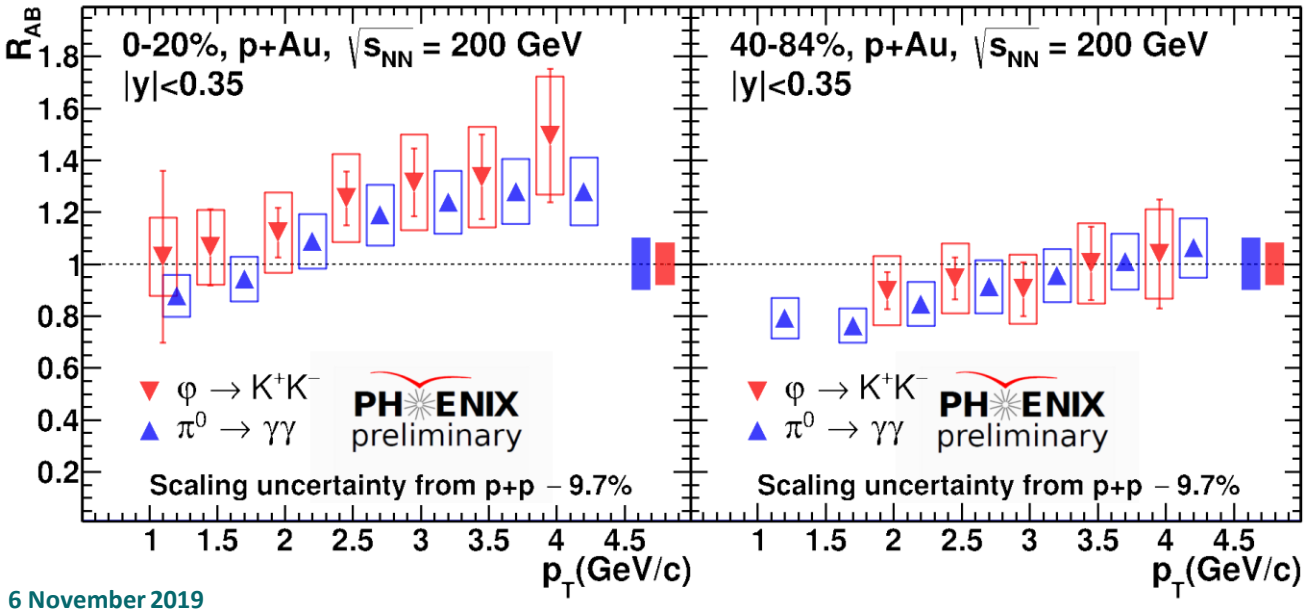
- Ordering $R_{pAu} > R_{dAu} > R_{HeAu}$ in 0-20%
- π^0&φ $R_{pAu} \approx R_{dAu} \approx R_{HeAu}$ in peripheral collisions

AT HIGH-p_T RANGE:

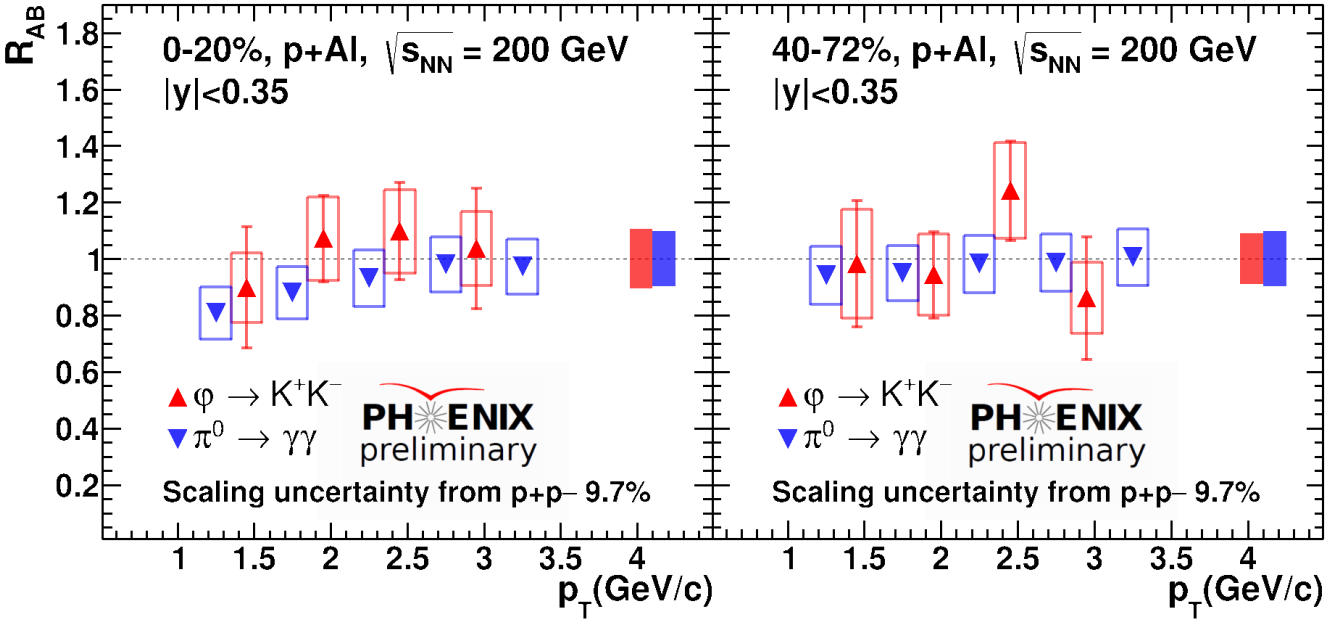
- π^0 R_{AB}'s consistent with each other at high-p_T
- **Hint of suppression in central collisions!**
- Hint of enhancement in peripheral collisions

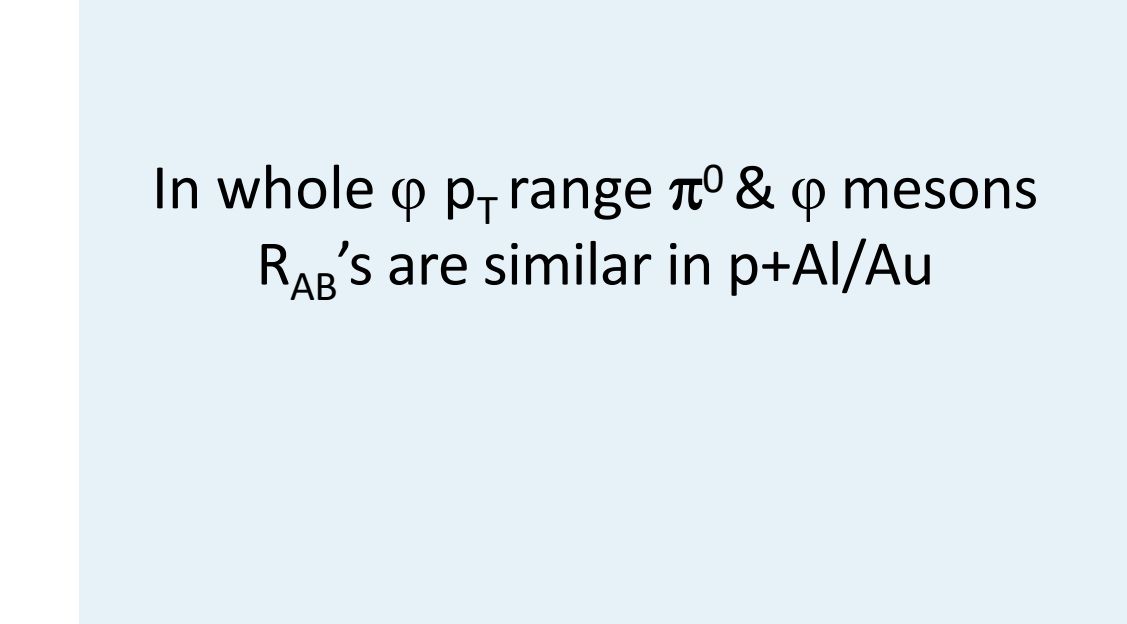
π^0 & φ R_{AB} in p+Al, p+Au, d+Au,^{3}He+Au

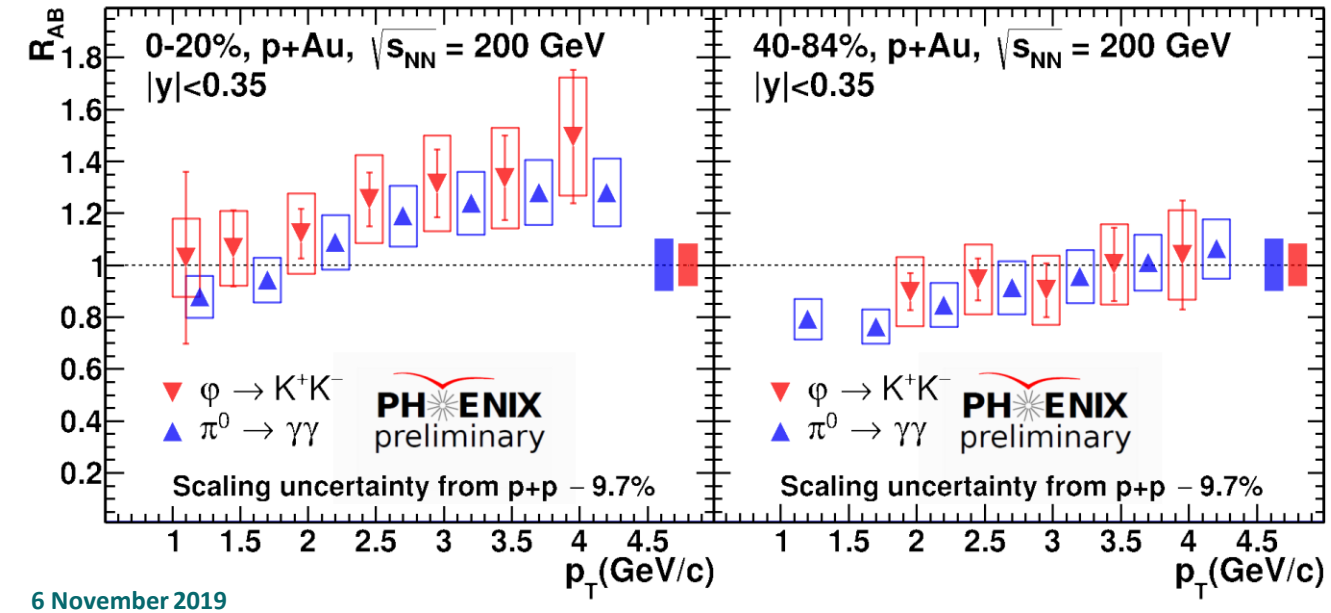


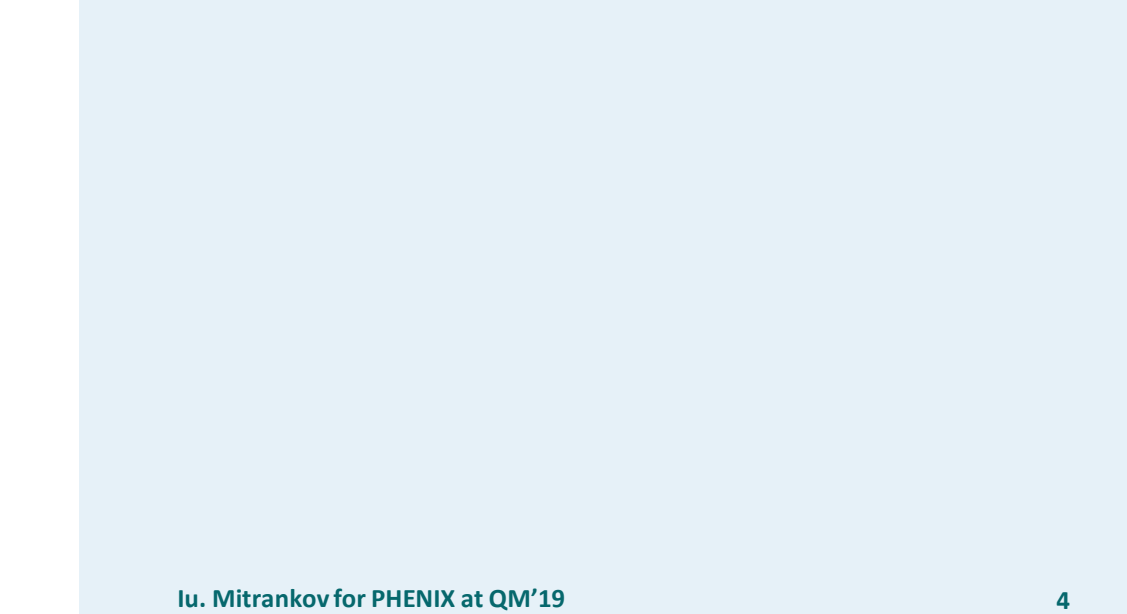


π^0 & φ R_{AB} in p+Al, p+Au, d+Au,^{3}He+Au



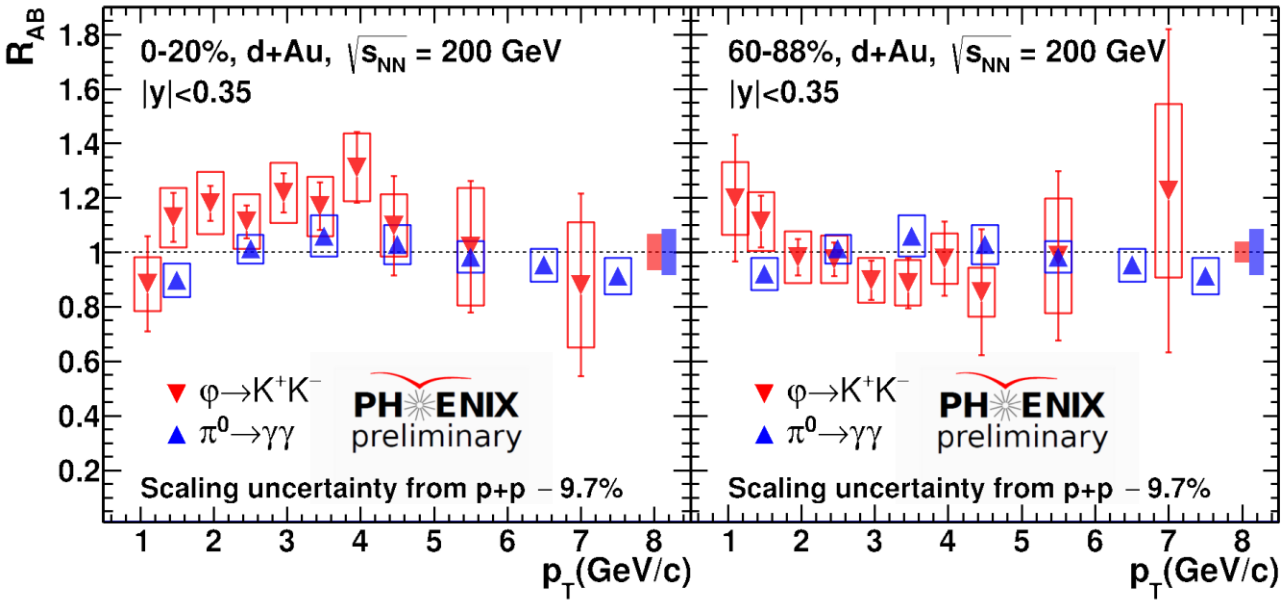


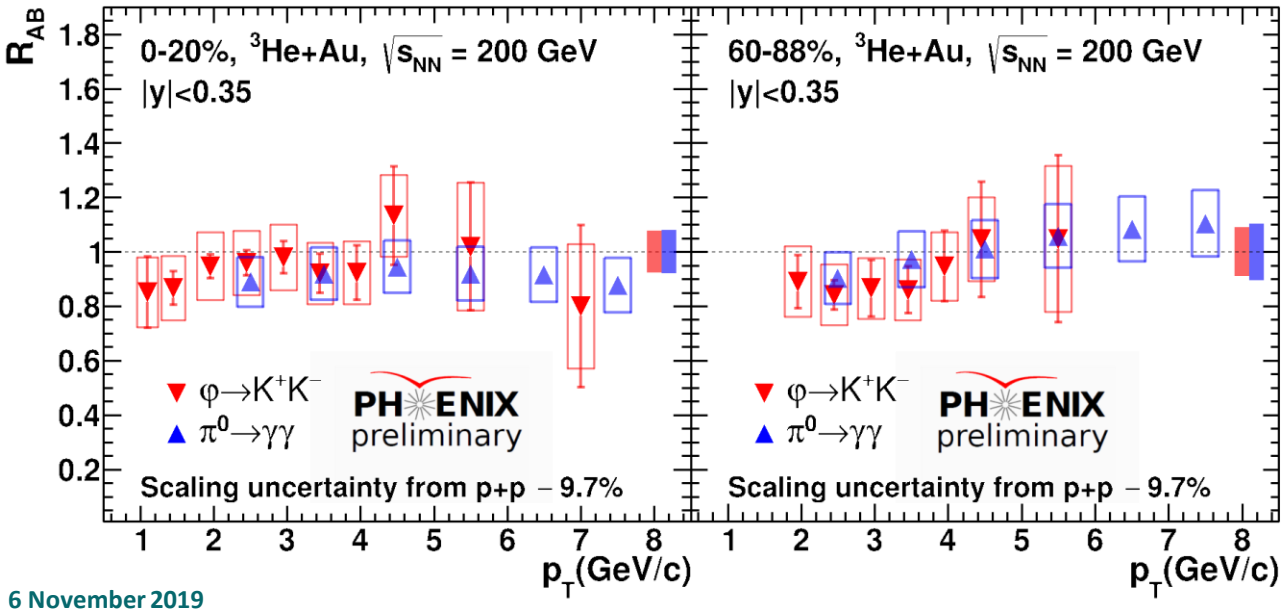




In whole φ p_T range π^0 & φ mesons R_{AB}'s are similar in p+Al/Au

π^0 & φ R_{AB} in p+Al, p+Au, d+Au, ^{3}He+Au





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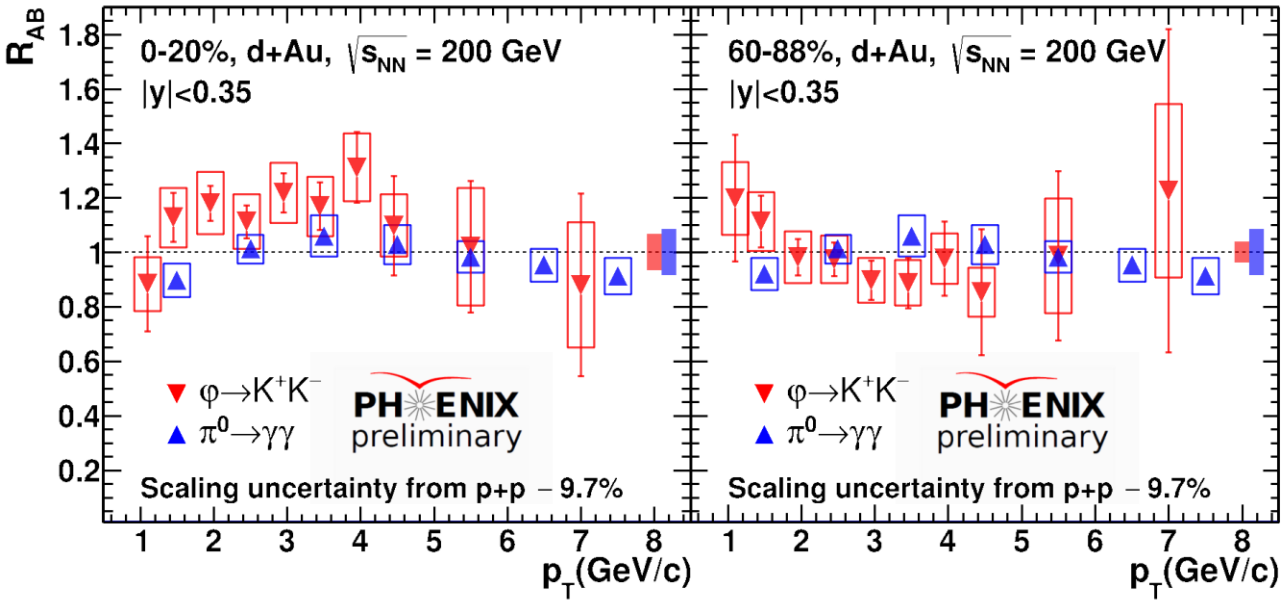

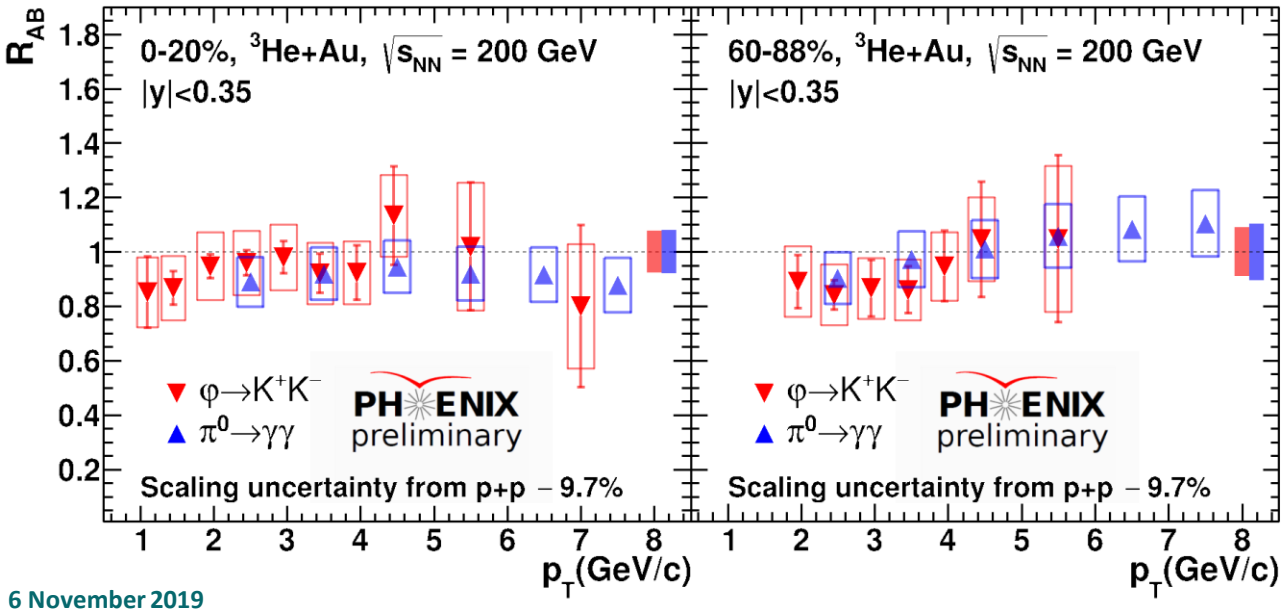

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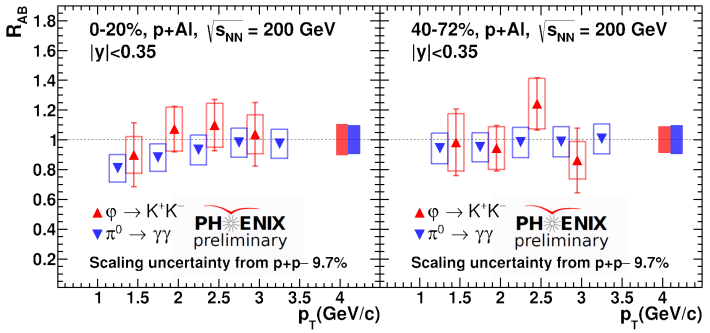
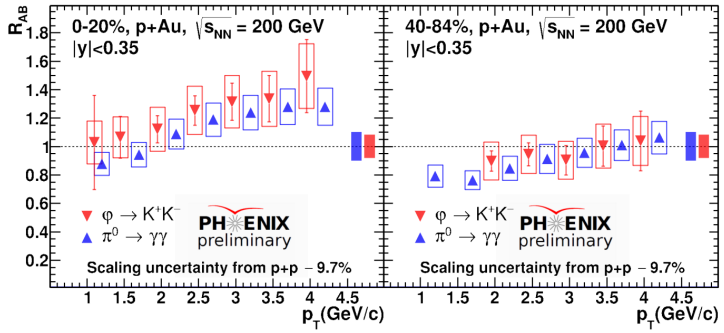
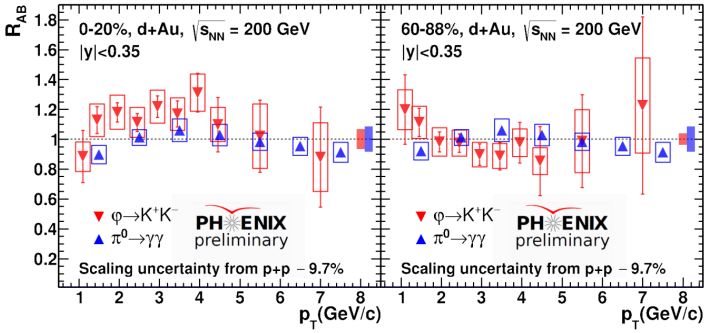
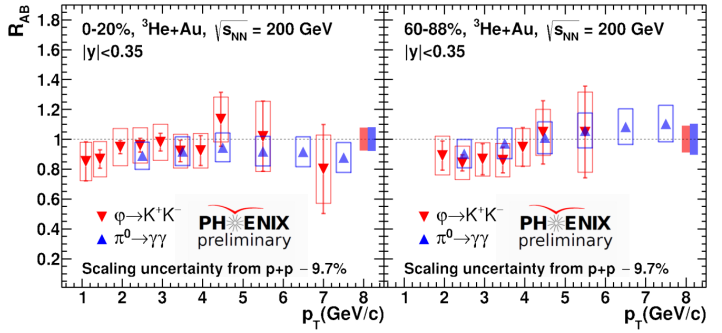
π^0 & φ R_{AB} in p+Al, p+Au, d+Au, ^{3}He+Au







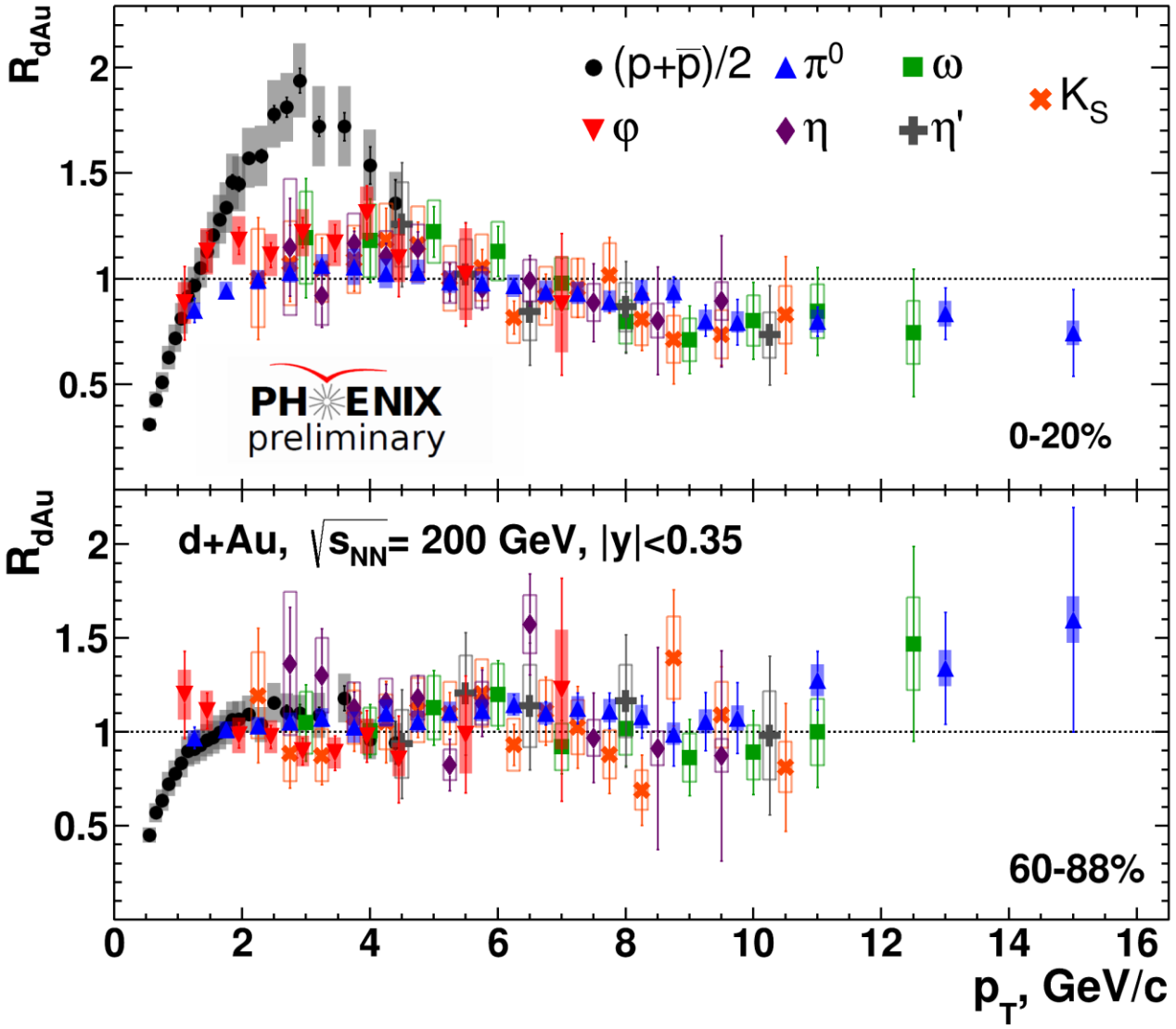


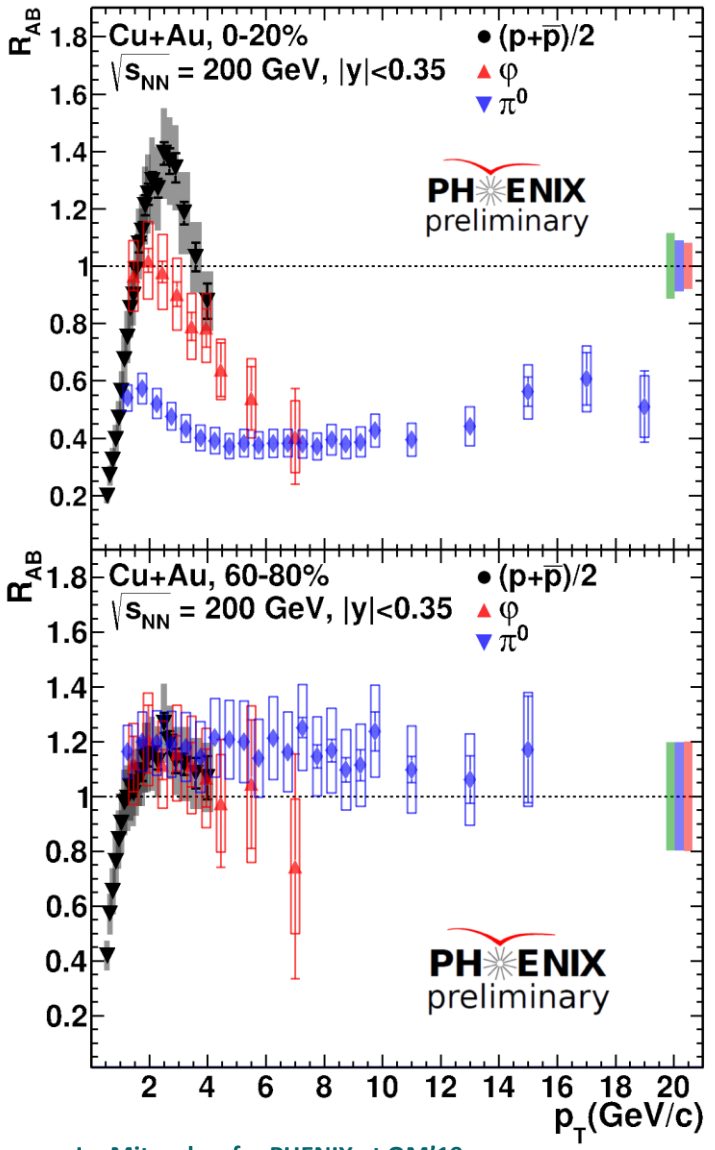
In whole φ p_T range π^0 & φ mesons R_{AB}'s are similar in p+Al/Au

In whole φ p_T range π^0 & φ mesons R_{AB}'s are similar in p/d/^{3}He+Au

Might indicate that CNM effects are not responsible for the differences between φ and π^0 seen in A+A

Comparisons to other light hadron's R_{AB} in p/d+Au collisions





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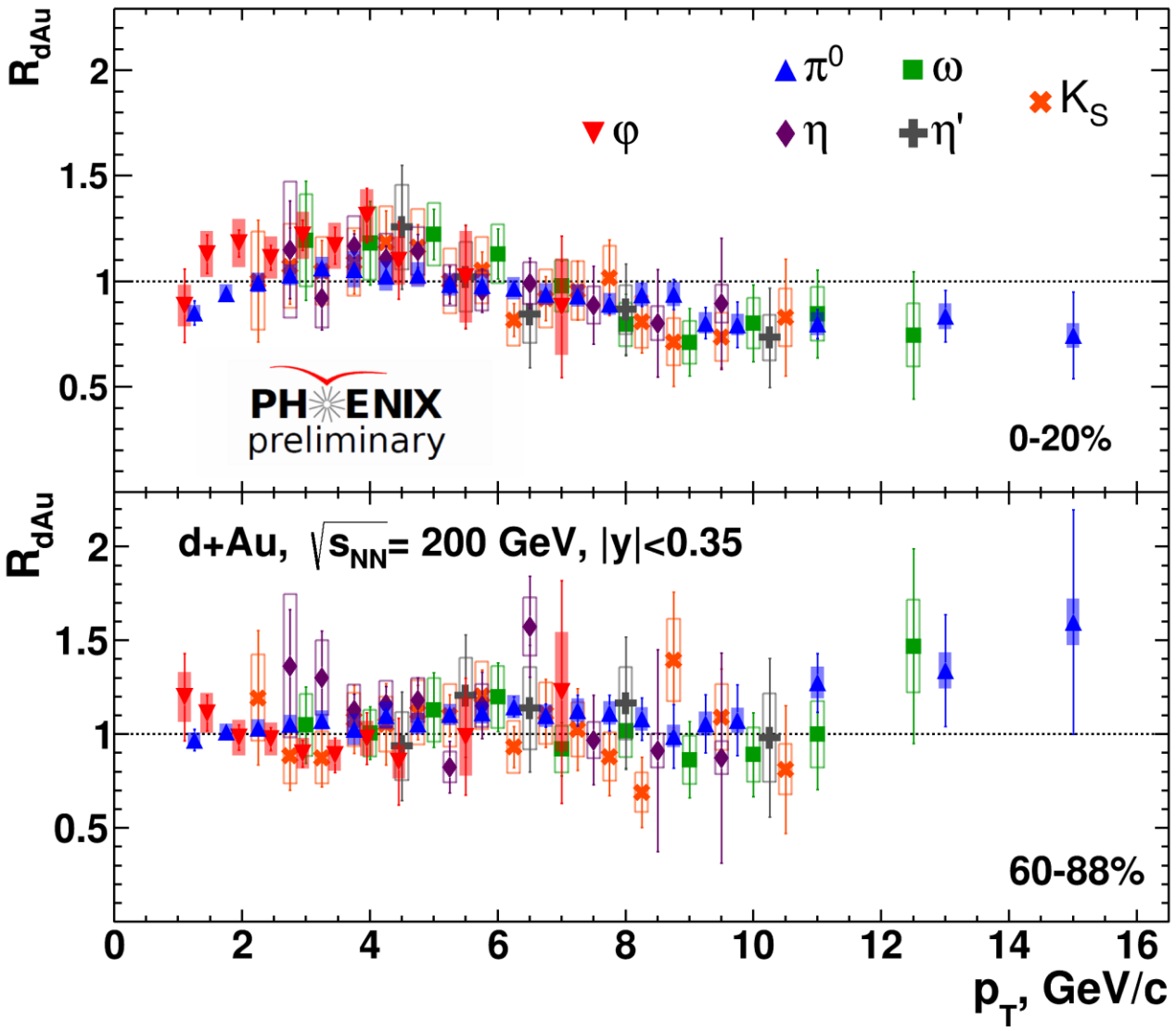
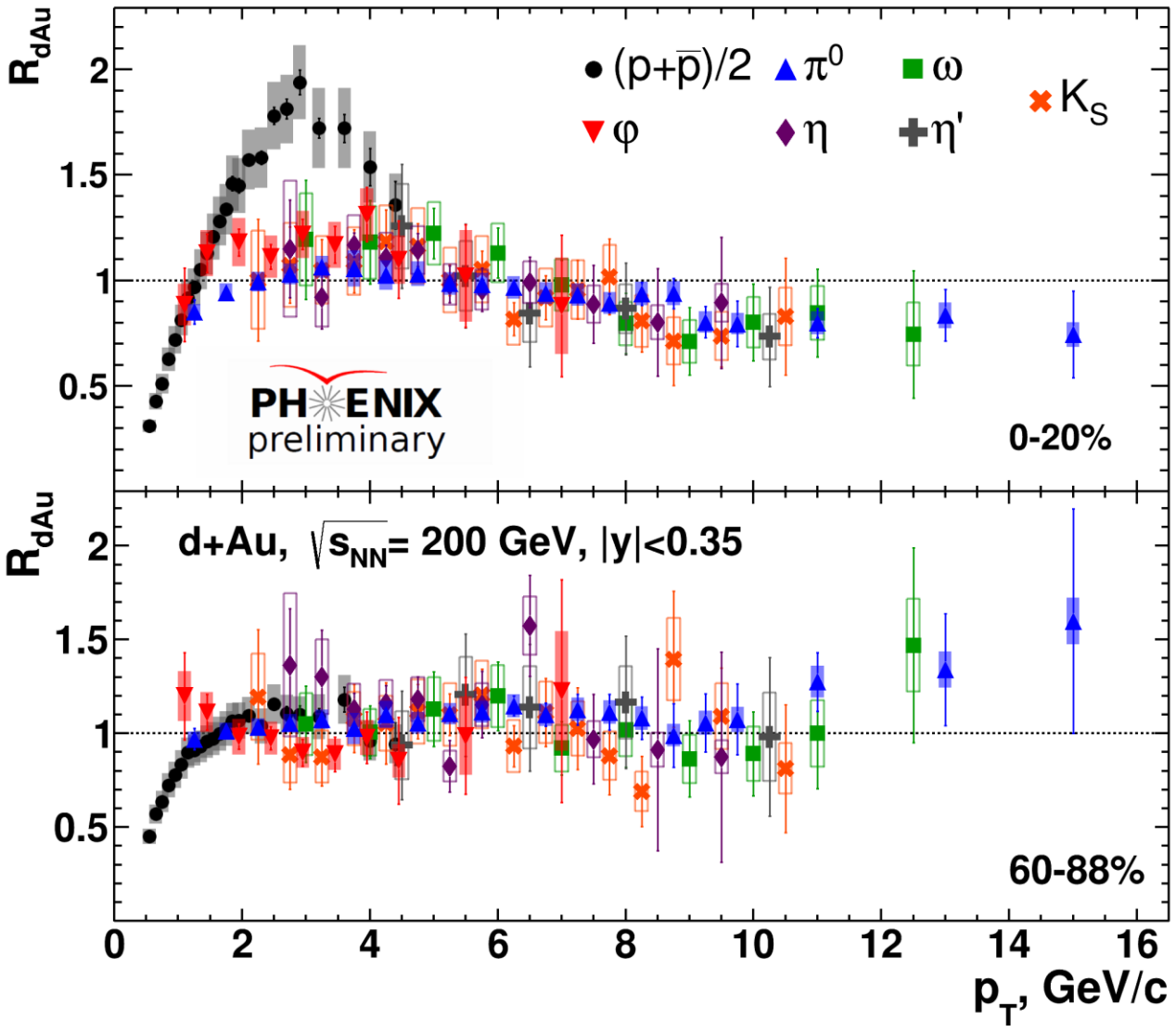


Light mesons R_{AB} exhibit similar shape in contrast to heavy-ion

Comparisons to other light hadron's R_{AB} in p/d+Au collisions



Light mesons R_{AB} exhibit similar shape in contrast to heavy-ion

Protons R_{AB} shows enhancement at moderate p_T as in heavy-ion

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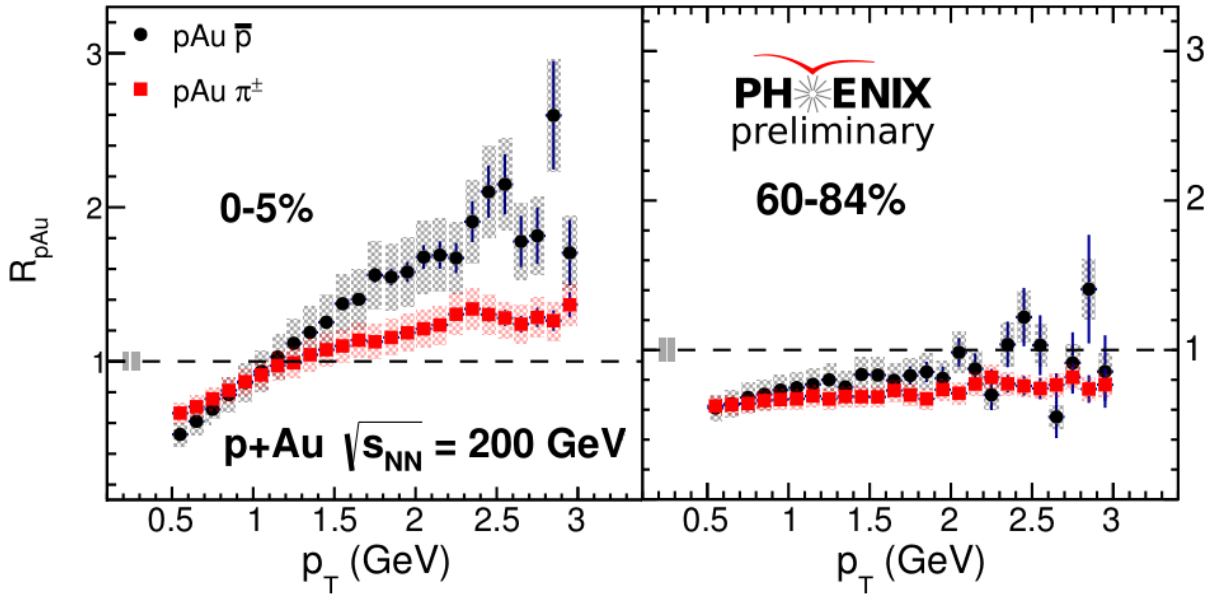
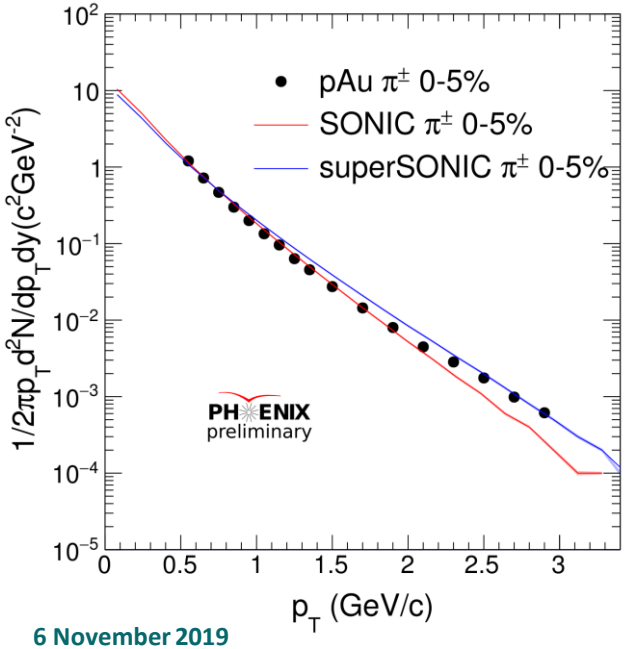
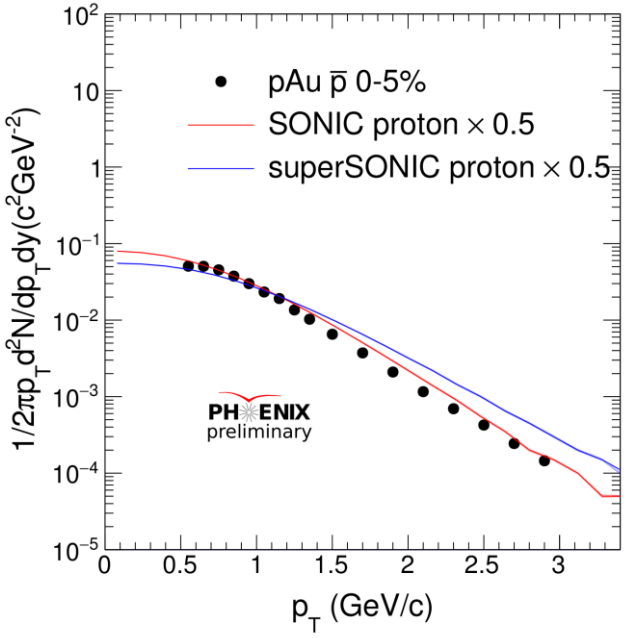






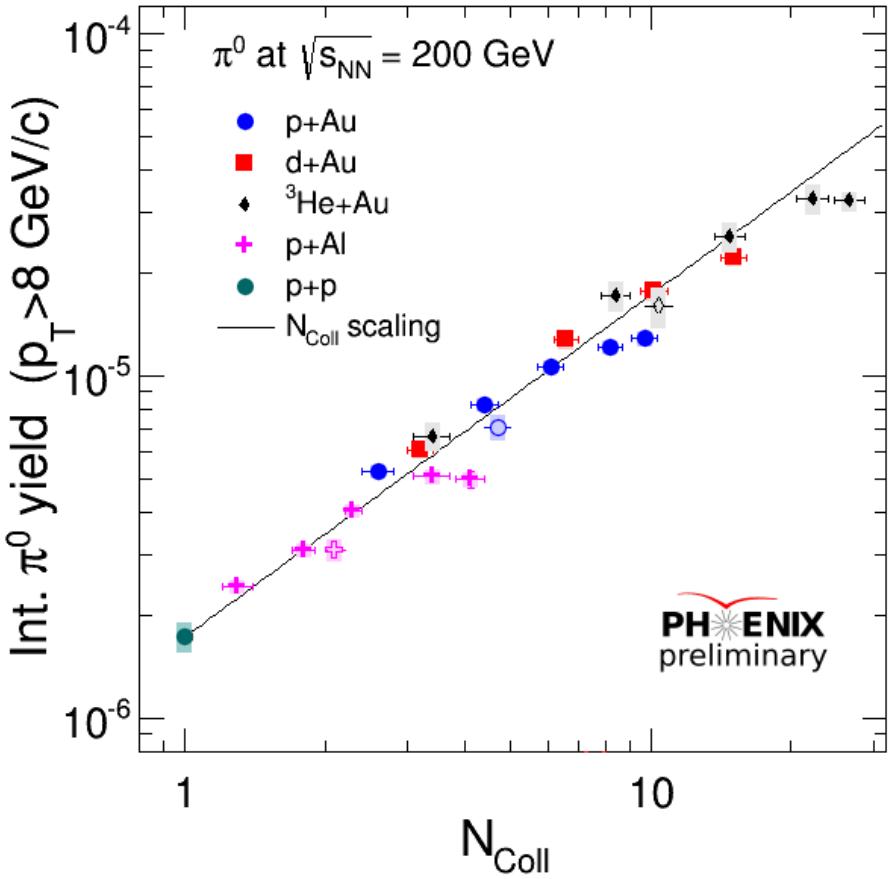
Light mesons R_{AB} exhibit similar shape in contrast to heavy-ion

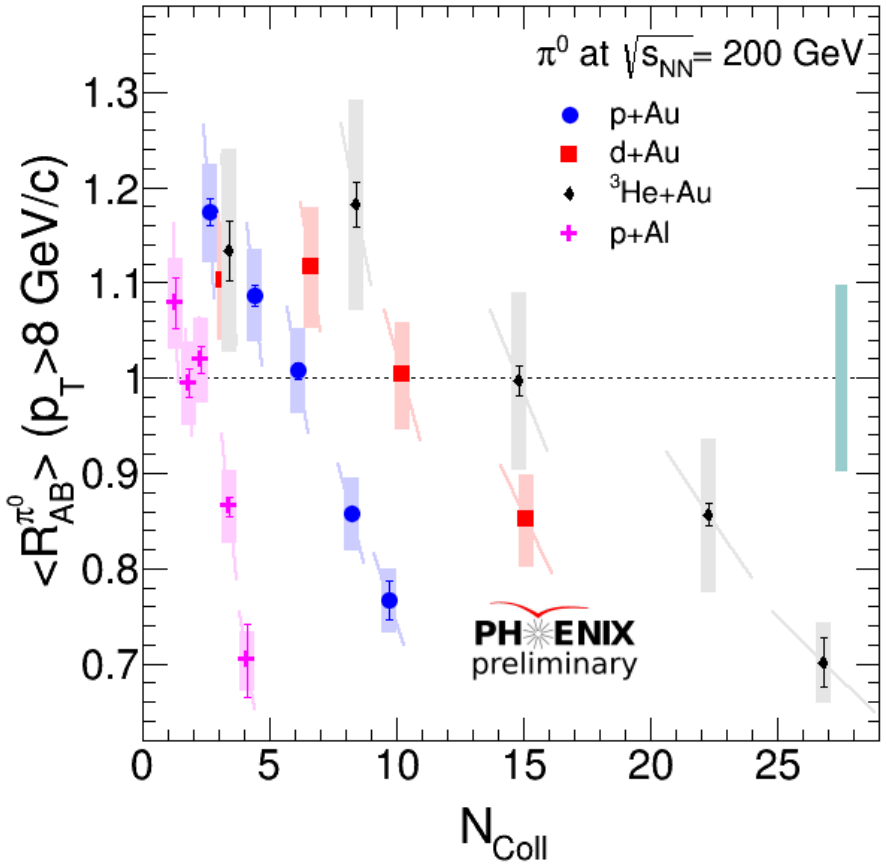
Protons R_{AB} shows enhancement at moderate p_T as in heavy-ion

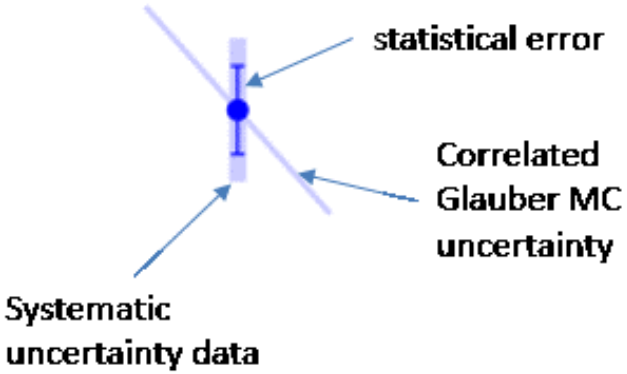
$\pi^{\pm}$ & $\bar{p}$ invariant yield in 0-5% described by SONIC and superSONIC

FLOW might be responsible for protons enhancement!

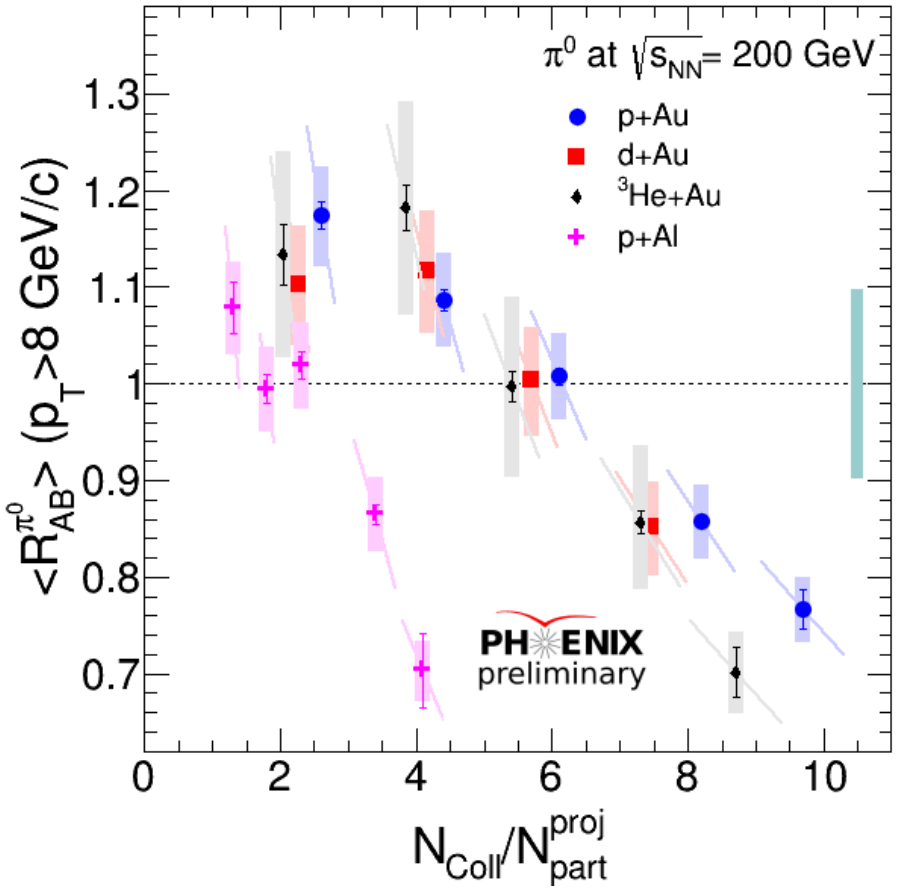
π^0 integrated yields & R_{AB} in p+Al, p+Au, d+Au, ^{3}He+Au

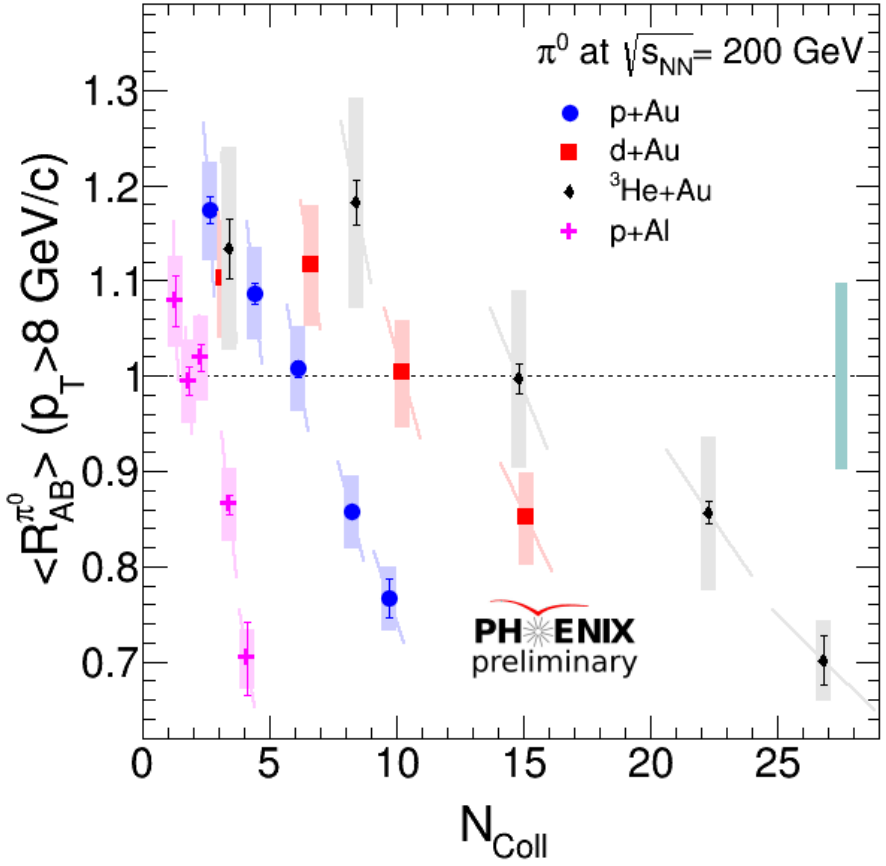


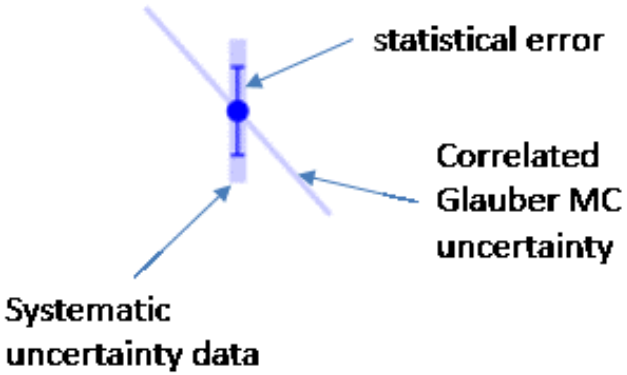




π^0 integrated yields & R_{AB} in p+Al, p+Au, d+Au, ^{3}He+Au







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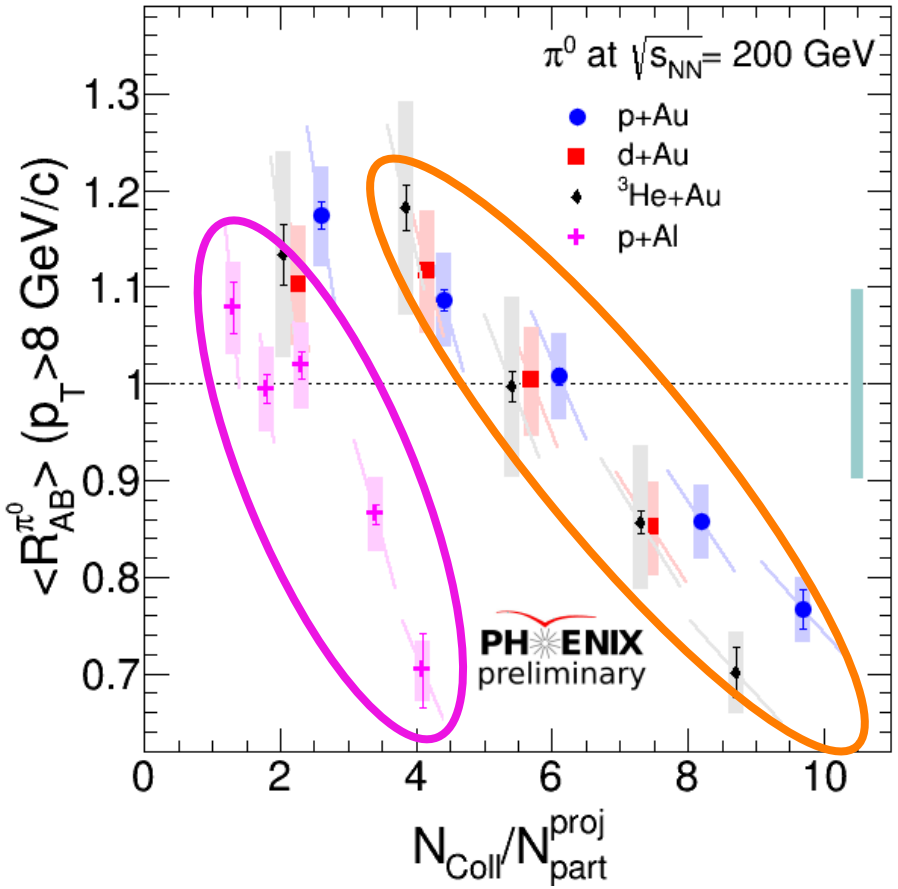
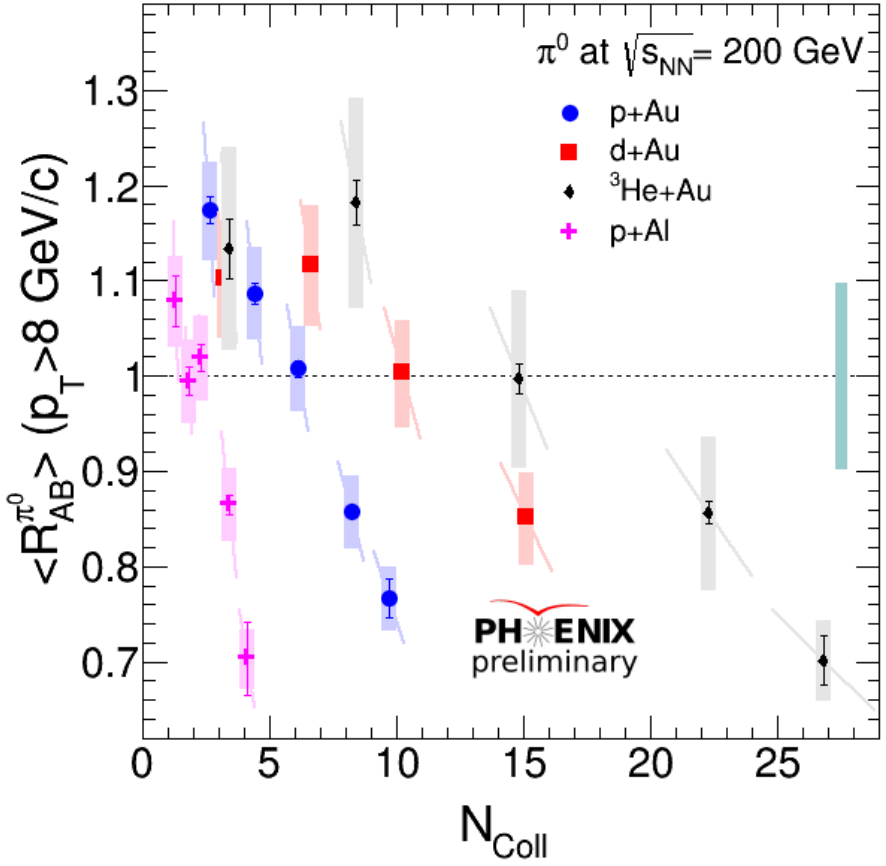
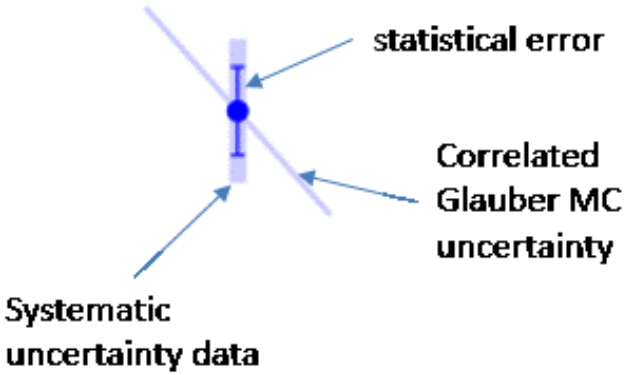
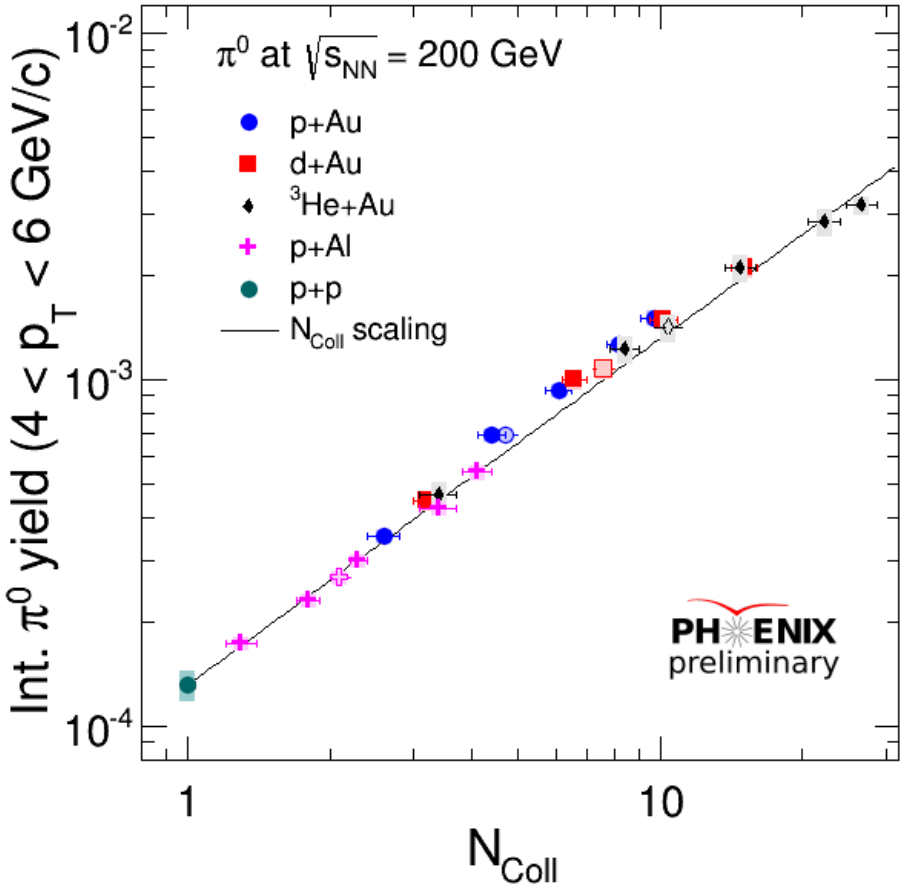


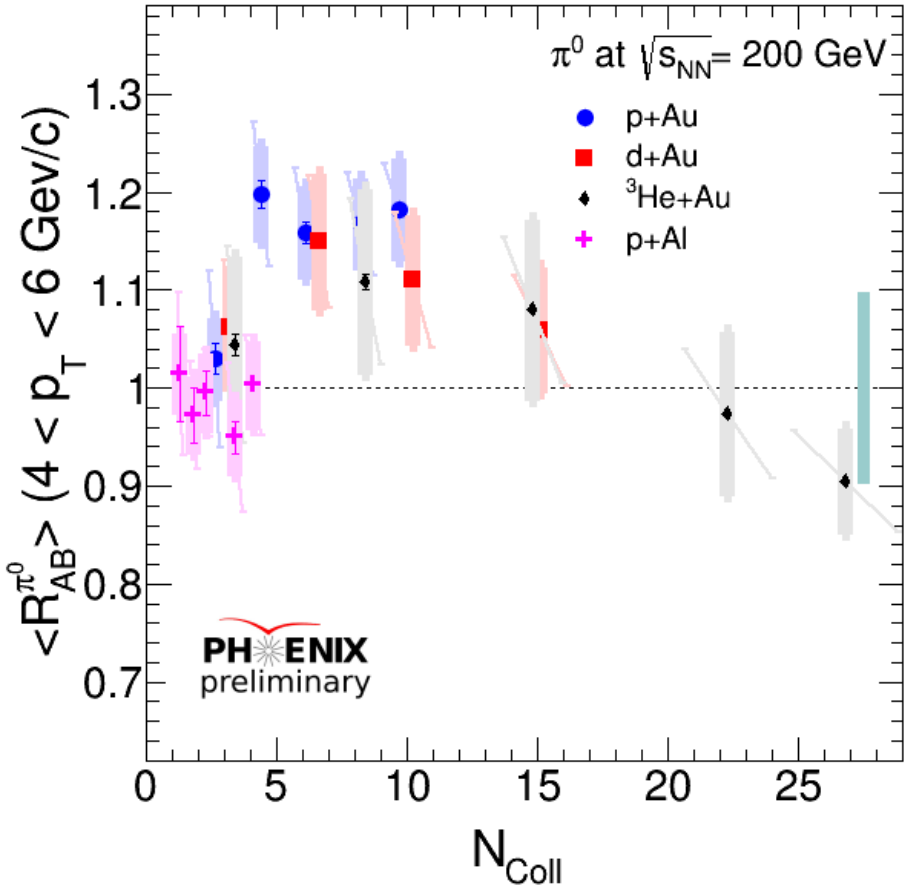




π^0 R_{AB}'s seem to scale with N_{coll}/N_{part}^{proj} for systems with same target at high-p_T

π^0 integrated yields & R_{AB} in p+Al, p+Au, d+Au, ^{3}He+Au





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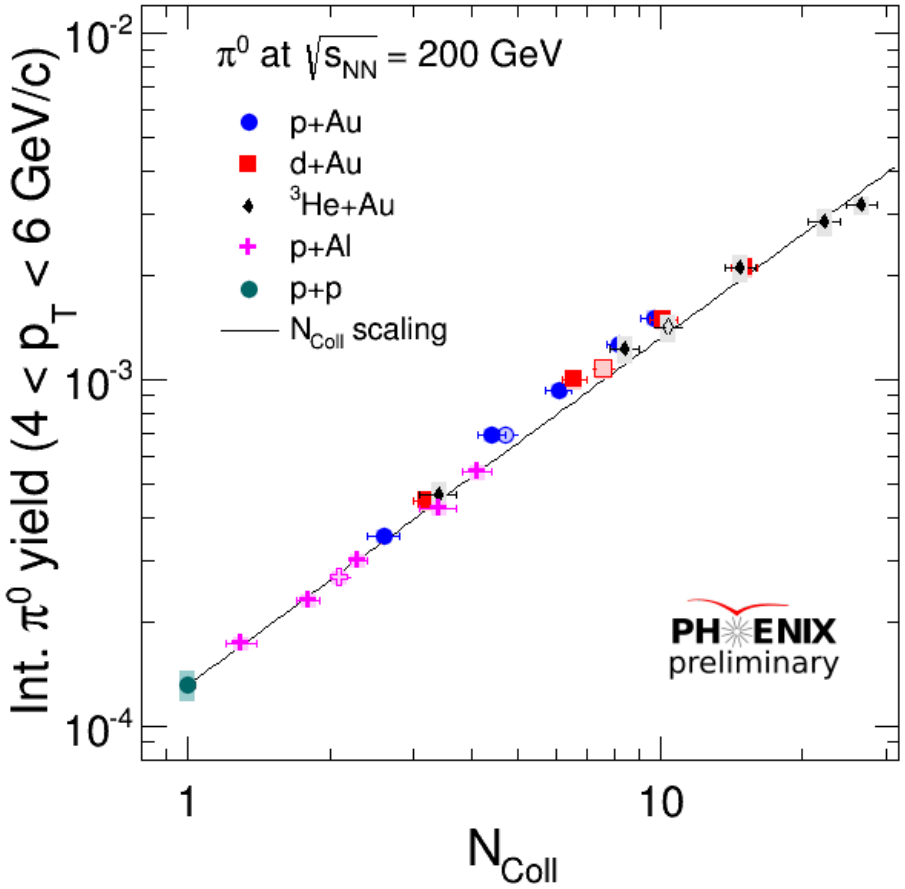
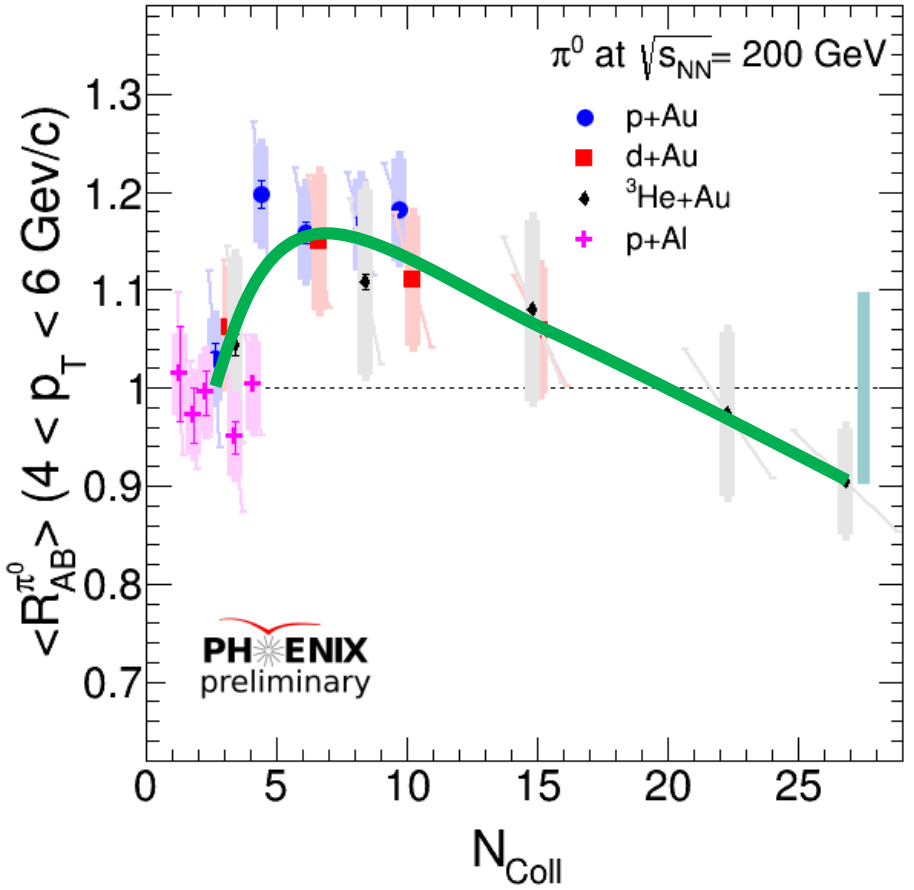
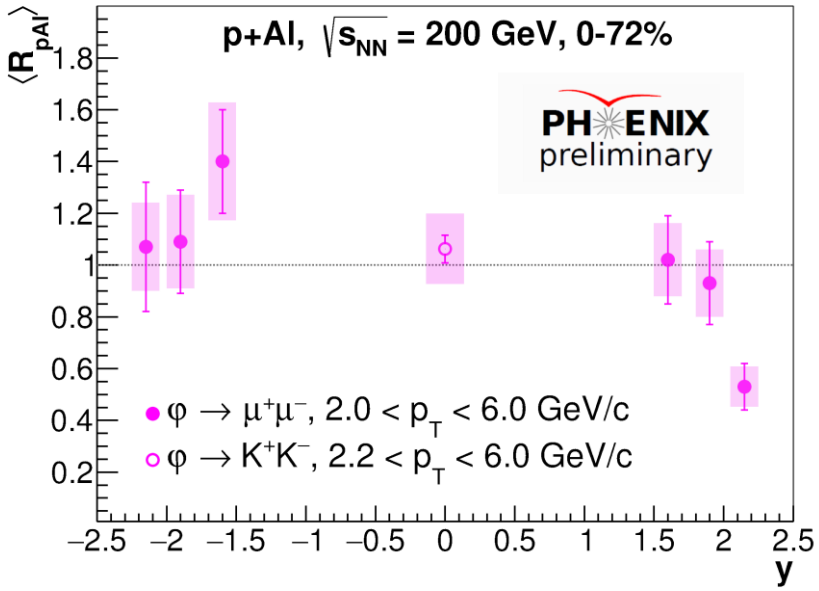
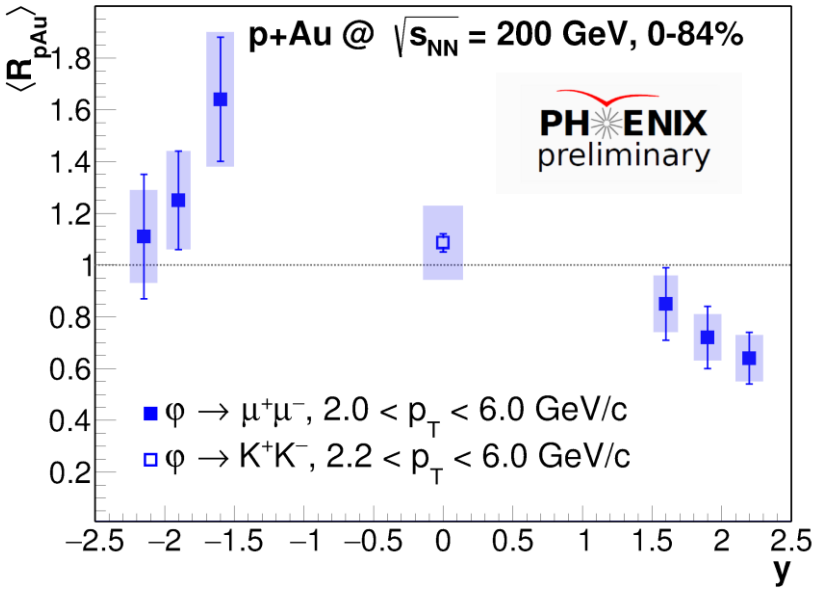


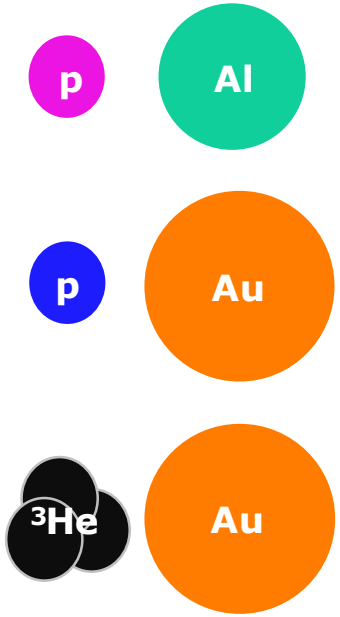


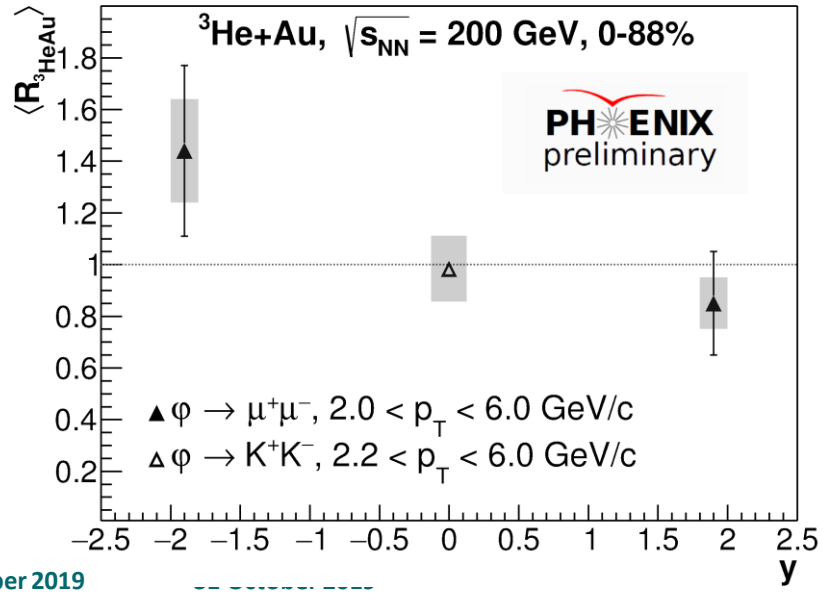
π^0 R_{AB} scales with N_{coll}

φ $\langle R_{AB} \rangle$ vs. rapidity in p+Al, p+Au, ^{3}He+Au

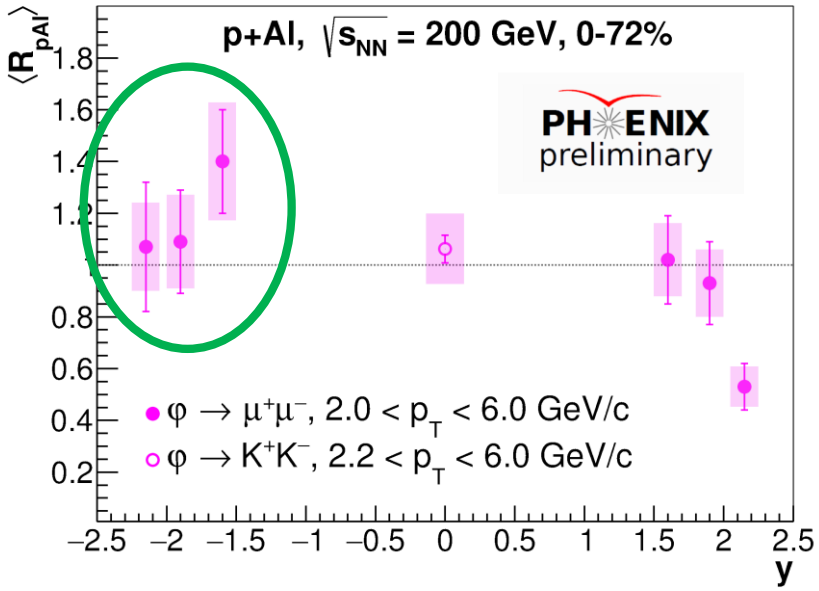


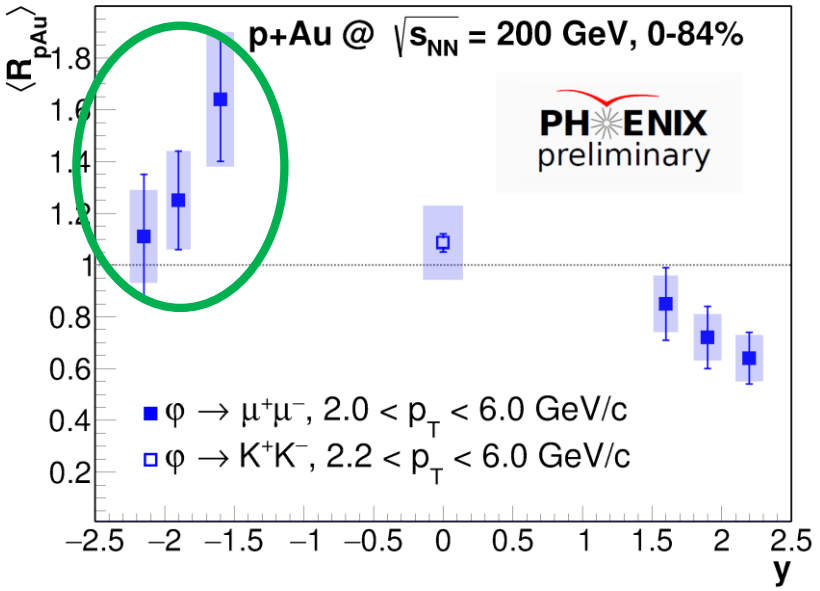


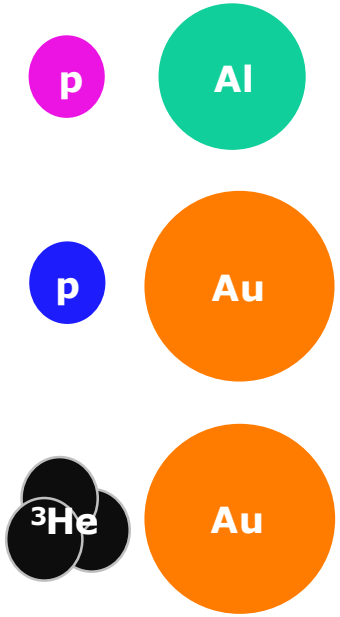


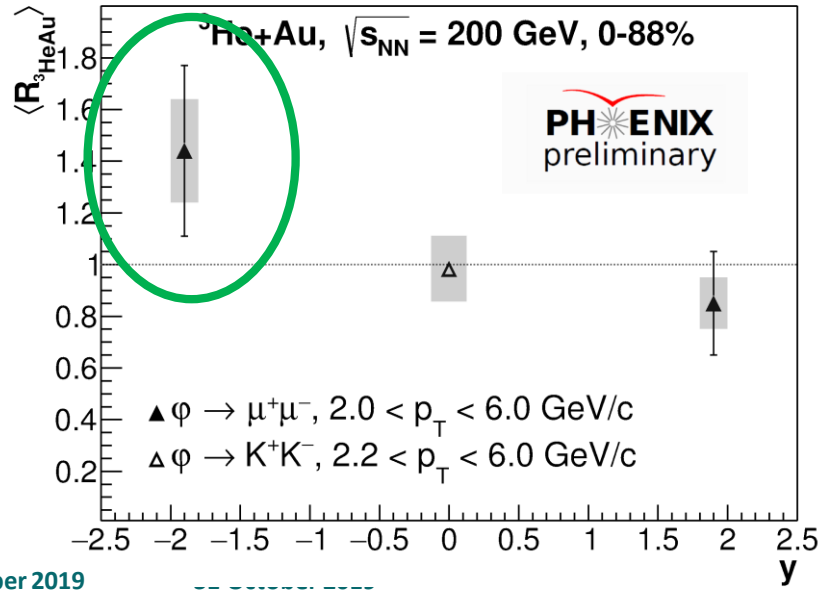


φ ⟨R_{AB}⟩ vs. rapidity in p+Al, p+Au, ^{3}He+Au



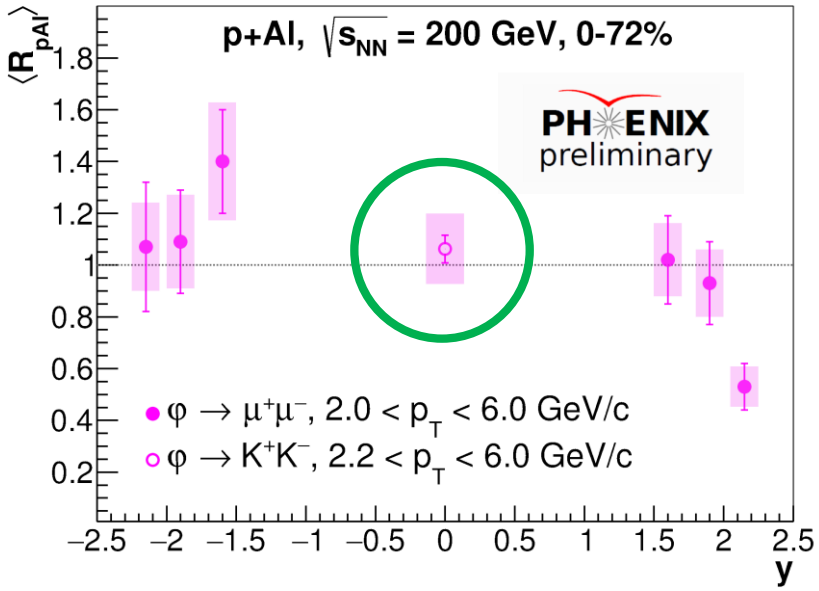


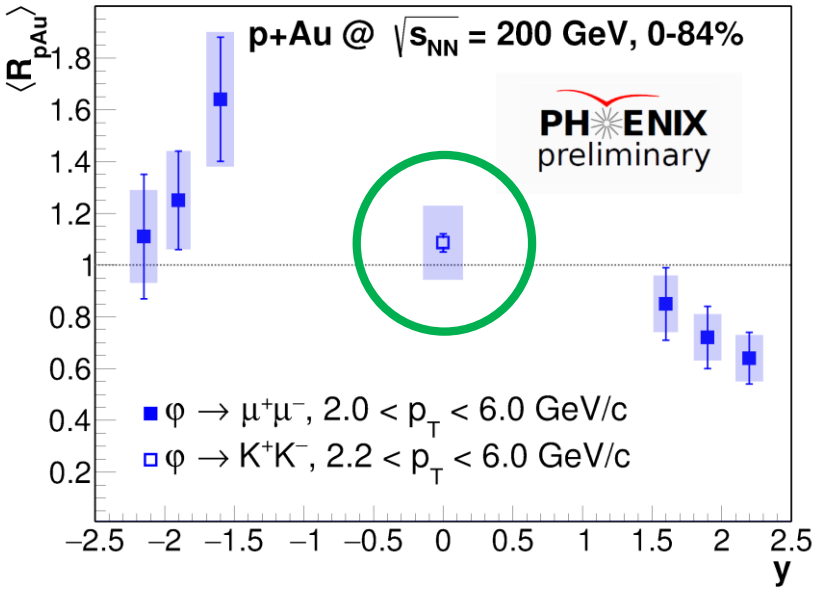


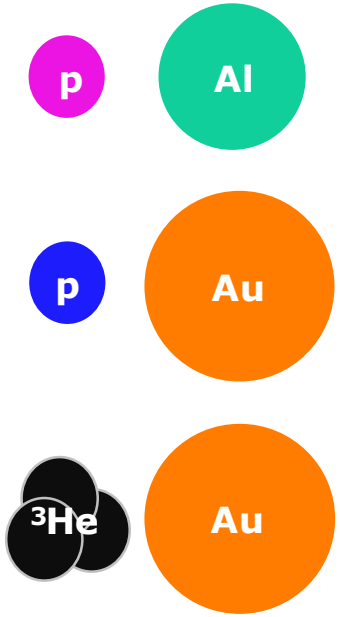


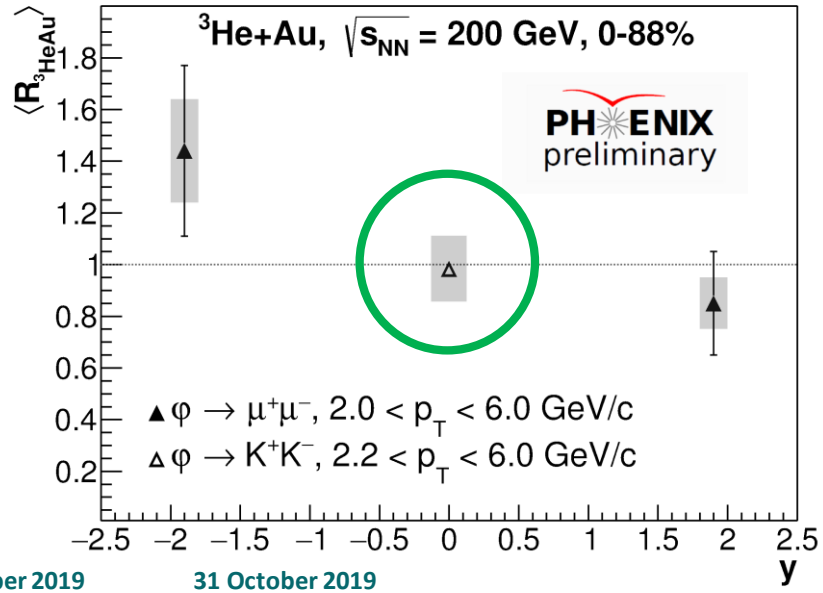
φ ⟨R_{AB}⟩ in Au-going – a hint of enhancement

φ ⟨R_{AB}⟩ vs. rapidity in p+Al, p+Au, ^{3}He+Au





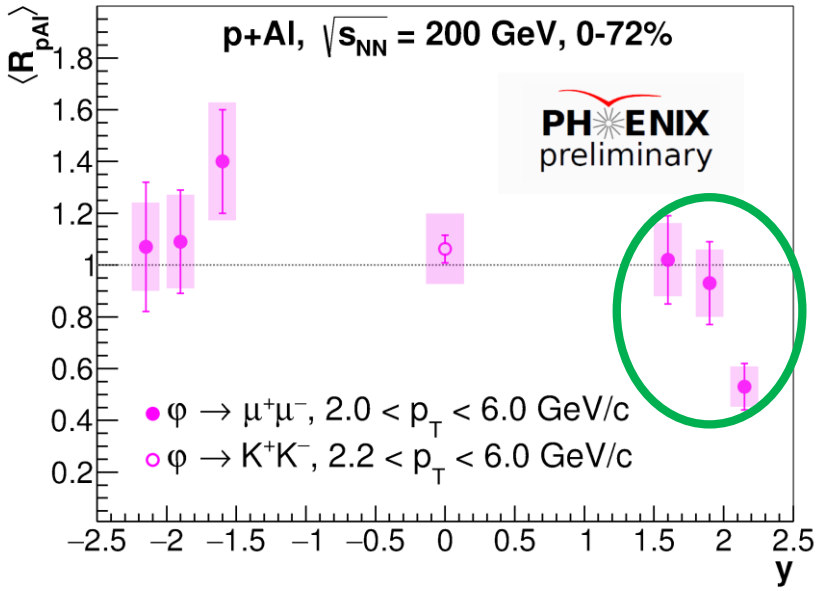


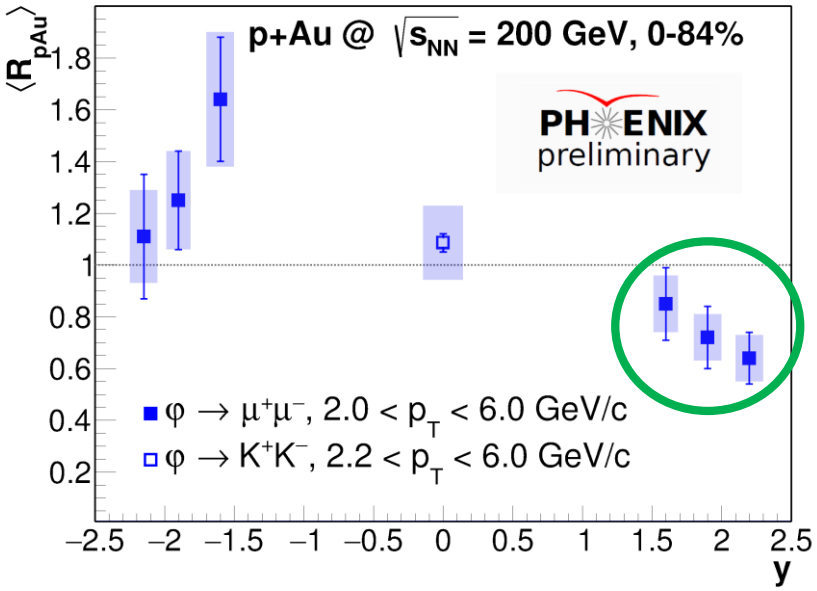


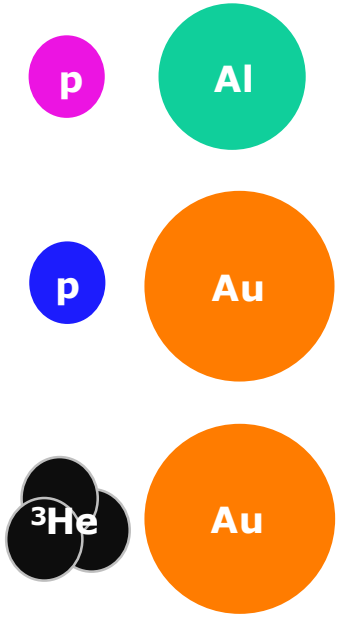
φ ⟨R_{AB}⟩ in Au-going – a hint of enhancement

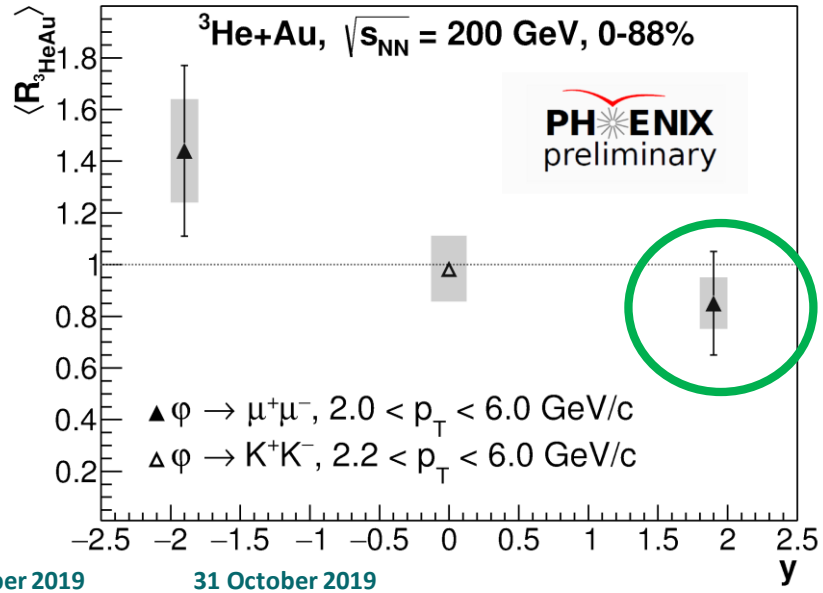
φ ⟨R_{AB}⟩ at midrapidity – equal to unity

φ ⟨R_{AB}⟩ vs. rapidity in p+Al, p+Au, ^{3}He+Au









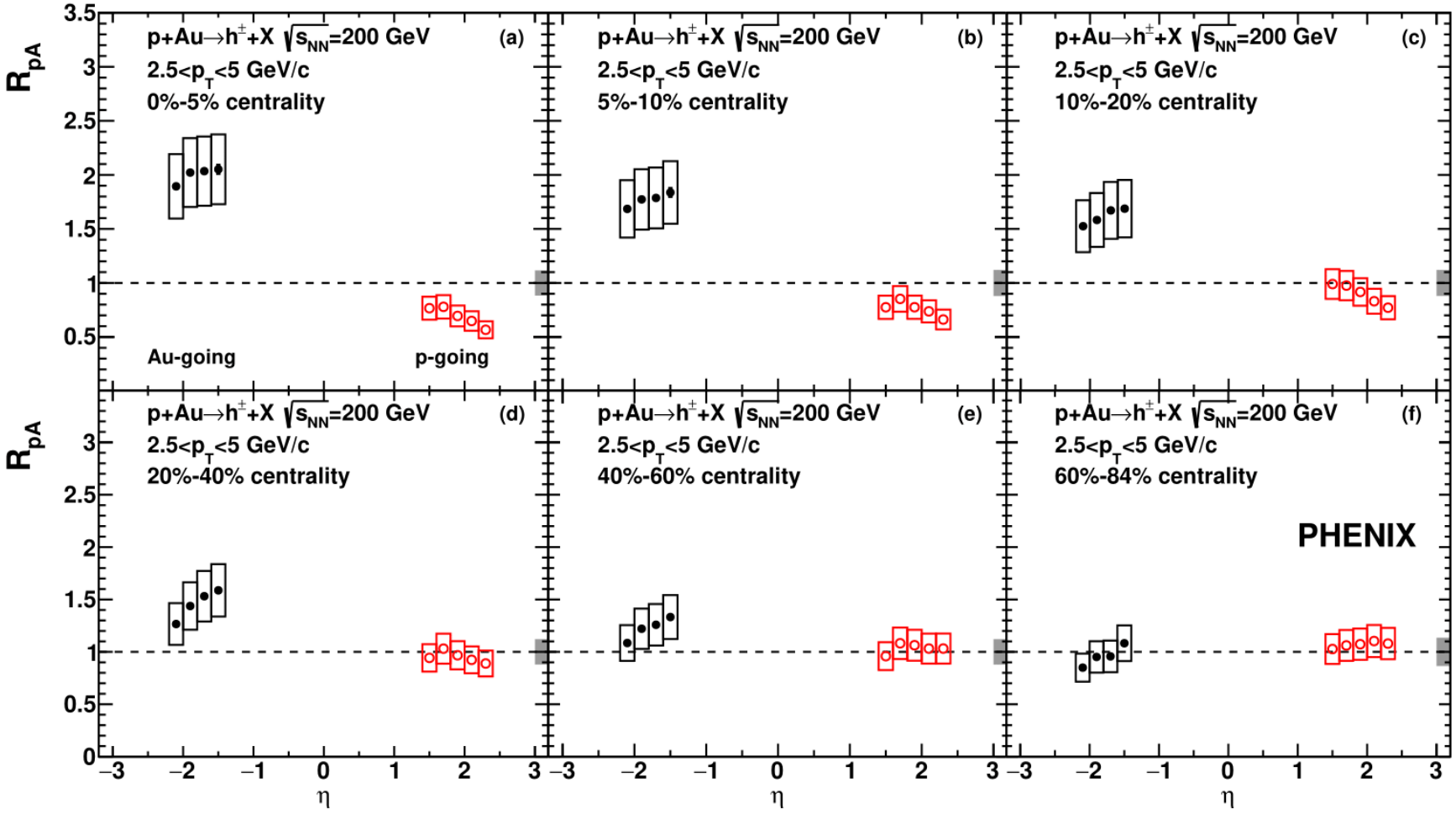
φ ⟨R_{AB}⟩ in Au-going – a hint of enhancement

φ ⟨R_{AB}⟩ at midrapidity – equal to unity

φ ⟨R_{AB}⟩ in p/He-going – a hint of suppression

$h^{\pm}$ $\langle R_{AB} \rangle$ (η) in p+Al and p+Au

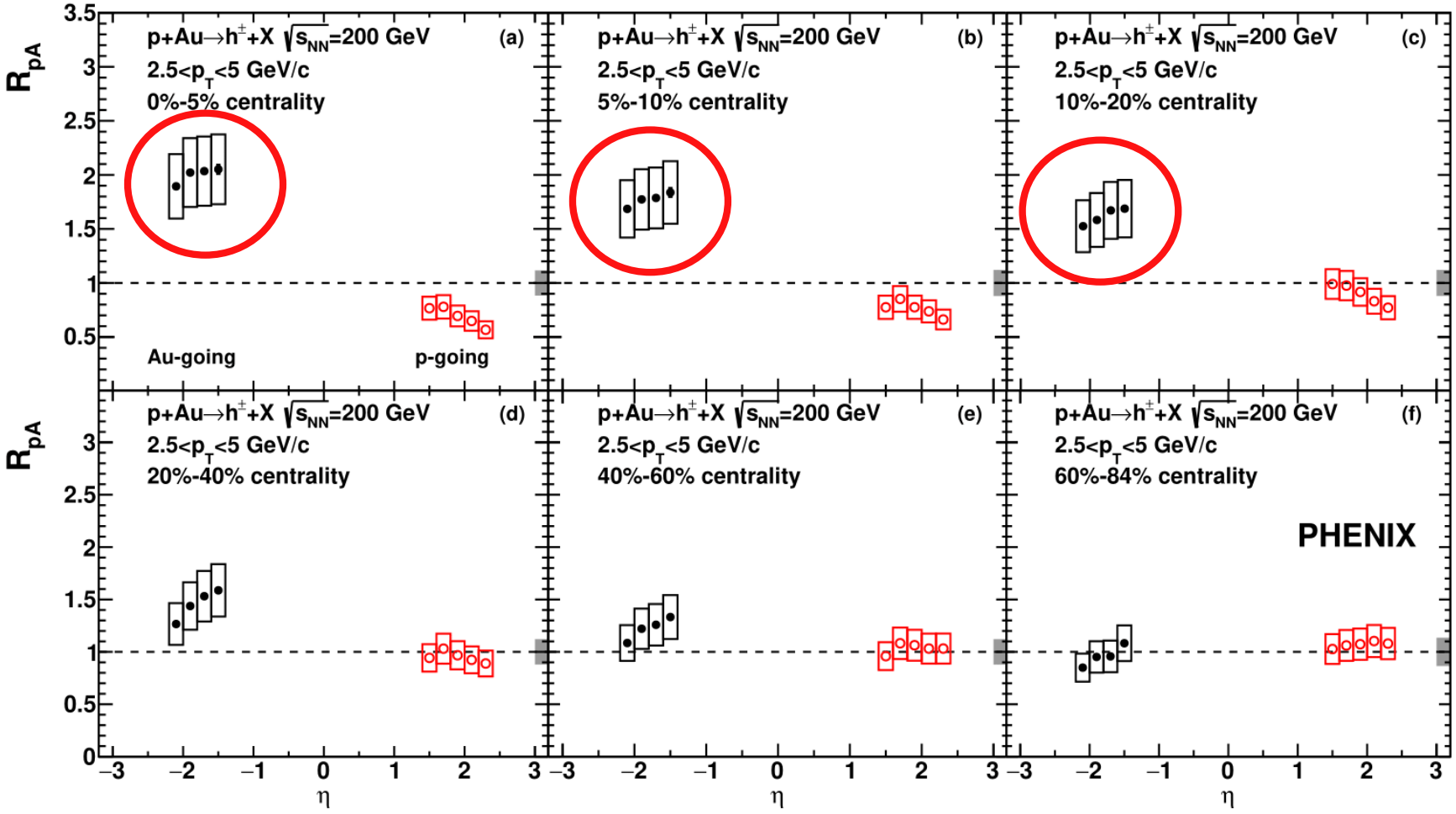
arXiv:1906.09928v1



Same $\langle R_{AB} \rangle$ behavior was observed for $h^{\pm}$ in p+Au central collisions:

$h^{\pm}$ $\langle R_{AB} \rangle$ (η) in p+Al and p+Au

arXiv:1906.09928v1

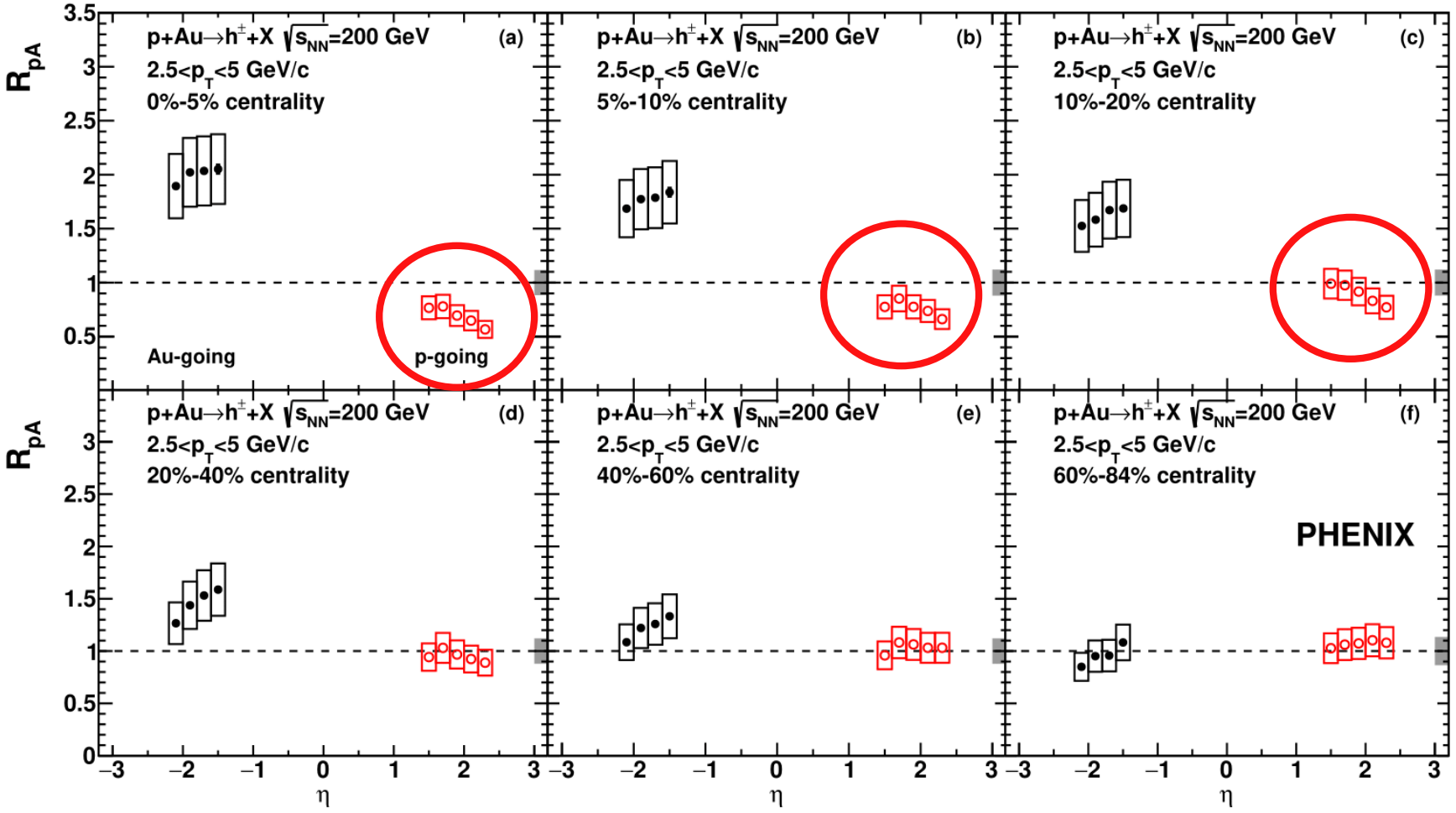


Same $\langle R_{AB} \rangle$ behavior was observed for $h^{\pm}$ in p+Au central collisions:

✓ Backward rapidity shows large enhancement

$h^{\pm}$ $\langle R_{AB} \rangle$ (η) in p+Al and p+Au

arXiv:1906.09928v1



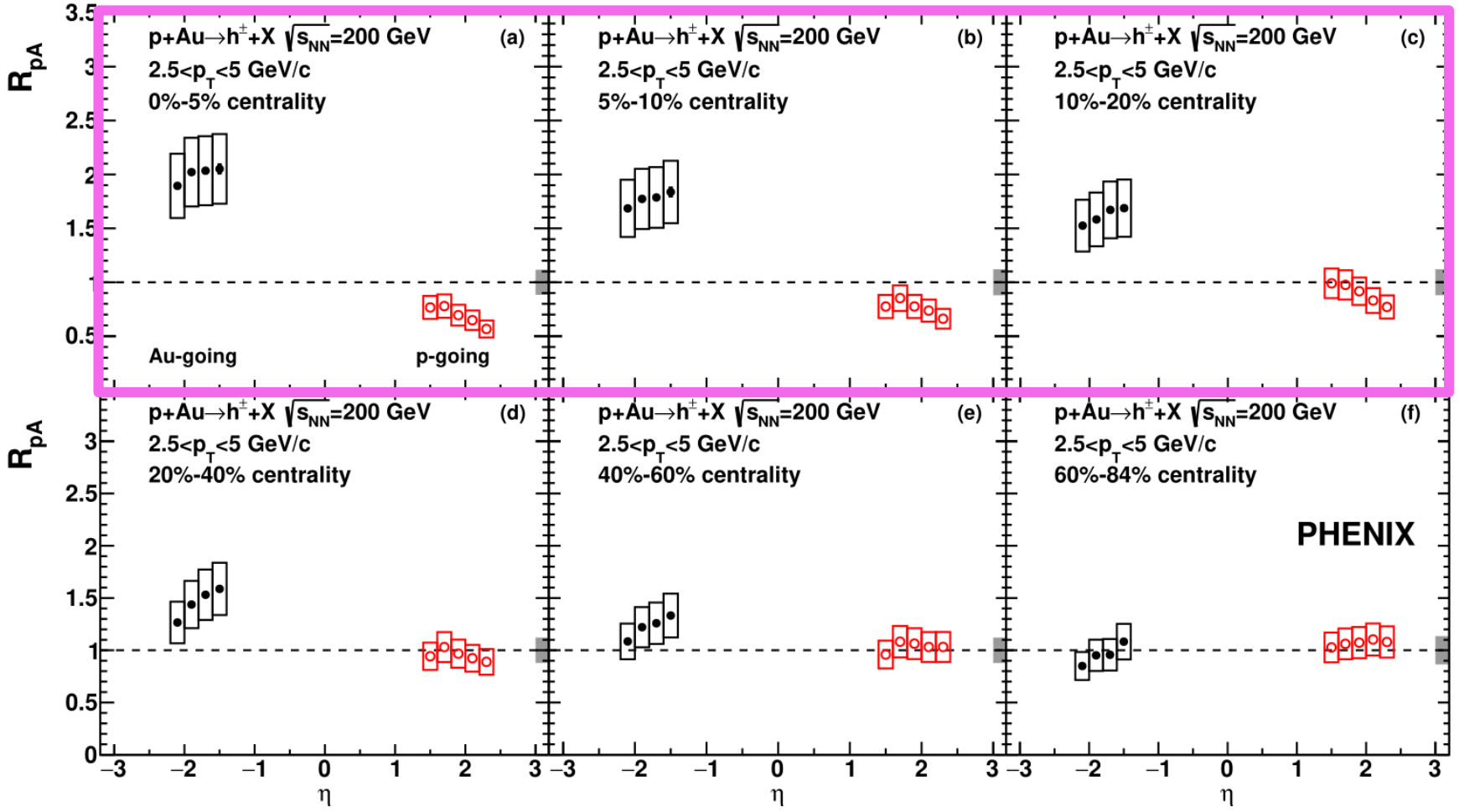
Same $\langle R_{AB} \rangle$ behavior was observed for $h^{\pm}$ in p+Au central collisions:

- ✓ Backward rapidity shows large enhancement
- ✓ Forward rapidity shows suppression

Strong centrality dependence

$h^{\pm}$ $\langle R_{AB} \rangle$ (η) in p+Al and p+Au

arXiv:1906.09928v1



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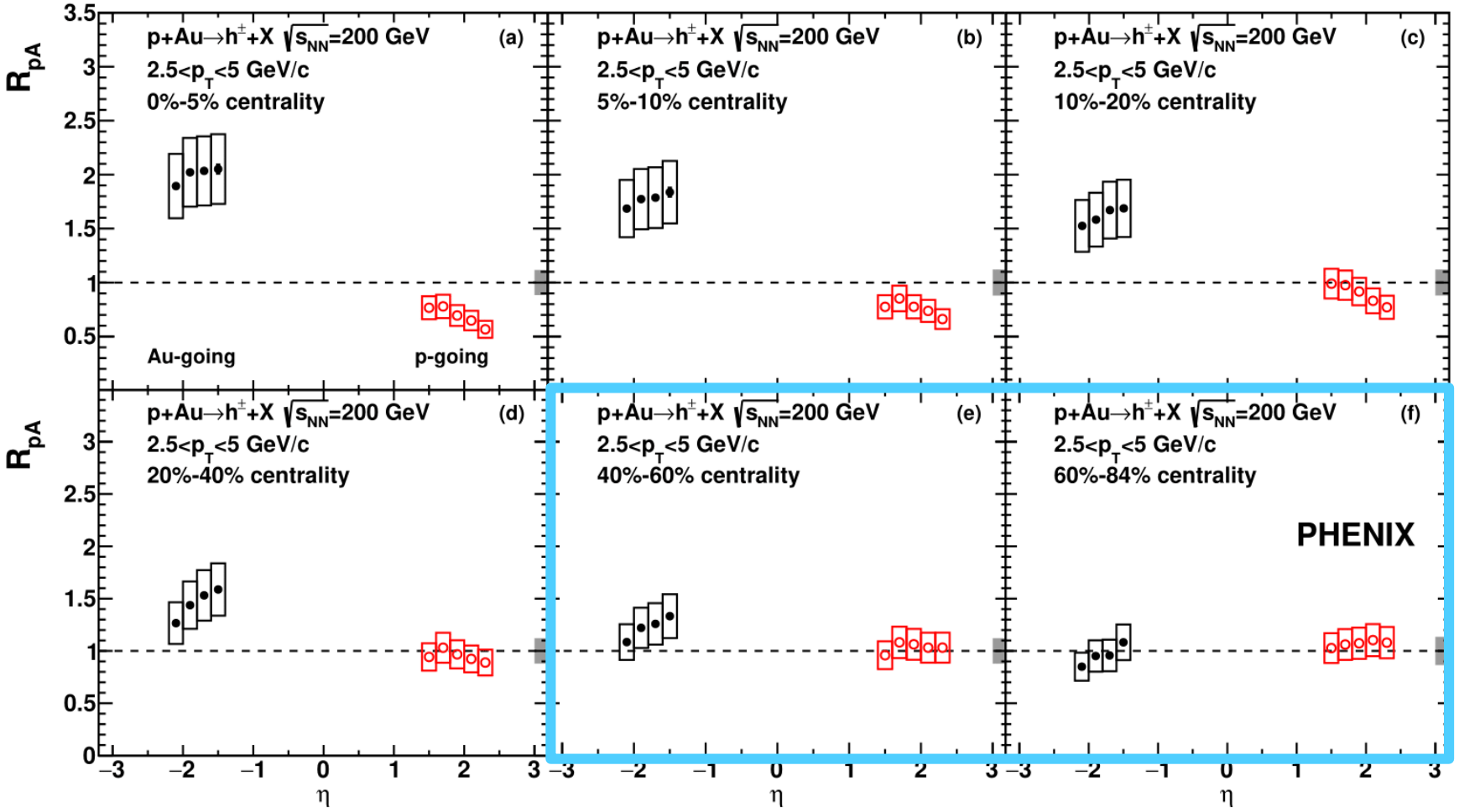

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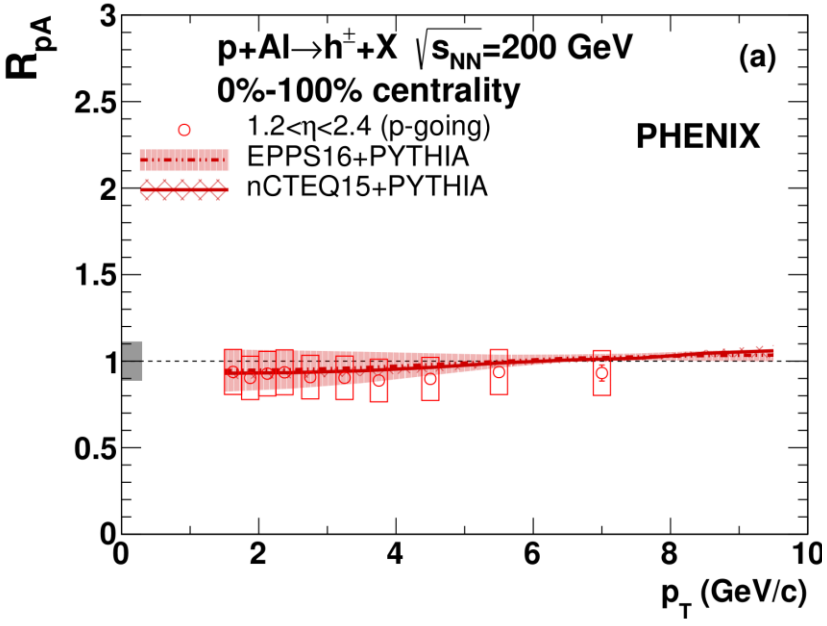

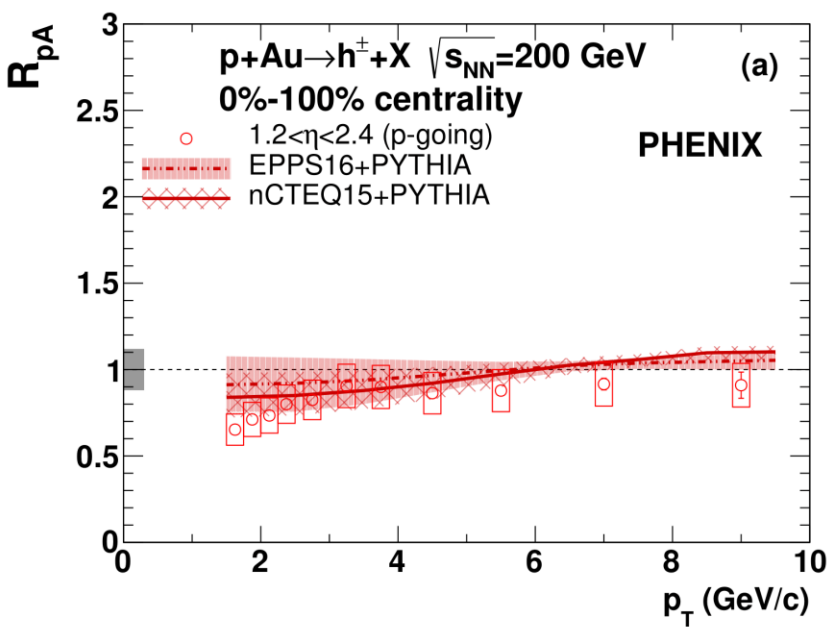

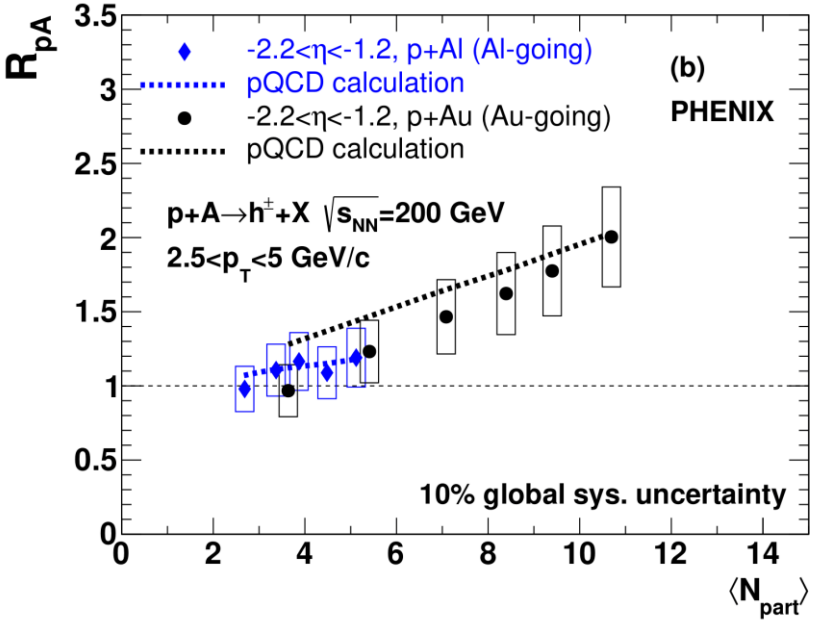

arXiv:1906.09928v1

$h^{\pm}$ R_{AB} in p-going direction is described by EPPS16+PYTHIA and nCTEQ15+PYTHIA

$\langle R_{AB} \rangle$ vs. N_{part} in A-going direction is described by pQCD multi scattering calculations

SUMMARY

- Integrated π^0 R_{AB} seem to:
  - ✓ scale with N_{coll} at moderate p_T
  - ✓ scale with N_{coll}/N_{part}^{proj} for same target at high-p_T
- φ & π^0 mesons R_{AB}'s are consistent in all centralities, while protons R_{AB}'s show enhancement in central collisions, $\pi^{\pm}$ and $\bar{p}$ are described by SONIC
- Hint of suppression for π^0 at high-p_T in central collisions
- Strong rapidity and centrality dependence of charged hadrons production in small systems, which is well described by CNM effects

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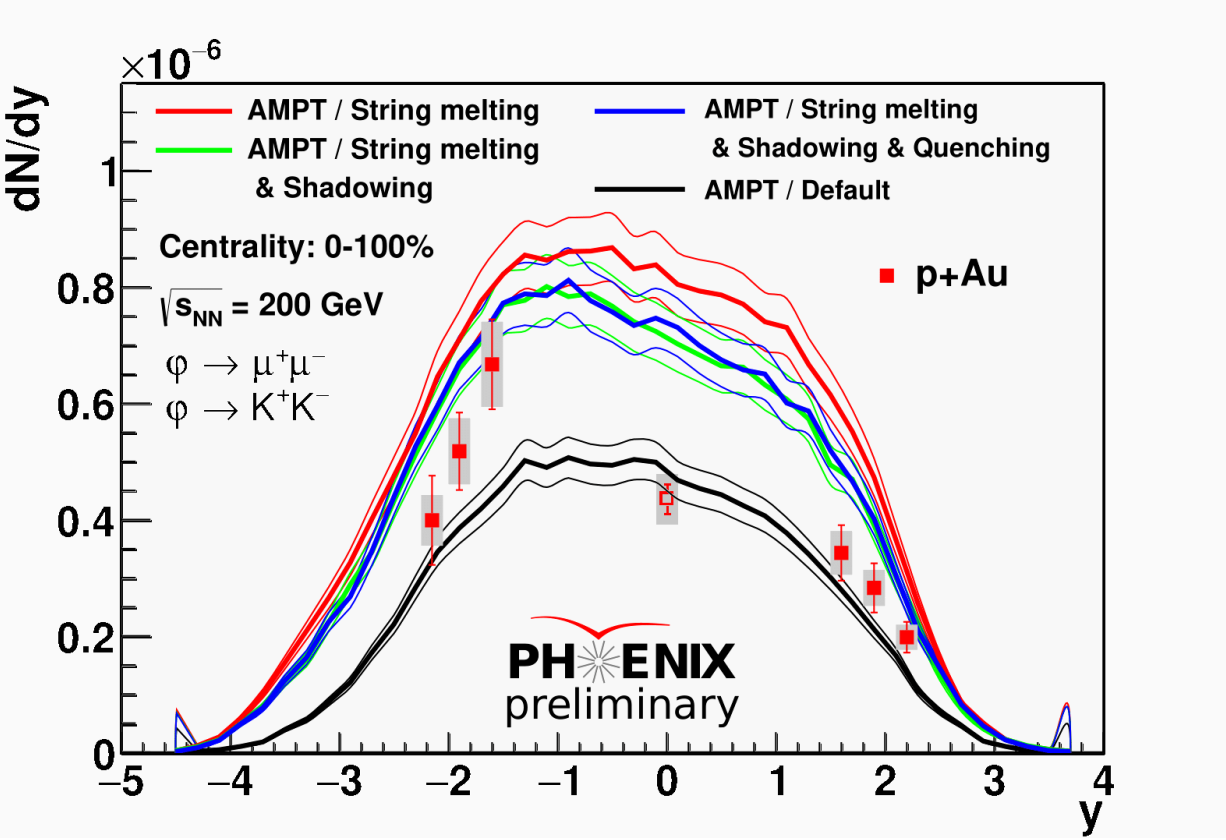
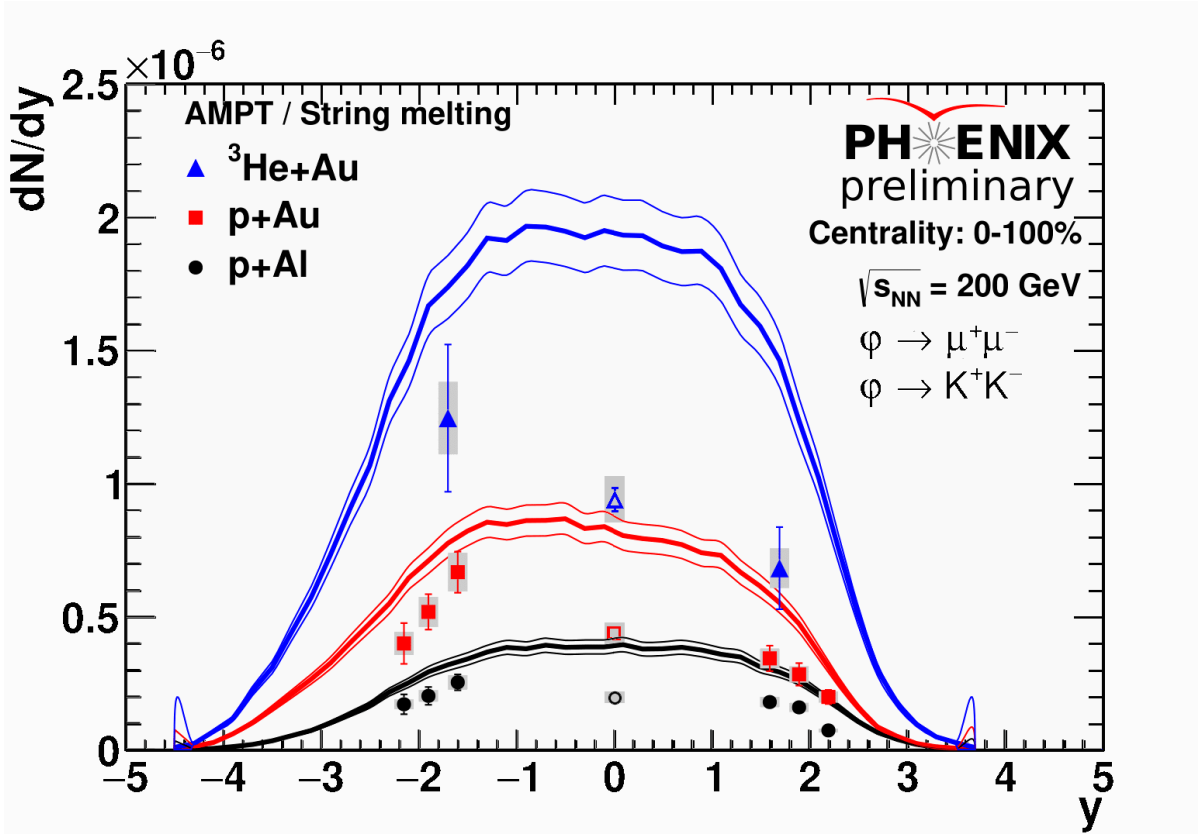
THANK YOU FOR YOUR ATTENTION!

BACKUP

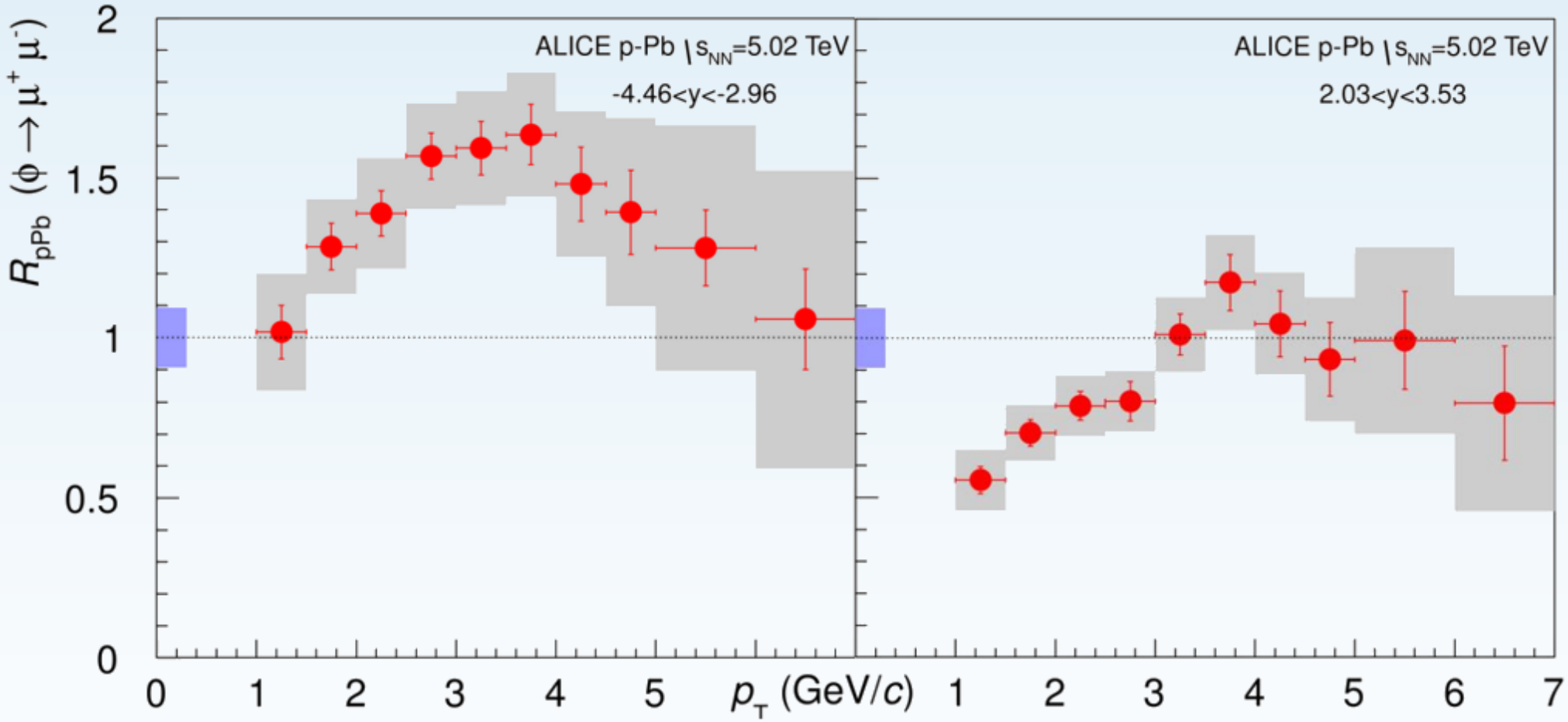




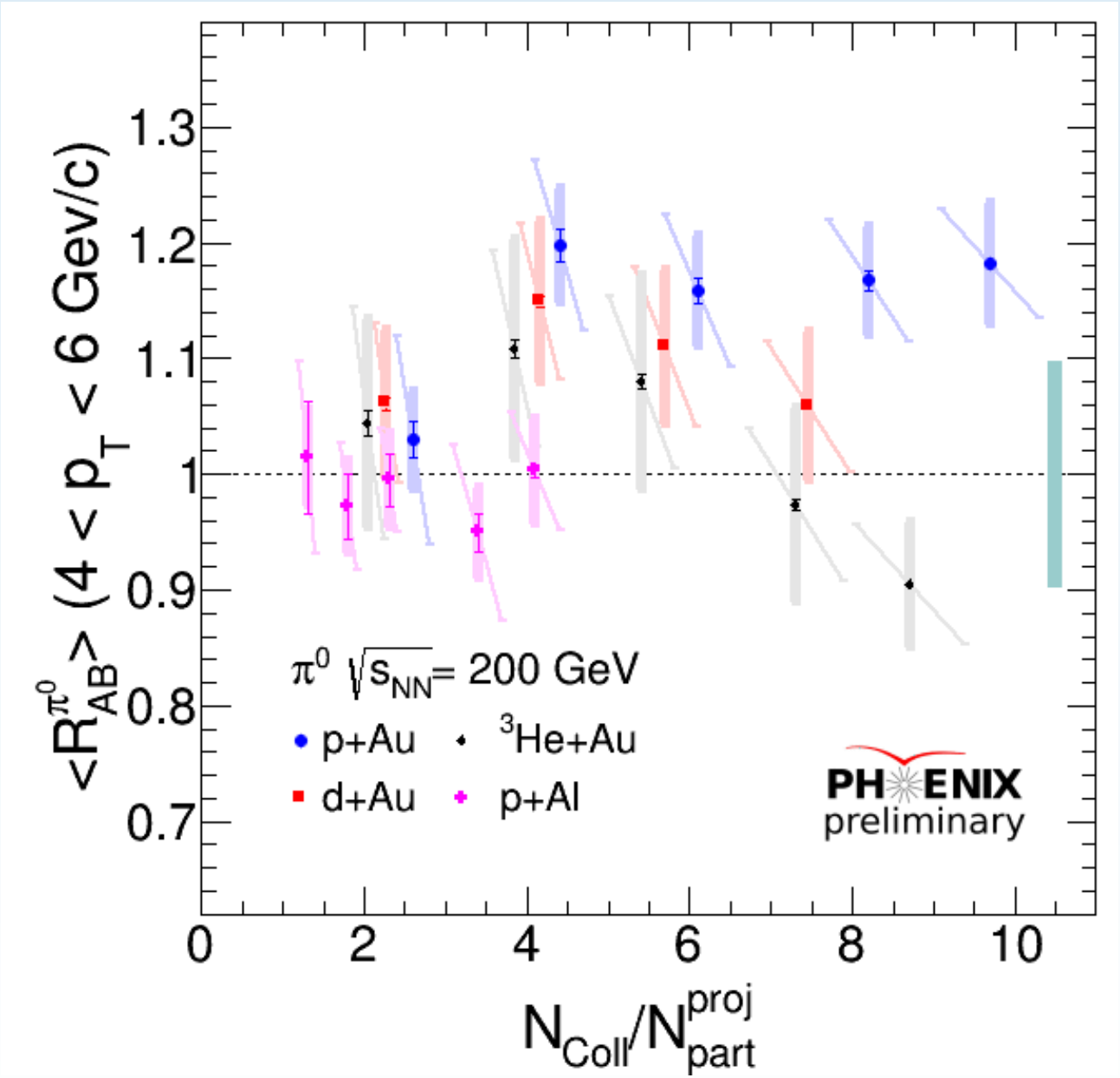
φ dN/dy (η) in p+Al, p+Au, ^{3}He+Au

Using these data sets allow to discriminate the various CNM effects included in models like AMPT and EPOS.

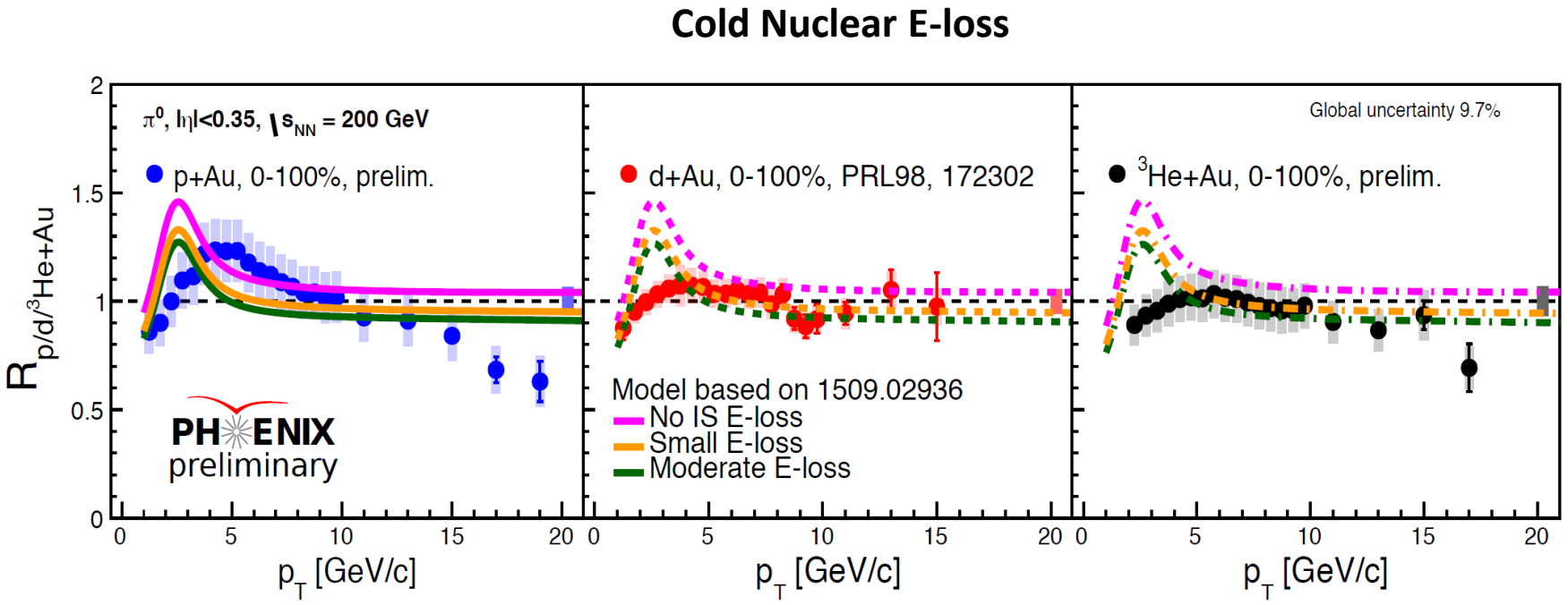
BACKUP

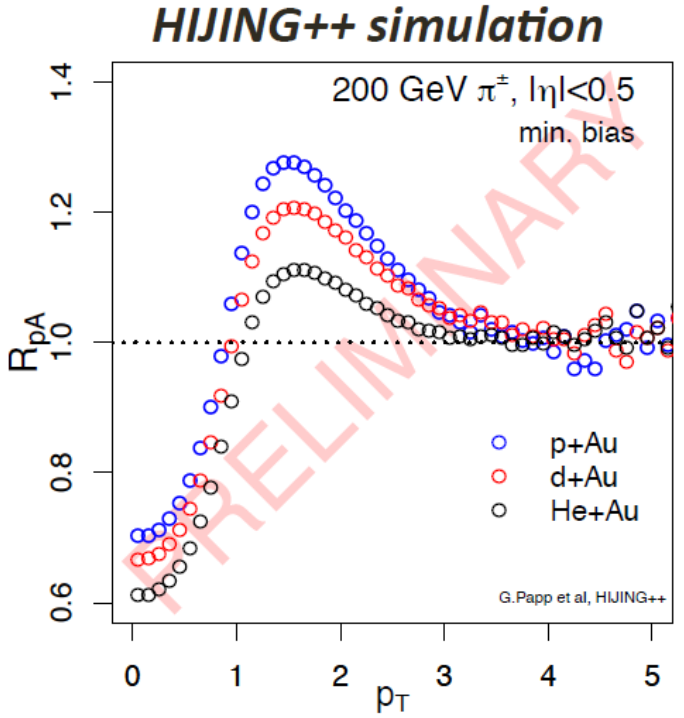

ALICE p-Pb √sNN=5.02 TeV
-4.46<y<-2.96
ALICE p-Pb √sNN=5.02 TeV
2.03<y<3.53
RpPb (φ→μ+μ-)
pT (GeV/c)
0
0.5
1
1.5
2
0
1
2
3
4
5
6
7

BACKUP


$<R_{AB}^{\pi^0}>$ $(4 < p_T < 6$ Gev/c)
1.3
1.2
1.1
1
0.9
0.8
0.7
0
2
4
6
8
10
N_{Coll}/N_{part}^{proj}
π^0 $\sqrt{s_{NN}}$= 200 GeV
p+Au
^{3}He+Au
d+Au
p+Al
PHENIX
preliminary

BACKUP





model	Ordering	Peak position	High-p_T
Cold Nuclear E-loss	X	X	V
HIJING++	V	X	X

π^0 R_{AB} in
p+Au, d+Au, ^{3}He+Au