Production of light flavor hadrons measured by PHENIX at RHIC

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For PHENIX collaboration

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Motivation

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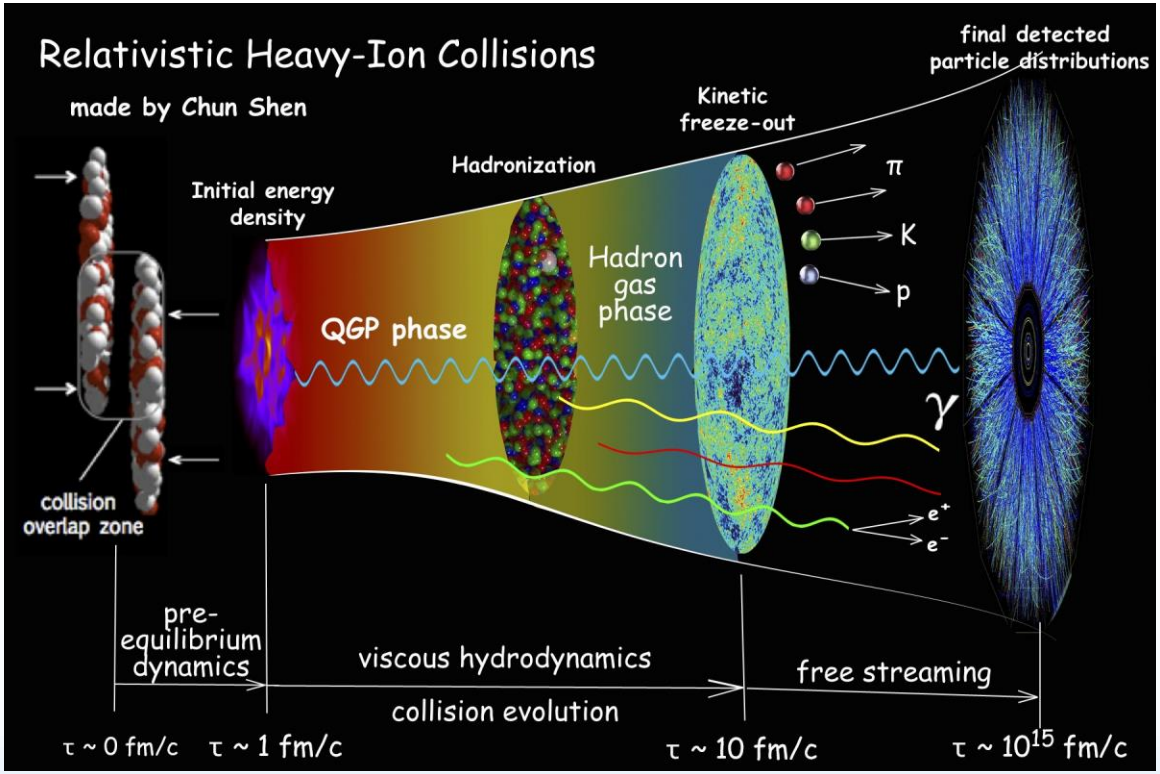
- Light flavor hadrons in A+A & p+A → properties of the produced medium & reaction dynamics;



Motivation

- Light flavor hadrons in A+A & p+A → properties of the produced medium & reaction dynamics;
- Different hadrons properties → observables in the soft sector & high-p_T probes & signatures of the onset of collectivity in collisions of small systems;

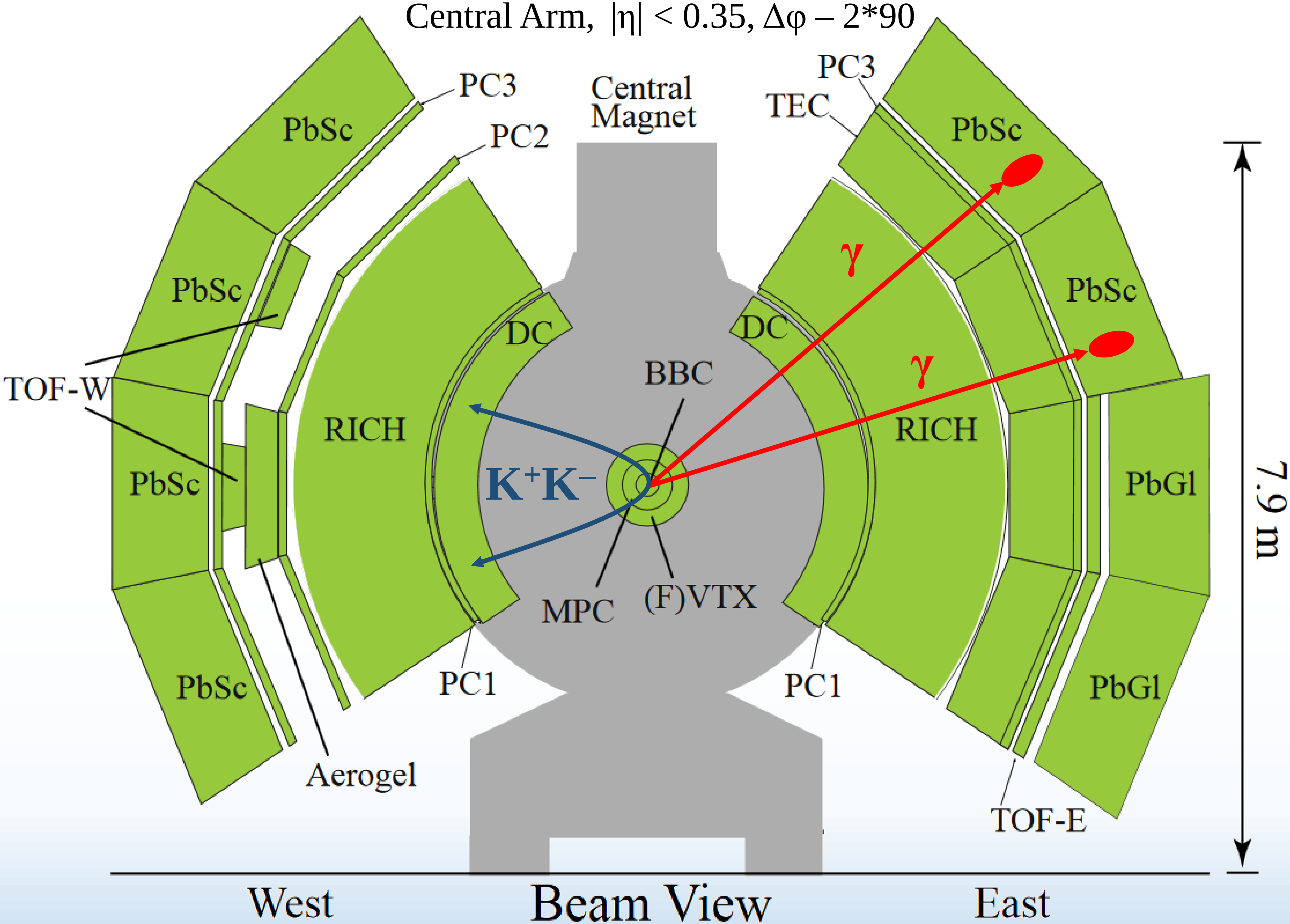
	π^0	η	ω	K*	K_S	φ
Mass, MeV	135	548	782	892	498	1019
Quark content	$u\bar{u}\|\|d\bar{d}$	$\frac{1}{6}(u\bar{u}+d\bar{d}-2s\bar{s})$	$\frac{1}{\sqrt{2}}(u\bar{u}+d\bar{d})$	$d\bar{s}$	$\frac{1}{\sqrt{2}}(d\bar{s}+s\bar{d})$	$s\bar{s}$
Lifetime, fm/c	$2.5\cdot10^{7}$	$1.6\cdot10^{5}$	23	4.16	$2.7\cdot10^{13}$	46

Motivation

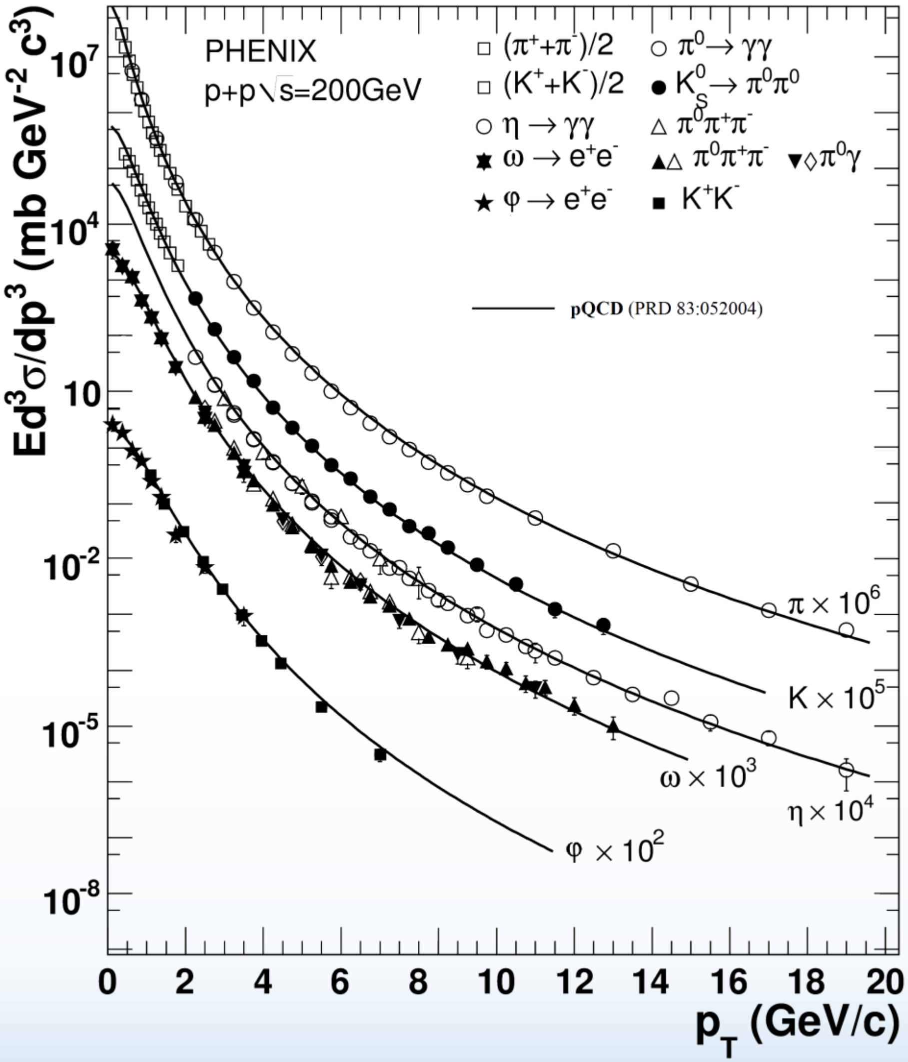
- Light flavor hadrons in A+A & p+A → properties of the produced medium & reaction dynamics;
- Different hadrons properties → observables in the soft sector & high p_T probes & signatures of the onset of collectivity in collisions of small systems;
- PHENIX measured **π^0, η, K*, K_S, φ & ω** in **p+p, p/d/^{3}He+Au, Cu+Cu, Cu+Au, Au+Au & U+U**:
  - ✓ Baseline measurements in p+p collisions;
  - ✓ Study of the parton energy loss in heavy ion collisions;
  - ✓ Cold nuclear matter effects in small systems;
- Comparison to higher energy experiments and theoretical model predictions.

The PHENIX Detector

Central Arm, $|\eta| < 0.35$, $\Delta\varphi$ – 2*90



Mesons spectra in p+p @ 200 GeV



- Results were found to be consistent between the different decay modes;
- Well described by the Tsallis distribution functional form with only two parameters:

✓ $T = 112.6 \pm 3.8 + (11.8 \pm 7.0)m_0[GeV/c^2]$ MeV;

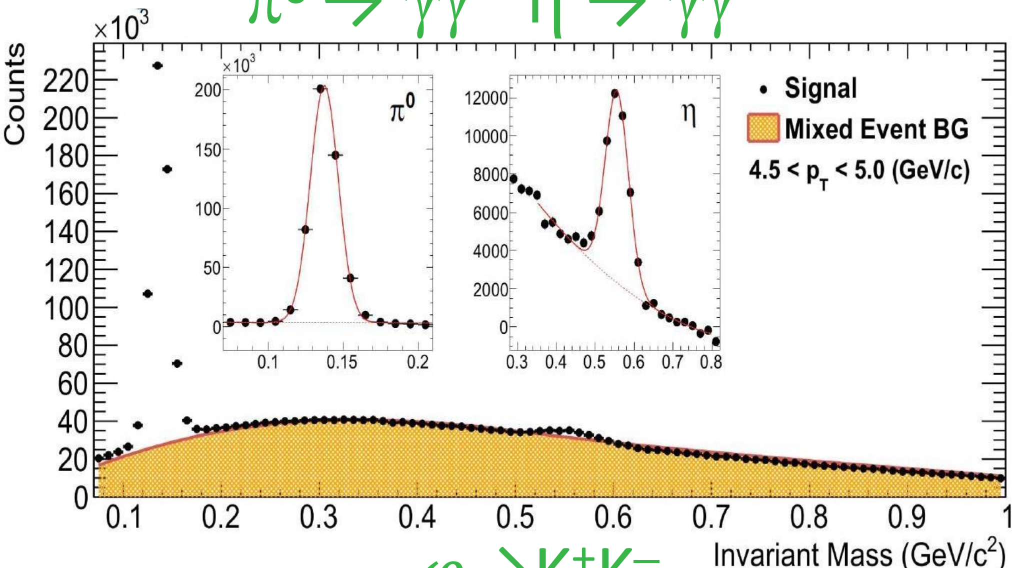
✓ $n = 9.48 \pm 0.14 + (0.66 \pm 0.39)m_0[GeV/c^2]$

(Phys.Rev.D83:052004)

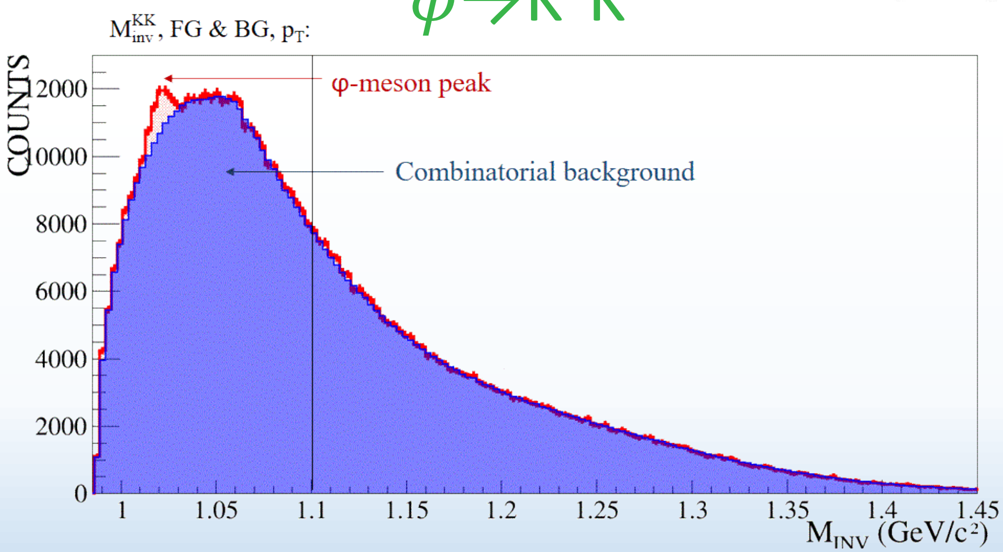
- Baseline to compare with more comlex and heavy p+A and A+A;
- Event generators tuning;
- Available parametrizations of fragmentation functions.

π^0, η, K_s, K*, φ & ω Reconstruction in p+A & A+A

$\pi^0 \rightarrow \gamma\gamma$ $\eta \rightarrow \gamma\gamma$



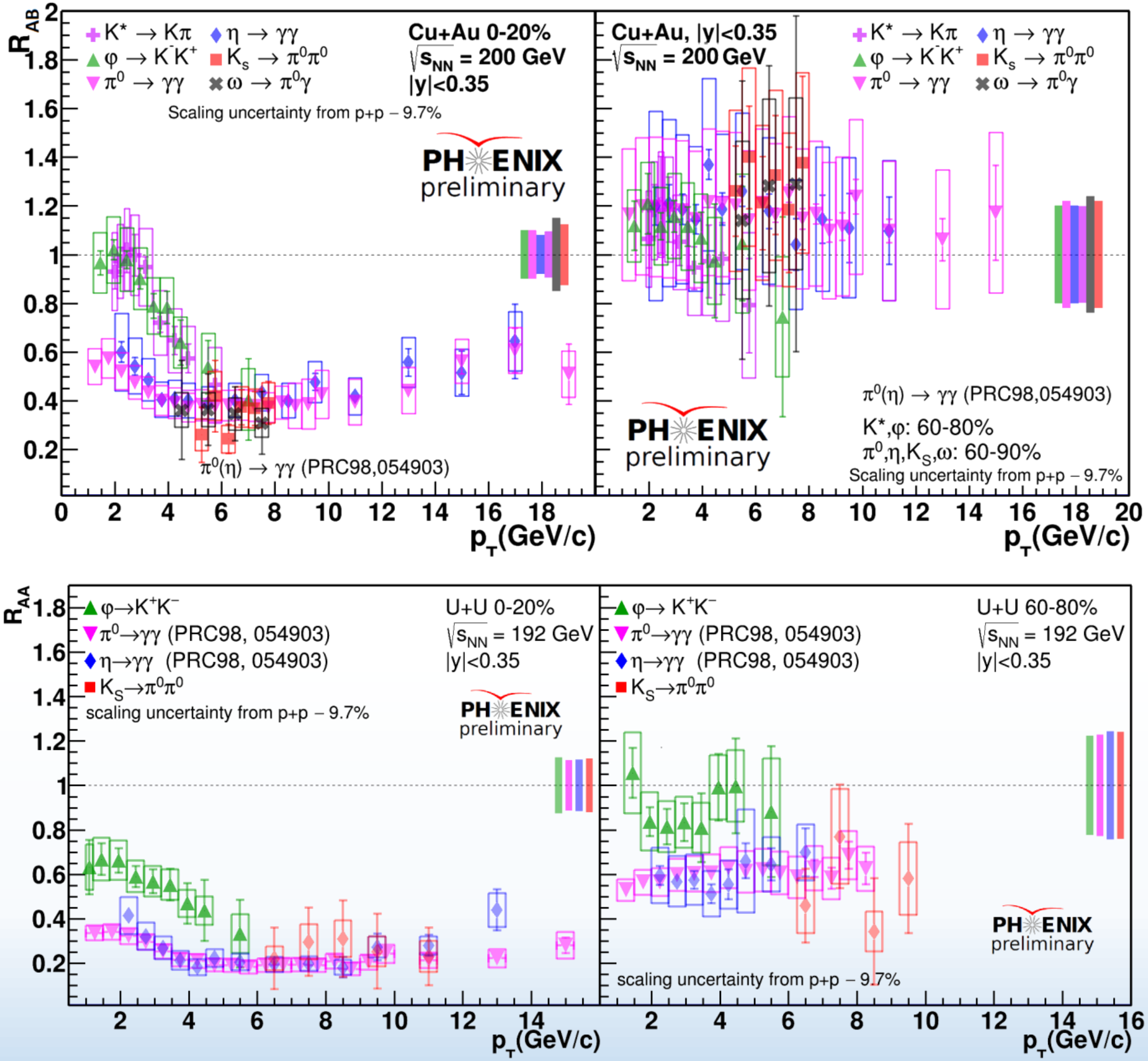
$\varphi \rightarrow K^+K^-$



	System	Decay modes	BR, %	Detector
π^0	p+p, d+Au, Cu+Cu, Au+Au, Cu+Au, U+U, p/^{3}He+Au	$\gamma\gamma$	~99	EMCal
η	p+p, d+Au, Cu+Cu, Au+Au, Cu+Au, U+U	$\gamma\gamma$	~39	EMCal
ω	p+p, d+Au, Cu+Cu, Au+Au, Cu+Au, U+U	$\pi^0\gamma$	~8.4	EMCal
K_S	p+p, d+Au, Cu+Cu, Cu+Au	$\pi^0\pi^0$	~30	EMCal
K*	p+p, d+Au, Cu+Cu, Cu+Au	$K^\pm\pi^\mp$	~67	DC+ToF
φ	p+p, d+Au, Cu+Cu, Au+Au, Cu+Au, U+U, p/^{3}He+Au	K^+K^-	~49	DC+ToF

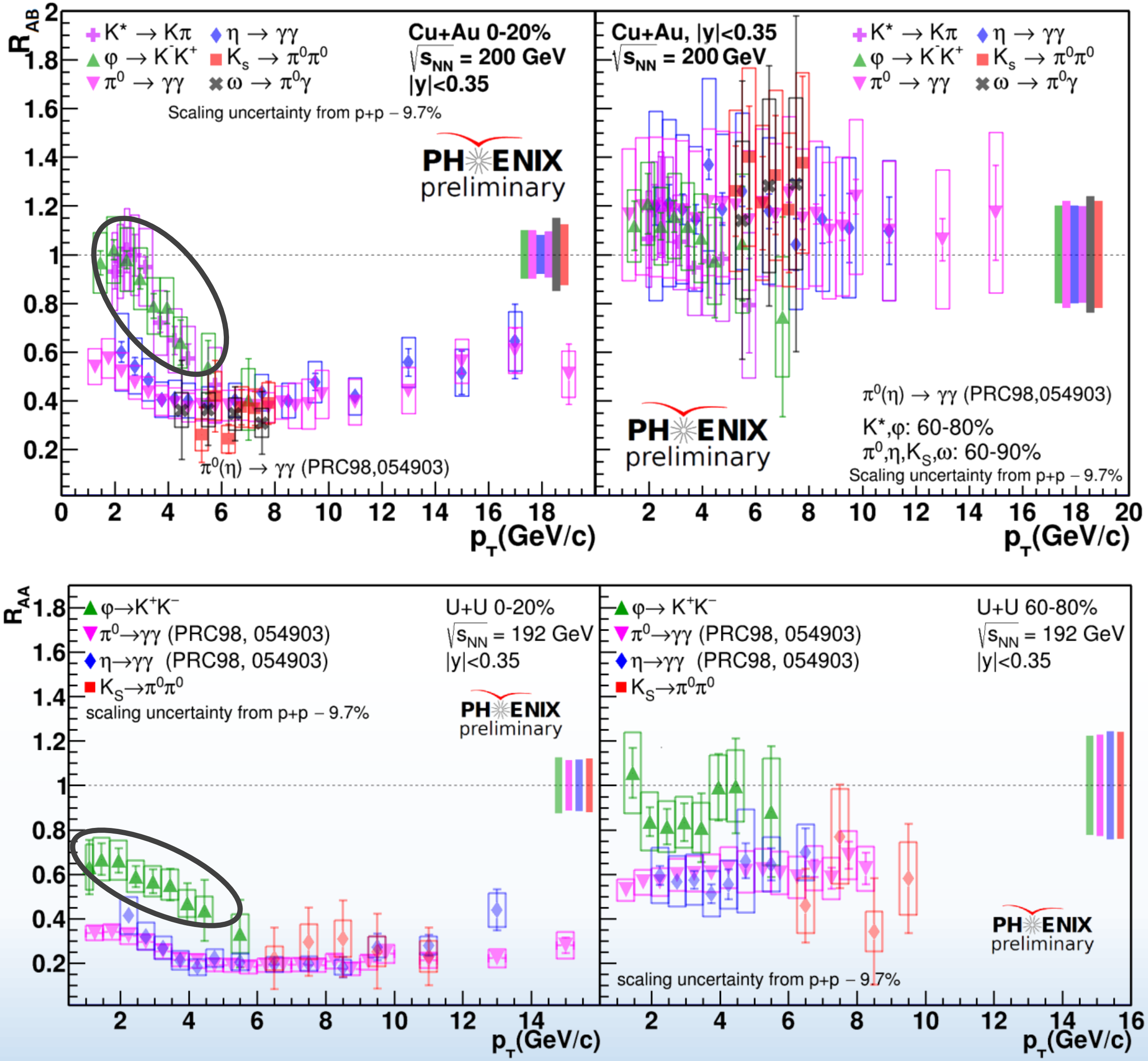
Large Systems

Light mesons R_{AB} at $\sqrt{s_{NN}}$=200 GeV



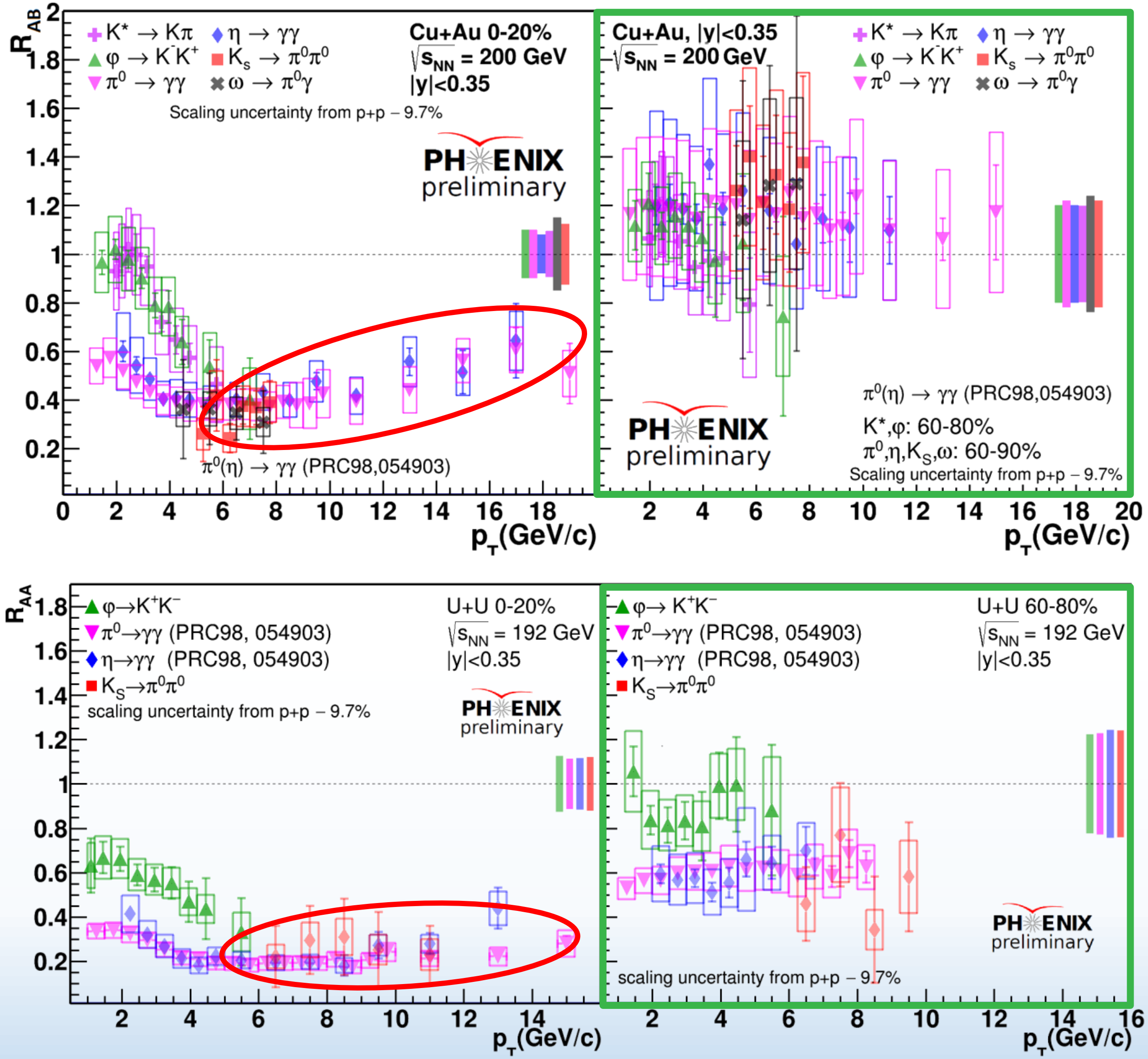
- New results in asymmetric Cu+Au at $\sqrt{s_{NN}}$=200 GeV & in deformed U+U at $\sqrt{s_{NN}}$=192 GeV;

Light mesons R_{AB} at $\sqrt{s_{NN}}$=200 GeV



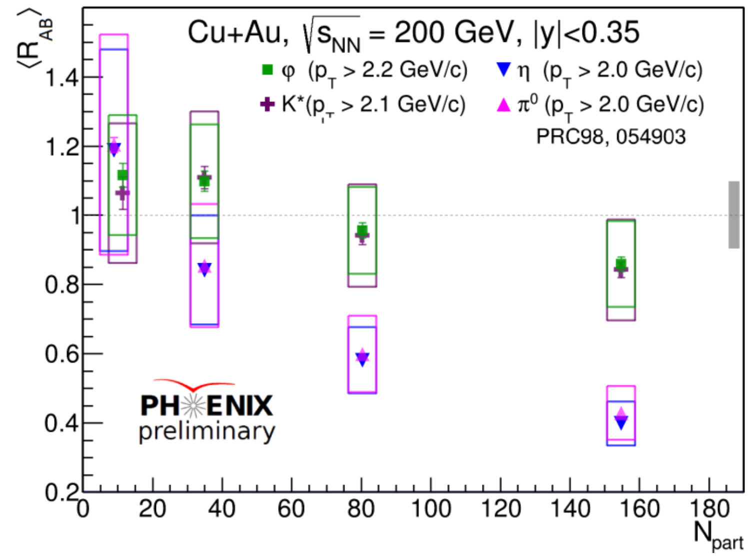
- In most central collisions φ & K* are less suppressed than π^0, η, K_s & ω in the intermediate p_T range;

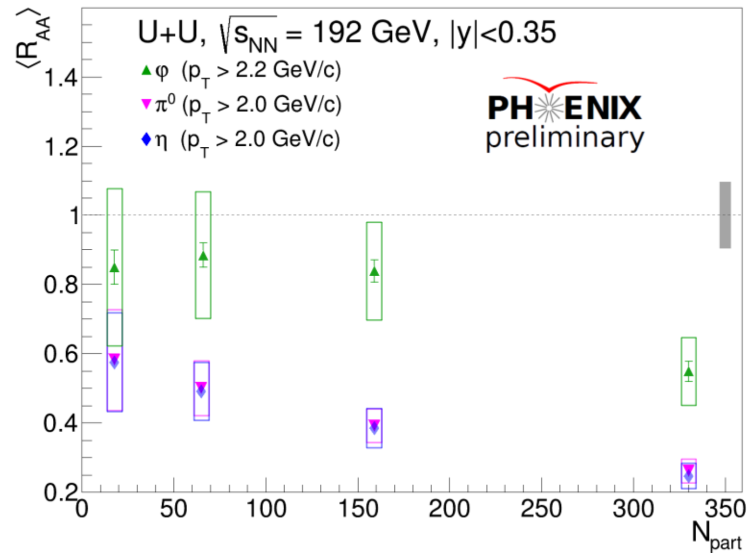
Light mesons R_{AB} at $\sqrt{s_{NN}}$=200 GeV

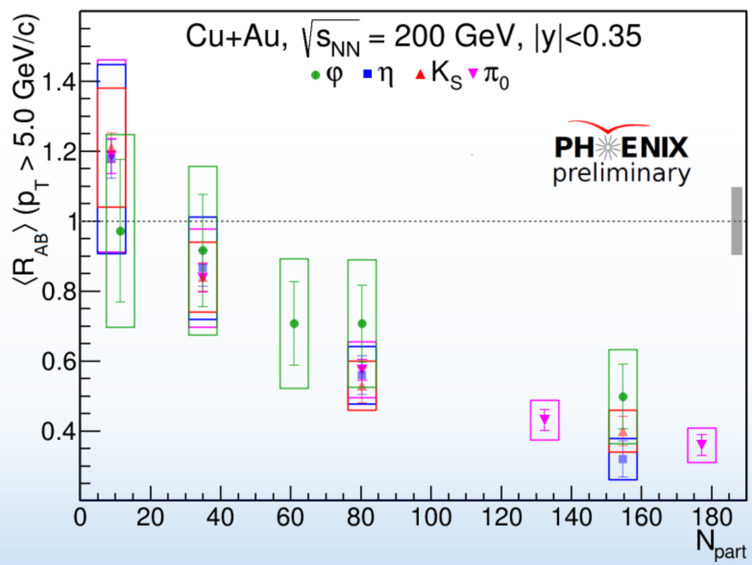


- In most central collisions φ & K* are less suppressed than π^0, η, K_s & ω in the intermediate p_T range;
- At p_T > 5 GeV/c, φ, K*, π^0, η, K_S, ω R_{AB} exhibit similar shape;
- R_{AB} in peripheral collisions consistent with each other within uncertainties.

Light mesons integrated R_{AB}

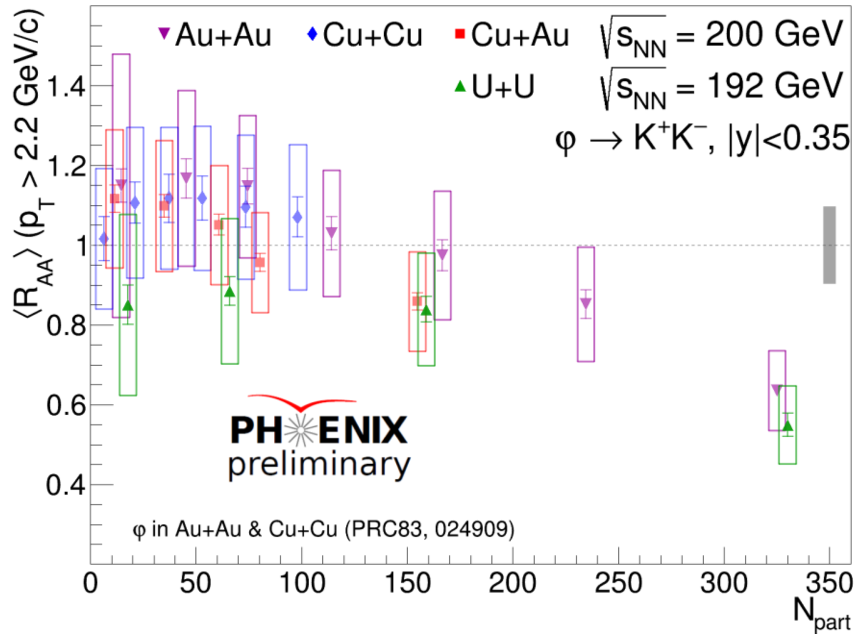


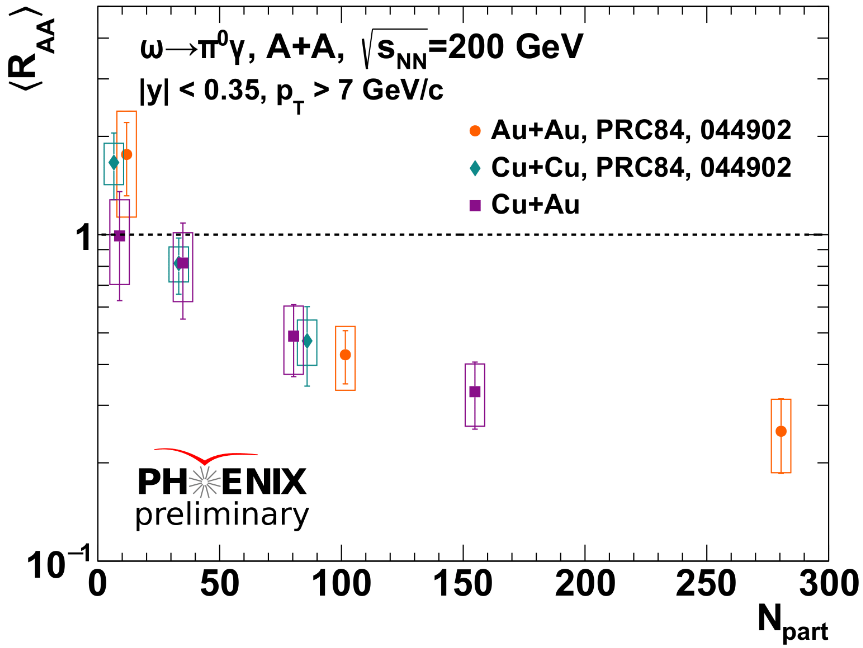


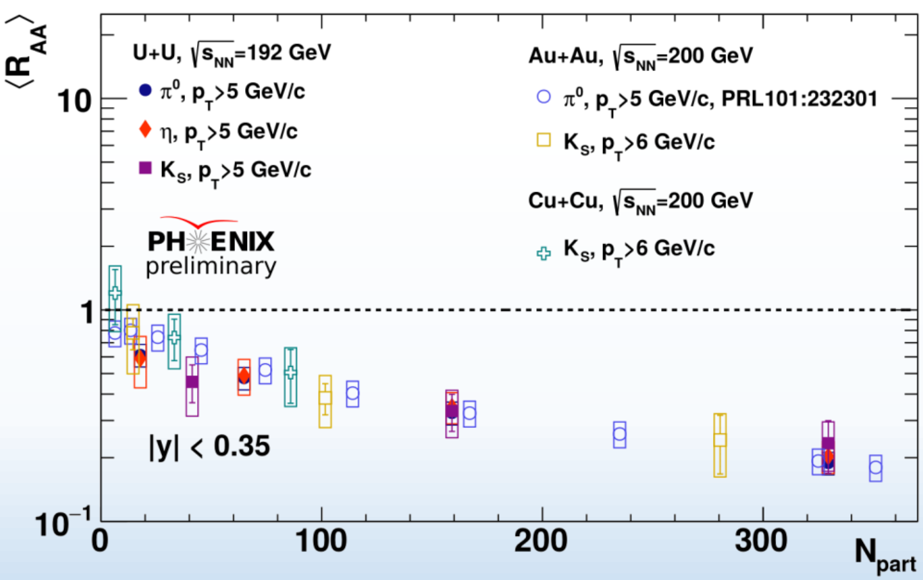


- The φ & K* integrated R_{AB} at $p_T \gtrsim 2$ GeV/c shows less suppression than π^0 & η;
- The φ, K*, π^0, η & K_S integrated R_{AB} at $p_T > 5$ GeV/c show same suppression level.

Light mesons integrated R_{AA}







- New results $\langle R_{CuAu} \rangle$ and $\langle R_{UU} \rangle$ are in agreement with previous $\langle R_{AuAu} \rangle$ and $\langle R_{CuCu} \rangle$;
  - ✓ Production and suppression of the light mesons seem to depend on nuclear overlap size, but not on its geometry.

Small systems:
p+Au, d+Au, ^{3}He+Au

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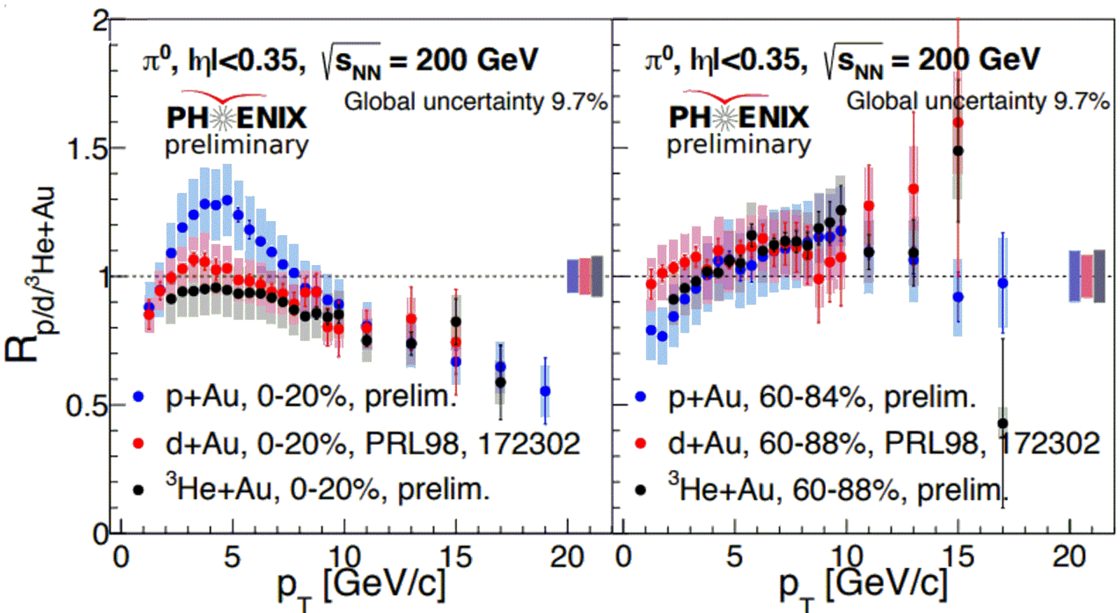
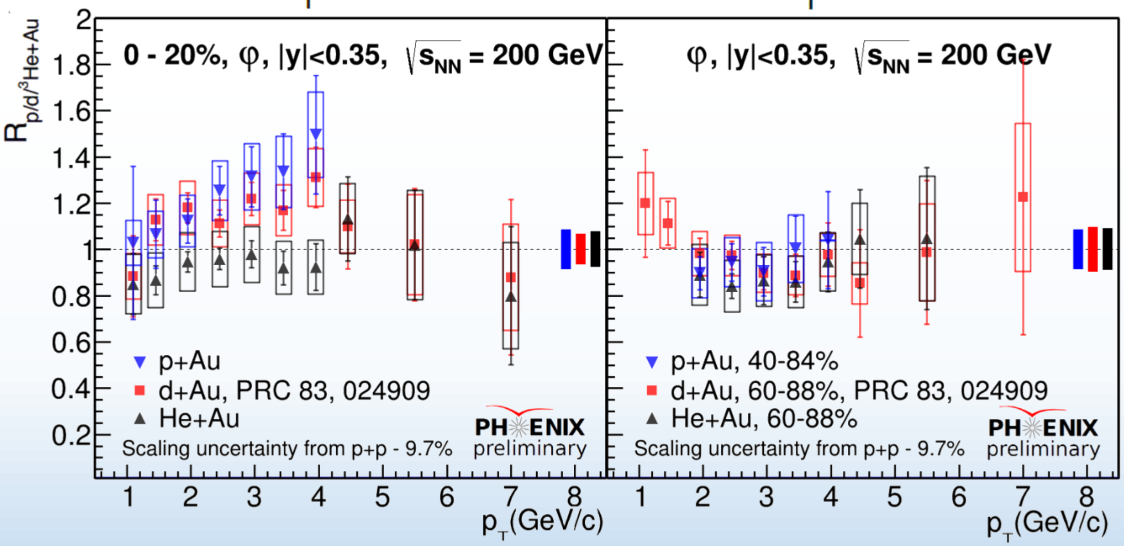
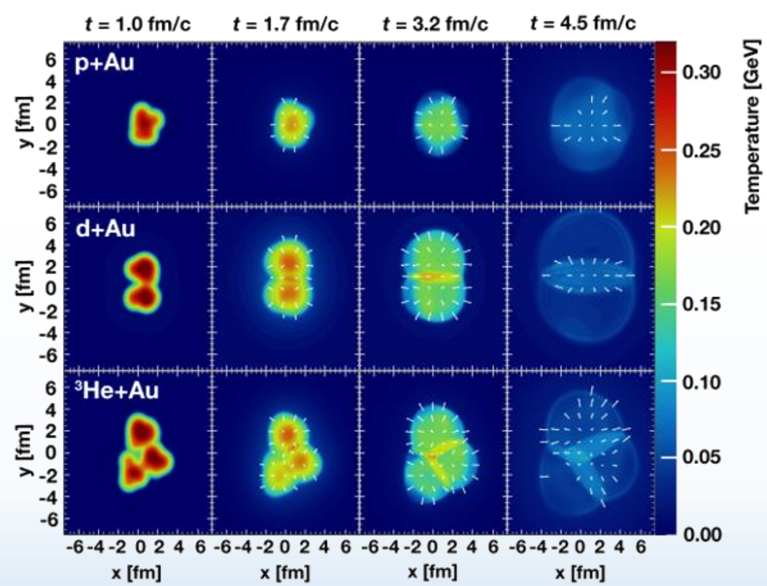
π^0 & φ R_{AB} in p+Au, d+Au, ^{3}He+Au

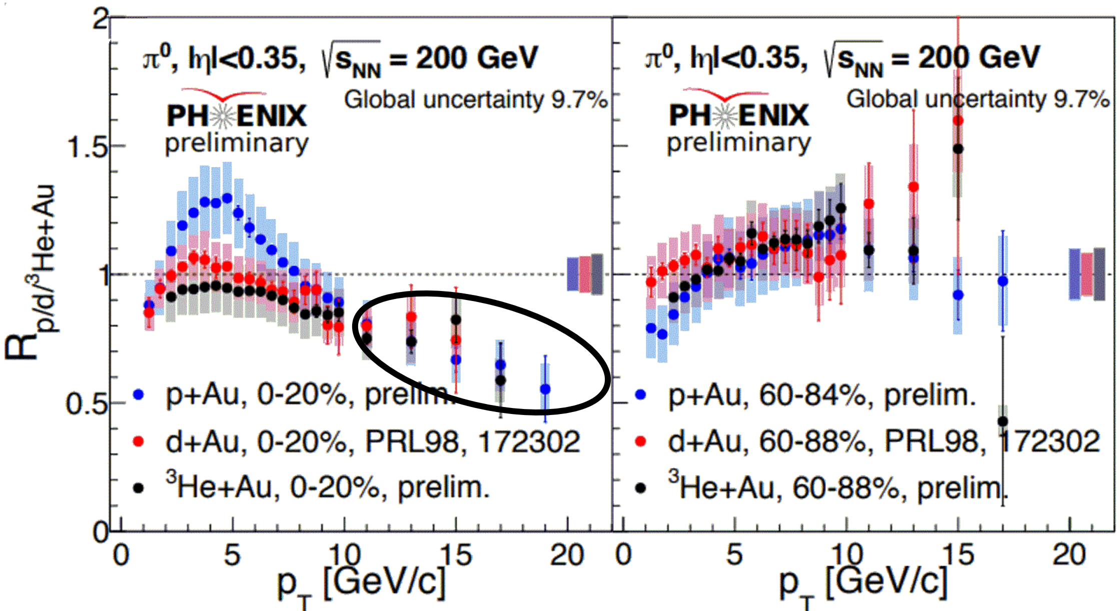


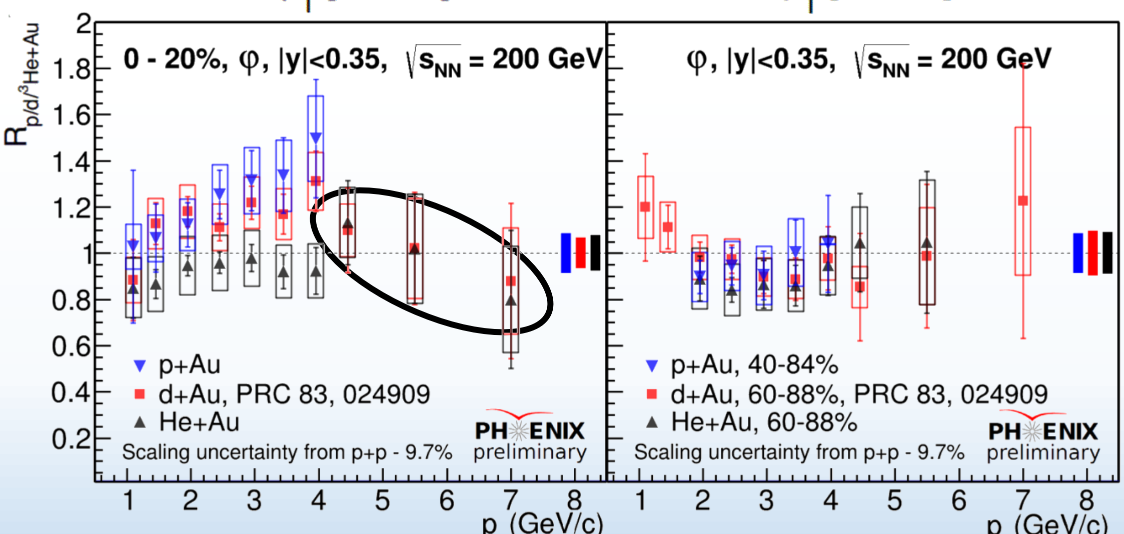


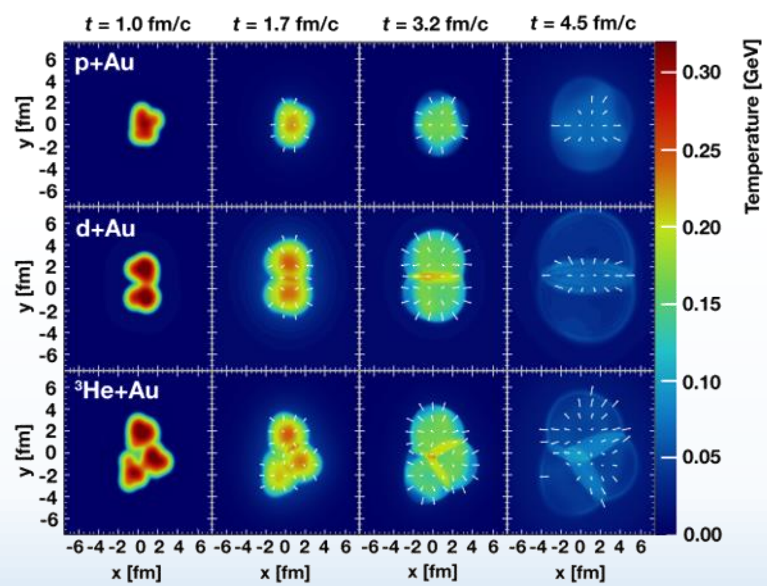


π^0 & φ R_{AB} in p+Au, d+Au, ^{3}He+Au

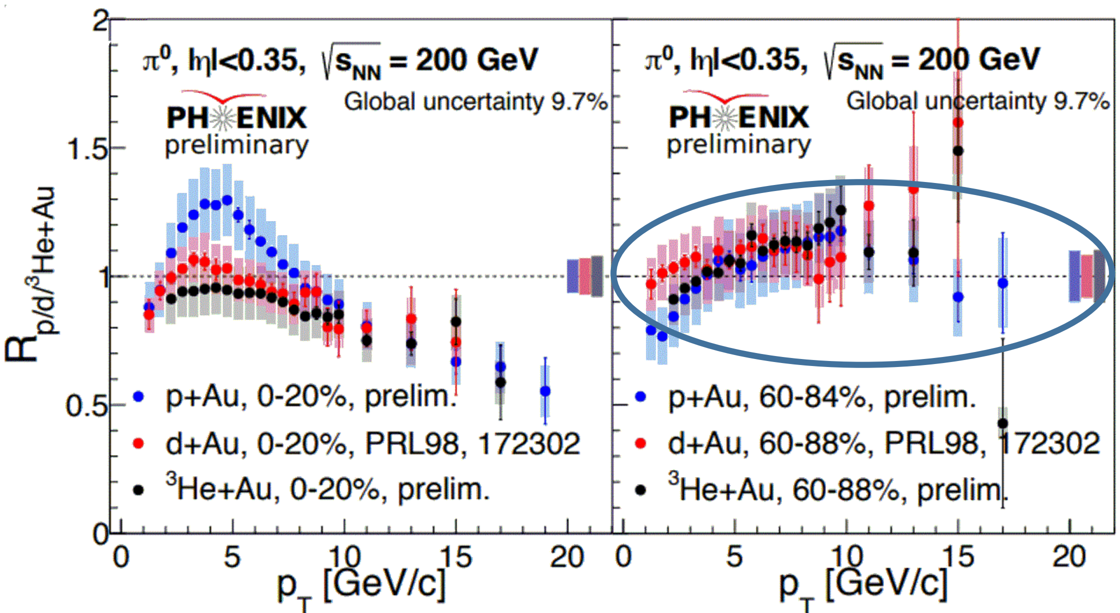
- Small systems consistent with each other at high-p_T in most central collisions;
- Hint of suppression at high-p_T in central collisions;

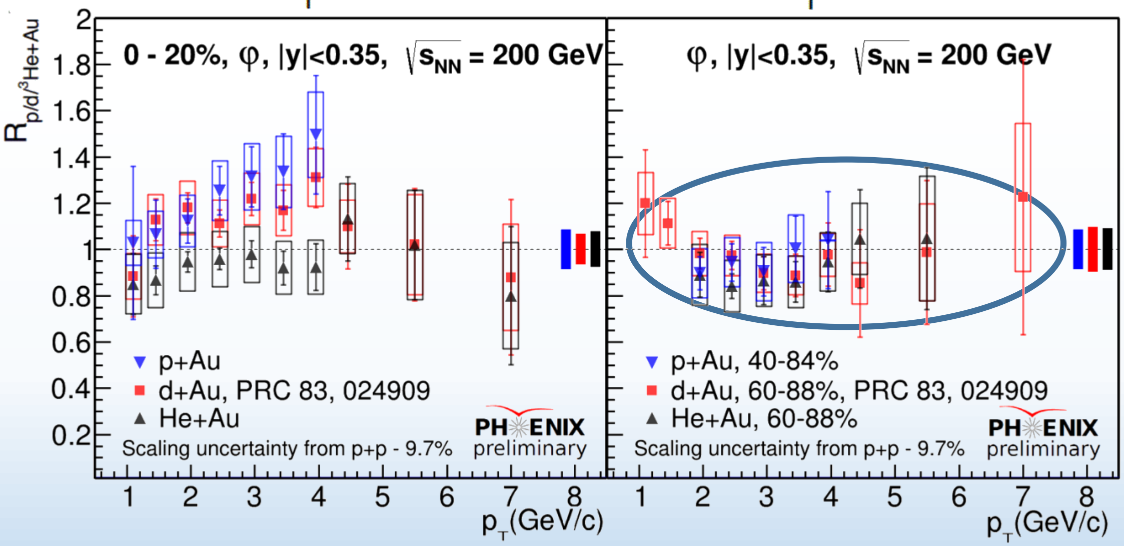




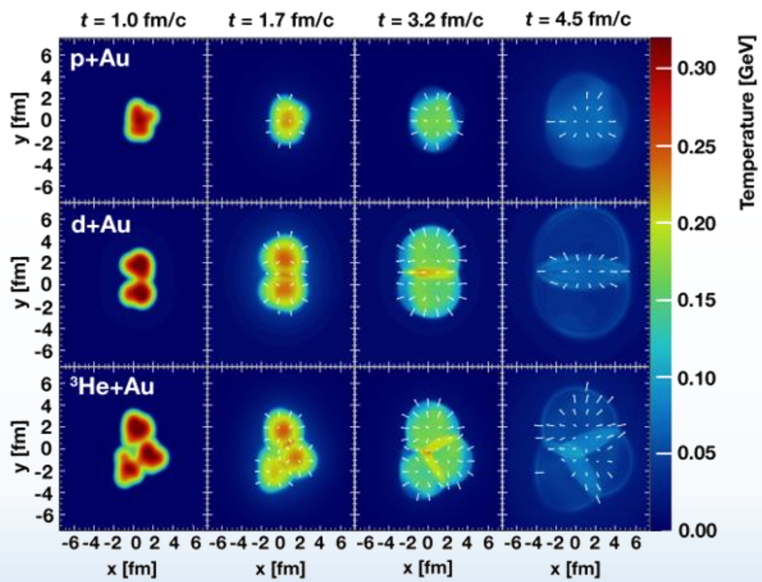


π^0 & φ R_{AB} in p+Au, d+Au, ^{3}He+Au

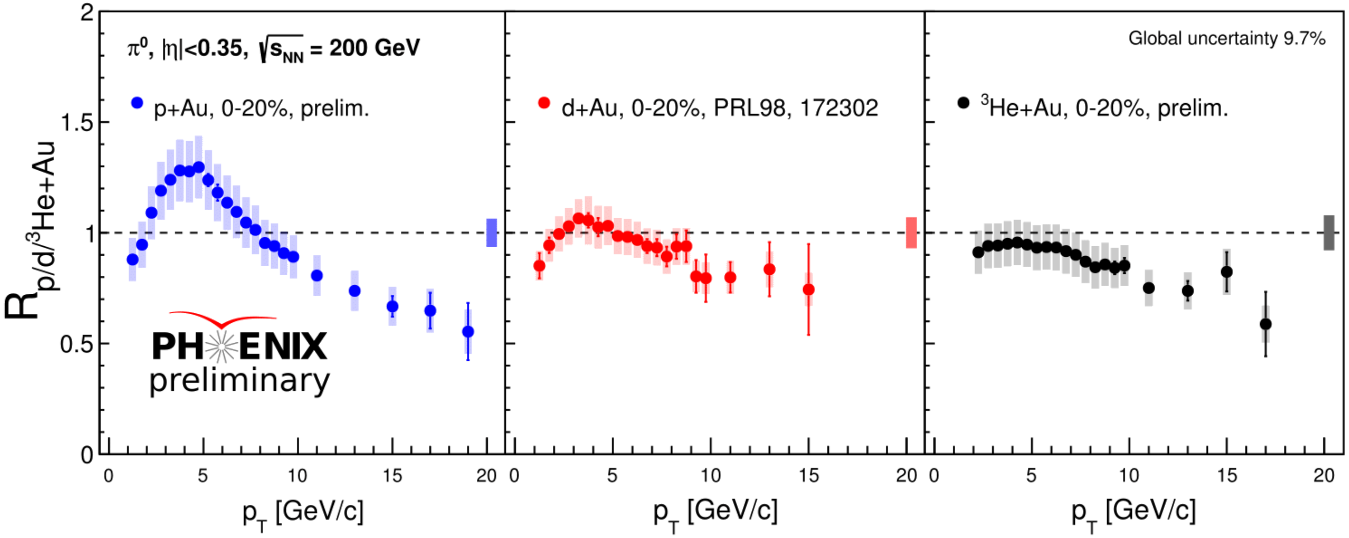


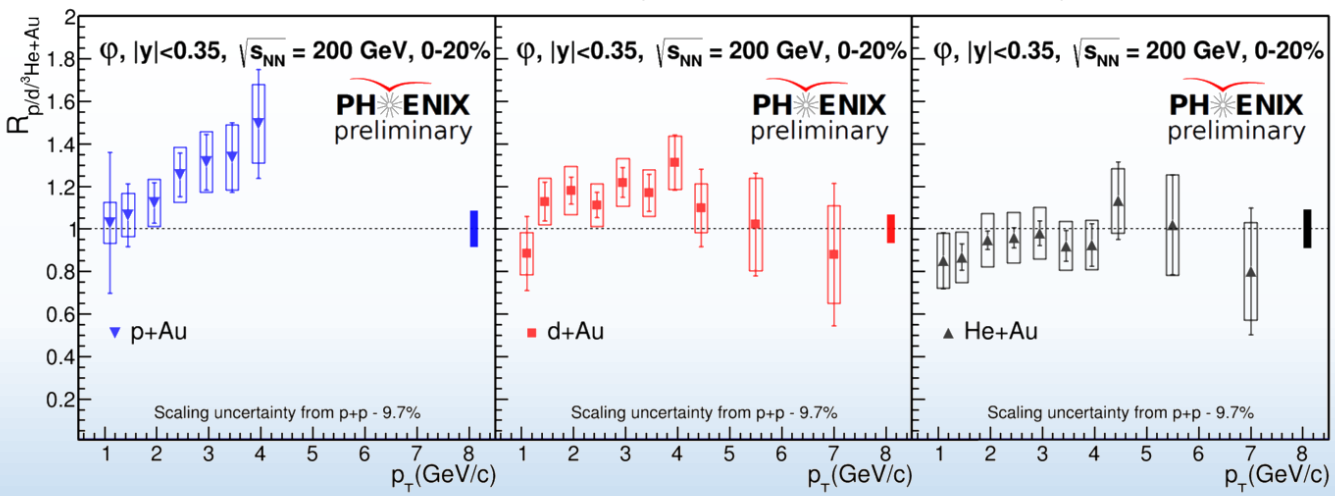


- Small systems consistent with each other at high-p_T in most central collisions;
- Hint of suppression at high p_T in central collisions;
- φ, π^0 $R_{pAu} \approx R_{dAu} \approx R_{HeAu}$ in peripheral collisions.



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





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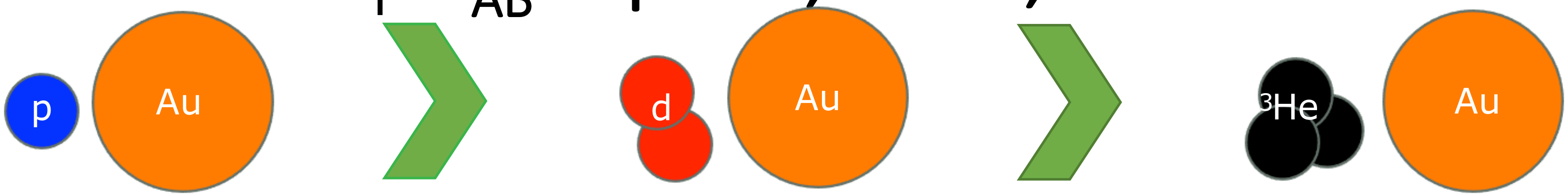
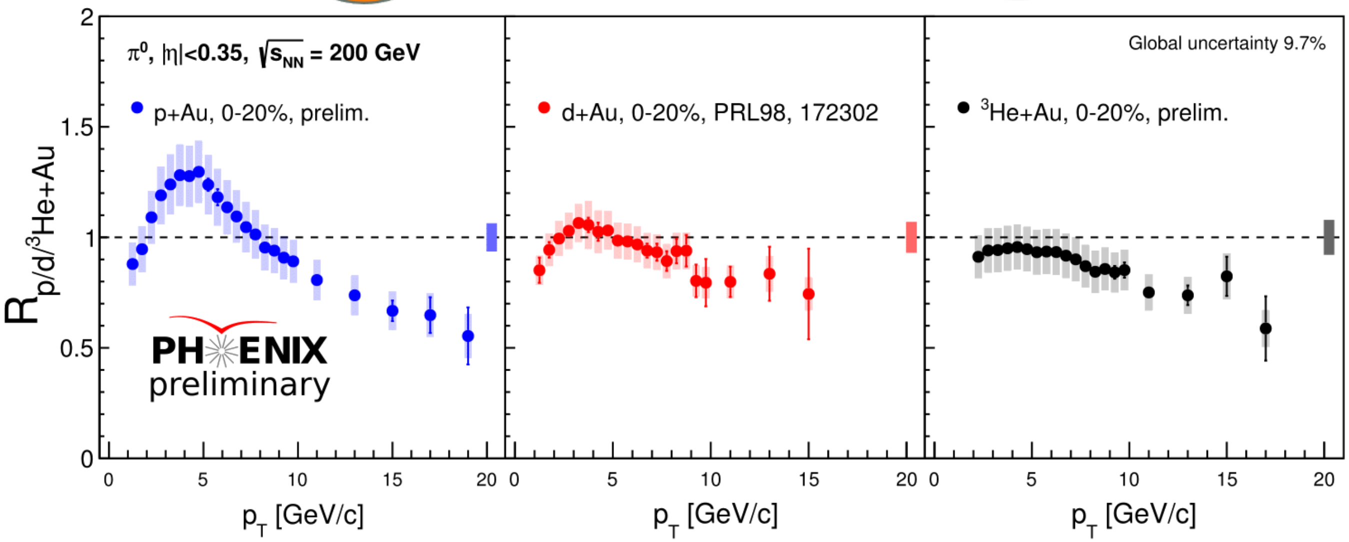
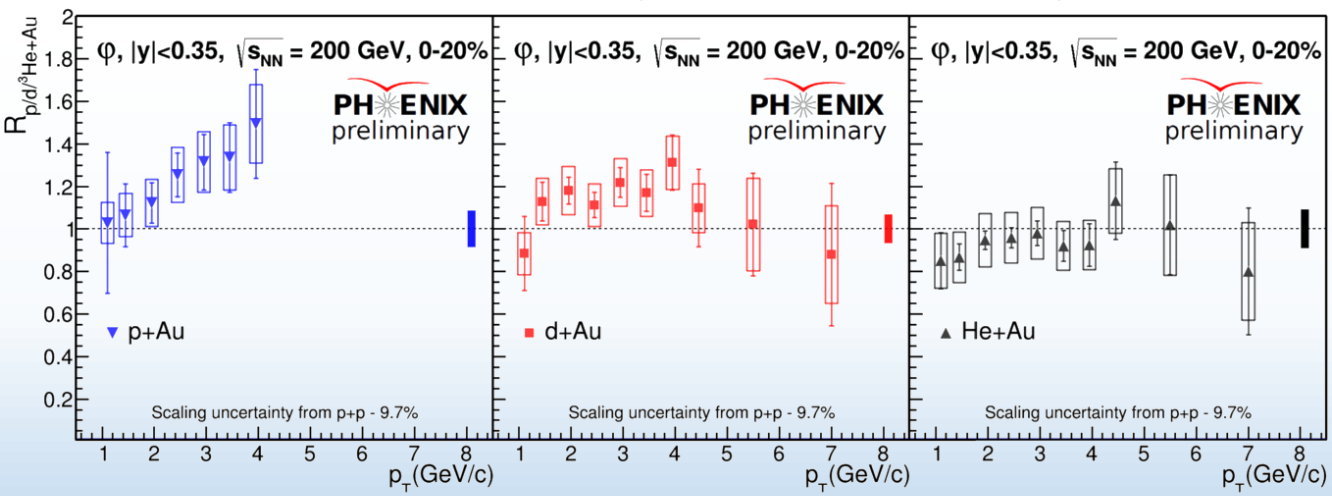
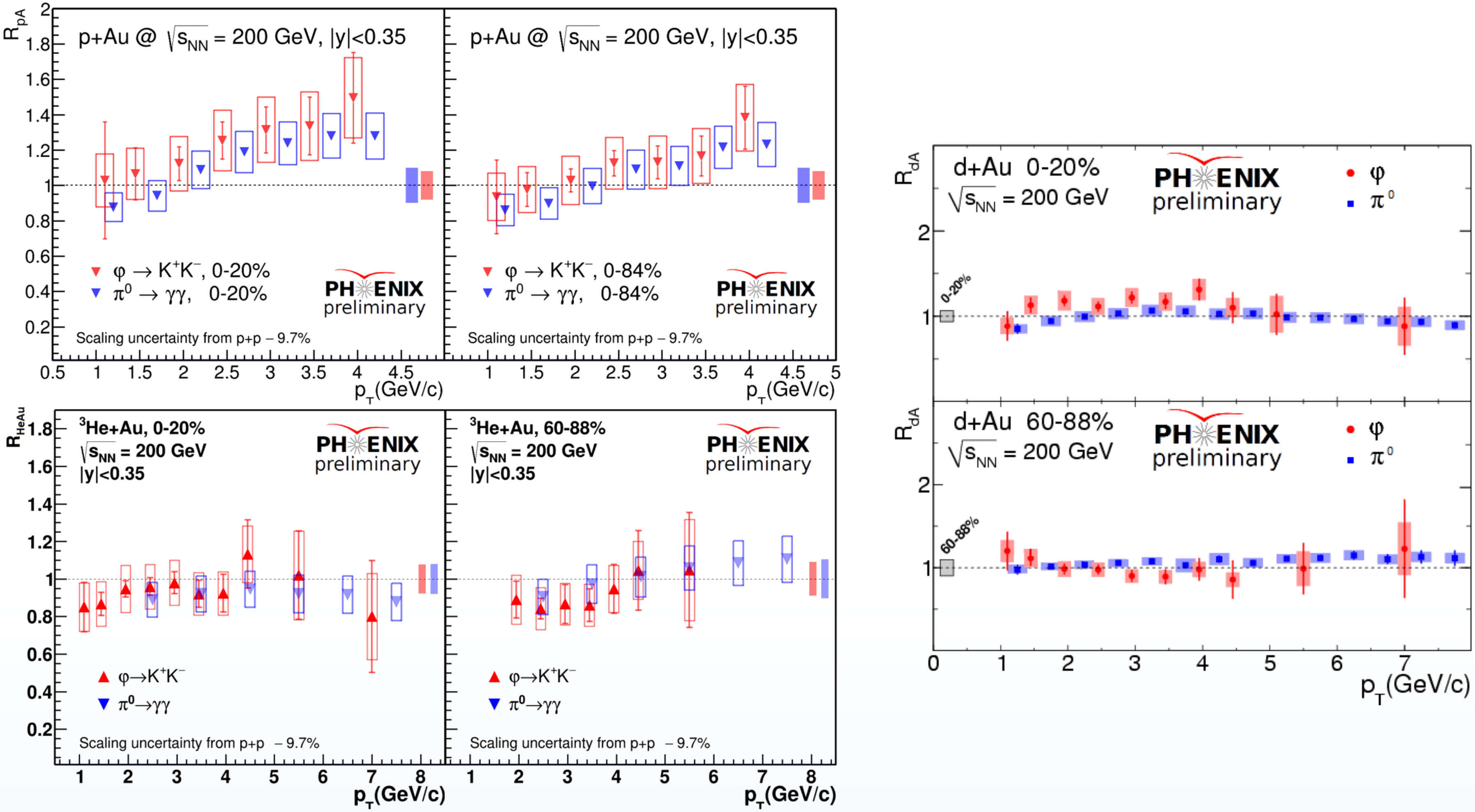






- In most central collisions in the intermediate p_T range ordering is seen
  - ✓ Suppression at $p_T \approx$ 5 GeV/c indicates a system size dependence

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



- In whole p_T range φ & π^0 mesons R_{AB} show similar suppression level:
  - ✓ That might indicate that CNM effects are not responsible for the differences between φ and π^0 seen in A+A.

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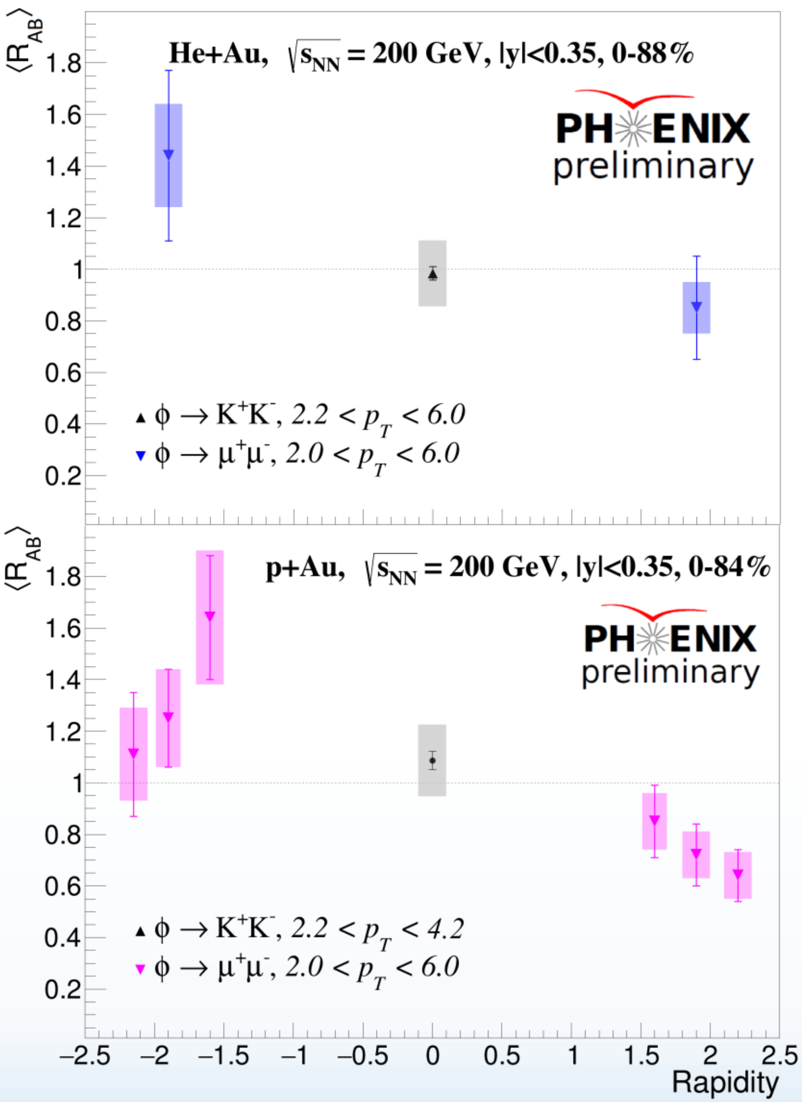
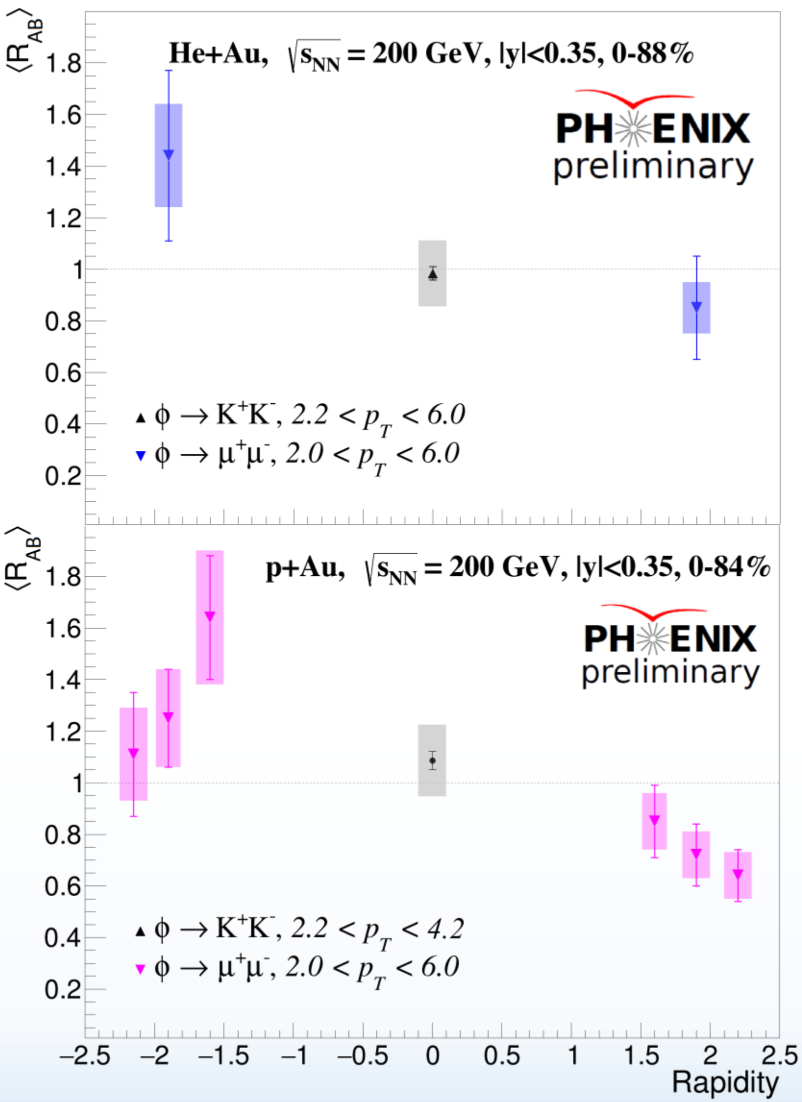
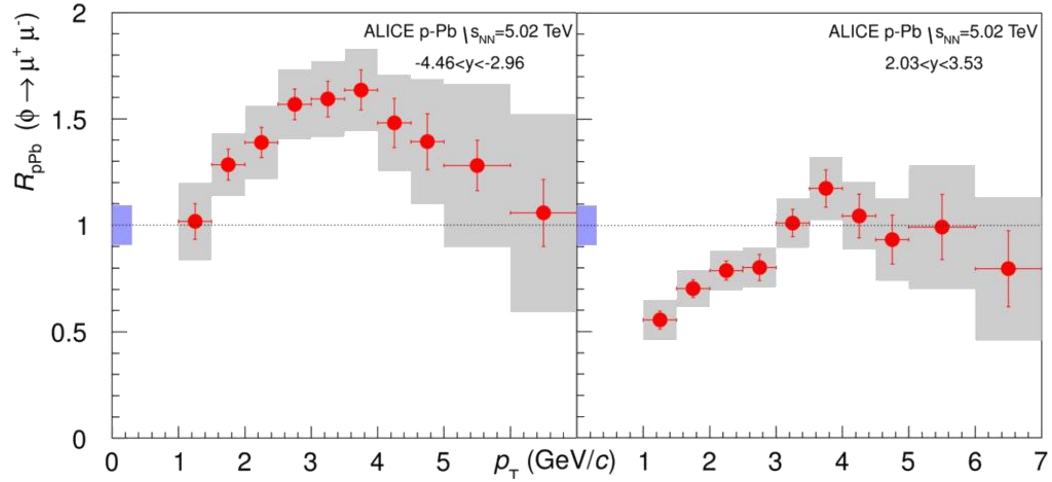
π^0 & $\varphi \langle R_{AB} \rangle (\eta)$ in p/d/^{3}He+Au



- $\varphi \langle R_{AB} \rangle$ in Au-going – a hint of enhancement;
- $\varphi \langle R_{AB} \rangle$ at midrapidity – equal to unity;
- $\varphi \langle R_{AB} \rangle$ in p/He-going – a hint of suppression;

π^0 & $\varphi \langle R_{AB} \rangle (\eta)$ in p/d/^{3}He+Au





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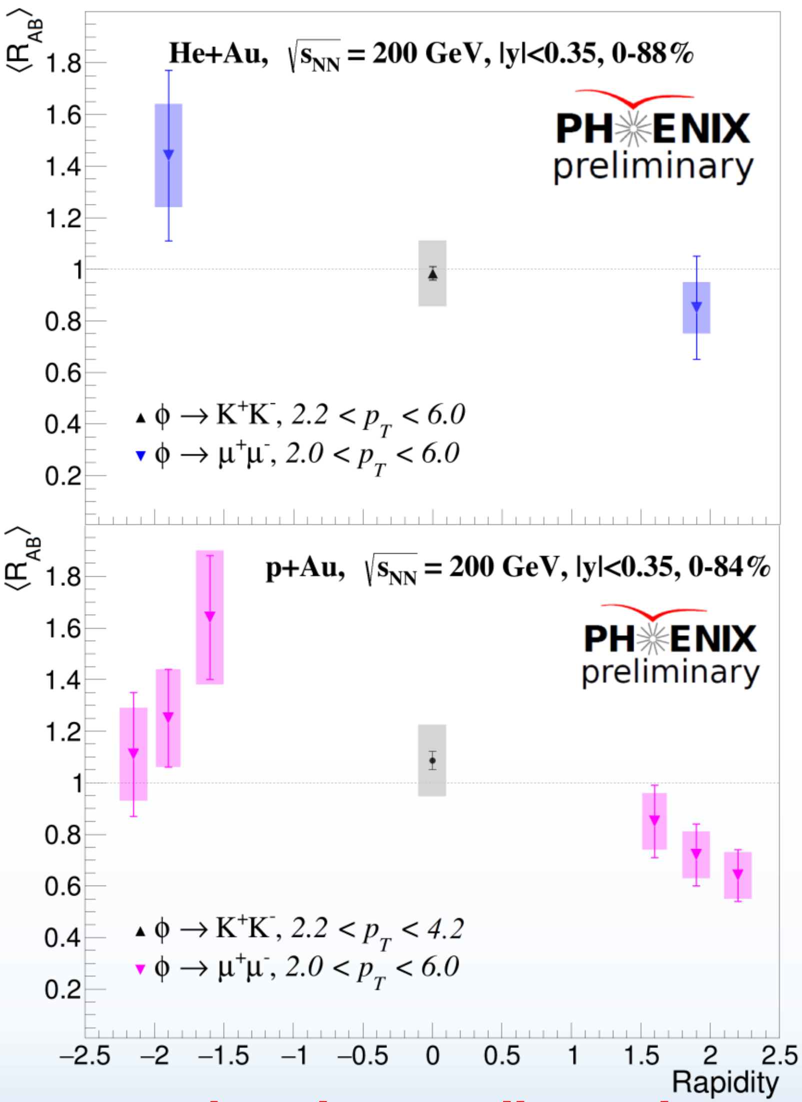
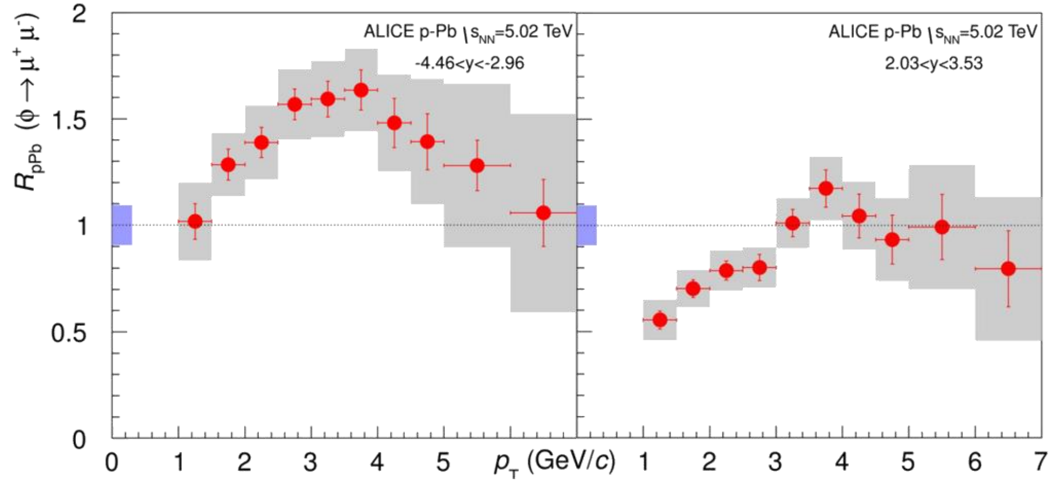
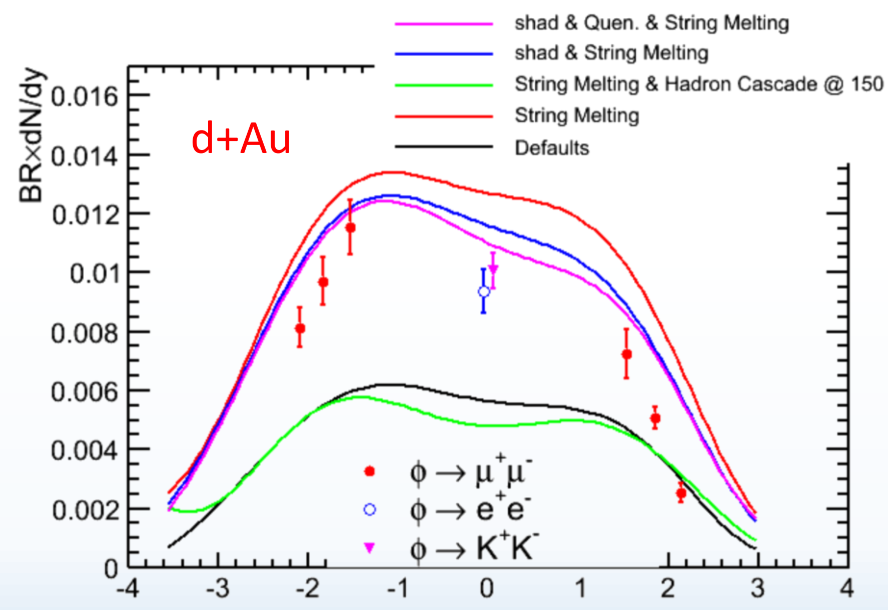
- $\varphi \langle R_{AB} \rangle$ at midrapidity – equal to unity;
- $\varphi \langle R_{AB} \rangle$ in p/He-going – a hint of suppression;
- Same $\varphi \langle R_{AB} \rangle$ behavior was observed in p-Pb at $\sqrt{s_{NN}}$=5.02 TeV at ALICE. (Nucl.Phys.A932,218)

π^0 & φ $\langle R_{AB} \rangle$ (η) in p/d/^{3}He+Au







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

Summary

- **Large Systems:**
  - Light mesons $\langle R_{AA} \rangle$ show same suppression level in Cu+Au, U+U, Au+Au and Cu+Cu;
    - ✓ Production and suppression of the light meson seems to depend on nuclear overlap size, but not on its geometry and not on its density;
  - φ & K* exhibit a different suppression pattern compared to lighter mesons (π^0, η, K_S, ω);
    - ✓ The observation of these patterns in many collision systems can provide a contribution to the understanding of the strangeness enhancement competing with energy loss;
- **Small systems:**
  - The φ & π^0 mesons R_{AB}'s are consistent in p/d/^{3}He+Au collisions in all centralities;
    - ✓ That might indicate that cold nuclear effects are not responsible for the differences between φ & π^0 seen in Au+Au, Cu+Cu, Cu+Au and U+U collisions;
  - In most central collisions in the intermediate p_T range there's an ordering of R_{pAu}>R_{dAu}>R_{HeAu} for both φ & π^0 mesons:
    - ✓ The ordering might indicate a system size dependence;
  - These results can provide additional constraints for the models that try to explain CNM effects (like AMPT, EPOS).

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Thank you for your attention!