LXX International conference "NUCLEUS – 2020.
Nuclear physics and elementary particle physics. Nuclear physics technologies"

φ-meson production in small systems collisions

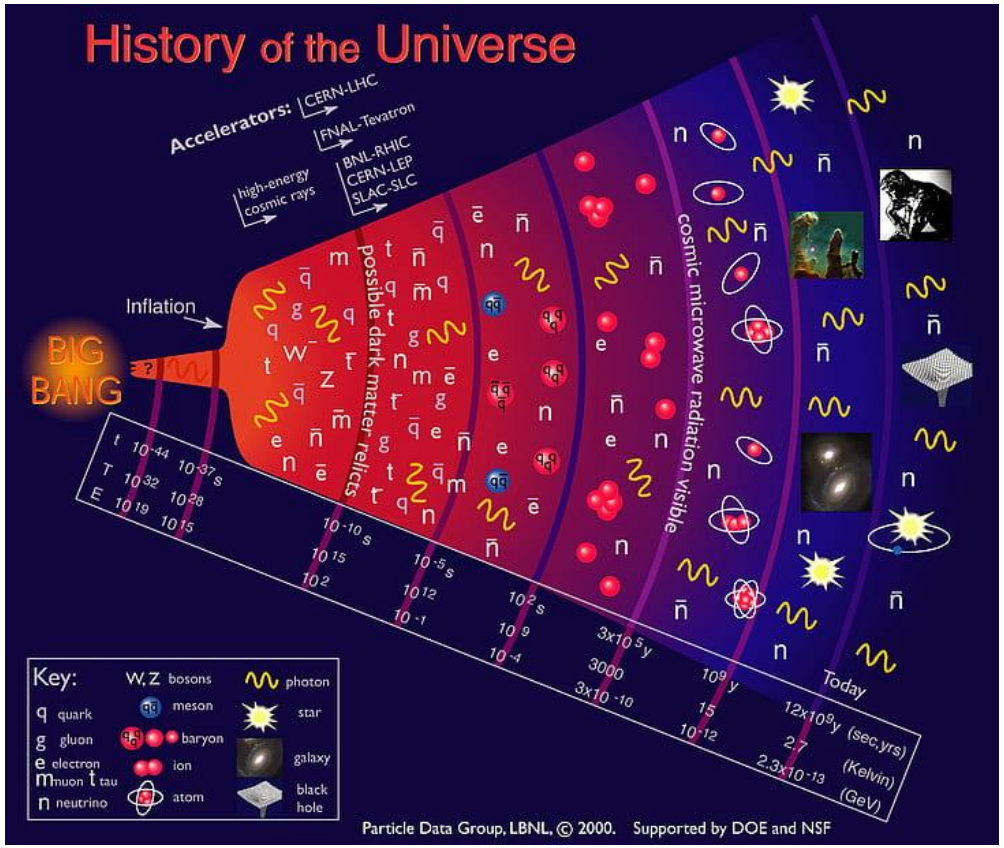
Larionova Mariia
For PHENIX collaboration

Motivation

Big Bang → QGP formation

↓

Hadronic gaze

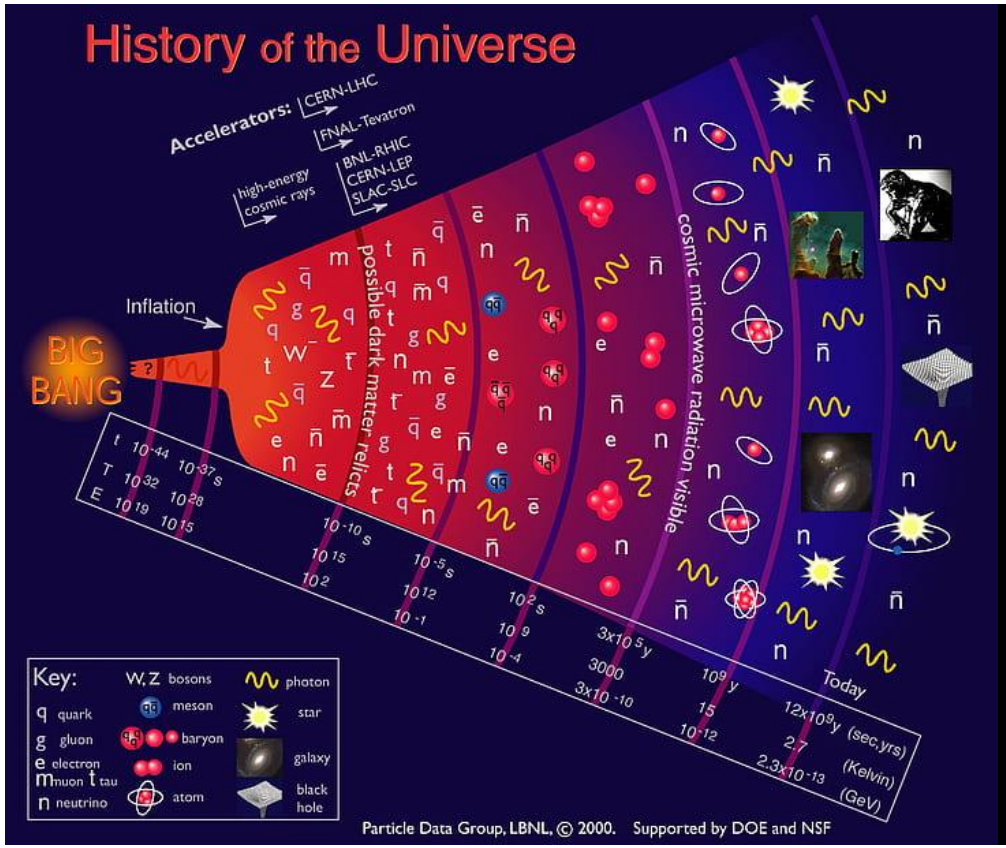


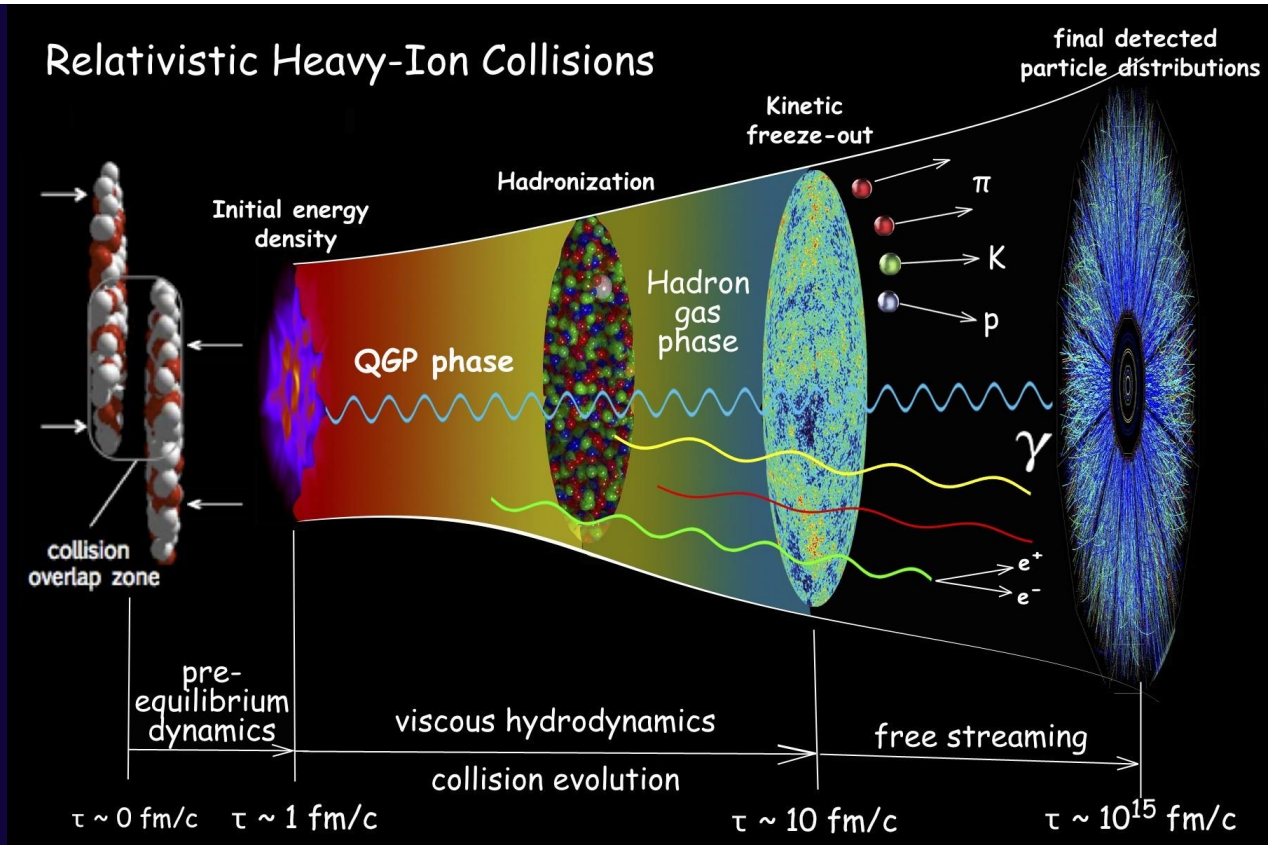
Motivation

Big Bang → QGP formation ← Relativistic Ion collisions

↓

Hadronic gaze



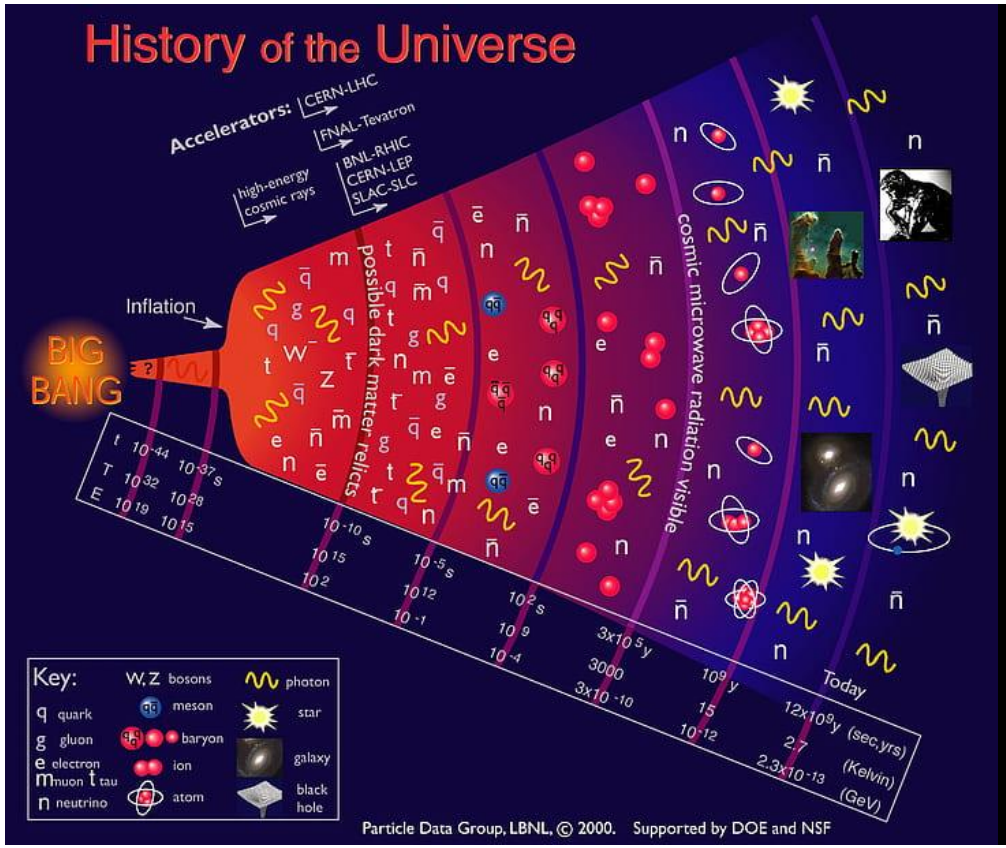


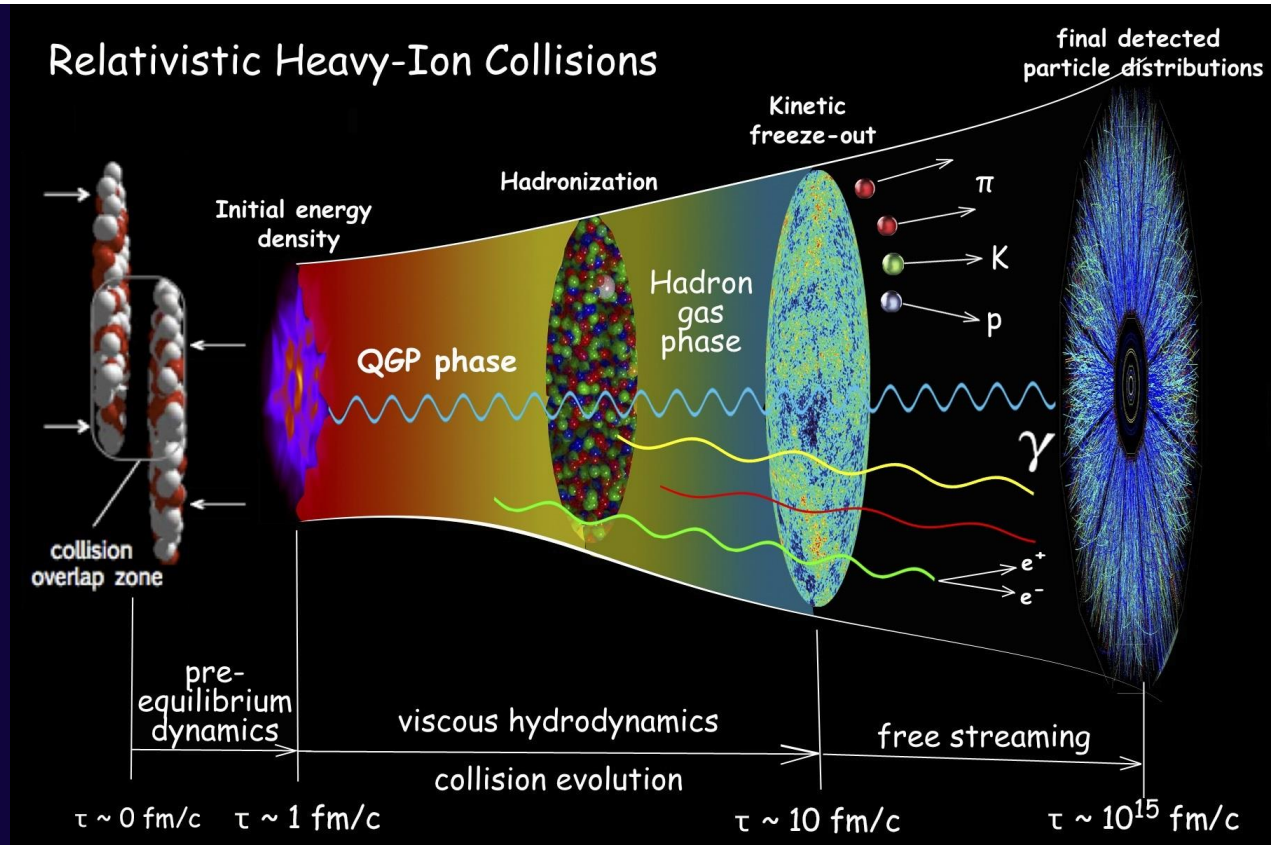
Motivation

Big Bang → QGP formation ← Relativistic Ion collisions

↓ ↓

Hadronic gaze → Study of hadron production





Motivation

φ-meson

- $\tau_{QGP} < \tau_{\varphi}$
- Small interaction cross-section with nonstrange hadrons

Clean probe to investigate the properties of QGP

Motivation

φ-meson

- $\tau_{QGP} < \tau_{\varphi}$
- Small interaction cross-section with nonstrange hadrons
- $\varphi(s\bar{s})$
- Measurable up to high-p_T

Clean probe to investigate the properties of QGP

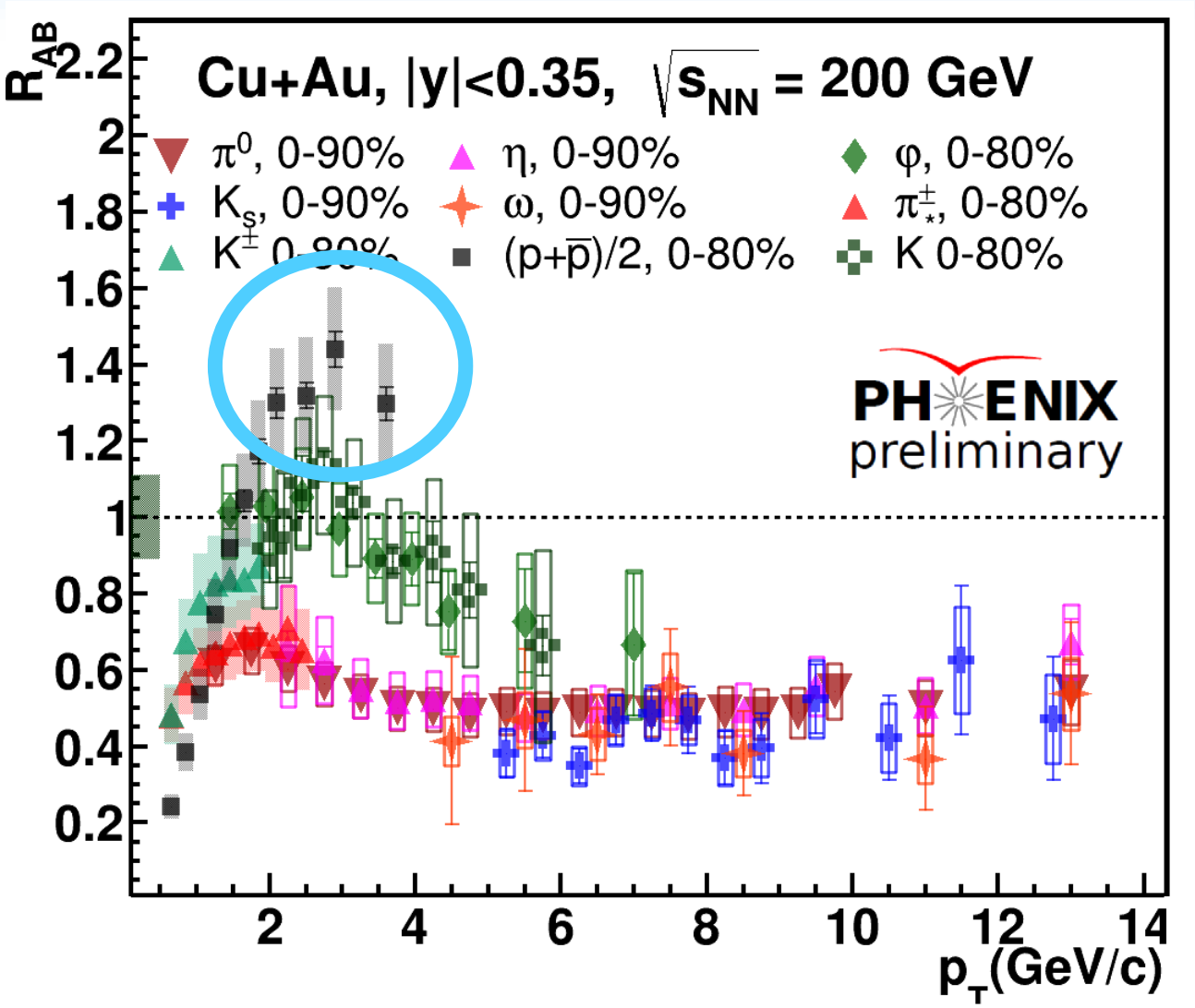
Signatures of QGP:

Strangeness enhancement

Jet quenching

Motivation

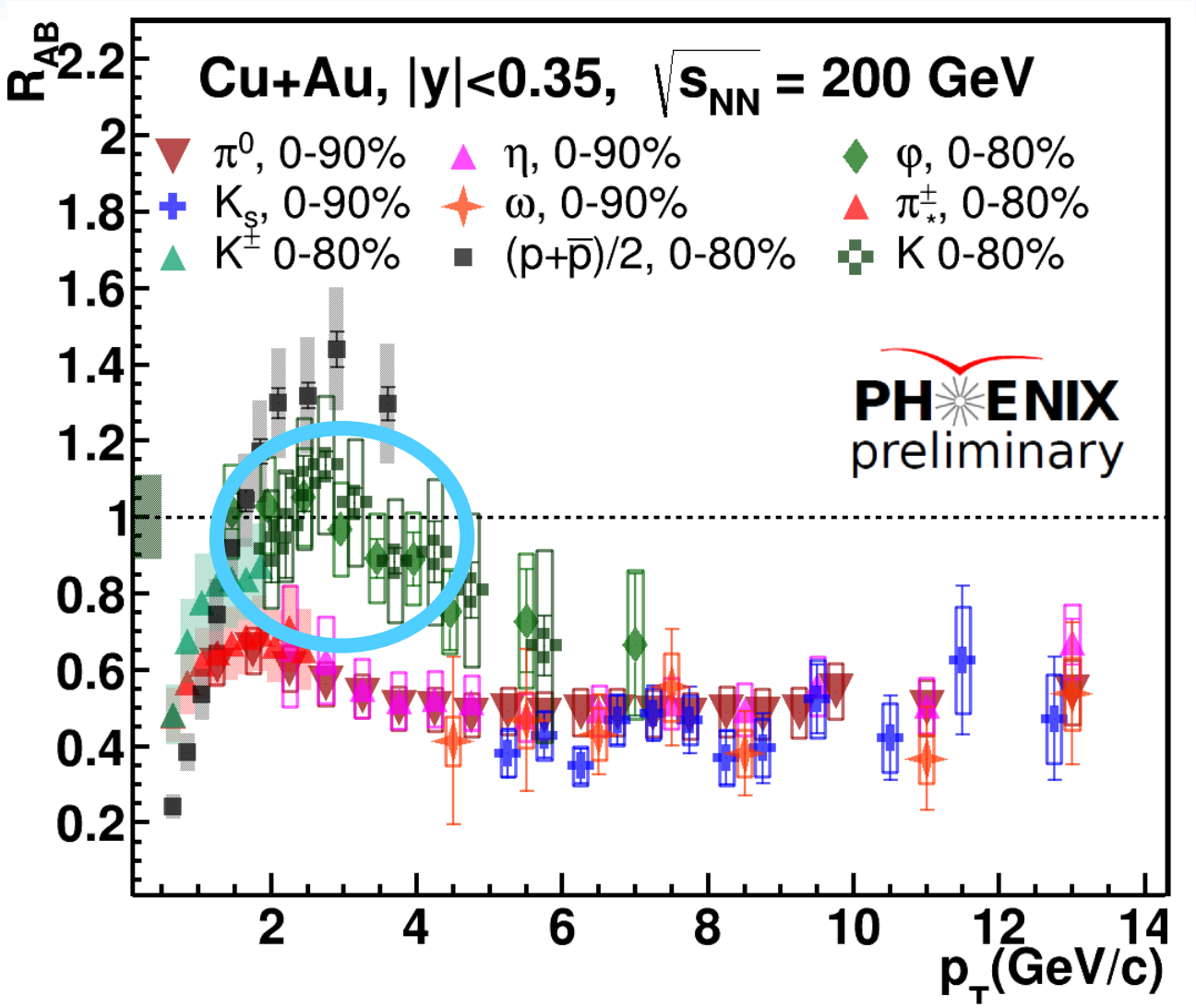
Heavy Ion collisions



"Baryon puzzle"

Motivation

Heavy Ion collisions

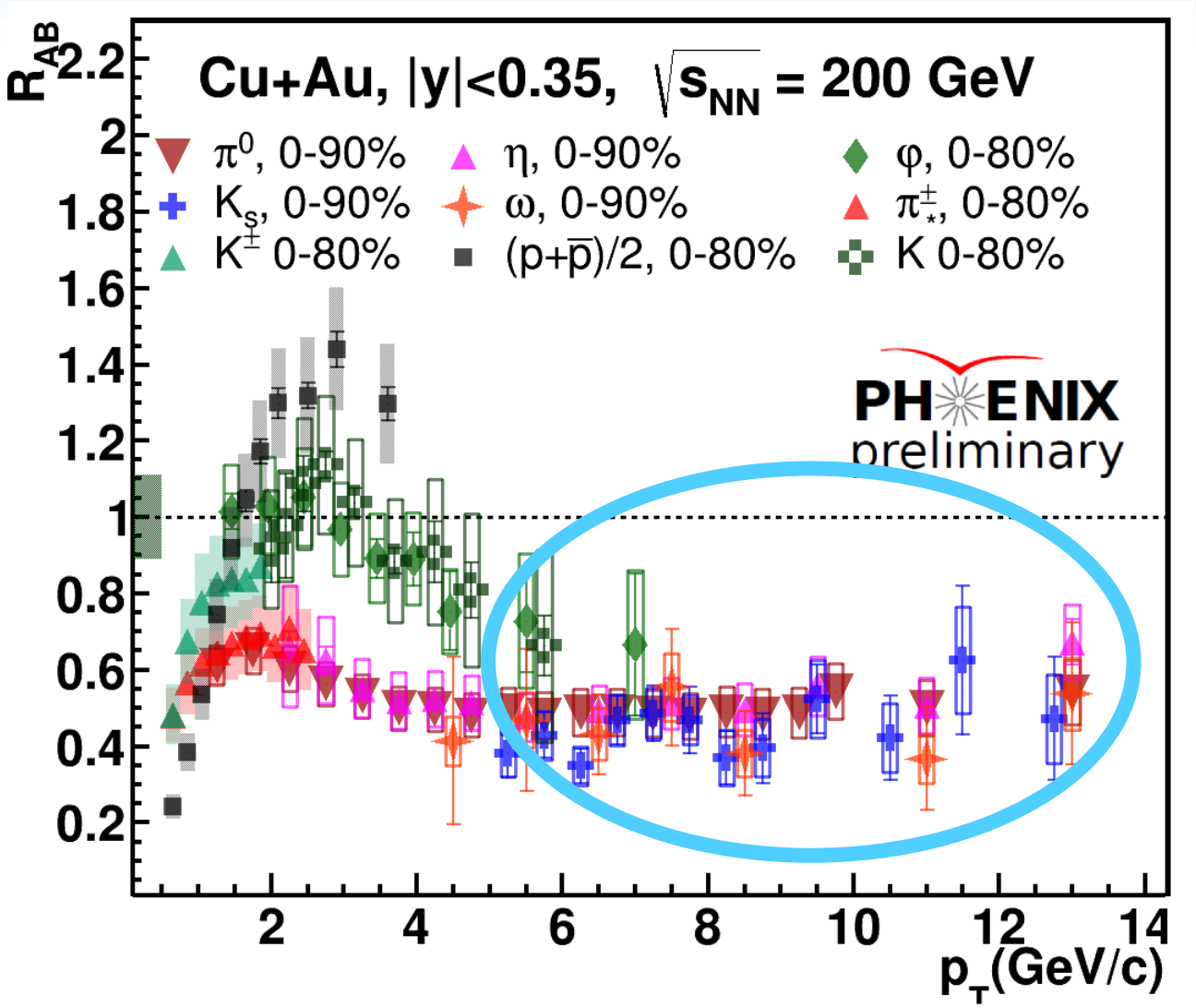


"Baryon puzzle"

φ and K* enhancement

Motivation

Heavy Ion collisions



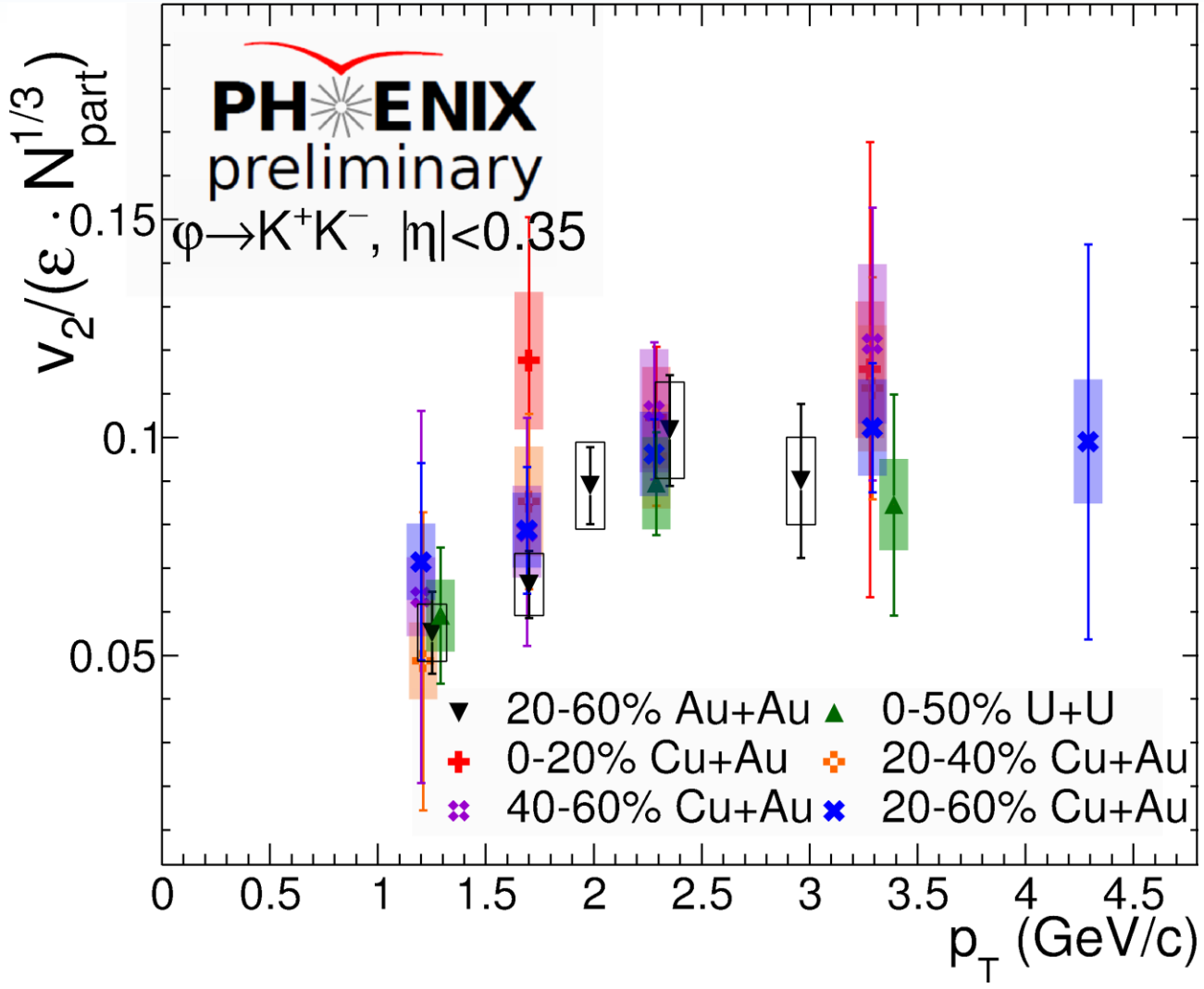
"Baryon puzzle"

φ and K* enhancement

High-p_T suppression

Motivation

Heavy Ion collisions



"Baryon puzzle"

φ and K* enhancement

High-p_T suppression

Elliptic flow scaling

Motivation

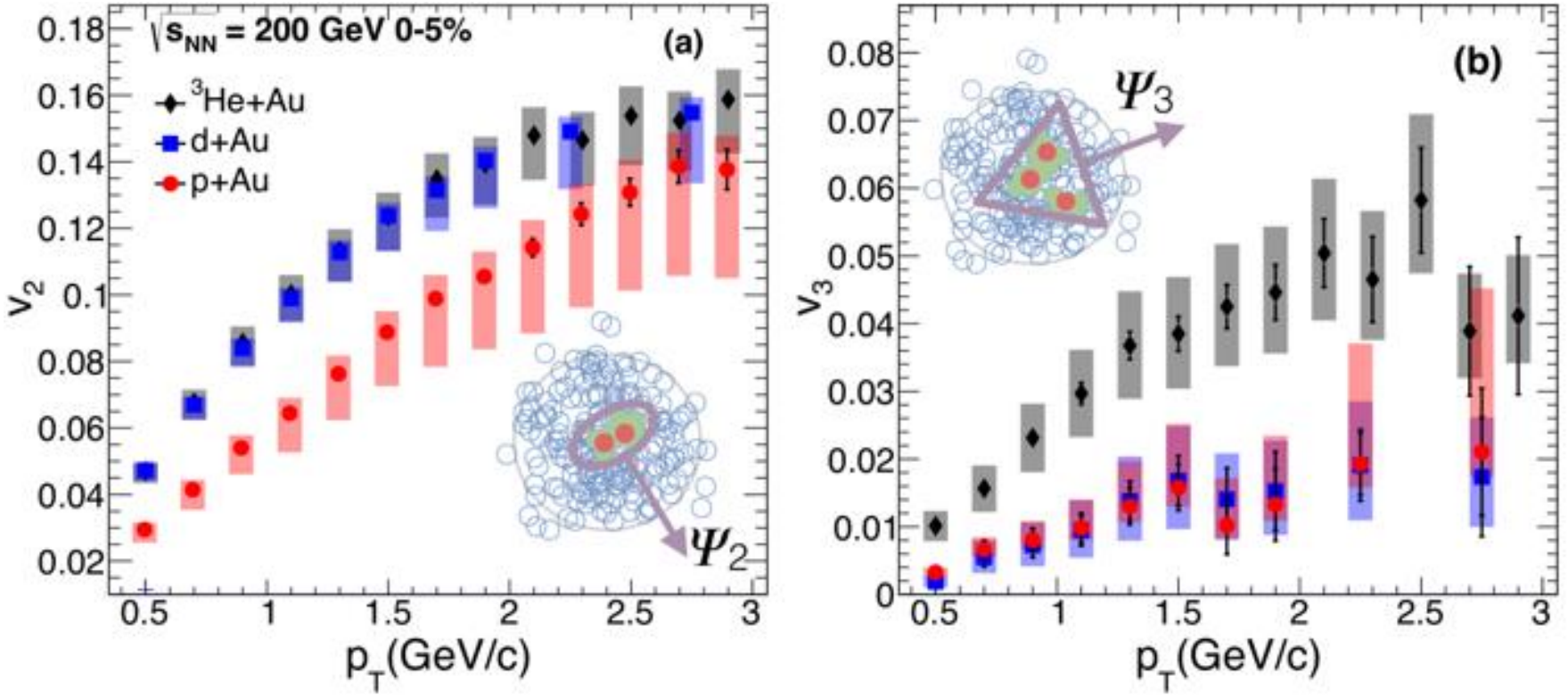
Small systems

Flow measurements → evidence for QGP droplets in small systems

Energy loss in the plasma?

If so, it would present itself in the hadrons spectra

Interpreting Large systems



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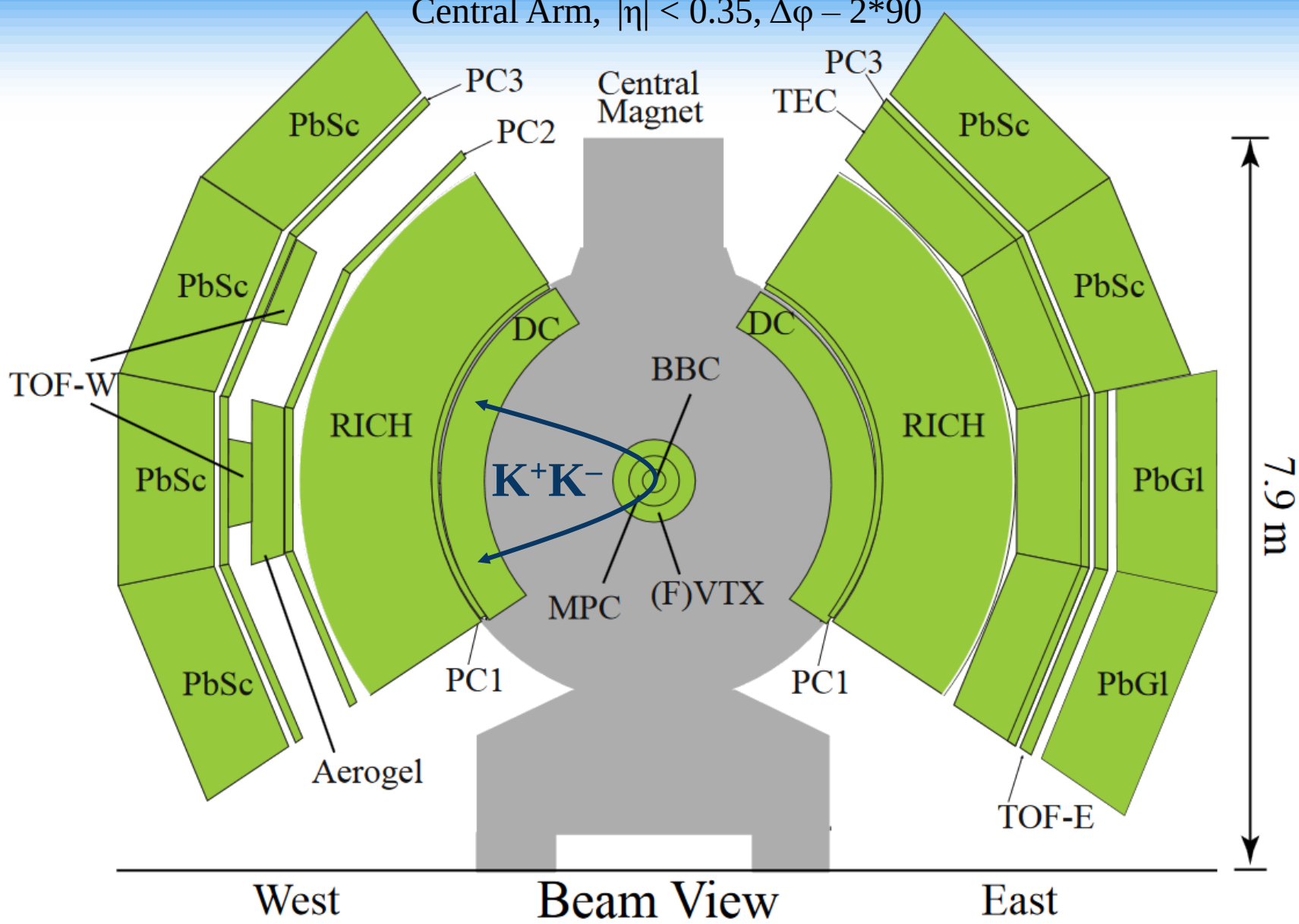
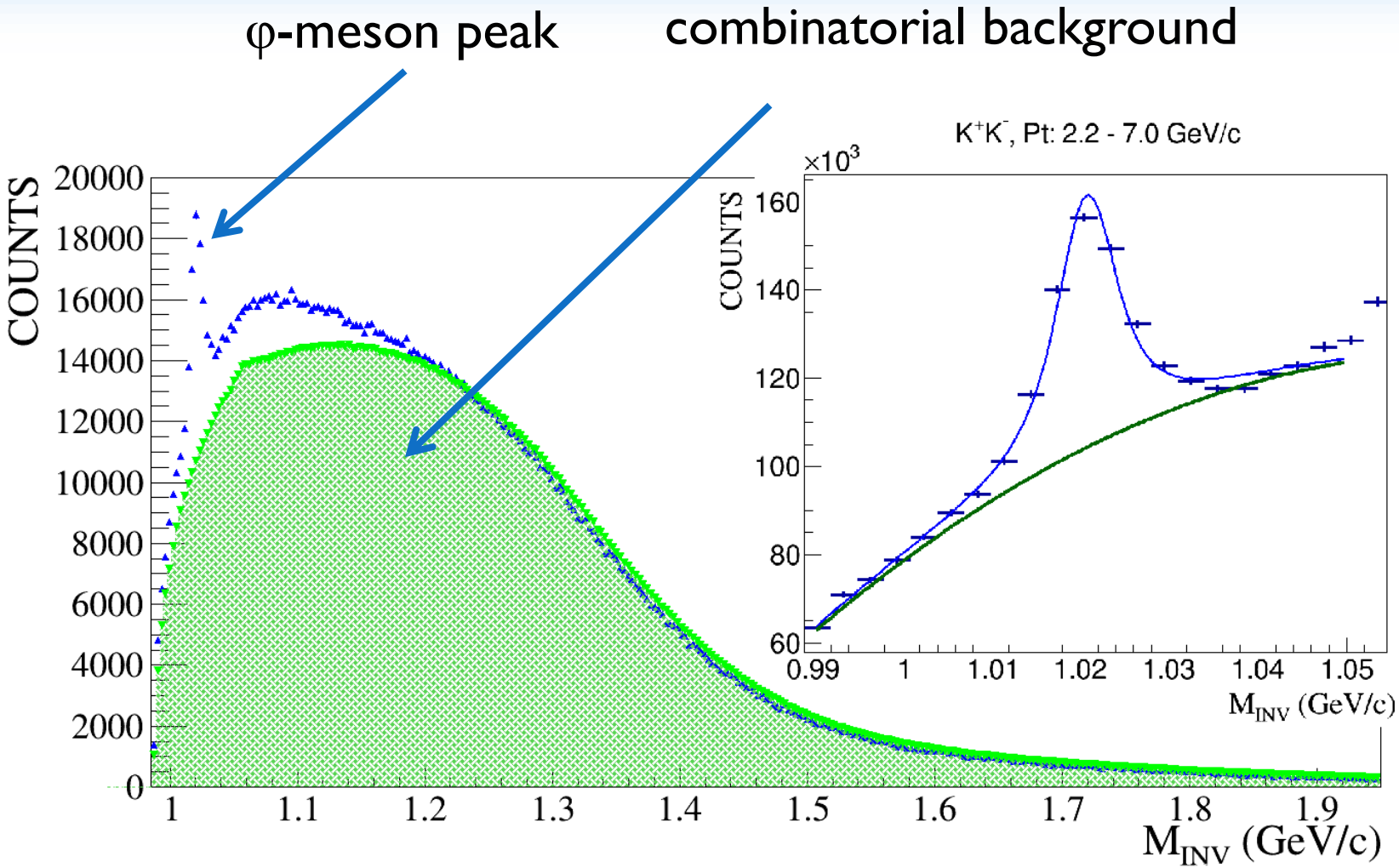
The PHENIX experiment



Invariant mass spectra



Systematic uncertainties

Type A: point-to-point uncorrelated

Type B: point-to-point correlated

- **peak extraction**
- peak simulation
- momentum scale

Type C: global or normalization

- N_{coll}
- event overlap

Invariant spectra

$$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy} = \frac{1}{2\pi p_T}\frac{1}{N_{coll}Br}\frac{1}{\varepsilon_{eff}(p_T)}\frac{N(\Delta p_T)}{\Delta p_T \Delta y}$$

p_T - transverse momentum

Δp_T- transverse momentum interval

y- rapidity

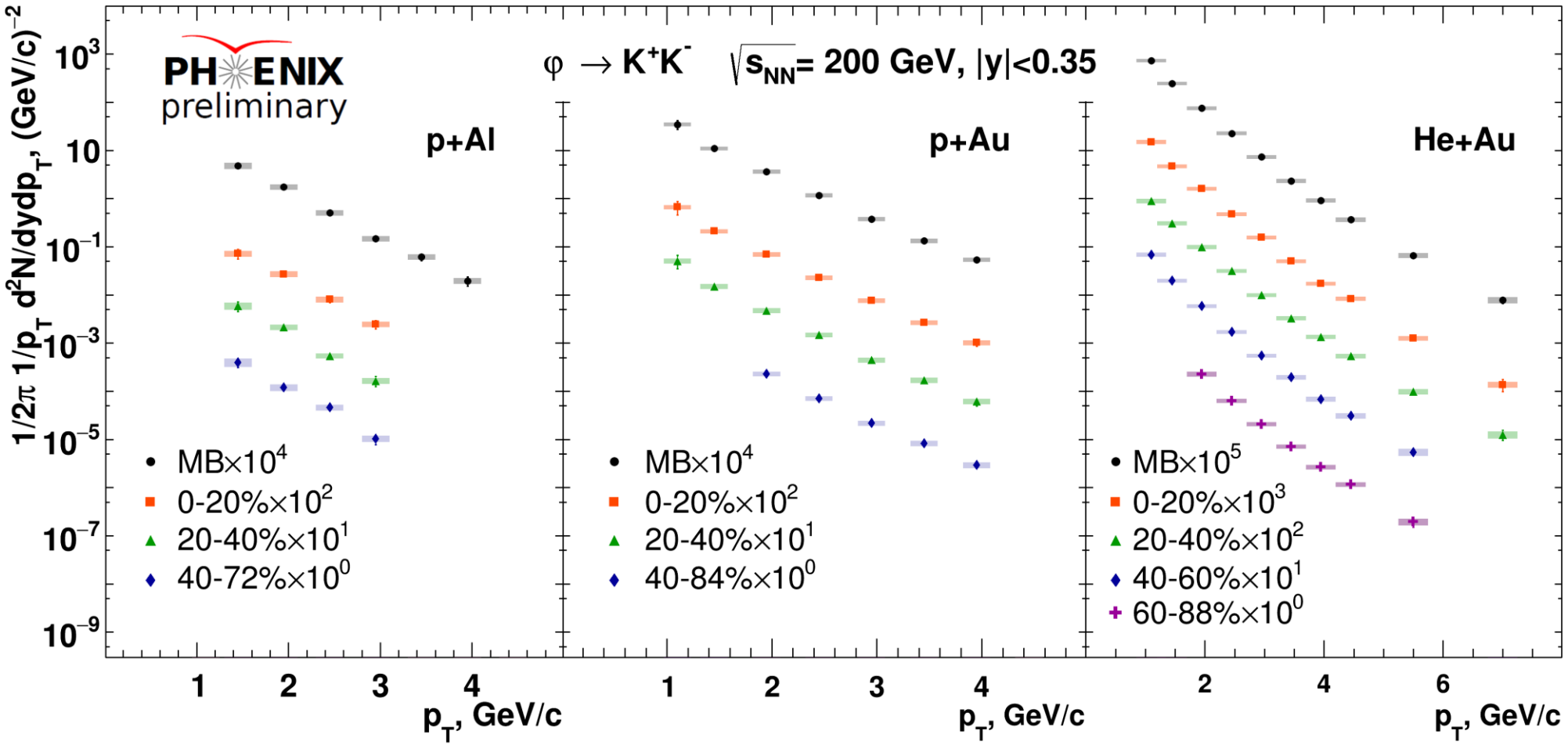
$N(\Delta p_T)$- number of mesons, detected by the experimental setup (raw yield)

N_{coll} - number of collisions in the centrality range

$\varepsilon_{eff}(p_T)$ - reconstruction efficiency, obtained by Monte-Carlo calculating of the decay, passing and reconstruction of the mesons in the PHENIX experimental setup

Br-branching ratio

Invariant spectra



Nuclear modification factors

Nuclear modification factors of nuclei collisions are used to study collective effects, affecting the spectra

$$R_{AB} = \frac{f_{bias} \cdot \sigma_{pp}^{inel}}{\langle N_{coll} \rangle} \cdot \frac{d^2 N_{AB}/dydp_T}{d^2\sigma_{pp}/dydp_T}$$

$d^2 N_{AB}/dydp_T$ – per-event yield of particle production in A+B collision

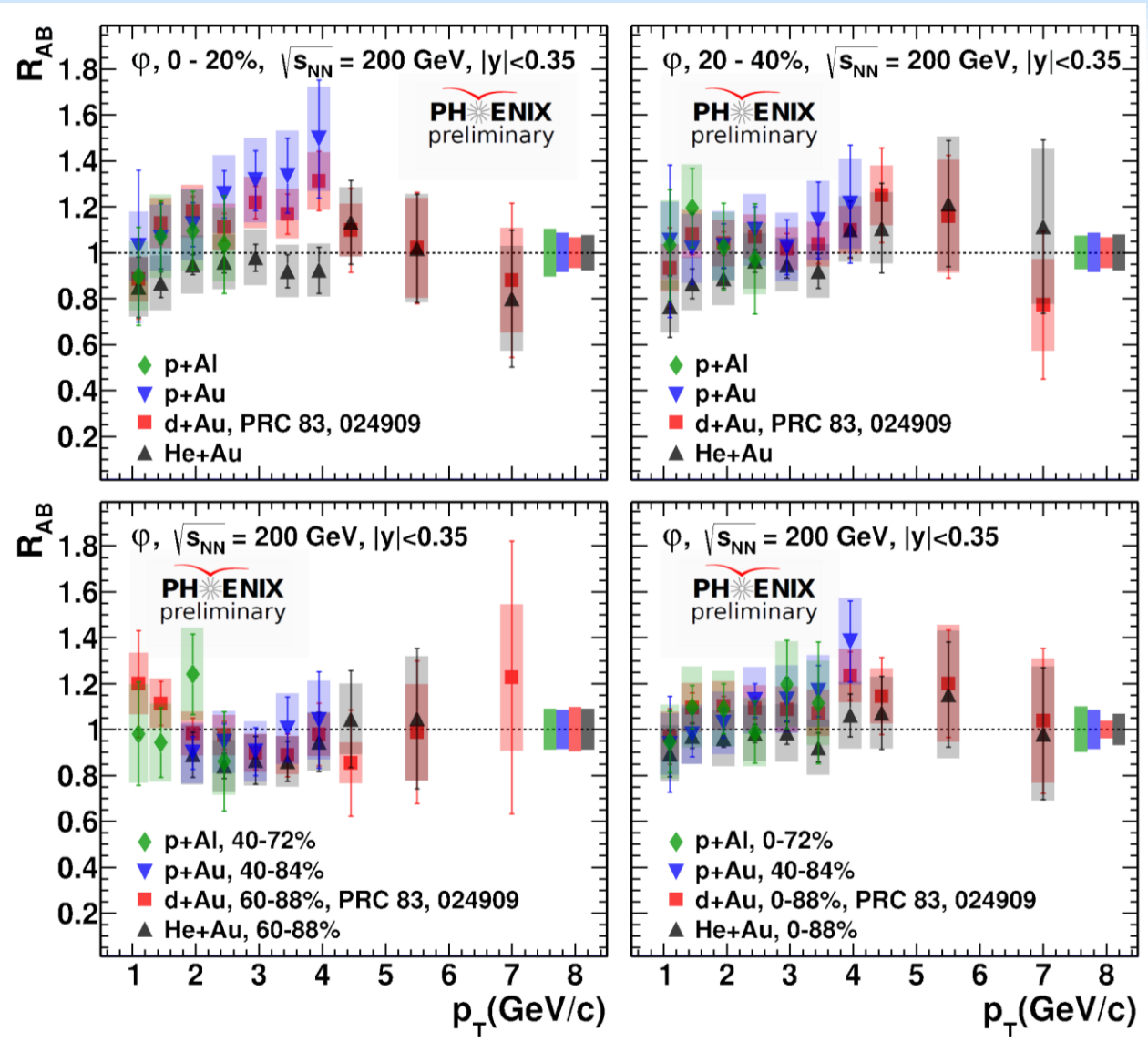
$d^2\sigma_{pp}/dydp_T$ – the production cross section in p+p collision

$\langle N_{coll} \rangle$ – number of nucleon-nucleon collisions in A+B system for selected centrality interval

f_{bias} – Bias factor

$\sigma_{pp}^{inel} = 42.2$ mb – total inelastic proton-proton cross section

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



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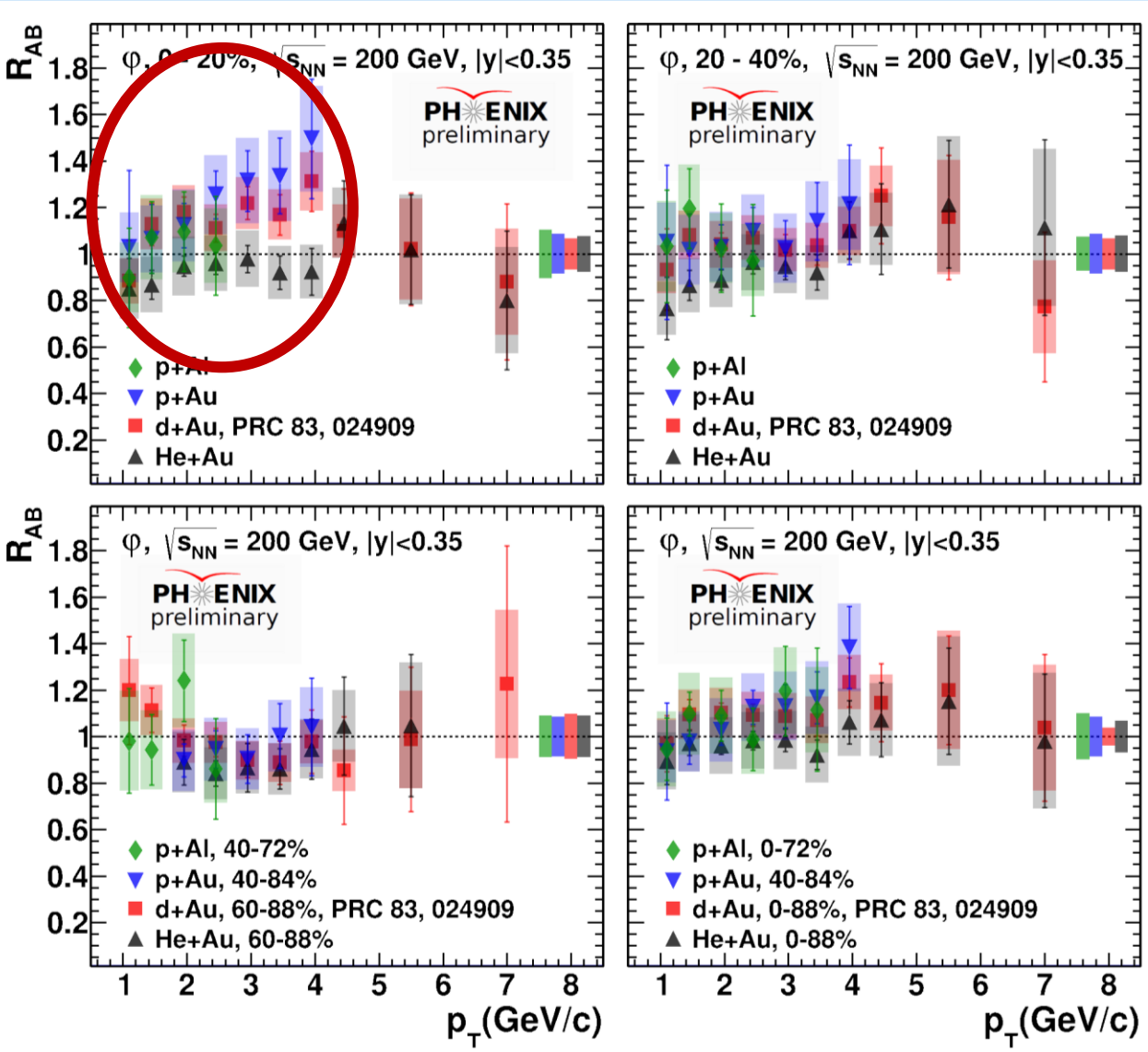
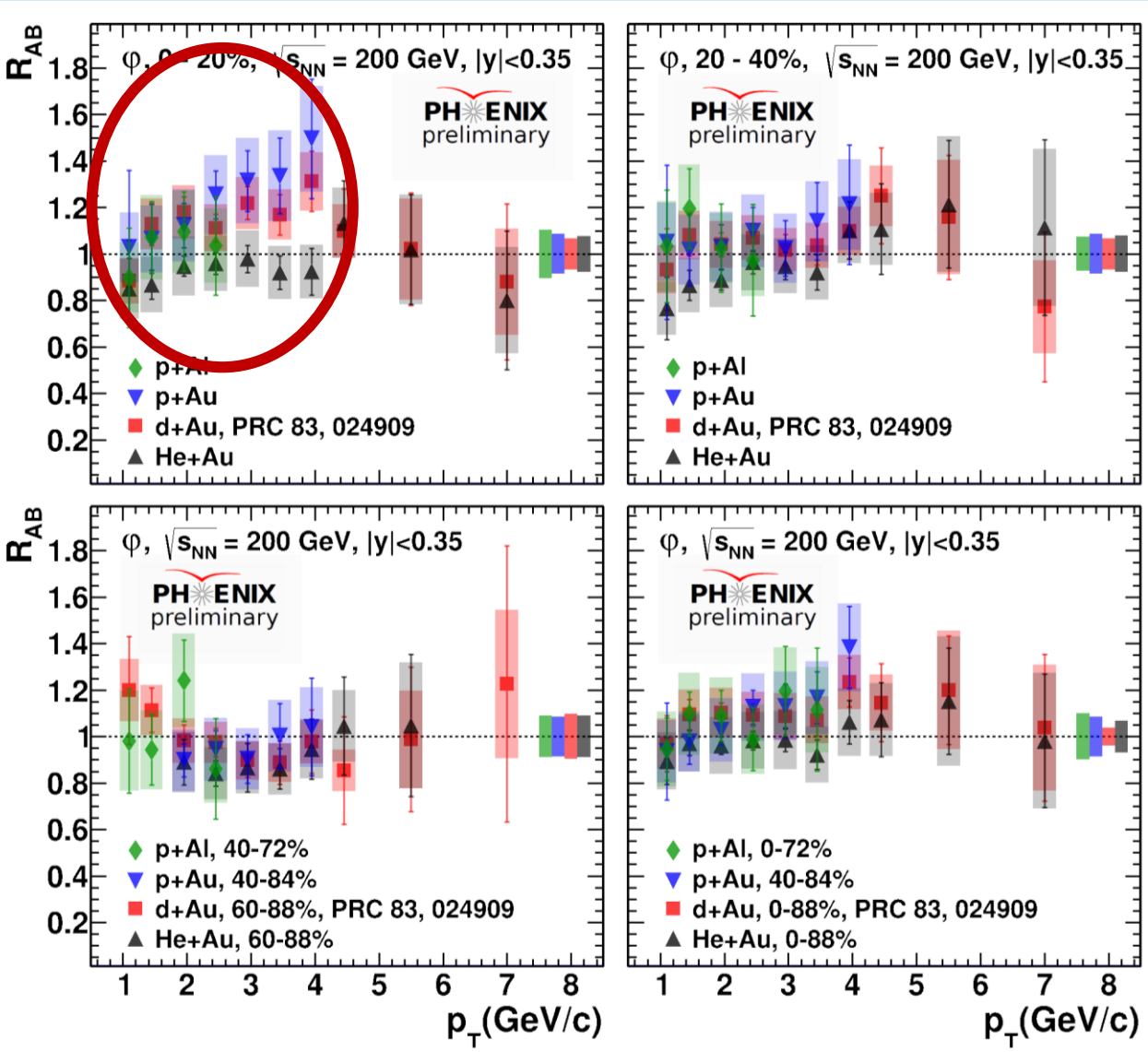


AT INTERMEDIATE p_T RANGE:

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

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



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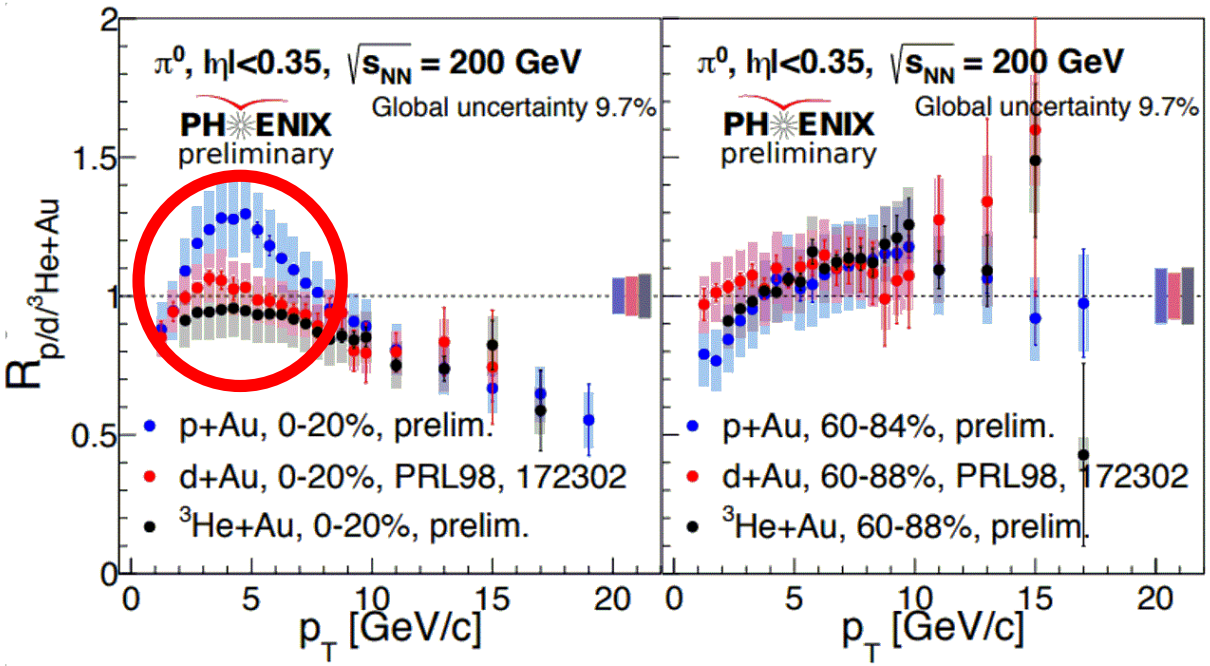
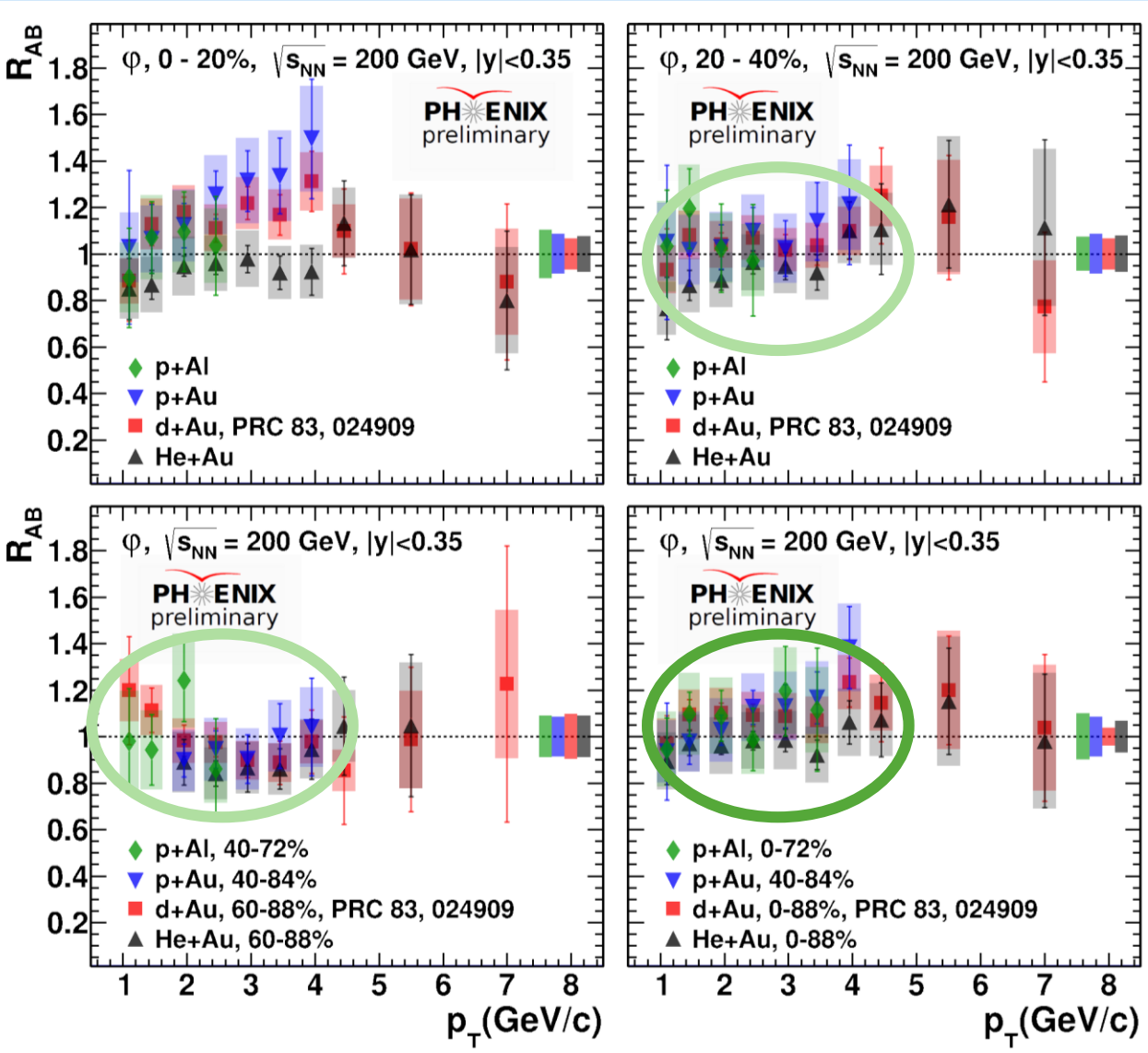


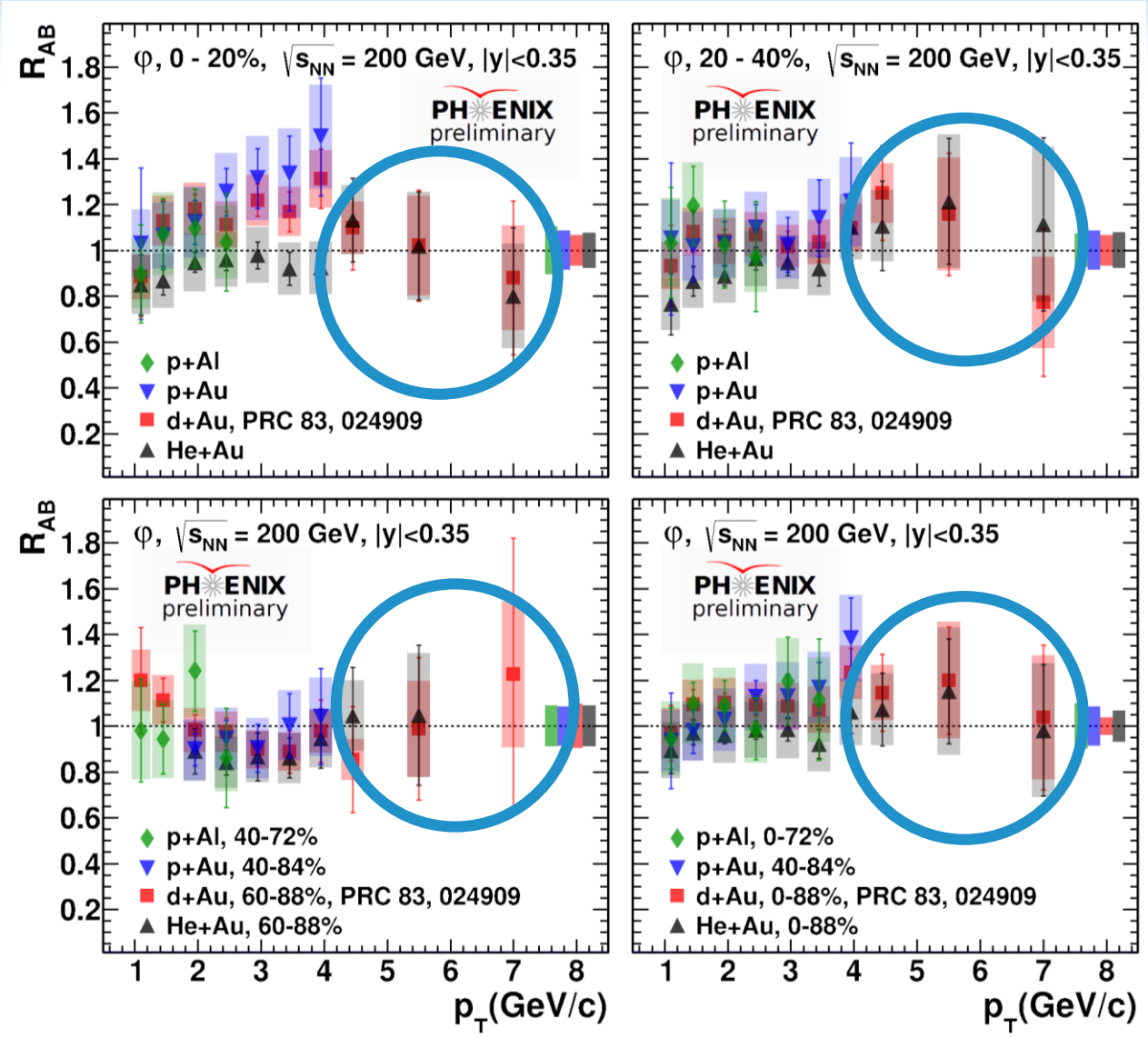
φ R_{AB} in p+Al, p+Au, d+Au, ^{3}He+Au



AT INTERMEDIATE p_T RANGE:

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

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



AT INTERMEDIATE p_T RANGE:

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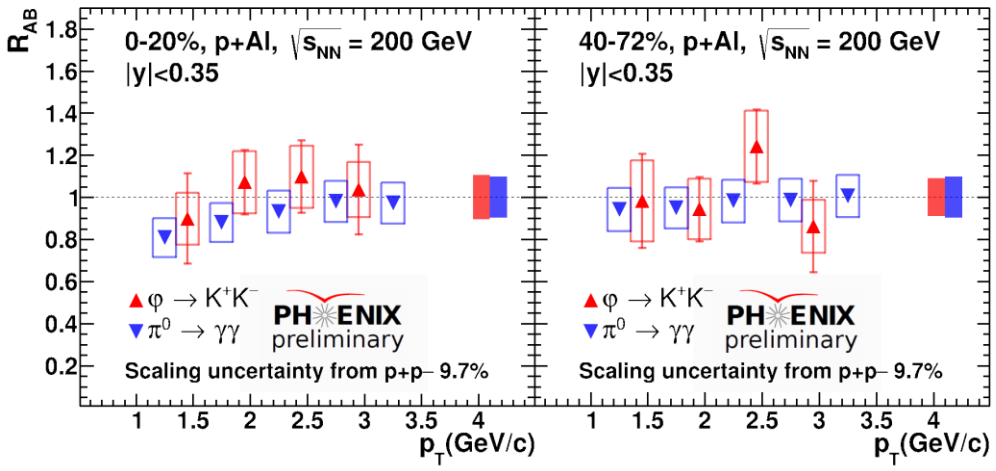
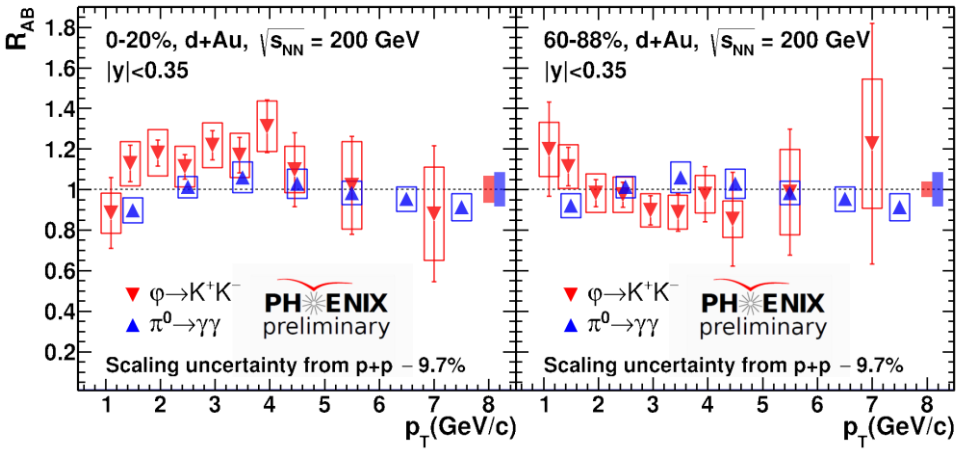
AT HIGH-p_T RANGE:

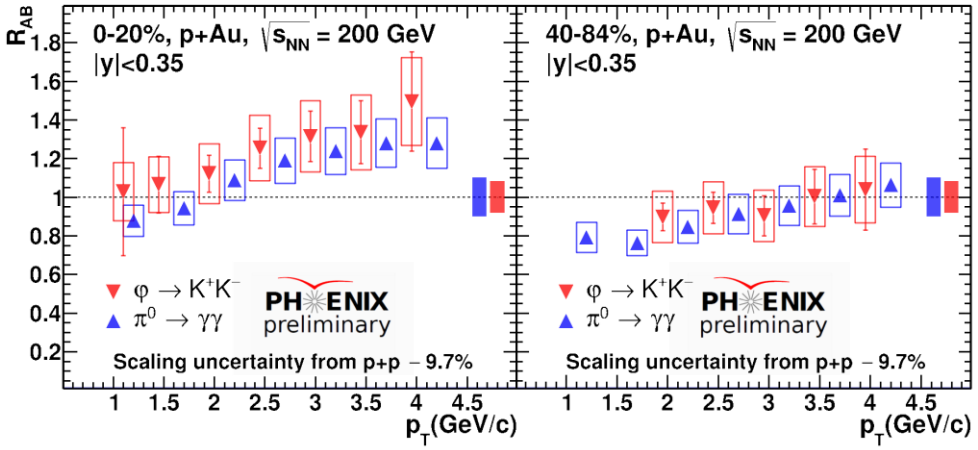
- φ R_{AB}'s consistent with each other at high-p_T

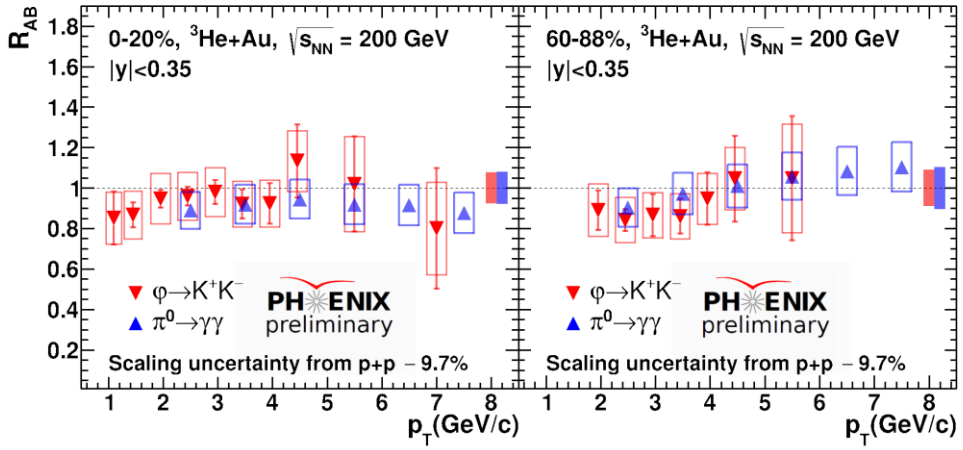
Jet quenching is not observed

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







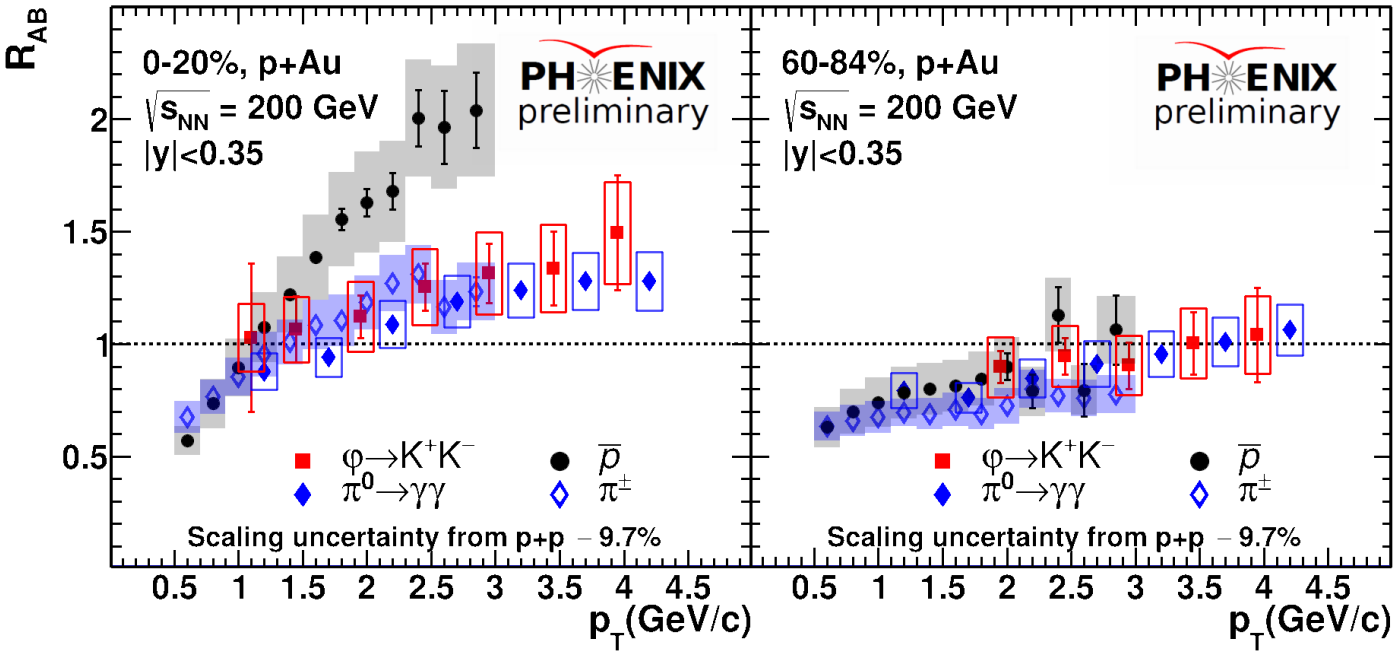


In whole φ p_T range π^0 and φ mesons R_{AB}'s are similar in small systems

Strangeness enhancement is not observed

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+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

Qualitatively consistent with the recombination model.

Summary

- Hint of ordering $R_{pAu} > R_{dAu} > R_{HeAu}$ in 0-20% at intermediate p_T range
- In other centralities in all p_T ranges φ meson nuclear modification factors for all light systems exhibit similar shape and equal to unity within uncertainties
  - Jet quenching is not observed
- φ & π^0 mesons R_{AB}'s are consistent in all centralities
  - Strangeness enhancement is not observed
  - Cold nuclear matter effects are not responsible for the difference seen in heavy-ion collisions
- φ & π^0 mesons R_{AB}'s are consistent in all centralities, while protons R_{AB}'s show enhancement in central collisions
  - Qualitatively consistent with the recombination model

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THANK YOU FOR ATTENTION!