Transverse Dynamics of Hadrons Produced in Au-Au Relativistic Collisions

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Outline

Motivation

studying relativistic heavy-ion collisions

Data used

experimental data and analysis methods

Results

key results from the analysis

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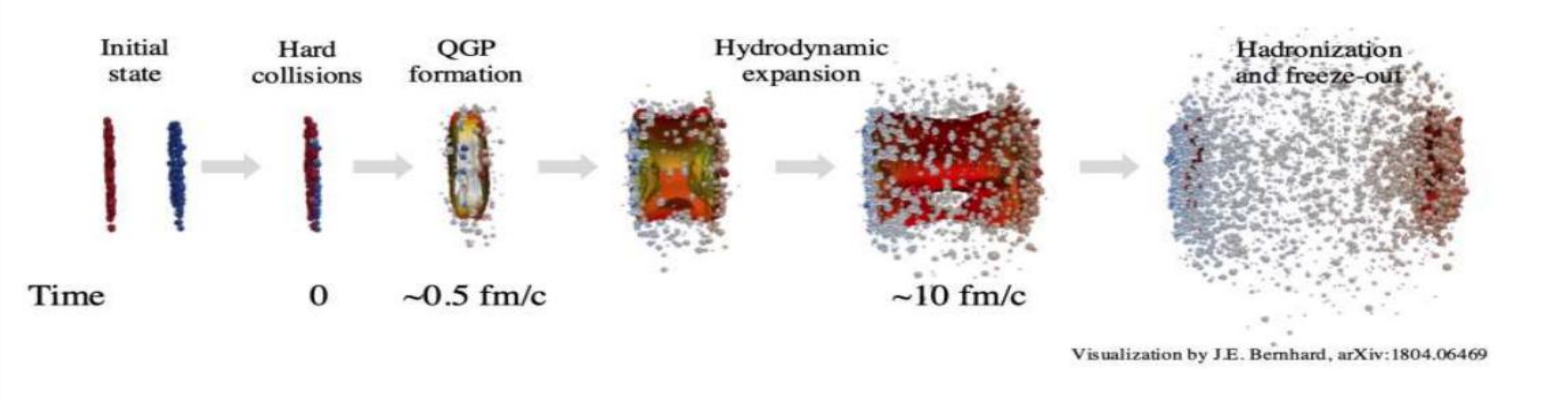
summary of findings and future work

Motivation

Relativistic heavy-ion collisions

- unique tool for recreating the state of matter that existed in the early Universe
- explore the nuclear matter phase diagram
- make connections with the matter found in astrophysical objects
- probe fundamental properties of QGP

Collision evolution



- Particles existing in the “fireball” undergo multiple interactions → thermal equilibrium → a collective behaviour is developing

- Matter develops a hydrodynamic **flow** (behaving as a relativistic fluid) → collective motion of particles → expansion of the system → differences in density and temperature occur

- **Focus** on the transverse collective flow → entirely generated and develops throughout the entire evolution of the system formed during the collision

Data used: Key Sources and Methods

- ★ **STAR experiment, Au-Au collisions at RHIC-BES energies $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 27 and 39 GeV**
- ★ **AMPT (A Multi-Phase Transport) simulations**

Transverse momentum spectra of strange hadrons were fitted using:

- For K0S, φ, Ω → exponential function:

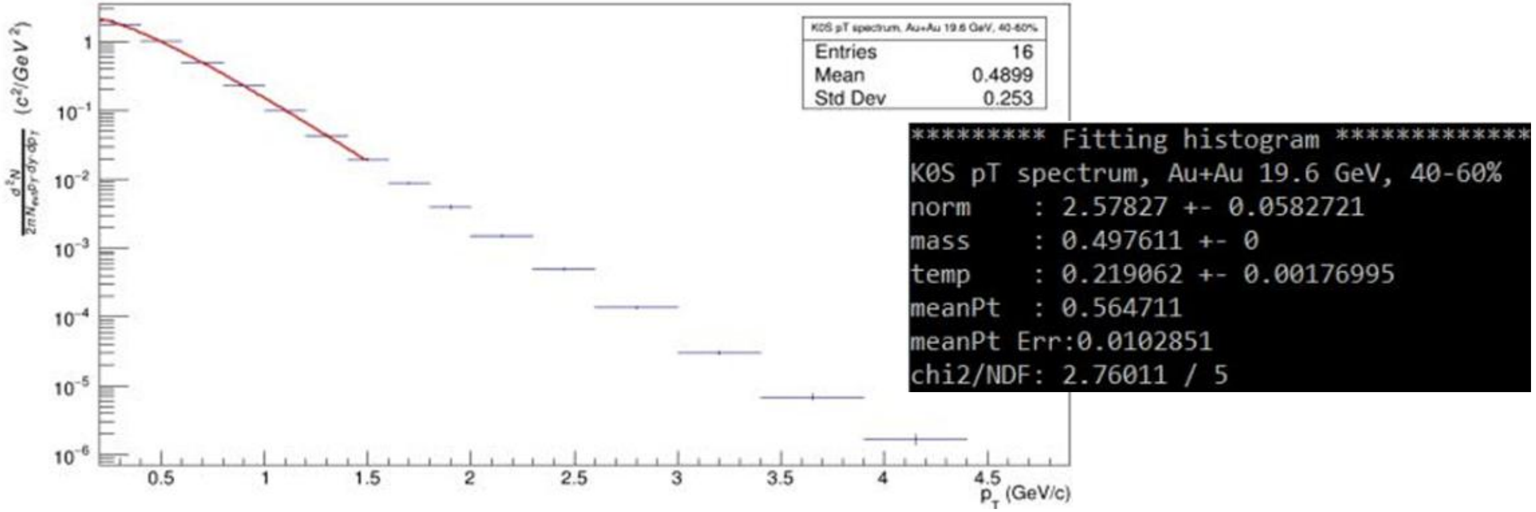
$$\frac{d^2N}{2\pi p_T dp_T dy} = A \exp\left(-\frac{m_T - m}{T}\right)$$

- For Λ, Ξ → Boltzmann function:

$$\frac{d^2N}{2\pi p_T dp_T dy} = A\, m_T \exp\left(-\frac{m_T - m}{T}\right)$$

The average transverse momentum:

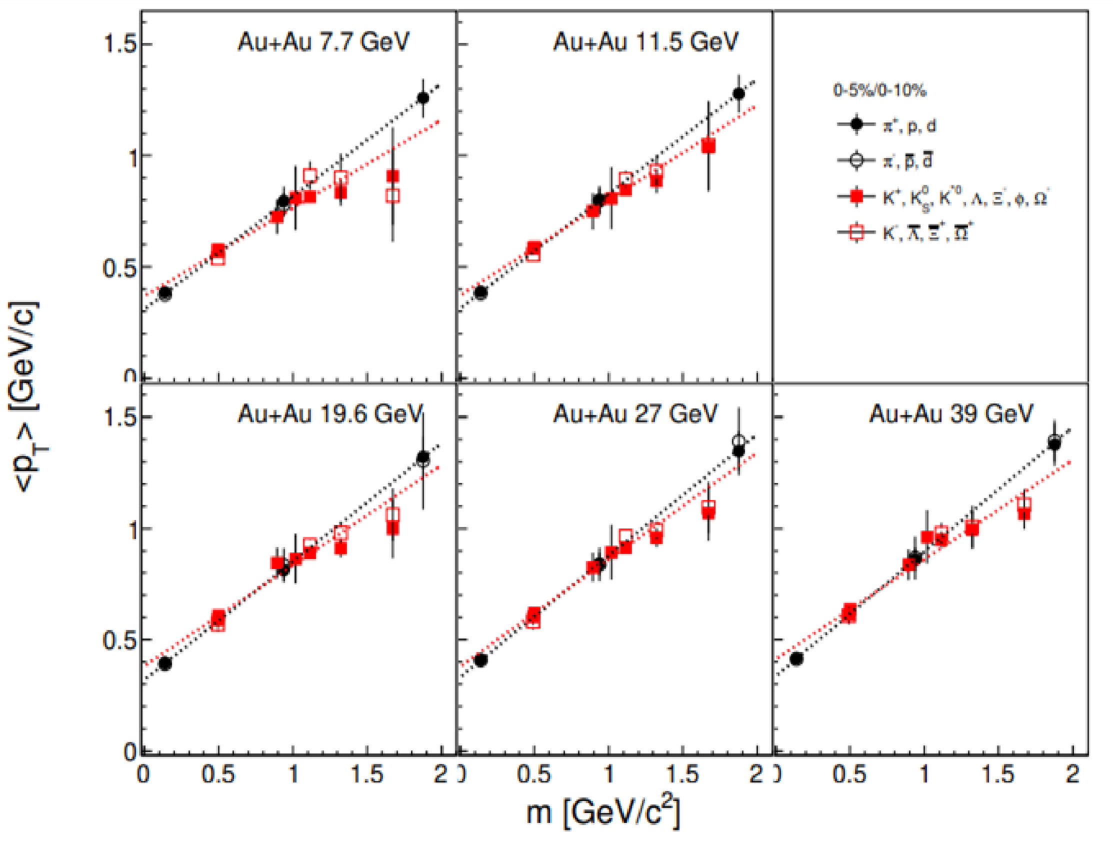
$$\langle p_T \rangle = \frac{\int_0^\infty p_T (2\pi p_T) f(p_T) dp_T}{\int_0^\infty (2\pi p_T) f(p_T) dp_T}$$



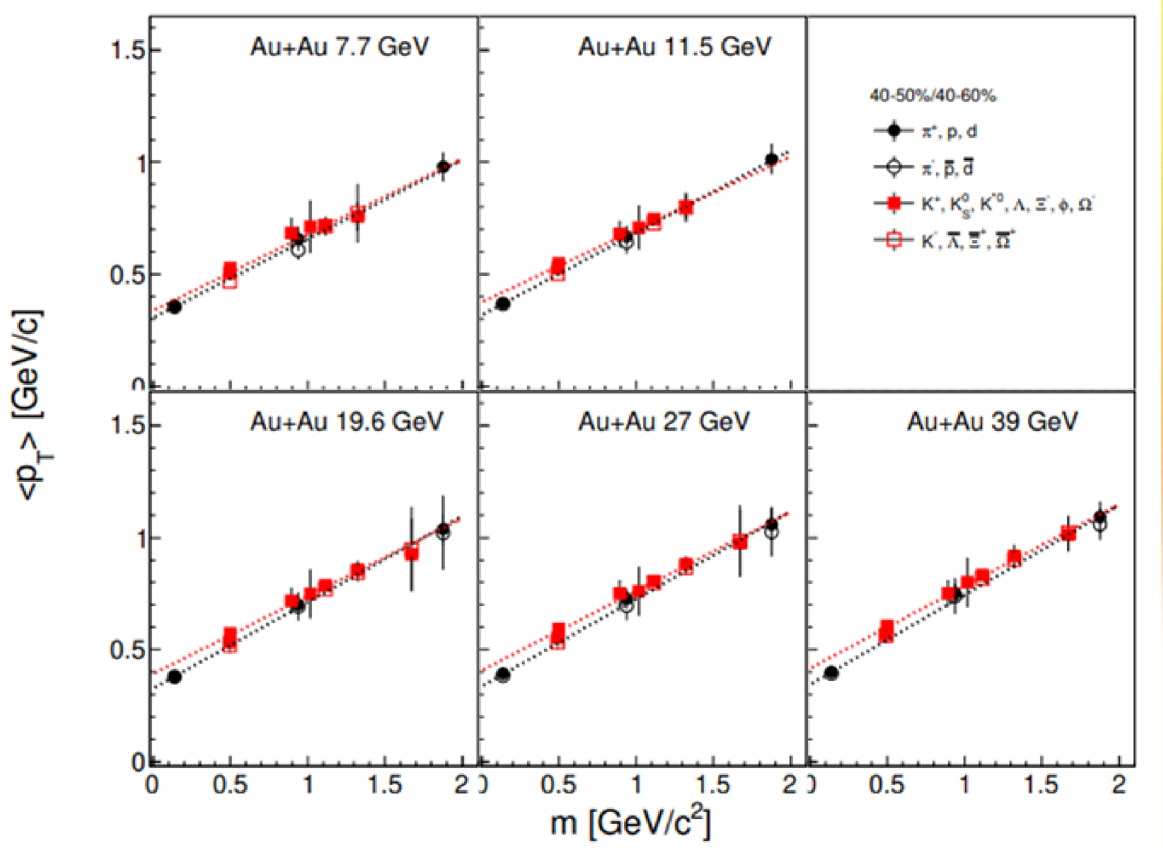
Fit range: $0<p_T<2$ GeV/c (for K^0_S, φ, Λ) and $0<p_T<2.6$ GeV/c (for Ξ, Ω)

$<p_T>$ values for $\pi^\pm$, $K^\pm$, p, p, K^{*0}, d and anti-d were taken from the STAR Collaboration results.

Results – experimental data



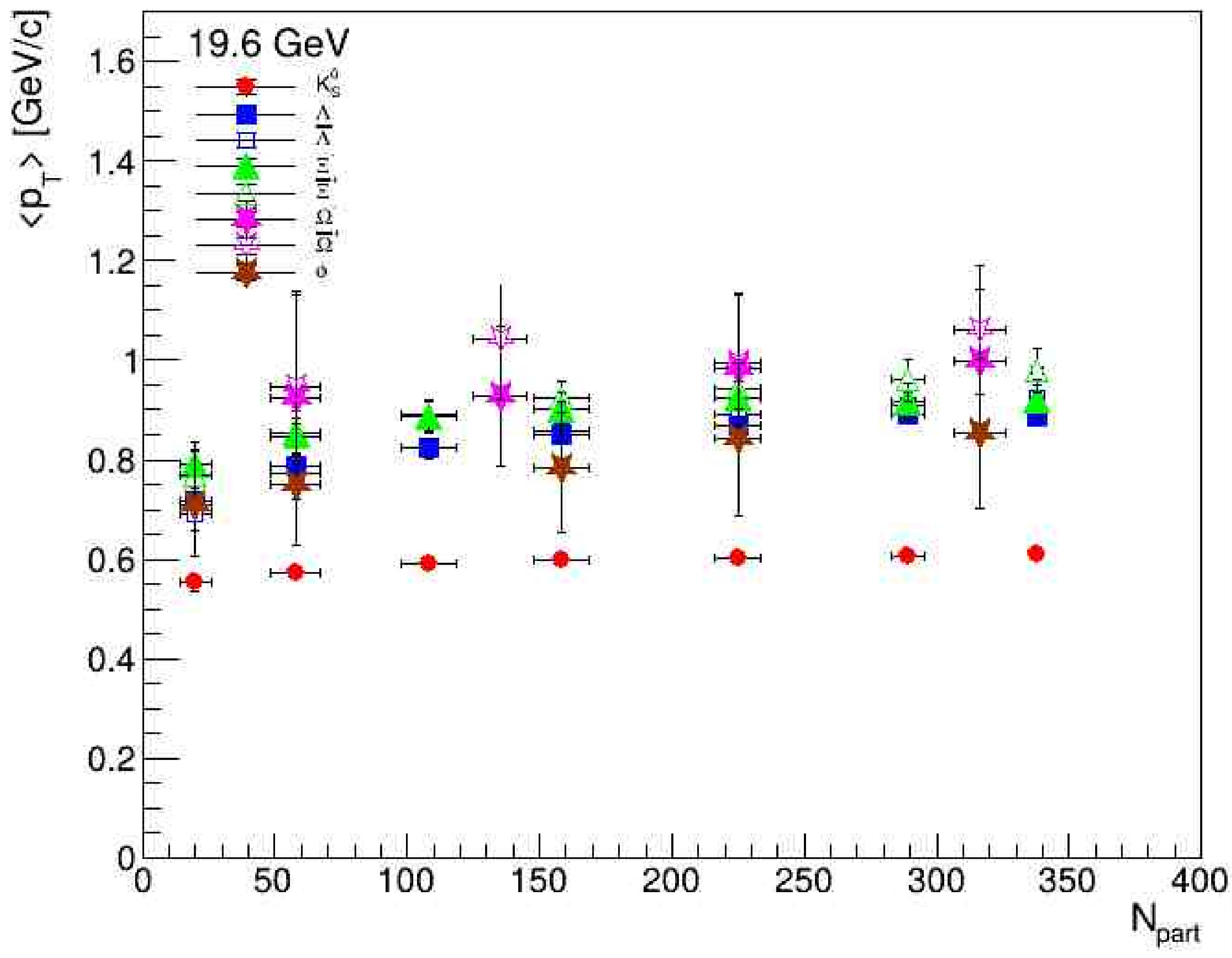
Central Au+Au collisions



Peripheral Au+Au collisions

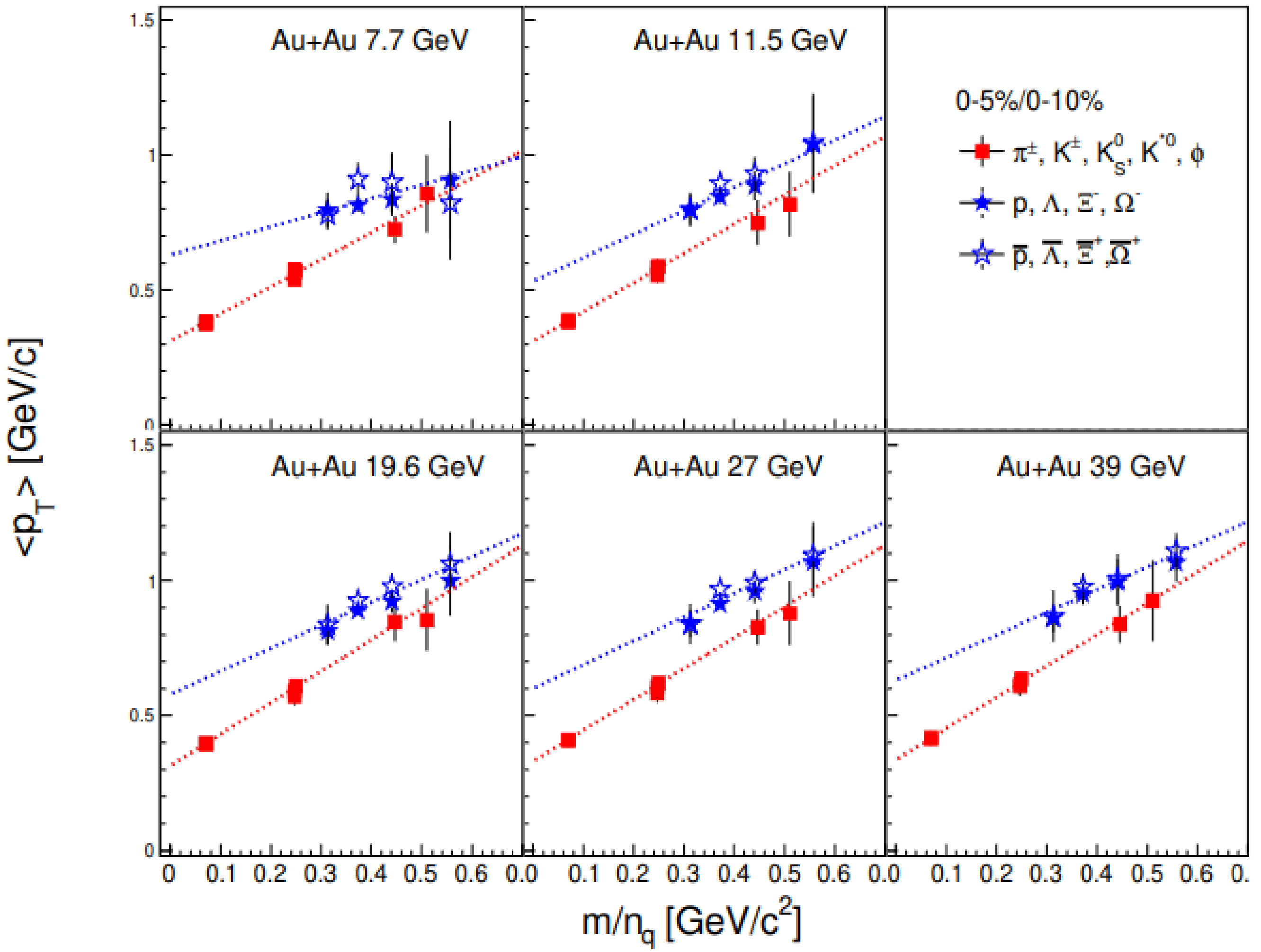
- $\langle p_T \rangle$ increases with the mass for all RHIC-BES energies - transverse collective flow generated in the hydrodynamic expansion of the fireball
- Smaller $\langle p_T \rangle$ values for peripheral collisions → weaker transverse collective flow - less influence on the p_T spectra
- The multistrange baryons deviate from the pattern - earlier F-O
- Particles and antiparticles have similar spectra characteristics at midrapidity

→ $\langle p_T \rangle$ increases with N_{part} for all energies → gradual development of the transverse collective motion with increasing overlapping region
→ $\langle p_T \rangle$ increases with increasing mass of the particles for all centrality classes - for K_S^0 the increase is less significant than for particles with greater mass - transverse collective flow contribution ~ with particle mass



The average transverse momentum, $\langle p_T \rangle$ as a function of N_{part} for Au-Au collisions at RHIC-BES energy of $\sqrt{s_{NN}} = 19.6\ GeV$

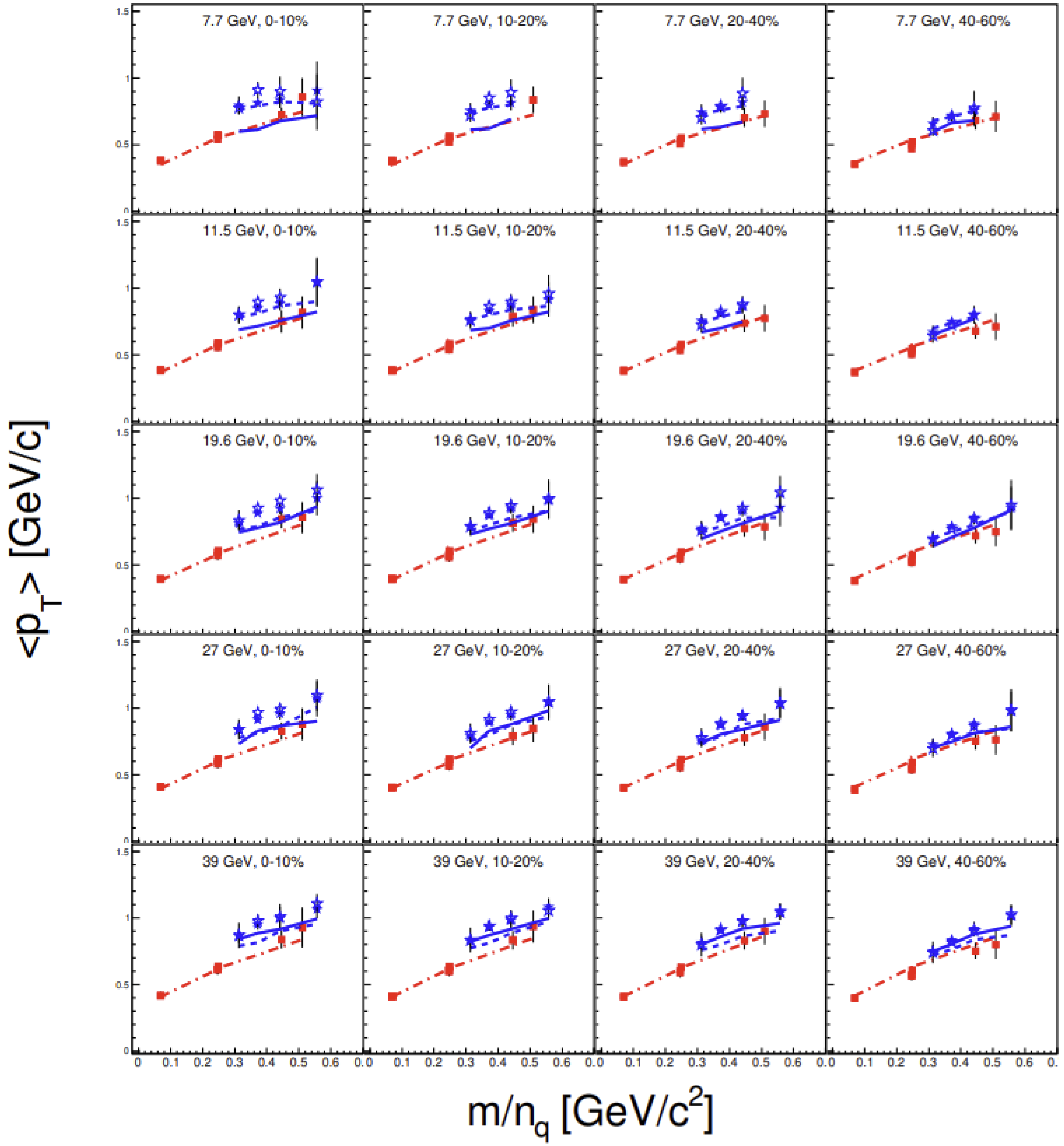
Average transverse momentum as a function of scaled particle mass



→ Different behaviours of mesons and baryons: two distinct linear trends are observed – no scaling is observed.

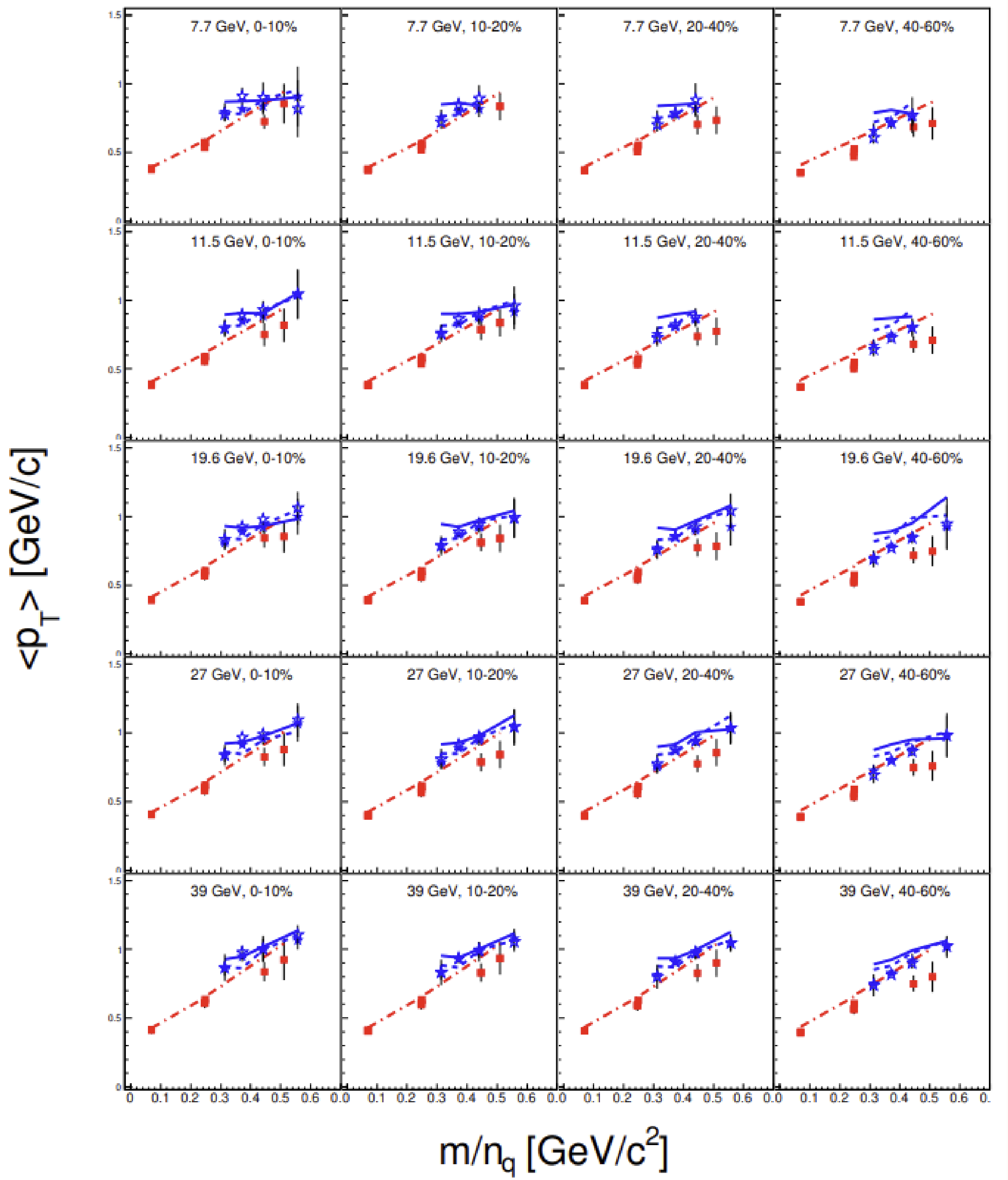
Comparison AMPT-SM and experimental data

- mesons are better described
- antibaryon data is underestimated for the two lower RHIC-BES energies; with increasing collision centrality, this difference becomes less significant
- only for most peripheral collision, the AMPT-SM data scales with reduced hadron mass



Comparison AMPT and experimental data

- (anti)baryons are better described
- overestimates the φ meson $<p_T>$ for all energies and centralities
- for peripheral collision, the AMPT slightly overestimates the experimental data



Conclusions

Summary of Findings

Average transverse momentum of particles produced in relativistic nuclear collisions → valuable insight into the collision dynamics and the properties of the resulting system

Future Work

- Comparative analysis with findings from other experimental collaborations
- Studying regions of interest within the nuclear matter phase diagram

THANK YOU!