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Strange hadron production in Au+Au collisions at RHIC Beam Energy Scan

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Strangeness production has been suggested as a sensitive probe into the early-time dynamics of the nuclear matter created in heavy-ion collisions, especially at high baryon density.

This poster will report on the measurements of strange hadron production in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 3$ GeV. The results include the transverse mass spectra, particle ratios, and their centrality dependence of strange hadrons (K^{-}, K_S^0, ϕ, Λ, Ξ^{-}). These new results will be compared with those from higher collision energies and discussed within the framework of thermal and transport model calculations.

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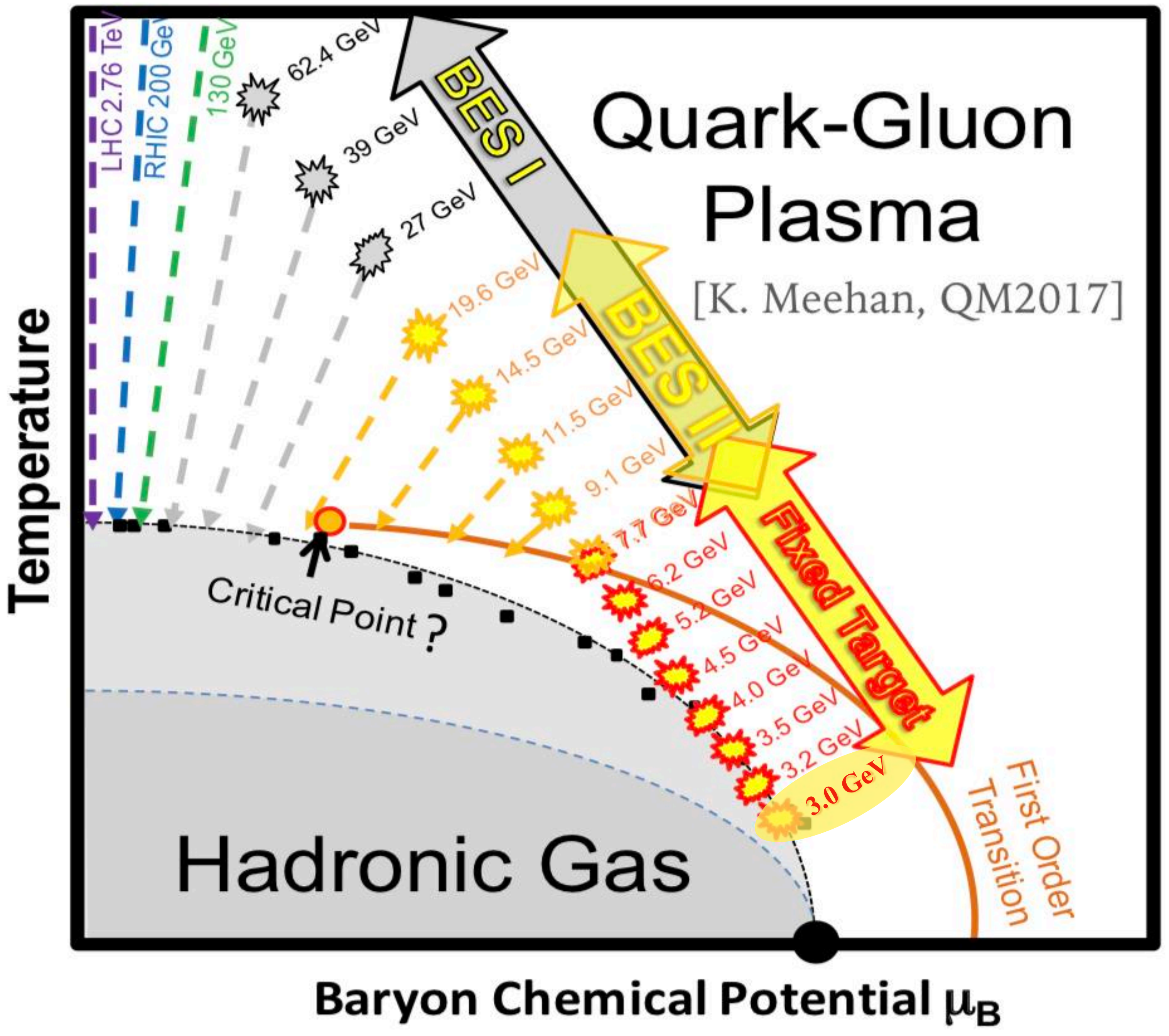
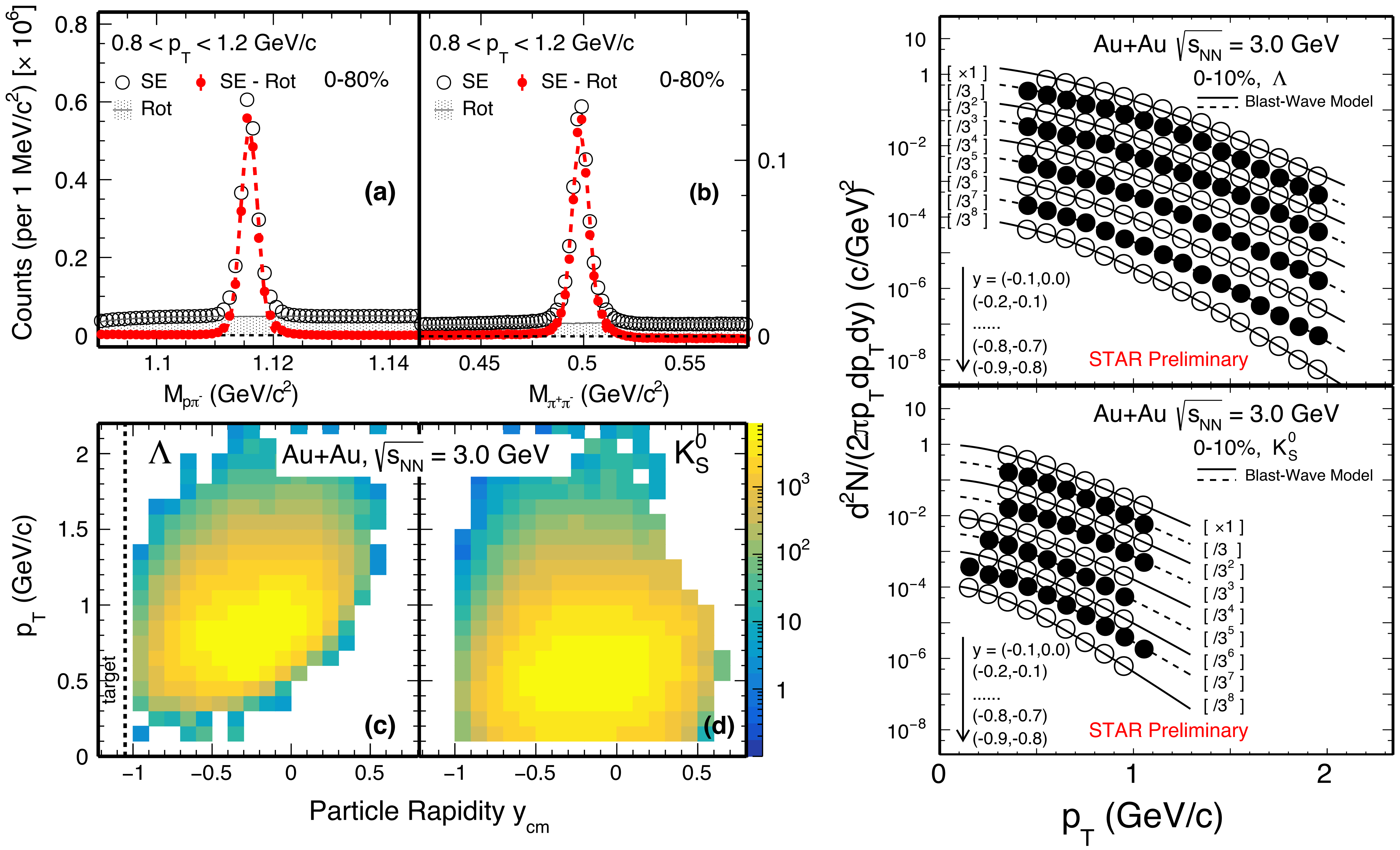
Introduction

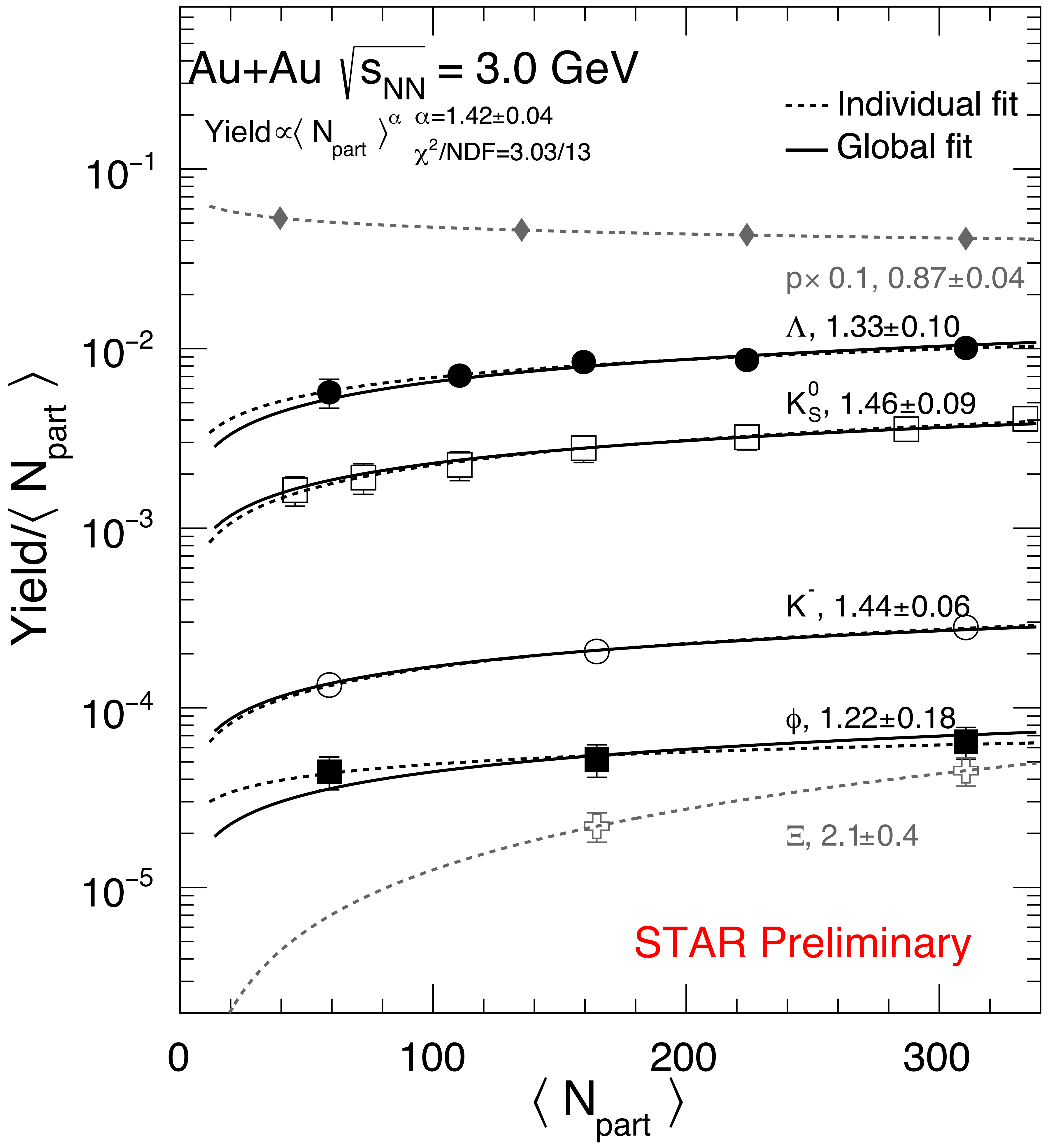


- Au+Au collisions @ 3GeV, where are we on this phase diagram? What are the properties of the medium?
- What is the strangeness production mechanism, especially at high baryon density region?
- We focus on strange particles: $K^-, K_S^0, \phi, \Lambda, \Xi^-$



- Decay channels: $\Lambda \to p\pi^-$, $K_S^0 \to \pi^+\pi^-$
- KF Particle package is used to improve the significance
- The combinatorial background is reconstructed by the rotation method
- Low p_T extrapolation: Blast-Wave function
  - Levy, m_T-exponential functions to estimate systematic uncertainty

Strangeness production vs $\langle N_{Part} \rangle$



- **Same dependence on the number of participating nucleons:**

  Strangeness yield (K^-, K^0_S, ϕ, Λ) $\propto \left\langle N_{part} \right\rangle^{\alpha}$, $\alpha = 1.42 \pm 0.04$

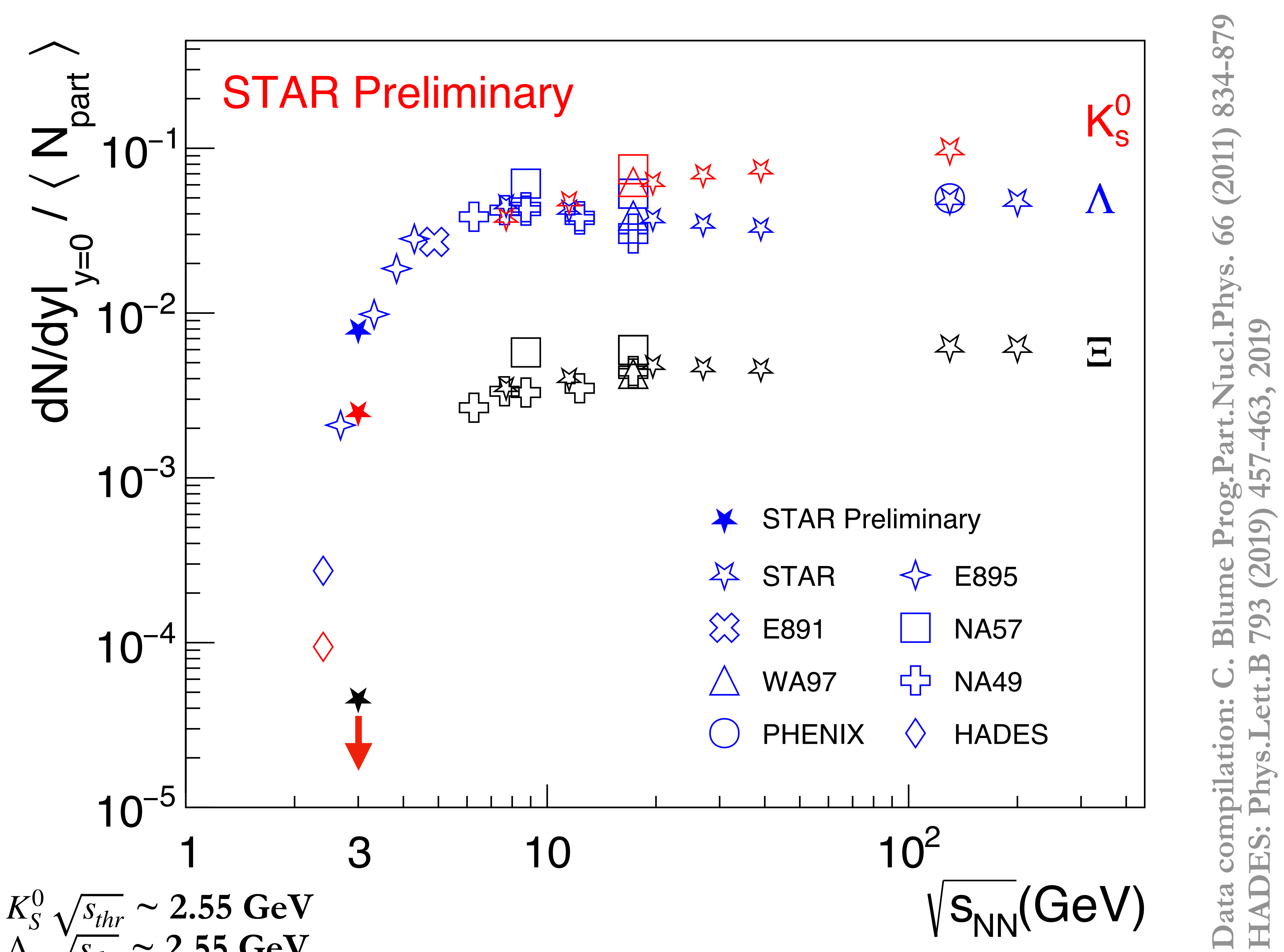
➡**Universal centrality dependence of strangeness production, not for proton**

➡**Ξ^- seems to deviate from the scaling trend**

- Possibly because it is produced below NN-thresholds

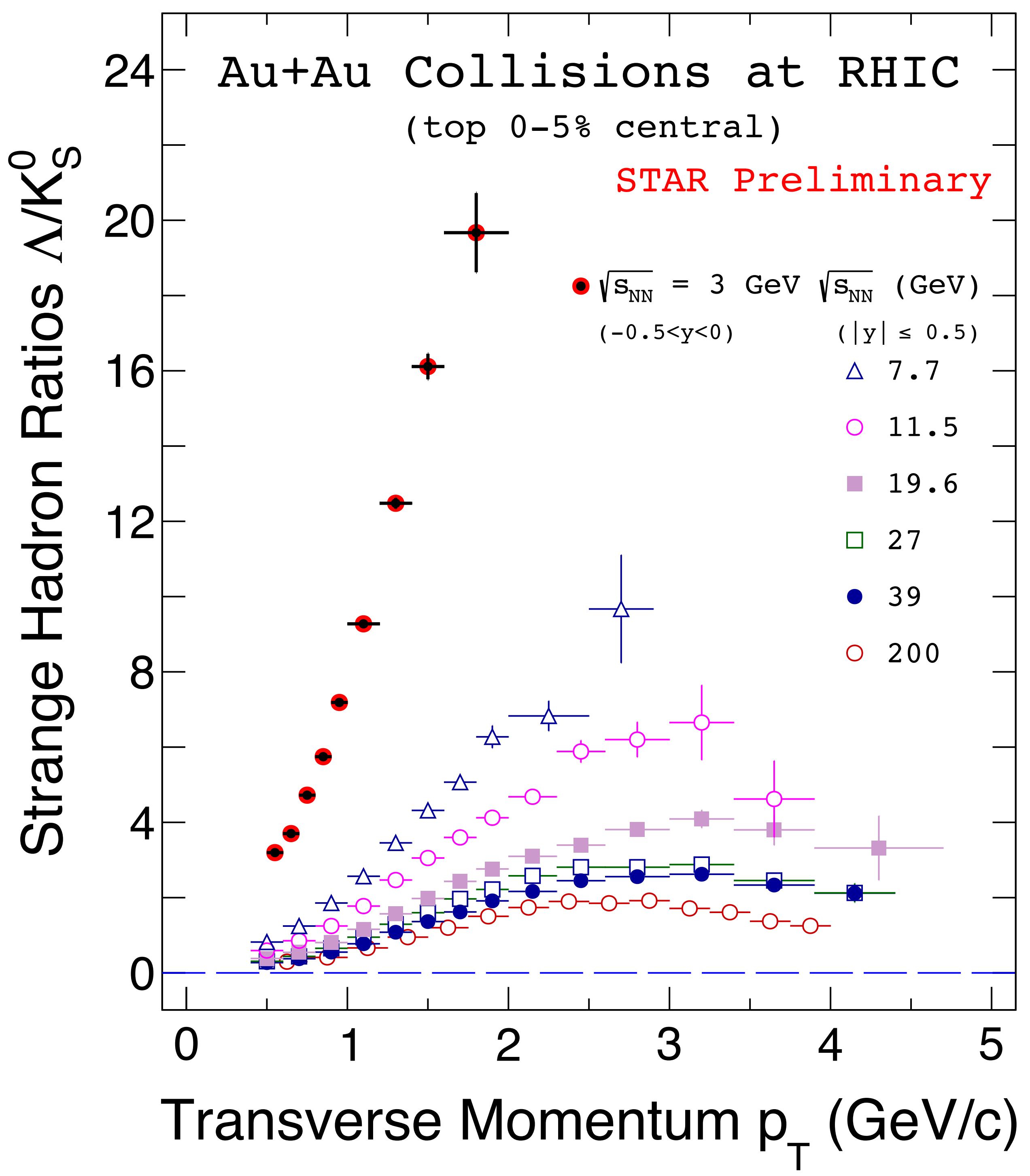
K^0_S $\sqrt{s_{thr}}$ ~ **2.55 GeV**
Λ $\sqrt{s_{thr}}$ ~ **2.55 GeV**
ϕ $\sqrt{s_{thr}}$ ~ **2.89 GeV**
Ξ^- $\sqrt{s_{thr}}$ ~ **3.25 GeV**

Strangeness production vs $\sqrt{s_{NN}}$



K_S^0 $\sqrt{s_{thr}}$ ~ 2.55 GeV
Λ $\sqrt{s_{thr}}$ ~ 2.55 GeV
Ξ^- $\sqrt{s_{thr}}$ ~ 3.25 GeV

- The lower production yield of K_S^0, Λ, Ξ^- at 3 GeV: local strangeness conservation may be required
- Ξ^- produced below NN-thresholds
- Following the world trend



J. Cleymans, arXiv:nucl-th/9704046
Phys. Rev. C 102 (2020) 34909 e-Print: 1906.03732
Phys. Rev. Lett. 108, 072301

Thermal model calculations give:

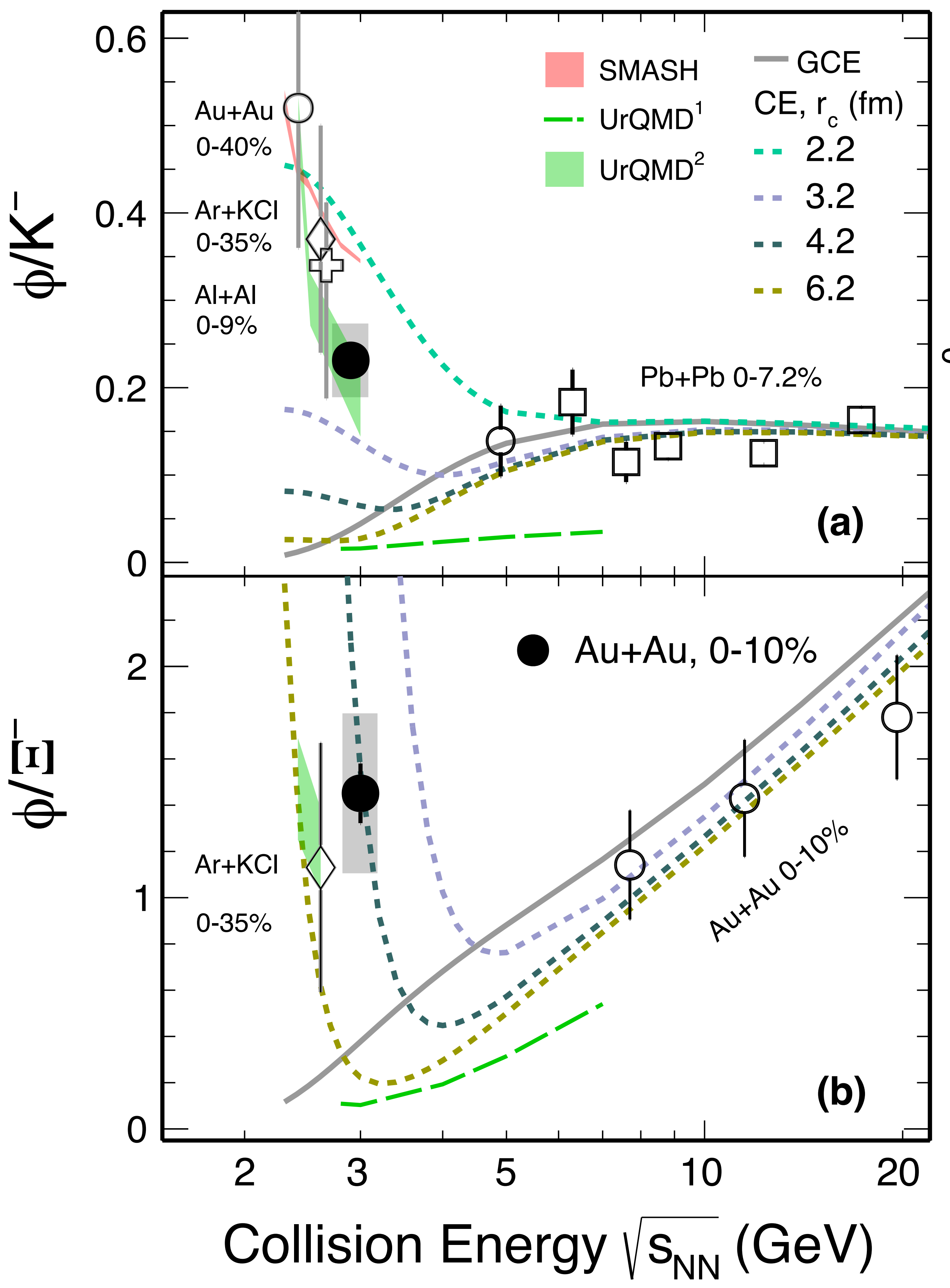
$$\frac{N(\Lambda)}{N(K_S^0)} \propto \exp\left(\frac{\mu_B(1-\sigma_S)}{T}\right)$$

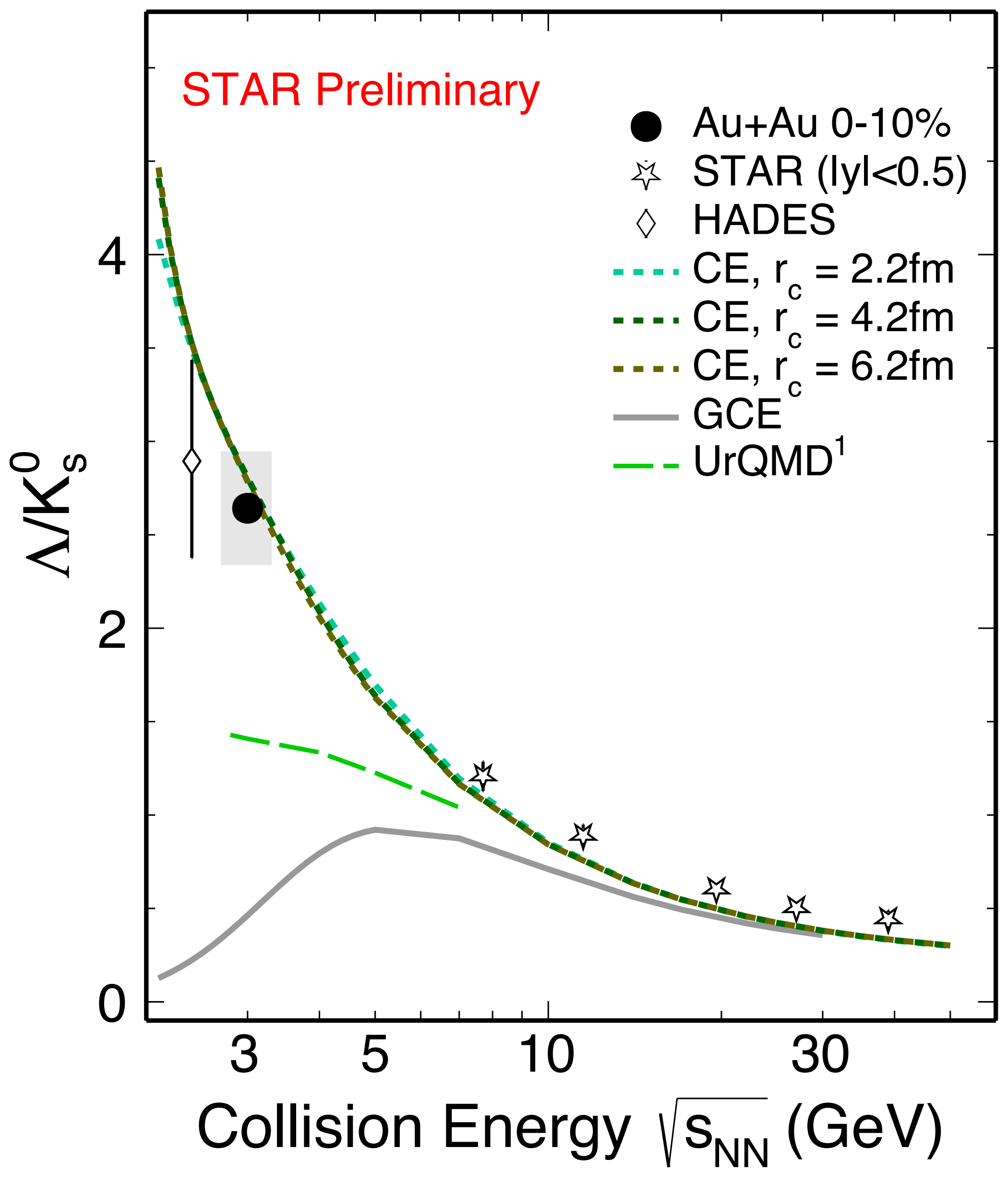
$$\sigma_S = \mu_S/\mu_B$$

Baryon chemical potential driven?

- At high energies, the ratios increase verse p_T and peak at about 3 GeV/c and then fall for higher p_T
- At low energies, the ratio increates much faster than at higher energies

Strangeness production vs $\sqrt{s_{NN}}$





r_c: correlation length, radius of the volume inside which the production of particles with open strangeness is canonically conserved

Data compilation: arXiv: 2108.00924
STAR: Phys. Rev. C 102 (2020) 34909
HADES: Eur. Phys. J. A (2016) 52: 178
UrQMD[1]: Prog. Part. Nucl. Phys. 41 (1998) 225-370
Thermal CE: Phys. Lett. B 603, 146 (2004)

- **At low energies, strangeness production is rare, local strangeness conservation may be required**
  - CE calculations with different r_c are needed to describe ϕ/K^- and ϕ/Ξ^-, respectively
  - GCE underpredicts the data at 3 GeV
- **Default UrQMD failed to describe the measurement data at low energies**
- **Transport models with high-mass resonance decay to ϕ and Ξ^- can reasonably describe data at low energies**

Summary and outlook

- **Strangeness production in Au+Au 3 GeV collisions**
  - ϕ/K^-, ϕ/Ξ^- and Λ/K_S^0 show a strong effect of canonical suppression
- **Precise measurements of ϕ/K^- and ϕ/Ξ^- on the centrality dependence, Λ/K_S^0 on the p_T, y dependence from the STAR BES-II, to constrain the model calculations**
  - iTPC+eTOF extend the low p_T reach to reduce systematic uncertainties
  - 2B 3GeV-run will reduce the statistical uncertainty by a factor of 3