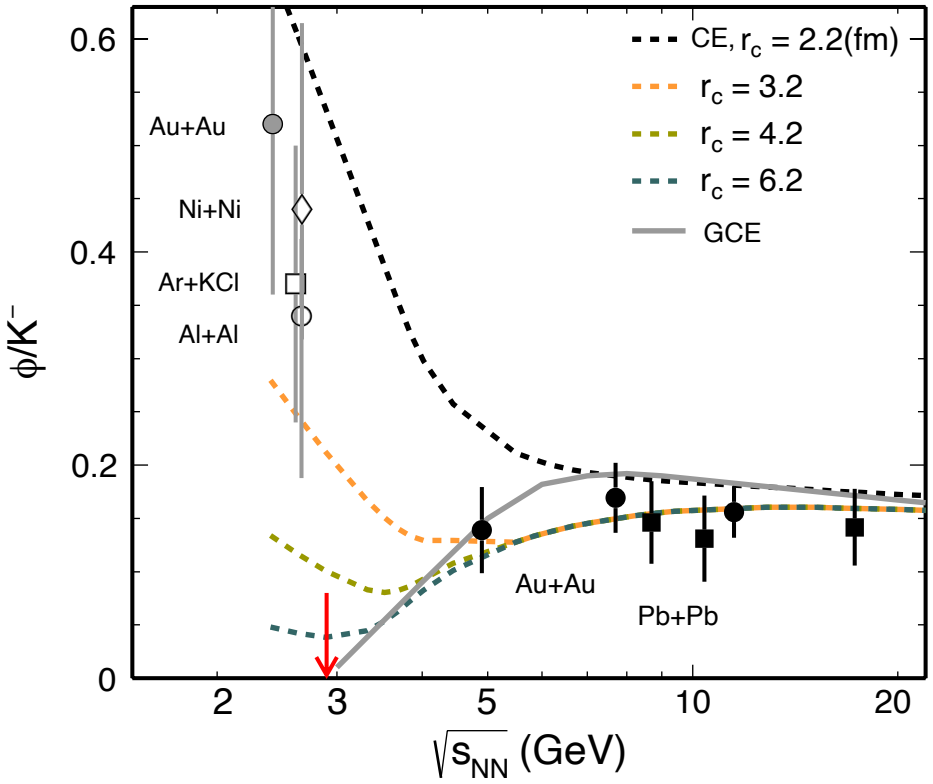
ϕ-meson Production in Au+Au Collisions at $\sqrt{s_{NN}}$ = 3.0 GeV from STAR

Guannan Xie (for the STAR Collaboration)
Lawrence Berkeley National Laboratory
April 17-20, 2021
APS April Meeting 2021

Supported in part by
U.S. DEPARTMENT OF ENERGY
Office of Science

Motivation

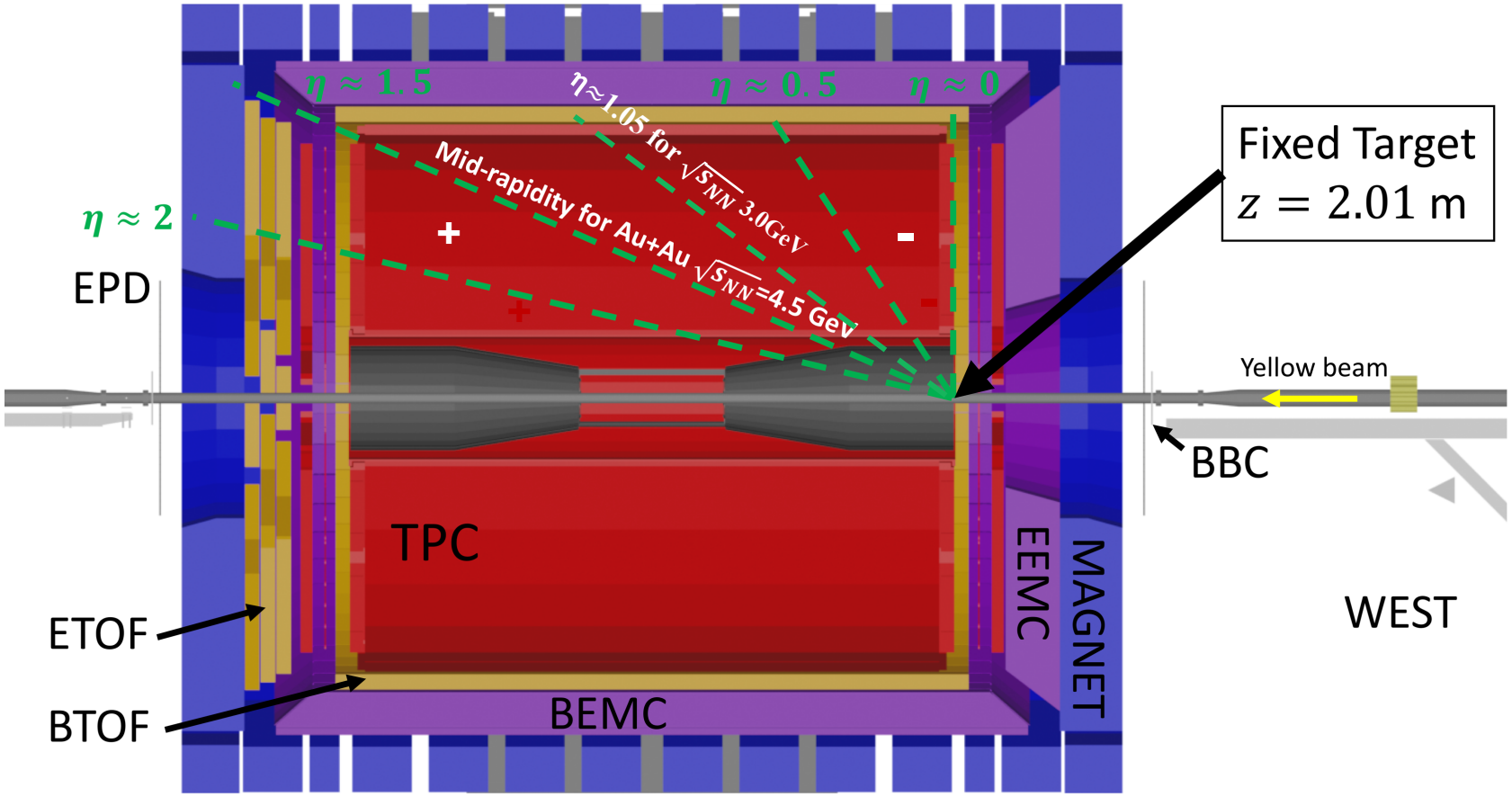
- ϕ meson ($s\bar{s}$) has a small hadronic cross section.
- The strange hadron yield and ratios may be sensitive to the strangeness production mechanism.
- Grand canonical ensemble (GCE) and canonical ensemble (CE) calculations are quite different at low energy.



HADES:
Phys. Lett. B 778, 2018.403-407,
Phys. Rev. C. 80.025209. (2009)
E917: Phys. Rev. C. 69.054901 (2004)

P. Braun-Munzinger:
Nucl. Phys. A 772, 167 (2006)
K. Redlich:
Phys. Lett. B 603, 146 (2004)

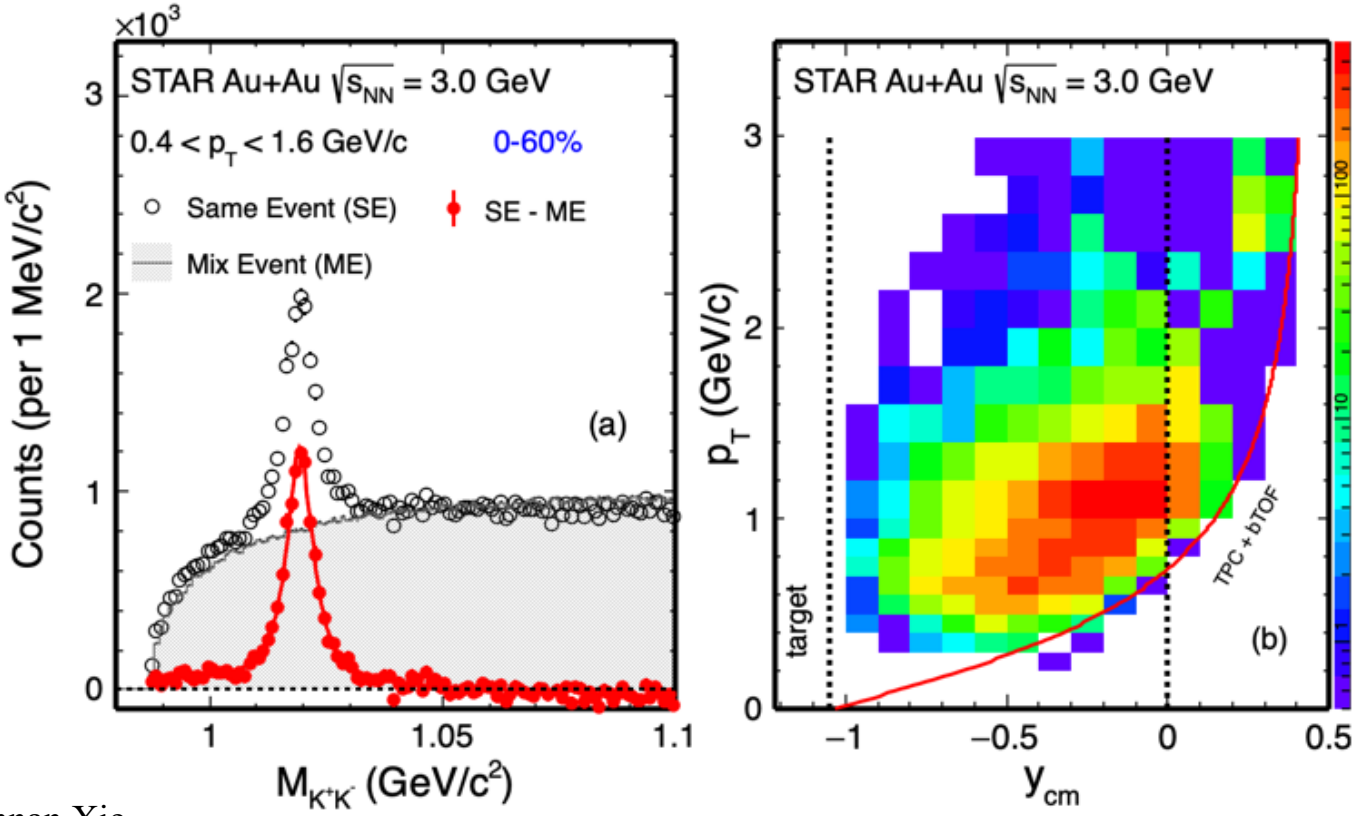
FXT Setup @ STAR



Conventions: beam-going direction is the positive direction

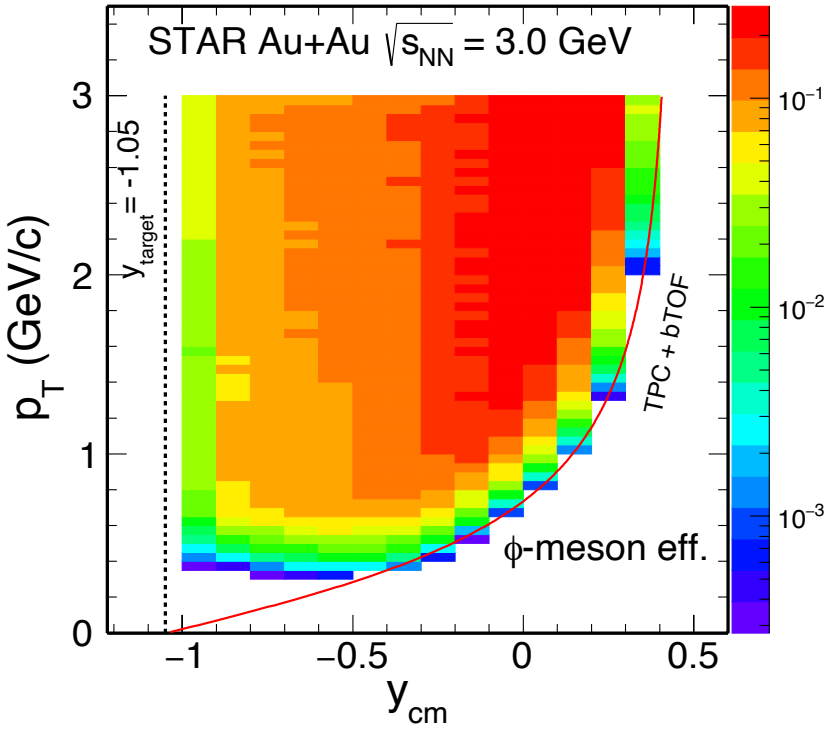
Analysis Procedure

- 2018 FXT 3.85GeV ($\sqrt{s_{NN}}$ = 3.0 GeV) ~250M, y_{mid} ~ 1.05.
- $\phi \rightarrow K^+ + K^-$ (hadronic channel).
- TPC (dE/dx) and TOF (β) for Kaon particle identification.
- ϕ meson signal was fitted with breit-wigner function.
- Wide p_T and centrality coverage for ϕ meson.

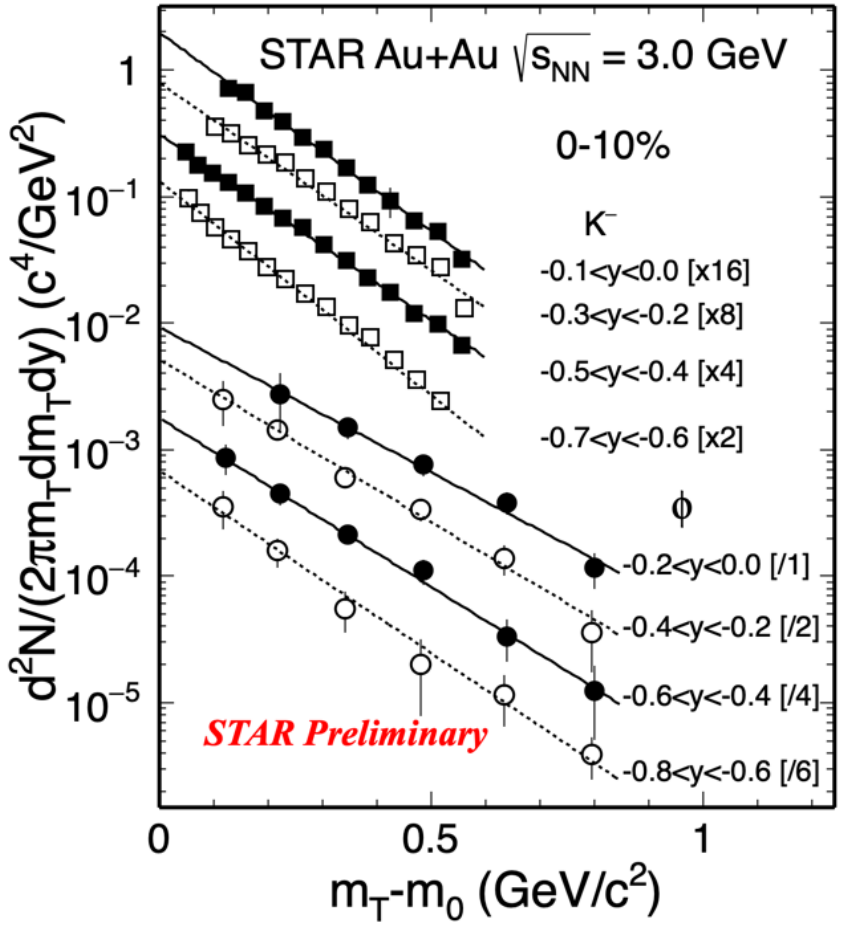


Efficiency Correction

- Tracking efficiency and acceptance effects are estimated with GEANT simulations embedded into real events.
- A data-driven method is used to extract tof matching and pid related efficiency.



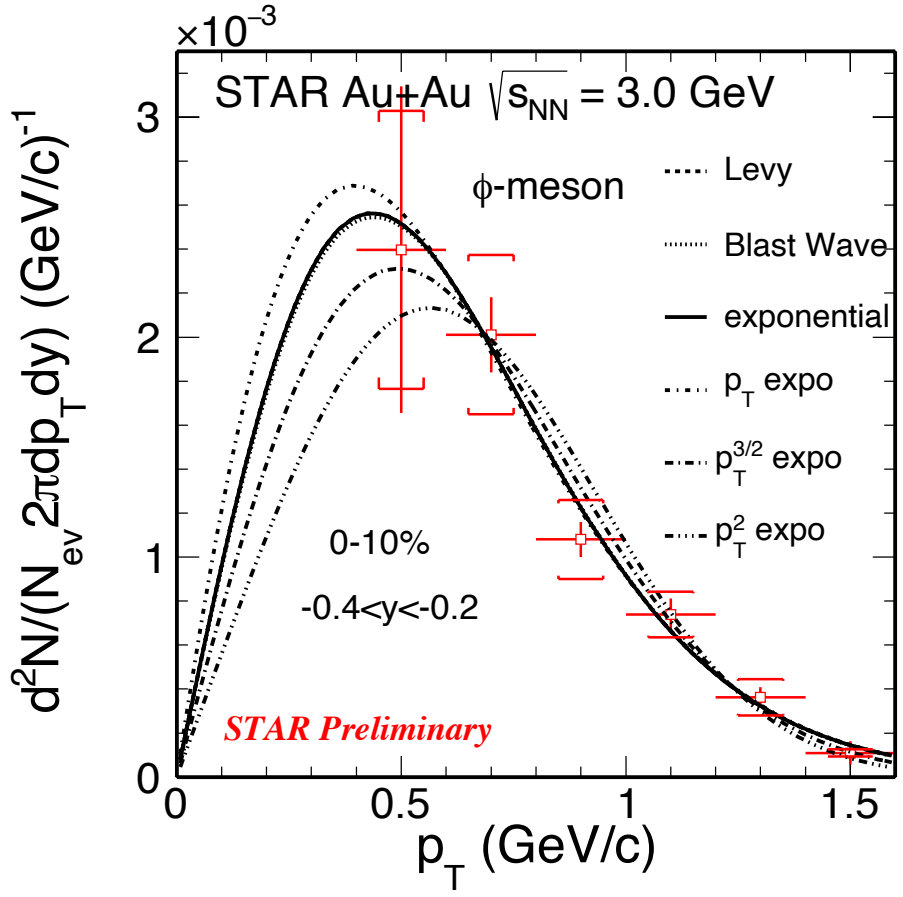
Efficiency Corrected m_T Spectra



ϕ-meson and K^- invariant yields in 0-10% most central collisions as a function of transverse kinetic energy (m_T-m_0) for various rapidity regions. Yields are fitted with an exponential.

Systematic Estimation

STAR: Phys. Rev. C. 034909 (2009)



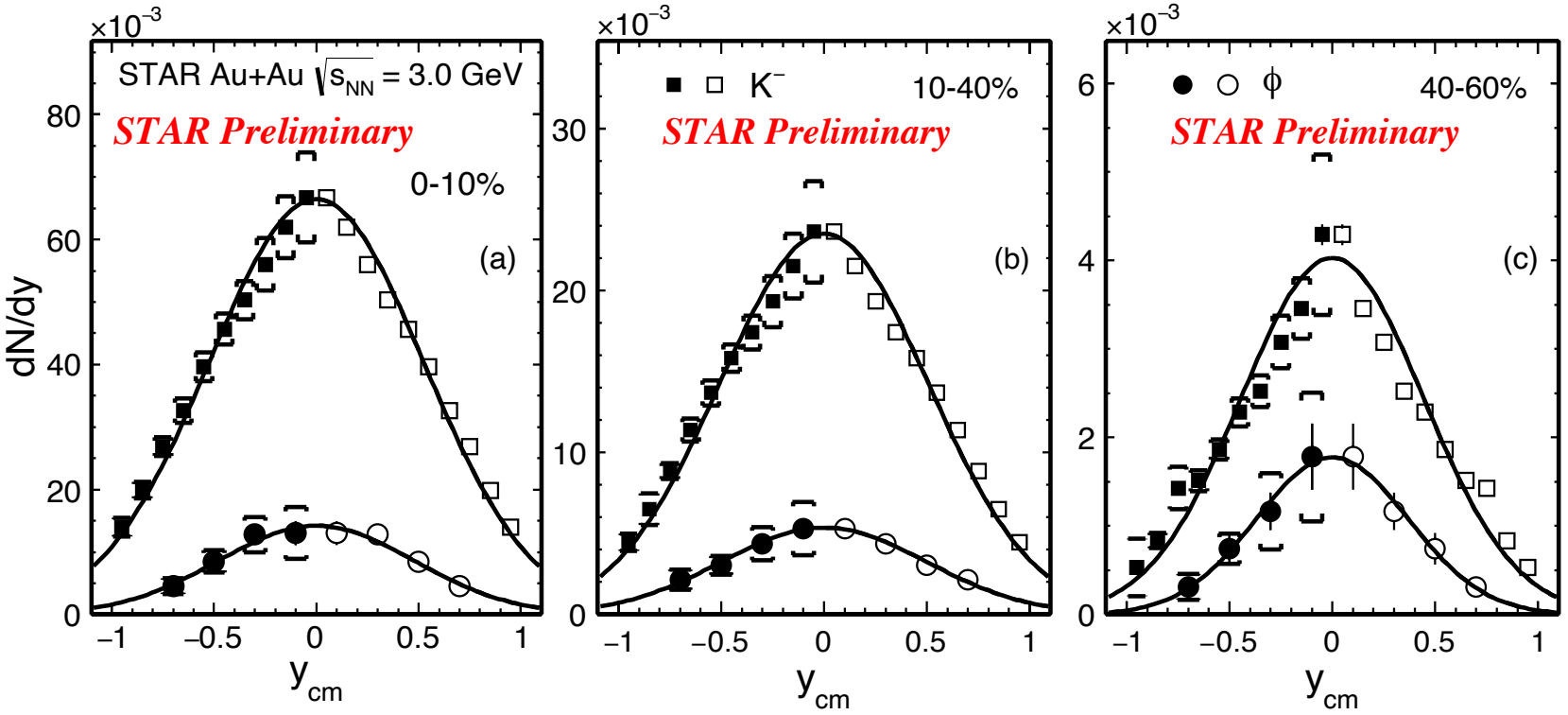
dN/dp_T extrapolation with various functions to capture the unmeasured p_T range: (systematic source)

- Levy
- Blast-wave
- m_T exponential
- $p_T^{3/2}$ exponential
- p_T^2 Gaussian

Other systematic sources:

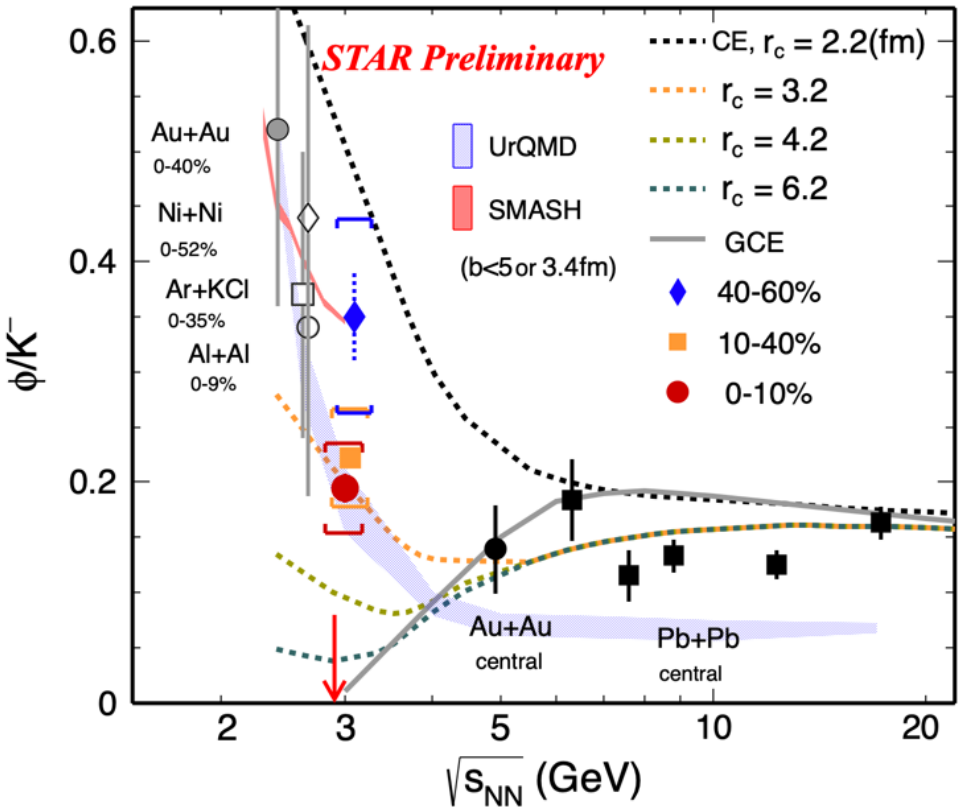
Tracking quality cuts and PID.

Yield : Rapidity Distribution



Rapidity distribution of K^- and ϕ-meson and the Gaussian extrapolation in y_{cm} for three centrality bins. Solid symbols are measured data, open ones are reflection.

ϕ/K^- Ratio



HADES: Phys. Lett. B 778, 2018.403-407, Phys. Rev. C. 80.025209. (2009); E917: Phys. Rev. C. 69.054901 (2004); NA49 : Phys. Rev. C 78, 044907 (2008), Phys. Rev. C 77, 024903 (2008), Phys. Rev. C 66, 054902 (2002)

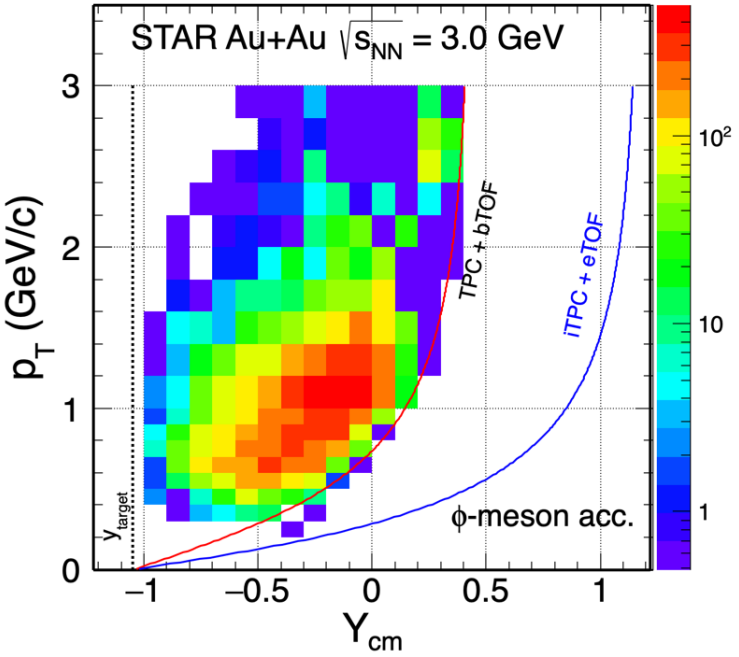
P. Braun-Munzinger: Nucl. Phys. A 772, 167 (2006); K. Redlich: Phys. Lett. B 603, 146 (2004); UrQMD: J. Phys. G: Nucl. Part. Phys. 43 (2016) 015104 (14pp); SMASH : Phys. Rev, C 99, 064908 (2019)

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

ϕ/K^- ratio as a function of center of mass energy $\sqrt{s_{NN}}$ compared with different model calculations. ~5σ deviation from zero (GCE) for 0-10% central collisions. Data favors the CE with rc~$3.2^{+0.2}_{-0.3} fm$. Transport models with resonance decays can reasonably describe data.

Summary and Outlook

- First measurements of ϕ-meson production in Au+Au collisions at $\sqrt{s_{NN}}$ = 3 GeV with energy just above the NN threshold*. ** A.I. Titov: Eur. Phys. J. A 7 (2000) 543-557*
- ϕ/K^- ratio deviates from zero with ~5σ for 0–10% central collisions.
- Data favors the CE with strangeness correlation length (r_c~3.2fm), while GCE show a clear discrepancy at low energy.
- Transport models with resonance decays can reasonably describe data.



Outlook

- Precise measurements of ϕ/K^- on the centrality dependence from the STAR BES-II, to constrain the model calculations.