Charged Meson Production in Au+Au $\sqrt{s_{NN}} = 3.0$ GeV Fixed-Target Collisions at STAR

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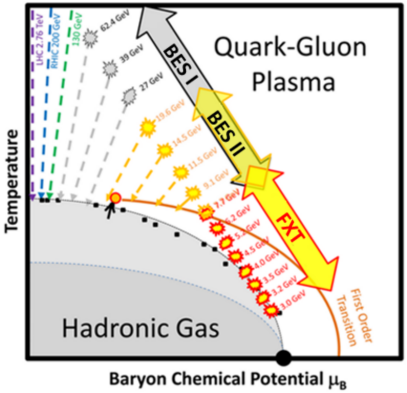
Outline

Motivation

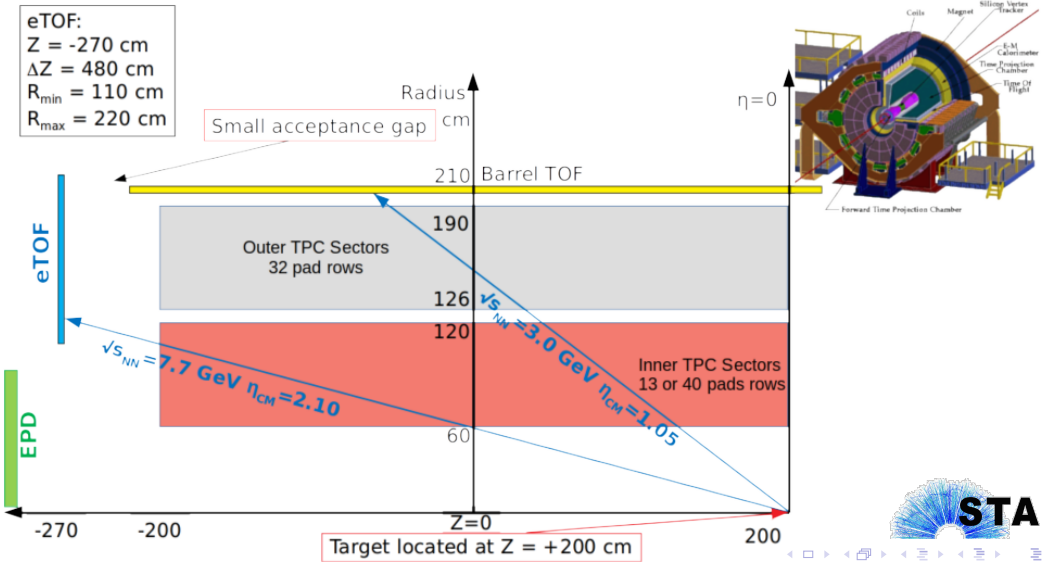
- Charged particle spectra can be used with a chemical equilibrium model to obtain thermal properties at chemical freeze-out[1]
- Particle ratios provide information about specific phenomena such as the Coulomb potential for pions and associated production for kaons
- Search for the onset of deconfinement with observables proposed by NA49 Collaboration[2]



[1] S. Wheaton *et al.*, Comput. Phys. Commun. 180, 84 (2009)
[2] V. Friese *et al.* (NA49 Collaboration), PoS CPOD2009, 005 (2009)

Outline

STAR Fixed-Target Geometry

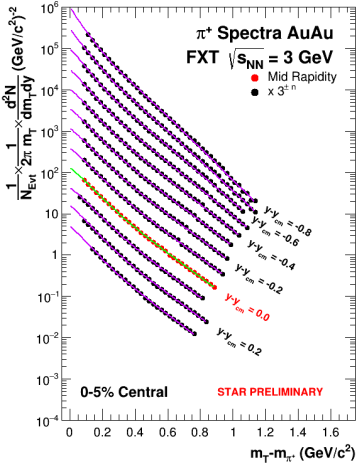


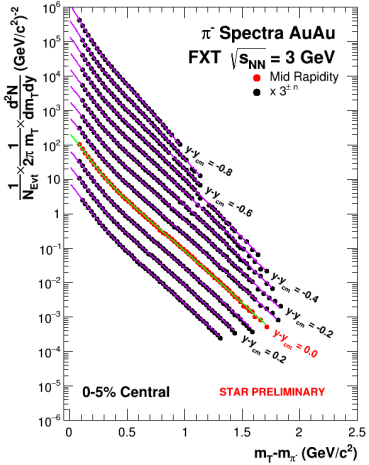
The STAR Fixed Target

- Target located at $z = 200$ cm
- Target is 0.25 mm thick - 1% interaction probability
- Target is held 2 cm below center of beam axis
- Collider filled with 12 bunches

Outline

Pion Spectra

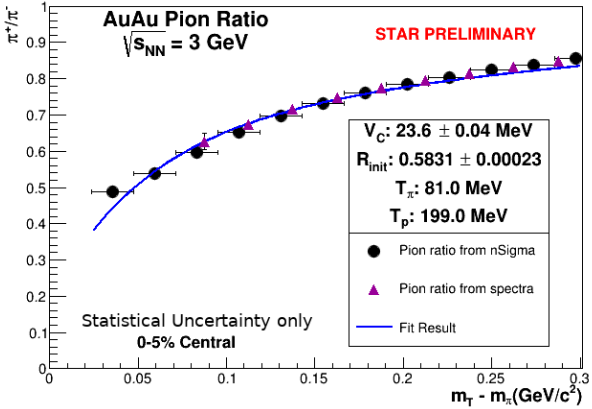




- Pion yields extracted from fitting dE/dx from TPC and $1/\beta$ from barrel ToF
- Pions described well by double thermal function[1] to describe thermal production and from Δ resonance

[1] J. Klay *et al.* (E895 Collaboration), Phys. Rev. C **68**, 054905 (2003)

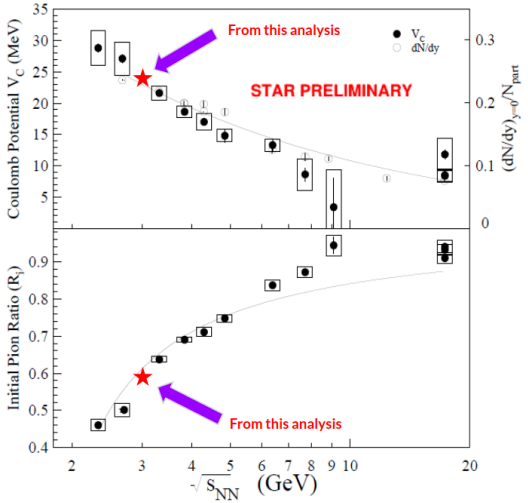
Pion Ratio



- Coulomb potential from positive interaction region modifies particle spectra[1]
- $\pi^{\pm}$ most sensitive hadron due to low mass
- $R_f(E_f) = \frac{E_f - V_C}{E_f + V_C} \frac{\sqrt{(E_f - V_C)^2 - m^2}}{\sqrt{(E_f + V_C)^2 - m^2}} \frac{A^+(e^{(E_f + V_C)/T_\pi} - 1)}{A^-(e^{(E_f - V_C)/T_\pi} - 1)}$
- Model does excellent job of describing shape of observed data

[1] D. Cebra *et al.*, arXiv:1408.1369 [nucl-ex]

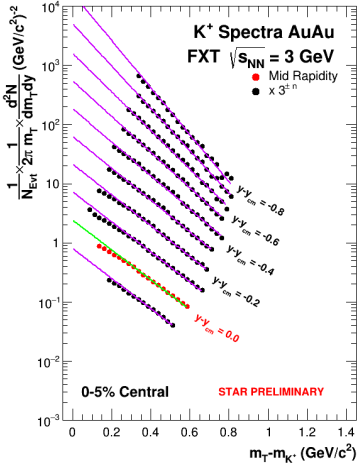
Coulomb Potential and Initial Pion Ratio

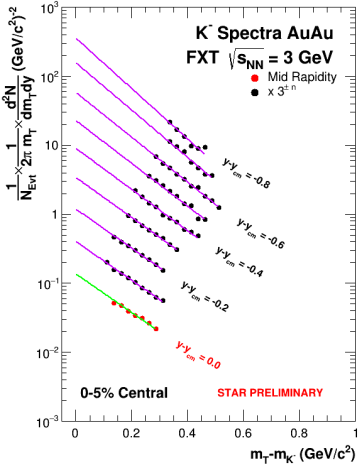


- Results from $\sqrt{s_{NN}} = 3.0$ GeV analysis follow trend observed across SIS, AGS, and SPS experiments[1]
- Decrease in Coulomb potential with rising collision energy tracks midrapidity dN/dy of protons

[1] D. Cebra *et al.*, arXiv:1408.1369 [nucl-ex]

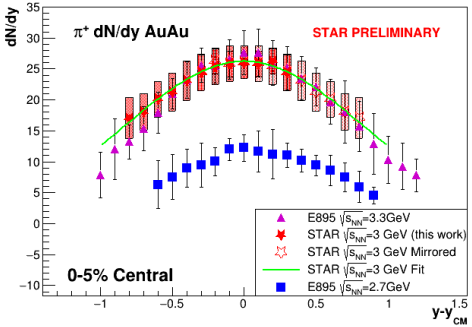
Kaon Spectra

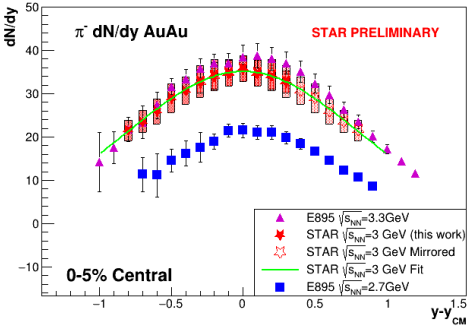




- Kaon yields extracted from fitting dE/dx from TPC and $1/\beta$ from barrel ToF
- Kaons described well by m_T exponential function

Pion Rapidity Density Distributions

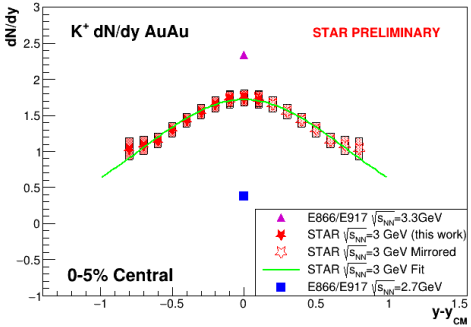


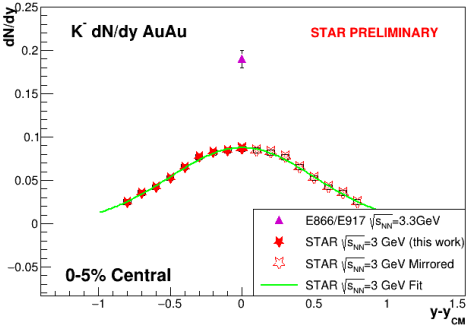


- Yields obtained from integrating fits of spectra and fit with Gaussian
- Yields agree well with results from E895[1] from the AGS

[1] J. Klay *et al.* (E895 Collaboration), Phys. Rev. C **68**, 054905 (2003)

Kaon Rapidity Density Distributions

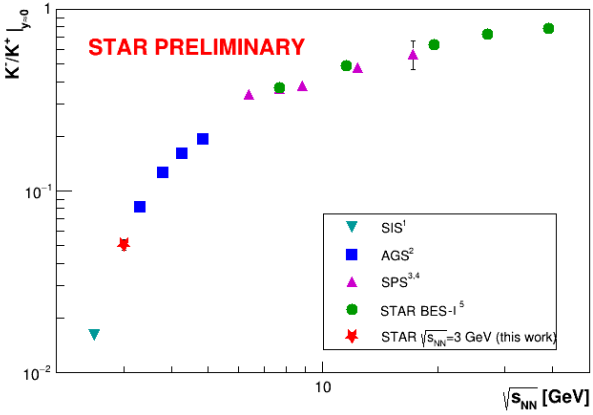




- Yields obtained from integrating fits of spectra and fit with Gaussian
- Yields follow the $\sqrt{s_{NN}}$ trend indicated by E866/E917[1] from the AGS

[1] L. Ahle *et al.* (E866 and E917 Collaborations), Phys. Lett. **B490**, 53 (2000)

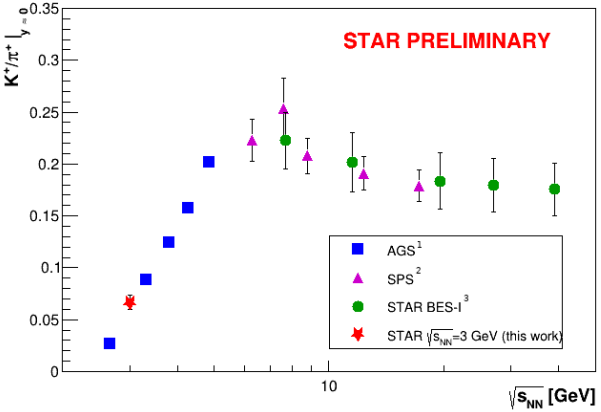
Kaon Ratio



- K^-/K^+ ratio shows relative importance of K^+ production in association with the Λ ($N + N \rightarrow N + \Lambda + K$)
- Result at $\sqrt{s_{NN}} = 3$ GeV follows trend seen in SIS, AGS, SPS, and RHIC data

[1] A. Forster *et al.* (KaoS Collaboration), J. Phys. G **28**, 2011 (2002)
[2] L. Ahle *et al.* (E866 and E917 Collaborations), Phys. Lett. **B490**, 53 (2000)
[3] C. Alt *et al.* (NA49 Collaboration), Phys. Rev. C **77**, 024903 (2008)
[4] S. Afanasiev *et al.* (NA49 Collaboration), Phys. Rev. C **66**, 054902 (2002)
[5] L. Adamczyk *et al.* (STAR Collaboration), Phys. Rev. C **96**, 044904 (2017)

Kaon to Pion Ratio



- K^+/π^+ ratio proposed by NA49 as a possible signal of onset of deconfinement
- STAR measurement from BES-I agree with SPS results
- Measurement at $\sqrt{s_{NN}} = 3.0$ GeV (this work) agrees well with AGS results

[1] L. Ahle *et al.* (E866 and E917 Collaborations), Phys. Lett. **B476**, 1 (2000)
[2] C. Alt *et al.* (NA49 Collaboration), Phys. Rev. C **77**, 024903 (2008)
[3] L. Adamczyk *et al.* (STAR Collaboration), Phys. Rev. C **96**, 044904 (2017)

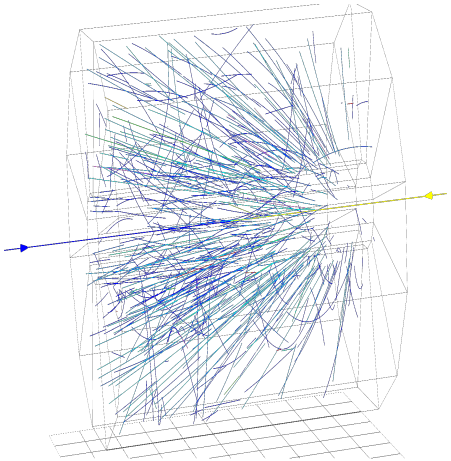
Outline

Conclusions and Outlook

- The STAR Fixed-Target program has started successfully
- Spectral shapes of the charged mesons agree well with those observed at previous fixed target experiments
- Coulomb potential follows trend from world data
- K^+ production in association with the Λ plays significant role at this energy
- Rapidity density distributions of charged mesons agree with results from AGS experiments
- Studies of higher fixed target energies will improve global systematics, particularly of strangeness production near threshold

Backup

Event and Track Selection Cuts



- Event selection
  - Select on minimum-bias events (using mixture of EPD, BBC, and VPD triggers)
  - $198 < V_z < 202$ cm
- Track selection
  - Track projects back to the primary vertex (at target location)
  - Distance of Closest Approach (DCA) ≤ 3