π, K, p Production and Thermodynamics Beyond Mid-Rapidity $\sqrt{s_{NN}} = 27$ GeV Au+Au at STAR

Supported in part by

UCDAVIS

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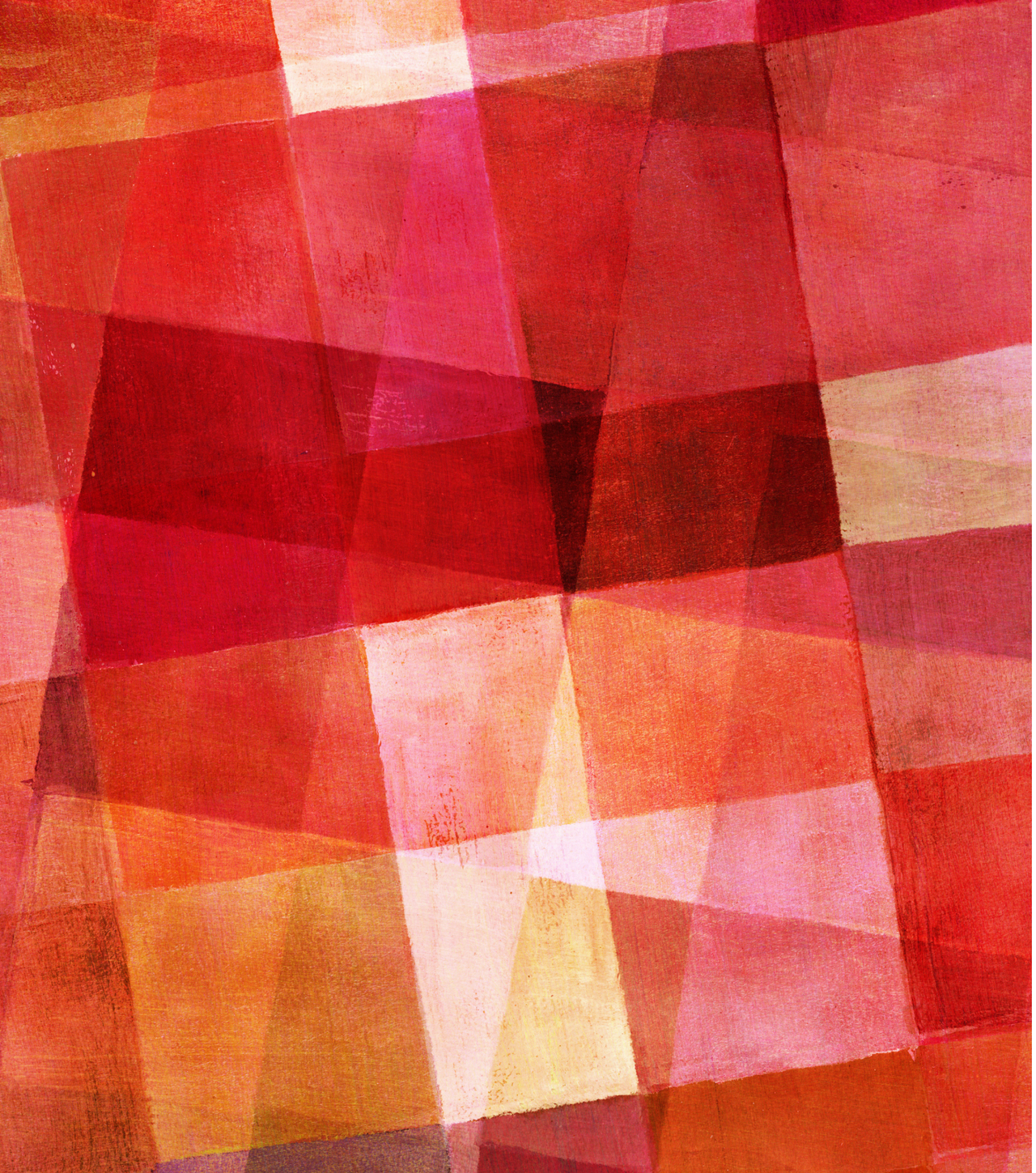
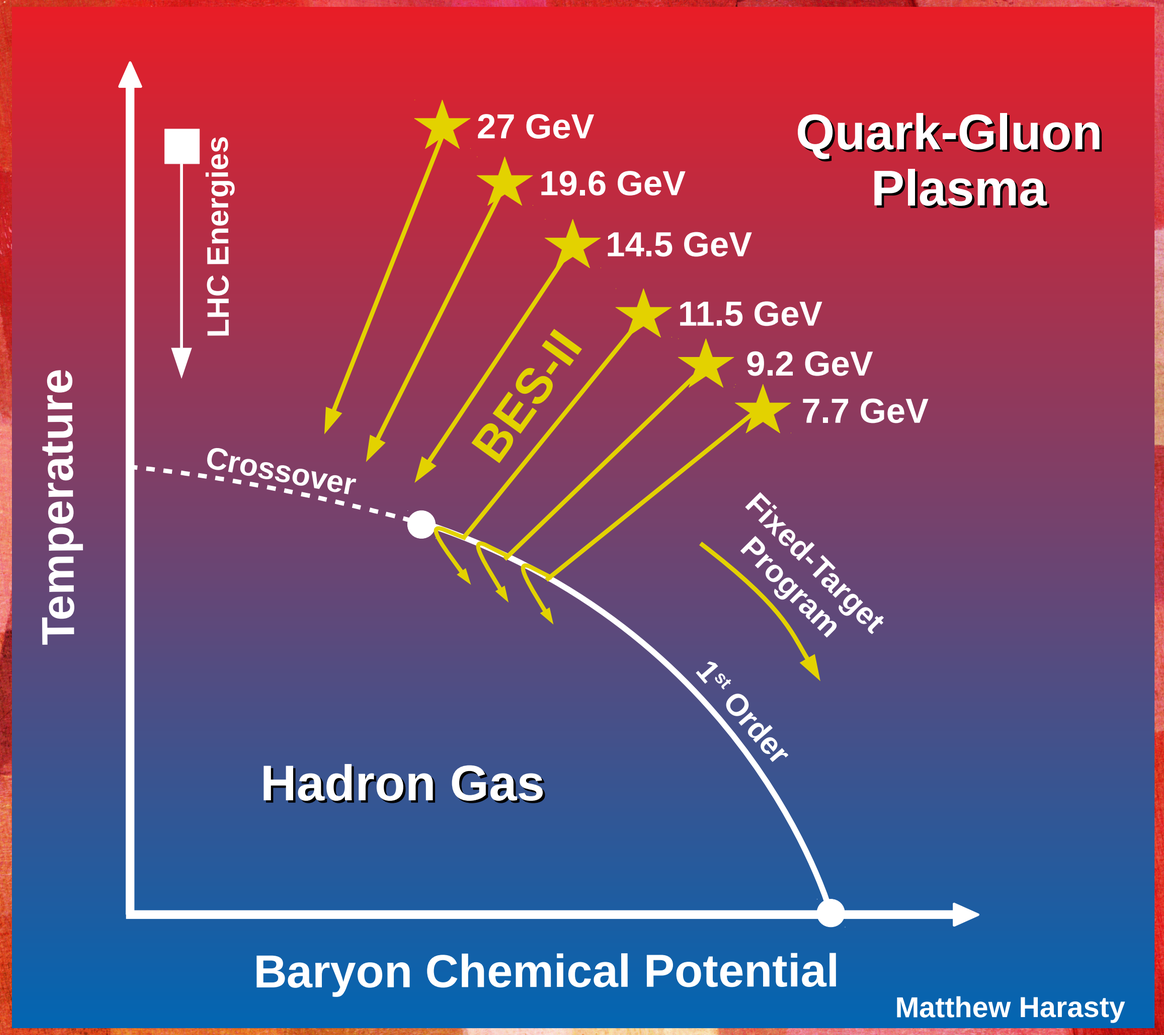


OVERVIEW

- Physics motivation
- The dataset
- Extraction of particle yields
- Corrections to yields
- Charged hadron ratios
- Baryon chemical potential
- Conclusions

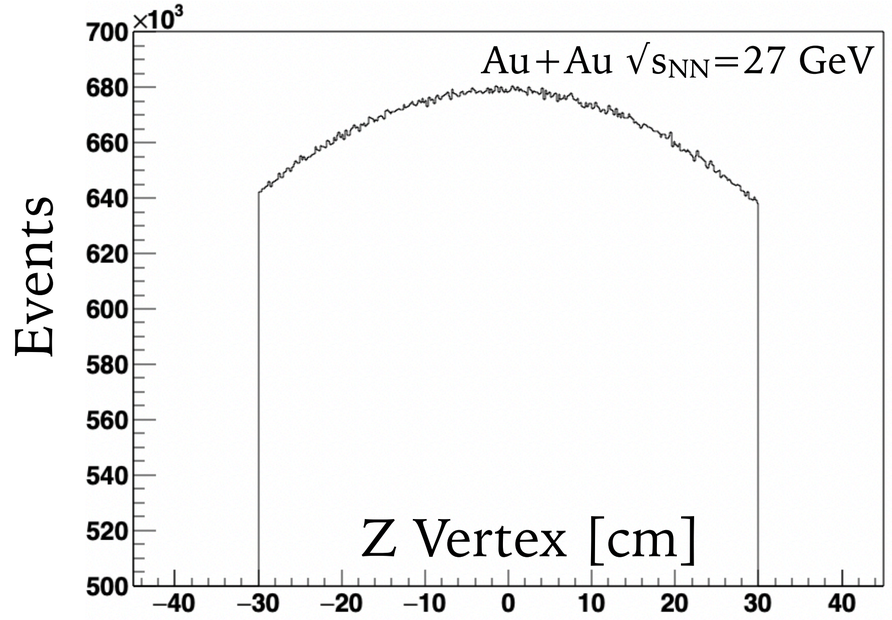
PHYSICS MOTIVATION

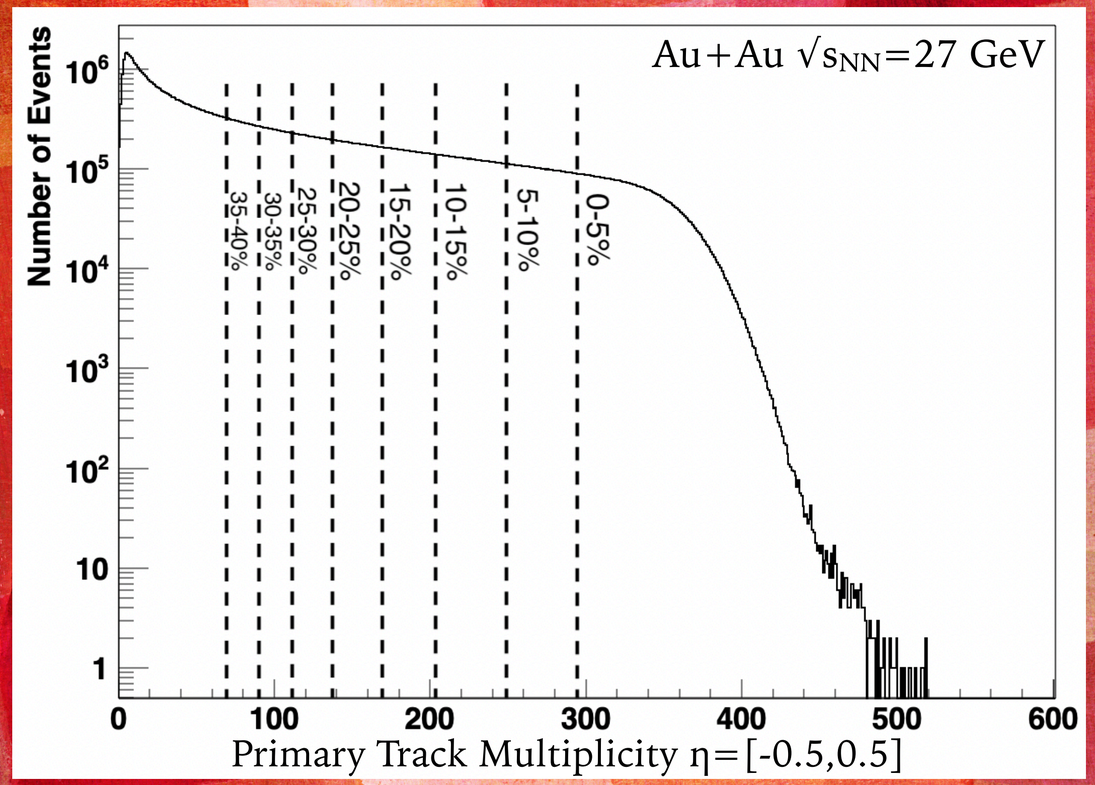


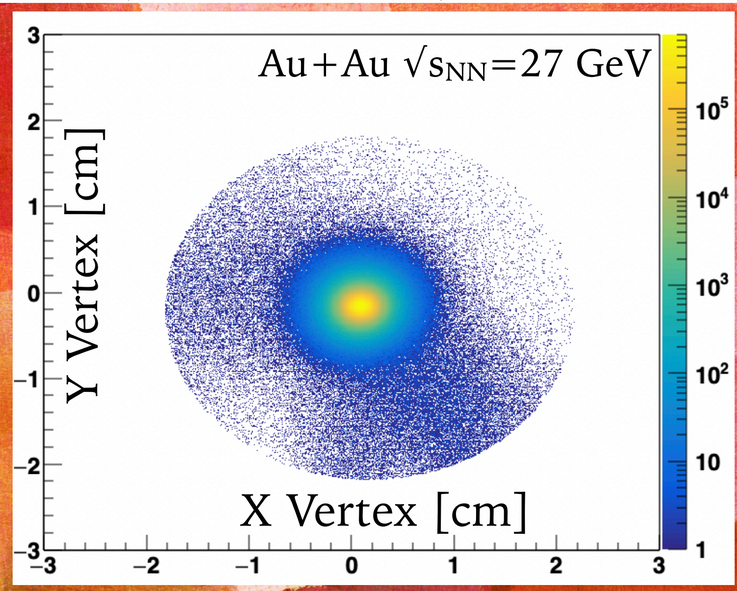
- Where we are on the QCD phase diagram?
- How do modes of particle production change as a function of centrality and rapidity?
- How do the chemical freeze-out temperature and baryon chemical potential change with centrality and rapidity?

DATASET & EVENT QUALITY

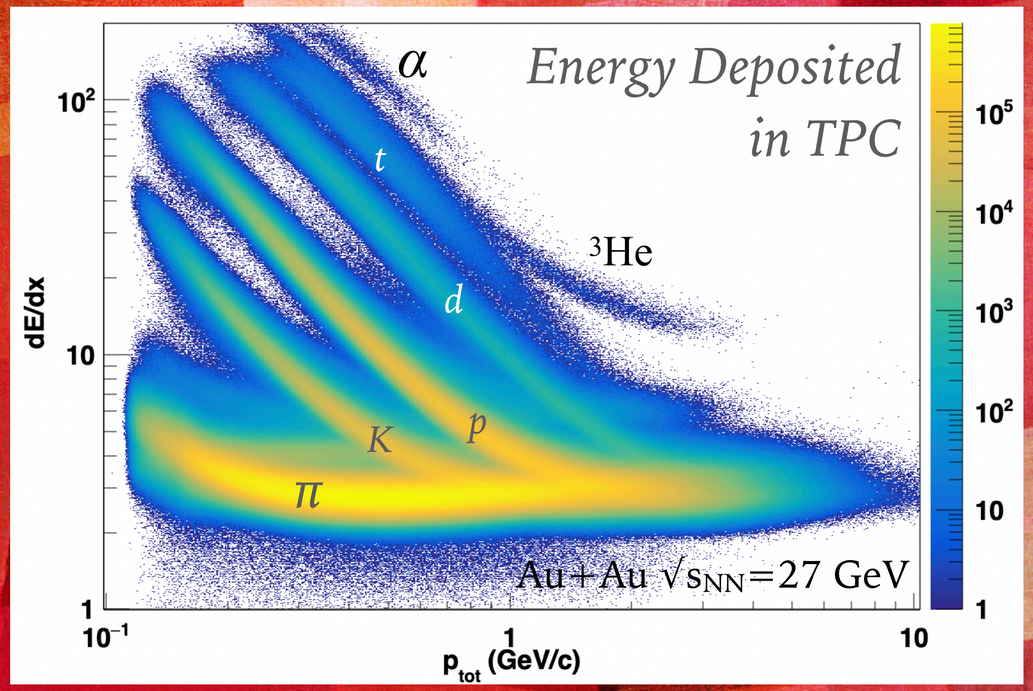
- Beam Energy Scan - II
- $\sqrt{s_{NN}}$ = 27 GeV Au+Au 2018
- Events used: 200M
- V_z = [-30, 30] cm
- V_r < 2.0 cm

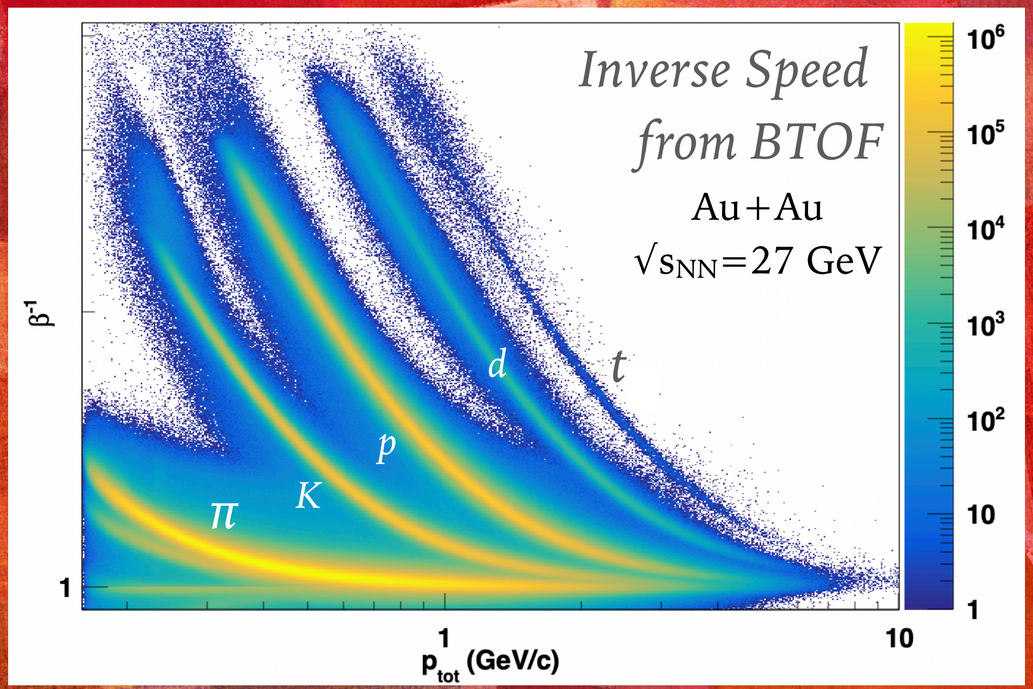


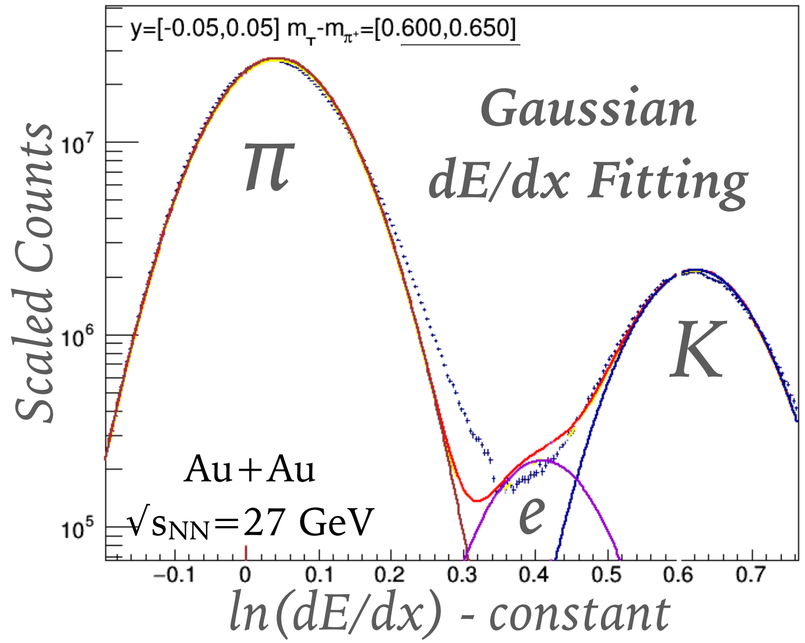


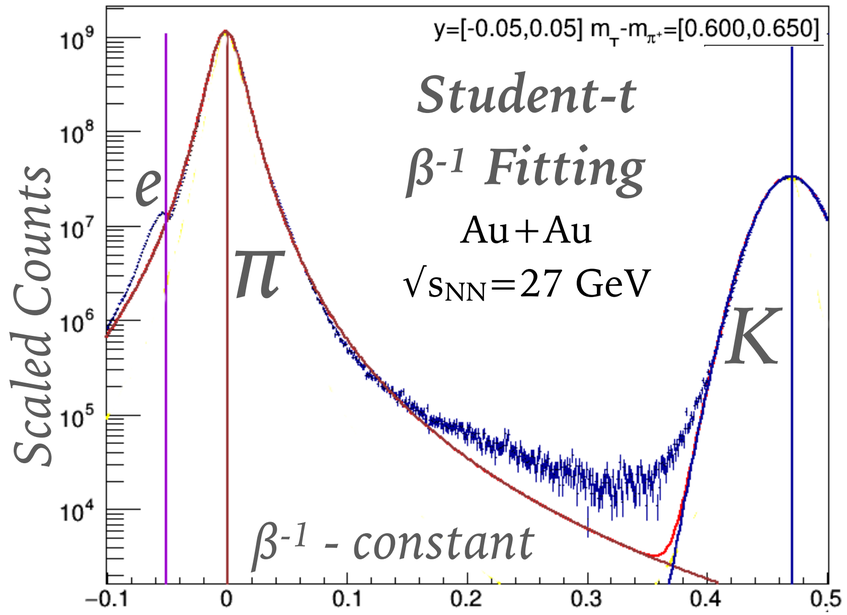


EXTRACTING RAW YIELDS



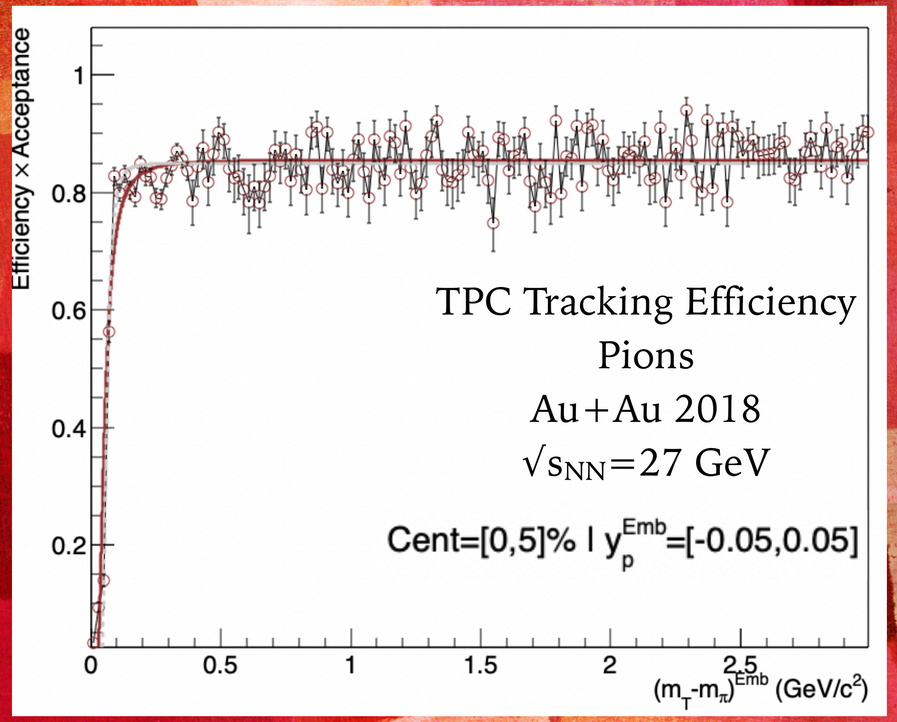


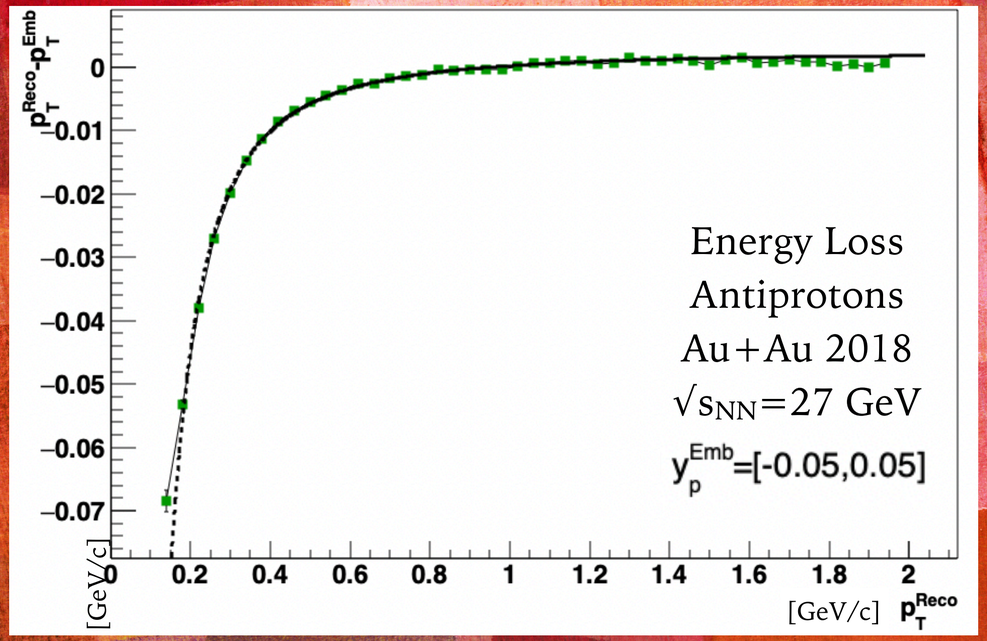




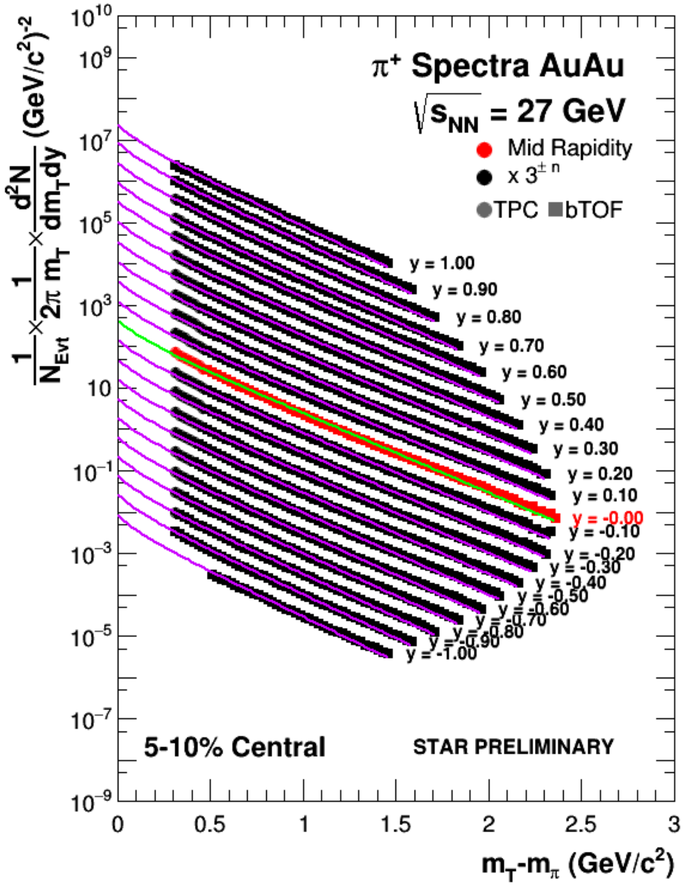
CORRECTIONS

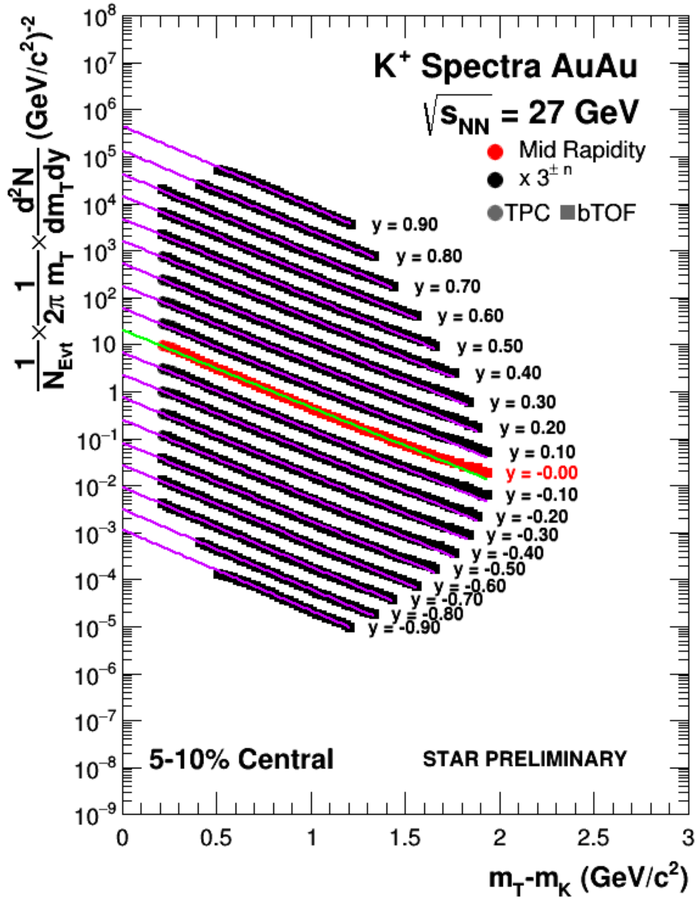
- bToF matching efficiency (data driven)
- TPC tracking efficiency
- Energy loss in TPC (K and p)
- Knockout protons (p Only)
  - Mainly beryllium beam pipe interactions
- Feed-down correction (π and p)

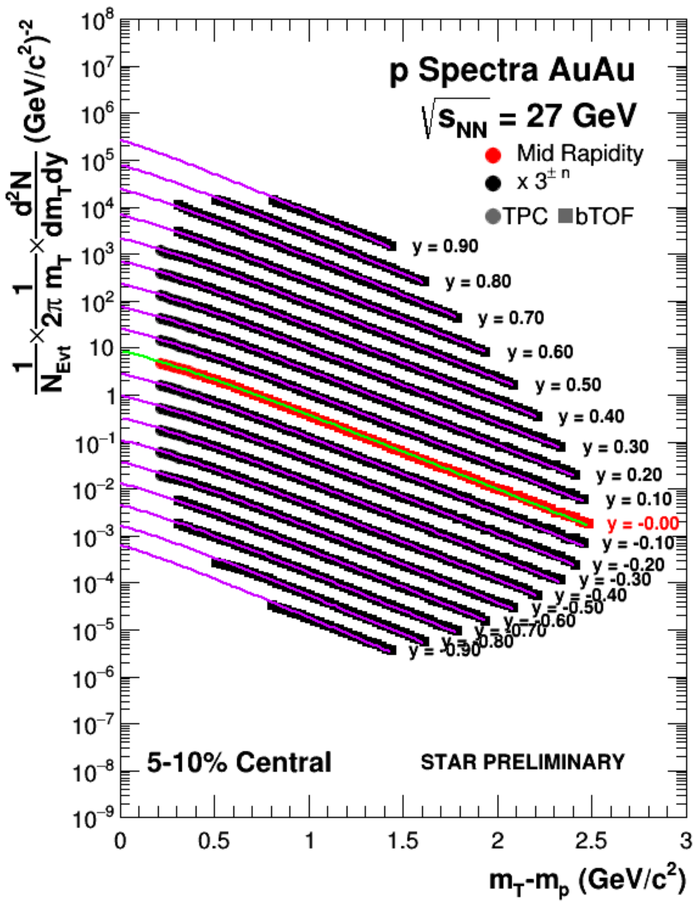




RAPIDITY DEPENDENT PARTICLE SPECTRA – 5-10% MOST CENTRAL COLLISIONS







Bose-Einstein:

$$f_{\mathrm{BE}}(m_T - m_0) = A\frac{1}{\exp(m_T/T) - 1}$$

m_T - m_K Exponential:

$$f_{m_T}(m_T - m_0) = A\frac{1}{\exp((m_T - m_0)/T)}$$

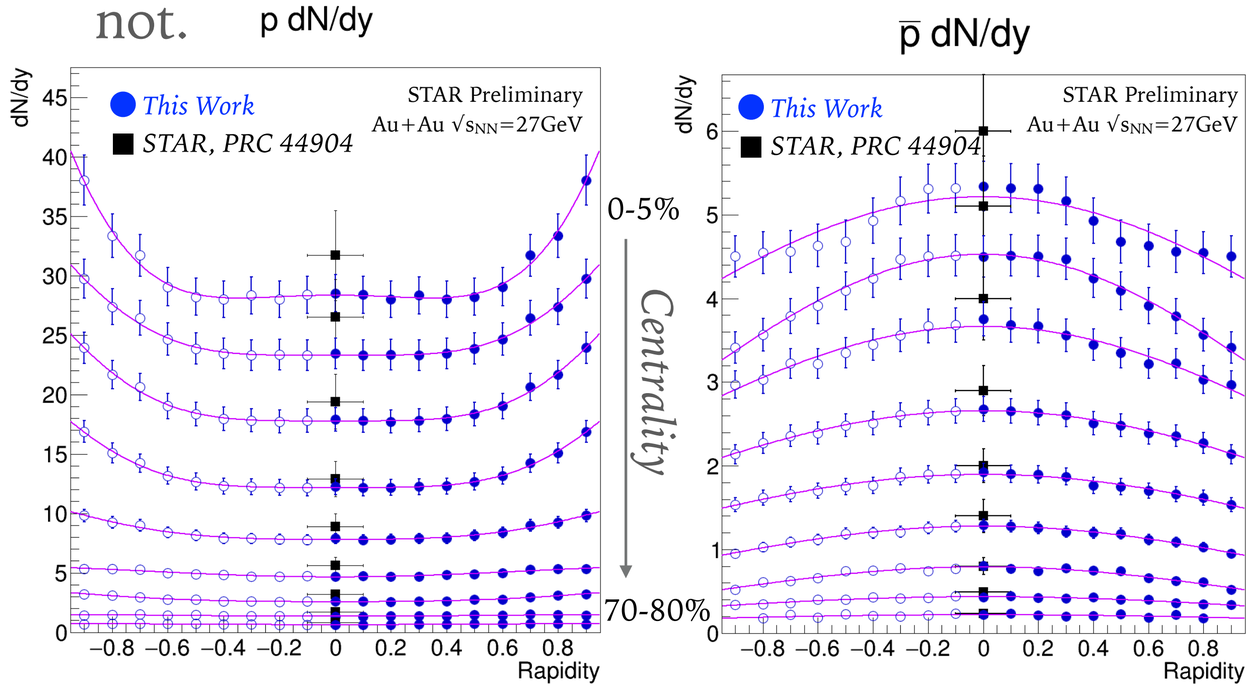
Fit Function: Blast Wave Model [Schnedermann, et al. PRC 48]

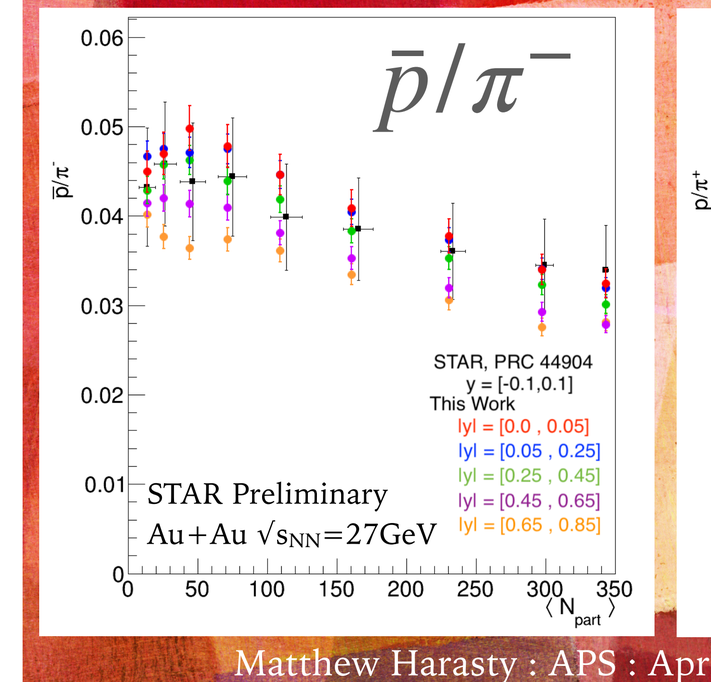
$$\frac{d^2N}{m_T dm_T dy} = A\int_0^R r dr m_T \times I_0\left(\frac{p_T \sinh\rho(r)}{T_{Kin}}\right) K_1\left(\frac{m_T \cosh\rho(r)}{T_{kin}}\right)$$

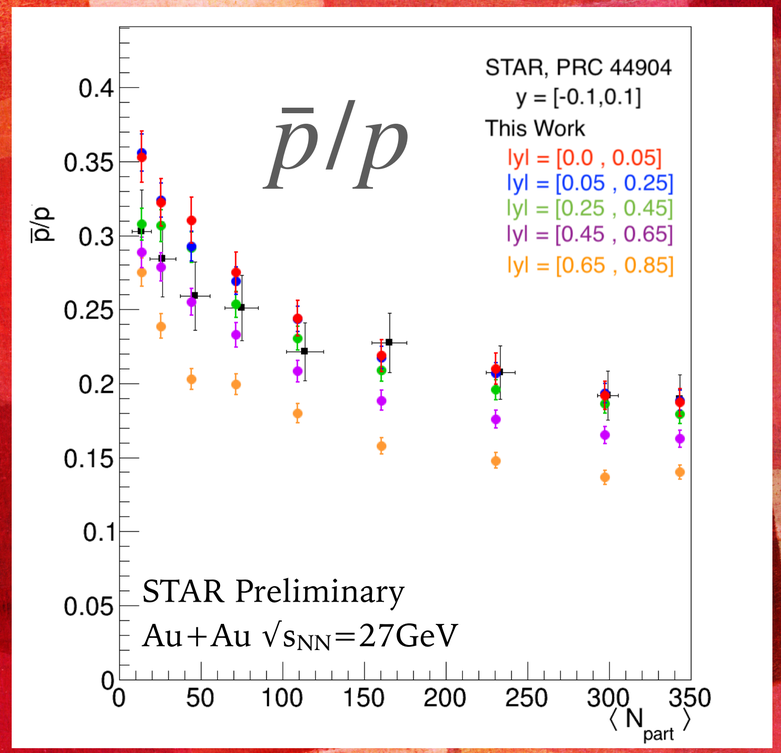
- Spectra fit over extended rapidity coverage
- Spectra fit over many centralities

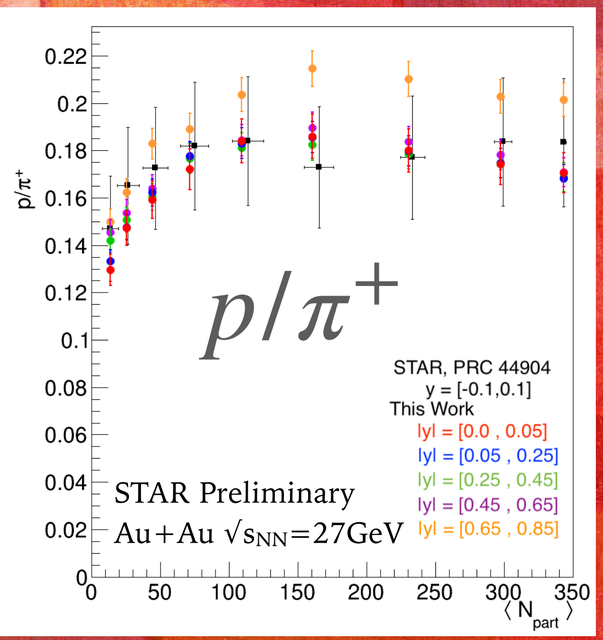
PROTON PRODUCTION

- Thermal and participant protons
- Baryon stopping
- Baryon chemical potential (μ_B)
- New results were feed-down corrected based on UrQMD, while the previous results were not.



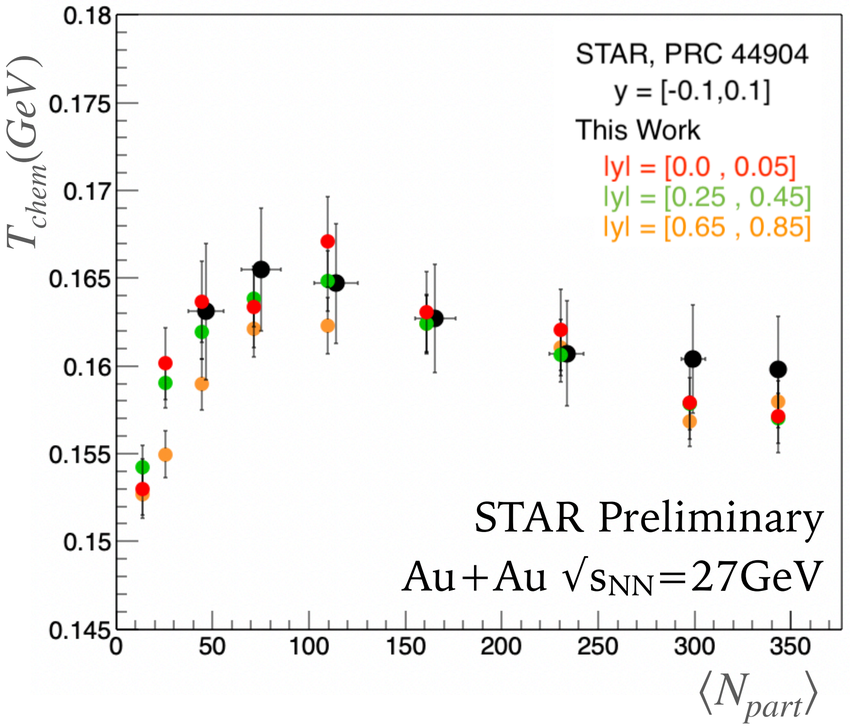




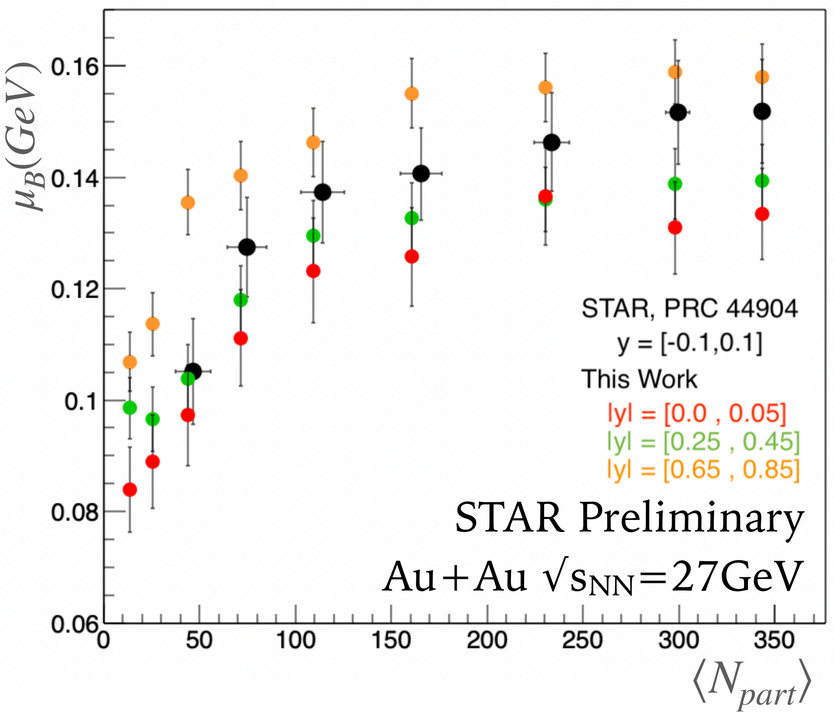


THERMUS RESULTS

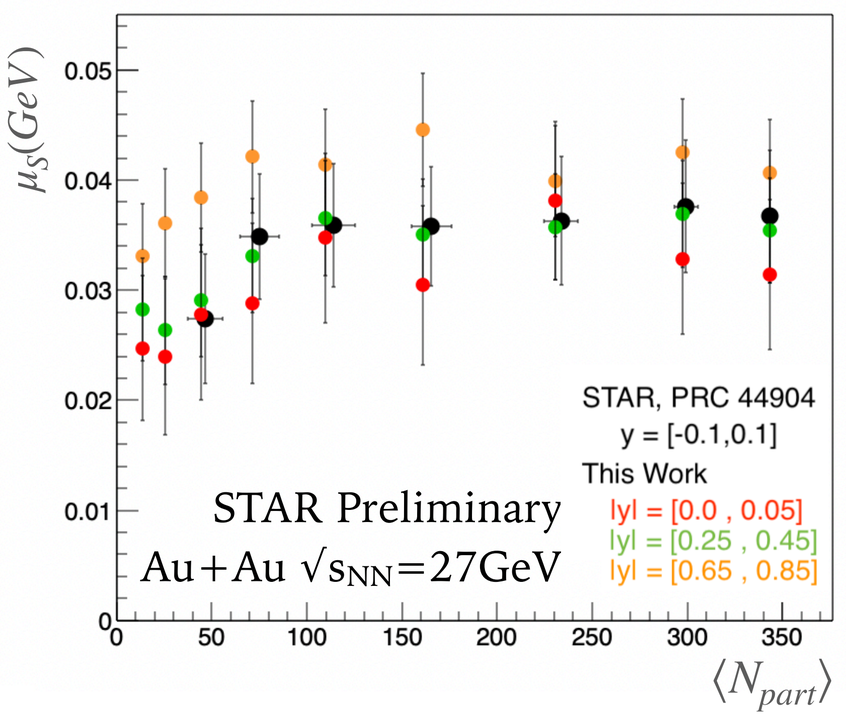
T_{chem}



μ_B

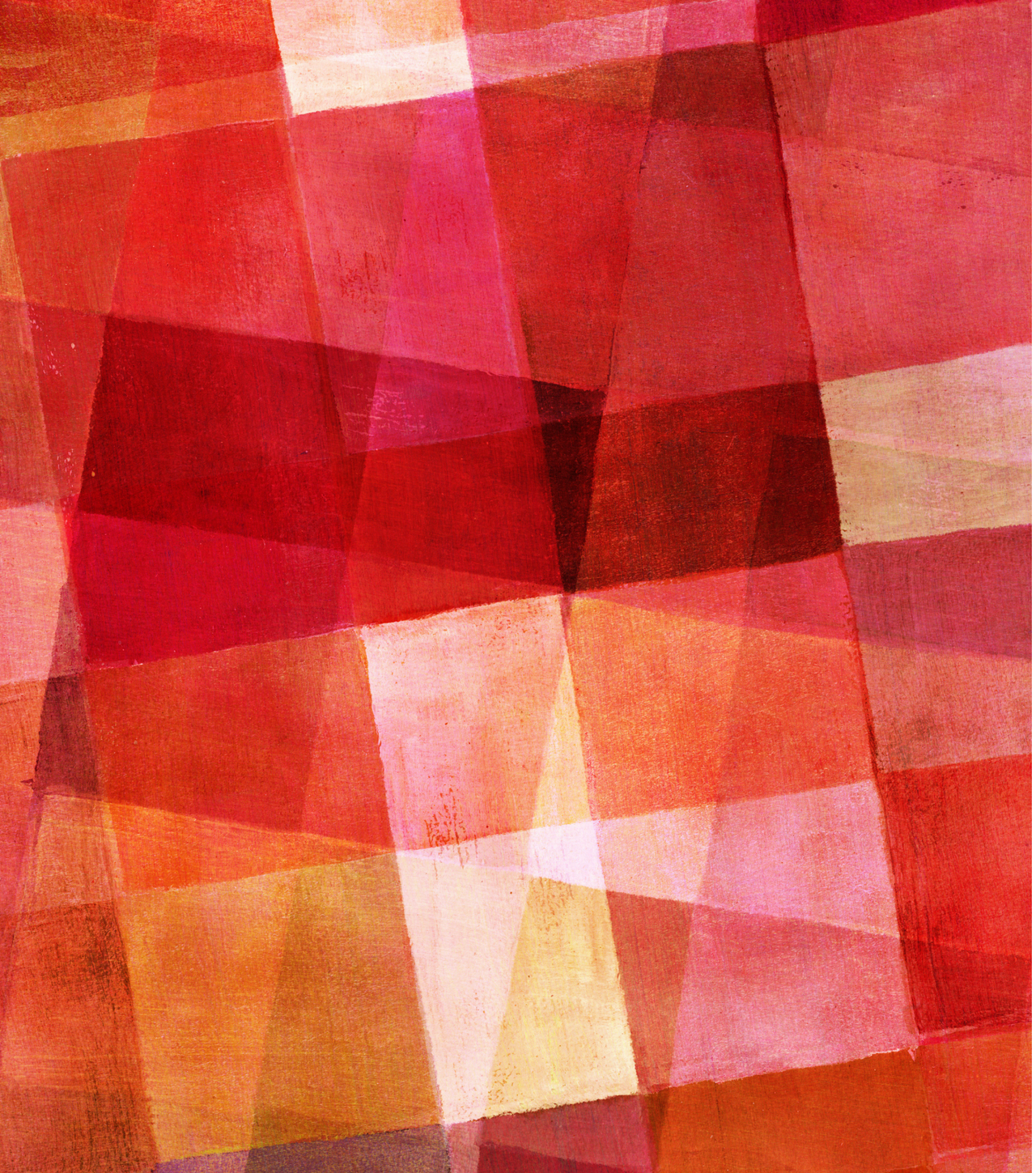


μ_S



- Only statistical errors are shown
- Grand-Canonical Ensemble
  - Energy and quantum numbers enforced on average

- $\Delta\mu_B \sim 25$ MeV for 1 unit of rapidity
- Peripheral events extend coverage



CONCLUSIONS

- Analysis of BES-II data underway
- $\sqrt{s_{NN}}$ = 27 GeV: π, K, p production has been measured beyond mid-rapidity
- Centrality dependence of particle production has been studied
- Study of thermodynamic variables
- Future Work:
  - Other collider energies:
    - $\sqrt{s_{NN}}$: 19.6, (17.1), 14.6, 11.5, 9.2, 7.7 GeV

REFERENCES

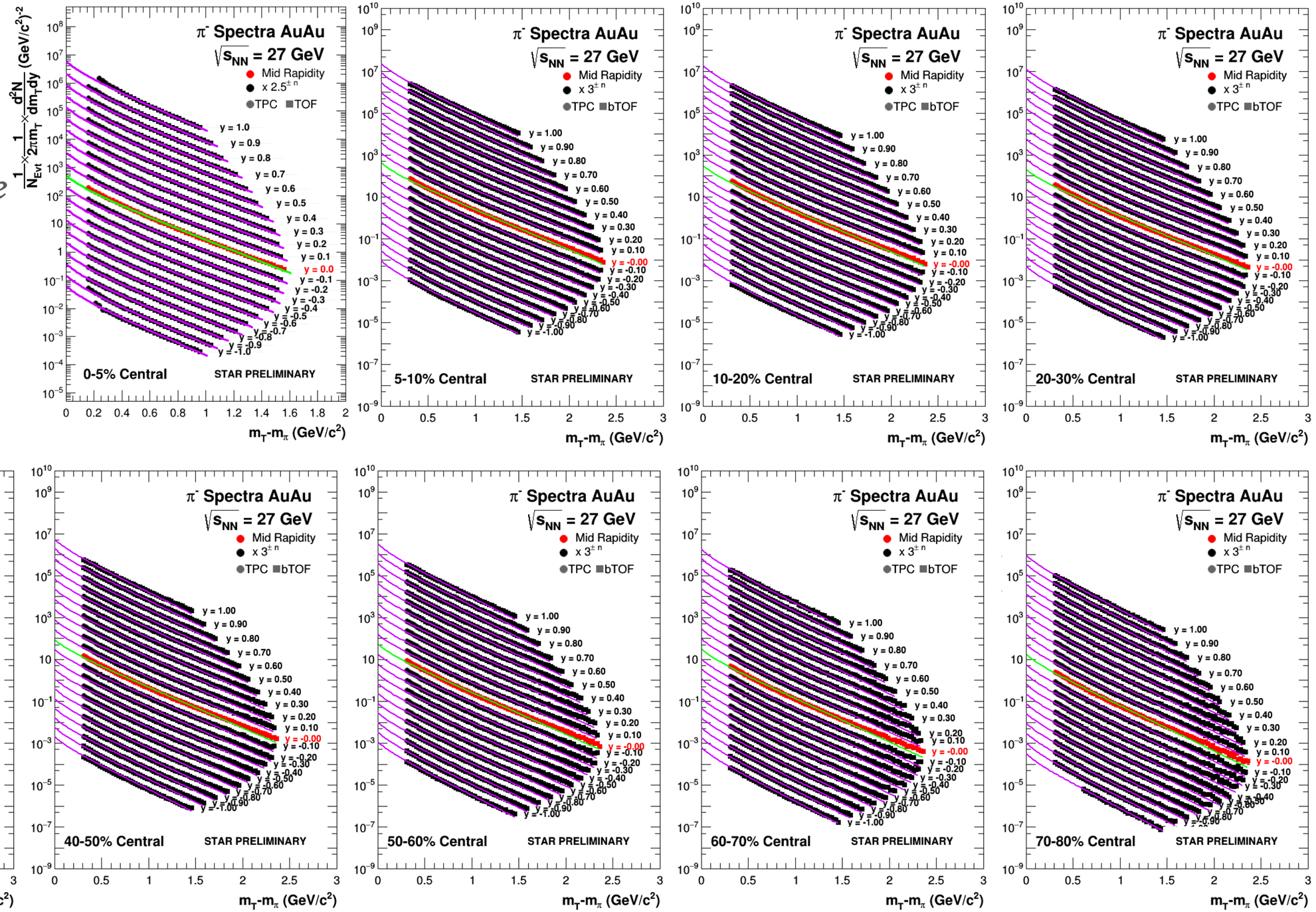
- [1] STAR, “Bulk Properties of the Medium Produced in the Relativistic Heavy-Ion Collisions from the Beam Energy Scan Program” Phys. Rev. C 96 p44904 (2017)
- [2] Schnedermann, Sollfrank, and Heinz. “Thermal phenomenology of hadrons from 200A GeV S+S collisions” Phys. Rev. C 48 p2462-2475 (1993)
- [3] Mekjain, Aram. “Properties of baryonic, electric and strangeness chemical potentials” Phys. Lett. B 651 p33-38 (2007)

Thank You

for Your Attention

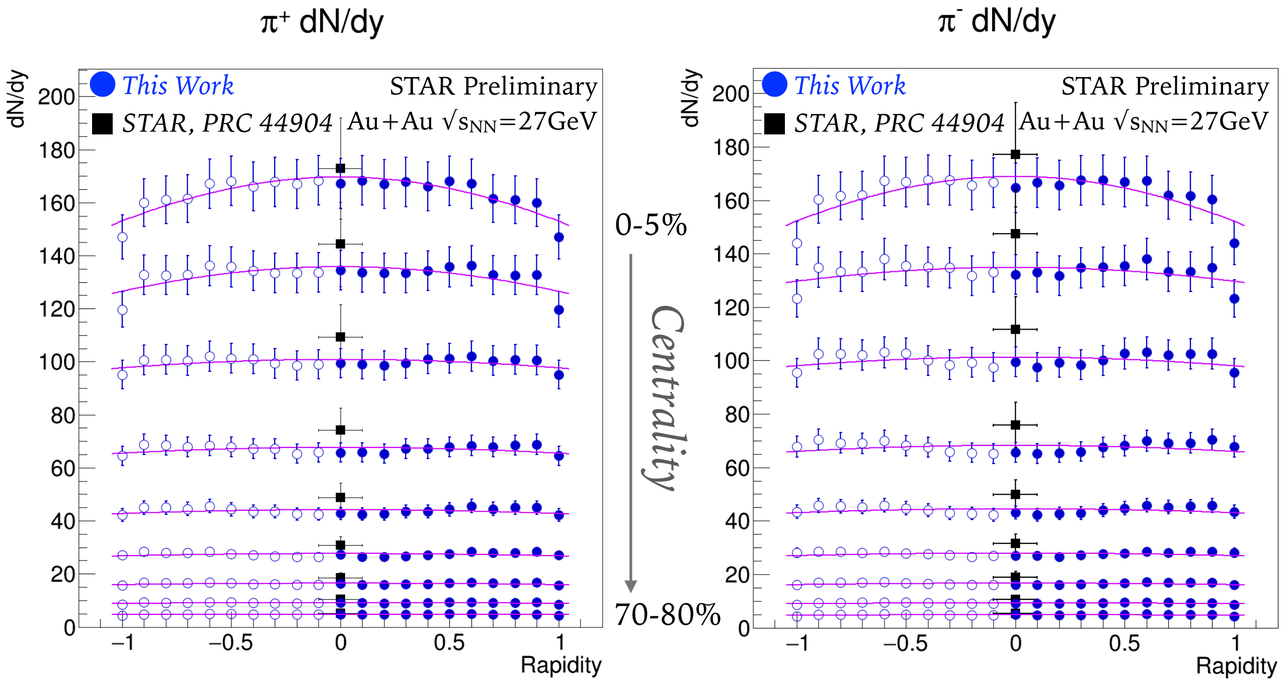
Centrality Dependence Of π⁻ Spectra

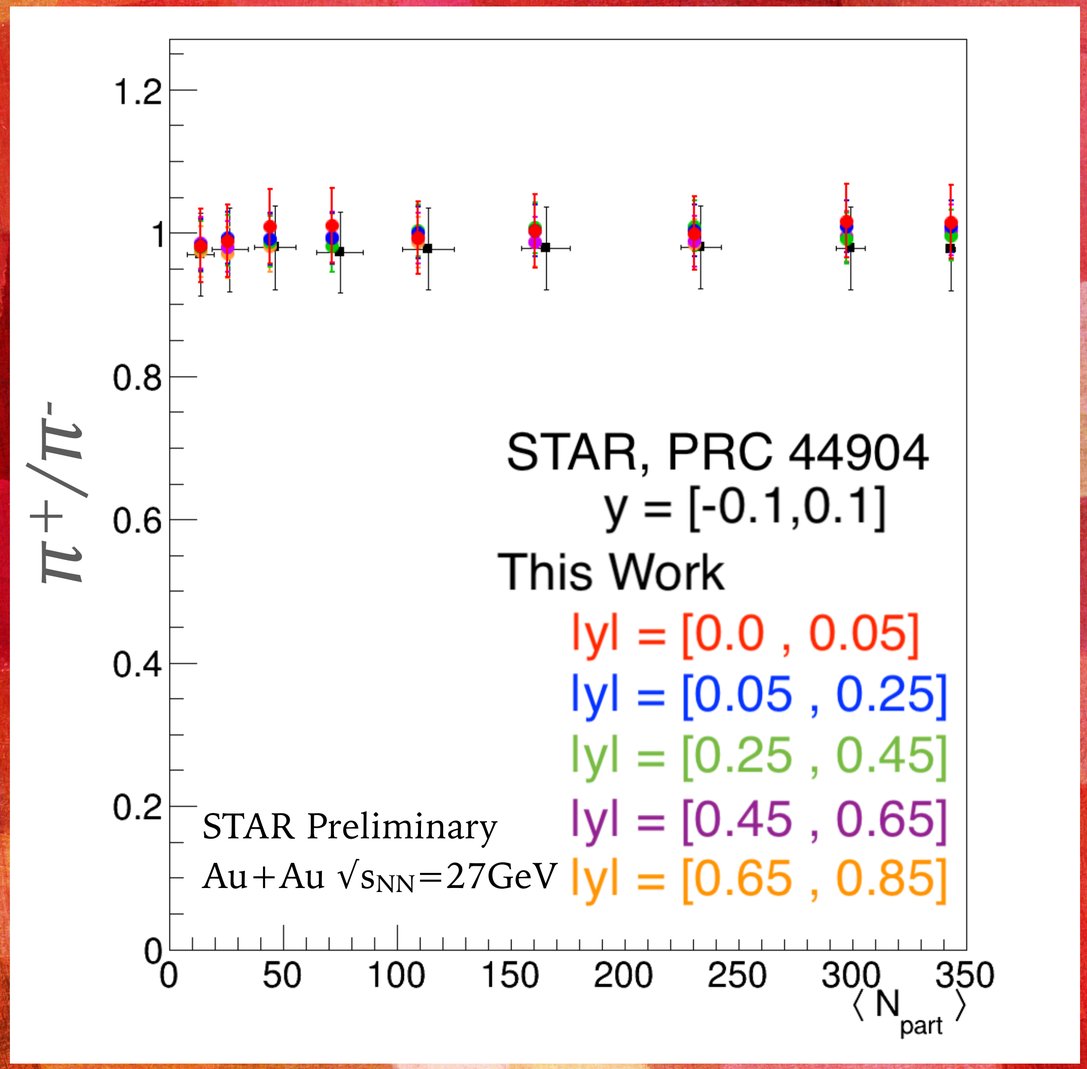
(Other π, K, p also measured)



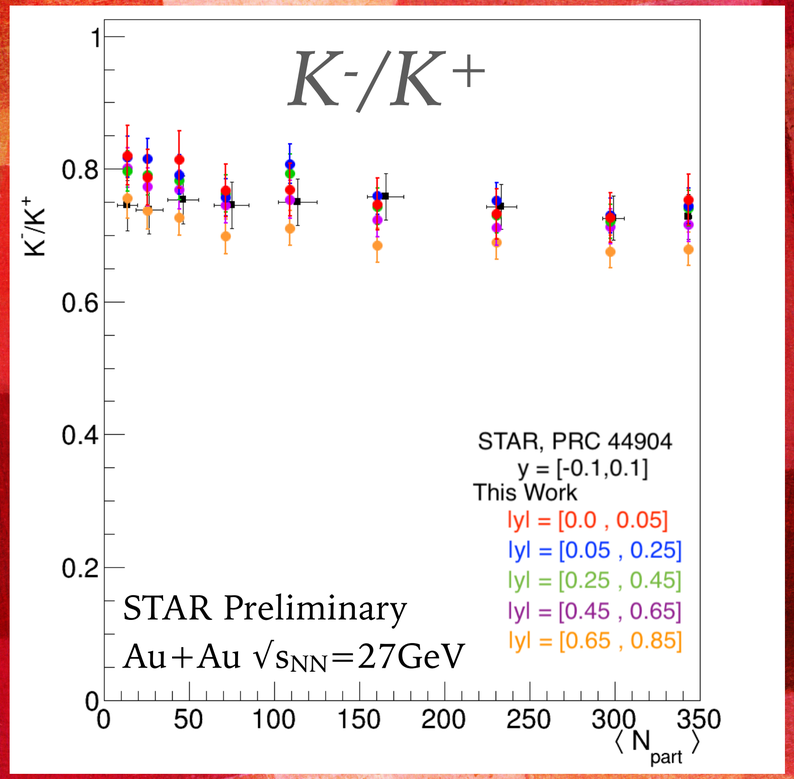
PION PRODUCTION

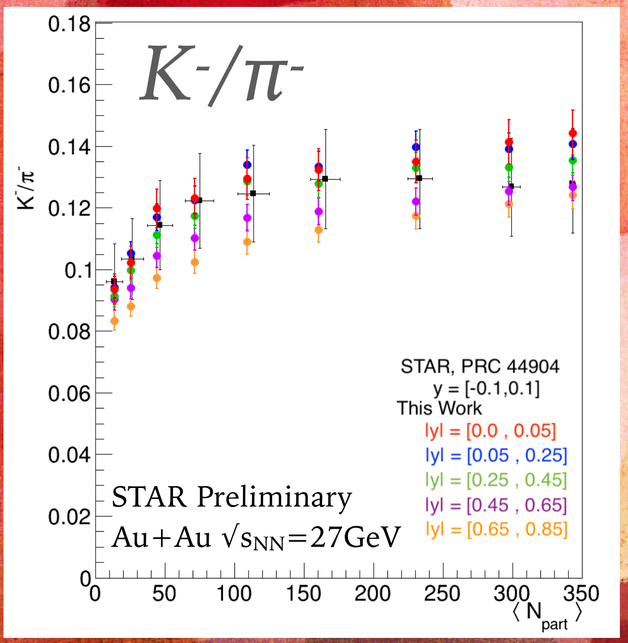
- Thermally produced
- Charge chemical potential (μ_Q)
- Little variation in ratio by centrality

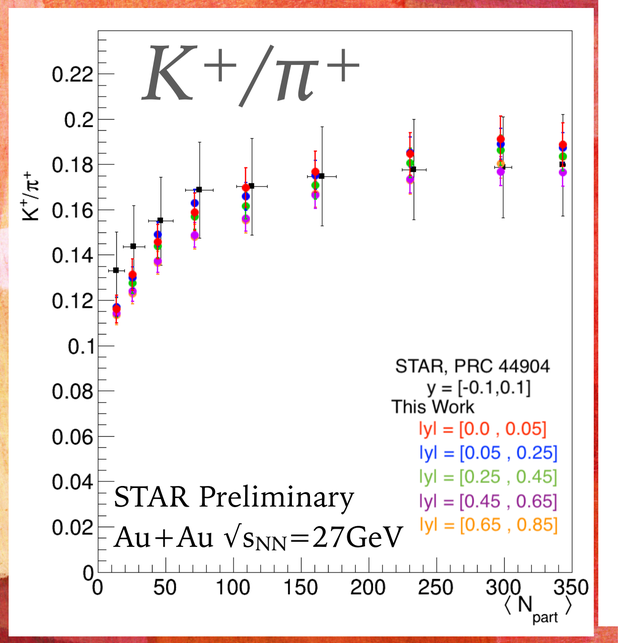




KAON PRODUCTION





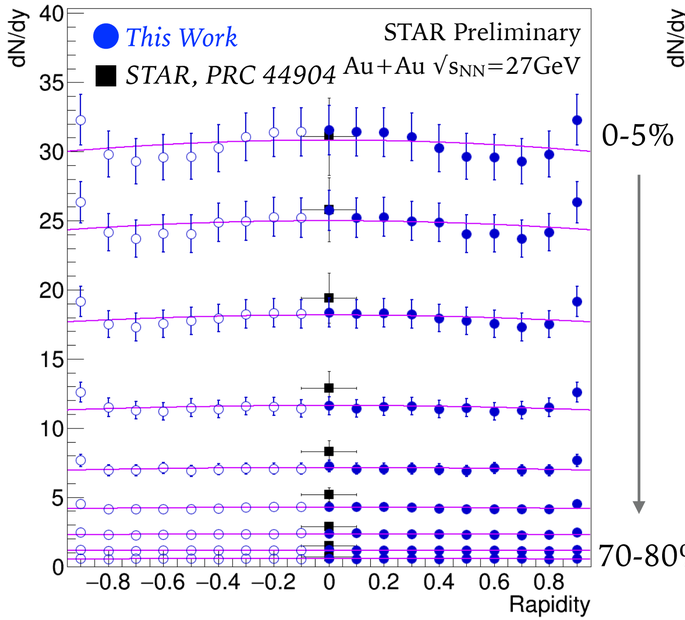


- Thermal production of K^+ and K^-
- ~1/3 of K^+: associated production

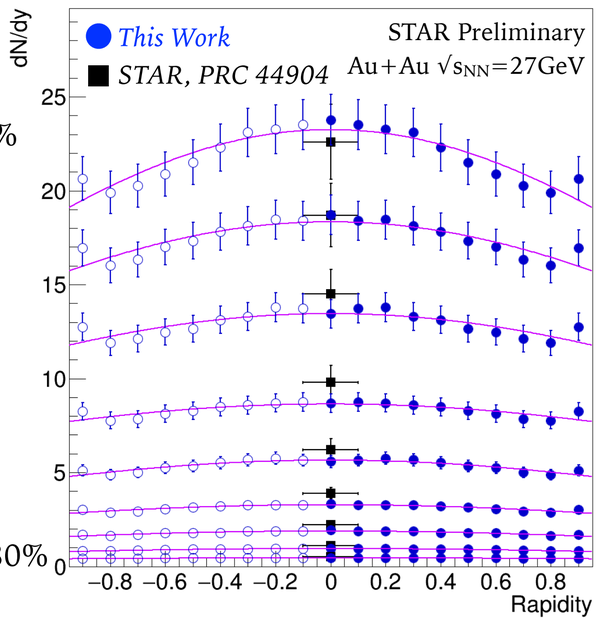
$$NN \rightarrow N\Lambda K^+$$

- Associated production increases with y
- Strangeness chemical potential (μ_S)

K^+ dN/dy



K^- dN/dy



BARYON CHEMICAL POTENTIAL FROM PROTON RATIO

$$\frac{N_{\bar{p}}}{N_p} = e^{-\frac{2\left(\mu_B+\mu_Q\right)}{T_{ch}}}$$

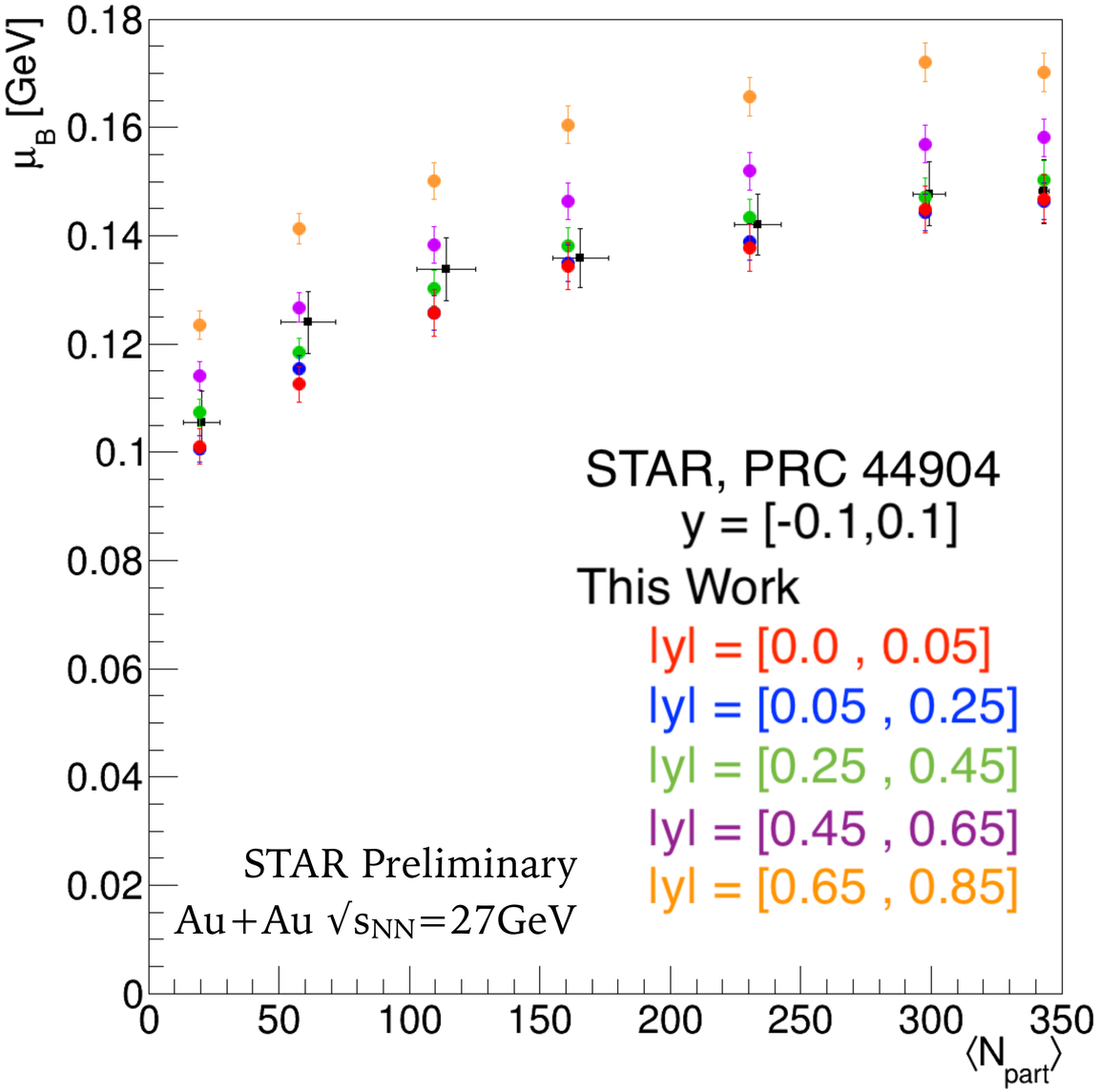
$$\mu_B = -\frac{T_{ch}}{2}\ln\frac{N_{\bar{p}}}{N_p} - \mu_Q$$

T_{ch} for each N_{part} are fixed

[STAR, PRC 44904 (2017)]

$$\mu_Q = -12.9 \text{ MeV}$$

[Mekjian, PLB 651 (1993)]



- $\Delta\mu_B \sim 25$ MeV for 1 unit of rapidity
- Peripheral events extend coverage:
  - $\mu_B = [100\text{MeV}, 170\text{MeV}]$