Fixed Target Results from STAR using Gold on Beam Pipe (Al) Events

The Coulomb Effect in Au+Al Collisions at

$\sqrt{s_{NN}}$ = 3.0, 3.5, and 4.5 GeV

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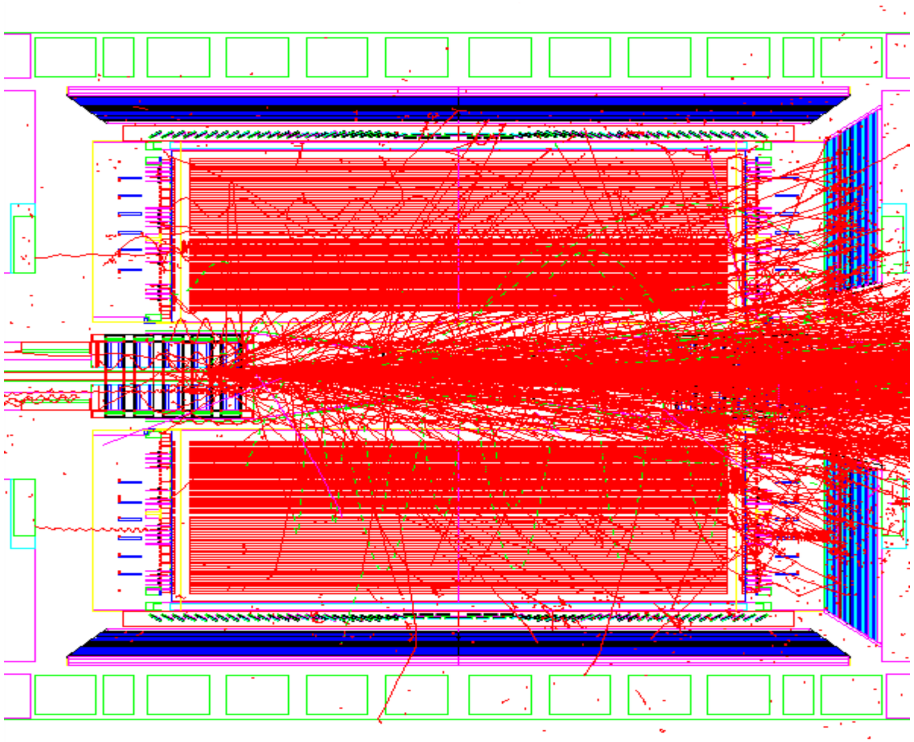
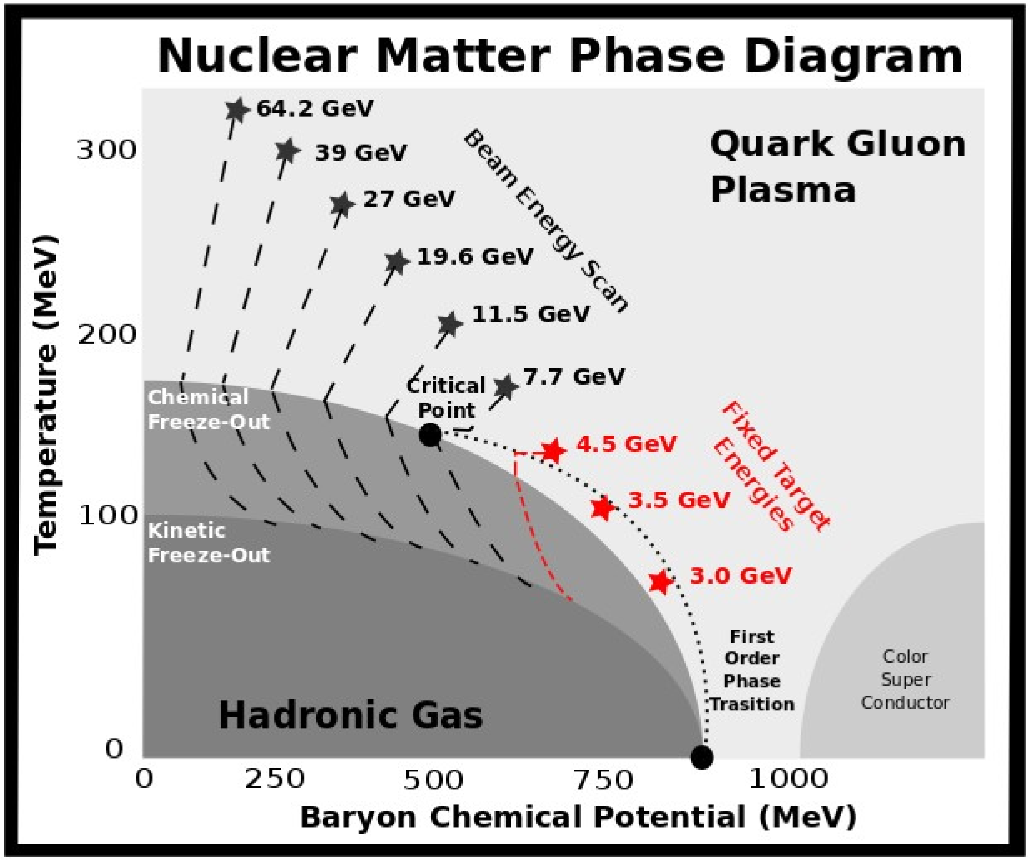
Outline

- Motivation for Fixed Target Analysis
- Event Selection
- Pion/Proton Acceptance
- Particle Identification
- Particle Spectra
- Coulomb Fit
- Conclusions



Simulation of Au+Al fixed target event in the STAR detector using URQMD and STARSIM.

Motivation



RHIC Beam Energy Scan Goals

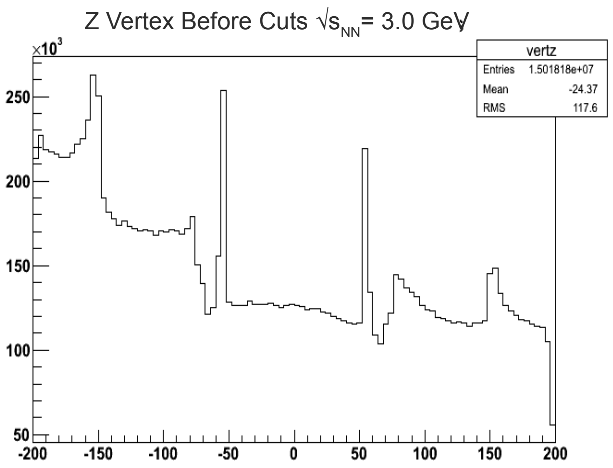
- Turn off QGP signatures
- Find Critical Point
- Study the existence and properties of a first order phase transition

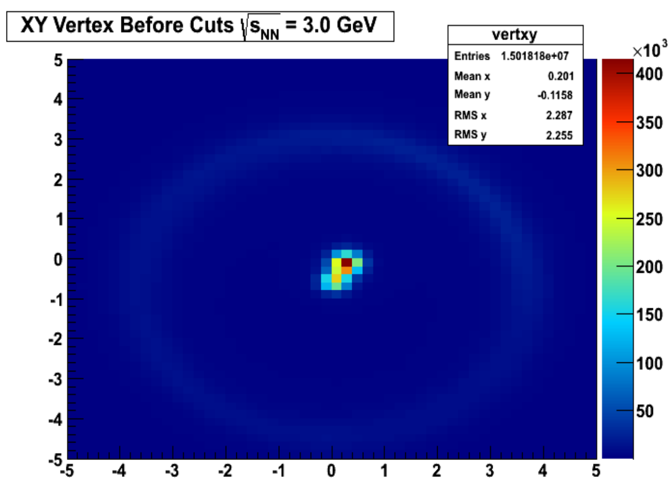
Fixed Target Analysis

- Extends the BES to lower energies to expand search
- Allows for STAR results to be compared to previous experiments

Event Selection

Before Cuts





Event Cuts

- Vertex Requirements -

$-200 \leq V_z \leq -150$ cm

$2 \leq V_R \leq 5$ cm

- Momentum -

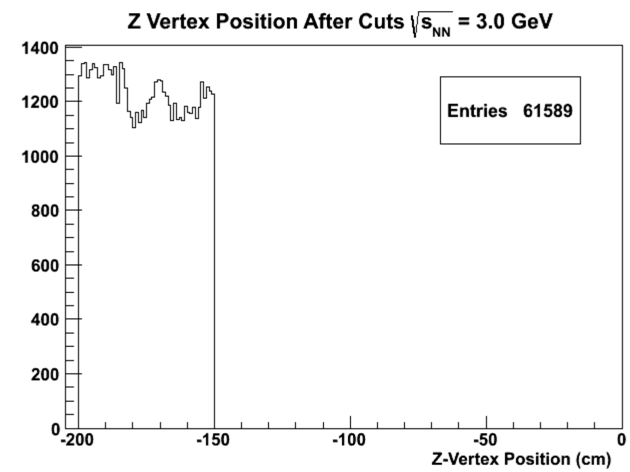
$$\sum_{Tracks} p_z > 0$$

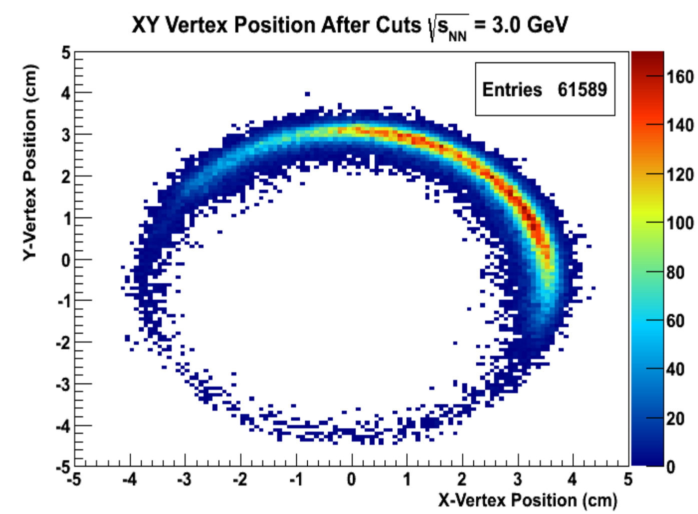
- Centrality Cut -

Top 10 %

Apply Cuts

After Cuts

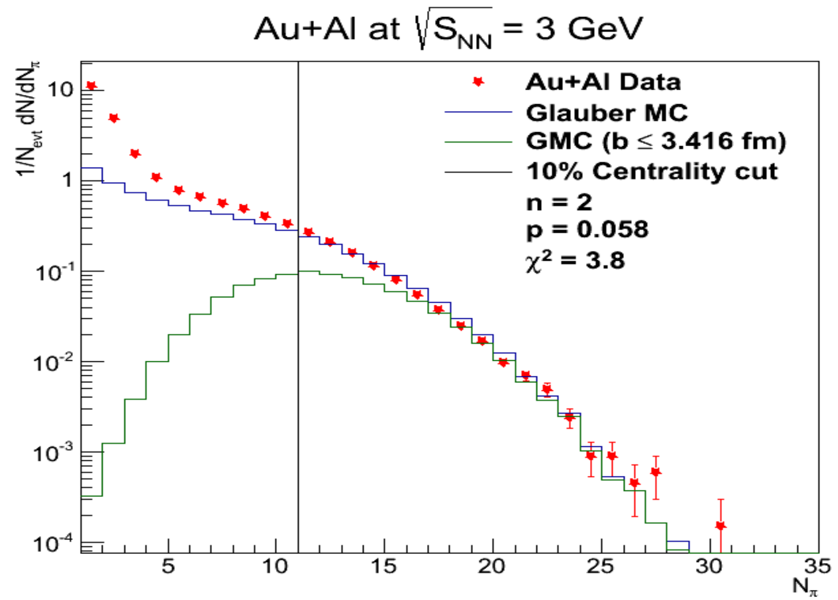


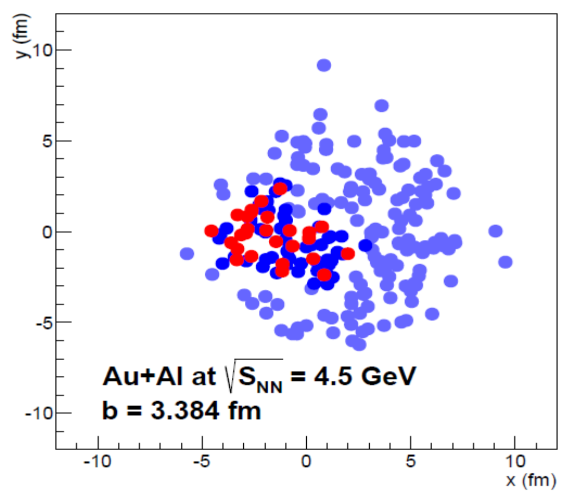


Centrality Cut

Centrality is determined using pion multiplicity

- Glauber Monte Carlo model is used to estimate number of participants (collisions)
- Pion multiplicity per participant (collision) is modeled with a negative binomial distribution
- Grid search is performed to find parameters of NBD which best fit the Au+Al pion multiplicity data

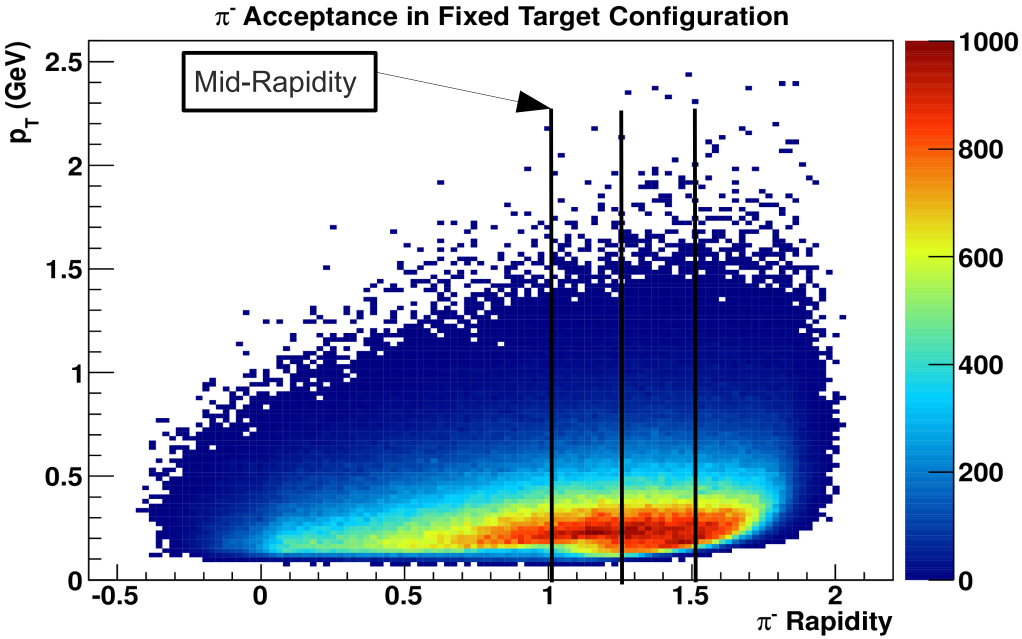


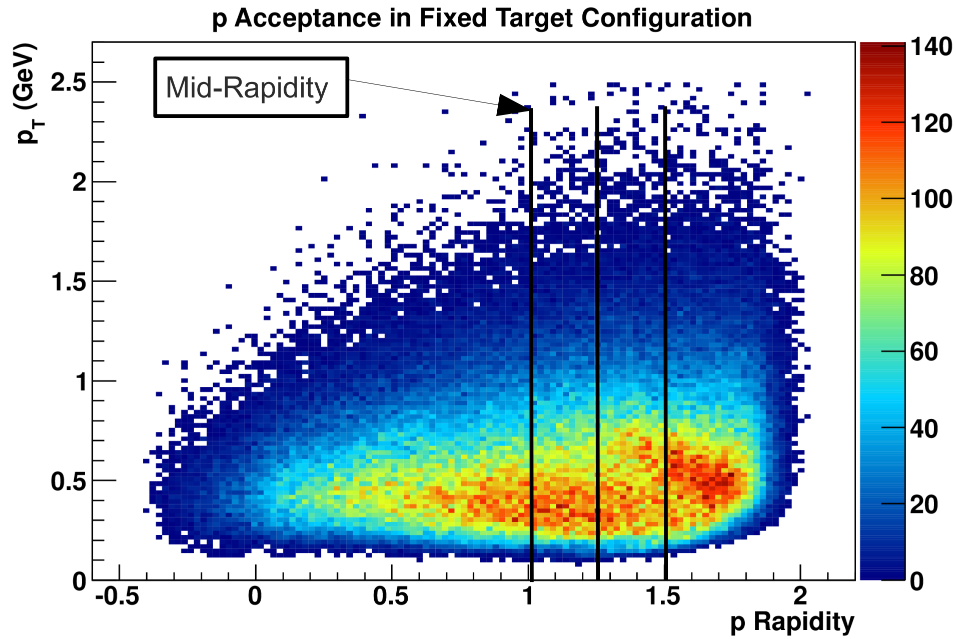


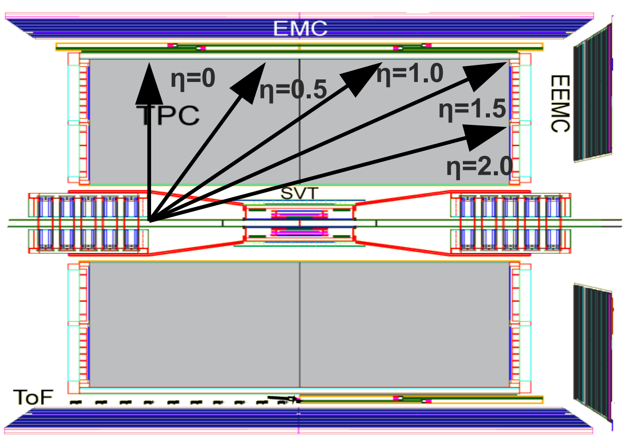
TOP: Comparison of Pion multiplicity from GMC simulation to data.

Left: Transverse section of an Au+Al event showing participant nucleons and overlap region.

Pion/Proton Acceptance





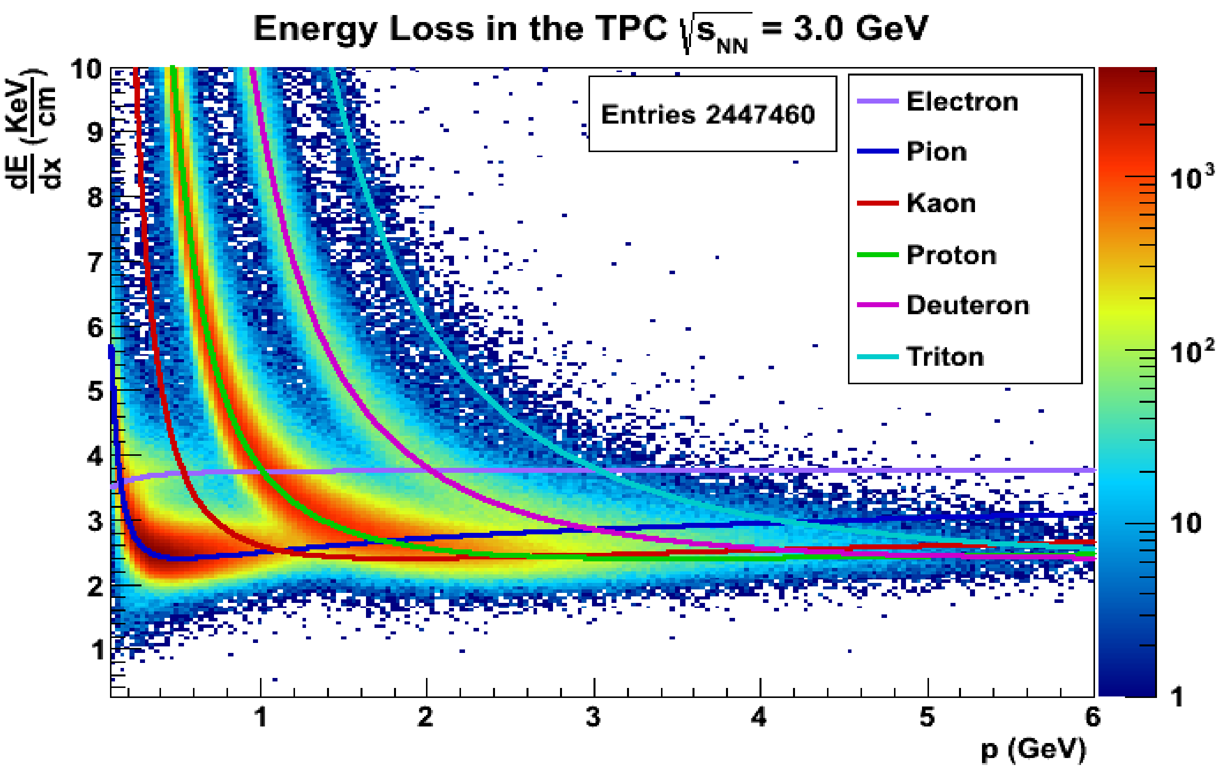


Acceptance

→ Midrapidity for 3.0 GeV is 1.05; 1.25 for 3.5 GeV and 1.5 for 4.5 GeV

→ STAR has good acceptance from midrapidity back to target rapidity (for all three energies)

Particle Identification and Fits



Above: Energy loss in the TPC as a function of momentum for tracks of events satisfying event selection criteria.

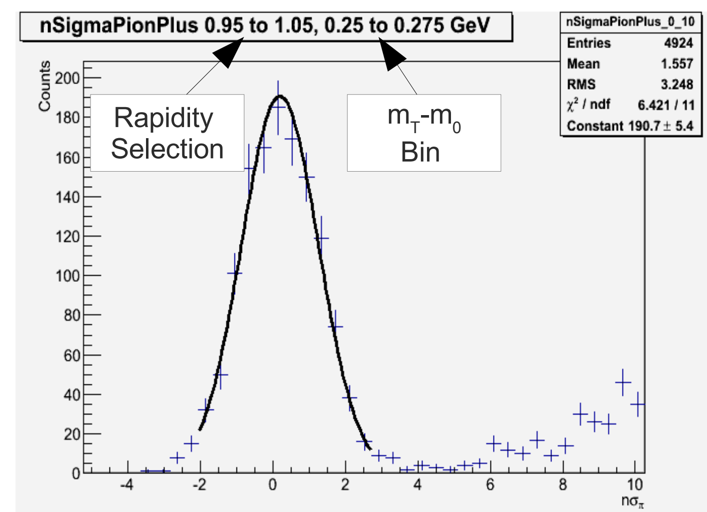
Right: Example of a Gaussian fit in a single m_T-m_0 bin used to extract pion yield.

Energy Loss in TPC

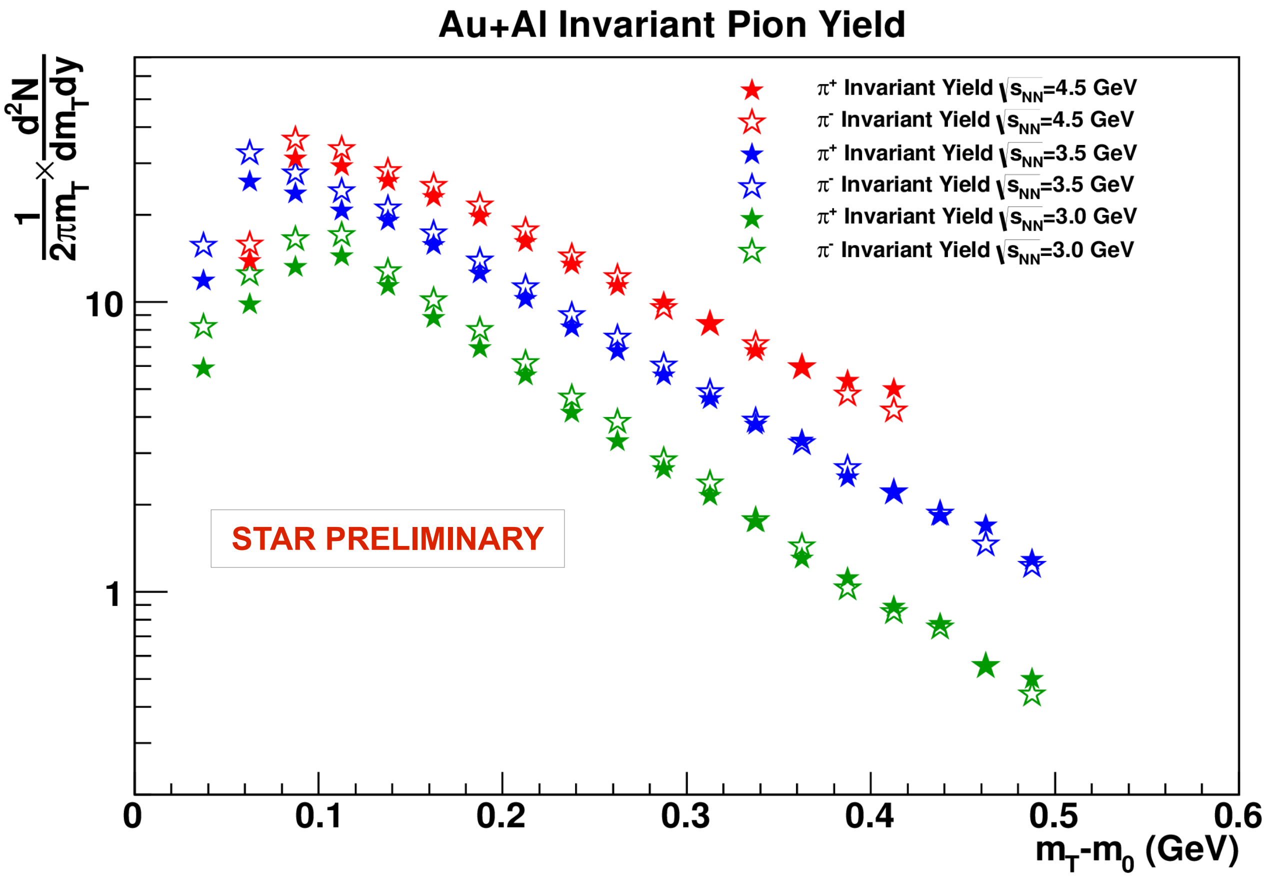
- Excellent PID capabilities in fixed target configuration

nσ Fit

- Tracks are separated into transverse mass bins and fit with Gaussians to extract yield



Pion Spectra



Uncorrected Pion Spectra

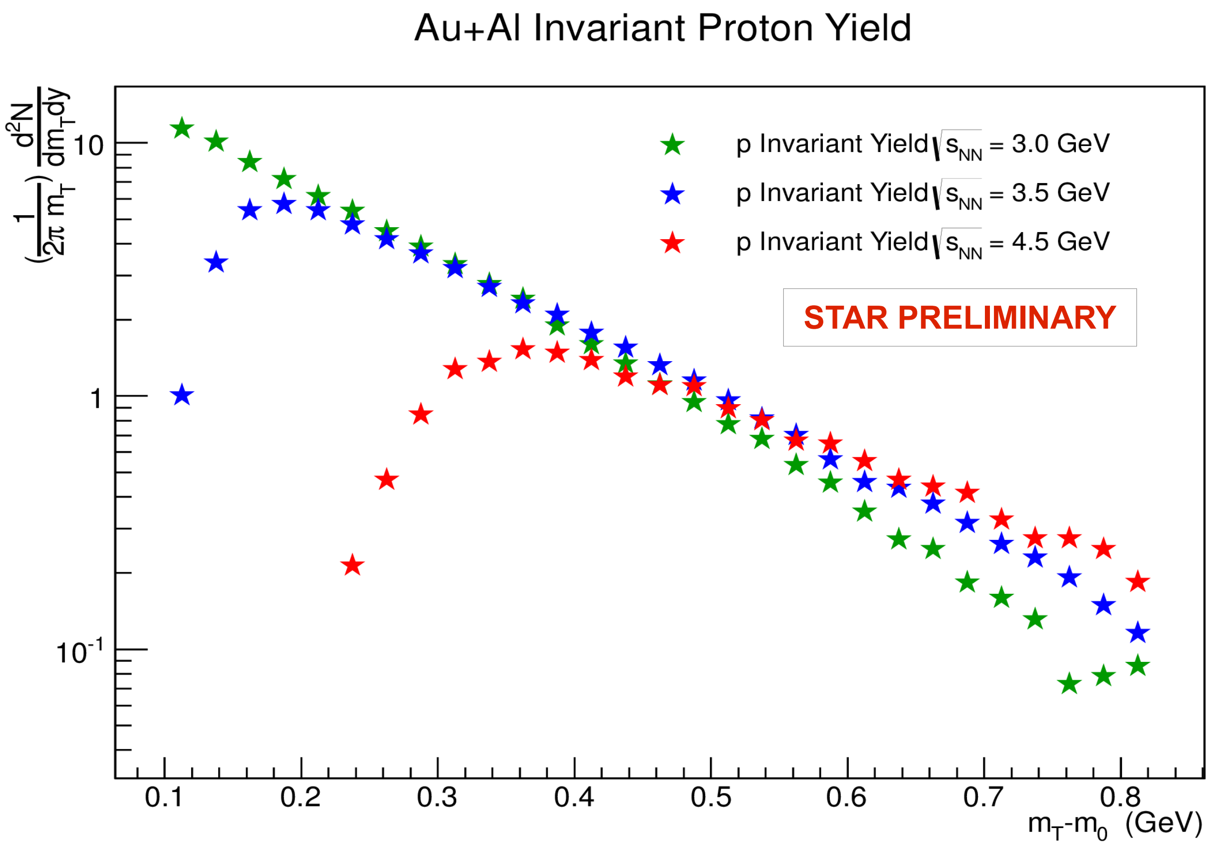
→ Efficiency corrections will primarily effect the lowest m_T-m_0 bins

→ Need study of detector material interaction effects

→ Pion yield expected to increase with energy

→ Slope parameter will be extracted and used in the Coulomb fit of the pion ratio

Proton Spectra



Uncorrected Proton Spectra

→ Efficiency corrections will primarily effect the lowest m_T-m_0 bins

→ Need study of detector material interaction effects

→ Proton yield expected to decrease with energy

→ Slope parameter will be extracted and used in the Coulomb fit of the pion ratio

Coulomb Fit to Pion Ratios

Coulomb Fit

The pion ratio is fit with a function of the form:

$$\frac{\pi^+}{\pi^-}(m_T - m_\pi) = R\frac{e^{(E+V_{Eff}/T_\pi)}-1}{e^{(E-V_{Eff}/T_\pi)}-1}J$$

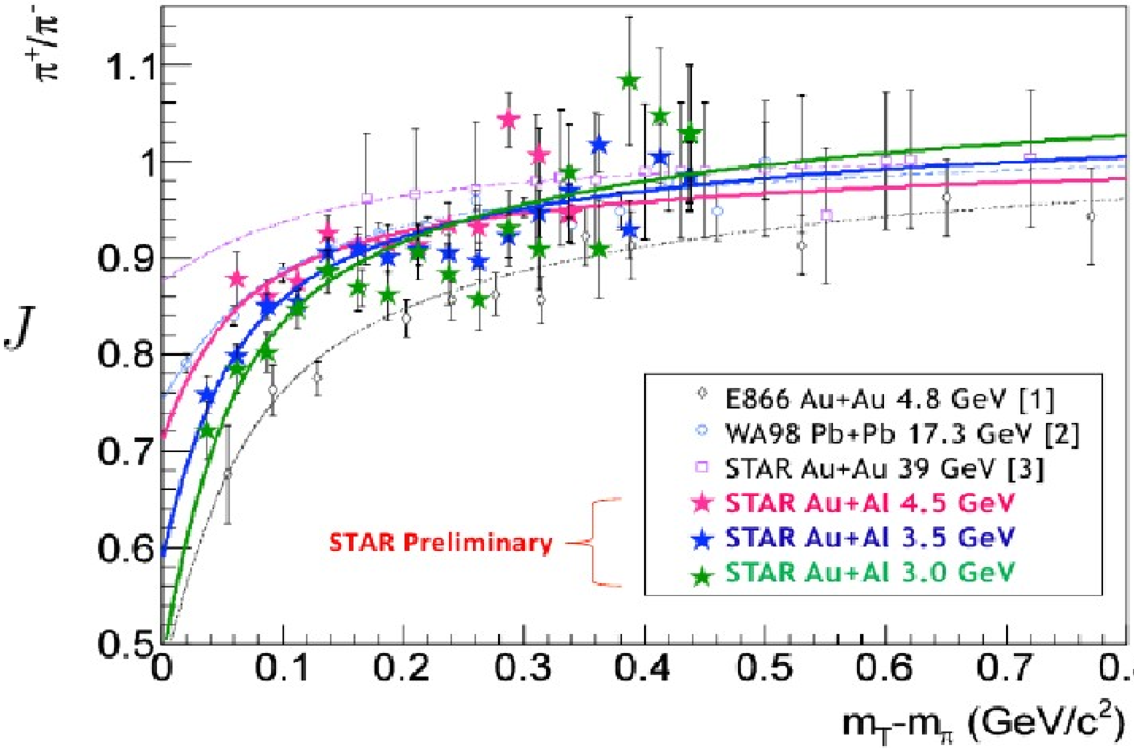
where J is the Jacobian, V_{Eff} is the effective potential given by

$$V_{Eff}(\gamma_\pi\beta_\pi) = V_C(1-e^{-E_{max}(\gamma_\pi\beta_\pi)/T_p})$$

where

$$E_{max}(\gamma_\pi\beta_\pi) = \sqrt{(m_p\gamma_\pi\beta_\pi)^2 + m_p^2} - m_p$$

V_C is the Coulomb Potential, and R is the initial pion ratio.



[1] L. Ahle et al. (E866) Nucl.Phys. A610, 139c (1996), and PRC57, R446 (1998).
[2] L. Rosselet et al. (WA98) Nucl.Phys. A698, 647c (2002).
[3] L. Kumar et al. (STAR) J.Phys.G; Nucl.Part.Phys. 38 (2011) 124145

Error bars are statistical only
Systematic error analysis of efficiency and background corrections is underway

Conclusions

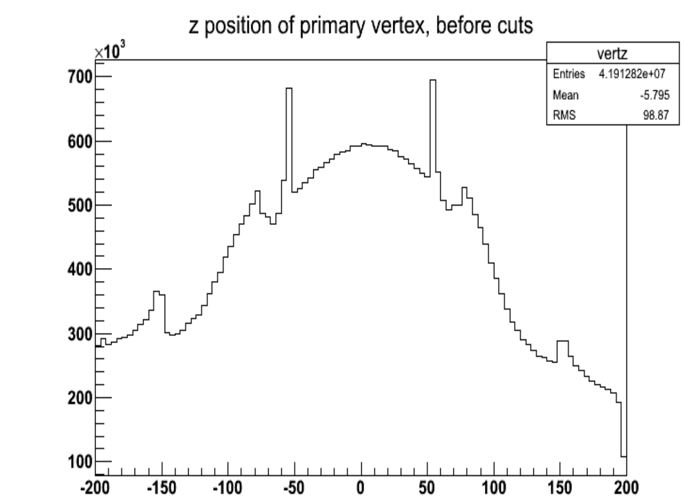
Analysis of Au+Al fixed target collisions at STAR using RHIC has been successful

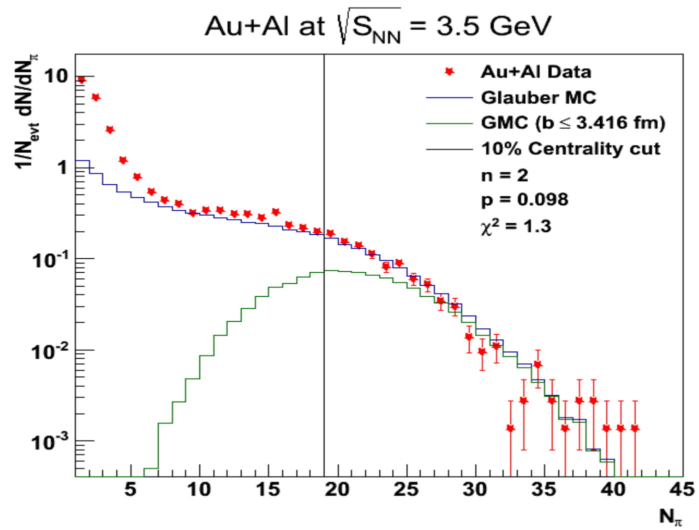
- Particle Identification for fixed target collisions is excellent
- STAR has good acceptance for fixed target collisions from midrapidity to target rapidity
- **STAR can be used to analyze fixed target collisions.**

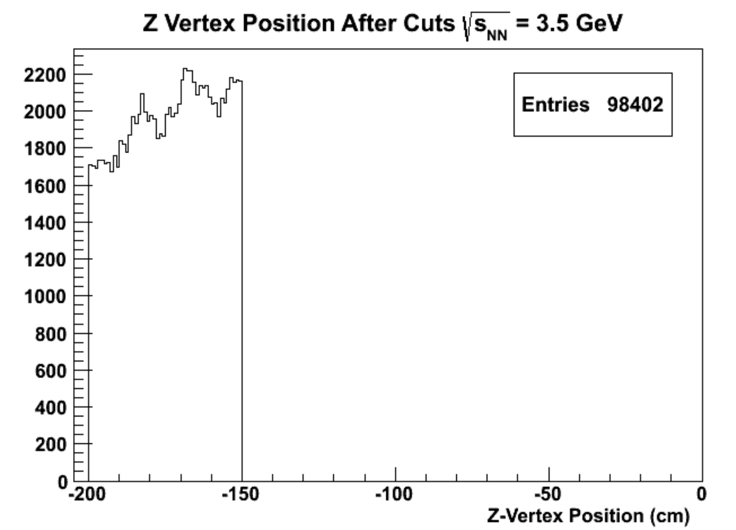
Acceptance and efficiency corrections will allow the ability to:

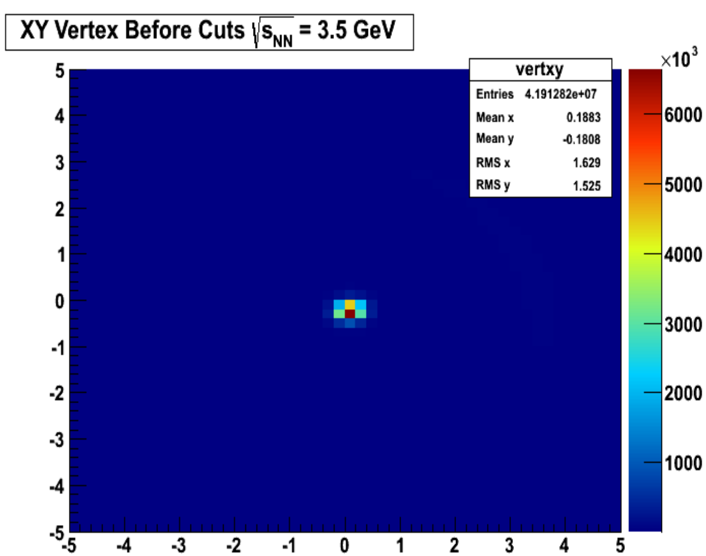
- Determine the energy dependence of the initial pion ratios and Coulomb potential

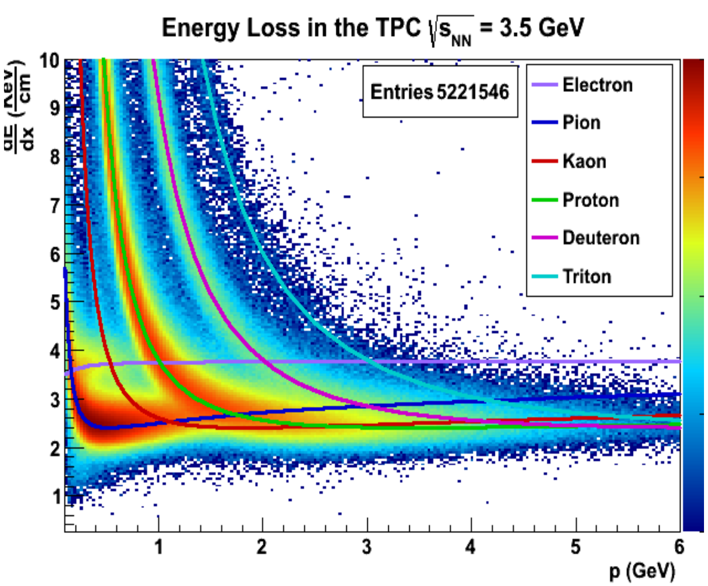
BackUp: 3.5 GeV

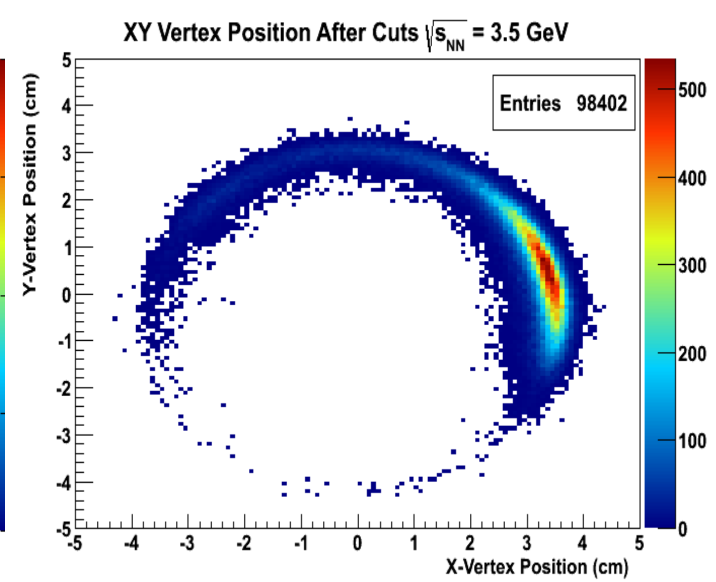












Backup: 4.5 GeV