Energy Systematics of the Coulomb Effect in Au+Au Collisions $\sqrt{s_{NN}}$ = 3.0 GeV at STAR

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Abstract

In Au+Au collisions at STAR, the colliding ions leave a positively charged interaction region, especially in the low energy collisions of the Beam Energy Scan II (BES-II) and Fixed-Target programs. Due to the Coulomb potential of this positive source, positively charged particles are pushed to higher momentum, while negatively charged particles are pulled toward lower momentum. This is most evident in the charged pions since they are the lightest hadrons and are produced copiously. By fitting the final ratio of pions, π^+/π^-, as a function of $m_T - m_\pi$ with a physics motivated model, we can extract the Coulomb potential, V_C, and initial pion ratio, R_i. These allow us to study the volume of the fireball and the charge chemical potential, respectively. Results from $\sqrt{s_{NN}}$ = 3.0 GeV will be presented along with comparisons to AGS, SIS, and SPS experiments.

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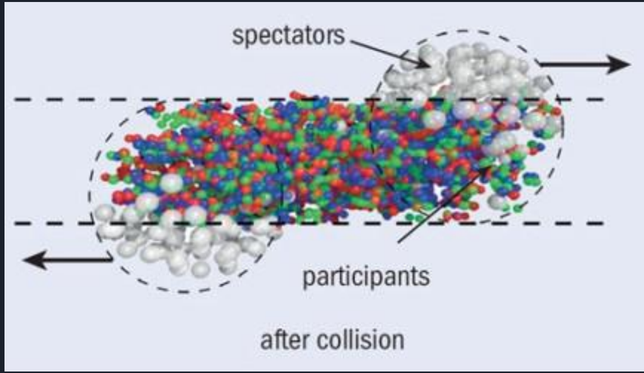
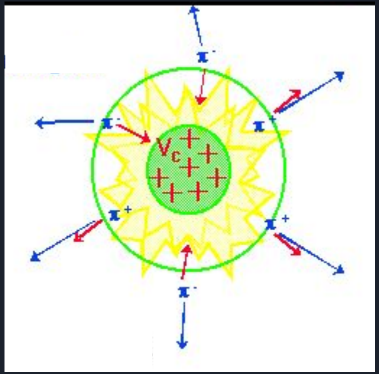
Introduction

1. STAR fixed target: A gold nucleus collides with another gold nucleus in a thin gold foil at close to the speed of light
2. At low bombarding energy (a few GeV), protons are stopped in the interaction region
3. The stopped protons produce a region of positive charge and provides a strong Coulomb potential
4. Using the equation for Coulomb potential of a point charge, we can estimate the **size of the fireball**
5. Pions, the lightest hadrons, are affected by this Coulomb potential more than heavier hadrons
6. Using a physics model which employs the correct transformation Jacobians and a Bose-Einstein distribution for the pions, we can extract the Coulomb potential from the final pion ratio

$$R_f(E_f) = \frac{E_f - V_C}{E_f + V_C} \frac{\sqrt{(E_f - V_C)^2 - m^2}}{\sqrt{(E_f + V_C)^2 - m^2}} \frac{A^+ (e^{(E_f + V_C)/T_\pi} - 1)}{A^- (e^{(E_f - V_C)/T_\pi} - 1)}$$



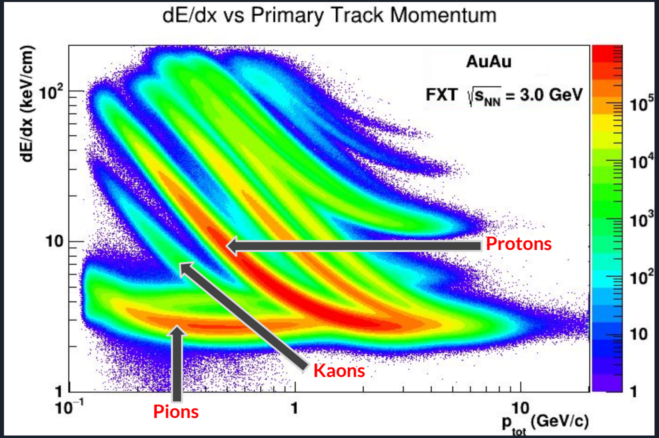
$$V_c(r) = \frac{Q}{4\pi\epsilon_0 r}$$

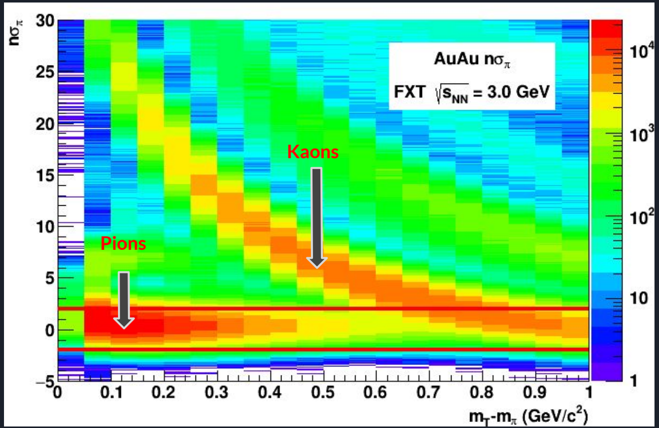


Work Cited:
D. Cebra et al. *Coulomb effect in Au+Au and Pb+Pb collisions as a function of collision energy*. 2014. arXiv: 1408.1369 [nucl-ex].

Methods

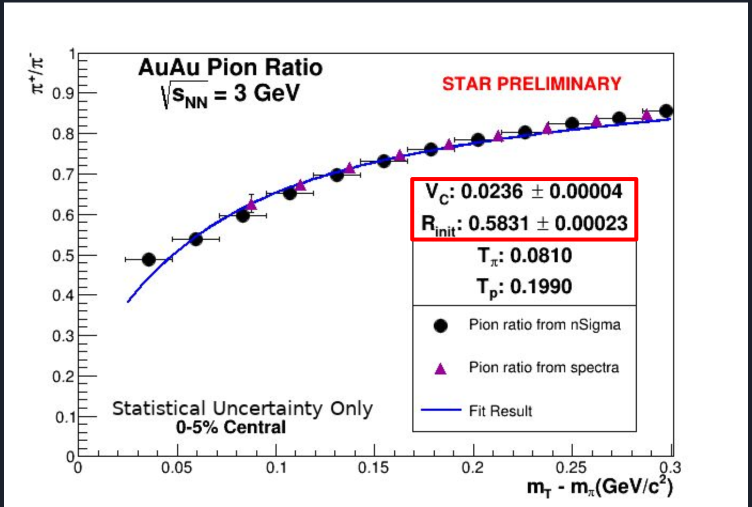
- Analyzing Pions in Au+Au FXT $\sqrt{s_{NN}}$ = 3.0 GeV
- 268 million events before quality cuts (242 million events after event cut)
- Event Selection Criteria:
  - Vertex in the target
  - Top 5% most central events. (If you are interested in centrality, see poster by Aaron Poletti for more details)
  - Tracks that trace back to the vertex (Tracks with a distance of closest approach to the interaction cartex of 3cm or less)
- Pion Identification:
  - nσ cut: |nσ| < 2
    - nσ: How many standard deviations a track's dE/dx is away from the predicted band.

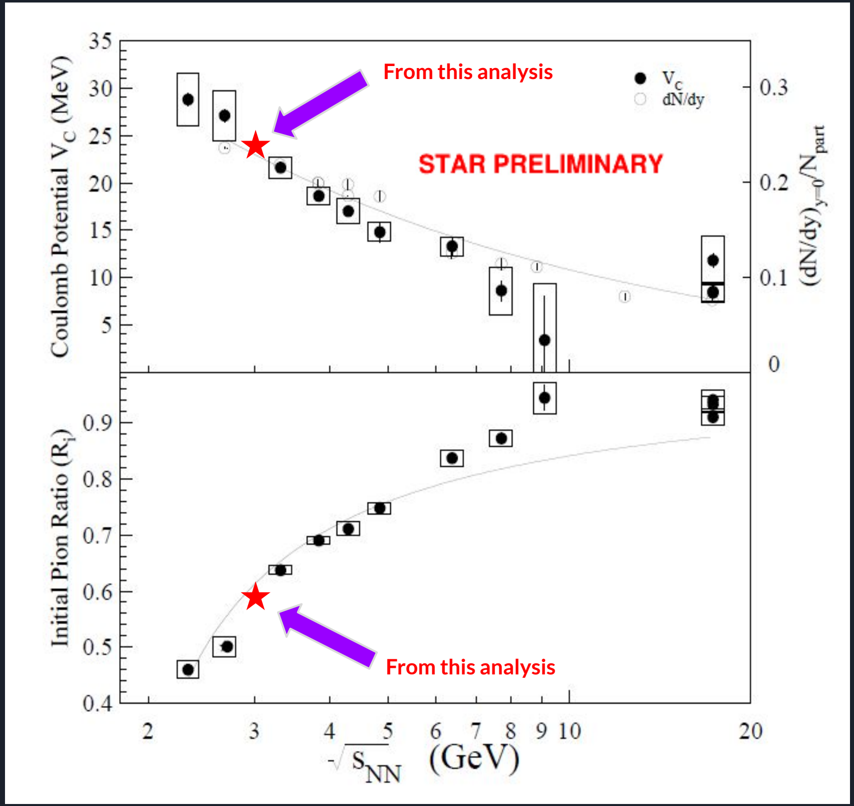




Results

- The ratio of pions is well-described by this Coulomb model
- The fit allows us to extract the Coulomb potential and initial pion ratio
- The extracted parameters are consistent with world data





Source: D. Cebra et al. *Coulomb effect in Au+Au and Pb+Pb collisions as a function of collision energy*. 2014. arXiv: 1408.1369 [nucl-ex].

Conclusions and outlook

- 3 GeV Coulomb potential V_C and initial pion ratio R_i follow the global trend of the energy dependence
- Excited to analyze higher energy data we collected:
  - $\sqrt{s}_{NN}$ = 3.2, 3.5, 3.9, 4.5, 5.2, 6.2, 7.2, 7.7 (GeV)
- Working on more sophisticated framework to take kaon contamination into account, necessary for the analysis at higher collision energies