Measurement of proton-Ξ^- correlation function in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at RHIC-STAR

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Introduction

The study of baryon-baryon interactions is important to understand existence of strangelets and various exotic hadrons, and for modeling of astronomical objects such as neutron stars. A detailed knowledge of nucleon-nucleon (NN) potentials exists in literature, however very little is known about interactions between anti-nucleons. Similarly lack of scattering data for hyperon-nucleon (YN) systems makes it difficult to construct YN potentials. In heavy-ion collisions, a large number of baryons are produced in each nucleus-nucleus collision, which allows us to study the NN and YN interactions. Measurements of two-particle correlation function are used to study the space-time dynamics of the source created in heavy-ion collisions. At low relative momentum, the two-particle correlations are effected by the Final State Interactions (FSI), making it possible to measure FSI between nucleon and multi-strange baryon (Ξ and Ω). In this poster, the first measurement of proton-Ξ correlation function from STAR experiment at $\sqrt{s_{NN}}$ = 200 GeV will be presented.

Femtoscopy

☆ Based on the correlation function: $C(\mathbf{k}^*) = \frac{P(\vec{p_a}, \vec{p_b})}{P(\vec{p_a})P(\vec{p_b})}$

- $\mathbf{k}^*$ is the relative momentum distribution, with $\vec{p_a} + \vec{p_b}$ =0

☆ Theoretically formula: $C(\mathbf{k}^*) = \int S(\mathbf{r}^*)|\Psi(\mathbf{k}^*, \mathbf{r}^*)|^2 d^3\mathbf{r}^*$

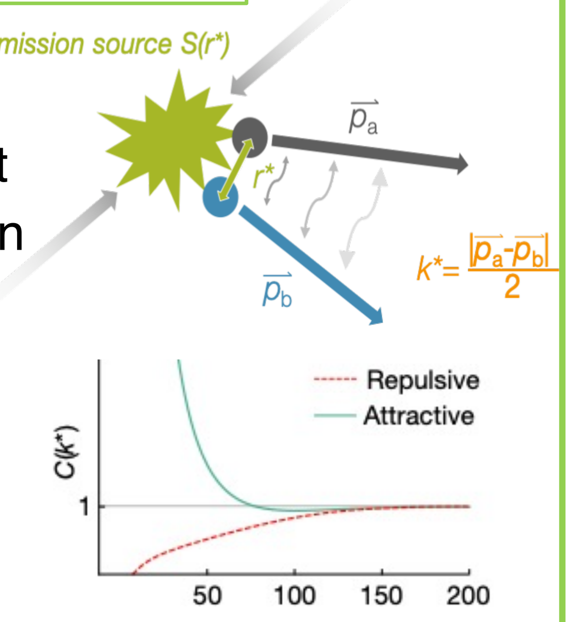
Source function

Relative wave function

Sensitivity to the interaction potential

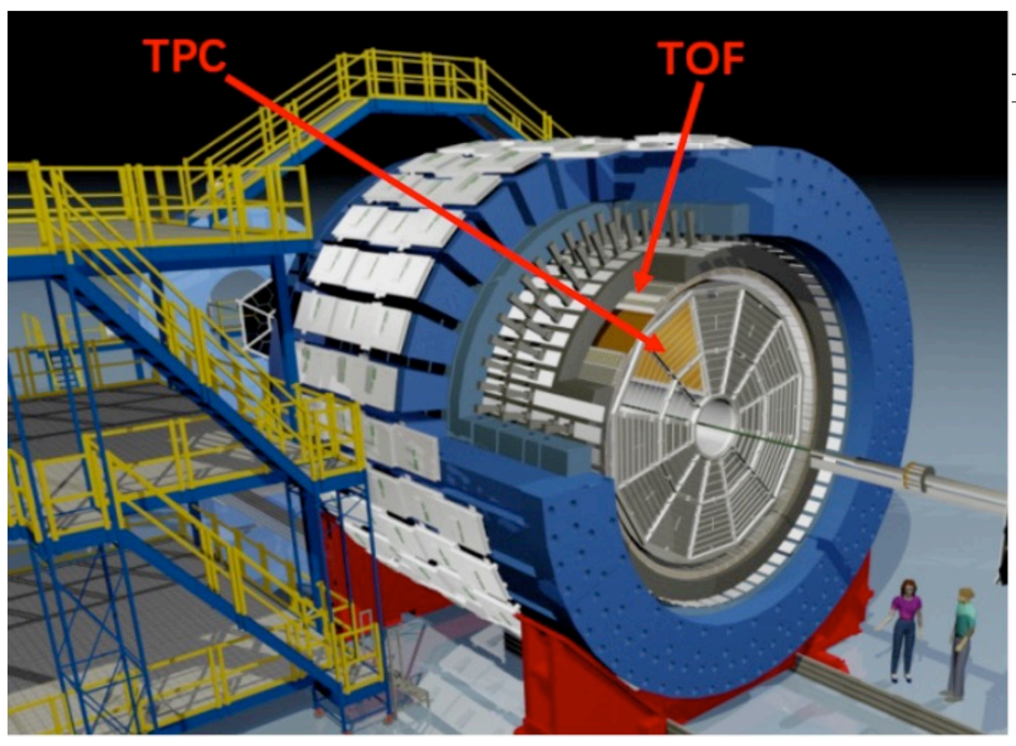
☆ Experimentally formula: $C(\mathbf{k}^*) = \frac{A(\mathbf{k}^*)}{B(\mathbf{k}^*)}$

- $A(\mathbf{k}^*)$ is signal correlation in same event
- $B(\mathbf{k}^*)$ is background correlation in mixed event
- Generally, the experimental correlation function accounts for the genuine correlation and it is affected by residual correlations and finite momentum resolution

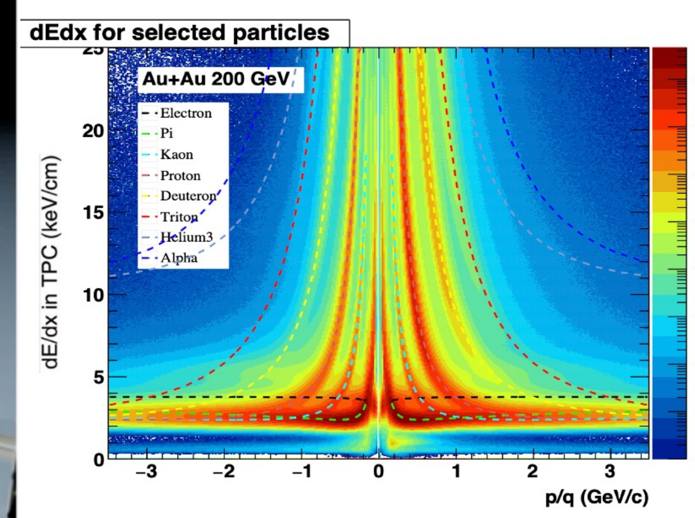


☆ The theoretical correlation function is computed by CATS from the shape of local potential provided by different models

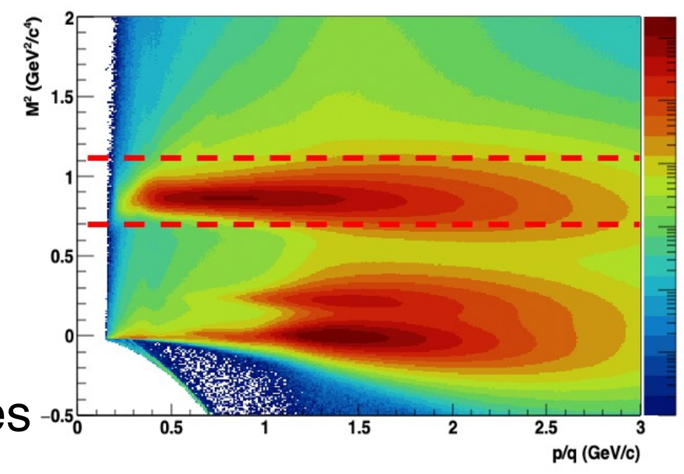
STAR Detector



PID in TPC



PID in TOF



☆ Excellent Particle Identification

☆ Large, Uniform Acceptance at Midrapidity

☆ Time Projection Chamber(TPC): Ionization energy loss dE/dx of charged particles

☆ Time of Flight(TOF): m^2 of charged particles

DataSet and Particle Selection

☆ Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

- Combine data taken at 2010,2011 and 2014
- High statistics data with minimum bias trigger event: 1.5Billion

☆ Proton selection: Use TPC and TOF to identify

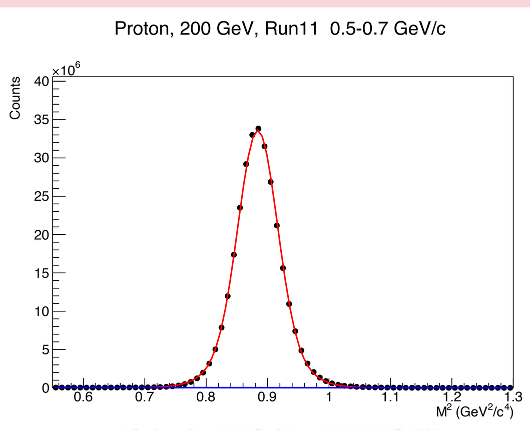
☆ Ξ^- reconstruction:

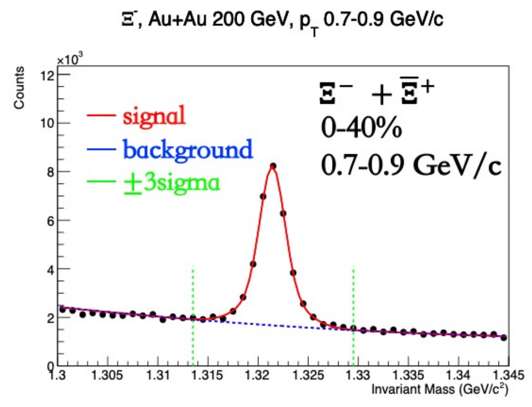
- Use helix method to reconstruct
- A set of topological cuts are applied to reduce background

☆ Fit function:

- Proton: Gaussian function(Signal)
  Exponential function(Background)
- Ξ^- : Double Gaussian function(Signal)
  2^{nd} Polynomial function(Background)

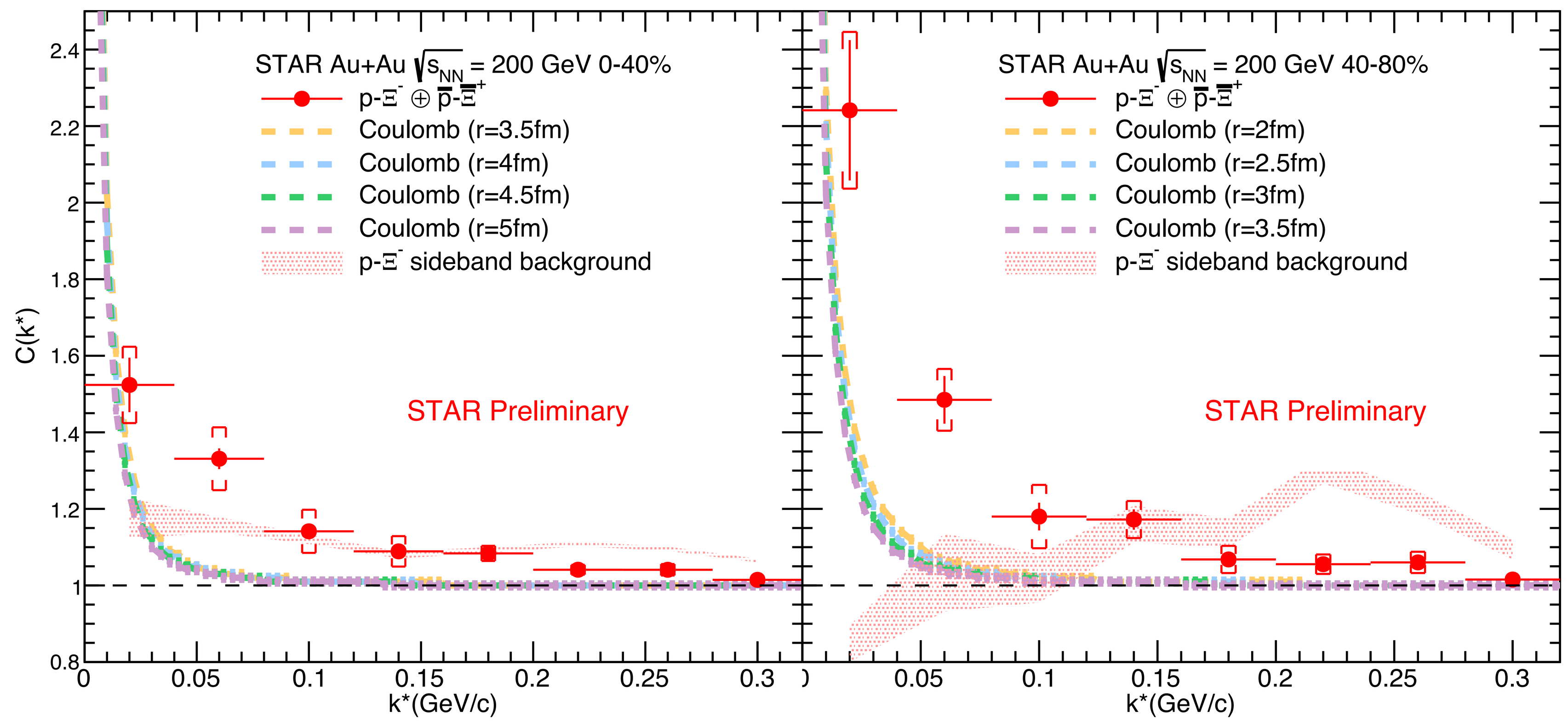
☆ Combine pΞ^- and $\bar{p}\bar{\Xi}^+$ pairs to improve signals counts





Particle	Decay	Branch Ratio	$c\tau$(cm)
Ξ^- (Ξ^+)	$\Lambda(\bar{\Lambda}) + \pi^-(\pi^+)$	99.887%	4.91
$\Lambda(\bar{\Lambda})$	$p(\bar{p})+\pi^-(\pi^+)$	63.9%	7.89

p-Ξ^- correlation function

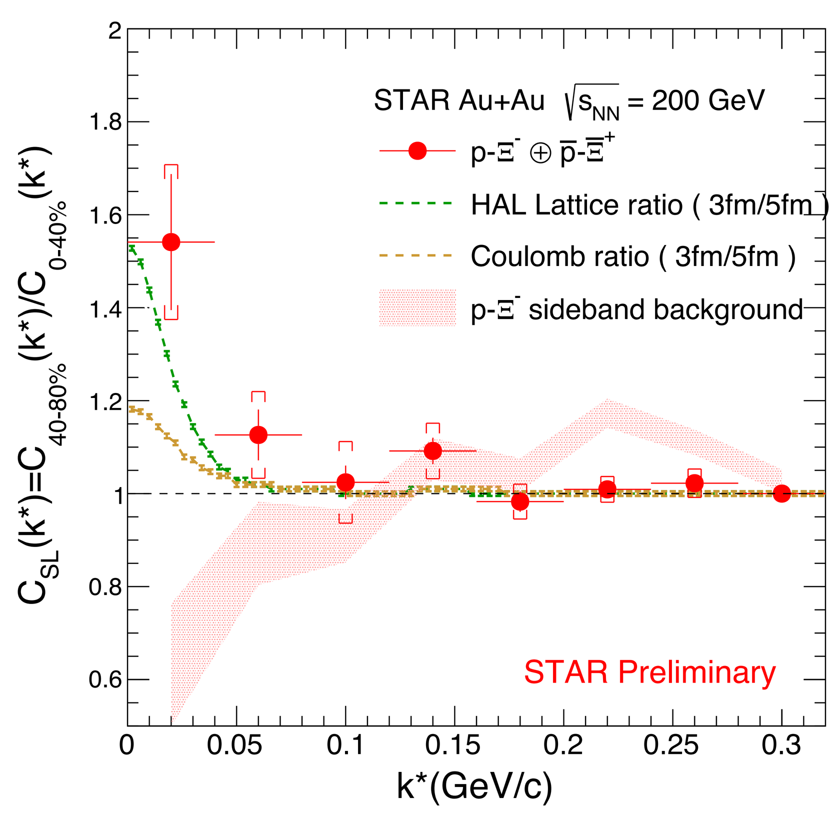


☆ Measured correlation functions enhance above unity – Attractive interaction in pΞ pairs

☆ Enhancement above Coulomb at two centralities --- Observation of the strong interaction

☆ Sensitive to the source size, more attractive interaction in small system

☆ Feed-down corrected, residual correlations are not corrected



☆The ratio $C_{SL}(k^*)$ = $\frac{CF(\text{small system})}{CF(\text{large system})} = \frac{CF(40\%-80\%)}{CF(0\%-40\%)}$ provides direct access to strong interaction of pΞ^-without much contamination from the Coulomb

☆Enhancement above Coulomb --- Hints presence of strong interaction in pΞ^-

Summary

☆The first measurement of correlation function for p-Ξ^- from Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV

☆The measured correlation functions from central and peripheral collisions and ratio all show an enhancement above Coulomb, indicates the existence of strong interaction in p-Ξ^- pairs

Outlook

➢Fit correlation function to extract physics parameters (source size, scattering length and effective range)

➢Look into more decay channels of H-dibaryon (p-Ω, $\Lambda\Lambda$)

➢Few body interaction and bound state search (d-Λ,d-Ξ,d-Ω)

Reference:

Nuclear Physics A 998 (2020) 121737

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drupal.star.bnl.gov/STAR/presentations