Study of ΛΛ correlations and search for the H-dibaryon with the STAR detector at RHIC

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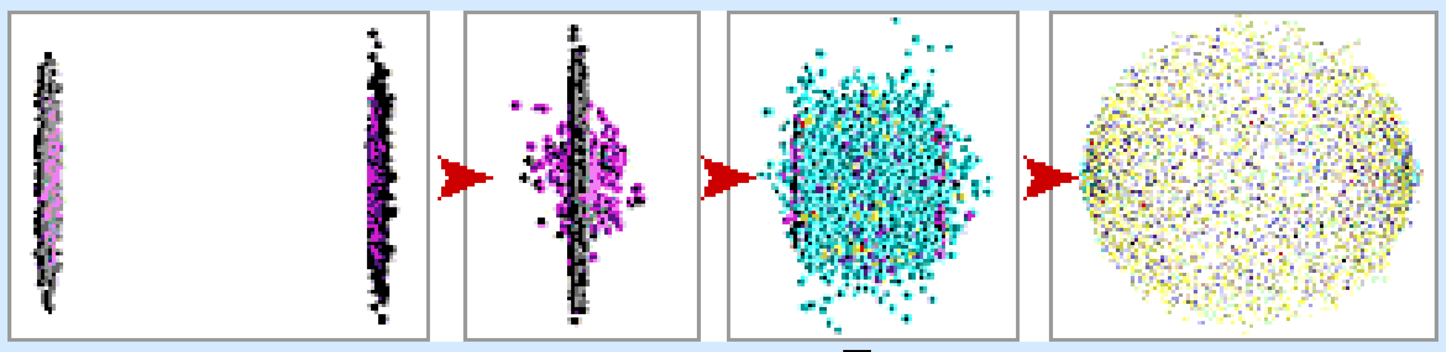
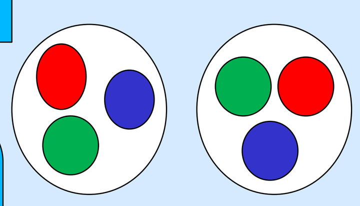
Abstract

Considerable experimental efforts have been devoted to search for the existence of H-dibaryon, a six quark state, proposed by Jaffe[1]. It has also been proposed that the H particle would appear as a bump in the ΛΛ invariant mass spectra if the H is a resonance state, or the H would lead to a depletion of the ΛΛ correlation near the threshold if the H is weakly bound. In this scenario, the mass of H is expected to be in the range (2230, 2380) MeV. Because of high rate of strange particle production per heavy ion collision, Relativistic Heavy Ion Collider (RHIC) is a unique place to search for the H-dibaryon. The ΛΛ correlation measurements at RHIC are sensitive to their mutual interactions, which can be used to probe whether there is a stable H particle or H resonance. This sensitivity is unique at RHIC because of the allowed range of ΛΛ scattering parameters in nucleus-nucleus collisions. We will present the measurement of ΛΛ correlations in Au+Au collisions at $\sqrt{s_{NN}}$=39 GeV and $\sqrt{s_{NN}}$=200 GeV using the STAR experiment at RHIC.

Motivation

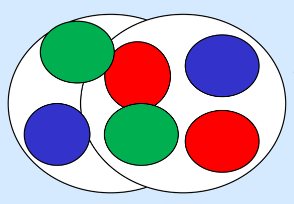


Two co-moving hyperons/ nonstrange baryons



Properties of H ($J^\pi=0^+$):
Mass – (1.2 – 2.8) GeV/c²
H→ΛΛ, ΛNπ,NNππ

Production of H dibaryon[1] (6quark state) through coalescence or scattering through resonance



Two particle correlation measurement with Λ, which are also sensitive to size of emitting region

Advantages :
- no Coulomb interactions
- sensitive to hyperon-hyperon interactions

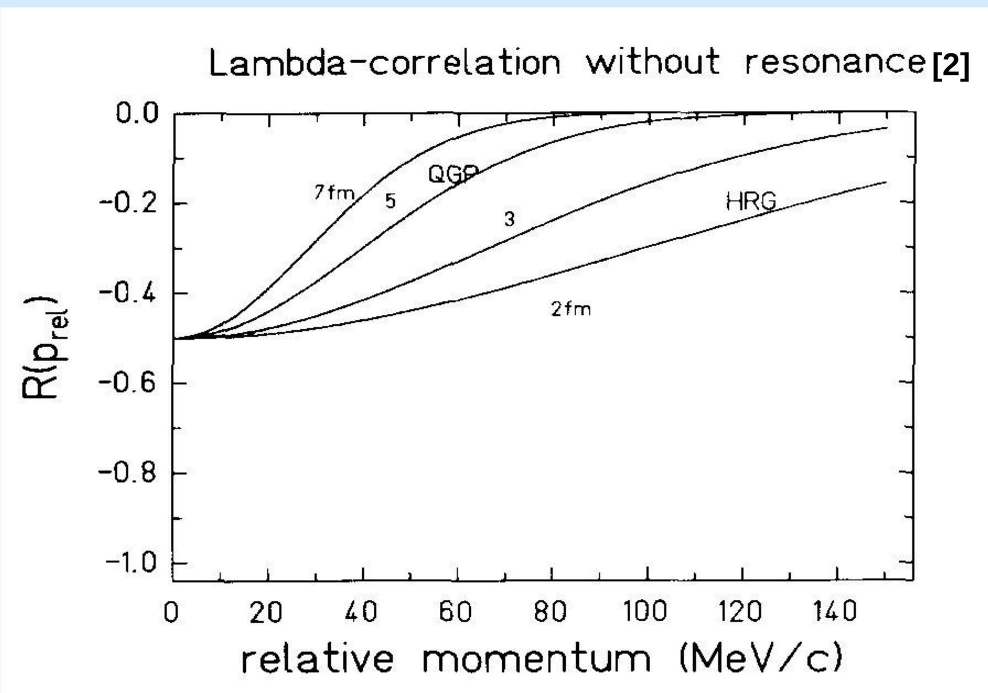
Lattice QCD predicts bound H with binding energy

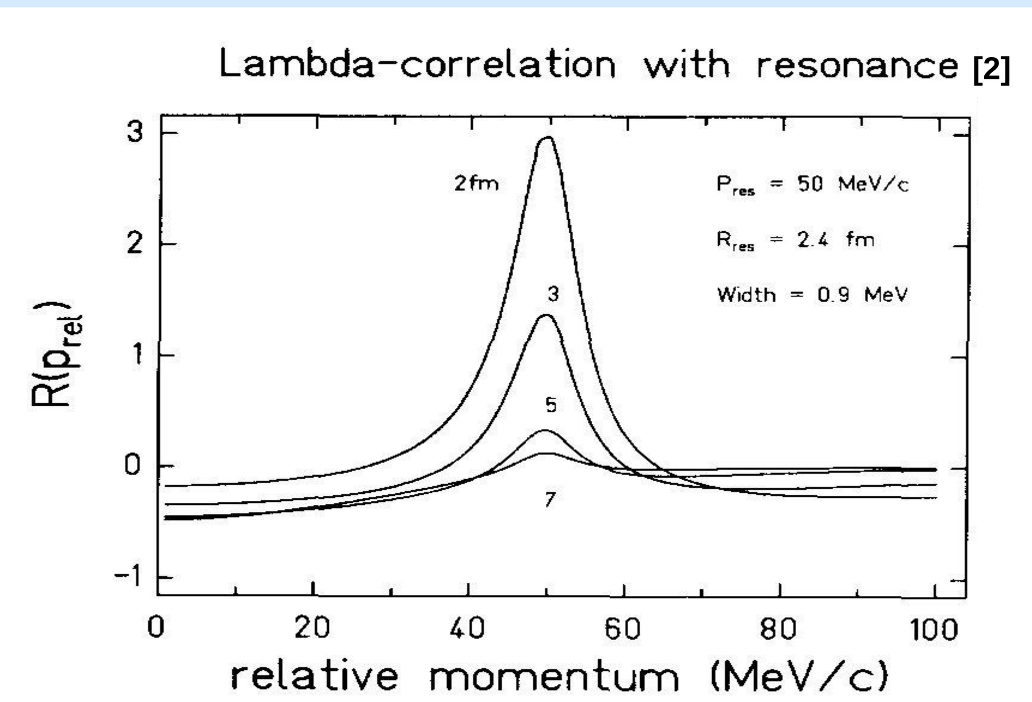
B = 16.6±2.1±4.6 MeV [3]

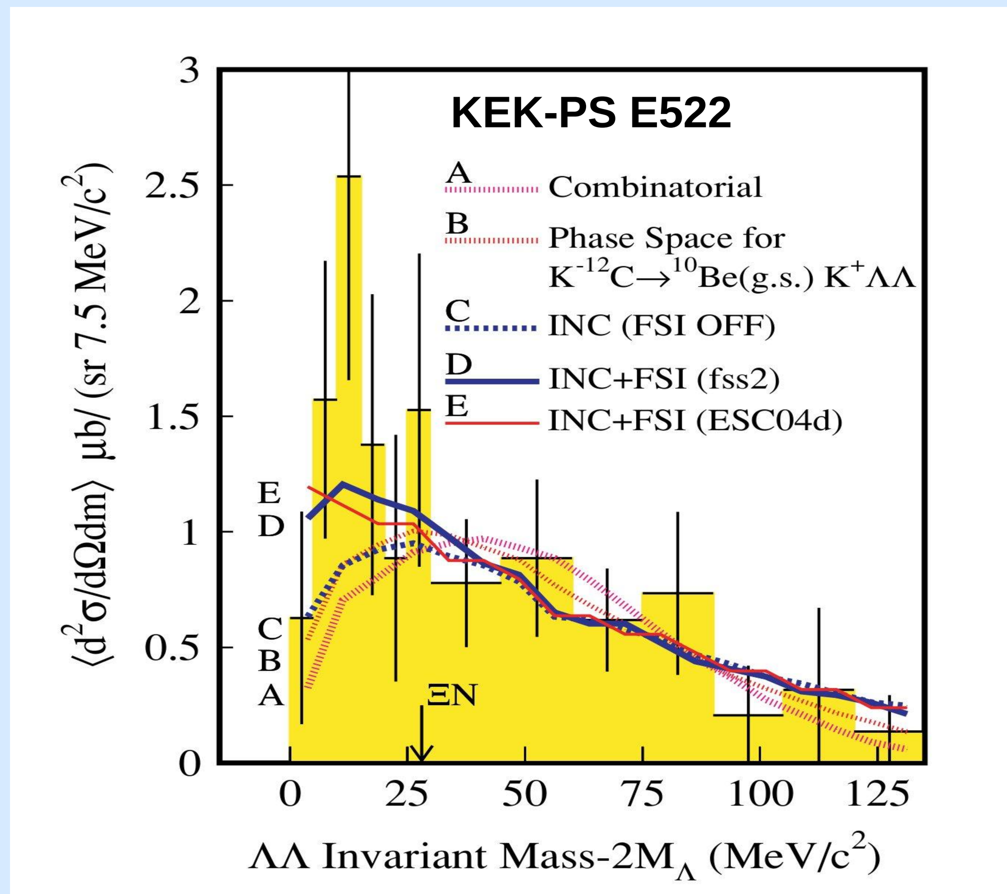
Experimental Searches for stable H^0:
- Double strangeness exchange reactions (e.g. $A(K^-,K^0)X$)
- Ξ^-A capture on nuclear targets with A ≥ 2
- p-N and NN collsions

scattering length ($a_{\Lambda\Lambda}$) = $-0.10^{+0.45}_{-2.37}\pm0.04$fm [4]

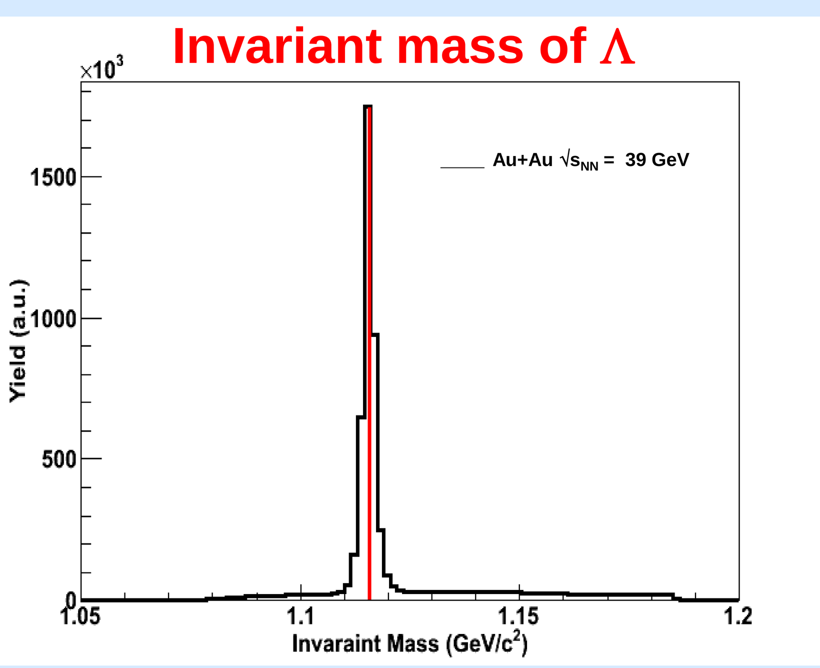
No/ weakly bound state [4,5]







Analysis



Topological cuts used $\sqrt{s}_{NN}$= 39 & 200 GeV :
- Events with 2Λ
- DCA Λ < 0.5 cm
- DCA proton > 0.6 cm
- DCA pion > 1.5 cm
- DCA proton to pion < 0.8 cm

Correlation function : $CF(Q)=\frac{A(Q)}{B(Q)}$

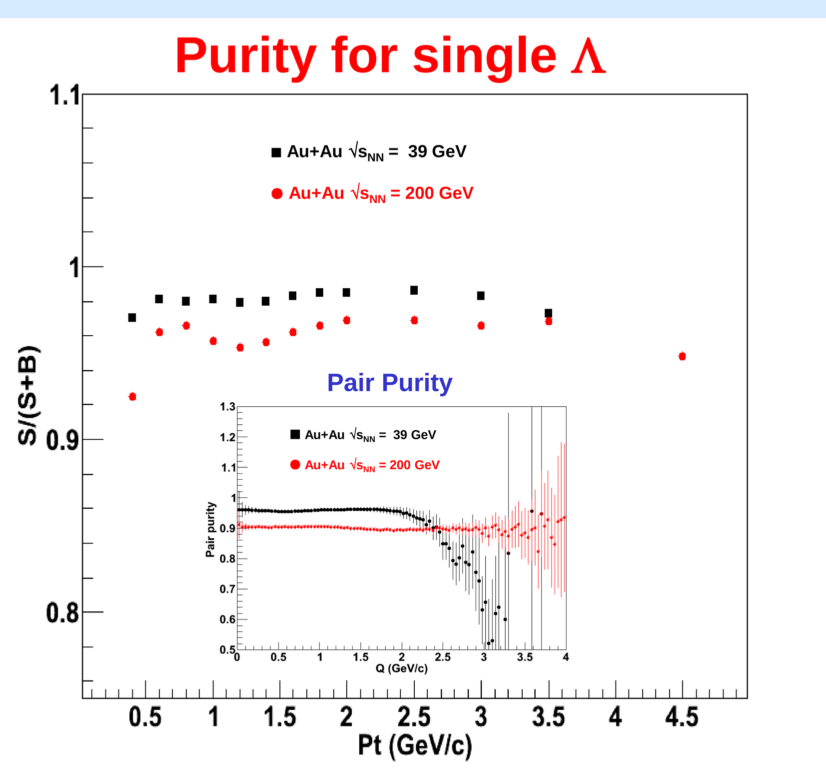
Where Q relative momentum between 2Λ, A(Q) is relative momentum from same event and B(Q) is reference distribution from mixed event

$$CF_{corrected}(Q)=\frac{CF_{measured}(Q)-1}{PP(Q)}+1$$

Where PP(Q) is pair purity given by

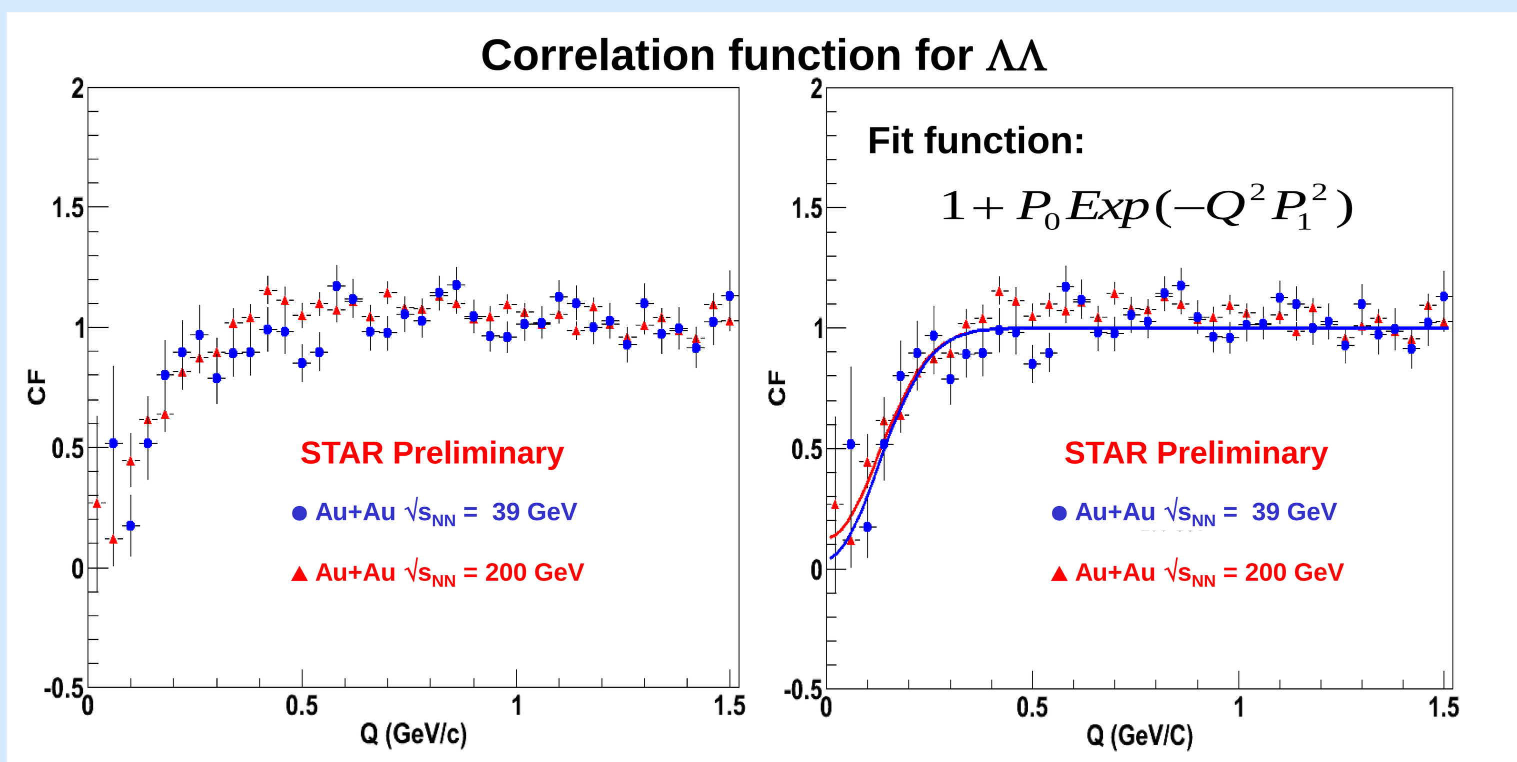
$$PP(Q)=\frac{S}{S+B}(Pt_i)\times\frac{S}{S+B}(Pt_j)$$

Where S is signal, B is background and Pt is transverse momentum for Λ_i and Λ_j



References:
[1] Jaffe, Phy Rev Lett 38 (1977) 195
[2] Greiner and Mϋller, Phy Lett B 219 (1989) 199
[3] S. R. Beane et al, Phys Rev Lett 106 (2011) 162001
[4] C. J. Yoon et al, Phy Rev C 75 (2007) 022201
[5] C. J. Yoon et al, Int J Mod Phy E 19 (2010) 2448

Results



Fit parameters(STAR Preliminary):

Au+Au $\sqrt{s_{NN}}$ = 39 GeV → P_1 = 1.06±0.24$_{stat}$ fm & P_0 = -0.91±0.24$_{stat}$, χ^2/ndf = 64.02/47

Au+Au $\sqrt{s_{NN}}$ = 200 GeV → P_1 = 1.11±0.10$_{stat}$ fm & P_0 = -0.87±0.12$_{stat}$, χ^2/ndf = 88.23/48

Summary

- The first measurement of correlation for ΛΛ from events having two Λ in Au+Au at $\sqrt{s_{NN}}$ = 39 GeV and $\sqrt{s_{NN}}$ = 200 GeV are presented
- Estimated source size for ΛΛ correlation is approximately 1 fm
- The depletion observed at low relative momentum may be sensitive to H^0 formation
- To conclude existence of H more statistics and theoretical calculations are needed

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