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

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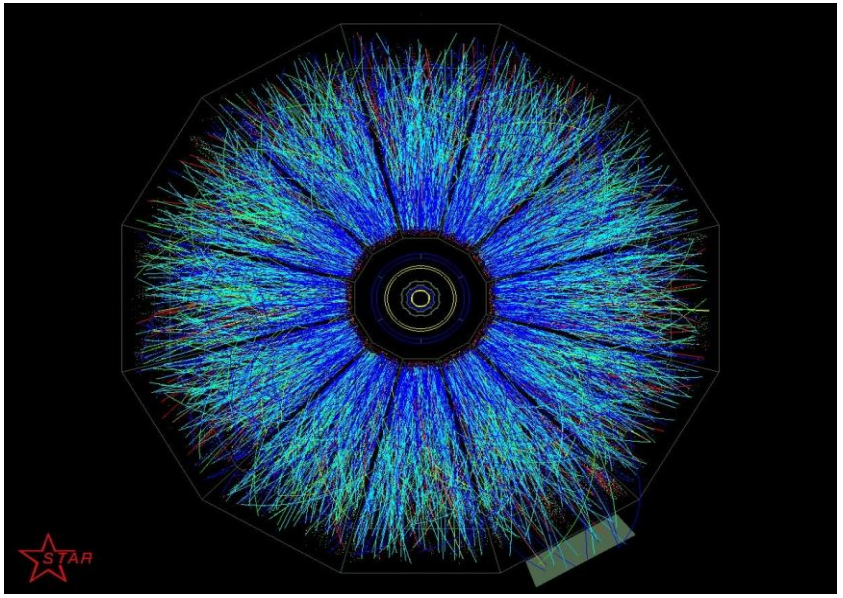


Outline

- Introduction
- Results and discussions
  - Correlation Function for $\Lambda\Lambda$
  - $\Lambda p\pi$ mass spectrum
- Summary

Introduction

- **Heavy Ion Collisions: a unique place**
  - Hadronic physics involving short-lived particles
  - Search of exotic particles with multiple strangeness

- **Correlation functions with Λ**
  - Sensitive to hyperon-hyperon interactions
  - Related to the size r_0 of the emitting region.
  - Shed some light on possibility of H (uuddss) formation
  - no Coulomb interactions

H dibaryon

- Six quark state (uuddss)*
- Properties : $J^{\pi} = 0^{+}$, mass : (1.9-2.8) GeV/c^2

$$\psi(\mathrm{H}) = \sqrt{\frac{1}{8}}\psi(\Lambda\Lambda) + \sqrt{\frac{4}{8}}\psi(\mathcal{N}\Xi) - \sqrt{\frac{3}{8}}\psi(\Sigma\Sigma)$$

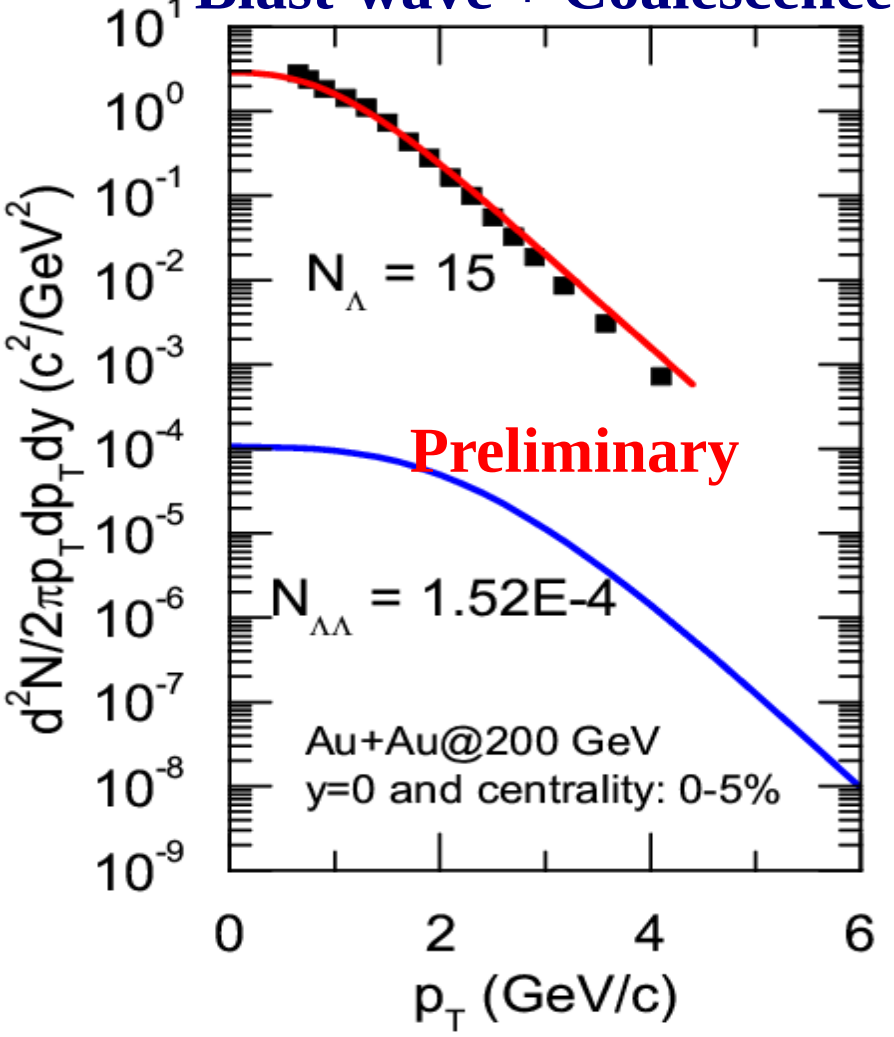
- Depending on the mass we have different decay modes of H:

Channel	Threshold mass (GeV/c2)	ΔS
ΛΛ	2.231	0
Λpπ	2.192	1
NNππ	2.152	2

* Phy Rev Lett 38 (1977) 195

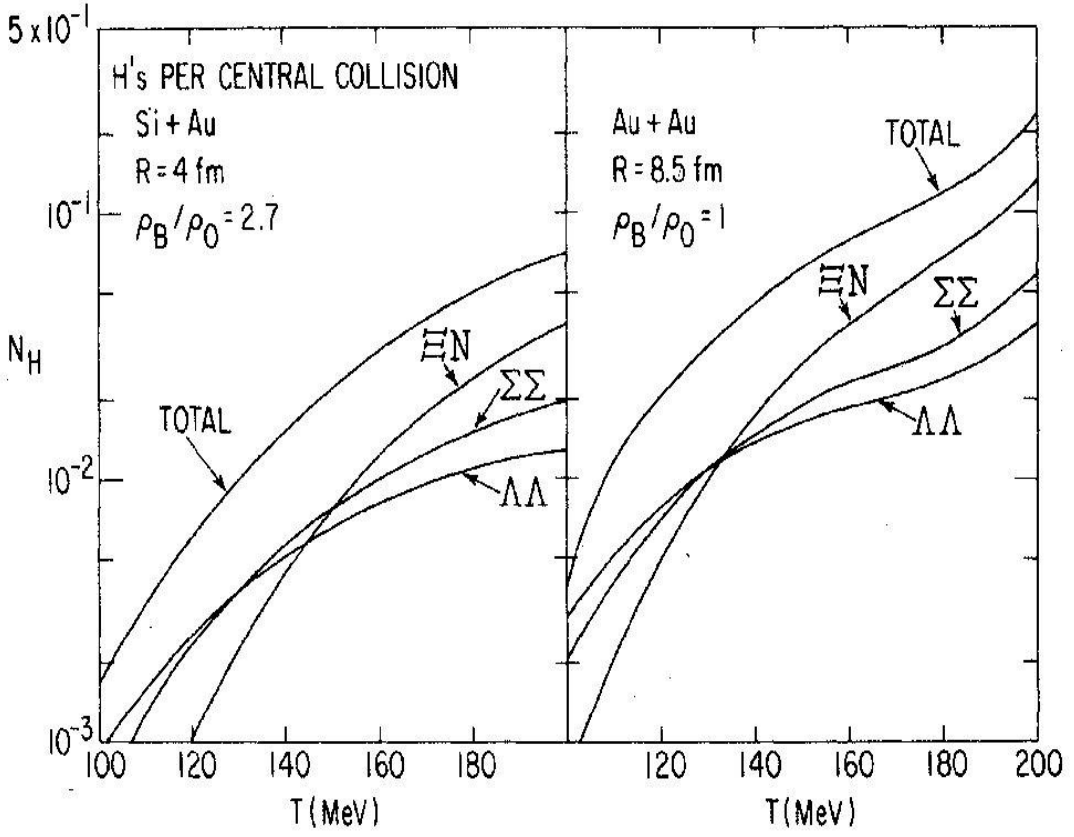
H-dibaryon production

Blast-wave + Coalescence*



*Lie-Wen Chen, 9th Workshop on QCD phase transitions and relativistic heavy ion collisions, China July 18-20 , 2011

Coalescence Model



Dover, Koch and May, Phy. Rev. C 40,115 (1989)

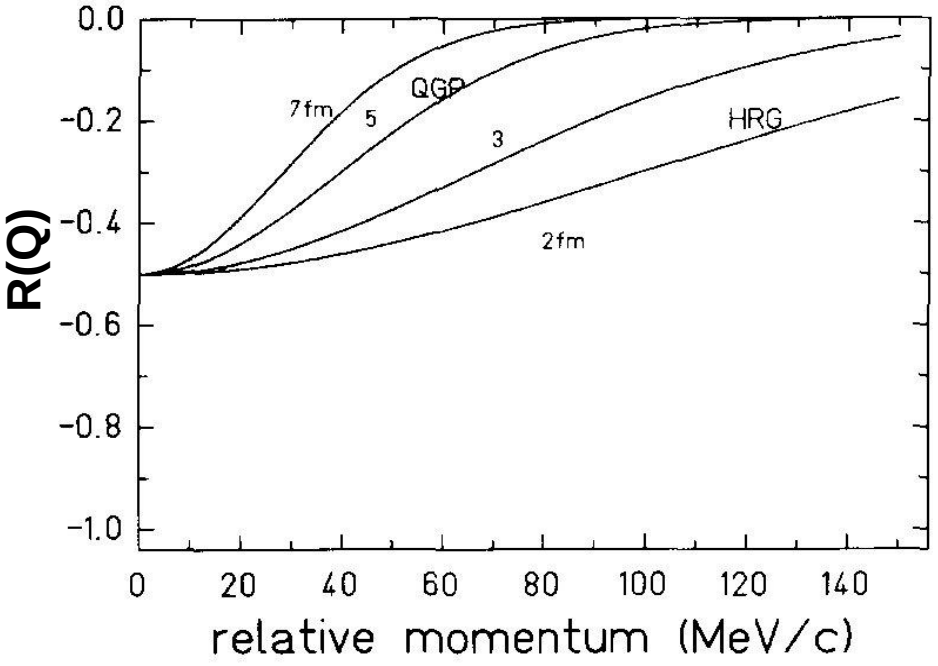
Two Particle Correlation Function

The two particle Correlation Function

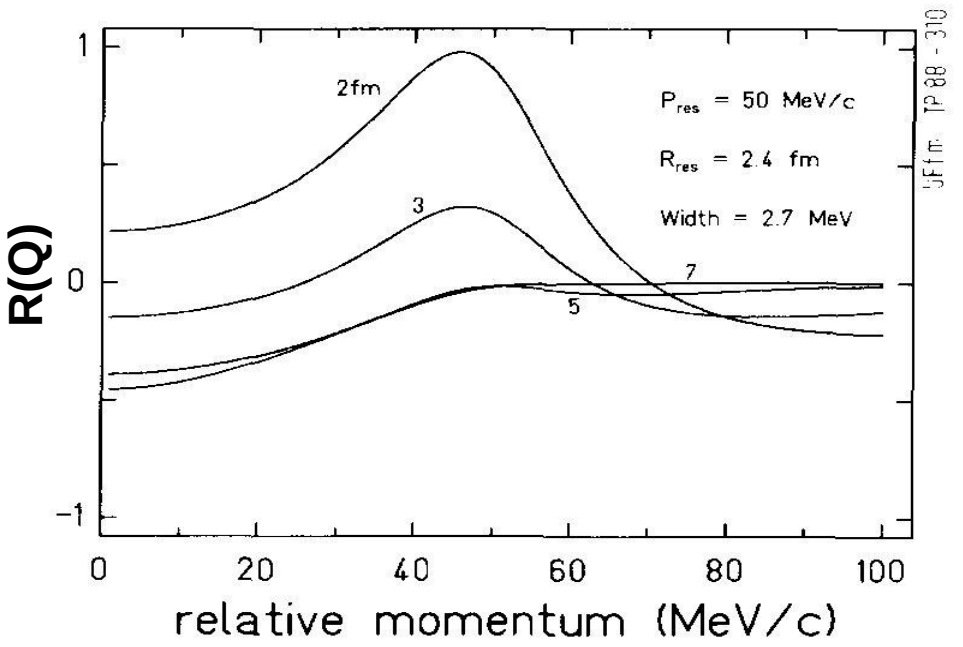
$$R(Q) = \lambda * \exp(-Q^2 r^2)$$

Where Q is relative momentum between two particles and
λ is degree of incoherence of the source

Λ-Λ correlation without resonance



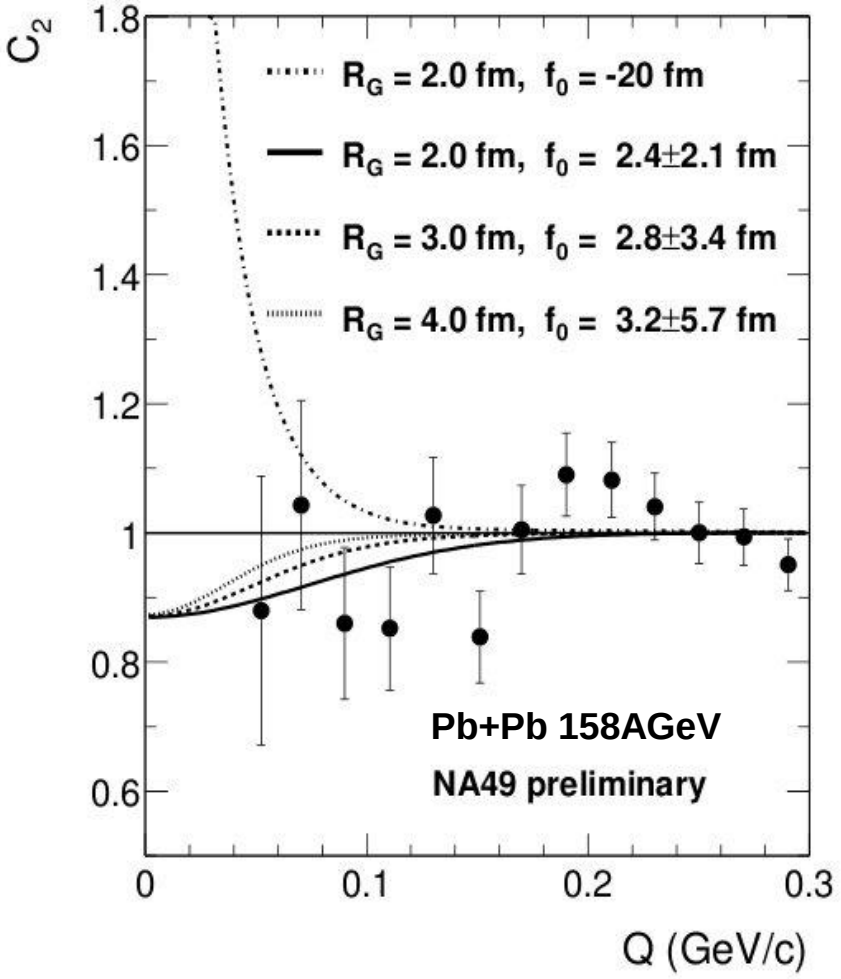
Λ-Λ correlation with resonance



Greiner and Muller, Phy Lett B 219, 199 (1989)

Previous measurements

ΛΛ correlations



Nucl Phys A 715 (2003) 55

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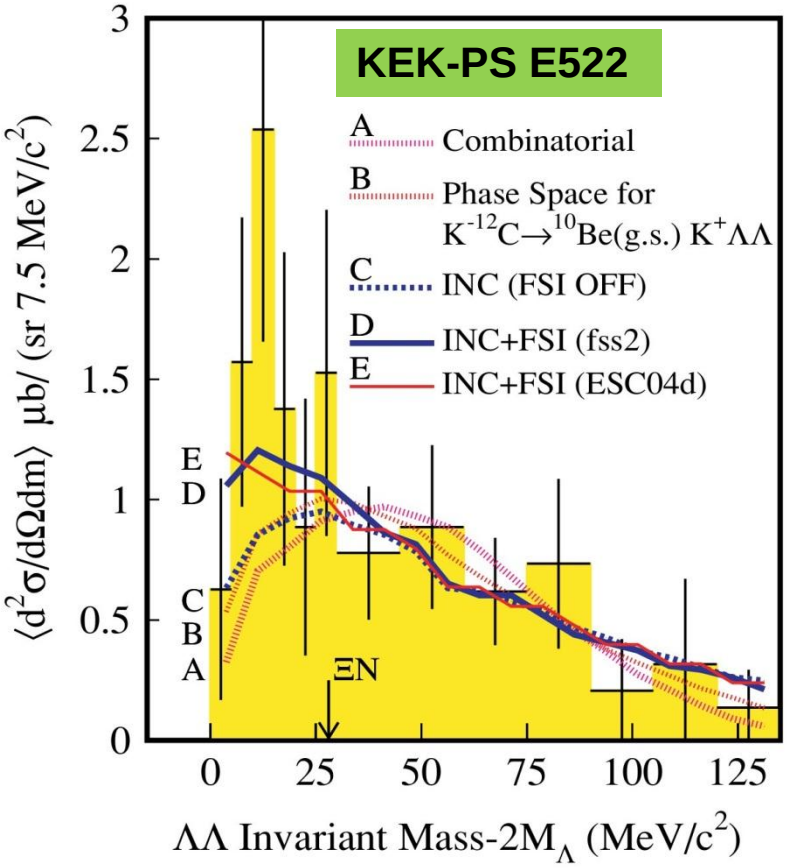


Scattering length

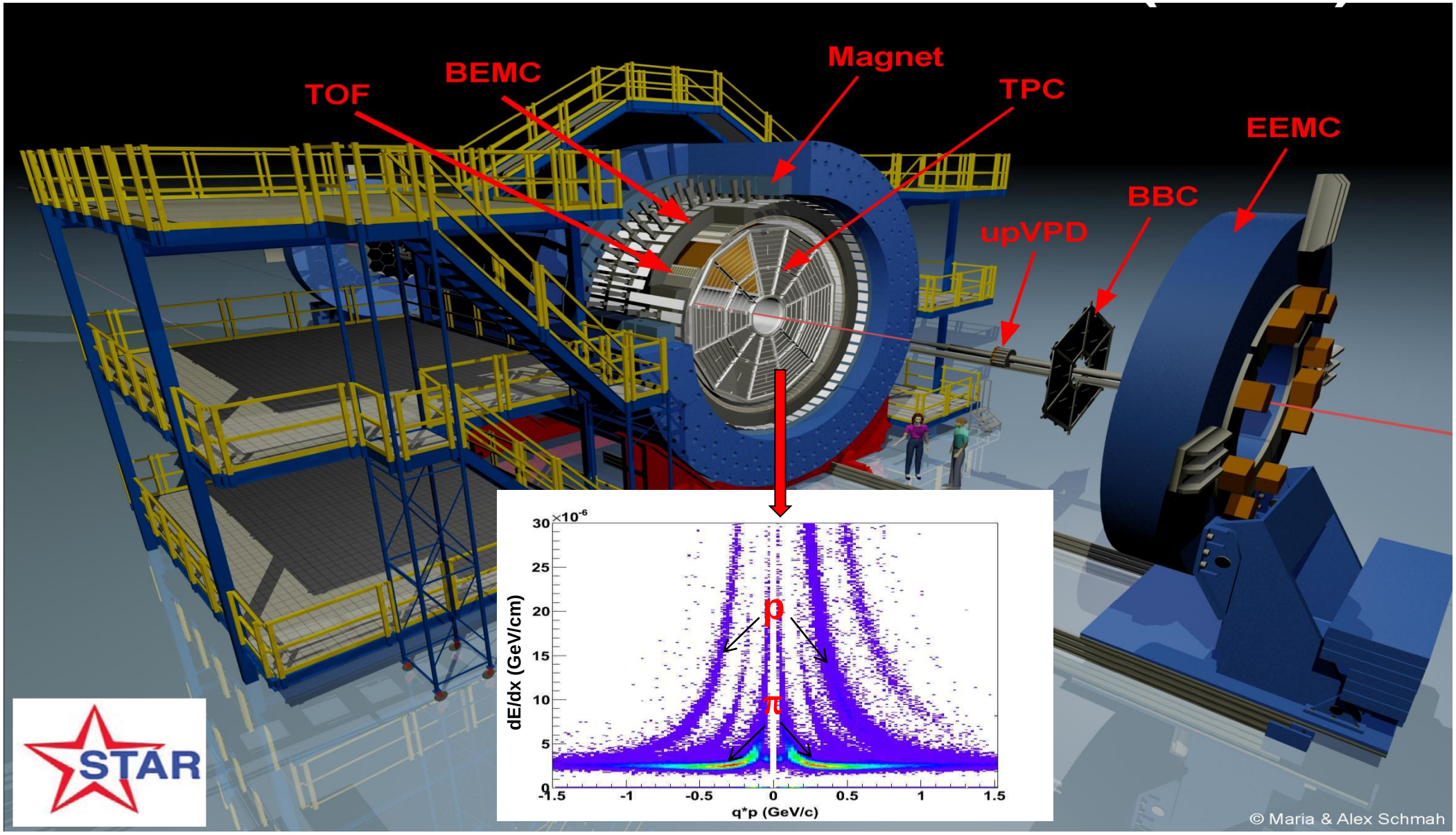
$a_{\Lambda\Lambda} = -0.10^{+0.45}_{-2.35} \pm 0.04$ fm

⬇

No/weakly bound state

Phy Rev C 75 (2007) 022201
Int J Mod Phy E 19 (2010) 2448

STAR detector



Data-set

Au+Au system @ 39, 62.4 and 200 GeV

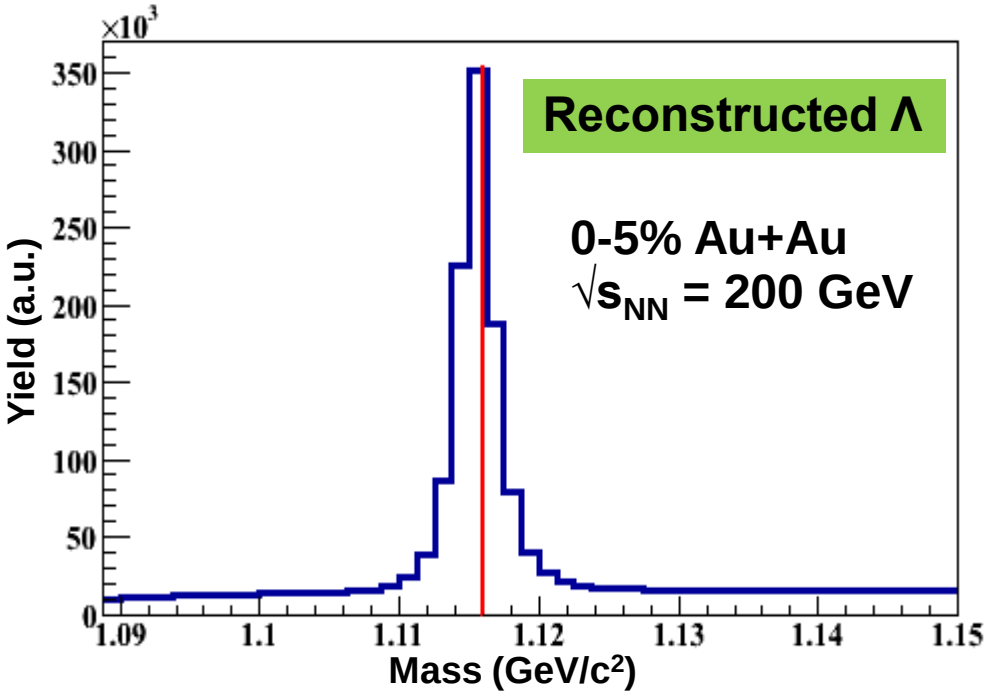
$\sqrt{s_{NN}}$	39 GeV	62.4 GeV	200 GeV
#events (ΛΛ analysis)	137 M MB	76M MB	275 M MB

MB → Minimum Bias (0-40% used)

Λ reconstruction

$\Lambda \rightarrow p\pi$ ($M = 1.1156$ GeV/c^2)
Branching ratio = 63%
Mean Life time: $\tau = 2.63\times10^{-10}$ s
$c\tau = 7.89$ cm
DCA Λ to Primary Vertex < 0.4 cm
DCA p to Primary Vertex > 0.6 cm
DCA π to Primary Vertex > 1.5 cm
$|M_\Lambda - M_{PDG}| < 0.004$ GeV/c^2
DCA p to π < 0.8 cm

* DCA → Distance of Closest Approach



Correlation Functions

Correlation Function (CF):

$$CF_{measured}(Q) = \frac{A(Q)}{B(Q)}$$

A(Q) – real pair, B(Q) – pair from mixed event and Q – relative momentum between two particles

Purity correction:

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

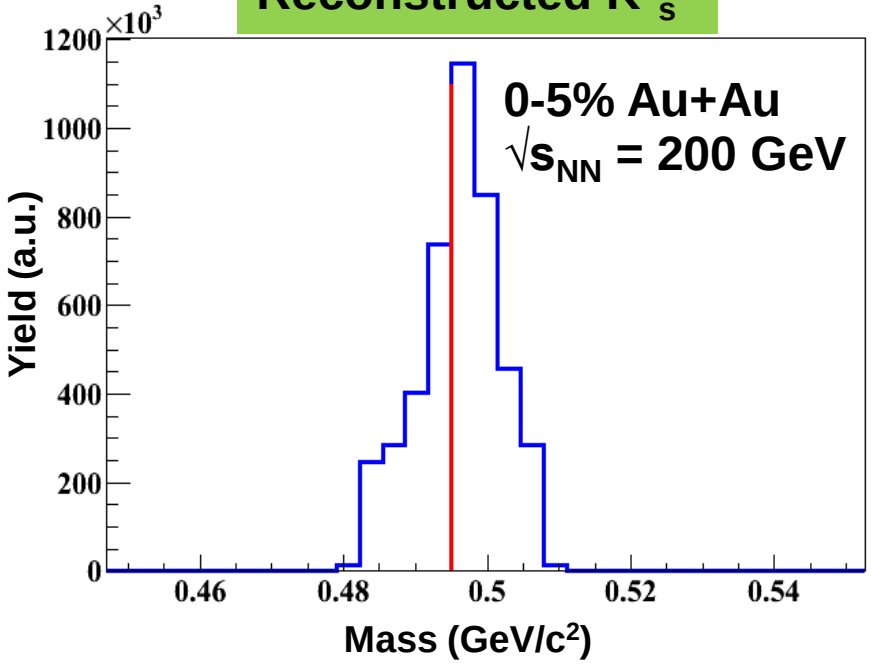
Pair Purity PP(Q):

$$PP(Q) = \frac{S}{S+B}(p_{T\,i}) \times \frac{S}{S+B}(p_{T\,j})$$

S – signal , B – background and p_T – transverse momentum

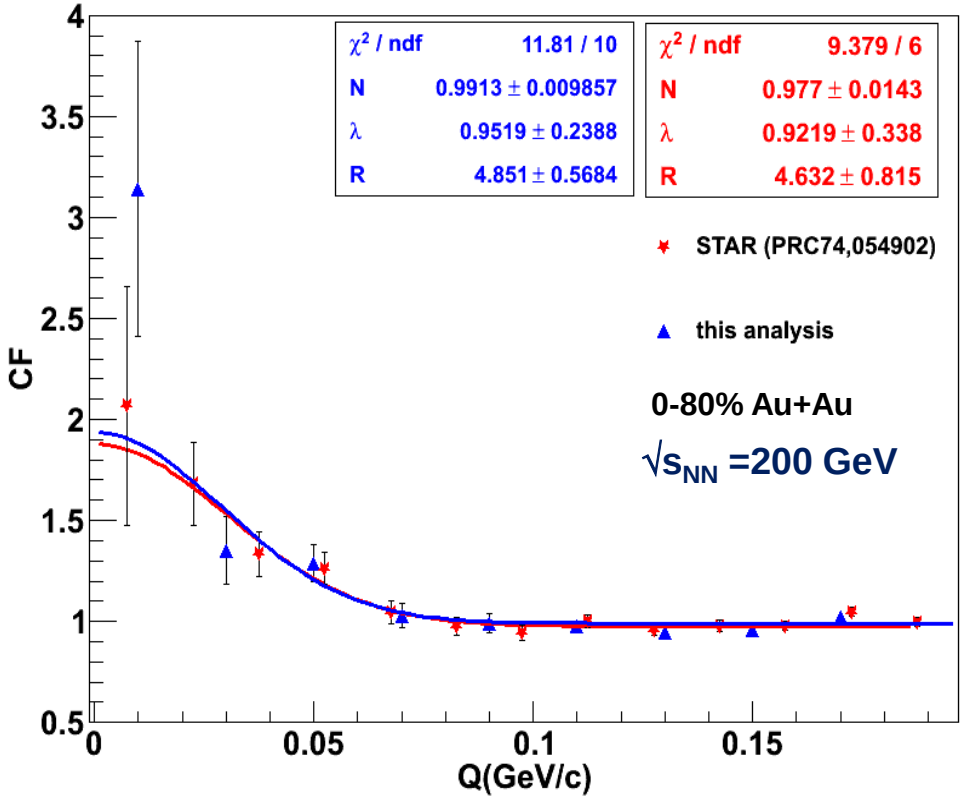
$K^0_s K^0_s$ Correlation Functions

Reconstructed K^0_s



- **A quick check on code sanity with previous published STAR measurement of $K^0_s K^0_s$ Correlation Functions**

Phy Rev C 74, 054902 (2006)



- **Fit function:**

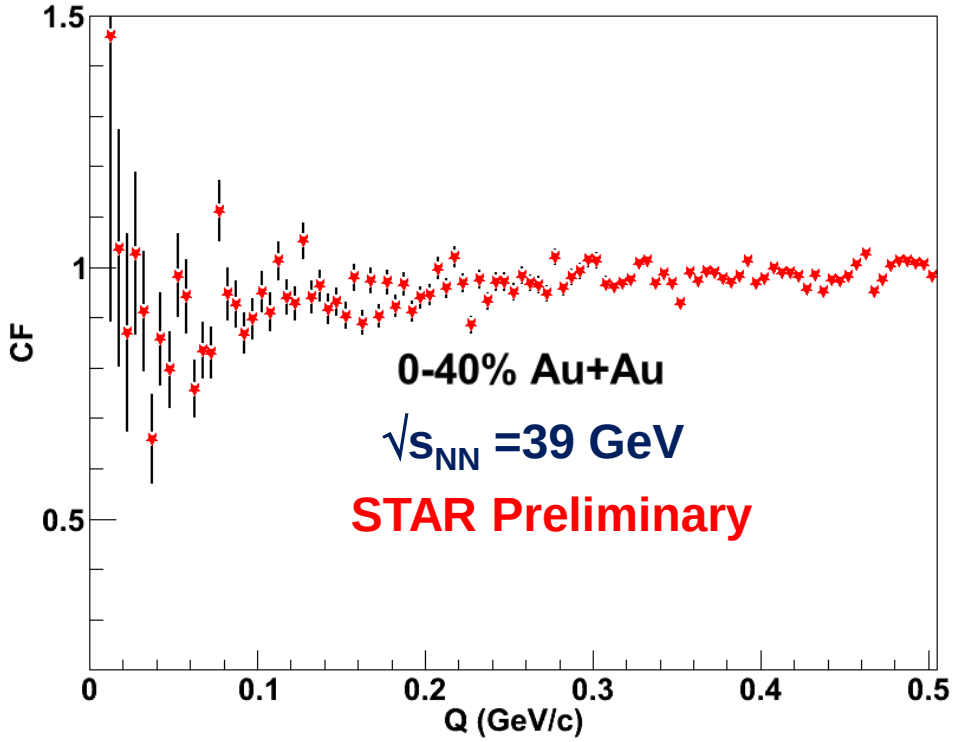
$$CF = N(1 + \lambda \exp(-Q^2 R^2))$$

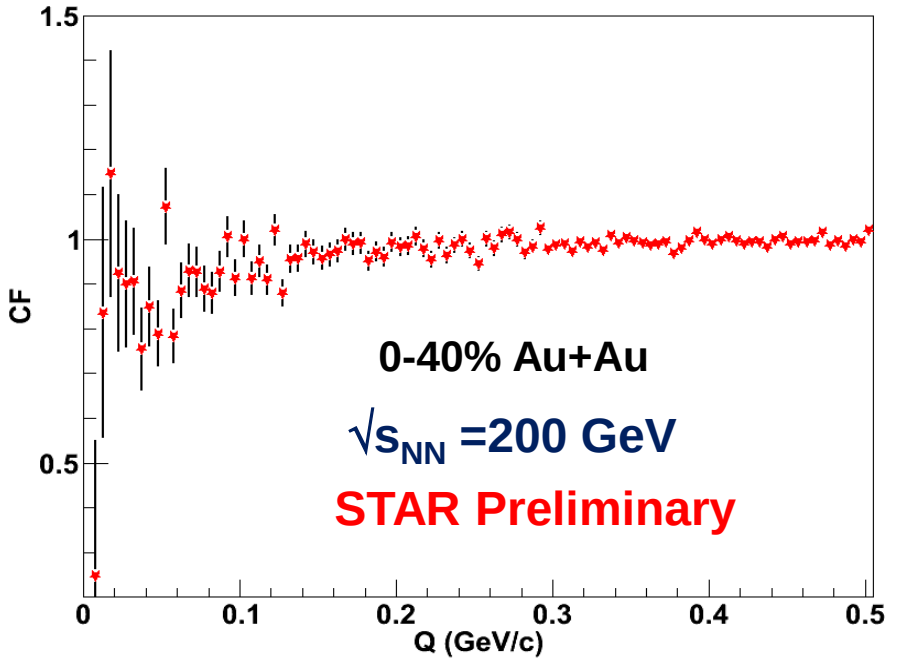
N – normalization, R – size parameter and λ – correlation strength

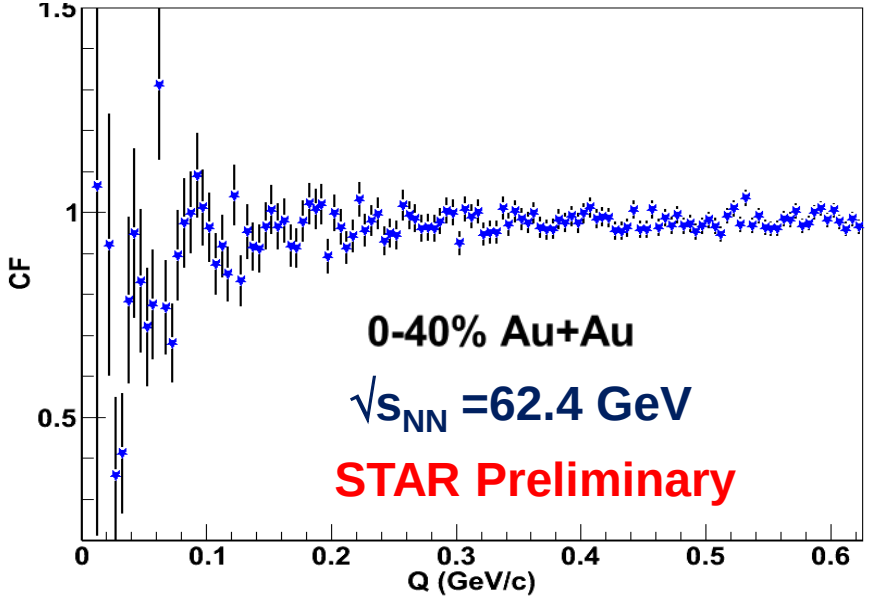
- **Fitting parameters are consistent with the published result within statistical errors**

ΛΛ analysis

Correlation functions for 0-40 % Au+Au collisions at $\sqrt{s_{NN}}$ = 39, 62.4 and 200 GeV







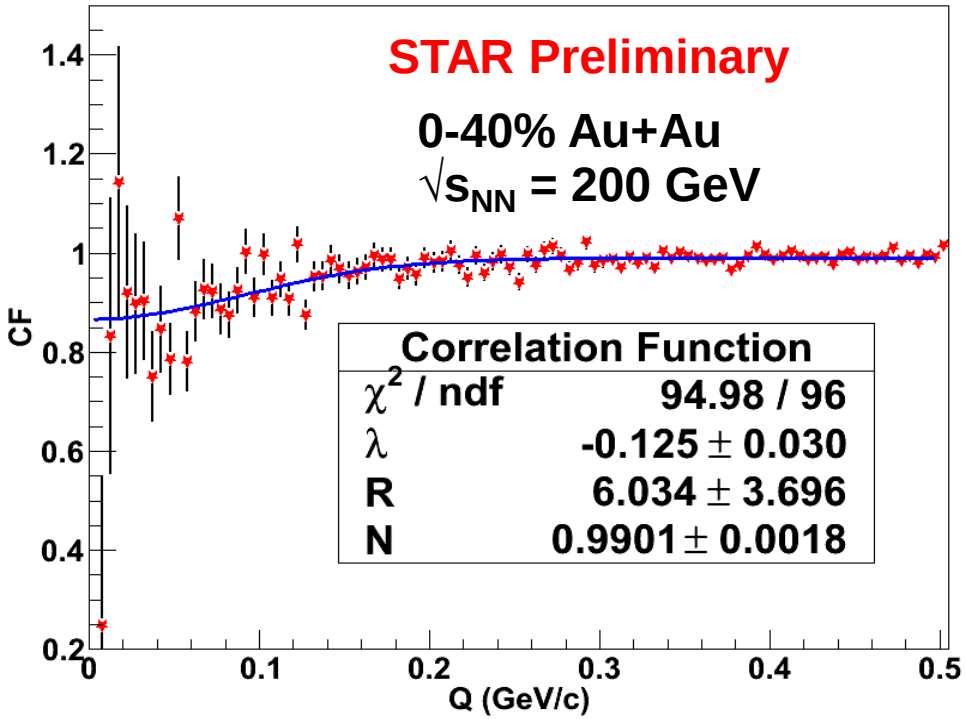
$\Lambda\Lambda$ analysis

- **Fit function:**

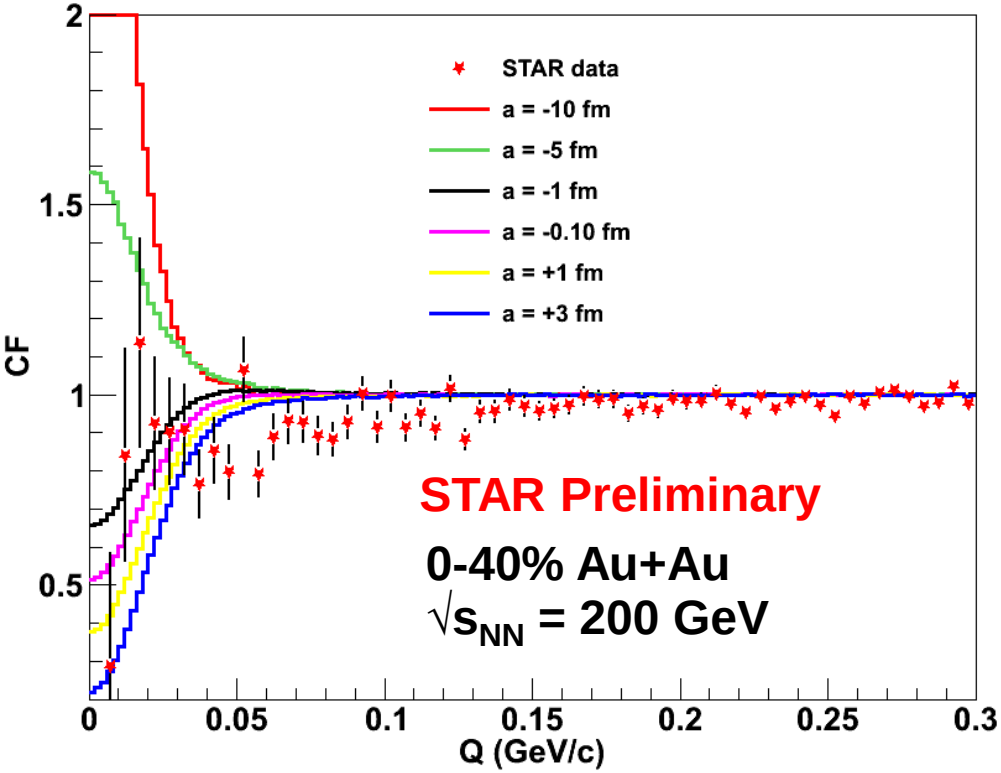
$$CF = N(1 + \lambda \exp(-Q^2 R^2))$$

N – normalization, R – size parameter and λ – correlation strength

- **No Final State Interactions (FSI) are considered**
- **λ and R may change because of FSI**

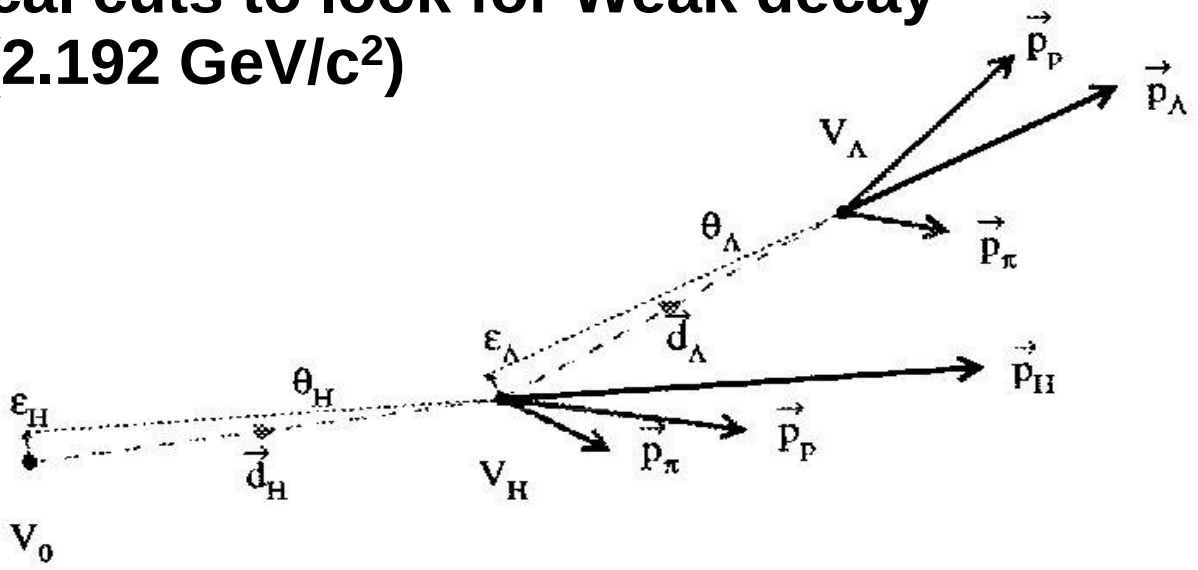


Comparison with correlation function for Gaussian source with different scattering length (a)



Cuts for Λpπ analysis

- **Topological cuts to look for Weak decay H→Λpπ (2.192 GeV/c²)**



0.25 cm < Λ dca to PV < 1cm

Λ decay length > 5 cm

P π decay length > 3 cm

$|d_\Lambda|$ > 3.5 cm

$|M_\Lambda - M_{PDG}| < 0.004$ GeV/c²

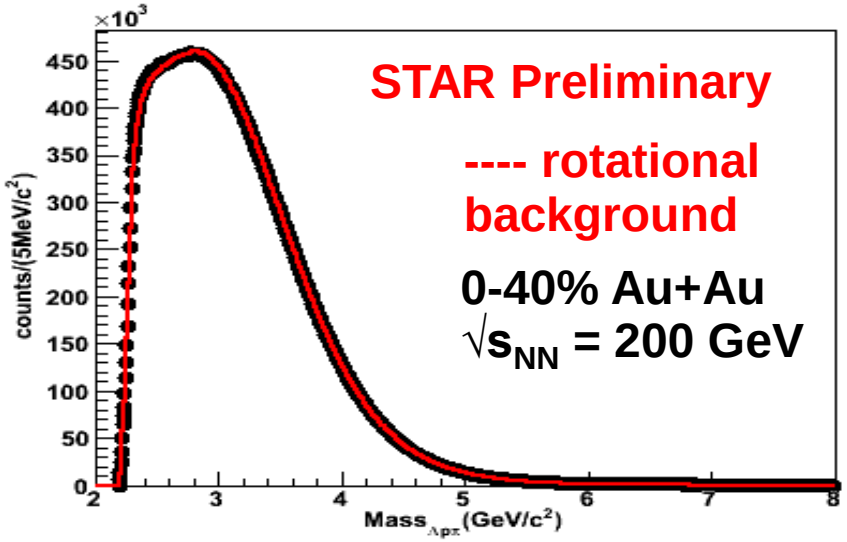
$M_{p\pi} < 1.110$ GeV/c²

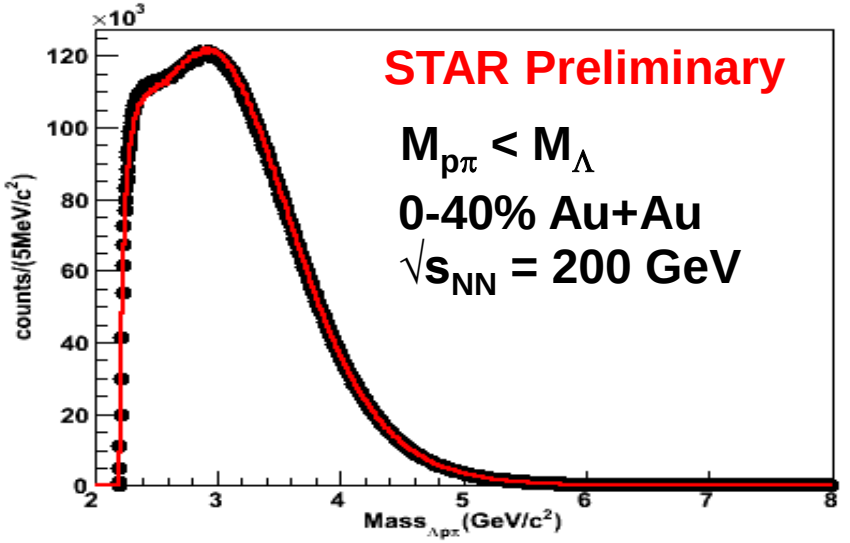
$\theta_\Lambda < 3$ Deg

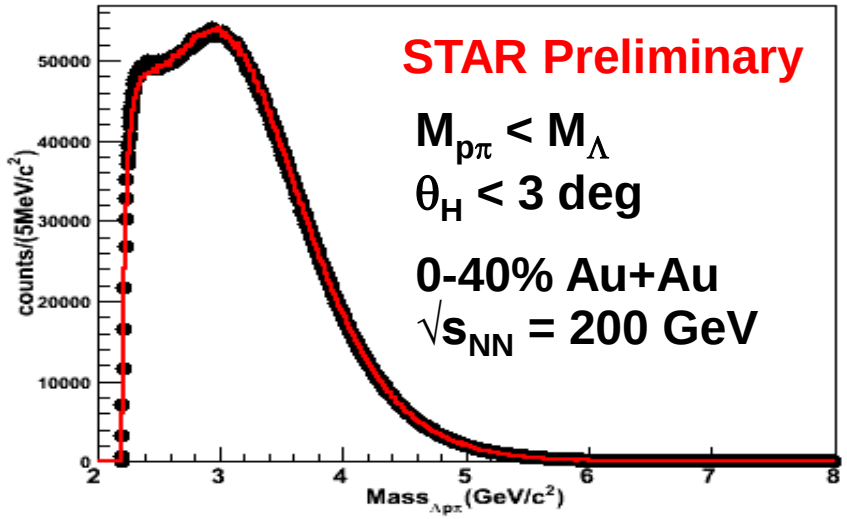
$\theta_H < 3$ Deg

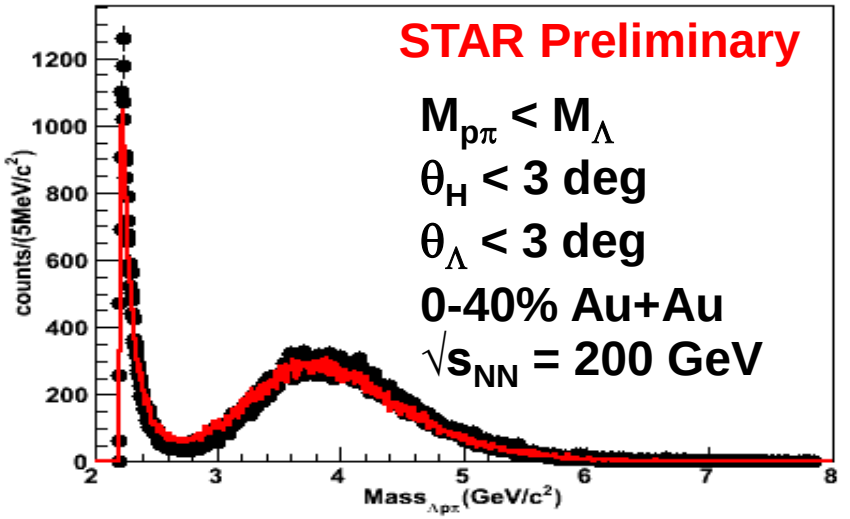
$\Lambda p\pi$ mass spectrum

- **$\Lambda p\pi$ mass spectrum after placing cuts one by one**









Summary

- **The first attempt for the measurement of correlation for ΛΛ in Au+Au collisions at $\sqrt{s_{NN}}$ = 39, 62.4 and 200 GeV are presented**

- **Preliminary measurement of Λpπ mass spectrum to look for H signal is presented**