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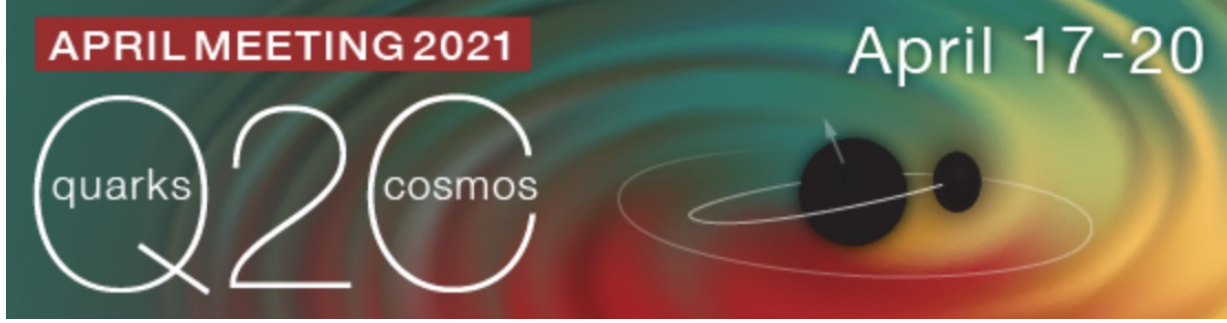

Measurement of proton-Ξ correlation function in Au+Au collisions at $\sqrt{s_{NN}}$ =200 GeV at RHIC-STAR

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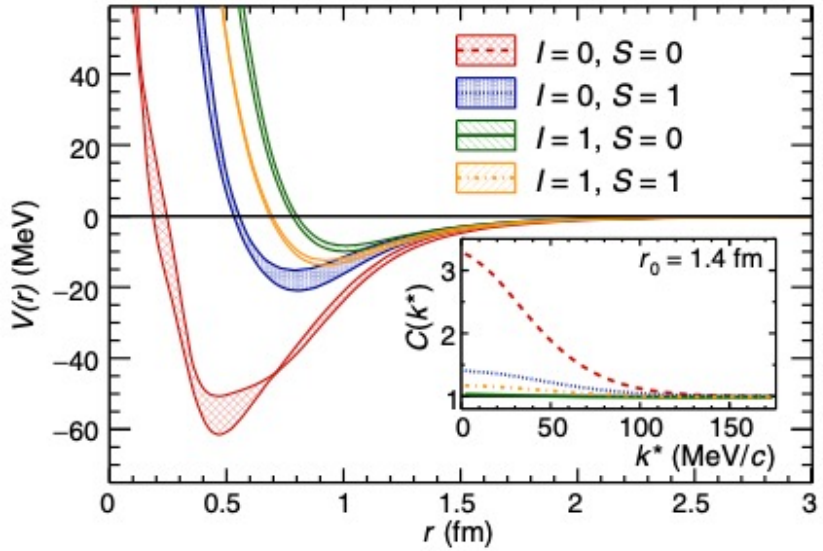
Outline

- ☆ Introduction
- ☆ The STAR Experiment
  - ☆ Dataset
  - ☆ Proton Identification
  - ☆ Ξ Reconstruction
- ☆ Results : Correlation Function
- ☆ Summary

Introduction

- Baryon-baryon interaction in the S=-2 sector has attracted attention in relation to the possible existence of H-dibaryon. So far no clear experimental evidence for any such bound states has been found.
- Lattice QCD potentials (HAL-QCD Collaboration) -- Predicted an attractive interaction in p-Ξ^-.
- An attractive p-Ξ^- interaction is observed in p-Pb and pp collisions at ALICE.

Hexaquark
Baryon-Baryon molecule



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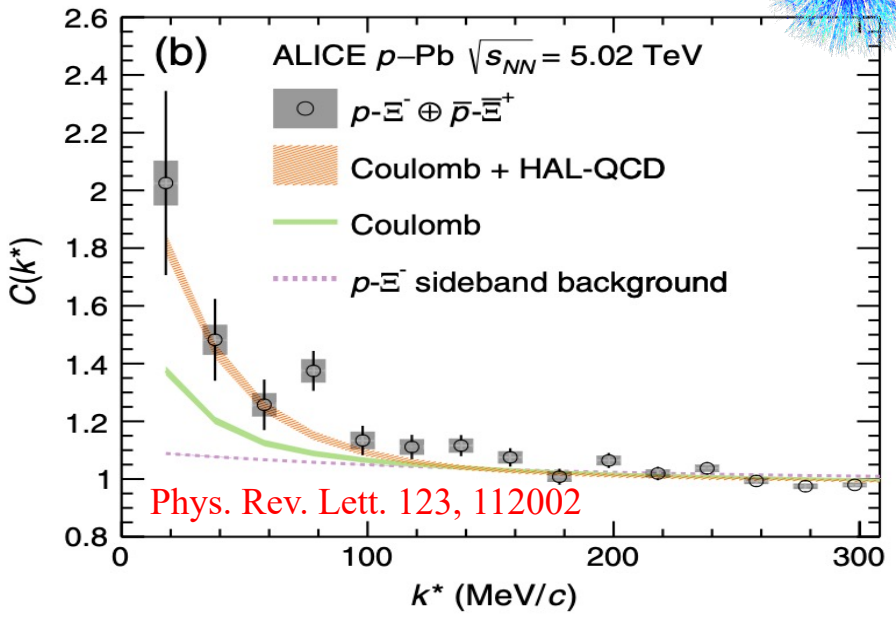
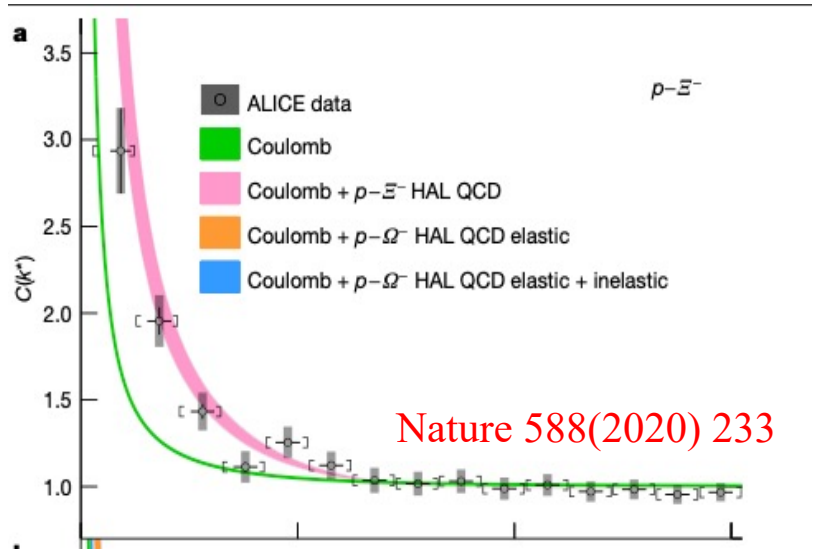


Phys. Rev. Lett. 123, 112002



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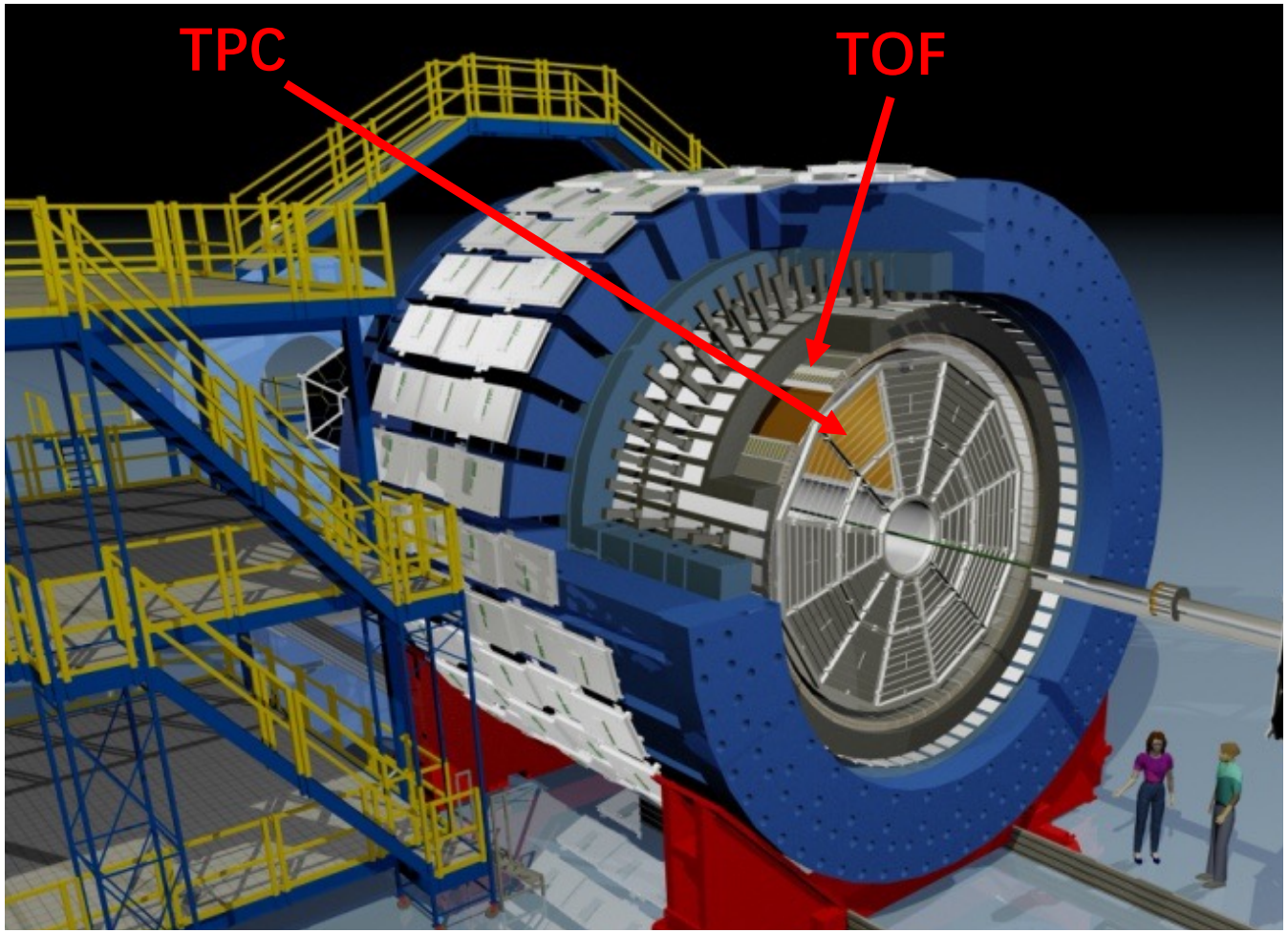
The Solenoidal Tracker At RHIC(STAR)



- **Excellent Particle Identification**
- **Large, Uniform Acceptance at Midrapidity**

Time Projection Chamber (TPC)

- ✓ Charged Particle Tracking
- ✓ Momentum reconstruction
- ✓ Particle identification from ionization energy loss (dE/dx)
- ✓ Pseudorapidity coverage $|\eta| < 1.0$

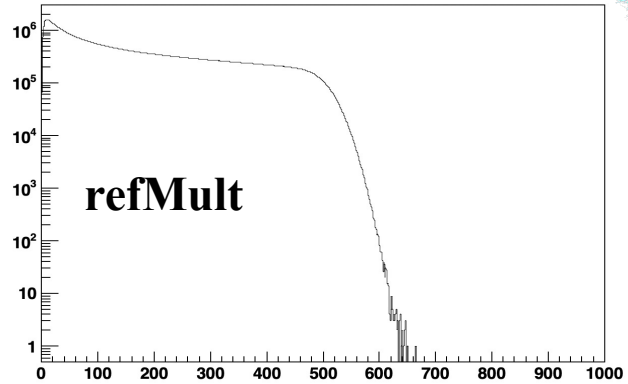
Time-of-Flight (TOF)

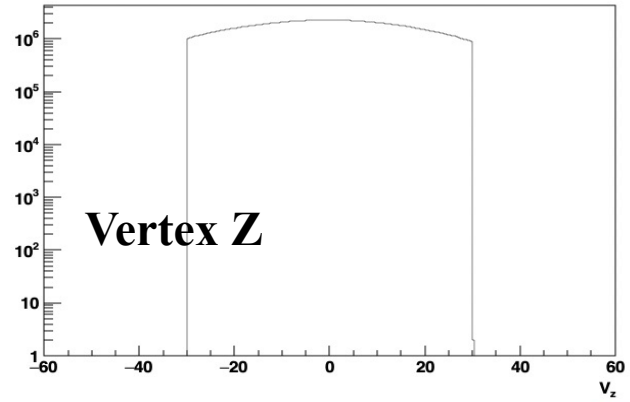
- ✓ Particle identification M^2
- ✓ Pseudorapidity coverage $|\eta| < 0.9$

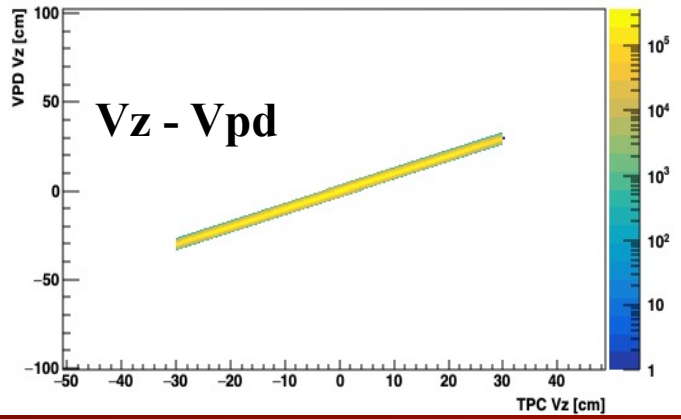
DataSet

- Au+Au at $\sqrt{s_{NN}}$ = 200GeV taken in 2010, 2011 and 2014

	Trigger ID (minimum bias)	|Vz| ,|Vr|, |Vz-Vpd|	Events
Run10	260001 260011 260021 260031	|Vz|<30cm |Vr|<2cm |Vz-Vpd|<3cm	~211M
Run11	350003 350013 350023 350033 350043	|Vz|<30cm |Vr|<2cm |Vz-Vpd|<3cm	~410M
Run14	450005 450015 450025 450050 450060	|Vz|<6cm |Vr|<2cm |Vz-Vpd|<3cm	~900M



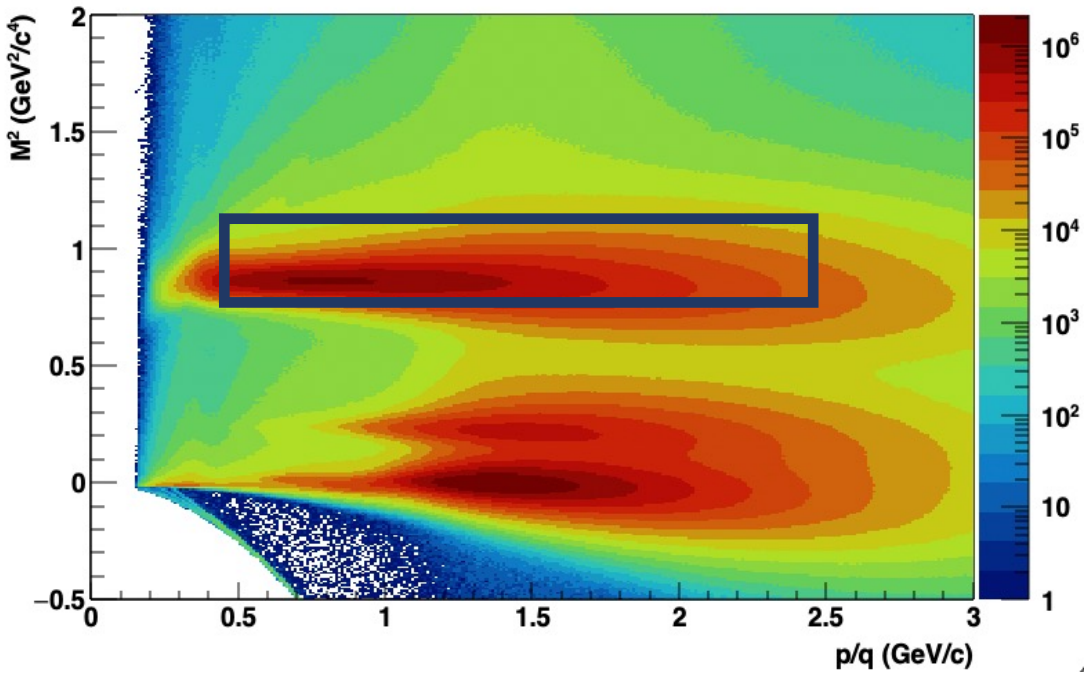




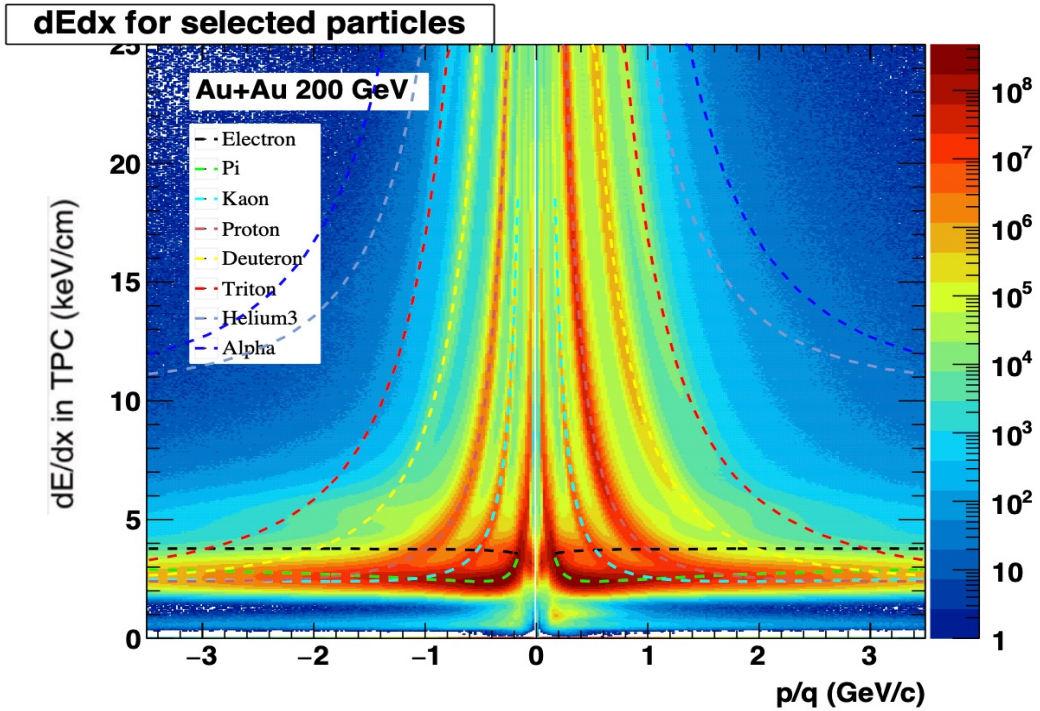
- Total statistic : ~1.5 Billion
- refMult : p_T > 0.1 GeV/c , DCA < 3cm

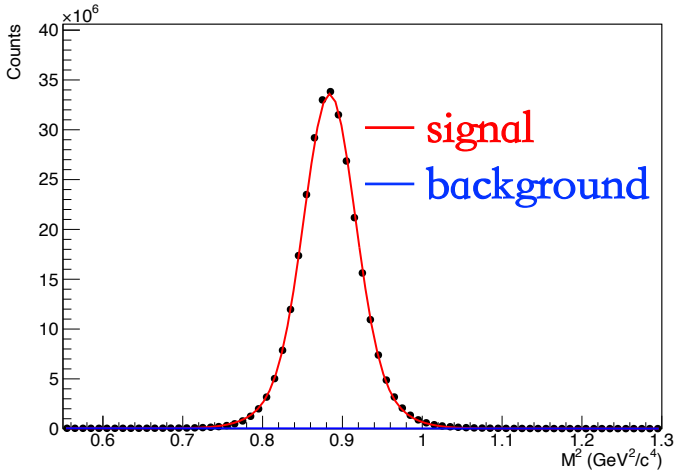
  nhitsFit >=10 , $|\eta| < 0.5$

Proton Identification



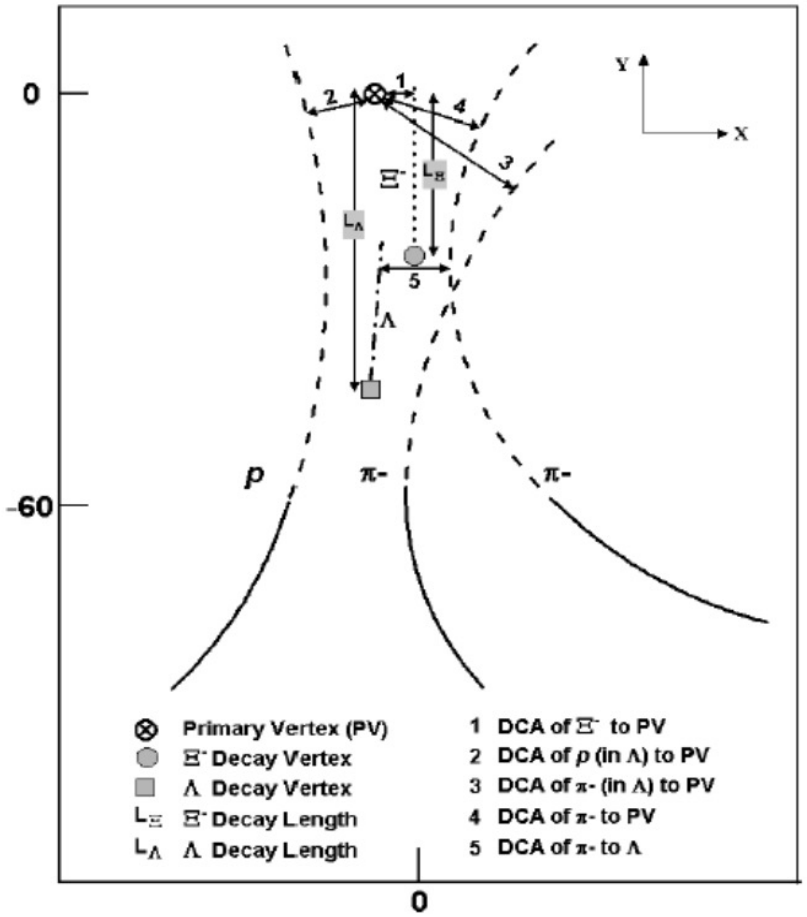
Proton, 200 GeV, Run11 0.5-0.7 GeV/c





- ☆ **Proton selection criteria：**
  - ☆ **nhitsFit > 20 ， $|N_{\sigma,p}| < 2$, DCA of proton < 0.5 cm**
  - ☆ **$0.75 < M^2 < 1.15$**
  - ☆ **$0.5 < p_T < 2.5$ GeV/c**
- ☆ **Fit function : double Gaussian + exp. function**
- ☆ **Proton Purity = $\frac{S}{S+B}$, ~99%**

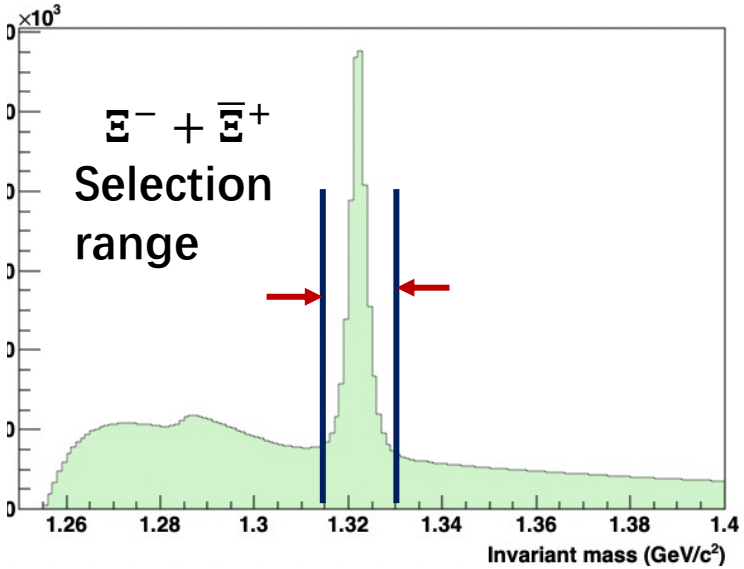
Ξ^- Reconstruction



$$\Xi^-(\bar{\Xi}^+) \to \Lambda(\bar{\Lambda}) + \pi^-(\pi^+), \quad 99.887\%$$

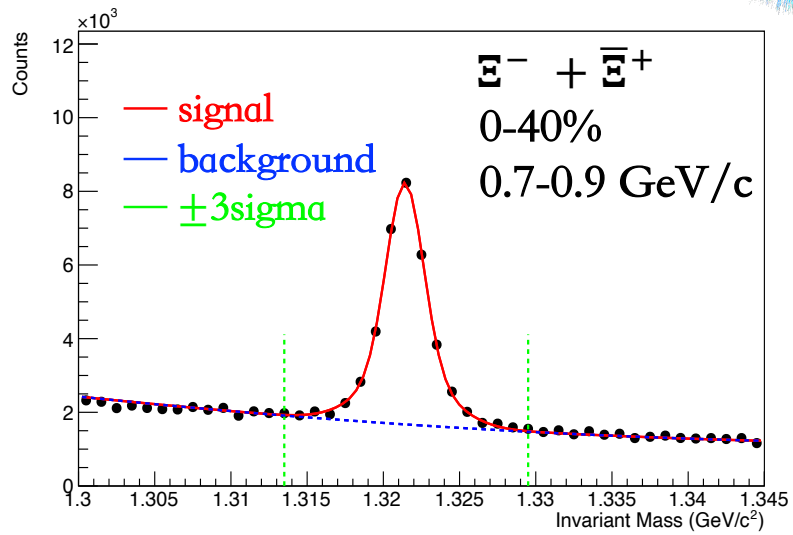
$$\Lambda(\bar{\Lambda}) \to p(\bar{p}) + \pi^-(\pi^+), \quad 63.9\%$$

Invariant mass

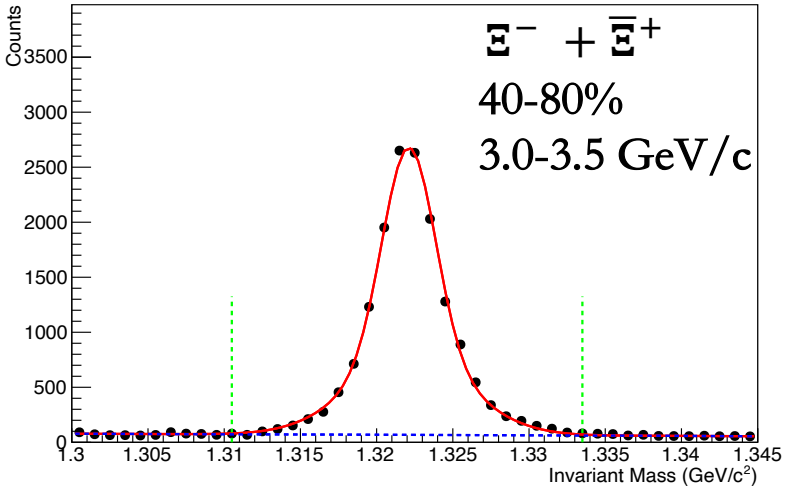


- ☆ **Two centralities have different background level**
- ☆ **Fit function : Double Gaussian + Polynomial function**

Ξ⁻, Au+Au 200 GeV, p_T 0.7-0.9 GeV/c



Ξ⁻, Au+Au 200 GeV, p_T 3.0-3.5 GeV/c



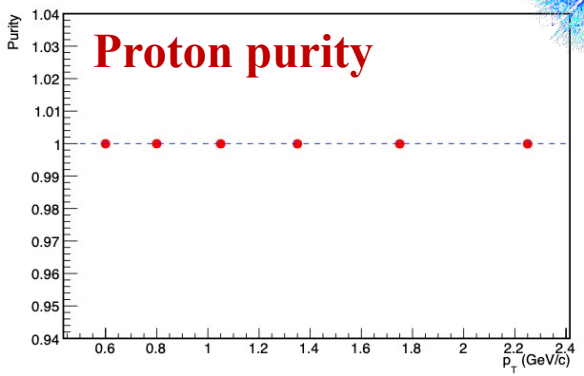
Correlation Function

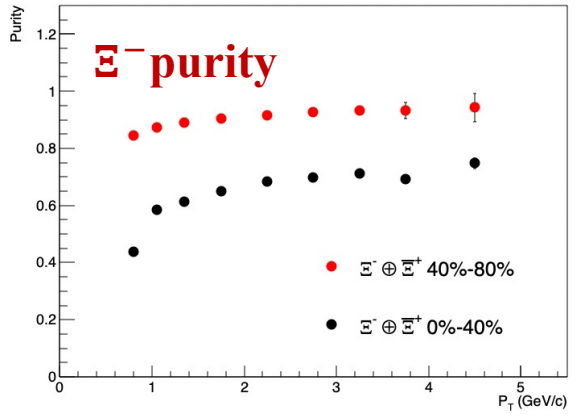
☆ **Two particles correlation function :** $C_{measured} = \frac{A(k^*)}{B(k^*)}$

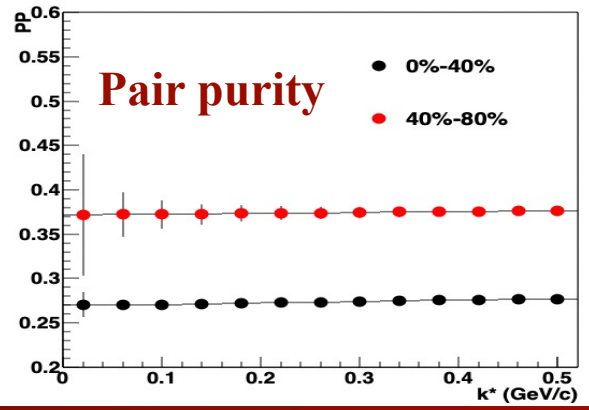
- ☆ A(k*) is the distribution of the invariant relative momentum for p & Ξ^- pairs or $\bar{p}$ & $\bar{\Xi}^+$ pairs from the same event, where k* is momentum of particle in pair reference frame.
- ☆ B(k*) is the reference distribution generated by mixing particles from different events with same centrality and with approximately the same vertex position along z-direction

☆ **Correction:**

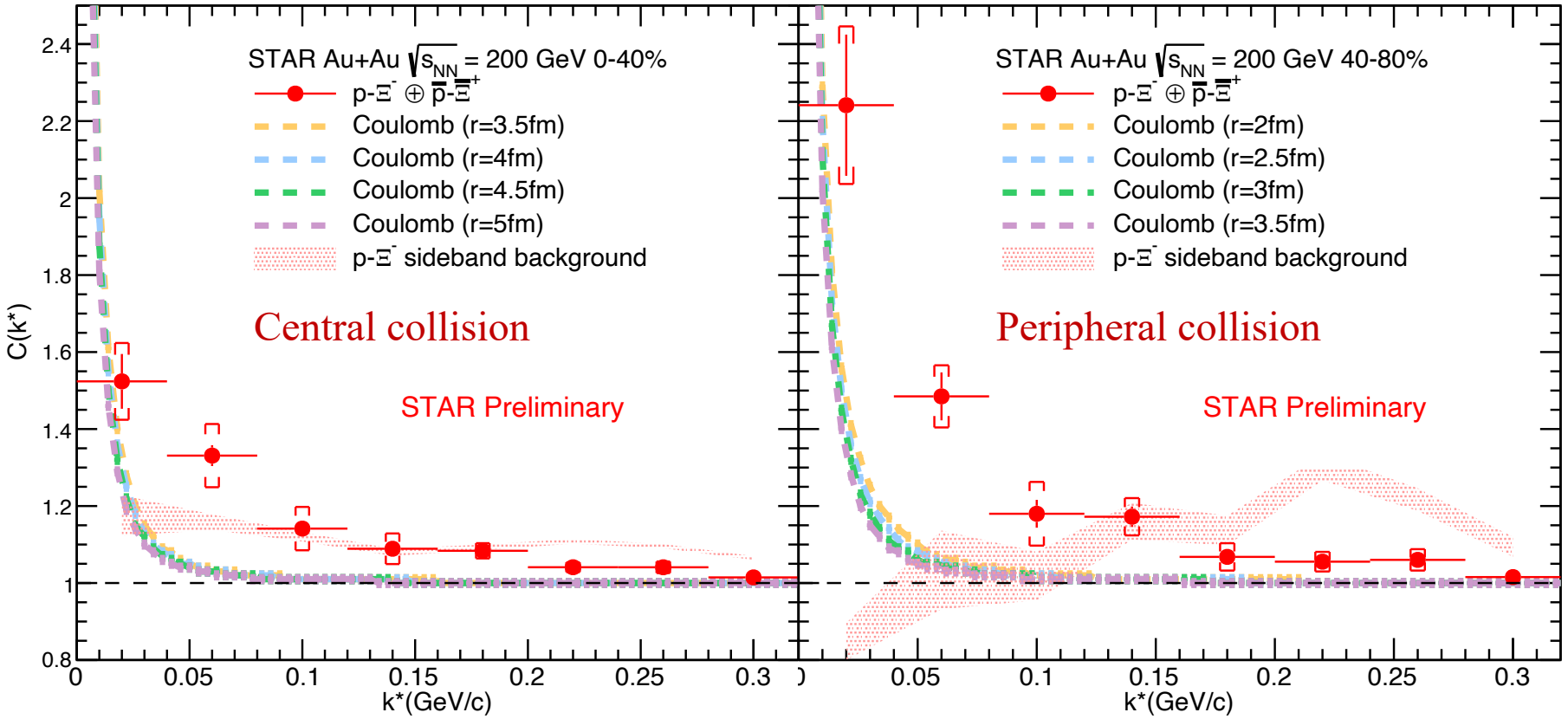
- ☆ **Purity correction:** $C'(k^*) = \frac{C_{measured}(k^*)-1}{P(k^*)} + 1$
  - ☆ P(k*)=P(Ξ^-) * P(proton)
  - ☆ P(Ξ^-) = S/(S+B) * Fr(Ξ^-) and P(proton)= PID *Fr(proton)
  - ☆ Fr is the fraction of primary to inclusive
  - ☆ Fr(proton) = 0.6 for central and 0.7 for peripheral
  - ☆ Fr(Ξ^-) = 0.438 (from Therminator model)







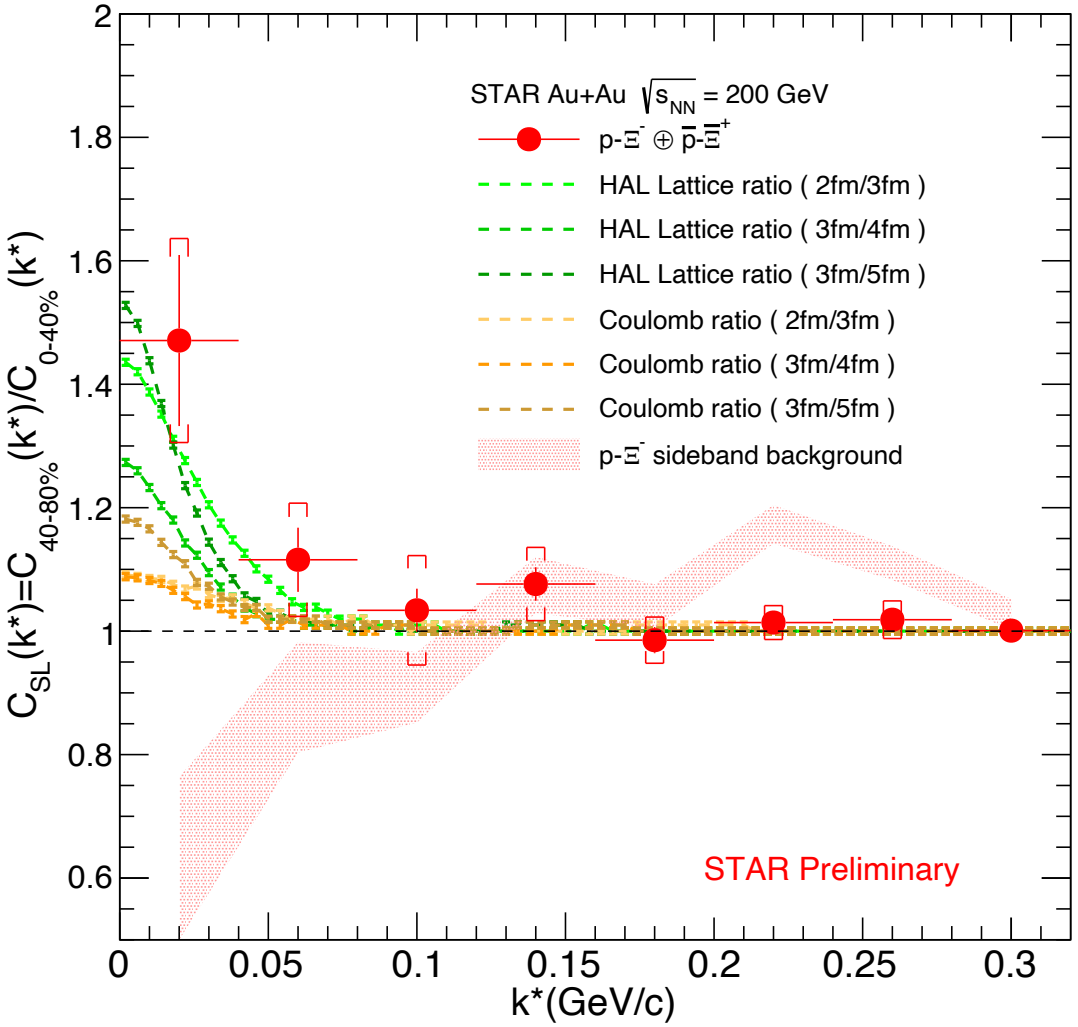
Results : Correlation Function



- **Compared with different source sizes of Coulomb interaction.** [1][2]
- **Enhancement above Coulomb --- Observation of the strong interaction.**
- **Sensitive to the source size, more attractive interaction in small system.**
- **Feed-down corrected, residual correlations are not corrected.**

[1] Nuclear Physics A 982(2019) 359-362
[2] Nature volume 527, pages345–348(2015)

Results : Correlation Function



☆ 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 $p\Xi^-$ without much contamination from the Coulomb[1]

☆ Enhancement above Coulomb --- Hints presence of strong interaction in $p\Xi^-$

☆ Follow HAL Lattice theory prediction (Strong interaction only)

[1] Nuclear Physics A 967 (2017) 856–859

Summary

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

☆ The ratio of correlation function for the peripheral collisions (small system) to central collisions (large system) is larger than unity at low relative momentum.

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

☆ Fit correlation function to extract physics parameters (source size, scattering length, effective range, etc..)

Thank you !