Brief Review on Omega Correlation Function Measurement

Speaker：Ziqian Zhou (周子谦)

Correlation Function: why, what and how

Why measure Correlation function

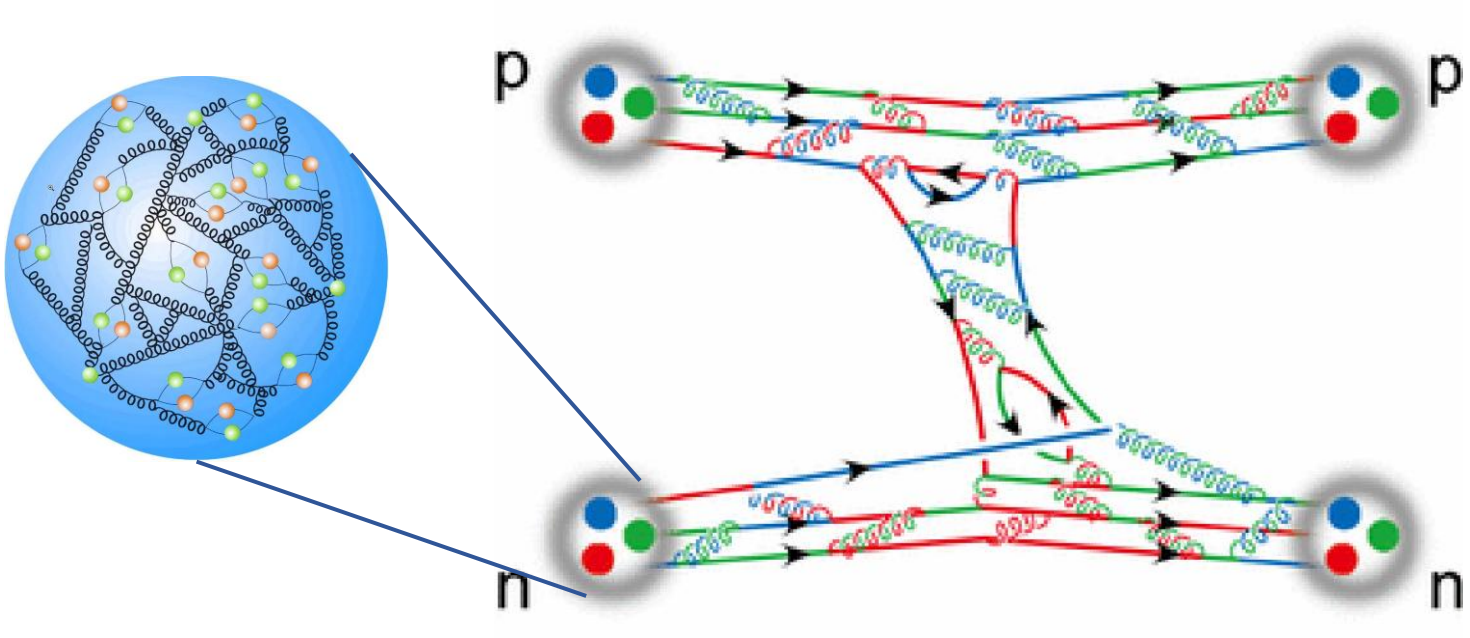


Fig from: Xu Feng's talk, A Lattice QCD Journey: From Nucleon Electric Polarizabilities to Electroweak Pion Production off a Nucleon, 2025

Correlation Function: why, what and how

What is Correlation function?

- Experimental approach: $C(k) = \xi(k)\frac{N_{SE}(k)}{N_{ME}(k)} = \frac{P(AB)}{P(A)\times P(B)}$
- Represents certain correlation
- Theoretical approach: $C(k) = \int S(r)|\psi(r,k)|^2 d^3 r$
- Decided by collision condition and interaction

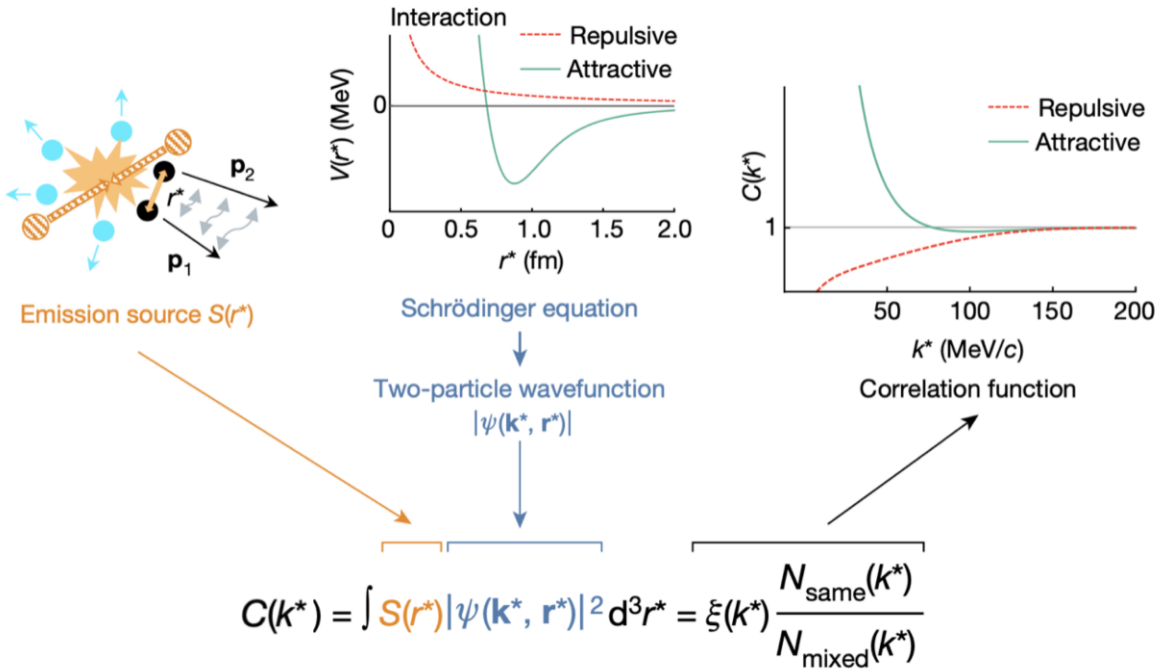
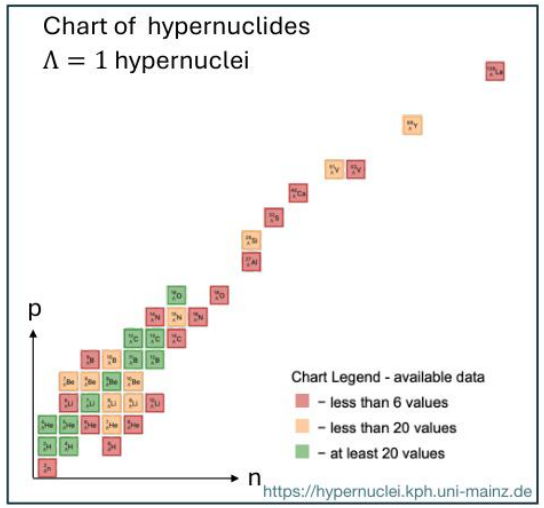


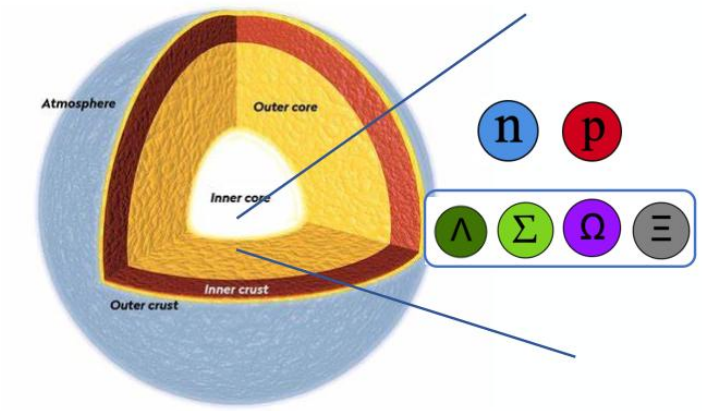
Fig from: ALICE Collaboration, Unveiling the strong interaction among hadrons at the LHC, Nature **588**, 232 (2020)

Correlation Function: why, what and how

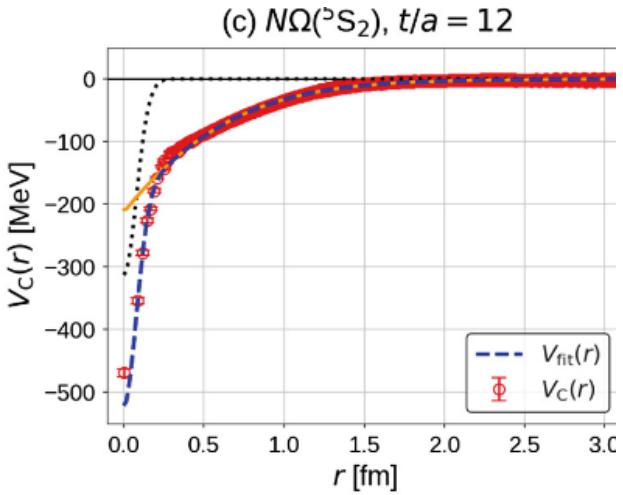
Why Omega?

- Hyperon interactions: benefits our understanding in strong interactions, heavy-ion-collisions and neutron stars
- Feasibility: sizable hyperon production, but multi Omega events are rare
- Theoretical prediction available





D. Lonardoni, et al. PRL 114, 092301 (2015)

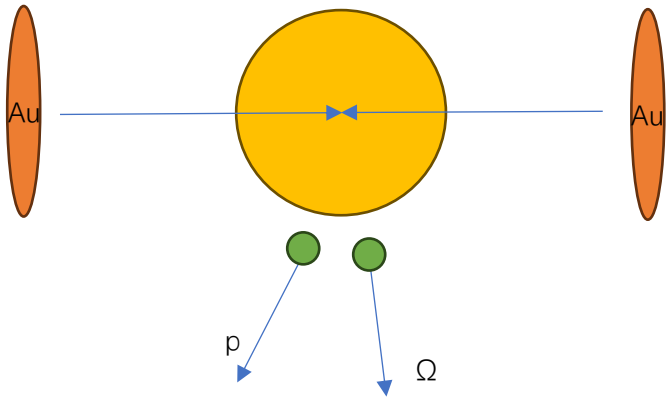


HAL QCD Collaboration. NΩ dibaryon from lattice QCD near the physical point. Phys. Lett. B 792, 284–289 (2019)

Current Result

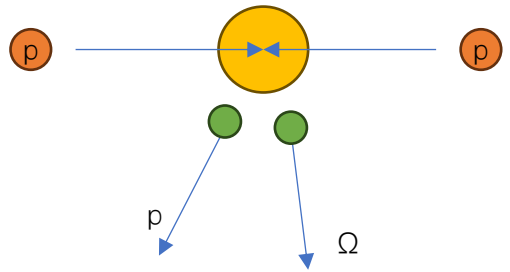
Measured p-Omega correlation function

Au-Au 200GeV



STAR Collaboration, Physics Letters B **790**, 490 (2019)

p-p 13TeV



ALICE Collaboration, Nature 588, 232 (2020)

Current Result

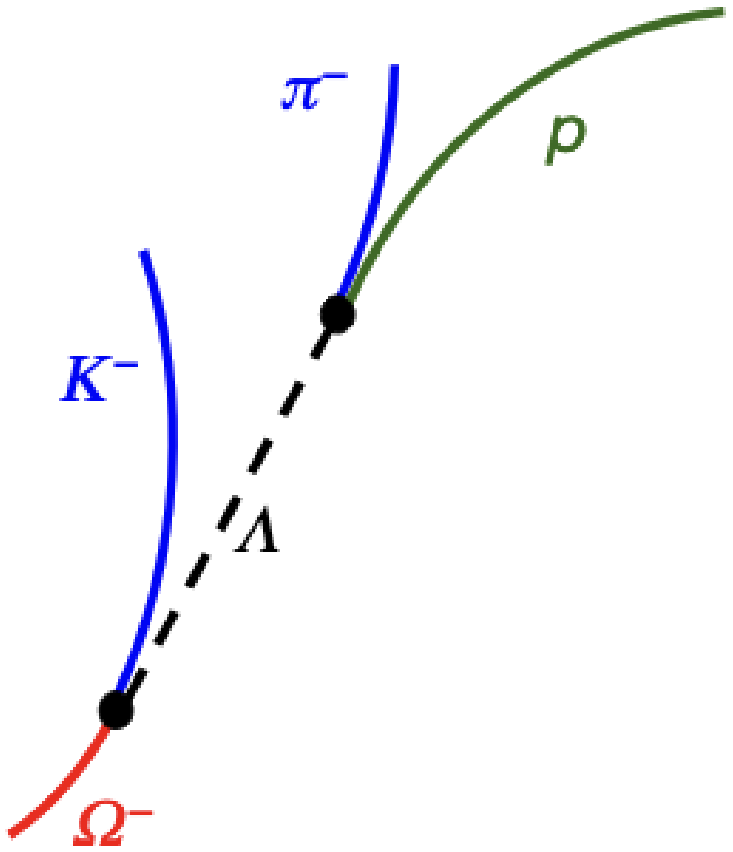
Omega reconstruction

- Omegas are detected through weak decay:

  $\Omega \rightarrow \Lambda + K^-$ 67.8%

- Subsequent decay:

  $\Lambda \rightarrow p + \pi^-$ 63.9%



ALICE Collaboration, Nature 588, 232 (2020)

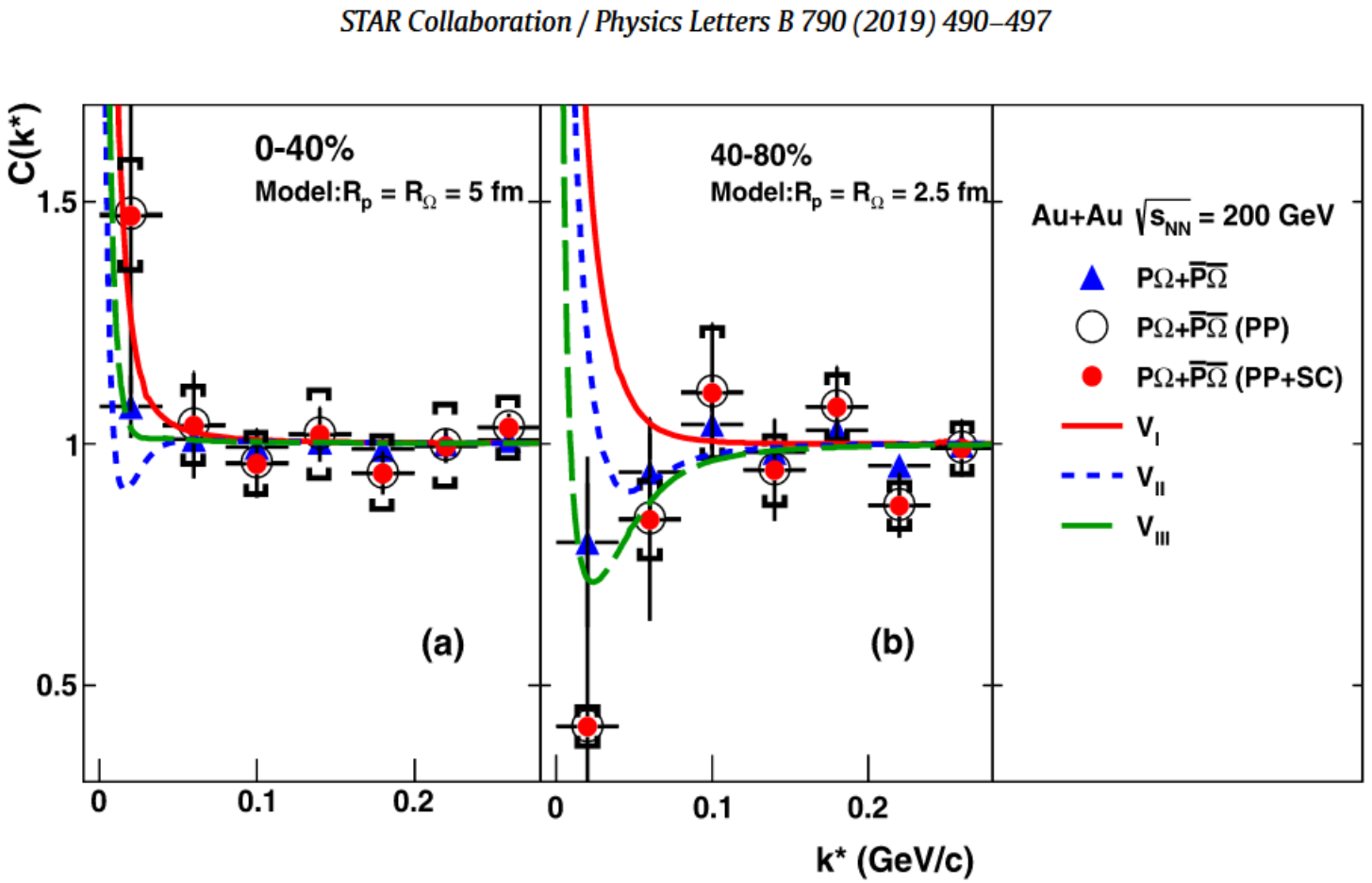
P-Omega measurement

Star Result

- Au-Au 200GeV
- Pairs : $p\Omega \oplus \bar{p}\bar{\Omega}$
- Centrality Group:

  0-40% (r=5fm) &

  40-80% (r=2.5fm)

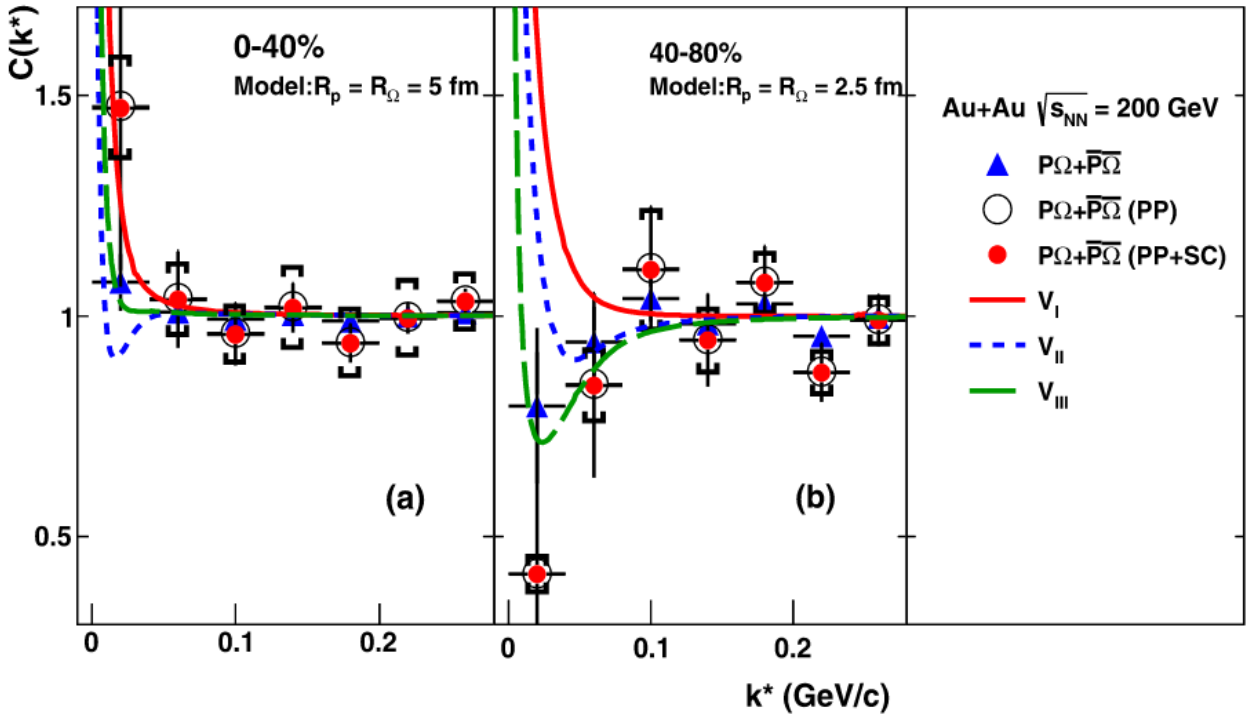


P-Omega measurement

Star Result

- Interaction:
  - HALQCD prediction V2
  - w/o bound state V1
  - w deep bound state V3
- Data correction:
  - No correction: ▲
  - pair-purity（PP） corrected: ◯
  - PP + smearing corrected: ●

STAR Collaboration / Physics Letters B 790 (2019) 490–497



P-Omega measurement

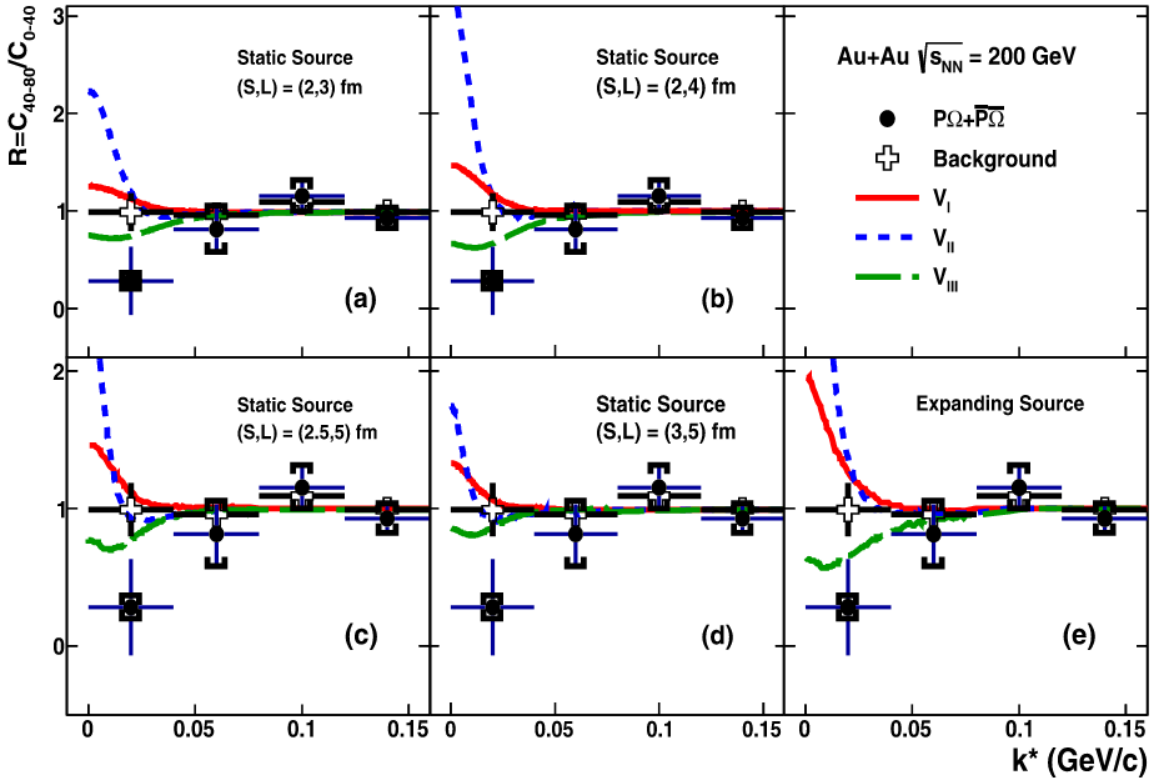
Star Result

- Define the ratio of correlation function from peripheral (40–80%) to central (0–40%) collisions:

$$R = C_{40-80}/C_{0-40}$$

- S: small source size
- L: large source size
- Characteristic of the ratio does not change with small variation in the source

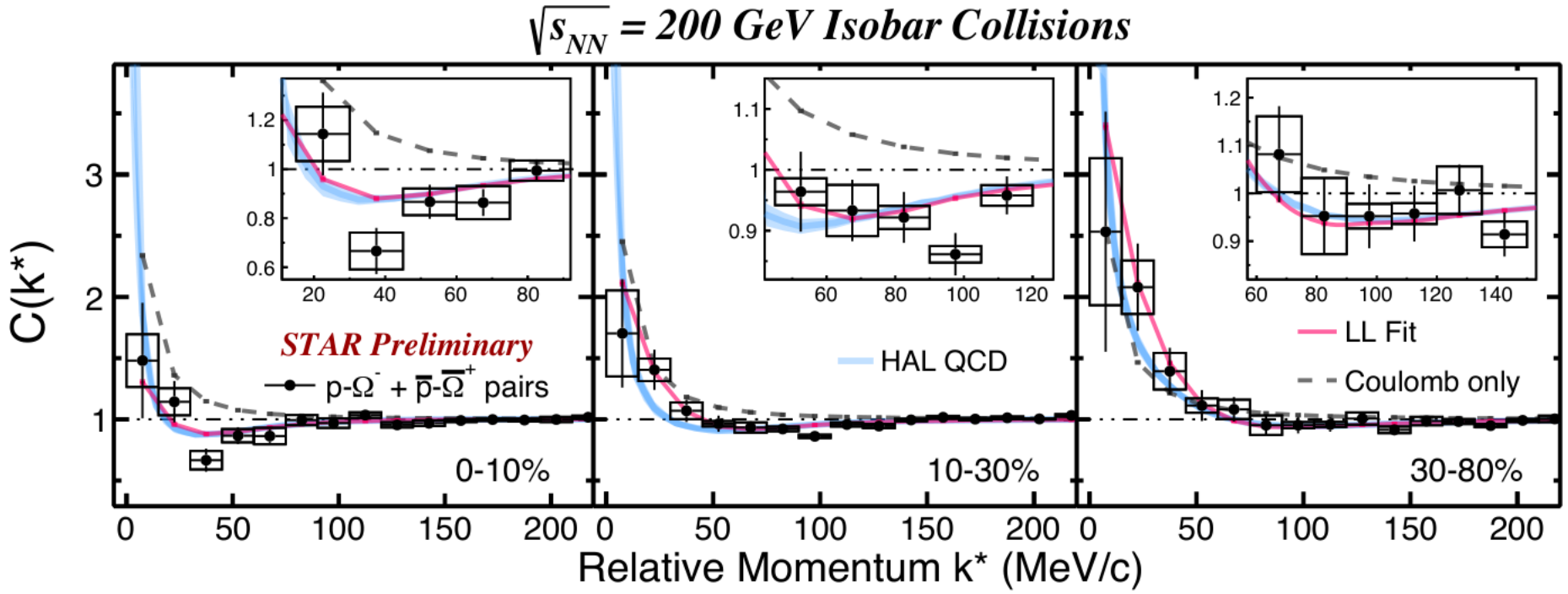
STAR Collaboration, Physics Letters B **790**, 490 (2019)



P-Omega measurement

Star Result —— Preliminary

Fig from: a talk by Kehao Zhang, 2025 QPT



- Prefer VII: shallow bound state
- Central to peripheral

P-Omega measurement

ALICE Result

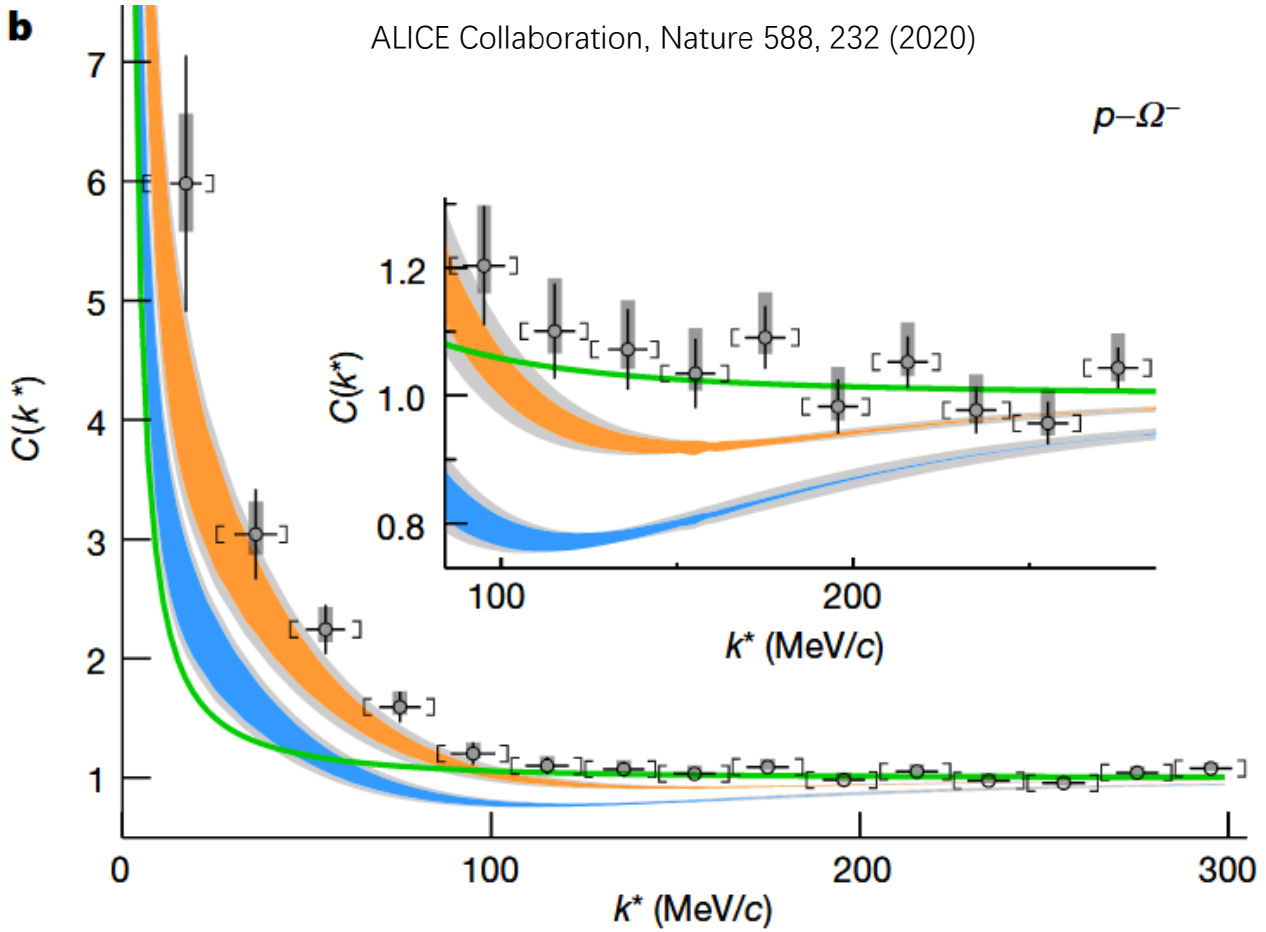
- Pairs :

$p\Omega \oplus \bar{p}\bar{\Omega}$

- High multiplicity pp

- Source size :

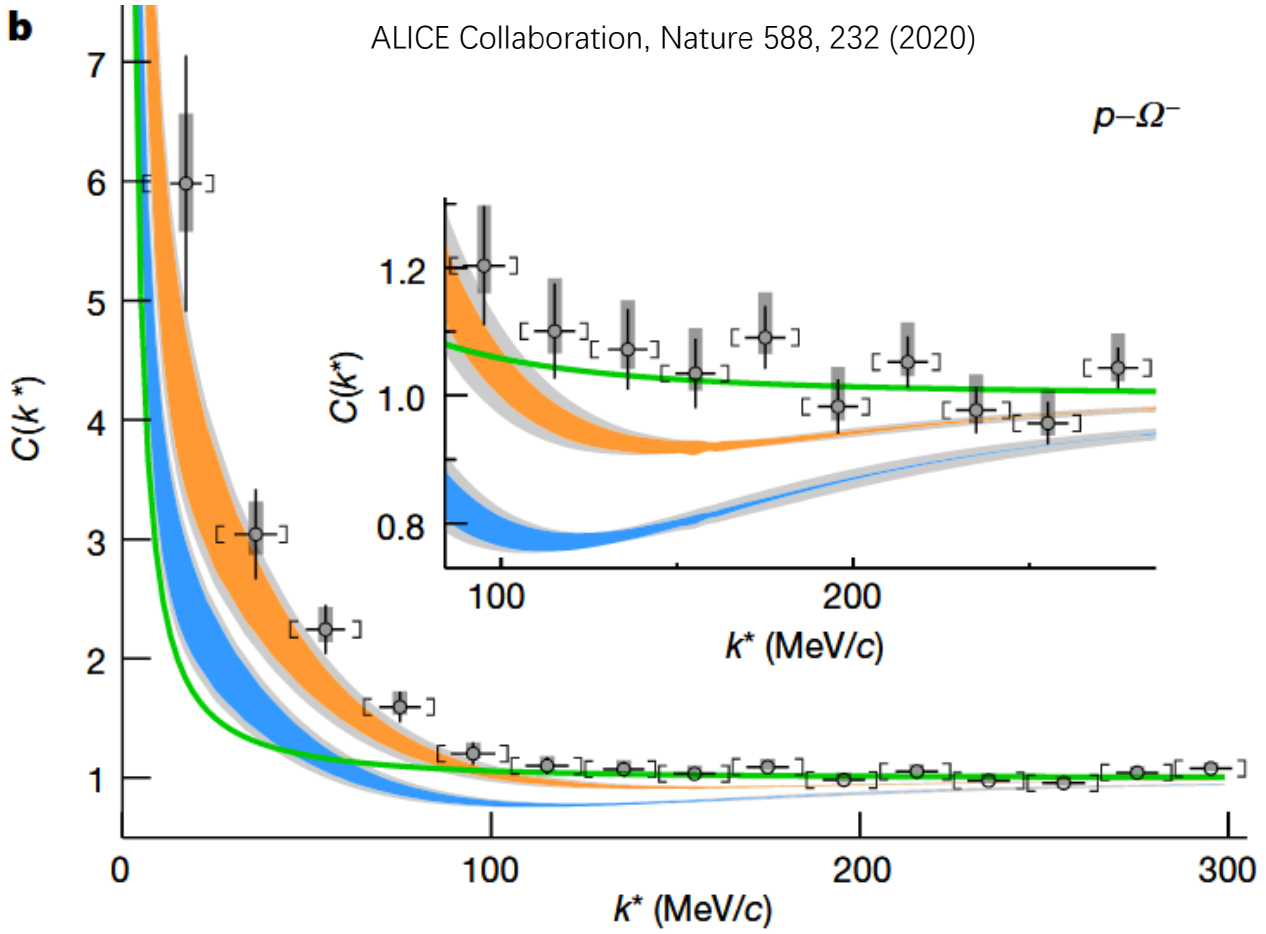
$0.95 \pm 0.06\mathrm{fm}$



P-Omega measurement

ALICE Result

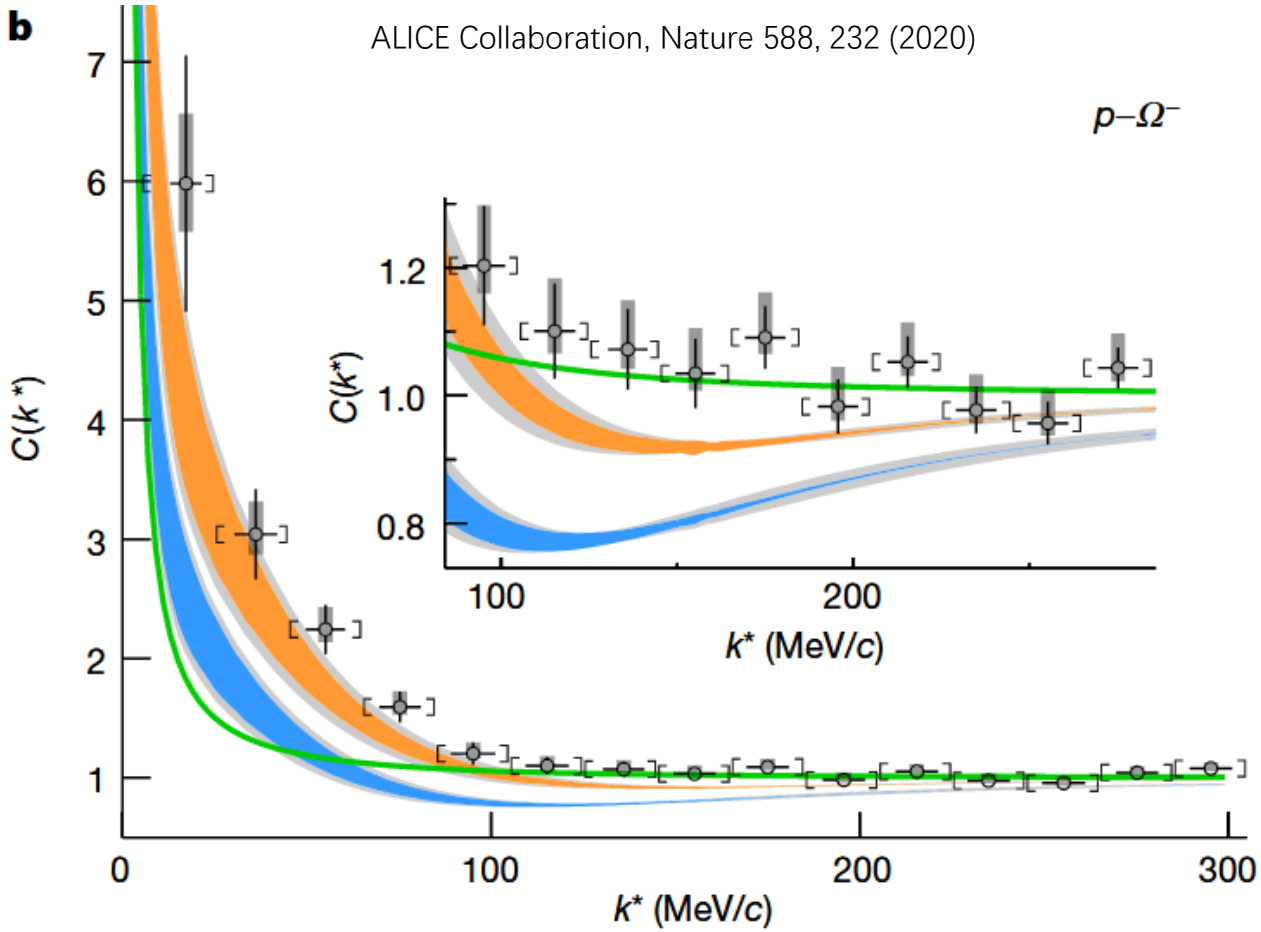
- Interaction:
  - Coulomb
  - Coulomb + HAL QCD
  - Coulomb + HAL QCD + inelastic



P-Omega measurement

ALICE Result

- Inset: depletion predicted in theory was not observed
- Unable to confirm a bound state



Summing up

- First step measurements had been done
- Attractive strong interaction can be conclude
- Need more statistic for further constraint

Summing up

- LHC Run3 with more data may help with the measurement
- 50-100 (Pb-Pb) and 1000 (p-Pb) times data in Run3[1]
- May result in a firm conclusion and interesting findings

[1] A. Collaboration, The ALICE experiment: a journey through QCD, Eur. Phys. J. C **84**, 813 (2024).

Thank You!