Lambda-proton correlations

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p–p correlation:

Strong interaction (attractive)
Coulomb interaction (repulsive)
Fermi-Dirac statistics

Λ–p correlation:

Strong interaction (attractive)

Λ–p strong interaction potential

A.R. Bodmer and Q.N. Usmani, Phys. Rev. C **31**, 1400 (1985)

Urbana-type attractive potential:
(from low energy Λ–p scattering and hypernuclei bind energy data)

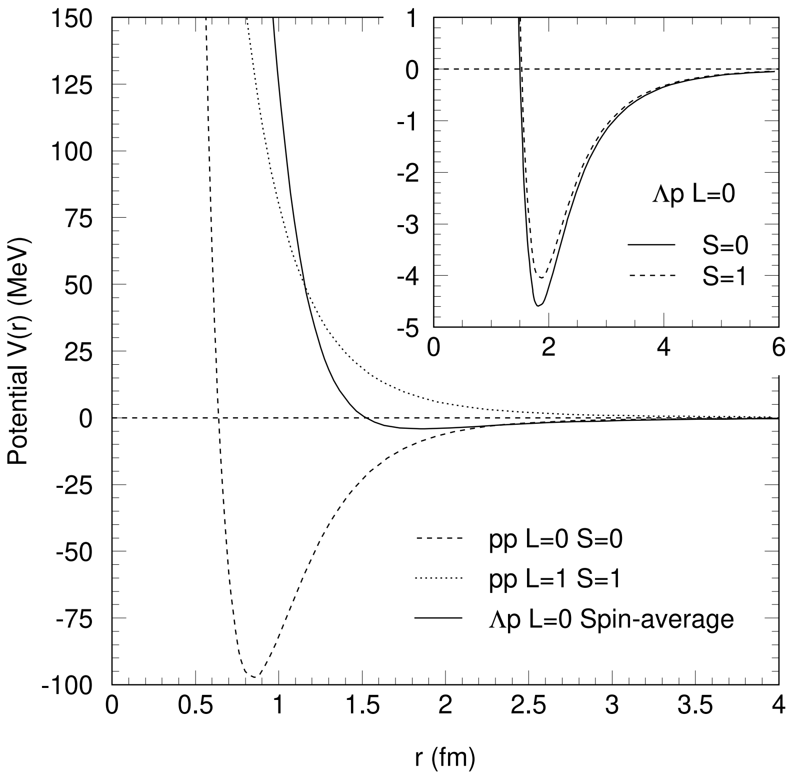
$$V_{\Lambda-p} = V_C - \left(\bar{V} - \frac{1}{4} V_\sigma \boldsymbol{\sigma}_\Lambda \cdot \boldsymbol{\sigma}_p\right) T_\pi^2$$

$$V_C = W_C \left[1 + \exp\left(\frac{r-R}{d}\right)\right]^{-1}; \quad W_C = 2137 \text{ MeV}, \ R = 0.5 \text{ fm}, \ d = 0.2 \text{ fm}$$

$$T_\pi = \left(1 + \frac{3}{x} + \frac{3}{x^2}\right) \frac{e^{-x}}{x} \left(1 - e^{-cr^2}\right)^2; \quad x = 0.7\, r, \ c = 2 \text{ fm}^{-2}$$

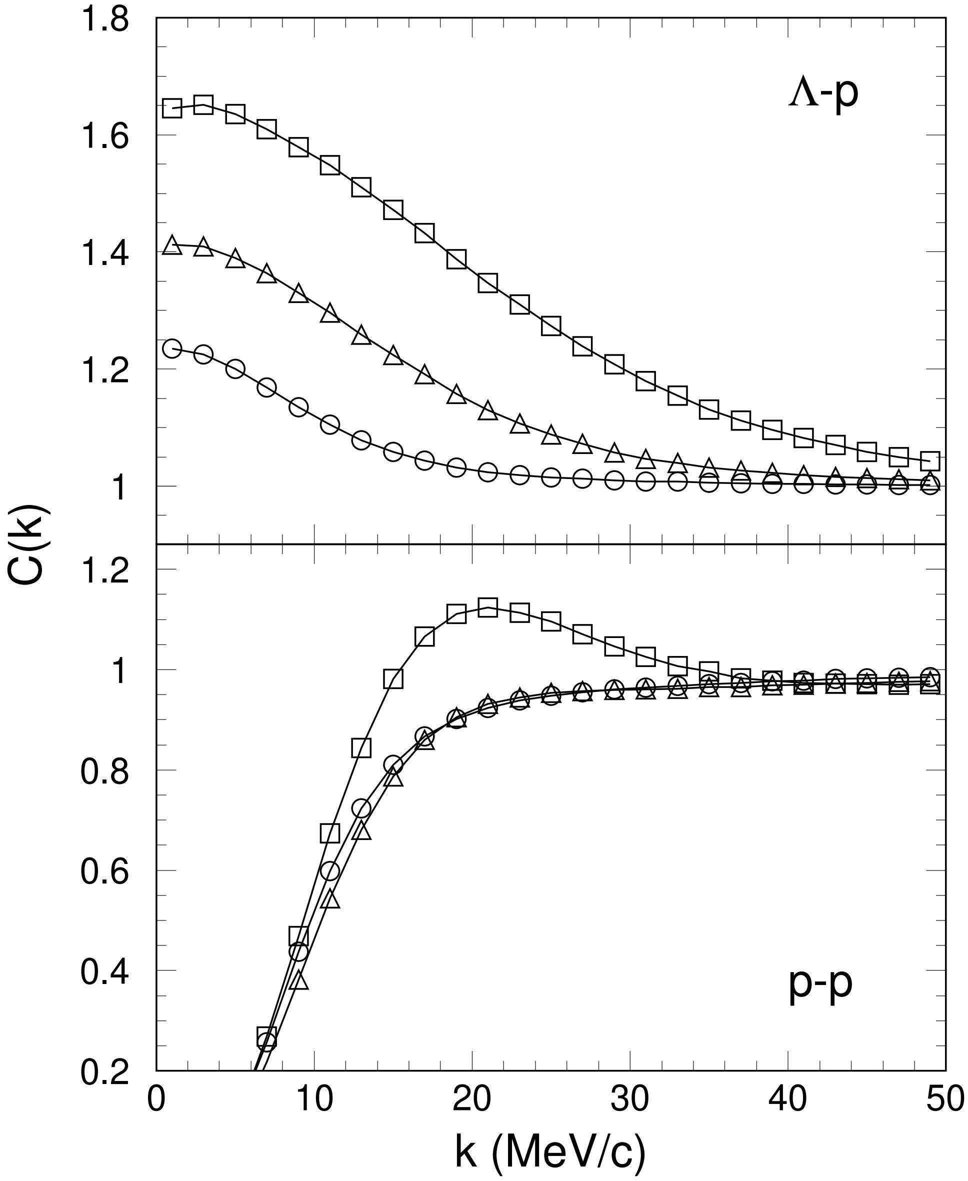
– Spin-independent part: $\bar{V} = 6.2 \pm 0.05$ MeV.

– Spin-dependent part: $0 < V_\sigma < 0.5$ MeV, not well determined.

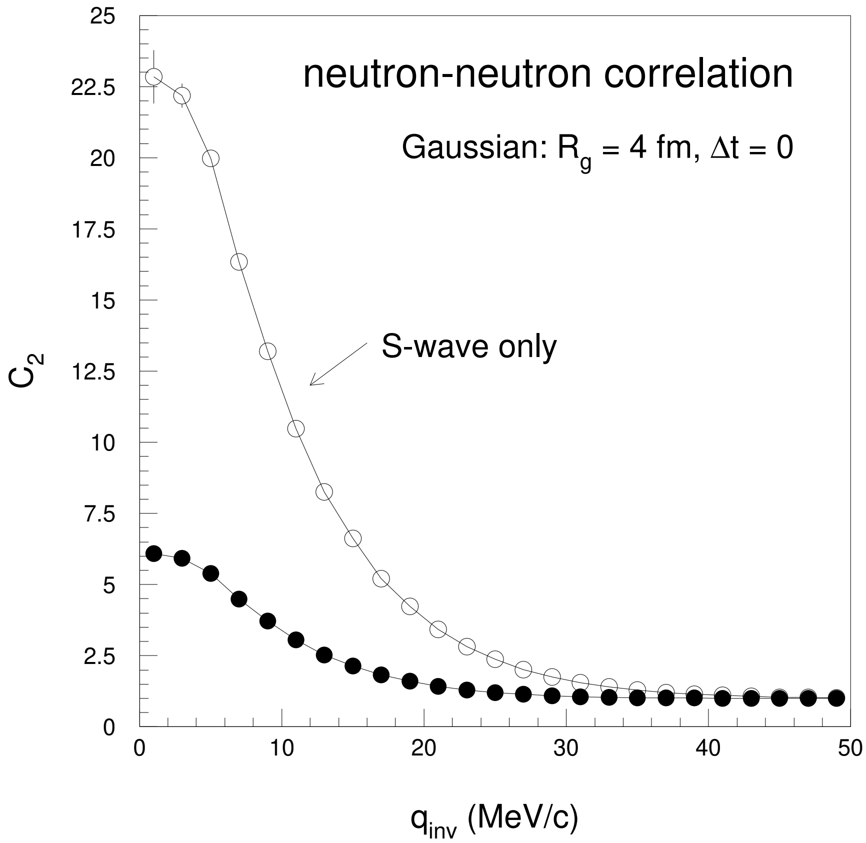


Λ–p Urbana-type potential compared to N–N Reid potential.

Λ–p vs p–p correlation



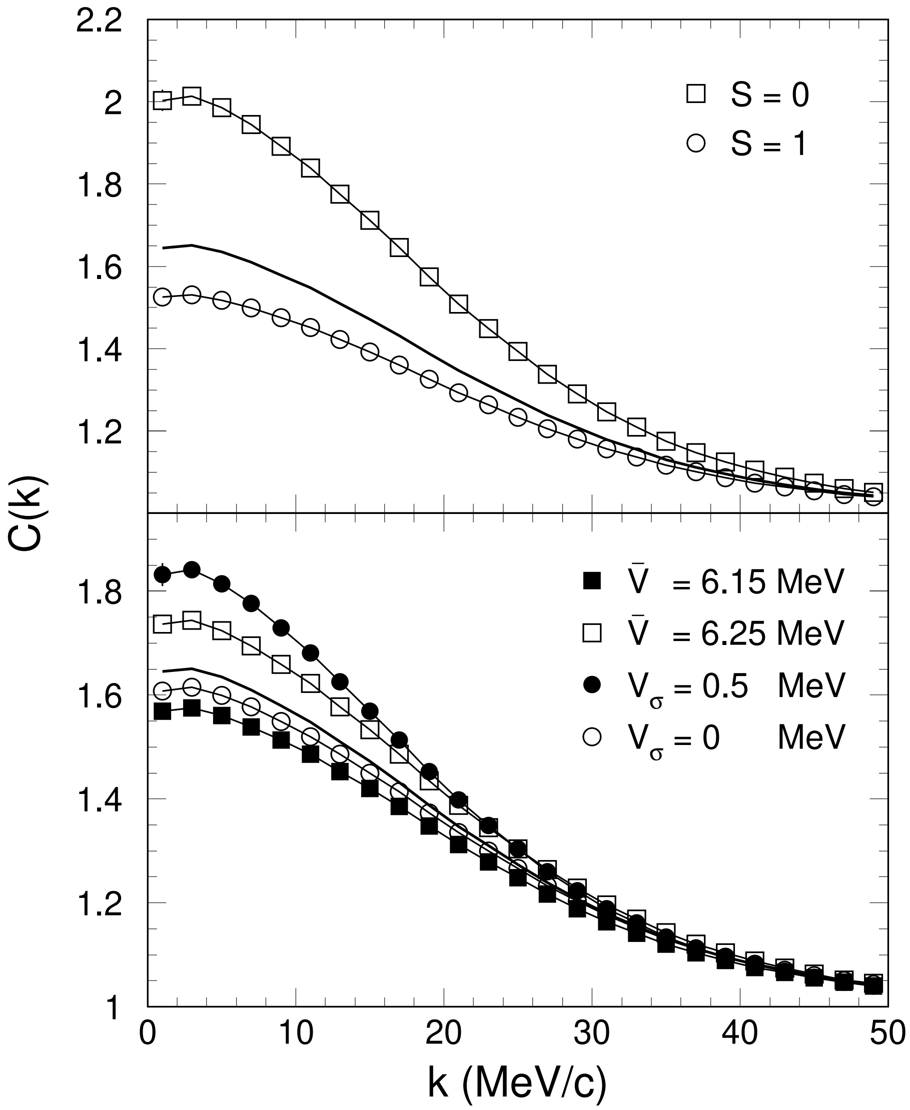
Λ–p correlations are more sensitive than p–p for determining large source sizes: no Coulomb repulsion, although N–N scattering length is much longer.



neutron-neutron correlation
Gaussian: R_g = 4 fm, Δt = 0
S-wave only
C_2
q_inv (MeV/c)
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0
0
10
20
30
40
50

Spin decomposition, Potential parameter uncertainties

As V_σ is not well understood, measuring the spin dependence of Λ–p correlation could in principle determine V_σ.

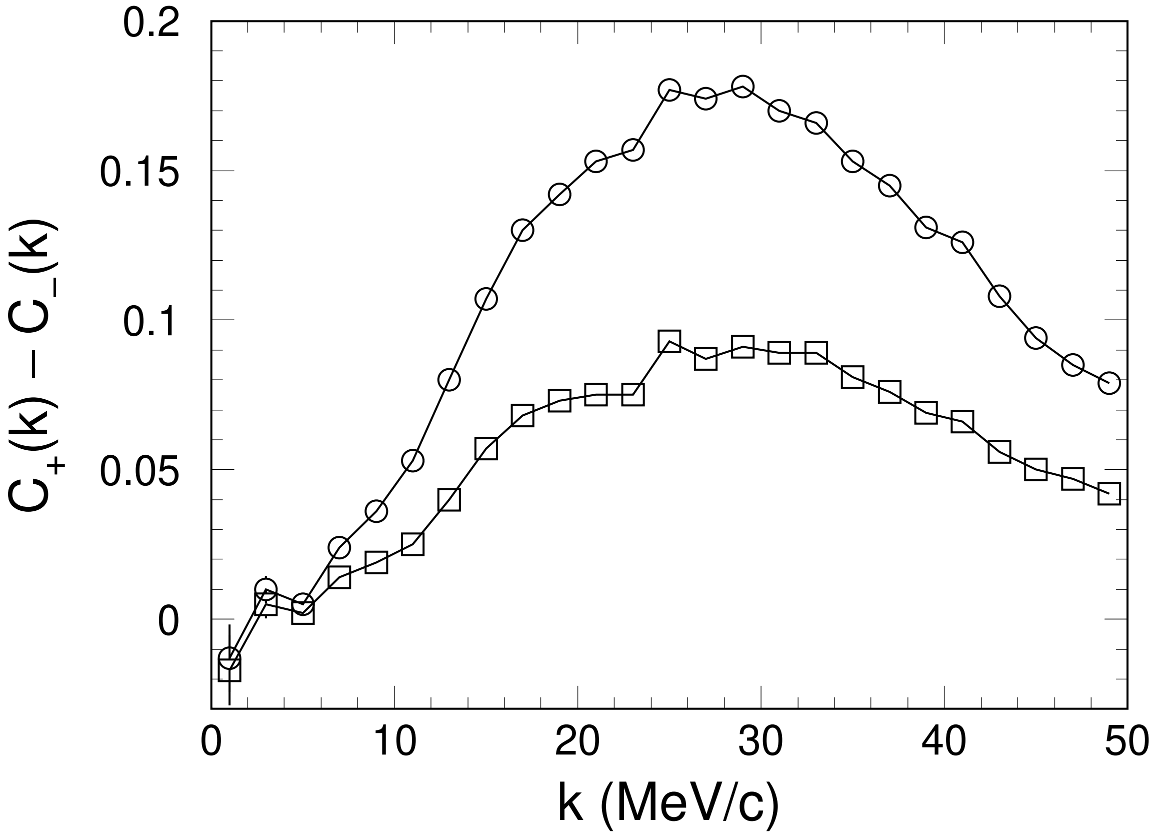


Potential parameter uncertainties translate to a $\pm$ 0.5 fm uncertainty in the extracted source size. Meanwhile, the large k tail still has good constrain on the source size.

Emission sequence of Λ and proton

R. Lednicky *et al.*, Phys. Lett. B **373**, 30 (1996)

To determine whether or not Λ and proton are emitted simultaneously: If Λ is emitted earlier, then stronger correlation if proton is faster; vice versa.



Δz might result if the Λ's would escape earlier than the protons.

Quantitative determination whether or not strange baryons freezeout similarly as nonstrange baryons, if a few percent errors at $k \sim 30$ MeV/c is achieved.

Why to measure Λ–p correlations – Physics Motivations

- **Larger sensitivity to baryon source size than traditional p–p correlations**
- **Probing strange baryon source**
- **Possibility to probe differences between Λ and proton sources**
- **Potentail for better understanding Λ–p strong interaction**
- **First of such studies**

Feasibilities of measurements in STAR

For proton Boltzmann temperature T=300 MeV, from pure phase space population: A total of **20 million pairs** results in

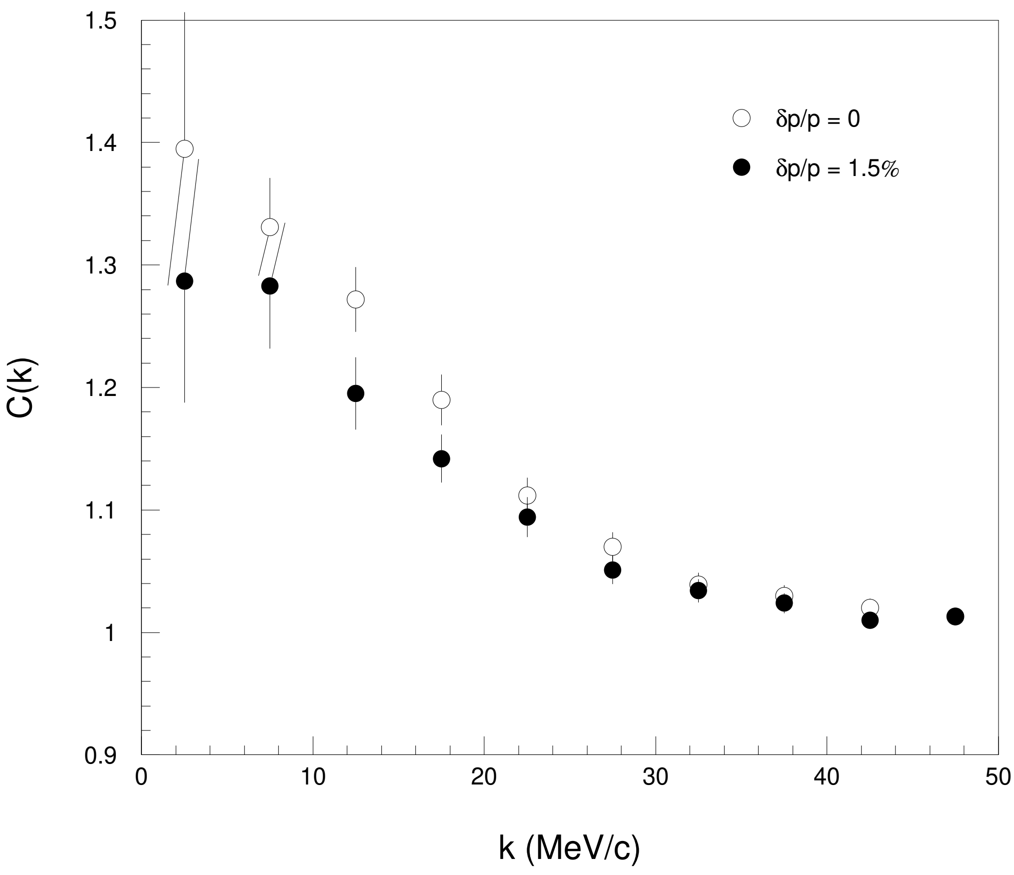
– 10 pairs in $0 < k < 5$ MeV/c

– 70 pairs in $5 < k < 10$ MeV/c

– 800 pairs in $25 < k < 30$ MeV/c

– 7000 pairs in $0 < k < 50$ MeV/c

STAR: 20 million pairs $\approx$ **2 million central Au+Au events.**
$\delta p/p \sim 1.5\%$ at momentum ~ 1 GeV/c.



Conclusions

- Λ–p correlation is investigated.
- Λ–p correlation is more sensitive to large source size than p–p .
- Λ–p correlation measurement in STAR is feasible.
- Quantitative determination of differences in Λ and proton source parameters is also experimentally feasible.
- Better understanding of Λ–p strong interaction and especially Λ–p spin-spin interaction exploiting the large abundance of low momentum Λ's from heavy-ion collisions?

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