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Modern problems of nuclear and elementary particle physics

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Momentum Sharing in Imbalanced Fermi Systems

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APCTP

Asia Pacific Center for Theoretical Physics

BLTP

Short-Range Nucleon-Nucleon Correlations Investigated with the Reaction $^{12}C(e, e' p p)$

PRL 74 (1995)

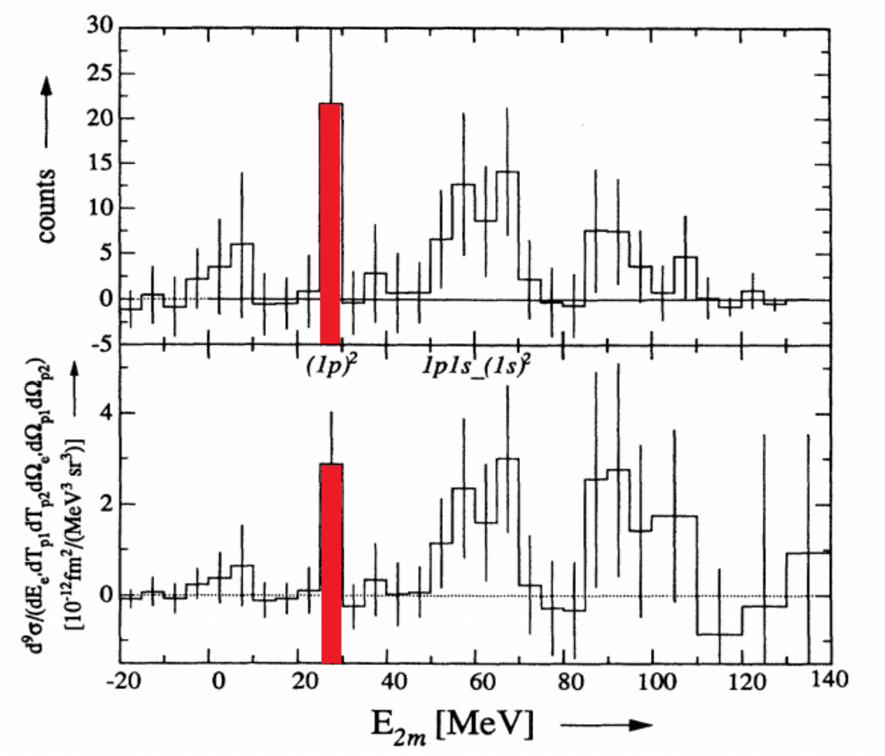
L. J.H. M. Kester, ' W. H. A. Hesselink, (NIKHEF),
F.W. Hersman, W. Kim (UNH)

- $^{12}C(e, e' p p)$ studied at an energy transfer ω= 212 MeV and a three momentum transfer $|\boldsymbol{q}|$= 70 MeV/c.

- The measured missing-energy spectrum shows a signature for knockout of proton pairs from $(1p)^2$, (1p, 1s), and $(1s)^2$ states.

- Measured cross section for the knockout of a $(1p)^2$ pair can largely be attributed to short-range nucleon-nucleon correlations.

Number of True Triple Coincidence Events



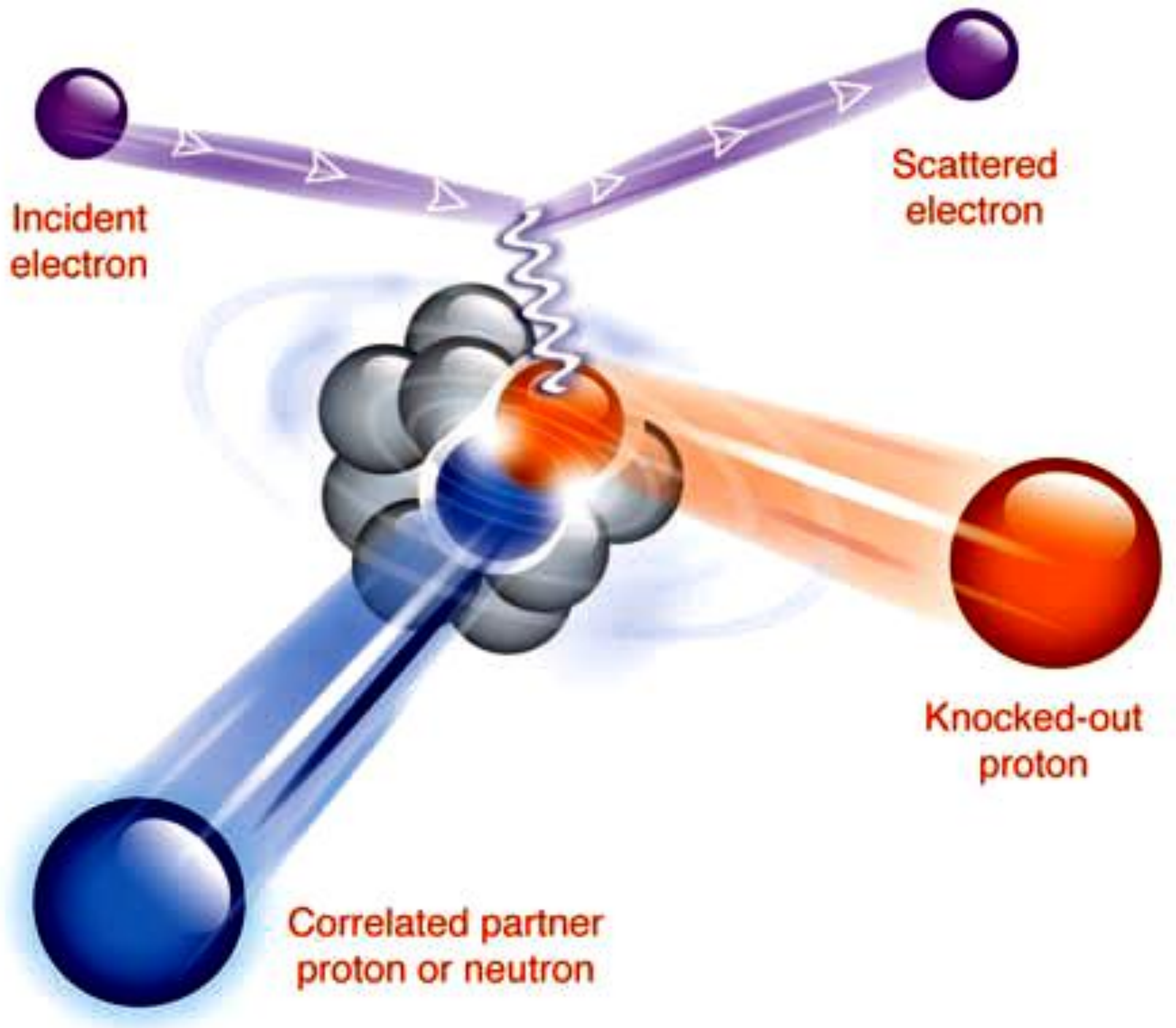
Upper panel - the total number of triple coincidences, is displayed as a function of the double missing energy $E_{2m} \equiv E_e - E'_e - T_{p_1} - T_{p_2} - T_{recoil}$. The data have been corrected for inefficiencies and accidental coincidences.

Lower panel - the cross sections obtained from these data are presented. They are corrected for radiative effects.

Short Range Correlation

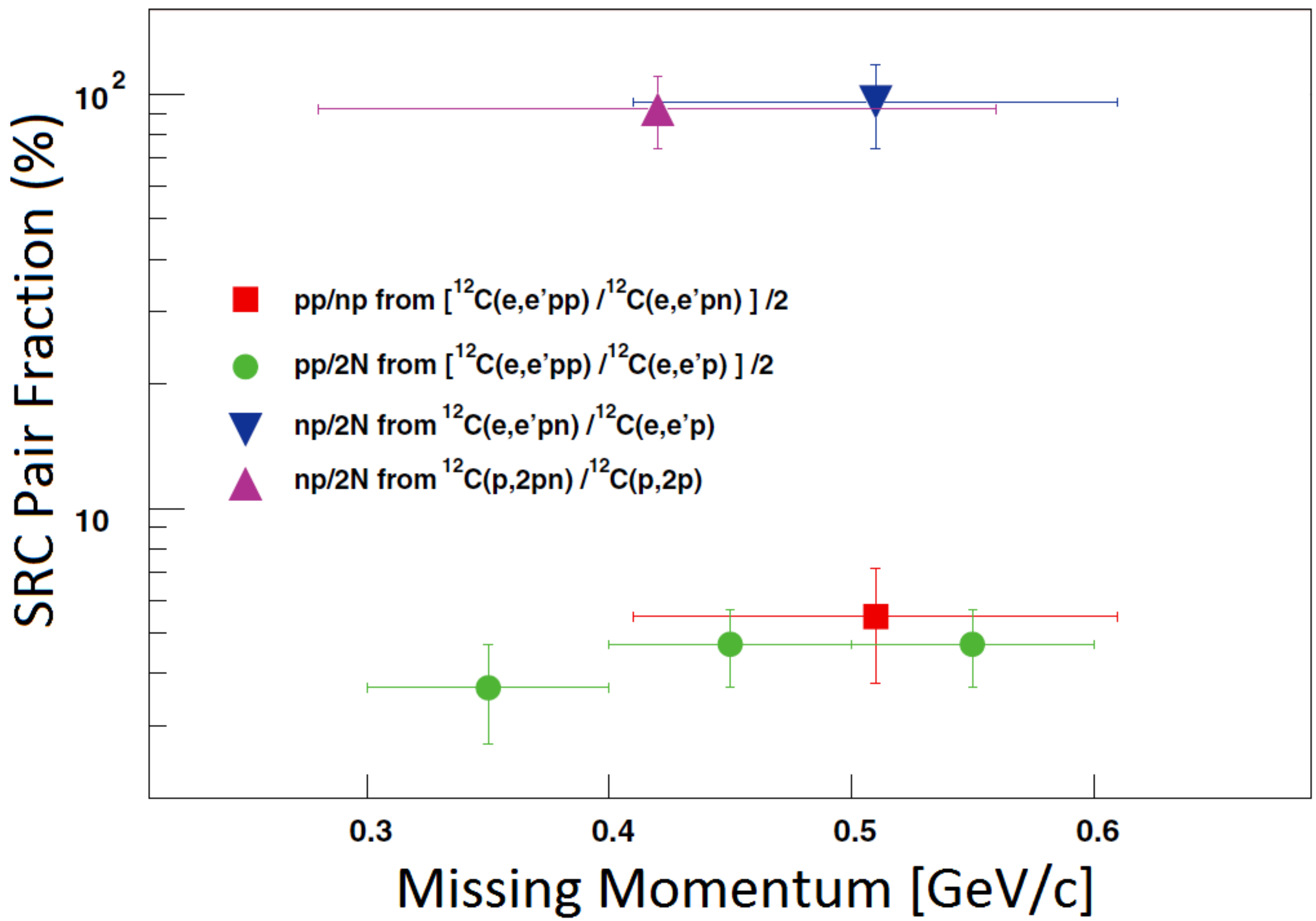
- The protons and neutrons in a nucleus can form strongly correlated nucleon pairs
- In electron scattering experiments, a proton is knocked out of the nucleus with high-momentum transfer and high missing momentum
- In ^{12}C the n-p pairs are nearly 20 times as prevalent as p-p pairs and, by inference, n-n pairs
- Difference between the types of pairs is due to the nature of the strong force and has implications for understanding cold dense nuclear systems such as neutron stars

Illustration of the $^{12}C(e,e'pN)$ Reaction

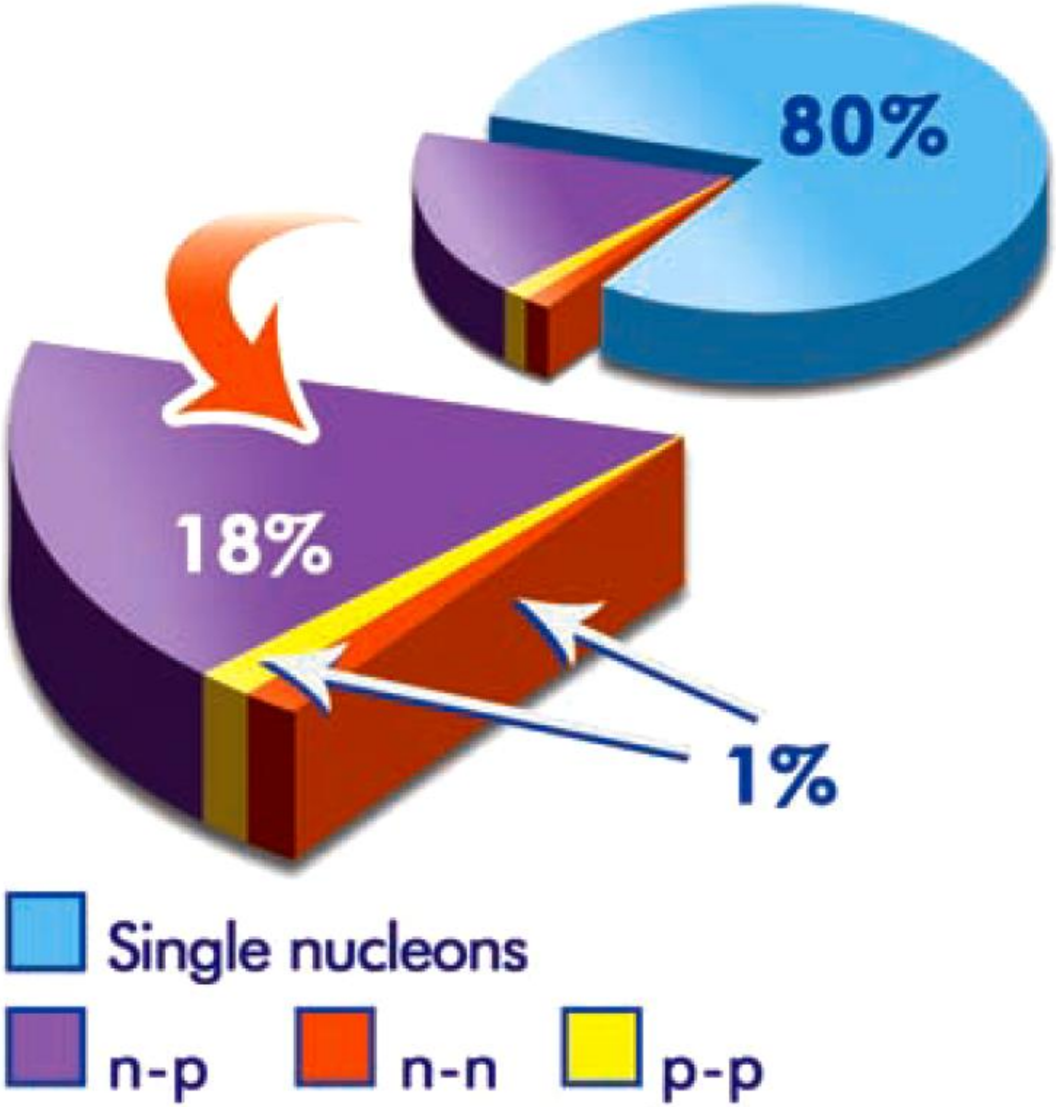


Fractions of Correlated Pair Combinations in Carbon as Obtained from the (e,e'pp) and (e,e'pn) Reactions, as well as from (p,2pn) Data

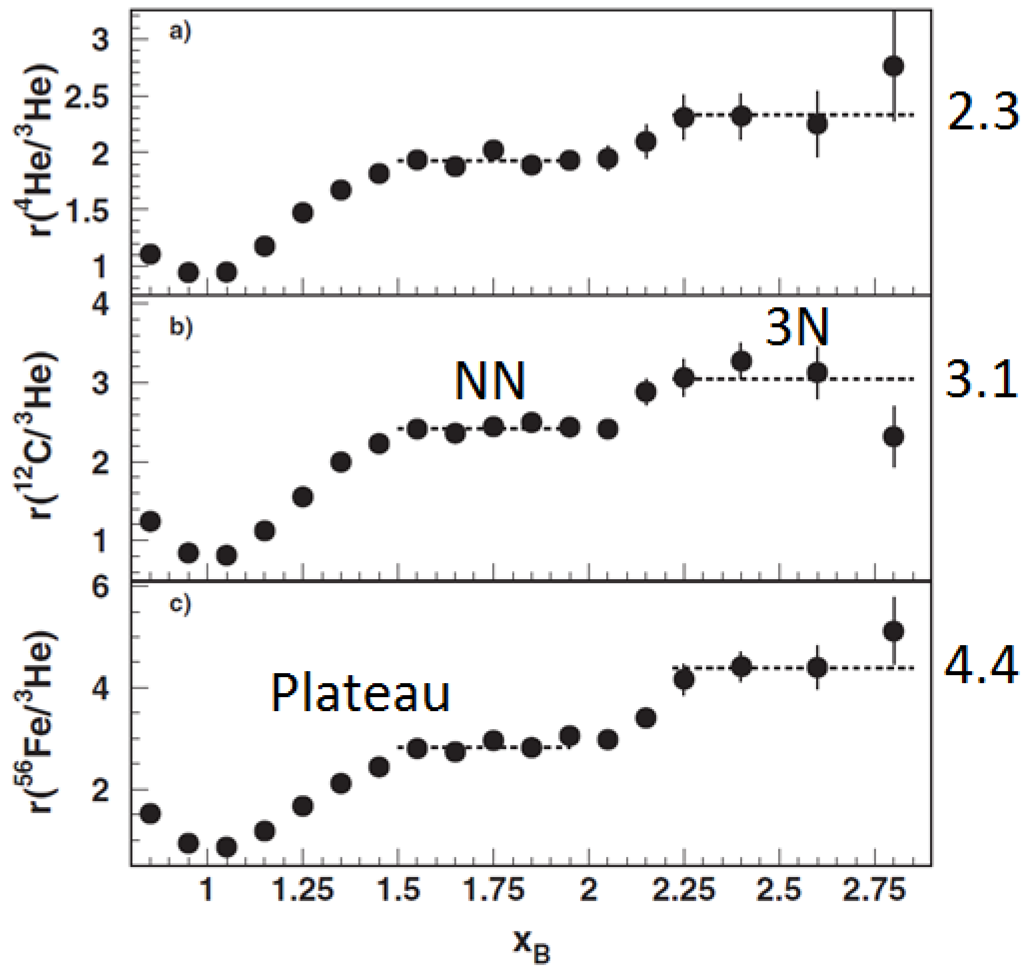
R. Subedi, Seonhu Choi (SNU) Jlab Hall A Collaboration
SCIENCE 320 (2008)



Average Fraction of Nucleons in the various Initial-state Configurations of ^{12}C



Two and Three Nucleon SRC Probabilities in Nuclei



Weighted cross section ratios of **(a)** ^{4}He, **(b)** ^{12}C, and **(c)** ^{56}Fe to ^{3}He as a function of x_B for Q^2 > 1.4 GeV^2

Ratios of A(e,e') Inclusive Electron Scattering

K. S. Egiyan *et al.*, CLAS Collaboration PRL 96, (2006)

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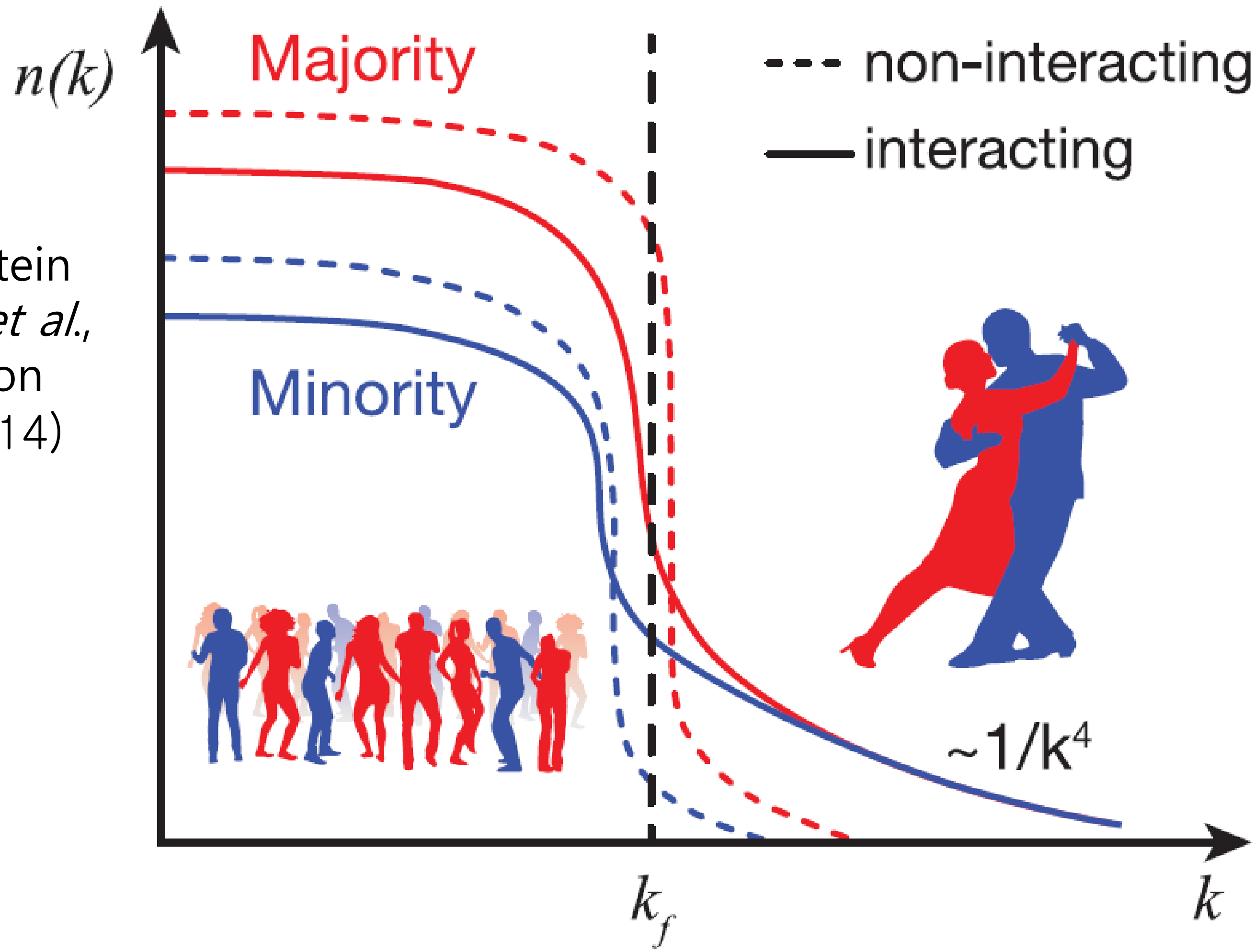
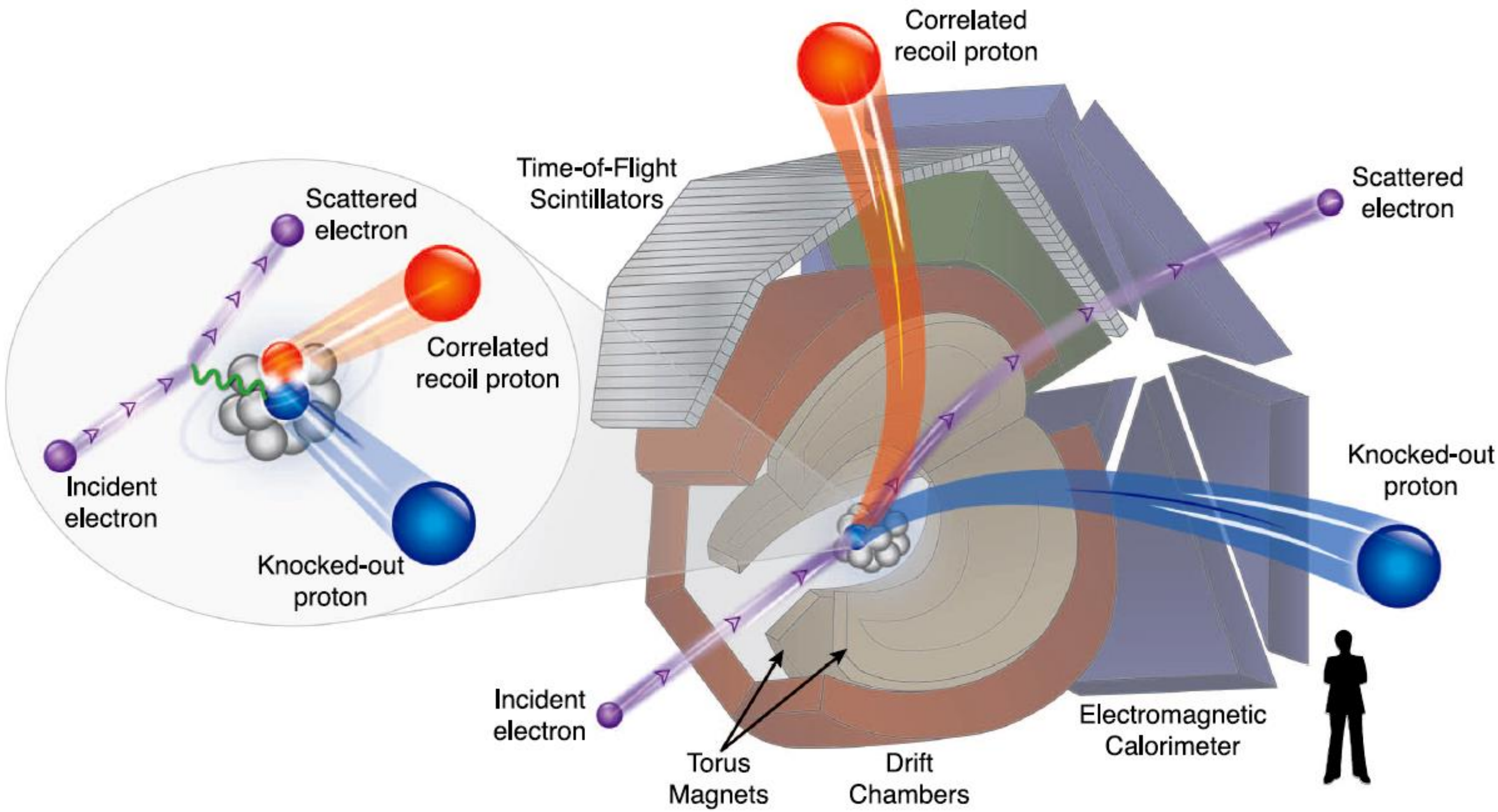
SCIENCE 346 (2014)

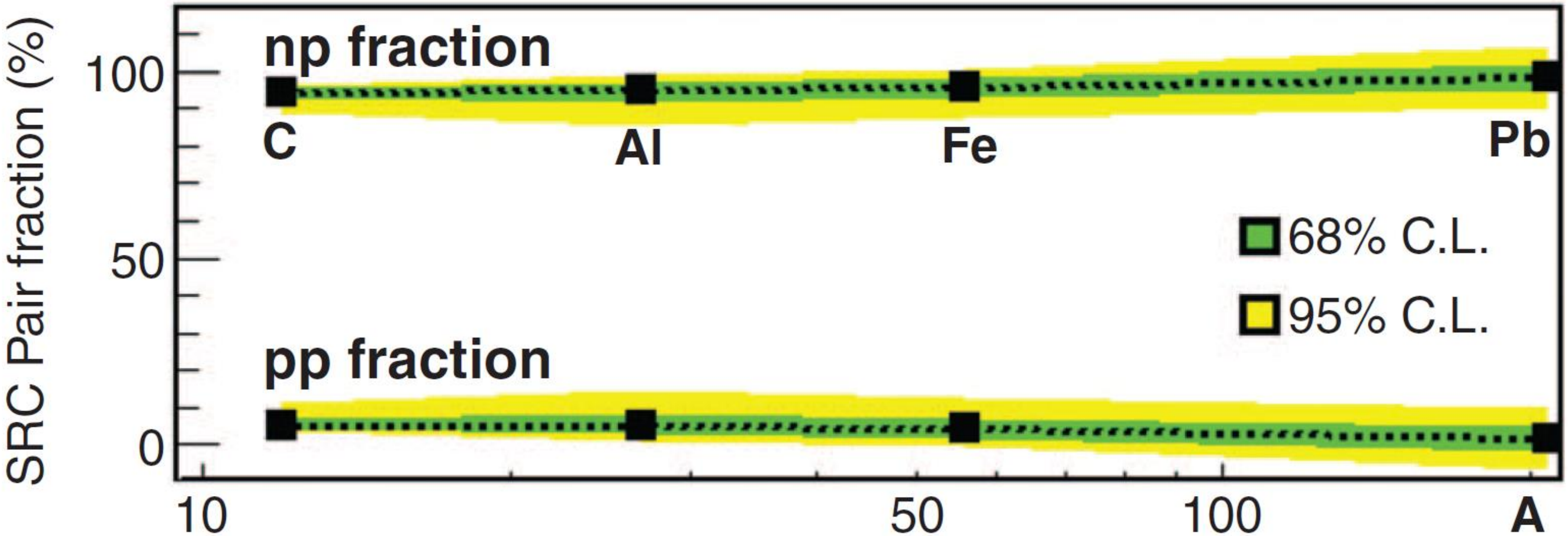


Schematic representation of the momentum distribution, n(k), of two-component imbalanced Fermi systems.

Illustration of the CLAS Detector with a Reconstructed Two-proton Knockout Event



Extracted Fractions of np and pp SRC Pairs



The green and yellow bands reflect 68 and 95% confidence levels (CLs).
np-SRC pairs dominate over pp-SRC pairs in all measured nuclei.

SUMMARY

- If the protons and neutrons did not interact, the Pauli Exclusion Principle would force the majority of fermions (usually neutrons) to have a higher average momentum

- The high-energy electron-scattering measurements using ^{12}C, ^{27}Al, ^{56}Fe, and ^{208}Pb targets show that even in heavy, neutron-rich nuclei, short-range interactions between the fermions form correlated high-momentum n-p pairs

- Thus, in neutron-rich nuclei, protons have a greater probability than neutrons to have momentum greater than the Fermi momentum

- This finding has implications ranging from nuclear few-body systems to neutron stars