Taking a *BigBite* Out of Short Range Correlations

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Overview

Nuclear physics is the study of the strong interaction between protons and neutrons within the nucleus. An electron beam provides the ideal probe for investigating the nucleus at extremely small distance scales; the higher the energy, the finer the detail probed. The Thomas Jefferson National Accelerator Facility (JLab) can provide a continuous electron beam with an energy of up to 6 GeV.

Physics Motivation

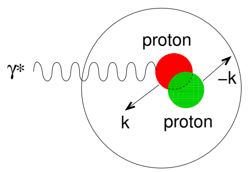


Figure 1: The two nucleon knockout process when a virtual photon is absorbed on an overlapping nucleon pair.

A nucleon-nucleon short range correlation occurs when the nucleon wavefunctions strongly overlap inside the nucleus. In the impulse approximation, a virtual photon is absorbed by one nucleon of the pair, knocking it out of the nucleus. To conserve momentum, its partner nucleon recoils with its initial momentum and is ejected from the nucleus (see Fig. 1).

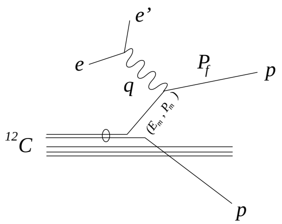


Figure 2: The triple coincidence reaction for $^{12}C(e,e'pp)$.

Short range correlations can manifest between neutron-neutron pairs, proton-neutron pairs and proton-proton pairs; we consider only the *proton-proton* channel here.

$^{12}C(e,e'pp)$ Experiment at JLab

Proton Momentum Calibration from Elastic Scattering

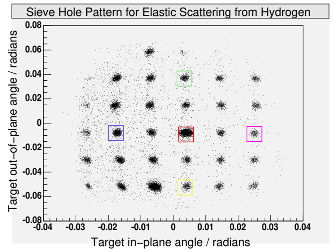
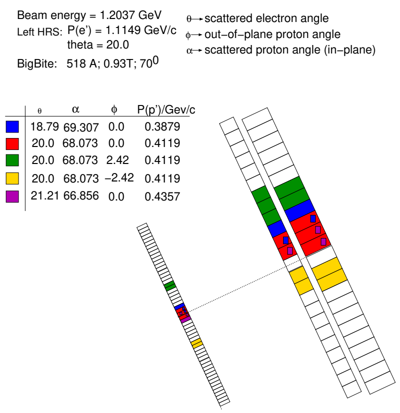


Figure 3: Plotted are the out-of-angle versus the in-plane angle for elastically scattered electrons from a liquid hydrogen target. Colors coded to the hit pattern of protons for electrons of certain angle and momenta as illustrated in Fig.4.



Color	θ	α	ϕ	P(p')/Gev/c
blue	18.79	69.307	0.0	0.3879
red	20.0	68.073	0.0	0.4119
green	20.0	68.073	2.42	0.4119
yellow	20.0	68.073	–2.42	0.4119
purple	21.21	66.856	0.0	0.4357

Figure 4: The three scintillator planes in the proton detector and the pattern of hits in the bars for events selected by cutting on the sieve hole pattern shown in Fig.3; note the color coding to illustrate which bars are illuminated by protons being scattered by electrons going through the each sieve hole.This gives a angle and momentum correspondence for determining a transport matrix for the proton detector.

- Experiment E01-015 to investigate short range correlations in carbon took data from January through April 2005 in Hall A at JLab.
- *Triple coincident* measurement performed using both high resolution spectrometers in Hall A and a third large acceptance spectrometer called *BigBite*.
- Scattered electron detected in left HRS.
- Struck proton detected in right HRS.
- Recoil partner proton detected in BigBite.

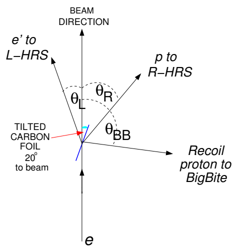


Figure 5: The kinematics setup for the triple coincident measurement; note the angle of the target foil, to minimize the amount of material traversed by the recoiling partner nucleon.

Kinematics

- Choose $X_B > 1$ and $Q^2 = 2\ (GeV/c)^2$ to help minimise competing effects, such as meson exchange currents and final state interactions.
- L-HRS: $\theta_L = 19.5^o$; $|\vec{p}(e')| = 3.724 - 3.762\ (GeV/c)$.
- R-HRS: $\theta_R = 32.0^o - 40.1^o$; $|\vec{p}(p)| = 1.23 - 1.45\ (GeV/c)$.
- BigBite: $\theta_{BB} = 99.0^o$; $|\vec{p}_{recoil}| = 0.25 - 0.6\ (GeV/c)$

Triple Coincidence Events

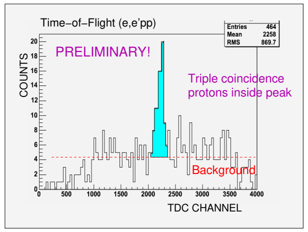


Figure 6: A *VERY PRELIMINARY* time-of-flight spectrum for triple coincident protons scattered from carbon. The peak indicated illustrates where the short range correlation information is buried.

BigBite Spectrometer

Figure 7: The BigBite magnet and proton detector during the experiment in the hall; notice the larger window on the scattering chamber to take advantage of the larger acceptance of BigBite.

- Spectrometer consists of a large acceptance, non-focusing dipole magnet, *BigBite* and a proton detector which has three layers of scintillator bars.
- Placed 1.1m from the target, BigBite has an angular acceptance of 96msr (compared to only 6msr for the two HRS') and a momentum acceptance of 250 - 900 (MeV/c).

Summary

The experiment E01-015 to search for short range correlations in carbon took data in Hall A at JLab from January through April 2005. Data was taken on both the (e,e'pp) and (e,e'pn) reactions although only the proton-proton channel is presented here. A preliminary time-of-flight spectrum illustrates the triple coincident events; however, much more work has yet to be done to extract any information about short range correlations from the data.

For further information please see the BigBite website:
http://hallaweb.jlab.org/equipment/BigBite/index.html

or the E01-015 experiment website:
http://hallaweb.jlab.org/experiment/E01-015/