Measuring relative momenta of SRC: Comparing $^3$He(e,e’pp) at $x>1$ and $x<1$

Lawrence Weinstein
For the CLAS Collaboration
Old Dominion University
Correlations: What to measure?

• Correlation probability
  – $A(e,e') / d(e,e')$

• Probability that a nucleon belongs to an SRC
  – Isospin decomposition
  – $A(e,e'pN) / A(e,e'p)$

• Relative and total momentum distributions
  – $A(e,e'pN)$

But how do we minimize Final State Interactions (FSI), Meson Exchange Currents (MEC), Delta ...?
NN Correlations vs 2N Currents

Two body currents strongly enhance the effects of correlations.
2N currents enhance correlations

Central correlations only

Central + tensor corr

MEC changes the magnitude of the cross section, not the distribution in $E_{\text{miss}}$ vs $\Theta_{pq}$

O(e,e’p) Ryckebusch
Measuring correlated $p_{\text{rel}}$ and $p_{\text{cm}}$: $A(e,e'pN)$ Kinematics choices

Hit backward moving nucleon
Correlated spectator recoils forwards
Detect two forward nucleons
$x > 1$
MEC and IC minimized in $(e,e')$ cross section

Hit forward moving nucleon
Correlated spectator recoils backwards
Detect forward and backward nucleons
$x < 1$
FSI minimized
FSI minimized at back angles

$d(e, e'p_s)X$

\[ \Theta_{pq} > 107^\circ \]

\[ \Theta_{pq} < 107^\circ \]

A.V. Klimenko et al. PRC 73, 035212 (2006).
$^3$He(e,eX) in CLAS \[\begin{aligned} \text{e2a and e2b} \\
2.2 \text{ and } 4.7 \text{ GeV electrons} \\
\text{Inclusive (e,e') trigger} \end{aligned}\]
CLAS 4.7 GeV $^3$He(e,e’pp)

Detect 2 protons, reconstruct the neutron

Integrate over large electron acceptance

H. Baghdasaryan et al., under CLAS review.

L. Weinstein, Trento 2011
\(^3\)He(e,e’pp)n nucleon energy balance:

Lab frame Dalitz plots

Proton detection threshold 0.25 GeV/c

Mostly pp knockout with a low energy neutron
$^{3}\text{He}(e,e'\text{ pp})n$ nucleon energy balance:

Lab frame Dalitz plots

Proton detection threshold 0.25 GeV/c

Mostly pp knockout with a low energy neutron

Spectator Correlated Pairs (not discussed here)
Baghdasaryan, PRL 105, 222501 (2010)
$^3\text{He}(e,e'\text{ pp})n$ nucleon energy balance:

Lab frame Dalitz plots

Proton detection threshold 0.25 GeV/c

Mostly pp knockout with a low energy neutron

Spectator Correlated Pairs (not discussed here)
Baghdasaryan, PRL 105, 222501 (2010)
pp knockout dominated by rescattering

Energy balance (Dalitz plot):
$^3\text{He}(e,e'\text{ pp})n$ events with spectator neutron

But let's look more closely ...

$L. \text{ Weinstein, Trento 2011}$
First: focus on FSI

Select $0.4 < p_p < 0.6$ GeV/c to maximize FSI

Isotropic neutron
FSI dominant

Slow p peaked at $\theta_{pq} = 70^\circ$
FSI dominant
First: focus on FSI

Select $0.4 < p_p < 0.6$ GeV/c to maximize FSI

Laget Calculations

$^3$He 3 Body Disintegration

Ground State Faddeev WF (Paris potential)

Slower $p$ peaked at $\theta_{pq} = 70^\circ$

FSI dominant

L. Weinstein, Trento 2011
pp knockout: try to minimize FSI

Two active nucleons:
$p_{\text{neutron}} < 200 \text{ MeV/c}$

Explore two configurations:
1. Two forward protons $x > 1$
   $\theta(pq) < 35^\circ$
2. Slower backward proton $x < 1$, $\theta(p_{\text{slow}}q) > 100^\circ$

Plot cross section vs $P_{\text{rel}} = (P_{\text{fast}} - q - P_{\text{slow}})/2$

Goal: measure SRC relative momentum distribution
Choosing proton angles chooses $x$

Forward protons
Omega $< Q^2/2m$
$x > 1$

Backward recoil proton
Omega $> Q^2/2m$
$x < 1$
pp knockout: correlations?

\[ p_{\text{rel}} = (p_1 - p_2 - q)/2 \ \text{(GeV/c)} \]

\[ \theta(pq) < 35^\circ (x > 1): \]
- Laget calculation
  1. FSI huge for all \( p \)
  2. Little MEC or IC
  3. Needs more precise FSI at \( p \sim 0.6 \ \text{GeV/c} \)

\[ \theta(pq) > 100^\circ (x < 1): \]
1. FSI only at \( p=0.4 \ \text{GeV/c} \)
2. Little MEC or IC
3. Not enough high-\( p \) (0.75 \( \text{GeV/c} \)) strength in \( \text{wf} \)

\( x > 1 \) and \( x < 1 \) momentum distributions very different

Backward (\( x < 1 \)) data more sensitive to initial state momentum distribution
Summary

1. $x < 1$ and $x > 1$ $pp$ relative momentum distributions disagree
2. $x < 1$ $pp$ KO data is much more sensitive to the $pp$ pair initial-state relative momentum distribution
   • Misak just showed that the $pp$ FSI is internal to the pair
3. $^3\text{He}(e,e'pp)n$ is insensitive to MEC and IC at both $x < 1$ and $x > 1$
   (according to the Laget calculation)

Relative $pp$ momentum distributions should be measured at $x < 1$
with a backward nucleon. (pn results may differ)
Thanks!

Thank you Mark and and grazie Claudio!

For this conference and for many wonderful discussions and ideas over the years!
Neutrons spectator but not isotropic

Forward protons
Omega < $Q^2/2m$
$x > 1$

Backward recoil proton
Omega > $Q^2/2m$
$x < 1$

L. Weinstein, Trento 2011