Analysis and Final State Interaction Update

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Student Update

- Last Collaboration Meeting (December 1, 2008)
  - Analyzed Kin 4 and presented result
- Since that time
  - Analyzed kin2a and kin2b
  - Worked with Misak on Final State Interactions
  - Re-analyzed Kin 4 (with replayed data)

Analysis Procedure

$$A_{phys} = \frac{A\Lambda + B}{C\Lambda^2 + D} \tag{1}$$

where $\Lambda = G_E^n/G_M^n$, and A, B, C and D are kinematic factors.

$$A_{obs} = P_e \cdot P_n \cdot D_{N_2} \cdot D_{background} \cdot D_p \cdot A_{phys} \tag{2}$$

and

$$A_{obs} = \frac{N_+ - N_-}{N_+ + N_-} \tag{3}$$

Analysis Procedure

Variable	Description	Determination
P_e	Electron beam polarization	Compton and Møller
P_n	Target polarization	AMK and others
D_{N_2}	Nitrogen dilution	from data
$D_{background}$	Background dilution	from data
D_p	Proton conversion factor	from data
$N_{+,-}$	Number of background subtracted events	from data
D_{FSI}	Dilution due to FSI effects	M. Sargsian

Kinematic 2a and 2b Asymmetry and Error Budget

Kin 2a – 11059 neutral events

Variable	Value	Uncertainty	% Uncertainty
A_{obs}	-0.0375	0.010(stat)	25.4%
D_{N_2}	0.928	0.0186	2.0%
$P_{^3He}$	0.375	0.0165	4.4%
P_e	0.862	0.011	1.3%
$D_{background}$	0.926	0.002	0.22%
$D_{p/n}$	0.819	0.0480	1.9%
P_n	0.86	0.02	2.3%
D_{FSI}	0.95	0.05	5.3%
$Aphys$	-0.2015	0.016	7.9% (syst.)

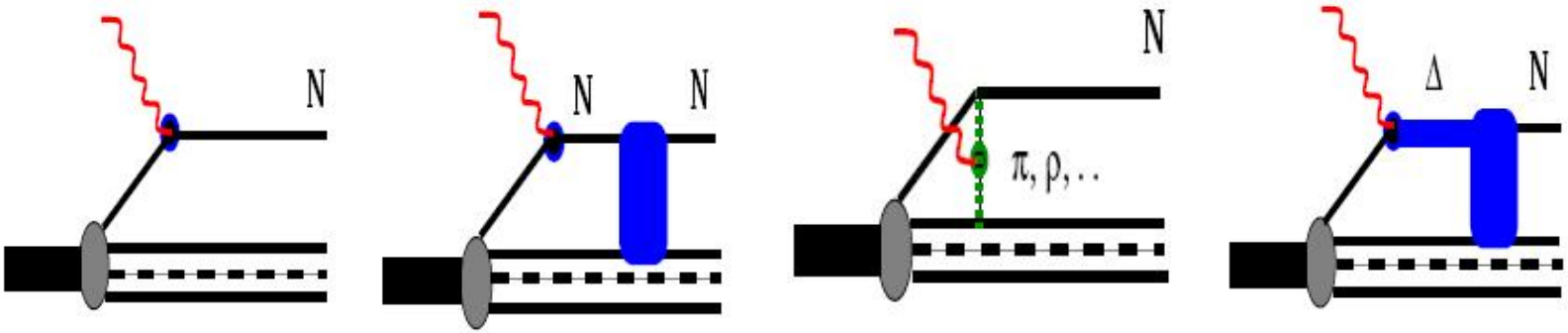
Kin 2b – 26032 neutral events

Variable	Value	Uncertainty	% Uncertainty
$Aobs$	-0.03779	0.006(stat)	16.4%
D_{N2}	0.951	0.012	1.3%
$P_{^3He}$	0.493	0.0222	4.5%
P_e	0.848	0.011	1.3%
$D_{background}$	0.948	0.001	0.1%
$D_{p/n}$	0.824	0.0262	3.2%
P_n	0.86	0.02	2.3%
D_{FSI}	0.95	0.05	5.3%
A_{phys}	-0.1489	0.012	8.2% (syst)

Combining asymmetries gives $A_{phys} = -0.1646 \pm 0.023$ (stat) ± 0.014 (syst.) (16.4%) This gives us $\Lambda = -0.188 \pm 0.024(12.7\%)$ (comb.)

Scattering Interactions

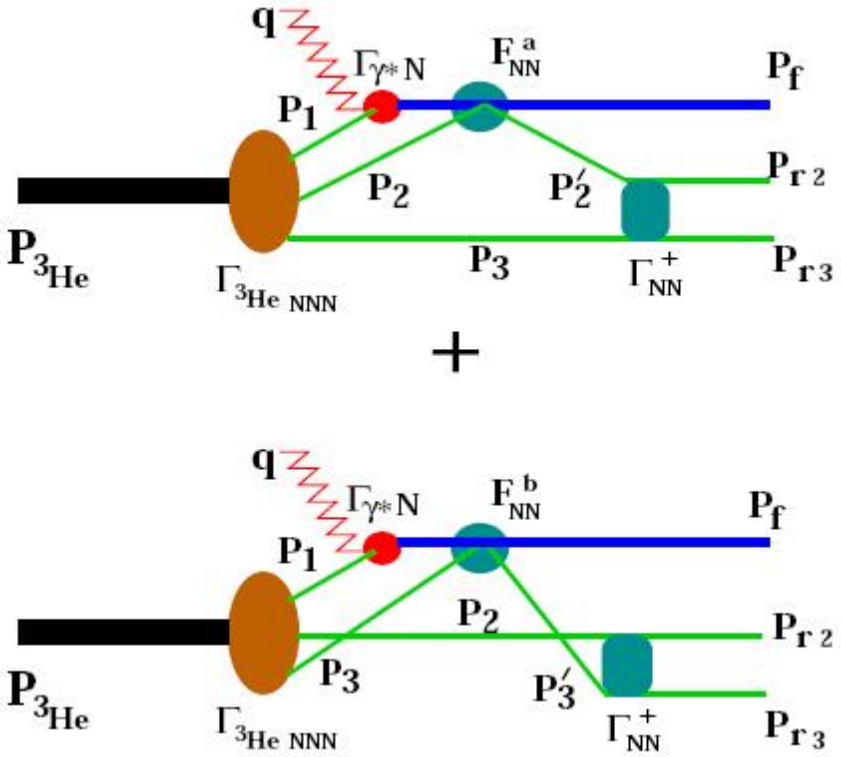
There are 4 main classes of interactions: Impulse Approximation, Final State Interactions, Meson Exchange Current, Isobar Current



MEC and IC small for high momentum transfer ($Q^2 \geq 1GeV$) FSI remain (determined by NN cross-sections)

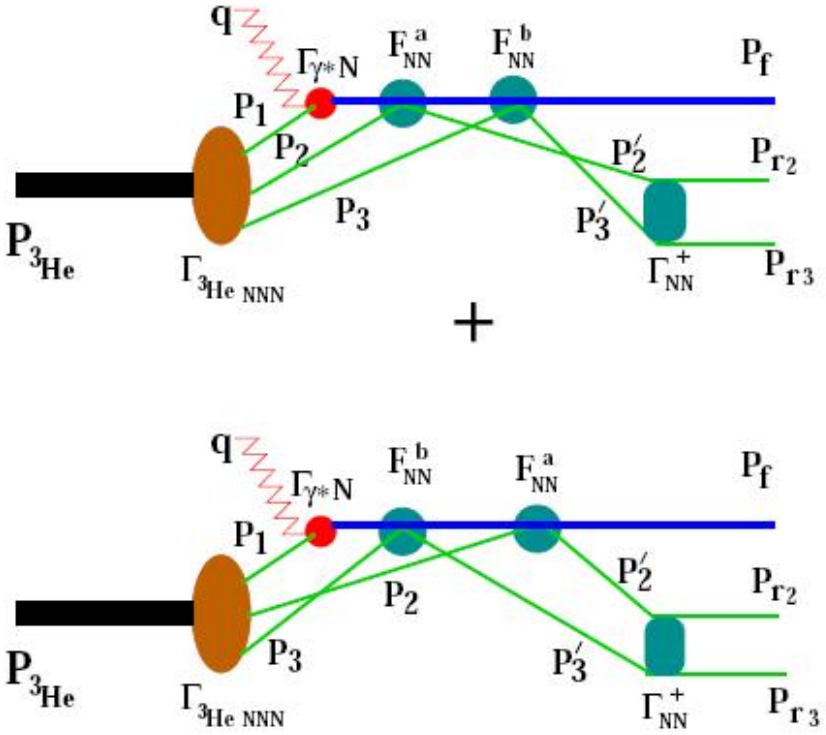
Final State Interaction Expansion

Single Rescattering Amplitudes



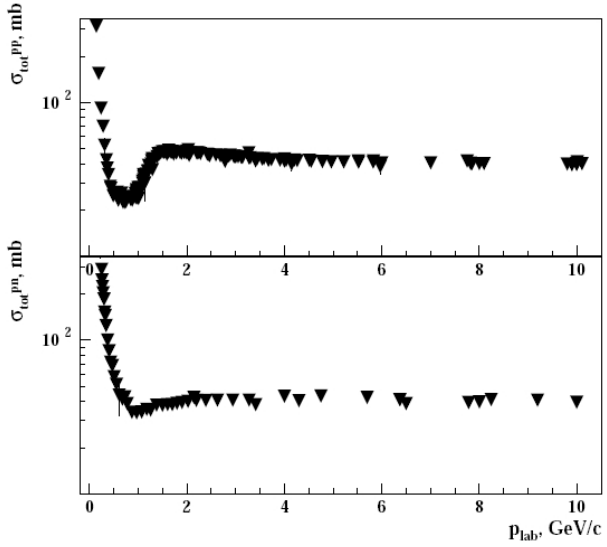
Final State Interaction Expansion

Double Rescattering Amplitudes

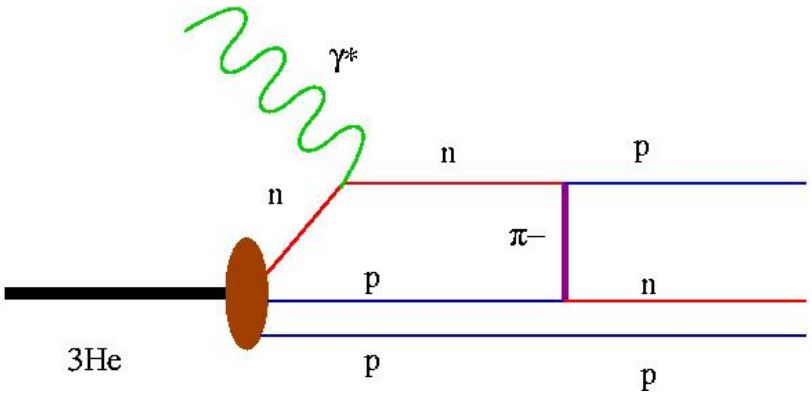


Dominance of FSI

MEC and IC scale with $1/Q^4$. FSI are based on NN cross sections, which are flat above a few GeV.



Charge Exchange



Per Misak, "numerically small, but large contribution to the asymmetry"

Generalized Eikonal Approximation – Relation to Glauber

Rescattering amplitude for deuteron:

$$A_1^\mu = -j^\mu(p_s + q, p_s)\frac{\sqrt{2E_s}}{2i}\int d^3r\phi(r)\theta(-z)\Gamma^{pn}(\Delta, -z, -b)e^{ip_s r}$$

where $\vec{r} = \vec{r_p} - \vec{r_n}$, and a generalized profile function Γ is defined:

$$\Gamma^{pn}(\Delta, z, b) = \frac{1}{2_i}e^{-i\Delta z}\int f_{pn}(k_\perp)e^{-ik\perp b}\frac{d^2k_\perp}{(2\pi)^2}.$$

And, $\Delta = \frac{q_0}{|\mathbf{q}|}(E_s - m)$.

Amplitude reduces to the Glauber appromiation in the limit $\Delta \to 0$

Generalized Eikonal Approximation – Differences from Glauber

- GEA allows calculations of short range correlations
- GEA and Glauber agree when recoil momentum is small (see next page)

$$T = \frac{\sigma^{IA+FSI}}{\sigma^{IA}}$$

- "The Q^2 dependence of T within GEA can be used as a baseline reference point to study the onset of the color coherence regime in high Q^2 exclusive reactions" (beyond the scope of this presentation)

State of the Calculation

- Recieved FSI and Charge Exchange code from Misak on April 8
  - Test runs okay
  - Longer runs timed out or otherwise cut off by Scientific Computing
- Misak has code running on cluster at FIU
  - With 48 clusters, each event takes 5 minutes
  - On batch farms, each event takes 2 hours
- Single event results somewhat troubling
  - Very large contribution from charge exchange
  - Perhaps related to large calculated E_{miss}

Re-Analysis of Kinematic 4

- Replayed runs (see Jon Miller's update)
- Modified approach to background, target and beam polarization.

Total Number of Neutral Events – 109174

Variable	Value	Uncertainty	% Uncertainty
A_{obs}	-0.0549	0.003(stat)	5.5%
D_{N_2}	0.939	0.009	1.0%
$P_{^3He}$	0.485	0.022	4.5%
P_e	0.83	0.03	3.6%
$D_{background}$	0.923	0.00008	0.9%
$D_{p/n}$	0.7798	0.014	1.8%
P_n	0.86	0.02	2.3%
D_{FSI}	0.95	0.05	5.3%
$Aphys$	-0.220	0.018	8.3% (sys.)

This provides a $\Lambda = -0.1643 \pm 0.015$ (stat – 9.1%) ± 0.03 (sys – 18.3%)
With $G_M^n = -0.1728 \pm 0.003$ (Kelly Parameterization)

$G_E^n = 0.0284 \pm 0.003$(stat) ± 0.0052 (sys) or ± 0.006 combined.

Concerns:

- Seem to have too few events – need to double check charge ID
- Concerned about error propogation from A_{phys} to Λ – mostly due to correlated errors that must be examined
- At this Q^2 can use real data for G_M^n

Plans

- Finish FSI
- Help with PRL (as needed)
- Write Disseration