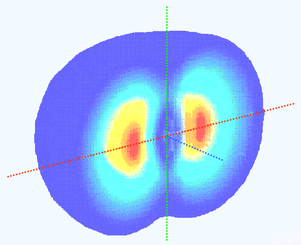
Studies of the Deuteron via (e,e′p) at High Q^2



Hall A — Jefferson Lab — E01-020

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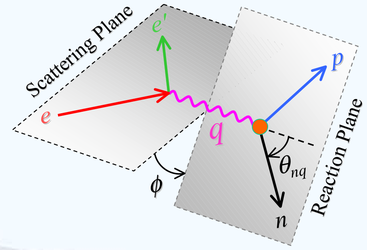
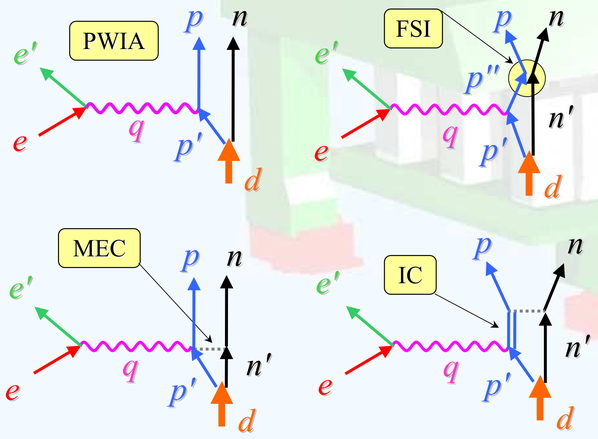


Theory

The Deuteron

- Discovered in 1932 as the nucleus of the deuterium atom.
- Most fundamental non-trivial nucleus with *complete* theoretical descriptions.
- Manifestation of *NN* interaction without complications from 3- or more-body effects.
- Starting point for understanding more complex nuclei.
- Under extreme kinematics, we can study short-distance aspects of *NN* force and possibly explicit QCD effects.

Electro-disintegration



Cross Section

$$\frac{d^5\sigma}{d\omega d\Omega_e d\Omega_p} = Kf\sigma_{Mott} \times (v_L R_L + v_T R_T + v_{TT} R_{TT} \cos 2\phi + v_{LT} R_{LT} \cos\phi)$$

where :

K is a kinematical factor,

f is a recoil factor,

σ_{Mott} is Mott Cross Section,

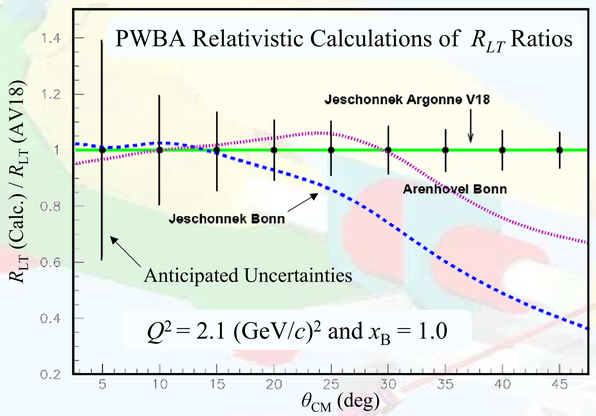
v_L, v_T, v_{TT} and v_{LT}, are leptonic factors and

R_L, R_T, R_{TT} and R_{LT} are response functions.

$$R_{LT} \equiv \frac{1}{Kf\sigma_{Mott}}[\sigma(\phi=0) - \sigma(\phi=180^\circ)] \rightarrow (R_{LT} \text{ Separation})$$

Motivations

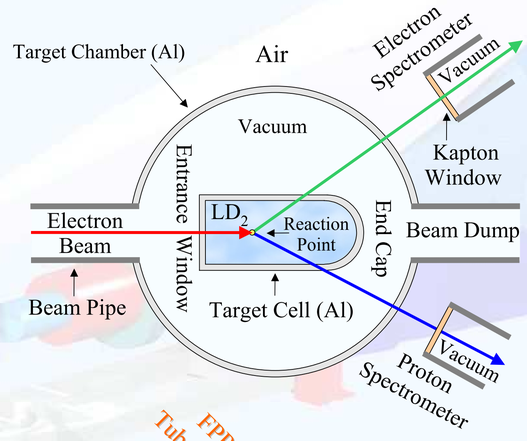
One of the main objectives of the experiment is to separate the longitudinal-transverse interference response function, R_{LT} , at the quasi-elastic peak. This separation will provide important constraints for relativistic theories of this reaction. In addition, the cross section as a function of neutron recoil momentum in a kinematics where the spectrum is expected to be largely insensitive to various reaction mechanism effects such as final state interaction (FSI), meson exchange currents (MEC) and isobar configurations (IC), will provide constraints on the deuteron wave function at short distance scales. Finally, we will study FSI through the angular distribution of the recoiling neutron and compare with theoretical calculations.

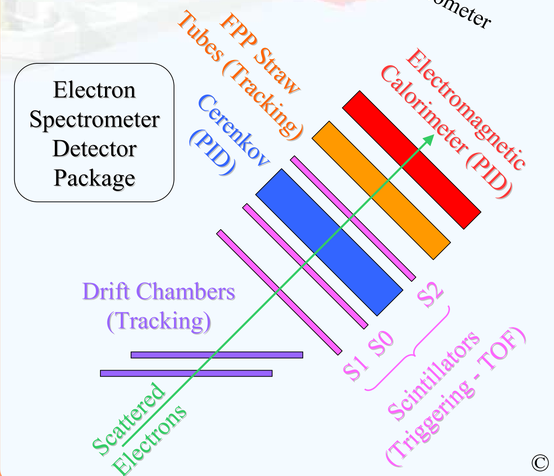


Neutron Direction	Q^2 (GeV/c)^2	p_m (MeV/c)	x_B	FSI	MEC / IC	Motivation
Parallel ($p_m \parallel q$)	2.1	100, 200, 300, 400 and 500	< 1	Minimum	Maximum	Emphasize MEC / IC
Anti-Parallel ($p_m \parallel -q$)	2.1	100, 200, 300, 400 and 500	> 1	Minimum	Minimum	Study Deuteron Short-range Structure
Perpendicular ($p_m \perp q$)	0.8 2.1 3.5	0, 100, 200, 300, 400 and 500	1	Variable	Minimum	Test Relativistic Models (R_{LT})
Neutron Angular Distribution	0.8 2.1 3.5	0, 100, 200, 300, 400 and 500	Variable	Variable	Variable	Study FSI

E01-020

Experiment E01-020 systematically explores the electro-disintegration of the deuteron over a broad kinematical range of four-momentum transfer, Q^2 = 0.8, 2.1 and 3.5 (GeV/c)^2 , and missing momentum, p_m = 0 - 0.5 GeV/c. This systematic approach will help to understand the deuteron structure for small distances between the two nucleons and thereby quantify the short-range part of the *NN* interaction, which is one of the fundamental missions of nuclear physics. The Experiment used the standard Hall A High Resolution Spectrometers in coincidence configuration in addition to the cryogenic target system with liquid and solid targets. Data taking was completed in November 2002.





Status

- The experiment ran for 2 months and collected about 2 TB of data for more than 120 different kinematics.
- Most optimizations and calibrations of the two spectrometers have been completed.
- Extensive software improvements have been made in *ESPACE* and *MCEEP*.
- Many new computer codes and scripts were written to display and optimize the different aspects of data.
- Several passes through the data were done to filter the coincidence events and the good current periods, etc.
- Some preliminary results were obtained.