Differential Cross Section for Proton Induced Deuteron Breakup at 108 MeV

Angelina Łobejko (Rusnok)

Institute of Physics, University of Silesia, Katowice for Few Nucleon System Collaboration:

1) Institute of Nuclear Physics, PAN, Kraków, Poland
2) KVI-CART, University of Groningen, Groningen, The Netherlands
3) Institute of Physics, Jagiellonian University, Kraków, Poland
4) Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland
5) Faculty of Physics, University of Warsaw, Warsaw, Poland
1) Experimental program:

- Measurement of $^2\text{H}(p, pd)$ elastic scattering at 108, 135 and 160 MeV
- Measurement of $^2\text{H}(p, pp)n$ breakup reaction at 108 and 160 MeV for over 100 kinematic configurations

2) Aim:

- Studies of 3NF
- Verification of predicted Coulomb and relativistic effects
- Tests of upcoming ChPT calculations
MWPC (Multi-Wire Proportional Chamber):

• active area of 38 x 38cm²;
• 3 planes, X, Y (236 wires), and U (296) - distance between two adjacent wire planes is about 12 mm;
• the efficiency of MWPC is about 90%.

The ΔE-E telescopes:

• the ΔE array is made of vertically placed thin plastic strips;
• the E array is made of 10 horizontally placed thick bars;

○ Angular acceptance of Wall:
  \[ \theta \in (10° - 35°) \]
  \[ \varphi \in \text{full } \varphi \]

○ Angular resolution:
  \[ \Delta \theta \approx 0.5° \]
  \[ \Delta \varphi \approx 0.5° - 3° \]
The Backward Part of Detector - Ball

- System of 149 phoswitches
- Liquid target system
- Together with Wall - angular acceptance of nearly $4\pi$
Particle Identification (PID)

- Based on $\Delta E-E$ technique;
- The events of interest are the coincidences of two charged particles:
  1) pp (breakup reaction),
  2) pd (elastic scattering),
- allows us to identify protons and deuterons;
Graphical cuts ("gates") were defined for each individual $\Delta E-E$ telescope;

- Small overlap of gates is allowed;
- three groups of events are well visible:
  - the spot of deuterons coming from the elastic scattering,
  - the long branch of protons coming from the breakup reaction,
  - the spot of elastically-scattered protons.
Calibration – Al target

- **Proton beam** energies: 70, 83, 97, 108, 120 MeV;
- **Al(p,p)Al** scattering.

- Events are defined by:
  - the **side** (S = right / left),
  - the **E detector number** (N = 0, 1, ..., 9),
  - the **polar angle** ($\theta = 12^\circ - 34^\circ$; step = 2$^\circ$).

- Energy for each detector:
  \[ C = \sqrt{c_1 \times c_2} \]

  supress effects of light attenuation along the bar

\[ \theta=16^\circ \]
Experimental data

- **Al**(p,p)**Al** scattering
- Detector number: $N=3$
- Theta angle: $\theta=16^\circ \pm 1^\circ$
- Side: $S=\text{left}$

Monte Carlo Simulation

- **Al**(p,p)**Al** scattering
- Energy detector number: $N=3$
- Theta angle: $\theta=16^\circ \pm 1^\circ$
- Side: $S=\text{left}$
1. Linear calibration
   - $y = aC + b$
   - Range: $> 50$ MeV

2. Quenching
   - $y = aC + b\sqrt{c}$
   - Range: $0$-50 MeV
Most important!

- to obtain an information about the $E_{\text{loss}}$ between the reaction point to $E$ detector

• Simulation:
  - proton beam (15-100 MeV),
  - $\theta$ angle (12°-34°).
- Kinematic configuration

\[ \begin{align*}
\theta_1 &= 16^\circ, \quad \theta_2 = 28^\circ, \\
\phi_{12} &= 160^\circ
\end{align*} \]

- $^2\text{H}(p,pp)n$ reaction kinematics determined by proton momenta $\vec{p}_1, \vec{p}_2$

- Configuration was defined by emission angles of two outgoing protons:
  \[ \theta_1 \pm 1^\circ, \quad \theta_2 \pm 1^\circ, \quad \phi_{12} \pm 5^\circ, \]

- The central line of the experimental band is lying on the theoretical kinematics

It confirms the correct energy calibration
Preparing for Background Subtraction

- Transformation of $E_2$ vs $E_1$ spectrum to $S$ (arclength variable) vs Distance of the points from kinematical curve;
- Each slice on the $S$ vs Distance spectrum is treated separately;
- The background is approximated by a linear function between the two limits of integration;
- The events below linear function is subtracted;

$\theta_1 = 16^\circ$, $\theta_2 = 28^\circ$, $\phi_{12} = 160^\circ$
$\theta_1 = 24^\circ, \theta_2 = 24^\circ, \phi_{12} = 160^\circ$

$\theta_1 = 16^\circ, \theta_2 = 28^\circ, \phi_{12} = 160^\circ$
Summary of Data Analysis

1. Particle Identification
2. Energy Calibration
3. Selection of Kinematics Configuration of Breakup Reaction
4. Background subtraction
5. Determination of Detection Efficiency
6. Normalization to Cross Section of Elastic Scattering
7. Comparison of Differential Cross Section for $^2\text{H}(\text{p},\text{pp})\text{n}$ Reaction at 108 MeV

DONE

TO DO

😊

❗
The preliminary analysis of the data taken with the BINA detector at CCB demonstrates a proper and efficient functioning of the forward part of this detector;

New data will be collected with high statistic for 108, 135 and 160 MeV.

Thank you for your attention!