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### 0.0.1 Neutron-Deuteron Analyzing Power Data at 19.0 and 22.5 MeV

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During the last two years, we made two measurements of  $n$ - $d$   $A_y(\theta)$ , at  $E_n = 19$  and 22.5 MeV, as part of a study of the three-nucleon analyzing power puzzle. Both experiments used the TUNL Shielded Neutron Source, the  ${}^2\text{H}(\vec{d}, \vec{n}){}^3\text{He}$  source reaction, a deuterated liquid scintillator as the center detector, and six pairs of neutron side detectors. To determine the neutron beam polarization, we used a polarimeter based around a  ${}^4\text{He}$  gas scintillator and two side detectors. The major change for the 22.5 MeV measurement was the greater amount of sulfur hexafluoride used in our FN tandem accelerator, in order to achieve higher terminal voltages (about 10 MeV). In taking the data and accomplishing the data analysis, four undergraduate researchers were involved, three supported by the TUNL-NSF REU program and one supported by funds from Penn State Altoona.

In sorting the data for each neutron detector, pulse-shape discrimination was used to reduce gamma-ray events in the time-of-flight (TOF) spectra. Gates were set in the TOF spectra for each side detector to identify the elastic and accidental events. These gates were used to sort spectra for the center detector and the  ${}^4\text{He}$  scintillator pulse height. Accidental backgrounds were removed from all pulse-height spectra, leaving small remaining backgrounds. In determining the beam polarization, we used the well-known point geometry  $A_y(\theta)$  for  $n + {}^4\text{He}$  scattering, with a correction factor applied via a Monte-Carlo simulation of all relevant finite-geometry and background effects in the polarimeter. For the pulse-height spectra of the deuterated scintillator, a linear fit was used to determine the remaining background, which ranged from 5 to 15 % of the total counts within our yield gates. Preliminary Monte-Carlo calculations show that multiple scattering and edge-effect events in the deuterated scintillator account for about half of the remaining background. Tests are underway to determine if the residual background (after the removal of multiple scattering and edge-effect events) has a polarization, within statistical uncertainties.

Preliminary TUNL data for  $n$ - $d$   $A_y(\theta)$  at 19 MeV and 22.5 MeV are displayed in Fig. 0.0–1, compared to three-body calculations based on the CD-Bonn NN potential (solid curve), and a Legendre polynomial fit (dotted curve). The error bars reflect only statistical uncertainties. Neighboring data are also displayed: the 16 MeV distribution of [Sag03] and the 30 MeV distribution of [Dob78]. The four plots nicely show the trend of  $n$ - $d$   $A_y(\theta)$  in this energy regime. The overall discrepancy between theoretical predictions and

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data lessens as  $E_n$  increases. At lower energies, such as the 16 MeV measurement, the discrepancy appears primarily in the maximum of  $A_y(\theta)$  at c.m. angles around  $130^\circ$ . For the 30 MeV measurement, the discrepancy is smaller and appears in the minimum of  $A_y(\theta)$  at c.m. angles around  $120^\circ$ . Our new 19 MeV and 22.5 MeV distributions show clearly the transition between these two regimes. Despite the fact that this preliminary TUNL data has not been corrected for remaining background, multiple scattering, or finite geometry, the data differ significantly from the predictions. Removing the remaining background and applying the results of the Monte Carlo calculations will tend to increase slightly the discrepancy between the data and predictions.

The 19.0 MeV experiment took about six weeks of beam time and measured sixteen data points covering the full  $A_y(\theta)$  distribution. Up to this point, we have only devoted a week of beam time to the 22.5 MeV measurement. In the coming year, we plan to improve the uncertainties of our data at the current angle settings and to measure  $A_y(\theta)$  at a second set of angles.

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[Dob78] H. Dobiasch *et al.*, Phys. Lett. **76B**, 195 (1978).

[Sag03] K. Sagara, 2003, personal communication.

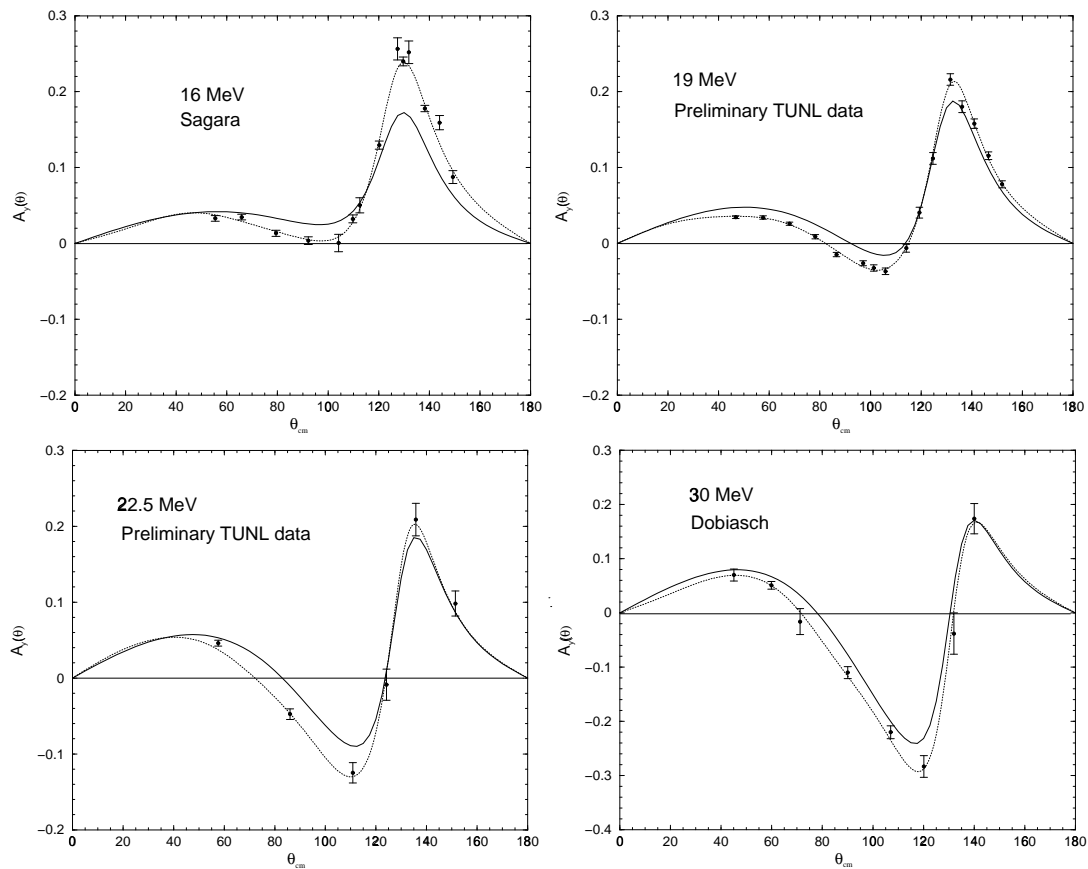


Figure 0.0–1: Preliminary TUNL data for  $n-d$   $A_y(\theta)$  at 19 MeV and 22.5 MeV, along with neighboring data at 16 MeV and 30 MeV. Each  $A_y(\theta)$  distribution is compared to three-body predictions using the CD-Bonn NN potential (solid curve). The dotted curves are Legendre polynomial fits to the data.