

A New Intense Source of Polarized Neutrons

Measurement of K_{zz}' for the $T(\vec{p}, \vec{n})$ Reaction
for Neutron Energies 0.5-1.9 MeV

J. R. Walston, C. R. Gould, D. G. Haase, B. W.
Raichle and M. L. Seely

North Carolina State University and Triangle Universities Nuclear
Laboratory

W. Tornow, W. S. Wilburn

Duke University and Triangle Universities Nuclear Laboratory

G. W. Hoffmann

University of Texas at Austin

S. I. Pentillä

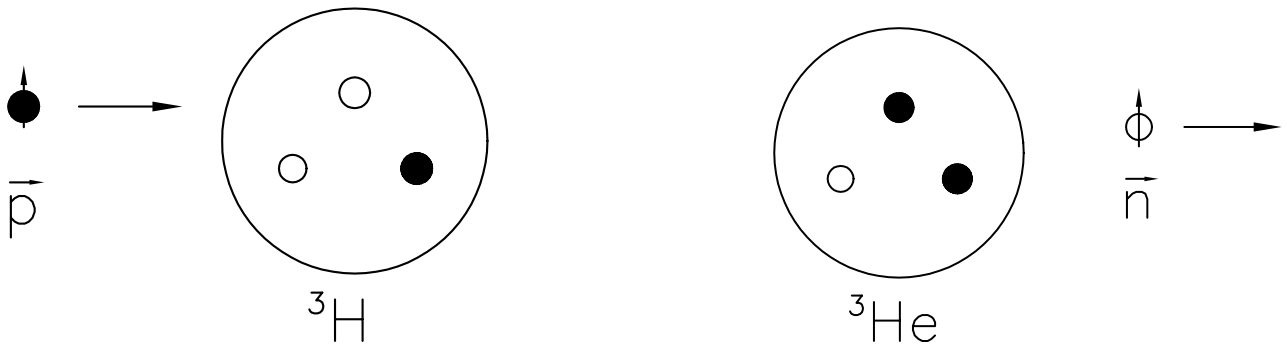
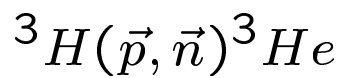
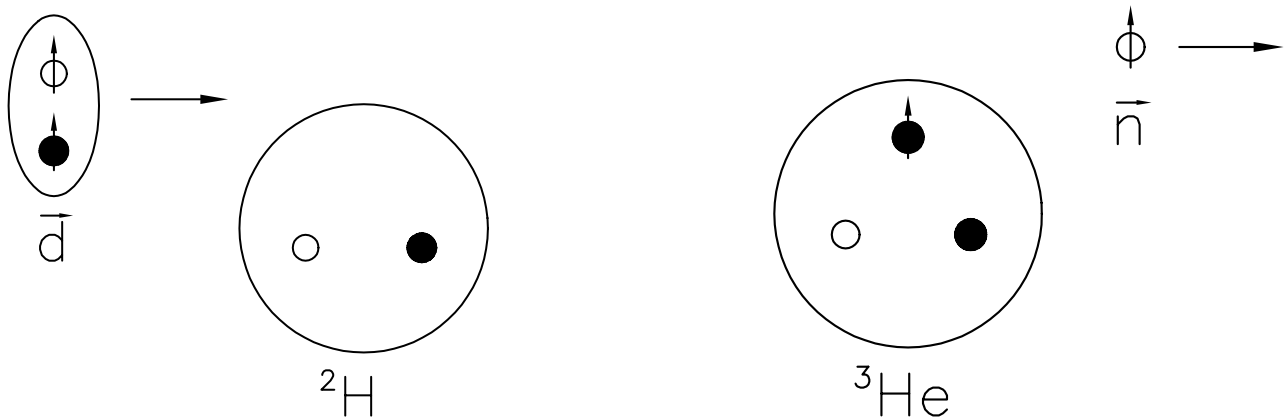
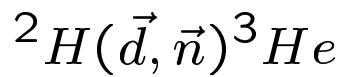
Los Alamos National Laboratory

- Introduction
- Polarized Neutron Beam
- Experimental Results
- Polarized Proton Target
- Summary

Polarized Neutron Production

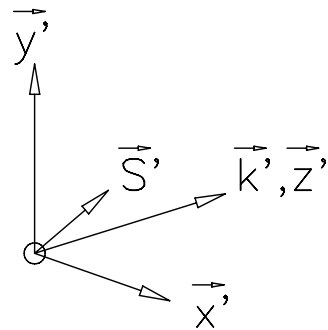
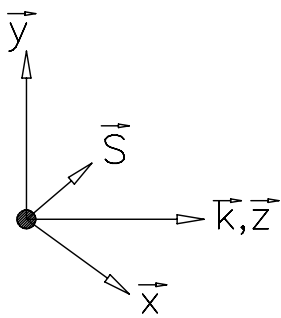
Accelerate charged particles with TUNL tandem accelerator (\vec{p} 's or \vec{d} 's), beam polarization normally $\approx 80\%$ from ion source.

Common Reactions:



How much of the polarization is transferred from charged particles to neutrons?

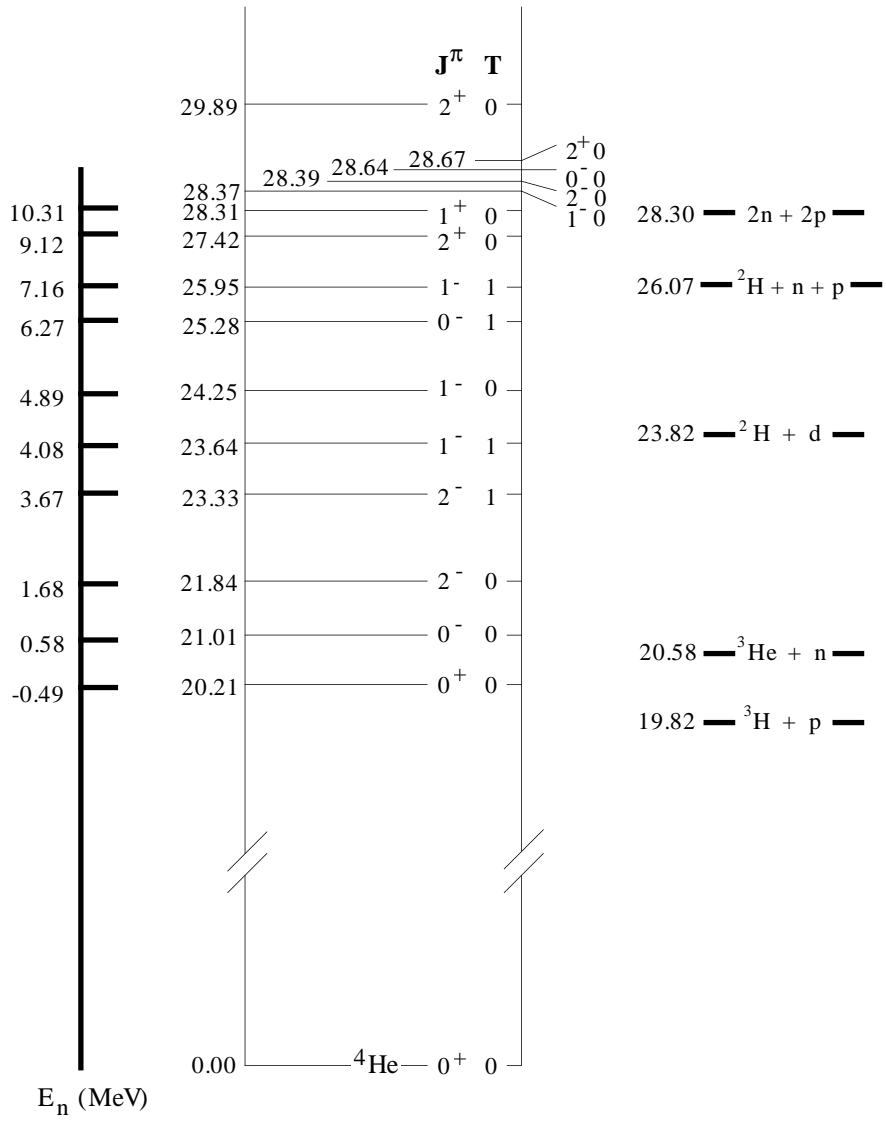
Define coordinates: (Madison Convention)



$$P_{n_{j'}} = K_i^{j'} P_{p_i} \quad i, j = x, y, z$$

$K_y^{y'}$ = transverse polarization transfer coefficient

$K_z^{z'}$ = longitudinal polarization transfer coefficient

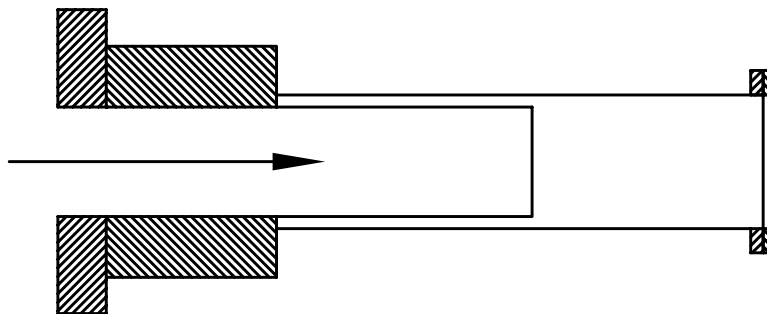


${}^4\text{He}$ binding energy = -28.30 MeV

Measurement of K_{zz}

Using TUNL polarized ion source we produce polarized protons, polarization $\approx 80\%$

Using tandem we accelerate protons to an energy of 1.3 to 2.7 MeV producing neutrons with the ${}^3\text{H}(\vec{p}, \vec{n}){}^3\text{He}$ reaction with energies from 0.5 to 1.9 MeV



Proton Polarization Measurement:

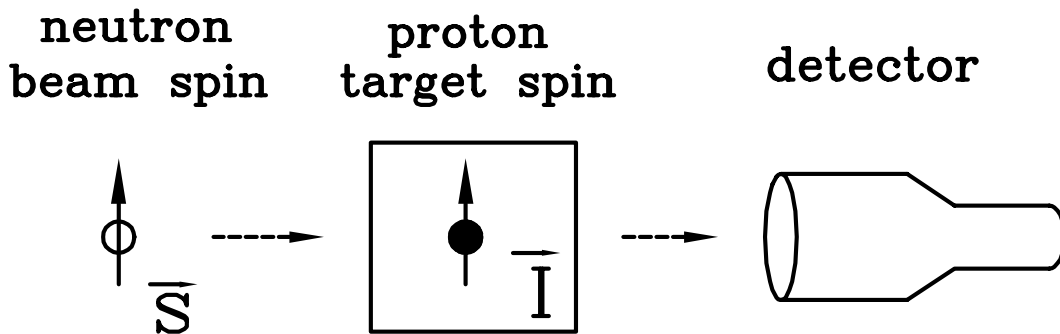
Lamb-shift spin filter polarimeter on source

High energy elastic scattering polarimeter

Neutron Polarimeter

Measure polarization at 0° : $K_z^{z'} \rightarrow K_z^z$

Polarized proton target \rightarrow n-p cross section difference is very large in this range ($\Delta\sigma_L \rightarrow 5 - 2$ b when $E_n \rightarrow 0.5 - 1.4$ MeV)



$$\Delta\sigma_L = (\overleftarrow{\leftarrow} - \overleftarrow{\rightarrow})$$

$P_t x =$ target polarization times thickness

$$P_n = K_z^{z'} P_p \quad \text{where} \quad P_p = \frac{N_+ - N_-}{N_+ + N_-}$$

Neutron Asymmetry Measurement

We will measure

$$P_n = \frac{2\epsilon}{P_{tx} \Delta\sigma_L}$$

where $\epsilon = \frac{N_+ - N_-}{N_+ + N_-}$ is the measured asymmetry in the neutron cross sections for beam spin up and down

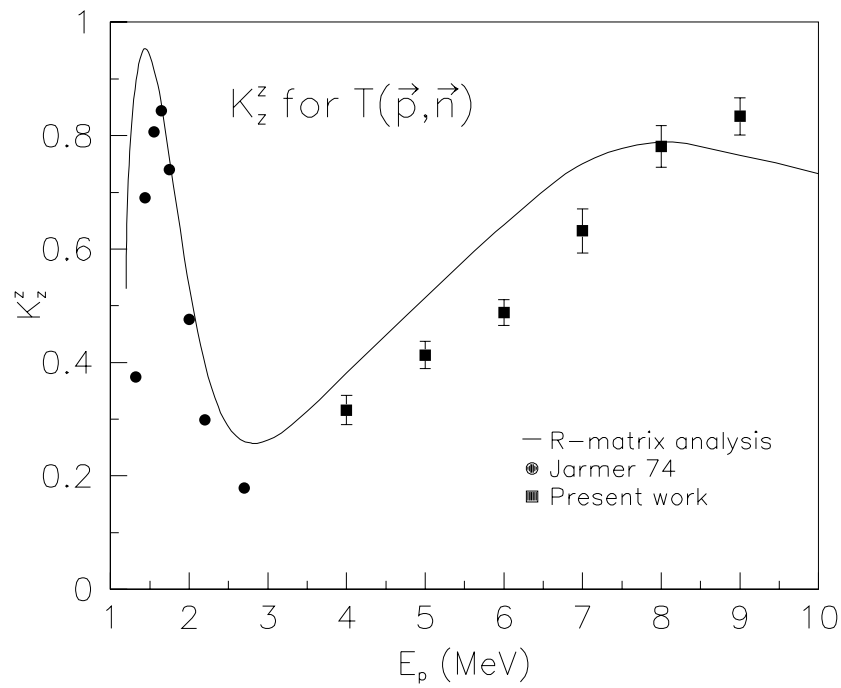
Nominal values:

$$P_{tx} \approx 0.04 \text{ b}^{-1}$$

$$\Delta\sigma_L \approx 5 \text{ b}$$

From K_z^z plot $P_n \approx 0.5$

We expect a neutron asymmetry $\epsilon \approx 0.05$!!



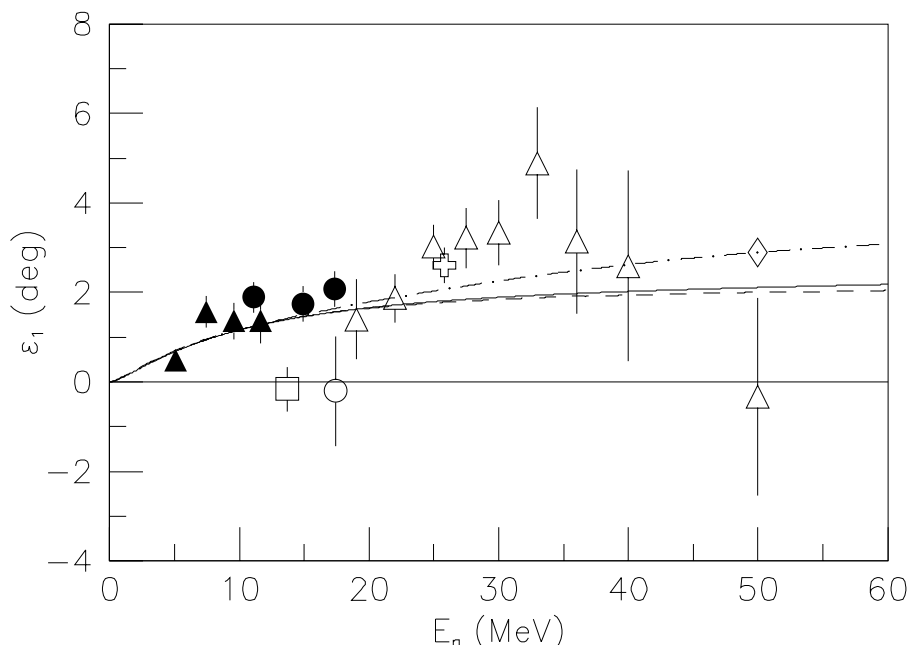
Proton Energy	K_z^z	\pm statistical
2.70	0.178	0.003
2.20	0.299	0.002
2.00	0.476	0.004
1.75	0.740	0.007
1.65	0.844	0.003
1.55	0.806	0.007
1.44	0.690	0.006
1.32	0.374	0.005

8.8% error on overall normalization

Polarized Proton Target

- Butanol doped with EHBA-CrIV
- ^3He evaporation refrigerator (≈ 50 mK)
- 2.5 Tesla magnetic field
- Polarize with microwaves
- Measure polarization with NMR

Target has been used to measure $\Delta\sigma_T$, will be used to measure $\Delta\sigma_L$ at 11-32 MeV neutron energy to determine phase shift parameter ϵ_1



Summary

- Described polarization transfer in neutron production reactions
- Discussed the specifics for $K_z^{z'}$ in $T(\vec{p}, \vec{n})$ reaction
- Presented new calculations showing possible structure from ${}^4\text{He } 0^-$ level
- Experimental data of K_z^z resonance ~ 600 keV

Future Work

- Measure K_z^z absolutely in this energy range to calibrate peak magnitude
- Measure $\Delta\sigma_L$ at $E_n=11-18$ MeV