TRI-PP-78-12
Jun 1978

A Monoenergetic Polarized Neutron Beam from 200 to 500 MeV

C. Amsler*, R.C. Brown†, D.V. Bugg, J.A. Edgington, C. Oram+
Queen Mary College, London, England

D. Axen, R. Dubois, L. Felawka, S. Jaccard§, R. Keeler, J. Va'vra‡
University of British Columbia, Vancouver, B.C., Canada

A. Clough, D. Gibson
University of Surrey, Guildford, England

G.A. Ludgate+, N.M. Stewart
Bedford College, London, England

L.P. Robertson
University of Victoria, Victoria, B.C., Canada

and

J.R. Richardson
University of California, Los Angeles, California, U.S.A.

Abstract

Improved measurements of the polarization of the TRIUMF neutron beam indicate a rather smaller decrease at high energies than were given in an earlier publication.

(Letter submitted to the Editor, Nuclear Instruments and Methods)

*Now at University of New Mexico, Albuquerque, New Mexico, U.S.A.
†Now at Rutherford Laboratory, Chilton, Oxon., England.
+Now at University of British Columbia, Vancouver, B.C., Canada.
§Now at SIN, Villigen, Switzerland.
‡Now at Carleton University, Ottawa, Canada.

The polarized neutron beam at TRIUMF is made by the charge exchange reaction of the polarized proton beam on liquid deuterium at 9° (lab), using the R_t configuration for spin transfer from initial proton to final neutron. This neutron beam was described in an earlier publication[1]), where our measurements of the neutron beam polarization and the resulting values of R_t are given for the energy range 220 to 520 MeV. Those measurements indicated a considerable drop in polarization from 220 to 495 MeV, and have led to some pessimism about using this technique to produce polarized neutron beams at still higher energies. However, the early measurements were of limited accuracy, namely ±12 to ±15% of the magnitude of the polarization. Since then, the beam has been in regular use, and measurements of higher accuracy are now available. The new results are statistically compatible with those reported previously, but show a much smaller decrease in the polarization with energy.

In the new measurements, the left-right scattering asymmetry of the polarized beam from liquid hydrogen was observed from 40° to 160° (c.m.) over the energy range 200-500 MeV. Neutrons scattering into a scintillation counter array were observed in coincidence with the conjugate protons recoiling into an array of multi-wire proportional chambers, which accurately measured the direction of the proton. Tight constraints on coplanarity and opening angle completely eliminated inelastic scattering. The asymmetry ε, for neutrons scattering through angle θ, is given by

$$\varepsilon_E(\theta) = \langle\sigma_n\rangle_E \cdot P_E(\theta),$$

where $\langle\sigma_n\rangle_E$ is the beam polarization, E is the neutron energy and $P_E(\theta)$ the polarizing power for n-p elastic scattering. We observe good agreement with the angular dependence of P_E measured by Cheng et al.[2]) and

Tinlot et al.[3]). The former authors measured P_E and the p-p polarizing power P_{pp} in the same experiment and claim an absolute normalization of ±3%. We have checked the absolute normalization of P_{pp} in a double scattering experiment[4]) with an absolute accuracy of ±1.5%, and have confirmed their results within their errors. We therefore have confidence in their absolute normalization of P_E. By normalizing our relative values of $P_E(\theta)$ to their results, we find the polarization of the neutron beam as shown in table 1.

The polarization of the proton beam $\langle\sigma_p\rangle$ at various energies was determined from measurements of the p-p asymmetry and our values of P_{pp}. Then the relation $\langle\sigma_n\rangle = R_t\langle\sigma_p\rangle$ was used to determine the R_t parameter for the $\vec{p}d \rightarrow \vec{n}$ reaction at 9° (lab). Values for R_t are also shown in table 1 and in the figure. The downward trend with energy is much less pronounced than that indicated by the early results, and suggest that this way of producing a polarized neutron beam may be useful at higher energies.

References

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Table 1

The polarization $\langle\sigma_n\rangle_E$ of the neutron beam, the polarization of the incident proton beam $\langle\sigma_p\rangle$, and the polarization transfer R_t for $\vec{p}d \rightarrow \vec{n}$ at 9° (lab)

Proton energy (MeV)	237	343	445	516
Neutron energy (MeV)	220	325	425	495
$\sigma_{n\ E}$ (%)	64	56	56	49
$\sigma_{p\ E}$ (%)	69	75	72	71
R_t (9° lab)	-0.81±0.04	-0.75±0.04	-0.78±0.04	-0.69±0.06

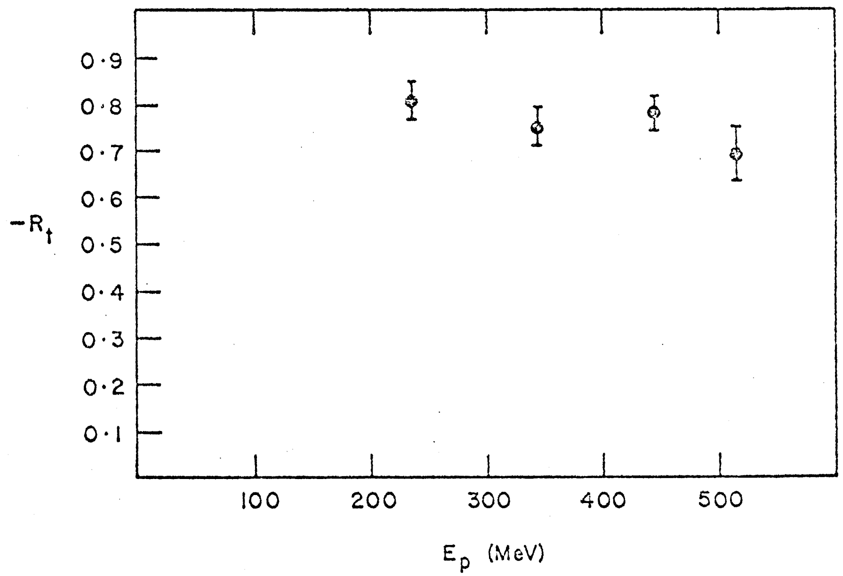

Fig. 1. $-R_t$ at 9° lab for the reaction $\vec{p}d \rightarrow \vec{n}$ as a function of the proton energy.