RESEARCH ARTICLE | SEPTEMBER 01 1995

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AIP Conf. Proc. 343, 182–186 (1995)
https://doi.org/10.1063/1.48855

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Abstract. The new intermediate energy Deuteron POLarimeter DPOL at RIKEN is described. DPOL is designed to measure all the vector and tensor polarization components simultaneously by utilizing the three reactions : ^{12}C(d,d_0), ^{1}H(d,^{2}He) and d+p. Preliminary results of the first test experiment with a polarized deuteron beam at 270 MeV are also presented.

INTRODUCTION

Many studies of spin excitations in nuclei have recently been performed in order to get information on the spin-dependent part of the effective nucleon-nucleon interaction. In the (p,p') reaction at intermediate energies ΔT=1 transitions are dominant because the vector-isoscalar (V_σ) component of the effective interaction is much weaker than the vector-isovector $V_{\sigma\tau}$ component. Therefore we have little information on the ΔT=0 spin excitations up to now from inelastic proton scattering or other probes. This is due both to the lack of useful probes as well as the weakness of V_σ in proton scattering.

Inelastic deuteron scattering should be one of the most efficient probes of ΔT=0 spin excitations, because it excites exclusively ΔT=0 states. Since the deuteron has a spin 1, we can define probabilities of non-spin-flip (S_0), spin-flip (S_1) and double-spin-flip (S_2), where Δm of $S_{\Delta m}$ is the change in S_y, the spin component of the deuteron perpendicular to the reaction plane (the y component in the Madison convention). S_1 will be a signature of spin excitations as S_{nn} is in the (p,p') reaction (1,2). S_1 is written, in terms of polarization observables as

$$S_1 = \frac{1}{9}(4 - P^{y'y'} - A_{yy} - 2K_{yy}^{y'y'}) \quad , \tag{1}$$

where yy denotes the tensor polarization and $P^{y'y'}$, A_{yy} and $K_{yy}^{y'y'}$ are the tensor polarizing power, the tensor analyzing power and the tensor-tensor polarization transfer, respectively. Thus measurements of the tensor-polarization observables are needed to extract S_1 via the ($\vec{d}$,$\vec{d}'$) reaction. This makes the measurement of S_1 in the (d,d') reaction much more difficult than that in the (p,p') reaction where the S_{nn} value can be derived from the vector-polarization transfer $K_y^{y'}$ alone.

DESIGN OF THE POLARIMETER

We are constructing the Deuteron POLarimeter DPOL at the RIKEN Accelerator Research Facility. It is designed to measure all the vector (it_{11}) and tensor (t_{20}, t_{21} and t_{22}) polarization components by utilizing three kinds of reactions, shown in table 1, as polarimetries. These reactions are measured semi-inclusively.

DPOL is located at the second focal plane (FP-2) of the spectrograph SMART (3) and the geometry is shown in fig. 1. Note that the reaction plane of SMART is vertical because a scattering angle is changed by using a beam swinger system.

A multiwire drift chamber (MWDC) and trigger plastic scintillators (0.5×18 ×80 cm^3 and 1.0×18×80 cm^3) are used for detecting scattered deuterons. These plastic scintillators, contain C and H, are also used as active scatterers for double scattering. The polarimeter-system consists of three hodoscopes, HOD1 (28 times 6.5×6.5×220 cm^3), HOD2 (12 times 6.5×6.5×220 cm^3) and HOD3 (2 times 1.0×13×100 cm^3), and two calorimeters, CM1 (6

TABLE 1: Reactions which are utilized as polarimetries. Corresponding components of analyzing power and triggers are also shown. Subscripts u and d in Hi=HODi denote upper and lower part of the hodoscopes, respectively.

	Reactions			Analyzing powers	Triggers
1 :	$d+{}^{12}$C	$\rightarrow$	$d+{}^{12}$C	iT_{11}	H1×CM1+H2×CM2
2 :	$d+p$	$\rightarrow$	^{2}He $(2p)+n$	T_{20} and T_{22}	H1×H1*
3 :	$d+p$	$\rightarrow$	$d+p$	all components	(H1+H2+H3)$_u$×(H1+H2+H3)$_d$

* coincidence events with two adjacent counters are excluded.

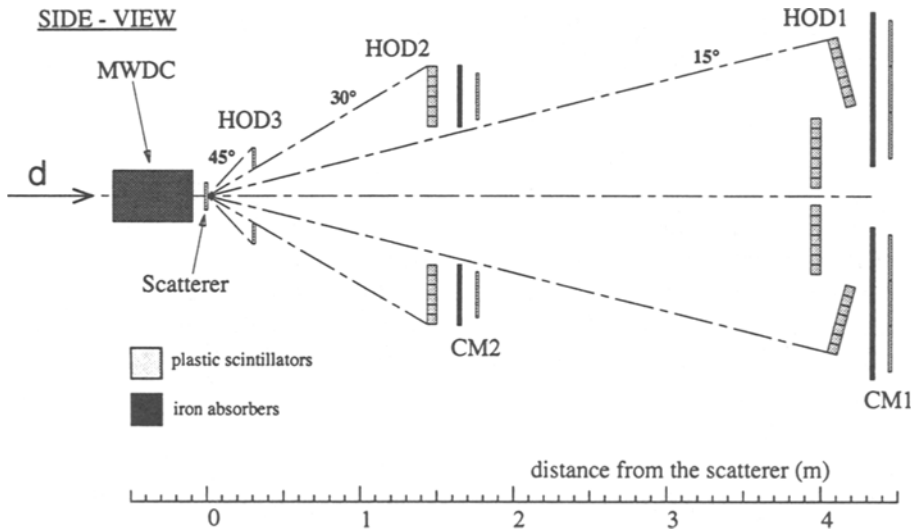

FIGURE 1: **A cross sectional view of the Deuteron POLarimeter DPOL. Details are described in the text.**

times 1.0×29×220 cm^3 and 1.8 cm thick iron absorbers) and CM2 (2 times 1.0×29×220 cm^3 and 1.8 cm thick iron absorbers). For all hodoscopes and calorimeters, plastic scintillators are used and they are viewed at both ends by photomultiplier tubes.

Three kinds of triggers for double scattering events corresponding to the three different reactions are shown in table 1. For the $^{12}C(d,d_0)$ event, calorimetry by using iron absorbers and scintillators is employed to identify deuterons. For the $^{1}H(d,^{2}He)$ and $^{1}H(d,d)$ event, two charged particles are detected in coincidence.

EXPERIMENT AND RESULT

The first experiment for testing the polarimeter-system has been recently performed with a 270 MeV polarized deuteron beam extracted from the RIKEN ring cyclotron.

Three combinations of the beam polarizations were used in this experiment and their ideal values of vector and tensor polarizations are $(p_Z, p_{ZZ}) = (0,-2)$, $(-1,+1)$ and $(+1,+1)$, respectively. The polarization axis was controlled with the Wien filter downstream of the ion source so that it lay on the normal or sideway direction of the scattering plane at FP-2. The beam polarization was monitored by using the d+p scattering at 270 MeV and typically 60-65 %

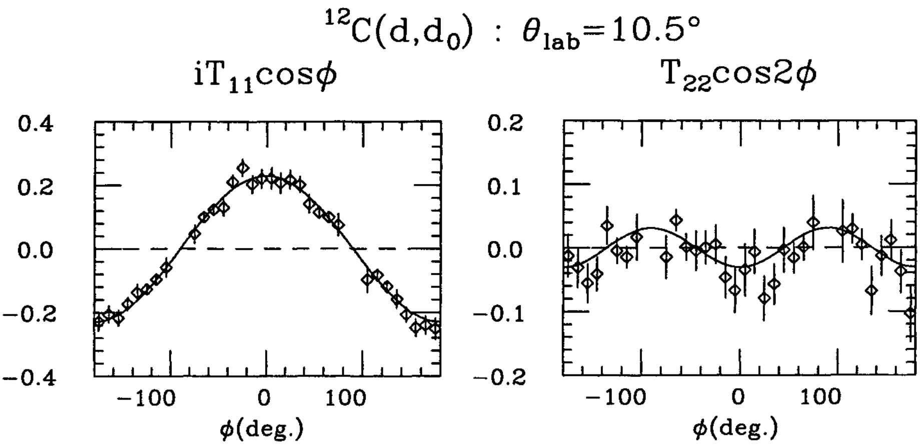

FIGURE 2: Typical fitting results for iT_{11} and T_{22} at θ_{lab}=10.5°. Only statistical errors are indicated in the figures.

polarization of the ideal value was obtained throughout the experiment.

The cross section with a polarized beam is written in terms of spherical analyzing powers as :

$$\sigma(\theta,\phi) = \sigma_0(\theta)\{1 + 2it_{11}iT_{11}(\theta)\cos\phi + t_{20}T_{20}(\theta) + 2t_{22}T_{22}(\theta)\cos 2\phi\} \quad , \quad (2)$$

where a T_{21}-term vanishes because the polarization axis is perpendicular to the direction of the incident beam. $iT_{11}\cos\phi$, T_{20} and $T_{22}\cos 2\phi$ values were obtained separately by using the $\sigma_0(\theta)$ value and the $\sigma(\theta,\phi)$ values for different combinations of the beam polarization. Finally, the effective analyzing powers were extracted by using a least squares fitting method. Fig. 2 shows typical fitting results of $iT_{11}\cos\phi$ and $T_{22}\cos 2\phi$ for the ^{12}C(d,d_0) events at θ_{lab}=10.5°.

Fig. 3 shows the preliminary results of the effective analyzing powers for the ^{12}C(d,d_0) events. Large iT_{11} values are obtained, consistent with the result of POMME (4).

SUMMARY

We are constructing the focal plane Deuteron POLarimeter DPOL at RIKEN in order to study the isoscalar spin excitations. The first test experiment has been performed to calibrate the effective iT_{11}, T_{20} and T_{22} values. The preliminary result for the ^{12}C(d,d_0) data shows large iT_{11} values. Further analysis and improvement of the polarimeter is now in progress.

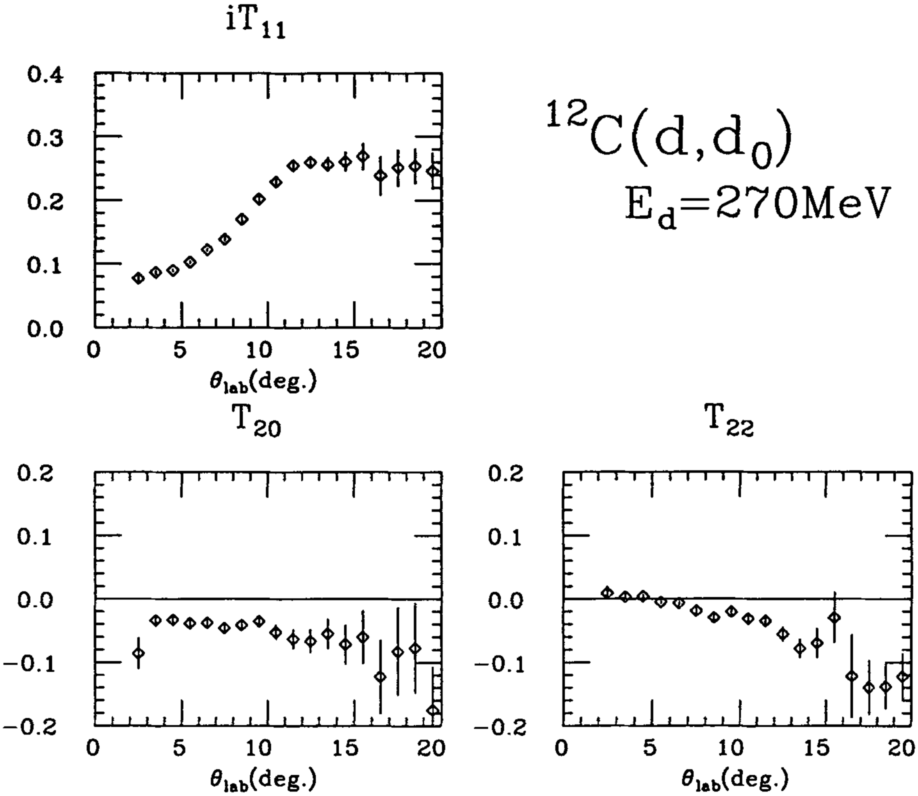

FIGURE 3: Preliminary results of the effective analyzing powers of DPOL for the $^{12}C(d,d_0)$ events.

ACKNOWLEDGEMENT

This work is supported financially in part by the Grant-in-Aid for Scientific Research No.04402004 of Ministry of Education, Science and Culture of Japan. The test experiment was performed at RIKEN under program number R138n.

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