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8.40 Production of a Polarized Deuteron Beam with a p_{xz} (t_{21}) Component at the SIN Injector Cyclotron

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The deuteron beam emerging from a polarized ion source has a longitudinal tensor polarization p_{zz}. After a rotation of the spin axis through the angles α and β the tensor component p_{xz} (or t_{21} in spherical notation) is given in the target coordinate system by

$$p_{xz} = -\sqrt{3}\, t_{21} = -\frac{3}{2} \sin\alpha \cos\alpha \sin\beta \cdot p_{zz} \qquad (1)$$

where α is the angle between the beam direction and the spin axis, and β is the angle between the normal to the scattering plane and the projection of the spin axis on the plane perpendicular to the beam direction[1].

This equation shows that one gets the maximum value of p_{xz} for $\alpha = 45^o$. For a cyclotron the spin axis normally is fixed by the magnetic field of the machine to be in the vertical direction. This gives $\alpha = 90^o$ and $p_{xz} = 0$, so that no p_{xz} dependence can be measured. However, most analyses and models are very sensitive just to this component, see for instance the phase shift analysis of $^4He(d,d)^4He$[2]. This shows the need, also with cyclotrons, to have a beam with a tensor component p_{xz}.

Hatanaka et al.[3] have produced a p_{xz} beam in 1983 with the 'Polarization Tagging Method'. Before the cyclotron the spin axis was rotated in the horizontal plane by a Wien Filter. The spin then rotates in the cyclotron around the magn.field and the spin direction is different for each turn. By selecting one turn by a kind of TOF measurement one can choose a certain direction of the spin. This procedure, however, involves a substantial loss of intensity.

We have used a system where the spin is rotated after the cyclotron. First the spin is turned into the horizontal plane with a superconducting solenoid and then it is rotated in this plane by bending magnets. Because of the small magnetic moment of the deuteron, one needs a large deflection angle. Fig. 1 shows a floor plane of the experimental area at SIN. In the solenoid S we rotate the spin in the

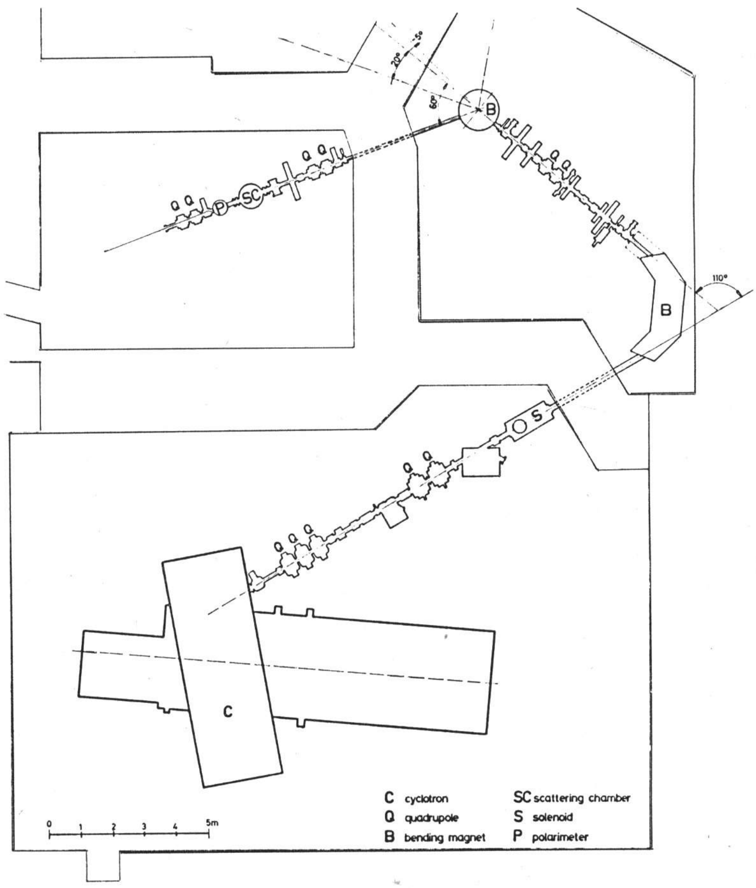

Fig. 1. Floor plan of the cyclotron and target area A.

horizontal plane. Afterwards with two bending magnets B we deflect the beam totally by φ = 170° into our target chamber SC. The coresponding spin rotation angle ϕ relative to the beam direction is given for deuterons as

$$\phi = \gamma \cdot (g-1) \cdot \varphi \qquad (2)$$

with $\gamma = (1-(\frac{v}{c})^2)^{-\frac{1}{2}}$ and $g = 0.857$.

For φ = 170° and 24 MeV deuterons the angle α in the target system is

$$\alpha = 90^\circ + \phi = 65.38^\circ.$$

Following eq.(1) this gives for p_{xz} a value of 75.8% of the maximum possible value at $\alpha = 45^\circ$.

The most critical point is to find the field needed to set the spin exactly in the horizontal plane. This is measured by scattering a purely vector polarized beam from ^{4}He, with two detectors left and right. The measured effect, corresponding to a determination of p_x, should be zero. Fig. 2 shows the measured polarization as a function of the magnetic field for E_d=24 MeV. To test for a possible depolarization in the solenoid we used the purely vector polarized beam too. We have measured with solenoid off and two detectors left and right, and solenoid on and two detectors up and down. Taking in account the calculated decrease in the polarization for α=65.38° both measurements gave the same result within a statistical error of ± 0.008, indicating no depolarization in the solenoid.

The big advantage of this method is that we have no intensity loss for the polarized beam. A first measurement with this new p_{xz} beam is given in a contribution[4] to this symposium.

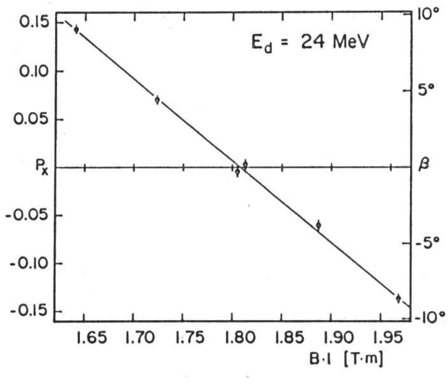

Fig. 2. Vector polarization as a function of the magnetic field in the solenoid. For p_x=0 the spin axis lies in the horizontal reaction plane.

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