Determination of the polarization of the ANKE polarized hydrogen storage cell target using the quasi–free $n\vec{p} \to d\pi^0$ reaction*

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During one week of beam time in January 2007 allocated for the double–polarized Charge–Exchange reaction study [1, 2], we used a 1200 MeV polarized (unpolarized) deuteron beam and a polarized hydrogen storage cell target of size $20 \times 15 \times 390$ mm^3. The preliminary results of the determination of the target polarization through the measurement of identified quasi–free $n\vec{p} \to d\pi^0$ events detected in the ANKE forward system, are presented.

Due to isospin invariance, the neutron analyzing power in the $\vec{n}p \to d\pi^0$ reaction should be identical to that of the proton in $\vec{p}p \to d\pi^+$, for which extensive data compilations are available (SAID). As shown by our earlier measurements with a polarized deuteron beam [3], the agreement of our results with the shape of the SAID predictions is very good for both small and large deuteron cm angles. This led to a determination of the vector polarization of the deuteron beam since, for the small Fermi momenta investigated here, there is a one–to–one relation between the deuteron and constituent neutron polarizations. The deduced value for P_z was completely consistent with that obtained from elastic $\vec{d}p$ scattering. Within small error bars, typically 2%, there was no sign of any effect arising from the tensor polarization of the deuteron beam.

For the January 2007 experiment using an unpolarized COSY deuteron beam and a polarized hydrogen storage cell target, the ϕ–dependence of the differential cross section $\sigma/\sigma_0 = 1 + Q_y A_y^p \cos\phi$ allowed us to extract the combination $Q_y A_y^p$. The known values of the proton analyzing power A_y^p of the $\vec{p}p \to d\pi^+$ leads to the determination of the hydrogen target polarization Q_y.

The Atomic Beam Source (ABS) of the ANKE polarized internal target (PIT) [4] has appeared in two spin modes: positive polarization Q_y^+ (spin-up, WFT is **off** and MFT is **on**) and negative polarization Q_y^- (spin-down, WFT is **on** and MFT is **on**). This has been managed by proper switching of the weak field transition (WFT) unit every 5 s **off** or **on**, while the medium field transition unit (MFT) was always switched **on**. In the following initial analysis it has assumed that $|Q_y^+| = |Q_y^-| = Q_y$.

The event identification has been done in the following way. Fig. 1 shows events from the $d\vec{p}$ interaction sample, where two charged particles were detected in the double–layer forward scintillation hodoscope. Polarized $\vec{\mathrm{H}}$ (unpolarized N_2) gas was used in the target cell and an incident deuteron beam of 1200 MeV energy employed. The figure shows the arrival–time differences for the two particles in the hodoscope (calculated after momentum and trajectory reconstruction under the assumption that both particles were protons) *versus* the measured difference of the two time signals from the scintillator. Thus, the two protons from the $dp \to (pp)n$ reaction should lie along the diagonal, with other pairs, such as dp_{sp} with a spectator proton from $dp \to dp_{sp}\pi^0$, being found elsewhere. Time-of-flight cuts applied to the distributions of Fig. 1 allow one to select the dp candidates and hence to derive the missing–mass squared distributions of the $dp \to dp\pi^0$ reactions presented in Fig. 2. For both the high deuteron momentum part (forward production in cm system), and the low momentum region (backward production),

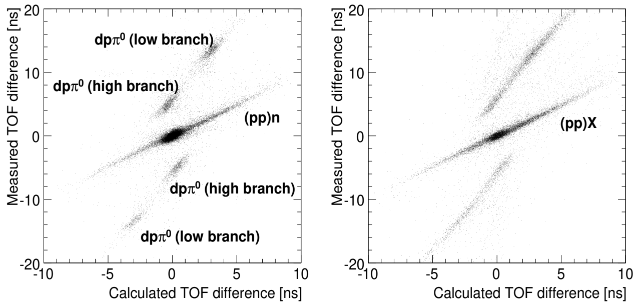

Fig. 1: Time difference of the two detected charged particles, calculated under the assumption that both particles are protons, *versus* the measured time difference for $\vec{\mathrm{H}}$ gas (left panel) and N_2 gas (right panel) in the storage cell.

the peaks corresponding to the unobserved π^0 are clearly seen. For small deuteron cm angles the spectrometer provides useful ϕ acceptance over the full angular range. However, for events in the backward hemisphere, this is restricted to $|\phi| < 60°$, in order to get $|\cos\phi| \gg 0$.

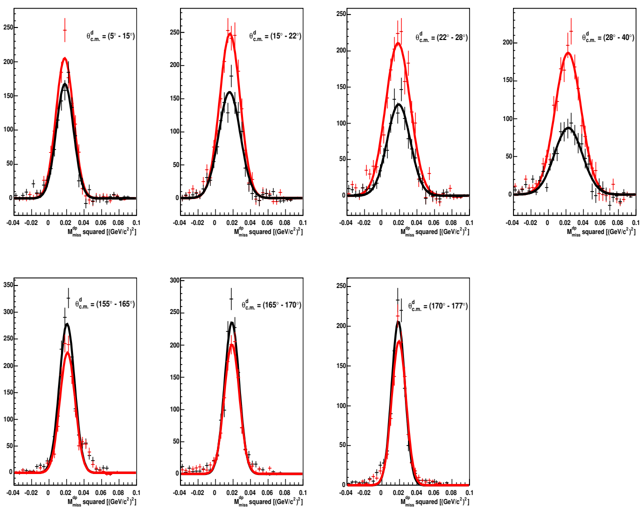

Fig. 2: Angular dependence of the missing–mass squared distribution for the reaction $d\vec{p} \to dp_{sp}X$ (upper row **High** branch, and lower row **Low** branch) measured with the storage cell and 1200 MeV deuteron beam. Red and black histograms stands, respectively, for data with target polarization 'spin-up' and 'spin-down', after background subtraction using N_2 data.

The background subtracted counts extracted from the different θ^d_{cm} angular intervals are listed in the Table 1 for two different spin states (N^+ and N^-). The background shape was taken from the N_2 data sample, as was discussed above.

Using the asymmetry value $\varepsilon = (N^+ - N^-)/(N^+ + N^-)$ determined for each individual θ^d_{cm} angular bin and the proper values for the averaged analyzing power $\langle A_y \rangle$ of

θ^d_{cm}	N^+	N^-	$\langle A_y \rangle$	$\langle cos\phi \rangle$	Q_y
11.2	1286.5	1030.4	0.179	-0.826	-0.747 ± 0.297
19.5	1817.4	1239.4	0.293	-0.860	-0.750 ± 0.173
25.8	1855.1	1045.1	0.361	-0.894	-0.866 ± 0.154
32.7	1747.8	879.4	0.416	-0.902	-0.881 ± 0.140
161.5	1222.6	1523.1	0.186	0.896	-0.655 ± 0.237
167.9	1095.8	1230.3	0.127	0.864	-0.526 ± 0.345
172.7	926.7	988.0	0.078	0.852	-0.483 ± 0.640

Table 1: The target polarization Q_y extarcted from the different θ^d_{cm} angular intervals.

protons from the SAID database, it was possible to extract the averaged target polarization value $\langle Q_y \rangle = \varepsilon / \langle A_y \rangle \cdot \langle cos\phi \rangle$ = 0.75 ± 0.06 with the $\chi^2/dof \approx 2/6$ (note that these results are PRELIMINARY).

References:

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