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MEASUREMENT OF THE ASYMMETRY IN THE ELECTRO-DISINTEGRATION OF TENSOR POLARIZED DEUTERONS AT THE NOVOSIBIRSK VEPP-3 RING

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ABSTRACT

A series of experiments with an internal tensor polarized deuterium target in the 2 GeV VEPP-3 electron storage ring in Novosibirsk is being performed. This paper describes the first results for a measurement of the tensor asymmetry in the quasi-elastic (e,e′p) reaction. The found results are compared to a non-relativistic calculation by Arenhövel and Leidemann, including meson-exchange currents, isobar admixtures and final-state interactions.

INTRODUCTION

While the new degrees of freedom included in the theoretical models often have only small effects upon unpolarized cross sections, polarization observables can be very sensitive to them [1]. The Novosibirsk/Argonne/NIKHEF-K collaboration is performing a series of experiments with tensor-polarized deuterium targets. These internal targets are operated in the 2 GeV electron storage ring VEPP-3 at the Budker INP in Novosibirsk [2] to study elastic electron scattering from [3], and breakup of [4, 5] tensor-polarized deuterons. Spin-dependent asymmetries can be extracted from a count rate difference in the two identical detector systems with different orientations to the polarization vector or in a single system from the count rate difference for two directions or signs of the tensor polarization. Because it is not necessary to have a very high energy resolution, large acceptance, non-magnetic detectors are used.

EXPERIMENTAL SETUP

The present polarized target is produced by a sextupole/RF-transition atomic beam source for tensor-polarized deuterons, supplying $1.5 \cdot 10^{16}$ atoms/second with a tensor polarization $P_{zz} = 1.0$ (± 0.05) with positive or negative sign. These deuterons are directed into a narrow, open-ended storage cell placed in the orbit of the VEPP-3 storage ring where stored electrons circulate, up to a cur-

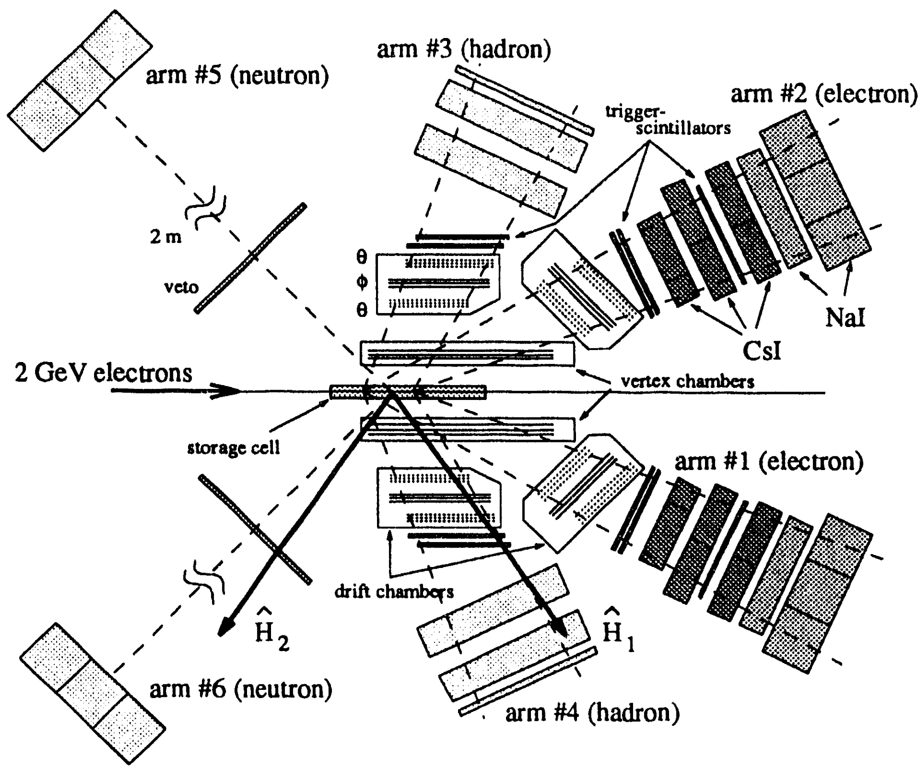

Figure 1: Schematic side view of the detector package around the target. Indicated are the two used magnetic field directions ($\hat{H}_1$ and $\hat{H}_2$).

rent of 200 mA and with a duty factor of $\approx 1\%$. The storage cell increases the target density to $3.5(\pm 0.5) \cdot 10^{12}$ atoms/cm^2. The cell is closed to a diameter of about 1×2 cm^2 during data taking. The effective polarization in the center part of the cell, visible to the detectors, was estimated to be about 65 ($\pm$20)% [6].

There are two identical systems with 3 detector arms, shown in fig. 1. The scattered electron is detected in a calorimeter, consisting of three 6 cm thick CsI layers containing 49 crystals, followed by two respectively 5 and 11 cm thick NaI layers with 6 crystals each. Attached to the long side of the $6 \times 6 \times 15$ cm^3 big CsI(Tl) crystals are wavelength-shifter plates which collect the scintillation light and reemit it at a wavelength of 610 nm at the edges, where it is sensed by photodiodes. The NaI(Tl) crystals all are read-out with photomultiplier tubes on one end. Three 1 cm thick trigger scintillators are used, two in front of the CsI and one between the second and third CsI layer. The total thickness of each calorimeter is about 16 radiation lengths. Viewed from the central 16 cm of the storage cell the calorimeters cover an angular acceptance of at least 20° to 30° in scattering angle θ and -30° to $+30^\circ$ in azimuthal angle ϕ. The knocked-out proton is detected in a hodoscope consisting of five layers of scintillator plastic with a thickness of 1.0, 1.0, 12.1, 12.6 and 1.5 cm, respectively. It has an angular acceptance of 60° to 70° in θ and of -30° to $+30^\circ$ in ϕ. The kinetic energy of the protons

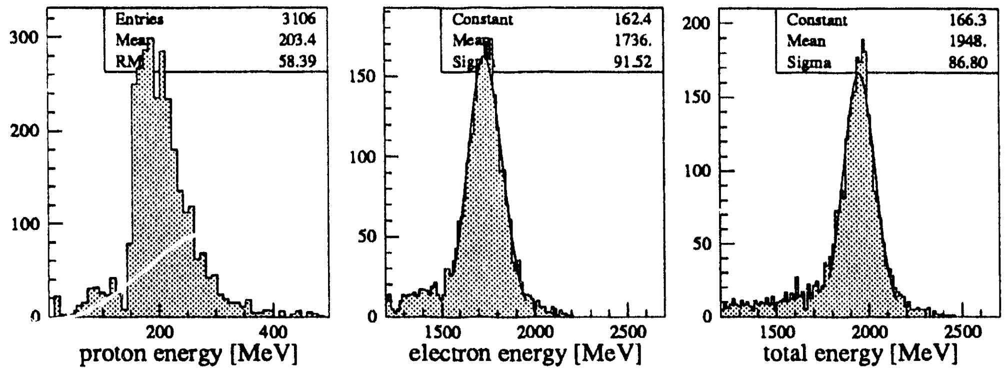

Figure 2: Energy histograms for elastic scattering from a hydrogen target. Shown are the proton, electron and the sum energy (latter two fitted by a gaussian).

is reconstructed using the deposit per layer. For the reconstruction of the particle tracks, several sets of wire chambers are used.

RESULTS

The reconstruction of both proton and electron energy for elastic scattering off a hydrogen target results in overcomplete kinematics. Adding the energy spectra of both particles yields the missing energy resolution and an absolute calibration for the calorimeters. The histograms in fig. 2 show the reconstructed proton and electron kinetic energy and the sum of these two for this reaction. The resolution obtained for protons (up to 500 MeV) was about 20%, for electrons about 11% and for the missing energy resolution 10% FWHM.

In fig. 3 the asymmetry measured in one detector for two opposite signs of the tensor polarization is compared with non-relativistic calculations by Arenhövel and Leidemann [1]. The different curves in the figure represent calculations for the plane wave born approximation (PWBA), with inclusion of respectively final state interaction effects (NORMAL/N), meson exchange currents (MEC) and isobar configurations (IC) for the kinematics listed in the graph. The data are taken with field direction H_1 (see fig. 1), an energy transfer between 140 and 300 MeV and an scattering angle for the electron between 16 and 24 degrees. The 4-momentum transfer ranges from 0.3 to 0.6 $(GeV/c)^2$ and the energy of the finalnp system up to 200 MeV. Thus, the average values equal the values for which the theoretical predictions are calculated.

CONCLUSIONS

Both the angular and the energy resolution were deteriorated due to high singles rates in the internal target area. A large background contribution originating from beam halo electrons scattering at the storage cell walls was observed. To reduce this background several meters upstream from the cell a set of four movable tungsten

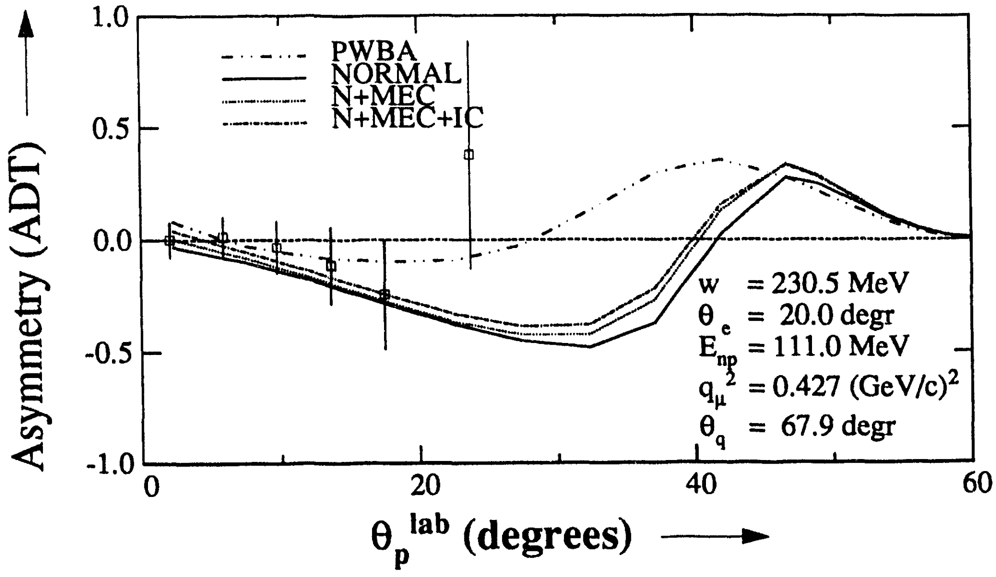

Figure 3: The predicted and found results for the asymmetry in the break-up channel at the quasi-elastic peak as a function of the angle between the momentum transfer vector and the direction of the outgoing proton.

scrapers was installed which served as a collimator. When the scrapers are moved in, the halo-electrons are deflected enough to dump them in the magnetic elements and the fixed collimator in front of the storage cell and detector area. Thus the singles rate in the detector area has been reduced 3 to 5 times.

The found results for the quasi-elastic asymmetry agree closely with the predictions, except for the last point. Clearly the statistics of the data have to be improved and calculations covering the complete acceptance of the detector set-up are needed to compare the data to. The first step to better statistics will be refining the analysis of the existing data. The second step will be repeating the measurement with a one or two orders of magnitude thicker target. The latter will be delivered by a laser driven source that presently is being developed at the Argonne National Laboratory and hopefully will be operational at Novosibirsk end of 1994.

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