NUCLEON-NUCLEON AND FEW-BODY STUDIES

A MEASUREMENT OF THE SPIN TRANSFER OBSERVABLE $D_{NN'}$ FOR p+p ELASTIC SCATTERING AT T_p=200 MeV

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In most models of the nucleon-nucleon interaction, an important parameter, and one which appears explicitly in meson-exchange formulations, is the πNN coupling constant, g_π^2. The strength of this coupling dictates much of the long-range behavior of the hadronic component of the N-N force, especially the tensor terms. Recent determinations of the values of both the neutral, g_o^2 (Ref. 1), and the charged, g_c^2 (Ref. 2), coupling constants, based primarily on the analysis of NN and πN scattering data, respectively, have been significantly smaller than values determined prior to 1987. These smaller coupling constants do not appear to agree with the value of g_π^2 required in meson-exchange models in order to yield the correct deuteron quadrupole moment and asymptotic D/S-state ratio.[3] These inconsistencies motivated our collaboration to investigate the sensitivity of g_π^2 to high precision spin observable data that could be obtained at IUCF. We found that the normal-component spin transfer observable $D_{NN'}$ for p+p elastic scattering is very sensitive to g_o^2, particularly over the angular range in which the NN scattering amplitude δ crosses zero.[4] Over this angular range, the momentum transfer q ranges from $\sim$ 0.3–0.8 fm^{-1}, which is sufficiently large that Coulomb effects are small, but sensitivity to multi-pion or heavy meson contributions is minimal. Of the existing $D_{NN'}$ data in the 150 MeV to 300 MeV energy range, none bracket the δ crossover (which occurs near $\theta_{lab} \approx 9°$), and all have relatively large statistical errors and normalization uncertainties.[5–7]

Experiment E367 successfully completed data acquisition in August, 1993. $D_{NN'}$ measurements were made at 10 angles (θ_{lab} = 5.0°, 7.2°, 8.4°, 9.7°, 11.8°, 15.0°, 19.1°, 24°, 30°, and 38°) and total errors (statistical plus systematic) of $\delta D_{NN'} = \pm 0.01$ were achieved at all but the largest angle. Acquisition of the needed calibration data for the focal plane polarimeter, FPP, was also completed in August, 1994 (see article in this report).

For E367, both outgoing protons from p+p elastic scattering were detected simultaneously, and their energies were accurately measured. The forward-going proton was momentum analyzed in the K600 spectrometer focal plane, FP. The septum magnet[8] was

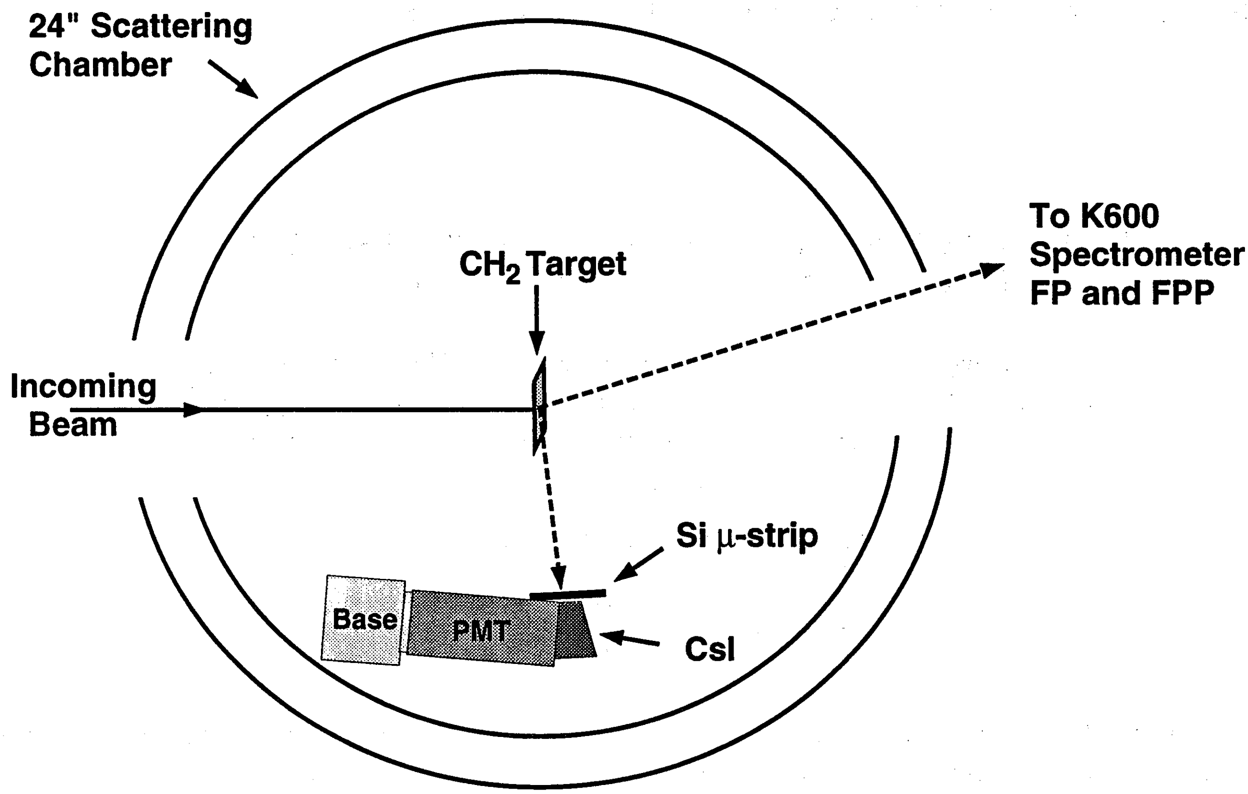

Figure 1. Top view of experimental setup in 24″ scattering chamber for E367.

used for forward-angle measurements at 5°–18°. After passing through the FP, the polarization of the forward-going proton was measured in the FPP. The recoil proton was detected in a Si/CsI detector telescope placed inside the 24″ scattering chamber (see Fig. 1). The Si detector measured 4.0 cm wide × 6.0 cm high, and consisted of 7 horizontal strips which were ganged together to form three sections consisting of the top three strips, the middle strip, and the bottom three strips. Relative coincidence rates in the three sections provided a very accurate gauge of the vertical position of the beam spot on target. The 500 μm thickness of the Si was sufficient to provide total energy information for protons from $\approx$ 1 to 8 MeV. For protons of higher energy, a ΔE signal resulted from the Si. Surrounding the Si was a Faraday cage constructed mainly of aluminum with a front face consisting of 1.2 μm aluminized mylar. Behind the Si μ-strip detector was a tapered CsI crystal, measuring 3.8 cm deep and 1.5 cm wide × 4.0 cm high on the front face. This crystal was optically glued to a 2″ Burle 8575 PMT attached to a compact, water-cooled base built in-house. The CsI crystal was sufficiently thick to stop protons up to 100 MeV. The combination of these two detectors in series gave the recoil telescope a dynamic energy range of ~1–100 MeV.

We chose to use a solid $(CH_2)_n$ target in this experiment since the advantages over using a liquid hydrogen target far outweighed the disadvantages. Using a solid target (as opposed to an extended liquid target) allowed us to know our event origin very well. The excitation spectrum of ^{12}C, simultaneously obtained in the focal plane, resulted in enough

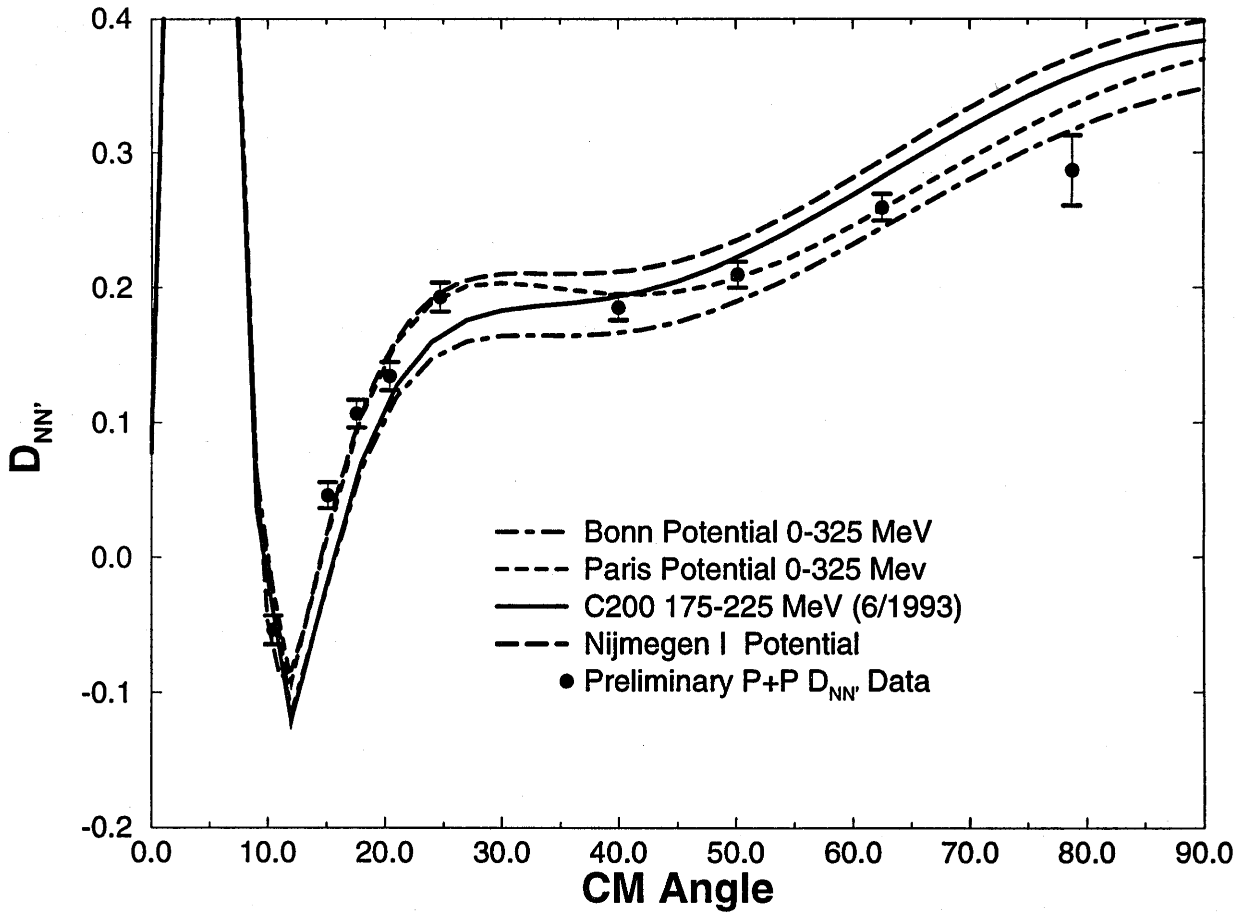

Figure 2. E367 preliminary $D_{NN'}$ data for p+p elastic scattering at T_p=200 MeV.

kinematic information to provide an absolute determination of the scattering angle. By comparing characteristics of ^{12}C peaks and the ^{1}H peak, we could constantly monitor beam and target properties with good sensitivity. The challenge of using a $(CH_2)_n$ target was in distinguishing p+p elastics from quasifree (p,2p) knockout. Since the minimum proton separation energy in ^{12}C is 16 MeV, the combined energy resolution of our FP and our recoil telescope of <5 MeV was more than sufficient to distinguish the two events. Thicknesses of the $(CH_2)_n$ targets used in this experiment ranged from 1.4 mg/cm^2 at 5.0° to 10 mg/cm^2 at 38°.

During data collection, no hardware coincidence requirement was made between the FP and the recoil telescope, and the recoil telescope information, if any, was read out for every good event in the FP. In the replay software, a proton that fell within the hydrogen peak in the FP spectrum was tagged as a good p+p elastic event only if a second proton fired the recoil detector(s) in coincidence and deposited the correct amount of energy. For recoil protons above 8 MeV, timing and energy requirements had to be satisfied for both the Si and the CsI detectors. "Accidentals" were tagged as those events which also consisted of a proton within the hydrogen peak in the FP spectrum and had a second proton that deposited the proper amount of energy in the recoil detector(s), but for which the relative timing of the protons differed from "true" coincidences by one beam burst. FPP spin-sorted left-right spectra for both "reals" and "accidentals" were made for all three sections of the Si detector. This allowed us to optimize subtraction of accidentals, since at most angles a large majority of the recoil protons were incident on the center section, which consisted of a single strip.

There are several systematic error checks available to us in the data. The ^{12}C elastic peak was present on the focal plane from 5° to 19°, and for both the ^{12}C elastic peak and the p+p peak, the induced polarization, P, and the analyzing power, A_y, were measured. These two observables should be equal; and since they are sensitive to different possible sources of systematic error, their comparison is an important means of systematic error evaluation. We also simultaneously measured $D_{NN'}$ for ^{12}C elastic scattering, which must be exactly 1. Careful evaluation of other possible systematic errors is presently underway.

Preliminary results of our analysis up to this point are presented in Fig. 2.

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SPIN CORRELATION COEFFICIENTS IN $\vec{p}\vec{p}$ ELASTIC SCATTERING AT 200 MeV

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An experiment to measure spin correlation coefficients in $\vec{p}\vec{p}$ elastic scattering with a stored, polarized beam on an internal, polarized target has been mounted in the A-region