Measurement of the absolute differential cross section for np elastic scattering near 200 MeV

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The np elastic scattering database at intermediate energies is plagued by experimental inconsistencies and cross section normalization difficulties [1]. This situation has led to an undesirable state of affairs, wherein the most sophisticated partial wave analyses (PWA) of the data [2] ignore the vast majority (including the most recent) of measured cross sections, the literature is filled with heated debates concerning experimental and theoretical methods [3], theorists propose radical "doctoring" of data to "salvage" allegedly flawed experiments [4], and one of the most fundamental parameters of meson-exchange theories of the nuclear force – the charged πNN coupling constant – hangs in the balance [1-3]. To provide an experimental resolution for existing discrepancies, we developed novel techniques [5] to carry out a new measurement in the IUCF Cooler ring via a very different approach from earlier experiments.

The experiment involved a kinematically complete double-scattering measurement. Neutrons of about 190 MeV were produced by the ^{2}H(p,n)2p reaction induced by a stored, electron-cooled proton beam in a deuterium gas jet target, permitting detection of the two low-energy recoil protons to tag and measure the four-momentum of each produced neutron. The recoil protons were detected in a double-sided silicon strip detector array utilizing novel self-triggering readout electronics [5]. Energetic protons from np scattering induced in a secondary CH_2 target were detected (in coincidence with the tagging protons) in a forward detector array spanning $90° \le \theta_{c.m.} \le 180°$. A graphite target carefully matched in transverse dimensions and in carbon density per unit area was frequently substituted for the CH_2 to permit an accurate background subtraction and reduce reliance on kinematic cuts to distinguish free from quasifree np scattering. These methods, combined with multiple internal crosschecks built into the data analysis, have allowed direct experimental determination of the absolute cross sections with a systematic uncertainty ~±1% and reliable measurement of the angular distribution shape for np backscattering.

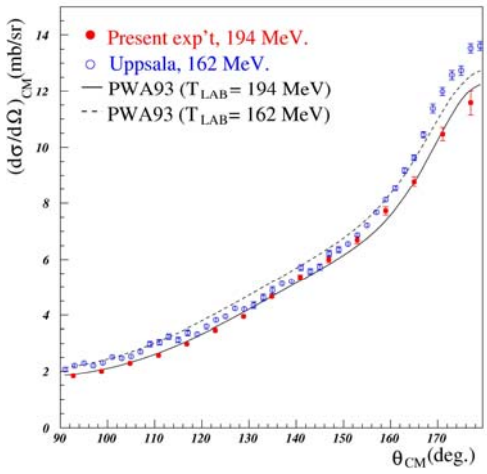

Figure 1. *The absolute differential cross section for np elastic scattering measured with a tagged beam of average kinetic energy 194 MeV, compared to theoretical calculations and to previous intermediate-energy experimental results.*

Results of the Cooler measurement at the average tagged-beam energy of 194 MeV are compared to predictions and to other recent intermediate-energy measurements in Fig. 1. Our

results are in good absolute agreement with the Nijmegen PWA93 calculations, over the full angular range covered in our experiment, with minor deviations that could presumably be removed by slight tuning of phase shifts. In contrast, the present results deviate systematically from the earlier measurements [1], especially in the steepness of the back-angle rise in differential cross section, which strongly influences pole extrapolations of the πNN coupling constant. These deviations are far larger than the expected differences attributable to the different neutron energies used in the various experiments. The present results should settle the debate for np scattering and provide a good cross section standard for intermediate-energy neutron scattering. A description of the facility has already been published [5], a letter reporting the results is shortly to be submitted, and a longer paper describing the analysis is in preparation.

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