Progress on CE71: A Precise Measurement of Absolute Cross Sections for np Scattering

T. Hossbach, W.W. Jacobs, A. Klyachko, T.E. Peterson, M. Planinic, T. Rinckel, M. Sarsour, E.J. Stephenson, S.E. Vigdor, S.W. Wissink, and Y. Zhou
IUCF

J. Rapaport
Ohio University

J. Blomgren, P. Nadel-Turonski, L. Nilsson, N. Olsson, S. Pomp and U. Tippawan
University of Uppsala

The goal of CE71 is to measure differential cross sections for np elastic scattering near 200 MeV bombarding energy to an absolute precision of ≈ ±1%, in order to settle serious discrepancies in the existing database and to test those partial wave and potential model analyses that have supported a low value ($g_\pi^2/4\pi \cong 13.6$) for the charged πNN coupling constant. In order to attain this precision, we commissioned a tagged neutron facility in the T-section of the Cooler ring in two runs in December 1999 and May 2000. At its heart is a set of four 6.4 cm square double-sided silicon strip detectors (DSSD's) with 0.48 mm readout pitch in two orthogonal directions, and self-triggering readout front-end electronics mounted on circuit boards surrounding the detectors. The DSSD's were used to detect the two low-energy (~ 1—15 MeV) recoiling protons from the ^{2}H(p,n)pp charge-exchange reaction induced by a cooled (unpolarized) 200 MeV proton beam on a deuterium gas jet target. Measurements of energy, position and arrival time for both outgoing protons permit reconstruction of each tagged neutron's energy (with a typical resolution σ~150 keV) and position of impact on the secondary target (with a resolution σ~2—3 mm). Commissioning of the facility was the Ph.D. thesis experiment of Todd Peterson. During 2002 a long instrumentation article covering the design and performance of this tagged neutron facility has been prepared and approved by the collaboration. It will shortly be submitted to *Nuclear Instruments and Methods*.

Production data for the np scattering cross section measurement were taken during August and September 2001, using carefully matched CH_2 and C (poco graphite) targets, each square slabs of side length 20.1 cm, containing 0.993×10^{23} C atoms/cm^2. The target densities and thicknesses were measured to a precision of ±0.4%, and were uniform to at least that precision. While the CH_2 target yielded a quasifree scattering background/free scattering signal ratio several times worse than anticipated with a liquid hydrogen target, it permitted more reliable background subtraction (since the two targets could be swapped frequently, in contrast to the very time-consuming empty/refill cycle anticipated for the liquid) and thickness uniformity. One-third of the time during the production run was devoted to background measurements utilizing the graphite secondary target, and a small amount of additional time was used for measurements with no secondary target. Examples of background-subtracted distributions for np scattering events (before application of any software cuts to suppress quasifree scattering contributions to the yield) are shown in the right-hand frames of Fig. 1. It can be seen in the lower distribution of reconstructed neutron scattering vertex positions that the runs with the C target not only subtract the events initiated on carbon in the CH_2 secondary target, but also those events initiated on other hydrogen in the neutron path (e.g., the Lucite light guide of the small upstream veto, SUV, scintillator located 10 cm in front of the target).

Analysis of the data from the production run has been slowed by the unexpected early departure, for quite different reasons, of the two graduate students who were going to work on this project. A post-doctoral research associate (Mirko Planinic) brought the analysis of data from the commissioning runs to an encouraging stage, indicated by the preliminary cross section results in Fig. 1. The absolute scale of the measurements in the figure is given by the tagged neutron detection, and has not been adjusted for comparison with the Nijmegen partial wave analysis prediction shown in the figure. A new post-doctoral associate, Murad Sarsour, who arrived at IUCF in Fall 2002, has begun the task of finalizing the analysis of both the np scattering and the simultaneously acquired pp scattering events. A total of more than 400,000 free np scattering events induced by tagged neutrons were collected during the production run. The statistical error bars, for the same angle bins represented in Fig. 1, will thus be reduced to typically ±1% for most bins, growing to ±3% for the bin nearest 180° c.m. We anticipate overall systematic errors of order ±1%, including the overall absolute normalization uncertainty. The analysis and a paper reporting the results should be completed during 2003.

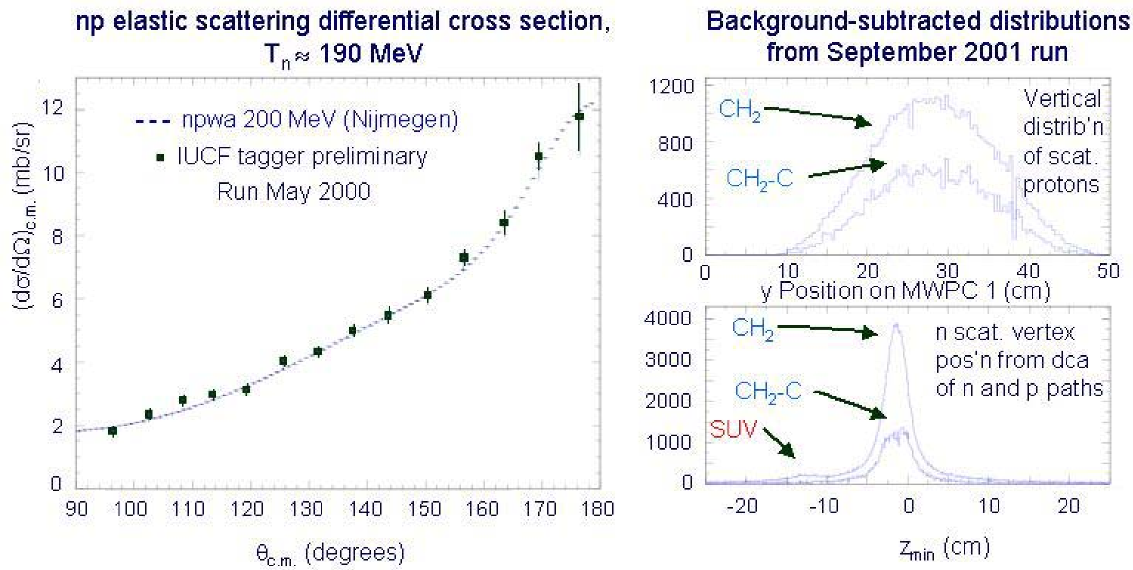

Figure 1. *Preliminary absolute differential cross section results from the commissioning run (compared to the angular distribution predicted by the relevant Nijmegen partial wave analysis in the left-hand frame) and background-subtracted distributions from the production run (right-hand frames) for np elastic scattering with tagged neutrons. Ongoing analysis of the data from the production run is expected to reduce statistical errors on the differential cross section measurements to ±1-3%, depending on angle, and systematic errors to about ±1%.*