STUDIES OF THE ^{12}C(p,n) AND ^{13}C(p,n) REACTIONS NEAR 180°

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The recoil detection program was continued with the running of the first phase of experiment CE-06 in November, 1988. The main purpose of this run was to measure the differential cross sections for the ^{12}C(p,n)^{12}N and ^{13}C(p,n)^{13}N reactions for neutrons emitted near 180°. As in previous runs, the QQSP spectrometer was used to detect the heavy–ion recoils. A magnet was installed inside the exit port of the QQSP in order to compensate for the bending of the beam by the dipole field. With this magnet, it was possible to transmit the beam through the zero–degree exit port of the spectrometer and into the beam dump, greatly reducing background. The (p,n) experiment required larger magnetic fields than had been used previously, and it is doubtful that the experiment could have been run successfully without the installation of this magnet.

The detectors, electronics, and data acquisition system were substantially the same as those used previously, and a paper describing this system has been published.[1] Briefly, the ions are magnetically analyzed by the QQSP and detected at the focal plane by a combination avalanche counter(PPAC)–wire chamber detector. The PPAC determines the ions' time of arrival, and therefore their velocity, while the wire chamber determines position, and therefore momentum/Q, where Q is the atomic charge. The ions also pass through a proportional counter, which measures dE/dx, from which the nuclear charge Z can be inferred. Knowing p/Q, v, and Z, it is possible to uniquely identify the ions in most cases.[1]

The system operated well during the November 1988 run, and there were no significant losses in beam time due to malfunctioning of detectors and/or electronics. Data were taken with ^{12}C and ^{13}C targets at an incident proton energy of 200 MeV. A total of about 20 millicoulombs of beam was accumulated for each target.

In a two–body reaction, the heavy–ion reaction product lies on an ellipse in the momentum–angle plane. Fig. 1 shows the ellipses of interest for 200 MeV protons on ^{12}C. The system was set to cover the high momentum recoils (corresponding to backward emitted light particles) for the following reactions: ^{13}C(p,p)^{13}C (Q=6), ^{13}C(p,n)^{13}N (Q=7), ^{13}C(p,π^+)^{14}C (Q=5), ^{13}C(p,π^0)^{14}N (Q=5), ^{13}C(p,γ)^{14}N (Q=6), and a similar list for the ^{12}C target. The ellipse is much larger for the (p,n) reaction and therefore a smaller

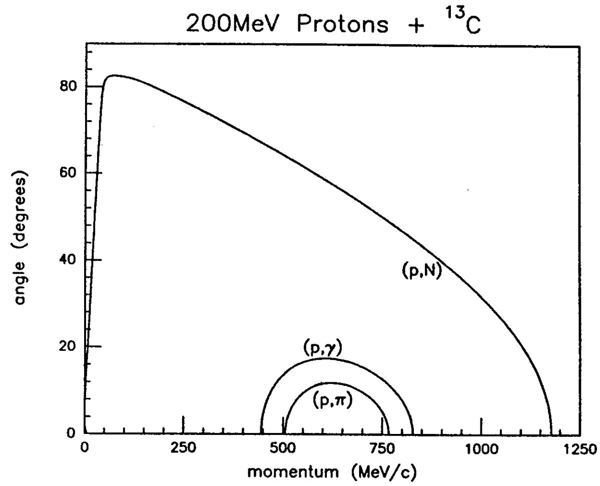

Figure 1. Loci in the momentum–angle plane of ions produced in two–body reactions with 200 MeV protons on ^{12}C. For reactions producing an isospin multiplet, the curves are too close together to be resolved in a figure of this size.

portion of the angular distribution was observed, but the region of interest near 180° was covered. In fact, the spectrometer accepted ions out to 10°, which for the (p,n) reaction corresponds to a center of mass angular range of about 160°-180°.

The data analysis is still in progress, but preliminary results are available for the (p,n) reactions, whose study was the main objective of the experiment. Fig. 2 shows a scatter plot of events in the rigidity–angle plane with a cut on the A/Q spectrum near 13/7 and a Z=6 charge window on the dE/dx vs 1/v spectrum. A line of events is seen in the region

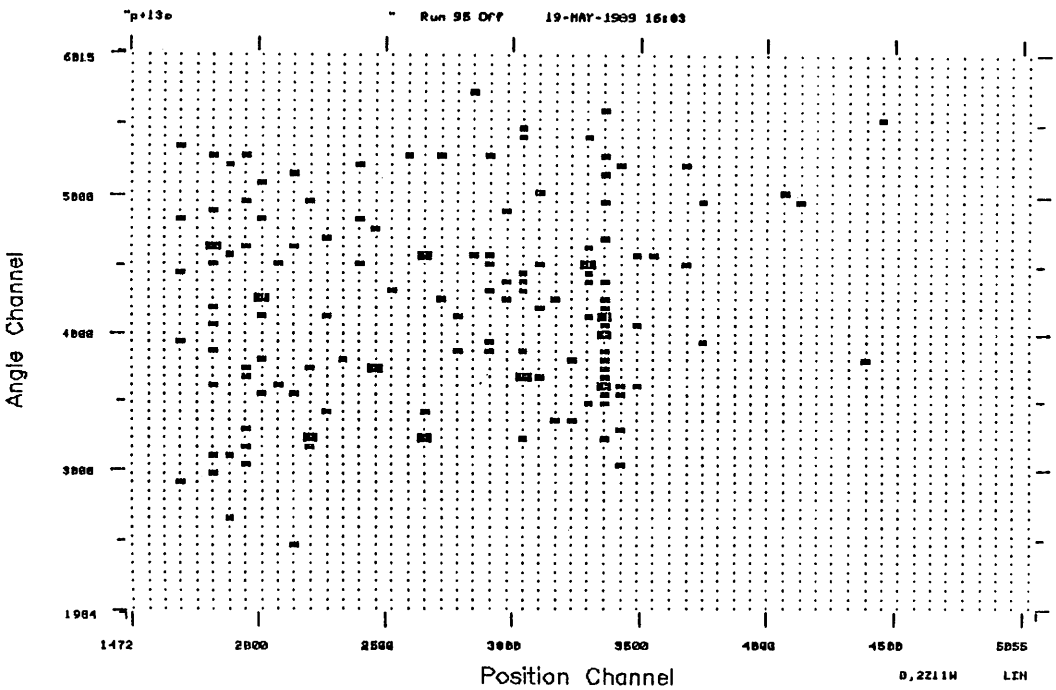

Figure 2. Counts in the position–angle plane with a cut on A/Q near 13/7 and a charge window on Z=7. The concentration of counts near position channel 3400 is attributed to the ^{13}C(p,n) reaction.

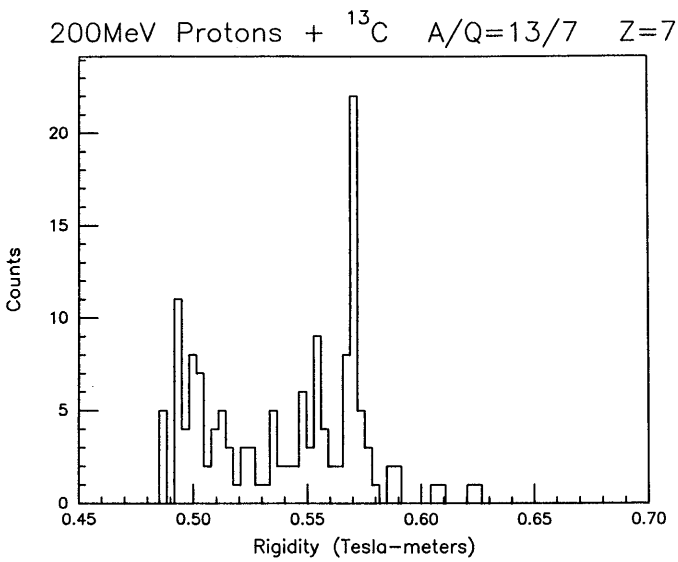

Figure 3. Rigidity spectrum for the two-dimensional histrogram of Fig. 2. The position of the peak is close to that expected for the $^{13}C(p,n)^{13}N$ reaction.

expected for the ^{13}N recoils from the $^{13}C(p,n)$ reaction. The presence of this reaction is more clearly established in Fig. 3, where the events are projected on to the rigidity axis and there is a strong peak at the correct position. A sharp peak is expected, since there is little bend in the ellipse over the covered angular region (Fig. 1). It is expected that most of the background will be eliminated after all of the software adjustments have been made. The preliminary analysis gives average cross sections of 0.13 nb/sr and 0.45 nb/sr for the $^{12}C(p,n)$ and $^{13}C(p,n)$ reactions, respectively, for neutrons emitted near 180°.

This experiment will form the basis of Mr. Zhou Yu's Ph.D. thesis. Mr. Yu is a graduate student at Northwestern University.

During the November 1988 run, data were taken on the charge–state population of heavy–ion recoils from thin carbon targets. In particular, it was desired to ascertain whether the population of high charge states would be depleted when 5–10 $\mu g/cm^2$ targets were used, as it is planned to use targets of this thickness in the Cooler ring. Measurements were made of the yield of ^{13}C ions from the $^{12}C(p,\pi^+)^{13}C$ reaction in the 6^+ charge state as a function of target thickness. Results are shown in Table I, where it can be seen that there is no significant loss of fully stripped ions for target thicknesses down to 5 $\mu g/cm^2$.

1. J. Homolka, et al., Nucl. Inst. Meth. **A260**, 418 (1987).

Table I.
Laboratory cross sections for producing 6^+ ^{13}C recoils from the $^{12}C(p,\pi^+)^{13}C$ reaction (high momentum branch – see Fig. 1)

Target Thickness $\mu g/cm^2$	Cross Section $\mu b/sr$
46	11.6 ± 1.2
20	12.4 ± 1.5
5.4	10.5 ± 1.8

POLARIZATION TRANSFER IN ^{19}F AND $^{39}K(p,n)$

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The nuclei ^{19}F and ^{39}K play unusually important roles in the saga of the missing GT strength. According to the shell model ^{39}K has a very simple structure – a single $d_{3/2}$ hole in the doubly magic ^{40}Ca core. However, it has been know for many years that the beta decay transition rate from ^{39}Ca to ^{39}K is significantly slower than the value that is uniquely specified by that simple structure model. The interpretation given to that fact is that the Gamow-Teller component of the decay is quenched to about 45% of the shell model value.

The transition rate from ^{19}Ne to ^{19}F, on the other hand, in the absence of any other information, might not seem anomalous, because the model of three particles outside a doubly magic closed shell allows enough uncertainty to accomodate it. However, we have previously measured $^{19}F(p,n)^{19}Ne$ and shown that essentially all of the GT strength up to at least 15 MeV of excitation is in the ground state transition, leading to the conclusion that the GT strength is quenched to about 66% of the shell model value.[1] The fact that almost all of the GT strength is in the isospin mirror transition also demonstrated that this nucleus has a special structure symmetry.