with our expectations from previous experience. The preliminary results with these cuts suggest that the GT to Fermi interaction strength ratios for $^{19}F(p,n)$ and $^{39}K(p,n)$ are consistent with the ratios obtained from $^{14}C(p,n)^{14}N$, using the $0^+ \rightarrow 1^+$ and $0^+ \rightarrow 0^+$ transitions as the references.

1. J. Rapaport, C. Gaarde, J. Larsen, C. Goulding, C. D. Goodman. C. Foster, D. J. Horen, T. Masterson, E. Sugarbaker, and T. N. Taddeucci, Nucl. Phys. **A431**, 301 (1984).

WEAK INTERACTION MATRIX ELEMENTS AND (p,n) CROSS SECTIONS

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A proportionality between zero-degree (p,n) cross sections and GT (Gamow-Teller) and F (Fermi) beta decay matrix elements was demonstrated about a decade ago and has since been exploited as a quantitative measure of GT strength functions in order to better understand nuclear structure and to calibrate neutrino detectors. The (p,n) reaction can be used as a quantitative probe because the specific cross sections,[1] $\hat{\sigma}_{GT}$ and $\hat{\sigma}_F$, show very little dependence on the structure details of the nucleus under study ($\hat{\sigma}_{GT}=\sigma_{GT}(p,n)/\mathrm{B(GT)}$; $\hat{\sigma}_F=\sigma_F(p,n)/\mathrm{B(F)}$) corrected for phase space and momentum transfer). The general trend of the mass dependence of the specific cross sections is understood in terms of an inceasing distortion with higher mass. However, in detail fluctuations of as much as ±50% have been observed betweeen adjacent masses. These fluctuations are not understood.

Only with the use of an empirically discovered relationship between the GT and F strengths in the reaction has it been possible to infer GT transition probabilities with greater precision than implied by the fluctuations. This relationship may be described as $R^2 = \hat{\sigma}_{GT}/\hat{\sigma}_F$ and $R = E_p/E_o$ where E_p is the proton beam energy and E_o is a constant,

$\approx$55 MeV. This relationship allows one to normalize GT transition peaks in a spectrum to the easily observed IAS peak. This empirical relationship does not have firm theoretical underpinnings.

The purpose of experiment 320 is to measure (p,n) cross sections for transitions with known beta decay strengths over a wide mass range, especially for odd-mass nuclei, in order to try to gain a better understanding of the fluctuations in the specific cross sections and the relationship between the GT and F strengths in the (p,n) reaction.

The experiment determines the specific cross sections, $\hat{\sigma}_{GT}$ and $\hat{\sigma}_F$, and the ratio $R^2=\hat{\sigma}_{GT}/\hat{\sigma}_F$. The ratio $\hat{\sigma}_{GT}/\hat{\sigma}_F$ is determined more precisely since it is independent of target thickness and current integration. The empirical values of R for ^{7}Li, ^{13,14}C, ^{26}Mg, ^{37}Cl and ^{42}Ca(p,n) in 60$\leq E_p \leq$200 MeV can be well represented by the relation[1] $R = E_p/E_o$ where E_o=55$\pm$0.4 MeV. However, some unexpected fluctuations of the ratio R are observed. In order to have a better understanding the physics behind these fluctuations, more data of R for medium and heavy weight nuclei are needed. Unfortunately, very few cases exist of known GT matrix elements in transitions that are accessible to (p,n), and the cross sections for these transitions are small.

The data shown here were taken with the stripper loop, which provides pulse separations greater than 2 μs without much loss of average beam current. The incident proton energy E_p was 160 MeV and the flight path was 120 m. The background from wraparound is strongly suppressed compared to operation without the stripper loop with a pulse separation of 120 ns.

An energy spectrum for ^{7}Li(p,n) is shown in Fig. 1, the two peaks correspond to the ground-state (gs) of ^{7}Be and the first excited state where the excitation energy, E_x, is 0.43 MeV. The energy resolution is about 300 keV in the combined spectrum for ten detectors.

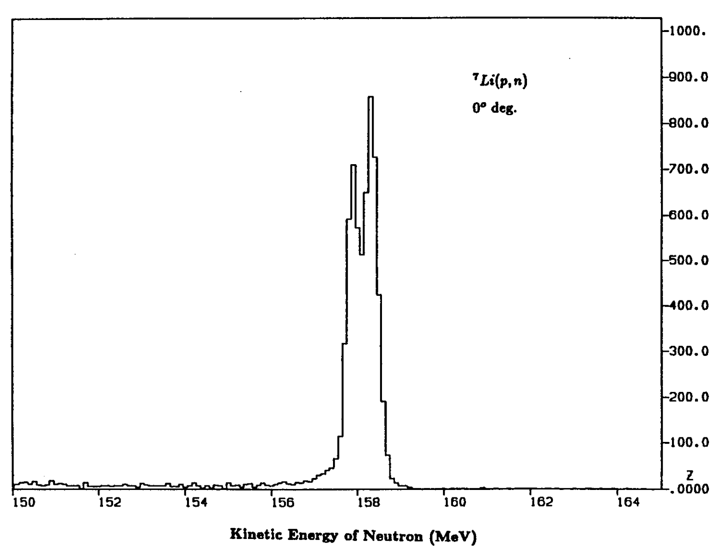

Figure 1. Neutron energy spectrum from ^{7}Li(p,n) at 0°. The two peaks correspond the transitions from the $3/2^-$ ground-state of ^{7}Li to the $3/2^-$ ground-state of ^{7}Be and $1/2^-$ 1^{st} excited state (E_x=0.42 MeV) in ^{7}Be.

The medium and heavy weight nuclei we studied in this experiment are ^{51}V, ^{113}In, ^{118}Sn and ^{141}Pr. The previously measured and published data[2] on ^{51}V(p,n) were taken under poor conditions with a resolution of nearly 1 MeV. The IAS transition (E_x=6.61 MeV) was not resolved from nearby strong GT transitions (E_x=5.96, 5.83 and 5.56 MeV). In the present study with an energy resolution 300 keV, the IAS transition is well resolved from these nearby GT transitions. The transition from the $7/2^-$ gs of ^{51}V to the $7/2^-$ gs of ^{51}Cr is a well isolated, weak GT transition and an excellent case for comparing the GT to F cross sections. The energy spectrum of ^{51}V(p,n) is shown in Fig. 2.

The GT transition from the $9/2^+$ gs in ^{113}In to the $7/2^+$ isomeric state in ^{113}Sn at 78 keV is more than 1 MeV away from the competing GT transition. The $1/2^+$ gs and the third excited $5/2^+$ state (E_x=0.41 MeV) in ^{113}Sn will not be excited to the zero-degree spectrum. The energy spectrum of ^{113}In(p,n) is shown in Fig. 3.

The transition from the 0^+ gs of ^{118}Sn to the 1^+ gs of ^{118}Sb (GT) is also resolved from the from nearby competing states. The transition from the $5/2^+$ gs of the ^{141}Pr to the $3/2^+$ gs of ^{141}Nd (GT) is about 1 MeV away from nearby GT transitions, therefore it can been resolved. However, this transition is weak and our spectrum contains only 77 counts in that peak. The uncertainty resulting from the statistics, background subtraction and peak fitting for the GT transition is 23%.

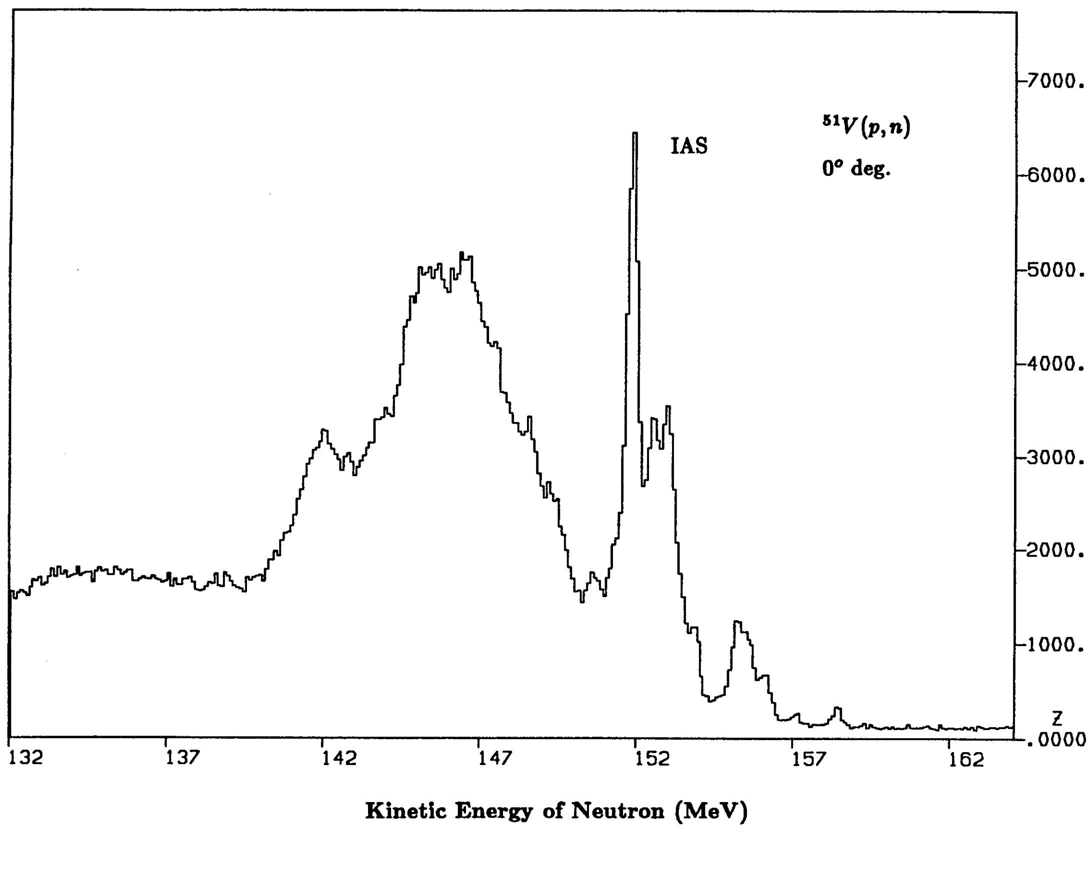

Figure 2. Neutron energy spectrum from ^{51}V(p,n) at 0°. The peak at 158.5 MeV is the $7/2^-$ ground-state in ^{51}Cr. The peak at 151.9 MeV is the IAS transition.

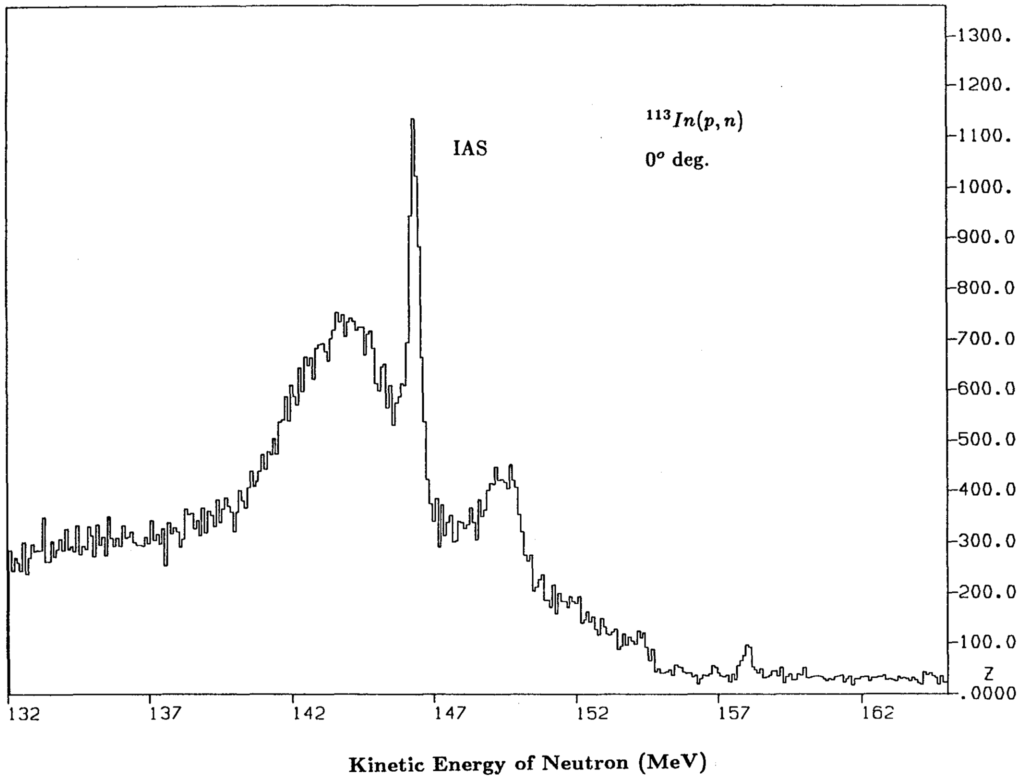

Figure 3. Neutron energy spectrum from ^{113}In(p,n) at 0°. The peak at 158 MeV is the $7/2^+$ isomeric state in ^{113}Sn at 78 keV. The $1/2^+$ ground-state is not excited in the zero-degree spectrum. The peak at 146.4 MeV is the IAS transition; and it is above a giant GT transition.

The empirical values R have been tabulated in Table I. In this Table, the B(GT) is the GT transition strength obtained from beta decay, and $B_{p,n}$(GT) is the GT strength for (p,n) and it differs from B(GT) by a factor, $(2J_i + 1)_{beta}/(2J_i + 1)_{(p,n)}$, where J_i is spin of the parent state in beta decay or (p,n). In all cases, the Fermi transition strength was assumed to be B(F) = N−Z. The σ_{GT}/σ_F is the ratio of the Gamow-Teller and Fermi transition cross sections, and the k(F)/k(GT) is the ratio of kinematic corrections, where k(F) and k(GT) goes to unity in the limit of zero momentum transfer. The values R are listed with corresponding uncertainties, which include statistics, their background subtraction and peak fitting.

The observed R values are slightly higher than the value 2.91±0.02 obtained using the relation E_p/E_o, ($E_o = 55 \pm 0.4$ MeV). Additional data to be taken at E_p=120 MeV should help to establish whether the apparent departures from the trend established from lighter even mass nuclei are real and whether they can be parameterized in terms of different values of E_o.

Table 1 Empirical Values of R

Nuclei	logft	B(GT)	$B_{p,n}$(GT)	B(F)	σ_{GT}/σ_F	k(F)/k(GT)	R
^{51}V	5.3906± 0.0016$^{a)}$	0.016±0.002	0.016±0.002	5	0.043±0.003	0.937	3.55±0.36
^{113}In	4.65± 0.12$^{b)}$	0.087±0.042	0.070±0.034	15	0.082±0.009	0.887	3.95±1.56
^{118}Sn	4.524± 0.013$^{c)}$	0.116±0.005	0.348±0.015	18	0.214±0.023	0.910	3.18±0.23
^{141}Pr	5.25± 0.01$^{d)}$	0.022±0.001	0.015±0.001	23	0.0096±0.0023	0.878	3.60±0.54

a) Ref. 3, b) Ref. 4, c) Ref. 5 and d) Ref. 6. The B(GT) were calculated using Eq. 1.2 in Ref. 1 and coupling constant values are those recommended by Wilkinson[7].

1. T.N. Taddeucci et al., Nucl. Phys. **A496**, 125 (1987).
2. J. Rapaport et al., Nucl. Phys. **A427**, 332 (1984).
3. R.L. Auble, Nucl. Data Sheets **23**, 163 (1978).
4. J. Lyttkens et al., Nucl. Data Sheets **33**, 1 (1981).
5. T. Tamura et al., Nucl. Data Sheets **51**, 329 (1987).
6. L.K. Peker, Nucl. Data Sheets **45**, 1 (1985).
7. D.H. Wilkinson, Nucl. Phys. **A377**, 474 (1982); P. Bopp et al., Phys. Rev. Lett. **56**, 919 (1986).