

## CHARGE EXCHANGE

### GAMOW-TELLER STRENGTHS FOR NEUTRINO DETECTORS

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In recent years, the physics of neutrinos has taken a prominent role in such diverse fields as astrophysics and elementary particle physics. Two topics played a central role in generating interest in these particles:<sup>1,2</sup>

- the ‘solar neutrino’ problem, an observed (and so far unaccounted for) discrepancy between the standard solar model and the standard model of elementary particles, and
- the possibility that the neutrinos have mass.

The latter topic may well be the determining factor for the evolution of the universe, if the neutrino mass proves sufficiently large to eventually “close” it.

In view of the importance of this subject, new neutrino detectors have been planned and are being scheduled to begin operation in the next few years.<sup>3</sup> Most of these detectors will use neutrino-capture processes in order to create charged particles that can subsequently be detected and counted. The process is like an inverse  $\beta$  decay reaction. It is obvious that in order to translate the number of detected charged particles into a number of neutrinos that pass through the detector, an accurate value for the neutrino capture cross

section of the active element of the detector is needed. Such a value can be provided by a (p,n) reaction since it has been shown<sup>4,5</sup> that the  $0^\circ$  (p,n) cross sections are proportional to the beta-decay transition strengths. Experiment E390, an investigation of GT strengths in substances of importance to neutrino detection, collected data at 100, 120 and 160 MeV on the  $^{40}\text{Ar}(p,n)^{40}\text{K}$ ,  $^{26}\text{Mg}(p,n)^{26}\text{Al}$ ,  $^{208}\text{Pb}(p,n)^{208}\text{Bi}$ ,  $^{59}\text{Co}(p,n)^{59}\text{Ni}$ , and  $^{37}\text{Cl}(p,n)^{37}\text{Ar}$  reactions.

### *Experimental setup*

Two different plastic scintillation detectors were used in the experiment. Both were situated on the  $0^\circ$  flight path in cross-section mode, with their long axis parallel to the neutron beam direction. The old IUCF neutron time-of-flight (NTOF) detector, our primary detector for this experiment, was set-up approximately 72 m from the target, while the new INPOL detector was further downstream at a distance of approximately 160 m. The two detectors made use of separate electronics set-ups and their signals were sent to two different computers running different data-acquisition systems.

The INPOL detector consists of four  $0.1 \times 1 \times 1 \text{ m}^3$  planes of neutron scintillators and two auxiliary planes of thin scintillators. The latter are used to detect charged particles when in polarimetry mode. They consist of three horizontal and two vertical scintillators each. The first three neutron scintillator planes consist of ten BC-517 liquid scintillator cells each. The cells are arranged vertically in the first plane and horizontally in the other two. The fourth plane consists of ten vertical BC-408 plastic scintillators. During the experiment the second plane of INPOL was in the shadow of the NTOF detector, so the spectra obtained from that plane lack the energy resolution achieved with the other planes.

### *Results*

Here we report only on the analysis of the data obtained from the  $^{26}\text{Mg}$  and  $^{40}\text{Ar}$  targets at 100, 120 and 160 MeV with INPOL. Unsubtracted missing-mass spectra for these targets are shown in Fig. 1. They incorporate cuts on pulse height, RF, the horizontal position of the detected neutron and the neutron mean times.

In the case of  $^{26}\text{Mg}$ , the Fermi  $0^+ \rightarrow 0^+$  transition from the ground state to the isobaric analogue state (IAS) of  $^{26}\text{Al}$  at 0.2282 MeV is clearly seen. Several other states appear in the spectrum, with the  $0^+ \rightarrow 1^+(1.0578 \text{ MeV})$  Gamow-Teller transition being the most prominent. The clean separation of the Fermi peak in the  $^{26}\text{Al}$  spectrum implies that it is possible to use this target to calibrate the spectra in units of  $\sigma\text{B}(\text{GT})$ .<sup>5</sup> It could also be used for effective analyzing-power calibration of the INPOL detector. An accurate  $A_{eff}$  value enables extraction of GT strengths from  $D_{NN}$  measurements.<sup>6</sup>

In the  $^{40}\text{Ar}$  case, the transition to the  $0^+$  isobaric analogue state of  $^{40}\text{K}$  at approximately 4.38 MeV can also be seen. Several GT transitions emerge at energies lower than the IAS. There is interest in estimating the strength of these transitions to calibrate the Icarus  $^{40}\text{Ar}$  detector at the Gran Sasso Laboratory. In calculations of the neutrino-capture cross sections expected for Icarus it had been assumed that the IAS transition will dominate the process.<sup>3</sup> The peak at about 16 MeV is a contaminant from the ground state of  $^{12}\text{N}$ .

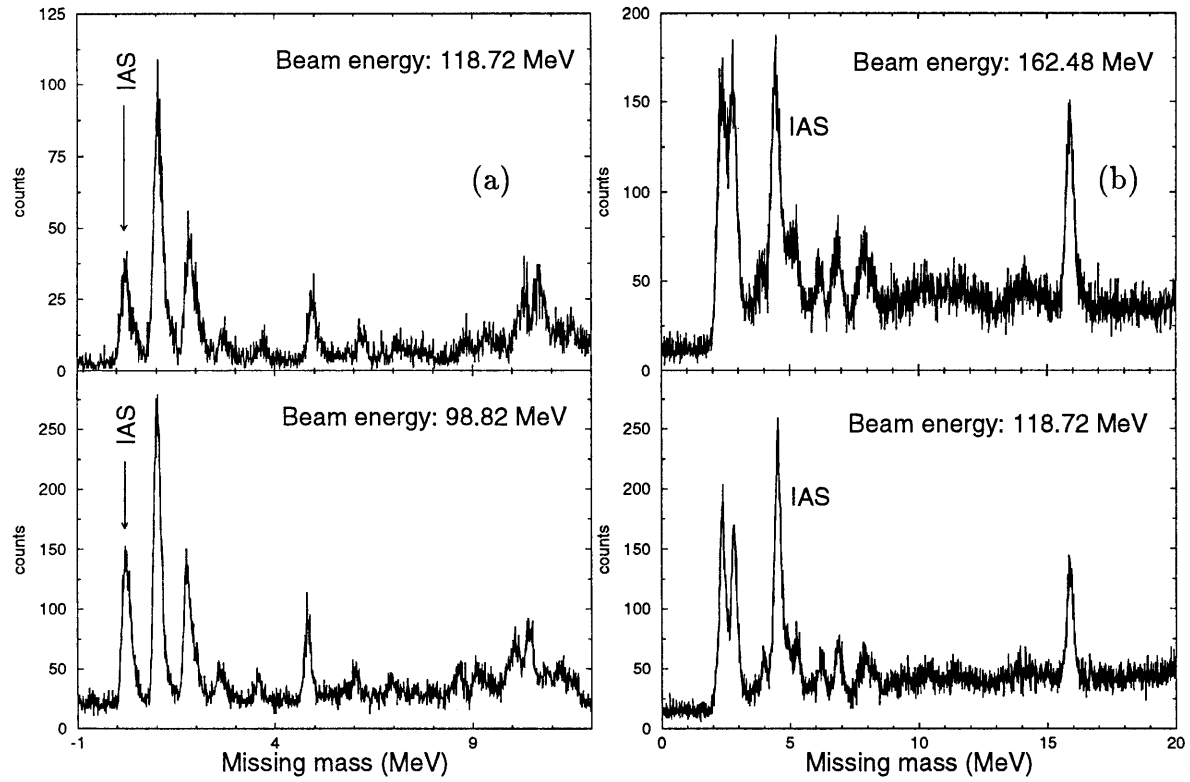


Figure 1. (a)  $^{26}\text{Al}$  spectra at 100 and 120 MeV. (b)  $^{40}\text{K}$  spectra at 120 and 160 MeV.

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