tive to the protons, supports the contention that the more complex particles are formed by successive nucleon pickup.

The only calculation presently available to which the data can be compared are semi-classical calculations. Cascade calculations predict a prominent quasi-elastic peak in the proton spectrum and this is not observed. For the more complex particles, only calculations, also semi-classical, using the exciton model are available. These only predict the angle integrated spectra but even for this the agreement between experiment and calculation is poor in both magnitude and shape.

As expected, the angular distributions for the various (fast) particles were forward peaked, the more strongly so the higher the particle energy. Figure 1 shows, as an example, the angular distributions of tritons from ^{208}Pb. Angular distributions were not greatly dependent on exit particle species or on target.

DECAY MODES OF THE NUCLEAR CONTINUUM EXCITED IN PROTON-NUCLEUS INTERACTIONS

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In plane particle-gamma coincidences have been measured following 80 MeV proton bombardment of ^{62}Ni using the cyclotron facilities of the two institutions. Particles were detected in a three element silicon and intrinsic germanium telescope placed at 25.5°, 35°, and 45.5° and three Ge(Li) gamma-ray detectors were located at 135°, -75°, and -138° with respect to the beam.

A preliminary analysis shows that discreet gammas corresponding to transitions among the low lying levels of various nickel isotopes are in coincidence with a proton spectrum consisting of a peak, FWHM=10 MeV, centroid about 10 MeV above threshold for each case, and a tail towards lower energies (see Fig. 1). The peaks in these spectra can be understood to arise from mechanisms such as $^{62}Ni(p,p')^{62}Ni^{*} \to x\tilde{n} + {}^{62-x}Ni$, where x is the number of evaporation neutrons. The tails reflect the role of processes such as $^{62}Ni(p,pxn)^{62-x}Ni$. More detailed analysis is now in progress.

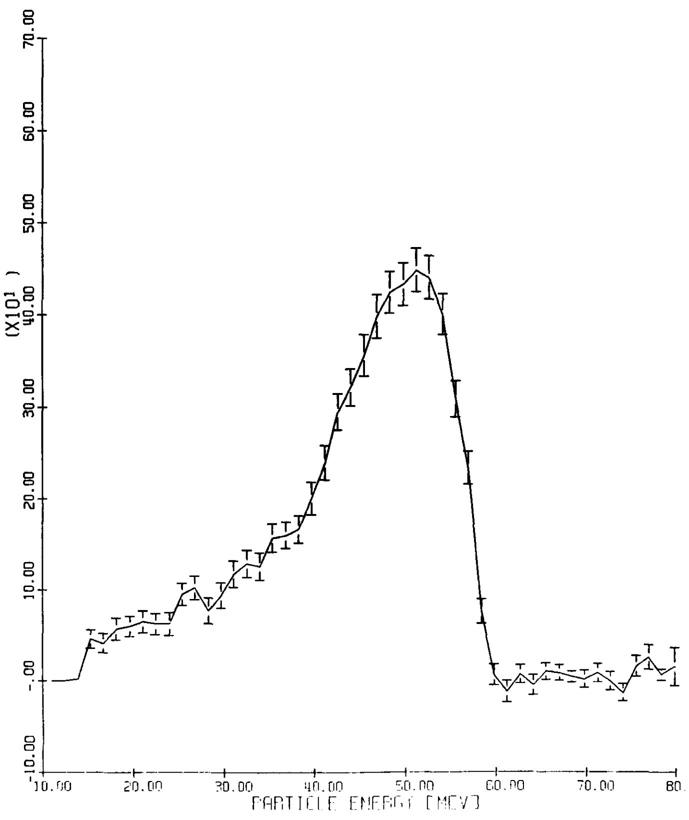

Figure 1. Protons in coincidence with the 1333 keV gamma-ray of ^{60}Ni. Both accidental coincidences and compton background have been subtracted from this spectrum.

Data have been sorted onto large arrays on the disk and for each of the three angles and in each of the three Ge(Li)-particle coincidences there are two dimensional arrays corresponding to prompt proton, deuteron and triton coincidences. Each has another separate array corresponding to twice the accidental rate to be subtracted. In addition there are gamma-gamma prompt and accidental arrays. Presently the gammas associated with continuum down to just below 60 MeV excitation are being explored, but in the early analysis one interesting feature is noticed.

The number of protons of energy E_p observed in true coincidence with any gamma-ray is proportional to

$$N_t^{coin}(E_p) \propto \langle M\gamma\rangle_{E_p} \bar{\Omega}_{E_p} \frac{d\sigma}{dE_p} \qquad (1)$$

and those in random coincidence are proportional to

$$N_r^{coin}(E_p) \propto C \langle M\gamma\rangle \bar{\Omega} \frac{d\sigma}{dE_p} \qquad (2)$$

where C is a constant that depends upon the resolving time of the electronics. In this experiment the C was such that accidentals were about 10% of the true coincidences. Inasmuch as $\bar{\Omega}_{E_p}$ is constant, taking the ratio of (1) to (2) gives a quantity proportional to the gamma multiplicity as a function of the proton scattering energy.

$$R(E_p) = N_t^{coin}(E_p)/N_r^{coin}(E_p)$$

$$= \frac{\bar{\Omega}_{E_p}}{C\langle M\gamma\rangle\bar{\Omega}} \langle M\gamma\rangle_{E_p} \sim C'\langle M\gamma\rangle_{E_p} \qquad (3)$$

In Fig. 2 this ratio is presented for protons at 25.5° in coincidence with the Ge(Li) at 135°. The other two gamma detectors show the same basic features and all include lower multiplicities in the 63 MeV region of giant resonance excitation.

Variations in this ratio for different proton energies may arise from different mechanisms associated with the various proton energies, e.g., both $^{62}Ni(p,p')^{62}Ni^* \to \tilde{n} + {}^{61}Ni^*$ and $^{61}Ni(p,p'\,n)^{61}Ni$ may be associated with 60 MeV protons but with very different gamma-ray multiplicities and excitations of the residual ^{61}Ni nucleus. Differences in the ratio may also appear from different components within excitation regions, such as resonance or continuum states near 17 MeV excitation.

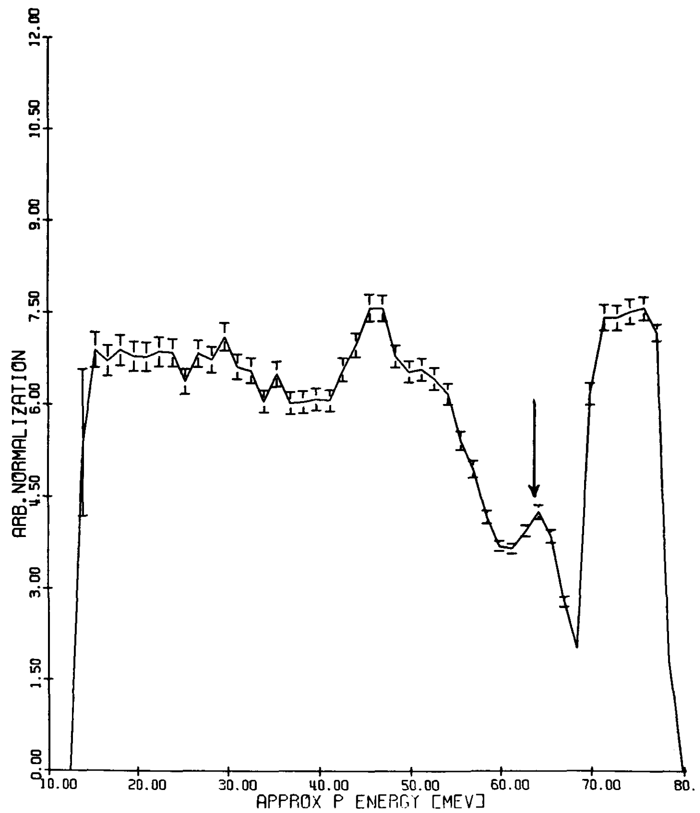

Figure 2. Gamma-ray multiplicity ratios (arbitrary normalization) with energy of protons at 25.5° for coincidences in any of the three Ge(Li) gamma ray detectors. The arrow indicates the position of giant resonance around 16.5 MeV excitation.

In the vicinity of the giant resonance (58-68 MeV proton energy) the ratio is smaller than the values to either side. The dip at 69 MeV is understood as strength near the ground state of ^{61}Ni with low gamma-ray multiplicity. The lower multiplicity in the resonance region could result from low multiplicity of the resonance and/or continuum. The fact that the ratio at 70-80 MeV is comparable to that of the continuum of 15-50 MeV proton energy indicates that the continuum multiplicity is likely fairly constant.

At 45° the resonance structure is less than 5% of the continuum in singles and the ratio in Fig. 3 is approaching the continuum value. In smaller bin sizes (not shown) there is a second dip present near the 2n threshold plus neutron evaporation energy.

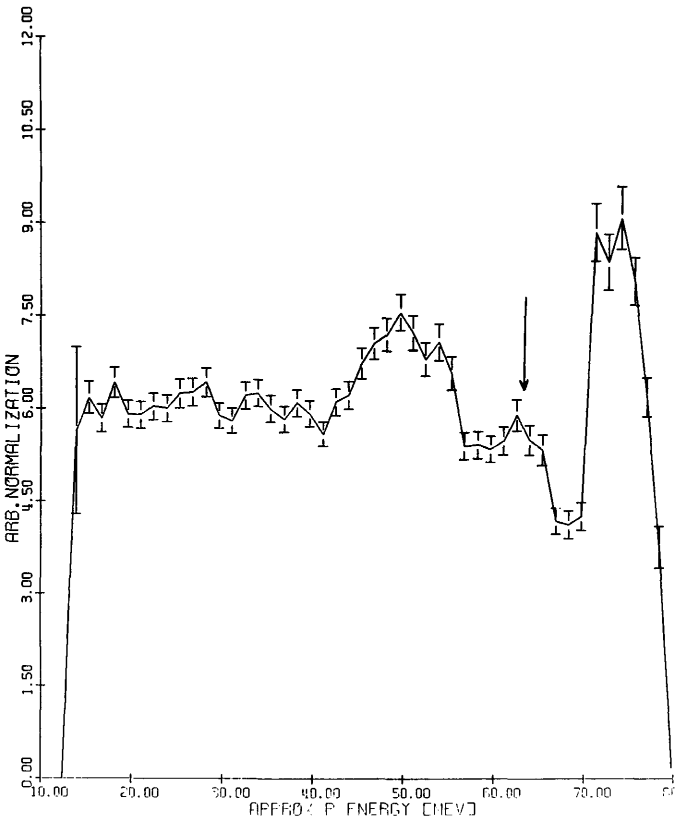

Figure 3. Gamma-ray multiplicity ratios (arbitrary normalization) with energy of protons at 45.5° for coincidences in any of the three Ge(Li) gamma ray detectors. The arrow indicates the position of giant resonance around 16.5 MeV excitation.

Ignoring explicit treatment of (p,pn) effects and in an empirical fashion, the continuum systematics are determined at 45° and the proportion of resonance at 25° is extracted from the accidental spectrum. This procedure implies that the resonance decays on average via 0.9 ± 0.4 gamma transitions and, with the strength of the resonance at 45°, this number should be adjusted downwards. The result is in contrast with the continuum value of 5 and with the result of the 150 MeV alpha bombardment. For the alpha experiment the continuum behavior is less clear but does seem to vary more rapidly across the resonance region. More detailed analysis is underway to attempt to understand this crucial discrepancy.

Measurements of the particle inclusive gamma multiplicity in a separate experiment does indicate smaller gamma multiplicities for ^{61}Ni transitions. We plan to perform a careful gamma multiplicity measurement into the continuum using an array of NaI detectors, a particle telescope, and a Ge(Li) detector for discreet transitions.

The present data are consistent with the resonance near 16.5 MeV excitation of ^{62}Ni decaying a significant fraction of the time directly to ground states or first excited states. Further investigations of the particle-gamma ray coincidences are underway with a focus upon the more general continuum behavior as well as the resonance observations. These analyses and the upcoming multiplicity measurement will hopefully provide some more direct evidence.