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DOPPLER BROADENING OF THE 6.322-MeV γ-RAY FROM ^{15}N FOLLOWING μ^- CAPTURE IN ^{16}O

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LAWRENCE RADIATION LABORATORY
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The very broad, 6.322-MeV ^{15}N line observed[1] following μ^- capture in ^{16}O can be fitted with a simple kinematic model by using the neutron energy spectra predicted in the resonance-capture calculation of Raphael, Uberall, and Werntz.[2] If we assume complete isotropy in the reaction sequence

$$\mu^- + {}^{16}O \rightarrow {}^{16}N^* + \nu$$

$${}^{16}N^* \rightarrow {}^{15}N^* + n$$

$${}^{15}N^* \rightarrow {}^{15}N + \gamma$$

and define $\vec{\beta}_1$ as the recoil velocity of the $^{16}N^*$ from ^{16}O, $\vec{\beta}_2$ as the recoil velocity of the $^{15}N^*$ from ^{16}N, and E_0 as the γ-ray energy in the $^{15}N^*$ rest frame, we can easily show that for monoenergetic neutron emission the γ ray will have the trapezoidal line shape shown in Fig. 1.

Summing over the neutron line spectrum of Ref. 2 and folding in detector resolution (12 keV or 2 PHA channels), we obtain the curve in Fig. 2.

The experimental data points can also be fitted by assuming the recoil of a monoenergetic neutron. The quality of this fit as a function of neutron energy (E_n) is indicated in the table.

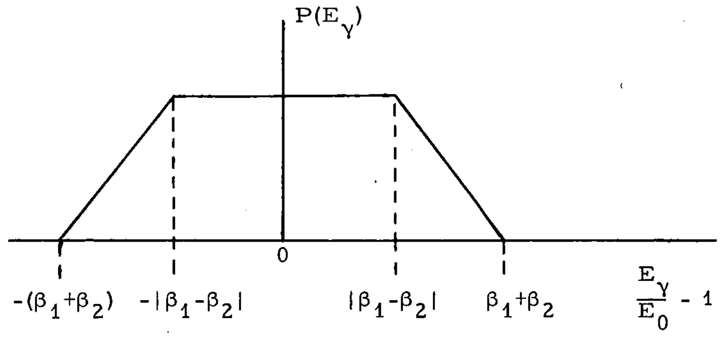

Fig. 1. Calculated line shape for monoenergetic neutron emission.

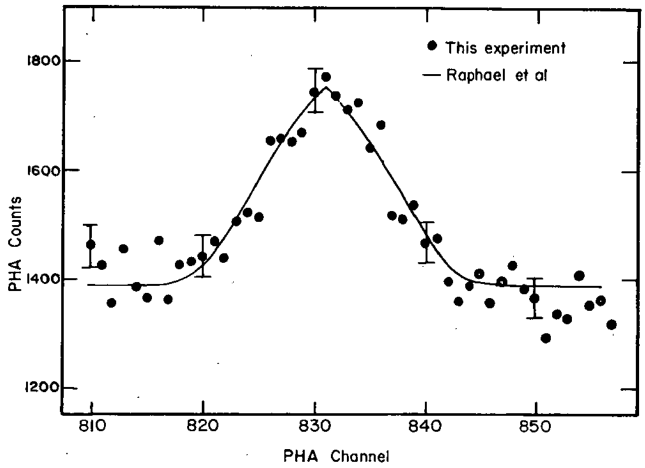

Fig. 2. Experimental data fitted with neutron spectrum of Ref. 2.

E_n(MeV)	χ^2/d	Confidence level (CL) (%)	E_n(MeV)	χ^2/d	Confidence level (CL) (%)
1	70/30	< 0.01	5	25.5/30	> 50
2	47/30	6	6	31.5/30	40
3	28/30	> 50	7	40.8/30	10
4	23.6/30	> 50	8	55.5/30	0.4

The data can, therefore, be well fitted (CL $\gtrsim$ 50%) with any spectrum of neutrons principally in the energy range of 3 to 6 MeV. However, a significant fraction of lower- or higher-energy neutrons would spoil this fit.

These limits imposed on neutron recoil energies are consistent both with the predictions of the resonance model and the μ^- capture

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Subject: UCRL-19348 "Doppler Broadening of the 6.322-MeV γ-Ray from ^{15}N Following μ^- Capture in ^{16}O" by S. N. Kaplan, R. V. Pyle, L. E. Temple, and G. F. Valby, September 1969

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neutron spectrum measurements reported by Evseev et al.[3]

It should be pointed out that the assumed isotropy does constitute an oversimplification because of correlation between the nuclear spin axis and the direction of neutrino emission. Therefore some modification of the above result can be expected if detailed account is taken of possible angular correlations.

References:

1. S. N. Kaplan, R. V. Pyle, L. E. Temple, and G. F. Valby, Phys. Rev. Letters 22, 795 (1969).

2. R. Raphael, H. Uberall and C. Werntz, Physics Letters 24B, 15 (1967).

3. Y. Evseev, T. Kozlowski, V. Roganov, and J. Woitkowska (these Proceedings).

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