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COMPARISON OF TOTAL PHOTONEUTRON YIELD FROM 160 AND 320 MEV BREMSSTRAHLUNG

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Berkeley, California

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That an appreciable fraction of the photoneutrons produced by a high energy (320 Mev) bremsstrahlung might be due to quanta of energy greater than 150 Mev was pointed out by L. Eyges[1] on analysis of high energy[2,3] and lower energy[4] absolute photoneutron production cross sections and of transition curves[2,5,6]. Eyges proposes that the nuclear absorption cross section for photons has a resonance maximum in the region of 15 to 20 Mev, then falls almost to zero and rises once again somewhere above 100 Mev. The results of the present experiment bear out the essential validity of this theory.

In this experiment, the total photoneutron yield measurements previously reported[2] for the 320 Mev bremsstrahlung from the Berkeley synchrotron were repeated at 160 Mev maximum energy for nine elements. Full energy (320 Mev) measurements were also made on these nine elements at the same time as a check. The experimental arrangement used was very similar to that previously described[2]. Neutrons were counted at 90° to the beam direction with a boron triflouride proportional counter in a "long counter" geometry of paraffin. The pulses from the counter were clipped to 0.5 microseconds pulse length.

The ionization chamber beam monitor was calibrated at both energies for equivalent numbers of low energy quanta by two methods. The first was the induced 10 minute half-life β^+ activity in copper foils due to the $Cu^{63}(\gamma n)Cu^{62}$ reaction as used by Sagane[7]. The second was the photodisintegration of

deuterium as determined by direct neutron counting from water and heavy water targets. Both of these reactions are presumably sensitive only to quanta below 50 Mev. The deuterium yield was 6.5 percent higher from 160 Mev bremsstrahlung than the copper yield for equal copper and deuterium yields at 320 Mev. The average of the deuterium and copper results was used.

Table I gives the ratios of total photoneutron yields for equivalent $Cu^{63}(\gamma n)$ and $D(\gamma n)$ reaction yields (i.e., for the same number of quanta below 30 Mev) from 320 Mev bremsstrahlung and 160 Mev bremsstrahlung.

TABLE I

Element	Be	C	Al	Fe	Cu	Mo	Ta	W	Pb
$\frac{\text{Yield at 320 Mev}}{\text{Yield at 160 Mev}}$	1.21	~~1.77~~ 1.18	1.48	~~1.61~~ 1.23	1.28	1.30	1.28	1.33	1.30

The probable counting errors of these ratios are less than 3 percent in every case except carbon (error ~~12~~ 4 percent). The relative yields at 320 Mev checked within statistics the previously reported values[2]. Although the beam pulse length at half energy was only 20 microseconds, no neutron pile-up occured in the counter because of the long average diffusion time (about 200 microseconds) of neutrons in the paraffin of the "long counter". Neutron pile-up and counts due to scattered gamma rays or electrons were checked for, both by increasing the counter voltage by 100 volts and by reducing the beam intensity by a factor of four. In both cases the counts per unit beam were the same within statistics, indicating negligible contribution from either effect.

If the calibration methods described can be assumed to normalize the beam to equal numbers of quanta between 0 and 30 Mev for full and half energy beams, the shapes of the bremsstrahlung spectra at these energies indicate that only quanta of greater than 140 Mev energy could account for the 30 percent increase

in yield actually observed.

References:

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