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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING

Bonnie E. Cushman

May 26, 1952

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Berkeley, California

SUMMARY OF THE RESEARCH PROGRESS MEETING OF APRIL 17, 1952

by

Bonnie E. Cushman

I. Excitation Function for Photoneutron Production. L. W. Jones.

The idea, advanced by Leonard Eyges, that an appreciable part of photoneutron production is due to high energy quanta has been investigated at the Berkeley synchrotron. Twelve elements were studied in an effort to find an excitation function for neutron production. Four processes must be considered:

1. Resonance absorption of gammas. The curve is sharply peaked at about 15 Mev for most elements studies.

2. Photoelectric effect.

3. Meson reproduction.

4. Interaction between meson and photon currents in the nucleus or virtual meson production. The threshold in this case may be lower than for the third process.

The neutrons were detected with a BF_3 long proportional counter surrounded by paraffin. No background problem was encountered since the discriminator level could be set to eliminate all but the neutron pulses. Diffusion of the neutrons in the paraffin and the resolving time of the counter were such that a sharp beam pulse could be used. Different energies used in the study were obtained by cutting off the rf at various fractions of the peak field. Corrections were made for target thickness (the consensus of opinion is that the best spectra to use in this type of experiment are those from thin targets). The yields at the different energies were normalized to 16.5 Mev using the $\beta+$ activity from the Cu^{63} (γ ,n) Cu^{62} reaction. The normalization agreed with those made by using the γ, n, reactions in deuterium and carbon. Statistics were very good; 3,000 - 10,000 counts were

obtained for each data point. Random systematic errors such as magnetic regulation and fluctuations in the Nunan monitoring meter amount to less than 2 percent. Overlap in the spectra for different energies was eliminated by the photon difference method. The curves for all the elements studies look essentially the same. Data for tantalum are given in Figures 1 and 2.

II. Multiple Meson Production. M. Ruderman

The solution of the equation of motion of the nucleon spin in the presence of a strong transient external force indicates that, for a sufficiently energetic interaction, most of the transferred energy goes into kinetic energy of spin rotation (isobar excitation) rather than into immediate meson emission. The isobar subsequently decays to the ground state with multiple emission. The angular momentum is related to the excitation energy:

$$L \sim \sqrt{2IE}$$

I is the moment of inertia. The number of emitted mesons is $n = L/n$. Taking for the isobar level separation the results of symmetrical pseudoscalar meson theory fitted to give a first excited state at ~ 300 Mev: $n \sim 2 \sqrt{E/Mc^2}$. This is very close to the results of Fermi's model: $n \sim 1.4 \sqrt{E/Mc^2}$. If, following Fermi, it is assumed that in a very high energy collision the collision products are determined by their statistical weights, the possibility of isobar production should therefore be included. For center-of-mass energy $W \gg 100\ Mc^2$ they have little effect. At higher energies they dominate because of their high spin and charge degeneracy. The meson multiplicity is $\sim 0.65(W/Mc^2)^{9/11}$. The ratio of antiprotons to mesons is $(0.07) \exp(-2Mc^2/kT)\ (Mc^2/kT)^{1/2}$, and $(kT/Mc^2) \sim (W/Mc^2)^{4/11}$ $(0.12) \gg 1$. The inclusion of isobars keeps this ratio small with a maximum near $kT/Mc^2 \sim 1$.

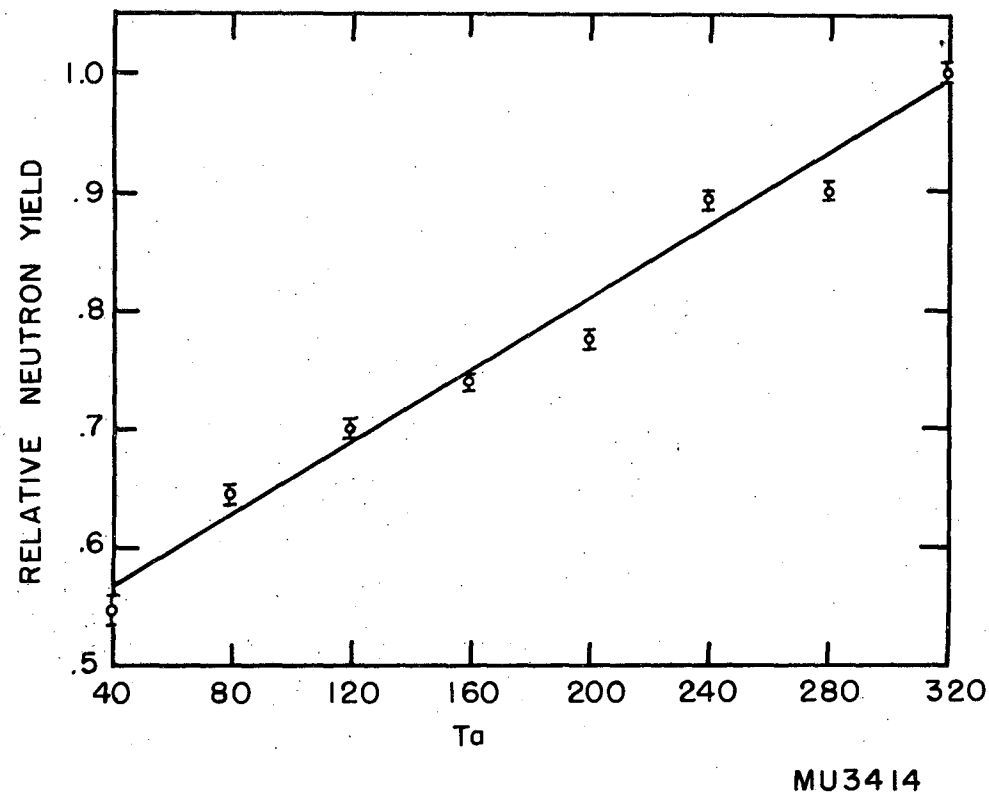
RELATIVE NEUTRON YIELD
1.0
.9
.8
.7
.6
.5
40
80
120
160
200
240
280
320
Ta
MU3414

Figure 1.

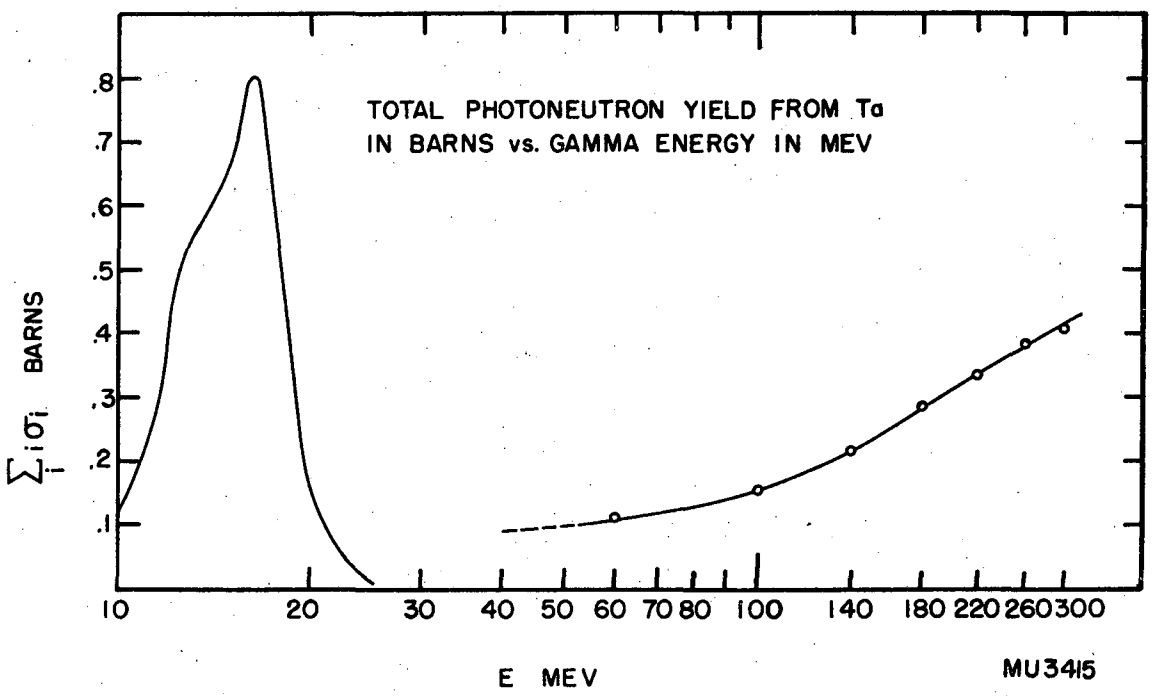
TOTAL PHOTONEUTRON YIELD FROM Ta
IN BARNS vs. GAMMA ENERGY IN MEV
$\sum_i \sigma_i$ BARNS
.8
.7
.6
.5
.4
.3
.2
.1
10
20
30
40
50
60
70
80
100
140
180
220
260
300
E MEV
MU3415

Figure 2.