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SUMMARY OF THE RESEARCH PROGRESS MEETING

Margaret Foss Folden

August 12, 1948

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Carbide & Carbon Chemicals Corp. K-25	21-24
Carbide & Carbon Chemicals Corp. Y-12	25-28
Columbia University (Dunning)	29
General Electric Company	30-33
Hanford Directed Operations	34-38
Iowa State College	39
Los Alamos	40-42
Monsanto Chemical Company, Dayton	43-44
National Bureau of Standards	45-46
Naval Radiological Defense Laboratory	47
NEPA	48
New York Directed Operations	49-50
Oak Ridge National Laboratory	51-58
Patent Advisor, Washington	59
Technical Information Division, ORDO	60-74
UCLA Medical Research Laboratory (Warren)	75
University of California, Radiation Laboratory	
Information Division	76-78
Chemistry Dept., Bldg. 5	79
Patent Dept., Bldg. 29	80
University of Rochester	81-82
Chicago Office of Directed Operations	83

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SUMMARY OF THE RESEARCH PROGRESS MEETING

Margaret Foss Folden

August 12, 1948

Cross Section of the Reaction $C^{12}(n,2n)C^{11}$. H. F. York

The cross section for producing C^{11} by the n,2n reaction on C^{12} with the differential n-p cross section at a fixed angle has been measured. This has been done at 40 Mev and 90 Mev and the results have been compared with a theoretical curve giving the relative cross section as a function of energy.

The experimental arrangement included a small polyethylene disc which was placed in the 90 Mev neutron beam and bombarded for twenty minutes. A proportional counter telescope with a 1 inch diaphragm in front was placed facing the disc along a line making an angle of 25° to the neutron beam. The distance from the disc to the diaphragm was 81 cm. All the protons from the disc which passed through the diaphragm and had more than 48 Mev were counted for the entire bombardment. By making a second run with no scatterer, and using the usual methods of n-p scattering, the number of protons produced by n-p collisions during the bombardment was determined.

After the bombardment the polyethylene target was placed under a Geiger counter, and its beta activity was determined. A thin polyethylene disc was also bombarded in an intense neutron beam simultaneously with one of the thicker discs in order to determine the correction for beta absorption in the thicker disc. It was necessary to use a thick disc in the runs made with the proportional counters because of the low intensity of the neutron beam outside the concrete shielding.

This procedure was repeated three times at 90 Mev and twice at 40 Mev, using an angle of 30° and appropriate absorber.

Calculating the $C^{12}(n,2n)C^{11}$ cross section, the number (Np) of protons steradian per second from the CH_2 target at 25° above a certain energy E_{min} is given by

$$Np = n_H \int_{E_{min}}^{\infty} N(E) \quad \sigma_{np}(\phi,E)dE \qquad (1)$$

where

n_H = number of H atoms in CH_2 disc

$N(E)$ = flux neutrons in beam of energy E

$\sigma_{np}(\phi,E)$ = differential cross-section in laboratory system for scattering of protons into the angle ϕ at energy E.

Since in the n-p scattering experiment an average $\sigma_{np}(\phi)$ over the same distribution of neutron energies as used in this experiment has been measured, we may replace the $\sigma_{np}(\phi,E)$ above by $\sigma_{np}(\phi)$ and remove it from under the integral. Hence

$$Np = n_H \; \overline{\sigma}_{np}(\phi) \int_{E_{min}}^{\infty} N(E)dE \qquad (2)$$

Similarly, the production of C^{11} per second (N_c) is given by

$$N_c = n_c \int_0^{\infty} \sigma_{C^{11}}(E)N(E)dE \qquad (3)$$

In this experiment, because of the spread in energy of the neutron beam used, it is possible to calculate $\sigma_{C^{11}}$ only if some assumption about the shape of $\sigma_{C^{11}}(E)$ is made. Two such shapes have been used: one, the theoretical curve; and two, $\sigma_{C^{11}}$ = constant over the energy distribution of the neutrons at each of the two energies used.

If the shape of the theoretical curve is assumed to be correct, then

$$\sigma(E) = K\, f(E) \text{ and } N_c = K\; n_c \int_0^{\infty} f(E)\, N(E)dE \qquad (4)$$

where

n_c = number of C atoms in the disc

$f(E)$ = relative value of $\sigma_{C^{11}}(E)$ as given by curve in Figure 1.

Thus

$$\frac{N_c}{N_p} = \frac{K}{2\,\sigma_{np}(\phi)} \; \frac{\int_0^{\infty} f(E)N(E)dE}{\int_{E_{min}} N(E)dE} \qquad (5)$$

or

$$K + 2\,\overline{\sigma}_{np}(\phi)\,\frac{N_c}{N_p}\,\frac{\int_{E_{min}}^{\infty} N(E)dE}{\int_{0}^{\infty} f(E)N(E)dE} \qquad (6)$$

If $\sigma_{C^{11}}$ is assumed to be constant over the neutron energy distribution used, then

$$\overline{C^{11}(E)} = 2\,\overline{\sigma_{np}}(\phi)\,\frac{N_c}{N_p}$$

N(E) for the 90 Mev has been measured and is shown in Figure 1. N(E) for 40 Mev is the theoretical curve calculated from the stripping process and is also shown in Figure 1. Any low energy tail on N(E) at the lower energies would not affect the experiment, since these neutrons would produce neither countable protons nor C^{11}.

One check on the theory is to find whether K is the same (or nearly so) at 40 Mev and 90 Mev.

N_p is given by $$N_p = \frac{c}{\Omega\, t_b}\left(N_{CH_2} - N_B\,\frac{Mon_{CH_2}}{Mon_B}\right) \qquad (7)$$

and

$$N_c = \varepsilon\,\frac{N_g - N_b}{(1-e^{-\lambda t_b})\,e^{-\lambda t_i}\,(1-e^{-\lambda t_g})} \qquad (8)$$

The ratio of the integrals in equation (6) has been calculated numerically and is

<u>5.22</u> for the 90 Mev bombardment

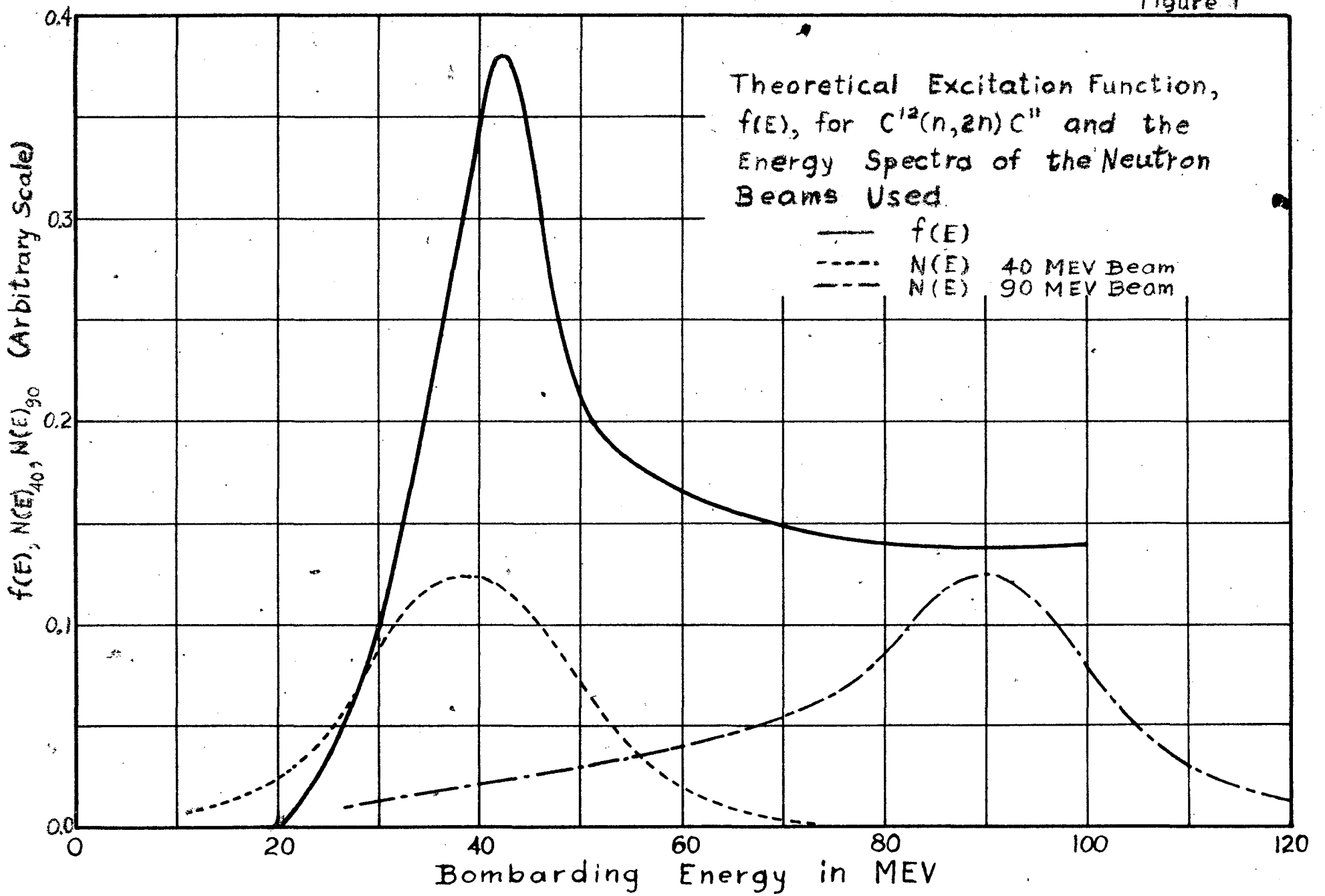
<u>4.16</u> for the 40 Mev bombardment

The average values of $\frac{N_c}{N_p}$ for the five runs made are 0.455 at 90 Mev and 0.238 at 40 Mev.

Using these values and

$$\overline{\sigma_{np}}\,(25^{\circ}\ 90\ \text{Mev}) = 25.9\ \text{millibarns}$$

Figure 1



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$$\overline{\sigma_{np}}(30^{\circ}\ 40\ \text{Mev}) = 48\ \text{millibarns}$$

one obtains

$$K_{40\ \text{Mev}} = 96$$

$$K_{90\ \text{Mev}} = 123$$

While these two values of K are not identical, they are nearly so, compared to the ratio between the cross-section at 40 Mev and 90 Mev from the theoretical curve, namely 2.7. Using the values of K, and the theoretical f(E)

$$\sigma_{C^{11}}(42)\ 37\ \text{millibarns}$$

$$\sigma_{C^{11}}(90)\ 17\ \text{millibarns}$$

Assuming (E) to be a constant over each neutron distribution,

$$\overline{\sigma_{C^{11}}}(40) = 23\ \text{millibarns}$$

$$\overline{\sigma_{C^{11}}}(90) = 18\ \text{millibarns}$$

However, since the neutron energy distribution at 40 Mev extends approximately from 27 to 51 Mev, and $\sigma_{C^{11}}(E)$ must be quite small in the lower part of this range, and then decrease again at higher energies, the existence of some sort of peak in the region around 40 Mev is quite probable.

Scintillation Counters, L. Wouters.

Following a number of improvements in experimental apparatus, more quantitative data are now expected with the use of anthracene in scintillation counters. Modifications have been made in Woods' technique for crystal formation. Experiments were made first with a flask to the base of which is attached a bulb as shown in Figure 2A. By lowering the temperature gradually over a period of two to five days a single large crystal grows through the capillary. More reliable results are now being obtained with a

closed capillary tube attached to the lower end of the flask as shown in Figure 2B. Perfect crystals of 1 inch in diameter and 1/4 inch thick have now been obtained, and larger crystals are expected to be formed in later experiments.

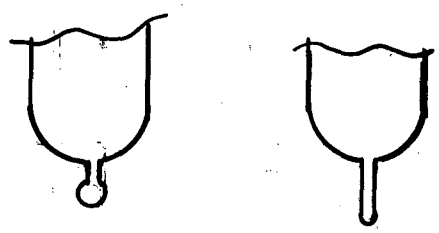

Fig. 2

A further difficulty was overcome after it was discovered that Eastman Kodak had changed their process of manufacture for anthracene. Ethylene glycol impurities have been found, and a reflux still was designed using alcohol and benzene for purification. Very good results have been obtained with this apparatus.

Improvements have also been made in the electronics of the apparatus. The rise time of the pulses has been measured and has been found to be 1/20 of a microsecond (connected directly to plates of the oscilloscope). Taking into account the solid angle, the amount of light emitted in the case of a β particle is about 10,000 blue photons. It was therefore determined that anthracene is about 30 percent efficient.

The coincidence method of operation has been found to be advantageous. It reduces the noise level coincidence due to the thermal noise process. Improved adjustment has been made possible using a current meter on the last plate. The thermionic emission is relatively constant from one photomultiplier tube to the next, but the gains are not constant. The current will consequently vary as a function of gain so that such a meter is useful in keeping the gain constant.

Plans are being made to get positive pulses from the photomultiplier by going back one stage permitting direct connection to a cathode follower as well as complete shielding. Some work has also been done on scaling circuits. Upon testing 256 scalers they were found to have poor characteristics. A discriminator circuit was arranged to make the pulse appear to be a gated pulse. The response was between 3 and 30 microseconds. Further work is planned. By using a cathode follower between succeeding scaling tubes, time constants may be kept down to .02 microseconds. This appears hopeful in meeting photomultiplier needs.

One scattering experiment was performed with the coincidence set-up in the 184-inch neutron beam. In plotting the function of the counting rate versus the gain a plateau was noted, caused by protons being scattered by neutrons into the second crystal. See Figure 3. Counts were obtained of 300 to 400 per minute. Further experiments are planned with improved mechanical arrangements.

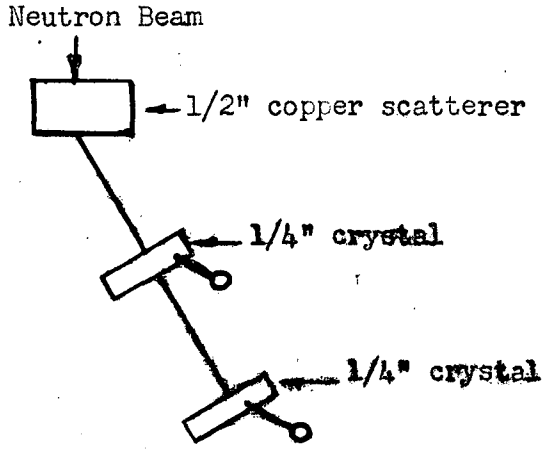

Fig. 3

Proton Conversion. K. MacKenzie

Proton conversion in the 184-inch cyclotron is progressing satisfactorily. The frequency limits are promising. They vary between 23.5 megacycles and 9.5 megacycles as shown in Figure 4. Protons which are picked up at 22.9 megacycles come out at 15.8 megacycles, which is calculated to be about 1/6 of the time. Deuterons picked

up at 11.5 megacycles come out at 9.8 megacycles, which is about 1/8 of the time. The trouble appears to be in the rotating part of the condensor, and apparently about 1/2 of the available power goes into the rotor of this condensor. In order to get ~~a dee~~ voltage the power ~~must be~~ removed from the rotor. It is thought the copper plating may possibly affect it. Tests are being made with small oscillators on the copper clad steel condensor and operation is expected within a month.

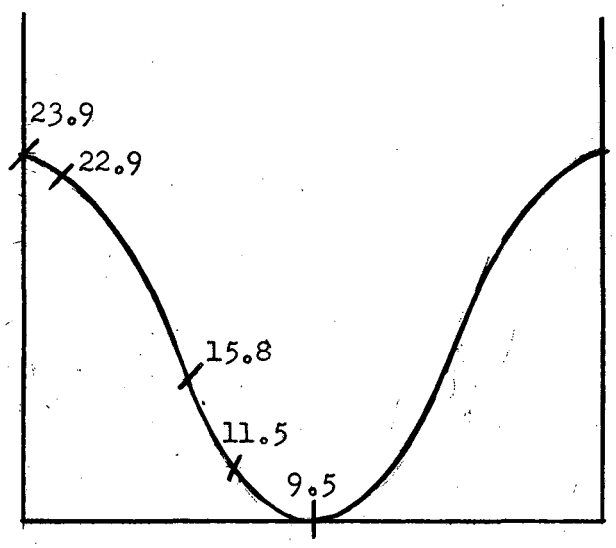

Fig. 4

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