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Physics-General

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Summary of the Research Progress Meeting

January 13, 1949

Henry P. Kramer

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Physics-General

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Summary of the Research Progress Meeting

January 13, 1949

Henry P. Kramer

High Energy Radiation from the Cyclotron Target. H. York.

In the past, measurements have been made of the γ radiation which is produced from a beryllium target by a rotating beam of deuterons accelerated in the 184-inch cyclotron. Since the conversion to proton acceleration has been completed, essentially the same experiment has been repeated in order to measure the γ radiation emanating from beryllium bombarded with protons.

The apparatus, Figure 1, is set up outside the shielding in line with the neutron channel through the concrete. γ-rays impinge on a tantalum foil and cause both positive and negative electrons to be emitted. A magnetic field which is normal to the incident beam deflects the electrons into circular paths, with particles of opposite charge moving in diverging directions. On both sides of the beam there is a battery of two coincidence counters which are separated by an aluminum foil. The principle of the measurement is then that each photon which strikes the tantalum target releases a positron and an electron and each one of these two particles will register on two counters operated in coincidence. Thus, a fourfold coincidence counts one γ photon.

A comparison of the results obtained with the deuteron beam and the proton beam is indicated on Figure 2. The energy distribution curve for γ-rays from proton bombardment shows a maximum at about 70 Mev. Further work will be necessary, however, to establish the validity of this energy distribution. One reason for its uncertainty is that each empirical point on the curve actually represents a considerable energy interval. For example, the position of the point at 68 Mev. means no more than that half the incident photons fell in the energy range from 63 to 73 Mev. and that a hypothetical triangular distribution for this range yielded the function value N_γ (68). For this

ason, a refinement and correction of the energy intervals is in order.

Closer analysis of the experiment is made necessary by a number of other factors. For example, it is known that the cross section for electron pair production is a function of the incident energy and probably increases by a factor of 1-1/2 from low to high energies. Moreover, losses due to scattering in the tantalum radiator had to be considered. This possibility was checked by replacing the 1 μ foil of Ta with a 3 μ foil. If there had been any losses due to scattering, the thicker foil would have accentuated these losses. It was found, however, that the two energy distribution curves obtained showed no appreciable difference.

In examining the reality of the curve, attention must be paid particularly to the ascending branch since a negative slope is expected for high energies but the increasing values at low energies are at variance with the results obtained with deuterons (Figure 2). It was decided to test the reality of the coincidences to see whether the counts which were registered by the coincidence arrangement had any significance. One check consisted of removing the radiator entirely. The number of counts dropped from 100 with the tantalum foil to 2 without it. Furthermore, when a lead brick was placed in front of one of the counters, no counts at all were registered.

The experiment will be repeated with the proton beam rotating in the opposite direction. It is expected that bombardment with this beam will yield a maximum on the γ-ray energy spectrum at 90 Mev.

The present result of the investigation is that 10^{-7} amp protons yield 1.6×10^{-27} γ-rays in the bombardment of beryllium. This is about 3×10^{3} times the number of γ-rays which were produced by deuterons. Another point of difference between the deuteron and the proton bombardment is in the angular distribution. If the γ-radiation were exclusively the result of bremsstrahlung, these differences would not be as pronounced as they are.

Physics-General

Neutron Energy Distribution. C. Leith.

Since the conversion of the 184-inch cyclotron to proton acceleration, work has been started to measure the flux and the energy distribution of the neutron beam which is produced by protons on a beryllium target. The method of making the measurements is essentially the same as that used for n-p scattering. (See Figure 3). The incident neutrons are scattered in a paraffin block and produce a shower of recoil protons. At some convenient angle, in this case 15° from the neutron beam, two anthracene scintillation counters are placed. The scintillations activate two photomultiplier tubes which are connected in coincidence. Discrimination between different values of the proton energy is accomplished by placing different thicknesses of copper absorber between the two counters.

In order to deduce the neutron energy distribution from the measured proton energy distribution several assumptions are necessary and a careful analysis of the mechanics of the experiment must be made. First of all, it is assumed that by far the dominant process which takes place when neutrons impinge on hydrogen nuclei is a 'billiard ball' recoil. It is an elementary calculation by which one deduces the neutron energies from the measured proton energies for this simple process. However, in order to present a hydrogen target to the neutron beam in a sufficiently compact form for a significant number of recoils, the hydrogen had to be contained in a compound, paraffin, CH_2. The effect produced by the interaction of neutrons with carbon nuclei was determined for each energy level, (thickness of Cu absorber), by replacing the paraffin target with a piece of graphite. The number of counts recorded for this arrangement was then subtracted from the number of counts registered for the paraffin scatterer, so that ultimately only the recoil protons were considered.

If one is interested in knowing how many neutrons at a given energy are produced in he beryllium target within the cyclotron, one must carefully trace the course of the particles from their source to the counters so that one may know what portion of the particles and their energies are lost to the coincidence counters along the way. First,

e 2 inch Be target has an absorption thickness of 35 to 45 Mev. The paraffin scatterer has an absorption thickness of 10 Mev. Finally, the absorption characteristics of the copper absorber must be considered. Ideally, of course, the piece of copper which is interposed between the two scintillation counters acts as a pure absorber. This ideal seems to be fairly well realized as long as the thickness of copper does not exceed a certain value, i. e. as long as the proton energies which must be measured are relatively low. The graph of Figure 4 shows a pure attenuation curve in the region of small absorber thicknesses. For larger absorber thickness, however, the curve deviates radically from a pure attenuation, since for high energies and long paths through the absorber, the cross sections for the reactions which bring about attenuation may no longer be regarded as constants of the energy. A correction will therefore have to be applied to account for the more than exponential attenuation of a long copper absorber and high incident energies.

It is intended to improve the experiment by minimizing sources of energy losses. For example, the experiment will be repeated with thinner Be targets and targets of other material.

Figure 5 and Figure 6 give a qualitative picture of the energy distribution and dN/dE. The tentative value for the energy of the cyclotron proton beam is 350 Mev. since the maximum value of the proton recoil energies was found to be about 310 Mev. corresponding to a thickness of about 3 inches of Cu. It is remarkable that neutrons are created in the beryllium target with a negligible loss of energy. The most plausible explanation for this is that the production of neutrons is brought about by charge exchange in the target.

The neutron flux from protons is about 1/50 of that from deuterons. Of course, one must take into account the fact that the proton beam is smaller by a factor of about 10. Preliminary measurements of the proton flux in the cyclotron by J. Vale indicate that it is about 1/2 μ amp.

Physics-General

Excitation Functions of the α, 2n and d, 2n Reactions on Bismuth. E. Kelly.

Work has been going on for the past two years to determine the excitation functions of various nuclear reactions on bismuth. Both the 60-inch cyclotron at Crocker Laboratory and the 184-inch cyclotron were used for α and d bombardment. The well known stack method was employed to mount the bismuth target. Aluminum foils of accurately known area and thickness are steamed with bismuth vapor. The coating of bismuth is accurately weighed and measured. In order to achieve a monoenergetic bombardment the beam was collimated and deflected. The energy of the beam was measured by means of an aluminum absorption wheel on whose circumference aluminum foils of graded thickness are mounted.

Figure 7 shows the excitation function for bismuth in the α beam of the 60-inch cyclotron. Up to 30 Mev. only one activity is observed, At^{211}. Beyond 30 Mev. the activity of At^{210} appears. The work could not be continued past 40 Mev. in the Crocker Laboratory for lack of higher energies. The 184-inch cyclotron had to be used and the continuation of the curve which was obtained there is shown in Figure 8.

The excitation functions for deuteron reactions in the 60-inch cyclotron are shown in Figure 9. Bi (d, 2n) Po^{209} represents a recent discovery. The half-life and hence the cross section of the new isotope are unknown. However, if it is characterized by pure α-decay, that is, if no K capture takes place, the half-life is expected to be about 200 years.

A complete description of the work with the exception of the recent discovery of the new isotope Po^{209} is set forth in "Some Excitation Functions of Bismuth", E. L. Kelly and E. Segrè, UCRL-207, November 10, 1948.

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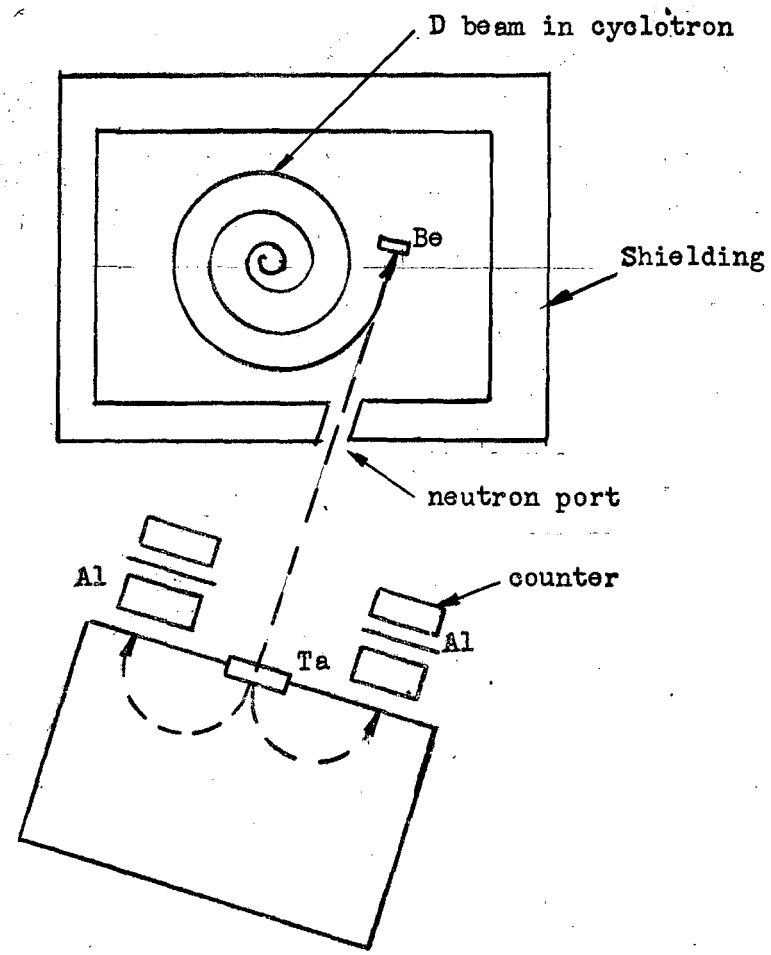

Fig. 1

Apparatus for the Measurement of γ-rays in the Neutron Beam

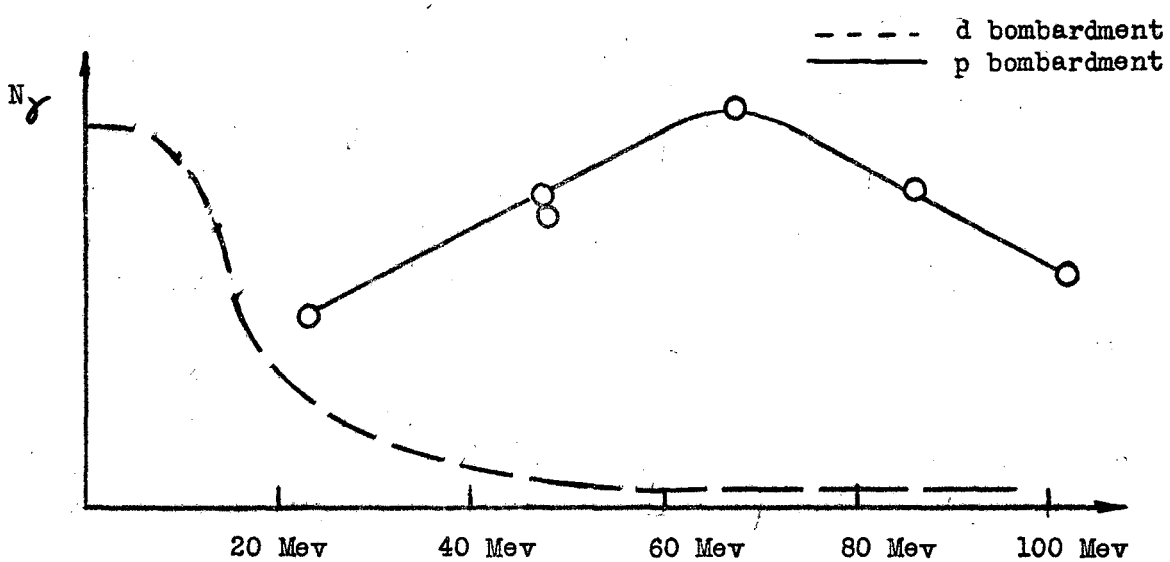

Fig. 2

Energy Distribution of γ-radiation from Beryllium Target

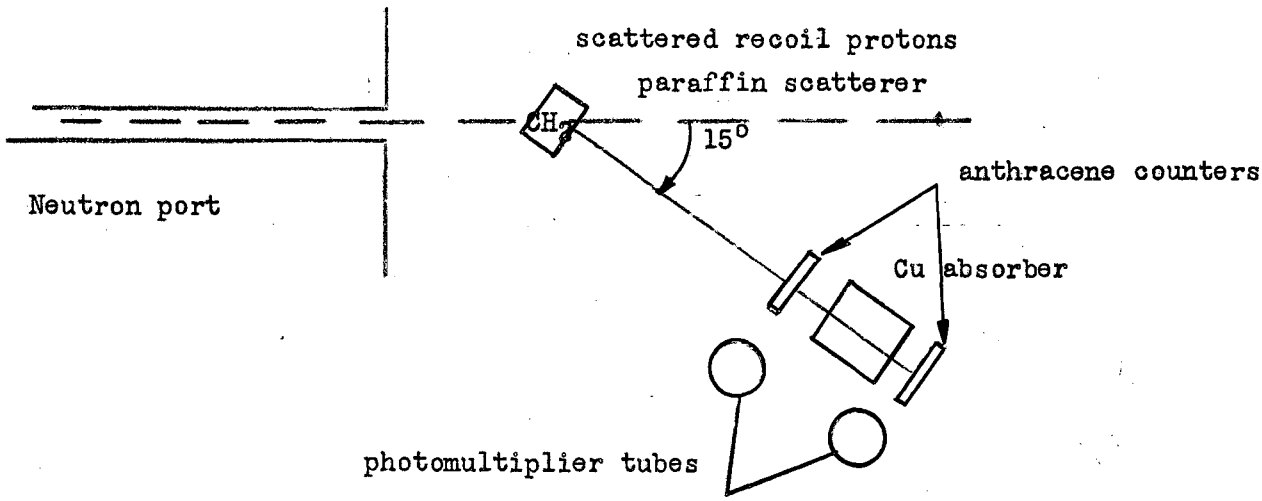

Fig. 3

Apparatus for Measurement of Energy of Neutron Beam

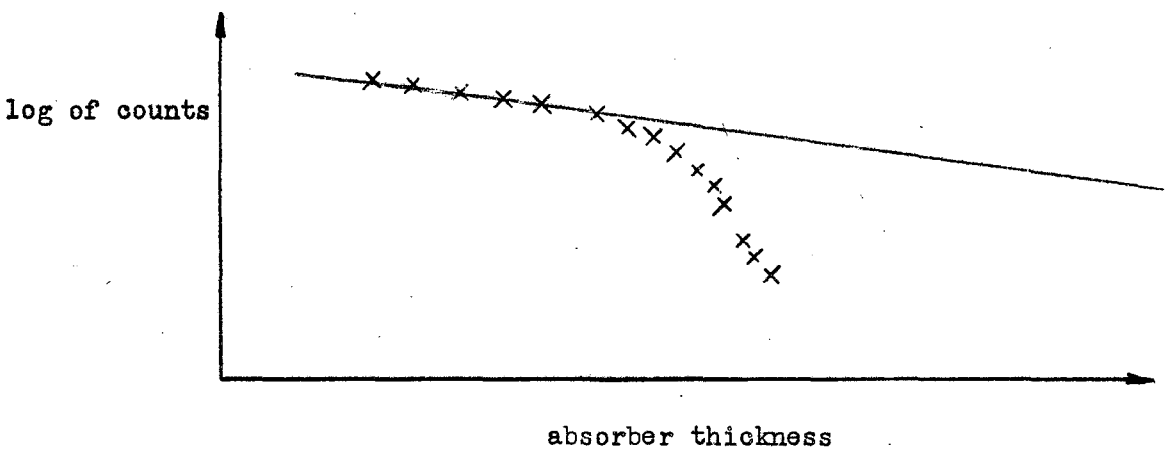

Fig. 4

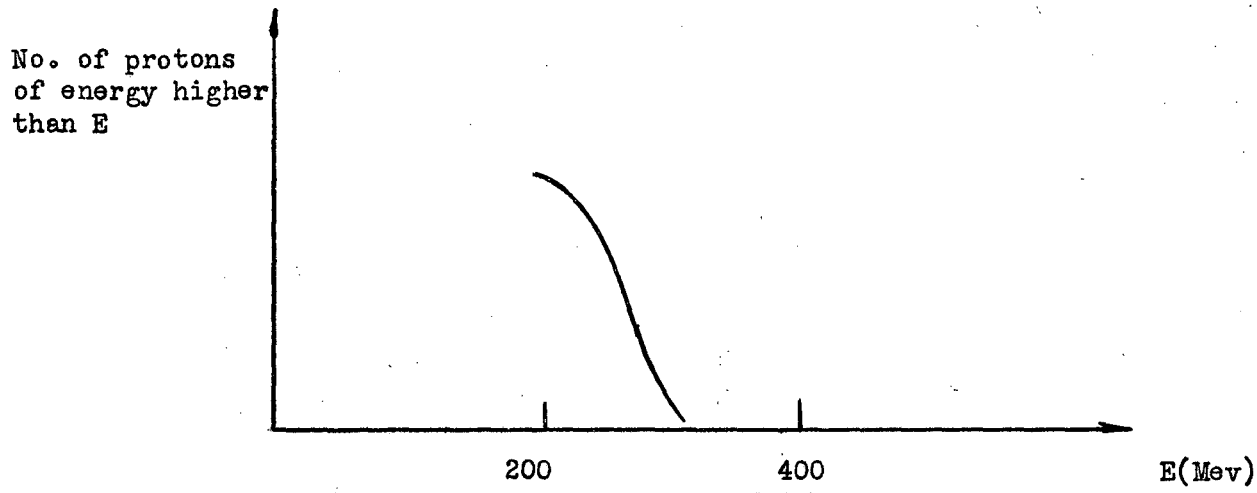

Fig. 5

Energy Distribution of Recoil Protons

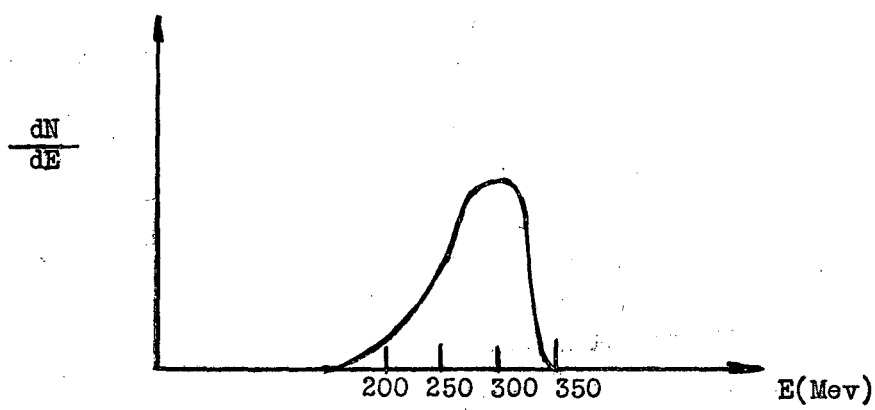

Fig. 6

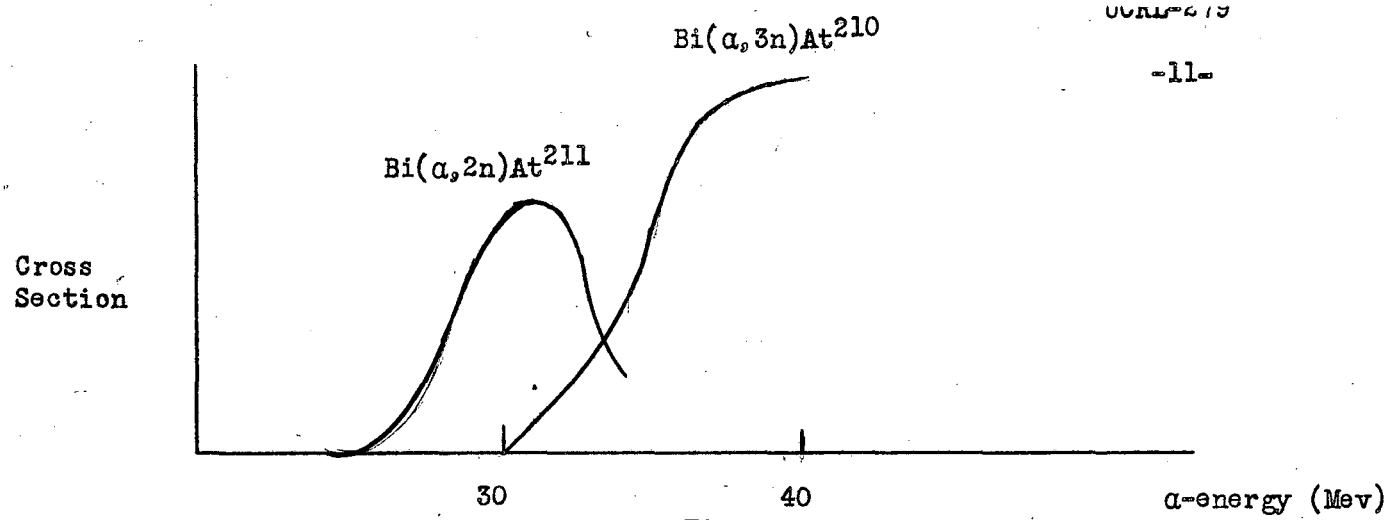

Fig. 7

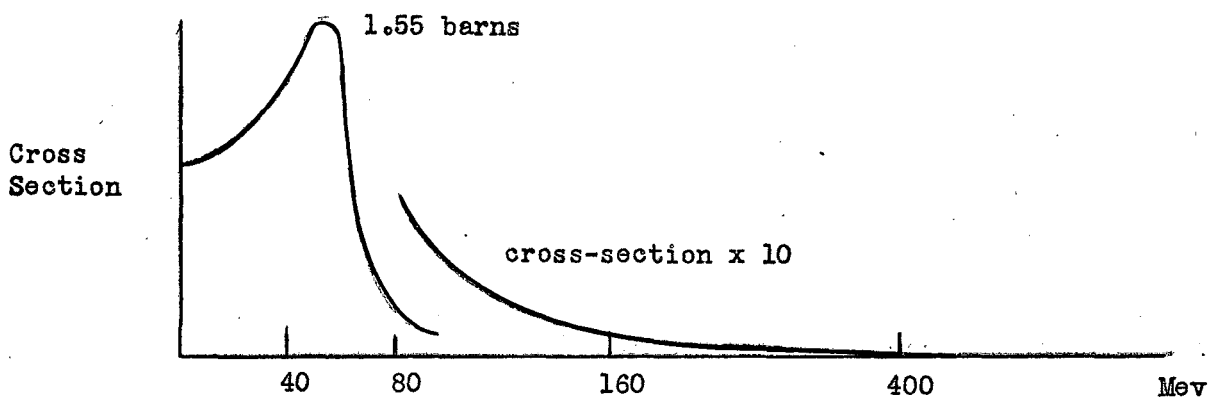

Fig. 8

Continuation of Excitation Function for $Bi(\alpha,3n)At^{210}$

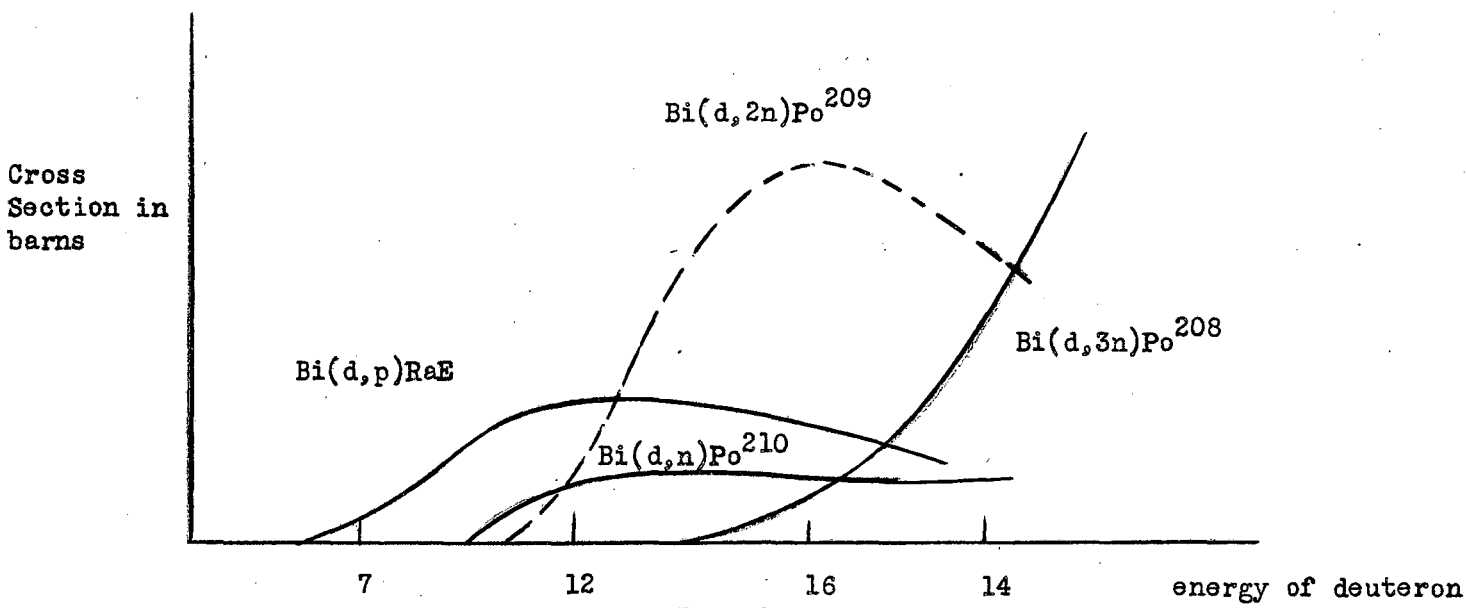

Fig. 9

Excitation Functions for Deuteron Bombardment

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