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Radiation Laboratory

Contract No. W-7595-eng-48

SUMMARY OF THE RESEARCH PROGRESS MEETING OF JANUARY 11, 1951

R. K. Wakerling

April 5, 1951

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Berkeley, California

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Delayed Neutron Emitter of Low Mass - William Gardner.

In addition to the delayed neutrons appearing with a 4.17 second half-life from the decay of N^{17} previously identified in this Laboratory, a 0.177 second emission has been discovered and tentatively identified as lithium 9. It is obtained by 190 Mev deuteron bombardment of boron and beryllium. The observations are made by rapidly moving film exposures of an oscilliscope screen displaying a scaled output of BF_3 chamber pulses.

Figure 1 illustrates the apparatus position in the deflected beam cave of the 184-inch cyclotron. The apparatus is so arranged that simultaneous with the shutting off of the cyclotron the camera photographing of the oscilliscope is started. The film flows at the rate of 4 feet per second, which gives the instrument a resolution of 20,000 count per second, with the ability to tell where each count occurred. Figure 2 gives a schematic diagram of the arrangement of the components of the equipment, and Figure 3 shows the camera and oscilloscope arrangement. A plot of the counting rate versus time is given in Figure 4.

The relative yield of the activity from several materials have been measured and the results are given in Table 1. With deuterons the ratio of yield from boron to the yield for beryllium is 2.2; with protons this ratio is 40. It is thought that the raction involved is the following one.

$$
\begin{array}{l}
Be^9 + H^2 \longrightarrow Li^9 + 2H^1 \\
\qquad\qquad\quad \downarrow \\
\qquad\qquad\quad Be^{*9} + \beta^- \\
\qquad\qquad\quad \downarrow \\
\qquad\qquad\quad Be^8 + n \\
\qquad\qquad\quad \downarrow \\
\qquad\qquad\quad 2He^4
\end{array}
$$

A beta ray spectograph measurement shows the energy of the beta ray to be 13 Mev which is consistent with the assumption that lithium 9 is the emitter.

A threshold experiment done with the proton probe and the internal beam of the 184-inch cyclotron indicates that the threshold for the production of the activity lies between 20 and 25 Mev.

Evidence of Deuteron Formation in the Reaction $p + p \rightarrow \pi + d$ - K. Crowe. The strong forward high energy peaks in the cross section of meson production by protons on protons indicated that a deuteron may be produced in the reaction. The shape of the peak and the energetics of the reaction have given further evidence that this is the case. In the present work the reaction $p + p \rightarrow \pi + d$ has been observed by a coincidence technique. By the use of a magnetic field to determine the momentum of the particles and by finding the ranges of the particles in aluminum, the reaction products have been identified by essentially measuring their masses. The experimental arrangements are shown in Figure 5. The 340 Mev external proton beam of the 184-inch cyclotron is allowed to strike a one-inch thick polyethylene target. Typical trajectories are shown for the meson and the deuteron in the forward direction. The orbits were located by using a wire with known current and tension. Each counter telescope is composed of four liquid scintillators, 4 by 5 by 3/4 inches in size, viewed by photomultipliers. The outputs were mixed using conventional electronics. The events recorded require both particles to have ranges large enough to enter the third counter of each telescope but to stop before the fourth counter. The range was varied with absorbers in the position shown. The integral range spectrum for the coincidence events is shown as a function of range in the deuteron telescope in Figure 6. The slope of the spectrum between 110 and 130 Mev corresponds to the variation of measured deuteron energy for production at various target depthsdue to its energy loss in passing through the rest of the target. Protons from the reaction $p + p \rightarrow \pi^{+} + n + p$ of approximately the same velocity as the deuteron would not appear at ranges greater than the deuteron range of 90 Mev. The lowest energy on Figure 6 corresponds to 0 absorber.

The momentum of the deuteron was measured by shifting the position of the deuteron telescope with the results shown in Figure 7. Deuterons produced at the front and back of the target are expected to have momenta of 630 and 710 Mev respectively. The cone of the coincidence deuterons was defined by the meson telescope to be approximately 2-1/2 inches in diameter. Protons from the reaction $p + p \rightarrow \pi^{+} + p + n$ for which the meson would be detected would appear at a maximum momentum of about 450 Mev/C, approximately 12-inches from the deuteron telescope. The main proton beam appears 855 Mev/C, 8-1/2-inches from the deuteron telescope. The deuteron mass calculated from this data is $2.2 {}^{+0.6}_{-0.4}$ proton masses. The meson mass was obtained by varying the magnetic field and measuring the range spectrum in the meson telescope. The value $270 {}^{+80}_{-90}$ electron masses was found. The errors in the mass would correspond to limits of uncertainty in the momentum resolution of the deuteron and meson telescopes.

Mesons produced by 340 Mev protons on carbon in the same solid angle do not appear to be accompanied by correlated deuterons. The meson telescope counts are approximately 90 percent mesons and the background appears to be incidental coincidences between the meson deuteron events and the excessive single rates of the final deuteron telescope counter. This work is progressing in an attempt to procure enough data to give a measurement of the absolute cross section.

Information Division
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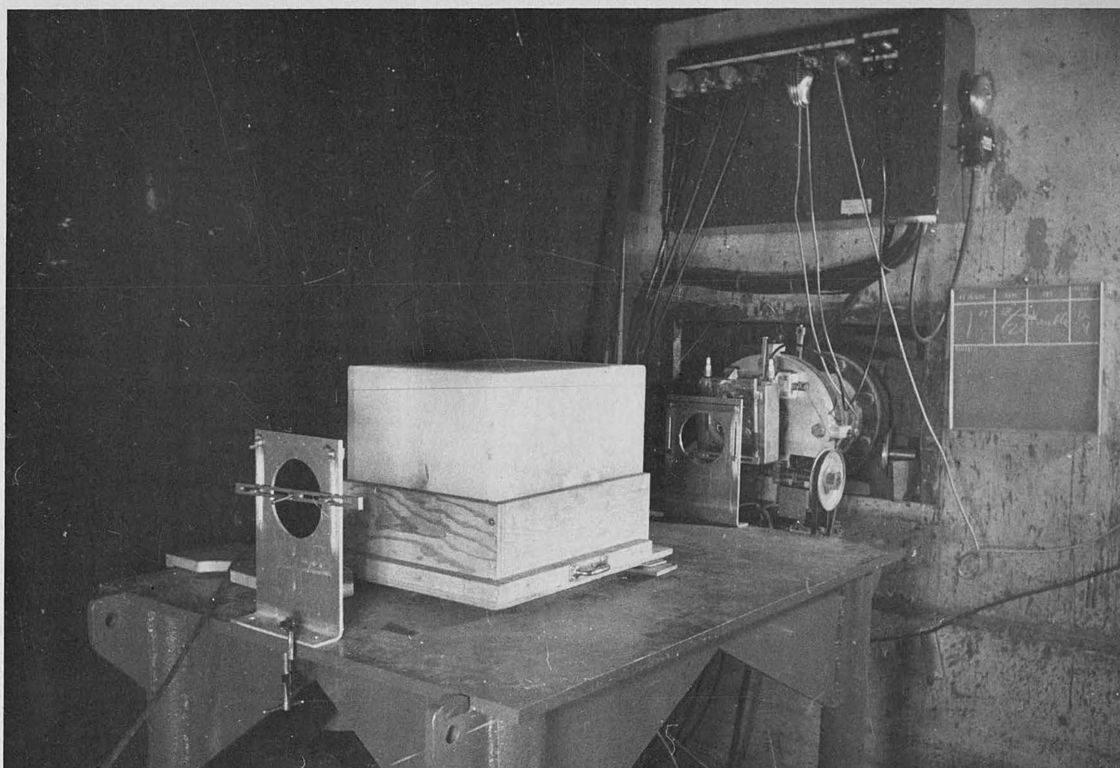
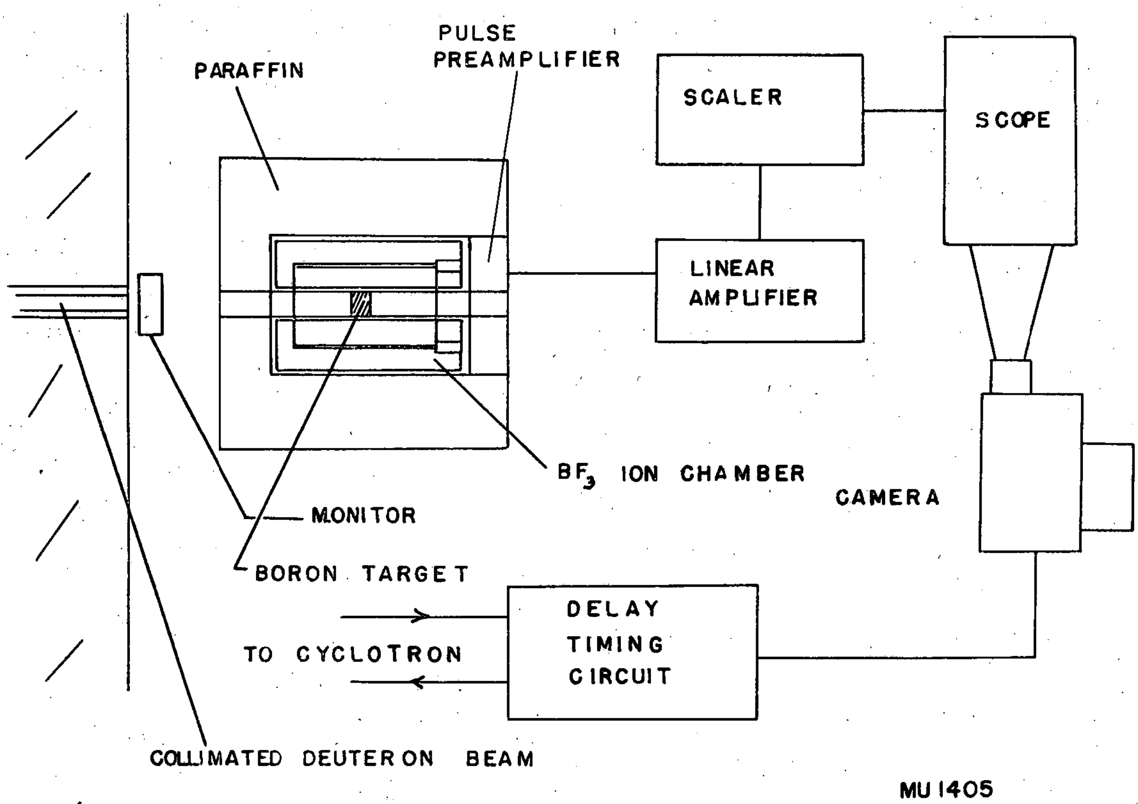


FIG. 1



PARAFFIN
PULSE PREAMPLIFIER
SCALER
SCOPE
LINEAR AMPLIFIER
BF3 ION CHAMBER
CAMERA
MONITOR
BORON TARGET
DELAY TIMING CIRCUIT
TO CYCLOTRON
COLLIMATED DEUTERON BEAM
MU 1405

FIGURE 2

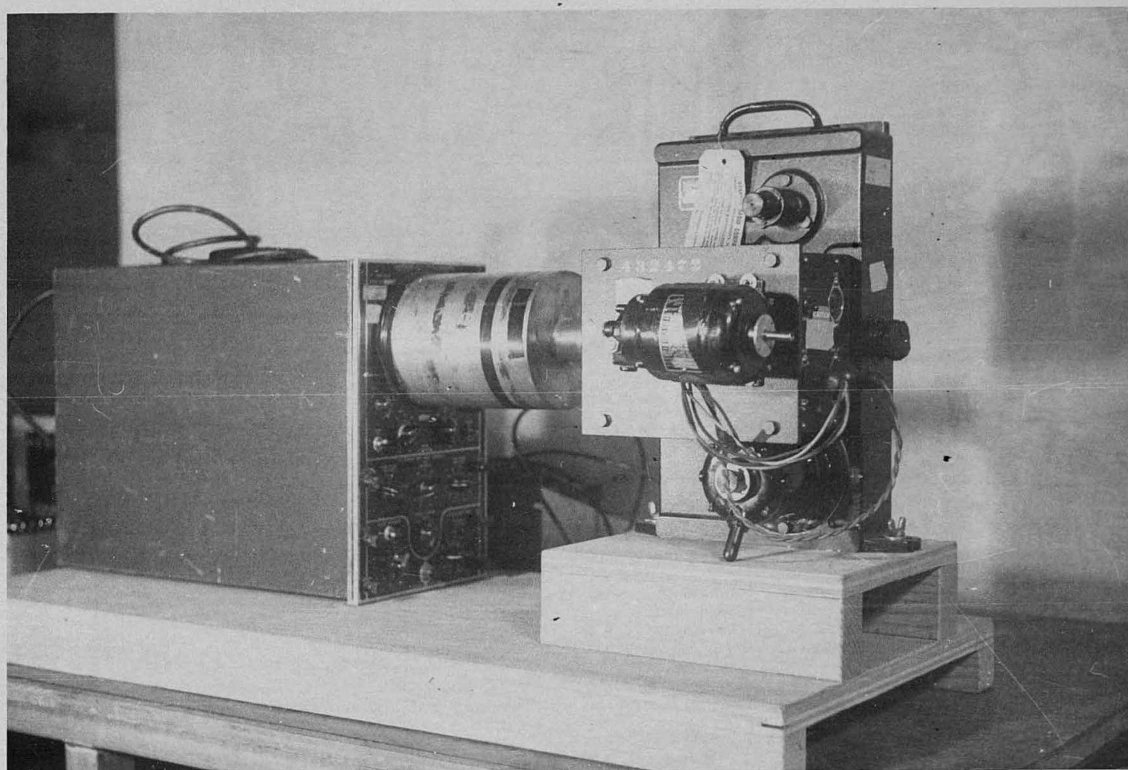


FIG. 3

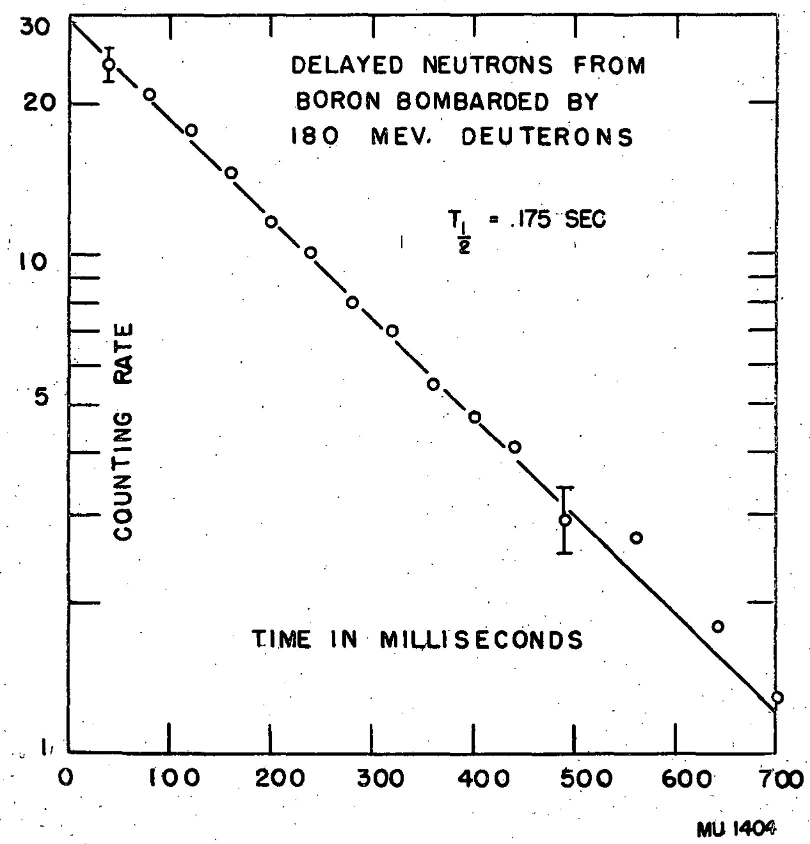

DELAYED NEUTRONS FROM
BORON BOMBARDED BY
180 MEV. DEUTERONS
$T_{\frac{1}{2}}$ = .175 SEC
COUNTING RATE
TIME IN MILLISECONDS
30
20
10
5
1
0
100
200
300
400
500
600
700
MU 1404

FIGURE 4

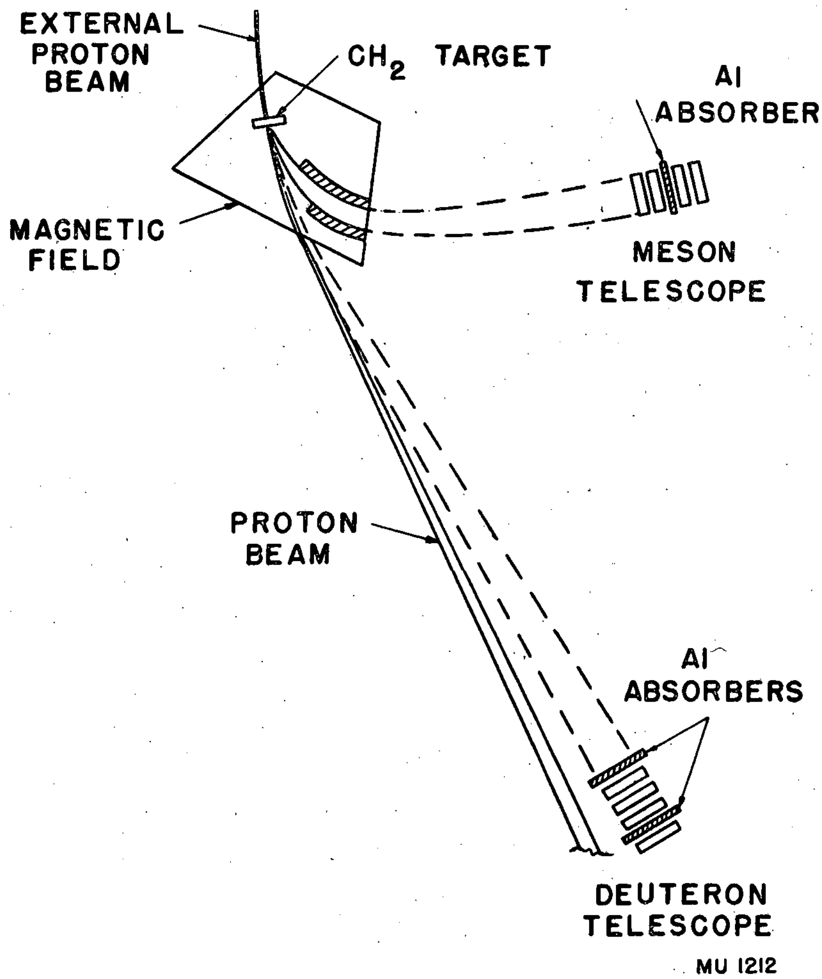

EXTERNAL PROTON BEAM
CH2 TARGET
Al ABSORBER
MAGNETIC FIELD
MESON TELESCOPE
PROTON BEAM
Al ABSORBERS
DEUTERON TELESCOPE
MU 1212

FIGURE 5

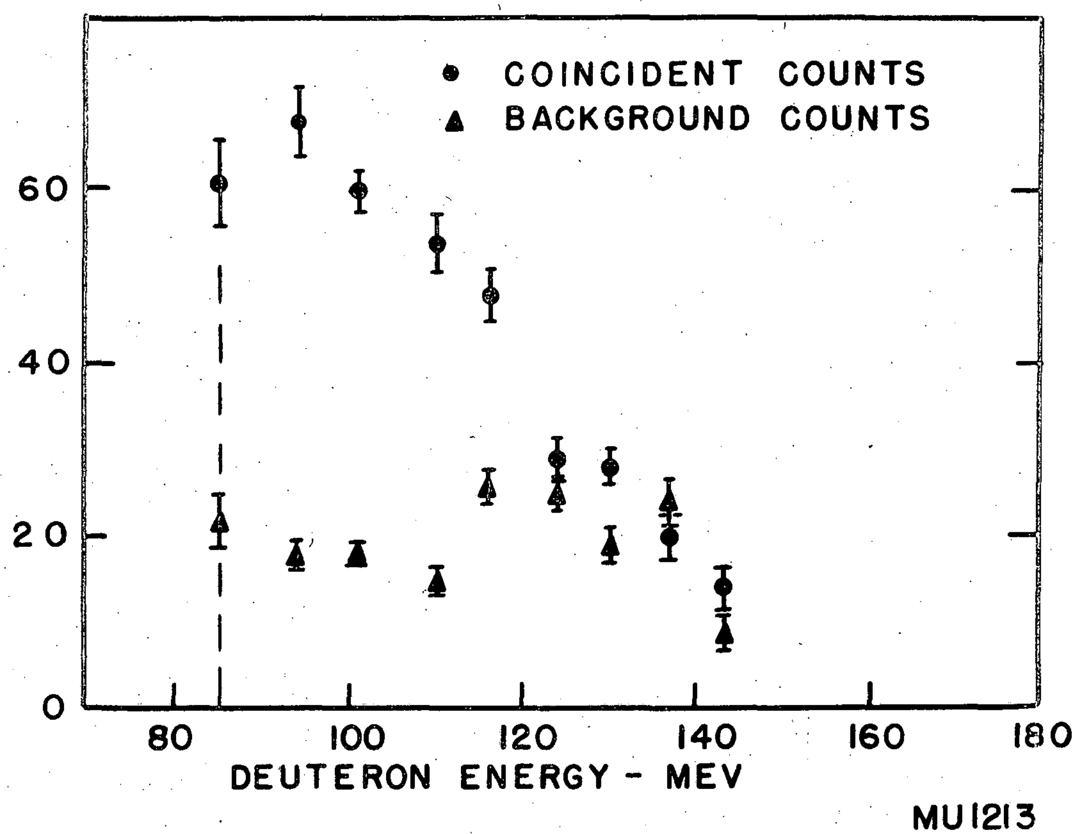
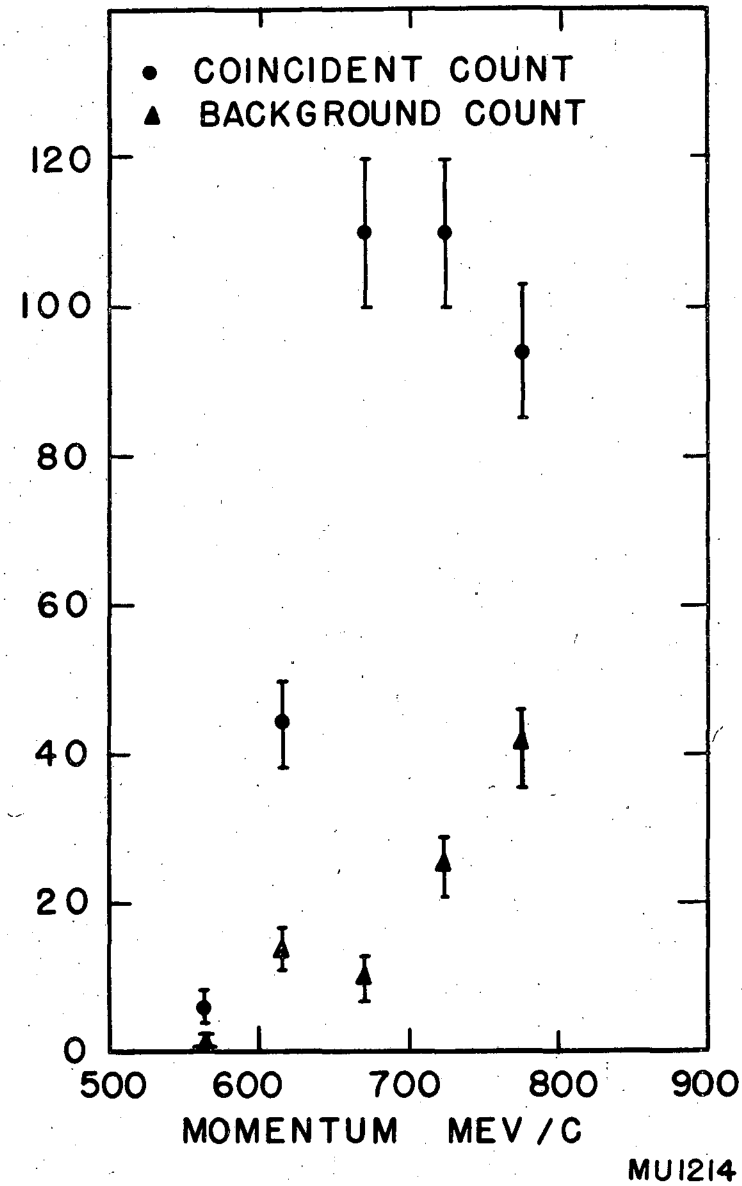

COINCIDENT COUNTS
BACKGROUND COUNTS
60
40
20
0
80
100
120
140
160
180
DEUTERON ENERGY - MEV
MU 1213

FIGURE 6



● COINCIDENT COUNT
▲ BACKGROUND COUNT
120
100
80
60
40
20
0
500
600
700
800
900
MOMENTUM MEV/C
MU1214

FIGURE 7