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Berkeley, California

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Radiation Laboratory, Department of Physics
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I. High Energy Spallation Products of Zn - Wm. J. Worthington, Jr.

An abstract is reporduced herewith of report UCRL-1627, which was the basis of the author's talk:

"Elemental zinc was bombarded with 340 Mev protons. A study was made of the various radioactive spallation product fractions resulting from such a bombardment. In the course of the work thirty-four radioactive nuclides from gallium through sodium were identified by separating the various elemental fractions chemically and characterizing the half-lives, type and energy of particulate radiation, and energy of x-rays of the isotopes. The formation cross sections were calculated for the isotopes identified. The general distribution of the spallation products in regard to quantity produced and position in the periodic chart was found to be in general agreement with results previously reported for spallation products of other elements.

One previously unidentified isotope was discovered. This isotope was identified as Ni^{56}."

II. Production of Mesons and Protons by Neutrons - Lee Neher.

In August, 1951, there wasn't much known about the production of mesons by neutrons. Some of the earliest work was done by Bradner, Rankin and O'Connell in December, 1949, who obtained the value $\pi^-/\pi^+ \sim 12$. At about the same time Chew and Steinberger derived theoretical calculations which seemed to fit the data. However, this value was expected to decrease with higher energies. This was confirmed by Clark at Rochester who found a reverse ratio for the meson production by protons. One reason why no one jumped to measure mesons from the neutron beam was the tremendous flux difference, the values being:

$$N, p \,/\, cm^2 \, sec \sim 10^7 \text{ at } 340 \text{ Mev}$$

$$N, n \,/\, cm^2 \, sec \sim 10^4 \text{ at } 280 \text{ Mev} \pm 40$$

Hence it is harder to measure mesons produced by neutrons than by protons. The proton beam being monocromatic was also an advantage explaining why proton beam was picked first.

The count of N_{π^+} in the neutron beam was expected to be about 1/50,000 of that in the proton beam and thus the problem of detection was necessarily more difficult. Scintillation counter detectors were used. By reducing the maximum beam, by looking at the π^- instead of the π^+ and by being able to use a thicker target the above ratio was brought down almost to 1/5 for a good experiment.

A two inch graphite cube was placed in center of neutron beam. In the path of the meson beam which emerged at 90^o were placed two counters, one at a distance of 30 cm and the other at 100 cm from the first. See Fig. 1. A time of flight method of detection was employed by connecting a coincidence circuit between the counters with a variable length delay line to counter number one. Thus the length of the delay line could be varied for proper coincidence.

Protons of course were to be expected. The mesons at 50 Mev have $\beta = 0.7$; and some of the protons at this Mev have $\beta = 0.4$. The object was to distinguish between them on the basis of their difference in velocity.

Too, there had to be an allowance for error since counters could not be placed too far apart. Two more experiments were run with the distances between counters increased to 200 cm and to 300 cm. In these an absorber was used in front of the second counter, designed to stop certain energy particles as desired. The resulting data is shown in Fig. 2. A curve drawn through the count values shows a plateau after the point where the maximum meson value is reached and before the rise due to protons. It is reasoned that this plateau is due to a mixture of both meson and proton counts. To obtain a rough separation between them the part of the curve due to protons was extrapolated back and by subtraction the decreasing portion of the meson curve was deduced as shown. Mesons were distinguished from protons by their range, since for the same velocity protons will penetrate farther than mesons. The proton to meson ratio was 6-1/2 in mass. The spectrum of the mesons showing the count versus energy is given in Fig. 3.

The energetics at 90° are all right if it is assumed that one is dealing with the high energy particles in the target nuclei. An attempt is being made to measure the π^{-}/π^{+} ratio; the biggest obstacle here is with the small π^{+} production.

III. New RCA Photomultiplier - L. Wouters. This tube has lots of stages in a linear arrangement, shown in Fig. 4. There are two main voltage divisions with a total of about 1650 V distributed between stages one to fourteen, and a total of 700 V distributed between stages fourteen through sixteen. Antimony coating is used and a cesium capsule is heated inside by induction to form the photo cathode, which is similar to the 5819 tube. The signal to noise ratio is nearly as good as in the 1P21, and better than in the 5819. It appears to have better characteristics than the rating assigned to it of 25 - 30 μa/lumen photosensitivity.

The dinodes are peculiarly shaped. See Fig. 5. The shape is such that protons can not easily go in a straight line to cause electron avalanching. There is some positive ion feed back or back streaming which accounts for the after-pulsing and "ghost" pulses. In this respect this tube is possibly worse than the 1P21. Space charge occurs just before the last stage. To overcome some of the space charge effects a grid of 300 V is interposed between stages 15 and 16, producing an accelerating-decelerating set up wherein a total of 800 V is reached. See Fig. 6. The charge limitation is about 1 amp. in this part of the structure.

The gain is about 5×10^{10}. When operated this way, space charge limited current pulses were seen of 0.4 amp. The scaler may be operated directly. A pulse signal on the scope still shows evidence of some space charge limitation.

The geometry is better than in 1P21. The transit time spread is better. Some difficulty will probably be caused by the great sensitivity of gain to voltage/stage and it may be hard to hold to constant voltage gain. The commercial tube will be shorter and will have co-axial signal leads to certain stages. This has some disadvantage in that one gets only one type of charge of pulse out, either positive or negative. It was suggested that internal by-passes be included. This tube is not affected by magnetic background as badly as the 5819. As to how soon the tubes will become available will depend on the demand.

Information Division
2/5/52 nw

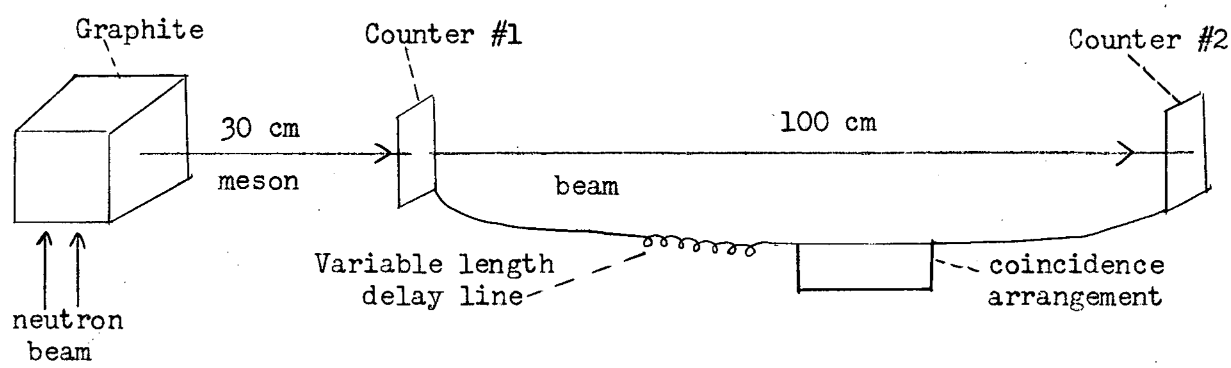
Graphite
Counter #1
Counter #2
30 cm
meson
100 cm
beam
Variable length
delay line
coincidence
arrangement
neutron
beam

Fig. 1

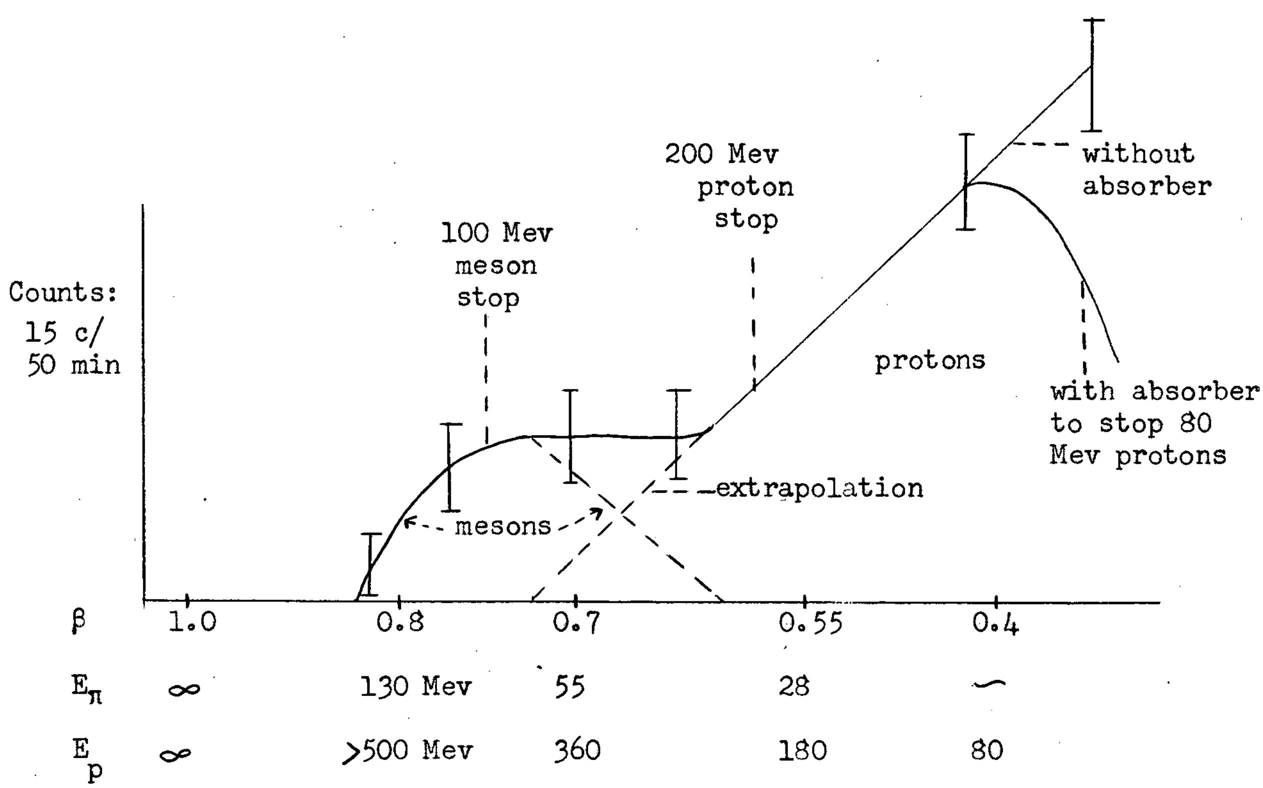
200 Mev
proton
stop
without
absorber
100 Mev
meson
stop
Counts:
15 c/
50 min
protons
with absorber
to stop 80
Mev protons
extrapolation
mesons
β
1.0
0.8
0.7
0.55
0.4
E_π
∞
130 Mev
55
28
~
E_p
∞
>500 Mev
360
180
80

Fig. 2

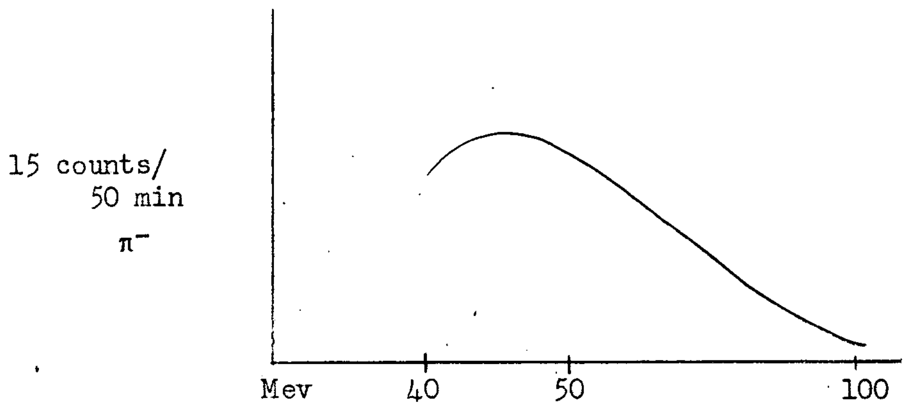

Fig. 3

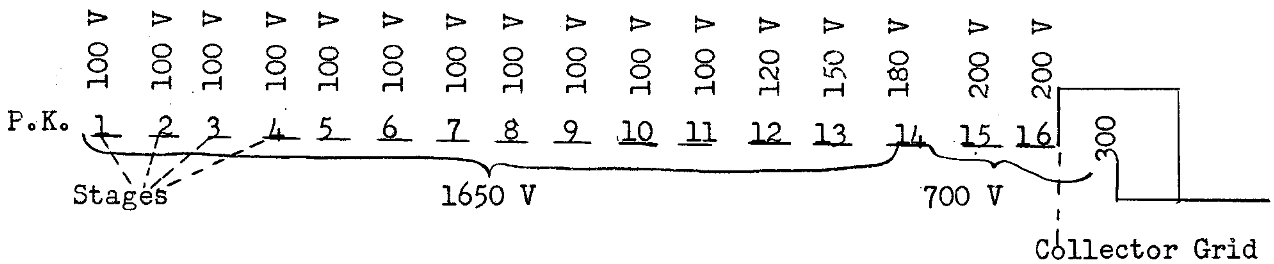

Fig. 4

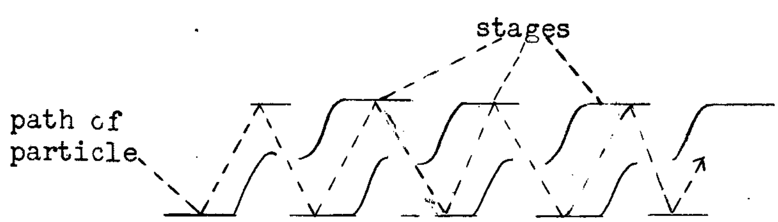

Fig. 5

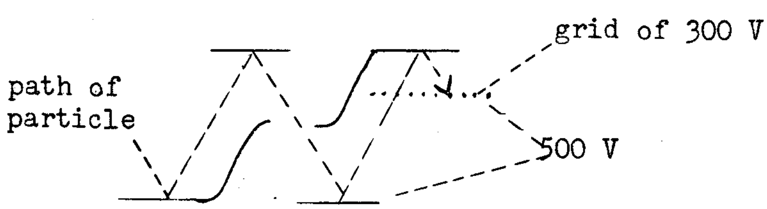

Fig. 6