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RADIATION LABORATORY

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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING of January 25, 1951

Bonnie E. Cushman

February 13, 1951

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Berkeley, California

SUMMARY OF THE RESEARCH PROGRESS MEETING of January 25, 1951

Bonnie E. Cushman

Emission Spectrum of Curium. J. Conway. In 1947 Warner isolated enough curium to give a spectrum, at which time 54 characteristic lines were found. Recently Crane has made more of this element available and further spectrographic investigation has been made.

Because of curium's high activity, the work was done in a glove box and the exhausted air was filtered through glass wool. Fig. 1 and 2 show the arrangement of the spectrograph in the dry box. This apparatus is no longer in use, others having been built since.

The Cm was dissolved in 0.1 N HCl and 0.1 μg samples were evaporated onto copper and carbon electrodes. The Cu electrode sample was sparked for 15 sec. using the Cu lines as a standard, while the carbon electrode was arced for 15 sec. at 7 amps., arcing iron at the same time to provide a standard. The lines found were measured only to 0.2 Å and so are not accurate enough for term analysis, although sufficient for identification purposes in ordinary chemical analysis. The lines identified thus far are listed in Table I. Those marked with an asterisk were found in the 1947 measurement.

Studies of π^0 Production in the Deflected Beam. R. Hildebrand. The process $p + C \longrightarrow \pi^0$ is known to occur with a cross section σ_C of approximately 5×10^{-28} cm^2 as measured by Crandall, Moyer and York. The cross section σ_H of the reaction $p + p \longrightarrow \pi^0$ has not been determined specifically and there is some doubt that the process actually occurs. Mr. Hildebrand's discussion related to efforts made to measure the ratio σ_C/σ_H. A ratio of 1/5 to 1/10 is easily explained theoretically one of 1/100 or 0 being much more difficult. Recent experiments show that it is less than 1/10 but that it cannot yet be said with certainty that it differs from 0.

Initial experiments using the internal beam of the cyclotron, with pair spectrometers and polyethylene and carbon detectors, were unsatisfactory because of the difficulty in monitoring the beam. Therefore the external beam was used with apparatus similar to that used by Panofsky, Steller and Steinberger at the synchrotron. However, the background at the cyclotron was unfavorable for this set-up and it was modified according to suggestions made by Leith. Assuming that there was no other process occurring to produce gamma rays other than π^0 decay, the gammas could be detected by converting them in a radiator into electron pairs which would be picked up by four scintillators in coincidence. (See Fig. 3) For a thin radiator one would expect the count to be proportional to $Z^2 \rho x/A$ where Z is the number of protons, ρ is the density, x the thickness and A the area of the radiator. It was shown that the count was linear with the target thickness when the background was eliminated. With the target thickness chosen so as to give the same stopping power in each case, the yield was also shown to vary linearly with $Z^2 \rho x/A$ as shown in Fig. 4.

To test whether another source of charged pairs was present, detectors were placed at an angle where it was known that the number of coincidences from gamma rays due to meson decay is negligible. It was found that the count was the same as that without a target (see Fig. 4). Since the background was worse with an aluminum target than with carbon or berylium, it might be thought that electron pairs are coming directly from the target. This problem will be investigated further. It seems hardly likely that the background is coming from another source of gamma rays, because a plot of counts vs. radiator thickness shows them to be high energy gammas, and gammas below 10 Mev can't be detected with this type of counter.

It is intended to refine the apparatus to detect pairs of gammas by means of a ring of coincidence detectors, thus obtaining angular distribution and an absolute cross section.

Relative cross sections were given as follows:

	Crandall, Moyer, York:	Hildebrand:
H		0.00 ± .04
Be	1	0.9
C		1
Al		1.7 ± .2
Cu	2.8	
Ta	4	

New Measurement of π^+ Meson Mass. F. Cartwright. The measurement of the π^+ meson mass was based on the experiment of Richman, Whitehead and Wilcox, who determined the cross section of π^+ production by protons on protons, using photographic emulsion detectors. The arrangement is shown in Fig. 5.

At the maximum energy of the π^+, the n and p formed will go off with the same momenta, and thus the mass of the meson can be found on a two body basis if a deuteron is formed. This situation is illustrated in Fig. 6. If the process does not involve deuteron formation the energy spectrum will be that of Fig. 7. Here the energy of the peak corresponds to that of the deuteron peak of Fig. 6. The peak of the energy curve is determined only by the mass of the meson and the energy of the proton beam. Therefore, in order to determine the meson mass, it is necessary to know which situation corresponds to the experimental conditions.

The beam energy was determined to ± 1 Mev by means of Cerenkov radiation immediately before and after the experiment. Since it proved to be the

same at both times, it was assumed that it did not change during the experiment. An expression for the resolution of the apparatus was derived and folded into the experimental curve and the result compared with the theoretical curves for the two cases. Agreement with the theoretical curve based on deuteron formation was good as may be seen in Fig. 8. Very recently Crowe has observed directly the deuteron produced in this process. Therefore the mass of the π^+ was calculated on this basis and found to be 275.1 ± 1.7 electron masses. It was pointed out that a difference of 1 Mev in the proton beam energy corresponds to about 1 e.m. difference in the meson mass.

Table I

Wave Lengths of Curium

Wave Length	Intensity Spark	Wave Length	Intensity Spark	Wave Length	Intensity Spark
2516.0	2	2968.9	4	3473.5*	7
2562.3	1	2984.5	3	3492.9	2
2585.8	2	2996.2	3	3498.9*	5
2616.8	2	2998.3	3	3503.7	3
2617.2	3	2998.8	2	3510.3	3
2625.4	2	3000.8	2	3518.5	2
2628.2	2	3004.1	2	3546.1*	5
2636.2	3	3037.4	2	3550.3	3
2651.1	4	3044.7	6	3567.4*	5
2653.7	4	3046.6	5	3570.4*	2
2677.0	1	3047.5	2	3573.0*	5
2693.8	1	3050.8	2	3581.3*	3
2704.8	1	3059.0	2	3585.6*	3
2707.1	1	3081.6	4	3591.9*	2
2710.1	1	3092.8	4	3619.9	2
2725.6	2	3096.4	1	3639.9	1
2727.7	3	3101.5	1	3643.5	1
2736.8	3	3104.9	1	3670.4*	2
2748.0	1	3118.3	3	3673.2	3
2773.5	2	3143.9	1	3691.7	3
2792.0	1	3161.8	3	3692.5*	3
2796.2	1	3186.4	1	3696.4	3
2796.4	1	3190.3	1	3697.3	2
2811.5	5	3195.6	1	3708.8	1
2817.4	4	3197.0	3	3709.6	1
2821.5	4	3197.5	2	3723.3	3
2832.2	6	3198.0	3	3732.3	3
2833.7	4	3210.0	4	3738.2*	3
2862.2	2	3220.7	6	3739.3*	4
2862.8	2	3230.3	4	3750.5	3
2872.0	3	3238.6	2	3763.6	4
2882.3	1	3252.6*	2	3767.3	3
2888.5	2	3279.4*	2	3778.2*	4
2888.1	1	3296.7*	6	3788.0	1
2909.1	2	3304.9*	2	3799.5	3
2913.1	4	3367.9*	3	3842.1	3
2920.7	5	3374.3*	3	3846.9*	2
2929.0	2	3382.7	2	3903.9	7
2933.2	3	3392.0	3	3908.2	6
2934.9	3	3417.1*	6	3936.6*	5
2935.4	3	3424.2	1	3941.5	1
2944.5	2	3425.9*	6	3942.1	1
2953.0	3	3436.5	1	3947.9	3
2955.6	2	3439.9	3	3948.8	2
2957.5	4	3446.6	2	3953.3	1
2961.8	2	3458.3	1	3957.5	1
2963.0	2	3461.7	7	3960.8*	2

Wave Length	Intensity Spark	Wave Length	Intensity Spark	Wave Length	Intensity Arc
3962.2	2	4239.8	3	2832.2	9
3962.8	2	4283.0	1	3019.6	9
3965.0	2	4289.2	1	3943.7	9
3970.2	2	4293.0	1		
3974.9*	6	4299.1	1		
3984.6	2	4301.5	5		
3990.9	1	4309.7	1		
4003.3*	8	4313.1	4		
4016.2	1	4318.7	3		
4017.0	1	4323.4	5		
4017.9	2	4324.8	4		
4018.4	2	4357.2	2		
4024.5*	3	4433.7	3		
4028.0*	2	4434.2	2		
4031.6*	1	4435.3	2		
4036.4	2	4442.0	3		
4052.4	1	4446.5	1		
4061.6	1	4455.2	2		
4078.9*	4	4546.9	1		
4089.8	4	4570.1	2		
4106.9	3	4608.3	2		
4118.1	2	4632.1	1		
4128.5	2	4665.4	2		
4130.4	2	4670.4	2		
4141.3*	3	4681.8	2		
4148.2	1	4722.8	4		
4156.5	1	4761.6	1		
4156.0	4	4873.8	3		
4164.3	1	4880.5	3		
4188.4	2	4905.6	4		
4194.3	2	4906.3	1		
4202.4	1	4925.5	3		
4208.0	6	4989.9	1		
4218.6	3				

*Lines also found in 1947 experiment.

MU 1311

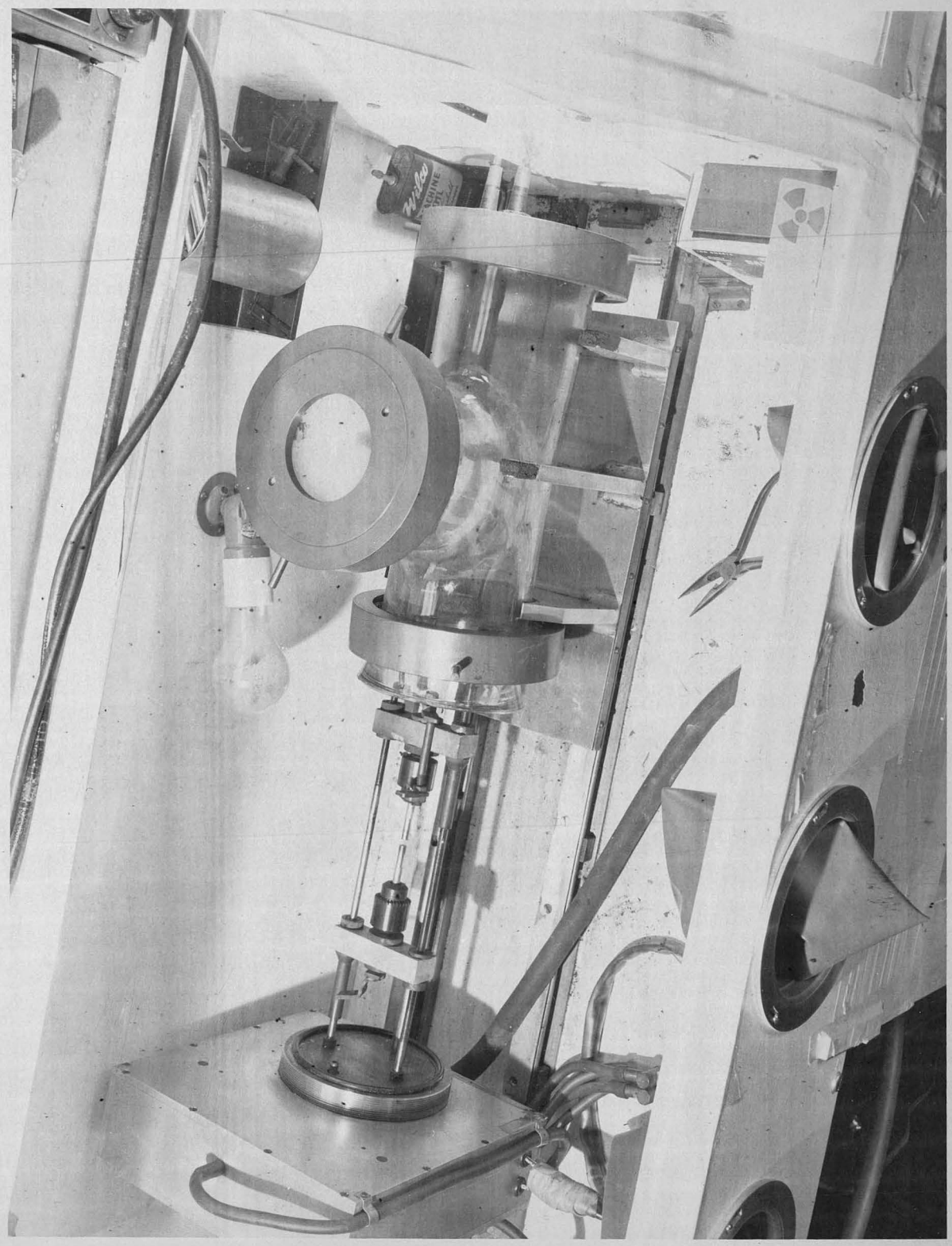

FIG. 1

KODAK—SAFETY FILM

OZ 941

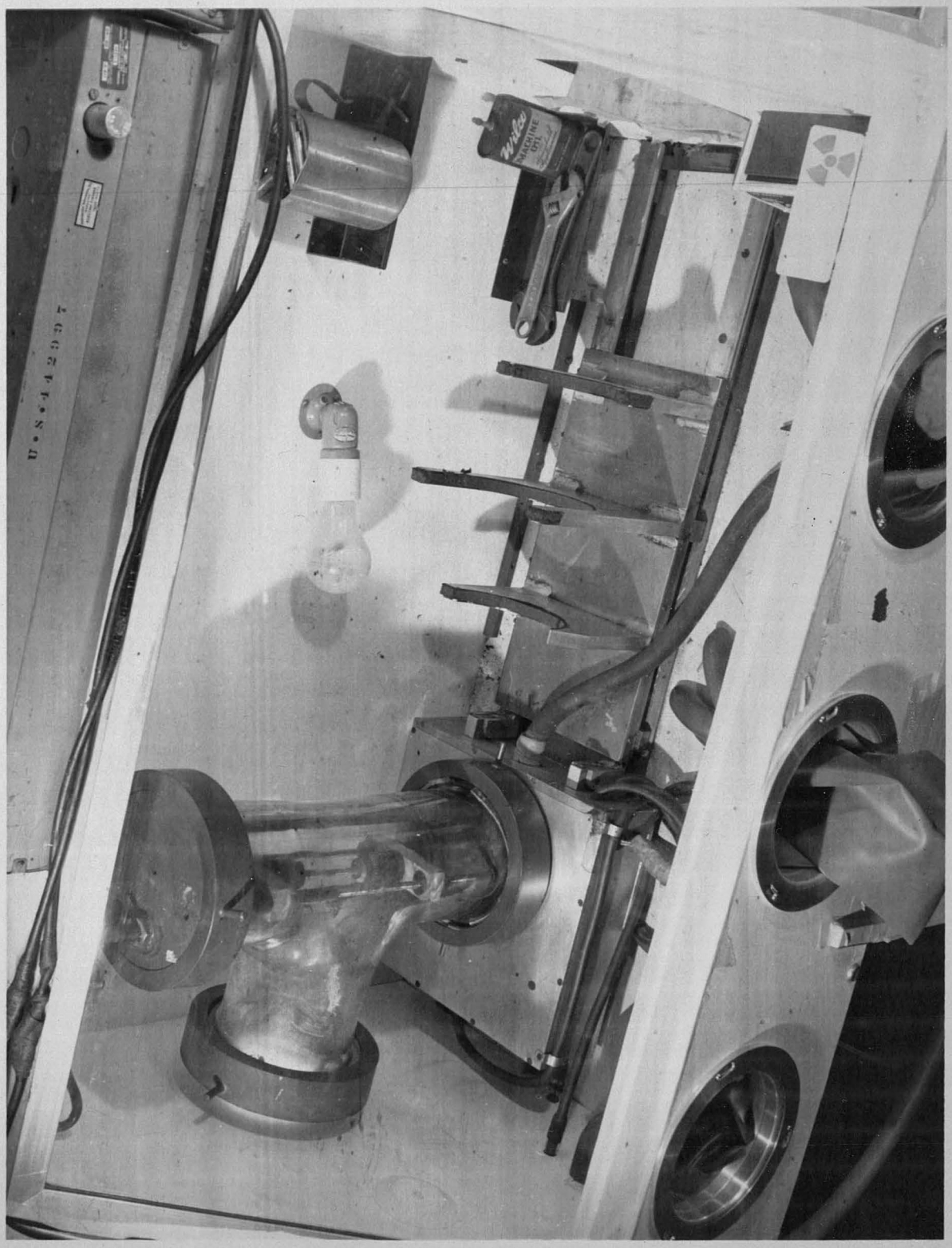

FIG. 2

OZ 942

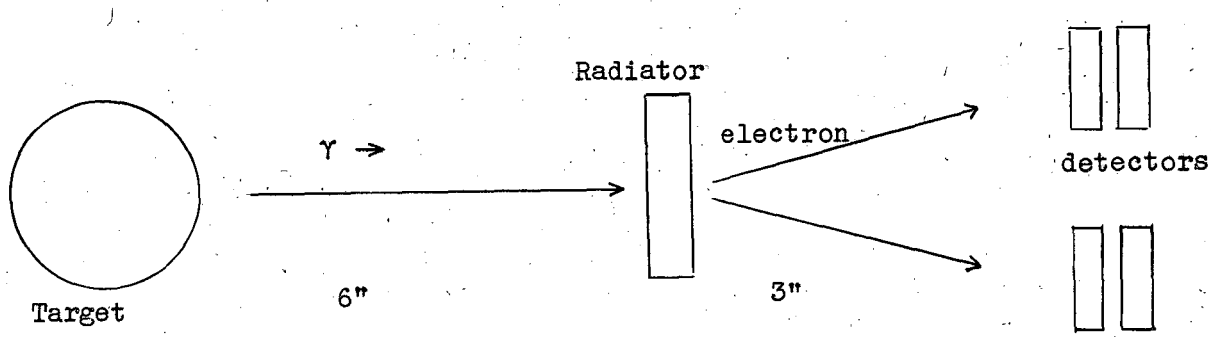
Radiator
electron
detectors
γ →
Target
6"
3"

Fig. 3

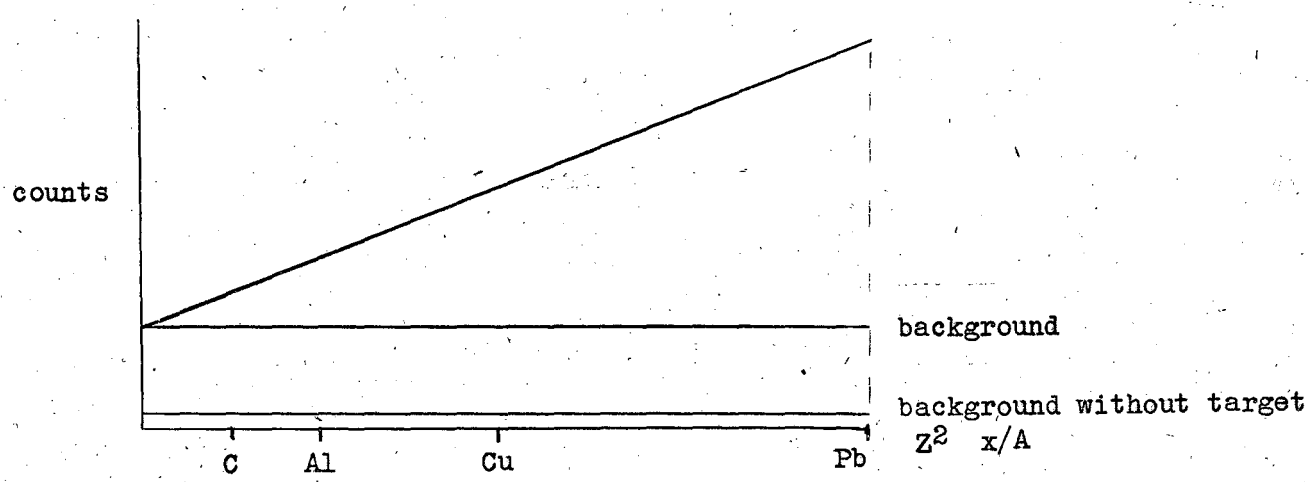
counts
background
background without target
C
Al
Cu
Pb
Z^2 x/A

Fig. 4

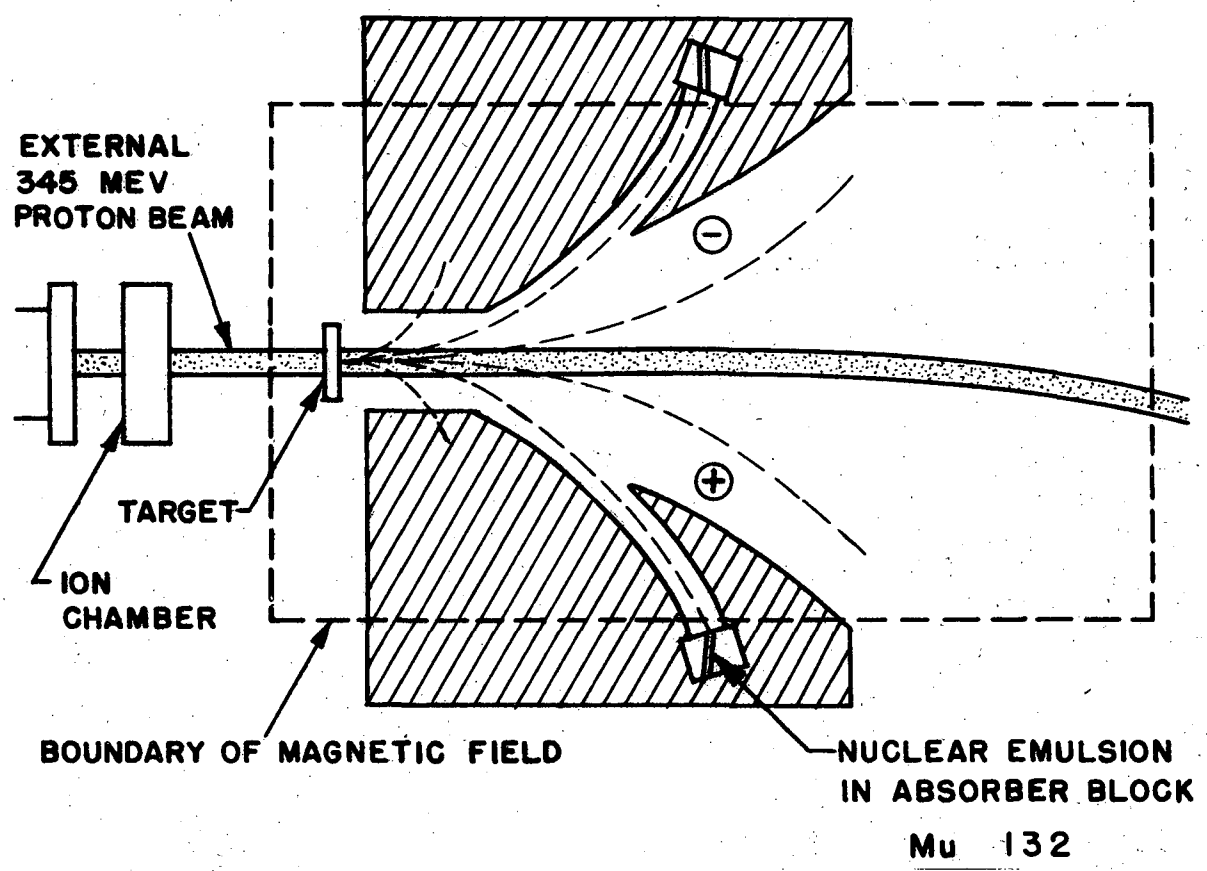
EXTERNAL
345 MEV
PROTON BEAM
TARGET
ION
CHAMBER
BOUNDARY OF MAGNETIC FIELD
NUCLEAR EMULSION
IN ABSORBER BLOCK
Mu 132

Fig. 5

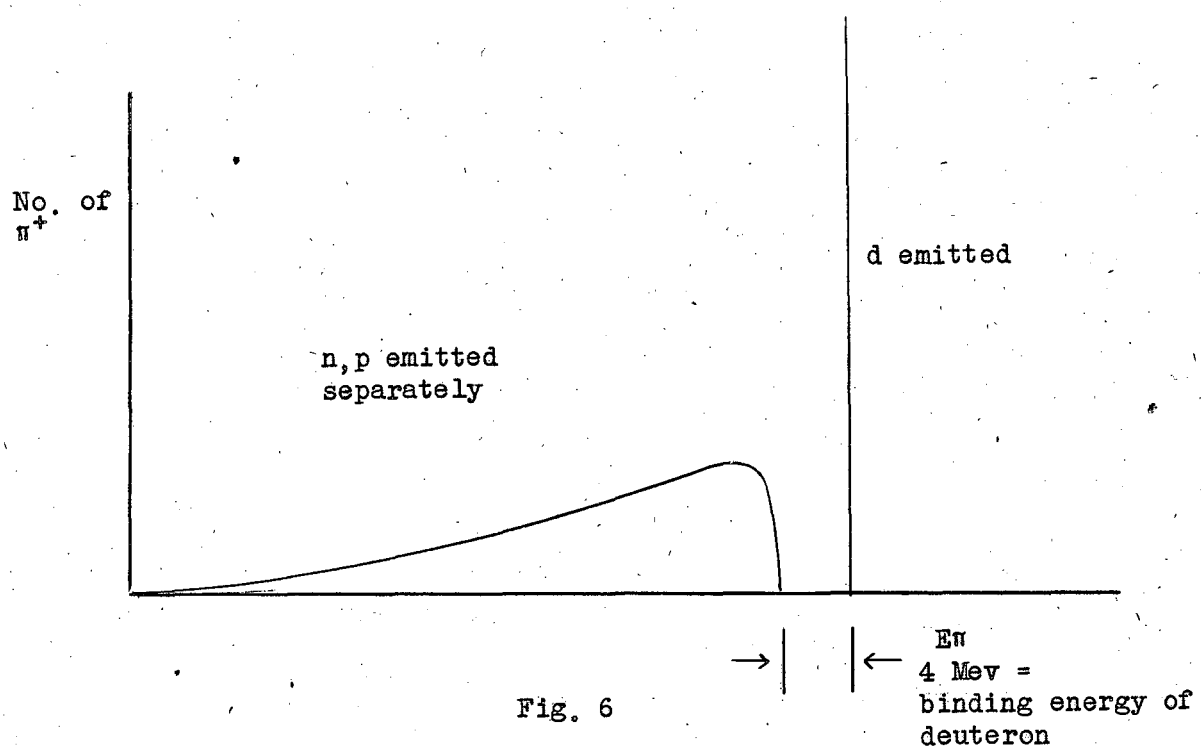
No. of
π^+
d emitted
n, p emitted
separately
E_π
4 Mev =
binding energy of
deuteron

Fig. 6

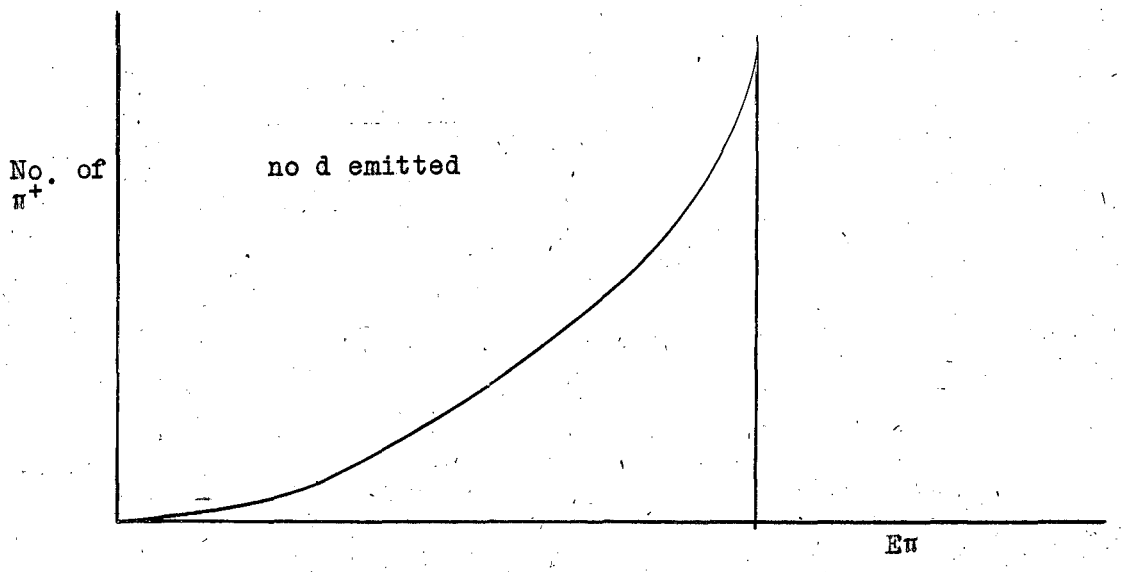
No. of
π^+
no d emitted
E_π

Fig. 7

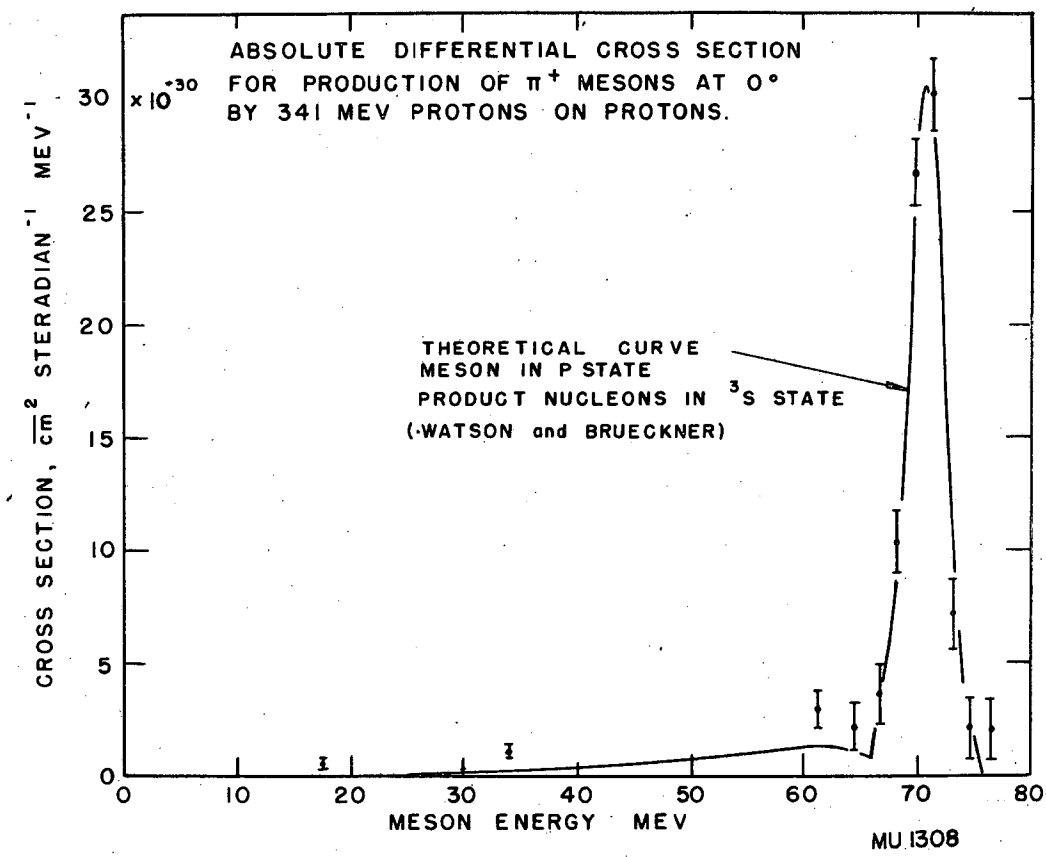
ABSOLUTE DIFFERENTIAL CROSS SECTION
FOR PRODUCTION OF π+ MESONS AT 0°
BY 341 MEV PROTONS ON PROTONS.
THEORETICAL CURVE
MESON IN P STATE
PRODUCT NUCLEONS IN 3S STATE
(WATSON and BRUECKNER)
CROSS SECTION, cm2 STERADIAN-1 MEV-1
x 10-30
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
MESON ENERGY MEV
MU 1308

Fig. 8