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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING of February 1, 1951

Bonnie E. Cushman

February 14, 1951

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Berkeley, California

SUMMARY OF THE RESEARCH PROGRESS MEETING of February 1, 1951

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I Meson to Proton Mass Ratios- W. Barkas

The particles were detected by an arrangement which allowed the protons and the three types of mesons to expose the same photographic plate (see Figs. 1, 2, and 3). The chief problem in measurement was range straggling, since the energy of the particles must be low enough that they stay in the emulsion; better results could be obtained by passing high energy particles through thicker material.

The value of the mass obtained for π mesons in earlier experiments was 276 ± 6 e.m. (See UCRL-577.) Error arose in part because the emulsion had to be calibrated in each case due to the varying water content. Other systematic errors were the target size, the measurements of the magnetic field and the apparatus dimensions, and the fact that the theory of range straggling was not completely understood.

When the velocities and charges of the particles are equal, then $M_1/M_2 = R_1/R_2 = P_1/P_2 = E_1/E_2 = N_1/N_2 = G_1/G_2 = \sigma_1/\sigma_2 = \theta_1/\theta_2$, where M is mass, R range, P momentum, E energy, N the number of particles in the track, G the integrated emptiness of the track, σ the number of straggling particles and θ the angular divergence of the track. Attention has been focused on the masses, ranges and momenta, since they are the more easily measured quantities. In the present experiment the meson range distribution was assumed to be normal. The mean range of 64 mesons was found to be 531 μ with a standard deviation of

about 1 μ, while a μ meson was found 11.6 standard deviations away. Masses were determined as follows: 76 π^+ mesons had a median of 277.6 e.m. with 0.25 percent probable error, and 28 π^- mesons had a median of 277.0 e.m. with 0.36 percent probable error. No values of μ meson mass were obtained, possibly because they decayed in flight. The copper absorber between the target and plate used to stop neutrons causes some scattering of the mesons and loss of momentum, but not all of the low energy mesons arise from this source. Systematic errors are the target size, azimuthal variation in the magnetic field, and the drift of the mean mass with momentum if q (in the relation $R/M = C(P/M)^q$) is not chosen correctly, although the value of q is apparently not at fault.

The best value of the π meson mass is found to be 277 e.m. The mass ratios of meson to proton are π^+ 0.1511 $\pm$ 0.0006 and π^- 0.1504 $\pm$ 0.0007.

II Binding Energy of the Di-neutron- L. Aamodt

In 1948 Feather (see Nature 162, 213) investigated the hypothetical reaction $He^6 \longrightarrow He^4 + 2n - 0.7$ Mev $\pm$ 0.2 Mev, where the last term of the equation is the upper limit of the binding energy of the di-neutron. Assuming that the transition $n^2 \xrightarrow{\beta} H^2$ is superallowed, he estimates the lifetime of the di-neutron to be between one and five seconds.

The present attempt by Panofsky, Crowe, Phillips and Aamodt to improve the statistics of the problem involved a pair spectrometer, capturing π^- in deuterium according to the reaction $\pi^- + d \longrightarrow 2n + \gamma$. If the neutrons are bound together, a monochromatic gamma spectrum should be obtained (see Fig. 4). 62 hours of running time gave about 1000 counts.

Stuart and Watson calculated the shape of the spectrum for various values of binding energy at the high energy end given by $dT/dk = (1/p)\sin^2\delta$ (see Fig. 5).

The resolving power of the spectrometer (13 Mev) was folded into the curves. Fig. 6 shows the experimental curve plotted logarithmically and the theoretical curves for different binding energies as calculated by Stuart and Watson. Fig. 7 gives the displacement of the peaks of these theoretical spectra as a function of binding energy. A value of three Mev corresponds to the plane wave case, i.e., when there is no interaction between the neutrons. The four experimental points are the judgments of the four observers and, being highly questionable, show at best that the value of the di-neutron binding energy must lie to the right of 200 kv of real binding energy (these points are to be moved back and forth horizontally on the graph).

Crowe plans to make 120-150 channels for the pair spectrometer, thereby improving the resolving power by a factor of three. The curves obtained will then be narrower and will not lose their shape when the resolving power is folded in.

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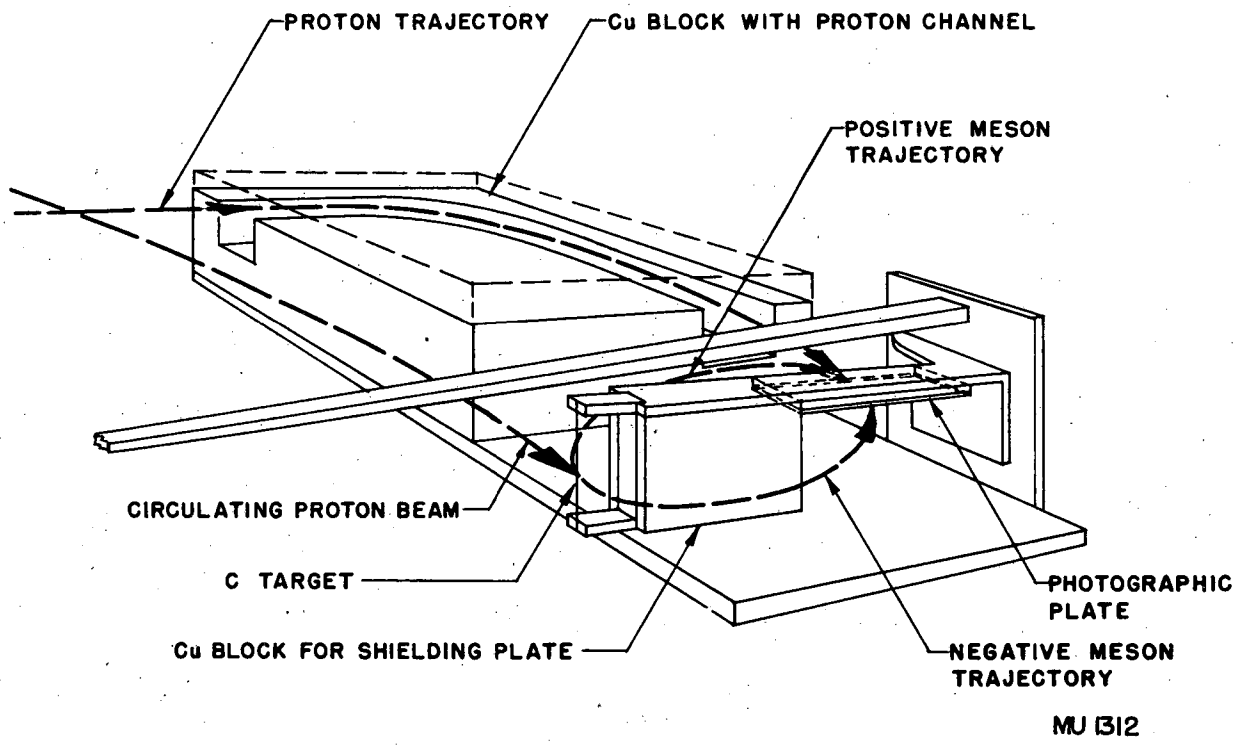
PROTON TRAJECTORY
Cu BLOCK WITH PROTON CHANNEL
POSITIVE MESON TRAJECTORY
CIRCULATING PROTON BEAM
C TARGET
Cu BLOCK FOR SHIELDING PLATE
PHOTOGRAPHIC PLATE
NEGATIVE MESON TRAJECTORY
MU 1312

Fig. 1

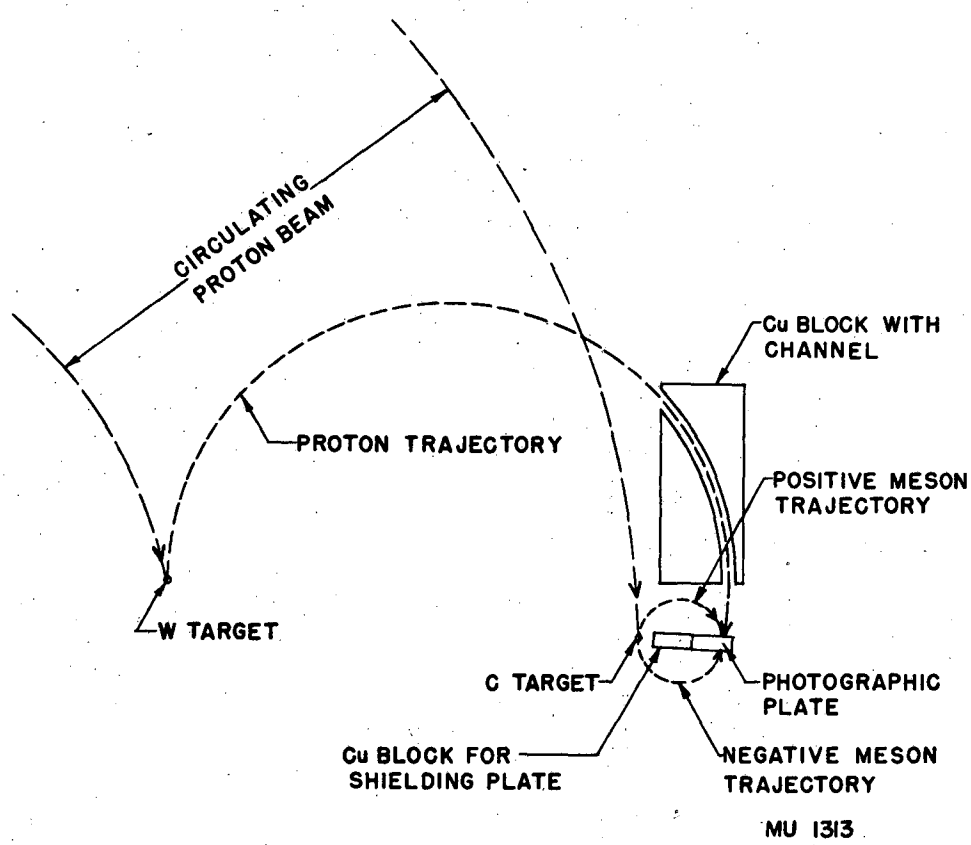
CIRCULATING PROTON BEAM
Cu BLOCK WITH CHANNEL
PROTON TRAJECTORY
POSITIVE MESON TRAJECTORY
W TARGET
C TARGET
PHOTOGRAPHIC PLATE
Cu BLOCK FOR SHIELDING PLATE
NEGATIVE MESON TRAJECTORY
MU 1313

Fig. 2

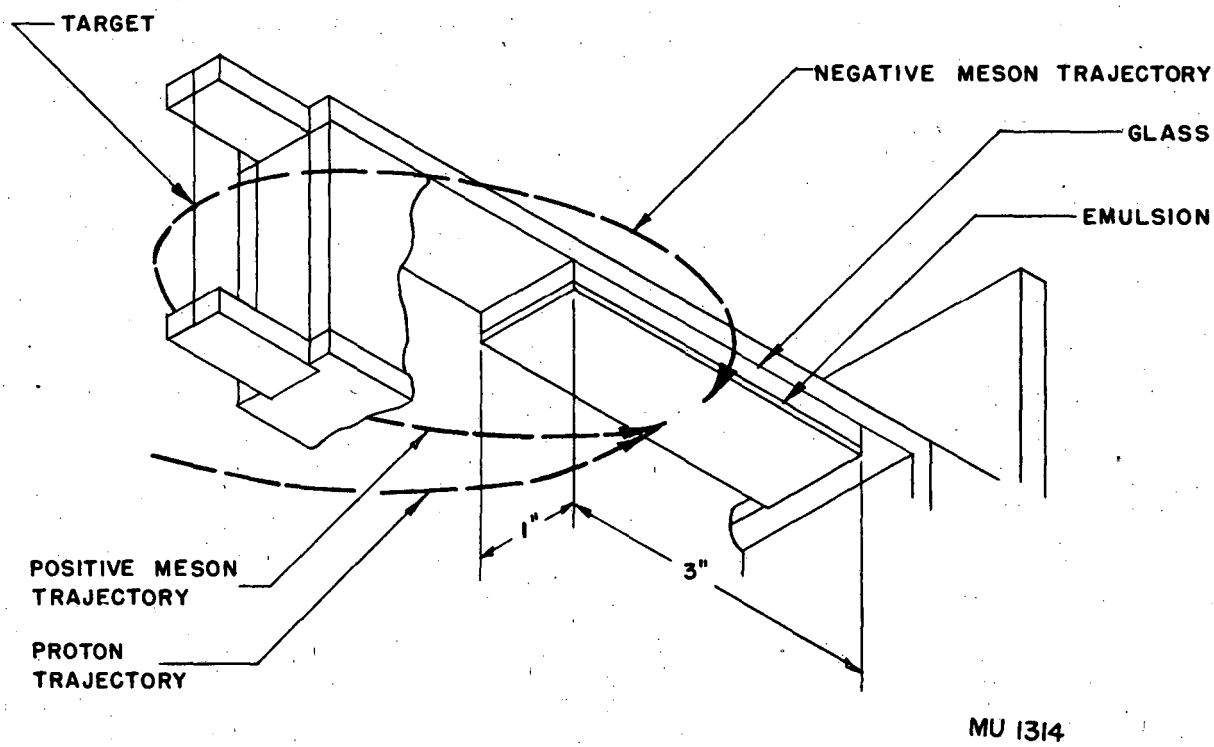
TARGET
NEGATIVE MESON TRAJECTORY
GLASS
EMULSION
POSITIVE MESON TRAJECTORY
PROTON TRAJECTORY
1"
3"
MU 1314

Fig. 3

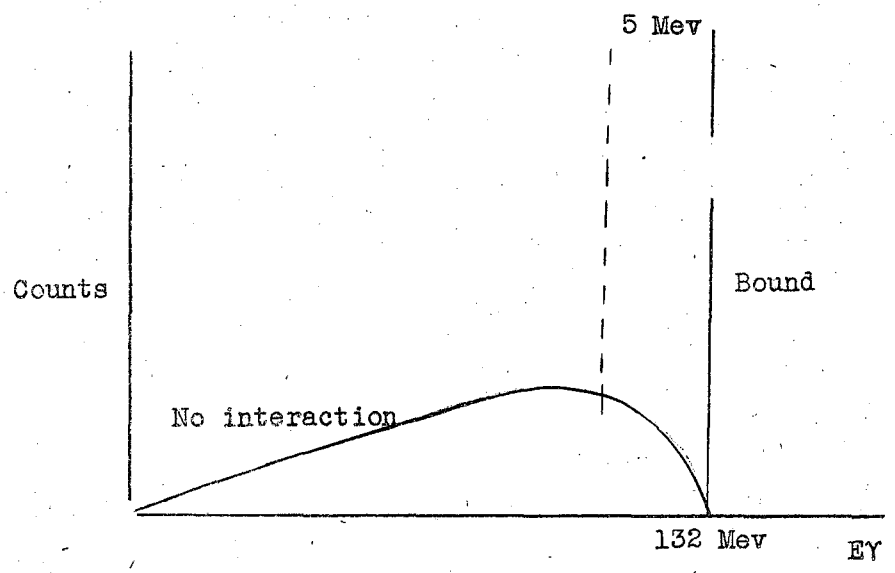
5 Mev
Counts
Bound
No interaction
132 Mev
Eγ

Fig. 4

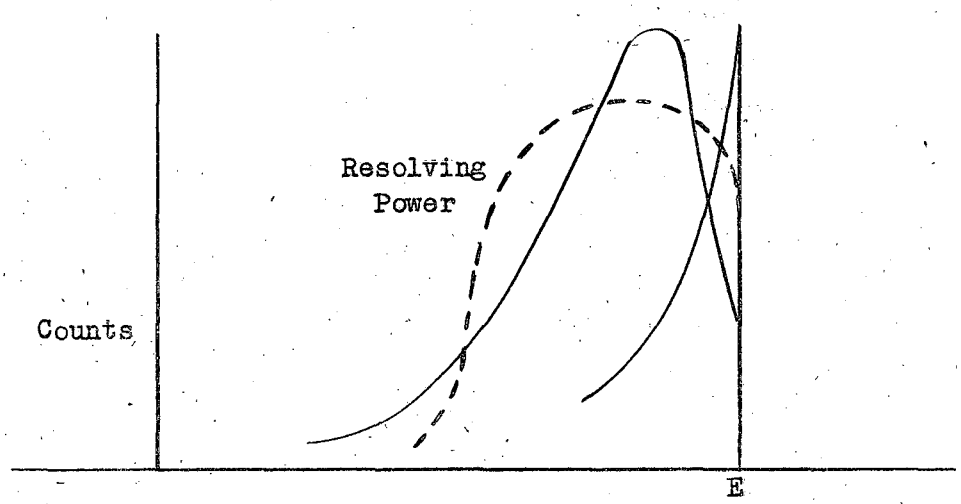
Resolving
Power
Counts
E

Fig. 5

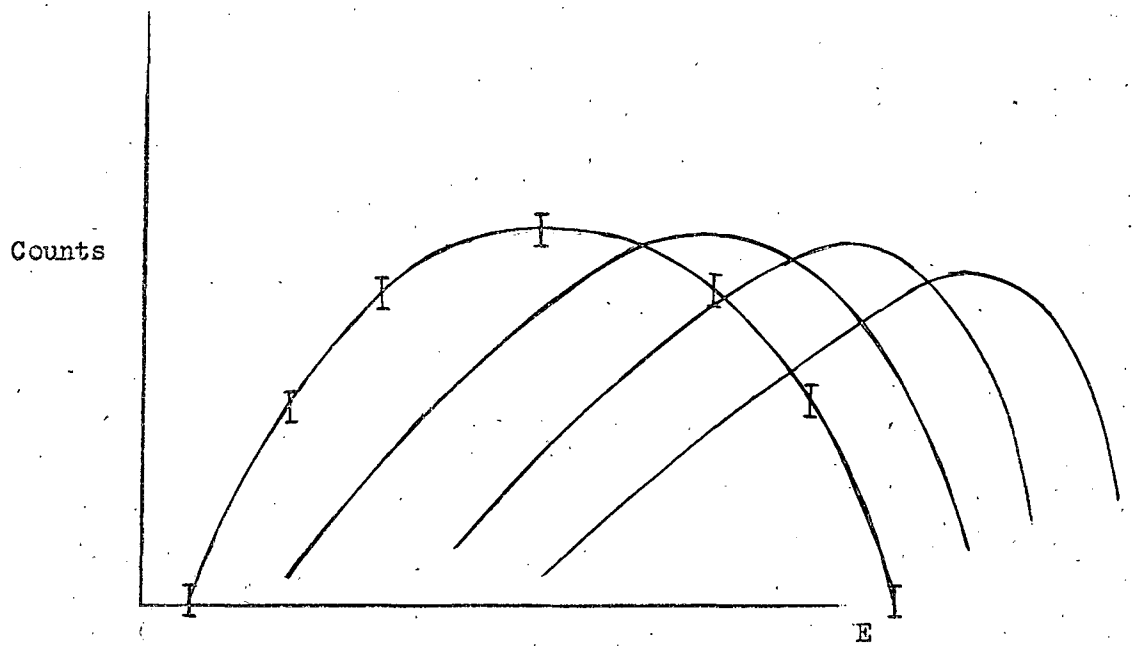
Counts
E

Fig. 6

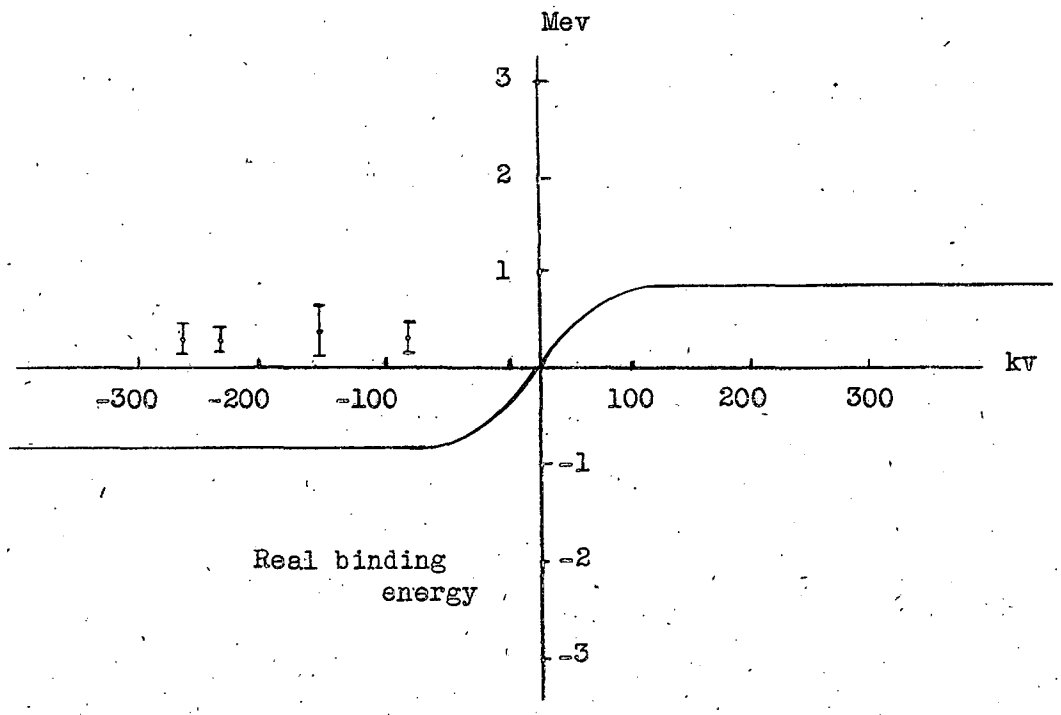
Mev
3
2
1
-1
-2
-3
kv
-300
-200
-100
100
200
300
Real binding
energy

Fig. 7