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REVIEW OF OBSERVATIONS OF MESON PRODUCTION AND BEHAVIOR AT THE UNIVERSITY OF CALIFORNIA RADIATION LABORATORY

Walter H. Barkas

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Berkeley, California

Review of Observations of Meson Production and Behavior at the University of California Radiation Laboratory

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Meson production has been observed at the University of California Radiation Laboratory using high energy beams of protons, alpha particles, photons and neutrons. The observations are consistent with the supposition that pi mesons of both signs are produced in the primary process. The threshold for production of mesons is somewhat above the mass-energy of the meson as expected.

For alpha particles some production has been observed as low as 266 Mev and the excitation function has been measured up to 380 Mev. The differential cross section for production in carbon by 380 Mev alphas of negative mesons is 3.8×10^{-32} sq. cm/carbon nucleus/per Mev/steradian. This applies to mesons of energy in the vicinity of four Mev observed in the forward direction.

For protons some production has been observed as low as 204 Mev, and the excitation function has been measured up to 340 Mev. The differential cross section for production of negative mesons by 340 Mev protons in carbon is 1.0×10^{-30} sq. cm/carbon nucleus/one Mev/steradian. This applies to mesons in the vicinity of twelve Mev observed in the forward direction.

The positive to negative production ratio of mesons by alpha particles is found to fall rapidly with atomic number in the low energy region of the meson spectrum. Protons produce many more high energy positive mesons in carbon than negative mesons of similar energy, while photons produce an excess of negative mesons. The cross section for meson production by 335 Mev photons is 1.2×10^{-29} cm^2/nucleon for mesons in the ranges 35-150 Mev.

Neutrons of about 300 Mev produce stars in nuclear emulsions. From about one in thirteen hundred of these stars, low energy mesons are observed.

Half lives of positive and negative pi mesons have been measured. In each case the half life is in the vicinity of 10^{-8} seconds.

High energy photons, which may be the decay products of neutral mesons, are observed to be produced at the cyclotron target under high energy proton bombardment.

The negative pi mesons which stop in the emulsion cause nuclear disintegrations yielding charged particles in 73.2 percent of the cases. Negative mu mesons arise from the decay in flight of negative pi mesons, and seldom, if ever, produce charged particle nuclear disintegrations in the emulsion. The positive pi mesons usually are observed to decay into a positive mu meson. The mu mesons are observed to have a range of 594 $\pm$ 6 microns in Ilford emulsion.

The stopping power of nuclear emulsions is found to be seriously affected by humidity. With dry Ilford emulsions the range-energy relation found for protons is

$$E = 0.25\ R^{0.58}$$

where E is the energy in Mev and R is the range in microns. This relation has been obtained for protons of energies 17-39 Mev.

FIGURE CAPTIONS

Fig. 1. Diagram showing plate holder and shielding utilized in observing negative mesons produced in the cyclotron.

Fig. 2. Relative production of negative mesons in the energy range 2-10 Mev by protons and alpha particles as a function of the beam energy. Observations of Jones and White.

Fig. 3. Diagram of plate holder used to observe low energy portion of meson energy spectrum. Experiment of Jones and White.

Fig. 4. Comparison of the distribution of prongs in stars initiated by sigma mesons with the prong distribution found to be produced by deuterons and alpha particles. Meson observations by Adelman and Jones.

Fig. 5. A number of examples of the appearance in C2 emulsion of the end of negative pi meson tracks which stop in the emulsion without making a star.

Fig. 6. Plate holder to measure simultaneously intensities of negative and positive mesons produced by alpha particles in a series of targets.

Fig. 7. Production ratio of low energy positive to negative mesons produced by alpha particles as a function of atomic number. Note that no low energy positive mesons are produced in the heavy element targets. Observations by Barkas.

Fig. 8. Apparatus used by Richardson in determining the half life of negative pi mesons. The intensity of a spiralling beam of mesons was measured after having traversed 180° and 540°.

Fig. 9. Event produced by high energy neutron in nuclear emulsion in which a meson is produced simultaneously with the emission of a high energy proton. The meson in turn is captured and produces a one prong star. Observation by Gardner.

Fig. 10. Photomicrograph of decay of positive pi meson into a mu meson, which in turn decays into an electron. NT4 emulsion. Observation by Jones.

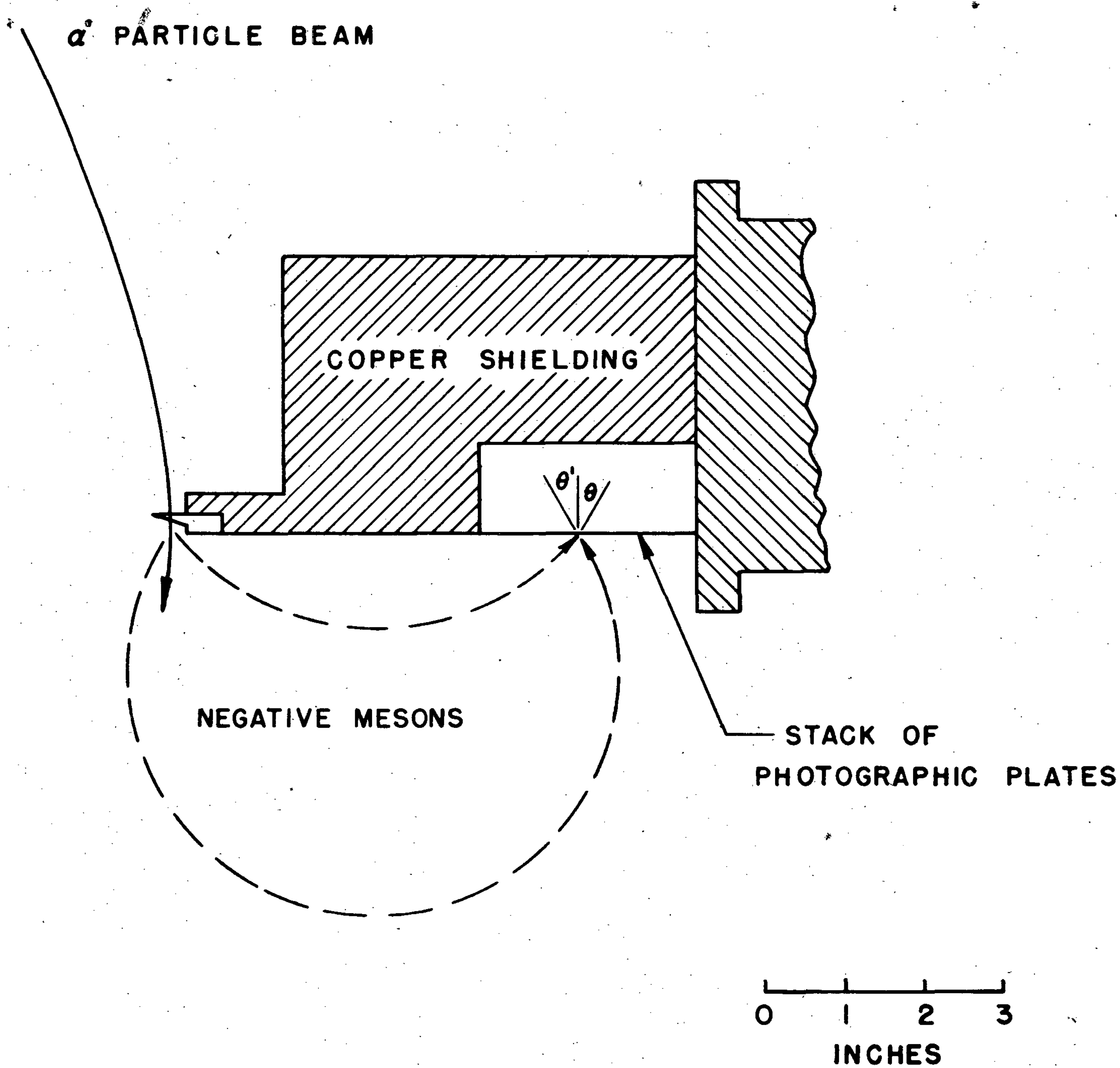
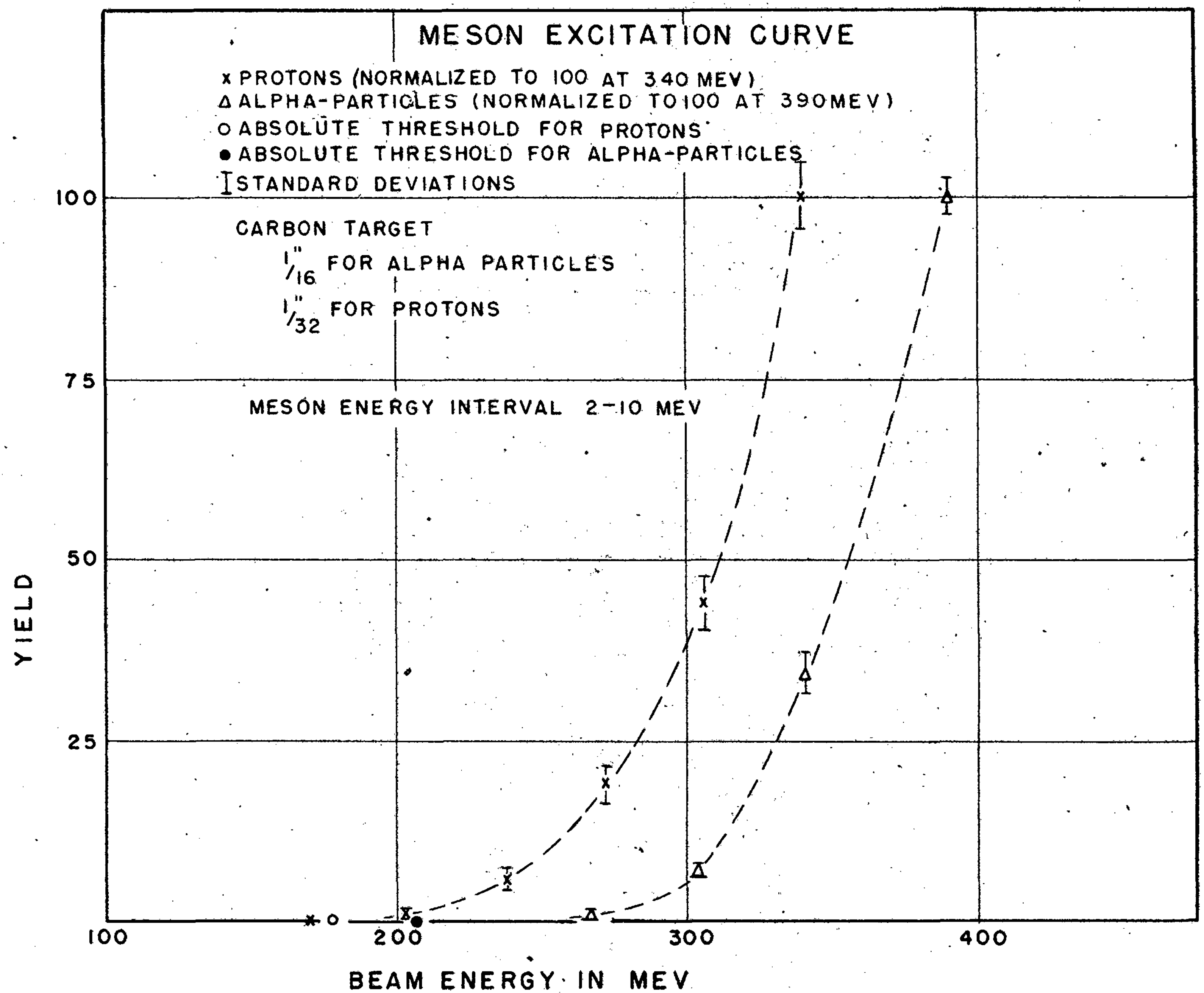

α PARTICLE BEAM
COPPER SHIELDING
θ'
θ
NEGATIVE MESONS
STACK OF
PHOTOGRAPHIC PLATES
0
1
2
3
INCHES

FIG. 1

OZ 569



MESON EXCITATION CURVE
x PROTONS (NORMALIZED TO 100 AT 340 MEV)
Δ ALPHA-PARTICLES (NORMALIZED TO 100 AT 390 MEV)
○ ABSOLUTE THRESHOLD FOR PROTONS
● ABSOLUTE THRESHOLD FOR ALPHA-PARTICLES
STANDARD DEVIATIONS
CARBON TARGET
1"/16 FOR ALPHA PARTICLES
1"/32 FOR PROTONS
MESON ENERGY INTERVAL 2-10 MEV
YIELD
100
75
50
25
100
200
300
400
BEAM ENERGY IN MEV

FIG. 2

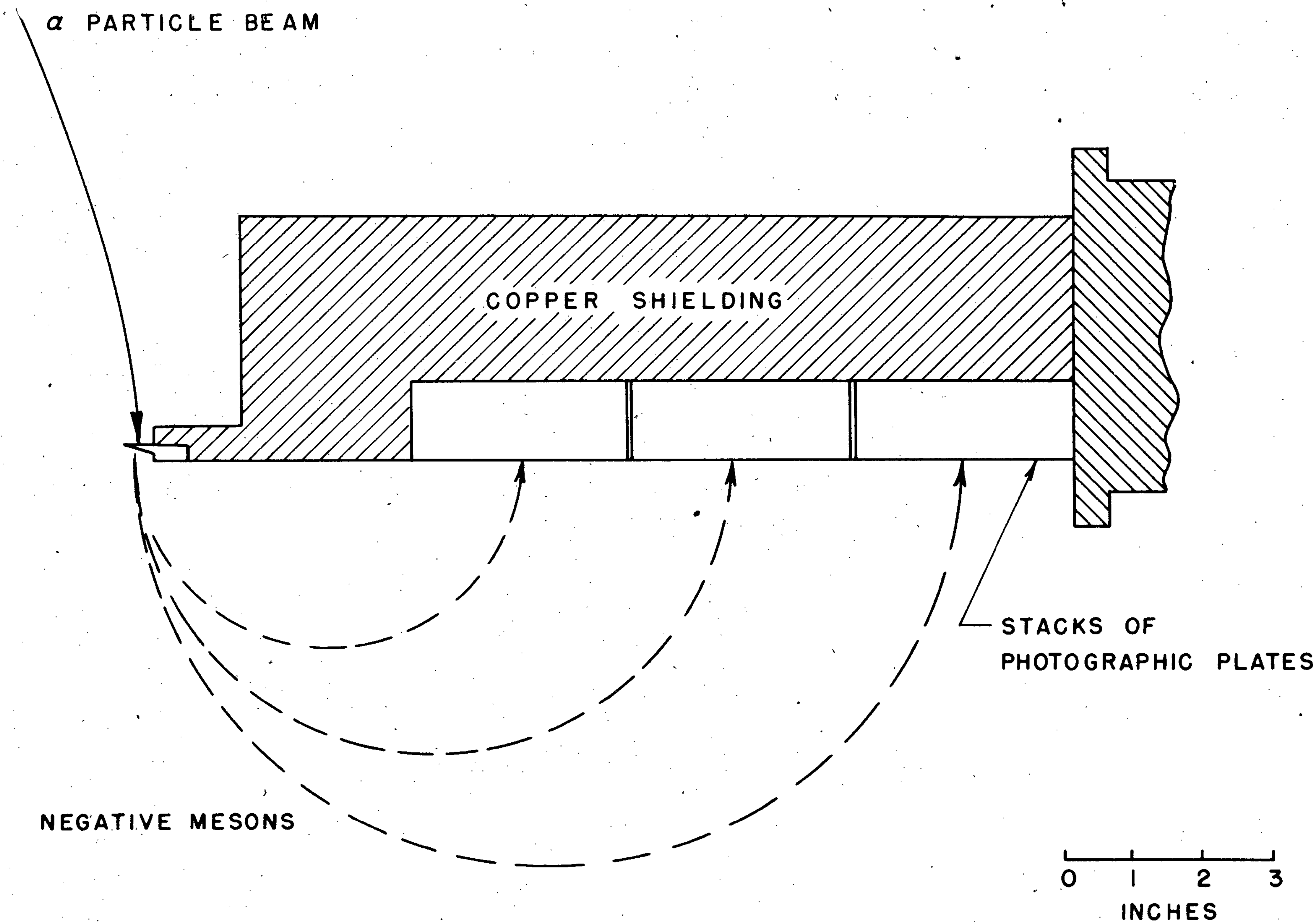

α PARTICLE BEAM
COPPER SHIELDING
STACKS OF
PHOTOGRAPHIC PLATES
NEGATIVE MESONS
0 1 2 3
INCHES

FIG. 3

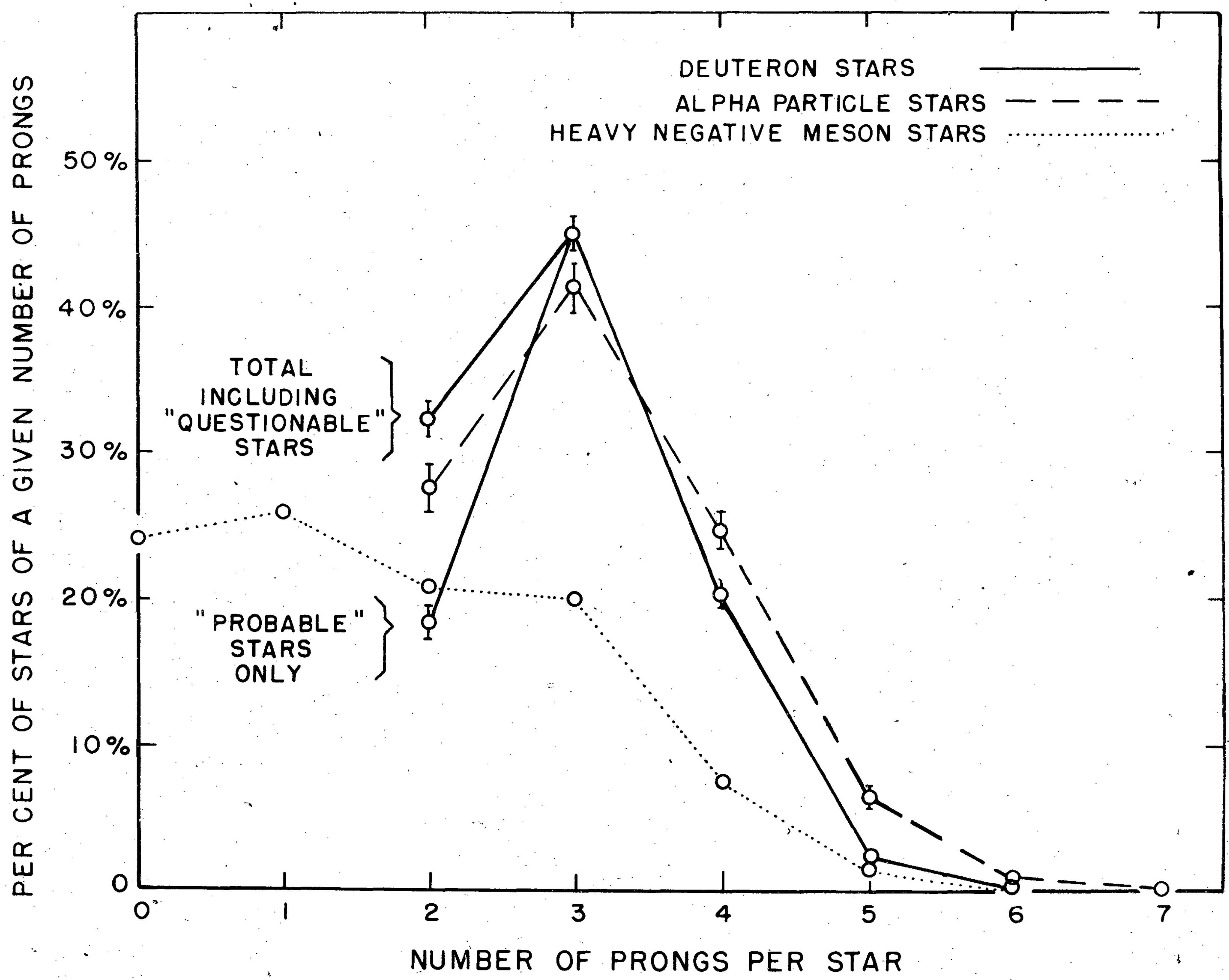

DEUTERON STARS
ALPHA PARTICLE STARS
HEAVY NEGATIVE MESON STARS
PER CENT OF STARS OF A GIVEN NUMBER OF PRONGS
50%
40%
30%
20%
10%
0
TOTAL INCLUDING "QUESTIONABLE" STARS
"PROBABLE" STARS ONLY
0
1
2
3
4
5
6
7
NUMBER OF PRONGS PER STAR

FIG. 4

OZ 574

FIG. 5

OZ 575

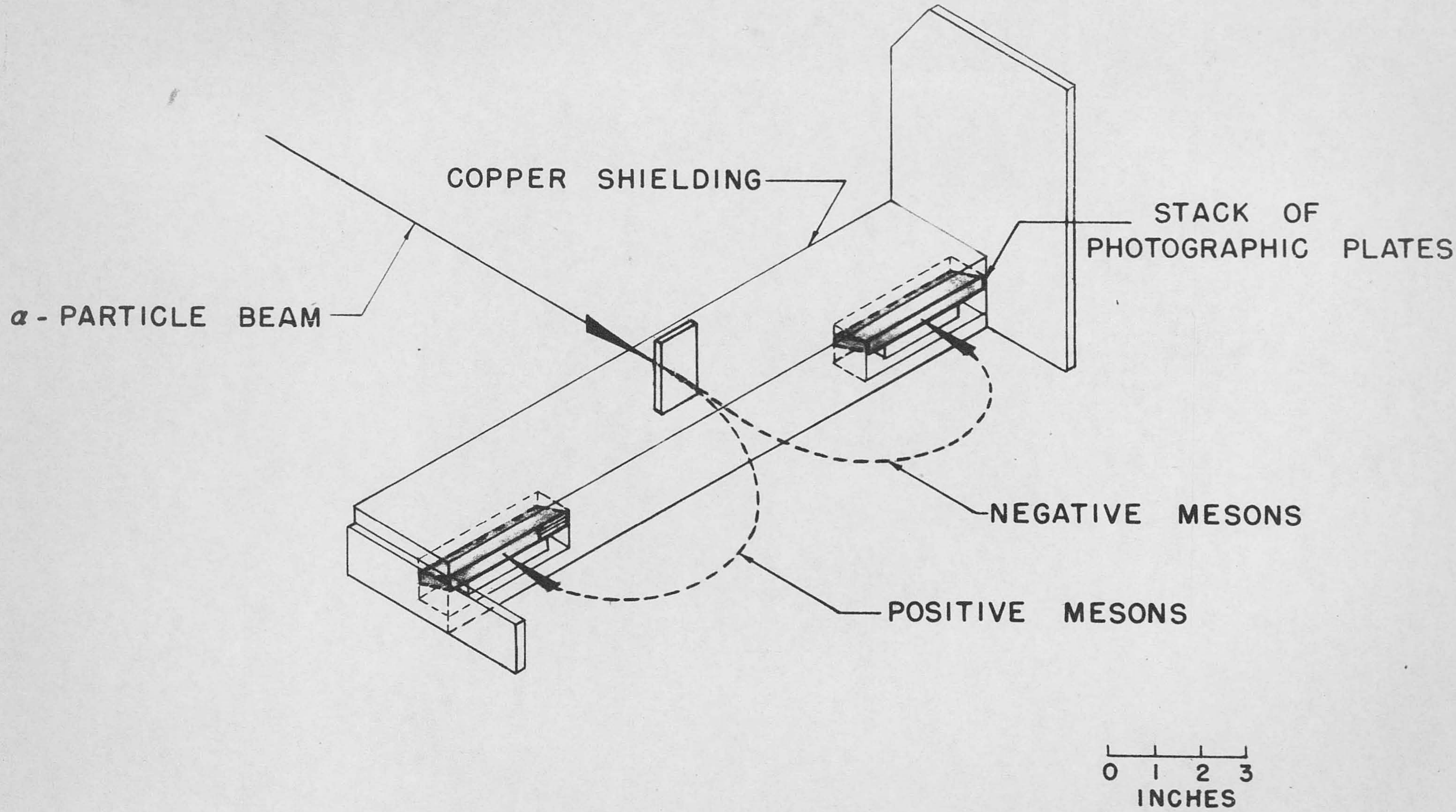
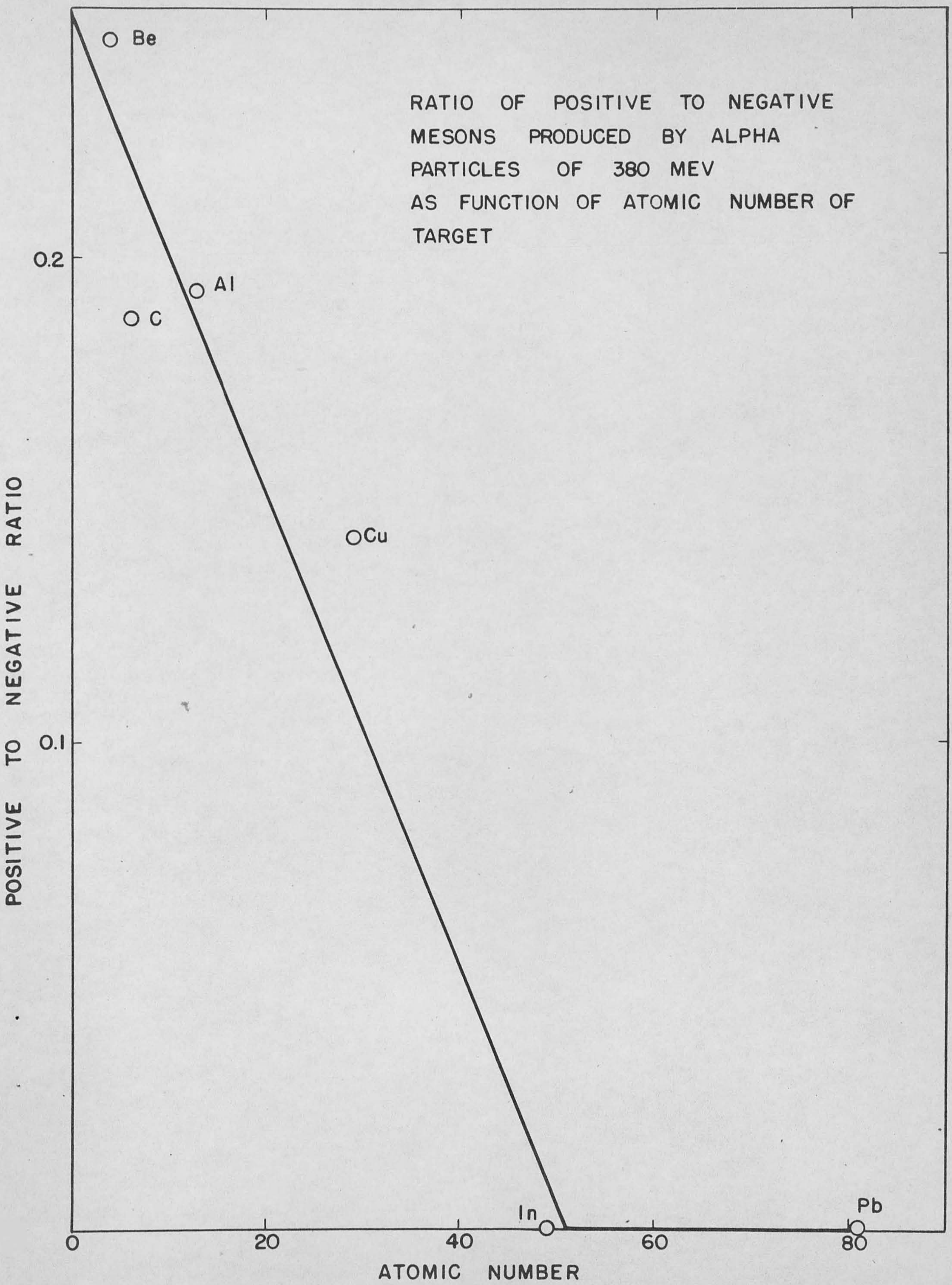

COPPER SHIELDING
STACK OF PHOTOGRAPHIC PLATES
α - PARTICLE BEAM
NEGATIVE MESONS
POSITIVE MESONS
0 1 2 3
INCHES

FIG. 6



RATIO OF POSITIVE TO NEGATIVE MESONS PRODUCED BY ALPHA PARTICLES OF 380 MEV AS FUNCTION OF ATOMIC NUMBER OF TARGET
POSITIVE TO NEGATIVE RATIO
ATOMIC NUMBER
0.2
0.1
0
20
40
60
80
Be
C
Al
Cu
In
Pb

FIG. 7

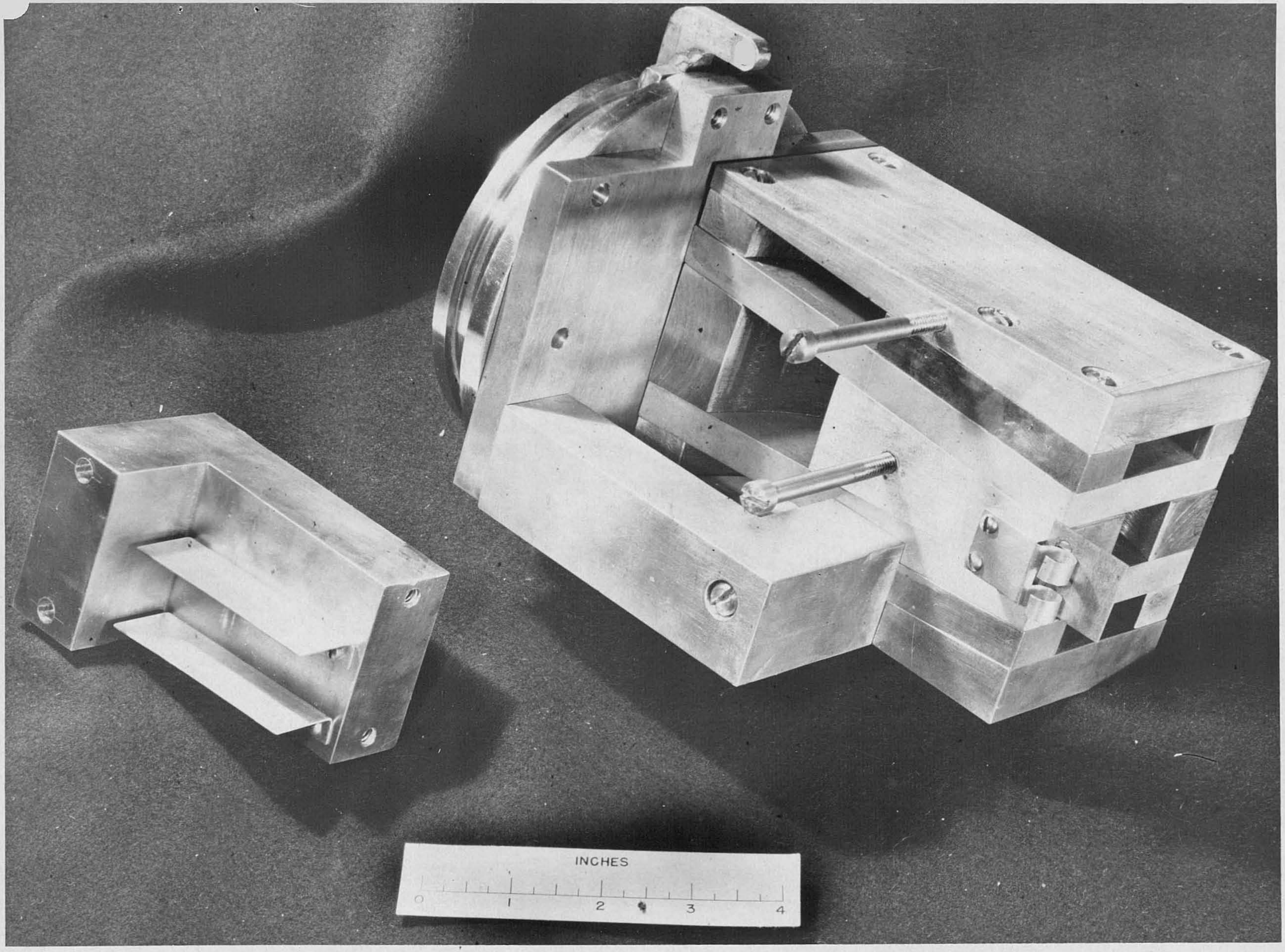


FIG. 8

OZ 571

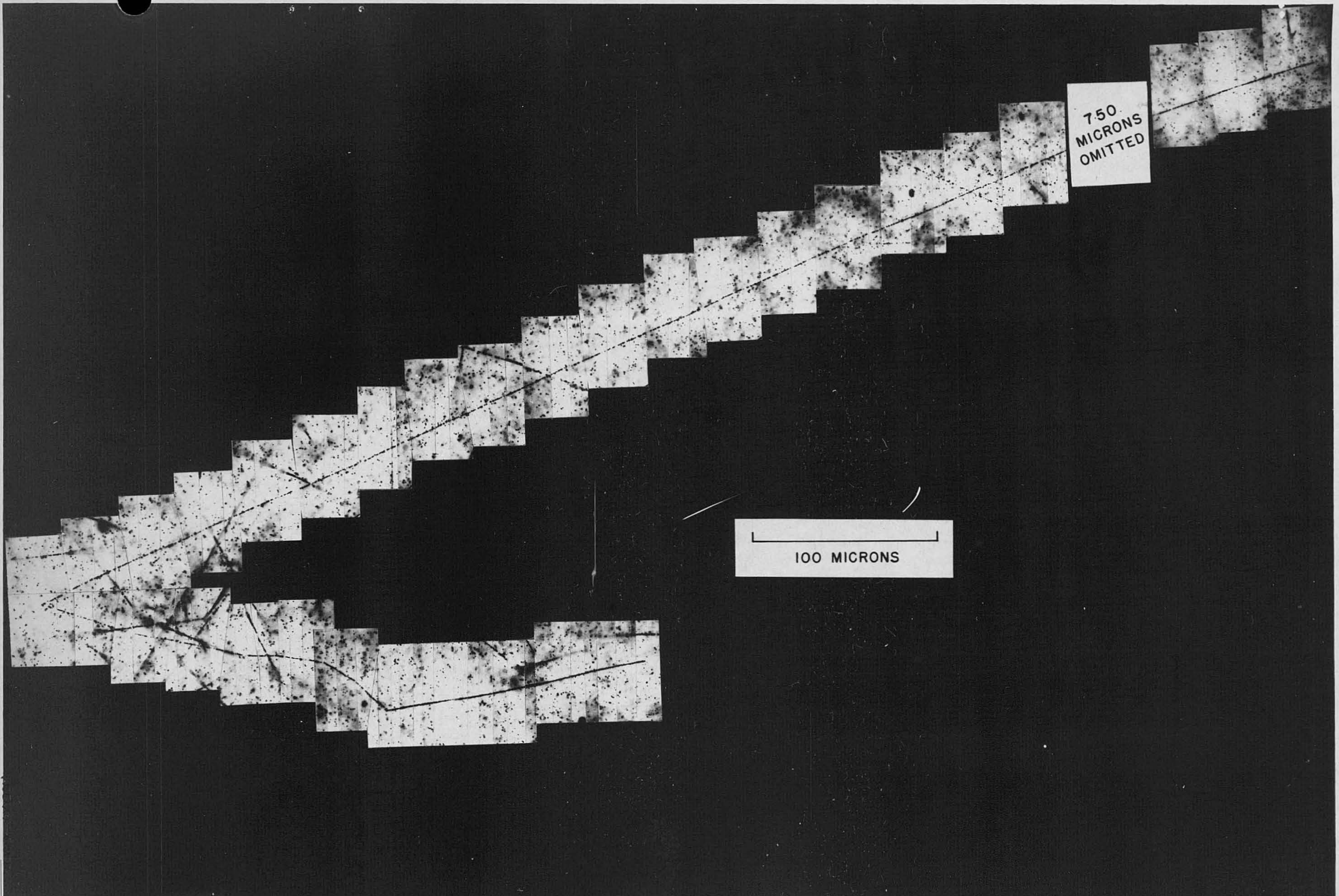


FIG. 9

OZ 578

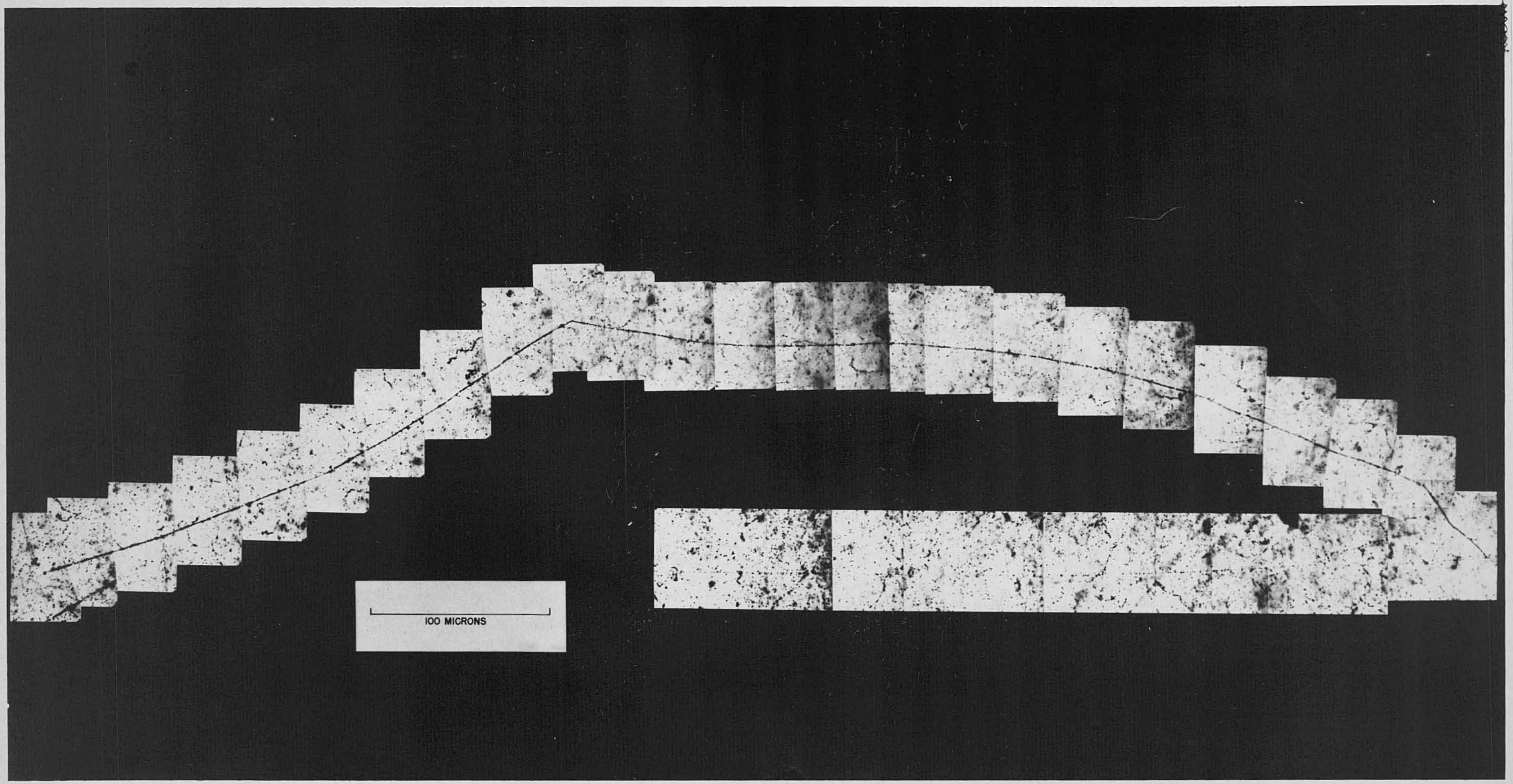


FIG. 10

OZ 577