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The Detection of Light and Heavy Mesotrons Outside the Tank of the 184" Cyclotron

by

Wolfgang K. H. Panofsky

Berkeley, California

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The Detection of Light and Heavy Mesotrons Outside the Tank of the 184" Cyclotron

by

Wolfgang K. H. Panofsky

Radiation Laboratory, Department of Physics
University of California, Berkeley, California
June 22, 1948

It is of general interest to make the mesons artificially produced in the 184-inch cyclotron available for general experiments outside the tank. Thus far only photographic techniques have been used in conjunction with the Berkeley meson work. By bringing the beam outside the tank it is hoped that cloud chamber, and possibly counter methods, may be used in meson studies. In addition, the measurement of the lifetime of the π meson appears possible if long meson trajectories are obtained.

The method discussed here accomplishes the removal of the mesons from the cyclotron tank by allowing the mesons produced in a thin target struck by the 380 Mev alpha particle beam to enter a region of very weak magnetic field which permits them to leave the tank along a path of weak curvature. The technical problem involved here is, therefore, to produce a magnetic shield which reduces the field of the cyclotron from about 14,000 gauss to about 1,000 gauss, and to place this shield within a very short distance of the circulating beam without disturbing the dynamics of the beam itself.

The main problem in the design of a magnetic shield of this type to operate in a magnetic field of 14,000 gauss is the problem of saturation of the iron. This problem can be met only if the flux density in the iron only slightly exceeds the flux density in the surrounding field. This condition can be met by using a shield whose major extent is perpendicular to the direction of the field. If we approximate such a shield by an oblate spheroid, the mathematical analysis of the saturation and shielding behavior of such a body in an external field can be made. As a result of this analysis, it can be shown that a shielding ratio of only 1.3 is obtainable for a shield of spherical geometry. For a spheroidal shield of axial ratio two to one, the shielding ratio of three to one is obtainable, while for an axial ratio of four to one, the shielding ratio of 30 to one is feasible in an external field of 14,000 gauss. The above calculations are based on cold rolled steel.

On the basis of these calculations a shield was designed in accordance with an axial ratio of four to one, bent in the shape of the trajectory computed from a set of magnetic measurements. The resultant overall geometry is shown in Figure 1. It is seen that the curvature of the mesons trajectories entering is greatly decreased in the shield, permitting the mesons to pass into the reentrant chamber in the side of the cyclotron. Figure 2 shows the magnetic field along the meson trajectory with and without the magnetic shield. The disturbance produced by this shield is only 5 per cent at the beam radius. This disturbance is compensated by a set of magnetic shims fastened to the pole of the cyclotron. Unfortunately it is not possible to calculate the focusing properties of the meson shield theoretically, owing to the very variable saturation conditions near the channel through which the mesons pass. An intensity of mesons expected from the channel is therefore difficult to predict. However, a counting rate of 1,000 mesons per minute for a beam current of 10^{-7} amperes of alpha particles is the best figure that can be calculated from the data known thus far.

Until now only four mesons have been detected inside the reentrant chamber in the cyclotron wall. Two of these were light mesons and two were heavy mesons. The fact that the light mesons are also obtained through this channel lends additional support to the belief that the light mesons are actually formed in the cyclotron target and are not produced by disintegration in flight.

Figure 3 shows a π meson as obtained in the reentrant cyclotron chamber. The total time of flight in the chamber is 10^{-8} seconds, and an additional 10^{-8} seconds is obtainable in the reentrant chamber without any additional magnetic changes. If the lifetime of the π meson is therefore not in excess of 5×10^{-8} seconds, the measurement of the lifetime should be possible in this geometry by a comparison of the numbers of π and μ mesons as a function of distance along the meson trajectory. It is also planned to check the focusing properties of the magnetic channel by means of one million volt alpha particles produced by a thick radioactive alpha sample mounted at the regular cyclotron target position.

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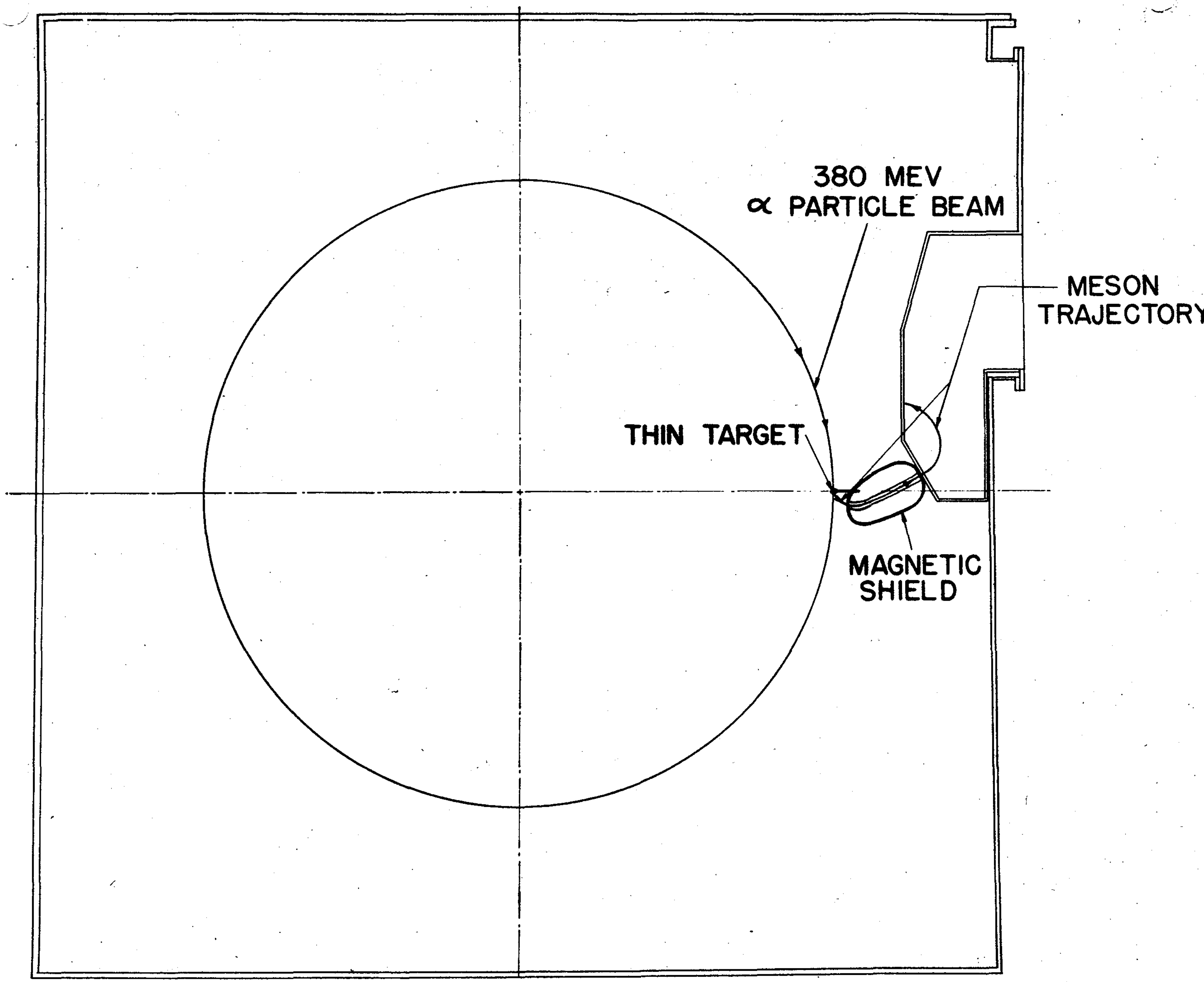
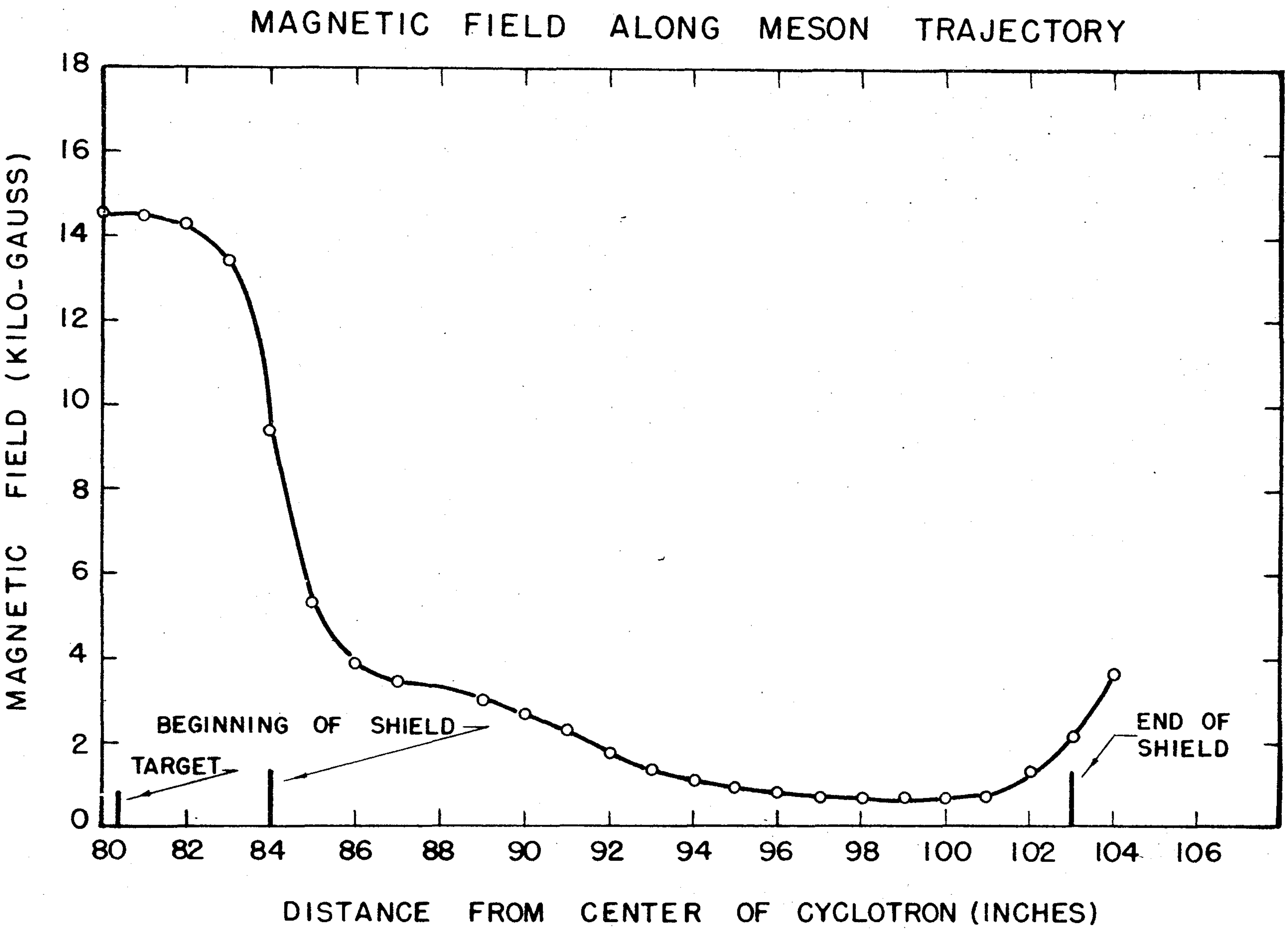

380 MEV
α PARTICLE BEAM
MESON
TRAJECTORY
THIN TARGET
MAGNETIC
SHIELD

FIG 1



MAGNETIC FIELD ALONG MESON TRAJECTORY
MAGNETIC FIELD (KILO-GAUSS)
0
2
4
6
8
10
12
14
16
18
80
82
84
86
88
90
92
94
96
98
100
102
104
106
BEGINNING OF SHIELD
TARGET
END OF SHIELD
DISTANCE FROM CENTER OF CYCLOTRON (INCHES)

FIG. 2

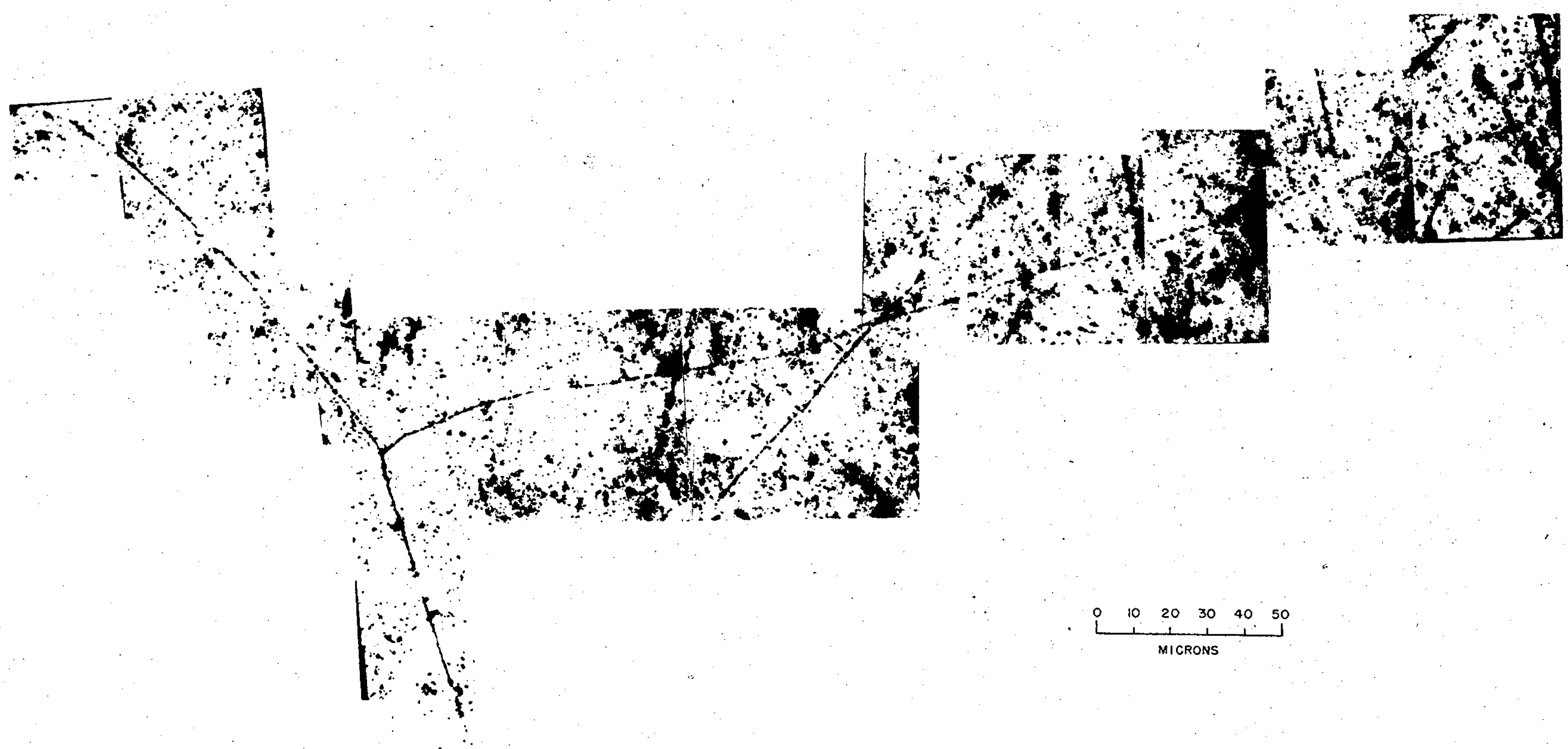


FIG. 3