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Radiation Laboratory

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF JUNE 1, 1950

R. K. Wakerling

October 26, 1950

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R. K. Wakerling

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

October 26, 1950

Acceleration of Carbon Atoms in the 60-inch Cyclotron. J. Miller.

Experiments on the acceleration of stripped carbon atoms have been carried out intermittently since about 1938. The beams secured were never large. With the development of new ion sources and the recent improvements made in the 60-in. cyclotron, it seemed advisable to try again to operate with carbon. In these experiments carbon dioxide gas was used and plans are under way to use carbon monoxide also.

A new experimental arrangement has been set up whereby the external beam after leaving the target snout passes in vacuum through an adjustable slit down the axis of a 26-in. tube and through a second slit which is adjustable in width and located in a horizontal position. The beam then traverses a foil wheel where various adsorbers may be placed in the path, after which it passes through a chamber where nuclear emulsions may be exposed and enters the beam measuring apparatus. This apparatus consists of two ionization chambers with foil windows and a Faraday cup between them. The entire assembly is enclosed in an evacuated chamber.

The apparatus is arranged to count the heavy ions in the beam and to measure their beam current with an electrometer at the same time. Since there is a certain amount of residual helium in the tank and since the alpha-particle resonance and the carbon atom resonance overlap, the measurement must be done in the presence of a residual alpha beam. A plan for electrically cancelling the alpha beam pulses is being used because of its simplicity. In experiments carried out thus far, good cancellation has

been obtained except where the alpha-particles were of greatest density; that is, near the alpha resonance.

Experimental runs with standard ion sources have yielded 20,000 carbon atoms per second through a slit 0.15 inches wide. It is thought that this represents about one tenth of the actual external beam. The oscillator power was 93 kw. The carbon beam increases rapidly with oscillator power and with the voltage and power put into the arc. However, it was found that a small beam of carbon ions could be obtained without the arc being struck, although it was necessary to have the ion source filament emitting electrons and a small arc voltage applied. This indicates that the final stripping of electrons from the carbon ions may occur in the radiofrequency field between the dees, and may account for the broad resonance curve for carbon ions, extending from 287 to 292 amp. magnet current, as compared with a spread of only 1-1/2 amp. for the residual alpha-particles. The relation of the two beams is roughly as indicated in Fig. 1. To avoid the alpha-particle contamination as much as possible, the magnet current was run at the low end of the range.

A carbon ion bombardment of aluminum was made to discover if chlorine 34 could be produced in this way. Aluminum was chosen since it has only one natural isotope and the chlorine 34 may be easily identified from its 33 minute activity which is long enough to allow a separation of the chlorine fraction from the aluminum foil and still give time for the activity to be counted. A bombardment of approximately one half-life in length was made employing aluminum foil of the highest purity that could be obtained. The foil was covered by another and folded in the manner shown in Fig. 2 and mounted on the probe head. The target arrangement was such as to allow a control over the production of alpha induced

activity. The range of the sextupally ionized carbon atom is 7.8 mills of aluminum.

It was possible to start counting 70 minutes after the conclusion of the bombardment with a counting range of 280 counts per second. The counting was carried out over a period of nine half-lives and indicated the half-life of induced activity to be approximately 34 minutes. This is an upper limit since it involves no correction for background, etc. The expected half-life should be between 32 and 34 minutes. To make the identification of the activity with chlorine 34 more certain, a check was made to verify that the electrons emitted were positive and not negative. Aluminum adsorption curves were also run on the samples. The yield of the bombardment is higher than expected which might indicate a larger beam than has been assumed. Experiments will be conducted to discover if the effect is due to alpha-particle contamination of the beam.

Mesons Produced from Liquid Hydrogen. V. Z. Peterson.

Studies have been made of mesons produced in a liquid hydrogen target bombarded by the deflected 340 Mev proton beam from the 184-in. cyclotron. Fig. 3 shows the general arrangement of the liquid hydrogen target and nuclear emulsions which were used to record mesons emitted. Fig. 4 shows the general view of the liquid hydrogen target with its associated pumping system. The initial run made using a line source geometry was done with a target built for use at the synchrotron by L. Cook. Plates were exposed at 30° and 45° but the plates at 45° were not useful because of the high background resulting from insufficient shielding. Plates exposed at 30° yielded 115 π-μ decays in an area of 1.7 cm^2. Fig. 5 shows the differential cross sections as a function of meson energy

where the variation solid angles and stopping power are taken into account.

Calculations made by Taylor and Chew of the energy spectrum of mesons produced by nucleon bombarding free nucleons on the basis of scalar interaction yielded curves with broad maxima whose mean energy was approximately half the maximum energy. The results to be expected on the basis of a pseudoscalar theory have also been calculated and give a broad peak shifting slightly toward higher energy. The experimental energy spectrum differs markedly from these theoretical predictions in that the peak is very sharp and occurs at the upper end. Chew has suggested the explanation that at the low final nucleon energy involved the proton and neutron cannot be treated as free particles. Since the mesons take most of the 20 Mev kinetic energy available in the center of mass system, the proton and neutron each have only about 1 Mev kinetic energy. At these energies the n-p scattering cross section is large and this strong interaction at low nucleon energies increases the probability that the corresponding high energy mesons will be emitted. Calculations based on this assumption give good agreement with the observed energy spectrum. It is believed that the energy resolution of the experimental arrangement is about 3 Mev which combined with the uncertainties of the proton beam energy and meson mass make it difficult to determine the values of the upper energy meson limit within 5 Mev.

Another set of measurements were made with a point source in order to better define the target thickness and improve the angular resolution. In order to improve the statistics and to cut down the background of scattered protons a sorting magnet was interposed between the source and the target. Again, mesons emitted at an angle of 30° to the beam

were measured. Fig. 6 shows the apparatus in place in the proton cave of the 184-in. cyclotron.

From a count of the number of mesons ending in a 1 mm wide strip of constant beam distance from the incident edge of the plate a plot of the number of mesons per mm strip as a function of distance gave rise to a range distribution which was converted into a plot of the differential cross section vs. meson kinetic energy as shown in Fig. 7. Absolute values are assigned from a knowledge of the charge collected by the ion chamber, the target thickness, and the solid angle energy intervals assigned by the geometry. A correction was introduced for the decay of the π-μ mesons in flight and the effects of the fringing magnetic field in the initial portion of the orbit of the meson. The results show the sharp peak in the spectrum at the higher meson energy in agreement with the line source experiments. The width of the peak at half maximum is slightly broader and the height of the peak is lower than those of the line source experiments. However, the cross section integrated over energy from 32 to 70 Mev is almost identical with the integrated value for the line source run, namely 7-1/2 x 10^{-29} cm^2 per steradian.

A measurement of the angular distribution of the μ meson resulting from π-μ decay was also measured in the experiments in an attempt to discover any possible asymmetry in the distribution. The results do not show the expected isotropic distribution within statistical errors.

A detailed discussion of these experiments may be found in report UCRL-713.

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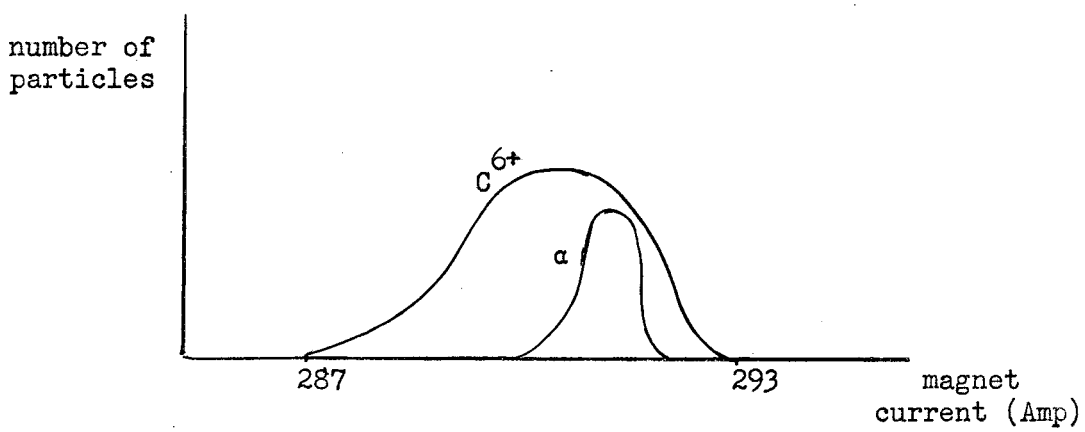

number of particles
C^{6+}
α
287
293
magnet current (Amp)

Fig. 1

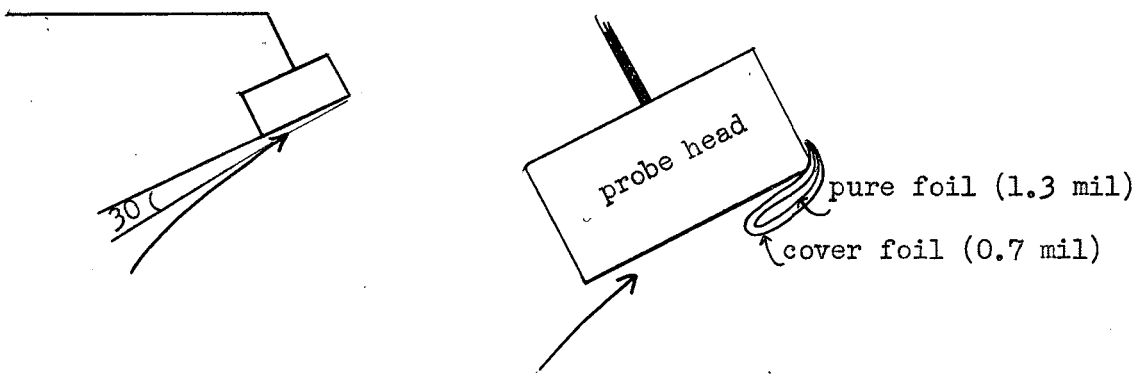
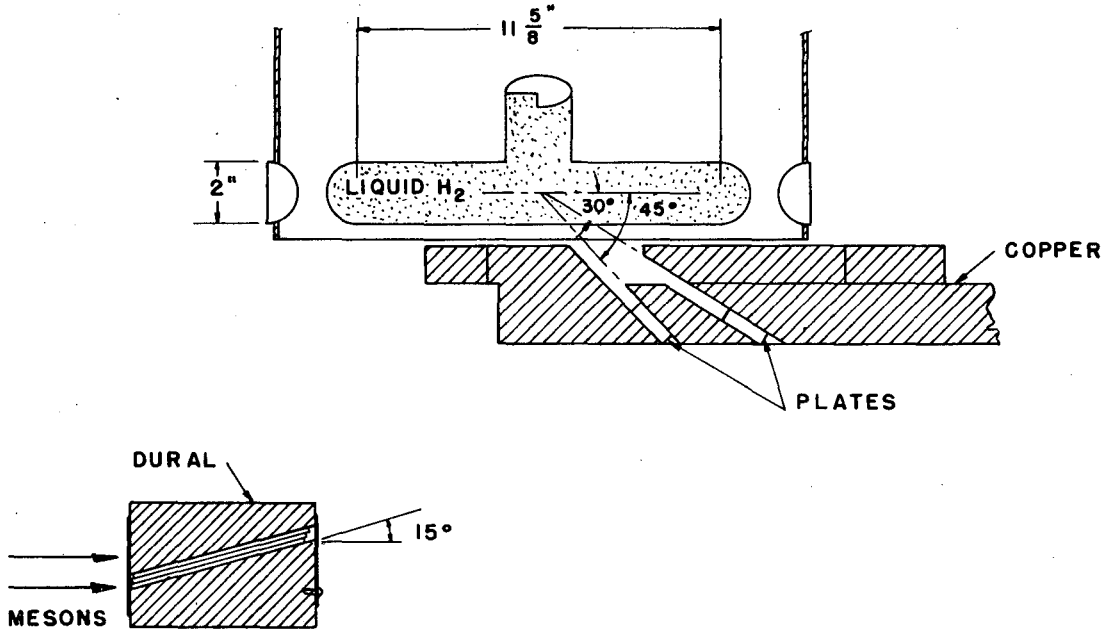

30°
probe head
pure foil (1.3 mil)
cover foil (0.7 mil)

Fig. 2



MU 278

LINE SOURCE GEOMETRY

Figure 3

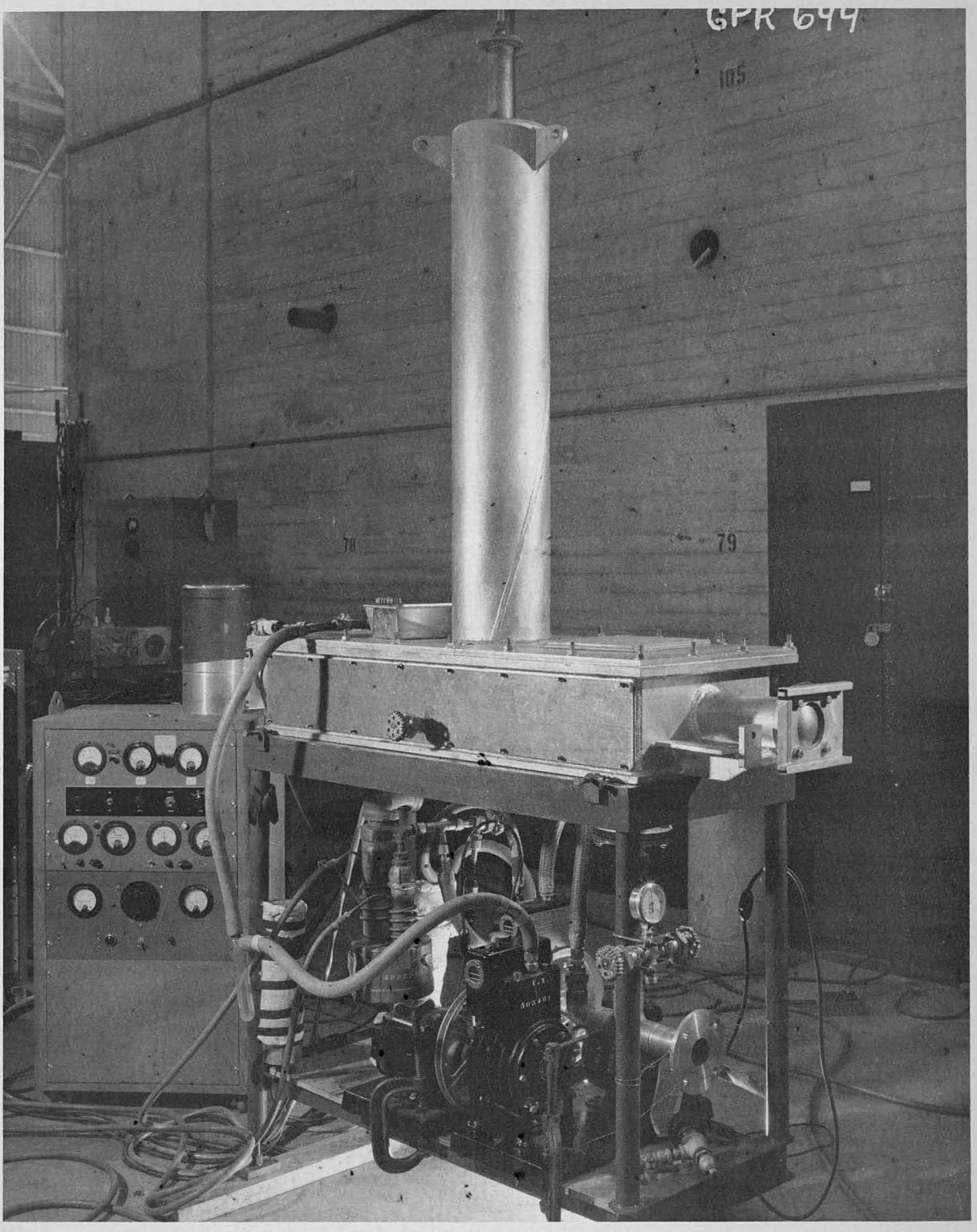


FIG. 4

LIQUID HYDROGEN TARGET WITH PUMPING SYSTEM

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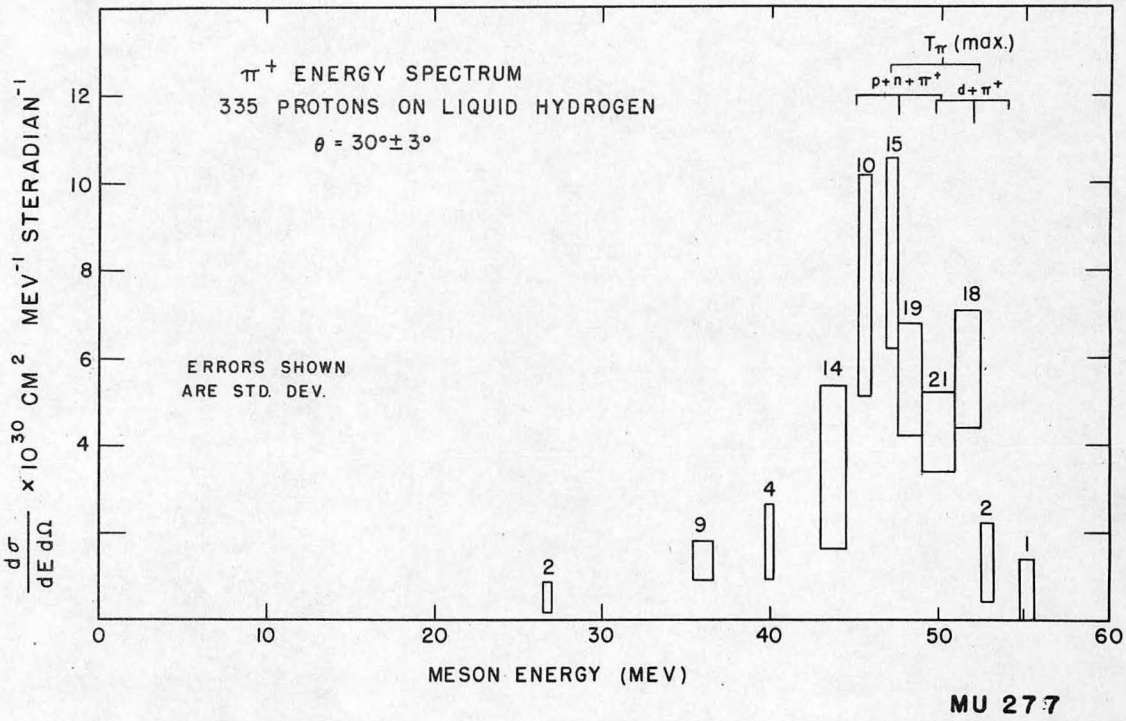


CROSS SECTION vs. MESON ENERGY AT 30° (LINE SOURCE)

Figure 5

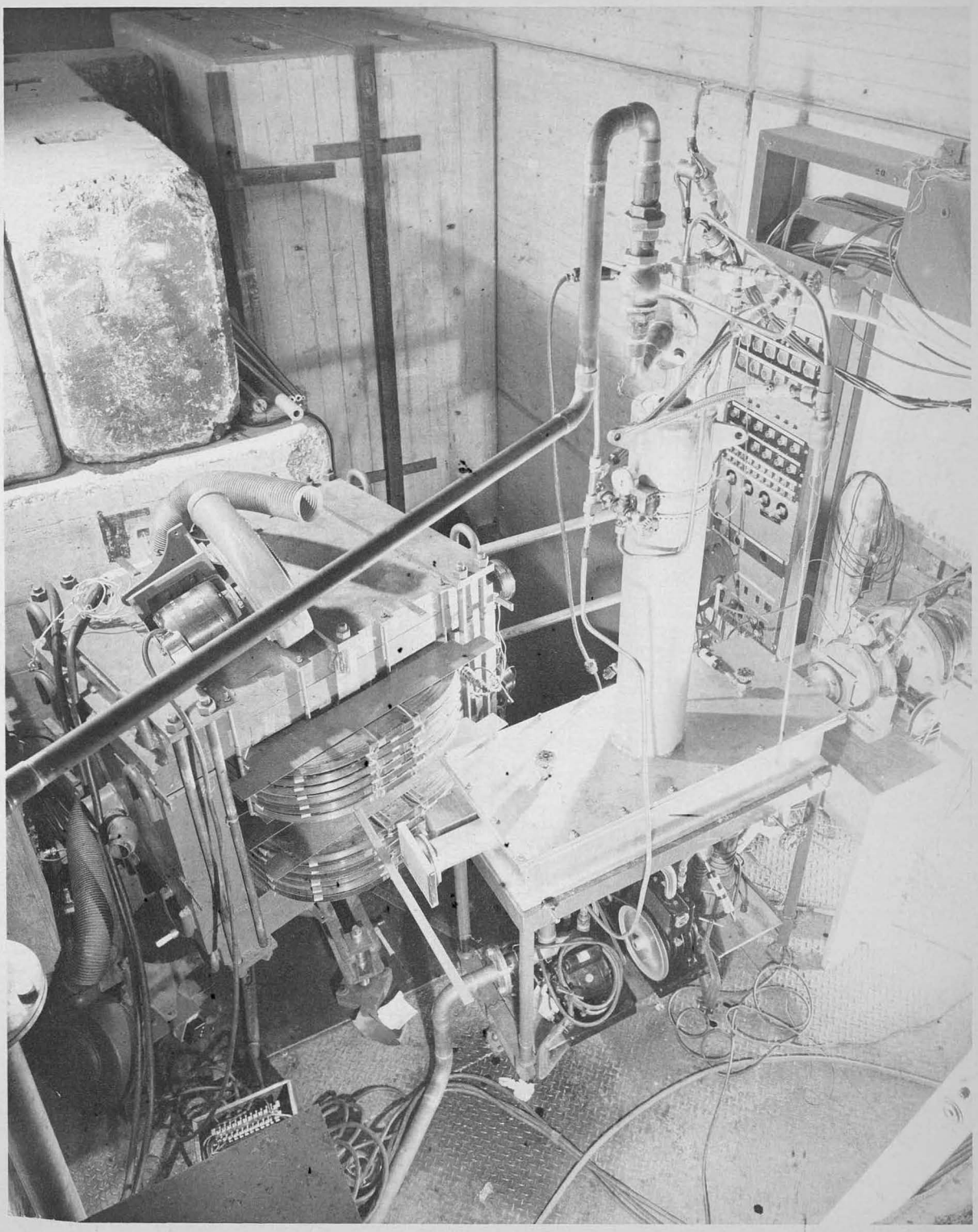
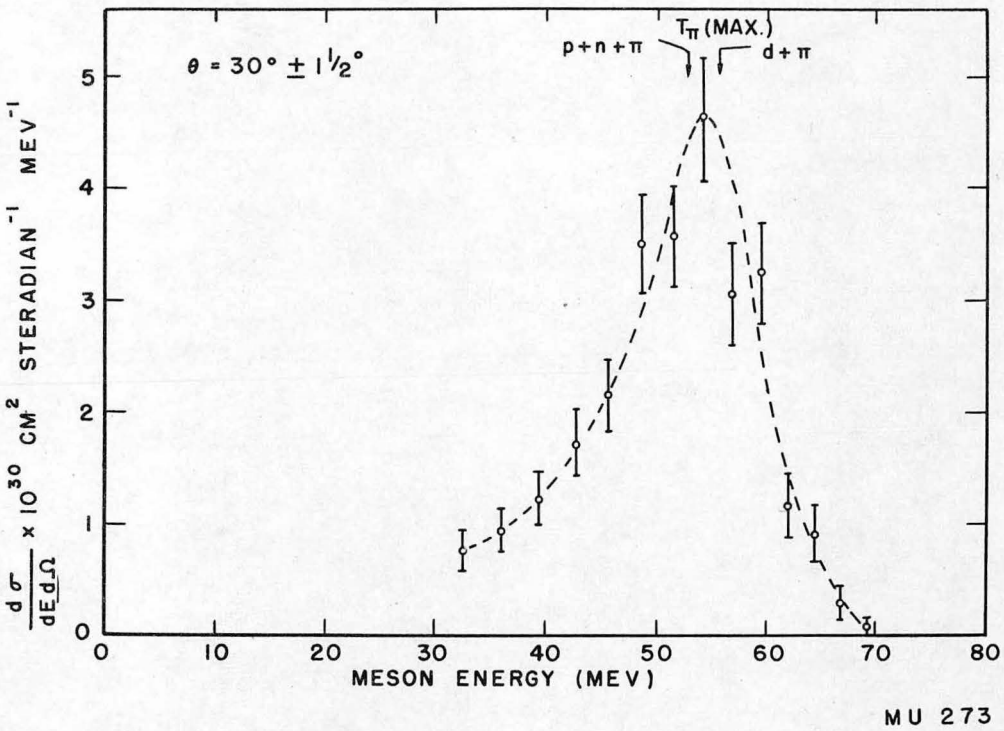


FIG. 6

TARGET IN PLACE, SHOWING FILLING AND VENTING SYSTEM

OZ 913



CROSS SECTION vs. MESON ENERGY AT 30° (POINT SOURCE) 14971-1

Figure 7