DEPTH DOSE MEASUREMENT OF NEGATIVE PIONS IN WATER

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ABSTRACT

A pion spectrometer(Q_1-Q_2-D-Q_3 type) has been constructed as the ETL pion channel to study depth dose distributions of negative pions in tissue equivalent materials (water). The depth dose peak were observed, and the peak position in water can be controlled by changing the thickness of the aluminum absorber placed in the entrance of the water bath.

I. INTRODUCTION

Recent interests in the applications of pion beams have allowed to radio-therapy due to the production of highly localized ionization induced by "star" formation. A pion spectrometer (Q_1-Q_2-D-Q_3 type) has been constructed as the ETL pion channel (1,2,3) to study depth dose distributions of negative pions in tissue equivalent materials.

II. ETL PION CHANNEL

A schematic layout of this channel is shown in Fig.1. A lead shield plate with an elliptical hole is set between a copper target and the inlet of the pion channel. The function of the first and second quadrupole magnets, Q_1 and Q_2, is to achieve large solid angle of 0.12 sr.. A lead absorber having an elliptical cross section with respect to axis of Q_1 Q_2 is set between Q_1 and Q_2 to reduce photoneutrons and X-rays, while the effective solid angle is reduced to 0.09 sr.. The focal plane of charged pions is designed so as to cross the center of the small quadrupole magnets Q_3. The vertical focusing is provided by the edge focusing of the bending magnet D and Q_3. The electron beam from a linear accelerator (TELL) is directly transported to the pion laboratory and is focused to the center of a π-target (copper) shown in Fig.1. The effective volume of the target is about 1.5cm $\times$ 2 cm $\times$ 2 cm. The target is set in front of the beam

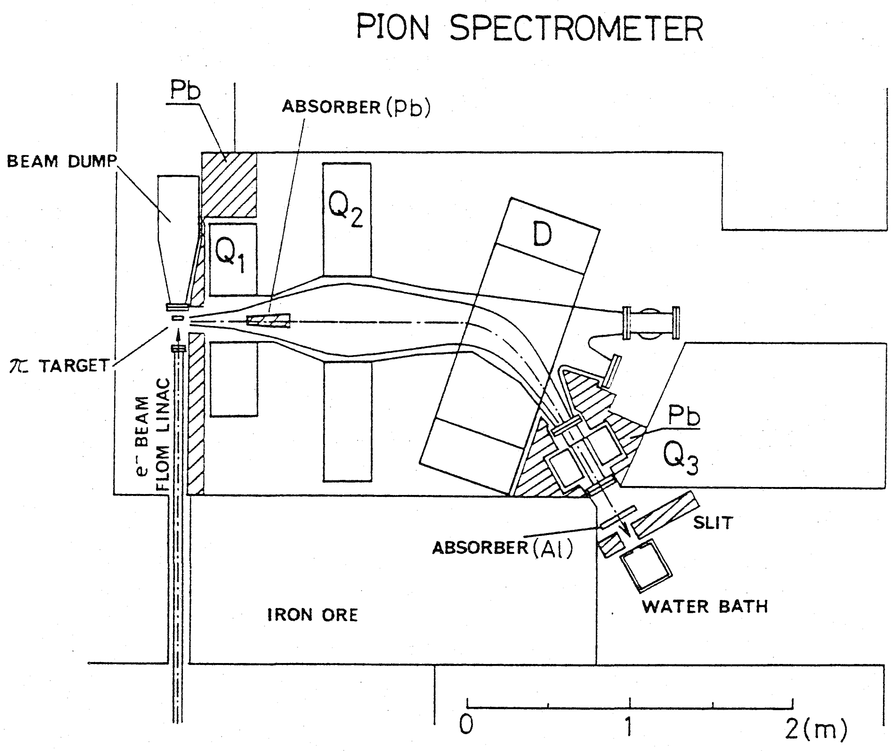

Fig.1 Layout of the ETL pion channel.

dump consisting of a tank filled with water, it is combining a Faraday cup for measurement of the electron beam current. The target and the Faraday cup are cooled with circulating water. The size and position of the electron beam are controlled by a focusing system and are watched by observing transition radiations from a thin aluminum plate attacked on the front surface of the target with a TV set.

The beam was always controlled to become a sise of the order of 5 mm ¢. The irradiated electrons generate high energy X-rays in the target and the X-rays produce pions, neutrons, electrons and positrons in the same target. About 70 % of the irradiated electron beam passed through the target and was captured by the Faraday cup. Of the ionizing radiations produced in the target, some of radiations scattered in near 90° direction with respect to the electron beam direction can pass through the elliptical hole of the lead shield plate set between the target and the pion channel. Some of charged particles such as charged pions(π^- and π^+), electrons and positrons are focused by Q_1 Q_2 and can pass through the Q_1 Q_2 channel, keeping away the lead absorber. Some of non-charged particles such as X-rays, neutrons and π^0 are absorbed or scattered by the absorber set between Q_1 and Q_2. π^- and π^+(135 MeV/c ± 5 %) from the copper target can be focused to a beam size of 3 cm × 3 cm on the focal plane by changing the direction of magnetic field of D.

III. DEPTH DOSE DISTRIBUTIONS OF PIONS

In the depth dose measurement, depth dose distributions of negative and positive pions in water have been measured using thermoluminescence dosimeters (TLDs, Mg_2SiO_4:Tb) as small size dose detectors. Figure 2 shows depth dose distributions of π^- in water. In the depth dose distributions of π^-, remarkable dose peaks have been seen near the range of π^- in water. These dose peaks are due to star formations, which is induced by heavy ions and protons scattered at the disintegration of π^-. The position of depth dose peak in the water bath can be controlled by changing the thickness of the aluminum absorber placed in the entrance of the water bath. Since the position of dose peak is determined by the total range of π^- in both water and the absorber. The absorber also functions as a scatter for electrons with the same momentum as π^- passing through the pion channel, since the electrons can be easily scattered by the absorber, compared with charged pions. No significant dose peak has been seen in the depth dose distribution of π^+ in water. Details on pions yield efficiencies and their electron energy dependence are discussed in else where.

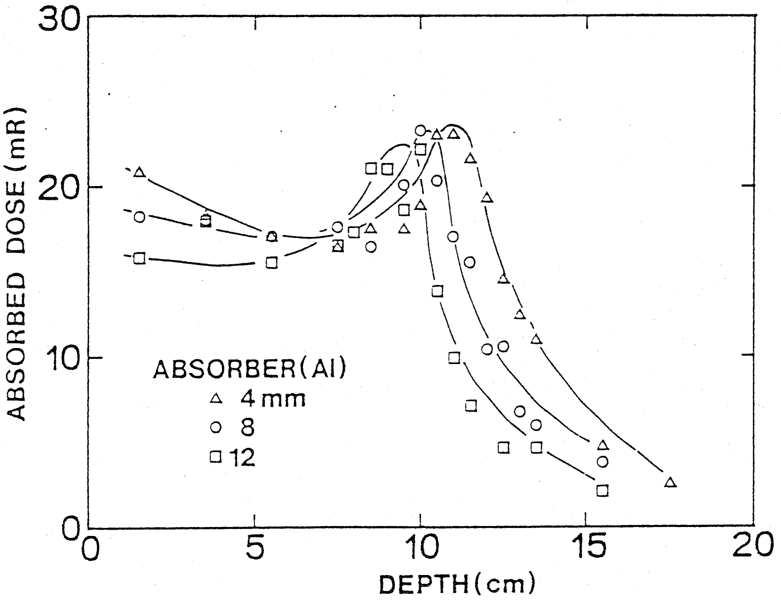

Fig.2 Depth dose distribution of π^- in water and control of the peak position of depth dose by changing the thickness of the aluminum absorber.

References

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