PRELIMINARY MEASUREMENTS OF NEGATIVE PION BEAM PROFILES
USING MULTIWIRE PROPORTIONAL CHAMBERS

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The energy deposited by a beam of negative pions has a distinct distribution as a function of depth in the absorber. The maximum dose is located near the end of the pion range where the large ionization loss under the Bragg peak is coupled with the absorption of pions by the adjacent nuclei. The shape of the depth-dose distribution strongly depends on the incident momentum \( p \) and momentum spread \( (dp/p) \) of the beam \( 1,2 \). Experimentally these parameters are easily determined and controlled by current adjustments in bending magnets.

The transverse dimensions of the dose region depend on the position, profile, and convergence (i.e. focus) of the incident beam. Previously these parameters have been measured by passing finger-shaped ionization chambers through the beam and also by photographic film exposures. The disadvantages of film are the relatively long time for exposure, therefore washing out any drift effects in the beam, and the delay encountered in having to develop the film. Current techniques for sweeping chambers or scintillators through the beam are also time-consuming (approximately 1 minute for each coordinate) and they introduce material into the beam which presumably distorts the image.

Ideally one would prefer a system which gives simultaneous readouts of the position and size of the beam with minimum interference in the beam. Wire spark chambers appear to have suitable characteristics for rapidly identifying the location and shape of high energy particle beams. Thus, during the tune-up
period preceding a recent irradiation of bean roots, preliminary investigations were made on the feasibility of multiwire proportional chambers for beam profile monitors.

The chambers were of the Charpak variety. A similar system has been described in detail elsewhere. Basically this arrangement consisted of two identical chambers mounted with their wire planes parallel. Each chamber supported 32 wires, one with wires running vertically, the other with wires running horizontally. The wires were made of molybdenum, 30 microns in diameter and spaced 3 mm apart. Two grids of stainless steel made with 50 micron wires, and with a transparency of ∼80% were mounted on each side of the frame at a distance of 8 mm from the wires. Each chamber was closed by two mylar sheets, 6 microns thick. The effective chamber cross-section was 100 cm x 100 cm.

These chambers were mounted directly on an amplifier box which contains a separate amplifier for each wire. A gated input, together with a 5 digit integrated circuit scalar was provided for each channel. A scanning system reads the counters of all 64 scalars automatically without affecting the counting. During the scanning, each channel number and its contents are both converted into analog voltages. The voltage corresponding to the channel number is applied to the X-axis of an oscilloscope, and the voltage corresponding to the channel content is applied to the Y-axis. The scalar contents are displayed at the rate of 1 kHz.

The first half of the oscilloscope corresponds to the vertical wire chamber (horizontal profile); the second half corresponds to the horizontal wire chamber (vertical profile).

The chambers were continuously flushed with a mixture of Ar and 6% CO₂. The grids were maintained at a negative d.c. voltage of -3000 V. Total amount of material crossed by the particles is ∼40 mg/cm².
RESULTS

Laboratory tests of chamber response were made with a 1 mCi $^{55}$Fe source. A typical output scan is shown in Fig. 1 with the source located near the center of the first chamber. The horizontal separation between each dot represents 3 mm in real space. The difference in peak height is due to the attenuation of the 6 keV X-ray by the first chamber. The response of each chamber was found to be identical by first sweeping the source across one chamber and then the other.

The apparatus was then moved into the experimental hall of the 70 MeV pion channel at the CERN SC (Fig. 2), and mounted immediately downstream from the beam intensity monitor. Figure 3 shows the profile of the first pions passing through the channel. The beam corresponds to a counting time of approximately 1 second. This beam is focused vertically in the center of the chamber, but with little focusing in the horizontal plane.

Beam current was then improved by adjusting LC5, LC6 and MC2 until the output of the intensity monitor maximized. This was later calculated to be $6.0 \times 10^5$ particles/sec with an energy of 96 MeV$^5$. Focusing of the beam was achieved by adjusting quadrupoles LD5, LD6. Figure 4a-b shows the focusing effect of two separate magnet settings with the chamber located as before.

Figure 5a shows the profile of the final beam taken adjacent to the integrator. The chamber was then moved downstream ($\sim$ 30 cm) to the exposure position and a beam profile measured. A comparison of Fig. 5b and 5a gives an indication of the convergence of the beam. These results were later compared with density measurements of photographic film. The agreement was very good.

Additional experiments were performed by sweeping the beam with the horizontal bending magnet MC2. The position of the beam was easily followed across the chamber.
CONCLUSIONS

The multiwire proportional chamber offers a convenient method for making rapid measurements of beam profiles and positions, with a minimum of interaction with the beam. Improved readout systems could continuously monitor the beam during an irradiation, and conceivably even send corrections back to the beam focusing elements.

Longitudinal displacement or a set of chamber systems along the beam axis could also yield information about the focusing properties of the beam.

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REFERENCES


RESPONSE OF MWPC TO 1mCi $^{55}$Fe PLACED AT CENTER OF FIRST CHAMBER

*ALL DRAWINGS ARE MADE FROM POLAROID PHOTOGRAPHS TAKEN OF OSCILLOSCOPE SCREEN. FULL SCALE = 100000 COUNTS*
PROFILE OF INITIAL \( \pi^- \) BEAM IMMEDIATELY DOWNSTREAM FROM BEAM INTENSITY MONITOR
FIG. 4

PROFILES OF $\pi$-BEAM WITH DIFFERENT SETTING OF FOCUSING ELEMENTS LD5 LD6
PROFILE OF $\pi^-$ BEAM; (a) ADJACENT TO BEAM INTENSITY MONITOR, (b) 30 cm DOWNSTREAM FROM BEAM INTENSITY MONITOR