

A "SPECIAL" HIGH INTENSITY PION BEAM

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I. Introduction

We discuss here "special" high intensity pion beams which are based on the following design criteria:

- 1) The highest intensity possible
- 2) Large $\Delta p/p$
- 3) Spot size $\leq 1/4$ in. $\times 1/4$ in.
- 4) The spatial definition of the pion beam can be determined by size of the target.

Based on these criteria we suggest a possible beam arrangement. This beam is suitable for the study of particle production at high transverse momenta. It is also suitable for the production of pion-induced tertiary beams such as a K_0 beam which would be relatively free of neutrons. These beams would not be suitable for more traditional applications such as total cross sections, elastic scattering, small angle inclusive studies, etc.

II. Yields

We have used the formulae of C. L. Wang for the invariant pion production cross sections. These fit all existing data from the AGS, CERN, and ISR within a factor 2 and explicitly make use of scaling. Figure 1 shows the invariant cross section $E d^3\sigma/dp^3$ for π^+ and π^- production at $p_{\perp} = 0$. The proton cross sections were obtained from the report of Sens at the XVI International Conference on High Energy Physics (Chicago and Batavia, September, 1972).

Figures 2 and 3 show the possible yields of π^+ and π^- mesons respectively for infinite solid angle, 12 μ sr and 3 μ sr. The natural collimation of these beams is clear from the fact that a major fraction of all the pions produced are collected with a 12 μ sr solid angle.

For a positive pion beam the contamination of protons will be one to one at 80 GeV and greater than 10 to 1 for energies greater than 220 GeV. This contamination is too large for the positive beam to be used for the purposes stated above, namely particle production by pions, and neutron free K_0 beams. Therefore, we concentrate our ideas on a negative pion beam.

III. Proposed Beam

Figure 4 shows the proposed beam. The quadrupole triplet focuses the pions from the production onto a secondary target. For 200 GeV the gradients required are ~ 6 kG/in. Since the beam is designed only for negative pions, a very small dispersion is required to separate the negative pions from the primary protons. The nominal deflection of the pions is 1.8 in. at 75 ft from the dispersing magnet. Using the beam for pions from 100 GeV to 300 GeV causes the proton beam to be deflected by 0.45 in. and 1.35 in. respectively. The triplet lens also tends to refocus the primary beam. If the emittance of the beam is less than 0.5 mm-mrad, then there should be no difficulty with the tails of the primary beam striking the secondary target.

The size of the secondary spot is dominated by chromatic aberration of the lens due to the large momentum spread of the desired pion beam. Figure 5 shows the projected spot sizes at the position of the secondary target due to chromatic aberration. Folded into the size should be a 2-mm diameter image due to a 1-mm diameter primary spot. We neglect this size in the foregoing considerations. Figure 6 shows the approximate solid angle vs $\Delta p/p$ for the proposed beam, for targets of 0.2-in. V \times 0.3-in. H and 0.1-in. V \times 0.2-in. H. At 200 GeV/c one would have yields of $1.9 \times 10^{-3} \pi^-$ /proton and $1.1 \times 10^{-3} \pi^-$ /proton respectively.

IV. Physics

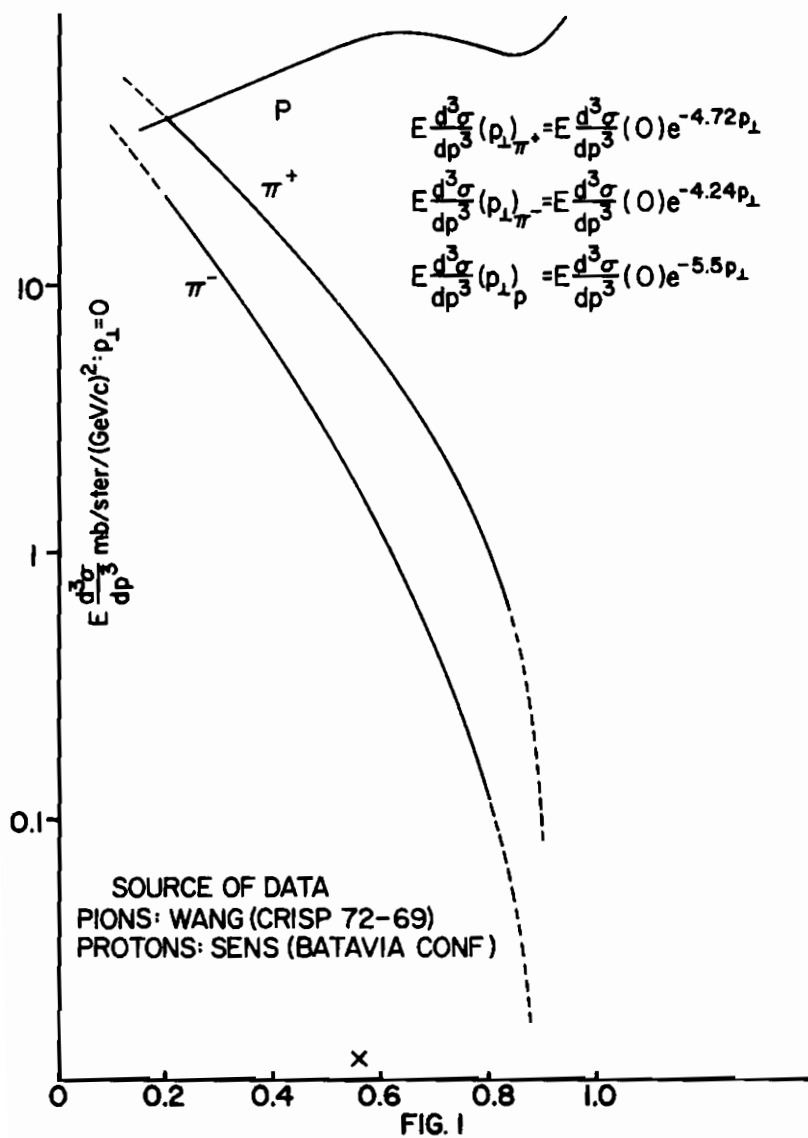
Our physics motivation is to study the production of particles at high transverse momentum with pions replacing protons. If there is any sense to the notion of quarks or partons it would seem that replacing incident protons by pions should lead to significant differences in the ratios of secondary particles produced as well as the shape of the transverse momentum distribution. Also direct muon production might be enhanced because of the definite anti-parton content of a pion beam. Figure 7 shows some preliminary data obtained with protons striking a 1/8-in. diameter tungsten target. The mean intensity was 1.5×10^{11} protons/pulse and the counting rate at 7.5 GeV/c was ~ 5 counts/hour. With a pion beam $\sim 10^{10}$ /pulse we might expect to reach the same sensitivity with runs of 10 hours.

V. Where To Install?

There are many possibilities. The pion beam is 200-ft long and the spectrometer that follows is 300 ft, so 500 ft of linear space is required. Such a beam could be fitted into the present Proton Center Lab with the requirement that 300 ft of new tunnel be built downstream for the spectrometer at 80 mrad. A pion beam and 90° c.m. spectrometer is very much in scale with many experiments and cannot be considered an extraordinary development.

VI. Acknowledgments

The author appreciates numerous discussions about pion beams with Bradley Cox. A conversation with Roy Rubinstein was particularly valuable in formulating the present proposal.



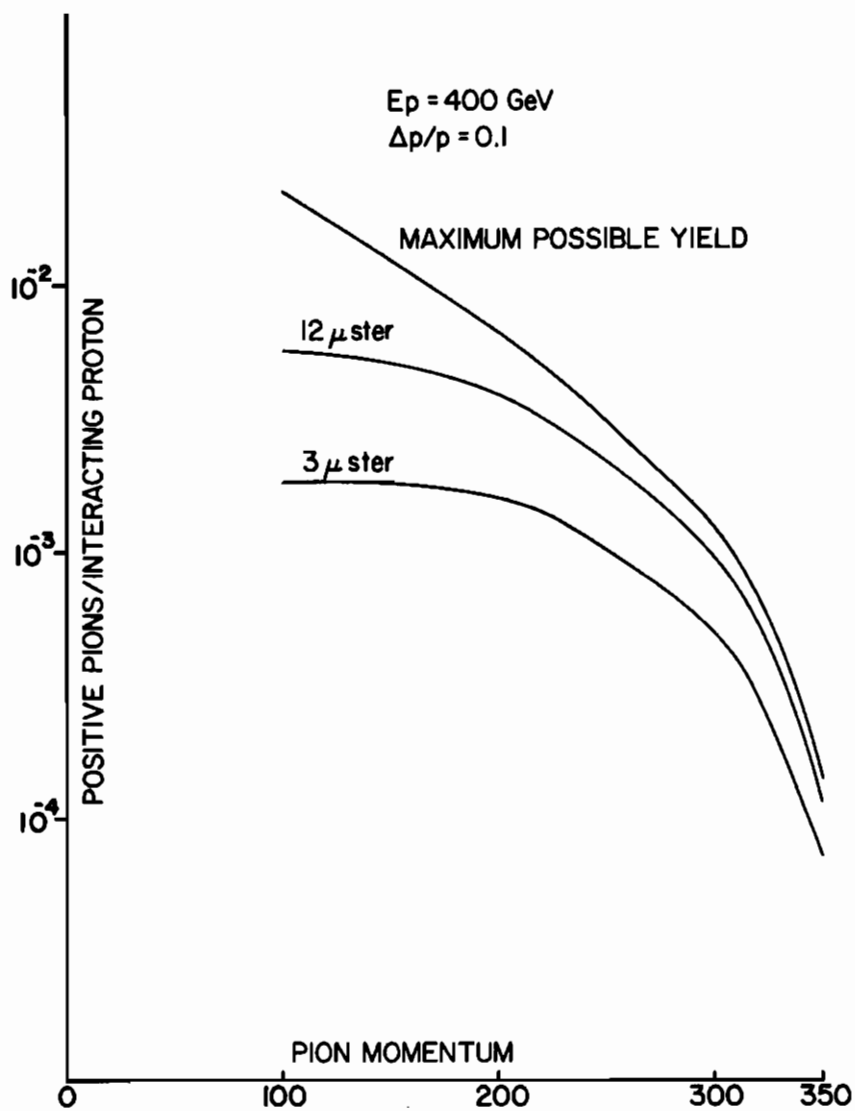


FIG.2

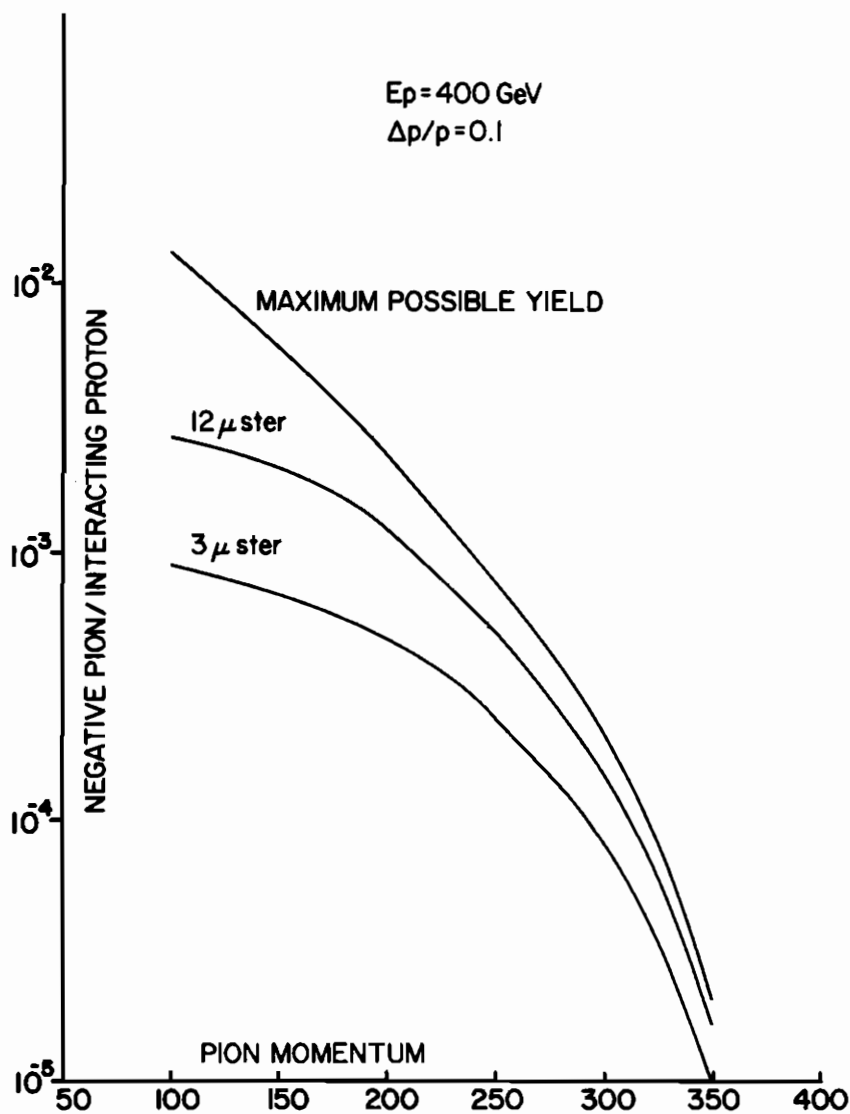


FIG.3

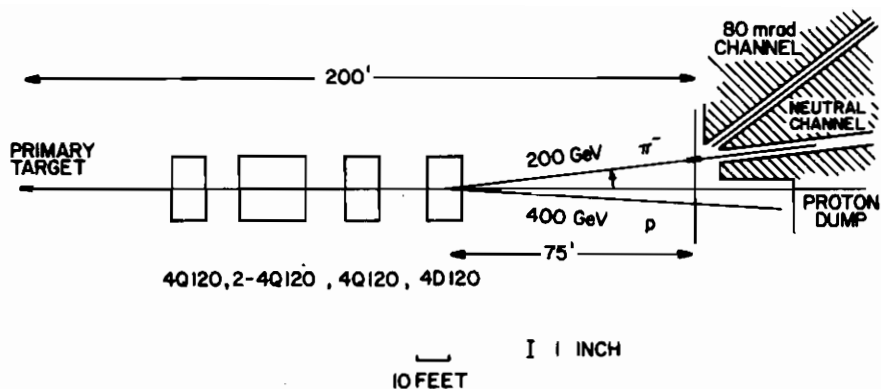


FIG. 4

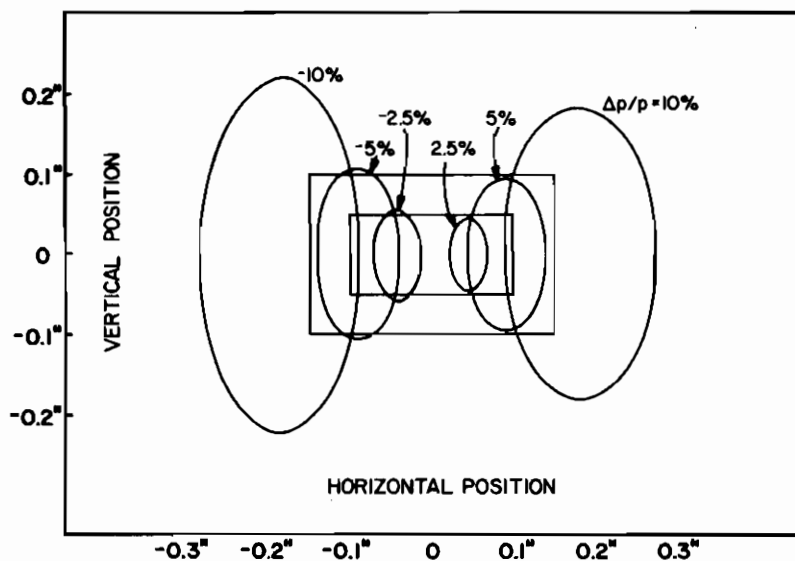


FIG. 5

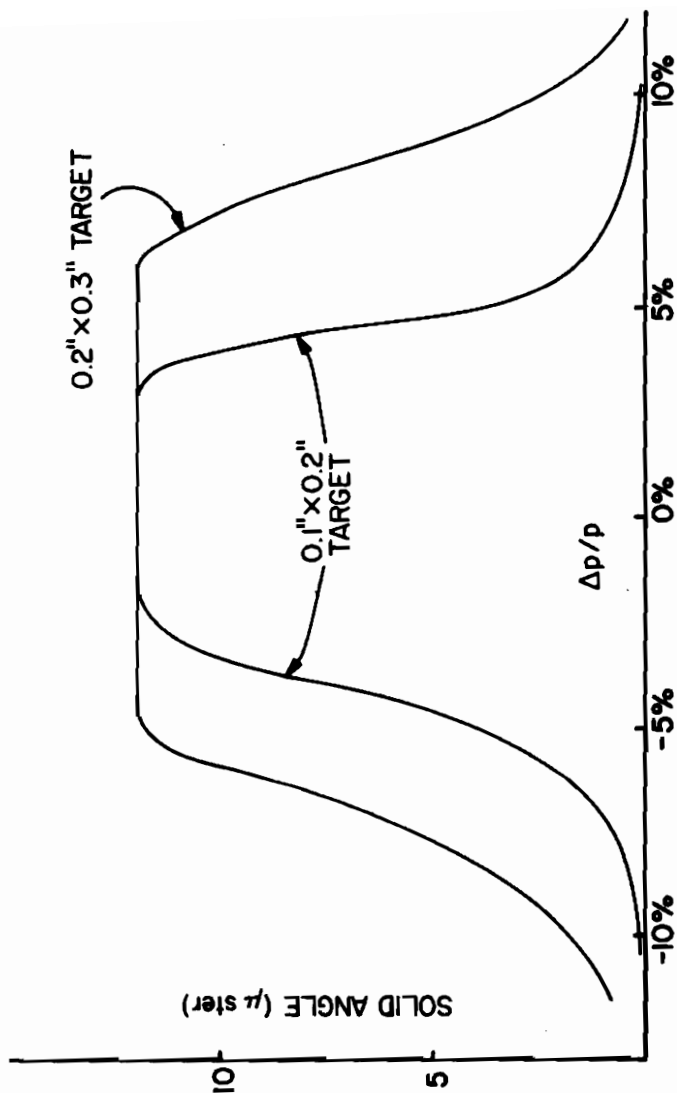


FIG. 6

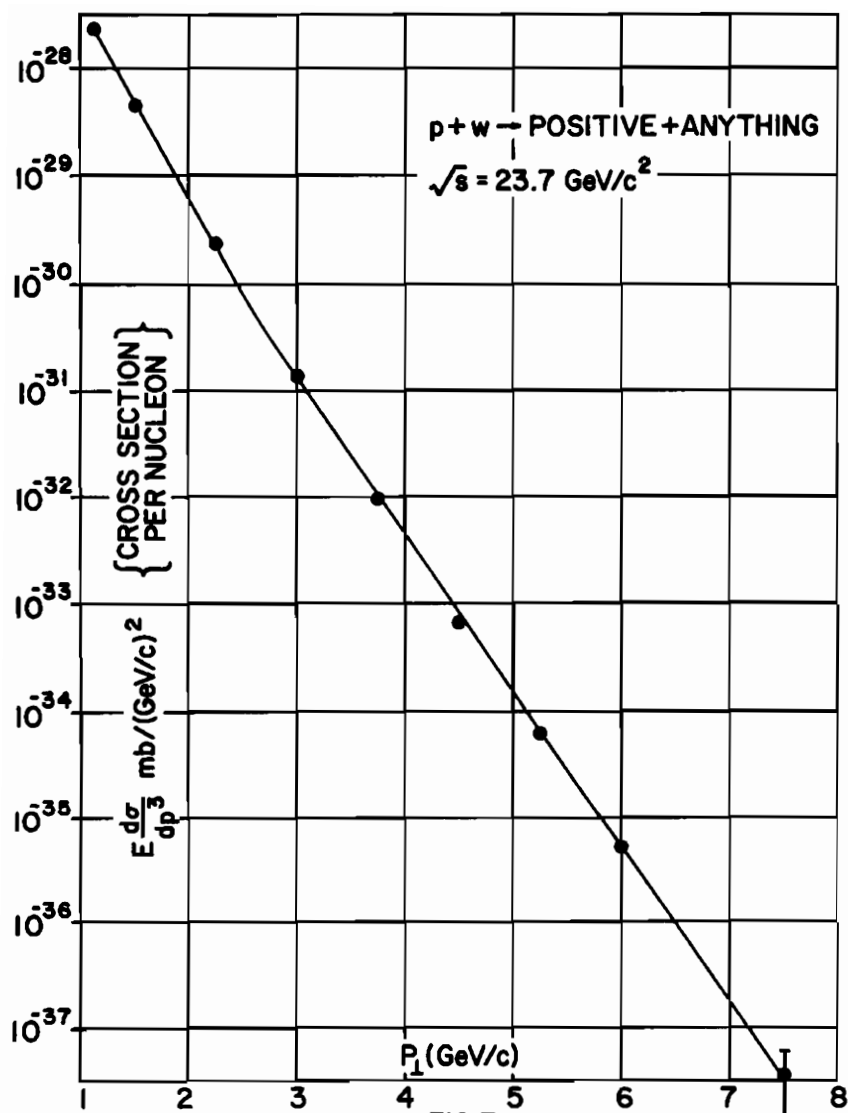


FIG. 7