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A MAGNETIC SPECTROMETER USING SPARK CHAMBERS TO OBTAIN LARGE SOLID ANGLE AND HIGH RESOLUTION IN π-π INTERACTION STUDIES

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A MAGNETIC SPECTROMETER USING SPARK CHAMBERS TO OBTAIN LARGE SOLID ANGLE AND HIGH RESOLUTION IN π-π INTERACTION STUDIES†

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An important technique used in the study of elementary particles involves the analysis of final-state correlations between pions produced in pion-nucleon interactions at high energies. In order to describe adequately the unstable "particles" produced, the invariant multipion mass, the momentum transfer, and the missing mass must be determined to within a fraction of the pion mass. Therefore, the energy-momentum balance involving the incident pion and final-state particles must be accurately measured.

In this work a large-aperture magnetic spectrometer employing spark chambers coupled with a large bending magnet has several important advantages:

(a) The size of the overall system is not restricted severely, so that full advantage may be taken of the analyzing power of the magnetic system.

(b) The amount of material put in the path of charged particles may be kept very small, limited to a few foil plates in those places where position measurements are needed.

(c) The use of a selective counter system in a relatively intense pion beam leads to a very rapid accumulation of useful data.

Figure 1 shows a schematic view of a system constructed to analyze final-state particles from $\pi^{\pm}$-p interactions at the Bevatron in the 2- to 5-BeV/c

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momentum range. The momentum of the incident π meson is determined by a spectrometer consisting of two small four-gap spark chambers placed 5 ft apart, followed by a deflecting magnet and another set of two spark chambers also 5 ft apart. The spatial resolution of the spark chambers, of about 1 mm, enables the direction of the meson entering and leaving the magnet to be determined to better than 0.6 mrad. The deflection in the magnet is approximately 0.23 rad. Thus the initial momentum is determined to approximately 0.3%. The error introduced by Coulomb scattering in the plates of the chamber is smaller than this for 90% of such scatterings.

After passing through this first momentum spectrometer the π mesons interact in an 11-in.-long liquid-hydrogen target. Two ten-gap spark chambers, before and after the target, are used to measure the incident and final-state particles, respectively. These chambers permit the interaction vertex inside thehydrogen target to be located to within about 1 mm. In addition, they give a fairly good measure of the relative production angles of the final-state particles. Like the beam-defining chambers, these chambers are made of 0.002-in. aluminum foil sandwiched between 3/8-in. Lucite picture frames.[1] The beam-defining chambers are 5 by 9 in. in active area. The first ten-gap chamber is 5 by 5 in. and the second, 10 by 24 in.

The momenta of the final-state mesons are measured with a second spectrometer. After the mesons produced by interactions in the target pass through the second ten-gap spark chamber, they enter a large deflecting magnet and are finally detected in four large spark chambers extending to a distance of 6 ft behind the deflecting magnet.

Given the final position and direction of a particle, the location of the production vertex in the hydrogen target, and the production angle, a once-overdetermined measurement of the momentum is obtained.

The second deflecting magnet operates at approximately 10 kG. With a 23-in. gap the vertical acceptance of the second spectrometer is ±8 deg around the beam direction. The horizontal acceptance is ±40 deg, so that the total laboratory solid angle subtended at the target is 0.36 sr.

The four chambers behind the magnet each have four gaps, 4 by 8-1/2 ft in area. These chambers are made by bonding 0.003-in. Al foil to Al frames. The frames are suspended in a gas-tight box with sides made of 0.007-in. Mylar. A stereo view of these chambers is given by mirrors below the chambers tilted at 6 deg to give an effective stereo angle of 12 deg. A wrap of scintillation counters around the downstream spark chambers is used in coincidence with several counters along the incident beam to initiate the trigger for the spark chambers.

All chambers are filled with a 10% helium — 90% neon mixture. They are continuously flushed at a low rate. The voltage pulse is 15 kV, triggered by spark gaps which in turn are triggered by a master spark gap which derives its pulse from a vacuum-tube amplifier using an EIMAC 4PR60A tetrode. All of the spark chambers are viewed by a single 35-mm camera which can be recycled in 40 msec, thus allowing approximately ten pictures to be recorded per Bevatron pulse.

REFERENCE

1. D. I. Meyer and K. M. Terwilliger, Thin-Foil Discharge Chambers, in Proceedings of an International Conference on Instrumentation for High-Energy Physics, Berkeley, 1960 (Interscience Publishers, Inc., New York, 1961).

FIGURE LEGEND

Fig. 1. Schematic of experimental layout.

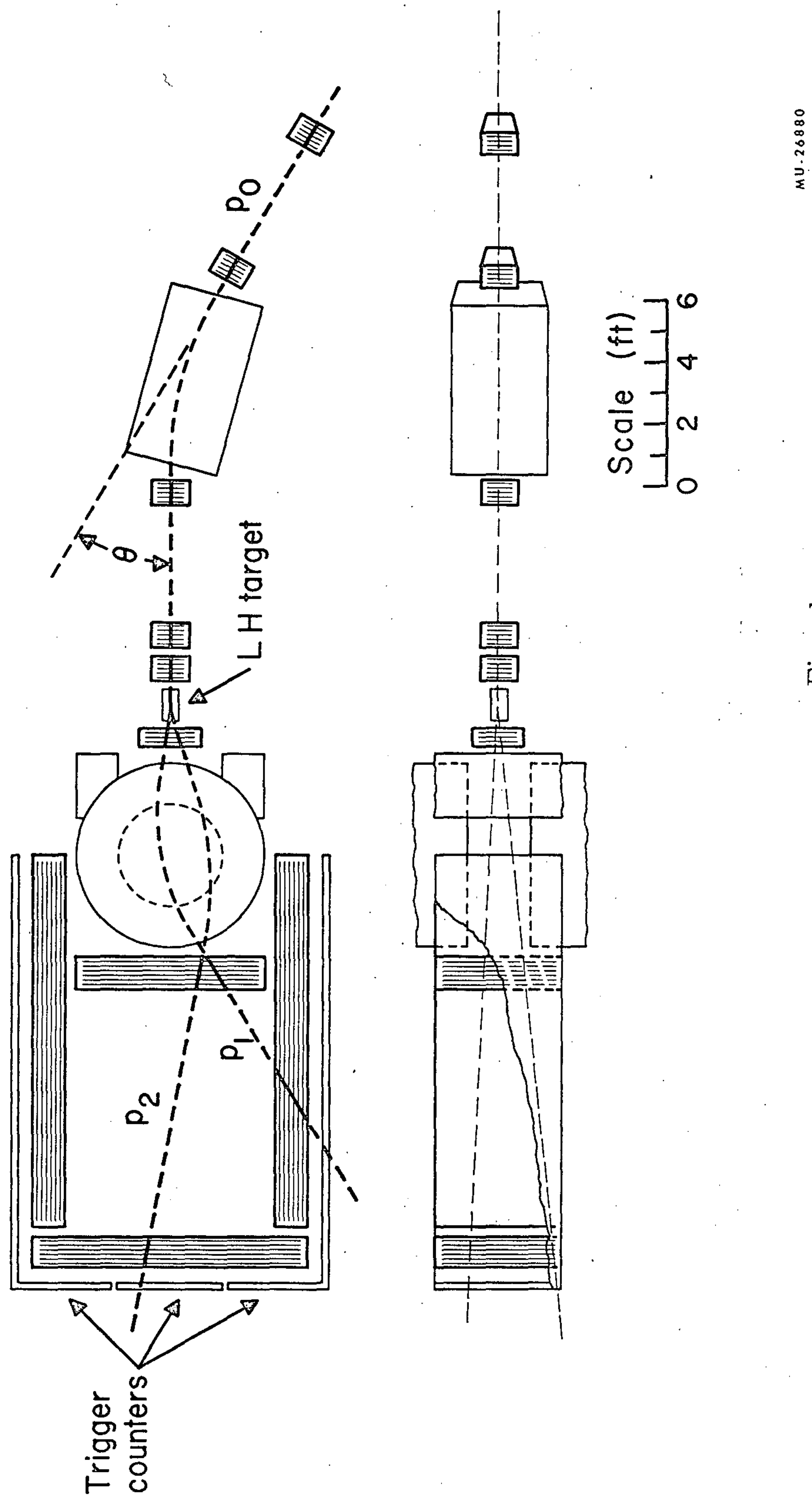

Fig. 1