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MASTER

A Search for Massive Particles Produced in Interactions at 30 BeV*

P. Franzini, B. Leontic, D. Rahm and N. Samios
Brookhaven National Laboratory, Upton, New York

M. Schwartz
Columbia University, New York, New York

We report here the results of a search for moderately stable negatively charged particles in the mass region of 2.5 - 5.0 BeV, produced in collisions of 30 BeV protons with tungsten nuclei at the Brookhaven A.G.S. The unitary symmetry[1] model of strong interactions has received an impressive amount of experimental confirmation.[2] This in turn has stimulated a great deal of speculation concerning the origin of such a symmetry, leading to the postulation of fundamental triplets of particles.[3,4] Searches for massive fractionally charged particles have thus far yielded negative results.[5] The present experiment was motivated by the conjectures of Gursey, Lee and Nauenberg[4] in which the fundamental triplets have integral charge and masses large compared to that of the nucleon. The limitations on the sensitivity of this search were determined by the maximum available machine energy and experimental background.

The experiment was performed in the high energy separated beam[6] at the A.G.S. using momentum analysis and time of flight measurement

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to detect the presence of heavy particles. An internal tungsten target was used with the beam emerging at an angle of 7^{o} with respect to the circulating beam. The beam aperture was 4.8×10^{-5} steradians and the momentum was 7 BeV/c. The beam had two stages of separation with the time of flight stations being placed just after the first mass slit and at the end of the beam; this distance was about 190 feet. The total length of the beam was 420 feet. The time resolution of the electronics was less than one (1) nanosecond. For a particle of 3 BeV mass, the time of flight difference with respect to pions is 17 nanoseconds.

The system was tuned to yield as large a rejection of π's and $\bar{p}$'s as possible and yet transmit a large band of masses. This was accomplished by opening the mass slits to $\sim$ 1/2" which corresponds to the maximum vertical acceptance of the 2nd stage of the beam. The voltages on the separator plates were adjusted to bring the π and $\bar{p}$ images just below the lower edge of the mass slit. The mass bite Δm in the region of 3 BeV mass is Δm = 1 BeV. The system was calibrated on π, p, d, t and $\bar{p}$ particles. The separators alone yield a rejection on the total pion and antiproton flux of $\approx$ 2000/1. This was further improved by a factor of 20 by the addition of a threshold Cerenkov counter[7] at the end of the beam. The overall rejection rate was $\simeq 10^{8}$.

The mass region from 2.5 - 5.5 BeV was covered in three settings of the separators. The sensitivity of this experiment can be expressed by giving the number of counts obtained due to massive particles, compared to the number of π's that would have been transmitted by the system with the separators tuned for pions. The equivalent number of pions was obtained by calibrating a monitor viewing the internal target with the number of pions transmitted. The equivalent pion flux versus mass is presented in figure 1. The ordinate gives the number of pions that the system would have transmitted for the corresponding mass value on the absisca. The total number of counts obtained in the mass region 2.5 - 5.5 BeV was eight (8), these being randomly distributed. At the maximum sensitivity, the upper limit for the observation of a heavy particle in the beam is $\approx 1/5\times10^8$ compared to pions. (Also shown on the graph is the mass acceptance for particles of charge 2/3 e. The signal outputs from the counters were set large enough so that 2/3 charged particles would have been counted.) It should be noted that the ratio of $\bar{p}/\pi$ in this beam is 1/100.

The center of mass energy available in a 30 BeV p-p collision is 8 BeV of which $\sim$ 6 BeV is available for production of new particles. If these particles are produced in pairs, the maximum detectable mass is 3 BeV. It is possible, however, to extend the available energy by making use of the Fermi motion in a heavy nucleus or the coherent recoil of clusters of nucleons.[8]

The extent to which this is possible has been recently investigated by Lederman et al.[9] at the Lawrence Radiation Laboratory in searching for $\bar{p}$ production below threshold as a function of primary proton energy. Using these preliminary results one could then say that if other massive particles are produced in interactions with the same coupling strength as $\bar{p}$'s, then at 3 BeV mass we should have observed $\sim 10^3$ particles and at 4 BeV about 3 particles. We have observed none. These are only rough order of magnitude estimates.

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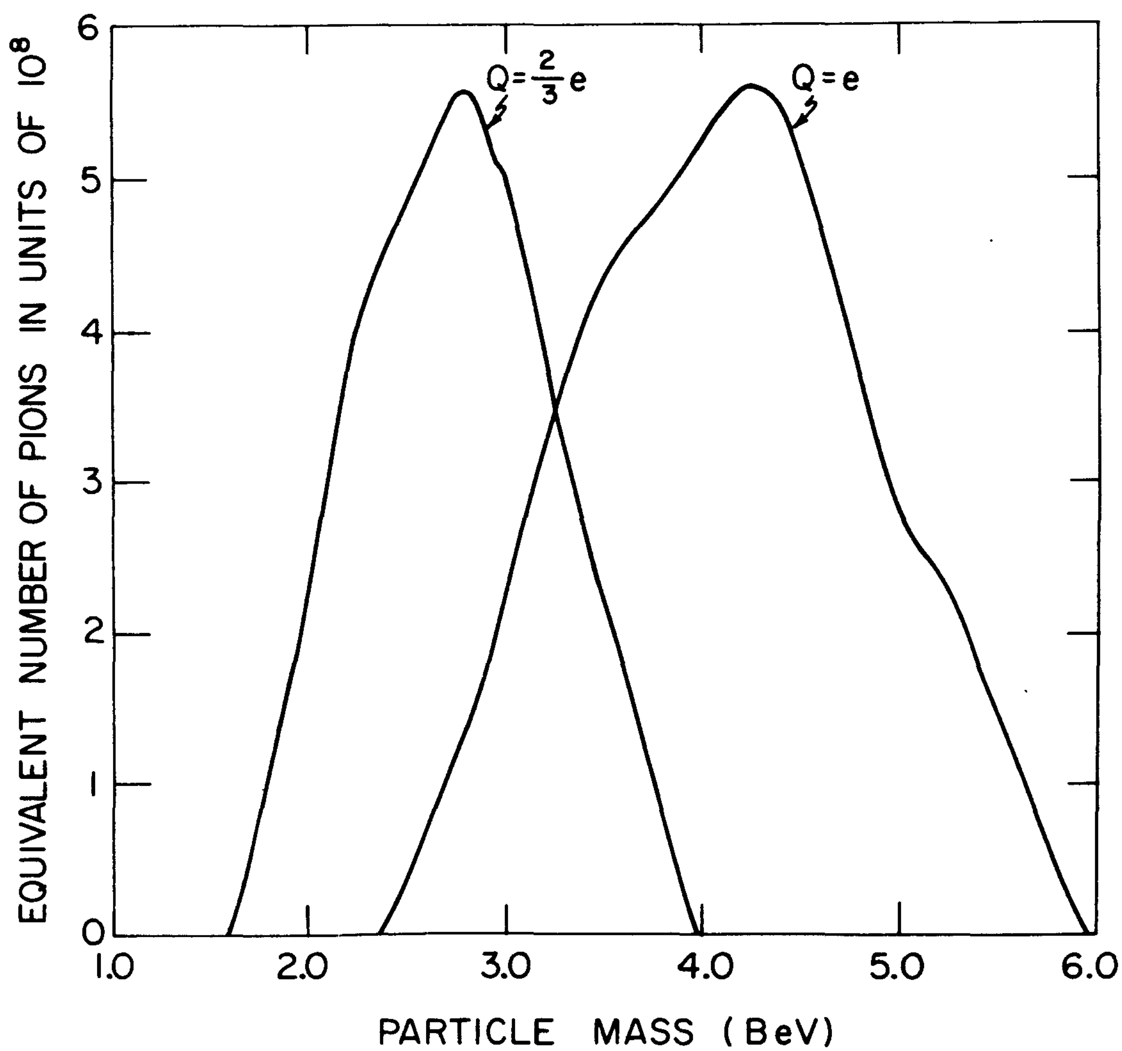
FIGURE CAPTIONS

Figure 1 Equivalent flux of pions that the beam would have transmitted versus the corresponding mass value that the beam was set to transmit. This mass range was covered in 3 different settings of the separators.


EQUIVALENT NUMBER OF PIONS IN UNITS OF 10^8
0
1
2
3
4
5
6
Q = 2/3 e
Q = e
1.0
2.0
3.0
4.0
5.0
6.0
PARTICLE MASS (BeV)