Fermi National Accelerator Laboratory

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PRODUCTION OF $\pi^{\pm}$, $K^{\pm}$, p, AND $\bar{p}$ BY 400 GeV/c PROTONS

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ABSTRACT

Data are presented on the relative yields of $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ with momenta between 60 and 370 GeV/c produced at forward angles by 400 GeV/c protons incident on a beryllium target.

In this note we report results on the relative yields of $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ with momenta between 60 and 370 GeV/c produced in proton-beryllium collisions at 400 GeV/c. These data were obtained during measurements of high energy total and absorption cross sections of charged hadrons on hydrogen, deuterium and heavy nuclei[1,2] using the Meson Laboratory M1 beam at Fermilab.

Studies of the secondary particle yields produced by protons have been carried out at most proton accelerators[3-7] not only to gain information on beam properties, but also to gain insight into the physical mechanism of particle production at increasingly higher momenta.

In this experiment we have used the 400 GeV/c extracted proton beam from the Fermilab synchrotron to extend our earlier measurements made at 200 and 300 GeV/c[6]. The proton beam was focussed to a spot of about 1/16" diameter on the Meson Lab beryllium target (1/16" x 1/16" x 8"), and the M1 beam used to study the particles produced in the target. The beam has recently been upgraded[8,9] so as to be able to transport charged particles up to 370 GeV/c.

The secondary beam intensities used were typically $\sim 2 \times 10^5$ particles per burst of 1.5 sec duration. The production angle varied between 2 and 3.5 mr; while absolute beam fluxes were very sensitive to this angle variation, particle ratios were found to be rather insensitive. Since beam line collimator settings were varied during the data taking according to the needs of the total cross section experiment, no attempt has been made to obtain absolute particle fluxes, but we have derived relative particle yields for each polarity of the secondary beam at the various momenta.

Particles were detected in 3 scintillation counters together with 2 large veto scintillation counters with holes centered on the beam. The final counter in our detection system was located 410 meters from the beryllium target. Particle identification was performed with two gas differential Cerenkov counters[10] of lengths 16 and 32 meters and respective Cerenkov angles of 15 and 7.5 mr, placed in a parallel section of the beam; for momenta above 310 GeV/c, the two counters were combined to form a single counter of 48 meters length and 5 mr Cerenkov angle. Figure 1 shows an example of a pressure curve at +340 GeV/c. Electron contamination in the secondary beam, measured with a 22 radiation length lead glass total absorption Cerenkov counter, was found to be negligible at the momenta studied here. Muons, identified by their ability to penetrate 6 meters of steel, were always less than 2% of the pion flux.

The fluxes of each particle at a given momentum were determined to typically ±10%. The data were corrected for muon contamination, particle decays and for absorption by material in the beam line to obtain the relative yields at the downstream end of the 8-inch beryllium target. The absorption correction was made assuming that the nuclear cross sections vary as $A^{2/3}$ and have no momentum dependence.[2]

The corrected data are given in Table I, and are plotted in Fig. 2 against $X_{Lab} = P_{Lab}/P_o$, where P_{Lab} is the secondary particle momentum and P_o is the incident proton momentum. Also given in Fig. 2 are curves through our earlier data[6] obtained with 200 and 300 GeV/c incident protons.

The results show that the relative particle yields have a strong dependence on X_{Lab}, but have little dependence on primary proton momentum. A comparison of these data with the predictions of the model of Hagedorn and Ranft[11] shows good agreement within the experimental errors.

We wish to thank the staff of Fermilab, in particular those of the Meson Laboratory, for the considerable help given in making these measurements possible.

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TABLE I. Relative yield (at the downstream end of the target) for each charge and momentum of particles produced by 400 GeV/c protons on beryllium.

P_{Lab} (GeV/c)	π %	K %	P %
+60	80.8 ± 2.1	5.6 ± 0.7	13.6 ± 1.6
-60	92.5 ± 1.3	5.5 ± 0.7	2.0 ± 0.3
+200	14.9 ± 1.8	3.1 ± 0.5	82.0 ± 2.1
-200	94.8 ± 1.6	4.4 ± 0.5	0.75 ± 0.10
+240	8.0 ± 1.0	2.0 ± 0.2	90.0 ± 1.5
-240	97.0 ± 1.3	2.8 ± 0.4	0.25 ± 0.04
+280	3.5 ± 0.4	0.92 ± 0.11	95.6 ± 1.6
-280	98.9 ± 0.2	1.10 ± 0.11	0.055 ± 0.007
+310	1.6 ± 0.2	0.56 ± 0.07	97.8 ± 1.3
-310	99.7 ± 0.2	0.33 ± 0.05	0.015 ± 0.003
+340	0.48 ± 0.06	0.28 ± 0.04	99.2 ± 0.2
-340	99.9 ± 0.2	0.063 ± 0.008	-
+370	0.056 ± 0.007	-	99.9 ± 0.2

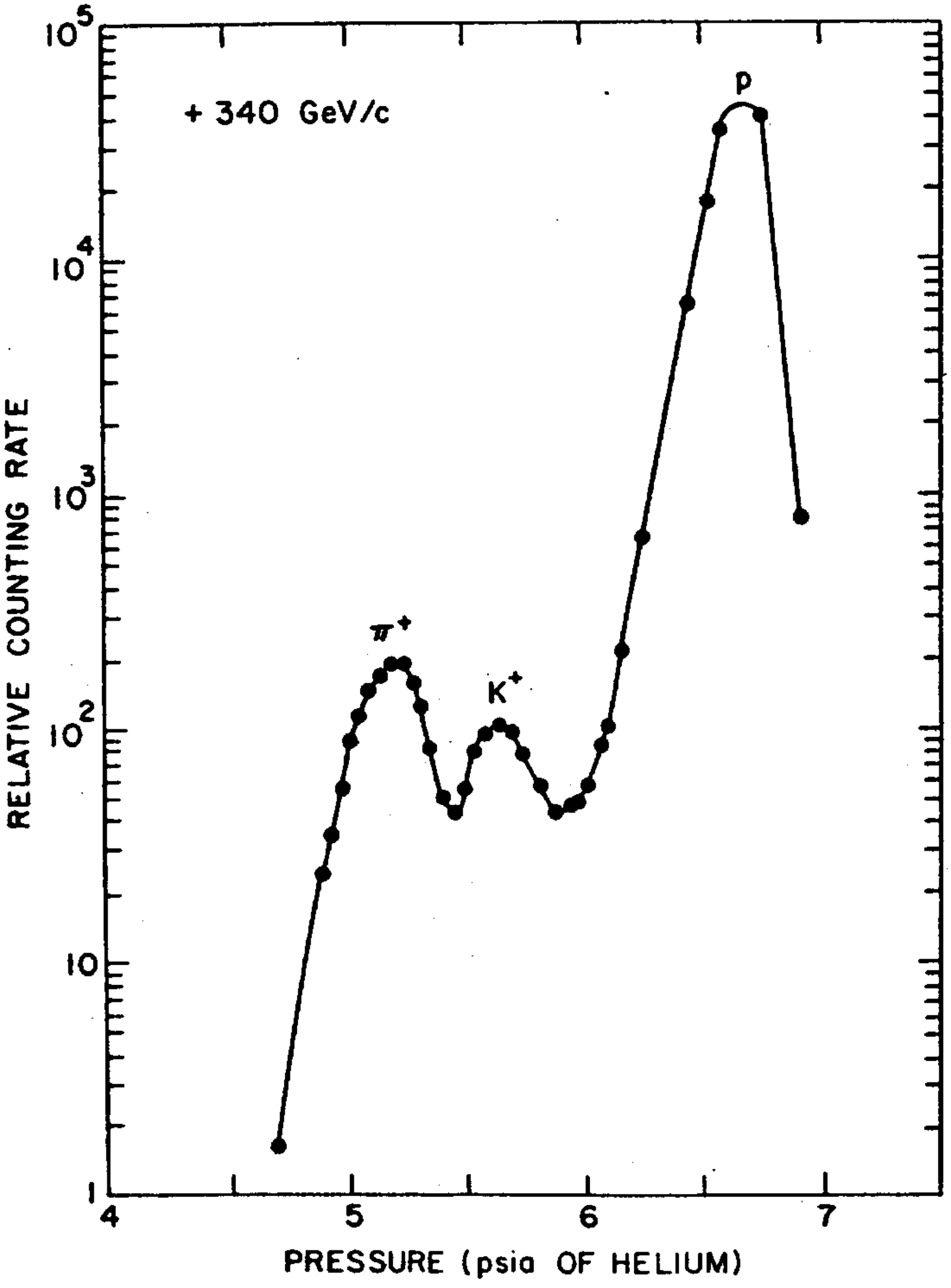

Fig. 1. Pressure curve obtained with the gas differential Cerenkov counter at +340 GeV/c.

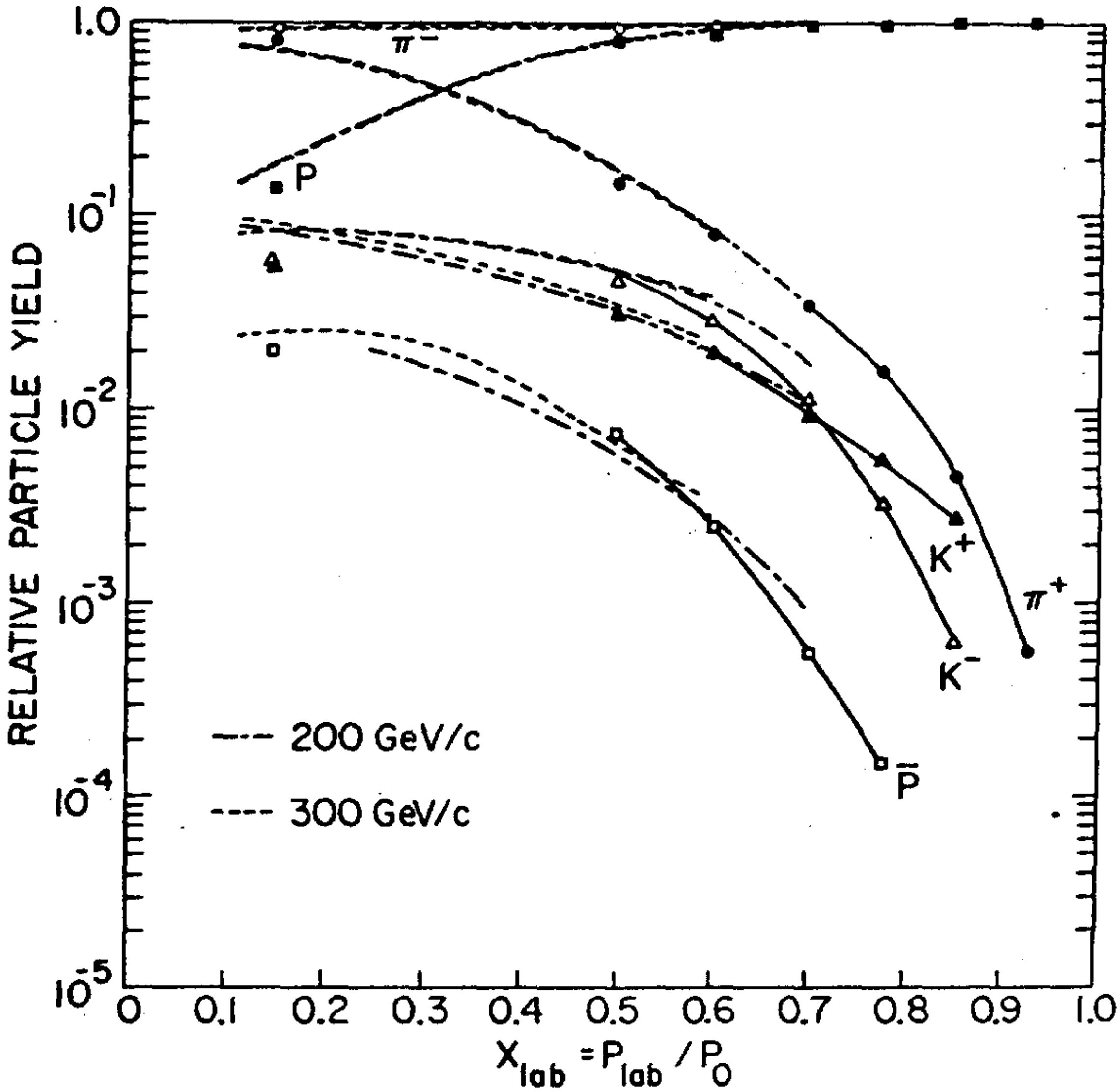

Fig. 2. Relative particle yield for each charge and momentum as a function of the variable $X_{Lab} = P_{Lab}/P_o$. Solid lines are to guide the eye. Dashed lines are curves through the 200 and 300 GeV/c data of Ref. 6.