



HYPERON AND ANTIHYPERON FLUXES
IN THE FERMILAB CHARGED HYPERON BEAM

Krzysztof Doroba

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The yields of hyperons and antihyperons in the Fermilab charged hyperon beam,¹ which is now under construction is an important question. The previous flux prediction was done in 1976^{1,2} and was based on low energy experiments (below 30 GeV) which was the only data available at that time. The recent results from CERN SPS charged hyperon beam³ allow me to update those predictions.

Figures 1 and 2 (taken from Ref. 3) present the CERN hyperon yields for 200/210 GeV/c incident protons in the forward direction from light target as well as the results from other experiments.⁴ Although there is an apparent inconsistency in the low energy data, the CERN high and low energy points show scaling. One may assume this scaling and the CERN parameterization to compute hyperon fluxes for 400 GeV/c incident protons. If this scaling assumption is incorrect then the hyperon fluxes will be even larger. Knowing the antihyperon to hyperon ratios one can also compute the yields of antihyperons.

The values of lifetimes and masses of the hyperons used in the calculations are those from Ref. 5, except for Ω^- lifetime where the new

value, $\tau = (0.82 \pm 0.06) 10^{-10}$ sec, has been used.⁶ The π^+/π^- and p/π^+ experimental ratios have been taken from Refs. 7 and 3 respectively. The values of the Σ/π ; Ξ/π ratios used as an input for the calculations are from a $(1 - x)^n$ parameterization of the data shown in Fig. 1.³ The antihyperon to hyperon ratio has been assumed to be equal to $(1 - x)^m$. This kind of parameterization is in agreement with the existing data on the $\bar{\Lambda}^0/\Lambda^0$ ratios.⁸ The value of the power m has been determined for $\bar{\Sigma}^+/\Sigma^+$ and $\bar{\Xi}^-/\Xi^-$ ratios using the only two existing data points at $x = 0.47$. For the $\bar{\Sigma}^-/\Sigma^-$ ratio the same power as for the $\bar{\Sigma}^+/\Sigma^+$ has been assumed. Because of the particle charges one should expect at large x in pp collision the $\bar{\Sigma}^-/\Sigma^-$ ratio to be higher than for $\bar{\Sigma}^+/\Sigma^+$. Because of this the prediction for the $\bar{\Sigma}^-$ yields is probably pessimistic.

When looking at the antihyperon to hyperon ratios as a function of strangeness (Fig. 2) one may guess that the $\bar{\Omega}^-/\Omega^-$ ratio should be close to 1 near $x = 0.47$. We have assumed this ratio to be exactly one for all x , e.g. $m = 0$. The amount of Ω^- itself has been determined assuming that for all x , the cross section behavior is given by

$$A \cdot \frac{\Omega^-}{\Xi^-} = \frac{\Xi^-}{\Sigma^-}$$

where the value of the constant A (6.64) has been defined using the only measured data point for Ω^- (at $x = 0.47$).

The fluxes of positive and negative hyperons and antihyperons produced in the forward direction at a distance of 10 m from the light target are shown in Fig. 3a and b. The expected numbers of other particles are also presented, once again using $(1 - x)^n$ parameterization from Ref. 3. The numbers are given per 10^6 outgoing beam particles at this distance.* The length of the E497 targetting magnet is 7 m and a total distance of about 10 m would allow for wire chamber to determine the position and angle of beam particles as well as distance for a small Cerenkov detector. It does not allow for quadrupoles to make the beam parallel. This could be done with superconducting energy doubler/saver quadrupoles. With three such magnets one will need an additional 6 m to render the beam parallel up to 350 GeV/c. To illustrate how this additional distance will affect the fluxes, Fig. 4 a and b show the expected fluxes 20 m from the target. Comparing the expected amounts of pions with predictions of the Wang formula⁹ one may estimate the number of incident protons required to obtain the desired beam intensity. This proton beam intensity for a magnetic channel with $dp/p \cdot d\Omega$ equal to $4.31 \cdot 10^{-8}$ sr and one interaction length light target is given in Fig. 5.

The possibility of targetting 1000 GeV protons from energy doubler /saver at an early date raises the question of what fluxes could be obtained using this hyperon channel. The increase of proton energy should improve especially the antihyperon fluxes because they are mostly

* Since the beam must pass through drift chamber, the intensity is limited to about 10^6 per second.

produced at small x . The expected fluxes 10 (20) m from target are presented in Fig. 6 (7) a and b. The required incident proton intensity is given in Fig. 8.

The calculated fluxes of hyperons and antihyperons are bigger than previously² expected. Even with the recently measured Ω^- lifetime this beam would allow the measurement of many Ω^- properties. The fluxes of Σ^- are extremely large and even with the uncertainty of Σ^- parameterization at large x they should indeed be the major component of our high energy beam.

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FIGURE CAPTIONS

- Fig. 1. Particle ratios at production target as a function of Feynman x at different energies. a) the Σ/π ratio and b) the Ξ^-/π^- ratio. Figure has been taken from Ref. 3. The low energy data are those from Ref. 4.
- Fig. 2. Particle ratios as a function of strangeness - from Ref. 3. The $\bar{\Lambda}^0/\Lambda^0$ point is from Ref. 4 (P. Skubic et al.).
- Fig. 3. Expected fluxes 10 m from target irradiated with 400 GeV protons. a) negative particles and b) positive particles.
- Fig. 4. Expected fluxes 20 m from target irradiated with 400 GeV protons. a) negative particles and b) positive particles.
- Fig. 5. Flux of 400 GeV/c protons at one interaction length target required to obtain 10^6 outgoing particles at given distance. The channel has $dp/p \cdot d\Omega = 4.31 \cdot 10^{-8}$ sr. For positive particles results for 10 and 20 m are practically the same.
- Fig. 6. Expected fluxes 10 m from target irradiated with 1000 GeV protons. a) negative particles and b) positive particles.
- Fig. 7. Expected fluxes 20 m from target irradiated with 1000 GeV protons. a) negative particles and b) positive particles.
- Fig. 8. Flux of 1000 GeV/c protons required to obtain 10^6 particles at given distance. Parameters of the channel are the same as for Fig. 5. Results for 10 and 20 m are practically the same.

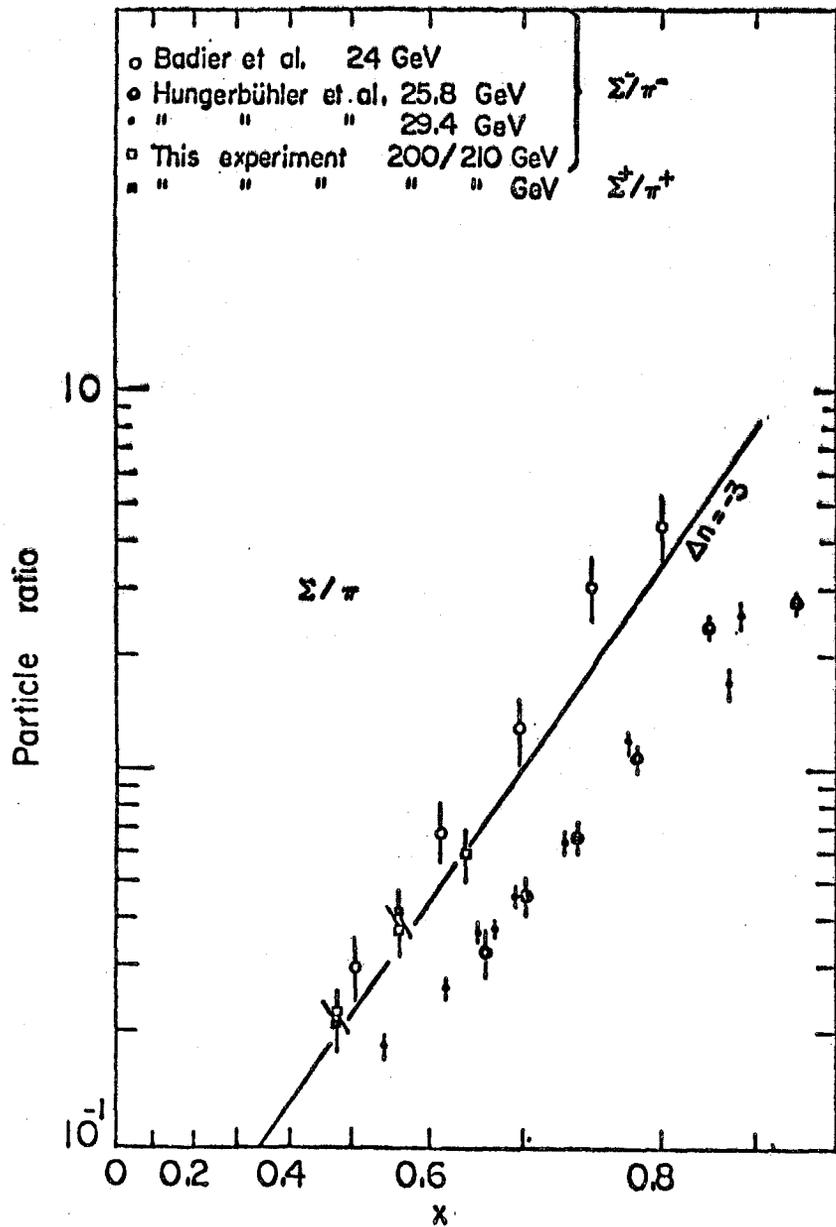


Fig.1 a

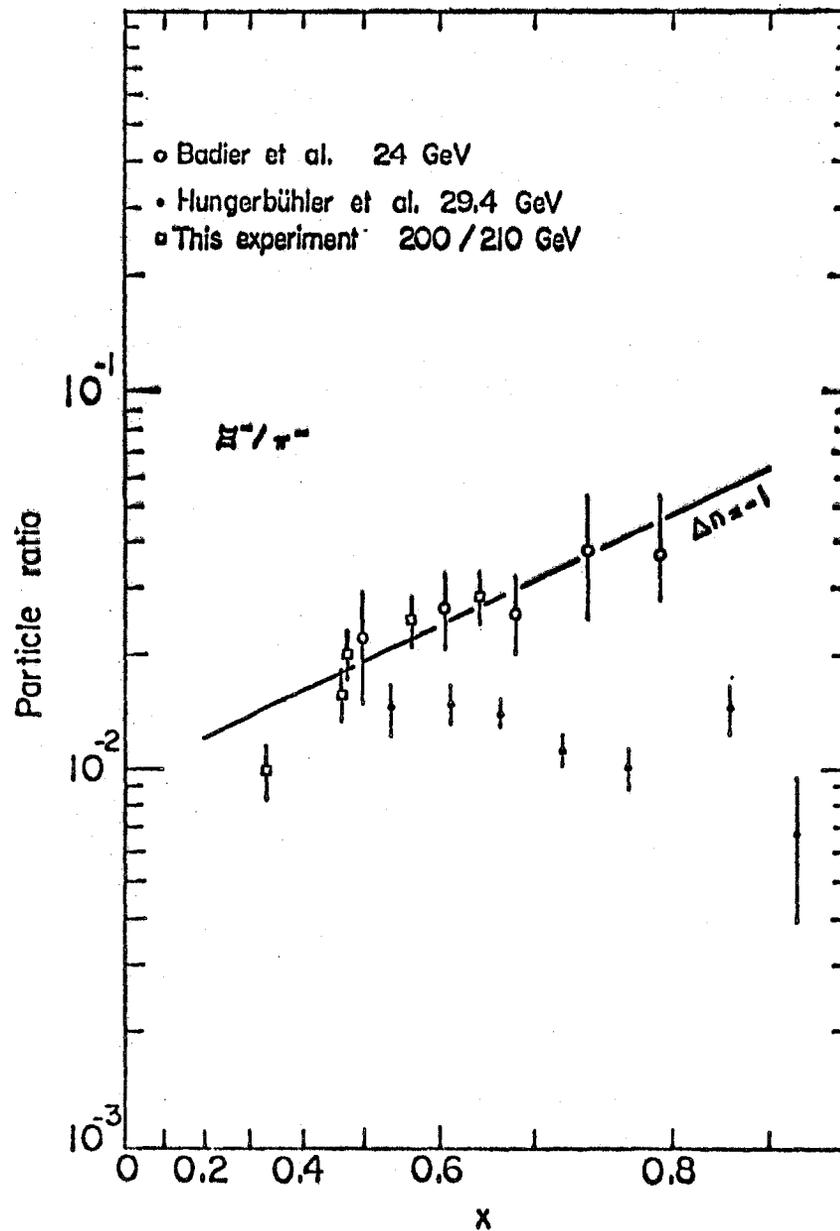


Fig.1 b

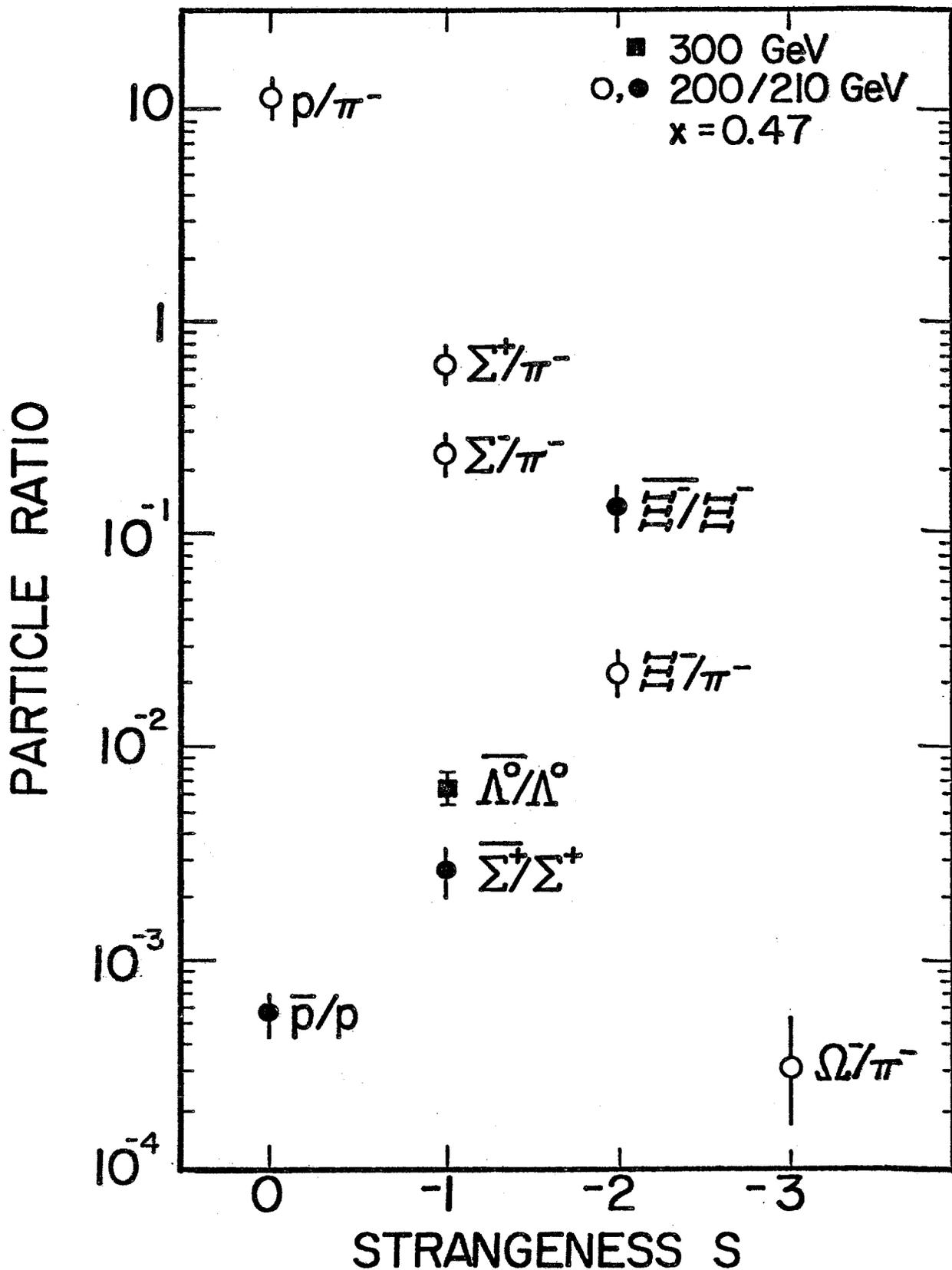


Fig.2

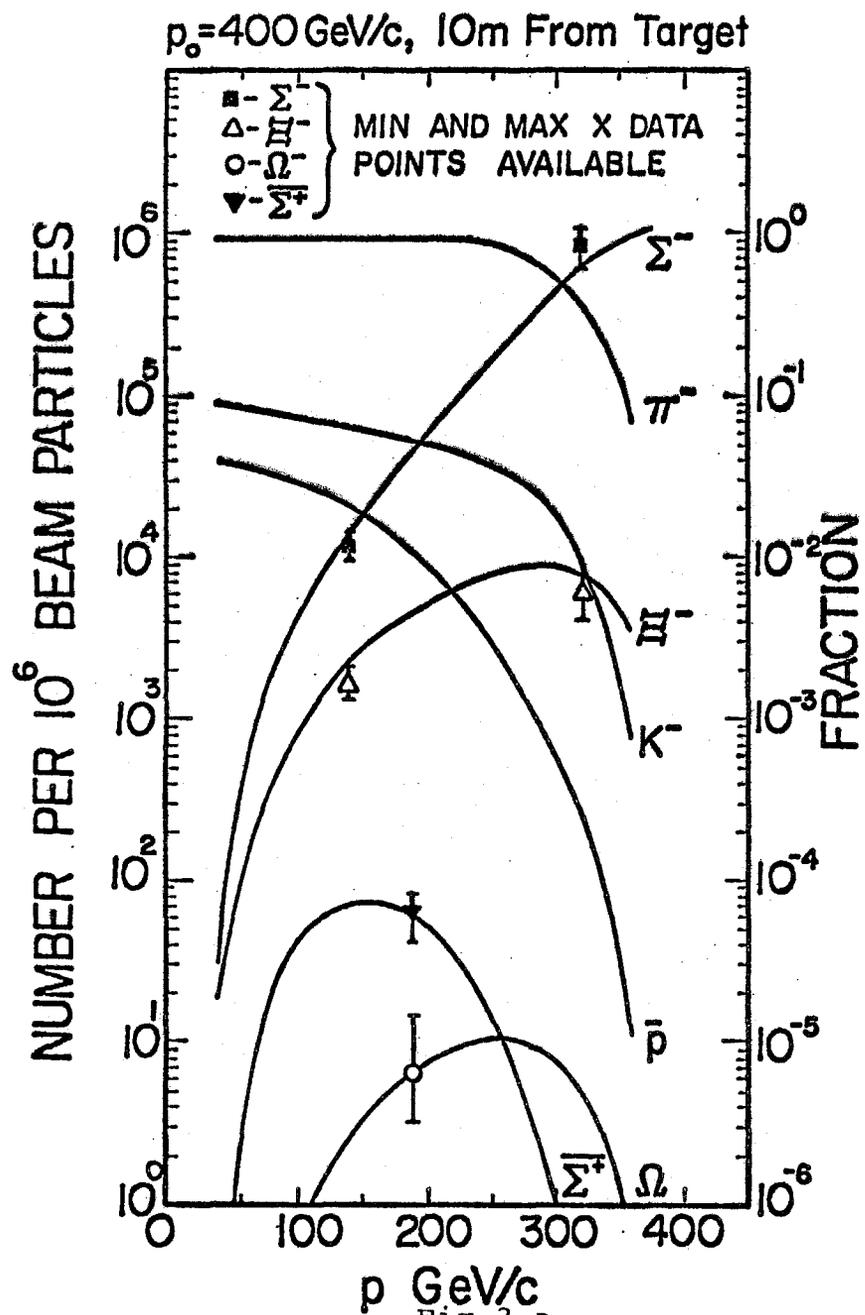


Fig.3 a

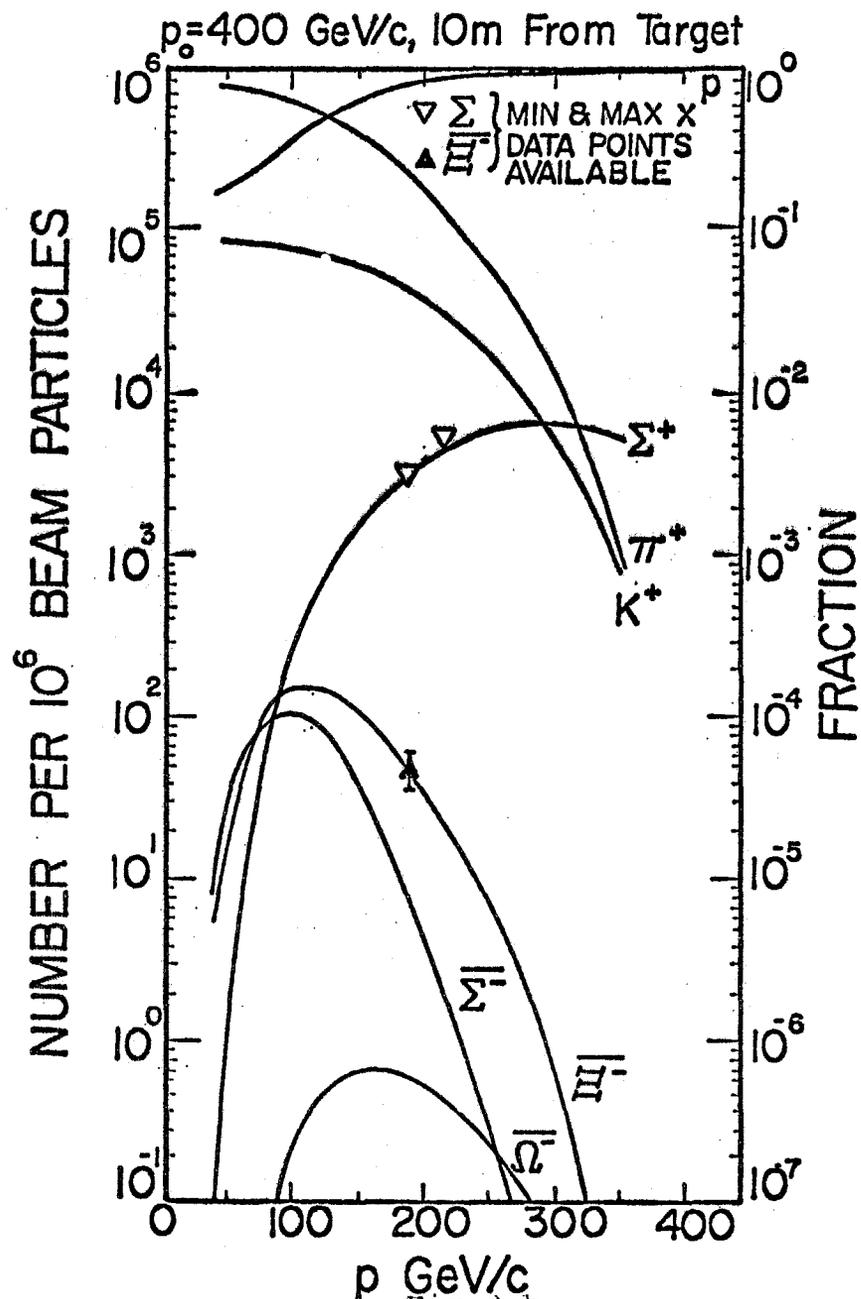


Fig.3 b

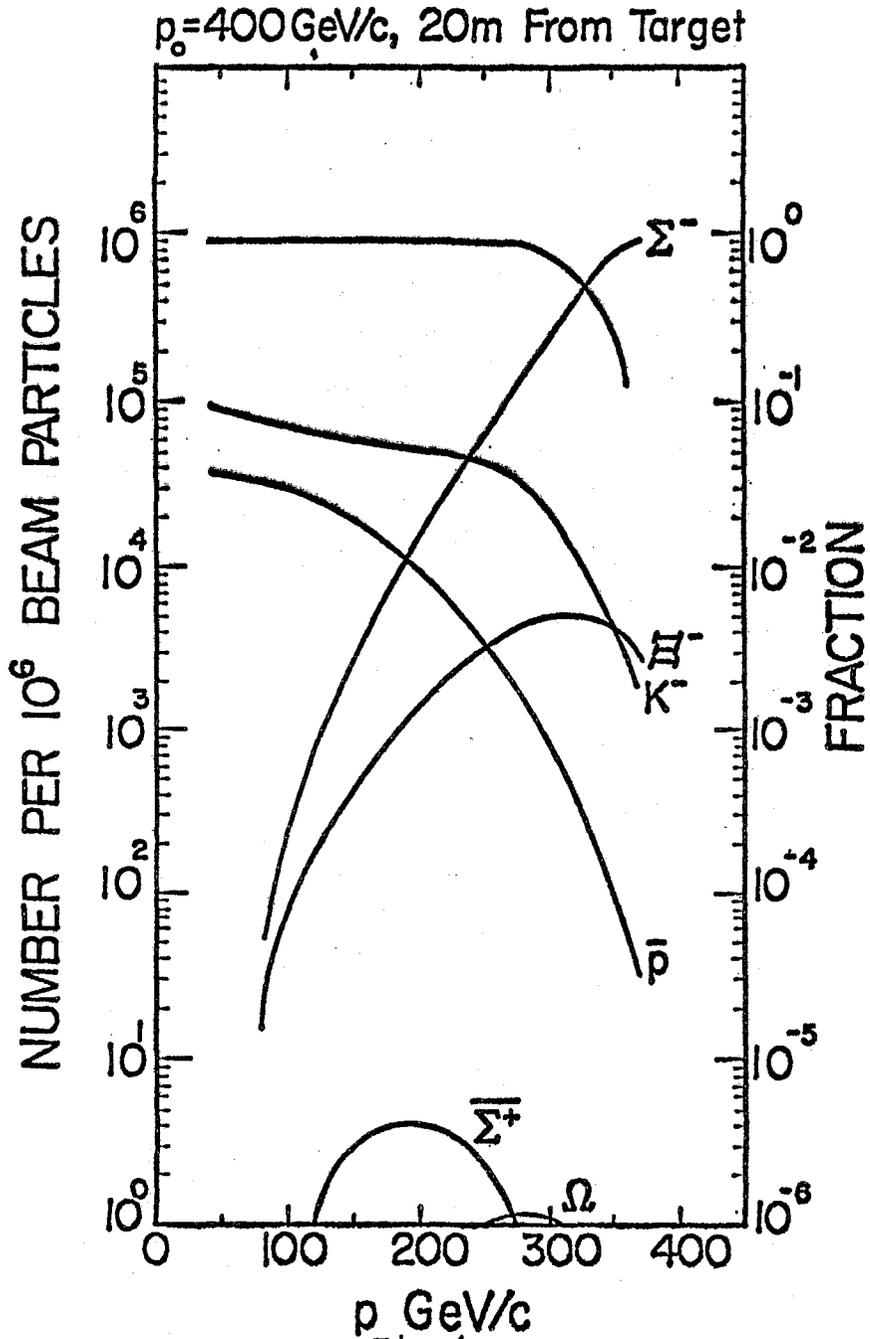


Fig.4 a

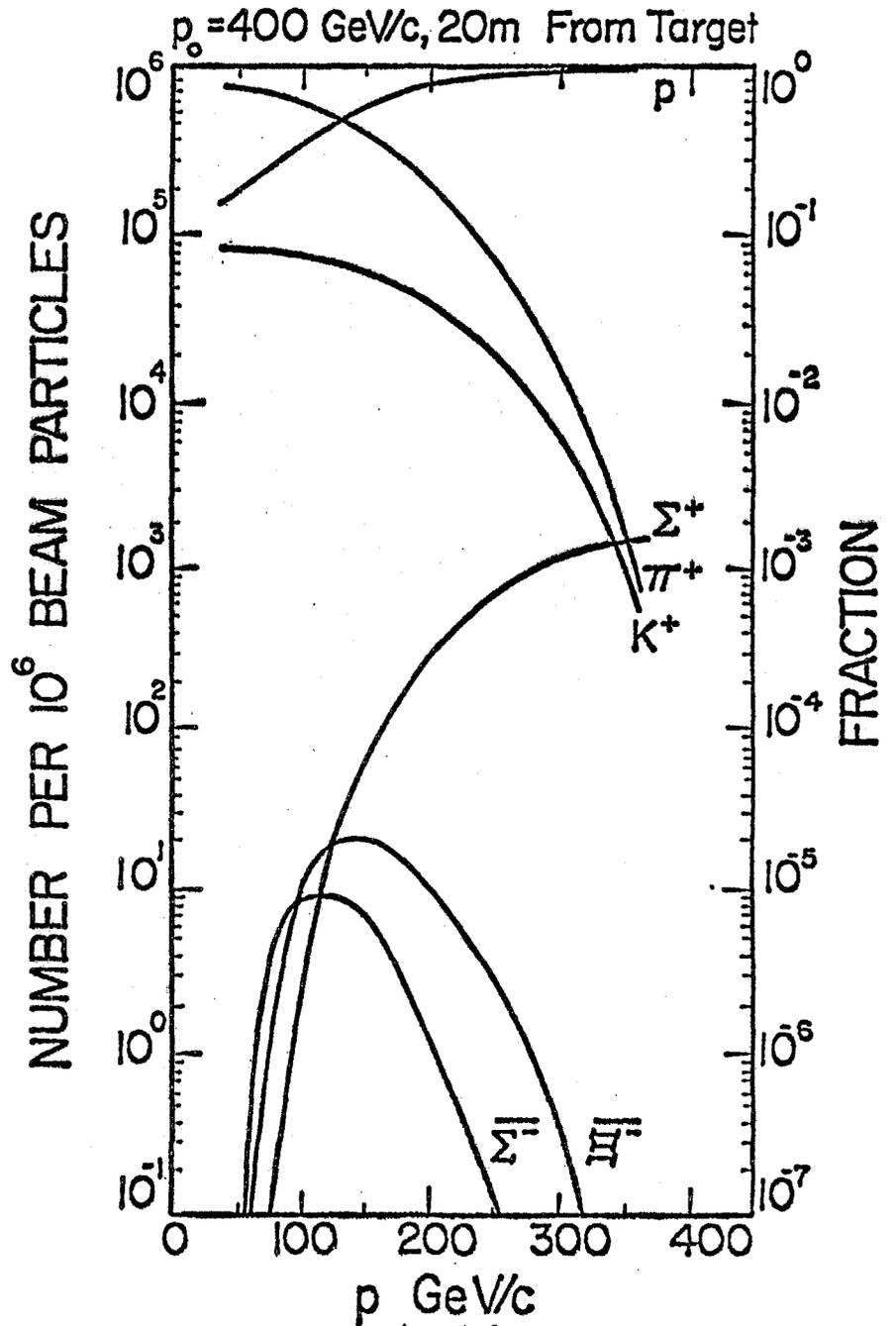


Fig.4 b

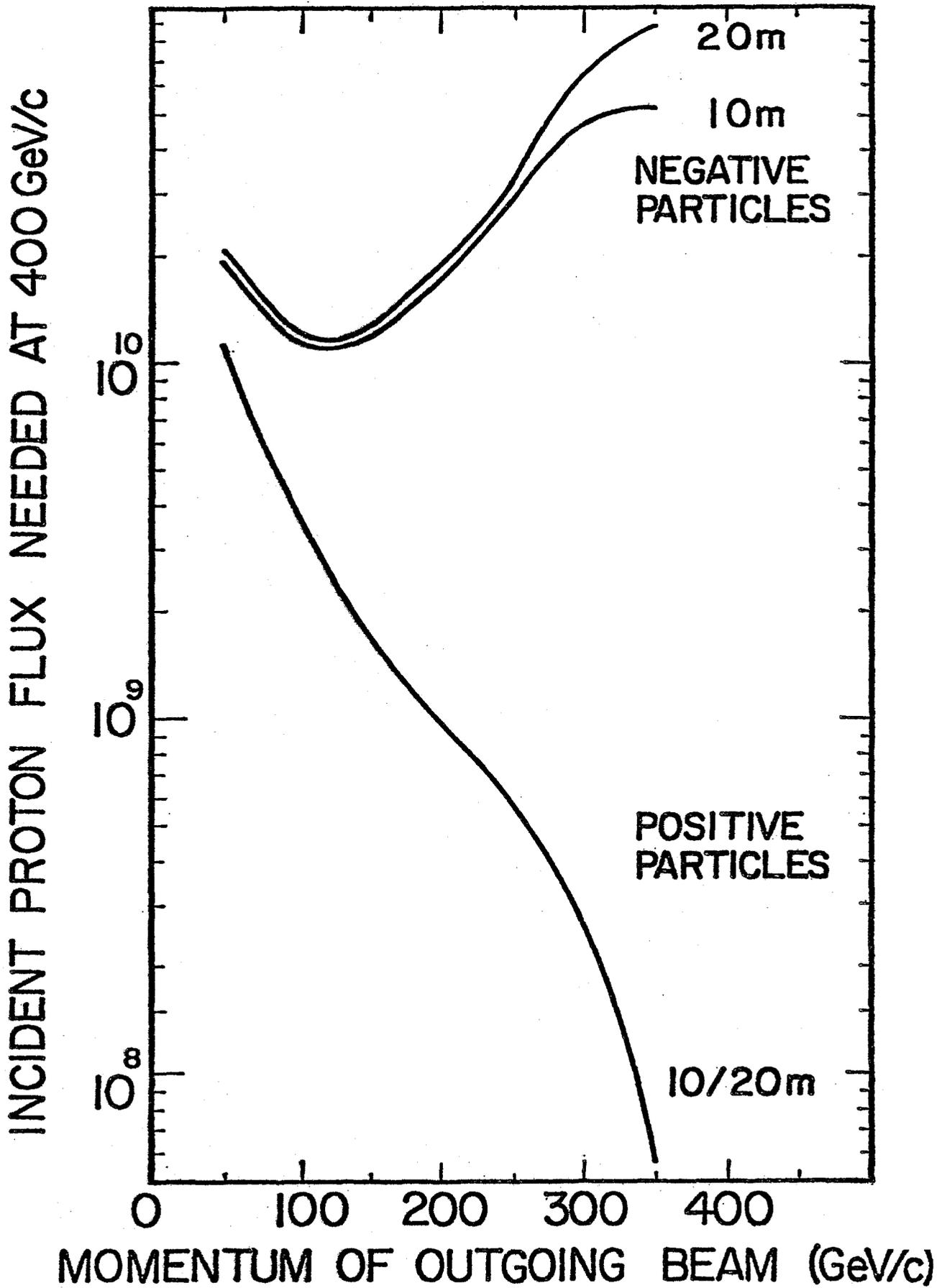


Fig. 5

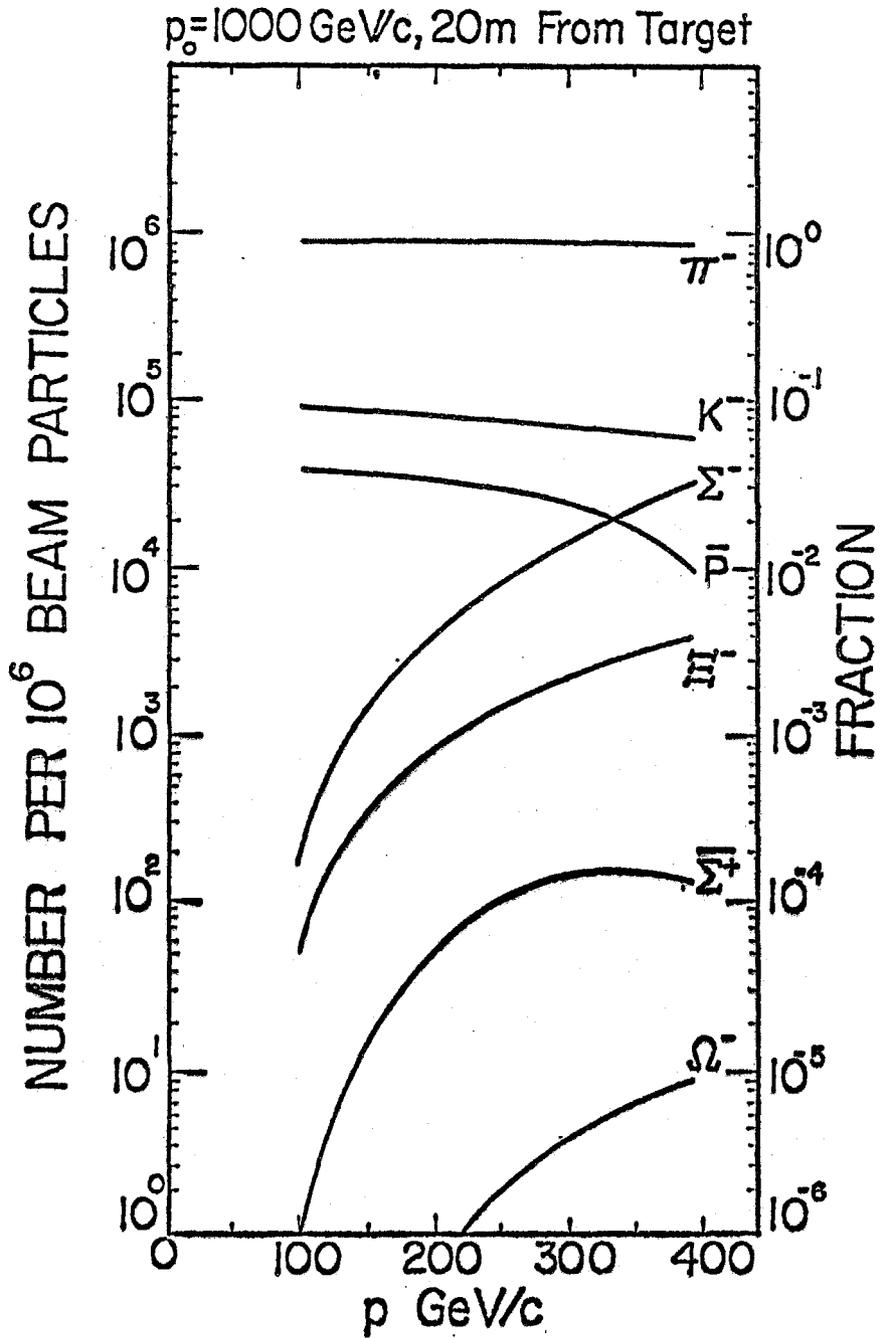


Fig. 7 a

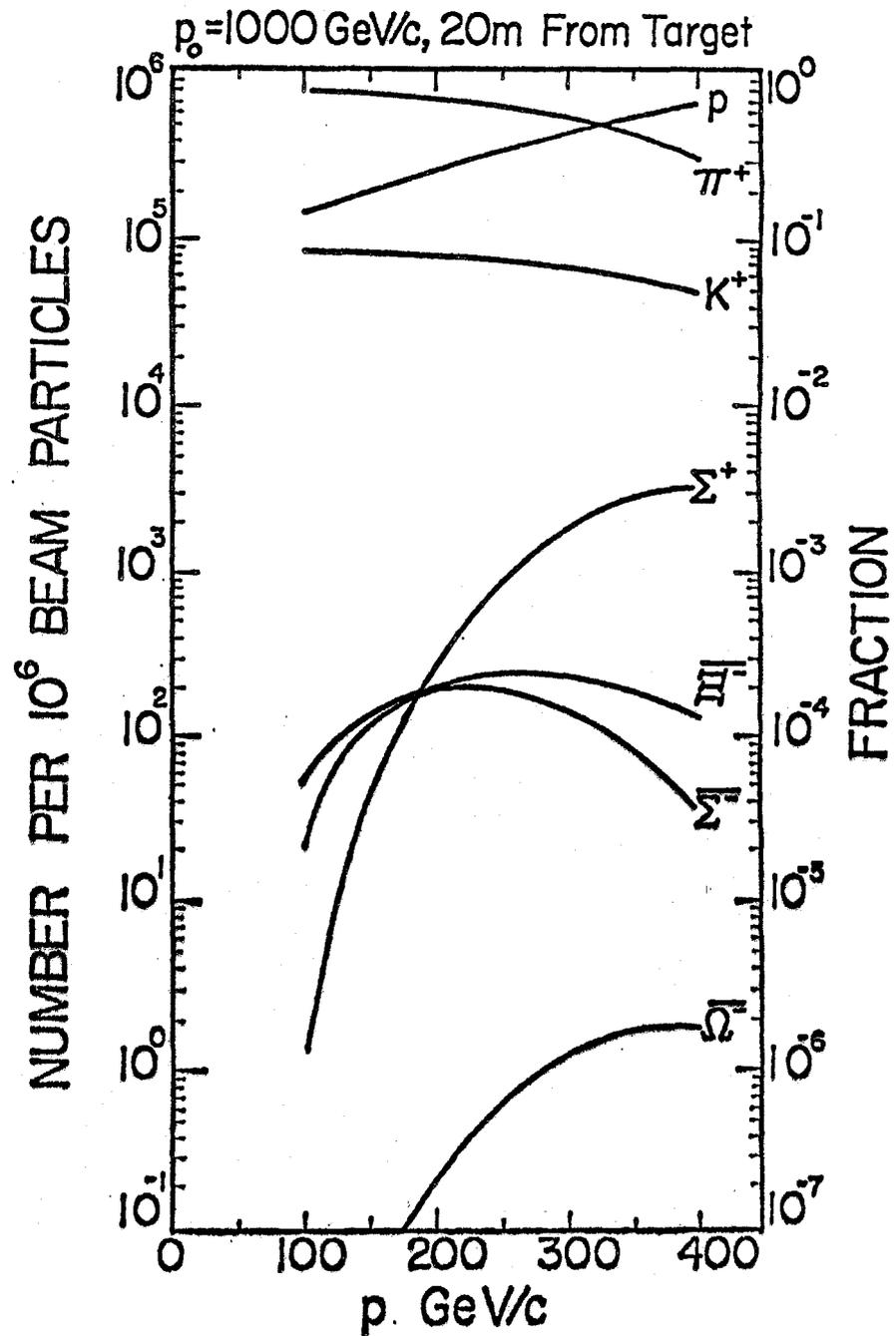


Fig. 7 b

INCIDENT PROTON FLUX NEEDED AT 1000 GeV/c

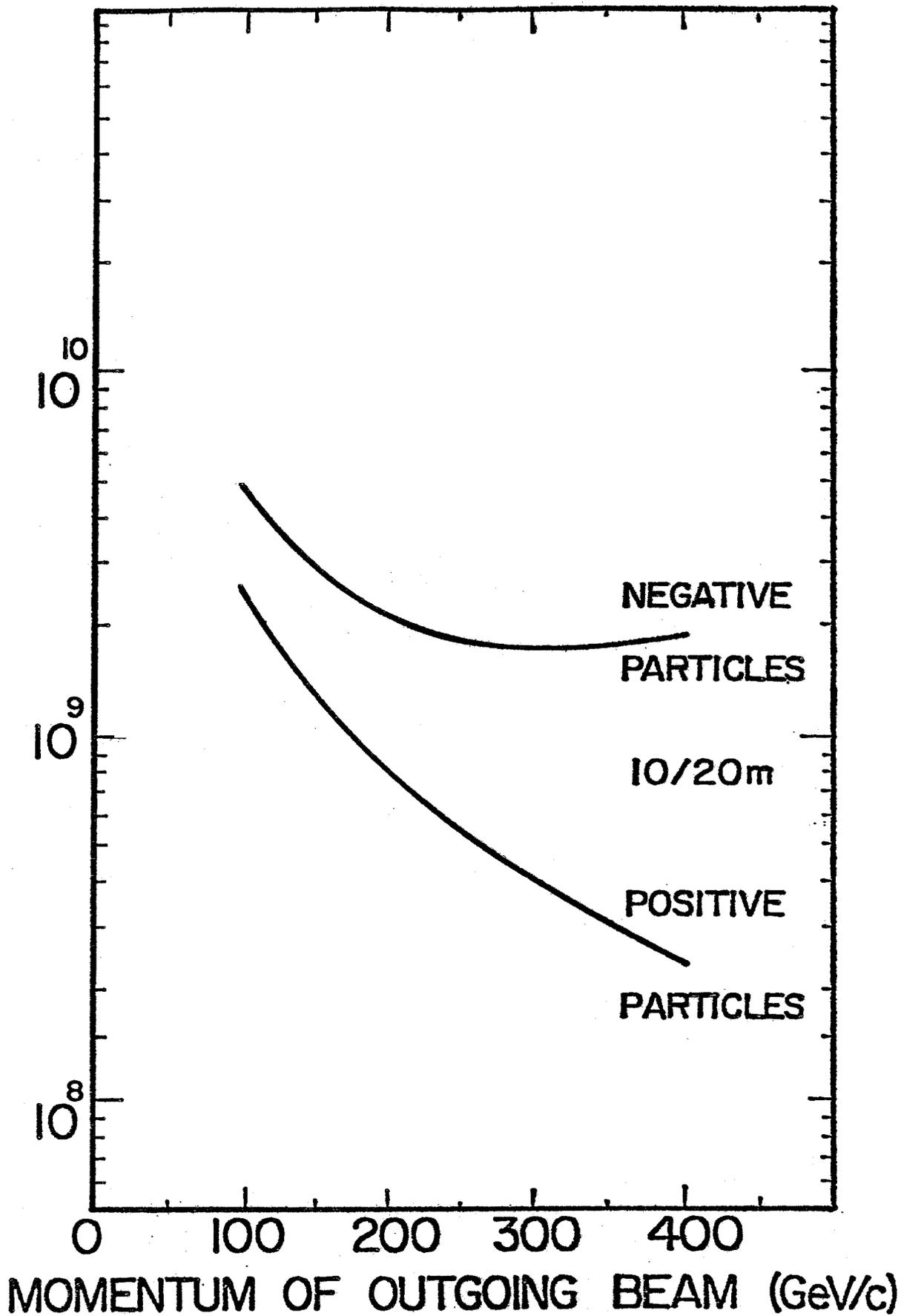


Fig.8