CHARGED HYPERON PRODUCTION BY 16-Gev/c π^- MESONS

J. Bartke,* R. Böck, R. Budde, W. A. Cooper, H. Filthuth, Y. Goldschmidt-Clermont, F. Grard,† G. R. MacLeod, A. Minguzzi-Ranzi, L. Montanet, W. G. Moorhead, D. R. O. Morrison, S. Nilsson, C. Peyrou, B. W. Powell, J. Trembley, and D. Wiskott
CERN, Geneva, Switzerland

I. Bertanza, C. Franzinetti, I. Manelli, and V. Silvestrini
Pisa University, Pisa, Italy

and

G. Brautti, M. Ceschia, and L. Chervosani
Trieste University, Trieste, Italy
(Received February 27, 1961)

The CERN 30-cm hydrogen bubble chamber was exposed to a beam of 16-Gev/c π^- mesons. In a sample of 35 000 pictures, 48 charged strange particles were found and the results obtained from them are given below. The events were measured on digitized machines. Measurements on three views were assembled, and helices fitted to the tracks by a least-squares method, using a Ferranti Mercury computer.[1,2] A further program tested various two-body decay kinematics.[3] By this means, π-μ decays and p scattering events were easily recognizable, but only in a few cases was it possible to distinguish kinematically between the decays $\Sigma^\pm \rightarrow \pi^\pm + n$ ("Σ_π"), $\Sigma^+ \rightarrow p + \pi^0$ ("Σ_p"), and $K \rightarrow \pi$ or μ (no evidence for Ξ or anti-Σ was found). It was possible to distinguish between pion and proton secondaries in all cases by means of ionization measurements using a mean gap length method. On a normal track the identification is better than one standard deviation up to 1.2 Gev/c and better than two standard deviations up to 0.8 Gev/c. The composition of the sample is given in Table I.

In many cases the primary track was short (< 5 cm) and its momentum therefore poorly measured. The assumption was therefore made that all charged V's were hyperons, unless they could be shown to be K mesons (two double events were excluded from the present analysis since the above assumption was not justified in these cases). The primary momentum could then be calculated from the secondary momentum and angle.

Table I. Composition of the sample.

Σ	positive	28
Σ	negative	18
K	positive	2
$\pi \rightarrow \mu$		25
p	scattering	2

In 11 cases the calculated primary momentum had two energetically possible values. In the absence of a means of distinction, the further assumption was made that the two values were equally probable.

The assumptions were justified by a lifetime determination which gave $\tau_{\Sigma^-} = (2.1^{+4.3}_{-1.1}) \times 10^{-10}$ sec and $\tau_{\Sigma^+} = (0.60^{+0.27}_{-0.17}) \times 10^{-10}$ sec, in agreement with accepted values. The angular distribution of the decays was compatible with isotropy in the c.m. system.

In order to find the number of hyperons produced, the probability of observation of each decay had to be determined. For this purpose 3 cm were subtracted from the potential path length of the hyperon in the chamber (since decays with very short tracks were unrecognizable) and the probability of decay in this distance found. Each event was weighted by the inverse of this probability. The mean weight was 1.8 for Σ^- and 1.3 for Σ^+. All results which follow are weighted in this way.

Scanning bias was looked for by plotting the distribution of ψ, the angle between the normal to the decay plane and the normal to the front glass. Because the angle between the incident track and the hyperon was small, one expects cylindrical symmetry so that the distribution of ψ, rather than $\cos\psi$, should be independent of ψ. No significant bias due to foreshortened decay angles was found on a plot for all events. Numbers were too small to plot Σ^+ and Σ^- separately.

Scanning bias can also be checked by the numbers of $\Sigma_p{}^+$ and $\Sigma_\pi{}^+$ observed which should be equal. In fact it was found that $\Sigma_p{}^+/\Sigma_\pi{}^+ = 1/4$. There was therefore bias operating against the Σ_p mode. The decay angle in this mode is about 6 times less, on average, than in the Σ_π mode.

Hence one would expect the Σ_π decays to be missed either when the decay angle is much foreshortened ($\cos\psi < 1/6$, i.e., $80° < \psi < 100°$ which is too small a region to be visible on the ψ plot, with our limited statistics) or when the momentum is about 6 times higher than the average.

These small biases will act equally on Σ_π^+ and Σ_π^- decays. It is therefore safe to take the ratio of $\Sigma_\pi^+/\Sigma_\pi^-$ as unbiased. The charge ratio can then be found by assuming that as many Σ_p^+ as Σ_π^+ had occurred. Taking the 22 Σ_π^+ and 18 Σ_π^- and applying the corrections, we find

$$\frac{\text{No. at production of } \Sigma^+}{\text{No. at production of } \Sigma^-}$$

$$= (\Sigma_\pi^+ + \Sigma_p^+)/\Sigma_\pi^- = 2\Sigma_\pi^+/\Sigma_\pi^- = 1.8^{+0.7}_{-0.5}.$$

By assuming that the numbers of Σ^+ and Σ^- have Poisson distributions with the means 22 and 18 (the numbers actually found), one can compute the expected distribution of the ratio Σ^+/Σ^-. The errors given above refer to the width at half height of that distribution.

The numbers at production correspond to cross sections of 0.35 ± 0.08 mb for Σ^+ and 0.19 ± 0.05 mb for Σ^-. These values may be compared with the Dubna results at 8 Gev.[4,5] They find 0.1 mb for the Σ^- production by π^- mesons on protons. The charge ratio is not given explicitly but seems to be less than 1.

The momentum distribution of the hyperons at production is best obtained from those which decay via the Σ_π mode since they are unbiased up to high momenta (i.e., higher than those of the observed hyperons). In the center-of-mass system of the colliding particles, the maximum momentum of either of a ΣK pair is 2.6 Gev/c. As shown in Fig. 1(a) and (b), the events analyzed had values ranging up to this maximum. The mean values were not significantly different for Σ^- and Σ^+:

$$\langle p^* \rangle \text{ for } \Sigma^- = 1.15 \pm 0.13 \text{ Gev}/c,$$

$$\langle p^* \rangle \text{ for } \Sigma^+ = 1.25 \pm 0.11 \text{ Gev}/c.$$

The mean transverse momenta were:

$$\langle p_t \rangle \text{ for } \Sigma^- = 0.54 \text{ Gev}/c,$$

$$\langle p_t \rangle \text{ for } \Sigma^+ = 0.58 \text{ Gev}/c.$$

If the lower momentum value is taken in the eleven ambiguous cases referred to above, lower limits are found:

$$\langle p_t \rangle \text{ for } \Sigma^- > 0.38 \text{ Gev}/c,$$

$$\langle p_t \rangle \text{ for } \Sigma^+ > 0.56 \text{ Gev}/c.$$

These are larger than the mean transverse momentum of π mesons produced in the interactions, which is 0.33 Gev/c.[6]

The angular distribution of the hyperon in the π-p center-of-mass system is shown in Fig. 2(a) for Σ_π^- and in 2(b) for Σ_π^+ and is seen to be

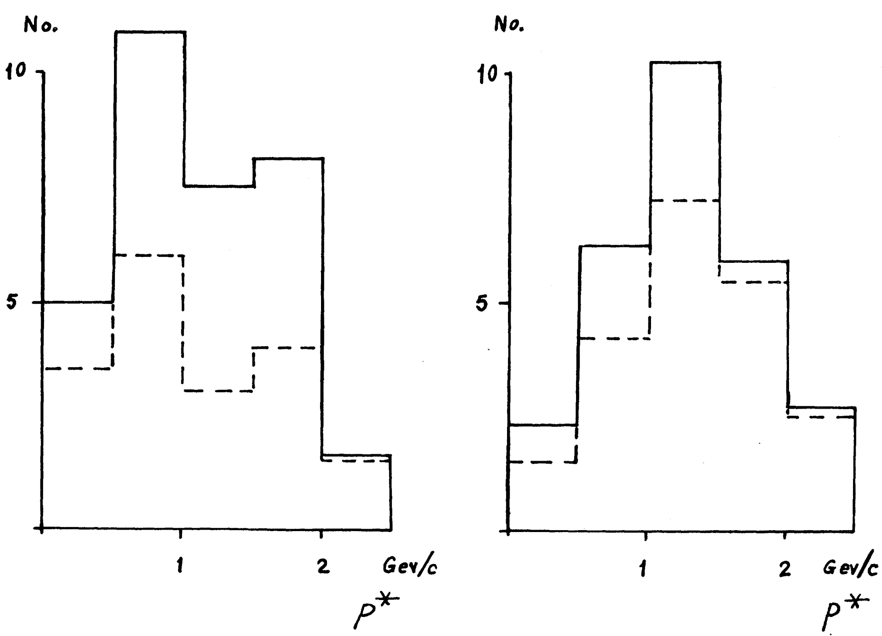

FIG. 1. Momentum distribution at production in the $\pi^- + p$ c.m. system (a) for Σ_π^-, and (b) for Σ_π^+. —— corrected numbers; --- uncorrected numbers.

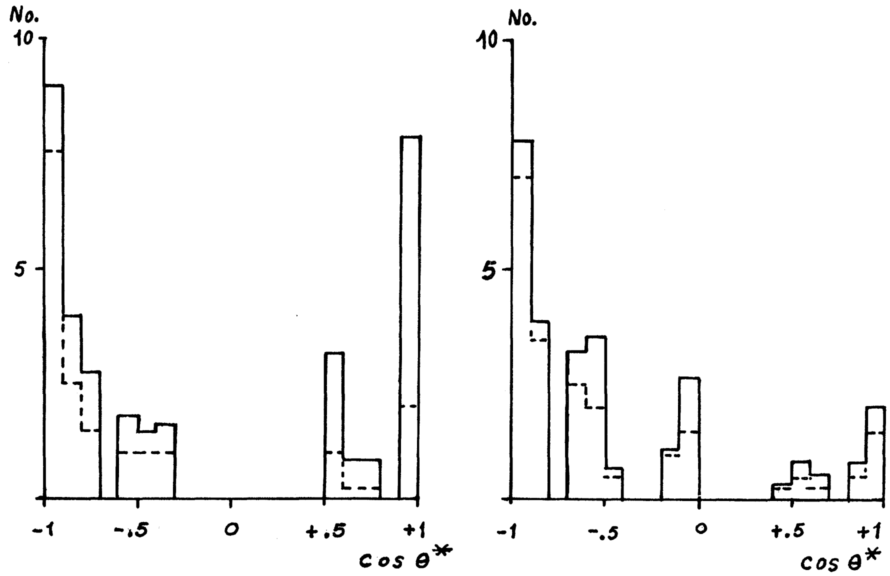

FIG. 2. Angular distribution at production in the π^-+p c.m. system (a) for Σ_π^-, and (b) for Σ_π^+. —— corrected numbers; --- uncorrected numbers.

peaked backward. This and the preponderance of positive hyperons are the most striking features of the results. Both are consistent with the interpretation of production via single meson exchange. In this case it is possible to make more detailed predictions. A comparison of these predictions with the present results, and those from further measurements on neutral and charged strange particles will be published in due course.

No significant difference was found between the multiplicity of jets with a charged V decay (4.4 ± 0.2) and of jets where no strange particle decay was visible (4.3 ± 0.1).

One of us (J.B.) wishes to thank the Ford Foundation for a fellowship during this work.

*On leave from the Institute of Nuclear Research, Krakow, Poland.

†On leave from Institut Interuniversitaire des Sciences Nucléaires, Brussels, Belgium.

[1]W. G. Moorhead, "A programme for the geometrical reconstruction of curved tracks in a bubble chamber," CERN Report 60-33 (unpublished).

[2]G. R. MacLeod, "Geometrical reconstruction for digitised protractor measurements," CERN Report 60-12 (unpublished).

[3]R. Böck, "Sub-routine for apex fit," CERN Internal Report (unpublished).

[4]M. I. Soloviev, Proceedings of 1960 Annual International Conference on High-Energy Physics at Rochester (Interscience Publishers, New York, 1960), p. 388 ff.

[5]L. P. Dzhanelidze et al., Joint Institute for Nuclear Research, Dubna, Report JINR-P563, 1960 (unpublished).

[6]Unpublished results from the University of Birmingham, Birmingham, England; Imperial College, London, England; and Clarendon Laboratory, Oxford, England.