Even at 6.2 Bev, the antiprotons appear only to the extent of one in 44 000 pions. Because of the decay of pions along the trajectory through the detecting apparatus, this number corresponds to one antiproton in 62 000 mesons generated at the target. It will be seen from Fig. 5 that there is no observed antiproton production at the lowest energy. Although the production of antiprotons does not seem to rise as sharply with increasing energy as might at first be expected, the data indicate a reasonable threshold for production of antiprotons. It must again be emphasized that Fig. 5 shows only the excitation function relative to the meson excitation function, hence the true excitation function is not known at this time. If and when detailed meson production excitation functions become known, data of the type shown in Fig. 5 may allow a true antiproton production excitation function to be determined. It should also be mentioned that the angle of emission from the target actually varies slightly with Bevatron energy. At 6.2 Bev, it is 3°, at 5.1 Bev it is 6°, and at 4.2 Bev it is 8° from the forward direction at the Bevatron target.

Possible spurious effects.—The possibility of a negative hydrogen ion being mistaken for an antiproton is ruled out by the following argument: It is extremely improbable that such an ion should pass through all the counters without the stripping of its electrons. It may be added that except for a few feet near the target the whole trajectory through the apparatus is though gas at atmospheric pressure, either in air or, near the magnetic lenses, in helium gas introduced to reduce multiple scattering.

None of the known heavy mesons or hyperons have the proper mass to explain the present observations. Moreover, no such particles are known that have a mean life sufficiently long to pass through the apparatus without a prohibitive amount of decay since the flight time through the apparatus of a particle of proton mass is 10.2×10^{-8} sec. However, this possibility cannot be strictly ruled out. In the description of the new particles as antiprotons, a reservation must be made for the possible existence of previously unknown negative particles of mass very close to 1840 electron masses.

The observation of pulse heights in counters $S1$ and $S2$ indicates that the new particles must be singly charged. No multiply charged particle could explain the experimental results.

Photographic experiments directed toward the detection of the terminal event of an antiproton are in progress in this laboratory and in Rome, Italy, using emulsions irradiated at the Bevatron, but to this date no positive results can be given. An experiment in conjunction with several other physicists to observe the energy release upon the stopping of an antiproton in a large lead-glass Čerenkov counter is in progress and its results will be reported shortly. It is also planned to try to observe the annihilation process of the antiproton in a cloud chamber, using the present apparatus for counter control.

The whole-hearted cooperation of Dr. E. J. Lofgren, under whose direction the Bevatron has been operated, has been of vital importance to this experiment. Mr. Herbert Steiner and Mr. Donald Keller have been very helpful throughout the work. Dr. O. Piccioni has made very useful suggestions in connection with the design of the experiment. Finally, we are indebted to the operating crew of the Bevatron and to our colleagues, who have cheerfully accepted many weeks' postponement of their own work.

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Observations of Negative K-Mesons and Charged Hyperons*

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Two pellicle stacks were exposed, in a negative K-meson channel of the Bevatron, to particles from a target bombarded by 6.2-Bev protons. The pellicles were area scanned for stars produced by stopped K^--mesons. Thirty stars were found in the first stack and have been described in detail previously.[1] In the second stack, 177 stars produced by stopped K^--mesons were found. A summary of the salient features of these 207 K^--meson stars is reported here.

The prong distribution of the K^--meson stars with one or more prongs is shown in Fig. 1. The stopped K^--mesons which produced zero-prong stars or stars with only a fast π meson, would not be detected with a high efficiency by the method of scanning that was employed. A few such cases were found but are not included in this report.

In many cases, charged π mesons, charged hyperons, and hyperfragments are observed from the K^--meson stars. The frequency of these events is summarized in Table I.[2]

In 15 cases the hyperon ejected from the K^- star was clearly positively charged because it decayed from rest or decayed in flight into a proton. In 12 cases the hyperon was clearly negatively charged because it produced a star from rest. In addition there were 3 events where a particle of nucleonic mass, from a K-meson star, came to rest in the emulsion with an associated low-energy electron at the ending. Although it is possible that some of these electrons may be accidental coincidences, it seems more probable that these electrons resulted from the atomic capture of stopped negative hyperons. It is to be expected that an appreciable fraction of the stopped negative hyperons would not produce stars in emulsion.[1] We estimate that the probability of electron ejection by a negative hyperon and a μ^- meson is of the same order of magnitude, i.e., about 25%.[3] The number of zero-prong hyperon stars is thus estimated to be $3/0.25=12$. The ratio Σ^-/Σ^+ is estimated to be 1.5. If one uses the hypothesis of charge independence for the reactions that involve the Σ hyperons[1,4] the number of Σ^0 hyperons that were produced is estimated to be 23 [i.e., $\frac{1}{2}(\Sigma^+ + \Sigma^-)$]. All of the K^--meson stars without charged hyperons are consistent with the assumption that a neutral hyperon was produced in each case. The ratio of Σ hyperons to Λ^0 hyperons is found to be $66/141 \cong 0.5$. The probability that a Λ^0 hyperon will be come trapped in a nuclear fragment and produce a hyperfragment is found to be $12/141 \cong 9\%$.

TABLE I. Frequency of various types of events.

Class	Number of stars	Remarks
Stars with charged π mesons	64	
Stars with hyperfragments	12	4 hyperfragments decayed mesonically.
Σ^+ decays into a π meson[a] from rest	5	
Σ^+ decays into a proton from rest	6	
Σ^+ decays in flight into a proton	4	In 3 of these 4 cases $v_p < v_\Sigma$. Therefore the possibility of inelastic proton scattering cannot be excluded. In all 4 cases the Q is consistent with a Σ^+ decay.
$\Sigma^\pm$ decays in flight into a $\pi^\pm$ meson[a]	5	
Σ^- stars produced from rest	12	11 of these stars have one prong, 1 has two prongs.
Tracks end with associated electrons	3	These particles are probably Σ^- hyperons which produced zero-prong stars.

[a] Minimum-ionizing particles from hyperon decays are assumed to be π mesons. None of these particles stopped in the emulsion.

It is found that about 70% of the stars with Σ hyperons have π mesons while about 37% of the K^--stars with Λ^0 hyperons have π mesons (π^0 mesons and Σ^0 hyperons are included in this estimate). The average energy of the π mesons from K^--stars with Λ^0 hyperons is considerably greater than the π-meson energy from stars with Σ hyperons. Because of this difference in energy, it is expected that more of the π mesons from stars with Λ^0 hyperons will be absorbed than from stars with Σ hyperons. This effect may partially explain the difference in the percentages (70 *vs* 37%).

Several facts suggest that the basic capture process for negative K-mesons is

$$K^- + \mathfrak{N} \rightarrow Y + \pi,$$

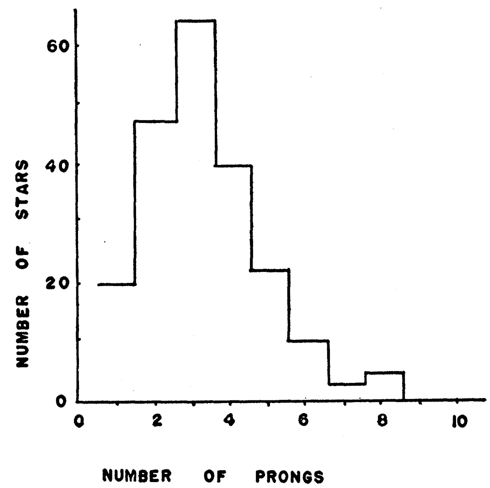

FIG. 1. The prong distribution of stars produced by stopped K^--mesons.

namely: (1) the relatively large number of stars with π mesons (~100 cases if π^0 mesons are included),[1,4] (2) the energy distribution of the charged hyperons, as shown in Fig. 2, strongly supports this reaction when the Fermi momentum of the nucleons is considered, and (3) in all cases the visible kinetic energy plus the π-meson rest mass is considerably less than the rest energy of the K^--meson.

A few of the energetic charged hyperons may be due to the absorption of the K-meson by two nucleons, although the possibility that they are due to capture by a single nucleon of high Fermi momentum cannot be excluded.

Since the detection efficiency for charged hyperon decays from K^--meson stars is very high, an unbiased estimate of the lifetime can be obtained. The combined lifetime of the Σ^+ and Σ^- hyperons is obtained from the 9 decays in flight by using the maximum-likehood method[5] and is found to be $(0.34_{-0.08}^{+0.14}) \times 10^{-10}$ sec. A second method[6] of estimating the lifetime is to utilize both positive and negative hyperons which stop as well as those that decay in flight. This yields a lifetime of

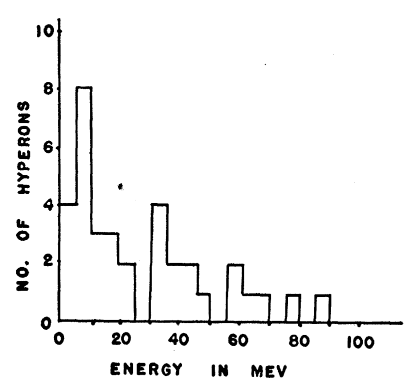

FIG. 2. The energy distribution of the charged hyperons.

$(1.41_{-0.27}^{+0.19})\times 10^{-10}$ sec. The disagreement between these two values may possibly be understood if the Σ^- hyperon has a longer lifetime than the Σ^+ hyperon. If it is assumed that all 5 of the mesonic decays in flight were Σ^+, we then obtain for the lifetime of the Σ^+ alone, by the second method, a value of $(0.76_{-0.15}^{+0.19})\times 10^{-10}$ sec.[7] (All quoted errors are standard deviations.)

It is interesting to note that the stopped Σ^- stars have a low prong multiplicity and a very low visible kinetic energy ($\sim$10 Mev). This result is in very good agreement with the prediction[8–11] that the basic Σ^- capture process is

$$\Sigma^- + p \rightarrow n + \Lambda^0.$$

In conclusion we reiterate that all of our observations on K^- mesons and charged hyperons are in excellent agreement with the predictions of Gell-Mann,[8] Nakano and Nishijima,[9] Pais,[10] and Sachs.[11]

The authors are indebted to Professor E. J. Lofgren for making the facilities of the Bevatron accelerator available to us. We are grateful to Mr. Roy Kerth for setting up the K-meson channel and assisting in the exposures. Mr. Donald Wold assisted in the scanning and analysis. Discussions with Professor R. G. Sachs and Professor G. Takeda were stimulating and helpful.

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† On leave of absence from Brookhaven National Laboratory.

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THE second Mexico meeting of the American Physical Society was held on the last three days of August, 1955. Those who had for five years been looking forward to a repetition of the 1950 Mexico meeting were amply gratified, and those who came for the first time experienced pleasures beyond what they could have foreseen. This was our first joint meeting with the Sociedad Mexicana de Física, which in 1950 was still in a nascent state. This was also our first meeting in the Ciudad Universitaria, which in 1950 was mostly an empty field with the steel skeleton of the Torre de Ciencias rising above it and is now a vast University campus adorned with splendid buildings in great number. All of our scientific sessions were held in one or another of four of its buildings. The first of them was the Inaugural Session, which was addressed in turn by Rector Nabor Carrillo of the University —Universidad Nacional Autónoma de Mexico is its full title; President Raymond T. Birge of the American Physical Society; and President Carlos Graef Fernandez of the Sociedad Mexicana de Física. Rector Carrillo then returned to the rostrum and formally opened our convention in the name of the President of the Republic, Adolfo Ruiz Cortines.

No distinction was made between the two Societies in arranging the programme: that is to say, papers both invited and contributed were distributed according to their topics, regardless of the affiliation of the speakers. Nearly all of the papers were given in English, a somewhat humiliating testimonial to the lesser competence of "norteamericanos" in mastering a foreign tongue. Professor S. A. Korff, however, gave an invited paper in Spanish, "El orígen de los rayos cosmicos," and also a few contributed papers were given in the language of the host country. All abstracts were rendered into Spanish and published in that language in a special issue of the *Revista Mexicana de Física*, by courtesy of the Sociedad and of Dr. Marcos Moshinsky, its editor. Nearly all of the invited papers pertaining to cosmic rays were chosen from the elementary-particle side of that fascinating field, for the remainder was the theme of the International Cosmic-Ray Congress held in the following week at Guanajuato. To this Congress our members were graciously invited.