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EXAMPLE OF $\Sigma^+ \to p+\gamma$ IN A HYDROGEN BUBBLE CHAMBER*

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Several searches have been made for the decay $\Sigma^+ \to p+\gamma$ of which two[1,2] claim negative results and two[3,4] claim positive results. All of the previous attempts were done in emulsions. In this Letter we present evidence of a $\Sigma^+ \to p+\gamma$ decay where the Σ^+ hyperon was produced by a K^- meson at rest in a hydrogen bubble chamber.

As part of our study of stopping K^- mesons in the Alvarez 15-in. hydrogen bubble chamber, we have measured all Σ^+ hyperons which were produced and did not decay into a light track. The events were found by a double general scan in which all K^- mesons entering a specified fiducial region were followed. The events were processed through a combined program of PANG and KICK called PACKAGE, and then the output was sorted by an EXAMIN program.

In our event, the K^- came to rest and produced a Σ^+ which decayed in flight. The proton came off backwards and stopped in the chamber. This type of configuration could be due to either

$$K^- + p \to \Sigma^+ + \pi^-, \quad \Sigma^+ \to p+\gamma \tag{1}$$

or

$$K^- + p \to \Sigma^+ + \pi^-, \quad \Sigma^+ \to p+\pi^0. \tag{2}$$

The unfitted data for the tracks are shown in Table I.

The near colinearity of the Σ^+ and π^-, and the close agreement of the beginning momentum of the K^- with the value of momentum obtained by range, strongly suggest that one should try to fit the production of the Σ^+ assuming the K^- stops. This fit is a 3-constraint fit since the magnitude of the Σ^+ momentum, from curvature, is too poorly determined to be used in the fitting. After propagating the Σ^+ to the decay vertex, we did a 1-constraint fit. The results for our three measurements are shown in Table II. As an additional check, we tried fitting the over-all event as a 4-constraint fit on another measurement and obtained

$$\chi^2(\Sigma^+ + p+\pi^0) = 147.54, \quad \chi^2(\Sigma^+ \to p+\gamma) = 0.59.$$

We now consider various interpretations of the event as a $\Sigma^+ \to p+\pi^0$ decay which would give

Table I. Unfitted data.

	P (MeV/c)	Phi (degrees)	Dip (degrees)
	Production Vertex		
K^-	221.8 ± 13.3 at beginning, from curvature	250.55 ± 0.51	7.42 ± 0.75
	213.2 ± 1.1 from range		
π^-	181.7 ± 7.3 from curvature	178.35 ± 0.23	23.39 ± 0.35
Σ^+	136.3 ± 1.9 from range	358.44 ± 4.29	-20.95 ± 4.09
	Decay Vertex		
Σ^+	5 mm length	1.55 ± 4.29	-20.93 ± 4.09
p	137.0 ± 1.0 from range	104.09 ± 2.24	29.41 ± 2.19

Table II. Vertex fits (chi-squares).

	Measurement number 1	2	3
$K^-+p\to\Sigma^++\pi^-$	0.35	0.77	0.88
$\Sigma^+\to p+\pi^0$	92.85	829.35 (first step)	96.48
$\Sigma^+\to p+\gamma$	5.08	0.09	3.66

rise to a poor fit, if they were possible.

(a) The Σ^+ could have decayed within 1 mm of the production vertex, and what we see is really a proton which then scatters. This is impossible since the proton would have to backscatter in the laboratory system.

(b) The proton could have scattered as it came out of the decay vertex. If it came from the Σ^+ decay, the track of the minimum recoil proton, such that the decay proton ends up in its observed final state, is greater than 2 mm. This recoil should be quite visible and cannot be hidden under the decay proton or Σ^+. We see no such recoil.

(c) The Σ^+ could have scattered just before decaying without giving rise to a visible recoil. If the hyperon has to decay with the proton ending up in the observed final state, the minimum recoil is 1.3 mm. This recoil should be quite visible and cannot be hidden under the decay proton or Σ^+ hyperon. We see no such recoil.

(d) The production vertex could have been slightly in flight. This could not explain the observed decay, since the unfitted data allows very little K^- momentum.

Our conclusion is that this event is, indeed, an example of the decay $\Sigma^+\to p+\gamma$. It was found in a sample of 237 $\Sigma^+\to p+\pi^0$ events with a confidence level of at least 1%, giving a branching ratio on the order of 0.4%.

We would like to express our deep appreciation of the help given us by the Alvarez group, especially Dr. Humphrey and Dr. Ross, in sending us the film and the original versions of the programs. We are particularly indebted to Professor G. A. Snow for his continual guidance throughout this work.

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