Determination of the $\Sigma^\pm \rightarrow \Lambda e^\pm \nu$ Decay Parameters*

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From about $6 \times 10^6$ stopping $K^-$-meson reactions in the Saclay 80 cm hydrogen bubble chamber 70 $\Sigma^- \rightarrow \Lambda e^- \bar{\nu}$ and 11 $\Sigma^+ \rightarrow \Lambda e^+ \nu$ decays have been identified. The ratio of the vector to axial vector coupling constant has been determined, $f_2/g_1 = -0.22 \pm 0.28$, consistent with the prediction $f_2 = 0$ of the CVC-theory. The branching ratios for the two decay modes are,

$$\frac{\Gamma(\Sigma^- \rightarrow \Lambda e^- \bar{\nu})}{\Gamma(\Sigma^- \rightarrow \text{all modes})} = (0.69 \pm 0.12) \times 10^{-4},$$

$$\frac{\Gamma(\Sigma^+ \rightarrow \Lambda e^+ \nu)}{\Gamma(\Sigma^+ \rightarrow \text{all modes})} = (0.29 \pm 0.10) \times 10^{-4}.$$  

The ratio,

$$\frac{\Gamma(\Sigma^+ \rightarrow \Lambda e^+ \nu)}{\Gamma(\Sigma^- \rightarrow \Lambda e^- \bar{\nu})} = 0.69 \pm 0.18,$$

agrees with the phase space ratio, 0.61, therefore a theory that includes no second class currents is consistent with the data.

I. Introduction

The purpose of this paper is to present further experimental information on the decay of unpolarized $\Sigma^\pm$-hyperons into $\Lambda e^\pm \nu$. The CVC-theory predicts that the vector current is absent in $\Sigma^\pm \rightarrow \Lambda e^\pm \nu$ decay except for contributions of weak magnetism. The electron-neutrino angular distribution and the $\Lambda$-polarization provide a sensitive test of the presence of a vector current.

The theory Cabibbo has proposed for the leptonic decays of baryons contains three parameters, the angle $\theta$, and the magnitude of the $F$ and $D$ reduced matrix elements of the axial vector current. From the integrated decay rate of $\Sigma^\pm \rightarrow \Lambda e^\pm \nu$ the magnitude of $D$ can be determined:

$$\Gamma(\Sigma^\pm \rightarrow \Lambda e^\pm \nu) \sim D^2 \cos^2 \theta.$$  

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Finally a deviation of the ratio of the rates
\[ \frac{\Gamma(\Sigma^+ \rightarrow \Lambda e^+ \nu)}{\Gamma(\Sigma^- \rightarrow \Lambda e^- \bar{\nu})} \]
from phase space, 0.61, would give information on the presence of second
class currents\(^2\).

II. Source of the \(\Sigma^{\pm}\)-Hyperons

Approximately \(6 \times 10^6\) \(K^-\)-mesons have been stopped in the Saclay
80 cm bubble-chamber at the CERN PS. The photographs have been
scanned for the reaction \(K^- p \rightarrow \Sigma^\pm \pi^\mp, \Sigma^\pm \rightarrow \Lambda e^\pm \nu\). The experimental
difficulty is associated with the low momenta of the \(\Sigma\)'s and \(\Lambda\)'s, the
\(\Sigma\)-track is usually short and the \(\Lambda\)-decay often does not resemble the
usual "\(V\)" of high momentum \(\Lambda\)'s.

To eliminate experimental biases after measuring the events, the
following selection criteria were applied:

a) The \(\Sigma\)-track had to be visible.
b) The \(\Sigma\)-momentum at the decay vertex had to exceed 80 MeV/c.
c) The \(\Lambda\) path length had to be less than 7 cm and for all events more
than 1 mm for \(\Sigma^+ \rightarrow \Lambda e^+ \nu\) decays.

With these criteria we were certain to eliminate background events
of the following types:

a) \(K^- p \rightarrow \Lambda \pi^0, \pi^0 \rightarrow e^+ e^- \gamma\), where one of the electrons resembles
a pion.
b) \(\Sigma^- p \rightarrow \Sigma^0 n, \Sigma^0 \rightarrow \Lambda \gamma\) or \(\rightarrow \Lambda e^+ e^-\), the \(\gamma\)-ray producing a Compton
electron near its origin or the positron being invisible.
c) \(\Sigma^+ \rightarrow p \pi^0, \pi^0 \rightarrow e^+ e^- \gamma\), the \(p\) and \(e^-\) simulating a \(\Lambda\)-decay.

All the events found according to the selection criteria were passed
through the spatial reconstruction and kinematic fitting programs Thresh
and Grind. Up to now there are 70 \(\Sigma^-\) and 11 \(\Sigma^+\) selected events\(^*\) fitting
the 7-constraint hypotheses \(K^- p \rightarrow \Sigma^{\pm} \pi^{\mp}, \Sigma^{\pm} \rightarrow \Lambda e^{\pm} \nu, \Lambda \rightarrow p \pi^-\).

Scanning inefficiencies might have occurred for \(\Lambda\)'s decaying at a
short distance from the \(\Sigma\)-vertex. A Monte Carlo calculation showed
that the length distribution of the \(\Lambda\)-flight path (in lab. syst.) is practically
independent of the type of decay, vector or axial vector.

\(^*\) There are 7 events included from a previous experiment\(^3\).

3. Courant, H., H. Filthuth, P. Franzini, A. Minguzzi-Ranzi, A. Segar, R. Eng