CERN-EP/81-03
15 January 1981

A MEASUREMENT OF TWO RESONANT CONTRIBUTIONS

IN THE Λ_C^+ BRANCHING RATIOS

M. Basile^{1,2)}, G. Cara Romeo²⁾, L. Cifarelli³⁾, A. Contin³⁾, G. D'Ali²⁾,
P. Di Cesare²⁾, B. Esposito⁴⁾, P. Giusti²⁾, T. Massam²⁾, F. Palmonari^{2,*)},
G. Sartorelli²⁾, G. Valenti²⁾ and A. Zichichi³⁾

ABSTRACT

The contribution of two resonant states Δ^{++} and $\overline{K}^{*0}$ to the Λ_C^+ decay has been measured. The world average is given.

Submitted to Nuovo Cimento

---

*) Now at the Istituto di Fisica dell'Università, Perugia, Italy.

1) Istituto di Fisica dell'Università, Bologna, Italy.

2) Istituto Nazionale di Fisica Nucleare, Bologna, Italy.

3) CERN, Geneva, Switzerland.

4) Istituto Nazionale di Fisica Nucleare, Lab. Naz., Frascati, Italy.

1. INTRODUCTION

The purpose of this paper is to report on a study of the contributions to the decay $\Lambda_c^+ \rightarrow pK^-\pi^+$ of the two well-known resonant states

$$\overline{K^{*0}} \rightarrow K^-\pi^+ \quad \text{and} \quad \Delta^{++} \rightarrow p\pi^+ . \quad (1)$$

The experiment has been performed using, as the Λ_c^+ production reaction, high-energy pp collisions at the CERN Intersecting Storage Rings (ISR). The reaction investigated was

$$pp \rightarrow \Lambda_c^+ + e^- + \text{anything} , \quad (2)$$

at a total pp c.m. energy of $\sqrt{s} = 62$ GeV.

2. EXPERIMENTAL SET-UP

The experimental set-up consists of a system of multiwire proportional chambers (MWPCs) in a large-volume, 10 kG magnetic field produced by the Split-Field Magnet (SFM). There are also gas Čerenkov counters and electromagnetic shower detectors for "electron" trigger, plus a large assembly of time-of-flight (TOF) counters for particle identification (p, K, π). Figure 1 shows a schematic layout of the set-up, which has been described in detail elsewhere¹⁾.

3. DATA ANALYSIS

From a sample of proton-proton collisions with an electron produced at 90° we obtained²⁾ a clear signal of the charmed baryon Λ_c^+ decaying via the channel $pK^-\pi^+$.

Firstly, the events were analysed in order to reduce the background contribution to genuine electron events. The contamination from charged hadrons simulating electrons was reduced to the 2% level. Background electrons from Dalitz π^0 and η decays and from external γ -conversions were rejected to the 50% level via pulse-height analysis with a dE/dx chamber placed near the intersection region.

From the sample of events left, we selected those with at least one positive particle with $x = 2p_L/\sqrt{s} \geq 0.3$ and an error on the measured momentum $\Delta p/p \leq 30\%$. In these events the positive particle with the highest x has been assumed to be a proton. In the invariant mass, $pK^-\pi^+$, $K^-(\pi^+)$ is any negative (positive) track not identified as an $\bar{p}$ or π^- (p or K^+) by the time of flight. All possible combinations are entered into the mass plot, provided they satisfy the following conditions:

- a) all particles are fitted to the vertex and have a momentum uncertainty $\Delta p/p \leq 30\%$;
- b) both K^- and π^+ are in the same rapidity hemisphere as that of the proton;
- c) the rapidity of both the K^- and the π^+ is greater than 1.0.

In order to enhance the Λ_c^+ signal, we have imposed one of the following conditions on the hemisphere opposite to that of the Λ_c^+ :

- i) either the presence of a leading system of charged particles with $x_{\text{total}} = \sum_{i=1}^n (x_i) \geq 0.5$, where $x = 2p_L/\sqrt{s}$;
- ii) or a signature for a leading system escaping detection, i.e. $x_{\text{total}} \leq 0.1$.

The above sum $\sum_{i=1}^n$ is extended to all particles fitted to the vertex and with $\Delta p/p \leq 30\%$. The results are shown in fig. 2.

In order to study the resonant contributions to the decay $\Lambda_c^+ \rightarrow pK^-\pi^+$ from

$$\Lambda_c^+ \rightarrow \overline{K^{*0}}p \quad \text{and} \quad \Lambda_c^+ \rightarrow \Delta^{++}K^- ,$$

the mass spectra for $K^-\pi^+$ and $p\pi^+$ have been studied in three different mass ranges for the $pK^-\pi^+$ mass spectrum. These are indicated in table 1.

Figure 3 shows the results. Above (fig. 3a) and below (fig. 3c) the Λ_c^+ mass range, the $K^-\pi^+$ and $p\pi^+$ mass spectra do not show any enhancement. This is not the case in fig. 3b, which corresponds to the Λ_c^+ mass range. Here we observe a peak in the mass spectrum of both the $K^-\pi^+$ and the $p\pi^+$, at mass values corresponding to $\overline{K^{*0}}$ and Δ^{++} , respectively.

Notice that the dashed-line histograms correspond to mass spectra with e^+ -triggered events. Here there is no evidence for any resonant state. This is another proof that, in order to have a clean Λ_c^+ signal, the e^- trigger is needed. In fact, the

associated production of Λ_c^+ with an anticharmed particle requires the presence of an e^- and not of an e^+ . The e^+ -triggered events were used to draw the shape of the background in the e^- -triggered spectra.

4. RESULTS

From the number of events above background in the $\overline{K}^{*0}$ and Δ^{++} peaks, and from the total number of observed Λ_c^+ , the following branching ratios are obtained:

$$\frac{\Lambda_c^+ \rightarrow \overline{K}^{*0} p}{\Lambda_c^+ \rightarrow p K^- \pi^+} = 0.28 \pm 0.16 ,$$

$$\frac{\Lambda_c^+ \rightarrow \Delta^{++} K^-}{\Lambda_c^+ \rightarrow p K^- \pi^+} = 0.40 \pm 0.17 .$$

The interest in these measurements is due to the fact that only two results^{3,4)} are available so far. Table 2 summarizes the present knowledge of these branching ratios. The world average is also given.

REFERENCES

- 1) R. Bouclier et al., Nucl. Instrum. Methods 125 (1975) 19.
M. Basile et al., Nucl. Instrum. Methods 163 (1979) 93.
M. Basile et al., preprint CERN-EP/80-118 (1980); Nucl. Instrum. Methods,
in print.
H. Frehse et al., Nucl. Instrum. Methods 156 (1978) 87.
H. Frehse et al., Nucl. Instrum. Methods 156 (1978) 97.
- 2) M. Basile et al., preprint CERN EP/80-214 (1980); submitted to Nucl. Phys. B.
- 3) G. Goldhaber, Topical Workshop on the Production of New Particles in Superhigh
Energy Collisions, Univ. of Wisconsin, Madison, 1979; LBL-10428, January
1980.
- 4) G. Sajot, Ph.D. Thesis, Univ. Paris VI, April 1980.

Table 1

Mass ranges of $pK^-\pi^+$ (GeV/c^2)

Below Λ_c^+	2.18-2.28
In the Λ_c^+ peak	2.28-2.38
Above Λ_c^+	2.38-2.48

Table 2

Branching ratios of $\overline{K}^{*0}$, Δ^{++} resonant contributions to the $\Lambda_c^+ \rightarrow pK^-\pi^+$ decay channel

	$\frac{\overline{K}^{*0}p}{pK^-\pi^+}$	$\frac{\Delta^{++}K^-}{pK^-\pi^+}$
SPEAR (Mark II) ³⁾	0.12 ± 0.07	0.17 ± 0.07
ISR (G. Sajot) ⁴⁾	0.41 ± 0.18	0.53 ± 0.22
ISR (this expt.)	0.28 ± 0.16	0.40 ± 0.17
World average { unweighted	0.27 ± 0.08	0.37 ± 0.10
weighted	0.18 ± 0.06	0.23 ± 0.06
$\frac{\Lambda_c^+ \rightarrow (\Delta^{++}K^- + \overline{K}^{*0}p)}{\Lambda_c^+ \rightarrow pK^-\pi^+} = \begin{cases} 0.64 \pm 0.13 \text{ (unweighted)} \\ 0.41 \pm 0.08 \text{ (weighted)} \end{cases}$		

Figure captions

Fig. 1 : Top view of the SFM detector, showing the MWPCs and the external apparatus for particle identification:

- i) C_i ($i = 0, \dots, 5$) are gas threshold $\check{\text{C}}$ erenkov counters;
- ii) SW_i ($i = 2, \dots, 5$) are lead/scintillator sandwiches;
- iii) LG_i ($i = 3, 4$) are lead-glass counters.

Notice that only coincidences C_0C_3 or C_0C_4 associated to a minimum energy release (≥ 500 MeV) in the electromagnetic shower detectors (LG_3 , SW_3 or LG_4 , SW_4) were used in the "electron" trigger.

Fig. 2 : Mass distribution of $pK^-\pi^+$ combinations selected as described in the text. The solid line is a fit to the mass spectrum with e^+ triggers. This shape represents the background.

Fig. 3 : Invariant mass spectra for $K^-\pi^+$ and $p\pi^+$ combinations as a function of three different cuts in the $pK^-\pi^+$ mass:

- a) $2.18 \leq m(pK^-\pi^+) < 2.28 \text{ GeV}/c^2$; (below Λ_c^+)
- b) $2.28 \leq m(pK^-\pi^+) \leq 2.38 \text{ GeV}/c^2$; (in the Λ_c^+ peak)
- c) $2.38 < m(pK^-\pi^+) \leq 2.48 \text{ GeV}/c^2$; (above Λ_c^+).

The full-line histograms refer to e^- triggers; the dashed-line histograms refer to e^+ triggers. The solid lines are fits to the mass spectra with e^+ triggers.

Fig. 1

Fig. 2

Fig. 3