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THE LEADING EFFECT IN Λ_c^+ PRODUCTION AT $\sqrt{s} = 62$ GeV
IN PROTON-PROTON COLLISIONS

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ABSTRACT

The longitudinal momentum distribution of the Λ_c^+ charmed baryon produced in the reaction $pp \rightarrow \Lambda_c^+ e^- X$ at 62 GeV in the pp c.m. system has been measured. A comparison with the data on Λ^0 and $\bar{\Lambda}^0$ production allows us to conclude that a leading effect is present in Λ_c^+ production.

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1. INTRODUCTION

In this paper the first measurement of the longitudinal momentum distribution of the charmed baryon Λ_c^+ produced in the reaction

$$pp \rightarrow \Lambda_c^+ + e^- + \text{anything} \quad (1)$$

is reported. The experiment has been carried out at a centre-of-mass energy of $\sqrt{s} = 62$ GeV.

The purpose of this study was to establish whether in the production of a heavy flavour in pp interactions, the "leading hadron effect" was present.

2. EXPERIMENTAL SET-UP

The data were obtained using the split-field magnet (SFM) spectrometer of the CERN Intersecting Storage Rings (ISR). Čerenkov counters were used together with electromagnetic shower detectors (EMSD) to trigger on electrons produced in a solid angle of about 0.2 sr around 90° . A large-area time-of-flight system was used for p, K, and π identification up to a momentum of about 1.5 GeV/c.

Figure 1 shows the top view of the apparatus. Details of the apparatus and of the single-electron trigger can be found elsewhere^{1,2}).

3. DATA ANALYSIS

In order to obtain a clean sample of directly produced electrons, the software analysis proceeded in two steps.

First, a software refinement of the trigger conditions, plus a request for a minimum-energy release in the EMSDs ($E > 500$ MeV), reduced the charged hadron contamination to the 2% level. Secondly, the analysis of the pulse-height of a dE/dx chamber, placed very near to the intersection region, rejected electrons from π^0 and η Dalitz decay and γ conversions. This allowed background reduction to the 50% level.

In the sample of single-electron events, a clean signal of Λ_c^+ decaying into $pK^-\pi^+$ was observed²). In order to reduce the combinatorial background, the proton

was identified as the fastest positive particle with $x_L \approx 2p_L/\sqrt{s} > 0.3$ in the event. According to previous measurements³⁾ the π^+ contamination ranges from 20% to 2%, decreasing exponentially with increasing x_L .

The K^- and the π^+ were any negative or, respectively, positive tracks not identified as $\bar{p}$ or π^- (respectively p or K^+) by the TOF system. Furthermore, they had to

- a) be fitted to the event vertex (within ± 5 cm) with a momentum uncertainty $\Delta p/p < 30\%$;
- b) be in the same rapidity hemisphere as that of the proton;
- c) have a rapidity greater than 1.0.

In order to enhance the Λ_c^+ signal, either the presence of a leading system of charged particles with $x_{\text{tot}} = \sum_{i=1}^n (x_{i_L}) > 0.5$, or a signature for a leading system escaping detection, i.e. $x_{\text{tot}} < 0.1$, has been imposed on the hemisphere opposite to that of the Λ_c^+ (the sum is extended to all particles fitted to the vertex and with $\Delta p/p < 30\%$). The final combination-to-event ratio was about 1.15.

Figure 2 shows the $pK^-\pi^+$ invariant mass spectrum for reaction (1). The background was determined, in the same invariant mass range, using the mass spectrum associated with the e^+ trigger, which, as expected for a charmed baryon, does not show any enhancements in the Λ_c^+ region.

4. RESULTS

The x_L distribution of the Λ_c^+ events was computed using as reference the x_L distribution of the events above $[2.38 < m(pK^-\pi^+) < 2.48 \text{ GeV}/c^2]$ and below $[2.18 < m(pK^-\pi^+) < 2.28 \text{ GeV}/c^2]$ the Λ_c^+ mass range. This was in order to determine the shape of the background events inside the Λ_c^+ mass range. All events had been corrected for the apparatus acceptance.

The experimental data are shown in Fig. 3. They have been fitted with a function: $\Delta N/\Delta |x_L| \propto (1 - |x_L|)^\alpha$. The dashed line is the best fit to the data. The exponent is found to be

$$\alpha = 0.40 \pm 0.25.$$

By comparing the longitudinal momentum distribution of the Λ_c^+ (quark composition: cud) with that of the Λ^0 (quark composition: sud), both of them produced in high-energy proton-proton collisions, the following remarks are in order. These two particles are very similar, since they have two quarks (ud) which might be in common with the incoming proton and one (c and s, respectively) which is not present in the pp initial state.

Figure 4 shows the experimental x_L distributions of the Λ^0 and $\bar{\Lambda}^0$ ⁴⁾ together with the experimental x_L distribution of the Λ_c^+ measured in the present experiment. The shapes of these distributions indicate that the Λ_c^+ is produced very similarly to the Λ^0 , and is much flatter in x than the $\bar{\Lambda}^0$.

The quantitative analysis is shown in Fig. 5, where the ratios $(\Lambda_c^+/\bar{\Lambda}^0)$ and (Λ_c^+/Λ^0) versus x_L are presented. The clear enhancement with increasing x_L for the $(\Lambda_c^+/\bar{\Lambda}^0)$ ratio (Fig. 5a) is evidence for a leading effect in the Λ_c^+ production. The flatness versus x_L of the ratio (Λ_c^+/Λ^0) (Fig. 5b), is evidence that the production mechanism of charmed and strange baryons in proton-proton interactions has analogous "leading hadron" effects.

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Figure captions

- Fig. 1 : Top view of the SFM detector, showing the MWPCs and:
- a) the time-of-flight system (TOF);
 - b) the electromagnetic shower detectors (EMSD) which are either lead-scintillator sandwiches (SW) or lead-glass (LG);
 - c) the gas threshold Čerenkov counters (C);
 - d) the dE/dx chamber (209).
- Fig. 2 : Difference between the $pK^-\pi^+$ invariant mass spectrum associated with e^- triggered events, and the same mass combination relative to e^+ triggered events.
- Fig. 3 : Experimental x_L distribution of the Λ_c^+ events. The dashed line is the fit: $\Delta N/\Delta |x_L| \propto (1 - |x_L|)^{0.4}$.
- Fig. 4 : Experimental x_L distribution of Λ^0 [(a), black circles] and $\bar{\Lambda}^0$ [(b), open circles] produced in proton-proton collisions at $\sqrt{s} = 53$ GeV. Also shown (c) is the x_L distribution for Λ_c^+ in this experiment.
- Fig. 5 : Quantitative comparison between $(\Lambda_c^+/\bar{\Lambda}^0)$ (a) and (Λ_c^+/Λ^0) (b) x_L distributions.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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