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The Leading Effect in Λ_c^+ Production at $\sqrt{s} = 62$ GeV in Proton-Proton Collisions.

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

$$\text{pp} \to \Lambda_c^+ + e^- + \text{anything} \tag{1}$$

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.

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-fligth 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].

(1) R. BOUCLIER, R. C. A. BROWN, E. CHESI, L. DUMPS, H. G. FISCHER, P. G. INNOCENTI, G. MAURIN, A. MINTEN, L. NAUMANN, F. PIUZ and O. ULLALAND: *Nucl. Instrum. Methods*, **125**, 19 (1975); M. BASILE, G. CARA ROMEO, L. CIFARELLI, A. CONTIN, G. D'ALI, P. GIUSTI, T. MASSAM, F. PALMONARI, G. SARTORELLI, G. VALENTI and A. ZICHICHI: *Nucl. Instrum. Methods*, **163**, 93 (1979); M. BASILE, G. CARA ROMEO, L. CIFARELLI, A. CONTIN, G. D'ALI, P. DI CESARE, B. ESPOSITO, L. FAVALE, P. GIUSTI, T. MASSAM, F. PALMONARI, G. SARTORELLI, G. VALENTI and A. ZICHICHI: *Nucl. Instrum. Methods*, **179**, 477 (1981); H. FREHSE, F. LAPIQUE, M. PANTER and F. PIUZ: *Nucl. Instrum. Methods*, **156**, 87 (1978); H. FREHSE, M. HEIDEN, M. PANTER and F. PIUZ: *Nucl. Instrum. Methods*, **156**, (1978).

(2) M. BASILE, G. CARA ROMEO, L. CIFARELLI, A. CONTIN, G. D'ALI, P. DI CESARE, B. ESPOSITO, P. GIUSTI, T. MASSAM, F. PALMONARI, G. SARTORELLI, G. VALENTI and A. ZICHICHI: *Measurement of associated charm production in pp interactions at $\sqrt{s} = 62$ GeV*, to be published in *Nuovo Cimento*.

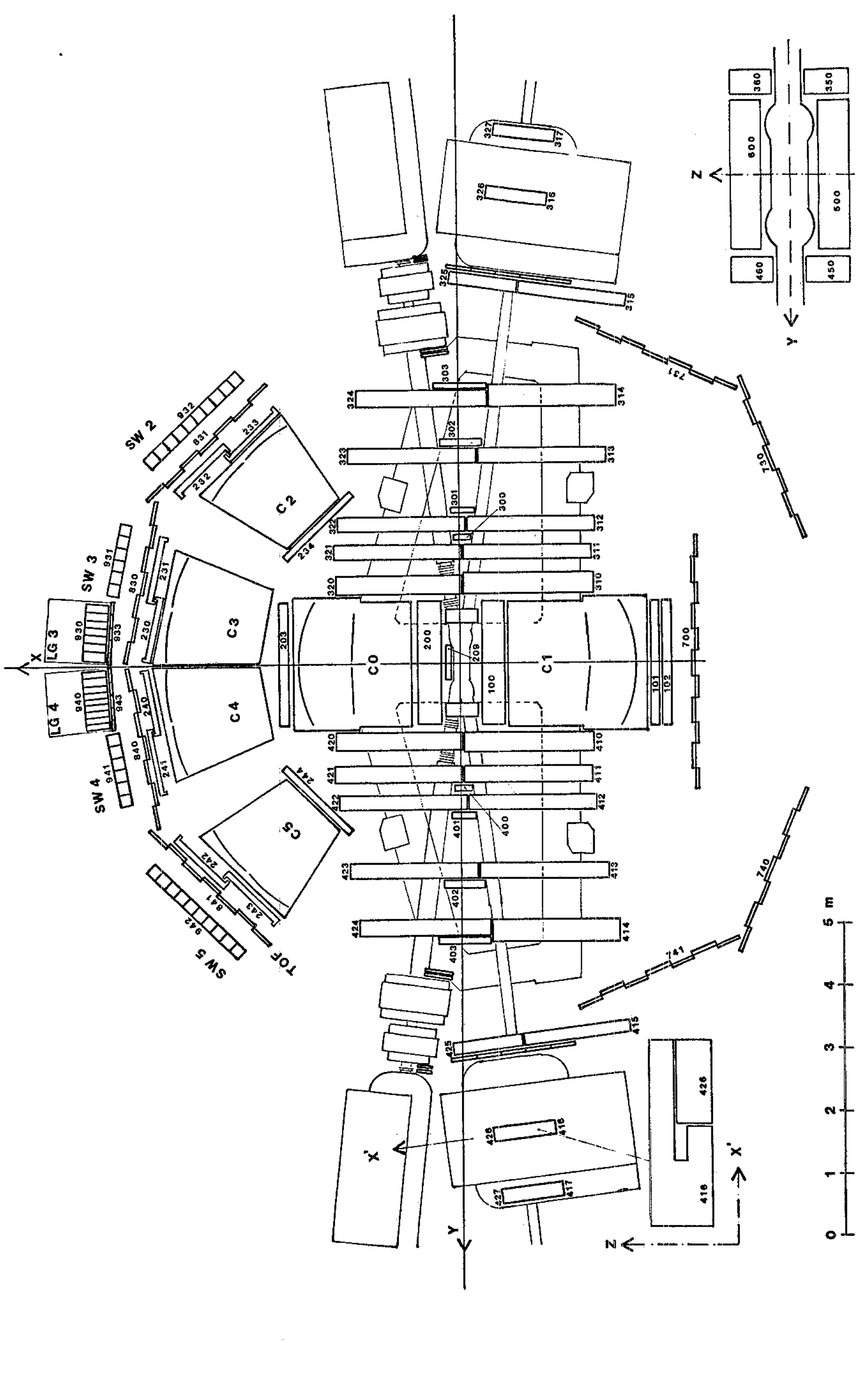

Fig. 1. – Top view of the SFM detector, showing the MWPCs and: *a*) the time-of-flight system (TOF); *b*) the electromagnetic shower detectors (EMSD) which are either lead-scintillator sandwiches (SW) or lead-glass (LG); *c*) the gas threshold Čerenkov counters (C); *d*) the dE/dx chamber (209).

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 of 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 observed (²).

In order to reduce the combinatorial background, the proton was identified as the fastest positive particle with $x_L \simeq 2p_L/\sqrt{s} > 0.3$ in the event. According to previous measurements (³) 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 time-of-flight 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 $x_{tot} = \sum_{i=1}^{n} (x_{i_L}) > 0.5$, or a signature for a leading system escaping detection, *i.e.* $x_{tot} < 0.1$, 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 back-

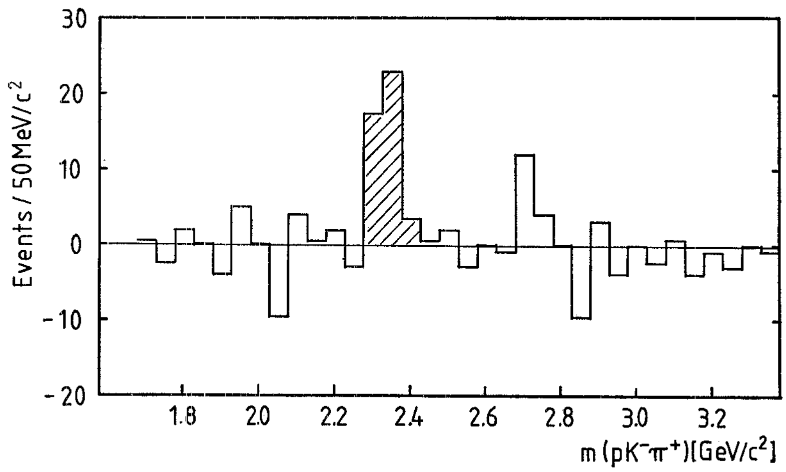

Fig. 2. – Difference between the $pK^-\pi^+$ invariant mass spectrum associated with e^--triggered events and the same mass combination relative to e^+-triggered events.

(³) P. Capiluppi, G. Giacomelli, A. M. Rossi, G. Vannini and A. Bussière: *Nucl. Phys. B*, **70**, 1 (1974).

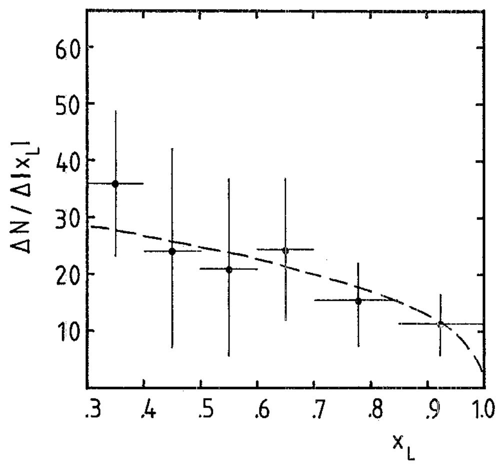

Fig. 3. – Experimental x_L distribution of the Λ_c^+ events. The dashed line is the fit: $\Delta N/\Delta|x_L| \propto \propto (1-|x_L|)^{0.4}$.

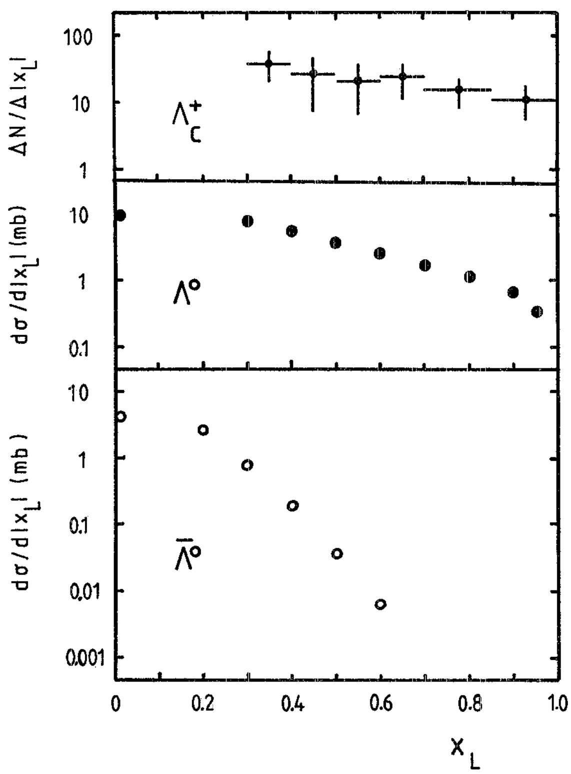

Fig. 4. – Experimental x_L distribution of Λ^0 (black circles) and $\bar{\Lambda}^0$ (open circles) produced in proton-proton collisions at $\sqrt{s} = 53$ GeV. Also shown is the x_L distribution for Λ_c^+ in this experiment.

ground was determined, in the same invariant mass range, using the mass spectrum associated to the e^+ trigger, which, as expected for a charmed baryon, does not show any enhancements in the Λ_c^+ region.

Results – The x_L distribution of the Λ_c^+ events was computed using as reference the x_L distribution of the events above $(2.38 \leqslant m(pK^-\pi^+) < 2.48\ GeV/c^2)$ and below $(2.18 \leqslant m(pK^-\pi^+) < 2.28\ GeV/c^2)$ 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 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

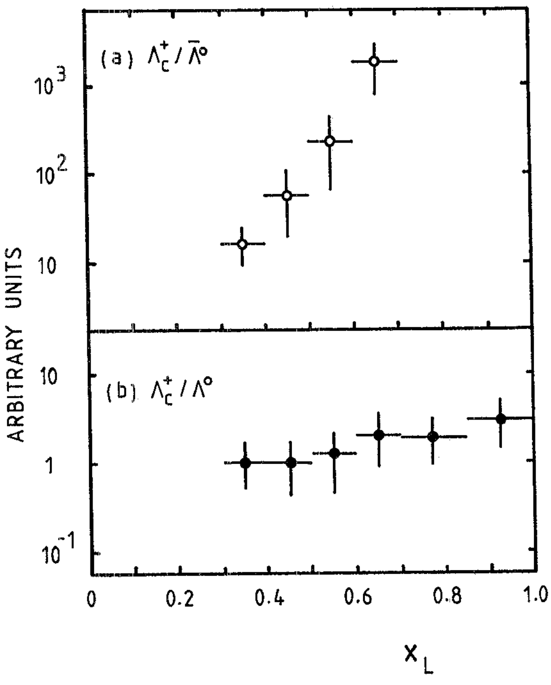

Fig. 5. – Quantitative comparison between $(\Lambda_c^+/\bar{\Lambda}^0)$ (*a*)) and (Λ_c^+/Λ^0) (*b*)) x_L distributions.

(4) S. Erhan, W. Lockman, T. Meyer, J. Rander, P. Schlein, R. Webb and J. Zsembery: *Phys. Lett. B*, **85**, 447 (1979).

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