ISTITUTO NAZIONALE DI FISICA NUCLEARE
Laboratori Nazionali di Frascati

LNF-81/46

M. Basile et al. : MEASUREMENT OF ASSOCIATED CHARM PRODUCTION IN pp INTERACTIONS AT $\sqrt{s}$ = 62 GeV

Estratto da :
Nuovo Cimento 63A, 230 (1981)

Servizio Documentazione
dei Laboratori Nazionali di Frascati
Cas. Postale 13 - Frascati (Roma)

IL NUOVO CIMENTO VOL. 63 A, N. 2 21 Maggio 1981

Measurement of Associated Charm Production in pp Interactions at $\sqrt{s} = 62$ GeV.

M. BASILE, G. CARA ROMEO, L. CIFARELLI, A. CONTIN, G. D'ALI, P. DI CESARE, B. ESPOSITO, P. GIUSTI, T. MASSAM, R. NANIA, F. PALMONARI, G. SARTORELLI, G. VALENTI and A. ZICHICHI

CERN - Geneva, Switzerland
Istituto di Fisica dell'Università - Bologna, Italia
Istituto Nazionale di Fisica Nucleare - Sezione di Bologna, Italia
Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Frascati - Frascati, Italia
Istituto di Fisica dell'Università - Perugia, Italia

(ricevuto il 10 Marzo 1981)

Summary. — The associated charm production has been studied in pp interactions at $\sqrt{s} = 62$ GeV. The comparison of the measured production cross-section and the e^-/π^- ratio with various theoretical models and with existing inclusive e/π measurements allows one to conclude that the most likely interpretation of the associated production is in terms of a charmed baryon Λ_c^+ produced forward, plus the $\bar{D}$ meson produced centrally.

1. – Introduction.

The study of associated production of charmed particles $(c, \bar{c})$ in proton-proton interactions has been and is still very difficult. The experiments have so far been centred on the inclusive production (1-4) of a single charmed particle,

(1) D. DRIJARD, H. G. FISCHER, W. GEIST, R. GOKIELI, P. G. INNOCENTI, V. KORBEL, A. MINTEN, A. NORTON, R. SOSNOWSKI, S. STEIN, O. ULLALAND, H. D. WAHL, P. BURLAND, M. DELLA NEGRA, G. FONTAINE, P. FRENKIEL, C. GHESQUIÈRE, D. LINGLIN, G. SAJOT, H. FREHSE, E. E. KLUGE, M. HEIDEN, A. PUTZER, J. STIEWE, P. HANKE,

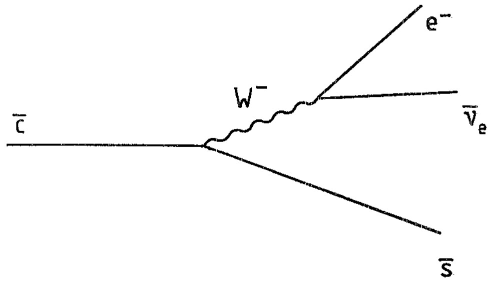
D^+ or Λ_c^+. Only preliminary data [5,6] have been reported for the associated production of charmed pairs in hadronic interactions.

In this paper, the associated production of a charmed baryon plus the anti-charmed particle is studied, together with an estimate of the cross-section. The reaction investigated in proton-proton collisions at $\sqrt{s} = 62$ GeV is

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

where the Λ_c^+ is identified via its decay mode $\Lambda_c^+ \to K^- p\pi^+$. The negative electron is the signature for the semi-leptonic decay of an anticharmed particle, where the antiquark transition follows the expected generalized Cabibbo dominance [7], as illustrated by the diagram

(2)



The results, as in previous experiments [2-6], obviously depend on the production mechanism chosen. A comparison of all experimental results with

W. HOFMANN, M. PANTER, K. RAUSCHNABEL, J. SPENGLER and D. WEGENER (CCHK COLLABORATION): *Phys. Lett. B*, **81**, 250 (1979).
(2) K. L. GIBONI, D. DIBITONTO, M. BARONE, M. M. BLOCK, A. BÖHM, R. CAMPANINI, F. CERADINI, J. EICKMEYER, D. HANNA, J. IRION, A. KERNAN, H. LUDWIG, F. MULLER, B. NAROSKA, F. NAVACH, M. NUSSBAUM, J. O'CONNOR, C. RUBBIA, D. SCHINZEL, H. SEEBRUNNER, A. STAUDE, R. TIRLER, G. VAN DALEN, R. VOSS and R. WOJSLAW (ACHMNR COLLABORATION): *Phys. Lett. B*, **85**, 437 (1979).
(3) W. LOCKMAN, T. MEYER, J. RANDER, P. SCHLEIN, R. WEBB, S. ERHAN and J. ZSEMBERY (UCLA-SACLAY COLLABORATION): *Phys. Lett. B*, **85**, 443 (1979).
(4) D. DRIJARD, H. G. FISCHER, W. GEIST, P. G. INNOCENTI, V. KORBEL, A. MINTEN, A. NORTON, S. STEIN, O. ULLALAND, H. D. WAHL, P. BURLAND, G. FONTAINE, P. FRENKIEL, C. GUESQUIÈRE, G. SAJOT, P. HANKE, W. HOFMANN, M. PANTER, K. RAUSCHNABEL, J. SPENGLER, D. WEGENER, H. FREHSE, E. E. KLUGE, M. HEIDEN, W. HERR, A. PUTZER, M. DELLA NEGRA, D. LINGLIN, R. GOKIELI, R. SOSNOWSKI and M. SZEPTYCKA (ACCDHW COLLABORATION): *Phys. Lett. B*, **85**, 452 (1979).
(5) *a*) CCHK AND ACCDHW COLLABORATIONS: *Production of charm in the* SFM *at the* ISR, presented by G. SAJOT at the *XX International Conference on High-Energy Physics, Madison, 1980*; *b*) W. M. GEIST: private communication.
(6) *a*) ACHMNR COLLABORATION: *Production of charmed particles at the* CERN ISR, presented by F. MULLER at the *XX International Conference on High-Energy Physics, Madison, 1980*; *b*) F. MULLER: private communication.
(7) A. ZICHICHI: *Riv. Nuovo Cimento*, **2**, No. 14 (1979).

various theoretical predictions suggests that the most likely mechanism is the forward production of a charmed baryon associated with a centrally produced anticharmed meson.

2. – Experimental procedure.

The experiment was performed by using the Split-Field Magnet (SFM) detector of the CERN Intersecting Storage Rings (ISR), with the addition of gas threshold Čerenkov counters and electromagnetic shower detectors, to trigger on electrons produced at 90°. The apparatus is shown in fig. 1. The trigger electron was detected by the coincidence of the two Čerenkov counters (C_0C_3 or C_0C_4) and by the condition of a minimum energy deposited in the corresponding electromagnetic shower detector (EMSD) (8): $E^e_{min} \geqslant 500$ MeV.

A small multiwire proportional chamber (MWPC) with analog read-out (« dE/dx » chamber) (9), placed near the intersection region, provided the necessary pulse-height information to reject the background electrons from Dalitz π^0 and η decays and from external γ conversions.

The software analysis allows a reduction of both charged- and neutral-hadron contaminations, via the off-line refinement of the triggering conditions and the rejection of the electron pairs originating from internal and external conversions.

Data collected during test runs and Monte Carlo simulations have been used to determine these contaminations in the final sample of e^+ and e^- events. The contamination due to charged hadrons is reduced to the 2% level. The neutral hadrons constitute a source of background that is much more difficult to reject, and the contamination level in the final sample is $\leqslant 50\%$.

The SFM, with its MWPC system, provided the momentum measurement for the charged secondaries. A fraction of these particles could be identified, in a momentum interval up to ~ 2 GeV/c (10), using the time information provided by a large time-of-flight system, TOF.

(8) 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).

(9) 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**, 97 (1978).

(10) 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).

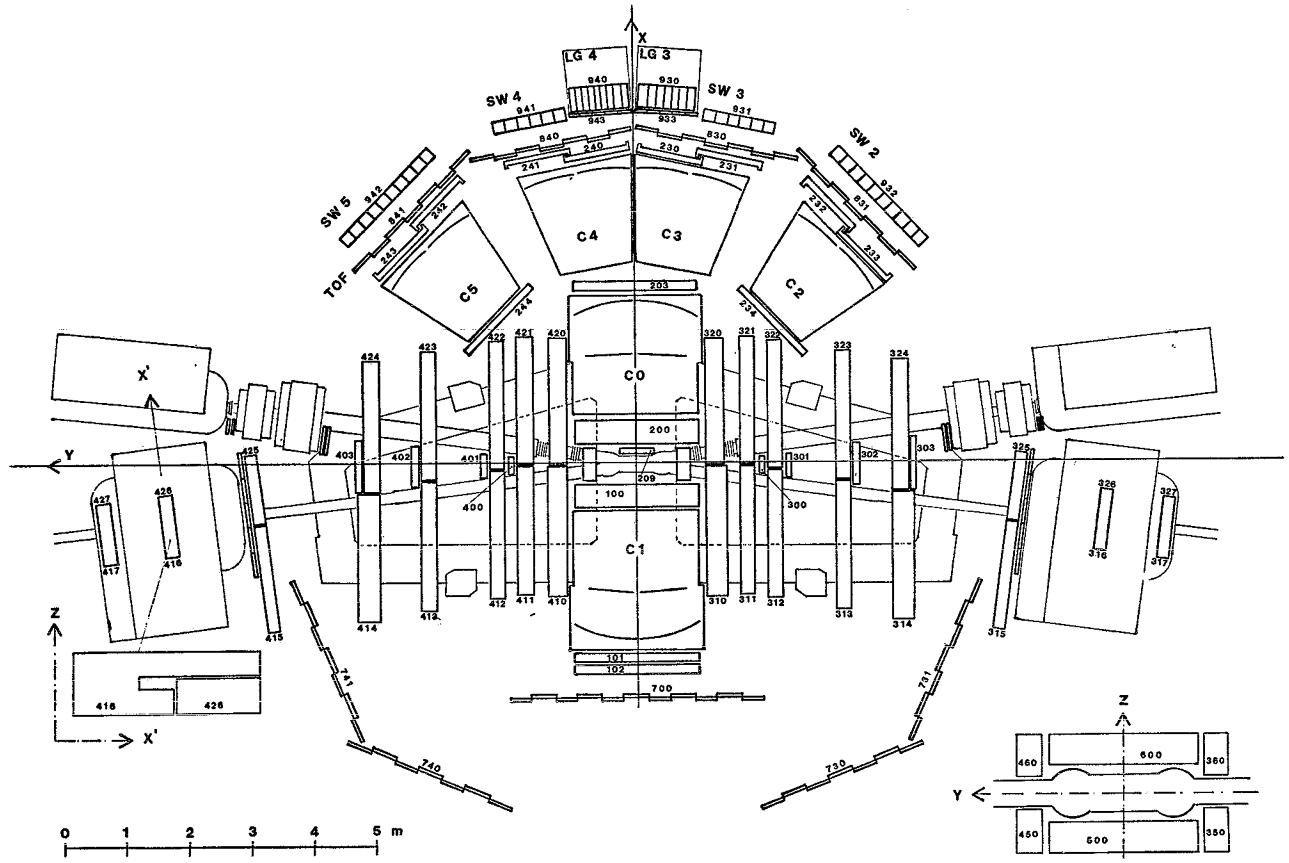


Fig. 1. – Top view of the SFM detector, showing the MWPCs and the external apparatus for particle identification: i) C_i ($i = 0, ..., 5$) are gas threshold Čerenkov counters; ii) the EMSDs consist of lead/scintillator sandwiches SW_i ($i = 2, ..., 5$) and lead-glass arrays LG_i ($i = 3, 4$); iii) the « dE/dx » is indicated by the number 209; iv) TOF is the time-of-flight system.

3. – Data analysis and mass spectra.

Using the procedure described above, we obtained a sample of $\sim 60\,000$ events, corresponding to an integrated luminosity $\mathscr{L} = 4.39 \cdot 10^{36}\ \text{cm}^{-2}$. From this sample, we have selected events with at least one positive particle with $x = 2p_L/\sqrt{s} \geqslant 0.3$ and an error on the measured momentum $\Delta p/p \leqslant 30\%$. In these events the positive particle with the highest x has been assumed to be a proton (*).

The final sample of events has been studied in two ways, with reference to the hemisphere opposite to that of the detected proton:

i) no conditions on the system of charged particles in this hemisphere,

ii) the requirement of either a leading system of charged particles with $x_{opp} \geqslant 0.5$, or a system with $x_{opp} \leqslant 0.1$ as a signature of a leading system escaping detection. $\left(\text{Notice that } x_{opp} = \sum_{i=1}^{n} (x^i_{opp}),\text{ where the sum is extended to all particles fitted to the vertex and with } \Delta p/p \leqslant 30\%.\right)$

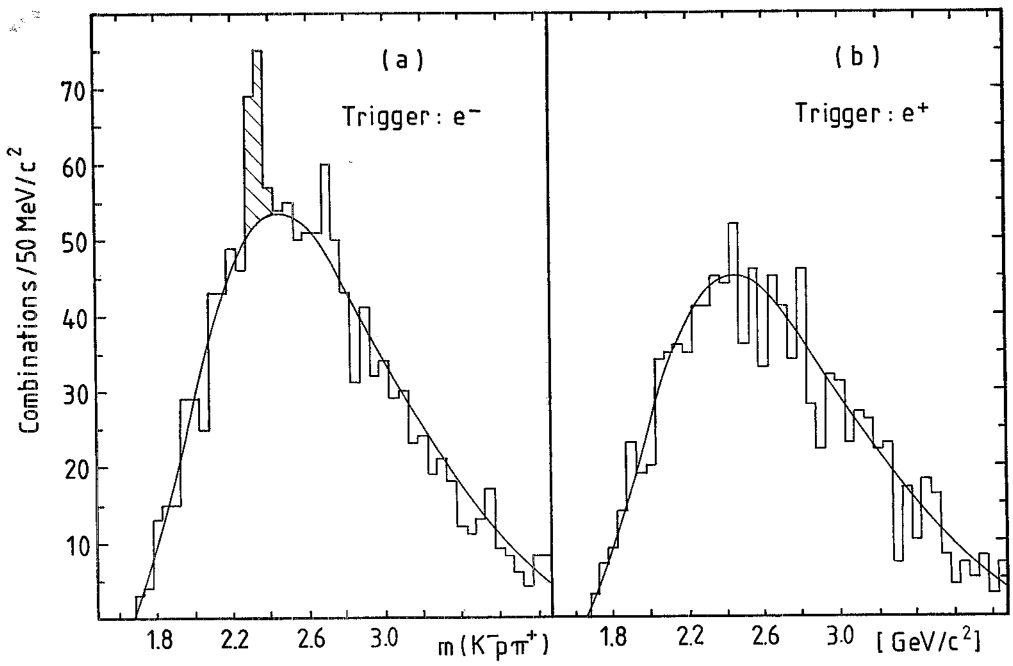


Fig. 2. – Mass distribution of $K^-p\pi^+$ combinations selected as described in the text: *a*) trigger particle $= e^-$, *b*) trigger particle $= e^+$.

(*) The p/π^+ ratio at $x = 0.3$ is already 1.5 and increases rapidly as a function of x.

In the invariant mass $pK^-\pi^+$, K^- (π^+) is any negative (positive) track, not identified as a $\bar{p}$ or π^- (K^+ or p) 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 $\Delta p/p \leqslant 30\%$,

b) both the K^- and the 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.

Figure 2*a*) shows the $pK^-\pi^+$ mass spectrum for the e^--triggered events when condition ii) is applied. A clear peak is observed at $m \simeq 2330$ MeV/c^2. Its width is compatible with the expected mass resolution. This peak is not

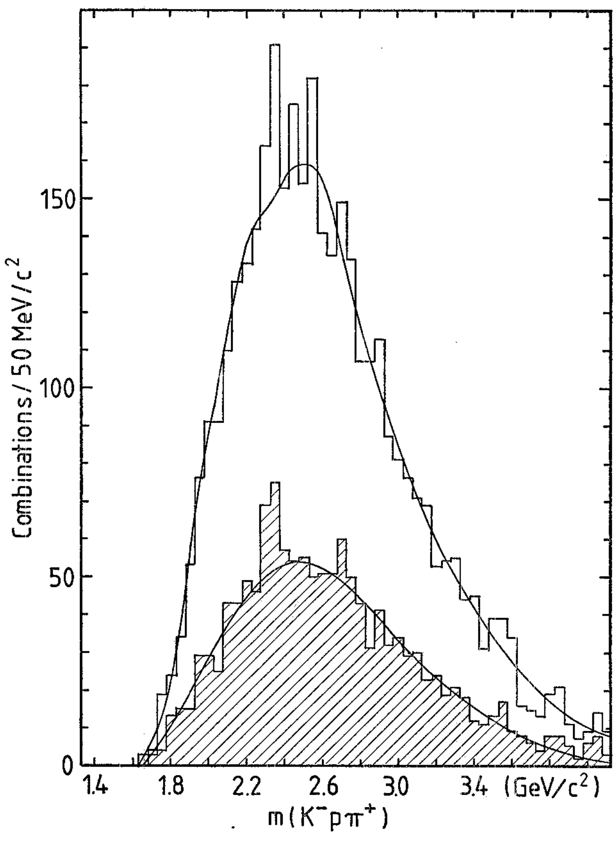


Fig. 3. – The $K^-p\pi^+$ invariant-mass distribution for e^--triggered events when, relative to the particles in the hemisphere opposite to that of the detected proton, i) no conditions are required (□), ii) the condition $\sum_{i=1}^{n} x^i_{\text{opp}} \geqslant 0.5$ or $\sum_{i=1}^{n} x^i_{\text{opp}} \leqslant 0.1$ is requested (▨). The lines are the fit to the background, *i.e.* the same mass spectra for e^+-triggered events.

present in the case of the e^+-triggered events (see fig. 2*b*)). In fact the associated $\Lambda_c^+\bar{D}$ production needs an e^-, not an e^+, in the final state (reaction (2)).

The mass shift of ~ 55 MeV/c² from the weighted world average value of the Λ_c^+ mass ([11]) ((2273 ± 6) MeV/c²) is due to local systematic effects in the SFM detector, already observed ([12]) when using the SFM as a mass spectrometer.

Note that, as shown in fig. 3, a clear improvement in the signal-to-background ratio is obtained when condition ii) is applied for the particles in the hemisphere opposite to that of the detected proton. This is evidence for a long-range correlation in charmed-particle production associated with a «leading» system in the opposite hemisphere.

4. – Results.

4·1. *Cross-sections.* – In order to compute the cross-section for reaction (1), an assumption must be made on the mass of the anticharmed particle, which could be either a meson $\bar{D}$ or a baryon $\bar{C}$. Since in the framework of the recombination or diffraction models—which seem to be the more likely processes for charm production in pp collisions—the production of a $\bar{D}C$ pair is much more natural than that of a $\bar{C}C$ pair, we have assumed that all the electrons come from the decay of the $\bar{D}$ meson.

The cross-section for the associated production of a $\bar{D}\Lambda_c^+$ pair has been computed by assuming the standard scaling law for the inclusive charm cross-section:

$$E\frac{d^3\sigma}{dp^3} = f(y/y_{max})\exp[-\alpha p_T]\,,$$

where $\alpha^{-1} = 0.5$ GeV/c.

The function $f(y/y_{max})$ gives the dependence on the longitudinal momentum and is parametrized as listed below:

$$\text{model I)}\qquad E\frac{d\sigma}{dx} \propto (1-x)^3\,,$$

$$\text{model II)}\qquad \frac{d\sigma}{dy} = \text{const}\,,$$

$$\text{model III)}\qquad \frac{d\sigma}{dx} = \text{const}\,.$$

([11]) PARTICLE DATA GROUP: *Review of particle properties, Rev. Mod. Phys.*, **52**, No. 2 (1980).

([12]) D. DRIJARD, H. G. FISCHER, W. GEIST, P. G. INNOCENTI, V. KORBEL, A. MINTEN, A. NORTON, S. STEIN, O. ULLALAND, H. D. WAHL, G. FONTAINE, P. FRENKIEL, C. GHESQUIÈRE, G. SAJOT, P. HANKE, W. HOFMANN, M. PANTER, K. RAUSCHNABEL, J. SPENGLER, D. WEGENER, H. FREHSE, E. E. KLUGE, M. HEIDEN, A. PUTZER, M. DELLA NEGRA, D. LINGLIN, R. GOKIELI and R. SOSNOWSKI: preprint CERN-EP/81-12 (1981), submitted to *Z. Phys. C*.

The detection efficiency for the electron and the overall acceptance of the apparatus were determined via Monte Carlo simulation. Table I summarizes the results obtained for different combinations of the longitudinal-momentum distributions of $\bar{D}$ and Λ_c^+.

TABLE I.

Model	$\bar{D}$	Λ_c^+	σ_{tot} (μb)
I)	$E(d\sigma/dx) \propto (1-x)^3$	$E(d\sigma/dx) \propto (1-x)^3$	4200
II)	$d\sigma/dy = $ const	$d\sigma/dy = $ const	750
III)	$d\sigma/dx = $ const	$d\sigma/dx = $ const	1125
I)-III)	$E(d\sigma/dx) \propto (1-x)^3$	$d\sigma/dx = $ const	184

In order to compute the total cross-section, we have used the following values for the branching ratios ([13,14]):

$$\frac{\bar{D} \to e^- \bar{\nu}_e + \text{anything}}{\bar{D} \to \text{all}} = 8.5\,\% , \qquad \frac{\Lambda_c^+ \to pK^-\pi^+}{\Lambda_c^+ \to \text{all}} = 2.2\,\% .$$

The cross-section values given in table I have an overall uncertainty of no more than 40%.

4.2. *The* e/π *ratio.* – The rapidity range covered by the apparatus for e^- detection is $-0.55 \leqslant y \leqslant 0.55$, while the transverse-momentum acceptance is determined by the EMSD energy thresholds mentioned above and discussed elsewhere ([8]).

From the observed number of $e^-\Lambda_c^+$, it is possible to derive important information on the longitudinal-momentum distribution of the associated $\Lambda_c^+\bar{D}$ production. We have considered two cases:

([13]) W. BACINO, T. FERGUSON, L. NODULMAN, W. SLATER, H. TICHO, A. DIAMANT-BERGER, G. DONALDSON, M. DURO, A. HALL, G. IRWIN, J. KIRKBY, R. BURNS, P. CONDON, P. COWELL and J. KIRZ: *Phys. Rev. Lett.*, **43**, 1073 (1979).

([14]) G. S. ABRAMS, M. S. ALAM, C. A. BLOCKER, A. M. BOYARSKI, M. BREIDENBACH, D. L. BURKE, W. C. CARITHERS, W. CHINOWSKY, M. W. COLES, S. COOPER, W. E. DIETERLE, J. B. DILLON, J. DORENBOSCH, J. M. DORFAN, M. W. EATON, G. J. FELDMAN, M. E. B. FRANKLIN, G. GIDAL, G. GOLDHABER, G. HANSON, K. G. HAYES, T. HIMEL, D. G. HITLIN, R. J. HOLLEBEEK, W. R. INNES, J. A. JAROS, P. JENNI, A. D. JOHNSON, J. A. KADYK, A. J. LANKFORD, R. R. LARSEN, M. J. LONGO, V. LÜTH, R. E. MILLIKAN, M. E. NELSON, C. Y. PANG, J. F. PATRICK, M. L. PERL, B. RICHTER, A. ROUSSARIE, J. J. RUSSELL, D. L. SCHARRE, R. H. SCHINDLER, R. F. SCHWITTERS, J. L. SIEGRIST, J. STRAIT, H. TAUREG, M. TONUTTI, G. H. TRILLING, E. N. VELLA, R. A. VIDAL, I. VIDEAU, J. M. WEISS and H. ZACCONE: *Phys. Rev. Lett.*, **44**, 10 (1980).

i) The longitudinal-momentum distribution of Λ_c^+ is totally independent of the source which produces the e^-.

The acceptance of the apparatus changes with the production mechanism for Λ_c^+. Thus, if the Λ_c^+ production follows model I), the observed number of $e^-\Lambda_c^+$ events corresponds to a production rate which is about 24 times higher than that following model III).

In order to obtain for the ratio e^-/π^- a value consistent with well-established measurements [15,16], the only possible model for Λ_c^+ production is model III). Table II shows all results.

TABLE II.

Model	Λ_c^+	e^-/π^-
I)	$E(d\sigma/dx) \propto (1-x)^3$	$(3.0 \pm 0.9) \cdot 10^{-3}$
II)	$d\sigma/dy = \text{const}$	$(3.5 \pm 1.0) \cdot 10^{-4}$
III)	$d\sigma/dx = \text{const}$	$(1.25 \pm 0.40) \cdot 10^{-4}$

ii) The longitudinal-momentum distribution of Λ_c^+ is correlated with the source of e^-.

As previously stated, we assume that the e^- source is the $\bar{D}$ meson.

Table III shows the corresponding values of e^-/π^- for the cases in which Λ_c^+ and $\bar{D}$ have the same longitudinal-momentum distributions (I), II), III)) and for the case in which the $\bar{D}$ is produced «centrally» (model I)), *i.e.*

$$E\frac{d\sigma}{dx} \propto (1-x)^3,$$

(15) F. MULLER: *Charmed particles: properties and production characteristics*, lectures given at the *International School of Subnuclear Physics, Erice, 1980* (see preprint CERN-EP/80-195 (1980)).

(16) F. W. BÜSSER, L. CAMILLERI, L. DI LELLA, B. G. POPE, A. M. SMITH, B. J. BLUMENFELD, S. N. WHITE, A. F. ROTHENBERG, S. L. SEGLER, M. J. TANNENBAUM, M. BANNER, J. B. CHÈZE, H. KASHA, J. P. PANSART, G. SMADJA, J. TEIGER, H. ZACCONE, and A. ZYLBERSTEJN: *Nucl. Phys. B*, **113**, 189 (1976); L. BAUM, M. M. BLOCK, B. COUCHMAN, J. CRAWFORD, A. DEREVSHCHIKOV, D. DIBITONTO, I. GOLUTVIN, H. HILSCHER, J. IRION, A. KERNAN, V. KUKHTIN, J. LAYTER, W. MARSH, P. MCINTYRE, F. MULLER, B. NAROSKA, M. NUSSBAUM, A. ORKIN-LECOURTOIS, L. ROSSI, C. RUBBIA, D. SCHINZEL, B. SHEN, A. STAUDE, G. TARNOPOLSKY and R. VOSS: *Phys. Lett. B*, **60**, 485 (1976); M. BARONE, M. BLOCK, A. BÖHM, F. CERADINI, D. DIBITONTO, J. IRION, A. KERNAN, J. LAYTER, F. MULLER, A. NAKKASYAN, B. NAROSKA, F. NAVACH, M. NUSSBAUM, A. ORKIN-LECOURTOIS, C. RUBBIA, M. SACHWITZ, D. SCHINZEL, H. SEEBRUNNER, B. SHEN, A. STAUDE, R. TIRLER, G. VAN DALEN, R. VOSS and R. WOJSLAW: *Nucl. Phys. B*, **132**, 29 (1978).

while the Λ_c^+ is produced «flat» in x (model III)), *i.e.*

$$\frac{d\sigma}{dx} = \text{const}.$$

TABLE III.

Model	$\bar{D}$	Λ_c^+	e^-/π^-
I)	$E(d\sigma/dx) \propto (1-x)^3$	$E(d\sigma/dx) \propto (1-x)^3$	$(6.5 \pm 2.6)\cdot 10^{-3}$
II)	$d\sigma/dy = \text{const}$	$d\sigma/dy = \text{const}$	$(9.5 \pm 3.8)\cdot 10^{-4}$
III)	$d\sigma/dx = \text{const}$	$d\sigma/dx = \text{const}$	$(8.8 \pm 3.5)\cdot 10^{-4}$
I)-III)	$E(d\sigma/dx) \propto (1-x)^3$	$d\sigma/dx = \text{const}$	$(2.5 \pm 1.0)\cdot 10^{-4}$

This last model seems to be the best one for producing a ratio e^-/π^- that is nearest to expectations.

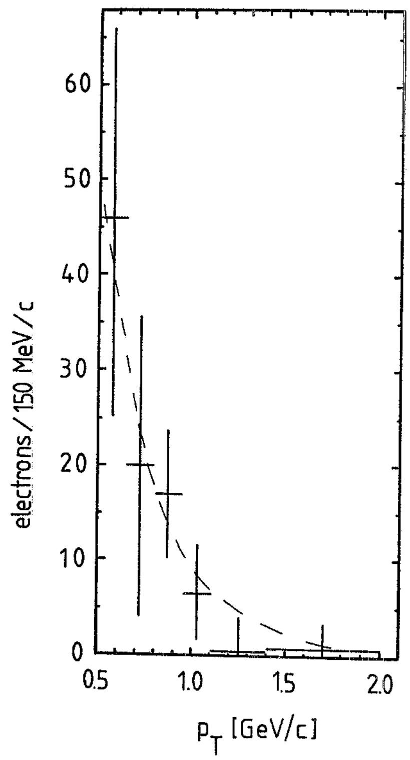


Fig. 4. – Experimental distribution of the transverse momentum of the electrons from the $\bar{D}$ decay. The dashed line represents the expected p_T distribution for electrons from $\bar{D}$ decay by using model I)-III). The relative fractions of three- and four-body decays of the $\bar{D}$ have been taken from ref. ([11]).

Other evidence supporting this choice is provided by the study of the p_T distribution for the e^-.

Figure 4 shows the experimental transverse-momentum distribution of the electrons associated with Λ_c^+. This distribution is determined by the difference between the p_T distribution of the electrons associated with a Λ_c^+ ($2.28 \leqslant m(K^- p \pi^+) \leqslant 2.38$ GeV/c^2) and the p_T distribution of the electrons associated with $K^- p \pi^+$ masses outside the Λ_c^+ mass range, these distributions being normalized to the same number of events. The expected p_T distribution of the electrons from $\bar{D}$ decay using model I)-III) is shown by the dashed line in fig. 4. The experimental results are in good agreement with expectations.

5. – Conclusions.

The experimental status of the charmed-baryon Λ_c^+ production cross-section, as measured at the ISR, is summarized in fig. 5. Also shown are some theoretical predictions for

a) diffractivelike $\Lambda_c^+ \bar{D}$ production [17],

b) $c\bar{c}$ pair creation by quark and gluon fusion models [18,19] ($q\bar{q} \to c\bar{c}$, $gg \to c\bar{c}$),

c) flavour excitation via gluon and quark scattering [18] ($gc \to gc$, $qc \to qc$),

d) $c\bar{c}$ pair production via gluons, computed by scaling the charm photoproduction cross-section [20] ($\gamma p \to c\bar{c}$+anything).

Even though the data points show large uncertainties, it seems possible to conclude that all theoretical predictions tend to give limits smaller than the experimental results [21]. This is even more true if we consider that, with the exception of the diffractive case, all the models predict the total charm cross-section. The measurements reported in fig. 5 refer only to Λ_c^+ inclusive production cross-section [22]. For example, it has been measured that the total cross-section for $pp \to D^+ + X$ is of the same order of magnitude [1,4,5] as for $pp \to \Lambda_c^+ + X$.

(17) G. GUSTAFSON and C. PETERSON: *Phys. Lett. B*, **67**, 81 (1977).
(18) B. L. COMBRIDGE: *Nucl. Phys. B*, **151**, 429 (1979).
(19) C. E. CARLSON and R. SUAYA: *Phys. Lett. B*, **81**, 329 (1979).
(20) H. FRITZSCH and K. H. STRENG: *Phys. Lett. B*, **78**, 447 (1978).
(21) R. J. N. PHILLIPS: *Phenomenology of new particle production*, rapporteur talk given at the *XX International Conference on High-Energy Physics, Madison, 1980.*
(22) F. MULLER: talk given at the *Cargèse International School of Physics, 1979* (see preprint CERN-EP/79-148 (1979)).

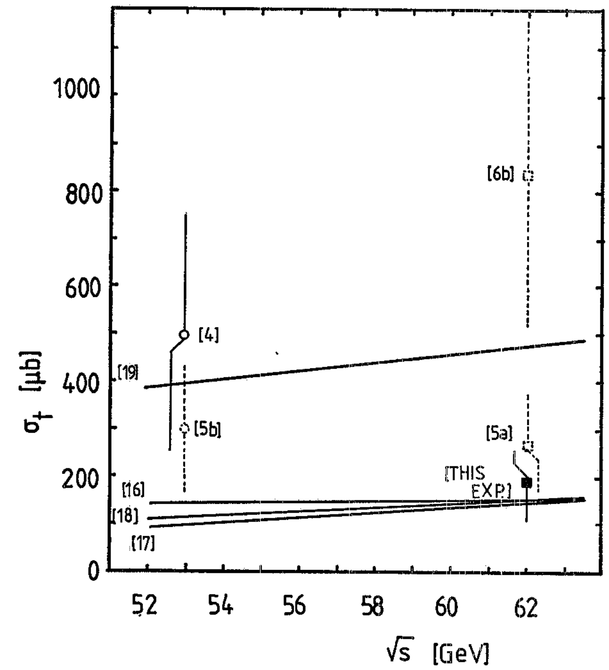


Fig. 5. – The Λ_c^+ charmed-baryon production cross-sections as measured by various ISR experiments. The dotted lines are unpublished results. Notice that ref. ([5b]) is a recent, unpublished, updated reanalysis of the measurement published in ref. ([4]). The circles are the measurements obtained by triggering on the hadronic decay of the Λ_c^+. The squares are the experiments in which the trigger was the electron from the semi-leptonic decay of the associated anticharmed particle. The data are all relative to the following model: $d\sigma/dx = \text{const}$ for the Λ_c^+, plus, for the case in which the electron was detected, $E(d\sigma/dx) \propto (1-x)^3$ for the $\overline{D}$. The curves are the theoretical predictions according to the models specified in the text.

The results of our experiment are further evidence for associated charm production and provide a measurement of the cross-section (table I and fig. 5) for $\Lambda_c^+\overline{D}$, in proton-proton interactions at $\sqrt{s} = 62$ GeV.

A comparison of the results obtained with the various models allows us to contribute to the understanding of an important detail in the associated production of $\Lambda_c^+\overline{D}$. In fact, the most likely interpretation of the $e^-\Lambda_c^+$ associated production is that the charmed baryon Λ_c^+ is produced forward, while the anticharmed meson $\overline{D}$ is produced centrally.

* * *

We are very grateful to the ISR staff for the excellent machine operation and to our group technicians, Messrs. J. BERBIERS, F. BEAUVAIS and G. MOLINARI, for their devoted work during the preparation, assembly and running of our experiment. The help of Mrs. N. BOIMOND and Mrs. Y. CHOLLEY has been very much appreciated. We wish to acknowledge the co-operation of the SFM detector group and the DD Division on-line support group.

Finally, some of us (LC, AC, GD, PG) would like to acknowledge helpful discussions with W. M. GEIST and F. MULLER.

● RIASSUNTO

Si è studiata la produzione associata di particelle con « charm » nelle interazioni pp a $\sqrt{s} = 62$ GeV. Il confronto dei valori misurati della sezione d'urto di produzione e del rapporto e^-/π^- con vari modelli teorici e con le esistenti misure del valore inclusivo di e/π permette di concludere che l'interpretazione piú probabile della produzione associata osservata si ha in termini di un barione charmato Λ_c^+ prodotto in avanti e di un mesone anticharmato $\bar{D}$ prodotto in zona centrale.

Измерение ассоциативного рождения шарма в pp взаимодействиях при $\sqrt{s}=62$ ГэВ.

Резюме (*). — В pp взаимодействиях при $\sqrt{s}=62$ ГэВ исследуется ассоциативное рождение шарма. Сравнение измеренного поперечного сечения образования и отношения e^-/π^- с различными теоретическими моделями и с имеющимися инклюзивными e/π измерениями позволяет сделать вывод, что наиболее вероятная интерпретация ассоциативного рождения возможна в терминах очарованного бариона Λ_c^+, рожденного в направлении вперед, плюс $\bar{D}$ мезон, рожденный центрально.

(*) *Переведено редакцией.*