PRELIMINARY RESULTS ON CHARM PRODUCTION BY 340 GeV/c π^- ON A TARGET OF Si AND W

WA82 Collaboration

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Abstract

The preliminary results on charm hadroproduction presented here have been obtained from the analysis of ≈ 25% of the data, collected by the WA82 experiment with the CERN Ω Spectrometer supplemented by a Si microstrip vertex detector. Charmed particles, produced in a thin segmented target of Si and W by 340 GeV/c π^- and selected by an impact parameter trigger, are identified by their invariant mass associated with well separated decay vertices. The charm D signal contains about 10^3 neutral and charged decays including ≈ 20% background.

Assuming a A^α nuclear dependence of the charm production cross section, α is found equal to $0.89 \pm 0.05 \pm 0.05$ for a data sample with $\langle x_F \rangle = 0.2$. The x_F and p_T distributions for charged D's are presented and discussed. No significant evidence for a leading particle effect is observed. First results on the identification of charm decays using secondary particle identification are also presented.

1. Introduction

The WA82 experiment performed with the CERN Ω Spectrometer [1] is intended to study with high statistics charm hadroproduction with emphasis on still unsettled problems like atomic number dependence of production cross-sections [2] and possible leading particle effects [3]. The charmed particles, produced in a thin segmented target of Si and W followed by a microstrip vertex detector (MVD), are selected using an impact parameter trigger ; spatial reconstruction allows to separate secondary vertices, among which exclusive charm decays are identifed by their invariant mass. We present results from the analysis of $\approx$ 25% of the available statistics on the atomic number dependence of D production cross section and x_F and p_T distributions of charged D mesons. The experiment made use of the RICH detector coupled to the Ω spectrometer for secondary particle identification, with the aim at improving the purity of the charmed particles sample.

2. Experimental details

The experimental set up is shown on Fig. 1. The 1.25 mm thick target is divided along the magnetic field direction into two equal sections. One section consists entirely of Si, the other one is a sandwich consisting of a 800 μm layer of W and a 450 μm layer of Si. The beam is steered so that the two sections receive approximately equal intensity. The MVD contains four 20 μm and nine 50 μm pitch detectors and is especially designed for triggering purposes. It is placed together with the target on an optical bench inside the Ω magnetic field. Upstream of the target a telescope of eight 20 μm pitch microstrip detectors is used to measure the beam position. To enrich the recorded interactions in multivertex events, the trigger logic, executed in $\approx$ 350 μsec by the fast hardware processor MICE [4], identifies the primary interactions associated with at least one track having an Impact Parameter (IP) between 0.1 and 1 mm. For charmed particles with mean life time τ, the average value of IP, the distance in the xz (non-bending) plane of a track to the primary vertex, is roughly equal to $c\tau$. The trigger condition is such that about 40% of the D meson signal is recorded with a measured enrichment factor of $\approx$ 15. Details on the MVD and on the trigger logic are given in [5]. With this set-up the experiment has collected $\approx 3 \times 10^7$ triggers (2/3 in a 340 GeV/c π^- beam and 1/3 in a 360 GeV/c p beam) corresponding to $\approx 6 \times 10^8$ interactions in the target.

3. Data analysis

About 7×10^6 triggers, recorded in the 1987 run with 340 GeV/c π^-, were analyzed through a program chain in order to identify the charmed particles produced in Si and W and which decay into the main hadronic channels. In order to reduce the computing load, the beam and the tracks were reconstruted for all events in the xz plane using only the beam telescope and MVD information. Events are retained which have a primary vertex reconstructed in the target plus two other tracks, one with IP > 70 μm and one with IP > 30 μm, crossing downstream of the target.

The selected events (13 % of the initial sample) are then reconstructed in space by a modified version of the TRIDENT program [6] which combines the information supplied by Ω and the MVD and performs the track and vertex fits.

0.3×10^6 events have a secondary vertex with at least two prongs reconstructed in space. Those events are further selected asking that :

(a) the secondary vertex must lie outside and downstream of the target,

(b) the distance between the main and secondary vertices is $> 6\ \sigma(x)$ (quadratic sum of the position measurement errors of the two vertices)

(c) the total momentum vector of the decay tracks must point to the primary vertex within 100 μm,

(d) the invariant mass error corresponding to the hypothetized decay channel is $< 12\ \mathrm{MeV}/c^2$

(e) the life time of the decaying particle is > 0.2 p sec.

Fig. 2 (a,b,c) shows the invariant mass distributions corresponding to Cabibbo favoured decays of charged and neutral D's into charged particles. The whole D signal of fig. 2(d) contains about 955 events including ≈ 20% background. (430 charged and 525 neutral decays).

4. A dependence

The structure of the target, reflected in the primary vertex z distribution (Fig. 3) allows the simultaneous measurement of the relative charm production cross sections on Si and W and so the determination of the A dependence with minimum systematic error. Events in a 50 μm wide region centered on the Si-W border are excluded. To correct for background contamination we assumed that events outside the D peak are representative of the background under the peak. Assuming the same detection efficiency in Si and W, taking into account the beam fluxes in the Si and W sections and correcting for background, we determine the ratio $\sigma(W)/\sigma(Si)$ and hence the factor α of the cross section parametrization $\sigma(A) = \sigma_o\ A^\alpha$:

$$\alpha(\mathrm{charm}) = 0.89 \pm 0.05 \pm 0.05.$$

The value of α for light flavours is strongly dependent on x_F [7] and there is some indication of a similar dependence in charm production [8] ; we note that the average value of x_F for our charm sample is $<x_F> = 0.2$. As a check, the method was applied to a K° sample resulting in $\alpha(K^\circ) = 0.69 \pm 0.005 \pm 0.05$ with $<x_F> = 0.06$, in agreement with the measured value in this x_F region [7].

5. Production dynamics

For charged D's, the global acceptance of the apparatus and of the filter and reconstruction algorithm was evaluated by processing Monte-Carlo events through the whole analysis chain. The acceptance has a maximum around $x_F = 0.2$ and decreases smoothly with x_F, having still sizable values up to $x_F \approx 0.9$; it is nearly flat with respect to p_T up to 2.4 GeV/c.

Fig. 4 shows the x_F distribution for the D^+ and D^- samples after correction for acceptance and background. Both are seen to be compatible with the curve of the form $(1-x_F)^n$ where $n = 3.40 \pm 0.45$ as determined from a fit to the combined $D^+ + D^-$ distributions. A combined run and χ^2 test [9] gives a confidence level of 10% that the two distributions obey the same law. We therefore do not observe significant evidence for leading effect.

The p_T distribution of charm production is often parametrized by $d\sigma/dp_T^2 \propto \exp(-ap_T^2)$. A single exponential of this form with $a = 1.2 \pm 0.1$ GeV^{-2} fits the data for $p_T^2 < 3$ GeV^2/c^2 but does not describe our data over the full range of p_T^2 which extends up to 16 GeV^2/c^2, well above values previously observed in hadroproduction. The form $d\sigma/dp_T^2 \propto \exp(-bp_T)$ however fits the data well with $b = 2.00 \pm 0.12$ GeV^{-1} (Fig. 5) corresponding to $<p_T^2> = 1.5 \pm 0.2$ GeV^2/c^2.

6. Particle identification

The RICH detector [10] with its 5m deep radiator filled with a mixture of N_2 and freon at atmospheric pressure is expected to separate π, K, p up to 50 GeV/c. Using the data from the UV detection chambers together with the information of the Ω spectrometer, a probability is assigned to the different mass hypotheses for each charged secondary particle from the comparison between the numbers of observed and expected photons, taking background into account. Fig. 6 shows an example of preliminary results concerning a sub-sample of candidates for the decay : $D^{+/-} \to K^{-/+}\pi^{+/-}\pi^{+/-}$. The dashed area corresponds to events sastisfying the requirement that, for the unlike sign particle, the K hypothesis has the highest probability. The signal to noise ratio is considerably increased while the loss in the peak is compatible with the background reduction.

Conclusion and prospects

From the analysis of about 25% of the available statistics and with the D mesons identified by invariant mass, the following results have been obtained :

The relative charm production cross-sections by 340 GeV/c π^- on Si and W have been measured leading to $\alpha = 0.89 \pm 0.05 \pm 0.05$.

The differential cross-section $d^2\sigma/dx_F\, dp_T^2 \propto (1-x_F)^n \exp(-bp_T)$ fits the data well with $n = 3.40 \pm 0.45$; $b = 2.00 \pm 0.12$ $(GeV/c)^{-1}$.

The D^+ and D^- x_F distributions do not show a significant leading effect.

Preliminary results using particle identification data show considerable improvement in the separation of charm from background.

The analysis of the rest of the available statistics is under way. The WA82 experiment is planned to run in 1989 with the prospect of obtaining statistics similar to the present ones with a different target (Cu, W) to check to A^α law.

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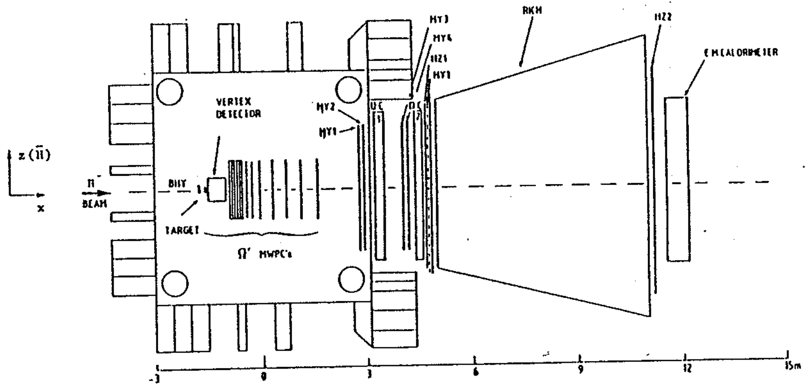

LAYOUT OF VERTEX DETECTOR

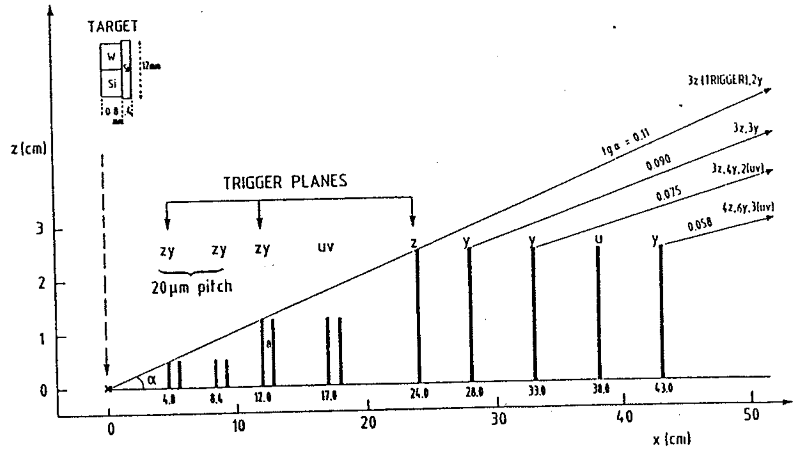

Fig. 1

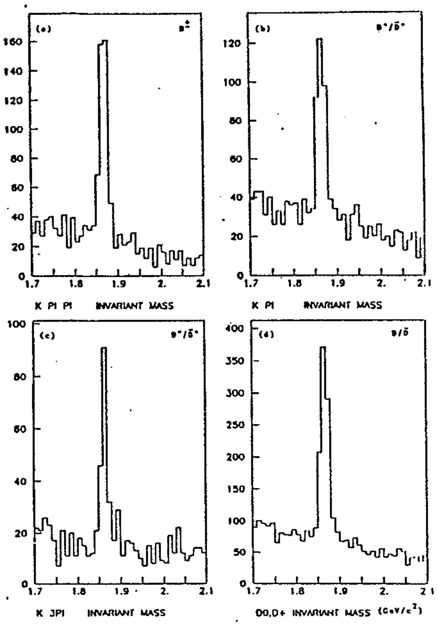

Fig. 2

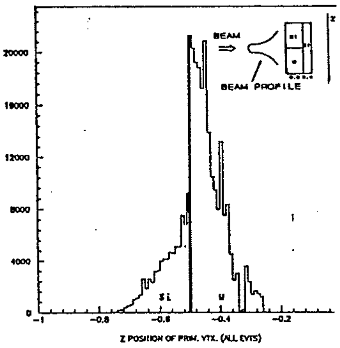

Fig. 3

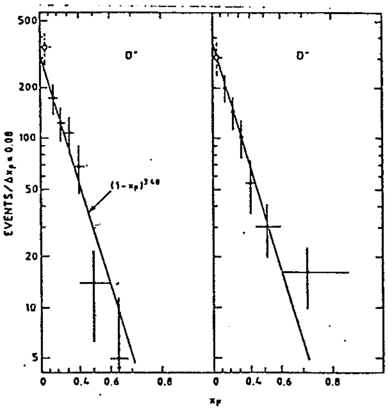

Fig. 4

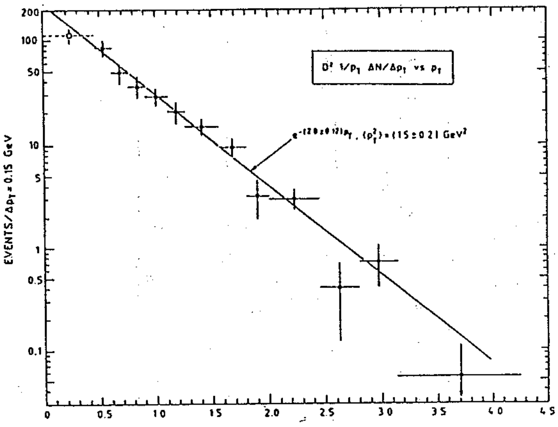
EVENTS/Δp_T = 0.15 GeV
200
100
50
10
5
1
0.5
0.1
D^± 1/p_T ΔN/Δp_T vs p_T
e^-(2.0±0.12)p_T , ⟨p_T^2⟩ = (1.5±0.21) GeV^2
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
p_T (GeV/c)

Fig. 5

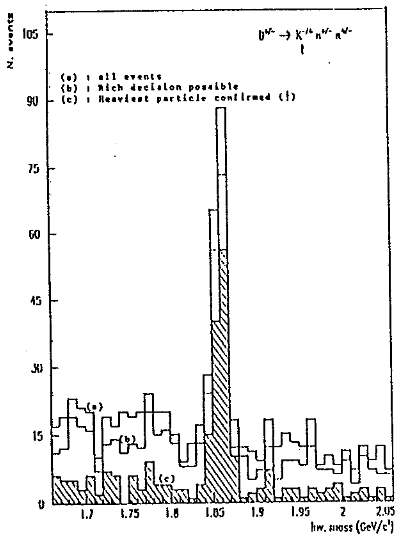
N. events
105
90
75
60
45
30
15
0
D^+/- → K^-/+ π^+/- π^+/-
(a) : all events
(b) : Rich decision possible
(c) : Heaviest particle confirmed (↑)
(a)
(b)
(c)
1.7
1.75
1.8
1.85
1.9
1.95
2
2.05
Inv. mass (GeV/c^2)

Fig. 6

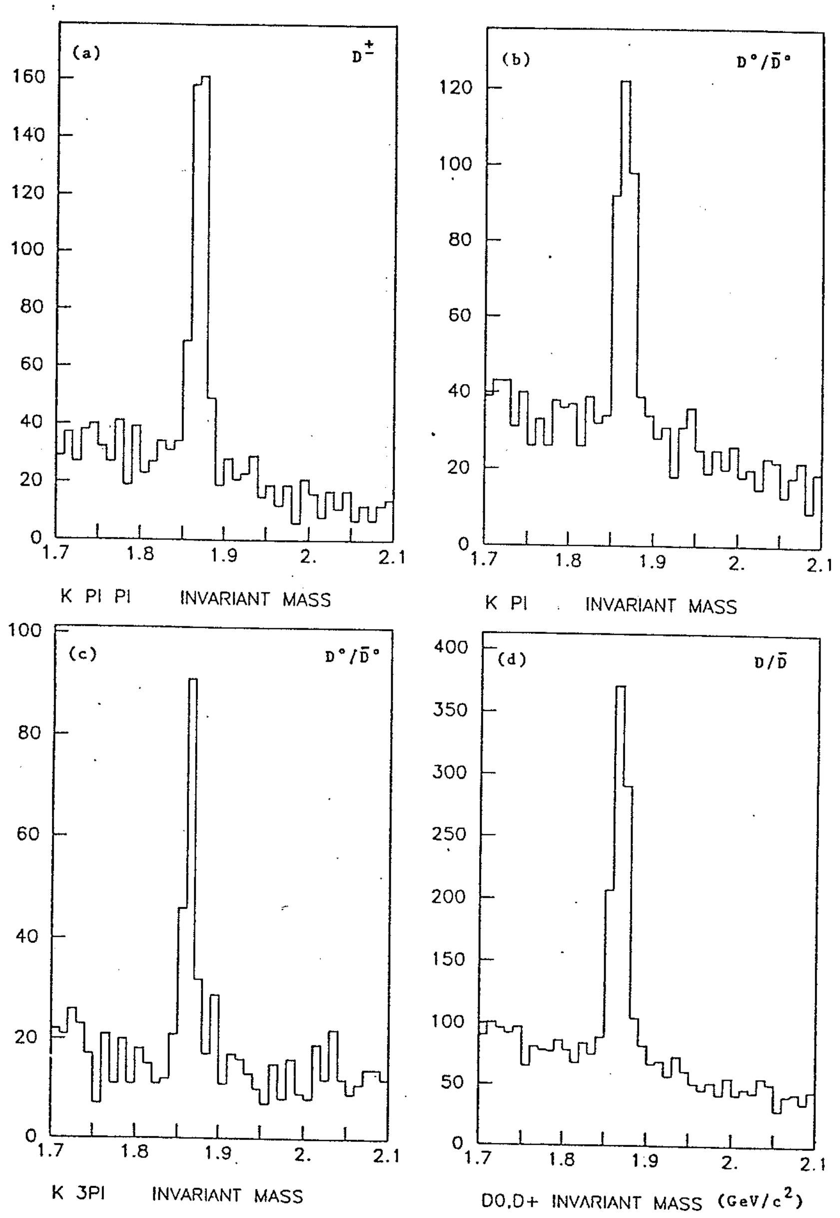
(a)
D±
0
20
40
60
80
100
120
140
160
1.7
1.8
1.9
2.
2.1
K PI PI INVARIANT MASS
(b)
D°/D̄°
0
20
40
60
80
100
120
1.7
1.8
1.9
2.
2.1
K PI INVARIANT MASS
(c)
D°/D̄°
0
20
40
60
80
100
1.7
1.8
1.9
2.
2.1
K 3PI INVARIANT MASS
(d)
D/D̄
0
50
100
150
200
250
300
350
400
1.7
1.8
1.9
2.
2.1
D0,D+ INVARIANT MASS (GeV/c^2)

Fig. 2

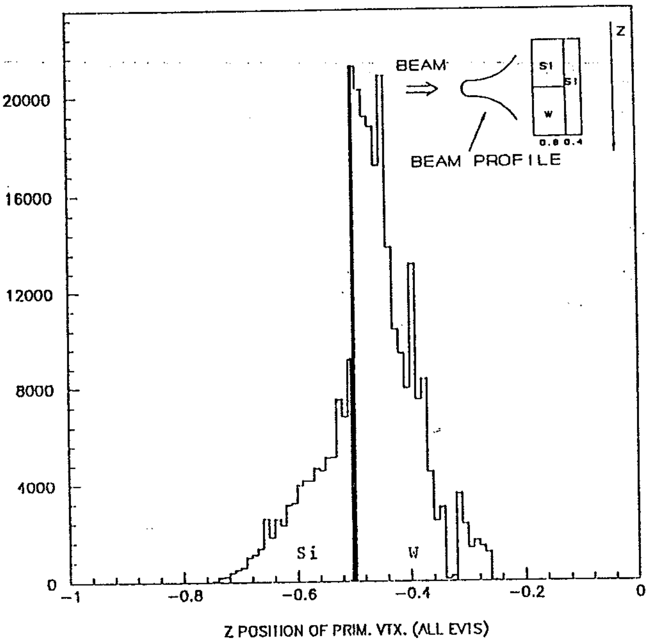
BEAM
BEAM PROFILE
Si
Si
W
0.8
0.4
Z
20000
16000
12000
8000
4000
0
−1
−0.8
−0.6
−0.4
−0.2
0
Si
W
Z POSITION OF PRIM. VTX. (ALL EVTS)

Fig. 3

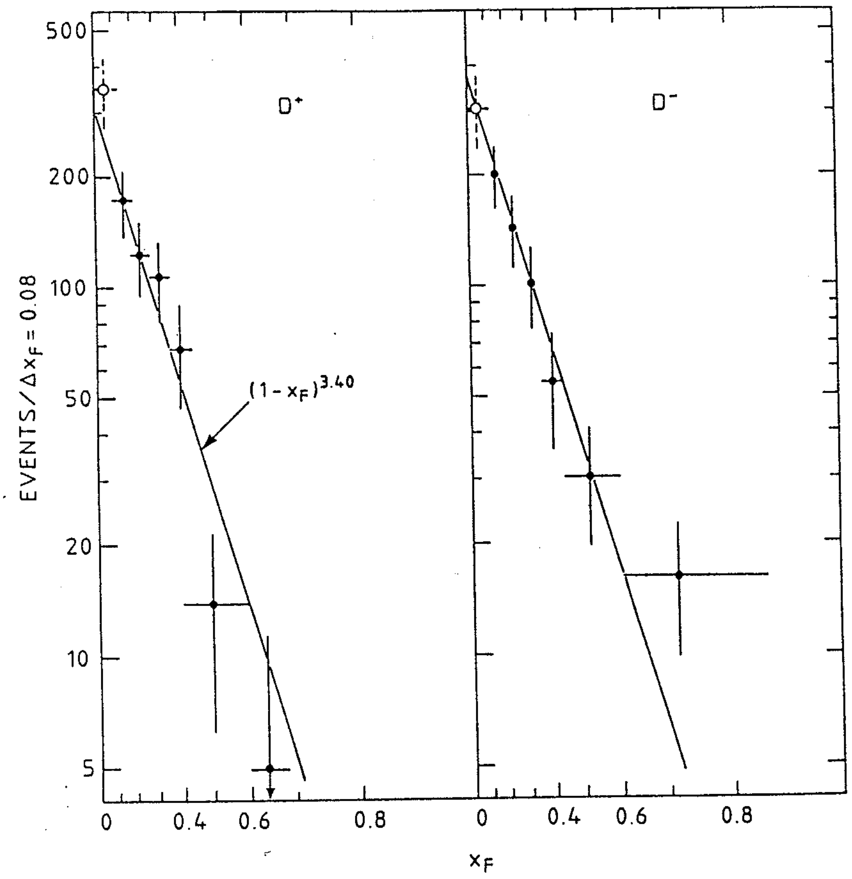
500
200
100
50
20
10
5
EVENTS/Δx_F = 0.08
D⁺
D⁻
(1 - x_F)^3.40
0
0.4
0.6
0.8
0
0.4
0.6
0.8
x_F

Fig. 4

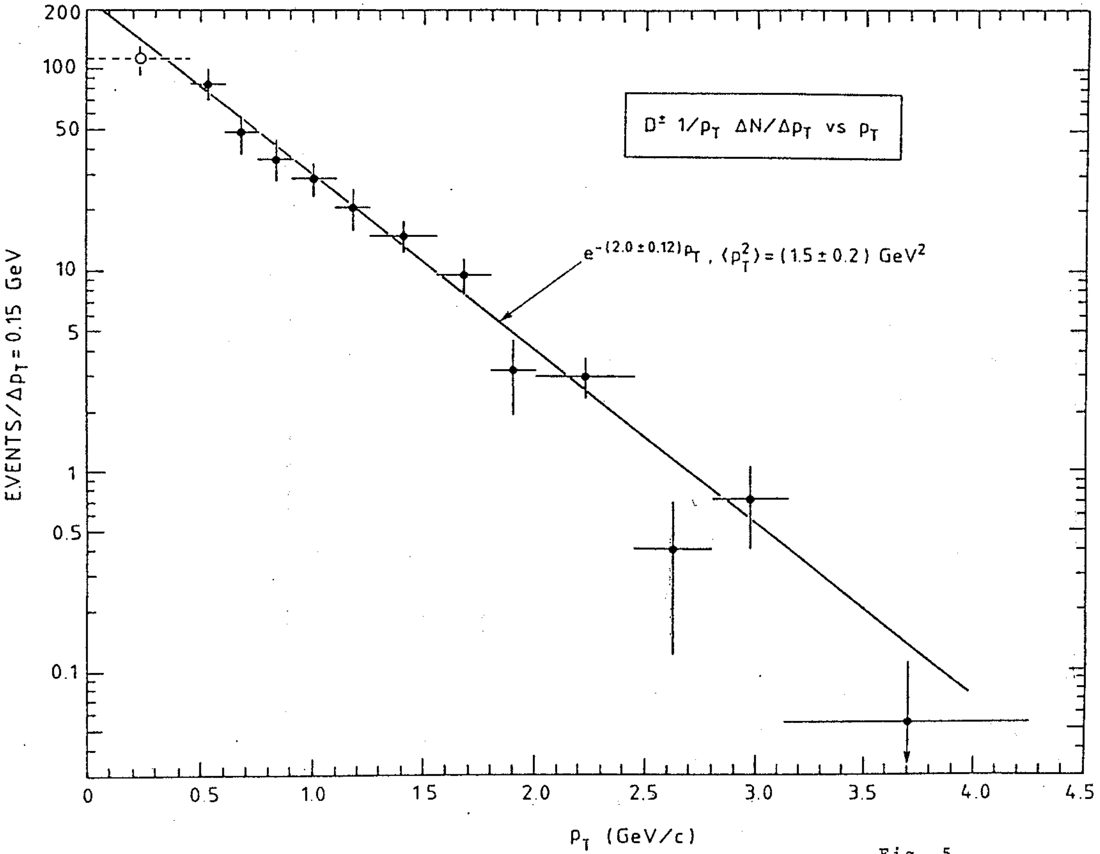
$D^{\pm}$ $1/p_T$ $\Delta N/\Delta p_T$ vs p_T
$e^{-(2.0\pm0.12)p_T}$, $\langle p_T^2\rangle = (1.5\pm0.2)$ GeV^2
EVENTS/Δp_T = 0.15 GeV
200
100
50
10
5
1
0.5
0.1
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
p_T (GeV/c)

Fig. 5

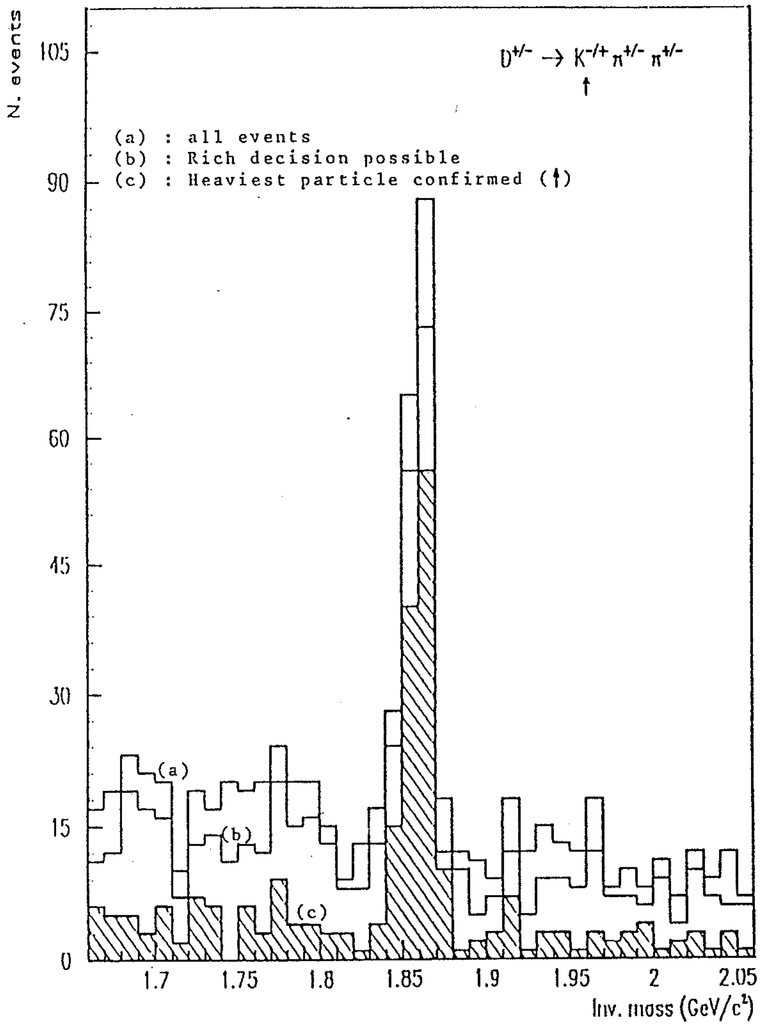N. events
0
15
30
45
60
75
90
105
$D^{+/-} \to K^{-/+} \pi^{+/-} \pi^{+/-}$
↑
(a) : all events
(b) : Rich decision possible
(c) : Heaviest particle confirmed (↑)
(a)
(b)
(c)
1.7
1.75
1.8
1.85
1.9
1.95
2
2.05
Inv. mass (GeV/c²)

Fig. 6