PRELIMINARY RESULTS ON $D^{\pm}$ PRODUCTION PROPERTIES IN THE INTERACTION OF 340 GeV/c π^- ON A TARGET OF Si AND W

WA82 Collaboration

Bologna[1]-CERN[2]-Genova[3]-Milano[4]-Mons[5]-Moscow[6]

M. Adamovich[6], Y. Alexandrov[6], F. Antinori[3], J.L. Bailly[5],
D. Barberis[2], W. Beusch[2], A. Buys[5], M. Dameri[3], M. Davenport[2],
J.P. Dufey[2], A. Forino[1], B.R. French[2], S. Gerasimov[6], R. Gessaroli[1],
F. Grard[5], R. Hurst[3], A. Jacholkowski[2], S. Kharlamov[6], K. Knudson[2],
J.C. Lassalle[2], P. Legros[5], L. Malinina[6], P. Mazzanti[1], C. Meroni[4],
F. Muller[2], B. Osculati[3], A. Quareni[1], N. Redaelli[4], L. Rossi[3],
G. Tomasini[3], D. Torretta[4], F. Viaggi[1] and M. Zavertyaev[6]

Presented by Mauro Dameri
INFN, Genova, Italy and CERN, Geneva, Switzerland

ABSTRACT

The atomic number dependence of the charm production cross section is determined by measuring the yields of charged D mesons produced by a 340 GeV/c π^- beam on a target made of Si and W. Assuming a production cross section dependence as A^{α}, we find $(D^{\pm}) = 0.98^{+0.13}_{-0.11}$. Results on the x_F and p_T dependence of charm production are also presented: there is no indication of a leading effect, and a high p_T tail is observed.

1. INTRODUCTION

So far the A-dependence of the charm hadroproduction cross section has been evaluated either measuring lepton yields in beam dump experiments [1-3] or comparing results from experiments using different target materials [4-5]. Both methods are quite model dependent, need large correction factors and the results show conflicting indications on the value of α. In the experiment presented here a simultaneous measurement of the relative charm production cross sections on Si and W is performed. The charmed particles, produced in a thin segmented target by a 340 GeV/c π^- beam and selected by a novel trigger, are identified by the invariant mass of the secondary vertices. The target structure allows a direct measurement of charmed particle yields produced simultaneously on Si and on W: this minimizes the systematic errors on α.

1.1 Experimental set-up

The set up of the WA82 Experiment [6] consists essentially of a thin target, a Silicon Microstrip Vertex Detector (MSVD) (fig. 1) and the Omega spectrometer at CERN. In the Omega reference system, the z-axis is vertical along the direction of the magnetic field. The 1.25 mm thick target is divided along z into two equal sections. One section consists

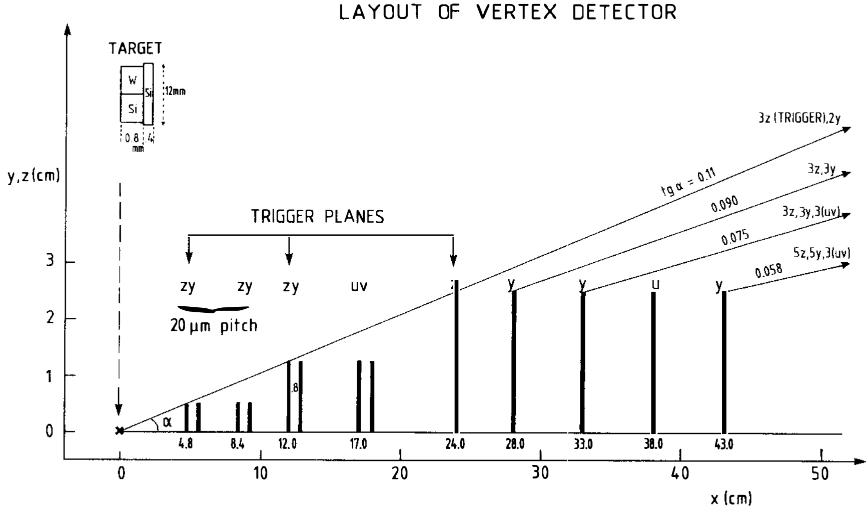


Fig. 1: MSDV layout.

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 MSVD 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 Omega magnetic field. A telescope of eight 20 μm pitch microstrip detectors is used to measure the beam position. In order to select multivertex events, the trigger logic, executed by the fast hardware processor MICE [7], identifies in ~ 350 μs the events with at least one track having an Impact Parameter (IP) between 0.1 and 1 mm, the range expected for charmed particles (IP is the distance in the z-projection of a track to the primary vertex). The spatial resolution of the trigger apparatus is $d(IP) \simeq 10 \oplus 60 / p(GeV/c)$ μm.

The charm enrichment factor of this trigger has been measured to be ~ 15. Details on the MSVD and on the trigger logic are given in [8]. With this set-up the experiment has collected ~ 3×10^7 triggers (2/3 with a π^- beam and 1/3 with a p beam) corresponding to 5×10^8 interactions in the target.

1.2 Data analysis chain

9×10^6 triggers, recorded in the 1987 run, were analyzed through a program chain in order to dig out a sample of charged charmed mesons produced in Si and W and decaying into the Cabibbo favoured channel $K^\mp$, $\pi^\pm$, $\pi^\pm$. In order to reduce the computing load, the beam and the tracks were reconstructed for all events in the x-z projection only using the beam telescope and MSVD information: events with a primary vertex in the target plus three other tracks, one with IP > 70 μm and two with IP > 30 μm, crossing downstream of the target, are selected. This step provided a loose preselection of charm decays with ≥ 3 charged tracks.

The 4.9×10^4 selected events, (0.5% of the initial sample), were reconstructed in space by a modified version of the TRIDENT program [9] which combines the information supplied by Omega with that supplied by the MSVD and performs the track and vertex fits.

1.3 Charm signal

To search for charm signals we selected secondary vertices with the following requirements:

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

(b) the distance between the main and secondary vertices > 3 σ,

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

(d) the invariant mass error < 12 MeV/c^2.

For charged D's the global acceptance of the apparatus, and of the filter and reconstruction algorithms, was evaluated processing Monte-Carlo events through the whole analysis chain. The acceptance decreases smoothly with x_F and can be described by $A(x_F) = k(1 - x_F)$ for $x_F > 0.1$, whereas $A(p_T)$ is a constant up to $p_T = 3$ GeV/c.

Using 3075 C3 vertices the $K \pi \pi$ invariant mass (fig. 2) shows a clear peak of events at the $D^{\pm}$ mass above a relatively low background.

1.4 Production dynamics

Defining as $D^{\pm}$ those events with:

$$|m(K \pi \pi) - m(D)| < 3\sigma(m)$$

we have a sample of 193 decay candidates (83 D^+ and 110 D^-) with a 20% background. This sample exhibits (fig. 3) an uncorrected lifetime distribution compatible with the world average lifetime ($\tau = 1.08$ ps).

To diminish the background we now use only the events with $\tau > 0.4$ ps.

The fit of the usual parametrization for the charm production cross section $d^2\sigma/dp_T^2\, dx_F = e^{-bp_T^2} (1 - |x_F|)^n$ to the experimental distribution, corrected for acceptance and background, yields the following value of the parameters (figs 4, 5):

$n = 3.38 \pm 0.55$ (for $x_F > 0.1$),

and $b = 1.17 \pm 0.12$ (for $p_T^2 < 3.2\ \mathrm{GeV}^2/c^2$).

The normalized x_F distributions for D^+ and D^- (fig. 6) do not show any significant difference, in particular for high x_F values; the Smirnov-Kolmogonov statistical test gives a confidence level > 50% that the two distributions obey the same law. Similarly no difference is seen in the x_F distribution between Si and W production. The p_T^2 distribution shows 8 events with $p_T > 2$ GeV/c, all of which produced in W.

1.5 A dependence

The special geometry of the target, reflected in the primary vertex z distribution (fig. 7), permits a direct measurement of the ratio $T = \sigma(W)/\sigma(Si)$. Excluding the events in a 100 μm wide region centered on the Si-W border we get the number of events produced on the Si and W sections of the target. Assuming the same efficiency in Si and W and taking into account the beam fluxes in the Si and W sections and the target geometry we calculate T and hence the factor α of the cross section parametrization $\sigma(A) \simeq \sigma_0 A^{\alpha}$. As a check, the method was applied to a K^0 sample resulting in $\alpha(K^0) = 0.69 \pm 0.05$ with $\langle x_F \rangle = 0.06$ in agreement with the measured value in that x_F region [10].

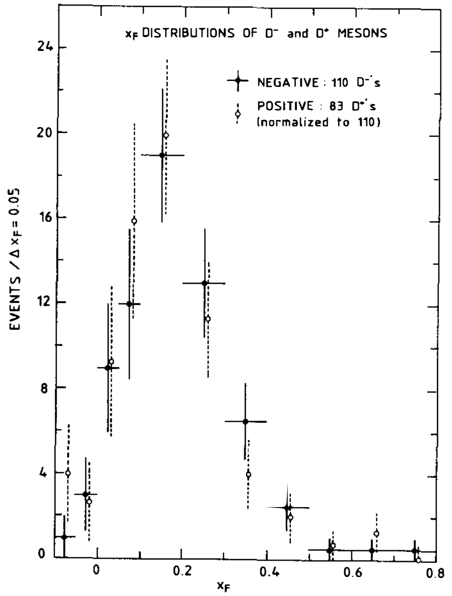


Fig. 6: D^+ and D^- normalized x_F.

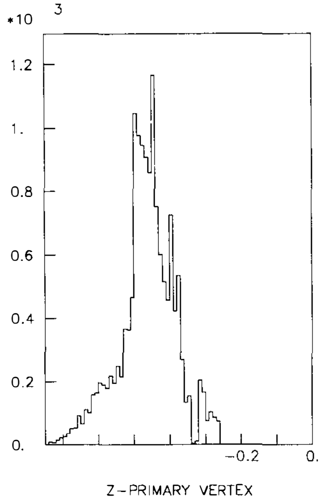
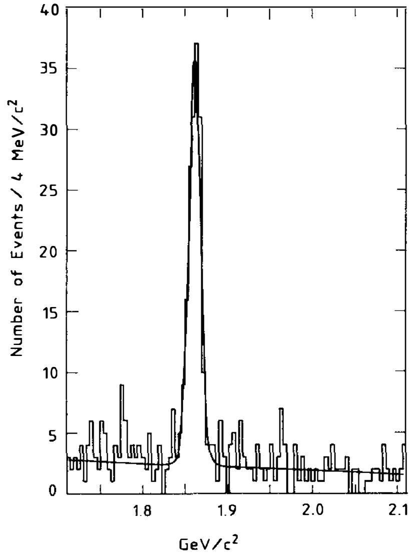


Fig. 7: z coordinate of the primary vertices.



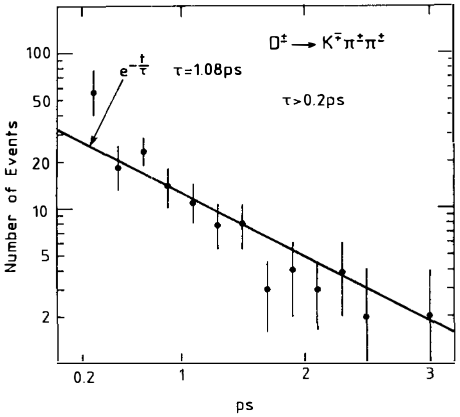
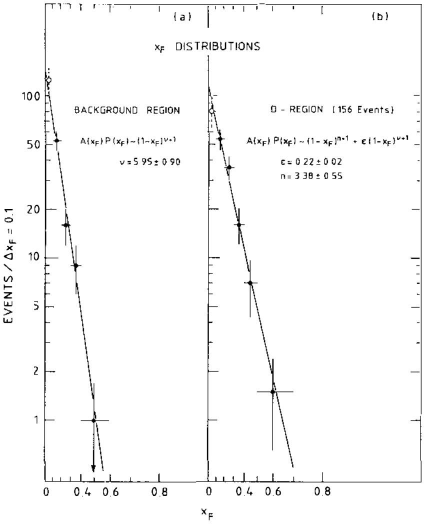


Fig. 2: (K π π) invariant mass for 3-prong secondary vertices.

Fig. 3: $D^{\pm}$ lifetime: the curve is only for eye help.



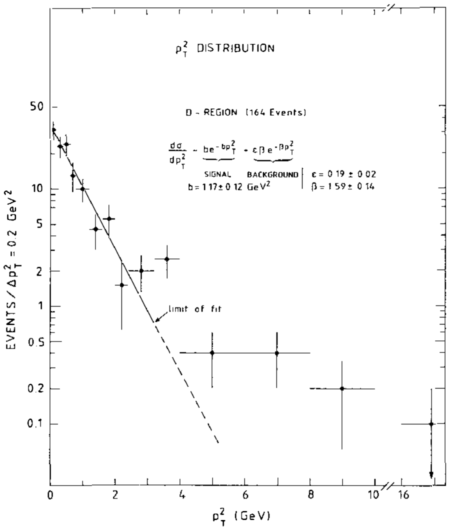


Fig. 4: $D^{\pm}$ x_F corrected for the acceptance: (a) background event, (b) events in the D region with background correction.

Fig. 5: $D^{\pm}$ p_T^2.

Assuming that the events outside the D peak selected by:

$$1700 < m(K\,\pi\,\pi) < 2100 \text{ MeV}/c^2; \quad |m(D) - m(K\,\pi\,\pi)| > 5\sigma(m)$$

are representative of the background under the D peak we get $\alpha(bg) = 0.60 \pm 0.08$, a value typical for light flavoured hadrons.

For the events in the $D^{\pm}$ peak we find, after using $\alpha(bg)$ for correcting the background contamination:

$$\alpha(D^{\pm}) = 0.98^{+0.13}_{-0.11}$$

where the errors are statistical only.

This value is stable with respect to the selection criteria and is more compatible with a linear dependence of the charm hadroproduction cross section on the nuclear mass number, than with the $A^{2/3}$ law favoured by some experiments [1-3].

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