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CHARM PRODUCTION FROM 400 AND 800 GeV/c
PROTON-PROTON COLLISIONS

A.T. Goshaw

Duke University, Durham, North Carolina 27706

For The NA27 and E743 Collaborations

I. INTRODUCTION

This is a report on charm particle production from pp interactions at 400 and 800 GeV/c as measured in experiments NA27 (CERN) and E743 (Fermilab). The 400 GeV/c data is final. It provides the most accurate charm production cross section measurement to date. The 800 GeV/c data is preliminary. The combined data provide a measurement, with small systematic error, of the energy dependence of charm hadroproduction from 27 to 39 GeV. These data are compared to the predictions of charm particle production via the QCD fusion model with various charm quark fragmentation schemes.

These experiments use the Lexan bubble chamber (LEBC) as both target and high resolution vertex detector. LEBC provides a volume of hydrogen 12 cm long by $7 \times 5 \text{ cm}^2$. It was exposed to a proton beam a few cm in height and a mm in depth and triggered on all pp interactions producing more than two charged particles. This trigger was essentially unbiased for events containing charm particles: a Monte Carlo estimate of this efficiency is $(98^{+2}_{-3})\%$. The track images recorded on 50 mm film

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consisted of 20 micron bubbles at a density of 80/cm. This allowed a reliable detection of tracks from a charm decay vertex with impact parameters down to 8 microns. A double scan of all the film resulted in the selection of charm decays surviving our cuts with an efficiency of over 90%.

The particles emerging from LEBC were momentum analyzed and identified by the European Hybrid Spectrometer (EHS) at CERN and by the Multi-Particle Spectrometer (MPS) at Fermilab. It is not appropriate in this brief report to discuss the detailed performance of these elegant spectrometers. However it should be noted that both had good $\pi^\pm/K^\pm/p^\pm$ separation via multiple Cherenkov counters, a transition radiation detector and an ISIS device (EHS only). In addition, the EHS has good π^0/γ and K^0/n detection capabilities via electromagnetic and neutral hadron calorimeters. For a more detailed description of these spectrometers see references [1] (EHS) and [2] (MPS).

II. SUMMARY OF CHARM DATA SAMPLE

Experiment NA27 had a sensitivity of 38.5 events/microbarn for the production of charm particles. A total of 324 events containing 557 charm decay candidates were selected by a double scan of the film for C1, C3, C5, V2, V4 and V6 decays. Experiment E743 has a sensitivity of about 15 events/microbarn for charm, but the data presented here come from a 9.0 events/microbarn subsample. The film in this experiment was scanned only for interactions producing C3, C5, V4 and V6 decays. This resulted in 165 events containing 210 charm decay candidates in the present subsample.

The actual number of events used from each experiment depends on the type of charm particle analysis being done. In this short report we will restrict ourselves to D meson

production properties and an estimate of the total cross section for charm production.

III. D MESON AND TOTAL CHARM PRODUCTION CROSS SECTIONS

III.A. PP INTERACTIONS AT 400 GEV/C ($\sqrt{s} = 29$ GeV)

The accuracy to which a charm production cross section can be measured is often limited by uncertainties in the exclusive and topological charm hadron decay branching ratios. This is a very severe problem for Λ_c and D_s production studies and is also a limitation for D meson production measurements if only a few decay channels are used. In order to avoid this problem we have measured the D meson production cross section by making use of C1, C3, C5, V2, V4 and V6 decays and thus our measurement is sensitive only to the branching ratio of D^0 decay to all neutrals (0.14 ± 0.04) [3]. In order to suppress Λ_c and D_s decays in the charged charm sample, we apply impact parameter and decay length cuts which tend to reject these particles because of their short lifetime and low Q values relative to a D^+ . These cuts also help to clearly define the decay topologies. A summary of the cuts used and the 217 surviving $D/\bar{D}$ decays is given in Table 1. In addition, C1 and V2 decays were accepted only if one particle had a transverse momentum greater than 250 MeV/c in order to eliminate strange particle decays.

Table 1 goes here

Table 1
Geometrical cuts applied to select the charm decays used for the $D/\bar{D}$ total cross section calculations.

Decay channel	Decays surviving all cuts $N_i(D)$	Decay length (mm)		Transverse length (mm)	Minimum impact parameter lower limit (μm)	Maximum impact parameter range (μm)
		Lower limit	Upper limit			
C1	39	2	90	0.6		100-1500
C3	74	1		2.0	20	100-2000
C5	6	1		2.0	20	100-2000
V2	67	2	30	0.2	20	60-500
V4	30	1		2.0	20	60-1500
V6	1	1		2.0	20	60-1500

The total cross section for D meson production was calculated as follows:

$$\sigma(D) = \left[\sum_{i=1}^3 N_i(D) w_i(D) / \eta_i \right] / (S \cdot BR)$$

where $N_i(D)$ is the number of decays surviving the cuts (Table 1), w_i the weight which corrects for the loss of events due to the cuts, η_i the scanning efficiency, BR the branching ratio [$BR(D^+ \rightarrow C1 + C3 + C5) = 1.0$, $BR(D^0 \rightarrow V2 + V4 + V6) = 0.86 \pm 0.04$] and $S = (38.5 \pm 1.1)$ events/ μb is the sensitivity of the experiment. The weights, w_i , were calculated from Monte Carlo simulations which determined the fraction of decays lost by our cuts. For more details see reference [4].

We have studied the stability of our calculated D cross sections to the cuts applied to the sample and to changes in the details of the Monte Carlo production/decay simulation. These uncertainties result in an estimated systematic error of 7% in the D^+/D^- and 9% in the $D^0/\bar{D}^0$ cross sections.

Using the above procedure, the calculated $D/\bar{D}$ inclusive cross sections (all X_F) for pp interactions at 400 GeV/c are:

$$\sigma(D^+/D^-) = (11.9 \pm 1.5) \mu b$$

$$\sigma(D^0/\bar{D}^0) = (18.3 \pm 2.5) \mu b$$

$$\text{and } \sigma(D/\bar{D}) = (30.2 \pm 3.3) \mu b$$

The errors quoted include the statistical plus systematic errors added in quadrature.

The $D/\bar{D}$ pair cross sections were measured using events with two charm decays surviving all our cuts. The

resulting cross sections are:

$$\sigma(D^+D^-) = (2.5 \pm 0.7) \mu b$$

$$\sigma(D^0\bar{D}^0) = (5.9 \pm 1.4) \mu b$$

$$\sigma(D^+\bar{D}^0 + D^-\bar{D}^0) = (6.2 \pm 1.3) \mu b$$

$$\text{and } \sigma(D\bar{D}) = (14.6 \pm 2.0) \mu b$$

Again, the errors include both estimated systematic plus statistical errors.

These measurements indicate that the $D/\bar{D}$ inclusive cross section is about twice the $D\bar{D}$ pair cross section. This means that the $\Lambda_c \bar{D}$ and $\bar{\Lambda}_c D$ cross sections cannot be large. A detailed analysis [5] allows us to establish the following limit (90% confidence level) on associated production: $\sigma(\Lambda_c \bar{D} + \bar{\Lambda}_c D) < 6.1 \mu b$.

The charm production cross sections quoted above are solid measurements made by the NA27 collaboration. I will next use these data to estimate the total charm production for pp interactions at 400 GeV/c in order to have a result that is directly comparable to QCD predictions (see Section V below).

The problem in obtaining an estimate of the $pp \rightarrow c\bar{c}X$ cross section from our $pp \rightarrow D/\bar{D}X$ measurement is that we have only an upper limit to the $(\Lambda_c \bar{D} + \bar{\Lambda}_c D)$ cross section and no measurement of the $\Lambda_c \bar{\Lambda}_c$ pair and $D_s/\bar{D}_s$ inclusive cross sections. The latter two are expected to be small. As a first order estimate, we use the predictions of the Lund scheme for charm quark fragmentation into charm hadrons in our pp production environment (see reference

[6] and Section V). This prediction is that $\Lambda_c \bar{\Lambda}_c$ and $\bar{\Lambda}_c D_s$ production are negligible and $D_s/\bar{D}_s$ production is 8% of the total $c/\bar{c}$ production cross section. Also, as measured from Ψ production [7], hidden charm production absorbs only about 1% of all $c\bar{c}$ pairs. Therefore I estimate:

$$\begin{aligned} \sigma(pp \rightarrow c\bar{c}X) &\sim \frac{\sigma(D/\bar{D}) + \sigma(\Lambda_c \bar{\Lambda}_c + \bar{\Lambda}_c D)}{2(0.92)(0.99)} \\ &= \frac{(30.2 \pm 3.3) + (< 6.1)}{2(0.92 \pm 0.04)(0.99)} \mu\text{b} \end{aligned}$$

or $\sigma(pp \rightarrow c\bar{c}X) \sim (14 \text{ to } 23) \mu\text{b}$

at $\sqrt{s} = 27 \text{ GeV}$.

This cross section estimate is compared to fusion model predictions in Section V.

IIIB. pp INTERACTIONS AT 800 GeV/c ($\sqrt{s} = 39 \text{ GeV}$)

The $D/\bar{D}$ inclusive cross section was measured in experiment E743 using basically the same technique described in Section III.A. However, only C3, C5, V4 and V6 decays were used so the measurement is subject to a systematic error associated with these topological decay branching ratios. The data sample after cuts includes 49 C3 and 10 V4 decays for which we used the branching ratios [8] $\text{BR}(D^+ \rightarrow C3) = (0.43 \pm 0.10)$ and $\text{BR}(D^0 \rightarrow V4) = (0.17 \pm 0.04)$. This is 60% of our final data and represents a sensitivity of $(9.0 \pm 1.0) \text{ events}/\mu\text{b}$. For more details of this calculation see reference [9]. The resulting $D/\bar{D}$ inclusive cross sections (all X_F) for pp interactions at 800 GeV/c are:

$$\sigma(D^+/D^-) = (34 \pm 10) \mu\text{b}$$

This increase in the charm production cross section by a factor of about two between $\sqrt{s} = 27$ and 39 GeV is consistent with QCD fusion model predictions. A detailed discussion of this comparison is made in Section V.

IV. D MESON DIFFERENTIAL PRODUCTION CROSS SECTIONS

The $D/\bar{D}$ differential production cross sections for 400 GeV/c pp collisions have been determined from 119 mesons with measured momenta and $X_F > 0$. The selection of these events makes use of kinematic fits to decay channels with particle identification information included to resolve fit ambiguities where possible. The details of the selection procedure have been described in reference 4. The data sample consists of 24 D^+ , 27 D^- , 22 D^0 and 29 $\bar{D}^0$ decays plus 16 $D^0/\bar{D}^0$ and 1 D^+/D^- ambiguous decays. Each event has been assigned a weight which corrects for bubble chamber visibility and spectrometer acceptance efficiencies. These weights are slowly varying functions of X_F and P_T of the $D/\bar{D}$ mesons. Our experiment is sensitive to all D mesons produced with $X_F > 0$.

The measured $d\sigma/dX_F$ and $d\sigma/dP_T^2$ spectra for $D/\bar{D}$ mesons are presented in Figure 1. The solid curves in Figures 1a and 1b show the result of a fit of these distributions to the empirical form:

$$d^2\sigma/dX_F/dP_T^2 = A(1-X_F)^n e^{-aP_T^2}$$

This reproduces the measured differential cross sections well with $n = (4.9 \pm 0.5)$ and $a = (1.0 \pm 0.1) (\text{GeV}/c)^{-2}$. A fit of the invariant cross section $(1/E) d^2\sigma/dX_F/dP_T^2$ to the same $(1-X_F)^m e^{-bP_T^2}$ form, yields $m = (3.2 \pm 0.6)$ and b

$$\sigma(D^0/\bar{D}^0) = (28^{+17}_{-15}) \mu b$$

$$\text{and } \sigma(D/\bar{D}) = (62^{+17}_{-15}) \mu b$$

The errors associated with the decay branching ratios have been added in quadrature with our experimental errors which are dominated by statistical uncertainties.

Again, I will **estimate** the total charm production cross section for $pp \rightarrow c\bar{c}X$ from the above measurements made by the E743 collaboration. The assumptions are those described in the discussion of the NA27 total cross section estimate. In addition, I assume that the ratio $\sigma(\Lambda_c \bar{D} + \bar{\Lambda}_c D)/\sigma(D/\bar{D})$ does not change from $\sqrt{s} = 27$ to 39 GeV and use the upper limit $6.1 \mu b / (30.2 \pm 3.3) \mu b$ measured in NA27. Therefore, an estimate of the total charm production cross section is:

$$\begin{aligned} \sigma(pp \rightarrow c\bar{c}X) &\sim \frac{\sigma(D/\bar{D})}{2(0.92)(0.99)} \left[1 + \frac{\sigma(\Lambda_c \bar{D} + \bar{\Lambda}_c D)}{\sigma(D/\bar{D})} \right] \\ &= \frac{(62^{+17}_{-15})}{2(0.92 \pm 0.04)(0.99)} \left[1 + \frac{< 6.1 \mu b}{(30.2 \pm 3.3) \mu b} \right] \end{aligned}$$

$$\begin{aligned} \text{or } \sigma(pp \rightarrow c\bar{c}X) &\sim (29 \text{ to } 55) \mu b \\ &\text{at } \sqrt{s} = 39 \text{ GeV} \end{aligned}$$

Finally, a measurement of the energy dependence of the cross section can be made. Using $D/\bar{D}$ meson production as a typical measurement of charm production, we find that:

$$\begin{aligned} \frac{\sigma(pp \rightarrow D/\bar{D} X) \text{ at } \sqrt{s} = 39 \text{ GeV}}{\sigma(pp \rightarrow D/\bar{D} X) \text{ at } \sqrt{s} = 27 \text{ GeV}} \\ = \frac{(62^{+17}_{-15}) \mu b}{(30.2 \pm 3.3) \mu b} = 2.05^{+0.60}_{-0.54} \end{aligned}$$

FIGURE 1: Differential cross sections for $D/\bar{D}$ production from pp collisions at 400 GeV/c: a) and b) show fits to the form $(1 - |X_F|)^n e^{-aP_T^2}$ with $n = 4.9 \pm 0.5$ and $a = (1.0 \pm 0.1) (\text{GeV}/c)^{-2}$; c) and d) show fusion model predictions normalized to the data (see the discussion in Section V for details)

$= (0.91 \pm 0.10) (\text{GeV}/c)^{-2}$. The average transverse momentum of the $D/\bar{D}$ mesons is $\langle P_T \rangle = (0.86 \pm 0.09) \text{ GeV}/c$. The X_F distribution is very central with $\langle X_F \rangle = (0.15 \pm 0.02)$. We emphasize that our experiment has good acceptance for $D/\bar{D}$ mesons produced with large X_F and therefore the data show that there is little leading $D/\bar{D}$ production.

$$\frac{\sigma(D/\bar{D}) X_F > 0.5}{\sigma(D/\bar{D}) X_F > 0.0} = 0.02 \quad \begin{array}{l} +0.02 \\ -0.01 \end{array}$$

Comparisons of these differential cross sections to QCD fusion model calculations are made in Section V.

All $D/\bar{D}$ mesons would have the same X_F and P_T spectra if there was no flavor dependence of the charm quark fragmentation into D mesons. Figure 2 shows the differential production spectra for various charm/charge states and the result of fits to $(1-X_F)^n e^{-aP_T^2}$. The D^- and D^0 mesons have production spectra that agree with the average of the $D/\bar{D}$, but the D^+ has a harder spectrum in both X_F and P_T^2 while the $\bar{D}^0$ has a softer spectrum. These results are presented in more detail in Table 2 where we show the results of fitting the X_F distributions in both the invariant $(1/E) d\sigma/dX_F$ and non-invariant $d\sigma/dX_F$ forms. Both fits lead to the conclusion that the D^+ mesons have an appreciably flatter X_F distribution than the $\bar{D}^0$ mesons. This is in disagreement with the simplest model of leading meson production in which the $\bar{c}$ quarks would be boosted to large X_F when they are picked up by the valence u/d quarks in the proton. A possible explanation can be found if we assume the proton is composed of a quark and a di-quark. The di-quark (a 3-bar of color) can combine with a c quark to form a color singlet system. This could form either a

FIGURE 2: Differential cross sections for D^+ , D^0 , D^- and D^0 meson production from pp collisions at 400 GeV/c. The solid curves are results of fits to the form

$$(1 - |x_F|)^n e^{-a p_T^2}.$$

charm baryon or fragment into a D meson plus a baryon and thus produce rather forward charm mesons. Thus D's could be produced more leading than $\bar{D}$'s if the protons valence di-quarks are appreciably faster than its valence quarks. For a more detailed discussion of this speculation see reference [10].

TABLE II

Fits to $\frac{d\sigma}{dx_F} \propto (1-x_F)^n$ and to $\frac{1}{E} \frac{d\sigma}{dx_F} \propto (1-x_F)^m$ for $x_F > 0$

	Number of Decays	n	m	$\langle p_T^2 \rangle$ (GeV/c) ²
All D	119	4.9±0.5	3.2±0.6	0.99±0.10
D ⁺	24	3.1±0.8	1.8±0.7	1.32±0.27
D ⁻	27	5.4±1.2	3.5±0.9	1.04±0.20
D ⁰	29	5.5±1.2	3.8±0.9	0.82±0.14
$\bar{D}^0$	22	8.1±1.9	6.2±1.4	0.62±0.14
D _{ambig}	17	3.9±1.1	2.9±0.9	0.93±0.30
[D ⁺ +D ⁰]	53	4.2±0.8	2.7±0.6	1.04±0.14
[D ⁻ + $\bar{D}^0$]	49	6.6±1.1	4.6±0.8	0.84±0.12

V. COMPARISONS OF D/ $\bar{D}$ PRODUCTION DATA TO THE QCD FUSION MODEL

The QCD fusion model can be used to calculate the D meson production spectrum. The calculation requires: 1) a description of the parton content of the proton, 2) calculation of the cross sections for the subprocesses $gg \rightarrow c\bar{c}$ and $q\bar{q} \rightarrow c\bar{c}$ and 3) some approximation to the $c \rightarrow D$ fragmentation process. Since the predictions of the model depend on the detailed treatment of the above components, we have allowed some variation of the input parameters. For a description of the parton content of the proton we use the structure functions determined by Duke and Owens (DO) [11] and Eichten et al (EHLQ) [12]. The intrinsic

parton transverse momentum plus soft gluon radiation effects were included by giving the colliding partons a transverse momentum, k_T , with distribution $dN/dk_T^2 = e^{(-k_T^2/\langle k_T^2 \rangle)}/\langle k_T^2 \rangle$. The parameter $\langle k_T^2 \rangle$ was allowed to vary between 0 and $(0.8)^2 \text{ (GeV/c)}^2$ [13]. The subprocess parton cross sections have been calculated by Combridge [14]. For the $c\bar{c}$ production threshold we use $(2m_c)^2$ where the charm quark mass is allowed to vary from 1.2 to 1.3 GeV/c^2 . The strong interaction coupling constant is given by $\alpha_s = (12 \pi/25)/\log(Q^2/\Lambda^2)$ where Λ is taken to be 0.2 GeV and Q^2 is allowed to vary between $(2 m_c)^2$ and s , the cm energy squared of the subprocess. Finally we investigated the sensitivity of the D meson differential production cross section to three different $c \rightarrow D$ fragmentation processes: 1) a delta-function in which all the longitudinal momentum of the charm quark is transferred to the D meson, 2) an empirical fragmentation function determined by Peterson et al [15] and 3) a fragmentation which approximates the final state $c\bar{q}$ and $\bar{c}q$ formation via color string breaking as described by the Lund model [6]. The latter depends on adjustable string parameters but these were not changed from the values determined by the Lund group from other data.

Comparisons of some predictions of this QCD fusion model, normalized to our data are shown in Figures 1c and 1d. The calculated X_F and P_T^2 distributions are relatively insensitive to the choice of structure functions and charm quark mass. The curves shown in Figures 1c and 1d were obtained using the EHLQ set one structure functions and a charm quark mass of 1.25 GeV/c^2 . The $d\sigma/dP_T^2$ distribution is sensitive to the effective parton intrinsic k_T and the QCD prediction with $\langle k_T^2 \rangle = 0$ does not fit the data. A value of $\langle k_T^2 \rangle = (0.8)^2 \text{ (GeV/c)}^2$, similar to that determined from Drell-Yan measurements [13], was used in

all our calculations.

The dashed curve in Figure 1c is the fusion model prediction with inputs fixed as described in the above paragraph and using a delta-function $c \rightarrow D$ fragmentation. This illustrates the basic parton level prediction. If the isolated $c \rightarrow D$ fragmentation function of Peterson et al [15] is added to the calculation, the predicted momentum spectrum is too soft and disagrees with both the measured $d\sigma/dX_F$ and $d\sigma/dp_T^2$ spectra. The Lund $c \rightarrow D$ fragmentation process is sensitive to the production environment of the $c\bar{c}$ pair since color singlet strings are formed between the charm quarks and the valence quarks and di-quarks left over from the proton after the hard scattering process. The predictions of this calculation [6] are given by the solid curves shown in Figures 1c and 1d. The fusion model plus Lund fragmentation clearly reproduces well the measured X_F and p_T^2 distributions of the total sample of $D/\bar{D}$ mesons. However, a closer examination of the predictions indicate some discrepancies between the model and our data. In particular, the fusion/Lund model does not predict our observation (Section IV) that the D mesons have a somewhat flatter X_F spectrum than the $\bar{D}$ mesons.

Finally, we compare the total charm production cross sections that were estimated in Section III to the predictions of the $O(\alpha_s^2)$ fusion model calculation. The difficulty with this comparison is that the fusion model prediction is uncertain for several reasons. First, the subprocess cross sections for $gg \rightarrow c\bar{c}$ and $q\bar{q} \rightarrow c\bar{c}$ are very sensitive to the threshold determined by the charm quark mass [16]. For example, if m_c is varied between 1.2 and 1.4 GeV/c^2 , the cross section for $pp \rightarrow c\bar{c} X$ varies by a factor of 2.2. Additional uncertainties arise from changes in the proton structure function and the choice of

Q^2 in α_s and the evolution of the structure function. In the following calculation we fix the charm quark current mass at $1.25 \text{ GeV}/c^2$ and vary the proton structure function (D01 or EHLQ1) and the choice of Q^2 ($(2m_c)^2$ to $\hat{s}$). The result is:

$$\begin{aligned} \sigma(pp \rightarrow c\bar{c}X) \text{ at } \sqrt{s} = 27 \text{ GeV} &= (8 \text{ to } 15) \mu\text{b} \\ \sigma(pp \rightarrow c\bar{c}X) \text{ at } \sqrt{s} = 39 \text{ GeV} &= (15 \text{ to } 29) \mu\text{b} \\ \text{QCD fusion model with } m_c &= 1.25 \text{ GeV}/c^2 \end{aligned}$$

Our data allows us to estimate the $c\bar{c}$ production cross sections to be (see Section III):

$$\begin{aligned} \sigma(pp \rightarrow c\bar{c}X) \text{ at } \sqrt{s} = 27 \text{ GeV} &= (14 \text{ to } 23) \mu\text{b} \\ \sigma(pp \rightarrow c\bar{c}X) \text{ at } \sqrt{s} = 39 \text{ GeV} &= (29 \text{ to } 55) \mu\text{b} \\ &\text{from NA27 and E743 data} \end{aligned}$$

The above suggests that the charm k-factor $\equiv [\sigma(pp \rightarrow c\bar{c}X)_{\text{experiment}}]/[\sigma(pp \rightarrow c\bar{c}X)_{O(\alpha_s^2) \text{ QCD}}]$ is:

$$k(\sqrt{s} = 27 \text{ GeV}) \sim \frac{18.5 \pm 4.5}{11.5 \pm 3.5} = 1.6 \pm 0.6$$

$$k(\sqrt{s} = 39 \text{ GeV}) \sim \frac{42 \pm 13}{22 \pm 7} = 1.9 \pm 0.8$$

That is, our data indicate that the charm k-factor is on the order of two if the charm quark current mass is $1.25 \text{ GeV}/c^2$. Note also that the $\sqrt{s}$ dependence of the $pp \rightarrow c\bar{c}X$ cross section is in agreement with the fusion model prediction.

It will be interesting to compare these results to recent calculations of higher order QCD contributions to $c\bar{c}$ production [17].

V. SUMMARY AND CONCLUSIONS

Experiments NA27 and E743 are providing reliable measurements of charm production from pp interactions at $\sqrt{s} = 27$ and 39 GeV. The most accurate charm production cross section measurement made to date is $\sigma(pp \rightarrow D/\bar{D}X) = (30.2 \pm 3.3) \mu\text{b}$ at $\sqrt{s} = 27$ GeV. A preliminary result at $\sqrt{s} = 39$ GeV is $\sigma(pp \rightarrow D/\bar{D}X) = (62^{+17}_{-15}) \mu\text{b}$.

The $D/\bar{D}$ meson production cross section increases by a factor of $2.05^{+0.60}_{-0.54}$ from $\sqrt{s} = 27$ to 39 GeV. This data plus some assumptions about Λ_c/D_s production allow us to estimate a charm k-factor of 1.8 ± 0.7 if the charm quark current mass is $1.25 \text{ GeV}/c^2$.

The measured differential cross section $(1/\sigma) d^2\sigma/dX_F dP_T^2$ for $D/\bar{D}$ production at $\sqrt{s} = 27$ GeV is well represented by the empirical form $(1 - |X_F|)^{(4.9 \pm 0.5)} e^{-(1.0 \pm 0.1)P_T^2}$. The production process is very central with $(98^{+1}_{-2})\%$ of the $D/\bar{D}$ mesons having $X_F < 0.5$. Our data suggests that the D mesons have a somewhat harder production spectrum than the $\bar{D}$ mesons in disagreement with the naive expectation of a preference for $\bar{c}$ quark pickup by proton u/d quarks. The fusion model reproduces the overall $D/\bar{D}$ differential cross section shape if the Lund $c \rightarrow D$ fragmentation scheme is used and an intrinsic k_T distribution with $\langle k_T^2 \rangle = (0.8 \text{ GeV}/c)^2$ is applied.

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