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An Estimate of the Double Pomeron Dijet Cross Sections at FELIX

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Abstract

We present estimates for high-p_T dijet cross sections at LHC, when the final state is kinematically of the kind associated with double-pomeron-exchange (DPE).

In this report, we present estimates for double pomeron exchange (DPE) dijet production. We use the Ingelman-Schlein model but with parton densities in the Pomeron that have been fit to diffractive deep-inelastic data. Then we estimate the non-perturbative suppression factor ('absorption') from the D0 data [4].

A general discussion about diffractive hard scattering at FELIX is given amongst these contributions in [2]. The proposed production mechanisms can be divided in exclusive DPE and inclusive DPE. Exclusive production means the production of two diffracted protons, two jets and nothing else: $p + p \to p + \text{jet} + \text{jet} + p$. In Ref. [1], a simple leading-twist QCD mechanism was presented, and references to other literature can be found. We termed this model nonfactorized double pomeron exchange (NDPE). Factorized double pomeron exchange (FDPE) then refers to the Ingelman-Schlein mechanism.

FDPE is consistent with QCD diffractive factorization [6]. This can be considered the "standard" mechanism. In addition, the DPE-dijet process has potentially exciting theoretical implications for strong interaction physics, because it was shown in [1] that QCD predicts an exclusive component to the process that violates factorization. This component is a generalization to double pomeron exchange of the 'coherent pomeron mechanism' identified by Collins, Frankfurt, and Strikman [5].

In any case, nonperturbative absorption effects are expected to reduce the cross section. An experimental measurement of the process at one energy could help in estimating the size of the nonperturbative effects. Such measurements are being done by CDF [3] and D0 [4], although at the moment only the first measurements have been reported. It is anticipated

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that within the next few years more data will be available from the Fermilab experiments. This will help facilitate better estimates of the expected cross section at the LHC. In this report we have used the limited data available from D0 and attempted to make conservative estimates for the DPE-dijet cross section at the LHC.

The existence of nonfactorizing exclusive contributions appears correct at the level of perturbative QCD. However, at the moment, the relative magnitude of factorization breakdown is unclear. Further data from the Fermilab experiments in the coming years will be useful in estimating the extent of factorization breakdown. For the time being, remaining conservative on our estimates, we consider only the FDPE process.

The FDPE cross section formula used in obtaining the results presented below is from [1]

$$\frac{d\sigma}{dE_T^2 dy_- dy_+} = \frac{\kappa^2}{256\pi E_T^4}\left(\frac{N}{16\pi}\right)^2 \int dx_{P_A} dx_{P_B} B^A_{t_A}(x_{P_A}) B^B_{t_B}(x_{P_B})$$
$$x_a f_{a/P_A}(x_a/x_{P_A}) x_b f_{b/P_B}(x_b/x_{P_B}) H^{ab}_{\rm incl}(\kappa), \qquad (1)$$

where N is a normalization factor [8] that we have set equal to $2/\pi$ to give the conventions of Donnachie and Landshoff [9]. (This is necessary to be consistent with the conventions used in the fits of parton densities in the pomeron made by Ref. [7].) We have used the following integral over the momentum transfer:

$$B^I_t(x_P) = \int_{\rm t_{min}}^0 dt\ |\beta_I(t)|^2 x_P^{-2\alpha_{\mathbf{P}}(t)}$$
$$= \sigma_0 x_P^{-2\alpha_0} \int_{\rm t_{min}}^0 dt\, e^{(b_0 - 2\alpha' \ln x_P)t}, \qquad (2)$$

where $\alpha_{\mathbf{P}}(t) \equiv \alpha_0 + \alpha' t$ is the pomeron trajectory function. We will use $\sqrt{\sigma_0} = 4.6\ {\rm mb}^{\frac{1}{2}}$, $b_0 = 3.8\ {\rm GeV}^{-2}$, $\alpha_0 = 1.08$ and $\alpha' = 0.25\ {\rm GeV}^{-2}$, following [10]. Formula (1) is the natural extension of the Ingelman-Schlein model to hard double pomeron exchange processes [11]. The results presented in the tables below are computed with the initial parton distribution functions that we used [1] (BC) and those obtained by Alvero et al. [7] (ACTW A–D, SG). In our calculations below, we set $\rm t_{min} = -1.0\ GeV^2$.

Our procedure for computing the suppression factor (often called absorptive corrections) is to determine it from the D0 data, and to assume it is independent of all parameters, in particular the center-of-mass energy.

In tables 1 and 2 we show predicted cross sections for two different sets of cuts with a minimum E_T of 5 GeV. Table 1 is provided for comparison of the present calculations with those in our paper [1],

Then in table 3 we show cross sections with kinematic cuts appropriate to the D0 data. In the fourth row of table 3, we state a phenomenologically determined suppression factor, that we will explain in a moment. Note that this suppression factor is substantial for the gluon-dominated fits (B, D, SG). It is these gluon-dominated fits that are strongly preferred when one includes diffractive photoproduction data in the fits.

The suppression factor should be multiplied by the cross sections quoted in the three rows above it to obtain our predicted cross section. This suppression factor was determined by requiring that the result in row two for $\sqrt{s} = 1800$ GeV agrees with the experimental dijet double GAP "cross section". There is no quoted experimental cross section for this process, but only ratios of cross sections. We have used the best estimate that we can ascertain from the D0 data [4,12], and come up with $\sigma^{exp}_{2gap-dijet} \approx 10 \times 10^{-12}$ barns. This estimate does not include resolution corrections which could be large [12].

Then in tables 4 and 5, we have applied the suppression factor to the $\sqrt{s} = 14,000$ GeV result to obtain the expected LHC cross section, which is given in row four on these tables.

I. RESULTS-FACTORIZED DOUBLE POMERON EXCHANGE CROSS SECTIONS

$\sqrt{s}$	$\sigma^{FDPE}_{dijet}(E_T^{min} = 5.0)$					
	BC	ACTW A	ACTW B	ACTW C	ACTW D	ACTW SG
(GeV)	$\times 10^{-2}$ (mb)	$\times 10^{-2}$ (mb)	$\times 10^{-2}$ mb	$\times 10^{-2}$ mb	$\times 10^{-2}$ mb	$\times 10^{-2}$ mb
630	0.0062	0.00086	0.060	0.00070	0.054	0.52
1800	0.22	0.024	2.15	0.025	2.0	5.8
14000	6.6	0.52	72.0	0.92	66.0	85.0

Table 1: Factorized Double Pomeron dijet cross section with initial parton distribution function of Berera and Collins and Alvero et. al. A–D+SG. The cuts are from (BC), $x_a, x_b < 0.05$ and $E_T > 5.0$ GeV.

$\sqrt{s}$	$\sigma^{FDPE}_{dijet}(E_T^{min} = 5.0)$					
	BC	ACTW A	ACTW B	ACTW C	ACTW D	ACTW SG
(GeV)	$\times 10^{-2}$ (mb)	$\times 10^{-2}$ (mb)	$\times 10^{-2}$ mb	$\times 10^{-2}$ mb	$\times 10^{-2}$ mb	$\times 10^{-2}$ mb
630	0.0050	0.00066	0.050	0.00054	0.045	0.35
1800	0.076	0.0072	0.78	0.0075	0.71	1.3
14000	0.73	0.043	7.2	0.074	6.5	6.1

Table 2: The same as Table 1, except that there is an additional cut on jet rapidity: $|y_1|, |y_2| < 1.0$.

$\sqrt{s}$	$\sigma^{FDPE}_{dijet}(E_T^{min} = 15.0)$					
	BC	ACTW A	ACTW B	ACTW C	ACTW D	ACTW SG
(GeV)	$\times 10^{-4}$ (mb)	$\times 10^{-4}$ (mb)	$\times 10^{-4}$ mb	$\times 10^{-4}$ mb	$\times 10^{-4}$ mb	$\times 10^{-4}$ mb
1800	0.016	0.0025	0.12	0.0020	0.11	1.3
14000	2.2	0.17	20.0	0.21	18.0	27.0
Suppression Factor	0.01	0.1	0.001	0.1	0.001	0.0001

Table 3: Factorized Double Pomeron dijet cross section with initial parton distribution function of Berera and Collins and Alvero et al. A–D+SG. The cuts are $x_a, x_b < 0.05$,

$|y_1|, |y_2| < 1.0$, and $E_T > 15.0$ GeV. The suppression factors are needed to bring the cross section into agreement with the D0 data [4], and the listed cross sections are *without* the suppression factor.

$\sqrt{s}$	$\sigma_{dijet}^{FDPE}(E_T^{min} = 10.0)$					
	BC	ACTW A	ACTW B	ACTW C	ACTW D	ACTW SG
(GeV)	$\times 10^{-4}$ (mb)	$\times 10^{-4}$ (mb)	$\times 10^{-4}$ mb	$\times 10^{-4}$ mb	$\times 10^{-4}$ mb	$\times 10^{-4}$ mb
1800	0.031	0.0049	0.26	0.0038	0.23	3.1
14000	1.0	0.095	8.8	0.10	8.0	14.0
Expected LHC cross section	0.010	0.0095	0.0088	0.010	0.008	0.0014

Table 4: Factorized Double Pomeron dijet cross section with initial parton distribution function of Berera and Collins and Alvero et al. A–D+SG. The cuts are $0.002 < x_a, x_b < 0.03$, $|y_1|, |y_2| < 1.0$, and $E_T > 10.0$ GeV. The last line is the FDPE cross section multiplied by the corresponding suppression factor in Table 3.

$\sqrt{s}$	$\sigma_{dijet}^{FDPE}(E_T^{min} = 20.0)$					
	BC	ACTW A	ACTW B	ACTW C	ACTW D	ACTW SG
(GeV)	$\times 10^{-5}$ (mb)	$\times 10^{-5}$ (mb)	$\times 10^{-5}$ mb	$\times 10^{-5}$ mb	$\times 10^{-5}$ mb	$\times 10^{-5}$ mb
1800	0.000012	0.0000033	0.00006	0.0000023	0.000054	0.011
14000	3.0	0.29	25.0	0.30	23.0	53.0
Expected LHC cross section	0.030	0.029	0.025	0.030	0.023	0.0053

Table 5: The same as Table 4, except with $E_T^{min} = 20.0$ GeV.

To briefly summarize the results, table 1 is provided for comparison of the present calculations with those in our paper [1], table 3 was computed with the cuts of D0, and tables 4 and 5 were computed with the cuts projected for FELIX.

For a projected luminosity of $10^{31}\text{cm}^{-2}\text{s}^{-1} = 10^7\text{barns}^{-1}\text{s}^{-1}$ at the LHC, in 1 year= 10^7 s, from the results of tables 4 and 5, one can anticipate 1×10^5 and 3×10^4 double pomeron dijet events per year for jet-$E_T > 10$ and 20 GeV respectively. These multiplicities still must be decreased by the experimental resolution correction, which is presently not available.

Notice that the cross sections with the different parton densities are widely different. The suppression factor, not unnaturally, brings the predicted cross sections much closer, with the exception of the SG case. The SG pdf corresponds to an initial gluon density in the pomeron that is strongly peaked at $\beta \to 1$, such as is preferred by H1 from their fits to the Q dependence of their diffractive DIS cross sections.

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