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QCD ANALYSIS OF THE DIFFRACTIVE MEASUREMENTS AT HERA AND TEVATRON*

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In the following, we present a QCD analysis of CDF data on single diffractive events and we extract the gluon fraction in the Pomeron from this study. Then, we combine both HERA and Tevatron results on diffraction in a same QCD framework to search for common parton distributions. As the dijet mass fraction, measured at CDF with a double diffractive exchange sample of events, is very sensitive to the gluon density in the Pomeron, we present some comparisons of this dijet mass fraction with gluon densities extracted from HERA or CDF single diffractive data.

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1. Introduction

In a previous paper [1], we have derived parton distributions for the Pomeron by applying QCD fits (following DGLAP evolution equations) to HERA data [2,3], showing that a large gluon content of the Pomeron can be extracted from hard diffraction in Deep Inelastic Scattering (DIS) at HERA. In reference [1] we have also mentioned that QCD fits obtained from HERA data allow to make direct comparisons for diffractive measurements at the Tevatron. In the following, we keep on this analysis and search for parton distributions in the Pomeron which can reproduce these CDF data and we combine both HERA and Tevatron results on diffraction. As the dijet mass fraction, measured at CDF with a double diffractive exchange sample of events, is very sensitive to the gluon density in the Pomeron, we present some comparisons of this dijet mass fraction with gluon densities extracted from HERA or CDF single diffractive data.

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2. QCD fits of CDF measurements $\tilde{F}_{jj}^{\mathrm{D}}$

Our aim in this paragraph is to reproduce the QCD analysis of reference [1] to CDF measurements of the diffractive jet cross-section measurement $\tilde{F}_{jj}^{\mathrm{D}}(\beta)$ at $Q^2 = 75$ GeV^2 [4], with

$$\tilde{F}_{jj}^{\mathrm{D}}(\beta) = \int_{x_{\mathbb{P}}=0.035}^{x_{\mathbb{P}}=0.095} f_{\mathbb{P}/p}(x_{\mathbb{P}}) F_{jj}^{\mathbb{P}}(Q^2,\beta) + f_{\mathbb{R}/p}(x_{\mathbb{P}}) F_{jj}^{\mathbb{R}}(Q^2,\beta) \;\; dx_{\mathbb{P}} \,. \qquad (1)$$

As was done in Ref. [1], we assign parton distribution functions to the Pomeron and to the Reggeon. A simple prescription is adopted in which the parton distributions of both the Pomeron and the Reggeon are parameterised in terms of non-perturbative input distributions at some low scale $Q_0^2 = 3$ GeV^2.

For the Pomeron, a quark flavour singlet distribution ($zS_q(z,Q^2) = u + \bar{u} + d + \bar{d} + s + \bar{s}$) and a gluon distribution ($zG(z,Q^2)$) are parameterised and evolved to higher Q^2 ($Q^2 = 75$ GeV^2) according to next-to-leading order DGLAP evolution equations. The trajectory intercepts are fixed to $\alpha_{\mathbb{P}} = 1.08$ and $\alpha_{\mathbb{R}} = 0.62$. We find a good convergence with $\chi^2/\mathrm{dof} = 5.72/7 = 0.82$ and comparisons between these QCD fits and the CDF data points is shown in figure 1. Moreover, the gluon density is found to be

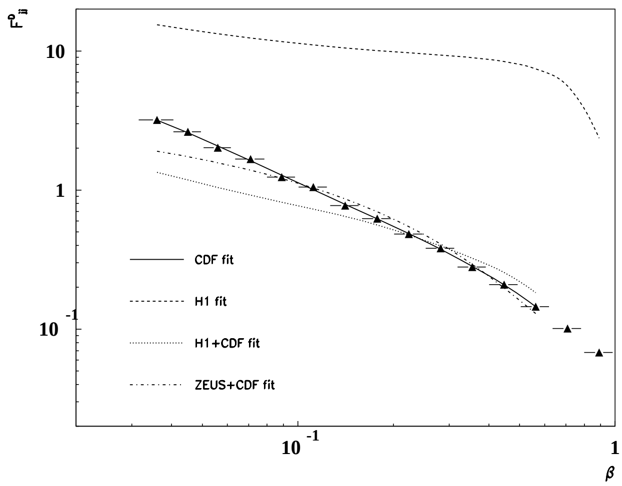

Fig. 1. Comparison between the CDF data points (triangles) and the QCD fits for CDF only (full line) as well as the QCD fits for both H1 and CDF measurements (dashed line for the fit of H1 data only and dotted line for the combined fit of H1 and CDF). We present also the combined fit of ZEUS and CDF data (dashed-dotted line).

proton-like with a gluon fraction in the Pomeron of $70 \pm 5\%$. Results are shown in figure 2. As this result is larger than expected from the fits of rapidity gaps fraction, we have searched for solutions with a lower gluon content. If we accept a higher χ^2, we have shown that we can modify slightly the set of parameters in order to find a gluon fraction of $60 \pm 5\%$ (with $\chi^2/\text{dof} = 12.3/7 = 1.75$).

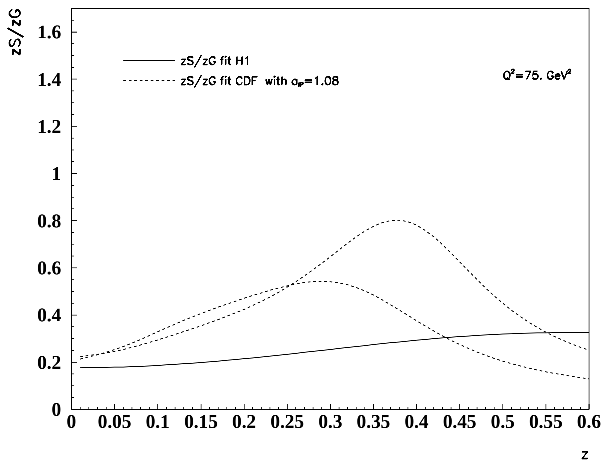

Fig. 2. Ratio of the quark flavour singlet (zS, left) by the gluon (zG, right) distributions of the Pomeron derived from H1 diffractive data (full lines) and CDF diffractive data (dashed lines). We present two different curves for CDF distributions at $Q^2 = 75$ GeV^2, which correspond to two different parametrisations for the input distributions.

In the discussion above we have also considered $\alpha_{\mathbb{P}} = 1.08$ and the results are presented with this value of the Pomeron intercept. Also, letting $\alpha_{\mathbb{P}}$ free in these QCD fits we can confirm that a soft value for the Pomeron intercept is favoured in the case of diffractive Tevatron data.

3. QCD fits of CDF and HERA

We have tried to fit together the measurements of H1 on $F_2^{D(3)}$ and of CDF on $\tilde{F}^{D}_{jj}$. We have found that, whatever the initial parametrisations considered, it is impossible to find a set of parametrisations for $zS(z, Q^2 = Q_0^2)$ and $zG(z, Q^2 = Q_0^2)$ which gives a reasonable QCD fits ($Q_0^2 = 3$ GeV^2). The result is presented in figure 1. For different parametrisations, the χ^2/dof value for H1 stays below 1.5 and the the χ^2/dof value for CDF is around 80. Hence, the combination of both data sets in the same fitting protocol is impossible.

Then, we redo the QCD analysis with ZEUS diffractive structure functions and CDF data. In this case, the statistical significance of the ZEUS data is not completely dominant as in the H1/CDF combined fits. We find a $\chi^2/\,$dof for ZEUS around 3 and a $\chi^2/\,$dof value for CDF is around 25. Here again, the $\chi^2/\,$dof is very bad and it is impossible to achieve a global fit of ZEUS diffractive structure functions and CDF single diffractive data.

4. Dijet mass fraction and QCD fits

As the dijet mass fraction (obtained from a sample of events with double Pomeron exchange at CDF) is also very sensitive to the gluon density in the Pomeron, we have tried to see if it was possible to reproduce the dijet mass shape from the gluon distribution extracted above from the QCD analysis of the single diffractive data at CDF. The result is presented in figure 3, which shows that the description is very bad. Also, when using the H1 QCD fit results to forecast the CDF dijet mass fraction, we get the comparison presented in figure 4. The description is fairly good. We can conclude that double diffraction at Tevatron (giving the dijet mass fraction) is closer to HERA hard diffraction (H1 structure function) than from the results deduced by fitting the single diffractive dijet cross-section $\tilde{F}^{\rm D}_{jj}$ of CDF.

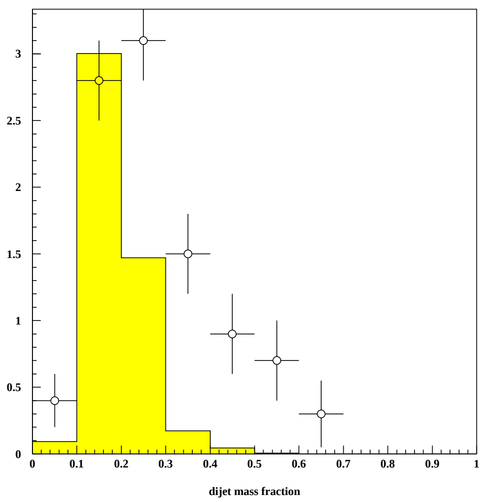

Fig. 3. Dijet mass fraction for CDF compared with expectations derived from CDF fits results. The points are CDF data and the dashed area the expectations from the gluon density extracted from the QCD analysis of the single diffractive CDF data. The description is very poor.

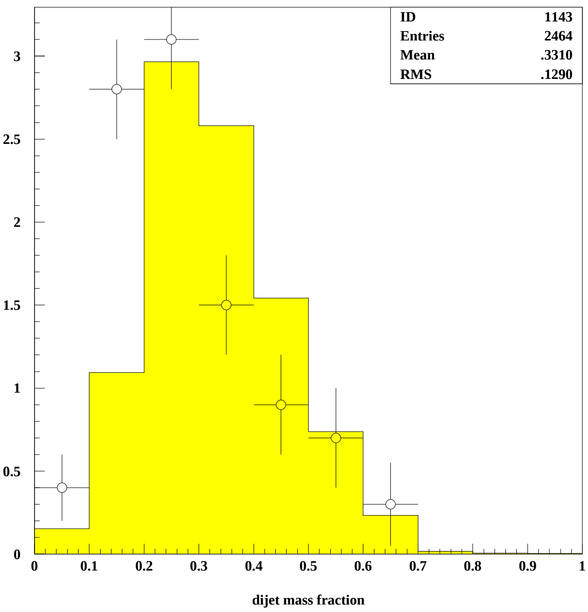

Fig. 4. Dijet mass fraction for CDF compared with expectations derived from H1 QCD fits results. The points are CDF data and the dashed area the expectations from the gluon density extracted from the QCD analysis of H1 diffractive structure functions. The agreement is fairly good.

5. Conclusions

In this paper, we have presented a QCD analysis of diffractive CDF data. We have extracted parton distributions in the Pomeron which can reproduce these CDF $\tilde{F}_{jj}^{\rm D}$ measurements. We have shown that the gluon density obtained is proton like and quite small at high β compared to HERA predictions. Also, the Pomeron intercept favoured by the QCD fits on CDF data is found to be $\alpha_{\mathbb{P}} = 1.08$ (whereas at HERA a harder value of $\alpha_{\mathbb{P}} = 1.20$ is deduced). Then, we have shown that a combined QCD analysis of both HERA and Tevatron results on diffraction is impossible. As the dijet mass fraction, measured at CDF with a double diffractive exchange events sample, is also very sensitive to the gluon density in the Pomeron, we have presented some comparisons of this dijet mass fraction with gluon density extracted from CDF and HERA single diffractive data. We have shown that the Pomeron gluon density extracted from CDF $\tilde{F}_{jj}^{\rm D}$ measurements cannot reproduce the dijet mass fraction shape but that the HERA gluon distribution could match. We can conclude that double diffraction at Tevatron is closer to HERA hard diffraction than from the results deduced by fitting the single diffractive dijet cross-section $\tilde{F}_{jj}^{\rm D}$ of CDF.

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