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LOOKING FOR THE DIFFRACTIVE EXCLUSIVE SIGNAL IN THE DIJET MASS FRACTION MEASUREMENT*

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New HERA QCD fits are used to extract the exclusive signal from the CDF dijet mass fraction R_{JJ} diffractive measurement, using several available models of inclusive diffraction. Subsequently, a prediction of dijet mass fraction distribution at the LHC is presented and the appearance of the exclusive signal in such measurement is discussed.

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Exclusive diffractive production of heavy mass objects has attracted much attention because it can potentially allow for unique measurements of final state characteristics. The fact that all energy lost by scattered protons is used to create a desired object (Higgs boson, dijets, diphotons, *etc.*) in the central rapidity region yields highly accurate reconstruction of its mass (*e.g.* Higgs mass precision can reach $\sigma(M) \sim 1$ GeV [1]). The energy flowing into diffractive system can be precisely computed using missing momenta of scattered protons measured by proton taggers placed in the LHC tunnel [2, 3]. In addition, the exclusive production amplitude has to satisfy specific selection rules [4] which force the production of 0^{++} states mainly. Hence an observation of just a few Higgs boson events in this channel gives us a non-trivial information about spin and C,P-parity of the boson.

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The knowledge of the exclusive production rate is so far not confidently known. The CDF collaboration advocated a presence of exclusive signal in the dijet production, analyzing the dijet mass fraction R_{jj} distribution [5]. It was an indirect measurement since the exclusive contribution was obtained by subtracting the inclusive diffractive contribution (where the energy lost by protons is used not only for producing the heavy object but also for pomeron remnants) from the measured signal. The inclusive contribution was calculated with the knowledge of diffractive PDFs as measured at HERA.

However, looking at newer QCD fits of HERA data presented in Ref. [6] one notices significant differences from the PDFs used in CDF analysis, mainly in the gluon distribution function. Its normalization has changed by a factor of 2 plus it turned out that the QCD fits poorly constrain the gluon density at large β, where β denotes the momentum fraction of the pomeron carried into the hard interaction by an interacting parton. This is quantitatively expressed as follows: multiplying the gluon density by a factor $(1-\beta)^{\nu}$, the uncertainty on the gluon translates to the uncertainty on the parameter ν as $\nu = 0.0 \pm 0.6$. It is important to see whether this uncertainty on the gluon distribution function cannot imitate the exclusive signal in the dijet mass fraction measurement.

1. Search for the exclusive signal at the Tevatron

In the CDF measurement [5], one requests two jets with p_{T} greater than a certain threshold $p_{\mathrm{T}}^{\mathrm{min}} = 10, 25$ GeV and defines the dijet mass fraction distribution R_{jj} as a ratio of the invariant dijet mass to the total diffractive energy in the event. We compared the data with two models for inclusive diffraction, namely Factorized (FM) [7] and BPR [8, 9] model. In the first case, diffractive cross section almost exactly factorizes to the flux factor and the parton distribution function; the only factorization breaking comes through the survival probability factor which is about 0.1 for the Tevatron energies and is predicted to be 0.03 for the LHC. Pomeron parameters are obtained from the fits at HERA. BPR model, on the other hand, is viewed as an exchange of two non-perturbative pomerons with soft pomeron parameters as determined by Donnachie and Landshoff [10].

In Fig. 1, one can see the comparison of the CDF dijet mass fraction data with $p_{\mathrm{T}}^{\mathrm{min}} = 10$ GeV with the Factorized model for inclusive diffraction using the new parton densities [6]. The blue curve denotes the calculation performed with official PDFs whereas the other distributions correspond to gluon density variations at high β for $\beta = -1, -0.5, 0, 0.5, 1$. We note that even taking into account the gluon uncertainties, one is unable to explain the tail of the R_{jj} distribution and further, accepting the limited data statistics for dijets with $p_{\rm T}$ above 25 GeV, the conclusion holds in this case as well. BPR model gives similar results; inclusive contribution by itself is insufficient to describe the data.

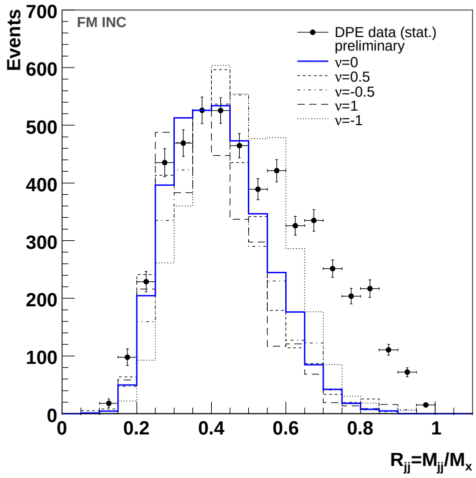

Fig. 1. Dijet mass fraction predicted by Factorized model (inclusive diffraction) for $p_{\rm T} > 10$ GeV jets. The uncertainty of the gluon density at high β is obtained by multiplying the gluon distribution by $(1-\beta)^{\nu}$ for different values of $\nu = -1, -0.5, 0, 0.5, 1$ (non-solid lines).

Therefore, the exclusive R_{jj} distribution predicted by Khoze–Martin–Ryskin (KMR) [11–13] exclusive model was added on top of the inclusive one, performing a fit of the two contributions to the data. The model is based on the direct coupling of perturbative gluons to the protons in the framework of unintegrated parton densities.

As seen in Fig. 2, left, one can describe the measured CDF data well by superimposing FM and KMR model. It is worth mentioning that the relative normalizations between the inclusive and the exclusive contributions obtained from the fit for $p_{\rm T}^{\rm min} = 10$ GeV and $p_{\rm T}^{\rm min} = 25$ GeV jets were consistent with each other. This allowed us to determine the relative normalization from the Tevatron measurement and to apply it when making predictions of R_{jj} for the LHC. Let us note that the other existing model for exclusive diffraction, the Bialas–Landshoff model (BL), is disfavored by the CDF data because it predicts a too slow decrease of the exclusive dijet production cross section as a function of jet $p_{\rm T}$. This is illustrated in Fig. 2, right.

Beside the pomeron inspired models, we also investigated a prediction of the Soft color interaction model (SCI) [15, 16] which successfully described number of HERA and Tevatron measurements [17]. The model interprets diffraction as a consequence of a special color rearrangement in the final state

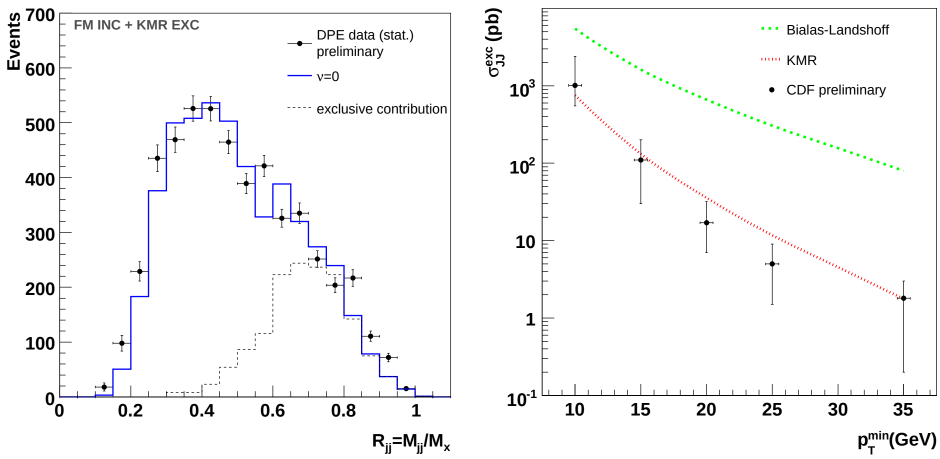

Fig. 2. Left: Dijet mass fraction for $p_{\mathrm{T}} > 10$ GeV jets. Inclusive contribution (FM) and exclusive contribution (KMR) are superimposed, hence the tail of R_{jj} is well described. Right: Exclusive cross section as a function of jet $p_{\mathrm{T}}^{\mathrm{min}}$ compared with the CDF data [5]. Bialas–Landshoff model clearly fails to describe the data whereas KMR model gives a rather good description.

controlled by just one probabilistic parameter. A detailed comparison with the data is given in [14]. Here we only mention that even though the model has some success to describe the shape of the dijet mass fraction distribution, it yields incorrect other fundamental characteristics of the measurement like the rapidity profiles of leading jets. The model as in current state cannot describe the CDF dijet data [5].

2. Dijet mass fraction at the LHC

Having fixed the relative normalization between the inclusive and exclusive production, we made a prediction of dijet mass fraction at the LHC environment. The prediction of R_{jj} for jets with p_{T} above 400 GeV is shown in Fig. 3, left. The exclusive contribution manifests itself as a peak towards high R_{jj}. The precise prediction of the dijet mass fraction distribution depends on many peculiarities, *e.g.* parameters of the pomeron flux, pomeron structure function, or survival probability factor. One of the important factors is the gluon density in the pomeron. Its tail at high β can significantly influence number of dijet diffractive events as demonstrated in Fig. 3, right. The signal due to the exclusive production could be mimicked by the uncertainty on the gluon. It is therefore desirable to perform QCD fits at the LHC to extract the pomeron parton densities precisely in order to be able to distinguish the rather elusive exclusive signal.

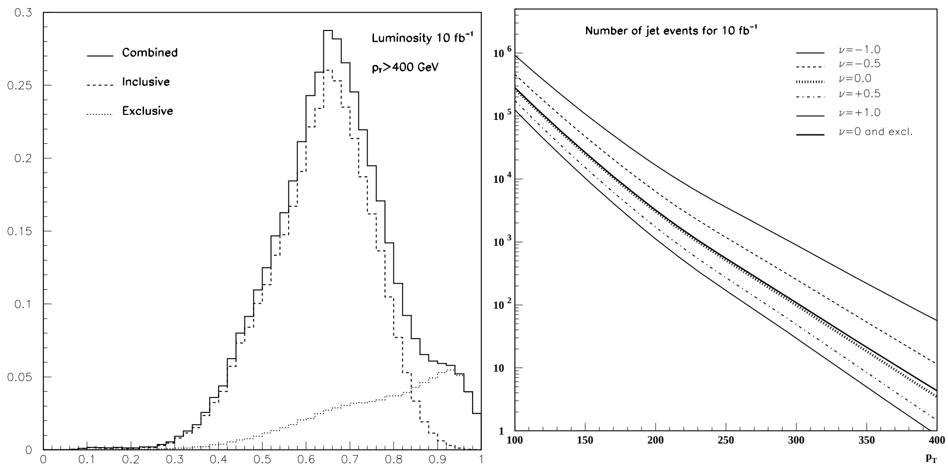

Fig. 3. Left: Dijet mass fraction at the LHC for jets $p_{\rm T} > 400$ GeV. Inclusive contribution (FM) and exclusive contribution (KMR) are superimposed. The exclusive signal appears at high R_{jj}. Right: Number of jet events as a function of a jet threshold. The gluon uncertainty in the calculation can overshadow the signal due to the exclusive events.

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