Summary of the “Diffraction and Vector Mesons” Working Group

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We summarise the contributions presented in the working group "Diffraction & Vector Mesons" at the XX International Workshop on Deep Inelastic Scattering (http://www.dis2012.uni-bonn.de/).

1 Introduction

In diffractive interactions in hadron-hadron or photon-hadron collisions at least one of the beam particles emerges intact from the collision, having lost only a small fraction of its initial energy, and carrying a small transverse momentum. Therefore no color is exchanged. The signature for such processes is the presence of a large gap in rapidity (large rapidity gap, LRG) between the two hadronic final states due to the absence of color flow. At high energy this is described by the exchange of an object with the quantum numbers of the vacuum, referred to as the pomeron in the framework of Regge phenomenology [1]. Many aspects of diffraction are well understood in QCD when a hard scale is present, which allows one to use perturbative techniques and thus to formulate the dynamics in terms of quarks and gluons.

Diffractive reactions have been extensively studied at HERA and at the Tevatron and are being studied at RHIC, JLAB and LHC. Updates on the available experimental data and on their theoretical interpretation were given at this workshop. In the present summary we focus on the path from HERA to the LHC through the Tevatron and RHIC.

At HERA events of the type $ep \to eXp$, in which the virtual photon dissociates and the proton remains intact, are termed single diffractive. The final state X can be studied inclusively or requirements can be applied to it (for instance it can be asked to contain at least a dijet system). Whereas vector meson photo (elettro)-production, $ep \to eVp$, occurs when the (virtual) photon produces a vector meson. Similarly, proton (antiproton)-proton single diffractive collisions, $pp \to Xp$ ($p\bar{p} \to X\bar{p}$), can be studied inclusively or semi-inclusively. A further type of events, $pp \to pXp$, termed central exclusive, occurs when the system X is centrally produced with both hadrons intact outgoing. Though central exclusive production (CEP) is not always associated to pomeron exchange, it was discussed in our working group.

Diffractive reactions have become a valuable tool for investigating the low-x structure of the proton and the behaviour of QCD in the high density regime. Many efforts in this direction, both experimental and theoretical, were presented in our working group. Standard (fixed order or DGLAP) approaches, which work very well in most of the perturbative regime so far explored, are expected to fail in the high-energy regime of QCD ($s \gg E_J^2, Q^2$, corresponding to large jet rapidities and small-x) due to large $\log(s/E_J^2)$ to all perturbative orders, which most probably need to be resummed. Up to now, no clear evidence of high-energy QCD dynamics has been found.

2 From HERA to hadron colliders

2.1 HERA diffractive structure function and PDFs

In the diffractive reaction $ep \to eXp$ at HERA, a photon of virtuality Q^2 dissociates interacting with the proton and produces the hadronic system X. The fraction of the proton momentum carried by the exchanged object is denoted by $x_{\mathbb{P}}$, while the fraction of the momentum of the exchanged object carried by the struck quark is denoted by β. As in the inclusive deep inelastic scattering (DIS) case, the cross section for diffractive DIS can be expressed in terms of a linear combination of structure functions, F_2^D and F_L^D. While F_2^D describes the total photon-proton process, F_L^D is only sensitive to the longitudinally polarised photon contribution. As for its inclusive counterpart, F_L^D is thus zero in the quark-parton model, but may acquire a non-zero value in QCD.

At this workshop a key step towards the completion of the measurements of the diffractive structure function F_2^D by the HERA experiments was achieved: H1 presented their final analysis with the LRG tecnique [2]. New measurements covering data taking periods 1999-2000 and 2004-2007 were combined with previously published results in order to provide a single set of diffractive cross sections. The latter are shown in Fig. 1 as a function of Q^2 for fixed values of $x_{\mathbb{P}}$ and β and compared to the ZEUS measurements and to theoretical predictions. H1 also presented the first direct measurement of F_L^D [3], shown in Fig. 1 where data points from different Q^2 and $x_{\mathbb{P}}$ values are plotted as a function of β and compared with the H1 2006 Fit B prediction (in order to remove the significant dependence on $x_{\mathbb{P}}$, the F_L^D points have been divided by the flux factor $f_{\mathbb{P}/p}$ taken from [4]). The final structure function measurements based on the proton tagged data were already published by H1 last year [5]. ZEUS published their final measurements, based on the data until the year 2000 [6].[1] With the exception of the H1 data taken with the Very Forward Proton Spectrometer (VFPS) [7], which are still under analysis, the H1 and ZEUS heritage on inclusive diffraction is settled. The next step is to combine the data and to come up with a HERA diffractive structure function. A first attempt has been taken by combining the H1 and ZEUS measurements based on the proton tagged samples [8]. Correlations of systematic uncertainties are taken into account by the combination method, leading to significantly improved precision. Figure 2 shows the combined cross section as a function of Q^2 at $x_{\mathbb{P}} = 0.05$, for different values of β in comparison with the individual measurements used for the combination. The reduction of the total uncertainty of the HERA measurement compared to the input cross sections is visible.

Measurements of particles produced at small angles to the proton beam at HERA are important for understanding the proton fragmentation and for model tuning, not only deep-inelastic scattering models but also those on the hadronic interactions of cosmic rays. H1 presented the first measurement of forward photon production in DIS [9]. All models used

[1] The forward instrumentation of the ZEUS detector was dismantled in the year 2000 before the luminosity upgrade of the HERA machine.

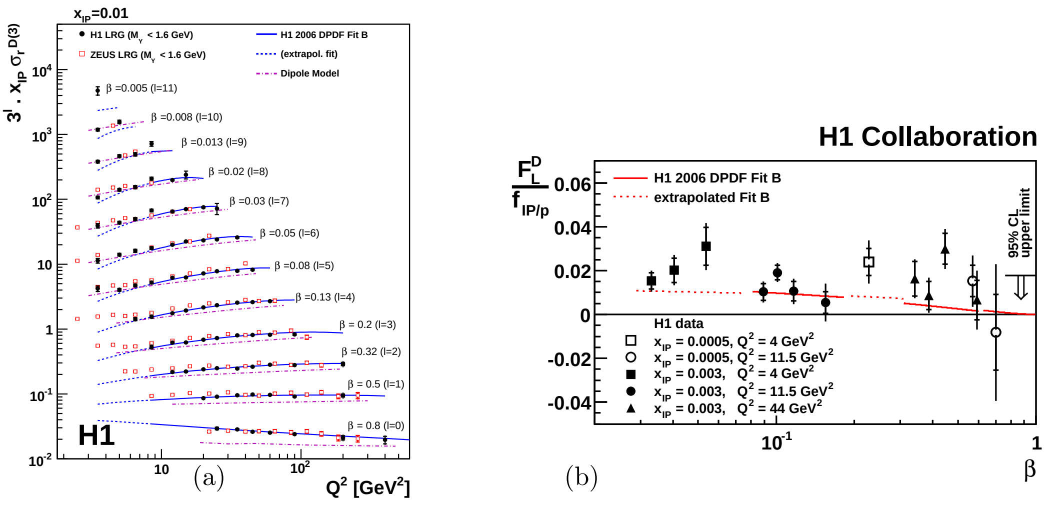

Figure 1: (a) H1 final results on the diffractive cross section measured with the LRG method (dots) compared to the ZEUS measurements (squares) and to theoretical models; (b) H1 results on the diffractive structure function F_L^D compared to the H1 2006 Fit B prediction.

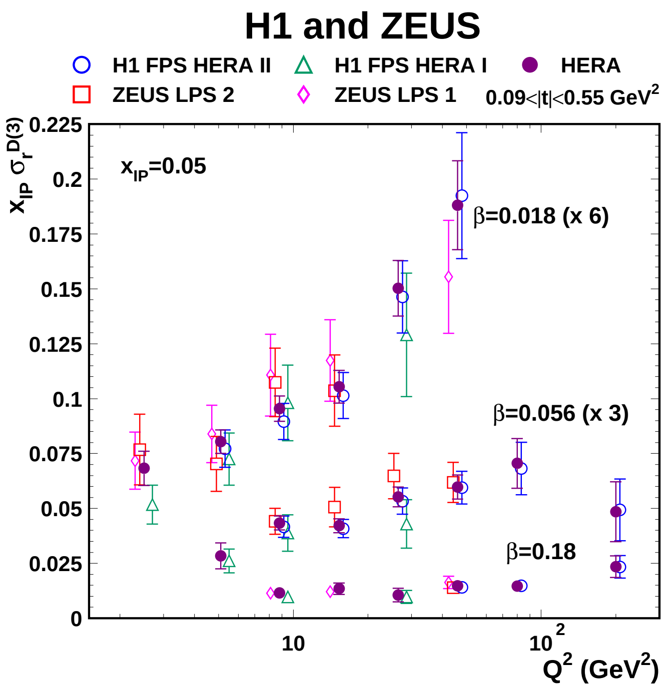

Figure 2: The diffractive cross section resulting from the combination of the H1 and ZEUS measurements as a function of Q^2 at $x_{\mathbb{P}} = 0.05$, for different values of β in comparison with the individual measurements used for the combination.

predict higher yield of photons than the data.

The HERA inclusive diffractive data were fitted repeatedly within the HERA experiments and by outside communities [10]. The new fit by S. Taheri et al. [11] is based on all the available HERA data (excluding the newest H1 results) and compared to all available HERA data, including those on F_L^D. As most of the fits on the market, it is based on the validity of a collinear factorization theorem in diffractive processes [12], which allows F_2^D to be written as a convolution of the usual partonic cross sections with diffractive parton distribution functions (DPDFs). The DPDFs, parametrised at a starting scale, are evolved according to the DGLAP equations [13] and fitted to the data. Ideally one would evolve in Q^2 for fixed values of $x_{\mathbb{P}}$ and of the four-momentum transfer t, or at least for fixed $x_{\mathbb{P}}$ if t is integrated over, but the rather limited statistics of the data makes this not trivial in most cases. Therefore an alternative approach often used is the assumption, known as "Regge factorization" hypothesis, that F_2^D can be expressed as the product of a flux, depending only on $x_{\mathbb{P}}$ and t, and the structure function of a particle-like object. Whether the data support this assumption or not is a controversial problem. In the new analysis by F. Ceccopieri [14] fit results are obtained either at fixed $x_{\mathbb{P}}$ or parameterizing the parton densities at the intial scale as a function of $x_{\mathbb{P}}$. Such approach can be extended to treat the t dependence of the cross section and will soon be tested on the final H1 data. DGLAP fits to the diffractive data deviate from the data with decreasing Q^2 below Q^2 of 5 GeV^2. These deviations have been shown by M. Sadzikowski [15] and L. Motyka [16] to be consistent with higher twist terms extracted from the saturation model (see Fig. 3). This is a first direct evidence of higher twist effects in DIS.

2.2 Factorisation tests

According to the factorization theorem, calculations based on DPDFs extracted from inclusive measurements should allow to predict cross sections for other diffractive processes. This was repeatedly proven with the HERA data on semi-inclusive final states [17]. In a recent H1 analysis [18], diffractive dijet data selected tagging the scattered proton are well described by the DPDF fits 'H1 Fit B 2006' and 'H1 Fit Jets 2007'. The factorization theorem does not hold in the case of diffractive hadron-hadron scattering [12]: indeed it has been known for years that the DPDFs extracted from the HERA data overestimate the rate of diffractive dijets at the Tevatron by one order of magnitude [19]. It was shown in [20] that this breakdown of factorization can be explained by screening effects. Because of the screening, the probability of rapidity gaps in high energy interactions to survive decreases since they may be populated by rescattering processes. The screening corrections are accounted for by the introduction of a suppression factor, which is often called the *survival probability of rapidity gaps*.

The question arises whether the breakdown of factorisation affects the distribution of the four-momentum transfer t at the proton vertex. Recent CDF data [21] show no Q^2 dependence of the exponential slope of the t-distribution from inclusive to dijet events with Q^2 up to 10000 GeV^2.

The HERA/Tevatron results are being extended by CMS [22] by studying diffractive events associated with high-p_T jets or W/Z bosons, which set the hard scale. Comparing the measured cross sections to Monte Carlo (MC) predictions based on the HERA DPDFs provides an estimate of the survival probability. The theoretical description of vector boson hadroproduction (H_A + $H_B \to B + X$, with X = W, Z, γ,...) can be improved by resumming the soft gluon emission terms into an additional factor $S(b, Q^2)$ which is universal. Such non-perturbative form factor is modified by corrections due to the intrinsic transverse momenta of partons. This is usually

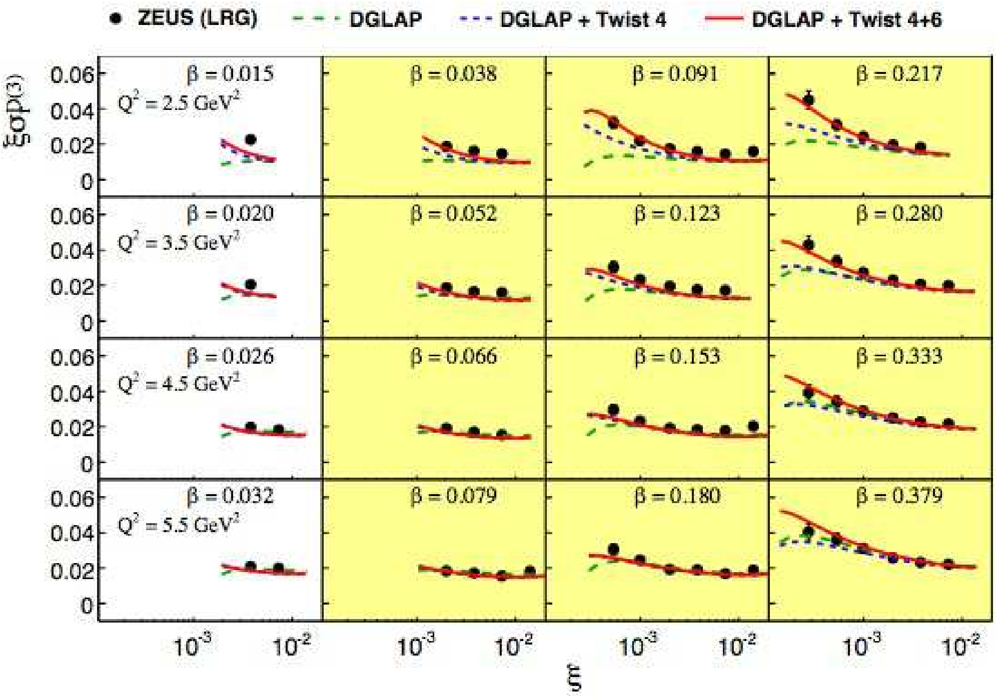

Figure 3: ZEUS diffractive cross section data compared to DGLAP predictions without and with twist 4 and 6 effects from ths saturation model.

taken into account by supplying S with yet another factor parameterised as $\exp(-gb^2)$ where $g = g_1 + g_2 \log(Q/2Q_0)$. K. Tanaka presented a first systematic determination of g_1 and g_2 by a global fit to experimental data [23].

2.3 Exclusive production

2.3.1 Vector meson production in DIS

The cross section for Υ photo-production at HERA, $\gamma p \to \Upsilon(1S)p$, was measured by ZEUS by collecting all data from 1996 to 2007 [24]. The exponential slope b ($\mathrm{d}\sigma/\mathrm{d}t \sim \exp(-b|t|)$) was measured for the first time in Υ production. For large values of the scale $Q^2 + M^2_{\mathrm{VM}}$ (around 90 GeV^2 in this case) b is related to the transverse size R_{T} of the interaction region, or, in other words, to the radius of gluons in the proton: $b \simeq R^2_{\mathrm{T}}/2$. The value $b = 4.3^{+2.0+0.5}_{-1.3-0.6}$ GeV^{-2} was found, in good agreement with the extrapolation of existing data at lower values of $Q^2 + M^2_{\mathrm{VM}} \lesssim 40$ GeV^2.

ZEUS also reported results on the exclusive production of di-pions [25]. This measurement allows the study of radially excited 2S states and orbitally excited 2D states of the ρ meson, through the reactions $\rho'(1450) \to \pi\pi$ and $\rho''(1700) \to \pi\pi$ respectively. The large statistics makes it possible to discriminate the small peaks of the ρ' and ρ''. Apart from the mass of the

ρ', the ensuing values of masses and widths of the excited states agree well with the Particle Data Group values, and in some cases are even more precise.

The theoretical description of vector meson production is often made in the framework of the colour dipole model, where the differential cross section is given by the convolution of 3 factors: the virtual photon $\psi^{(\gamma^*)}(z,r;Q^2)$ and vector meson $\psi^{(V)}(z,r)$ wave functions, and the colour dipole cross section $N(x,r)$. The last is a non-perturbative, universal object well constrained by F_2 HERA data, and its particular functional form/parameterisation correspond to different models. The photon wave function $\psi^{(\gamma^*)}$ can be computed in QED, including QCD corrections. On the contrary, the vector meson wave function can be only parameterised in terms of a form factor, whose computation is beyond the domain of perturbative QCD.

The key observation is that such form factor formally satisfies the equation of a string living in a 5-dimensional Anti-de-Sitter space, where the would-be fifth dimensional coordinate ζ is given by a particular combination of kinematic variables: $\zeta = \sqrt{z(1-z)}r$. By solving the string equation, R. Sandapen [26] showed that the Regge-like mass spectrum of the ρ-meson, $M^2 = 4\kappa^2(n + L + S/2)$, is correctly reproduced for $\kappa = 0.55$ GeV. He found the analytic expression of the meson wave function which has no free parameters to be adjusted, and used it to describe the HERA data, by adopting the Colour-Glass-Condensate model for the dipole cross section. At low Q^2, where this approach is expected to be valid, the description is quite good, whereas at large Q^2 the cross section is underestimated.

Another method for deriving the dipole cross sections from first principles and taking into account the dependence on the impact parameter b was presented by J. Berger [27]. It is based on the evolution of the the Balitski-Kovchegov equation from a b dependent initial condition of Glauber-Mueller type. In this initial condition the skewed gluon density is used. In order to reproduce the HERA data, an additional correction to the photon wave function at low Q^2 is required, which is however universal for all mesons and processes. The data description is good for J/ψ and ϕ production, less good for ρ cross section. Quite remarkably, the main features of the inclusive F_2 measurements are also reproduced.

Diffractive neutrino-production of pions from the Minerva facility at Fermilab were presented by M. Siddikov [28]. The scattering $\nu\ T \to \mu\ \pi^+\ T$ is observed on both protonic and nuclear (C, Fe, Pb) targets T. A description of the data is then attempted by exploiting the colour dipole model, with the PCAC property to constrain the diffraction amplitude of chiral mesons. A fair description of the total cross section on protons is found for neutrino energies larger than 20 GeV, while below such values the colour dipole model fails since it does not take into account the contribution of resonances. The description on nuclear targets is made by means of a toy model based on the Gribov-Glauber approach for nuclei where only π and a_1 are present and where the Adler relation is assumed to be valid for nucleons at $Q^2 = 0$. The main result is that the Adler relation is broken on nuclei for neutrino energies larger than 10 GeV due to absorptive (shadowing) corrections.

2.3.2 Tevatron and LHC

One of the major challenges of CDF run II has been the measurement of exclusive production processes. After the study of the exclusive production of dijets, dileptons, Z, J/ψ and χ_c [29], recently CDF observed the exclusive production of two photons [30]. Whereas the lepton pairs and Z are purely QED processes, the J/ψ is produced by photo-production, mediated by photon-pomeron exchange. The exclusive dijet system, the charmonium and the diphotons are produced by double pomeron exchange via quark-loop.

Similar to the latter production mechanism, with a heavy quark loop and no other particles produced, the process termed central exclusive production (CEP) has become very attractive in the latest years looking towards the possibility of measuring an exclusive Higgs at the LHC; beyond the Higgs, the main advantage comes from the fact that any observed resonance exclusively produced in such a way must be dominantly in a spin 0, CP even state, therefore allowing a clean determination of its quantum numbers. Previous analysis are being updated taking into account the recent exclusion bounds from the LHC. Notably, M. Tasevsky [31] showed the latest updates of a study of the MSSM Higgs. At high luminosity, when the pileup events will fill the rapidity gap and make the rapidity gap requirement fail, to tag the CEP Higgs or any other central system exclusively produced forward proton detectors will be needed, the proposed installation of which at ATLAS is at the stage of LOI. CMS has a similar project at the stage of a proposal for the upcoming upgrades of the LHC. Forward proton detectors would open possibilities of searches beyond the Higgs. Studies of two photon exclusive production of Z (E. Chapon [32]) and W (E. Chapon, A. Szczurek [33]) pairs give the sensitivity to trilinear and quartic anomalous coupling between the photon and the W/Z bosons. Tagging the protons in the final state will allow to improve the reach on anomalous couplings by four orders of magnitude.

Exclusive production is already being investigated at the LHC at $\sqrt(s) = 7$ TeV. The LHCb experiment reported studies of exclusive dimuon production [34]. The production mechanism is either two photon fusion or resonance decay. Exclusive J/ψ, ψ‘ and χ_c states were observed. Two photon exclusive production of muon pairs provides an excellent tool for luminosity calibration. A similar analysis on exclusive dilepton production was presented by the CMS experiment [35]: in both the electron and muon channels the cross section was measured and compared to QED predictions. CMS is also searching for exclusive diphoton production, for which an upper limit on the cross section was set.

2.3.3 Nucleon-nucleon reactions

V. Lyuboshitz [36] showed how to parameterise the rate of the reaction $n + p \rightarrow p + n$ in terms of isospin operators and unknown scalar coefficients $c_i : i = 1, 2, 3$. By means of a series of steps involving crossing invariance, isospin covariance and the optical theorem, he found a relation for the phase of the coefficient c_1 (in front of the identity operator) in terms of the measurable cross sections $\mathrm{d}\sigma_{dp\rightarrow(pp)n}/\mathrm{d}t$, $\mathrm{d}\sigma_{np\rightarrow pn}/\mathrm{d}t$, σ_{pp} and σ_{np}. Unfortunately, at present there are no reliable experimental data for the first (deuteron dissociation) cross section, and a quantitative estimate of c_1 is not possible yet.

3 High-energy/small-x QCD

3.1 Theory

We know that the growth of the gluon density predicted by the linear DGLAP and BFKL evolution cannot go on without bounds, because saturation effects set in at high parton densities as required by unitarity. However, the kinematical region where such effects become important depends on the details of the models adopted to describe the parton evolution. D. Zaslavski presented a study of saturation where the BFKL evolution at next-to-leading logarithmic (NLL) accuracy is improved by the DGLAP resummation [37]. The regularization of the infrared has been implemented by an absorptive boundary, which means that if the gluon density reaches a given threshold at some scale of momenta, it is set to zero for momenta lower than that scale. The outcome of the numerical evolution is that the resummation of collinear contributions and also the NLL BFKL corrections are necessary to avoid unstable behaviours (oscillations, negativity) of the gluon density. Furthermore, one observes a sizeable delay of the saturation scale $Q_s(Y)$, in the sense that it starts growing for rather large values of rapidity $Y \simeq 5$. This may have an important phenomenological impact for the onset of saturation effects.

Small-x physics can be studied also with MC techniques. Usually, the small-x information is included as a correction to standard collinear fragmentation, but it is possible to set up event generators based on the BFKL framework which directly adresses small-x processes. This is the case for the Monte Carlo proposed by C. Salas [38]. It is based on the non-forward BFKL kernel which is expected to govern the small-x evolution of diffractive events. Her implementation is very interesting, in fact it takes into account some new features like the bootstrap condition on the gluon trajectory and an analytic model for the running coupling devised by Webber, which is compatible with power-corrections. The code at leading logarithmic (LL) level is ready and shows good convergence and stability. A first study on the average number of gluons emitted versus rapidity has been done. Compared with the forward LL BFKL case, she observes less gluon emissions.

Another physical ingredient that can be included in MCs is QCD color coherence, namely the angular dependence of parton emissions on the colour charge of the emitter. In order to assess the importance of coherence effects in small-x physics, M. Deak [39] has compared two MCs: the first, devised by Webber, is based on the CCFM equation and includes coherence effects; the second, written by Sabio-Vera and Stephens, does not. The comparison has been done at fixed coupling α_s and in the LL approximation. The speaker studied the tendency of the intermediate partons to diffuse in the IR region when the rapidity distance Y of the two jets is increased at fixed p_{T}, and he found that the CCFM MC diffuses in the IR earlier (at smaller Y) than BFKL. He then showed the Y dependence of the azimuthal angular moments predicted by the two MCs, concluding that BFKL shows more azimuthal decorrelation (less angular dependence) than CCFM.

3.1.1 High-energy factorization in Mueller-Navelet jets

A process which is expected to be a gold-plated observable in revealing high-energy QCD dynamics is the production of Mueller-Navelet (MN) jets, i.e., two hard jets, one very forward and the other very backward, with any kind of radiation outside the jets. This configuration is expected to minimize the collinear partonic evolution of QCD which occurs in emissions of partons with strongly ordered transverse momenta, and to enhance the high-energy dynamics which should happen in the emission of partons with strongly ordered rapidities.

The cross section for Mueller-Navelet jets in the high-energy limit is given by the convolution of partonic PDFs $f(x)$, jet vertices $V(x, \boldsymbol{k})$ and the gluon Green's function (GGF) $G(\hat{s}, \boldsymbol{k}_1, \boldsymbol{k}_2)$. All these factors are known at next-to-leading order (NLO) and next-to-leading logarithmic (NLL) accuracy, but the actual calculation is not straightforward due to the large number of (numerical) integrations that have to be performed in the convolution and also within the jet vertices themselves.

A key observation is that the 4 integrations in $(\boldsymbol{k}_1, \boldsymbol{k}_2)$ can be reduced to one if one projects the GGF and the vertices onto the LL BFKL eigenfunctions, i.e., if one takes Mellin momenta of $|\boldsymbol{k}| \to \nu$ and computes angular Fourier momenta with respect to the relative azimuthal angle of the two jets $\phi_1 - \phi_2 \to n$. In this case we have close analytic expressions for $G_{\nu,n}$.

The computation of the Mellin transform for the vertices $V_{\nu,n}$ was done numerically [40] for the exact NLO jet vertex, however it is very time consuming.

A. Papa [41] showed that it is possible to have a compact analytic expression for the NLO jet vertex in the limit of small jet radius $R \to 0$. He provided explicit and rather compact expressions for both the quark and gluon initiated vertices, by showing that all IR singularities cancel and that the jet radius has a logarithmic dependence on R like $V_{\nu,n} = A_{\nu,n} \ln R + B_{\nu,n} + \mathcal{O}(R^{-2})$. He claims that his results can be used for fast and hopefully reliable phenomenological analysis of MN jets, since the small-cone approximation is very good up to $R \simeq 0.7$ (at least for $s \sim E_J^2$).

A more theoretical analysis has been presented by J.D. Madrigal [42] who computed the MN jet cross-section in the $N = 4$ supersymmetric Yang-Mills theory (SYM). The motivation for such a study relies in the fact that SYM is a supersymmetric version of QCD which is also conformally invariant ($\beta(\alpha) = 0$) and therefore it is expected to be solvable in the planar limit. Furthermore, it provides many informations on the analytic structure of QCD and gauge theories in general, and it coincides with QCD at tree level and in LL approximation. Thus, the hope is that we might learn something about the relations between QCD and SYM also from comparing observable quantities.

The choice of the renormalization scheme and scale is a crucial aspect. By adopting for QCD the MOM scheme and fixing the scale with the BLM procedure which absorbs the β_0 coefficients in the perturbative expansions to all orders, QCD shows a quasi-conformal behaviour. For instance, the hard pomeron exponent turns out to have a very flat dependence on the hard scale provided by the (almost) equal jet energies, but the agreement is only qualitative, the absolute values being quite different: arount 0.18 for QCD and twice as much for SYM. Closer agreement has been found in the ratio of angular moments $C_m/C_n \equiv \langle cos(m\phi)\rangle/\langle cos(n\phi)\rangle$ where ϕ is the azimuthal angle between the two jets. In this case, normalization effects almost cancel and if one restricts $m, n > 0$ then the instabilites of the BFKL series for $n = 0$ are absent, and one finds a rather good agreement between QCD and SYM estimates. The ensuing suggestion of the speaker is that such ratios should be good observables for detecting high-energy dynamics in QCD.

In the direction of developing analytical techniques for the computation of higher-order corrections to the factors entering high-energy factorization formulas, J. Madrigal [42] and M. Hentschinski [43] have computed the two-loop correction to the gluon trajectory and the one-loop corrections to the partonic impact factors, respectively, by using the Lipatov's effective action for high-energy QCD. This effective action possesses an unconventional feature, because it has additional degrees of freedom besides the fundamental fields of QCD. This is required for a correct treatment of NLL effects. Furthermore, in order to avoid overcounting of perturbative contributions, one has to perform proper subtractions. Both speakers have shown how to set up the subtraction procedure in the cases under study, reproducing eventually the known results obtained within standard BFKL resummation in perturbation theory. The method of the effective action seems promising for computing higher-order corrections or even new quantities relevant for high-energy QCD.

3.2 Experiments

Measurements of hadronic final states are a rich testing ground for QCD dynamics at small x. Recent results come from HERA, RHIC and LHC.

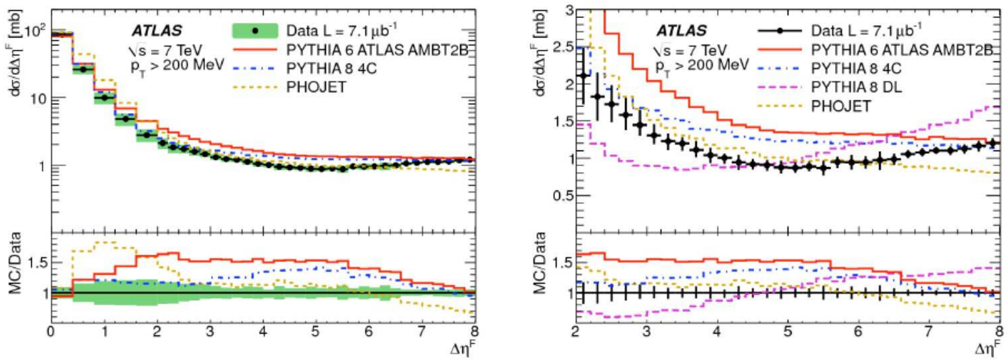

Figure 4: Cross section measured by ATLAS on a sample of inclusive minimum bias data applying the rapidity gap requirement in comparison with MC models.

- H1 data [44] on azimuthal correlations between the forward jet and the scattered positron were compared to predictions of generators based on different evolution approaches as well as to next-to-leading order calculations; cross sections are best described by a BFKL-like model; the DGLAP based RAPGAP model is substantially below the data; the CCFM-based CASCADE provides a reasonable description of the data but shows sizeable sensitivity to the unintegrated gluon density; NLO DGLAP predictions are in general below the data, but still in agreement with the large theoretical uncertainty.

- PHENIX measurements [45] on forward dihadron correlation in d-Au collisions confirm a suppression effect in comparison to the yield in proton-proton collisions depending strongly on the impact parameter (the more central the collision, the more suppressed the yield) and on the rapidity of the two hadrons (the more forward the particles, the stronger the suppression). This is a possible manifestation of saturation-like effects already observed in the BRAHMS data [46].

- ATLAS presented results [47] based on rapidity gap measurements on a sample of inclusive minimun bias data. The cross section is studied as a function of the largest distance from the edge of the detector to the first calorimeter track with p_{T} larger than a given threshold. It turns out that increasing the p_{T} cut produces larger rapidity gaps. Data have been compared to different MC models, none of which adresses all the aspects of the data (see Fig. 4). A further study consisted in fitting large rapidity gap data by using the Donnachie-Landshoff model implementation in PYTHIA 8. The result obtained for the pomeron intercept, $\alpha_P(0) = 1.059 \pm 0.003 \pm 0.035$, is consistent with the DIS value.

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