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Combined measurement of the inclusive diffractive cross section at HERA

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Summary. — A combination is presented of the inclusive diffractive cross sections measured by the H1 and ZEUS Collaborations at HERA. The analysis concentrates on deep inelastic scattering data selected with the Large Rapidity Gap technique. The data span three orders of magnitude in negative four-momentum transfer squared, Q^2. Correlations of systematic uncertainties are taken into account by the combination method, resulting in improved precision.

PACS 13.60.Hb – Total and inclusive cross sections (including deep-inelastic processes).

1. – Introduction

Diffractive processes have been studied extensively in deep-inelastic ep scattering (DIS) at the HERA collider [1-3]. Such interactions, $ep \to eXp$, are characterised by the presence of a leading proton in the final state carrying most of the initial energy and by the presence of a large gap in rapidity between the proton and the rest of the hadronic system. The kinematic variables used to describe diffractive DIS are the four-momentum squared of the exchanged boson([1]), Q^2, the longitudinal momentum fraction of the proton carried by the diffractive exchange, $x_{I\!P}$, and the longitudinal momentum fraction of the struck parton with respect to the diffractive exchange, β. The latter two are related to the Bjorken scaling variable, x, by $x = x_{I\!P}\beta$.

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([1]) For the kinematic coverage of the data discussed in this analysis, only virtual photon exchange is relevant.

Combining the H1 and ZEUS diffractive data can provide the most accurate measurement of DIS diffractive cross sections, over a wide kinematic range. The analysis reported here follows previous attempts to combine HERA diffractive results [4, 5]. The final goal is to release a unique set of HERA inclusive diffractive cross sections to be used as input for a QCD analysis to extract HERA diffractive parton densities.

2. – Combination of the H1 and ZEUS diffractive cross sections

The data used for the combination consist of the H1 [1] and ZEUS [2] diffractive cross section measurements, based on the requirement of a Large Rapidity Gap (LRG). H1 results are based on data collected in the year 1997 corresponding to an integrated luminosity of $12.6\,\text{pb}^{-1}$. For the high-Q^2 region ($Q^2 > 133\,\text{GeV}^2$) $61.6\,\text{pb}^{-1}$ of data collected in 1999 and 2000 were used. The ZEUS data were collected in the years 1999 and 2000, and correspond to a luminosity of $62.4\,\text{pb}^{-1}$. The kinematic range of the combined data is $2.5 \le Q^2 \le 1600\,\text{GeV}^2$, $0.0017 \le \beta \le 0.8$ and $0.0003 \le x_{I\!P} \le 0.03$.

The ZEUS data are extracted at the H1 β and $x_{I\!P}$values, but at different Q^2 values. To account for the different Q^2 binning choices the H1 data points are swum to the ZEUS Q^2 values by applying small correction factors calculated using the "H1 Fit B" parametrization [1].

The LRG-based analyses are affected by backgroud due to events in which the proton dissociates into a low mass state N, which escapes undetected into the beam pipe. This background affects the global normalization of the measured cross sections without any dependence on the kinematics [1, 2]. The coverage in mass of the proton dissociative system N, M_N, of the H1 and ZEUS data is different. A global factor of 0.91 ± 0.07 [2] is applied to the ZEUS data, to correct to the H1 M_N range, $M_N < 1.6\,\text{GeV}$. After such correction a 13% normalization discrepancy remains between the ZEUS and H1 data, with the ZEUS data higher [2]. A further 0.87 factor is applied to ZEUS points, therefore fixing the normalization to that of the H1 measurement.

The data are combined with the same procedure already used for previous HERA combined results [6]. The method is based on χ^2 minimization and takes into full accout the correlated systematic uncertainties. Since both cross section sets, from H1 and ZEUS, are supposed to represent a common truth, forcing them to agree provides a cross calibration of the measurements and allows a significant reduction of the systematic uncertainty.

3. – Results

In the minimization procedure 494 individual measurements are averaged to 341 unique points. The fit reveals some inconsistency between the data sets ($\chi^2/n_{dof} = 366/153$). To improve the quality of the combination a region where the disagreement between the H1 and ZEUS measurements is bigger is identified and excluded. A cut on the mass of the hadronic final state X, M_X, is applied to reject the region where the reconstruction of the kinematic variables might be affected by the contribution of detector noise and where vector meson production dominates. Only measured points with $M_X > 4\,\text{GeV}$ are hereafter included in the combination(2). After such selection the

(2) Since $\beta = Q^2/(M_X^2 + Q^2)$, cutting on the M_X variable corresponds implicitly to cutting on Q^2 and β.

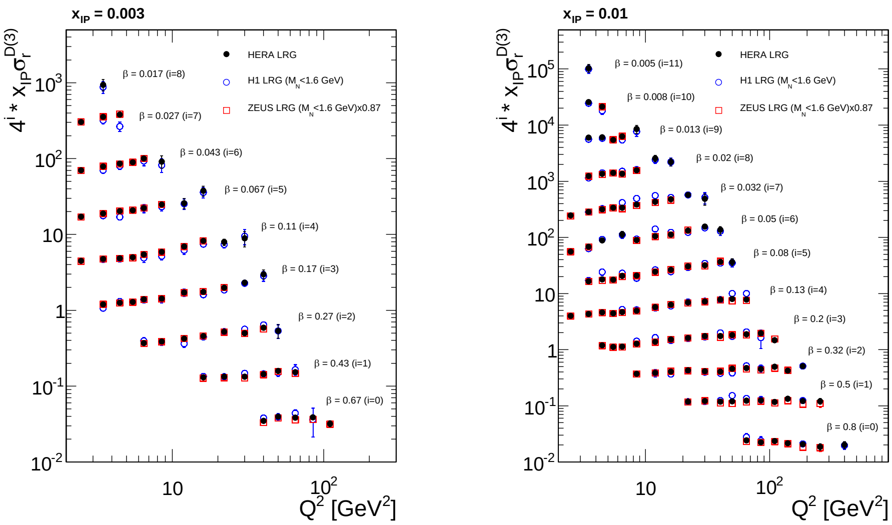

Fig. 1. – The β and Q^2 dependences ot the HERA combined diffractive reduced cross section, multiplied by $x_{I\!P}$, at $x_{I\!P} = 0.003$ (left) and $x_{I\!P} = 0.01$ (right), compared to the H1 and ZEUS measurements.

combined points are 268 and the consistency between the two experiments is improved ($\chi^2/n_{dof} = 146/113$). In addition, no strong evidence of tensions depending on the kinematics is observed in the pull distributions. There are in total 14 sources of correlated systematic uncertainties. All systematic errors shift by less than 1σ of the nominal value in the averaging procedure, with the exception of the H1 electromagnetic energy scale that shifts by 1.8σ. Several correlated systematic uncertainties are reduced significantly; notably, the contribution of the H1 calorimeter noise is reduced by more than a factor of 2.

In fig. 1 the combined data([3]) are compared to the input H1 and ZEUS data. The combination is driven by the ZEUS results because of the higher statistics. The combined measurement shows an average 17% improvement in accuracy and precision with respect to the ZEUS measurements. Furthermore, the averaging procedure allows a gain of 9% in accuracy compared to a simple weighted average thanks to the reduction of several systematic uncertainties.

4. – Conclusions

The H1 and ZEUS diffractive cross sections based on the LRG method are combined for the first time with a procedure taking into accout the correlated systematic error sources. The procedure leads to a significant reduction of the systematic uncertainty.

([3]) The authors take full responsibility for this combined data set; it is not an official H1/ZEUS result.

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