CHARM AND THE VIRTUAL PHOTON AT HERA

B. J. WEST (ON BEHALF OF THE ZEUS COLLABORATION)
Department of Physics and Astronomy, University College London,
Gower Street, London, WC1E 6BT, UK

The dependence of the virtual-photon structure on its virtuality, Q^2, has been studied for the first time in events containing dijets and a charm particle. The ratio of dijet cross sections at low $x_\gamma^{\rm obs}$ relative to high $x_\gamma^{\rm obs}$ as a function of Q^2 is presented and compared to the predictions of LO pQCD. The ratio does not change significantly with Q^2, in marked contrast to previous measurements which did not require the presence of a charm particle.

1 Introduction

The partonic structure of real photons is well established from studies of $\gamma\gamma$ processes at LEP and jet photoproduction studies at HERA. In leading-order perturbative QCD (LO pQCD) two components contribute to jet photoproduction processes at HERA: direct photon processes where the entire momentum of the photon takes part in the hard subprocess; and resolved photon processes where the photon acts as a source of partons, and one of these, carrying a fraction of the photon's momentum, enters the hard subprocess. It is expected that as the photon virtuality, Q^2, becomes non-zero these resolved processes will be suppressed relative to the direct processes. In particular, pQCD predicts that for $(E_T^{jet})^2 >> Q^2$, the virtual photon parton distribution functions (PDFs) that parameterise the structure should decrease logarithmically as Q^2 grows, until $Q^2 \approx (E_T^{jet})^2$, at which point only the direct contribution should remain. Studies of dijet production from virtual photons at HERA support these predictions and are discussed elsewhere in these proceedings[1].

It has also been shown that requiring the presence of charm in the final state of jet photoproduction processes suppresses the partonic structure of the real photon[2]. The question of whether these two phenomena - suppression in the presence of a non-zero virtuality and suppression in the presence of charm - share a common physical mechanism, is a natural and important one to ask for the understanding of heavy flavour production in a hadronic environment. It is this question that has been studied by the ZEUS collaboration[3], and is addressed in this contribution.

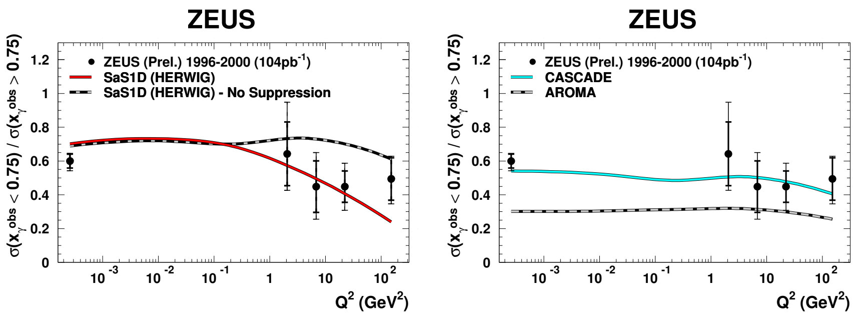

Figure 1. Ratio of low to high $x_\gamma^{\rm obs}$ for events with a D^* compared to the predictions of the SaS1D photon structure function (upper) and the AROMA and CACSADE MCs (lower).

2 Event selection

The data presented correspond to an integrated luminosity of 104 pb^{-1} collected with the ZEUS detector at HERA. The ratio of the low and high $x_\gamma^{\rm obs}$ dijet cross sections has been measured in the restricted kinematic region:

- $0.2 < y < 0.65$;
- $Q^2 < 1.0$, $1.0 < Q^2 < 4.5$, $4.5 < Q^2 < 10.5$, $10.5 < Q^2 < 49.0$ and $49.0 < Q^2 < 5000.0$ GeV^2;
- $E_T^{jet1,2} > 7.5,\ 6.5$ GeV; $|\eta^{jet}| < 2.4$;
- $p_T(D^{*\pm}) > 3.0$ GeV; $|\eta(D^{*\pm})| < 1.5$;

where jets were reconstructed using the longitudinally invariant k_T cluster algorithm[4] in the laboratory frame, $D^{*\pm}$ mesons were identified through the $K2\pi$ decay mode using the ΔM method[5] and $x_\gamma^{\rm obs} = \frac{\sum_{2jets}(E_T \cdot e^{-\eta})_{jet}}{2 \cdot y \cdot E_e}$.

3 Comparison to LO pQCD predictions

The cross section ratio $R = \sigma(x_\gamma^{\rm obs} < 0.75)/\sigma(x_\gamma^{\rm obs} \geq 0.75)$ as a function of Q^2 is compared to several LO pQCD predictions in Figure 1. Within the errors, the cross section ratio is consistent with being constant as a function of Q^2. The left plot shows two predictions from the HERWIG[6] Monte Carlo generator using the SaS1D[7] virtual photon structure function with and without

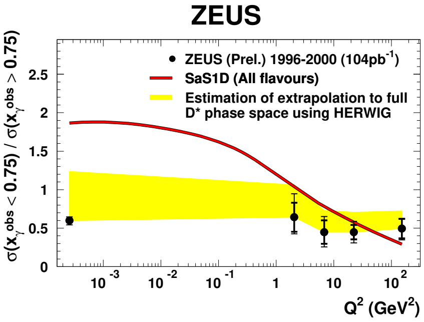

Figure 2. Ratio of low to high $x_\gamma^{\rm obs}$ for events with a D^* compared to the predictions of the SaS1D photon structure function for the ratio without a D^* tag.

suppression enabled. The prediction without suppression serves as a check that any suppression with Q^2 has a physical origin rather than being due to some kinematic bias. This prediction is constant as a function of Q^2, confirming that no such bias exists. The prediction including suppression shows the expected fall with increasing Q^2 and gives a reasonable description of the data.

In the right plot of Figure 1, the same data are compared to two predictions which implement no specific partonic structure for the photon, generating all low $x_\gamma^{\rm obs}$ events from parton showers in two different schemes. The AROMA[8] model, which implements the DGLAP[9] evolution scheme, lies below the data. The CASCADE[10] model, which implements a version of the CCFM[11] evolution scheme, is much closer to the data.

4 Comparison to ratio without a D^* tag

The fact that the ratio does not change significantly with Q^2 is in marked contrast to the case in which the charm requirement is not made, and suggests that the suppression of the low $x_\gamma^{\rm obs}$ cross section due to charm and the suppression due to photon virtuality are not independent. To quantify this, the ratio is compared to the prediction of the SaS1D virtual photon PDF for the ratio without a $D^{*\pm}$ requirement.

Before comparing this "all flavours" prediction to the measured $D^{*\pm}$ ratio, any bias due to the restricted D^* kinematics must be evaluated. MC studies[3] have shown that $D^{*\pm}$'s from resolved events, which pass all other cuts of section 2, are more likely than those from direct events to fail the $\eta(D^{*\pm})$ and $p_T(D^{*\pm})$ cuts. Thus the $D^{*\pm}$ kinematic cuts are themselves a source of suppression of the resolved contribution. The effect of extrapolating the ratio to the full $D^{*\pm}$ kinematic range has been estimated using the HERWIG MC. The effect of this extrapolation and the comparison to the "all flavours" case is shown in Figure 2 and confirms quantitatively the qualitative conclusion drawn above. The ratio of the low $x_\gamma^{\rm obs}$ cross section to the high $x_\gamma^{\rm obs}$ contribution falls off much slower in the presence of charm than it does when charm is not required.

5 Summary

The ratio of the dijet cross sections for $x_\gamma^{\rm obs} < 0.75$ and $x_\gamma^{\rm obs} \geq 0.75$ as a function of Q^2 for events containing a $D^{*\pm}$ has been presented. In order to describe the ratio using LO pQCD it appears to be necessary either to introduce a virtual photon structure to DGLAP evolution or to use CCFM evolution.

The ratio was found to fall much more slowly in the presence of charm than it does when charm is not required, demonstrating for the first time that the observed suppressions of the low $x_\gamma^{\rm obs}$ cross section due to non-zero photon virtuality and due to charm are not independent.

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