Photon initiated double parton scattering: a new light on the proton structure

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Abstract

In this contribution, we present possible new advantages of observing double parton scattering (DPS) processes initiated by photon-proton interactions. As discussed, in principle, the observation of DPS processes could lead to access fundamental information on double parton distribution functions of the protons. These new quantities, appearing in the DPS cross section, represent a novel and promising tool to access the 3D partonic structure of the proton, complementary to TMDs and GPDs. In fact, dPDFs encode double parton correlations in hadrons which cannot be accessed through, e.g., GPDs. Up to date, however, dPDFs are almost unknown and, in particular, their dependence on the transverse distance of partons. In our analyses [1, 2, 3, 4] we discussed the impact of both perturbative and non perturbative double parton correlations in dPDFs. In addition, our collaboration also investigated how these effects affect an experimental observable called effective cross section, σ_{eff} [5, 6]. However, as proved in Refs. [7, 8] in proton-proton collisions, the information on the partonic proton structure are quite limited due to the lack of information on dPDFs and their relative first moment called effective form factor (eff), the latter entering the definition of σ_{eff}. Let us mention that recently lattice data on the pion moments of dPDFs [9] have been used to extract information on the quark distances in the meson and to test holographic models of the pion structure [10, 11], Furthermore, in this contribution we focus on the possibility to observe DPS in processes initiated by quasireal photons [12]. In such a photoproduction process, the offshellness of the photons is controlled by measuring leptons, proton or ions from the impinging beam scattered at low angle. At such low virtualities, the photon will fluctuate hadronically and/or electromagnetically in a the $q - \bar{q}$ pair which then initiates a double parton scattering on the proton. The key idea is that the photon transverse size could be almost controlled by measuring the virtuality and, in turn, the interaction rate in the DPS mechanism could appreciated offering information on the transverse proton structure. In our analysis we prove that the dependence of $\sigma^{\gamma p}_{eff}$ on the photon virtuality Q^2 could be quasi-directly related to the mean transverse distance between two partons in the proton active in the DPS process. Moreover, different models of the photon and proton effs have been used to calculate, for the first time, $\sigma^{\gamma p}_{eff}(Q^2)$.

These results have been then used to estimate the DPS cross section for the four jets production via DPS in HERA kinematics, since in this channel collaborations reported significant MPI effects on the four jets cross sections, and exposed in their analyses possible contamination of the DPS processes. By estimating the expected number of events at given integrated luminosity we conclude that DPS processes in photoproduction gives a significant fraction of the four jet production cross sections, if cuts on transverse momenta of the jets are low enough. Moreover, also the DPS peculiar dependence on Q^2 could be tested against models of the proton structure, with the possibility to consider even more exotic final state, involving, for example, single or double quarkonia. Finally in Ref. [12] a procedure to extract mean transverse distance between two partons in the proton from $\sigma^{\gamma p}_{eff}(Q^2)$ has been developed.

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