Diffractive and Exclusive production with CMS

Dipanwita Dutta on behalf of CMS Collaboration*
Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA

A significant fraction (≈ 20-30%) of the total inelastic cross section of particle production in hadronic collisions at high energies can be attributted to diffractive interactions, characterized by the presence of at least one large rapidity gap (LRG) in the final state. The LRG, defined as a region in pseudorapidity devoid of particles, is presumed to be formed by a color-singlet exchange carrying quantum numbers of the vacuum, often referred to as Pomeron. Fig. 1 shows the main types of diffractive processes: single dissociation (SD), double dissociation (DD) and central dissociation (CD). When a hard scale is present in the process (e.g. when the final state includes high-pT jets, W or Z bosons, etc.) perturbative QCD (pQCD) is applicable and the dynamics can be formulated in terms of partons. But soft diffractive processes are traditionally modeled phenomenologically by Regge theory and these models suffer from large uncertainties when extrapolated to higher energies. Experimental results at LHC provide important input for tuning various models and event generators [1].

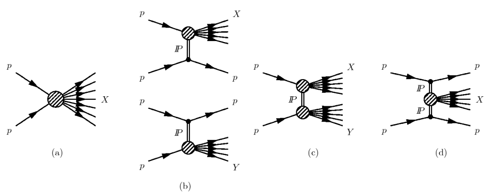

FIG. 1: Schematic diagrams of (a) non-diffractive, $pp \to X$, and diffractive processes with (b) single dissiociation, $pp \to Xp$ or $pp \to pY$, (c) double-dissociation, $pp \to XY$, and (d) central dissociation, $pp \to pXp$. The X(Y) represents a dissociated-proton or a centrally-produced hadronic system.

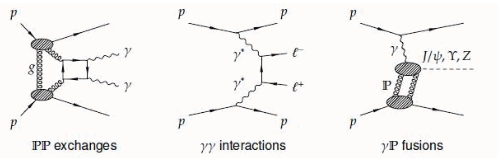

FIG. 2: Schematic diagrams of central exclusive process (CEP) (a) pomeron-pomeron (b) photon-photon (c) photon-pomeron.

Another class of processes with a LRG in the final state is central exclusive process (CEP). The CEP is a process of the type: $pp \to p + X + p$ with X being a well defined system e.g. di-lepton or di-jet. The "+" sign denotes the absence of additional activity between the outgoing protons and X. The final state consists of the scattered protons, that survive the interaction intact, and of the system X or its decay products. In the CEP three distinct processes may be involved, namely photon-photon, photon-pomeron and pomeron-pomeron interactions as shown in Fig. 2. The system X is reconstructed in the central CMS barrel, while forward detectors are used to veto non-exclusive events. Exclusive di-lepton production $\gamma\gamma \to l^+l^-$ is a nearly pure QED process Therefore its cross section is precisely known. Its measurement at the LHC is an independent cross check of the the absolute luminosity calibration [2, 3]. The CEP of di-photons provides information on several ingredients needed for the exclusive Higgs search, that is on the unintegrated gluon distribution g(x1; x2), the Sudakhov form factor (i.e. the probability of no gluon radiation) and on the rapidity gap survival probability S^2 (i.e. the probability of no other parton-parton interactions)[3]. Several processes beyond the Standard model predict an anomalous quartic gauge coupling (AQGC) which can be translated into a higher production

*Electronic address: `dutta.dipa@gmail.com`

rate, or discrepancies in the kinematic distributions of multiple final state particles. LHC experiments have been predicted to be sensitive to such behaviours when involving the two-photon interactions and a search for these anomalous couplings is performed in the CMS experiment with the data collected in 2011 at $\sqrt{s} = 7$ TeV, using the challenging yet previously unobserved two-photon production of $W^{\pm}$ bosons pairs [4], where both the gauge bosons decay leptonically.

The exclusive production of vector mesons, which can be studied in Ultreperipheral collisions (UPC), can be described phenomenologically by photon-pomeron exchange. Large mass vector mesons (J/ψ, Υ), provide a hard scale, a perturbative QCD approach can be employed and production has been successfully modelled in terms of exchange of two gluons with no net colour transfer. Recent results of exclusive photoproduction of J/ψ in UPC PbPb and pPb collisions with ALICE [5] and in pp collisions with LHCb [6], confirmed the expectations that UPCs are a very promising probe to study the gluon distributions in nucleons and in nuclei at small x. Exclusive photoproduction of Upsilon states (1S, 2S, 3S) are measured in their dimuon decay channel on top of the photon-photon decaying to dimuon QED continuum in pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV (for integrated luminosity of $L_{int} = 35$ nb^{-1}) and in pp at $\sqrt{s} = 7$ TeV ($L_{int} = 5.24$ fb^{-1}). The total Υ photoproduction cross sections as well as the t-differential distributions are compared to various theoretical predictions. The impact of these data on the central values and uncertainties of the low-x gluon distribution will be assessed.

References

[1] CMS Collaboration, CMS-PAS-FSQ-12-005.
[2] CMS Collaboration, JHEP **01**, 052 (2012).
[3] CMS Collaboration, JHEP **11**, 080 (2012).
[4] CMS Collaboration, JHEP **07**, 116 (2013).
[5] ALICE Collaboration, Phys. Lett. **B 718**, 1273 (2013); *ibid* arXiv:1406.7819 [nucl-ex].
[6] LHCb Collaboration, J. Phys. G 41, 055002 (2014).