Diffraction & Forward Physics in CMS: results and perspectives

Patricia Rebello Teles¹,a on behalf of the CMS Collaboration
¹ Centro Brasileiro de Pesquisas Físicas – CBPF, Rio de Janeiro-RJ, 22290-180, Brazil

Abstract. In this plenary talk given at ISMD2014 the interesting CMS analyses on diffractive proton-proton cross section and Mueller-Navelet dijet azimuthal decorrelations performed at √s = 7 TeV were presented.

1 The CMS Detector: Central & Forward regions

A detailed description of the CMS detector can be found in Ref. [1]. According Fig. 1, in the central part of the apparatus are located the electromagnetic and hadron calorimeters (ECAL and HCAL, respectively) as well as the forward component of the hadron calorimeter, HF (Hadronic Forward), covering the 2.9 < |η| < 5.2 region. The very forward angles are covered at one end of CMS (the 6.6 < |η| < 5.2 region) by the CASTOR calorimeter. In addition, two elements of the CMS monitoring system, the Beam Scintillator Counters (BSC) and the Beam Pickup Timing eXperiment (BPTX) devices, are used to trigger the CMS readout. In the same figure the joint set of CMS-TOTEM near-beam detectors is shown as well.

2 Diffraction at CMS: the pp diffraction dissociation cross section at √s = 7TeV

The composition of the total pp cross section is

σtot = σEL + σSD + σDD + σCD + σND

where "SD" means Single-Diffractive, "DD" means Double Diffactive, "CD" means Central Diffractive and "ND" means Non-Diffractive, all belonging to the inelastic cross section σINEL.

At LHC the elastic cross section, σEL ≈ 25mb, is about 20% of the σtot [2] and the inelastic, σINEL ≈ 69mb, is responsible for about 80% of σtot [3].

Inside the inelastic part the diffractive processes are characterized by large rapidity gaps (LRG), Δη ≈ ηmax − ηmin where η = (1/2) ln [(E + p⊥)/(E − p⊥)] according to Fig. 2.

Moreover, hadronic interactions with LRG are mediated by Pomeron exchange, based on the trajectory of Regge theory α(1) = 1 + ε + α′t, with t = (p1 − p2)².

Figure 2. Diffractive and non-diffractive processes in pp collisions.

The first CMS analysis presented in this talk [4] has used the PYTHIA8-MBR (Minimum Bias Rockefeller) [5] and PYTHIA8-4C (with diffraction from Schuler & Sjostrand) [6] for comparison, with α′ = 0.25GeV⁻². The data were collected in 2010 using a low pileup scenario which is the most suitable for diffractive event selection using a LRG signature.

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Signal in both BPTX (Beam Pick-up Timing Experiment) detectors and activity in any of the BSC (3.2 < |η| < 4.7) were required for the presence of two bunches along with minimal activity in the central CMS detector (Minimum Bias trigger). In addition, Single Diffractive (SD) and Double Diffractive (DD) events were separated with CASTOR (6.6 < |η| < 5.2).

To accept low to moderate diffractive masses (12 < M_X < 100 GeV), no vertex was required. The diffractive offline selection was based on LRG within |η| < 4.7 (HF was not used, therefore limiting central CMS detector coverage), the proton momentum loss ξ was reconstructed from particles in |η| < 4.7 according expressions

\[ ξ ≈ \frac{Σ(E_i × p_i)}{\sqrt{s)}}, \]

where M_X is the mass of the diffractive system.

Three experimental topologies based on the position of the LRG were analysed according to Fig. 3, as well as the distributions for the Minimum Bias data samples, following the aforementioned experimental topologies, compared with PYTHIA8-MBR predictions. The cuts to select the samples for SD1, SD2 and DD topologies with a central LRG signature were η_{max} < 1, η_{min} > −1 and Δη > 3, respectively, where η_{max(min)} is the highest (lowest) η of a particle candidate within |η| < 4.7.

One can see the SD and DD contributions from SD2 event sample in the top of the Fig. 5. Comparison with PYTHIA8-MBR, PYTHIA8-4C, and PYTHIA6 [7] MC simulations were done with two values of Pomeron intercept in the MBR model. It is shown that PYTHIA8-4C does not reproduce the falling behavior of SD and in the -5.5 < log_{10}ξ < -2.5 region the total SD cross section reaches σ_{SD}^{Total} = 4.27 ± 0.04(stat.) ± 0.38(syst.) mb.

In Fig. 4 the SD and DD contribution from SD2 event sample (three samples tagged according CASTOR) are best described by Pythia8-MBR tune.

In addition, the DD contribution from DD event sample is shown in the right side of the Fig. 5. Over the region Δη > 3, M_X > 10 GeV and M_Y > 10 GeV, the cross section value approaches σ^{DD} = 0.93 ± 0.01(stat.) ± 0.25(syst.) mb.

An alternative approach to the study of diffractive events is to measure the differential cross section of the forward rapidity gap "Δη^f". In Fig. 6 we can notice the exponential falling of the ND contribution and the diffractive plateau at Δη^f > 3 with mixtures of SD and DD events for all stable final-state particles with p_T > 200 MeV in |η| < 4.7. A good description using PYTHIA8-MBR with...
C2 were analysed. The analysis of this talk [8] were
in the presence of BFKL contributions [8]. In
the direction, leading to a decorrelation. The observation
of jets are no longer back-to-back (Δη > 3.0) between the
Muller-Navelet (MN) jets and, hence, the MN
increases with an increasing rapidity interval
the BFKL approach, that is the number of emitted partons
increases due to energy-momentum conservation near the
phase-space boundary. Thus, coplanarity of MN jets results
in an increase of average cosines.

The azimuthal angle decorrelation depends also on
multiple particle interactions (MPI), producing additional
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The ratios of $C_n$ are expected to be more sensitive to BFKL effects (See Fig. 11). PYTHIA and HERWIG++ show good agreement at low $\Delta \eta$, but discrepancies in the large $\Delta \eta$ region. On the other hand SHERPA is above the data while CASCADE is far below the data. NLL BFKL calculation describes the ratios quite well, especially the $C_2/C_1$ one.

4 Summary

Two interesting CMS results related with inclusive Single Diffractive and Double Diffractive cross section measurement at 7 TeV and BFKL effects through azimuthal decorrelations in MN jets were presented. The forward and diffractive physics show as a perfect testing ground for models and theories [10].

We notice the importance of Monte Carlo generators comparisons and tuning for better data matching. In addition, several 8 TeV analyses, with 2012 data and integrated luminosity $\approx 20 fb^{-1}$ are in progress.

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