Measurements of associated production of vector bosons and jets in CMS

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ABSTRACT

The most recent results of Standard Model physics using 8 and 13 TeV proton-proton collision data recorded by the CMS detector during the LHC Runs I and II are reviewed. This overview includes studies of several results of vector boson production in association with jets. The outlined results are compared to the corresponding theoretical predictions and no significant deviation is observed.

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1 Introduction

Standard Model (SM) V+Jets results using the LHC Run I and II data have provided us a possibility to perform extensive tests of the electroweak and strong interactions. These measurements are made with the datasets collected by CMS corresponding to integrated luminosities up to 19.8 fb$^{-1}$ at $\sqrt{s} = 8$ and 13 TeV respectively.

2 Measurement of Z+jets cross section

2.1 Z+jets differential cross section at 8 and 13 TeV

Differential cross section measurements for Z boson production in association with jets at $\sqrt{s} = 8(13)$ TeV, in the electron and muon (muon) decay channels, using a data sample corresponding to an integrated luminosity of 19.6(2.5) fb$^{-1}$ [1,2]. The measurements are compared with calculations obtained from different multileg ME event generators with leading order (LO) MEs (tree level), NLO MEs and a combination of NLO and LO MEs. Fig.1 shows measured differential cross sections as a function of 1st ME event generators with leading order (LO) MEs (tree level), NLO MEs and a combination of NLO and LO MEs. The ratios of the theoretical predictions obtained from MadGraph 5 + Pythia 6, Sherpa 2, and MG5_aMC+ Pythia 8 to the measurements are also shown.

Figure 1: The differential cross section for $Z(\rightarrow \ell\ell)$+jets production measured as a function of the leading jet $p_T$ (left) and leading jet transverse momentum and rapidity (right) compared to the predictions [1].

2.2 Z+b jets differential cross section at 8 TeV

CMS Collaboration has also measured the associated production of a Z boson with at least one jet originating from a b quark in proton-proton collisions using $\sqrt{s} = 8$ TeV dataset corresponding to an integrated luminosity of 19.8 fb$^{-1}$ [3]. In this measurement, Z bosons are reconstructed through their decays electrons and muons. The differential cross sections has been reported as a function of several observables exploiting the kinematics of the b jet and the Z boson. The ratios of the differential cross section for the associated production with at-least one b jet to the associated production with any jet are also reported. The differential cross section for the dijet system and production of Z boson with two b jets is also measured. Results are compared with theoretical prediction based on two different flavour schemes for the choice of initial-state partons. Selected differential fiducial cross section results for Z(1b) production as function of leading b jet and $\Delta\phi_{zb}$ are shown in Fig.3.
2.3 Z+c jets differential cross section at 8 TeV

The production of a $Z(\to \ell\ell)$ boson (where $\ell = e$ or $\mu$) and a charm-quark jet ($Z + c$) in proton-proton collisions at $\sqrt{s} = 8$ TeV is reported in the Reference [4]. The differential production cross section of $Z + c$ and ratio of $Z + c$ and $Z + b$ are measured with data collected by the CMS experiment corresponding to an integrated luminosity of 19.7 fb$^{-1}$. Jets originating from heavy flavour quarks are identified using semileptonic decays of c- or b-flavoured hadrons and hadronic decays of charm hadrons. Differential cross section results are reported as a function of transverse momentum of the Z boson and of the heavy flavour jet in Fig. [4].
3 Measurements of W+jets cross section

3.1 W+jets differential cross section at 8 and 13 TeV

Differential cross sections for a $W(\rightarrow \mu\nu)$ boson in association with jets is presented in the References [3, 6]. The measurement is based on the 13(8) TeV proton-proton collisions data corresponding to integrated luminosity of 2.5(19.6) fb$^{-1}$ recorded by the CMS detector. The cross sections are reported as a function of jet multiplicity, the jet transverse momenta and the scalar sum of the jet transverse momenta for different luminosity of 2

$\sigma(T+\mu\nu)/d\mu\nu$ [pb GeV$^{-1}$] = 8 TeV)

Figure 4: Differential $Z+c$ cross section (left) and $(Z+c)/(Z+b)$ cross sections ratio (right) as a function of the transverse momentum of the jet. Statistical uncertainties in the data are shown as error bars. The solid rectangles indicate the total experimental uncertainty [3].
3.2 $W+bb$ jets differential cross section at 8 TeV

The production cross section of a $W(\rightarrow \ell\nu, \text{where } \ell = e, \mu)$ boson with exactly two $b$ jets with $p_T > 25$ GeV and $\eta < 2.4$ and no other jets with $\eta < 4.7$, is measured using 8 TeV proton-proton collisions data corresponding to an integrated luminosity of 19.8 fb$^{-1}$ [7]. The results are also compared to theoretical prediction as shown in Fig. 7.

![Figure 7](image)

Figure 7: Left: Comparison between the measured $W(\rightarrow \ell\nu) + bb$ cross section and various QCD predictions. The orange band indicates the uncertainty in the given sample associated with PDF choice and the yellow band represents the uncertainty associated with DPI. The labels 4F and 5F refer to the four- and five-flavour PDF schemes [7]. Right: Efficiency of a gap activity veto in dielectron and dimuon events with $BDT > 0.92$, as a function of the leading soft jet $p_T$ [8].

4 EWK production of $Z+2$ jets at 13 TeV

The production of two electroweak jets (produced in hard interaction) in association with a $Z(\rightarrow \ell\ell, \text{where } \ell = e, \mu)$ boson is measured in proton-proton collision at $\sqrt{s} = 13$ TeV using data recorded by the CMS experiment...
corresponding to integrated luminosity of 35.9 fb$^{-1}$ [8]. The measurement is extracted in the kinematic region defined by $M_{\ell\ell} > 50$ GeV, $M_{jj} > 120$ GeV and transverse momentum $p_{Tj} > 25$ GeV. The cross section of the process is measured to be $\sigma_{EW}(\ell\ell jj) = 552 \pm 19$ (stat.) $\pm 55$ (syst.) fb which is found to be in good agreement with SM prediction at leading order accuracy. Additionally, the associated jet activity of events in a signal-enriched region is also studied, and the measurements are found to be in agreement with QCD predictions, as shown in Fig. 7 (right).

5 Conclusions

CMS has made several SM V+Jets measurements using the LHC Run I and II datasets corresponding to integrated luminosities upto 19.8 (35.9) fb$^{-1}$ at $\sqrt{s} = 8$ (13) TeV. All of the results are found to be consistent with the SM predictions. The SM will be tested with an unprecedented level of precision in new unexplored territories during the Run II, setting as well the ground for new physics.

References

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