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Study of W and jets associated production with CMS

S. Gonzi(*) on behalf of the CMS Collaboration
Università di Firenze and INFN, Sezione di Firenze - Firenze, Italy

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Summary. — We present a study of jets production in association with W bosons in proton-proton collisions at a centre-of-mass energy of 7 TeV using the full 2010 data-set collected by CMS corresponding to an integrated luminosity of $(35.9 \pm 1.4)\,\mathrm{pb}^{-1}$.

PACS 13.38.Be – Decays of W bosons.
PACS 29.85.Fj – Data analysis.

The study of the production of vector bosons W in association with hadronic jets provides a stringent test of perturbative QCD calculations. Moreover, this process is a significant source of background in searches for new physics and for studies of the top quark; a precise measurement of its cross section is then essential. This paper presents a study of W + jets production performed by the CMS detector [1] in proton-proton collisions at $\sqrt{s} = 7\,\mathrm{TeV}$ with $35.9\,\mathrm{pb}^{-1}$ of integrated luminosity collected in 2010 [2].

Monte Carlo (MC) simulation samples with a W or a Z boson in association with jets are generated with the MadGraph [3] parton-level event generator on the basis of a matrix element calculation. MadGraph is interfaced to the PYTHIA [4] software for a parton shower simulation. Top background processes are generated with MadGraph while QCD multi-jet and γ + jets processes are generated with PYTHIA alone. Whenever available, a NNLO or NLO normalization is performed. Minimum-bias events are superimposed to the hard interaction to simulate the event pile-up observed in data.

Signal selection begins with the identification of a so-called "leading lepton". For electron candidates we require a transverse-momentum selection $p_T > 20\,\mathrm{GeV}$ and a fiducial region of the ECAL supercluster $|\eta| < 2.5$, with $1.44 < |\eta| < 1.57$ excluded. The selected electron must match the object that triggered the event readout and pass some tight quality requirements (including identification, isolation, and conversion rejection). If a second electron of $p_T > 10\,\mathrm{GeV}$, detected within the ECAL fiducial region, passes a looser set of quality cuts and its invariant mass with the leading electron is in the range [60–120] GeV, then the event is rejected. Events with a muon with $p_T > 15\,\mathrm{GeV}$ and $|\eta| < 2.4$ are rejected to reduce $t\bar{t}$ contamination.

(*) E-mail: sandro.gonzi@fi.infn.it

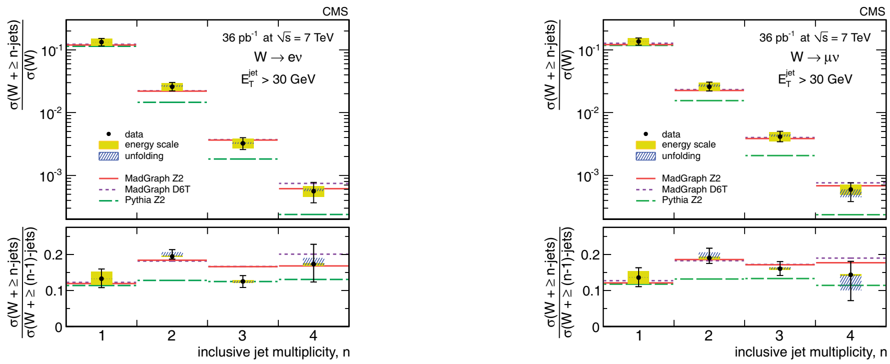

Fig. 1. – The ratio $\sigma(\mathrm{W}+\geq n$ jets$)/\sigma(\mathrm{W})$ and $\sigma(\mathrm{W}+\geq n$ jets$)/\sigma(\mathrm{W}+\geq (n-1)$ jets$)$ in the electron channel (left) and the muon channel (right) compared to predictions from MadGraph and PYTHIA with different tunes (Z2 and D6T tunes).

For muon candidates we require the presence of an isolated high-quality muon with $p_T > 20\,\mathrm{GeV}$ in the region $|\eta| < 2.1$. If a second muon of $p_T > 10\,\mathrm{GeV}$ is detected in the region $|\eta| < 2.5$, and its invariant mass with the leading muon is in the range [60–120] GeV, the event is rejected. Finally, we require a transverse mass $M_T > 20\,\mathrm{GeV}$.

Jets are reconstructed with the anti-k_T clustering algorithm [5] in a $R = 0.5$ cone. Jets are selected in the tracker acceptance $|\eta| < 2.4$, with $E_T > 30\,\mathrm{GeV}$ to reduce the pile-up effects.

In order to provide model-independent results, we quote them within the lepton and jet acceptance, and only correct for efficiency of the selection. The lepton efficiencies are obtained by means of a tag-and-probe method with fits on the invariant-mass distributions in Z/γ^* + jets data samples.

In order to estimate the scaling rule of jets at the particle level, we apply an unfolding procedure that removes the effects of jet energy resolution and reconstruction efficiency.

The main sources of systematic uncertainties are the determination of the jet energy and jet energy resolution. We apply the jet energy scale (JES) corrections, to account for the detector response and inhomogeneities, and a pile-up energy correction. All statistical and systematic uncertainties are propagated in the unfolding procedure.

From the unfolded exclusive jet multiplicity distributions we derive the inclusive ones and we calculate two sets of ratios: $\sigma(\mathrm{W}+\geq n\,\text{jets})/\sigma(\mathrm{W})$ and $\sigma(\mathrm{W}+\geq n\,\text{jets})/\sigma(\mathrm{W}+\geq (n-1)\,\text{jets})$, where $\sigma(W)$ is the inclusive cross section. The results are reported in fig. 1, where the systematic uncertainties associated with the JES and the unfolding are shown as error bands. For a large number of jets, the PYTHIA simulation alone fails to describe the data, while the MadGraph + PYTHIA simulation agrees well, as expected.

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