W + JETS IN PP COLLISIONS AT 7 TeV WITH ATLAS

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ABSTRACT

We report on measurements of differential and inclusive cross sections of W boson production in association with jets, as well as measurements of jets containing B-hadrons. The data are compared to predictions at next-to-leading order. In addition, we present a study of the invariant mass distribution of jet pairs produced in association with a W boson.

OBJECT RECONSTRUCTION

W boson selection

- One isolated lepton: $p_T > 20$ GeV
- Missing transverse energy: $E_T^{\text{miss}} > 25$ GeV
- Transverse mass of the (l, E_T^{miss}) system: $m_T > 40$ GeV
- Events with a second lepton of the same flavor are rejected

Electron: identification based on calorimeter clusters and tracks in the Inner Detector (ID) in $|\eta| < 2.5$

Muon: identification based on the combined parameters of Muon Spectrometer (MS) and ID tracks in $|\eta| < 2.4$

Missing Transverse Energy (E_T^{miss}): based on the sum of calorimeter cell energy deposits in topological clusters calibrated at the electromagnetic scale, corrected for hadron response and muon energy

Jets: reconstructed using the Anti- k_T algorithm with a cone of $R = 0.4$ and $\Delta R_{\text{jet, lep}} > 0.5$. Jet energy scale calibrated using simulation, single hadron and γ -jet events

W + JETS

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Unfolding procedure (bin-by-bin) used to produce particle level distributions, correcting for all detector effects, including acceptance and reconstruction efficiency

Jet properties: $p_T > 20$ GeV and $|\eta| < 2.8$

Measurements in agreement with multi-parton matrix element generators and particle level predictions

- Leading-order event generators (ALPGEN, SHERPA) normalized to NNLO cross sections
- Next-to-leading order calculations from MCFM ($N_{\text{jet}} \leq 2$), BLACKHAT-SHERPA ($N_{\text{jet}} \leq 3$)
- Poor agreement with LO PYTHIA in high jet multiplicity

JET MULTIPLICITY

FIRST JET P_T

MOTIVATION

W + jets physics is a fundamental ingredient for reestablishing the Standard Model at 7 TeV, and for testing perturbative QCD calculations at next-to-leading order. In addition, W + jets final states are used in Standard Model measurements and new physics searches to identify heavy particles and measure their properties.

BACKGROUNDS

Electroweak: Estimated from simulation according to the different physics processes

- W -> $\tau \nu$ and Z -> $\tau \tau$ where τ decays to e or μ (PYTHIA), Z -> ll where one of the leptons is not identified (ALPGEN), Diboson (WW, WZ, ZZ) production (HERWIG)

Top: The tt and single-top backgrounds are estimated from simulation (MC@NLO, POWHEG)

- Normalization of the tt component is measured in data in the $N_{\text{JET}} \geq 4$ bin for the W + b-jets analysis

Multi-jet (QCD): Data-driven techniques are used to estimate the QCD component

- Electron channel: a QCD template is obtained by loosening the electron identification requirements, and its normalization is determined by a multi-component fit to the Missing E_T distribution
- Muon channel: a similar method to that of the electron channel is used in the W + jets analyses. The W + b-jets analysis uses the matrix method, with isolation as discriminating variable

W + b-JETS

Paper in preparation

W + b cross section: extracted from maximum likelihood fit of secondary vertex mass distribution

- Fit performed in the 1-jet and 2-jet bins, after requiring a b-tagged jet
- Event yield corrected to particle level using ALPGEN

b-jets identification: based on secondary vertex reconstruction

Jet properties: $p_T > 25$ GeV and $|\eta| < 2.1$

First 7 TeV measurement of non-resonant production of W boson with 1 or 2 b-jets

Results compatible with next-to-leading order QCD calculation within 1.5 σ

NLO Prediction [F. Caola et al. arXiv:107.3714]			
Fiducial Cross Section (NLO) [pb]			
1j	$2.9^{+0.40}_{-0.36}$ (scale) $^{+0.18}_{-0.02}$ (PDF) $^{+0.19}_{-0.10}$ (m_b) ± 0.20 (non-pert.)		
2j	$1.9^{+0.81}_{-0.87}$ (scale) $^{+0.02}_{-0.02}$ (PDF) $^{+0.06}_{-0.06}$ (m_b) ± 0.13 (non-pert.)		
1+2j	$4.8^{+1.20}_{-0.73}$ (scale) $^{+0.32}_{-0.03}$ (PDF) $^{+0.25}_{-0.15}$ (m_b) ± 0.34 (non-pert.)		

MEASURED FIDUCIAL CROSS SECTION OF W + b AND W + bb PROCESSES

W + 2 JETS AND DIJET INVARIANT MASS

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The invariant mass distribution of jet pairs produced in association with a W boson is studied in 1 fb⁻¹ of pp collisions at $\sqrt{s} = 7$ TeV

The CDF Collaboration has observed a significant excess of events in the 120-160 GeV range of this distribution in 7.3 fb⁻¹ of $p\bar{p}$ collisions at 1.96 TeV. [Phys.Rev.Lett.106:171801,2011, www-cdf.fnal.gov/physics/ewk/2011/wj/7_3.html]

Event selection used in addition to the W boson selection (above)

- Transverse momentum of dijet system: $p_T^{\text{JJ}} > 40$ GeV
- Dijet separation: $|\Delta\eta| < 2.5$
- Separation between E_T^{miss} and leading jet: $\Delta\phi_{\text{MET}, J1} > 0.4$
- Exactly 2 jets (distributions studied with and without this cut)
- Selection not optimized for observation of diboson component

JET MULTIPLICITY ($N_{\text{JETS}} \geq 2$)

Cross section scaling from Tevatron to LHC is dependent on physics processes:

- W + ($n \geq 2$) jets: from 22 to 440 pb [CDF and ATLAS meas.]
- WW/WZ -> lvqq: from 3.7 to 15.3 pb [MCFM prediction]
- CDF Excess: scaling is model dependent

Agreement with Standard Model is observed in the invariant mass distributions of two leading jets for $N_{\text{JETS}} = 2$ and inclusive samples

INVARIANT MASS OF TWO LEADING JETS

Statistical interpretation: systematic uncertainties are assumed to follow Gaussian distributions, and their nuisance parameters are varied to best describe the data with the background-only hypothesis.

Correcting for the look-elsewhere effect, the p-value of the most significant excess in the 100-300 GeV region is 37.1%

DATA-BACKGROUND COMPARISON WITH NUISANCE PARAMETERS SET TO MAXIMUM LIKELIHOOD ESTIMATE