Z+jets Results from CDF

Lorenzo Ortolan

IFAE Barcelona

DOI: http://dx.doi.org/10.3204/DESY-PROC-2012-02/166

The CDF collaboration has an interesting and comprehensive program on the study of jet production in association with a Z/γ^* boson. These measurements are important because Z/γ^*+jets events are a background in many searches of new physics and in particular $Z/\gamma^* + b-$jet represents the main and irreducible background for Higgs boson produced in association with a Z/γ^* where the Higgs decays in two b quarks.
In this contribution new measurements of Z/γ^*+jets differential cross section and the $Z/\gamma^* + b-$jet cross section ratio with respect to the Z inclusive cross section are presented. The results are performed with the complete dataset collected at CDF and are compared with the next-to-leading order predictions.

1 Introduction

The study of jet production in association with a Z boson at hadron colliders is fundamental not only because it allows to test the perturbative QCD predictions but also because it represents an important background to many searches of new physics, for example Higgs and SUSY. For this reason dedicated measurements of Z/γ^*+jet and $Z/\gamma^* + b-$jet cross sections are crucial to improve the understanding and the modeling of these processes.

2 Z/γ^*+jet Cross section measurement

The CDF collaboration recently presented updated results for Z/γ^*+jet in $Z/\gamma^* \to \mu^+\mu^-$ muon [1] and $Z/\gamma^* \to e^+e^-$ electron [2] channels. Here the measurement is presented combining the two channels using the complete dataset collected at CDF. For both channels the same kinematics cuts are used and the measurements are defined in the same phase space.
Events are required to have two high p_T ($p_T \geq 25$ GeV/c) central ($|\eta| \leq 1.0$) leptons with an invariant mass between 66 and 116 GeV/c^2. The jets are reconstructed with the MidPoint[3] algorithm in a cone of 0.7 and are required to have $p_T \geq 30$ GeV/c and $|Y^{jet}| \leq 2.1$. The background is estimated using data driven techniques and Monte Carlo programs. In particular fakes contributions (QCD dijet, W+jets and decay in flight) are estimated with data driven sample while backgrounds coming from $t\bar{t}$, diboson (ZZ, WW, ZW) are evaluated with PYTHIA Monte Carlo. The global contribution from background represents less than 10 %.
The measurement at calorimetric level is unfolded back to hadron level to take into account resolution effects and the detector acceptance of $Z \to l^+l^-$. The unfolding is done using ALP-

GEN+PYTHIA Monte Carlo with Tune Perugia 2011[4]. The results are compared with several predictions at different perturbative orders (NLO evaluated by MCFM, NLO by BLACKHAT+SHERPA, $\bar{n}NLO$ by LOOPSIM+MCFM) and corrected for non perturbative effects (underlying events and hadronization) using ALPGEN+PYTHIA. Differential cross section distributions (Figure 1) are well described by theory predictions. The main systematic uncertainty is due to the error in the jet energy scale and varies between 3-15 %. The renormalization and factorization scale and PDF uncertainties are calculated for the theoretical predictions.

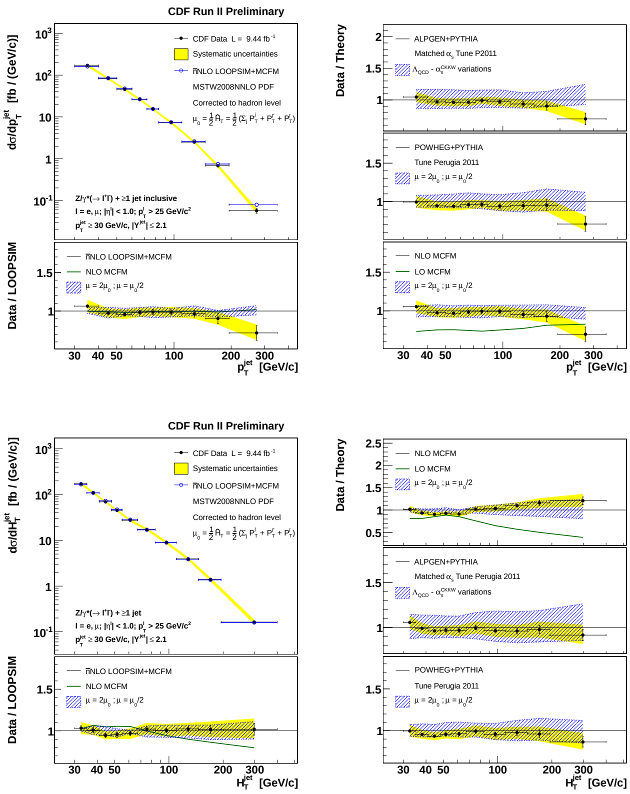

Figure 1: Measured inclusive jet differential cross sections as a function of jet transverse momentum and H_T^{jet} in $Z+ \geqslant 1$ jet events. Data (black dots) are compared to $\bar{n}NLO$ predictions (open circles). The shaded bands show the total systematic uncertainty, except for the 5.8% luminosity uncertainty.

3 $Z/\gamma^* + b-$jet Cross section measurement

The $Z/\gamma^* + b-$jet cross section measurement at CDF was previously published with 2 fb^{-1} of integrated luminosity [5]. Here an update of this measurement based on 9 fb^{-1}[6] (the full

CDF dataset) is presented. It is performed as a per-jet cross section measurement ratio with respect to Z/γ^* inclusive cross section and Z/γ^*+jet cross section. This is done because in this way some systematics (luminosity uncertainty, lepton ID) are largely canceling in the ratio.
The events are required to have two high energy leptons (electrons or muons) with an invariant mass between 66 and 116 GeV/c^2 and a central ($|Y^{jet}| \leq 1.5$) high p_T ($p_T \geq 20$ GeV/c) jet clustered with MidPoint 0.7. The $Z/\gamma^* \rightarrow l^+l^-$ selection is improved to optimize the lepton identification efficiency. This is done using cuts on the outputs of two artificial neural networks trained to separate fake signals from real leptons. The improvement on the Z acceptance is $\sim$30/40 % respectively for muon and electron channel.
The identification of the b jet is done with a Secondary Vertex Tagger. Since the tagged sample is not pure, the b quark composition is extracted from a fit to the mass of a displaced secondary vertex reconstructed within the jet. The measurement is unfolded back to the hadron level to the total phase space and normalized to the Z/γ^* inclusive and Z/γ^*+jet cross section. The main systematics is coming from the variation of the template shape due to a track reconstruction inefficiency and due to b-tagging efficiency uncertainty.
The results obtained is $\frac{\sigma(Z+\mathrm{b})}{\sigma(Z)} = 2.61 \pm 0.23 \pm 0.29 \times 10^{-3}$ and $\frac{\sigma(Z+\mathrm{b})}{\sigma(Z+\mathrm{jet})} = 2.08 \pm 0.18 \pm 0.27 \times 10^{-2}$. These are compared (Table 1) to NLO predictions evaluated with MCFM and corrected for non perturbative effects, at different re-normalization scales. Within the uncertainty the measured cross section is in agreement with the theory, but a large uncertainty is present due to the choice of the re-normalization scale.

	Measured	NLO $Q^2 = m_Z^2 + p_{T,Z}^2$	NLO $Q^2 = < p_{T,jet}^2 >$
$\frac{\sigma(Z+\mathrm{b})}{\sigma(Z)}$	$2.61 \pm 0.23 \pm 0.29 \times 10^{-3}$	2.3×10^{-3}	2.8×10^{-3}
$\frac{\sigma(Z+\mathrm{b})}{\sigma(Z+\mathrm{jet})}$	$2.08 \pm 0.18 \pm 0.27 \times 10^{-2}$	1.8×10^{-2}	2.2×10^{-2}

Table 1: The results of per jet $Z + b-$jet cross section ratio with respect to Z/γ^* inclusive and Z/γ^*+jet cross section. These results are compared with the predictions done at NLO with MCFM at different re-normalization/factorization scales.

Using the same analysis strategy the $Z/\gamma^* + b-$jet differential cross sections as a function of jet rapidity and jet p_T are performed and the results are shown in Figure 2.

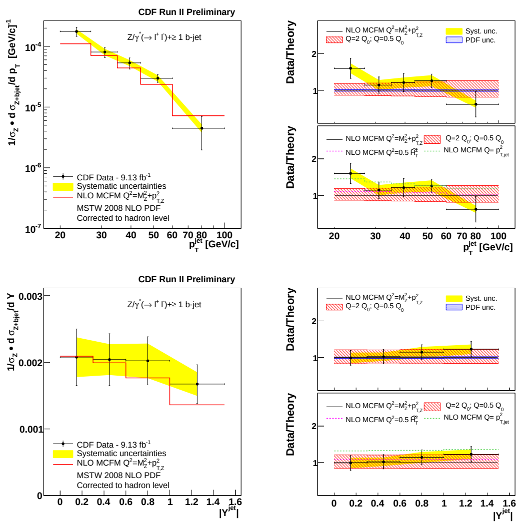

Figure 2: Differential cross section as a function of jet p_T and jet rapidity compared with NLO prediction by MCFM. In the ratio there is the comparison at different renormalization and factorization scales. The predictions are affected by large scale uncertainty.

4 Summary

In this report, measurements of Z/γ^{*}+jet differential cross section have been presented using the complete dataset available at CDF. It was found that the data is well described by the theoretical predictions corrected by non perturbative effects.
It has been also reported the per-jet $Z/\gamma^{*}+b-$jet cross section ratio measurement with respect to the Z/γ^{*} inclusive and Z/γ^{*}+jet cross section and the differential cross section distribution as a function of jet p_T and jet rapidity. Results are in agreement with NLO predictions.

References

[1] CDF Collaboration, *CDF Conference Note 10216*.

[2] CDF Collaboration, *CDF Conference Note 10394*.

[3] A. Abulencia et al. (CDF Collaboration), *Measurement of the inclusive jet cross section in $p\bar{p}$ interactions at $\sqrt{(s)} = 1.96\ TeV$ using a cone-based jet algorithm*, *Phys. Rev. D* **74**, 071103(R) (2006).

[4] Cooper et al., *Monte Carlo tuning in the presence of the Matching*, PH-CERN-TH/2011-228

[5] T. Aaltonen et al., *Phys. Rev. D.* **79**, 052008 (2009).

[6] CDF Collaboration, *CDF Conference Note 10594*.