PROCEEDINGS OF SCIENCE

Z+jets Results from CDF

Lorenzo Ortolan*
IFAE Barcelona
E-mail: loreorto@ifae.es

The CDF collaboration has an interesting and comprenhensive program on the study of jet production in association with Z boson. These measurements are important because Z+jets events are background in many searches of new physics and in particular Z+b jet represents the main and irreducible background for Higgs boson produced in association with a Z and where the Higgs decays in two b quarks.
In this contribution are presented the differential cross section of Z+jet production in function of transverse momentum of the jet, jet rapidity and jet multiplicity and the Z+bjet cross section ratio with respect to the Z inclusive and Z+jet cross section. All these measurement were performed at CDF. The results are compared with next-to-leading order predictions.

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*Speaker.

1. Introduction

The production of jets in association with a Z boson at hadron colliders is a very important process to study because it permits to test the perturbative QCD predictions and because represents an important background to many searches of new physics, for example Higgs and SUSY. For this reason dedicated measurements of Z+jet and Z+bjet cross sections are crucial to improve the understanding and the modeling of these processes.

2. Z+jet Cross section measurement

The CDF collaboration recently presented update results for Z+jet in $Z/\gamma \rightarrow \mu^+\mu^-$ muon channel and $Z/\gamma \rightarrow e^+e^-$ electron channel. Here the measurement is presented separately for the two channels using 6 fb^{-1} of data. For both channels the same kinematics cuts are used and the measurements are defined in the same phase space.
For muon channel the events are required to have two high p_T ($p_T \geq 25$) central ($|\eta_\mu| \leq 1.0$) muons with an invariant mass between 66 and 116 GeV/c^2. The Jets are reconstructed with MidPoint [4] algorithm in a cone of 0.7 and are required to have $p_T \geq 30$ and $|Y^{jet}| \leq 2.1$. The background is estimated using data driven tecquiniques and Monte Carlo programs. In particular QCD dijet, W+jets and decay in flight contributions are estimated with the data using same charge dimuon events. Backgrounds coming from $t\bar{t}$, diboson (ZZ, WW, ZW) are evaluated with Monte Carlo samples. The global contribution from background represents less than 10 %.
The measurement at calorimetric level is unfold back to hadron level to take into account unfolded resolution effects and the detector acceptance of $Z \rightarrow l^+l^-$. The unfolding is done using ALPGEN+PYTHIA Monte Carlo. The results are compared with next-to-leading order (NLO) predictions evaluated with MCFM and corrected for non perturvative effects (underling events and hadronization) using Pythia Tune A. All the differential cross section distributions (Figure 1) are in agreement with the theory and the main systematics that affects the measurement between 3-15 (%) is the uncertainty on the Jet energy scale. For the theory prediction a systematic due to renormalization and factorization scale and PDF uncertainty is calculated.

The measurements for Z+jet cross section in $Z/\gamma \rightarrow e^+e^-$ channel was already published [5] and presented with 1.7 fb^{-1} of integrated luminosity, here it is shown an update of this measurement done with $6 fb^{-1}$. The measurement is defined as for the muons, and differs only because in electron channel one of the electron can be reconstructed in the forward region of the detector ($1.1 \leq \eta^e \leq 2.8$.)
Figure 2 shows the good agreement between data and theoretical prediction also for this channel in the differential cross section for at least two jets in function of the transverse momentum of the jet and in function of jet multiplicity.

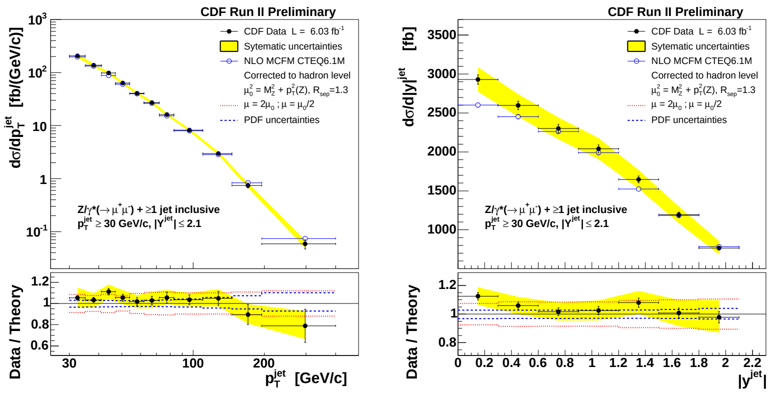

Figure 1: Measured inclusive jet differential cross sections as a function of jet transverse momentum in $Z+\geqslant 1$ jet events and as a function of jet rapidity. Data (black dots) are compared to NLO predictions (open circles). The shaded bands show the total systematic uncertainty, except for the 5.8% luminosity uncertainty. The dashed and dotted lines indicate the PDF uncertainty and the variation with μ_0 of the NLO pQCD predictions, respectively.

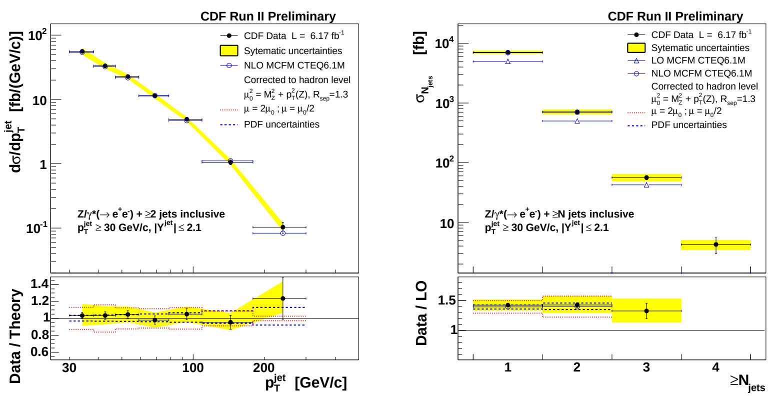

Figure 2: Measured inclusive jet differential cross sections as a function of jet transverse momentum in $Z+\geqslant 2$ jet events and as a function of jet multiplicity.

3. Z+b jet Cross section measurement

The Z+bjet cross section measurement at CDF was already published with 2 fb^{-1} of integrated luminosity [6]. Here is presented an update of this measurement based on 8 fb^{-1}. It is performed as a per jets cross section measurement ratio with respect Z inclusive cross section and Z+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. For the $Z/\gamma \to e^+e^-$ channel the same kinematics cuts to reconstruct the Z as in the Z+jet analysis that is presented before, are used, while for the $Z/\gamma \to \mu^+\mu^-$ the selection is improved to optimize the significance. This is done using cuts on the outputs of two artificial

	Measured	NLO $Q^2 = m_Z^2 + p_{T,Z}^2$	NLO $Q^2 = < p_{T,jet}^2 >$
$\frac{\sigma(Z+b)}{\sigma(Z)}$	$2.84 \pm 0.29 \pm 0.29 \times 10^{-3}$	2.3×10^{-3}	2.8×10^{-3}
$\frac{\sigma(Z+b)}{\sigma(Z+jet)}$	$2.24 \pm 0.24 \pm 0.26 \times 10^{-2}$	1.8×10^{-2}	2.2×10^{-2}

Table 1: The Results of per jet Z+bjet cross section ratio with respected to Z inclusive and Z+jet cross section. These results are compared with the predictions done at NLO with MCFM at different renormalization/factorization scales.

neural networks trained to separate QCD backgrounds from real muons. The improvement on the Z acceptance is ∼30 %.

The identification of the b jet is done with a Secondary Vertex Tagger that identifies jets with a secondary vertex reconstructed inside, taking the advantage of the large b life time. 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 (Figure 3). The measurement is unfolded back to the hadron level to the total phase space and normalized to the Z inclusive and Z+jet cross section. The main systematics is coming from the variation of the template shape sue to a track reconstruction inefficiency and due to b-tagging efficiency uncertainty.

The results obatined is $\frac{\sigma(Z+b)}{\sigma(Z)} = 2.84 \pm 0.29 \pm 0.29 \times 10^{-3}$ and $\frac{\sigma(Z+b)}{\sigma(Z+jet)} = 2.24 \pm 0.24 \pm 0.26 \times 10^{-2}$. These are compared (Table 1) to NLO prediction evaluated with MCFM and corrected for non perturbative effects, at different renormalization 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 renormalization scale.

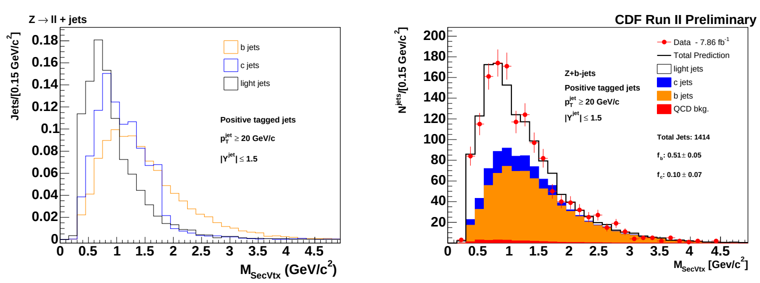

Figure 3: The templates for the mass of a displaced secondary vertex used for fitting the data. These templates are built with ALPGEN+PYTHIA Monte Carlo tools. On the right the result of the fit.

References

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

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

[3] CDF Collaboration, `CDF Conference Note 10594`.

[4] A. Abulencia et al. (CDF Collaboration), *Phys. Rev. D* **74**, 071103(R) (2006).

[5] T. Aaltonen et al. (CDF Collaboration), *Phys. Rev. Lett.* **100**, 102001 (2008).

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