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A Measurement of the Ratio of Inclusive Cross Sections $\sigma(p\overline{p} \to Z + b \text{ jet})/\sigma(p\overline{p} \to Z + \text{jet})$ at $\sqrt{s} = 1.96$ TeV

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In this talk we present a measurement of the ratio of inclusive cross sections $\sigma(p\overline{p} \to Z + b \text{ jet})/\sigma(p\overline{p} \to Z + \text{jet})$ at $\sqrt{s} = 1.96$ TeV based on approximately 180 pb^{-1} of data collected with the DØ detector. Combining the $Z \to e^+e^-$ and $Z \to \mu^+\mu^-$ channels, the ratio was found to be $0.023 \pm 0.004(stat) \pm 0.002(syst)$.

1. Introduction

Heavy flavor production in association with a Z vector boson is an important background to Higgs searches in the ZH channel. Furthermore, due to the $bg \to Zb$ process with an initial state b-quark from the sea, it can also be used as a probe of the proton's b-quark Parton Distribution Function (PDF).

This analysis measures the ratio of $Z + b$ jet and $Z +$jet inclusive cross sections combining the dielectron and dimuon decay channels of the Z. Taking the ratio has the advantage that many systematic errors (e.g. luminosity uncertainty) cancel.

2. Event Selection

In the dimuon channel $Z \to \mu^+\mu^-$ events are identified by requiring two loose and isolated muons with $p_T > 15$ GeV/c and $|\eta| < 2.0$. Both muons must have a matching track and are required to have opposite charges. A mass window cut of 65.0 GeV/$c^2 < M_{\mu\mu} < 115.0$ GeV/c^2 yields a sample of approximately 11,500 Z's.

In the dielectron channel $Z \to e^+e^-$ events are selected by requiring two isolated EM clusters with $p_T > 15$ GeV/c and $|\eta| < 2.5$. At least one of the clusters is required to have an associated track. Taking advantage of the good energy resolution of the calorimeter a mass window cut of 80.0 GeV/$c^2 < M_{ee} < 100.0$ GeV/c^2 yields a sample of approximately 15,600 Z's.

Jets are reconstructed with a clustering algorithm of $\Delta R = 0.5$ and are required to be taggable with $p_T > 20.0$ GeV/c and $|\eta| < 2.5$. Figure 1 shows the E_T distribution of taggable jets.

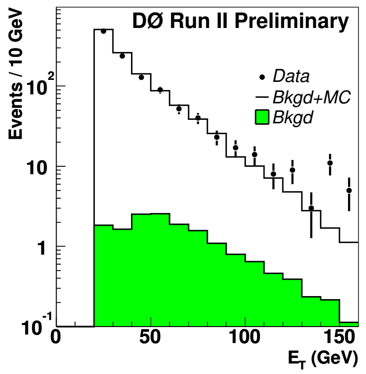

Fig. 1. E_T distribution of taggable jets after selection of Z candidate events and combining dielectron and dimuon channels. QCD background is derived from data, MC is $Z+$jet ALPGEN interfaced with PYTHIA for parton showering and full GEANT detector simulation. A jet is considered taggable if it has matching tracks.

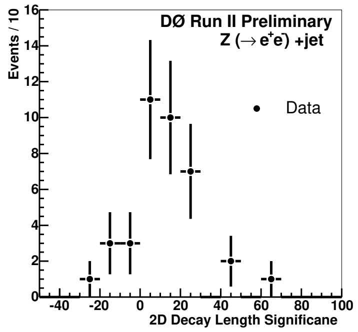

Fig. 2. Distribution of the 2 dimensional decay length significance (DLS). The DLS parameter is derived by taking the ratio of the distance between the primary and secondary vertices in the plane transverse to the beam and the error of the same quantity. An asymmetry in the DLS signifies heavy flavor production.

A secondary vertex b-tagging algorithm is used to identify heavy flavored jets. Figure 2 shows the distribution of the decay length significance indicating the production of heavy flavor.

After applying b-tagging 27 (22) events remain in the $Z \to e^+e^-$ ($Z \to \mu^+\mu^-$) sample.

3. Determining the $\sigma(p\overline{p} \rightarrow Z + b \text{ jet})/\sigma(p\overline{p} \rightarrow Z + \text{jet})$ cross section ratio

In order to extract the desired cross section ratio, one needs to disentangle the *light*-, *c*- and *b*-quark contributions. After background is subtracted, two equations, one before (Eq. 1) and one after (Eq. 2) *b*-tagging is applied, allow us to determine the contributions from different flavors in the remaining events (N, ϵ and t denote number of events, tagging efficiencies and taggabilities for different jet types, respectively).

$$(N - N_{bkg})_{before} = t_b N_b + t_c N_c + t_l N_l \tag{1}$$

$$(N - N_{bkg})_{after} = \epsilon_b t_b N_b + \epsilon_c t_c N_c + \epsilon_l t_l N_l \tag{2}$$

While the *light*-quark and *b*-quark tagging efficiencies (ϵ_l and ϵ_b) are derived from data, MC has to be used for the *c*-quark efficiency by assuming that $(\epsilon_c/\epsilon_b)_{data} = (\epsilon_c/\epsilon_b)_{MC}$.
Similarly, the *light*-quark taggability t_l is derived from data, while $(t_b/t_l)_{data} = (t_b/t_l)_{MC}$ is assumed to estimate the *b*-quark taggability t_b. We assume $t_c = t_b$.
At this point we are left with 2 equations and 3 unknows. Therefore we require $N_c = 1.69 N_b$ based on an MCFM [a] next-to-leading order calculation.
After these assumptions, the final cross section ratio can be calculated with Eq. 3,

$$\frac{\sigma(p\overline{p} \rightarrow Z + b)}{\sigma(p\overline{p} \rightarrow Z + j)} = \frac{N_b}{N_b + N_c + N_l} \tag{3}$$

and the result is $0.023 \pm 0.004(stat) \pm 0.002(syst)$.
This result is compatible with the theoretical prediction of 0.018 ± 0.004 [1]. The largest source of systematic uncertainty is due to the *b*-tagging efficiency and jet energy scale.

In summary, a first measurement of *b*-quark production in association with Z bosons has been presented, and found to be in good agreement with Standard Model expectations.

References

1. J.M. Campbell, R.K. Ellis, F. Maltoni, S. Willenbrock, *Phys. Rev.* **D69**, 074021 (2004).

[a] http://mcfm.fnal.gov/