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DØ Papers on QCD with Vector Bosons Submitted to DPF '96

D.P. Casey, W. Chen and T. Joffe-Minor
For the DØ Collaboration
Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

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p_T DEPENDENCE OF INCLUSIVE Z BOSON PRODUCTION

Dylan P. Casey
for the DØ Collaboration

University of Rochester, Rochester, New York, 14620

We present preliminary results for the measurement of $[1/\sigma]d\sigma/dp_T$ for the Z boson observed in the e^+e^- channel for $p_T < 50$ GeV/c. The data are from a luminosity of $\sim 90\ pb^{-1}$ collected with the DØ detector during the 1994–1995 Tevatron run. The differential spectrum is sensitive to non-perturbative predictions of QCD.

1 Introduction

The measurement of the differential p_T distribution for the Z boson provides a sensitive test of the resummation formalism used to describe low-p_T vector boson production. Besides being of interest on its own merits [1], because the uncertainty in the phenomenology of vector boson production contributes 65 MeV to the total uncertainty on M_W [2], a precise measurement of $d\sigma/dp_T$ can also improve the precision in M_W. The Z is chosen over the W for this study because the p_T resolution is significantly better for Z events ($\delta p_T(Z) \sim 1.0$ GeV/c and $\delta p_T(W) \sim 4.0$ GeV/c).

2 Data selection

The data are from the 1994-1995 run of the Tevatron, corresponding to ~ 90 pb^{-1} of total luminosity. For the final data selection, both electron candidates are required to have $E_T > 25$ GeV, $|\eta| \leq 1.1$, and the ϕ of each electron candidate is required to be within the central 90% of the front-surface area of each calorimeter module in order to avoid cracks between the modules. The invariant mass of each Z candidate is restricted to $75 < M_{ee} < 105$ GeV. In addition, both electron candidates are required to be of high quality, *i.e.*, be isolated and have a shower shape consistent with that of an electron, and at least one of the candidates is required to have a charged track pointing to the shower in the calorimeter.

The ultimate goal of the analysis is to obtain an absolute measurement of the differential cross section where detector effects (*e.g.*, smearing in p_T) have been accounted for. For this preliminary result, we account for p_T--dependent efficiency corrections and compare the shape ($[1/\sigma]d\sigma/dp_T$) to resolution–smeared theory.

3 Acceptance and Background

The acceptance defined by the fiducial and kinematic selection criteria varies as a function p_T (Z), and therefore the cross section in each p_T bin must be corrected for this effect. The acceptance is determined on average for each bin using a fast Monte Carlo detector simulator developed for the measurement of the W mass. The most significant distortions of the shape as a function of p_T are from the E_T and η requirements imposed on the data.

The total background level is obtained by fitting the e^+e^- invariant mass spectrum to a Breit–Wigner convoluted with a Gaussian, plus an exponential with fixed slope for the background. The relative normalization of the signal to background is allowed to float. The slope of the background spectrum is determined using dielectron events in which both electron candidates fail the quality criteria for the signal, but pass the same kinematic and fiducial criteria used for the signal. The fitted background level is found to be 2.5%.

The shape of the background as a function of p_T is determined using the same set of failed dielectron events, but with an additional invariant mass requirement of $75 < M_{ee} < 105$ GeV. A simple parameterization was chosen using the function $(p_T + \alpha)e^{\beta p_T}$, where α and β are fit parameters with values $\alpha = 0.99$ and $\beta = -0.125$. The uncertainties in the shape and level of background are conservatively assigned to be 50% for each bin in p_T

4 Results

The cross section in each p_T bin is extracted using the method of statistical inference[3]. The joint posterior probability is obtained using Bayes' Theorem: $P(a_i, b_i, \sigma_i | d_i, I) = P(d_i | a_i, b_i, \sigma_i, I) P(a_i|I) P(b_i|I) P(\sigma_i|I)/Z$, where Z is the normalization requirement, I represents our implicit assumptions and we have assumed that the acceptance (a_i), background (b_i), and the true cross section (σ_i) are logically independent. The likelihood, $P(d_i|a_i, b_i, \sigma_i, I)$, is a Poisson distribution for the data, d_i, given the expected number of events, μ_i, where $\mu_i = La_i\sigma_i + b_i$ and L is the total luminosity. The priors for the background and acceptance are taken to be Gaussian distributions with the measured value as the mean and the uncertainty as the standard deviation. The prior for the cross section is taken to be flat over $[0, 10]nb$. The final cross section in each bin is obtained by integrating over a_i and b_i, and calculating the first moment. The standard deviation in each bin ($\sqrt{<x^2> - <x>^2}$) is assigned to be the uncertainty. The preliminary result for $[1/\sigma]d\sigma/dp_T$ is shown in Figure 1. Also shown for comparison is the phenomenology from Ladinsky and Yuan[1], using MRSA structure functions, and smeared with the DØ detector resolutions.

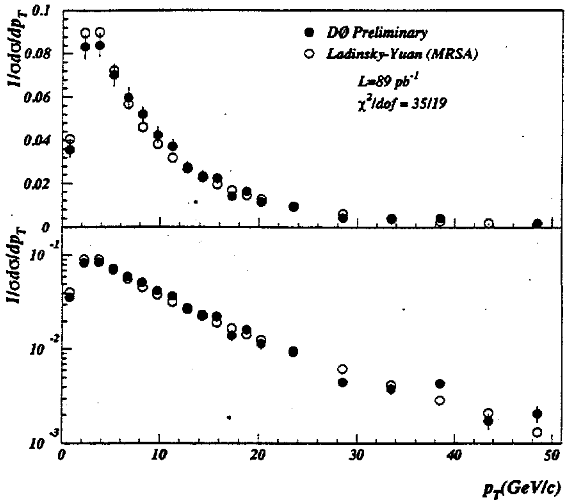

Figure 1: The extracted differential cross section compared to resolution–smeared theory.

In the future, the analysis will include ~50% more data by including regions of $|\eta| > 1.1$. We expect to reduce the bin size in the region $p_T < 15$ GeV/c to less than 1.0 GeV/c, improve the systematic errors on the acceptance and background, obtain the unsmeared distribution, and determine an absolute cross section.

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