Measurement of the Differential Z^0-Boson Production Cross-Section as Function of Transverse Momentum with the DØ Detector at the TeVatron

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The measurement of the differential production cross-section of the Z^0-boson as function of transverse momentum ($d\sigma/dp_T$) in the decay channel $Z^0 \rightarrow \mu^+\mu^-$ is performed using a data sample collected with the DØ experiment [1] corresponding to an integrated luminosity of $L \sim 146.9\,\mathrm{pb}^{-1}$.

Besides being of intrinsic interest in the study of QCD, a precise understanding of the Z^0 boson production has important benefits for other measurements e.g. the measurement of the W mass based on the lepton transverse momentum. Furthermore Z^0 production is a major background to searches.

The muon tracks are detected and reconstructed with the DØ muon system. The event selection requires two oppositely charged muons identified by tracks in the central detector that are matched with tracks in the muon chambers. A cut ($p_\mathrm{T}(\mu_1) > 20\,\mathrm{GeV}$ and $p_\mathrm{T}(\mu_2) > 10\,\mathrm{GeV}$) on the transverse momenta of the muon tracks and the requirement that the tracks have to be isolated from other tracks in the central detector rejects the QCD-background. Cuts on the scintillation times and on the distance of closest approach of the muon track to the reconstructed vertex reduce the background from cosmic-ray muons.

Since the `GEANT` simulation incorporates an idealized geometry of the tracking system and some of the dead material is not completely implemented, the Monte Carlo (MC) simulation is tuned to describe the data by smearing of the transverse muon momenta. The resolution of these momenta is then improved by a constrained fit to the Z^0 mass.

The raw measurement of the $p_T(Z^0)$ has to be corrected for acceptance and resolution effects. Two methods, the *bin-by-bin* correction and a technique based on regularized unfolding have been applied to obtain the true distribution. The *bin-by-bin* correction is based on a scale factor ϵ_i, calculated from MC, which corrects the data in each bin i. Regularized unfolding is performed using the program *Run* [2], which uses a maximum likelihood fit including a regularization term to smoothen unwanted oscillations for the unfolding. The results of both methods are combined.

Figure 1 shows the measurement in the decay channel $Z^0 \rightarrow \mu^+\mu^-$ compared to the RunI measurement [3] in the decay channel $Z^0 \rightarrow e^+e^-$. To better compare both measurements the simulated distribution is shown for the bin widths used in RunI as well as for the bin widths of this analysis. As the default version of Pythia (LO parton shower simulation) with nominal parameters fails to accurately describe the data, the MC generator is tuned to the RunI measurement (also shown in Figure 1). To obtain a proper description of the transverse momentum in simulation, four parameters, which affect the distribution of the intrinsic transverse momenta of the partons inside the proton and the parton shower evolution, are varied. The resulting $p_T(Z^0)$ spectra are compared to the RunI measurement using a Kolmogorov test and the optimal value for each parameter is found by maximizing the Kolmogorov probability of the corresponding parameter.

Figure 1 shows good agreement between the two measurements within the errors. Also the tuned Pythia gives a good description over the entire $p_T(Z^0)$ range.

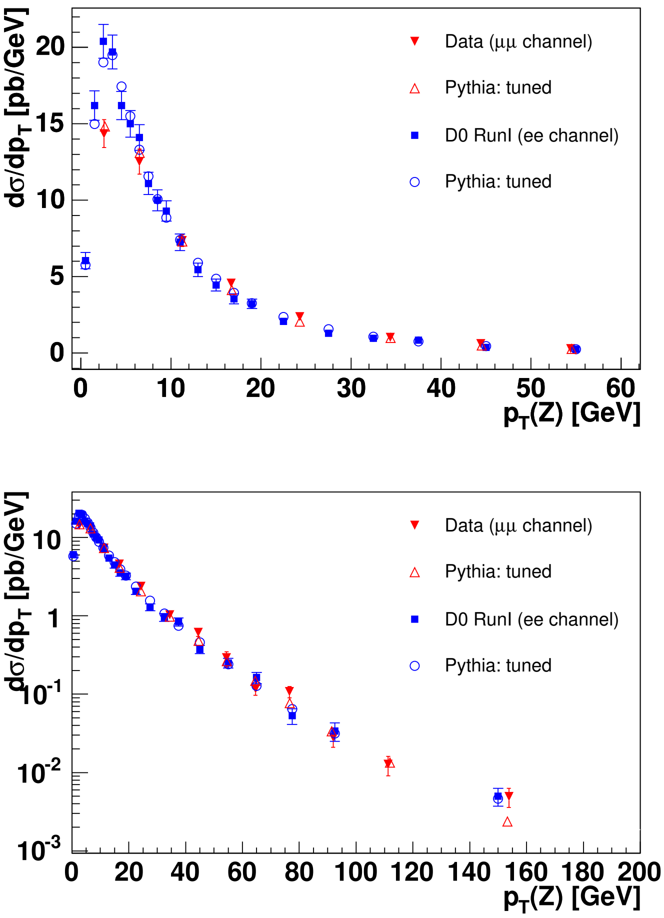

Fig. 1: The differential cross-section of the Z^0 boson as a function of $p_T(Z^0)$ (normalized to the result of the RunI measurement); Upper plot: linear scale $p_T(Z^0) < 60\,\mathrm{GeV}$; Lower plot: logarithmic scale full $p_T(Z^0)$ range

The ratio of the differential cross section $d\sigma/dp_T$ predicted by Pythia with the tuned and the default parameters, respectively, can be used to define weights by which the fully simulated MC samples, produced with the default parameter settings, can be reweighted according to the generated $p_T(Z^0)$ to match the tuned distributions.

References

[1] T. Christiansen *et al.*, Annual report 2000, p. 34.
[2] V. Blobel, OPAL Technical Note TN361 (1996).
[3] DØ Collaboration, B. Abbott *et al.*, Phys.Rev. **D61** (2000) 032004