Measurement of the Z/γ^* transverse momentum spectrum with ATLAS

Klemens Müller, On behalf of the ATLAS collaboration
University of Bonn, Physikalisches Institut
D-53115 Bonn, GERMANY

A measurement of the Z/γ^* transverse momentum (p_{T}^Z) in $\sqrt{s} = 7$ TeV proton-proton collisions at the LHC is presented. The measurement extends the range in p_{T}^Z up to 350 GeV using $Z \to e^+e^-$ and $Z \to \mu^+\mu^-$ decays collected with the ATLAS detector in data sets of $35\,\mathrm{pb}^{-1}$ and $40\,\mathrm{pb}^{-1}$, respectively.

1 Introduction

The study of the Z boson transverse momentum, relative to the beam axis, is sensitive to initial state quark and gluon radiation. It allows to test QCD predictions and phenomenological models. In addition the description of vector boson transverse momentum is crucial for measurement of the W mass. The approach to calculate the differential cross section in p_{T}^Z depends on the energy scale, given by p_{T}^Z. In the region of large $p_{\mathrm{T}}^Z \sim M_Z$, perturbative QCD calculations are expected to be reliable; however, these fixed order predictions diverge for vanishing p_{T}^Z. In the region of $p_{\mathrm{T}}^Z \ll M_Z$, the leading contribution to the cross section comes from multiple soft gluon emissions, which is treated by resummation of leading logarithms up to all orders in α_s. An alternate way to describe the low p_{T}^Z region is given by parton shower generators.

2 Selection of $Z \to \ell^+\ell^-$ Candidates

The measurement uses $Z \to e^+e^-$ and $Z \to \mu^+\mu^-$ decays in pp collisions at $\sqrt{s} = 7$ TeV collected with the ATLAS detector in data sets with integrated luminosity of $35\,\mathrm{pb}^{-1}$ and $40\,\mathrm{pb}^{-1}$ [1], respectively. Events were triggered requiring the presence of a single electron/muon with $p_{\mathrm{T}} > 15/18$ GeV. A preselection of events required at least one primary vertex to be reconstructed using at least 3 tracks. Z decays were selected by choosing events which contained a pair of oppositely charged electrons or muons with an invariant mass of $66 < m_{ll} < 116$ GeV. A common fiducial acceptance was chosen for electrons and muons given by $p_T > 20$ GeV and $|\eta| < 2.4$. Electron identification was based upon the shape of electromagnetic showers in the calorimeter and track quality criteria. Muons were reconstructed by identifying matching tracks from the inner detector and the muon spectrometer and combining the measurements. Muon tracks were required to originate from the primary vertex and to be isolated to suppress background from heavy flavour production. The selection yielded 8923 $Z \to e^+e^-$ and 15060 $Z \to \mu^+\mu^-$ candidate events [1].

3 Results and Conclusions

The differential cross section in p_{T}^{Z} was measured in the ee and $\mu\mu$ channels up to 350 GeV. The observed data were corrected for detector effects and QED final state radiation using correction factors per p_{T}^{Z} bin which were determined from PYTHIA signal MC. The differential cross section was normalized to the inclusive cross section in the fiducial volume, cancelling the luminosity uncertainty and uncertainties on total signal efficiencies. The $Z \to e^+e^-$ and $Z \to \mu^+\mu^-$ channels were combined with χ^2 minimization, taking into account correlated systematic errors, giving excellent agreement, with $\chi^2/\mathrm{dof} = 17.0/19$ [1].

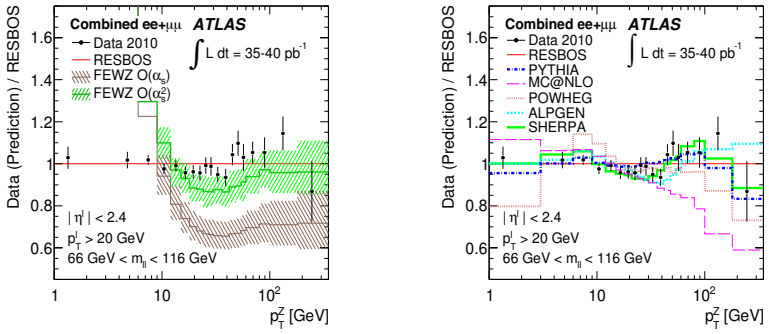

Figure 1: Ratios of the combined data and various predictions over the RESBOS prediction for the normalized differential cross section as a function of p_{T}^{Z}. Left: FEWZ predictions at $\mathcal{O}(\alpha_s)$ and $\mathcal{O}(\alpha_s^2)$; right: predictions from the generators PYTHIA, MC@NLO, POWHEG, ALPGEN, and SHERPA. The FEWZ predictions are shown with combined scale, α_s, and PDF uncertainties. The data points are shown with combined statistical and systematic uncertainty. At low p_{T}^{Z} the $\mathcal{O}(\alpha_s)$ and $\mathcal{O}(\alpha_s^2)$ predictions of FEWZ diverge and are omitted.

The observed normalized differential cross section was compared with the various types of predictions. The ratio of the data and the predictions over the RESBOS prediction is shown in Fig. 1. Fixed order perturbative QCD predictions, as provided by FEWZ at $\mathcal{O}(\alpha_s)$ and $\mathcal{O}(\alpha_s^2)$, describe the data for $p_{\mathrm{T}}^{Z} > 18$ GeV within the scale uncertainty. Resummation of leading logarithms matched to fixed order pQCD calculations as implemented in RESBOS give good agreement over the entire p_{T}^{Z} range. This shows the importance of resummation at relatively high p_{T}^{Z}. Various event generators are available that use fixed order matrix element calculations for the hard process matched with parton showers. ALPGEN and SHERPA implement tree level matrix elements for Z boson production in association with up to 5 hard partons, matched to parton showers. Both give good description of the data over the entire spectrum. The generators MC@NLO and POWHEG deviate from data at low and high p_{T}^{Z}, while Pythia describes well the measurement over the entire range.

References

[1] The ATLAS Collaboration, "Measurement of the transverse momentum distribution of Z/γ^* bosons in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector", Phys. Lett. B **705** 415-434 (2011)