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Klemens Müller, for the ATLAS Collaboration
universitätbonn

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

Why measure Z p_T?

In hadron collisions the Z boson is produced with a non zero transverse momentum relative to the beam axis, p_T, mainly due to initial state quark or gluon radiation. Thus, the Z-p_T allows to probe QCD predictions and phenomenological models. Fixed order perturbative QCD predictions are expected to describe the high p_T region where the cross section is dominated by radiation of a single hard parton. At low p_T, multiple soft gluon emission becomes important, which can be approximated by resummation of leading logarithms to all orders in α_s or modeled by parton shower generators.

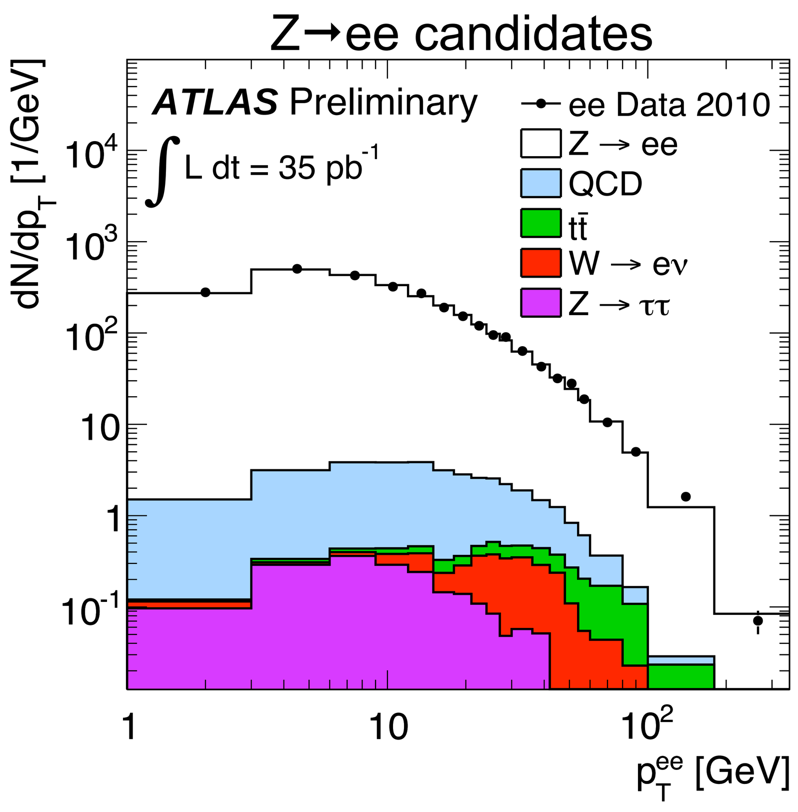
Selection of Z→ll candidates

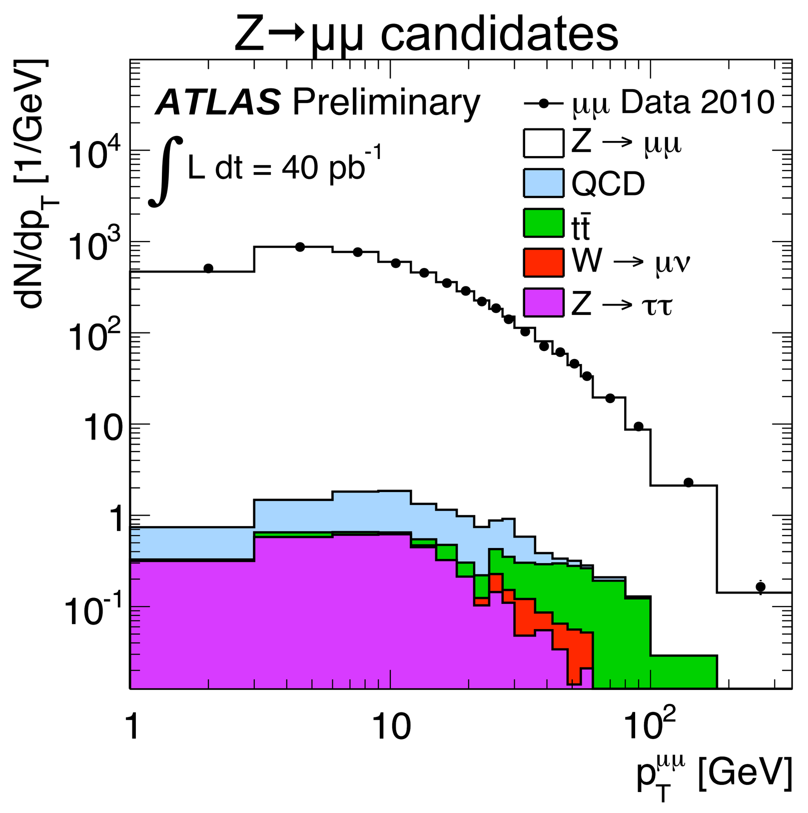
7TeV pp collisions with integrated luminosity 35/40pb^{-1} in ee/μμ channel

Collision event candidates: a primary vertex reconstructed by at least 3 tracks
Trigger: single electron/muon trigger p_T>15/13GeV (fully efficient for di-electron, 97.7% efficient for di-muon, flat in p_T of Z)
Z candidates:
- 2 oppositely charged electrons or muons
- Invariant mass 66GeV<m^{ll}<116GeV
- Common acceptance for electrons, muons: p_T>20GeV, |η|<2.4

Electrons:
- Reconstructed from energy deposits in calorimeter matched to inner detector tracks.
- Identification selection based on shower shape and track quality variables to provide rejection against hadrons.
- Transition region between endcap and barrel calorimeter excluded.

Muons:
- Identified by matching tracks in the inner detector and muon spectrometer.
- Track parameters from combined measurement.
- Originating from primary vertex.
- Track based isolation.





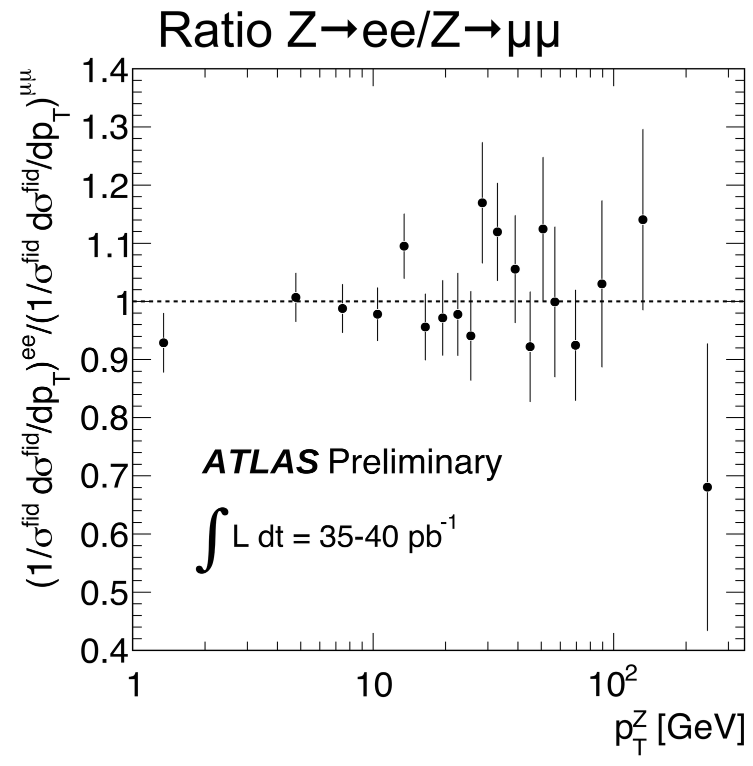
Backgrounds

Z→ττ, W→lν , tt production: estimated from simulation and NNLO or NNL-NLO cross section predictions. 0.3% in the ee-channel, 0.2% in the μμ-channel.
QCD multijet production: estimated from data driven methods. (1.2±0.6)% in the ee-channel, (0.2±0.2)% in the μμ-channel.

Differential cross section measurement

Observed data are corrected for detector effects and QED FSR using correction factors per p_T bin which are determined from MC. The measured differential cross section is normalised to the inclusive cross section in the fiducial volume. The measurement is limited by statistics except for the first two bins where the systematic error is slightly larger.

Combination: The Z→ee and Z→μμ channels are combined with χ^2 minimization, taking into account correlated systematic errors, giving excellent agreement, with χ^2/dof = 17.0/19.

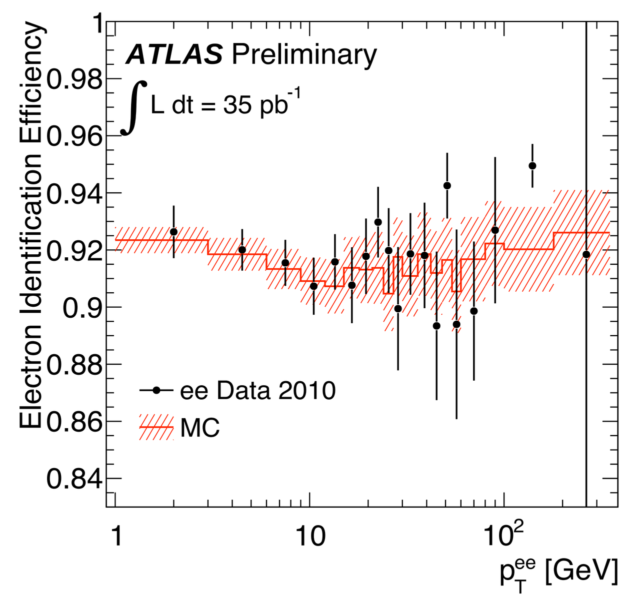


Systematic uncertainties

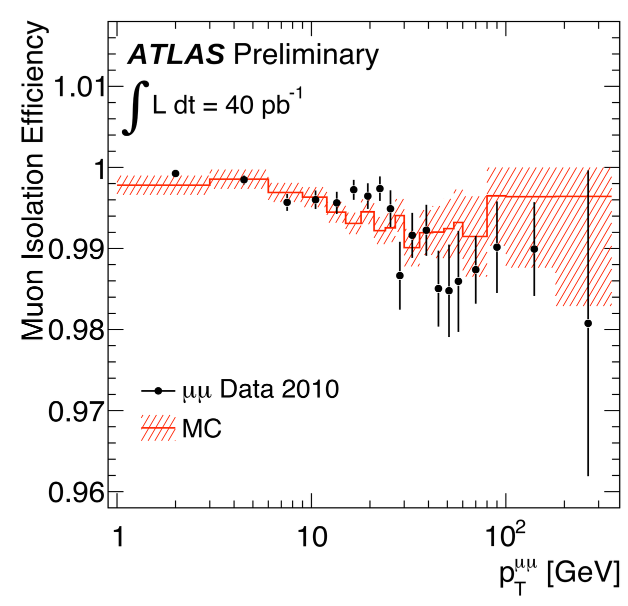
Lepton reconstruction and identification: Z p_T dependence of efficiencies determined with tag-and-probe method.
Lepton momentum (energy) scale and resolution: scale and resolution corrections of simulation are varied within their uncertainties estimated from fit to Z line shape.
Unfolding procedure: correction factors depend on shape of assumed underlying p_T distribution, evaluated by unfolding MC samples reweighted to different true Z p_T distributions (RESBOS, MC@NLO and data unfolded with matrix method).

Uncertainty on normalized cross section	Low p_T (ee/μμ)	High p_T (ee/μμ)
Lepton reconstruction and identification	1%	5%
Lepton energy/momentum scale, resolution	2.7% / 0.7%	4% / 0.1%
Unfolding procedure	3.6% / 4.7%	4.2% / 2.9%

Electron Identification Eff.



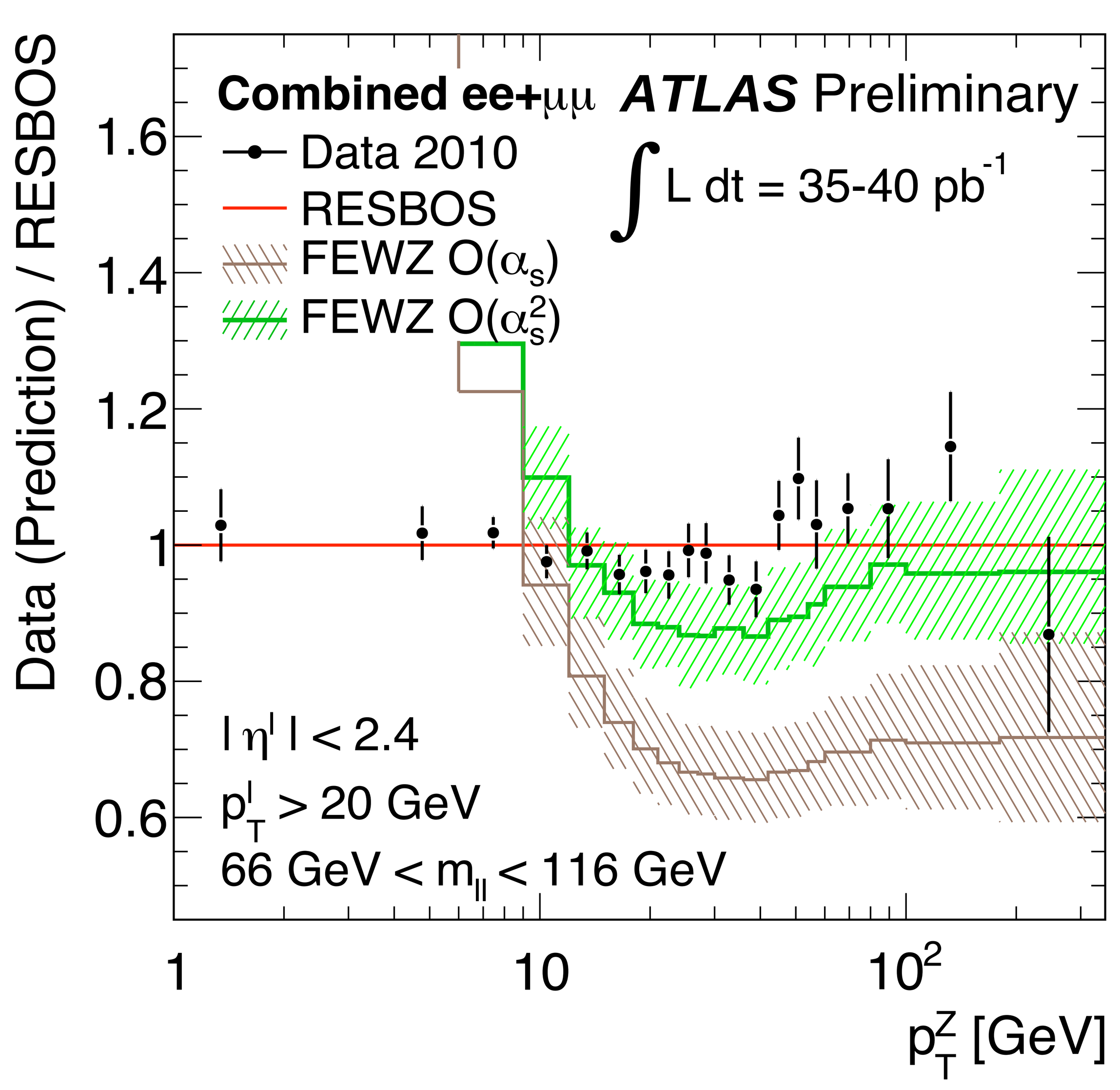
Muon Isolation Efficiency



Results 1: Comparison with QCD predictions

FEWZ, which provides perturbative QCD predictions at fixed order $O(\alpha_s)$ and $O(\alpha_s^2)$, describes the data for p_T>18GeV within the scale uncertainty.

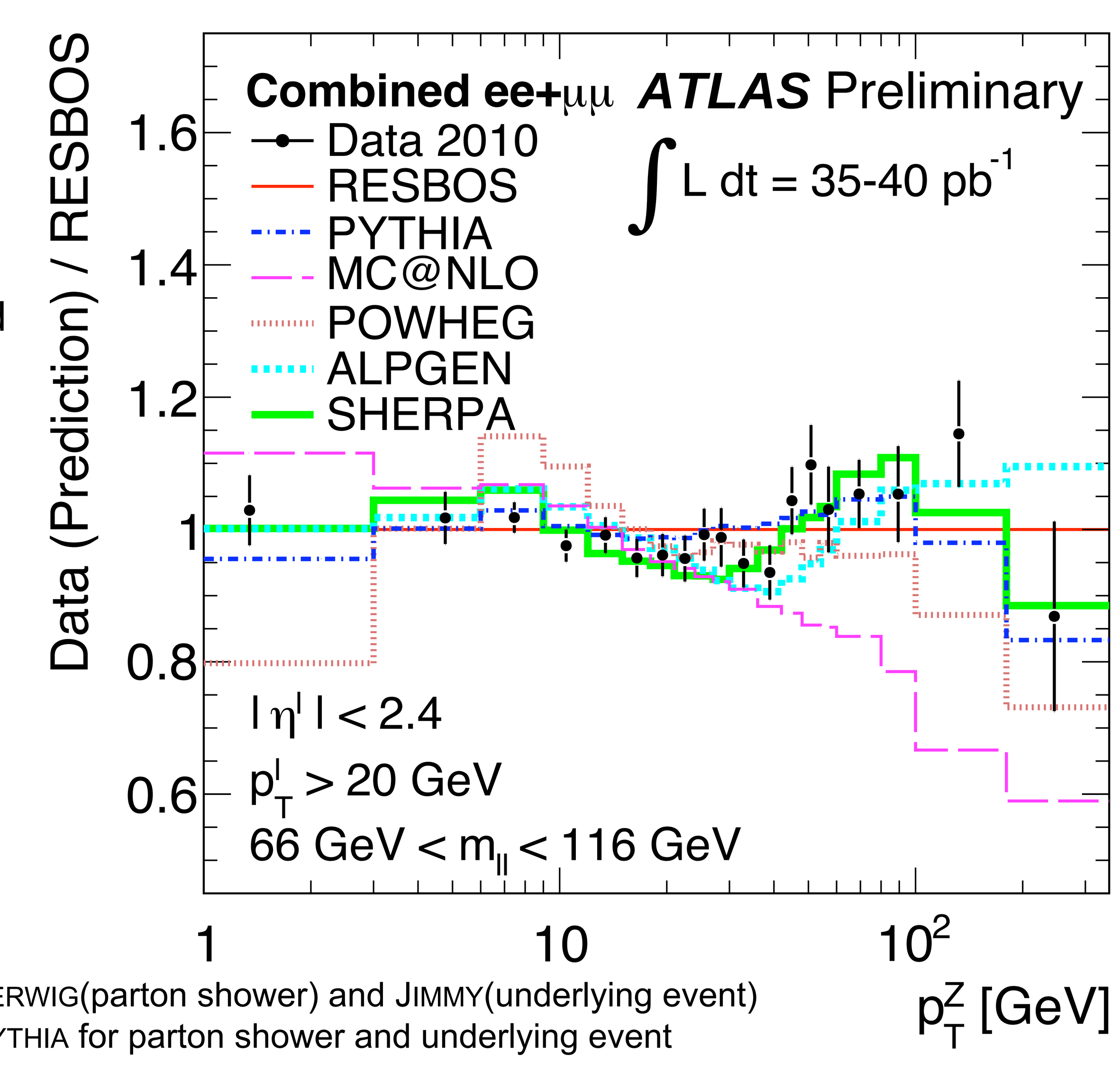
RESBOS combines resummed and fixed order pQCD calculations, it gives good agreement over entire p_T range, showing the importance of resummation also at relatively high p_T.



Results 2: Comparison with event generators

ALPGEN and **SHERPA** implement tree level matrix elements for Z boson production in association with up to 5 hard partons, matched to parton showers. Give good description over entire spectrum.

Parton shower event generators **MC@NLO*** and **POWHEG**** deviate from data at low and high p_T, while **PYTHIA** describes well the measurement over the entire range.



* MC@NLO is interfaced to HERWIG(parton shower) and JIMMY(underlying event)
** POWHEG is interfaced to PYTHIA for parton shower and underlying event

References: "Measurement of the transverse momentum distribution of Z/γ* bosons in proton-proton collisions at √s = 7 TeV with the ATLAS detector" - under final collaboration review