W/Z boson production in leptonic final states at the ATLAS experiment

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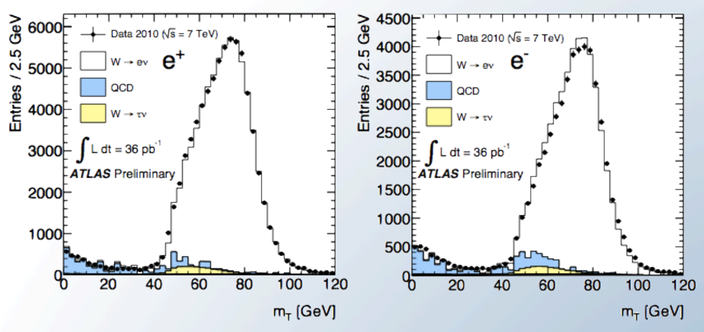
The Drell-Yan production cross sections of W and Z bosons are an important testing ground for Quantum Chromodynamics: their study is a strong benchmark for testing next-to-leading order theoretical calculations and constraining the proton parton distribution functions (PDFs). W and Z are standard high p_T candles, which can be used to study lepton reconstruction performances and whose production rate can be used for luminosity measurement. Furthermore, a full understanding of electroweak signatures is a necessary step towards new physics searches.

With the complete p-p collision data at 7 TeV collected in 2010 (~35 pb^{-1}), the ATLAS Collaboration measured the W and Z/γ^* $\sigma_{tot} = \sigma_{W/Z} \times BR(W/Z \to l\nu/ll) = \frac{N - B}{A_{W/Z} \cdot C_{W/Z} \cdot L_{int}}$ in final states with muons or electrons, where N is the number of candidate events measured in data, B the number of background events, $C_{W/Z}$ is the selection efficiency in the fiducial region, measured from data, $A_{W/Z}$ is a term accounting for the extrapolation to the full kinematic region (obtained from PYTHIA). Fiducial regions are defined in Table 1.

W→eν

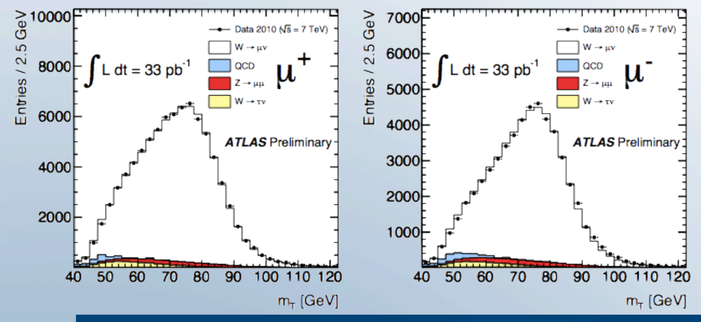
72207 W⁺ candidates
49103 W⁻ candidates



- primary vertex with ≥3 tracks;
- request one tight electron with E_T > 20 GeV in fiducial region;
- request MET > 25 GeV;
- m_T > 40 GeV;
- EW backgrounds (MC): W→τν (2.6%), ttbar (0.4%), Z→ττ (0.17%), Z→ee (0.16%), diboson (0.12%);
- QCD background [2.6% for W⁺, 4.3% for W⁻]: template fit to MET distribution (control sample from data without MET requirement and inverting electron identification criteria);
- systematic uncertainty on QCD from template variation [5%].

W→μν

84103 W⁺ candidates
55163 W⁻ candidates



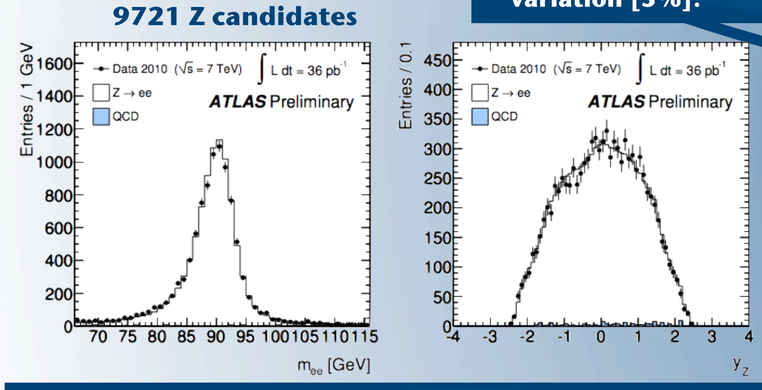
- primary vertex with ≥3 tracks, cosmic rejection;
- request a combined (ID + MS) muon with p_T > 20 GeV in fiducial region closer than 1 cm to PV;
- muon track isolation requirement ($\sum p_T/pT(\mu)$ < 0.2 in a ΔR < 0.4 cone);
- request MET > 25 GeV;
- m_T > 40 GeV;
- EW backgrounds (MC): Z→μμ (3.5%), W→τν (2.8%), ttbar (0.4%), Z→ττ (0.1%), diboson (0.1%);
- QCD background [1.7±0.2±0.7%]: extrapolated from control regions defined reversing isolation and MET requirements.

$W \to e\nu$:	$p_{T,e} > 20$ GeV, $\lvert\eta_e\rvert < 2.47$ excluding $1.37 < \lvert\eta_e\rvert < 1.52$, $p_{T,\nu} > 25$ GeV, $m_T > 40$ GeV
$W \to \mu\nu$:	$p_{T,\mu} > 20$ GeV, $\lvert\eta_\mu\rvert < 2.4$, $p_{T,\nu} > 25$ GeV, $m_T > 40$ GeV
$Z \to ee$:	$p_{T,e} > 20$ GeV, both $\lvert\eta_e\rvert < 2.47$ excluding $1.37 < \lvert\eta_e\rvert < 1.52$, $66 < m_{ee} < 116$ GeV
Forward $Z \to ee$:	$p_{T,e} > 20$ GeV, one $\lvert\eta_e\rvert < 2.47$ excluding $1.37 < \lvert\eta_e\rvert < 1.52$, other $2.5 < \lvert\eta_e\rvert < 4.9$, $66 < m_{ee} < 116$ GeV
$Z \to \mu\mu$:	$p_{T,\mu} > 20$ GeV, both $\lvert\eta_\mu\rvert < 2.4$, $66 < m_{\mu\mu} < 116$ GeV

Table 1: fiducial regions

Z→ee

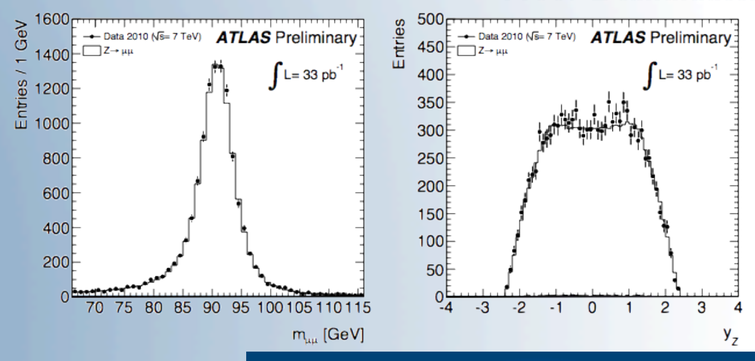
9721 Z candidates



- primary vertex with ≥3 tracks;
- request two opposite charged medium electrons with E_T > 20 GeV in fiducial region;
- 66 < m_{ee} < 116 GeV;
- EW backgrounds (MC): W→eν, Z→ττ, ttbar W→τν (total 0.3%), diboson (0.2%);
- QCD background [1.8%]: template fit to m_{ee} distribution of a control sample with reduced background rejection;
- systematic uncertainty on QCD varying electron identification criteria, background fit functions and fit ranges [18%].

Z→μμ

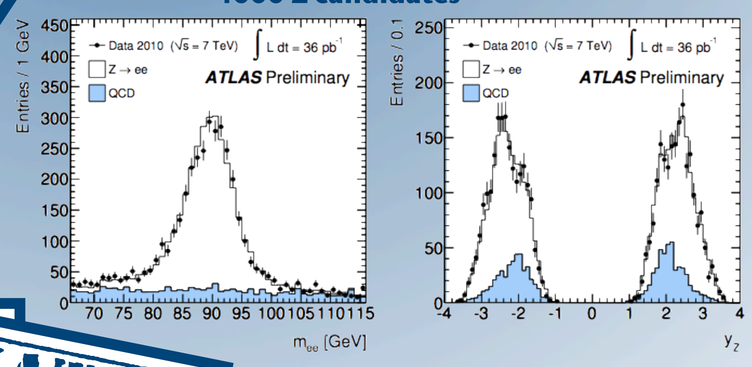
11669 Z candidates



- primary vertex with ≥3 tracks, cosmic rejection;
- request 2 combined (ID + MS) muons with p_T > 20 GeV in fiducial region closer than 1 cm to PV;
- muon track isolation requirement ($\sum p_T/pT(\mu)$ < 0.2 in a ΔR < 0.4 cone);
- 66 < $m_{\mu\mu}$ < 116 GeV;
- EW backgrounds (MC): W→μν (0.006%), ttbar (0.1%), Z→ττ (0.07%), diboson (0.2%);
- QCD background [0.22±0.16±0.09%]: extrapolated from control regions and corrected for signal and EW background contamination;
- systematic uncertainty on QCD obtained varying isolation definition, regions boundaries and propagating uncertainties in EW background subtraction.

forward Z→ee

4000 Z candidates



- primary vertex with ≥3 tracks
- request one tight electron with E_T > 20 GeV in fiducial region;
- request an electron in 2.5 < |η| < 4.9 (calorimeter information only, no charge requirements);
- 66 < m_{ee} < 116 GeV;
- EW backgrounds [2.0%]: mainly from W→eν plus a forward jet faking an electron;
- total background obtained fitting m_{ee} distribution [27.5±0.7±3.1%].

MAIN SYSTEMATICS

- luminosity [3.4%];
- MET resolution and scale [2%];
- acceptance (different PDF and generator choices) [~3/4%];

Electrons

- W: reconstruction [1.5%] and identification [1.1%];
- Z: reconstruction [3%] and identification [1.6%];

Forward Electrons

- Z: identification [8.2%], background [3.2%] and pile-up [1.7%];

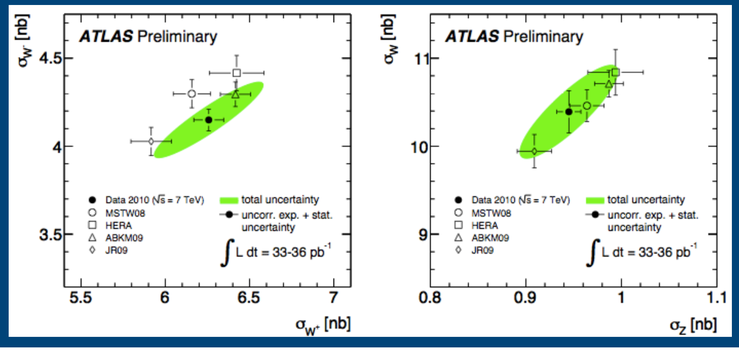
Muons

- W: QCD background [0.8%];
- Z: reconstruction [0.8%] and isolation [0.6%];

Combined results

Combining W and Z cross section measurements allows to compare the results with the QCD calculation for the PDF.
Electron and muon channels results are combined treating acceptance, luminosity and (for W) missing transverse energy uncertainties as fully correlated and all others as uncorrelated.
Within the respective uncertainties, the NNLO prediction based on the different PDF sets available at NNLO is compatible with ATLAS measurement.

	$\sigma^{tot}_{W^{(\pm)}} \cdot BR(W \to l\nu)$ [nb]
W^+	$6.257 \pm 0.017(sta) \pm 0.152(sys) \pm 0.213(lum) \pm 0.188(acc)$
W^-	$4.149 \pm 0.014(sta) \pm 0.102(sys) \pm 0.141(lum) \pm 0.124(acc)$
W	$10.391 \pm 0.022(sta) \pm 0.238(sys) \pm 0.353(lum) \pm 0.312(acc)$
	$\sigma^{tot}_{Z/\gamma^*} \cdot BR(Z/\gamma^* \to ll)$ [nb], $66 < m_{ll} < 116$ GeV
Z/γ^*	$0.945 \pm 0.006(sta) \pm 0.011(sys) \pm 0.032(lum) \pm 0.038(acc)$



Also the ratio between the W and Z cross section is shown. Under the assumption that the proton sea content is flavor symmetric, the ratio of the two cross sections is a rather PDF insensitive quantity.
The results obtained are consistent with the predictions, thus supporting the assumption of a flavor independent quark sea.

Precision on fiducial cross sections reaches 4.4% [W→lν] / 3.6% [Z→μμ] / 5.1% [Z→ee] and is dominated by luminosity uncertainty.

Ratio	Data
W^+/Z	$6.563 \pm 0.049(sta) \pm 0.134(sys) \pm 0.098(acc)$
W^-/Z	$4.345 \pm 0.034(sta) \pm 0.095(sys) \pm 0.065(acc)$
W/Z	$10.906 \pm 0.079(sta) \pm 0.215(sys) \pm 0.164(acc)$