Draft version 0.40

ATLAS NOTE

ATL-COM-PHYS-2013-217

November 15, 2013

Measurement and QCD Analysis of Differential Inclusive $W^{\pm} \to \ell\nu$ and $Z \to \ell\ell$ Production and Leptonic Decay Cross Sections with ATLAS

Bachas, K[1], Bellomo, M[2], Bührer, F[3], Camarda, S[5], Cooper-Sarkar, A[4], Dassoulas, J[5], Hickling, R S[6], Ellinghaus, F[7], Issever, C[4], Jeske, C T[8], Froidevaux, D[2], Iconomidou-Fayard, L[9], Glazov, A[5], Guillemin, T[9], Kapliy, A[10], Karnevskiy, M[7], Klein, M[11], Klein, U[11], Kretzschmar, J[11], Kono, T[12], Lewis, A[4], Lohwasser, K[3], Lisovyi, M[5], Matsushita, T[13], Maurer, J[14], Onyisi, P[15], Richter-Was, E[16], Rizvi, E[6], Radescu, V[5], Sommer, P[3], Sedov, G[5], Serre, T[14], Schaffer, A[9], Schmitt, S[17], Sendler, J[7], Shochet, M[10], Tseng, J[4], Vincter, M[18], Wielers, M[19], Yatsenko, E[5]

Towards the Paper – M.Klein with M.Bellomo and J.Kretzschmar for the W,Z 11 Team

663 pages
of support
3678 lines

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CERN
6.12.13
WZ Meeting

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WZ Meeting

Measurement and QCD analysis of differential inclusive $W^{\pm} \to \ell\nu$ and $Z/\gamma^{*} \to \ell\ell$ production and leptonic decay cross sections with ATLAS

STDM-2012-20

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Corresponding editor(s)

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A list of supporting internal notes and their authors can be found at:
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/WZGroupInclusiveMeasurement

Supporting internal notes

COM-PHYS-2013-217 https://cds.cern.ch/record/1517987

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Comments are due by: Comments deadline

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←stick to PRD (format)

This week:
informed Edboard that:

muons ready,
electrons: G4, MCd11, ey…
..combination
..theory predictions
..QCD fits – all being done
Support note:
available for evaluation

paper draft – end of February

Abstract – 2010 W,Z Paper

CERN-PH-EP-2011-143
Submitted to Phys. Rev. D

Measurement of the inclusive $W^{\pm}$ and Z/γ^{*}cross sections in the e and μ decay channels in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

The ATLAS Collaboration*
(Dated: December 6, 2011)

The production cross sections of the inclusive Drell-Yan processes $W^{\pm} \to \ell\nu$ and $Z/\gamma^{*} \to \ell\ell$ ($\ell = e, \mu$) are measured in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector. The cross sections are reported integrated over a fiducial kinematic range, extrapolated to the full range and also evaluated differentially as a function of the W decay lepton pseudorapidity and the Z boson rapidity, respectively. Based on an integrated luminosity of about $35\,\mathrm{pb}^{-1}$ collected in 2010, the precision of these measurements reaches a few per cent. The integrated and the differential $W^{\pm}$ and Z/γ^{*} cross sections in the e and μ channels are combined, and compared with perturbative QCD calculations, based on a number of different parton distribution sets available at NNLO.

PACS numbers: 12.38.Qk, 13.38.Be, 13.38.Dg, 13.85.Qk, 14.60.Cd, 14.60.Ef, 14.70.Fm, 14.70.Hp

arXiv:1109.5141v3 [hep-ex] 5 Dec 2011

Phys.Rev. D85 (2012) 072004, 119 citations [Higgs has 2000 today]

Abstract : Strange quark paper 12

Determination of the strange quark density of the proton from ATLAS measurements of the $W \to \ell\nu$ and $Z \to \ell\ell$ cross sections

The ATLAS Collaboration
(Dated: July 9, 2012)

A QCD analysis is reported of ATLAS data on inclusive $W^{\pm}$ and Z boson production in pp collisions at the LHC, jointly with ep deep inelastic scattering data from HERA. The ATLAS data exhibit sensitivity to the light quark sea composition and magnitude at Bjorken $x \sim 0.01$. Specifically, the data support the hypothesis of a symmetric composition of the light quark sea at low x. The ratio of the strange-to-down sea quark distributions is determined to be $1.00^{+0.25}_{-0.28}$ at absolute four-momentum transfer squared $Q^2 = 1.9$ GeV^2 and $x = 0.023$.

PACS numbers: 12.38.Qk, 13.38.Be, 13.38.Dg, 13.85.Qk

Phys.Rev.Lett. 109 (2012) 012001 46 citations

Abstract: New Paper

Measurement and QCD analysis of differential inclusive $W^{\pm} \to \ell\nu$ and $Z/\gamma^{*} \to \ell\ell$ production and leptonic decay cross sections with ATLAS

The ATLAS Collaboration*

(Dated: December 6, 2013)

This paper presents new measurements of $W^{\pm} \to \ell\nu$ and $Z/\gamma^{*} \to \ell\ell$ ($\ell = e, \mu$) inclusive cross sections based on proton-proton collisions at $\sqrt{s} = 7$ TeV with an integrated luminosity of 4.7 fb^{-1}, collected with the ATLAS detector in 2011. The double differential Z/γ^{*} cross sections are measured as a function of the boson rapidity, in intervals of di-lepton mass from 46 to 150 GeV. The charge dependent differential W production cross sections are provided in bins of lepton-pseudorapidity. The data are also presented as integrated cross sections, in the fiducial region of the measurement and extrapolated to full phase space, and the lepton transverse momentum dependencies are also investigated. The distributions for the main observables are compared to Monte Carlo simulations. Results obtained separately for the electron and muon channels are combined and compared to predictions computed at NNLO QCD for different sets of parton distribution functions, integrated over transverse momentum. The measured $W^{\pm}$ and Z/γ^{*} cross sections are input to a dedicated NNLO QCD analysis also using HERA data. New constraints are obtained on the parton distributions in the proton, including an improved determination of the strange quark density.

Combination of the W,Z cross section measurements, one extra dimension, +QCD Fit

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A. Plots to be approved and used at conferences

IV – Electron and Muon Measurements

III. Electron and muon measurements
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  1. Event selection
  2. Muon reconstruction - performance
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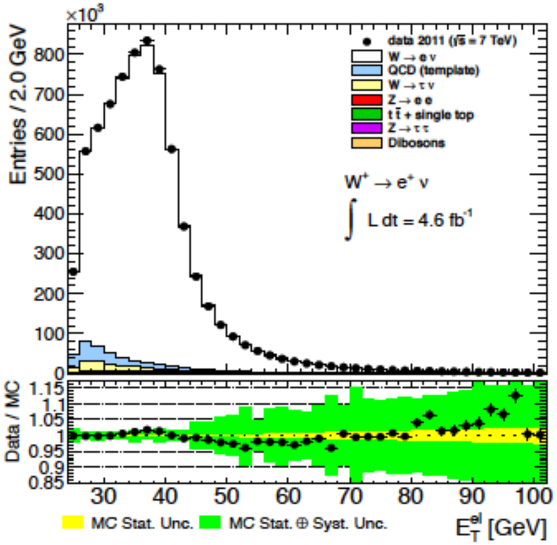
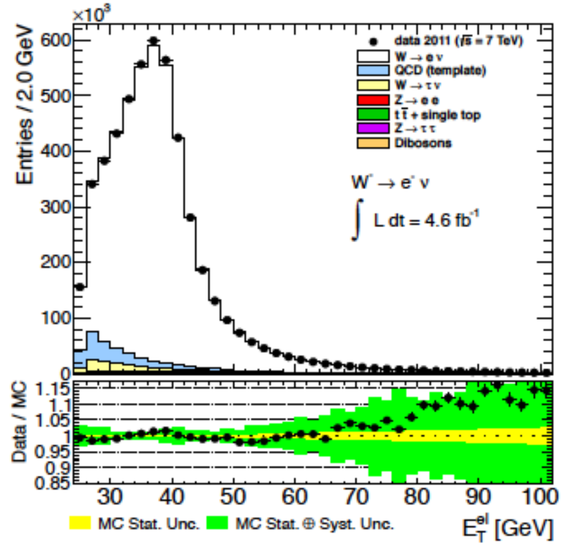
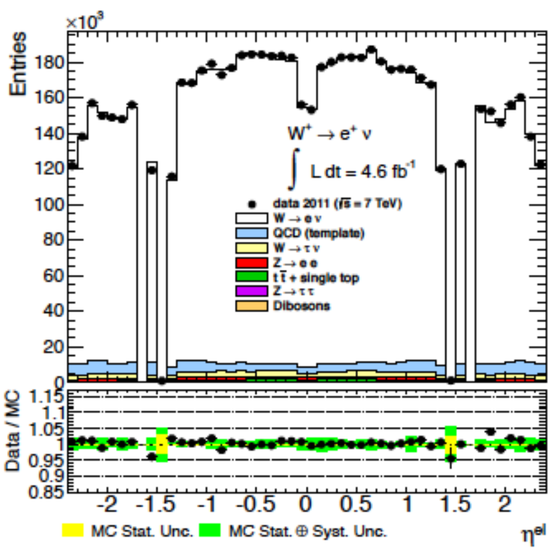
Control plots



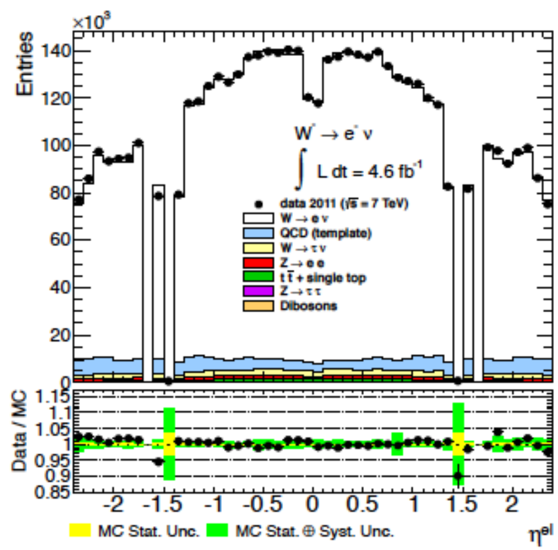
(a) E_T : e^+



(b) E_T : e^-

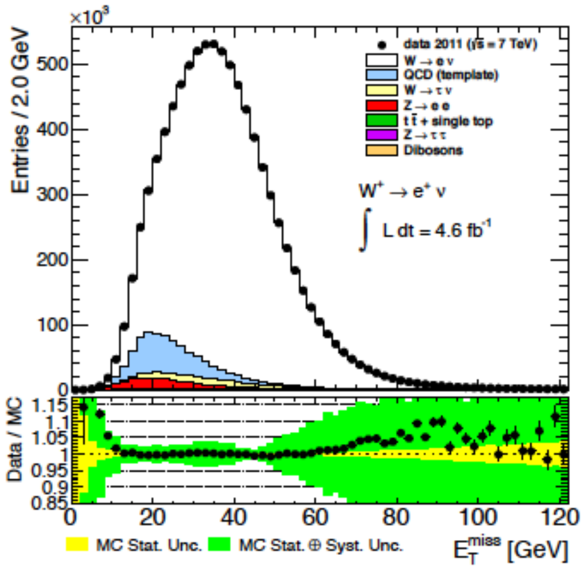


(c) η : e^+

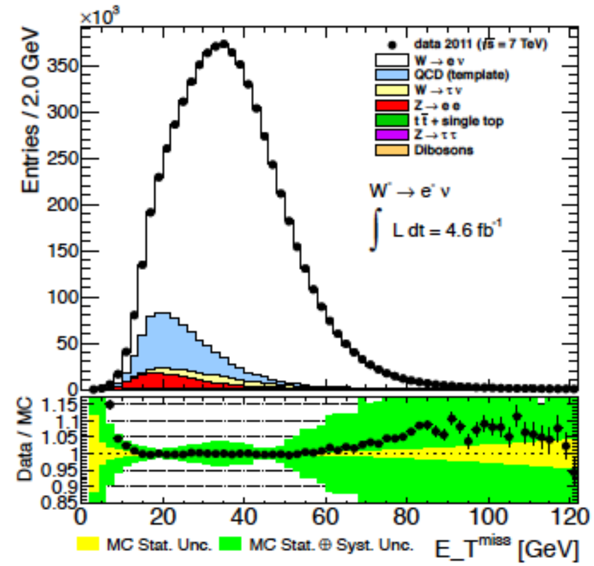


(d) η : e^-

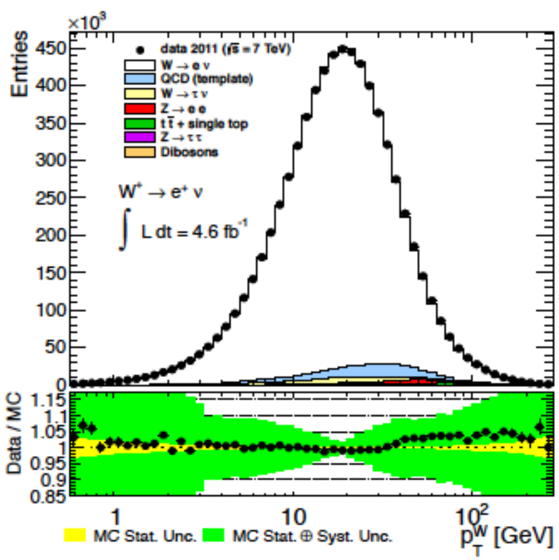
Control plots



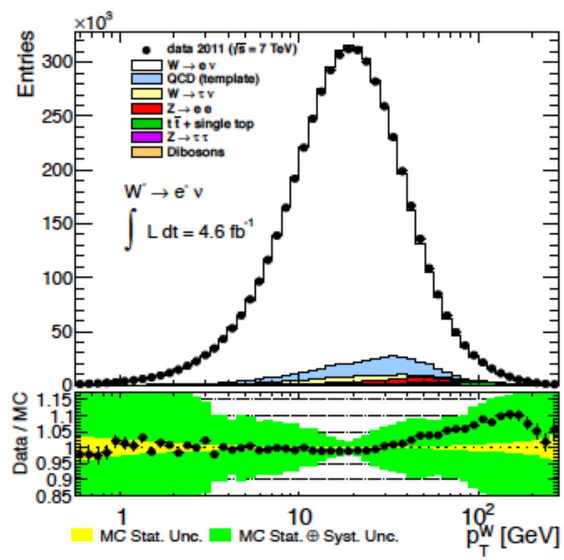
(a) E_T^{miss} : W^+



(b) E_T^{miss} : W^-



(e) p_T^W : W^+



(f) p_T^W : W^-

Also muons, Z plots

(8 + 4)*2

24 plots?

IV – Cross section results

IV. Cross section results
- A. Analysis procedure
- B. Cross section measurements
  - 1. Electron channels
  - 2. Muon channels
- C. Combined electron and muon cross sections
  - 1. Data combination
  - 2. Integrated cross sections
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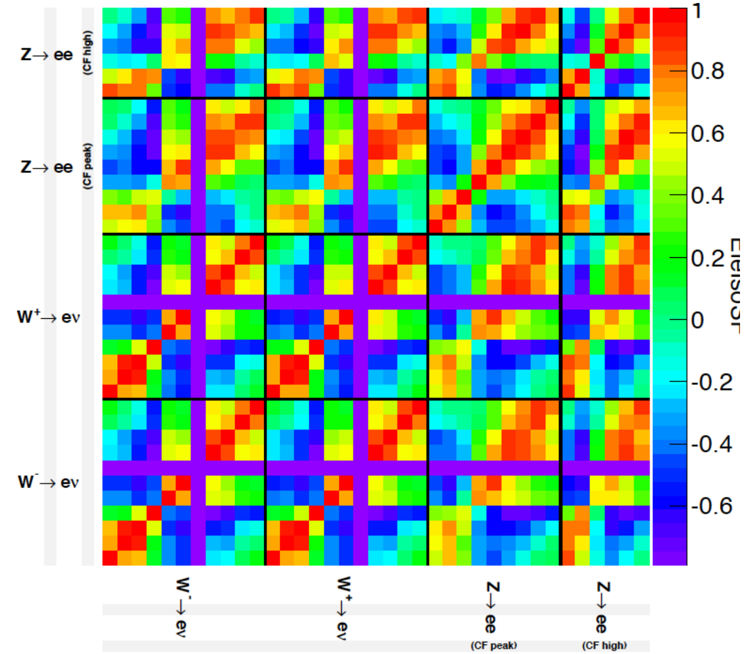
Data Combination

	Channel				
Uncertainty Source	$W\to e\nu$	$Z\to ee$	$Z\to ee$ (CF)	$W\to\mu\nu$	$Z\to\mu\mu$
Lepton Energy (Momentum) Scale	1	1	1	2	2
Electron Energy Resolution	3	3	3	–	–
Muon Momentum Resolution (ID)	–	–	–	4	4
Muon Momentum Resolution (MS)	–	–	–	5	5
Muon Curvature	–	–	–	6	6
Electron Charge MisID	7	–	–	–	–
Jet Energy Scale	8	–	–	8	–
Jet Resolution	9	–	–	9	–
MET Energy Scale	10	–	–	10	–
MET Resolution	11	–	–	11	–
Electron ID Tight SF	13	13	13	–	–
Electron Fwd ID SF	–	–	14	–	–
Lepton Trigger SF	15	16	15	17	17
Lepton Reco SF	18	18	18	19	19
Lepton Iso SF	20	–	20	21	21
Boson Pt Reweighting	23	23	23	23	23
TheoryME	24	24	24	24	24
TheoryPS	25	25	25	25	25
TheoryPDF	26	26	26	26	26
Pileup Rescaling	27	27	27	27	27
Background (EWK)	28	28	43	28	28
Background (Multijet)	29	30	31	32	33
Electron ID Tight SF (stat)	u36	u36	u36	–	–
Electron Fwd ID SF (stat)	–	–	u37	–	–
Electron Trigger SF (stat)	u38	u39	u38	–	–
Electron Reco SF (stat)	u40	u40	u40	–	–
Electron Iso SF (stat)	u41	–	u41	–	–
Muon SF (stat)	–	–	–	u42	u42
Background Statistical Uncertainty	u	u	u	u	u
Extrap. ME	34	34	34	34	34
Extrap. PS	35	35	35	35	35
Extrap. Uncor.	u	u	u	u	u

Table 133: Summary of the correlations for the uncertainties. Each number represents a nuisance parameter. Cells with a shared nuisance parameter are treated as correlated, whereas cells containing *u* are treated as uncorrelated. *uN* represents an uncertainty which is uncorrelated bin-to-bin, but correlated across cells with the same *N*.



$$\chi^2(\vec{m},\vec{b}) = \sum_{k,i} \frac{[m_i - (\mu_k^i + \sum_j \gamma_{j,k}^i m^i b_j)]^2}{(\Delta_k^i)^2} + \sum_j b_j^2 \quad (5)$$

with

$$(\Delta_k^i)^2 = (\delta_{sta,k}^i)^2 \mu_k^i (m^i - \sum_j \gamma_{j,k}^i m^i b_j) + (\delta_{unc,k}^i m^i)^2.$$

Will want to provide detailed information, many tables, but cannot publish all the beauty..

$y_{min}-y_{max}$	0.00–0.20	0.20–0.40	0.40–0.60	0.60–0.80	0.80–1.00	1.00–1.20	1.20–1.40	1.40–1.60	1.60–1.80	1.80–2.00	2.00–2.20	2.20–2.40	2.40–2.80	2.80–3.20	3.20–3.60
$d\sigma/dy$ [pb]	133.45	133.06	132.82	131.77	131.36	129.32	126.82	125.48	122.9	119.69	114.83	110.27	98.504	72.096	43.997
δ_{sta}, %	0.18498	0.18494	0.18702	0.19247	0.19053	0.19907	0.20189	0.21423	0.22946	0.25656	0.30868	0.37489	0.33129	0.48088	1.1438
δ_{unc}, %	0.090892	0.080804	0.075377	0.081086	0.082161	0.080193	0.075146	0.079085	0.085494	0.11425	0.15613	0.21685	0.57096	0.93769	2.3726
δ_{cor}, %	0.259836	0.261868	0.26685	0.266621	0.27522	0.278769	0.300792	0.321918	0.45023	0.607066	0.664363	0.597885	1.1709	4.40205	5.4311
δ_{tot}, %	0.331653	0.330616	0.334466	0.338684	0.344671	0.351812	0.369976	0.39469	0.512512	0.668883	0.749025	0.738264	1.34415	4.52643	6.03609
γ_{1}, %	0.002	0.002	0.003	0.001	-0.002	-0.005	-0.006	-0.005	-0.002	0.006	-0	-0.002	-0.01	-0.124	-0.213
γ_{2}, %	0.067	0.068	0.067	0.068	0.071	0.072	0.077	0.08	0.082	0.084	0.089	0.096	0.117	0.258	0.23
γ_{3}, %	-0.012	-0.015	-0.013	-0.016	-0.02	-0.025	-0.03	-0.032	-0.034	-0.037	-0.044	-0.039	-0.013	-0.012	0.023
γ_{4}, %	-0.031	-0.031	-0.028	-0.026	-0.023	-0.018	-0.017	-0.013	-0.011	-0.007	-0.008	-0.003	-0.009	-0.043	-0.077
γ_{5}, %	-0.02	-0.016	-0.018	-0.018	-0.016	-0.014	-0.019	-0.016	-0.011	-0.006	-0.011	-0.007	0.001	-0.028	-0.015
γ_{6}, %	0.016	0.013	0.013	0.011	0.008	0.004	0.004	0.001	-0.003	-0.006	-0.009	-0.009	0.021	0.152	0.19
γ_{7}, %	-0.018	-0.018	-0.018	-0.018	-0.016	-0.015	-0.02	-0.023	-0.022	-0.022	-0.021	-0.023	-0.032	-0.058	-0.068
γ_{8}, %	0.035	0.036	0.033	0.033	0.035	0.03	0.027	0.025	0.024	0.019	0.014	0.001	0.001	0.024	0.033
γ_{9}, %	0.004	0.003	0.001	-0	-0.003	-0.007	-0.006	-0.01	-0.017	-0.025	-0.03	-0.041	-0.012	0.078	0.139
γ_{10}, %	-0.001	0.002	0.002	0.003	0	0.001	-0.003	-0.005	-0.004	0.001	-0.001	-0.01	-0.029	-0.099	-0.104
γ_{11}, %	-0.005	-0.004	-0.004	-0.004	-0.002	-0.002	-0.003	-0	0.007	0.014	0.014	0.016	0.024	0.069	0.081
γ_{12}, %	-0.005	-0.002	-0.003	-0.001	0.002	0.003	0.003	0.008	0.012	0.012	0.014	0.025	0.031	0.074	0.062
γ_{13}, %	0.014	0.015	0.016	0.015	0.015	0.016	0.017	0.017	0.017	0.015	0.012	0.008	0.006	-0.002	0.007
γ_{14}, %	0.002	0.003	0.003	0.004	0.004	0.005	0.006	0.005	0.005	0.007	0.01	0.019	0.032	0.084	0.101
γ_{15}, %	0.011	0.012	0.012	0.012	0.013	0.011	0.011	0.012	0.014	0.016	0.017	0.017	0.015	0.006	-0.01
γ_{16}, %	0.015	0.014	0.013	0.011	0.007	0.004	0.001	-0.003	-0.009	-0.015	-0.02	-0.028	-0.023	-0.014	0.024
γ_{17}, %	0.01	0.009	0.009	0.009	0.009	0.005	0.002	-0.001	-0.001	-0.003	-0.006	-0.008	-0.015	-0.036	-0.033
γ_{18}, %	0.006	0.005	0.005	0.001	-0.002	-0.005	-0.009	-0.013	-0.017	-0.013	-0.016	-0.024	-0.027	-0.05	-0.039
γ_{19}, %	-0.004	-0.003	-0.004	-0.003	-0	-0.001	0.001	0.001	0.001	0.002	0.006	0.016	0.042	0.128	0.179
γ_{20}, %	0.015	0.015	0.015	0.013	0.011	0.011	0.008	0.004	-0.003	-0.009	-0.016	-0.015	-0.026	-0.076	-0.093
γ_{21}, %	-0.014	-0.011	-0.012	-0.011	-0.01	-0.011	-0.011	-0.01	-0.008	-0.003	0.001	0.001	0.014	0.065	0.116
γ_{22}, %	-0.006	-0.005	-0.006	-0.004	-0.003	-0.004	-0.003	-0.003	-0.004	-0.006	-0.009	-0.013	-0.007	0.023	0.024
γ_{23}, %	0.016	0.015	0.015	0.015	0.013	0.012	0.012	0.01	0.005	0.002	0.001	0.012	0.039	0.122	0.138
γ_{24}, %	-0.002	-0.003	-0.004	-0.003	-0.001	-0.002	-0.002	-0	0	-0.003	-0.007	-0.007	-0.027	-0.071	-0.088
γ_{25}, %	-0.002	-0.004	-0.004	-0.006	-0.005	-0.009	-0.007	-0.007	-0.006	-0.012	-0.017	-0.025	-0.03	-0.062	-0.061
γ_{26}, %	-0.009	-0.012	-0.012	-0.015	-0.021	-0.024	-0.024	-0.029	-0.035	-0.036	-0.033	-0.033	0.009	0.181	0.262
γ_{27}, %	0.018	0.014	0.016	0.016	0.017	0.018	0.021	0.025	0.026	0.028	0.034	0.047	0.056	0.042	0.059
γ_{28}, %	-0.007	-0.011	-0.014	-0.014	-0.019	-0.018	-0.018	-0.02	-0.027	-0.032	-0.032	-0.012	0.103	0.514	0.649
γ_{29}, %	-0.041	-0.04	-0.038	-0.037	-0.038	-0.033	-0.035	-0.033	-0.029	-0.022	-0.027	-0.051	-0.12	-0.386	-0.416
γ_{30}, %	-0.005	0	0	0.003	0.01	0.008	0.009	0.009	0.011	0.006	-0	-0.022	-0.057	-0.225	-0.223
γ_{31}, %	-0.04	-0.042	-0.041	-0.041	-0.044	-0.043	-0.039	-0.037	-0.035	-0.031	-0.035	-0.052	-0.109	-0.32	-0.357
γ_{32}, %	-0.059	-0.059	-0.057	-0.062	-0.069	-0.076	-0.079	-0.09	-0.096	-0.101	-0.108	-0.135	-0.174	-0.392	-0.438
γ_{33}, %	-0.055	-0.052	-0.05	-0.051	-0.051	-0.05	-0.052	-0.056	-0.061	-0.071	-0.069	-0.072	-0.059	-0.046	-0.053
γ_{34}, %	-0.016	-0.017	-0.016	-0.018	-0.018	-0.023	-0.023	-0.035	-0.045	-0.062	-0.062	-0.063	0.007	0.229	0.254
γ_{35}, %	0.038	0.03	0.029	0.027	0.023	0.023	0.028	0.027	0.023	0.024	0.016	-0.003	-0.03	-0.11	-0.136
γ_{36}, %	0.017	0.018	0.015	0.016	0.019	0.017	0.018	0.022	0.026	0.035	0.043	0.038	-0.031	-0.23	-0.335
γ_{37}, %	0.028	0.03	0.028	0.025	0.028	0.025	0.022	0.018	0.02	0.012	0.014	0.001	-0.022	-0.106	-0.081
γ_{38}, %	0.032	0.035	0.035	0.035	0.03	0.035	0.031	0.033	0.038	0.036	0.031	-0.005	-0.097	-0.314	-0.273
γ_{39}, %	-0.047	-0.046	-0.047	-0.051	-0.059	-0.06	-0.061	-0.065	-0.065	-0.053	-0.054	-0.072	-0.115	-0.329	-0.524
γ_{40}, %	-0.011	-0.007	-0.013	-0.014	-0.012	-0.021	-0.024	-0.018	-0.019	-0.018	-0.019	-0.018	-0.076	-0.38	-0.497
γ_{41}, %	-0.054	-0.05	-0.046	-0.042	-0.041	-0.036	-0.037	-0.036	-0.034	-0.042	-0.044	-0.053	-0.065	-0.206	-0.371
γ_{42}, %	-0.006	0	-0.003	-0.001	0.014	0.01	0.007	0.021	0.032	0.052	0.05	0.068	0.041	-0.061	-0.134
γ_{43}, %	-0.017	-0.013	-0.016	-0.019	-0.024	-0.019	-0.022	-0.016	-0.012	0.003	0.006	0.004	-0.035	-0.259	-0.345
γ_{44}, %	-0.007	-0.009	-0.012	-0.009	-0	-0.012	-0.007	-0.013	-0.026	-0.035	-0.035	-0.046	-0.006	0.117	0.162
γ_{45}, %	-0.036	-0.038	-0.037	-0.03	-0.022	-0.025	-0.021	-0.019	-0.016	-0.018	-0.015	-0.027	-0.099	-0.317	-0.374
γ_{46}, %	-0.023	-0.029	-0.03	-0.03	-0.041	-0.037	-0.048	-0.041	-0.037	-0.038	-0.05	-0.071	-0.164	-0.602	-0.717
γ_{47}, %	0.036	0.035	0.032	0.033	0.037	0.05	0.043	0.059	0.081	0.102	0.106	0.114	0.108	0.02	-0.068
γ_{48}, %	-0.018	-0.011	-0.019	-0.01	-0.016	-0.009	-0.009	-0.008	-0.017	-0.024	-0.019	-0.031	-0.059	-0.11	-0.153
γ_{49}, %	0.01	0.013	0.013	0.002	0.006	0.011	0.024	0.019	-0.004	-0.005	-0.008	0.017	0.051	0.195	0.356
γ_{50}, %	-0.017	-0.027	-0.019	-0.013	-0.002	0.001	0.004	-0.003	0.017	0.01	0.02	0.01	-0.039	-0.161	-0.33
γ_{51}, %	-0.052	-0.054	-0.054	-0.048	-0.038	-0.038	-0.047	-0.044	-0.032	-0.022	-0.034	-0.061	-0.263	-0.93	-1.121
γ_{52}, %	-0.039	-0.026	-0.029	-0.032	-0.036	-0.027	-0.041	-0.042	-0.047	-0.032	-0.047	-0.058	-0.116	-0.313	-0.451
γ_{53}, %	0.008	0.013	0.015	0.007	0.005	-0.003	0.004	-0.025	-0.045	-0.077	-0.074	-0.083	-0.055	0.186	0.493
γ_{54}, %	-0.004	-0.005	-0.002	-0	-0	0.001	-0.001	-0.018	-0.032	-0.059	-0.043	0.036	0.24	0.894	0.89
γ_{55}, %	-0.013	-0.011	-0.009	-0.01	-0.02	-0.023	-0.019	-0.038	-0.031	-0.074	-0.06	-0.107	-0.069	0.003	0.655
γ_{56}, %	0.012	0.013	0.018	0.021	0.012	0.026	0.032	0.057	0.074	0.075	0.098	0.15	0.333	0.985	1.505
γ_{57}, %	-0.003	-0.005	-0.004	-0.01	-0.013	-0.011	-0.007	-0.029	-0.047	-0.072	-0.086	-0.157	-0.287	-0.667	-0.649
γ_{58}, %	-0.064	-0.073	-0.085	-0.09	-0.088	-0.085	-0.088	-0.071	-0.032	-0.011	-0.016	-0.093	-0.387	-1.43	-1.989
γ_{59}, %	0.053	0.045	0.039	0.036	0.037	0.042	0.046	0.055	0.086	0.104	0.101	0.019	-0.232	-1.029	-1.635
γ_{60}, %	0.004	0.006	-0.004	0.009	0.024	0.017	0.016	0.038	0.068	0.108	0.1	0.053	-0.34	-1.698	-2.045
γ_{61}, %	0.063	0.062	0.063	0.067	0.064	0.064	0.068	0.067	0.08	0.087	0.095	0.044	-0.125	-0.673	-0.733
γ_{62}, %	0.045	0.051	0.049	0.05	0.055	0.054	0.064	0.054	0.07	0.066	0.07	-0.049	-0.432	-1.605	-1.635
γ_{63}, %	0.034	0.038	0.05	0.043	0.034	0.039	0.048	0.008	-0.004	-0.048	-0.042	-0.09	-0.004	0.453	0.683
γ_{64}, %	0.019	0.024	0.02	0.027	0.034	0.028	0.028	0.023	0.038	0.052	0.056	-0.026	-0.225	-1	-1.075
γ_{65}, %	0.017	0.018	0.023	0.015	0.022	0.025	0.027	-0.003	-0.028	-0.057	-0.058	-0.003	0.202	1.084	1.097
γ_{66}, %	0.023	0.02	0.017	0.018	0.016	0.015	0.012	0.021	0.032	0.051	0.059	0.083	0.14	0.208	0.056
γ_{67}, %	-0.025	-0.025	-0.038	-0.029	-0.016	-0.027	-0.037	-0.024	-0.028	-0.004	-0.005	0.072	0.131	0.091	0.008
γ_{68}, %	0.01	0.013	0.022	0.019	0.016	0.025	0.033	0.038	0.056	0.075	0.077	-0.003	-0.283	-1.057	-1.193
γ_{69}, %	0.015	0.02	0.021	0.024	0.027	0.025	0.029	0.006	-0.018	-0.057	-0.065	-0.097	-0.037	0.289	0.479
γ_{70}, %	0.011	0.014	0.014	0.014	0.02	0.019	0.019	-0.004	-0.026	-0.053	-0.059	-0.027	0.099	0.574	0.641
γ_{71}, %	0.002	0.002	0.017	0.013	0.001	0.015	0.023	0.05	0.078	0.104	0.108	0.062	-0.12	-0.561	-0.59
γ_{72}, %	-0.021	-0.025	-0.026	-0.025	-0.028	-0.031	-0.037	-0.047	-0.072	-0.084	-0.087	-0.023	0.089	0.413	0.475
γ_{73}, %	-0.002	-0.004	-0.003	-0.01	-0.015	-0.012	-0.013	-0.012	-0.009	-0.008	-0.006	0.01	0.026	0.089	0.093
γ_{74}, %	-0.033	-0.037	-0.038	-0.035	-0.035	-0.037	-0.046	-0.042	-0.049	-0.047	-0.053	-0.016	0.009	0.029	-0.059
γ_{75}, %	-0.054	-0.055	-0.054	-0.051	-0.061	-0.053	-0.057	-0.011	0.038	0.09	0.098	0.1	0.058	-0.214	-0.465
γ_{76}, %	0.02	0.027	0.024	0.029	0.03	0.035	0.044	0.09	0.178	0.263	0.291	0.214	0.075	-0.562	-0.562
γ_{77}, %	0.006	0.003	0.005	0.013	0.004	0.013	0.019	0.074	0.171	0.283	0.316	0.263	0.197	-0.329	-0.288
γ_{78}, %	0.02	0.022	0.021	0.022	0.027	0.021	0.024	0.032	0.031	0.034	0.031	0.027	0.006	-0.003	0.22
γ_{79}, %	-0.005	-0.009	-0.015	-0.008	0.002	-0.007	-0.021	-0.011	-0.106	-0.138	-0.174	-0.019	-0.027	0.154	0.253
γ_{80}, %	0.02	0.012	0.011	0.014	0.009	0.002	-0.01	-0.01	-0.09	-0.126	-0.156	-0.052	-0.096	0.038	0.155
γ_{81}, %	-0.005	-0.007	-0.008	-0.01	-0.012	-0.011	-0.009	-0.013	0.009	0.014	0.019	-0.017	-0.039	-0.16	-0.365
γ_{82}, %	0.032	0.031	0.033	0.037	0.039	0.042	0.046	0.043	0.047	0.043	0.044	0.045	0.017	-0.016	0.031
γ_{83}, %	-0.013	-0.012	-0.014	-0.014	-0.014	-0.015	-0.016	-0.009	0.008	0.028	0.043	0.021	0.066	0.18	0.255
γ_{84}, %	0.019	0.02	0.019	0.017	0.015	0.011	0.008	0.008	-0.001	-0.005	-0.008	-0.009	-0.013	0.009	0.113
γ_{85}, %	-0.075	-0.073	-0.074	-0.077	-0.08	-0.081	-0.082	-0.079	-0.062	-0.044	-0.027	-0.079	-0.015	0.146	0.226
γ_{86}, %	-0.029	-0.029	-0.029	-0.032	-0.033	-0.037	-0.035	-0.034	-0.052	-0.075	-0.084	0.054	0.061	-0.131	-0.175
γ_{87}, %	-0.001	-0.001	-0.001	-0.001	-0.002	-0.003	-0.003	-0.003	-0.003	-0.004	-0.003	-0.001	0.002	0.004	0.023

Table 135: Combined differential cross section for $Z \to \ell^+\ell^-$ process $d\sigma/dy$ measured for $66 < M_{\ell\ell} < 116$ GeV and $P_{t,\ell} > 20$ GeV. All uncertainties are quoted in % with respect to the cross-section values. δ_{stat}, δ_{unc}, δ_{corr} and δ_{tot} represent statistical, uncorrelated systematic, correlated systematic and total uncertainties. $\gamma_1 - \gamma_{87}$ represent diagonalised correlated systematic uncertainties, which are correlated bin-to-bin and across W$^+$,W$^-$ and Z measurements.

Z*3

$\eta_{min}-\eta_{max}$	0.00–0.21	0.21–0.42	0.42–0.63	0.63–0.84	0.84–1.05	1.05–1.37	1.37–1.52	1.52–1.74	1.74–1.95	1.95–2.18	2.18–2.50
$d\sigma/dy$ [pb]	429.64	427.6	422.13	417.42	408.47	400.48	380.69	371.15	357.57	336.86	312.87
δ_{sta}, %	0.10926	0.1026	0.10044	0.10544	0.11004	0.086292	0.16662	0.1213	0.11365	0.10753	0.1201
δ_{unc}, %	0.13851	0.13006	0.12409	0.13222	0.13361	0.13163	0.20985	0.17066	0.16084	0.15677	0.23165
δ_{cor}, %	0.485216	0.439091	0.461779	0.506666	0.484561	0.462084	0.485487	0.542027	0.521075	0.553665	0.664114
δ_{tot}, %	0.516292	0.469301	0.488596	0.534144	0.514548	0.488154	0.554524	0.581061	0.55705	0.585393	0.713536
γ_{1}, %	-0.015	0.052	0.022	0.005	0.027	0.022	0.019	0.091	0.023	0.023	-0.045
γ_{2}, %	0.148	0.136	0.15	0.147	0.17	0.156	0.146	0.177	0.171	0.175	0.193
γ_{3}, %	0.022	0.002	-0.02	-0.099	-0.038	-0.023	-0.03	-0.043	-0.041	-0.075	-0.076
γ_{4}, %	-0.063	-0.024	-0.034	-0.048	-0.047	-0.027	0.011	0.023	0.006	0.036	0.001
γ_{5}, %	0.057	0.034	0.041	0.031	0.002	0.014	0.012	-0.008	-0.012	-0.035	-0.008
γ_{6}, %	0.036	0.011	0.014	0.016	0.013	-0	0.012	0.021	-0.002	0.007	0.011
γ_{7}, %	0.006	-0.018	-0.033	-0.018	-0.018	-0.023	-0.025	0	-0.04	0.006	-0.039
γ_{8}, %	0.009	0.011	0.015	0.016	0.009	0.038	0.003	-0.007	-0.004	0.021	0.004
γ_{9}, %	-0.014	-0.002	-0.007	0.009	-0.014	-0.004	-0.007	-0.009	-0.013	-0.027	-0.023
γ_{10}, %	-0.011	-0.002	0.004	0.01	0.004	0.015	-0.011	-0.004	0.018	0	0.003
γ_{11}, %	-0.001	-0.005	-0.002	-0.005	0.005	0.007	0.016	0.014	-0.006	-0.007	0.026
γ_{12}, %	-0.014	-0.015	-0.016	-0.016	-0.014	0.008	0.003	0.006	-0.01	-0.001	0.021
γ_{13}, %	0.007	0.003	-0.013	0.001	-0.012	-0.011	-0.025	-0.017	-0.028	-0.026	-0.025
γ_{14}, %	-0.005	-0.006	-0.011	-0.016	-0.01	-0.001	-0.007	0.003	-0.006	0.002	0.001
γ_{15}, %	-0.02	-0.012	-0.004	-0.014	-0.004	0.002	0.012	0.018	-0.006	-0.004	0.01
γ_{16}, %	0.014	0.005	0.005	0.003	0.003	-0.003	0.002	0.005	-0.004	-0.013	-0.011
γ_{17}, %	-0.013	-0.006	0.002	0	-0.001	-0.003	0.02	0.001	0.003	-0.005	-0.01
γ_{18}, %	0.012	0.015	0.017	0.004	0.003	-0.008	0.002	0.003	-0.005	-0.003	-0.015
γ_{19}, %	0.003	0.007	0.01	-0.002	-0.005	0.003	0.001	-0.013	0.006	-0.007	0.007
γ_{20}, %	-0.007	-0.008	0.01	-0.013	-0.01	-0.022	0.007	0.022	-0.003	0.006	-0.016
γ_{21}, %	0.006	0.011	0.012	-0.031	-0.014	0.003	-0.005	-0	-0.008	-0.012	-0.015
γ_{22}, %	0.007	0.007	0.001	0.019	-0.006	0.006	-0.009	-0.016	0.003	-0.018	-0.023
γ_{23}, %	-0.011	-0.001	0.016	-0.013	-0.001	-0.009	0.004	0.005	0.003	0.012	0.003
γ_{24}, %	-0.006	-0.006	0.001	-0.008	0.002	0.009	-0.009	-0	0.009	-0.001	-0.006
γ_{25}, %	-0.011	0.005	0.014	-0.001	0.01	-0.001	0.006	0.011	0	-0.003	-0.003
γ_{26}, %	-0.005	-0.012	-0.025	-0.01	-0.007	-0.019	-0.016	-0.016	-0.013	-0.027	-0.017
γ_{27}, %	-0.039	-0.008	-0.008	-0.024	-0.003	-0.011	-0.016	-0.011	-0.007	-0.001	0.001
γ_{28}, %	-0.002	-0.008	0.006	0.009	0.001	-0.034	-0.025	-0.02	-0.023	-0.004	-0.009
γ_{29}, %	-0.051	-0.018	-0.005	-0.014	-0.009	-0.008	-0.008	-0.01	-0.004	0.001	-0.015
γ_{30}, %	-0.047	-0.023	-0.027	-0.055	-0.049	-0.008	0.007	-0.005	-0.02	-0.028	-0.043
γ_{31}, %	0.051	0.024	0.057	0.016	0.034	0.043	0.021	0.029	0.01	-0	0.033
γ_{32}, %	-0.059	-0.069	-0.08	-0.111	-0.094	-0.11	-0.085	-0.105	-0.105	-0.141	-0.171
γ_{33}, %	-0.11	-0.083	-0.086	-0.089	-0.112	-0.06	-0.099	-0.038	-0.077	-0.053	-0.06
γ_{34}, %	0.047	0.031	0.054	-0.011	0.015	0.014	0.051	0.026	0.011	0.005	-0.041
γ_{35}, %	0.098	0.108	0.107	0.121	0.121	0.071	0.066	0.087	0.09	0.112	0.08
γ_{36}, %	0.008	0.005	-0.012	0.004	0.013	-0.01	-0.015	-0.022	-0.003	0.003	0.001
γ_{37}, %	0.081	0.086	0.089	0.107	0.107	0.086	0.096	0.12	0.093	0.102	0.11
γ_{38}, %	0.067	0.042	0.056	0.046	0.078	0.082	0.078	0.06	0.048	0.035	0.047
γ_{39}, %	-0.008	-0.013	-0.023	-0.034	-0.073	-0.049	-0.04	-0.062	-0.062	-0.062	-0.087
γ_{40}, %	0.015	0.039	0.05	0.05	0.022	0.026	0.021	0.048	0.037	0.045	0.052
γ_{41}, %	-0.077	-0.068	-0.054	-0.072	-0.015	-0.023	-0.035	-0.041	-0.057	-0.051	-0.051
γ_{42}, %	-0.009	-0.045	-0.014	-0.011	-0.046	-0.013	-0.012	-0.016	0.004	0.021	0.022
γ_{43}, %	-0.109	-0.11	-0.134	-0.137	-0.18	-0.164	-0.153	-0.157	-0.136	-0.122	-0.175
γ_{44}, %	0.033	0.002	-0.007	0.015	0.042	0.007	0.017	0.016	0.016	0.011	-0.04
γ_{45}, %	-0.092	-0.017	-0.019	-0.065	0.016	-0.036	-0.024	-0.04	-0.041	-0.042	-0.023
γ_{46}, %	0.023	0.02	0.034	0.048	-0.026	-0.017	0.025	0.022	0.031	0.046	0.011
γ_{47}, %	-0.021	-0.001	-0.049	-0.046	-0.006	0.007	-0.002	0.012	0.035	0.056	0.092
γ_{48}, %	0.06	0.054	0.043	0.03	0.026	0.036	0.028	0.052	0.049	0.046	0.03
γ_{49}, %	0.051	0.056	0.066	0.054	0.023	0.034	0.071	0.07	0.057	0.05	0.031
γ_{50}, %	0.005	0.01	-0.02	0.014	-0.001	0.029	0.014	0.005	-0.003	-0.02	-0.021
γ_{51}, %	-0.037	-0.062	-0.108	-0.067	-0.005	-0.029	-0.036	-0.037	-0.027	-0.027	-0.02
γ_{52}, %	0.009	0.011	-0.003	0.022	0.052	0.047	0.039	0.032	0.016	0.002	0.002
γ_{53}, %	0.064	0.069	0.069	0.08	0.037	0.093	0.101	0.101	0.081	0.098	0.062
γ_{54}, %	0.044	0.03	0.025	0.008	0.011	0.004	0.039	0.062	0.048	0.06	0.046
γ_{55}, %	-0.07	-0.097	-0.092	-0.054	-0.083	-0.114	-0.093	-0.113	-0.118	-0.127	-0.154
γ_{56}, %	-0.064	-0.023	-0.021	-0.01	0.019	0.032	0.009	0.005	0.009	0.005	0.01
γ_{57}, %	0.087	0.071	0.067	0.096	0.084	0.06	0.116	0.114	0.081	0.082	0.043
γ_{58}, %	-0.135	-0.144	-0.103	-0.122	-0.109	-0.099	-0.103	-0.094	-0.098	-0.076	-0.06
γ_{59}, %	0.011	0.031	0.021	0.003	-0.027	-0.01	-0.012	-0.021	-0.015	-0.006	-0.019
γ_{60}, %	-0.116	-0.119	-0.083	-0.076	-0.098	-0.115	-0.085	-0.123	-0.112	-0.142	-0.168
γ_{61}, %	0.082	0.023	0.07	-0.014	-0.005	-0.008	-0.003	-0.021	-0.053	-0.061	-0.11
γ_{62}, %	-0.054	0.011	-0.038	-0.013	-0.029	0.008	-0.059	-0.021	-0.025	-0.035	-0.043
γ_{63}, %	0.009	-0	0.031	0.035	0.015	0.057	0.071	0.064	0.082	0.046	0.036
γ_{64}, %	0.079	0.109	0.124	0.146	0.128	0.126	0.143	0.166	0.206	0.201	0.238
γ_{65}, %	-0.098	-0.077	-0.08	-0.075	-0.087	-0.08	-0.092	-0.08	-0.092	-0.088	-0.08
γ_{66}, %	0.049	-0.007	0.021	0.069	-0.003	0.017	0.037	0.031	0.037	0.048	0.031
γ_{67}, %	0.003	0.024	-0.005	0.044	-0.016	0.034	0.025	0.042	0.041	0.043	0.035
γ_{68}, %	0.032	0.022	0.009	0.016	0.03	0.03	0.015	0.03	0.048	0.062	0.099
γ_{69}, %	-0.007	-0.008	-0.008	0.008	-0.033	0.007	-0.051	-0.049	-0.032	-0.028	-0.052
γ_{70}, %	-0.064	-0.037	-0.047	-0.039	-0.013	-0.041	-0.072	-0.07	-0.054	-0.106	-0.131
γ_{71}, %	0.04	0.013	0.022	0.036	0.005	0.018	0.011	-0.006	0.008	0.008	0.055
γ_{72}, %	-0.004	-0.008	0.006	-0.012	-0.046	-0.034	-0.049	-0.049	-0.042	-0.079	-0.078
γ_{73}, %	0.004	0.009	0.02	0.02	0.009	0.002	-0.004	-0.017	-0.049	-0.029	-0.091
γ_{74}, %	0.007	-0.026	-0.031	-0.025	-0.003	-0.04	-0.018	-0.038	-0.037	-0.047	-0.05
γ_{75}, %	-0.042	-0.022	-0.042	-0.043	-0.041	-0.043	-0.048	-0.038	-0.048	-0.042	-0.016
γ_{76}, %	-0.022	-0.031	-0.021	-0.007	-0.006	-0.008	-0.015	-0.03	0.026	0.026	0.03
γ_{77}, %	0.02	0.017	0.019	0.003	-0.001	0.004	-0.01	-0.034	-0.023	-0.041	-0.063
γ_{78}, %	0.114	0.11	0.093	0.131	0.1	0.091	0.103	0.119	0.117	0.116	0.169
γ_{79}, %	-0.044	-0.034	-0.036	-0.053	-0.038	-0.036	-0.046	-0.083	-0.06	-0.054	-0.072
γ_{80}, %	0.003	-0.005	0.003	0.02	0.002	0.002	-0.007	0.04	0.052	0.064	0.082
γ_{81}, %	-0.049	-0.031	-0.024	-0.042	-0.025	-0.023	-0.029	-0.088	-0.025	-0.007	-0.033
γ_{82}, %	-0.025	-0.023	-0.023	-0.035	-0.013	0.002	-0.016	0.013	0.011	0.021	0.017
γ_{83}, %	0.026	0.026	0.025	0.027	0.021	0.019	0.029	0.018	0.016	0.012	0.004
γ_{84}, %	-0.054	-0.021	-0.015	-0.046	-0.009	0.011	0.01	0.02	-0.01	-0.022	-0.154
γ_{85}, %	-0.066	-0.072	-0.087	-0.105	-0.105	-0.103	-0.106	-0.097	-0.088	-0.074	-0.052
γ_{86}, %	-0.014	-0.017	-0.023	-0.029	-0.03	-0.031	-0.028	-0.021	-0.029	-0.027	-0.026
γ_{87}, %	0.021	0.015	0.016	0.035	0.028	0.015	-0.011	0.011	0.021	0.026	0.079

W * 2

Table 137: Combined differential cross section for $W^- \to \ell^-\nu$ process $d\sigma/d\eta^-$ measured for $p_{t,\ell} > 20$ GeV, $P_{t,\nu} > 25$ GeV and $M_t > 40$ GeV. All uncertainties are quoted in % with respect to the cross-section values. δ_{stat}, δ_{unc}, δ_{corr} and δ_{tot} represent statistical, uncorrelated systematic, correlated systematic and total uncertainties. $\gamma_1 - \gamma_{87}$ represent diagonalised correlated systematic uncertainties, which are correlated bin-to-bin and across W$^+$,W$^-$ and Z measurements.

Shifts from combination

Table not into the paper..?
but Chi2 values - updated

Index	Systematic	Shift	Error
1	MuonTriggerSF	0.47	0.85
2	MuonRecoSF	1.02	0.51
3	MuonIsoSF	0.21	1.00
4	MuonResID	0.04	1.00
5	MuonResMS	-0.17	0.99
6	MuonScaleK	0.05	0.96
7	MuonScaleC	0.06	0.84
8	PtSherpa	-0.56	0.97
9	PtPowheg	-0.03	0.97
10	PileUpScaling	-0.08	0.99
11	TheoryPDF	0.15	0.99
12	TheoryME_smoothed	0.18	0.53
13	TheoryPS_smoothed	0.27	0.66
14	BkgQCDZmm	0.78	0.93
15	BkgEWK	-0.25	0.96
16	MuonIsoSFstat_0	-0.11	1.00
17	MuonRecoSFstat_0	-0.01	0.98
18	MuonRecoSFstat_1	-0.07	0.99
19	MuonRecoSFstat_2	-0.08	0.97
20	MuonRecoSFstat_3	-0.22	0.99
21	MuonRecoSFstat_4	-0.03	1.00
22	MuonRecoSFstat_5	0.04	1.00
23	MuonRecoSFstat_6	-0.00	0.99
24	MuonRecoSFstat_7	-0.23	0.99
25	MuonRecoSFstat_8	0.00	1.00
26	MuonRecoSFstat_9	-0.05	1.00
27	MuonRecoSFstat_10	-0.04	1.00
28	MuonRecoSFstat_11	0.01	1.00
29	MuonRecoSFstat_12	-0.04	1.00
30	MuonRecoSFstat_13	-0.01	1.00
31	MuonRecoSFstat_14	0.01	1.00
32	MuonRecoSFstat_15	0.05	1.00
33	MuonTriggerSFstat_0	-0.51	0.91
34	MuonTriggerSFstat_1	0.39	0.95
35	MuonTriggerSFstat_2	-0.06	0.95

Index	Systematic	Shift	Error
36	MuonTriggerSFstat_3	-0.37	0.95
37	MuonTriggerSFstat_4	0.16	0.96
38	MuonTriggerSFstat_5	0.12	0.95
39	MuonTriggerSFstat_6	-0.03	0.97
40	MuonTriggerSFstat_7	-0.00	0.99
41	MuonTriggerSFstat_8	-0.09	0.98
42	MuonTriggerSFstat_9	-0.06	0.99
43	MuonTriggerSFstat_10	-0.27	0.99
44	MuonTriggerSFstat_11	0.14	0.98
45	MuonTriggerSFstat_12	-0.04	0.95
46	MuonTriggerSFstat_13	-0.07	0.98
47	MuonTriggerSFstat_14	-0.09	0.98
48	MuonTriggerSFstat_15	-0.14	0.97
49	Extrap_ME	0.00	0.39
50	Extrap_PS	-0.25	0.71
51	EleTriggerSFZee	0.12	0.94
52	EleChargeMisId	-0.05	0.96
53	EleRes	-0.95	0.77
54	EleScaleStat	-0.09	0.94
55	EleScaleR12Stat	1.31	0.77
56	EleScalePSStat	-0.03	0.97
57	EleScaleMethod	-0.78	0.91
58	EleScaleGen	-0.23	0.85
59	EleScaleLowPt	-0.02	1.00
60	BkgQCDZee	0.12	0.69
61	EleIdTightSF_0	0.38	0.97
62	EleIdTightSF_1	-0.94	0.95
63	EleIdTightSF_2	-0.21	0.98
64	EleIdTightSF_3	-0.38	0.97
65	EleIdTightSF_4	-0.06	0.98
66	EleIdTightSF_5	0.14	0.97
67	EleIdTightSF_6	-0.11	0.98
68	EleIdTightSF_7	-0.30	0.98
69	EleIdTightSF_8	-0.03	0.98
70	EleRecoSF_0	-0.66	0.89

Index	Systematic	Shift	Error
71	EleRecoSF_1	1.28	0.94
72	EleRecoSF_2	0.66	0.97
73	EleRecoSF_3	-0.12	0.93
74	EleRecoSF_4	-0.09	0.98
75	EleRecoSF_5	-0.50	0.97
76	EleRecoSF_6	0.19	0.97
77	EleRecoSF_7	0.11	0.98
78	EleTriggerSFStat_0	0.59	0.98
79	EleTriggerSFStat_1	-0.18	0.99
80	EleTriggerSFStat_2	-0.13	0.99
81	EleTriggerSFStat_3	-0.12	0.99
82	BkgEWKZCF	-0.50	0.79
83	BkgQCDZeecf	0.44	0.40
84	EleIdFwdTightSF_0	1.75	0.54
85	EleIdFwdTightSF_1	-0.55	0.85
86	EleIsoSF_0	0.06	0.97
87	EleIsoSF_1	0.42	0.99
88	EleIsoSF_2	0.01	1.00
89	EleIsoSF_3	0.14	1.00
90	EleTriggerSF_0	0.71	0.73
91	MetScale	0.25	0.86
92	MetRes	0.21	0.95
93	JetScale	0.25	0.94
94	JetScaleNPV	-0.10	0.98
95	JetScaleMu	0.09	0.98
96	JetRes	0.07	0.99
97	PileupScale	0.38	0.99
98	BkgQCDAntiIsoWmn	-0.13	0.91
99	BkgQCDFitRange	0.00	0.95
100	BkgQCDFitPeriod	-0.04	0.98
101	BkgQCDAntiIsoWen	0.52	0.92
102	BkgQCDblayer	-0.02	0.94
103	BkgQCDLooseNotMedium	-0.51	0.87

Table 139: Shifts and errors of the correlated systematic uncertainties from the combination of differential cross section measurements.

V - Comparison with NNLO QCD

V. Comparison with NNLO QCD
- A. Theoretical framework
- B. Integrated cross section ratios
- C. Differential Z/γ^* measurements
  1. Mass distribution
  2. Rapidity distribution
- D. Differential $W^\pm$ measurements
  1. Pseudorapidity distributions
  2. Charge asymmetry

$$Z: p_{T,\ell} > 20 \text{ GeV},\ |\eta| < 2.5,\ 66 < m_{\ell\ell} < 116 \text{ GeV}$$

$$W: p_{T,\ell} > 25 \text{ GeV},\ |\eta| < 2.5,\ p_{T,\nu} > 25 \text{ GeV},\ m_T > 40 \text{ GeV}$$

The combination was performed following the same procedure as for the differential measurements. The combined integrated fiducial cross sections for the Z, W^+, W^- and $W^\pm$ are:

$$\sigma^{fid}_{Z/\gamma^*} \cdot BR(Z/\gamma^* \to ll) = 0.4995 \pm 0.0003(\text{stat}) \pm 0.0004(\text{uncor}) \pm 0.0015(\text{corr}) \pm 0.0090(\text{lumi}) \text{ nb}$$

$$\sigma^{fid}_{W^+} \cdot BR(W \to l\nu) = 2.9240 \pm 0.0009(\text{stat}) \pm 0.0027(\text{uncor}) \pm 0.0165(\text{corr}) \pm 0.0526(\text{lumi}) \text{ nb}$$

$$\sigma^{fid}_{W^-} \cdot BR(W \to l\nu) = 1.9425 \pm 0.0006(\text{stat}) \pm 0.0025(\text{uncor}) \pm 0.0111(\text{corr}) \pm 0.0350(\text{lumi}) \text{ nb}$$

$$\sigma^{fid}_{W} \cdot BR(W \to l\nu) = 4.8665 \pm 0.0011(\text{stat}) \pm 0.0036(\text{uncor}) \pm 0.0272(\text{corr}) \pm 0.0876(\text{lumi}) \text{ nb}$$

Plots on integrated cross sections and ratios vs PDFs ..

Uncertainties

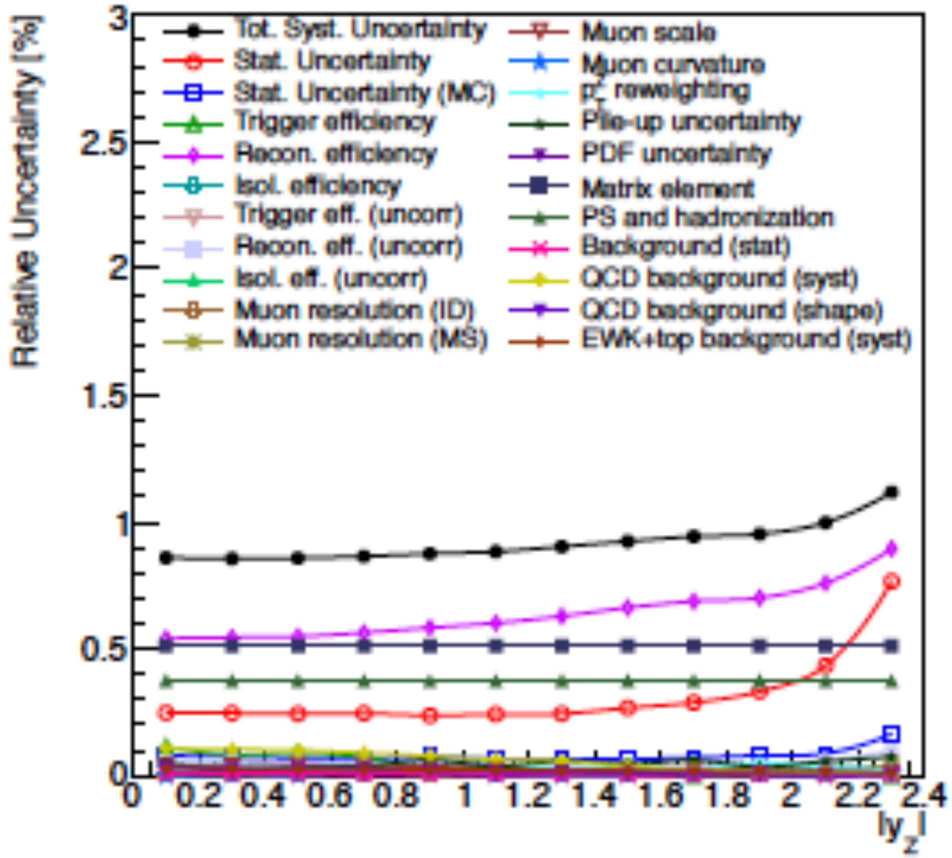
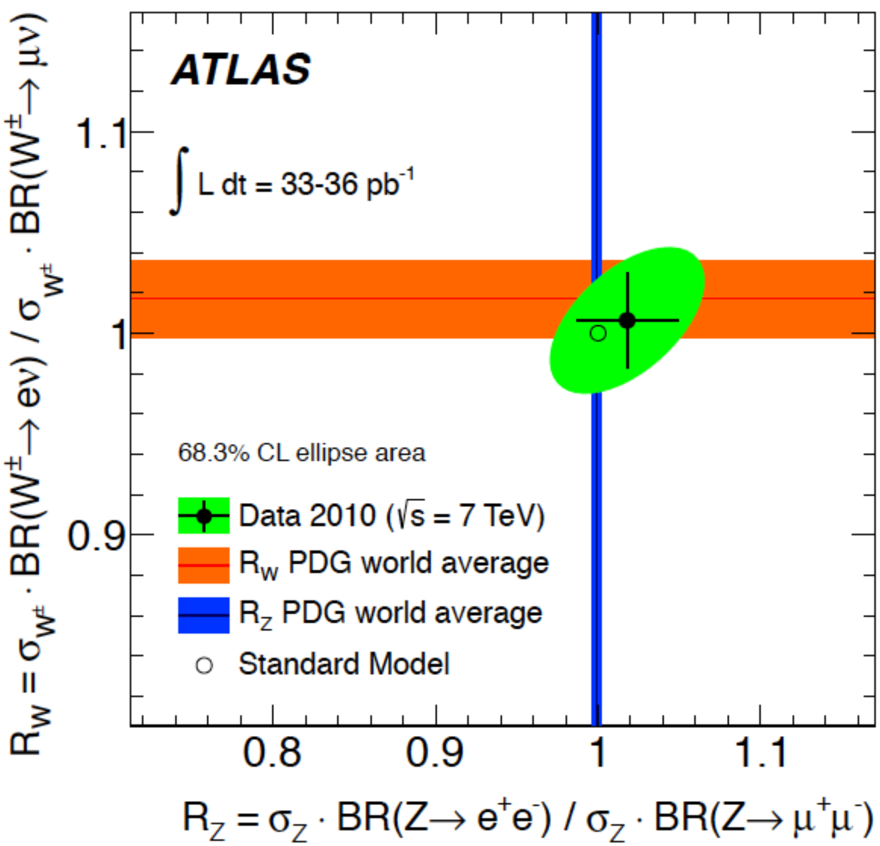


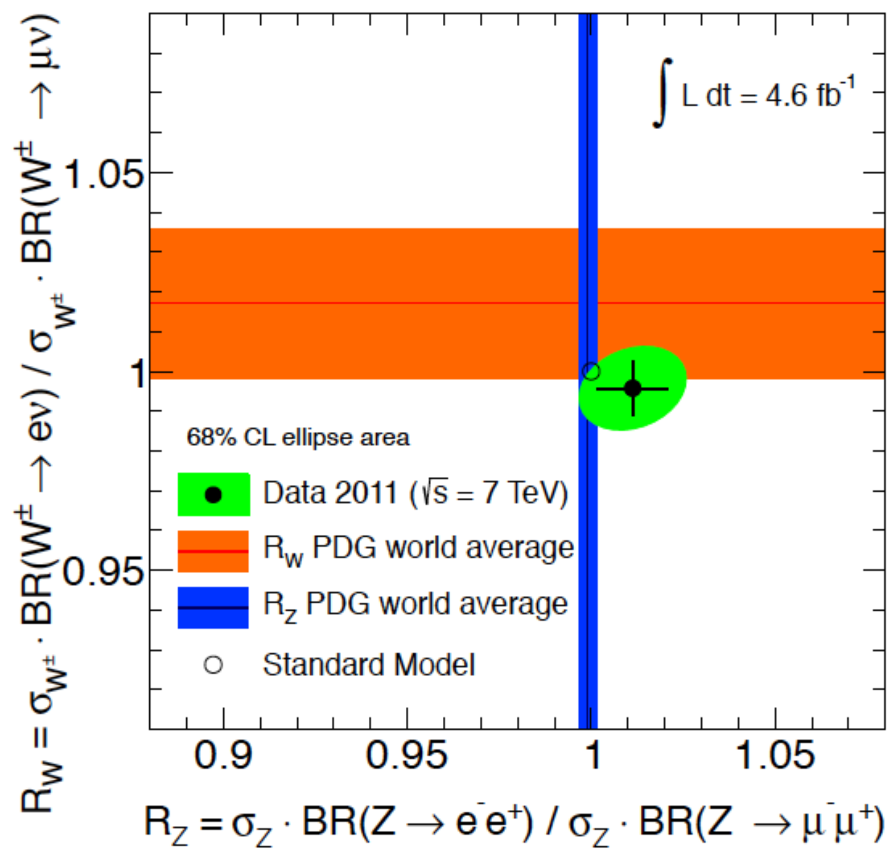
Figure 159: Relative uncertainties in percent, as a function of $|y_Z|$ for 66 – 116 GeV mass region.

Electron-muon universality

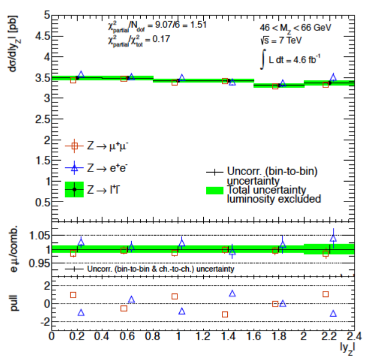
2010 paper



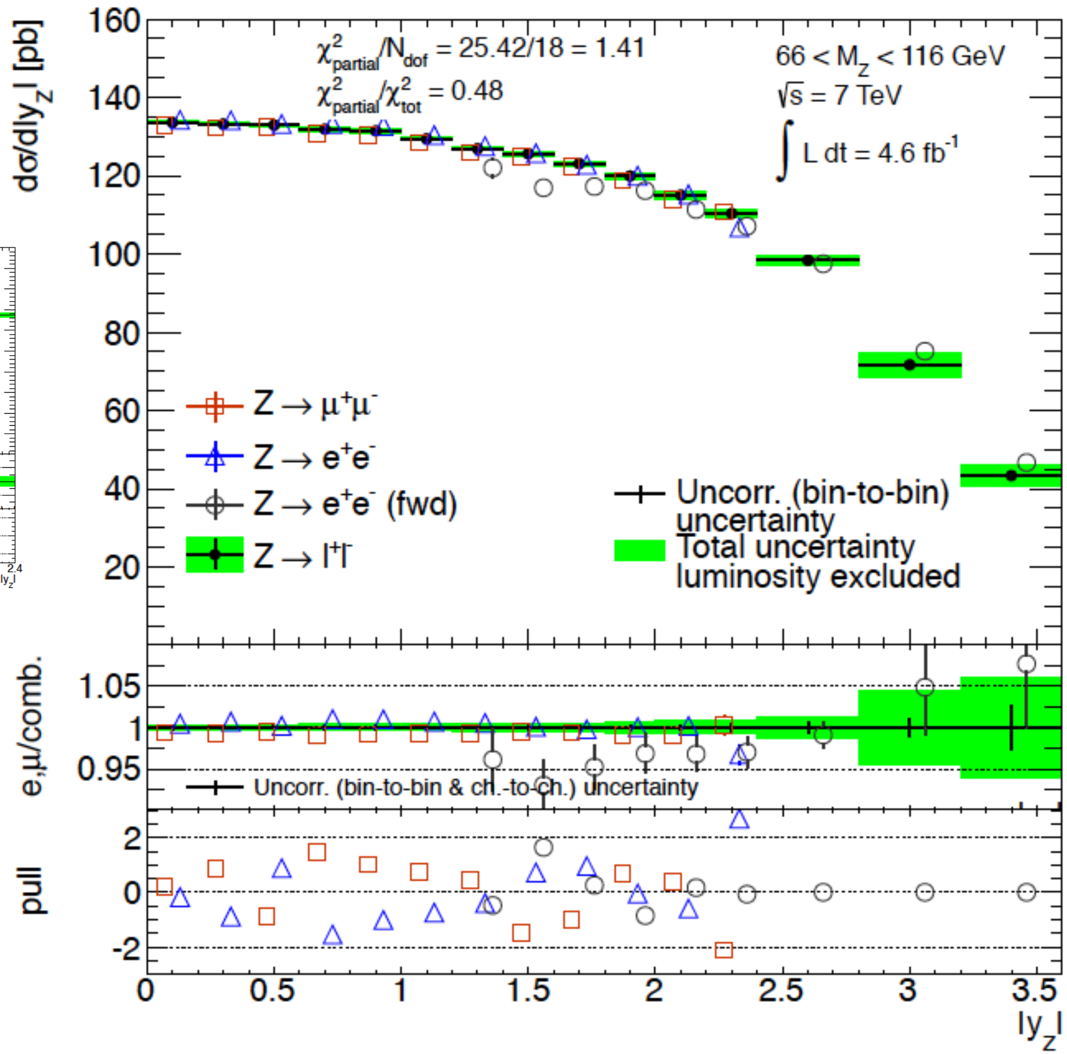
2011 result

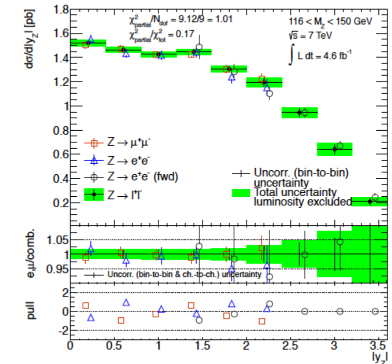


Combination plots to show cross sections



(a) Z: $46 < m_{\ell\ell} < 66$ GeV



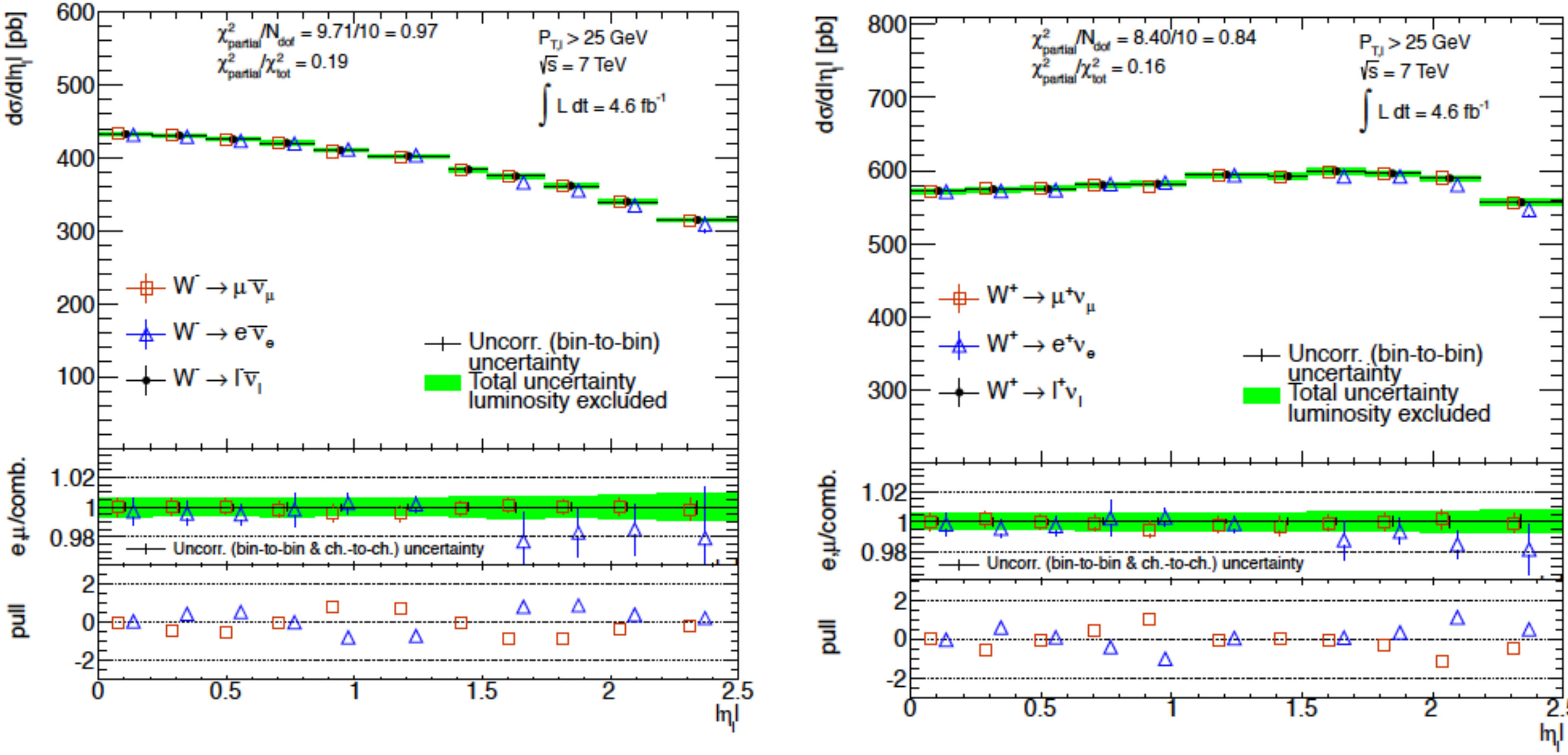


(b) Z: $116 < m_{\ell\ell} < 150$ GeV

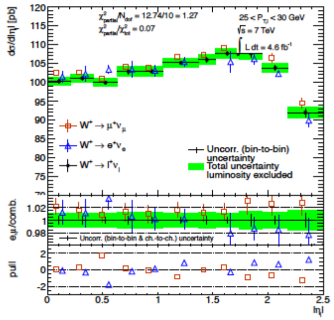
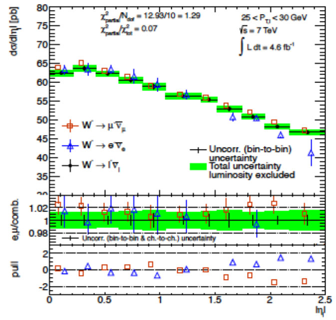
Pulls??

Figure 188: Differential $d\sigma/d|y_Z|$ cross section measurement for $Z/\gamma^* \to \ell\ell$ in the region $66 < m_{\ell\ell} < 116$ GeV. Also shown are the measurements in each bin with uncorrelated uncertainties and the pull from each point.

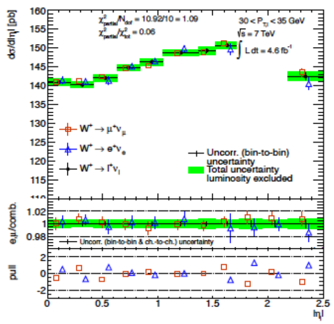
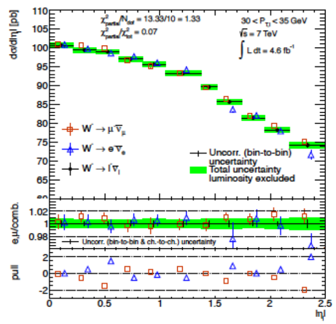
Combination plots to show cross sections



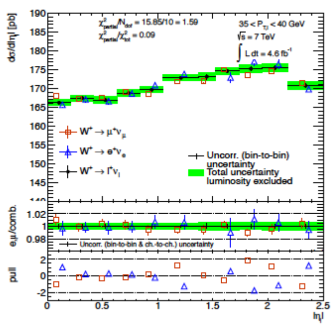
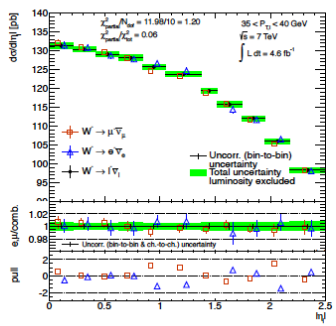
Combination plots to show cross sections

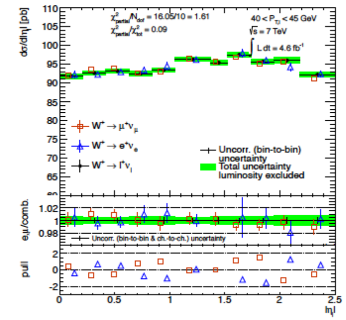
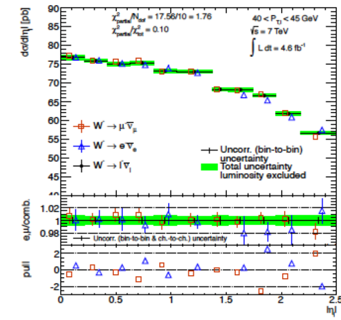
(a) W^+: $25 < p_T < 30$ GeV (b) W^-: $25 < p_T < 30$ GeV

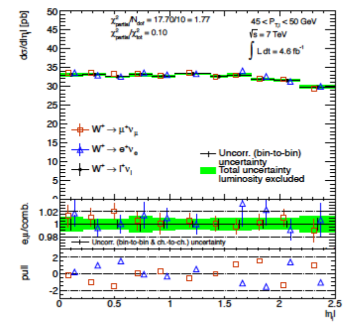
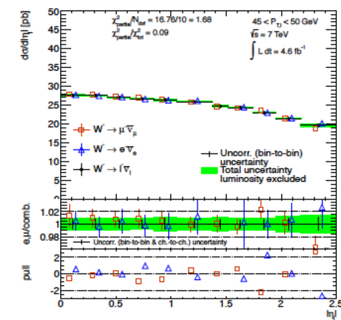
(c) W^+: $30 < p_T < 35$ GeV (d) W^-: $30 < p_T < 35$ GeV

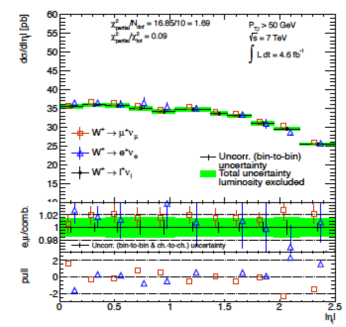
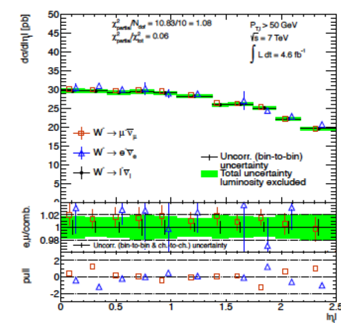
(e) W^+: $35 < p_T < 40$ GeV (f) W^-: $35 < p_T < 40$ GeV

(a) W^+: $40 < p_T < 45$ GeV (b) W^-: $40 < p_T < 45$ GeV

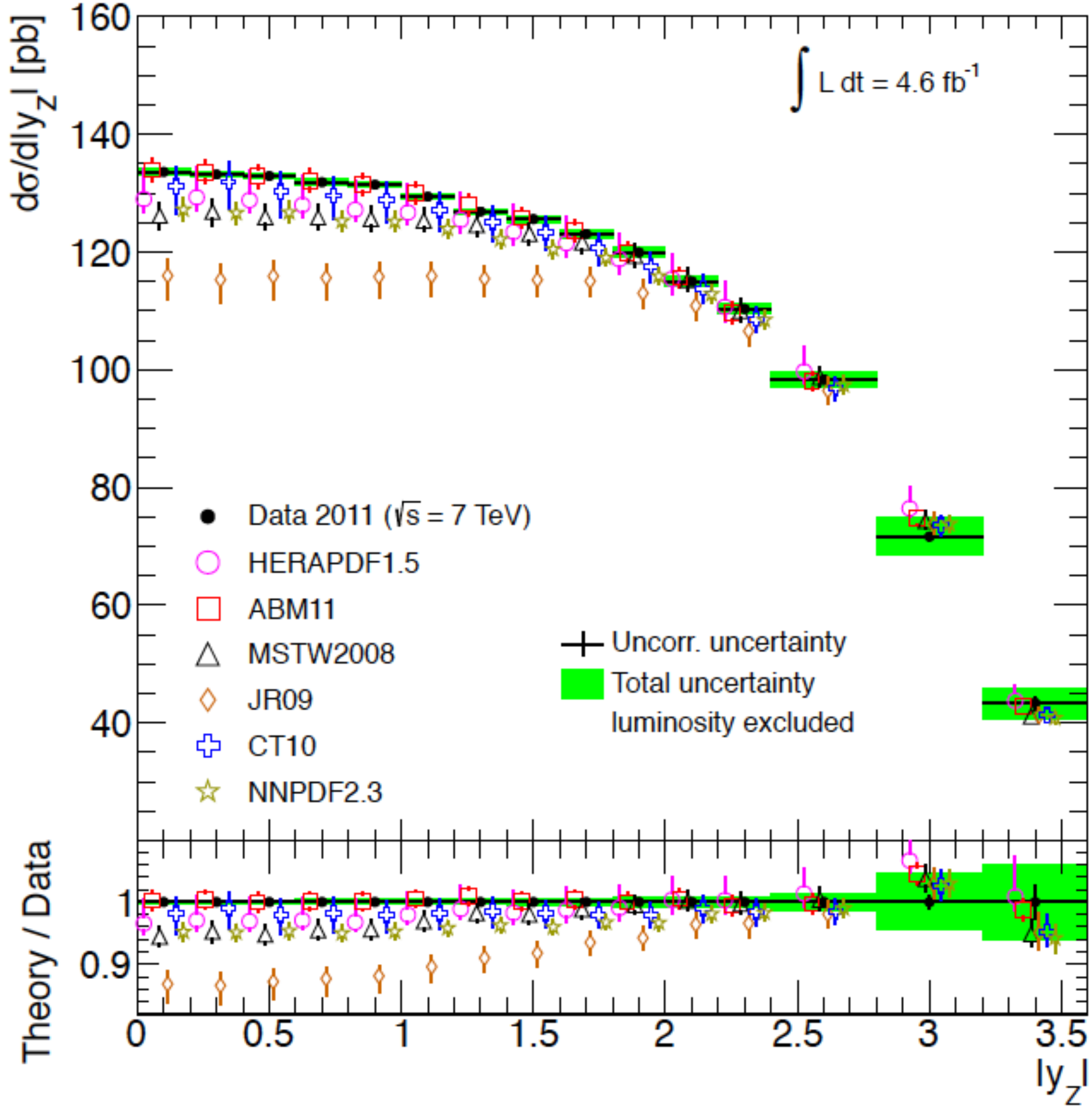
(c) W^+: $45 < p_T < 50$ GeV (d) W^-: $45 < p_T < 50$ GeV

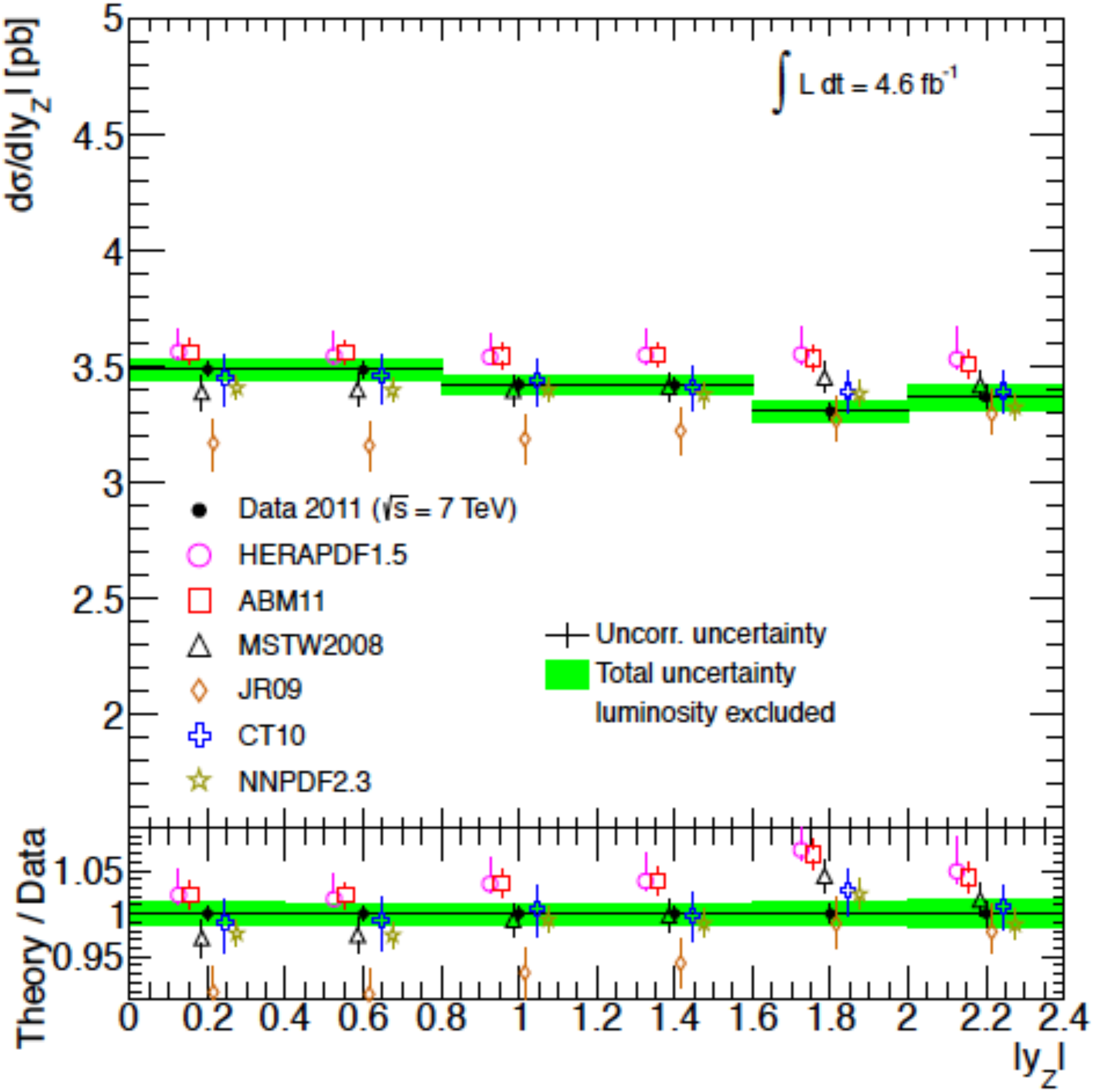
(e) W^+: $p_T > 50$ GeV (f) W^-: $p_T > 50$ GeV

pT dependent W combination 6*2 plots – too detailed.?

Cross Sections vs Theory

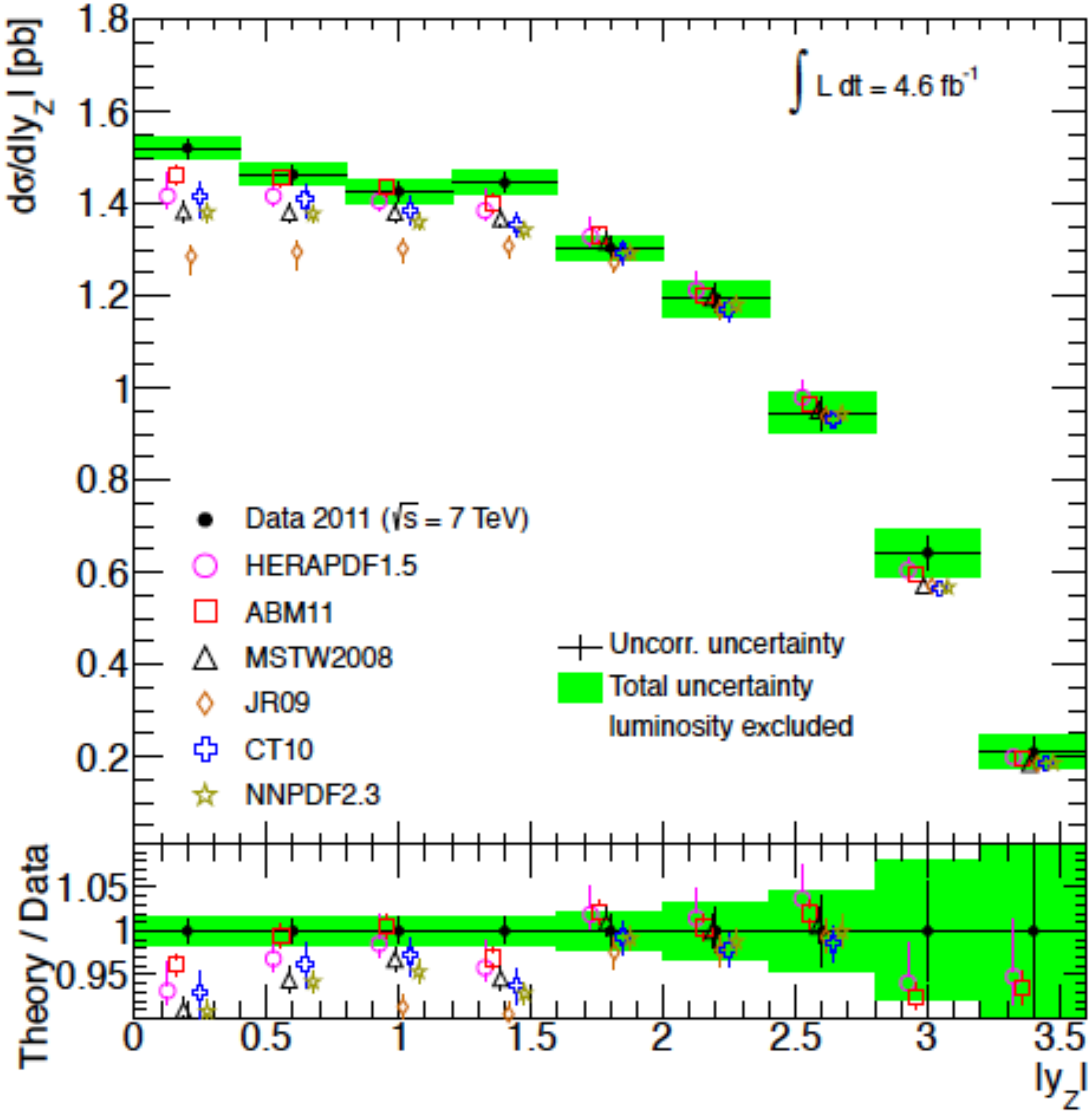


Cross Sections vs Theory



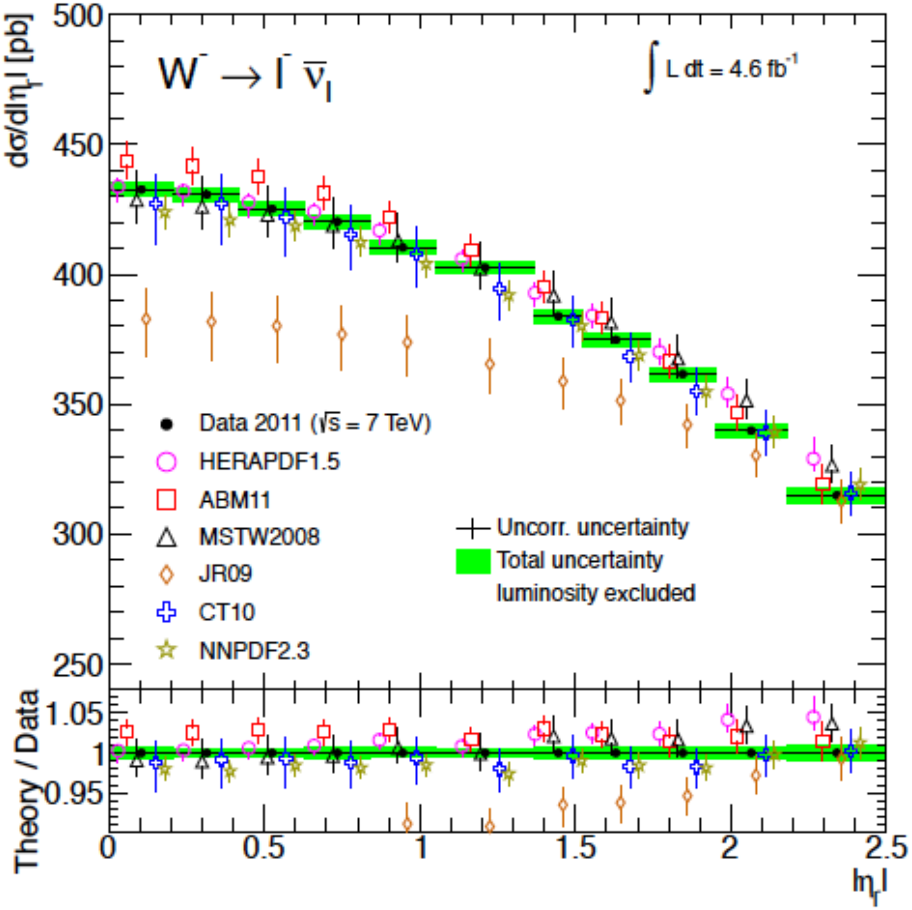
(a) Z: $46 < m_{\ell\ell} < 66$ GeV

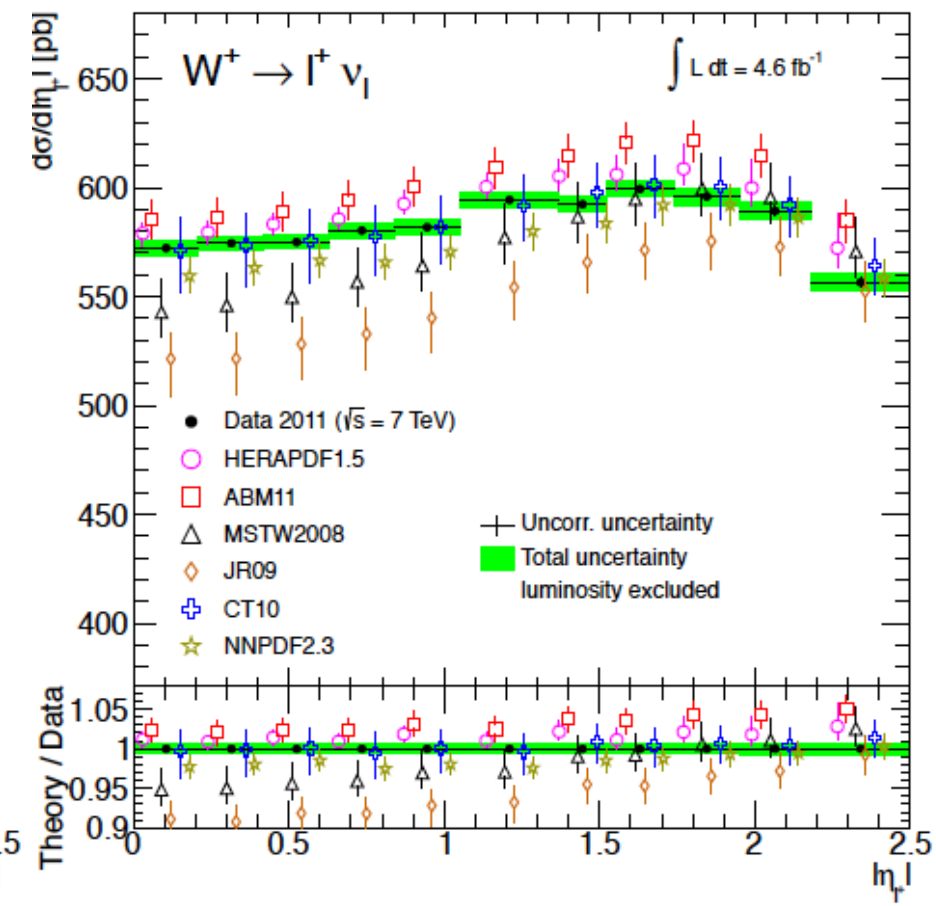
Cross Sections vs Theory



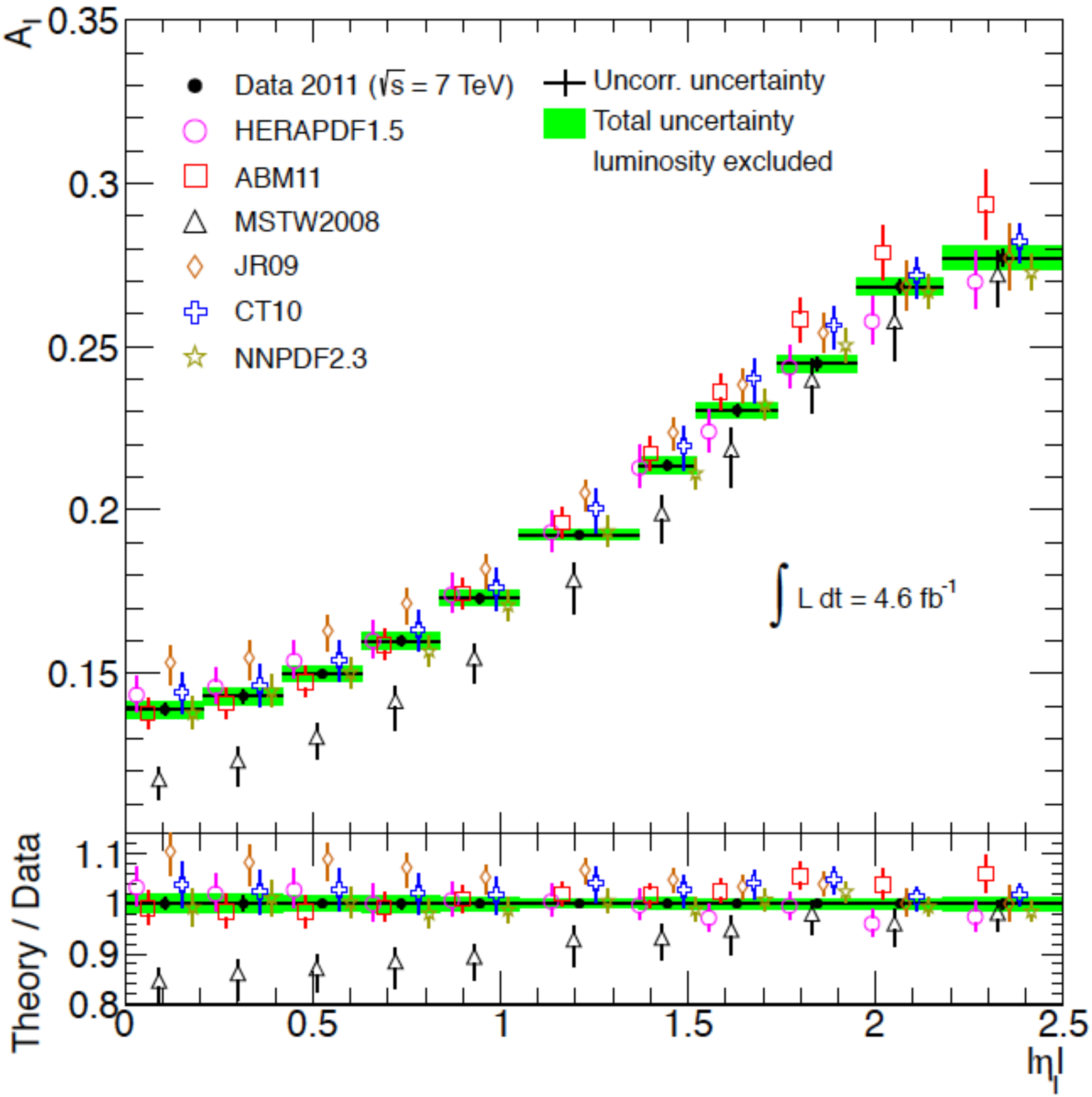
(b) Z: $116 < m_{\ell\ell} < 150$ GeV

Cross Sections vs Theory





W Charge Asymmetry vs Theory



PDF updates?
NNPDFxx
MSTW08mod
??
Note we publish in spring 14

Some of the comparison plots currently Reappear in appendix on thy predictions

Appendix on Theory Prediction in Support Note

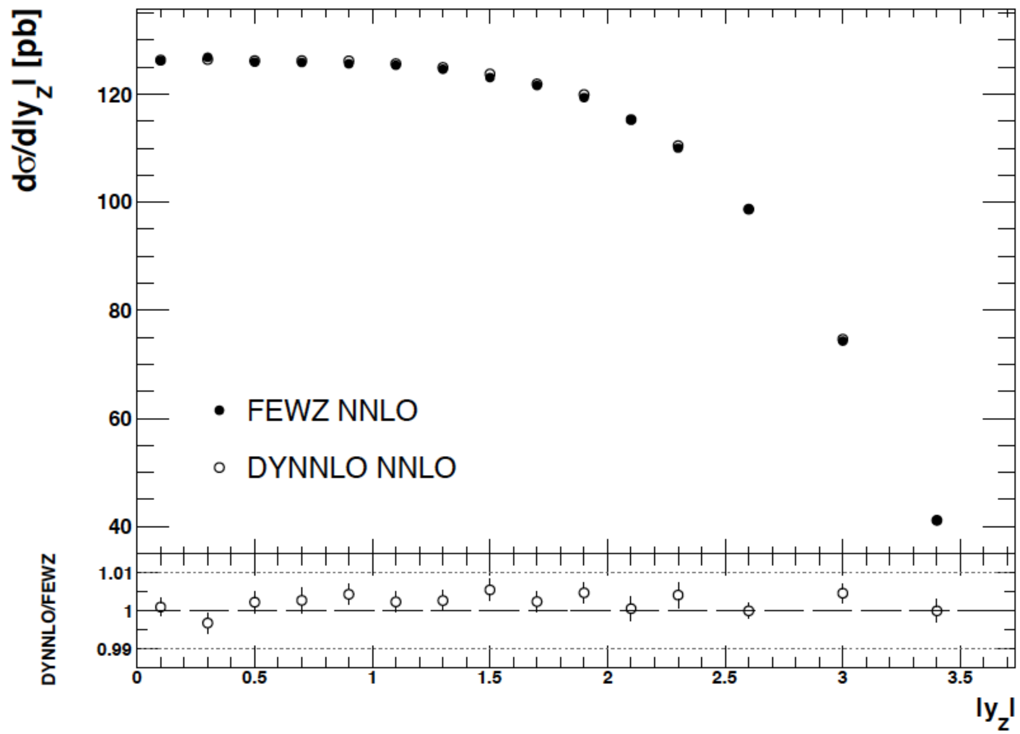


Figure 401: The differential NNLO QCD predictions with NLO EW corrections calculated with FEWZ (dots) and DYNNLO+SANC (open circles) for the Z boson production in the region $66 < m_{ll} < 116$ GeV. The error bars represent the numerical precision reported by the calculations.

Impressive (amount of) precision + technical work done, that needs still to be described, will otherwise get lost and not appreciated either.

VI - QCD Analysis

$$\chi^2 = \sum_i \frac{\left[\mu_i - m_i\left(1 - \sum_j \gamma_j^i b_j\right)\right]^2}{\delta_{i,\mathrm{unc}}^2 m_i^2 + \delta_{i,\mathrm{stat}}^2 \mu_i m_i \left(1 - \sum_j \gamma_j^i b_j\right)} + \sum_j b_j^2 + \sum_i \ln \frac{\delta_{i,\mathrm{unc}}^2 m_i^2 + \delta_{i,\mathrm{stat}}^2 \mu_i m_i}{\delta_{i,\mathrm{unc}}^2 \mu_i^2 + \delta_{i,\mathrm{stat}}^2 \mu_i^2},$$

Flexible Parametrisation:

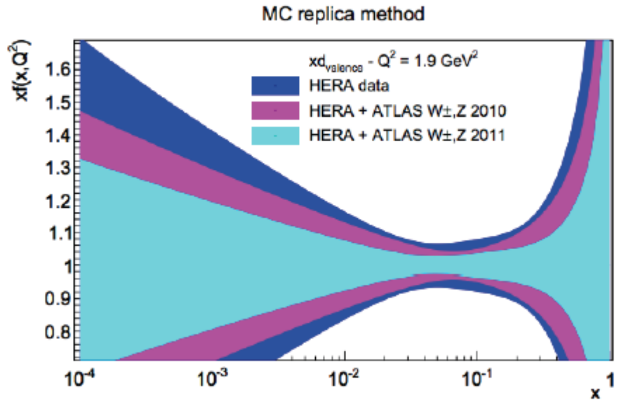
The "flexible parametrisation" is a simple extension of the Standard approach described above by adding extra two free parameters (D, E) for each of the parametrised PDFs. This leads to a total of 22 free PDF parameters (+1 for the r_s).

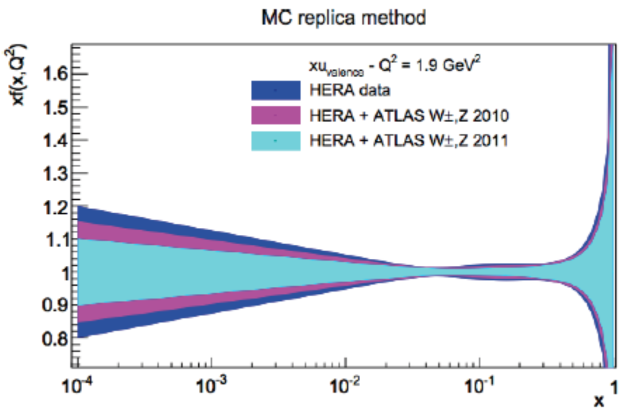
Data
HERA – which HERA
WZ 10 and 11 or only 11?

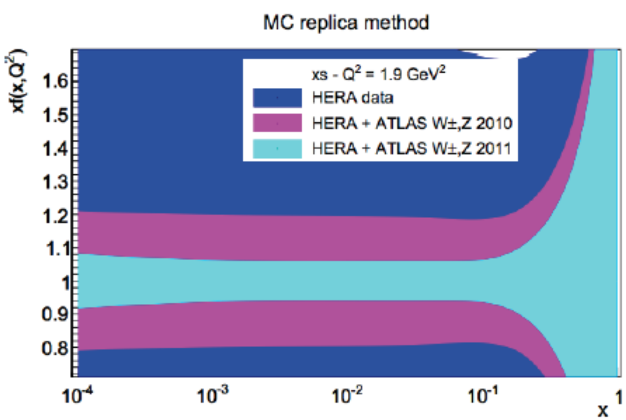
$$xu_v(x) = A_{u_v} x^{B_{u_v}} (1-x)^{C_{u_v}} (1 + D_{u_v} x + E_{u_v} x^2) \quad (58)$$
$$xd_v(x) = A_{d_v} x^{B_{d_v}} (1-x)^{C_{d_v}} (1 + D_{d_v} x + E_{d_v} x^2) \quad (59)$$
$$x\bar{U}(x) = A_{\bar{U}} x^{B_{\bar{U}}} (1-x)^{C_{\bar{U}}} (1 + D_{\bar{U}} x + E_{\bar{U}} x^2) \quad (60)$$
$$x\bar{D}(x) = A_{\bar{D}} x^{B_{\bar{D}}} (1-x)^{C_{\bar{D}}} (1 + D_{\bar{D}} x + E_{\bar{D}} x^2) \quad (61)$$
$$xg(x) = A_g x^{B_g} (1-x)^{C_g} (1 + D_g x + E_g x^2) - A'_g x^{B'_g} (1-x)^{C'_g}. \quad (62)$$

$$xu_v(x) = A_{u_v} x^{B_{u_v}} (1-x)^{C_{u_v}} (1 + E_{u_v} x^2)$$
$$xd_v(x) = A_{d_v} x^{B_{d_v}} (1-x)^{C_{d_v}}$$
$$x\bar{U}(x) = A_{\bar{U}} x^{B_{\bar{U}}} (1-x)^{C_{\bar{U}}}$$
$$x\bar{D}(x) = A_{\bar{D}} x^{B_{\bar{D}}} (1-x)^{C_{\bar{D}}}$$
$$xg(x) = A_g x^{B_g} (1-x)^{C_g} - A'_g x^{B'_g} (1-x)^{C'_g}.$$

Final chi^2, final parameterisations?, r_s or s(x)?







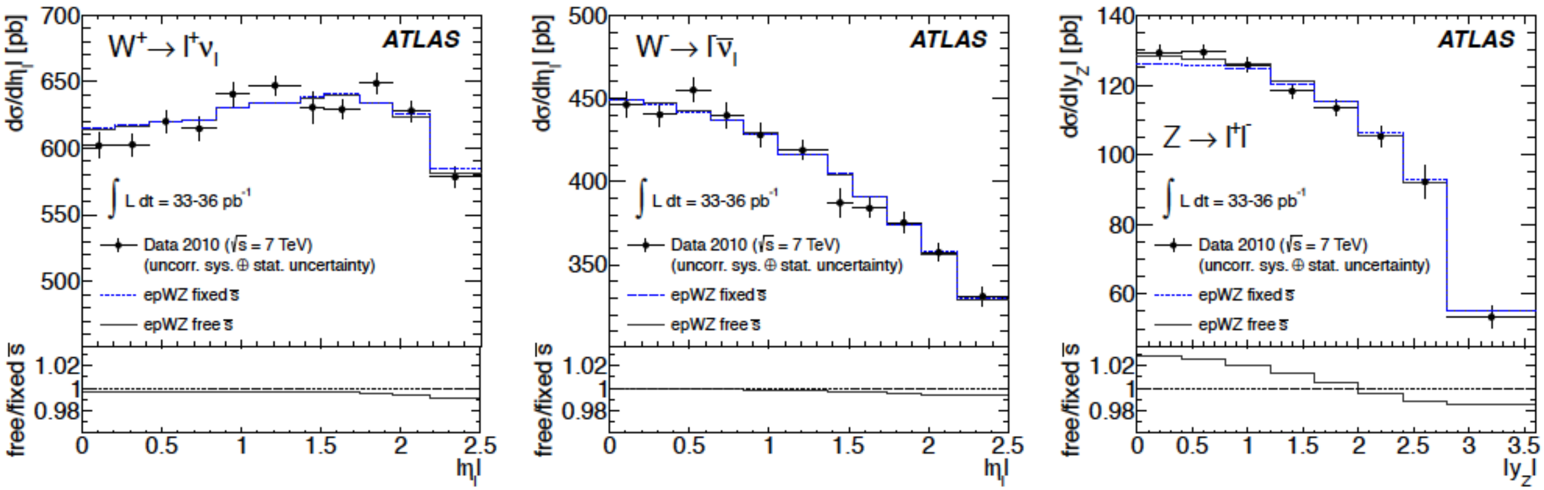
VI - QCD Analysis

	HERAFitter(Mandy)
Z low partial χ^2/N_{DF}	11.8(12.9)/6
Z central partial χ^2/N_{DF}	15.1(16.7)/15
Z high partial χ^2/N_{DF}	19.2(18.9)/9
$W-$ partial χ^2/N_{DF}	12.0(13.4)/11
$W+$ partial χ^2/N_{DF}	12.4(13.6)/11
Correlated χ^2	32.6(29.2)
luminosity shift(in units of 1.8%)	1.56 ± 0.15
r_s	$1.19(1.19) \pm 0.07$

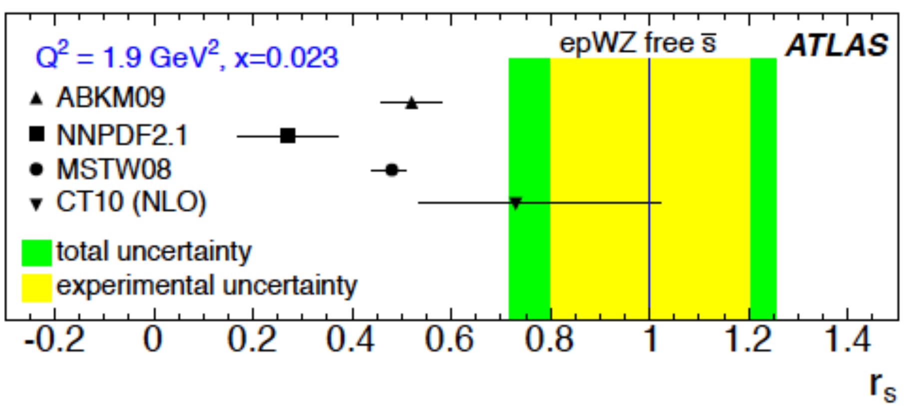
QCD Fit Results TO BE UPDATED

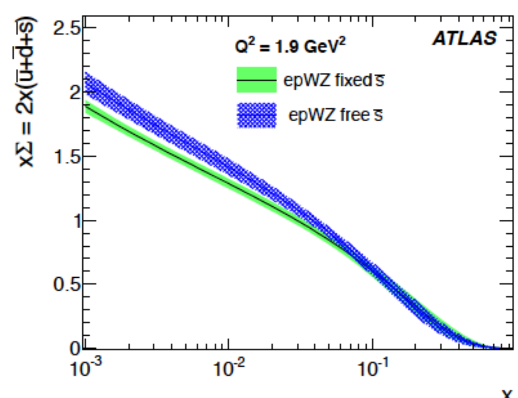
VI. QCD Analysis
A. Data input
B. Fit procedure
C. Fit results
1. Parton distributions
2. Comparisons with data
D. Determination of the strange quark density

QCD Fit Results in Strange Paper



Want to illustrate: data description, PDFs, strange and consequences (light sea)
Prepare later PDFset for LHAPDF..





A really beautiful paper to come