Measurement of the Neutral Current DY process with the ATLAS detector

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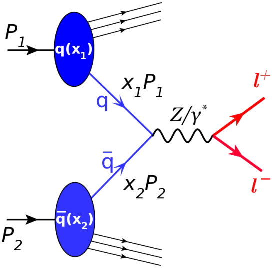
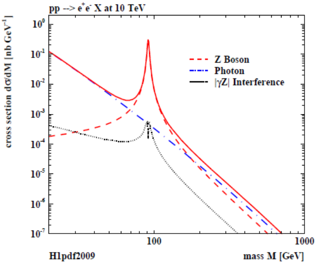
on behalf of the ATLAS collaboration

DIS 2014 Warsaw

30/04/2014





- Measurements in low and high mass regions are complementary to the Z mass peak cross-section.
- Below and above the Z mass peak the Drell-Yan cross section is dominated by a virtual photon exchange.

"Measurement of the low-mass Drell-Yan differential cross section at $\sqrt{s} = 7$ TeV using the ATLAS detector" arXiv:1404.1212 ^{*new}

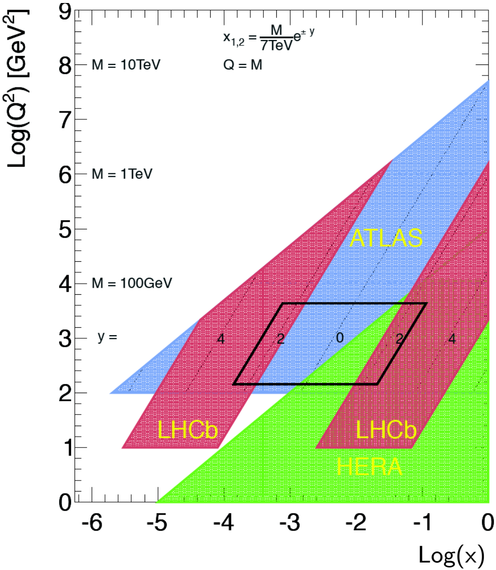
"Measurement of the high-mass Drell-Yan differential cross-section in pp collisions at $\sqrt{s} = 7$ TeV" Phys. Lett. B 725 (2013) pp. 223-242

- Since the measurement is photon exchange dominated it has different sensitivity to up-type, down-type quarks and anti-quarks compared to measurements near the Z resonance:

$$\sigma_{\gamma^*} \sim 0.44(u\bar{u}+c\bar{c})+0.11(d\bar{d}+s\bar{s}+b\bar{b})$$
$$\sigma_Z \sim 0.29(u\bar{u}+c\bar{c})+0.37(d\bar{d}+s\bar{s}+b\bar{b})$$

- Complementary to DIS kinematic region.

- Test of the Standard Model predictions at NLO, NNLO, and NLO matched to LL parton shower calculations.



Low mass Drell-Yan measurement

Two analyses are performed in the Low Mass region:

Nominal measurement

1.6 fb^{-1} of 2011 data at $\sqrt{s} = 7$ TeV

electron and muon channels

Fiducial region:

$26 < M_{\ell\ell} < 66$ GeV

$p_T^{\ell,\text{leading}} > 15$ GeV, $p_T^{\ell,\text{sub-leading}} > 12$ GeV

$|\eta^\ell| < 2.4$

Extended measurement

35 pb^{-1} of 2010 data at $\sqrt{s} = 7$ TeV

muon channel

Fiducial region:

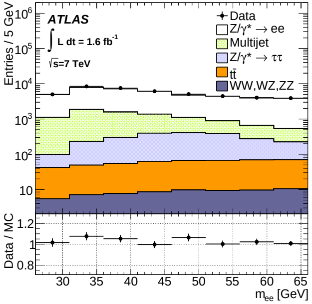
$12 < M_{\mu\mu} < 66$ GeV

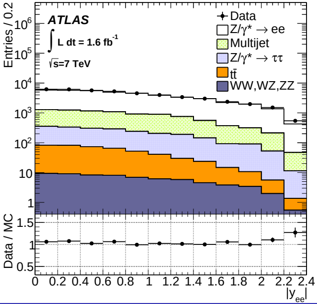
$p_T^{\mu,\text{leading}} > 9$ GeV, $p_T^{\mu,\text{sub-leading}} > 6$ GeV

$|\eta^\mu| < 2.4$

Low mass Drell-Yan. Nominal electron channel

- Inclusive multijet production is the largest source of background:
  - between **5%** and **15%** from the data from highest to lowest mass bins.
  - estimated from the data using isolation distribution.
- The dominant source of the systematic uncertainty is coming from the background estimation and electron reconstruction efficiency.
- The total uncertainty of the measurement is 3.2% - 6% from highest to lowest mass bins.

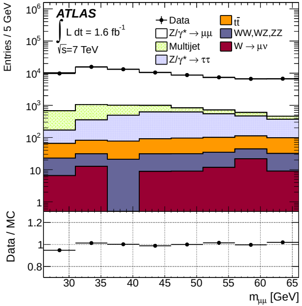


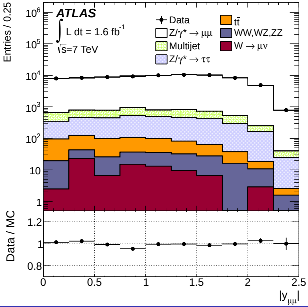


Low mass Drell-Yan. Nominal muon channel

- The main backgrounds arise from $Z/\gamma^* \to \tau\tau$ and multijet production.
  Form highest to lowest mass bins:
  - $Z/\gamma^* \to \tau\tau$ **6%** - **1%** of the data,
  - multijet **1%** - **5%** of the data.

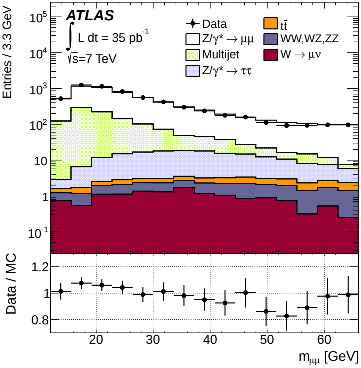
  - estimated using both MC and data-driven template fit.
- The dominant source of the systematic uncertainty is coming from the isolation efficiency.
- The nominal muon measurement has total precision 1.9 - 3.6% from highest to the lowest mass bins.

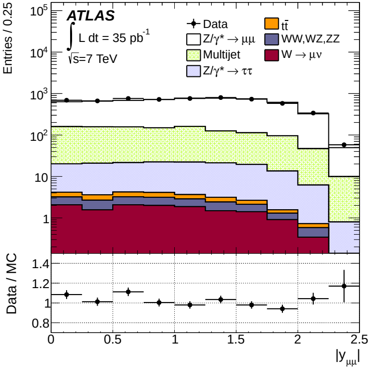




Low mass Drell-Yan. Extended muon channel

- The extended muon measurement benefits from the low-treshold trigger used in 2010 and allows to extend invariant mass region up to 12 GeV.
- The largest background source is from multijet production: **6%** to **23%** from the data from highest to lowest $M_{\ell\ell}$.
- The dominant systematic uncertainty is coming from the isolation efficiency.
- The total precision of the measurement is 7% - 13% from highest to lowest bins.

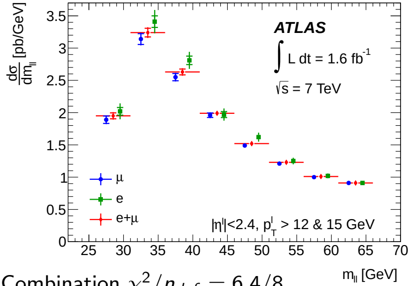




Low mass Drell-Yan. Cross-section measurement

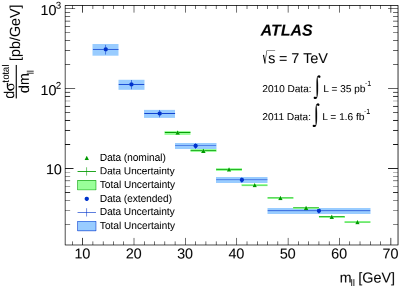
1. The differential cross section $d\sigma/dM_{\ell\ell}$ calculation in each channel:
   a) background events are subtracted from the data,
   b) the data is **unfolded** for - detector acceptance,
   - selection efficiency
   - and resolution effects.

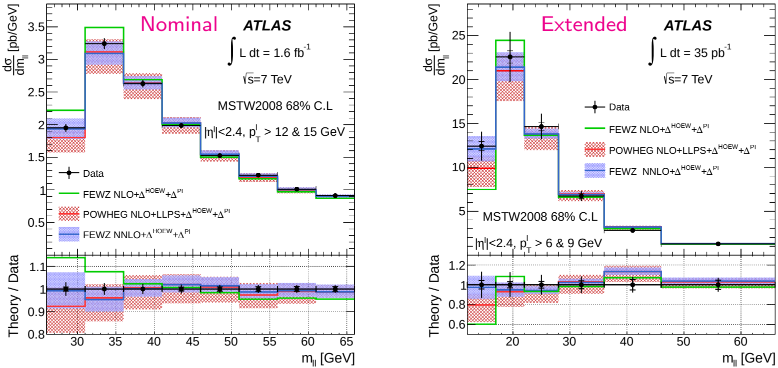
2. **Combination** of the electron and muon data for the nominal measurement using the χ^2 minimisation method. The total uncertainty is reduced to 1.6-3%.



Combination $\chi^2/n_{dof} = 6.4/8$

3. Extrapolation of nominal combined data and extended data to the **full phase space** using NNLO `FEWZ` calculations.

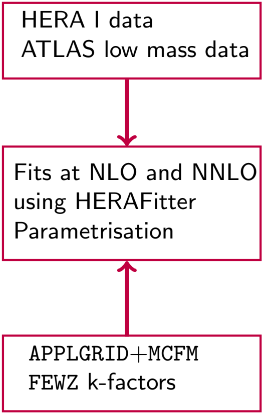




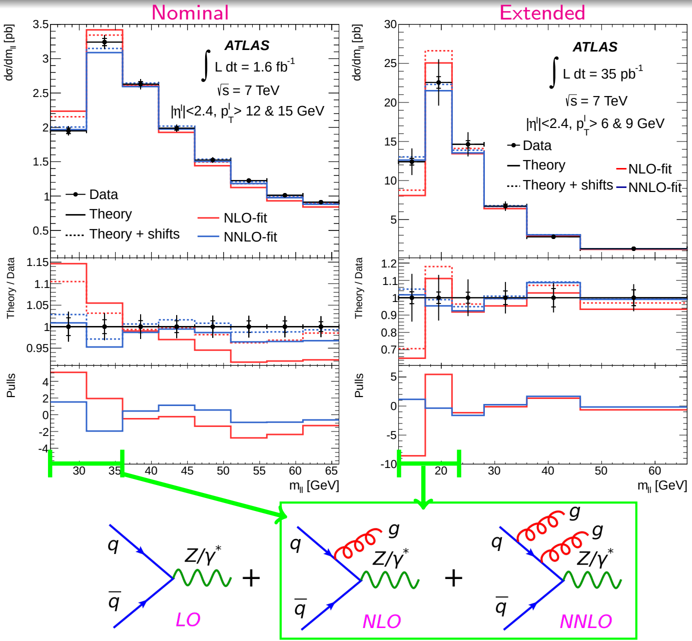
- The measurements are compared to theoretical predictions from `FEWZ` at NLO and NNLO and from `POWHEG` at NLO + LL resummed parton shower.
- Corrections are applied to account for higher order electroweak radiative effects and photon induced processes $\gamma\gamma \to \ell\ell$.
- The `FEWZ` NLO predictions provide a poor description of the data at low $M_{\ell\ell}$.

Low mass Drell-Yan. QCD analysis

- QCD analysis of the data is performed to investigate the disagreement with pure NLO calculations.
- The Low mass Drell-Yan are included to NLO and NNLO fits of HERA DIS data: the χ^2 function is evaluated after fitting the PDFs to the data.
- The parametrisation:
  quark distributions
  $xq_i(x) = A_i x^{B_i}(1-x)^{C_i} P_i(x)$
  gluon distribution
  $xg(x) = A_g x^{B_g}(1-x)^{C_g} P_g(x) - A'_g x^{B'_g}(1-x)^{C'_g}$
- APPLGRID and MCFM theoretical predictions at NLO.
- Higher order electroweak corrections including photon induced corrections and NNLO k-factors are applied to the theory.



Low mass Drell-Yan. QCD analysis



- NLO fit is not able to describe the data
- Good description from the NNLO calculation

NLO Fit	NNLO Fit
Nominal χ^2/n_{dof}	
40.7/8	8.5/8
Extended χ^2/n_{dof}	
117.1/6	7.8/6

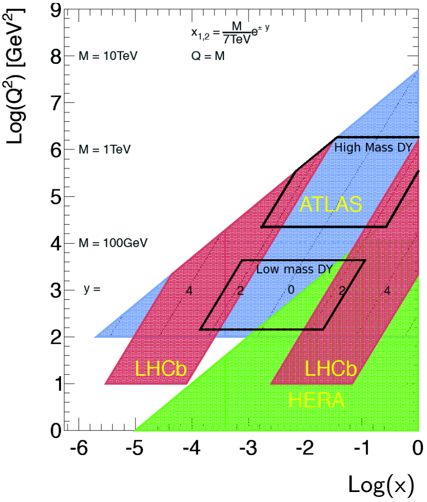
- At low masses the phase space is constrained by p_T^ℓ: $M_{\ell\ell} \sim 2p_T^\ell$

High Mass Drell-Yan measurement

Electron channel
4.9 fb^{-1} of 2011 data at $\sqrt{s} = 7$ TeV

Fiducial region:
$116 < M_{ee} < 1500$ GeV
$p_T^{\pm e} > 25$ GeV
$|\eta^e| < 2.5$

- The measurement allows for precision test of perturbative QCD.
- Access to poorly known distribution of antiquarks at large x.



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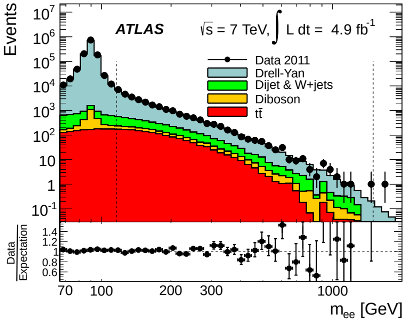
High Mass Drell-Yan measurement

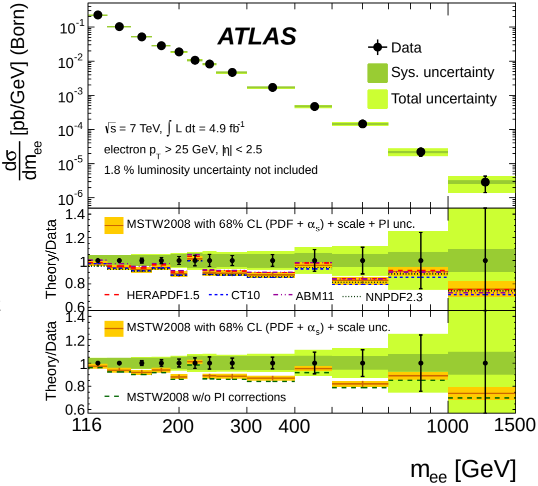


- The dominant background contributions (6-16% depending on M_{ee}) are from dijet and $W + jets$ production.
- The total systematic uncertainty of the measurement is 4.2% for lower mass region to 9.8% for the highest mass region.

Source of uncertainty	116–130 GeV [%]	1000–1500 GeV [%]
Total background estimate (Stat.)	0.1	7.6
Total background estimate (Syst.)	1.3	3.1
Electron energy scale & resolution	2.1	3.3
Electron identification	2.3	2.5
Electron reconstruction	1.6	1.7
Bin-by-bin correction	1.5	1.5
Trigger efficiency	0.8	0.8
MC statistics (C_{DY} stat.)	0.7	0.4
MC modelling	0.2	0.3
Theoretical uncertainty	0.3	0.4

High Mass Drell-Yan measurement

- The measurement is compared to FEWZ calculations at NNLO QCD with NLO electroweak corrections using the G_μ electroweak parameter scheme.
- The lower ratio plot shows the influence of the photon-induced corrections on the MSTW2008 prediction. The effect has the same size as the choice of different PDFs.
- The Standard Model predictions are consistent with the data.



Summary

- The ATLAS Neutral-Current Drell-Yan measurements cover the invariant dilepton mass range between 12 and 1500 GeV.
- The measurements agree well with the NNLO QCD and NLO+LLPS QCD calculations corrected for higher-order electroweak effects including a photon induced term.
- The data sensitive to photon induced corrections could contribute to photon PDF constraints.
- The measurements in different mass regions are sensitive to different quark distributions within the proton and can be used for PDF fits.