UNIVERSITY OF LIVERPOOL

ATLAS EXPERIMENT

MEASUREMENT OF THE HIGH-MASS DRELL-YAN CROSS-SECTION AT ATLAS

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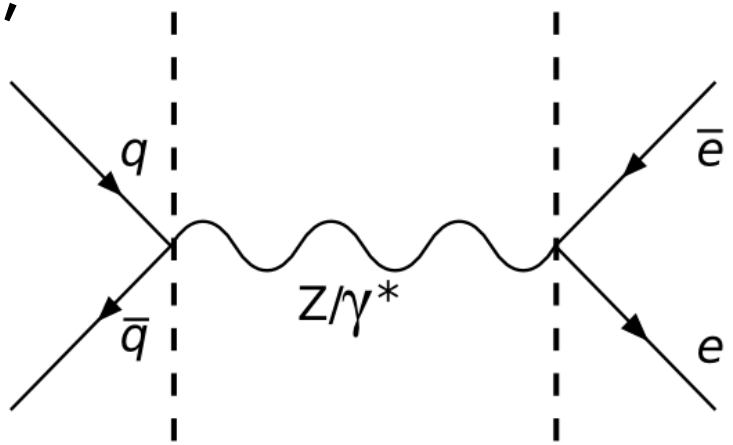
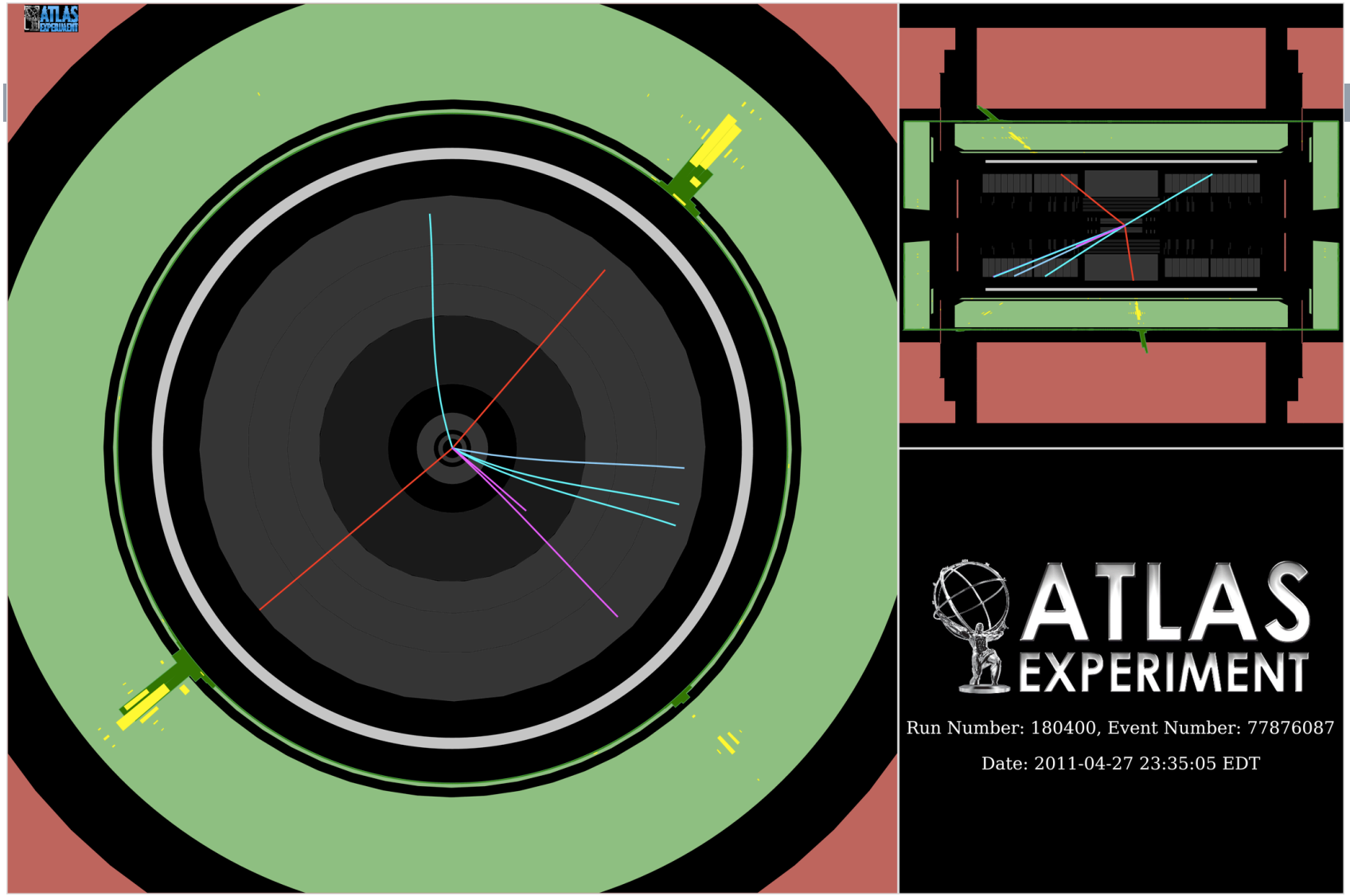
Analysis Overview

- Drell-Yan process: Production of Z/γ^*, di-lepton decay
- Simple signature, relatively low background
- Measurement:
  - $d\sigma/dm_{ee}$, <u>di-electron only</u>
  - Range 116 – 1500 GeV
  - Fiducial region $|\eta_e| < 2.5$, $p_t^e > 25$ GeV
- Full 2011 data set (4.9 fb^{-1}) at $\sqrt{s} = 7$ TeV
- Conference note: [http://cds.cern.ch/record/1493623]



Di-electron event, invariant mass = 920 GeV

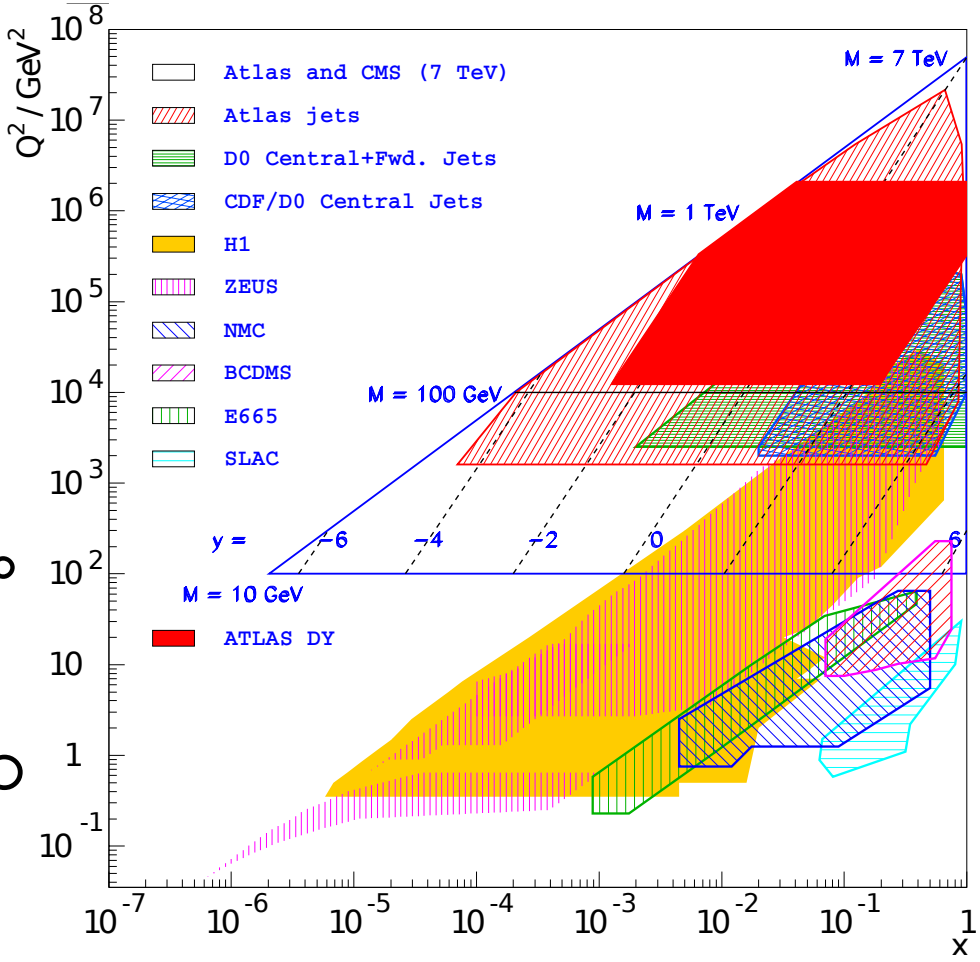


[http://cds.cern.ch/record/1356190]

Motivation: PDFs & pQCD

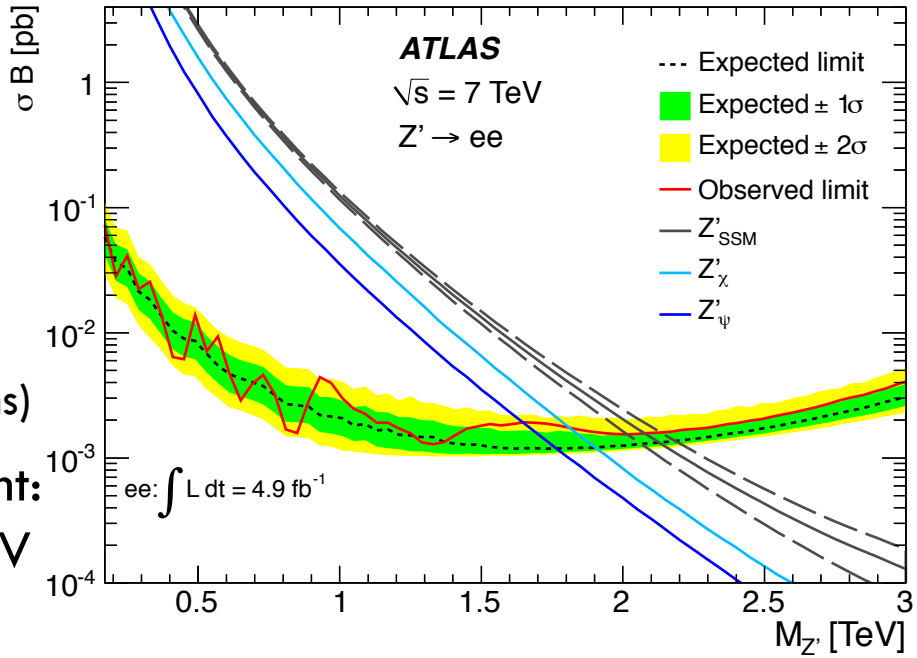
- Kinematic plane plot:
  - x: Bjorken-x, proton momentum fraction carried by struck parton
  - Q^2: scale of interaction
  - y: Rapidity of system

    (note: $x_{1,2} = (M/\sqrt{s})\, e^{\pm y}$)
  - Red area: fiducial region
- Higher scale: x large ➔ sensitive to behaviour of parton distribution function (PDFs) in these regions
- Theory: pQCD calculations at NNLO
- But also sensitive to higher order electroweak corrections



Motivation: Searches

- Z' search: Search for resonances [http://arxiv.org/abs/1209.2535]
- 2011 data sets limit at:
  - 2.07 TeV (di-electron)
  - 2.22 TeV (di-electrons & di-muons)
- High-mass Drell-Yan measurement: follow-up to search, up to 1.5 TeV is feasible



- Extends Standard Model Z/γ^* measurement (66–116 GeV)
- Measurement could improve background modelling for searches

(DY: irreducible background for di-lepton final states)

Event Selection & Backgrounds

Event Selection

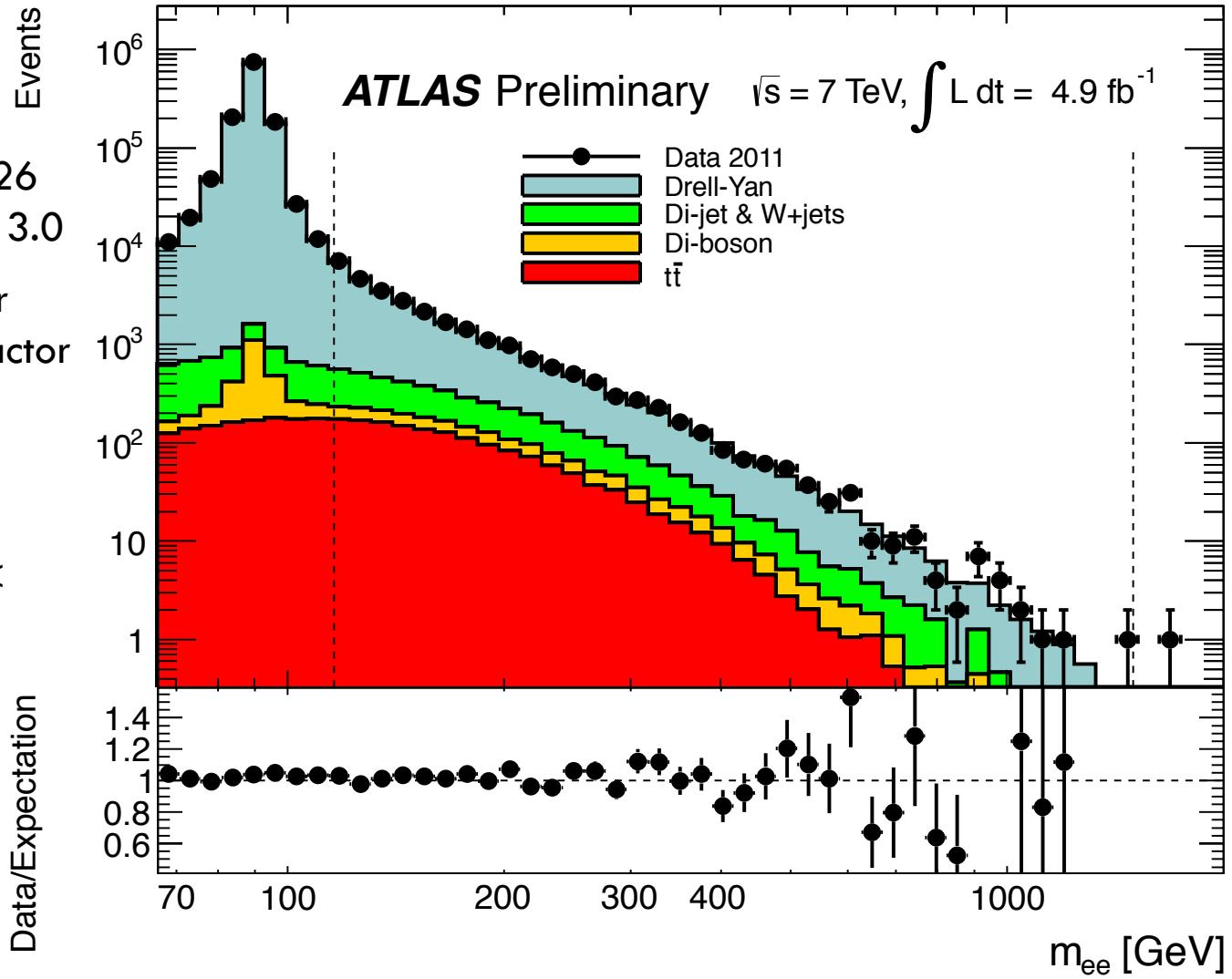
- Di-photon trigger ($E_t > 20$ GeV)
- Standard data quality cuts
- Fiducial cuts ($|\eta_e| < 2.47$, excluding calorimeter crack region $1.37 < |\eta_e| < 1.52$)
- Transverse momentum ($p_t > 25$ GeV)
- "Medium" electron identification criterion
- Isolation of leading electron (Total $E_t < 7$ GeV in $\Delta R = 0.2$ cone around electron)

Backgrounds

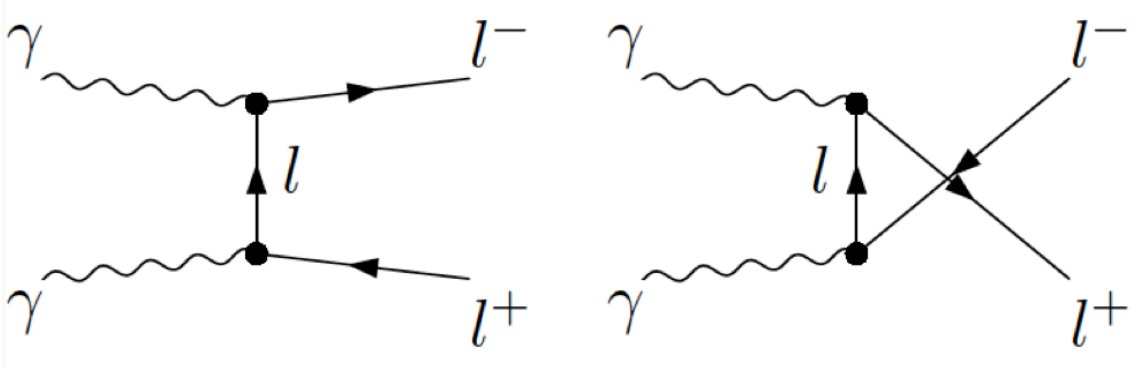
- QCD + W+jets:
  - Data-driven estimation
  - 6-16%
- Di-leptonic top pairs:
  - MC@NLO 4.01 (CT10)
  - Up to 5%
- Di-boson:
  - HERWIG 6.520 (MRSTMCal)
  - Up to 9%

Data to Monte Carlo Comparison

- Monte Carlo: Pythia 6.426 (MRSTMCal) + PHOTOS 3.0
- MC includes higher order QCD & EW correction factor ("k-factor")
- Data set contains 26844 candidate events (within range 116 GeV < m_{ee} < 1500 GeV)



Additional Background



- Additional Background:
  - Photon-induced (PI) di-electron production (non-resonant production)
  - Calculate partonic cross-section for fiducial region
  - Calculated at LO with MRST2004QED PDF and added to theory prediction (see later)

Cross-Section Measurement

- Cross-section in 13 mass bins, calculated as:

$$\frac{d\sigma_{\text{fid}}}{dm_{ee}} = \frac{N_{\text{sig}}}{C_{\text{DY}}\, L_{\text{int}}} \frac{1}{\Gamma_{\text{bin}}}.$$

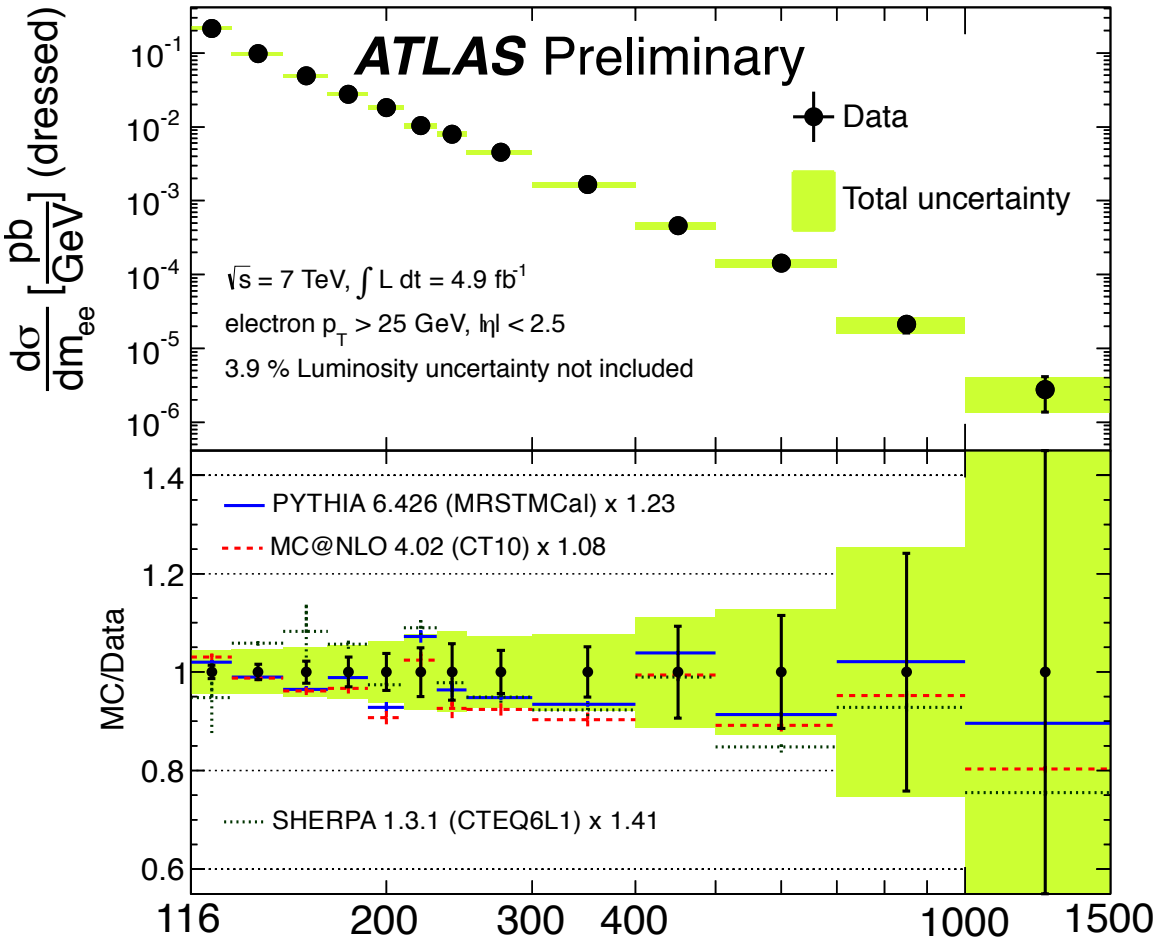
- C_{DY} is a correction factor:
  - $N_{\text{reconstructed, detector}} / N_{\text{generator, fiducial}}$
  - Derived using Monte Carlo: Pythia 6.426 (MRSTMCal) + PHOTOS 3.0
  - Cross-check & systematics with MC@NLO (CT10) + HERWIG + JIMMY 4.31 + PHOTOS 3.0
- Cross-section for:
  - Born-level (before QED final state radiation)
  - Dressed-level (recombining electrons & QED final state radiated photons within $\Delta R < 0.1$ of electron)

Measurement Uncertainties

Source of systematic uncertainty	Bin: 116 – 130 GeV [%]	Bin: 1000 – 1500 GeV [%]
Total background estimate	1.3	8.2
Electron reconstruction & identification	2.8	3.0
Electron energy scale & resolution	2.1	3.3
Unfolding method	1.5	1.5
Trigger efficiency	0.8	0.8
MC modelling	0.2	0.3
MC statistics	0.7	0.4
Total experimental uncertainty	4.2	9.8
Luminosity uncertainty	3.9	3.9
Theoretical C_{DY}	0.1	0.3
Comparison: statistical data uncertainty	1.1	50

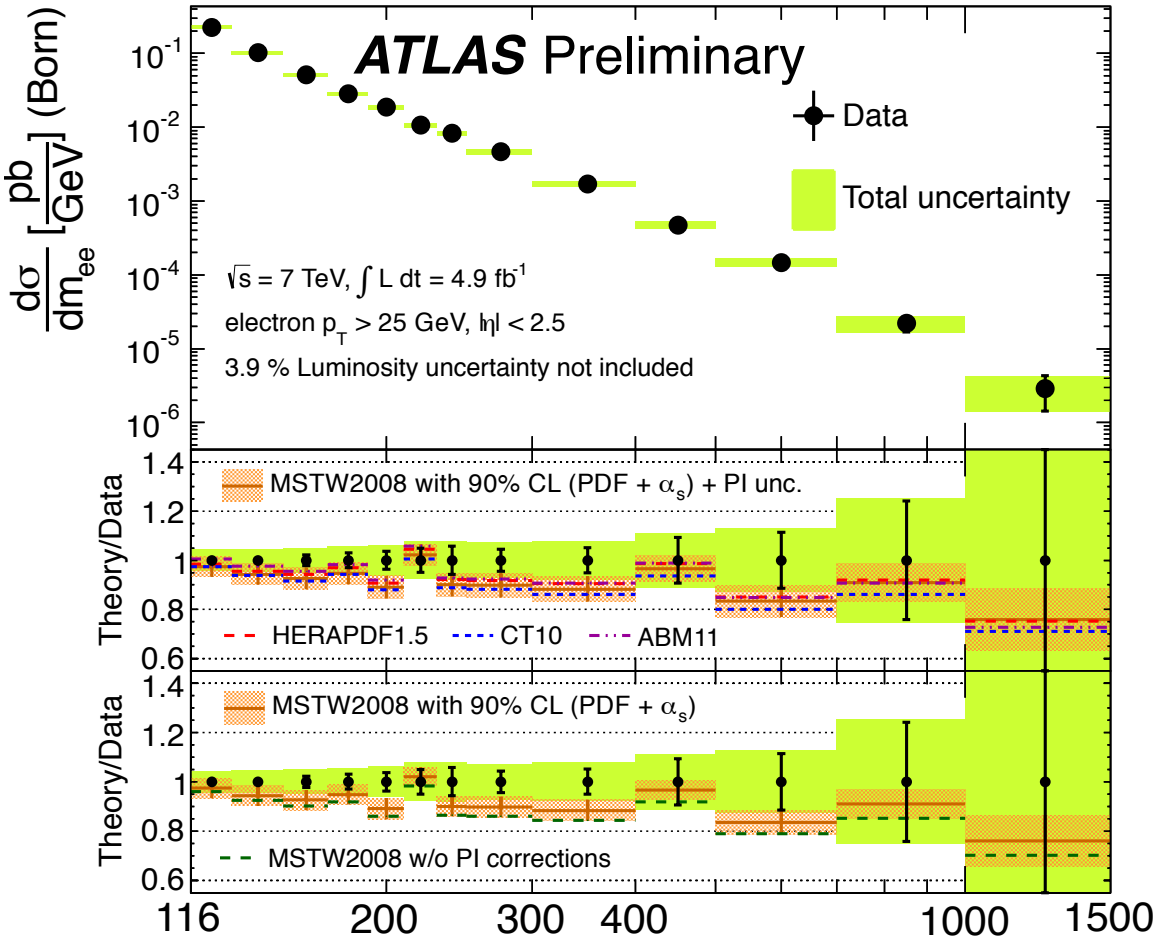
Results

- Dressed-level comparison of cross-sections with three Monte Carlos
- MCs normalised to data (no higher-order QCD or EW corrections applied)
- Shape well described



Results

- Born-level theory comparison: FEWZ 3.1 calculations
- Shown with 90% error band (PDF + α_s)
- NNLO pQCD + NLO EW
- All PDFs within MSTW2008 band
- Includes photon-induced (PI) corrections
- Theory & data show good agreement



Summary

- Measured the mass-differential DY cross-section (116 – 1500 GeV) in the di-electron channel with full 2011 data from ATLAS (4.9 fb^{-1}) at $\sqrt{s} = 7$ TeV
- Statistical precision ranging from 1-50% and systematic uncertainties ranging from 4-10%
- ATLAS data consistent with HO EW corrected NNLO QCD prediction including photon-induced processes

Backup Slide – Cross-section Table

m_{ee} bin [GeV]	$\frac{d\sigma}{dm_{ee}}$(Born)	$\frac{d\sigma}{dm_{ee}}$(dressed)	Stat. error [%]	Syst. error [%]
116-130	2.24×10^{-1}	2.15×10^{-1}	1.1	4.2
130-150	1.02×10^{-1}	9.84×10^{-2}	1.4	4.3
150-170	5.12×10^{-2}	4.93×10^{-2}	2.0	4.6
170-190	2.84×10^{-2}	2.76×10^{-2}	2.7	4.7
190-210	1.87×10^{-2}	1.82×10^{-2}	3.0	5.3
210-230	1.07×10^{-2}	1.04×10^{-2}	4.4	6.1
230-250	8.23×10^{-3}	7.98×10^{-3}	5.2	5.9
250-300	4.66×10^{-3}	4.52×10^{-3}	4.3	5.8
300-400	1.70×10^{-3}	1.65×10^{-3}	5.1	5.9
400-500	4.74×10^{-4}	4.58×10^{-4}	9.4	6.3
500-800	1.46×10^{-4}	1.41×10^{-4}	11	5.7
800-1000	2.21×10^{-5}	2.13×10^{-5}	24	7.5
1000-1500	2.88×10^{-6}	2.76×10^{-6}	50	9.8

Backup Slide – Born vs. Dressed