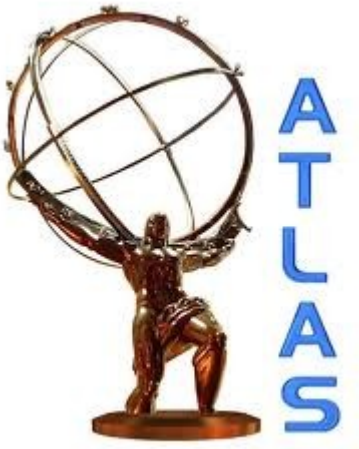


Production of W and Z bosons in ATLAS

Z. Czyczula (on behalf of the ATLAS collaboration)
University of Oslo

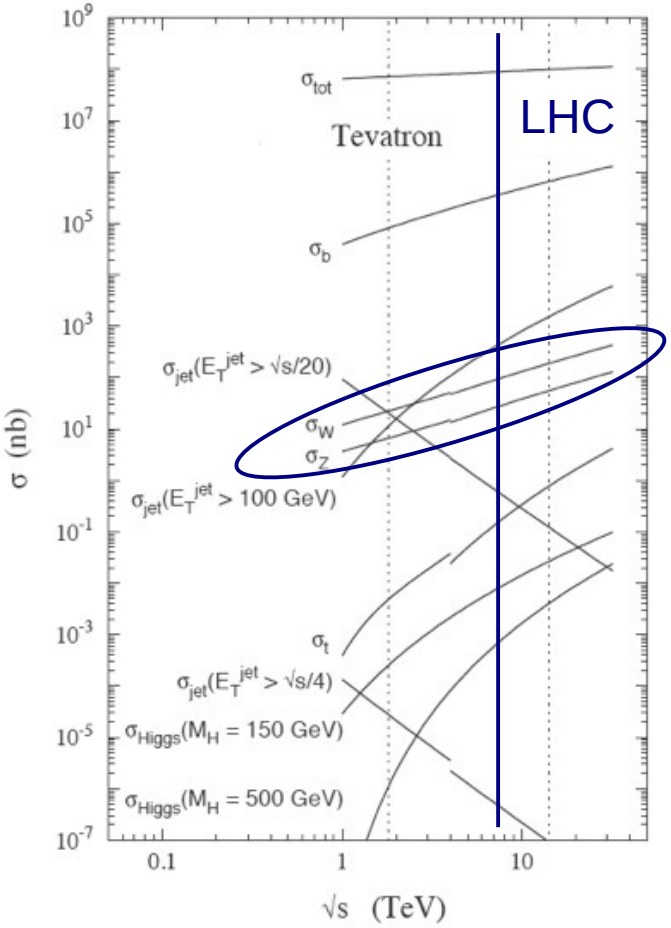
Rediscovery of the Standard Model @ turn-on of the LHC

W and Z bosons abundantly produced @ LHC

- Provide high stats probe of the ATLAS detector
  - ·Lepton reconstruction and ID
  - ·MET scale and resolution
  - ·Trigger efficiency
  - ·Tracking efficiency

- Important backgrounds for BSM searches

- New experimental conditions
- · Probe of proton's PDFs at low-x values (√s=7TeV)



Overview of the talk

- Identification of leptons and missing transverse energy (ETmiss) in ATLAS

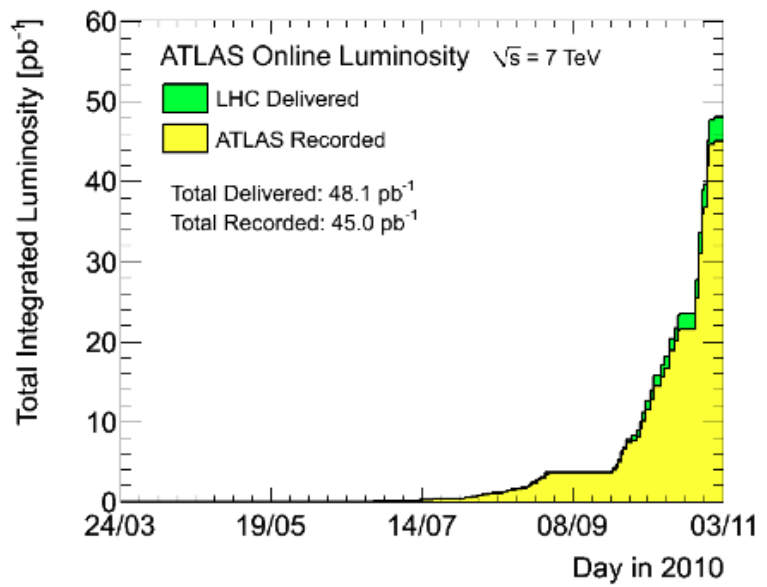
- W boson using first data (< 1 pb^{-1}):
  - · Inclusive cross section in e and μ channels (CERN-PH-EP-2010-037)
  - · W charge asymmetry in e and μ channels (CERN-PH-EP-2010-037)
  - · first observation of tau leptons (ATLAS-CONF-2010-097)

- Z boson using first data (< 1 pb^{-1}):
  - · Inclusive cross section in ee and $\mu\mu$ channels (CERN-PH-EP-2010-037)

- Prospects for the measurements using full ATLAS 2010 data:
  - · Inclusive cross section
  - · W/Z differential cross section
  - · W/Z+ jets cross section

(https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasResults)

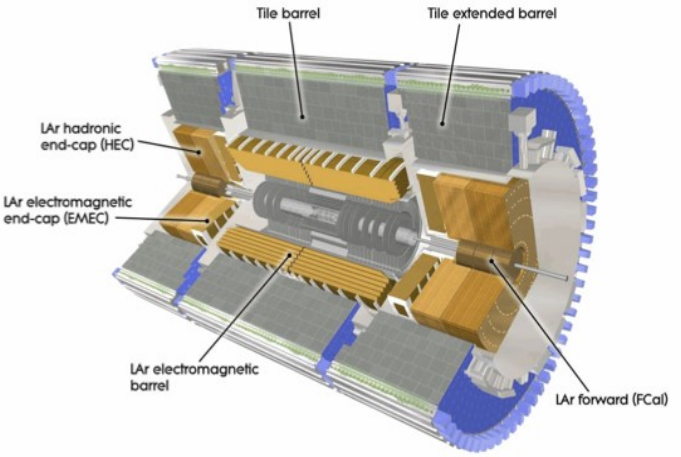
- Summary



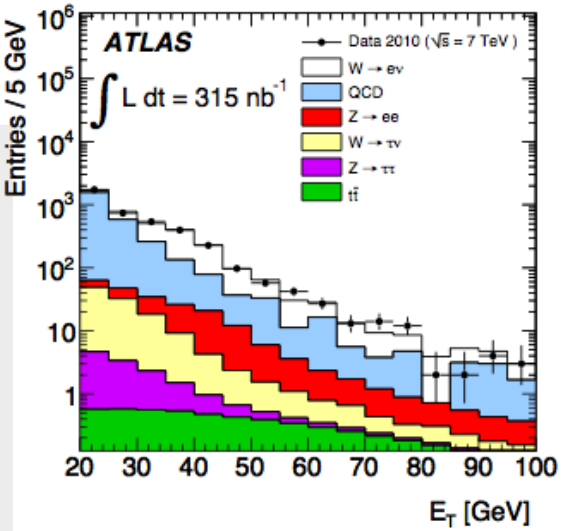
Electrons in ATLAS

- Trigger: L1 (hardware), $|\eta|<2.5$, $E_T>10$ GeV

- Preselection: $E_T>20$ GeV, $|\eta|<2.47$ excluding $1.37<|\eta|<1.52$
  - ***Loose* electron**:
    Shower shape from middle layer of EM calo,
    Energy leakage into the hadronic calo
  - ***Medium* electron**, add:
    Shower shape in the fine-granularity layer of EM calo
    Track quality variables, cluster-track matching
  - ***Tight* electron**, add:
    Ratio of cluster energy and track momentum
    Tighter track quality criteria + conversion flagging algo



Tight electron



- Performance:
  - Energy scale (±3%) - test beam
  - Eff from W→eν sample, well modelled in MC:
    medium: 90%±4.0(syst)±1.4(stat), *tight* 74.2%±3.0(syst)±1.3(stat)
  - Charge MisID: 1.9/0.6 % for *medium/tight electron*
    (MC studies with extra material in ID and in front of EM calo)

Muons in ATLAS

- Trigger: L1 (hardware), p_T >6 GeV, $|\eta|$<2.4

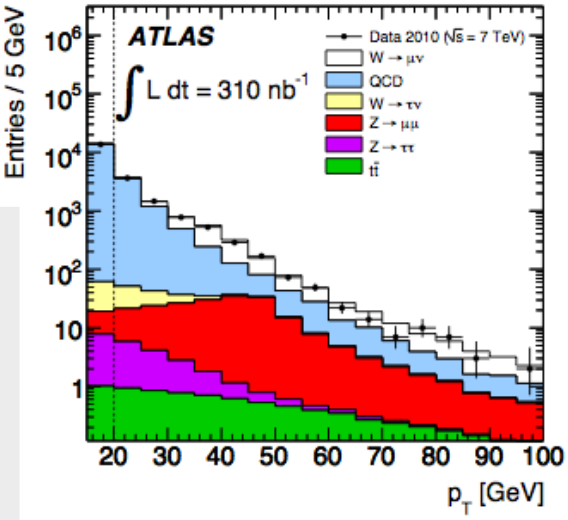
Stand-alone(MS) muon: based entirely on muon spectrometer

Combined muon: associates a stand-alone muon track to ID track

- Selection:
  - $|\eta|$<2.4 (trigger cut),
  - p_T>20 GeV (*combined*)
  - p_T>10 GeV (*stand-alone*)
  - $|p_T$ (*combined*) - p_T(*MS*)| <15 GeV

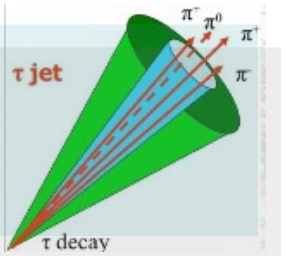
- Performance – fully data driven
  - p_T scale (±1%),
  - p_T resolution (±2(3)% barrel(end-cap)) from fit to Z
  - Eff: isolated combined wrt ID tracks: 99.4±2.4(syst)±0.6(stat)
  - well modelled in MC, x-check usning tag-and-probe on Z

Combined muon

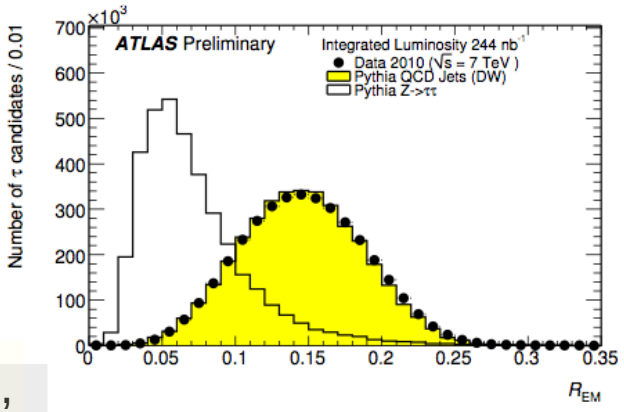


Taus in ATLAS

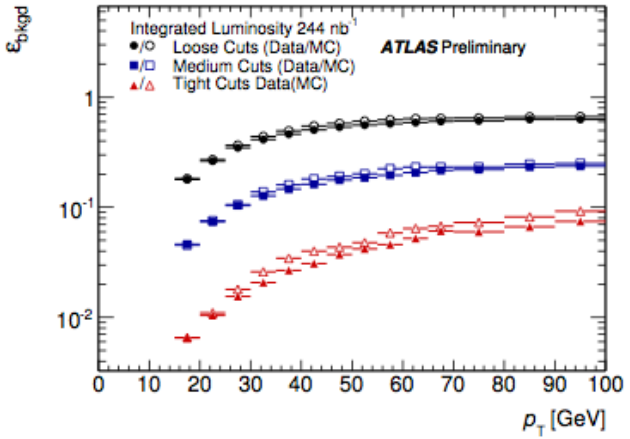
- Tau-lepton characteristics:
  - Short lifetime → not possible to distinguish $\tau \rightarrow e/\mu$ from prompt e/μ
  - Hadronic tau: narrow jet, 1/3 tracks (75/33 % accompanied with neutrals)



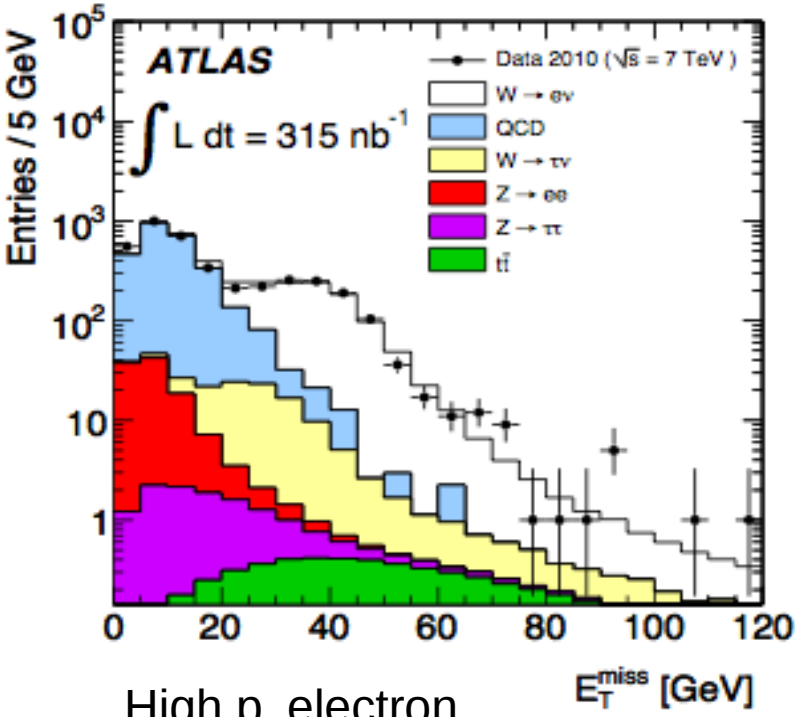
- Reconstruction: track seeded (p_T >6 GeV), calo seeded (topo cluster E_T >10 GeV) both if $\Delta R(seed)<0.2$
- Identification:
  - ID variables include: EM radius, track width
  - *Loose,Medium,Tight* : MC signal efficiency: 60/50/30 %



- Systematics: energy scale (2.1/8.5/9.6% for l*oose/medium/tight*), pile-up

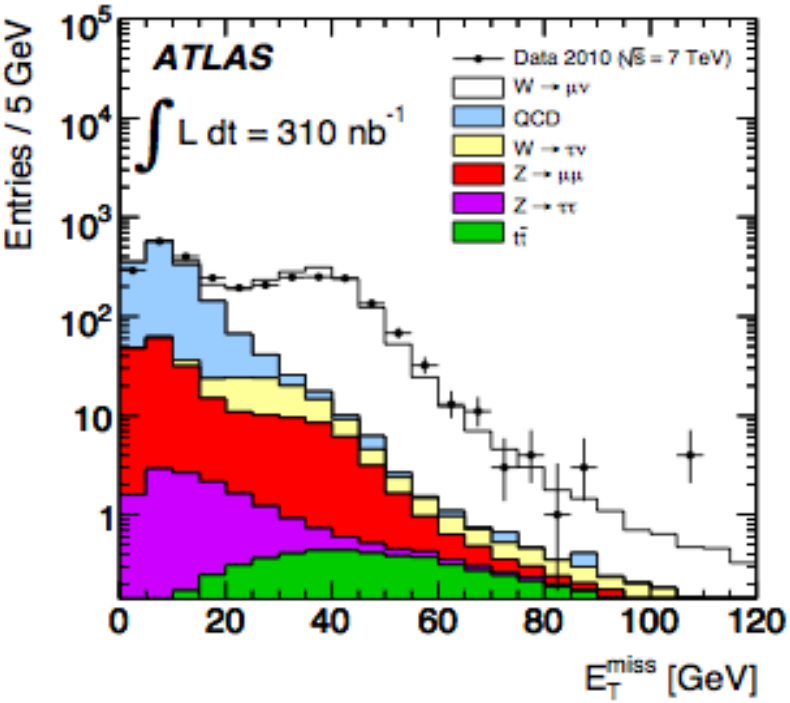


Missing transverse energy in ATLAS



High p_T electron

- Etmiss reconstruction:
  - Calorimeter based - sum of cell energy deposits (@ EM scale) inside topological clusters
  - Corrections for hadronic deposits
  - Muon corrections



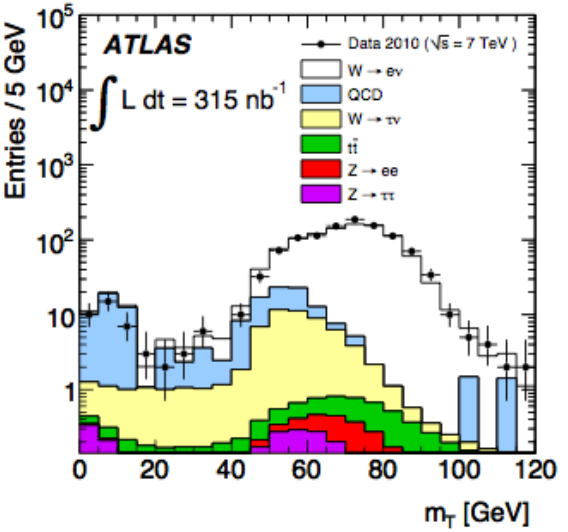
High p_T muon

- Systematics:
  - Mainly from topo cluster energy scale (20 % for p_T~500 MeV, 5 % at high p_T)
  - Other sources: imperfect modelling of response to low energy hadrons, resolution, underlying event and pile-up

Selection of W decays ($e\nu$ and $\mu\nu$ channels)

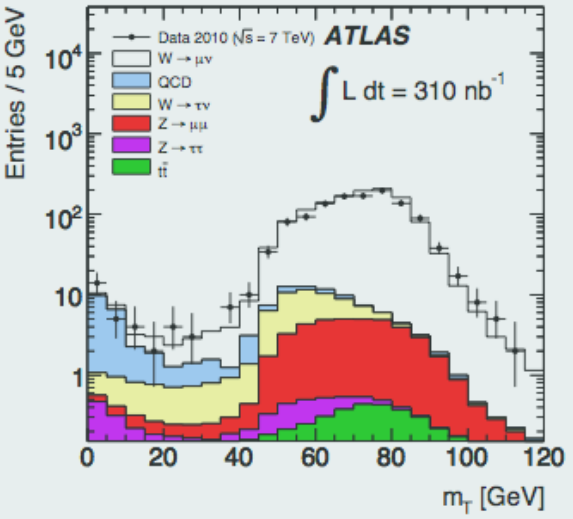
Electron channel

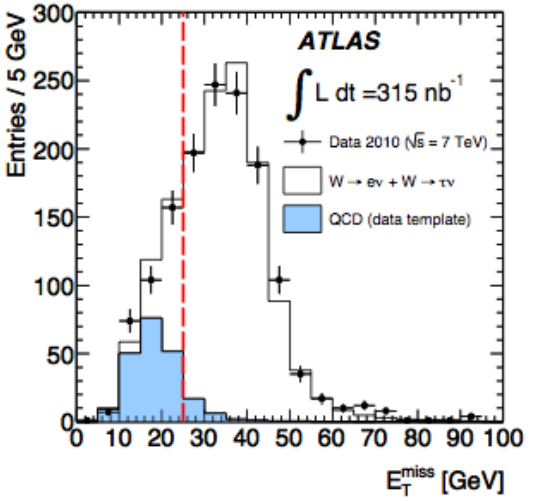
- Selection: *tight* electron, ETmiss>25 GeV, m_T>40 GeV
  - 1069 selected in data
- Small backgrounds (6%) estimated using fit to ETmiss
  - QCD bkg template from data using relaxed e ID criteria (anti *tight* anti-isolation)
  - Wtaunu and signal templates from MC



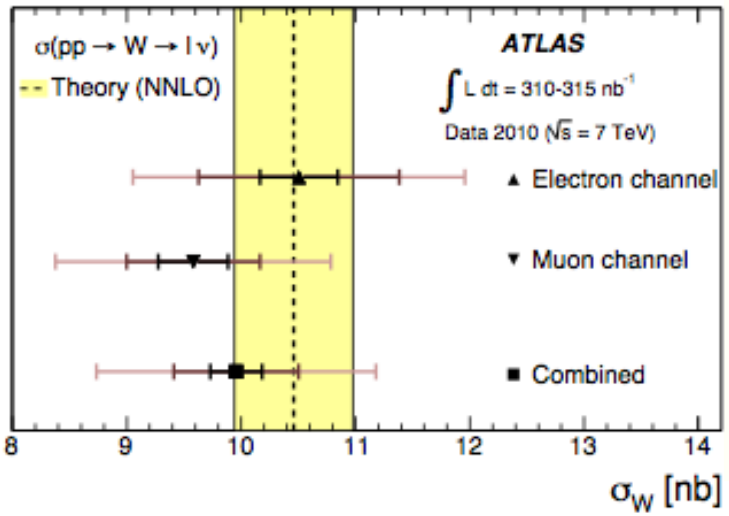
Muon channel

- Selection: isolated *combined* muon, Etmiss>25 GeV, m_T>40 GeV
  - 1181 events selected in data
- Small backgrounds (9%)
  - EW from MC
  - QCD from data
  - Similarity relation in Etmiss and isolation plane, corrected for correlations and signal and EW bkg in control region
  - Relaxed isolation





Inclusive W cross section ($e\nu$ and $\mu\nu$ channels)



- Method

$$\sigma(W)BR(W>l\nu) = \frac{N_W}{A_W C_W L_W}$$

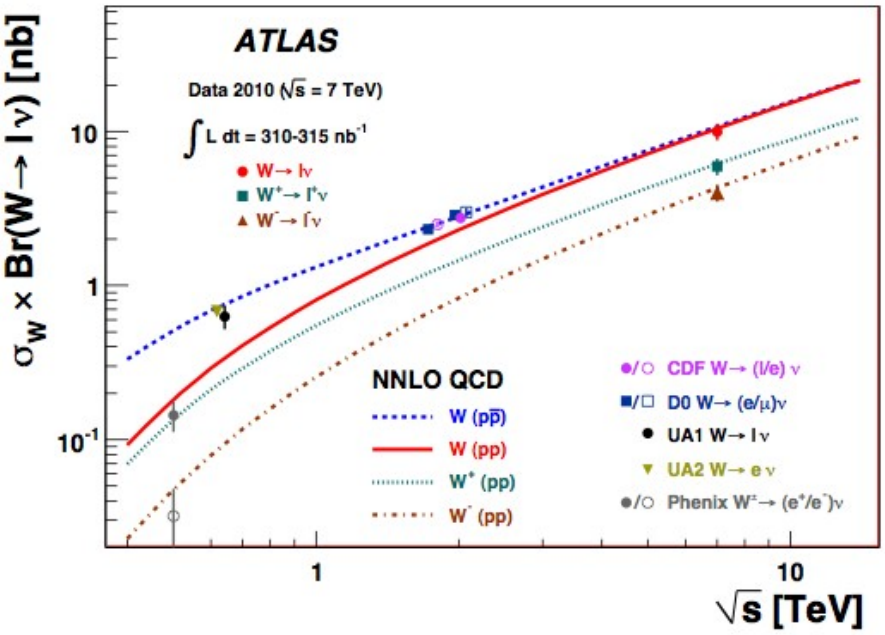
A_W : fiducial acceptance estimated from MC

A_W=46.2/48.0 % (e/μ channel)

C_W : trigger, reconstruction and identification efficiency

C_W=65.9/75.8 % (e/μ channel)

L_W : integrated luminosity

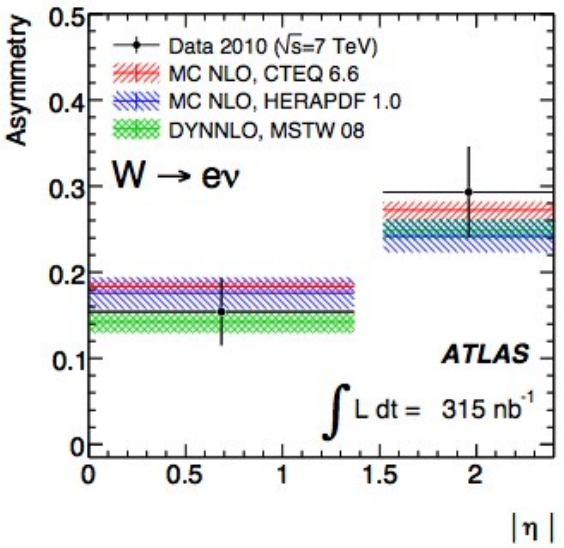


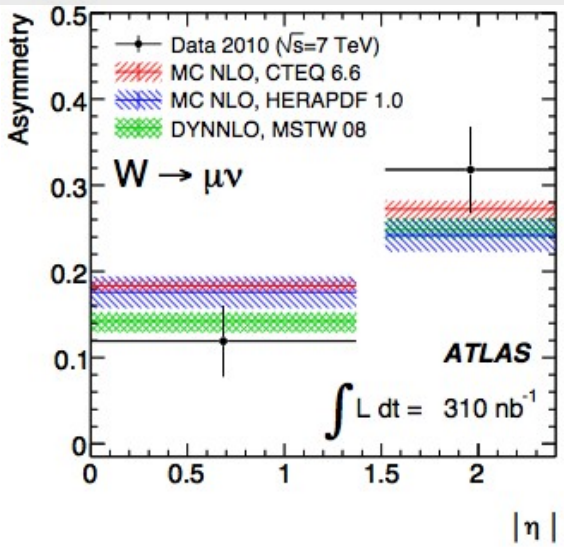
- Uncertainties:
  - Luminosity 11 %
  - A_W: 3 %, PDFs and modelling of W
  - C_W : 7% (4%) in e (μ) channel.
    - e channel: material effects, energy scale
    - μ channel: reconstruction efficiency
- Result:
  9.96±0.23 (stat)±0.50 (syst)±1.10 (lumi) nb
- Theory:
  10.46±0.52 nb

W->lν charge asymmetry ($e\nu$ and $\mu\nu$ channels)

- The asymmetry: $A_l = \frac{\sigma(W^+)-\sigma(W^-)}{\sigma(W^+)+\sigma(W^-)}$, $\sigma(W^{+/-}) = \sigma^{tot}(W^{+/-})\, A_W$
- Reflects different contect of u and d (valence) quarks in the proton
  -> probe of proton structure functions in kinematic regime at the LHC

- Measured in 2 η ranges : $0 < \eta < 1.37$ and $1.52 < \eta < 2.4$
- Probe of different <x> of the partons
- Combined electron and muon channel
- Uncertainties 5%
- Electron channel: charge misID, energy scale, bkg subtraction
- Muon channel: momentum scale and resolution, trigger efficiency



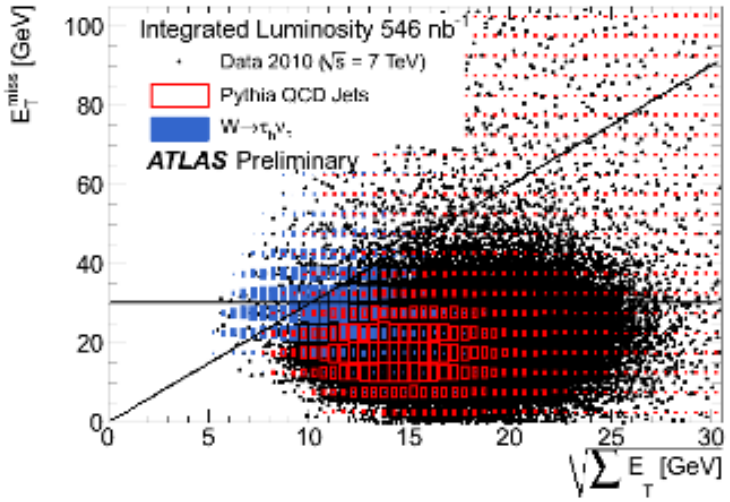


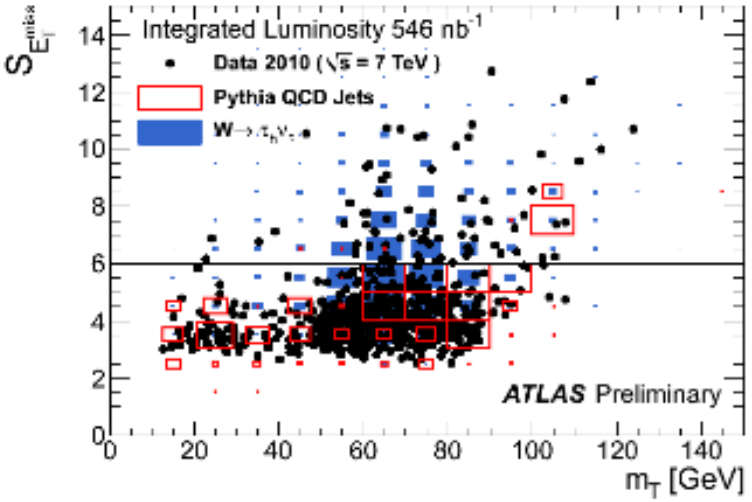
Measured asymmetry:

$A_l = 0.20 \pm 0.02(stat) \pm 0.01(syst)$

- Good agreement with theory
- Too high uncertainties to Discriminate models

Selection of $W \to \tau\nu$ events





- Trigger (eff = 99.7 % from MC)
  - E_T > 5 GeV at Level 1 (hardware)
  - Track p_T > 6 GeV and missing E_T > 5 GeV at Level 2
  - Missing E_T > 15 GeV at the Event Filter

- Event selection
  - ***Tight* tau** (both seeded) with 20 GeV<p_T < 60 GeV and not within 1.3<|η|<1.7
  - **ETmiss** > 30 GeV
  - **Electron and muon veto** flags & veto events with *loose* electrons and *combined* muons
  - **ETmiss significance** cut

$$S_{E_T^{miss}} = \frac{E_T^{miss}}{0.5 \cdot \sqrt{\sum E_T}}, \quad > 6$$

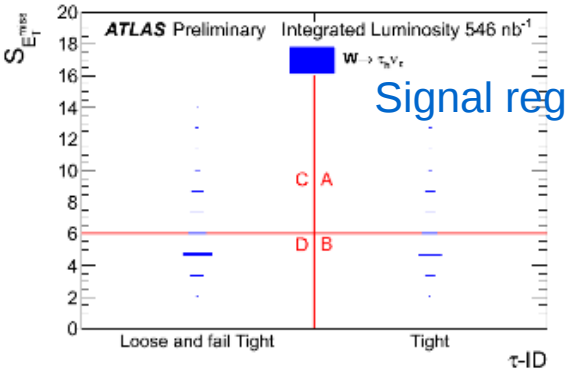
- Stricter event selection than in e and μ channels due to much larger backgrounds

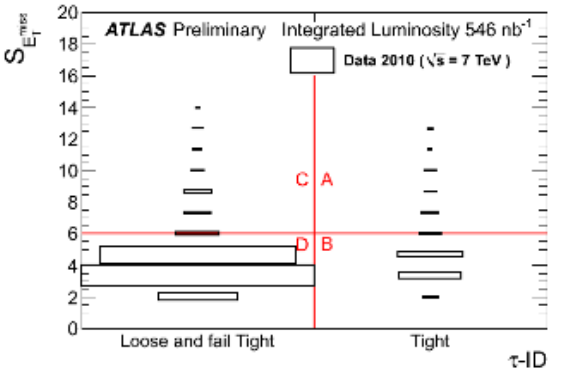
-> low acceptance for signal (~5%)

First observation of taus in ATLAS

Controlling the backgrounds

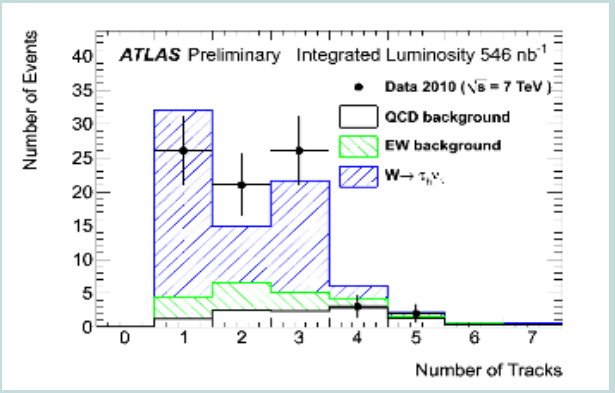
- EW (**W,Z**) backgrounds (**15%**), estimated using **MC**
  - Systematics (31%): lepton veto, MC model, tau energy scale
- **QCD** background (**15%**), estimated from **data**
  - N_{QCD} in the signal region corrected for signal and EW bkgs contamination in the control regions.
  - Systematics (29%): correlation of ETmiss significance and tau ID and corrections for signal and EW bkgs.

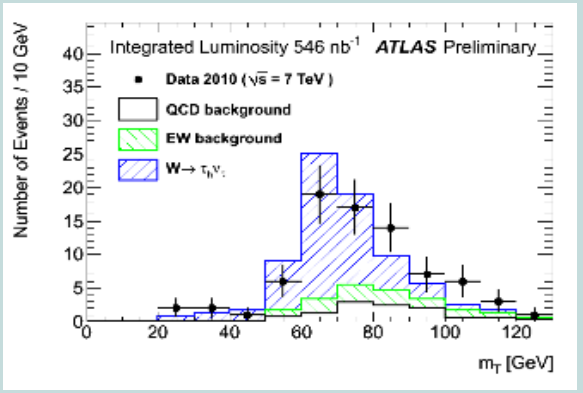


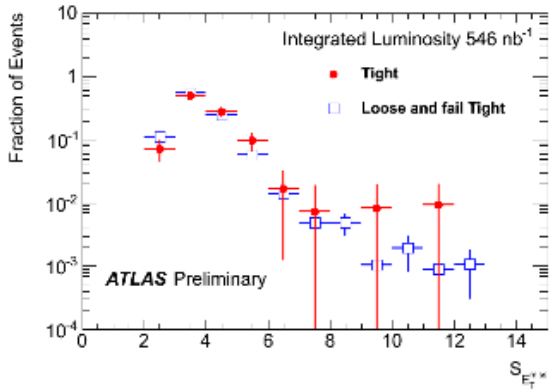


Observed: 55.1±10.5(stat)±5.2(syst)
Expected: 55.3±1.4 (stat)±16.1 (syst)

- Systematics for MC signal: tau energy scale, MC model, luminosity





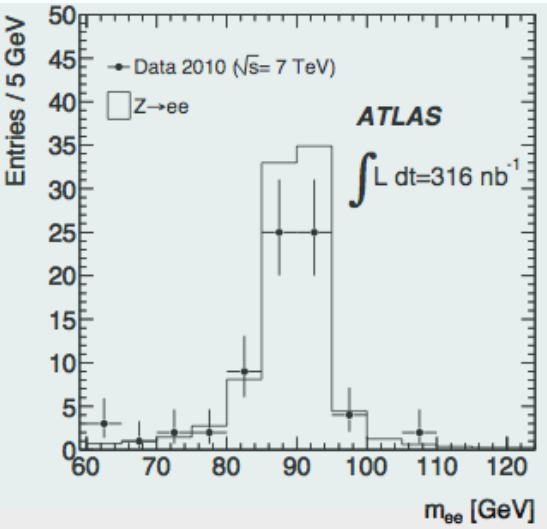


Cross section measurement ongoing with larger statistics sample

Selection of Z decays (ee and $\mu\mu$ channels)

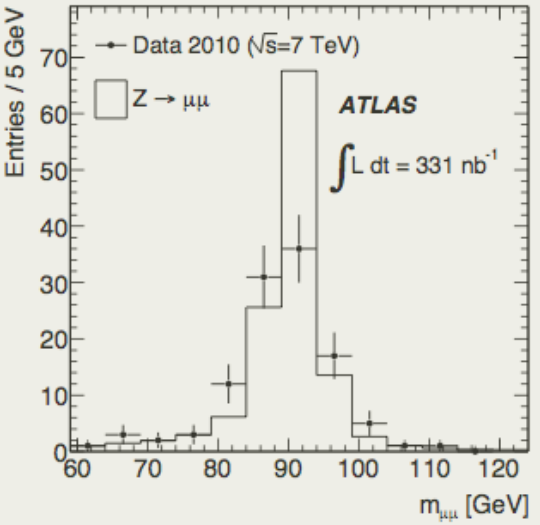
Electron channel

- Selection: two *medium* opposite charge electrons, 66< M(ee) <116 GeV
  - 70 events selected in data
- Small backgrounds (1%) mainly QCD, estimated from data
  - fit to M(ee) (QCD template from data)
  - Additional same sign versus opposite sign check

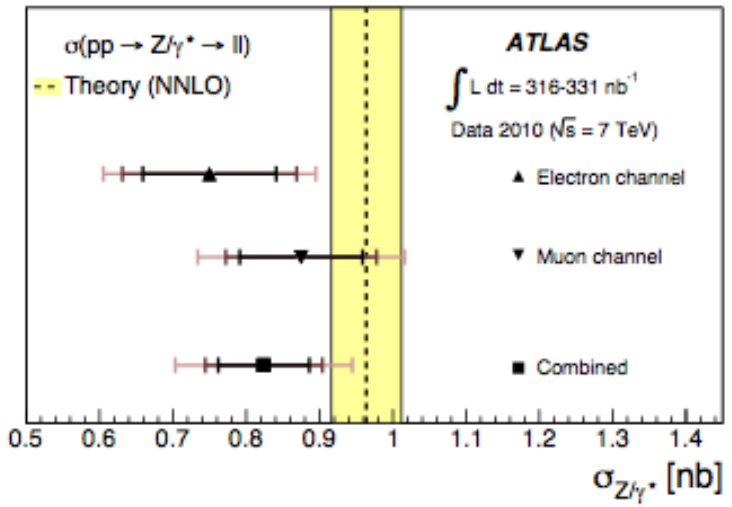


Muon channel

- Selection: two isolated *opposite charge combined* Muon, 66< M($\mu\mu$) <116 GeV
  - 109 events selected in data
- Backgrounds very small (<1 %), estimated on MC



Z cross section measurement (*ee* and $\mu\mu$ channels)



•Method

$$\sigma(Z)BR(Z\to ll) = \frac{N_Z}{A_Z C_Z L_Z}$$

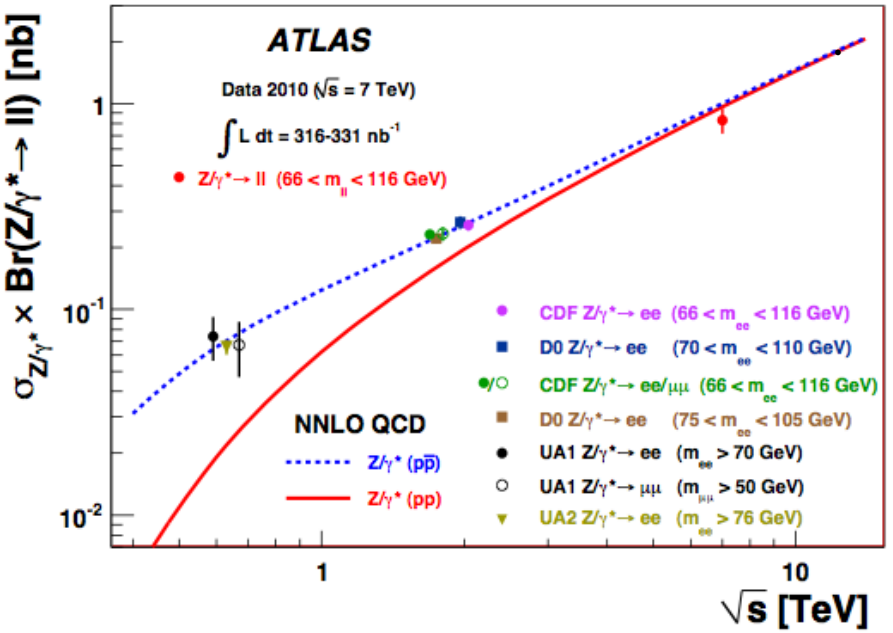
A_Z : fiducial acceptance estimated from MC

A_Z =44.6/48.6 % (e/μ channel)

C_Z : trigger, reconstruction and identification efficiency

C_Z =65.1/77.3 % (e/μ channel)

L_Z : integrated luminosity

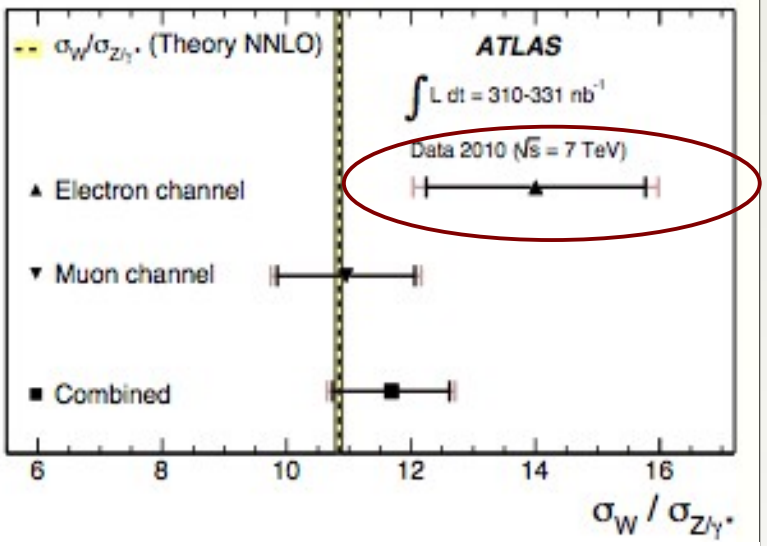


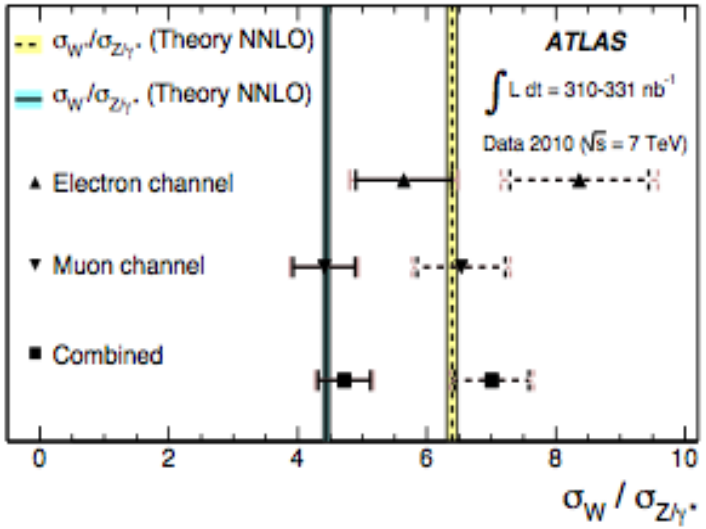
•Uncertainties:

- Luminosity 11 %
- A_Z: 3 %, PDFs and modelling of Z
- C_Z : 9.4% (5.5%) in e/μ channel.
  e channel: material effects, reco,ID efficiency
  μ channel: reco efficiency

- Result:
  0.82±0.06 (stat)±0.05 (syst)±0.09 (lumi) nb
- Theory:
  0.96±0.05 nb

W/Z cross section ratio (electron and muon channels)





$$R = \frac{\sigma(W)BR(W \to l\nu)}{\sigma(Z)\,BR(Z \to ll)} = \frac{N_W A_Z C_z}{N_Z A_W C_W}$$

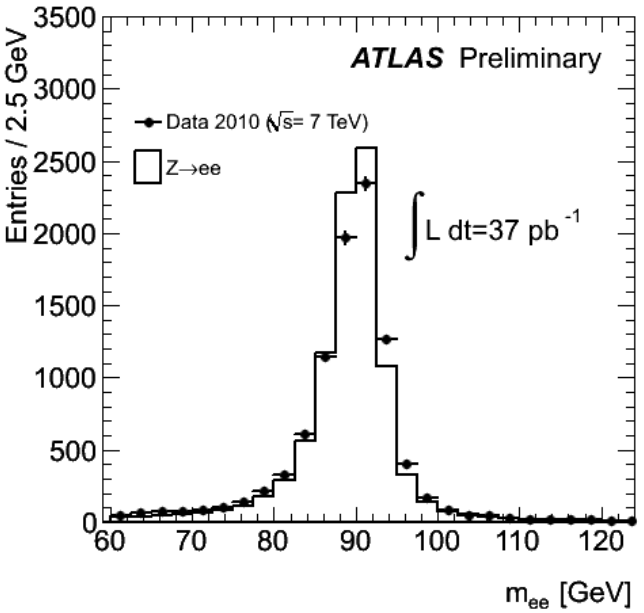
- Partial cancellation of theoretical and experimental uncertainties (lumi, lepton energy scale, pdf)

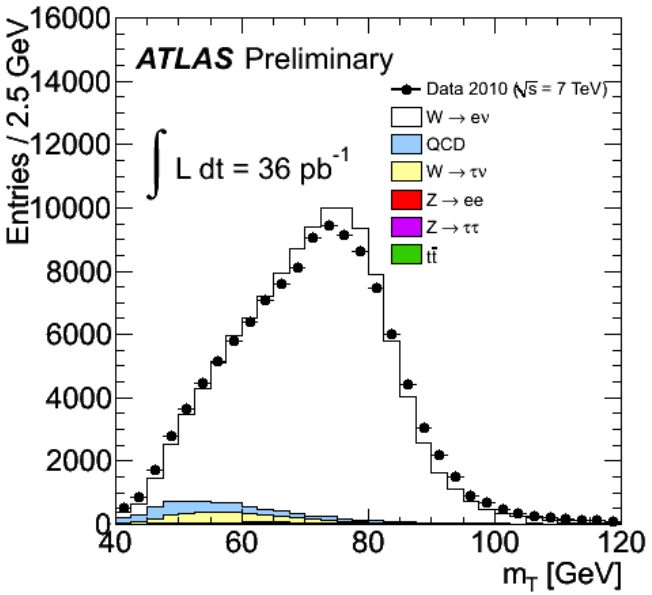
Result: R=11.7±0.9(stat)±10.4(syst)
Theory: 10.840±0.054 @ NNLO)
Tevatron result: 10.84±0.15(stat)±0.14(syst)

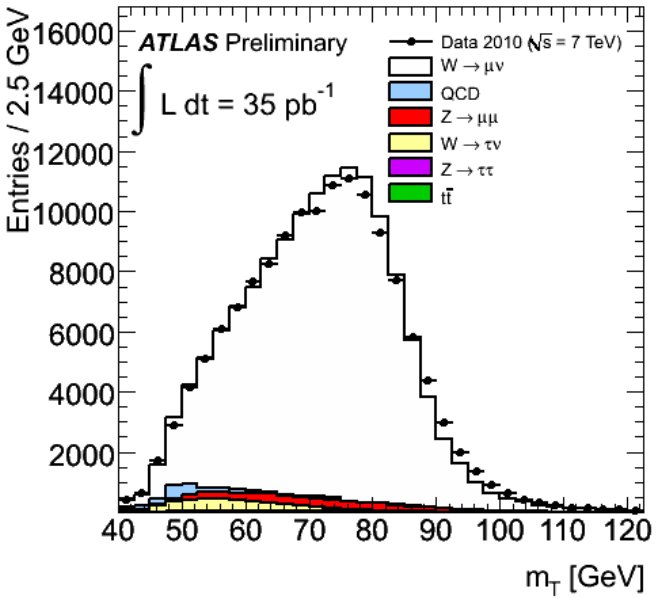
- can be used to extract SM parameters (Γ_W)

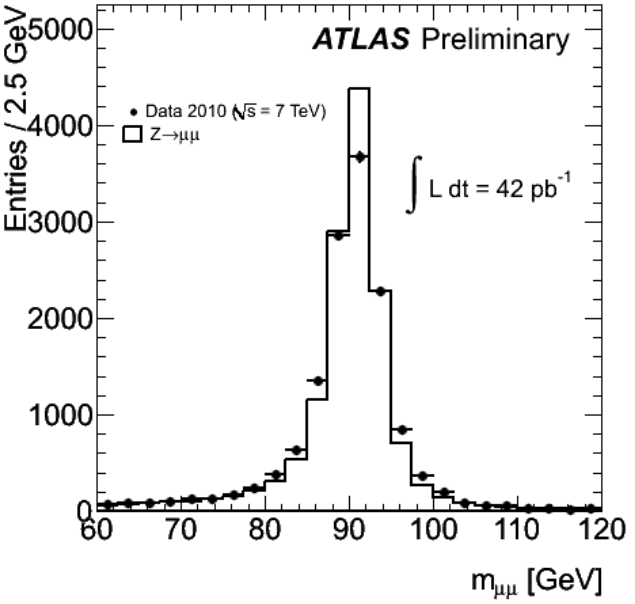
Prospects: W/Z cross section measurement with all 2010 data - 100 times higher statistics

- Full high level trigger for both electrons and muons
- Same event selection



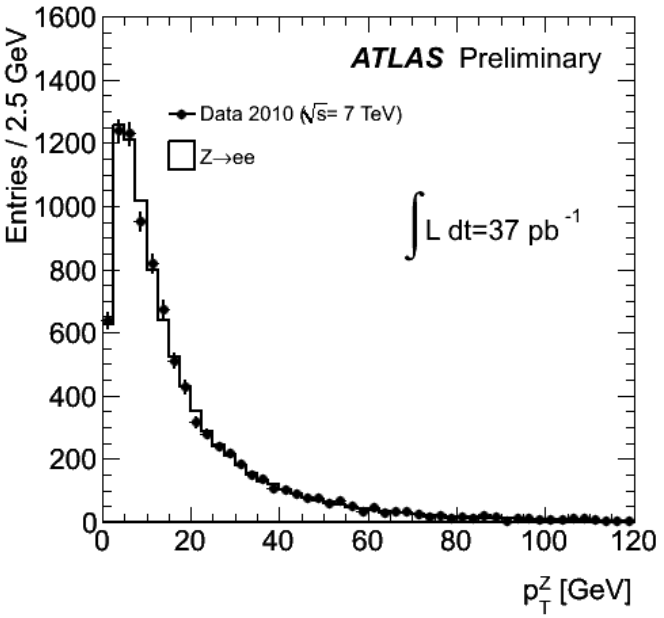


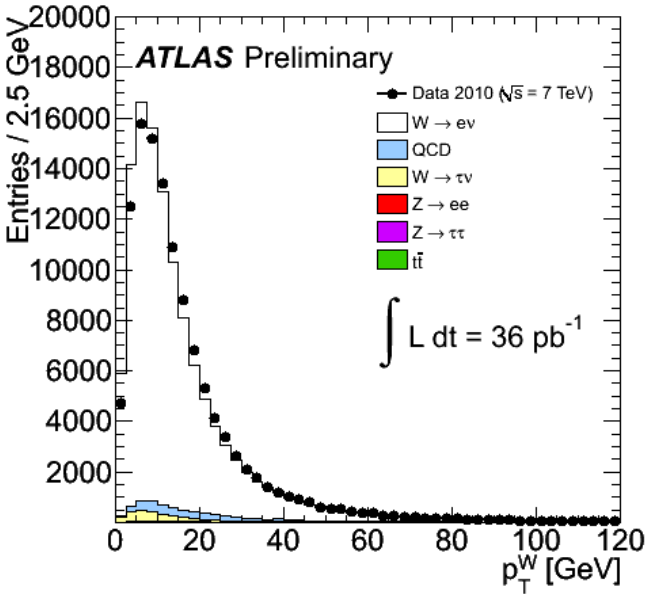


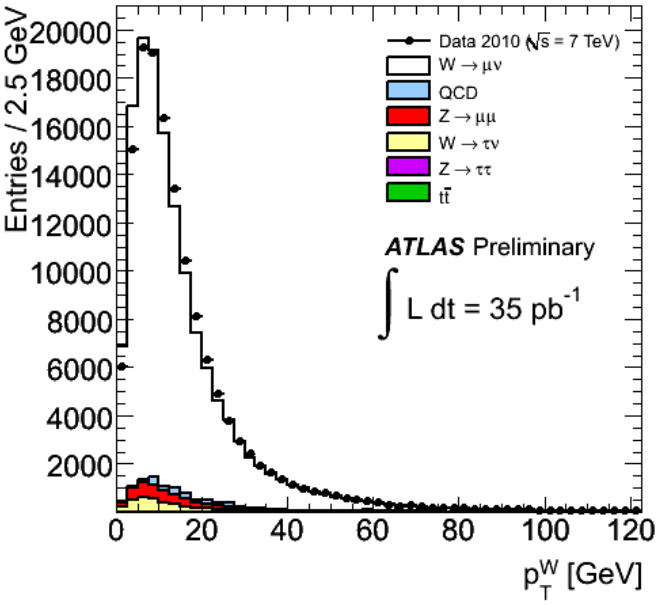


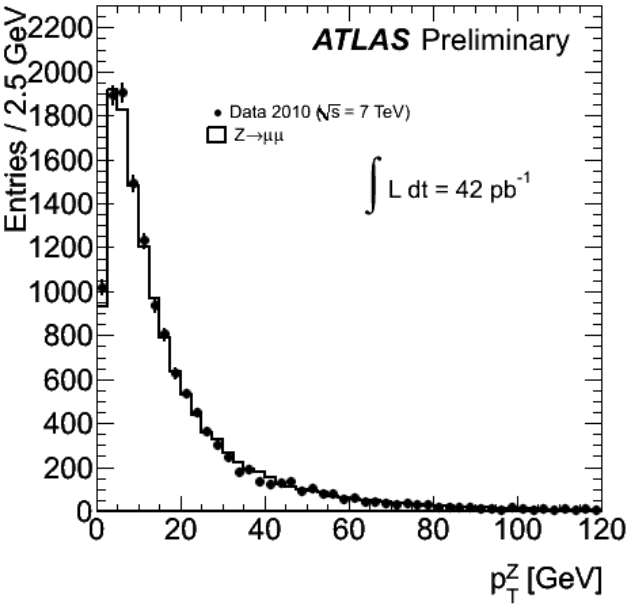
Prospects: W/Z differential cross section (all 2010 data)

- Important test of QCD
  - Low W/Z p_T : dominated by soft gluon emission (resummation)
  - High W/Z p_T: radiation of single high p_T parton (perturbative)





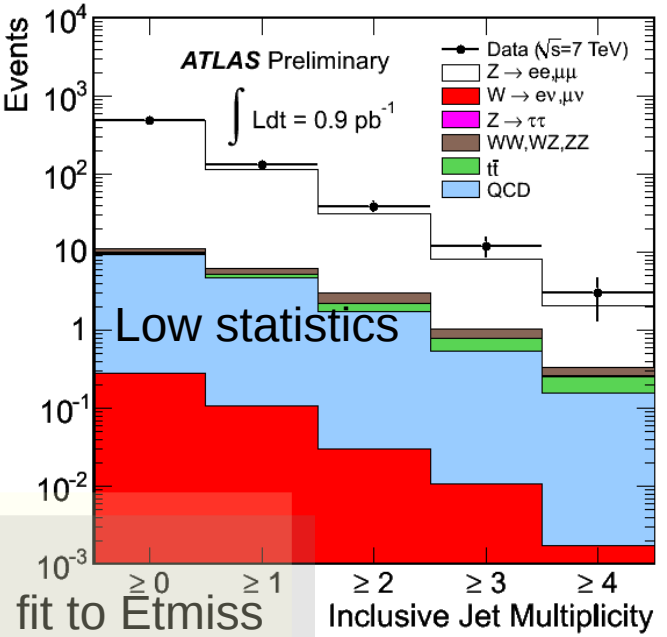




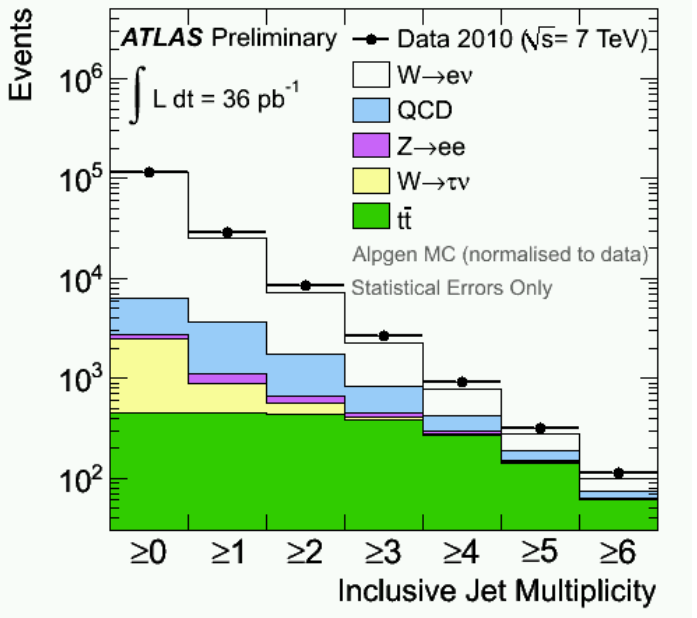
Prospects: W/Z +jets cross section

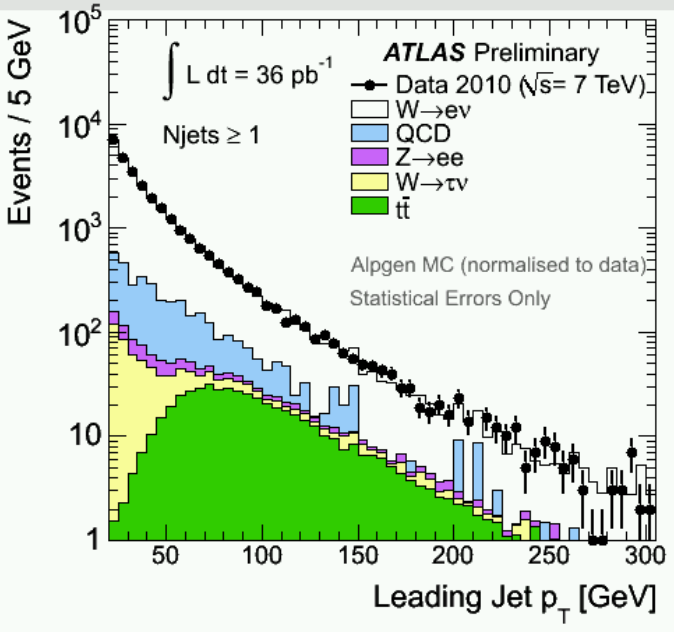
- Test of perturbative QCD (constraint on α_s)

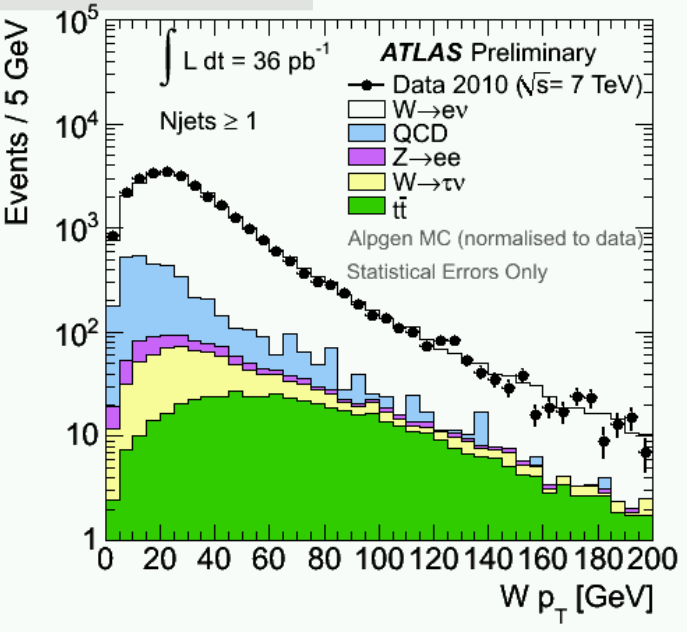
- Selection:
  - Follows inclusive W/Z selection
  - Jets: anti-k_T algorithm with R=0.4, $|\eta|<2.8$, p_T >20 GeV



- Backgrounds: EW normalized to NNLO,
  QCD template from MC + data-drive scale factors derived from fit to Etmiss
- Dominant systematics: jet energy scale and resolution



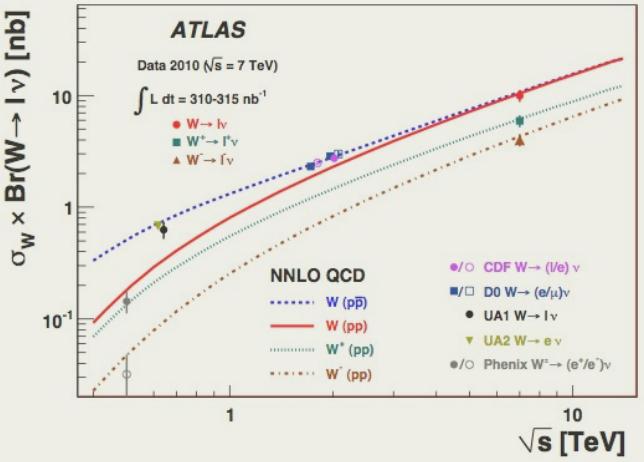


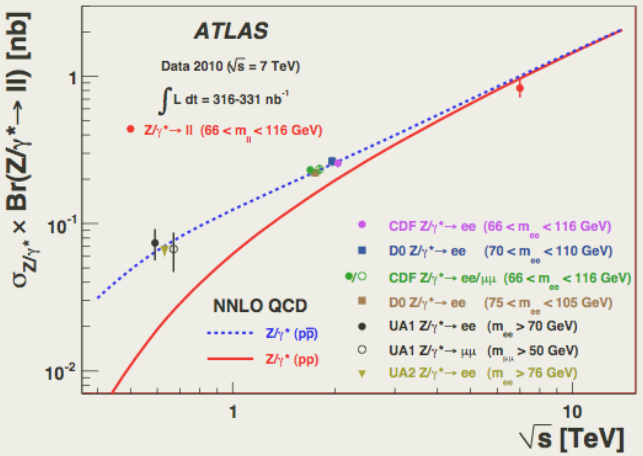


Summary & conclusions

- All objects used for reconstruction of Z and W bosons in ATLAS are well understood

- Measurements of the W and Z cross section probed the SM in the new energy regime



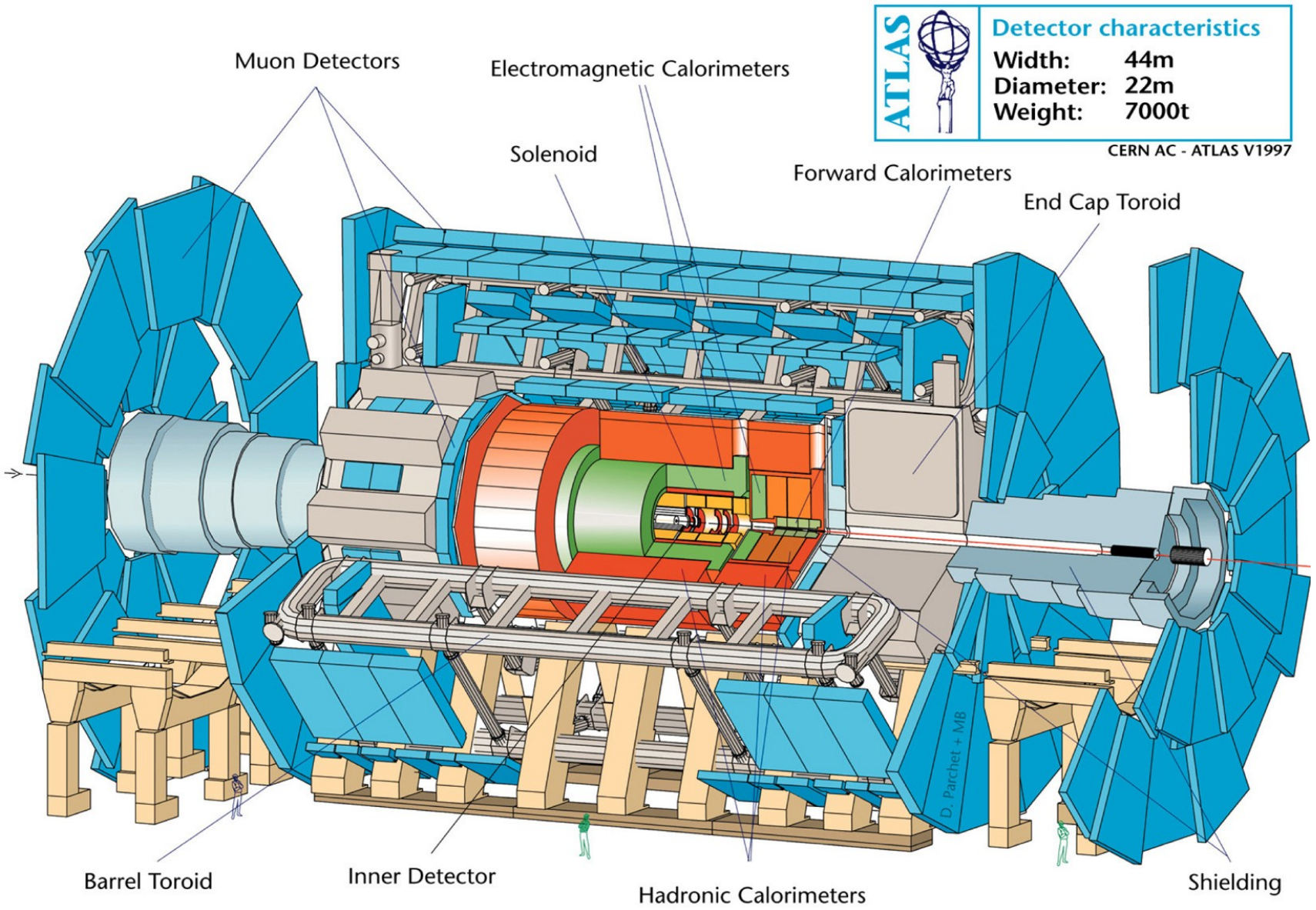


- W charge asymmetry confirmed experimentally

- Results based on all 2010 ATLAS data will allow:
  - Better precision → possible constraints on proton´s pdfs and Γ_W
  - More measurements: differential cross section, W/Z+jets inclusive and differential cross section, Z→$\tau\tau$ and W→$\tau\nu$ cross sections
  - Futher validation of reconstruction and identification of objetcs

Back up slides

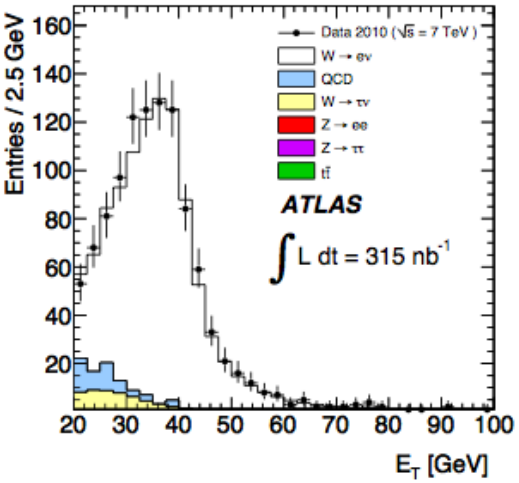
The ATLAS detector

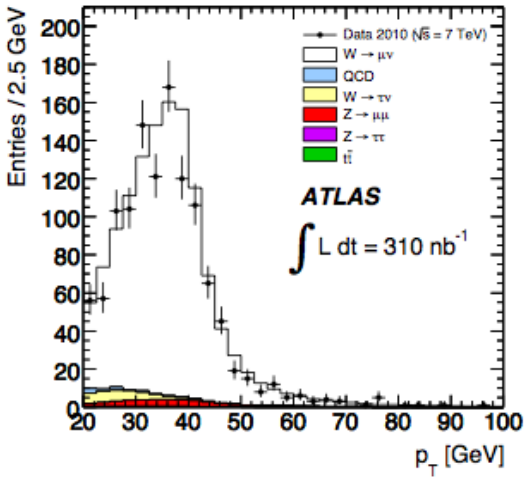


SM cross sections from MC

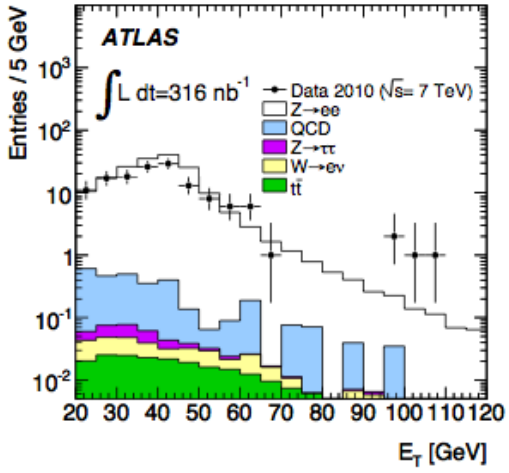
Physics process	Generator	$\sigma \cdot$ BR [nb]		
$W \to \ell\nu \quad (\ell = e, \mu)$	PYTHIA [25]	10.46±0.52	NNLO	[5, 8]
$W^+ \to \ell^+\nu$		6.16±0.31	NNLO	[5, 8]
$W^- \to \ell^-\overline{\nu}$		4.30±0.21	NNLO	[5, 8]
$Z/\gamma^* \to \ell\ell \quad (m_{\ell\ell} > 60$ GeV)	PYTHIA	0.99±0.05	NNLO	[5, 8]
$W \to \tau\nu$	PYTHIA	10.46±0.52	NNLO	[5, 8]
$W \to \tau\nu \to \ell\nu\nu\nu$	PYTHIA	3.68±0.18	NNLO	[5, 8]
$Z/\gamma^* \to \tau\tau \quad (m_{\ell\ell} > 60$ GeV)	PYTHIA	0.99±0.05	NNLO	[5, 8]
$t\bar{t}$	MC@NLO [26, 27], POWHEG [31]	0.16±0.01	NLO+NNLL	[28–30]
Dijet (e channel, $\hat{p}_T > 15$ GeV)	PYTHIA	1.2×10^6	LO	[25]
Dijet (μ channel, $\hat{p}_T > 8$ GeV)	PYTHIA	10.6×10^6	LO	[25]
$b\bar{b}$ (μ channel, $\hat{p}_T > 18$ GeV, $p_T(\mu) > 15$ GeV)	PYTHIA	73.9	LO	[25]
$c\bar{c}$ (μ channel, $\hat{p}_T > 18$ GeV, $p_T(\mu) > 15$ GeV)	PYTHIA	28.4	LO	[25]

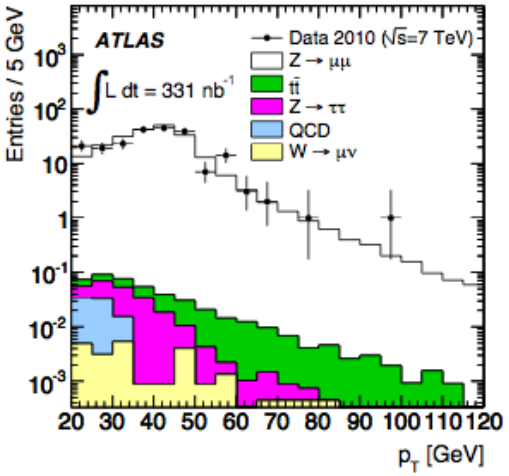
Electron E_T and muon p_T after final W/Z selection





Requirement	Number of candidates	
	$W \to e\nu$	$W \to \mu\nu$
Trigger	6.5×10^6	5.1×10^6
Lepton: e with $E_T > 20$ GeV or μ with $p_T > 20$ GeV	4003	7052
Muon isolation: $\sum p_T^{ID}/p_T < 0.2$	–	2920
$E_T^{miss} > 25$ GeV	1116	1220
$m_T > 40$ GeV	1069	1181





Requirement	Number of candidates	
	$Z \to ee$	$Z \to \mu\mu$
Trigger	6.5×10^6	5.1×10^6
Two leptons (ee or $\mu\mu$ with $E_T(p_T)$ >20 GeV)	83	144
Muon isolation: $\sum p_T^{ID}/p_T < 0.2$	–	117
Opposite charge ee or $\mu\mu$ pair:	78	117
$66 < m_{\ell\ell} < 116$ GeV	70	109

Backgrounds methods for W (electron/muon channel)

W->eν :

Binned max llh fit to Etmiss:

· Signal and EW background templates from MC

· Data driven QCD template-anti iso and anti tight electrons (template xchecked with MC)

· Systematics: different template (vary isolation), two fit ranges: 0-25 GeV and 15-100 GeV

· yields: 28.0+/-3.0(stat)+/-10(syst)

Fit to isolation

·relaxed tight->loose e ID due to too low stat (keep Etmiss and m_T)

· yields: 48.0+/-17.0 (stat) – error dominated by error on tight to loose rejection

MC: yields: 30.8 +/-6.1 (stat)

W->$\mu\nu$:

Matrix Method:

· Iso eff for non-QCD from Z->$\mu\mu$, for QCD from p_T 15-20 GeV extrapolated to high p_T using MC

· yields: 21.1+/-4.5(stat)+/-8.7(syst) – syst from isolation for QCD events

Similarity relation

· Plane of Etmiss vs isolation – NQCD in signal region from non-iso sample, normalised using Low Etmiss regime.

· Corrected for signal and EW background contamination in the signal region

· yields: 13.5+/-0.9(stat)+/-12.7(syst)

MC: yields 9.7+/-0.4

Bkds from cosmic muons estimated using non collision events that pass the W selection

Background methods for Z (electron and muon channel)

Z->ee

Fit of BW convolved with Gaussian to model signal and second order polynomial for bkgs to $50<m_{ee}<130$ GeV

- Template for fitting inv mass by relaxing e ID criteria from medium ->loose
- data driven loose to medium rejection applied
- yields: 0.91+/-0.11 (stat)+/- 0.41 (syst)
- Same method on MC yields: 0.87+/-0.04(stat)
- Systematics: vary level of e ID, bin size, first order polynomial for bkds, kinematic dependance rejection factors

Same sign cross check yields:

- 3 events, 2.3 evepected from Z->ee events

Z->μμ

- MC yields 0.04
- Data driven limited by statistics (no same sign muon pairs found in data)

Backgrounds for W and Z

ℓ	Observed candidates	Background (EW+$t\bar{t}$)	Background (QCD)	Background-subtracted signal N_W^{sig}
e^+	637	$18.8 \pm 0.2 \pm 1.7$	$14.0 \pm 2.1 \pm 7.1$	$604.2 \pm 25.2 \pm 7.6$
e^-	432	$14.7 \pm 0.2 \pm 1.3$	$14.0 \pm 2.1 \pm 7.1$	$403.2 \pm 20.8 \pm 7.5$
$e^\pm$	1069	$33.5 \pm 0.2 \pm 3.0$	$28.0 \pm 3.0 \pm 10.0$	$1007.5 \pm 32.7 \pm 10.8$
μ^+	710	$42.5 \pm 0.2 \pm 2.9$	$12.0 \pm 3.0 \pm 4.6$	$655.6 \pm 26.6 \pm 6.2$
μ^-	471	$35.1 \pm 0.2 \pm 2.4$	$10.9 \pm 2.4 \pm 4.1$	$425.0 \pm 21.7 \pm 5.4$
$\mu^\pm$	1181	$77.6 \pm 0.3 \pm 5.4$	$22.8 \pm 4.6 \pm 8.7$	$1080.6 \pm 34.4 \pm 11.2$

ℓ	Observed candidates	Background (EW+$t\bar{t}$)	Background (QCD)	Background-subtracted signal N_Z^{sig}
$e^\pm$	70	$0.27 \pm 0.00 \pm 0.03$	$0.91 \pm 0.11 \pm 0.41$	$68.8 \pm 8.4 \pm 0.4$
$\mu^\pm$	109	$0.21 \pm 0.01 \pm 0.01$	$0.04 \pm 0.01 \pm 0.04$	$108.8 \pm 10.4 \pm 0.0$

Experimental efficiencies (C_W and C_Z)

	$W \to e\nu$		$Z \to ee$		$W \to \mu\nu$		$Z \to \mu\mu$	
	Central value	Relative uncertainty	Central value	Relative uncertainty	Central value	Relative uncertainty	Central value	Relative uncertainty
$\varepsilon_{\text{event}}$	1.000	$< 0.2\%$	1.000	$< 0.2\%$	0.998	$<0.2\%$	0.998	$<0.2\%$
ε_{lep}	0.749	5.2%	0.943	4.2%	0.886	2.7%	0.894	2.7%
$\varepsilon_{\text{trig}}$	0.998	$< 0.2\%$	0.998	$< 0.2\%$	0.815	1.9%	0.811	1.9%
α_{reco}	0.882	3.9%	0.732	3.2%	1.051	2.3 %	1.007	0.7 %
C_W, C_Z	0.659	7.0%	0.651	9.4%	0.758	4.0%	0.773	5.5%

Electron channel

Parameter	$\delta C_W/C_W(\%)$	$\delta C_Z/C_Z(\%)$
Trigger efficiency	<0.2	<0.2
Material effects, reconstruction and identification	5.6	8.8
Energy scale and resolution	3.3	1.9
$E_{\text{T}}^{\text{miss}}$ scale and resolution	2.0	-
Problematic regions in the calorimeter	1.4	2.7
Pile-up	0.5	0.2
Charge misidentification	0.5	0.5
FSR modelling	0.3	0.3
Theoretical uncertainty (PDFs)	0.3	0.3
Total uncertainty	7.0	9.4

Muon channel

Parameter	$\delta C_W/C_W(\%)$	$\delta C_Z/C_Z(\%)$
Trigger efficiency	1.9	0.7
Reconstruction efficiency	2.5	5.0
Momentum scale	1.2	0.5
Momentum resolution	0.2	0.5
$E_{\text{T}}^{\text{miss}}$ scale and resolution	2.0	-
Isolation efficiency	1.0	2.0
Theoretical uncertainty (PDFs)	0.3	0.3
Total uncertainty	4.0	5.5

Theoretical acceptance (A_W and A_Z)

MC	A_{W^+} $W^+ \to e^+\nu$	A_{W^-} $W^- \to e^-\nu$	A_W $W \to e\nu$	A_Z $Z/\gamma^* \to e^+e^-$	A_W/A_Z
PYTHIA MRST LO*	0.466	0.457	0.462	0.446	1.036
PYTHIA CTEQ6.6	0.479	0.458	0.471	0.455	1.035
PYTHIA HERAPDF1.0	0.477	0.461	0.470	0.451	1.042
MC@NLO HERAPDF1.0	0.475	0.454	0.465	0.440	1.057
MC@NLO CTEQ6.6	0.478	0.452	0.465	0.445	1.045
	A_{W^+} $W^+ \to \mu^+\nu$	A_{W^-} $W^- \to \mu^-\nu$	A_W $W \to \mu\nu$	A_Z $Z/\gamma^* \to \mu^+\mu^-$	A_W/A_Z
PYTHIA MRSTLO*	0.484	0.475	0.480	0.486	0.988
PYTHIA CTEQ6.6	0.499	0.477	0.490	0.496	0.987
PYTHIA HERAPDF1.0	0.496	0.479	0.489	0.492	0.994
MC@NLO HERAPDF1.0	0.494	0.472	0.483	0.479	1.008
MC@NLO CTEQ6.6	0.496	0.470	0.483	0.485	0.996

Summary of input for cross section calculation

	W^+				W^-				W			
Electron channel												
	value	stat	syst	lumi	value	stat	syst	lumi	value	stat	syst	lumi
N_W^{sig}	604.2	25.2	7.6	2.0	403.2	20.8	7.5	1.5	1007.5	32.7	10.8	3.5
L_W [nb^{-1}]	315	-	-	35	315	-	-	35	315	-	-	35
C_W	0.656	-	0.046	-	0.662	-	0.046	-	0.659	-	0.046	-
A_W	0.466	-	0.014	-	0.457	-	0.014	-	0.462	-	0.014	-
Muon channel												
	value	stat	syst	lumi	value	stat	syst	lumi	value	stat	syst	lumi
N_W^{sig}	655.6	26.6	6.2	4.7	425.0	21.7	5.4	3.9	1080.6	34.4	11.2	8.5
L_W [nb^{-1}]	310	-	-	34	310	-	-	34	310	-	-	34
C_W	0.765	-	0.031	-	0.748	-	0.030	-	0.758	-	0.030	-
A_W	0.484	-	0.015	-	0.475	-	0.014	-	0.480	-	0.014	-

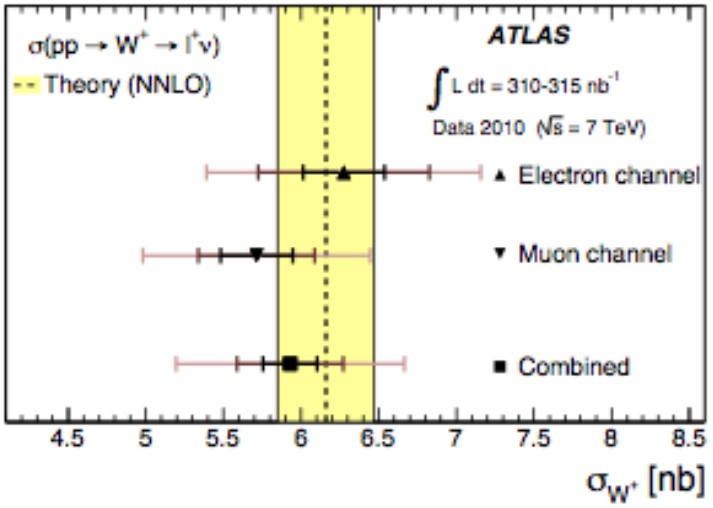
	Z/γ^*							
	Electron channel				**Muon channel**			
	value	stat	syst	lumi	value	stat	syst	lumi
N_Z^{sig}	68.8	8.4	0.4	0.0	108.8	10.4	0.0	0.0
L_Z [nb^{-1}]	316	-	-	35	331	-	-	35
C_Z	0.651	-	0.061	-	0.773	-	0.043	-
A_Z	0.446	-	0.018	-	0.486	-	0.019	-

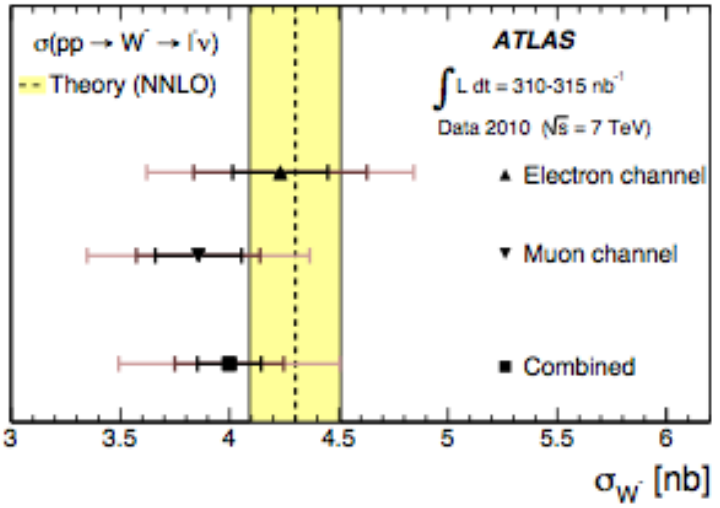
Fiducial and total cross section

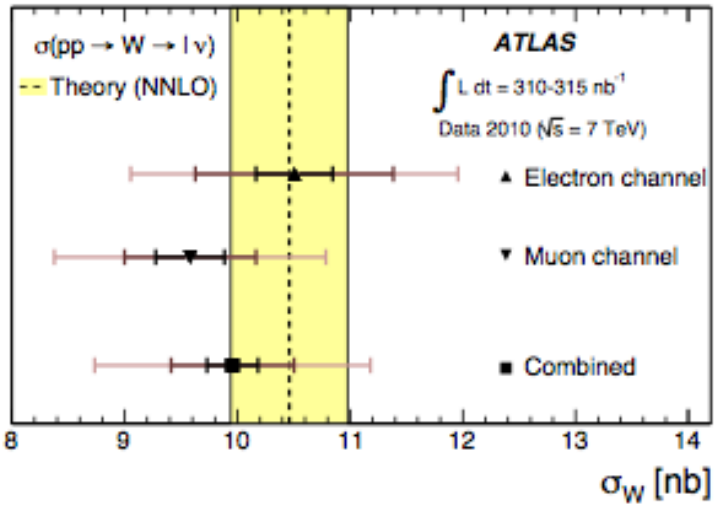
	$\sigma^{\text{fid}}_{W^{(\pm)}} \cdot \text{BR}(W \to e\nu)$ [nb]	$\sigma^{\text{fid}}_{W^{(\pm)}} \cdot \text{BR}(W \to \mu\nu)$ [nb]
W^+	$2.92 \pm 0.12(\text{stat}) \pm 0.21(\text{syst}) \pm 0.32(\text{lumi})$	$2.77 \pm 0.11(\text{stat}) \pm 0.12(\text{syst}) \pm 0.30(\text{lumi})$
W^-	$1.93 \pm 0.10(\text{stat}) \pm 0.14(\text{syst}) \pm 0.21(\text{lumi})$	$1.83 \pm 0.09(\text{stat}) \pm 0.08(\text{syst}) \pm 0.20(\text{lumi})$
W	$4.85 \pm 0.16(\text{stat}) \pm 0.34(\text{syst}) \pm 0.53(\text{lumi})$	$4.60 \pm 0.15(\text{stat}) \pm 0.20(\text{syst}) \pm 0.51(\text{lumi})$
	$\sigma^{\text{fid}}_{Z/\gamma^*} \cdot \text{BR}(Z/\gamma^* \to ee)$ [nb], $66 < m_{ee} < 116$ GeV	$\sigma^{\text{fid}}_{Z/\gamma^*} \cdot \text{BR}(Z/\gamma^* \to \mu\mu)$ [nb], $66 < m_{\mu\mu} < 116$ GeV
Z/γ^*	$0.33 \pm 0.04(\text{stat}) \pm 0.03(\text{syst}) \pm 0.04(\text{lumi})$	$0.43 \pm 0.04(\text{stat}) \pm 0.02(\text{syst}) \pm 0.05(\text{lumi})$

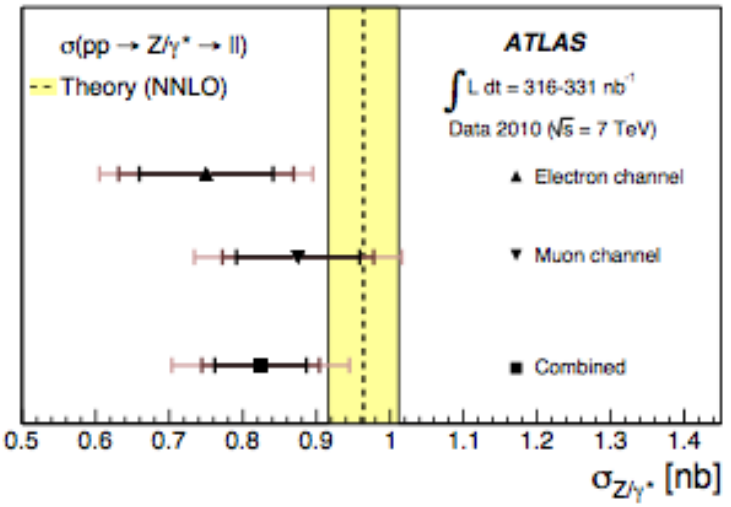
	$\sigma^{\text{tot}}_{W^{(\pm)}} \cdot \text{BR}(W \to e\nu)$ [nb]	$\sigma^{\text{tot}}_{W^{(\pm)}} \cdot \text{BR}(W \to \mu\nu)$ [nb]
W^+	$6.27 \pm 0.26(\text{stat}) \pm 0.48(\text{syst}) \pm 0.69(\text{lumi})$	$5.71 \pm 0.23(\text{stat}) \pm 0.30(\text{syst}) \pm 0.63(\text{lumi})$
W^-	$4.23 \pm 0.22(\text{stat}) \pm 0.33(\text{syst}) \pm 0.47(\text{lumi})$	$3.86 \pm 0.20(\text{stat}) \pm 0.20(\text{syst}) \pm 0.42(\text{lumi})$
W	$10.51 \pm 0.34(\text{stat}) \pm 0.81(\text{syst}) \pm 1.16(\text{lumi})$	$9.58 \pm 0.30(\text{stat}) \pm 0.50(\text{syst}) \pm 1.05(\text{lumi})$
	$\sigma^{\text{tot}}_{Z/\gamma^*} \cdot \text{BR}(Z/\gamma^* \to ee)$ [nb], $66 < m_{ee} < 116$ GeV	$\sigma^{\text{tot}}_{Z/\gamma^*} \cdot \text{BR}(Z/\gamma^* \to \mu\mu)$ [nb], $66 < m_{\mu\mu} < 116$ GeV
Z/γ^*	$0.75 \pm 0.09(\text{stat}) \pm 0.08(\text{syst}) \pm 0.08(\text{lumi})$	$0.87 \pm 0.08(\text{stat}) \pm 0.06(\text{syst}) \pm 0.10(\text{lumi})$

Total cross section - plots

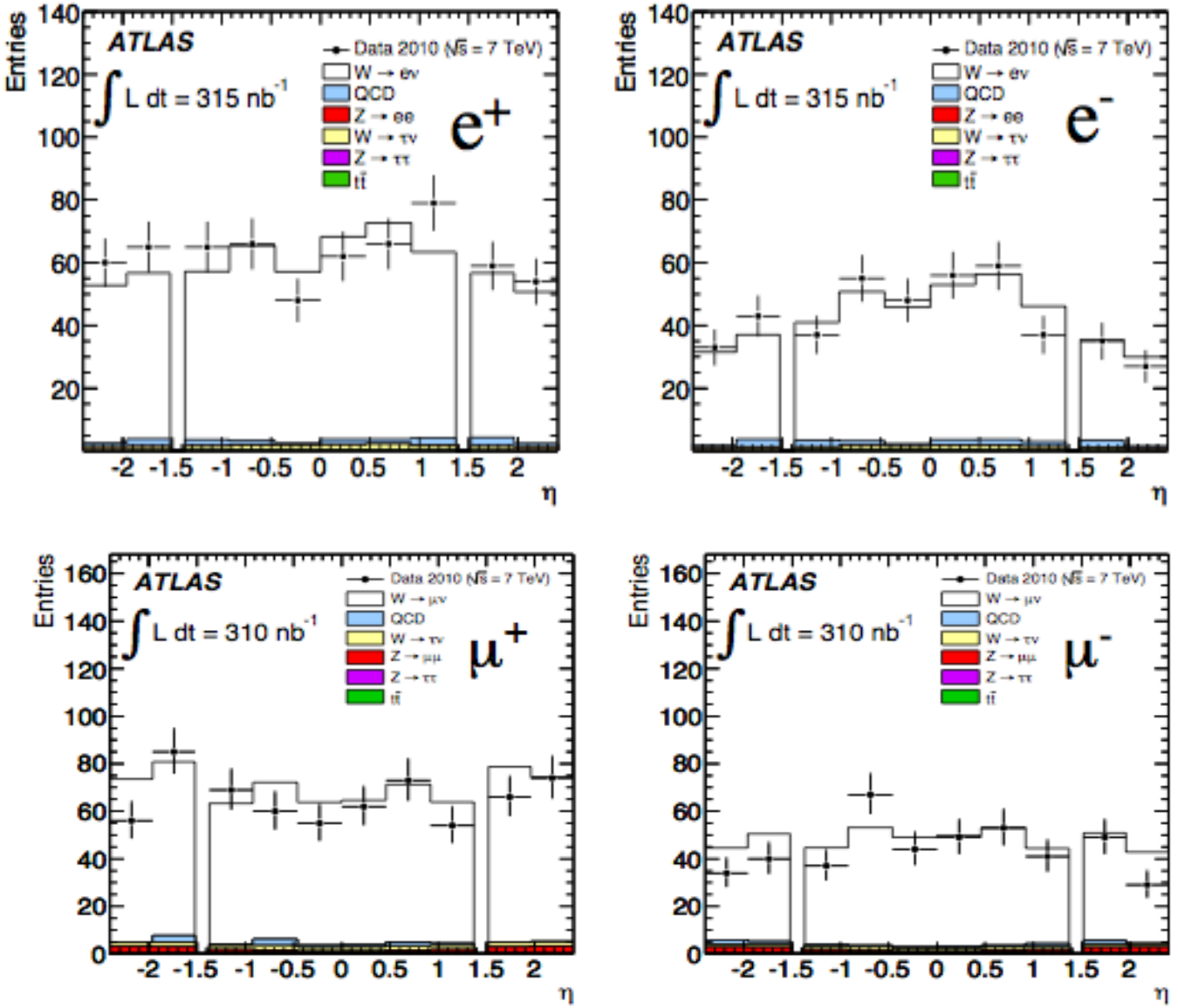








Pseudorapidity of leptons from W (after full selection)



Cross section ratio

Measured

	$R^{e}_{W^{(\pm)}/Z}$	$R^{\mu}_{W^{(\pm)}/Z}$
W^+	8.4 ± 1.1 (stat) ± 0.6 (syst)	6.5 ± 0.7 (stat) ± 0.3 (syst)
W^-	5.7 ± 0.7 (stat) ± 0.4 (syst)	4.4 ± 0.5 (stat) ± 0.2 (syst)
W	14.0 ± 1.8 (stat) ± 0.9 (syst)	11.0 ± 1.1 (stat) ± 0.5 (syst)

$$R^{\ell}_{W^+/Z} = 7.0 \pm 0.6\ (\text{stat}) \pm 0.3\ (\text{syst}),$$

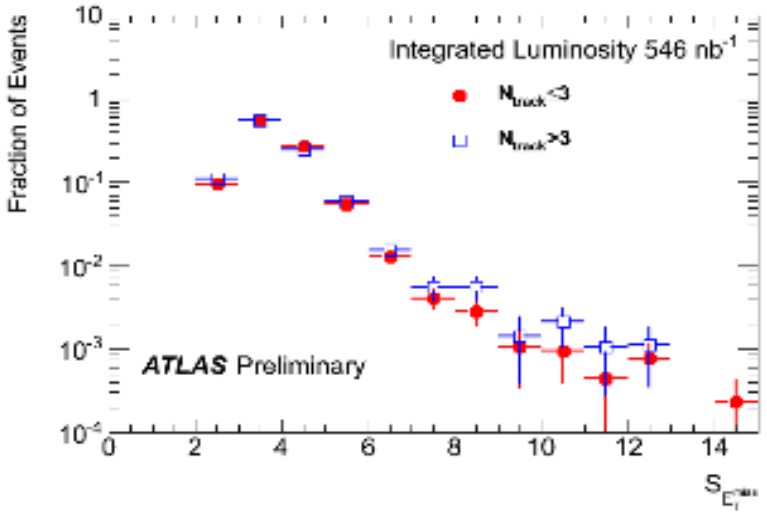
$$R^{\ell}_{W^-/Z} = 4.7 \pm 0.4\ (\text{stat}) \pm 0.2\ (\text{syst}),$$

$$R^{\ell}_{W/Z} = 11.7 \pm 0.9\ (\text{stat}) \pm 0.4\ (\text{syst}).$$

Theory

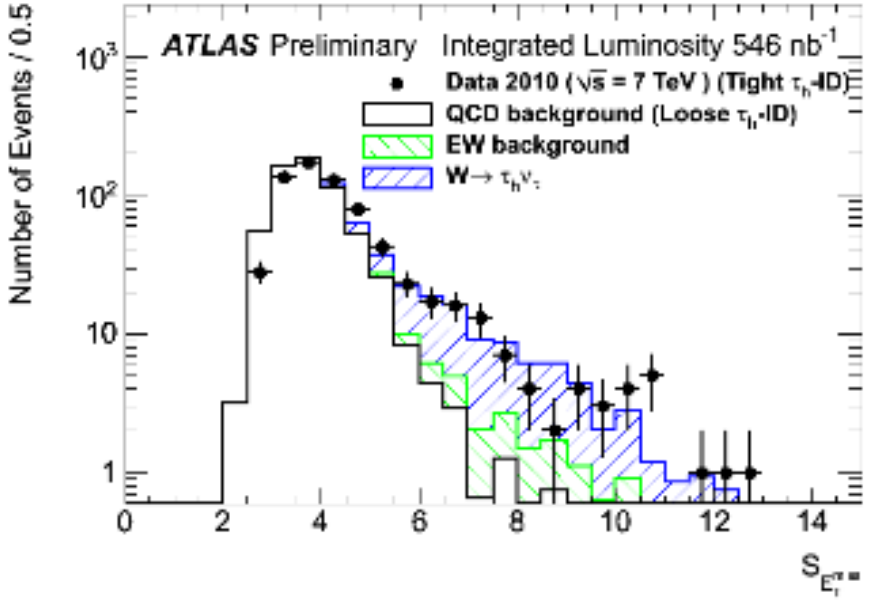
$$R^{NNLO}_{W^+/Z} = 6.387^{+0.077}_{-0.057}, \quad R^{NNLO}_{W^-/Z} = 4.445^{+0.036}_{-0.054}, \quad \text{and} \quad R^{NNLO}_{W/Z} = 10.840 \pm 0.054.$$

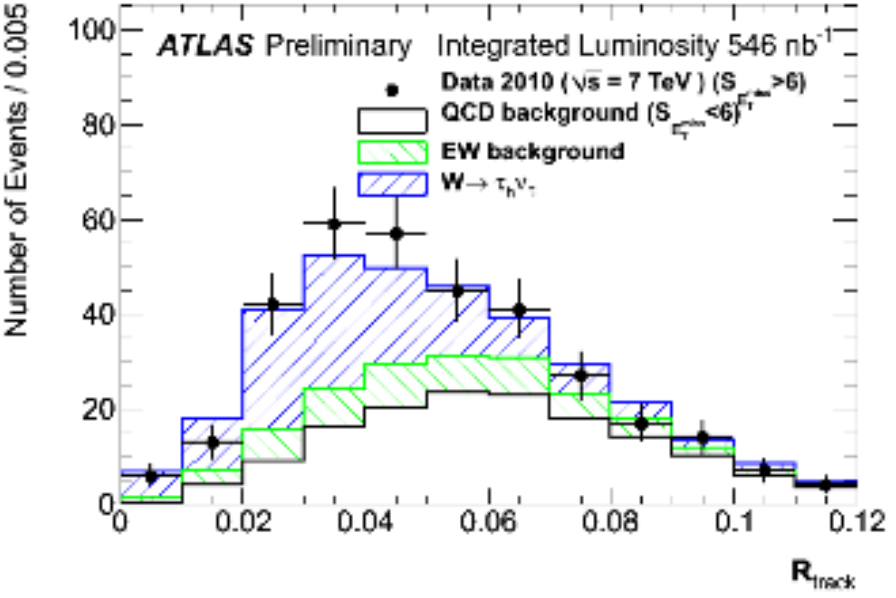
Controlling the QCD background (tau channel)



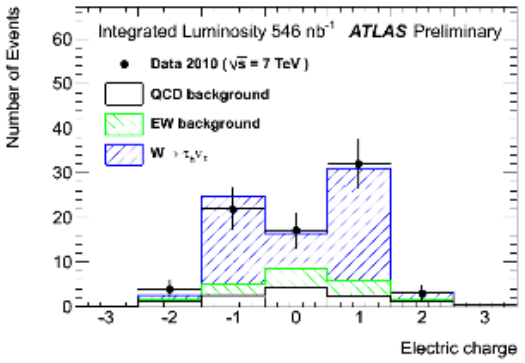
$$N^A_{QCD} = (N^B - c_B(N^A - N^A_{QCD}))\frac{N^C - c_C(N^A - N^A_{QCD})}{N^D - c_D(N^A - N^A_{QCD})}.$$

Region	A	B	C	D
Data	78	607	254	7107
$W \to \tau_h \nu_\tau$	55.3±1.4	39.5±1.2	71.0±1.6	54.2±1.4
EW	11.8±0.4	6.5±0.2	44.5±0.7	22.1±0.5
c_i		0.69±0.02	1.72±0.05	1.14±0.03

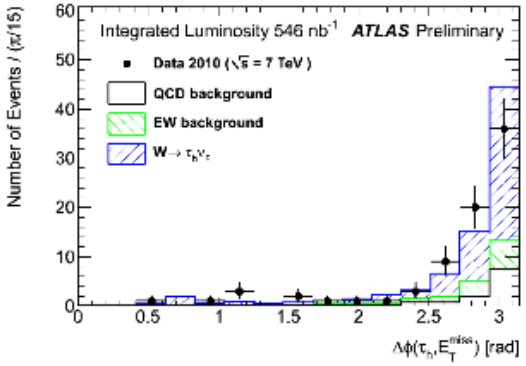


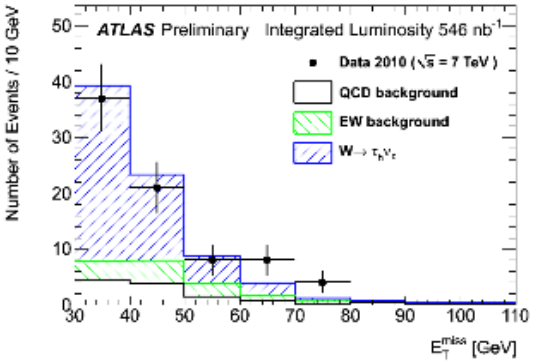


Observation of W in the tau channel

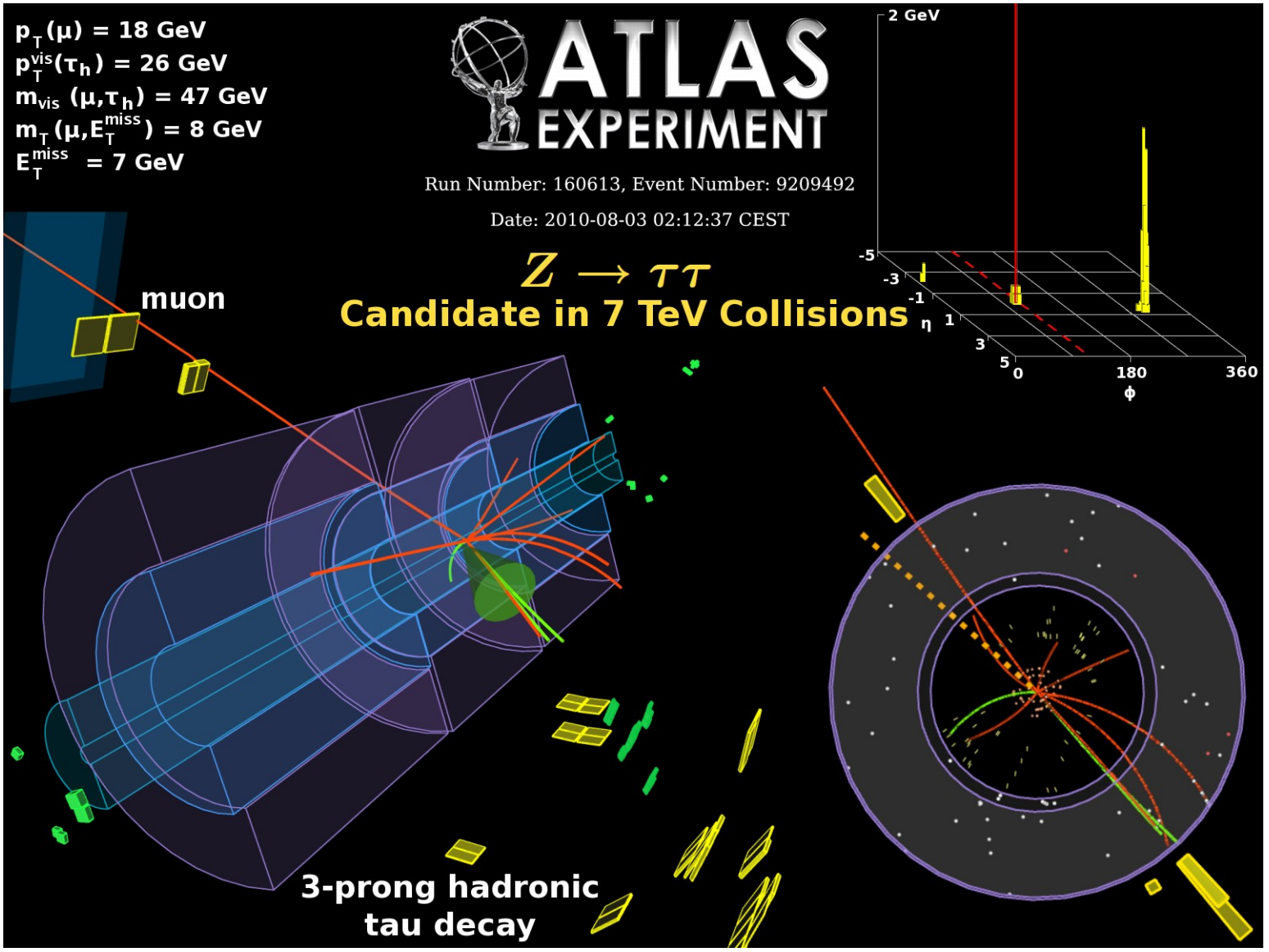


	$W \to \tau_h \nu_\tau$ (MC expectation)	EW background (MC expectation)	QCD background (data-driven estimate)
Central values [events]	55.3	11.8	11.1
Statistical uncertainty [events]	±1.4	±0.4	±2.3
Systematic uncertainties			
Theoretical cross section	± 5%	±5%	–
Luminosity	± 11%	±11%	–
Energy scale	±21%	±14%	–
Lepton veto	–	±19%	–
Pile-up	±1%	±0.2%	–
Monte Carlo model	±16%	±17%	–
QCD background estimation	–	–	±29%
Total systematic uncertainty [events]	±16.1	±3.7	±3.2

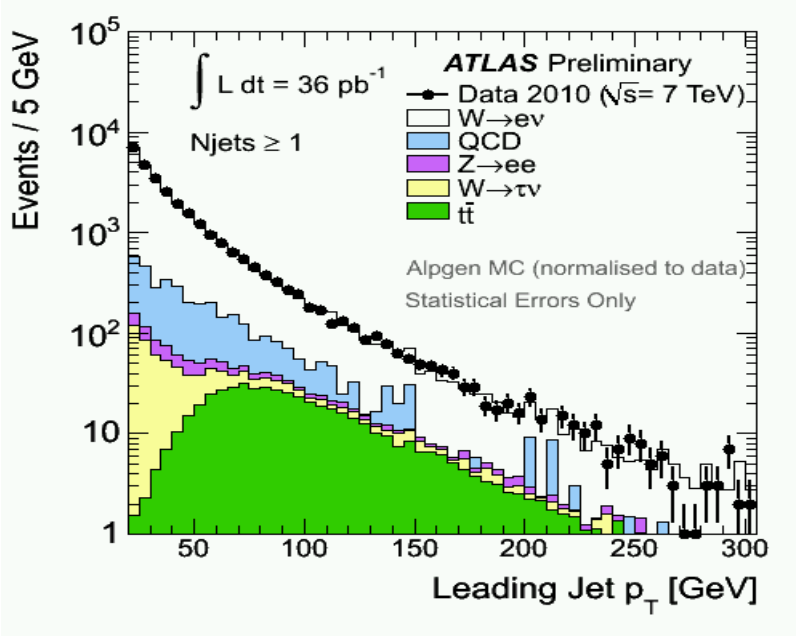


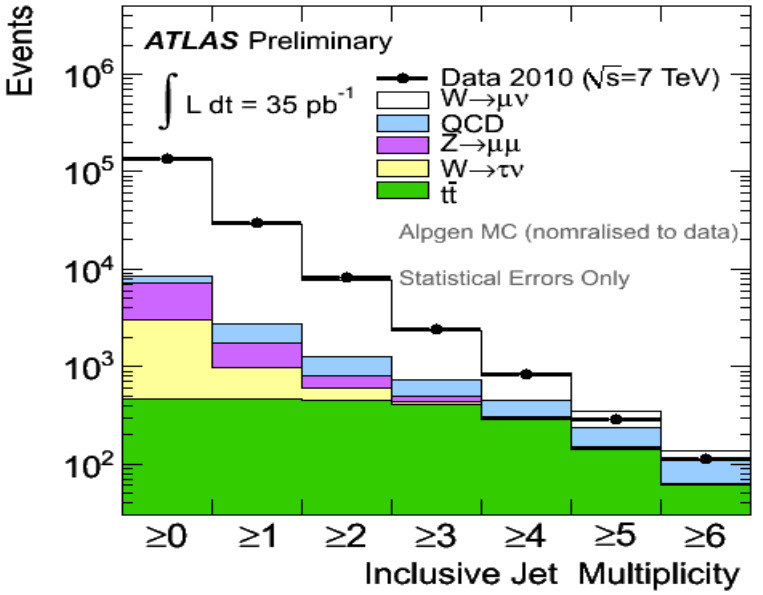


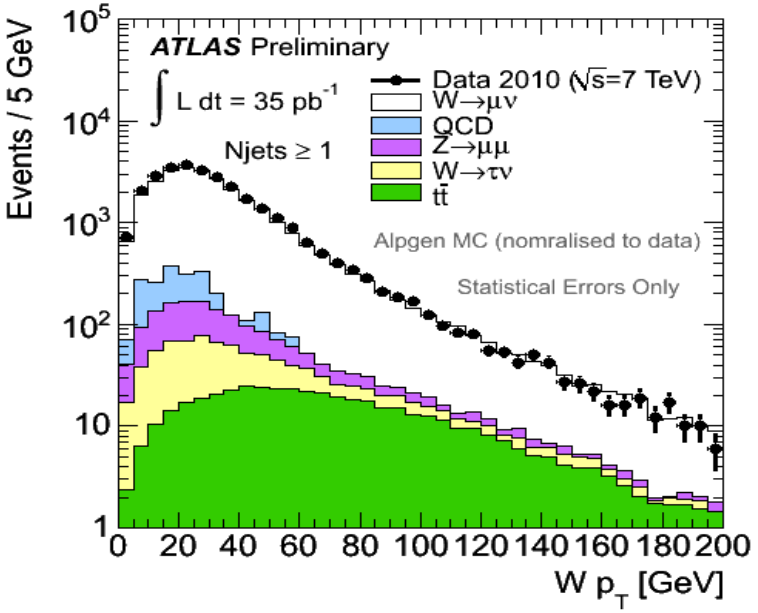
First Z->tautau event



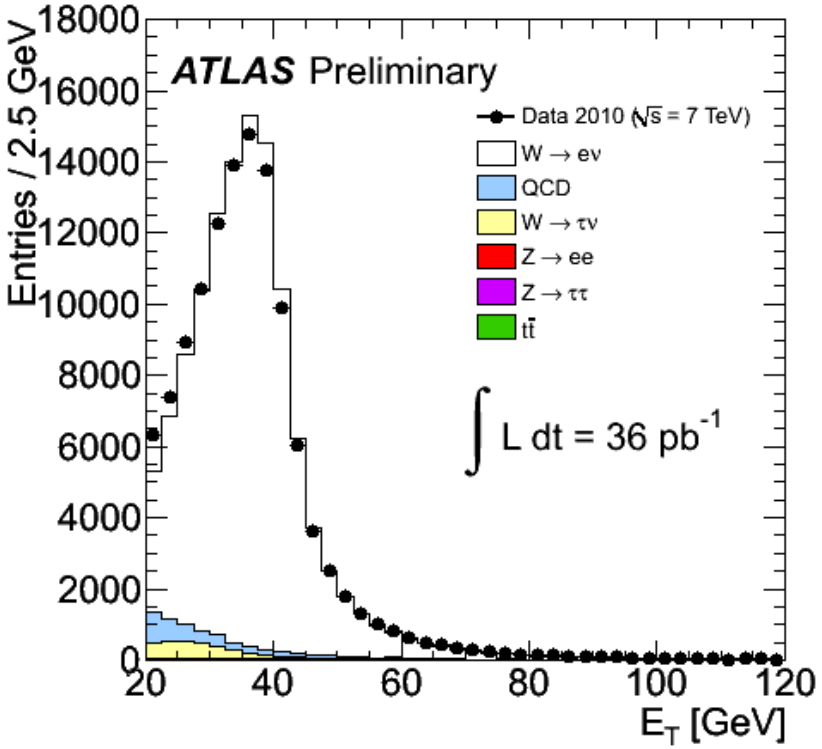
Prospects: W + jets cross sections (muon channel)

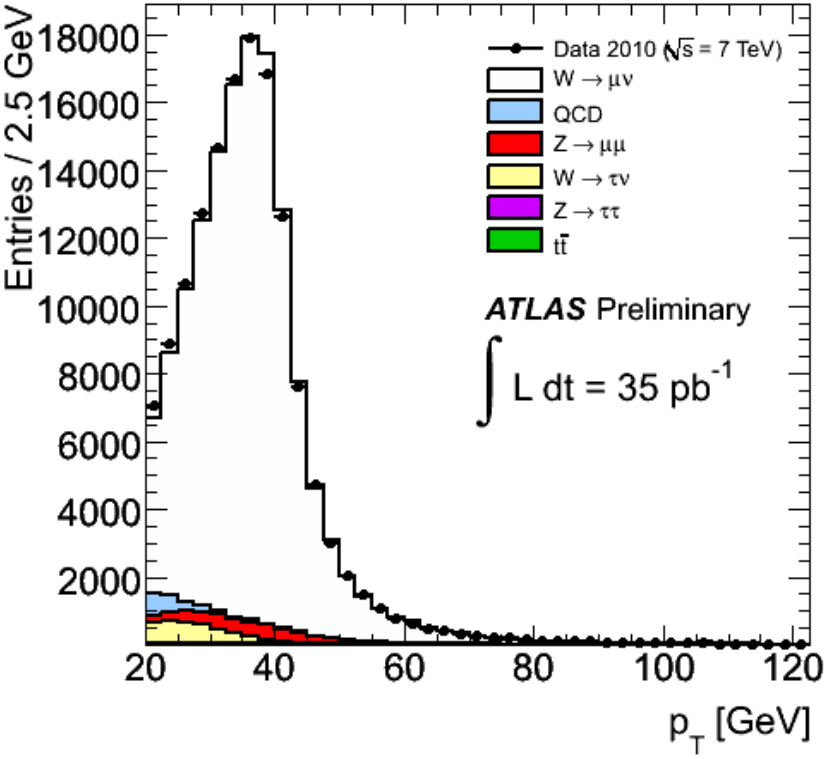




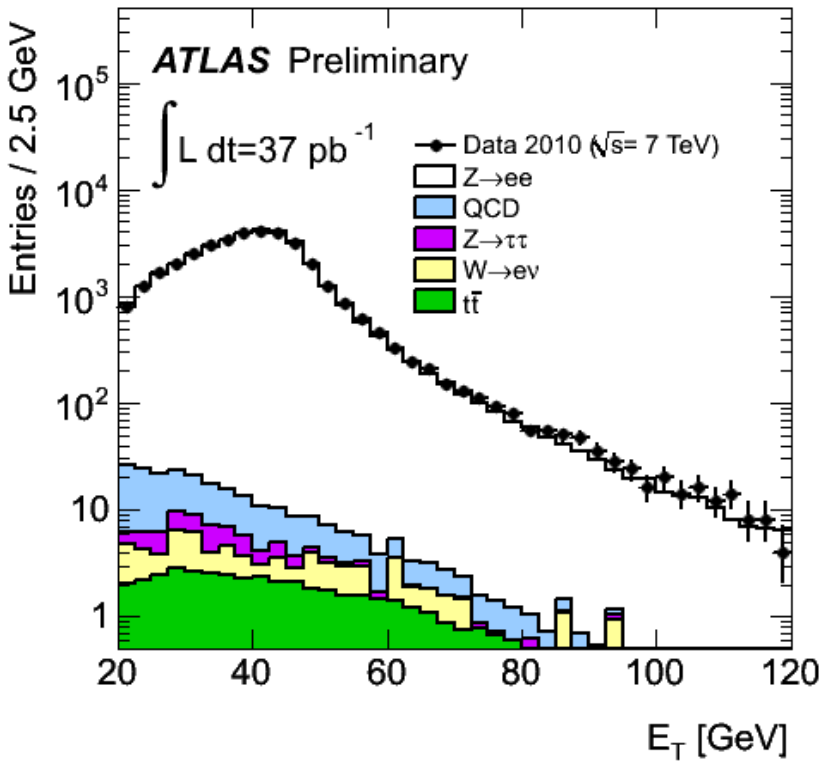


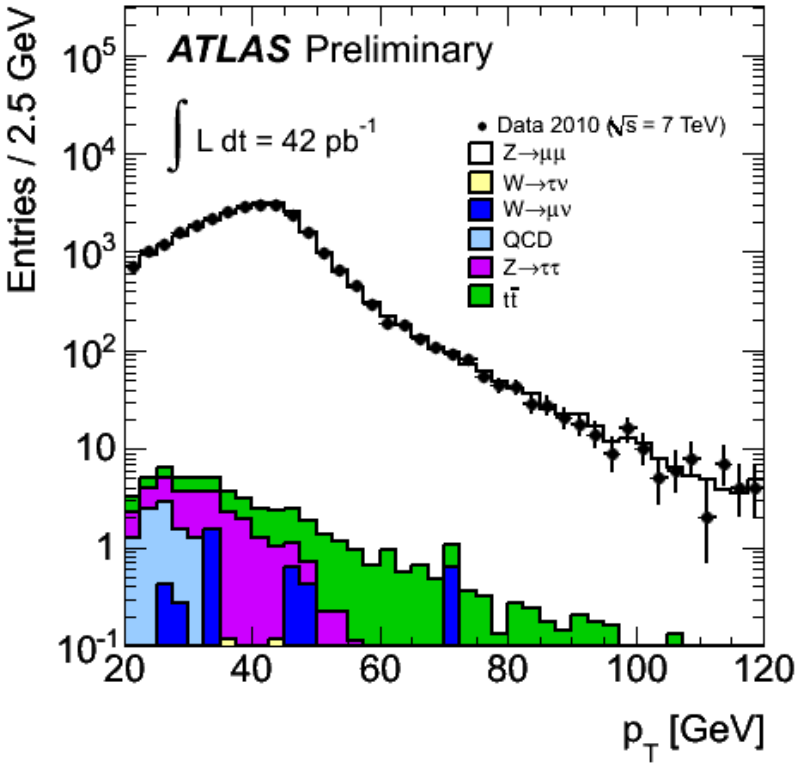
Full ATLAS 2010 data: leptons from W





Full ATLAS 2010 data: leptons from Z





Full ATLAS 2010 data: ETmiss