ATLAS Moriond2011 results W/Z, Higgs and SUSY

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LHC Physics Discussion

Overview

I. Overview

II. W/Z results

III. Higgs results

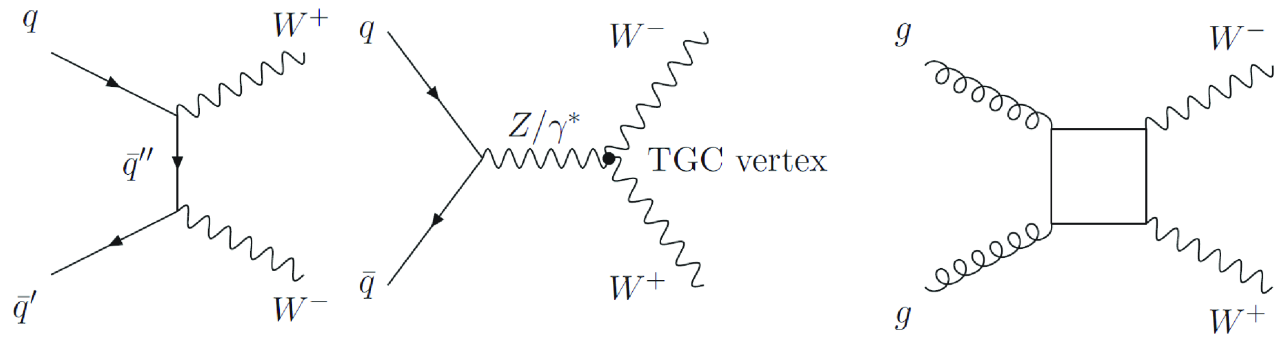
IV. SUSY results

V. Summary

Disclaimer

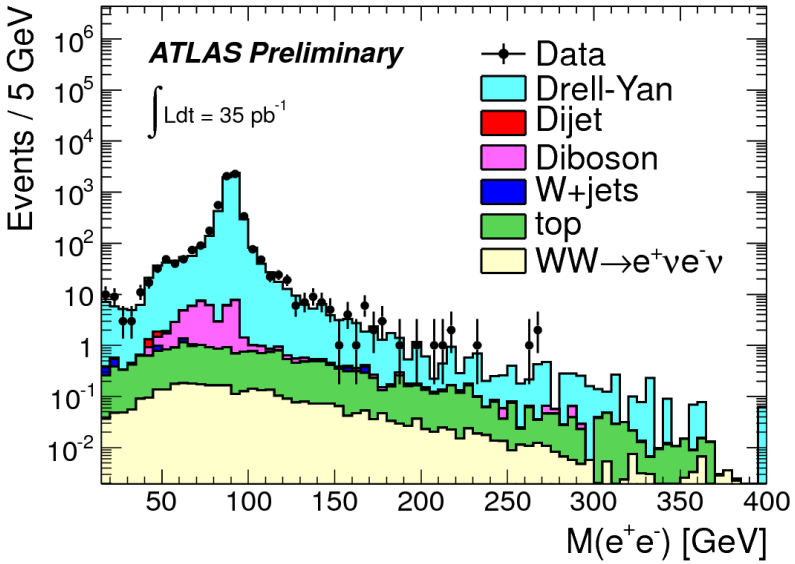
Large W/Z, Higgs and SUSY program at ATLAS.
This talk covers only a small fraction. For more detailed information see references.

WW production cross section

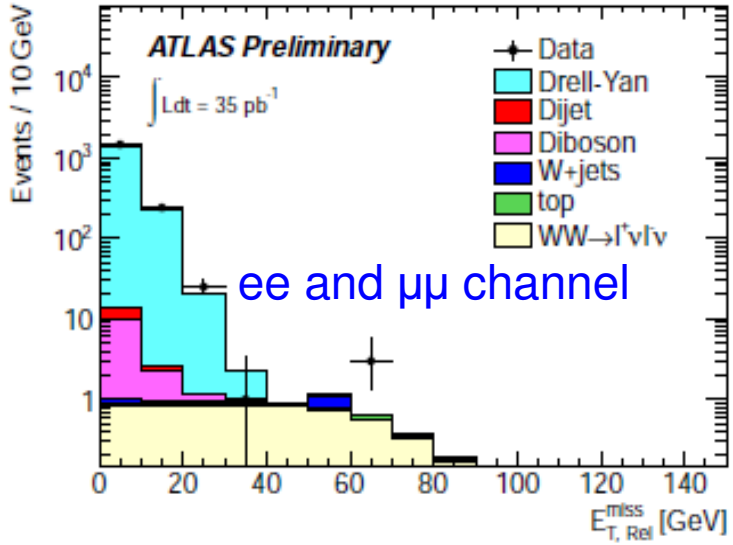


- Important test of Standard Model → sensitivity to triple gauge boson coupling
- Irreducible background for H → WW searches

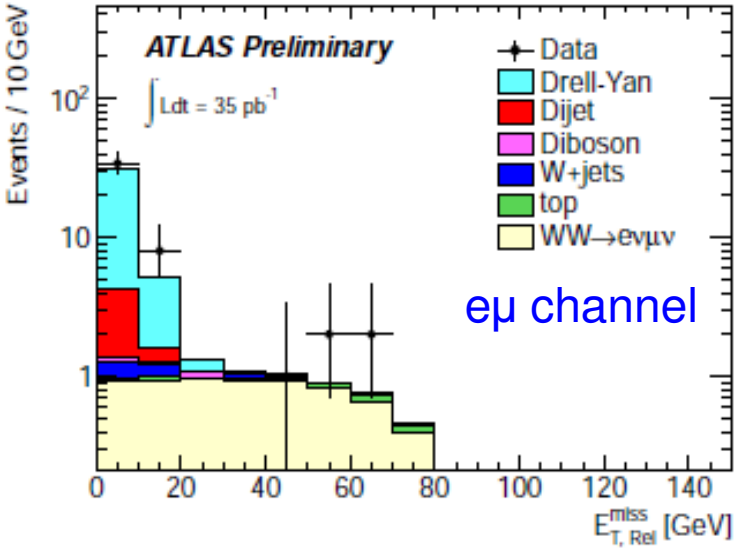
- Signature: $W^{\pm} \rightarrow l^{\pm}\nu$, where l is electron or muon, large missing E_T
- Main background:
  - Drell-Yan, two high-p_T charged leptons and false missing transverse energy
  - Top, W^+W^- pair production with additional jets, veto against high-p_T jets
  - W+jet, high-p_T charged lepton and missing E_T, "fake" leptons from misidentified jet
  - Diboson (WZ, ZZ, Wγ), high-p_T charged lepton, missing E_T and photon misidentified as electron

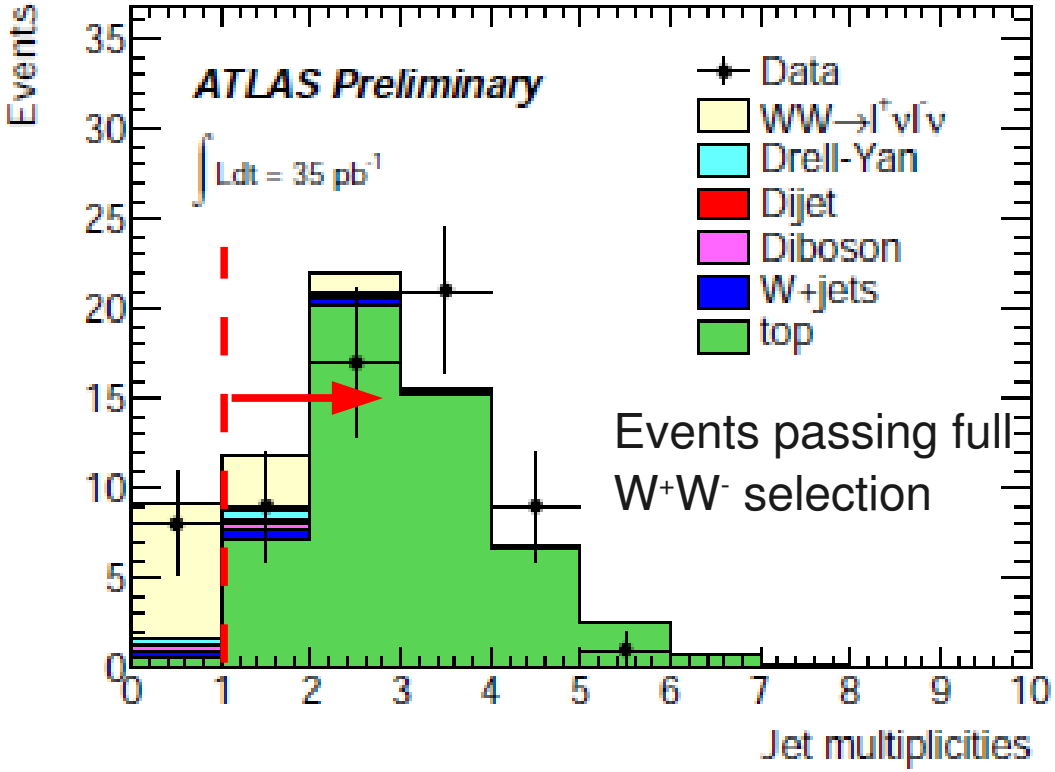


WW production cross section



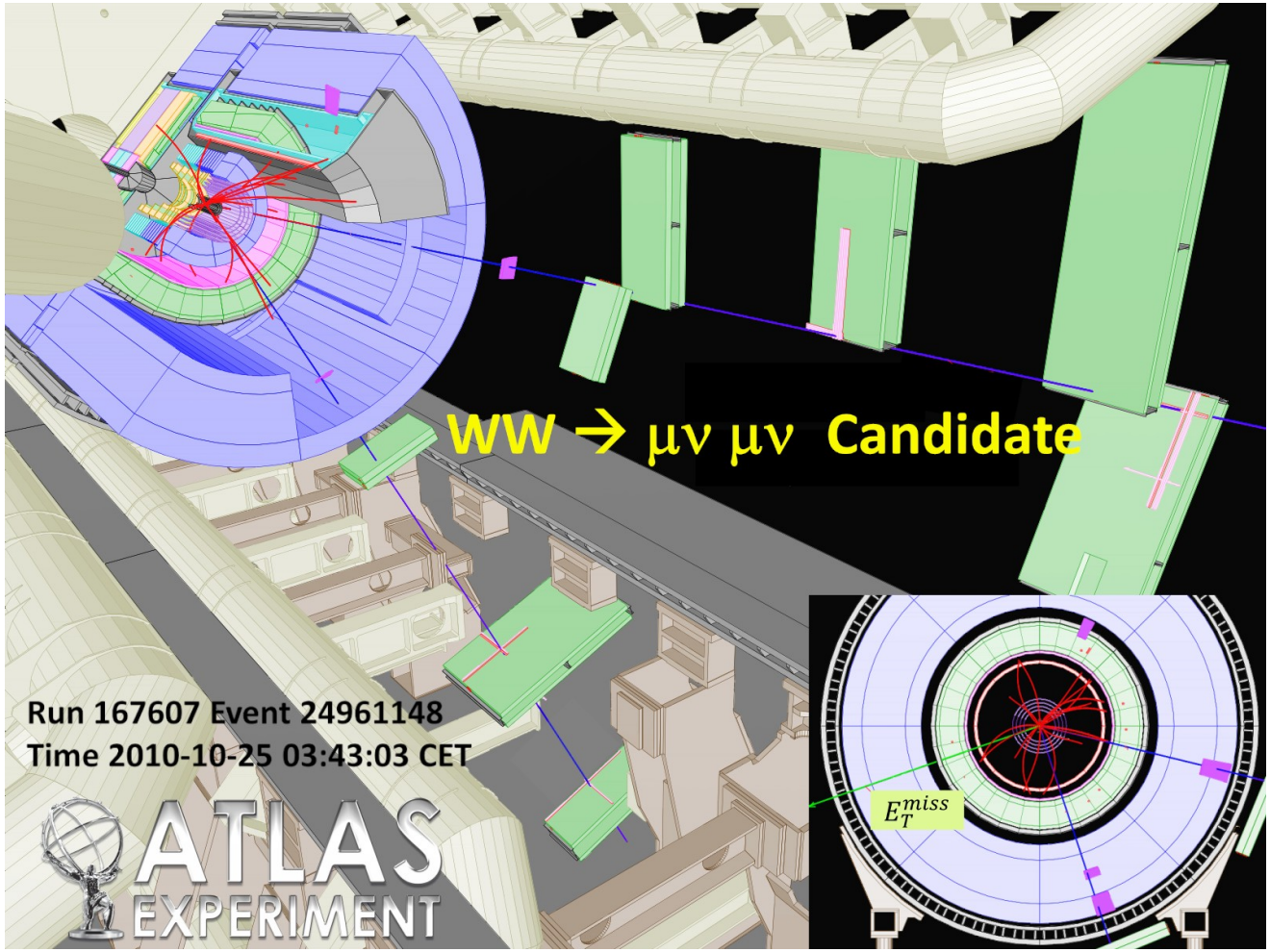
No hadronic jets with p_T > 20 GeV and |η| < 3





Jet veto: $e^+e^-+E_T^{miss}$:	1
$\mu^+\mu^-+E_T^{miss}$:	2
$e\mu+E_T^{miss}$:	5

WW production cross section



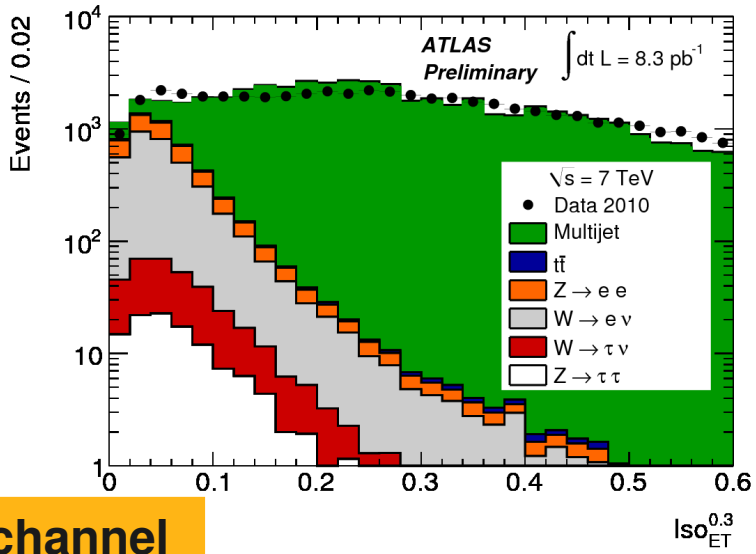
Run number	Event number	$p_T(\mu^-)$ [GeV]	η (μ^-)	ϕ (μ^-)	$p_T(\mu^+)$ [GeV]	η (μ^+)	ϕ (μ^+)	E_t^{miss} [GeV]	ϕ (E_t^{miss})
167607	24961148	25.4	-0.60	-1.86	40.5	-1.01	-2.92	61.1	0.33

$Z \rightarrow \tau\tau$

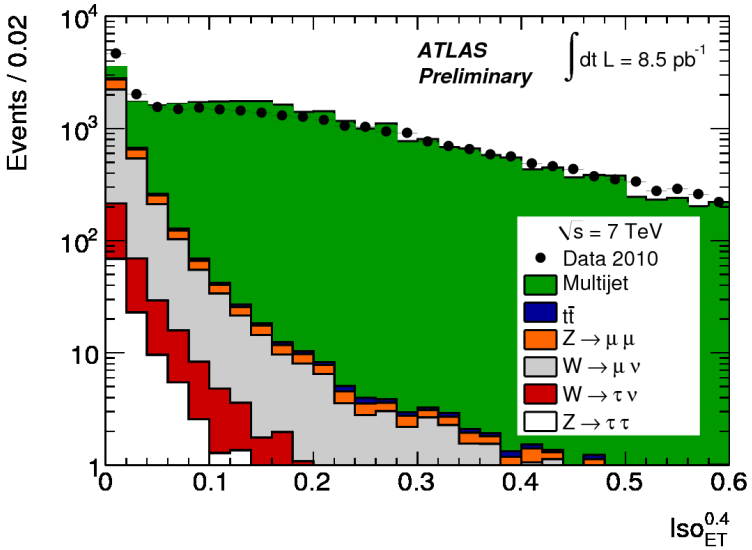
- Re-observe SM process such as $Z \rightarrow \tau\tau$ to understand detector
- Background process to:
  - Higgs boson ($H \rightarrow \tau\tau$)
  - Supersymmetry
  - Exotic scenarios
- One lepton decaying into an electron/muon and one into hadrons, 8.3 pb^{-1} for electron channel, 8.5 pb^{-1} for muon channel

- Event selection:
  - One isolated lepton (e or μ) passing $E_T > 15$ GeV and tight selection
  - One hadronically decaying τ-lepton, $p_T > 15$ GeV, $|\eta| < 2.5$, passing tight cuts
  - E_T^{miss} to suppress W+jet background

Electron channel



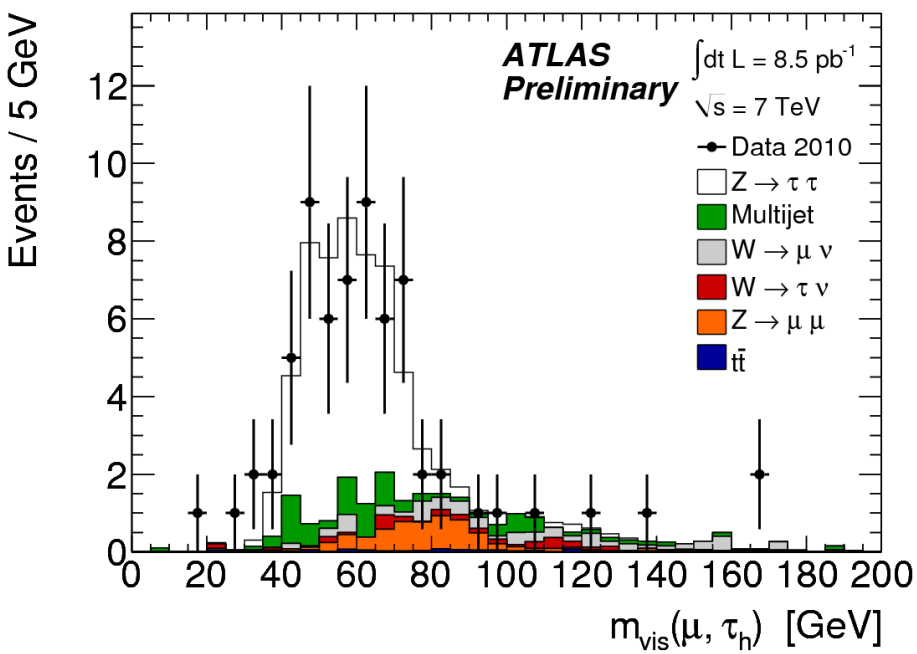
Muon channel



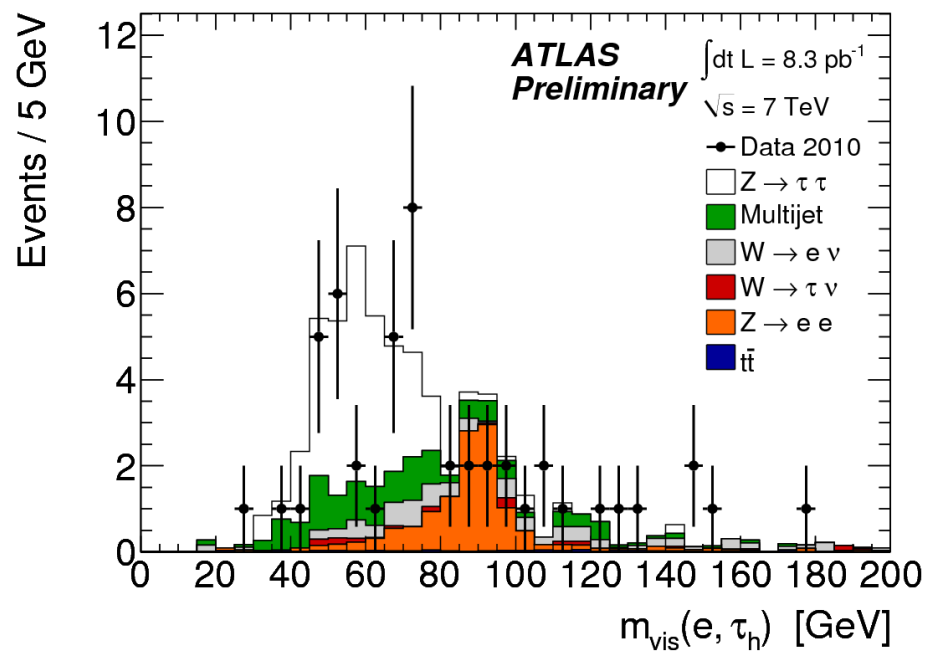
$Z \rightarrow \tau\tau$

	Muon channel	Electron channel
Data (after all selection)	51	29
Total estimated background	9.9±2.1	11.8±1.7
Data (after background subtraction) SM Signal Expectation	41.1±7.1(stat.)±2.1(bkg. est.) 39.9±1.8(stat.)±6.7(syst.)	17.2±5.4(stat.)±1.7(bkg. est.) 24.5±1.4(stat.)±7.9(syst.)

Muon channel

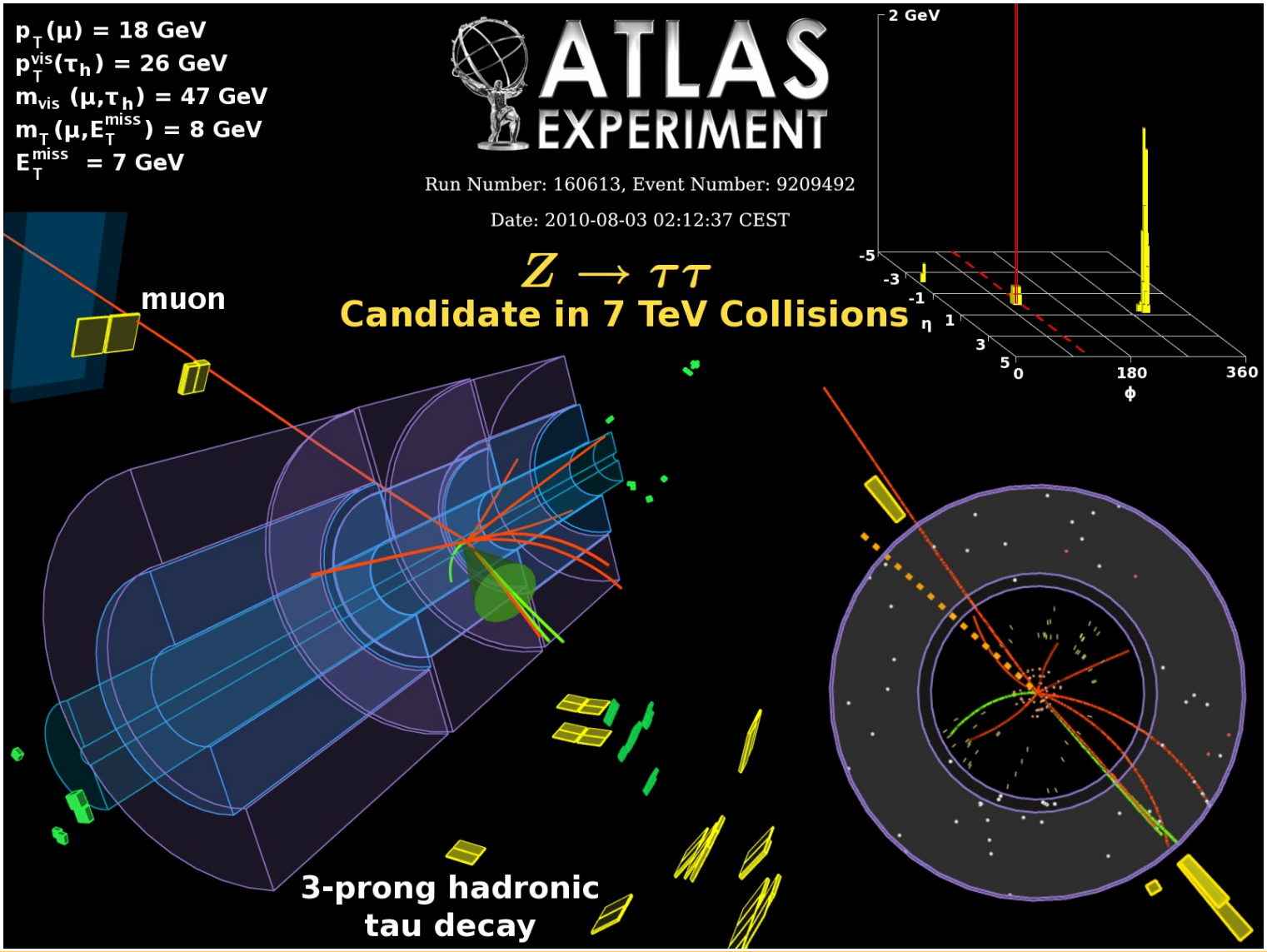


Electron channel



$Z \rightarrow \tau\tau$

First observation of $Z \rightarrow \tau\tau$ candidates in ATLAS



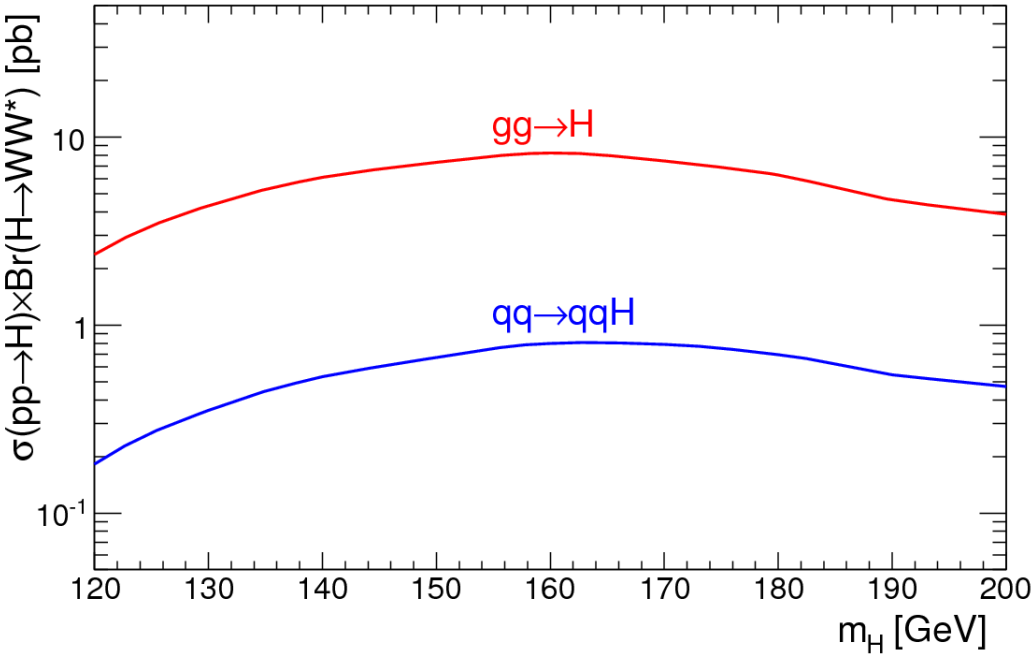
W/Z analysis references

- Measurement of the Muon Charge Asymmetry from W Bosons Produced in pp Collisions at √s = 7 TeV with the ATLAS Detector, submitted to PLB
  http://arxiv.org/abs/1103.2929
- Measurement of the production cross section of W+gamma and Z+gamma at sqrt(s) = 7 TeV with the ATLAS Detector
  ATLAS-CONF-2011-013
- Measurement of the WW production cross section in proton-proton collisions at √s = 7 TeV with the ATLAS detector
  ATLAS-CONF-2011-015
- Observation of Z->tautau (lepton-hadron) Decays with the ATLAS detector
  ATLAS-CONF-2011-010

$H \rightarrow WW \rightarrow l\nu l\nu$

- Production via gluon fusion and vector boson fusion (VBF)
- Decay into electrons and muons
- Background:
  - WW, WZ, ZZ
  - $Z \rightarrow \tau\tau$
  - tt and single top

- Preselection:
  - Two OS leptons, leading lepton p_T > 20 GeV, second lepton p_T > 15 GeV
  - For OSSF leptons: m_{ll} > 15 GeV and not close to Z-peak ($|m_Z - m_{ll}|$ > 10 GeV)
  - E_T^{miss} > 30 GeV
  - $\Delta\phi_{ll}$ < 1.3 (1.8) for m_H < 170 GeV (>170 GeV)



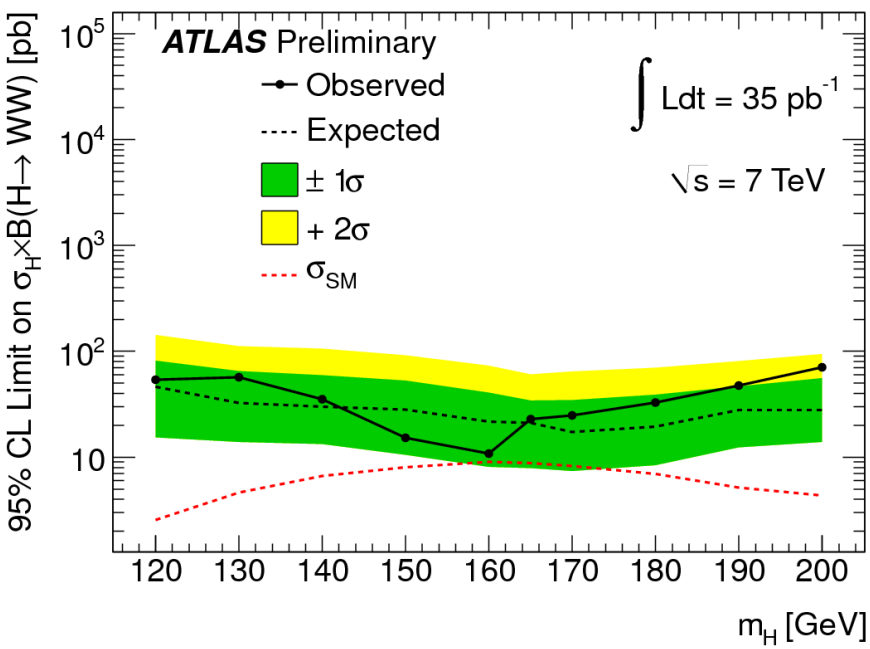
- Three analyses with 0 Jets, 1 Jet and 2 Jets, each with additional cuts
- Events separated according to lepton channel (ee, μμ, eμ)

H → WW → lνlν

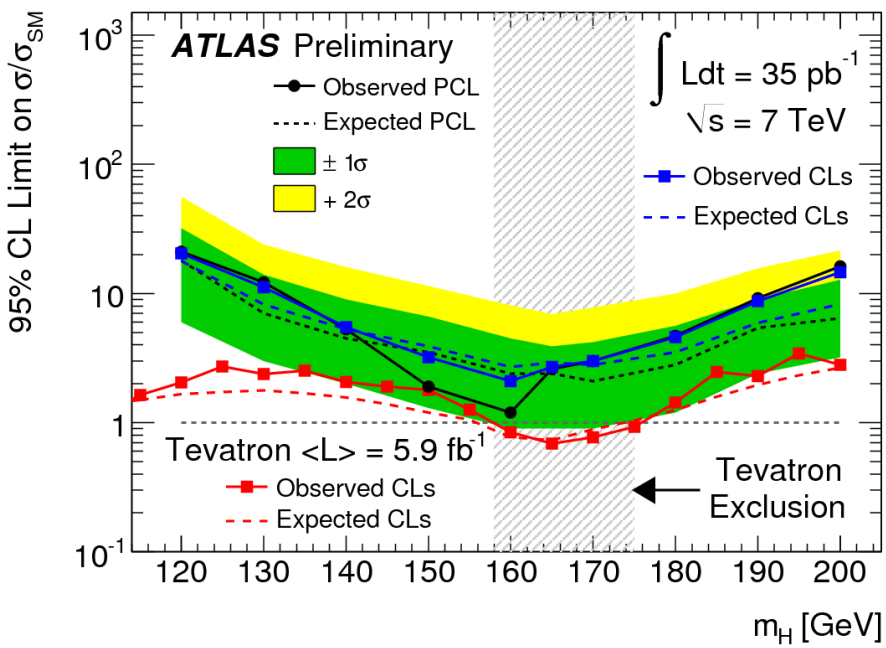
	0 Jets	1 Jet	2 Jets
Data	3	1	0
Background	1.7±0.3	1.3±0.5	0.02±0.03
Higgs	1.3±0.4	0.6±0.2	0.06±0.03

- X-sec limit: 54 (11, 71) pb at m_H = 120 (160, 200) GeV
- 1.2 x SM cross section σ_{SM} excluded at m_H = 160 GeV

95% C.L. exclusion limit as function of m_H

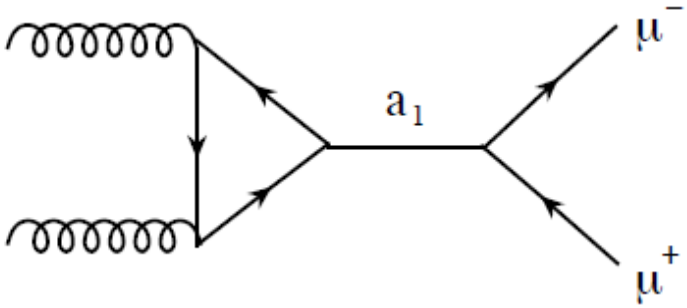


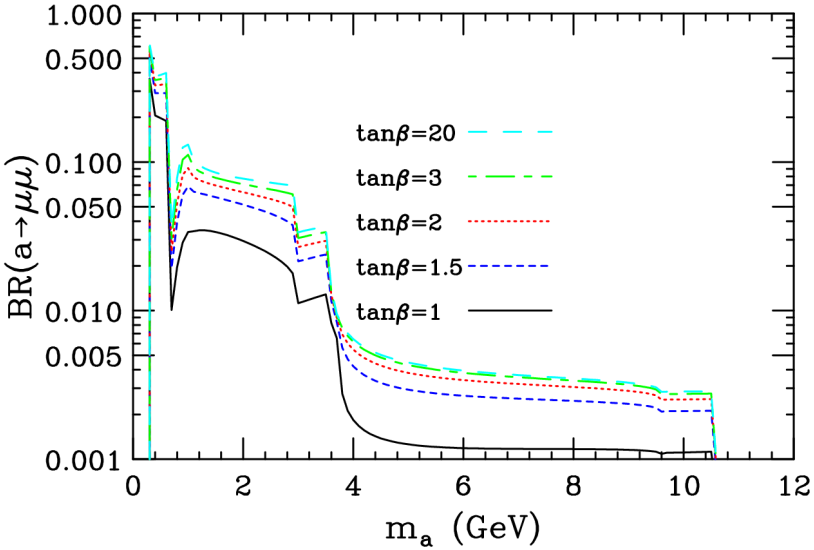
Limit with respect to SM prediction



$a \rightarrow \mu\mu$ at low masses

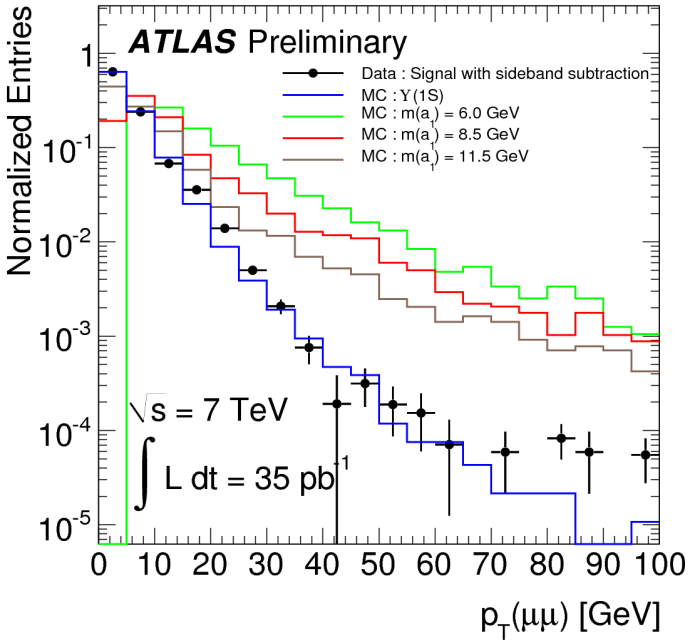
- Very light CP-odd Higgs boson, predicted in next-to-minimal extensions of SUSY models (NMSSM)
- Production via $gg \rightarrow a_1$
- Search range of 6 – 9 GeV and 11 – 12 GeV → avoid region dominated by ϒ resonance





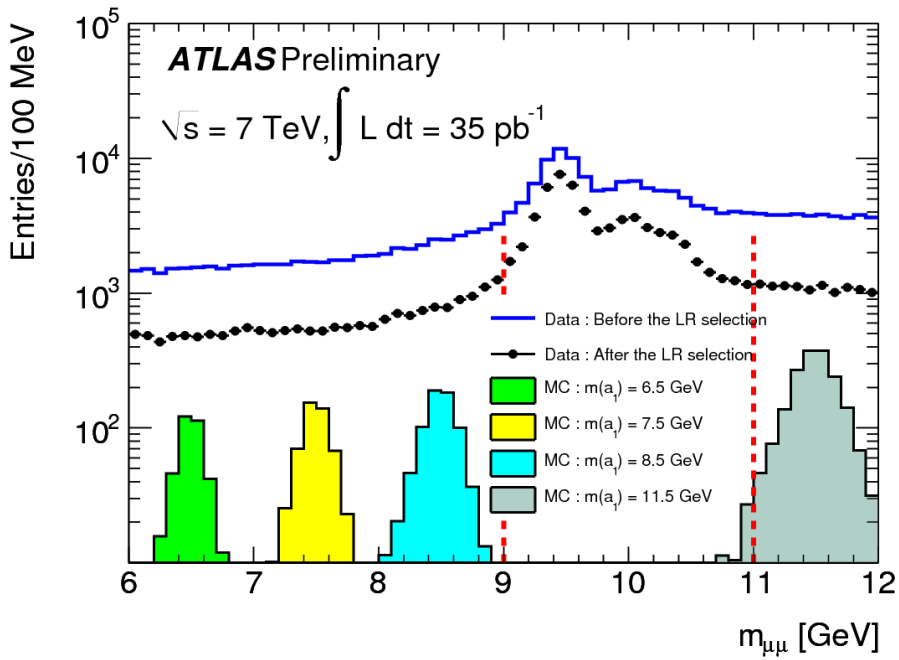
Branching ratio for $a_1 \rightarrow \mu^+\mu^-$ vs. a_1 mass

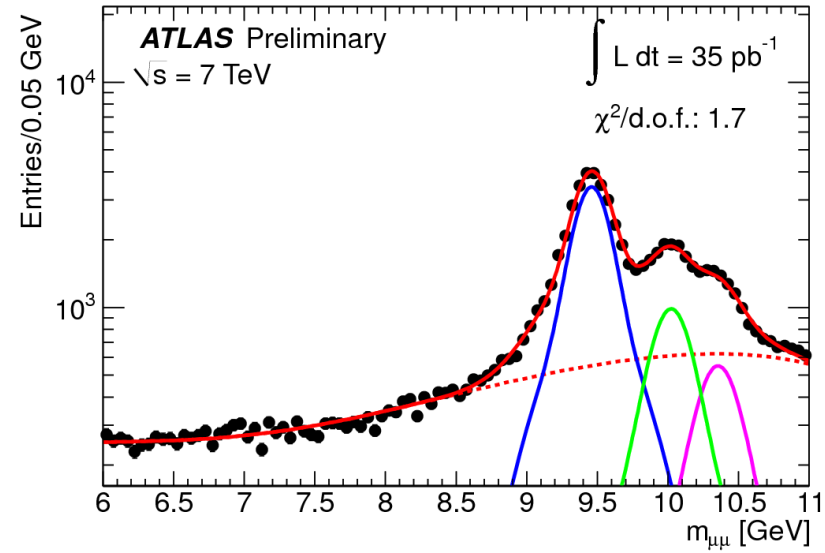
- Dimuon selection with $4.5 < m_{\mu\mu} < 14$ GeV
- Good vertex

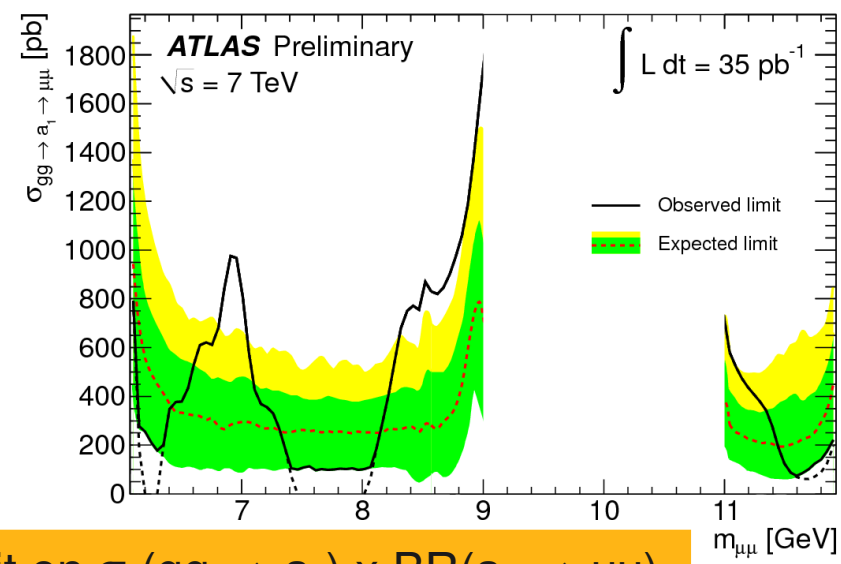


a → μμ at low masses

- Blue, green and magenta corresponds to ϒ1S, 2S and 3S predictions
- Dashed red curve represents fitted background







Likelihood ratio selection to increase significance of potential a → μμ signal from background $m_{\mu\mu}$ spectrum before and after LL ratio selection

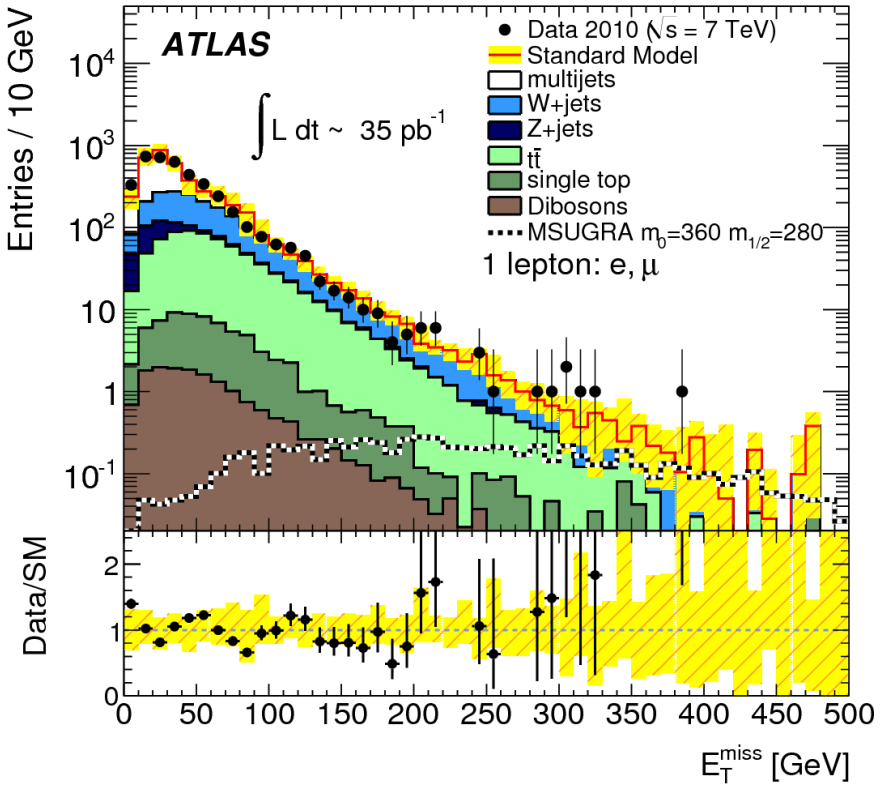
Limit on σ (gg → a_1) x BR(a_1 → μμ)

Higgs analysis references

- Search for a Standard Model Higgs Boson in the Mass Range 200-600 GeV in the Channels $H → ZZ → l^+ l^- \nu \bar{\nu}$ and $H → ZZ → l^+ l^- q \bar{q}$ with the ATLAS Detector
  ATLAS-CONF-2011-026
- Higgs Boson Searches using the H → WW(∗ →ℓνℓDecay Mode with the ATLAS Detector at 7 TeV
  ATLAS-CONF-2011-005
- Search for the Higgs boson in the diphoton final state with 38 pb^{-1} of data recorded by the ATLAS detector in proton-proton collisions at sqrt(s)=7 TeV
  ATLAS-CONF-2011-025
- Search for neutral MSSM Higgs bosons decaying to tau+tau- pairs in proton-proton collisions at sqrt(s)=7 TeV with the ATLAS Experiment
  ATLAS-CONF-2011-024
- Search for NMSSM light CP-odd Higgs a1 with μ+μ– final states with pp collisions at root s =7 TeV in ATLAS
  ATLAS-CONF-2011-020

Jets+lepton+E_T^{miss}

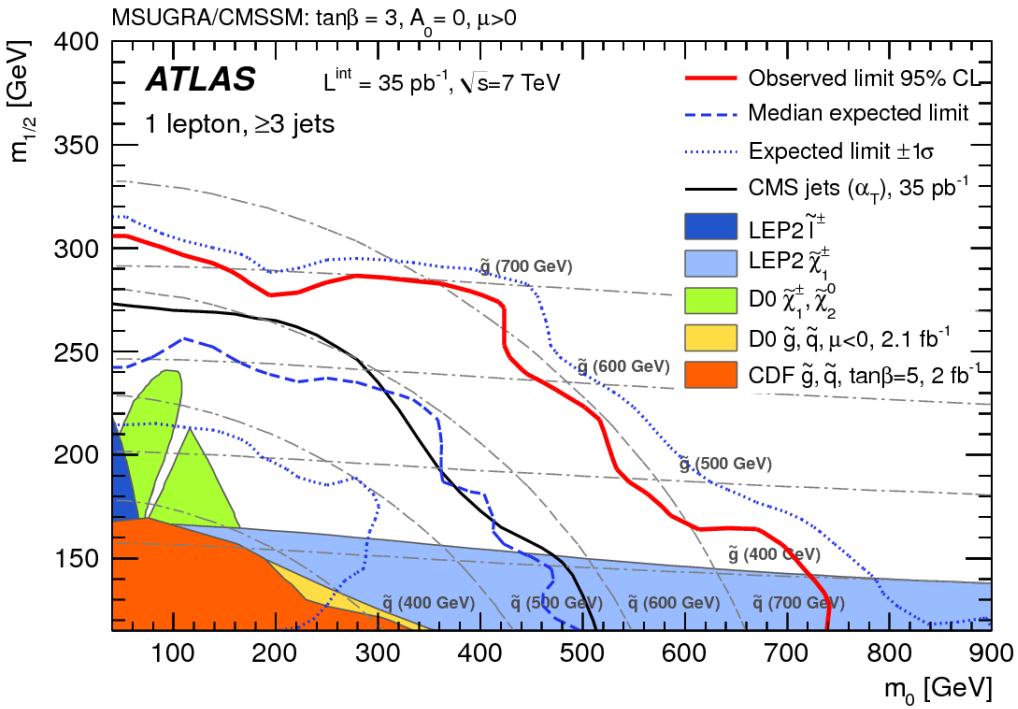
- One reconstructed primary vertex with at least 5 tracks
- Exact one electron or muon with p_T > 20 GeV
- Three jets with p_T > 30 GeV
- Leading jet with p_T > 60 GeV
- $\Delta\phi(jet_i, E_T^{miss})$ > 0.2 (i=1,2,3)
- E_T^{miss} > 125 GeV
- Background:
  - Top quark pair production and W+jet estimated from combined fit in three control regions
  - QCD multijet with jet misidentified as isolated lepton purely data driven



Jets+lepton+E_T^{miss}

Electron channel	Signal region
Observed events	1
Fitted top events Fitted W/Z events Fitted QCD events	1.34±0.52 (1.29) 0.47±0.40 (0.46) $0.0^{+0.3}_{-0.0}$
Fitted sum of bkg events	1.81±0.75
Muon channel	**Signal region**
Observed events	1
Fitted top events Fitted W/Z events Fitted QCD events	1.76±0.67 (1.39) 0.49±0.36 (0.71) $0.0^{+0.5}_{-0.0}$
Fitted sum of bkg events	2.25±0.94

Parameter	A_0	tanβ	μ
Value	0 GeV	3	>0



Observed and expected 95% C.L. Exclusion limits and 1σ variation on expected limit

For equal squark and gluino masses, gluino masses < 700 GeV excluded at 95% C.L.

Dilepton+E_T^{miss} with flavor subtraction

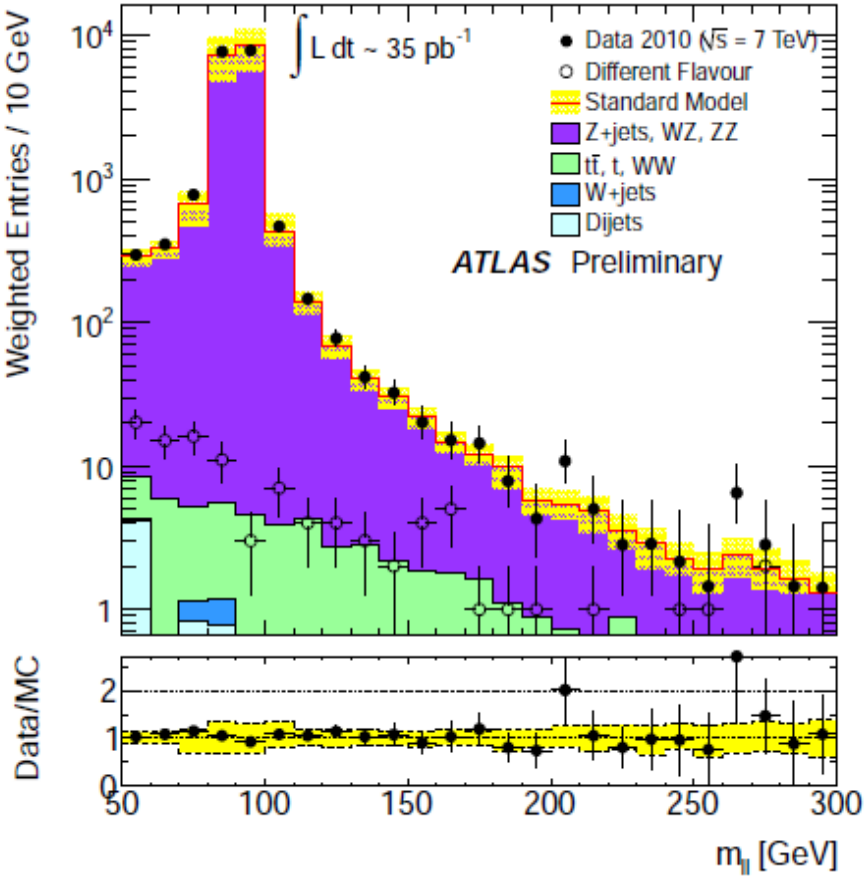
- OSSF leptons over OSDF leptons (e and μ)
- In SUSY via decay chain

$$\tilde{\chi}_2^0 \rightarrow \tilde{\ell}\ell^\pm \rightarrow \tilde{\chi}_1^0\ell^+\ell^- \qquad \tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0\ell^+\ell^-$$

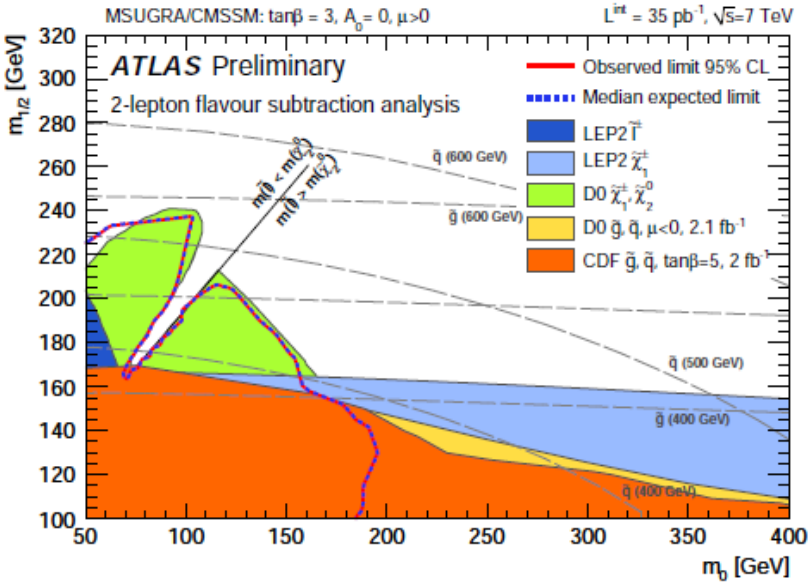
- Model independent measurements of SUSY masses
- Background:
  - QCD
  - tt, single top
  - W, Z/γ*
  - Diboson (WW, WZ, ZZ)
  - Drell-Yann
- Flavor subtraction performed via

$$\mathcal{S} = \frac{N(e^\pm e^\mp)}{\beta(1-(1-\tau_e)^2)} - \frac{N(e^\pm\mu^\mp)}{1-(1-\tau_e)(1-\tau_\mu)} + \frac{\beta N(\mu^\pm\mu^\mp)}{(1-(1-\tau_\mu)^2)},$$

τ_e τ_μ electron and muon plateau trigger efficiency, β ratio of electron to muon efficiency times acceptance



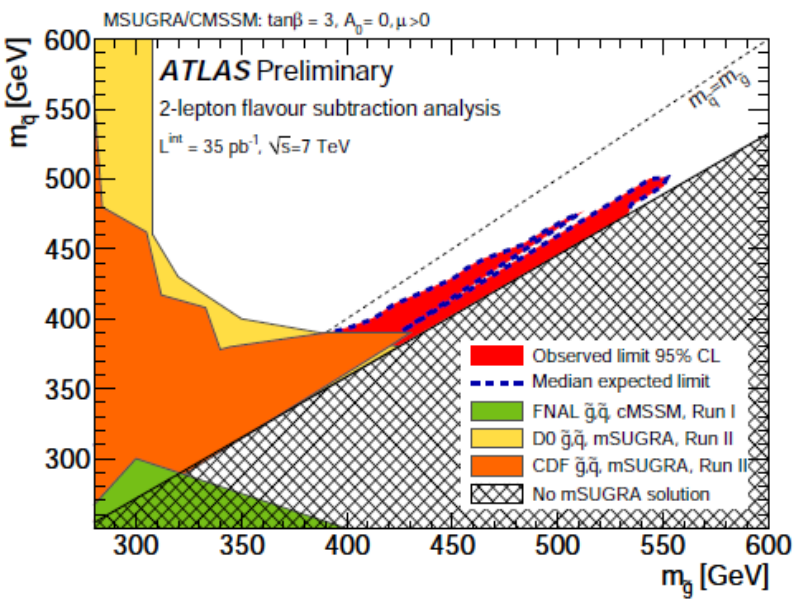
Dilepton+E_T^{miss} with flavor subtraction



S_{obs} = 1.98±0.15(β)±0.02(τ_e)±0.06(τ_μ)

S_{SM} = 2.06±0.79(stat.)±0.78(sys.)

Process	$\mathcal{S}_b$
Z/γ^*+jets	0.86 ± 0.33 (stat.) ± 0.74 (sys.)
Dibosons	0.51 ± 0.04 (stat.) ± 0.12 (sys.)
$t\bar{t}$	0.34 ± 0.61 (stat.) ± 0.13 (sys.)
Single top	-0.10 ± 0.23 (stat.) ± 0.08 (sys.)
Fakes	0.46 ± 0.31 (stat.) ± 0.10 (sys.)
SM total	2.06 ± 0.79 (stat.) ± 0.78 (sys.)



<u>24 parameter space in MSSM, fixed parameters:</u>

m_A = 1000 GeV, μ = 1.5min(m_g,m_q), tanβ = 4, A_t = μ/tanβ, and A_l = μ tanβ

First and second generation: common squark mass and slepton mass parameters

Third generation: sfermion masses set to 2 TeV

<u>95 % C.L. Lower limit for m_g = m_q + 10 GeV:</u>

m_q = 503 (558) GeV for compressed spectrum (light neutralino)

SUSY analysis references

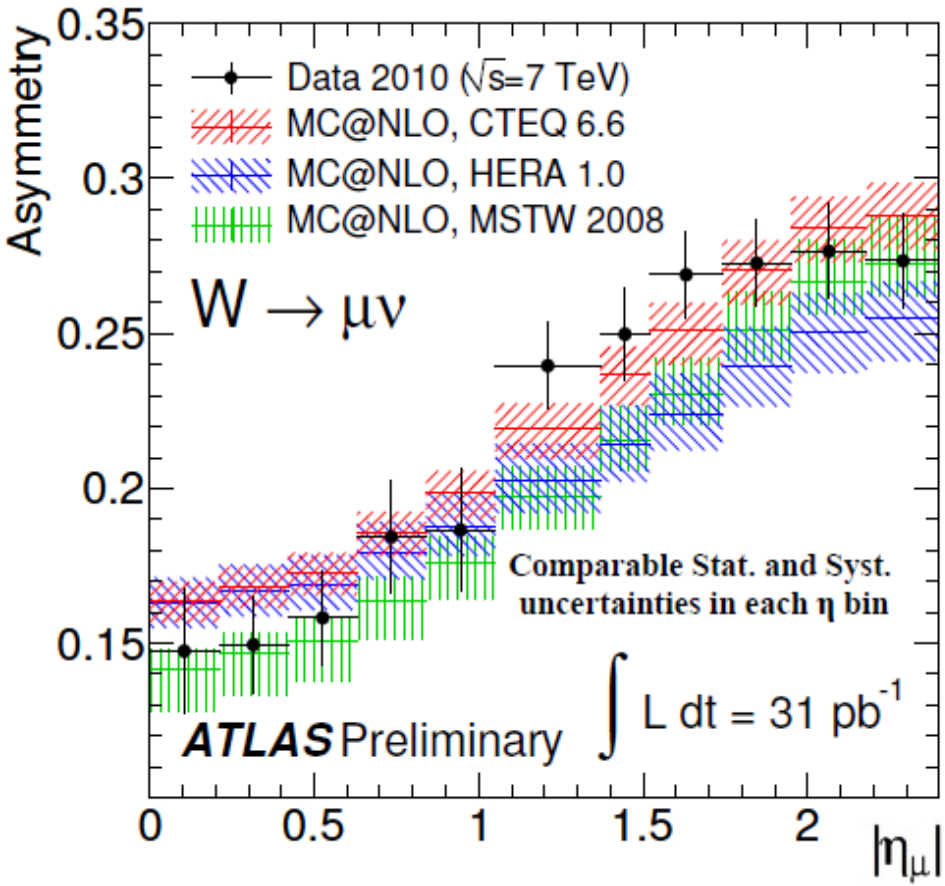
- Search for stable hadronising squarks and gluinos with the ATLAS experiment at the LHC, submitted to PLB
  http://arxiv.org/abs/1103.1984
- Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in sqrt(s) = 7 TeV proton-proton collisions, submitted to PLB
  http://arxiv.org/abs/1102.5290
- Search for supersymmetry using final states with one lepton, jets, and missing transverse momentum with the ATLAS detector in sqrt{s} = 7 TeV pp, accepted by PRL
  http://arxiv.org/abs/1102.2357
- Search for an excess of events with an identical flavour lepton pair and significant missing transverse momentum in $\sqrt{s}$ = 7 TeV proton-proton collisions at the ATLAS experiment
  in pipeline

Summary

- Diboson: WW cross section measured and first Wγ and Zγ x-section measurements at 7 TeV
- W asymmetry in the μ channel measured
- No hint for Higgs at ATLAS
- Dominant background distributions determined with data driven techniques
- Close to the SM sensitivity in $H \rightarrow WW \rightarrow l\nu l\nu$ (1.2xSM) already with 35 pb^{-1}
- SUSY searches has just began, lots of SUSY papers published or in pipeline
- Expected sensitivity beyond 1 TeV already for 2011

Backup

W Charge Asymmetry

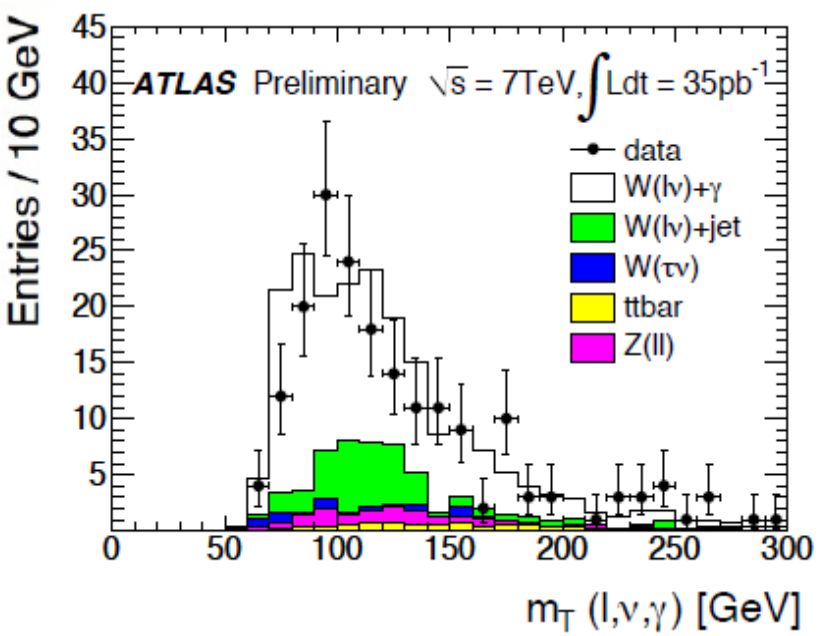


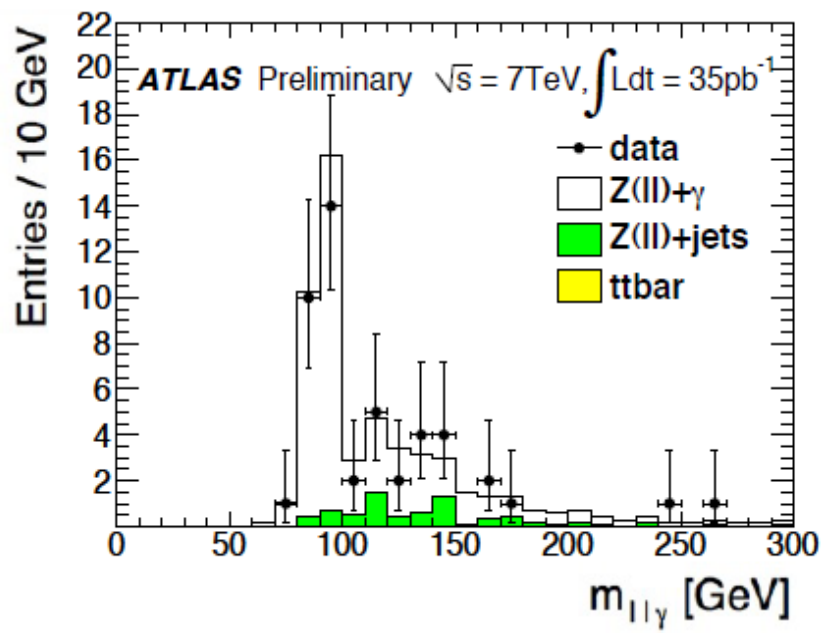
$$A_\mu = \frac{\frac{d\sigma_{W\mu^+}}{d\eta_\mu} - \frac{d\sigma_{W\mu^-}}{d\eta_\mu}}{\frac{d\sigma_{W\mu^+}}{d\eta_\mu} + \frac{d\sigma_{W\mu^-}}{d\eta_\mu}}$$

Production cross section of Wγ and Zγ

Wγ	e-channel	μ-channel
Event Yield	95	97
W+Jets Bkg (Data)	16.9 ± 6.4 ± 7.3	16.8 ± 4.7 ± 7.3
EW Bkg (MC)	10.1 ± 0.8 ± 1.1	12.4 ± 0.9 ± 1.4

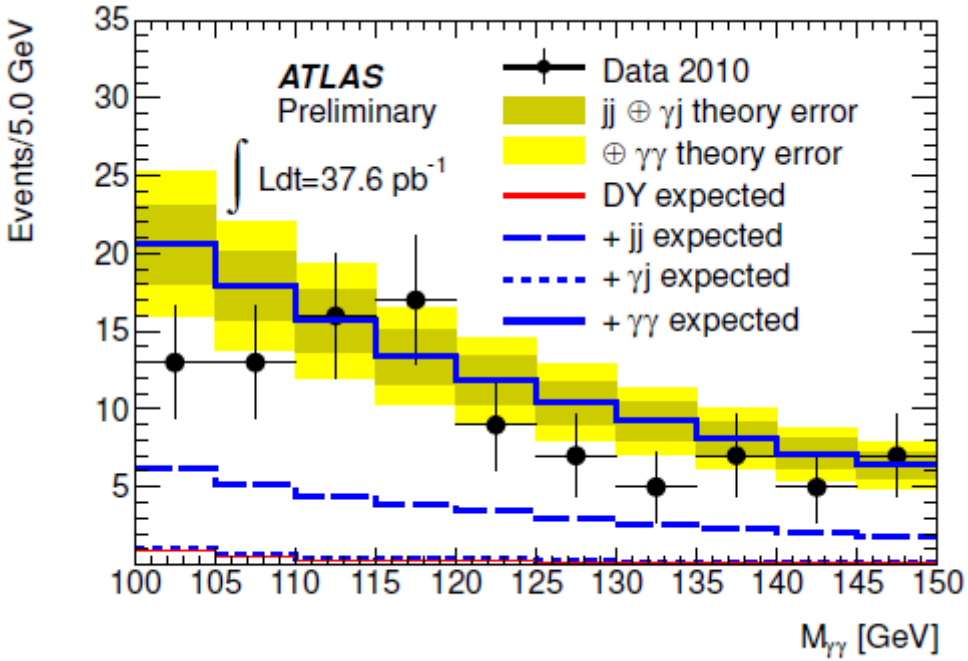
Zγ	e-channel	μ-channel
Event Yield	25	23
Background (MC)	3.8 ± 3.8	3.4 ± 3.4

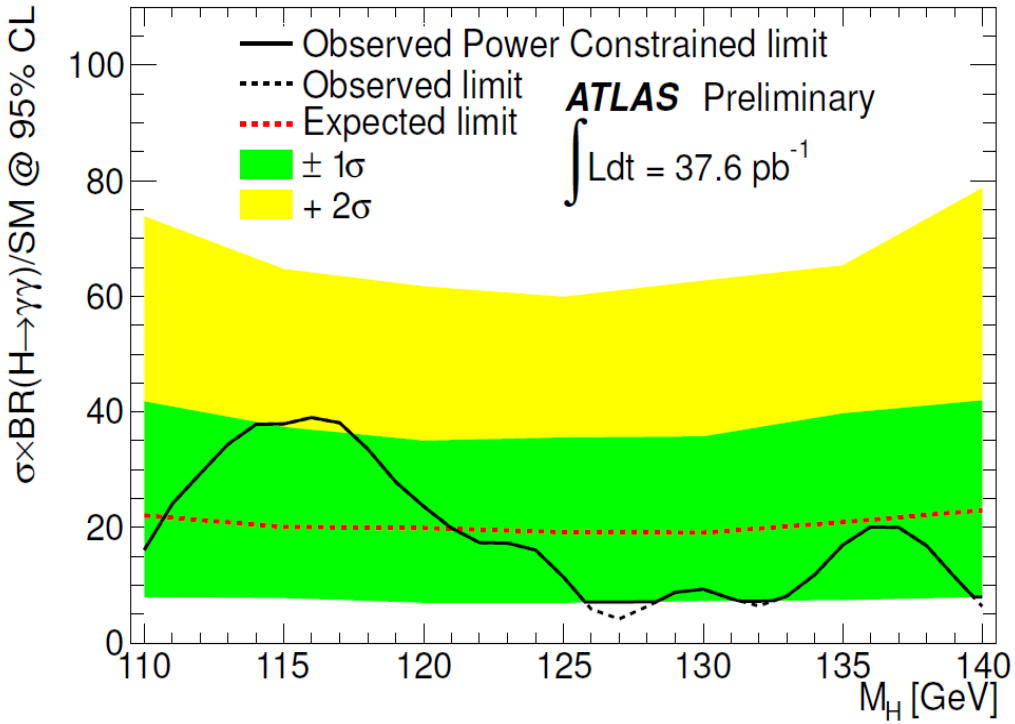




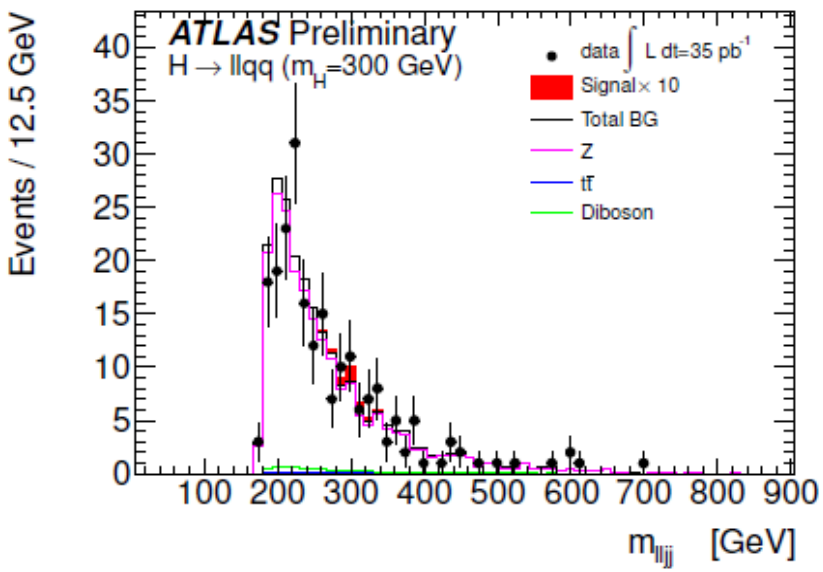
H->γγ

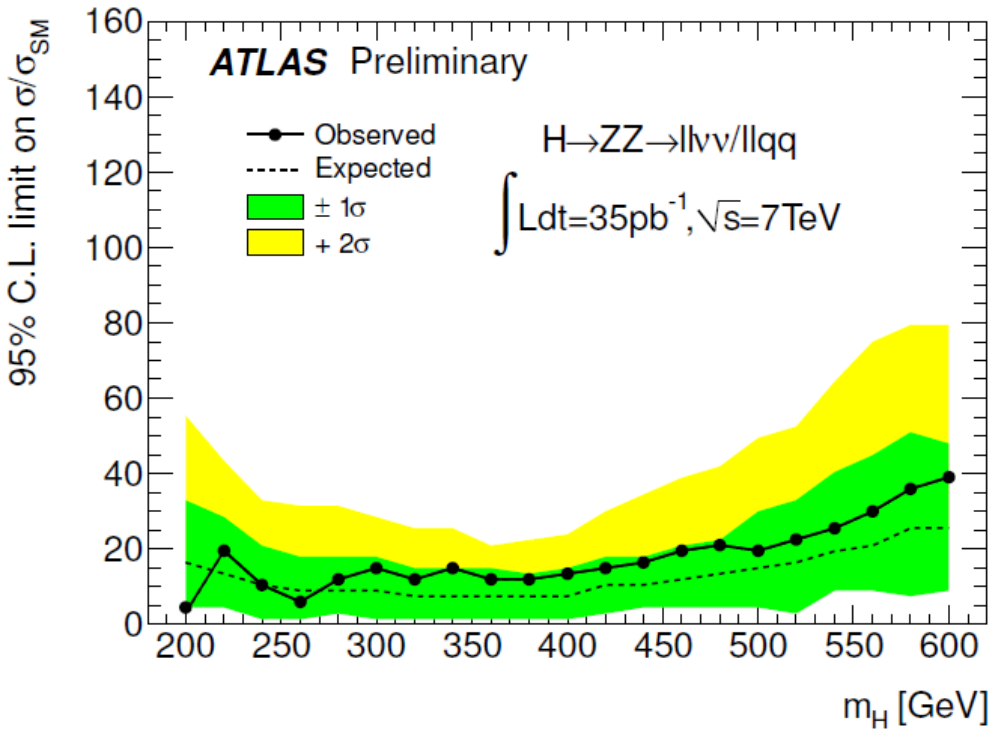
Source	Uncertainty (%)
Luminosity	±3.4
Cross section	+20/-15
Photon identification	±11
Photon Isolation	±10
Trigger	+1.1/-3.7
Energy resolution	±13 on σ_M





H->ZZ->llνν/llqq





- improves sensitivity for large M_H where H→ZZ→4 leptons rates gets small
- 2 leptons (e,μ) with p_T>20GeV 76 GeV < M_{ll} <106 GeV
- llqq: final discriminant M_{lljj} MET<50 GeV , 70< Mjj<105 GeV, M_H>360 GeV: p_T(jets)>50GeV, $\Delta\phi_{ll}, \Delta\phi_{jj} < \pi/2$
- llνν: final discriminant : transverse mass b-jet veto, MET>66/82GeV, $\Delta\phi_{ll}$ <2.64/2.25forM_H</≥260GeV