Exotics Searches at ATLAS

Elisa Pueschel
University of Massachusetts, Amherst

On Behalf of the ATLAS Collaboration
LISHEP 2013
March 17-23

Exotics at ATLAS

- Broad program, impossible to cover all topics in this talk

- Focus on latest searches based on a number of theoretical models

  - Resonance searches

    - Dilepton

    - WZ → lνl'l'

    - Type III Seesaw Heavy Fermions

- Leptoquark search

- Long-lived multicharged particle search

- Hidden sector searches

  - Prompt electron jets from Higgs decay

  - Prompt lepton jets from squark decay in Hidden Valley scenario
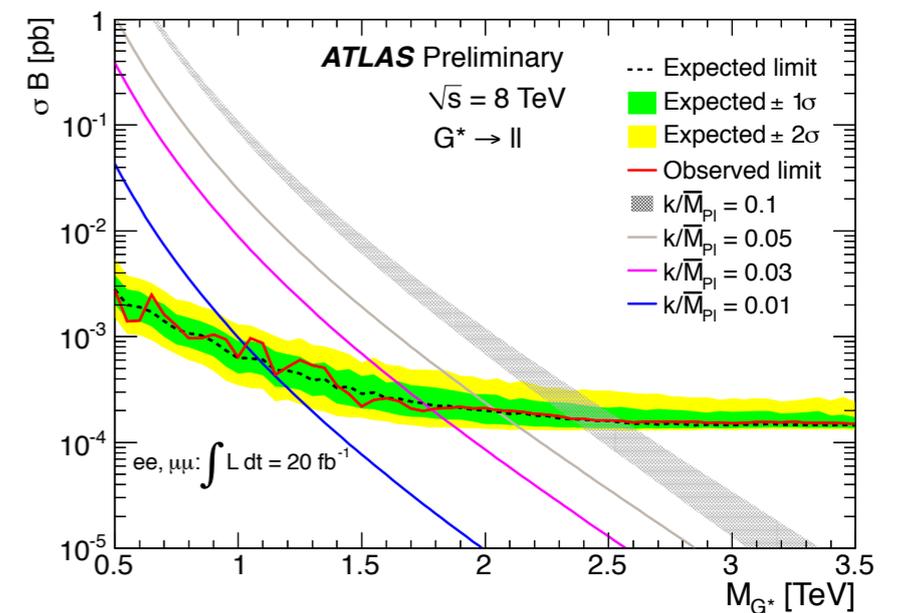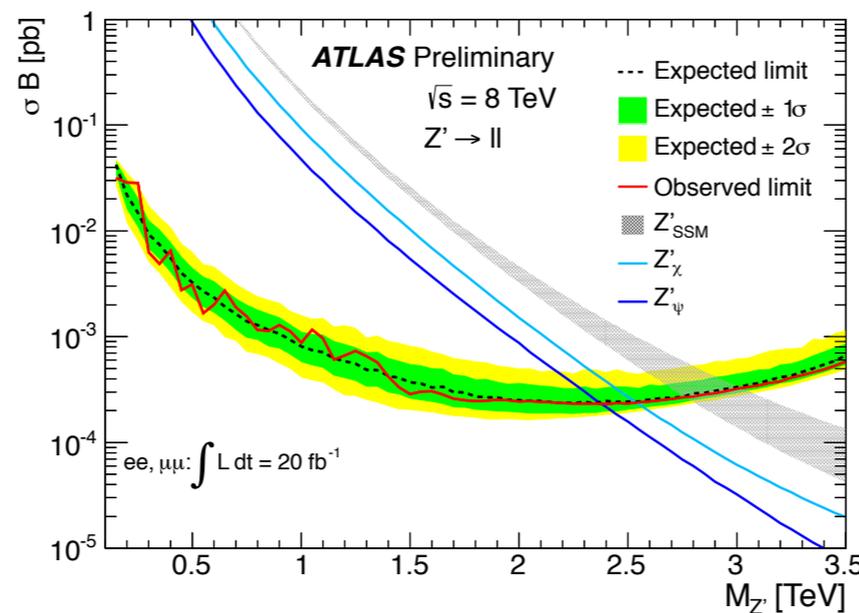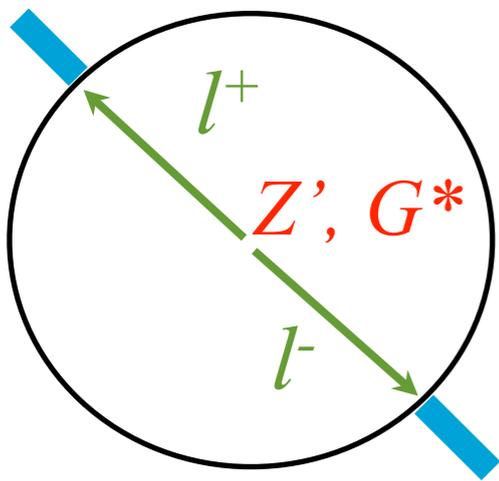
Dilepton Resonance Search

$\sqrt{s}$ = 8 TeV, 20 fb^{-1}

Z'→ll: GUT E$_6$ models
G*→ll: Randall-Sundrum
extra dimensions

e$^+$e$^-$: diphoton trigger
$\mu^+\mu^-$: single muon trigger
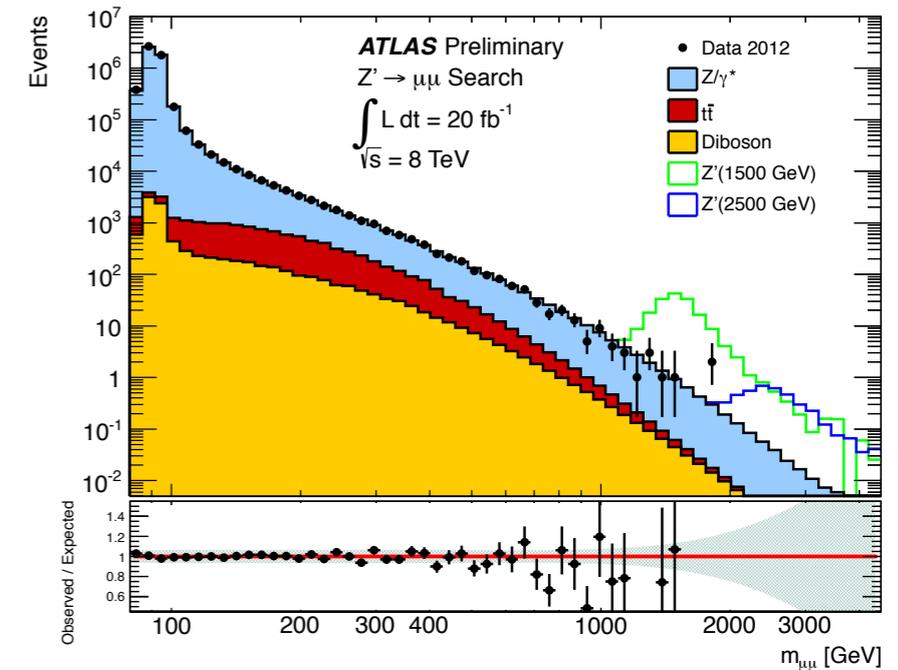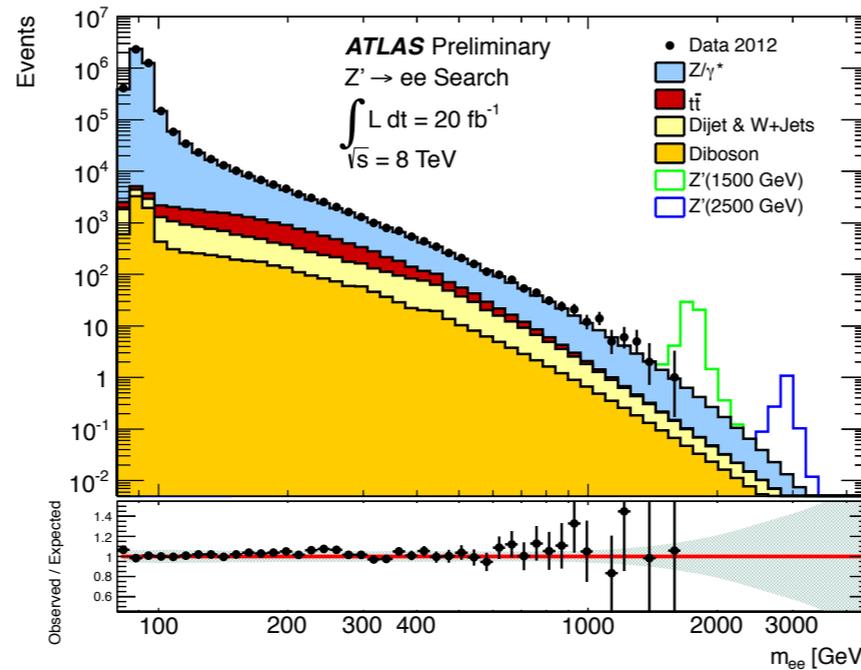
main backgrounds: Z/Υ^*→ll (Drell-Yan), also QCD multijet and W+jets in e$^+$e$^-$ channel

Exclude Z'$_{SSM}$ < 2.86 TeV, Z'$_{E6}$ 2.38-2.54 TeV   Exclude G* < 2.47 TeV

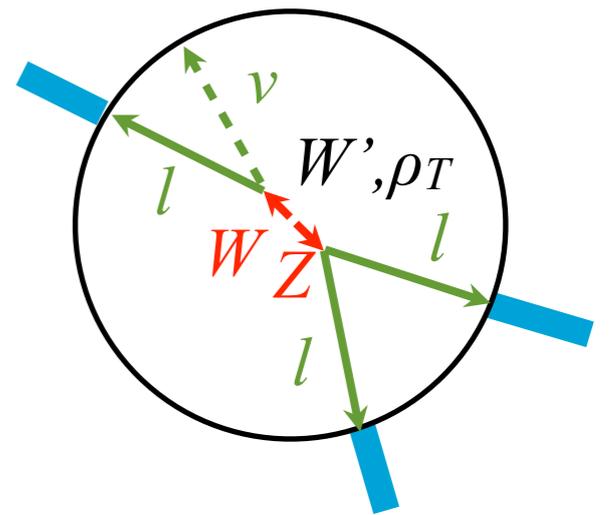ATLAS-CONF-2013-017

3

Search for Resonant WZ→lνl'l' production

$\sqrt{s}$ = 8 TeV, 13.0 fb^{-1}

W': extended gauge models, composite/Little Higgs
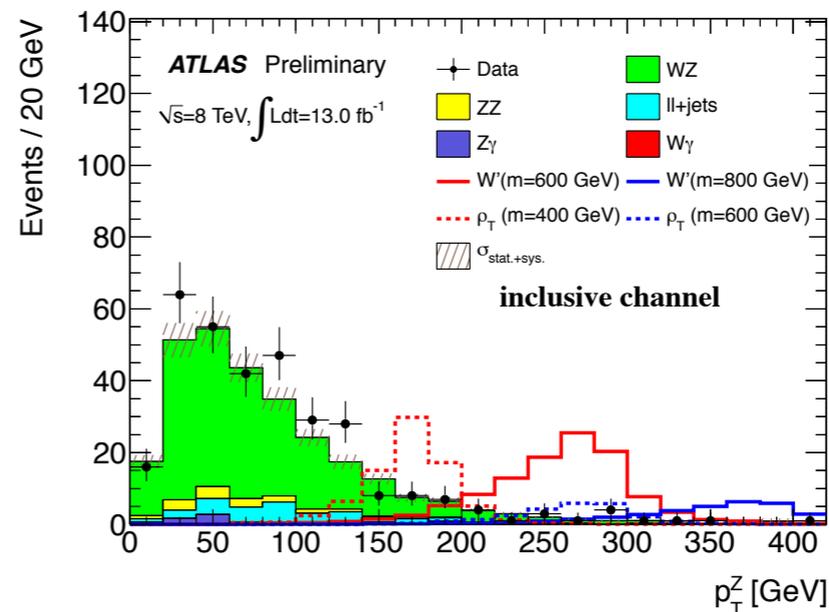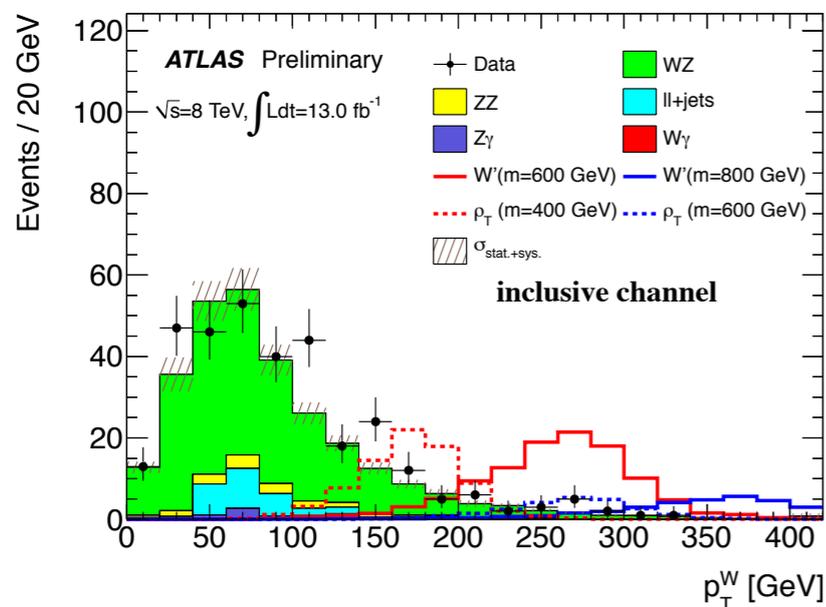ρ_T: low scale technicolor

Selection: 3 leptons with pT > 25 MeV, veto events with additional leptons
Require lepton pair with same flavor, opposite charge, invariant mass <20 GeV from Z mass

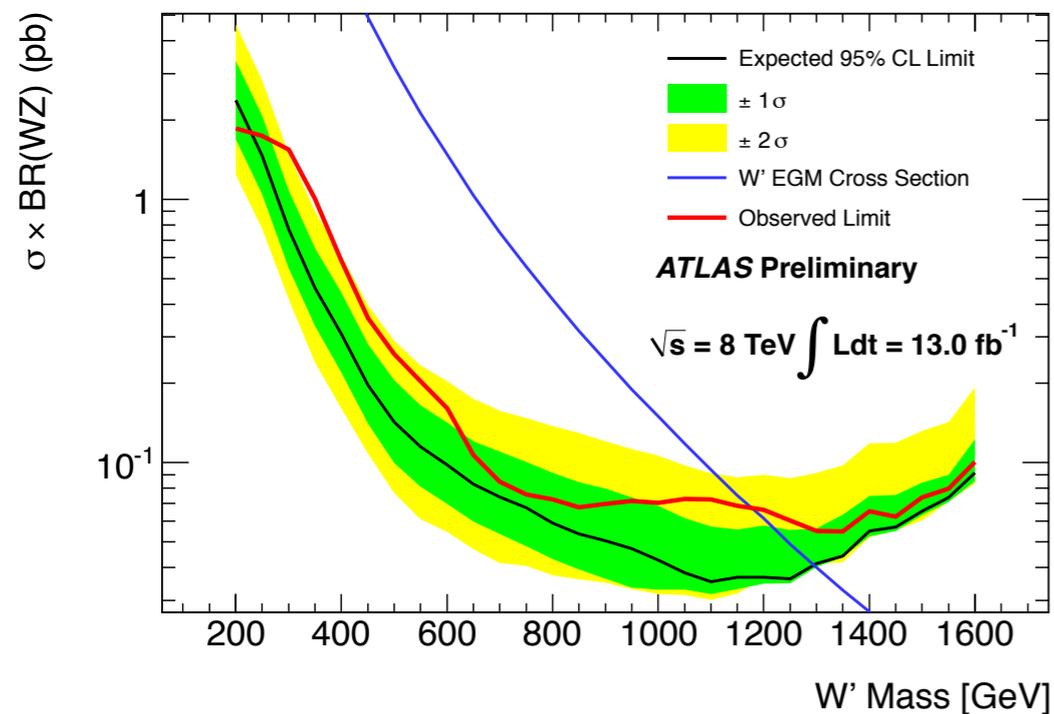Main backgrounds: WZ, ZZ, Zɣ, W/Z+jets
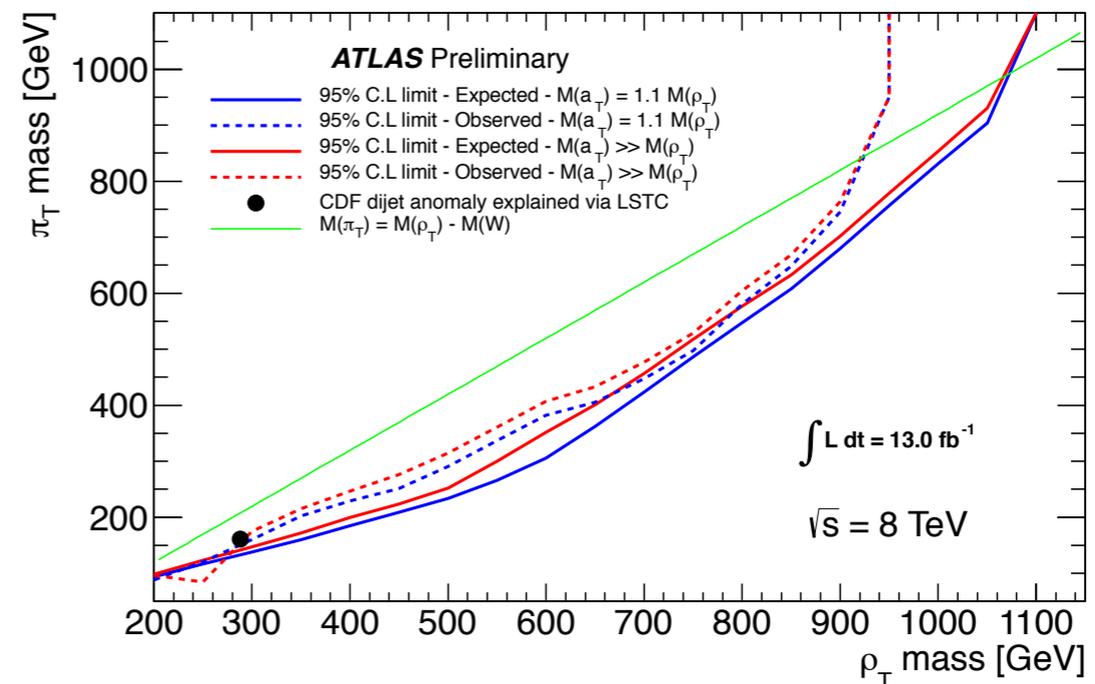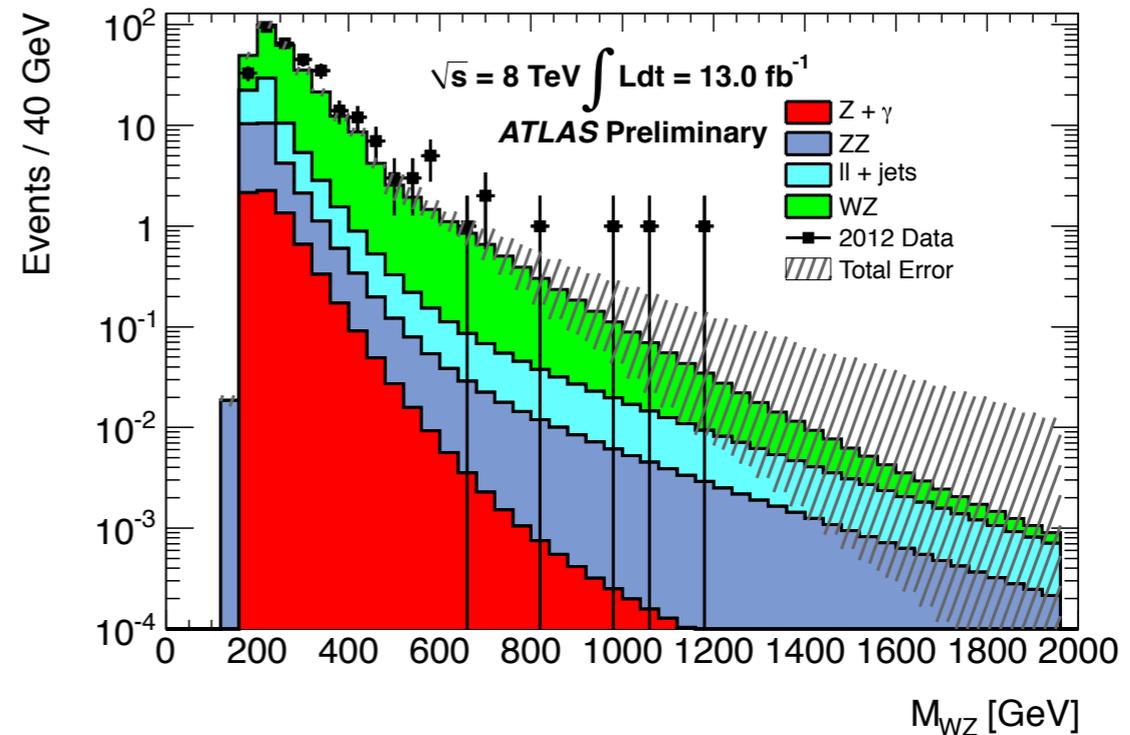

Data/simulation also agrees for m$_Z$, m^W_T

4

Search for Resonant WZ→lνl'l' production

Background estimation: MC fit with a double exponential for non-WZ background, single exponential for WZ background

Exclude W' < 1180 GeV

Exclude ρ_T < 920 GeV

Search for Type III Seesaw Model Heavy Fermions

$\sqrt{s}$ = 8 TeV, 5.8 fb^{-1}

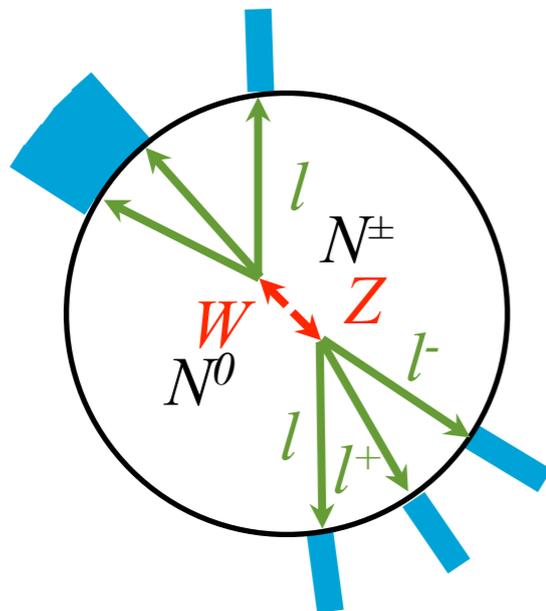Suppression of neutrino mass via two new fermionic triplets
$N^{\pm} \to Zl$, $N^0 \to Wl$

$pp \to N^{\pm}N^0$
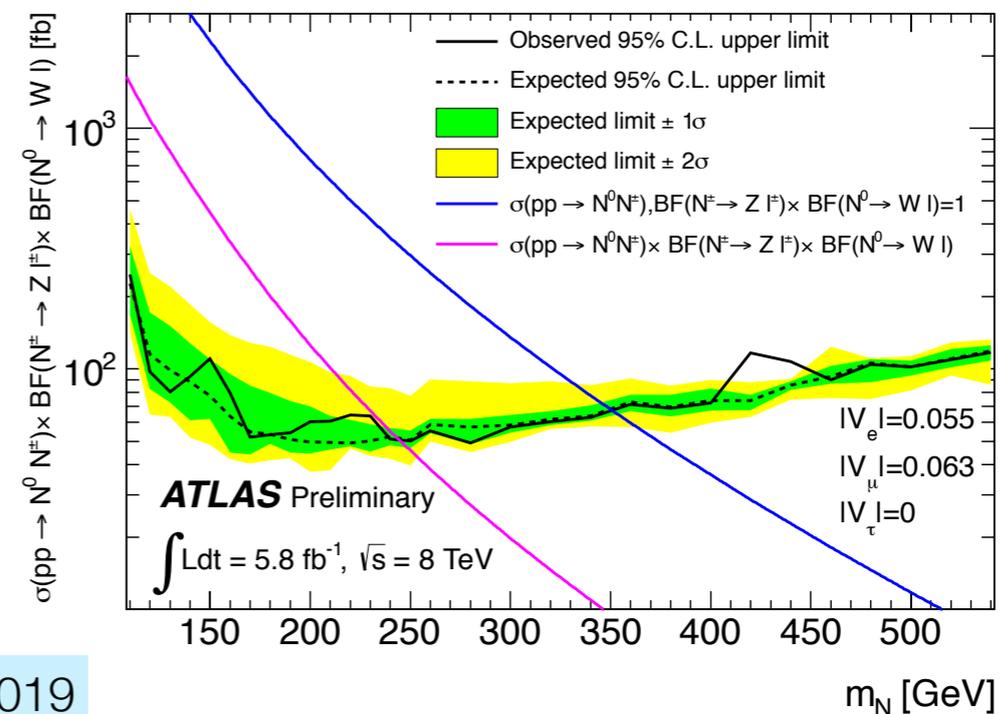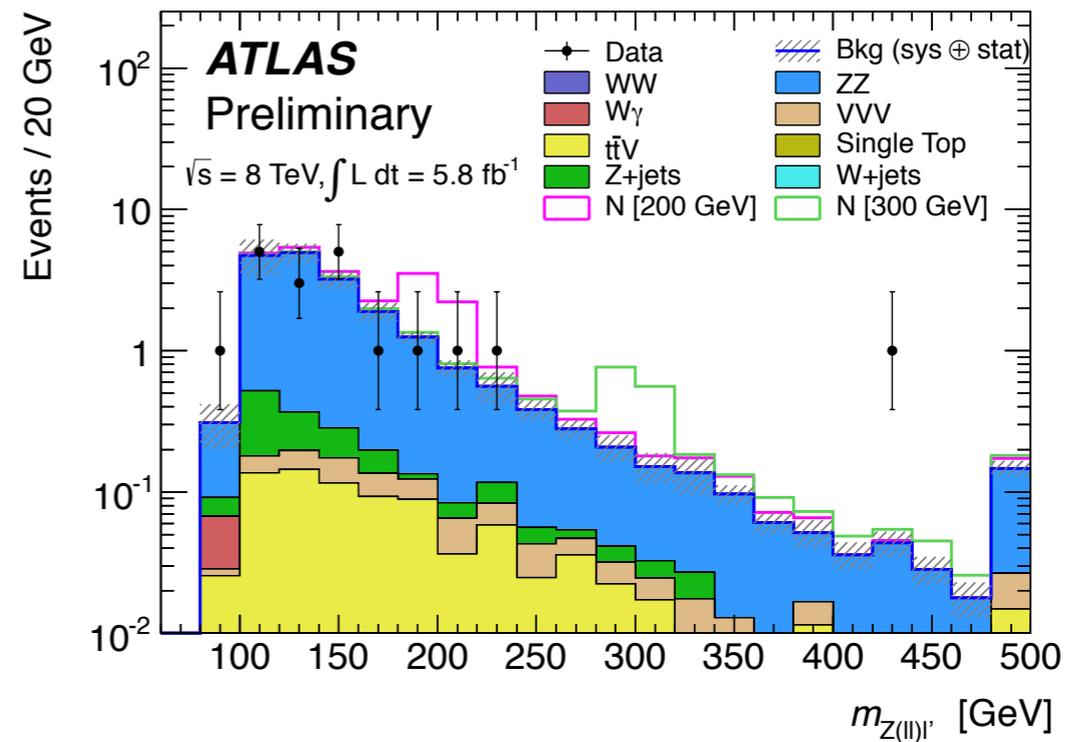multi lepton final state, one pair from Z

Selection:
4 leptons in final state, suppress Z+jet and WZ bkgs
Veto 2nd Z, suppress ZZ contamination
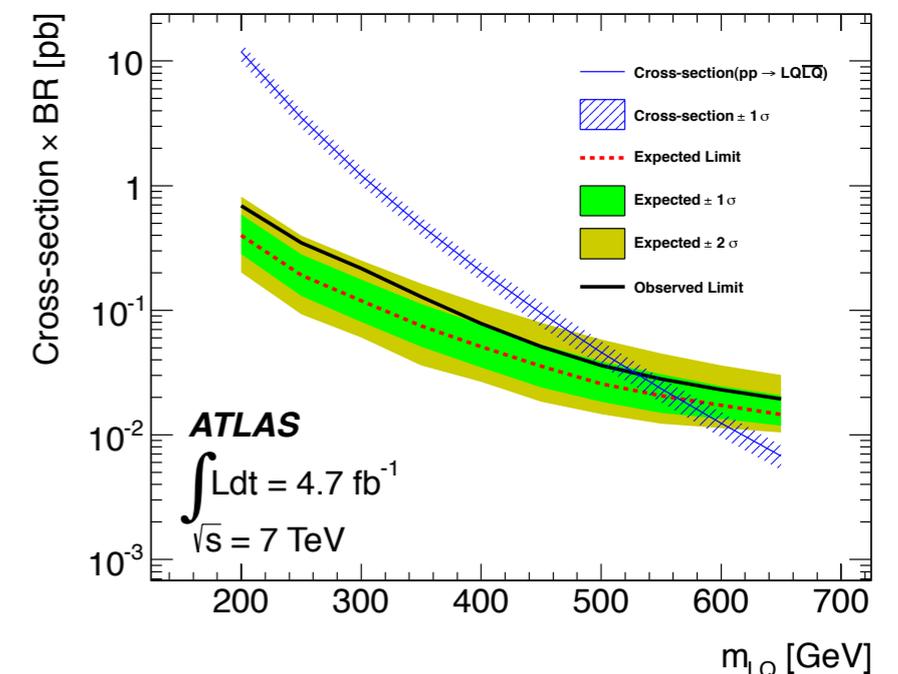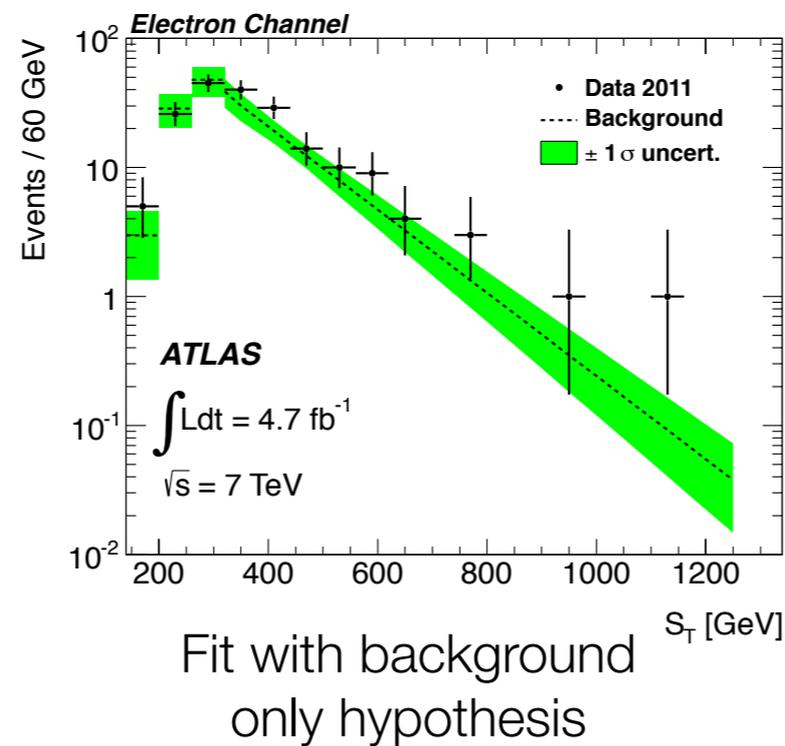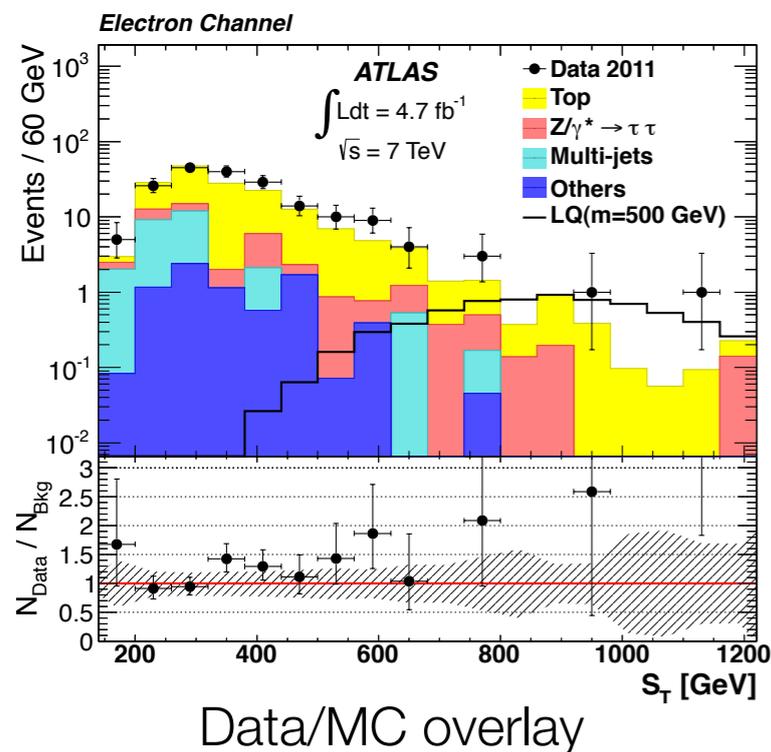

ATLAS-CONF-2013-019

Leptoquark Search

$\sqrt{s}$ = 7 TeV, 4.7 fb^{-1}

Lepton+baryon number, technicolor models, GUT theories

3 generations: LQ3→**τ**b, Select 1l, 1**τ**$_{had}$, E^{miss}$_T$, two high p$_T$ jets

Fit background-only hypothesis for

$$S_T = p_T^{e/\mu} + p_T^{\tau} + p_T^{jet1} + p_T^{jet2} + E_T^{miss}$$

Data/MC overlay

Fit with background
only hypothesis
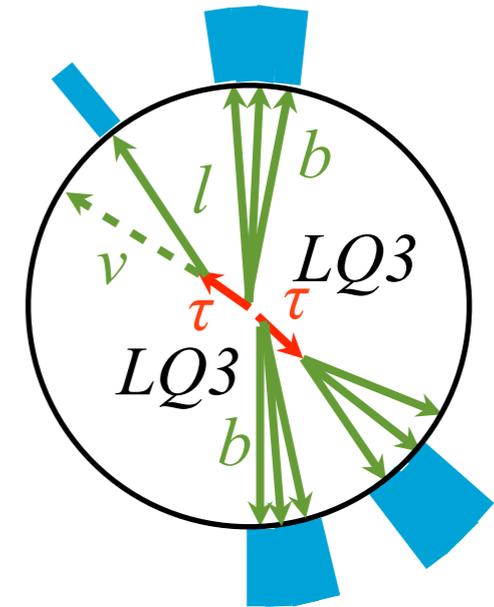
No deviation from background hypothesis
in electron or muon channel

mLQ3 < 534 GeV excluded
at 95% CL

http://arxiv.org/abs/1303.0526

Multicharged Particle Search

$\sqrt{s}$ = 7 TeV, 4.4 fb^{-1}

Models with multi-charged particles: dyons, long-lived black holes, Q-balls, |q| = 2-6e
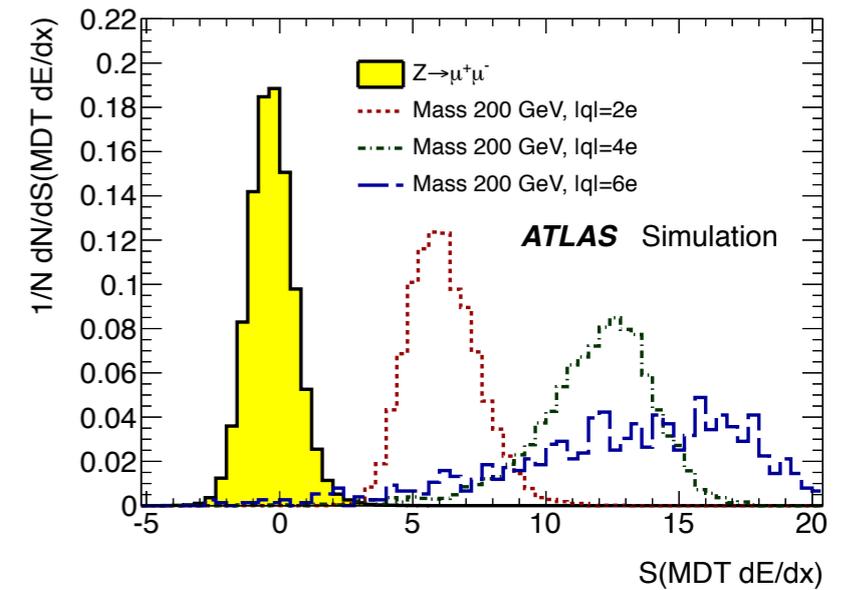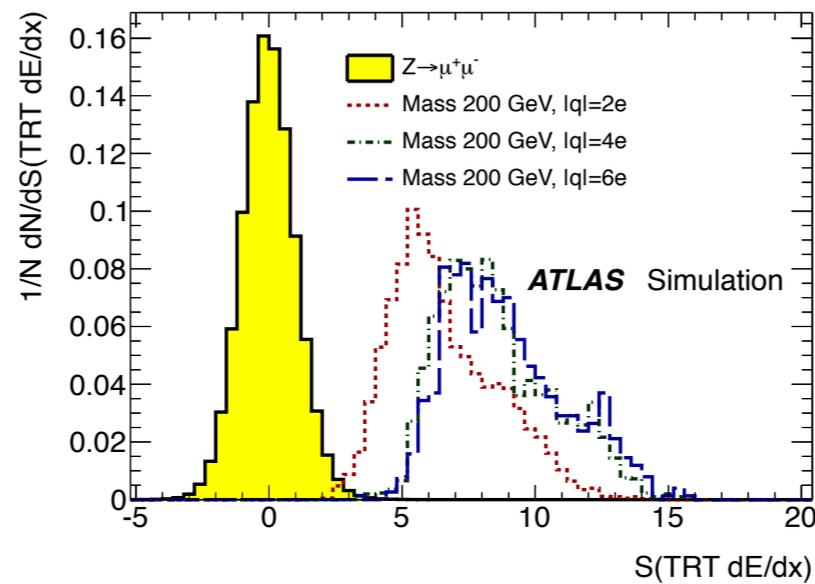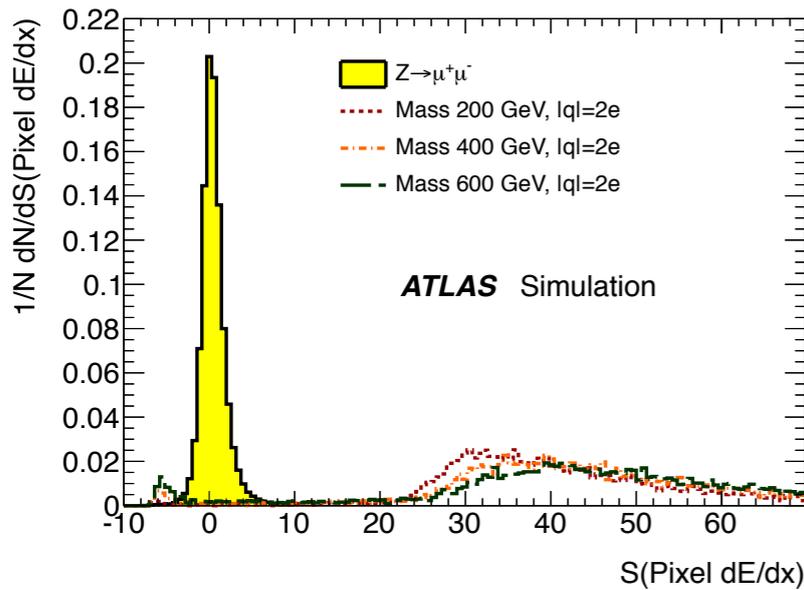
Long-lived→track in muon spectrometer, characteristic dE/dx signature

$$S(dE/dx) = \frac{dE/dx_{track} - <dE/dx_\mu>}{\sigma(dE/dx_\mu)}$$

Fraction of high threshold hits in the TRT also used to discriminate between signal and background

http://arxiv.org/abs/1301.5272

Lepton Jets and Hidden Sectors

- Hidden sectors appear in many models

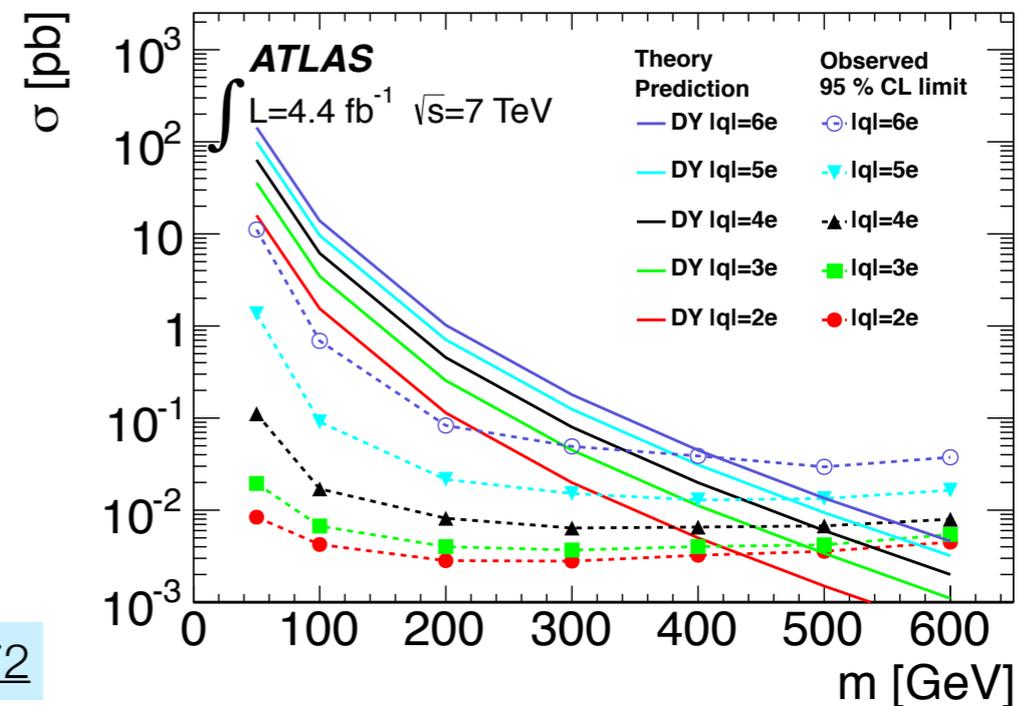 - SUSY models, string theory models, Hidden Valley scenarios

- Astrophysical measurements of positron excess inspired several lepton-jet models

  - Hidden sector dark photon decays to collimated e^+e^- or $\mu^+\mu^-$ pair

3 step model   2 step model

Higgs decay $\rightarrow$ ($h_{d,1}$) $\rightarrow$ $h_{d,2}$ $\rightarrow$ dark photon $\rightarrow$ electron jets

Squark $\rightarrow$ LSP $\rightarrow$ dark photon $\rightarrow$ electron jet

WH Production with Higgs → Prompt Electron Jets

$\sqrt{s}$ = 7 TeV, 2.04 fb⁻¹

m_{Higgs} 100, 125, 140 GeV

$mass_{dark\ photon}$ 100, 200 MeV

Selection: W, 2 electron jets
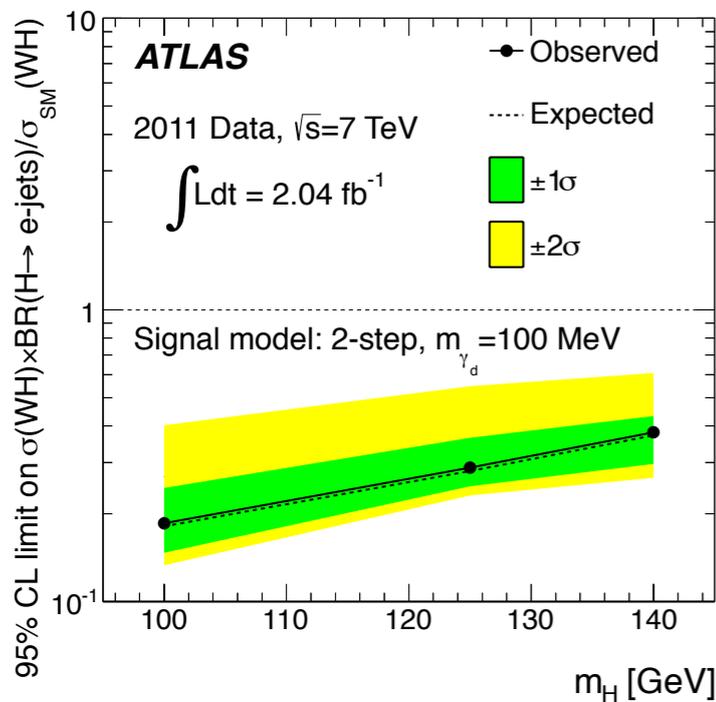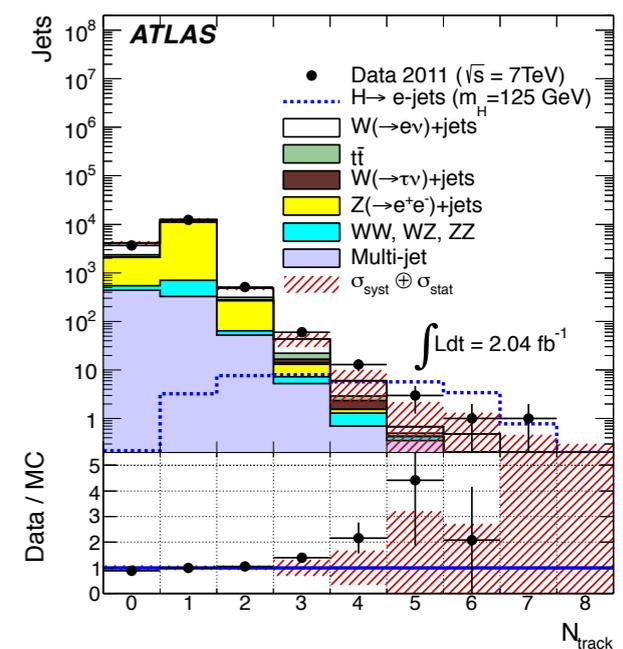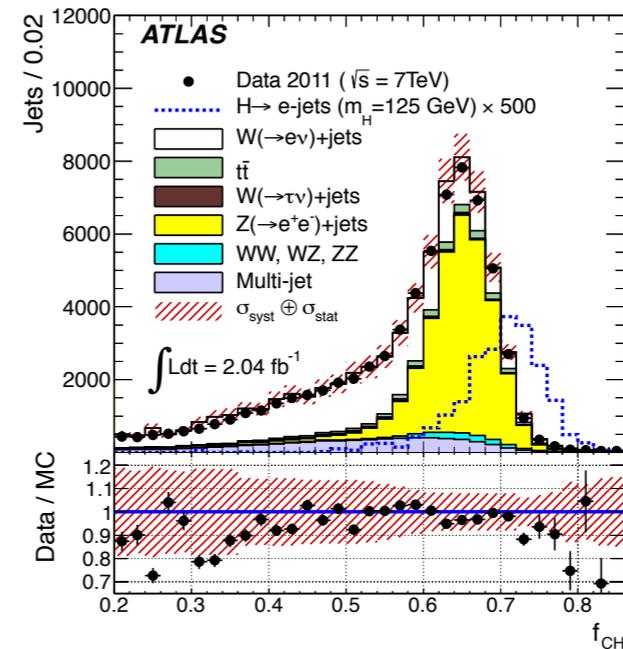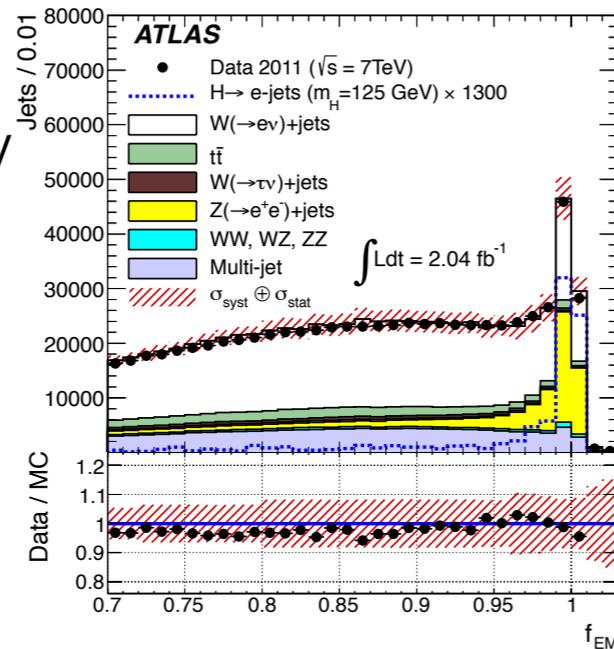
Dominant background:
W+jets, top

Energy fraction in
EM calorimeter

Energy fraction in
hadronic calorimeter

Number of tracks
associated with jet
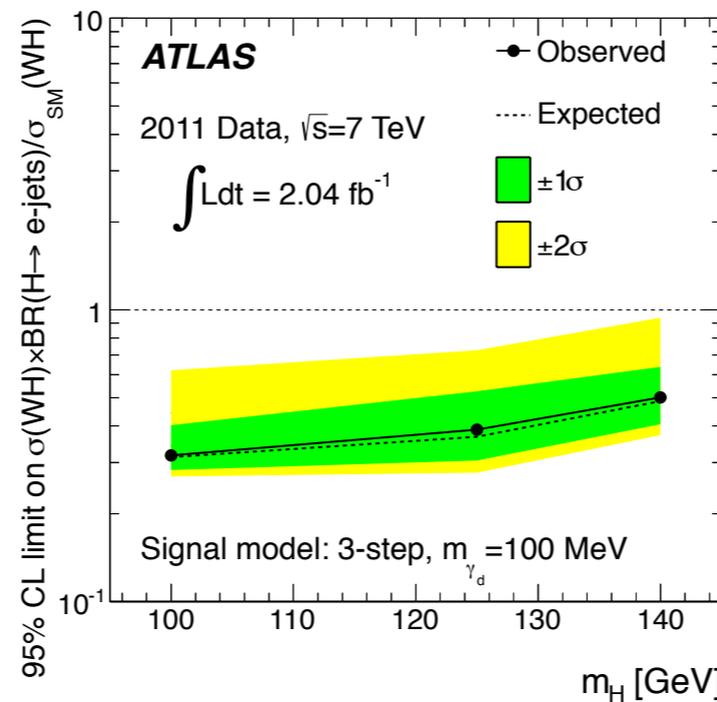
Higgs → electron jets at
branching ratio 24-45%
excluded for m_{Higgs} = 125
GeV @ 95% CL

http://arxiv.org/abs/1302.4403

Hidden Valley Prompt Lepton Jets

$\sqrt{s}$ = 7 TeV, 4.5 fb^{-1}

Dark photon decay to muon or electron jets

Muon jets: ≥ 2 lepton-jets of ≥ 2μ's or ≥ 1 lepton jet of ≥ 4μ's

Electron jets: ≥ 2 lepton-jets, cannot resolve individual electrons in calorimeter

Main background: multi-jet production

Electron-jet selection

Muon-jet selection

$R_{\eta 2}$ = electron cluster energy concentration
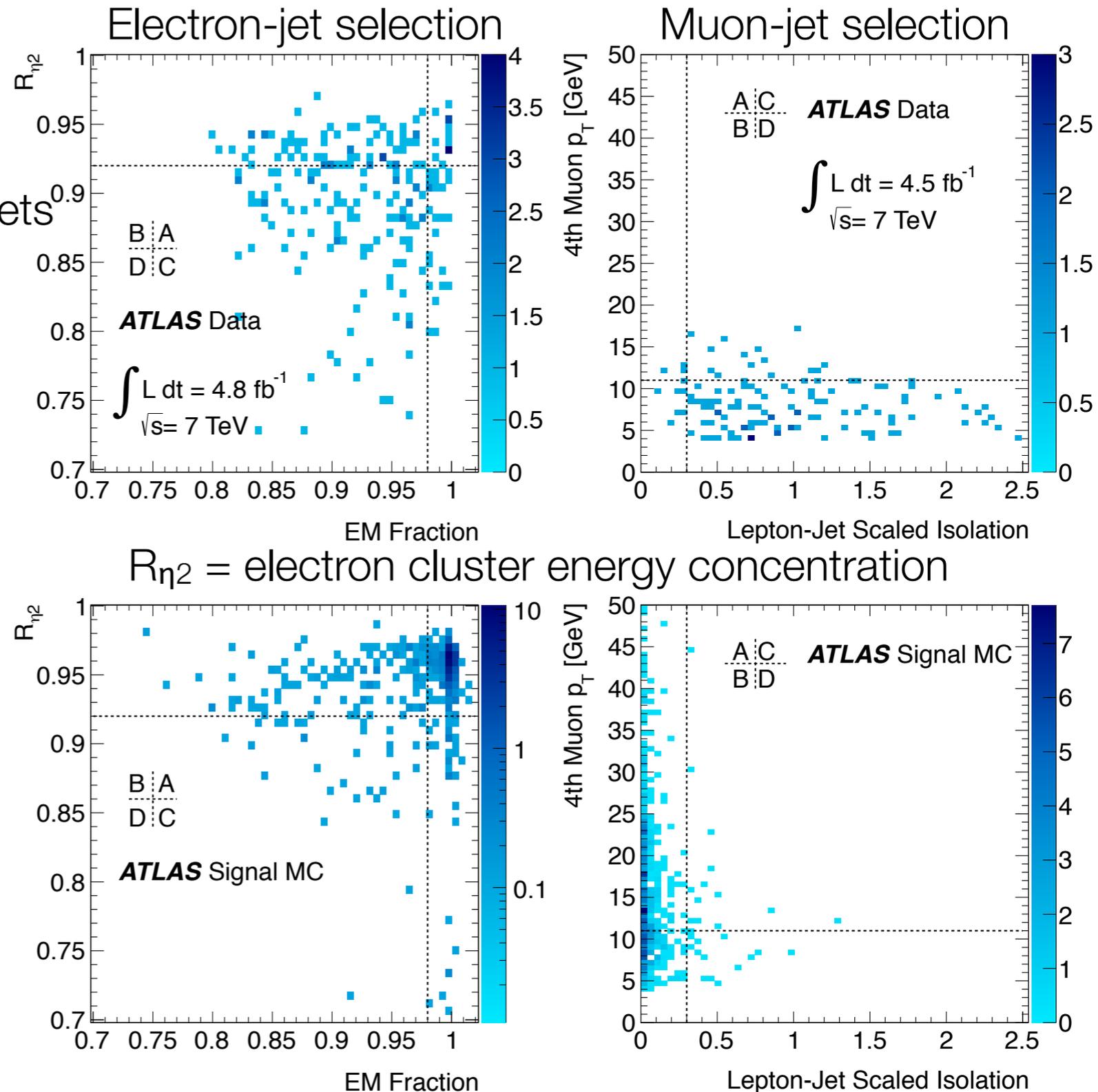
Hidden Valley Prompt Lepton Jets

Signal parameters		Electron LJ Obs. (Exp.) pb	1 muon LJ Obs. (Exp.) pb	2 muon LJ Obs. (Exp.) pb
α_d	m_{γ_D} [MeV]			
0.0	150	0.082 (0.082)	–	–
0.0	300	0.11 (0.11)	0.060 (0.035)	0.017 (0.011)
0.0	500	0.20 (0.21)	0.15 (0.090)	0.019 (0.012)
0.10	150	0.096 (0.10)	–	–
0.10	300	0.37 (0.37)	0.064 (0.036)	0.018 (0.011)
0.10	500	0.39 (0.39)	0.053 (0.035)	0.018 (0.011)
0.30	150	0.11 (0.11)	–	–
0.30	300	0.40 (0.40)	0.099 (0.055)	0.020 (0.012)
0.30	500	1.2 (1.2)	0.066 (0.043)	0.022 (0.015)

Dark sector gauge coupling:
Determines amount dark
sector radiation

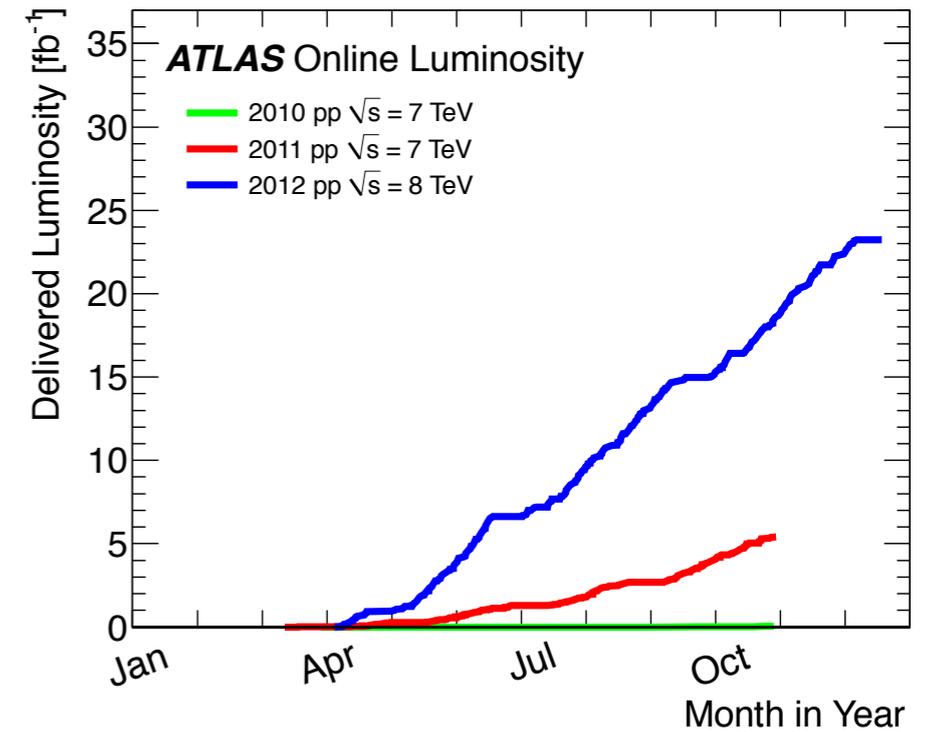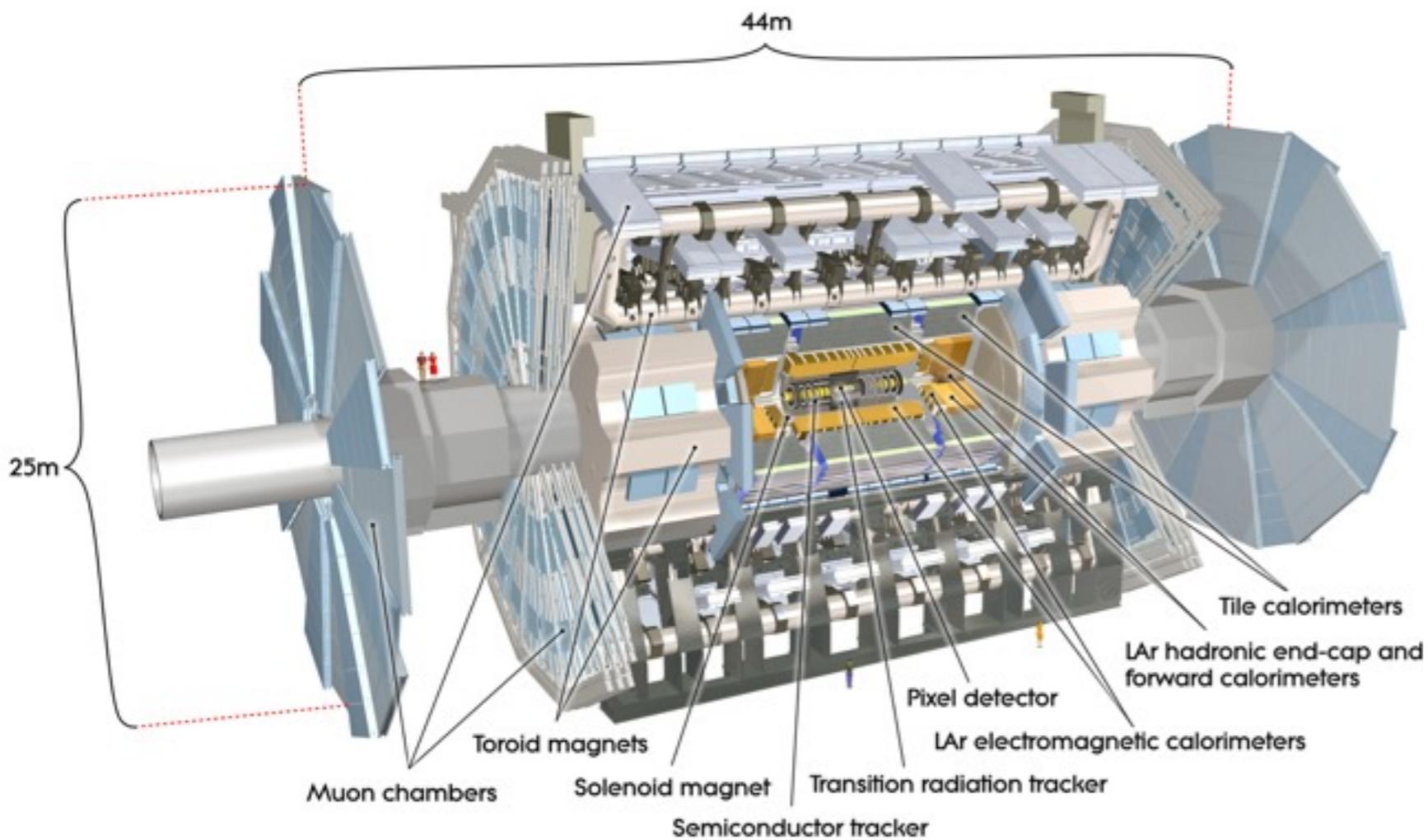Limits on cross section times branching ratio: 0.017-1.2 pb

Phys. Lett. B 719 (2013) 299-317

Conclusions

- Cross-section of new searches

  - Addressing a broad range of models and signatures

- No sign of new physics yet!

- Update of analyses to $\sqrt{s}$ = 8 TeV with full 20 fb^{-1} integrated luminosity is work in progress

Backup

ATLAS Detector

WY and ZY Production Measurement

- **Channels allow simultaneous tests of Standard Model predictions and searches for BSM physics**

- Test consistency with standard model W and Z self couplings

- Search for anomalous WWY, ZZY, and ZYY triple-gauge-boson couplings (aTGC)

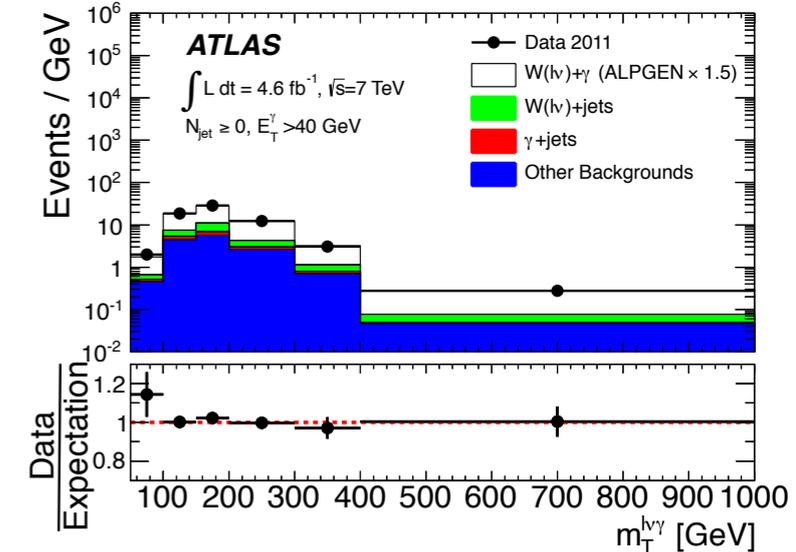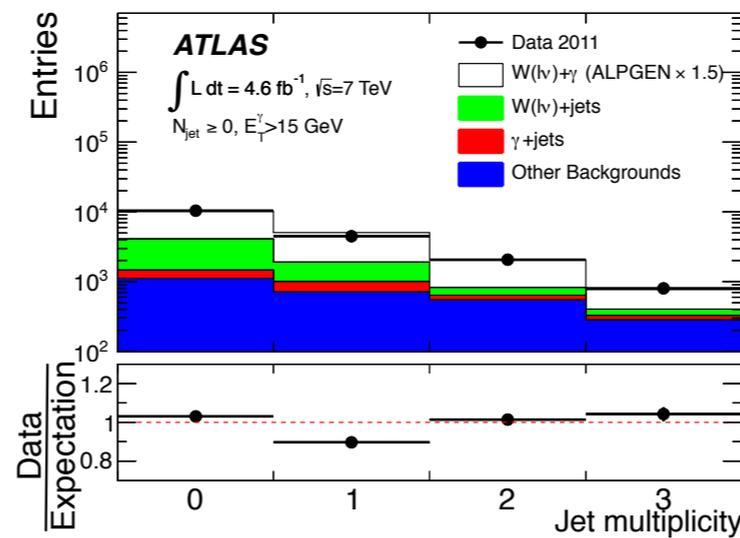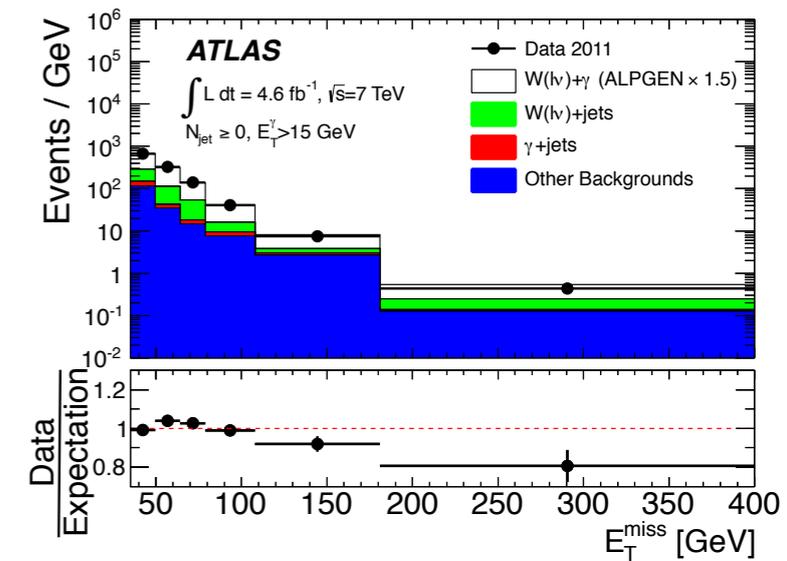- Search for technicolor vectors resonances in ZY, WY channels

(a)u-channel   (b)t-channel

(c)FSR   (d)s-channel

(e)fragmentation   (f)fragmentation
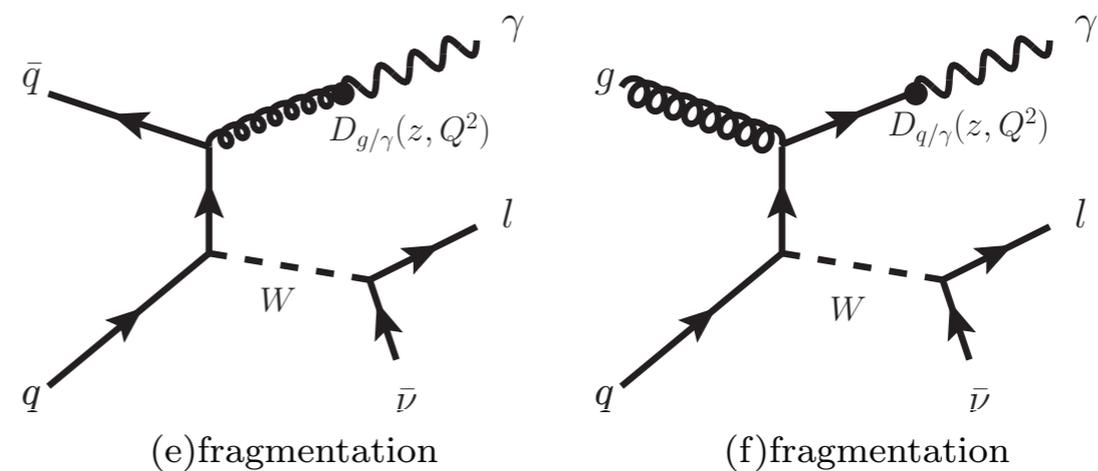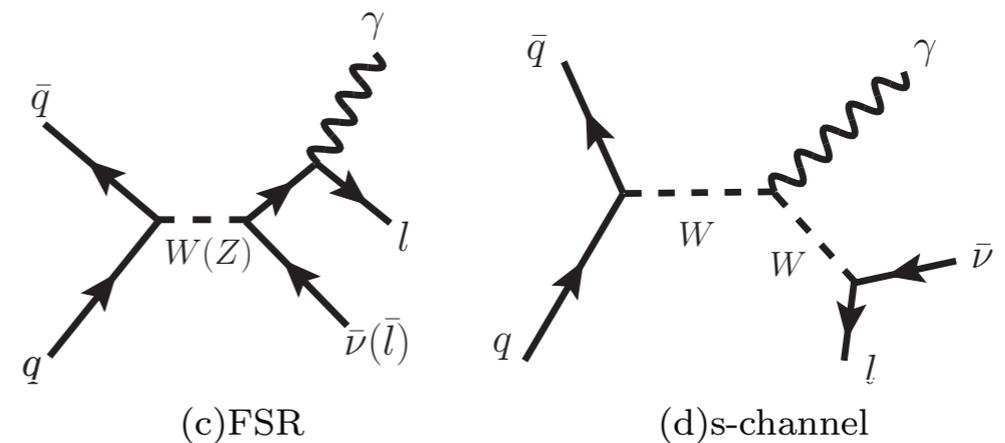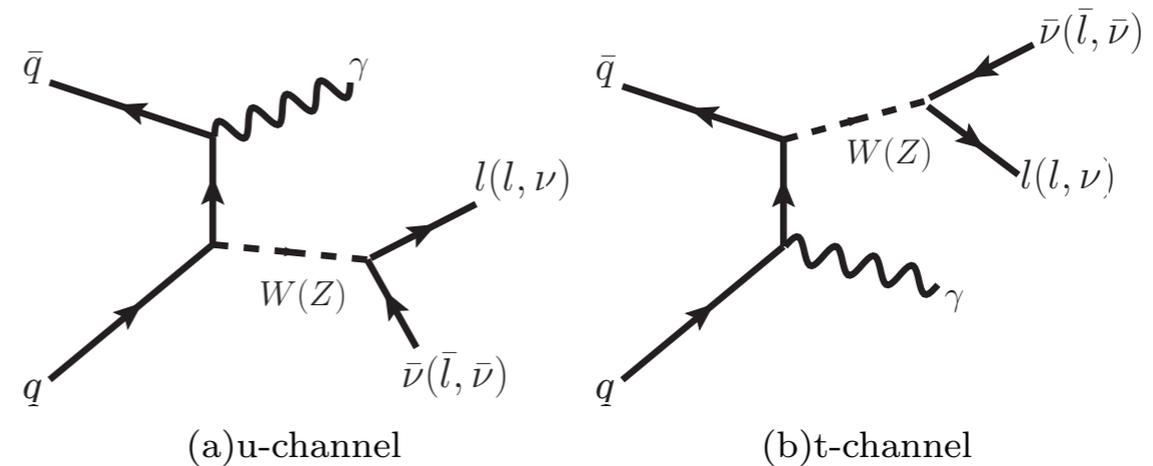
Wϒ and Zϒ Production Measurement

- Signal processes

  - pp → lνϒ + X

  - pp → l⁺l⁻ϒ + X

  - pp → νν_barϒ + X

- Backgrounds: Z(l⁺l⁻), Z(τ⁺τ⁻), W(τν), WW, tt_bar, single t, photon mis-identification as jet or election
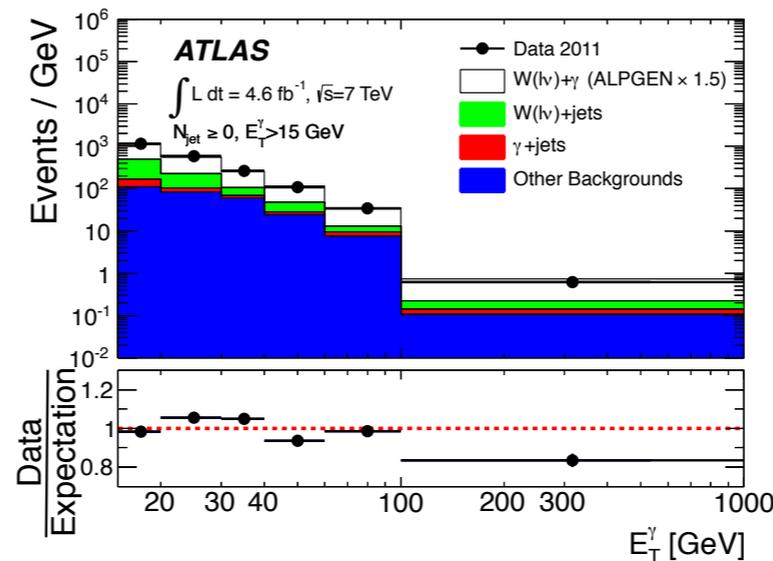
pp → l⁺l⁻ϒ + X : E^Υ_T, jet multiplicity, $m^{ll\Upsilon}$
pp → νν_barϒ + X : E^Υ_T, E^{miss}_T, jet multiplicity also show good agreement
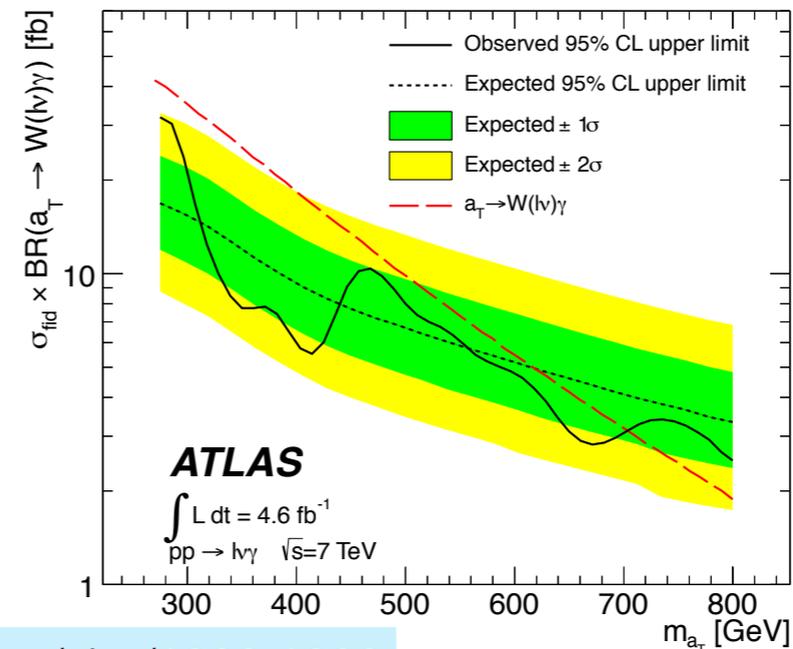
Wϒ and Zϒ Cross Section and aTG Coupling
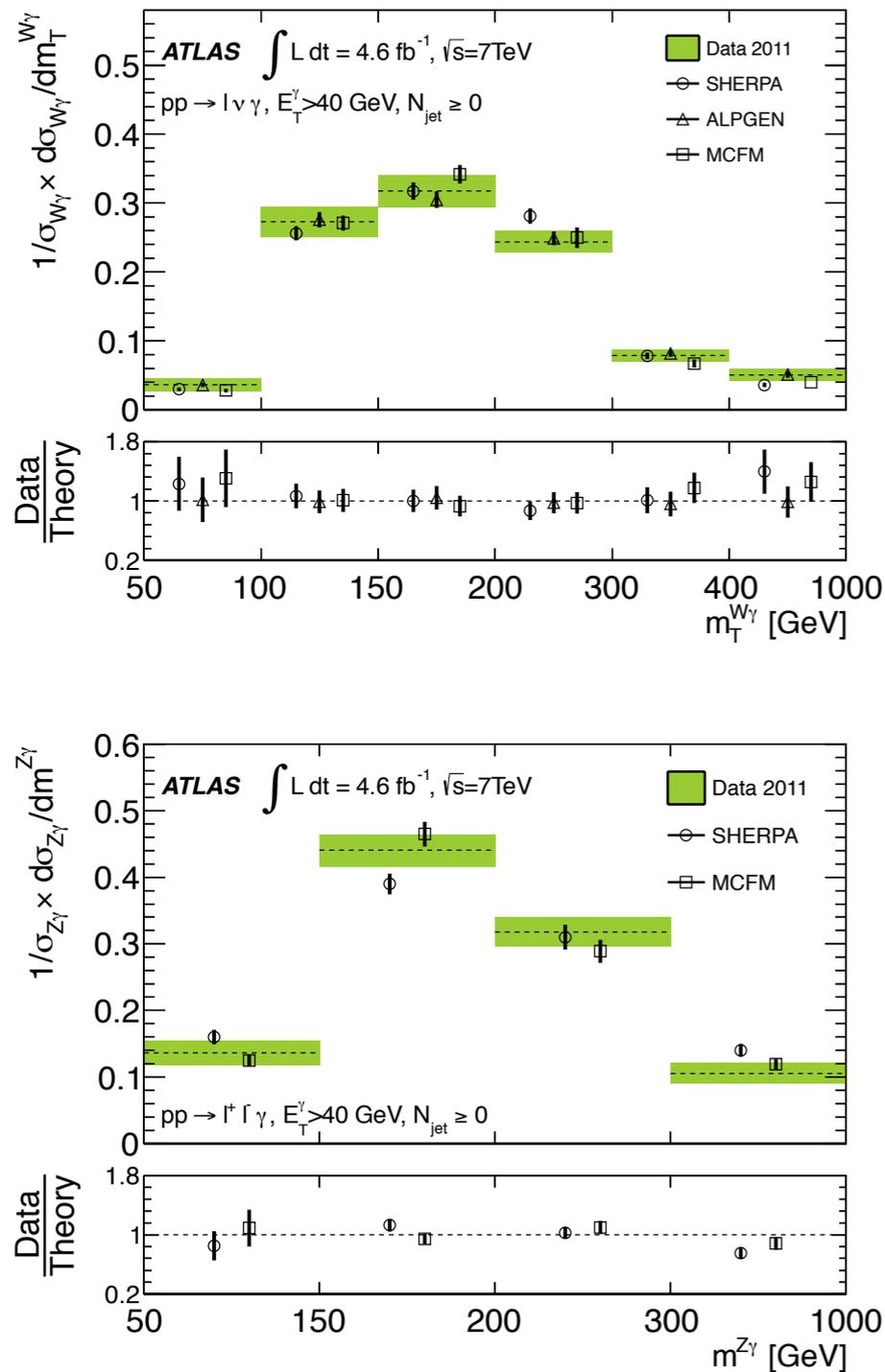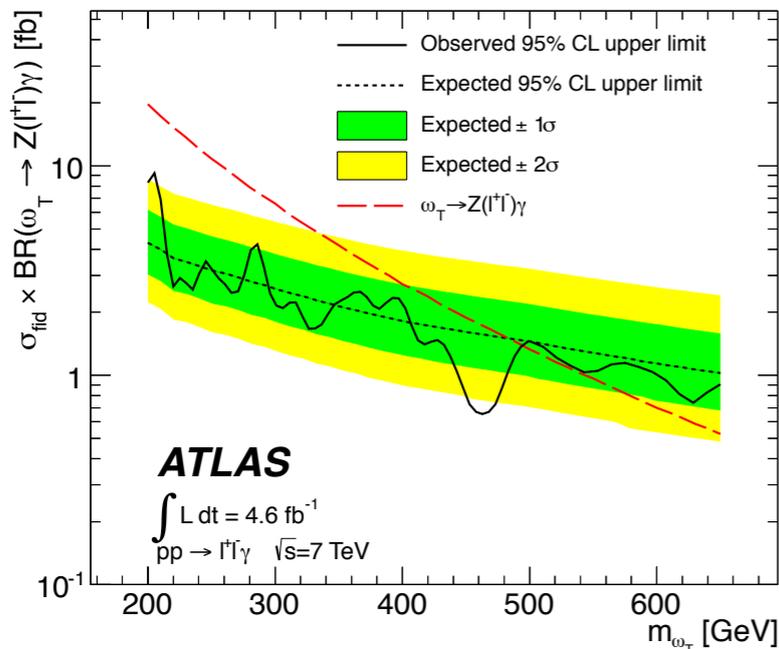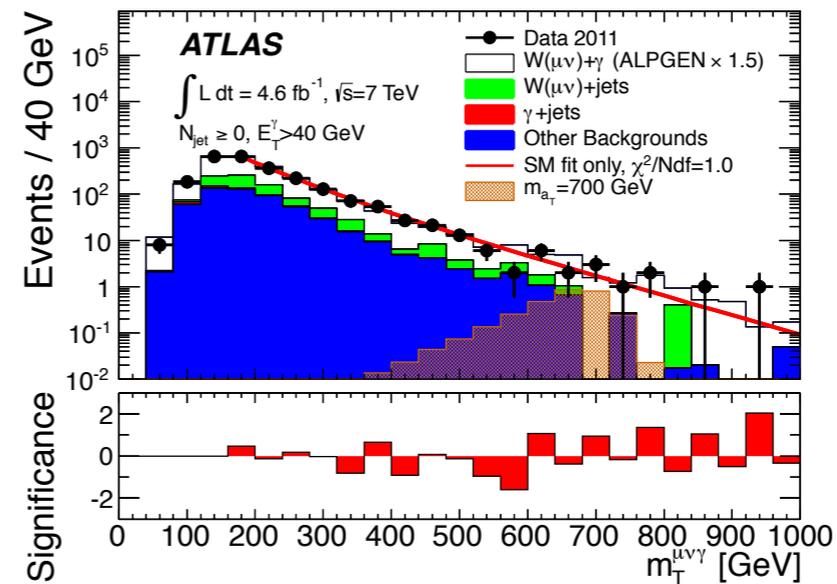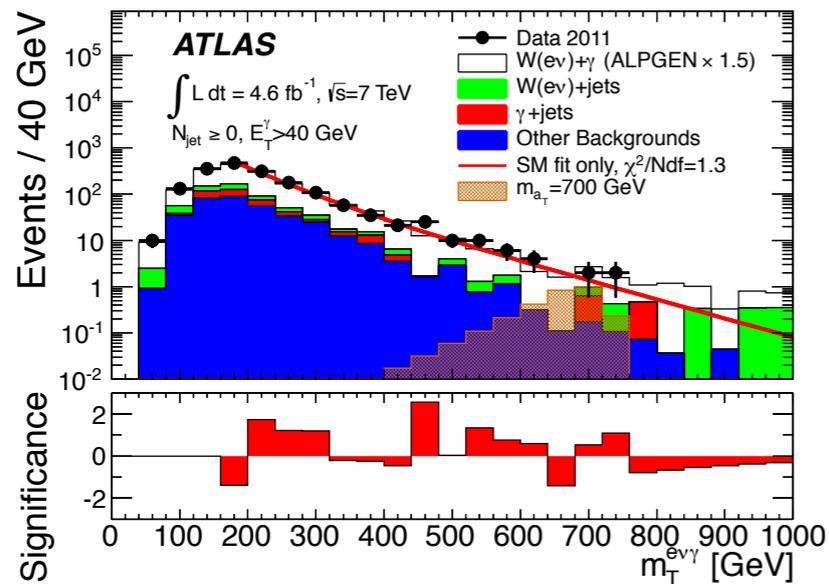

Good agreement between data and generator predictions for differential cross section as a function of jet multiplicity (for different E^{Υ}_T thresholds) and E^{Υ}_T (inclusive & exclusive)
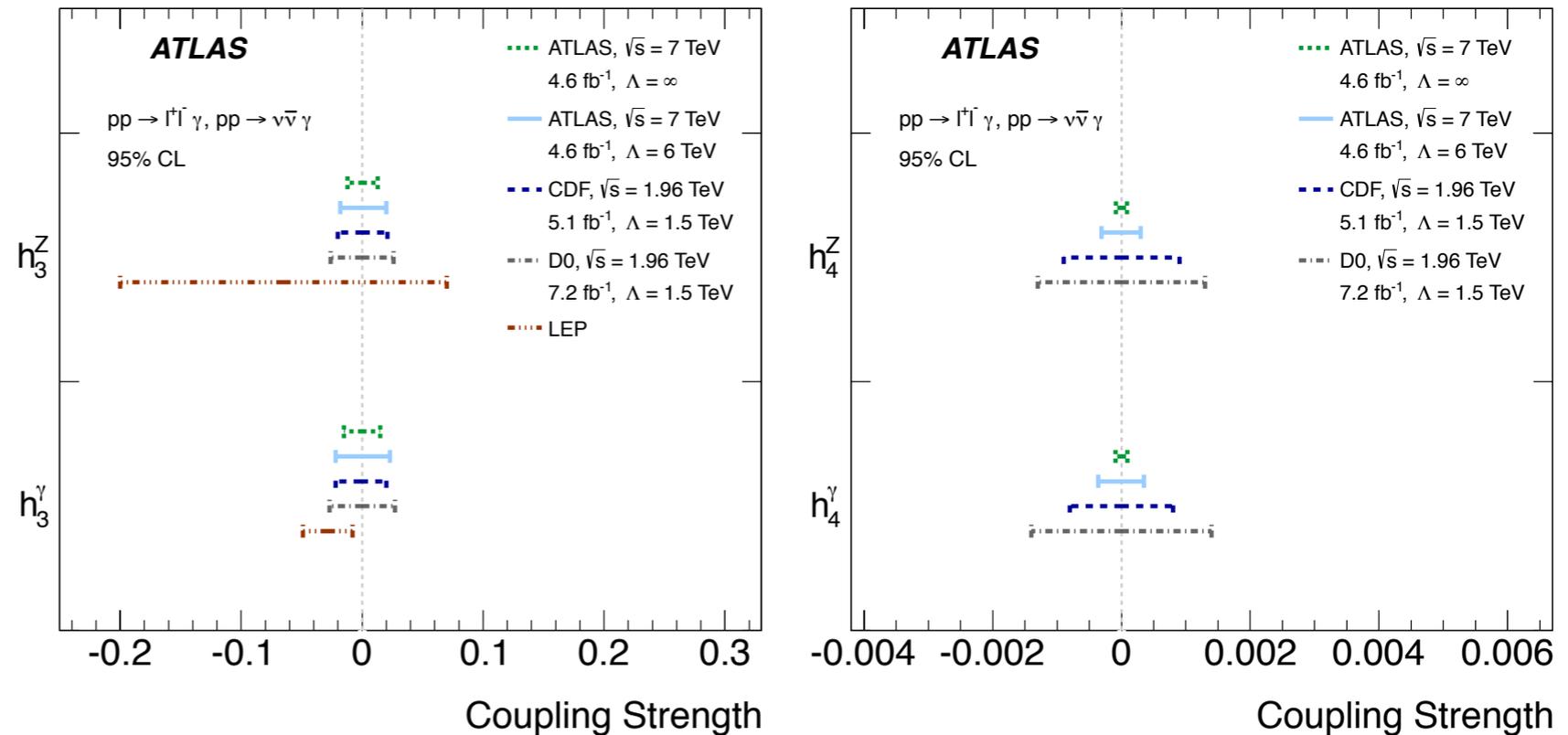
aTG couplings consistent with zero and other measurements in pp → lνϒ + X

WΥ and ZΥ Resonance Search

Fit 3-body transverse mass for (lνΥ) final state, 3-body invariant mass for (llΥ) final state
Crystal Ball function for signal, double exponential for SM background
Fit is consistent with background-only hypothesis in both channels