Search for resonant diboson production with the ATLAS detector

Peter Loscutoff, UC Berkeley/LBNL

On Behalf of the ATLAS Collaboration

at

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Marseille, France

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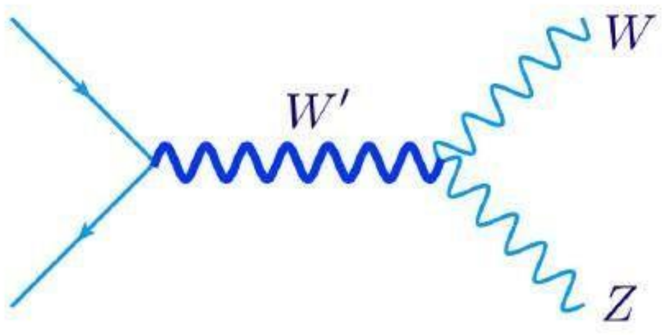
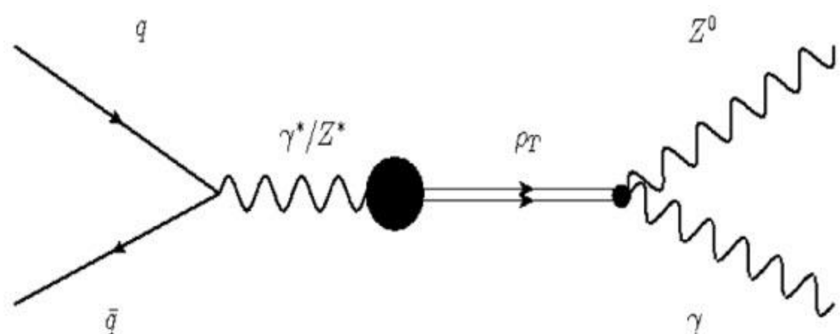
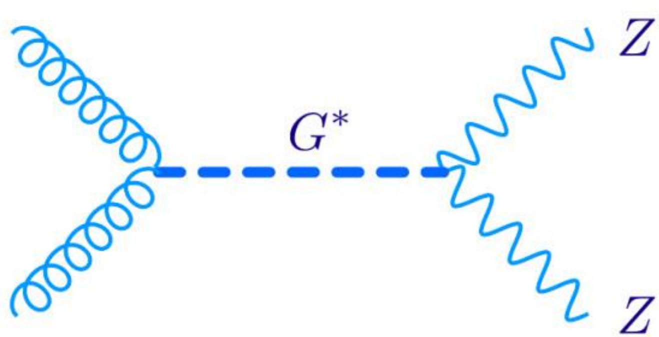
Motivation







Diboson production is a key test of electroweak symmetry breaking

A diboson resonance could be produced by a wide range of BSM theories

- **EGM/SSM V'**: Which provides a reasonable model independent template for many other theories
- **Technicolor: ρ_T, a_T, ω_T:** Some Technicolor models, eg: MWTC are consistent with the Higgs observation and would preferentially decay to dibosons
- **Extra Dimensions: RS Graviton:** Some extra dimensional models of gravity predict heavy resonances decaying to vector bosons.

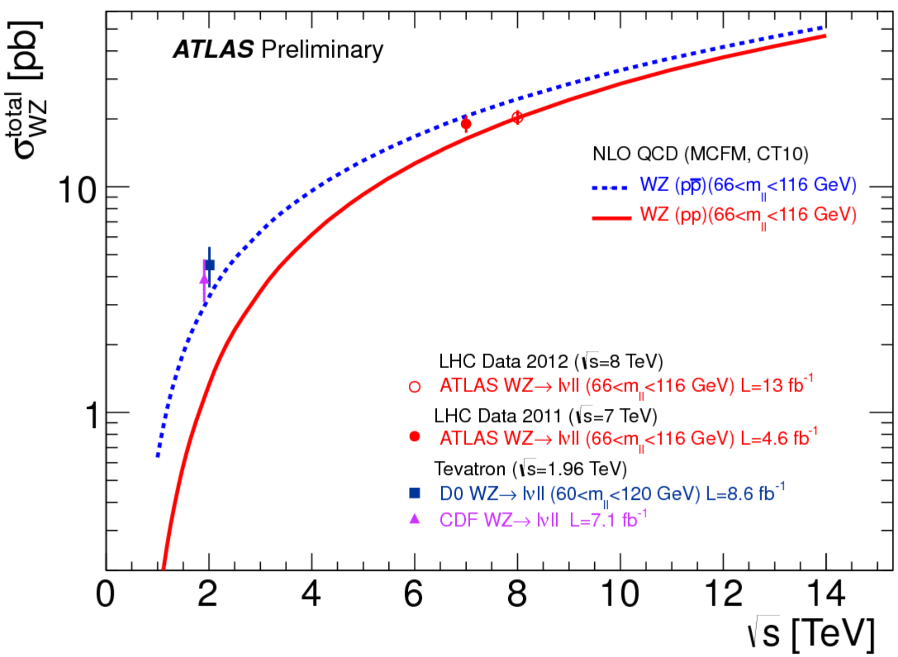
Summary of Diboson Resonance Analyses

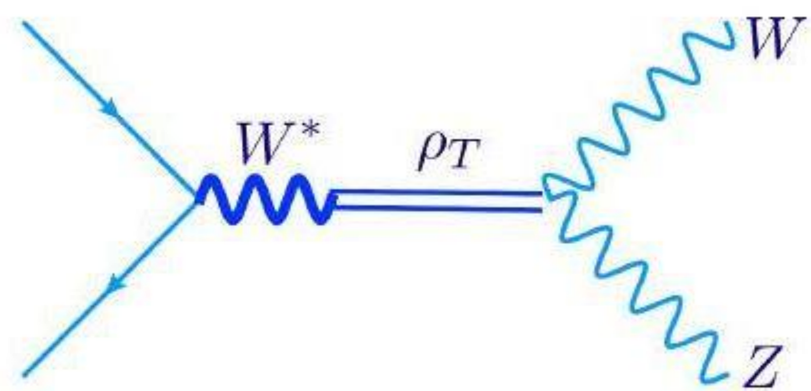
Final State	Channel	Dataset Used	Expected Reach
lνll	**WZ**	**13fb^{-1} at 8 TeV**	**W' ~ 1300 GeV**
lljj	**WZ, ZZ**	**7.2fb^{-1} at 8 TeV**	**bulk G* ~ 870 GeV**
llγ, lνγ	**Zγ, Wγ**	**4.6fb^{-1} at 7 TeV**	**a_T ~ 620 GeV**
lνlν	WW	4.6fb^{-1} at 7 TeV	bulk G* ~740 GeV
lνjj	WZ,WW	1fb^{-1} at 7 TeV	-
llll	ZZ	1fb^{-1} at 7 TeV	G* ~ 860 GeV

- Neutral channels (WW,ZZ), have significant overlap in interest with Higgs analyses.
- I will focus mainly on the results using the 8 TeV dataset, **ZZ→lljj** and **WZ → lνll**
- Also, one new 7 TeV result, **Zγ →llγ, Wγ →lνg**

WZ → lνll

Introduction





- We have an excellent understanding of Standard Model WZ production.
- High mass region can still be sensitive to new physics.
- Three leptons in final selection gives a very clean channel
- As a baseline model, consider EGM W', which provides a good parameterization of any narrow resonance.
- MWTC can also provide resonant production of $\rho_T \rightarrow WZ$
- The use of missing energy makes the WZ mass resolution large compared to the natural width of these signals.

$WZ \rightarrow l\nu ll$

Selection

- Exactly 3, e or μ with p_T > 25 GeV
- E_T^{miss} > 25 GeV
- $|m(ll) - m(Z)| < 20$ GeV
- $m_T(W) < 100$ GeV

- Recover the W p_Z by assuming the W boson is on-shell*
- Separate the signal from the Standard Model control region by requiring back-to-back vector bosons: $\Delta\phi > 2.6$ and $\Delta y < 1.8$

Z+Jets Control Region:

$m_T(W) < 25$ GeV

$E_T^{miss} < 25$ GeV

No angular requirements

Signal Region:

$m_T(W) < 100$ GeV

$E_T^{miss} > 25$ GeV

$\Delta\phi > 2.6$ and $\Delta y < 1.8$

WZ Control Region:

$m_T(W) < 100$ GeV

$E_T^{miss} > 25$ GeV

$\Delta\phi < 2.6$ or $\Delta y > 1.8$

Backgrounds

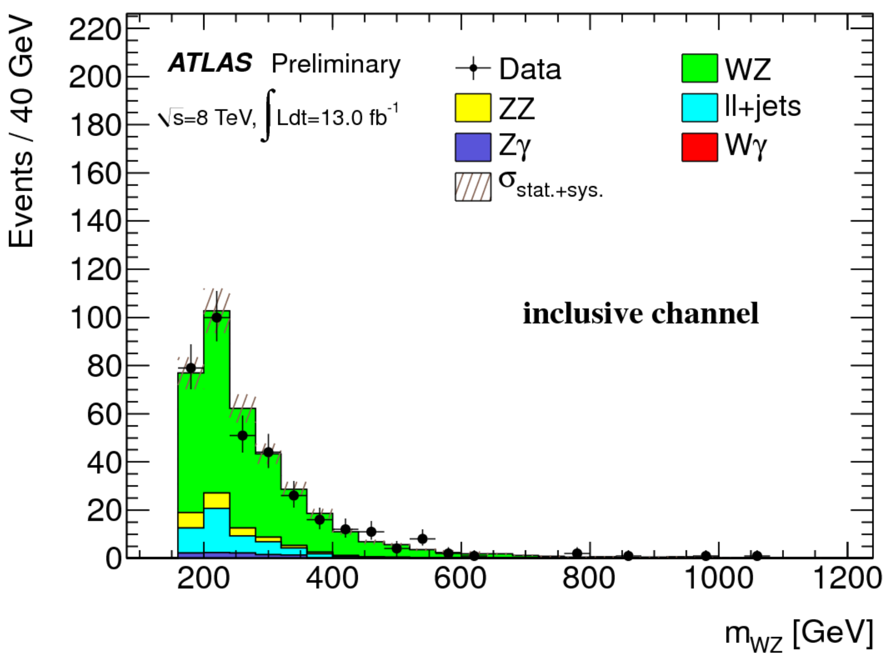
- Events with at least three prompt leptons: WZ, ZZ
- Photons passing lepton selection: $Z\gamma$
- Jets faking leptons: top, Z+jets
- A data driven method is used to measure the contribution of jets faking leptons.

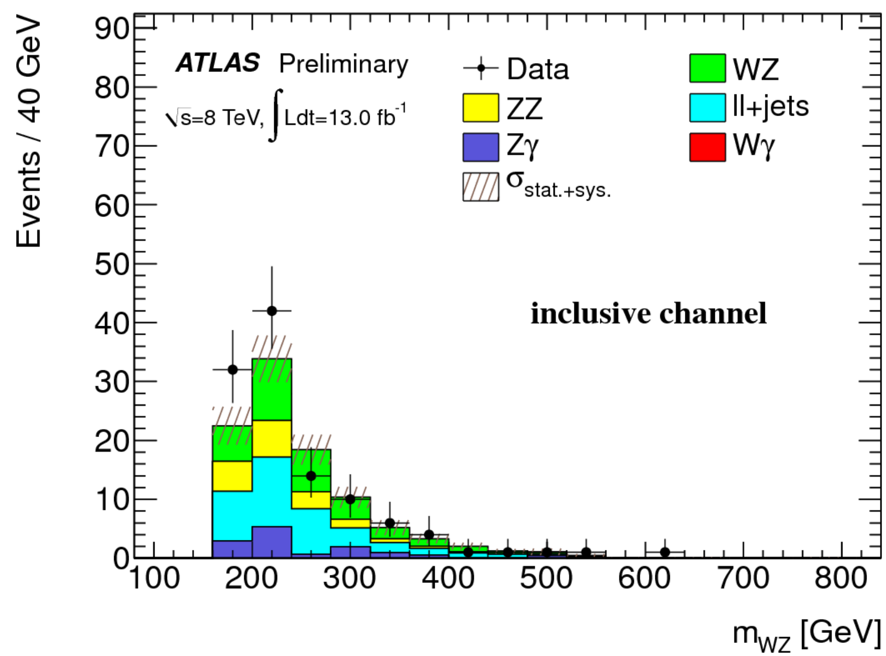
*This is actually a quadratic constraint, which gives two possible solutions for p_Z. The smaller solution is used.

WZ → lνll

Control Regions

- The Δϕ and Δy cuts provide a sample dominated by **Standard Model WZ** but insensitive to any resonance signal.
- Low E_T^{miss} and $m_T(W)$ provide a sample with a significant contribution from **Z+jets** with a fake third lepton





WZ → lνll

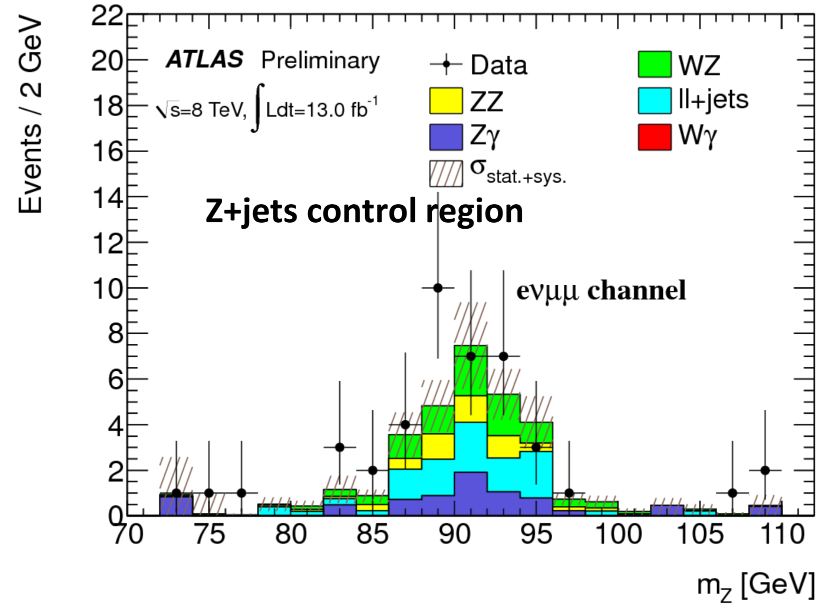
Fakes

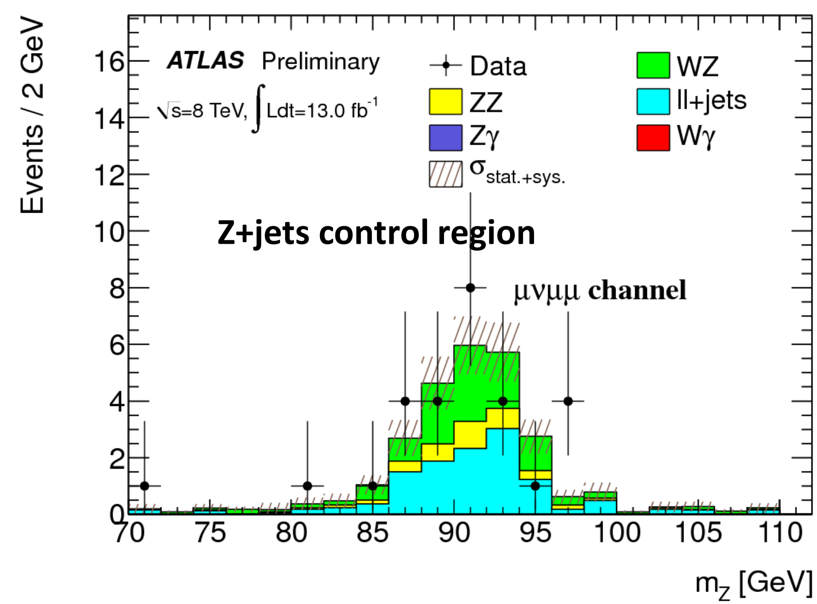
- Derive a fake factor in a region dominated by fake leptons

$$f = \frac{N^{\mathrm{control}}_{\mathrm{analysis}}}{N^{\mathrm{control}}_{\mathrm{loose}}}$$

- Estimate signal region contamination by scaling events with 2 good, 1 loose leptons by fake factor.

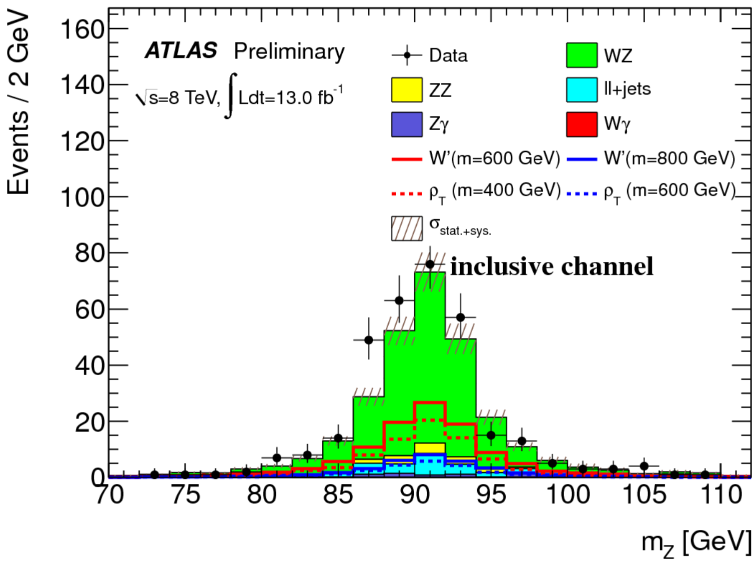
- Consistent results between a fake factor measured in Z+jets (statistically dominated) and dijets (systematically dominated)

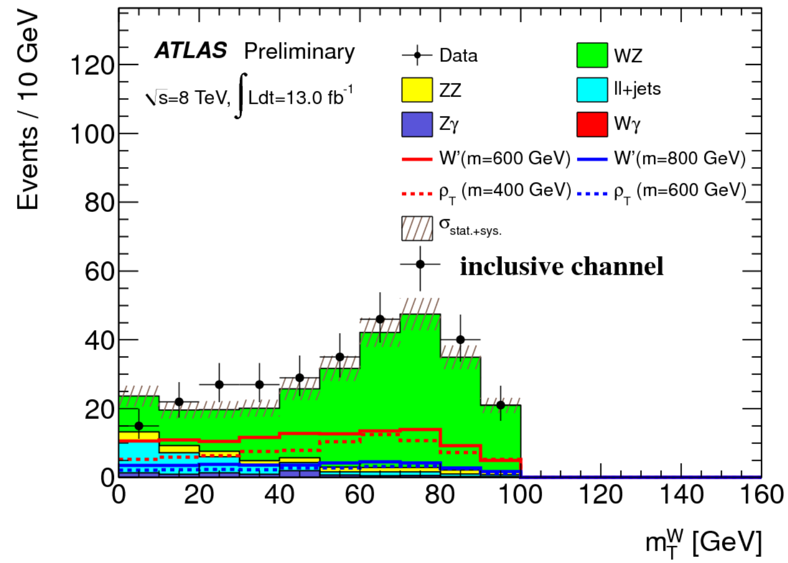


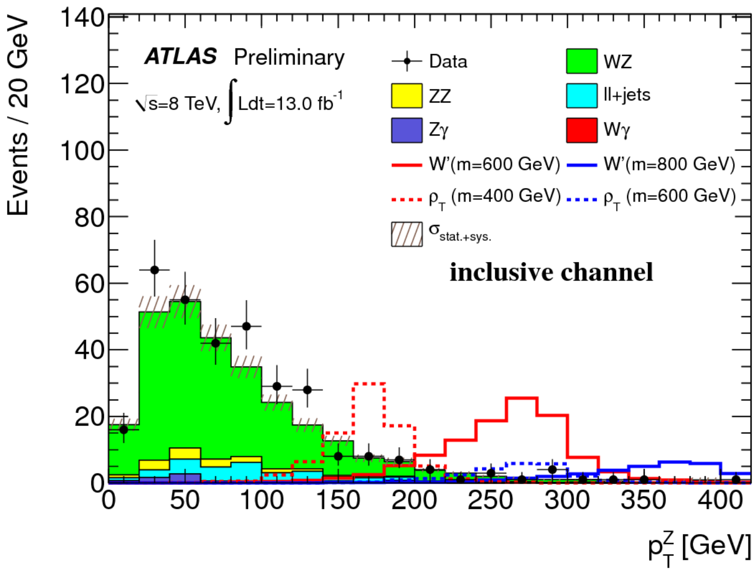


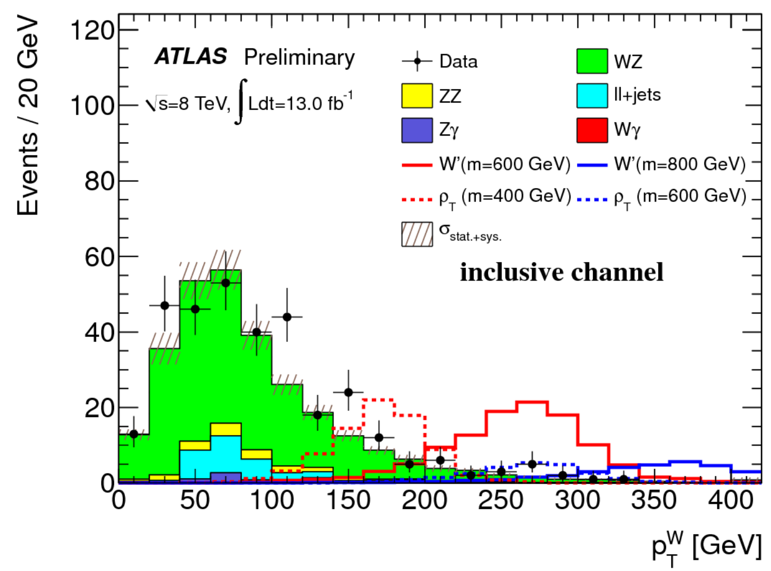
WZ → lνll

Signal Region Kinematics





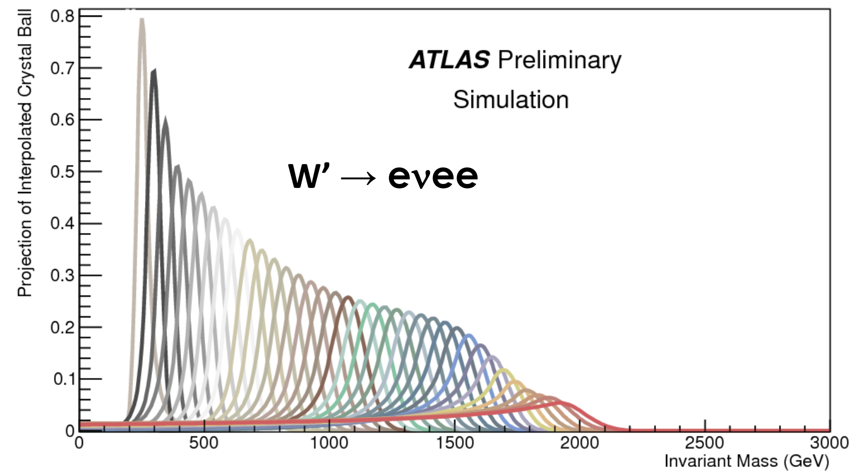


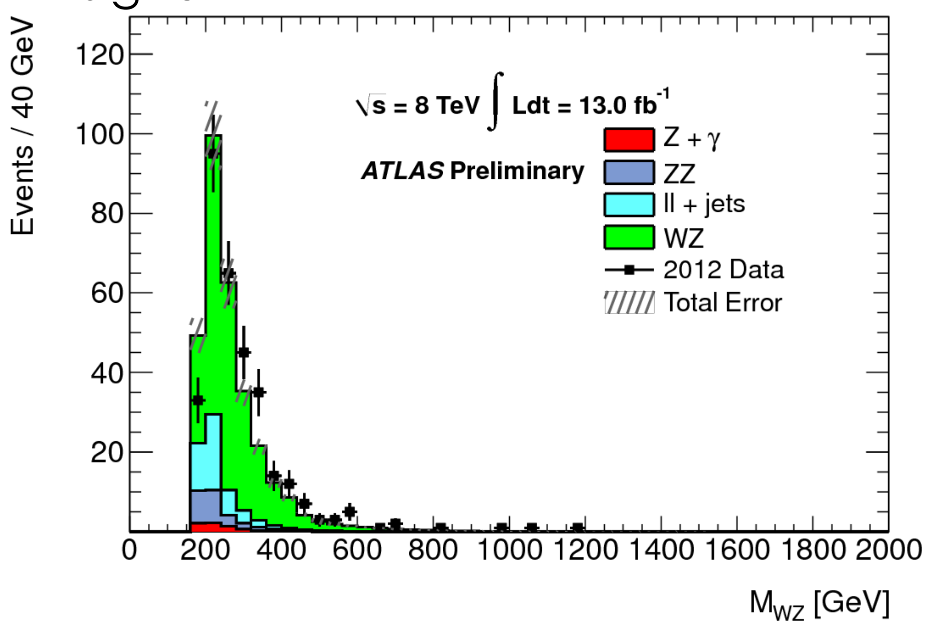


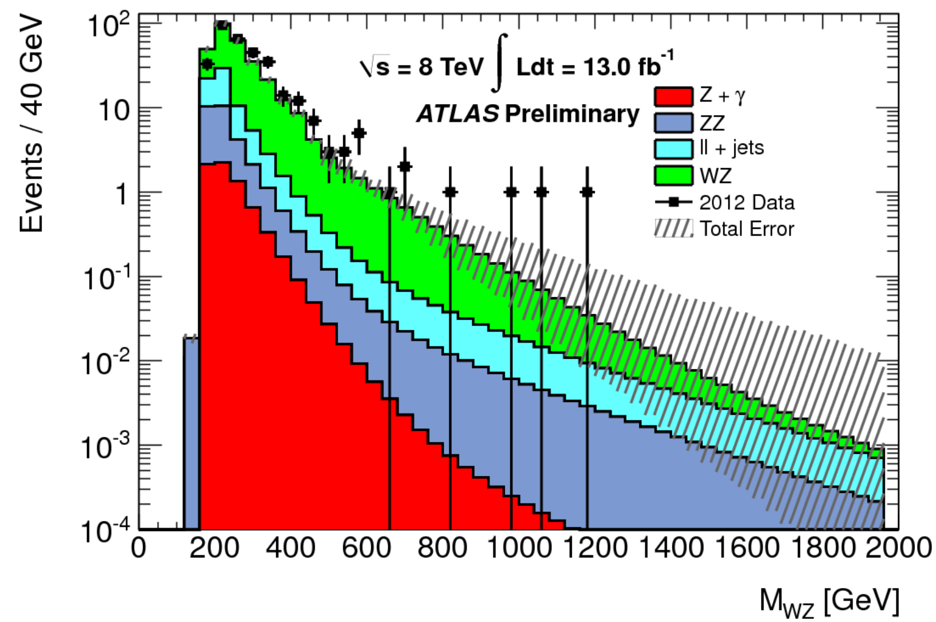
WZ → lνll

Limit Setting Preparation

- The WZ invariant mass is used to set limits
- To populate the tail of this distribution, a smooth curve is fit to the background distributions
- A dense distribution of potential signals is generated, so that any bump is well explained by some signal



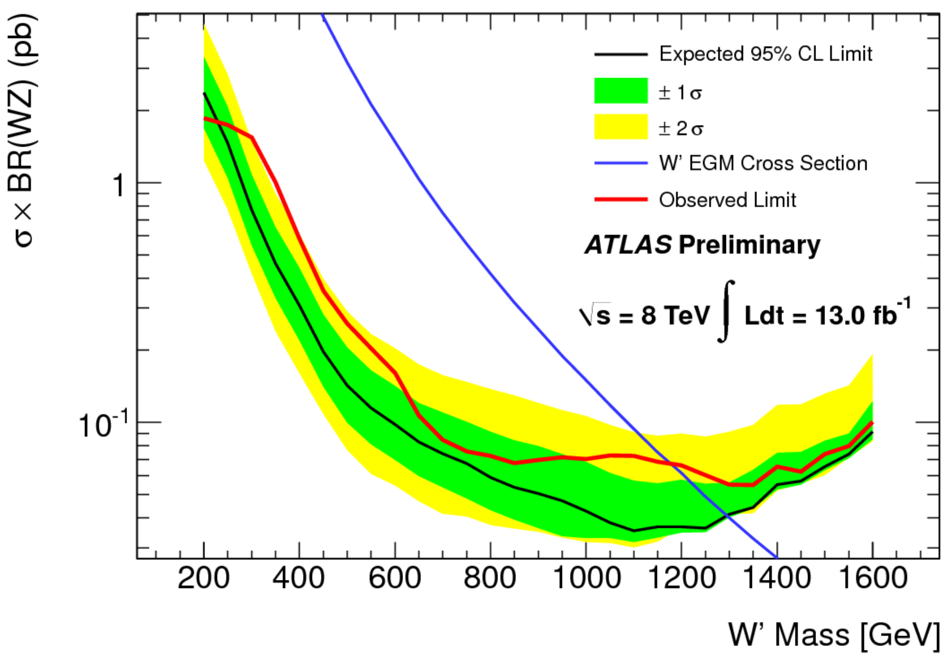


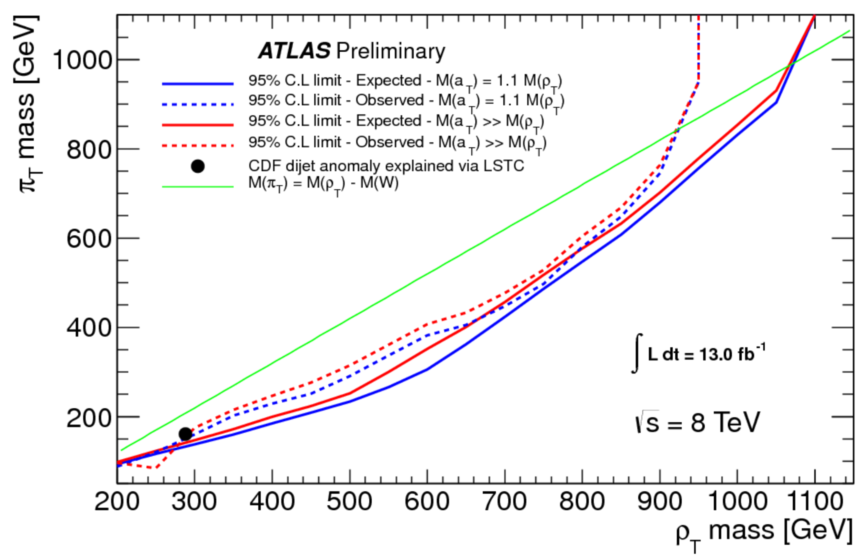


WZ → lνll

Limits

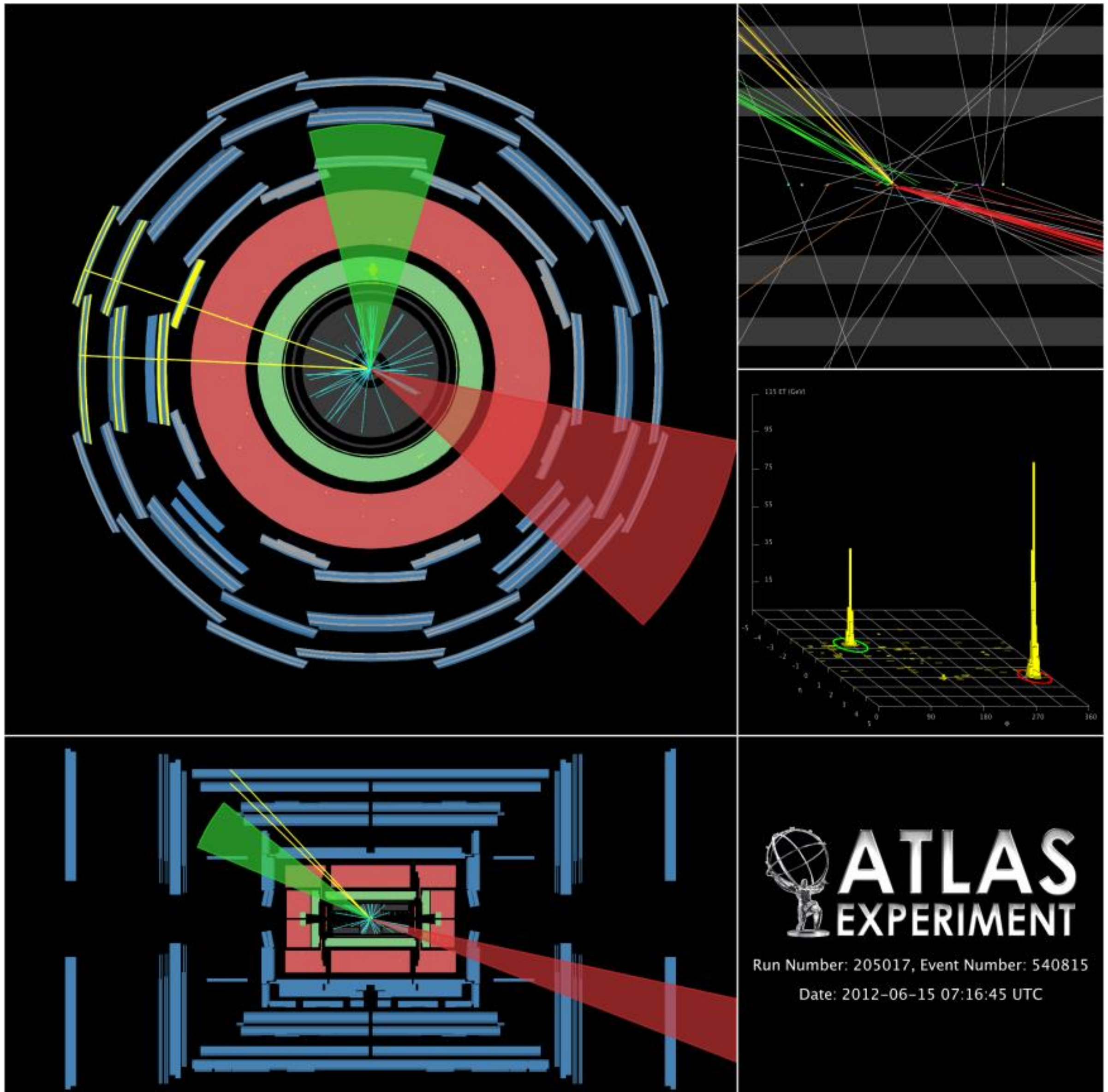
- No new physics is observed
- Set limits using m(WZ)
- Exclude an **EGM W' < 1180 GeV**
- Exclude a $\boldsymbol{\rho_T}$ **< 920 GeV** for $m(\rho_T) = m(\pi_T) + m(W)$
- Background extrapolation at high mass comes with large uncertainty



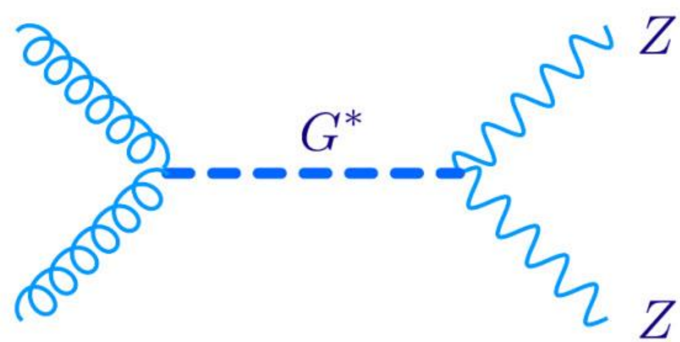


ZZ → lljj

Introduction



- G* -> ZZ is used here as a benchmark model
- Bulk RS-graviton has enhanced BR to Z (also, W, H, t)



$ZZ \rightarrow lljj$

Selection

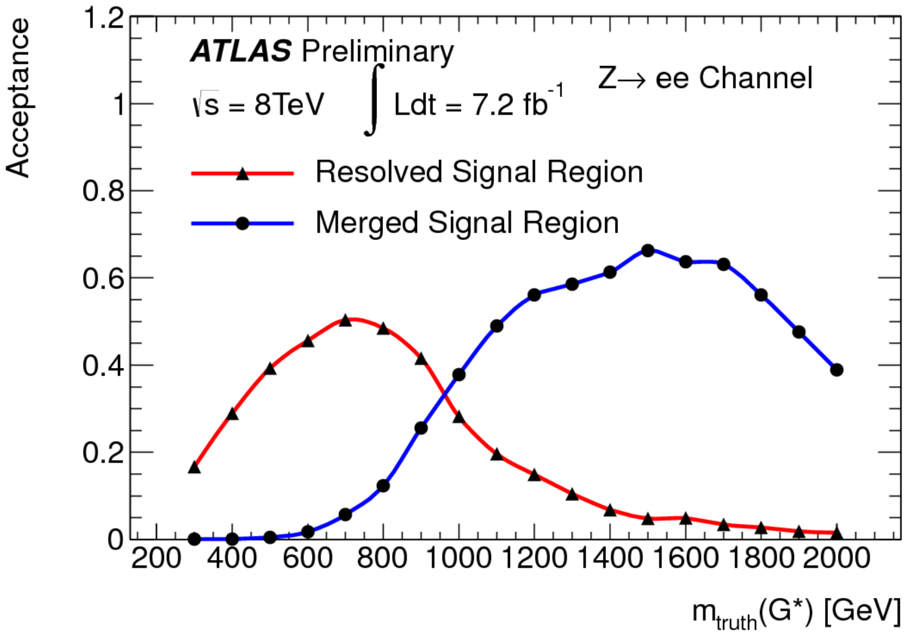
- Exactly 2, e or μ with $p_T > 25$ GeV
- $|m(ll) - m(Z)| < 25$ GeV
- anti-k_T jets with $R = 0.4$, $p_T > 30$ GeV

For low resonant masses, the $Z \rightarrow jj$ decay will result in two distinct jets. In this **resolved** region:

- $p_T(ll) > 50$ GeV
- $\Delta\phi(j,j) < 1.6$
- $m(jj)$ between 65 and 115 GeV

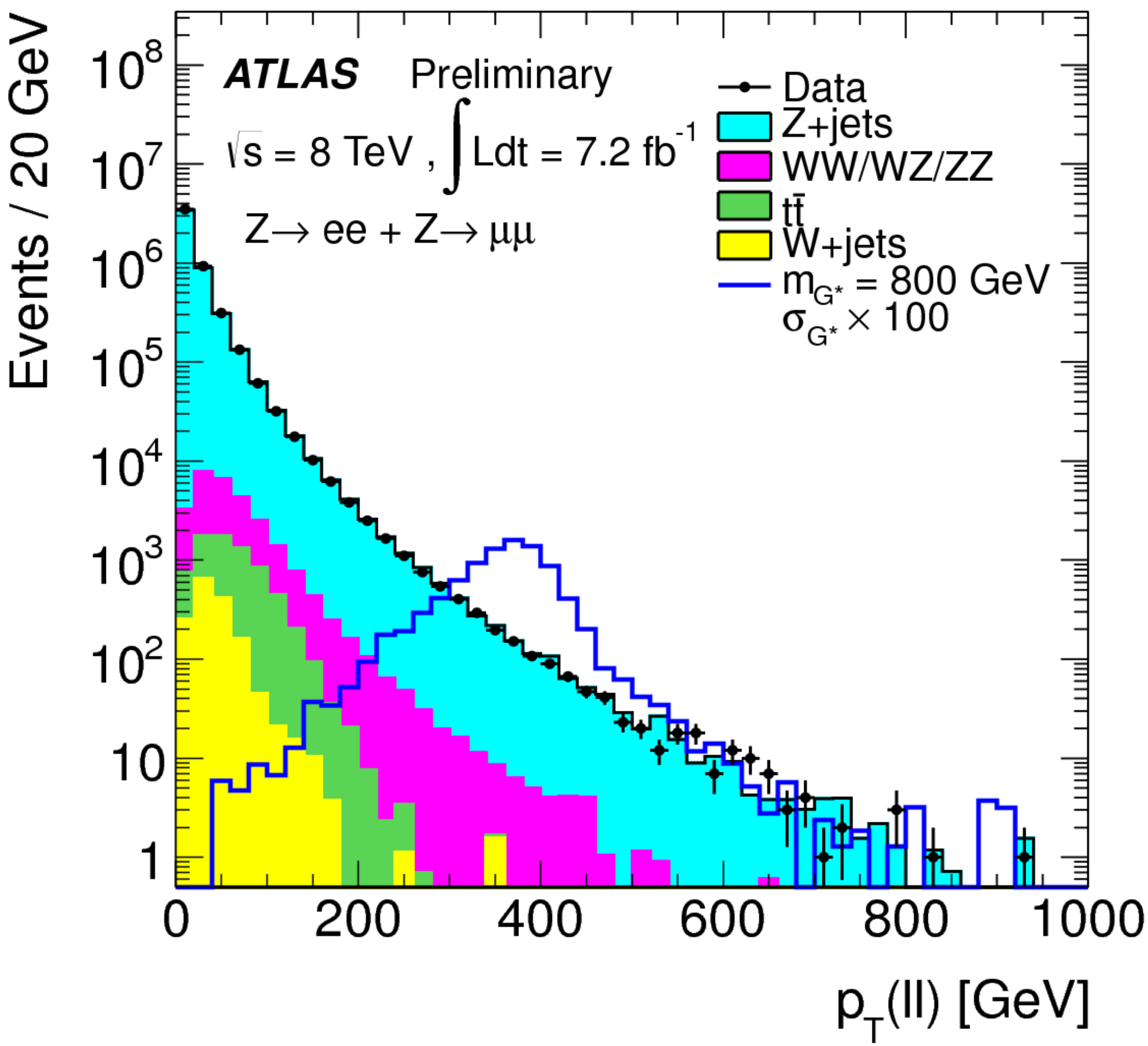
For high resonant masses, the $Z \rightarrow jj$ decay will merge into a single massive jet. In this **merged** region:

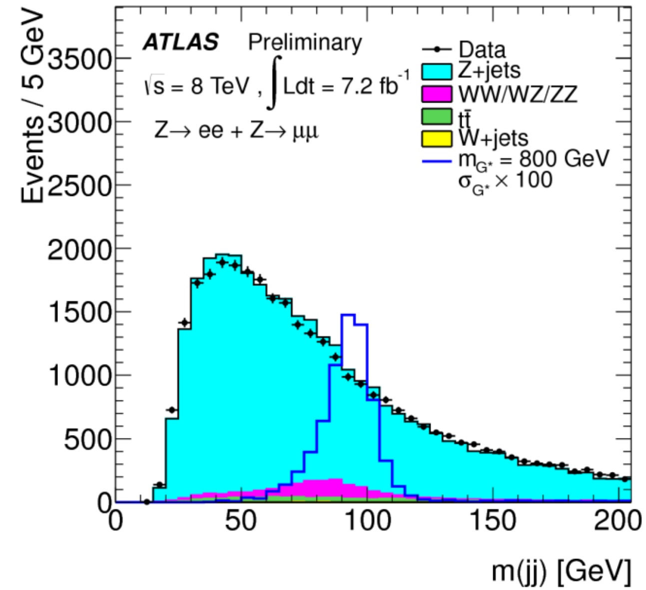
- $p_T(ll) > 200$ GeV
- $p_T(j) > 200$ GeV
- $m(j) > 40$ GeV

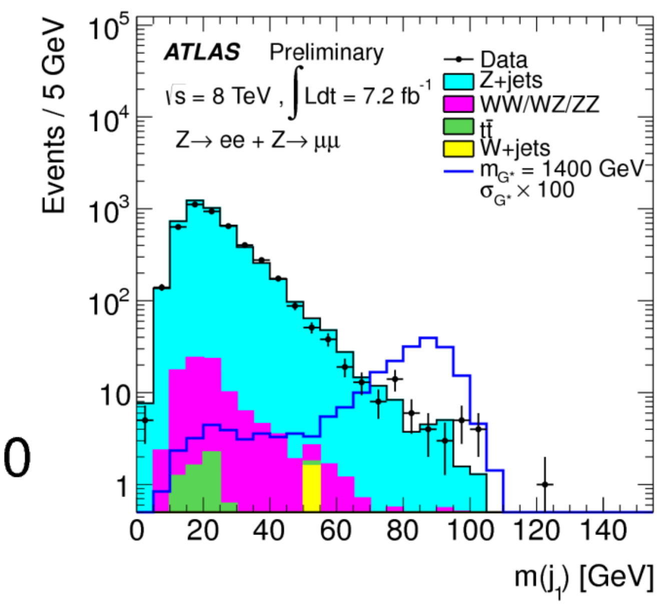


ZZ → lljj

Backgrounds

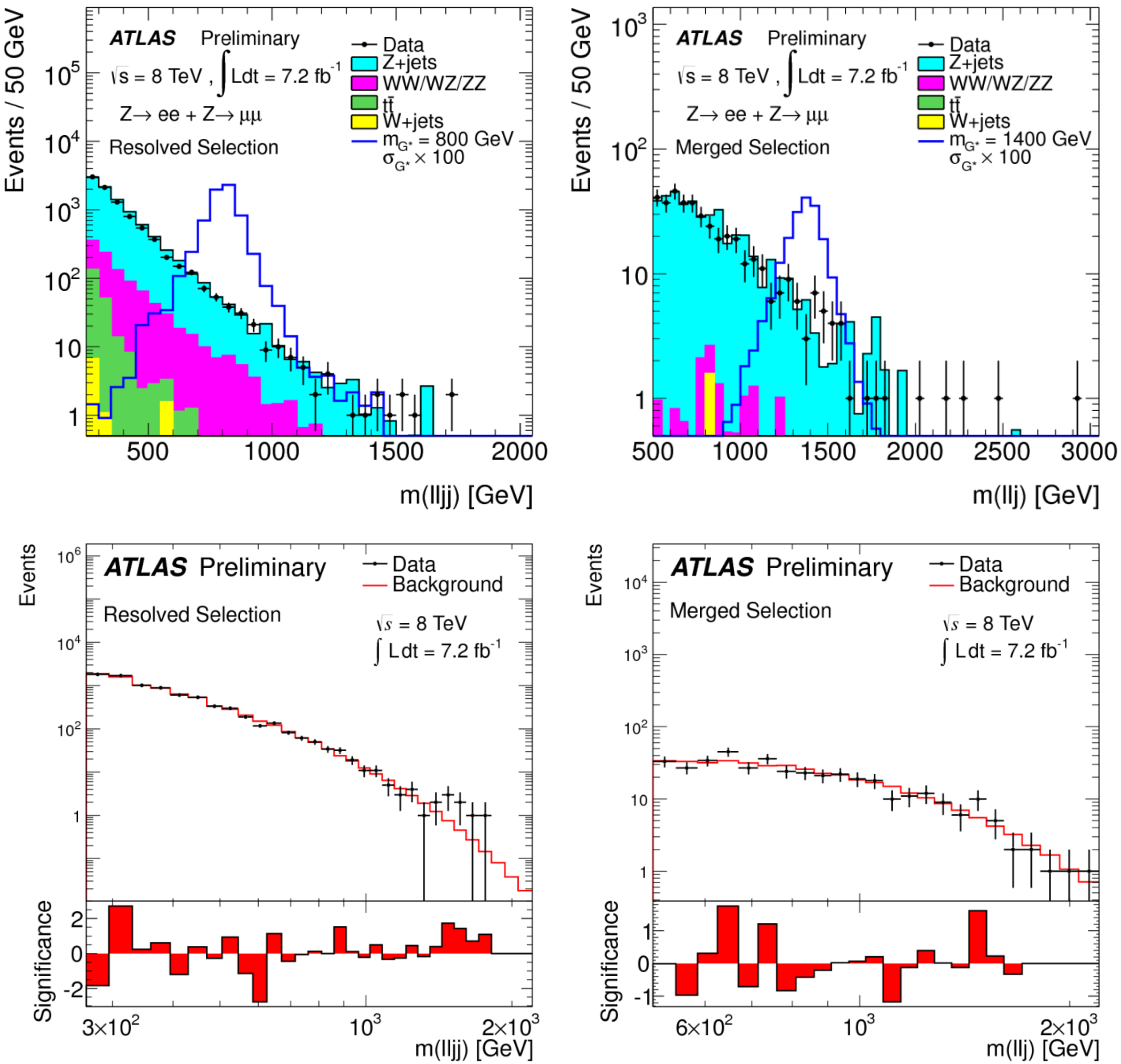






ZZ → lljj

Background Fit



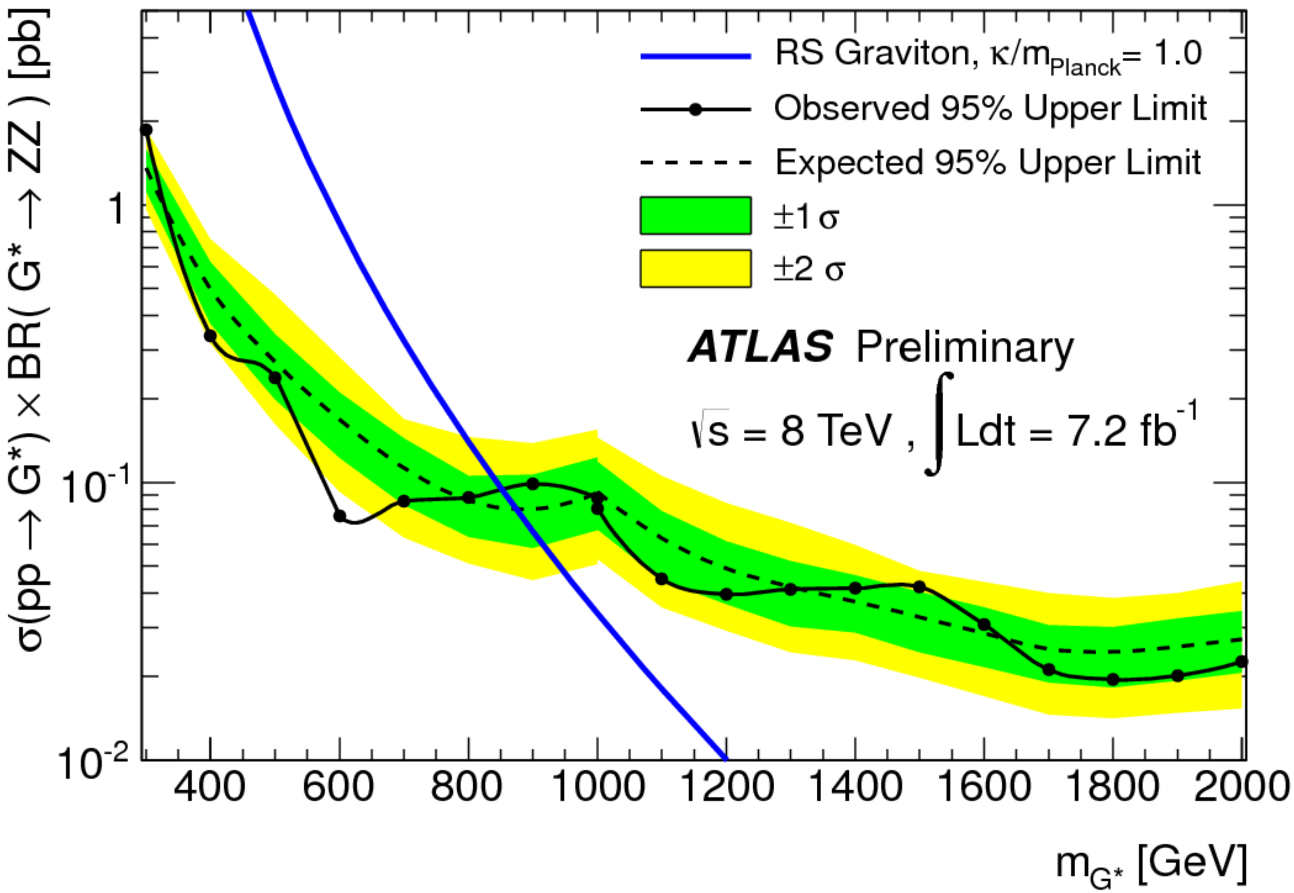
- Data driven background from smooth fit to m(llj), m(lljj)

$$f(m; p_{0,1,2,3}) = p_0 \cdot \frac{(1-x)^{p_1}}{x^{p_2 + p_3 \cdot \ln(x)}}$$

- Binning consistent with detector resolution
- Look for localized excess over this fit background

ZZ → lljj

Limits

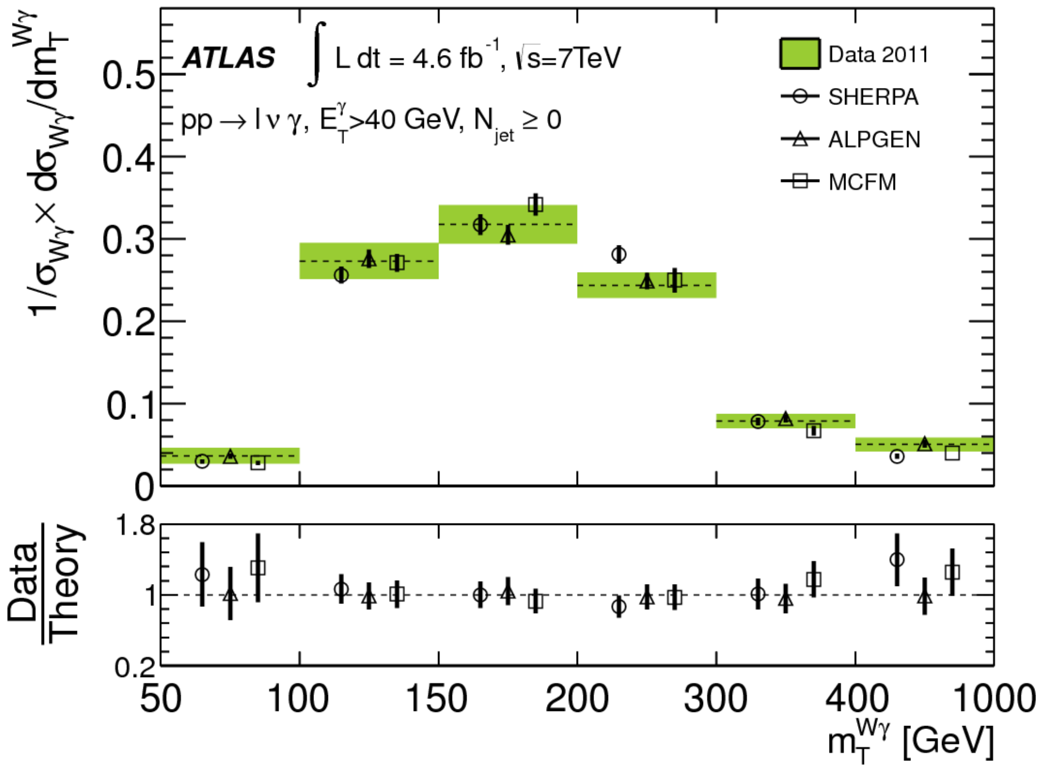


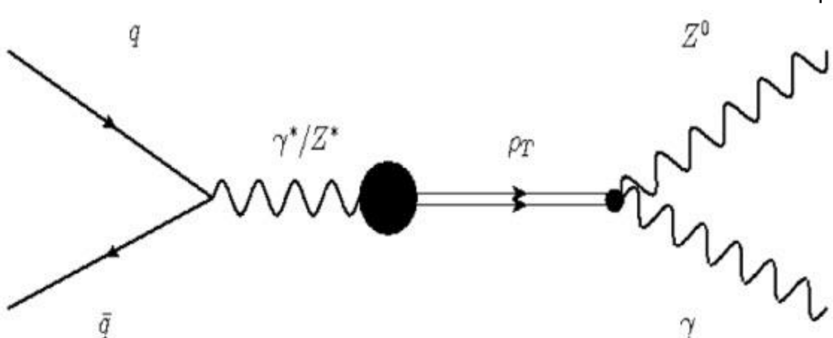
- The BumpHunter algorithm is used to look for a resonant signal on the fit background.
- No such bump is found
- Set limits using m(llj), m(lljj)

- For κ/m_{Planck} = 1.0, exclude $\mathbf{m_{G*} < 850}$ **GeV**
- Resolved region used for limits below 1000 GeV
- Merged region used for limits above 1000 GeV

Wγ, Zγ

Introduction

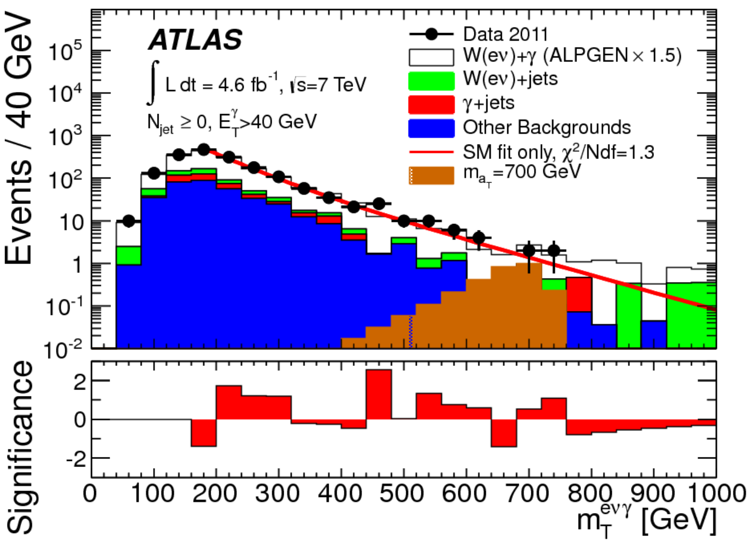


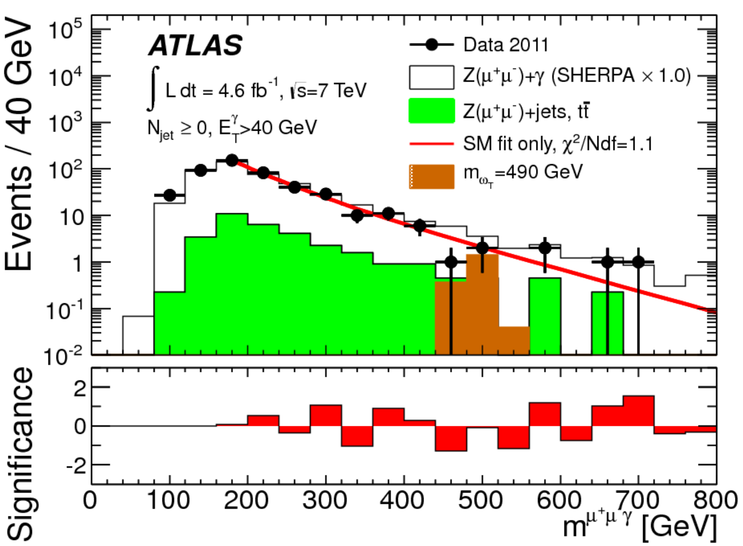


- The Standard Model integrated and differential cross sections are measured
- 7 TeV analysis
- Focus on resonant production part of analysis
- Technicolor models give $a_T \to W\gamma$ and $\omega_T \to Z\gamma$
- First Vγ search at the LHC

Wγ, Zγ

Events





Wγ events selected with:

- $p_T(e,\mu) > 25$ GeV
- $E_T^{miss} > 35$ GeV
- $p_T(\gamma) > 40$ GeV
- $m_T(W) > 40$ GeV
- $|m(l\gamma) - m(Z)| > 15$ GeV

- $l\nu\gamma$ transverse mass is used to set limits

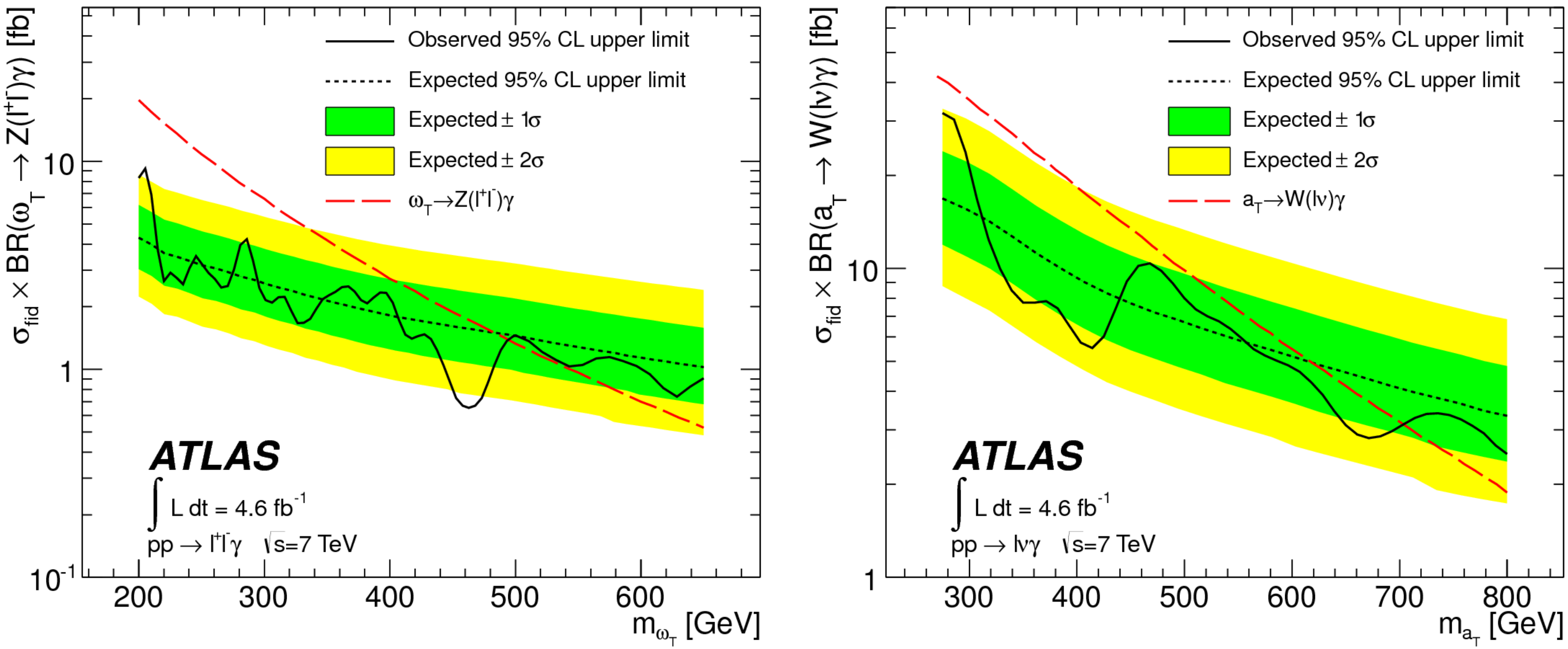
Zγ events selected with:

- $p_T(e,\mu) > 25$ GeV
- Exactly two leptons
- $m(ll) > 40$ GeV
- $p_T(\gamma) > 40$ GeV

- $ll\gamma$ invariant mass is used to set limits

Wγ, Zγ

Limits



- The data are well described by the Standard Model backgrounds
- Set limits using $m(ll\gamma)$, $m_T(l\nu\gamma)$
- Exclude **$m(\omega_T)$ < 494 GeV**
- Exclude **$m(a_T)$ < 704 GeV**

Conclusions

- Described in detail recent ATLAS searches for diboson resonances.
- Good agreement with Standard Model predictions. Excellent limits have been set on these models.
- Results from the 8 TeV dataset in 2012 are just starting to come, more results will follow in different channels and using the full dataset.
- Diboson channels continue to provide clean searches for new physics.
- Look forward to updates with the full 2012 dataset!

Summary of Diboson Resonance Analyses

Final State	Channel	Dataset Used	Exlclusion Limits	Reference
lνll	**WZ**	**13fb^{-1} at 8 TeV**	**W' < 1180 GeV**	**ATLAS-CONF-2013-015**
lljj	**WZ, ZZ**	**7.2fb^{-1} at 8 TeV**	**bulk G* < 850 GeV**	**ATLAS-CONF-2012-150**
llγ, lνγ	**Zγ, Wγ**	**4.6fb^{-1} at 7 TeV**	**a_T < 700 GeV**	**CERN-PH-EP-2012-345**
lνlν	WW	4.6fb^{-1} at 7 TeV	bulk G* < 840 GeV	CERN-PH-EP-2012-197
lνjj	WZ,WW	1fb^{-1} at 7 TeV	-	ATLAS-CONF-2011-097
llll	ZZ	1fb^{-1} at 7 TeV	G* < 845 GeV	CERN-PH-EP-2012-026