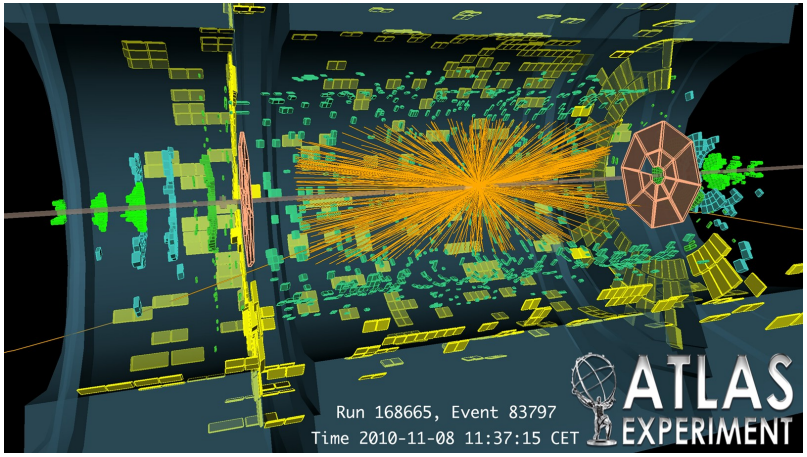


Recent results on Exotic searches from the ATLAS experiment at the LHC

J. Benitez (The University of Iowa)

representing the ATLAS collaboration

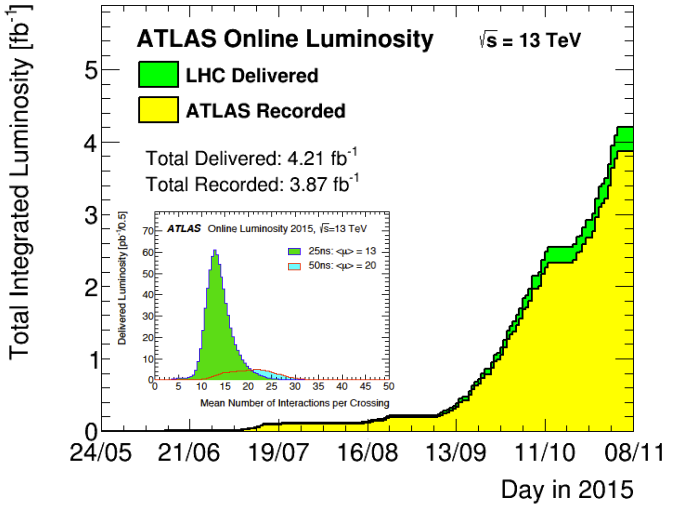
THE UNIVERSITY OF IOWA

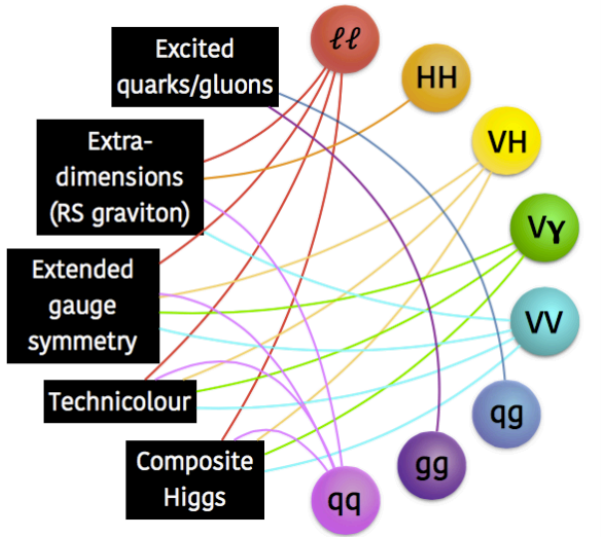
January 7, 2016

6th International Workshop on
High Energy Physics in the LHC Era

New results at $\sqrt{s}$ =13 TeV

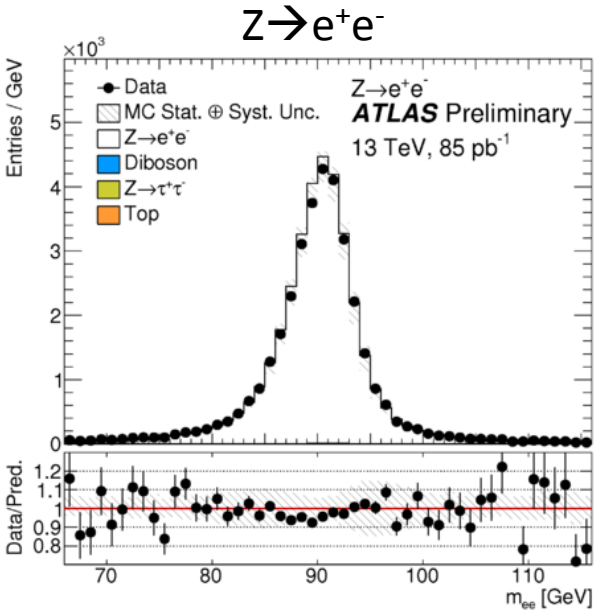
- Leptonic final states:
  - e/μ and missing energy
  - e^+e^-, $\mu^+\mu^-$
  - $e^+\mu^-$
- Di-jet/photon mass spectra:
  - jet-jet
  - γ-jet
  - γ–γ
- Di-boson resonances:
  - *WZ, WW, ZZ,*
  - *WH, ZH*

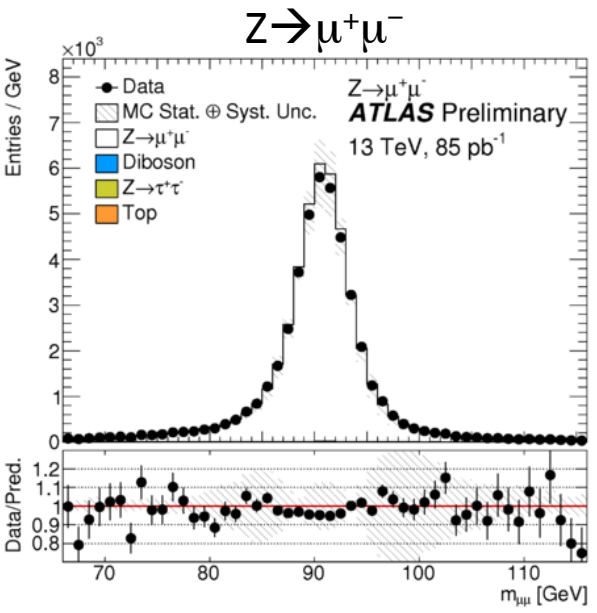




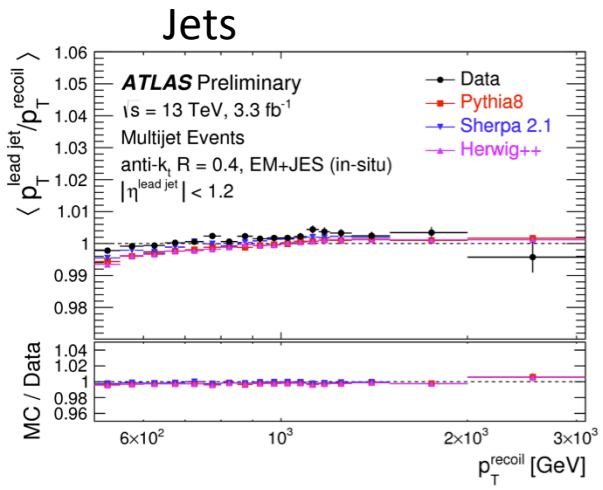
Object performance at 13 TeV

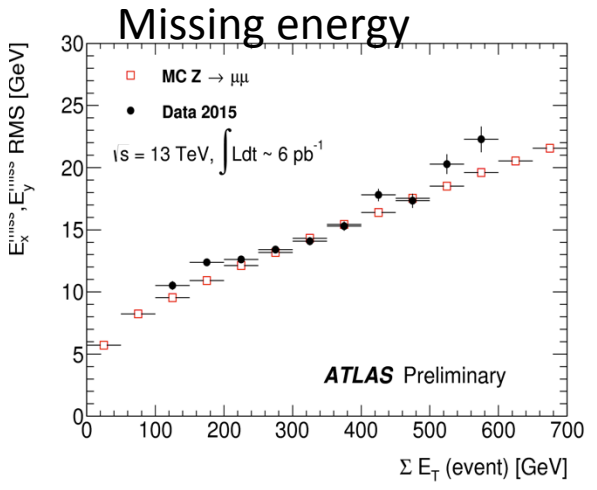
- Electrons and Muons calibrated with Z events
- Differences in efficiency and energy scale corrected





- Jet calibration based on Run I extrapolation and checked in multi-jet events.
- Missing energy resolution checked with Z→μμ events





Leptonic final states

Tests for Z' or W' gauge bosons

lepton + E_T^{miss}

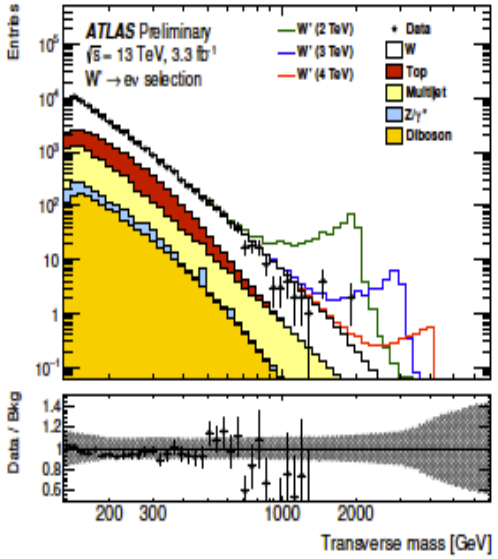
ATLAS-CONF-2015-063

- Reconstruct exactly one isolated lepton with $p_T > 65$GeV.
- The missing transverse energy in the event must exceed 55 GeV.
- Search in the transverse mass:

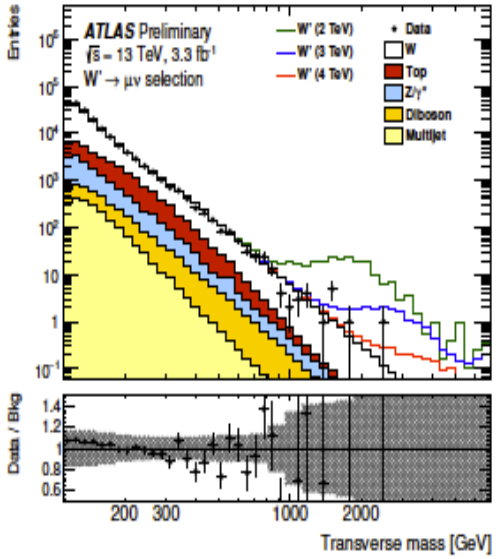
$$m_T = \sqrt{2 p_T E_T^{miss} (1 - \cos \phi_{\ell\nu})},$$

- Test for heavy spin-1 W' bosons.

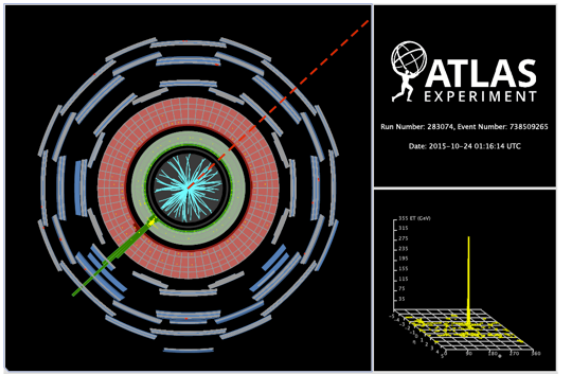
Electrons

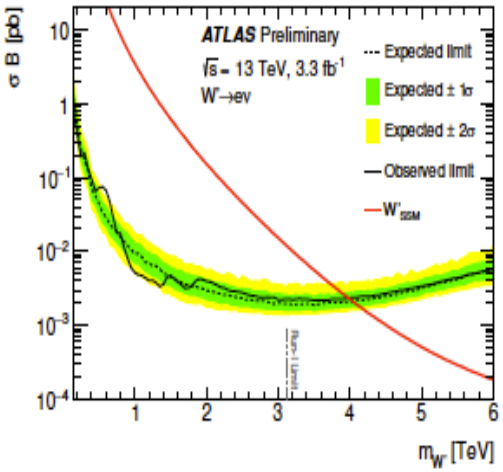


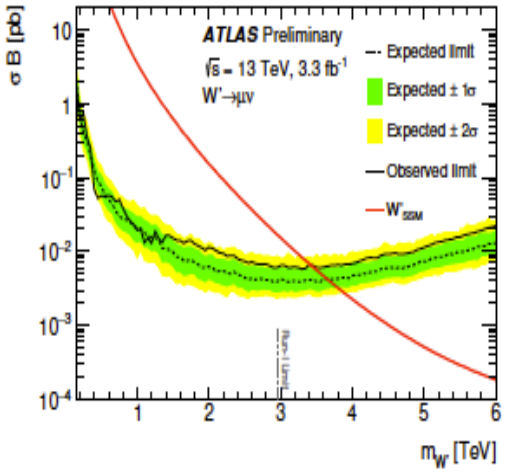
Muons



Event with one electron





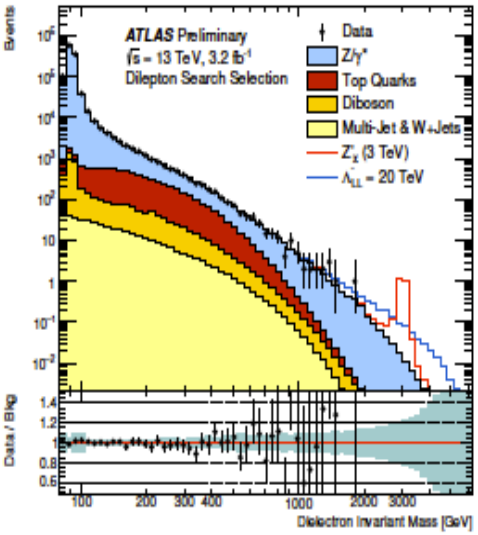


search in e^+e^-, $\mu^+\mu^-$

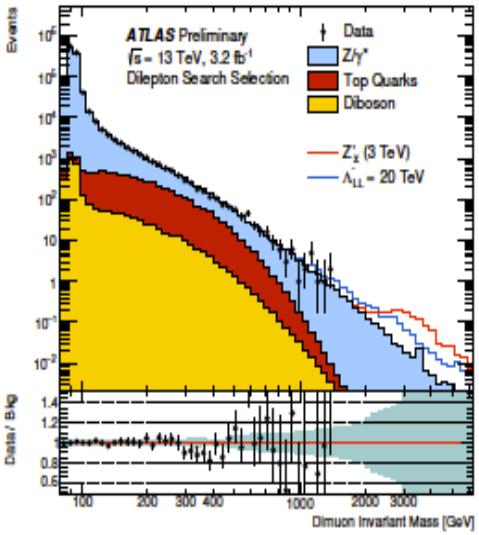
ATLAS-CONF-2015-070

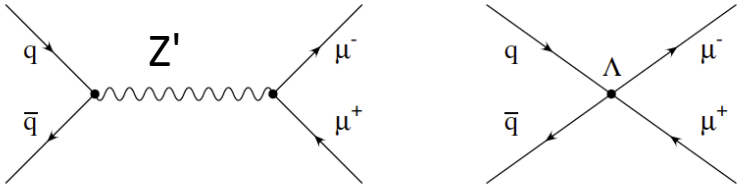
- Select a pair of leptons
  - well isolated
  - matched to the primary vertex
  - E_T or p_T > 30 GeV.
- Main background from Drell-Yan Z/γ production.
- Test di-lepton masses up to 5 TeV!
- Search for heavy Z' bosons or contact interactions.

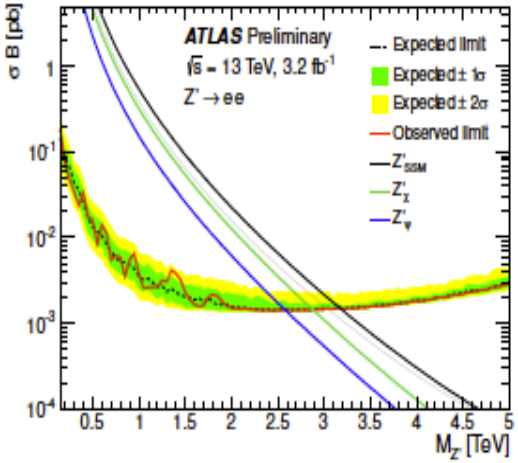
Electrons

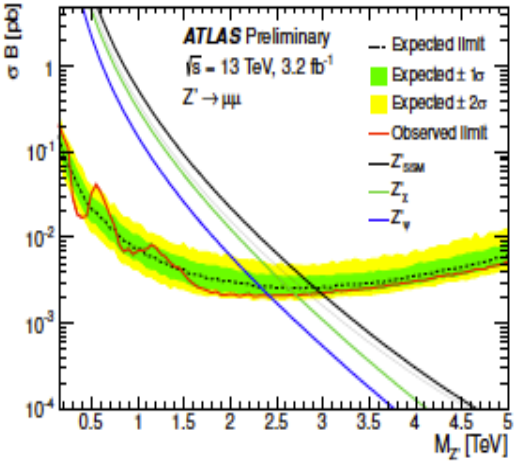


Muons





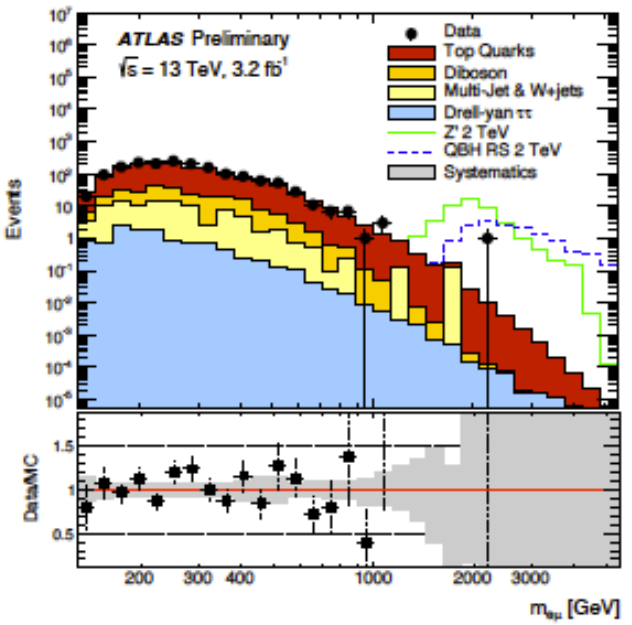


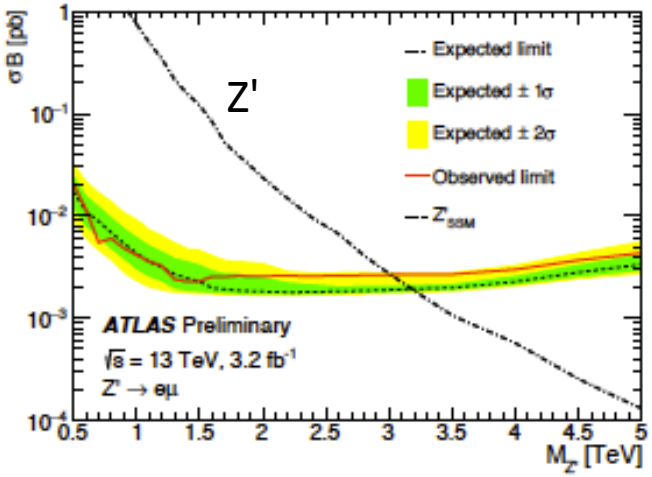


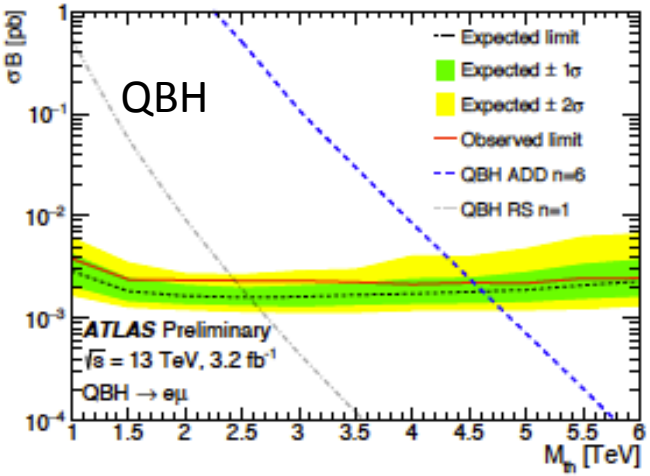
search in $e^+\mu^-$

- Require different flavor leptons
- Main background from $t\bar{t} \rightarrow W^+W^-$
- Test for LFV in Z' models and quantum black holes in RS and ADD models.
- No excess observed.

ATLAS-CONF-2015-072







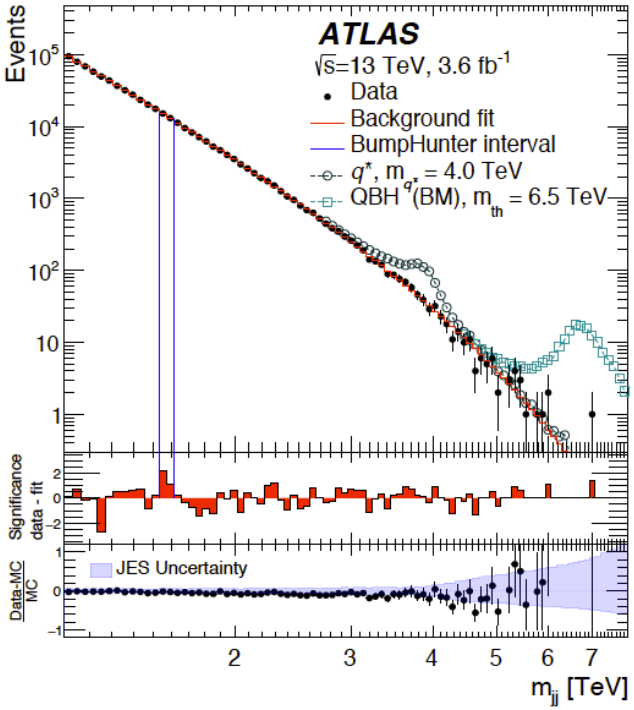
di-jet, γγ, γ-jet mass spectra

Tests for q^*, quantum black holes, Z'/W', heavy Higgs models

di-jet resonances

arXiv:1512.01530v2

- Jet selections:
  - $p_T(j_1) > 440$ GeV, $p_T(j_2) > 50$ GeV
  - compatibility with primary vertex
- Multi-jet background reduced with requirement on rapidity difference $|y^*| = |(y_1-y_2)/2| < 0.6$
- Di-jet mass resolution ~2% over full mass range
- Background modeled with a power law function.
- Look for a narrow resonance or an excess.



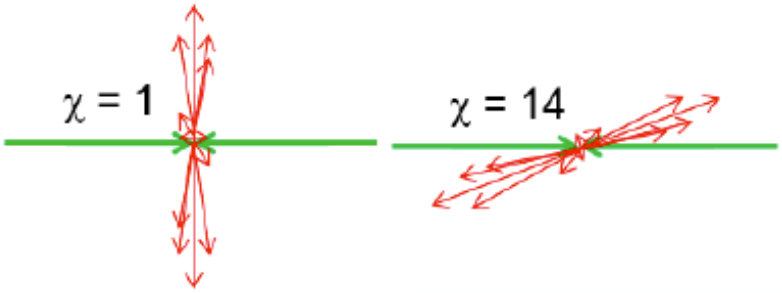
di-jet angular analysis

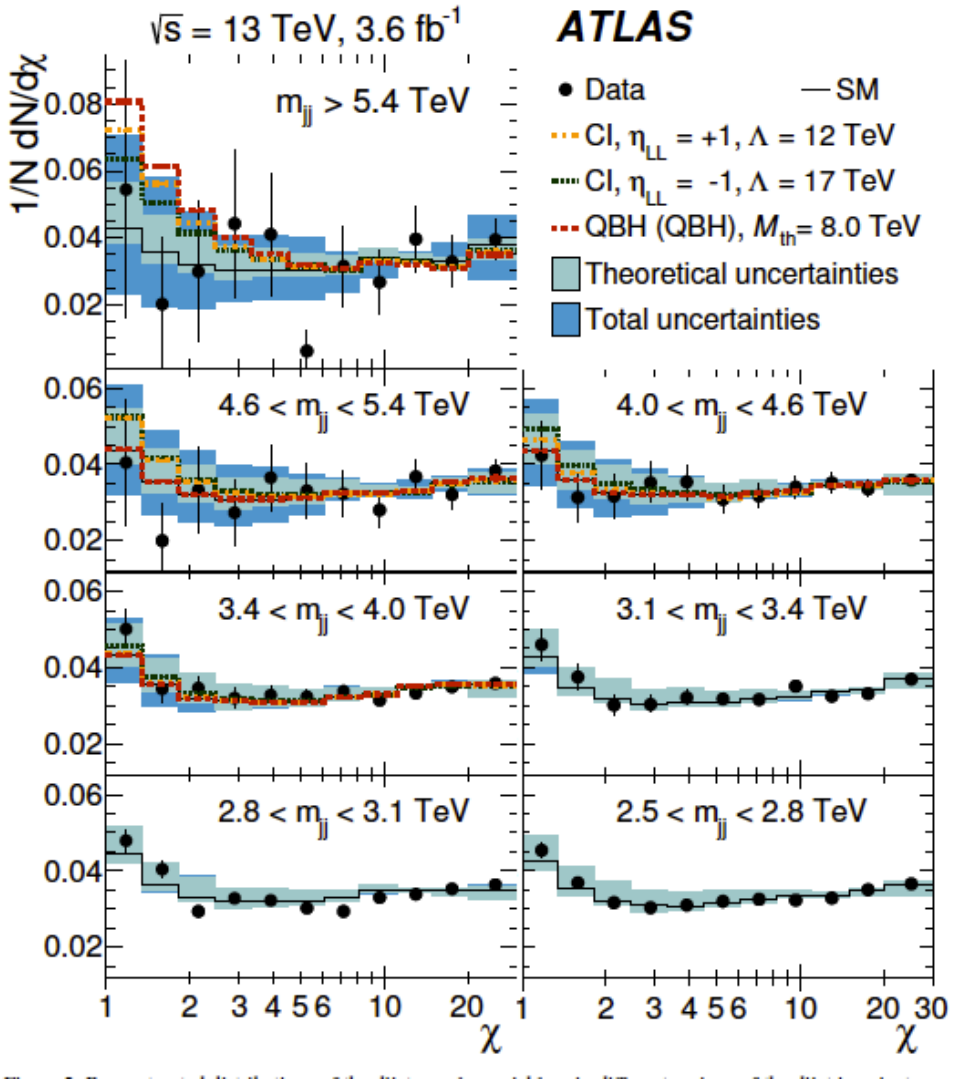
arXiv:1512.01530v2

- Angular analysis performed in slices of m_{jj} above 2.5 TeV
- Define frame invariant rapidity variable

$$\chi = e^{2|y^*|}$$

- Signal expected at low χ for quantum black holes and contact interaction models





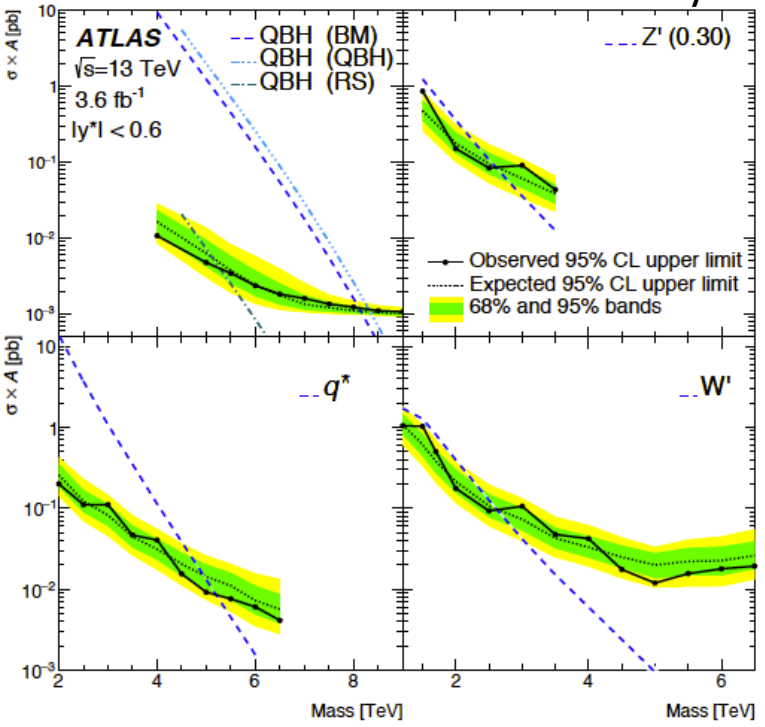
di-jet results

arXiv:1512.01530v2

- The m(jj) region above 5.4 TeV was previously unexplored.
- Large improvements in the exclusion limits over Run I.

Model	95% CL Exclusion limit		
	Run 1 Observed	Observed 13 TeV	Expected 13 TeV
Quantum black holes, ADD (BlackMax generator)	5.6 TeV	8.1 TeV	8.1 TeV
Quantum black holes, ADD (QBH generator)	5.7 TeV	8.3 TeV	8.3 TeV
Quantum black holes, RS (QBH generator)	–	5.3 TeV	5.1 TeV
Excited quark	4.1 TeV	5.2 TeV	4.9 TeV
W'	2.5 TeV	2.6 TeV	2.6 TeV
Contact interactions (η_{LL} =+1)	8.1 TeV	12.0 TeV	12.0 TeV
Contact interactions (η_{LL} =−1)	12.0 TeV	17.5 TeV	18.1 TeV

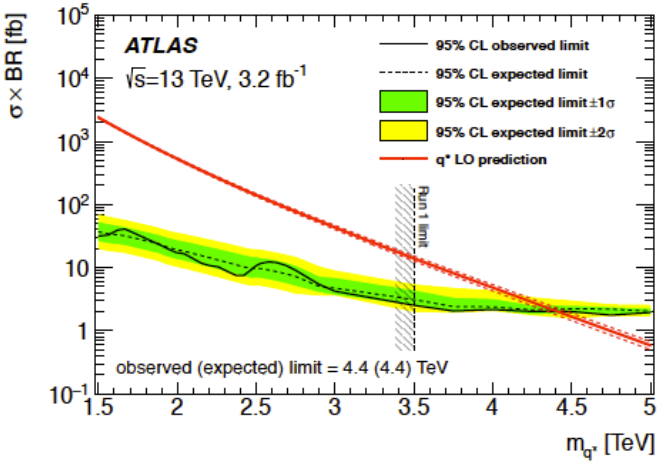
Resonant analysis

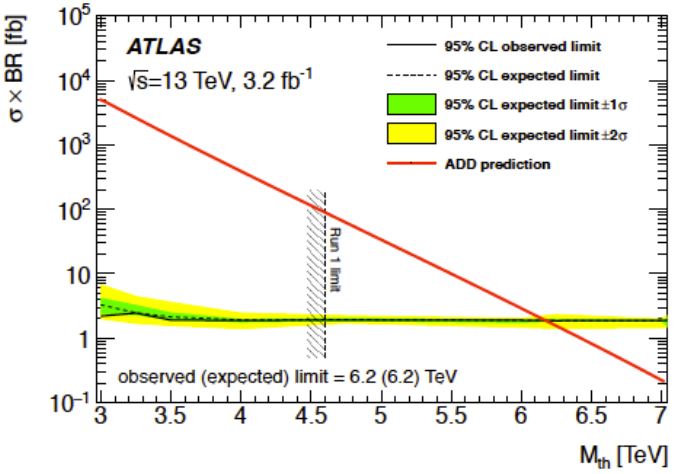


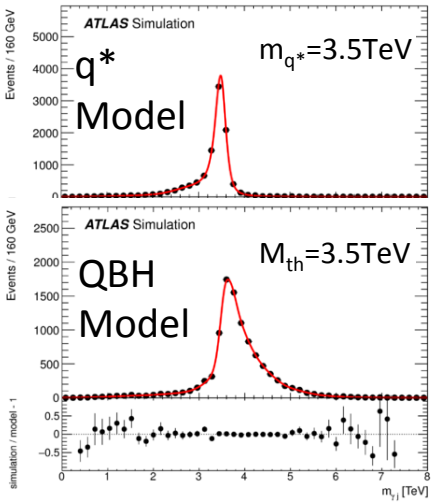
γ+jet search

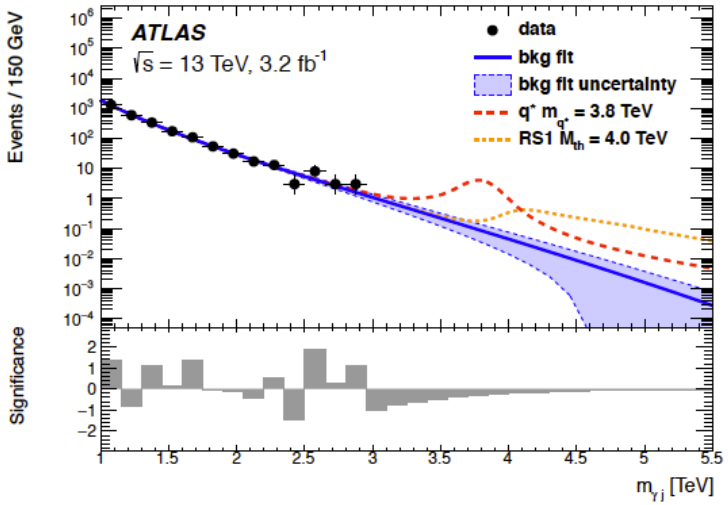
arXiv:1512.05910

- Test quantum black holes (QBH) and excited quark models
- Events are selected with a well isolated photon. Both the photon and jet must have $E_T > 150$ GeV
- γ+jet mass resolution is ~2.5% up to 6 TeV
- Exclusion limits surpass Run I analysis.







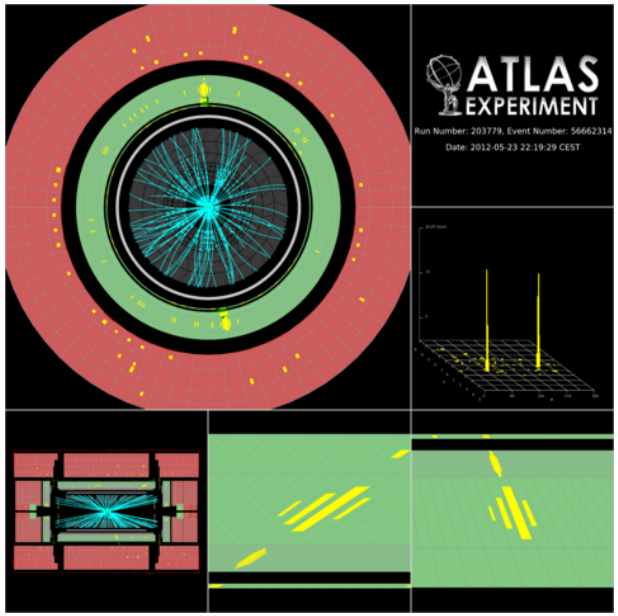


γγ search

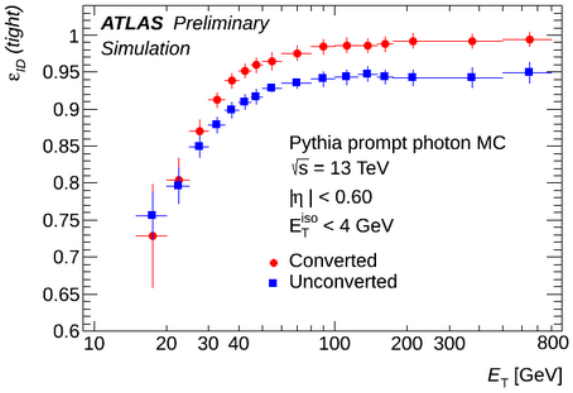
- Select two isolated photons
- Photon energy calibrated using Z→ee events
- Energy selections relative to the signal mass

$$E_T^{\gamma 1}/m_{\gamma\gamma} > 0.4 \text{ and } E_T^{\gamma 2}/m_{\gamma\gamma} > 0.3$$

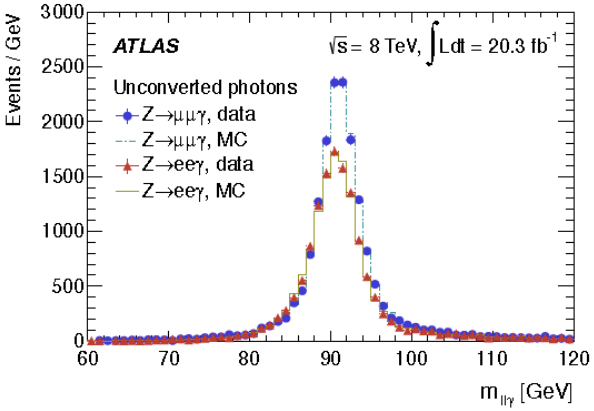
- Signal efficiencies range between 20-45% depending on the mass and production mechanism
- Main background is from non-resonant di-photon (90%) and jet (10%) production



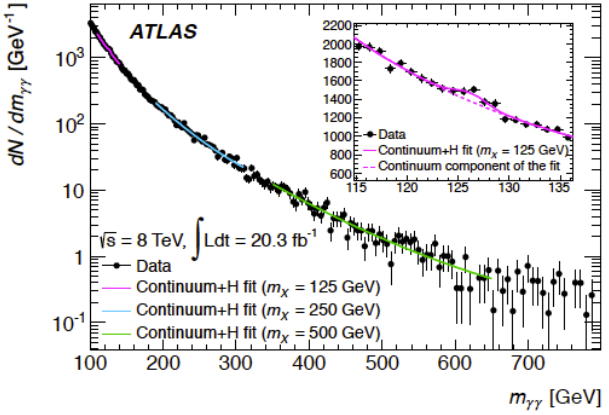
photon efficiency



Z→llγ events



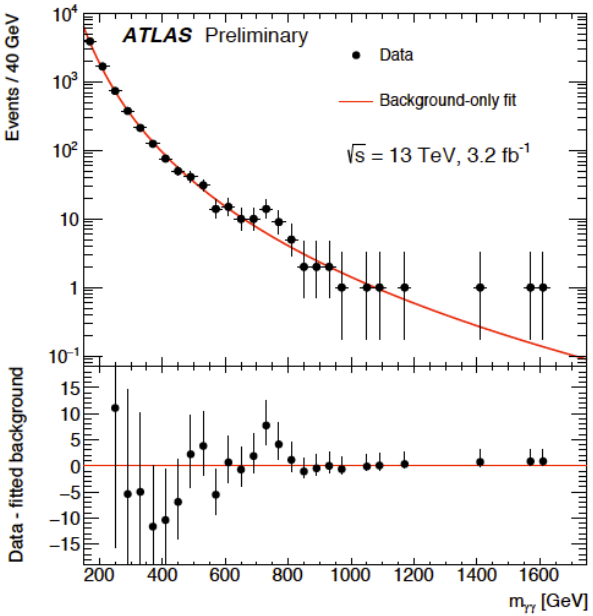
Run I (8 TeV) Results



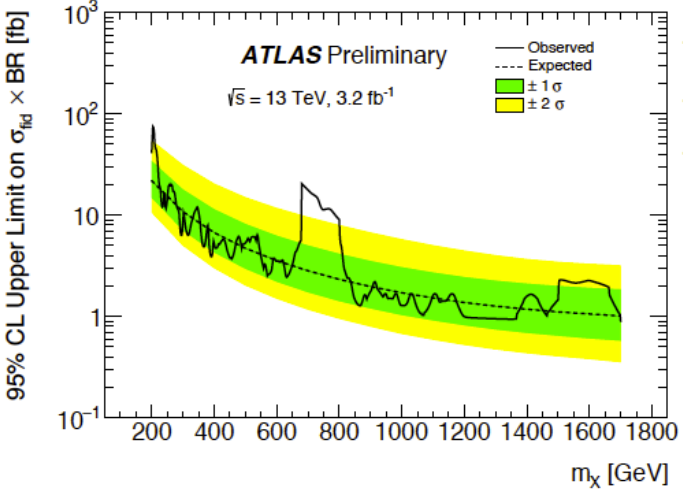
13 TeV γγ results

ATLAS-CONF-2015-081

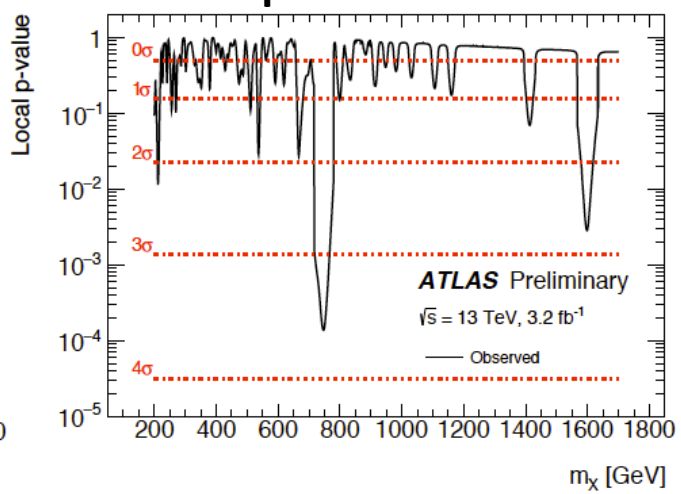
- Run II shows some excess at m(γγ) ~ 750 GeV
- Significance: local ~3.6σ, global ~2.0 sigma, estimated using a narrow width signal model.
- Using width Γ~45 GeV gives larger significances: 3.9σ local (**2.3σ global**)
- Run I analysis did not see excess, but is still compatible within 2.3σ of the current result assuming gluon fusion production.



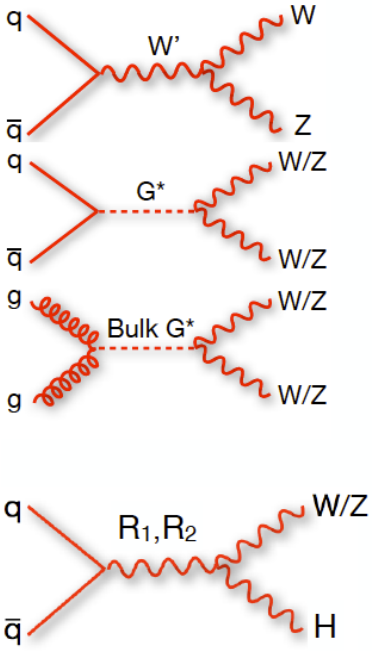
Exclusion Limits



Local p-value in NWA



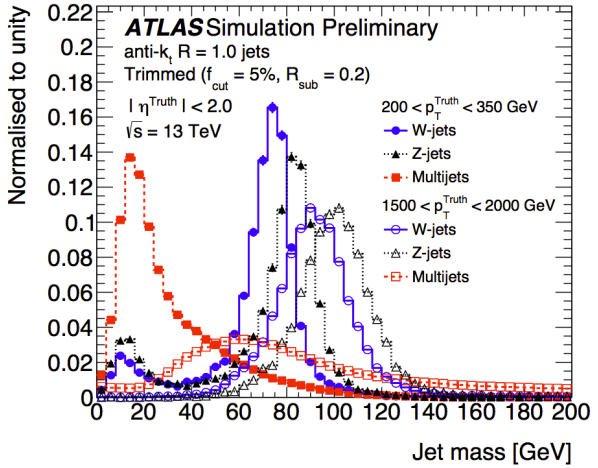
Diboson Resonances
WW, WZ, ZZ, WH, ZH



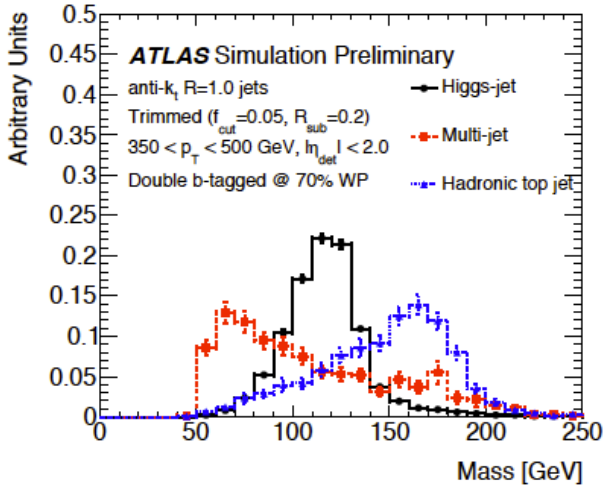
Boosted Boson tagging

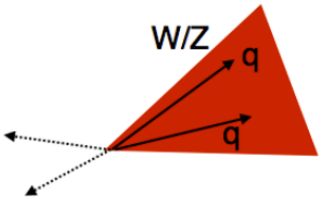
- Use large-R (1.0) jets for boosted W, Z, or Higgs reconstruction.
- Grooming/trimming is applied using small-R (0.2) sub-jets.
- Jet energy and mass are corrected with simulation
- Discriminate against QCD jets with jet substructure variables: p_T dependent energy correlation (D2) and track multiplicity
- Higgs tagging uses R=0.2 track jets associated to the large-R jet.

W,Z jets

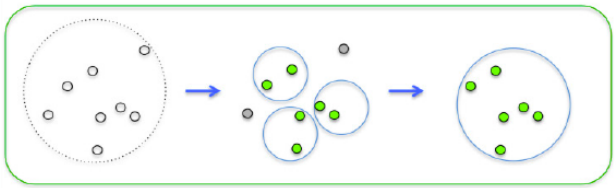


Higgs jets

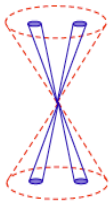




Jet grooming



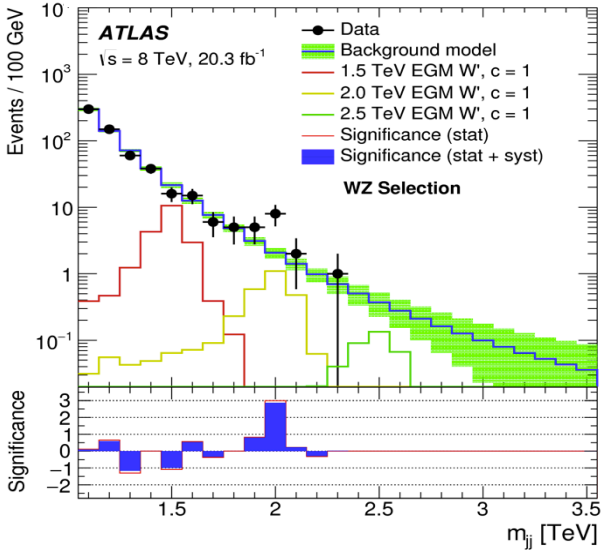
VV to JJ

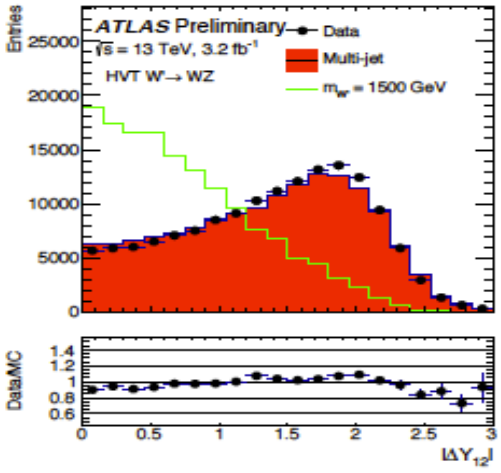


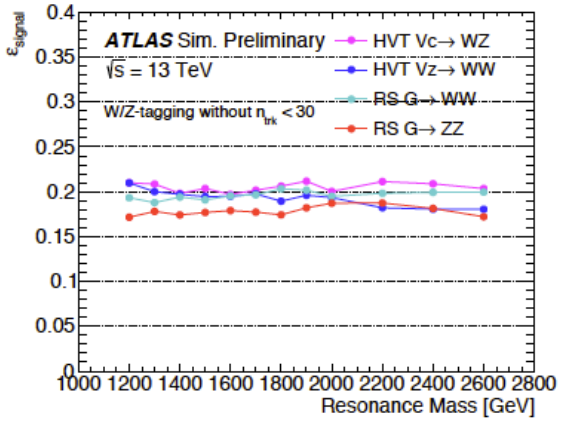
ZZ, WW, WZ with di-jets

- Search for resonances with two boson-tagged jets.
- Multi-jet background reduced with selections on di-jet rapidity difference $|y^*| < 1.2$ and jet track multiplicity ($n_{trk} < 30$)
- Signal efficiency is nearly constant.
- Run I results showed a 3.4 σ excess at 2 TeV in the WZ distribution.

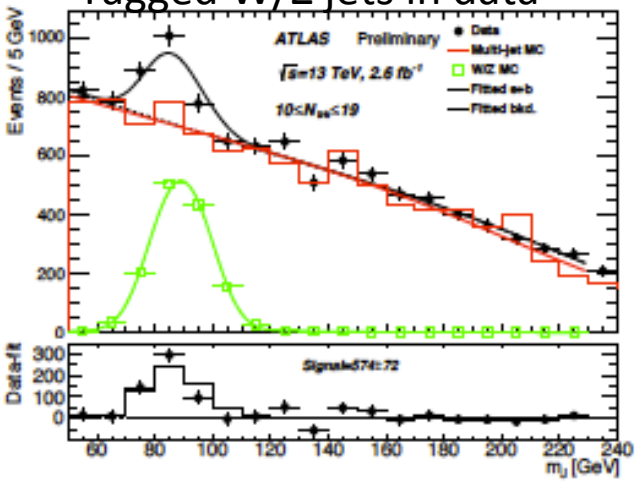
Run I WZ search

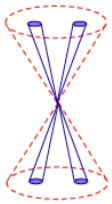






Tagged W/Z jets in data





ZZ, WW, WZ with di-jets

13 TeV results

ATLAS-CONF-2015-073

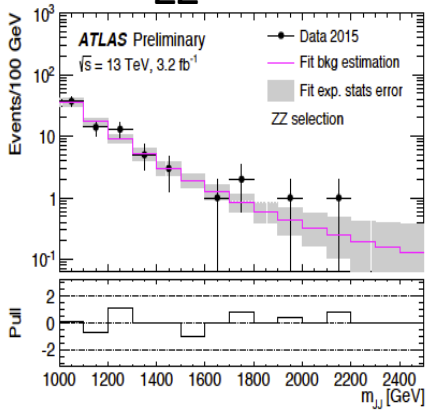
- No clear excess observed, but sensitivity not strong enough to exclude Run I excess

- Background model:

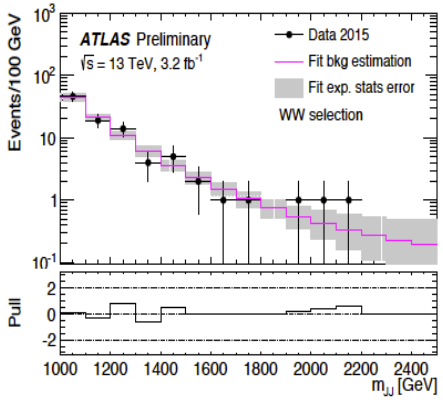
$$\frac{dn}{dx} = p_1(1-x)^{p_2+\xi p_3} x^{p_3},$$

- Test narrow resonances with HVT model and RS black holes in ZZ

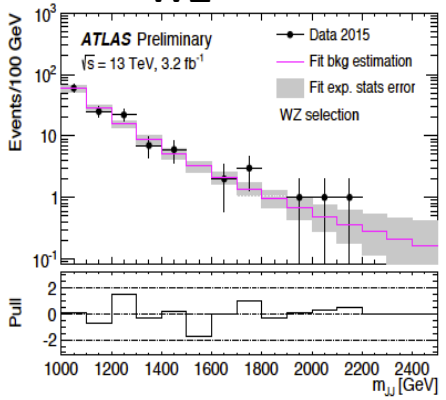
ZZ

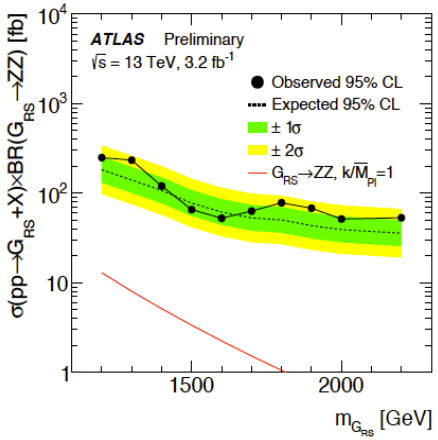


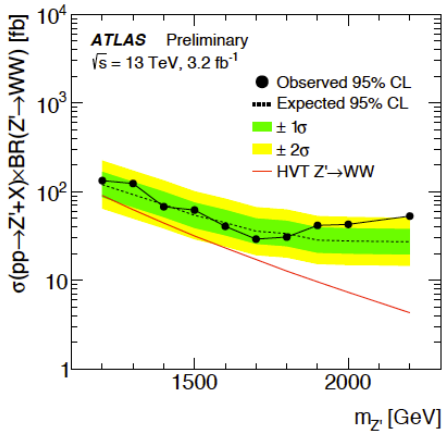
WW

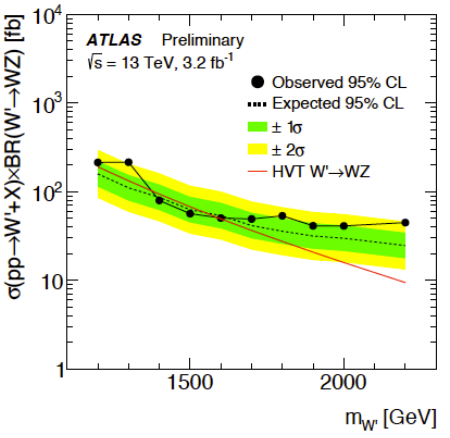


WZ

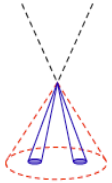








WZ → qqvv, qqll



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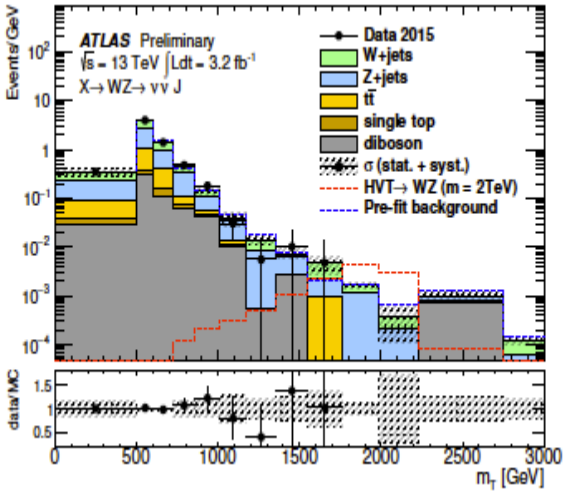
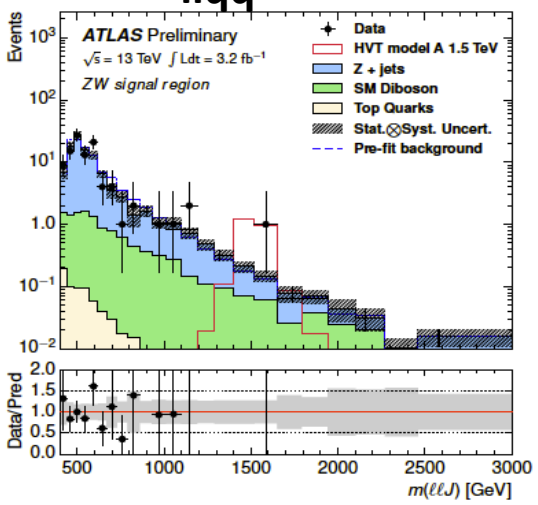
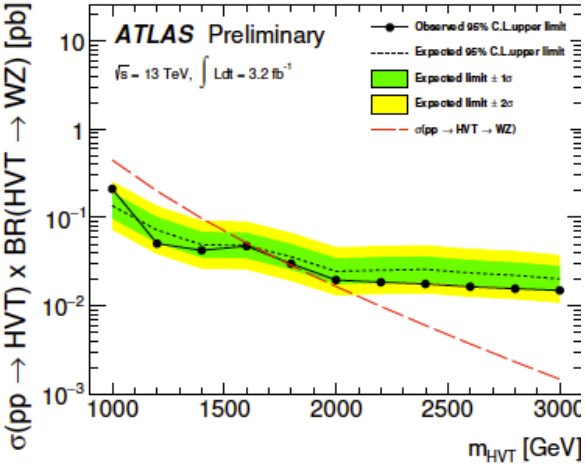
- Events triggered with missing energy or di-lepton from Z
- Reconstruct W with boson-tagged large-R jet
- Signal mass resolution is ~20% for vvqq , ~8% for llqq
- Main background from Z+jet events.
- Test narrow W' models.

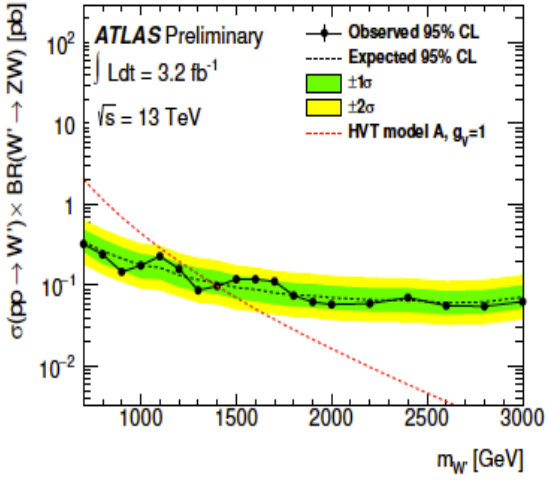
vvqq



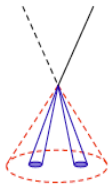
llqq







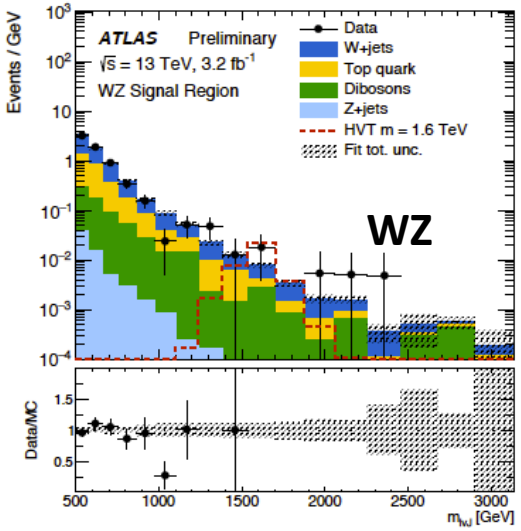
WV (with W to lv)

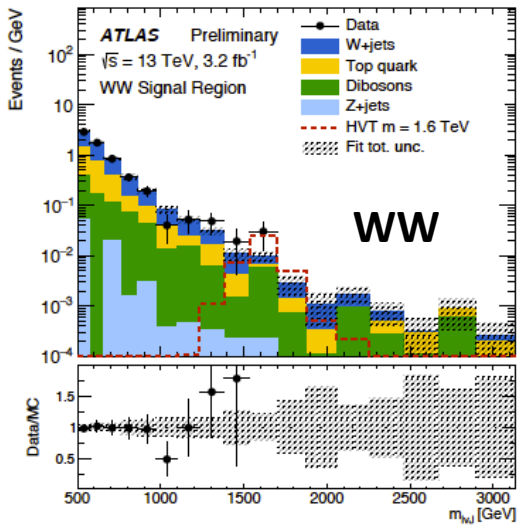


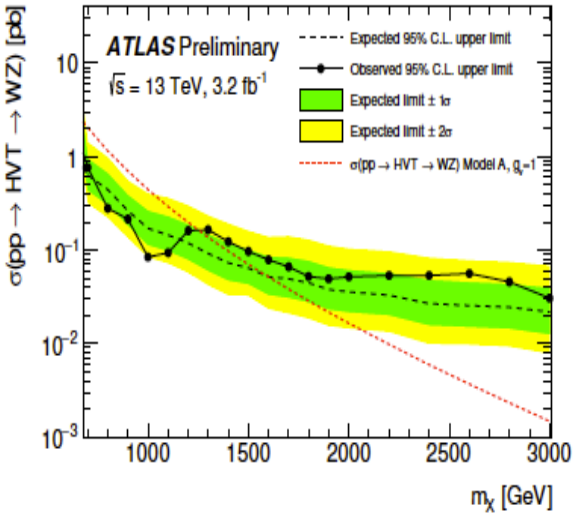
WZ, WW → lvqq

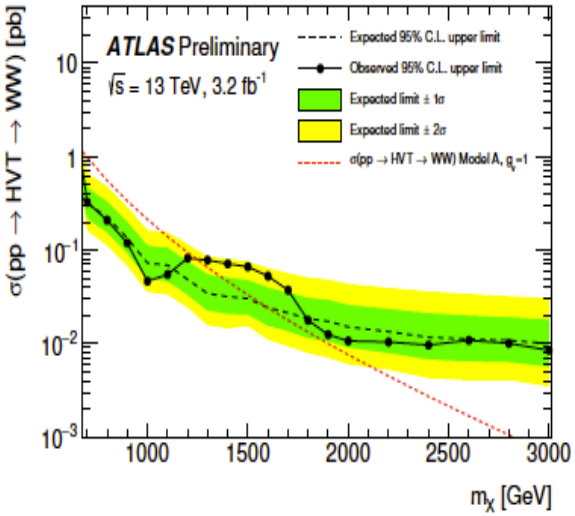
ATLAS-CONF-2015-075

- Trigger events with single isolated lepton from the W.
- Neutrino p_Z estimated by applying W mass constraint.
- Reconstruct additional Z or W with tagged large-R jet.
- Test narrow Z'/W' models.





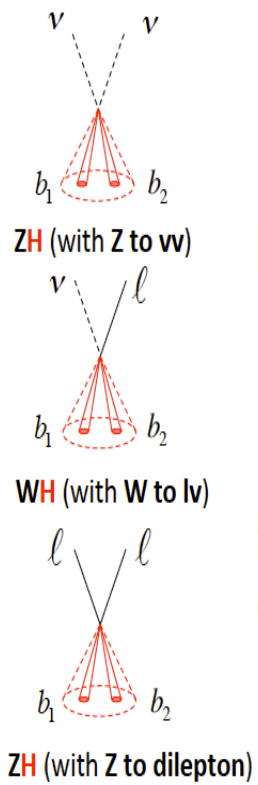


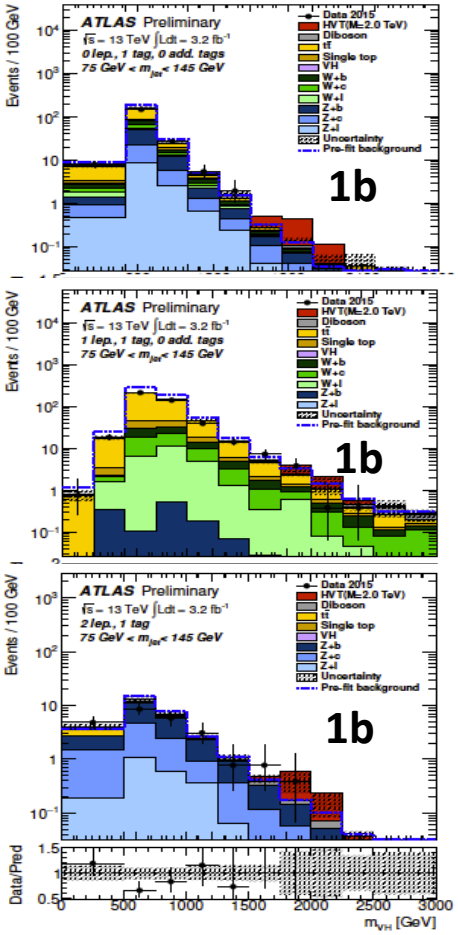


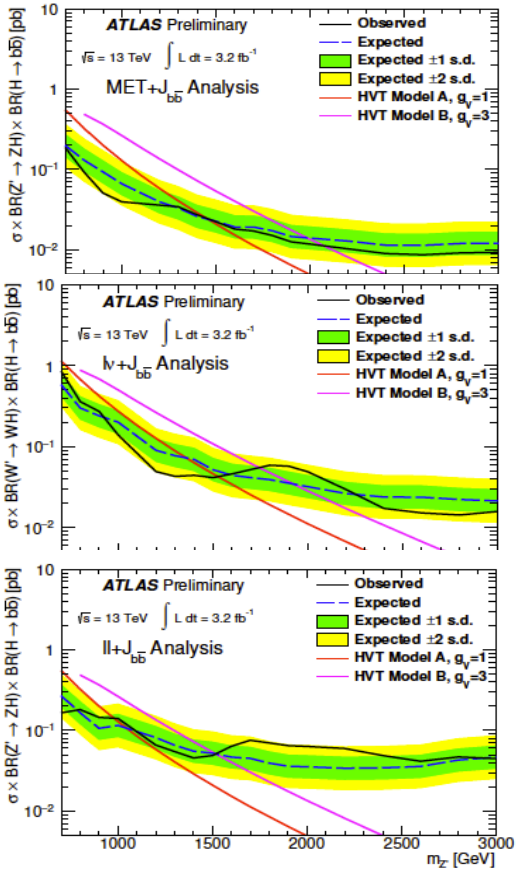
WH, ZH → lvbb, vvbb, llbb

ATLAS-CONF-2015-074

- Explore high mass, Run I analysis stopped at 1.8 TeV
- Final states depending on W or Z decay, leptons/E_T^{miss} used for trigger
- Higgs identification with 1 or 2 b-tagged track jets in large-R jet





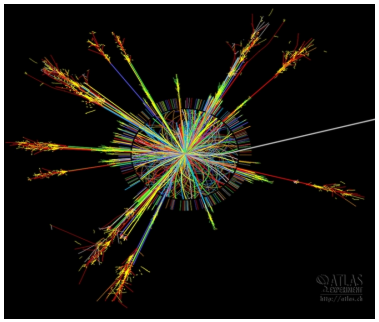


Conclusions

- A summary has been presented of the new exotic results from the 13 TeV data-set collected by ATLAS.
- Searches have been carried out with di-leptons and a lepton plus missing energy, as well as with pairs of photons and jets.
- Searches with a pair of vector bosons or a vector boson and the Higgs boson have been performed at high mass using boosted reconstruction techniques.
- The sensitivity in many of these searches already exceeds that of Run I and new mass regions have been explored.
- In the di-photon mass spectra the region around 750 GeV exhibits an excess of events with a global significance of ~2.3 standard deviations. More data is needed this mass region.

For a complete description of these results see the ATLAS public webpage:
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/December2015-13TeV

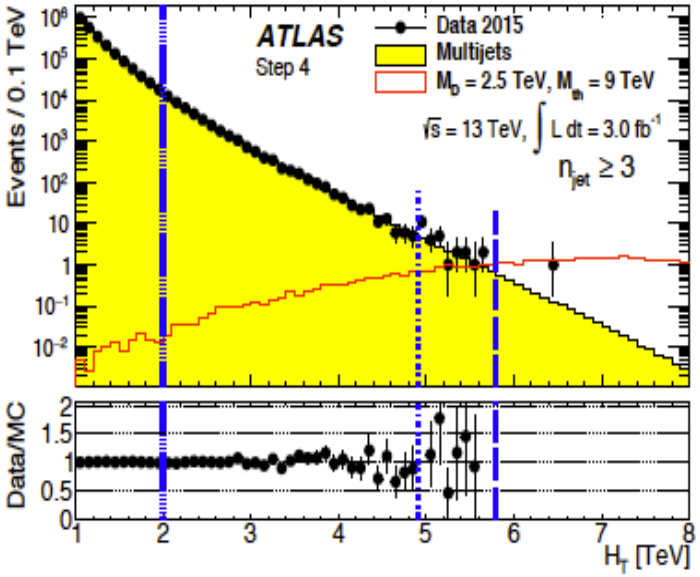
additional slides

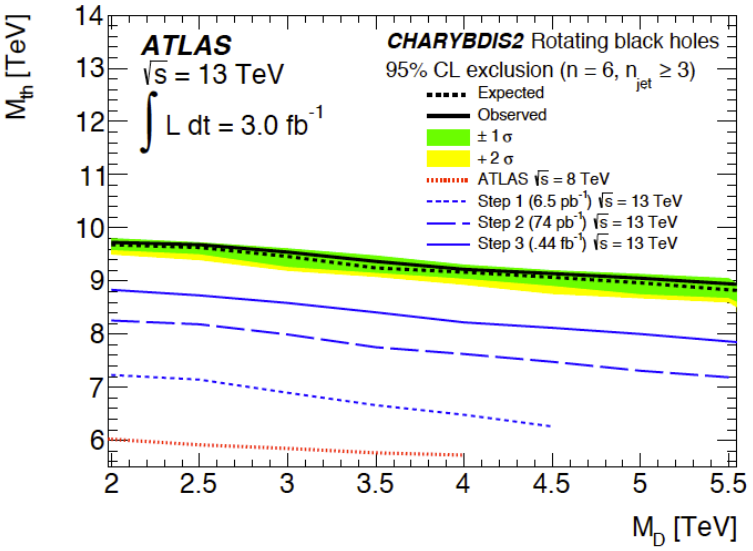


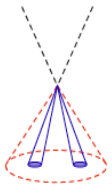
multi-jet events

arXiv:1512.02586v1

- Use scalar sum of transverse jet energy in the event (H_T)
- Look for events with large multiplicity ($n_{jet} \geq 3$)
- Background shape determined in iterative steps (bootstrap)
- Test strong gravity, micro black holes and string ball production
- Large improvement over Run I in black hole threshold mass exclusion







ZZ → vvqq, l^+l^-qq

ATLAS-CONF-2015-068
ATLAS-CONF-2015-071

- Reconstruct missing energy or di-lepton and large-R jet
- Mass resolution is ~20% (vvqq), ~8% (llqq)
- Background dominated by Z+jet events
- Test QBH (RS G*), HVT Z', and Heavy Higgs models