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ATLAS EXPERIMENT

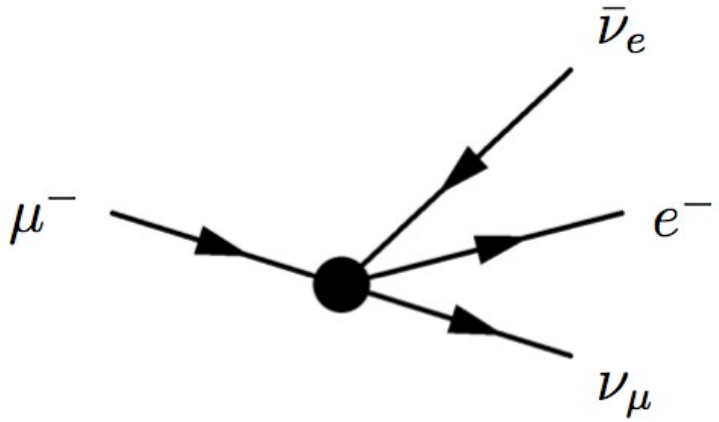
Searches for resonant and non-resonant new phenomena from ATLAS

Alison Elliot, University of Victoria
on behalf of the
ATLAS Collaboration

Introduction: Resonant and non-resonant searches

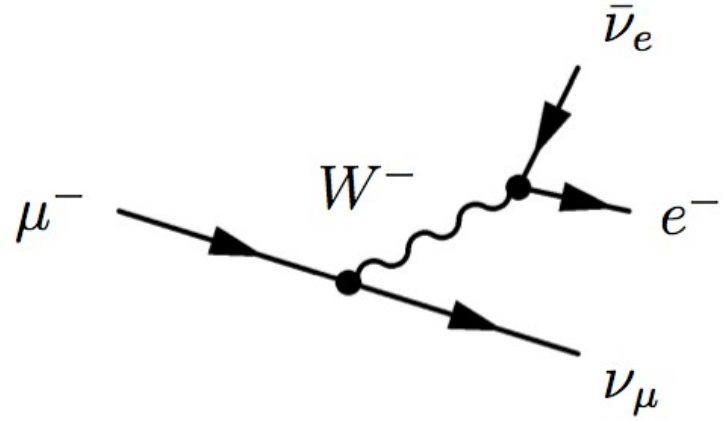
Non-Resonant:

- Contact interactions can be found in a non-resonant search.
- Looks for an overall increase in total number of signal events.
- Can be mistaken for high energy QCD effects.



Resonant:

- Mediator particle decays can be found in a resonant search.
- Looks for a narrow or broad peak on top of a continuum.

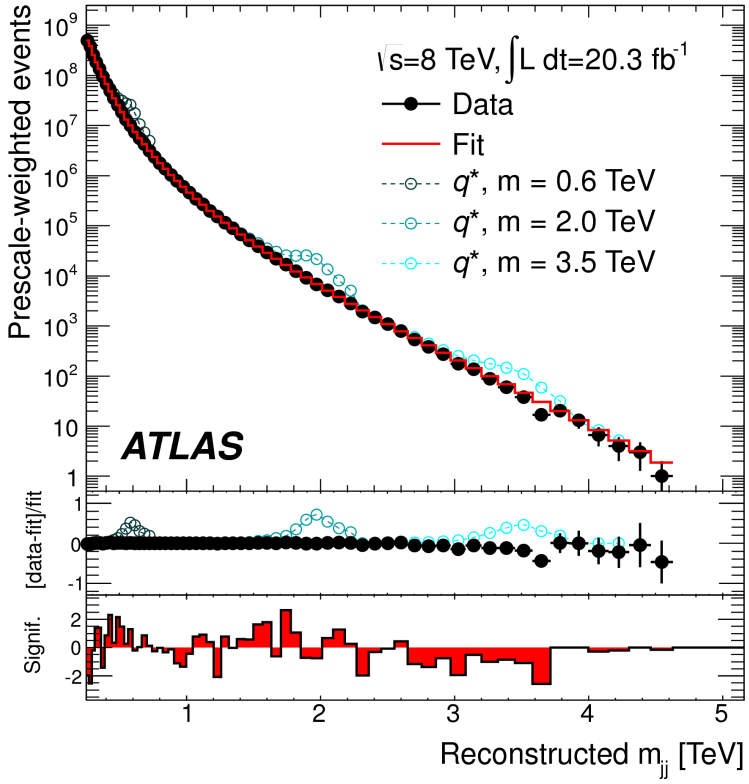


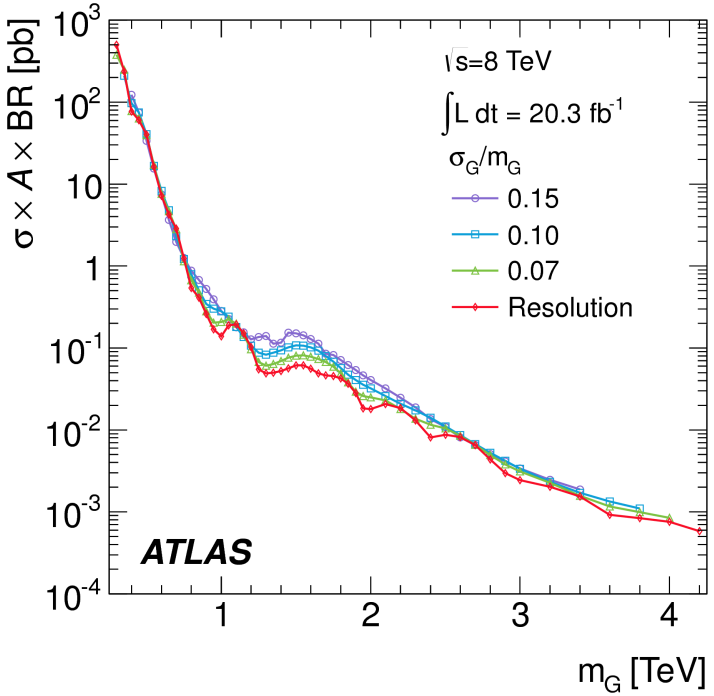
Di-jet searches (resonant 8 TeV)

Phys. Rev. D. 91, 052007 (2015), arXiv:1407.1376 (resonant)

Event Selection

- Single jet trigger
- At least two jets in event
- $m_{jj} > 250$ GeV
- Rapidity (y) of leading jets < 2.8
- Transverse momentums (p_T) > 50 GeV
- $|y^*| = ½ |y_1 - y_2| < 0.6$





Phenomenological Models (limits [TeV])

Excited quarks, q*: $m_{q^*} > 4.06$

Color-octet scalars, s8 $m_{s8} > 2.70$

Heavy W' gauge bosons $m_{W'} > 2.45$

Chiral W* gauge bosons

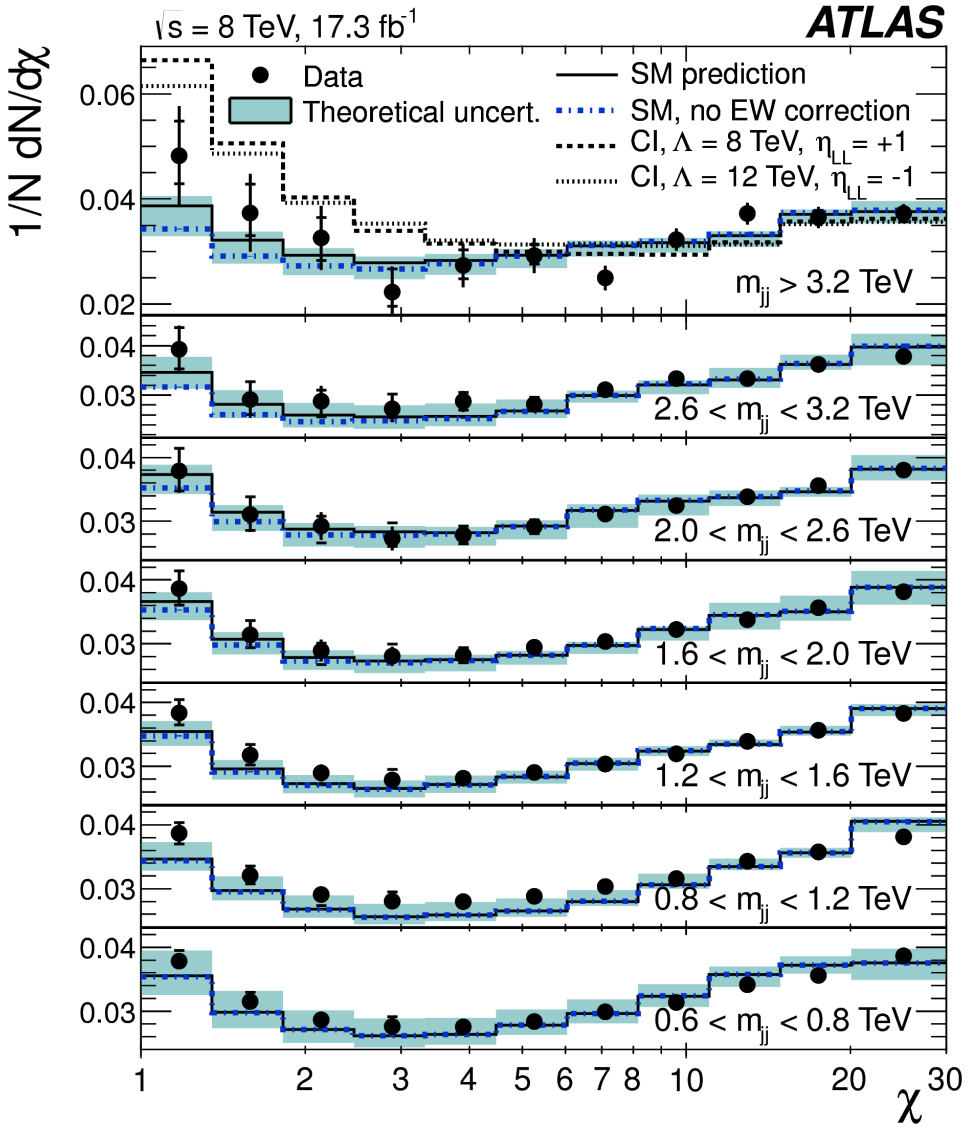
m_{W^*} leptophobic > 1.75

m_{W^*} leptophilic > 1.65

Quantum black holes $m_{BH} > 5.66$

Di-jet Searches (non-resonant 8 TeV)

Phys. Rev. Lett. 114, 221802, (2015)
arXiv:1504.00357



Event Selection:

- Single jet trigger
- At least two jets in event
- $m_{jj} > 600$ GeV
- Rapidity boost of system:
  $|y_B| = ½ |y_1 + y_2| < 1.1$
- $|y^*| = ½ |y_1 - y_2| < 1.7$

Scattering angle between two jets: $\chi \equiv e^{|y1-y2|} = e^{2|y^*|}$

Models:

- Strong gravity
- Contact interactions
  - $\Lambda >$ 8.1 TeV (destructive interference)
  - $\Lambda >$ 12.0 TeV (constructive interference)

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Di-lepton (resonant)

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Leptons:

Normalized to data under Z peak

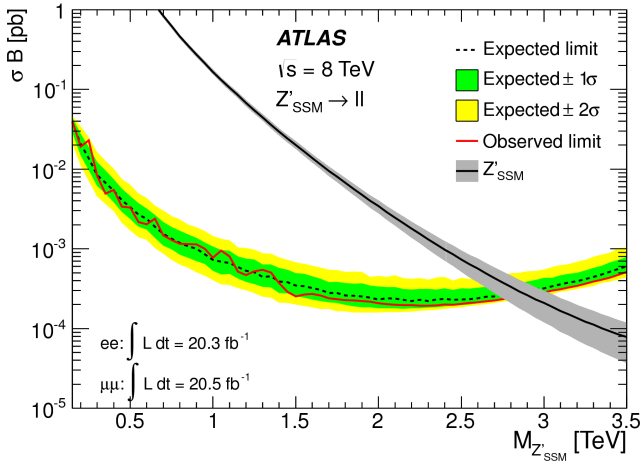
Electrons:

- Di-EM calorimeter clusters trigger
- Shower profile and leakage, tracking quality
- Calorimetric isolation

Muons:

- Single muon triggers
- Inner detector & Muon Spectrometer quality
- Track isolation
- Opposite sign

Phys. Rev. D. 90, 052005 (2014), arXiv:1405.4123

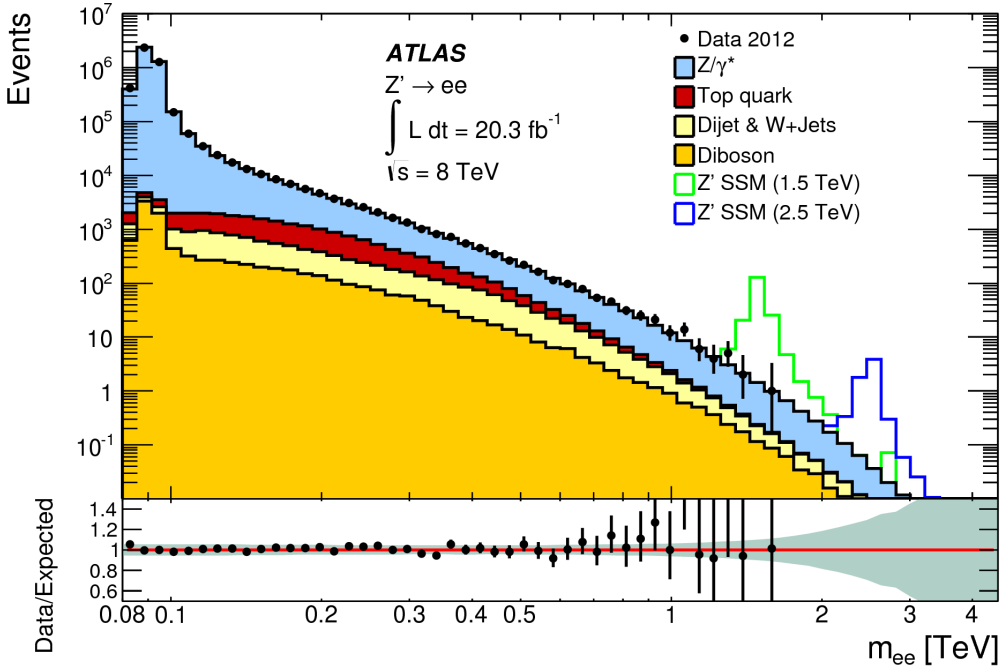


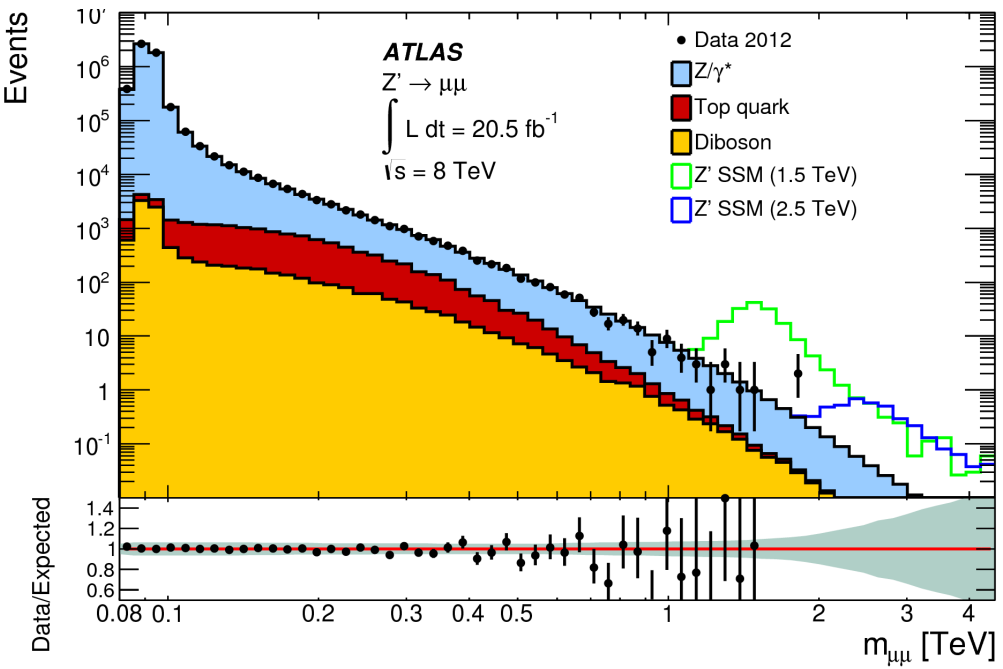
Phenomenological Models (and limits in [TeV])

Sequential SM, Z'_{SSM},	$m_{Z'} > 2.9$ TeV
Grand Unification, Z'_{χ}, Z'_{ψ},	$m_{Z'} > 2.62, 2.51$
Z* Bosons,	$m_{Z^*} > 2.85$ TeV
Spin-2 Graviton, ($k/\overline{M}_{Pl}=0.1$)	$m_{G^*} > 2.68$ TeV
QBH	
ADD:	$m_{th} > 3.65$ TeV
RS:	$m_{th} > 2.24$ TeV

Minimal Walking Technicolor Model

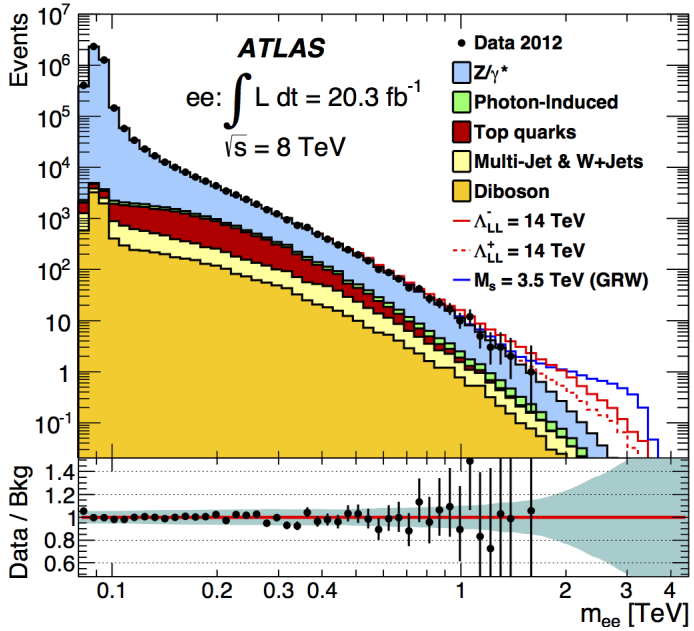
$M_A > 1.96$, $M_{R1} > 1.99$ (for $\tilde{g} = 2$)

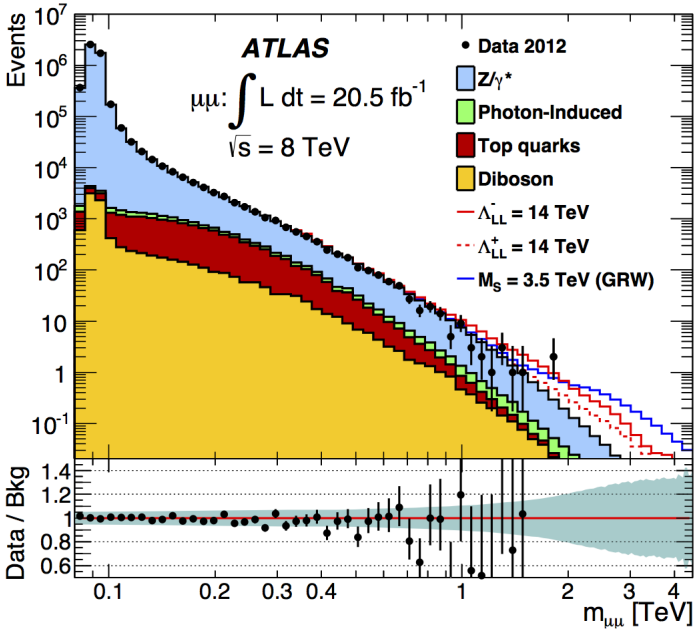




Di-lepton (non-resonant)

Eur. Phys. J. C (2014) 74:3134, arXiv:1407.2410 (non-resonant)



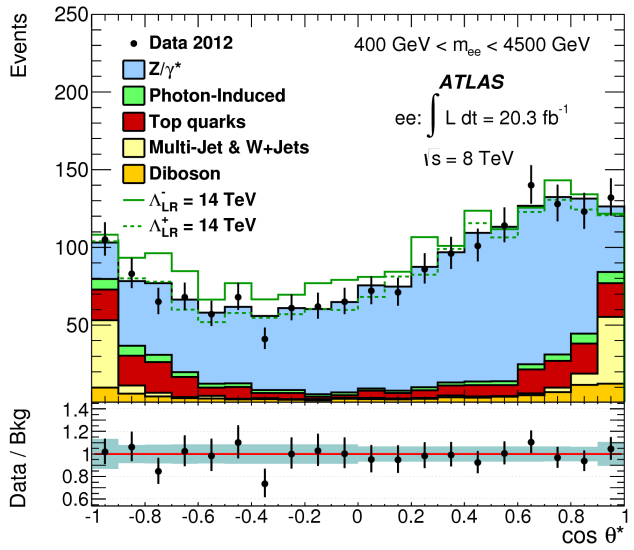


Contact Interactions $\Lambda > 26.3$ TeV (L-R constructive)

Coupling between $q_{L,R}$ and $\ell_{L,R}$ probed for contact interactions

Large extra spatial dimensions $M_S > 5.0$ TeV (HLZ n=3 ADD)

The string scale M_S is probed for interference and graviton effects



Leptons:

- $m_{\ell\ell} > 80$ GeV
- Background scaled to data in region 80 GeV < $m_{\ell\ell}$ < 120 GeV
- Control region for verification 120 GeV < $m_{\ell\ell}$ < 400 GeV

Electrons:

- Di-EM calorimeter clusters trigger
- Shower profile and leakage, tracking quality
- Calorimetric isolation
- Opposite sign

Muons:

- Single muon triggers
- Inner detector & Muon Spectrometer quality
- Track isolation
- Opposite sign

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Lepton + MET

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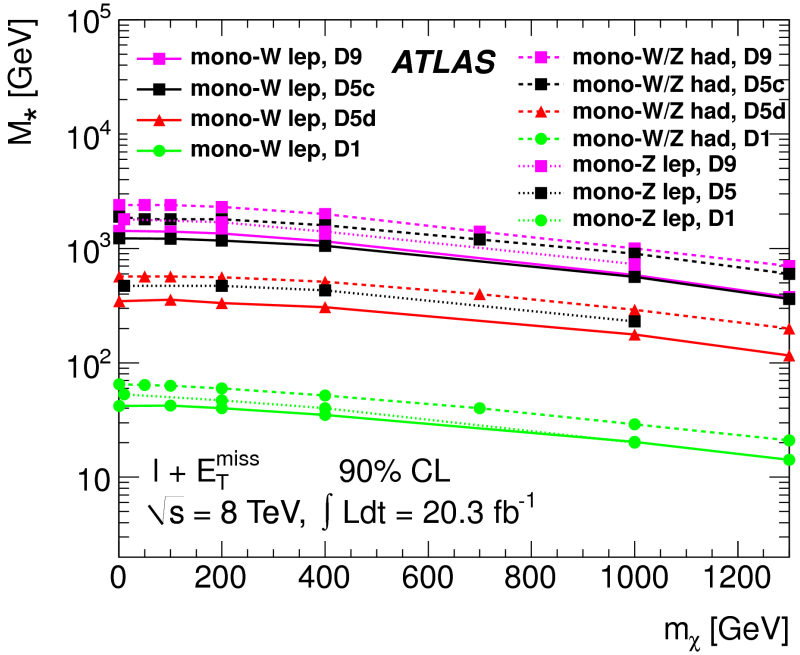
JHEP 09 (2014) 037, arXiv:1407.7494



Phenomenological Models (limits [TeV])

SSM W' gauge bosons $m_{W'} > 3.24$ TeV

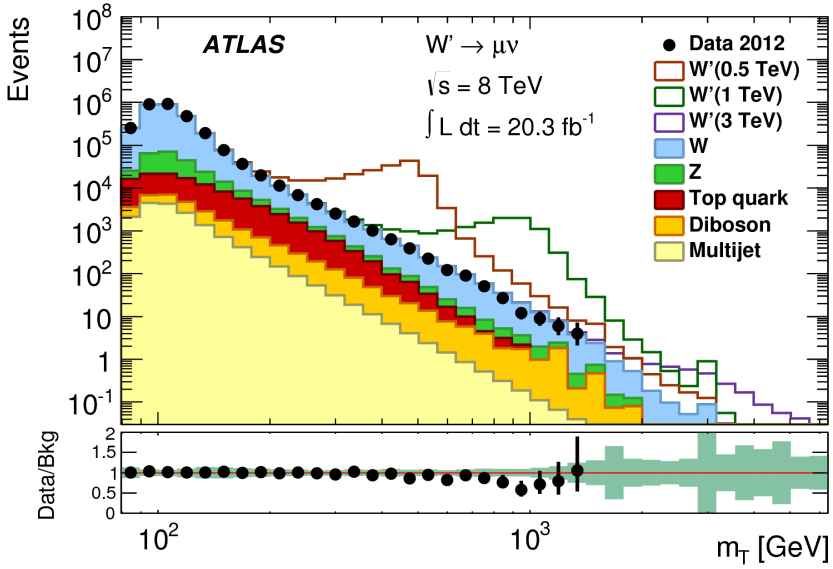
Chiral W* gauge bosons $m_{W^*} > 3.21$ TeV

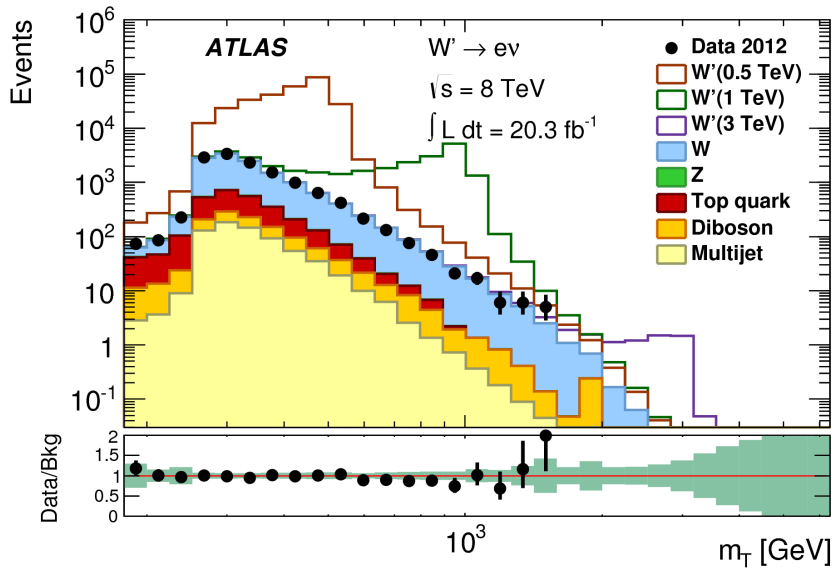
Dark Matter Effective Field Theory (DM EFT):
Various M* limits for different DM masses

Event Selection

- Single EM or muon trigger
- Electron: E_T and $E_T^{miss} > 125$ GeV
- Muon: p_T and $E_T^{miss} > 45$ GeV
- Isolated lepton

$$m_T \equiv \sqrt{(2p_T E_T^{miss}(1 - \cos \varphi_{\ell\nu}))}$$

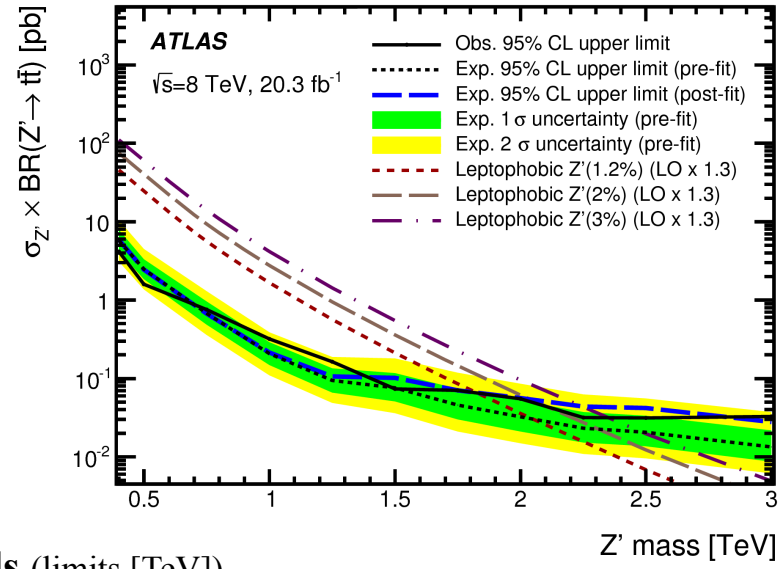




Lepton + jets

Event Selection

- Single electron, single muon, and large-radius jet triggers
- Isolated leptons with $E_T > 25$ GeV (e), $p_T > 25$ GeV (mu)
- Transverse mass: $m_T \equiv \sqrt{(2p_T E_T^{miss}(1 - \cos \varphi_{\ell\nu}))}$
- $E_T^{miss} > 25$ GeV
- $E_T^{miss} + m_T > 60$ GeV
- Boosted Topologies (large-radius jet along with lepton + small jet)
- Resolved Topologies (four small-radius jets individually resolved)

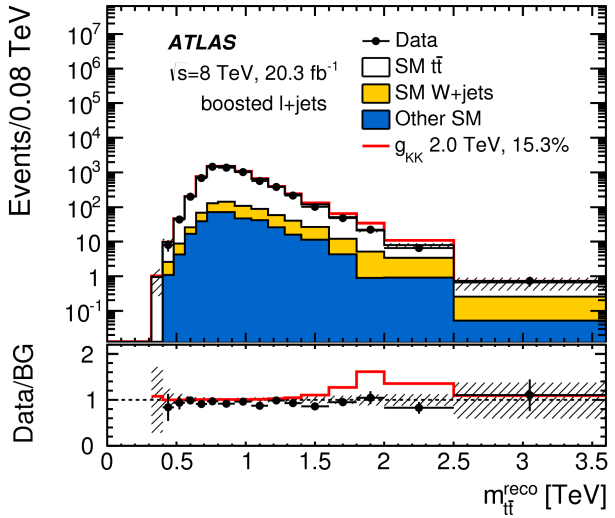


Phenomenological Models (limits [TeV])

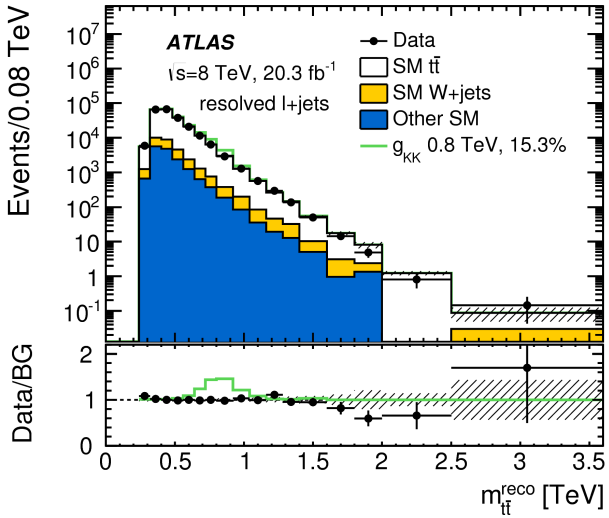
- Topcolour-assisted-technicolour Z'_{TC2} $m_{Z'} > 1.8$ TeV
- Bulk RS Kaluza–Klein gluon, $m_{gKK} > 2.2$ TeV
- Bulk RS Kaluza–Klein graviton, no limits set
- Scalar resonance, no limits set

Accepted by JHEP (2015)
arXiv:1505.07018

Boosted



Resolved



Di-photon

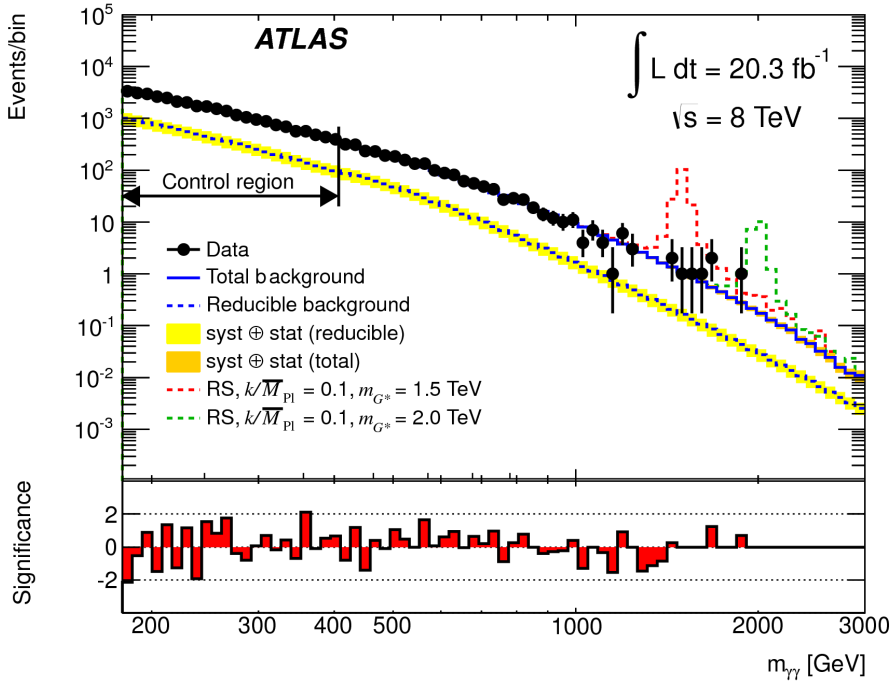
Phys. Rev. D 92, 032004 (2015)
arXiv:1504.05511

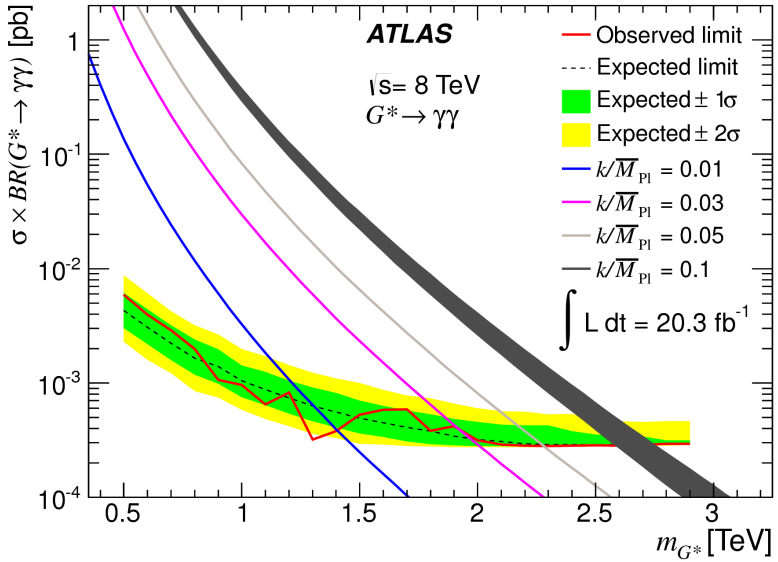
- Randall-Sundrum (RS) Model of extra spacial dimensions, leading to spin-2 gravitons

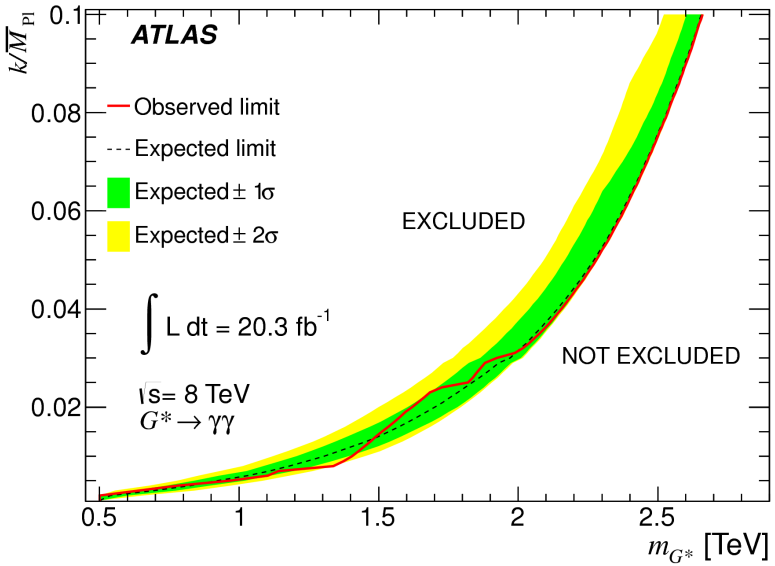
$$m_{G^*} > 2.66 \text{ TeV } (k/\overline{M}_{Pl}=0.1)$$

$$m_{G^*} > 1.41 \text{ TeV } (k/\overline{M}_{Pl}=0.01)$$

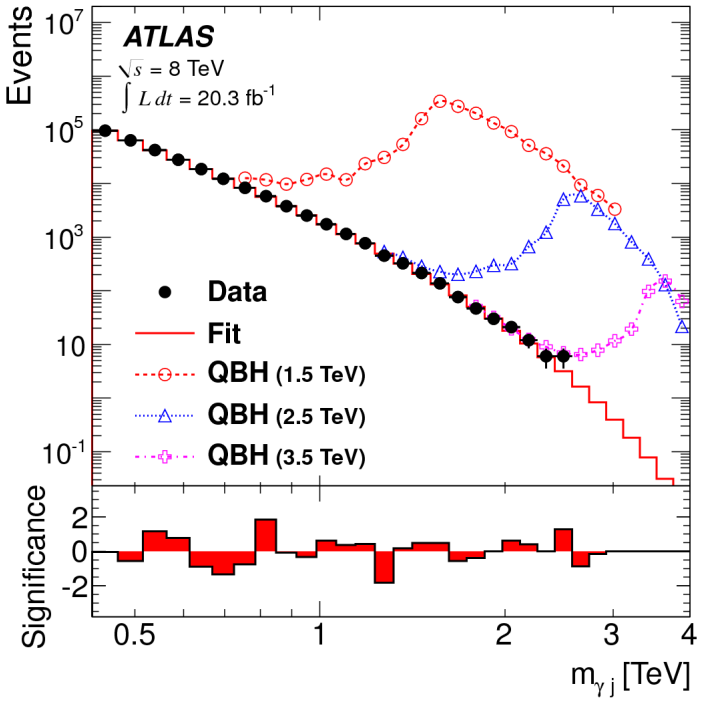
- Di-photon trigger
- Calorimetric isolation
- Shower shape quality

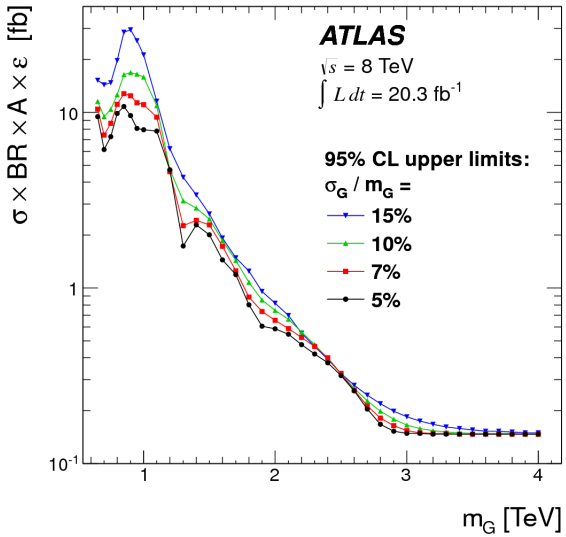




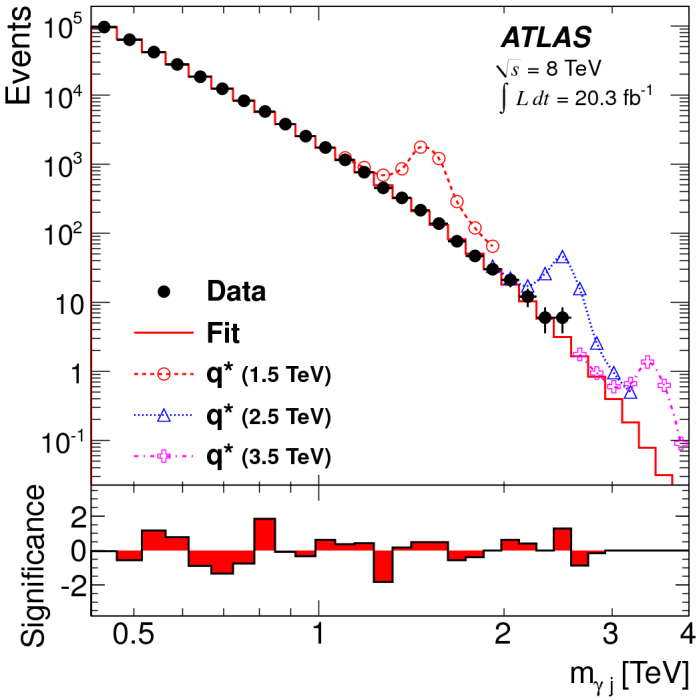


Photon + jet





PLB 728, 562 (2013)
arXiv:1309.3230



Phenomenological Models (limits [TeV])

- QBH model $M_{th} > 4.6$ TeV
- Generic gaussian-shape, exclude m_G of 4 GeV (5% width, visible σ near 0.1)
- Excited-quark model $m_{q^*} > 3.5$ TeV

- One photon and one jet candidate, each with $p_T > 125$ GeV
- Central, isolated photon
- Pseudorapidity $\Delta\eta = |\eta_\gamma - \eta_{jet}| > 1.6$

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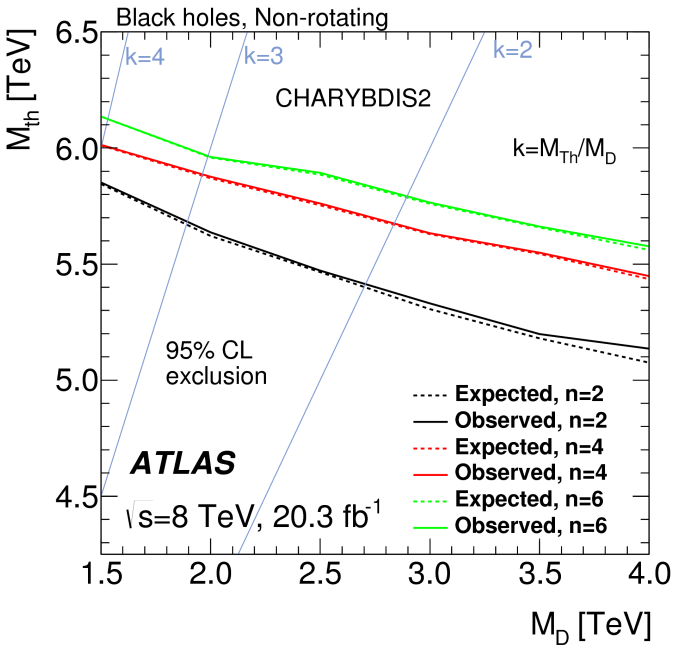
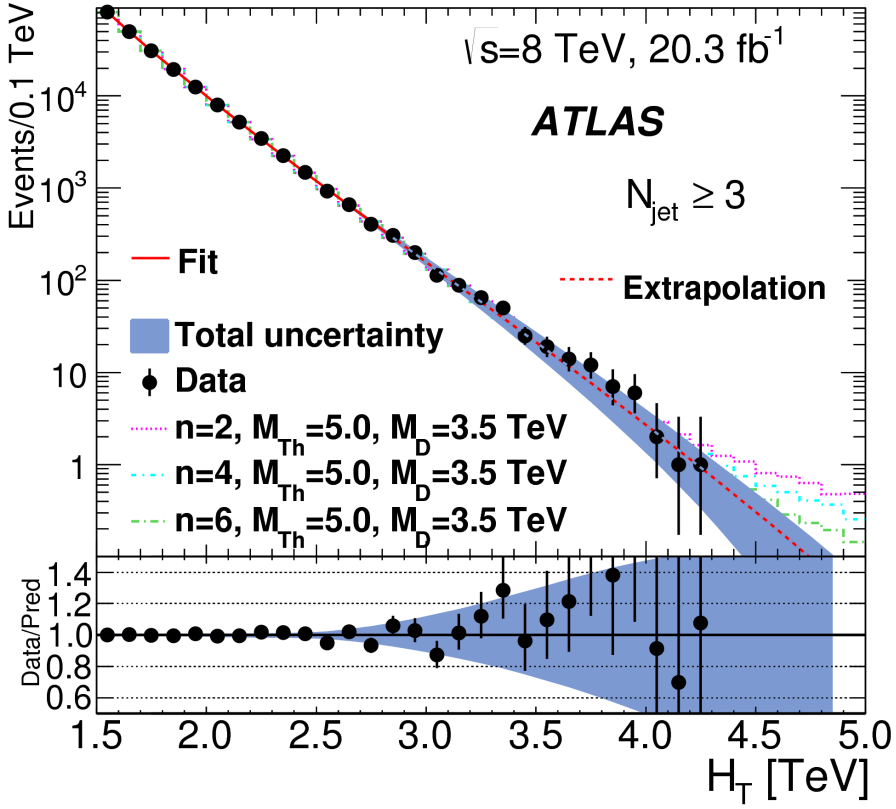
Multi-jets (8 TeV)

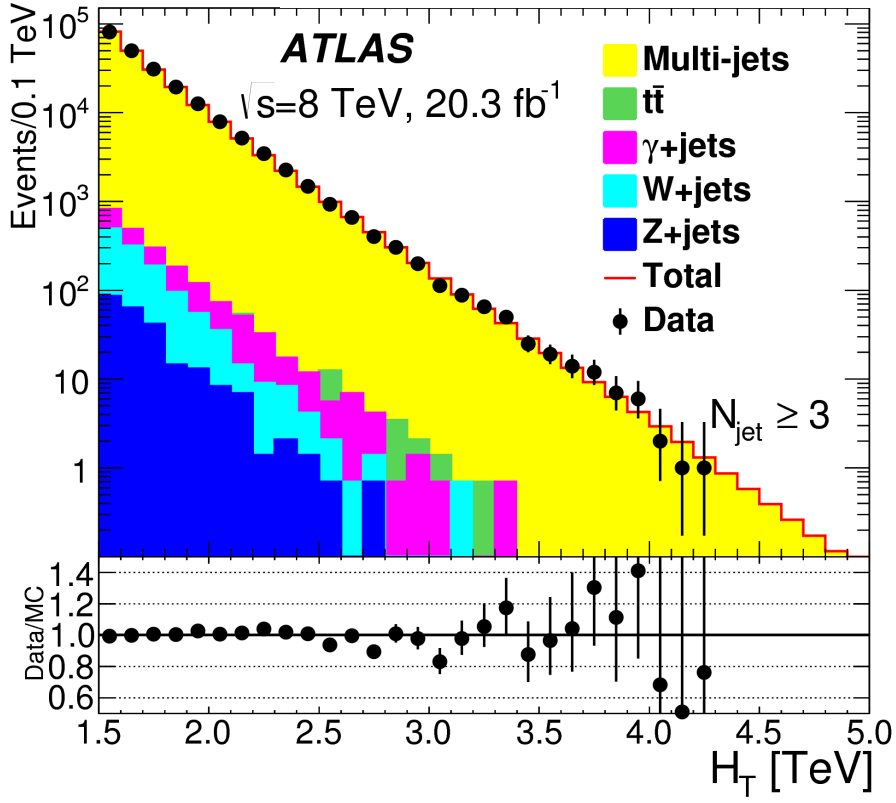
JHEP 07 (2015) 032,
arXiv:1503.08988

H_T is defined as the scalar sum of p_T of jets in the event

- High H_T trigger, efficient > 1.2 TeV (> 1.5 TeV used in analysis)
- Three or more central jets with p_T > 50 GeV
- SM background estimated by low H_T region extrapolation through generators PYTHIA 8, Herwig++, and ALPGEN MC
- Black holes and string balls searched for in most sensitive regions

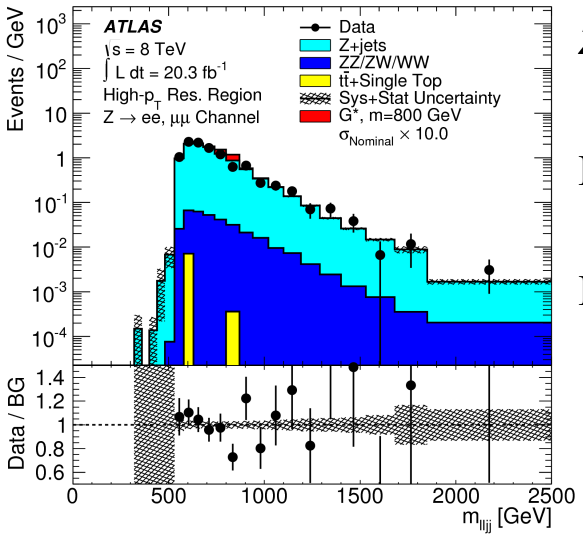






Di-bosons

Eur. Phys. J. C (2015) 75:209, arXiv:1503.04677

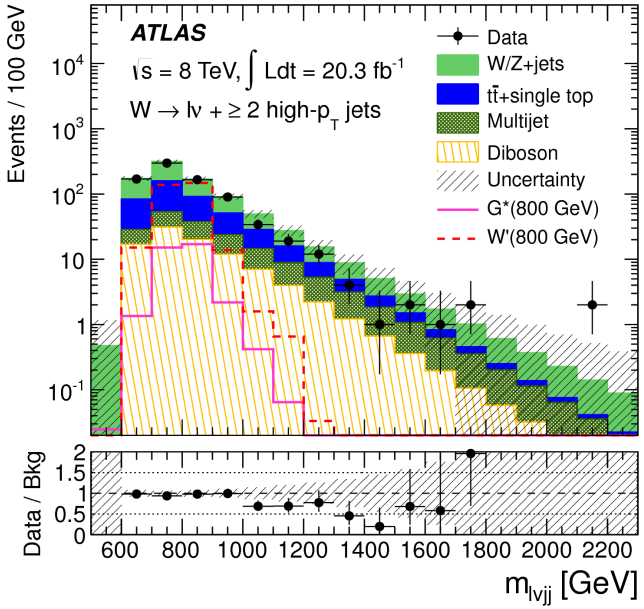


$ZV \rightarrow \ell\ell jj$

Resolved – high or low p_T jets

Leptons or jets in mass window of Z, or Z/W

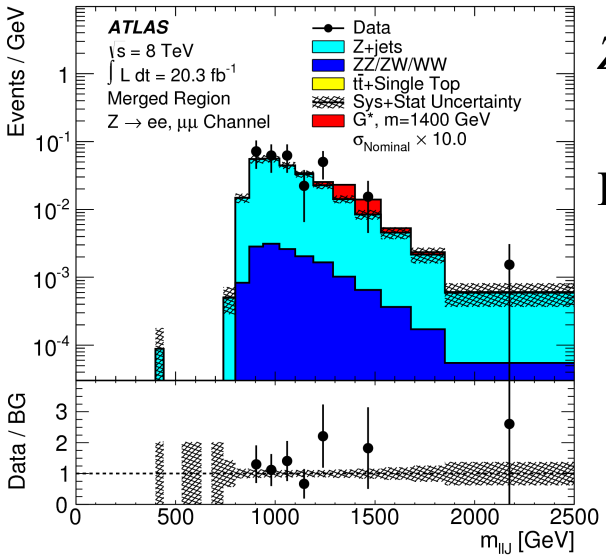
Eur. Phys. J. C (2015) 75:69, arXiv:1409.6190



$WV \rightarrow \ell\nu jj$

Resolved – high or low p_T jets

Lepton + E_T^{miss} or jets in mass window of W, or Z/W

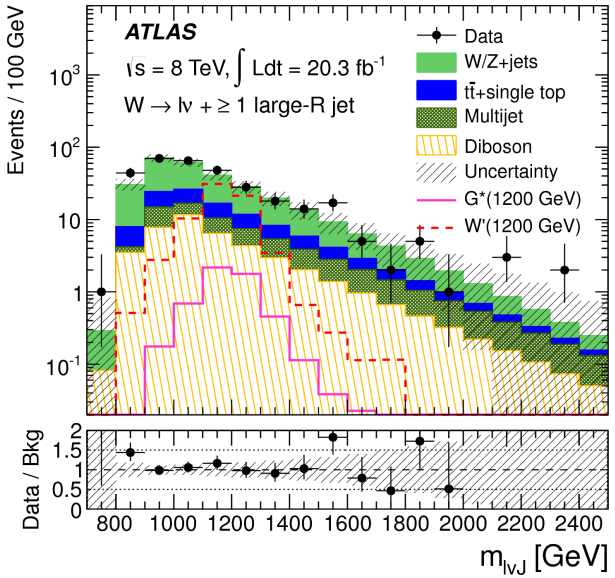


$ZV \rightarrow \ell\ell J$

Boosted – one large Z/W boson jet

$m_{W'} > 1.59$ TeV

$m_{G^*} > 740$ GeV



$WV \rightarrow \ell\nu J$

Boosted – one large Z/W boson jet

$m_{W'} > 1.49$ TeV

$m_{G^*} > 760$ GeV†

†see erratum

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Di-bosons

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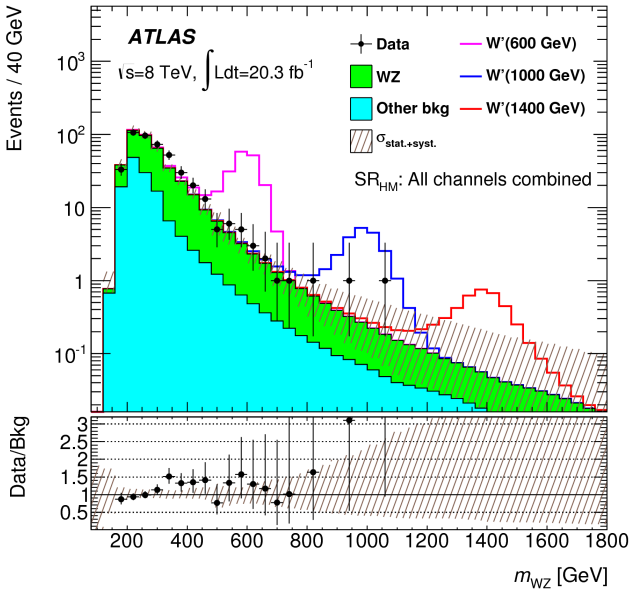
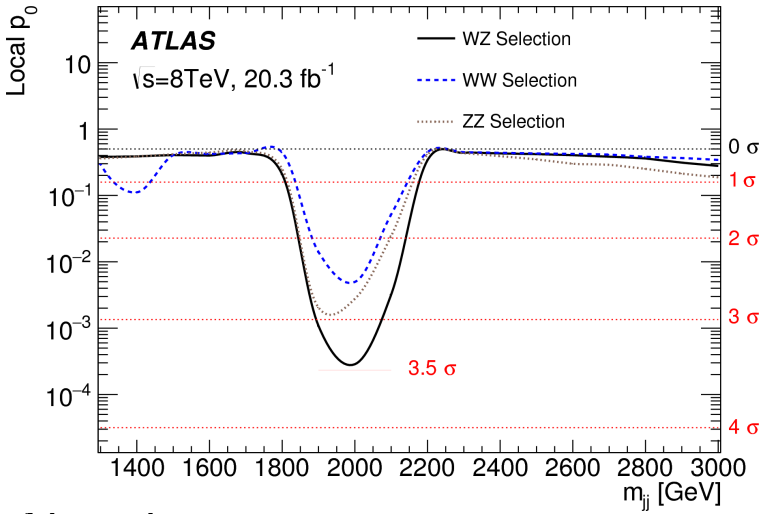


$WZ \rightarrow \ell\nu\ell\ell'$ (low and high mass regions defined with $m_{W'}$, $\Delta\varphi$)

Three charged tracks, Δy separated W, Z bosons

$m_{W'} > 1.52$ TeV

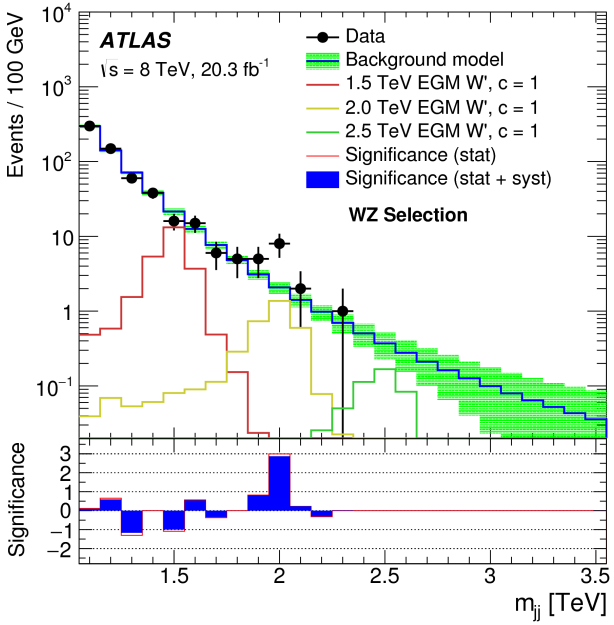
PLB 737, 223 (2014)
arXiv:1406.4456

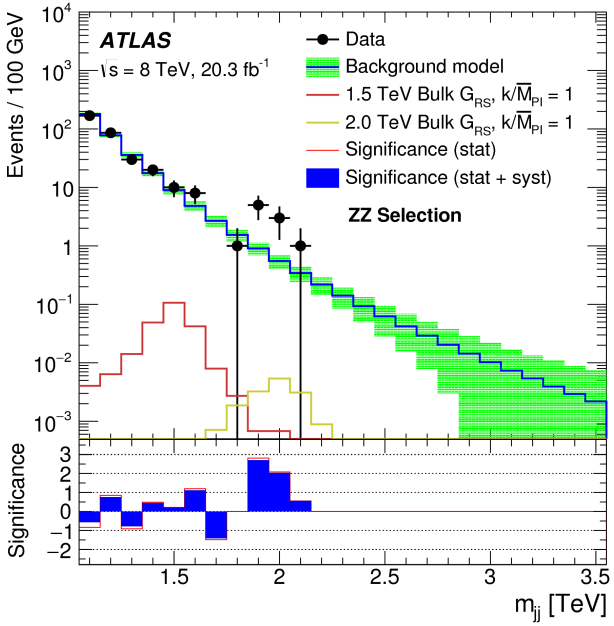


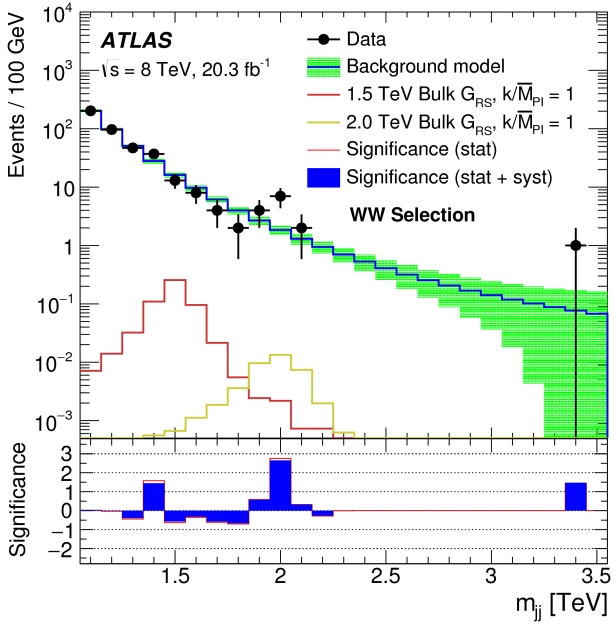
$VV \rightarrow JJ$ (Boosted jets)

High p_T boosted jets selected in regions orthogonal to other di-boson searches

Submitted to JHEP
arXiv:1506.00962

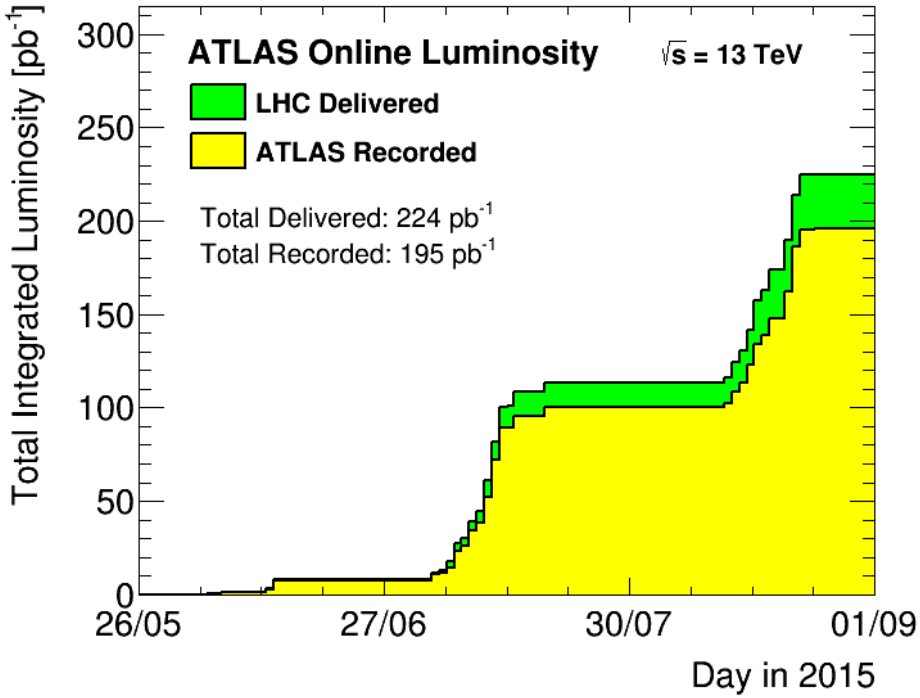


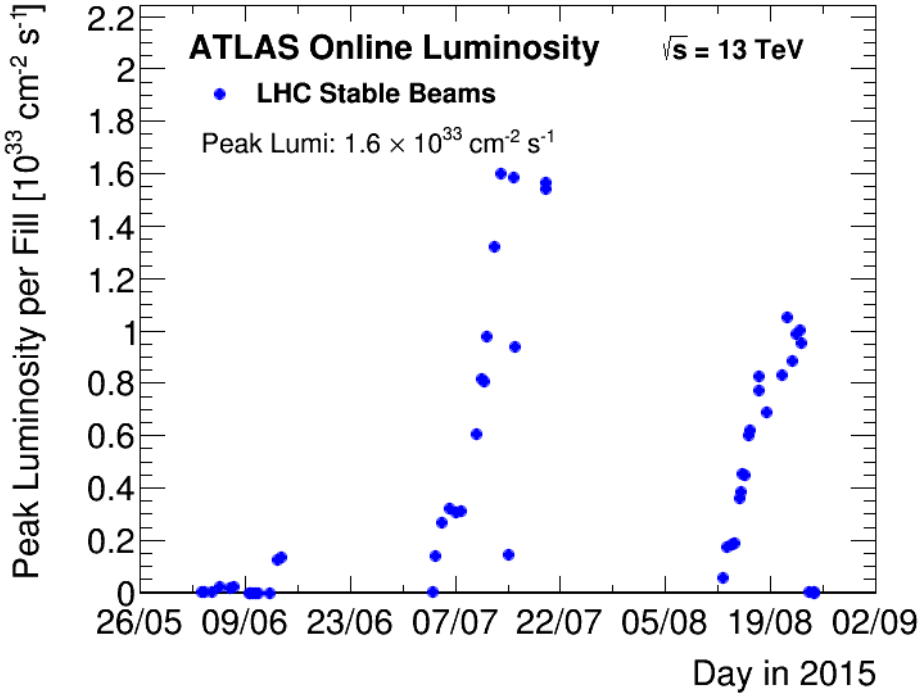




New: Run-2 Results

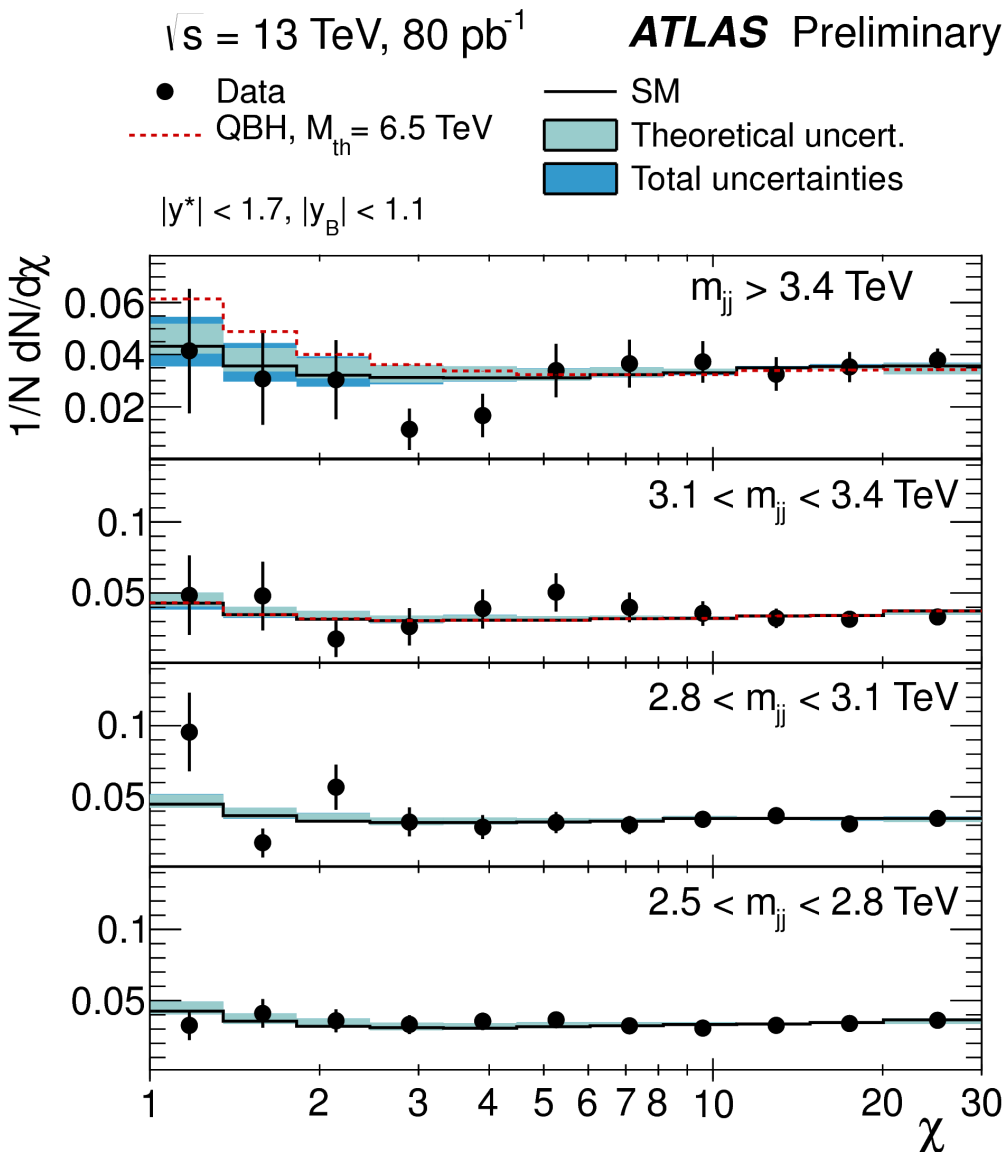
https://twiki.cern.ch/twiki/bin/view/AtlasPublic/LuminosityPublicResultsRun2

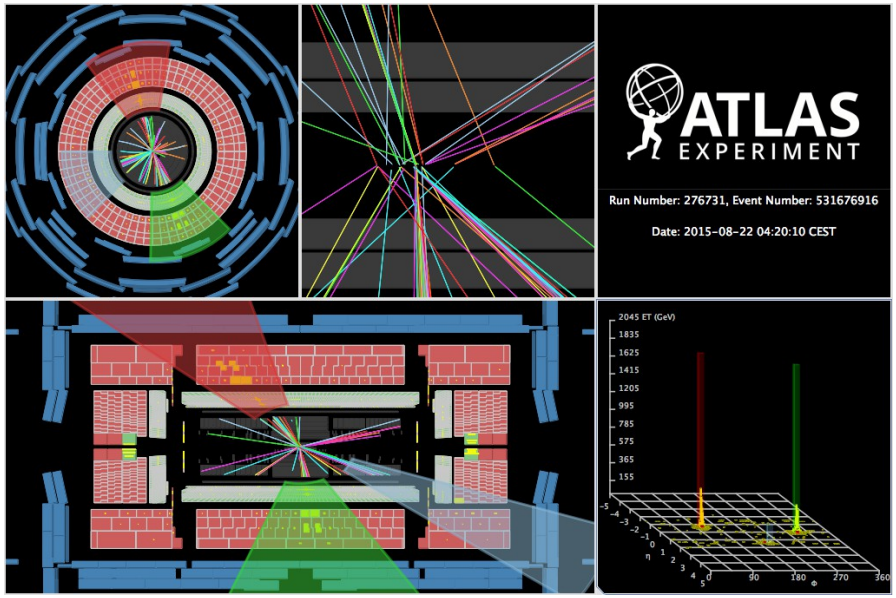


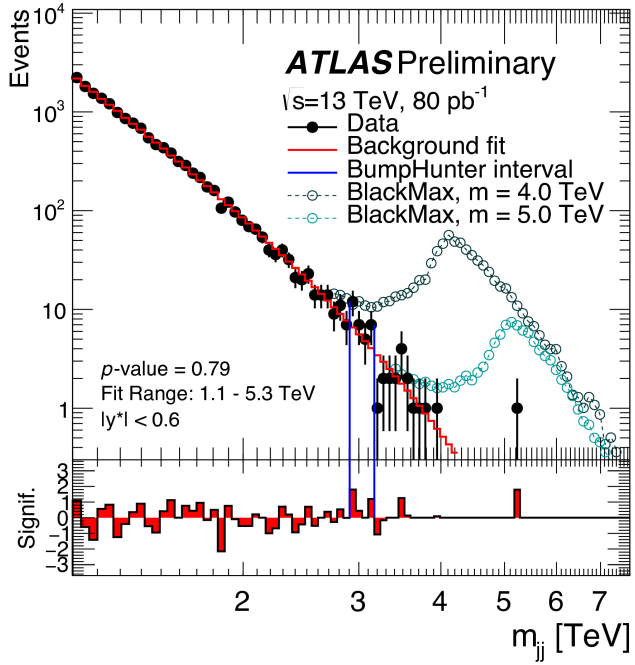


Di-jets (13 TeV)

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2015-042/

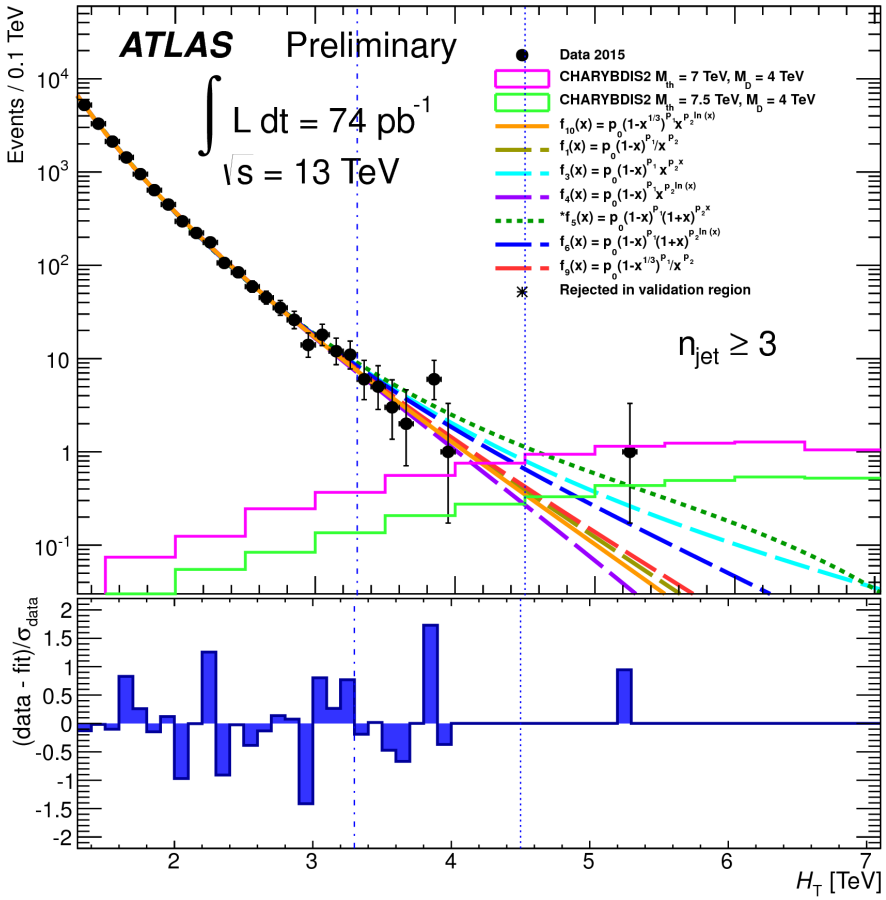


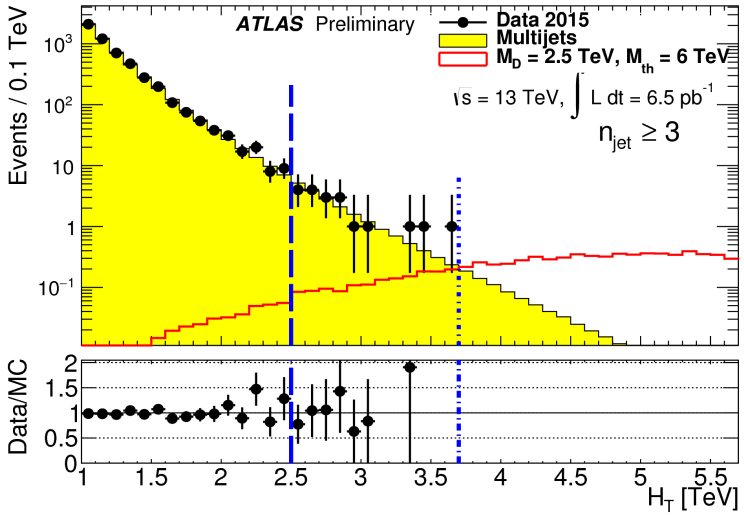


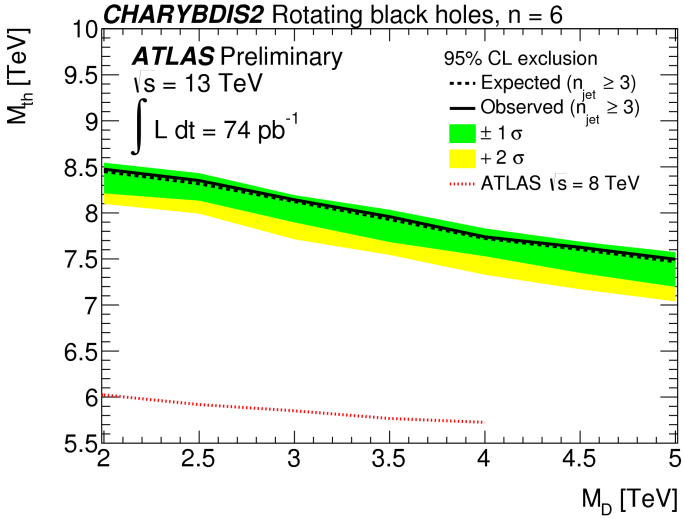


Multi-jets (13 TeV)

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2015-043/







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Conclusion

ATLAS EXPERIMENT

- Searches through many final states
- No significant excesses in any channels
  - Potential hints of new physics in di-boson channels
  - Very good agreement between data and Monte Carlo shapes in lepton + MET, di-lepton and multi-jets
- Excellent performance ATLAS Run-1
- New opportunities upcoming in Run-2
  - First data analyzed
  - Run-1 sensitivities should hopefully be exceeded by end of 2015

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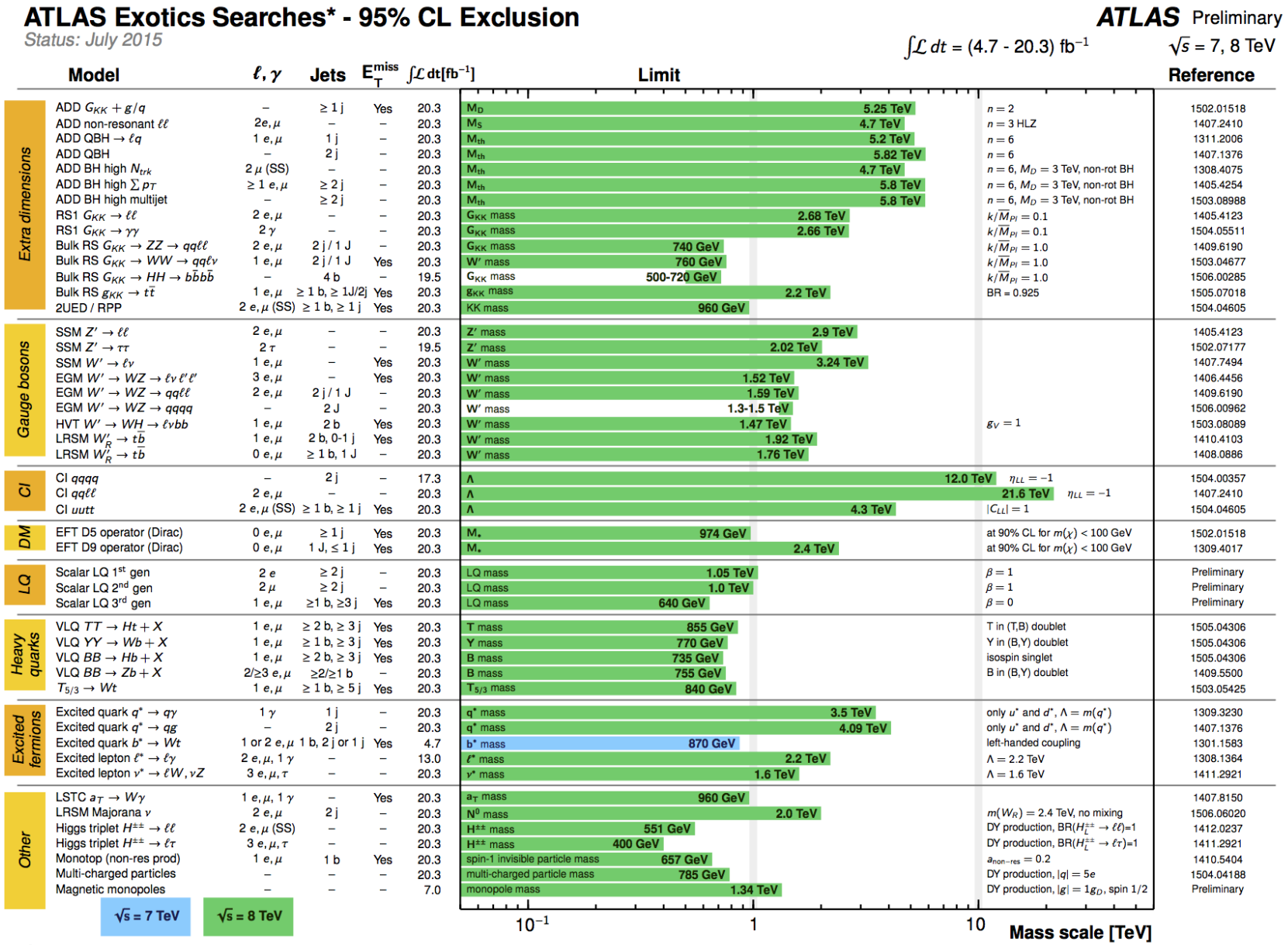
Full Exotics search summary

ATLAS EXPERIMENT



*Only a selection of the available mass limits on new states or phenomena is shown.