Highlights of ATLAS 13 TeV 2015 LHC Run2 Results

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Outline

- SM EW
- SM Top
- SM Higgs
- BSM Higgs Search
- SUSY Search
- Dark Matter Search
- Exotic Search
- Diboson Resonance

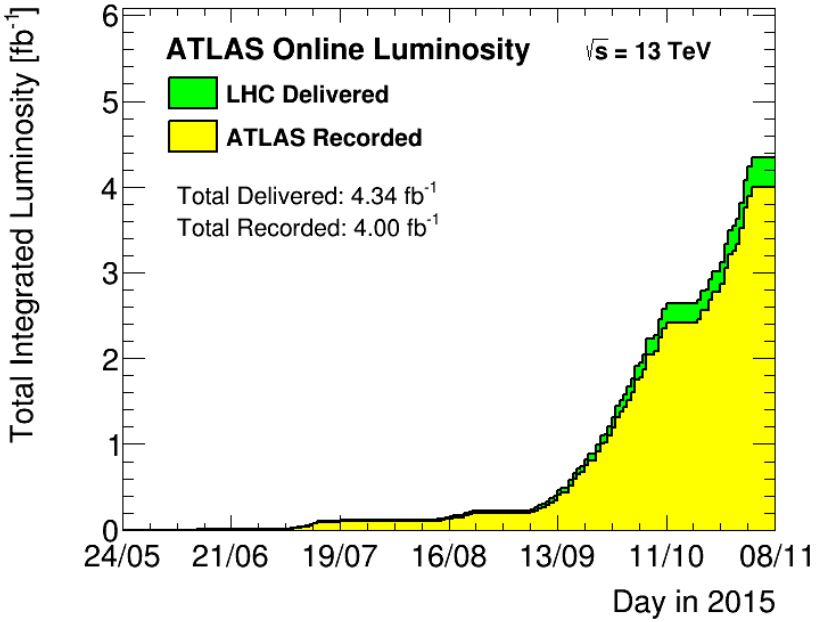
The France-China Particle Physics Laboratory (FCPPL)

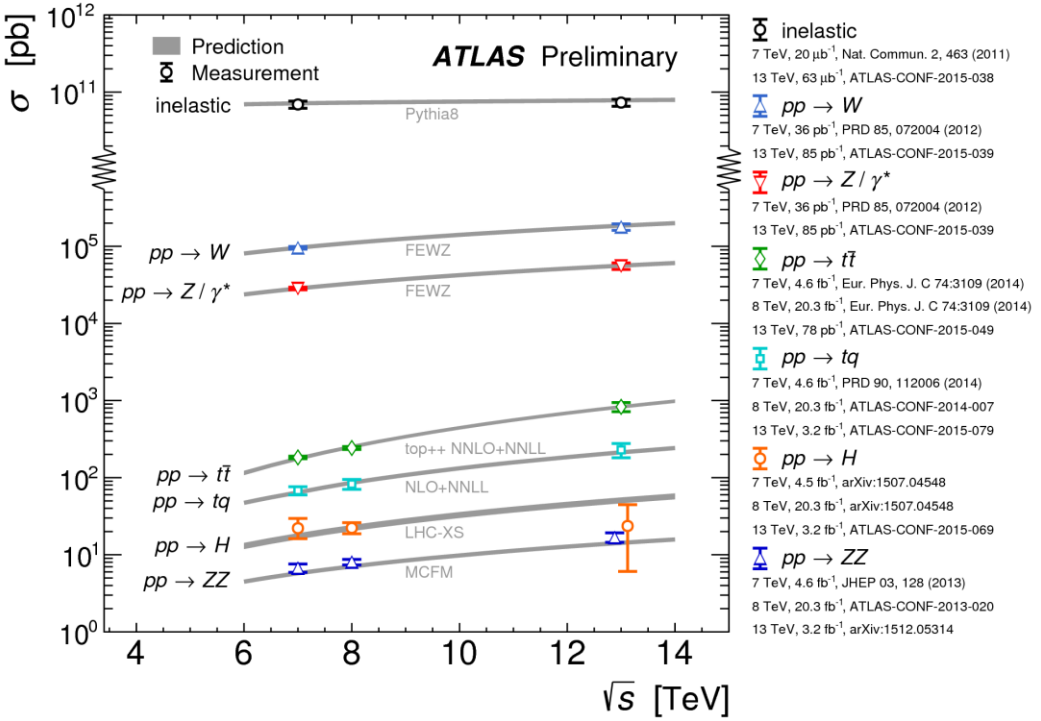
Strasbourg, France

March 30 – April 2, 2016

LHC Restart at 13 TeV (Run2) in 2015

- LHC restart: April 2, 2015
- Proton beams circulating at 450 GeV: April 5, 2015
- Proton beam energy reaches 6.5 TeV: April 10, 2015
- ATLAS accumulated 4 fb^{-1} data: November 4, 2015
- LHC EOYE results: December 15, 2015

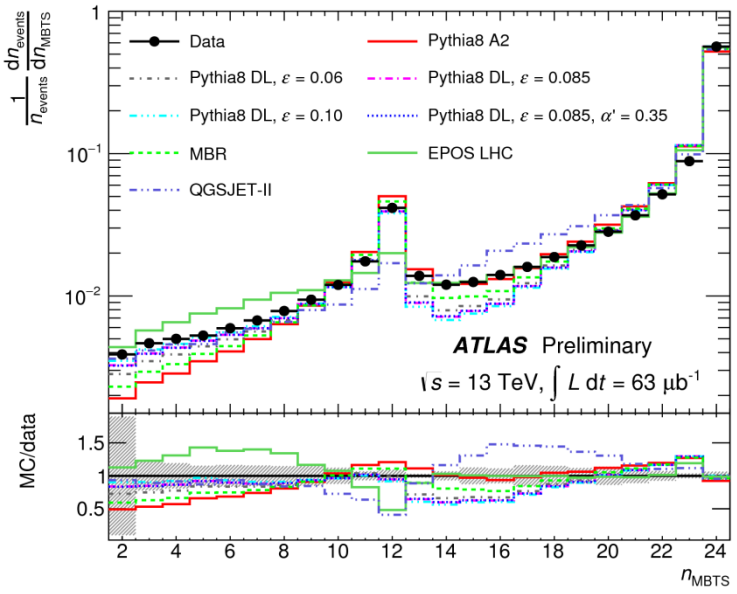




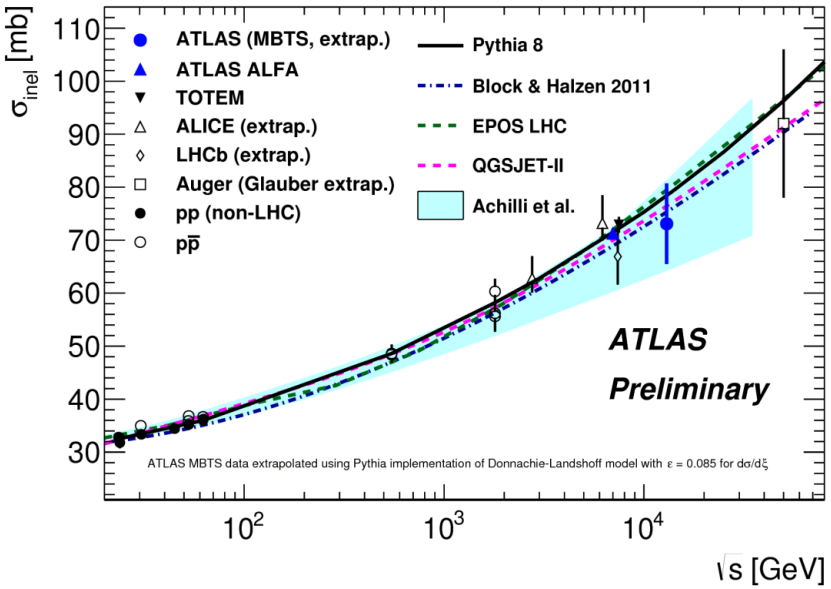
Inelastic pp Cross Section

- Using low pileup dataset ($\mu < 0.05$)
- Analysis with new MBTS scintillators ($2.1 < |\eta| < 3.9$)
- Result dominated by luminosity uncertainty (~9%)
- 4.2M events selected in 63 μb^{-1}, estimated 1% background

N_{MBTS} above threshold (Data vs. MCs)



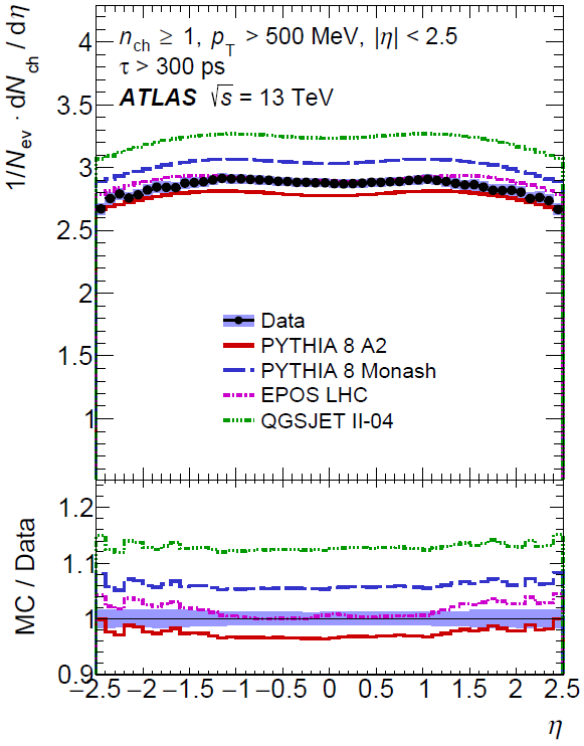
$73.1 \pm 0.9\,(\text{exp.}) \pm 6.6\,(\text{lum.}) \pm 3.8\,(\text{extr.})$ mb

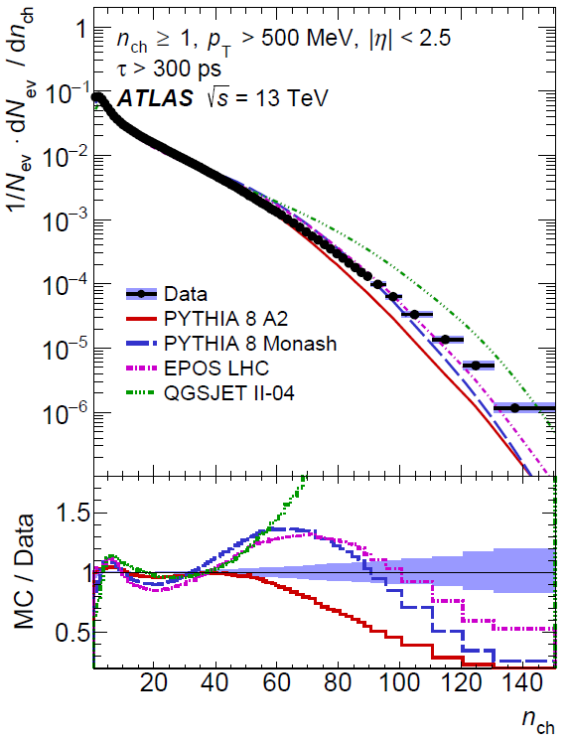


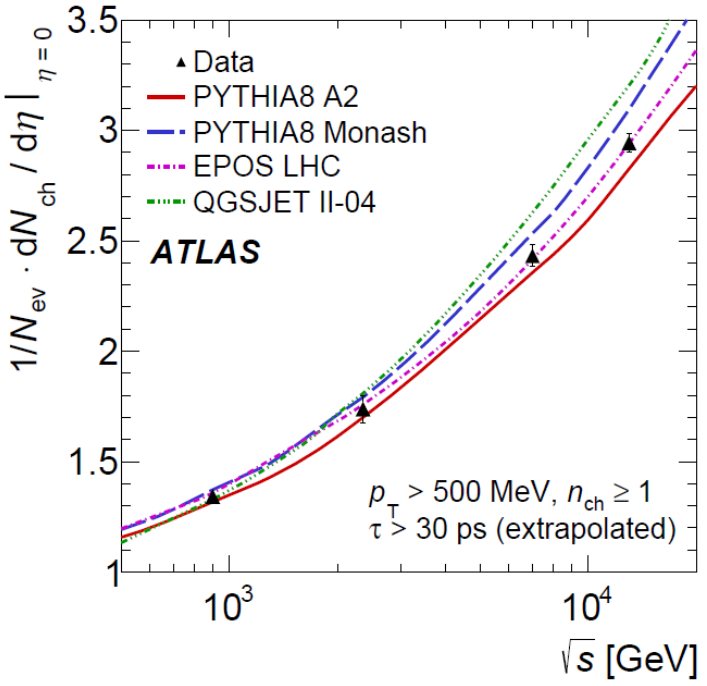
Charged-particle Multiplicity

arXiv:1602.01633

- Inclusive charged-particle measurements in pp collisions provide insight into the strong interaction in the low-energy, non-perturbative region of QCD.
- Charged-particle multiplicity for events with $n_{ch} \geq 1$, $p_T > 500$MeV, $|\eta| < 2.5$ validate pileup modeling for early analysis at 13 TeV at Run2.
- Int. Lumi = 170 μb^{-1}, data sample of about 9M events
- **The results highlight clear difference between MC models and measured distributions.**







W/Z Cross Section

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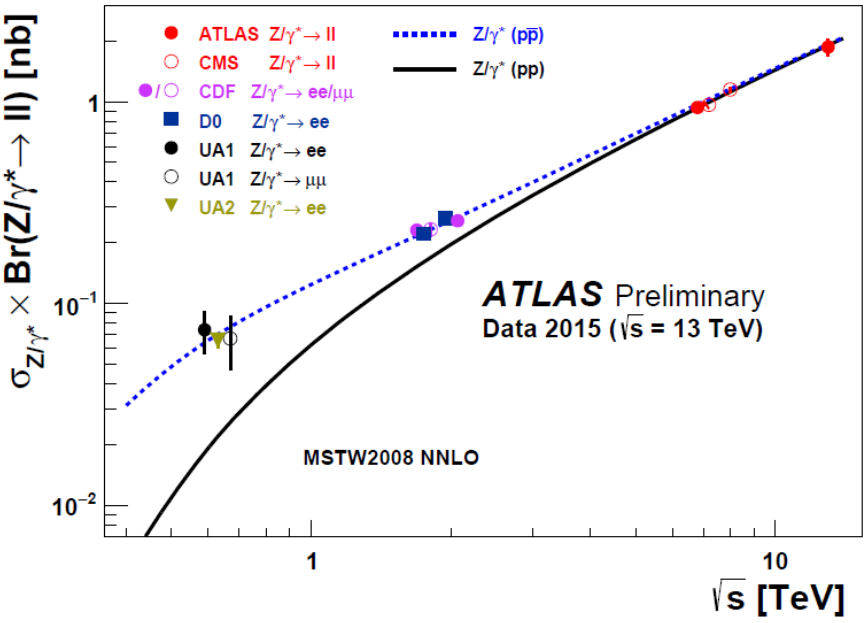
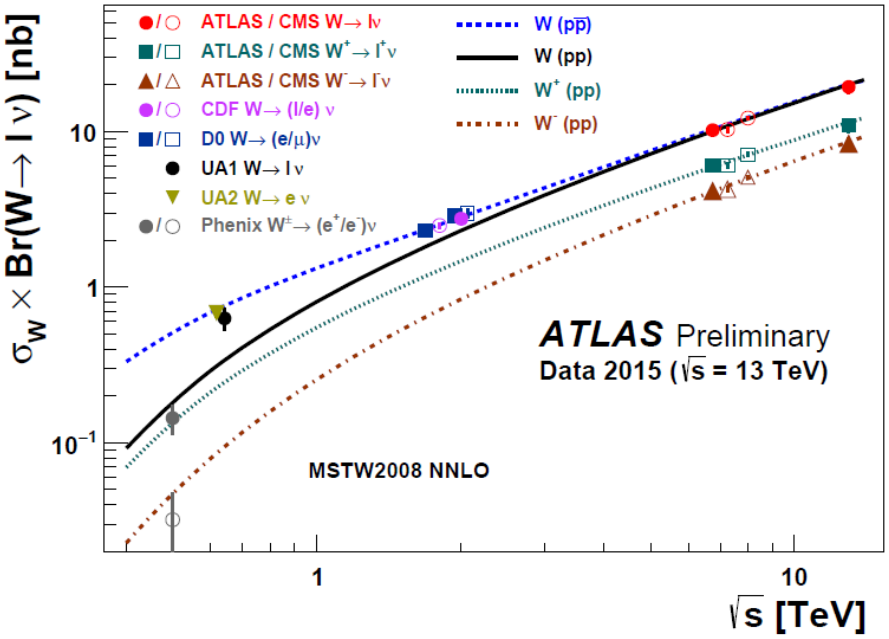
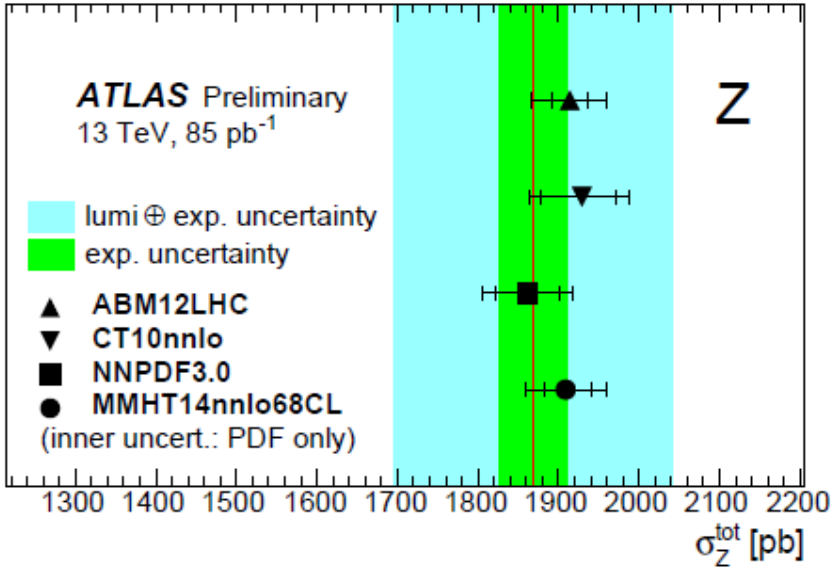
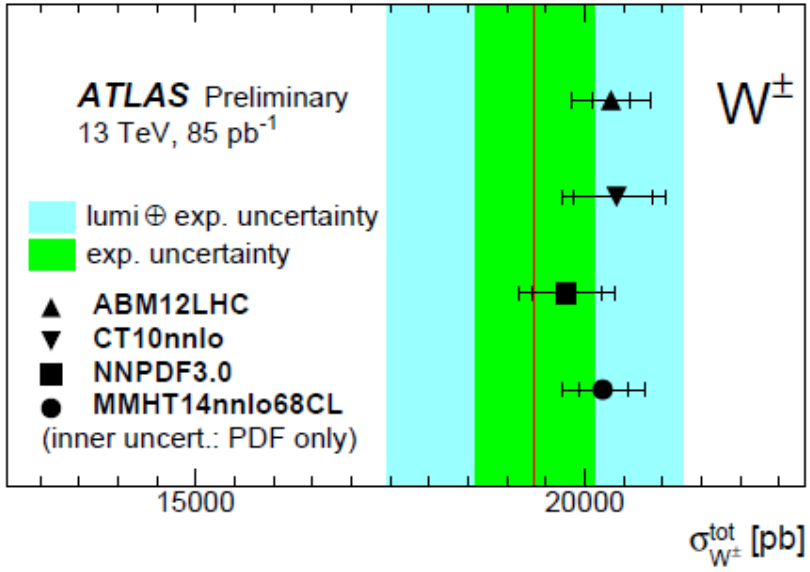


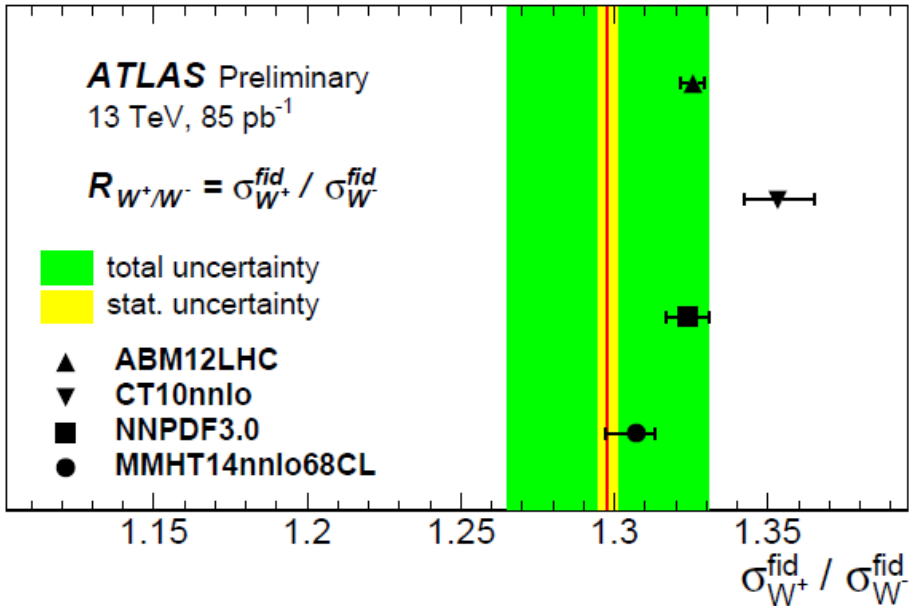




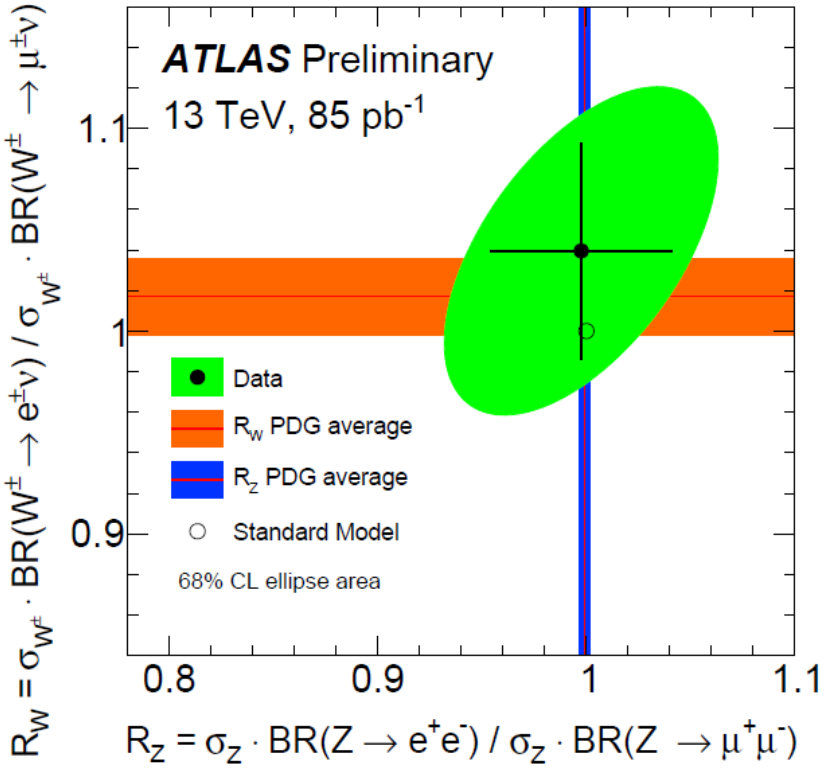


W/Z Production

- **Ratio of W^+ to W^- production fiducial cross sections (red) compared to predictions based on different PDF sets.**



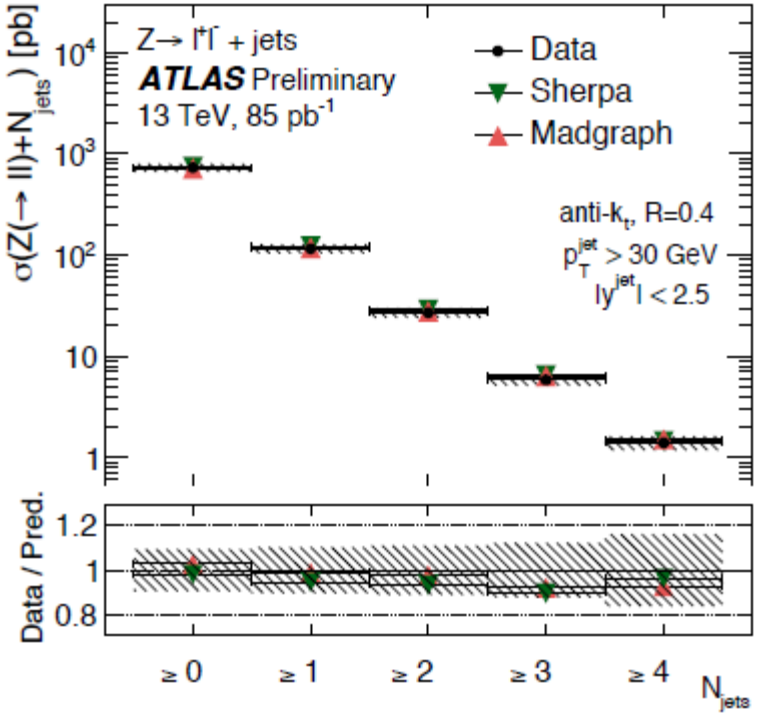
- **Ratio of the electron- and muon-channel measurements of the Z and W boson, experimental check of the lepton universality**

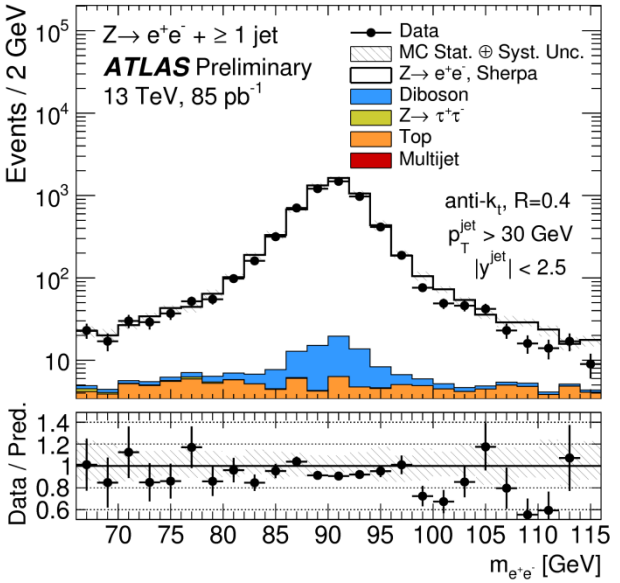


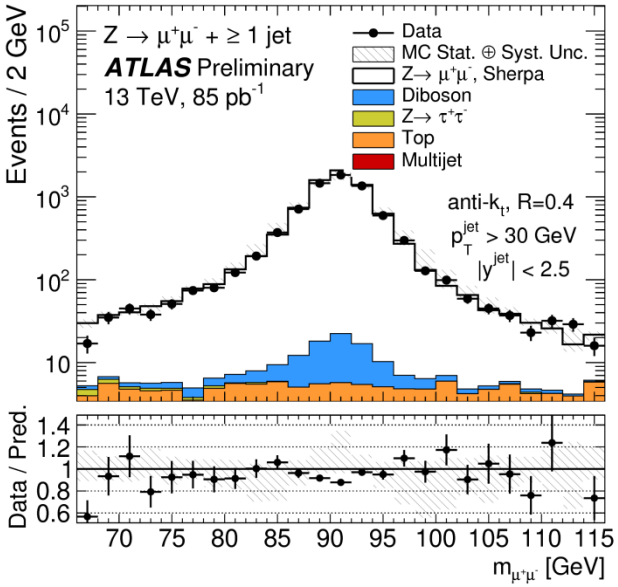
Z + Jets Cross Section

ATLAS-CONF-2015-041

- Inclusive Z event selection
- Particle-level fiducial cross section
  - Jet P_T > 30 GeV, |y|<2.5
- Main backgrounds from top, diboson
- Systematics dominated by Lumi, Jets







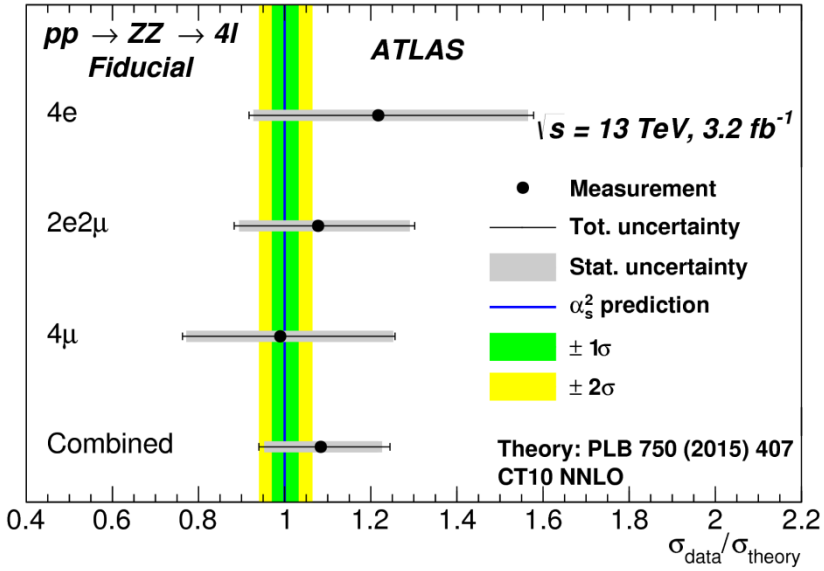
ZZ Cross Section

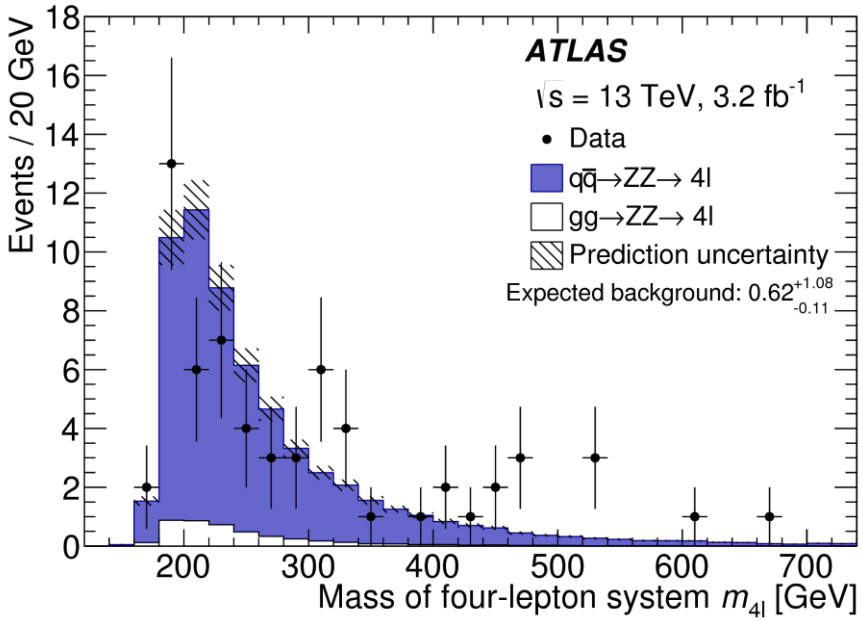
Phys. Rev. Lett. 116, 101801 (2016)

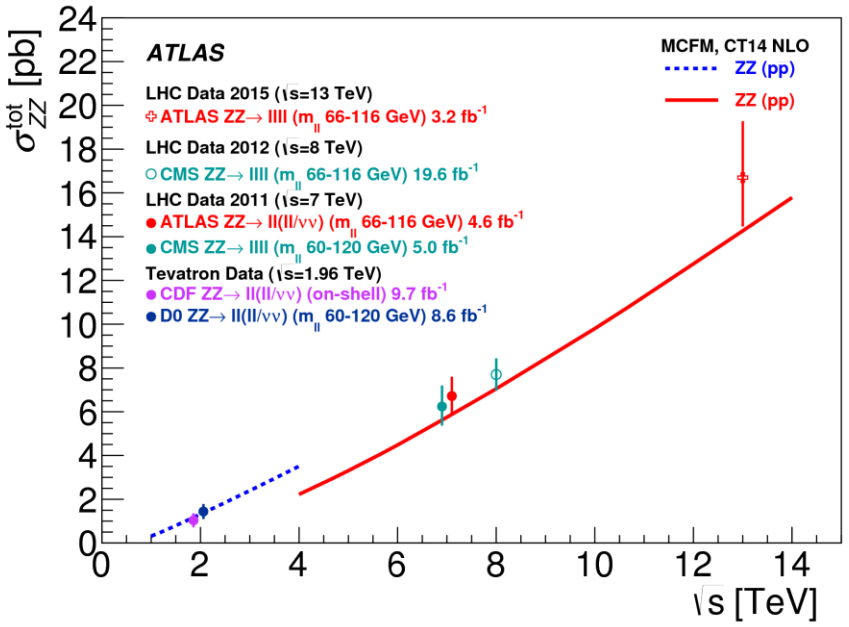
- ZZ→4ℓ, P_T>20 GeV, |η|<2.47(2.4)
- $M_{ZZ} \in$ 66-116 GeV
- Observed 63 events, N_{bg}=0.62

$$\sigma_{ZZ}^{tot}\ \text{(theory)} = 15.6^{+0.4}_{-0.4}\ \text{pb}$$

$$16.7\ ^{+2.2}_{-2.0}(\text{stat.})\ ^{+0.9}_{-0.7}(\text{syst.})\ ^{+1.0}_{-0.7}(\text{lumi.})\ \text{pb}$$







Top pair cross section

ATLAS-CONF-2016-005

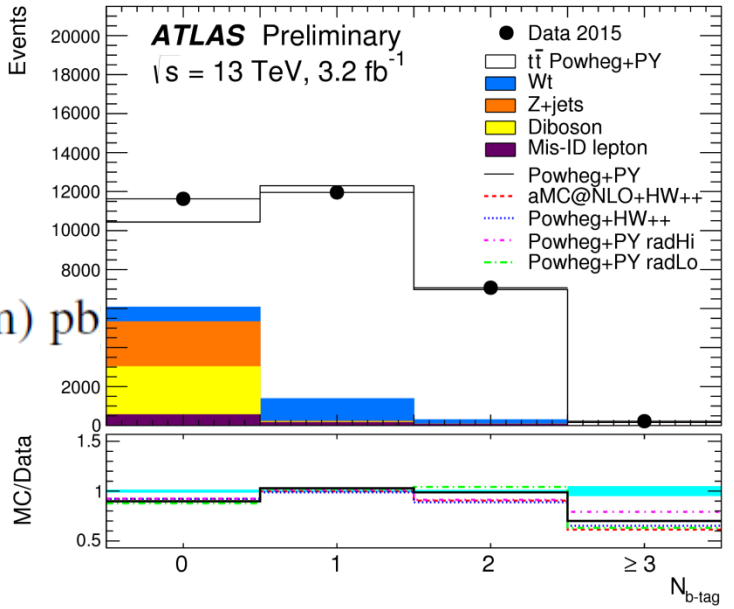
➔ tt ➔ bbWW ➔ bb eμνν (OS-eμ)

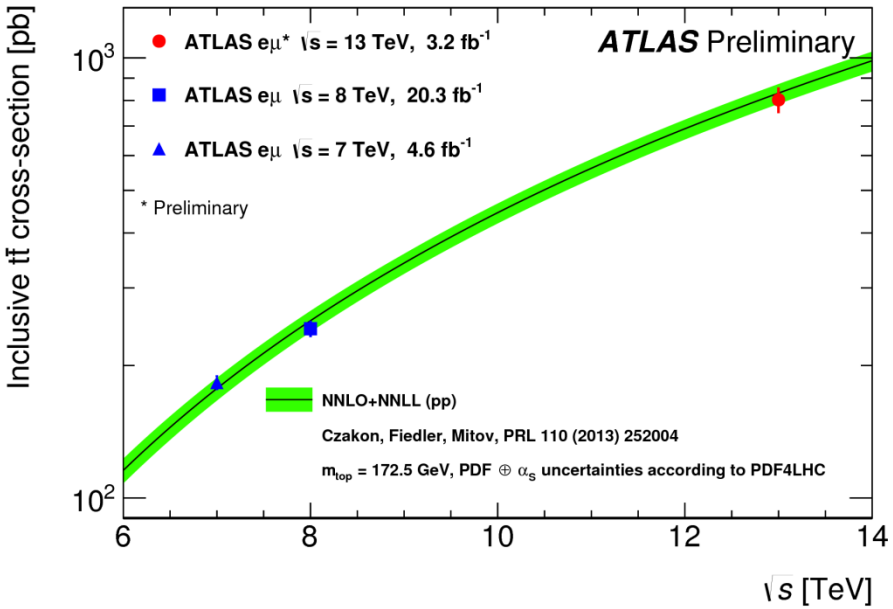
➔ 1 or 2 b-tag jets using MV2c20 @70%

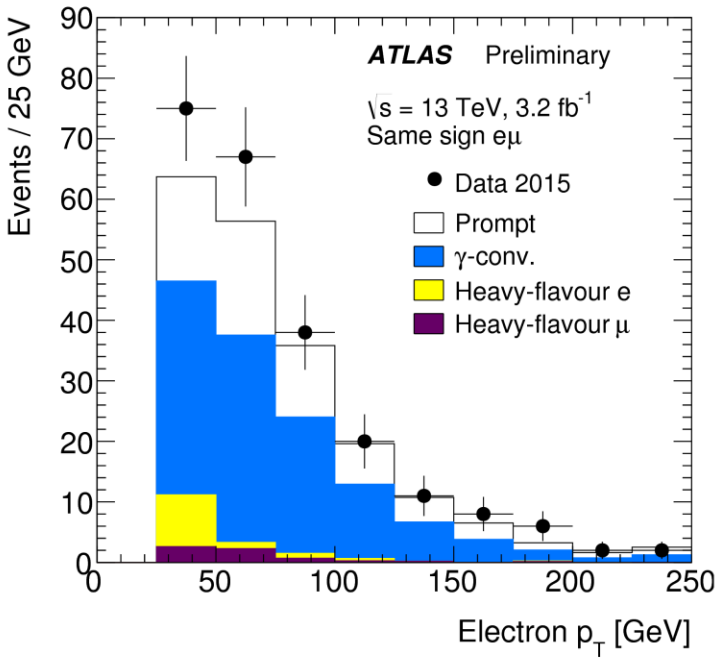
$$\sigma_{t\bar{t}} = 803 \pm 7\ (\text{stat}) \pm 27\ (\text{syst}) \pm 45\ (\text{lumi}) \pm 12\ (\text{beam})\ \text{pb}$$

➔ Measured cross section agrees well with NNLO+NNLL theoretical prediction

$$\sigma_{t\bar{t}}^{\text{NNLO+NNLL}} = 832^{+40}_{-46}\ \text{pb}$$



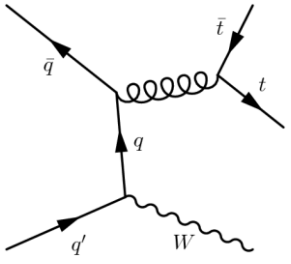


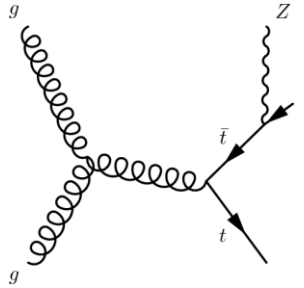


ttW and ttZ Cross Section

ATLAS-CONF-2016-003

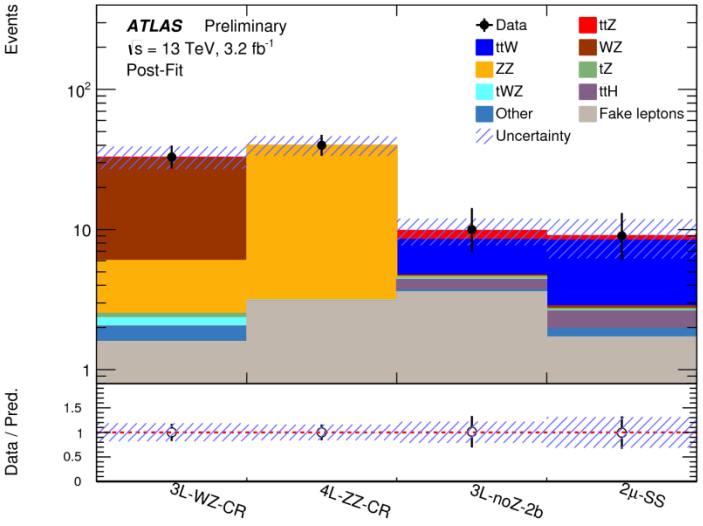
- **SS dilepton channel targets ttW production**
- **Trilepton and tetralepton channels are sensitive to ttZ production**

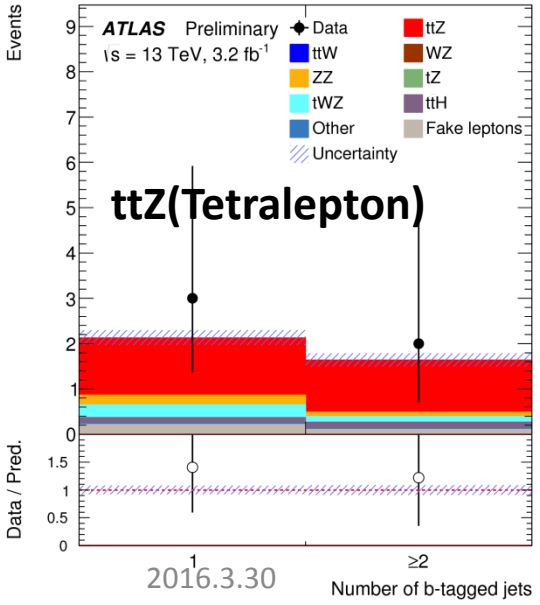


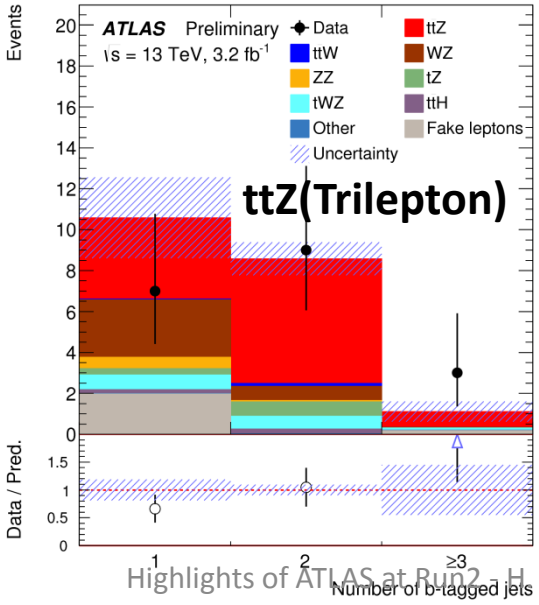


Process	$t\bar{t}$ decay	Boson decay	Channel
$t\bar{t}W^{\pm}$	$(\mu^{\pm}\nu b)(q\bar{q}b)$	$\mu^{\pm}\nu$	SS dimuon
	$(\ell^{\pm}\nu b)(\ell^{\mp}\nu b)$	$\ell^{\pm}\nu$	Trilepton
$t\bar{t}Z$	$(\ell^{\pm}\nu b)(q\bar{q}b)$	$\ell^{+}\ell^{-}$	Trilepton
	$(\ell^{\pm}\nu b)(\ell^{\mp}\nu b)$	$\ell^{+}\ell^{-}$	Tetralepton

$$\sigma_{t\bar{t}Z} = 0.9 \pm 0.3 \text{ pb}$$







ttW (SS-dimuon):

N_{obs}=9, N_{bg}=2.9, N_{ttZ}=0.65, N_{ttw} = 5.45

ttW (Trilepton):

N_{obs}=10, N_{bg}=4.7, N_{ttZ}=1.4, N_{ttw} = 3.7

$$\sigma_{t\bar{t}W} = 1.4 \pm 0.8 \text{ pb}$$

SM Higgs and BSM Higgs

- Higgs cross section
- Higgs → di-photon
- High mass Higgs → di-photon
- Higgs → ZZ* → 4l
- High mass Higgs → ZZ* → 4l, 2l2q, 2l2ν
- High mass resonance X → WH, ZH
- Double Higgs HH → bb$\gamma\gamma$, bbbb
- MSSM H/A →$\tau\tau$

Higgs Cross Section

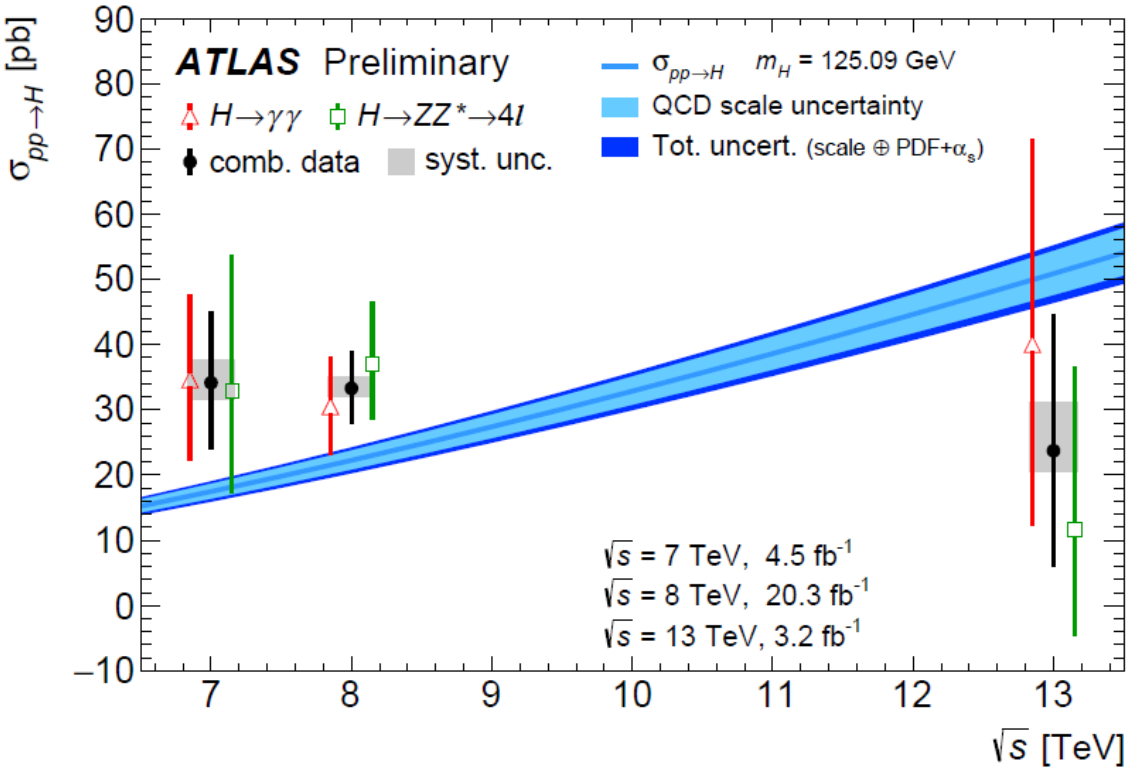
ATLAS-CONF-2015-069

- Total cross sections are measured for H→γγ, H→ZZ*→4ℓ using 7, 8 and 13 TeV data

Total cross section [pb]	7 TeV	8 TeV	13 TeV
$H \to \gamma\gamma$	35^{+13}_{-12}	$30.5^{+7.5}_{-7.4}$	40^{+31}_{-28}
$H \to ZZ^* \to 4\ell$	33^{+21}_{-16}	37^{+9}_{-8}	12^{+25}_{-16}
Combination	34 ± 10 (stat.) $^{+4}_{-2}$ (syst.)	$33.3^{+5.5}_{-5.3}$ (stat.) $^{+1.7}_{-1.3}$ (syst.)	24^{+20}_{-17} (stat.) $^{+7}_{-3}$ (syst.)
LHC-XS	17.5 ± 1.6	22.3 ± 2.0	$50.9^{+4.5}_{-4.4}$

- LHC-XS theory predictions based on Higgs mass of 125.09 GeV, and calculation up to NNLO in QCD.

➔ The measured cross sections are compatible within quoted uncertainties.



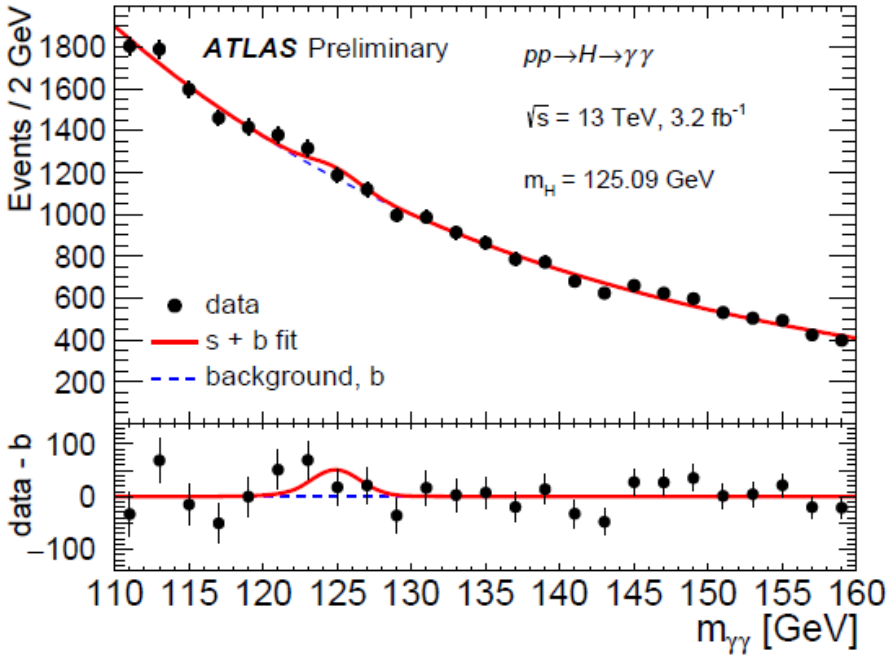
Higgs → di-photon

ATLAS-CONF-2015-060

- For m_H=125.09 GeV, the expected S/B ratio is 4.2% for 90% of signal.
- The observed (expected) significance above no-signal hypothesis is 1.5σ (1.9σ)

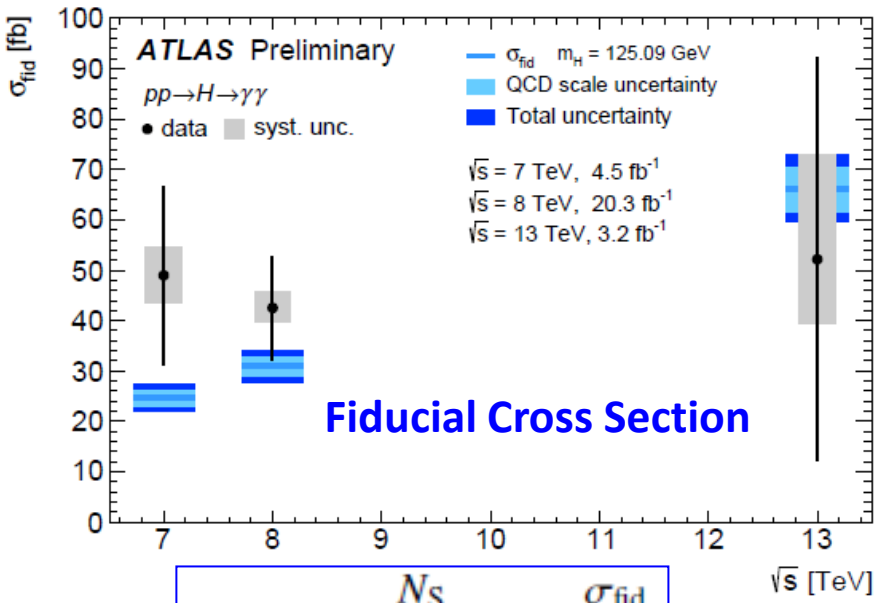
$$N_{exp} = 143 \pm 71\,(stat.)\,^{+39}_{-6}\,(syst.)$$

$$N_S = 113 \pm 74\,(stat.)\,^{+43}_{-25}\,(syst.)$$



Fiducial Selection Cuts

Two highest-p_T photons:	$\lvert\eta^\gamma\rvert < 2.37$
Relative-p_T:	$E^\gamma_{T,1}/m_{\gamma\gamma} \geq 0.35$, $E^\gamma_{T,2}/m_{\gamma\gamma} \geq 0.25$
Mass window:	$105\,\text{GeV} \leq m_{\gamma\gamma} < 160\,\text{GeV}$
Photon isolation:	$E_{T,iso} < 0.1 \times E^\gamma_T + 1\,\text{GeV}$



Fiducial Cross Section

$$\sigma_{tot} = \frac{N_S}{\mathcal{L}_{int}\,\mathcal{B}\,\mathcal{A}\,C} = \frac{\sigma_{fid}}{\mathcal{B}\,\mathcal{A}}$$

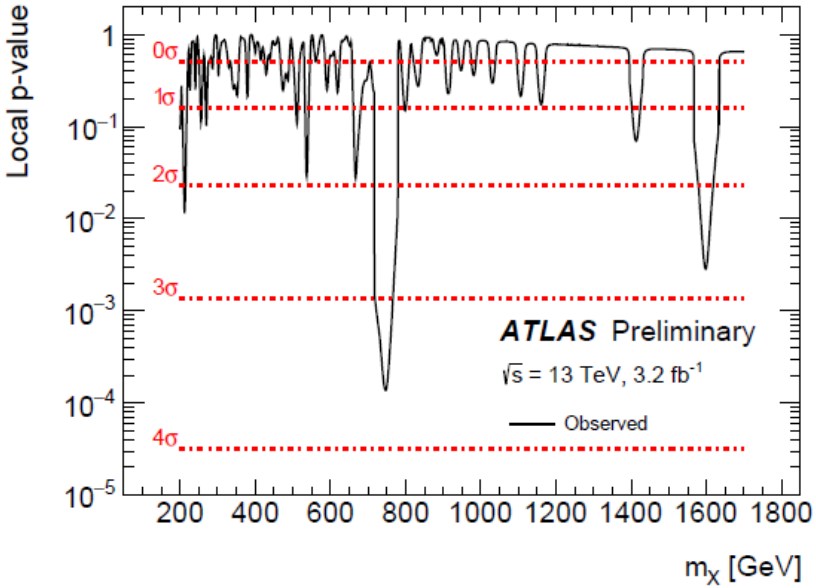
$\sqrt{s}$	Measured total cross section [pb]	LHC-XS prediction [pb]
7 TeV	35 ± 12 (stat.) ± 4 (syst.) ± 1 (lumi.)	17.5 ± 1.6
8 TeV	30.5 ± 7.1 (stat.) $^{+2.6}_{-2.5}$ (syst.) ± 0.9 (lumi.)	22.3 ± 2.0
13 TeV	40 ± 26 (stat.) $^{+16}_{-10}$ (syst.) ± 2 (lumi.)	$50.9\,^{+4.5}_{-4.4}$

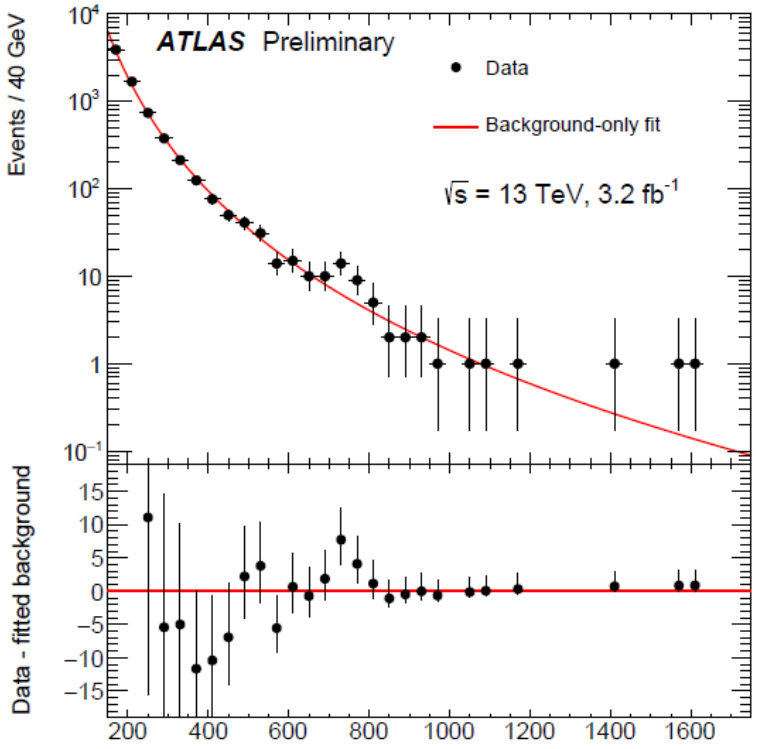
Search for resonance X → γγ

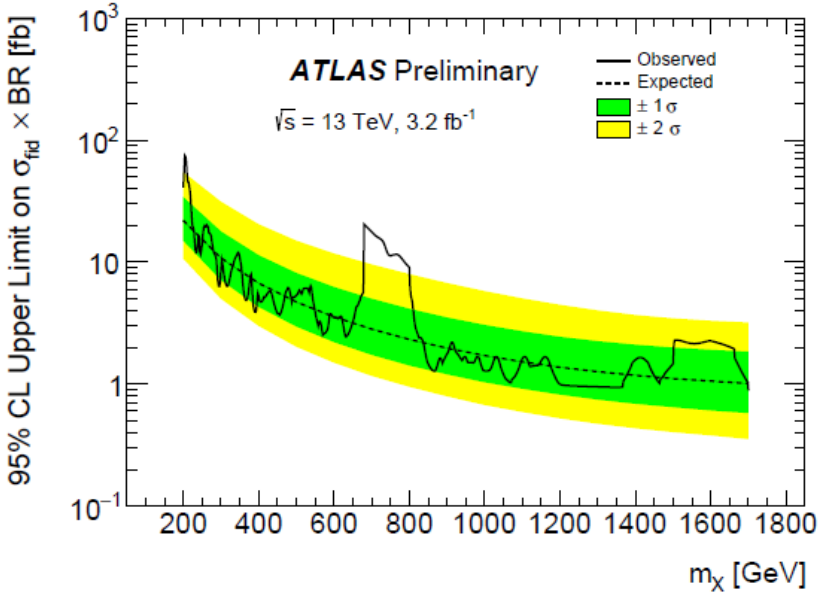
ATLAS-CONF-2015-081

- A search for new resonance decays to two photons with $m_{\gamma\gamma}$>200 GeV, predicted in models with an extended Higgs sector.

→ A local (global, LEE) significance of 3.6σ (2σ was observed ~750 GeV. $m_X \in [200 - 2000]$ GeV





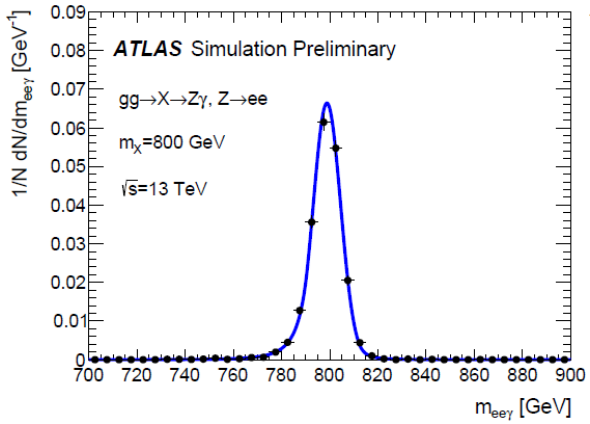


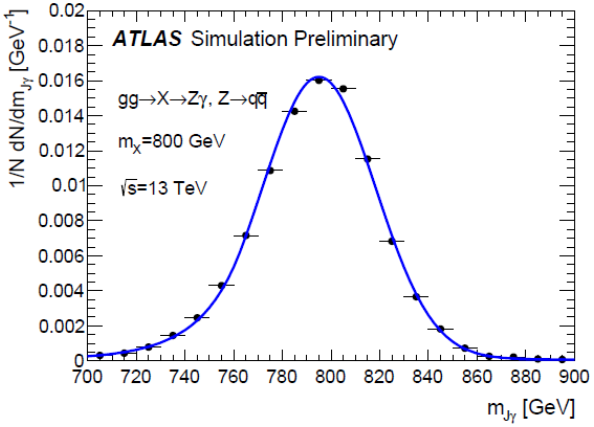
Search for Resonance X → Zγ

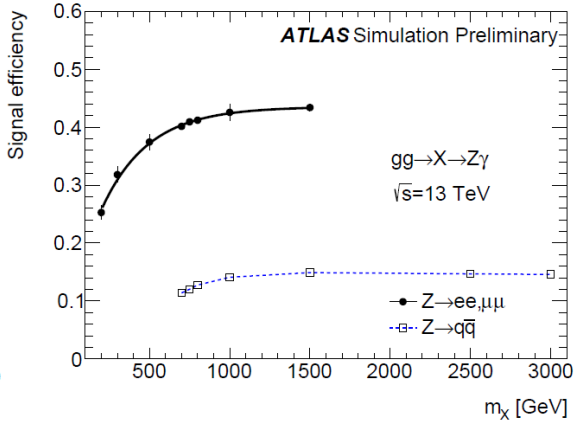
ATLAS-CONF-2016-010

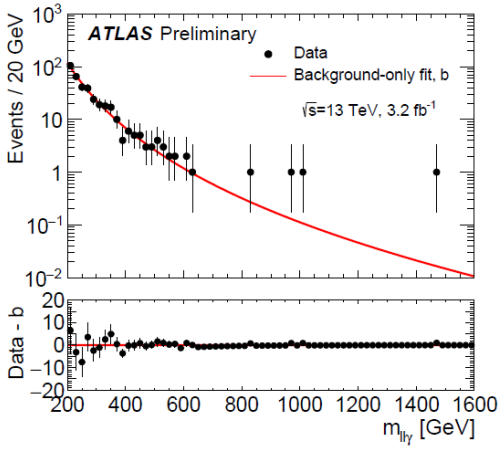
Search for new resonance X decays into Zγ, Z→ℓℓ or jj

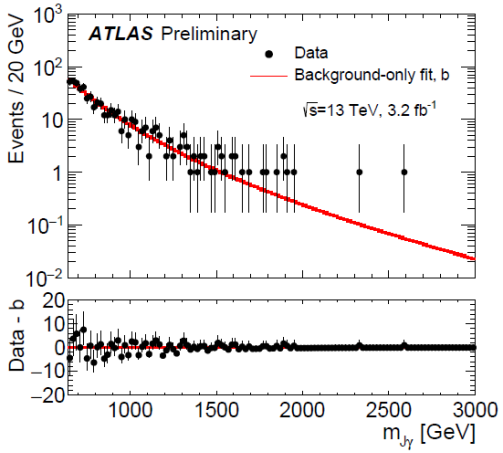
→The data agree with MC expected background, the observed (exptected) limits range between 295 (230) fb for m_x=340 GeV and 8.2 (10) fb for m_x=2.15TeV

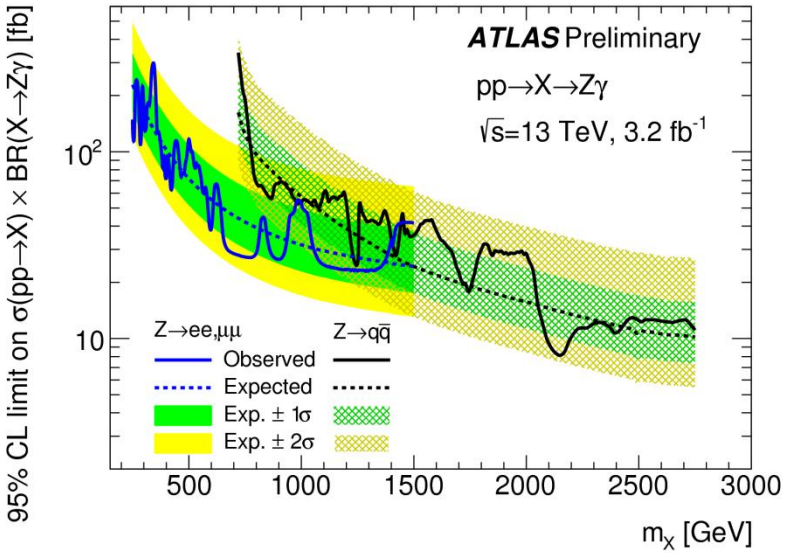






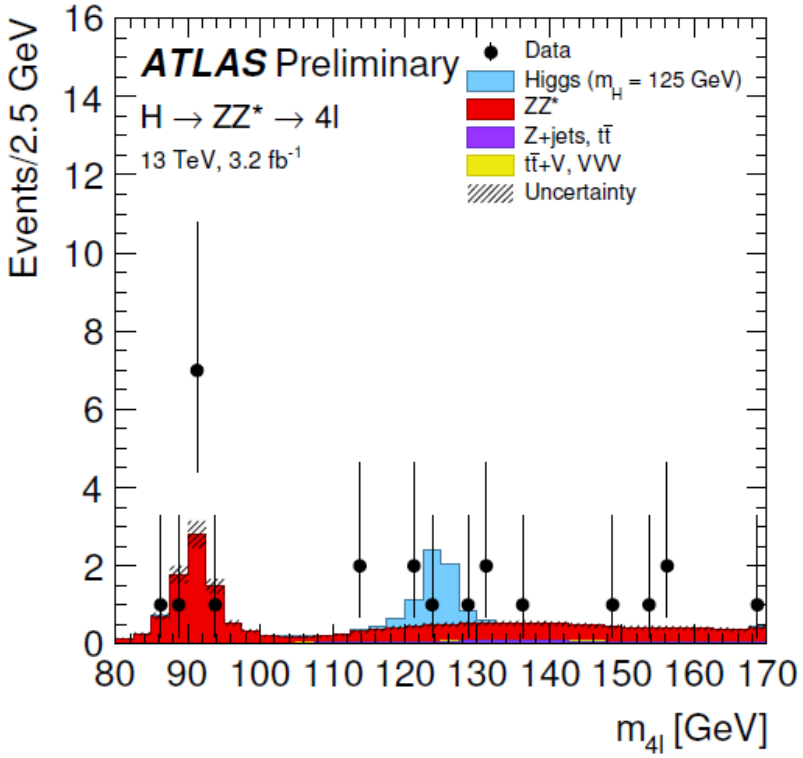


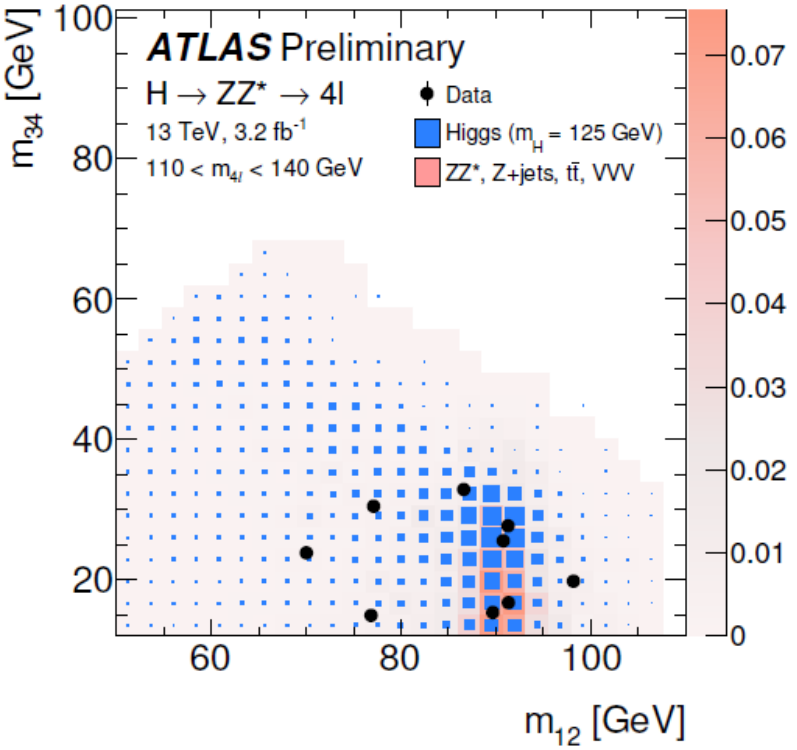




Higgs → ZZ* → 4ℓ

ATLAS-CONF-2015-059

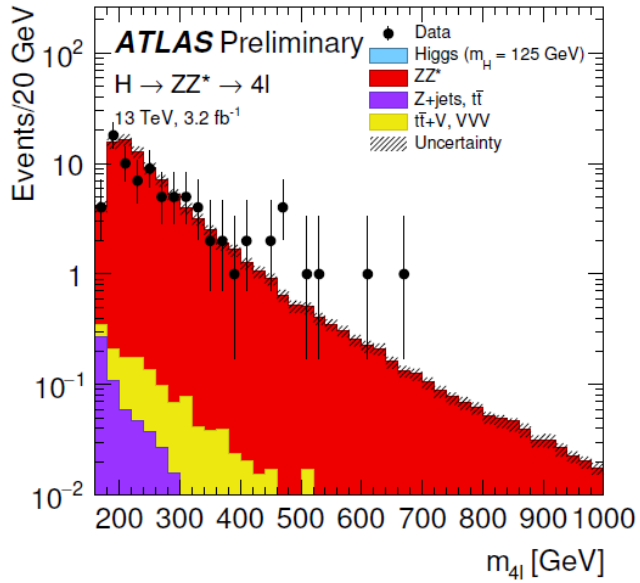


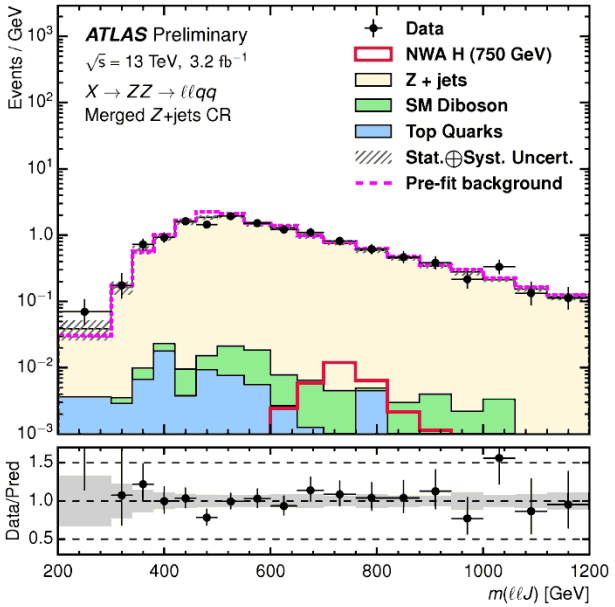


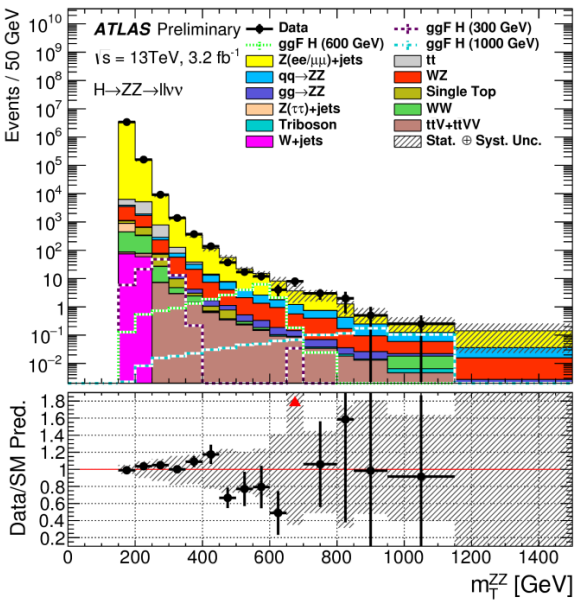
Final state	Signal full mass range	Signal	ZZ^*	$Z+jets, t\bar{t}$ $t\bar{t}V, VVV, WZ$	S/B	Expected	Observed
4μ	1.79 ± 0.21	1.67 ± 0.20	0.64 ± 0.06	0.08 ± 0.03	2.3	2.39 ± 0.21	1
$2e2\mu$	1.19 ± 0.14	1.06 ± 0.13	0.44 ± 0.04	0.07 ± 0.03	2.1	1.57 ± 0.14	1
$2\mu 2e$	1.07 ± 0.16	0.96 ± 0.15	0.34 ± 0.05	0.09 ± 0.02	2.2	1.40 ± 0.16	2
$4e$	1.01 ± 0.15	0.88 ± 0.13	0.32 ± 0.05	0.09 ± 0.02	2.1	1.30 ± 0.14	0
Total	5.06 ± 0.60	4.57 ± 0.54	1.74 ± 0.19	0.34 ± 0.06	2.2	6.65 ± 0.58	4

Search for Heavy Higgs →ZZ

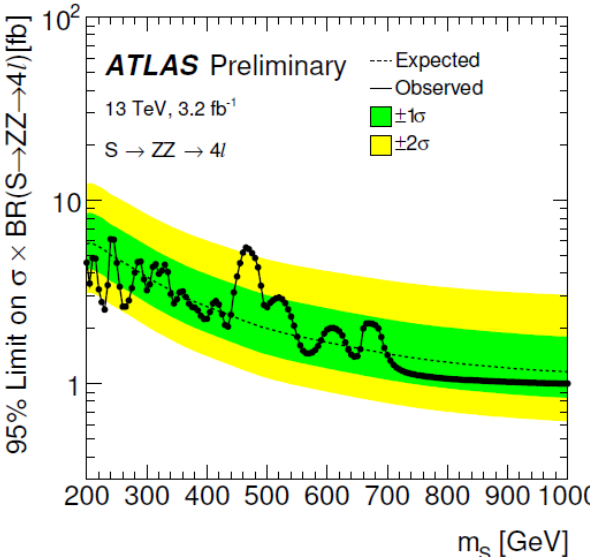
ATLAS-CONF-2015-059
ATLAS-CONF-2016-016
ATLAS-CONF-2016-012



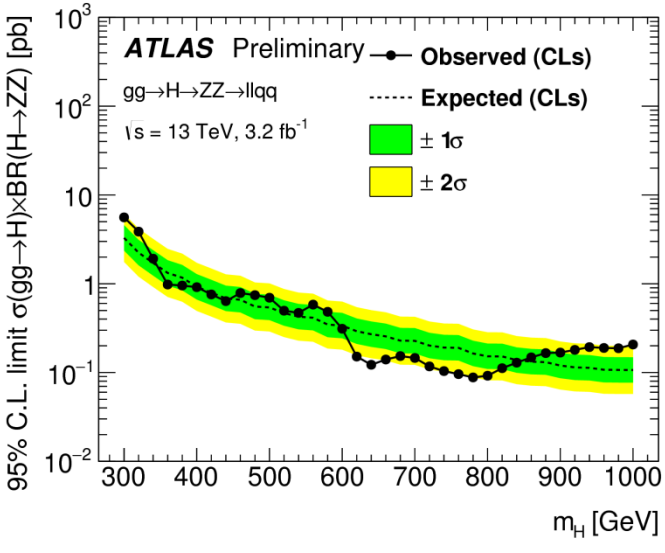




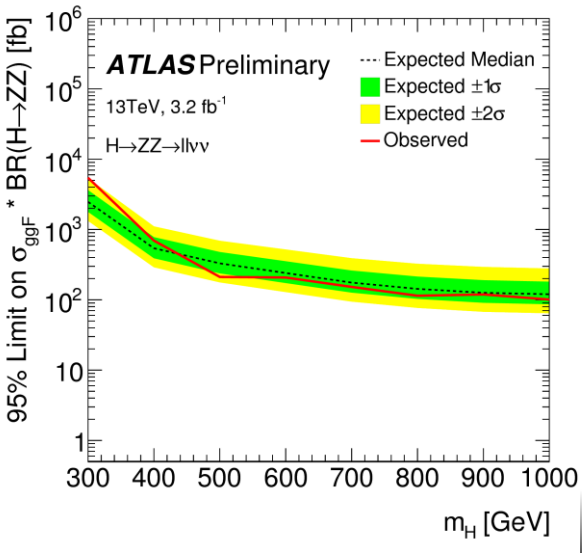
H→ZZ*→4l



H→ZZ*→2l2q



H→ZZ*→2l2ν

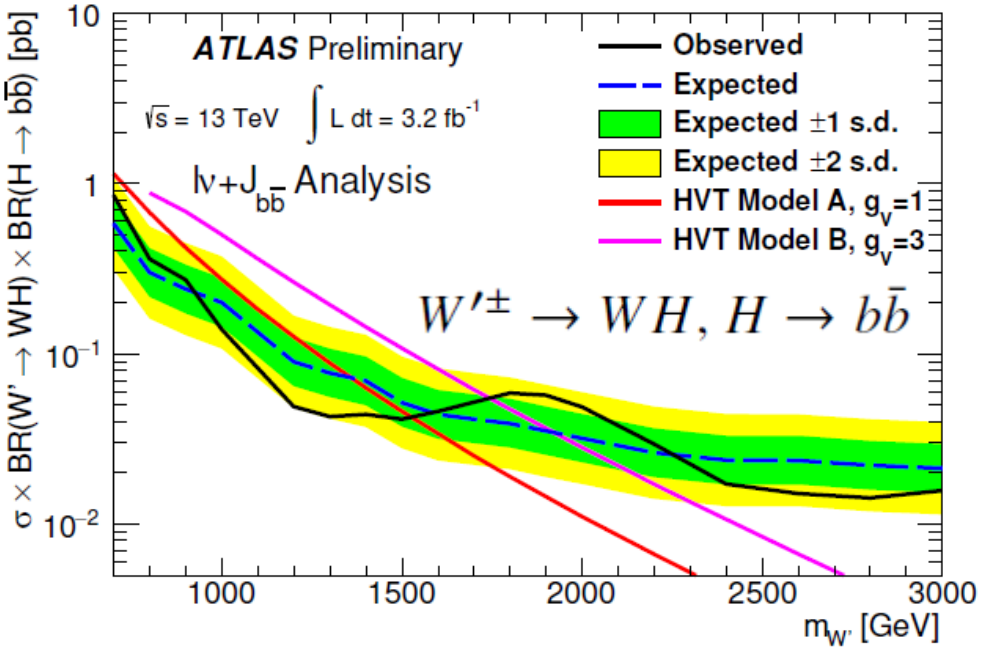


Search for X→WH and ZH

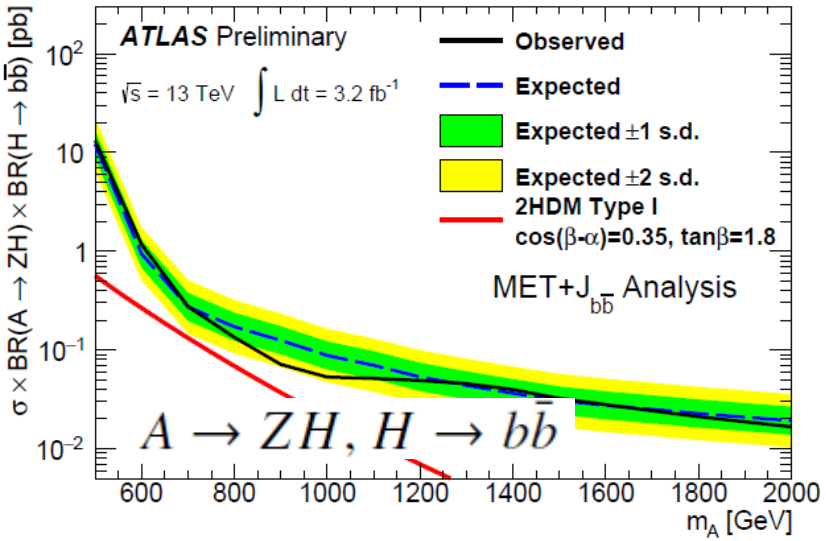
ATLAS-CONF-2015-074

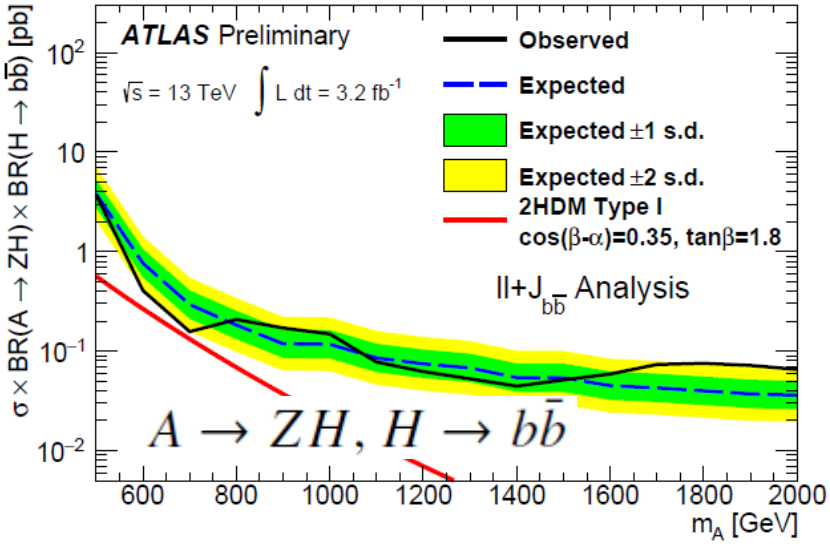
- Search for a new resonance X via WH / ZH
- Heavy Vector Triplets (HVT) benchmark
  - Model A, W' < 1490 GeV is excluded at 95% CL
  - Model B, W' < 1740 GeV is excluded at 95% CL

Two b-tags			
	$\nu\nu b\bar{b}$	$\ell\nu b\bar{b}$	$\ell\ell b\bar{b}$
backgrounds	36.9 ± 3.4	81 ± 8	7.2 ± 1.1
data	38	85	7



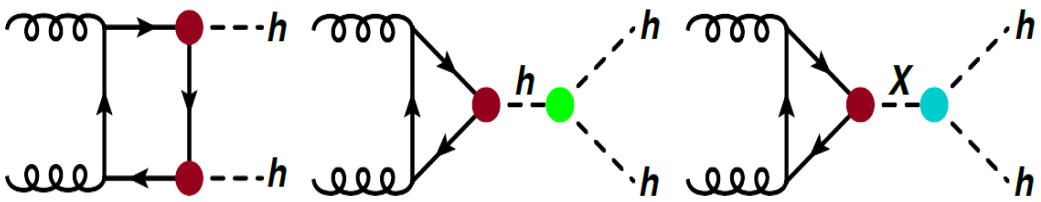
$\ell\ell b\bar{b}$, $\ell\nu b\bar{b}$, $\nu\nu b\bar{b}$





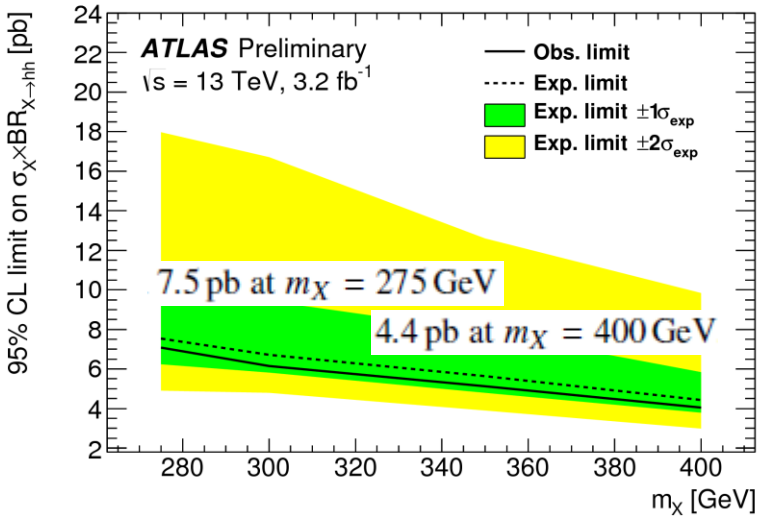
Search for BSM HH→bbγγ

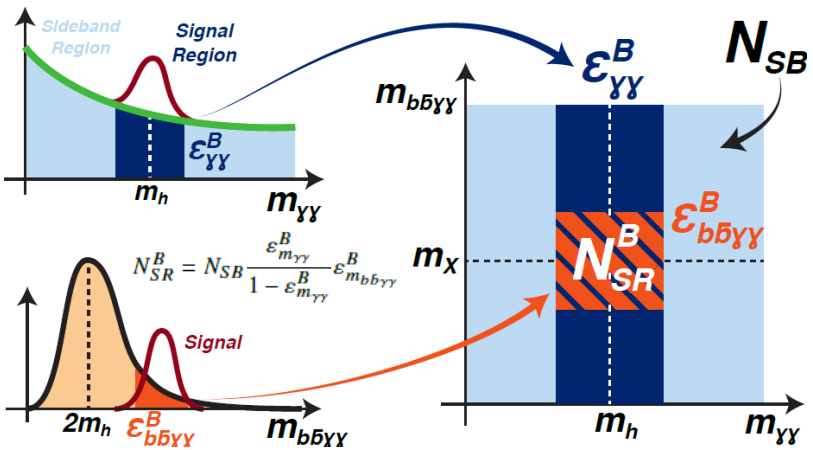
ATLAS-CONF-2016-004

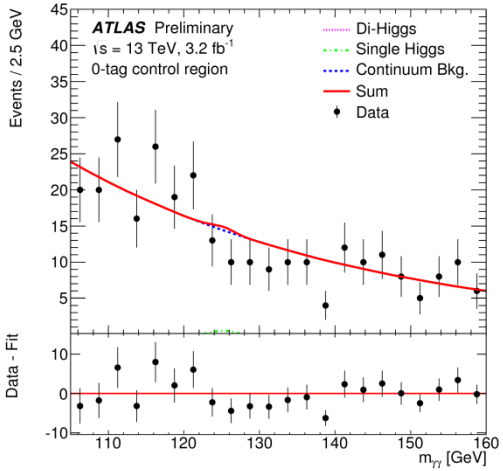


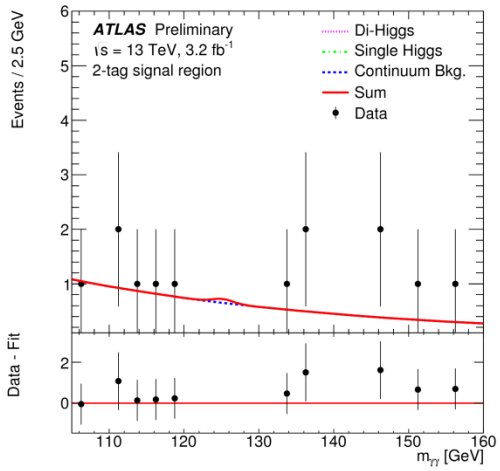
Process	0-tag	2-tag
Continuum background	35.8 ± 2.1	1.63 ± 0.30
SM single-Higgs	1.8 ± 1.5	0.14 ± 0.05
SM di-Higgs	<0.001	0.027 ± 0.006
Observed	27	0

- BSM: 2HDM, MSSM, twin or composite Higgs models predicts the existence of a heavy Higgs could decay into two lighter SM-like higgs.
- bbγγ is promising for the search as it benefits from large h→bb BR, clean peak with high h→γγ mass resolution
- MadGraph5_MC@NLOv2.2.2 with Pythia8 parton shower







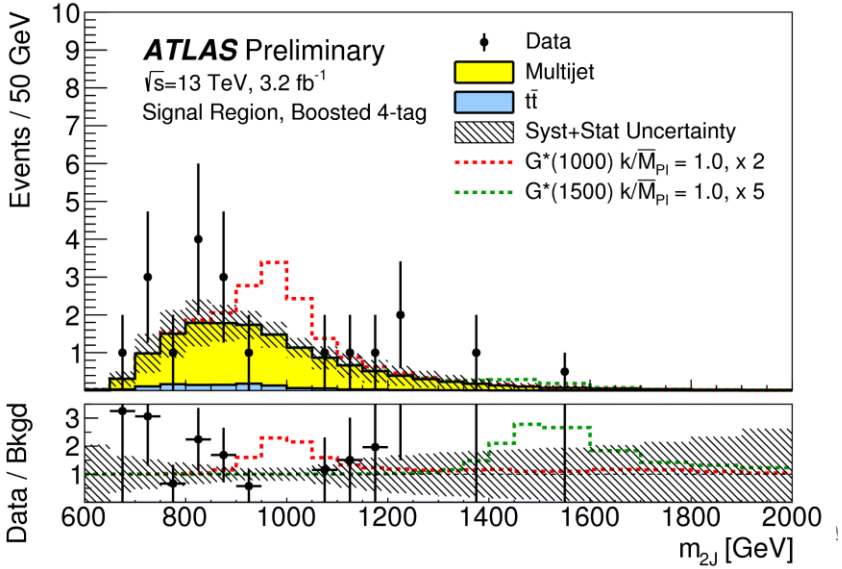


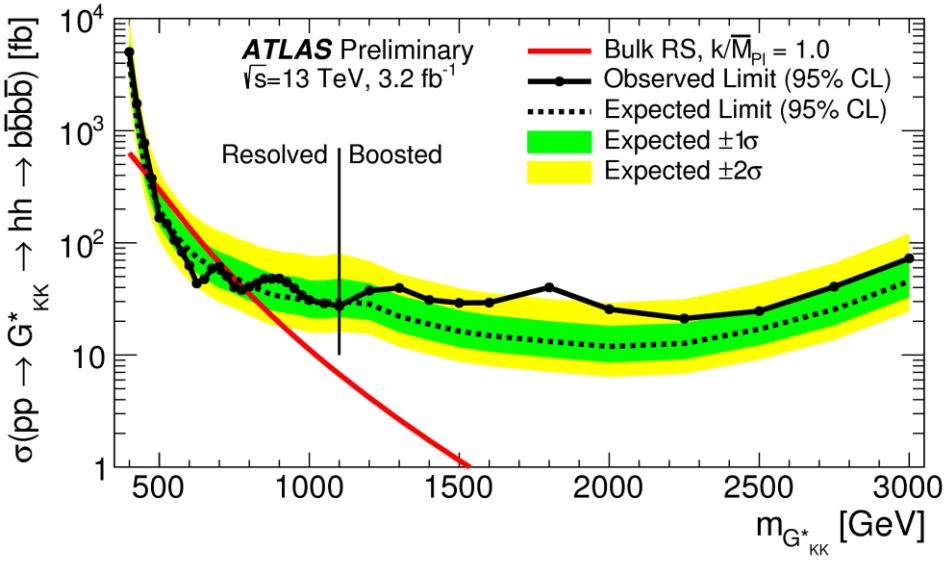
Observed limit ranges between 7pb and 4pb for Resonance X with masses in range 275-400 GeV

Search for BSM HH→bbbb

ATLAS-CONF-2016-017

- Randall-Sundrum (RS) model, spin-2 Kaluza-Klein(KK) excitations of the graviton G^*_{KK} are produced via ggF, $G^*_{KK} \rightarrow hh \rightarrow bbbb$
- The sensitivity is best in bbbb channel for resonance mass above 500GeV if comparing with bbττ, bbγγ, γγWW final states
- **Two analyses**: **"resolved"** analysis is focused for low-mass hh system where 4 b-jet can be well separated, **"boosted"** analysis focuses on high-mass hh system where two b-jets cannot be resolved due to high boost.
- 95% CL upper limit for mass [600,3000] GeV: $\sigma\left(pp \rightarrow G^*_{KK} \rightarrow hh \rightarrow b\bar{b}b\bar{b}\right) < 70$ fb

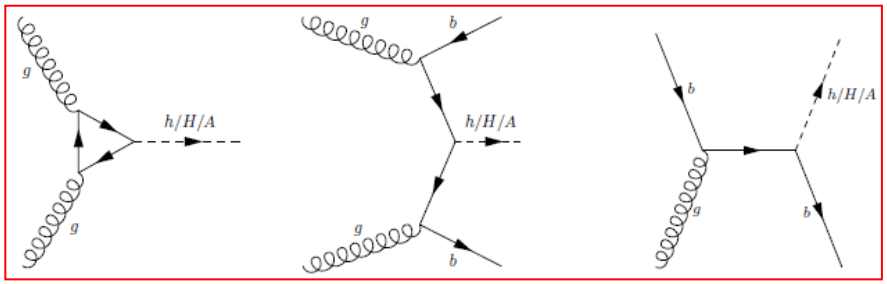




Search for MSSM H/A→ττ

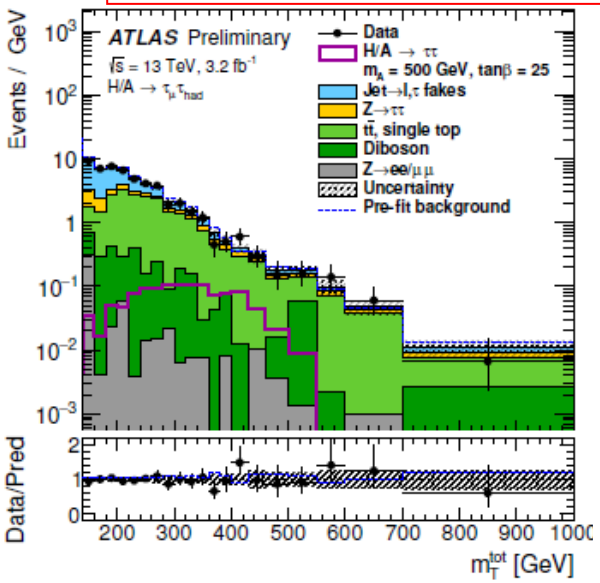
ATLAS-CONF-2015-061

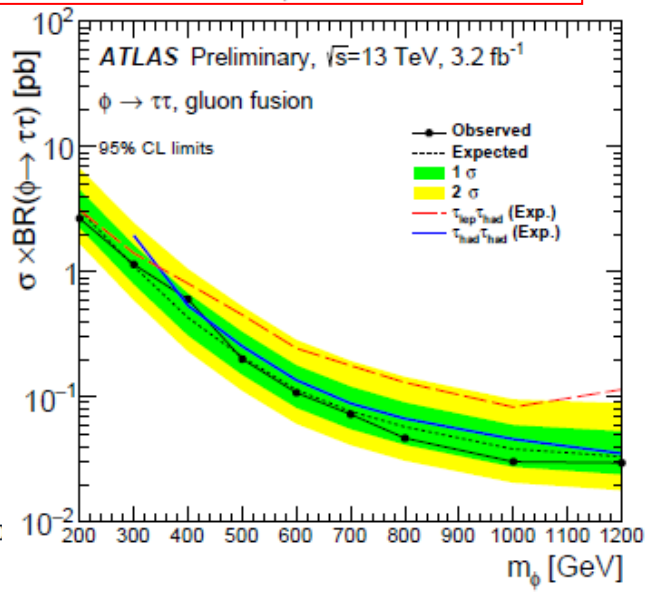
- MSSM is an extension of the SM which provides a framework addressing the naturalness problem, gauge coupling unification and existence of dark matter.
- The MSSM contains two Higgs doublets: **two CP-even (h,H), one CP-odd (A) and two charged Higgs ($H^{\pm}$).**
- Neutral MSSM Higgs in the ττ decay mode with at least one tau hadronic decays, cross section limits for ggF (b-associated) are:

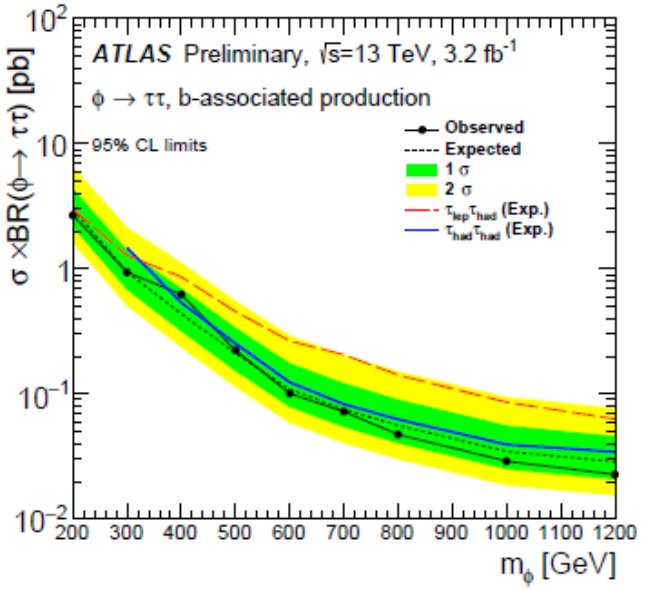


$$\sigma \times BR > 2.7(2.7) \text{ pb at } m_{\phi} = 200 \text{ GeV}$$

$$\sigma \times BR > 0.030(0.023) \text{ pb at } m_{\phi} = 1.2 \text{ TeV}$$





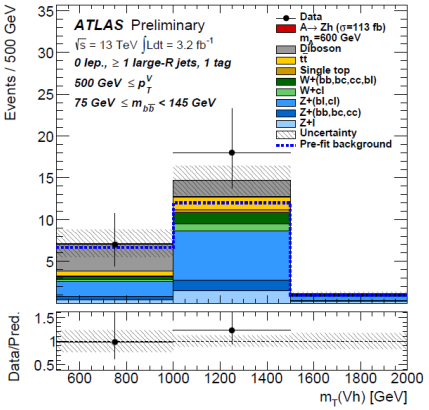


2HDMs: A→Zh→ℓℓbb

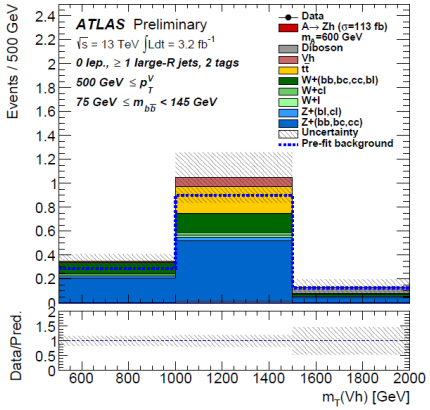
ATLAS-CONF-2016-015

- ➔ Search for heavy, CP-odd Higgs boson, A → Zh →ℓℓbb
- ➔ Z → ee, μμ, νν are considered
- ➔ **No evidence for production of A boson is observed**

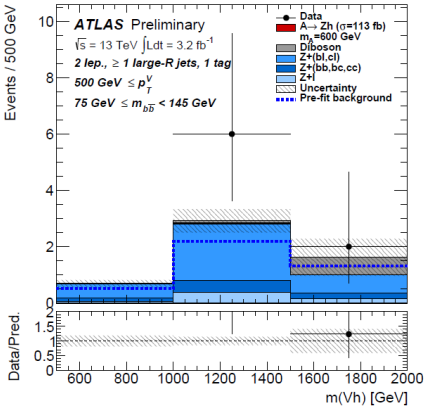
$$m_{\mathrm{T}}^{Zh} = \sqrt{(E_{\mathrm{T}}^{h} + E_{\mathrm{T}}^{\mathrm{miss}})^2 - (\vec{p}_{\mathrm{T}}^{\,h} + \vec{E}_{\mathrm{T}}^{\mathrm{miss}})^2}$$



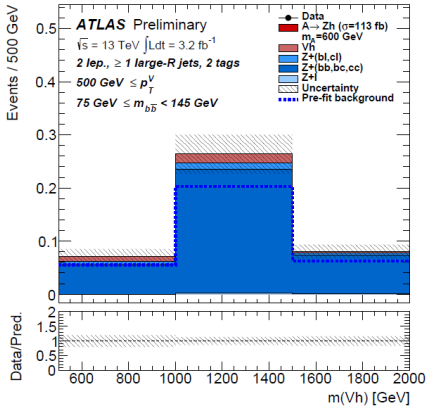
(a) 0-lepton, 1-tag, $p_{\mathrm{T}}^{Z} > 500$ GeV



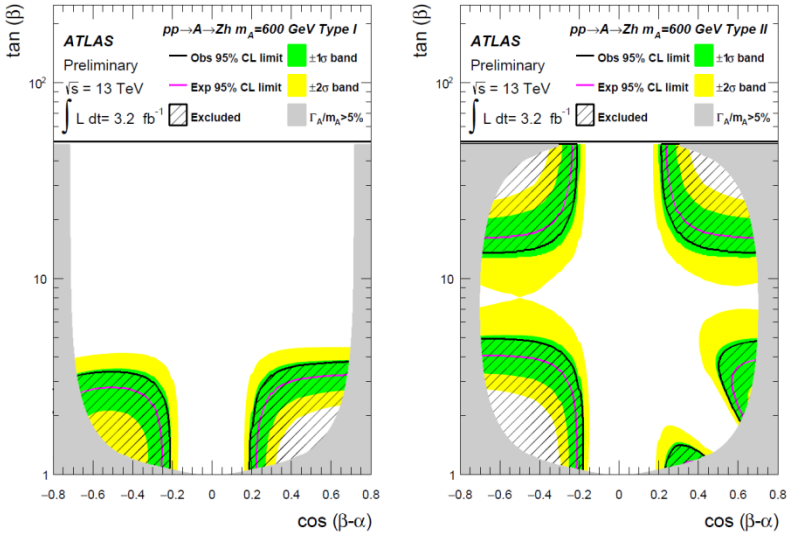
(b) 0-lepton, 2-tag, $p_{\mathrm{T}}^{Z} > 500$ GeV

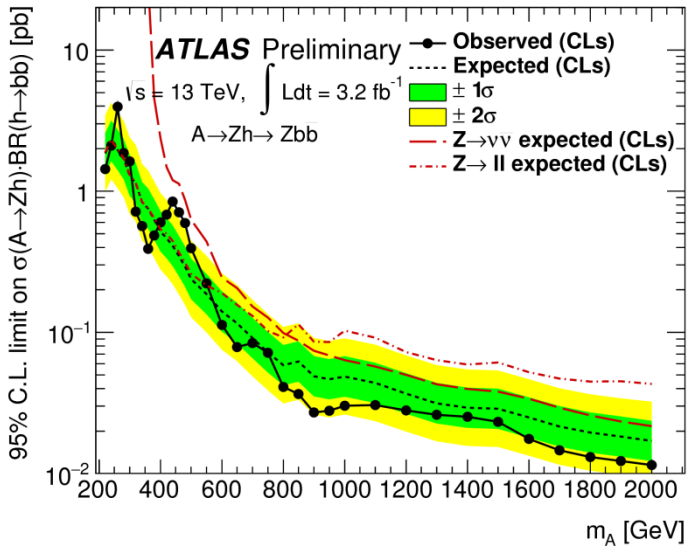


(c) 2-lepton, 1-tag, $p_{\mathrm{T}}^{Z} > 500$ GeV



(d) 2-lepton, 2-tag, $p_{\mathrm{T}}^{Z} > 500$ GeV





SUSY, Dark Matter, Exotic, Diboson

- SUSY: stop, sbottom, gluino
- Dark Matter – mono W/Z
- Dark Matter associated with Higgs
- W' → $\ell\nu$
- Z' → $\ell\ell$
- Heavy Gravity → multi-jets
- LFV X → $e\mu$
- Diboson resonance: WW, WZ, ZZ

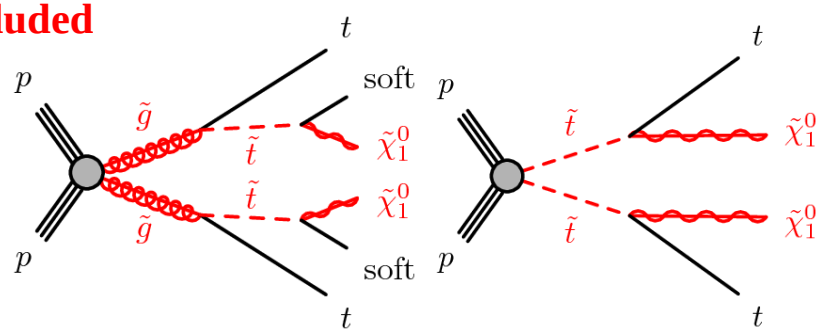
Search for stop pair

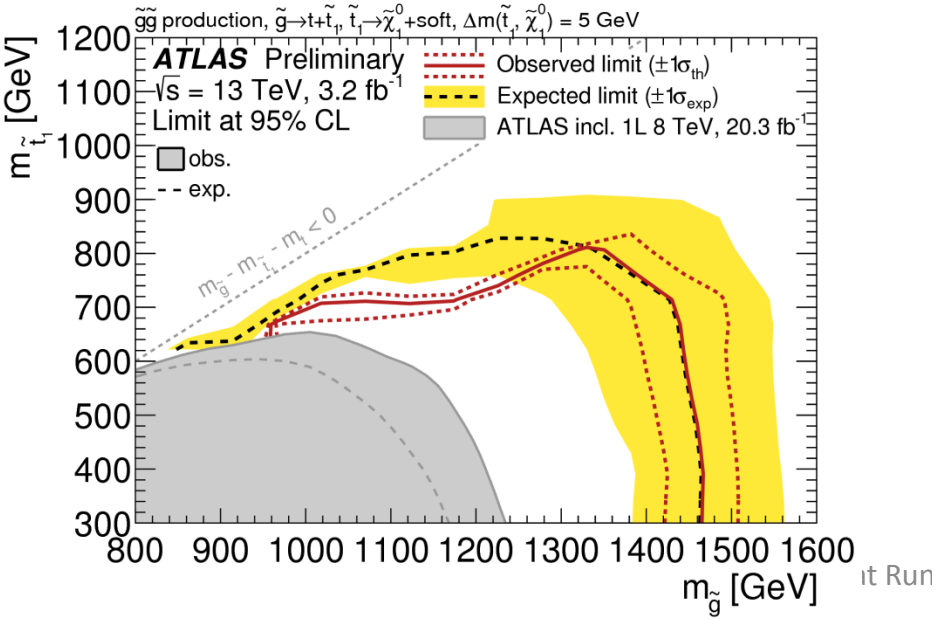
ATLAS-CONF-2016-007

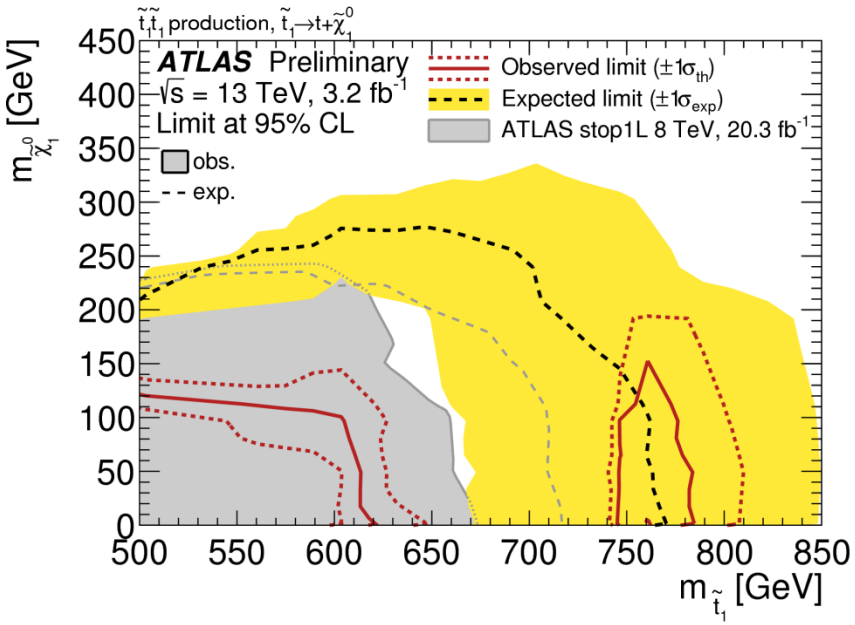
➔ SUSY is a natural solution to the hierarchy problem. If R-parity is conserved, SUSY particles are produced in pairs and LSP is stable. The stop is expected to be light due to it's large contribution to the Higgs mass radiative correction.

➔ **Scenario #1**: Gluino-mediated pair production, assuming 100% BR via stop➔c+neutralino, and mass splitting of 5 GeV. **M_{Gluino} < 1460 GeV is excluded**

➔**Scenario #2:** direct pair production of stop (➔ top + neutralino), **excludes stop mass from 745 to 780 GeV for a massless neutralino at 95% CL.**







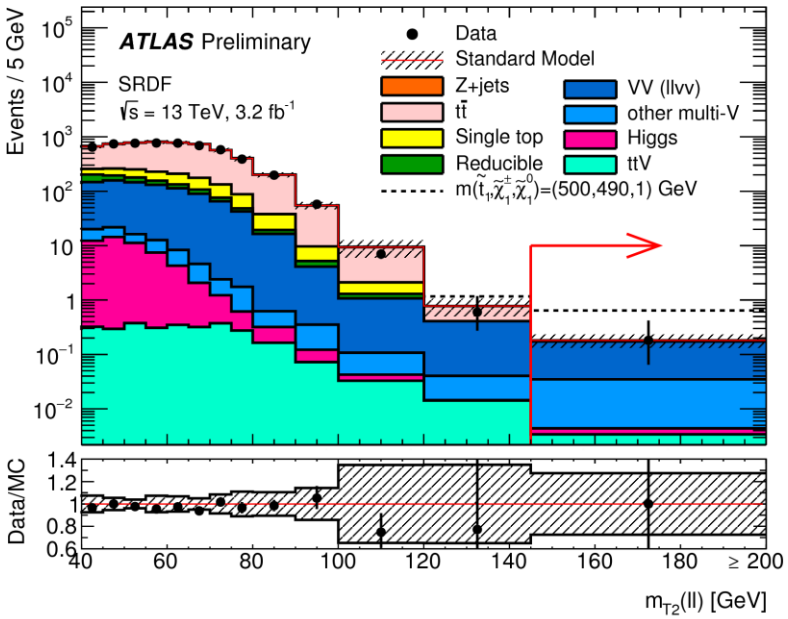
Search for stop (2-lepton)

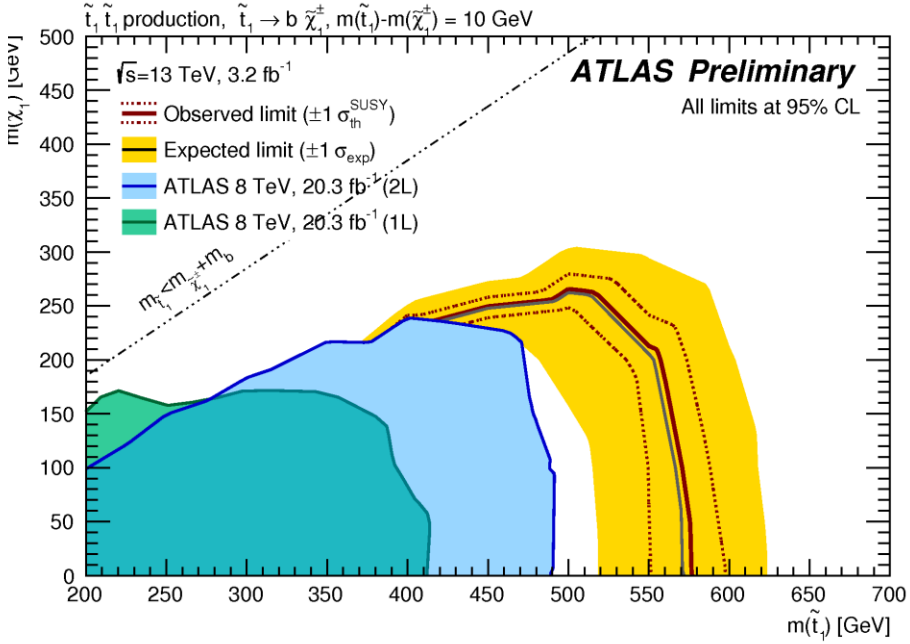
ATLAS-CONF-2016-009

- In the framework of a generic R-parity conserving MSSM, SUSY particles are produced in pairs, the LSP is stable and candidate for DM.
- Cross sections > 1.3(2.1) fb for SRDF (SRSF) are excluded at 95% CL
- Stop mass below 577 GeV are excluded at 95% CL.

$$\tilde{t}_1 \rightarrow \tilde{\chi}_1^{\pm} b \rightarrow \tilde{\chi}_1^0 W b \qquad m(\tilde{t}_1) - m(\tilde{\chi}_1^{\pm}) = 10 \text{ GeV}$$

$$m_{T2}(\mathbf{p}_{T,1}, \mathbf{p}_{T,2}, \mathbf{p}_T^{miss}) = \min_{\mathbf{q}_{T,1}+\mathbf{q}_{T,2}=\mathbf{p}_T^{miss}} \{\max[\, m_T(\mathbf{p}_{T,1}, \mathbf{q}_{T,1}), m_T(\mathbf{p}_{T,2}, \mathbf{q}_{T,2})\,]\}$$



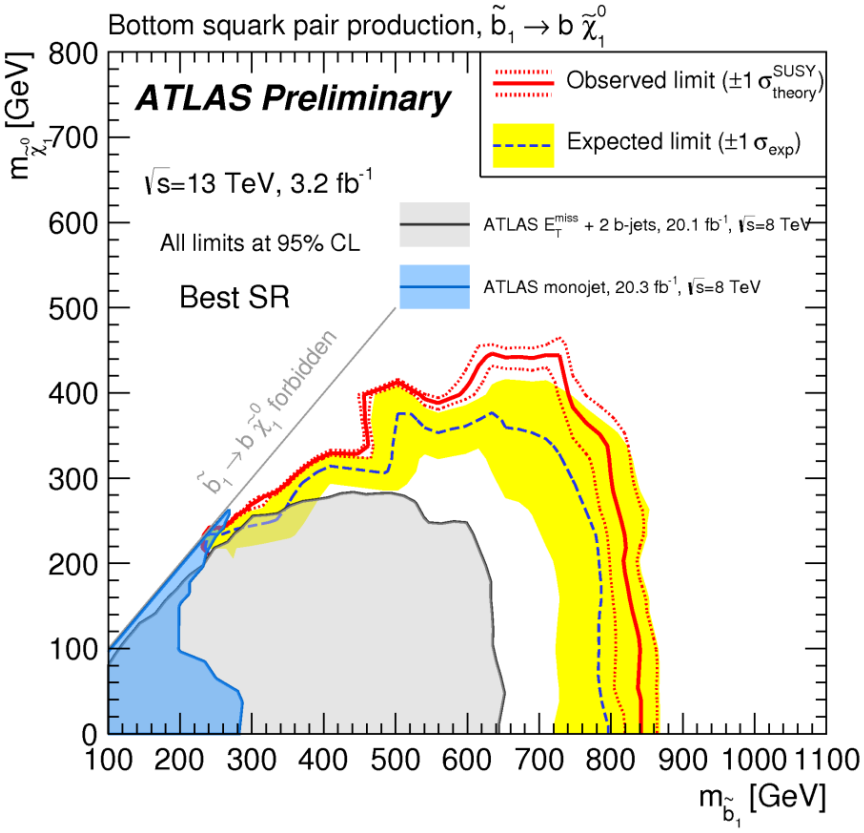


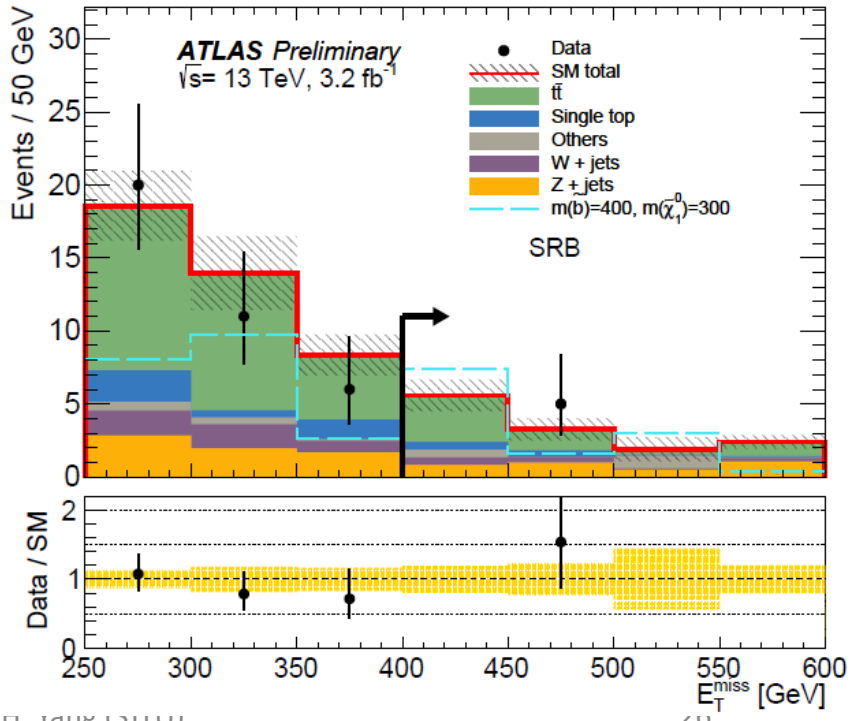
Search for sbottom pair

ATLAS-CONF-2015-066

- Search for bottom squarks pair decaying exclusively as b-quark and LSP neutralino. The signature has 2 b-jets and large MET. $\tilde{b}_1 \rightarrow b\tilde{\chi}_1^0$
- Bottom squark mass < 800 GeV are excluded for neutralino mass below 360 GeV at 95% CL.

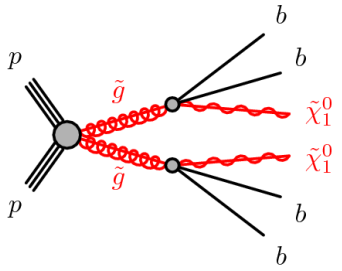
Signal channel	$\langle \epsilon A \sigma \rangle^{95}_{obs}$ [fb]	S^{95}_{obs}	S^{95}_{exp}
SRA250	2.74	8.8	$15.8^{+6.3}_{-4.4}$
SRA350	1.90	6.1	$8.1^{+3.7}_{-2.3}$
SRA450	1.16	3.7	$4.4^{+2.6}_{-1.0}$
SRB	1.57	5.0	$8.5^{+3.9}_{-2.4}$

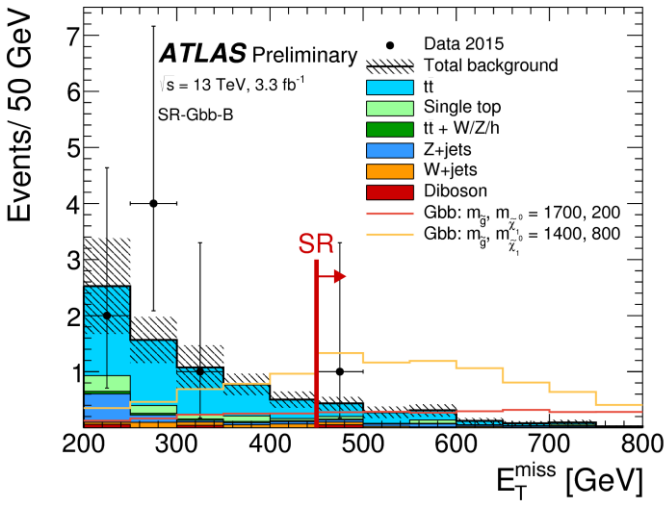


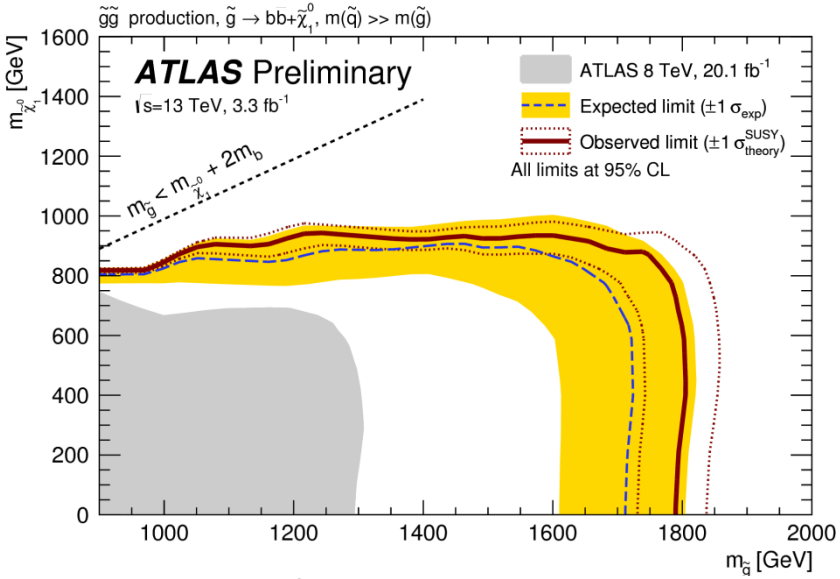


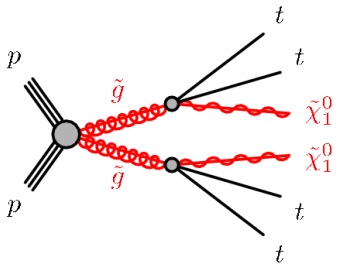
Search for gluino pair

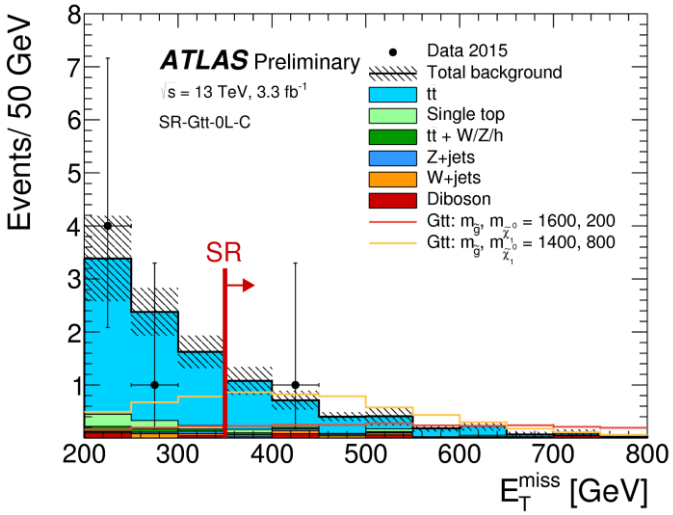
ATLAS-CONF-2015-067

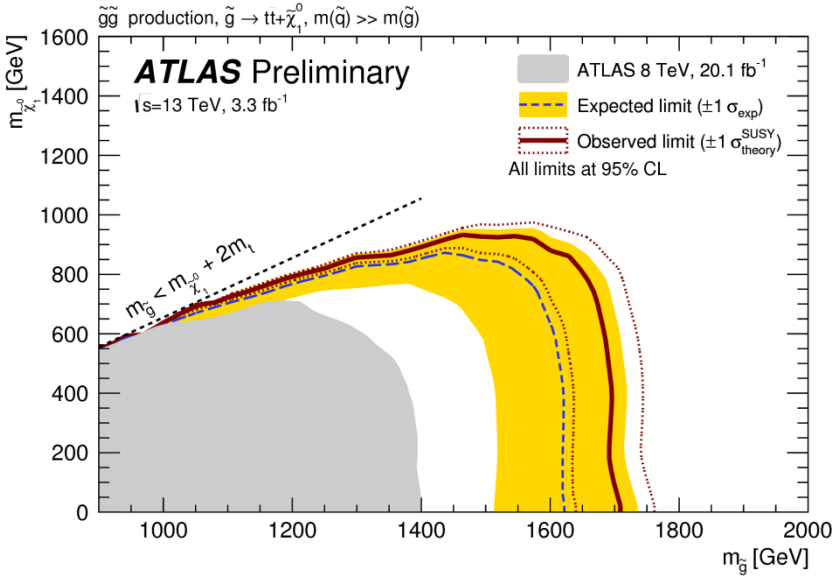








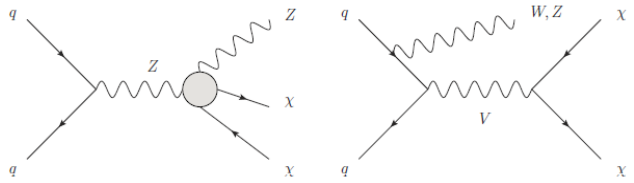




Search for DM with mono-W/Z

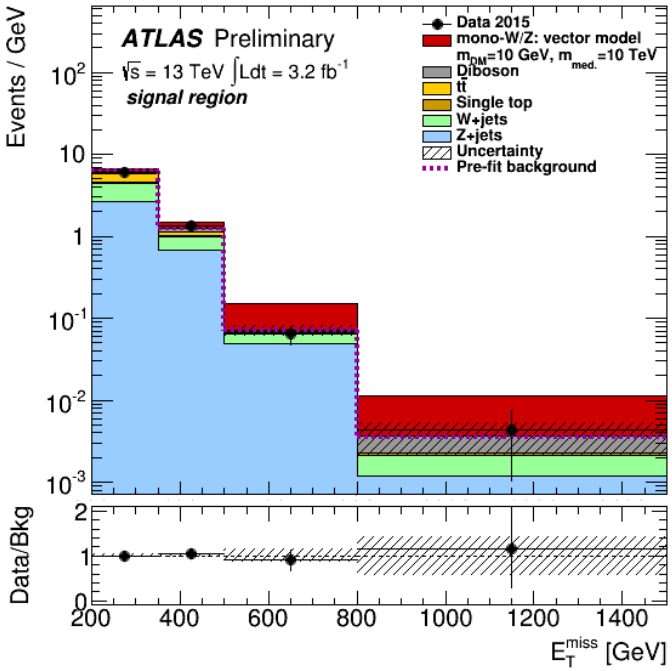
ATLAS-CONF-2015-080

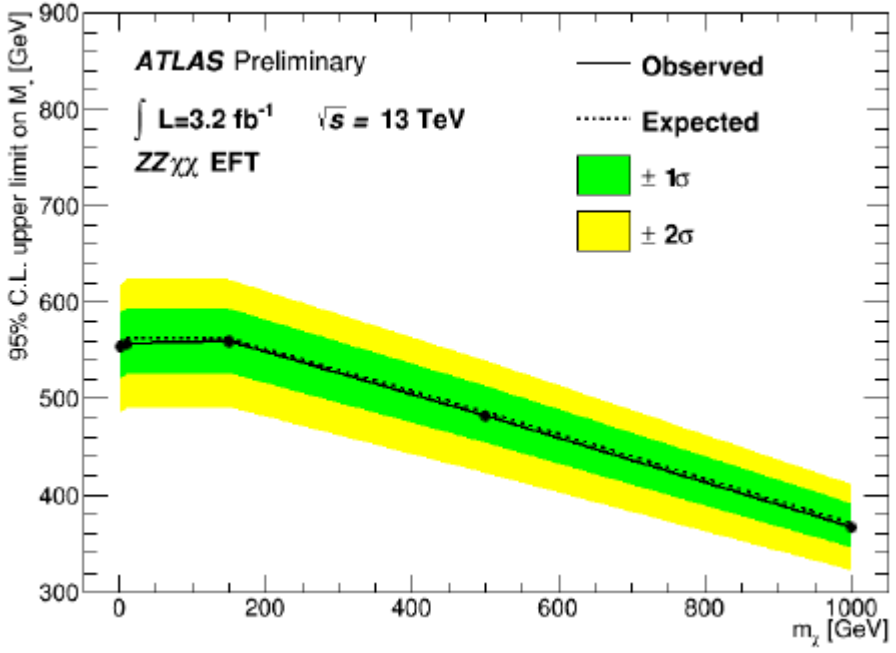
- Search for DM associated with a jet, a photon, a W/Z, a Higgs boson plus large MET etc.
- Models: ZZχχ EFT and vector-mediated simplified model



Process	events
Z+jets	519 ± 31
W+jets	326 ± 22
$t\bar{t}$ and single-top	217 ± 18
Diboson	88 ± 12
Total Background	1150 ± 30
Data	1143

➢ No significant excess over the SM is observed.

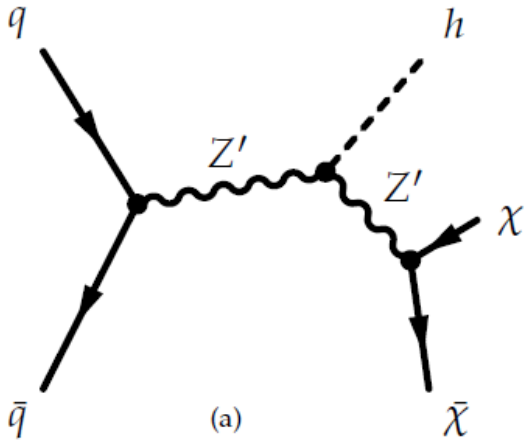




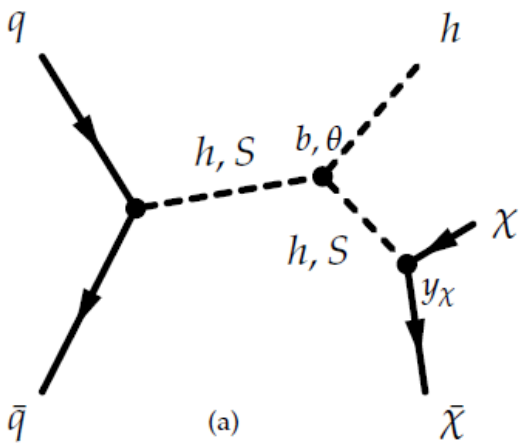
Search for Higgs + DM

ATLAS-CONF-2015-059

- To search for Dark Matter (MET) associated with a Higgs boson.



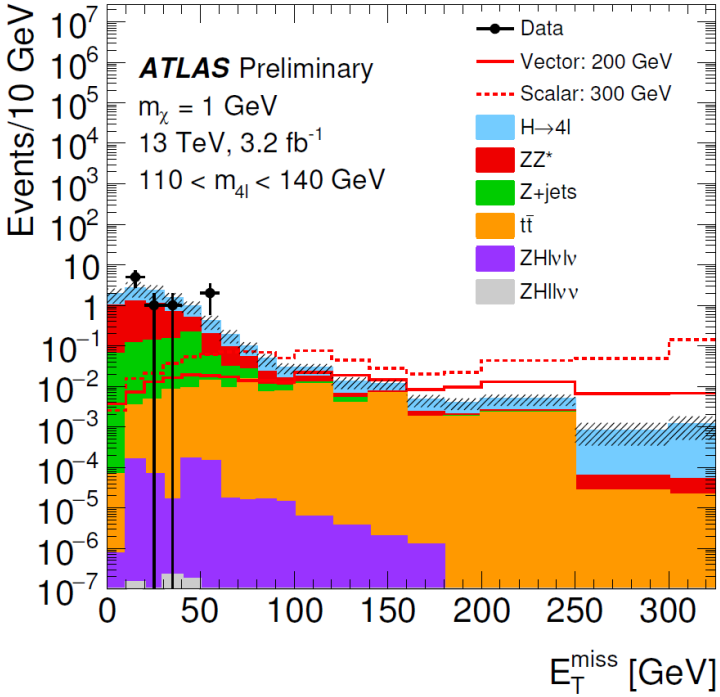
Vector mediator hZ'



Scalar mediator hS

No significant excess is found in search for Higgs boson with large MET.

Process	High-E_T^{miss} category (E_T^{miss} > 100 GeV)	Low-E_T^{miss} category (E_T^{miss} < 100 GeV)
$H \to ZZ^* \to 4\ell$	$(2.1 \pm 0.6) \cdot 10^{-2}$	4.9 ± 0.5
ZZ^*	$(0.7 \pm 0.4) \cdot 10^{-2}$	4.4 ± 0.4
Z+jets and $t\bar{t}$	$(3.1 \pm 1.2) \cdot 10^{-2}$	0.8 ± 0.5
$ZH(\ell\nu\ell\nu)$	$(1.2 \pm 0.6) \cdot 10^{-5}$	$(5.8 \pm 0.8) \cdot 10^{-4}$
$ZH(\ell\ell\nu\nu)$	$(1.3 \pm 0.8) \cdot 10^{-7}$	$(8.2 \pm 1.5) \cdot 10^{-7}$
Total background	$(5.9 \pm 1.6) \cdot 10^{-2}$	10.1 ± 1.0
Vector mediator signal $m_\chi = 1$ GeV, $m_{med} = 200$ GeV	$(9.7 \pm 3.3) \cdot 10^{-2}$	$(1.3 \pm 0.6) \cdot 10^{-1}$
Scalar mediator signal $m_\chi = 1$ GeV, $m_{med} = 300$ GeV	0.41 ± 0.14	0.44 ± 0.09
Data	0	9



Search for W' → $\ell\nu$

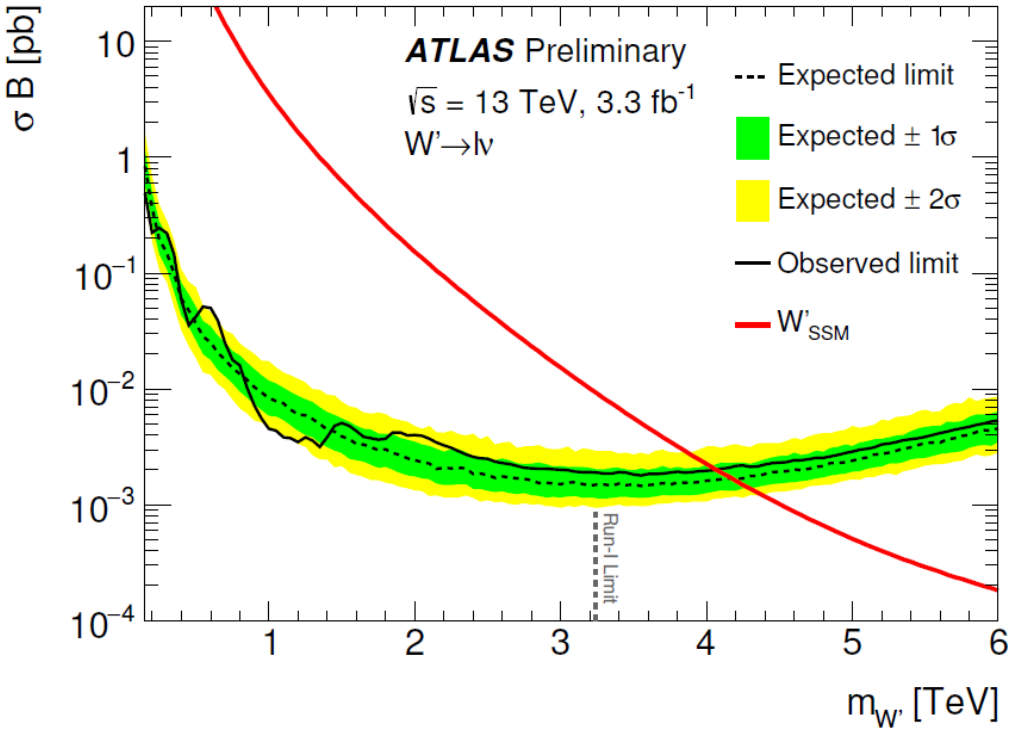
ATLAS-CONF-2015-063

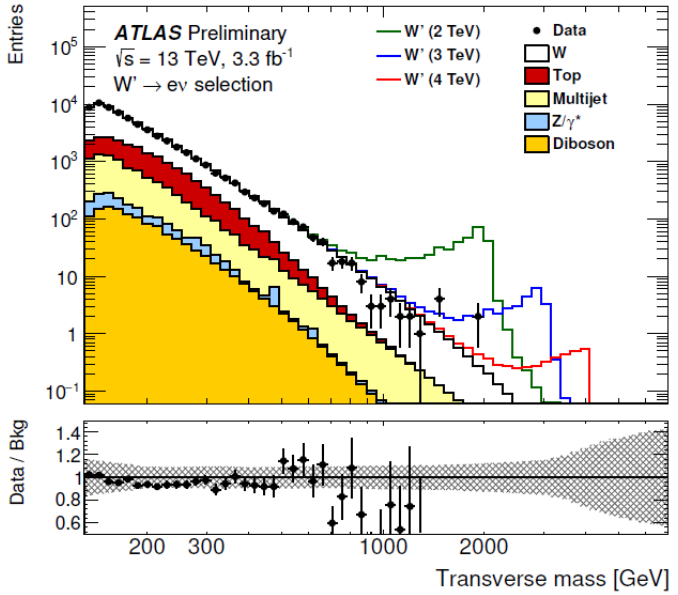
- BSM models predict new spin-1 boson (SSM W'), it is heavier version of the SM W boson.

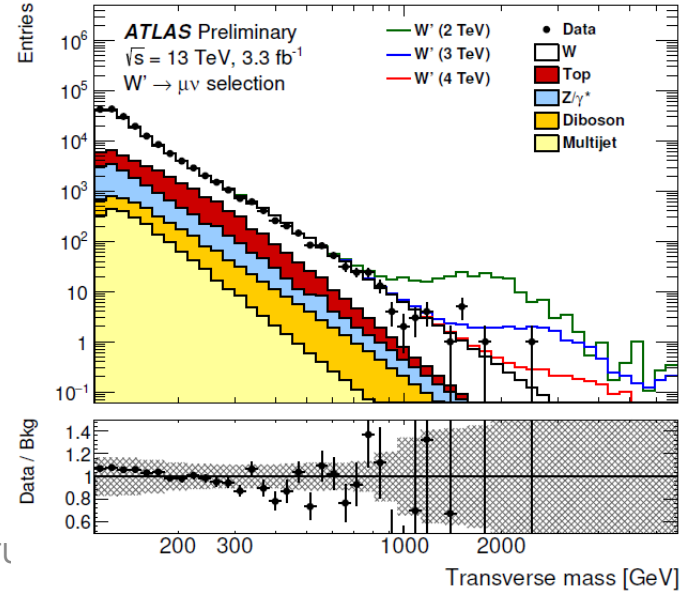
$W' \rightarrow \ell\nu$ channel

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

Decay	$m_{W'}$ limit [TeV] Expected	Observed
$W' \rightarrow e\nu$	4.03	3.98
$W' \rightarrow \mu\nu$	3.66	3.42
$W' \rightarrow \ell\nu$	4.18	4.07







Search for Z' → $\ell\ell$, and tt

ATLAS-CONF-2015-070
ATLAS-CONF-2016-014

- BSM models predict new spin-1 boson (Z')
- Dilepton (ee or μμ) is a key search channel

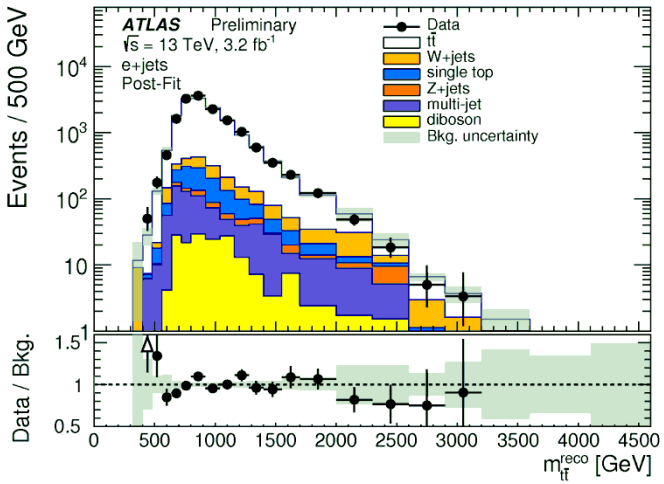
Model	Width [%]	ee [TeV]		$\mu\mu$ [TeV]		$\ell\ell$ [TeV]	
		Exp	Obs	Exp	Obs	Exp	Obs
Z'_{SSM}	3.0	3.17	3.18	2.91	2.98	3.37	3.40
Z'_{χ}	1.2	2.87	2.88	2.64	2.71	3.05	3.08
Z'_{ψ}	0.5	2.58	2.58	2.32	2.42	2.74	2.79

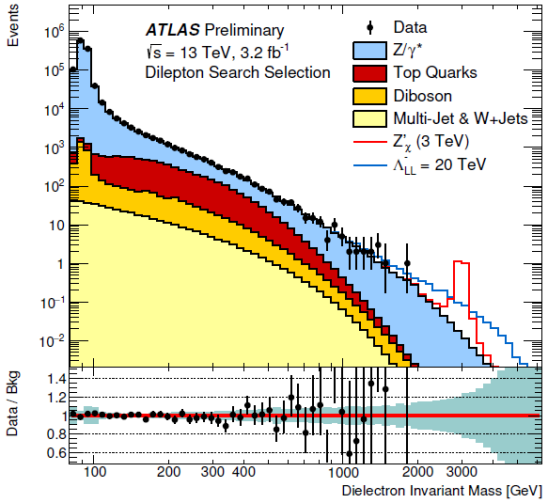
→ Sequential SM (Z'_{SSM}) provides a common benchmark

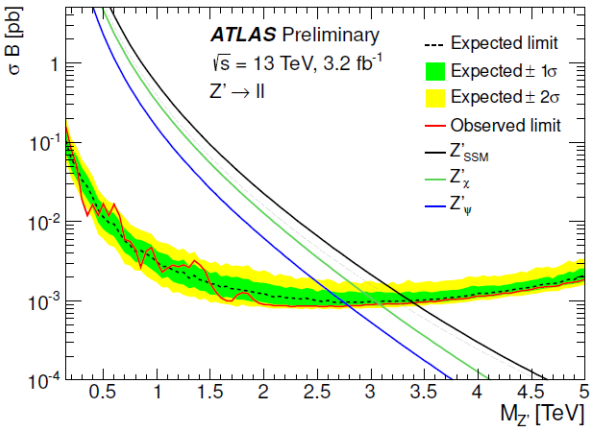
→ GUT inspired models based on E6 gauge group, two neutral bosons (Z'_{ϕ}, Z'_{χ}) mix with an angle θ_{E6}.

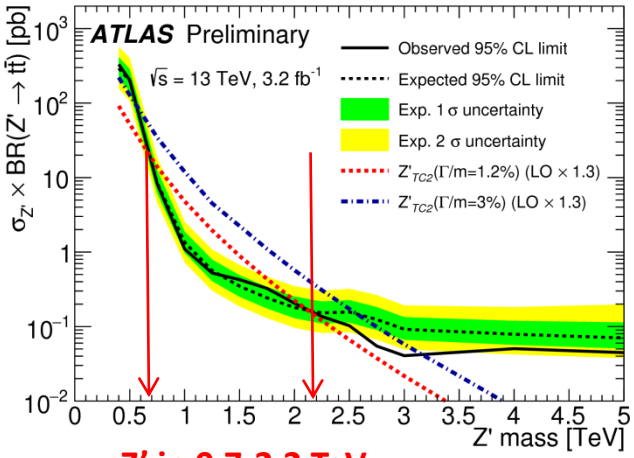
$$Z'(\theta_{E_6}) = Z'_{\psi}\cos\theta_{E_6} + Z'_{\chi}\sin\theta_{E_6} \qquad Z'_{\psi},\ Z'_{\eta},\ Z'_{N},\ Z'_{I},\ Z'_{S},\ \text{and}\ Z'_{\chi}$$

❖ Topcolour-assisted technicolor
Z' → tt→bWbW, 1 W leptonic decay







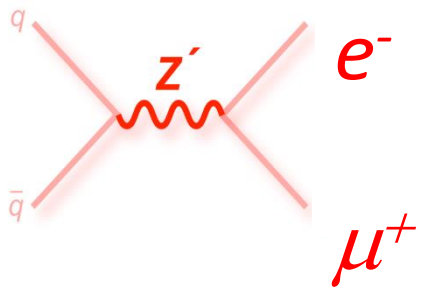


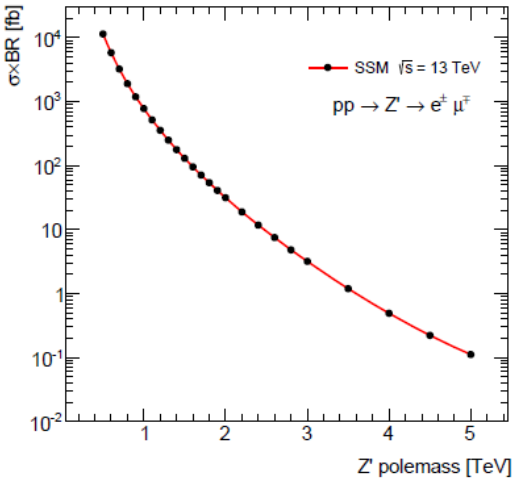
Z' in 0.7-2.2 TeV excluded at 95% CL

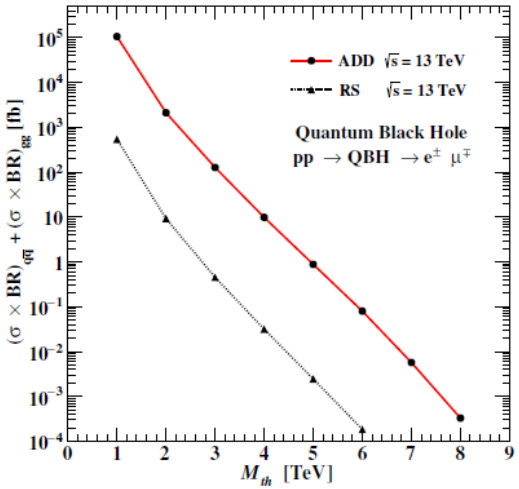
Search for BSM LFV eμ Resonance

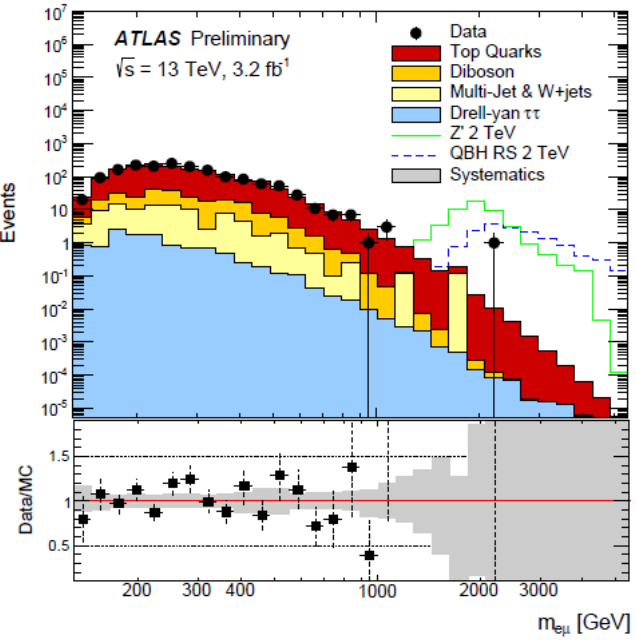
ATLAS-CONF-2015-072

- LF is conserved in SM, however, LFV is allowed in some extensions of the SM with additional gauge symmetries, eg. SSM Z', RPV SUSY, low-scale gravity model QBH.
- di-lepton channels: eμ, currently adding eτ, μτ final states

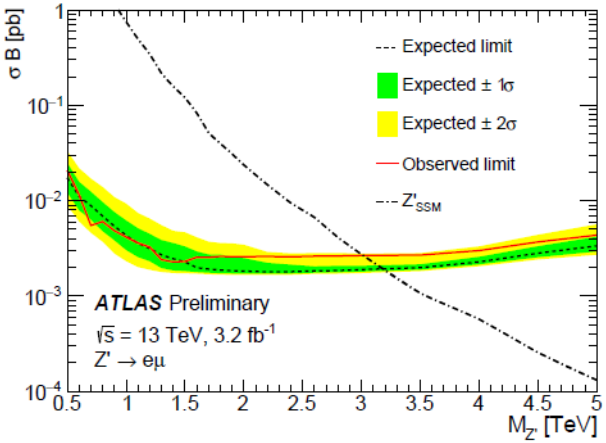


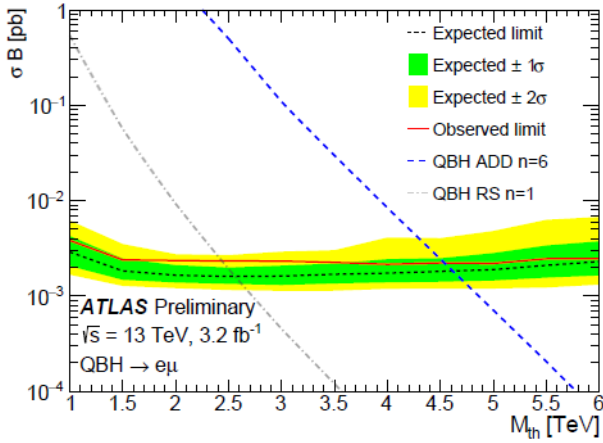






Model	Expected Limit [TeV]	Observed Limit [TeV]
Z′ SSM	3.19	3.01
QBH ADD n=6	4.62	4.54
QBH RS n=1	2.56	2.44

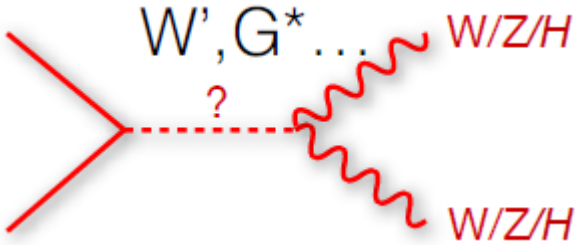




Search for Diboson Resonance

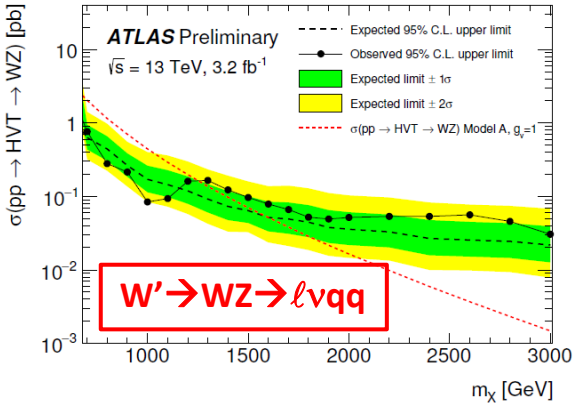
ATLAS-CONF-2015-071
ATLAS-CONF-2015-075

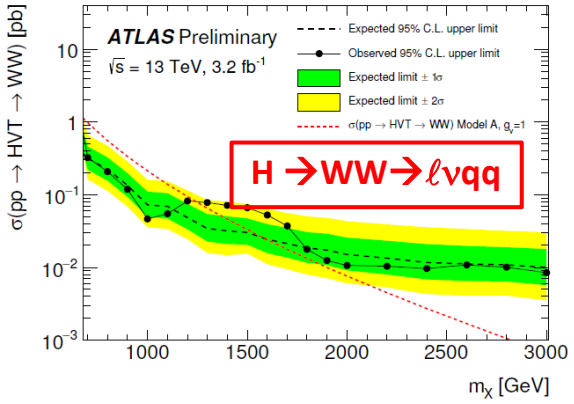
- **Search for heavy resonances in diboson final states (eg. $\ell\ell$qq, $\nu\nu$qq, $\ell\nu$qq , qqqq), well-motivated extensions to the SM and has very rich phenomenology. LHC Run1 observed some excess which needs cross check using 13 TeV data at Run2**
  - Heavy Vector Triplet (HVT) model A, BR(W'→ WZ) ~ 2%
  - Kaluza-Klein (KK) modes in Randall-Sundrum(RS) graviton model, BR(G*→ZZ)~ 8-10%
  - Generator: MadGraph5 2.2.2 (NNPDF23LO)

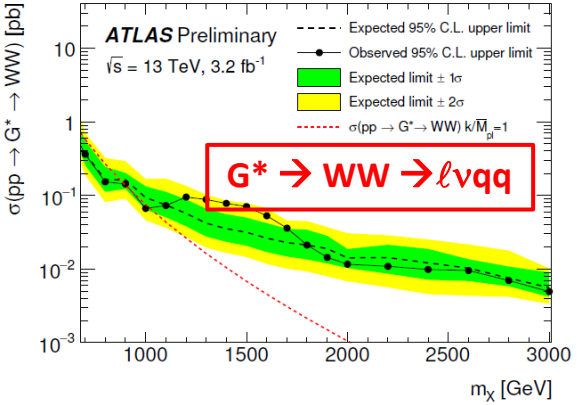


- **Two heavy Higgs-like boson hypotheses are tested (H→WW→ $\ell\nu$qq):**
  - Narrow Width Assumption (NWA, SM Higgs width of 4MeV) ,
  - Large Width Assumption (LWA, 5-15% of heavy Higgs mass)

- **No evidence is observed, masses below 1060 GeV and 1250 GeV are excluded at 95% CL for spin-2 RS G*→WW and H→WW. Upper limits on σ × BR(H→WW) with NWA/LWA ∈ [0.02, 0.3]pb**



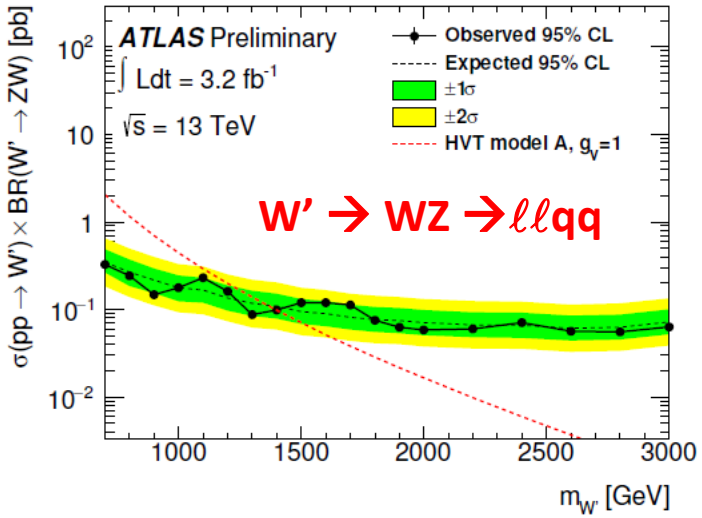




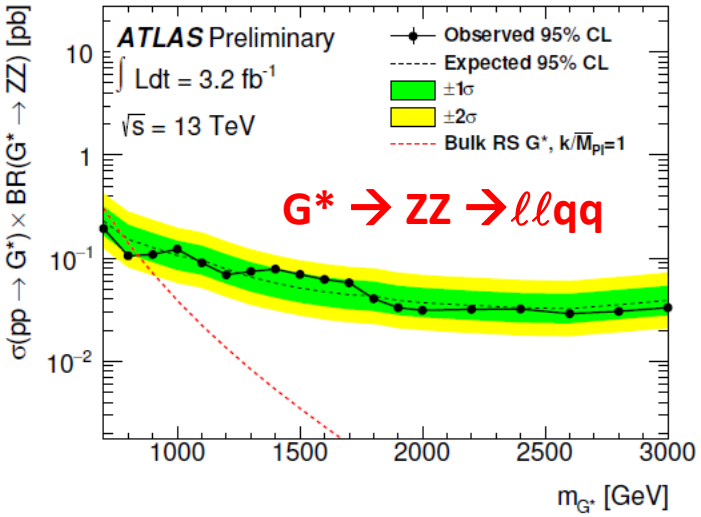
Search for Diboson Resonance

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

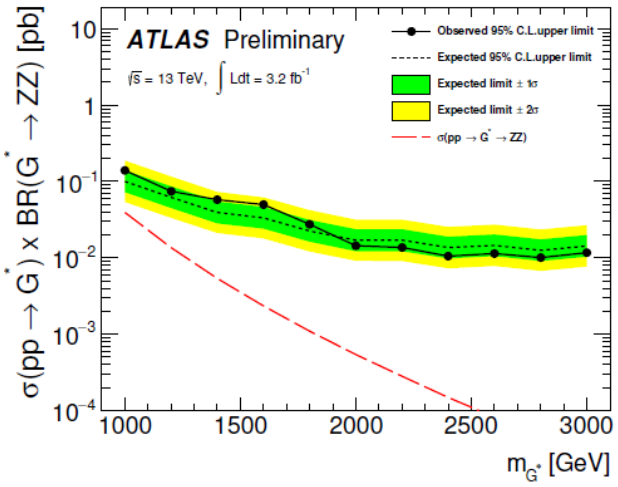
Observed W' > 1.4 TeV



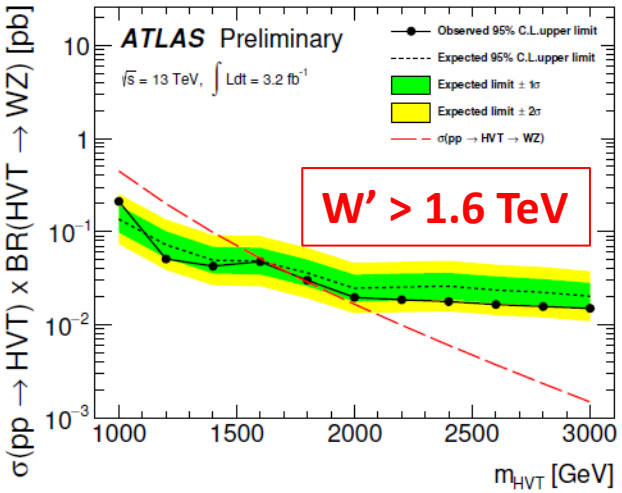
G* > 850 (expected >790) GeV



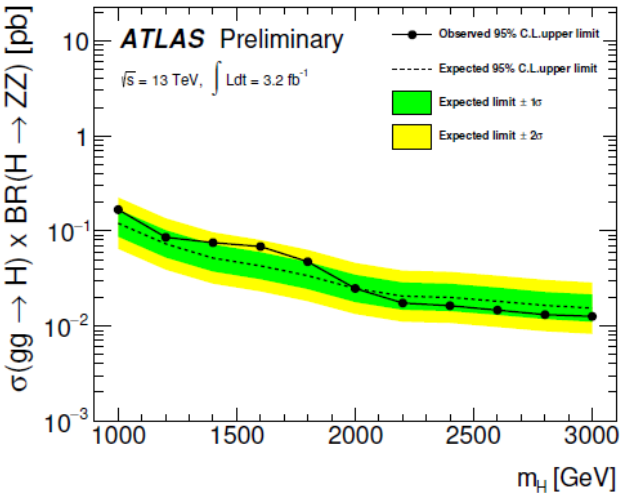
G* → ZZ → ννqq



W' → WZ → ννqq



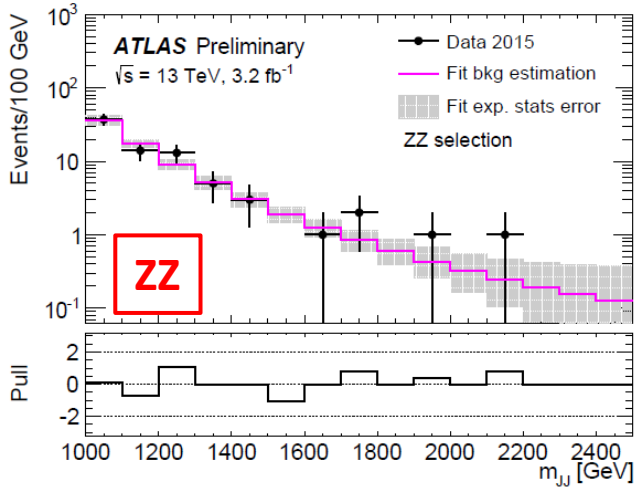
H → WZ → ννqq

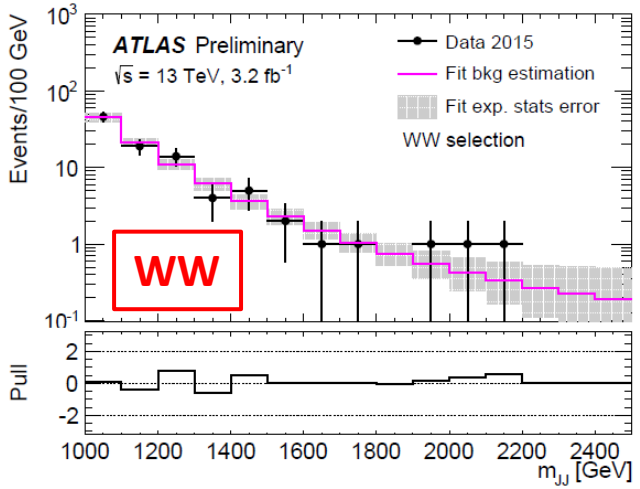


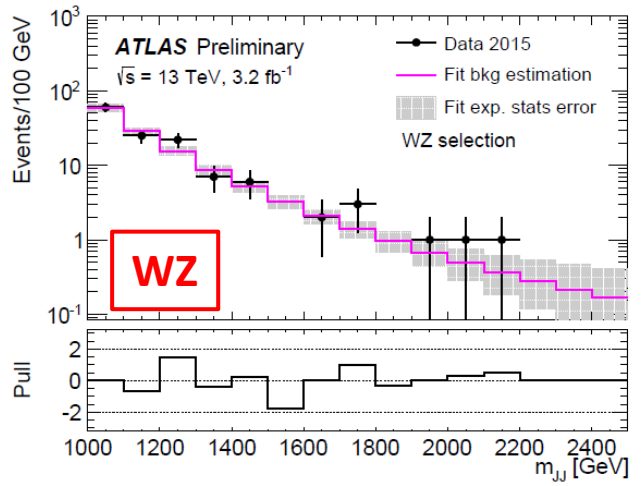
Search for Diboson Resonance

ATLAS-CONF-2015-073

- Focus on ZZ/WW/WZ decay into four-quark final states ➔ two fat jets
- Two anti-kt jets with R=1.0, n_{trk}<30, jet P_T>200 GeV, $|\eta|$<2.0, m_{jet}>50 GeV

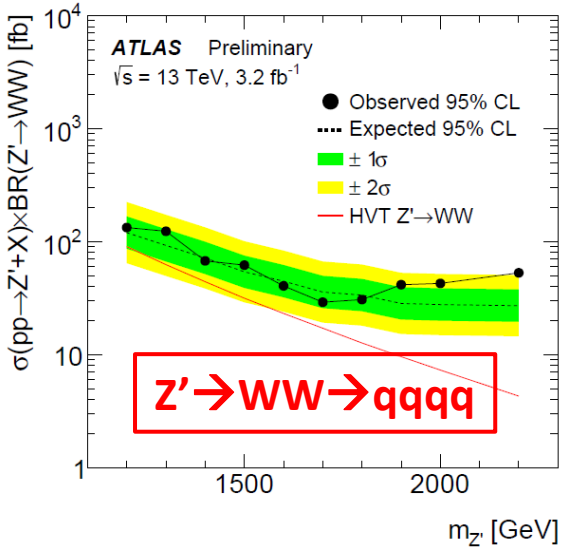


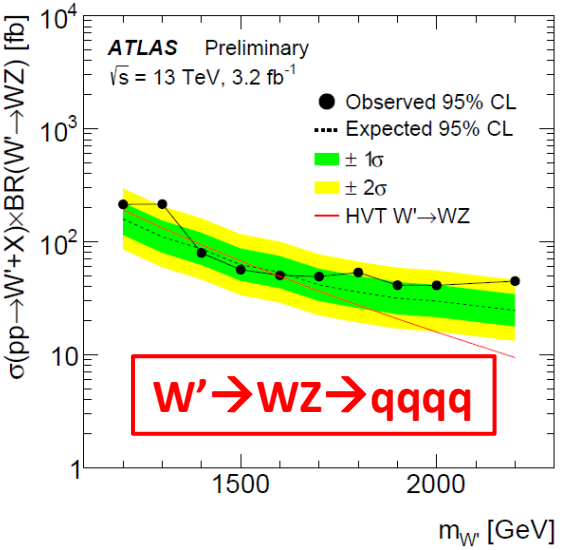




m [TeV]	Γ_{HVT} [GeV]	$W' \to WZ$ $\sigma \times$BR [fb]	$Z' \to WW$ $\sigma \times$BR [fb]	$\Gamma_{G_{RS}}$ [GeV]	$G_{RS} \to WW$ $\sigma \times$BR [fb]	$G_{RS} \to ZZ$ $\sigma \times$BR [fb]
1.3	33.3	62.7	28.7	76	7.2	3.9
1.6	40.9	23.3	10.6	96	2.0	1.1
2.0	51.0	7.6	3.35	123	0.47	0.25

➔Results exclude HVT W' model in the mass range from 1.38 to 1.6 TeV at 95% CL through its decay to WZ.





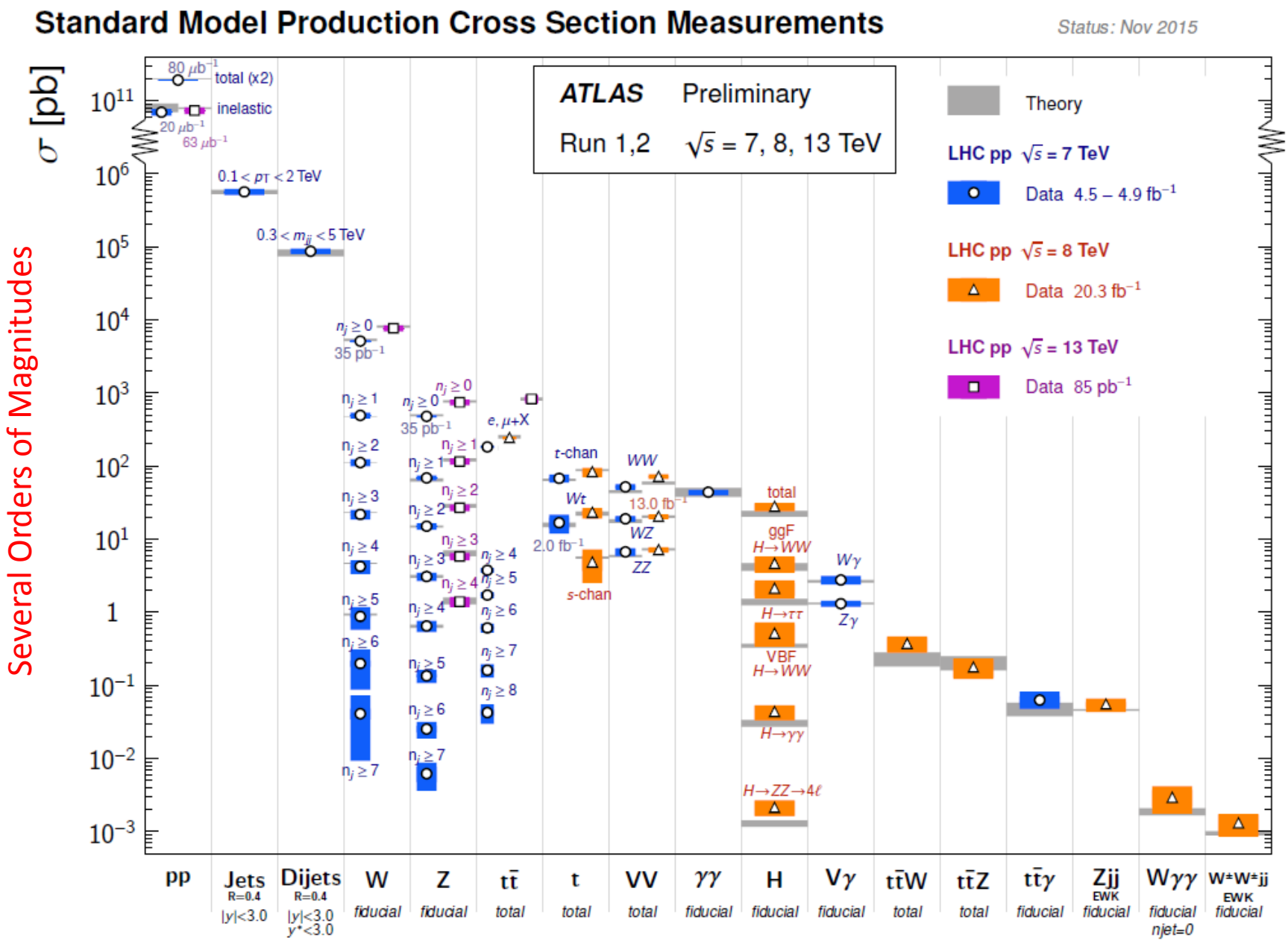
Summary

ATLAS made tremendous efforts and progresses based on the LHC Run2 13 TeV data collected in 2015, ranging from SMEW, Top, Higgs, and extensive searches for BSM Higgs, SUSY, Dark Matter, Exotic and Diboson resonances etc.

More interesting results from LHC Run2 are coming, please stay tuned !

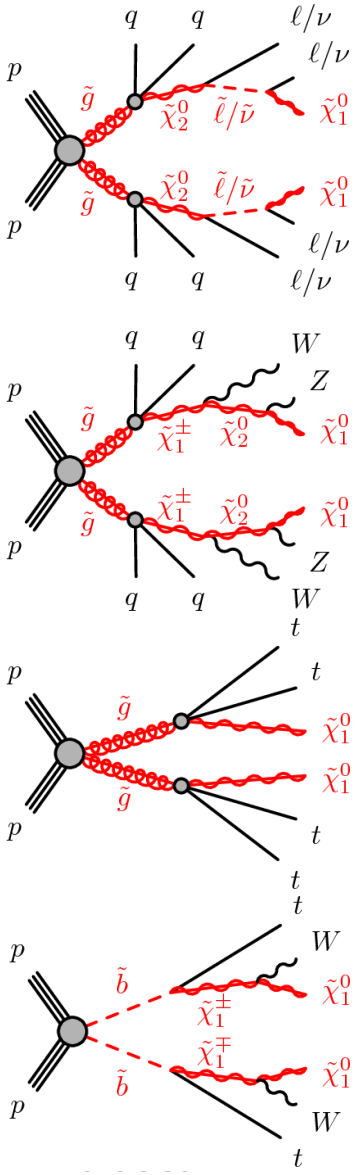
Thank you very much !

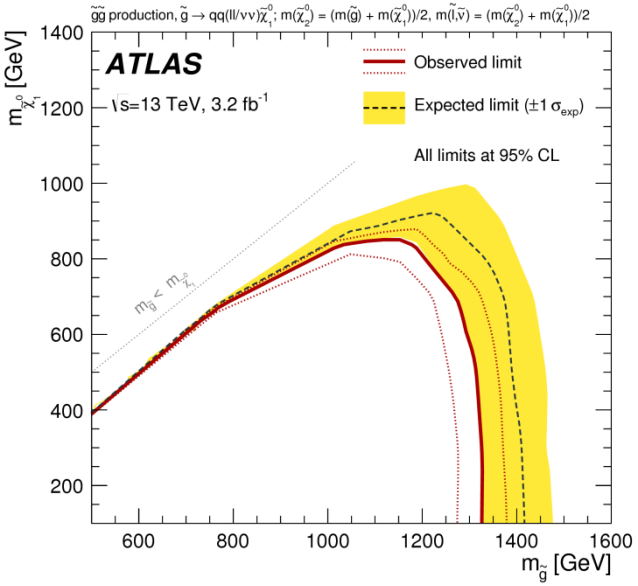
https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CombinedSummaryPlots/SM/

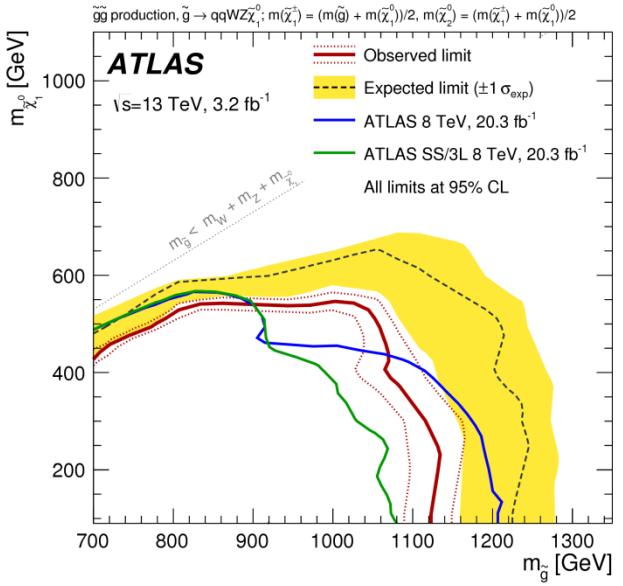


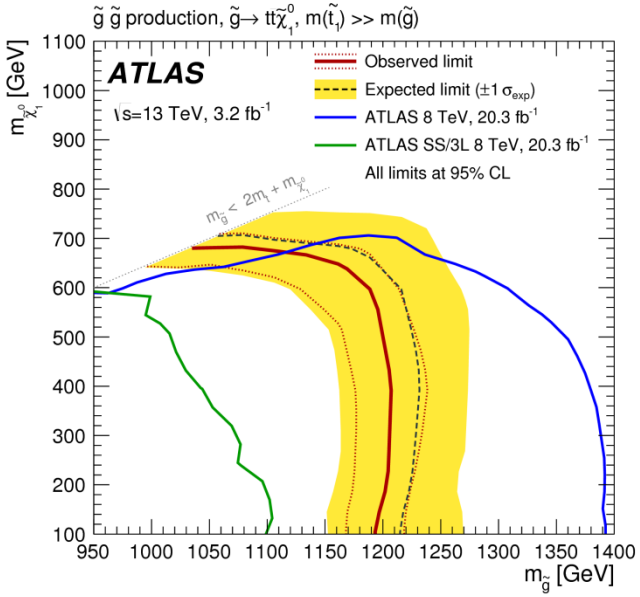
Search for SUSY Gluino and sbottom

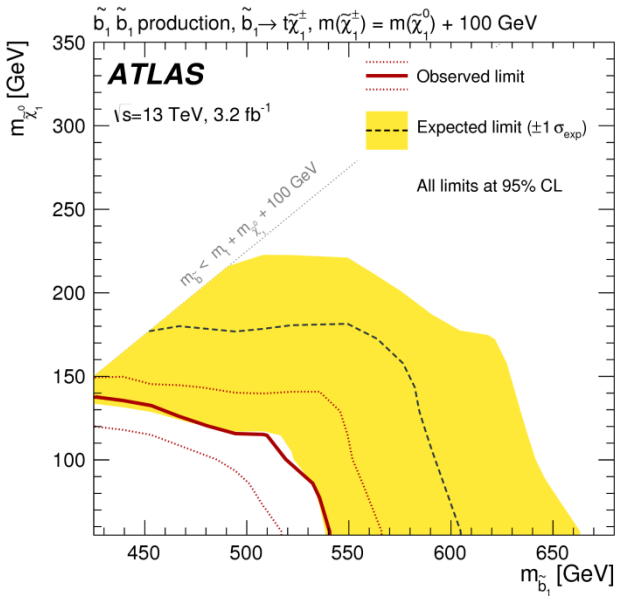
arXiv:1602.09058











Search for Gravity

JHEP03 (2016) 026

- Some models of gravity postulate a fundamental gravitational scale comparable to EW scale, allowing production of **micro Black Hole and String Balls** at LHC.
- BH decay is considered to be a stochastic process, different number of particles (jets) has identical kinematic distributions. It motivates search in inclusive jet multiplicity slices.

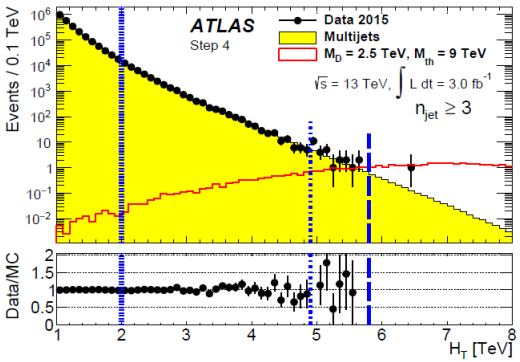
Search Strategy: three regions of H_T

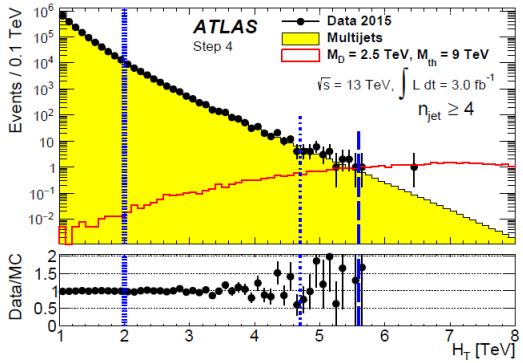
Control region : $C < H_T < V$

Validation region : $V < H_T < S$ (N_{MC}>20)

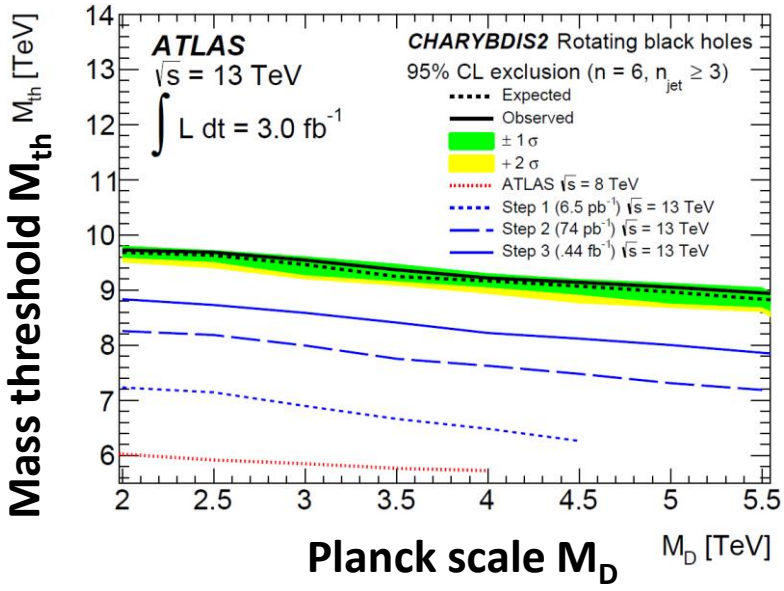
Signal region : $H_T > S$ ($\Delta N_{extrap} \sim 0.5$)

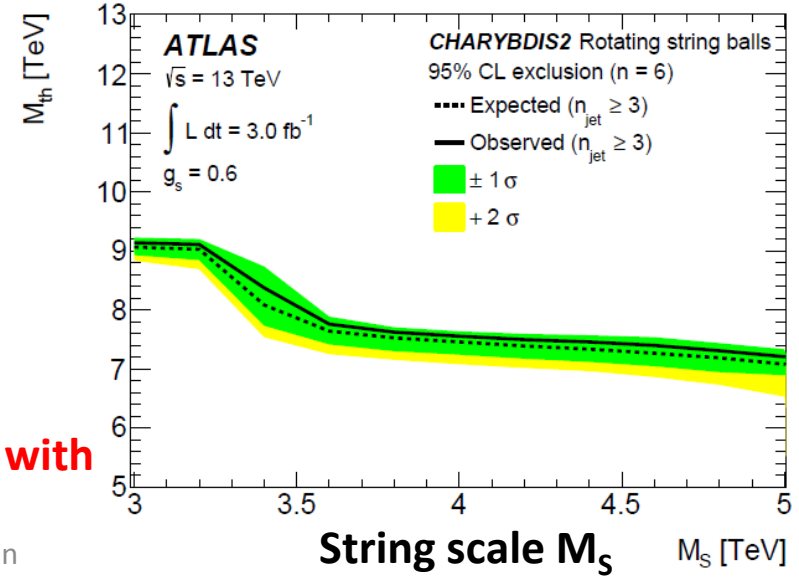
Four steps: 6.5pb^{-1}, 74pb^{-1}, 0.44fb^{-1}, 3.0fb^{-1}





No excess is seen at large H_T , cross section > 1.6 fb with H_T > 5.8 TeV are excluded for models with > 3 jets.

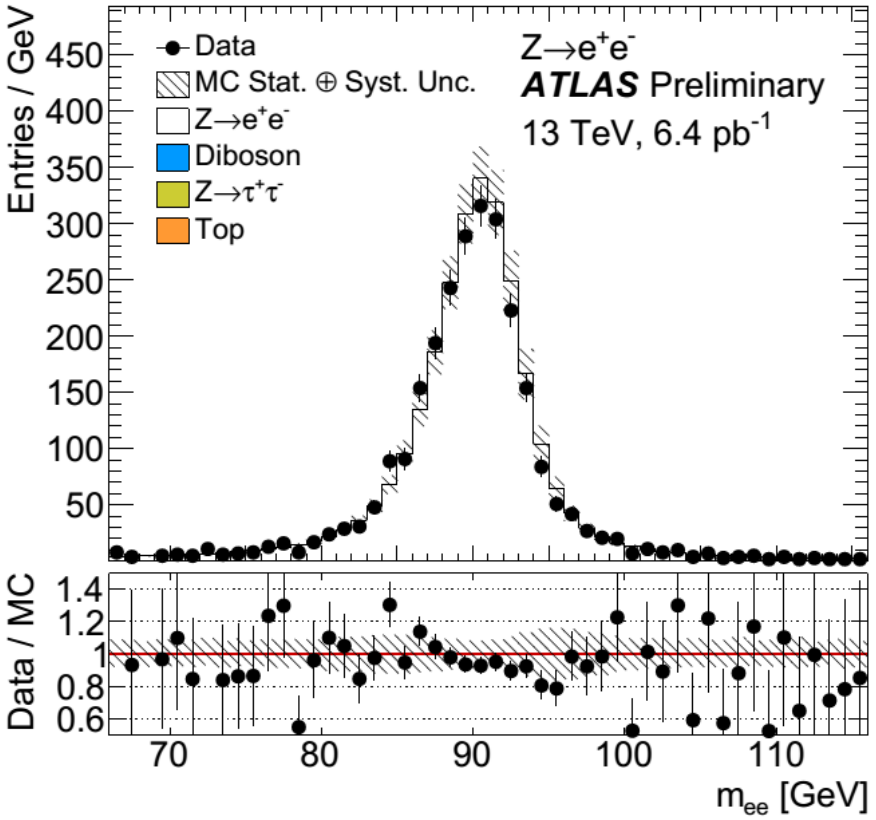


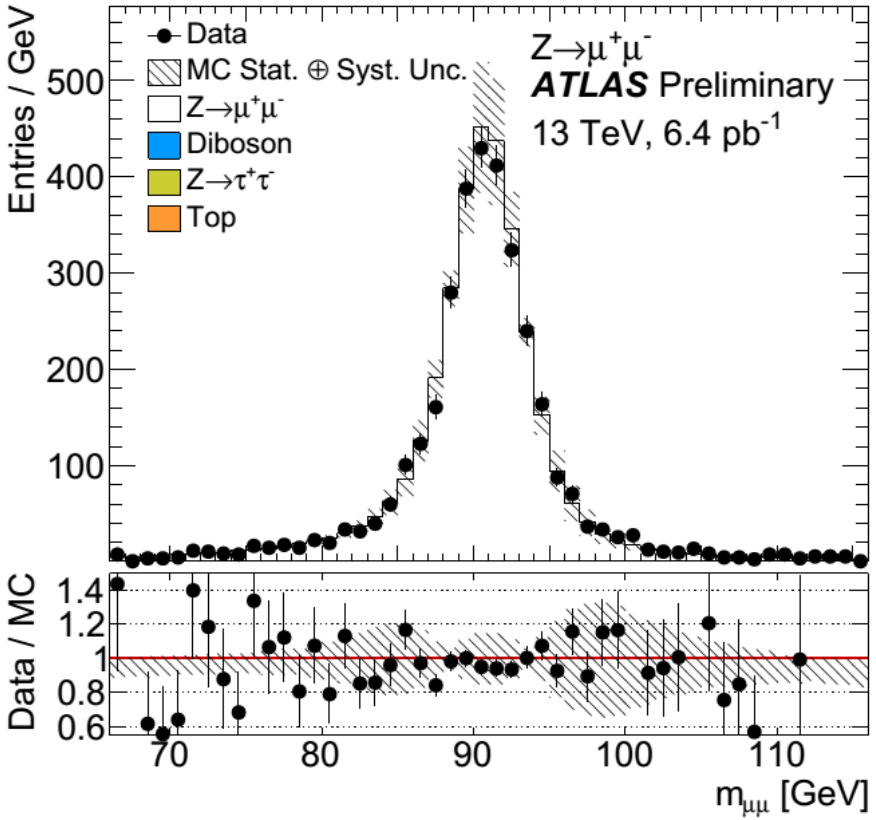


13 TeV Z plots

ATL-PHYS-PUB-2015-021

Very early Run II data, reasonable agreement with MC





Z candidates: two leptons with pt > 25 GeV, 66<M(ll)<116 GeV

$|\eta_\mu|$<2.4, $|\eta_e|$<2.47 excluding [1.37, 1.52]

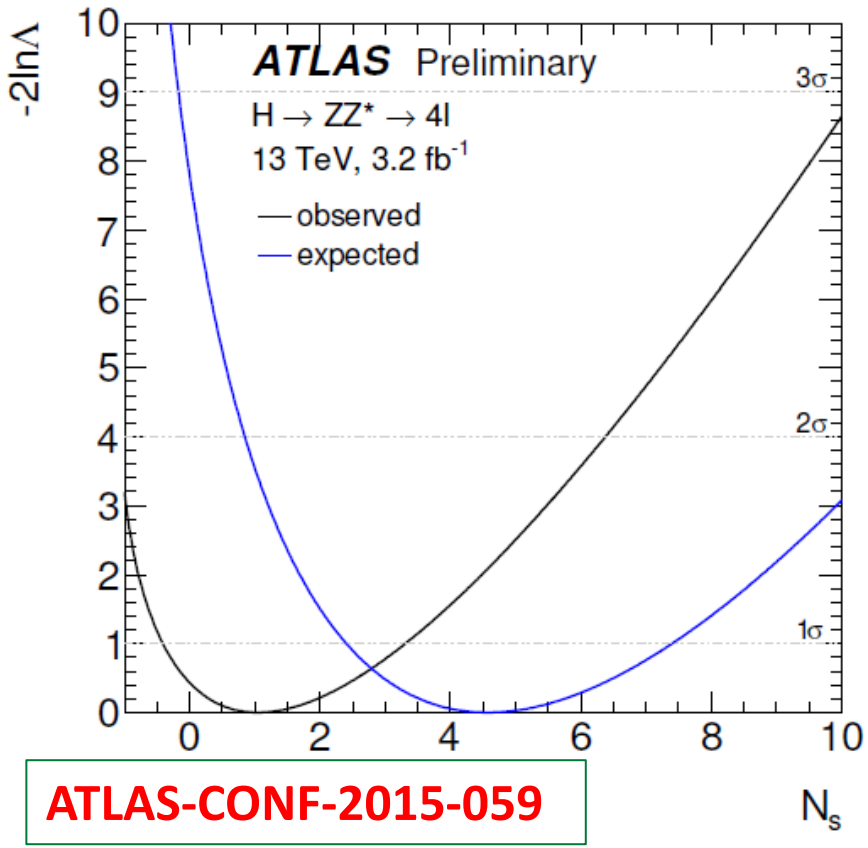
Higgs Fiducial and Total Cross Section

- Total and fiducial cross section measurement.

$$\sigma^{\text{tot}} = \frac{N_s}{\mathcal{A} \cdot C \cdot \mathcal{B} \cdot \mathcal{L}_{\text{int}}}$$

$$\sigma^{\text{fid}}_{4\ell} = \frac{N_s}{C \cdot \mathcal{L}_{\text{int}}}$$

At 13 TeV, an upper limit on Higgs production cross section of 69pb is derived at 95% CL.



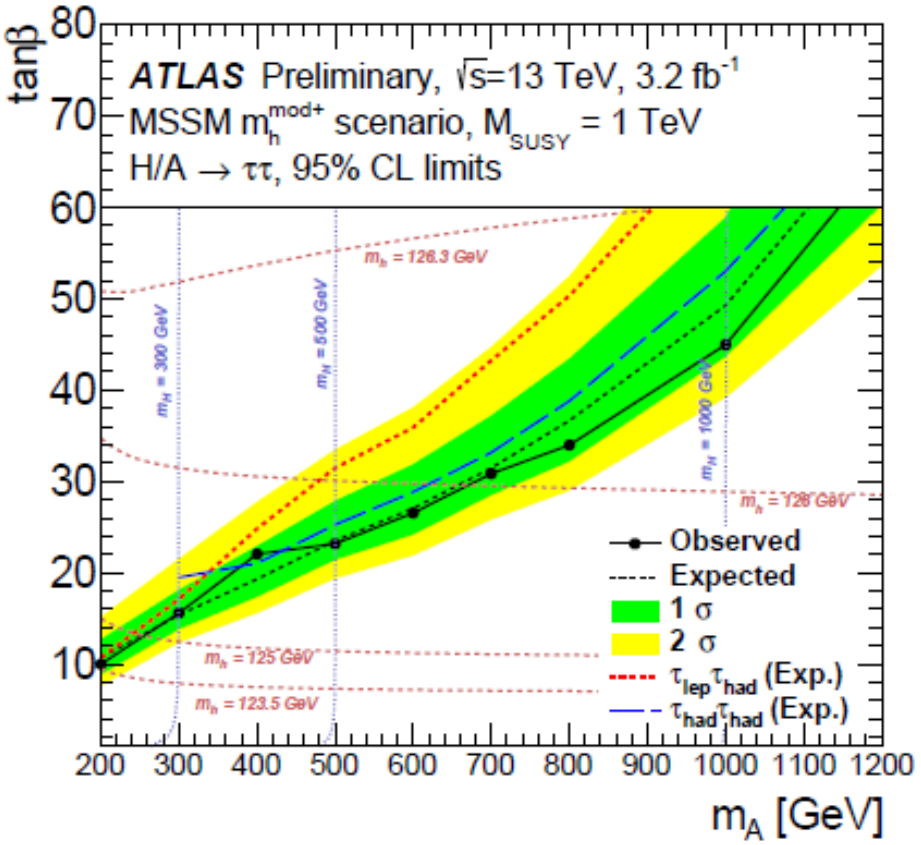
ATLAS-CONF-2015-059

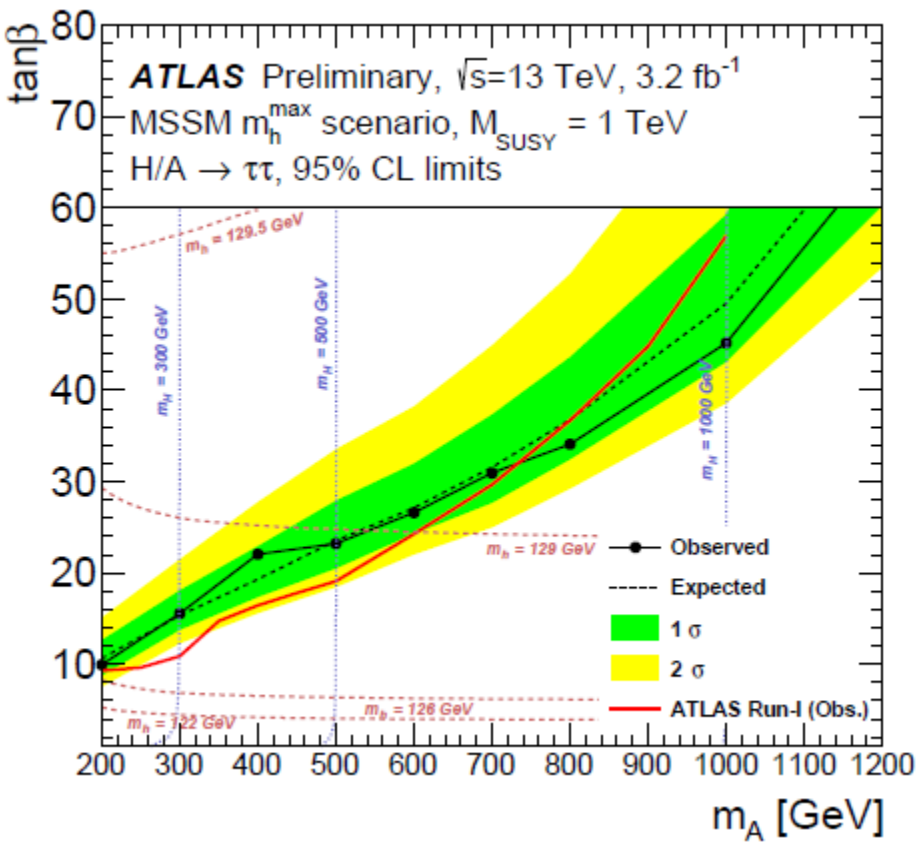
Data set [TeV]	N_s	$\sigma^{\text{fid}}_{4\ell}$ [fb]	$\sigma^{\text{fid}}_{\text{theory}}$ [fb]	σ^{tot} [pb]	$\sigma^{\text{tot}}_{\text{theory}}$ [pb]
7	$4.5\ ^{+2.8}_{-2.2}$	$1.9\ ^{+1.2}_{-0.9}$	1.03 ± 0.11	$33\ ^{+21}_{-16}$	17.5 ± 1.6
8	$24.0\ ^{+6.0}_{-5.3}$	2.1 ± 0.5	1.29 ± 0.13	$37\ ^{+9}_{-8}$	22.3 ± 2.0
13	$1.0\ ^{+2.3}_{-1.5}$	$0.6\ ^{+1.3}_{-0.9}$	2.74 ± 0.28	$12\ ^{+25}_{-16}$	$50.9\ ^{+4.5}_{-4.4}$

Search for MSSM H/A→ττ

ATLAS-CONF-2015-061

- In the MSSM m_h^{mod+} scenario, the parameters are chosen such that radiative corrections give a light CP-even Higgs mass of ~ 126 GeV in the decoupling limit. this search excludes tanβ > 10 for m_A=200 GeV at 95% CL.





A bit about the models...

Slide borrowed from V. Cavaliere...

Charged (WZ)

Sequential Standard Model (W', spin-1)

* Trilinear W'WZ coupling set by Extended Gauge Model: ~ $(M_W/M_{W'})^2$

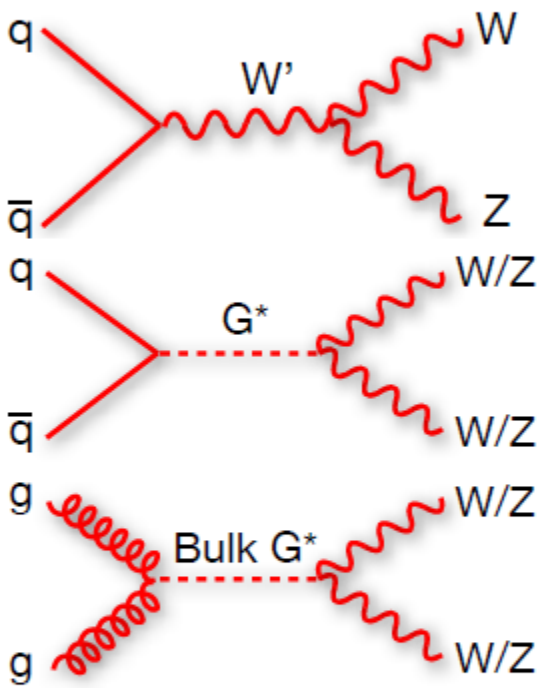
Neutral (WW,ZZ,HH)

Randall-Sundrum graviton (RS G*, spin-2)

* Traditional benchmark model with extra dimensions

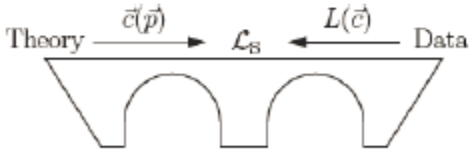
Bulk RS graviton (Bulk G*, spin-2)

* Graviton couples more with heavy particles (W, Z, t)
* Smaller σ, but larger branching ratio to WW, ZZ



Minimal Walking Technicolor (R_1,R_2, charged and neutral)

* Technicolor with minimal ingredients, can decay to ZH and WH



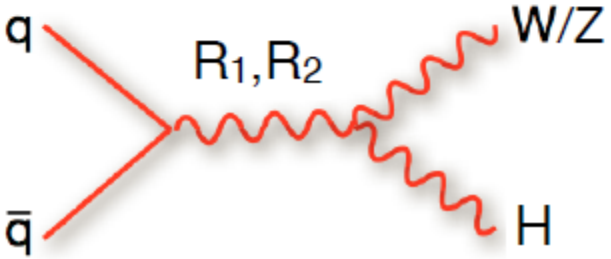
HVT (Simplified Lagrangian)

Model A

* weakly coupled vector resonances from extension of the gauge group

Model B

* produced in a strong scenario e.g. composite higgs model



ZZ & WZ → *llqq*

Both analyses require a dilepton pair compatible with the decay of a Z boson
Treatment of hadronic boson decay varies

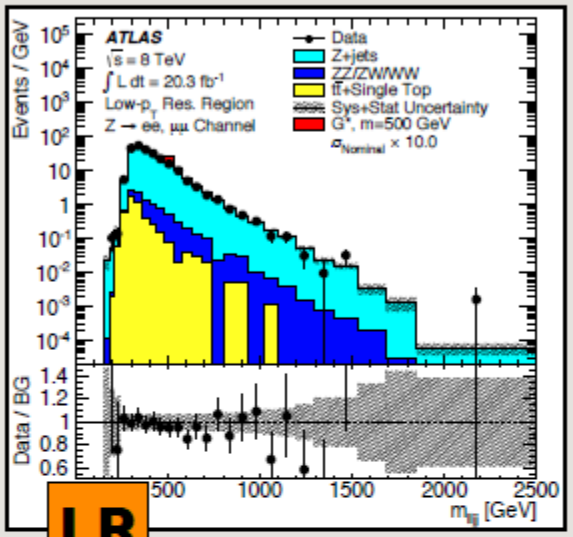
arxiv.1409.6190

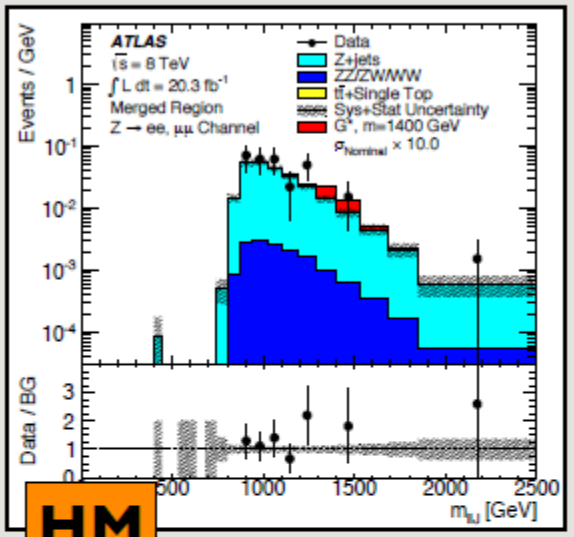
ATLAS

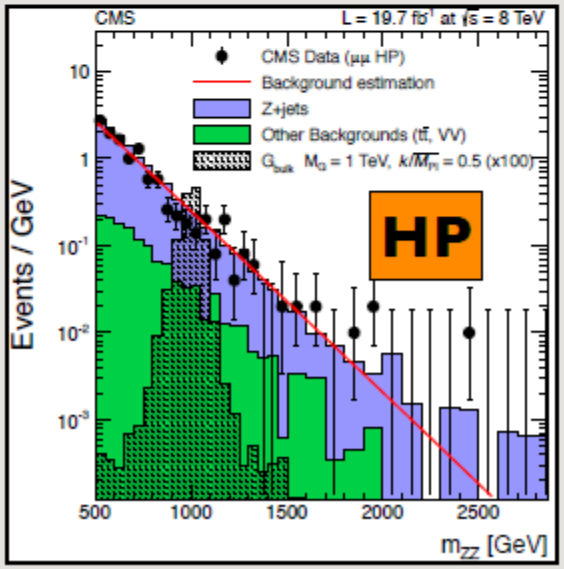
See also poster by E. Cheremushkina

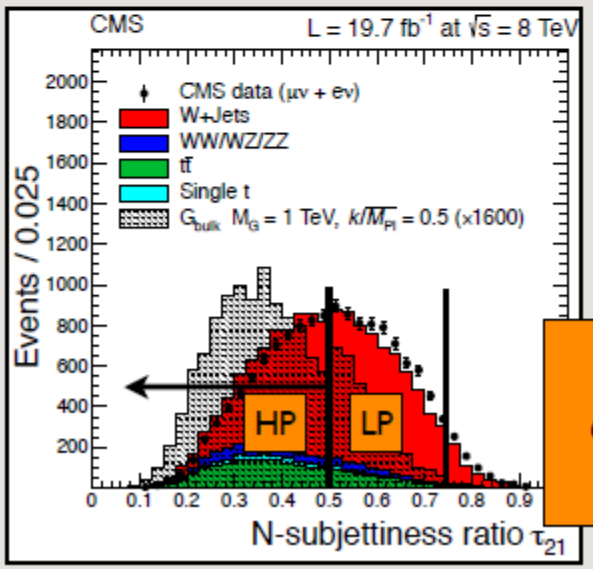
Symmetric p_T requirement on the dilepton / dijet pair used to split the analysis in 3 categories:

Low-Resolved: 100 GeV
High-Resolved: 250 GeV
High-Merged: R=1.2 large radius jet, 400 GeV









arxiv.1405.3447

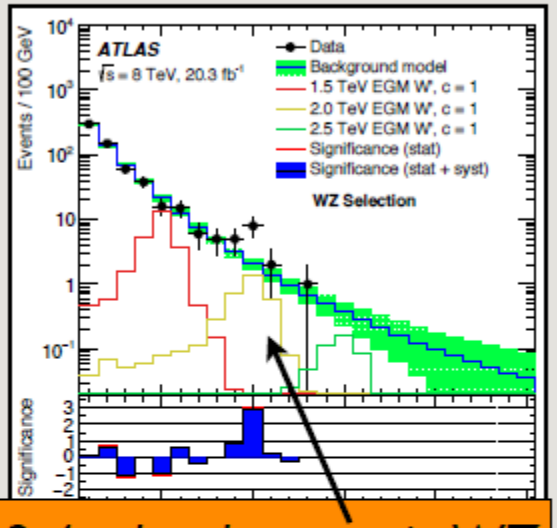
CMS

Two 'merged' selections based on subjettiness ratio to increase sensitivity in the low/high mass (high/low **purity**) regimes

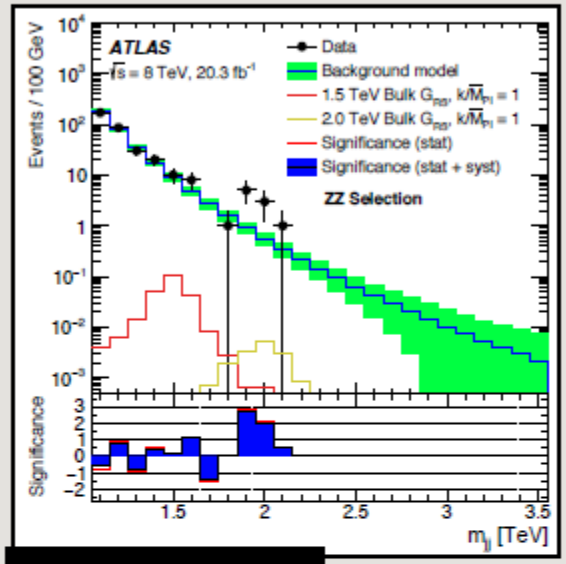
In both cases, excellent agreement is found between SM predictions and data...

ZZ & WZ & WW → *qqqq*

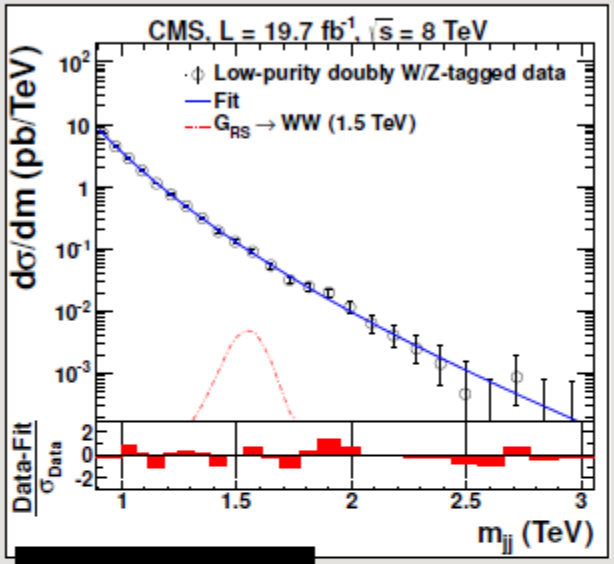
Dijet boosted final state: Identification of di-boson state is through the use of tagging techniques



3.4σ local excess in WZ channel (2.5σ global)!



arxiv.1506.00962



arxiv.1405.1994

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Dedicated selection for all 3 channels based on W/Z jet mass requirements (26 GeV windows), implying **statistical overlap** between channels

2 large **CA** R=1.2 jets with $n_{trk} < 30$ are required in the events, satisfying boson tagging requirements (grooming & filtering). Extra topology requirements are used to reduce QCD backgrounds

CMS

Require 2 **CA** R=0.8 jets in the events along with topology requirements to reduce backgrounds

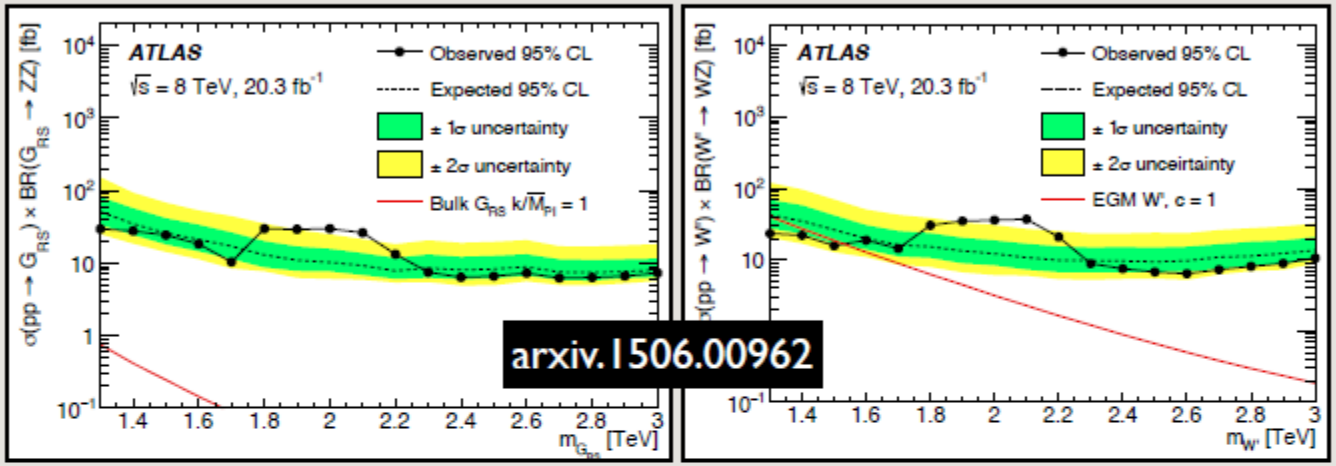
Jets are W/Z-tagged based on a combination of pruned mass and subjettiness requirements Separate events into 1/2 tag category, and use same **HP/LP** classification as in the *llqq* analysis

ZZ & WZ & WW → *qqqq* Limit Setting

ATLAS

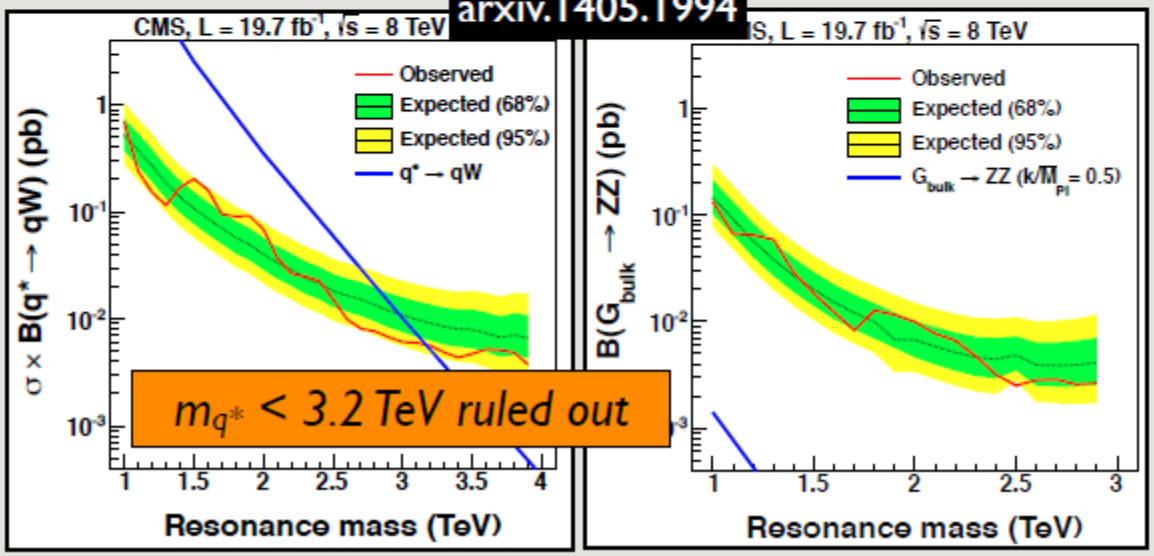
Limits set on RS Gravitons and EGM W'

Excesses seen in all 3 channels (overlapping), at 3.4σ, 2.9σ and 2.4σ local significance



arxiv.1506.00962

arxiv.1405.1994



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Limits set on RS Gravitons and W'

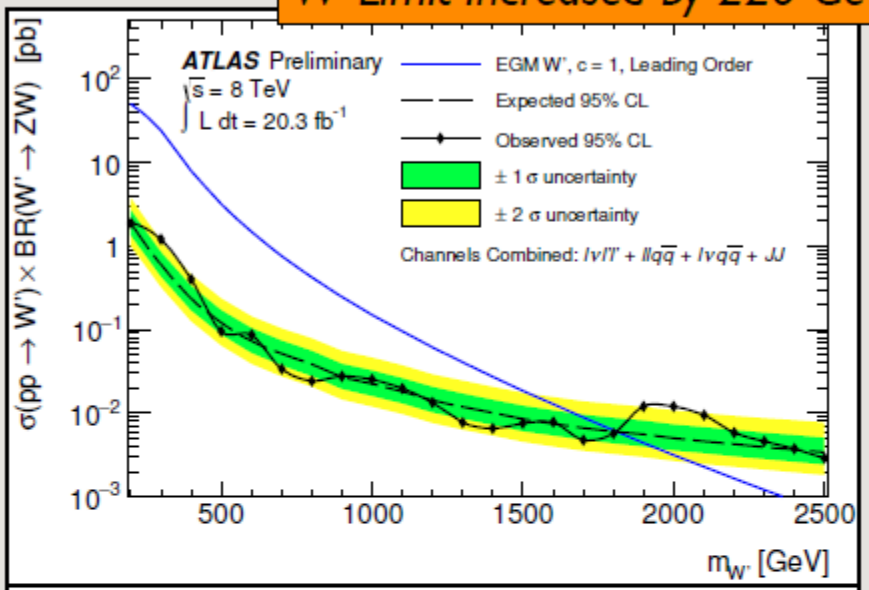
Due to single tag category, unique sensitivity to excited quark scenarios (q*→qW/qZ)!

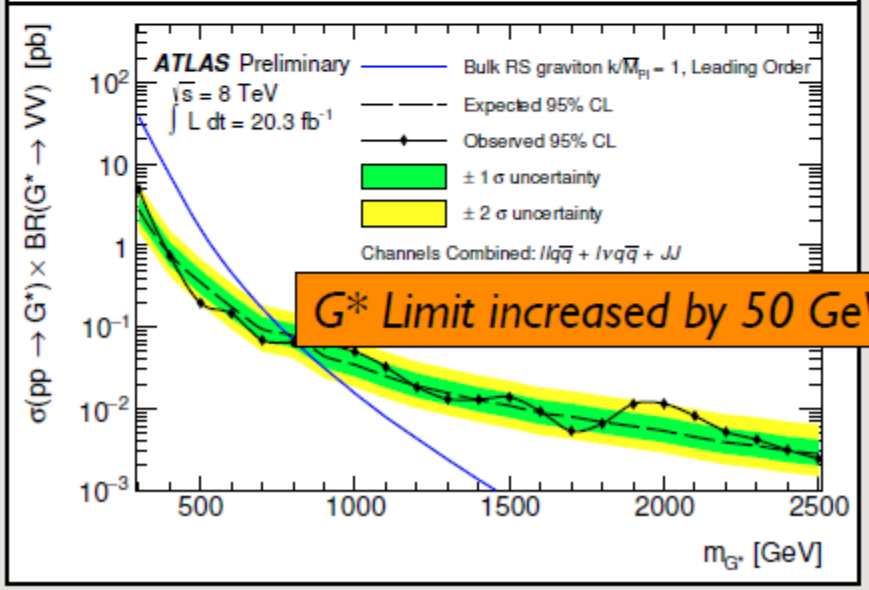
WW / WZ / ZZ Combination ATLAS only

New!

ATLAS-CONF-2015-045

W' Limit increased by 220 GeV





G Limit increased by 50 GeV*

Combination of four statistically independent searches (of which *lvll* is the only one not shown in this talk, see arxiv:1406.4456)