

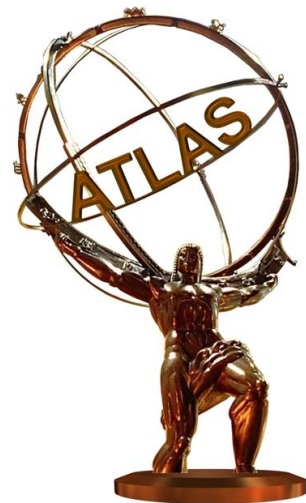
# Exotic and SUSY Searches at ATLAS

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University of Michigan



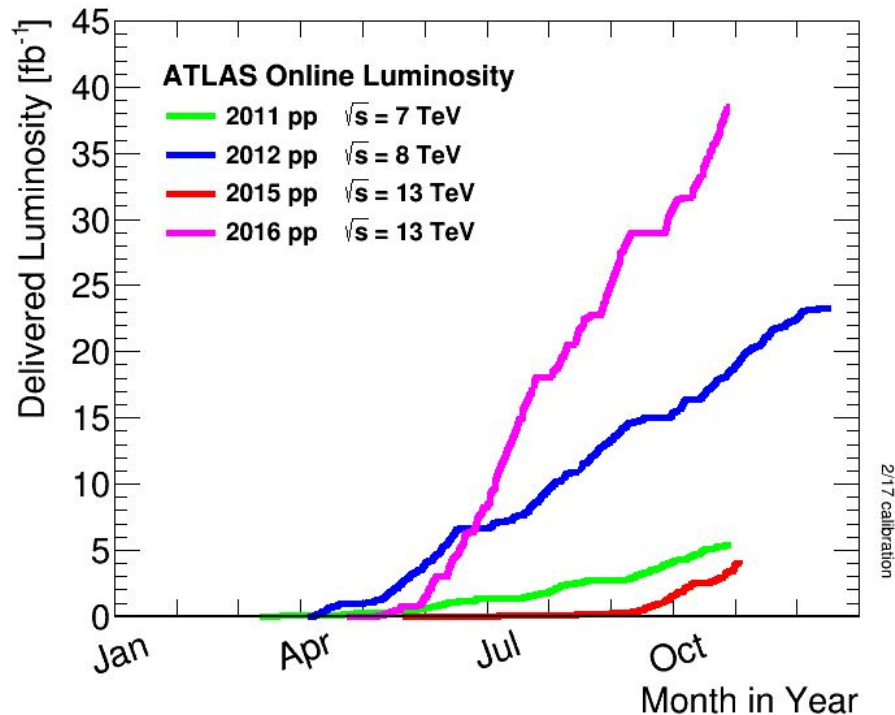
U.S. DEPARTMENT OF  
**ENERGY**

Office of Science



# Introduction

- LHC has provided us with  $40 \text{ fb}^{-1}$  of new data what do we see?
- Establishing the landscape
  - Dijet - **NEW**
  - Lepton+MET - **NEW**
  - W/Z+h - **NEW**
- Narrowing in on SUSY
  - Jets+MET - **NEW**
  - b-Jets+MET - **NEW**
  - sTop 0L - **NEW**
  - H/Z+MET - **NEW**



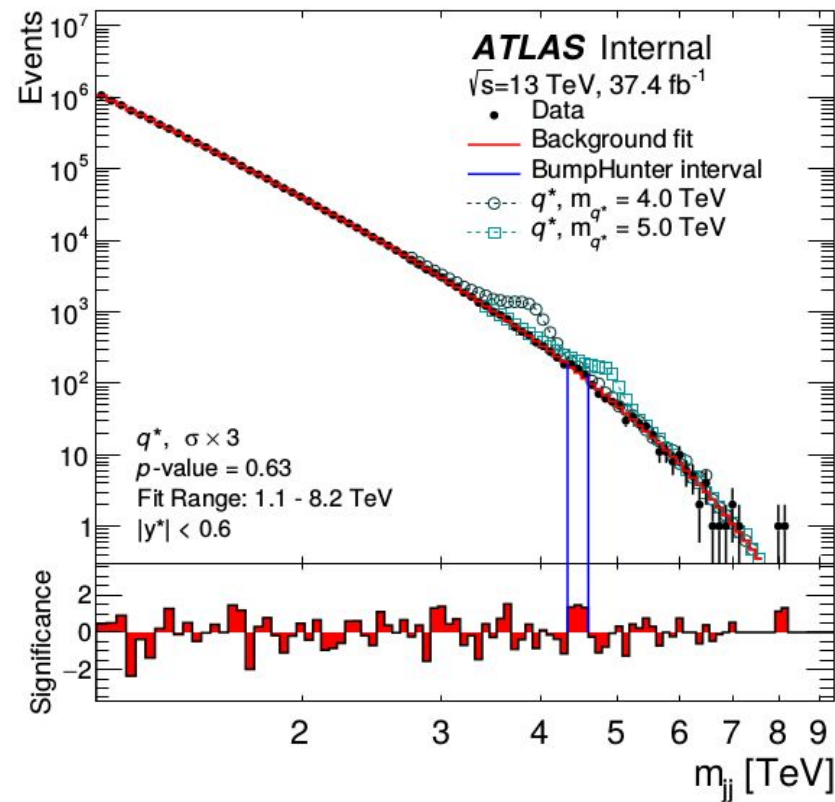
# Dijets

- **Dijets are an excellent way to look for new physics**
  - Particles produced at the LHC must have some way of coupling to partons
  - Looking for decays into dijets provides sensitivity to a broad range of new physics possibilities
- **Main background: SM dijet production**
- **Two search strategies**
  - Resonance
    - Bump hunt in the falling standard model  $m_{jj}$  spectrum
  - Angular
    - Look for the excess in  $\chi = e^{2|y^*|} \sim \frac{1 + \cos \theta^*}{1 - \cos \theta^*}$

$\theta^*$  = polar angle in the dijet centre-of-mass frame

# Dijets - Resonance

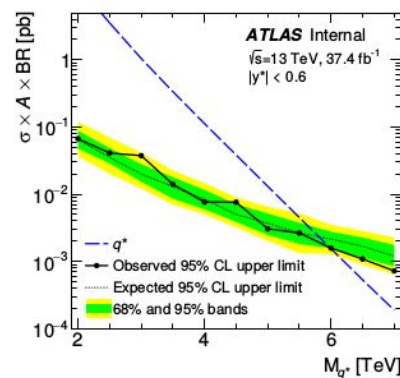
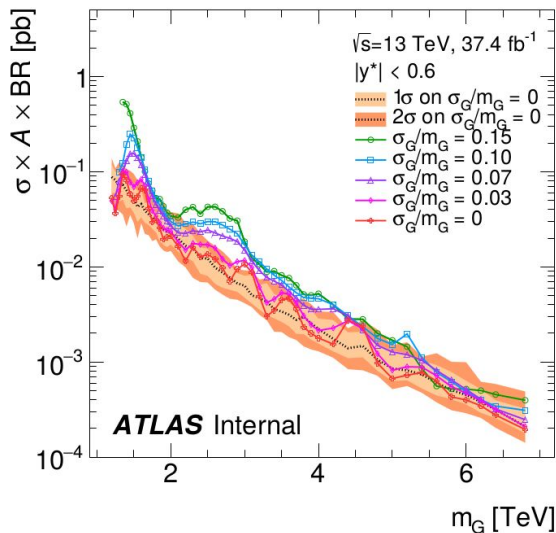
- To reduce the QCD contributions a cut is made on  $|y^*| < 0.6$ 
  - $\frac{1}{2}$  rapidity difference
- 440 GeV and 60 GeV leading/subleading jet pT cuts
- Fit from 1.1 - 8.2 TeV
  - **No significant excess seen**



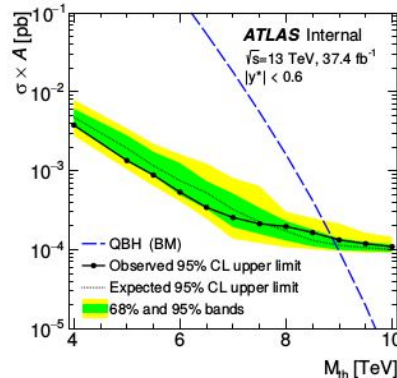


# Interpretations

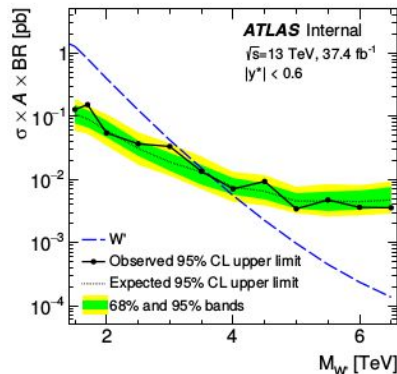
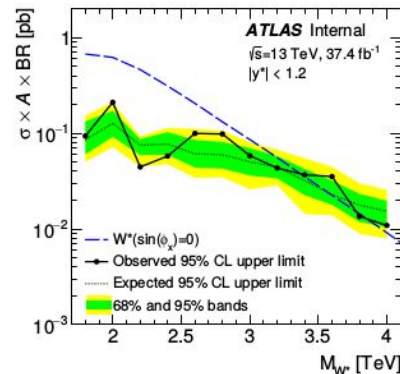
- Limits are set on several models
  - $q^*$ ,  $W'$ ,  $W^*$ , Quantum Black Holes
- Generic Gaussian limits can be used to test other models with a standard prescription



(a)  $q^*$



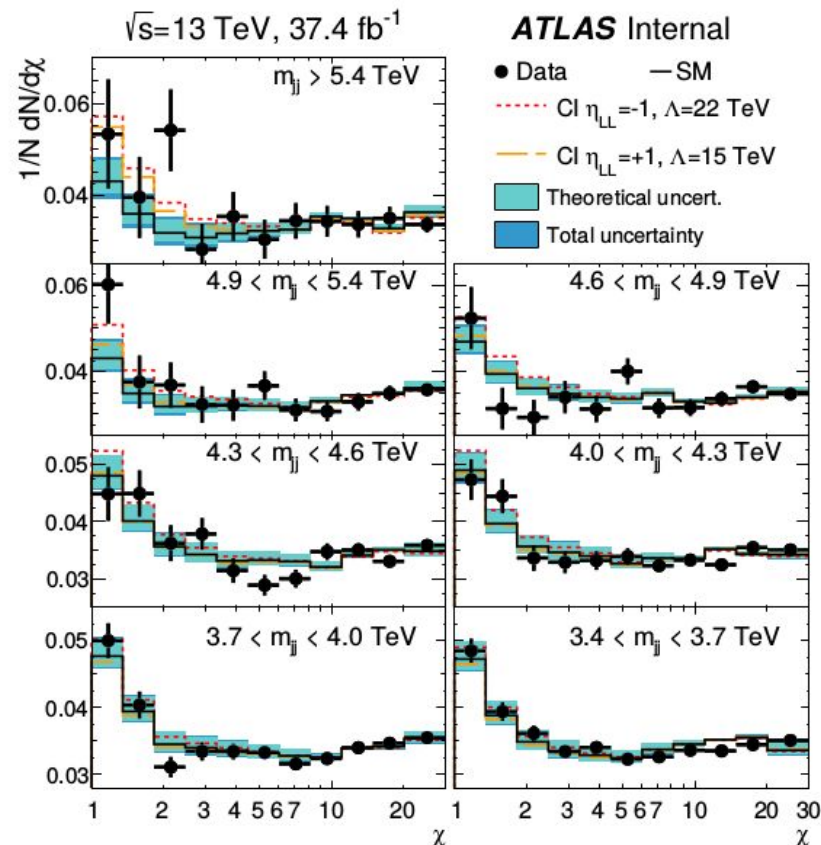
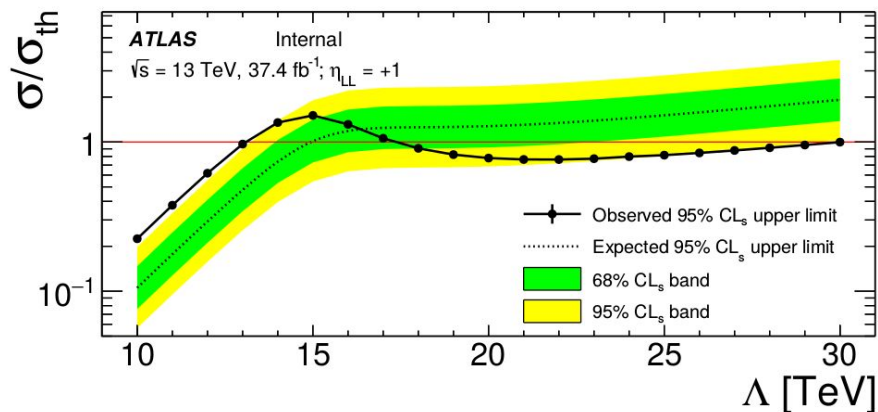
(b) BLACKMAX



# Angular

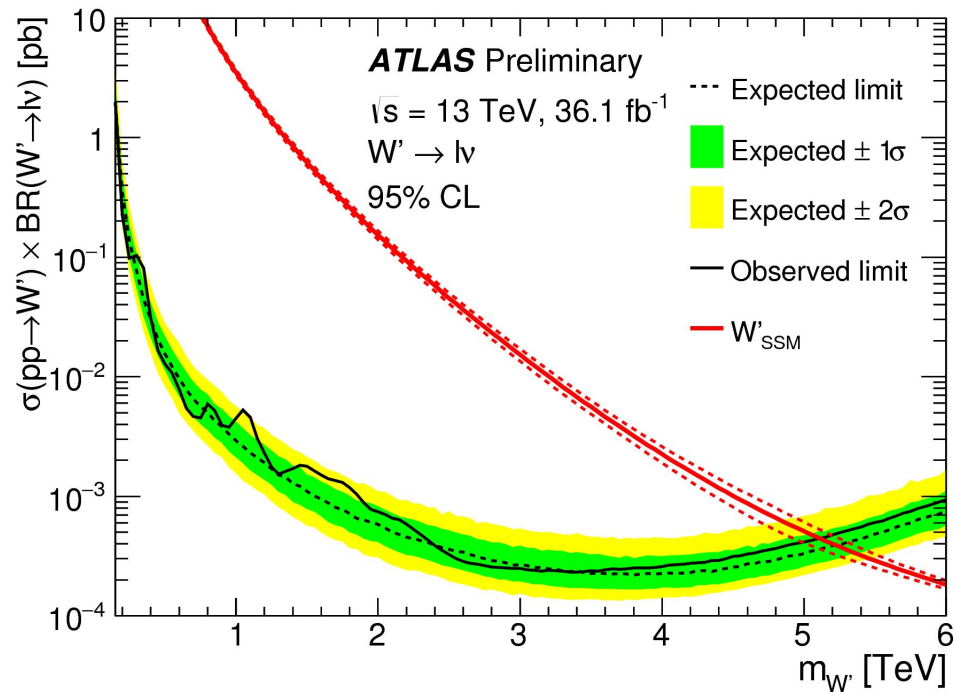
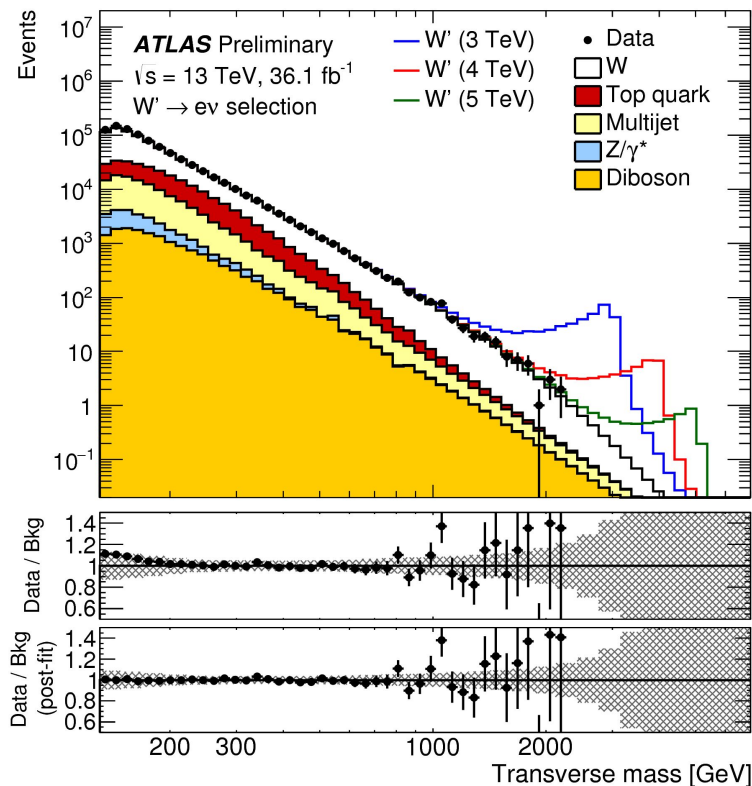
$$\chi = e^{2|y^*|} \sim \frac{1 + \cos \theta^*}{1 - \cos \theta^*}$$

- Effective contact interactions can produce signals at low values of  $\chi$   
More pronounced at higher  $m_{jj}$
- Limits are placed on constructive and destructive interference models

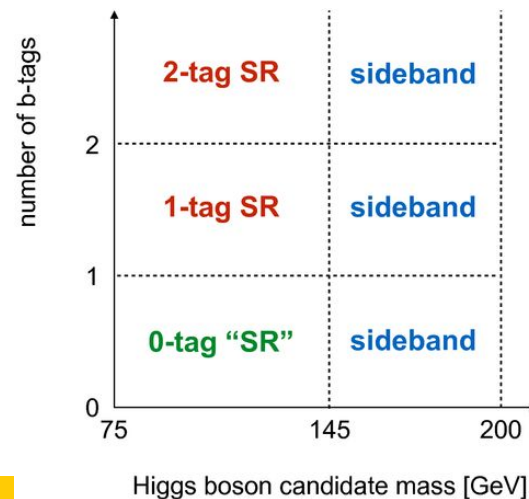
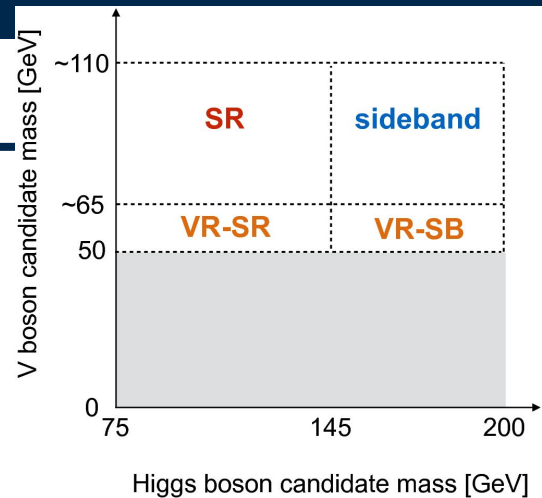
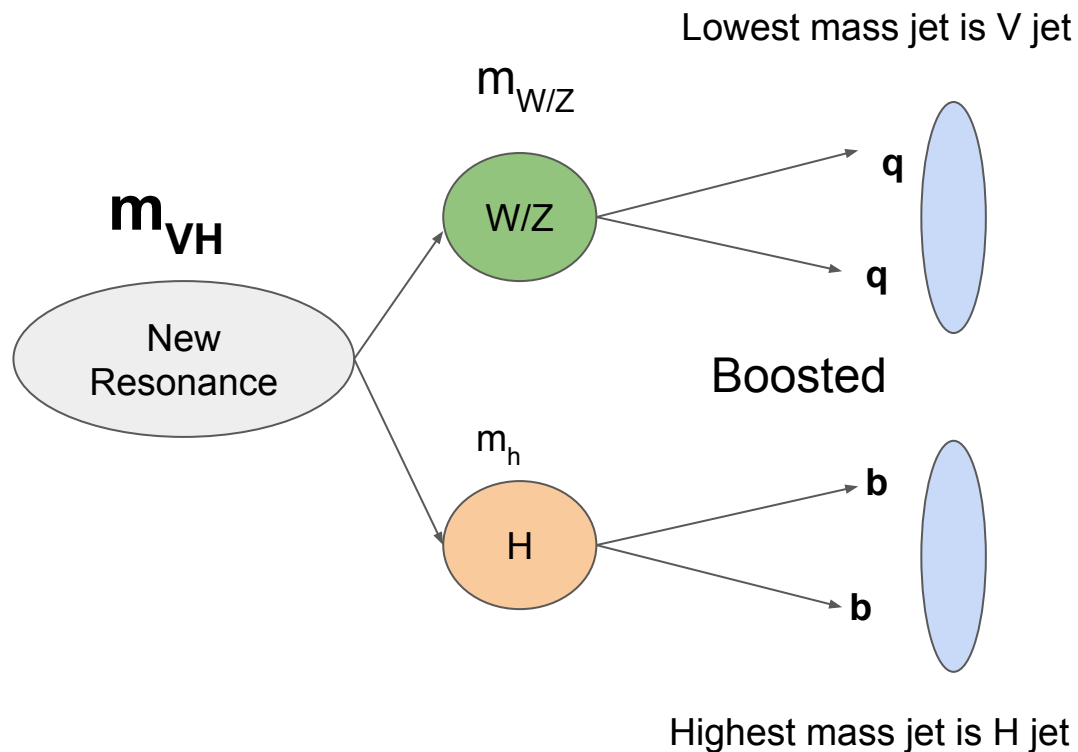


# $\ell\nu$ +jets ATLAS-CONF-2017-016

- 1 lepton + MET, fits transverse mass

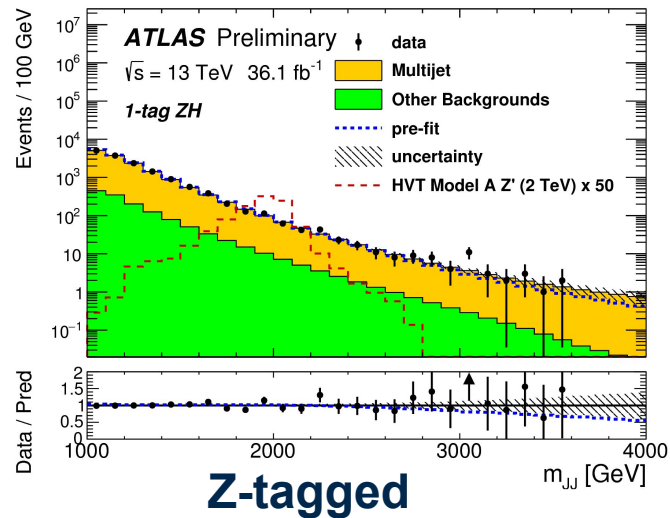
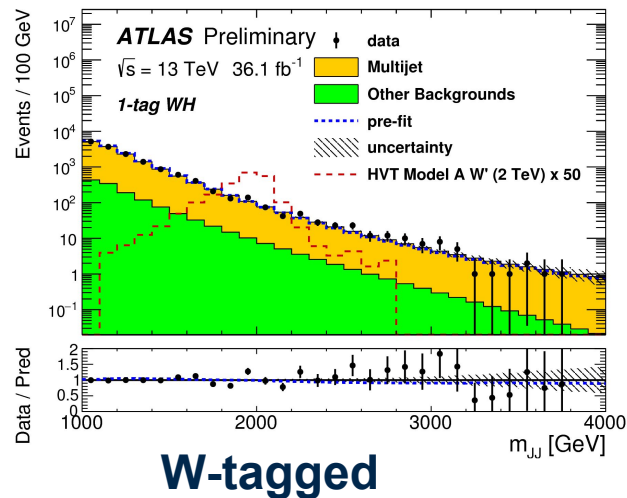


# $WZ+h$ $\square$ $qqbb$ [ATLAS-CONF-2017-018](#)

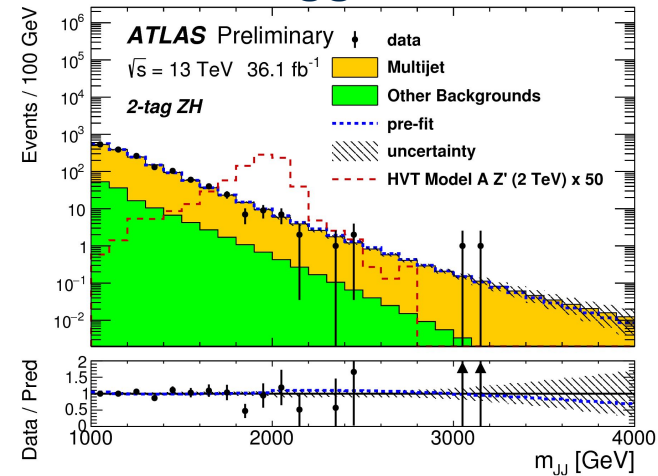
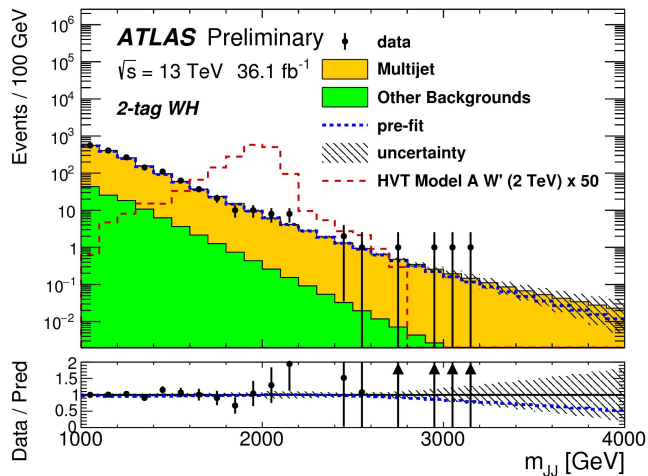


# Results

## 1 $b$ -tags

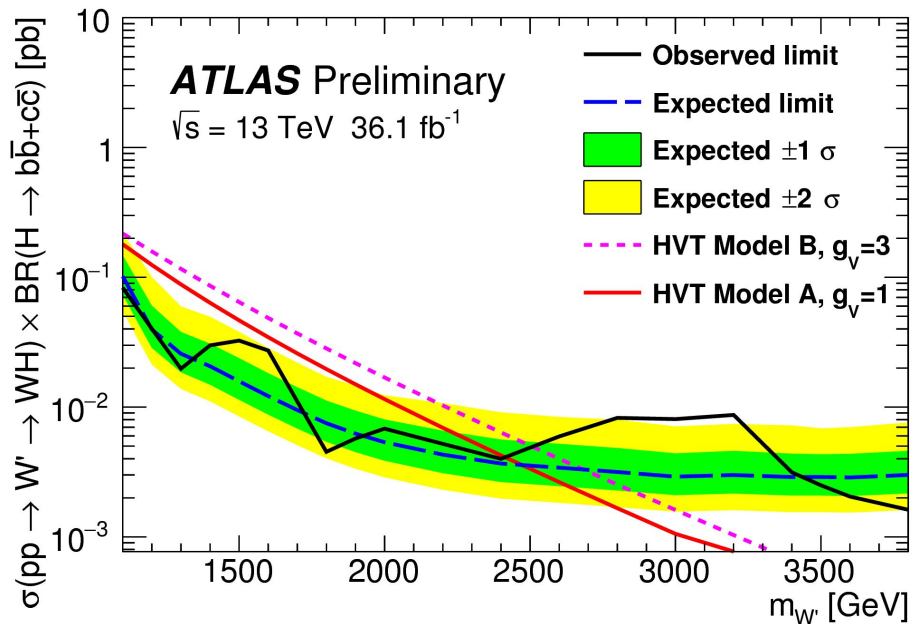
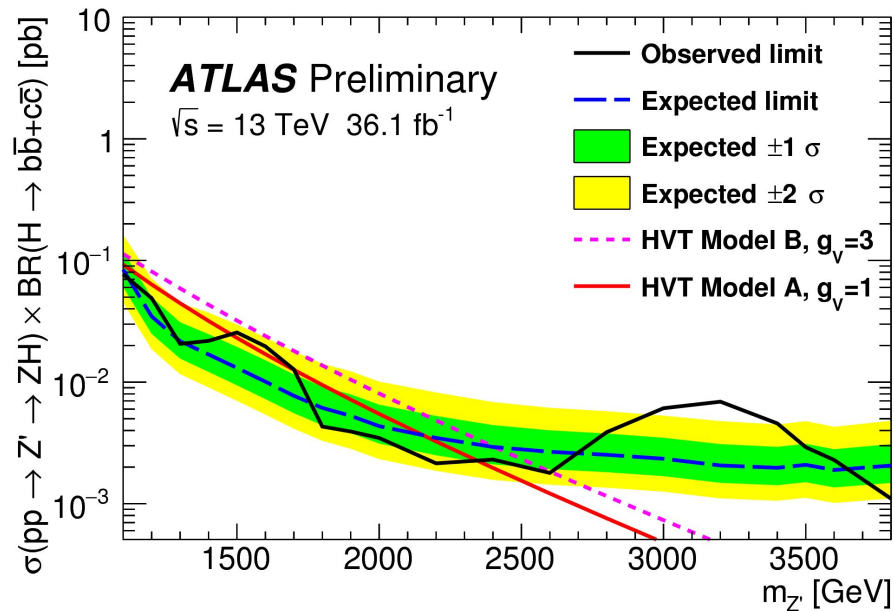


## 2 $b$ -tags



# Limits

- 3.3  $\sigma$  local (2.2  $\sigma$  global) seen at around 3 TeV
  - Z' and W' limits reported

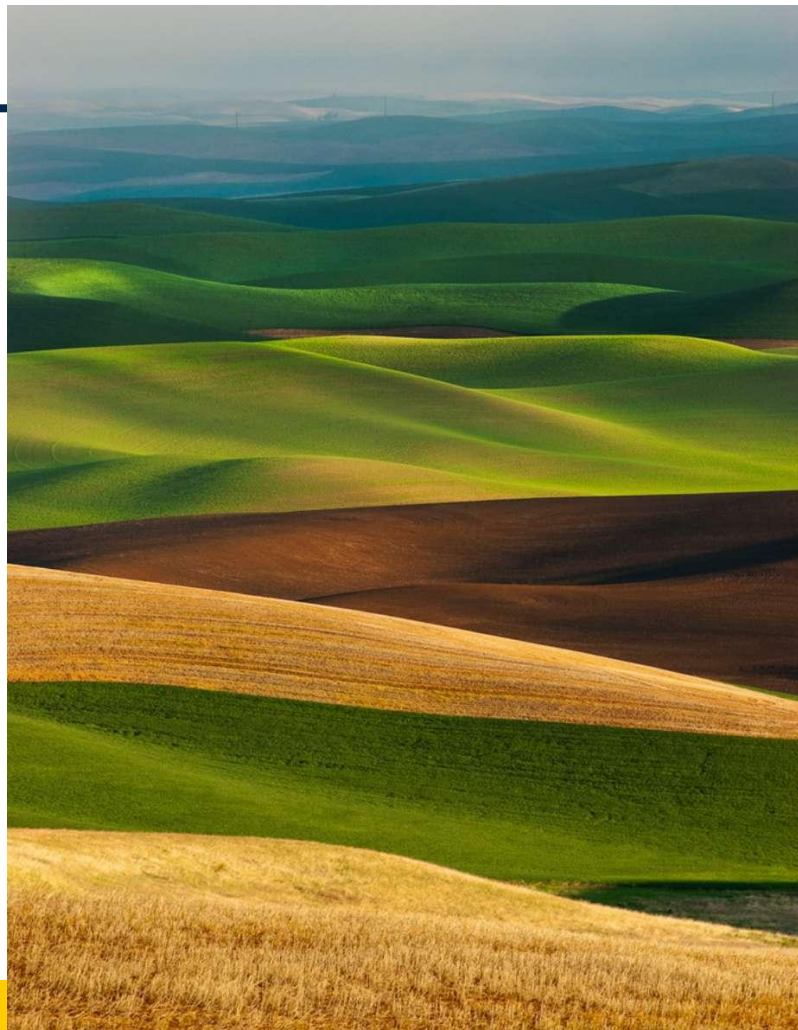




# The landscape

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- We haven't seen any mountains yet
- Generic searches excellent for exploring a broad range of new physics models
- We may need the power gained by optimizing on more specific models
- **For the rest of this talk I will discuss new results looking for SUSY**



# Looking for SUSY

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- SUSY has a rich phenomenology with diverse and complicated final states
- Searches start from key processes
  - i.e. squark and gluinos production with 0 leptons
- Define several sensitive signal regions resulting from that process
- Look at all of them for new physics
- Discover the secrets of the universe
  - Or.. Interpret the results as a limit



# Jets + MET [ATLAS-CONF-2017-022](#)

- **Processes**

- Squark or gluino production

- **Signature**

- Large  $m_{\text{eff}}$

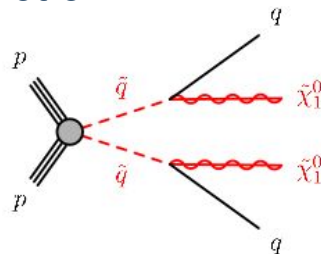
- 2-5 Jets

- Direct decay

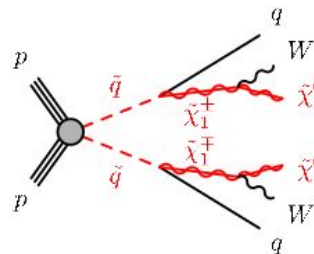
- 5-6 jets

- Decay with W/Z

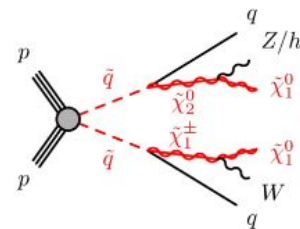
- Build signal regions from these variables



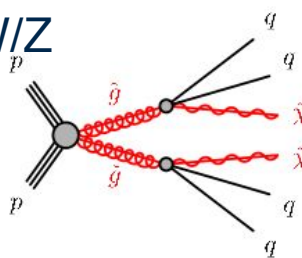
(a)



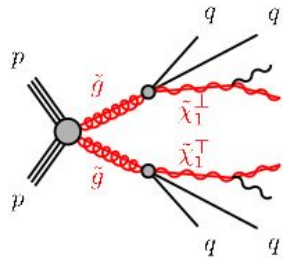
(b)



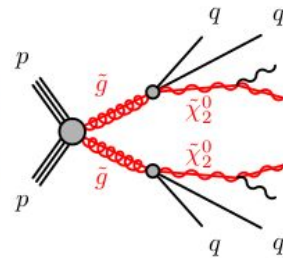
(c)



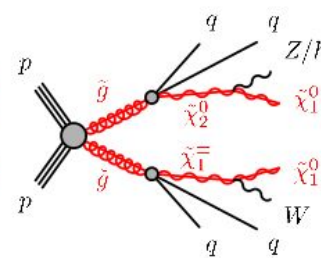
(d)



(e)



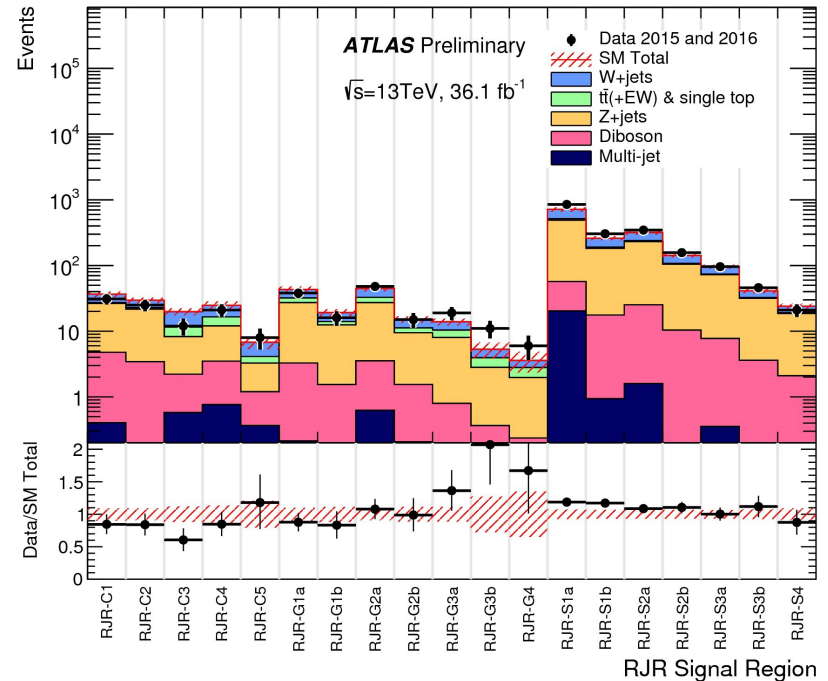
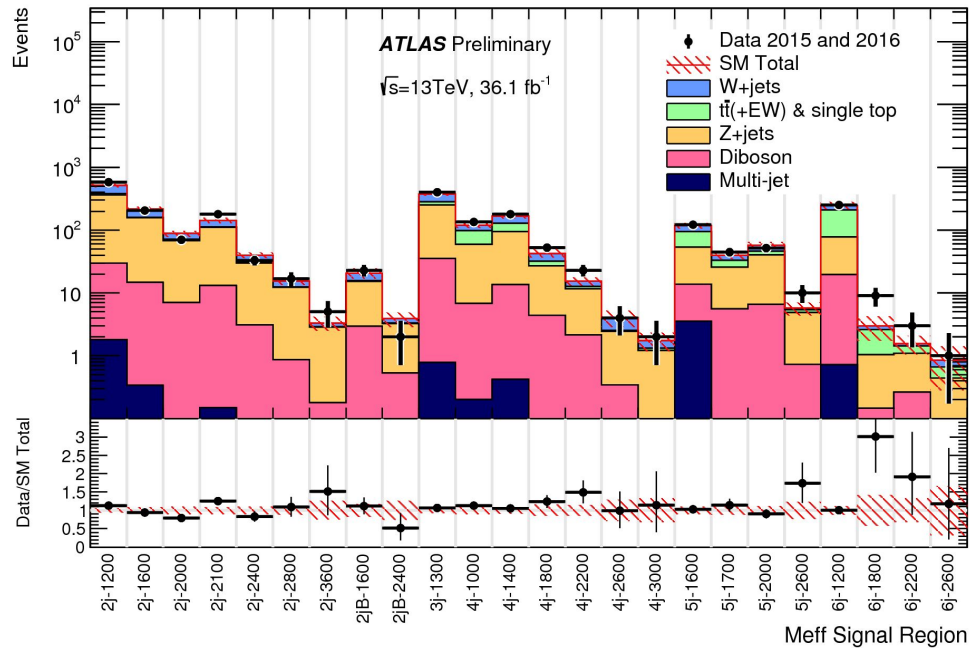
(f)



(g)

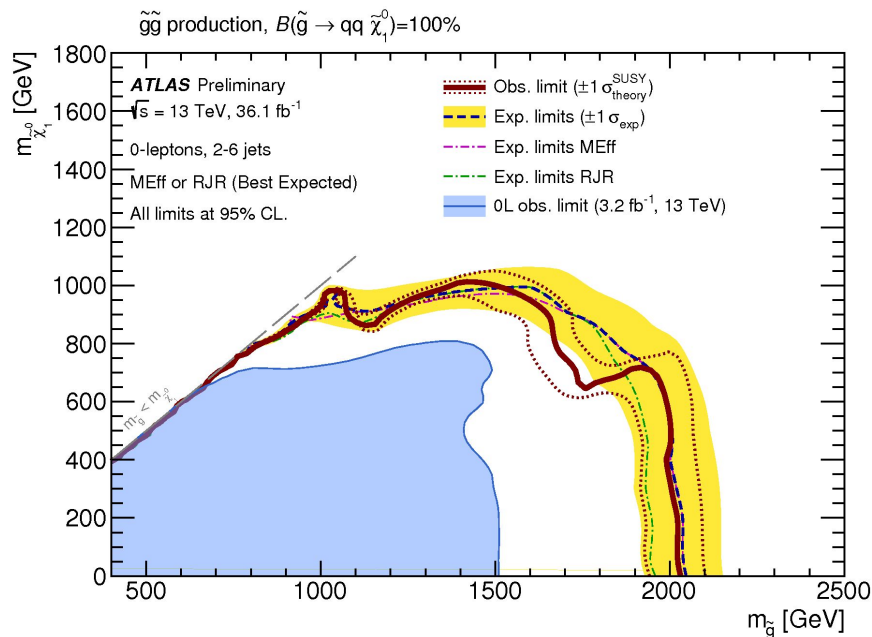
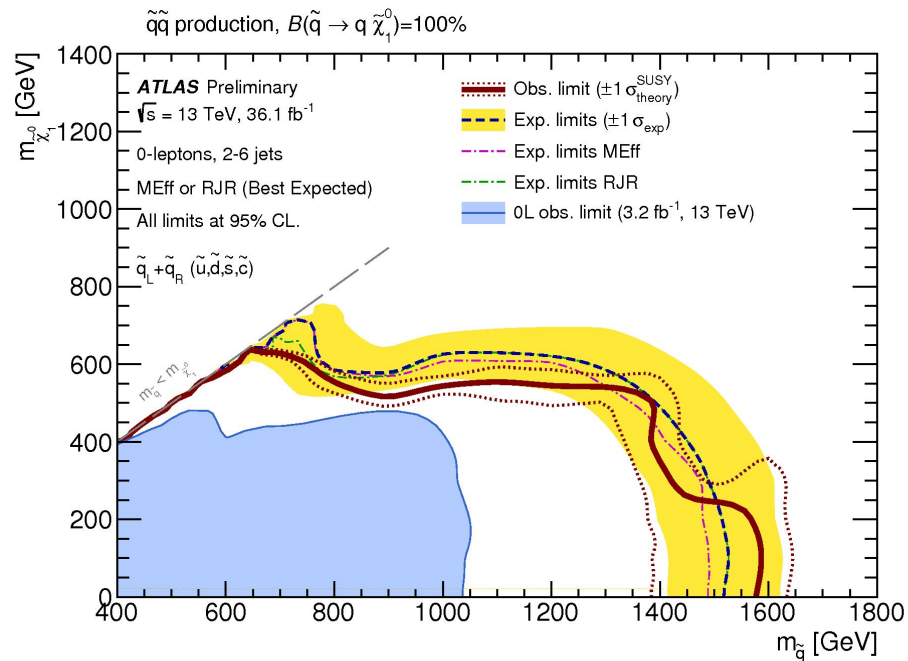
# Results

- With full dataset no significant excess is seen
  - Set limits



# Squark and gluino limits

Exclusions  $\sim 1.6$  and  $\sim 2$  TeV for squarks and gluinos



# 0/1L + MET+multiple b-jets [ATLAS-CONF-2017-021](#)

- **Processes**

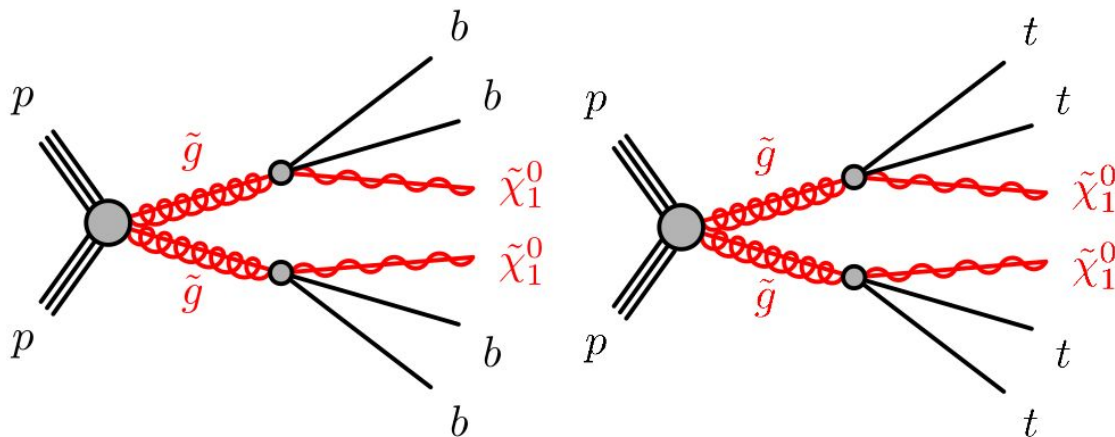
- Gluino production

- **Signature**

- At least 3 b-jets
- Large  $m_{\text{eff}}$
- High MET
- 5-7 Jets
  - Decay to b's
- 7-8 jets, (1L)
  - Decay to top's

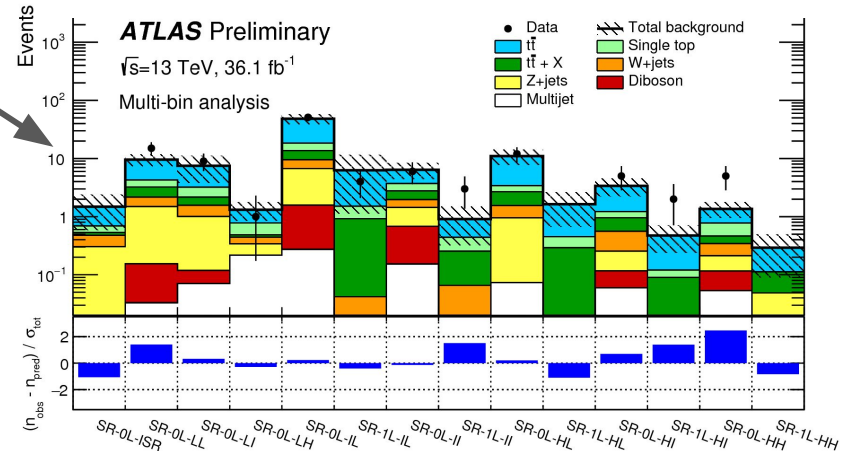
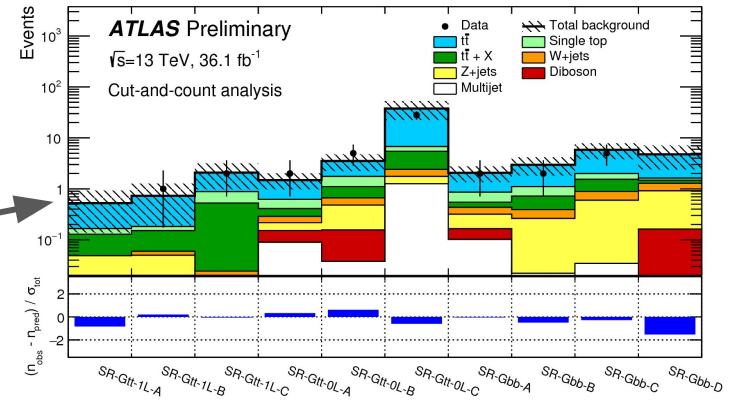
- **Signal regions**

from these variables

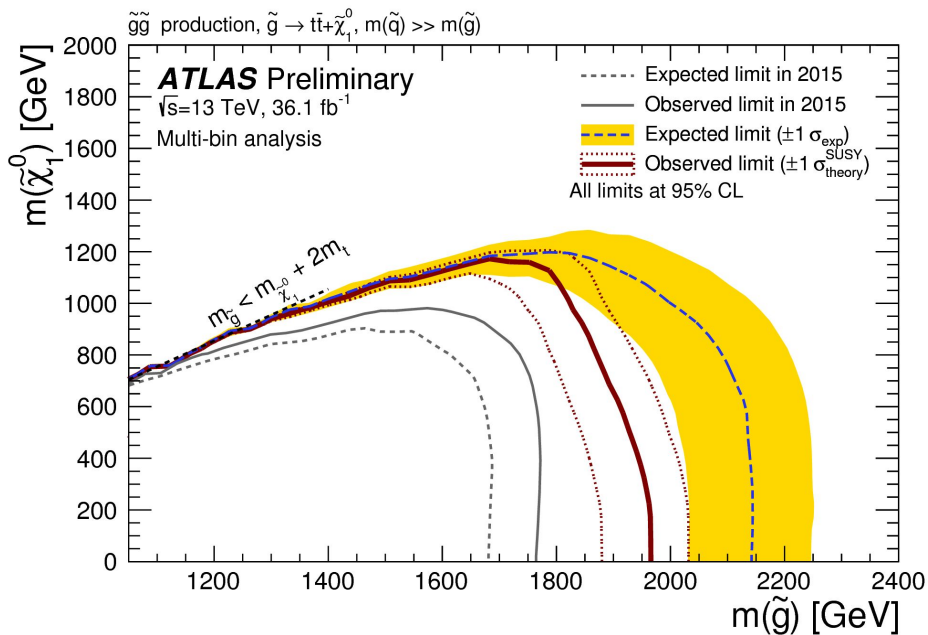
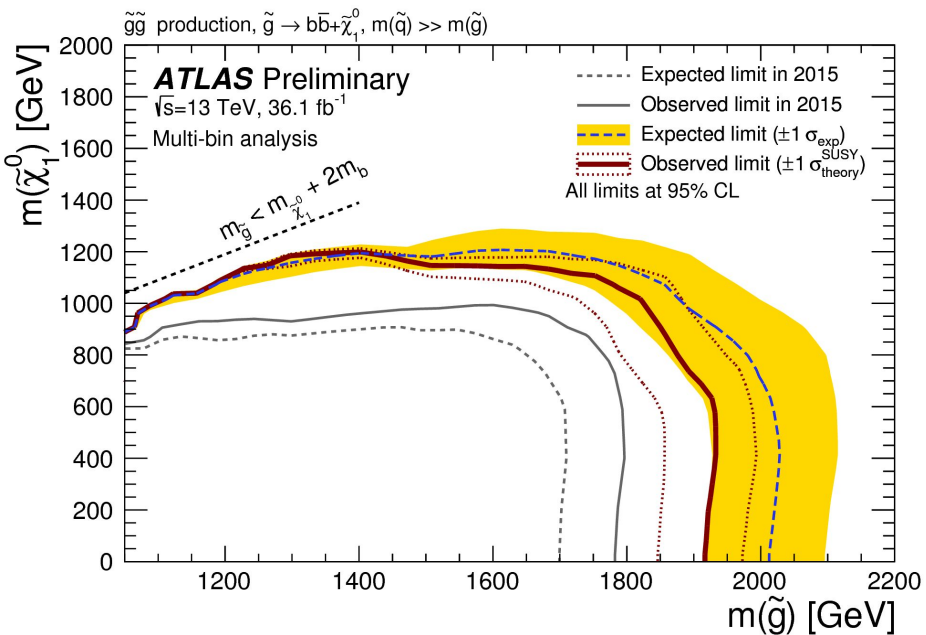
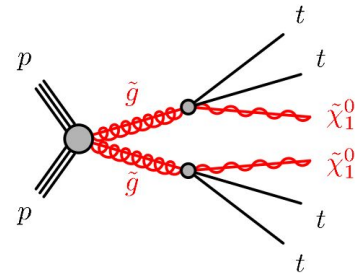
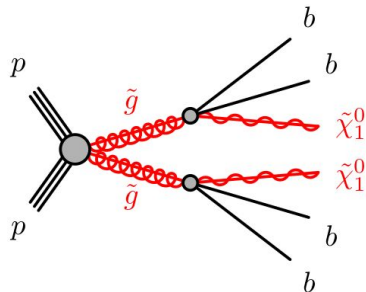


# Results

- Search with two strategies
  - **a cut and count strategy**
    - Overlapping signal regions
    - Maximise the expected discovery power
  - **A multi-bin strategy**
    - Non-overlapping signal regions
    - Strengthens exclusion limits
- Both search strategies agree well with the observed data
- Use multi-bin strategy to set limits



# Limits



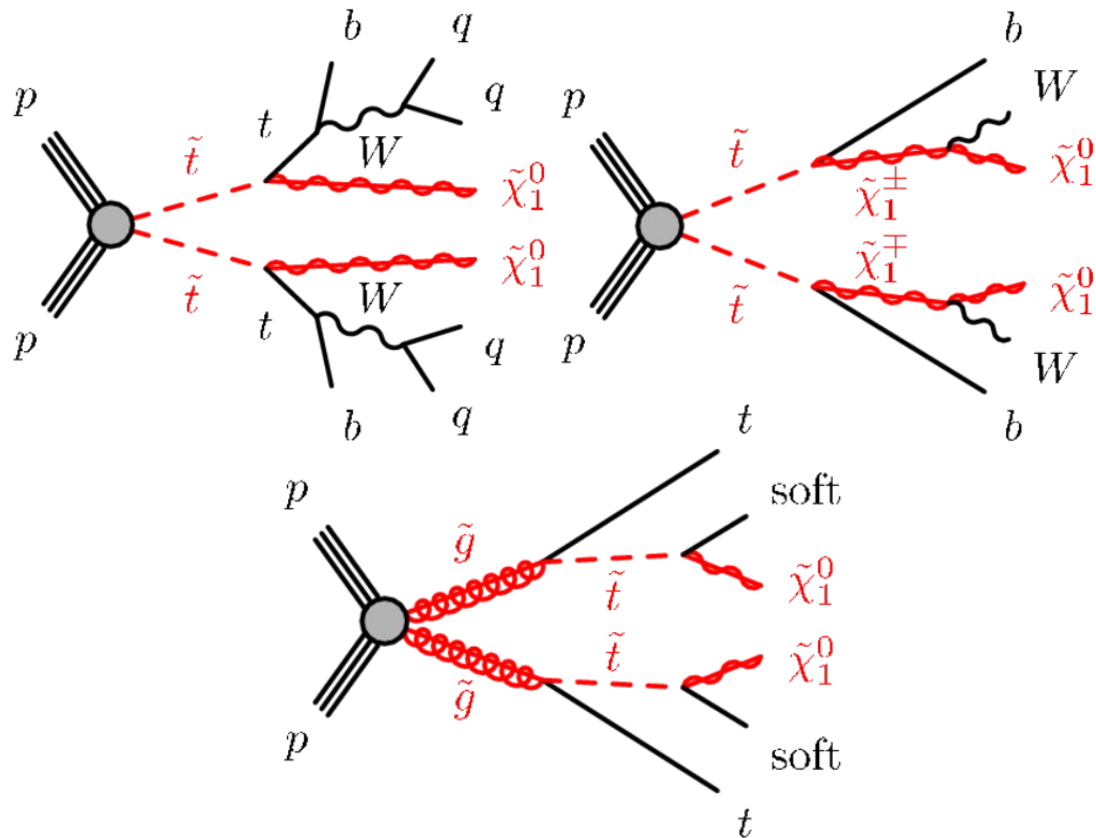
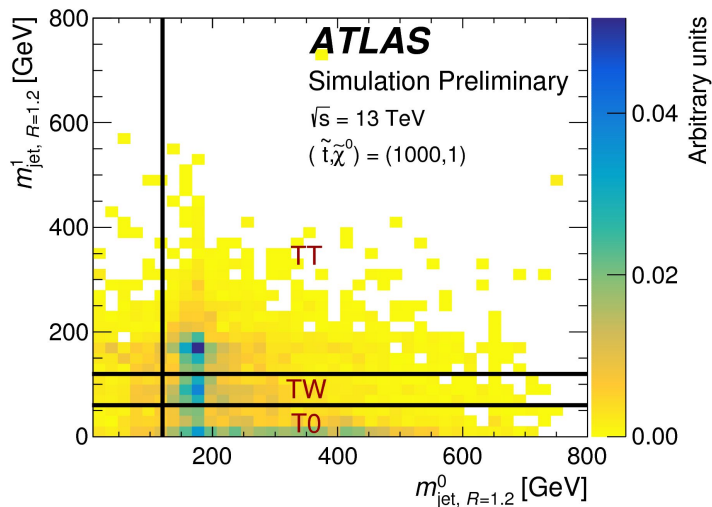
# sTop pair production 0L [ATLAS-CONF-2017-020](#)

- Processes

- Stop pair production

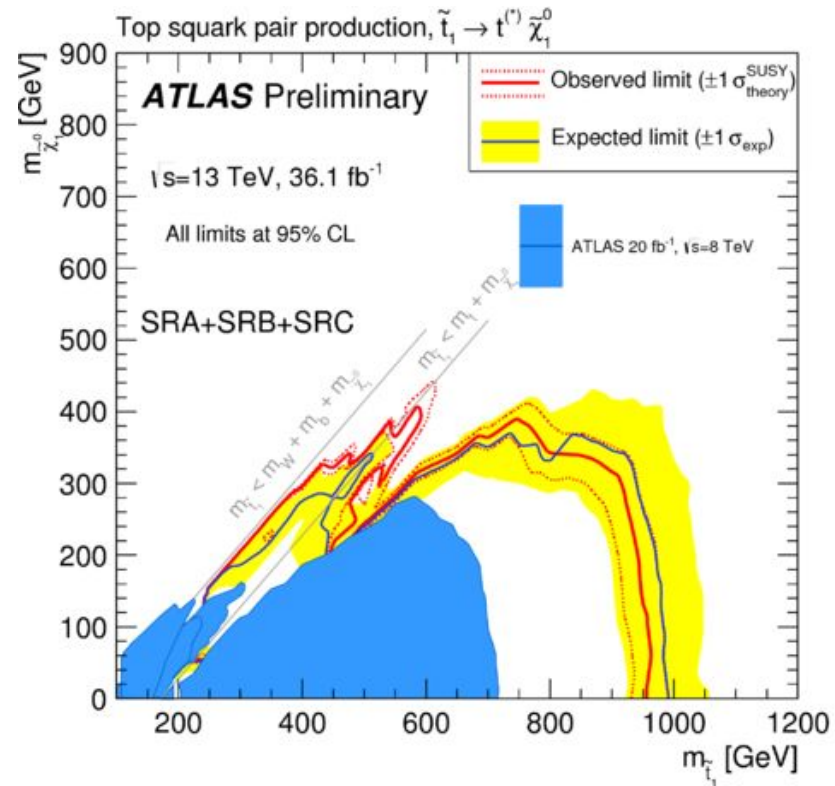
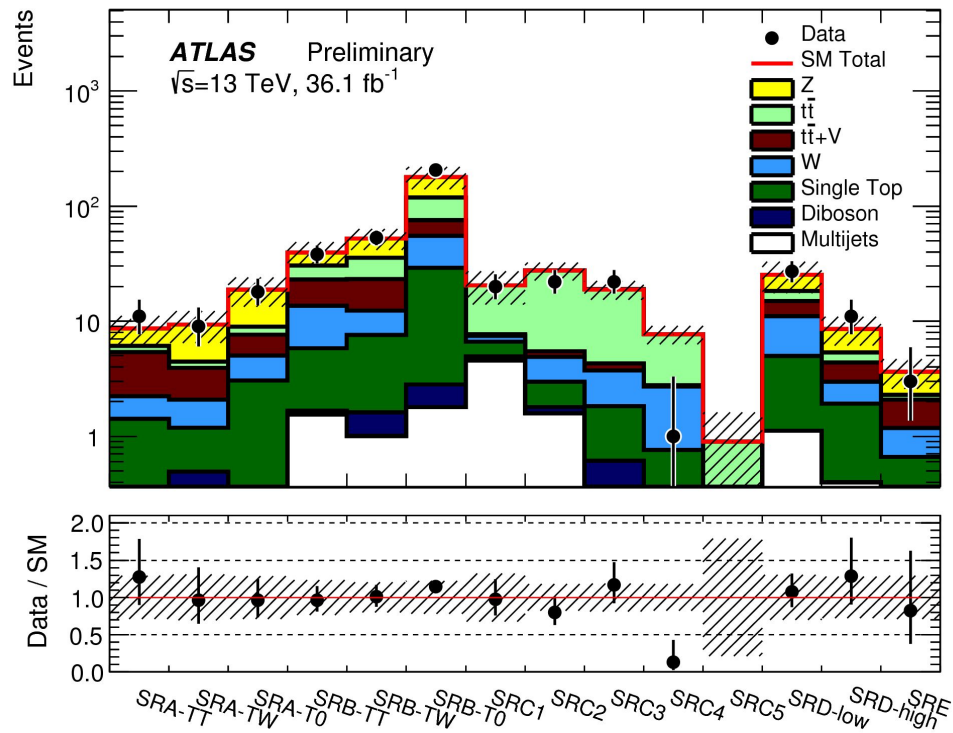
- Signature

- $\geq 4$  Jets
  - Combinations with  $M_t$
  - Combinations with  $M_W$
- Missing Energy





# Results and Limits





# sTop pair production with a Higgs or a Z boson

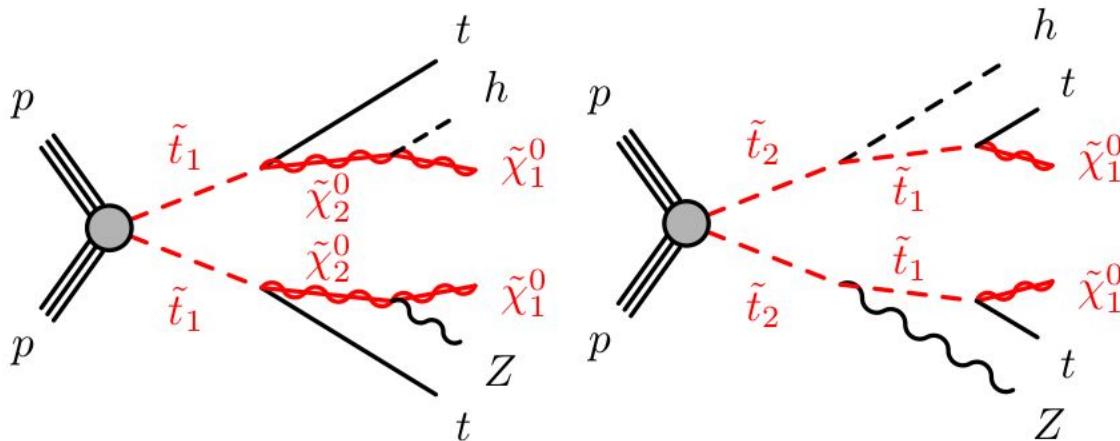
[ATLAS-CONF-2017-019](#)

- **Processes**

- Stop pair production

- **Signature**

- 3l+1b
- 1l+4b
- Split to enhance different decay modes of H and Z
  - More on next slide



# Signal Region

- Two event selections
  - **3l+1b** -3 Regions
  - **1l+4b** - 3 Regions

Requirement / Region	SR <sub>A</sub> <sup>1ℓ4b</sup>	SR <sub>B</sub> <sup>1ℓ4b</sup>	SR <sub>C</sub> <sup>1ℓ4b</sup>
Number of leptons	1–2	1–2	1–2
$n_{b\text{-tagged jets}}$	$\geq 4$	$\geq 4$	$\geq 4$
$m_T$ [GeV]	–	$>150$	$>125$
$H_T$ [GeV]	$> 1000$	–	–
$E_T^{\text{miss}}$ [GeV]	$> 120$	$> 150$	$> 150$
Leading $b$ -tagged jet $p_T$ [GeV]	–	–	$<140$
$m_{bb}$ [GeV]	95–155	–	–
$p_T^{bb}$ [GeV]	$> 300$	–	–
$n_{\text{jets}} (p_T \gtrsim 60 \text{ GeV})$	$\geq 6$	$\geq 5$	–
$n_{\text{jets}} (p_T \gtrsim 30 \text{ GeV})$	–	–	$\geq 7$

Requirement / Region	CR <sub>ttZ</sub> <sup>3ℓ1b</sup>	CR <sub>VV</sub> <sup>3ℓ1b</sup>
Number of leptons	$\geq 3$	$\geq 3$
$ m_{\ell\ell} - m_Z $ [GeV]	$< 15$	$< 15$
Leading lepton $p_T$ [GeV]	$> 40$	$> 40$
Leading jet $p_T$ [GeV]	$> 60$	$> 30$
$n_{b\text{-tagged jets}}$	$\geq 1$	0
$n_{\text{jets}} (p_T > 30 \text{ GeV})$	$\geq 4$	$\geq 4$
$E_T^{\text{miss}}$ [GeV]	$< 100$	–
$p_T^{\ell\ell}$ [GeV]	–	–

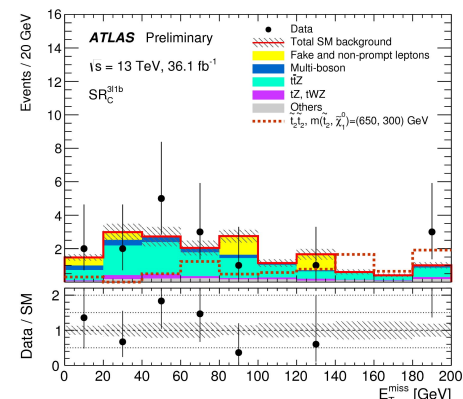
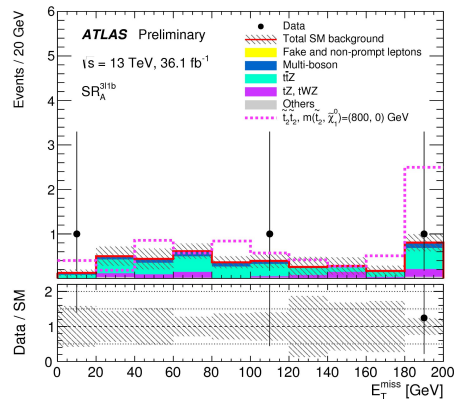
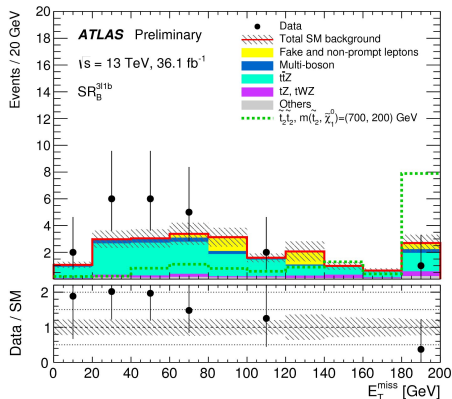
# Results

A

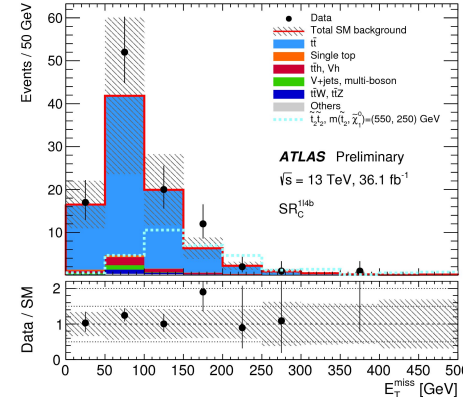
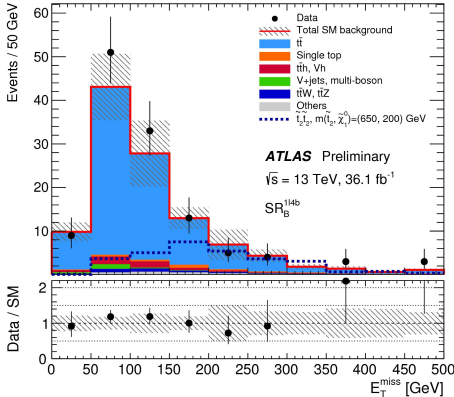
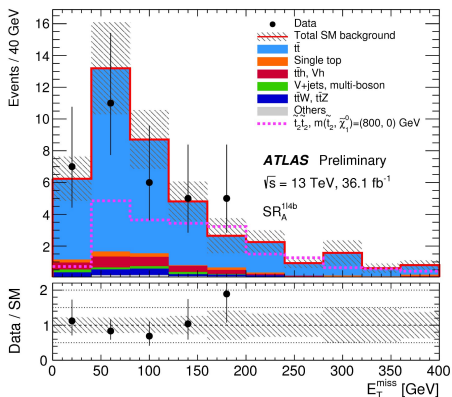
B

C

SR 3l +1 b

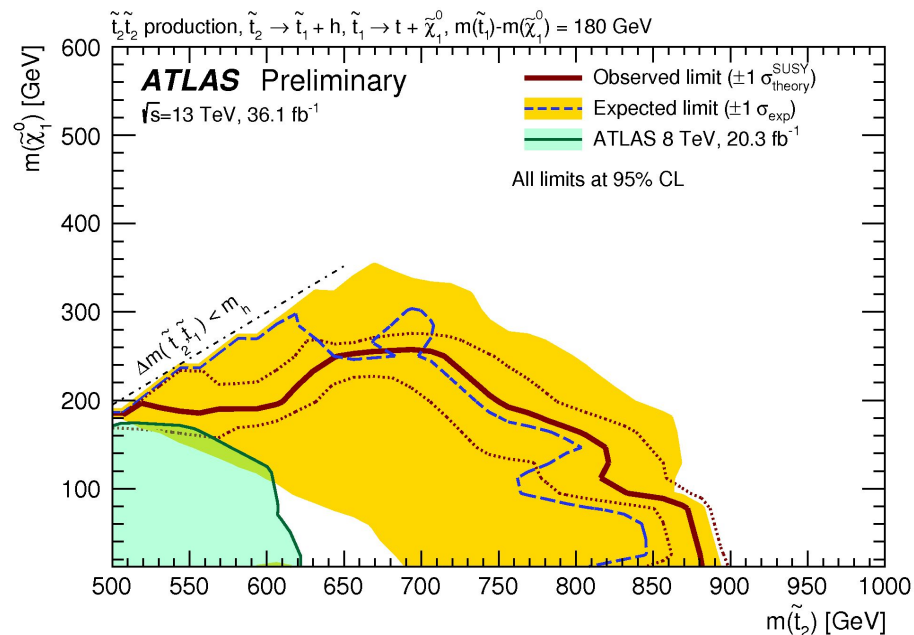
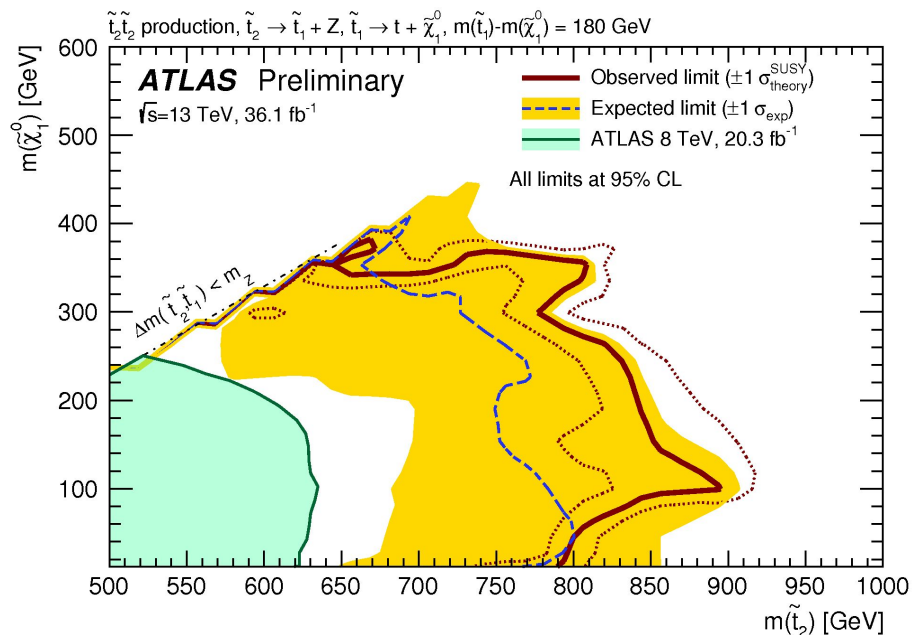


SR 1l +4 b



# Results

- No signal found
  - good improvement on previous limits



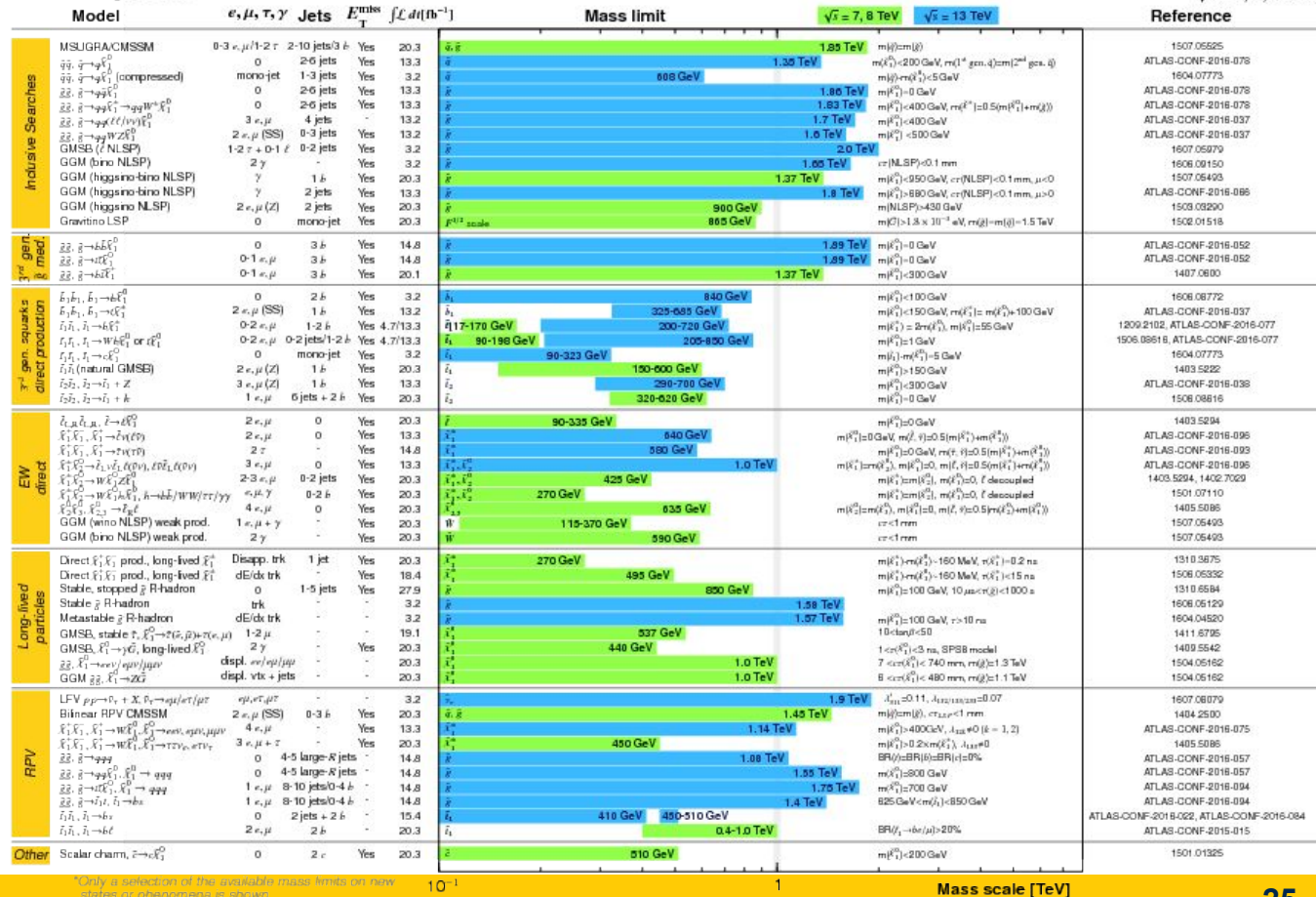
# Other Searches

## ATLAS SUSY Searches\* - 95% CL Lower Limits

Status: August 2016

ATLAS Preliminary

$\sqrt{s} = 7, 8, 13 \text{ TeV}$



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

$10^{-1}$

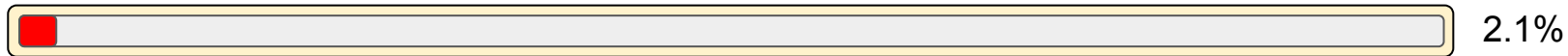
1

Mass scale [TeV]

# Conclusions

- ATLAS is exploring the large 2015+2016 datasets
  - About 2% of the of the  $3\text{ab}^{-1}$  program

LHC Status



⚙ *Running...*

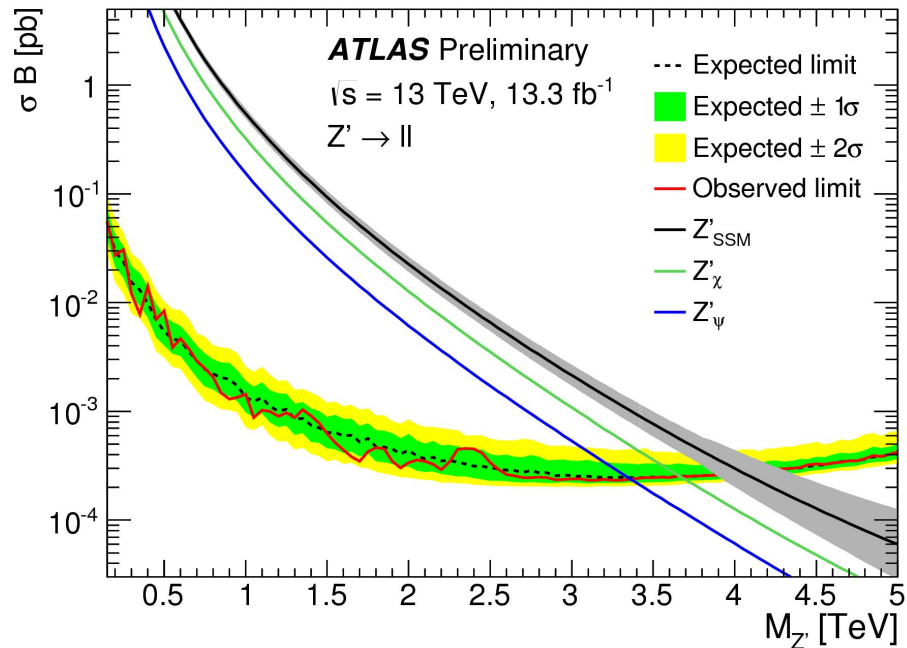
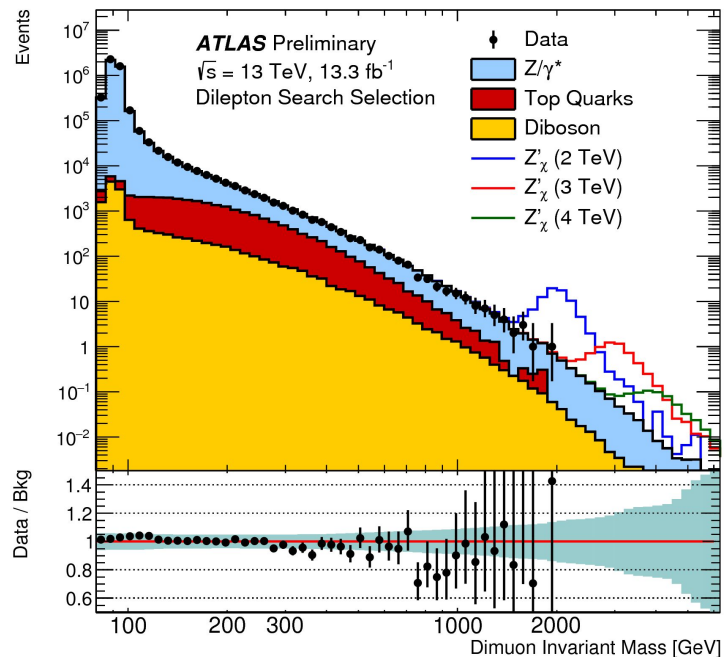
- No signs of new physics
- More complicated final states being explored
  - SUSY limit continuing to strengthen
  - Look for more results in the near future

# Backup

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# Dilepton: [ATLAS-CONF-2016-045](#)

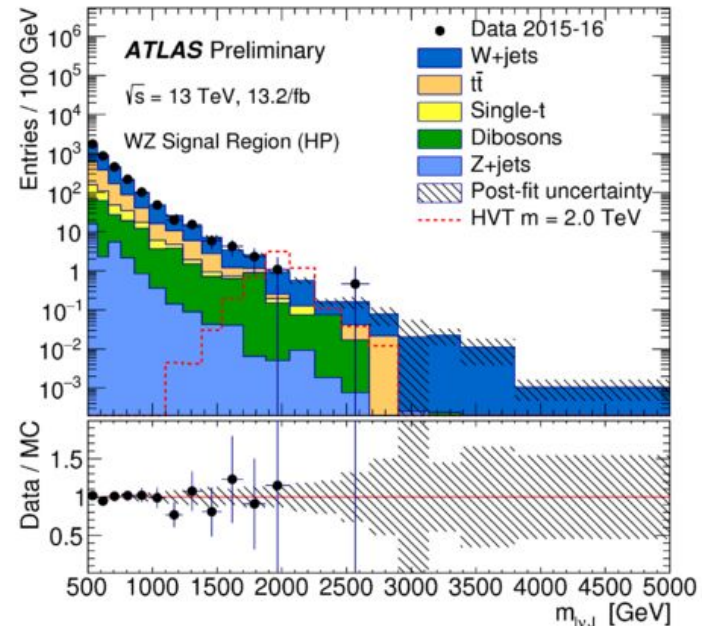
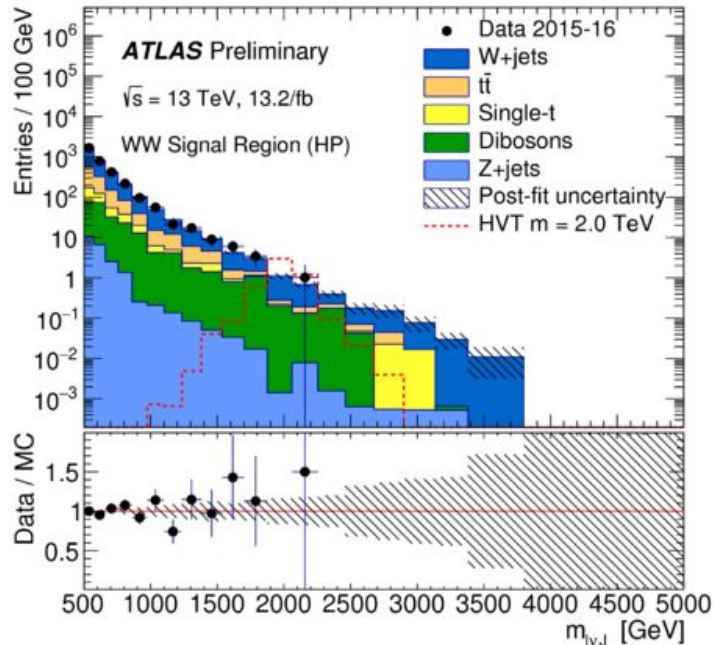
- As a reminder of where we left you at ICHEP
- 2-lepton selection for  $Z'$ , fits  $M(l,l)$





# Diboson Resonance $\ell\nu qq$ : [ATLAS-CONF-2016-062](#)

- The  $\ell\nu qq$  final state
  - 1-lepton+MET + 1 boosted jet with mass at  $M_Z$  or  $M_W$



# Limits $lvqq$

- Limits are placed on both  $Z' \rightarrow WW$  and  $W' \rightarrow WZ$

