Search for high mass resonances with ATLAS

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Spring Institute:
Challenging the Standard Model after the Higgs discovery
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Introduction

- After Higgs discovery, the Standard Model (SM) is a self-consistent theory
- So far in good agreement with data

- Many ***experimental*** observations not explained in the SM
  - Nature of Dark Matter/Energy
  - Baryon asymmetry
  - neutrino masses

- ***Theory*** problems:
  - Hierarchy problem: $m_{EW}/M_{Pl} \sim 10^{-16}$
  - How to accomodate qravity
  - Unexplained hierarchical structure of Yukawa couplings

Model and ideas to address them:

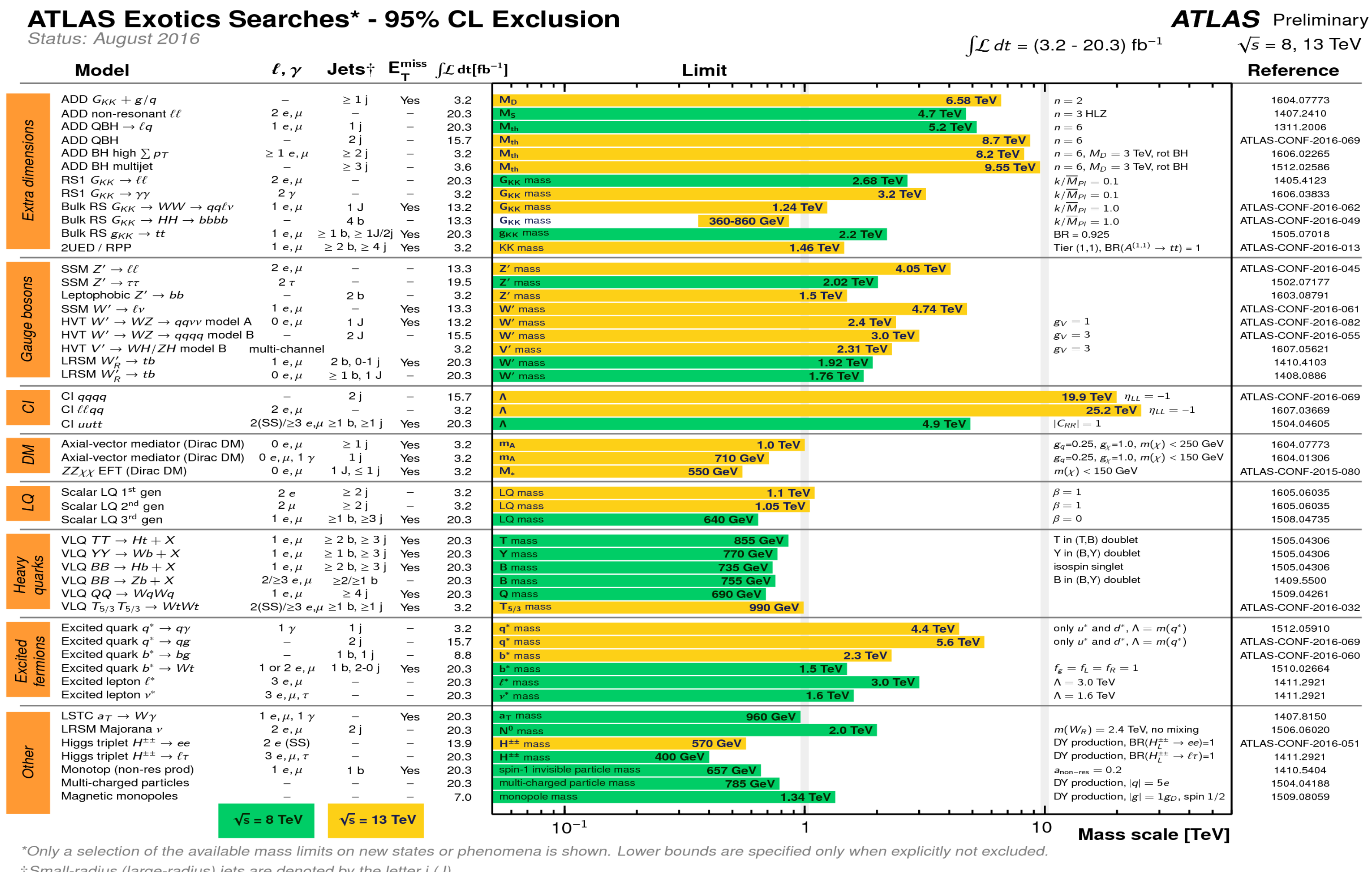
- SUSY
- **(*)** Compositeness, Extra dimensions
- **(*)** Extended Higgs Sector
- Top Partner
- **(*)** W'/Z'
- Minimal Dark Matter
- Hidden Sectors

(*) in this talk

Search of physics beyond the SM is well motivated

Introduction

ATLAS has an extensive search program to prove or discard models



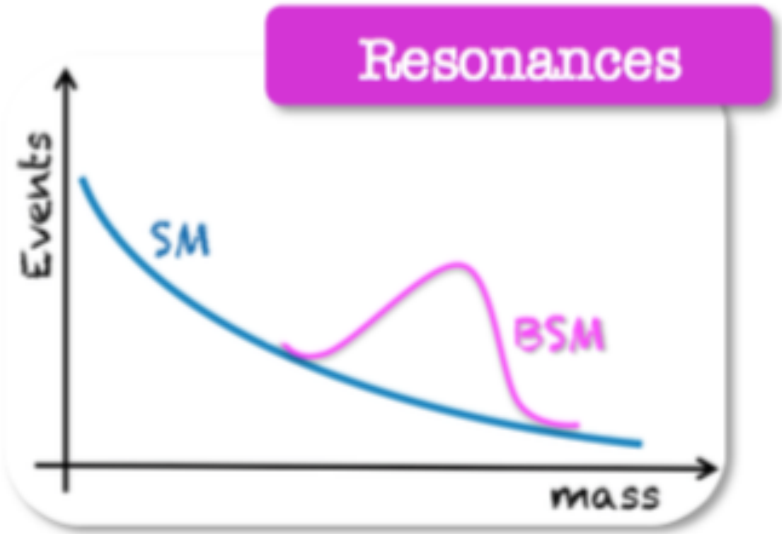
(*) (*) (*) (*)

ATLAS_Exotics_Summary

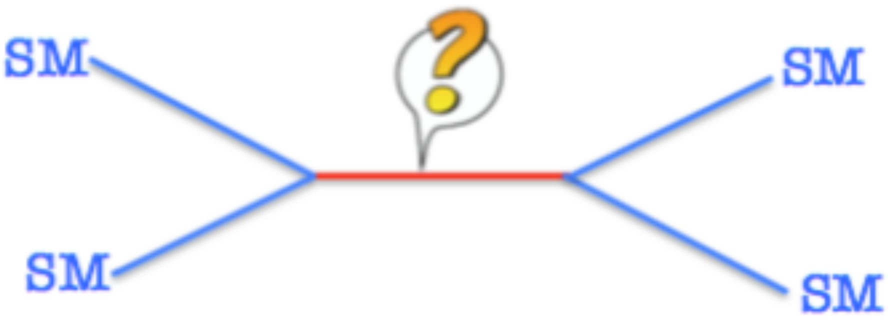
(*) models tested in this talk

Search for resonances

Plots from A.C Gonzalez



Search for resonances as for bumps the



- SM background modelling crucial
  - both data driven techniques and simulation
- Various signatures with different resonances widths
- Aim to model independent limits

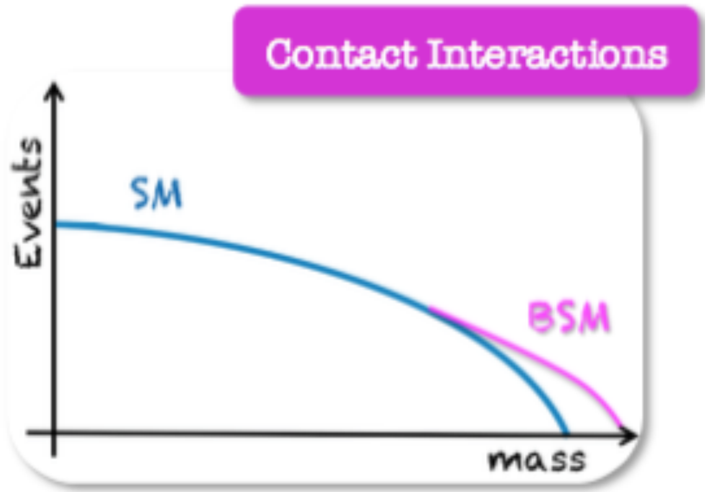
Use all decay channels

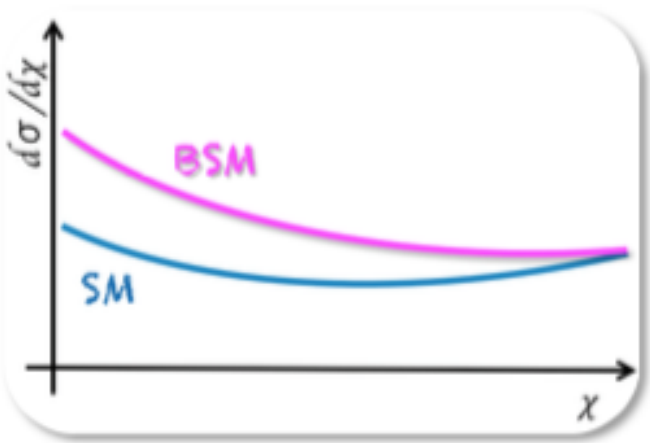
- Fully hadronic
  - di-jet, V(qq)+H(qq)
- With leptons
  - dileptons, lepton + E_T^{miss}
- with Photons
  - photon + E_T^{miss}

in this talk

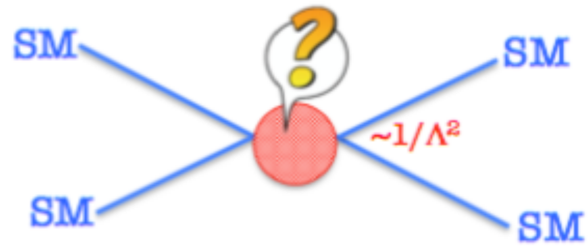
Search for deviations

Plots from A.C Gonzalez





Search for modifications in angular and mass distributions arising from **new contact interaction (CI) scales**.



New **mediating particle** with a mass much higher than the energy exchange modeled as contact interaction with new physics at **energy scale** Λ.

- Dilepton
  - Broad excess in invariant mass distributions
- Dijets
  - CI is often more isotropic than QCD→use angular information

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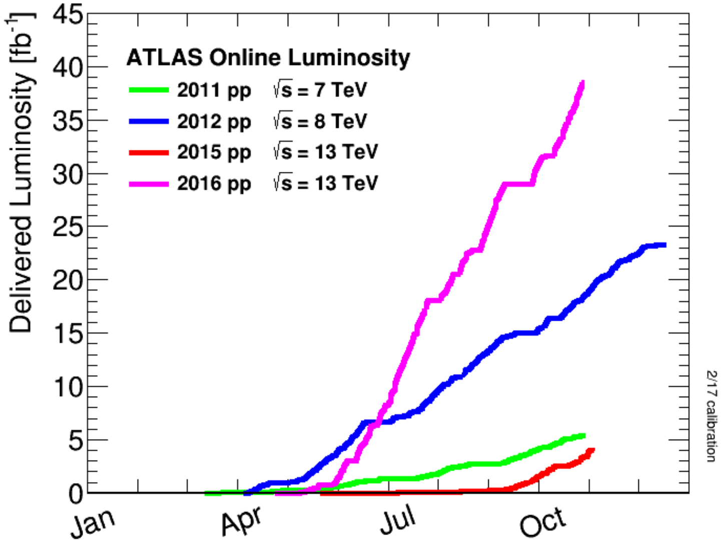
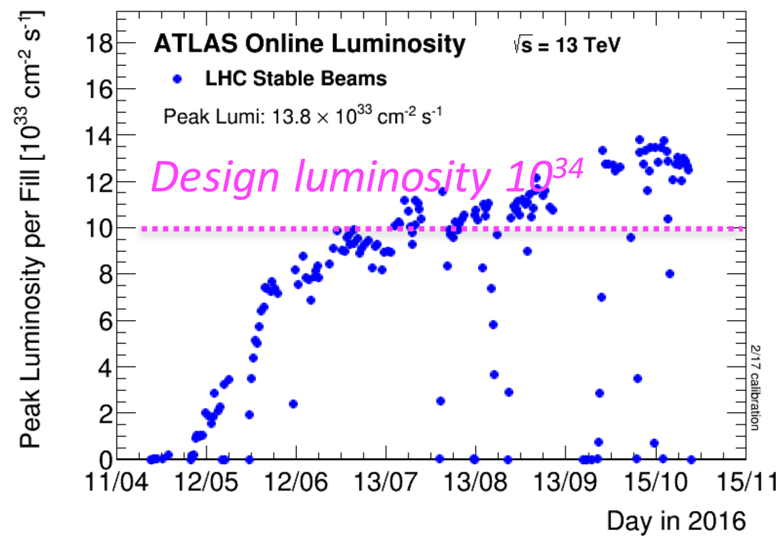
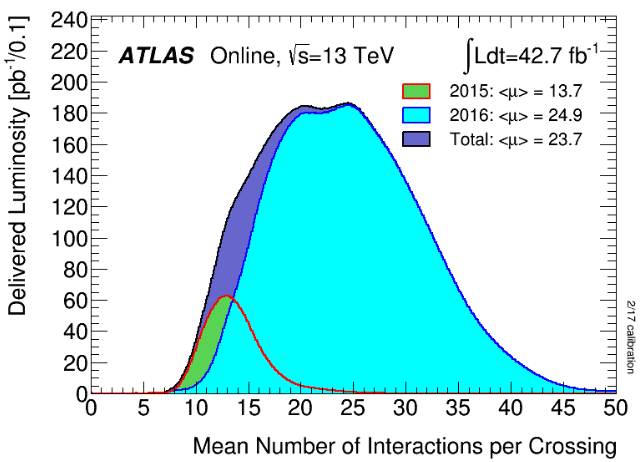
ATLAS

Excellent performance of LHC at √s =13 TeV in Run 2 (2015+2016) and high **data taking efficiency** by detectors

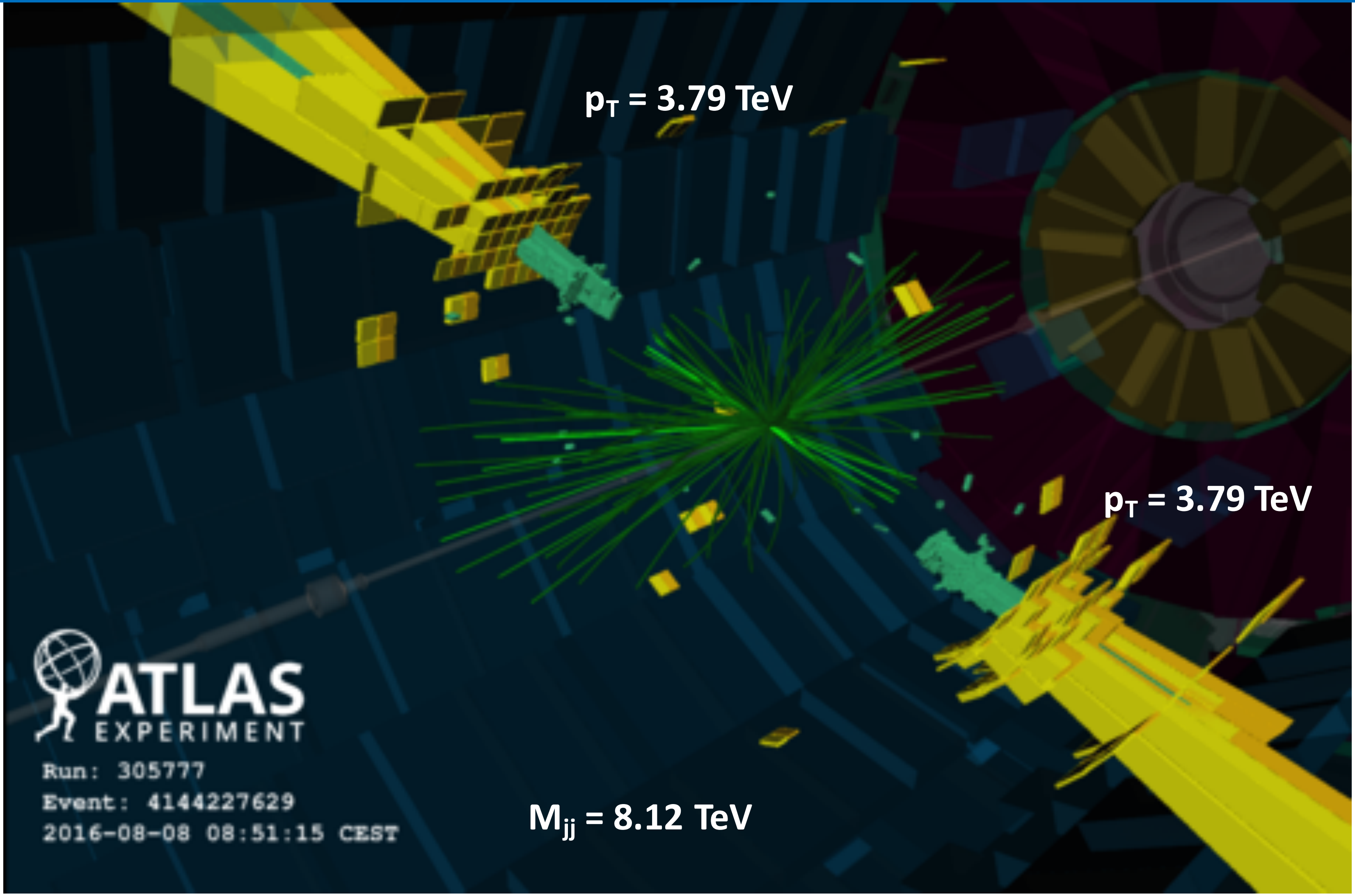






- ~40 fb-1 @ 13 TeV recorded in 2015 and 2016
- Data quality efficiency 93-95%
- Increased pile-up conditions with
  →challenging reconstruction

Search for new phenomena in di-jets

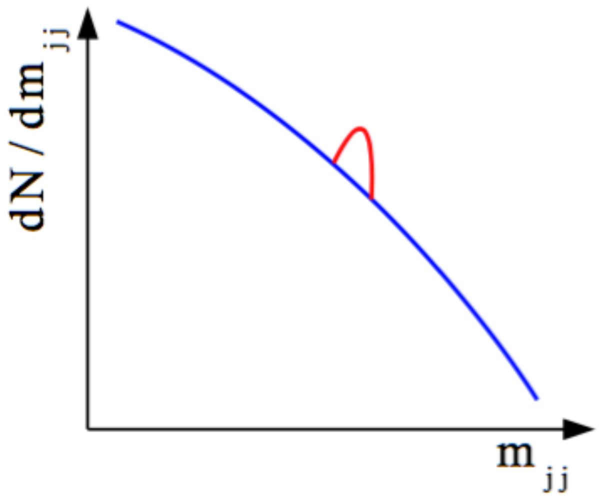


arXiv:1703.09127

Search for new phenomena in di-jets

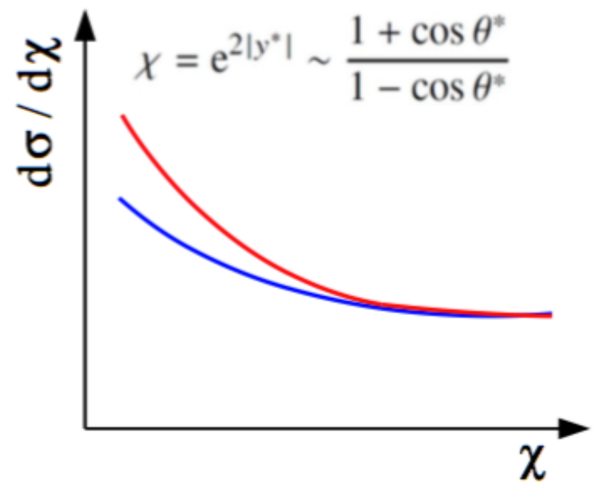
Di-jets final states sensitive to a broad class of new phenomena, through **generic** features of Beyond Standard Models (BSM) signals

Resonances searches



- localized excess in the m_{jj} distribution
- Sensitive to narrow resonance:
  - **Quantum Black Hole (QBH), Excited quark (q*), W', excited W***

Di-jets angular distributions anomalies:

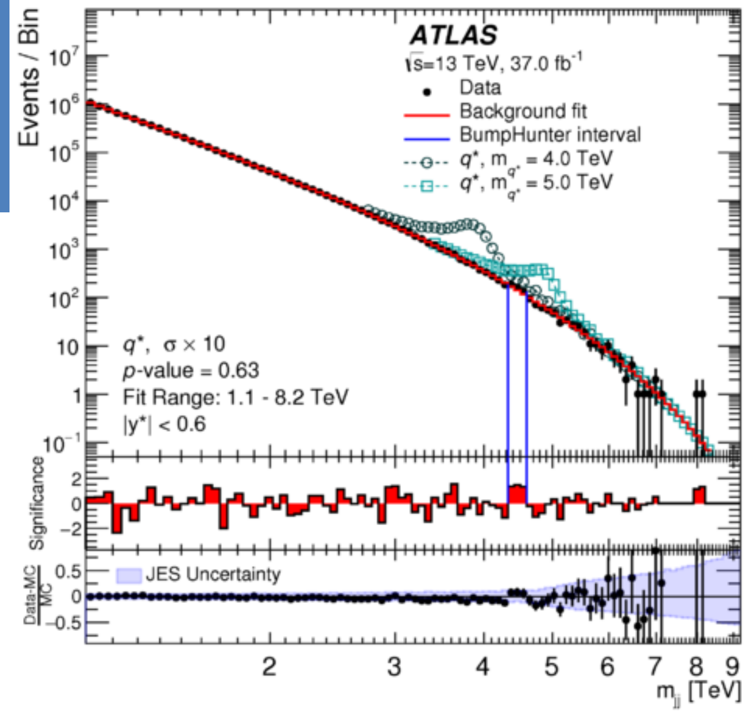


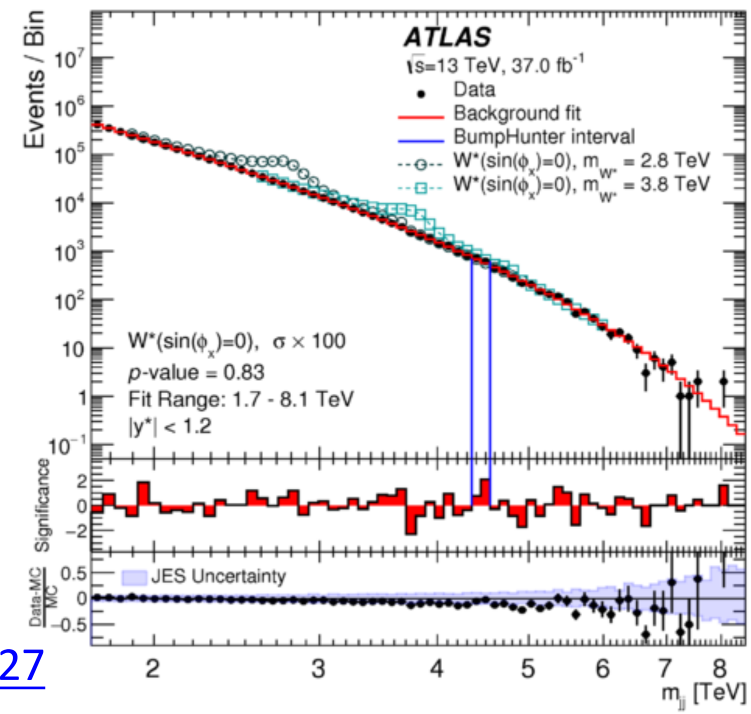
- BSM give more isotropic signature wrt to QCD
- More sensitive to non-resonant signals
  - **Contact interactions at compositeness scale Λ**

Resonance Search in di-jets

- Single jet trigger $p_T > 380$ GeV
- $p_T^{lead(sub)} > 440\ (60)$ GeV
- To suppress t-channel scattering:
  - $y^* < 0.6(1.2)$, $y^* = |\ y_{lead} - y_{sublead}\ | / 2$
  - $m_{jj} > 1.1(1.7)$ TeV (for W*)
    - fully efficient trigger selection
  - Smooth QCD background from a Sliding Window Fit
- BumpHunter algorithm to scan for excesses
  - Most discrepant interval: 4326 – 4595 GeV
  - global significance of 0.63 (0.83 for W*)

No evidence of a localized contribution from BSM phenomena





arXiv:1703.09127

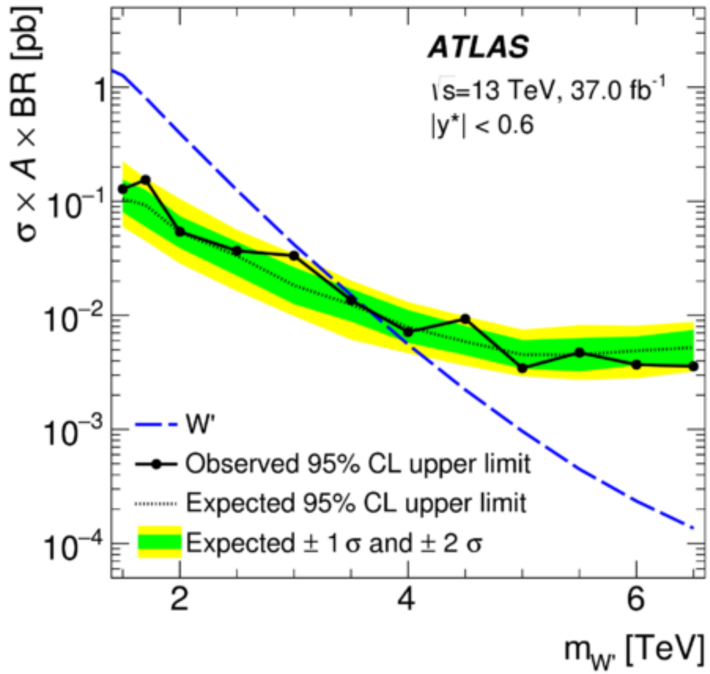
Resonance Search in di-jets: Exclusion limits

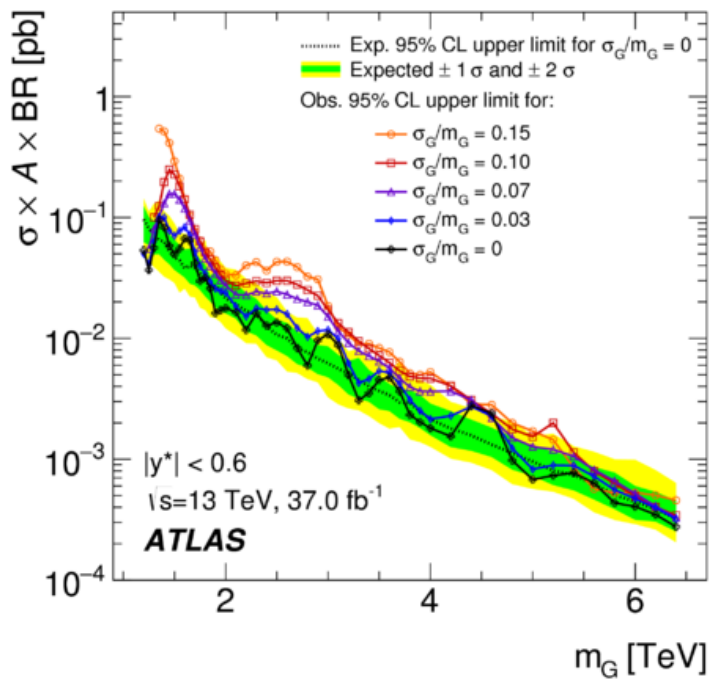
95 %CL exclusion limit		
Model	Observed	Expected
Quantum Black Hole, ADD	8.9 TeV	8.9 TeV
Excited quark	6.0 TeV	5.8 TeV
W’	3.7 TeV	3.7 TeV
W*	3.4 TeV, 3.8-3.9 TeV	3.6 TeV

Improved limits from 7% to 40% wrt analysis based on 3.2 fb^{-1}

Limits on generic Gaussian signals

- can be re-interpreted with various signal models at particle level
- MC-based folding methods to factorize physics & detector effects

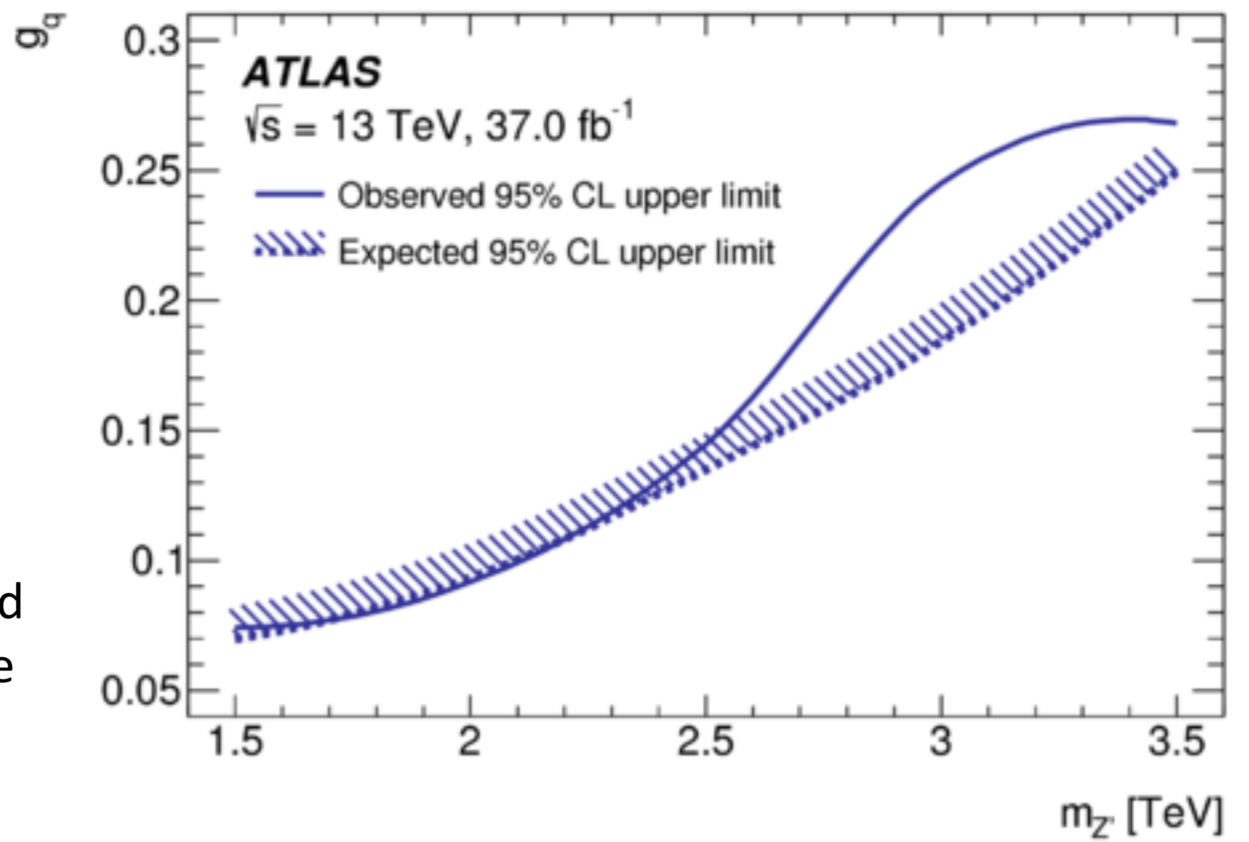




Resonance Search in di-jets: Limits on Z'

Z' model:
axial-vector couplings to SM quarks and to Dirac fermion dark matter

Assume decay to DM negligible:
→ rate and resonance width depend only on the coupling to quarks, g_q, and the mass of the resonance $m_{Z'}$



For g_q=0.6 the intrinsic width of the Z' in the mass range of interest increases to 15%.→ Results limited $g_q \leq 0.5$

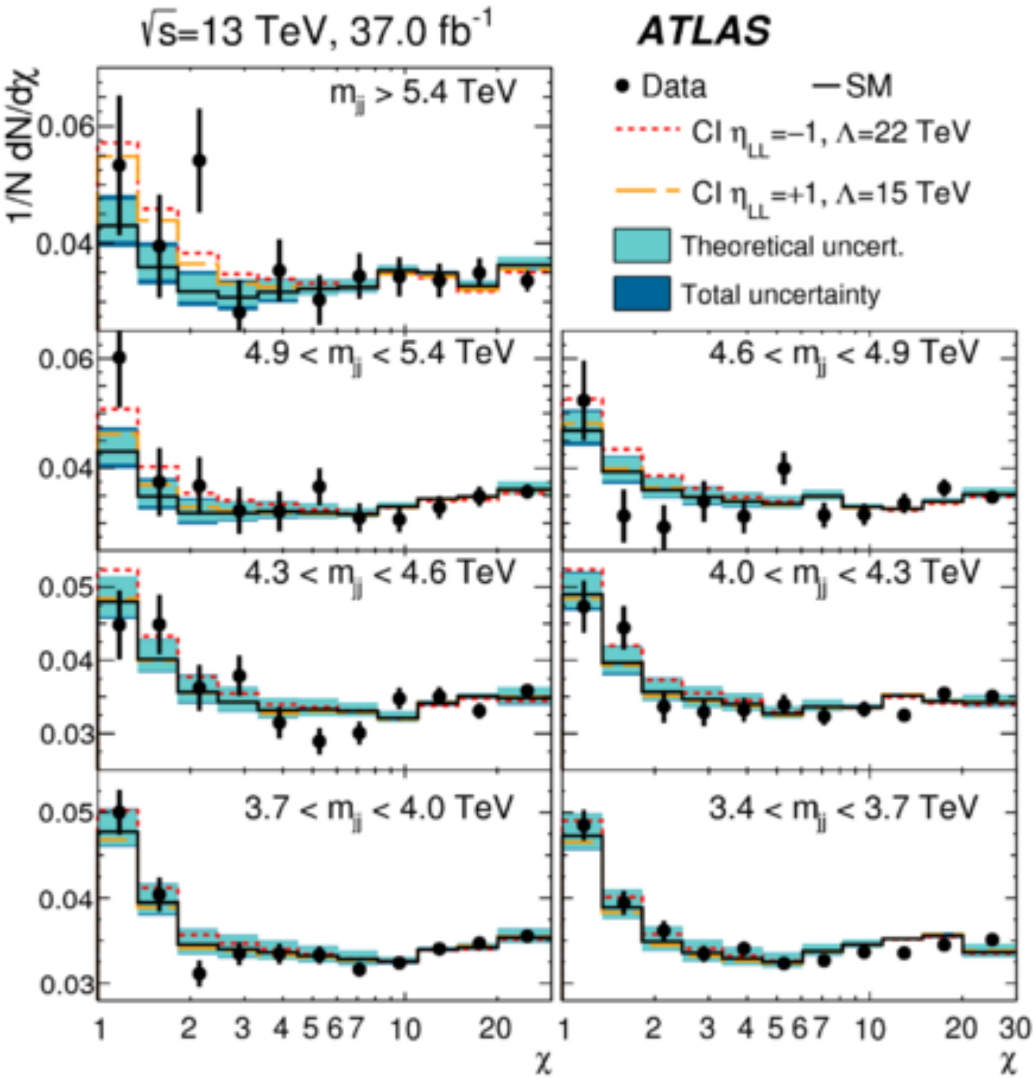
Angular Searches in di-jets

- Single jet trigger $p_T > 380$ GeV, $p_T^{lead(sub)} > 440(60)$ GeV
- $y^* < 1.7$, $y_B < 1.1$, $m_{jj} > 2.5$ TeV, y_B semi-sum of rapidities

- Signal: Contact interactions at compositeness scale Λ

$$L_{qq} = \frac{2\pi}{\Lambda^2}[\eta_{LL}(\bar{q}_L\gamma^\mu q_L)(\bar{q}_L\gamma_\mu q_L) + \eta_{RR}(\bar{q}_R\gamma^\mu q_R)(\bar{q}_R\gamma_\mu q_R) + 2\eta_{RL}(\bar{q}_R\gamma^\mu q_R)(\bar{q}_L\gamma_\mu q_L)],$$

$\eta_{LL} = \pm 1$, $\eta_{RR} = \eta_{RL} = 0$



- QCD background described by MC, normalized to data in each m_{jj} bin

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

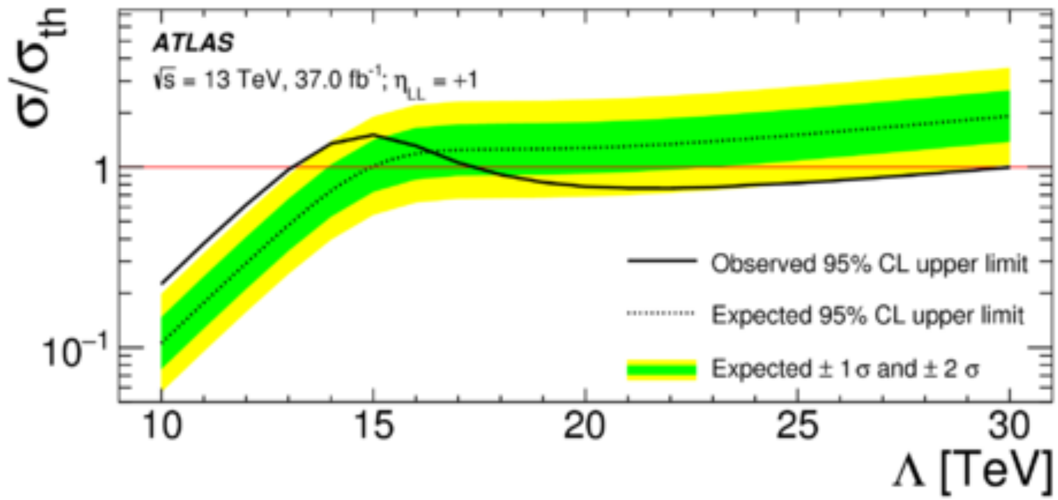
- Dominant Uncertainty:
  - Jet energy scale (exp) and renormalization/factorization scales (theory)

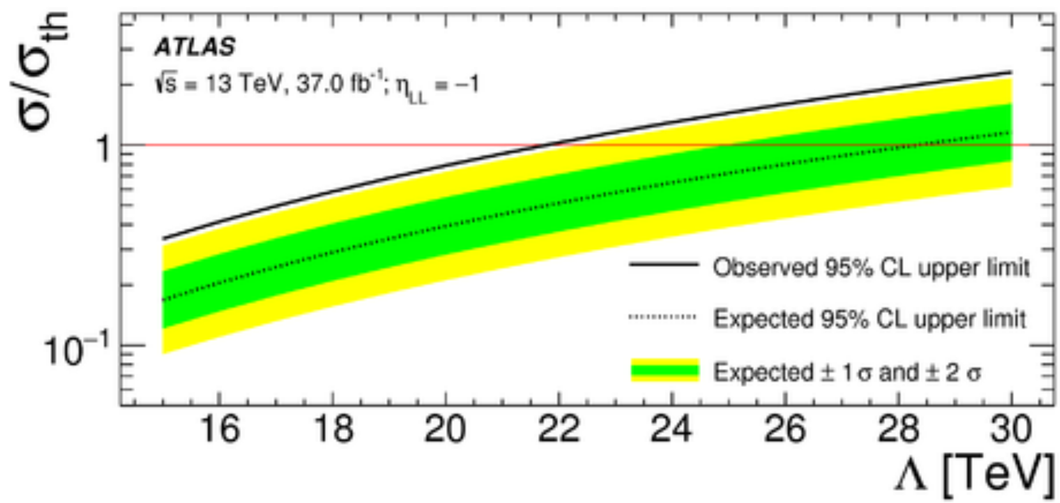
Angular Searches in di-jets: Exclusion limits on contact interactions

No deviations from background expectations

95 %CL exlusion limit on Λ		
Model	Observed	Expected
η_{LL}=-1	21.8 TeV	28.3 TeV
η_{LL}=+1	13.1 TeV 17.4-29.5 TeV	15.0 TeV

-10% less sensitivity to other benchmark models compared to resonance search





Negative (positive) interference of signal model η_{LL} = +1(-1) with SM QCD

Diboson Resonances

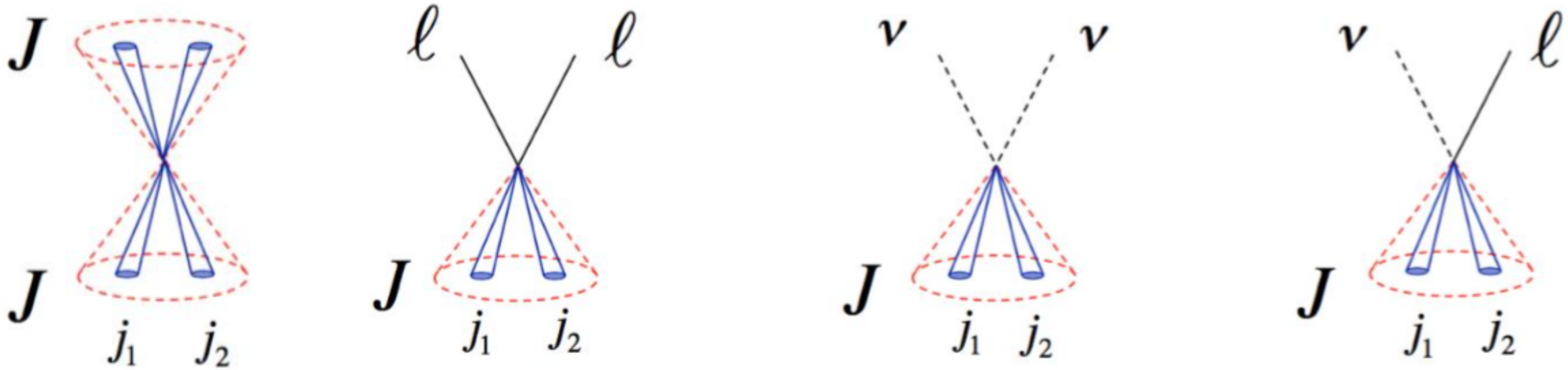
Many BMS predict resonances decaying to VV, VH, HH (V=W,Z)

Spin-0
- Scalar CP-even singlet
- S/G* → WW/ZZ
- Scalar CP-odd Higgs
- (2HDM) A Zh

Spin-1
- Heavy weakly coupled vector triplet (HVT)
- $V^{\pm}$→WZ/Zh or
- V_0→ WW/ZZ

Spin-2
- Randall-Sundrum Graviton G*→WW/ZZ

In this talk



Boosted (J) or Resolved (j1,j2) technique used depending on boson p_T

At low mass, exploit leptonic channels, intermediate mass lepton+jets, high mass m_{VH}>1 TeV "all hadronic" decay

Diboson Resonances: V(qq) H(bb) Search

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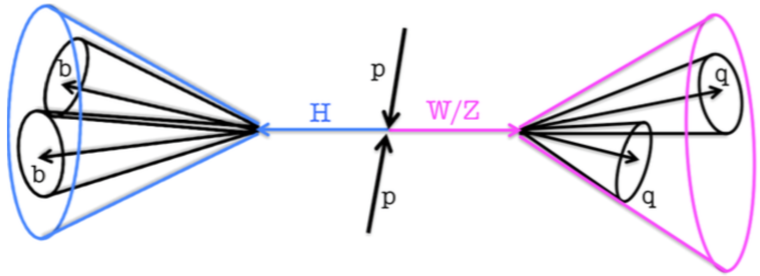
Advantages

Large BRs: W/Z→qq (67%), H→bb (~70%)



Benchmark :

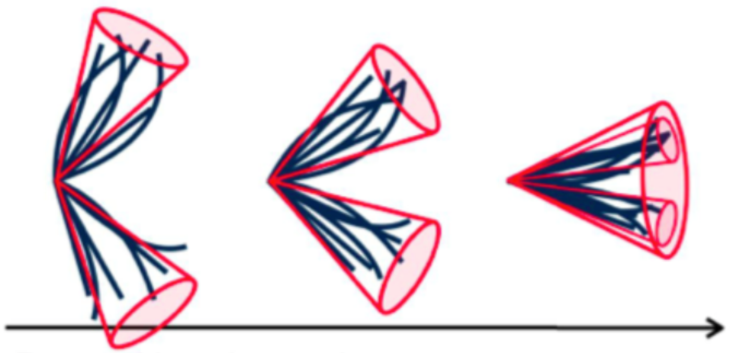
- Heavy Vector Triplet bosons Z'/W'
  - Couple to the Higgs/SM gauge bosons and to fermions
- *Model A*: comparable BR to fermions and gauge bosons.
- *Model B*: Suppressed couplings to fermions

Strategy:

- Search highly boosted (pT>1 TeV) V→qq and H→bb
  - Better QCD rejections
- Reconstruct large R =1.0 jets to capture decay sub-jets

→ **boson tagging** techniques crucial

- Discriminate signal jets from background jets from QCD/ pile-up jets



W/Z tagging techniques

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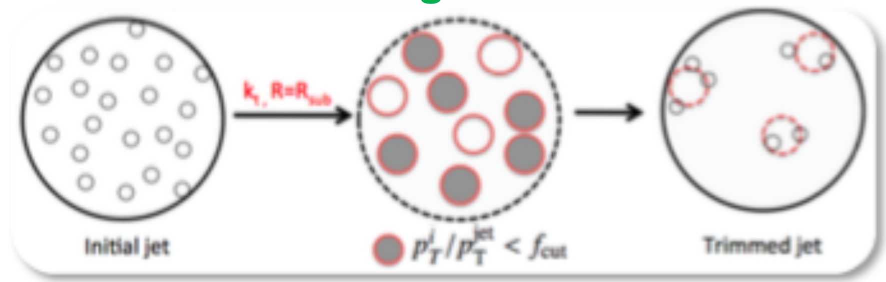
- Reconstruct **large R-jets**: **Anti-k_t, R=1.0 jet**
- Use **Trimming** to improve mass resolution
- Combine tracking information (better angular resolution)

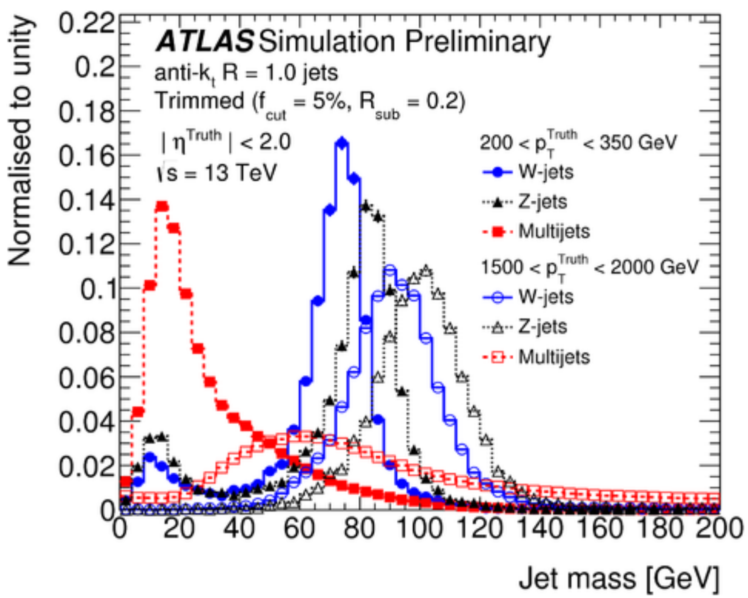
$$m_J \equiv w_{\text{calo}} \times m_J^{\text{calo}} + w_{\text{track}} \times \left(m_J^{\text{track}} \frac{p_T^{\text{calo}}}{p_T^{\text{track}}} \right)$$

Trimming

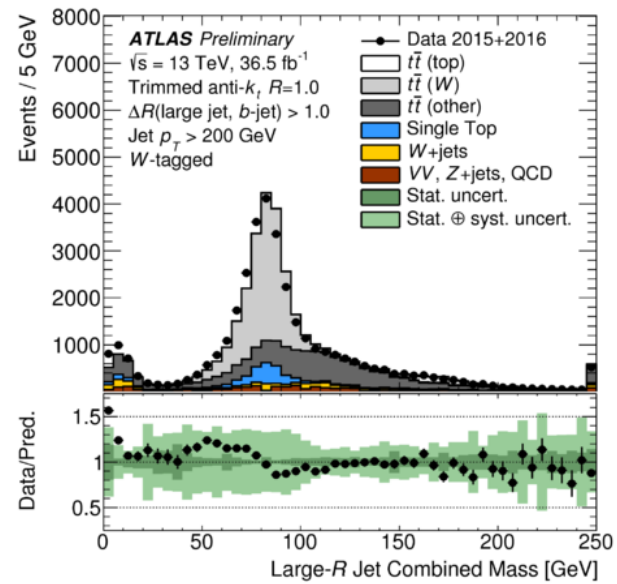


Specific for **W/Z tagging**:

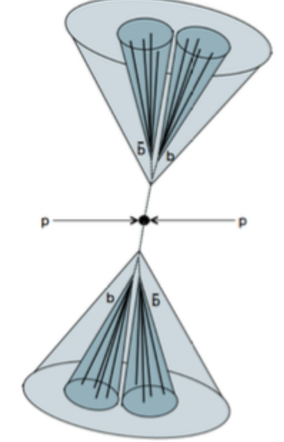
- p_T-dependent mass window
- Cut on $D2^{\beta=1}$ exploits 2 and 3-point energy correlation functions



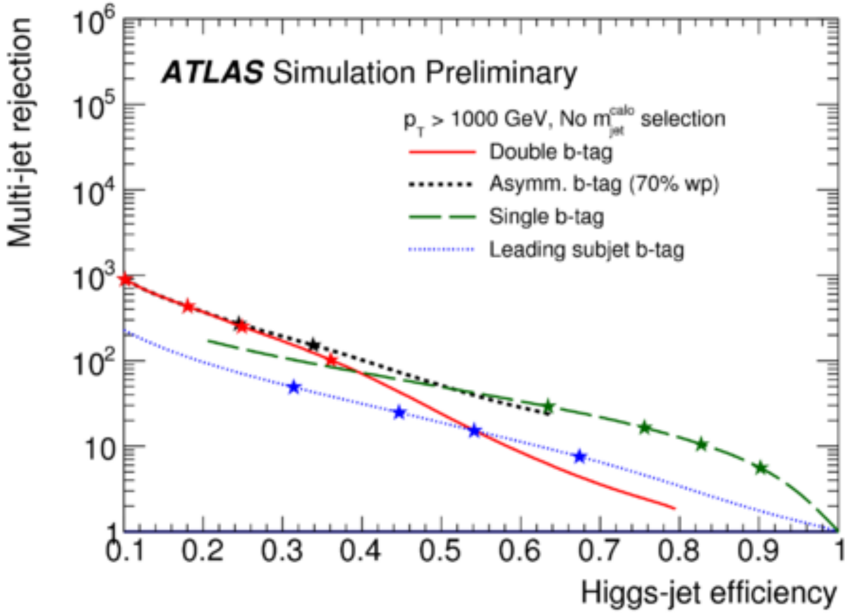
50% efficient for W/Z, ~2% efficient for QCD jets

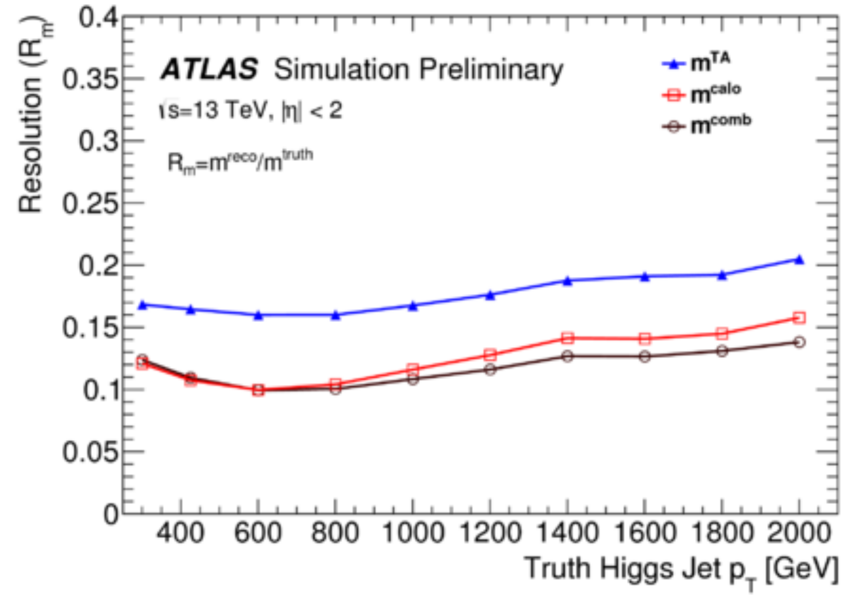


H →bb tagging techniques



- Require
  - Matching R=0.2 b-tagged track jet(s) to calorimeter jet
  - Trimmed jet mass and the trimmed jet energy correlation ratio $D_2^{\beta=1}$
  - For H $p_T \gtrsim 1$ TeV, track jets start to merge → only require one





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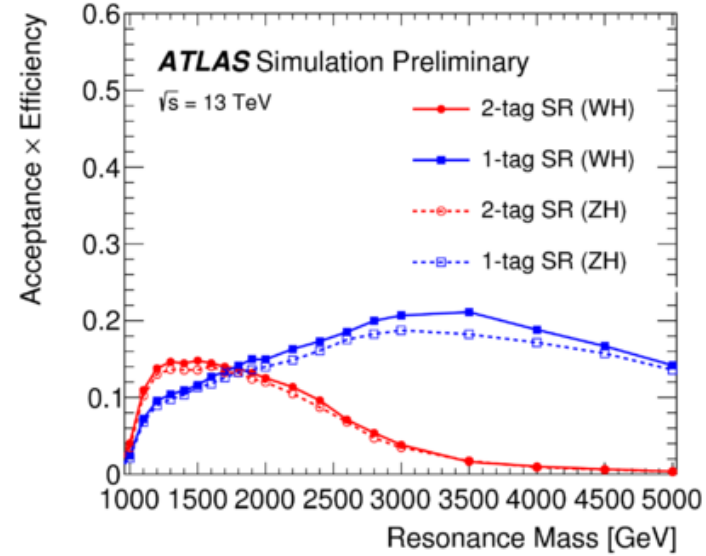
V(qq) H(bb) Search

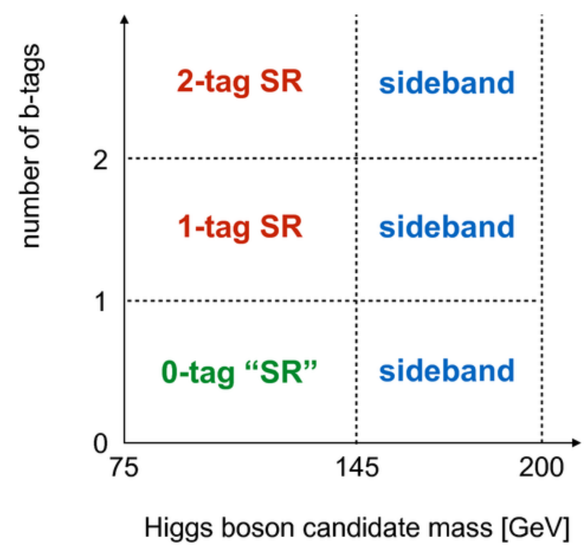
- Leading(sub) jet $p_T > 450(250)$ GeV
- Larger mass jet assigned as Higgs candidate
- H and W/Z tagging applied

- Events categorized #*b*-tagged track jets associated to the *H*-jet (1-tag and ≥2-tag)
- WH and ZH SRs not orthogonal : ~ 60% overla



- Multijet background from 0-tag sample

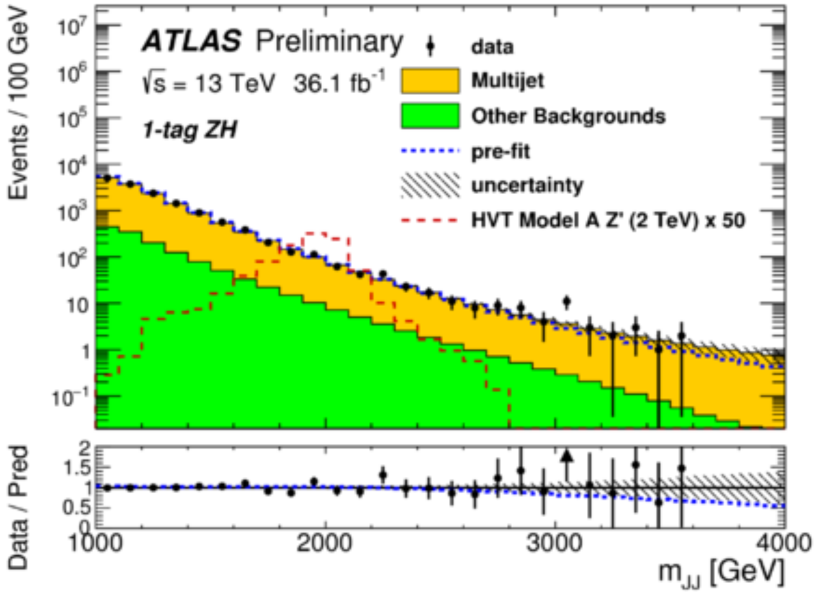
- SR normalization from sideband

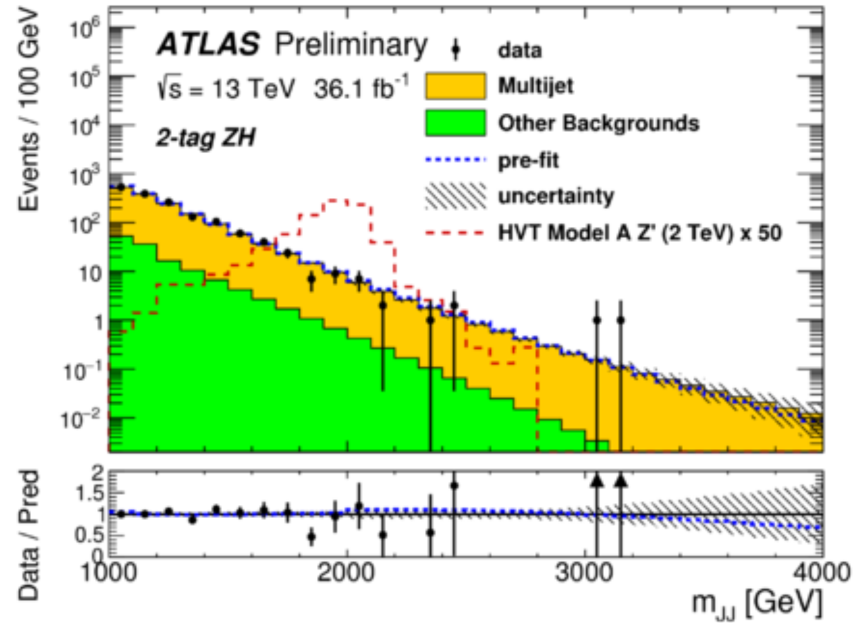


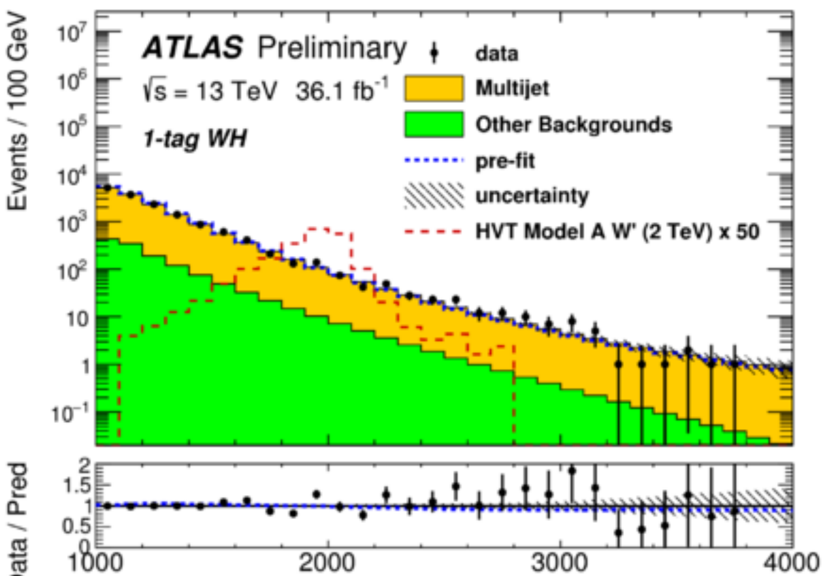
- Main systematic uncertainty:
  - signal@m=2TeV : 10-15 %
    - from B-tagging and Jet mass resolution
  - Backgrund: ~ 5%
    - from b-tagging and tt normalization

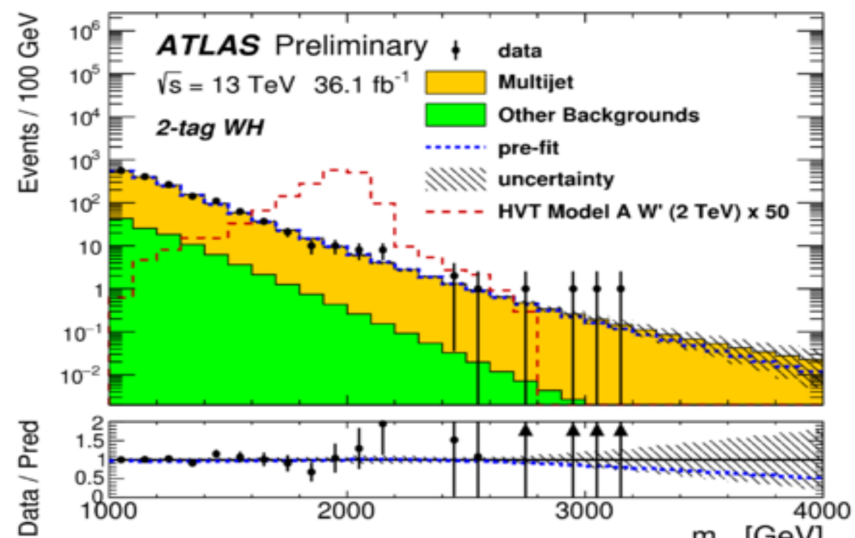
V(qq) H(bb) Results

Probing **ZH** and **WH** not orthogonal









V(qq) H(bb) Limits

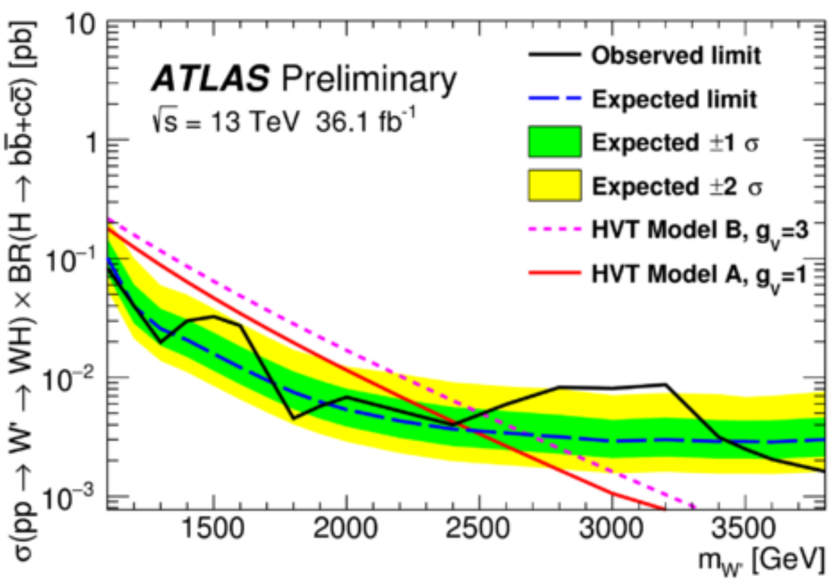
No large deviations from SM expctations

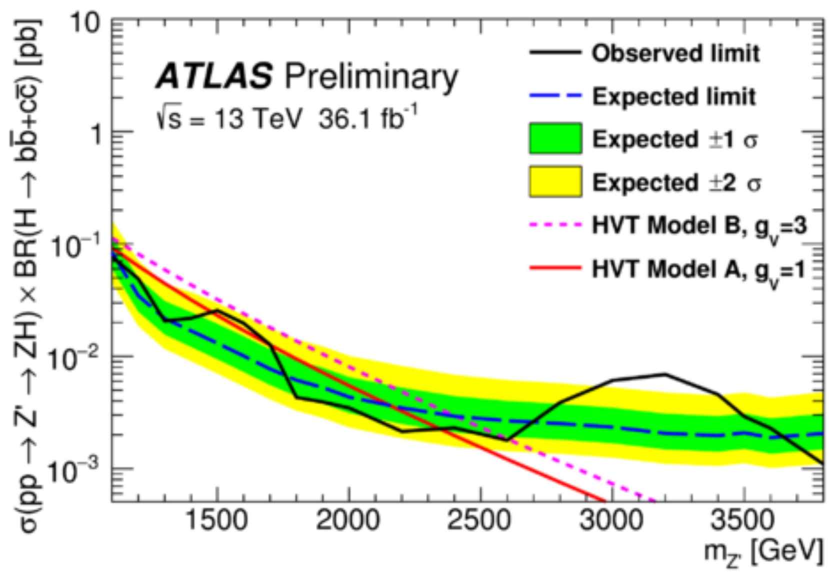
- Largest excess found at 3.0 TeV in ZH channel, with **global** significance of **2.2σ,** Local 3.3 σ

Limits on Heavy Vector Triplet (HVT) W' and Z'.

- Model A: comparable BR to fermions and gauge bosons.
- Model B: Suppressed couplings to fermions.

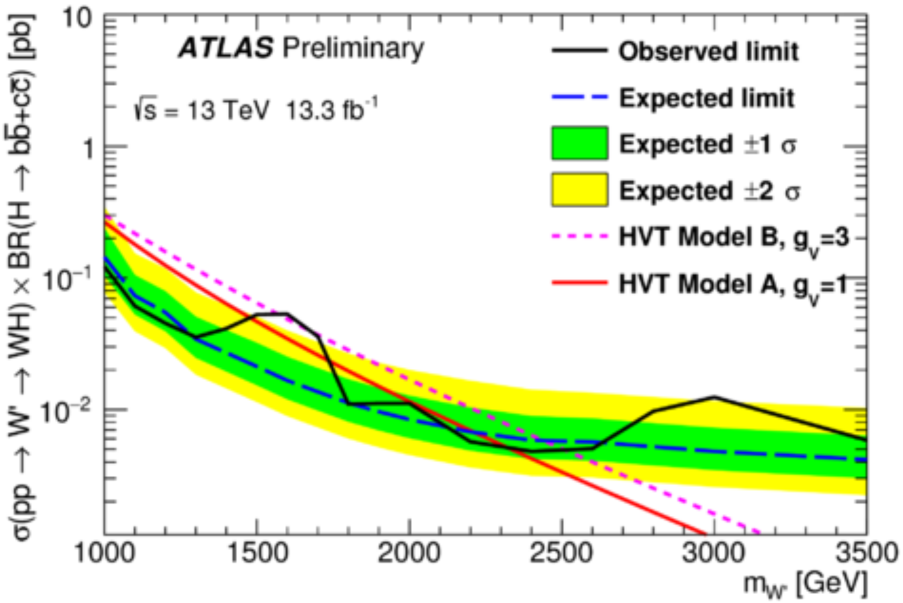
- Fit **WH** and **ZH** signal regions separately.
  Combining 1-tag and 2-tag regions in each case.

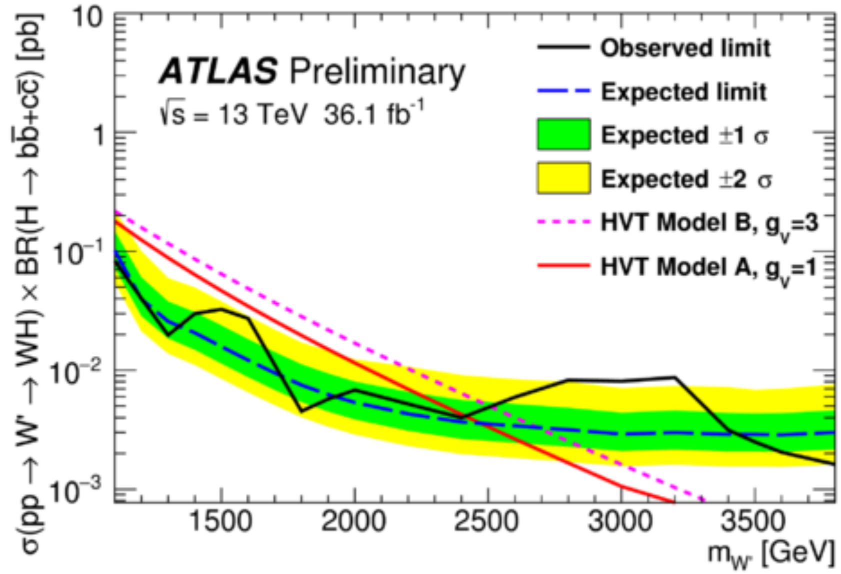


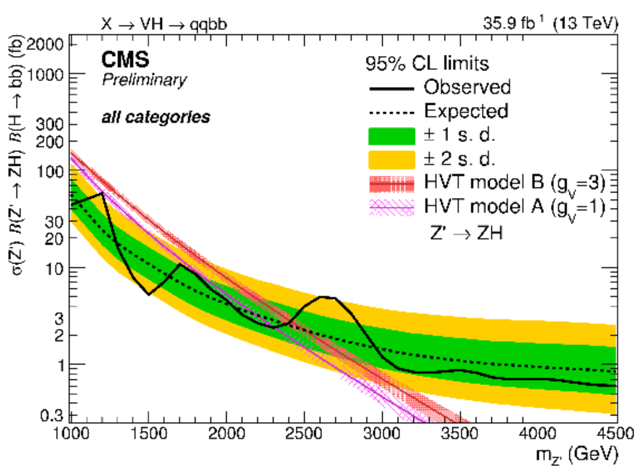


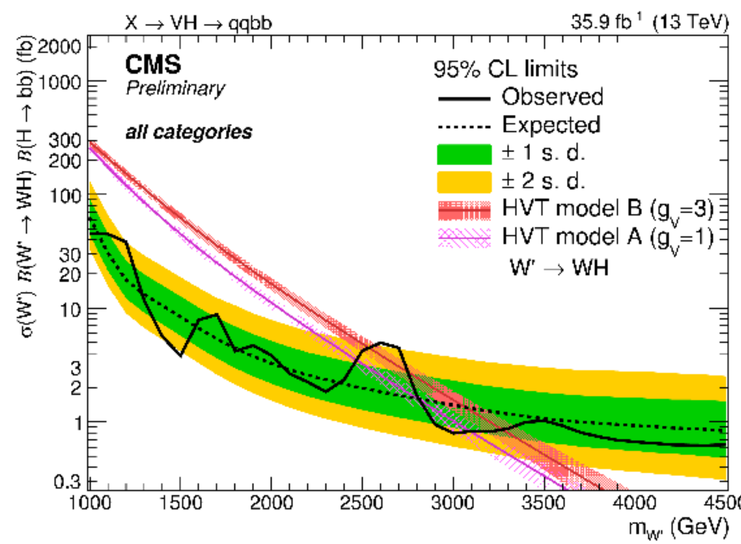
V(qq) H(bb) Results

- The slight excess is not new, but hasn't grown
- CMS: a small excess not in the same place

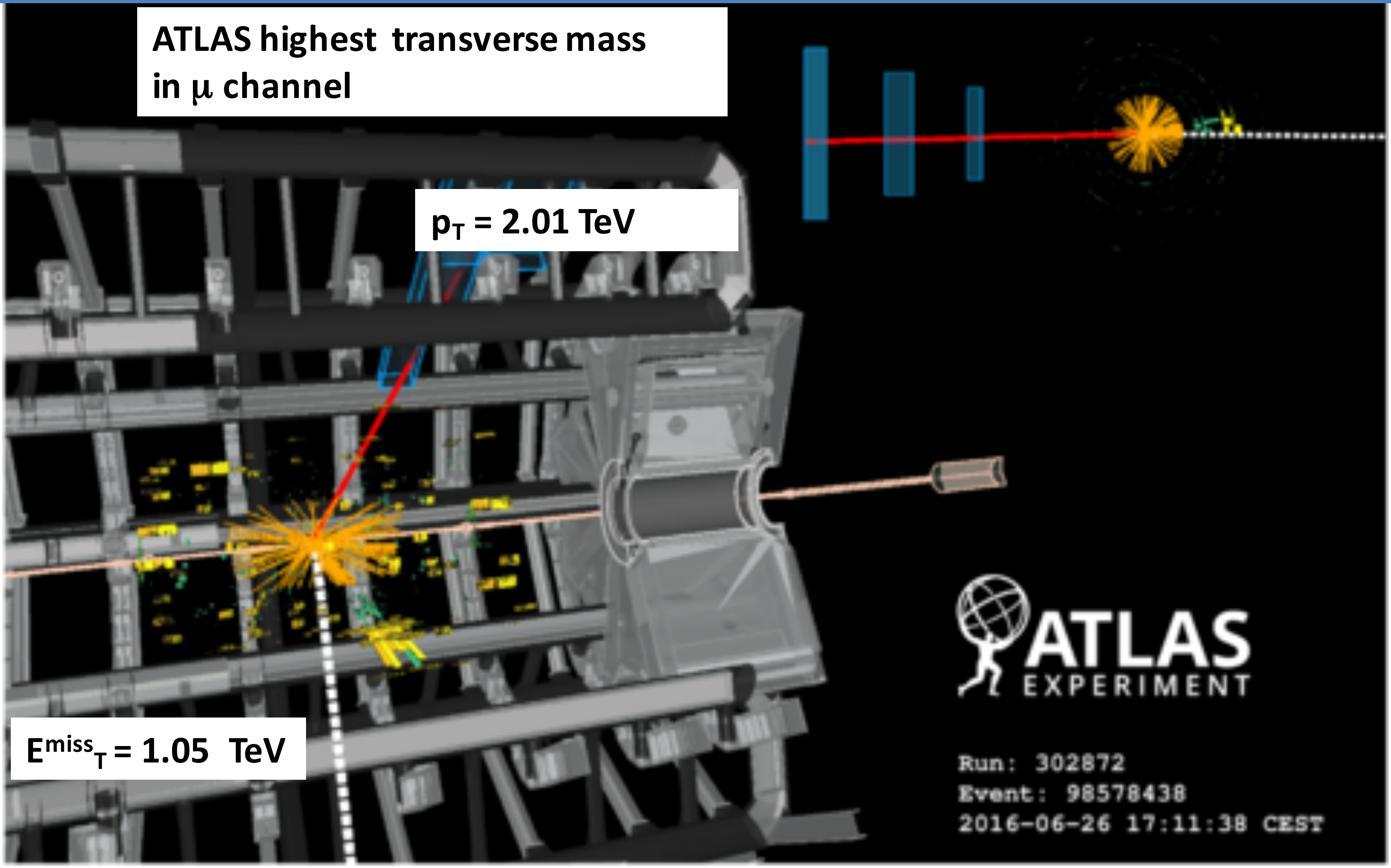








Search for new resonances decaying to a charged lepton and a neutrino



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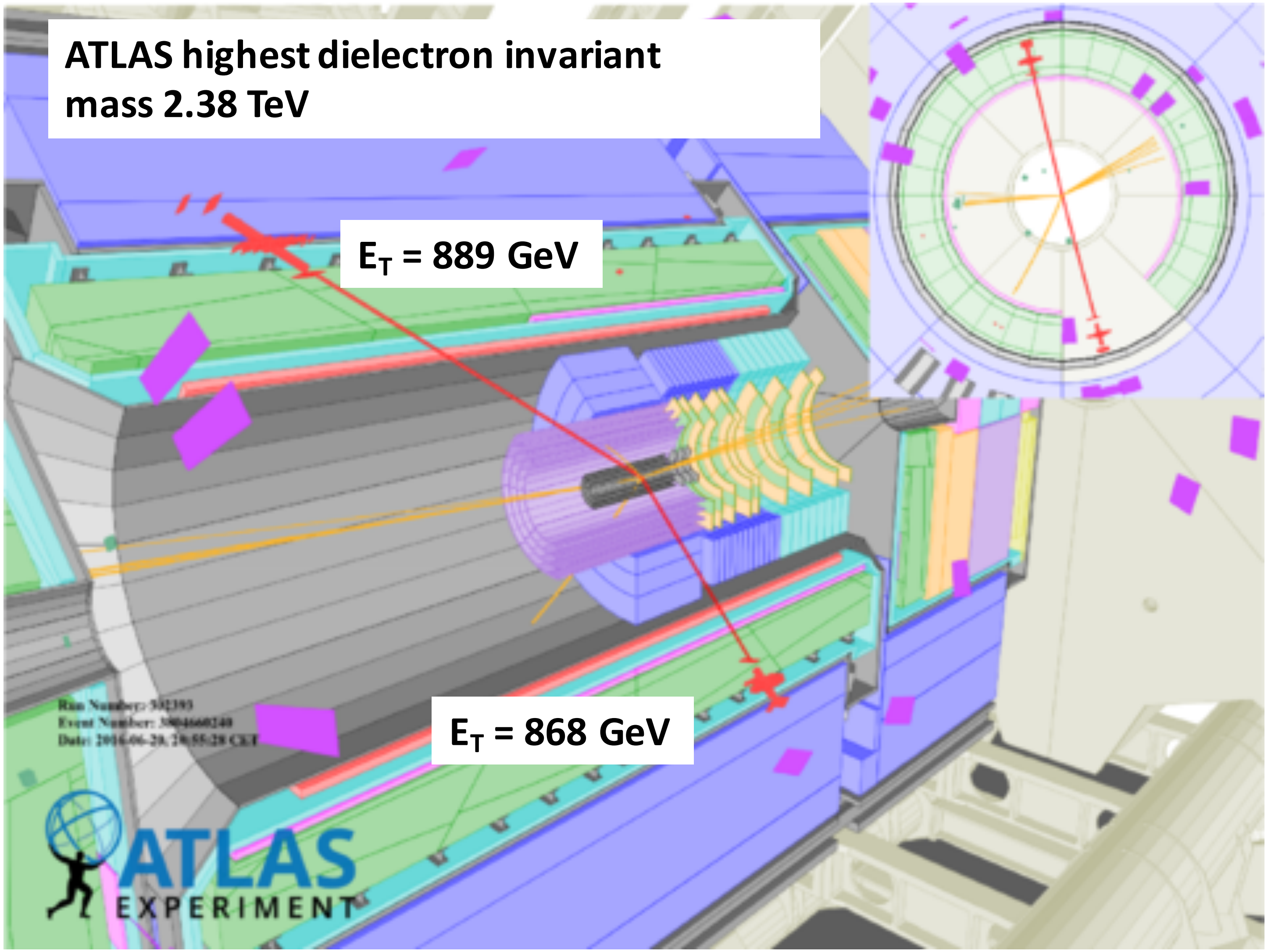
Search of high-mass resonances in the dilepton final state



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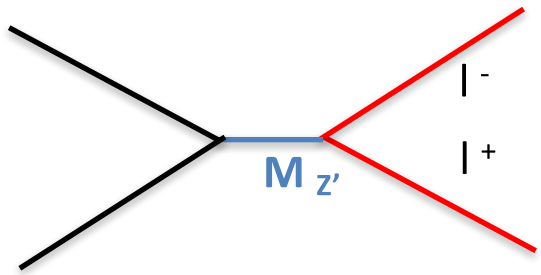
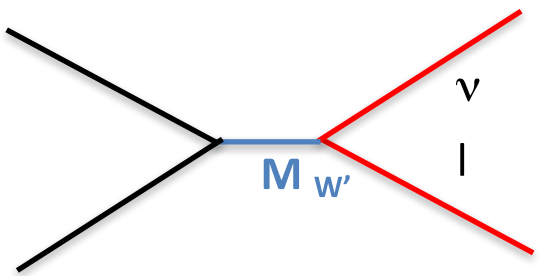
Searches with Leptons

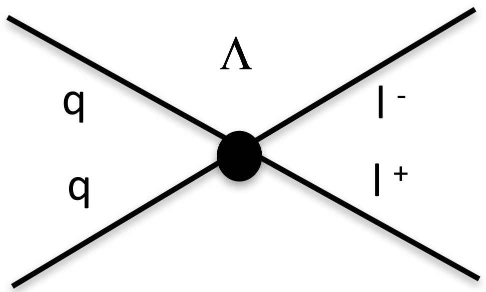
Di-lepton and Lepton + E_T^{miss} final states sensitive to a broad class of new phenomena





1. **Direct search** of narrow new heavy resonances
   - Sequential Standard Model (SSM):
     Z' ,W' with same couplings to fermions as Z/W
   - For Z' :Grand unified Theories (GUT) inspired E6 gauge group:
     - predicts two neutral gauge bosons mixing to $Z'(\theta_{E6}) = Z'_{\psi}\cos(\theta_{E6}) + Z'_{\chi}\sin(\theta_{E6})$
     - Signals considered for 6 values of θ_{E6}

2. **Non-resonant** deviations from predicted SM dilepton mass spectrum.
   - new interactions or compositeness in $qq \rightarrow l^+l^-$
   - contact interaction rappresentation



Searches with Leptons: Analysis strategy

Dilepton Selection

- Di electron and single triggers.
- 1 e (μ) with E_T (p_T) > 30 GeV
- ε^{tot} = 73% (44%) for ee ($\mu\mu$) channel
  for $m_{Z'}$ = 3 TeV

- **Look for excess in m_{ll} distirbution**

Lepton + E^T_{miss} Selection

- Single electron(μ) triggers
- Tight ID e(μ) p_T > 65(55) GeV
- E_T^{miss} > 65(55) GeV, m_T > 130 GeV
- ε^{tot} = 81% (77%) for e, 50% (46%) for μ @ $m_{W'}$ = 2 TeV (4 TeV)

- **Look for excess in m_T distirbution:**

$$m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}} E_{\mathrm{T}}^{miss} \cdot (1 - \cos \Delta\phi)}$$

Backgrounds

Real lepton(s):

- Drell-Yan (dominant) by MC
  - NLO Powheg generator
    mass dependent correction to NNLO QCD
  - mass-dependent EW-corrections at NLO
- $t\bar{t}$, single-top, WW, WZ, and ZZ by MC

jet faking electrons:

W +jets and multi-jet events estimated from data

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Dilepton Search: Systematics uncertainty

Source	Dielectron channel		Dimuon channel	
	Signal	Background	Signal	Background
Luminosity	3.2% (3.2%)	3.2% (3.2%)	3.2% (3.2%)	3.2% (3.2%)
MC statistical	<1.0% (<1.0%)	<1.0% (<1.0%)	<1.0% (<1.0%)	<1.0% (<1.0%)
Beam energy	2.0% (4.1%)	2.0% (4.1%)	1.9% (3.1%)	1.9% (3.1%)
Pile-Up effects	<1.0% (<1.0%)	<1.0% (<1.0%)	<1.0% (<1.0%)	<1.0% (<1.0%)
DY PDF choice	N/A	<1.0% (8.4%)	N/A	<1.0% (1.9%)
DY PDF variation	N/A	8.7% (19%)	N/A	7.7% (13%)
DY PDF scale	N/A	1.0% (2.0%)	N/A	<1.0% (1.5%)
DY α_S	N/A	1.6% (2.7%)	N/A	1.4% (2.2%)
DY EW corrections	N/A	2.4% (5.5%)	N/A	2.1% (3.9%)
DY γ-induced corrections	N/A	3.4% (7.6%)	N/A	3.0% (5.4%)
Top Quarks theoretical	N/A	<1.0% (<1.0%)	N/A	<1.0% (<1.0%)
Dibosons theoretical	N/A	<1.0% (<1.0%)	N/A	<1.0% (<1.0%)
Reconstruction efficiency	<1.0% (<1.0%)	<1.0% (<1.0%)	10% (17%)	10% (17%)
Isolation efficiency	9.1% (9.7%)	9.1% (9.7%)	1.8% (2.0%)	1.8% (2.0%)
Trigger efficiency	<1.0% (<1.0%)	<1.0% (<1.0%)	<1.0% (<1.0%)	<1.0% (<1.0%)
Identification efficiency	2.6% (2.4%)	2.6% (2.4%)	N/A	N/A
Lepton energy scale	<1.0% (<1.0%)	4.1% (6.1%)	<1.0% (<1.0%)	<1.0% (<1.0%)
Lepton energy resolution	<1.0% (<1.0%)	<1.0% (<1.0%)	2.7% (2.7%)	<1.0% (6.7%)
Multi-jet & W+jets	N/A	10% (129%)	N/A	N/A
Total	10% (11%)	18% (132%)	11% (18%)	14% (24%)

Largest Theory uncertainty

Largest exp. uncertainty

Largest uncertainty at high mass due to extrapolation

Background and signal systematic uncertainties at dilepton masses of 2 TeV (4 TeV)

Lepton + E_T^{miss} : Systematics uncertainty

Source	Electron channel		Muon channel	
	Background	Signal	Background	Signal
Trigger	negl. (negl.)	negl. (negl.)	2% (2%)	2% (2%)
Lepton reconstruction and identification	negl. (negl.)	negl. (negl.)	5% (6%)	5% (7%)
Lepton momentum scale and resolution	4% (5%)	4% (3%)	3% (9%)	1% (1%)
E_T^{miss} resolution and scale	$< 0.5\%$ ($< 0.5\%$)	$< 0.5\%$ ($< 0.5\%$)	$< 0.5\%$ (1%)	1% (1%)
Jet energy resolution	$< 0.5\%$ ($< 0.5\%$)	$< 0.5\%$ ($< 0.5\%$)	$< 0.5\%$ ($< 0.5\%$)	$< 0.5\%$ ($< 0.5\%$)
Pile-up	1% ($< 0.5\%$)	1% ($< 0.5\%$)	$< 0.5\%$ (1%)	1% ($< 0.5\%$)
Multijet background	12% (109%)	N/A (N/A)	1% (1%)	N/A (N/A)
Diboson & top extrapolation	5% (21%)	N/A (N/A)	5% (13%)	N/A (N/A)
PDF choice for DY	1% (19%)	N/A (N/A)	$< 0.5\%$ (1%)	N/A (N/A)
PDF variation for DY	8% (20%)	N/A (N/A)	7% (11%)	N/A (N/A)
EW corrections for DY	4% (9%)	N/A (N/A)	4% (5%)	N/A (N/A)
Luminosity	3% (3%)	3% (3%)	3% (3%)	3% (3%)
Total	17% (115%)	5% (5%)	12% (21%)	6% (8%)

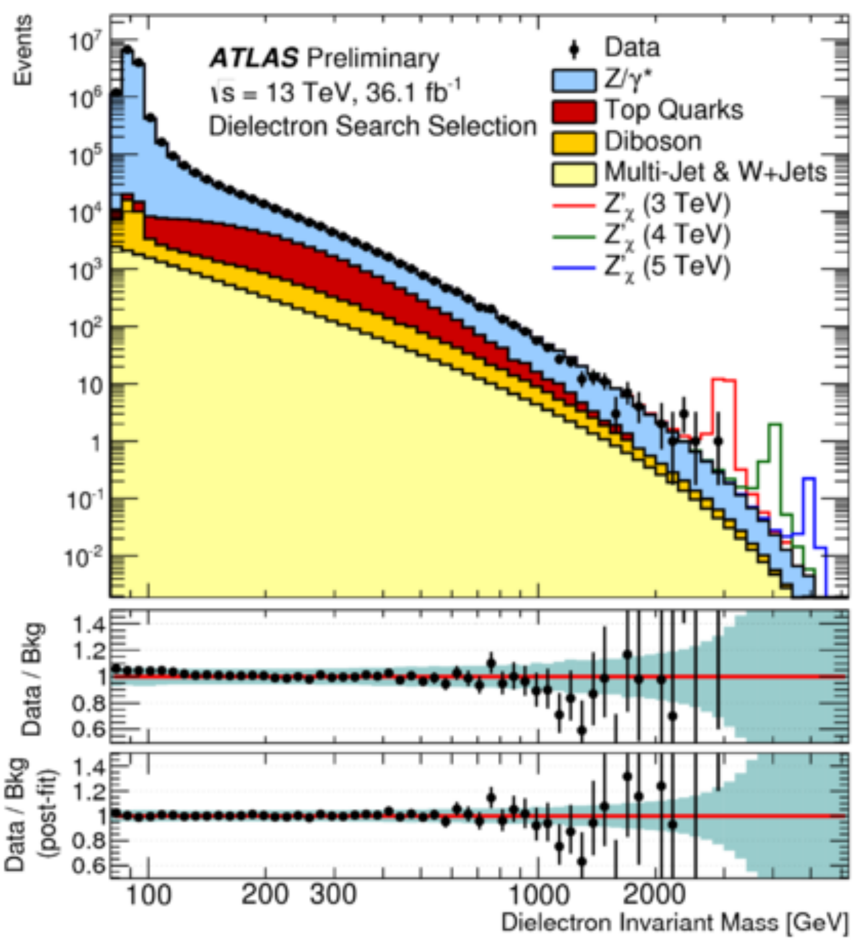
Largest exp. uncertainty

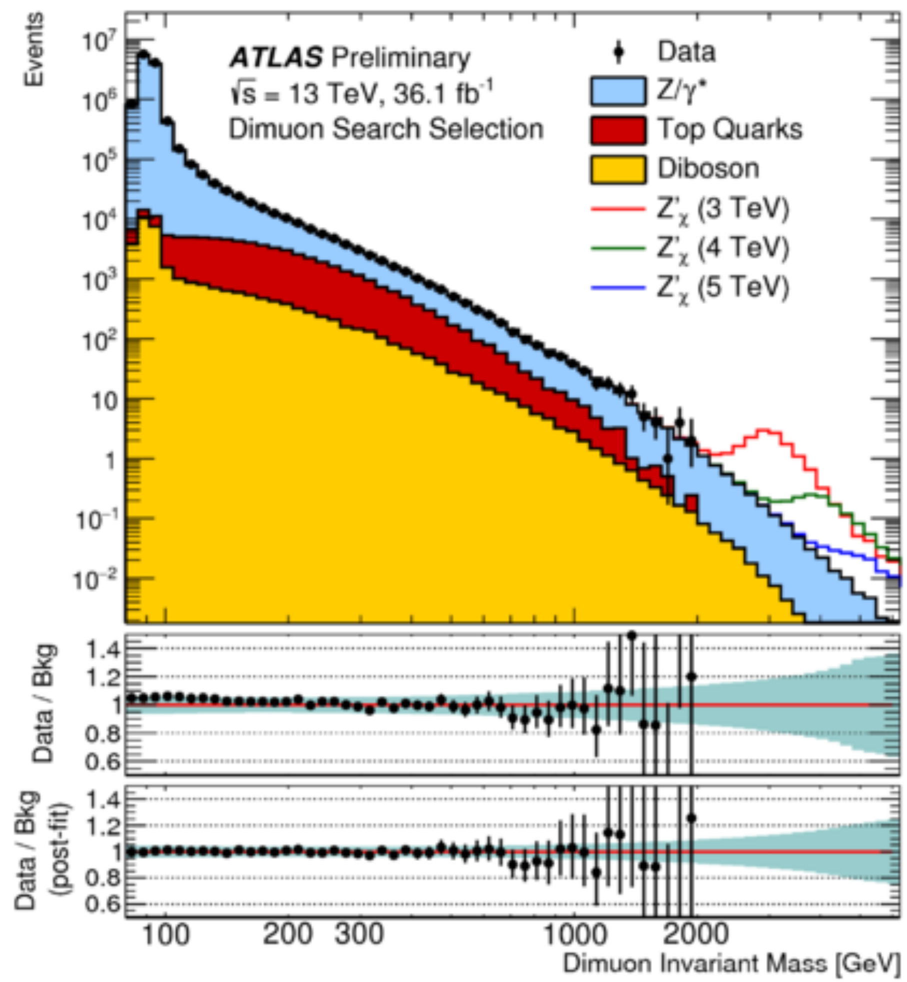
Largest uncertainty at high mass due to extrapolation

Largest Theory uncertainty

Background and signal systematic uncertainties at $m_{W'}$ = 2 TeV (4 TeV)

Dilepton Search: Result





No significant excess is observed

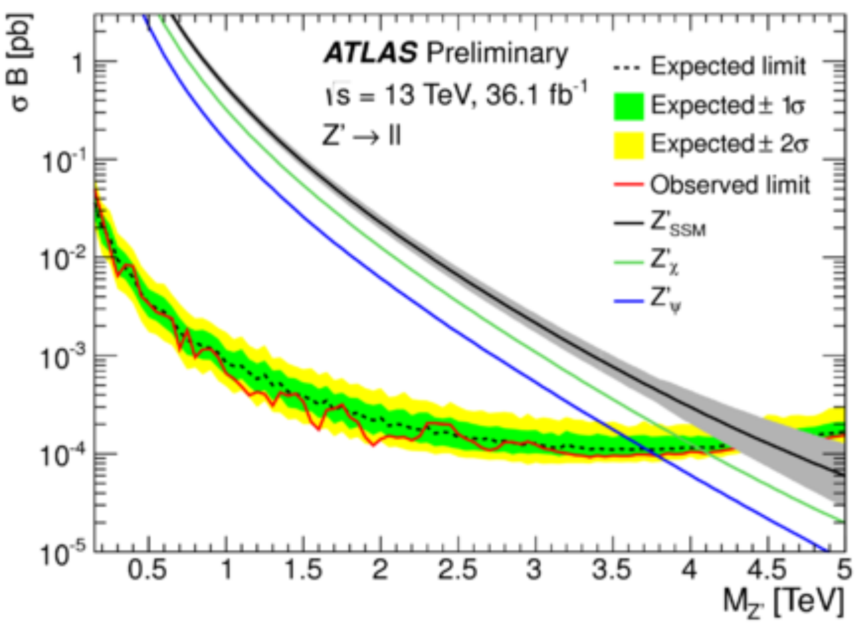
Most significant excess in di-electron mass spectrum is observed at 2.37 TeV, global significance of -0.2σ.

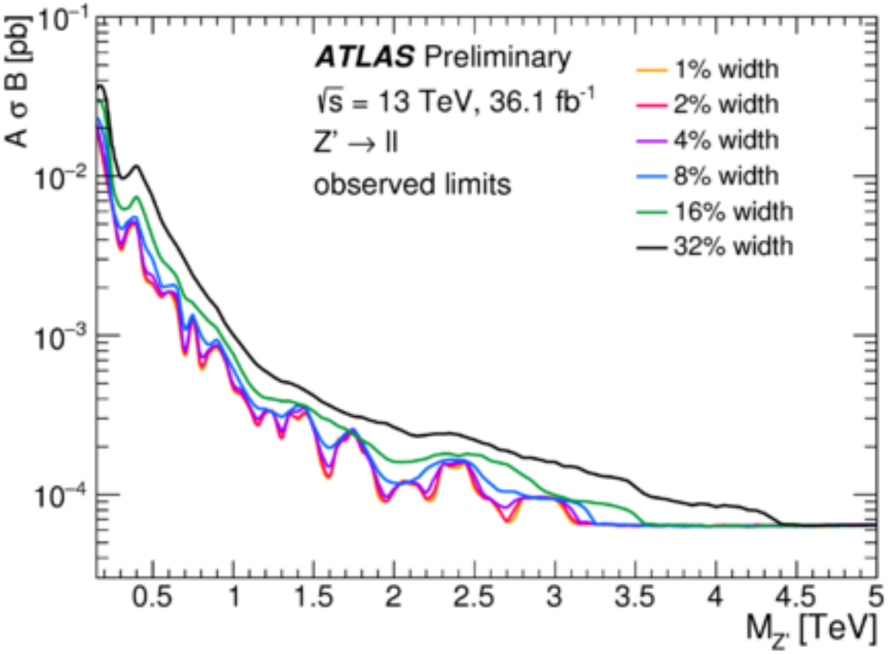
Dilepton Search: Limits

For various **Z' models**
upper limits are set for Z' cross sections times BR wrt $m_{Z'}$

Generic limits:

- fiducial cuts ($p_T > 30$ GeV, $|\eta|<2.5$) on signal templates and a mass window of x 2 the signal width (Breit-Wigner).
- Other models can be interpreted with these cross-sections



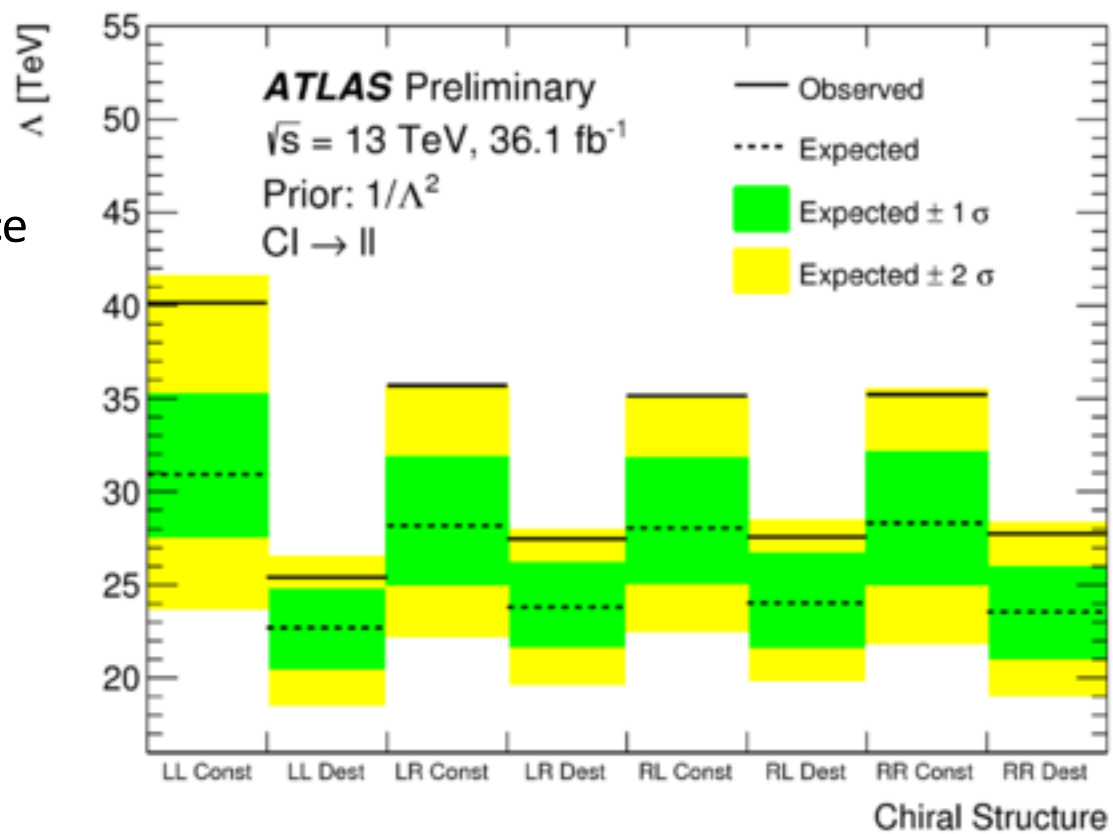


Limit increased by up to 700 GeV wrt limit obtained with 3.2 fb^{-1}

Dilepton Search:
Exclusion limits on contact interactions

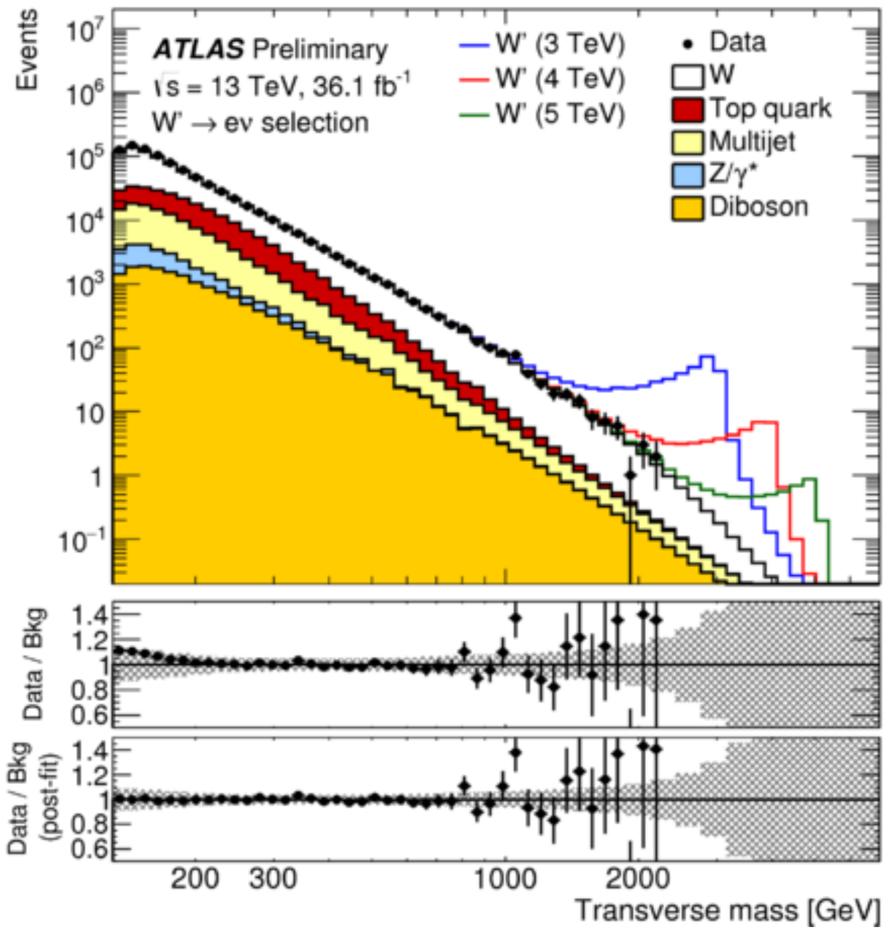
- Different chiral structures tested:
  - Left-right ,left-left, right-rights
    - $\eta_{LR\,(RL)} = \pm 1$
    - $\eta_{LL(RR)} = \pm 1$
    - the others to zero
- (con)destructive interference of signal model η_{ij} = -1(+1) with SM QCD
- **Limits on Λ between 23.5 and 40.1 TeV**

$$\mathcal{L} = \frac{g^2}{\Lambda^2}[\eta_{LL}(\bar{q}_L\gamma_\mu q_L)(\bar{\ell}_L\gamma^\mu\ell_L) + \eta_{RR}(\bar{q}_R\gamma_\mu q_R)(\bar{\ell}_R\gamma^\mu\ell_R) + \eta_{LR}(\bar{q}_L\gamma_\mu q_L)(\bar{\ell}_R\gamma^\mu\ell_R) + \eta_{RL}(\bar{q}_R\gamma_\mu q_R)(\bar{\ell}_L\gamma^\mu\ell_L)]$$

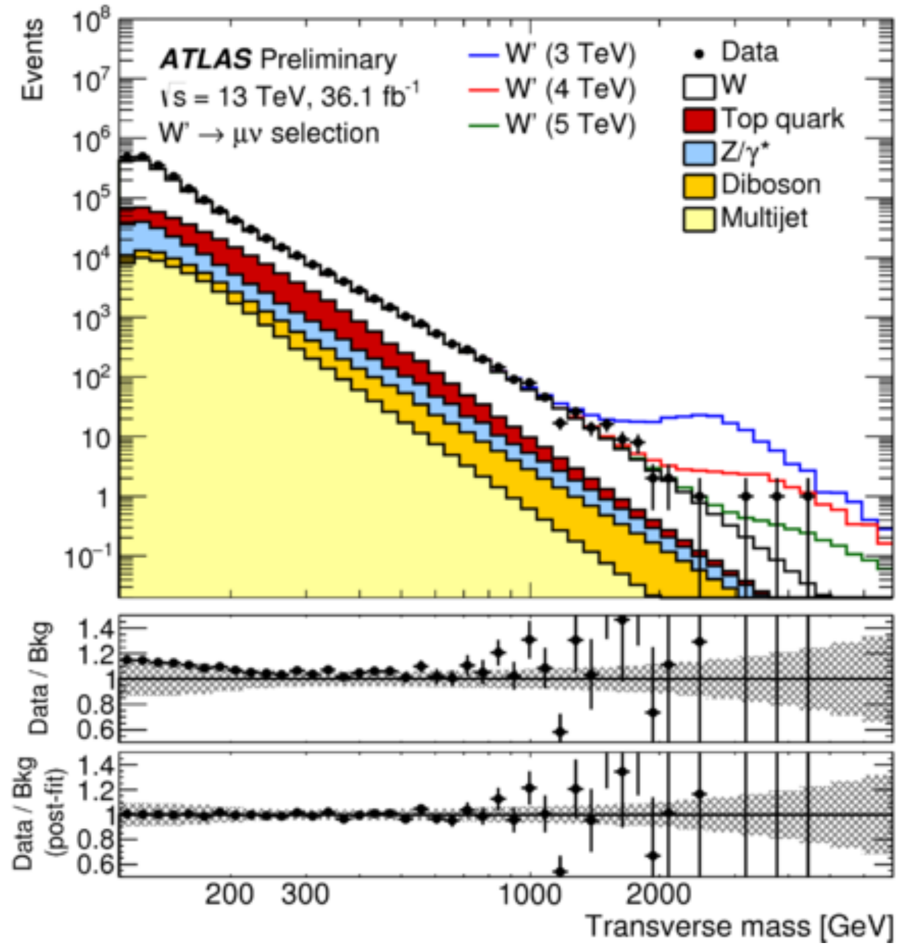


Lepton + E_T^{miss} Search: Result

No significant excess is observed

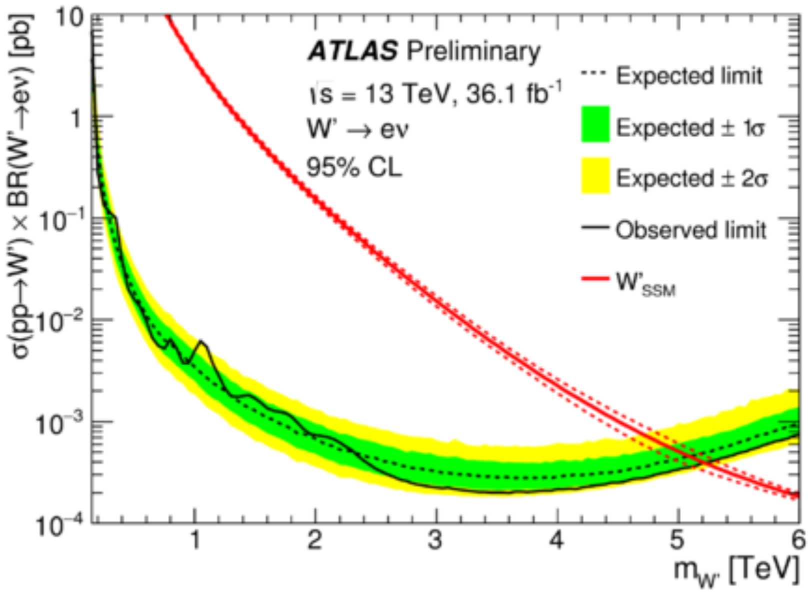


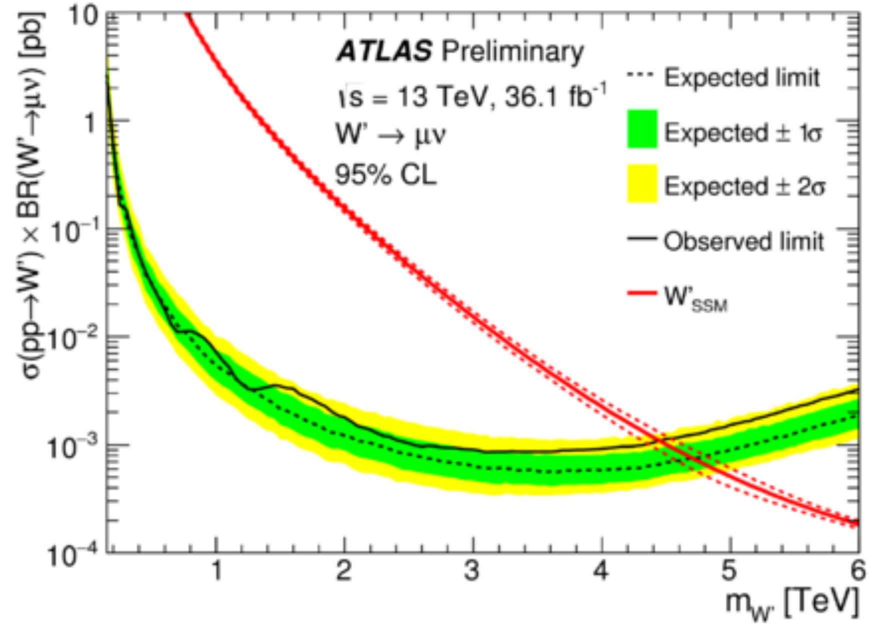
most significant excess at $m_{W'}$ = 1.1 TeV:
local (global) significance of 2.3 (0.6)



most significant excess at $m_{W'}$ ~ 5 TeV:
local (global) significance of 1.8 (0.1)

Lepton + E_T^{miss} Search: Limits on $\sigma \cdot BR$



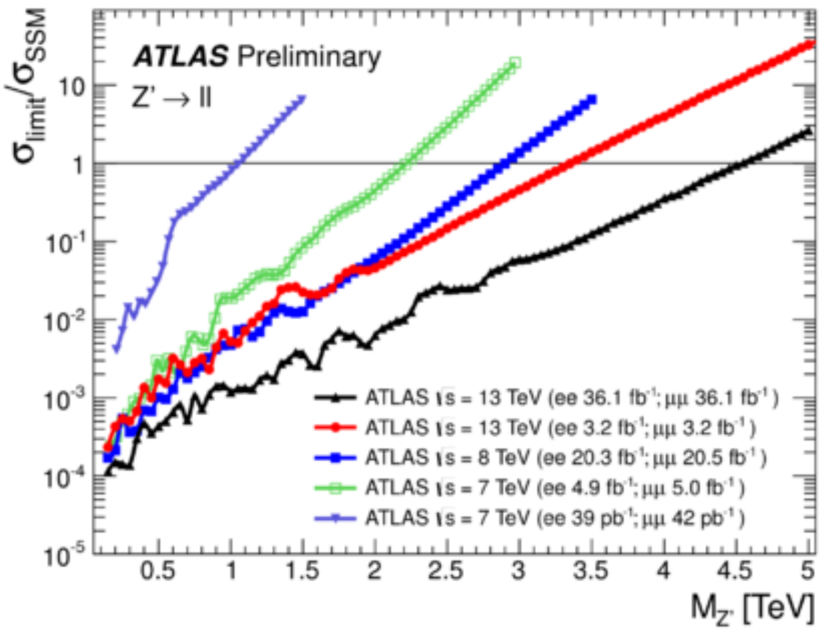


- **Observed (Exp) limits on m W'_{SSM}**
  - **5.22 (5.10) TeV for e channel**
  - **4.45 (4.71) TeV for μ channel**
  - **5.11 (5.24) TeV combined**

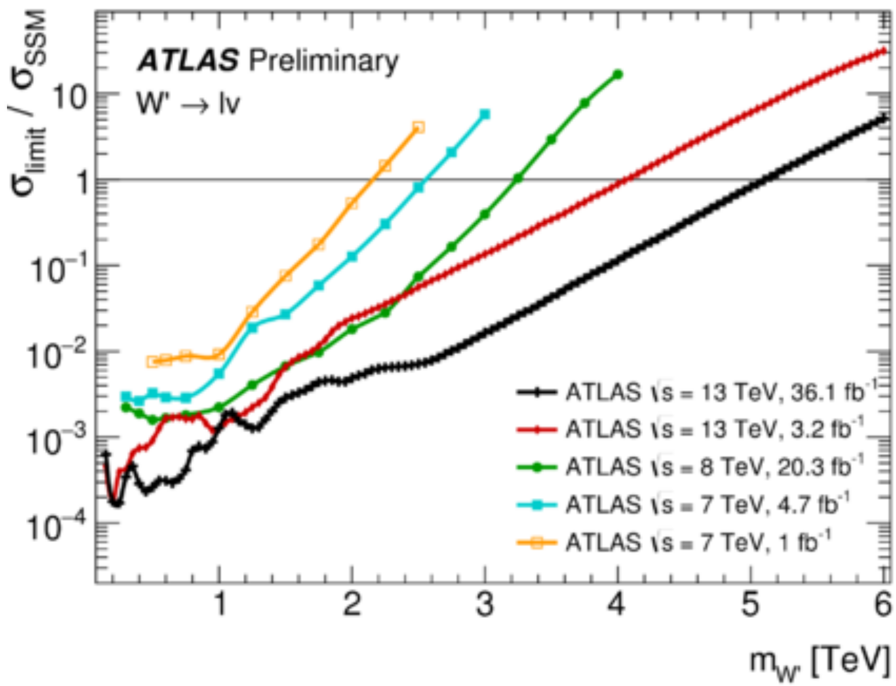
Limits improved by ~ 1 TeV wrt previous analysis based on 3.2 fb^{-1}

Searches with Leptons

Significant improvement wrt previous ATLAS searches

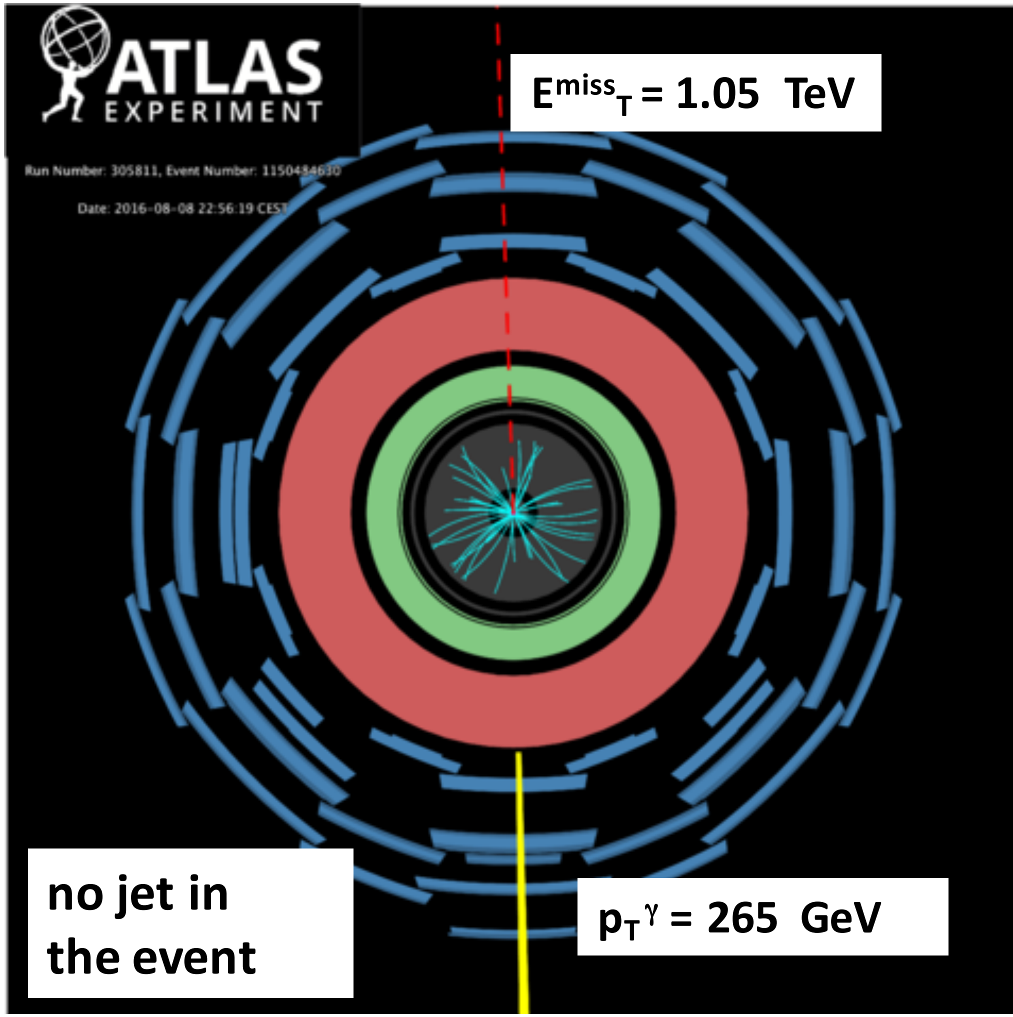


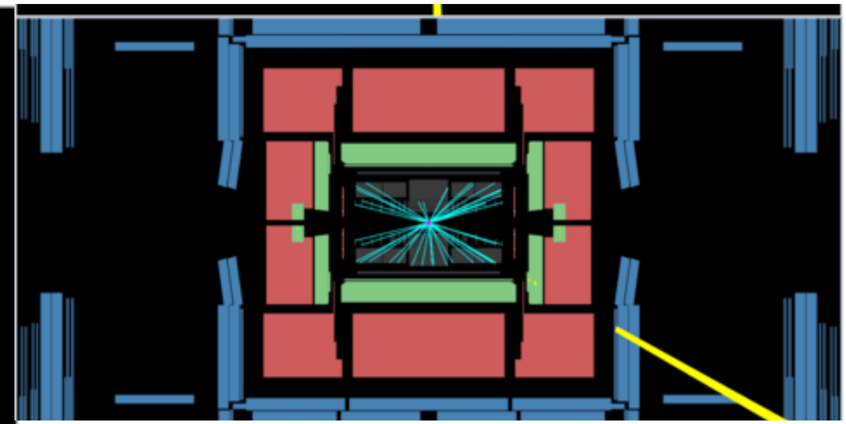
Observed limits to the Z'SSM cross section from the combination of di-electron and di-muon channels.



Observed limits to the W'SSM cross section from the combination of electron and muon channels.

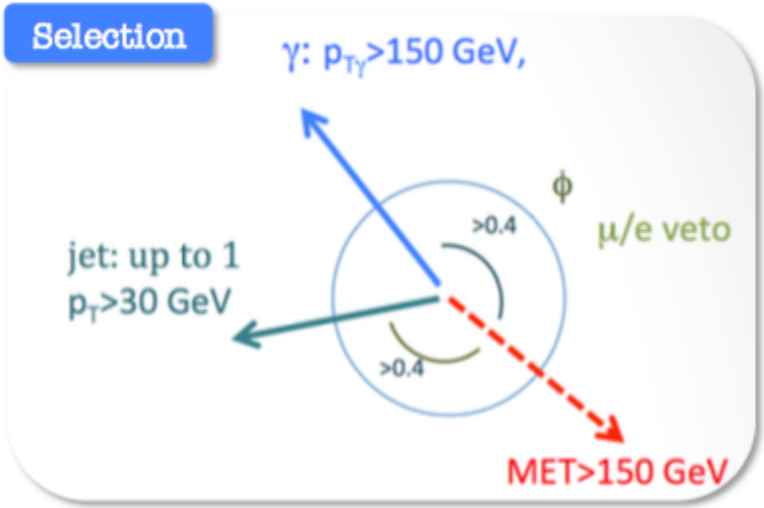
Photon + E_T^{miss} search





Photon + E_T^{miss} search

- Many BSM introduce e new bosons which can decay into Gauge Bosons:
  - Consider $X \to Z\gamma$, $Z \to \nu\nu$
  - Search excess of $\gamma + E_T^{miss}$ events
- Benchmark model:
  - Scalar resonance $2<m_V<5$ TeV, Γ=4 MeV, simulated with Powheg

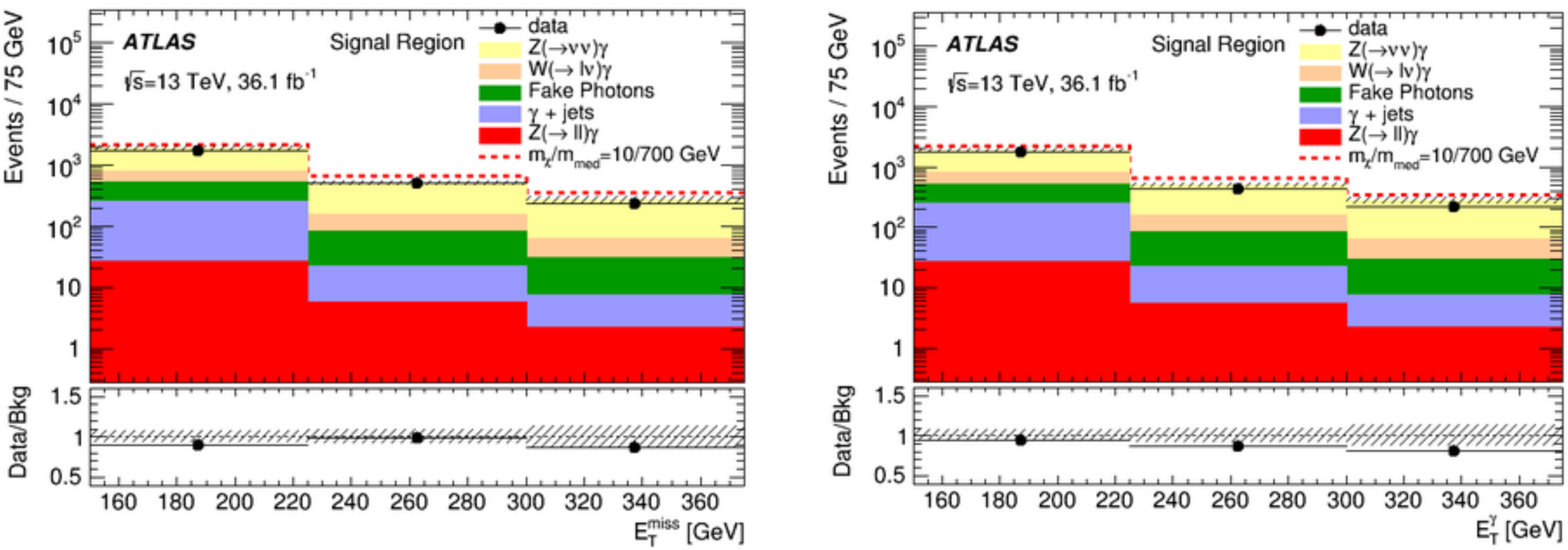


Event cleaning	Quality and Primary vertex				
Leading photon	$E_T^\gamma > 150 GeV$, $\|\eta\| < 1.37$ or $1.52 < \|\eta\| < 2.37$, tight, isolated, $\|z\| < 0.25$ m, $\Delta\phi(\gamma, E_T^{miss}) > 0.4$				
$E_T^{miss}/\sqrt{\Sigma E_T}$	> 8.5 GeV$^{1/2}$				
Jets	0 or 1 with $p_T > 30 GeV$, $\|\eta\| < 4.5$ and $\Delta\phi(\text{jets}, E_T^{miss}) > 0.4$				
Lepton	veto on e and μ				
	SRI1	SRI2	SRI3	SRE1	SRE2
E_T^{miss} [GeV]	> 150	> 225	> 300	150–225	225–300
Selected events in data	2400	729	236	1671	493
Events with 0 jets	1559	379	116	1180	263

3 signal regions for resonances searches

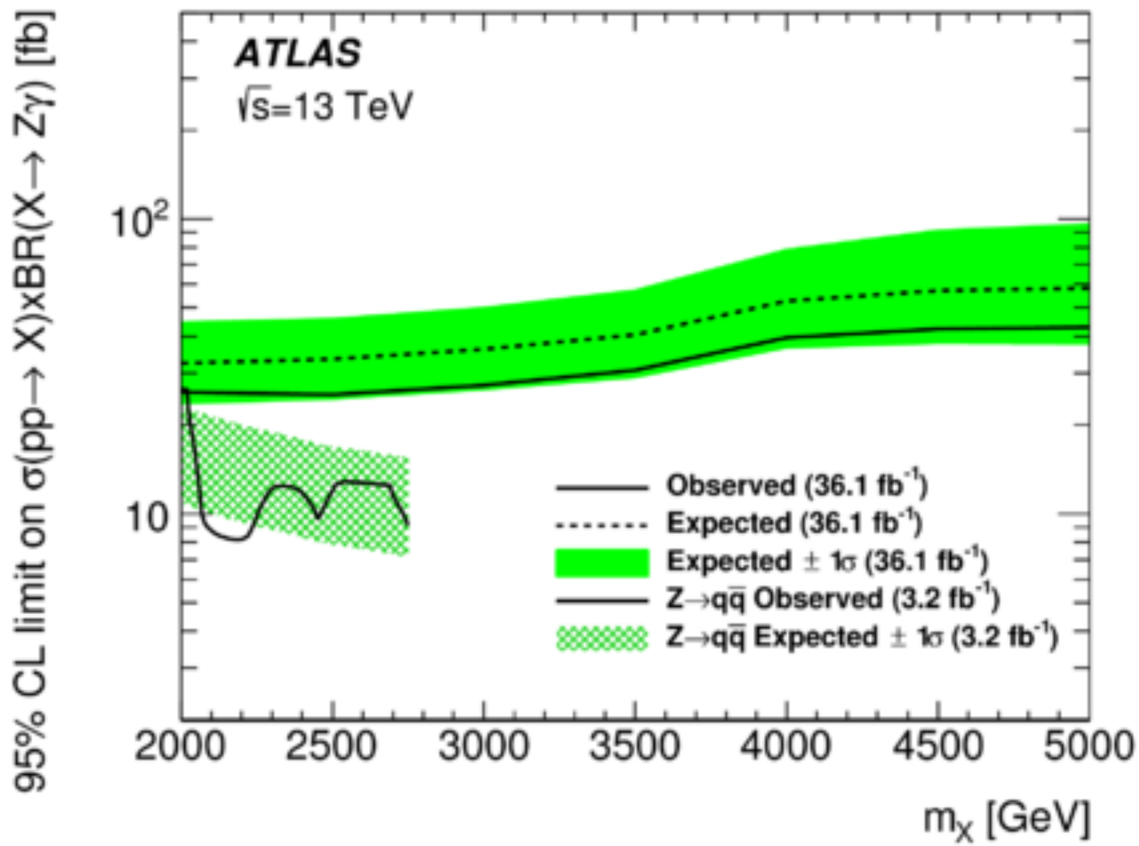
Photon + E_T^{miss} search

- Background:
  - **Z(νν)+** γ (ISR) (dominant) ,W(→lν)γ, Z(→ν ν)γ, γ + jets
    - From simulation and normalized in dedicated CRs
  - Fake γ from electron and jets from *W/Z*+jets, diboson and multi-jet events
    - from data



Main uncertainties: Statistical from CRs: 9%.

Photon + E_T^{miss} search



Zγ, Z →νν complement to searches using *Zγ , Z →qq* at higher masses

Conclusions

Search for new physics has been performed using full 2015+2016 dataset

No deviations from SM expectations are observed

- **Di-jets final states**
  - Limits on resonances masses between 3.4 and 8.9 TeV
  - contact interactions scale $\Lambda > 13 - 29$ TeV

- **Lepton+neutrino final state:** W'_{SSM} excluded for $M_{W'} > 5.1$ TeV

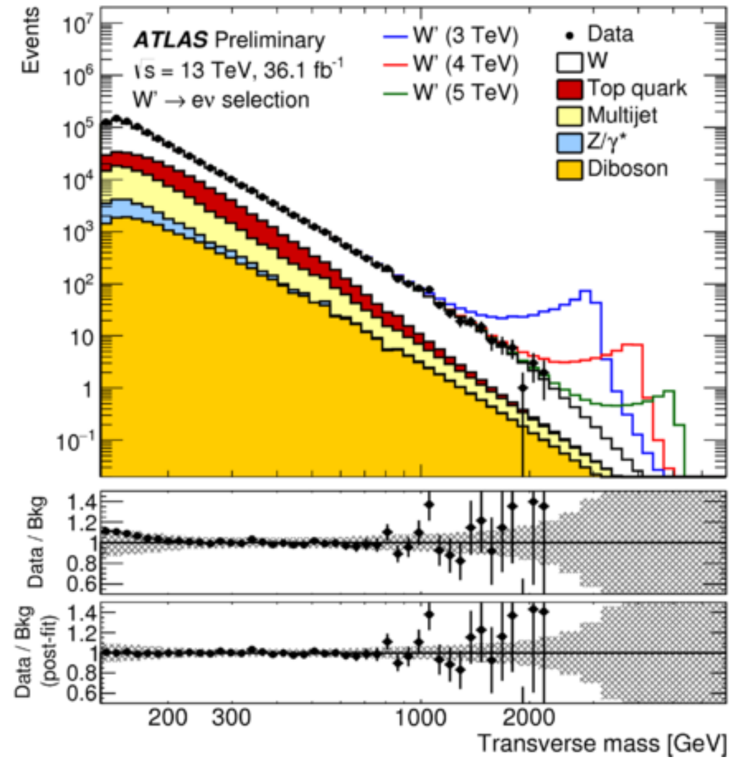
- **Dilepton final state:**
  - Z'_{SSM} excluded for $M_{Z'} > 4.5$ TeV
  - contact interactions scale $\Lambda > 23\text{-}40$ TeV

- **Photon + E_T^{miss} final state**
  - Upper limits on σxBR for a Z(νν)gamma resonance set for masses between 2-5 TeV.

Backup

Search of W' → e ν: event yield

- Tight ID electron $p_T >$ 65 GeV
- E_T^{miss} > 65 GeV, m_T > 130 GeV
- Bkg with "real" leptons estimated with MC
  - Largest from W Drell-Yan production
- Bkg from misidentified objet: data-driven
- Acc × ε = 81% (77%) @ $m_{W'}$ = 2 TeV (4 TeV)



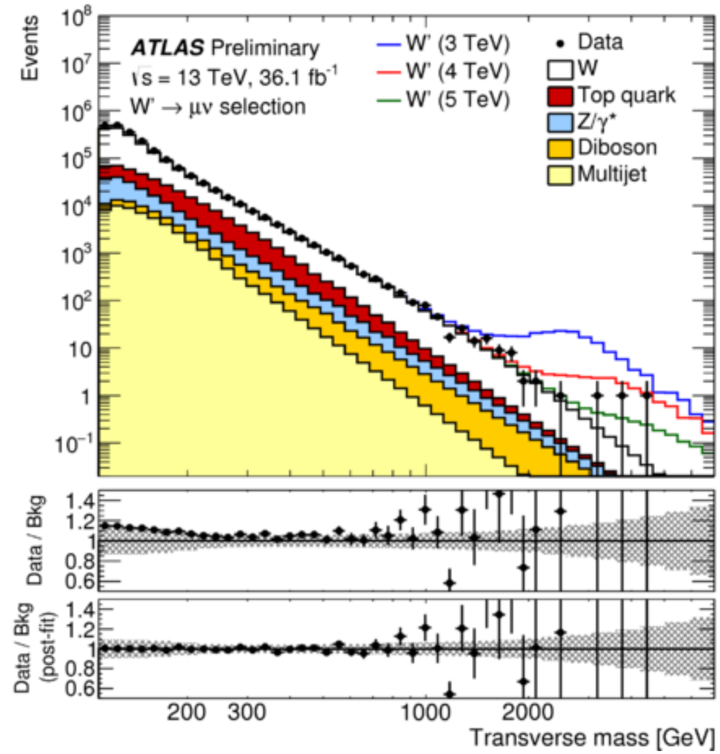
m_{ll} (TeV)	0.6-1	1-2	2-3	3-7
Obs	1931	246	4	0
Exp SM	1960±140	224±23	5.7±1.4	0.4±0.4
SM+ W' 2 TeV	2260± 160	3930 ±80	380±80	1.4±0.4

- Syst. Uncertainty for Bkg and Signal: 7% (115%) and 21% (10%) m_T = 2 TeV (4 TeV)

No significant excess is observed

most significant excess at $m_{W'}$ = 1.1 TeV: local (global) significance of 2.3 (0.6)

Search of W' → μ ν: event yield



- Tight ID muon $p_T >$ 55 GeV
- E_T^{miss} > 55 GeV, $m_T >$ 130 GeV
- Bkg with “real” leptons estimated with MC
  - Largest from W Drell-Yan production
- Bkg from misidentified objet: data-driven
- Acc × ε = 50% (46%) @ $m_{W'}$ = 2 TeV (4 TeV)

m_{ll} (TeV)	0.6-1	1-2	2-3	3-7
Obs	1392	177	3	3
Exp SM	1320±90	150±13	4.7±0.6	0.63±0.13
SM+ W’ 2 TeV	1740±100	1870±90	374±28	18±4

- Syst. Uncertainty for Bkg and Signal: 12% (21%) and 6% (8%) m_T = 2 TeV (4 TeV)

No significant excess is observed

most significant excess at $m_{W'}$ ~ 5 TeV: local (global) significance of 1.8 (0.1)

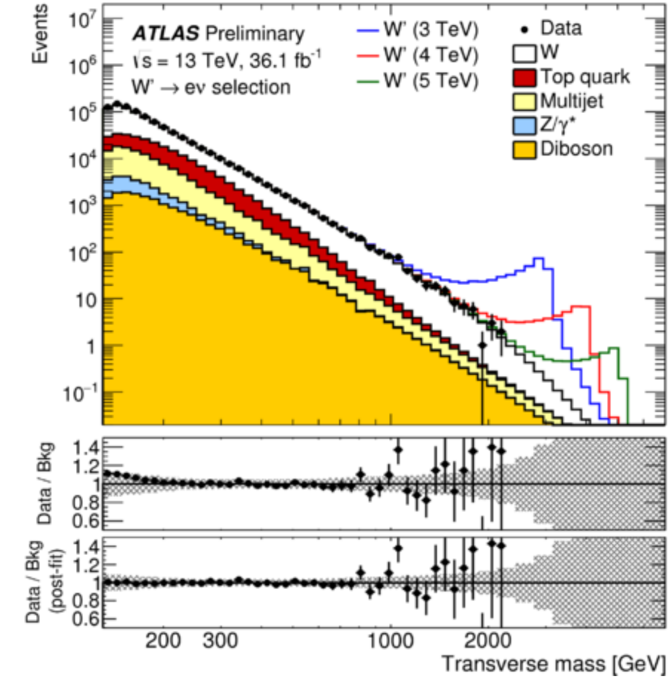
Search for new resonances decaying to a charged lepton and a neutrino

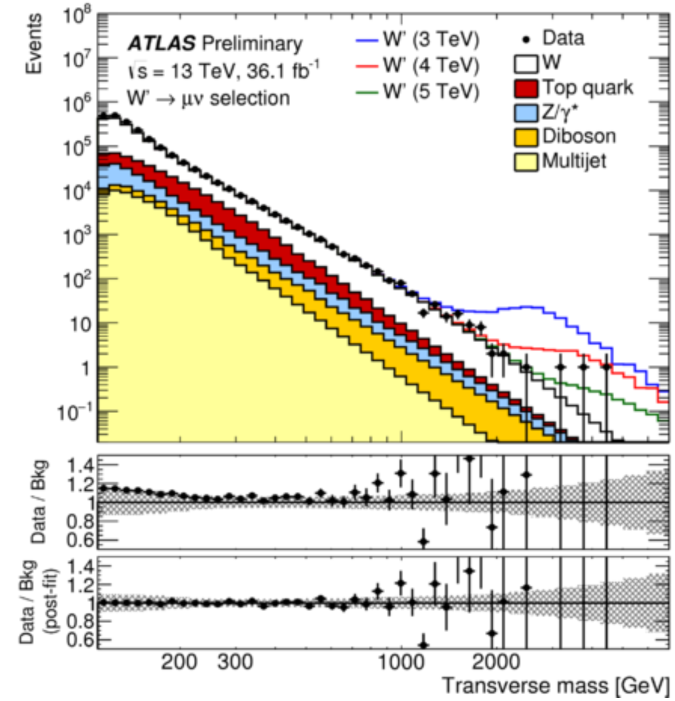
- BSM models introduce new heavy charged Spin-1 gauge-bosons W’
- W’ →lν experimental signature

- Benchmark model: Sequential Standard Model (SSM)
  - Same fermion coupling as the SM W
  - no coupling to W,Z
  - Interference between W and W’ neglected

- Analysis Strategy:
  - exactly one high- p_T lepton and large missing transverse energy
  - Compare transverse mass distribution to SM predictions

$$m_T = \sqrt{2 p_T E_T^{miss} \cdot (1 - \cos \Delta\phi)}$$





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