Search for Exotics (and Higgs) Physics beyond the Standard Model with the ATLAS Detector

Kenji Hamano (University of Victoria)
on behalf of the ATLAS Collaboration

University of Victoria

Plan of this talk

- LHC and ATLAS detector.
- Signature based search strategy.
- Dileptons/Multi-leptons signature
- Lepton(s) + jet(s) signature
- Dijets/Multi-jets signature
- Top quarks signature
- Vector bosons signature
- Other signatures
- Conclusions.

Other topics

- BSM Higgs:
  - "Beyond the Standard Model Higgs Physics Using the ATLAS Detector" (Guillermo Hamity).
- Dark Matter:
  - "Searches for Dark Matter with the ATLAS Detector" (Ketevi Assamagan).
- Supersymmetry (SUSY):
  - "SUSY Searches in the ATLAS Detector" (Lawrence Lee JR).

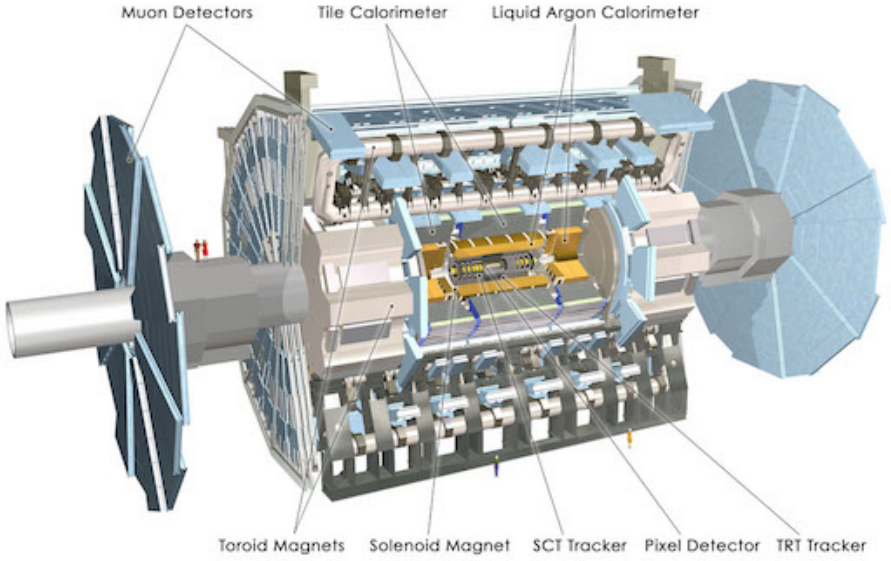
LHC

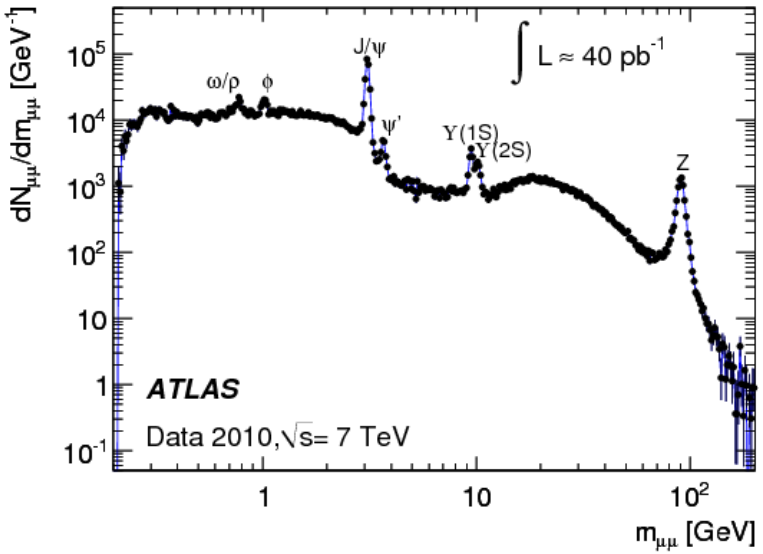
- Large Hadron Collider (LHC)
  - Collide two protons (pp-collision).
  - Center of mass energy:
    - Run1: 2011, 7 TeV, ~5 fb^{-1}; 2012, 8 TeV, ~20 fb^{-1}
    - Run2 (2015 ~): 13 TeV or 14 TeV

- Only recent results with 8TeV data are presented in this talk.
- Selection is based on my preference.

ATLAS Detector

- From inside to outside
  - Inner tracker: reconstruct charged tracks.
  - Calorimeter: detect particle energies.
    - Electromagnetic calorimeter: electros and photons
    - Hadronic calorimeter: charged and neutral hadrons.
  - Muon detector: detect muons.



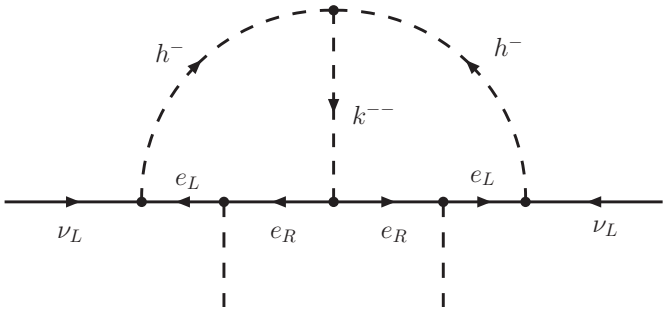


Need for BSM physics

- There are many problems with the Standard Model (SM).
  - Hierarchy Problem
  - Neutrino mass term
  - Dark matter
  - Gravity
  - …
- Possible solution is a Beyond the Standard Model (BSM) physics?
  - Supersymmetry?
  - Extra dimensions?
  - Higher symmetry/Unified model?
  - Seesaw mechanism?
  - …

Signature based search (1)

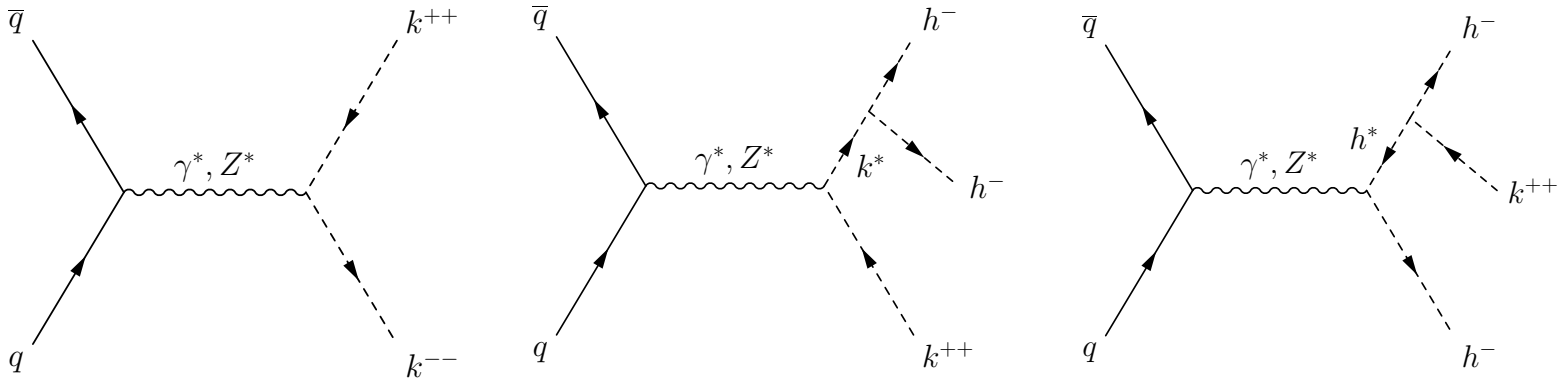
- To search for a new physics, experimentalists look for particles in final states produced by the new physics.
- An example: Zee-Babu model
  - Physics point of view:
    - A model to generate small neutrino mass with a two loop diagram.
    - Introduce two new scalar particles: h^+, k^{++}
    - Lepton flavor violation is also introduced.
  - Experimental point of view:
    - Look for the new particles.
    - How they are produced in pp-collisions?
    - How they decay?



ArXiv:0711.0483

Signature based search (2)

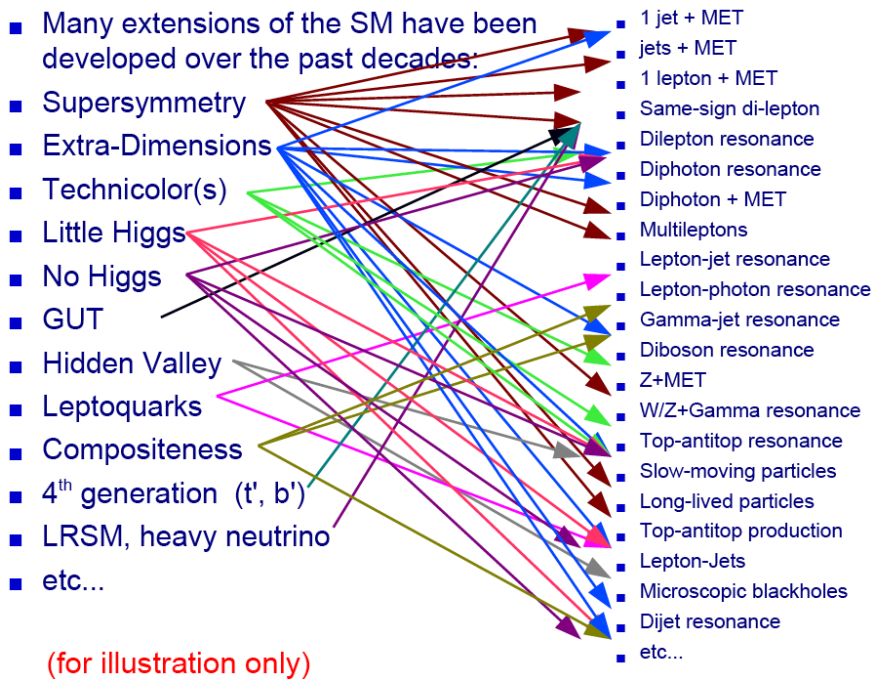
- Production



  - The new particle k is either pair produced or produced along with h.
- Decay
  - $k^{++} \rightarrow e^+e^+, e^+\mu^+, \mu^+\mu^+$, etc.
- Look for same-sign lepton pair(s) in final states.

Signature vs Physics models

- Many new physics models can be searched by same signature.
  - (Example) Same-sign diletpon signature:
    - SUSY, Universal Extra Dimensions, Left-right symmetric models, neutrino mass models, Doubly charged Higgs, Vector-like quarks.
- A new model can be probed by many signatures.
  - (Example) Type III seesaw model:
    - 2 leptons + 2 jets
    - 3 leptons
    - 4 leptons



Dileptons/Multi-leptons

More details on Blue analysis

- Dileptons
  - Opposite-sign same flavor
    - High mass resonance search (arXiv:1405.4123, PRD90,052005(2014))
      - Heavy gauge boson Z', Excited boson Z*, Spin-2 graviton, Quantum Black Holes, Technicolor
    - Non-resonant dileptons (arXiv:1407.2410, EPJC)
      - Contact Interaction (llqq), Large Extra Dimensions
  - Opposite-sign mixed flavor
    - Lepton Flavor Violation: Z → e μ (arXiv:1408.5774, PRD90,072010(2014))
  - Same-sign dileptons (arXiv:1412.0237, JHEP)
    - SUSY, Extra dimension, Neutrino mass models, Doubly-charged Higgs
- 3 or more leptons (arXiv:1411.2921)
  - SUSY, Neutrino mass models, Doubly-charged Higgs

Dileptons/Multi-leptons (2)

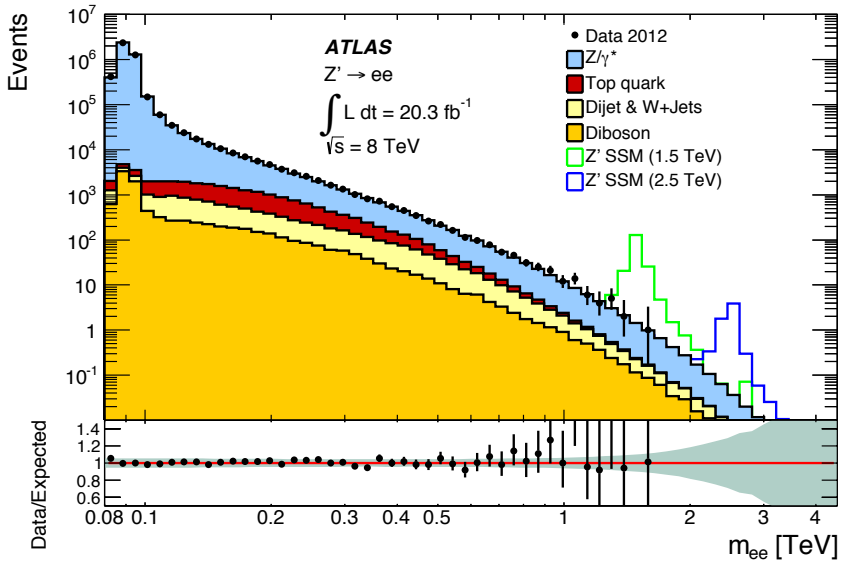
- Diphoton resonance (arXiv:1210.8389, NJP15,242(2013))
  - KK Graviton (Extra dimensions)

Dilepton resonance (arXiv:1405.4123, PRD90,052005(2014))

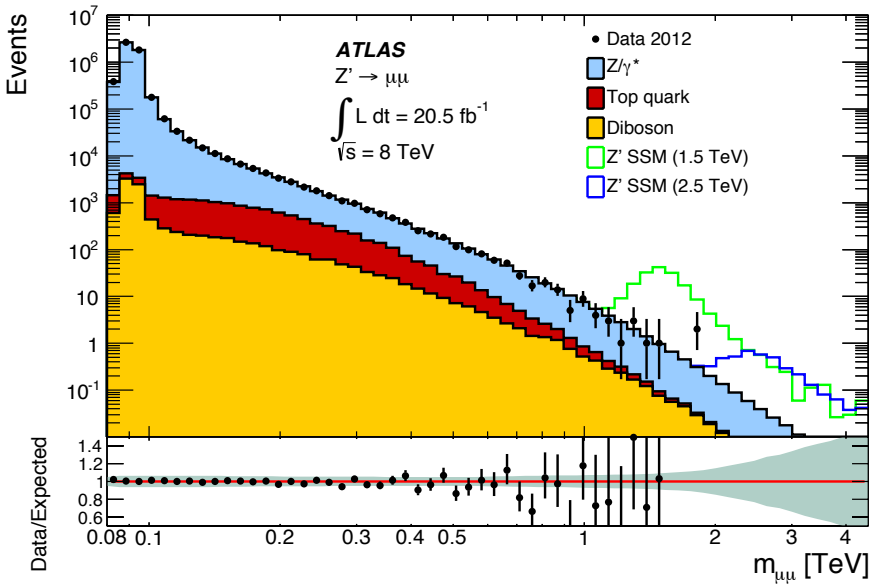
- Z′ and Z* → l^+l^-

- Two isolated opposite-charge same-flavor leptons.
- Electron: leding E_T>40GeV, subleading E_T>30GeV
- Muon p_T>25GeV

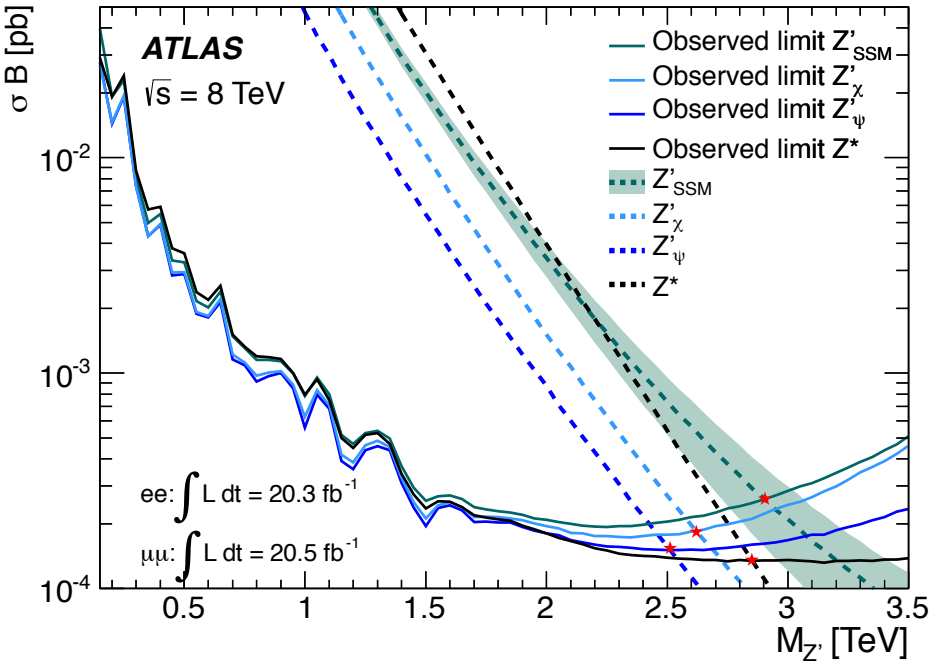
ee mass



μμ mass



Dilepton Resonane (2)



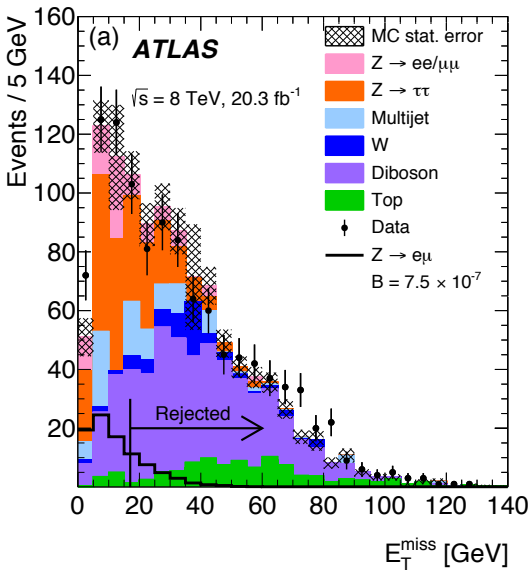
Mass limits

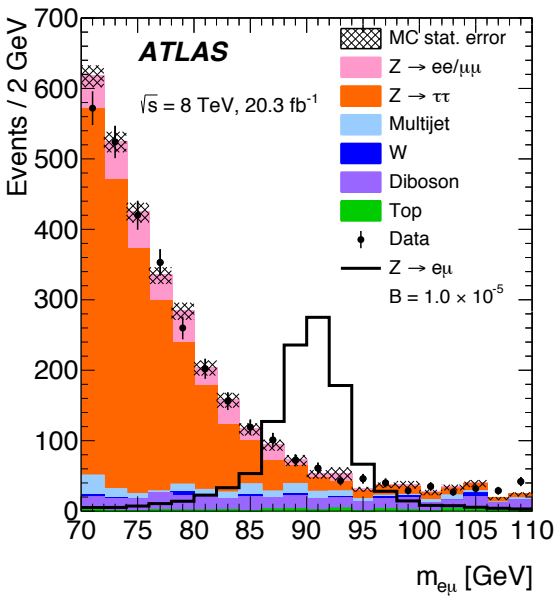
Model	Width [%]	Observed Limit [TeV]	Expected Limit [TeV]
Z'_{SSM}	3.0	2.90	2.87
Z'_{χ}	1.2	2.62	2.60
Z'_{ψ}	0.5	2.51	2.46
Z^*	3.4	2.85	2.82

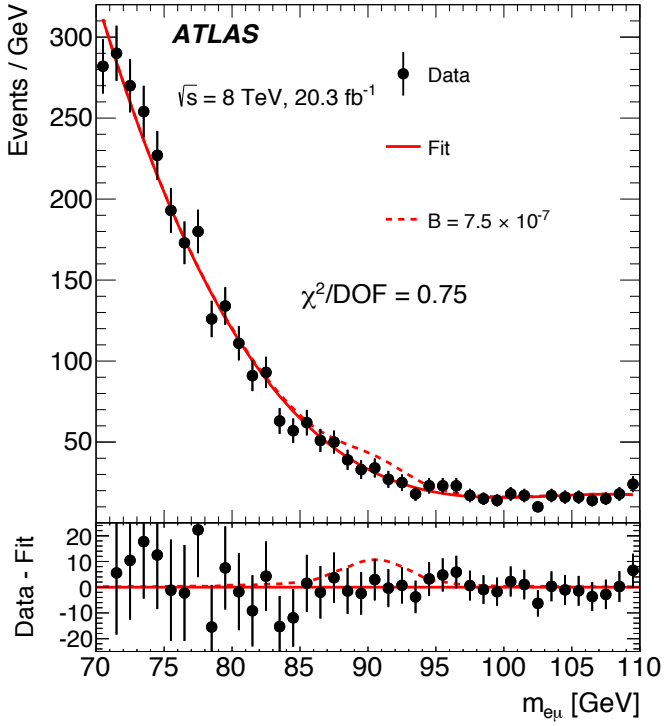
LFV Z → e μ (arXiv:1408.5774, PRD90,072010(2014))

- Lepton Flavor Violation (LFV) decay Z→eμ.

Isolated e with E_T>25GeV
Isolated μ with p_T>25GeV
Missing E_T<15GeV



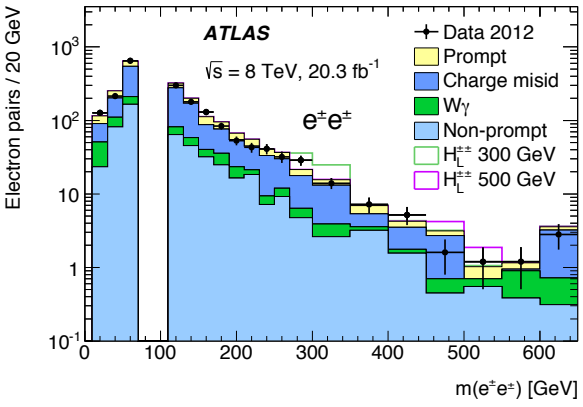


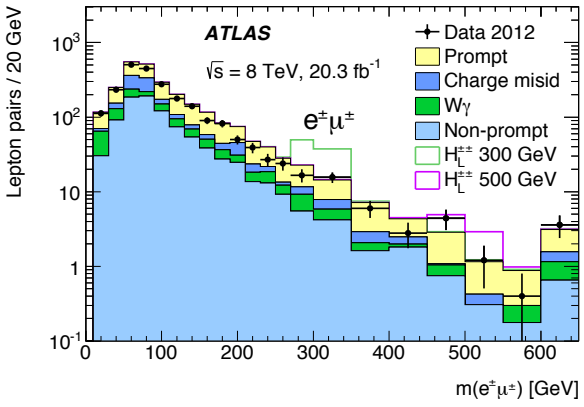


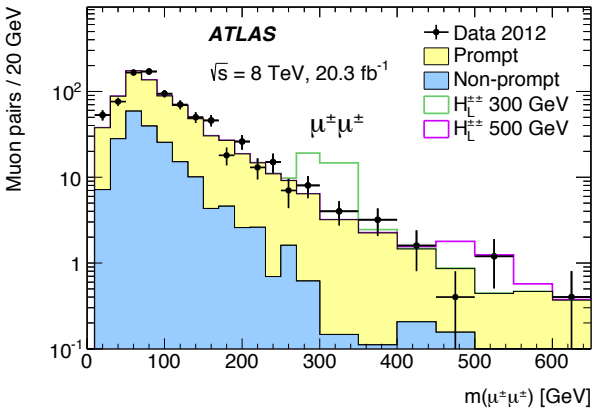
B(Z → eμ) < 7.5*10^{-7}

Same-sign dilepton (arXiv:1412.0237, JHEP)

- Two isolated same-sign leptons:
  - Electron leading pT>12GeV, others pT>6GeV
  - Muon leading pT>18GeV, others pT>12GeV
- Z-veto

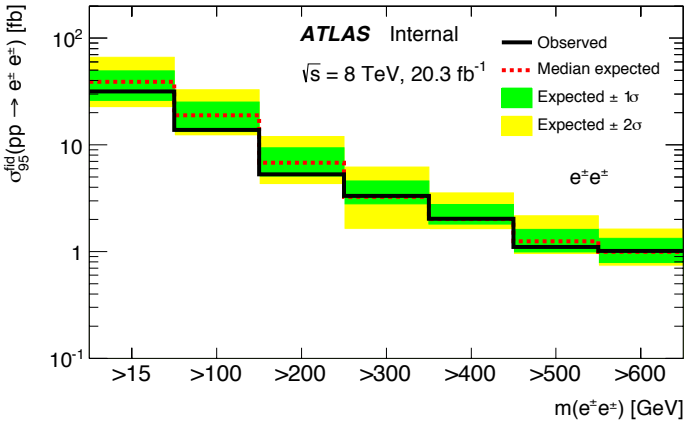


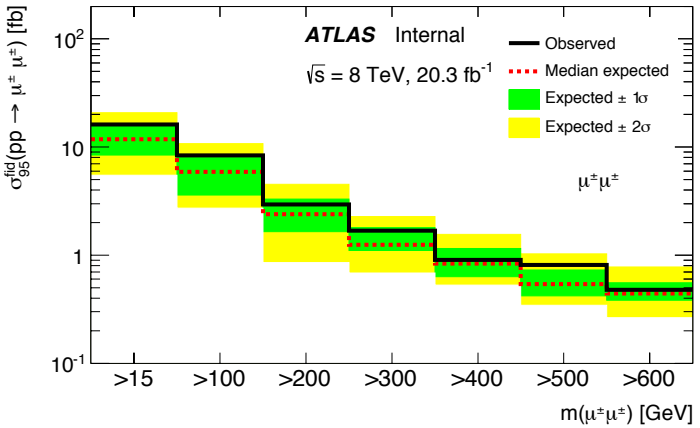


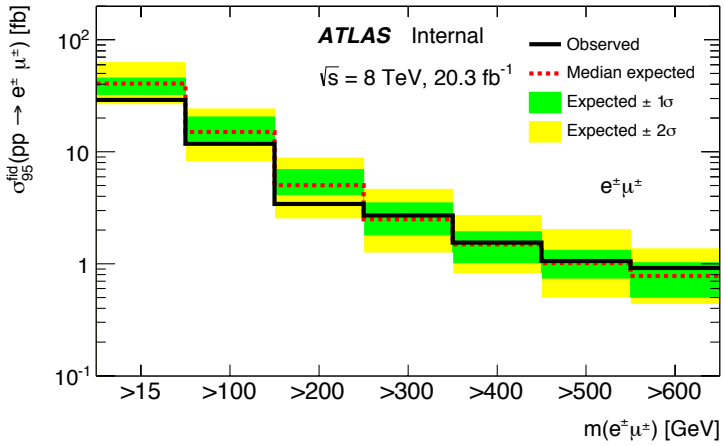


Same-sign dilepton (2)

- Fiducial cross section limits







Doubly-charged Higgs mass limits:

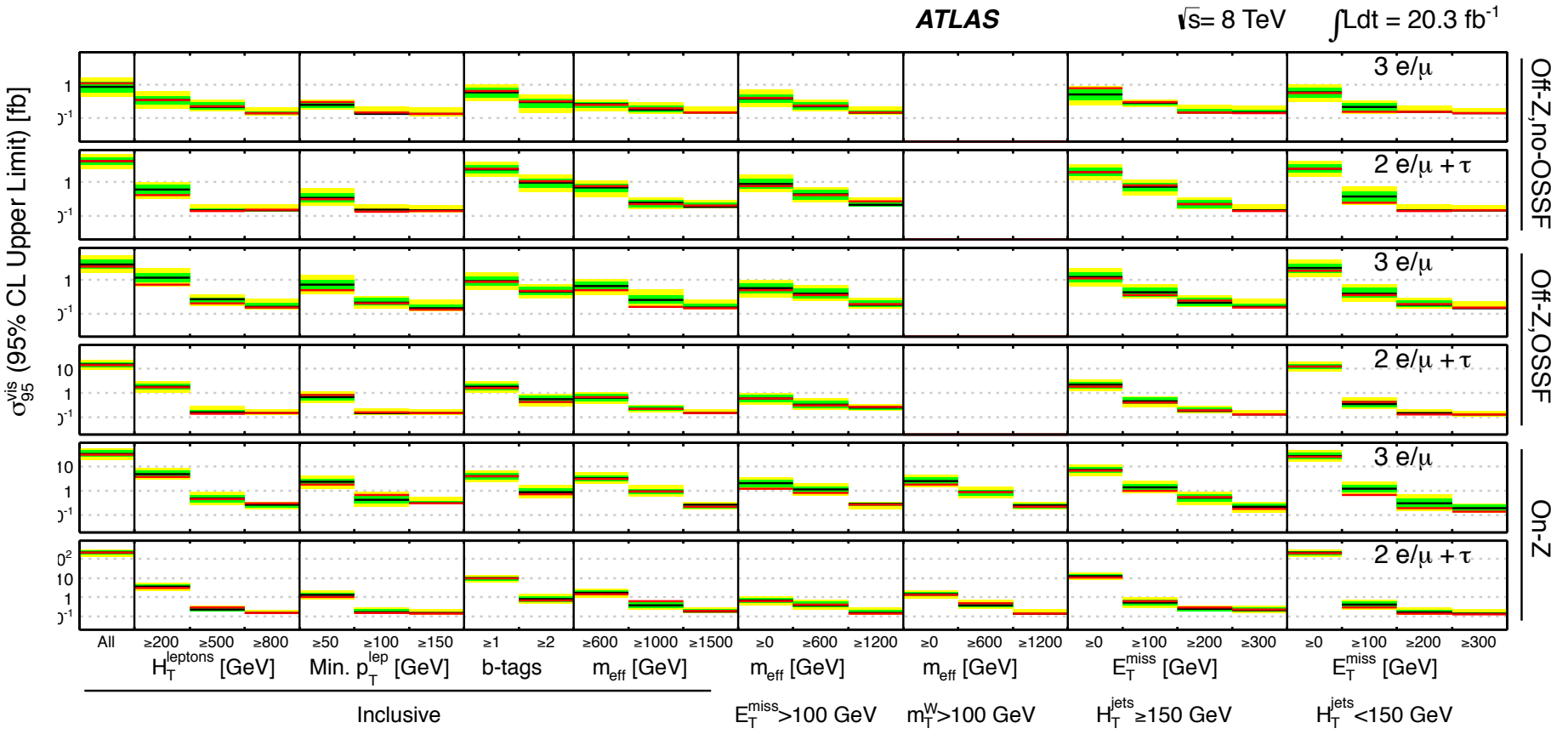
	95% CL lower limit [GeV]					
	$e^{\pm}e^{\pm}$		$e^{\pm}\mu^{\pm}$		$\mu^{\pm}\mu^{\pm}$	
Signal	Expected	Observed	Expected	Observed	Expected	Observed
$H_{\mathrm{L}}^{\pm\pm}$	553 ± 30	551	487 ± 41	468	543 ± 40	516
$H_{\mathrm{R}}^{\pm\pm}$	425 ± 30	374	396 ± 34	402	435 ± 33	438

3 or more charged leptons (arXiv:1411.2921)

- Event selection
  - 3 or more isolated leptons
  - Leading lepton: electron or muon with p_T>26GeV
  - Second lepton: electron or muon with p_T>15GeV
  - Third lepton: electron or muon with p_T>15GeV or tau with p_T>20GeV
- This is a generic search and include multiple Signal Regions depending on
  - On-Z, Off-Z
  - MET = missing transverse energy
  - H_T = scalar sum of p_T
  - m_{eff} = scalar sum of missing E_T, jet H_T and lepton p_T

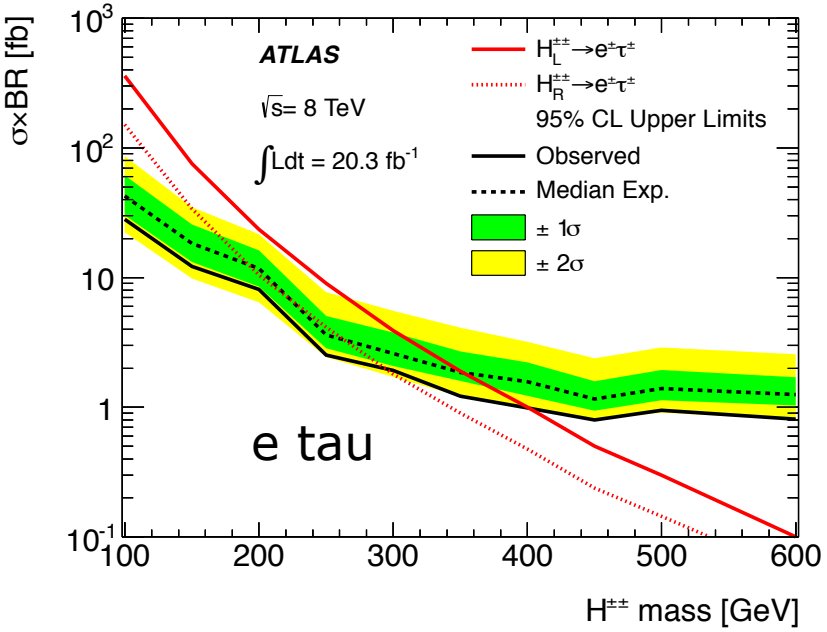
3 or more leptons (2)

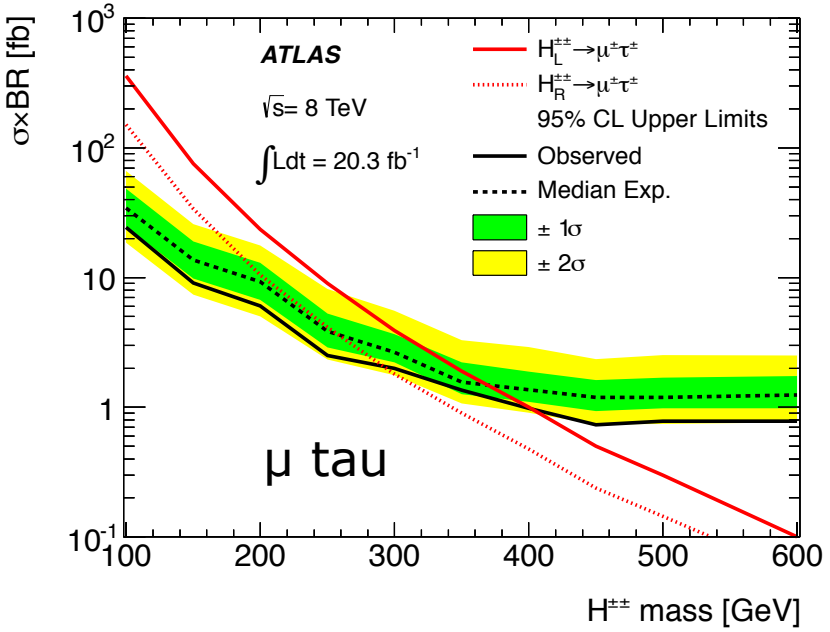
- Cross section limits in various signal regions:



3 or more leptons (3)

- Doubly-charged Higgs in tau decay mode:





Mass limit : $H_L^{++} > 400$ GeV

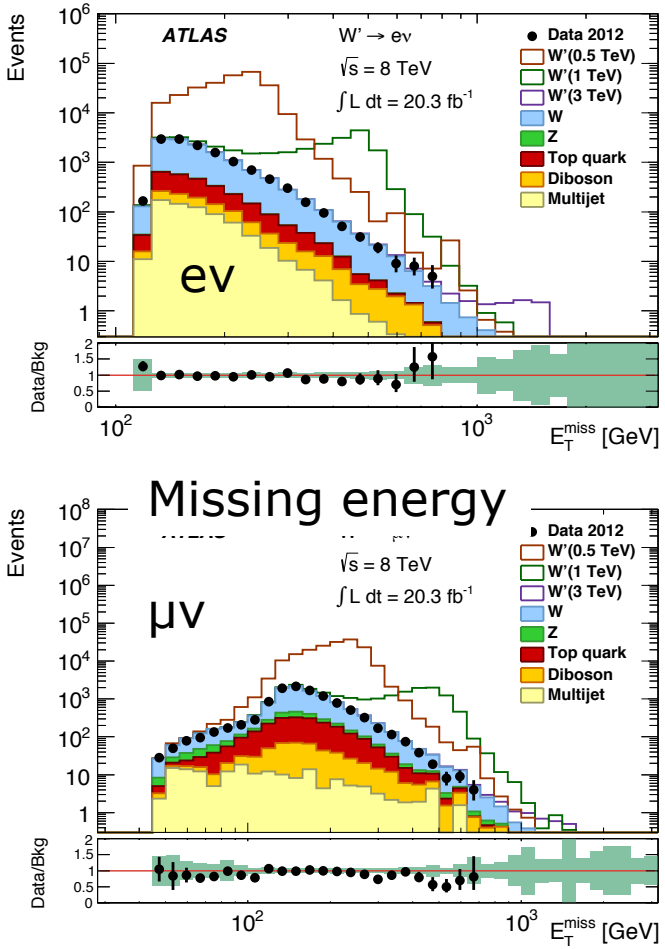
Lepton + X

More details on Blue analysis

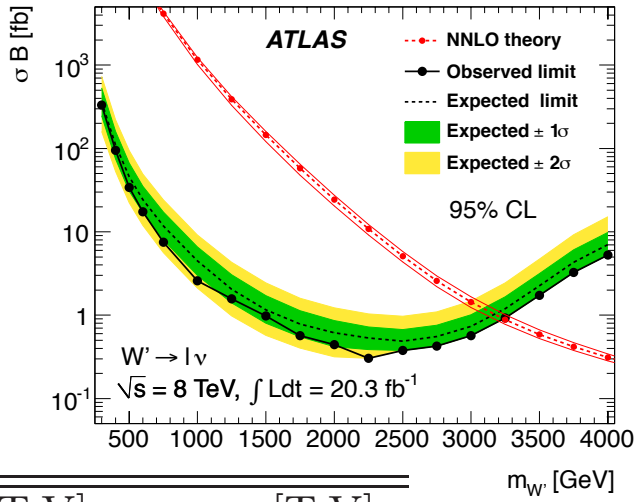
- Lepton + X general search (ATLAS-CONF-2014-006)
  - Events with isolated electrons, photons, muons, jets.
- Lepton + MET (neutrino) (arXiv:1407.7494, JHEP09(2014)037)
  - Heavy gauge boson W', Exited boson W*.
- Lepton + jet
  - Scalar Leptoquarks:
    - 1st generation (arXiv:1112.4828, PLB709(2012)158-176)
    - 2nd generation (arXiv:1203.3172, EPJ C72(2012)2151)
    - 3rd generation (arXiv:1303.0526, JHEP06(2013)033)
  - Microscopic Black Holes (arXiv:1405.4254, JHEP08(2014)103)
  - Quantum Black Holes (arXiv:1311.2006, PRL112,091804(2014))
  - Excited Leptons (arXiv:1308.1364, NJP15(2013)093011)

L + Missing energy (arXiv:1407.7494, JHEP09(2014)037)

- W’ and W* → l + ν



- One isolated electron with E_T>125GeV + MET>125GeV
- Or one muon with p_T>45GeV + MET>45GeV
- No additional lepton with p_T>20GeV



Mass limits

	$m_{W'}$ [TeV]		m_{W^*} [TeV]	
Decay	Exp.	Obs.	Exp.	Obs.
$e\nu$	3.13	3.13	3.08	3.08
$\mu\nu$	2.97	2.97	2.83	2.83
Both	3.17	3.24	3.12	3.21

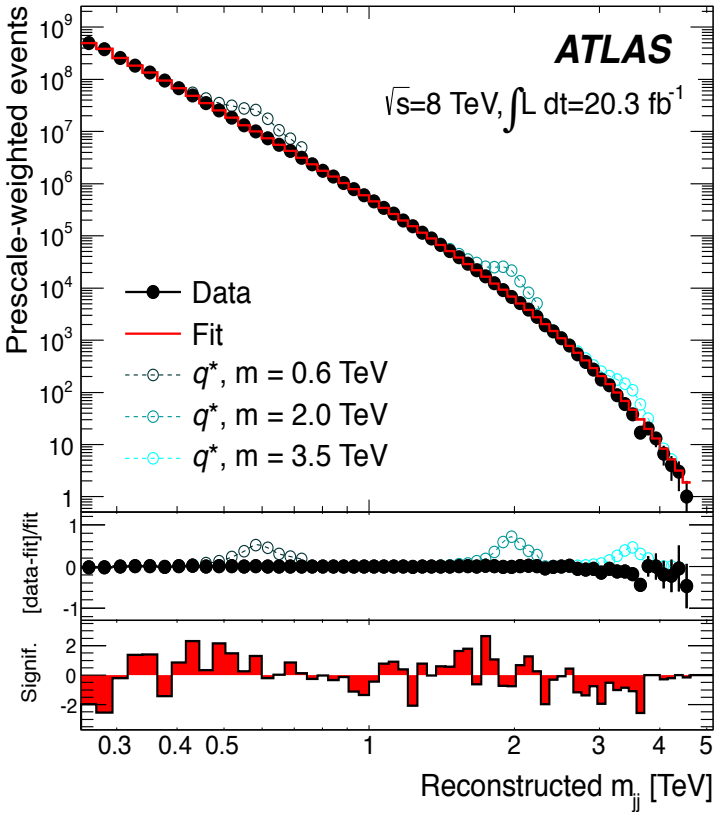
Dijets/Multi jets

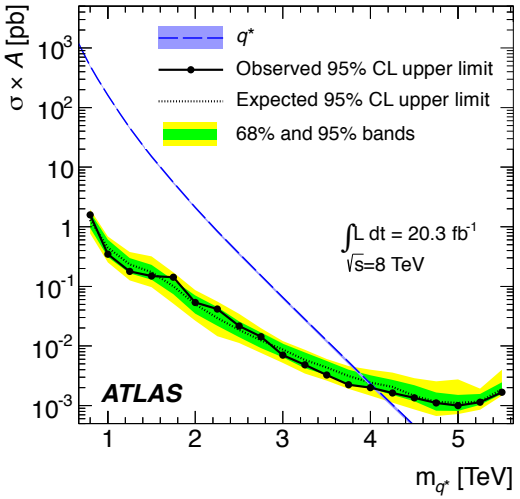
More details on Blue analysis

- Dijet resonance (arXiv:1407.1376, PRD)
  - Excited quarks, Color octet scalars, Heavy and excited W bosons, Quantum black holes,
- Multi jets
  - Resonant Higgs Pair Production (ATLAS-CONF-2014-005)
    - X → HH → bbbb
    - Two Higgs doublet models, KK graviton
- Photon + jet (arXiv:1309.3230, PLB728,562(2013))
  - Quantum Black Holes, Excited quarks
- Dark matter search:
  - "Searches for Dark Matter with the ATLAS Detector" (Ketevi Assamagan).

Dijet resonance (arXiv:1407.1376, PRD)

- Two well measured jets with p_T>50GeV
- m_{jj} > 250GeV



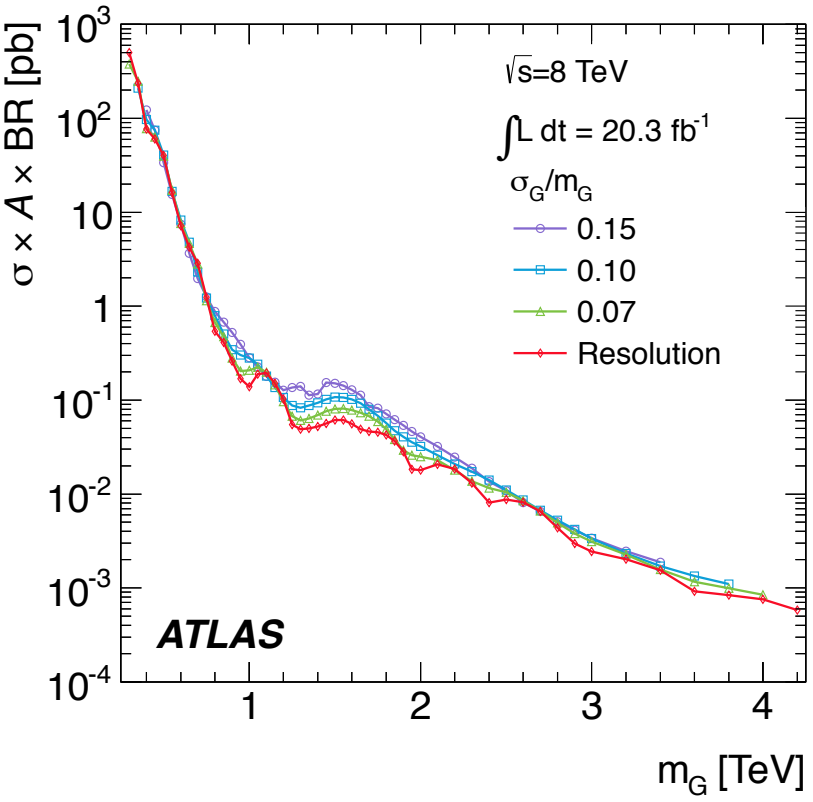


Mass limits

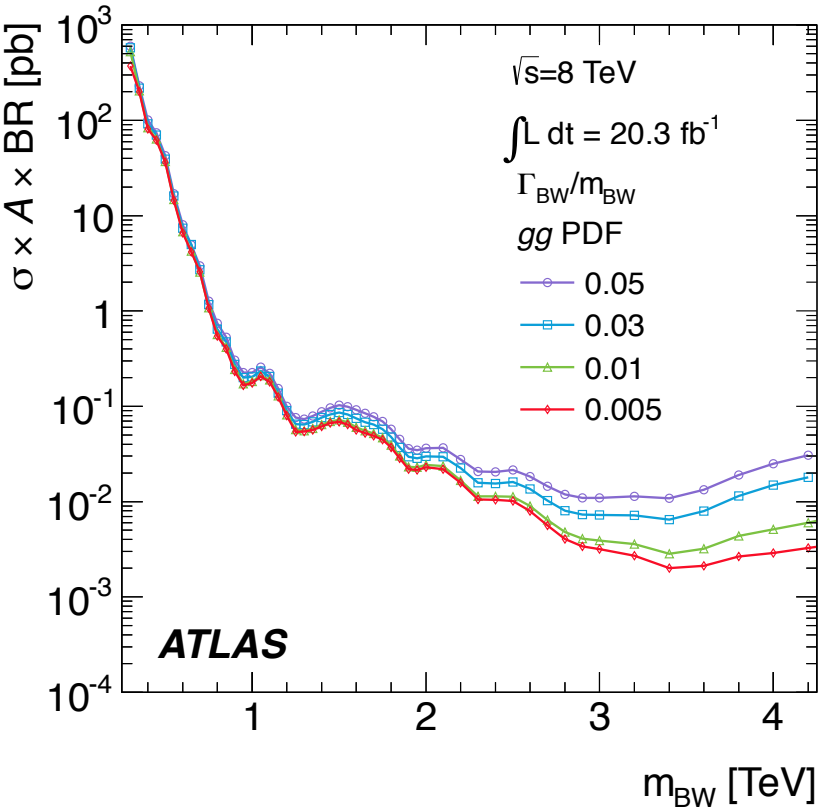
Model and Final State	95% CL Limits [TeV] Expected	Observed
$q^* \to qg$	3.99	4.09
$s8 \to gg$	2.83	2.72
$W' \to q\bar{q}'$	2.51	2.45
Leptophobic $W^* \to q\bar{q}'$	1.93	1.75
Leptophilic $W^* \to q\bar{q}'$	1.67	1.66
QBH black holes (q and g decays only)	5.82	5.82
BLACKMAX black holes (all decays)	5.75	5.75

Dijet resonance (2)

Gaussian resonance limits



B-W narrow resonance limits



Top quark final states

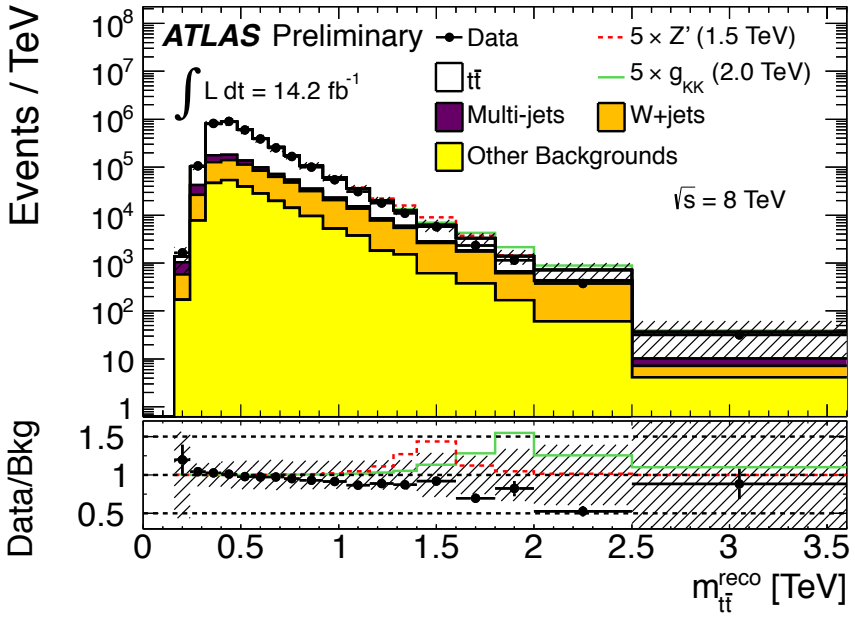
More details on Blue analysis

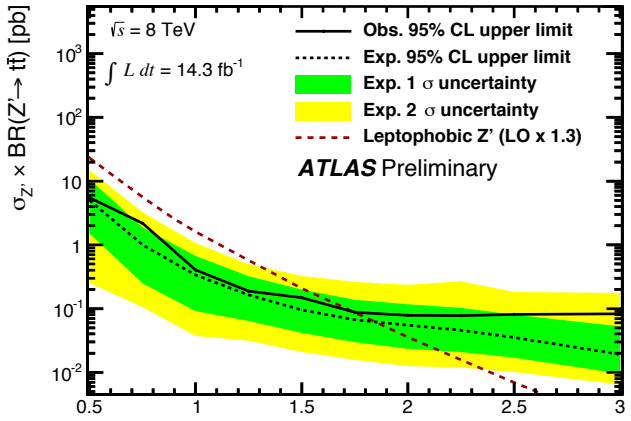
- ttbar resonance (ATLAS-CONF-2013-052)
  - Leptophobic topcolor Z', Kaluza-Klein gluons
- Same-sign top etc. (ATLAS-CONF-2013-051)
  - 4^{th} generation down-type chiral quarks (b'), Vector Like Quarks, Composite top partners ($T_{5/3}$), Same-sign top pairs, Contact interactions.
- Vector Like Quarks (VLQ)
  - Little Higgs, Composite Higgs.
  - VLQ → H + t (ATLAS-CONF-2013-018)
  - VLQ → W + b (ATLAS-CONF-2013-060)
  - VLQ → Z + t/b (arXiv:1409.5500, JHEP)
- W' → t b:
  - l + jets final states (arXiv:1410.4103, PLB)
  - qqbb final states (arXiv:1408.0889, EPJC)

ttbar resonance (ATLAS-CONF-2013-052)

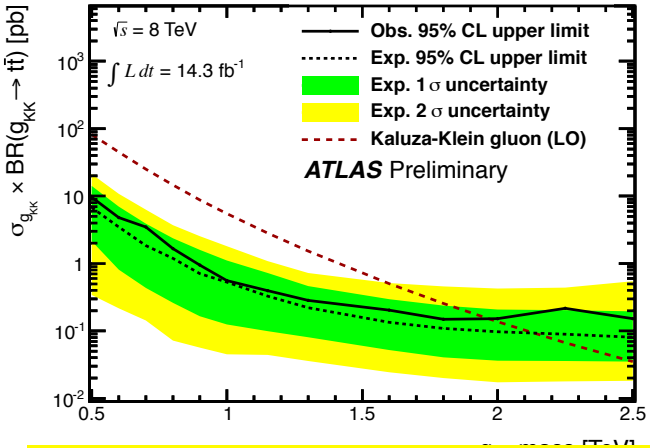
- ttbar → b l + bbar l

- Isolated lepton (p_T>25GeV) + well defined b-jet
- e+jets: MET>30GeV, m_T>30GeV
- μ+jets: MET>20GeV, MET+m_T>60GeV
- Angular distance between l and j <1.5





Topcolor Z' mass < 1.9 TeV

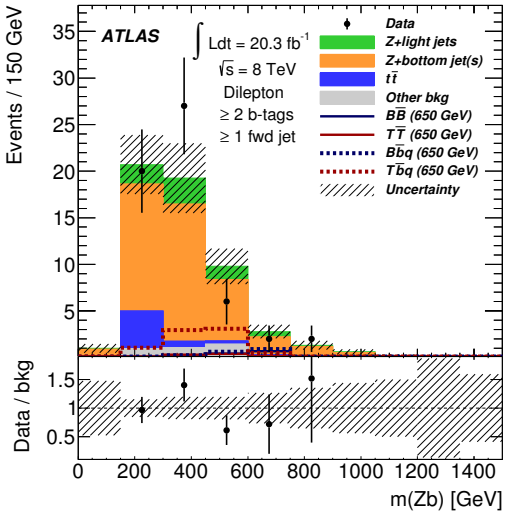


KK gluon mass < 2.1 TeV

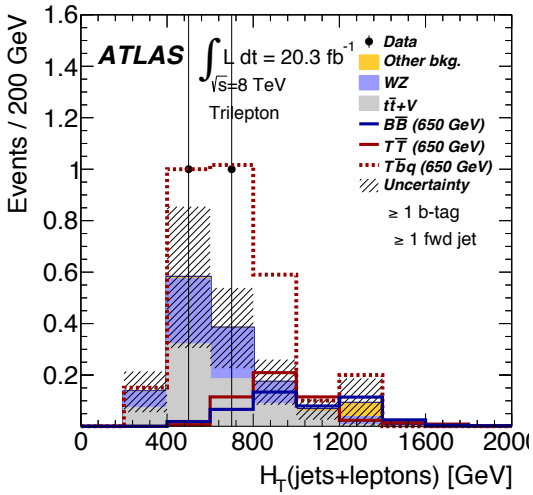
VLQ → Zt/b (arXiv:1409.5500, JHEP)

- T → Zt → *l*l*b*l*ν*, B → Zb → *l*l*b*

- Isolated electrons and muons
- Well defined b-jet
- Z candidate: opposite-charge, same –flavor leptons with
  |m(ll) – m(Z)| < 10GeV



Event selection			
Z boson candidate preselection ≥ 2 central jets $p_{\mathrm{T}}(Z) \geq 150$ GeV			
Dilepton channel		**Trilepton channel**	
$= 2$ leptons		≥ 3 leptons	
≥ 2 b-tagged jets		≥ 1 b-tagged jet	
Pair production	**Single production**	**Pair production**	**Single production**
$H_{\mathrm{T}}(\mathrm{jets}) \geq 600$ GeV	≥ 1 fwd. jet	–	≥ 1 fwd. jet
Final discriminant			
$m(Zb)$		$H_{\mathrm{T}}(\mathrm{jets+leptons})$	

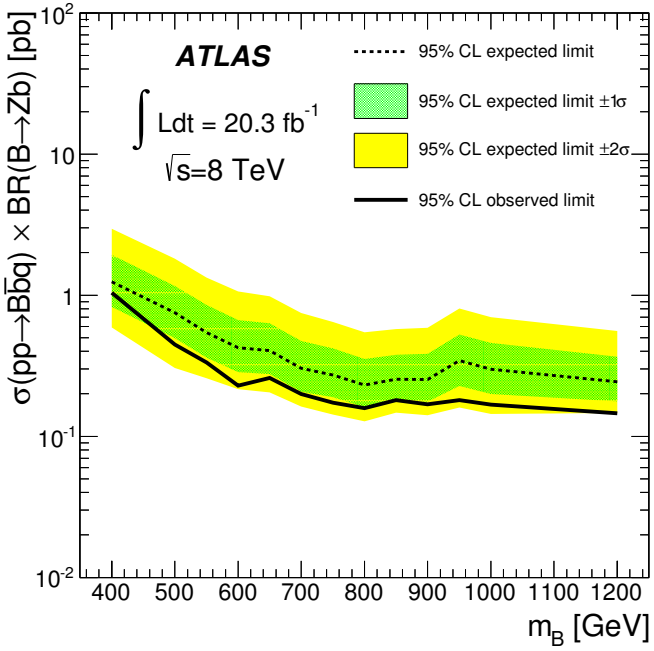


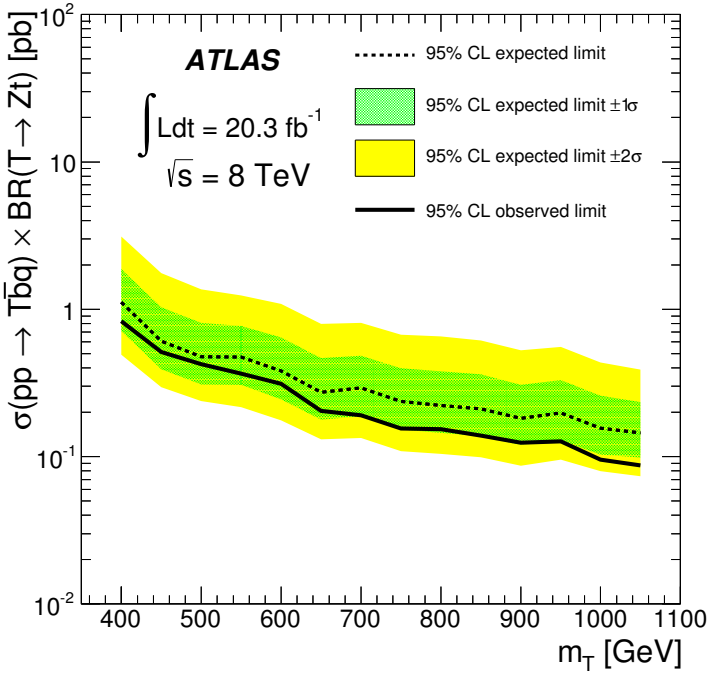
VLQ → Zt/b (2)

Pair production mass limits:

	Singlet mass limit [GeV]			Doublet mass limit [GeV]		
Hypothesis	Dilepton	Trilepton	Comb.	Dilepton	Trilepton	Comb.
$B\bar{B}$	690 (665)	610 (610)	685 (670)	765 (750)	540 (530)	755 (755)
$T\bar{T}$	620 (585)	620 (620)	655 (625)	705 (665)	700 (700)	735 (720)

Single production cross section limits:



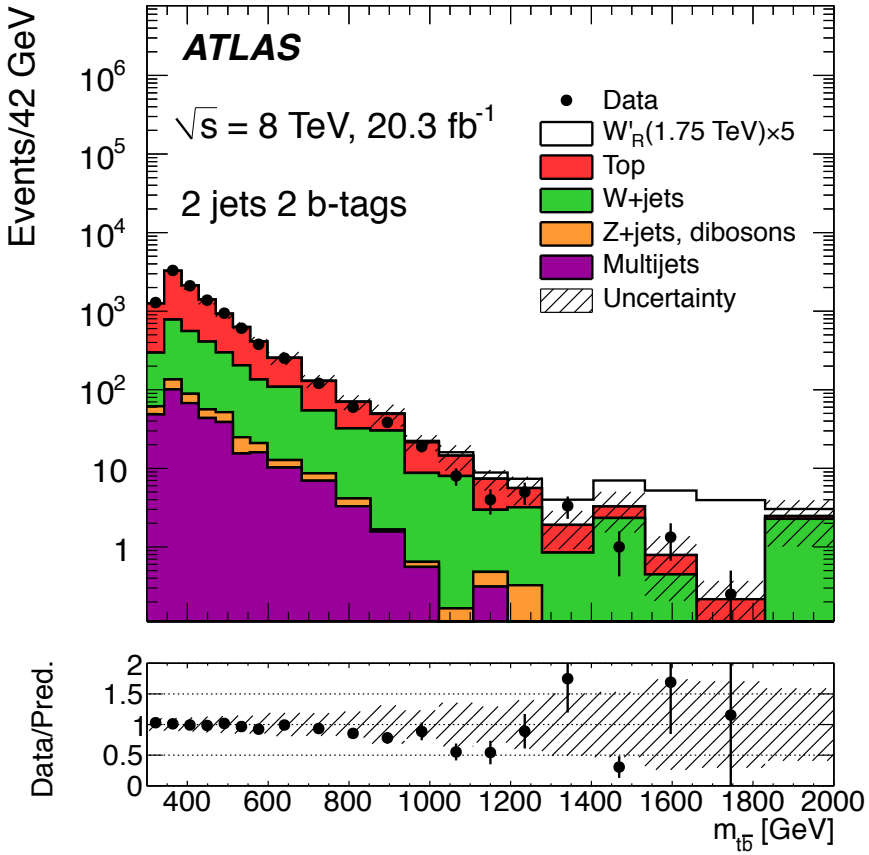


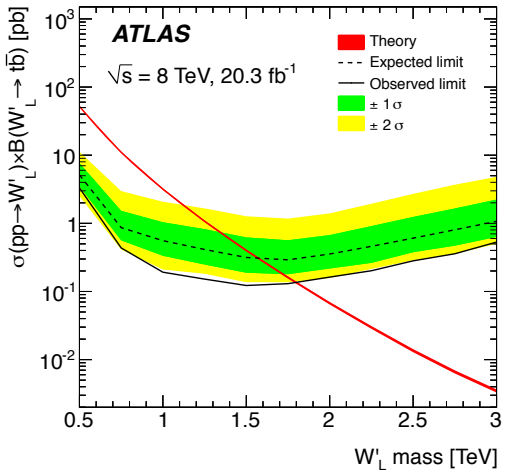
W’ → tb (L+jets) (arXiv:1410.4103, PLB)

- Isolated leptons with p_T>30GeV
- Well measured jets with p_T>25GeV

- W’ → t bbar → W(lv)b bbar

- 1 lepton + 2 b-jets (+ jet)
- MET>35GeV
- m_T(W)+MET>70GeV





W_L' > 1.70 TeV

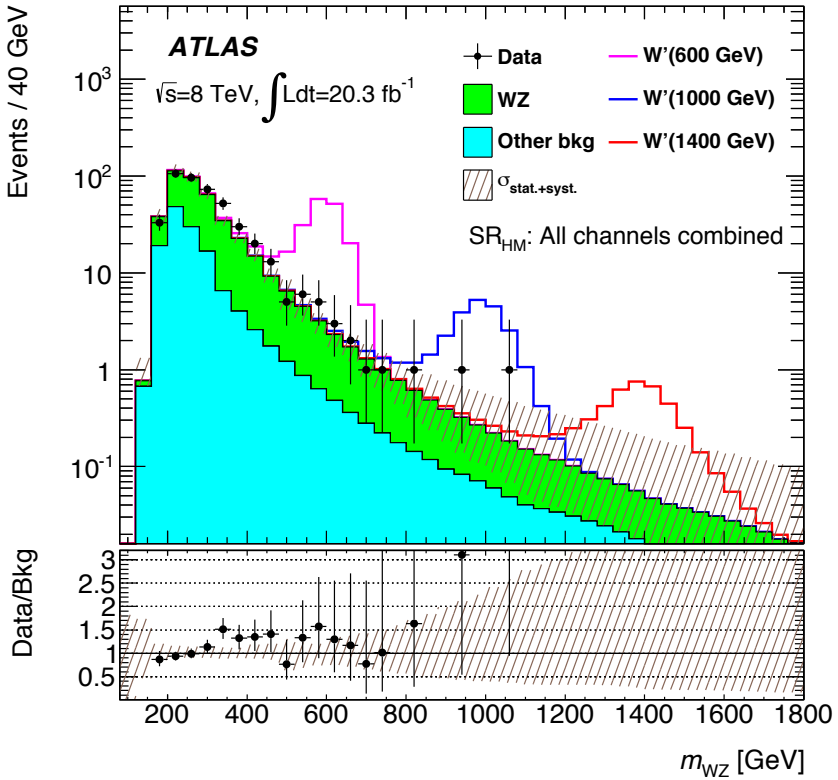
Vector boson final states

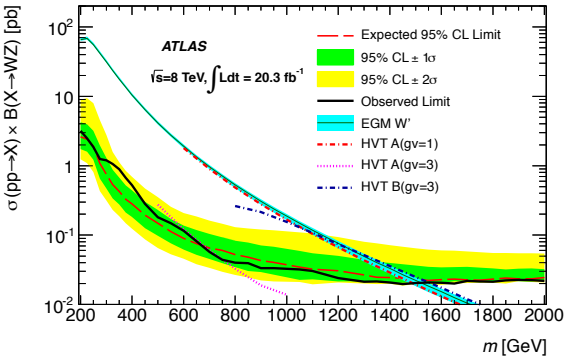
More details on Blue analysis

- Diboson resonances (V = Z or W)
  - GUT, Little Higgs, Technicolor, Composite Higgs, Extra dimensions.
  - WZ → lνll (full leptonic) (arXiv:1406.4456, PLB737,223(2014))
  - ZZ/ZW → lljj (arXiv:1409.6190, EPJC)
  - Wγ and Zγ (arXiv:1407.8150, PLB738,428(2014))
  - WH/ZH → Wjj/Zjj (ATLAS-CONF-2013-074)
- Heavy lepton search
  - Heavy neutrino → Wν (ATLAS-CONF-2012-139)
    - Left-right symmetric model
  - Heavy lepton → Z*l* (ATLAS-CONF-2013-019)
    - Type III seesaw model

WZ → lνll (full leptonic) (arXiv:1406.4456, PLB737,223(2014))

- Exactly 3 isolated leptons with pT>25GeV
- MET>25GeV
- Z candidate: opposite-charge same-flavor leptons with |m(ll) – m(Z)| < 20GeV



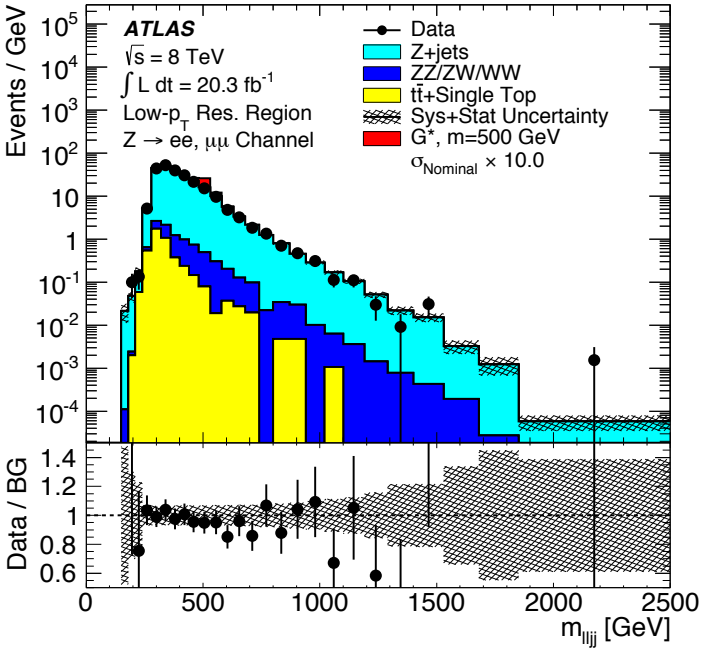


Extended Gauge Model W' mass limits

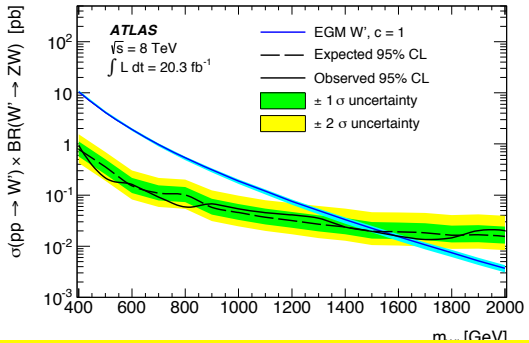
	Excluded EGM W' lower mass [TeV]				
	$evee$	μvee	$ev\mu\mu$	$\mu v\mu\mu$	combined
Expected	1.21	1.16	1.17	1.16	1.49
Observed	1.20	1.19	1.06	1.17	1.52

ZZ/ZW→llqq (arXiv:1409.6190, EPJC)

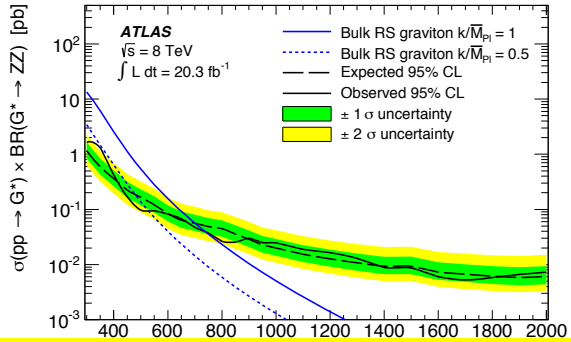
- Exactly two isolated oppsite-charge, same-flavor leptons with
  66GeV < |m(ll) – m(Z)| < 116GeV
- qq side: two well measured jets or one large-R jet. Mass agrees with Z or W.



- Extended Gauge Model W' → WZ
- KK Graviton G* → ZZ



EGM W' mass > 1590 GeV



Bulk RS G* mass > 740 GeV

Other Signatures

More details on Blue analysis

- Exotic charges
  - Highly ionizing particles (arXiv:1207.6411, PRL109(2012)261803)
    - Magnetic monopoles
- Long Lived Particles (LLP)
  - LLP decays away from the pp interaction point.
  - Look for displaced decay point (vertex).
  - Special trigger is required.
  - Displaced lepton-jets (LJ):
    - H → dark photon (arXiv:1409.0746, JHEP)
  - Displaced jets:
    - Heavy scalar → Hidden Valley LLP pair (ATLAS-CONF-2014-041)
- BSM Higgs specific searches:
  - "Beyond the Standard Model Higgs Physics Using the ATLAS Detector" (Guillermo Hamity).

Other Signatures

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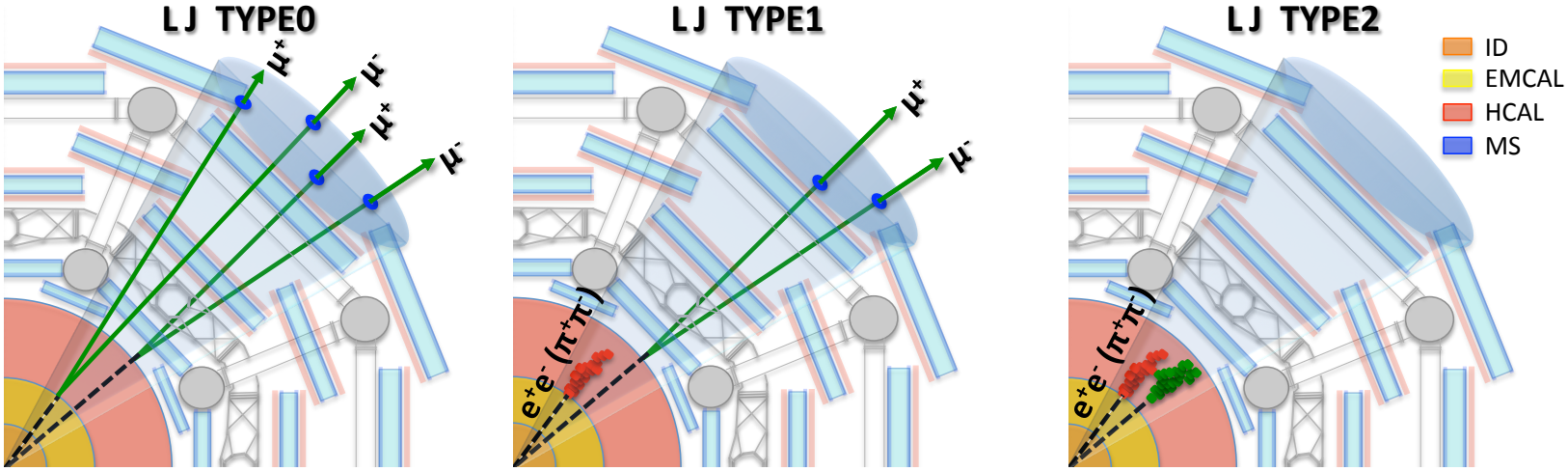
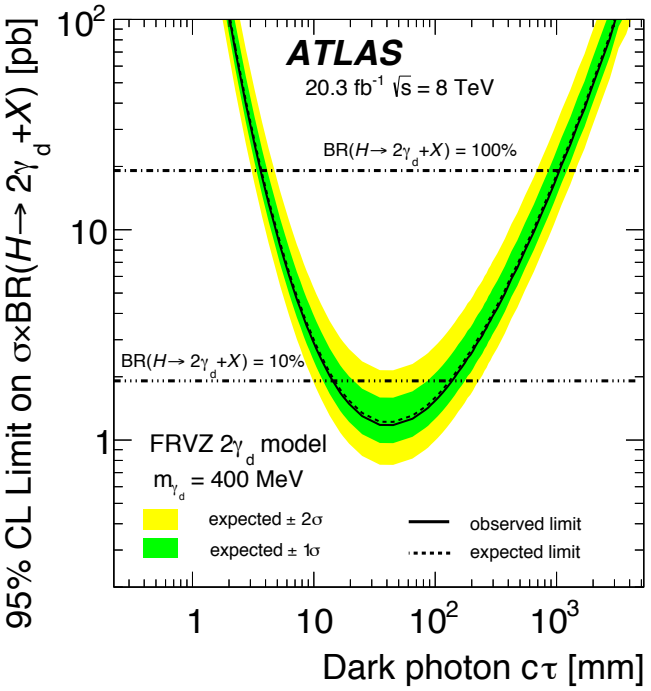
LLP → lepton-jets (arXiv:1409.0746, JHEP)

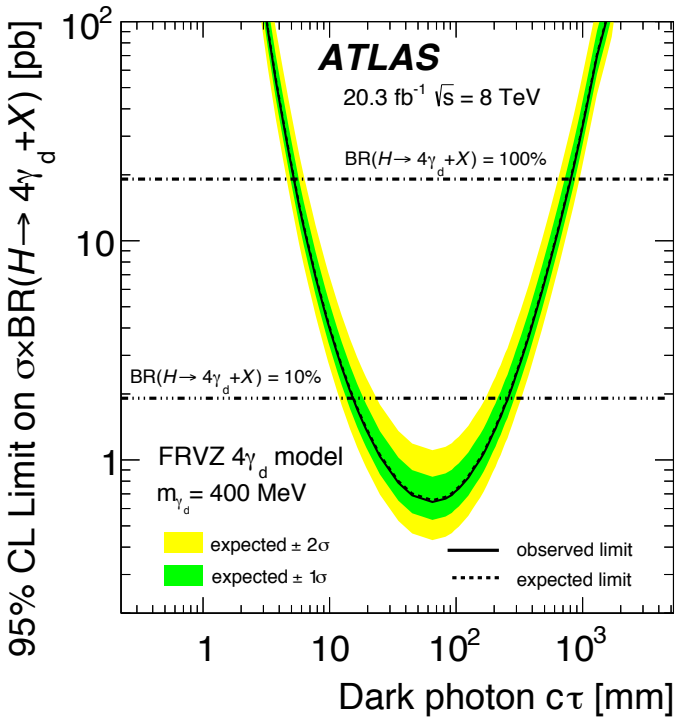
- pp → 2(4) dark photons → 2(4) lepton-jets (LJ)
- Dark photons decay in the calorimeter.



- LJ signature:
  - μμ: two muons in the muon detector and no near-by jets.
  - ee: one jet in the calorimeter.
  - No matching tracks in the inner tracker.
  - Type0 (muons),Type1 (muons and jets), Type2 (jets)
- Two LJs with back-to-back (large angular separation)

LLP → lepton-jets (2)





FRVZ model	Excluded $c\tau$ [mm] BR(10%)
$H \rightarrow 2\gamma_d + X$	$14 \leq c\tau \leq 140$
$H \rightarrow 4\gamma_d + X$	$15 \leq c\tau \leq 260$

Conclusions

- Signature based search was done to look for physics Beyond the Standard Model (BSM).
- Recent results with 2012, 8TeV data are presented.
- No significant deviation from the Standard Model.
- Limits are set for new physics models/particles.
- Please see other talks for BSM Higgs, Dark Matter and SUSY.

ATLAS Exotics Searches* - 95% CL Exclusion

Status: ICHEP 2014

ATLAS Preliminary

$\int \mathcal{L}\, dt$ = (1.0 - 20.3) fb^{-1} $\sqrt{s}$ = 7, 8 TeV

	Model	ℓ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Mass limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	1-2 j	Yes	4.7	M_D 4.37 TeV	$n = 2$	1210.4491
	ADD non-resonant $\ell\ell$	2e,μ	–	–	20.3	M_S 5.2 TeV	$n = 3$ HLZ	ATLAS-CONF-2014-030
	ADD QBH $\rightarrow \ell q$	1 e,μ	1 j	–	20.3	M_{th} 5.2 TeV	$n = 6$	1311.2006
	ADD QBH	–	2 j	–	20.3	M_{th} 5.82 TeV	$n = 6$	to be submitted to PRD
	ADD BH high N_{trk}	2 μ (SS)	–	–	20.3	M_{th} 5.7 TeV	$n = 6$, $M_D = 1.5$ TeV, non-rot BH	1308.4075
	ADD BH high $\sum p_T$	≥ 1 e,μ	≥ 2 j	–	20.3	M_{th} 6.2 TeV	$n = 6$, $M_D = 1.5$ TeV, non-rot BH	1405.4254
	RS1 $G_{KK} \rightarrow \ell\ell$	2 e,μ	–	–	20.3	G_{KK} mass 2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
	RS1 $G_{KK} \rightarrow WW \rightarrow \ell\nu\ell\nu$	2 e,μ	–	Yes	4.7	G_{KK} mass 1.23 TeV	$k/\overline{M}_{Pl} = 0.1$	1208.2880
	Bulk RS $G_{KK} \rightarrow ZZ \rightarrow \ell\ell qq$	2 e,μ	2 j / 1 J	–	20.3	G_{KK} mass 730 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2014-039
	Bulk RS $G_{KK} \rightarrow HH \rightarrow b\bar{b}b\bar{b}$	–	4 b	–	19.5	G_{KK} mass 590-710 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2014-005
	Bulk RS $g_{KK} \rightarrow t\bar{t}$	1 e,μ	≥ 1 b, $\geq$ 1J/2j	Yes	14.3	g_{KK} mass 2.0 TeV	BR = 0.925	ATLAS-CONF-2013-052
	S^1/Z_2 ED	2 e,μ	–	–	5.0	$M_{KK} \approx R^{-1}$ 4.71 TeV		1209.2535
	UED	2 γ	–	Yes	4.8	Compact. scale R^{-1} 1.41 TeV		ATLAS-CONF-2012-072
Gauge bosons	SSM $Z' \rightarrow \ell\ell$	2 e,μ	–	–	20.3	Z' mass 2.9 TeV		1405.4123
	SSM $Z' \rightarrow \tau\tau$	2 τ	–	–	19.5	Z' mass 1.9 TeV		ATLAS-CONF-2013-066
	SSM $W' \rightarrow \ell\nu$	1 e,μ	–	Yes	20.3	W' mass 3.28 TeV		ATLAS-CONF-2014-017
	EGM $W' \rightarrow WZ \rightarrow \ell\nu\,\ell'\ell'$	3 e,μ	–	Yes	20.3	W' mass 1.52 TeV		1406.4456
	EGM $W' \rightarrow WZ \rightarrow qq\ell\ell$	2 e,μ	2 j / 1 J	–	20.3	W' mass 1.59 TeV		ATLAS-CONF-2014-039
	LRSM $W'_R \rightarrow t\bar{b}$	1 e,μ	2 b, 0-1 j	Yes	14.3	W' mass 1.84 TeV		ATLAS-CONF-2013-050
	LRSM $W'_R \rightarrow t\bar{b}$	0 e,μ	≥ 1 b, 1 J	–	20.3	W' mass 1.77 TeV		to be submitted to EPJC
CI	CI $qqqq$	–	2 j	–	4.8	Λ 7.6 TeV	$\eta = +1$	1210.1718
	CI $qq\ell\ell$	2 e,μ	–	–	20.3	Λ 21.6 TeV	$\eta_{LL} = -1$	ATLAS-CONF-2014-030
	CI $uutt$	2 e,μ (SS)	≥ 1 b, ≥ 1 j	Yes	14.3	Λ 3.3 TeV	$\lvert C\rvert = 1$	ATLAS-CONF-2013-051
DM	EFT D5 operator (Dirac)	0 e,μ	1-2 j	Yes	10.5	M_* 731 GeV	at 90% CL for $m(\chi) < 80$ GeV	ATLAS-CONF-2012-147
	EFT D9 operator (Dirac)	0 e,μ	1 J, ≤ 1 j	Yes	20.3	M_* 2.4 TeV	at 90% CL for $m(\chi) < 100$ GeV	1309.4017
LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	1.0	LQ mass 660 GeV	$\beta = 1$	1112.4828
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	1.0	LQ mass 685 GeV	$\beta = 1$	1203.3172
	Scalar LQ 3rd gen	1 e,μ, 1 τ	1 b, 1 j	–	4.7	LQ mass 534 GeV	$\beta = 1$	1303.0526
Heavy quarks	Vector-like quark $TT \rightarrow Ht + X$	1 e,μ	≥ 2 b, ≥ 4 j	Yes	14.3	T mass 790 GeV	T in (T,B) doublet	ATLAS-CONF-2013-018
	Vector-like quark $TT \rightarrow Wb + X$	1 e,μ	≥ 1 b, ≥ 3 j	Yes	14.3	T mass 670 GeV	isospin singlet	ATLAS-CONF-2013-060
	Vector-like quark $TT \rightarrow Zt + X$	2/$\geq$3 e,μ	$\geq$2/$\geq$1 b	–	20.3	T mass 735 GeV	T in (T,B) doublet	ATLAS-CONF-2014-036
	Vector-like quark $BB \rightarrow Zb + X$	2/$\geq$3 e,μ	$\geq$2/$\geq$1 b	–	20.3	B mass 755 GeV	B in (B,Y) doublet	ATLAS-CONF-2014-036
	Vector-like quark $BB \rightarrow Wt + X$	2 e,μ (SS)	≥ 1 b, ≥ 1 j	Yes	14.3	B mass 720 GeV	B in (T,B) doublet	ATLAS-CONF-2013-051
Excited fermions	Excited quark $q^* \rightarrow q\gamma$	1 γ	1 j	–	20.3	q^* mass 3.5 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1309.3230
	Excited quark $q^* \rightarrow qg$	–	2 j	–	20.3	q^* mass 4.09 TeV	only u^* and d^*, $\Lambda = m(q^*)$	to be submitted to PRD
	Excited quark $b^* \rightarrow Wt$	1 or 2 e,μ	1 b, 2 j or 1 j	Yes	4.7	b^* mass 870 GeV	left-handed coupling	1301.1583
	Excited lepton $\ell^* \rightarrow \ell\gamma$	2 e,μ, 1 γ	–	–	13.0	ℓ^* mass 2.2 TeV	$\Lambda = 2.2$ TeV	1308.1364
Other	LSTC $a_T \rightarrow W\gamma$	1 e,μ, 1 γ	–	Yes	20.3	a_T mass 960 GeV		to be submitted to PLB
	LRSM Majorana ν	2 e,μ	2 j	–	2.1	N^0 mass 1.5 TeV	$m(W_R) = 2$ TeV, no mixing	1203.5420
	Type III Seesaw	2 e,μ	–	–	5.8	$N^\pm$ mass 245 GeV	$\lvert V_e\rvert$=0.055, $\lvert V_\mu\rvert$=0.063, $\lvert V_\tau\rvert$=0	ATLAS-CONF-2013-019
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$	2 e,μ (SS)	–	–	4.7	$H^{\pm\pm}$ mass 409 GeV	DY production, BR($H^{\pm\pm} \rightarrow \ell\ell$)=1	1210.5070
	Multi-charged particles	–	–	–	4.4	multi-charged particle mass 490 GeV	DY production, $\lvert q\rvert = 4e$	1301.5272
	Magnetic monopoles	–	–	–	2.0	monopole mass 862 GeV	DY production, $\lvert g\rvert = 1g_D$	1207.6411

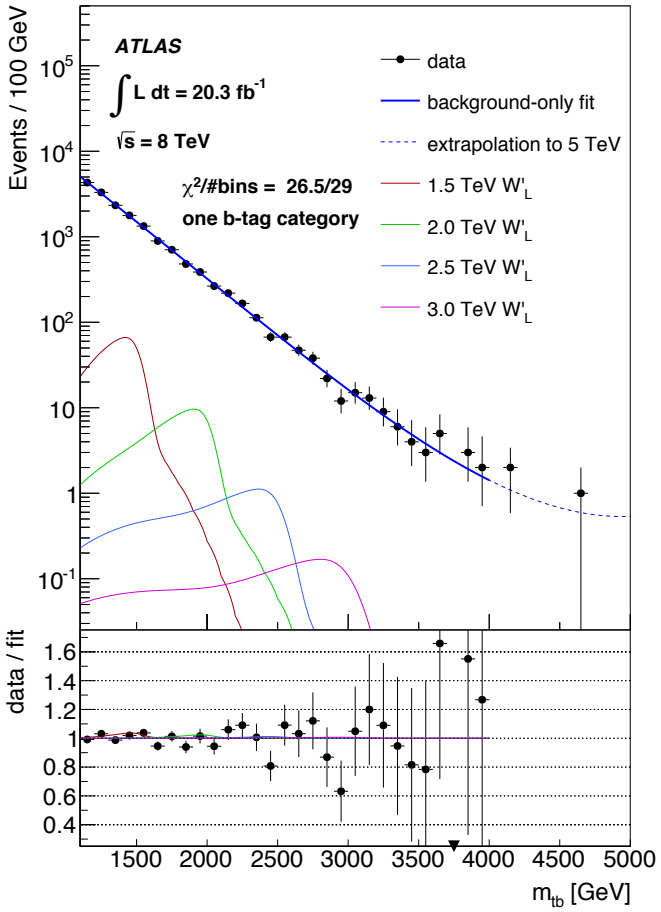
$\sqrt{s}$ = 7 TeV | $\sqrt{s}$ = 8 TeV

10^{-1} 1 10 **Mass scale [TeV]**

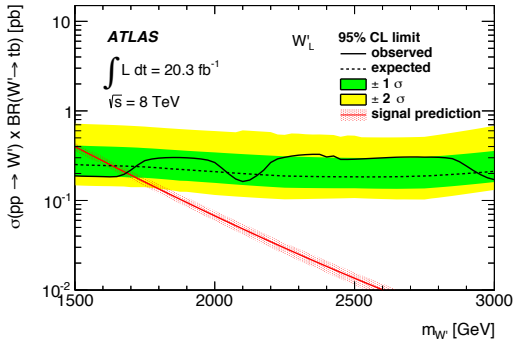
**Only a selection of the available mass limits on new states or phenomena is shown.*

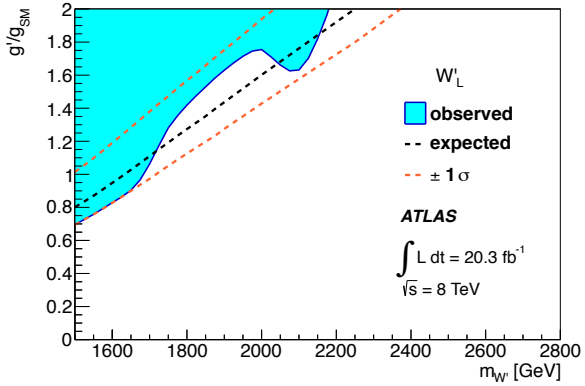
W’ → tb (qqbb) (arXiv:1408.0886, EPJC)

- W’ → t bbar → W(qq)b bbar



- One large-R jet with p_T>350GeV
- Large-R jet is widely distributed and include W(qq) and b.
- One b-jet with p_T>350GeV
- Angular distance between large-R jet and b-jet > 2.0

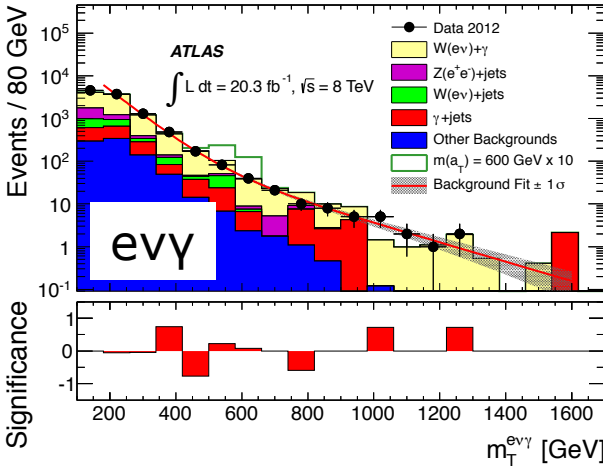


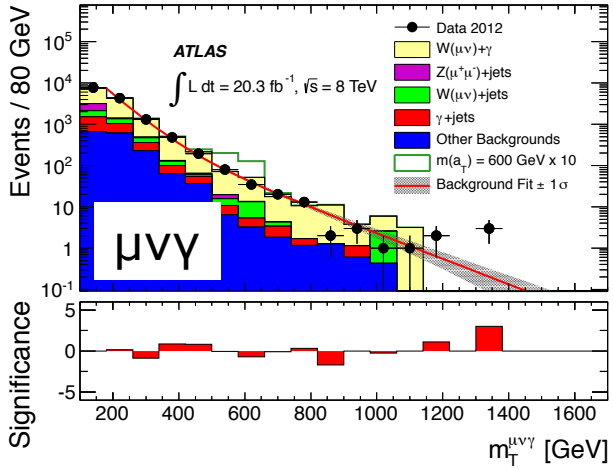


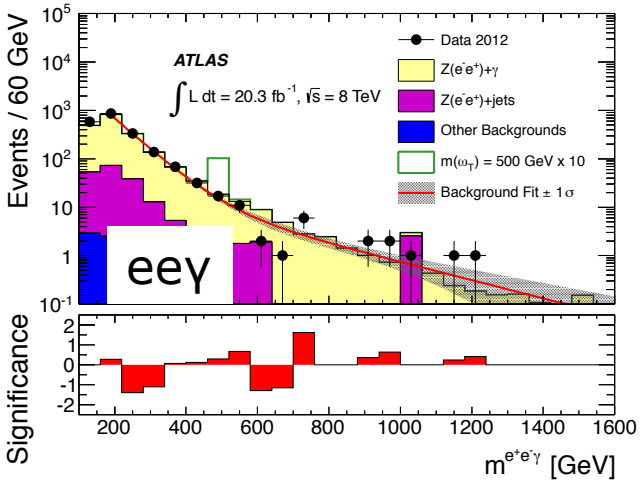
M(W’) > 1.68 TeV

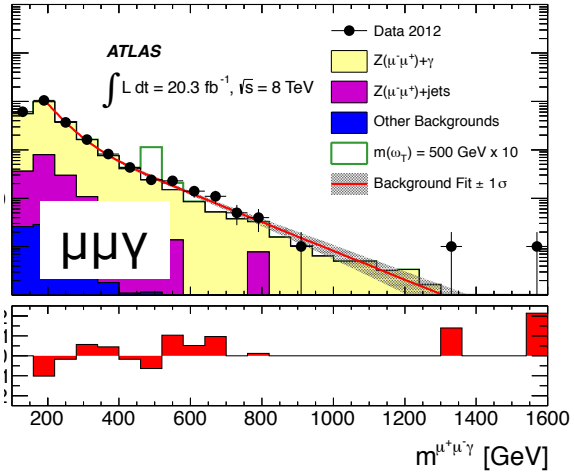
Wγ and Zγ (arXiv:1407.8150, PLB738,428(2014))

- W→lν, Z→ll mode





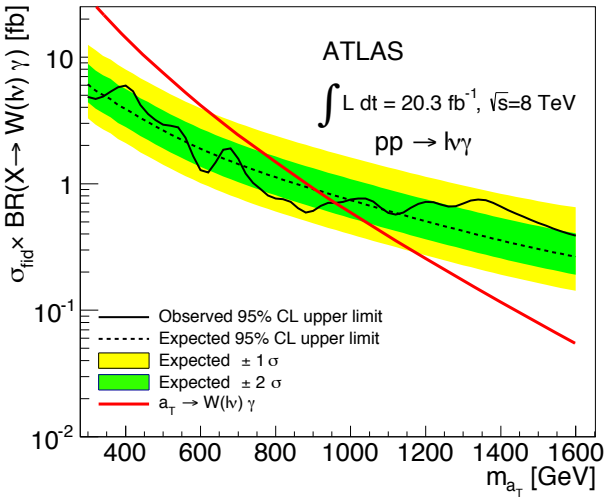


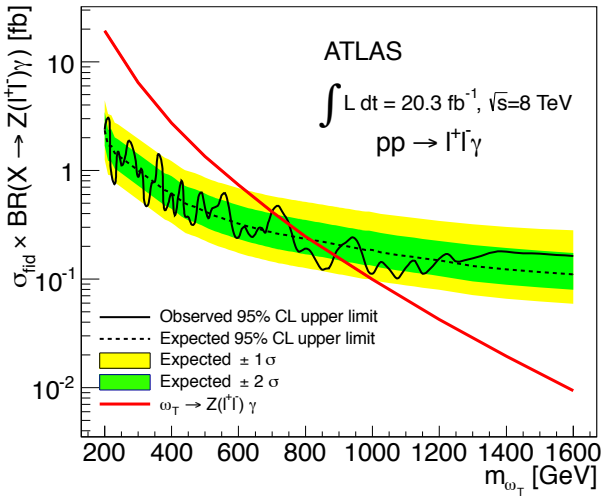


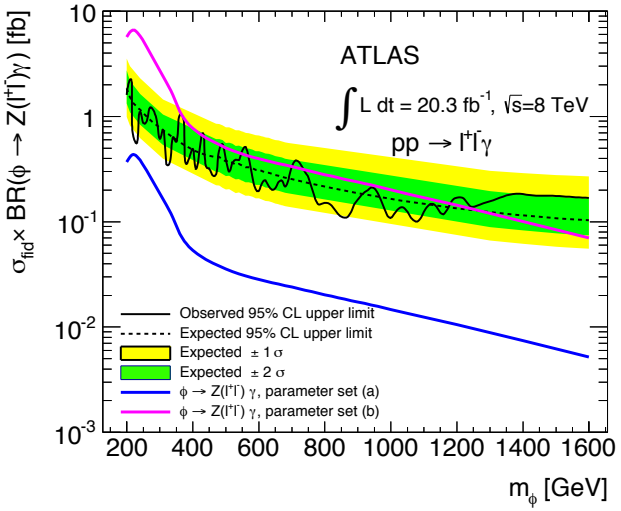
lνγ mode:
- Lepton p_T>25GeV
- Photon E_T>45GeV
- MET>35GeV

llγ mode:
- 65<|m(ll) – m(Z)|<115GeV
- Photon E_T>40GeV

Wγ and Zγ (2)





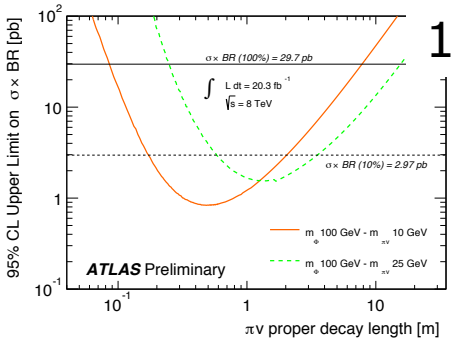


- Low Scale Technicolor model:
  - $M(a_T) > 960$ GeV
  - $M(\omega_T) > 890$ GeV
- Singlet scalar resonance:
  - $M(\varphi) > 1180$ GeV

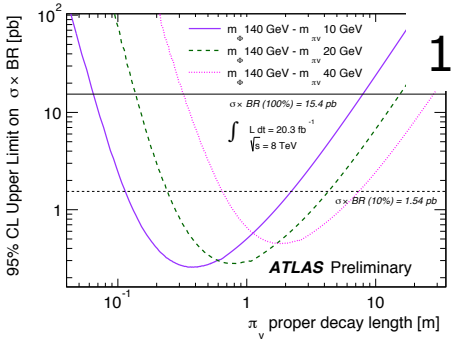
LLP pair (ATLAS-CONF-2014-041)

- Heavy scalar boson (Φ_{HS}) → LLP (π_v) pair

- LLP candidate:
  - Narrow jet in hadronic calorimeter
  - Small energy deposit in EM calorimeter.
  - No matching track in the inner tracker.

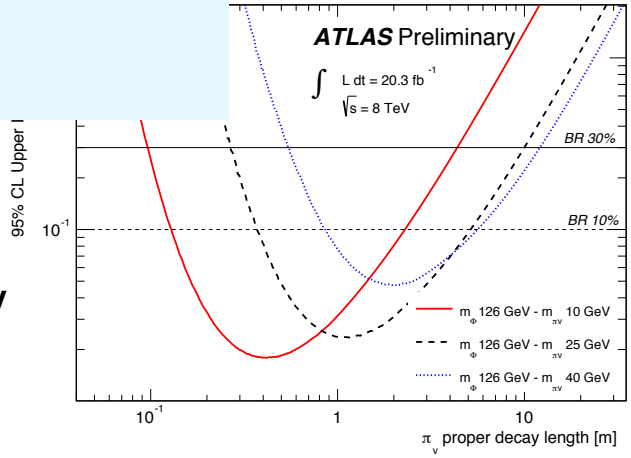


100 GeV



140 GeV

126 GeV



Excluded proper decay length

MC sample m_Φ, $m_{\pi v}$ [GeV]	excluded range 30% BR $\Phi_{HS} \rightarrow \pi_v\pi_v$ [m]	excluded range 10% BR $\Phi_{HS} \rightarrow \pi_v\pi_v$ [m]
126, 10	0.10 - 4.38	0.13 - 2.30
126, 25	0.27 - 10.01	0.37 - 5.12
126, 40	0.54 - 12.11	0.86 - 5.62