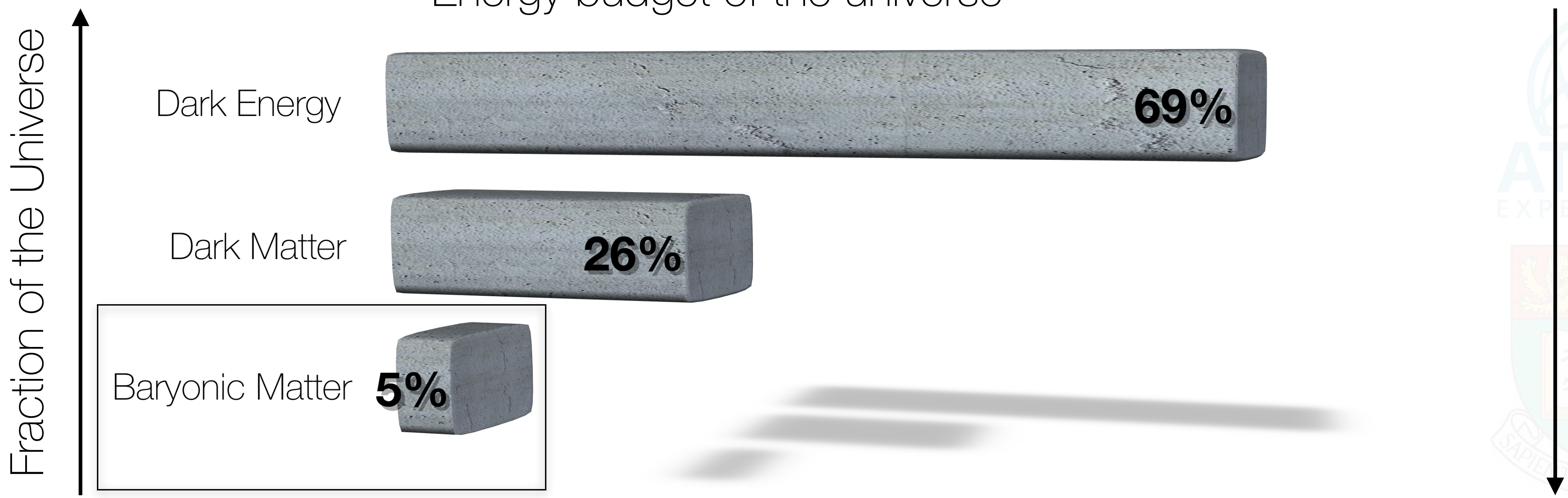
BSM searches in ATLAS

Prepared by: Nicola Orlando (The University of Hong Kong)
Presented by: Alison Elliot (The University of Victoria)

for the ATLAS Collaboration

Fingerprints of BSM physics

Energy budget of the universe

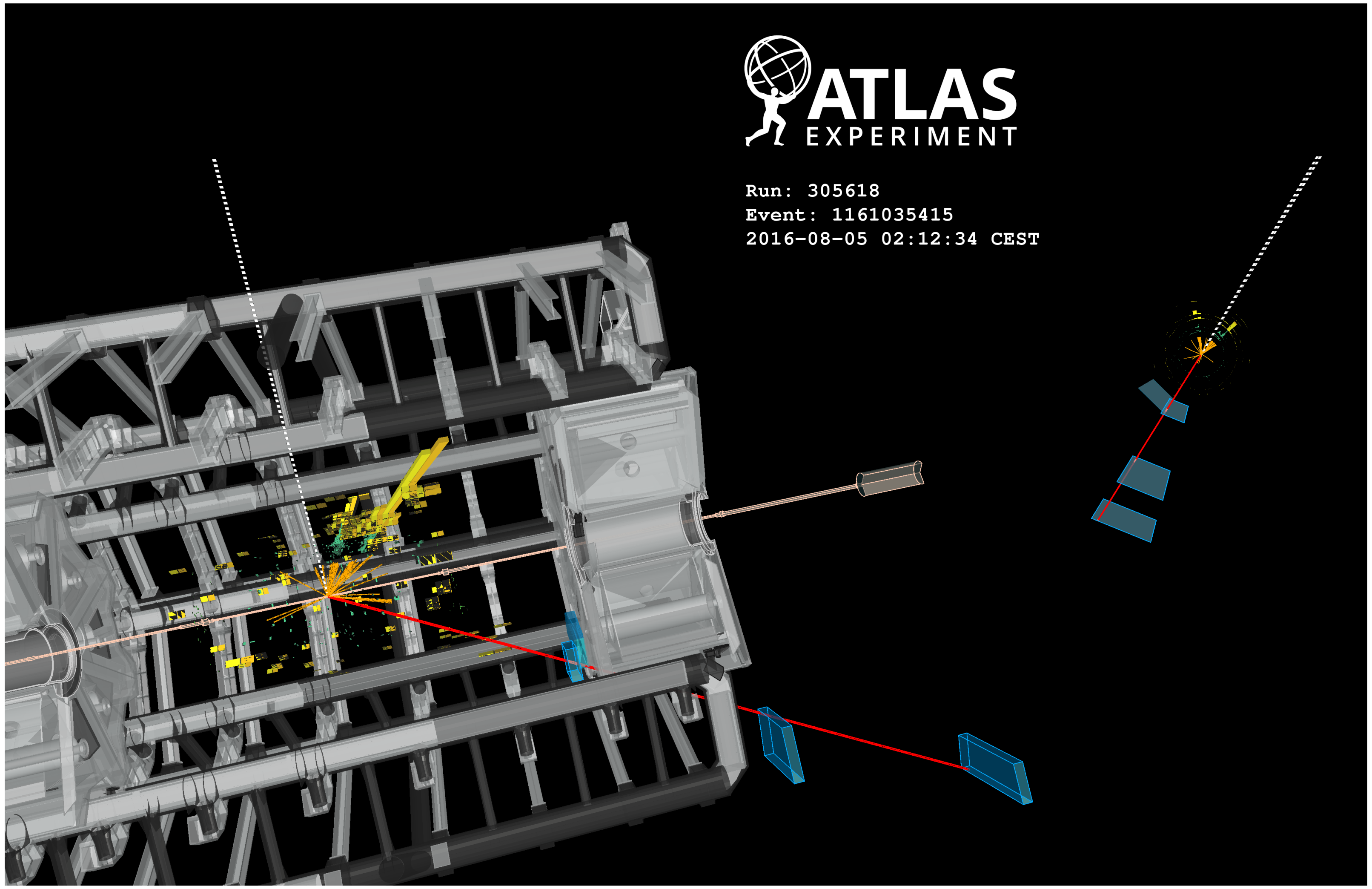


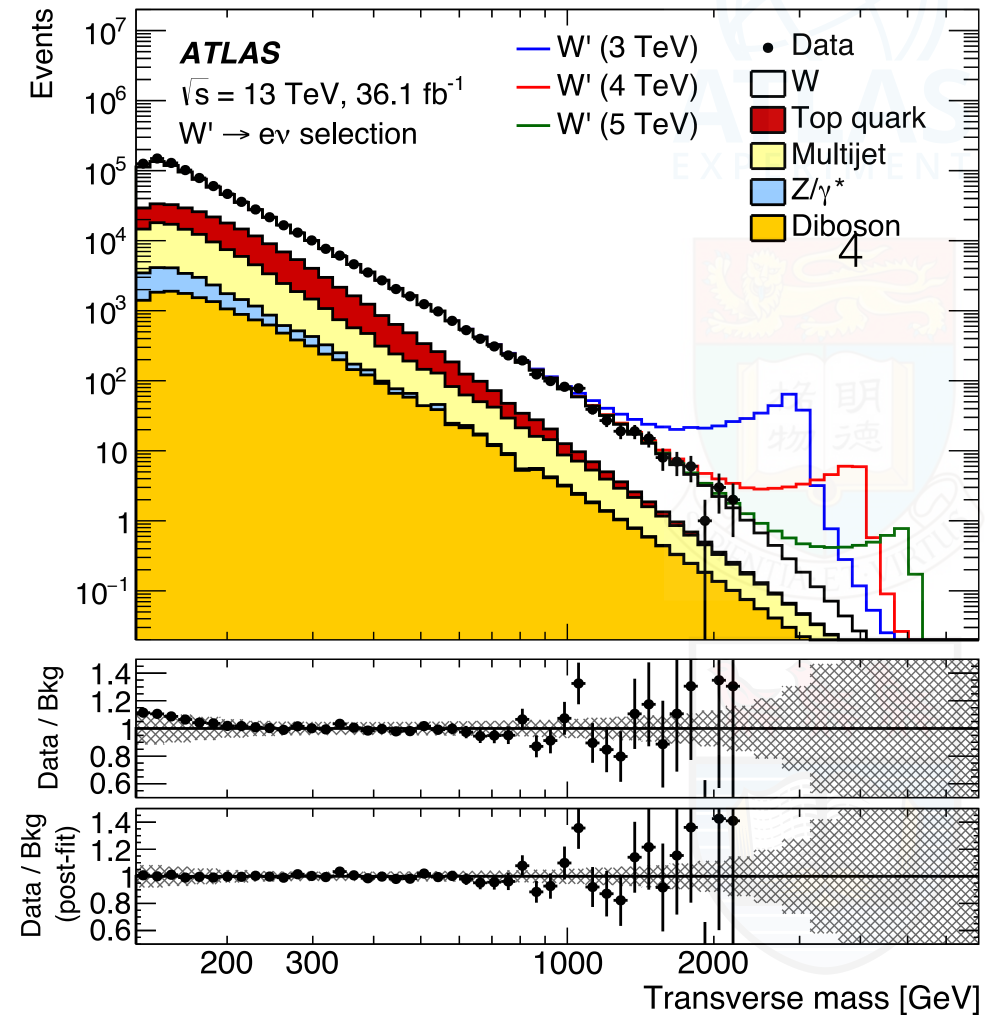
Neutrino mass theories not experimentally verified
Not enough **CP violation** to account for matter-antimatter asymmetry in the universe
Fine tuning in the Higgs and Yukawa sectors

Looking for BSM in ATLAS

- **Searches for exotic particles**
    - Different models solve: naturalness problem, dark-matter candidates, extended symmetries, heavy neutrinos, …
    - Characterised by multiple signatures, multiple interpretations
- **Searches for supersymmetry (SUSY)**
    - Solves naturalness problem, has dark-matter candidates
    - Characterised by high (low) missing transverse energy for R-parity conserving (violating) models
- **Searches for new Higgs bosons** (falls in both previous categories)
    - Targeting signatures inspired by models extending the Higgs sector

author: Nicola Orlando | The University of Hong Kong
presenter: Alison Elliot | The University of Victoria





Clear resonant signature, high precision knowledge of the main background

W'/Z' searches in leptonic final states

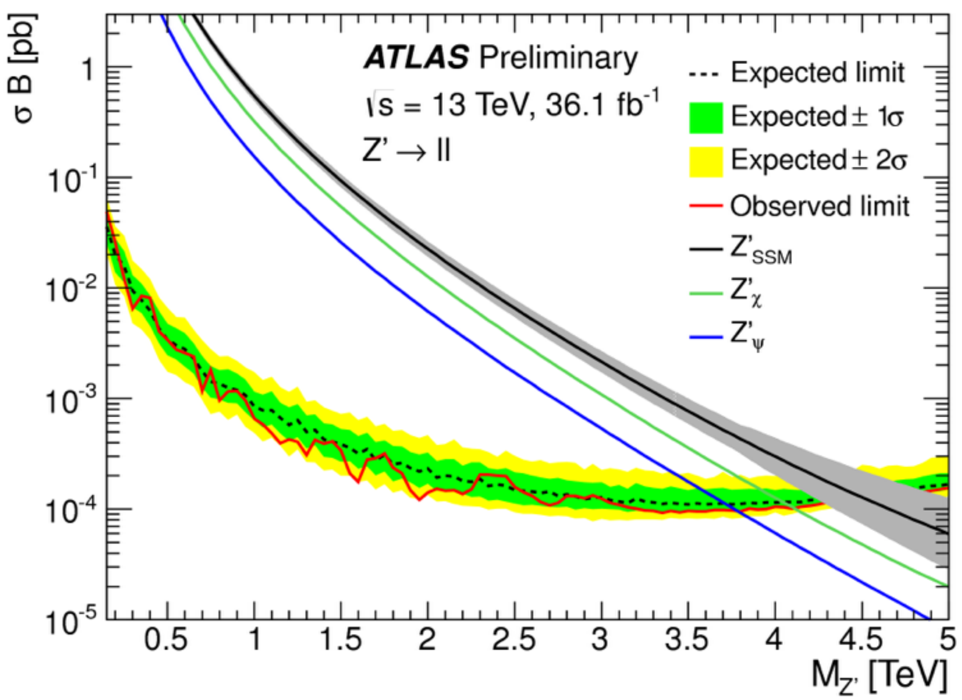
References

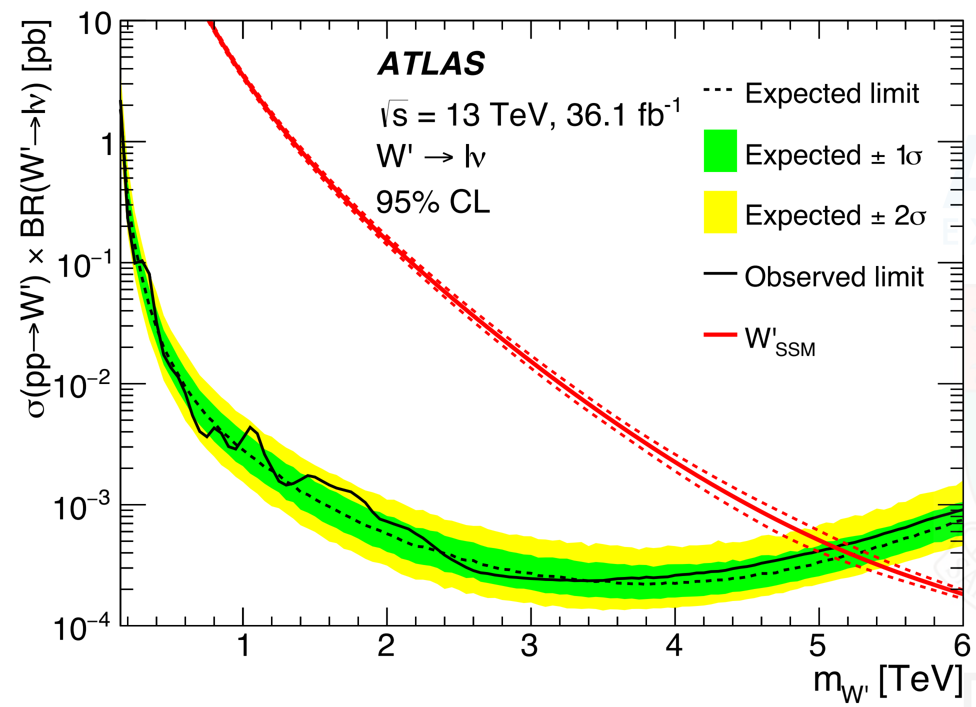
Dilepton resonance search ATLAS-CONF-2017-027

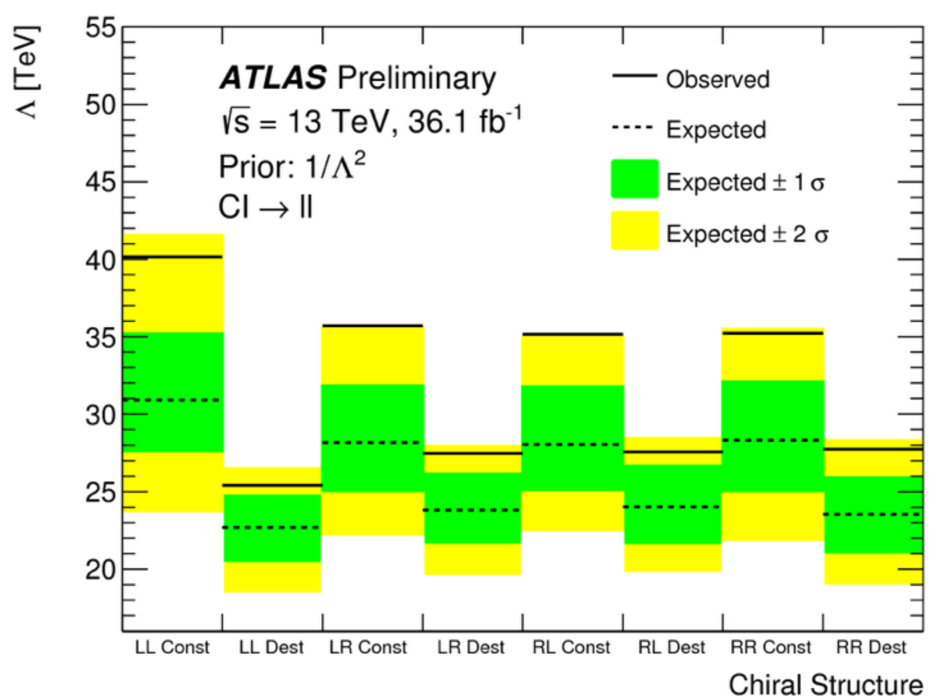
Lepton + missing energy resonance search EXOT-2016-06

W'/Z' searches in leptonic final states

Testing several benchmarks as well as simplified models with narrow-width signal hypotheses







Search for anomalous non-resonant di-lepton production

Tested different chiral structures and interference scenarios in contact interactions

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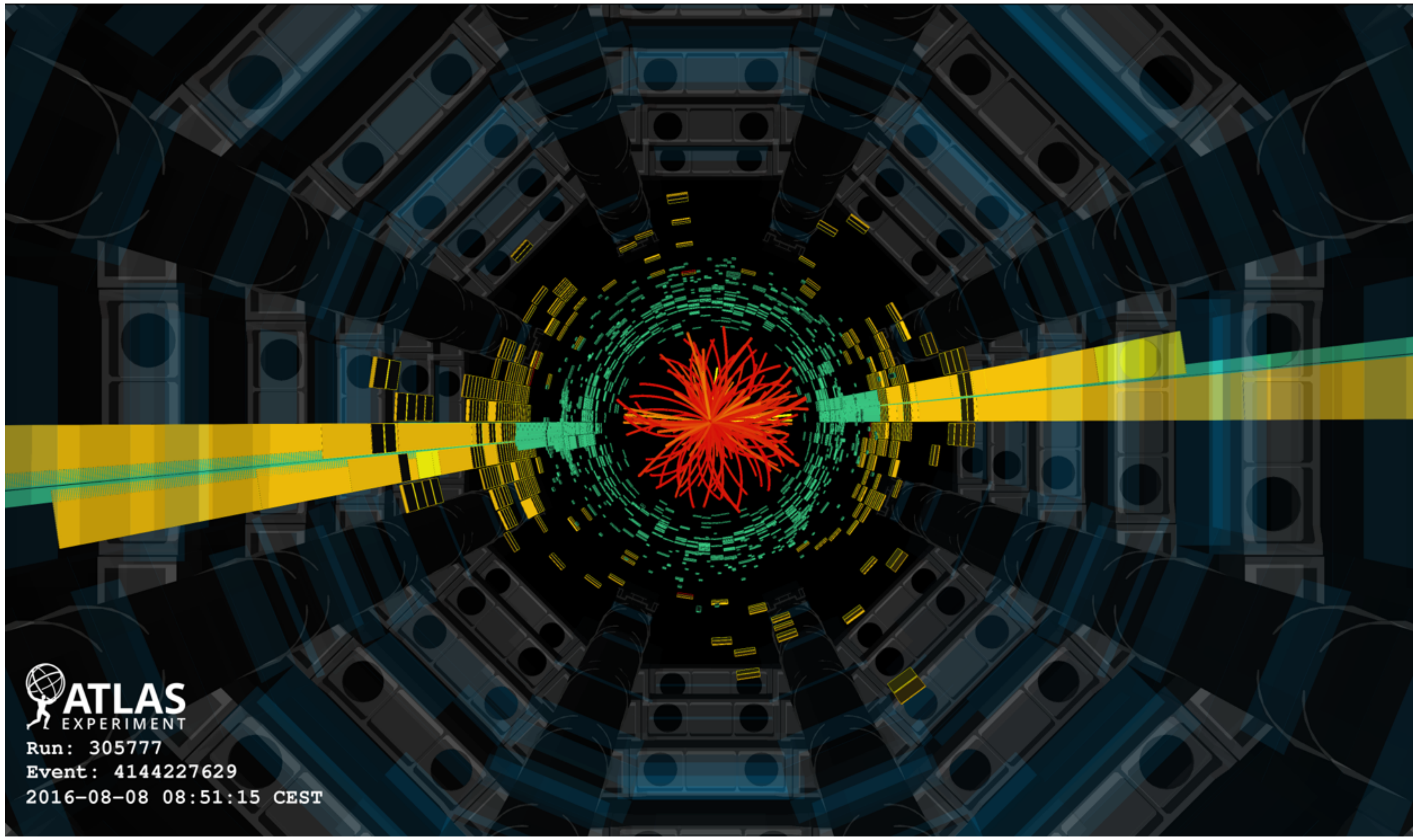
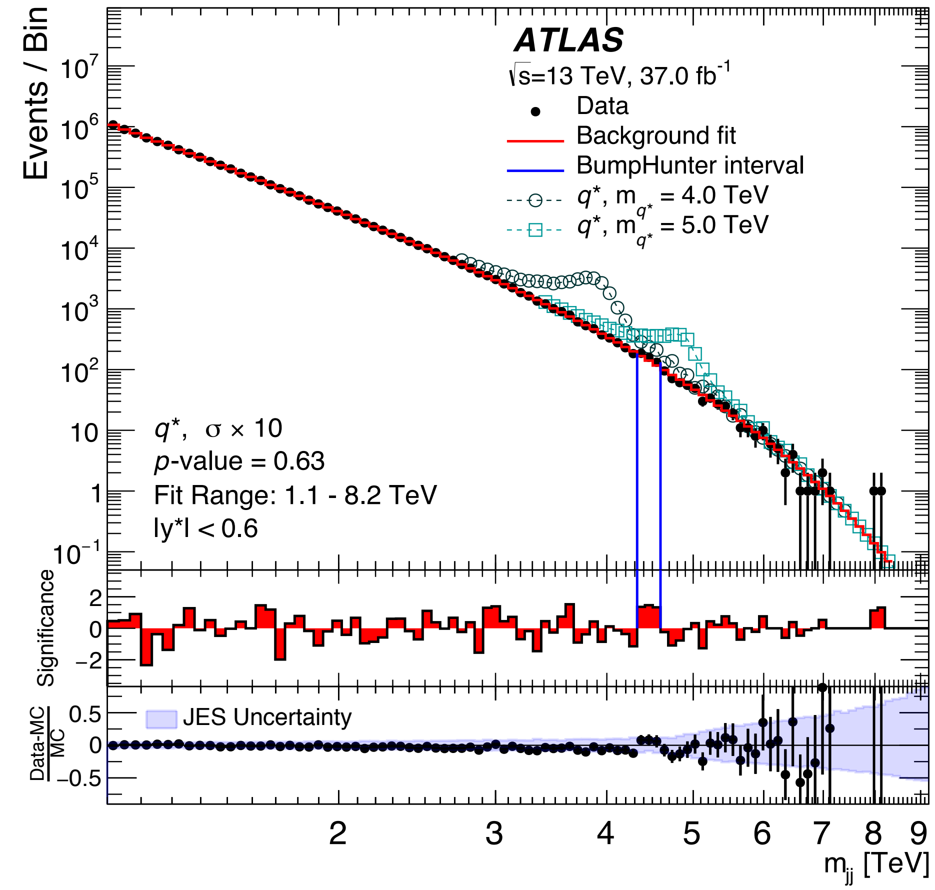




Clear and spectacular signature, smooth background controlled with unbinned models

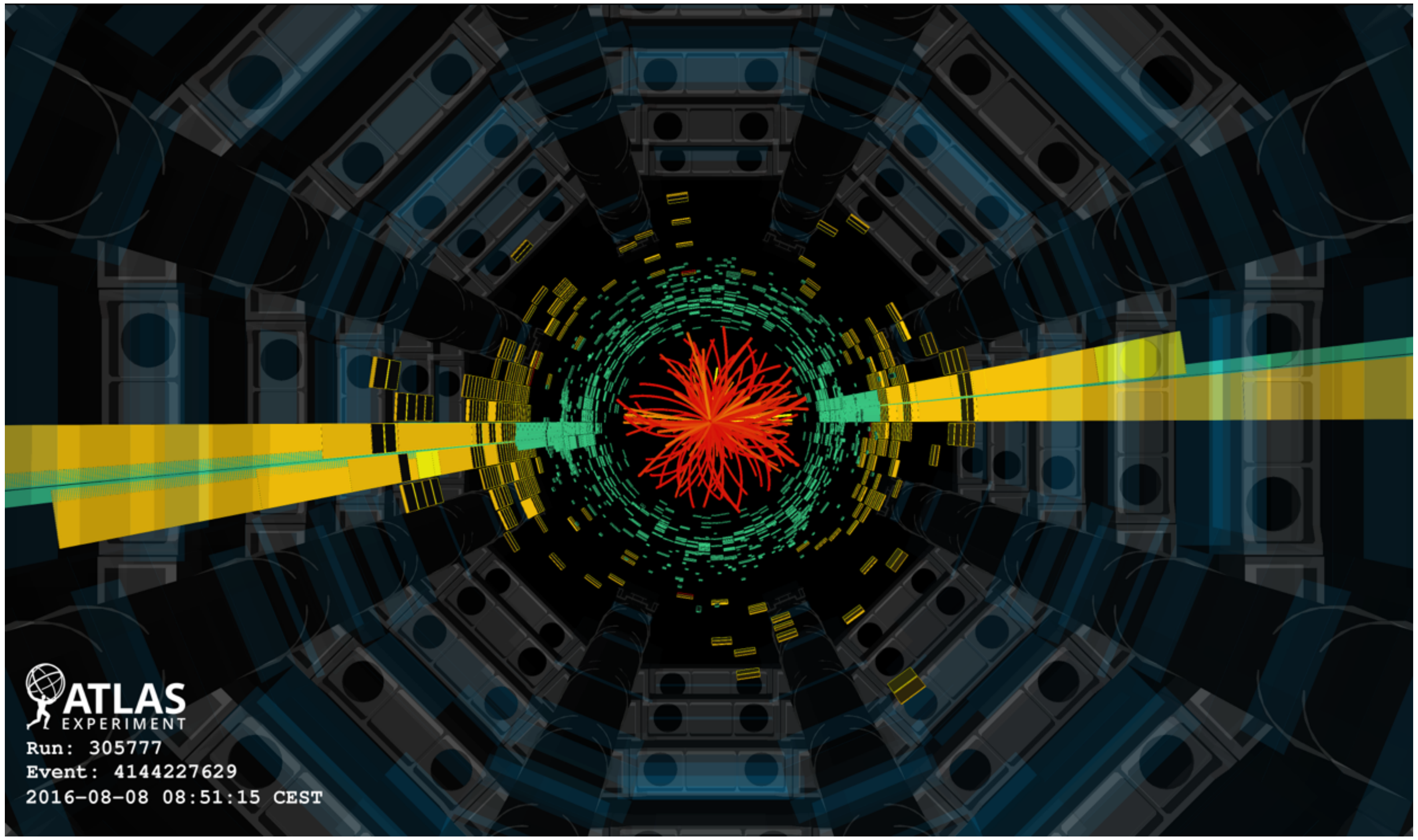
Angular correlations between the jets provide extra handles on signal-to-background separation

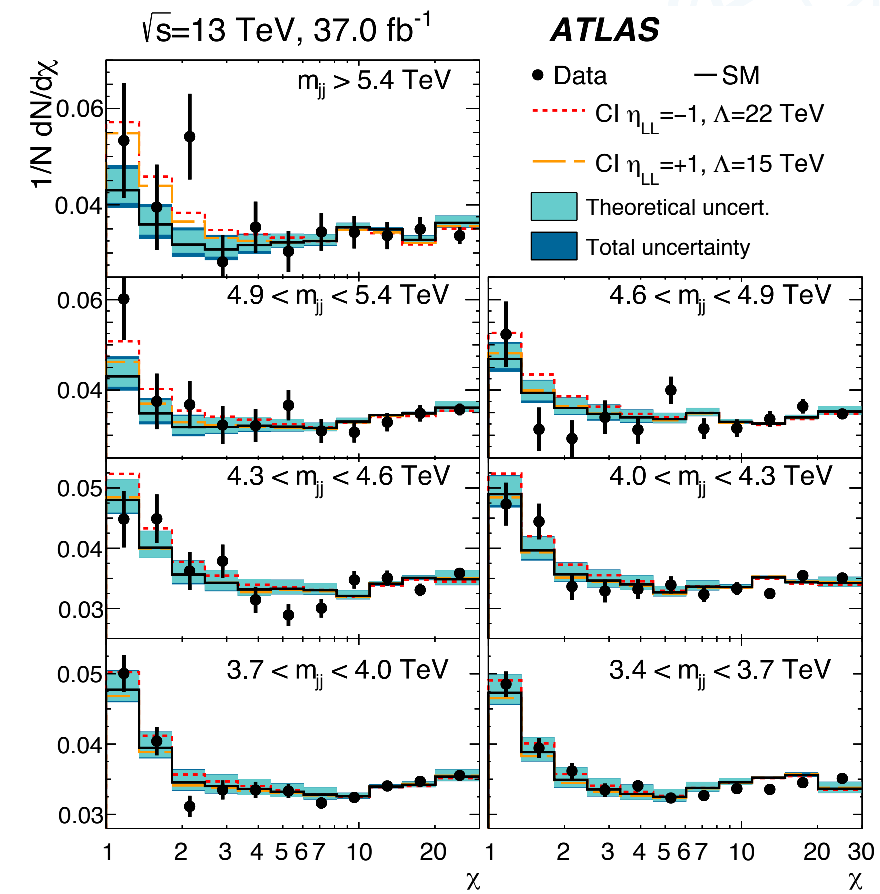
Di-jet resonances

References

Di-jet analysis arXiv:1703.09127

Di-jet resonance search with b-jets ATLAS-CONF-2016-060





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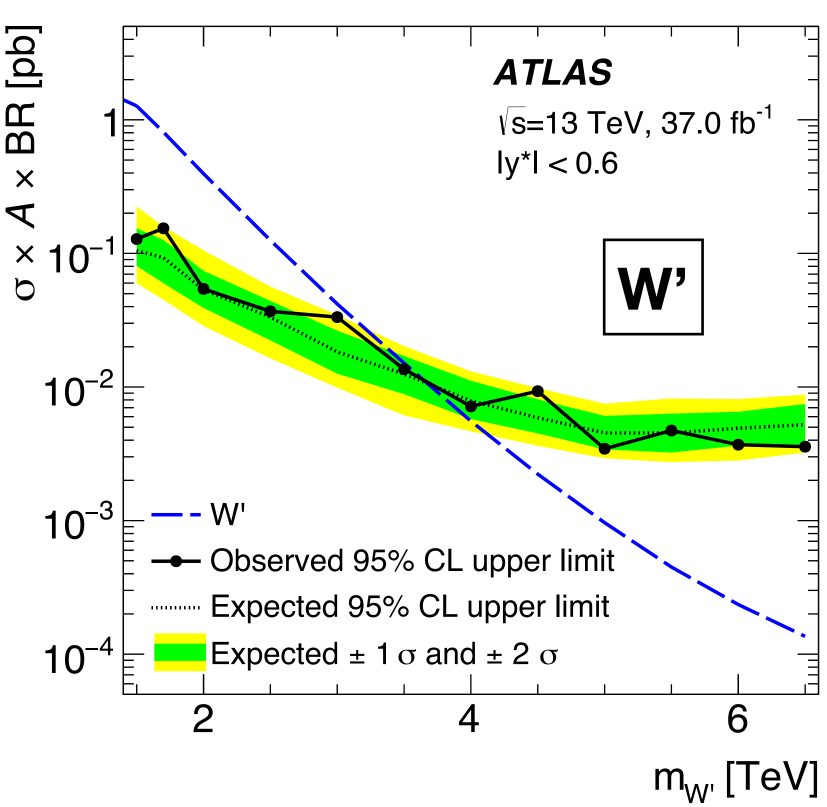
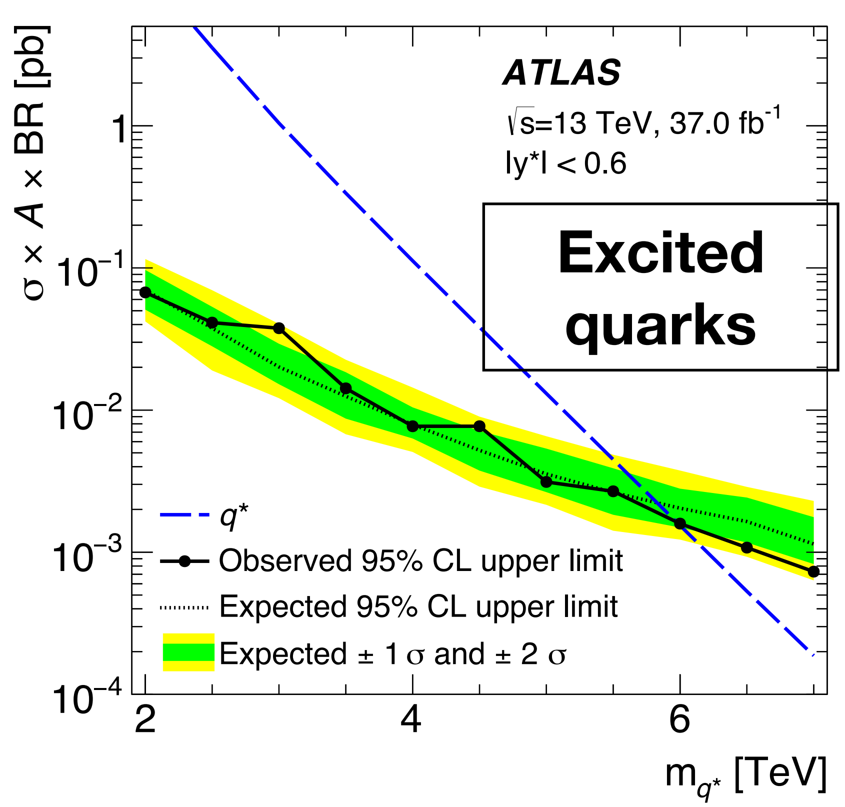
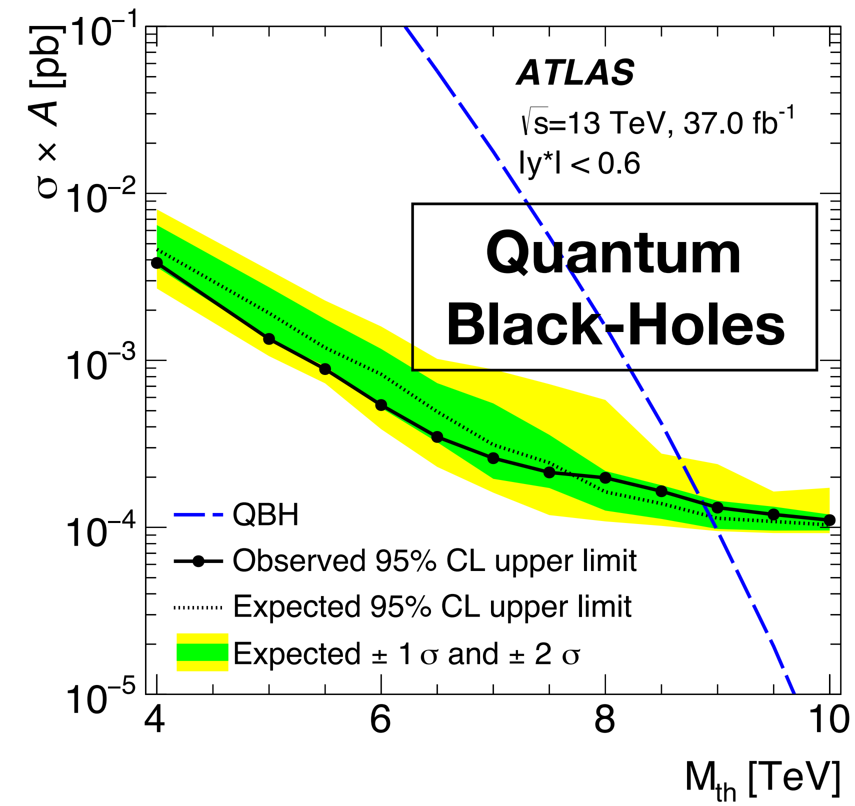
Di-jet resonances

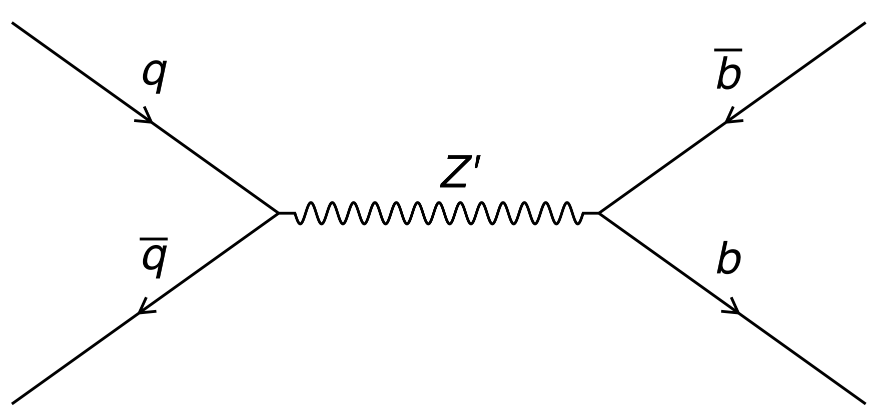


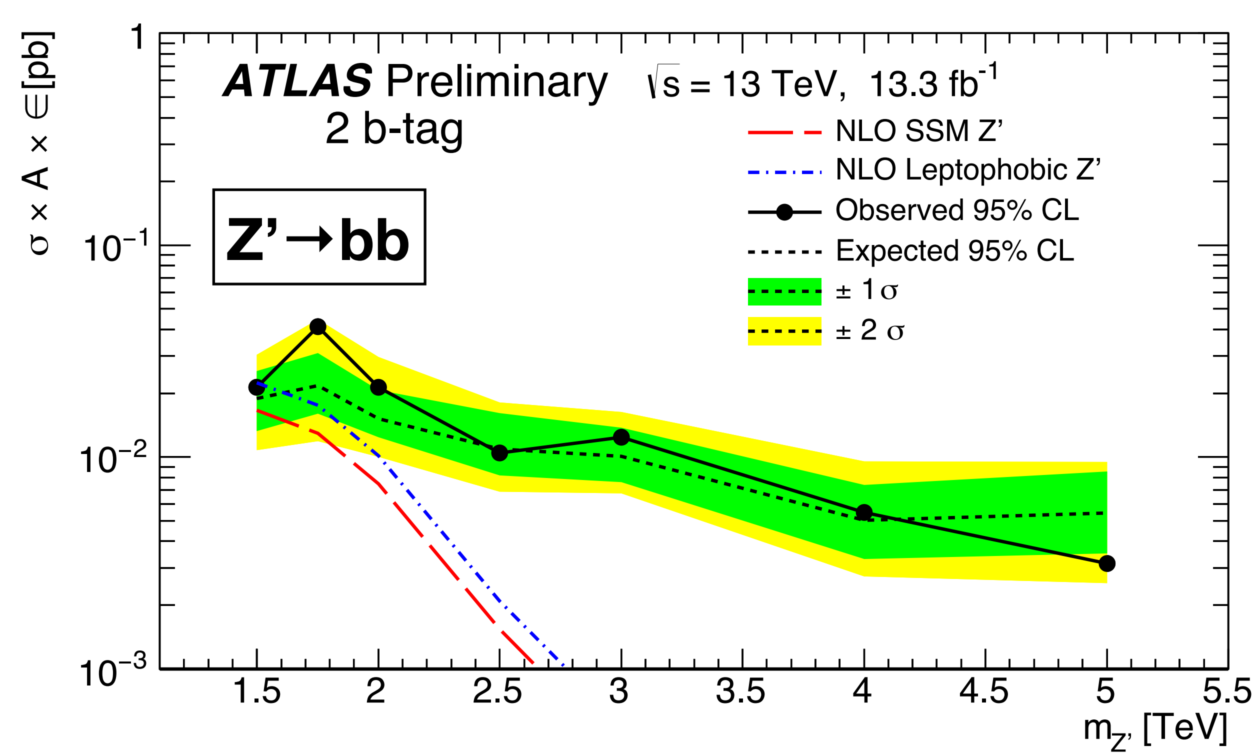




Di-jet resonate search based on **b-tagged jets**

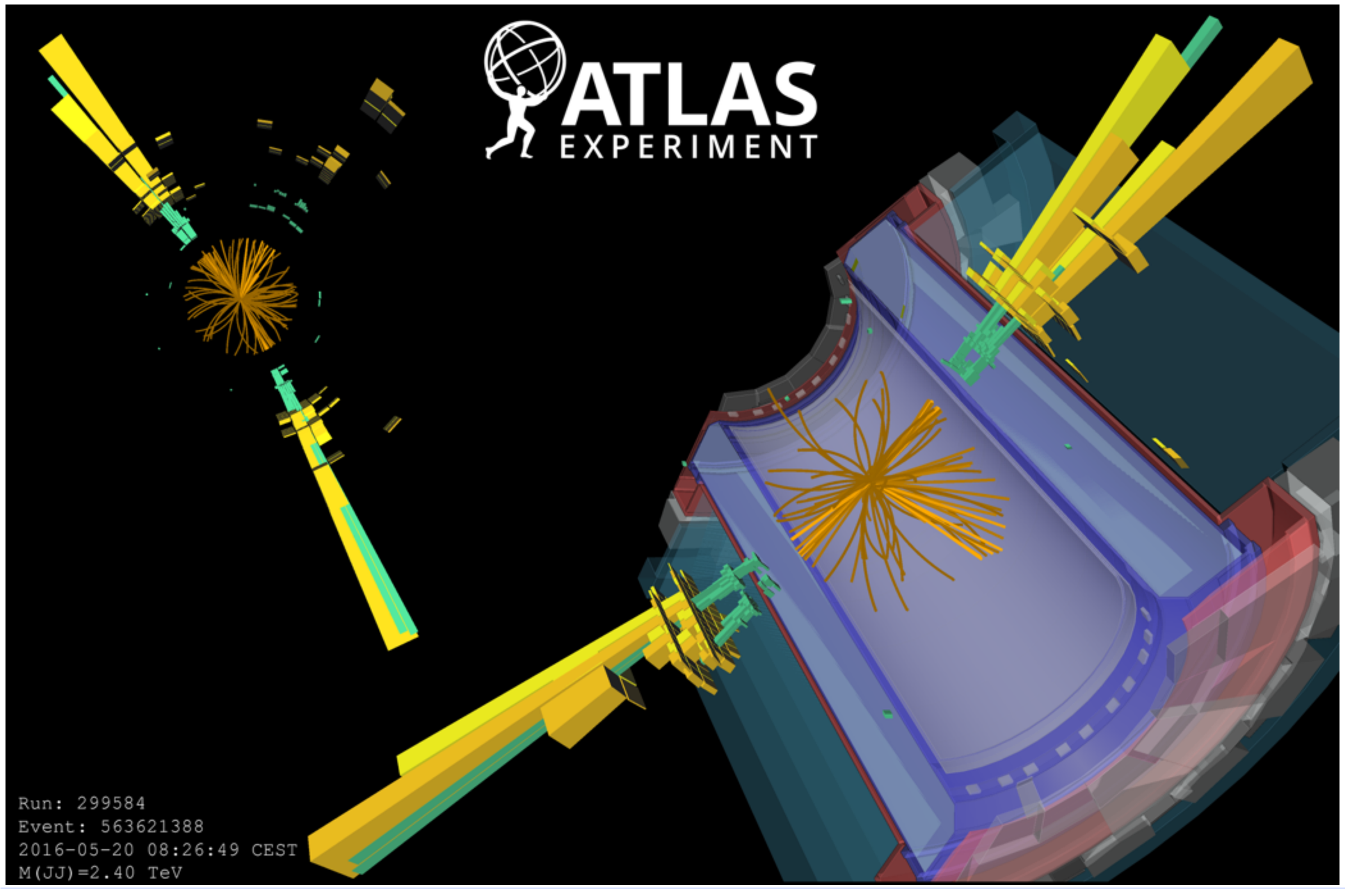
Several benchmark analyses, including generic signals with gaussian shaped mjj peak



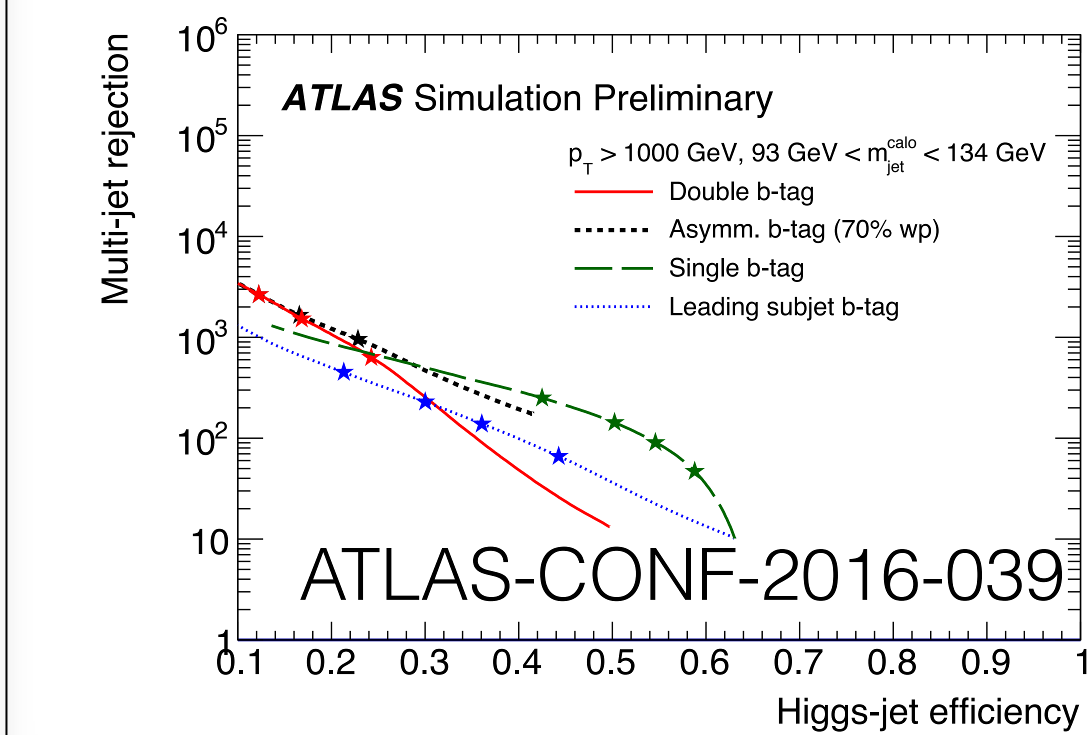


Searches for heavy resonances in several decay channels: WW, ZZ, WZ, WH, ZH

Expecting bosons with **high boost**



Exploits extensively **boosted vector boson and Higgs boson tagging**



Interpretation: decays of heavy spin-0 spin-1, spin-2 particles with small widths (up to ~10%)

Di-boson resonances

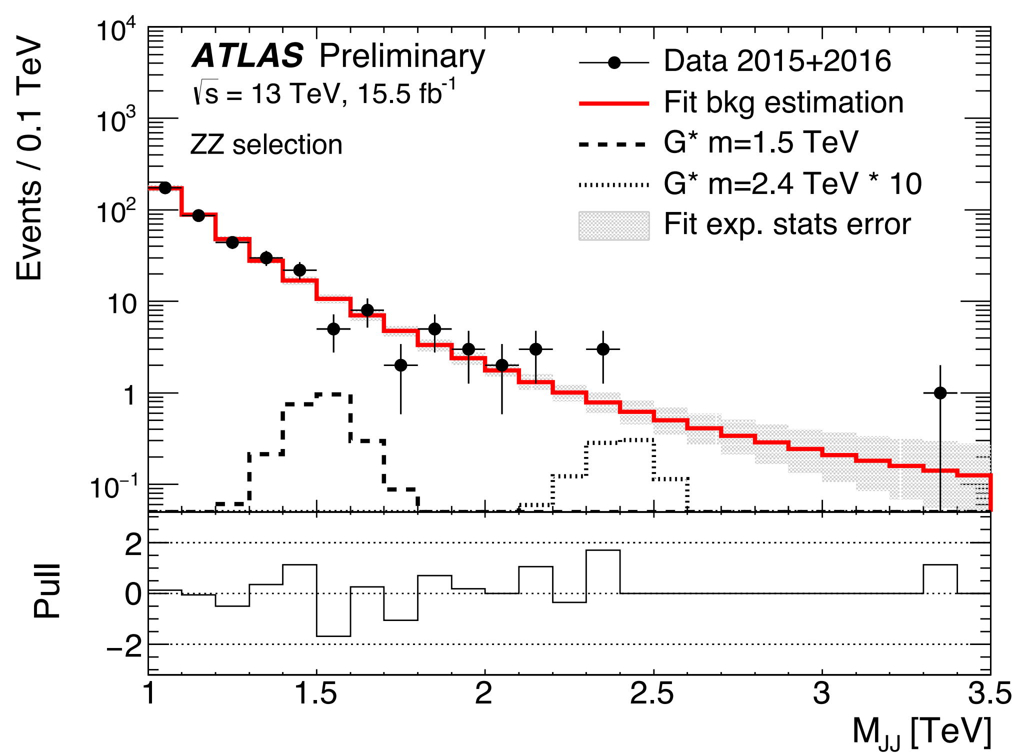
See talk by Andrey Ryzhov today

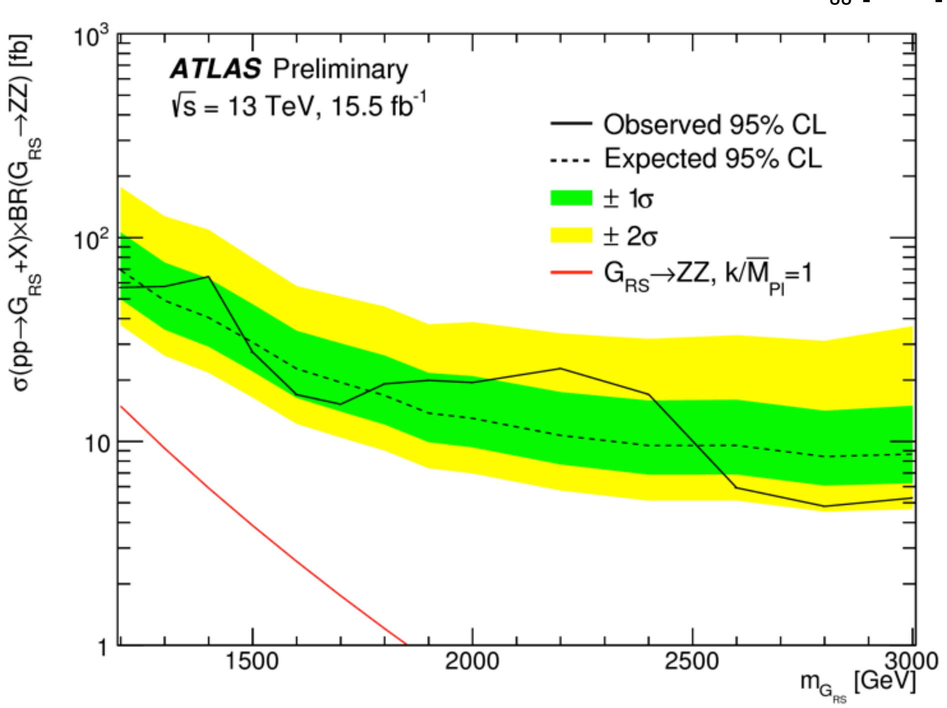
References

WH and ZH qqbb resonance search ATLAS-CONF-2017-018
WW/WZ/ZZ hadronic resonance search ATLAS-CONF-2016-055
WW/WZ lvqq resonance search ATLAS-CONF-2016-062
WZ/ZZ ll/vv + qq resonance search ATLAS-CONF-2016-082

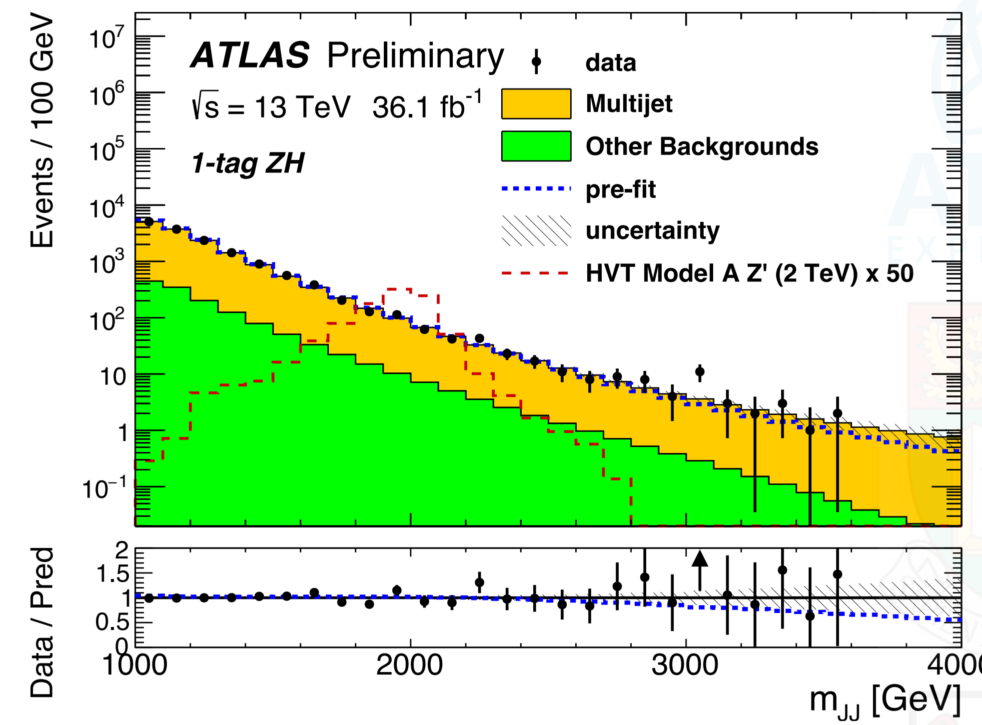
Di-boson resonances fully hadronic

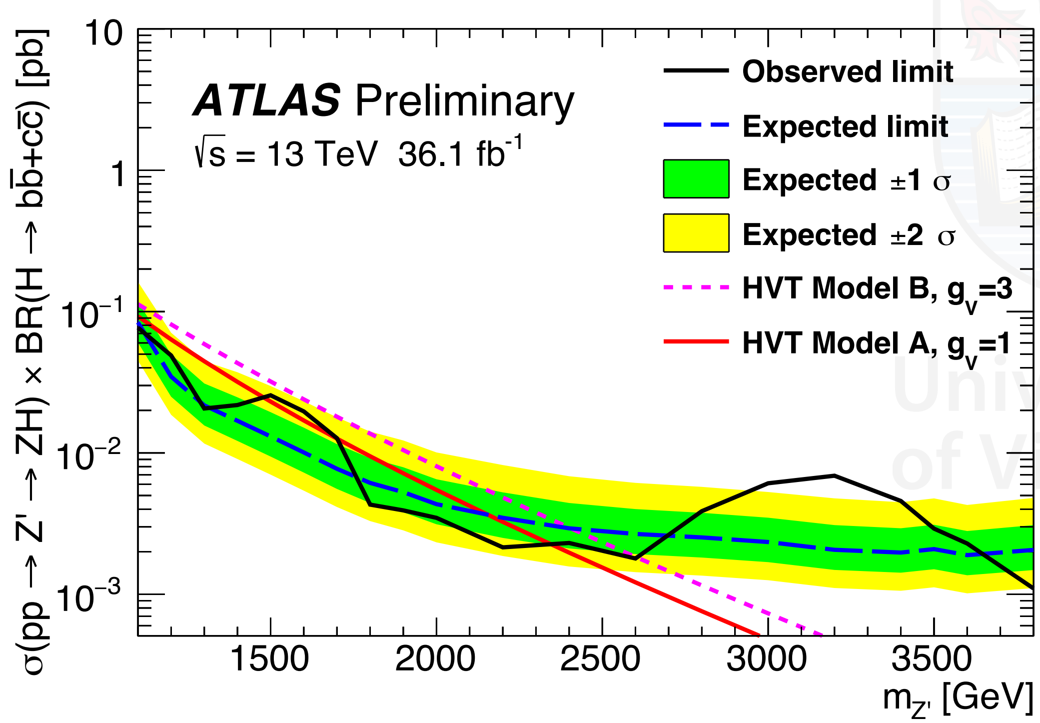
Decays in WW, ZZ and WZ





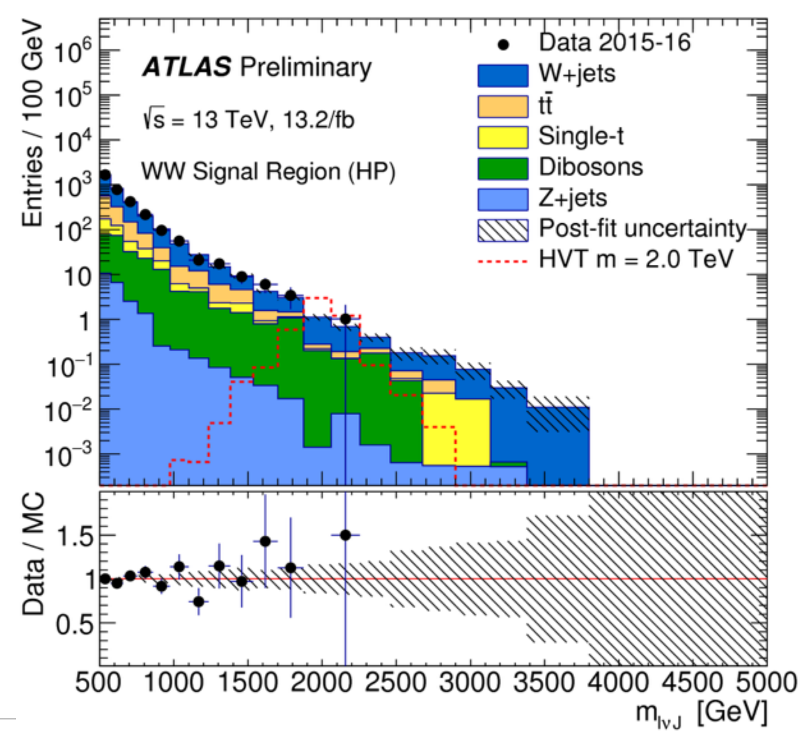
Decays in WH and ZH

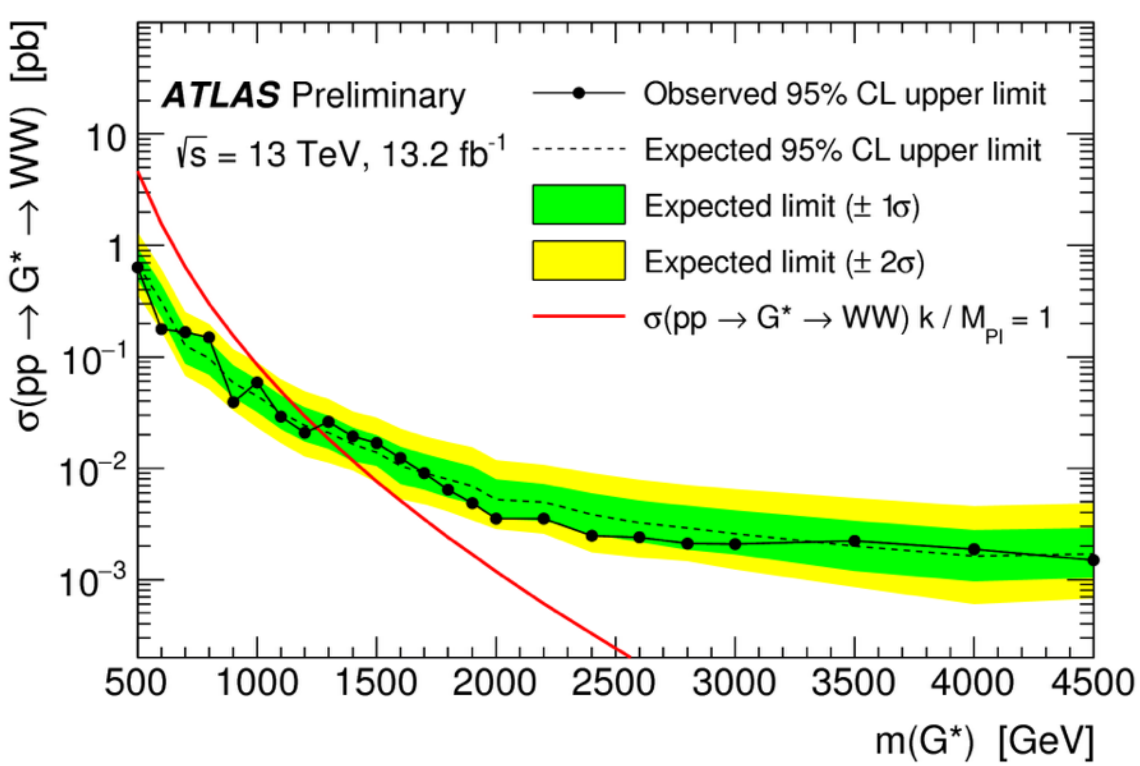




Di-boson resonances semi-leptonic

lvqq





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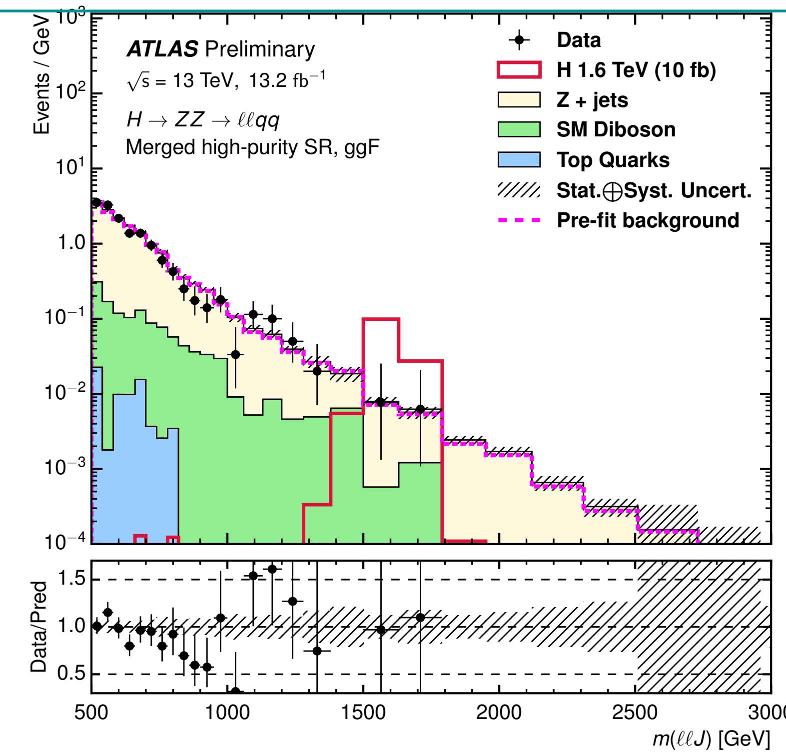

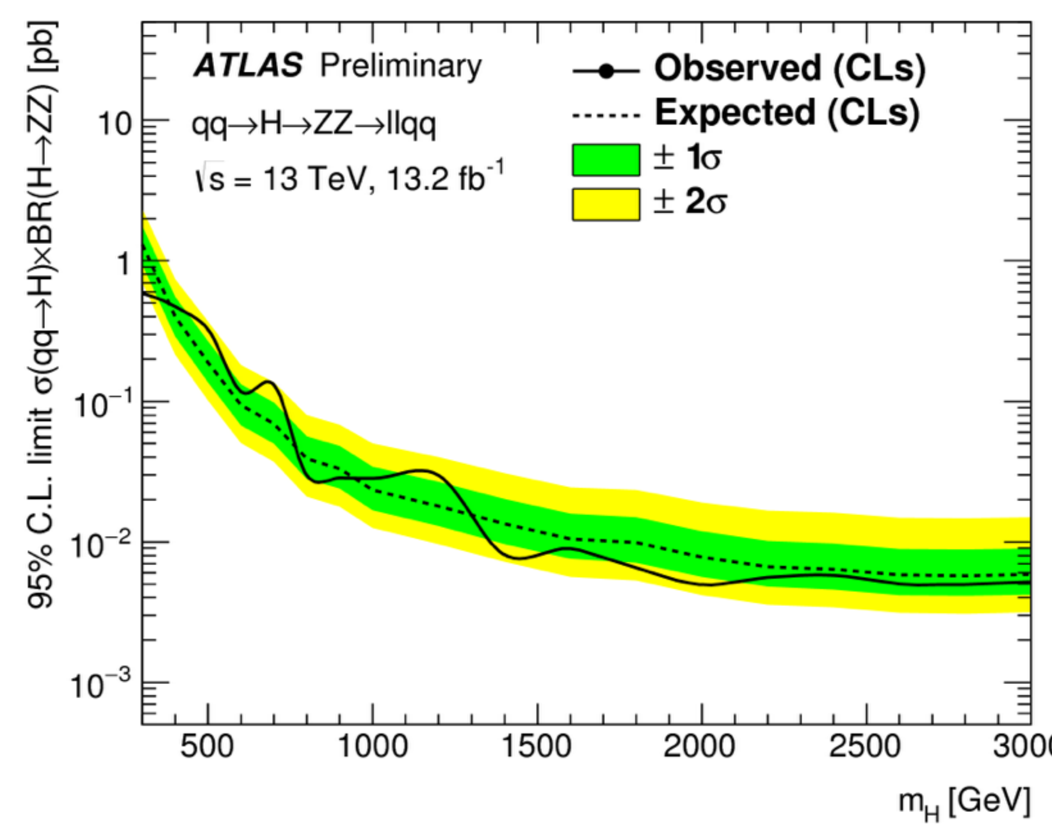

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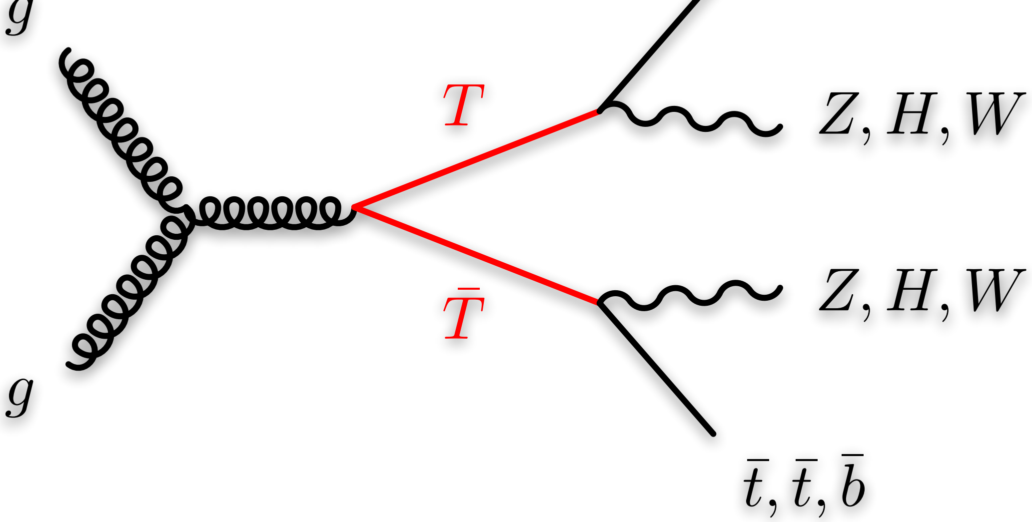
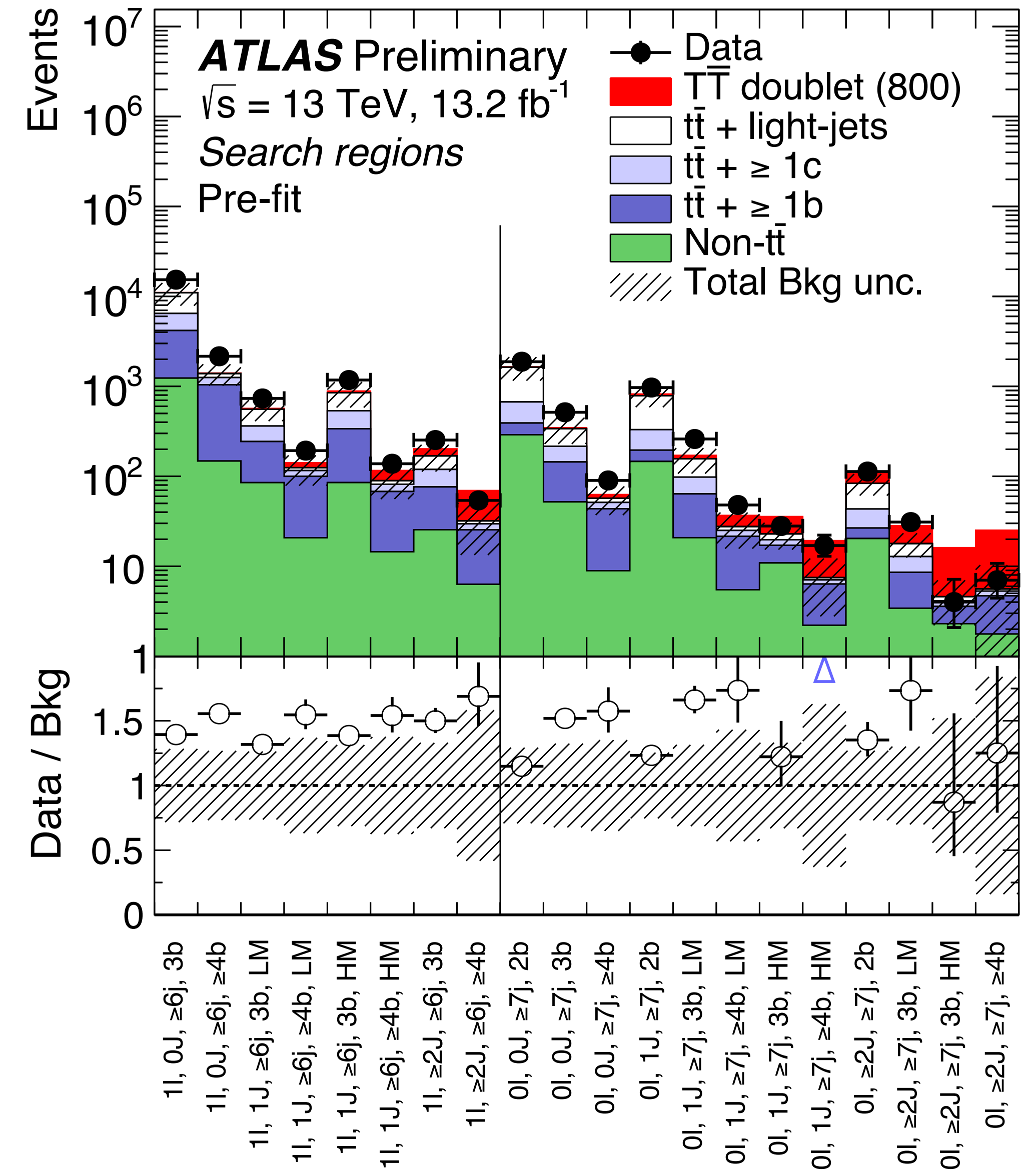




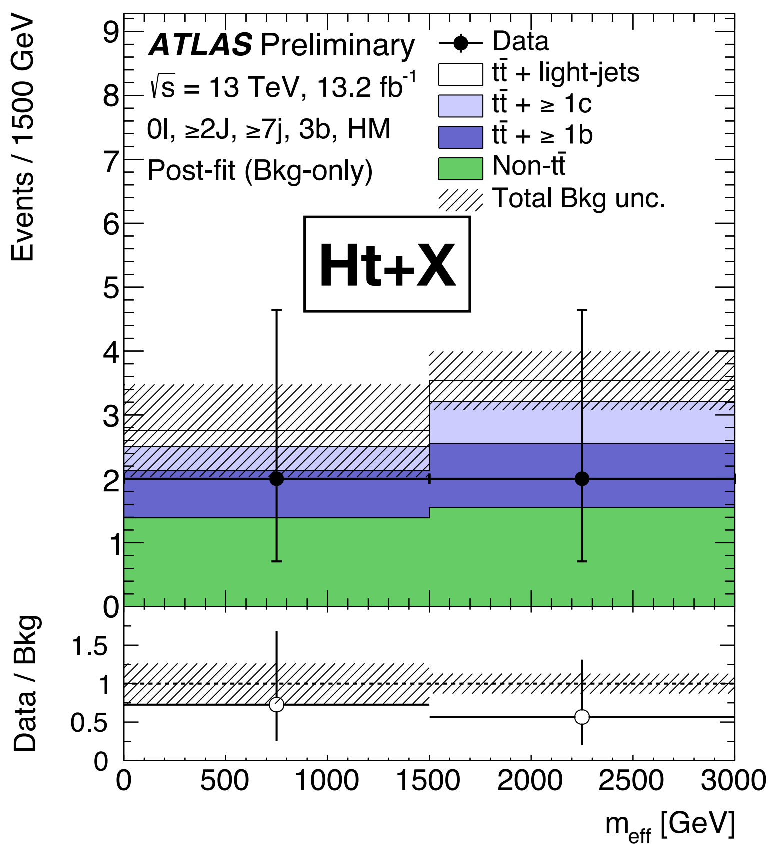
- Here focusing on **vector-like top quark** (T)
- **Final states** typically enriched in third generation quarks, with or without high missing transverse energy and boosted objects
- Decays in 2nd and 1st generation fermions and down-type vector-like quark not considered
- Searches using simultaneously multiple regions and shape analyses

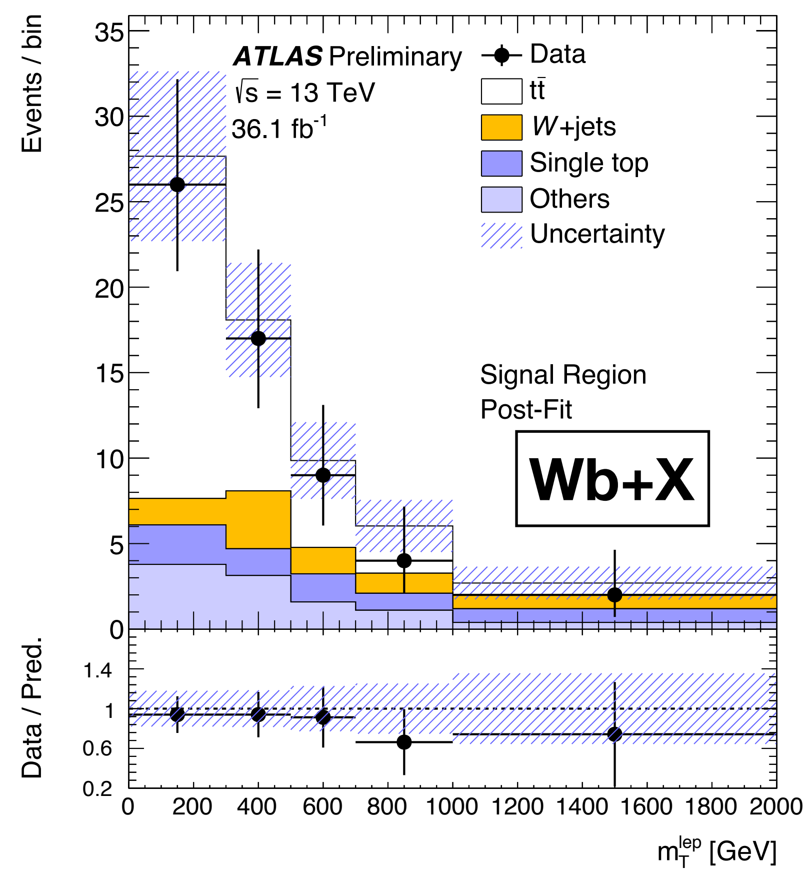
Searches for vector like quarks

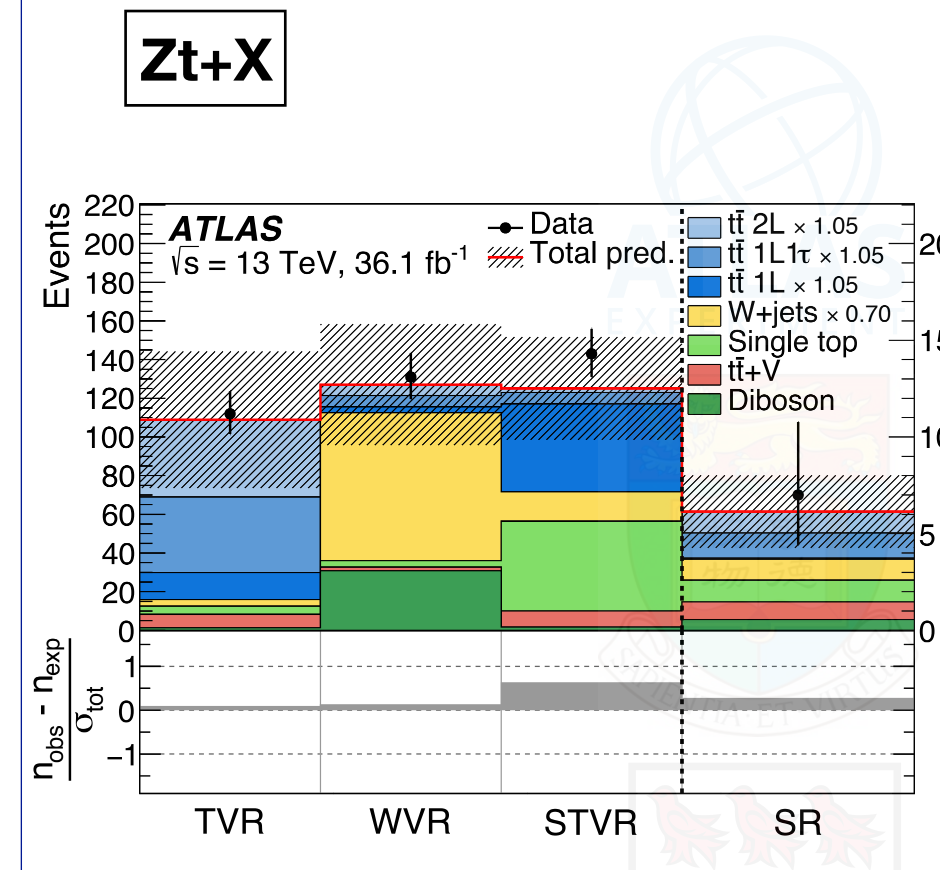
References

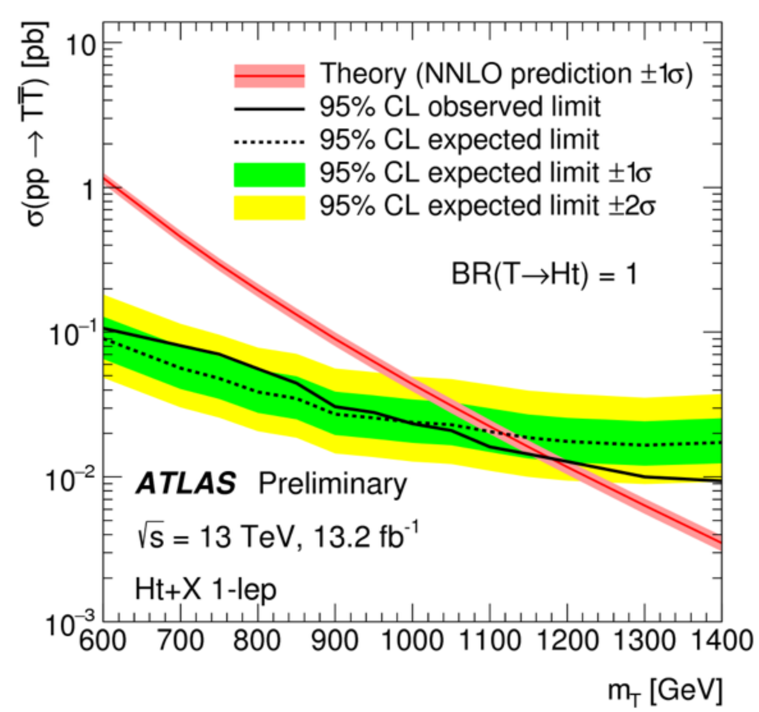
Pair production of vector-like top quarks in l+jets+missing energy arXiv:1705.10751
Search in tt + heavy flavour in l+jets+missing energy ATLAS-CONF-2016-104
Pair production of vector like quarks in l+jets (including b-jet+W-jet) ATLAS-CONF-2016-102

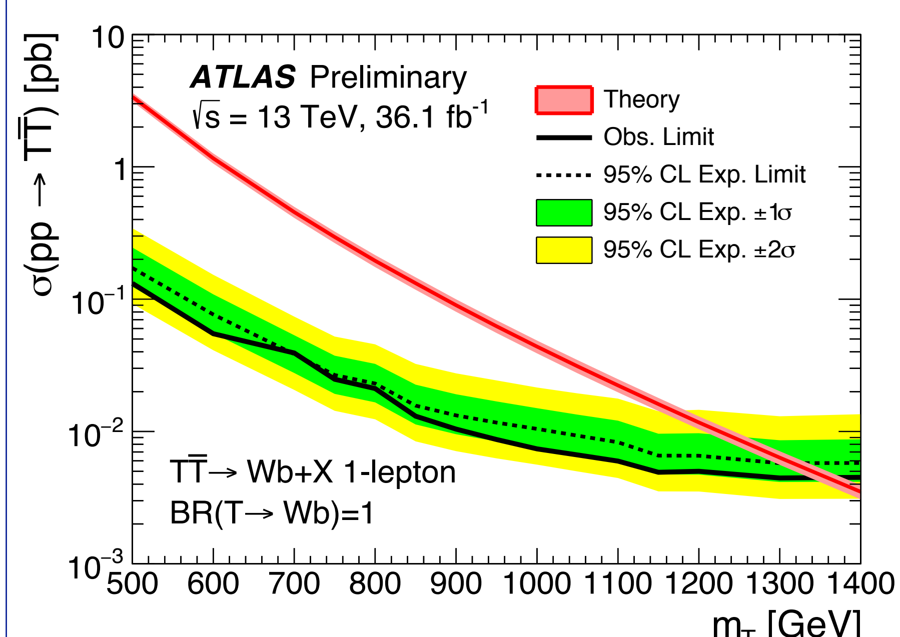
Searches for vector like quarks

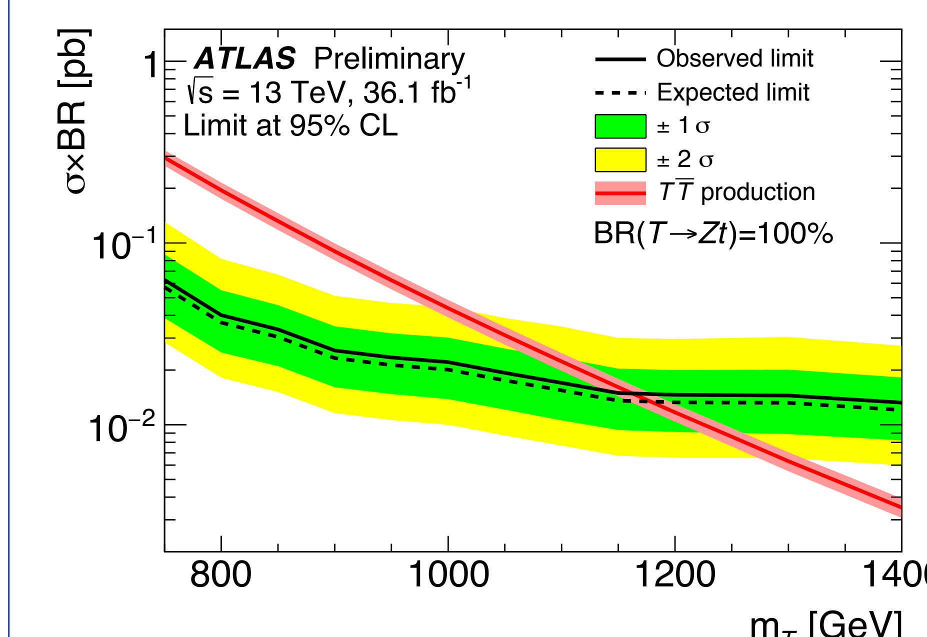




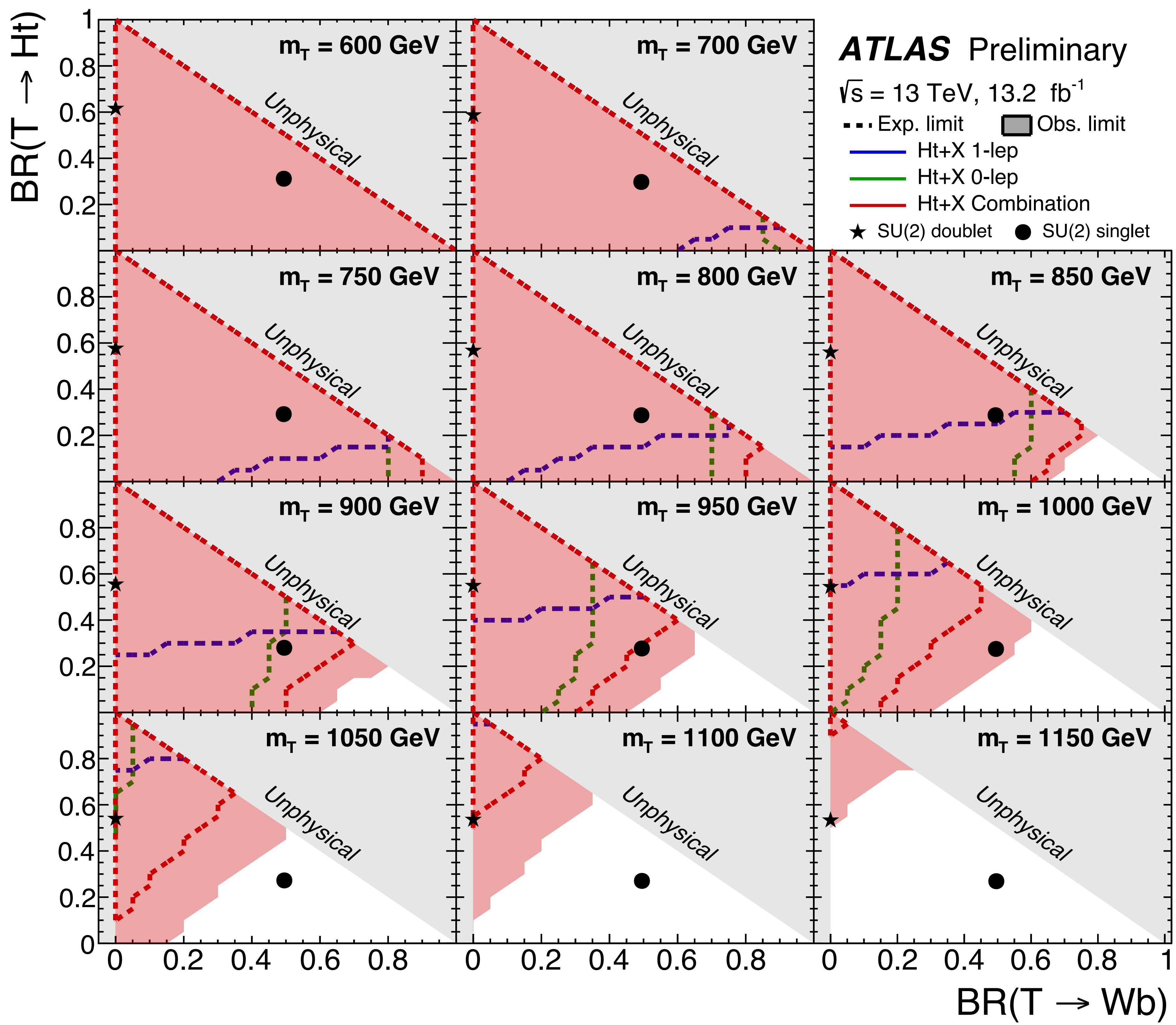








Searches for vector like quarks



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Summary exotics

ATLAS Exotics Searches* - 95% CL Exclusion

Status: August 2016

ATLAS Preliminary

$\int \mathcal{L}\,dt = (3.2 - 20.3)$ fb^{-1} $\sqrt{s}$ = 8, 13 TeV

	Model	ℓ, γ	Jets†	E_T^{miss}	$\int \mathcal{L}\,dt$[fb^{-1}]	Limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	≥ 1 j	Yes	3.2	M_D 6.58 TeV	$n = 2$	1604.07773
	ADD non-resonant $\ell\ell$	2 e, μ	–	–	20.3	M_S 4.7 TeV	$n = 3$ HLZ	1407.2410
	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	–	15.7	M_{th} 8.7 TeV	$n = 6$	ATLAS-CONF-2016-069
	ADD BH high $\sum p_T$	≥ 1 e, μ	≥ 2 j	–	3.2	M_{th} 8.2 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	1606.02265
	ADD BH multijet	–	≥ 3 j	–	3.6	M_{th} 9.55 TeV	$n = 6$, $M_D = 3$ TeV, rot BH	1512.02586
	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 $G_{KK} \rightarrow \gamma\gamma$	2 γ	–	–	3.2	G_{KK} mass 3.2 TeV	$k/\overline{M}_{Pl} = 0.1$	1606.03833
	Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell\nu$	1 e, μ	1 J	Yes	13.2	G_{KK} mass 1.24 TeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2016-062
	Bulk RS $G_{KK} \rightarrow HH \rightarrow bbbb$	–	4 b	–	13.3	G_{KK} mass 360-860 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2016-049
	Bulk RS $g_{KK} \rightarrow tt$	1 e, μ	≥ 1 b, ≥ 1J/2j	Yes	20.3	g_{KK} mass 2.2 TeV	BR = 0.925	1505.07018
	2UED / RPP	1 e, μ	≥ 2 b, ≥ 4 j	Yes	3.2	KK mass 1.46 TeV	Tier (1,1), BR($A^{(1,1)} \rightarrow tt$) = 1	ATLAS-CONF-2016-013
Gauge bosons	SSM $Z' \rightarrow \ell\ell$	2 e, μ	–	–	13.3	Z' mass 4.05 TeV		ATLAS-CONF-2016-045
	SSM $Z' \rightarrow \tau\tau$	2 τ	–	–	19.5	Z' mass 2.02 TeV		1502.07177
	Leptophobic $Z' \rightarrow bb$	–	2 b	–	3.2	Z' mass 1.5 TeV		1603.08791
	SSM $W' \rightarrow \ell\nu$	1 e, μ	–	Yes	13.3	W' mass 4.74 TeV		ATLAS-CONF-2016-061
	HVT $W' \rightarrow WZ \rightarrow qq\nu\nu$ model A	0 e, μ	1 J	Yes	13.2	W' mass 2.4 TeV	$g_V = 1$	ATLAS-CONF-2016-082
	HVT $W' \rightarrow WZ \rightarrow qqqq$ model B	–	2 J	–	15.5	W' mass 3.0 TeV	$g_V = 3$	ATLAS-CONF-2016-055
	HVT $V' \rightarrow WH/ZH$ model B	multi-channel			3.2	V' mass 2.31 TeV	$g_V = 3$	1607.05621
	LRSM $W'_R \rightarrow tb$	1 e, μ	2 b, 0-1 j	Yes	20.3	W' mass 1.92 TeV		1410.4103
	LRSM $W'_R \rightarrow tb$	0 e, μ	≥ 1 b, 1 J	–	20.3	W' mass 1.76 TeV		1408.0886
CI	CI $qqqq$	–	2 j	–	15.7	Λ 19.9 TeV	$\eta_{LL} = -1$	ATLAS-CONF-2016-069
	CI $\ell\ell qq$	2 e, μ	–	–	3.2	Λ 25.2 TeV	$\eta_{LL} = -1$	1607.03669
	CI $uutt$	2(SS)/≥3 e,μ	≥1 b, ≥1 j	Yes	20.3	Λ 4.9 TeV	$\lvert C_{RR}\rvert = 1$	1504.04605
DM	Axial-vector mediator (Dirac DM)	0 e, μ	≥ 1 j	Yes	3.2	m_A 1.0 TeV	g_q=0.25, g_χ=1.0, $m(\chi) < 250$ GeV	1604.07773
	Axial-vector mediator (Dirac DM)	0 e, μ, 1 γ	1 j	Yes	3.2	m_A 710 GeV	g_q=0.25, g_χ=1.0, $m(\chi) < 150$ GeV	1604.01306
	$ZZ\chi\chi$ EFT (Dirac DM)	0 e, μ	1 J, ≤ 1 j	Yes	3.2	M_* 550 GeV	$m(\chi) < 150$ GeV	ATLAS-CONF-2015-080
LQ	Scalar LQ 1st gen	2 e	≥ 2 j	–	3.2	LQ mass 1.1 TeV	$\beta = 1$	1605.06035
	Scalar LQ 2nd gen	2 μ	≥ 2 j	–	3.2	LQ mass 1.05 TeV	$\beta = 1$	1605.06035
	Scalar LQ 3rd gen	1 e, μ	≥1 b, ≥3 j	Yes	20.3	LQ mass 640 GeV	$\beta = 0$	1508.04735
Heavy quarks	VLQ $TT \rightarrow Ht + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	T mass 855 GeV	T in (T,B) doublet	1505.04306
	VLQ $YY \rightarrow Wb + X$	1 e, μ	≥ 1 b, ≥ 3 j	Yes	20.3	Y mass 770 GeV	Y in (B,Y) doublet	1505.04306
	VLQ $BB \rightarrow Hb + X$	1 e, μ	≥ 2 b, ≥ 3 j	Yes	20.3	B mass 735 GeV	isospin singlet	1505.04306
	VLQ $BB \rightarrow Zb + X$	2/≥3 e, μ	≥2/≥1 b	–	20.3	B mass 755 GeV	B in (B,Y) doublet	1409.5500
	VLQ $QQ \rightarrow WqWq$	1 e, μ	≥ 4 j	Yes	20.3	Q mass 690 GeV		1509.04261
	VLQ $T_{5/3} T_{5/3} \rightarrow WtWt$	2(SS)/≥3 e,μ	≥1 b, ≥1 j	Yes	3.2	$T_{5/3}$ mass 990 GeV		ATLAS-CONF-2016-032
Excited fermions	Excited quark $q^* \rightarrow q\gamma$	1 γ	1 j	–	3.2	q^* mass 4.4 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1512.05910
	Excited quark $q^* \rightarrow qg$	–	2 j	–	15.7	q^* mass 5.6 TeV	only u^* and d^*, $\Lambda = m(q^*)$	ATLAS-CONF-2016-069
	Excited quark $b^* \rightarrow bg$	–	1 b, 1 j	–	8.8	b^* mass 2.3 TeV		ATLAS-CONF-2016-060
	Excited quark $b^* \rightarrow Wt$	1 or 2 e, μ	1 b, 2-0 j	Yes	20.3	b^* mass 1.5 TeV	$f_g = f_L = f_R = 1$	1510.02664
	Excited lepton ℓ^*	3 e, μ	–	–	20.3	ℓ^* mass 3.0 TeV	$\Lambda = 3.0$ TeV	1411.2921
	Excited lepton ν^*	3 e, μ, τ	–	–	20.3	ν^* mass 1.6 TeV	$\Lambda = 1.6$ TeV	1411.2921
Other	LSTC $a_T \rightarrow W\gamma$	1 e, μ, 1 γ	–	Yes	20.3	a_T mass 960 GeV		1407.8150
	LRSM Majorana ν	2 e, μ	2 j	–	20.3	N^0 mass 2.0 TeV	$m(W_R) = 2.4$ TeV, no mixing	1506.06020
	Higgs triplet $H^{\pm\pm} \rightarrow ee$	2 e (SS)	–	–	13.9	$H^{\pm\pm}$ mass 570 GeV	DY production, BR($H_L^{\pm\pm} \rightarrow ee$)=1	ATLAS-CONF-2016-051
	Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$	3 e, μ, τ	–	–	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, BR($H_L^{\pm\pm} \rightarrow \ell\tau$)=1	1411.2921
	Monotop (non-res prod)	1 e, μ	1 b	Yes	20.3	spin-1 invisible particle mass 657 GeV	$a_{non-res} = 0.2$	1410.5404
	Multi-charged particles	–	–	–	20.3	multi-charged particle mass 785 GeV	DY production, $\lvert q\rvert = 5e$	1504.04188
	Magnetic monopoles	–	–	–	7.0	monopole mass 1.34 TeV	DY production, $\lvert g\rvert = 1g_D$, spin 1/2	1509.08059

Legend: $\sqrt{s}$ = 8 TeV (green) | $\sqrt{s}$ = 13 TeV (yellow)

Mass scale [TeV] (axis: 10^{-1}, 1, 10)

*Only a selection of the available mass limits on new states or phenomena is shown. Lower bounds are specified only when explicitly not excluded.

†Small-radius (large-radius) jets are denoted by the letter j (J).

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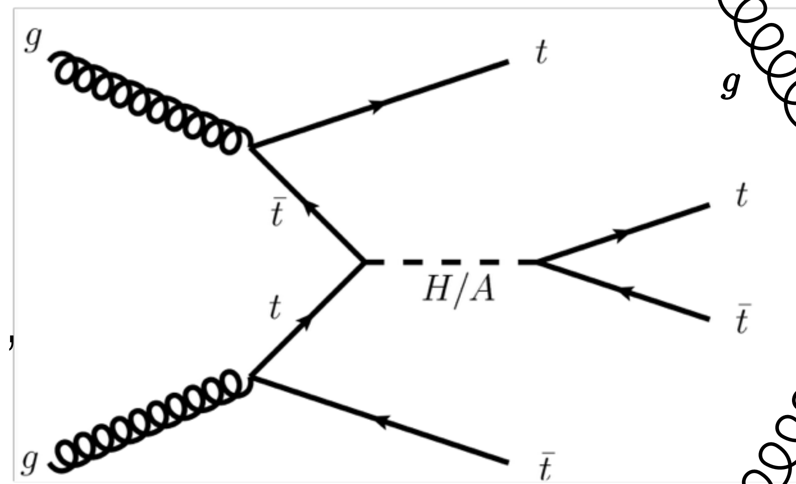
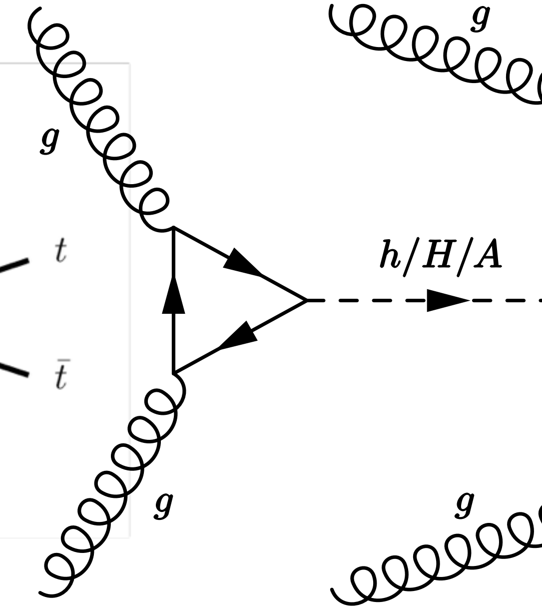
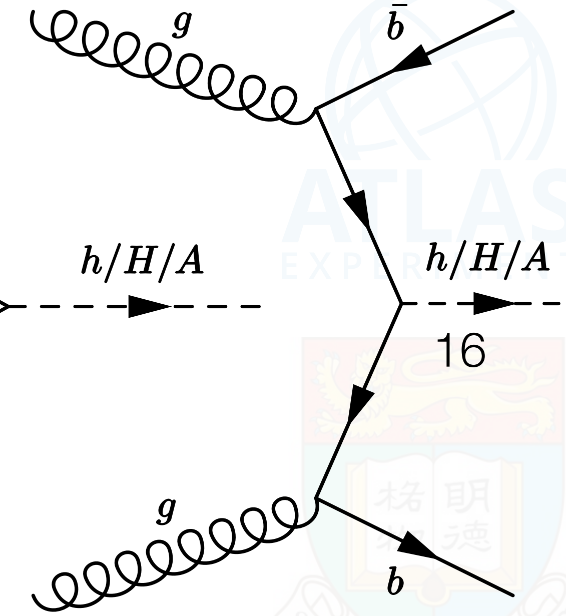
- Considers several production modes and decay channels, here focusing on:
- **Production modes:** gluon-fusion, b-associated, top-associated
- **Decays:** pairs of photons, taus, top-quarks, tau-leptons



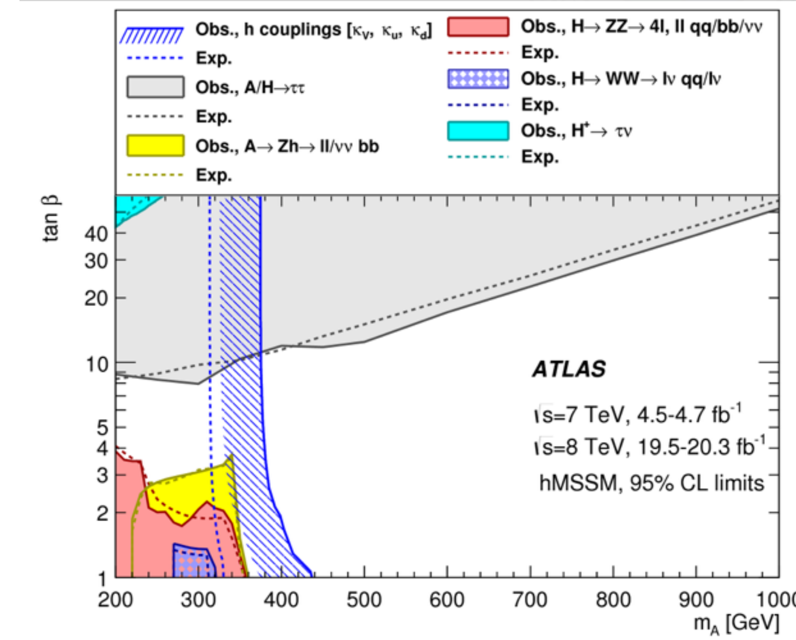




Interpretation in 2HDM or simplified scenarios MSSM-inspired

Low mass constraints dominated by Standard Model Higgs boson coupling measurement

Weak constraints for $m_H > 2\ m_{top}$



Searches for exotic neutral Higgs bosons*

See talk by Damian Alvarez Piqueras

References

Search for scalar diphoton resonances ATLAS-CONF-2016-059

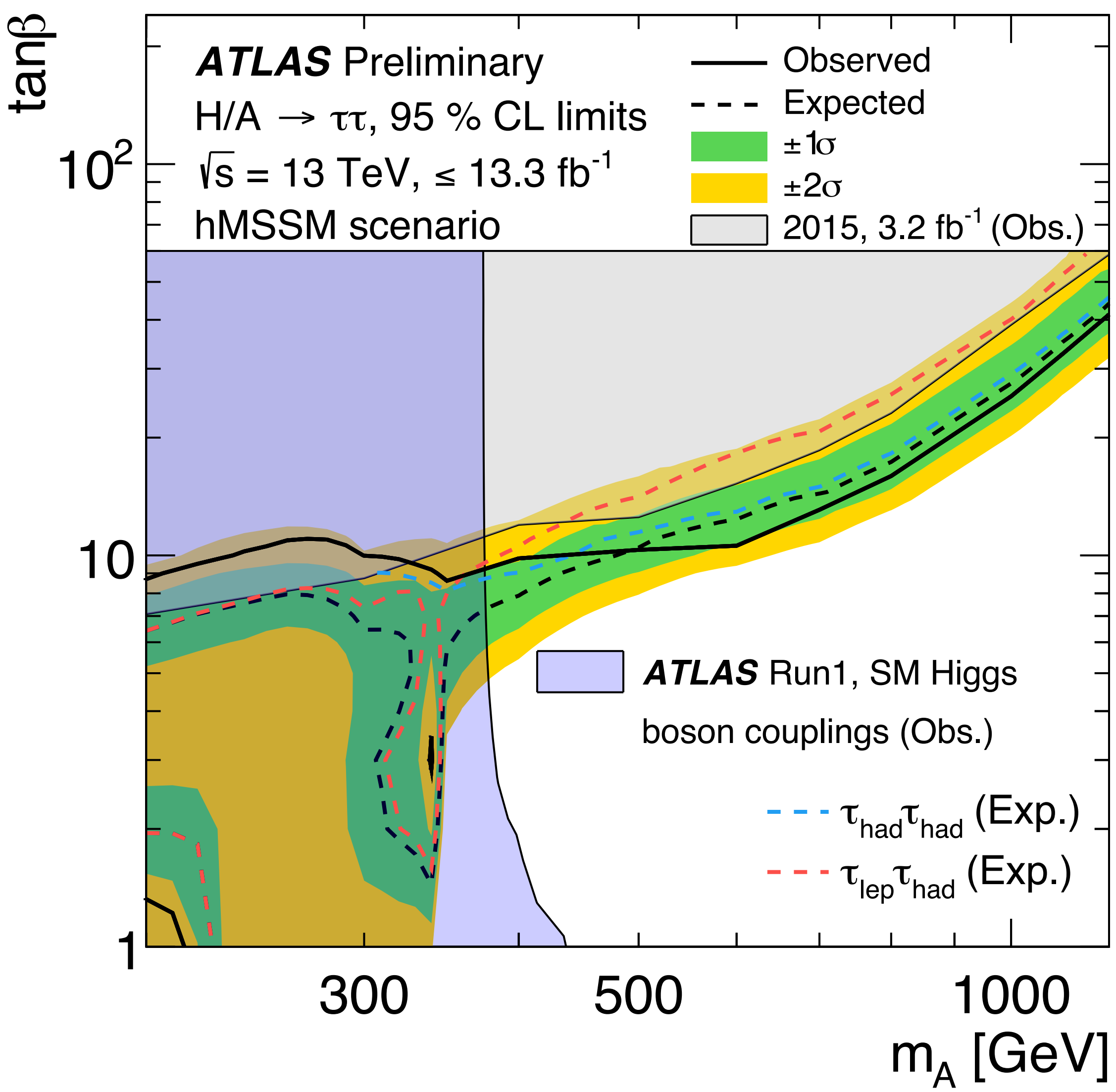
Search for MSSM Higgs in tau-tau resonances ATLAS-CONF-2016-085

Search for scalar A/H to top quark pair (8 TeV) ATLAS-CONF-2016-073

Other searches for exotic neutral Higgs bosons

Search for H→ττ in gluon fusion and b-associated production

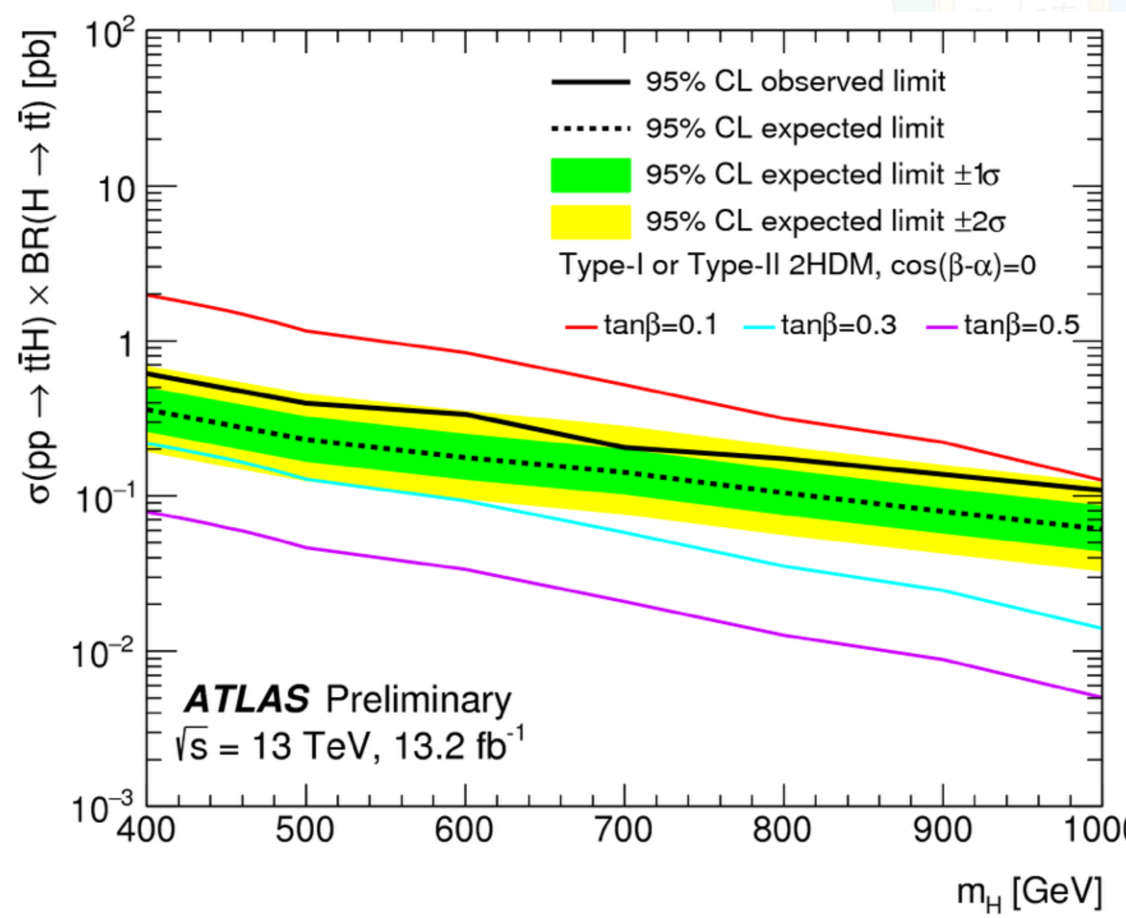
Excludes a wide region of the parameter space in hMSSM



Search for H→tt in tt-associated production

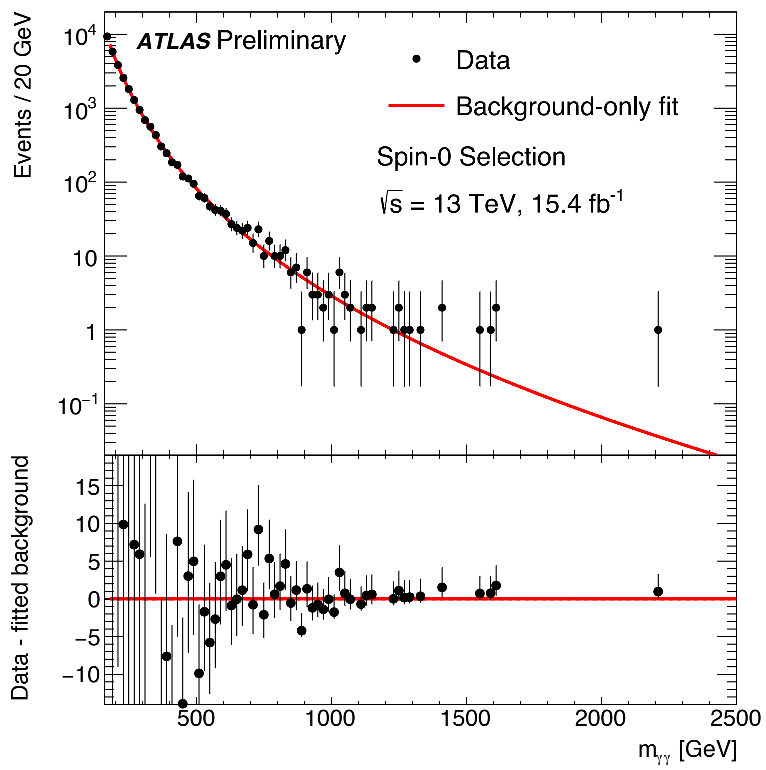
Probes low tanβ 2HDM benchmarks

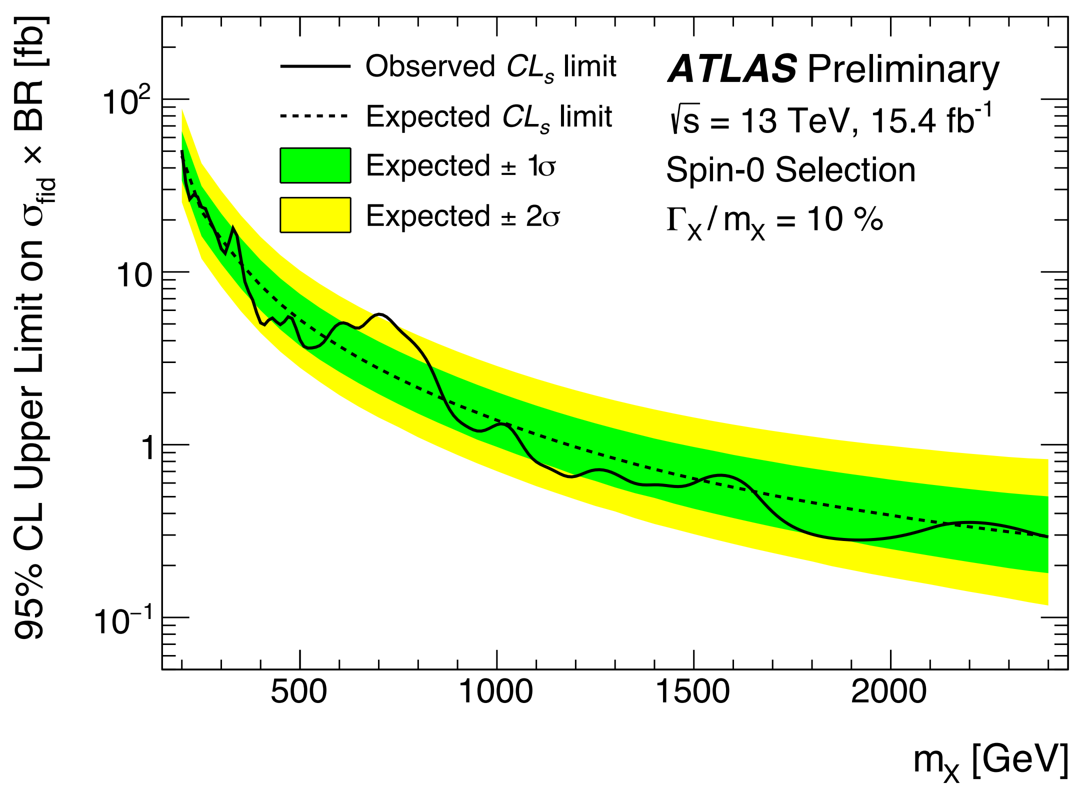
Overcomes the large interference with the Standard Model background observed for gluon fusion H→tt searches

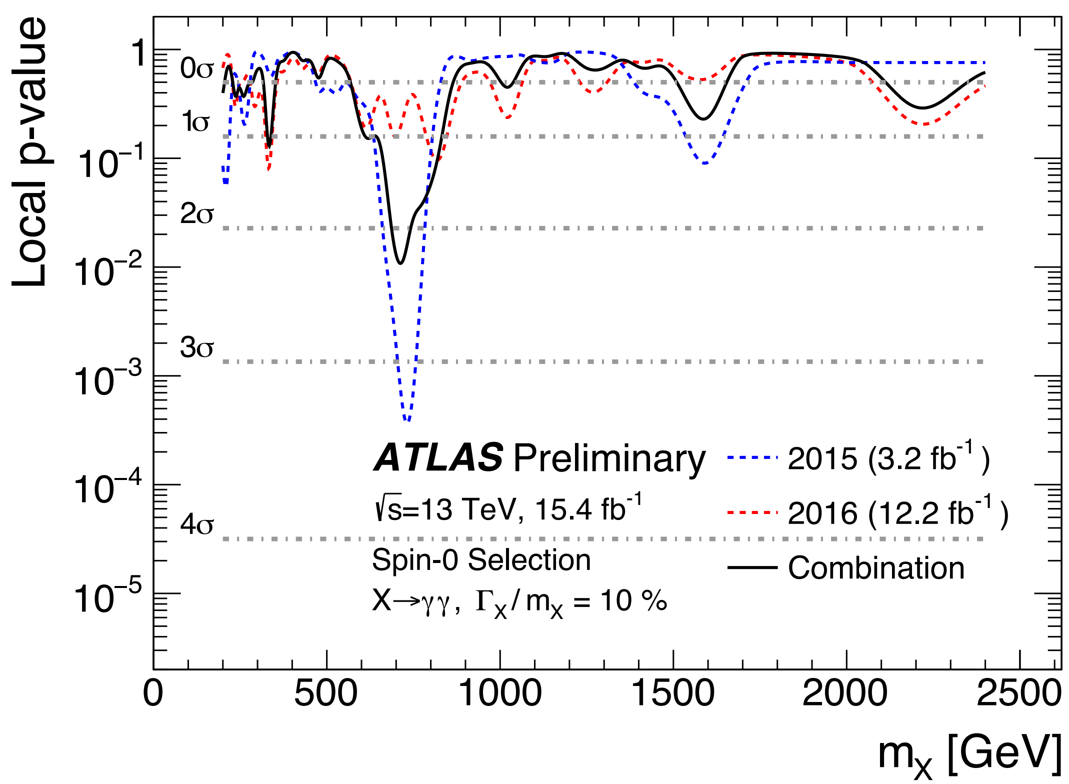


Other searches for exotic neutral Higgs bosons

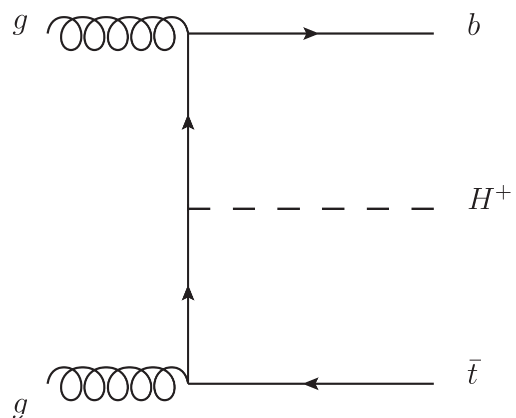
- **Strategy** based on the clear expect topology
- High E_T photons, **mass resolution** between 2.3 GeV to 15 GeV in the mass range between 0.2 to 2 TeV
- **Reanalysed 2015** data lead to a 3.4σ local significance excess at 730 GeV
- **No significant excess in 2016 data**
- Maximum global excess in the combined 2015+2016 dataset is below 1σ







Searches for charged Higgs bosons

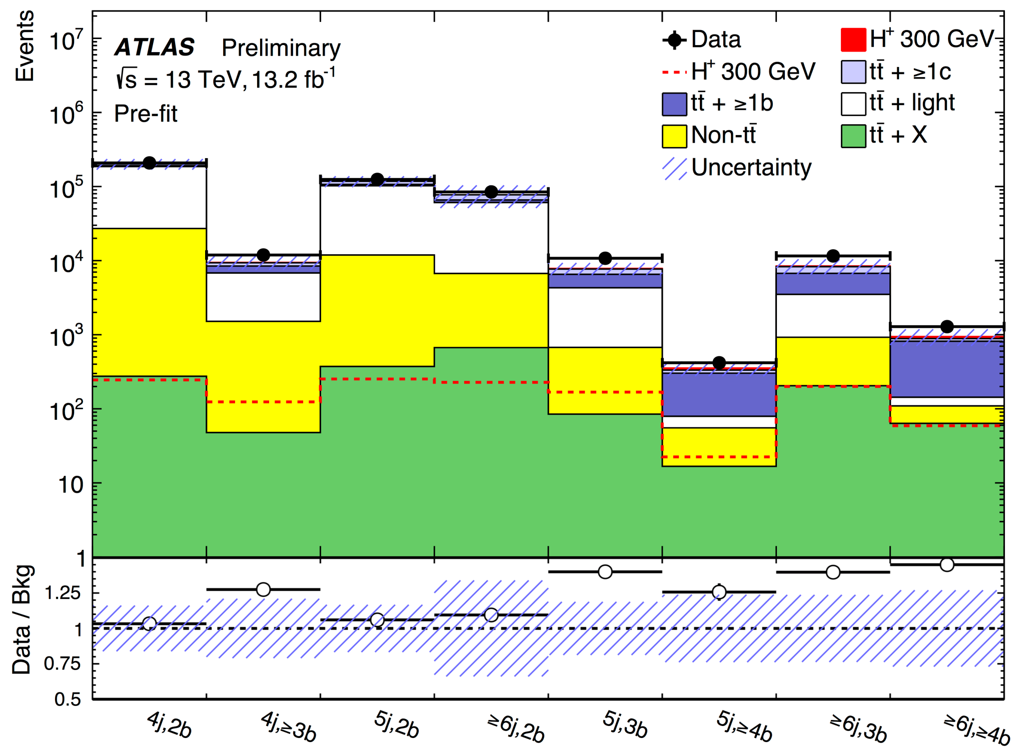


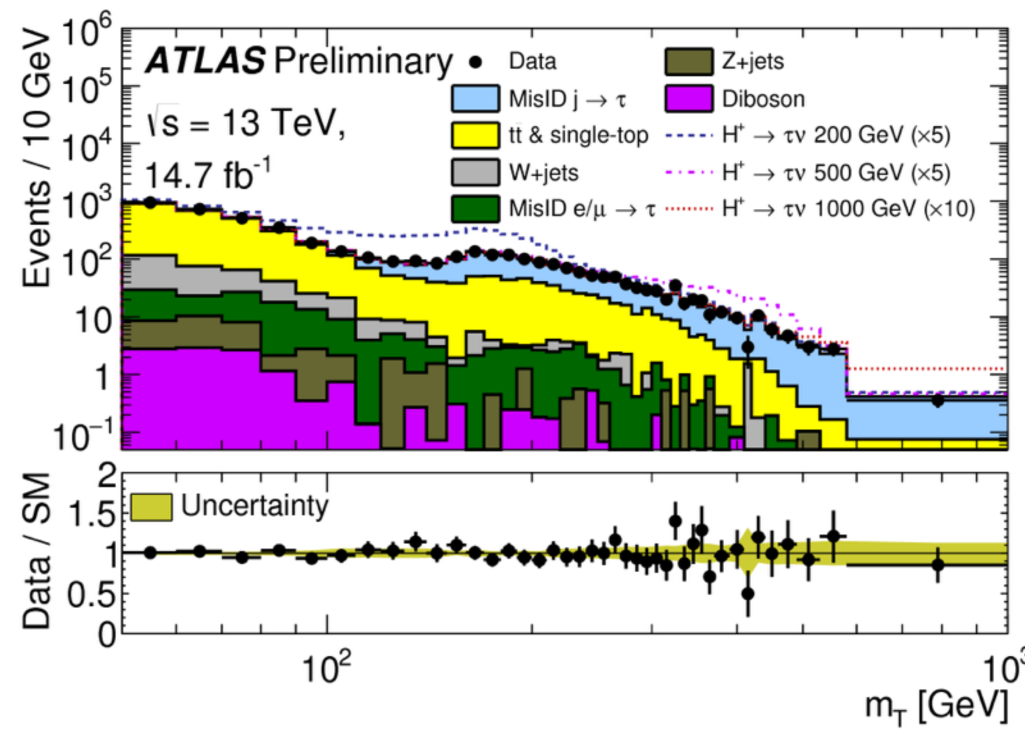
Focus on high mass charged Higgs boson (m_{H^+}>200 GeV)

Production modes: top-bottom associated

Decays: τν leptons (m_T based analysis) and top-bottom quarks (MVA analysis)

The searches target 2HDM type I/II scenarios





References

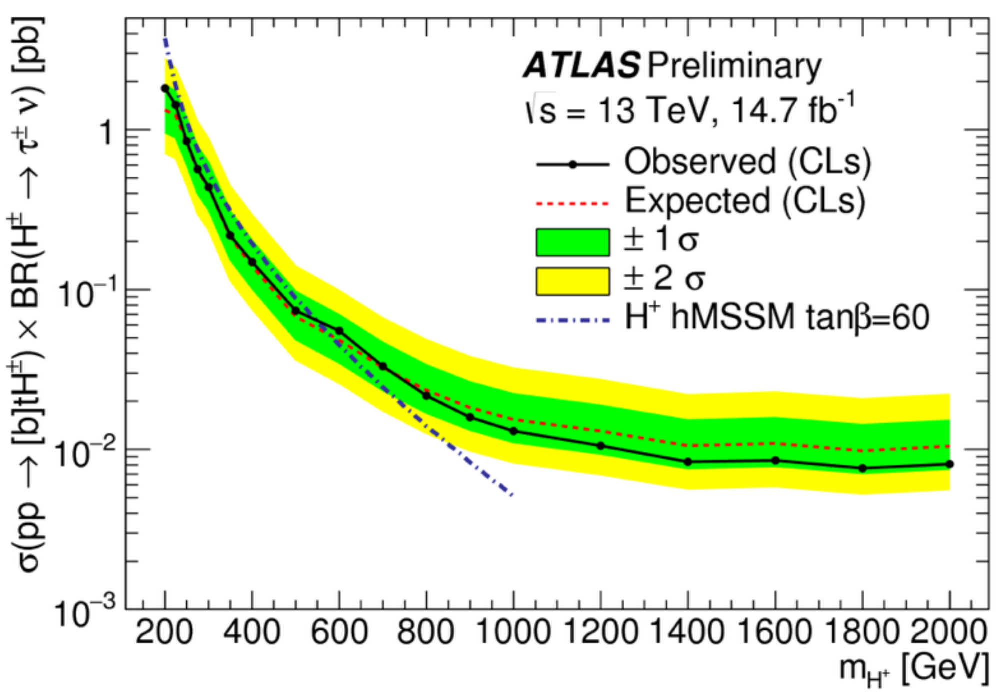
Search for charged higgs in t+b channel ATLAS-CONF-2016-089

Search for charged higgs in tag + jets channel ATLAS-CONF-2016-088

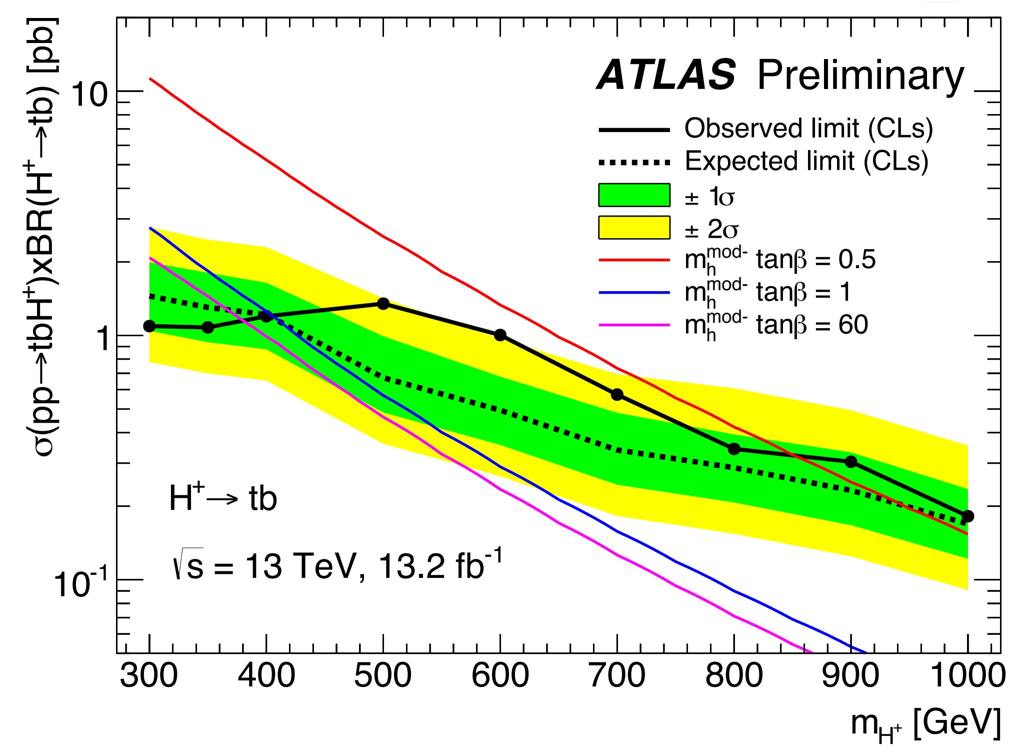
Searches for charged Higgs bosons

Model independent exclusion

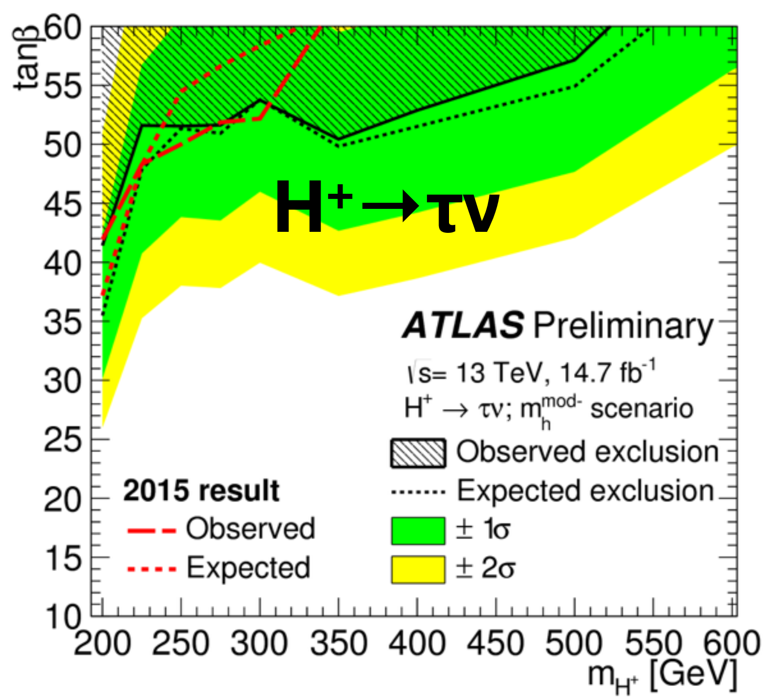
$H^+ \to \tau\nu$

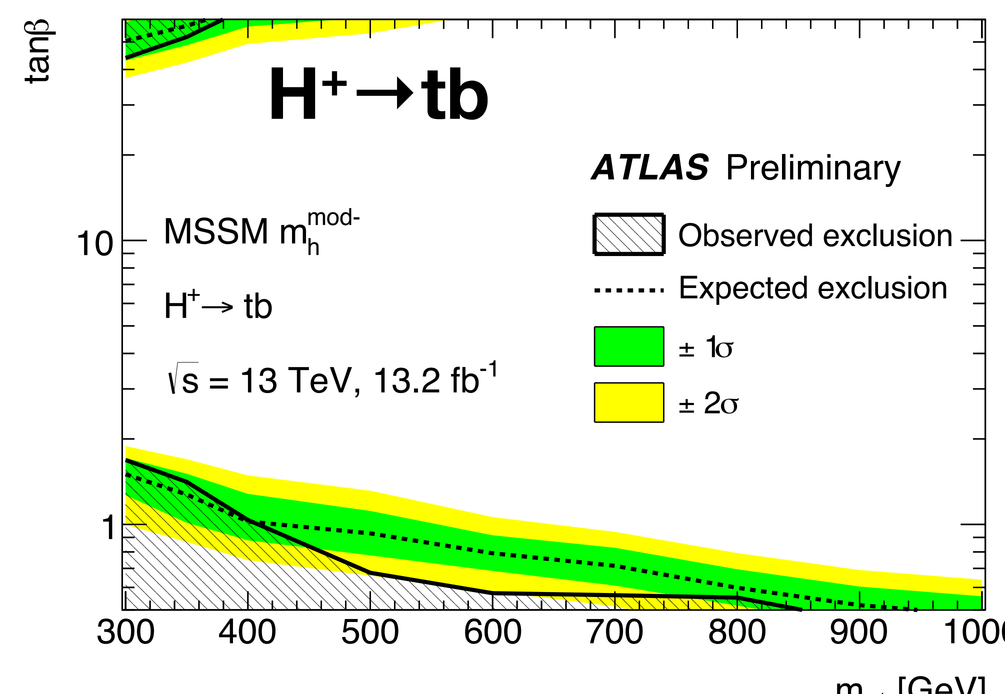


$H^+ \to tb$

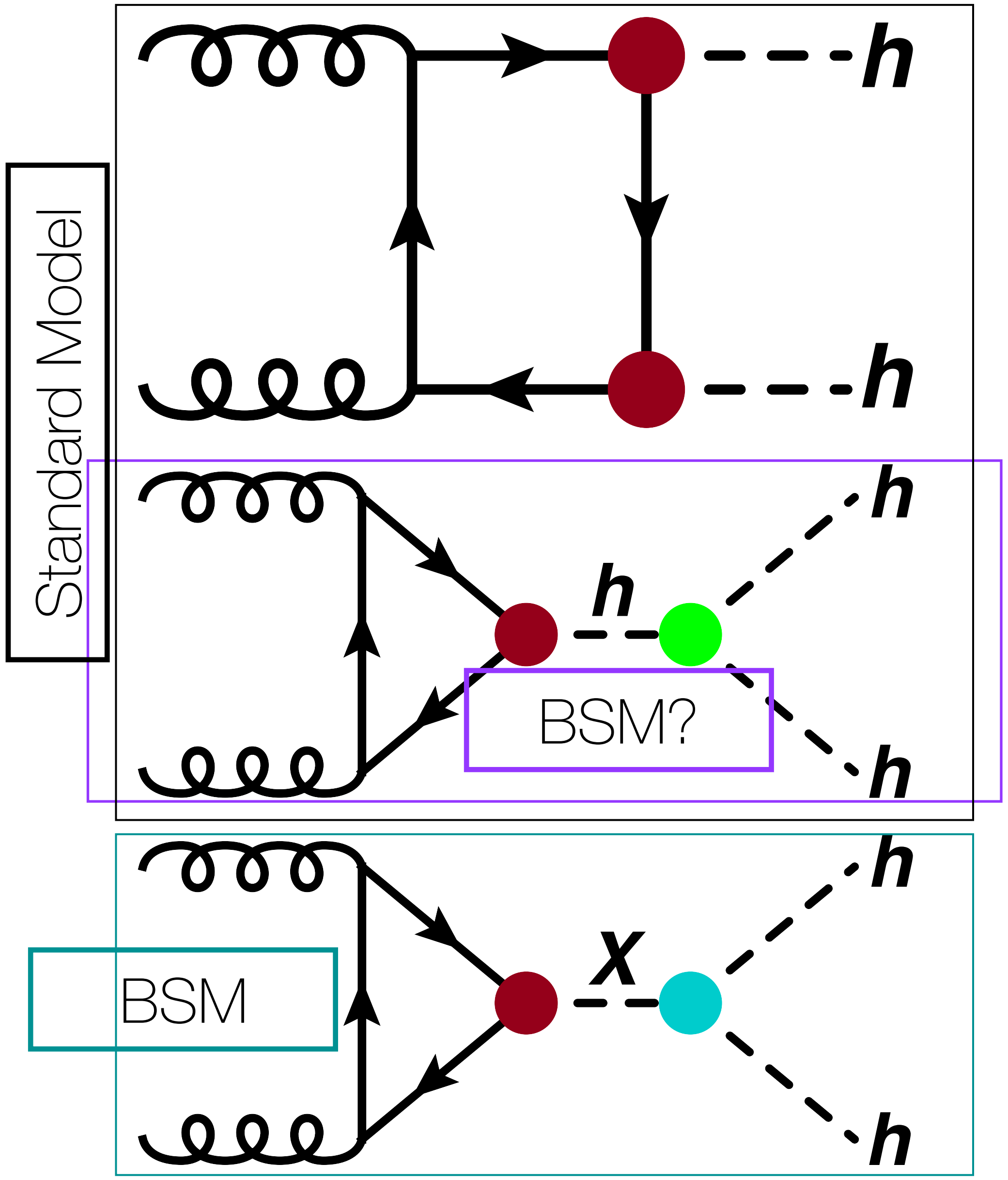


Interpretation in the hMMSM



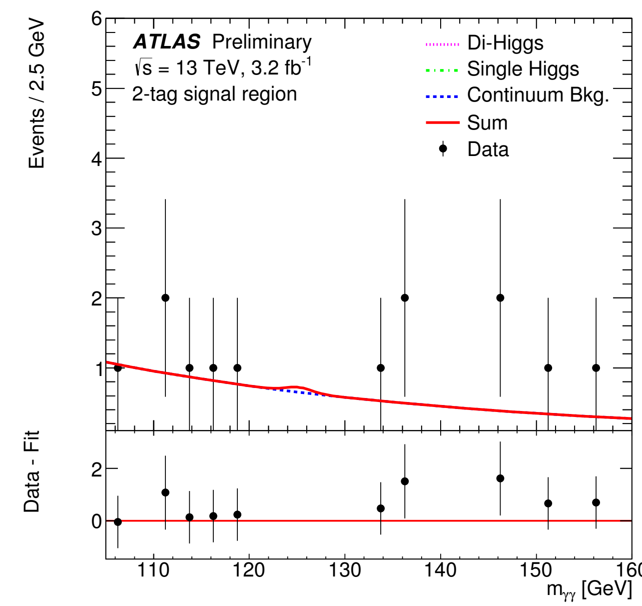


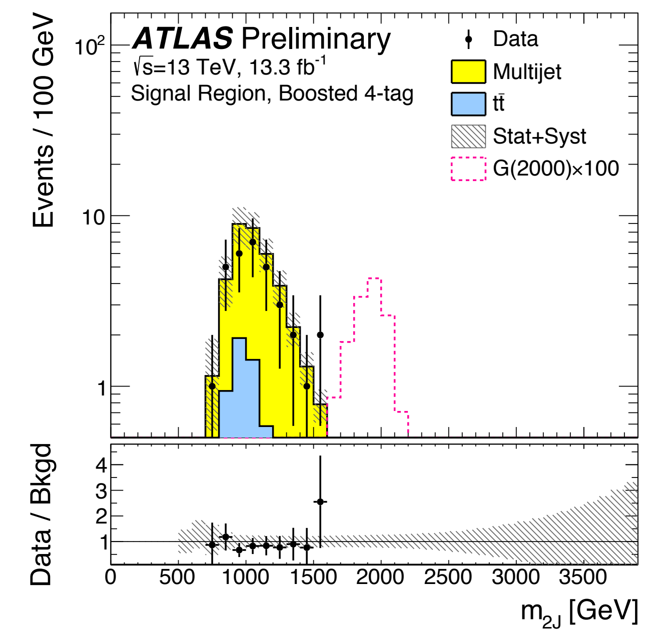
author: Nicola Orlando | The University of Hong Kong
presenter: Alison Elliot | The University of Victoria



Standard Model hh rate is expected to not to be observable at LHC with the current dataset due to the small cross section and negative interference between the production modes→σ(hh)~33 fb

BSM can be tested for Non- resonant production (via anomalous trilinear coupling) and Resonant production of new particles





Anomalous di-Higgs searches

References
search for di-higgs to bbbb ATLAS-CONF-2016-049
search for di-higgs to bbγγ ATLAS-CONF-2016-004

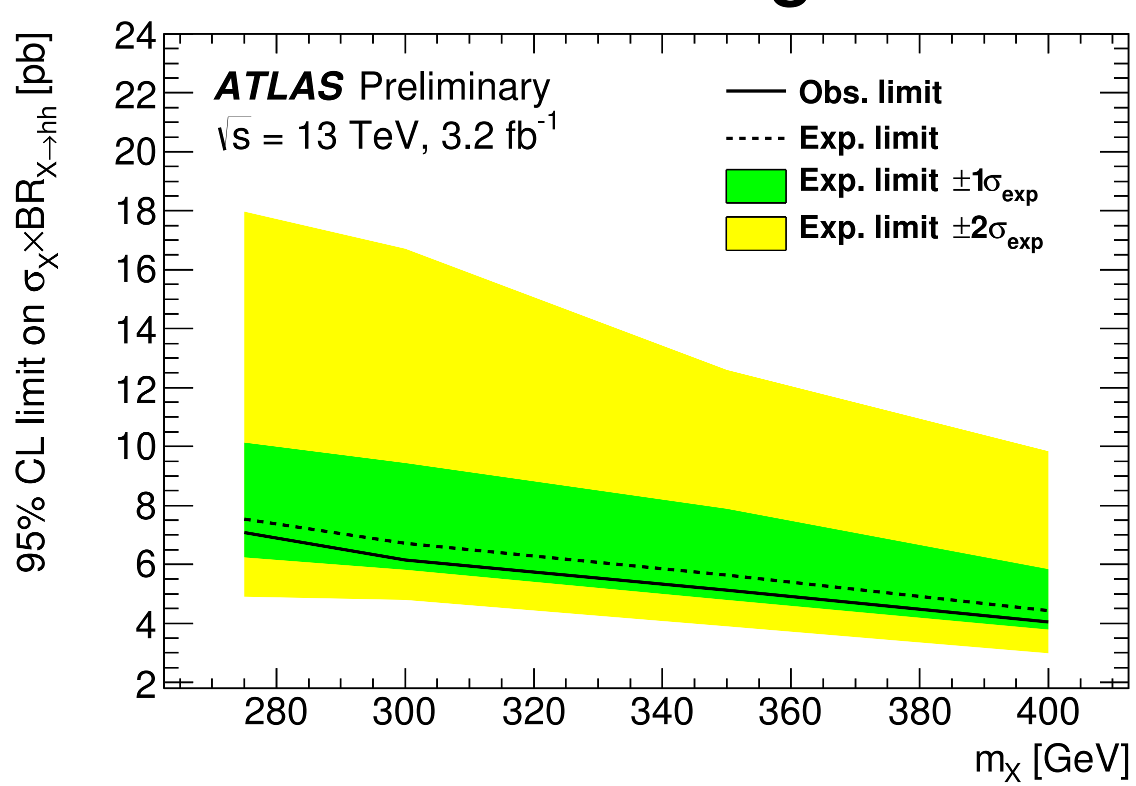
Anomalous di-Higgs searches

hh→bbγγ

Exploiting the high branching ration of h→bb (58%) and resolution for the h→γγ

Non resonant signal with 3.9 pb cross section times branching ratio is excluded

Resonant signal

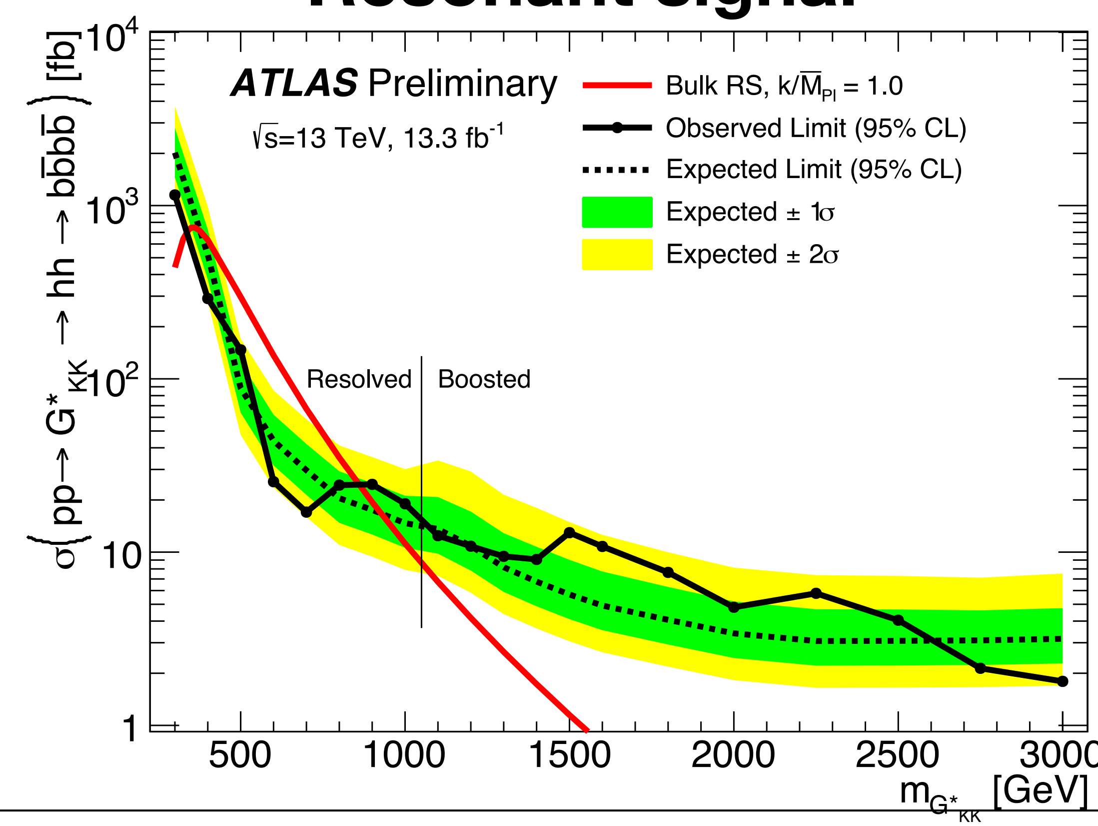


hh→bbbb

Combining a search with resolved and boosted-merged topologies

Non resonant signal with 330 fb cross section times branching ratio is excluded

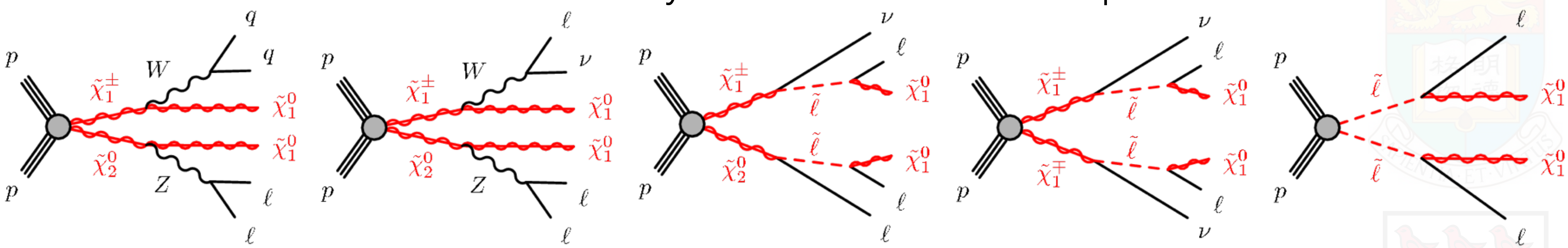
Resonant signal



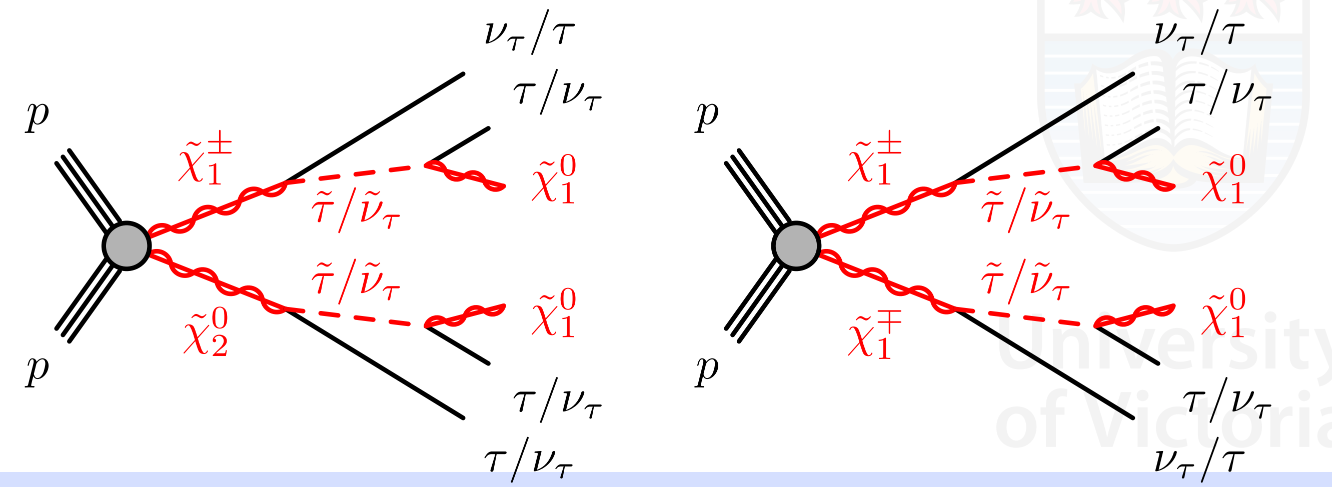
author: Nicola Orlando | The University of Hong Kong
presenter: Alison Elliot | The University of Victoria

Searching for pair production of electroweakinos: pair of charginos, chargino plus next-to-lightest neutralino, and sleptons pairs

Small cross section due to lack of colour charge of the electroweakinos, cross sections dictated by the assumed mass spectrum



Searches using hadronic taus to target **staus** and **stau-neutrinos** mediated decay chains



SUSY electroweak production

See talk by Huajie Cheng

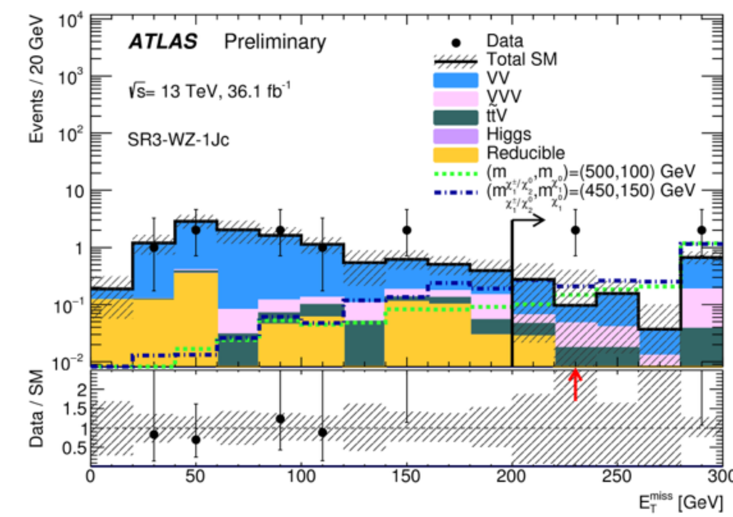
References

SUSY EW with 2 or 3 leptons in final state ATLAS-CONF-2017-039

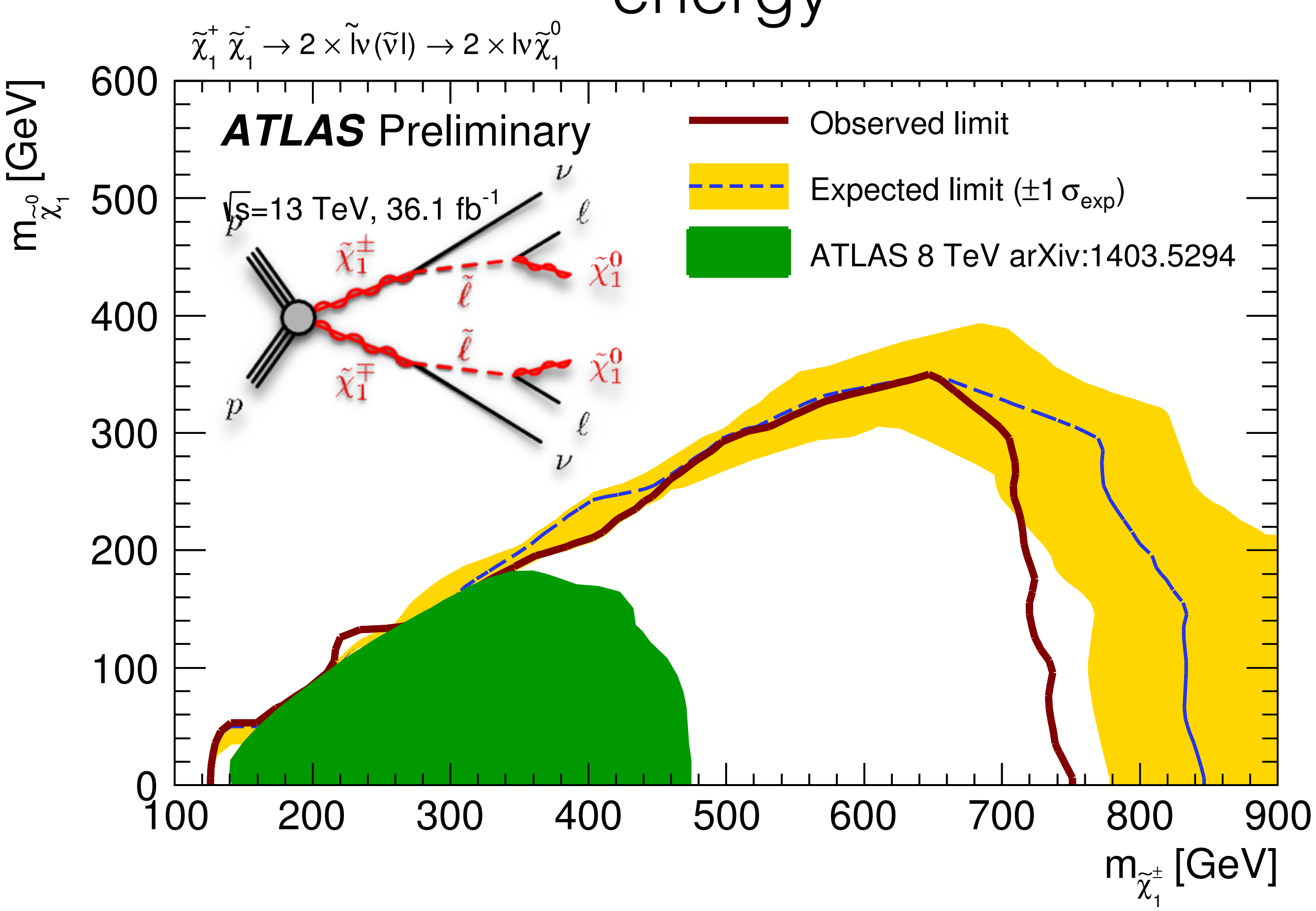
SUSY EW charginos and neutralinos search with taus in final state ATLAS-CONF-2017-035

SUSY electroweak production

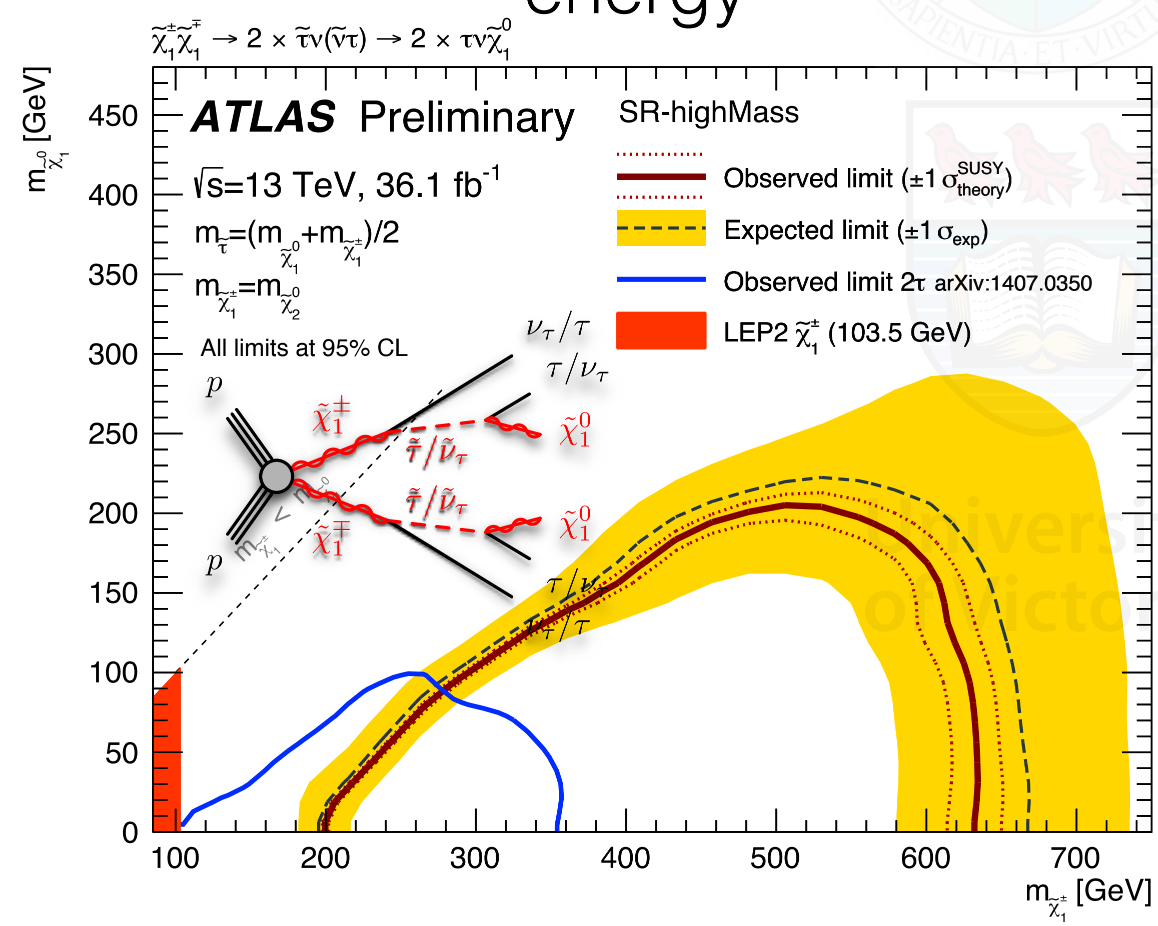
Multiple signal regions based on **lepton** multiplicities and **large missing transverse energy**
Signatures typically involving **low jet multiplicities**



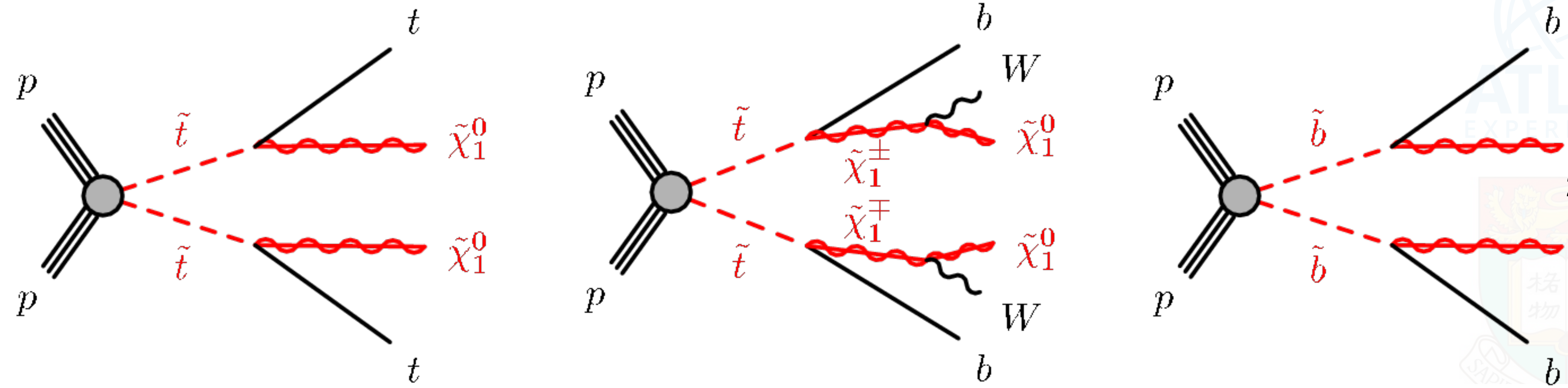
2leptons+high missing transverse energy

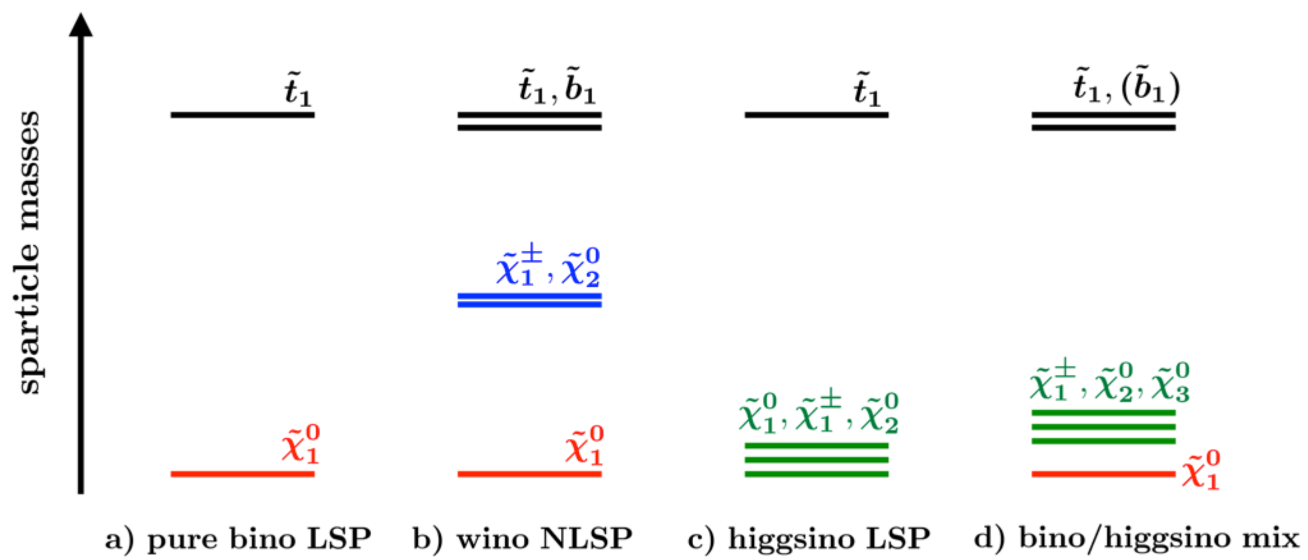


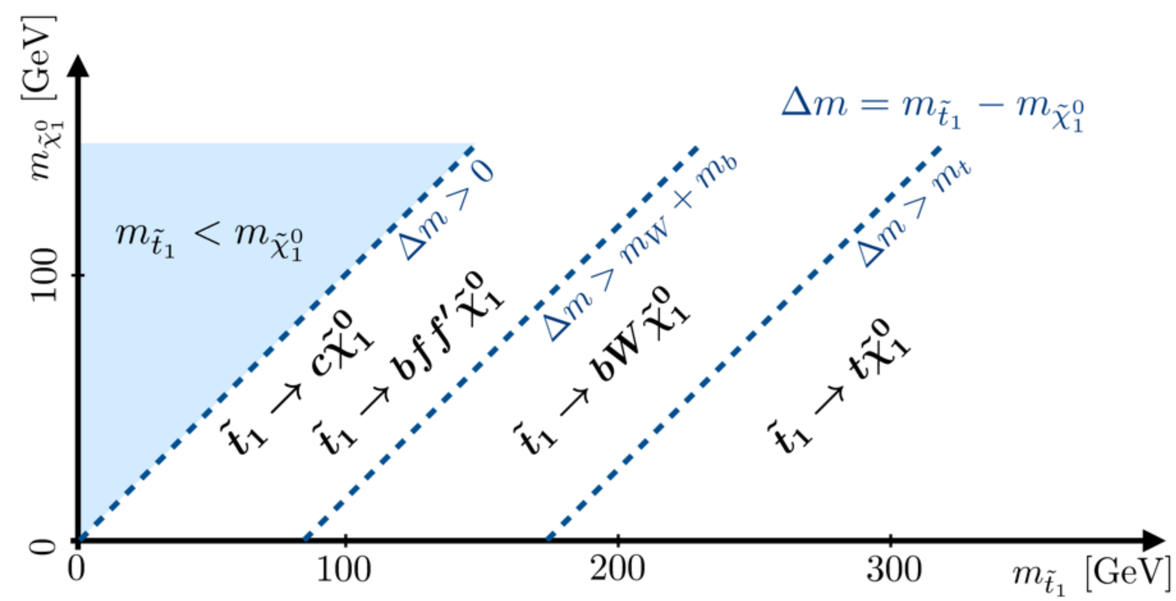
2taus+high missing transverse energy



author: Nicola Orlando | The University of Hong Kong
presenter: Alison Elliot | The University of Victoria







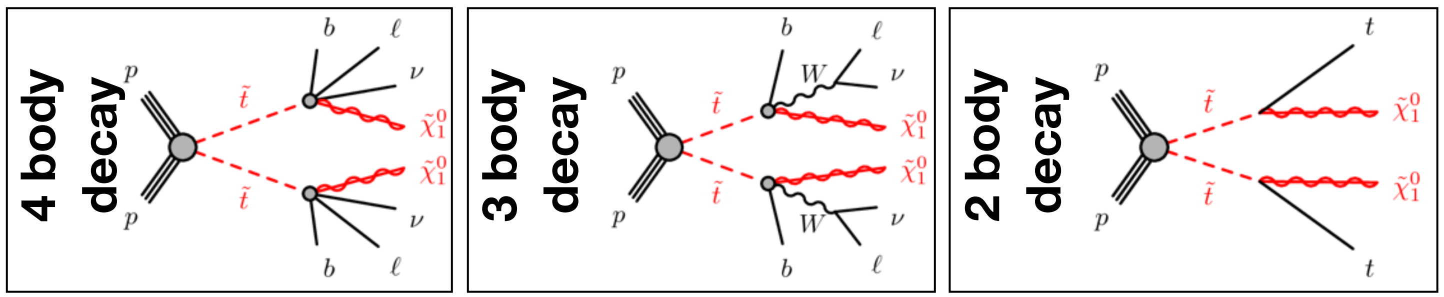
Direct stop and sbottom searches

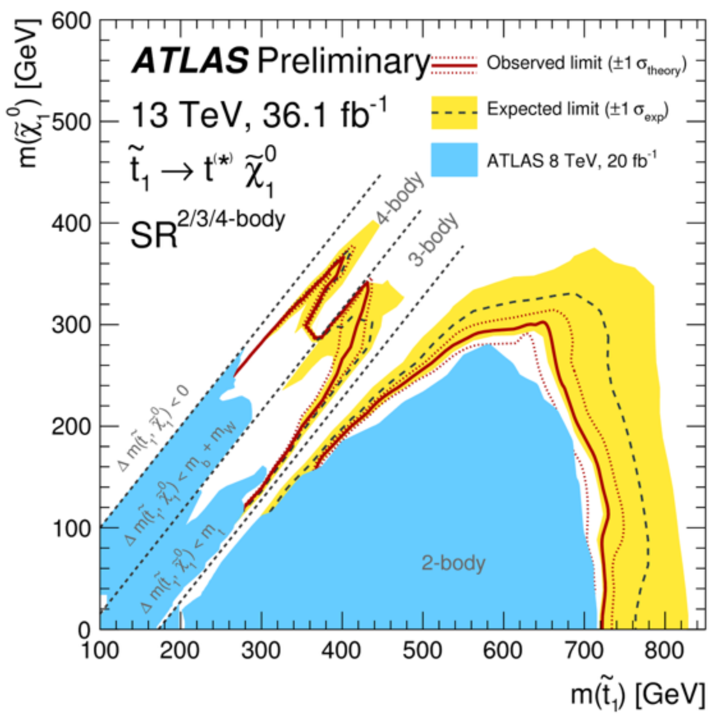
References

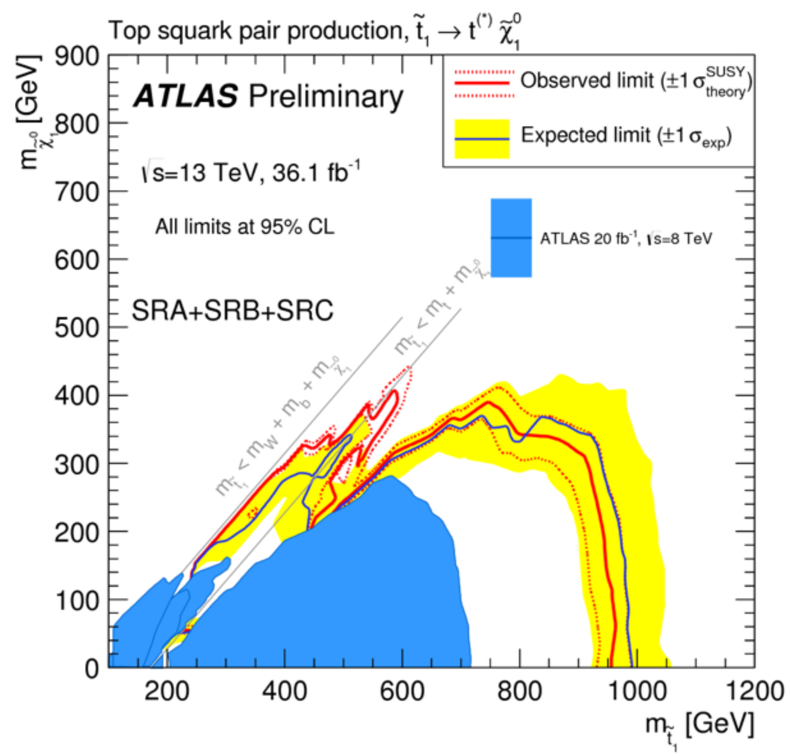
Search for top squark pairs with two leptons ATLAS-CONF-2017-034
Search for a top squark with jets + missing energy ATLAS-CONF-2017-020
Search for top squark pairs with lepton + jet + missing energy ATLAS-CONF-2017-037
Search for top and bottom squarks with b-jets and missing energy ATLAS-CONF-2017-038
Search for top squark pairs with H or Z + missing energy arXiv:1706.03986

Direct stop and sbottom searches

Structures in the limits dictated by the phase space for producing on-shell Ws and tops







Stop 0/2 leptons

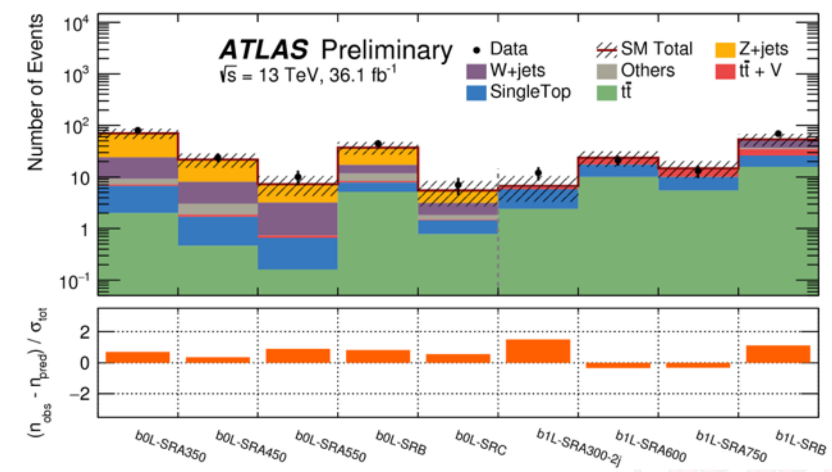
Several discriminating variables are used to separate different decay chains from the background

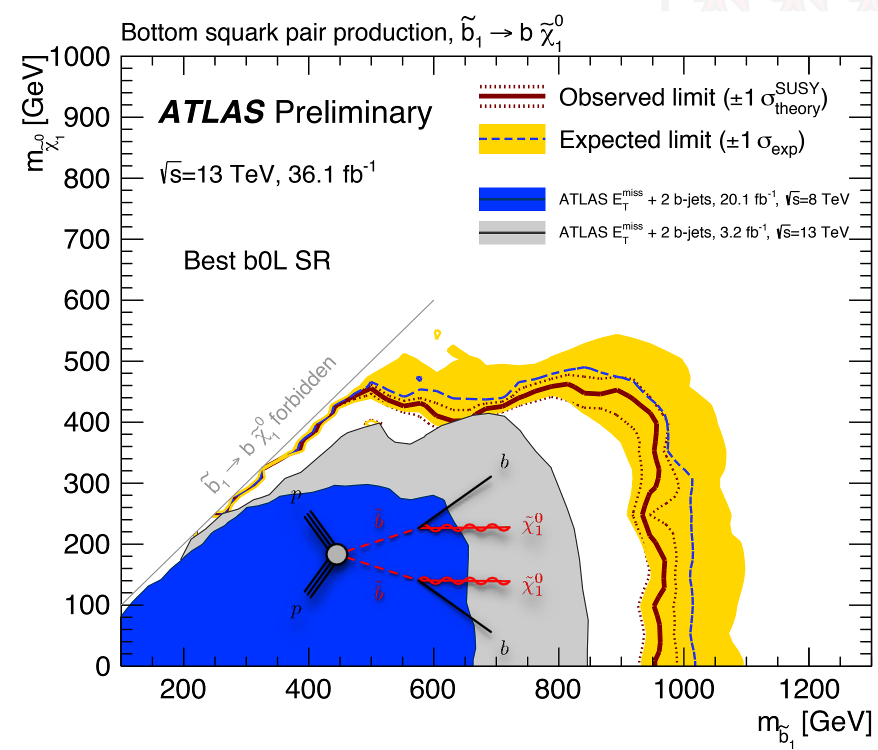
Several signal regions are defined for 2/3/4 body decays

Sbottom

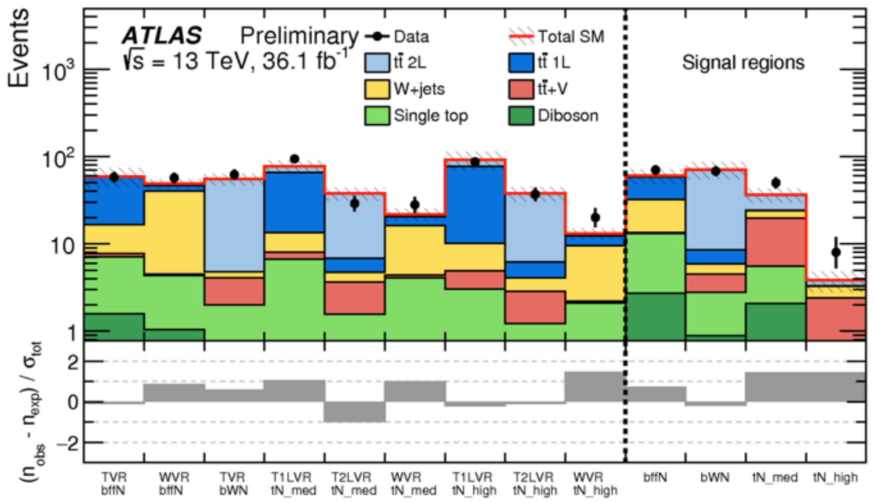
About 20 discriminating variables used to define nine signal regions

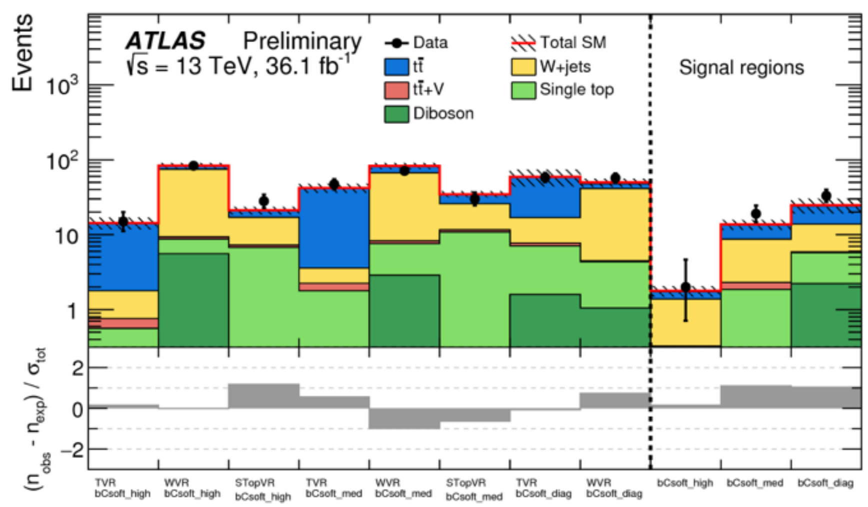
Background controlled in more than 20 control and validation regions

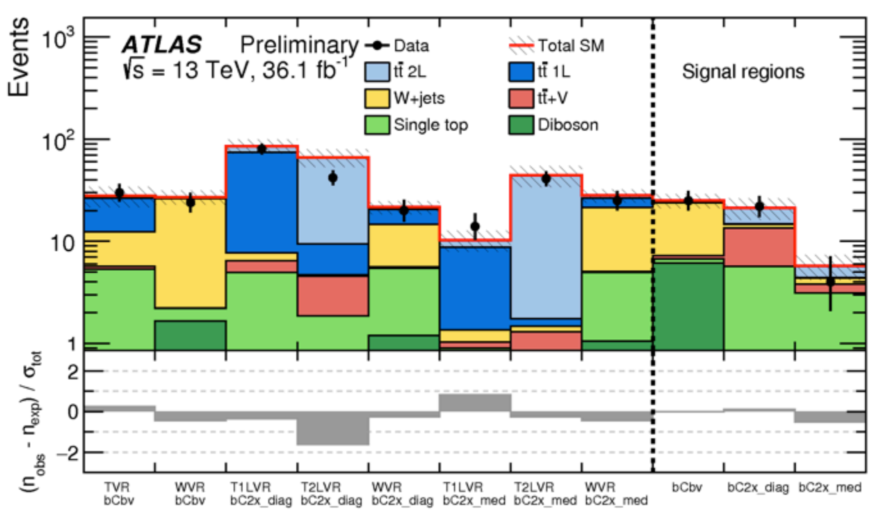




Direct stop and sbottom searches







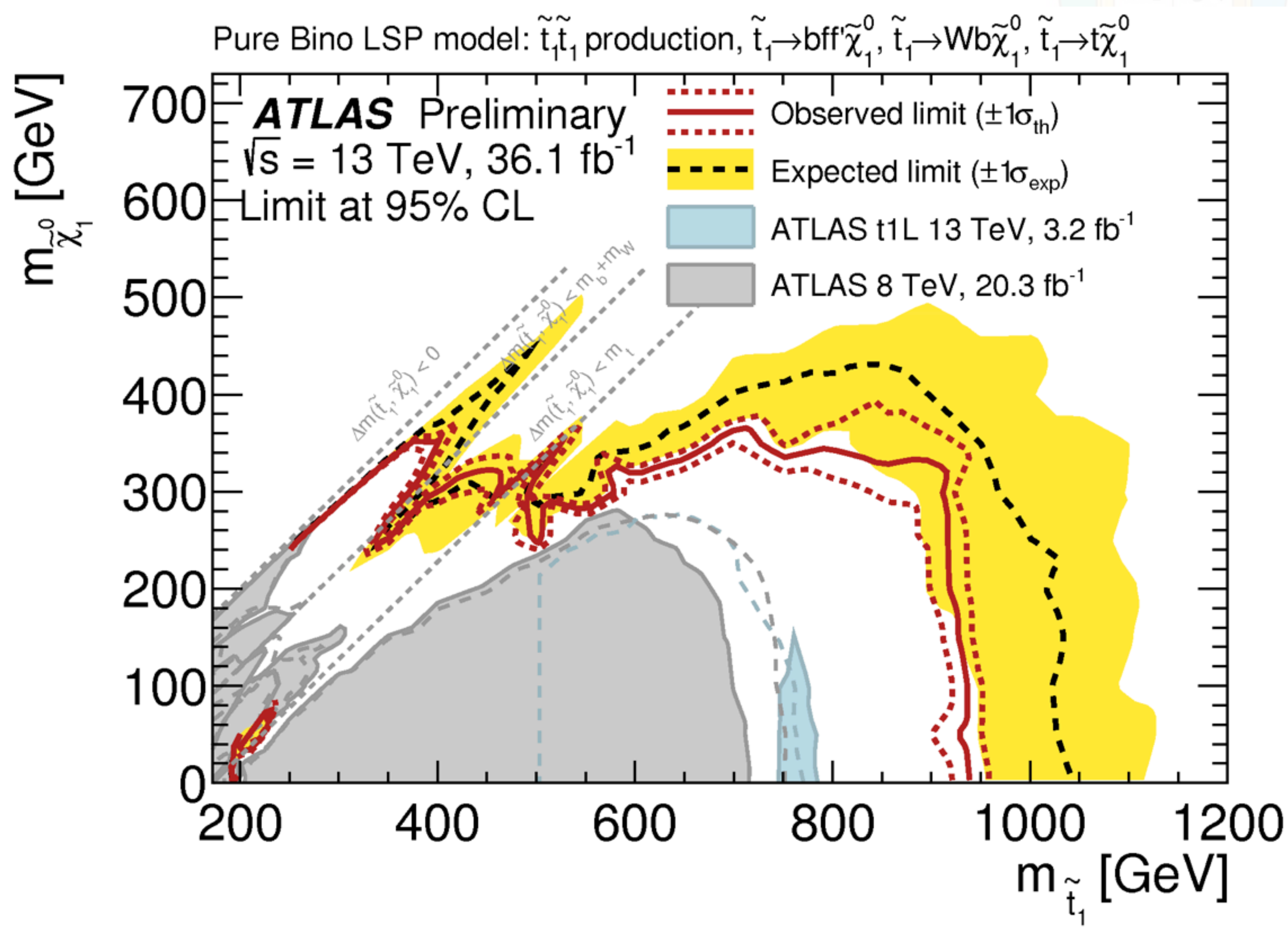
Stop 1 lepton

Multiple analyses with multiple signal interpretations, including Dark Matter produced in association with top-quarks

Using classic **cut-and-count** method as well as **shape fits**

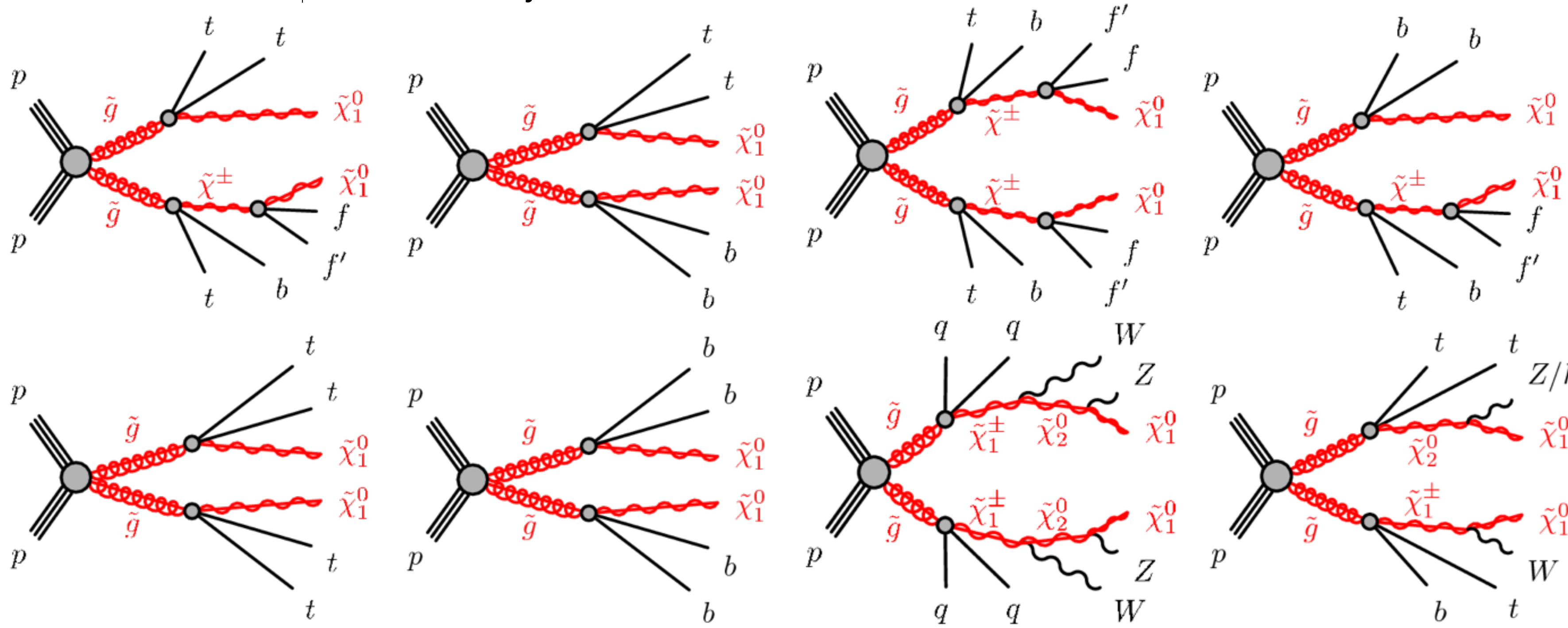
Multivariate approach used to cover compressed regions

Several dedicated analysis techniques, including reconstruction of soft-lepton and hadronic top-quark decays



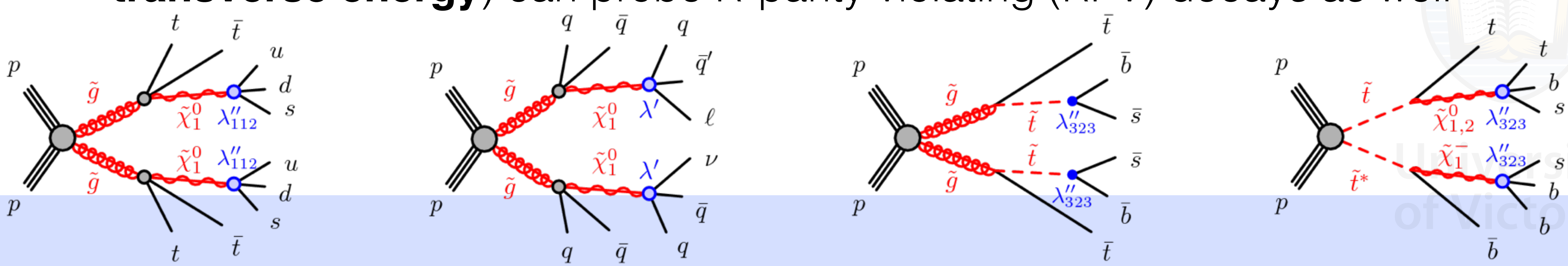
author: Nicola Orlando | The University of Hong Kong
presenter: Alison Elliot | The University of Victoria

SUSY strong production and RPV



Key features: high m_{eff} missing-E_T analysis
Separate analyses depending on lepton multiplicity: **0/1 lepton and 2 same-sign leptons / 3 leptons (2/3 leptons)**

Gluino pairs production (final states with **high jet multiplicity and low missing transverse energy**) can probe R-parity violating (RPV) decays as well



See talk by Oliver Ricken today

References

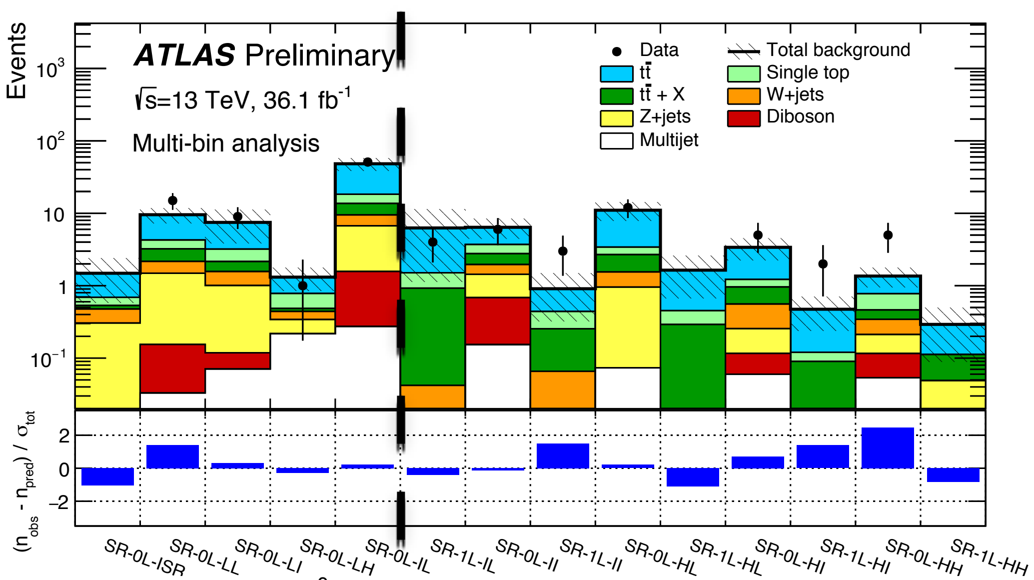
- Search in multi-jet + missing energy with large jets and flavour tagging ATLAS-CONF-2017-033
- Search in 2 or 3 leptons + jets arXiv:1706.03731
- Search in multi-b-jets and missing energy ATLAS-CONF-2017-021
- Search for squarks and gluinos with jets + missing energy ATLAS-CONF-2017-022
- RPV search in lepton + many jets arXiv:1704.08493
- RPV top squark pair search in jets ATLAS-CONF-2017-025
- RPV top squark pair search with 2 l + 2 jets ATLAS-CONF-2017-036

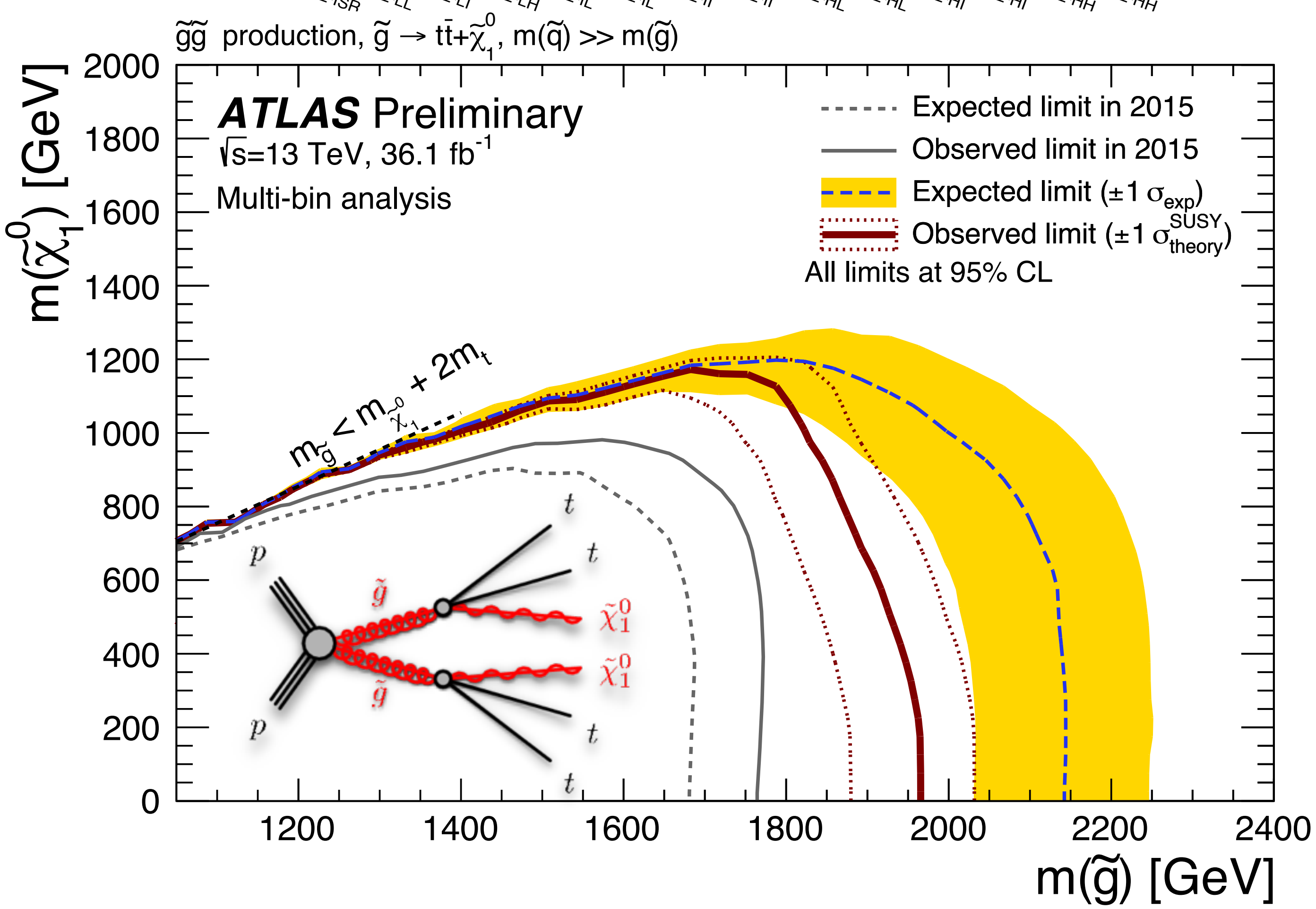
SUSY strong production

QFTHEP2017 | June 26-July 3, 2017, Yaroslavl Russia

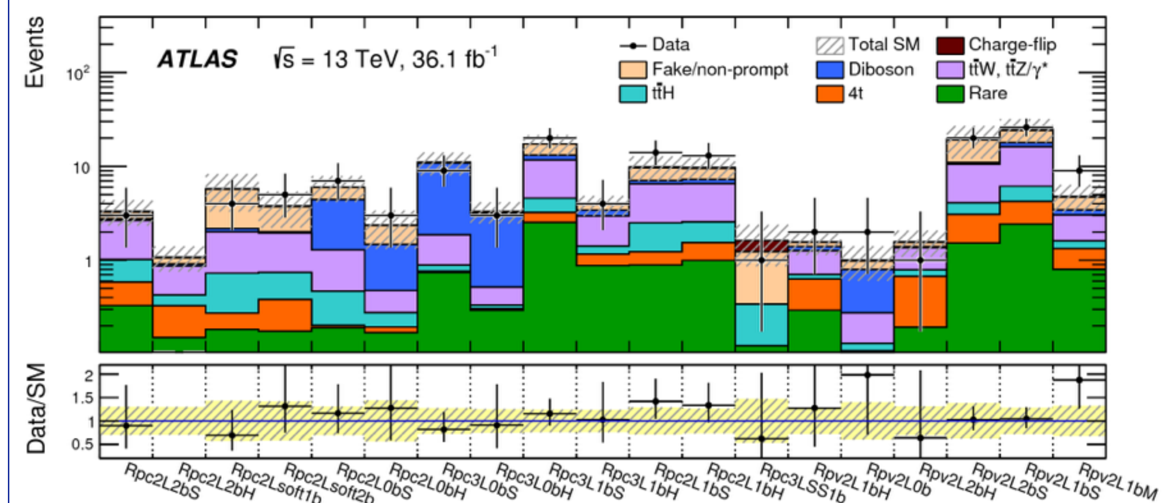
0/1 lepton

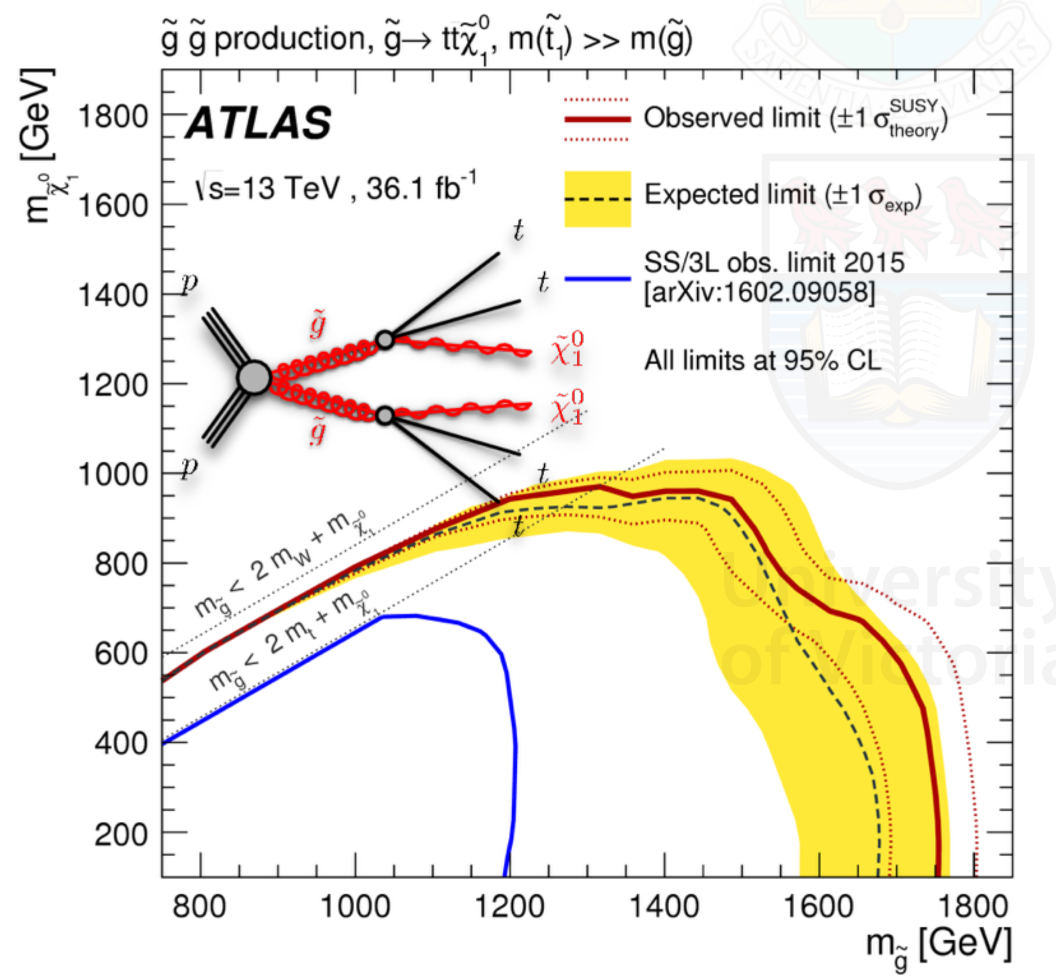
Simultaneous fit to all signal regions





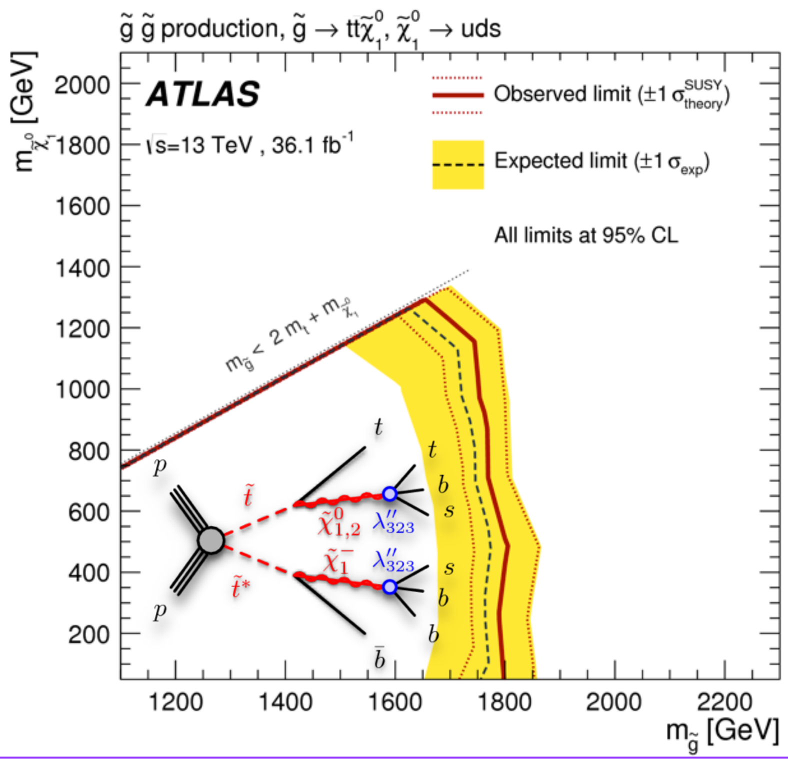
2/3 leptons



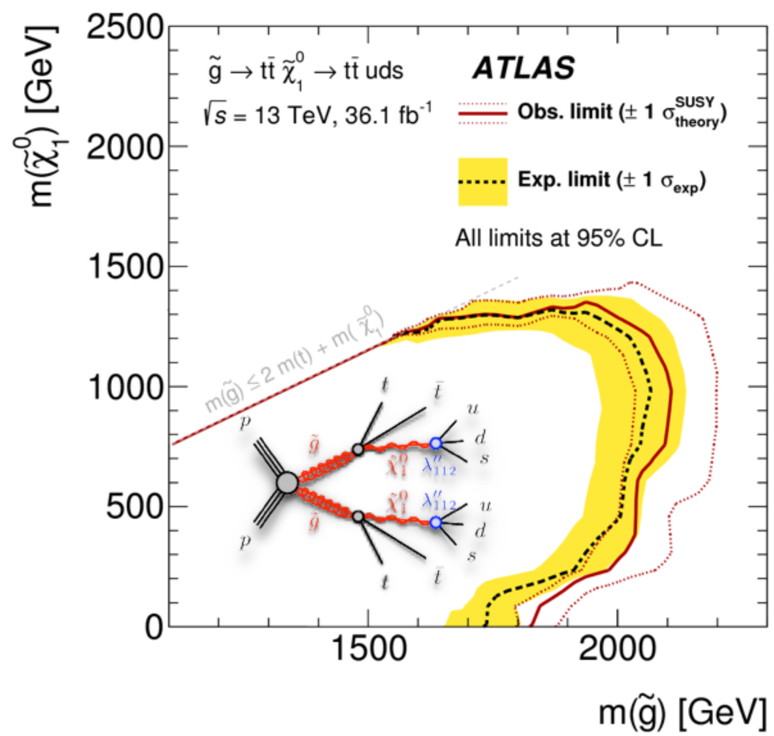


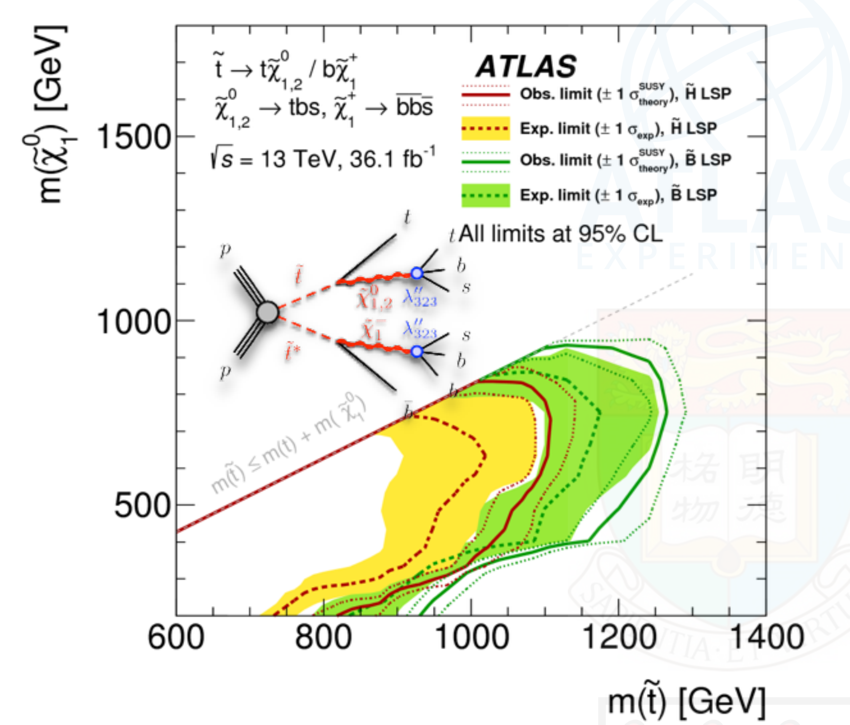
RPV SUSY

2/3 leptons



1 lepton

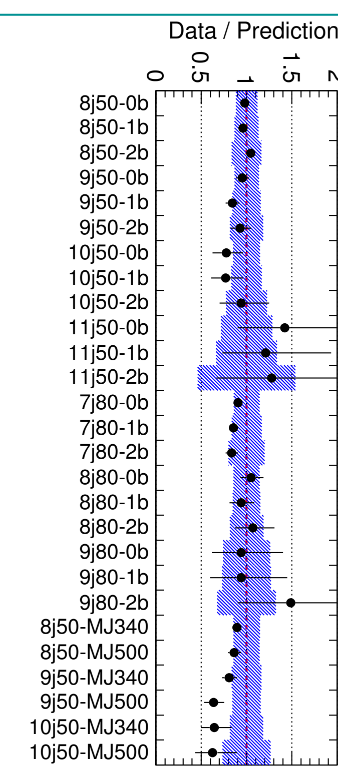


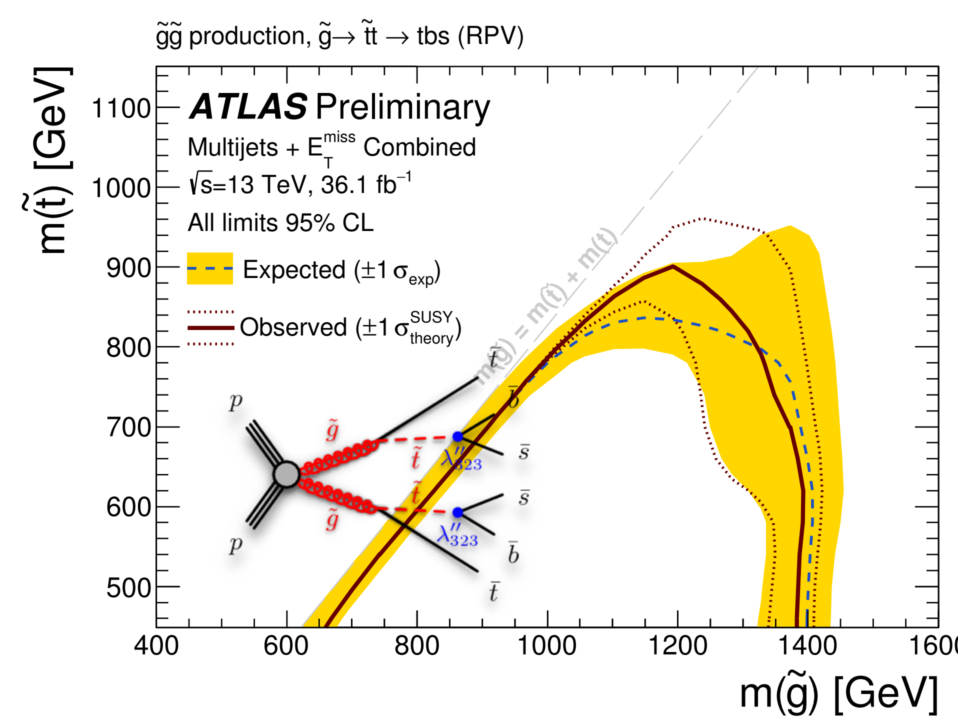


0 leptons, high jet multiplicity

Other searches based on very high jet multiplicities (up to 11) and mass of boosted hadronic top-quark decays

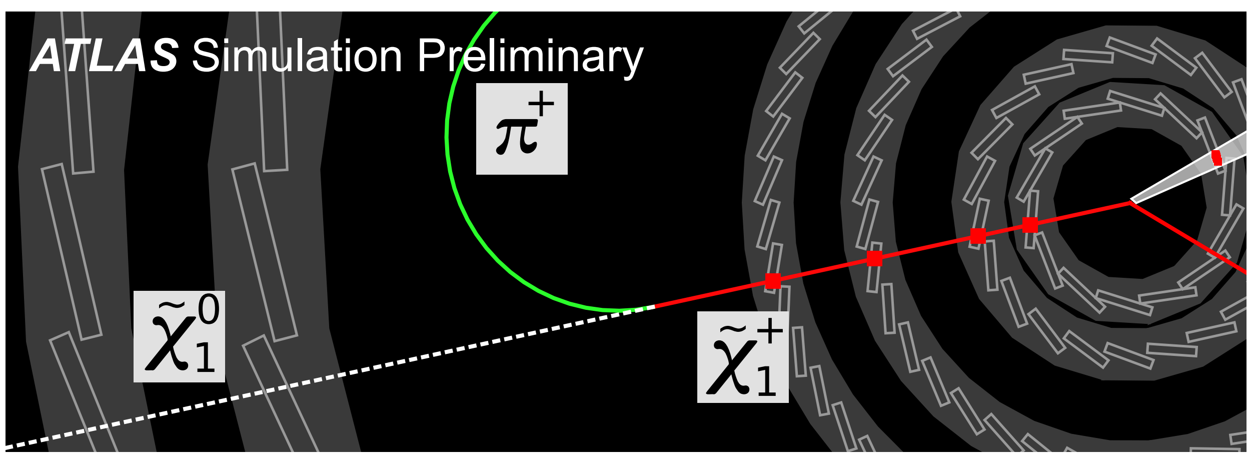
Targets both **RPV and RPC gluino pair production**





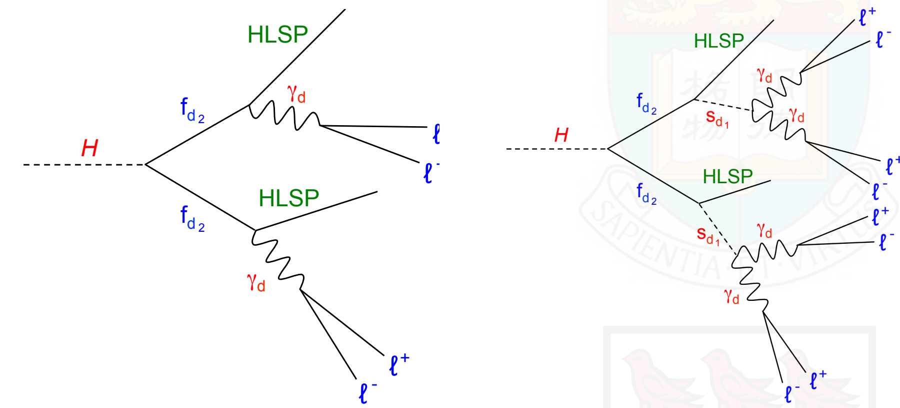
Non standard searches for long lived BSM particles (SUSY, dark-sector, ..)→Very dedicated strategies (triggers, topologies, reconstruction)

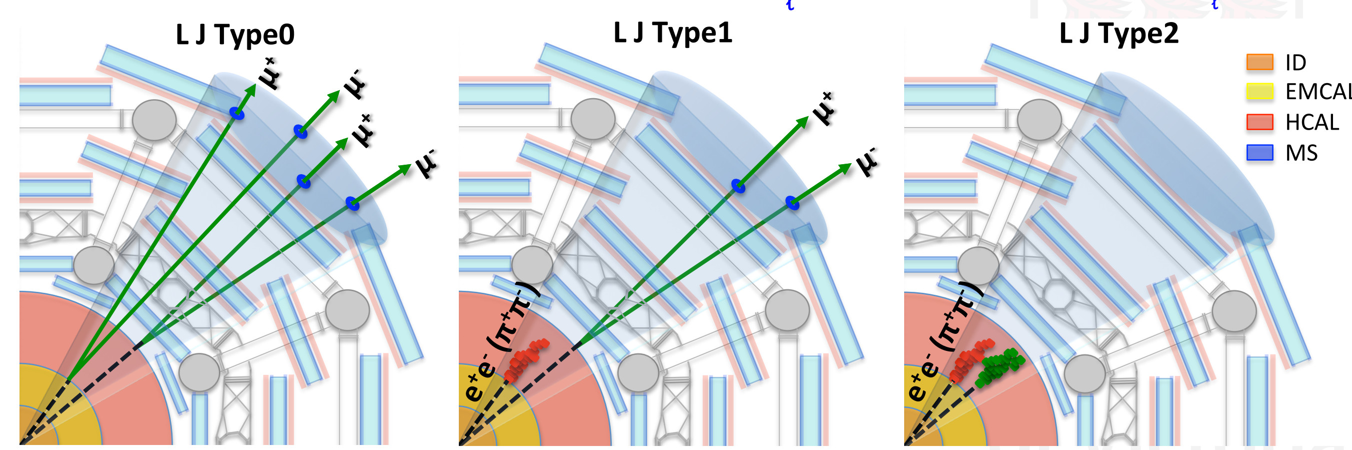
SUSY Long lived chargino nearly mass degenerate with a neutralino LSP
Disappearing track signature
Analysis is optimised for low chargino lifetimes (~2ns)→Exploits track-segments reconstructed in the inner-tracker layers



Dark sector particles from Higgs bosons decay

Signature: collimated light leptons or hadrons





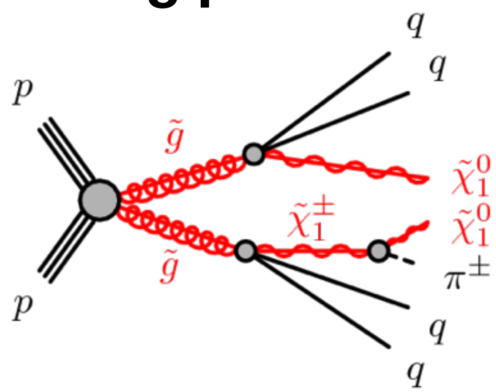
Long lived particles

References
Search for long-lived charginos through disappearing tracks ATLAS-CONF-2017-017
Search for long-lived neutral particles to lepton-jets ATLAS-CONF-2016-042
Search for long-lived particles with displaced vertices and missing energy ATLAS-CONF-2017-026

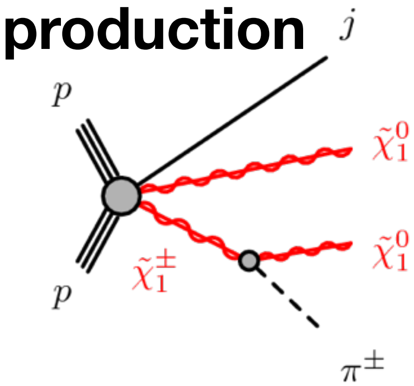
Long lived particles

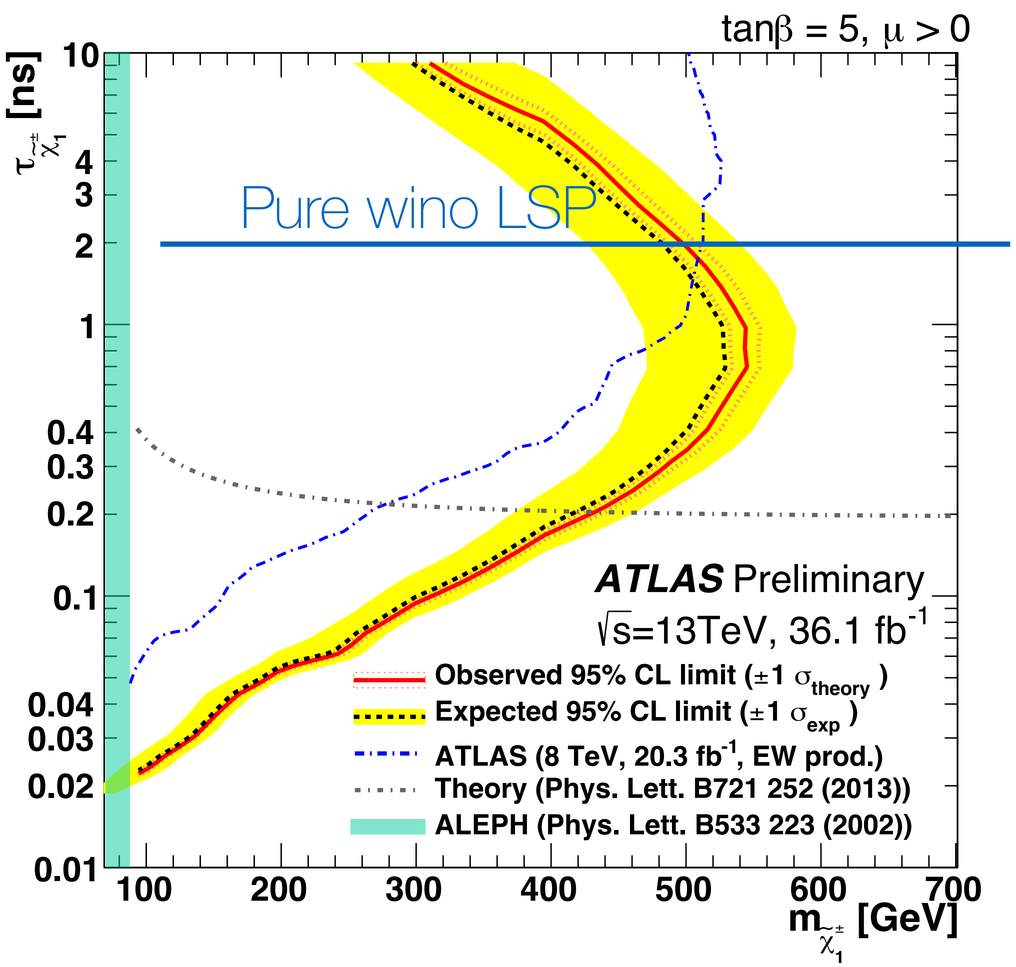
Long lived chargino search based on two production modes

Strong production

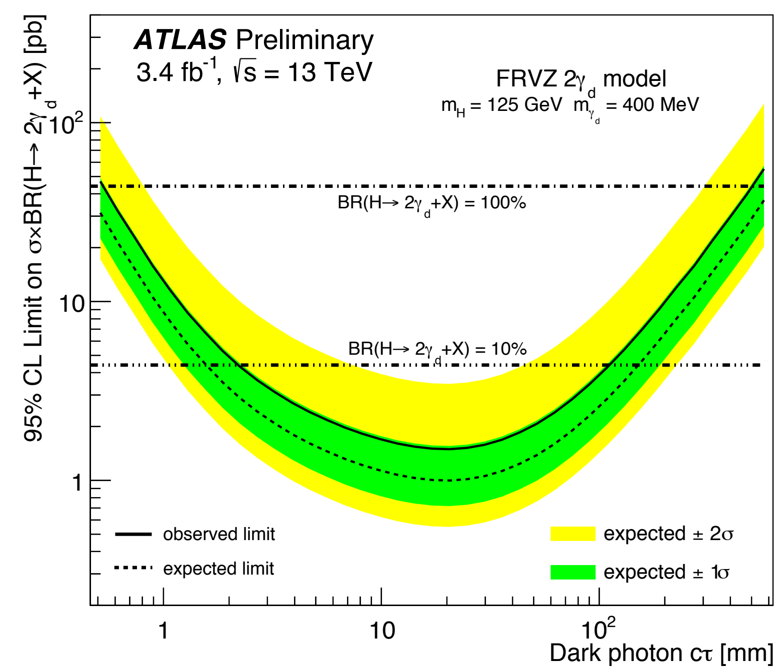


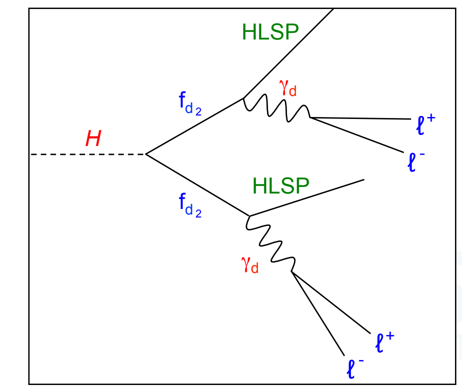
Electroweak production





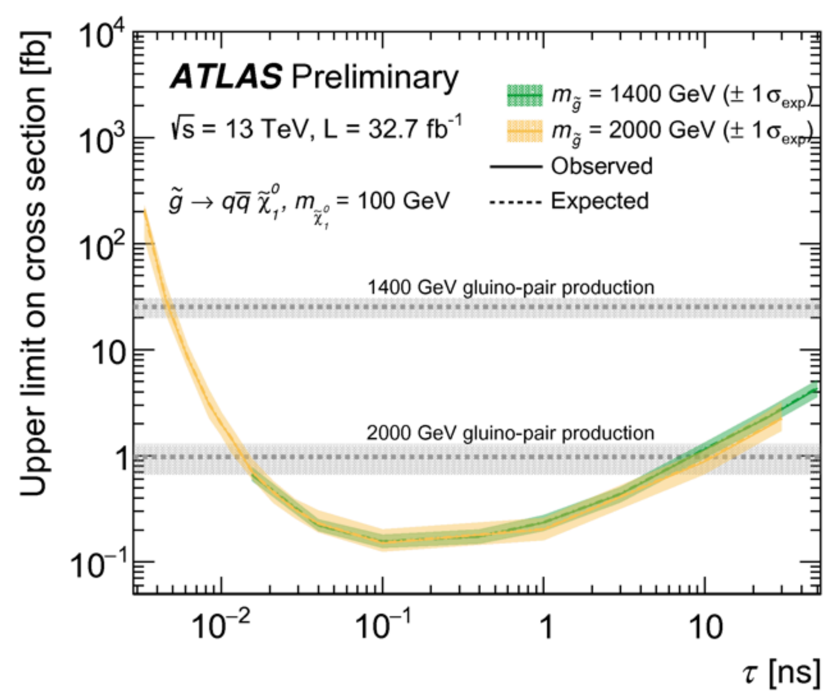
$2\gamma_d$+X

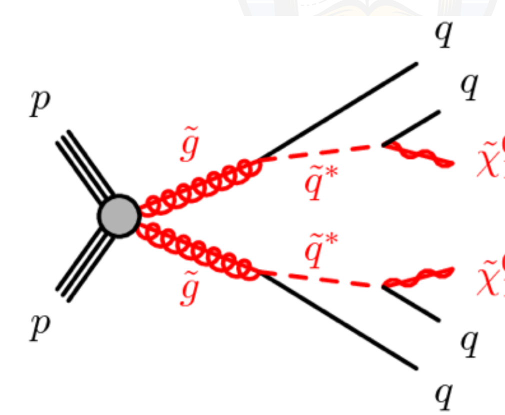




Assuming dark photon mass of 0.4 GeV

(Dark) Gauge coupling assumed to be small→No contribution from dark-radiation is considered





SUSY summary

ATLAS SUSY Searches* - 95% CL Lower Limits

May 2017

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

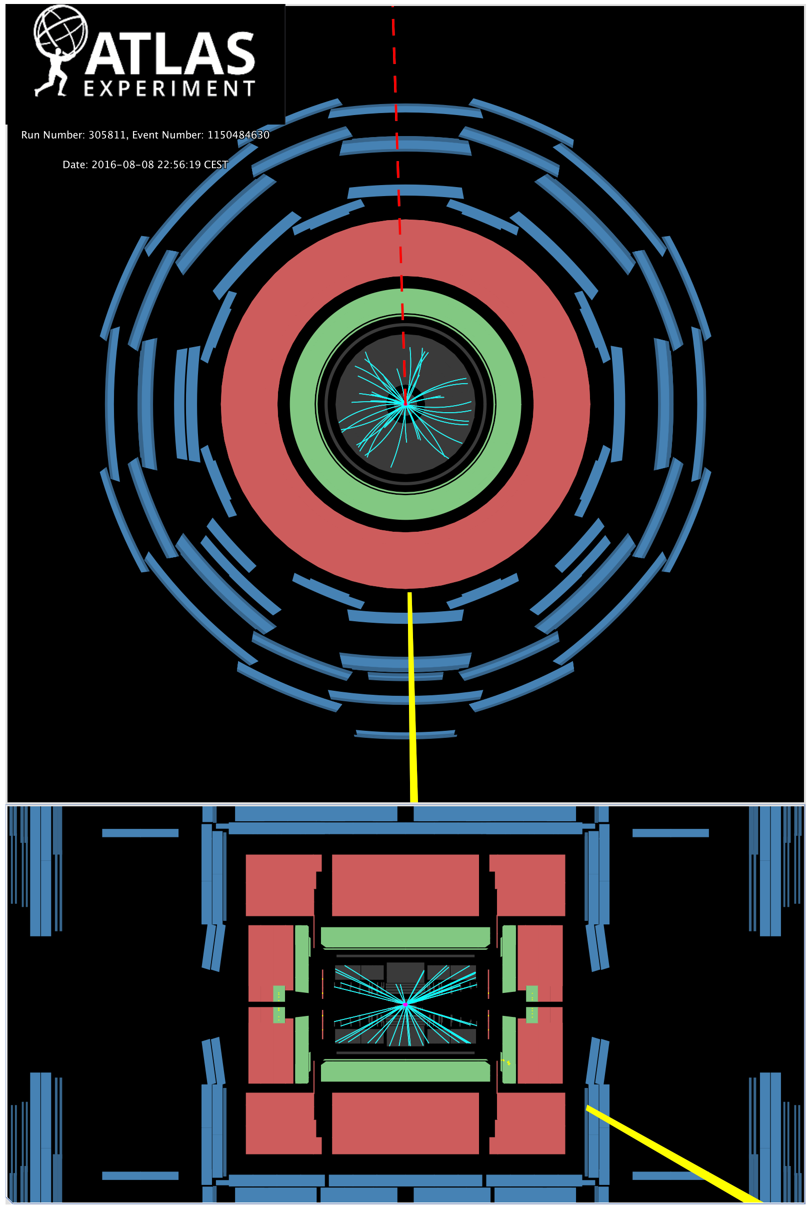
$\sqrt{s}$ = 7, 8 TeV | $\sqrt{s}$ = 13 TeV

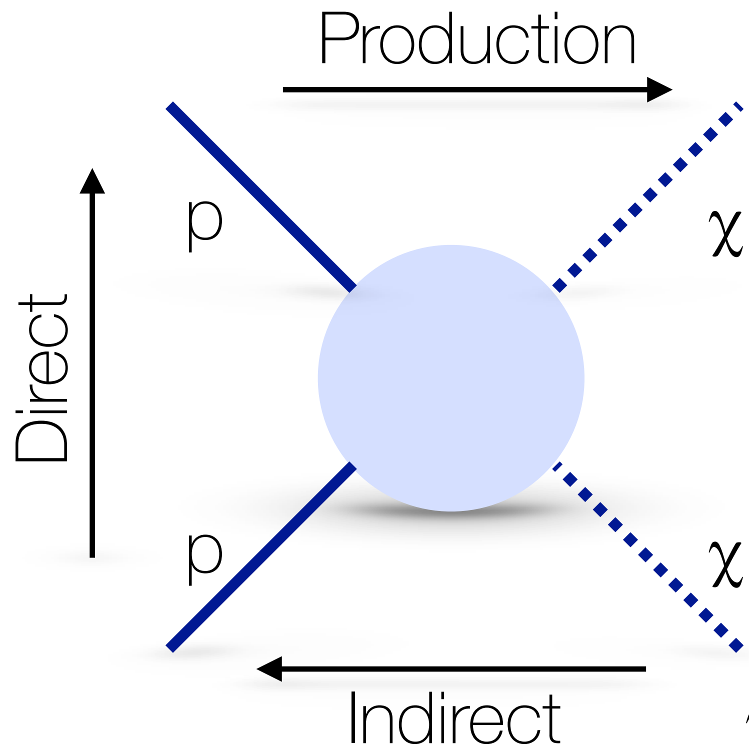
	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[\mathrm{fb}^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde q,\tilde g$ 1.85 TeV	$m(\tilde q)=m(\tilde g)$	1507.05525
	$\tilde q\tilde q$, $\tilde q\to q\tilde\chi^0_1$	0	2-6 jets	Yes	36.1	$\tilde q$ 1.57 TeV	$m(\tilde\chi^0_1)$<200 GeV, m(1st gen. $\tilde q$)=m(2nd gen. $\tilde q$)	ATLAS-CONF-2017-022
	$\tilde q\tilde q$, $\tilde q\to q\tilde\chi^0_1$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde q$ 608 GeV	$m(\tilde q)$-$m(\tilde\chi^0_1)$<5 GeV	1604.07773
	$\tilde g\tilde g$, $\tilde g\to q\bar q\tilde\chi^0_1$	0	2-6 jets	Yes	36.1	$\tilde g$ 2.02 TeV	$m(\tilde\chi^0_1)$<200 GeV	ATLAS-CONF-2017-022
	$\tilde g\tilde g$, $\tilde g\to qq\tilde\chi^\pm_1\to qqW^\pm\tilde\chi^0_1$	0	2-6 jets	Yes	36.1	$\tilde g$ 2.01 TeV	$m(\tilde\chi^0_1)$<200 GeV, $m(\tilde\chi^\pm)=0.5(m(\tilde\chi^0_1)+m(\tilde g))$	ATLAS-CONF-2017-022
	$\tilde g\tilde g$, $\tilde g\to qq(\ell\ell/\nu\nu)\tilde\chi^0_1$	3 e,μ	4 jets	-	36.1	$\tilde g$ 1.825 TeV	$m(\tilde\chi^0_1)$<400 GeV	ATLAS-CONF-2017-030
	$\tilde g\tilde g$, $\tilde g\to qqWZ\tilde\chi^0_1$	0	7-11 jets	Yes	36.1	$\tilde g$ 1.8 TeV	$m(\tilde\chi^0_1)$ <400 GeV	ATLAS-CONF-2017-033
	GMSB ($\tilde\ell$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	3.2	$\tilde g$ 2.0 TeV		1607.05979
	GGM (bino NLSP)	2 γ	-	Yes	3.2	$\tilde g$ 1.65 TeV	$c\tau$(NLSP)<0.1 mm	1606.09150
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde g$ 1.37 TeV	$m(\tilde\chi^0_1)$<950 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	$\tilde g$ 1.8 TeV	$m(\tilde\chi^0_1)$>680 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	ATLAS-CONF-2016-066
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde g$ 900 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale 865 GeV	$m(\tilde G)>1.8\times10^{-4}$ eV, $m(\tilde g)=m(\tilde q)$=1.5 TeV	1502.01518
3rd gen. $\tilde g$ med.	$\tilde g\tilde g$, $\tilde g\to b\bar b\tilde\chi^0_1$	0	3 b	Yes	36.1	$\tilde g$ 1.92 TeV	$m(\tilde\chi^0_1)$<600 GeV	ATLAS-CONF-2017-021
	$\tilde g\tilde g$, $\tilde g\to t\bar t\tilde\chi^0_1$	0-1 e,μ	3 b	Yes	36.1	$\tilde g$ 1.97 TeV	$m(\tilde\chi^0_1)$<200 GeV	ATLAS-CONF-2017-021
	$\tilde g\tilde g$, $\tilde g\to b\bar t\tilde\chi^+_1$	0-1 e,μ	3 b	Yes	20.1	$\tilde g$ 1.37 TeV	$m(\tilde\chi^0_1)$<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde b_1\tilde b_1$, $\tilde b_1\to b\tilde\chi^0_1$	0	2 b	Yes	36.1	$\tilde b_1$ 950 GeV	$m(\tilde\chi^0_1)$<420 GeV	ATLAS-CONF-2017-038
	$\tilde b_1\tilde b_1$, $\tilde b_1\to t\tilde\chi^\pm_1$	2 e,μ (SS)	1 b	Yes	36.1	$\tilde b_1$ 275-700 GeV	$m(\tilde\chi^0_1)$<200 GeV, $m(\tilde\chi^\pm_1)=m(\tilde\chi^0_1)$+100 GeV	ATLAS-CONF-2017-030
	$\tilde t_1\tilde t_1$, $\tilde t_1\to b\tilde\chi^\pm_1$	0-2 e,μ	1-2 b	Yes	4.7/13.3	$\tilde t_1$ 117-170 GeV, 200-720 GeV	$m(\tilde\chi^\pm_1)=2m(\tilde\chi^0_1)$, $m(\tilde\chi^0_1)$=55 GeV	1209.2102, ATLAS-CONF-2016-077
	$\tilde t_1\tilde t_1$, $\tilde t_1\to Wb\tilde\chi^0_1$ or $t\tilde\chi^0_1$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3/36.1	$\tilde t_1$ 90-198 GeV, 205-950 GeV	$m(\tilde\chi^0_1)$=1 GeV	1506.08616, ATLAS-CONF-2017-020
	$\tilde t_1\tilde t_1$, $\tilde t_1\to c\tilde\chi^0_1$	0	mono-jet	Yes	3.2	$\tilde t_1$ 90-323 GeV	$m(\tilde t_1)$-$m(\tilde\chi^0_1)$=5 GeV	1604.07773
	$\tilde t_1\tilde t_1$ (natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde t_1$ 150-600 GeV	$m(\tilde\chi^0_1)$>150 GeV	1403.5222
	$\tilde t_2\tilde t_2$, $\tilde t_2\to\tilde t_1+Z$	3 e,μ (Z)	1 b	Yes	36.1	$\tilde t_2$ 290-790 GeV	$m(\tilde\chi^0_1)$=0 GeV	ATLAS-CONF-2017-019
	$\tilde t_2\tilde t_2$, $\tilde t_2\to\tilde t_1+h$	1-2 e,μ	4 b	Yes	36.1	$\tilde t_2$ 320-880 GeV	$m(\tilde\chi^0_1)$=0 GeV	ATLAS-CONF-2017-019
EW direct	$\tilde\ell_{L,R}\tilde\ell_{L,R}$, $\tilde\ell\to\ell\tilde\chi^0_1$	2 e,μ	0	Yes	36.1	$\tilde\ell$ 90-440 GeV	$m(\tilde\chi^0_1)$=0	ATLAS-CONF-2017-039
	$\tilde\chi^+_1\tilde\chi^-_1$, $\tilde\chi^+_1\to\tilde\ell\nu(\ell\tilde\nu)$	2 e,μ	0	Yes	36.1	$\tilde\chi^\pm_1$ 710 GeV	$m(\tilde\chi^0_1)$=0, $m(\tilde\ell,\tilde\nu)=0.5(m(\tilde\chi^\pm_1)+m(\tilde\chi^0_1))$	ATLAS-CONF-2017-039
	$\tilde\chi^\pm_1\tilde\chi^\mp_1/\tilde\chi^0_2$, $\tilde\chi^+_1\to\tilde\tau\nu(\tau\tilde\nu)$, $\tilde\chi^0_2\to\tilde\tau\tau(\nu\tilde\nu)$	2 τ	-	Yes	36.1	$\tilde\chi^\pm_1$ 760 GeV	$m(\tilde\chi^0_1)$=0, $m(\tilde\tau,\tilde\nu)=0.5(m(\tilde\chi^\pm_1)+m(\tilde\chi^0_1))$	ATLAS-CONF-2017-035
	$\tilde\chi^\pm_1\tilde\chi^0_2\to\tilde\ell_L\nu\tilde\ell_L\ell(\tilde\nu\nu)$, $\ell\tilde\nu\tilde\ell_L\ell(\tilde\nu\nu)$	3 e,μ	0	Yes	36.1	$\tilde\chi^\pm_1,\tilde\chi^0_2$ 1.16 TeV	$m(\tilde\chi^\pm_1)=m(\tilde\chi^0_2)$, $m(\tilde\chi^0_1)$=0, $m(\tilde\ell,\tilde\nu)=0.5(m(\tilde\chi^\pm_1)+m(\tilde\chi^0_1))$	ATLAS-CONF-2017-039
	$\tilde\chi^\pm_1\tilde\chi^0_2\to W\tilde\chi^0_1Z\tilde\chi^0_1$	2-3 e,μ	0-2 jets	Yes	36.1	$\tilde\chi^\pm_1,\tilde\chi^0_2$ 580 GeV	$m(\tilde\chi^\pm_1)=m(\tilde\chi^0_2)$, $m(\tilde\chi^0_1)$=0, $\tilde\ell$ decoupled	ATLAS-CONF-2017-039
	$\tilde\chi^\pm_1\tilde\chi^0_2\to W\tilde\chi^0_1h\tilde\chi^0_1$, $h\to b\bar b/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde\chi^\pm_1,\tilde\chi^0_2$ 270 GeV	$m(\tilde\chi^\pm_1)=m(\tilde\chi^0_2)$, $m(\tilde\chi^0_1)$=0, $\tilde\ell$ decoupled	1501.07110
	$\tilde\chi^0_2\tilde\chi^0_3$, $\tilde\chi^0_{2,3}\to\tilde\ell_R\ell$	4 e,μ	0	Yes	20.3	$\tilde\chi^0_{2,3}$ 635 GeV	$m(\tilde\chi^0_2)=m(\tilde\chi^0_3)$, $m(\tilde\chi^0_1)$=0, $m(\tilde\ell,\tilde\nu)=0.5(m(\tilde\chi^0_2)+m(\tilde\chi^0_1))$	1405.5086
	GGM (wino NLSP) weak prod., $\tilde\chi^0_1\to\gamma\tilde G$	1 e,μ + γ	-	Yes	20.3	$\tilde W$ 115-370 GeV	$c\tau$<1 mm	1507.05493
	GGM (bino NLSP) weak prod., $\tilde\chi^0_1\to\gamma\tilde G$	2 γ	-	Yes	20.3	$\tilde W$ 590 GeV	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde\chi^+_1\tilde\chi^-_1$ prod., long-lived $\tilde\chi^\pm_1$	Disapp. trk	1 jet	Yes	36.1	$\tilde\chi^\pm_1$ 430 GeV	$m(\tilde\chi^\pm_1)$-$m(\tilde\chi^0_1)$~160 MeV, $\tau(\tilde\chi^\pm_1)$=0.2 ns	ATLAS-CONF-2017-017
	Direct $\tilde\chi^+_1\tilde\chi^-_1$ prod., long-lived $\tilde\chi^\pm_1$	dE/dx trk	-	Yes	18.4	$\tilde\chi^\pm_1$ 495 GeV	$m(\tilde\chi^\pm_1)$-$m(\tilde\chi^0_1)$~160 MeV, $\tau(\tilde\chi^\pm_1)$<15 ns	1506.05332
	Stable, stopped $\tilde g$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde g$ 850 GeV	$m(\tilde\chi^0_1)$=100 GeV, 10 $\mu s<\tau(\tilde g)<$1000 s	1310.6584
	Stable $\tilde g$ R-hadron	trk	-	-	3.2	$\tilde g$ 1.58 TeV		1606.05129
	Metastable $\tilde g$ R-hadron	dE/dx trk	-	-	3.2	$\tilde g$ 1.57 TeV	$m(\tilde\chi^0_1)$=100 GeV, τ>10 ns	1604.04520
	GMSB, stable $\tilde\tau$, $\tilde\chi^0_1\to\tilde\tau(\tilde e,\tilde\mu)+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde\chi^0_1$ 537 GeV	10<tanβ<50	1411.6795
	GMSB, $\tilde\chi^0_1\to\gamma\tilde G$, long-lived $\tilde\chi^0_1$	2 γ	-	Yes	20.3	$\tilde\chi^0_1$ 440 GeV	1<$\tau(\tilde\chi^0_1)$<3 ns, SPS8 model	1409.5542
	$\tilde g\tilde g$, $\tilde\chi^0_1\to ee\nu/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde\chi^0_1$ 1.0 TeV	7 <$c\tau(\tilde\chi^0_1)$< 740 mm, $m(\tilde g)$=1.3 TeV	1504.05162
	GGM $\tilde g\tilde g$, $\tilde\chi^0_1\to Z\tilde G$	displ. vtx + jets	-	-	20.3	$\tilde\chi^0_1$ 1.0 TeV	6 <$c\tau(\tilde\chi^0_1)$< 480 mm, $m(\tilde g)$=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde\nu_\tau+X$, $\tilde\nu_\tau\to e\mu/e\tau/\mu\tau$	$e\mu,e\tau,\mu\tau$	-	-	3.2	$\tilde\nu_\tau$ 1.9 TeV	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1607.08079
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde q,\tilde g$ 1.45 TeV	$m(\tilde q)=m(\tilde g)$, $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde\chi^+_1\tilde\chi^-_1$, $\tilde\chi^+_1\to W\tilde\chi^0_1$, $\tilde\chi^0_1\to ee\nu, e\mu\nu, \mu\mu\nu$	4 e,μ	-	Yes	13.3	$\tilde\chi^\pm_1$ 1.14 TeV	$m(\tilde\chi^0_1)$>400GeV, $\lambda_{12k}\neq0$ (k = 1, 2)	ATLAS-CONF-2016-075
	$\tilde\chi^+_1\tilde\chi^-_1$, $\tilde\chi^+_1\to W\tilde\chi^0_1$, $\tilde\chi^0_1\to\tau\tau\nu_e, e\tau\nu_\tau$	3 e,μ + τ	-	Yes	20.3	$\tilde\chi^\pm_1$ 450 GeV	$m(\tilde\chi^0_1)>0.2\times m(\tilde\chi^\pm_1)$, $\lambda_{133}\neq0$	1405.5086
	$\tilde g\tilde g$, $\tilde g\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde g$ 1.08 TeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2016-057
	$\tilde g\tilde g$, $\tilde g\to qq\tilde\chi^0_1$, $\tilde\chi^0_1\to qqq$	0	4-5 large-R jets	-	14.8	$\tilde g$ 1.55 TeV	$m(\tilde\chi^0_1)$=800 GeV	ATLAS-CONF-2016-057
	$\tilde g\tilde g$, $\tilde g\to t\bar t\tilde\chi^0_1$, $\tilde\chi^0_1\to qqq$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde g$ 2.1 TeV	$m(\tilde\chi^0_1)$= 1 TeV, $\lambda_{112}\neq0$	ATLAS-CONF-2017-013
	$\tilde g\tilde g$, $\tilde g\to\tilde t_1t$, $\tilde t_1\to bs$	1 e,μ	8-10 jets/0-4 b	-	36.1	$\tilde g$ 1.65 TeV	$m(\tilde t_1)$= 1 TeV, $\lambda_{323}\neq0$	ATLAS-CONF-2017-013
	$\tilde t_1\tilde t_1$, $\tilde t_1\to bs$	0	2 jets + 2 b	-	15.4	$\tilde t_1$ 410 GeV, 450-510 GeV		ATLAS-CONF-2016-022, ATLAS-CONF-2016-084
	$\tilde t_1\tilde t_1$, $\tilde t_1\to b\ell$	2 e,μ	2 b	-	36.1	$\tilde t_1$ 0.4-1.45 TeV	BR($\tilde t_1\to be/\mu$)>20%	ATLAS-CONF-2017-036
Other	Scalar charm, $\tilde c\to c\tilde\chi^0_1$	0	2 c	Yes	20.3	$\tilde c$ 510 GeV	$m(\tilde\chi^0_1)$<200 GeV	1501.01325

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

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

author: Nicola Orlando | The University of Hong Kong
presenter: Alison Elliot | The University of Victoria





χ = Dark matter particle
p = Standard Model particle

Production (colliders)

$p+p \rightarrow \chi+\chi$

Indirect (cosmology)

$\chi+\chi \rightarrow p+p$

Direct
(underground experiments)

$\chi+p \rightarrow \chi+p$

Signatures based on large missing transverse energy recoiling against Standard Model particle

Interpretation of searches based on simplified models with various kind of mediators (scalar, vectors, ..)

Dark Matter searches

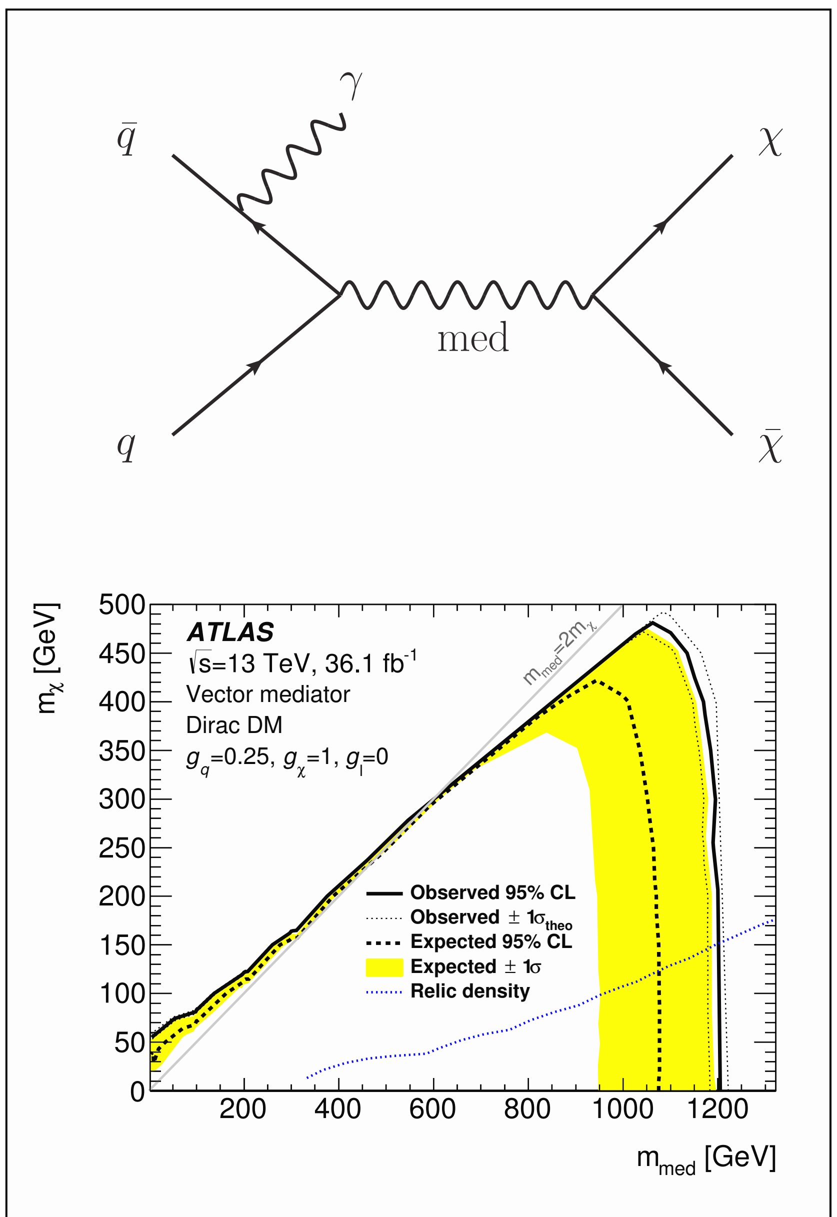
References

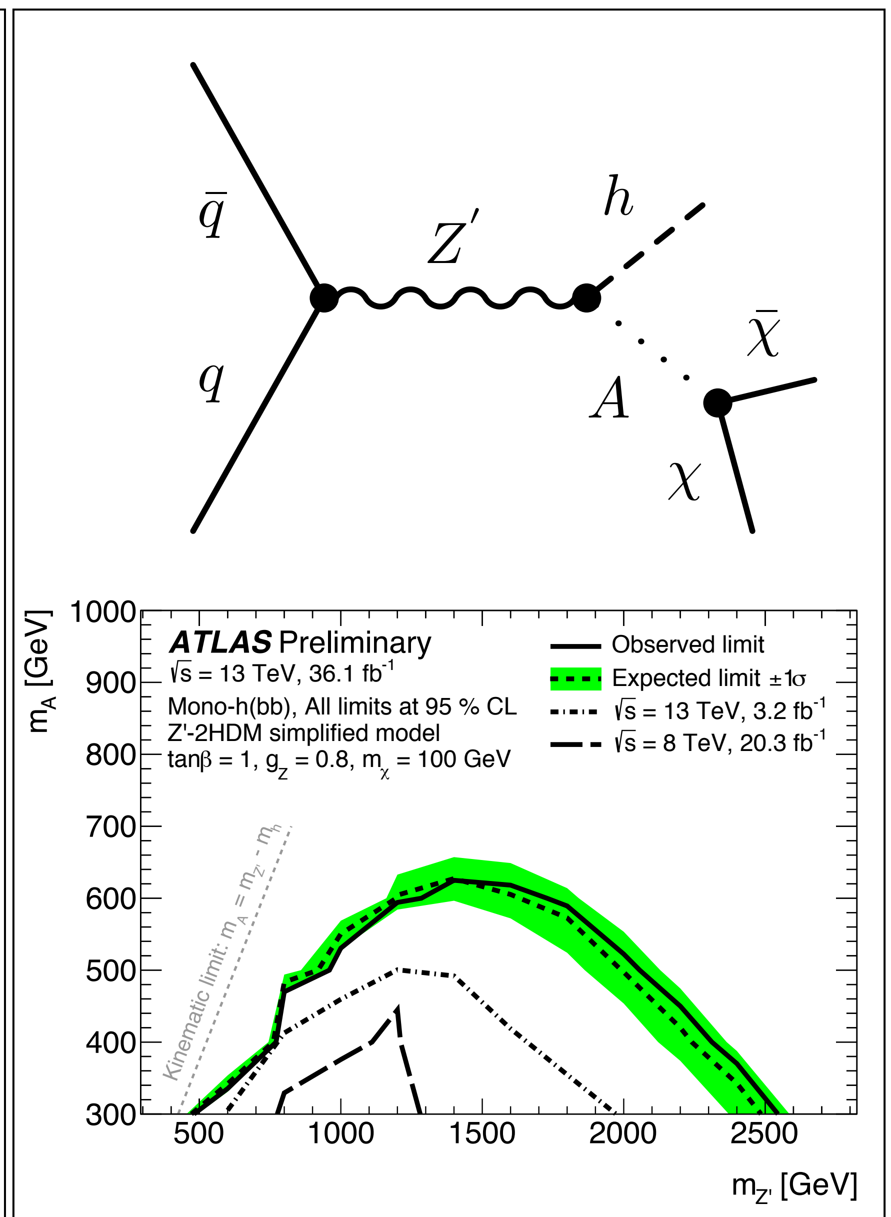
Mono-photon search arXiv:1704.03848
Mono-H to bb search ATLAS-CONF-2017-028
bb + missing energy search ATLAS-CONF-2016-086

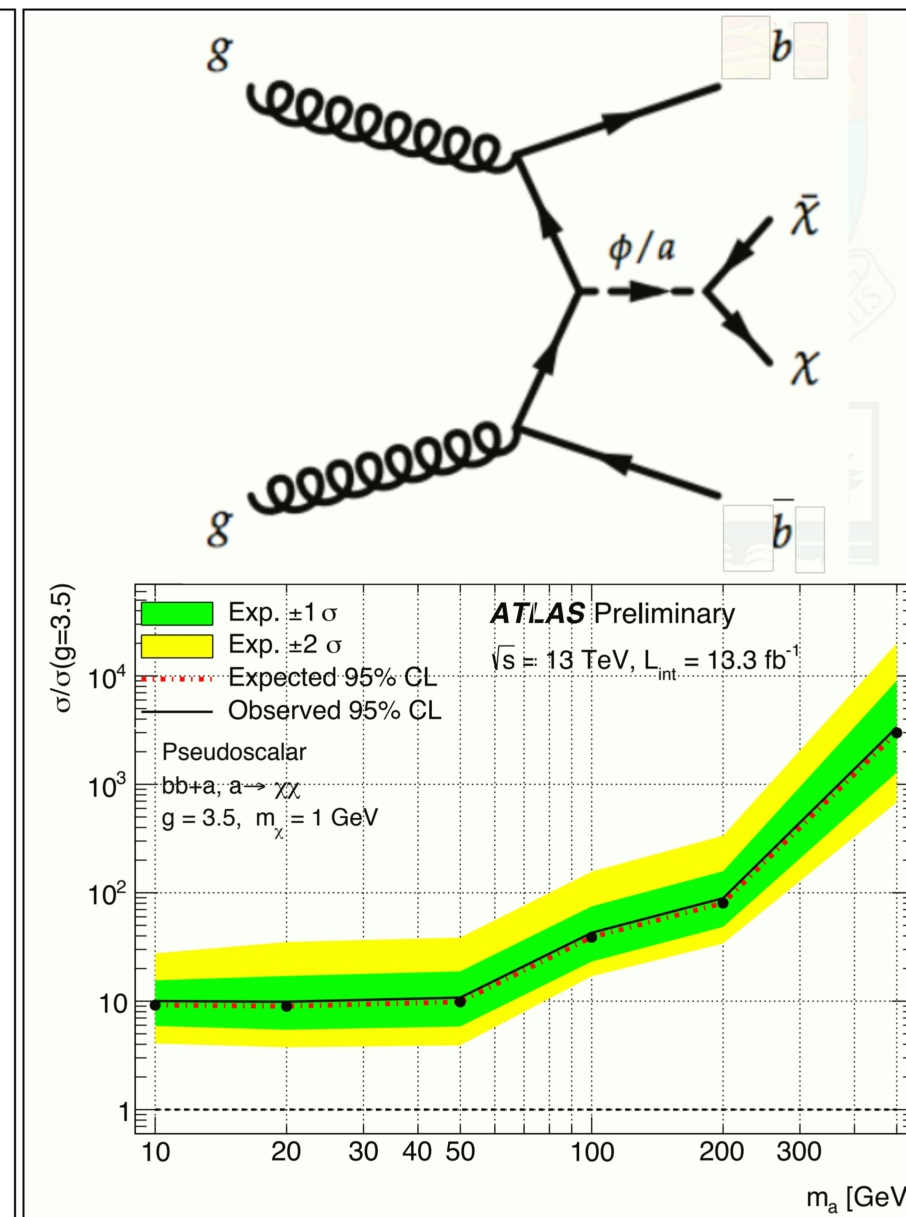
Dark Matter searches

Interpretation assumes couplings of masses of the BSM particles in the simplified models

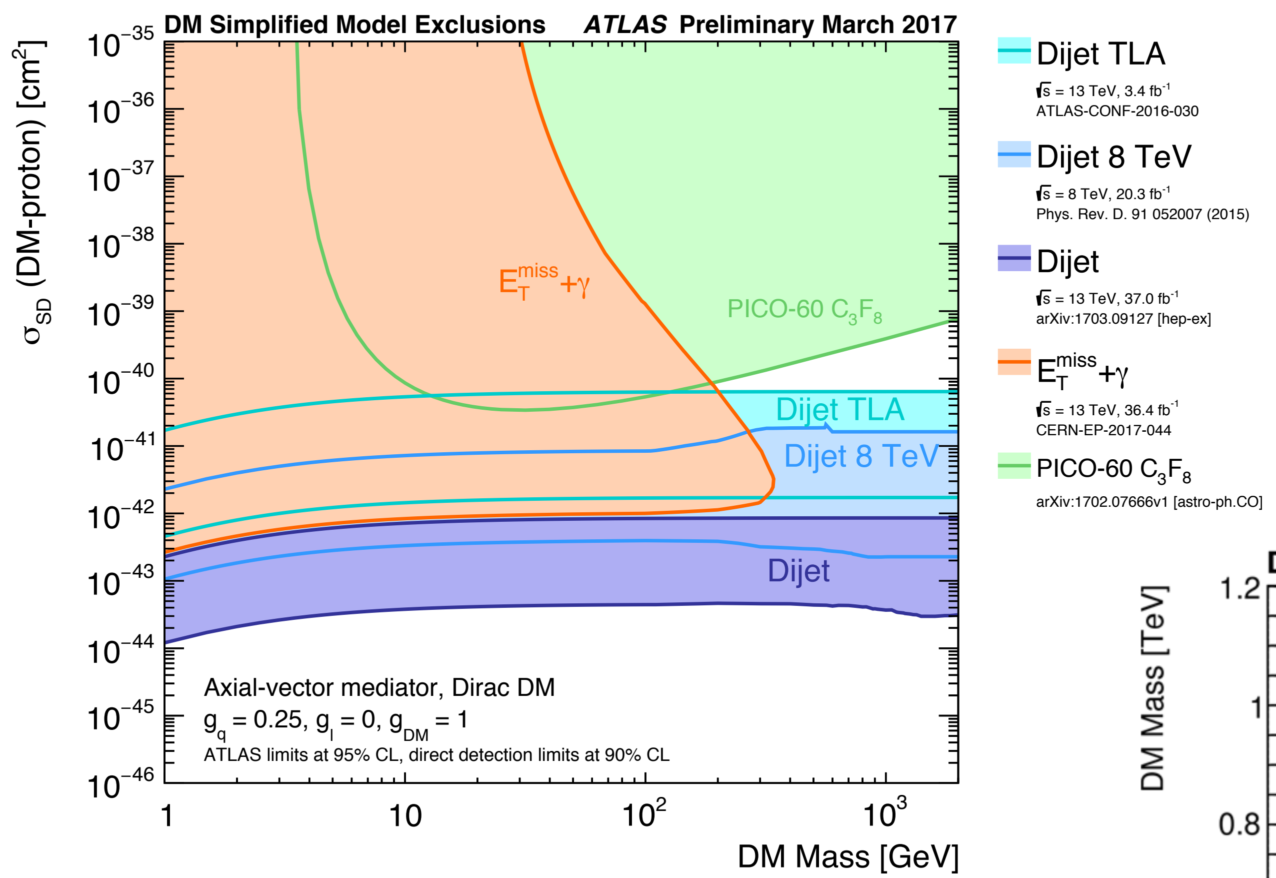
Limits quoted on mediators and/or dark matter particle mass assuming certain values of the couplings in the models



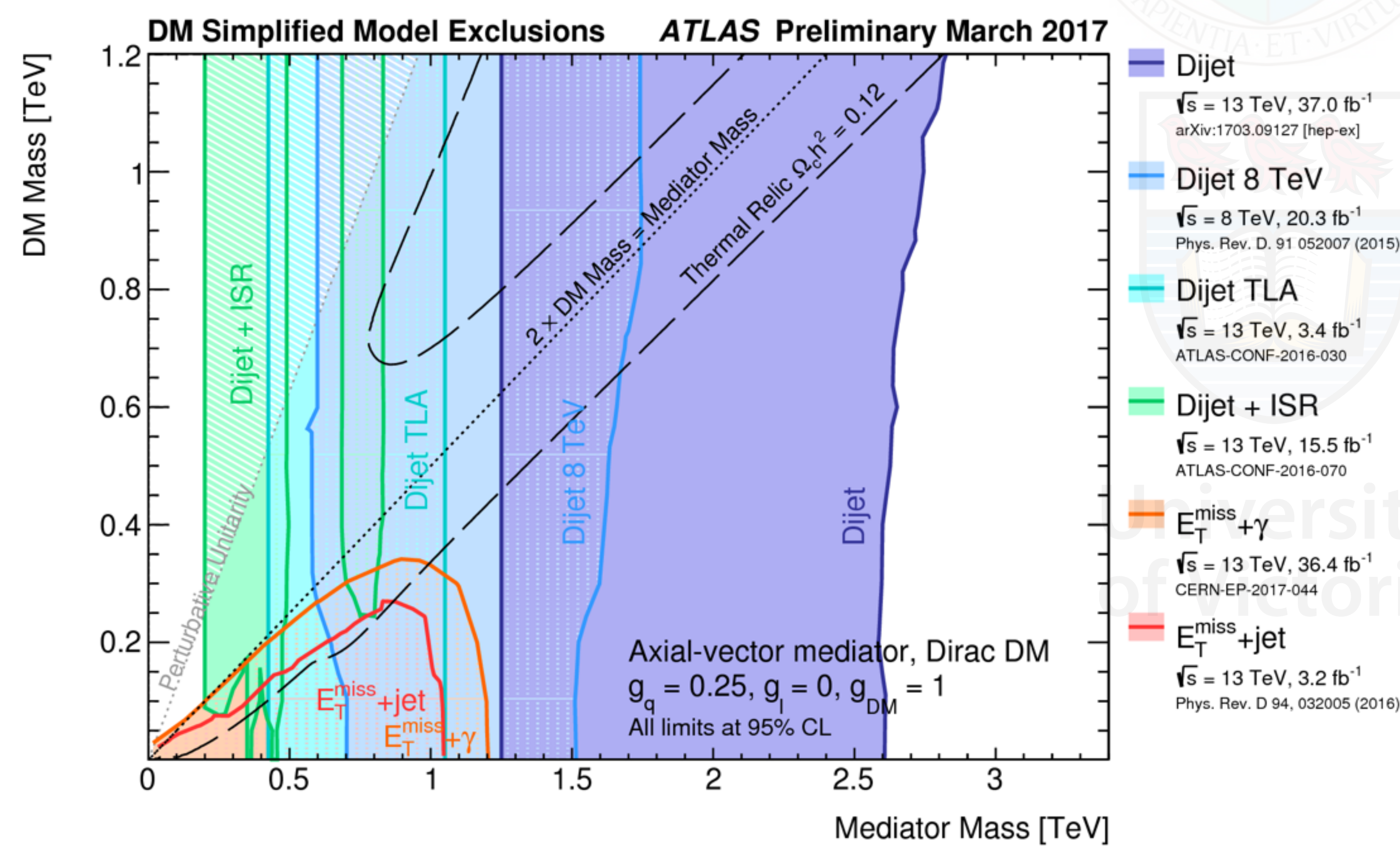




Dark Matter searches



For specific dark matter models agreed on by a number of searches, complementary or competitive limits can be combined with direct detection



Summary

- Wide search program covering plenty of signatures and interpretations
- No evidence of new physics yet
- But we know that *something* is out there…