Searches for new physics such as Dark Matter with the ATLAS detector

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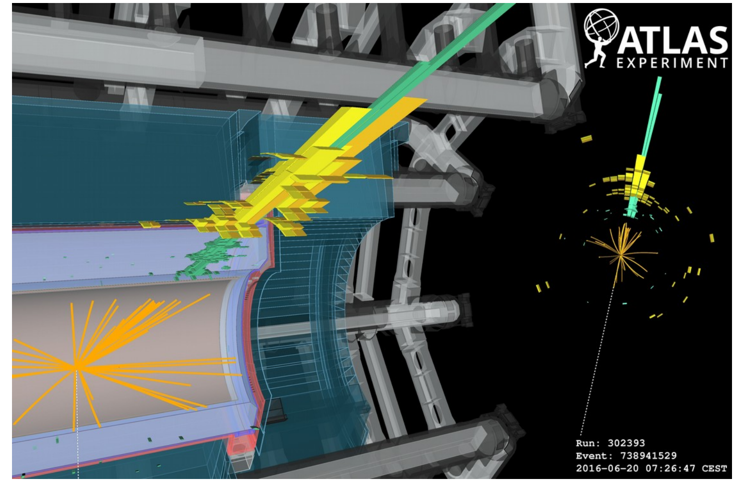
on behalf of the ATLAS Collaboration

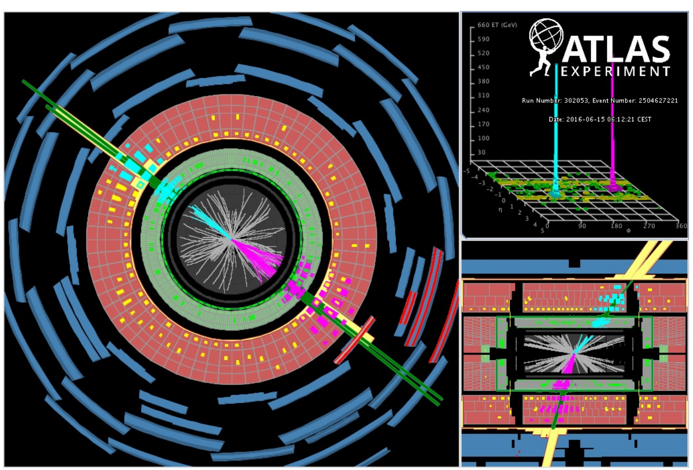
Universidad Nacional de La Plata – IFLP CONICET

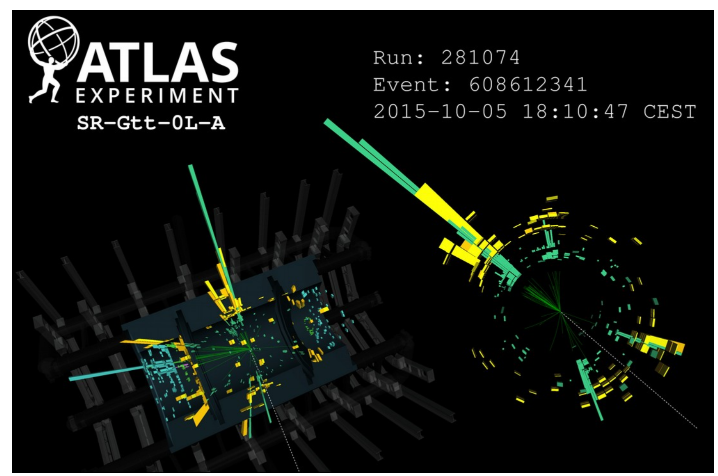
15 -19 July 2019 Buenos Aires, Argentina

Outline



- ATLAS – LHC @ Run-2
- Beyond Standard Model Results
  - SUSY (Conventional, Unconventional Signatures)
  - Dark Matter (Direct X+MET and Mediator Resonances)
- Future Prospects for HL-LHC



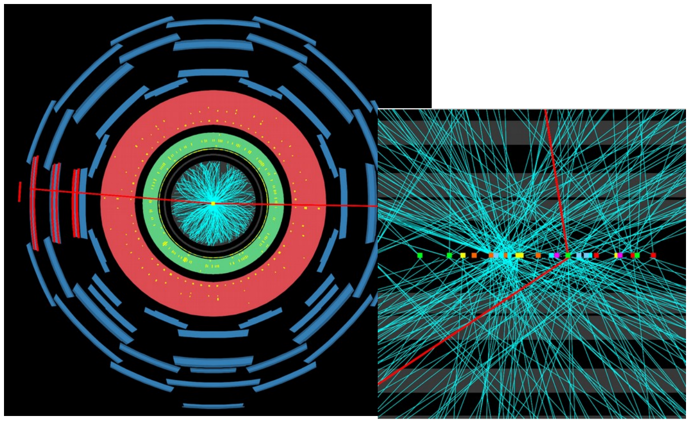


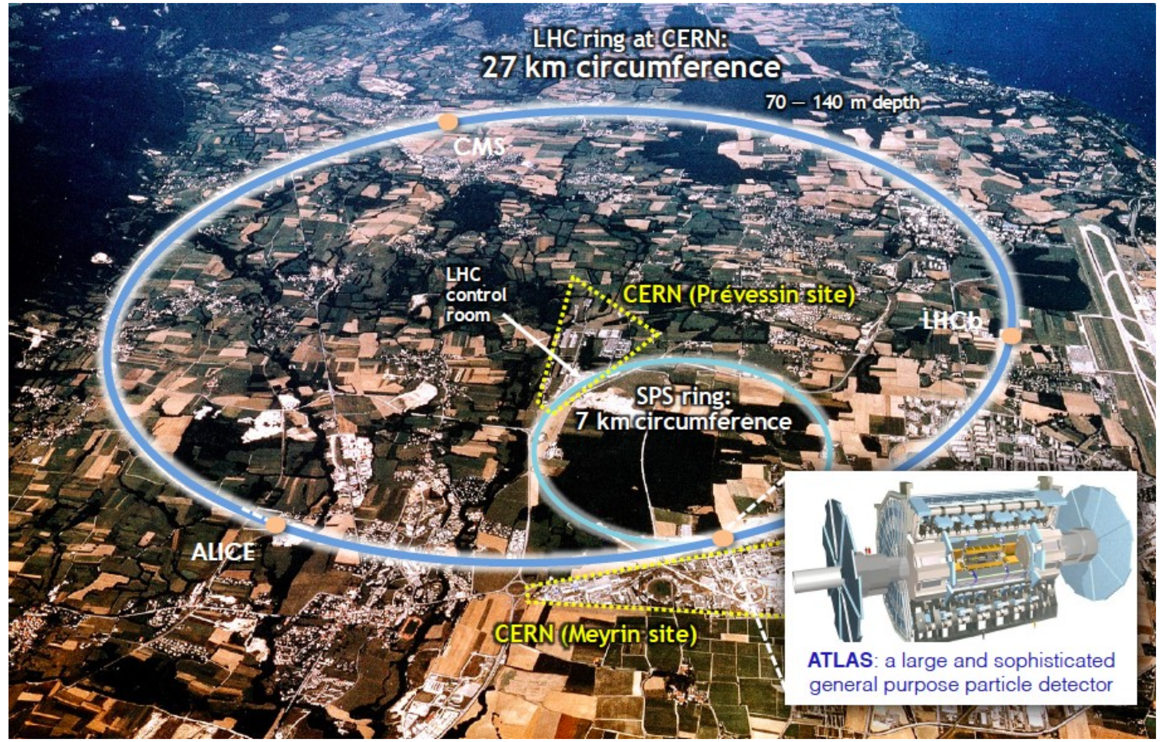
LCH-ATLAS Run-2

Run 1 (2010-2012): **7-8 TeV**

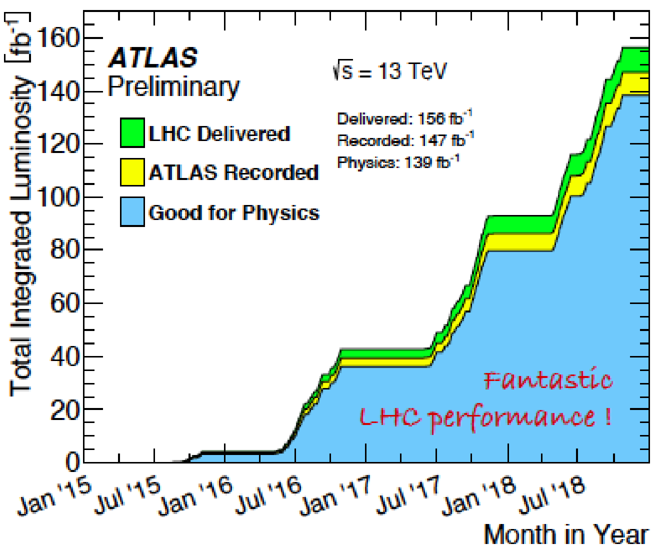
Run 2 (2015-2018): **13 TeV**

Run 3 (2021-2023): **14 TeV**

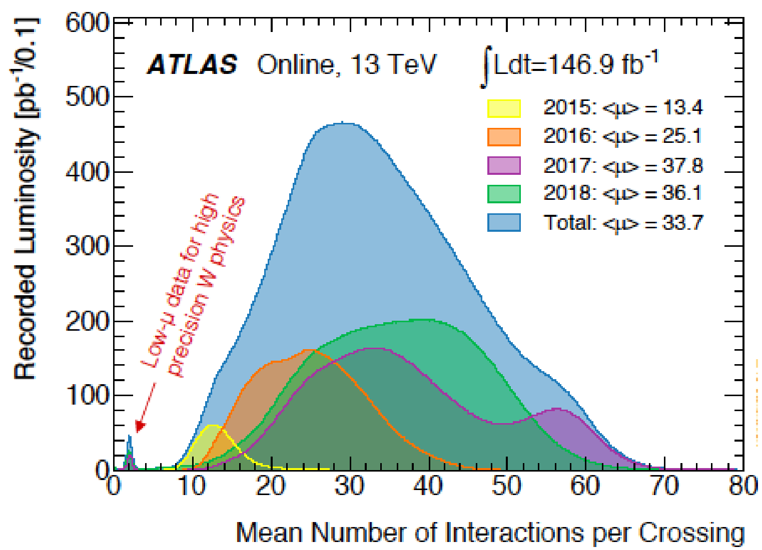




Integrated pp luminosity during Run-2

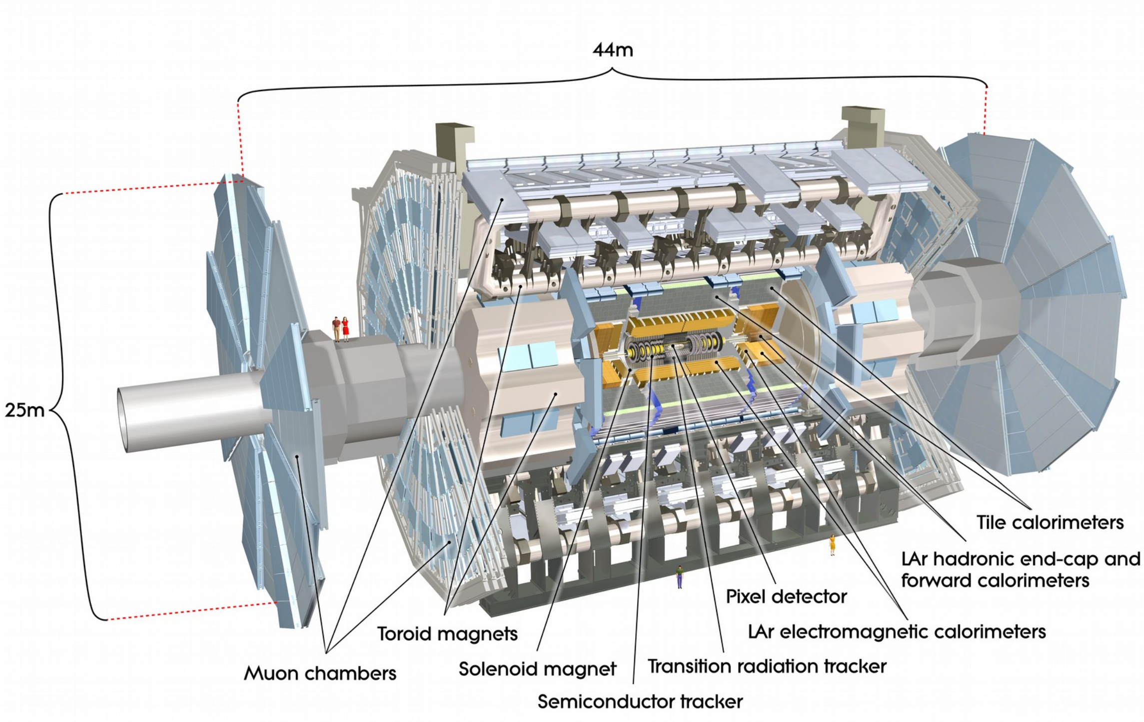


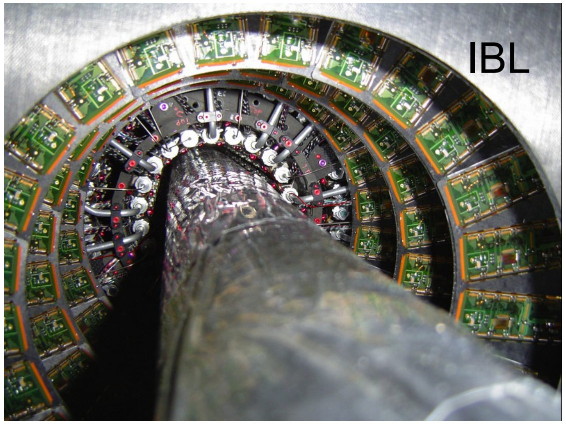
High-luminosity comes with a challenge



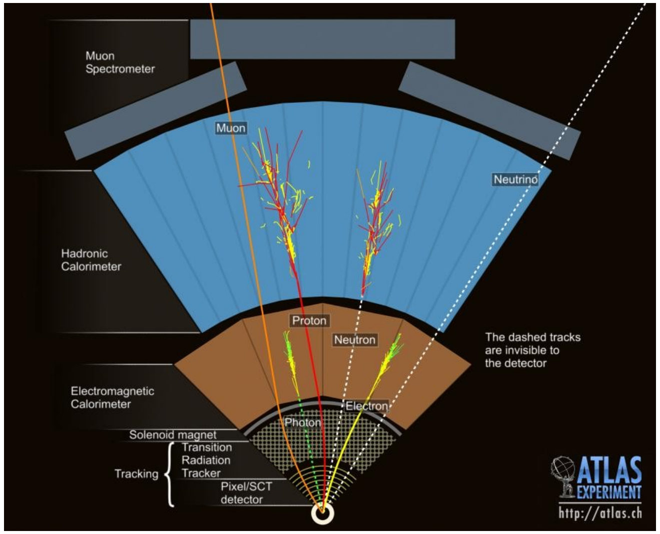
Excellent data taking (94%) and data quality (95%) efficiencies thanks to highly committed ATLAS operator and shifter teams. Integrated luminosity in Run-2 measured to 1.7% precision ATLAS-CONF-2019-021

ATLAS Improvements during 2013-14 Shutdown for Run-2

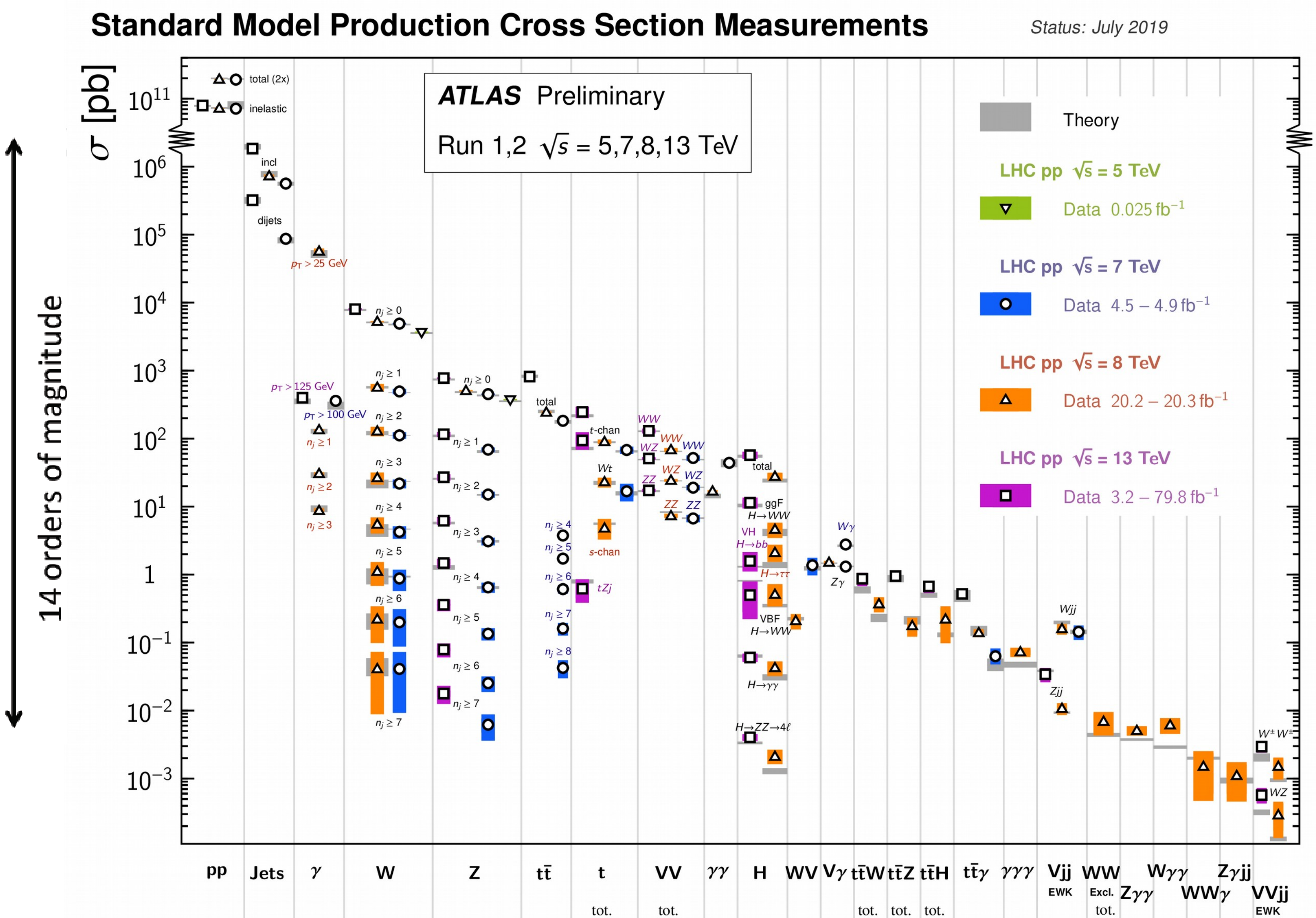




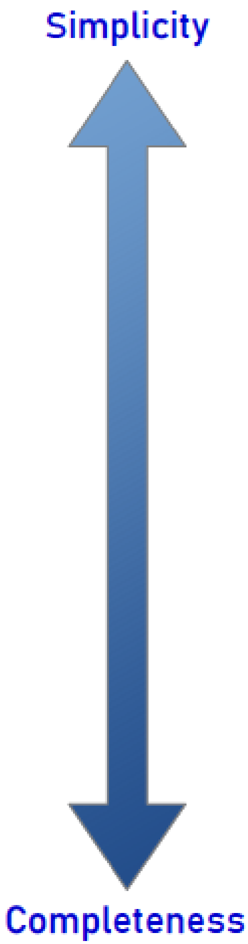
- Infrastructure
  - New beam-pipe, improvements to magnet and cryogenic system
- Detector consolidation
  - Muon chambers completion and various repairs
- 4th silicon pixel detector layer (IBL)
  - Innermost Pixel detector layer at 3.3 cm from beam pipe
- Trigger/DAQ
  - Increase max. L1 rate from 75kHz to 100kHz. New L1 topological trigger. New Central Trigger Processor. Merge L2 and HLT farms.



ATLAS: What we did find !



Dark Matter from...



Effective Field Theories

– We don't know what the higher-scale physics is, but we can integrate it out.

"Simplified Models"

– We introduce a few additional degrees of freedom, but don't try to make statements about the complete theory.

Complete Theories

– We add a full set of new DoF's and expect them to explain everything (e.g. SUSY).

Physics Beyond Standard Model: Why SUSY ?

Could solve:

- Hierarchy problem

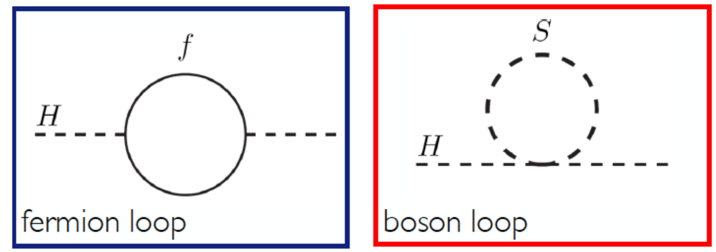
Low-mass top squarks cancel SM contributions to Higgs mass

- Unification gauge coupling

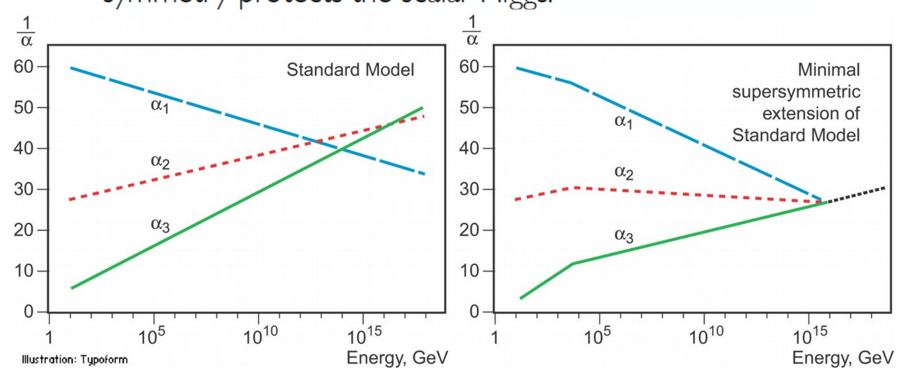
Presence of sparticles (at TeV scale) changes running of couplings

- Dark matter

Lightest SUSY particle can be massive, stable and weakly interacting. R-parity protects lightest SUSY particle from decaying



fermion and boson loops contribute with different signs to the Higgs radiative corrections; fermion-boson symmetry protects the scalar Higgs.

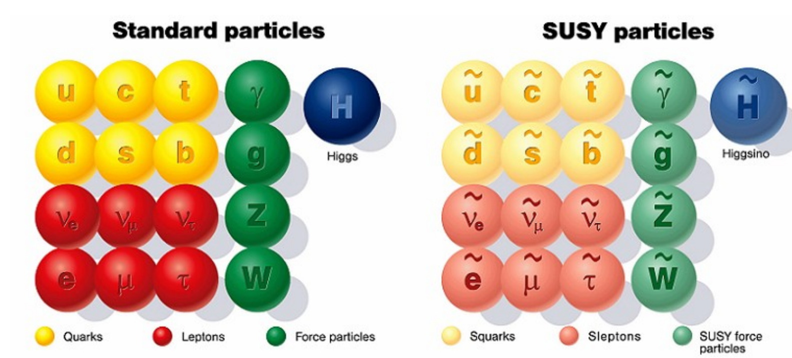


How?:

- Generalization of SM: symmetry between force and matter particles
- Introduces sfermions and gauginos

doubles particle content wrt SM

With 100 free parameters wide range of possible experimental signatures

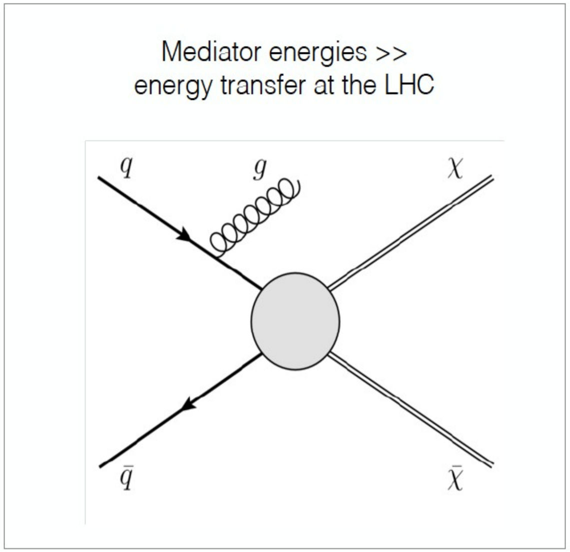


Sfermions: $q, \ell \longleftrightarrow \tilde{q}, \tilde{\ell}$

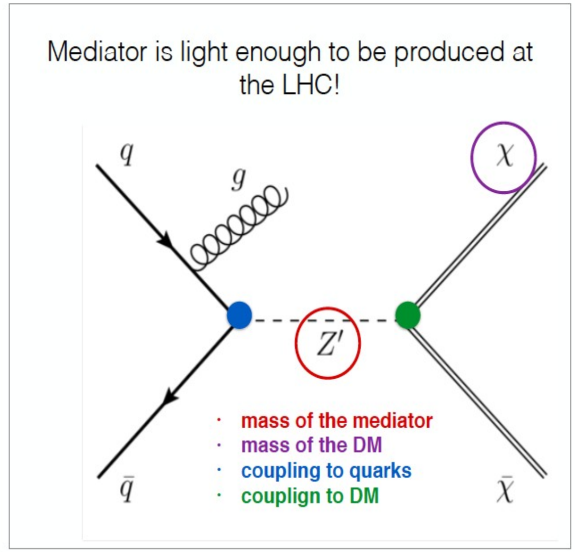
Gauginos: e.g. $g \longleftrightarrow \tilde{g}$

ATLAS-CMS Dark Matter Forum for Run-2

Effective field theories



Simplified models



29

Zeynep Demiragli

In Run-2 the ATLAS and CMS experiments moved away from the use of EFT inspired models (questionable validity at high-Q^2)

A set of well-defined simplified s-channel exchange diagrams with heavy mediators is now considered motivated by a number of different considerations

Mostly 4 parameters:

- Mediator mass (M_{Med})
- WIMP mass (m_χ)
- 2 couplings (g_q,g_χ), typically (1, 0.25)

DM as as Dirac-fermionic WIMPs

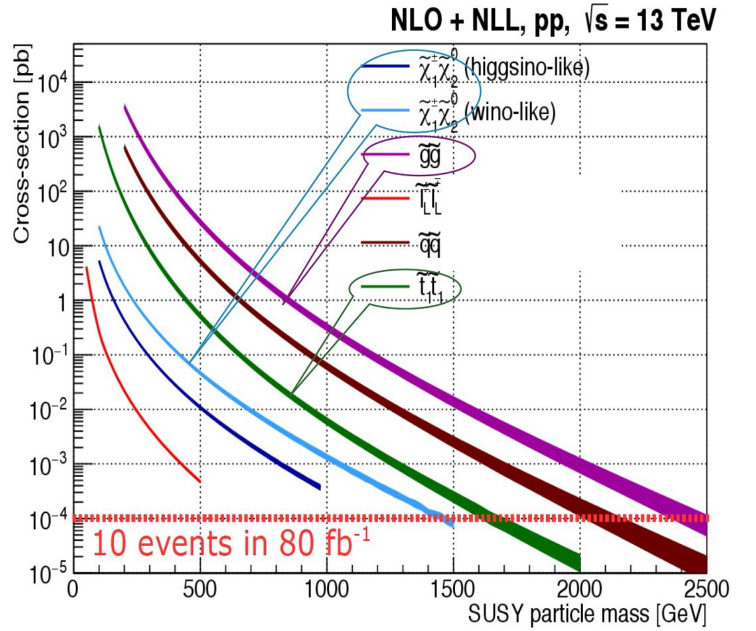
- Neutral, stable, weakly interacting particles with mass O(100 GeV)

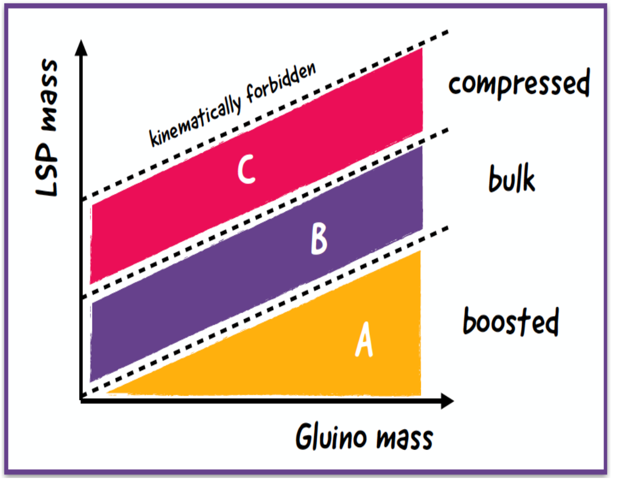
arXiv:1507.00966v

SUSY Searches: Paradigm Shift

Having found no SUSY so far in "standard" channels (strong production, large mass splittings), the searches are shifting in the following directions:

- Compressed spectrum scenarios (e.g, stop nearly degenerate with top quark + neutralino masses)
  - Use ISR as an important tool to boost compressed system
- Search for EW production of SUSY particles
  - Sensitivity for Higgsino pair production rapidly increasing the reach
- Search for SUSY via Higgs boson in decay chains
  - Just started to be sensitive
- Long-Lived Particles
- Go beyond the R-parity conserving models





Search strategy for new physics

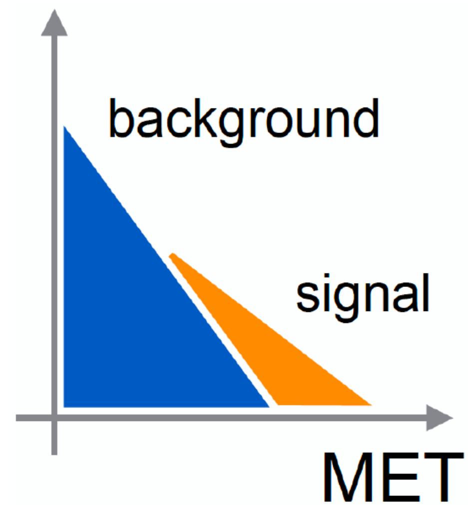
Standard Model
Top, multijets
Z, W, WZ, WWZ, Higgs

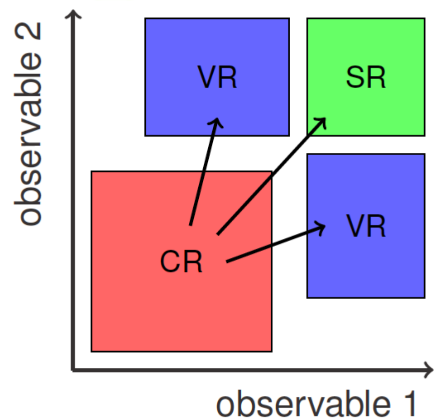
Reducible
Determined from data
Analysis specific

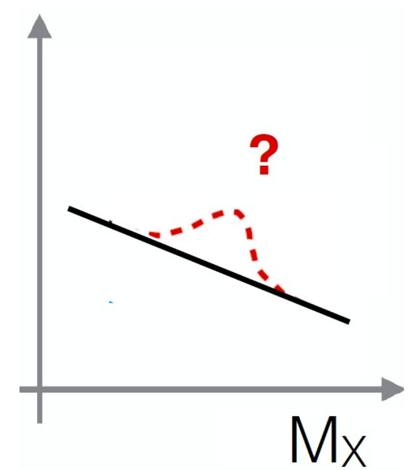
Irreducible
Normalize MC in Control Regions
Small contributions - rely on MC

Validation
Cross check SM predictions with Data

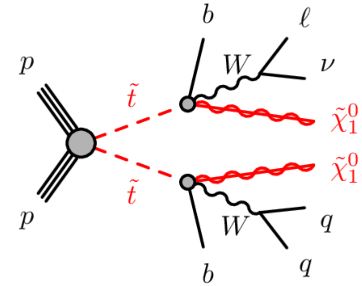
Signal



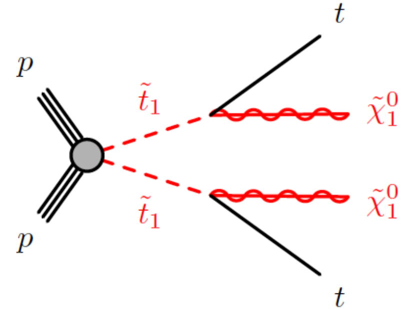
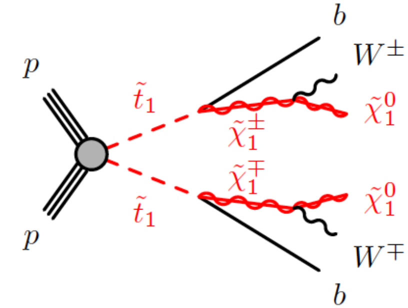


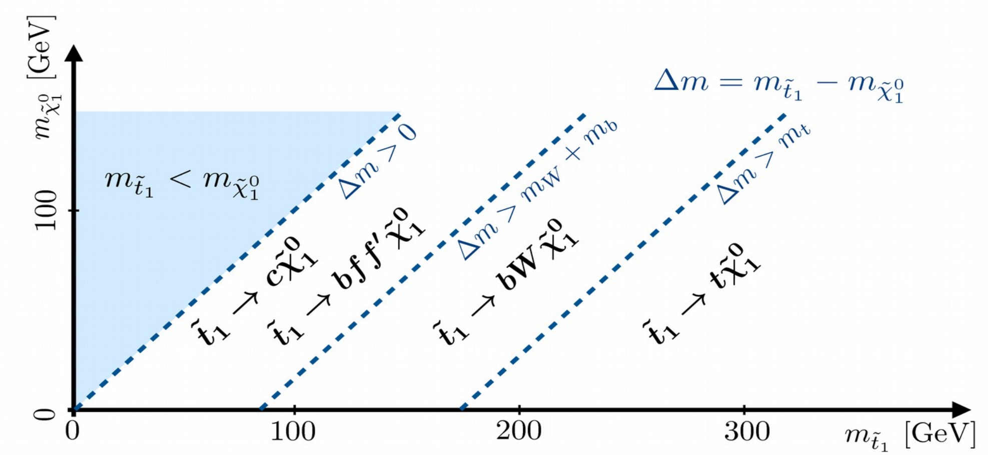


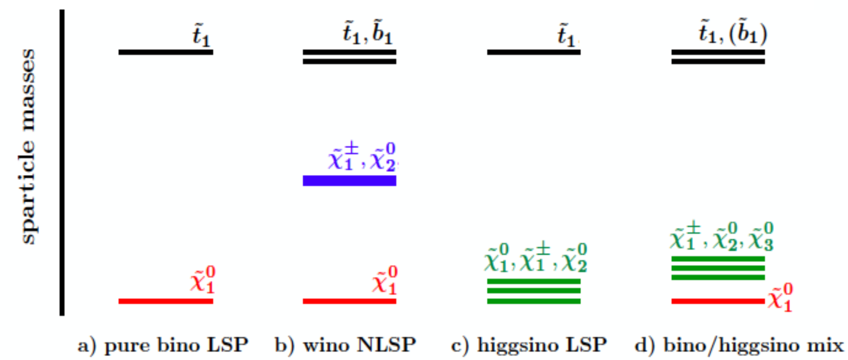
Direct pair production of top and bottom squark

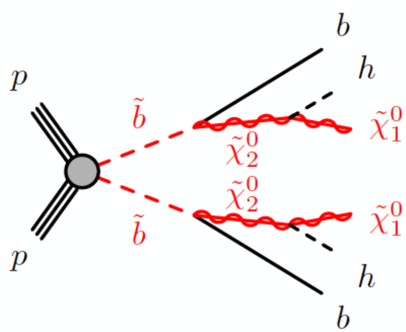
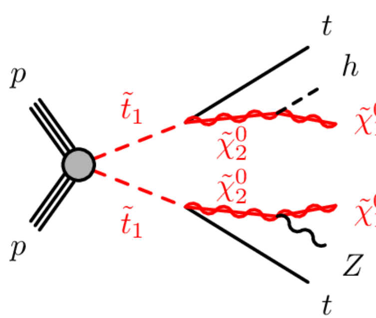


- All SUSY particles are considered to be heavy except for t_1 (b_1) and χ
- Different analysis techniques are required in different $\Delta m(t_1, \chi^0_1)$ regime



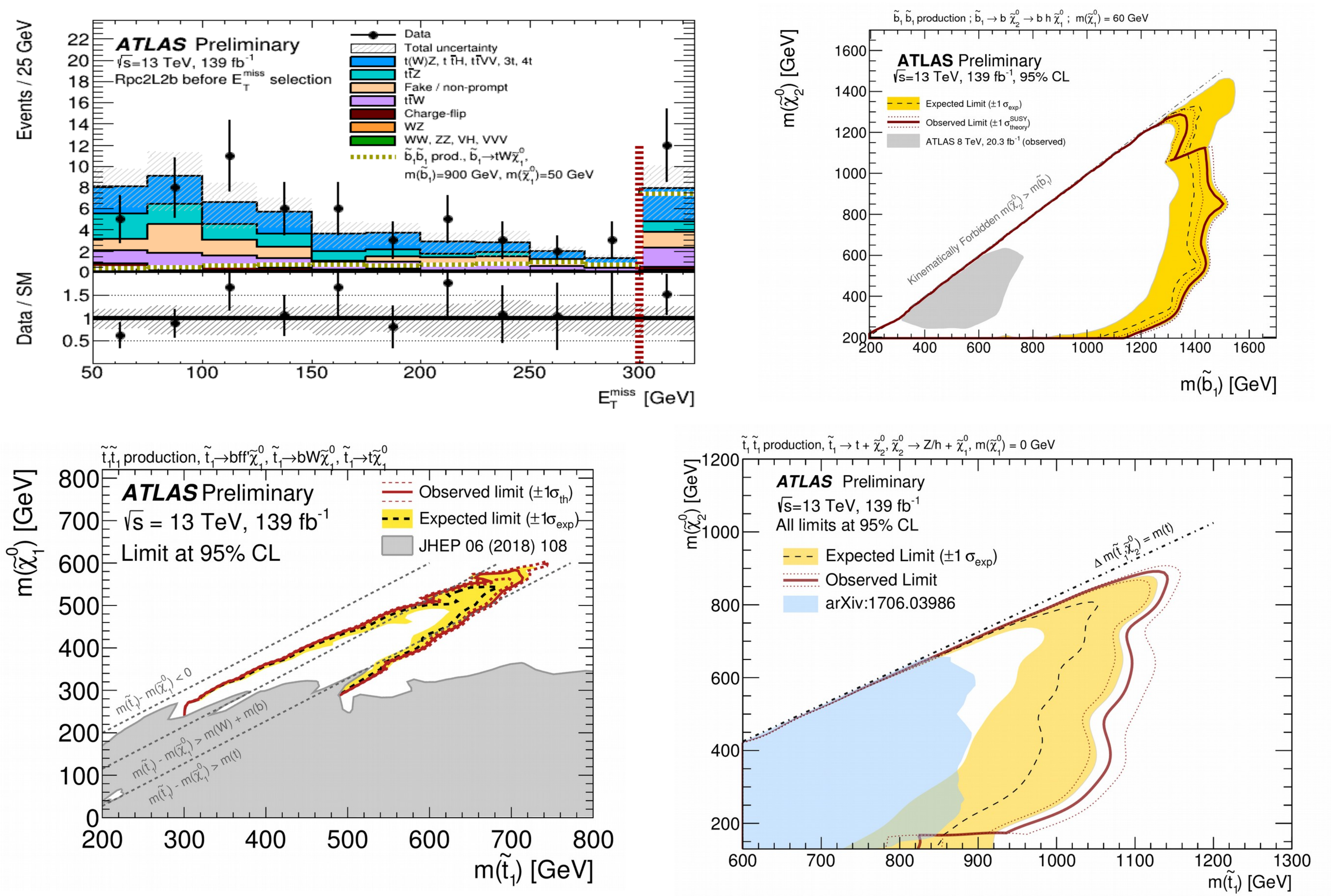


- h (bb) decay leads to multi b-jets final state
- OS 2-leptons from Z decay and an additional lepton(s) from top decay leads to multi-leptons final state.
- Different W decay modes with 1 lepton, SS 2 lepton or 3 leptons all sensitive for 3rd generation squarks

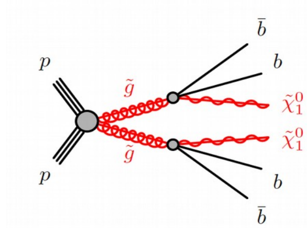
ATLAS-CONF-2019-011 /15 /16/17

Top and Bottom Squark

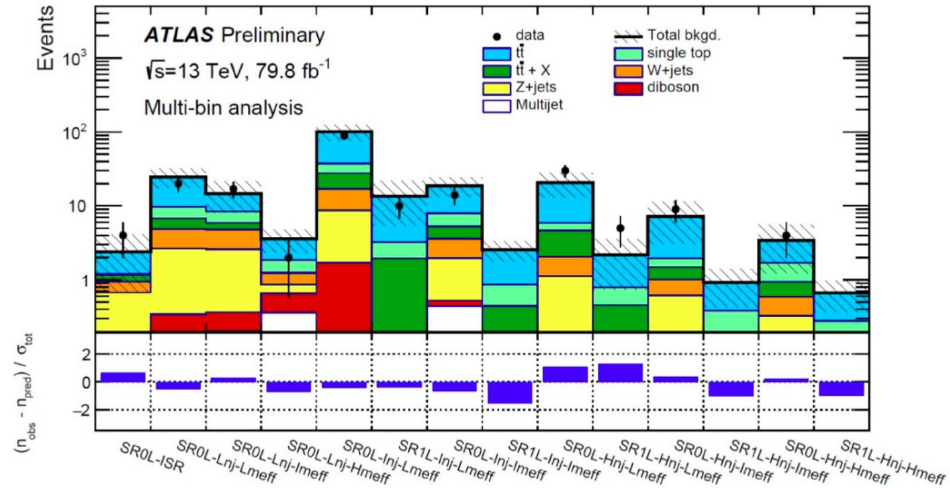


The Higgs at 125 GeV inspires O(1TeV) stop. If natural SUSY exists, we are decreasing the places where it can hide

Multi b jets

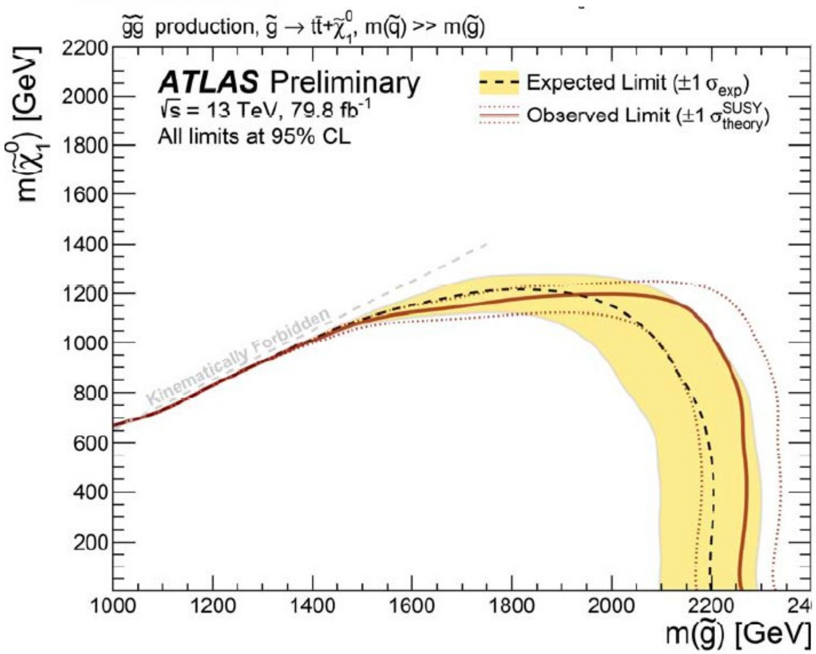


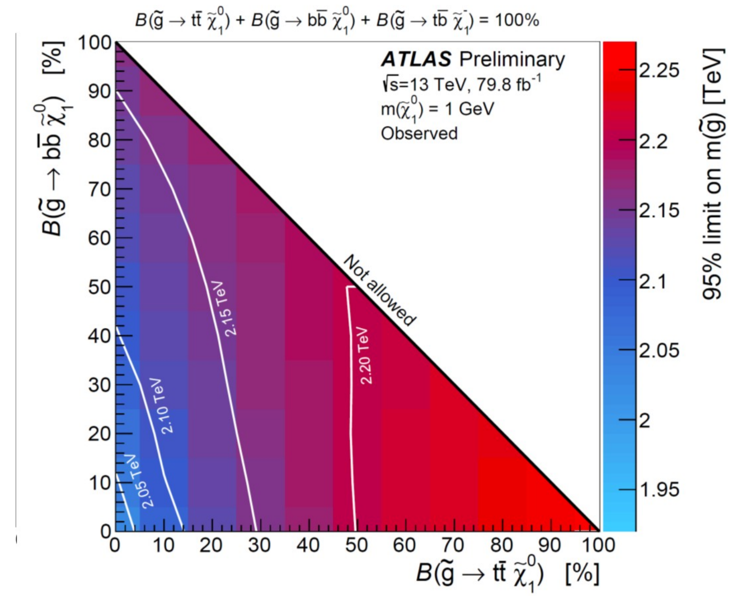
gluinos decaying via third generation off-shell squarks to the lightest neutralino



Exclusion stream uses meff shape & jet multiplicity information to perform a multi-bin fit. All search regions dominated by ttbar + heavy flavour events.

$$H_{\mathrm{T}} = \sum_{\text{visible}} |p_{\mathrm{T}}| \qquad m_{\mathrm{eff}} = H_{\mathrm{T}} + E_{\mathrm{T}}^{\mathrm{miss}}$$



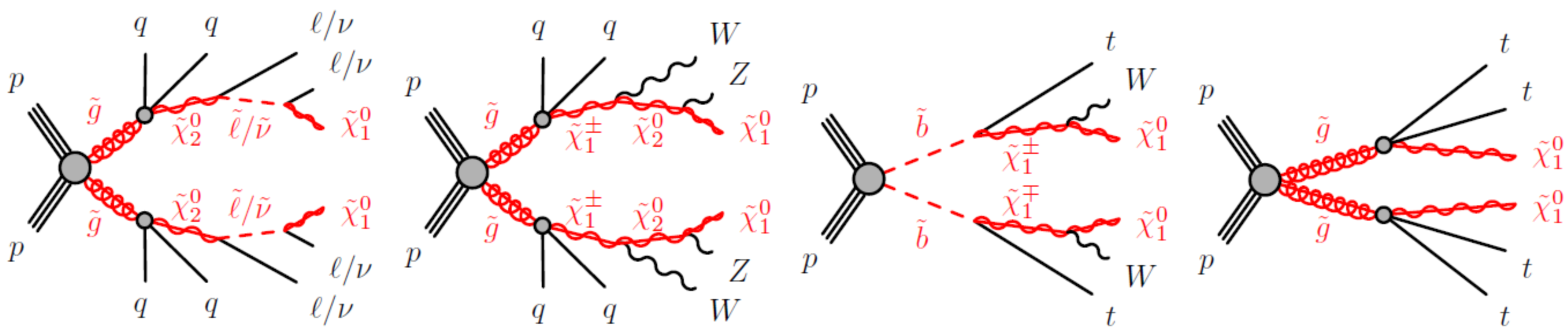


All the regions of the multi-bin analysis are statistically combined to set model-dependent upper limits. Observed constraints on gluino masses reach 2.2 TeV for Gtt simplified models

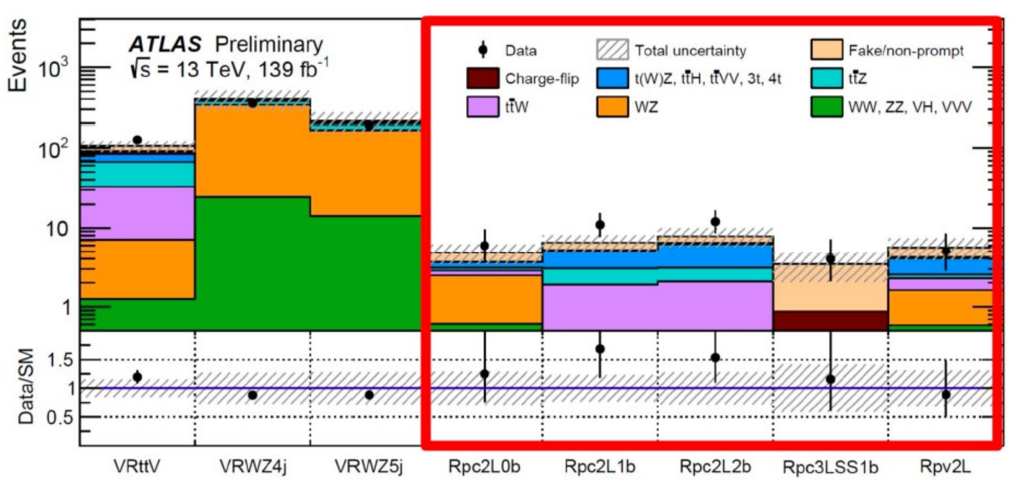
Limits also interpreted as a function of the gluino BR to Gtt / Gbb / Gtb

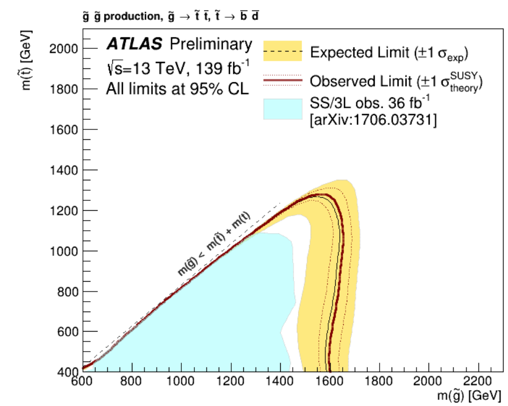
ATLAS-CONF-2018-041

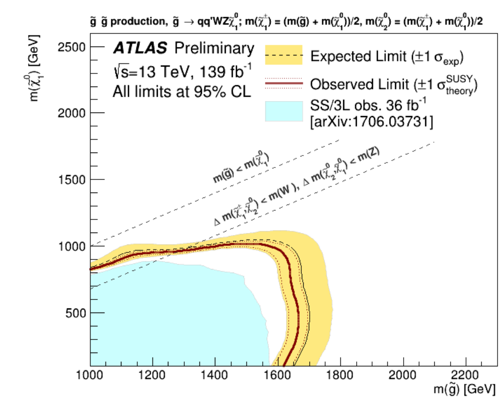
Final states with jets & 2 same-sign leptons or 3 leptons



Search for strongly produced SUSY particles in SS/3L+jets events.
Low SM background from same-sign requirement







No significant excess observed → gluino exclusion up to 1.6 TeV

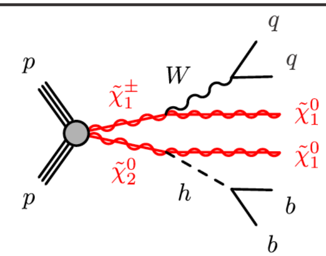
ATLAS-CONF-2019-015

EWK production of chargino/neutralino decaying to Wh

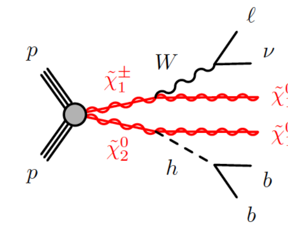
Assuming mass-degenerated and wino-like χ^{+}_{1} / χ^{0}_{2} , and a bino-like χ^{0}_{1}

Masses of χ^{+}_{1} / χ^{0}_{2} smaller than 680 GeV are excluded for a massless χ^{0}_{1}. Unprecedented sensitivity to high-mass region by the signatures with b-jets (0ℓbb and 1ℓbb)

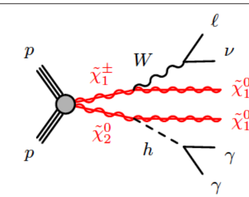
Fully hadronic signature ($0\ell bb$)



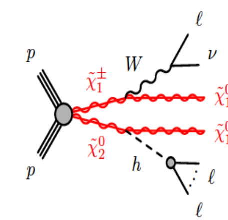
Single lepton + 2 b-jets signature ($1\ell bb$)

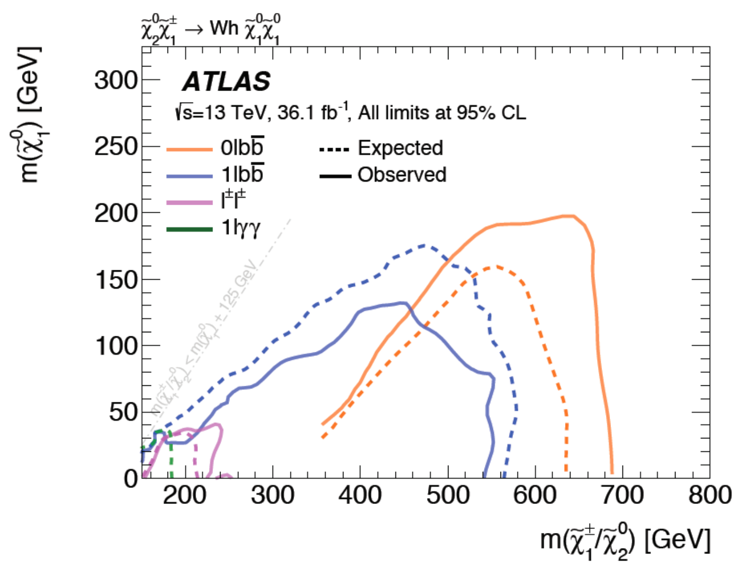


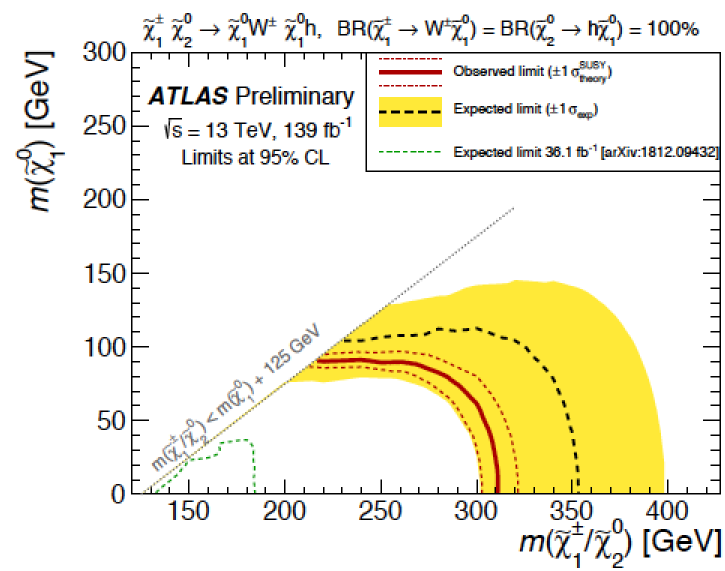
Single lepton + diphoton signature ($1\ell\gamma\gamma$)



Same-sign dilepton ($\ell^{\pm}\ell^{\pm}$) and 3 lepton signatures (3ℓ)





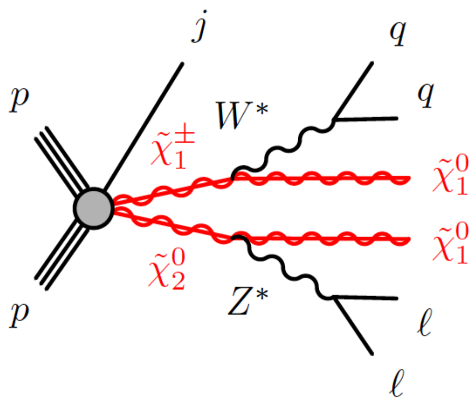


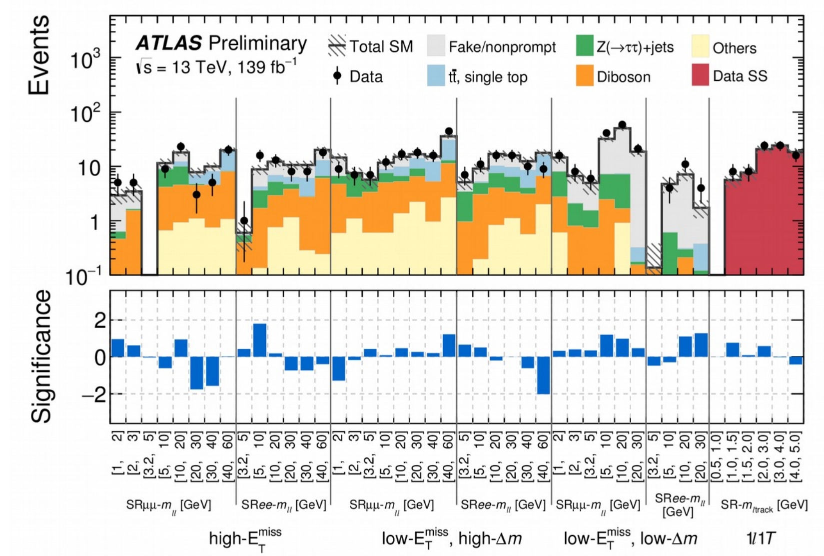
Updated analysis with full Run-2 data

SUSY-2017-01 / ATLAS-CONF-2019-019

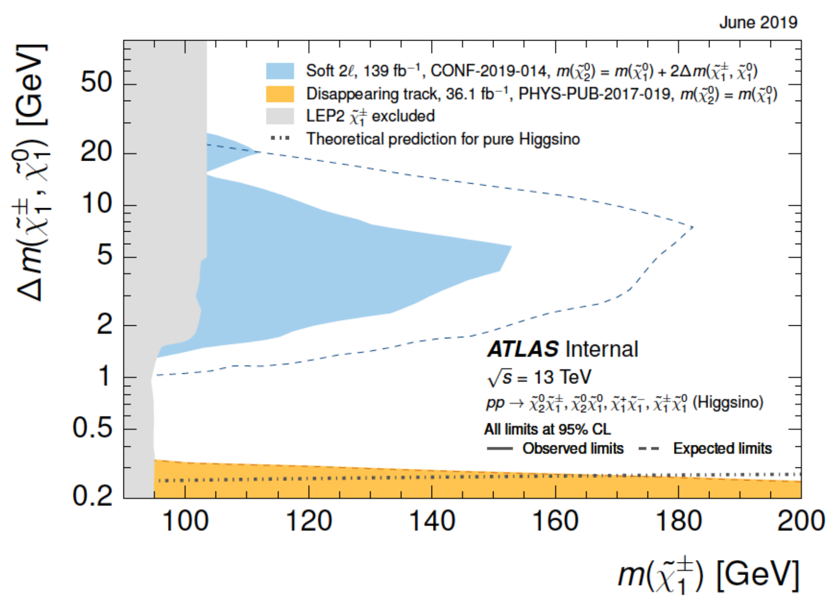
Higgsino searches

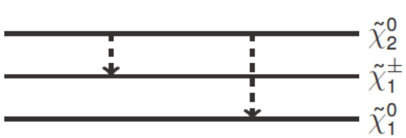
Motivated by naturalness arguments Higgsino mass parameter μ is near the weak scale, while the bino and wino mass parameters, M1 and M2, can be significantly larger |μ| ≪ |M1|,|M2|. Compressed scenarios.





- ISR allows highly efficient triggering at lower masses. Soft leptons are required (3-4.5 GeV)
- Additional 1 lepton + 1 track SR improves efficiency of very small mass splitting.
- First ATLAS search to use a track as a proxy for a charged lepton.
- For the Higgsino simplified model, exclusion limits at 95% CL are set up to masses of 145 GeV and down to mass splittings of 2.5 GeV





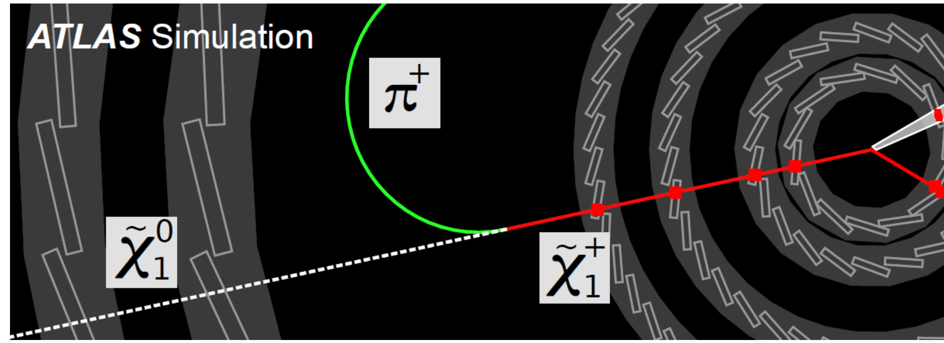
$\Delta m(\tilde{\chi}_2^0, \tilde{\chi}_1^\pm, \tilde{\chi}_1^0) \sim$ a few GeV

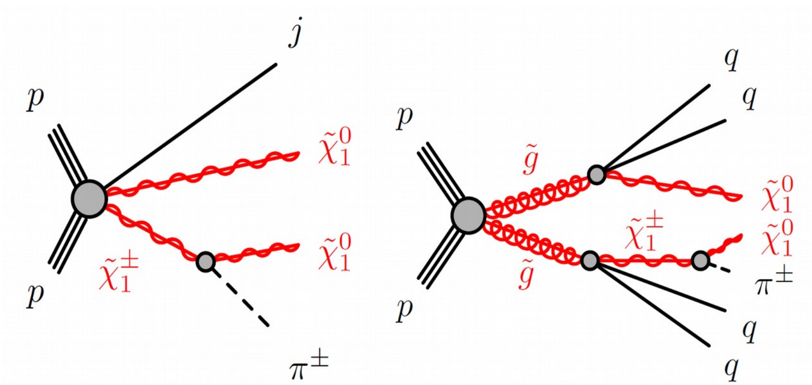
ATLAS-CONF-2019-014

Search for disappearing tracks

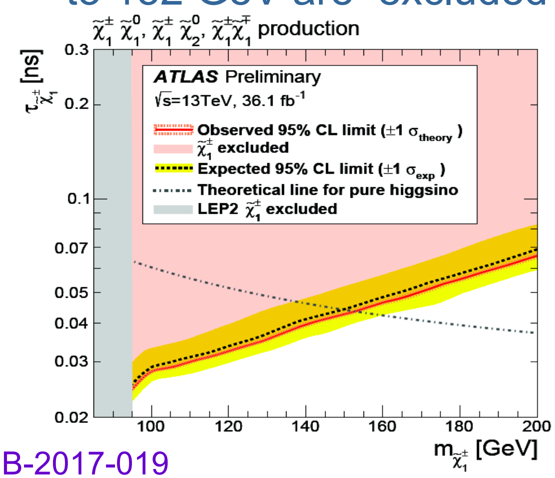
Sensitivity gains from use of ATLAS IBL

Search for long-lived charged particles (charginos) leading to disappearing track + MET Pixel-only trackless with IBL reduce minimum track length to 12 cm (from 30 cm in Run-I)





A for pure-higgsino signature, chargino masses up to 152 GeV are excluded



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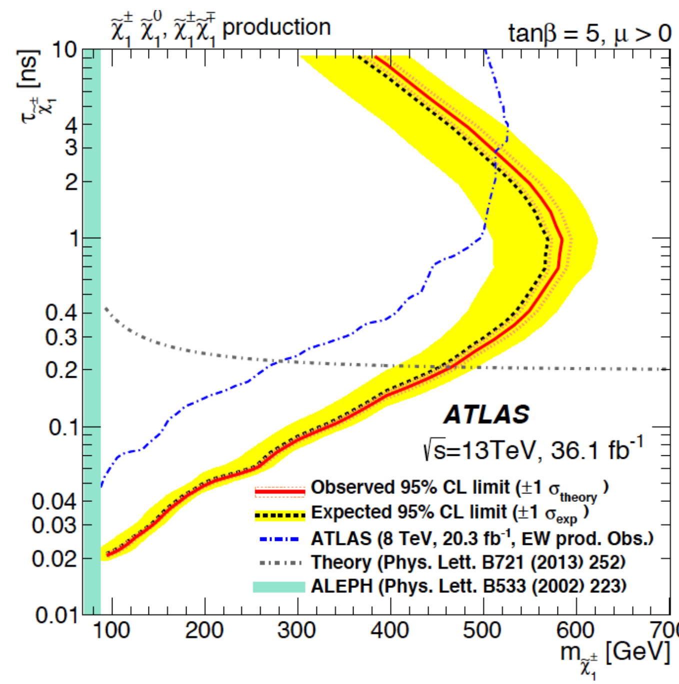
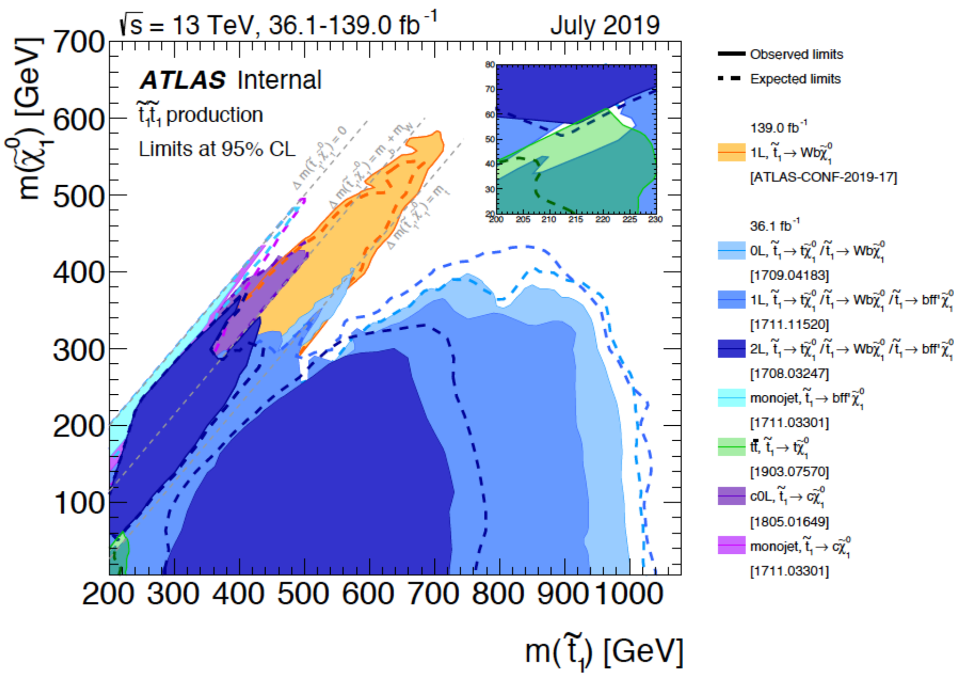
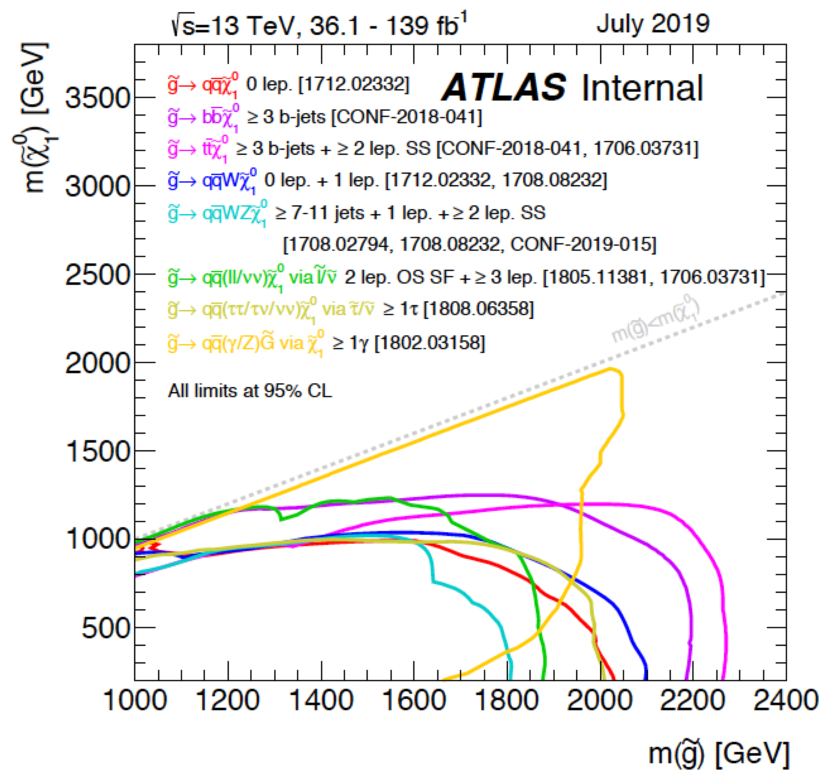


Almost pure wino LSP scenario

JHEP 06 (2018) 022

SUSY Limits June - July 2019



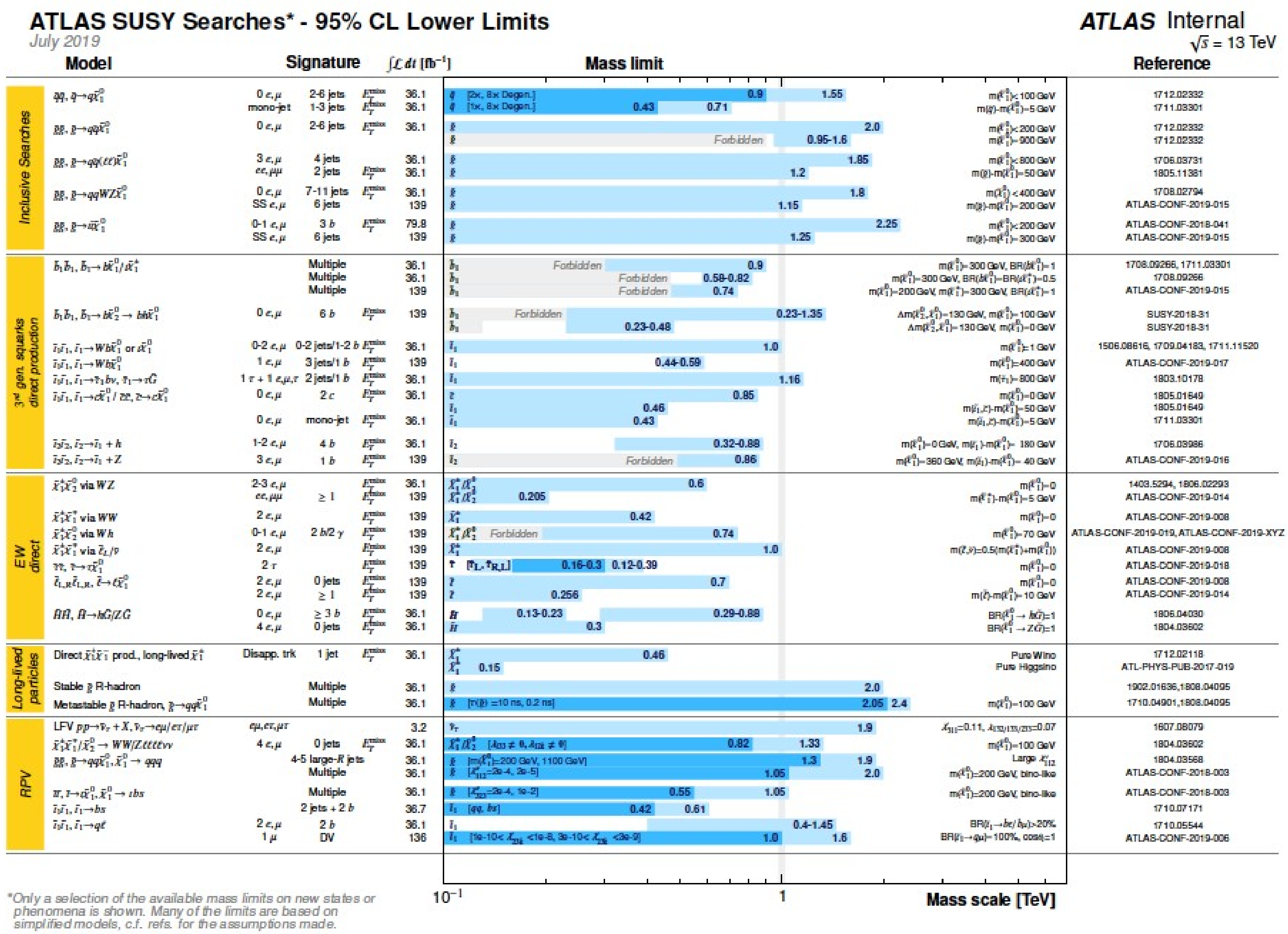


Simplified models limits exploiting 2015-2018 Run 2 dataset

- 1.6-2.2 TeV exclusion for gluinos at low LSP mass
- Some scenarios excluding 1 TeV stops

Note that these plots overlay contours belonging to different decay channels, different particle mass hierarchies, and simplified decay scenarios. Care must be taken when interpreting them.

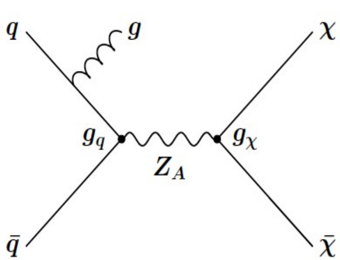
Search for supersymmetric particles

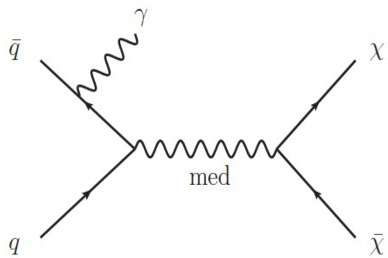


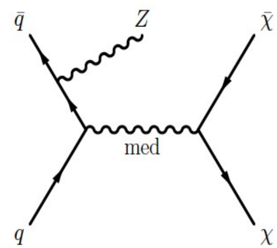
Simplified models limits exploiting 2015-2018 Run 2 dataset

- 1.6-2.2 TeV exclusion for gluinos at low LSP mass, up to 1.8 TeV for squarks (8-fold degeneracy)
- Some scenarios excluding 1 TeV stops
- Up to 700 GeV limits for gauginos and sleptons

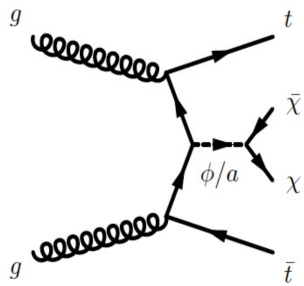
Mono X Analysis - General Analysis Strategy

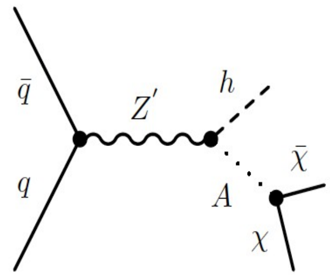






Non-interacting DM particles → Missing transverse energy (MET)





X (γ, jet, $W^{\pm}$, Z, h)

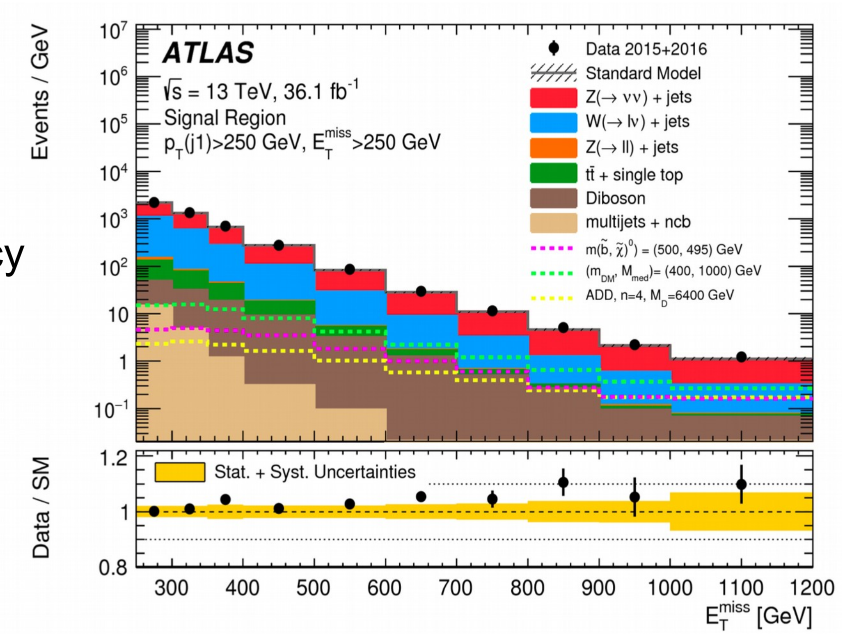
Event Selection

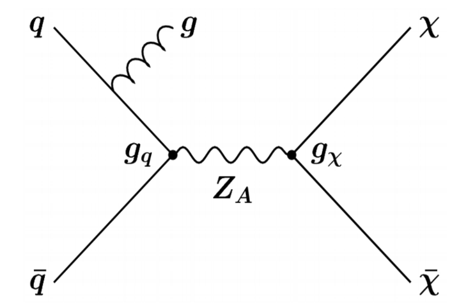
- High MET, compatible with production
- If X=γ, jet → high p_T(X) with quality criteria
- If X=W, Z, h → reconstruct mass within a windows
- Large MET (χ)
- Veto events with other “good” physics objects, like leptons

The searches focus in look for excess in different regions of high MET, and in case of absence of excess, exclusion limits are extracted for the model

Mono-Jet

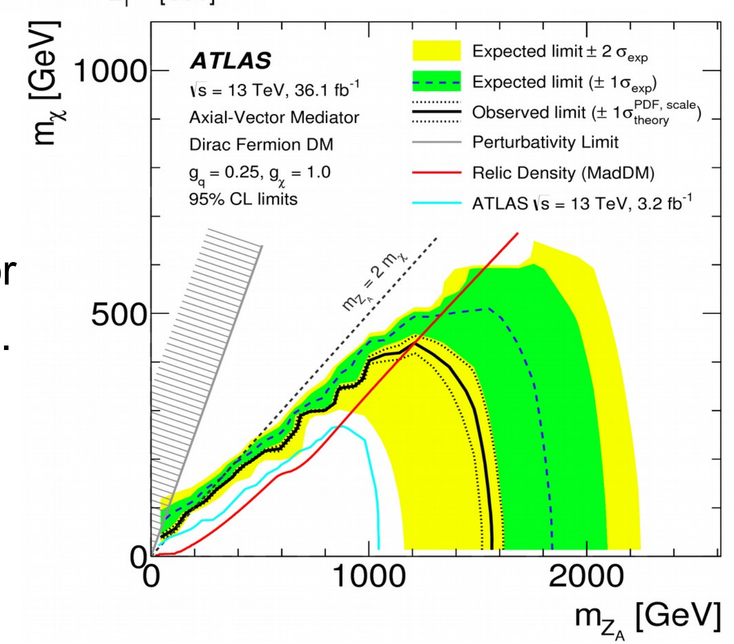
- Signature
  - High p_T Jet + MET
- MET triggers: efficiency reaches ~100% at 250 GeV
- Main backgrounds
  - Z(vv) + jets
  - W(lv) + jets





Mono-jet is one of the most powerful channels

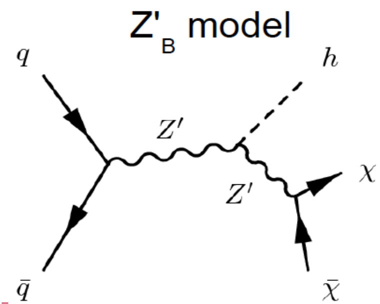
For couplings $g_q = 0.25$, $g_\chi = 1.0$, axial-vector and vector mediators excluded up to 1.55 TeV for low DM masses.

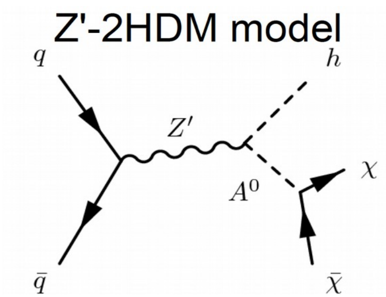


JHEP 01 (2018) 126

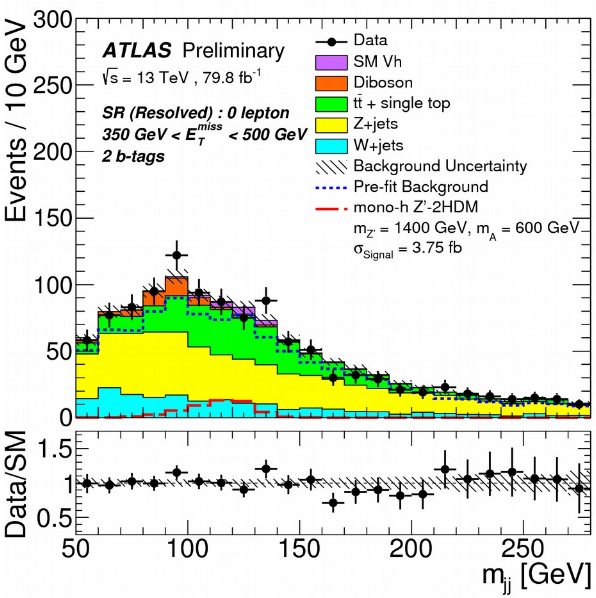
Mono-Higgs (bb)

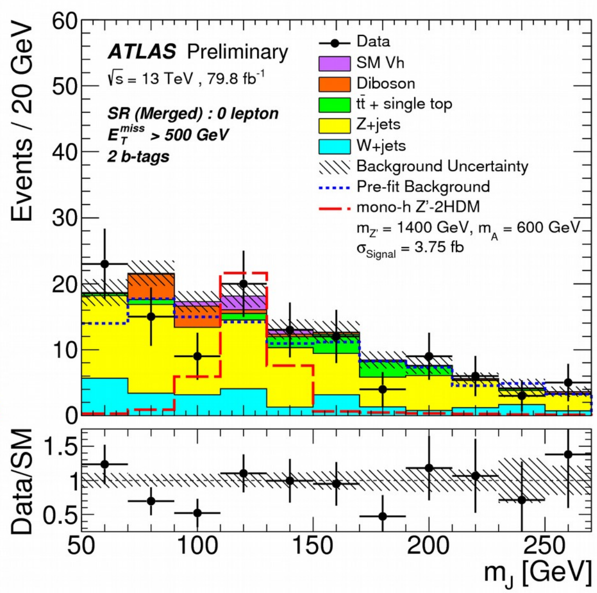
Models in which the higgs couples to dark sector particles, e.g. higgs couplings to the mediator

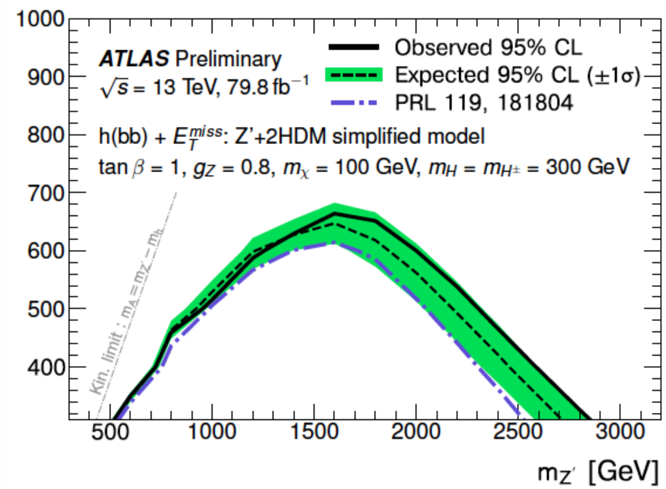




- Not ISR (small coupling)
- Mainly Simplified Models:
  - s-channel vector mediator radiating Higgs
- Other models considered:
  - s-channel scalar mediator radiating Higgs
  - Z'-2HD simplified model
  - scalar 2HD simplified model
  - Additional parameters as: $g_{Z'Z'h}$, mixing angles..





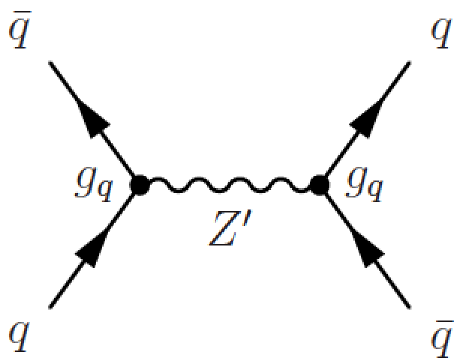


Masses of the Z' are excluded up to 2.8 TeV depending on the choices for other model parameters.

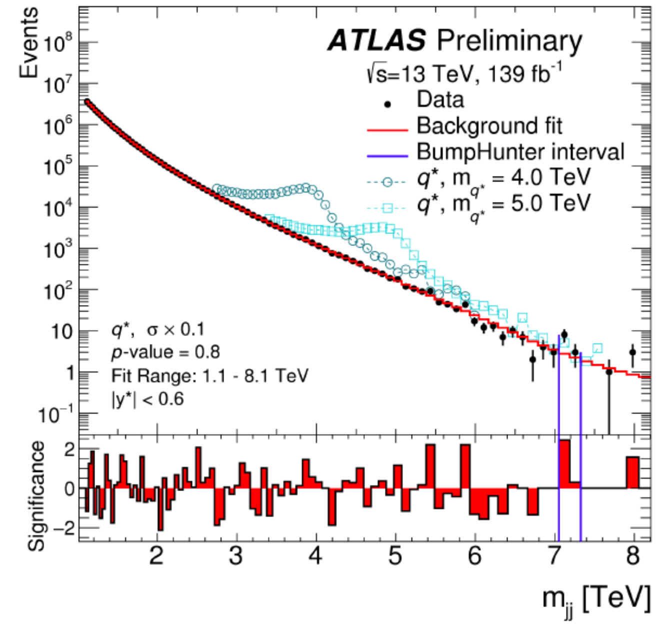
ATLAS CONF-2018-39

New phenomena in dijet

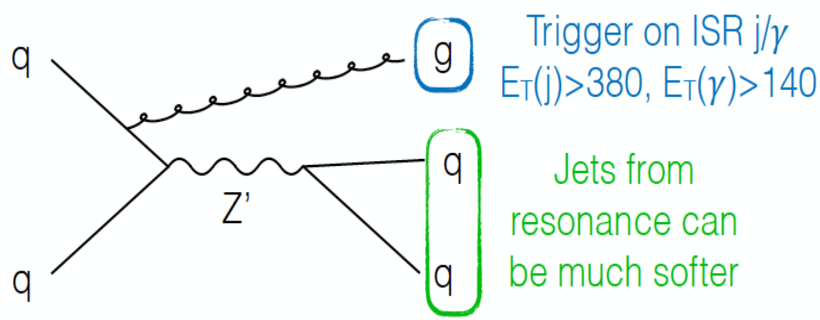
If there is a mediator that couples to quarks and DM then we can forget about the DM and look for the mediator. Many BSM models that predict dijet excesses (Quantum black holes, excited quarks, and W′ and Z′ bosons)



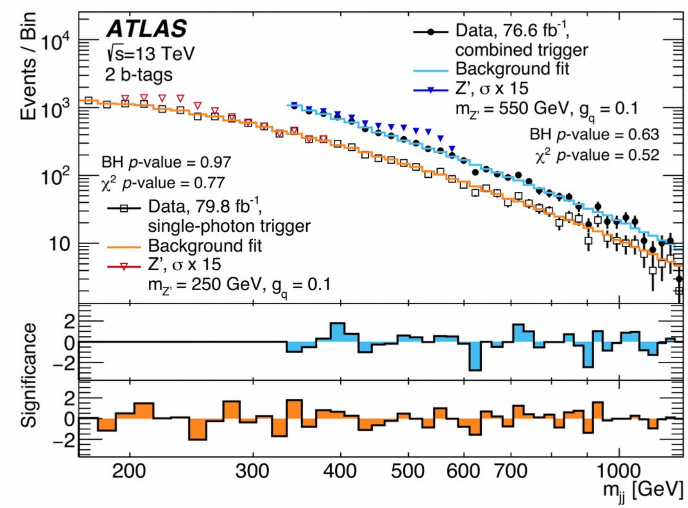
2 high p_T jets, m_{jj} is the discriminant, search for bump (resonance) on a smooth, falling background. Background modelled by a parametrized function.



Standard dijet search sensitive to $m_{jj} \geq 1$ TeV limited by trigger thresholds.



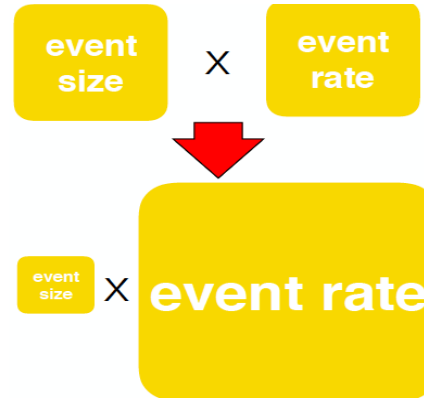
At Z' masses below ~ 200 GeV, resonance jets merge in large-R jet



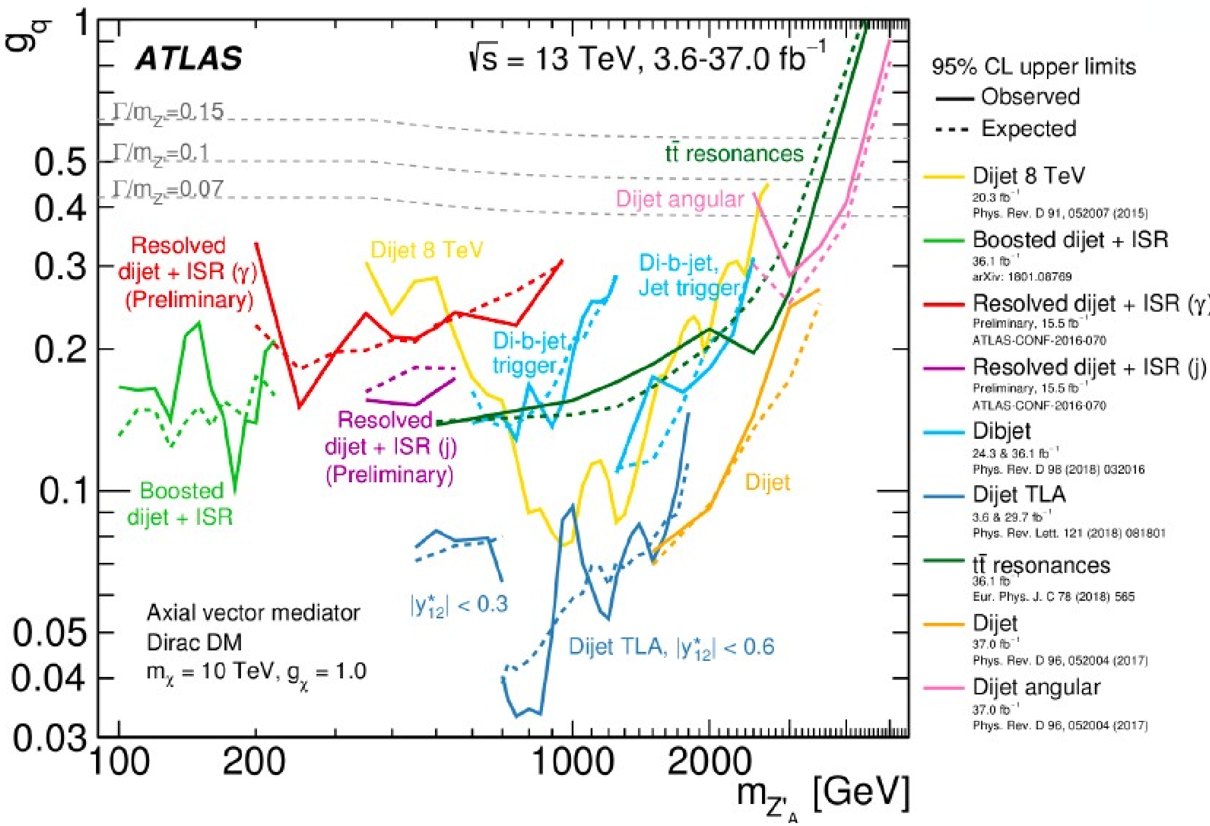
Recent results from resolved dijet system. SM physics provides the boost, so the recoiling object is model-independent. Photon+dijet including new b-tagged channels.

Phys. Lett. B 795 (2019) 56, ATL-CONF-2018-052

New phenomena in dijet



It is also possible to use a Trigger-level search, with dedicated data stream, to go down to 450 GeV



- Coupling values above the solid lines excluded, as long as the signals are narrow enough to be detected using these searches.
- The boosted dijet+ISR analysis has the best reach for low masses, excluding mediator at ~100 GeV
- Mediator excluded at ~ 2.6 TeV

JHEP 1905 (2019) 142

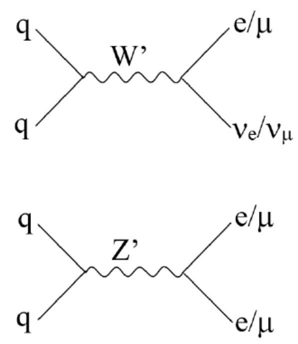
High-mass resonances decaying into leptonic states

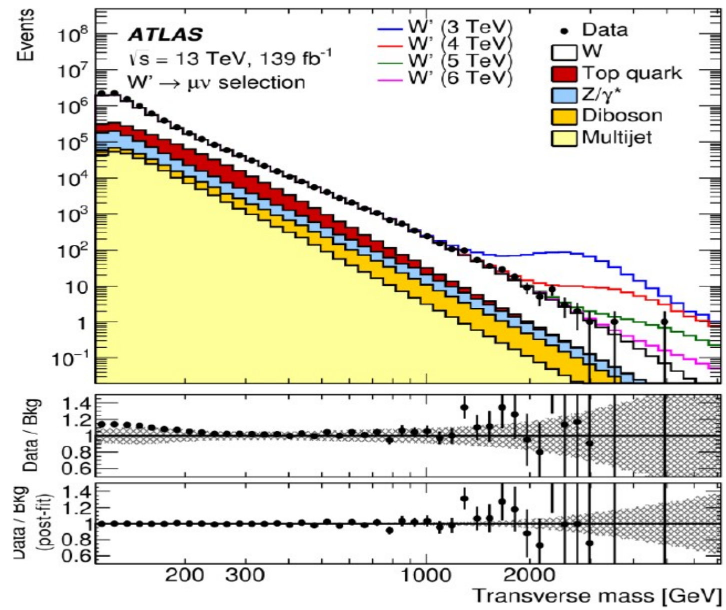
New spin-1 vector bosons (W', Z') explored

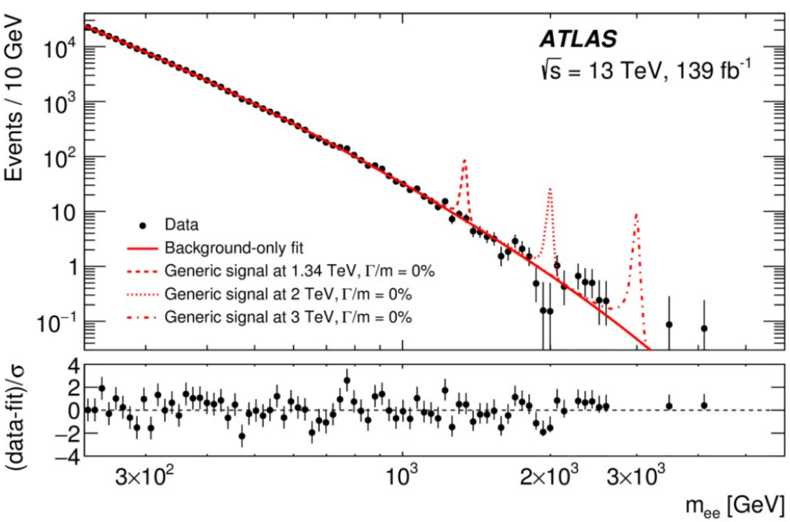
Sequential Standard Model (SSM)
- W'/Z' couples to fermions with the same strength as SM W/Z.
- Couplings to W/Z are ignored.

E6-motivated Grand Unification model
- Two Z's (Z'_χ, Z'_ψ) are predicted.

Heavy Vector Triplet (HVT) model
- Provides generic framework with couplings of W'/Z' to fermions and Higgs.







Highest ee event mass 4.06 TeV

Decay	$m(W')$ lower limit [TeV] Observed	Expected
$W' \to e\nu$	6.0	5.7
$W' \to \mu\nu$	5.1	5.1
$W' \to \ell\nu$	6.0	5.8

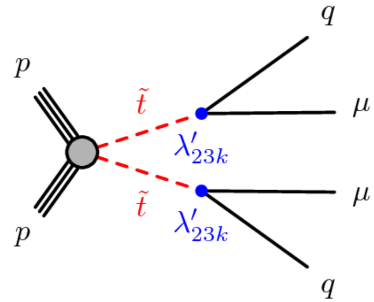
Sequential Standard Model

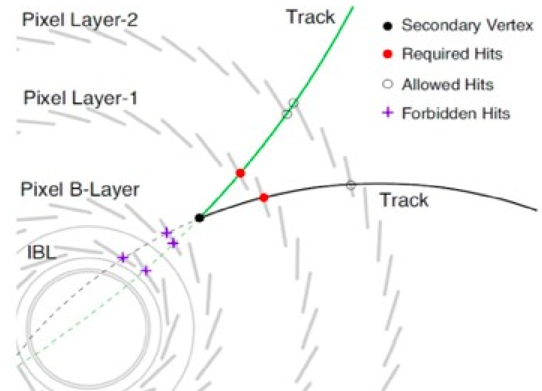
Model	Lower limits on $m_{Z'}$ [TeV] ee obs	ee exp	$\mu\mu$ obs	$\mu\mu$ exp	$\ell\ell$ obs	$\ell\ell$ exp
Z'_ψ	4.1	4.3	4.0	4.0	4.5	4.5
Z'_χ	4.6	4.6	4.2	4.2	4.8	4.8
Z'_{SSM}	4.9	4.9	4.5	4.5	5.1	5.1

arxiv:1906.05609 / arxiv1903.06248

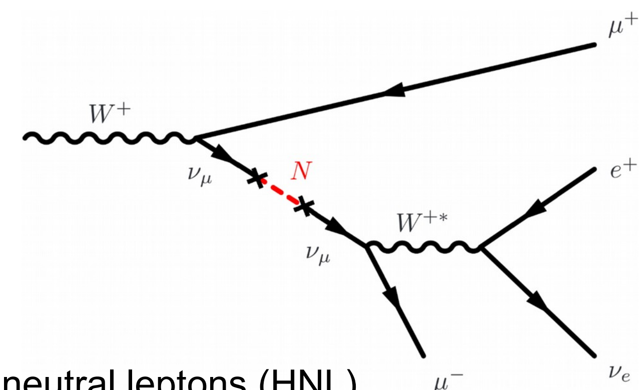
Search program for long-lived massive particles

Multiple reasons to be long-lived: small couplings, compressed mass spectrum, highly virtual intermediate states, R-parity violating models, R-Hadrons

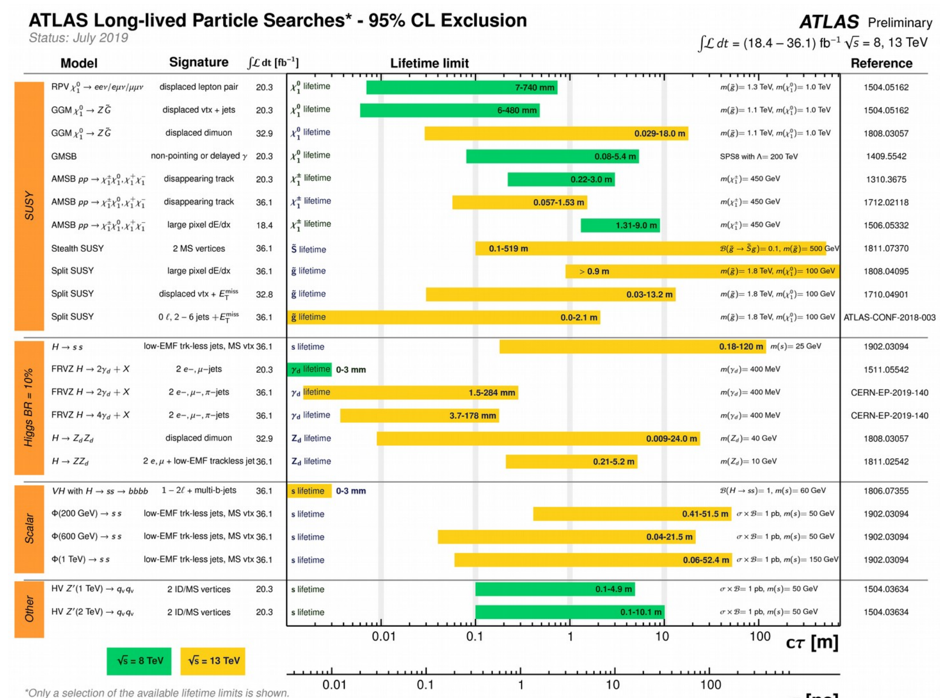




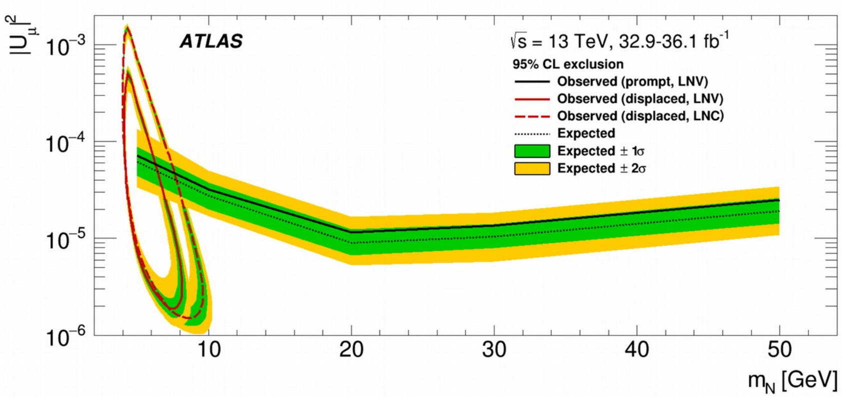
Events with displaced vertices



LLP decays occurring at 4 mm < r < 300 mm from the PV



Heavy neutral leptons (HNL)
Prompt muon from the W boson + displaced vertex (DV) with low p_T tracks leptons. Approx. 0 background search



lifetime has a dependence on coupling strength and m_N

arXiv:1905.09787, ATLAS-CONF-2019-006

Search for exotic particles

ATLAS Exotics Searches* - 95% CL Upper Exclusion Limits

Status: May 2019

ATLAS Preliminary

$\int \mathcal{L}\, dt = (3.2 - 139)\ \text{fb}^{-1}$ $\sqrt{s} = 8, 13$ TeV

	Model	ℓ, γ	Jets†	E_T^{miss}	$\int \mathcal{L}\, dt[\text{fb}^{-1}]$	Limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	$0\ e, \mu$	$1-4$ j	Yes	36.1	M_D 7.7 TeV	$n = 2$	1711.03301
	ADD non-resonant $\gamma\gamma$	$2\ \gamma$	–	–	36.7	M_S 8.6 TeV	$n = 3$ HLZ NLO	1707.04147
	ADD QBH	–	2 j	–	37.0	M_{th} 8.9 TeV	$n = 6$	1703.09127
	ADD BH high $\sum p_T$	$\geq 1\ e, \mu$	≥ 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 $G_{KK} \to \gamma\gamma$	$2\ \gamma$	–	–	36.7	G_{KK} mass 4.1 TeV	$k/\overline{M}_{Pl} = 0.1$	1707.04147
	Bulk RS $G_{KK} \to WW/ZZ$	multi-channel			36.1	G_{KK} mass 2.3 TeV	$k/\overline{M}_{Pl} = 1.0$	1808.02380
	Bulk RS $G_{KK} \to WW \to qqqq$	$0\ e, \mu$	2 J	–	139	G_{KK} mass 1.6 TeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2019-003
	Bulk RS $g_{KK} \to tt$	$1\ e, \mu$	≥ 1 b, ≥ 1J/2j	Yes	36.1	g_{KK} mass 3.8 TeV	$\Gamma/m = 15\%$	1804.10823
	2UED / RPP	$1\ e, \mu$	≥ 2 b, ≥ 3 j	Yes	36.1	KK mass 1.8 TeV	Tier (1,1), $\mathcal{B}(A^{(1,1)} \to tt) = 1$	1803.09678
Gauge bosons	SSM $Z' \to \ell\ell$	$2\ e, \mu$	–	–	139	Z' mass 5.1 TeV		1903.06248
	SSM $Z' \to \tau\tau$	$2\ \tau$	–	–	36.1	Z' mass 2.42 TeV		1709.07242
	Leptophobic $Z' \to bb$	–	2 b	–	36.1	Z' mass 2.1 TeV		1805.09299
	Leptophobic $Z' \to tt$	$1\ e, \mu$	≥ 1 b, ≥ 1J/2j	Yes	36.1	Z' mass 3.0 TeV	$\Gamma/m = 1\%$	1804.10823
	SSM $W' \to \ell\nu$	$1\ e, \mu$	–	Yes	139	W' mass 6.0 TeV		CERN-EP-2019-100
	SSM $W' \to \tau\nu$	$1\ \tau$	–	Yes	36.1	W' mass 3.7 TeV		1801.06992
	HVT $V' \to WZ \to qqqq$ model B	$0\ e, \mu$	2 J	–	139	V' mass 3.6 TeV	$g_V = 3$	ATLAS-CONF-2019-003
	HVT $V' \to WH/ZH$ model B	multi-channel			36.1	V' mass 2.93 TeV	$g_V = 3$	1712.06518
	LRSM $W_R \to tb$	multi-channel			36.1	W_R mass 3.25 TeV		1807.10473
	LRSM $W_R \to \mu N_R$	$2\ \mu$	1 J	–	80	W_R mass 5.0 TeV	$m(N_R) = 0.5$ TeV, $g_L = g_R$	1904.12679
CI	CI $qqqq$	–	2 j	–	37.0	Λ 21.8 TeV η_{LL}^-		1703.09127
	CI $\ell\ell qq$	$2\ e, \mu$	–	–	36.1	Λ 40.0 TeV η_{LL}^-		1707.02424
	CI $tttt$	$\geq 1\ e, \mu$	≥ 1 b, ≥ 1 j	Yes	36.1	Λ 2.57 TeV	$\lvert C_{4t}\rvert = 4\pi$	1811.02305
DM	Axial-vector mediator (Dirac DM)	$0\ e, \mu$	$1-4$ j	Yes	36.1	m_{med} 1.55 TeV	g_q=0.25, g_χ=1.0, $m(\chi) = 1$ GeV	1711.03301
	Colored scalar mediator (Dirac DM)	$0\ e, \mu$	$1-4$ j	Yes	36.1	m_{med} 1.67 TeV	g=1.0, $m(\chi) = 1$ GeV	1711.03301
	$VV\chi\chi$ EFT (Dirac DM)	$0\ e, \mu$	1 J, ≤ 1 j	Yes	3.2	M_* 700 GeV	$m(\chi) < 150$ GeV	1608.02372
	Scalar reson. $\phi \to t\chi$ (Dirac DM)	0-1 e, μ	1 b, 0-1 J	Yes	36.1	m_ϕ 3.4 TeV	$y = 0.4$, $\lambda = 0.2$, $m(\chi) = 10$ GeV	1812.09743
LQ	Scalar LQ 1st gen	1,2 e	≥ 2 j	Yes	36.1	LQ mass 1.4 TeV	$\beta = 1$	1902.00377
	Scalar LQ 2nd gen	1,2 μ	≥ 2 j	Yes	36.1	LQ mass 1.56 TeV	$\beta = 1$	1902.00377
	Scalar LQ 3rd gen	$2\ \tau$	2 b	–	36.1	LQ_3^u mass 1.03 TeV	$\mathcal{B}(\mathrm{LQ}_3^u \to b\tau) = 1$	1902.08103
	Scalar LQ 3rd gen	0-1 e, μ	2 b	Yes	36.1	LQ_3^d mass 970 GeV	$\mathcal{B}(\mathrm{LQ}_3^d \to t\tau) = 0$	1902.08103
Heavy quarks	VLQ $TT \to Ht/Zt/Wb + X$	multi-channel			36.1	T mass 1.37 TeV	SU(2) doublet	1808.02343
	VLQ $BB \to Wt/Zb + X$	multi-channel			36.1	B mass 1.34 TeV	SU(2) doublet	1808.02343
	VLQ $T_{5/3}T_{5/3} \lvert T_{5/3} \to Wt + X$	2(SS)/$\geq 3\ e,\mu$	≥ 1 b, ≥ 1 j	Yes	36.1	$T_{5/3}$ mass 1.64 TeV	$\mathcal{B}(T_{5/3} \to Wt)$= 1, $c(T_{5/3}Wt)$= 1	1807.11883
	VLQ $Y \to Wb + X$	$1\ e, \mu$	≥ 1 b, ≥ 1j	Yes	36.1	Y mass 1.85 TeV	$\mathcal{B}(Y \to Wb)$= 1, $c_R(Wb)$= 1	1812.07343
	VLQ $B \to Hb + X$	$0\ e,\mu, 2\ \gamma$	≥ 1 b, ≥ 1j	Yes	79.8	B mass 1.21 TeV	κ_B= 0.5	ATLAS-CONF-2018-024
	VLQ $QQ \to WqWq$	$1\ e, \mu$	≥ 4 j	Yes	20.3	Q mass 690 GeV		1509.04261
Excited fermions	Excited quark $q^* \to qg$	–	2 j	–	139	q^* mass 6.7 TeV	only u^* and d^*, $\Lambda = m(q^*)$	ATLAS-CONF-2019-007
	Excited quark $q^* \to q\gamma$	$1\ \gamma$	1 j	–	36.7	q^* mass 5.3 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1709.10440
	Excited quark $b^* \to bg$	–	1 b, 1 j	–	36.1	b^* mass 2.6 TeV		1805.09299
	Excited lepton ℓ^*	$3\ e, \mu$	–	–	20.3	ℓ^* mass 3.0 TeV	$\Lambda = 3.0$ TeV	1411.2921
	Excited lepton ν^*	$3\ e, \mu, \tau$	–	–	20.3	ν^* mass 1.6 TeV	$\Lambda = 1.6$ TeV	1411.2921
Other	Type III Seesaw	$1\ e, \mu$	≥ 2 j	Yes	79.8	N^0 mass 560 GeV		ATLAS-CONF-2018-020
	LRSM Majorana ν	$2\ \mu$	2 j	–	36.1	N_R mass 3.2 TeV	$m(W_R) = 4.1$ TeV, $g_L = g_R$	1809.11105
	Higgs triplet $H^{\pm\pm} \to \ell\ell$	2,3,4 e, μ (SS)	–	–	36.1	$H^{\pm\pm}$ mass 870 GeV	DY production	1710.09748
	Higgs triplet $H^{\pm\pm} \to \ell\tau$	$3\ e, \mu, \tau$	–	–	20.3	$H^{\pm\pm}$ mass 400 GeV	DY production, $\mathcal{B}(H_L^{\pm\pm} \to \ell\tau) = 1$	1411.2921
	Multi-charged particles	–	–	–	36.1	multi-charged particle mass 1.22 TeV	DY production, $\lvert q\rvert = 5e$	1812.03673
	Magnetic monopoles	–	–	–	34.4	monopole mass 2.37 TeV	DY production, $\lvert g\rvert = 1g_D$, spin 1/2	1905.10130

$\sqrt{s}$ = 8 TeV | $\sqrt{s}$ = 13 TeV partial data | $\sqrt{s}$ = 13 TeV full data

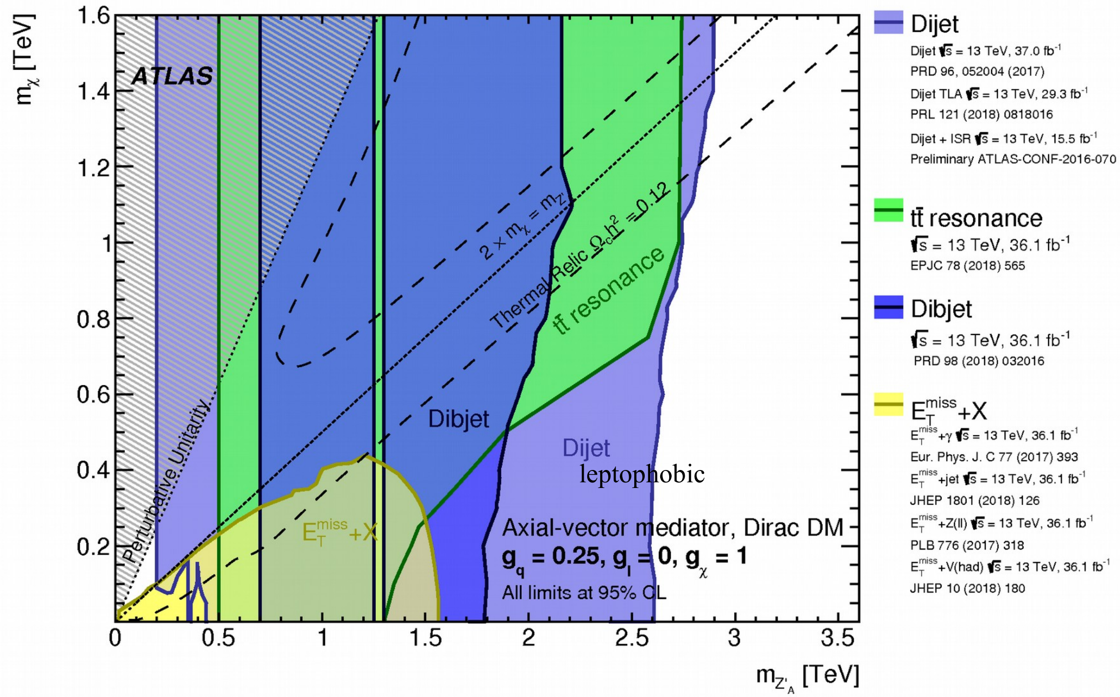
10^{-1} 1 10 **Mass scale [TeV]**

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

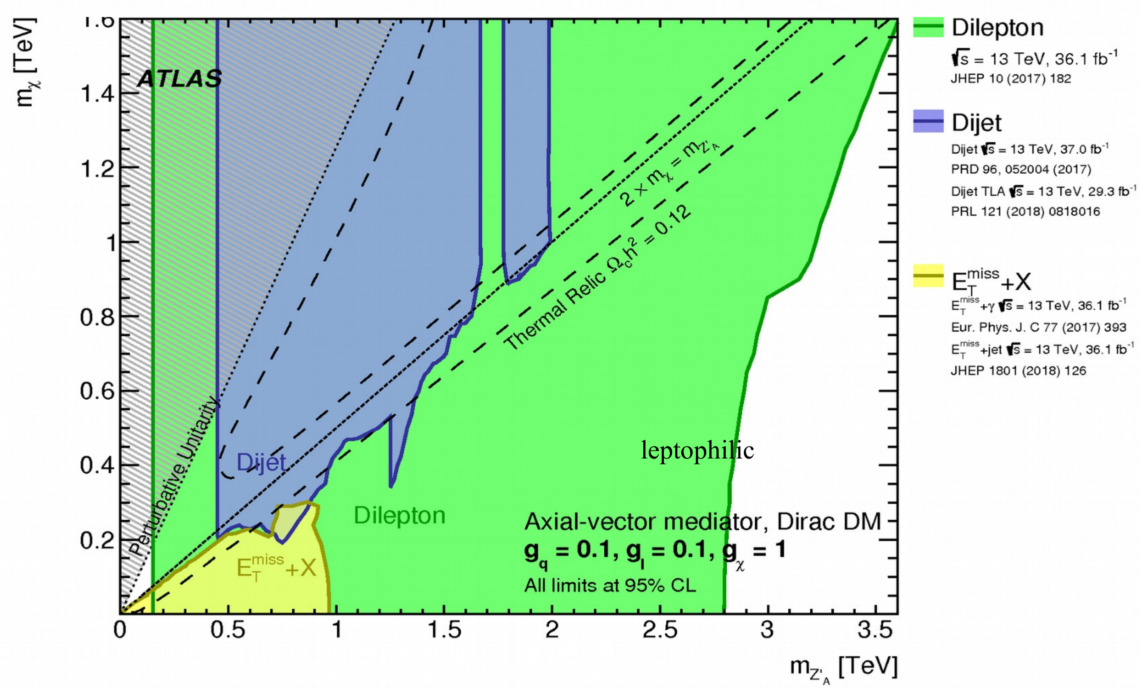
†Small-radius (large-radius) jets are denoted by the letter j (J).

Search DM

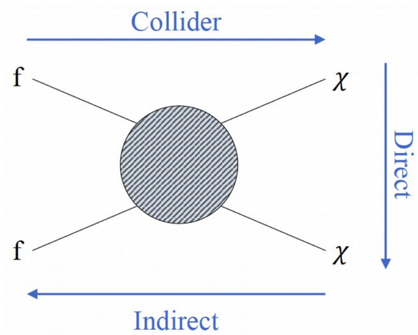
Dijet searches can exclude mediator masses between 50 GeV and 2.7 TeV for almost whole DM mass range.

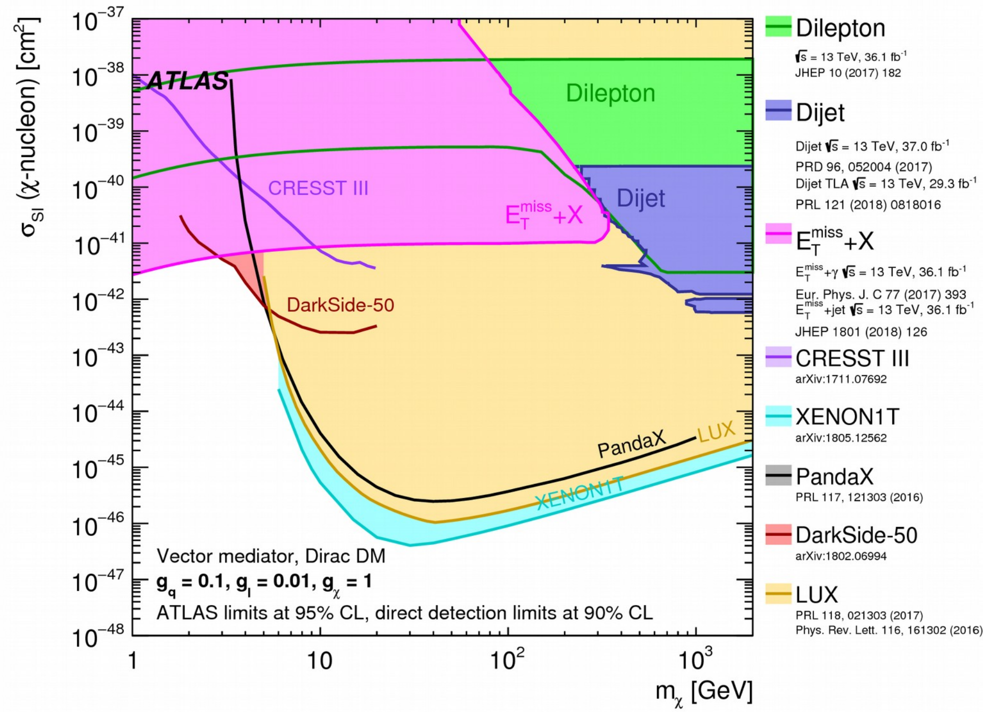


Big picture change with the choice of couplings.
Dijet and Mono-X constrains weakened if $g_q = 0.25 \rightarrow 0.1$



Comparison to direct detection



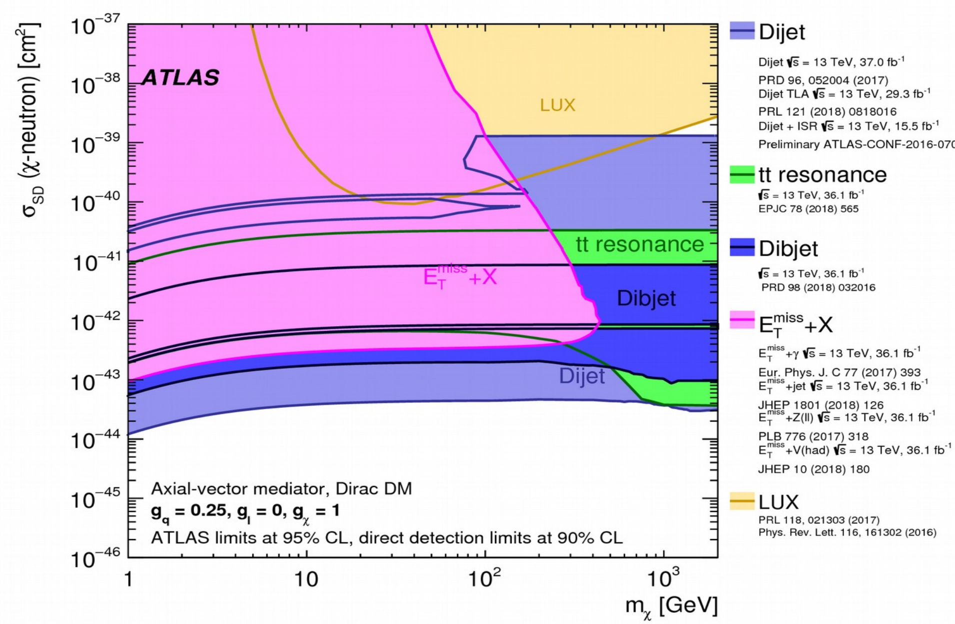


Rates of DM production are used to calculate (model dependent) interaction cross sections of other processes involving DM particles.

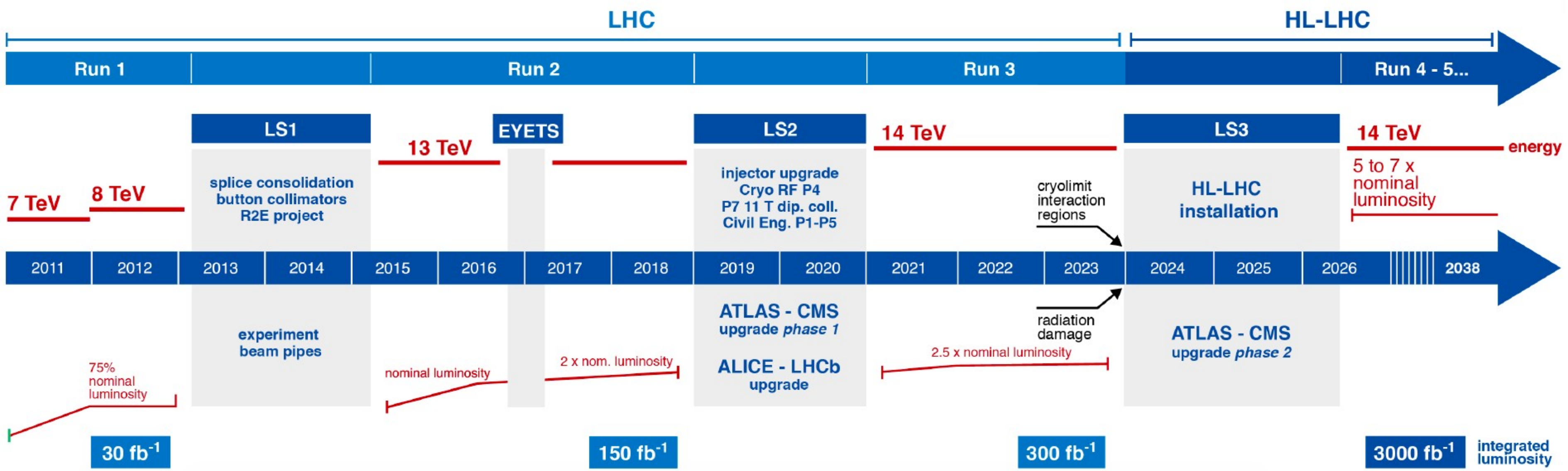
Strong limits for low-mass DM-nucleon cross section.

Collider limits stronger than direct detection for spin-dependent interactions.

Model dependent comparisons, different for different coupling values.



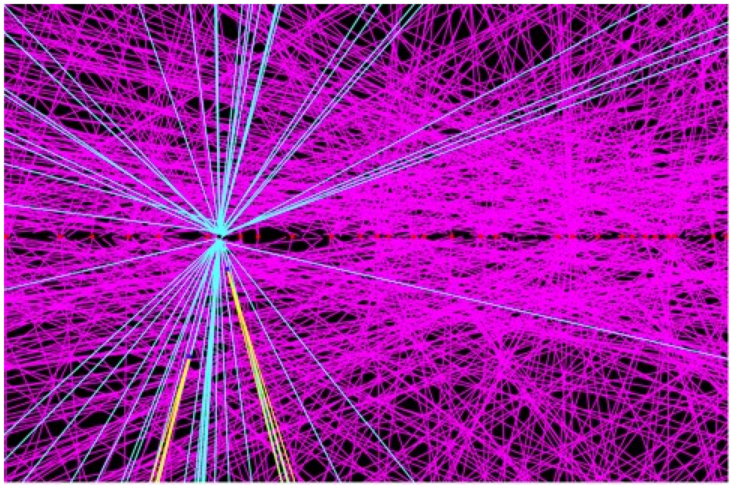
HL-LHC & ATLAS



Luminosidad nominal $=1 \times 10^{34} cm^{-2}s^{-1}$

ATLAS upgrades include

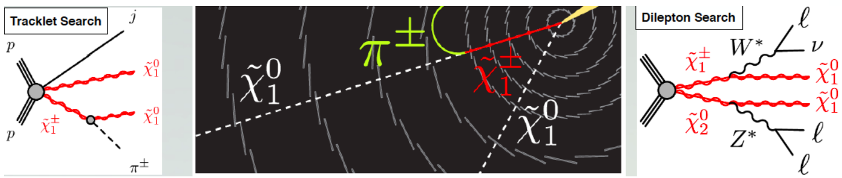
- DAQ and trigger systems (L1 and HLT - 10 kHz)
- Inner tracker (ITk): new all-Si tracker with $|\eta|<4.0$
- Electronics upgrade for LAr and Tile calorimeters, muon system
- New muon chamber in the inner endcap region
- High granularity timing detector in endcap 30 ps timing resolution

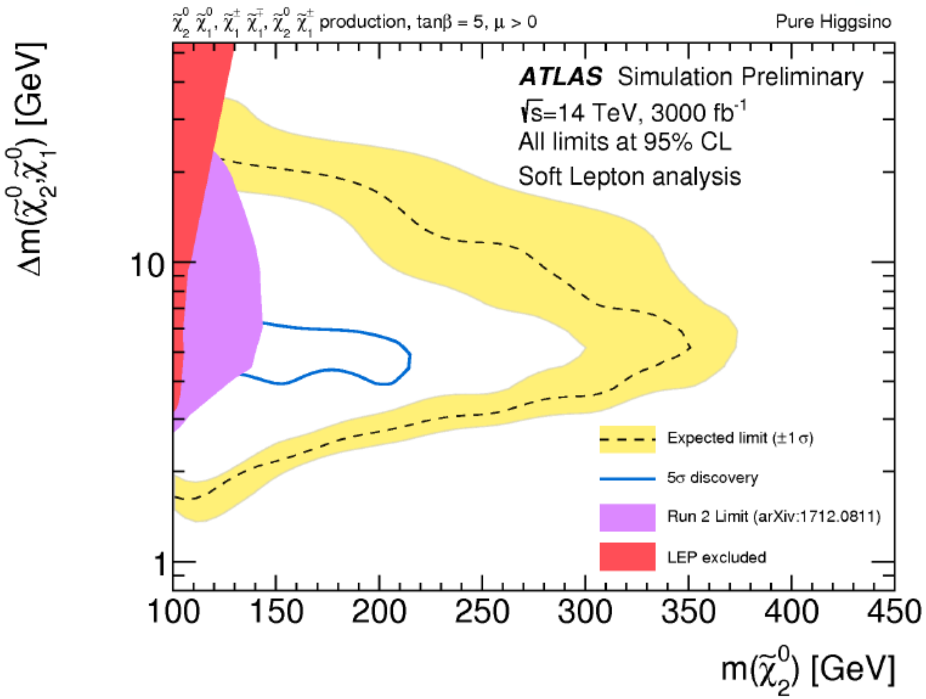


<μ> ~200 $t\bar{t}$ events

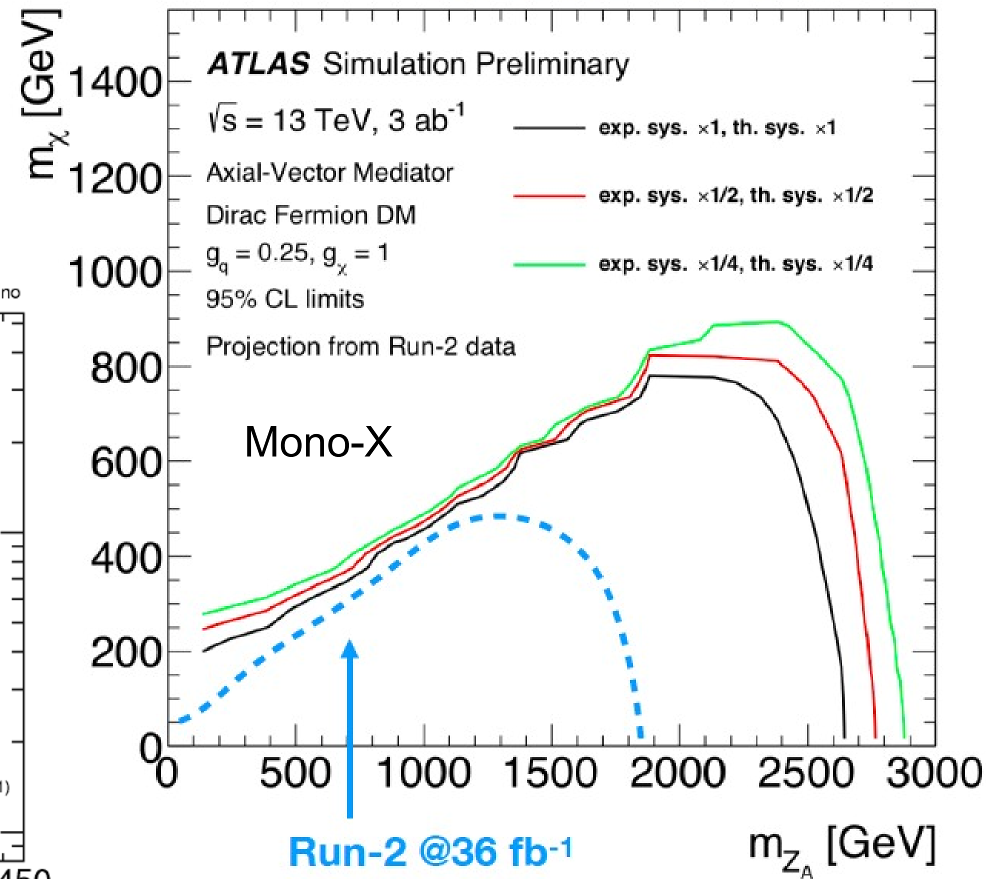
Physics prospects HL-LHC

ATL-PHYS-PUB-2018-043





Large tracking improvements



Run-2 @36 fb^{-1}
JHEP 01 (2018) 126
Phys. Rev. D 97 (2018) 092005

With 3000/fb, the discovery potential and the exclusion limits on the mediator mass are 2.5 -3 TeV depending on uncertainties

Conclusions

- Very extensive set of BSM analyses but no evidence for any new physics yet
  - masses in simplified models reaching the natural 2 TeV limit

- Up to now searches in ideal models based on simple BR assumption and straightforward parameter values
  - unexplored phase space for lower masses in more complicated scenarios

- In the near future more data is to be added (~150 – 300 – 3000 fb^{-1})
  - many unconventional signatures and models to be explored
  - not only accumulate luminosity but improvements in performances and new analysis strategies and techniques

straightforward

unconventional

Backup slides