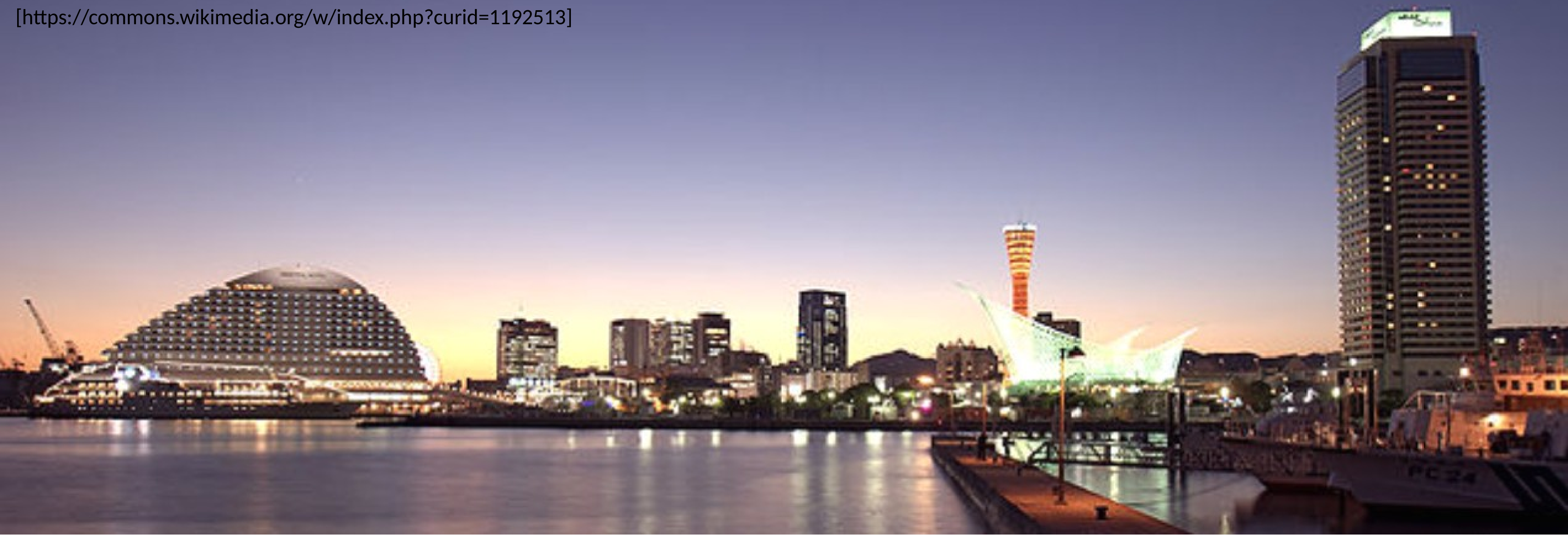


[https://commons.wikimedia.org/w/index.php?curid=1192513]

Searches for electroweak production of supersymmetric gauginos and sleptons with the ATLAS detector

Jeanette Lorenz (LMU Munich)

On behalf of the ATLAS Collaboration

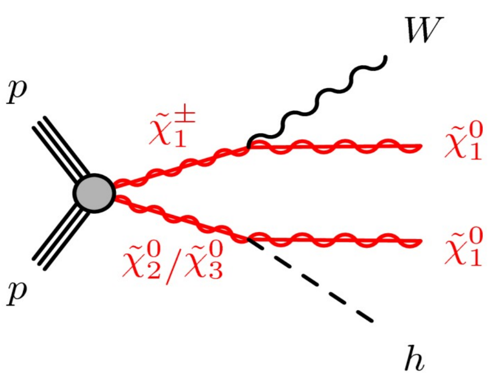
ATLAS EXPERIMENT

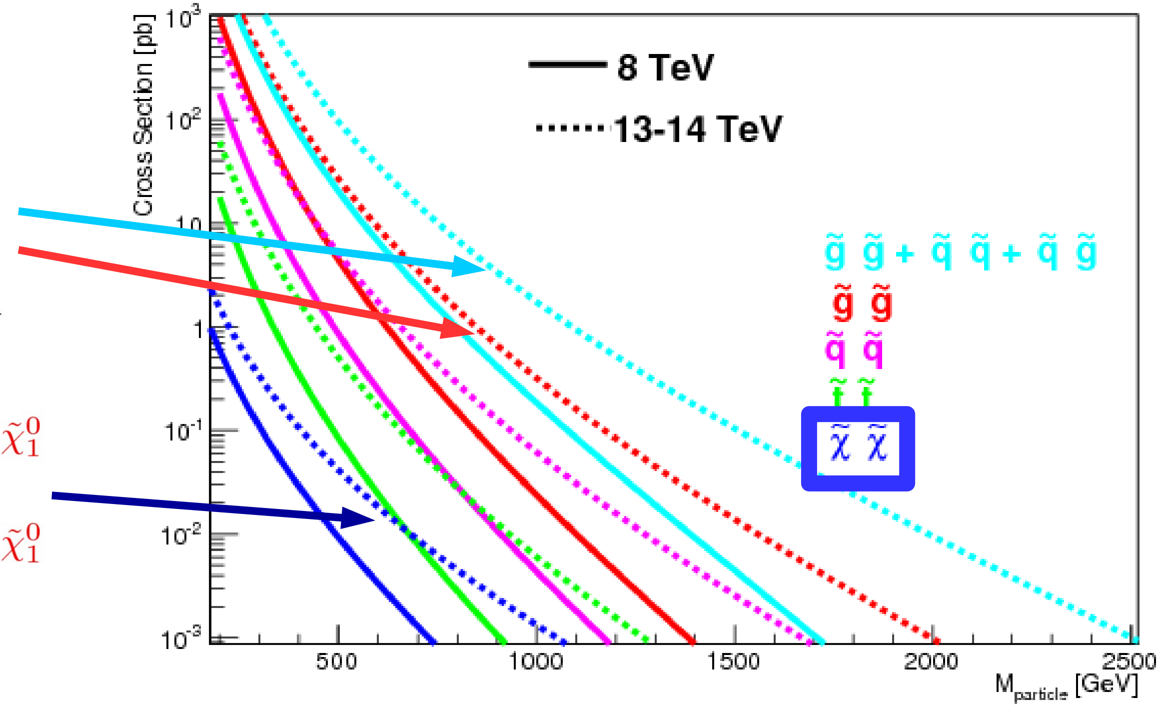
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Kobe, 18.4.2018

Searches for charginos, neutralinos and sleptons

Most searches for Supersymmetry in LHC Run 2 so far for gluinos and squarks (including stop/sbottom)





Searches for charginos, neutralinos and sleptons challenging:

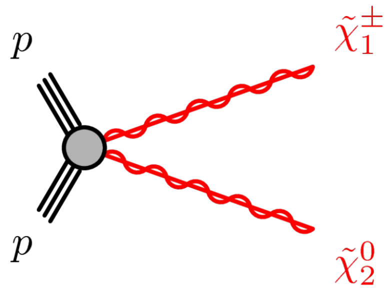
- Lower cross section (compared to gluino/squark production),
- Compressed final states for Higgsino signatures,
- Complex mixing structure.

Relatively light higgsinos/charginos/neutralinos well motivated by naturalness.

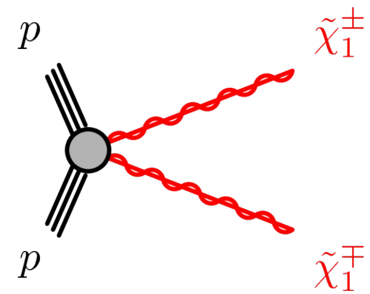
Typical production modes

Superpartners of $W^{+/-/0}$, h/H, $H^{+/-}$ and A^0 mix to charginos and neutralinos

→ cross sections and decay properties determined by mass and Higgsino/Wino/Bino fraction

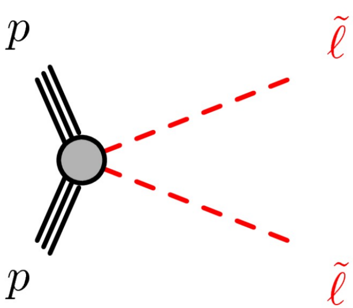


Wino: 45 fb
Higgsino: 11 fb



Wino: 22 fb
Higgsino: 6 fb

(500 GeV particles)

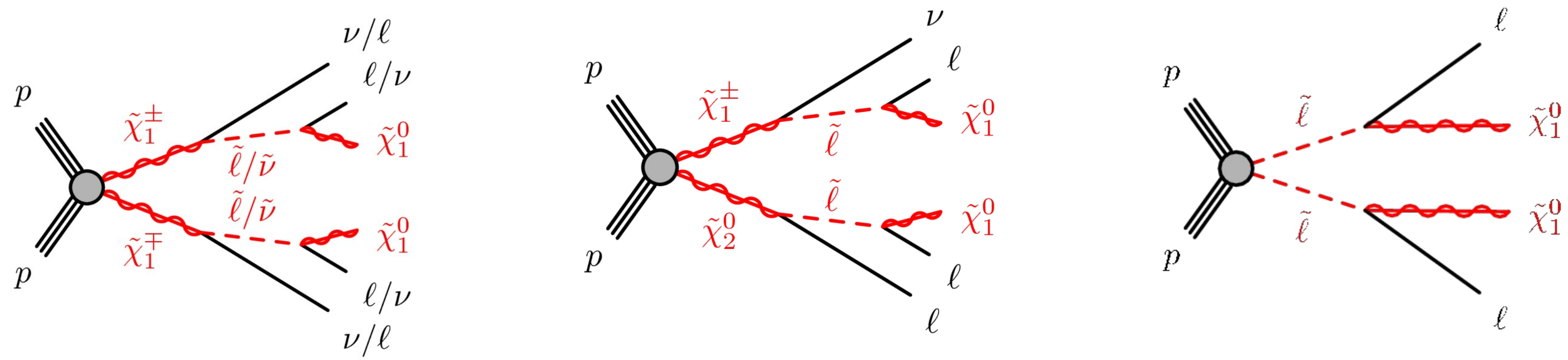


Superpartners of leptons → sleptons

~ 0.5 fb (left-handed) @ 500 GeV

In comparison $t\bar{t}$ pair production: 818 pb

Possible decay modes



Decays of charginos/neutralinos/sleptons often studied in multi-lepton signatures + E_T^{miss}:

→ *2,3 or 4 leptons*
→ *rather clean signatures*

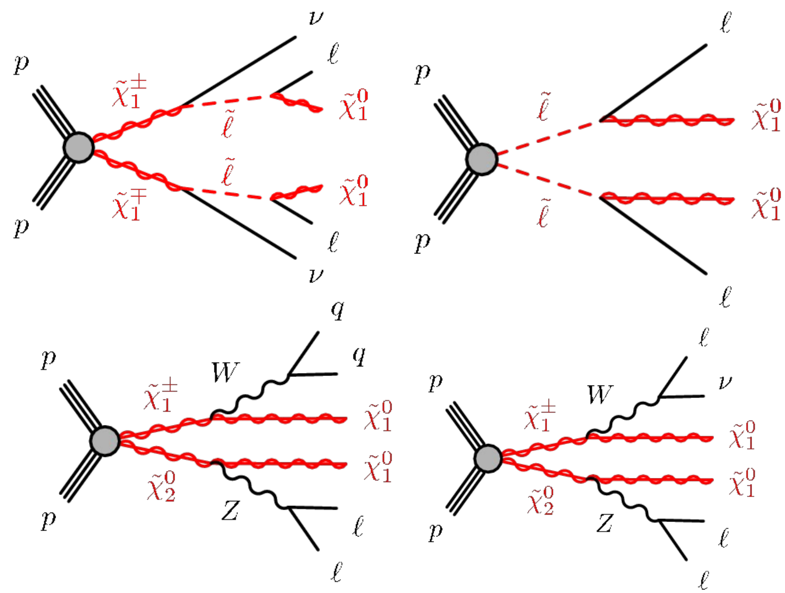
- Main backgrounds:
  - Irreducible: mainly diboson production, sometimes $t\bar{t}$ (+ X)
    → *estimation using control and validation regions*
  - Reducible: fakes → data-driven background estimation
- Often suppression of top backgrounds by (b-tagged) jet veto

2 or 3 leptons

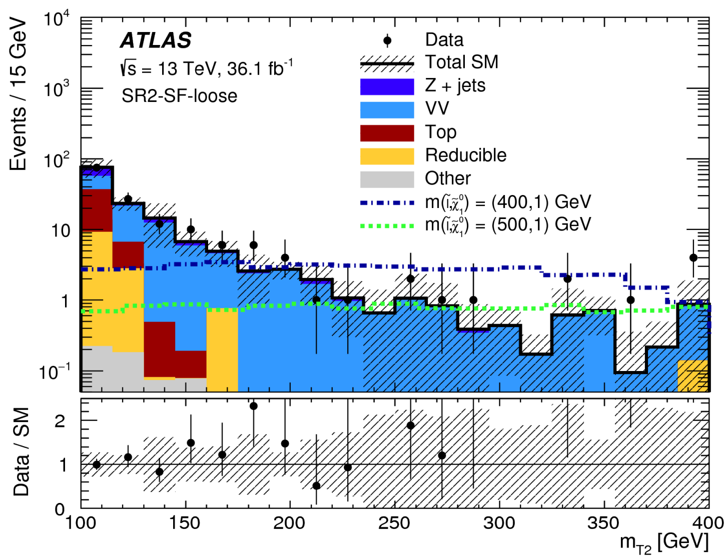
[arXiv:1803.02762]

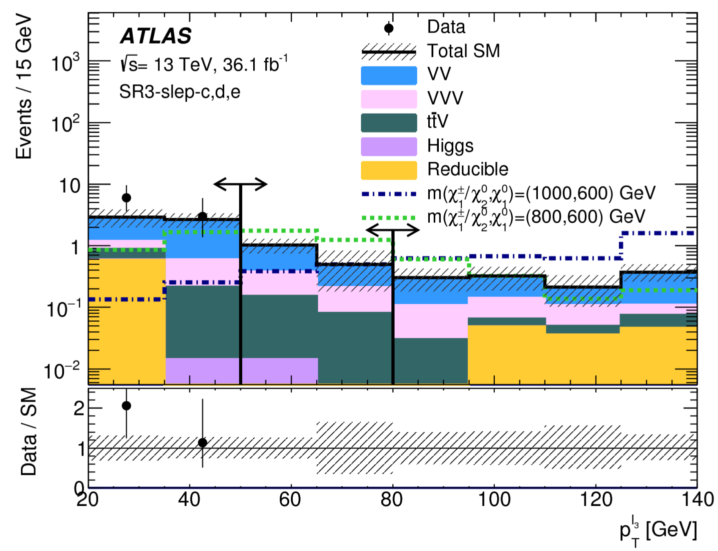
Three categories:

- 2 leptons + 0 jets
  → *direct or indirect production of sleptons*
- 2 leptons + >= 2 jets
  → *chargino/neutralino decays mediated by gauge bosons*
- 3 leptons
  → *chargino/neutralino pair production*



Separation (depending on channel) via
$m_{T2} = \min_{\mathbf{q}_T}\left[\max\left(m_T(\mathbf{p}_T^{\ell 1}, \mathbf{q}_T), m_T(\mathbf{p}_T^{\ell 2}, \mathbf{p}_T^{\text{miss}} - \mathbf{q}_T)\right)\right]$, m_{ll}, E_T^{miss}, p_T (third lepton)





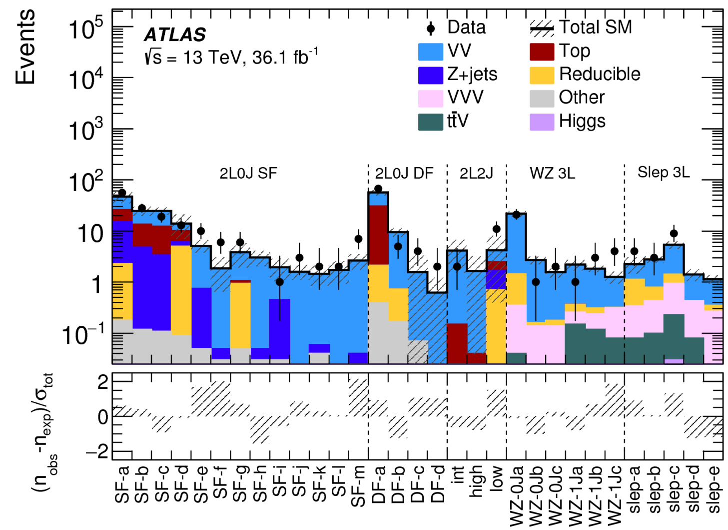
2 or 3 leptons

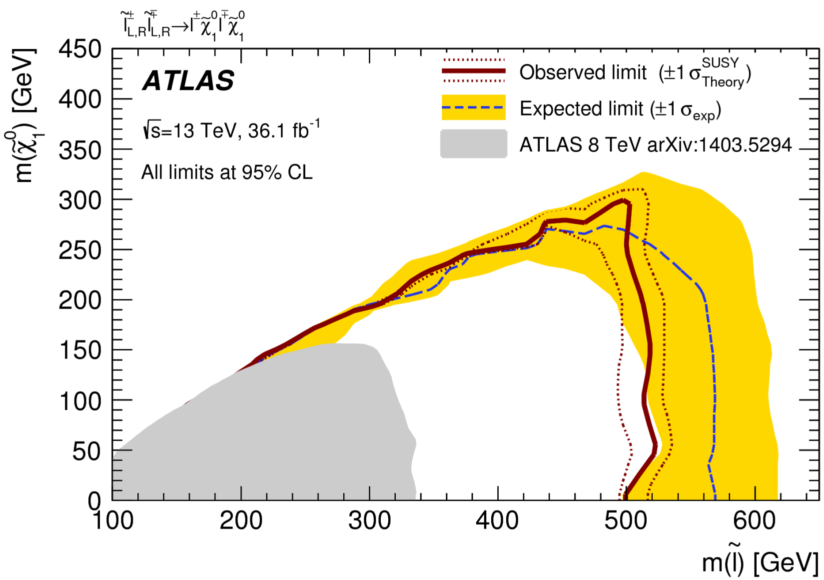
[arXiv:1803.02762]

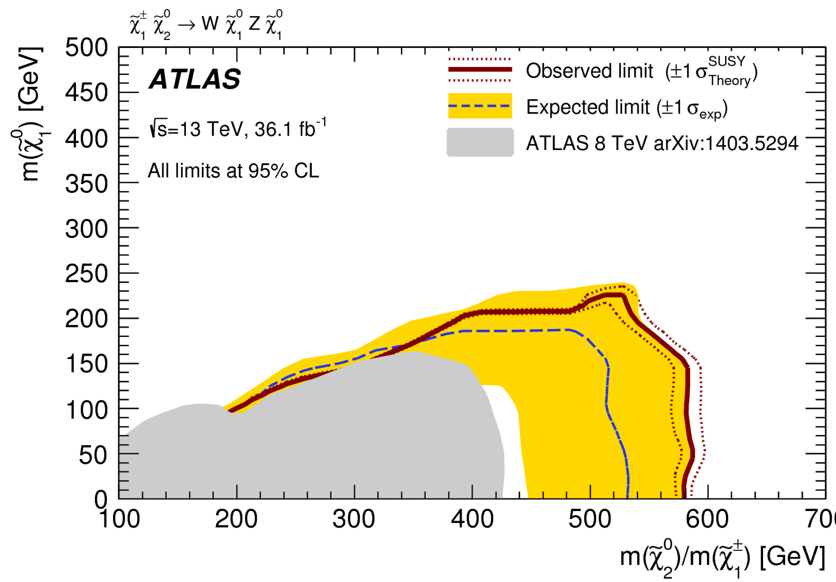
No significant excess seen.

Signal regions fitted simultaneously to derive limits.

- Limits on sleptons reaching up to 500 GeV.
- Limits on charginos/neutralinos with gauge-mediated decays reaching up to 580 GeV.







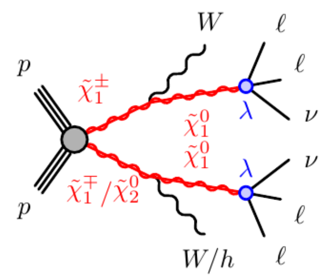
4 leptons

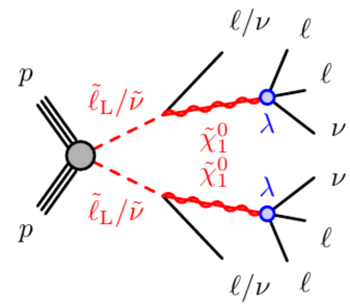
New!

[arXiv:1804.03602]

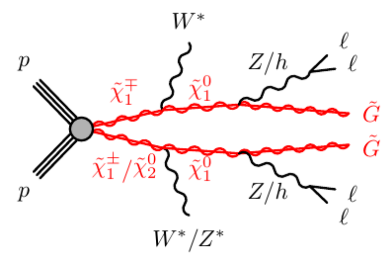
Lightest neutralino decaying to SM particles in RPV scenarios → potentially high lepton multiplicity in final state

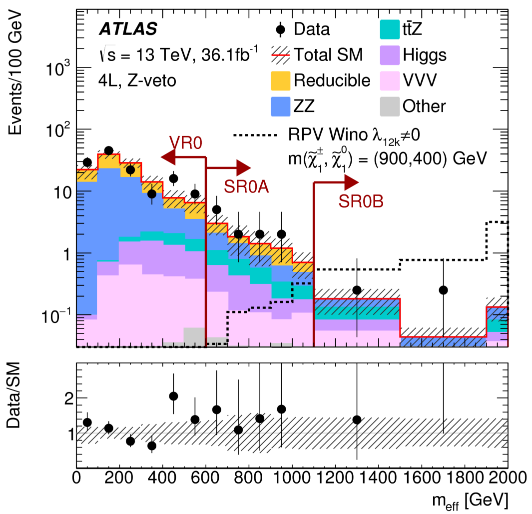
→ *high lepton multiplicity also in certain RPC scenarios*

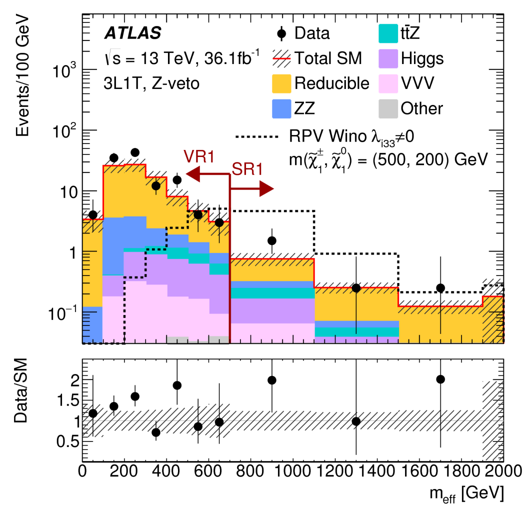


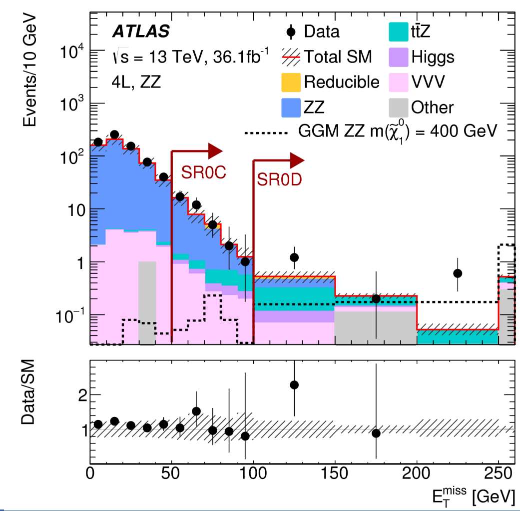


- >=4 leptons, 0 - 2 hadronically decaying taus
- 6 different SRs to gain optimal sensitivity to different models
- Cutting on m_{eff} or E_T^{miss} and veto or requirement on Z bosons
- Main backgrounds: ZZ, $t\bar{t}Z$ and fakes









4 leptons

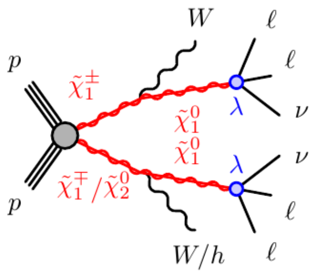
New!

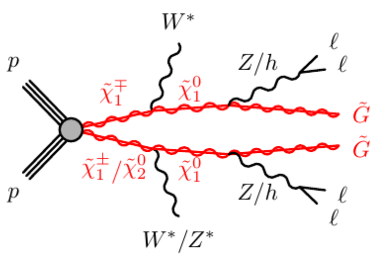
[arXiv:1804.03602]

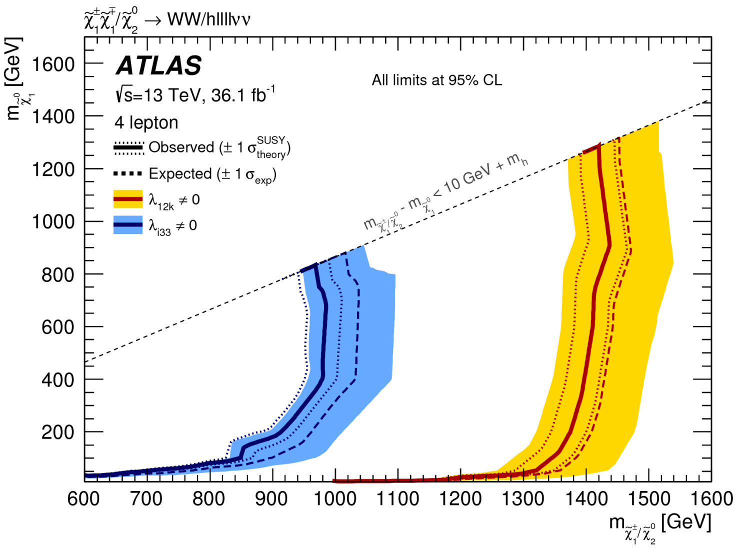
No significant excess seen.

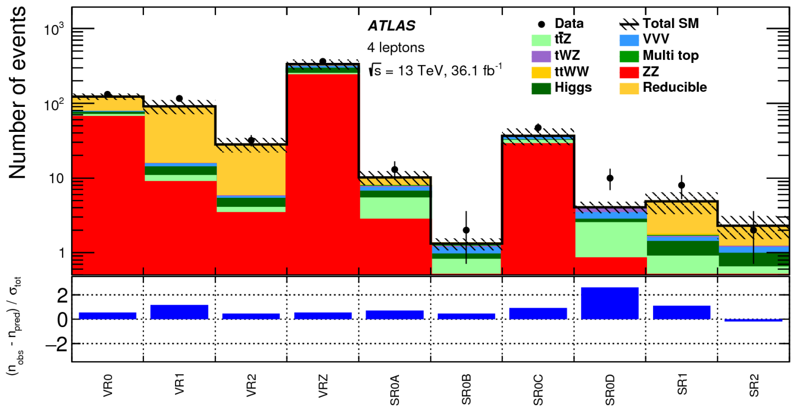
Example limits:

Gaugino production with RPV decay



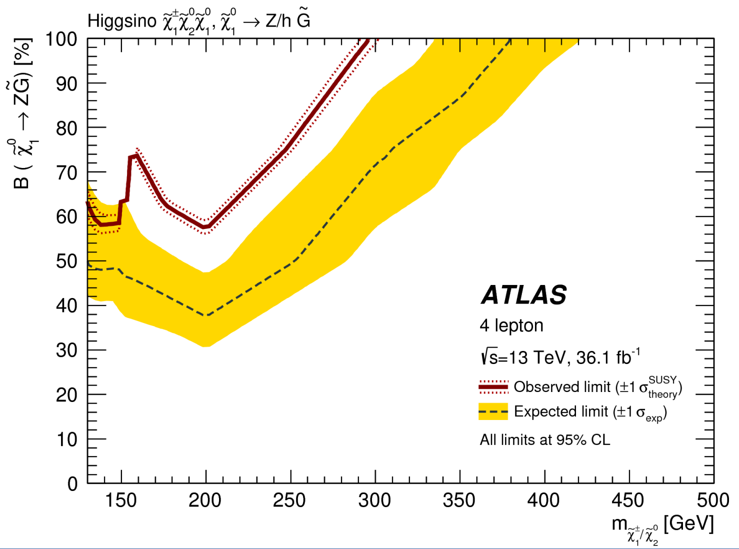






General gauge mediated:

- Compressed Higgsino states
- 4 leptons from $\tilde{\chi}^0_1$ to gravitino



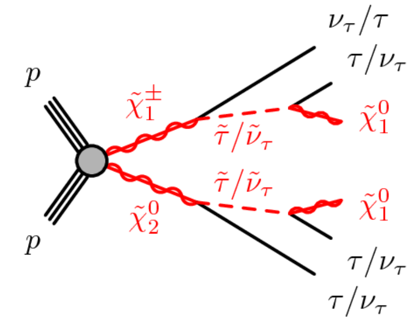
Final states with taus

[Eur. Phys. J. C 78 (2018) 154]

Search for chargino/neutralino production with decays via staus or tau sneutrinos to the lightest neutralino

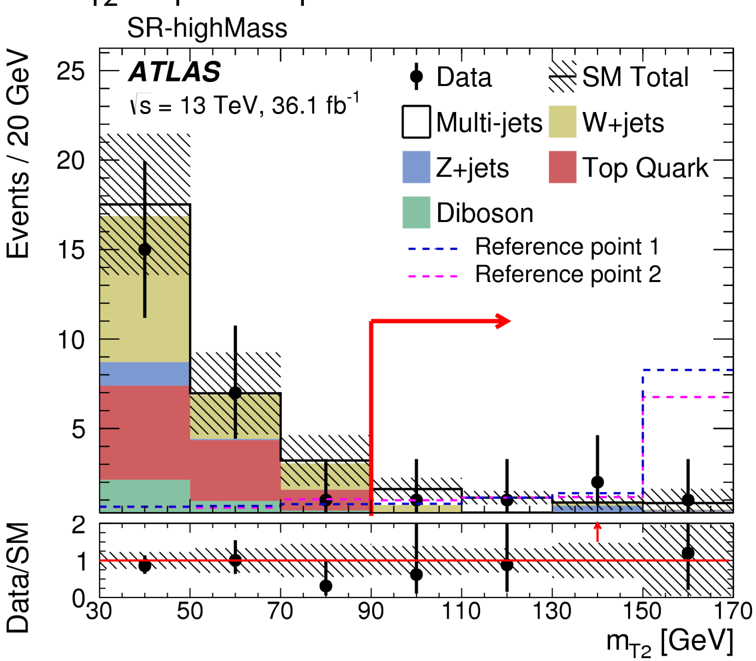
→ taus in the final state

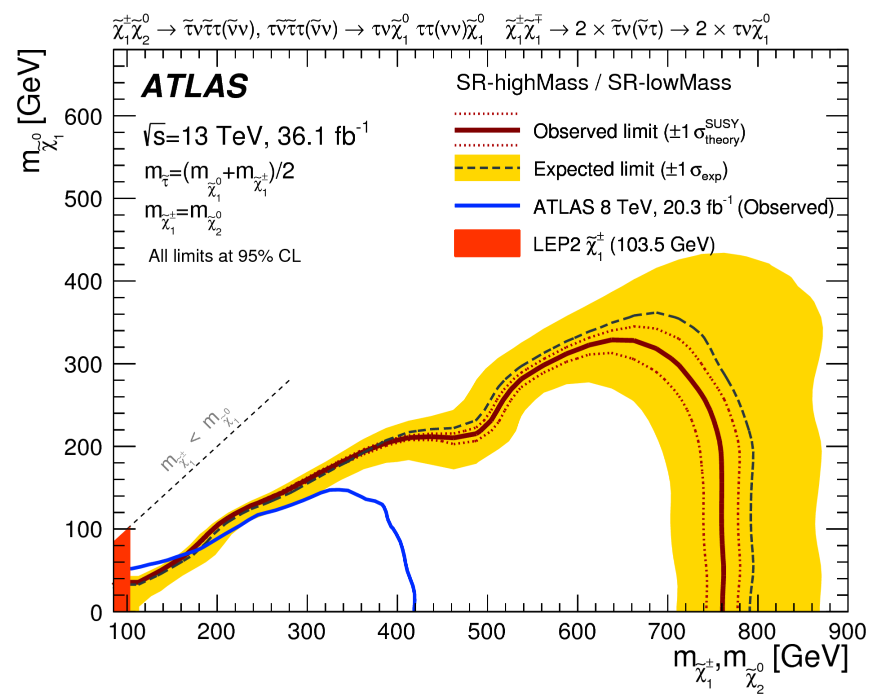
→ light staus as NLSP could predict the right amount of relic DM density in coannihilation channel



Event selection for two SRs:

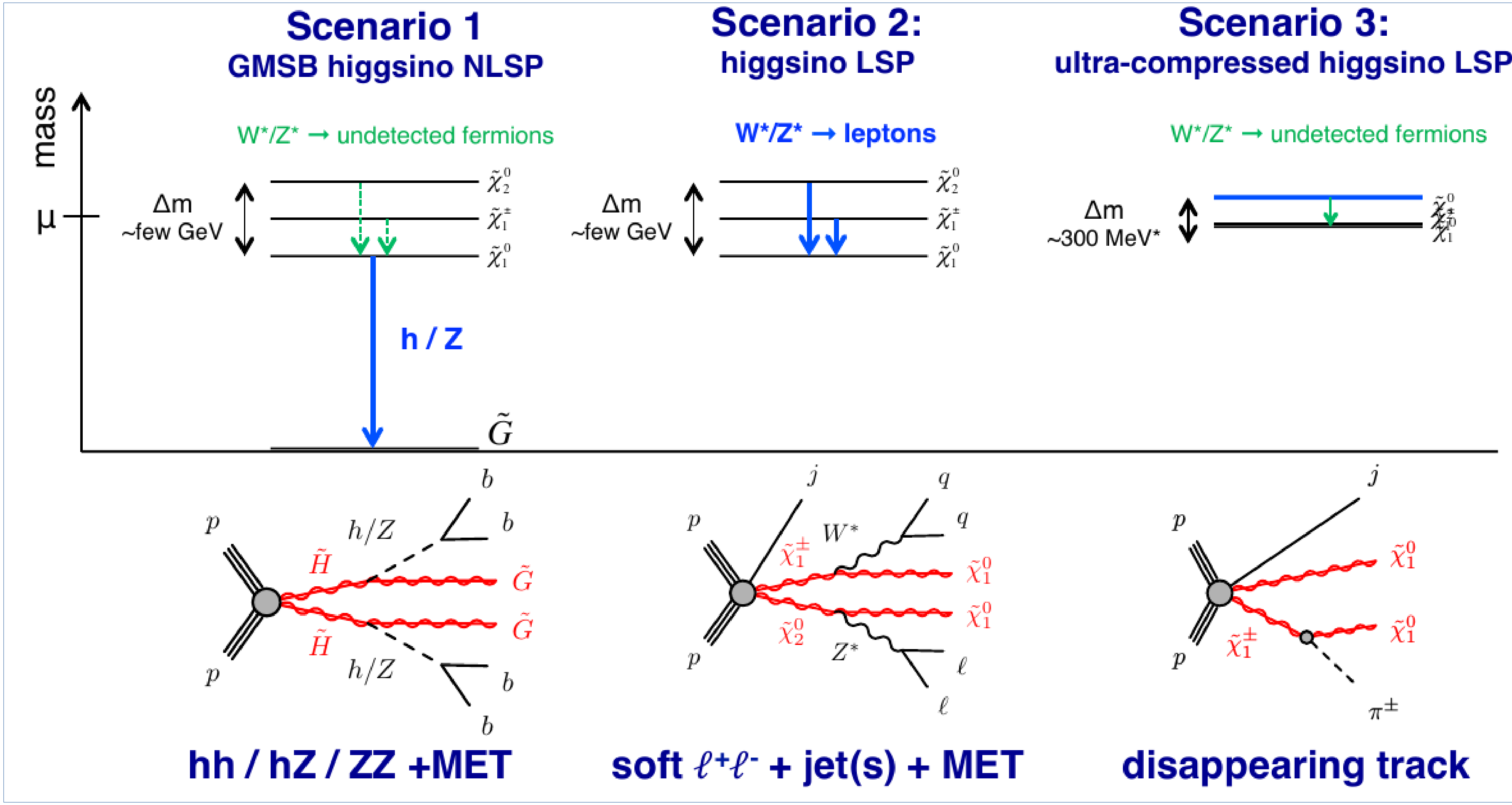
- >= two hadronical decaying taus, B-veto, Z-veto
- M_{T2}, E_T^{miss}, p_T of taus





Higgsinos searches

Naturalness arguments require light higgsinos with similar masses.



[B. Hooberman, SUSY17]

Higgsino searches with 4b

[ATLAS-CONF-2017-081]

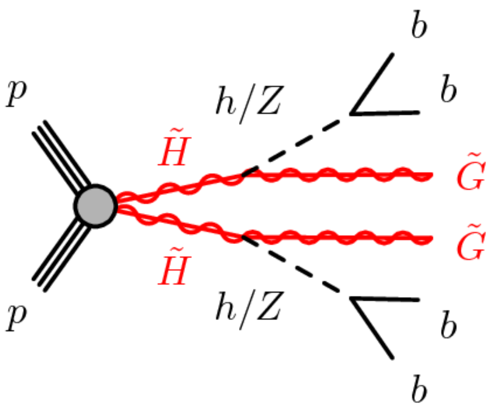
Final state with 4 b-jets

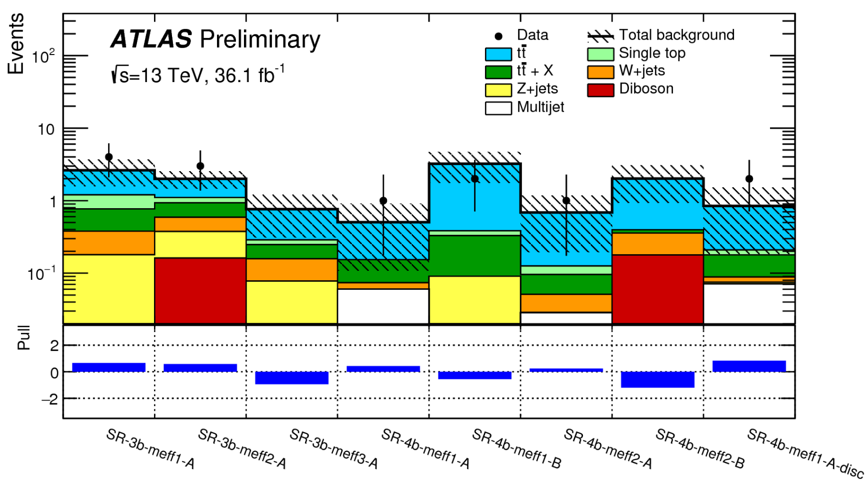
→ *key to separate from high hadronic background*

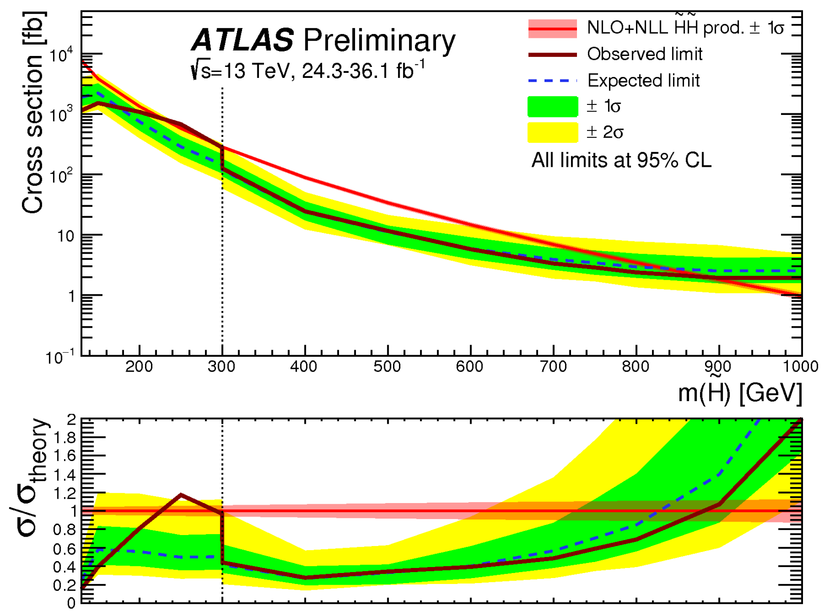
2 different sets of SRs: >= 4 jets of which >= 3 b-jets + E_T^{miss}

→ *low mass, targeting low μ with low E_T^{miss}*

→ *high mass, targeting high μ with high E_T^{miss}*







Compressed higgsinos/sleptons

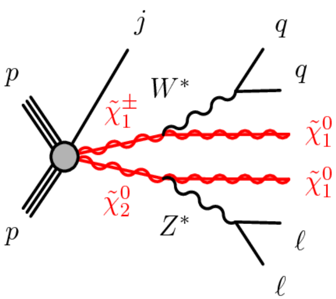
[Phys. Rev. D 97 (2018) 052010]

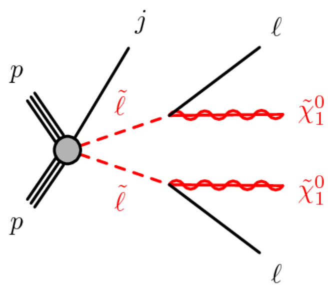
Significant lower invariant mass m_{ll} for models with higgsinos

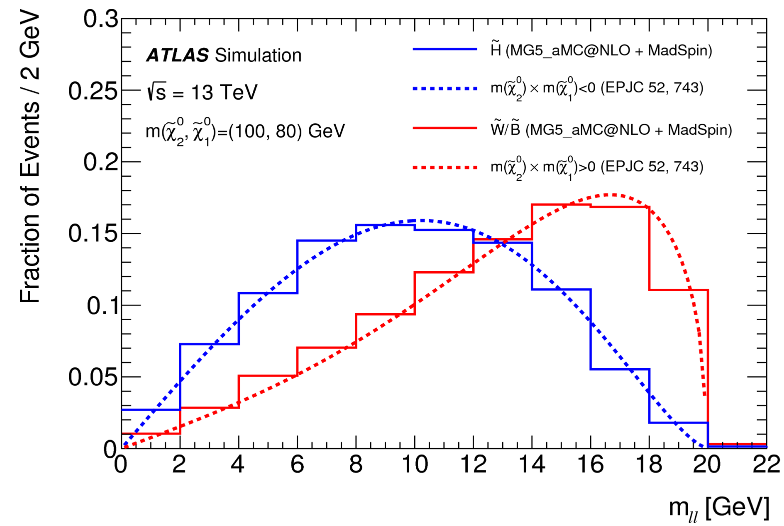
→ *analysis requiring extremely low energetic leptons and low m_{ll}*

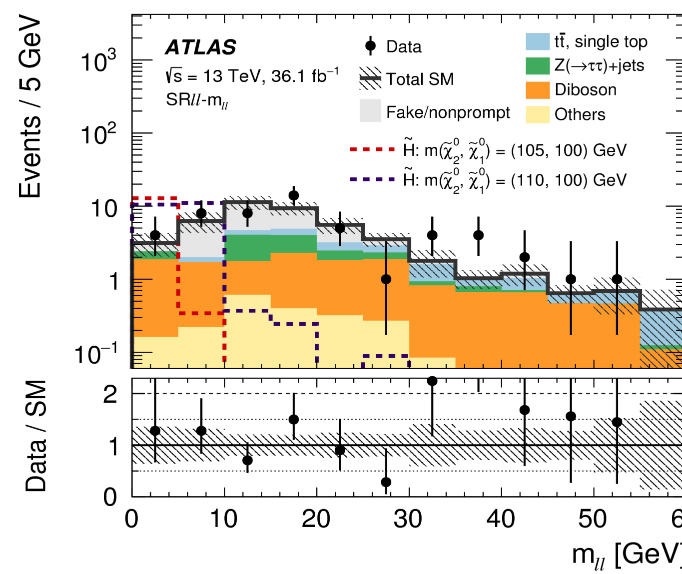
→ *using electrons down to p_T = 4.5 GeV and muons down to p_T = 4 GeV and m_{ll} = 1 GeV*

→ *huge progress in reconstruction of low energetic leptons*









Two searches:

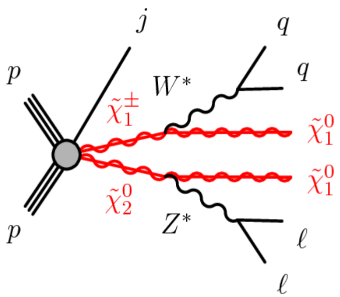
- Direct production of higgsinos using m_{ll}
- Direct production of sleptons using m_{T2}

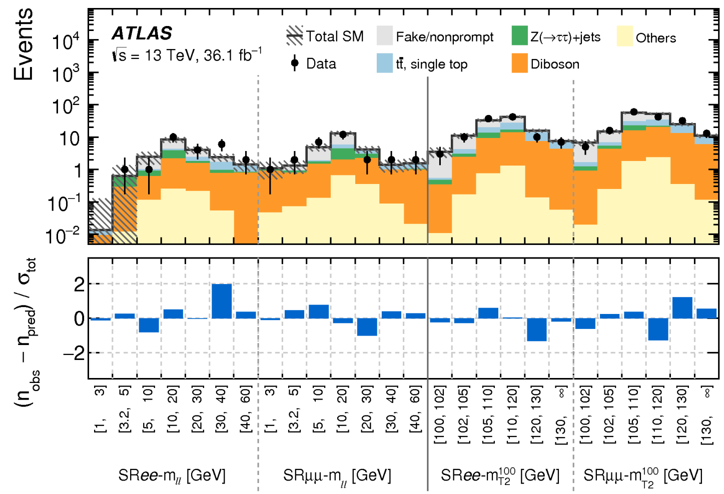
→ *key is estimation of fake backgrounds!*

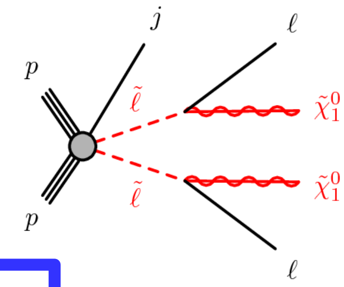
Compressed higgsinos/sleptons

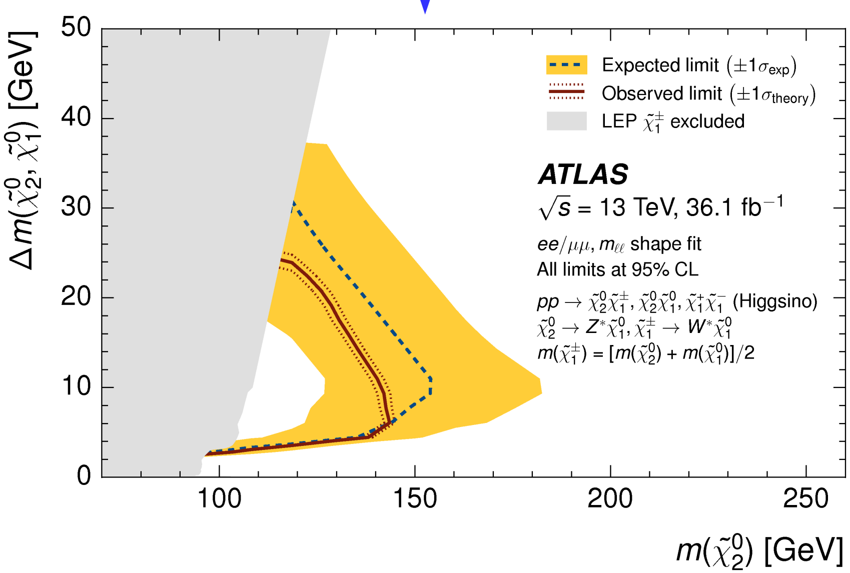
[Phys. Rev. D 97 (2018) 052010]

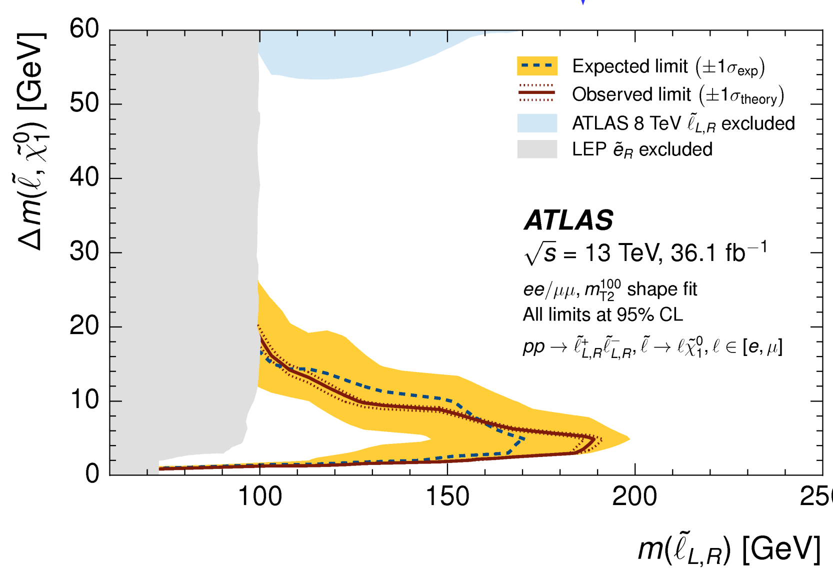
No significant excess seen.









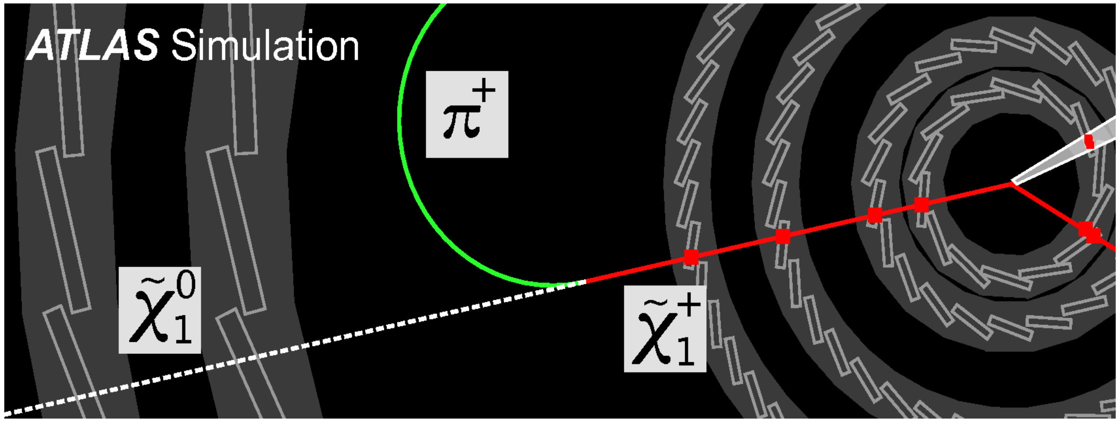


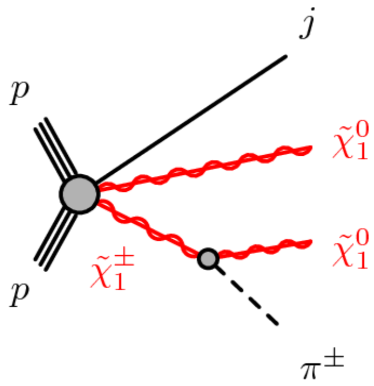
Disappearing tracks

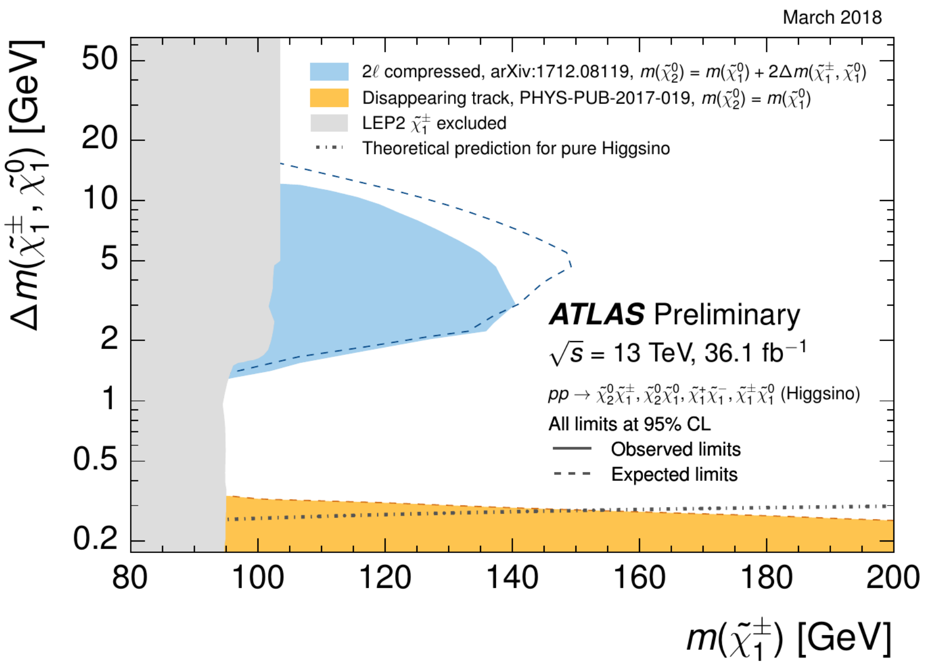
[arXiv:1712.02118]

Long-lived chargino decaying to invisible + pion
→ *disappearing track*

Addition of IBL in LS1 allowed reconstruction of smaller minimal track lengths down to 12 cm
→ *pixel-only tracklets*



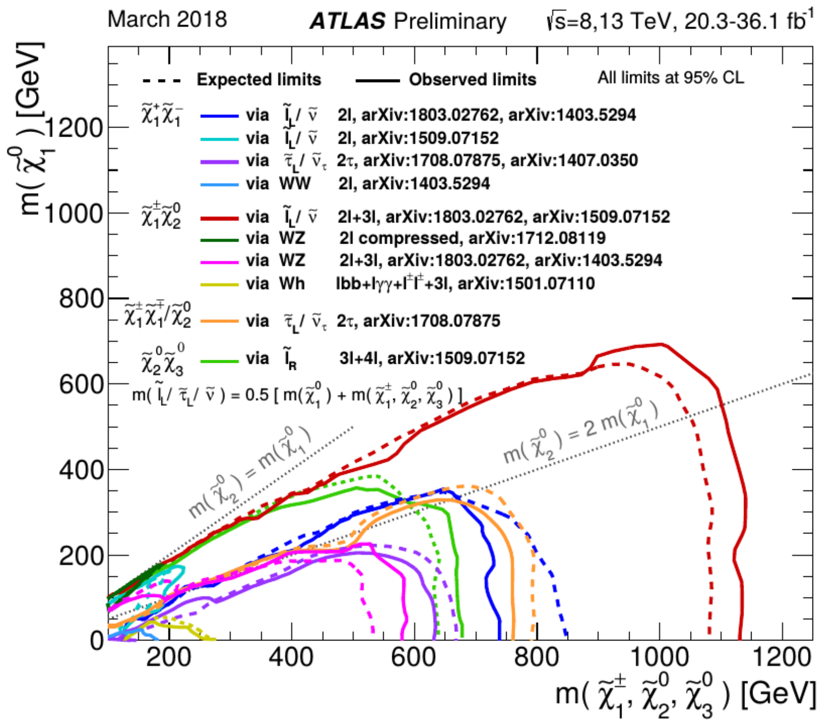




Old LEP limits partially superseded first time at LHC.

Summary

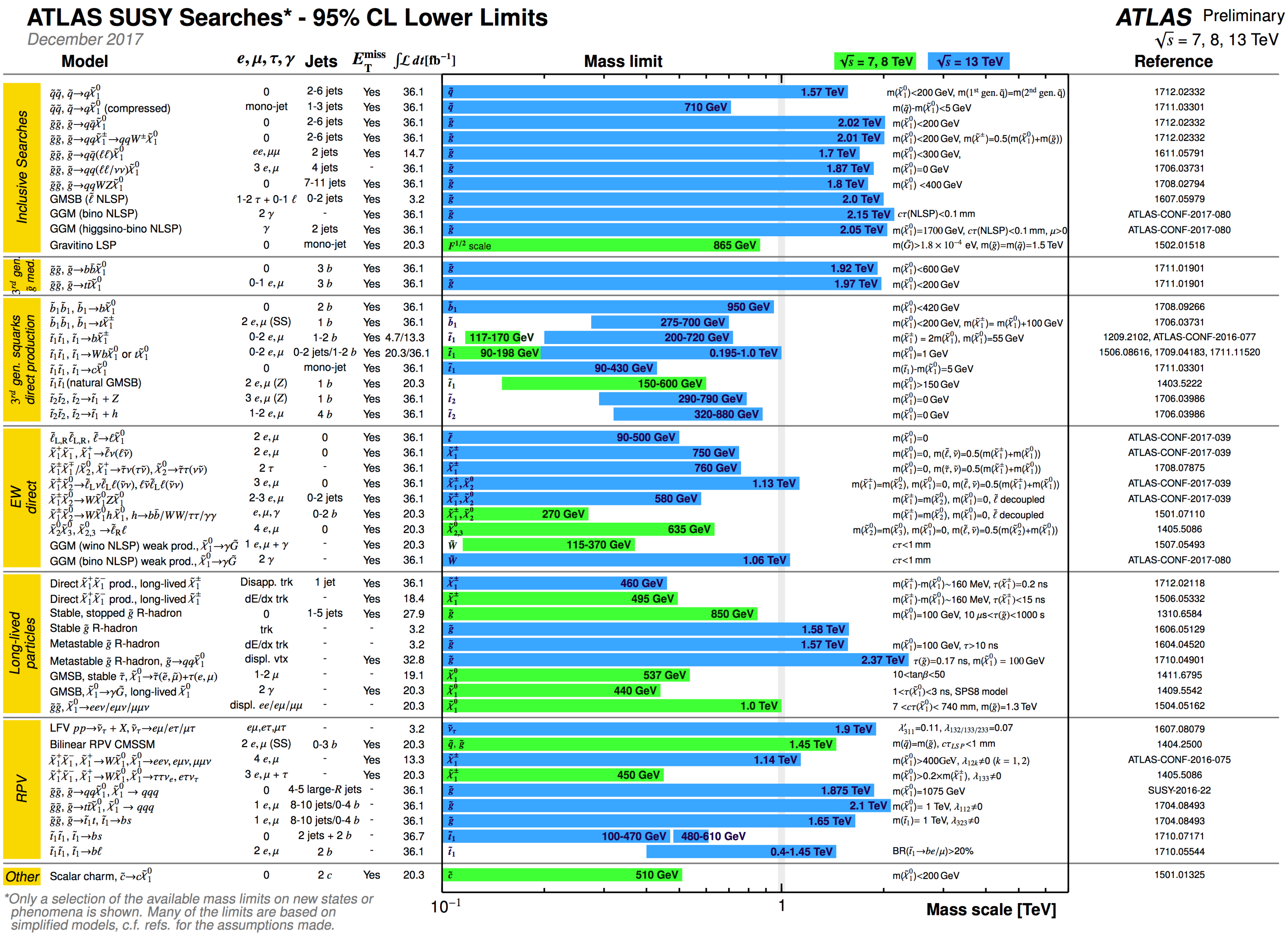
- Starting to harvest the results of searches for charginos, neutralinos and sleptons in LHC Run 2.
- No significant excess seen yet.
- First time exceeding long-standing LEP limits in certain scenarios.
- All results available at:



https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

Backup

Summary


ATLAS SUSY Searches* - 95% CL Lower Limits
December 2017
ATLAS Preliminary
$\sqrt{s}$ = 7, 8, 13 TeV
Model | e, μ, τ, γ | Jets | E_T^{miss} | $\int \mathcal{L} dt[fb^{-1}]$ | Mass limit | $\sqrt{s}$ = 7, 8 TeV | $\sqrt{s}$ = 13 TeV | Reference
Inclusive Searches
$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 36.1 | $\tilde{q}$ 1.57 TeV | $m(\tilde{\chi}_1^0)$<200 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$) | 1712.02332
$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ (compressed) | mono-jet | 1-3 jets | Yes | 36.1 | $\tilde{q}$ 710 GeV | $m(\tilde{q})-m(\tilde{\chi}_1^0)$<5 GeV | 1711.03301
$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 36.1 | $\tilde{g}$ 2.02 TeV | $m(\tilde{\chi}_1^0)$<200 GeV | 1712.02332
$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 36.1 | $\tilde{g}$ 2.01 TeV | $m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$ | 1712.02332
$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}(\ell\ell)\tilde{\chi}_1^0$ | $ee, \mu\mu$ | 2 jets | Yes | 14.7 | $\tilde{g}$ 1.7 TeV | $m(\tilde{\chi}_1^0)$<300 GeV, | 1611.05791
$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\nu\nu)\tilde{\chi}_1^0$ | 3 e, μ | 4 jets | - | 36.1 | $\tilde{g}$ 1.87 TeV | $m(\tilde{\chi}_1^0)$=0 GeV | 1706.03731
$\tilde{g}\tilde{g}, \tilde{g}\to qqWZ\tilde{\chi}_1^0$ | 0 | 7-11 jets | Yes | 36.1 | $\tilde{g}$ 1.8 TeV | $m(\tilde{\chi}_1^0)$ <400 GeV | 1708.02794
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 | 36.1 | $\tilde{g}$ 2.15 TeV | $c\tau$(NLSP)<0.1 mm | ATLAS-CONF-2017-080
GGM (higgsino-bino NLSP) | γ | 2 jets | Yes | 36.1 | $\tilde{g}$ 2.05 TeV | $m(\tilde{\chi}_1^0)$=1700 GeV, $c\tau$(NLSP)<0.1 mm, μ>0 | ATLAS-CONF-2017-080
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.
$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{b}\tilde{\chi}_1^0$ | 0 | 3 b | Yes | 36.1 | $\tilde{g}$ 1.92 TeV | $m(\tilde{\chi}_1^0)$<600 GeV | 1711.01901
$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$ | 0-1 e, μ | 3 b | Yes | 36.1 | $\tilde{g}$ 1.97 TeV | $m(\tilde{\chi}_1^0)$<200 GeV | 1711.01901
3rd gen. squarks direct production
$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$ | 0 | 2 b | Yes | 36.1 | $\tilde{b}_1$ 950 GeV | $m(\tilde{\chi}_1^0)$<420 GeV | 1708.09266
$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$ | 2 e, μ (SS) | 1 b | Yes | 36.1 | $\tilde{b}_1$ 275-700 GeV | $m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_1^0)$+100 GeV | 1706.03731
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\tilde{\chi}_1^\pm$ | 0-2 e, μ | 1-2 b | Yes | 4.7/13.3 | $\tilde{t}_1$ 117-170 GeV 200-720 GeV | $m(\tilde{\chi}_1^\pm)=2m(\tilde{\chi}_1^0)$, $m(\tilde{\chi}_1^0)$=55 GeV | 1209.2102, ATLAS-CONF-2016-077
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$ | 0-2 e, μ | 0-2 jets/1-2 b | Yes | 20.3/36.1 | $\tilde{t}_1$ 90-198 GeV 0.195-1.0 TeV | $m(\tilde{\chi}_1^0)$=1 GeV | 1506.08616, 1709.04183, 1711.11520
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$ | 0 | mono-jet | Yes | 36.1 | $\tilde{t}_1$ 90-430 GeV | $m(\tilde{t}_1)-m(\tilde{\chi}_1^0)$=5 GeV | 1711.03301
$\tilde{t}_1\tilde{t}_1$(natural GMSB) | 2 e, μ (Z) | 1 b | Yes | 20.3 | $\tilde{t}_1$ 150-600 GeV | $m(\tilde{\chi}_1^0)$>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 | $m(\tilde{\chi}_1^0)$=0 GeV | 1706.03986
$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+h$ | 1-2 e, μ | 4 b | Yes | 36.1 | $\tilde{t}_2$ 320-880 GeV | $m(\tilde{\chi}_1^0)$=0 GeV | 1706.03986
EW direct
$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$ | 2 e, μ | 0 | Yes | 36.1 | $\tilde{\ell}$ 90-500 GeV | $m(\tilde{\chi}_1^0)$=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 | $\tilde{\chi}_1^\pm$ 750 GeV | $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$ | ATLAS-CONF-2017-039
$\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp/\tilde{\chi}_2^0, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu}), \tilde{\chi}_2^0\to\tilde{\tau}\tau(\nu\tilde{\nu})$ | 2 τ | - | Yes | 36.1 | $\tilde{\chi}_1^\pm$ 760 GeV | $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$ | 1708.07875
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$ | 3 e, μ | 0 | Yes | 36.1 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 1.13 TeV | $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$ | ATLAS-CONF-2017-039
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$ | 2-3 e, μ | 0-2 jets | Yes | 36.1 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 580 GeV | $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $\tilde{\ell}$ decoupled | ATLAS-CONF-2017-039
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$ | e, μ, γ | 0-2 b | Yes | 20.3 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 270 GeV | $m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $\tilde{\ell}$ decoupled | 1501.07110
$\tilde{\chi}_2^0\tilde{\chi}_3^0, \tilde{\chi}_{2,3}^0\to\tilde{\ell}_R\ell$ | 4 e, μ | 0 | Yes | 20.3 | $\tilde{\chi}_{2,3}^0$ 635 GeV | $m(\tilde{\chi}_2^0)=m(\tilde{\chi}_3^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_2^0)+m(\tilde{\chi}_1^0))$ | 1405.5086
GGM (wino NLSP) weak prod., $\tilde{\chi}_1^0\to\gamma\tilde{G}$ | 1 $e, \mu + \gamma$ | - | Yes | 20.3 | $\tilde{W}$ 115-370 GeV | $c\tau$<1 mm | 1507.05493
GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0\to\gamma\tilde{G}$ | 2 γ | - | Yes | 36.1 | $\tilde{W}$ 1.06 TeV | $c\tau$<1 mm | ATLAS-CONF-2017-080
Long-lived particles
Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$ | Disapp. trk | 1 jet | Yes | 36.1 | $\tilde{\chi}_1^\pm$ 460 GeV | $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$~160 MeV, $\tau(\tilde{\chi}_1^\pm)$=0.2 ns | 1712.02118
Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$ | dE/dx trk | - | Yes | 18.4 | $\tilde{\chi}_1^\pm$ 495 GeV | $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$~160 MeV, $\tau(\tilde{\chi}_1^\pm)$<15 ns | 1506.05332
Stable, stopped $\tilde{g}$ R-hadron | 0 | 1-5 jets | Yes | 27.9 | $\tilde{g}$ 850 GeV | $m(\tilde{\chi}_1^0)$=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 | $m(\tilde{\chi}_1^0)$=100 GeV, τ>10 ns | 1604.04520
Metastable $\tilde{g}$ R-hadron, $\tilde{g}\to qq\tilde{\chi}_1^0$ | displ. vtx | - | Yes | 32.8 | $\tilde{g}$ 2.37 TeV | $\tau(\tilde{g})$=0.17 ns, $m(\tilde{\chi}_1^0)$ = 100 GeV | 1710.04901
GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$ | 1-2 μ | - | - | 19.1 | $\tilde{\chi}_1^0$ 537 GeV | 10<tanβ<50 | 1411.6795
GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$ | 2 γ | - | Yes | 20.3 | $\tilde{\chi}_1^0$ 440 GeV | 1<$\tau(\tilde{\chi}_1^0)$<3 ns, SPS8 model | 1409.5542
$\tilde{g}\tilde{g}, \tilde{\chi}_1^0\to eev/e\mu\nu/\mu\mu\nu$ | displ. $ee/e\mu/\mu\mu$ | - | - | 20.3 | $\tilde{\chi}_1^0$ 1.0 TeV | 7 <$c\tau(\tilde{\chi}_1^0)$< 740 mm, $m(\tilde{g})$=1.3 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
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to eev, e\mu\nu, \mu\mu\nu$ | 4 e, μ | - | Yes | 13.3 | $\tilde{\chi}_1^\pm$ 1.14 TeV | $m(\tilde{\chi}_1^0)$>400GeV, $\lambda_{12k}\neq0$ (k = 1, 2) | ATLAS-CONF-2016-075
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\nu_e, e\tau\nu_\tau$ | 3 $e, \mu + \tau$ | - | Yes | 20.3 | $\tilde{\chi}_1^\pm$ 450 GeV | $m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^\pm)$, $\lambda_{133}\neq0$ | 1405.5086
$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$ | 0 | 4-5 large-R jets | - | 36.1 | $\tilde{g}$ 1.875 TeV | $m(\tilde{\chi}_1^0)$=1075 GeV | SUSY-2016-22
$\tilde{g}\tilde{g}, \tilde{g}\to tt\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$ | 1 e, μ | 8-10 jets/0-4 b | - | 36.1 | $\tilde{g}$ 2.1 TeV | $m(\tilde{\chi}_1^0)$= 1 TeV, $\lambda_{112}\neq0$ | 1704.08493
$\tilde{g}\tilde{g}, \tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$ | 1 e, μ | 8-10 jets/0-4 b | - | 36.1 | $\tilde{g}$ 1.65 TeV | $m(\tilde{t}_1)$= 1 TeV, $\lambda_{323}\neq0$ | 1704.08493
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$ | 0 | 2 jets + 2 b | - | 36.7 | $\tilde{t}_1$ 100-470 GeV 480-610 GeV | 1710.07171
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\ell$ | 2 e, μ | 2 b | - | 36.1 | $\tilde{t}_1$ 0.4-1.45 TeV | BR($\tilde{t}_1\to be/\mu$)>20% | 1710.05544
Other
Scalar charm, $\tilde{c}\to c\tilde{\chi}_1^0$ | 0 | 2 c | Yes | 20.3 | $\tilde{c}$ 510 GeV | $m(\tilde{\chi}_1^0)$<200 GeV | 1501.01325
*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.
10^{-1}
1
Mass scale [TeV]

2 or 3 leptons – background estimation

[arXiv:1803.02762]

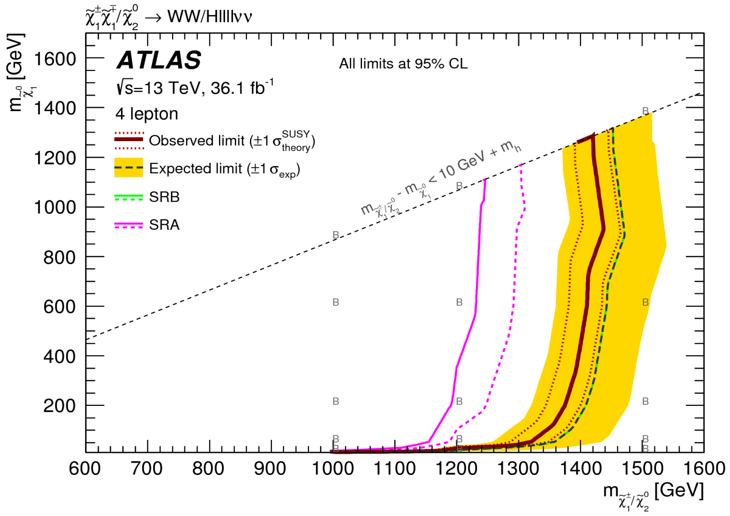
Background estimation summary			
Channel	2ℓ+0jets	2ℓ+jets	3ℓ
Fake/non-prompt leptons	Matrix method		Fake-factor method
$t\bar{t} + Wt$	CR	MC	Fake-factor method
VV	CR	MC	CR (WZ-only)
Z+jets	MC	γ+jet template	Fake-factor method
Higgs/ VVV/ top+V	MC		

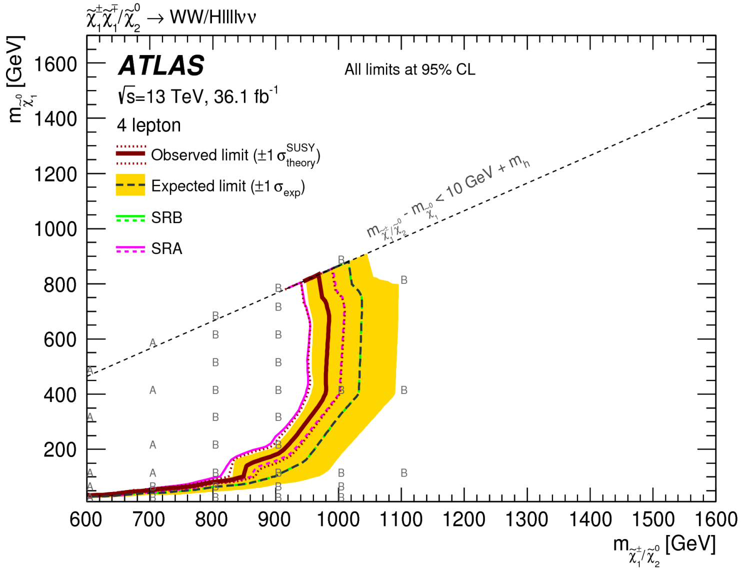
4 leptons – detailed results

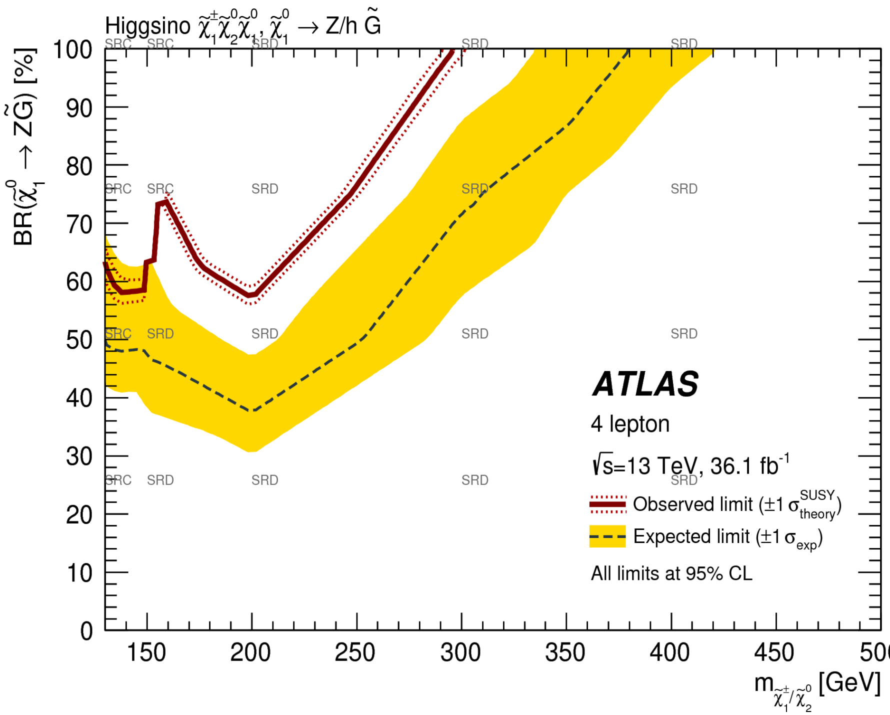
Sample	SR0A	SR0B	SR0C	SR0D	SR1	SR2
Observed	13	2	47	10	8	2
SM Total	10.2 ± 2.1	1.31 ± 0.24	37 ± 9	4.1 ± 0.7	4.9 ± 1.6	2.3 ± 0.8
ZZ	2.7 ± 0.7	0.33 ± 0.10	28 ± 9	0.84 ± 0.34	0.35 ± 0.09	0.33 ± 0.08
$t\bar{t}Z$	2.5 ± 0.6	0.47 ± 0.13	3.2 ± 0.4	1.62 ± 0.23	0.54 ± 0.11	0.31 ± 0.08
Higgs	1.2 ± 1.2	0.13 ± 0.13	0.9 ± 0.8	0.28 ± 0.25	0.5 ± 0.5	0.32 ± 0.32
VVV	0.79 ± 0.17	0.22 ± 0.05	2.7 ± 0.6	0.64 ± 0.14	0.18 ± 0.04	0.20 ± 0.06
Reducible	2.4 ± 1.4	$0.000^{+0.005}_{-0.000}$	$0.9^{+1.4}_{-0.9}$	$0.23^{+0.38}_{-0.23}$	3.1 ± 1.5	1.1 ± 0.7
Other	0.53 ± 0.06	0.165 ± 0.018	0.85 ± 0.19	0.45 ± 0.10	0.181 ± 0.022	0.055 ± 0.012
$\langle\epsilon\sigma\rangle^{95}_{obs}$ fb	0.32	0.14	0.87	0.36	0.28	0.13
S^{95}_{obs}	12	4.9	31	13	10	4.6
S^{95}_{exp}	$9.3^{+3.6}_{-2.3}$	$3.9^{+1.6}_{-0.8}$	23^{+8}_{-5}	$6.1^{+2.1}_{-1.3}$	$6.5^{+3.5}_{-1.3}$	$4.7^{+2.0}_{-1.3}$
CL_b	0.76	0.74	0.83	0.99	0.86	0.47
$p_{s=0}$	0.23	0.25	0.15	0.011	0.13	0.61
Z	0.75	0.69	1.0	2.3	1.2	0

Table 8: Expected and observed yields for 36.1 fb^{-1} in the signal regions. “Other” is the sum of the tWZ, $t\bar{t}WW$, and $t\bar{t}t\bar{t}$ backgrounds. Statistical and systematic uncertainties are included. Also shown are the model-independent limits calculated from the signal region observations; the 95% CL upper limit on (a) the visible cross section times efficiency ($\langle\epsilon\sigma\rangle^{95}_{obs}$), (b) the observed number of signal events(S^{95}_{obs}), and (c) the signal events given the expected number of background events (S^{95}_{exp}, $\pm 1\sigma$ variations of the expected number) calculated by performing pseudo-experiments for each signal region. The last two rows report (d) the CL_b value for the background-only hypothesis, and finally (e) the one-sided p_0-value and the local significance Z (the number of equivalent Gaussian standard deviations).

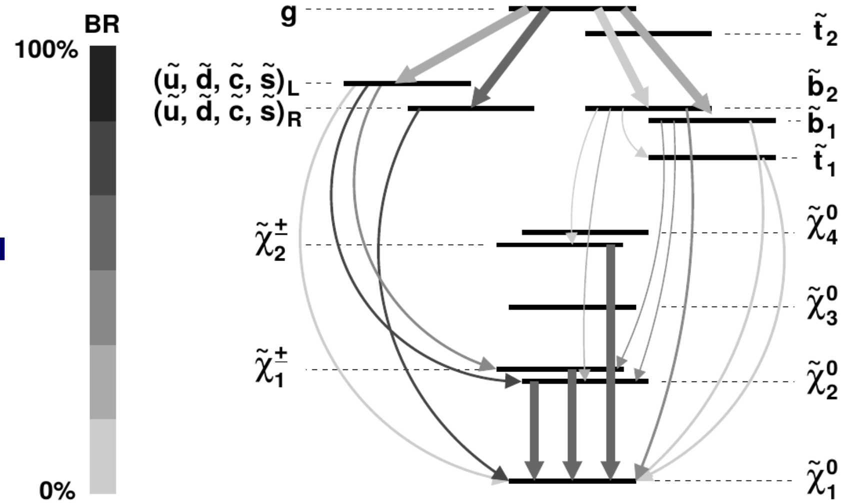
4 leptons – which SRs are used



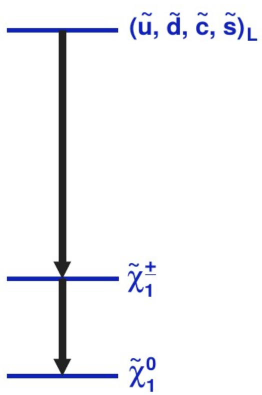




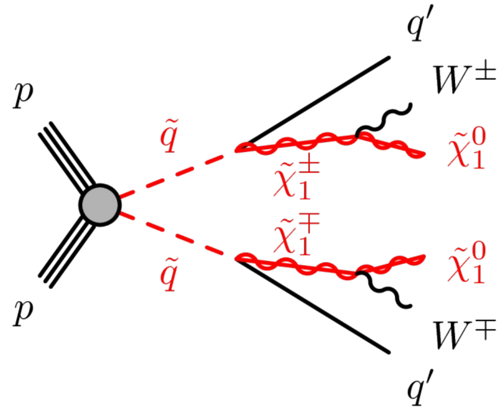
Supersymmetric models



Usually only look at a specific decay chain



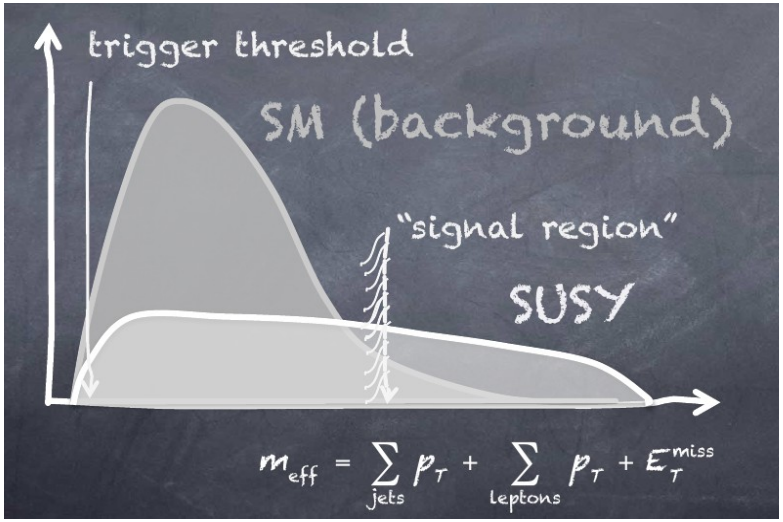
Simplified model

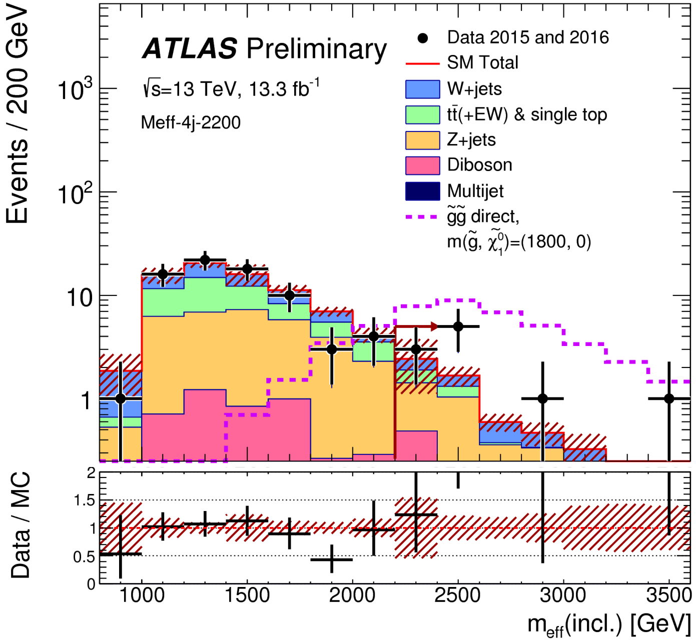


Distinguish signal from background

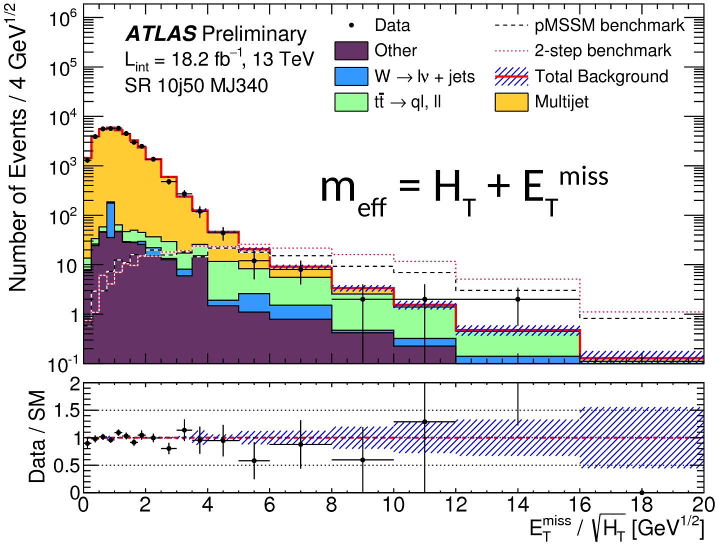
Use kinematic variables to discriminate signal from background.

Most analyses try to use simple combination of cuts on kinematic variables → ' cut-and-count', but also more and more shape analyses or analyses using more sophisticated techniques, e.g. machine learning





[ATLAS-CONF-2016-078]



[ATLAS-CONF-2016-095]

Essential to estimate the backgrounds

- **Reducible backgrounds:** backgrounds with another final state in comparison to the signal
- **Irreducible backgrounds:** backgrounds show the same final state as the signal