PHENO 2018

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

Sonia Carrà on behalf of the ATLAS collaboration

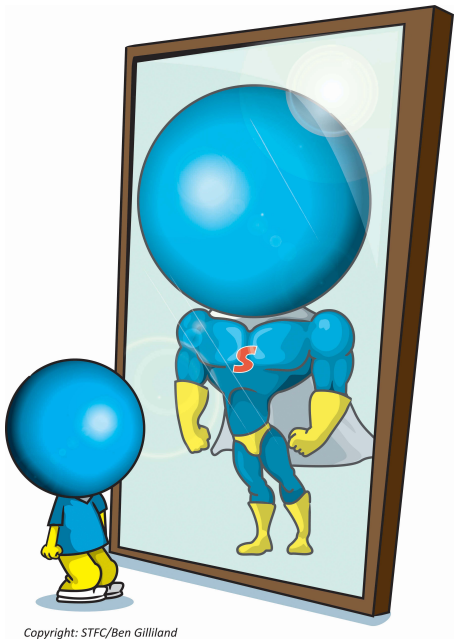
Università degli Studi di Milano - INFN Sezione di Milano

May 7-9, 2018

Outline

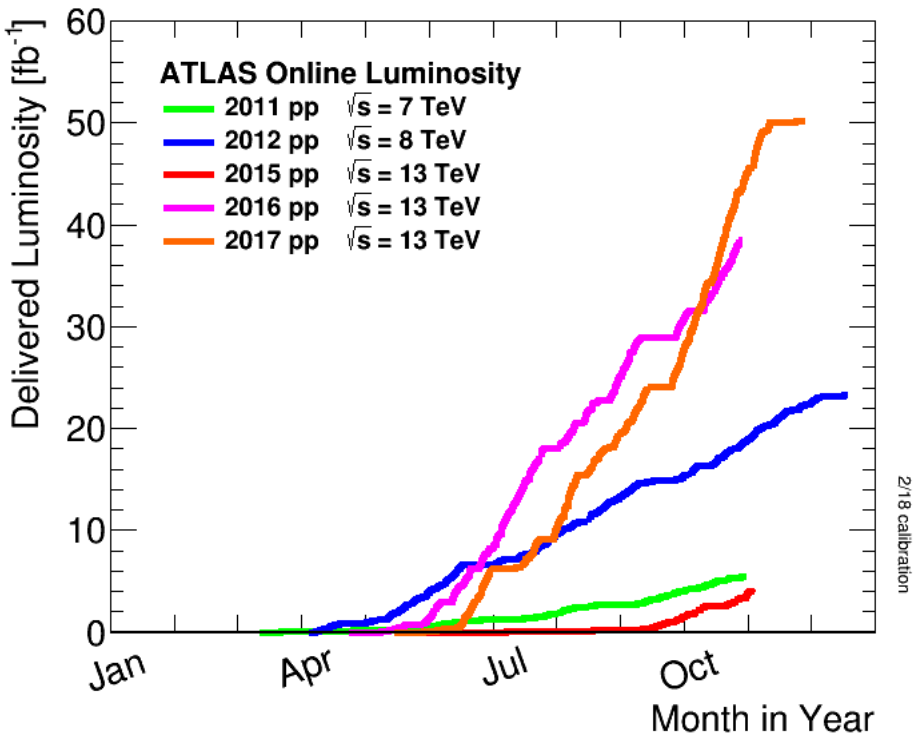
- LHC and the ATLAS detector
- motivation: beyond the Standard Model physics
- electroweak supersymmetic particles production
- searches considered:

Model	Signature	Link
gaugino and $\tilde{\ell}$ to $\tilde{\chi}^0$	2-3 leptons	**[1803.02762]**
gaugino and $\tilde{\ell}$ to $\tilde{\chi}^0$	soft leptons	**[1712.08119]**
gaugino to $\tilde{\chi}^0$	taus	**[1708.07875]**
gaugino to $\tilde{G}$	b-jets	**[CONF-2017-081]**



- summary plots and conclusions

Large Hadron Collider

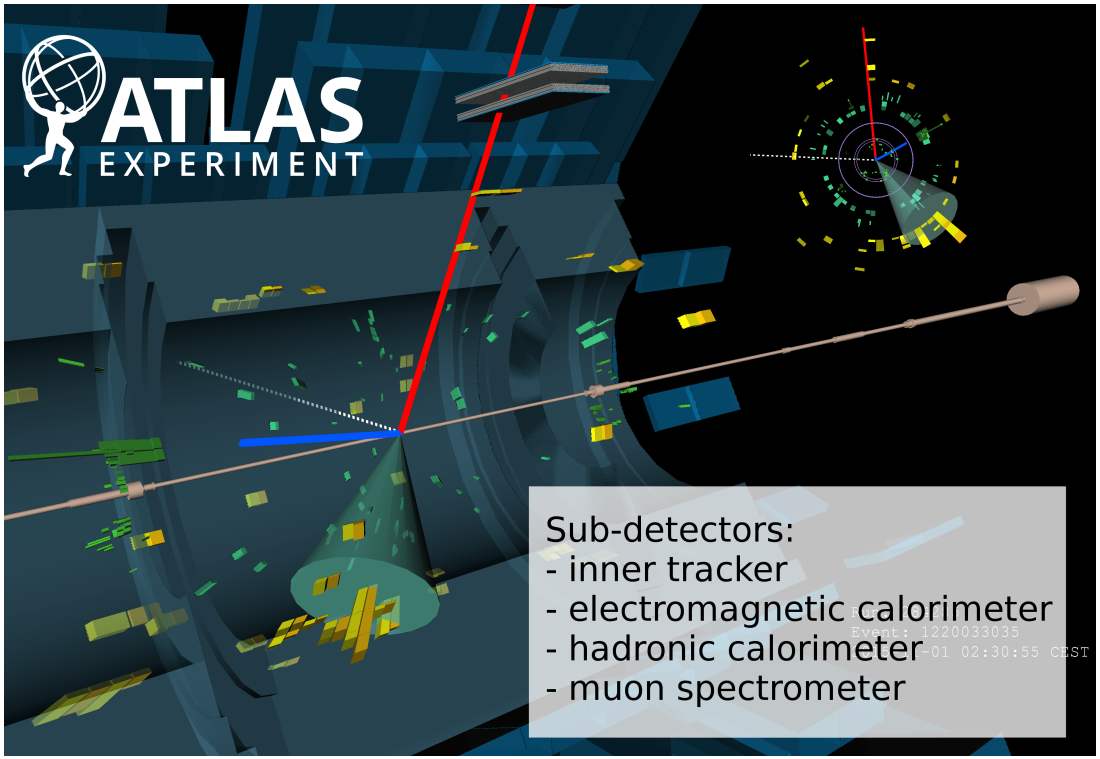


[ATLAS luminosity plot]

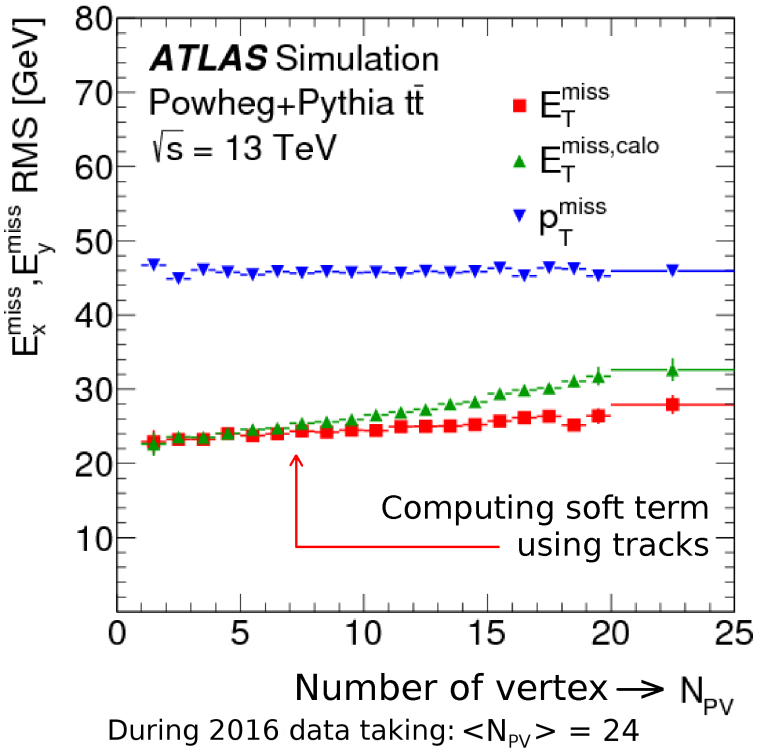
- **Proton-proton collisions**
- 2010-2012: Run 1 with $\sqrt{s} = 7 - 8$ TeV
- 2015-2018: **Run 2** with $\sqrt{s} = 13$ TeV
- Energy and luminosity increased since Run1
- More collected data: $N_{events} = \sigma_{production} \times L$

Presented searches use the data collected by ATLAS in 2015-2016
$\rightarrow$ Integrated luminosity after data quality: **36.1 fb^{-1}**

ATLAS detector



[ATLAS event display]



[p_T^{miss} performance - 1802.08168]

Weakly interacting particles escaping the detector. Momentum conservation in the plane transverse to the beam → **missing transverse momentum** due to the invisible particles.

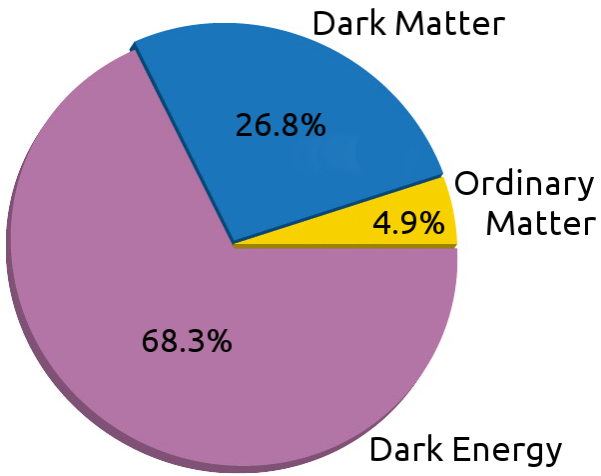
p_T^{miss} defined as the negative vectorial sum of visible momenta

Beyond the Standard Model

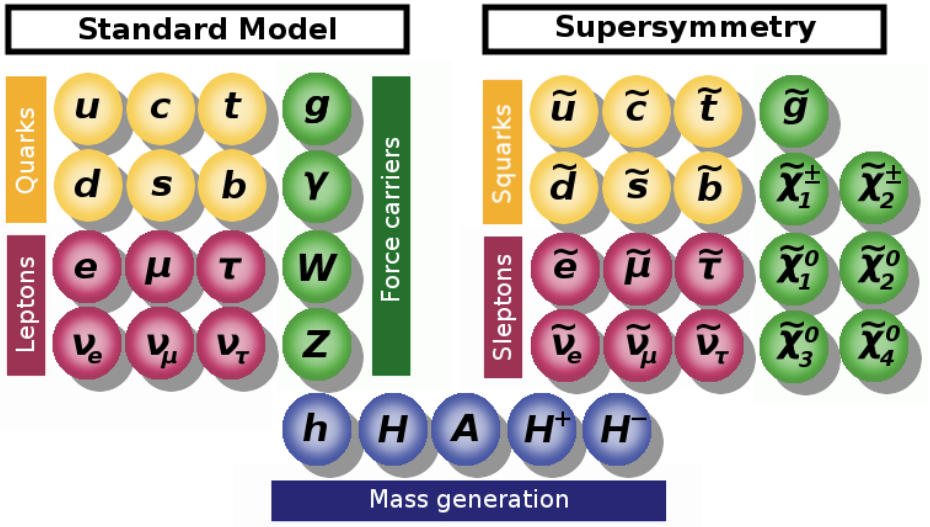
Standard Model: not a complete theory, many open questions:

- dark matter nature
- Higgs mass sensitivity to GUT/Planck-mass physics

Supersymmetry (SUSY) can solve these problems.

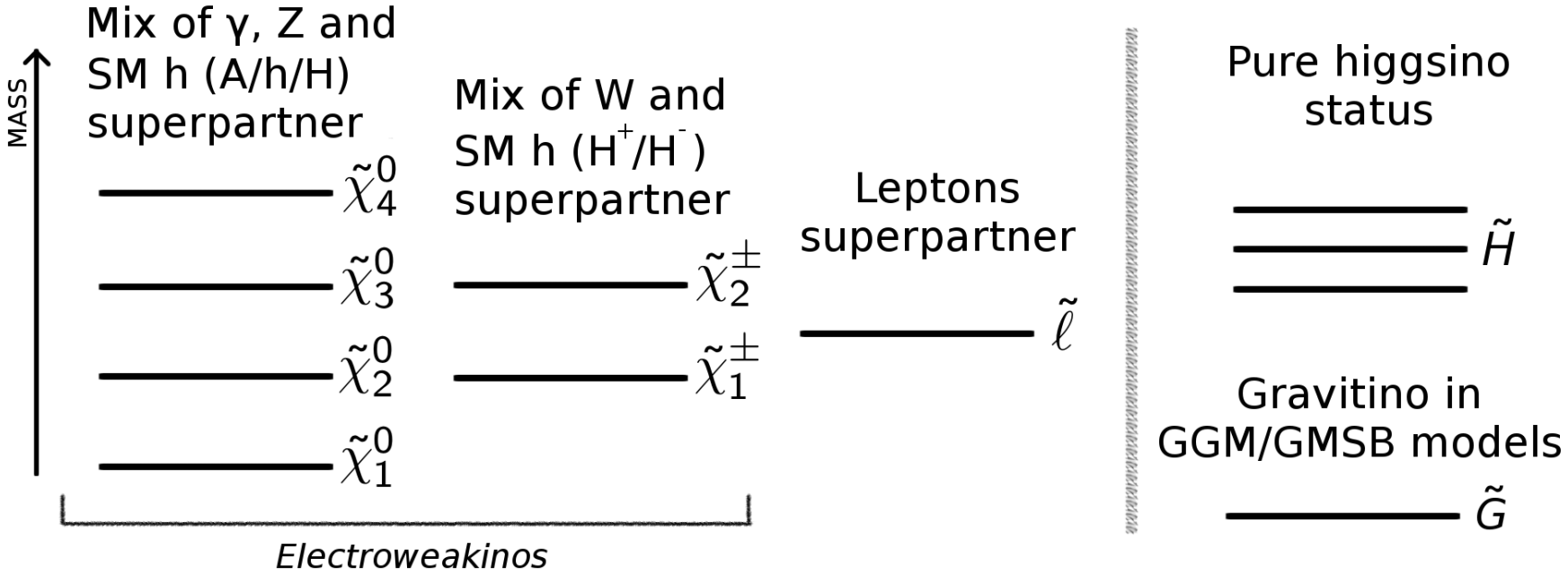


[Credit: ESA/Planck collaboration]



SUSY particles production: strong production has larger cross section, but colored sparticles excluded up to 2 TeV.
Electroweak production can dominate SUSY production at the LHC if the masses of colored sparticles are larger.

Electroweak SUSY spectrum



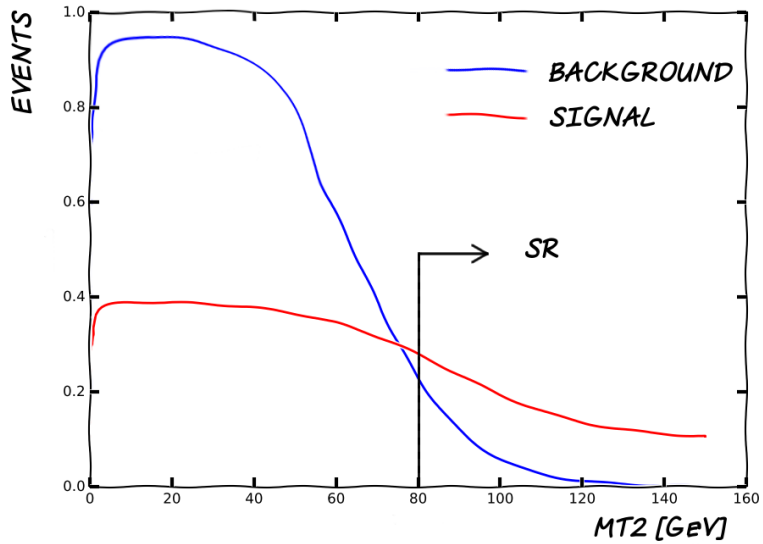
- Chargino ($\tilde{\chi}^\pm$) and neutralino ($\tilde{\chi}^0$) are mixed states of W,Z e h bosons superpartner(*wino*, *bino* e *higgsino*)
- Status mix and mass hierarchy are different depending on the model
- Pure higgsino status is also possible ($\tilde{H}$)
- General gauge mediation (GGM) - gauge-mediated symmetry breaking (GMSB) models consider also the gravitino ($\tilde{G}$)
- R-parity conservation
- LSP = lightest supersymmetric particle

Analysis strategy

- Considering a SUSY model, there are many Standard Model processes with the same signature (background processes)
- SUSY cross sections are very small compared to the SM ones
- Selecting a kinematic region with a good signal/background ratio $\rightarrow$ **signal region** (SR)
- As example, plot shows the *stransverse mass* (m_{T2}), computed using 2 visible objects (leptons or jets) and missing transverse energy (E_T^{miss})

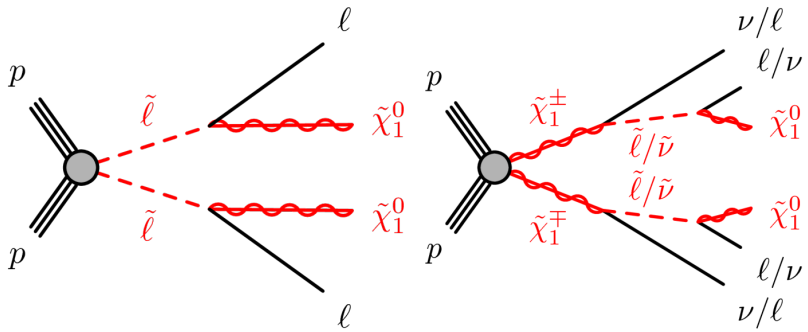
Process	xsec
$t\bar{t}$	832 pb
$\tilde{t}\tilde{t}$ - 500 GeV	5 pb
$\tilde{\chi}^{\pm}\tilde{\chi}^{\mp}$ - 500 GeV (wino)	22 fb
$\tilde{\chi}^{\pm}\tilde{\chi}^{\mp}$ - 500 GeV (higgsino)	6 fb
$\tilde{\ell}\tilde{\ell}$ - 500 GeV	0.5 fb

[1407.5066] [1207.2159] [1304.0790] [1310.2621]

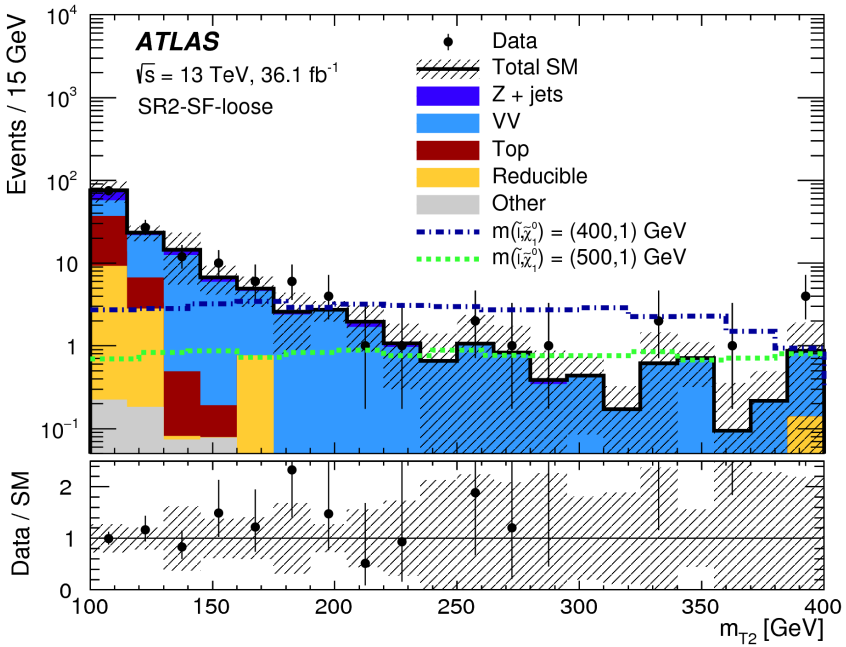


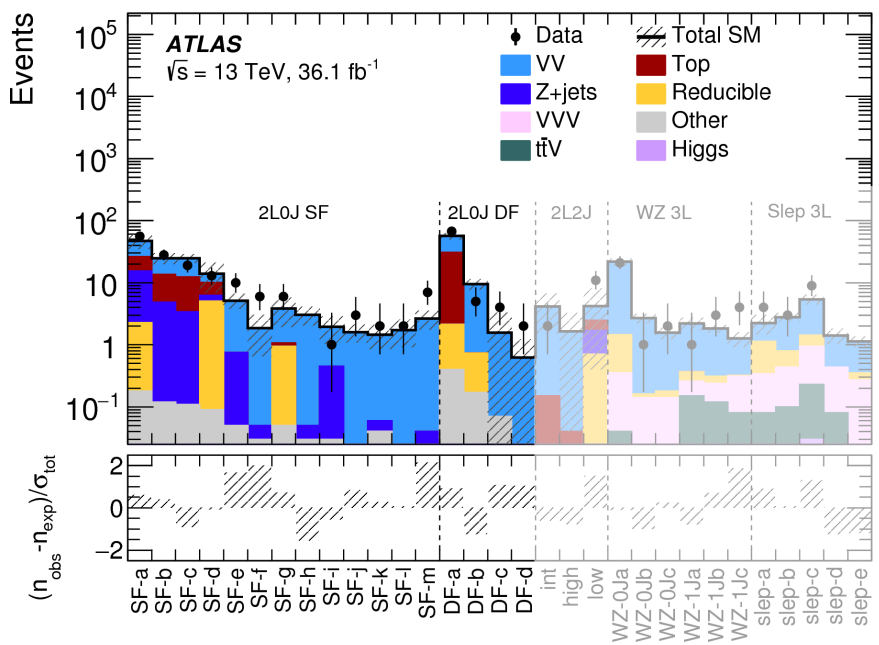
Chargino and slepton direct production

[1803.02762]

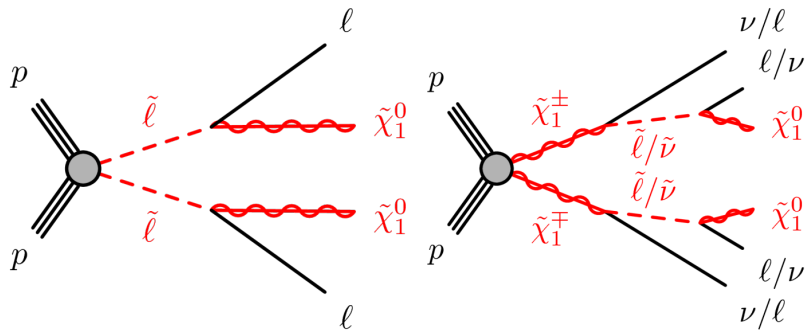


- 2 leptons (e or μ), no jets and large E_T^{miss}
- $\tilde{\chi}^0 \rightarrow$ LSP and stable
- SR with large m_{T2} and $m_{\ell\ell}$



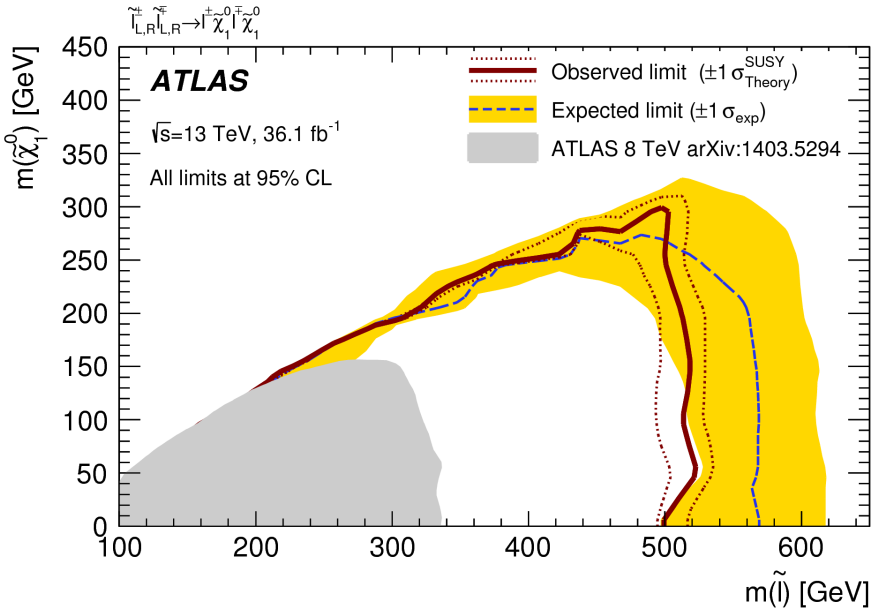


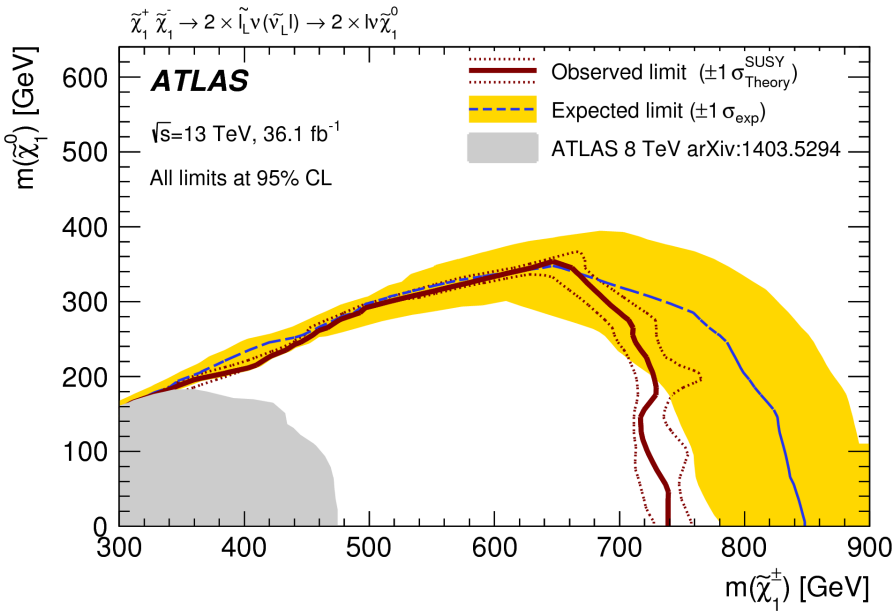
Chargino and slepton direct production



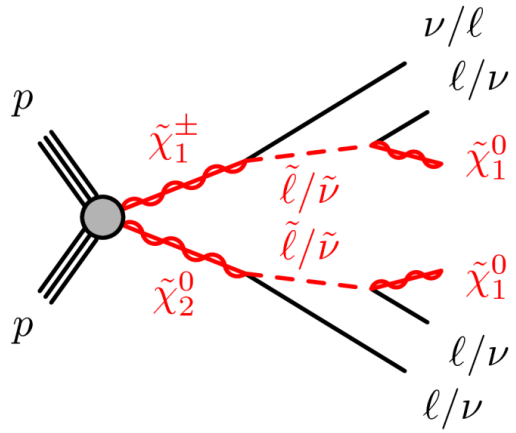
[1803.02762]

- s-electron and s-muon mass degenerate
- no excess observed



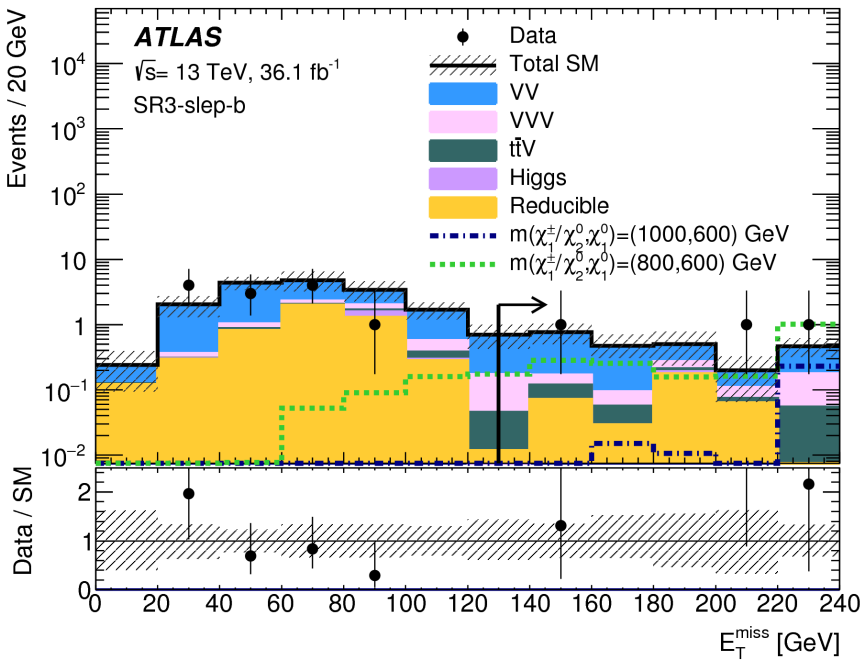


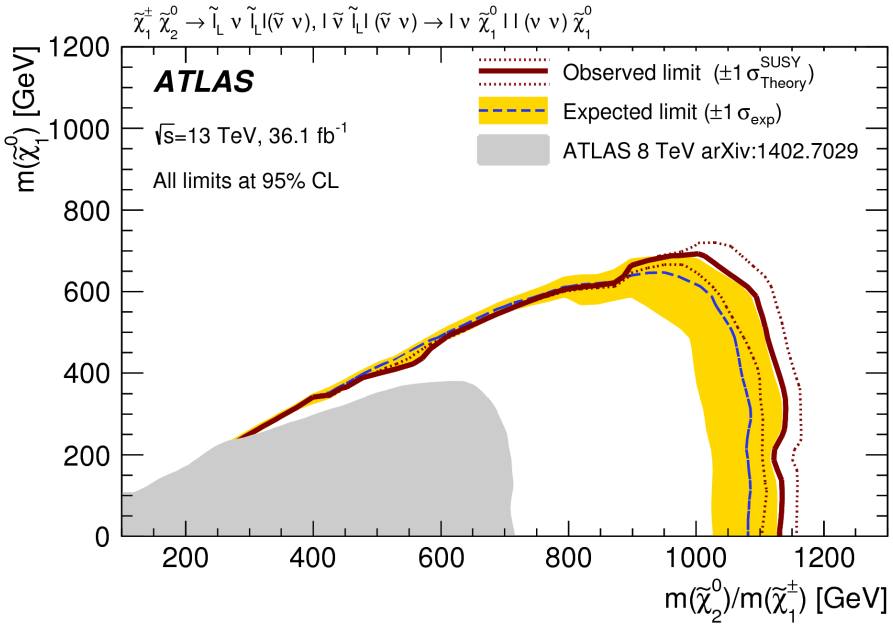
Gauginos via sleptons



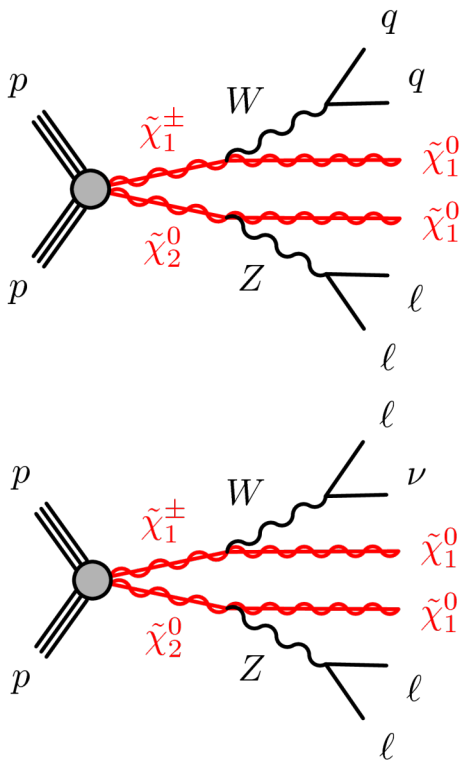
[1803.02762]

- 3 leptons (e or μ)
- SR with large E_T^{miss}, vetoing on leptons with $m_{\ell\ell}$ close to Z boson mass
- no excess observed



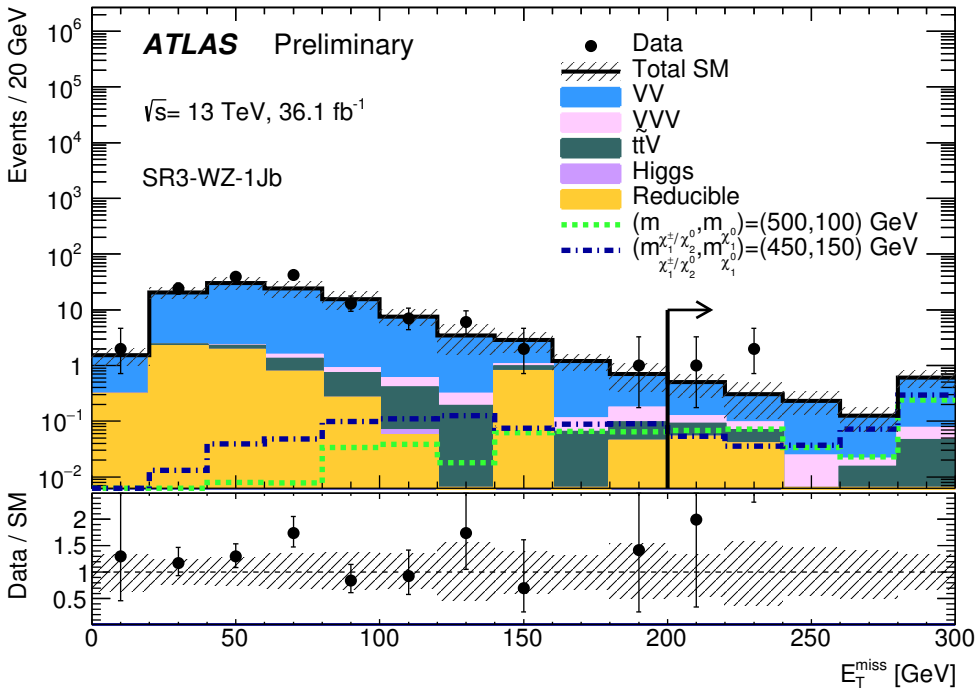


Gauginos via W/Z

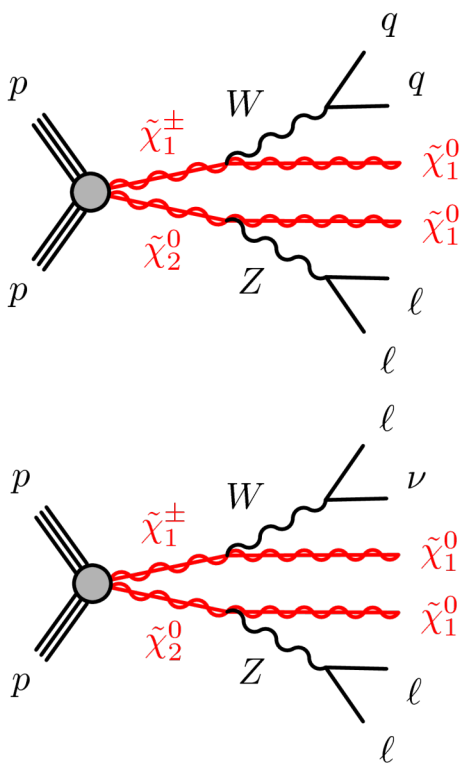


[1803.02762]

- Different signature depending on W boson decay
- 2 leptons and jets
- 3 leptons

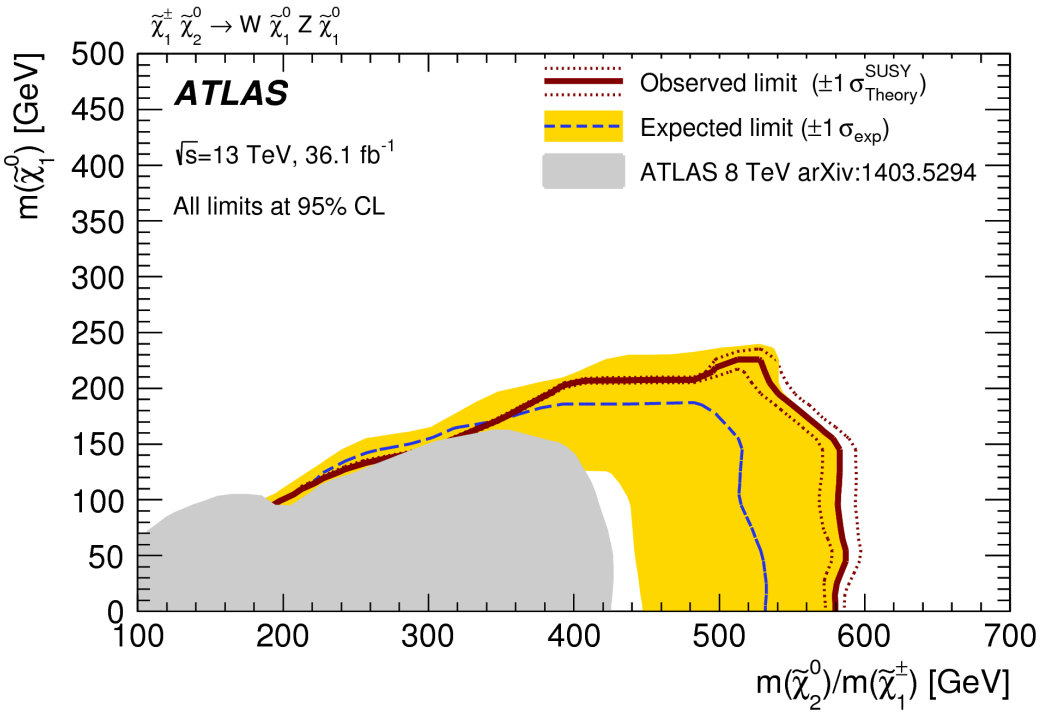


Gauginos via W/Z

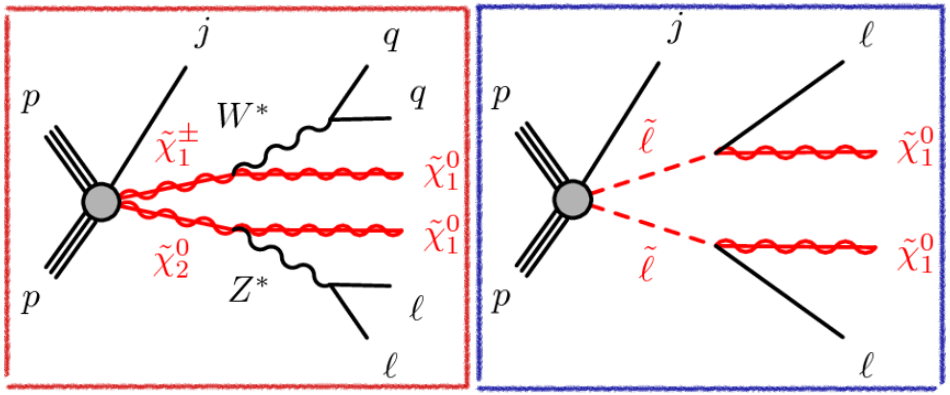


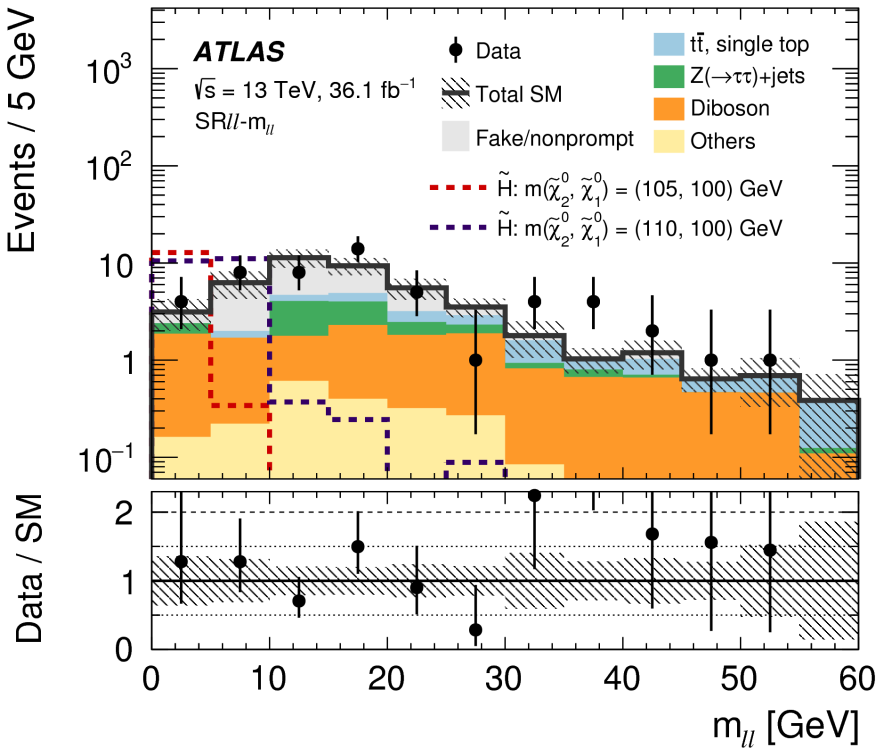
[1803.02762]

- No excess
- Combined exclusion limit

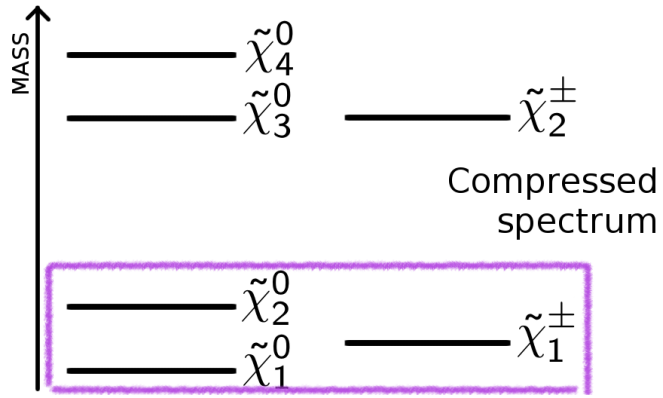


Gaugino and slepton with soft leptons



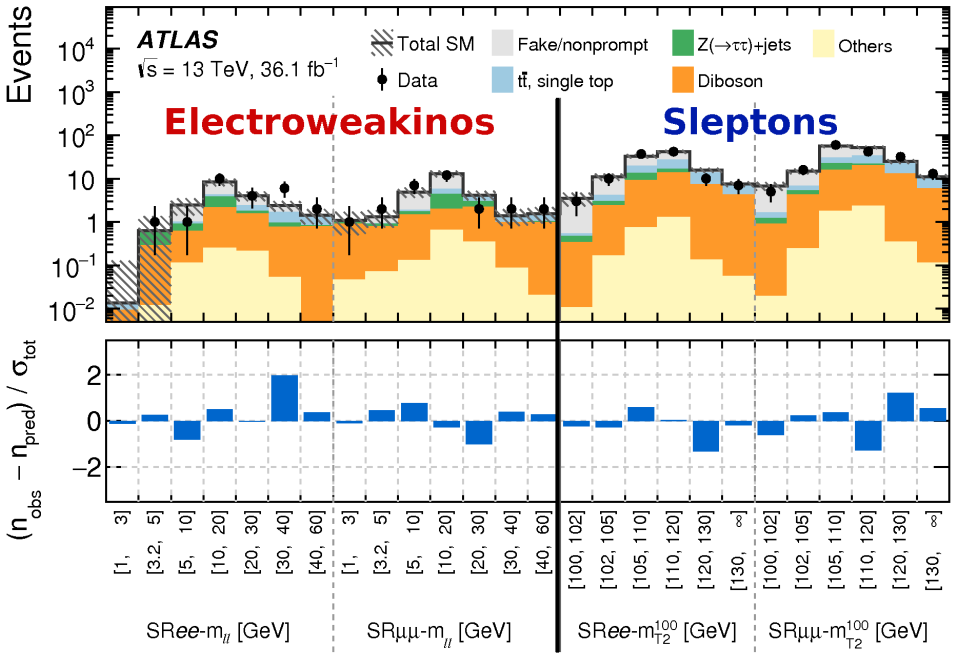


[1712.08119]



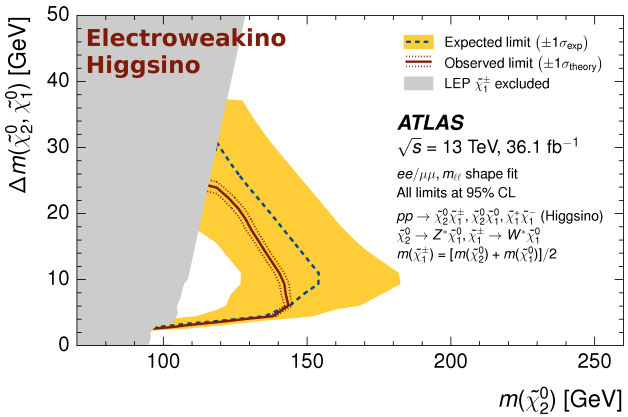
- $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ are higgsino-bino or wino-bino states
- **soft leptons** (e or μ) and E_T^{miss}
- Initial state radiation to boost the system
- Signal selection: $m_{\ell\ell} \in [1,60]$ GeV and large E_T^{miss}

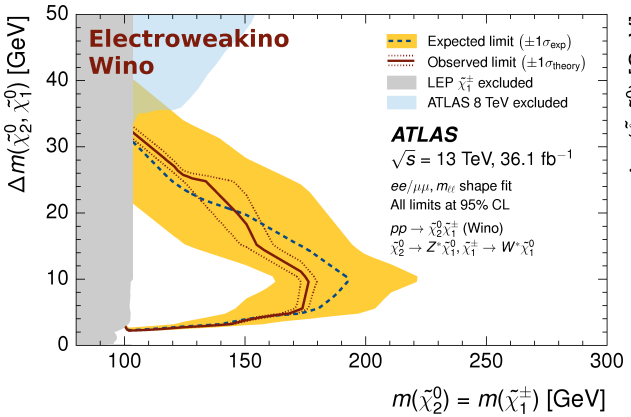
Gaugino and slepton with soft leptons

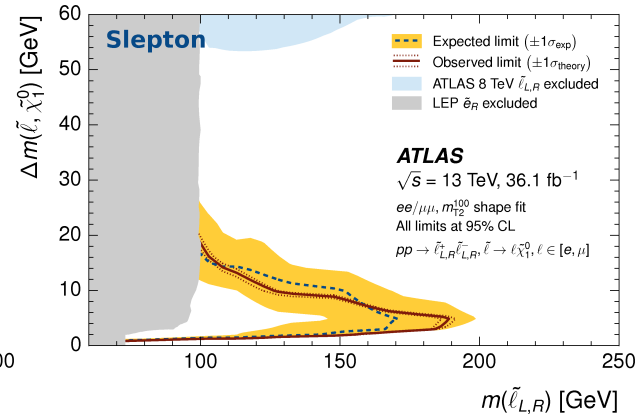


[1712.08119]

- No significant excess observed in the SRs
- New limits on the SUSY particles masses → first higgsino result since LEP

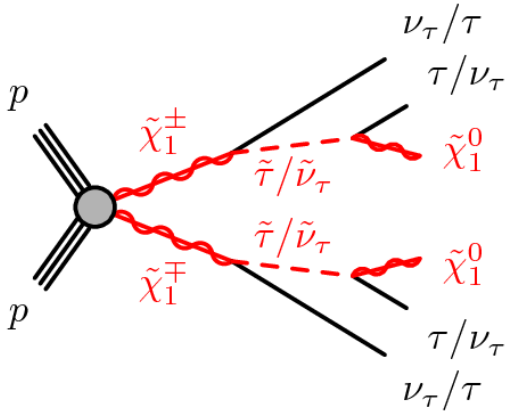




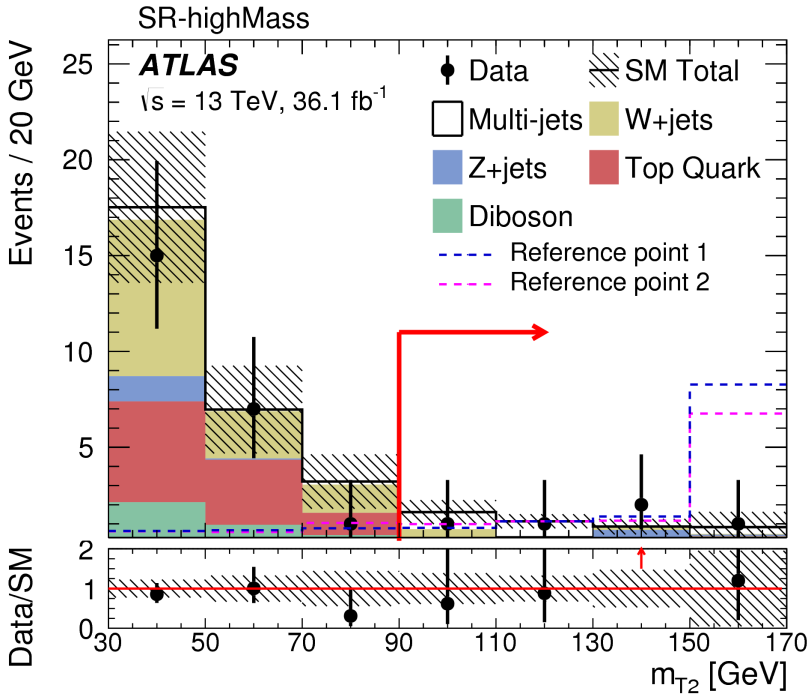


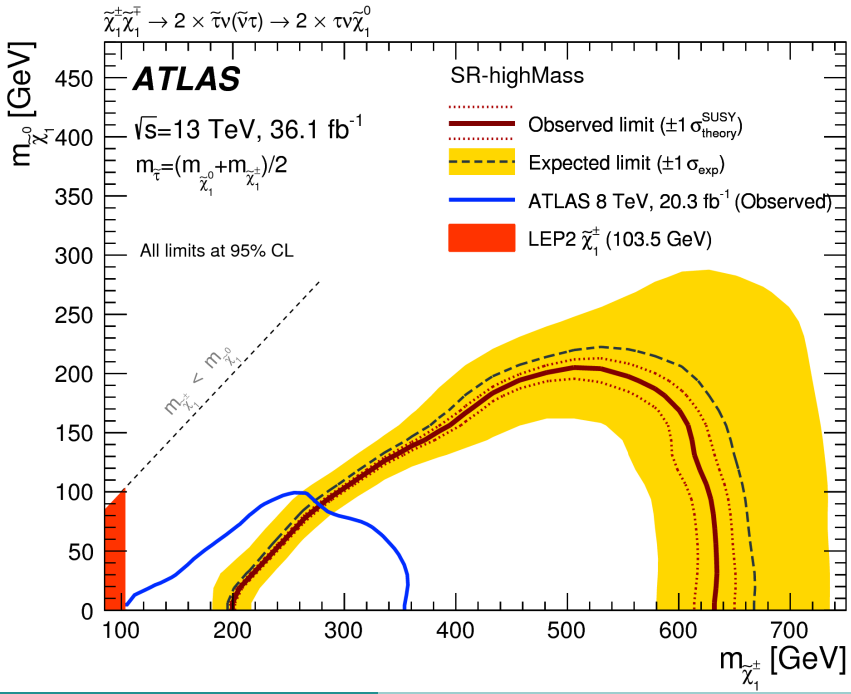
Gauginos with taus

[1708.07875]



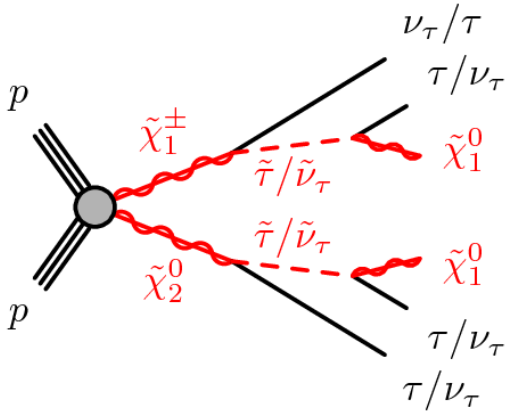
- SUSY search with tau leptons, different kinematic from e and μ
- $\tilde{\chi}_1^\pm$ is pure wino status and $\tilde{\chi}_1^0$ is LSP
- SR with large m_{T2}, computed using taus candidate
- No excess observed



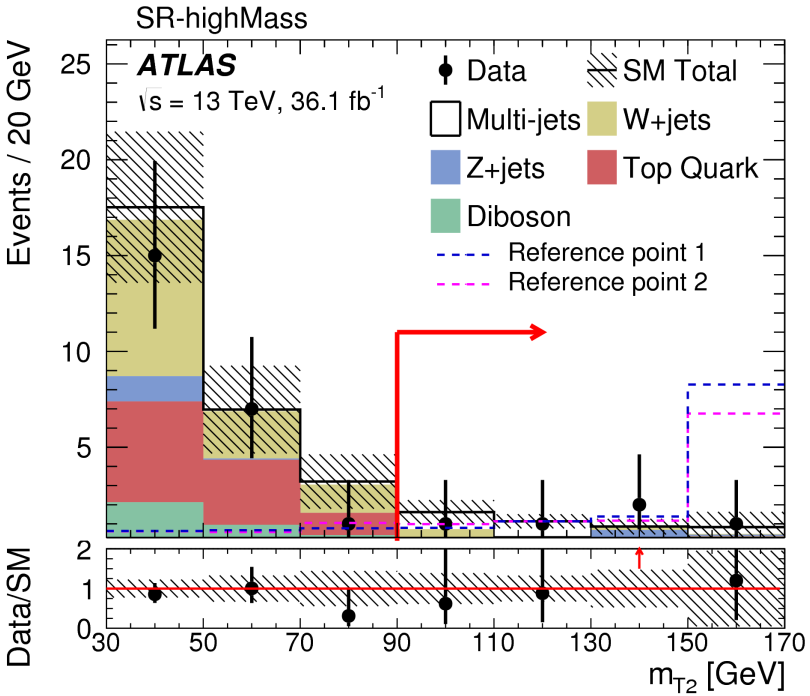


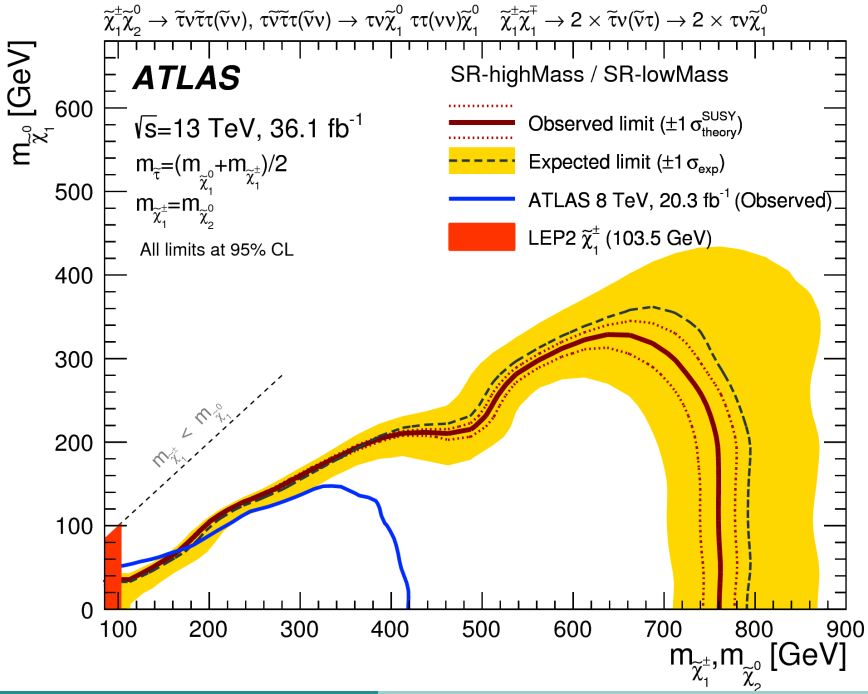
Gauginos with taus

[1708.07875]



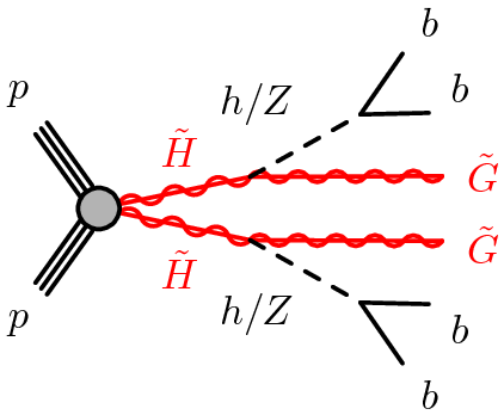
- SUSY search with tau leptons, different kinematic from e and μ
- $\tilde{\chi}_1^\pm$ is pure wino status and $\tilde{\chi}_1^0$ is LSP
- SR with large m_{T2}, computed using taus candidate
- No excess observed



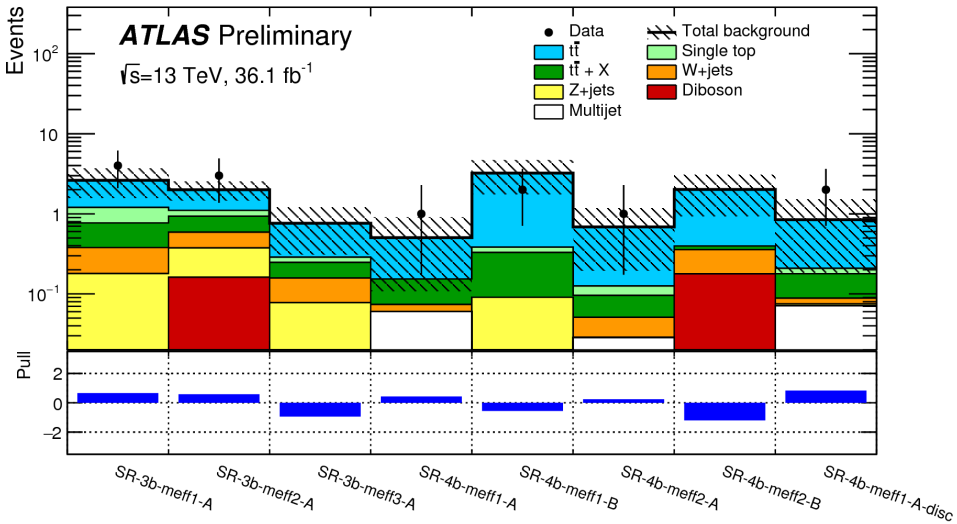


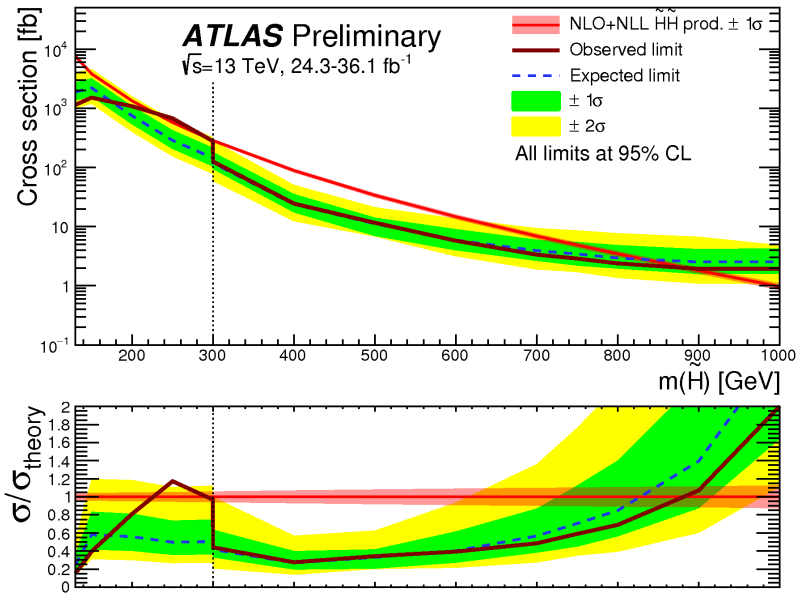
Gauginos to $\tilde{G}$ with 3 b-jets

[ATLAS-CONF-2017-081]



- GGM/GMSB model
- $\tilde{G}$ is LSP, with negligible mass
- At least 3 b-tagged jets, additional jets and E_T^{miss}
- No significant excess observed
- Limits on the $\tilde{H}$ cross section production

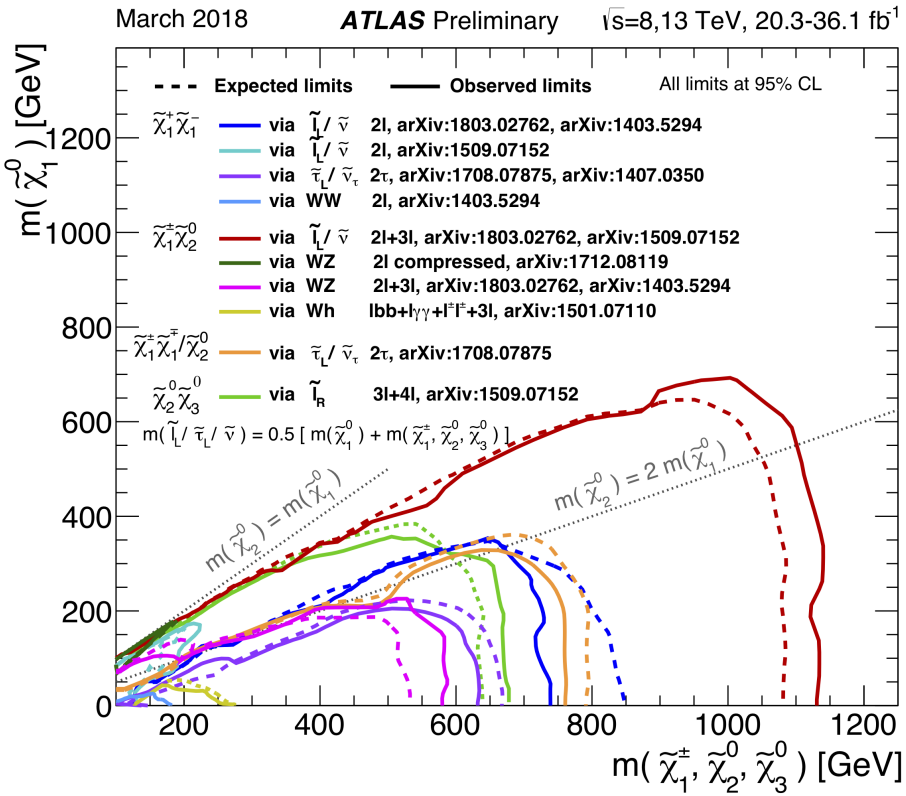




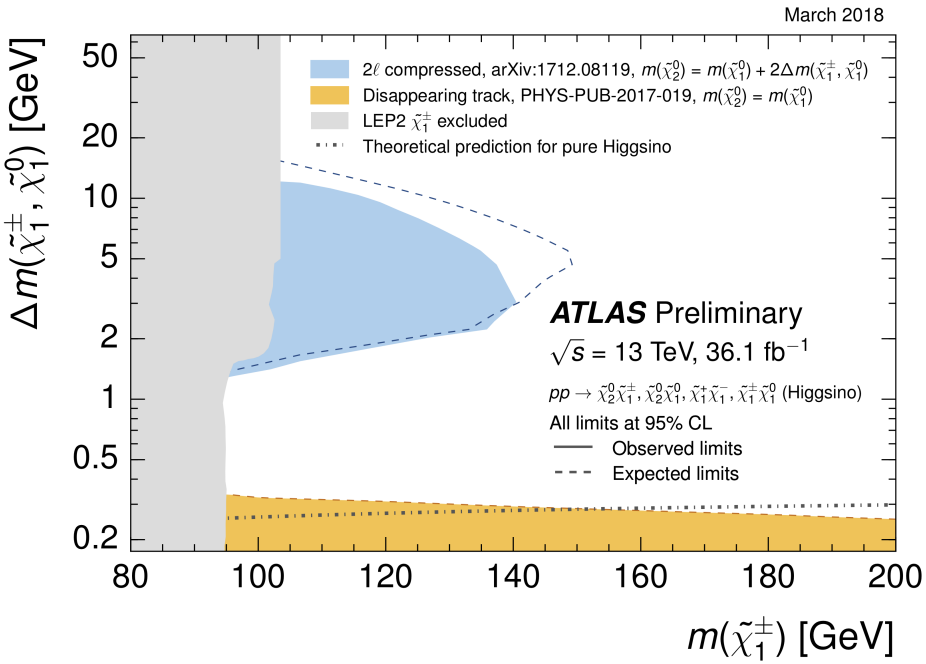
Summary plots

ATLAS electroweak SUSY searches summary plots

- $\tilde{\chi}_1^+\tilde{\chi}_1^-$ (wino), $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ (wino) and $\tilde{\chi}_2^0\tilde{\chi}_3^0$ (higgsino) pair production



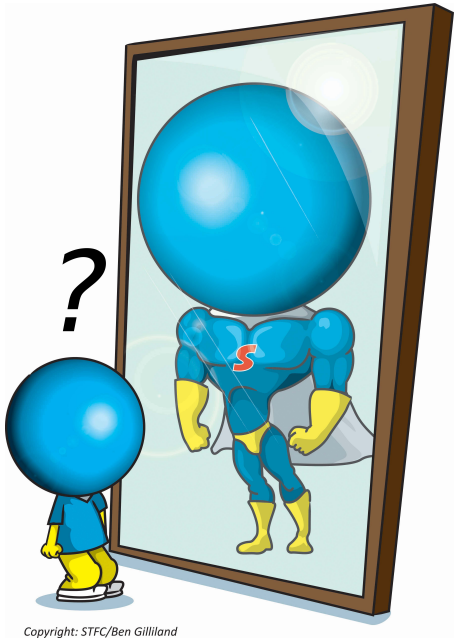
- $\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^\pm\tilde{\chi}_2^0$, $\tilde{\chi}^\pm\tilde{\chi}_1^0$ and $\tilde{\chi}_1^0\tilde{\chi}_2^0$ pair production, higgsino case



[ATLAS Supersymmetry summary plots]

Conclusions

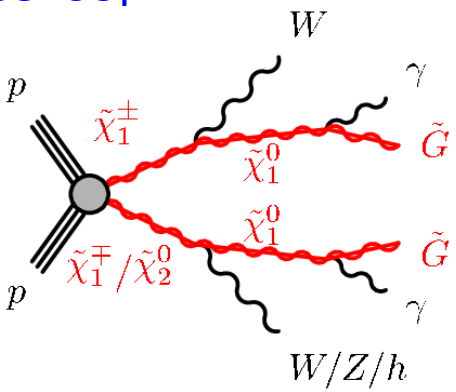
- ATLAS SUSY electroweak searches, with different signatures, were presented
- In all the considered cases, no significant differences were observed between data and SM prediction
- Exclusion limits were place on the SUSY particles masses
- Run 1 limits were largely improved by the new analysis



Additional material

Gauginos with photons

[1802.03158]



- GGM/GMSB model
- $\tilde{G}$ is LSP with negligible mass
- 2 photons (75 GeV) and large E_T^{miss}
- No excess observed