Searches for supersymmetric higgsinos with the ATLAS detector

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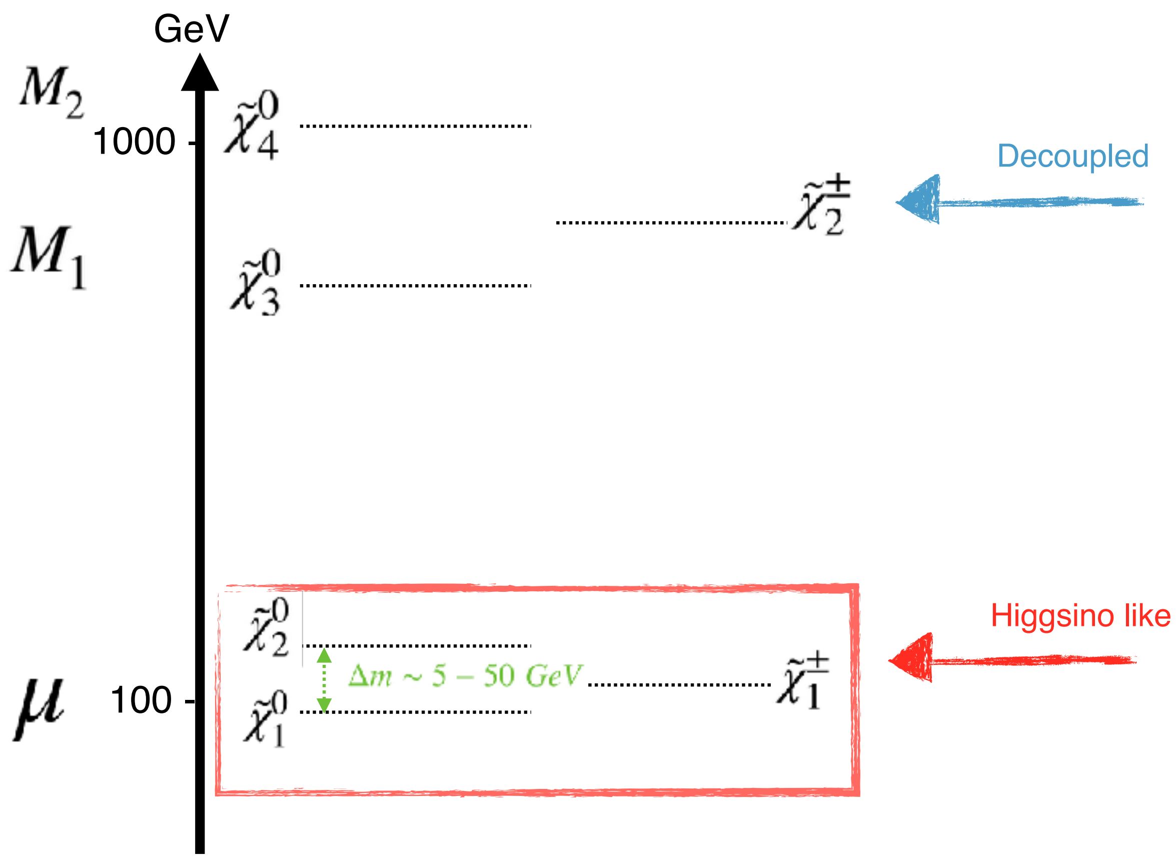
Naturalness and Higgsinos

Compressed spectra motivated in many SUSY scenarios



- μ is the tree level higgs mass, must be light for naturalness
- **Pure higgsinos** could have very small mass splitting: $\mathcal{O}$**(100 MeV)**
- **Moderate mixing** could get to $\mathcal{O}$**(1-10 GeV)**
- Soft decay product from higgsinos decay
  - challenging to detect!

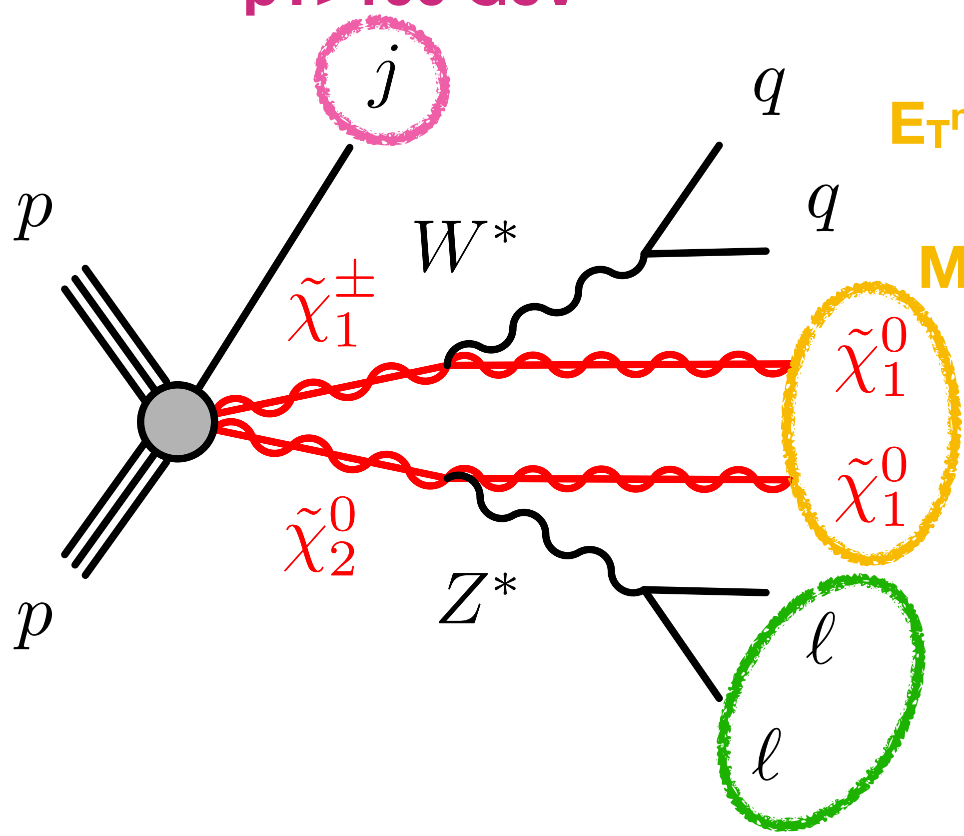
Up until recently only LEP limits

higgsino signal

Phys. Rev. D 97 (2018) 052010 analysis targeting very compressed spectra :

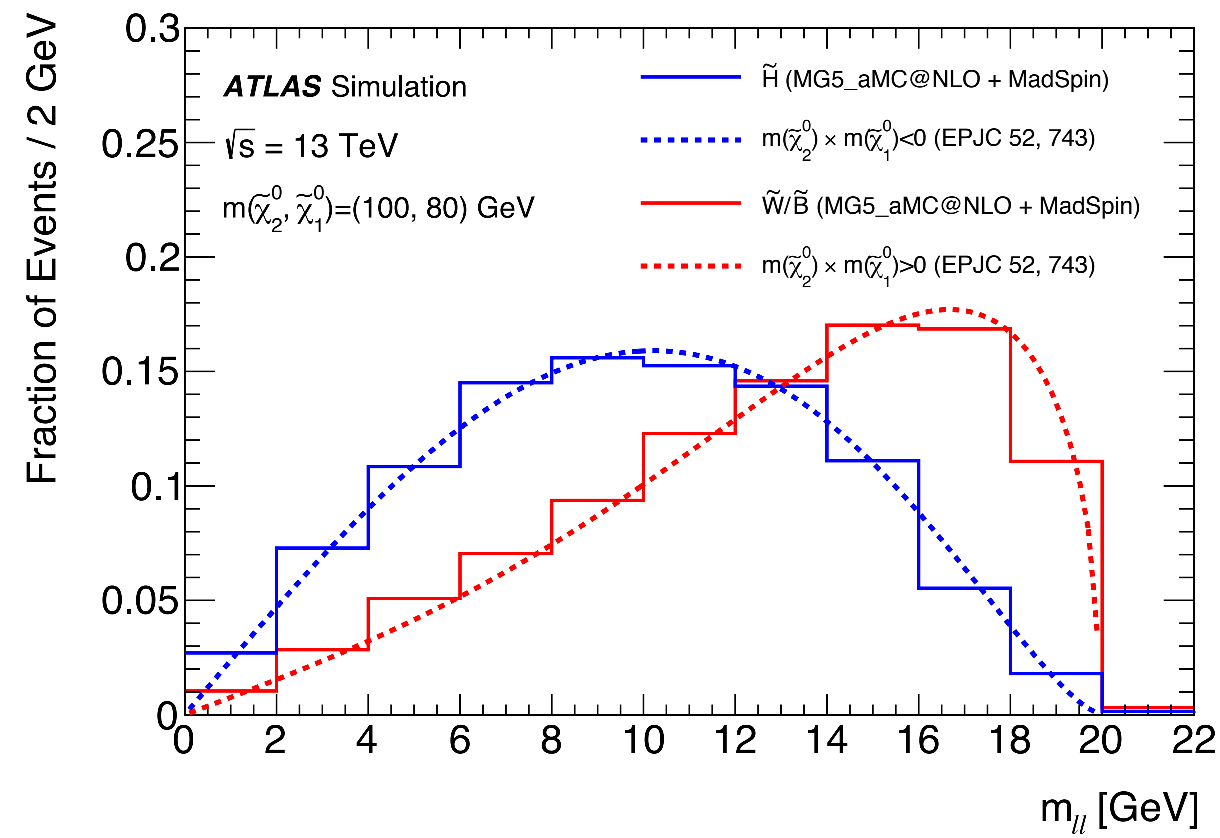
Boost to MET from ISR jet
pT>100 GeV

E_T^{miss}> 200 GeV
+
MET Triggers



Very soft leptons

p_T>4(4.5) GeV for muons (electrons)



Targeting low $m_{\ell\ell}$ region

- Kinematic edge at $\Delta m(\chi_2, \chi_1)$
- shape fit in $m_{\ell\ell}$>1 GeV & $m_{\ell\ell}$<60 GeV

Signal Region

Signal Region (SR) defined by maximizing the statistical significance

Select ISR topology

Soft leptons

Remove contribution from resonance and Z→ττ

Enhance sensibility

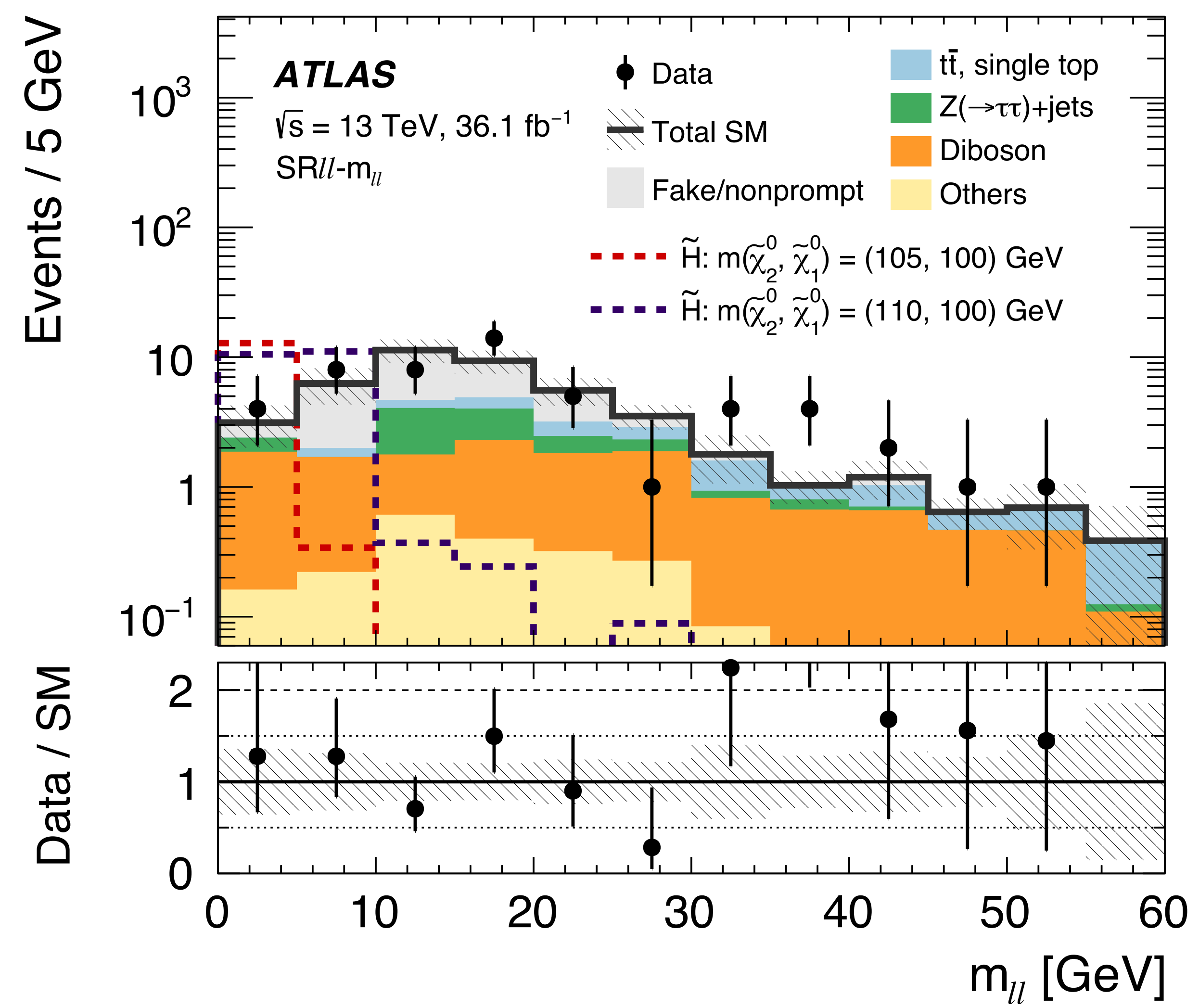
Variable	Requirement
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 200 GeV
Leading jet $p_{\mathrm{T}}(j_1)$	> 100 GeV
$\Delta\phi(jet, \mathbf{p}_T^{miss})$	> 2.0
$\min \Delta\phi(anyjets, \mathbf{p}_T^{miss})$	> 0.4
$N_{\mathrm{b-jet}}^{20}$, 85% WP	Exactly zero
N_{leptons}	Exactly two baseline and two signal
Lepton charge and flavour	$e^{\pm}e^{\mp}$ or $\mu^{\pm}\mu^{\mp}$
Leading electron (muon) $p_{\mathrm{T}}^{\ell_1}$	$> 5(5)$ GeV
Subleading electron (muon) $p_{\mathrm{T}}^{\ell_2}$	$> 4.5(4)$ GeV
$m_{\tau\tau}$	Veto [0, 160] GeV
$m_{\ell\ell}$	$> 1, < 60$ GeV, veto [3, 3.2] GeV
$\Delta R_{\ell\ell}$	> 0.05
Variable	**Selections optimised for Higgsinos**
$E_{\mathrm{T}}^{\mathrm{miss}}/H_{\mathrm{T}}^{\mathrm{leptons}}$	$> \mathrm{Max}\left(5.0, 15 - 2 \cdot m_{\ell\ell}/\ \mathrm{GeV}\right)$
$\Delta R_{\ell\ell}$	< 2.0
$m_{\mathrm{T}}^{\ell_1}$	< 70 GeV

Background estimation

Different strategy to estimate backgrounds

Background process	Origin in signal region	Estimation strategy
$t\bar{t}$, tW	b-jet fails identification	CR using b-tagging
Diboson	Irreducible leptonic decays	VR using $E_T^{miss}/\left(p_T^{\ell_1}+p_T^{\ell_2}\right)$
$(Z\to\tau\tau)$ + jets	Irreducible fully leptonic taus	CR using $m_{\tau\tau}$
$(W\to\ell\nu)$ + jets	Jet fakes second lepton	Fake factor, same sign VR
$(Z\to ee,\mu\mu)$ + jets	Instrumental E_T^{miss}	Monte Carlo
Low mass Drell-Yan	Instrumental E_T^{miss}	VR and Monte Carlo
Other rare processes	Irreducible leptonic decays	Monte Carlo

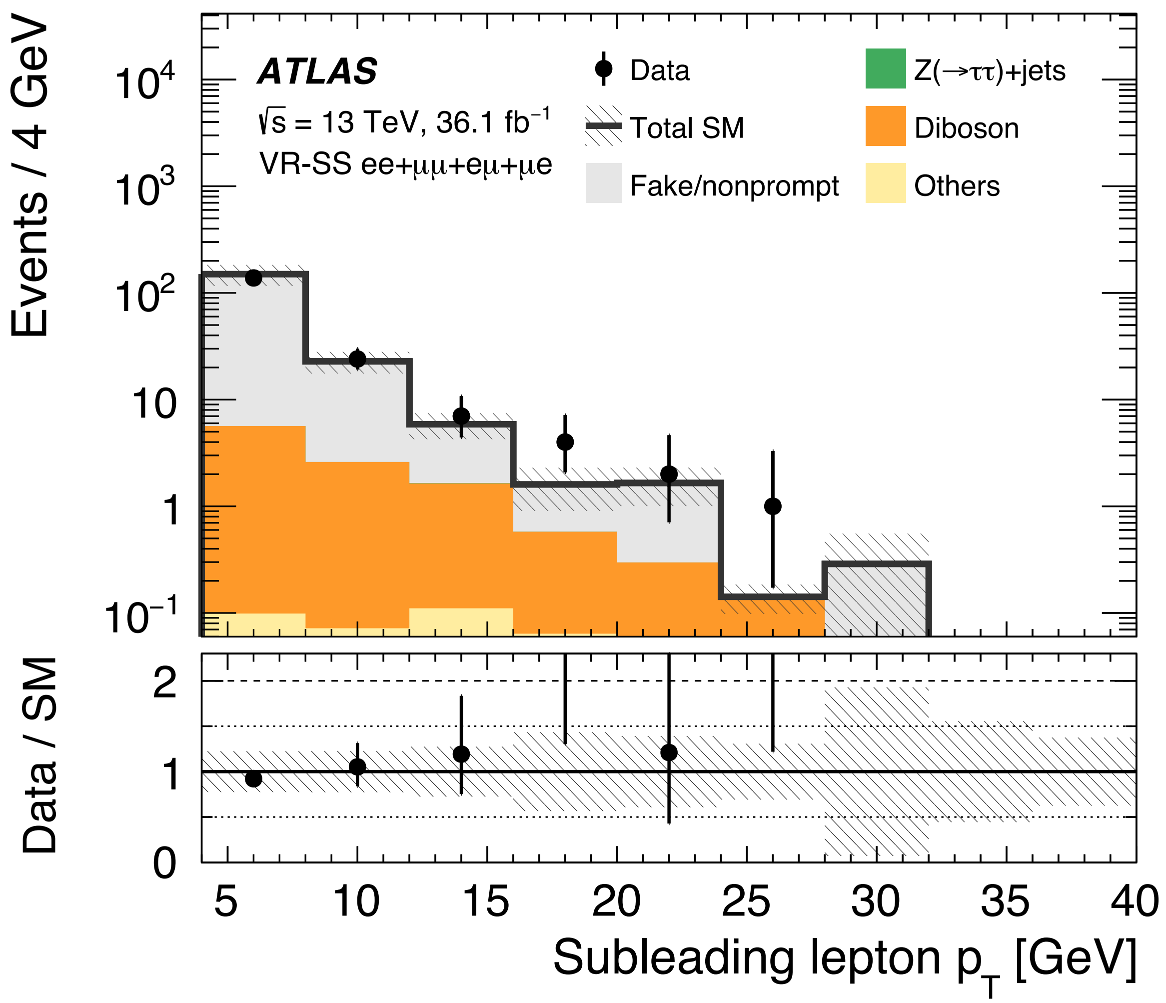
- Control Region to constraint MC to observed data
- Validation Region to compare estimate to data
- Fake factor uses Data Driven method



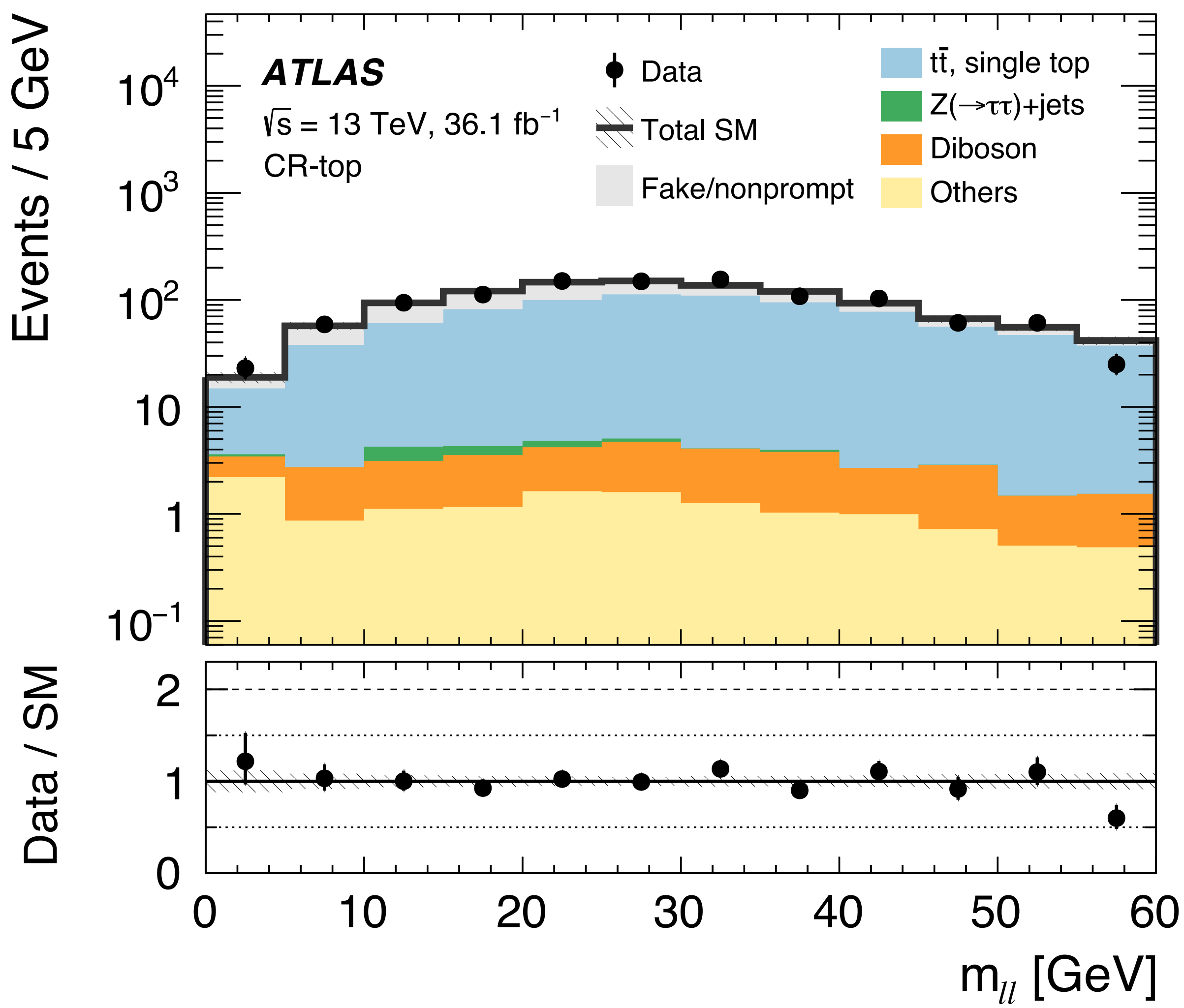
Main backgrounds comes from non prompt leptons (fakes) and instrumental E_T^{miss}.

Background estimation

Background under control

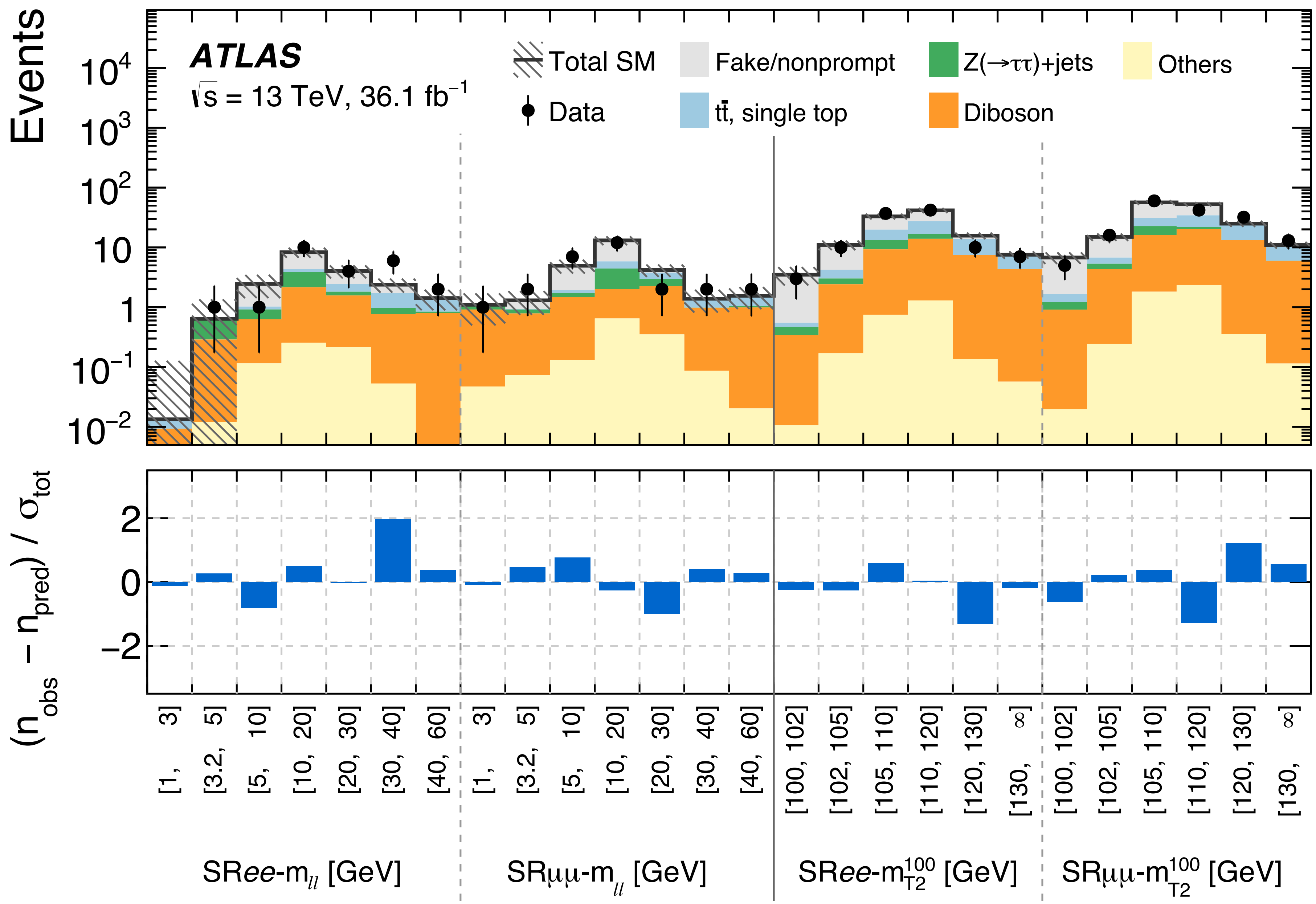


Fake enriched VR: low p_T leptons are well modeled



b-tagged CR: $m_{\ell\ell}$ correctly modeled
No resonance present

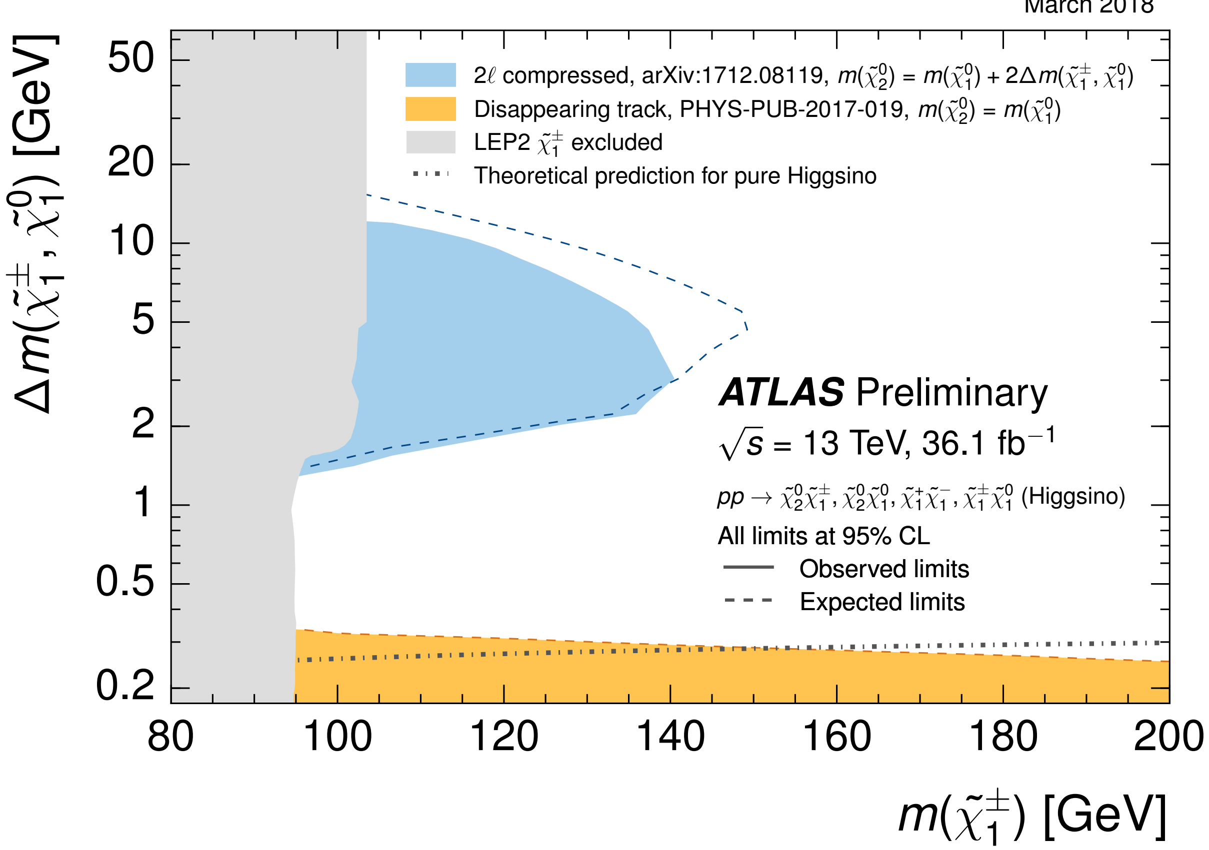
Results: Signal Region Yields



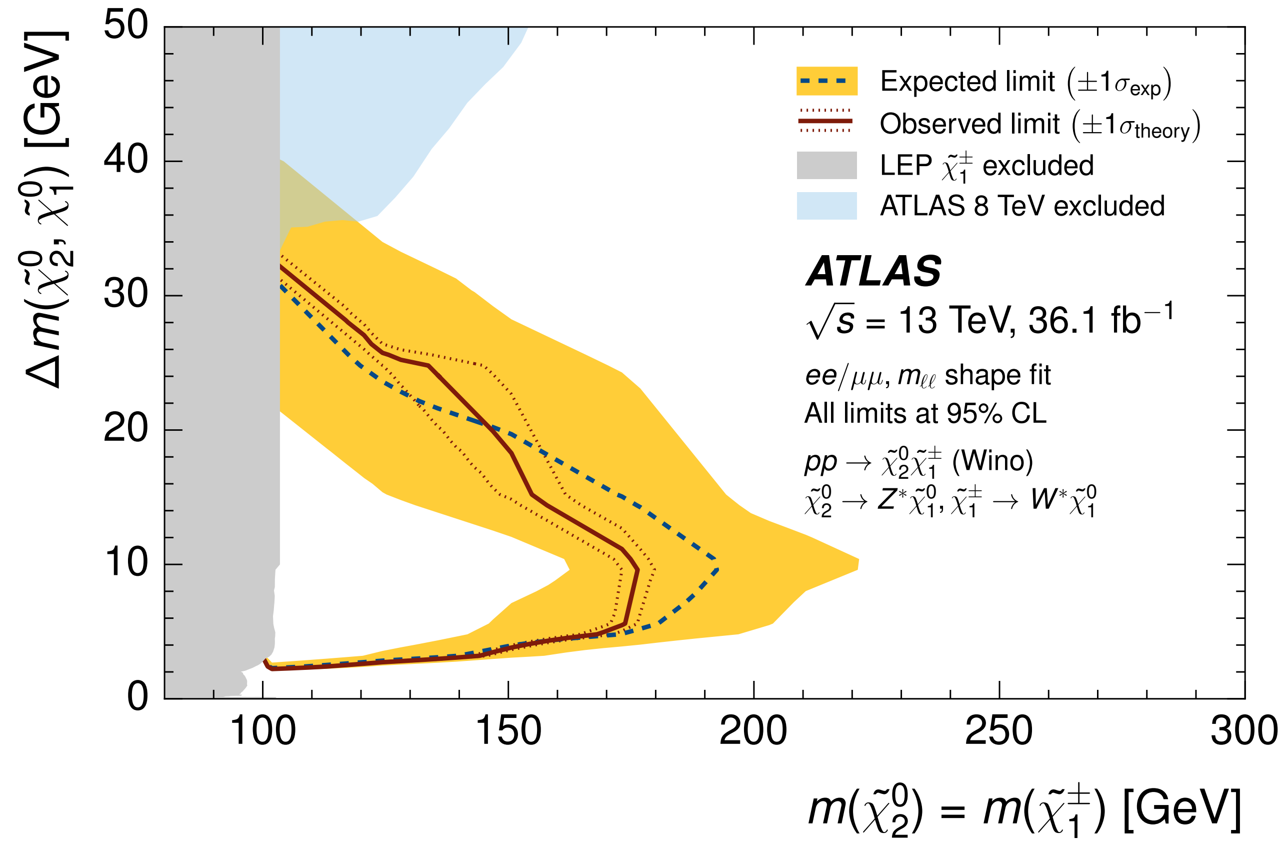
No significant excess observed!
Set limits on supersymmetric particles mass

Results: Signal Region Yields

Higgsino limits



Wino-Bino limits



Set limits on supersymmetric particles masses.
Also reinterpret results as Wino-Bino scenario

- higgsino: $\Delta m(\chi_2, \chi_1)$=3 GeV and m_{χ_2} = 130 GeV
- Wino-Bino: $\Delta m(\chi_2, \chi_1)$=2.5 GeV and m_{χ_2} = 170 GeV

Conclusions

- Higgsinos searches are well motivated by naturalness
  - Compressed scenarios with very soft leptons
- No excess observed. Set limits
  - higgsinos exluced up to 130 GeV and 3 GeV mass splitting
  - Wino-Bino excluded up to 170 GeV and 2 GeV mass splitting
- First new results since LEP limits on higgsino mass

BACK UP

Systematic uncertainties

Statistical uncertainties dominates in the very first bin. In higher bins uncertainty due to non-prompt leptons estimation is dominant