Status of global SUSY fits

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Outline

1 Global Fits
   - What?
   - Why?
   - How?

2 Likelihoods and constraints
   - Collider searches
   - Dark matter constraints
   - Precision observables
   - Flavour physics

3 Results
   - GUT-scale SUSY: CMSSM, NUHM1, NUHM2
   - Weak-scale SUSY: MSSM7, pMSSM10, pMSSM11
   - Other SUSY models

4 Summary and outlook
What are global fits?

Global fit in statistics

Statistical fit of one or more models to several data sets simultaneously

- Generalisation of non-linear regression
- Goodness-of-fit
- Parameter estimation
- Comparison of models
Global Fits

**Why** do we need global fits?

- Many SUSY theories
  - Which one is better?
- SUSY models have a large amount of parameters
  - Explore full parameter space
  - Where is my theory valid?
- Many experimental constraints
  - Collider searches, dark matter, precision observables, flavour anomalies,...
  - Simultaneously include all constraints
  - Does my theory fit the experimental data?
Global Fits

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  - Does my theory fit the experimental data?

![Graphs and tables showing experimental data and theoretical predictions for SUSY parameters.](image-url)
Global Fits

**How** do we do global fits?

- Combine all constraints into a **composite likelihood**

\[ \mathcal{L} = \mathcal{L}_{\text{Collider}} \mathcal{L}_{\text{Higgs}} \mathcal{L}_{\text{DM}} \mathcal{L}_{\text{Flavour}} \ldots \]

- Perform an extensive **parameter scan**
  - Old-school sampling methods (random, grid) are inefficient
  - Impossible to make statement about statistics
  - Need **smart sampling strategies** (differential, nested, genetic, ...)

- **Rigorous** statistical interpretation (frequentist/Bayesian)
  - Goodness-of-fit
  - Parameter estimation
  - Model comparison
Likelihoods and constraints
Likelihoods

Collider searches

- LHC searches for SUSY particles
  - $\tilde{q}, \tilde{g}$: 0-lepton + $E_T$ searches
  - $\tilde{t}, \tilde{b}$: b-jets or (0-2) leptons + $E_T$
  - $\tilde{\chi}_i^0, \tilde{\chi}_i^\pm, \tilde{l}$: ≥ 2 leptons + $E_T$
  - $\tilde{\chi}_i^0$: monojet + $E_T$

- LEP SUSY searches
  - $\tilde{\chi}_i^0, \tilde{\chi}_i^\pm, \tilde{l}$
  - relevant for light, degenerate spectra

- Higgs physics
  - mass constraint $m_h \approx 125$ GeV
  - signal strengths from LHC and LEP
  - invisible Higgs decays
    $\text{BF}(h \to \text{inv.}) \leq 0.26$

Likelihoods

Dark matter constraints

- Relic density of DM
  - \( \tilde{t}, \tilde{b}, \tilde{\tau} \) coannihilation
  - \( \tilde{\chi} \)\( \tilde{\chi} \) coannihilation
  - \( h/Z/A/H \) resonant annihilation

- Direct detection
  - Spin-independent: LUX, XENON1T, PandaX
  - Spin-dependent: IceCube, PICO-60

- Indirect detection
  - \( \gamma \)-rays from DM ann.: Fermi-LAT
  - \( \nu \)s from DM ann. in the sun: IceCube

\[ \Omega_c h^2 = 0.1188 \pm 0.0010 \]


[Schumann, M., arXiv:1903.03026]
Likelihoods

Precision observables

- Electroweak precision
  - \( m_W = 80.385 \pm 0.015 \) GeV
  - \( \sin^2 \hat{\theta}(M_Z) = 0.23153 \pm 0.00016 \)
  - \( \Gamma(Z \to \text{inv.}) = 499.0 \pm 1.5 \) MeV

- Anomalous magnetic moment \( \mu \)
  - \( a_{\mu}^{\text{SM}} = (11659180.2 \pm 4.9) \times 10^{-10} \)
  - \( a_{\mu}^{\exp} = (11659208.9 \pm 6.3) \times 10^{-10} \)

\[\text{[PDG, Chin. Phys. C38 (2014) 090001]}
\[\text{[CMS & LHCb, Nature 522 (2015) 68]}
\[\text{[PDG, Chin. Phys. C40 (2016) 090001]}
Likelihoods

Flavour physics

- **B and D meson decays**
  - Tree-level (semi)leptonic decays
  - Electroweak penguins $B^0 \rightarrow K^{*0} \mu^+ \mu^-$
    
    [LHCb, JHEP 02 (2016) 104]
  
  - Rare leptonic decays
    $B^0 \rightarrow \mu^+ \mu^- \ & B_s^0 \rightarrow \mu^+ \mu^0$
    
    

- $B \rightarrow X_s \gamma$

- **Lepton flavour universality ratios**
  - $R_{K^{(*)}} = \frac{BF(B\rightarrow K^{(*)} \tau \nu \tau)}{BF(B\rightarrow K^{(*)} l \nu_l)}$
  
  - $R_{D^{(*)}} = \frac{BF(B\rightarrow D^{(*)} \tau \nu \tau)}{BF(B\rightarrow D^{(*)} l \nu_l)}$

Results
GUT-scale SUSY

CMSSM

- $m_0$, $m_{1/2}$, $A_0$, $\tan \beta$, $\text{sign}(\mu)$
- LHC Run 1, LUX 2013
  - $\tilde{\chi}^+$ coann / A-funnel at large $m_0$
  - $\tilde{\tau}$ coann region at low mass

[Fittino, EPJC 76 (2016) no.2, 96]

[MasterCode, EPJC 74 (2014) 2922]
GUT-scale SUSY

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- LHC Run 2, LUX 2016
  - $\tilde{\tau}$ coann region is gone (95%CL)
  - $\tilde{t}$ coann region at low mass

[EasyScanHEP, PLB 769 (2017) 470-476]

[GAMBIT, EPJC 77 (2017) no.12 824]
GUT-scale SUSY

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- $m_0$, $m_{1/2}$, $A_0$, $\tan \beta$, $\text{sign}(\mu)$
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  - $\tilde{\chi}^+ \text{ coann} / A$-funnel at large $m_0$
  - $\tilde{\tau} \text{ coann region at low mass}$
- LHC Run 2, LUX 2016
  - $\tilde{\tau} \text{ coann region is gone (95%CL)}$
  - $\tilde{t} \text{ coann region at low mass}$
- Long lived and compressed spectra searches can probe $\tilde{t} \text{ coann region}$
- XENON1T, LZ and Darwin can exclude $\chi^+/A$-funnel

[LAGBIT, EPJC 77 (2017) no.12 824]
GUT-scale SUSY

NUHM

- NUHM1: $m_0 \rightarrow m_0, m_H$
- NUHM2: $m_0 \rightarrow m_0, m_{H_u}, m_{H_d}$
- LHC Run 1, LUX 2013
  - No upper limit on $m_{1/2}$ and $m_0 < 0$
  - Large $\tilde{\tau}$ coann region

[MasterCode, EPJC 74 (2014) 2922]
GUT-scale SUSY

NUHM

- NUHM1: $m_0 \rightarrow m_0, m_H$
- NUHM2: $m_0 \rightarrow m_0, m_{H_u}, m_{H_d}$
- LHC Run 1, LUX 2013
  - No upper limit on $m_{1/2}$ and $m_0 < 0$
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- LHC Run 2, LUX 2016
  - $\tilde{\tau}$ coann region remains
  - Increased $\tilde{t}$ coann
  - No lower limit on $m_0$ for all $m_{1/2}$

[MasterCode, EPJC 74 (2014) no.12, 3212] [GAMBIT, EPJC 77 (2017) no.12, 824]
GUT-scale SUSY

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- Can be probed by compressed $\tilde{\chi}$ and DM direct detection

[GAMBIT, EPJC 77 (2017) no.12 824]
GUT-scale SUSY

NUHM

- NUHM1: \(m_0 \rightarrow m_0, m_H\)
- NUHM2: \(m_0 \rightarrow m_0, m_{H_u}, m_{H_d}\)
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  - \(\tilde{\tau}\) coann region remains
  - Increased \(\tilde{t}\) coann
  - No lower limit on \(m_0\) for all \(m_{1/2}\)
- Can be probed by compressed \(\tilde{\chi}\) and DM direct detection
- No longer good prediction for \(a_\mu\)
Weak-scale SUSY

MSSM7

- $A_{u3}, A_{d3}, m_{H_u}, m_{H_d}, m_{\tilde{f}}, M_2, \tan \beta, \text{sign}(\mu)$ at $Q = 1$ TeV
- $\tilde{\chi}^+$ coann region ($\mu < M_1$), with contributions from $A/H$-funnel and $h/Z$-funnel
- $\tilde{t}, \tilde{b}$ coann region, with $A/H$-funnel (no $\tilde{\tau}$ coann)
- Compressed $\tilde{t} - \tilde{\chi}^0$ or $\tilde{\chi}^0 - \tilde{\chi}^+$ (Run 2)
Weak-scale SUSY

MSSM7

- $A_{u3}$, $A_{d3}$, $m_{H_u}$, $m_{H_d}$, $m_{\tilde{f}}$, $M_2$, $\tan \beta$, sign($\mu$) at $Q = 1$ TeV
- $\tilde{\chi}^+$ coann region ($\mu < M_1$), with contributions from $A/H$-funnel and $h/Z$-funnel
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- Compressed $\tilde{t} - \tilde{\chi}^0$ or $\tilde{\chi}^0 - \tilde{\chi}^+$ (Run 2)

[GAMBIT, EPJC 77 (2017) no.12, 879]
Weak-scale SUSY

pMSSM10

- \( M_1, M_2, M_3, m_{\tilde{q}}, m_{\tilde{q}_3}, m_{\tilde{l}}, A, \mu, M_A, \tan \beta \) at \( M_{SUSY} \)
- Dominant \( \tilde{\chi}^+ \) coann, with minor \( h/Z \)-funnel and \( \tilde{\tau} \) coann
- Target \( h/Z \)-funnel and \( \tilde{\tau} \) coann, but miss \( \tilde{\chi}^+ \) coann (Run 1)
- SI direct detection can probe \( \tilde{\chi}^+ \) coann
- Great fit to \( a_\mu \) due to light \( \tilde{\chi}^+ \) and \( \tilde{l} \)

[MasterCode, EPJC 75 (2015) no.9, 422] [Mastercode, EPJC 75 (2015) 500]
Weak-scale SUSY

pMSSM10

- $M_1, M_2, M_3, m_{\tilde{q}}, m_{\tilde{q}_3}, m_{\tilde{\tau}}, A, \mu, M_A, \tan \beta$ at $M_{SUSY}$
- Dominant $\tilde{\chi}^+$ coann, with minor $h/Z$-funnel and $\tilde{\tau}$ coann
- Target $h/Z$-funnel and $\tilde{\tau}$ coann, but miss $\tilde{\chi}^+$ coann (Run 1)
- SI direct detection can probe $\tilde{\chi}^+$ coann
- Great fit to $a_\mu$ due to light $\tilde{\chi}^+$ and $\tilde{\tau}$

[MasterCode, EPJC 75 (2015) no.9, 422] [Mastercode, EPJC 75 (2015) 500]
Weak-scale SUSY

pMSSM11

- $M_1, M_2, M_3, m_{\tilde{q}}, m_{\tilde{g}}, m_{\tilde{l}}, m_{\tilde{l^3}}, A, \mu, M_A, \tan \beta$ at $M_{SUSY}$
- Run 2 searches push $\tilde{q}, \tilde{g}$ and $\tilde{\chi}^0$ masses ($h/Z$-funnel gone)
- New coann mechanisms open
- Great fit to $a_\mu$ constraint, strong effect on $\tilde{\chi}$ composition
- Future SI direct detection (LZ, XENONnT) can probe $1\sigma$

[MasterCode, EPJC 78 (2018) no.3, 256]
Weak-scale SUSY

pMSSM11

- $M_1, M_2, M_3, m_\tilde{q}, m_\tilde{q}_3, m_\tilde{t}, m_\tilde{t}_3, A, \mu, M_A, \tan\beta$ at $M_{SUSY}$
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- $M_1, M_2, M_3, m_{\tilde{q}}, m_{\tilde{g}}, m_{\tilde{l}}, m_{\tilde{\chi}_3}, A, \mu, M_A, \tan \beta$ at $M_{\text{SUSY}}$
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[MasterCode, EPJC 78 (2018) no.3, 256]
Other SUSY models

**EWMSSM**

- $M_1, M_2, \mu, \tan \beta, \ A_i = 0, m_{\tilde{t}, \tilde{q}} = 3 \text{ TeV}, \ M_3, m_A = 5 \text{ TeV}$
- LHC Run 2 searches for light electroweakinos
- No exclusion for light electroweakinos

![Graph showing m(\tilde{\chi}^0_1) vs m(\tilde{\chi}^+_1) with labeled regions for 1σ and 2σ CL](image)

[GAMBIT, EPJC 79 (2019) no.5, 395]
Other SUSY models

EWMSSM

- Profile likelihoods for $m_{\tilde{\chi}_1^0, \pm}$
- Clear preference for light electroweakinos
- Fits mild excesses shown in ATLAS multi-lep analyses
- Best fit bino LSP $m_{\tilde{\chi}_1^0} \sim 50 \ (67) \ \text{GeV}$
- Local significance $3.3\sigma \ (2.9\sigma)$

[GAMBIT, EPJC 79 (2019) no.5, 395]
Other SUSY models

SU(5)

- Variation of NUHM2 $m_0 \rightarrow m_5, m_{10}$
  
  $$(q_L, u^c_L, e^c_L) \in 10, (l_L, d^c_L) \in \bar{5}$$

- New coann mechanisms: $\tilde{u}_R/\tilde{c}_R$ and $\tilde{\nu}_\tau$

- Compressed $\tilde{\chi} - \tilde{q}$ might evade detection

[MasterCode, EPJC 77 (2017) no.2, 104]
Other SUSY models

Sub-GUT

- $m_0$, $m_{1/2}$, $A_0$, $\tan \beta$, sign($\mu$), $M_{\text{in}} \in (10^3, 10^{16})$ GeV
- Best fit at $M_{\text{in}} \sim 10^8$ GeV
- Slight better fit the CMSSM, due to BR($B_{s,d} \rightarrow \mu^+\mu^-$)
- Preference for hybrid $A/H$-funnel and $\tilde{t}$ coann

[MasterCode, EPJC 78 (2018) no.2, 158]
Other SUSY models

**mAMSB**

- $m_0$, $m_{3/2}$, $\tan \beta$, $\text{sign}(\mu)$ [$A_i$, $M_i$ determined by anomalies]
- Different hierarchy of gauginos $M_2 < M_1 < M_3$
- $\tilde{\chi}^0$ is wino, Higgsino or mixed
- Heavy spectrum if DM is only $\tilde{\chi}^0$, lighter if part

[MasterCode, EPJC 77 (2017) no.4, 268]
Summary
Conclusions

- SUSY global fits are the way forward
  - Smart sampling of models with many parameters
  - Composite likelihoods with multitude of constraints
- Run 2 data and new DD detection push to heavy spectra
  - Compressed $\tilde{\chi}^0 - \tilde{\chi}^+$ or $\tilde{\chi}^0 - \tilde{t}$ might evade searches
  - LZ, XENON will probe $A/Z$-funnel and $\chi - \tilde{\chi}$ coann
- Weak-scale models allow more freedom
  - Other mechanisms of coann ($h/Z$, $\tilde{l}$, $\tilde{q}$)
  - Can fit $a_\mu$, strongly affects spectrum ($\tilde{\chi}$ composition, light $\tilde{l}$)
- Other models present different phenomenology
  - Light $\tilde{u}_R$, $\tilde{\nu}_\tau$ in SU(5)
  - Different hierarchy of gauginos in mAMSB
- Recasts of simplified model analyses can give surprising results, even hints of new physics
Thanks!

Supersymmetry will never die.
People who do SUSY will.
-Folklore
Backup
CMSSM

Profile likelihood ratio Λ = $L/L_{\text{max}}$

- $m_1/2$ (GeV)
- $m_0$ (GeV)
- $A_0$ (GeV)
- $\tan \beta$

Best fit

GAMBIT 1.0.0

T. Gonzalo (Monash U)
SUSY global fits
SUSY 19, 20/05/19
CMSSM

Best fit

Profile likelihood ratio $\Lambda = \frac{L}{L_{\text{max}}}$

$\mu > 0$

$\mu < 0$

T. Gonzalo (Monash U) SUSY global fits SUSY 19, 20/05/19 24 / 24
CMSSM

\[ \Omega h^2 = 0.119 \pm 0.028 \]

Profile likelihood ratio \( \Lambda = \frac{L}{L_{\text{max}}} \)

\[ \log_{10}(\Omega \chi h^2) \]

\[ 0 \quad 500 \quad 1000 \quad 1500 \quad 2000 \quad 2500 \]

\[ m_{\tilde{\chi}_0^0} (\text{GeV}) \]

\[ 0.2 \quad 0.4 \quad 0.6 \quad 0.8 \quad 1.0 \]

\[ \text{Fermi } \tau^+ \tau^- \quad \text{Fermi } \bar{b} \bar{b} \quad \text{Fermi } b \bar{b} \quad 15\text{y, 60 dwarfs} \quad \text{CTA Galactic Halo } b \bar{b} \quad 500h \]
CMSSM

-profile likelihood ratio $\Lambda = \frac{L}{L_{\text{max}}}$

-Log scale: $\log_{10}(f \cdot \sigma_{SI}^p / \text{cm}^2)$

-meson mass $m_{\tilde{\chi}_1^0}$ (GeV)

-Discovery limits from various experiments:
  - LUX 2016
  - XENON1T (2ty)
  - XENONnT/LZ (20ty)
  - DARWIN (200ty)

-Neutrino floor

-IC79 $b\bar{b}$, $\tau^+\tau^-$

-PICO-60 ($C_3F_8$)

-PICO-250L ($C_3F_8$)

-CMSSM Best fit

-log scale: $\log_{10}(f \cdot \sigma_{SI}^p / \text{cm}^2)$

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-PICO-250L ($C_3F_8$)
NUHM1

Profile likelihood ratio $\Lambda = \frac{L}{L_{\text{max}}}$

$m_H (\text{GeV})$

$m_{1/2} (\text{GeV})$

$A_0 (\text{GeV})$

$tan \beta$

---

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Profile likelihood ratio $\Lambda = \frac{L}{L_{\text{max}}}$

$m_0$ (GeV) vs. $m_{1/2}$ (GeV)

$m_0$ (GeV) vs. $m_{H_u}$ (GeV)

$m_{1/2}$ (GeV) vs. $m_{1/2}$ (GeV)

$m_{1/2}$ (GeV) vs. $m_{H_u}$ (GeV)
MSSM7

Profile likelihood ratio $\Lambda = L/L_{\text{max}}$

$A_{d_3}$ (GeV)

$\tan \beta$

$\mu$ (GeV)
MSSM7

Profile likelihood ratio $\Lambda = \frac{L}{L_{\text{max}}}$

$\Omega h^2 = 0.119$

$\log_{10}(\Omega \chi^0 h^2)$

$0, 1000, 2000, 3000$ GeV

$\tilde{\chi}_0^0$ (GeV)

CTA Galactic Halo $b\bar{b}$ 500h
MSSM7

Profile likelihood ratio $\Lambda = L/L_{\text{max}}$

$\log_{10}(f \cdot \sigma_{SI} / \text{cm}^2)$

$\log_{10}(f \cdot \sigma_{SD} / \text{cm}^2)$

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pMSSM11

\[ \tilde{\chi}_1^{\pm} \text{ coann.} \quad \text{slep coann.} \quad \text{gluino coann.} \quad \text{stop coann.} \]

\[ \text{A/H funnel} \quad \text{stau coann.} \quad \text{squark coann.} \quad \text{sbot coann.} \]
pMSSM11
### EW MSSM

#### MSSM field content

<table>
<thead>
<tr>
<th>Name</th>
<th>Spin</th>
<th>Gauge ES</th>
<th>Mass ES</th>
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<td>Higgs bosons</td>
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<td>$H_u^0$ $H_d^0$ $H_u^+$ $H_d^-$</td>
<td>$h$ $H$ $A$ $H^\pm$</td>
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<td>sleptons</td>
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<tr>
<td>neutralino</td>
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<td>$\tilde{B}$ $\tilde{W}^3$ $\tilde{H}_u^0$ $\tilde{H}_d^0$</td>
<td>$\tilde{\chi}_1^0$ $\tilde{\chi}_2^0$ $\tilde{\chi}_3^0$ $\tilde{\chi}_4^0$</td>
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<td>chargino</td>
<td>1/2</td>
<td>$\tilde{W}^\pm$ $\tilde{H}_u^+$ $\tilde{H}_d^-$</td>
<td>$\tilde{\chi}_1^\pm$ $\tilde{\chi}_2^\pm$</td>
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<tr>
<td>gluino</td>
<td>1/2</td>
<td>$\tilde{g}$</td>
<td>-</td>
</tr>
</tbody>
</table>
EW MSSM

Parameters

- 4-D parameter space \((m_{H_d}^2, m_{H_u}^2 \rightarrow \mu, m_A)\)

\[
m_h \rightarrow 125 \text{ GeV}
\]

\[
M_3, m_A \rightarrow 5 \text{ TeV} \quad \{M_1, M_2, \mu, \tan \beta\}
\]

\[
m_{\tilde{t}}, m_{\tilde{q}} \rightarrow 3 \text{ TeV}
\]

\[
A_u, A_d, A_e \rightarrow 0
\]

- Parameter ranges

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Priors</th>
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<tbody>
<tr>
<td>(M_1(Q))</td>
<td>[-2 TeV, 2 TeV]</td>
<td>hybrid, flat</td>
</tr>
<tr>
<td>(M_2(Q))</td>
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<tr>
<td>(\mu(Q))</td>
<td>[-2 TeV, 2 TeV]</td>
<td>hybrid, flat</td>
</tr>
<tr>
<td>(\tan \beta(m_Z))</td>
<td>[0, 70]</td>
<td>flat</td>
</tr>
</tbody>
</table>
**Likelihoods**

- **Invisible decays** \( \Gamma(Z \to \text{inv.}) = 499.0 \pm 1.5\) MeV \( \text{BF}(h \to \text{inv.}) \leq 0.19 \)

- **LEP limits**

- **LHC searches**

<table>
<thead>
<tr>
<th>Likelihood label</th>
<th>Source</th>
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<tbody>
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<td>ATLAS_4b</td>
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<td>ATLAS_4lep</td>
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<td>ATLAS_MultiLep_2lep_0jet</td>
<td>ATLAS multilepton EW search</td>
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<tr>
<td>ATLAS_MultiLep_2lep_jet</td>
<td>ATLAS multilepton EW search</td>
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<tr>
<td>ATLAS_MultiLep_3lep</td>
<td>ATLAS multilepton EW search</td>
</tr>
<tr>
<td>ATLAS_RJ_2lep_2jet</td>
<td>ATLAS recursive jigsaw EW search</td>
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<tr>
<td>ATLAS_RJ_3lep</td>
<td>ATLAS recursive jigsaw EW search</td>
</tr>
<tr>
<td>CMS_1lep_2b</td>
<td>CMS (Wh) search</td>
</tr>
<tr>
<td>CMS_2lep_soft</td>
<td>CMS 2 soft opposite-charge lepton search</td>
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<tr>
<td>CMS_2OSlep</td>
<td>CMS 2 opposite-charge lepton search</td>
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<tr>
<td>CMS_MultiLep_2SSlep</td>
<td>CMS multilepton EW search</td>
</tr>
<tr>
<td>CMS_MultiLep_3lep</td>
<td>CMS multilepton EW search</td>
</tr>
</tbody>
</table>
Scan strategy

- **First scans**
  - Differential evolution scanner (Diver) on jDE mode
  - Flat & hybrid (log-flat-log) priors
  - Targeted scans for $M_2 < 500$ GeV and $\mu < 500$ GeV
  - Simulated 100k/500k Pythia events per parameter point
  - Samples contain $\sim 2.4$M valid points

- **Sampling issues**
  - Large MC uncertainty
  - Signal region flip-flop

- **Postprocessing**
  - More Pythia events
    - $2\sigma/3\sigma \geq 4$M events
    - $1\sigma \geq 16$M events
    - best 500 points $\geq 4$M events
  - $\sim 240$k valid samples
Results
Conclusions

- No clear exclusion for light electroweakinos
  - Careful with simplified models
- Favoured by several analyses
  - ATLAS 4\ell,
  - ATLAS RJ 3\ell,
  - ATLAS multi-\ell (2\ell, 3\ell)
- Minor excess
  - \( m_{\tilde{\chi}_1^0} \sim 50 \text{ GeV} \)
  - Local significance 3.5\sigma
- Might be a hint of new physics
Analysis: results

- Contribution from each analysis to the 1σ, 2σ and 3σ best-fit regions:
  \[ \ln \mathcal{L}(s + b) - \ln \mathcal{L}(b) \]

- **Blue:** better than background-only
  **Red:** worse than background-only

- Most important contributions to best-fit region:
  - ATLAS_4lep
  - ATLAS_RJ_3lep
  - ATLAS_MultiLep_2lep_jet
  - ATLAS_MultiLep_3lep
  - CMS_MultiLep_3lep
Analysis: results

- More detailed look on
  - ATLAS_4lept
  - ATLAS_RJ_3lept
  - ATLAS_MultiLep_2lept_jet
  - ATLAS_MultiLep_3lept

- Sudden changes in likelihood due to changes in most sensitive SR

- Light $\tilde{\chi}_3^0$ preferred by ATLAS_4lept and ATLAS_MultiLep_3Lep

- Heavy $\tilde{\chi}_4^0$ disfavoured by ATLAS_MultiLep_2lept_jet and ATLAS_MultiLep_3Lep

- The «expected» tension between ATLAS_MultiLep_3Lep and ATLAS_RJ_3lept observed for heavy $\tilde{\chi}_4^0$ (production of higgsino $\tilde{\chi}_2^0, \tilde{\chi}_3^0, \tilde{\chi}_1^\pm$)
**Results**

Lots of processes relevant for the best-fit point:

- $\tilde{\chi}_2^0 \tilde{\chi}_3^0$ production, with e.g.
  $\tilde{\chi}_2^0 \rightarrow Z + \tilde{\chi}_1^0$, $\tilde{\chi}_3^0 \rightarrow W^- + \tilde{\chi}_1^+ \rightarrow W^- + W^+ + \tilde{\chi}_1^0$

- $\tilde{\chi}_2^\pm \tilde{\chi}_2^\mp$ production, with e.g.
  $\tilde{\chi}_2^\pm \rightarrow W^\pm + \tilde{\chi}_2^0 \rightarrow W^\pm + Z + \tilde{\chi}_1^0$

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  $\tilde{\chi}_2^\pm \rightarrow W^\pm + \tilde{\chi}_1^0$, $\tilde{\chi}_3^0 \rightarrow Z + \tilde{\chi}_2^0 \rightarrow Z + Z + \tilde{\chi}_1^0$

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  $\tilde{\chi}_2^\pm \rightarrow W^\pm + \tilde{\chi}_2^0 \rightarrow W^\pm + Z + \tilde{\chi}_1^0$, $\tilde{\chi}_3^0 \rightarrow W^- + \tilde{\chi}_1^+ \rightarrow W^- + W^+ + \tilde{\chi}_1^0$

- $\tilde{\chi}_2^\pm \tilde{\chi}_4^0$ production, with e.g.
  $\tilde{\chi}_2^\pm \rightarrow W^\pm + \tilde{\chi}_2^0 \rightarrow W^\pm + Z + \tilde{\chi}_1^0$, $\tilde{\chi}_4^0 \rightarrow Z + \tilde{\chi}_1^0$

- $\tilde{\chi}_2^0 \tilde{\chi}_2^0$ production, with e.g.
  $\tilde{\chi}_2^\pm \rightarrow h + \tilde{\chi}_1^\pm \rightarrow h + W^\pm + \tilde{\chi}_1^0$, $\tilde{\chi}_2^0 \rightarrow Z + \tilde{\chi}_1^0$

- $\tilde{\chi}_2^\pm \tilde{\chi}_3^0$ production, with e.g.
  $\tilde{\chi}_2^\pm \rightarrow W^\pm + \tilde{\chi}_2^0 \rightarrow W^- + \tilde{\chi}_1^+ \rightarrow W^+ + W^- + \tilde{\chi}_1^0$

- $\tilde{\chi}_2^\pm \tilde{\chi}_4^0$ production, with e.g.
  $\tilde{\chi}_2^\pm \rightarrow Z + \tilde{\chi}_1^\pm \rightarrow Z + W^\pm + \tilde{\chi}_1^0$, $\tilde{\chi}_4^0 \rightarrow h + \tilde{\chi}_2^\pm \rightarrow h + Z + \tilde{\chi}_1^0$

...