Dark matter & the pMSSM

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pMSSM scan overview

- Most SUSY searches are optimized in terms of simplified models, but the full MSSM contains 120 free parameters
- Explore future sensitivity in a framework that goes **beyond simplified SUSY models**
  - The pMSSM uses motivated assumptions to reduce the total number of parameters to a more tenable **19 parameters**
- Sample the 19D parameter space using a **Markov chain Monte Carlo** (details in yesterday's talk)
  - **McMC Likelihood** steers the scan into regions of parameter space that are favored by existing measurements
  - **Logarithmic stepping** ensures that lower masses are explored with finer granularity than higher masses

Parameter ranges

- We perform a **grand scan** that aims to cover the accessible ranges of many collider scenarios

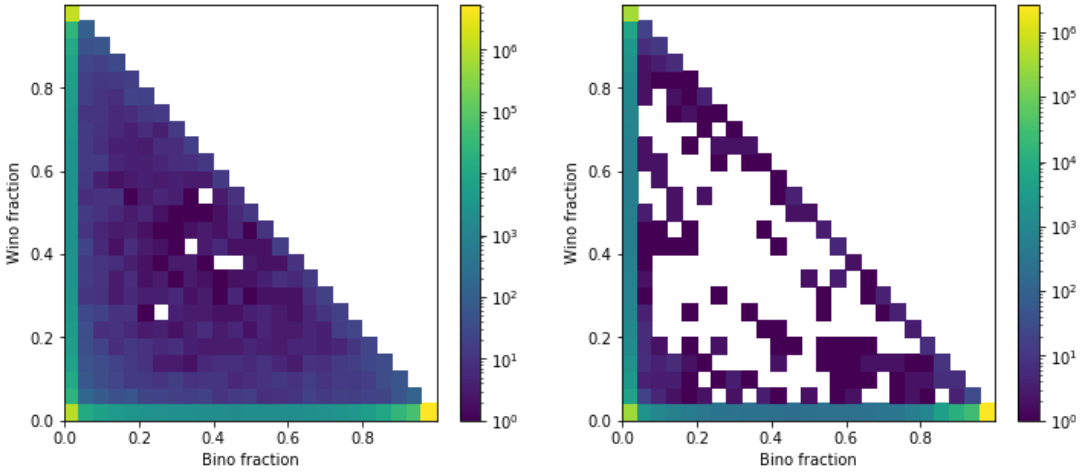
Param.	Definition	Range
M_A	mass of psuedoscalar Higgs boson	100 GeV - 25 TeV
$\tan\beta$	ratio of Higgs vevs	1 - 60
$\lvert\mu\rvert$	Higgs-higgsino mass parameter	80 GeV - 25 TeV
$\lvert M_1\rvert$	bino mass parameter	1 GeV - 25 TeV
$\lvert M_2\rvert$	wino mass parameter	70 GeV - 25 TeV
M_3	gluino mass parameter	200 GeV - 50 TeV
$m_{\tilde{L}^{1,2}}$	$1^{\text{st}}/2^{\text{nd}}$ gen. left-handed slepton mass	90 GeV - 25 TeV
$m_{\tilde{R}^{1,2}}$	$1^{\text{st}}/2^{\text{nd}}$ gen. right-handed slepton mass	90 GeV - 25 TeV
$m_{\tilde{L}^3}$	3^{rd} gen. left-handed slepton mass	90 GeV - 25 TeV
$m_{\tilde{R}^3}$	3^{rd} gen. right-handed slepton mass	90 GeV - 25 TeV
$m_{\tilde{q}^{1,2}}$	$1^{\text{st}}/2^{\text{nd}}$ gen. left-handed squark mass	200 GeV - 50 TeV
$m_{\tilde{u}^{1,2}}$	$1^{\text{st}}/2^{\text{nd}}$ gen. right-handed u-type squark mass	200 GeV - 50 TeV
$m_{\tilde{d}^{1,2}}$	$1^{\text{st}}/2^{\text{nd}}$ gen. right-handed d-type squark mass	200 GeV - 50 TeV
$m_{\tilde{q}^3}$	3^{rd} gen. left-handed squark mass	100 GeV - 50 TeV
$m_{\tilde{u}^3}$	stop quark mass	100 GeV - 50 TeV
$m_{\tilde{d}^3}$	sbottom quark mass	100 GeV - 50 TeV
$\lvert A_\tau\rvert$	τ trilinear coupling	1 GeV - 7 TeV
$\lvert A_b\rvert$	bottom trilinear coupling	1 GeV - 7 TeV
$\lvert A_t\rvert$	top trilinear coupling	1 GeV - $3(m_{\tilde{q}^3} m_{\tilde{u}^3})^{1/2}$

Maxima chosen to cover points accessible at ~100 pp TeV collider

Electroweakino composition of LSP

- Most sampled points have ~pure in EWino composition
  - Mostly : > 80%, Mixed: > 40%/40%

	McMC accepted	Post-process accepted
Mostly wino	488,346	126,376
Mostly bino	1,902,877	930,519
Mostly higgsino	411,475	106,183
Mixed wino/bino	37	6
Mixed bino/higgsino	6,578	991
Mixed wino/higgsino	3,477	341
Other	27,350	3,519



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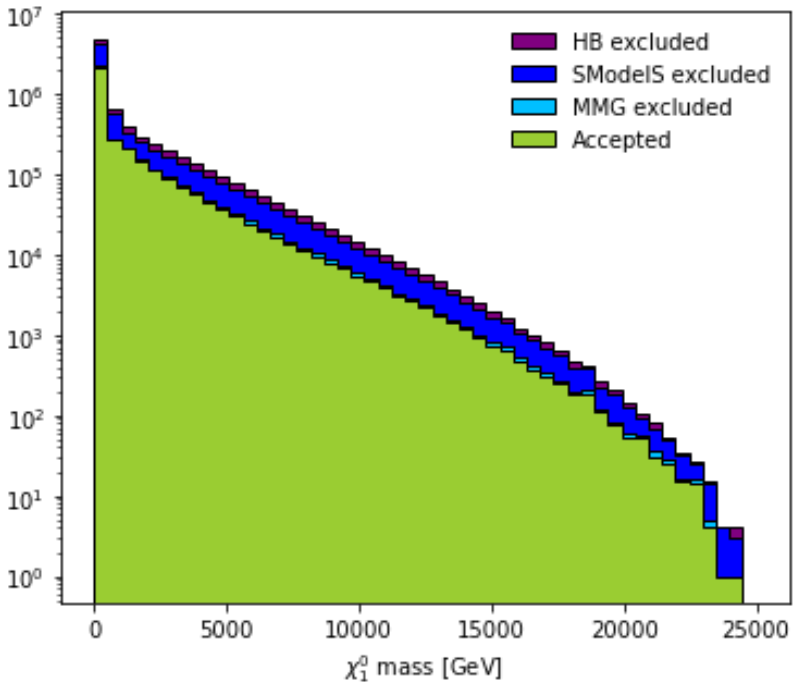
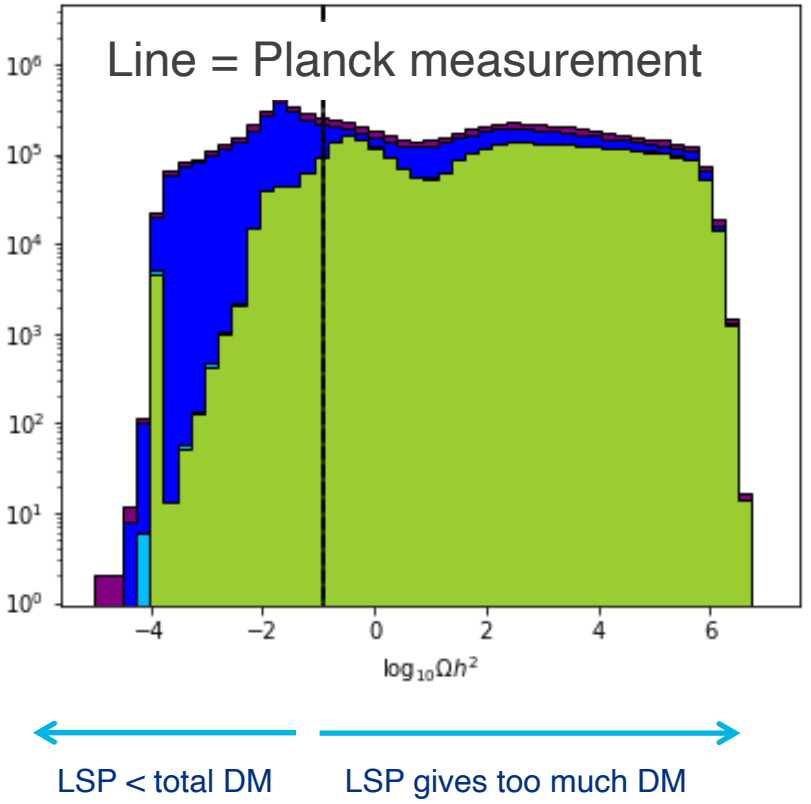
Beyond the McMC: further excluded points

- **Purple**: excluded at 95% CL by HiggsBounds (HB)
  - LHC Higgs searches (Run 1 and 2)
- **Royal blue**: allowed by HB, excluded at 95% CL by SModelS
  - LHC SUSY searches (Run 1 and 2)
- **Sky blue**: allowed by HB and SModelS, excluded at 95% by MicrOMEGAs
  - Including Z → invisible, LEP DM searches, DM mass limits, direct detection experiments
- **Green**: passing all selection

DM mass, relic density

- LHC searches exclude points with low relic density
  - Mostly corresponds to wino-like DM





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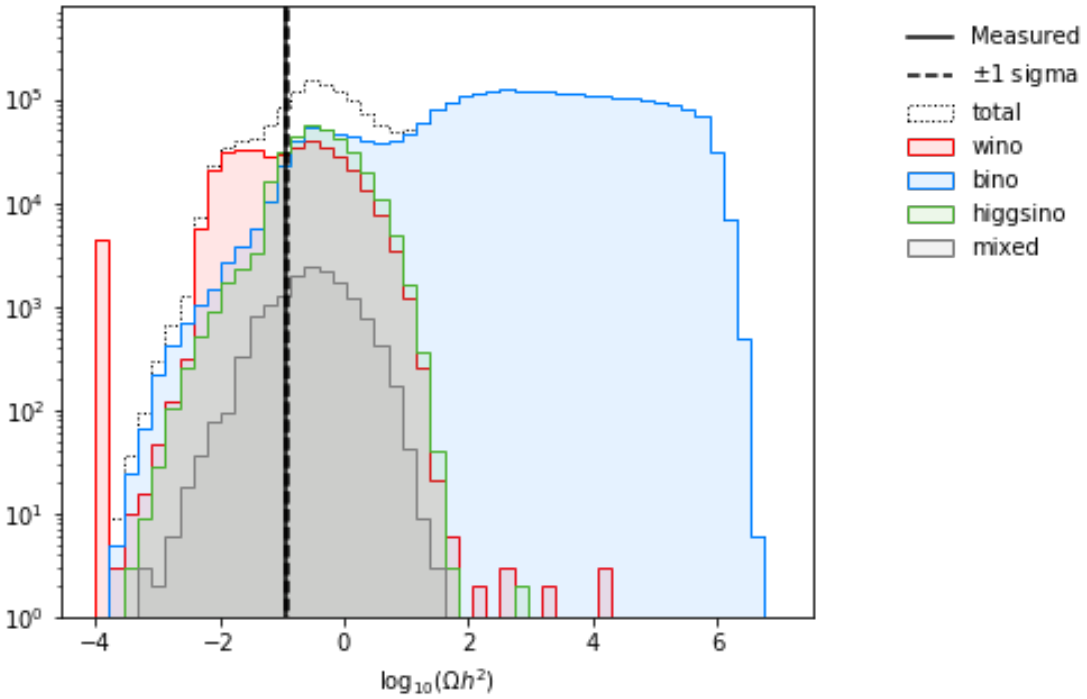
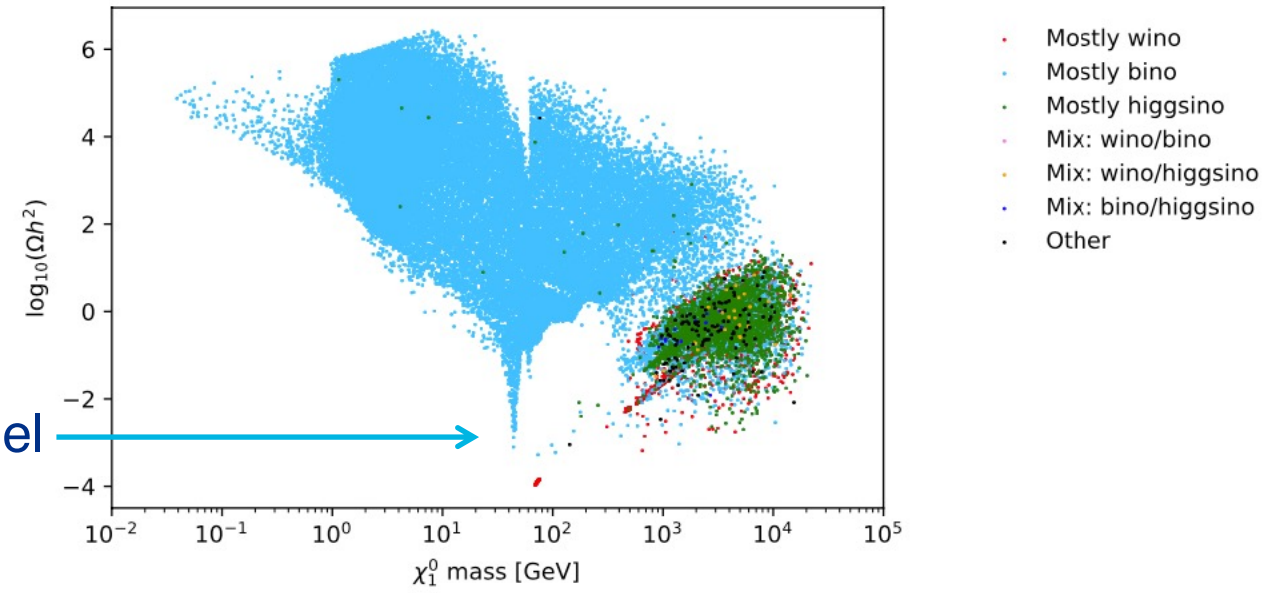
DM relic density per EWino state

- Wino-like LSP tends to have lower relic density, bino-like tends to have high
- Higgsino-like, mixed in the middle



LSP mass vs relic density

- Bino-like DM allowed to have light mass (artifact of ranges)
  - Too high relic density: requires co-annihilation
- Other EWino states ~roughly~ in agreement with measured relic density of 0.120 (±0.001)

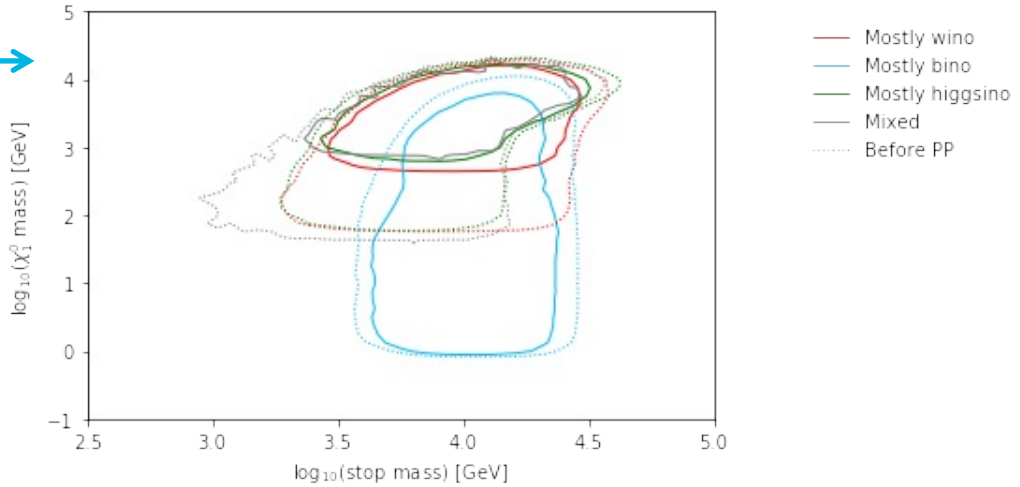


LSP mass vs. stop mass

- For bino-like DM, stop mass tends to be a bit heavier

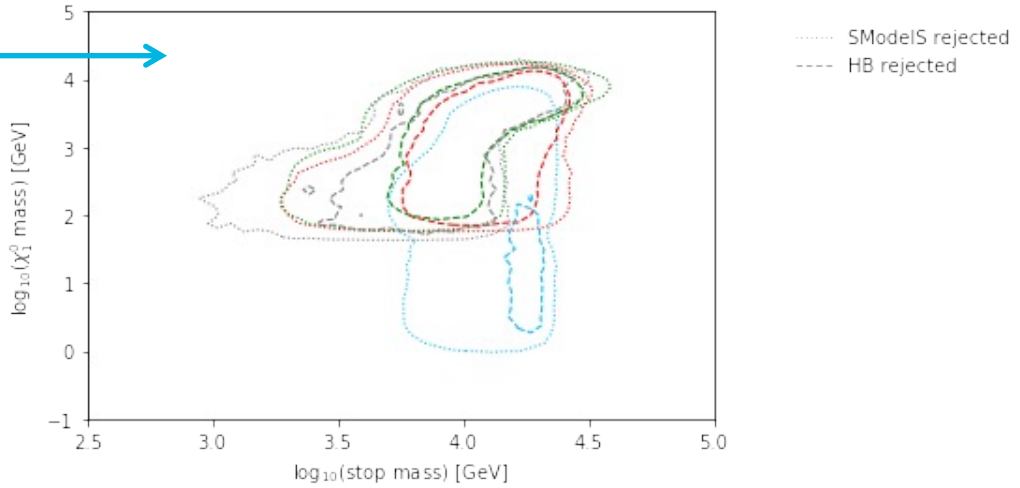
Preferred region →

Contours represent
0.1% of scanned points



Impact of PP selection →

LHC searches reject
low stop masses



Summary

- Performed some simple studies of EWino dark matter using the pMSSM grand scan
  - Want to check how your favorite future experiment performs? The scanned points are available on snowmass-connect
- Event generation for $\mu\mu$ collisions is underway for selected points!