SUSY scenarios we're not looking for* but should be

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Disclaimer

Many important “loopholes” are covered in existing or planned searches

- RPV
- Reduced MET

  compressed spectra, “stealth” SUSY,...
- Long decay chains
- NLSP → gravitino + X

  ⋮

This talk will discuss a few areas that may benefit from more attention

A personal selection, no attempt at completeness

The Big Picture

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125 GeV Higgs

SM-like couplings

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Simplicity vs. Naturalness

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Naturalness = no tuning of parameters

Simplicity = minimality of structure & assumptions

An Unnatural Story

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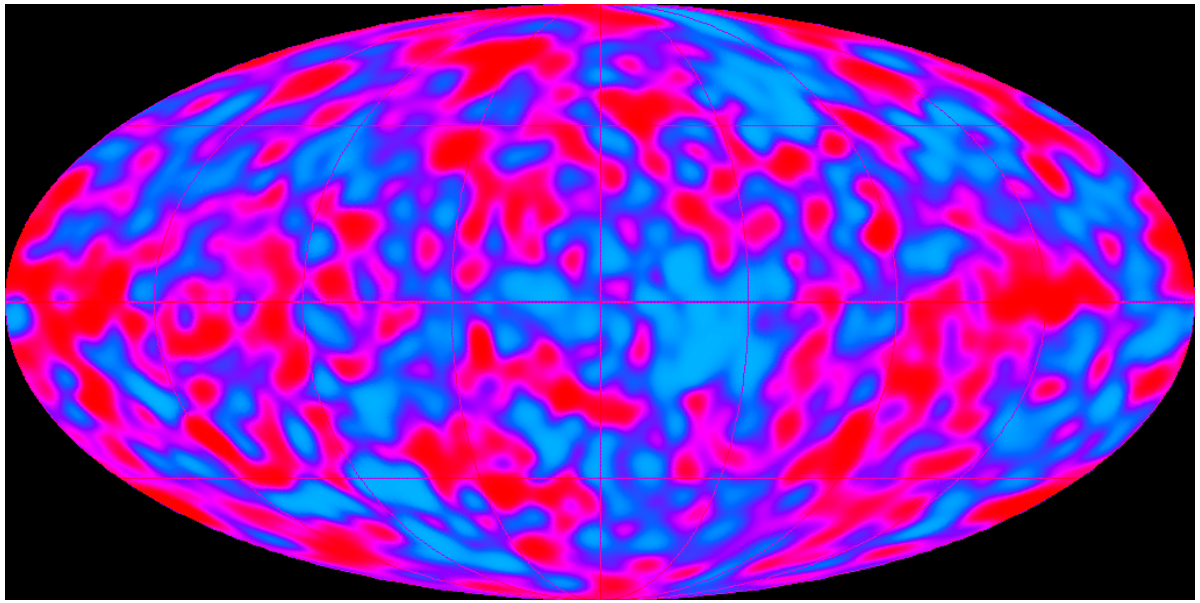

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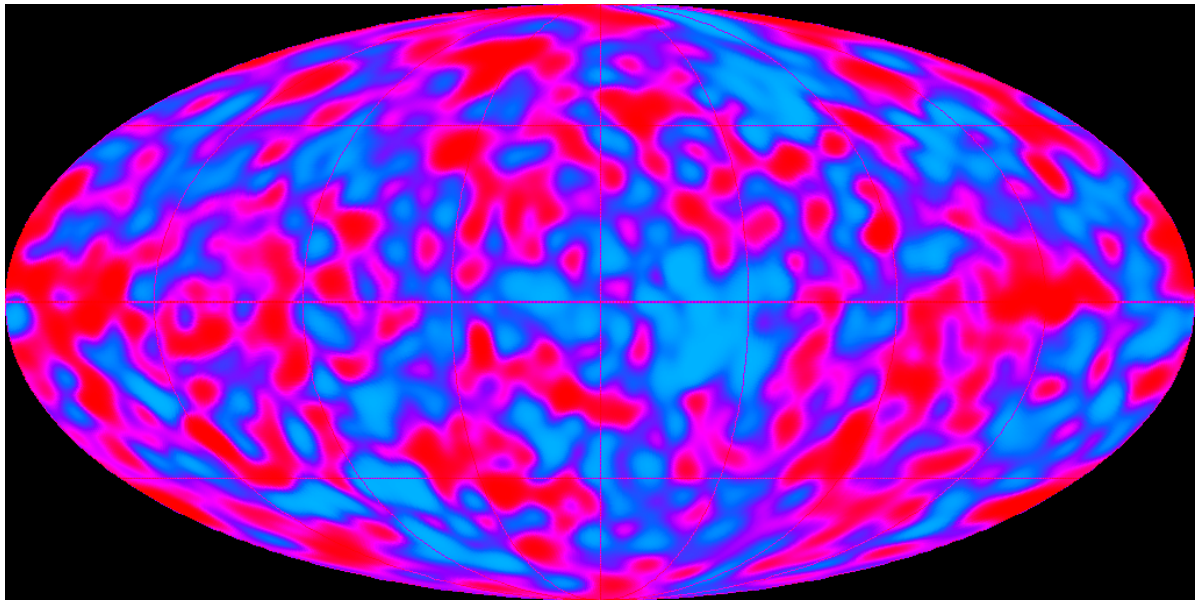
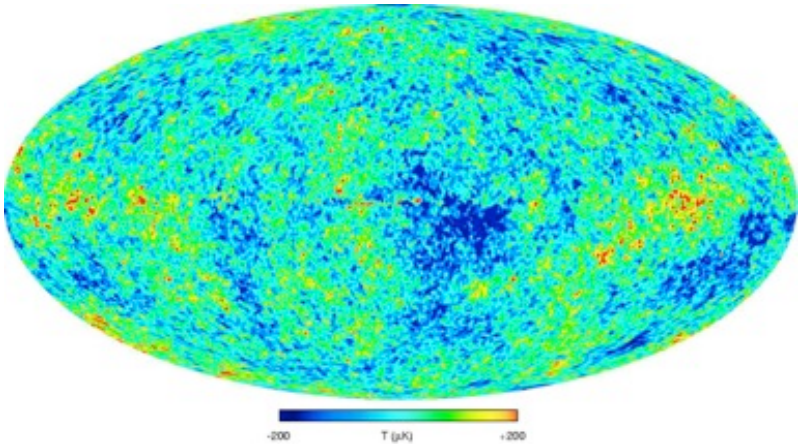
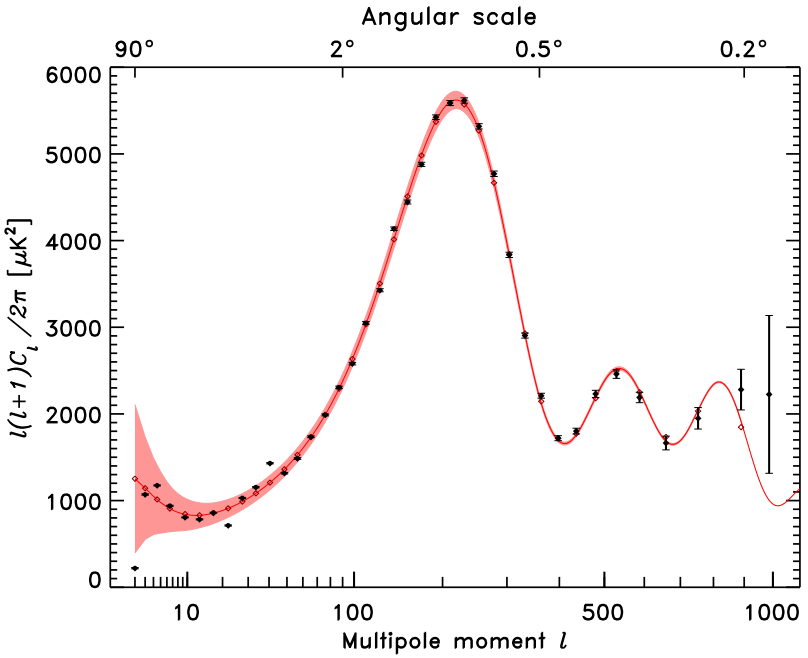


So what about the quadrupole?

Tuning!


-200
T (μK)
+200


Angular scale
90°
2°
0.5°
0.2°
6000
5000
4000
3000
2000
1000
0
$l(l+1)C_l/2\pi$ [μK^2]
10
100
500
1000
Multipole moment l

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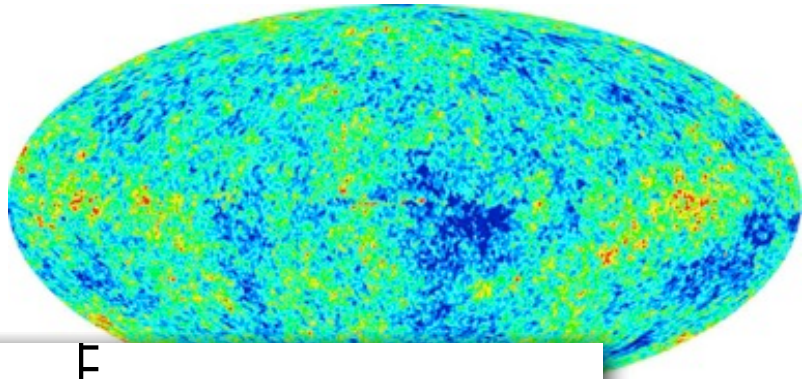

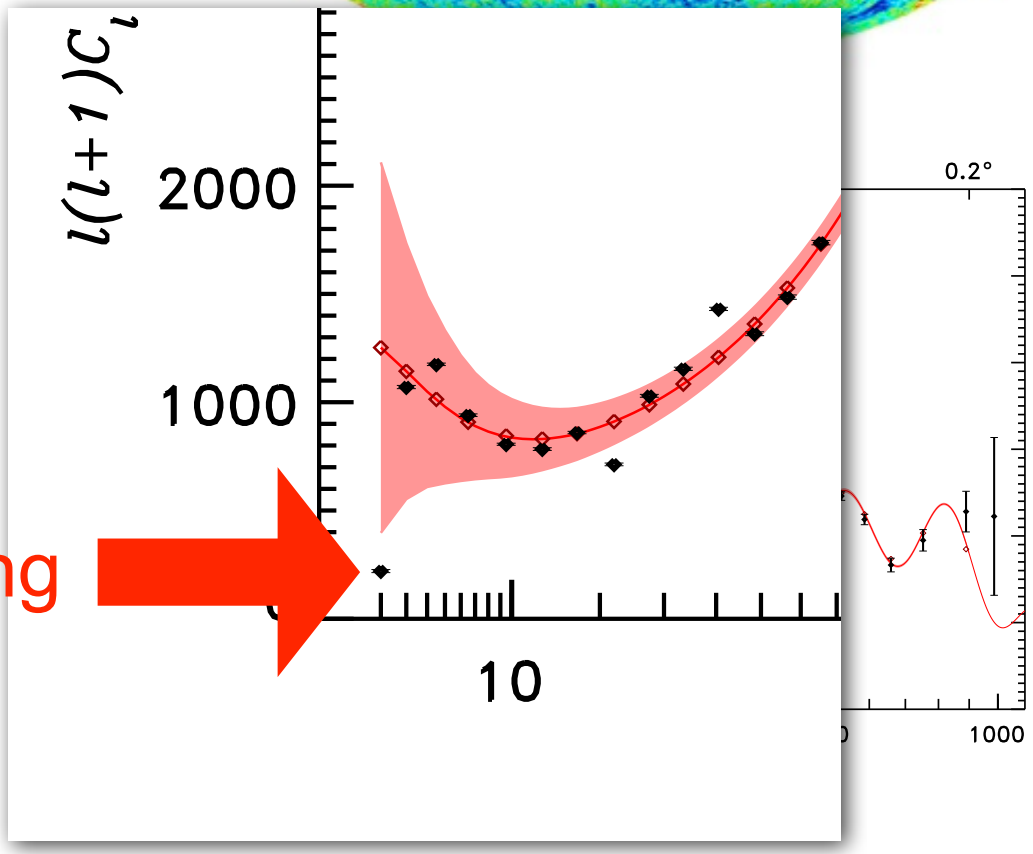

1% tuning

Outline

- Tuned SUSY
- Natural SUSY

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  - BMSSM Higgs
  - Displaced vertices

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    - R-parity violation
    - Hidden sector dark matter

Tuned SUSY

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MSSM with one tuning is arguably the <u>simplest</u> explanation of particle physics data

Implications:

- SUSY most likely "just around the corner"
- Keep looking for standard SUSY signals

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Requirements:

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$$m_{\tilde{t}} \lesssim 500 \text{ GeV} \longleftrightarrow$$
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EWino searches,
stop, sbottom searches

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But also: Higgs sector beyond MSSM

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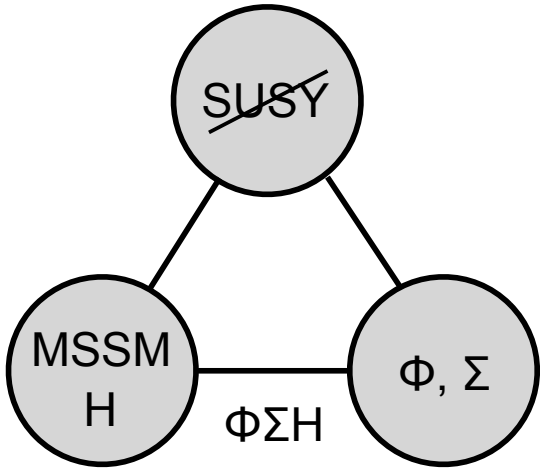

"auxilliary" Higgs sector

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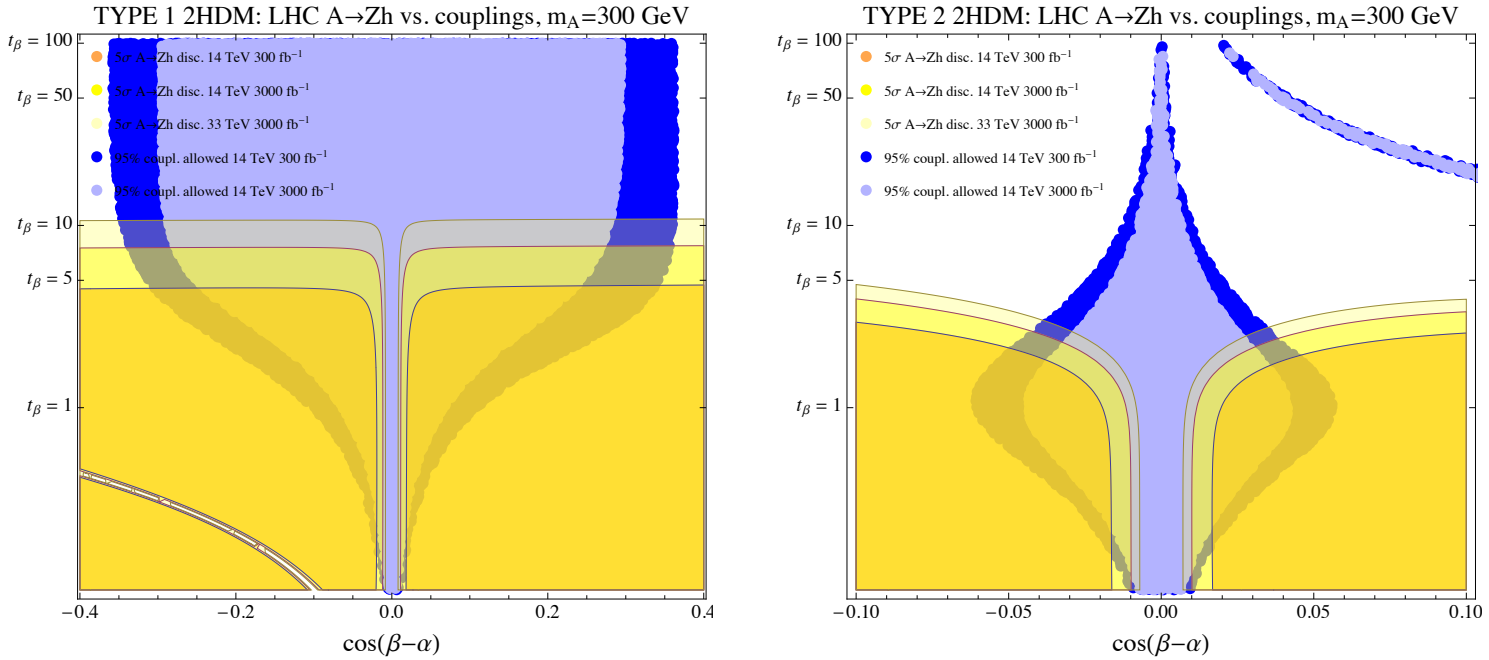
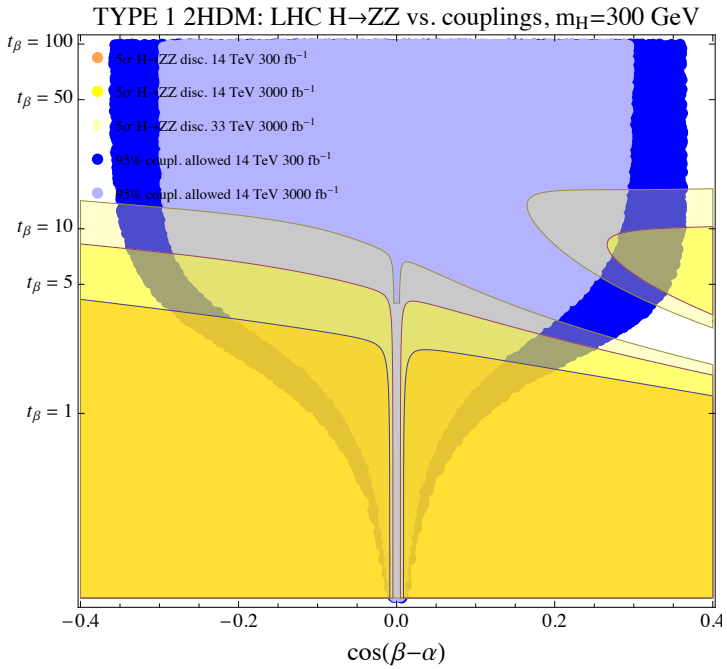
Example: A → Zh → (ll)(bb) or (ττ)

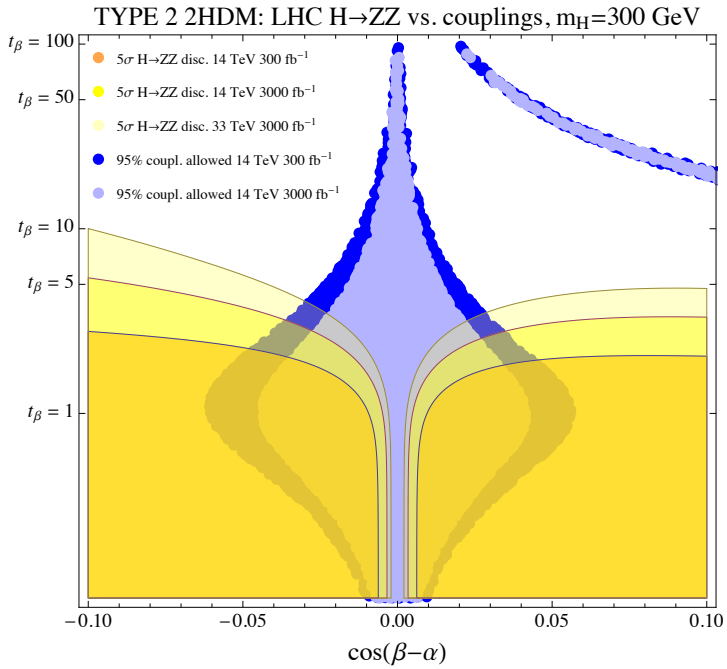


Brownson, Kukartsev, Narain, Heintz, Stupak, Craig Snowmass 2013

BMSSM Higgs Signals

Also: H → ZZ → (ll)(ll)





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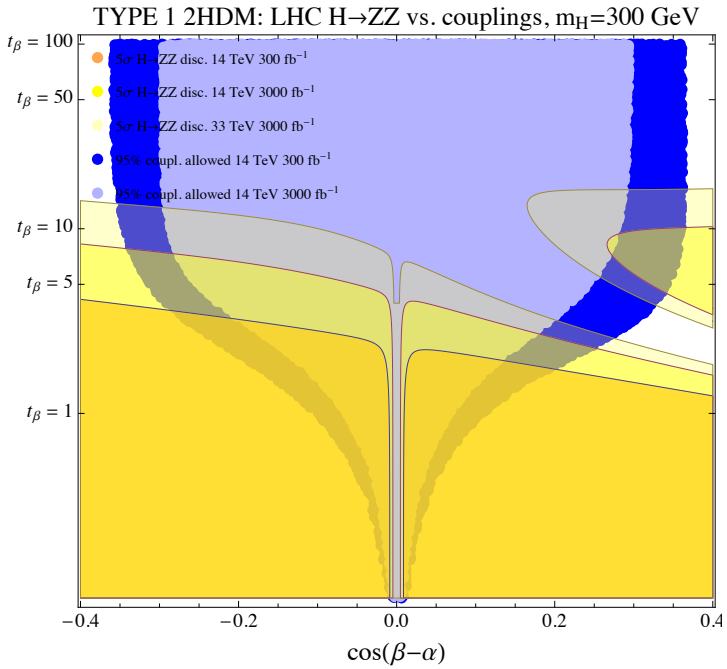

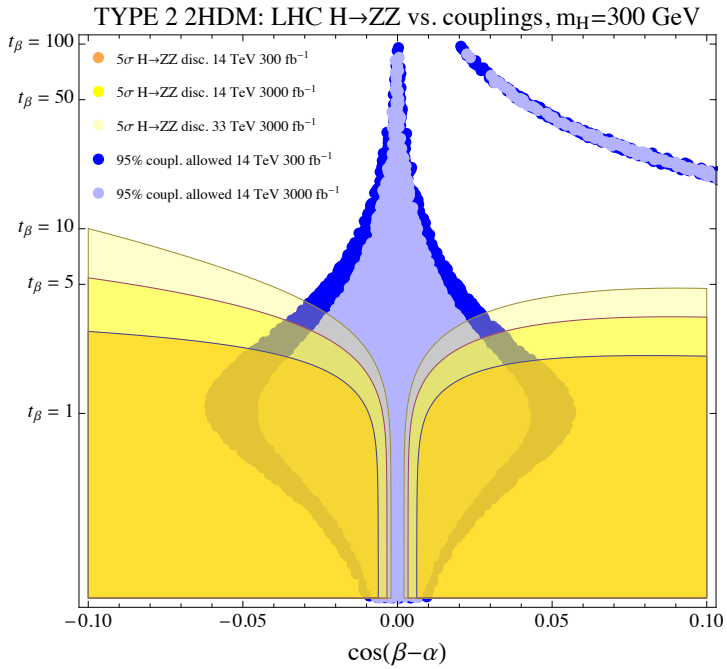

Other examples deserving further study:

H/A → tt, bb, ττ H → hh

H → A Z → ZZh

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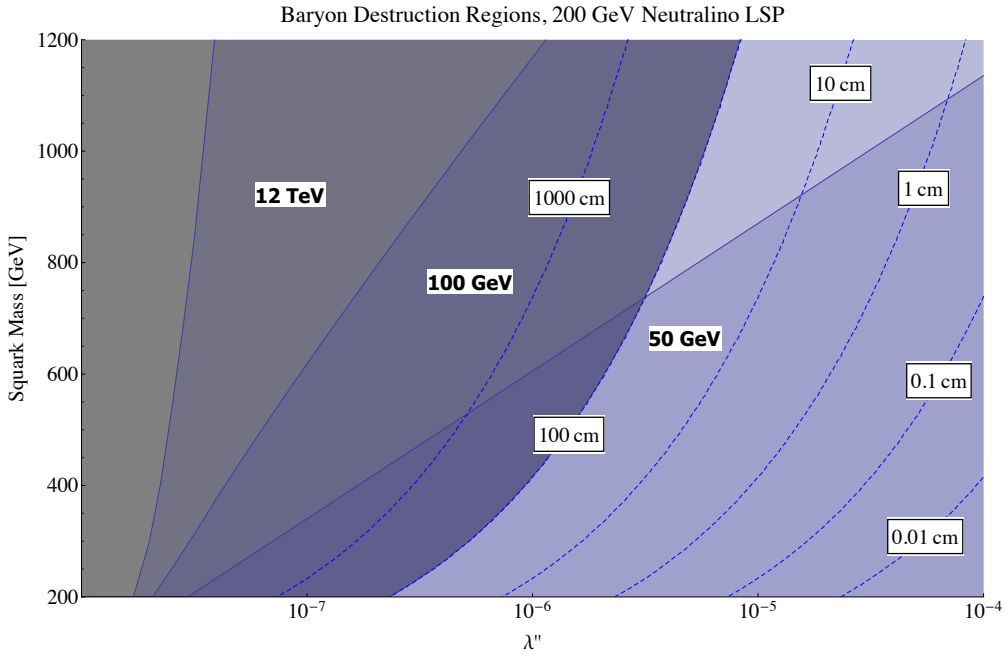
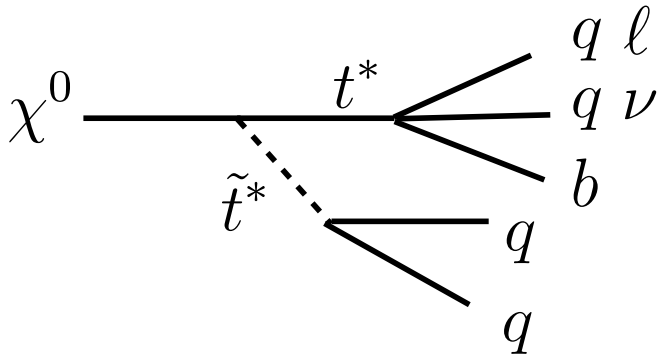
UDD destroys baryon asymmetry in early universe

⇒ requires low scale baryogenesis



Displaced RPV

NLSP = neutralino



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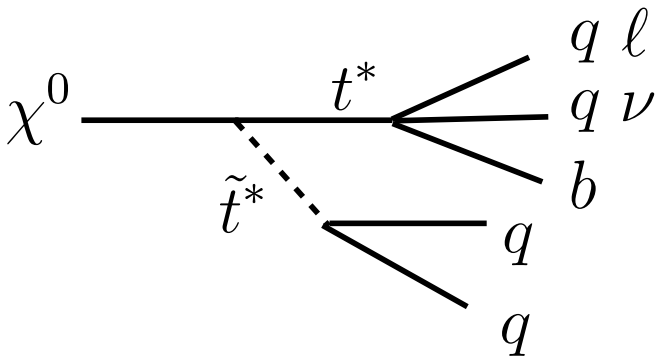
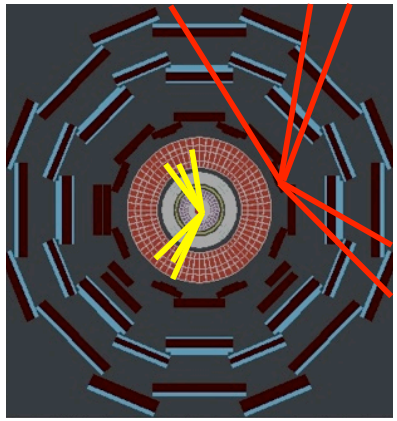


$\Rightarrow$ displaced vertex



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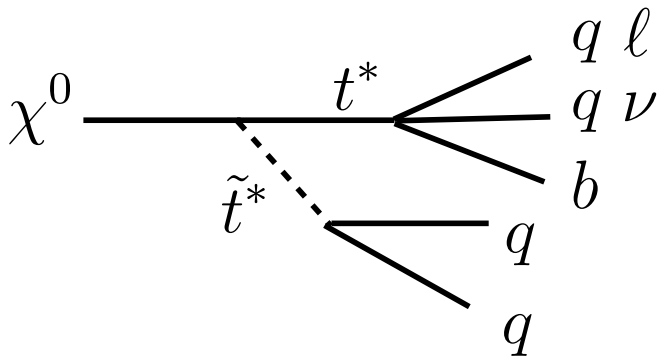

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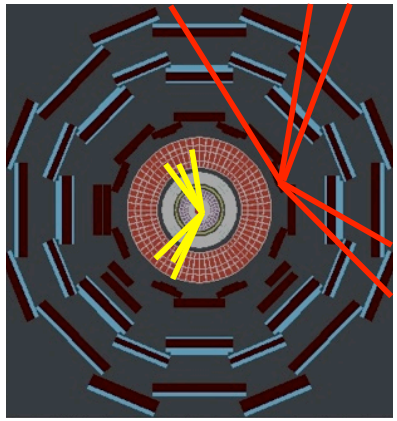

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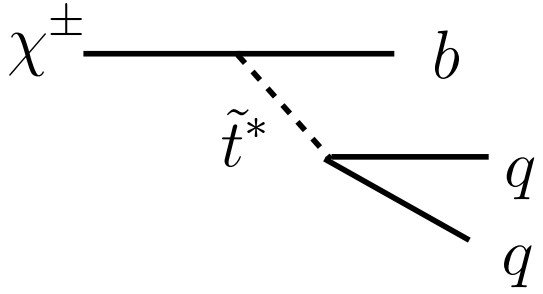

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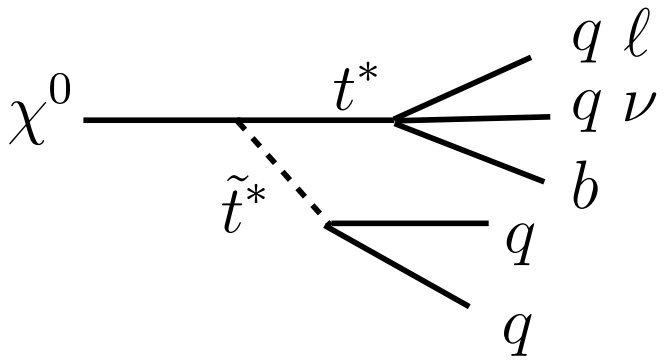

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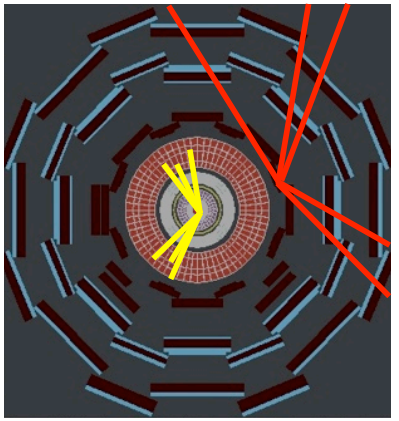

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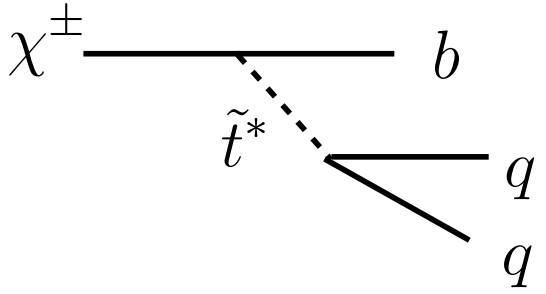
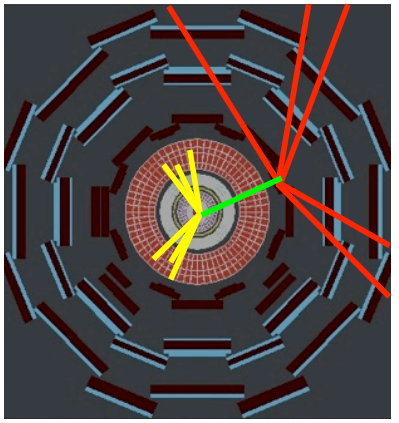


$\Rightarrow$ exploding track



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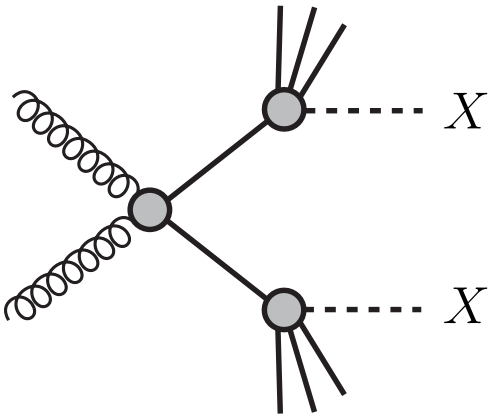
SUSY WIMP:



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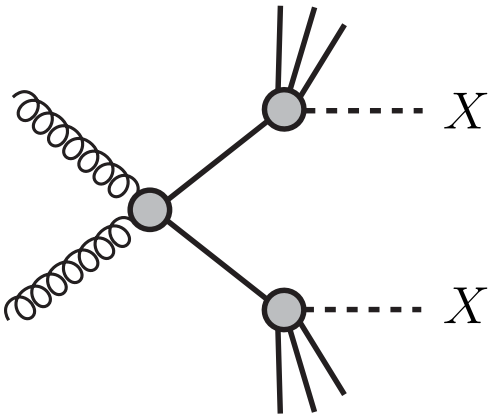

In the absence of signals in direct detection and collider searches, look at plausible mechanisms beyond WIMPs

$\Rightarrow$ new signals?

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LOSP dominates universe, then decays

$$\Omega_X = \frac{m_X}{m_{\rm LOSP}}\Omega_{\rm LOSP}$$

X = gravitino or ...

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(Hall, Jedamzik, March-Russell, West 2009)

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$m_X \gtrsim {\rm keV}$ (structure formation)

⇒ motivates highly displaced decays

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(Kaplan, ML, Zurek 2009)

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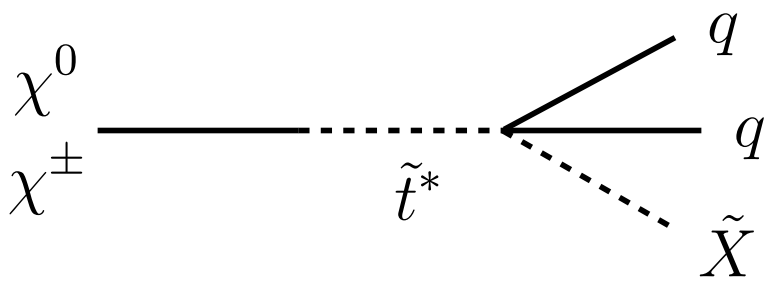
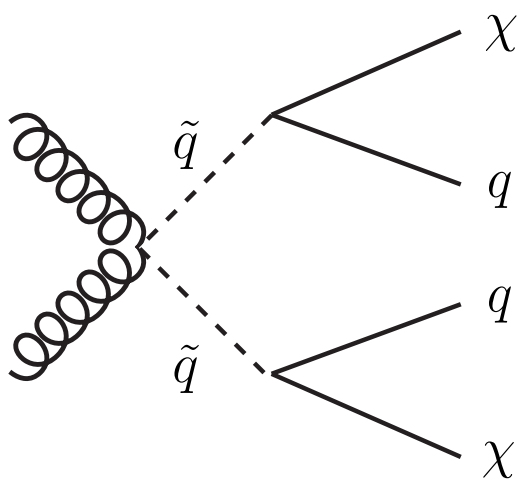
Decay:

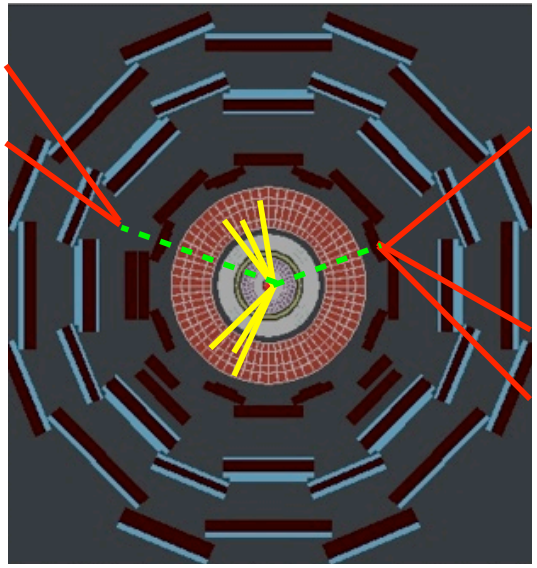


$$c\tau \sim \mathrm{cm} \left(\frac{M}{\mathrm{TeV}}\right)^4 \left(\frac{m_{\tilde{t}}}{500\ \mathrm{GeV}}\right)^4 \left(\frac{m_\chi}{100\ \mathrm{GeV}}\right)^{-9}$$

Displaced Optimism

Displaced vertices open the possibility of fully reconstructing SUSY events





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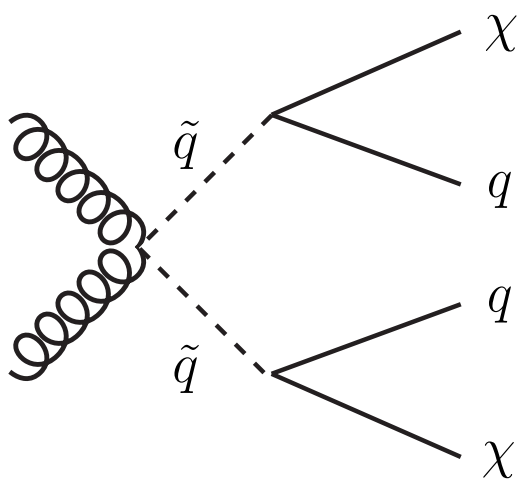

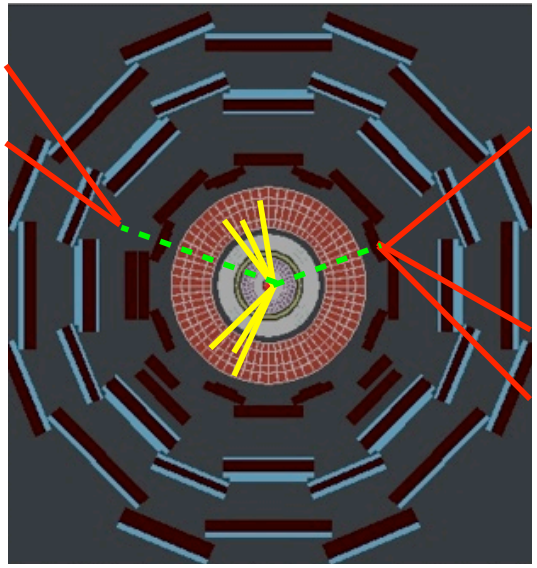

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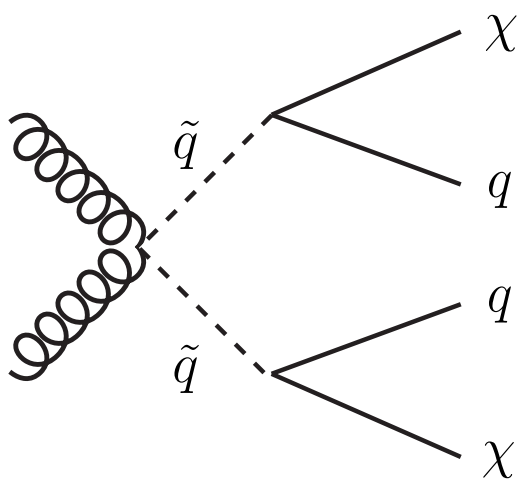
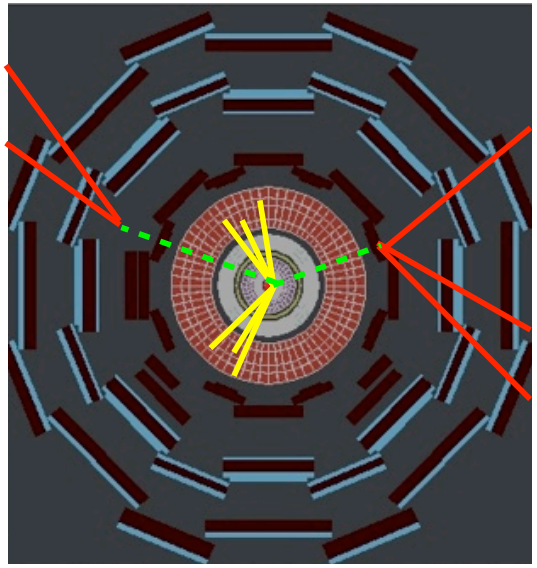


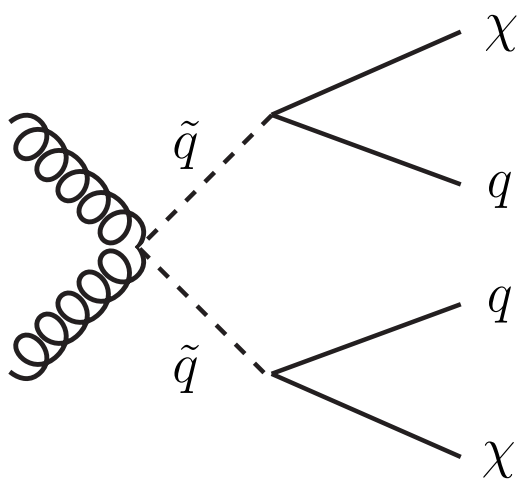


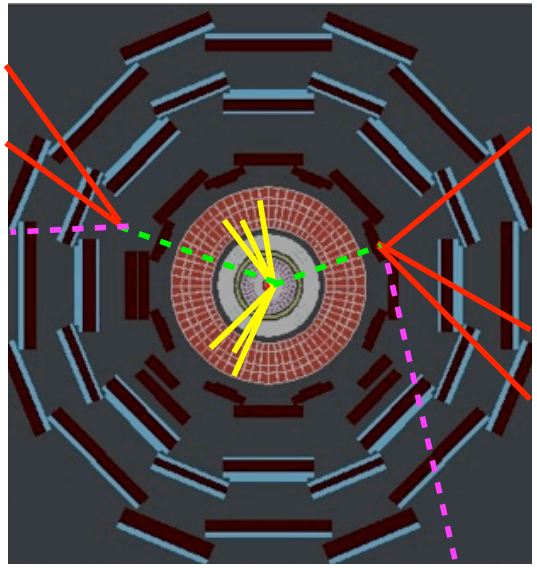
LOSP = charged: SUSY fully reconstructed

LOSP = neutral: $\vec{v}_{\mathrm{LOSP}}$ from vertex position + timing

Displaced Optimism

Displaced vertices open the possibility of fully reconstructing SUSY events





LOSP = charged: SUSY fully reconstructed

LOSP = neutral: $\vec{v}_{\mathrm{LOSP}}$ from vertex position + timing

Constraining/measuring dark matter mass possible

Conclusions

- Impressive breadth and depth of SUSY searches

- Both tuned and natural versions of SUSY are still plausible and important to test

- BMSSM Higgs and displaced vertices are important