mSUSY

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No observation of SUSY thus far.

If none after the upgrade, what next (if anything) for SUSY research?

A partial cancellation of quadratic sensitivity is better than nothing. SUSY may still live at a higher scale.

What is the scale?

Necessarily imprecise business. Few "theorems."

Much discussion already. Arguments exist for a variety of scales.

10 TeV 100 TeV >1000 TeV

Better understanding informs:
-interpretation of results from future experiments
-decisions about what experiments to build

10 TeV

fine-tuning ~ part in 10^4.

m_h=125GeV in the MSSM for tan β > 6 and A-terms of order m_{SUSY} or smaller.

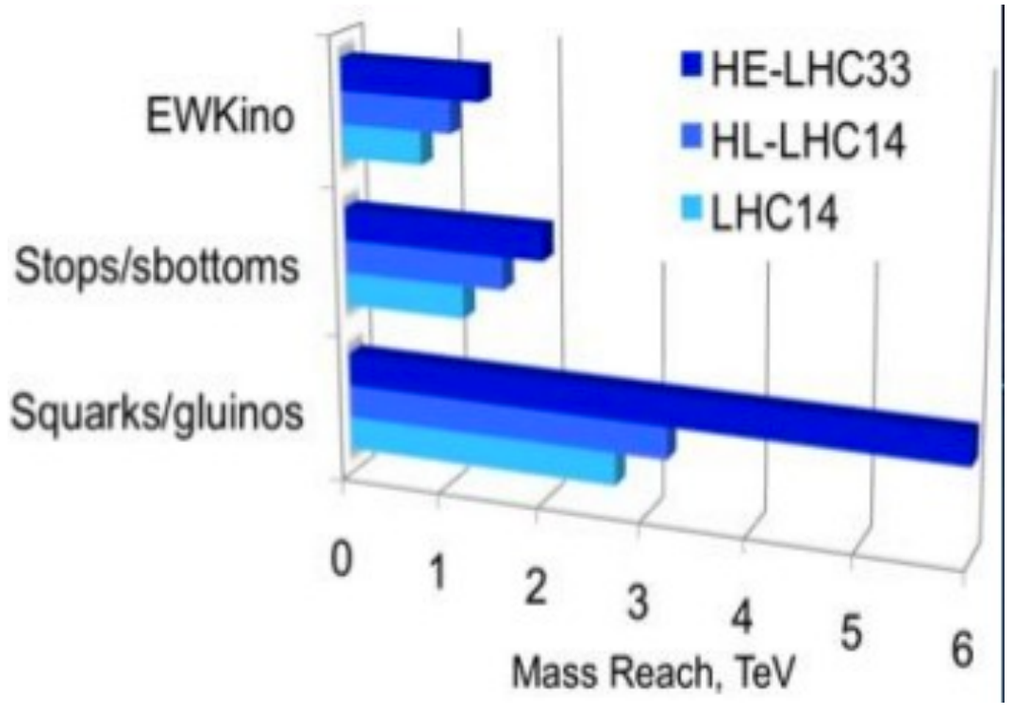
structure still necessary in the soft sector to suppress FCNC, EDM
Gabbiani, Gabrielli, Masiero, Silvestrini

Any moduli need to be > 30 TeV for cosmological reasons Banks, Kaplan, Nelson

Experimental prospects:

LHC14 with 3ab^{-1} will pair-produce less than 10 stop pairs if the stops are heavier than about 2.5 TeV.

100 TeV VHE-LHC may reach ~14 TeV stops.
K. Howe, Brookhaven Snowmass workshop



[If the -inos are all parametrically lighter and observable, how well can we measure tan β in their mixing?]

100 TeV

Scale appears in the context of the moduli problem

May exist very weakly-interacting scalars with masses small compared to M_p (e.g. string moduli). Some moduli candidates naturally have masses of order or less than the SUSY-breaking scale (e.g. saxion, inflaton). Banks, Dine, Graesser

When moduli decay in the early universe they may destroy the light elements. Reheating temperature sufficiently high for masses of order 30-100 TeV. Banks, Kaplan, Nelson

Virtue: may produce wino dark matter (m_{wino}~200 GeV) nonthermally. Moroi, Randall
However:
-100 TeV may not be high enough to avoid overproduction Bose, Dine, P.D.
-nonthermal wino DM in tension with indirect detection (HESS, Fermi) Fan, Reece

Might imagine avoiding LSP DM problems; e.g., RPV + axion DM.
For given $\theta_0 f_a$, preventing axion domination before T=1 eV limits T_{Reheat} (m_ϕ)

$m=100\ \text{TeV}$, $f_a=M_p/16\pi^2 \Rightarrow \theta_0 \sim 10^{-2}$ Bose, Dine, P.D.

10^3-10^9 TeV ("PeV-ZeV")

Tuning > part in 10^8, m_h obtained for tan β < 2-3 Degrassi, Di Vita, Elias-Miro, Espinosa, Giudice, Isidori, Strumia

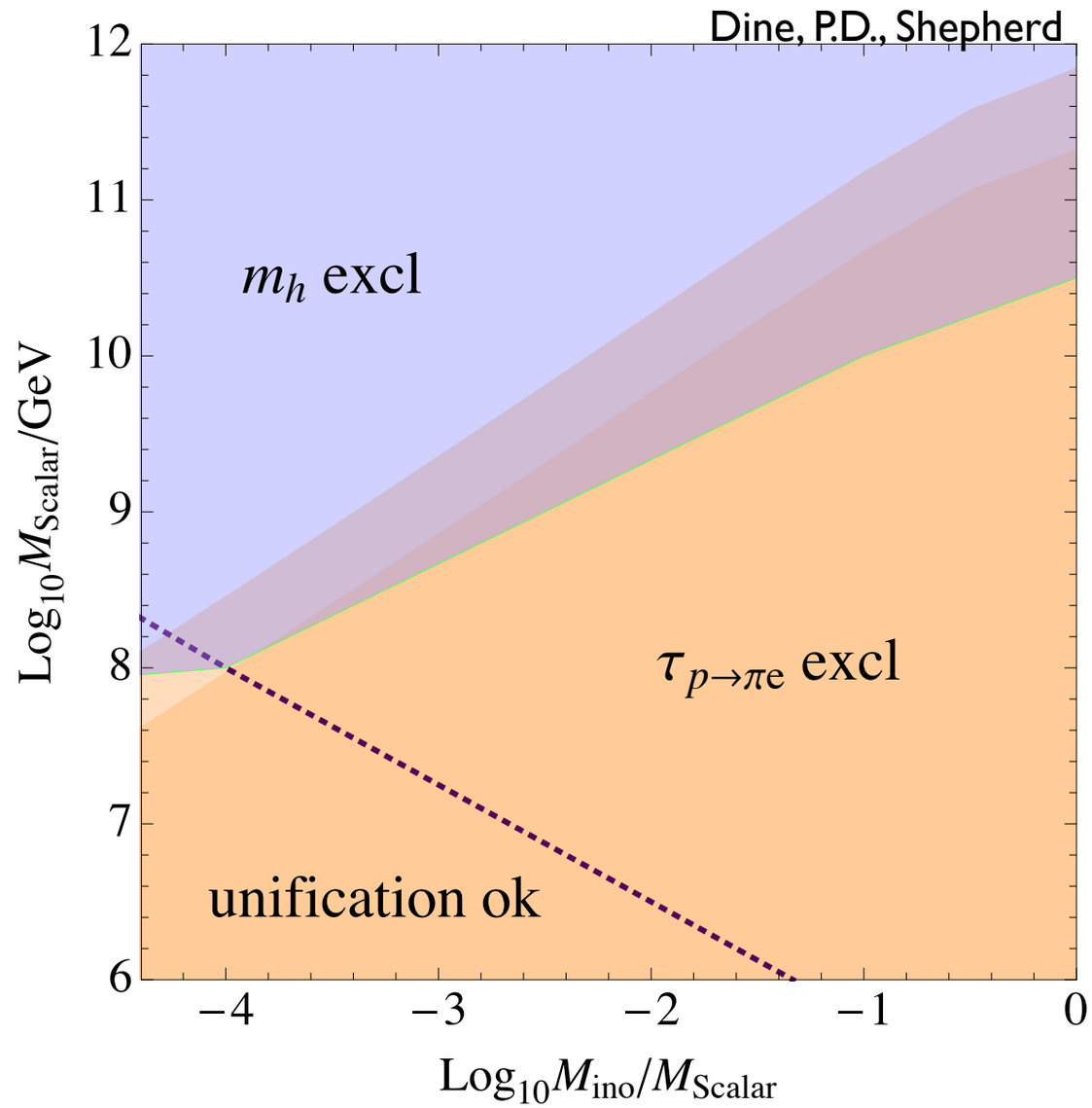
FCNCs and EDMs sufficiently decoupled at the PeV scale. Wells; McKeen, Pospelov

⇒ less structure needed for PeV SUSY?

Wells, Giudice, Romanino; Arvanitaki, Craig, Dimopoulos, Villadoro; Arkani-Hamed, Gupta, Kaplan, Weiner, Zorawski

But without flavor symmetry, may have proton decay from dim 5 operators $W \sim 1/M_p$ QQQL, uude

Above ~10^9 GeV, protons ok; tension with both Higgs mass and unification



Anomaly-mediated (mini-split) spectrum can give ~3 TeV wino: thermal DM

Also in tension with absence of signals in indirect detection Cohen, Lisanti, Pierce, Slatyer; Fan, Reece

Figuring out the distinguishing properties of different possible SUSY scales is an important problem.

Examples exist of arguments for and against various possibilities.

Goal is to infer the scale on theoretical grounds. Probably impossible, but we may narrow down the most plausible candidates.