Review of pMSSM studies

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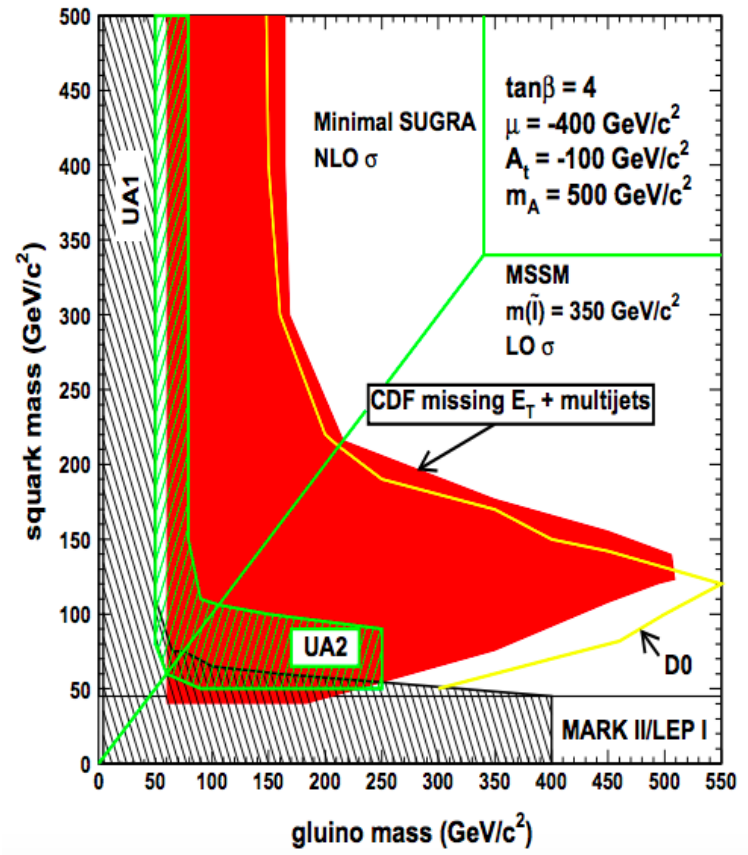
(Re)interpreting LHC new physics search results: tools and methods

LPC
October 19, 2017

Collider SUSY searches

An old question: how to describe search results?



CDF, 1997

Over 100 free parameters in minimal supersymmetry

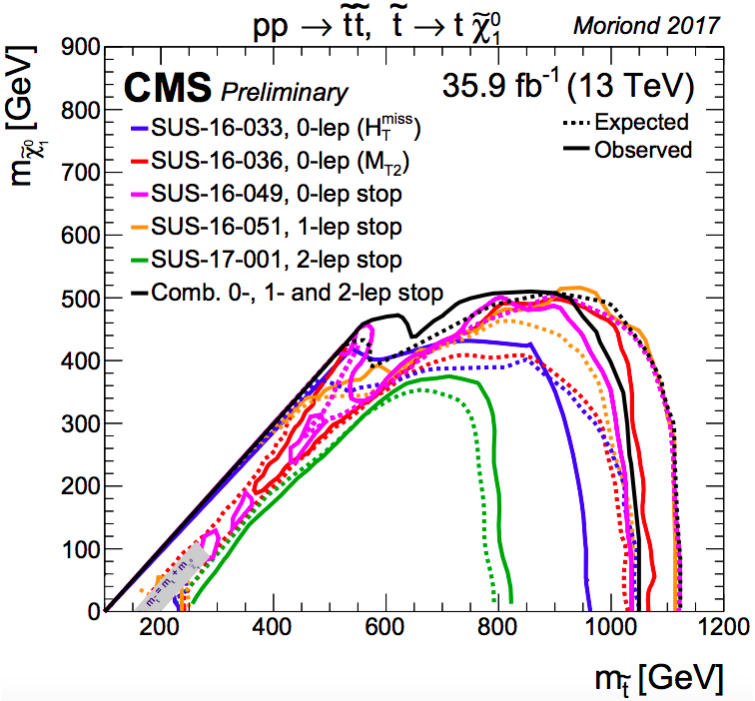
Predict new particles completely from assumptions about UV physics

Pro: progress is easy to see

Con: what if UV physics is different?

Collider SUSY searches

Trade top-down assumptions for bottom-up ones



In simplified models, most new particles are decoupled

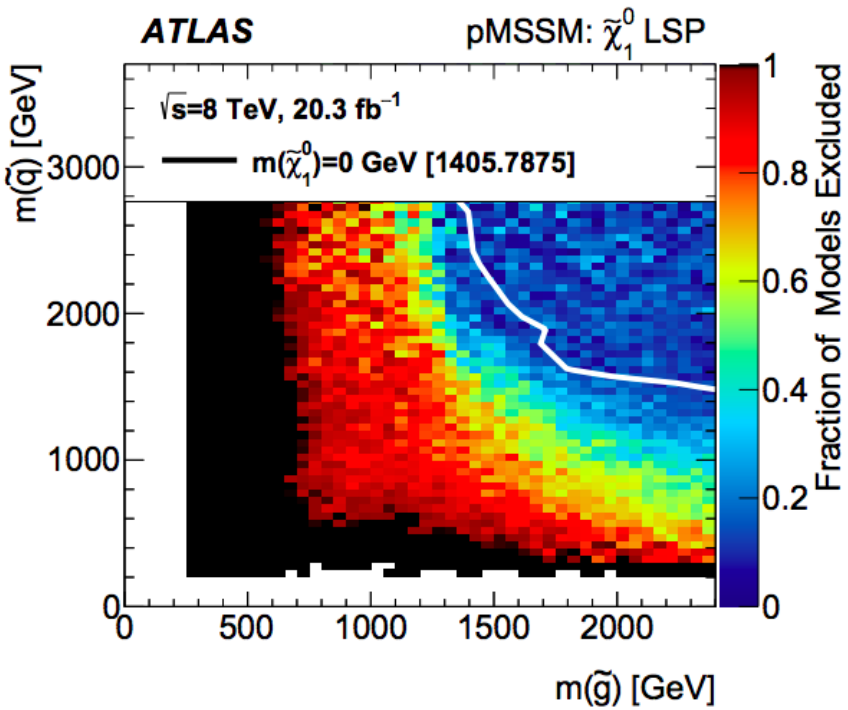
Alwall, Schuster, Toro 2008

Pro: physical, straightforward assumptions for search reach

Con: what if new physics has several states at the same scale?

Collider SUSY searches

Scan-style approaches make fewer assumptions



Throw darts (or MCMC) at a large parameter space

Test set of points surviving existing constraints against incoming search results

Pro: full generality

Con: simplicity, coverage

The pMSSM

Phenomenological = assumptions about SUSY parameters based on experimental results

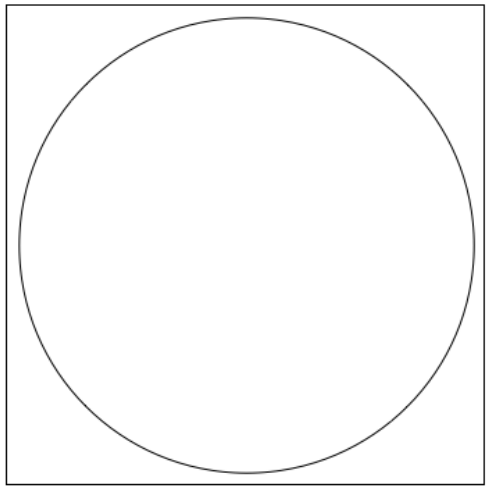
e.g. no flavor-changing neutral currents → diagonal sfermion mass matrices

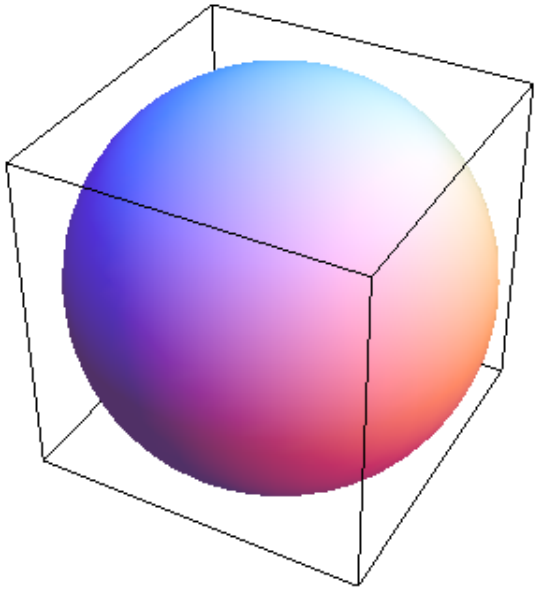
From full MSSM, left with 10-20 numbers:

gaugino/Higgsino and sfermion masses, L-R sfermion mixing, and Higgs sector parameters

Parameter scans in high dimensional space

Large number of variables → curse of dimensionality





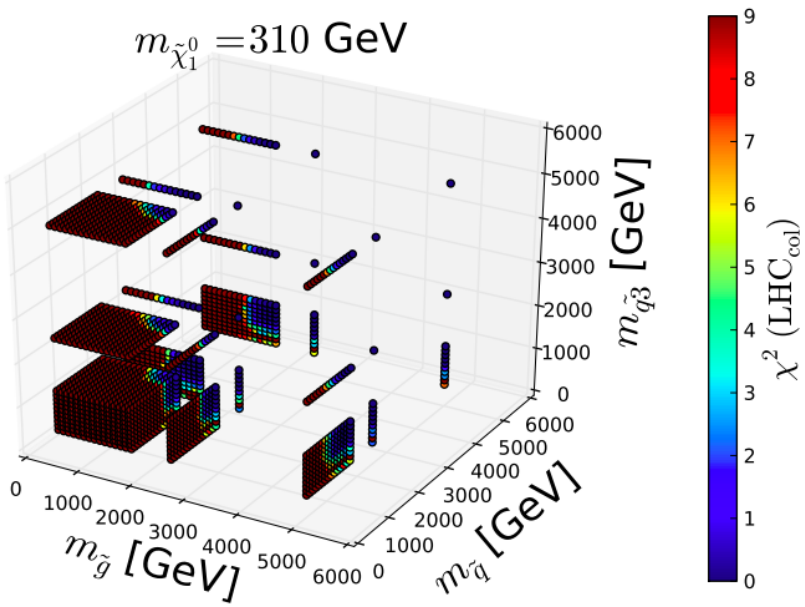
Most pMSSM points are “extreme” in at least one way

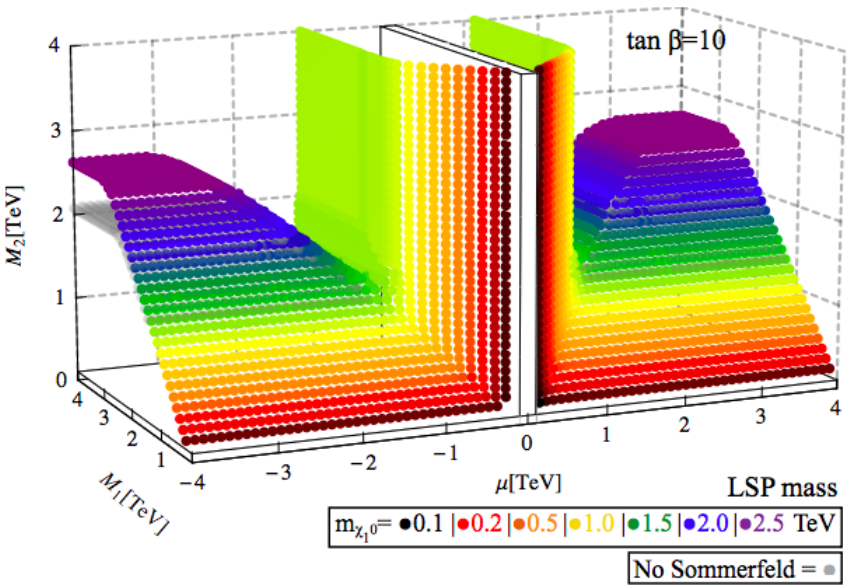
Parameter scans in high dimensional space

One approach: reduce number of dimensions

Eventually approaches simplified model limit

MasterCode collaboration, 2015



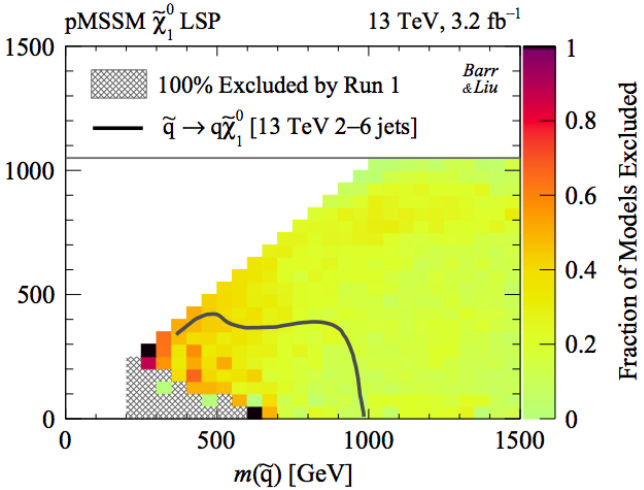


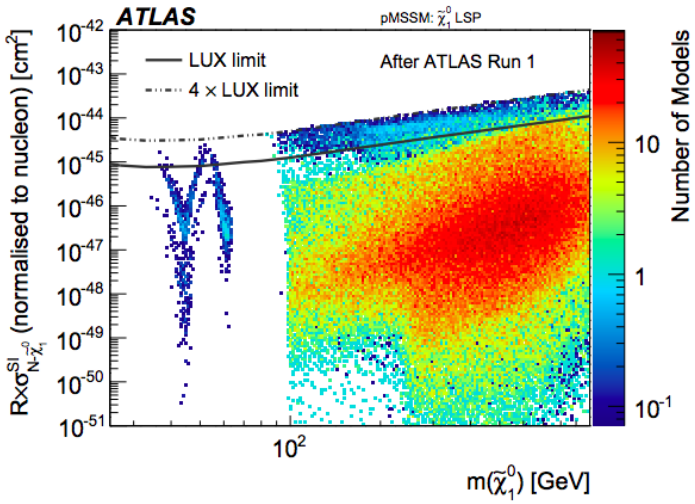
Bramante et al, 2015

Can also use Markov Chain Monte Carlo to converge faster on region of interest

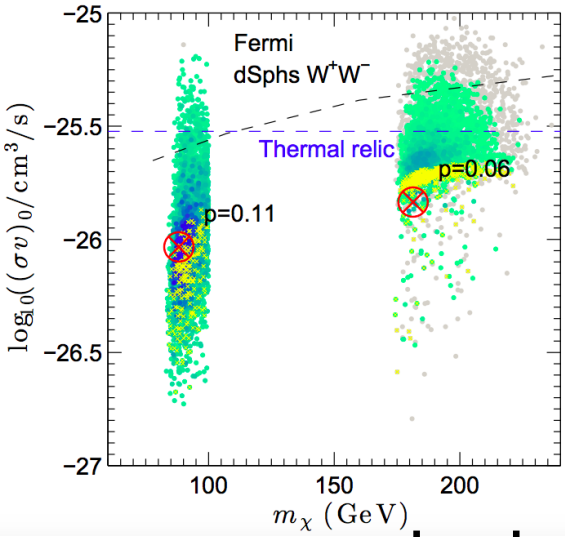
Why is this worth it?

Find gaps in search coverage

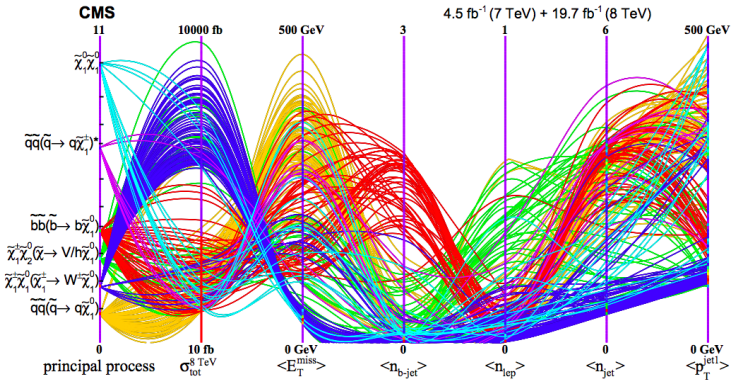




Compare different experiments



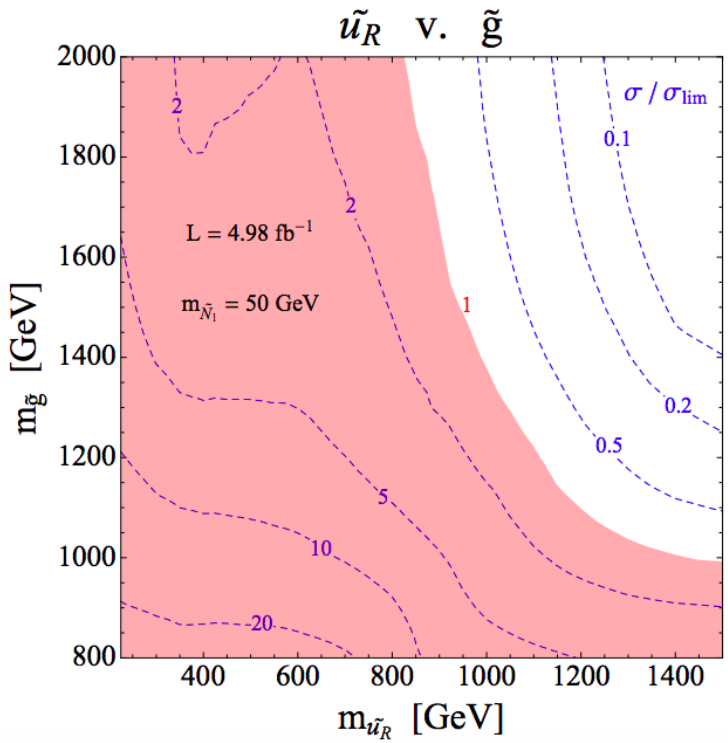
Investigate potential signals

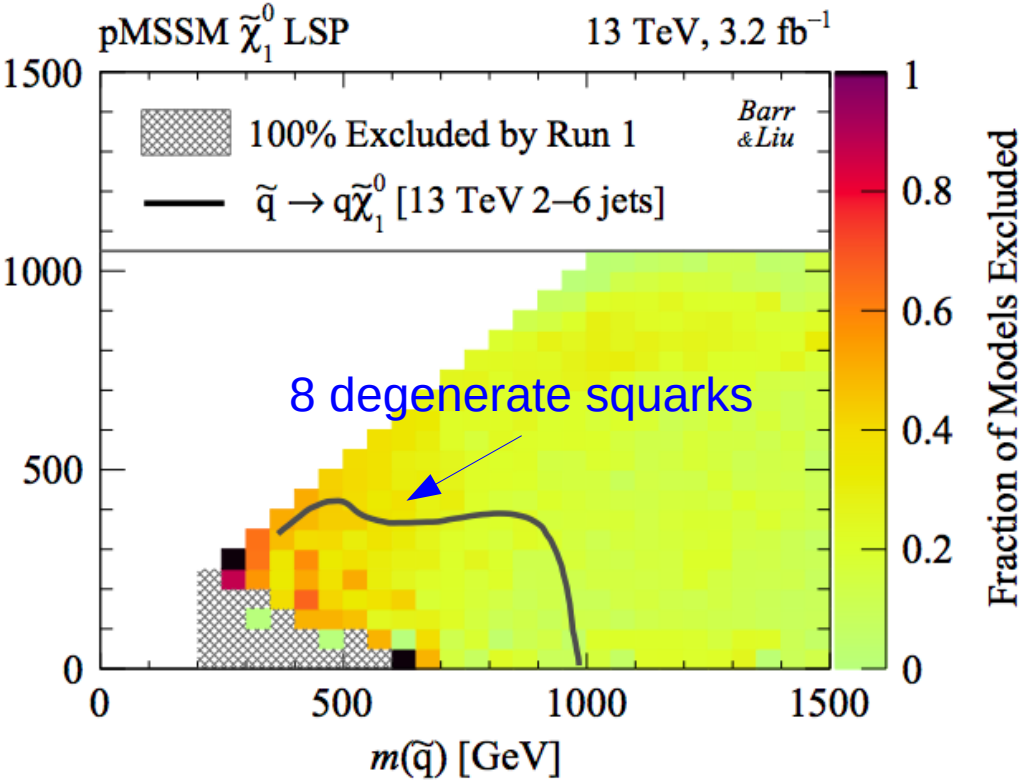


Propose new search channels

Gaps in search coverage

If squarks aren't degenerate, production cross section is drastically reduced



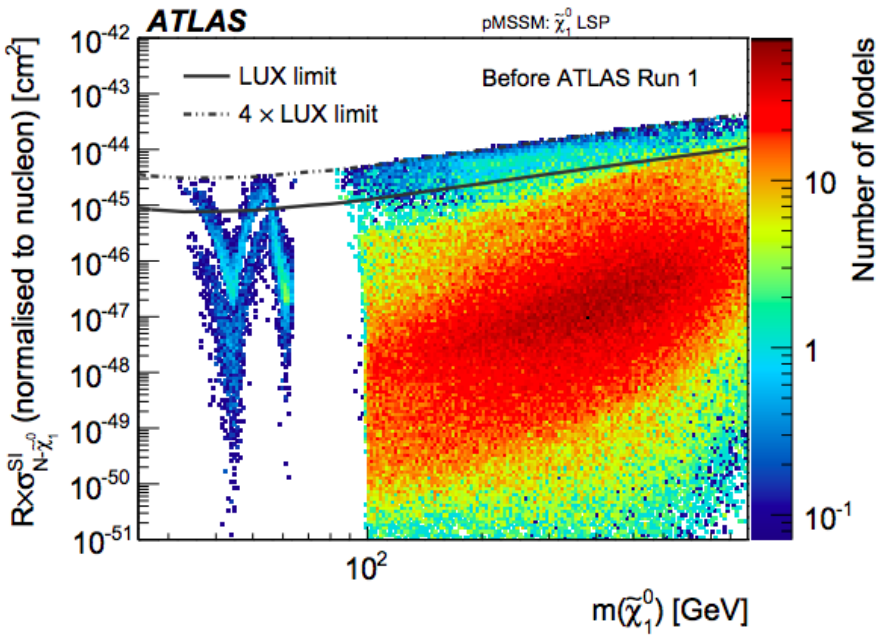


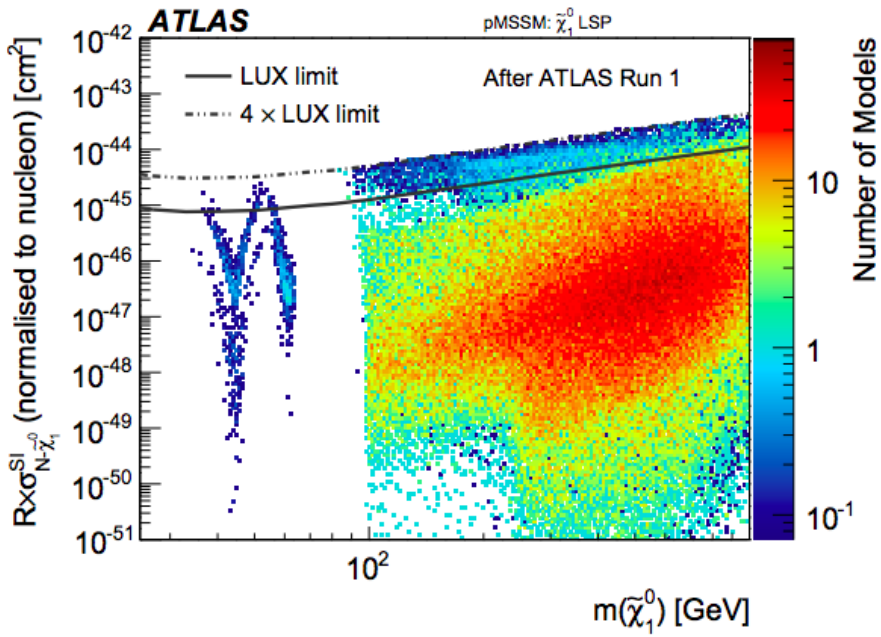
lightest squark only

Barr, Liu 2016

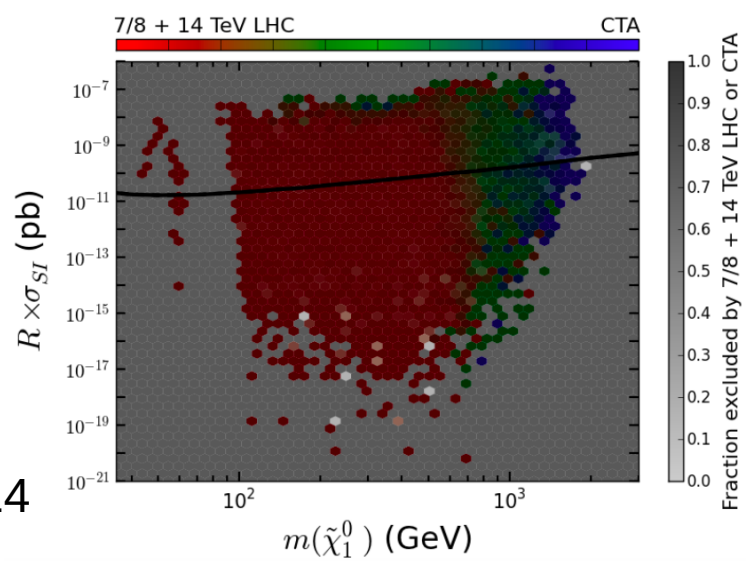
Mahbubani, Papucci, Perez, Ruderman, Weiler 2012

Compare different experiments





Complementarity between colliders and DM detection

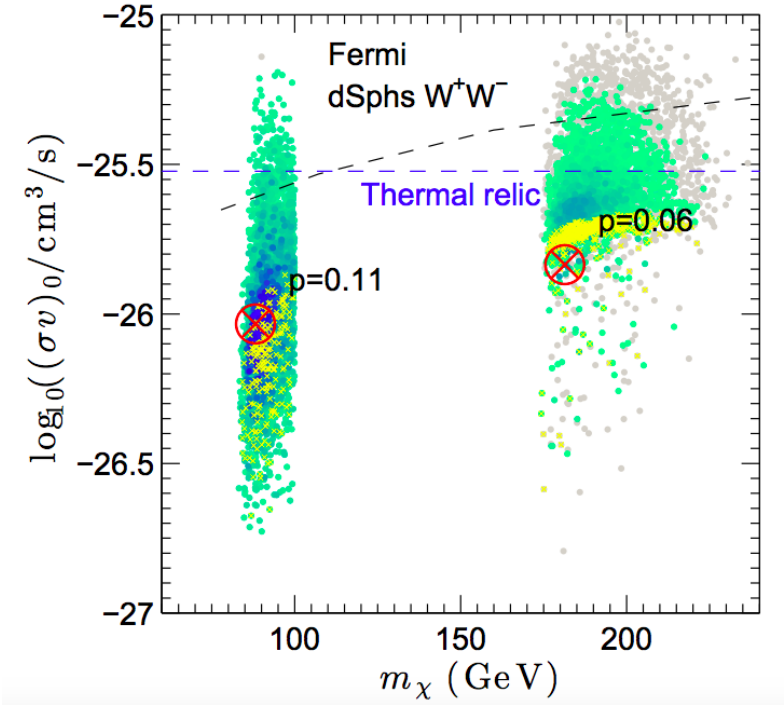


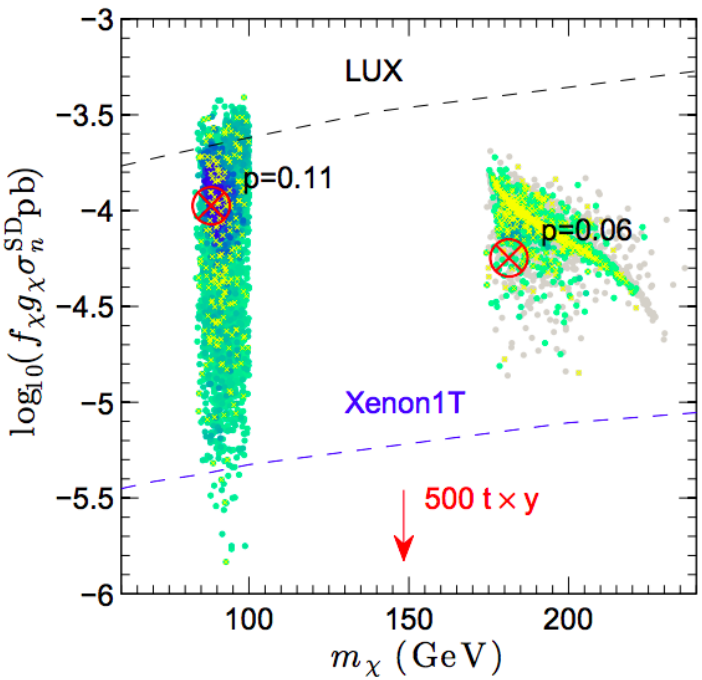
Cahill-Rowley et al., 2014

Investigate potential signals

Extra photons from Galactic Center from Fermi-LAT

Fit with neutralino annihilations to WW, tt



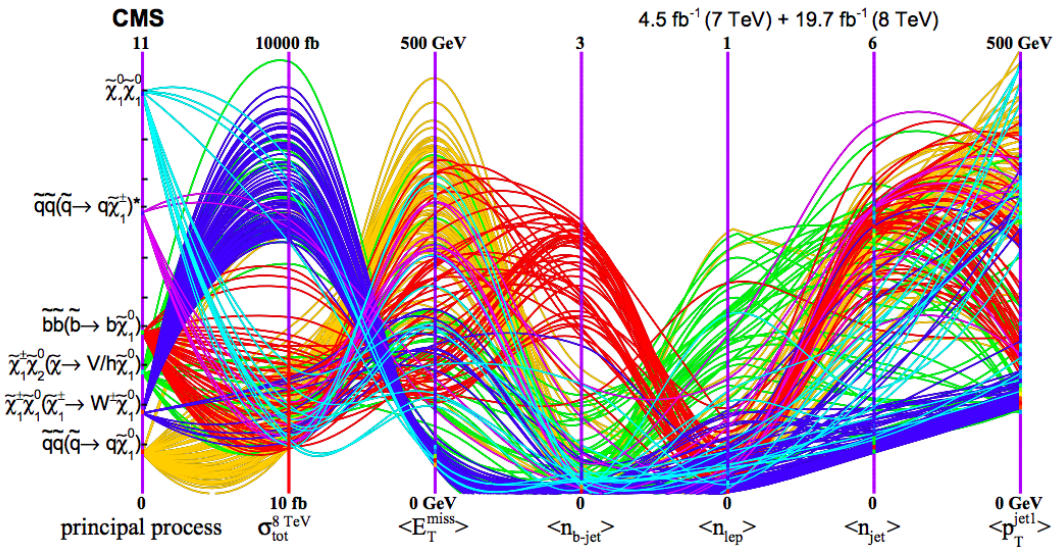


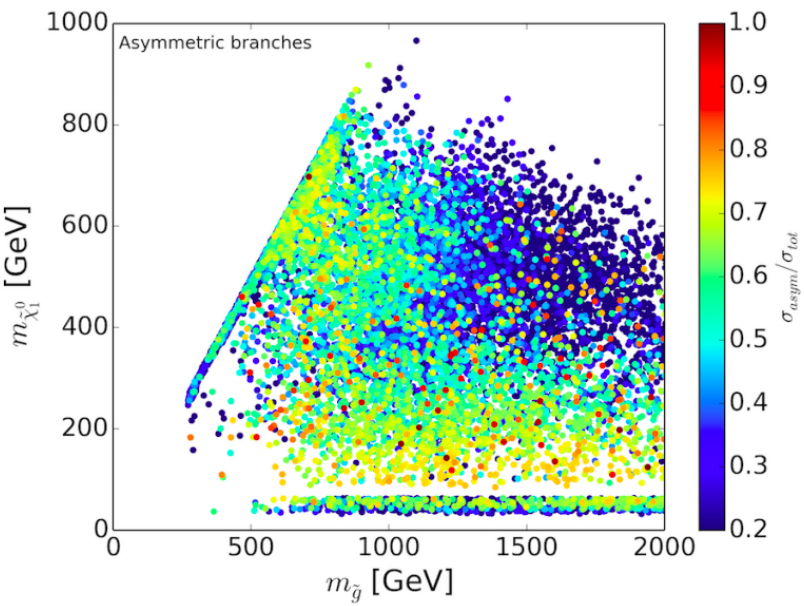
Can be probed by future direct detection

Bertone et al., 2015

Propose new search channels

Features of signal events from models not excluded by CMS pMSSM study



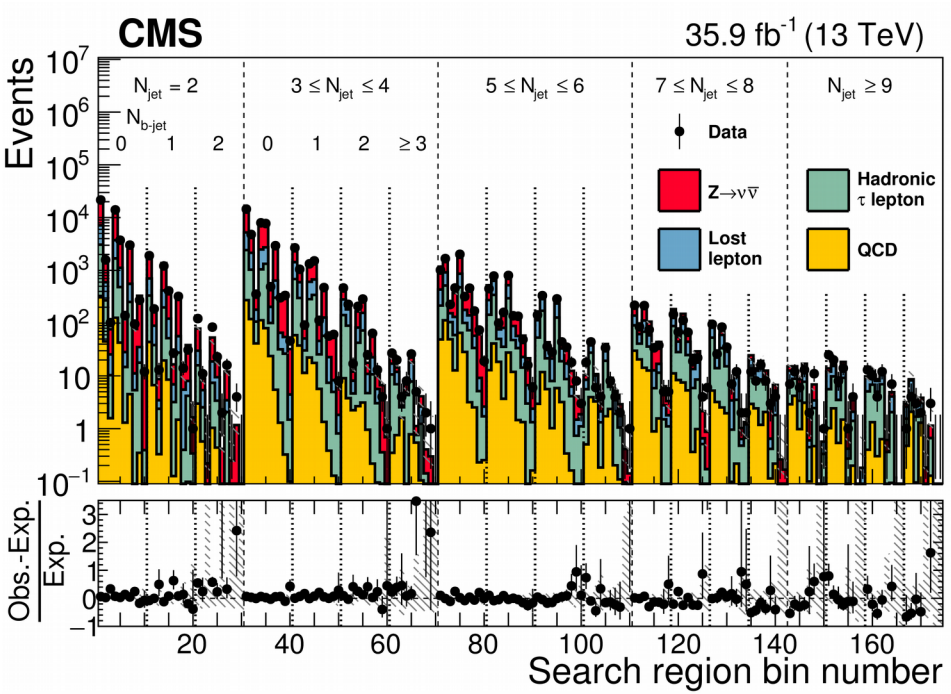


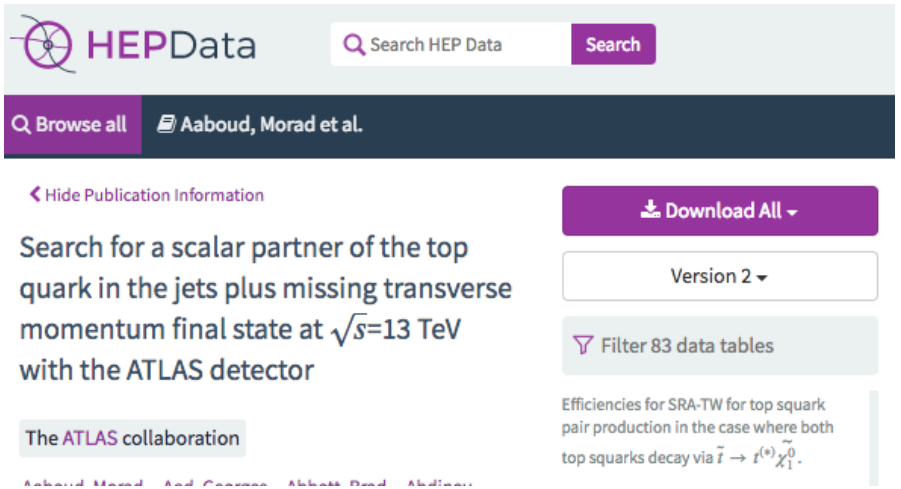
New search topologies not covered by existing simplified model constraints

Ambrogi et al., 2017; see talk by S. Kraml

Improvements in search data

Today: many more search regions, with complicated cuts compared to early Run 1

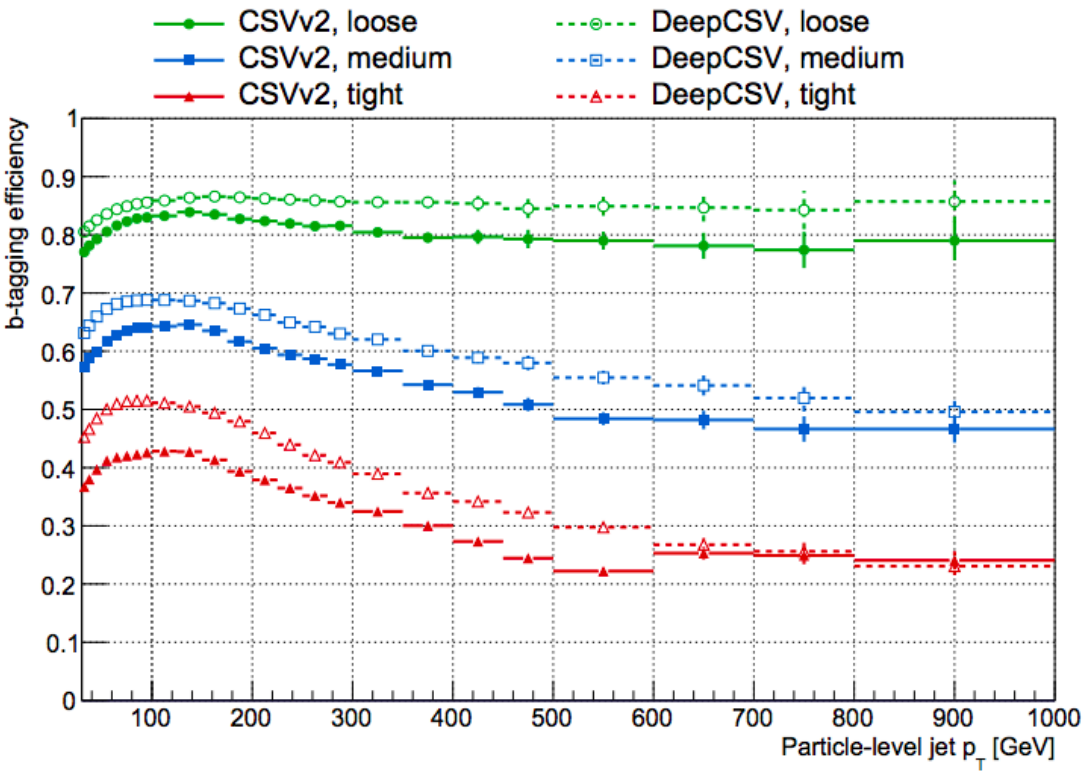




More information provided, including benchmarks and cutflows

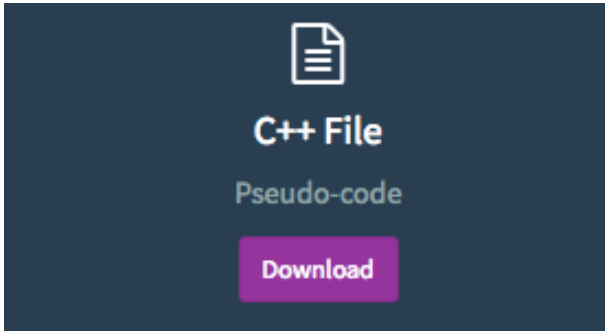
ATLAS on HEPData; see talk by A. Buckley

Improvements in search data



Efficiencies also given numerically

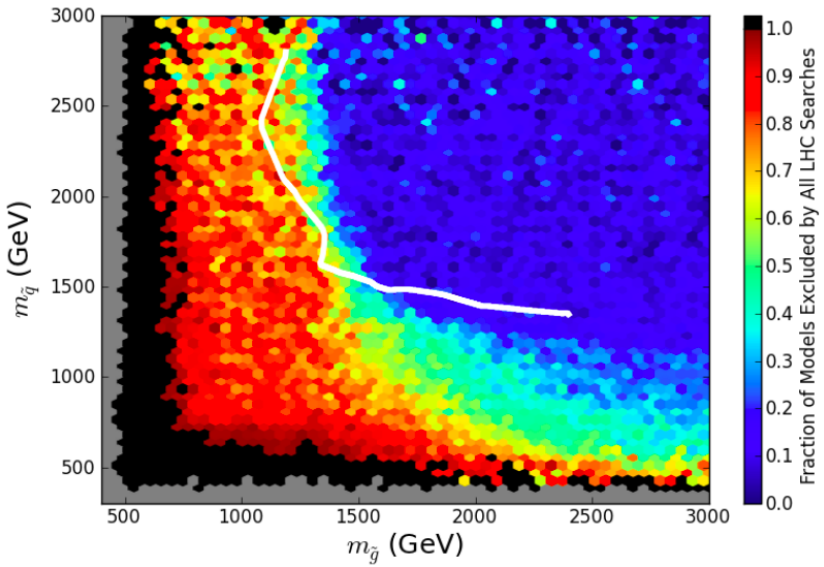
CMS for Moriond 2017

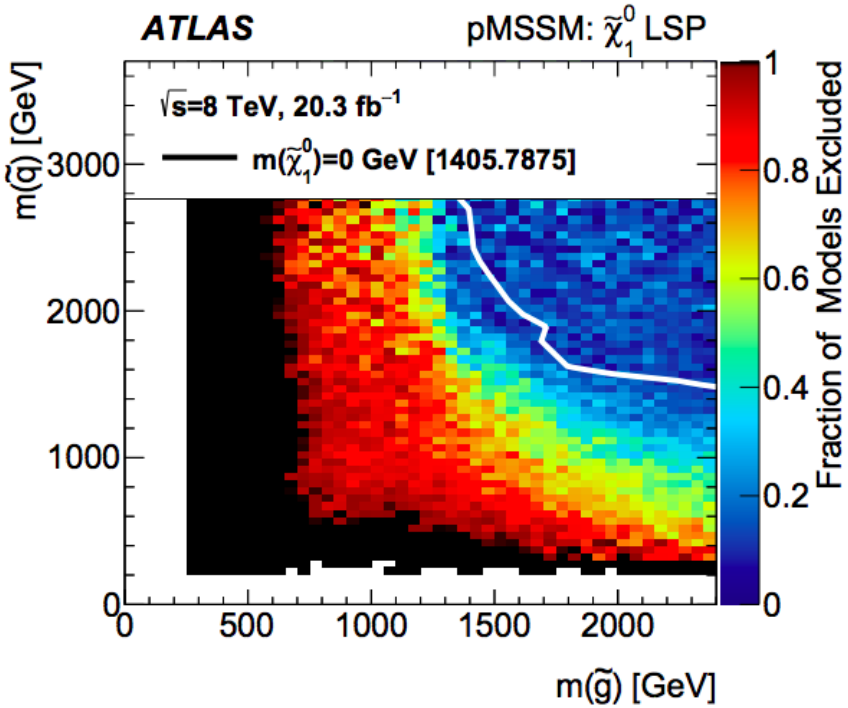


ATLAS on HEPData

Some code provided for analysis, not plug and play yet but allows for comparison

Improvements in search data





Cahill-Rowley, Hewett, AI, Rizzo, 2013

8 TeV, 6 fb^{-1}

ATLAS, 2015

8 TeV, 20 fb^{-1}

Will the next versions of these plots be closer?

Summary

The phenomenological MSSM: a SUSY parameter scan to examine search reach in full generality

Further applications in *systematically* comparing different experiments, exploring excesses, and suggesting new search strategies

Reinterpretation possible only because of thorough and clear descriptions of experimental searches; this is getting even better!