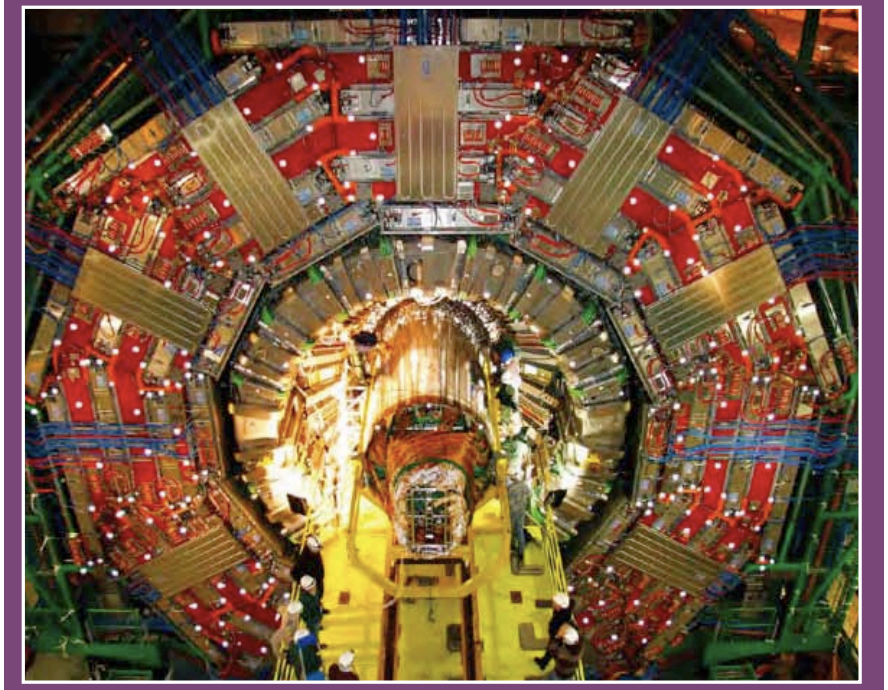
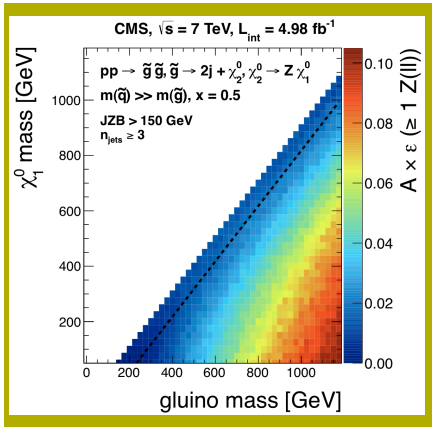
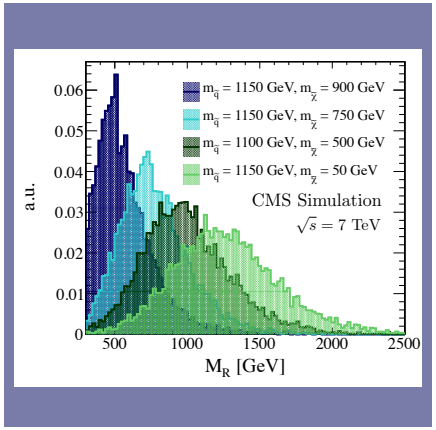
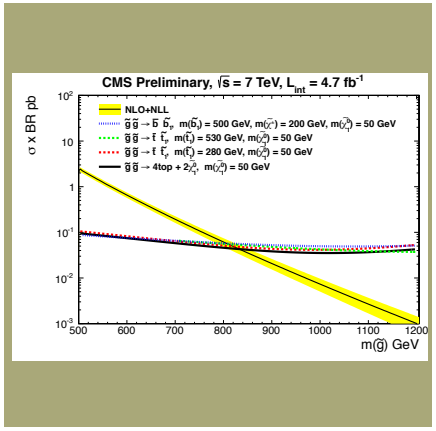
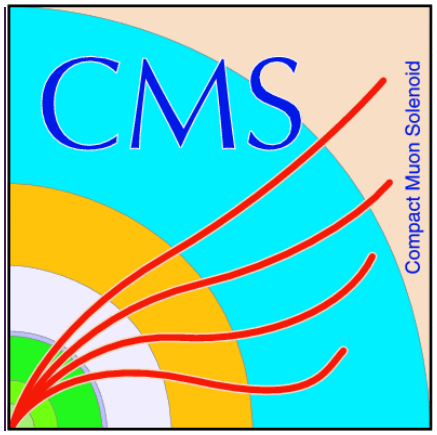










Interpretations of CMS SUSY analyses in simplified model space (SMS)

on behalf of the CMS collaboration

Christopher Rogan

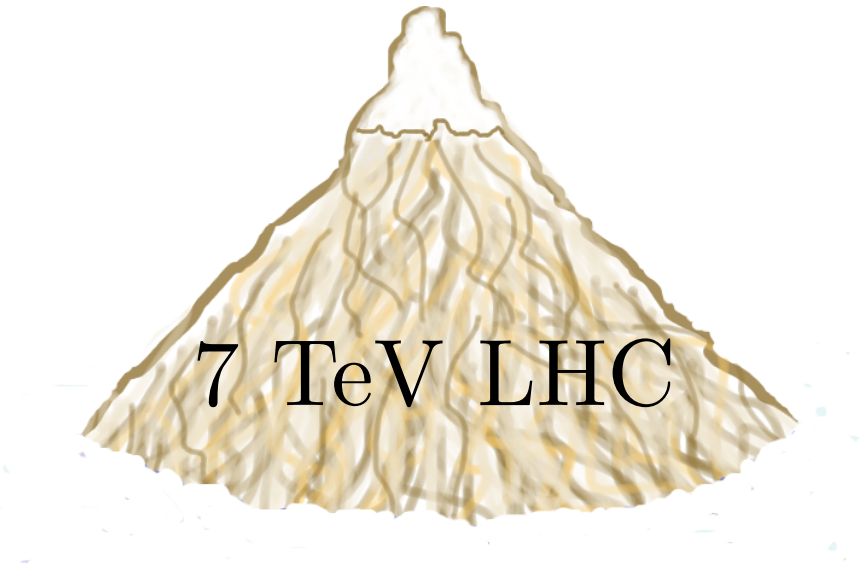
California Institute of Technology

ICHEP 2012 – Melbourne, Australia - 4-11 July 2012

CMS SUSY Searches

Explore previously inaccessible phase space ➔
unlocked with 7 TeV and 8 TeV pp collisions at the LHC

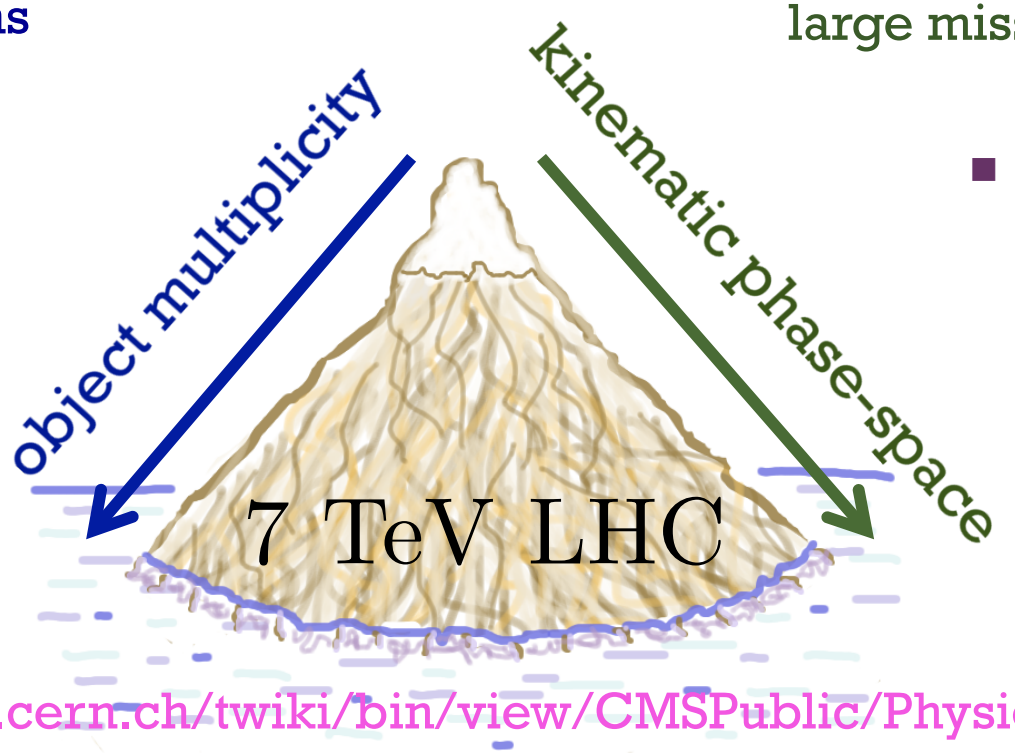
Look for deviations from Standard Model expectations
➔ can make inferences about SUSY and other BSM physics



LHC Phase Space

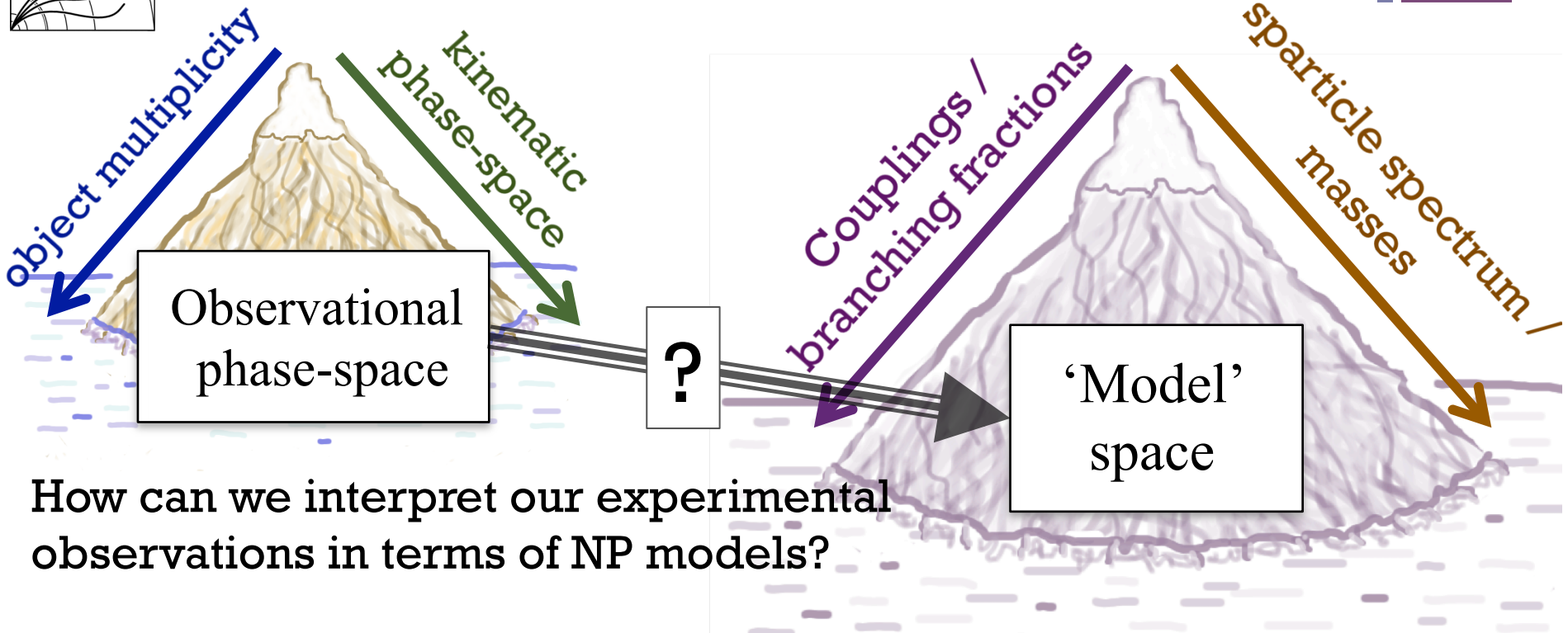
SUSY in the phase space of observables

- Production of 3rd generation super-partners can result in final states with tops and b-jets
- Sparticles decaying to W/Z/ γ /leptons
- Cascading decays through SUSY and SM spectrum can lead to high object multiplicities
- Heavy sparticles decaying to SM particles ➔ large visible momenta
- R-parity conservation ➔ large missing momenta
- Resonances, kinematic edges, mass sensitive variables…



https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

Interpreting LHC Phase Space

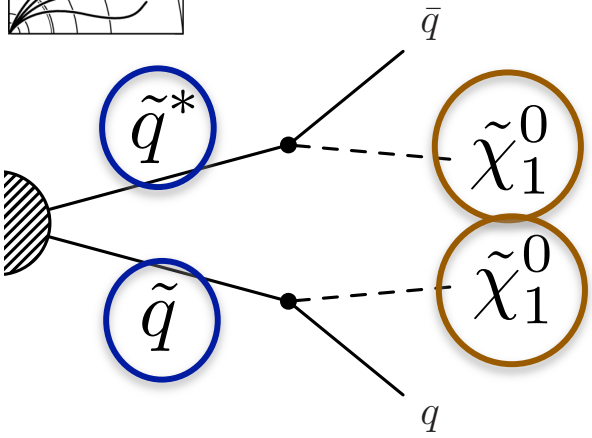


How can we interpret our experimental observations in terms of NP models?

- Constrained models (cMSSM, GGM) are 'complete' with interesting signatures and predictions BUT do they cover all possible NP 'model' space? Can results interpretations be generalized to other NP models?

- With simplified model space (SMS) we can interpret results directly on simplified sparticle spectra for specific topologies of interest – building blocks that can be used to generalize to a more complete 'model'-space

Anatomy of a simplified model

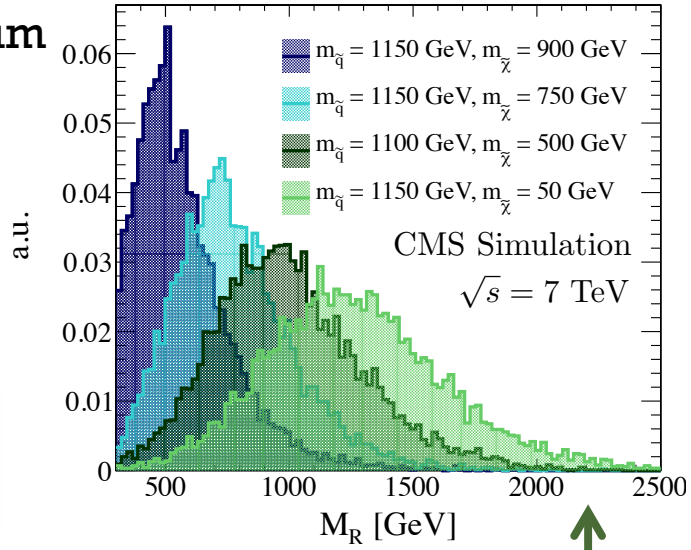


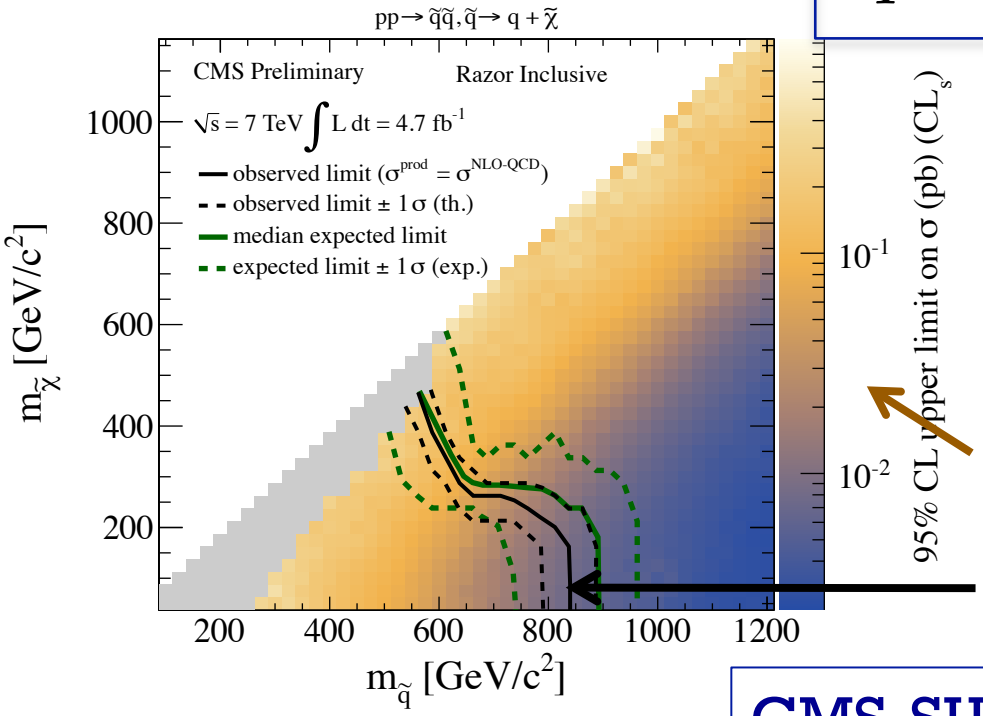
Simplified sparticle spectrum with only squarks and LSP's

Only one production mechanism – di-squarks

Only one decay:

$$\tilde{q} \rightarrow q\tilde{\chi}_1^0$$





Results in events with jets and MET

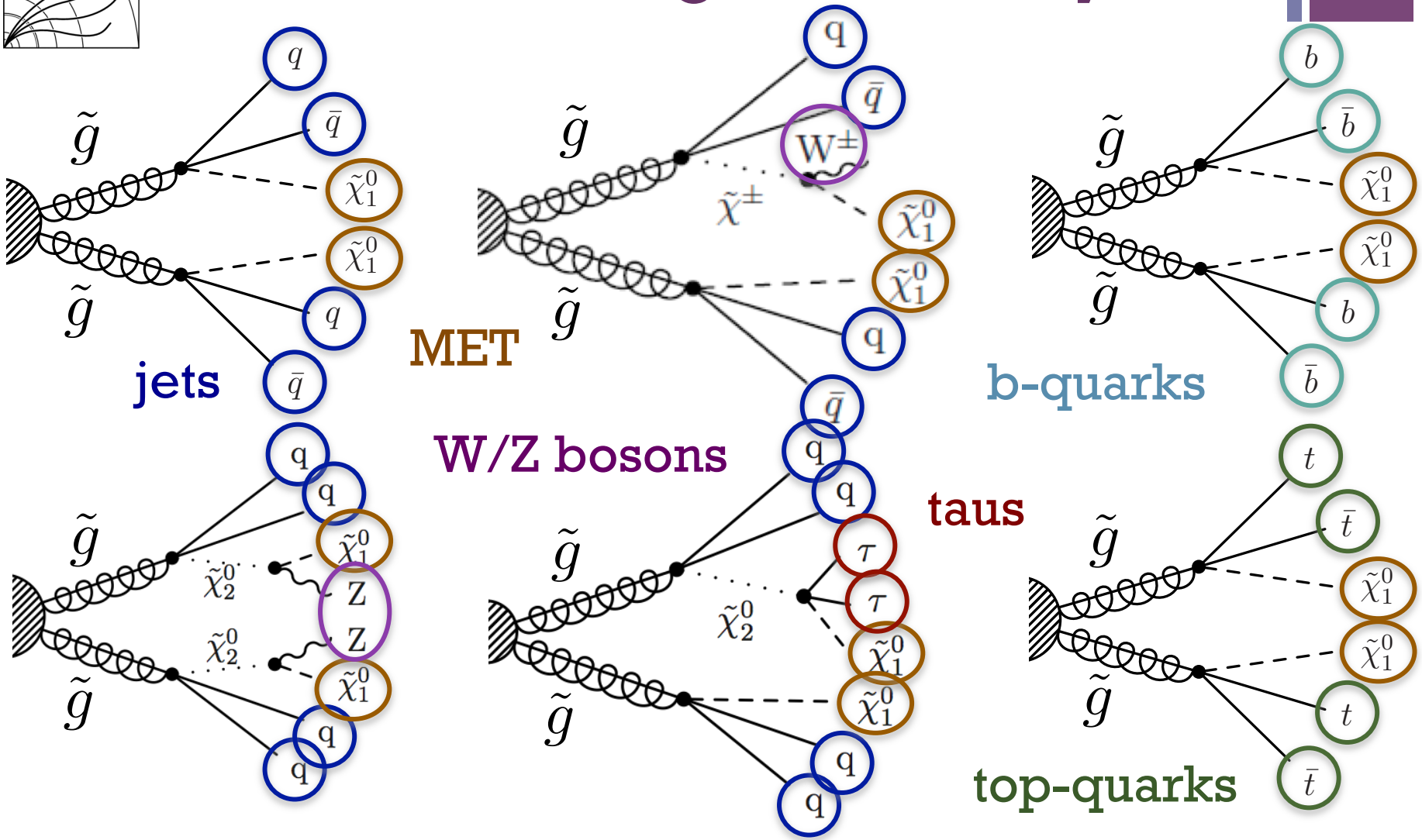
Different sparticle masses can result in very different kinematic behavior ➔ can probe a range of phase-space with one simplified topology!

cross section upper limits determined as a function of sparticle masses

theoretical x-sections can be used to interpret exclusions in mass-space

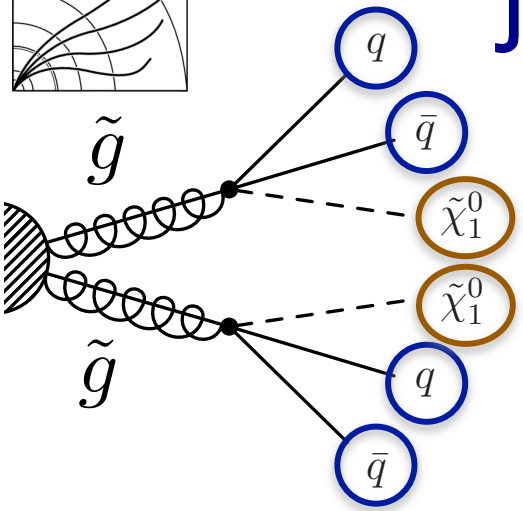
CMS-SUS-12-005

Leviathan of gluino decays



Instead of assuming the couplings/BR's from a particular model, we can consider final-state SMS possibilities separately

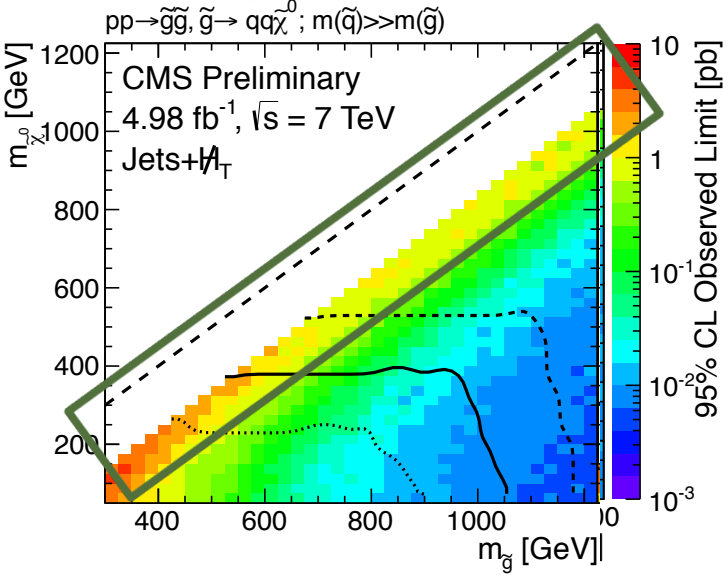
Jets + MET final states



- In CMS, usually multiple analyses searching in a given final state
- SMS's help us understand analyses' complementarity, redundancy (both important) and identify regions of phase space where we could improve searches (like compressed spectra)

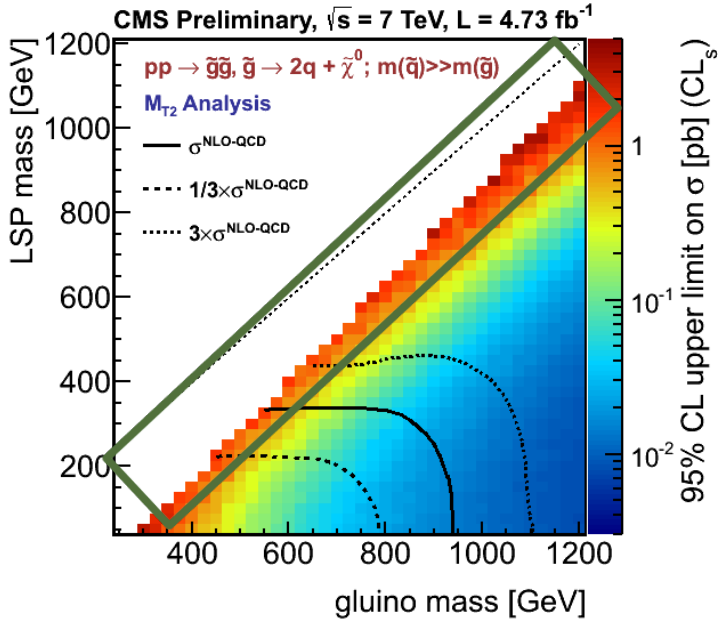
$H_T / \not{H}_T$ based

CMS-SUS-12-011



H_T / M_{T2} based

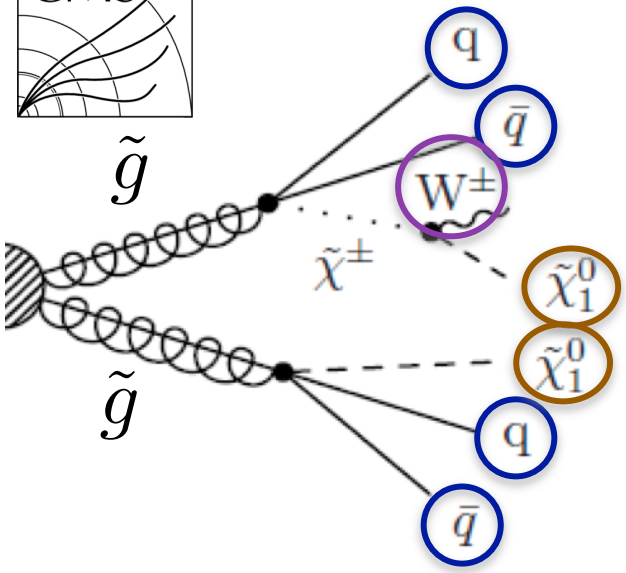
CMS-SUS-12-002



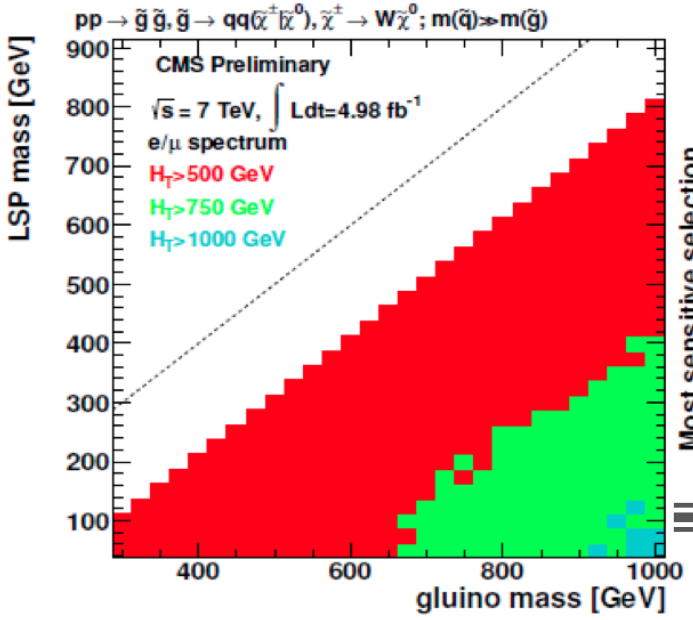
See talk by S. Sharma for more details about hadronic final state analyses

1 lepton + jets + MET

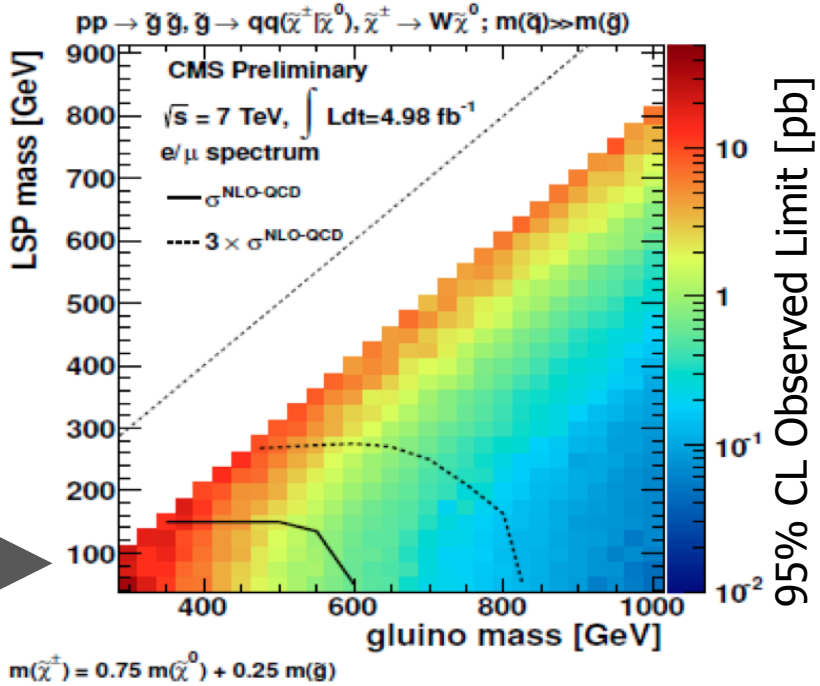
- In CMS, search analyses often have multiple signal regions, defined by different kinematic requirements
- SMS's help us understand how these different kinematic regions contribute sensitivity to different models



CMS-SUS-12-010

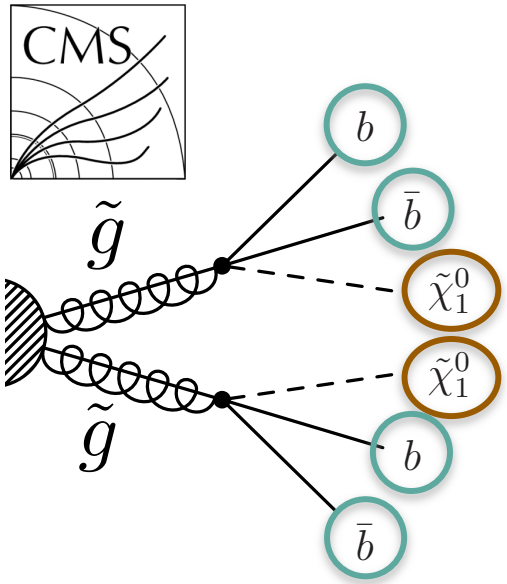


H_T / $\not{E}_T$ based



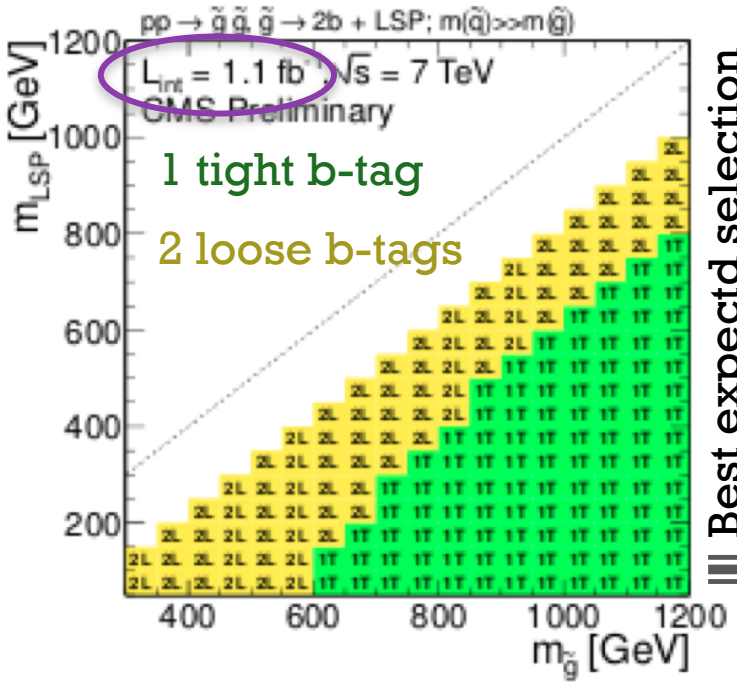
See talk by K. Mazmudar for more details about single lepton final state analyses

b-tags + jets + MET



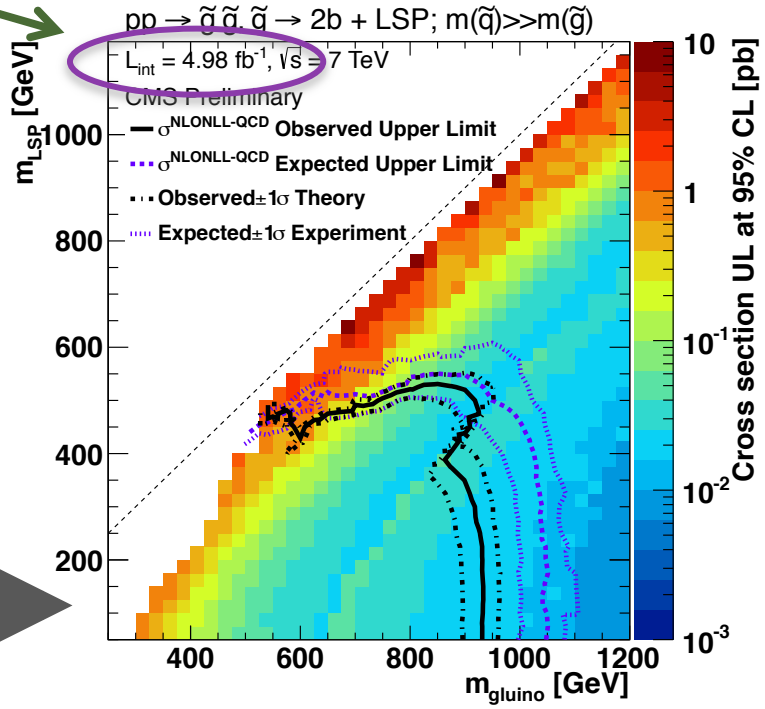
- In CMS, search analyses often have multiple signal regions, defined by different object requirements
- SMS's help us understand how these different object selections contribute sensitivity to different models (here, motivated 3b-tag selection used for full 2011 dataset)

CMS-SUS-12-003

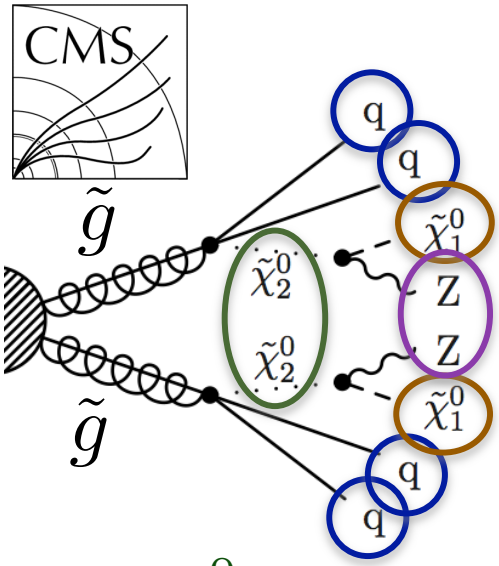


Best expectd selection

$H_T / \not{E}_T$ based



See talk by A. Cakir for more details about 3rd generation SUSY searches

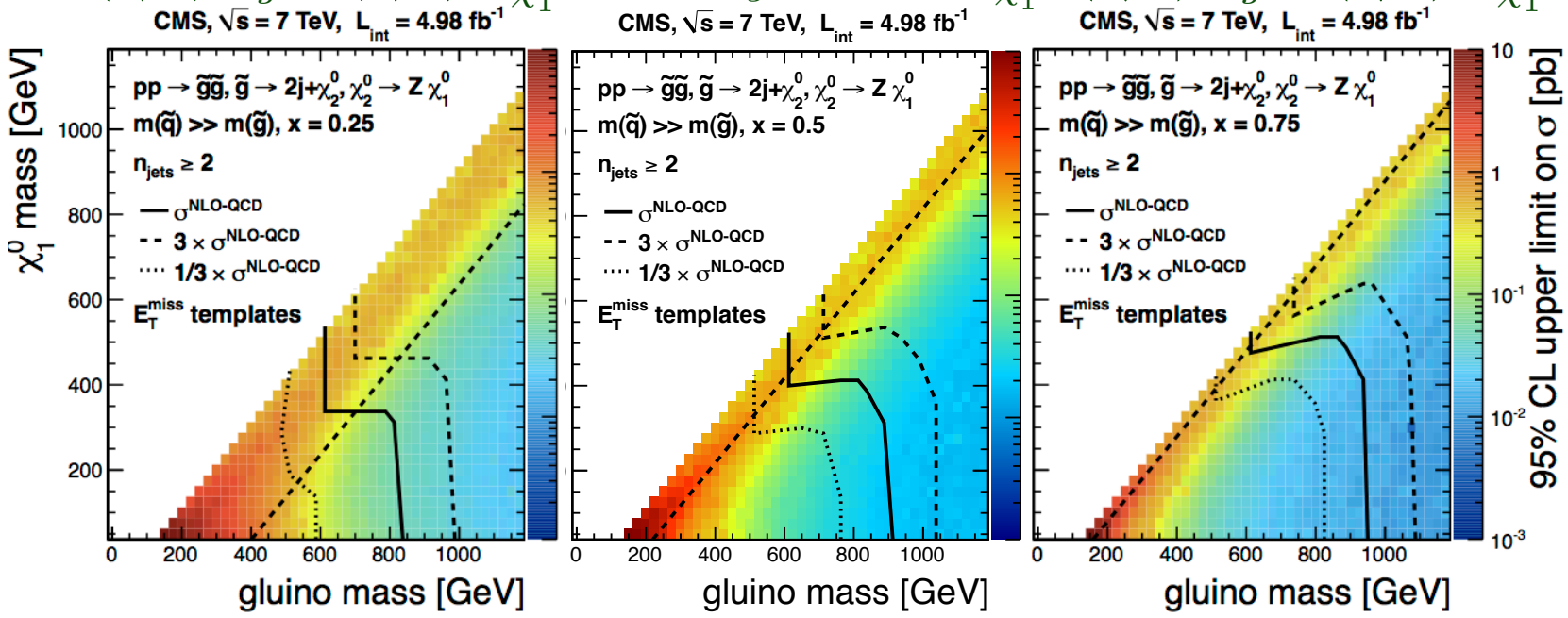


Z boson + jets + MET

- We also consider SMS's with more than two non-trivial masses in the spectrum
- Here, a search requiring a leptonic Z, jets and MET is not only sensitive to gluino and LSP masses, but also to the intermediate neutralino mass

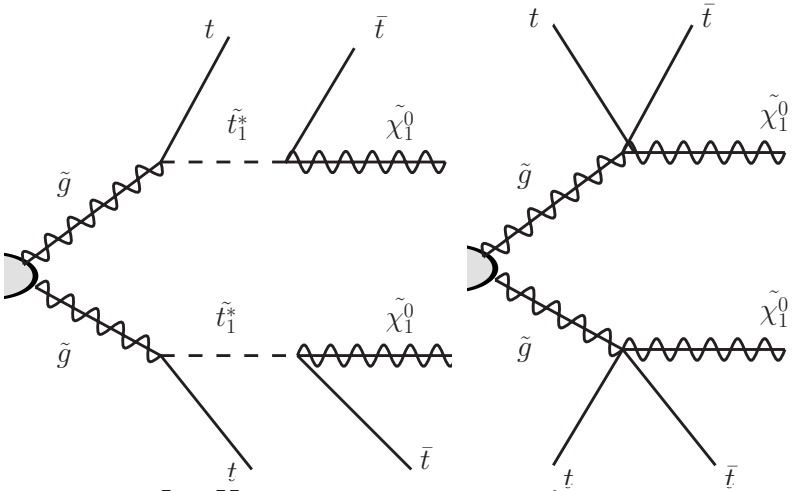
$$\text{mass } \tilde{\chi}_2^0 = (1/4)m_{\tilde{g}} + (3/4)m_{\tilde{\chi}_1^0} \quad (1/2)m_{\tilde{g}} + (1/2)m_{\tilde{\chi}_1^0} \quad (3/4)m_{\tilde{g}} + (1/4)m_{\tilde{\chi}_1^0}$$

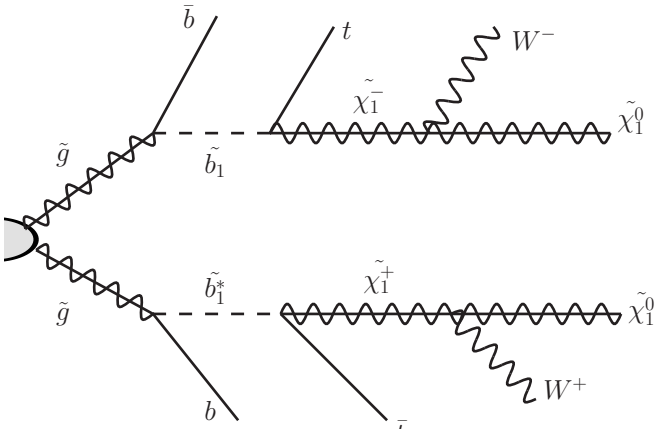
CMS-SUS-11-021



See talk by P. Ruiz del Arbol for more details about multiple lepton SUSY searches

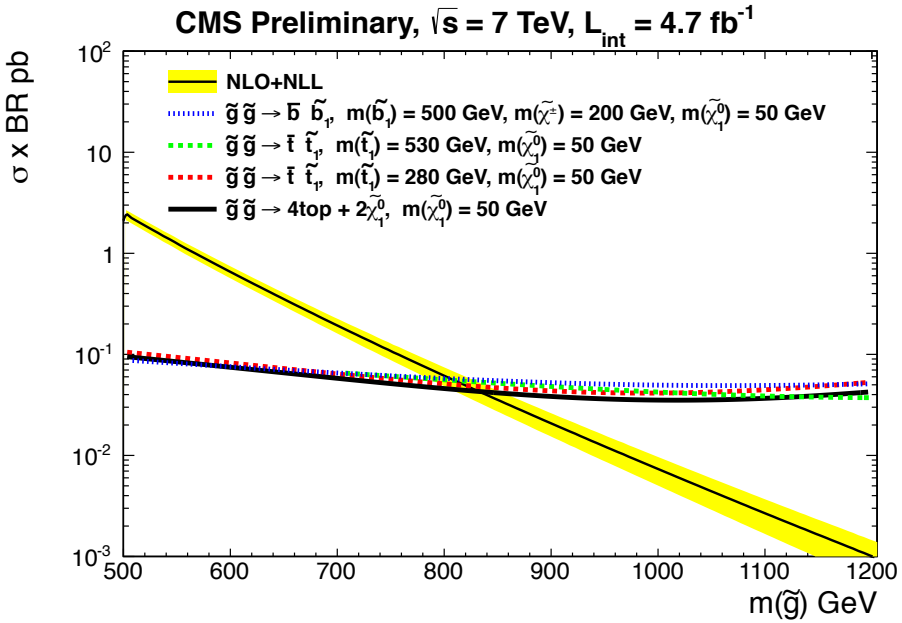
SS di-leptons + b-tags + MET



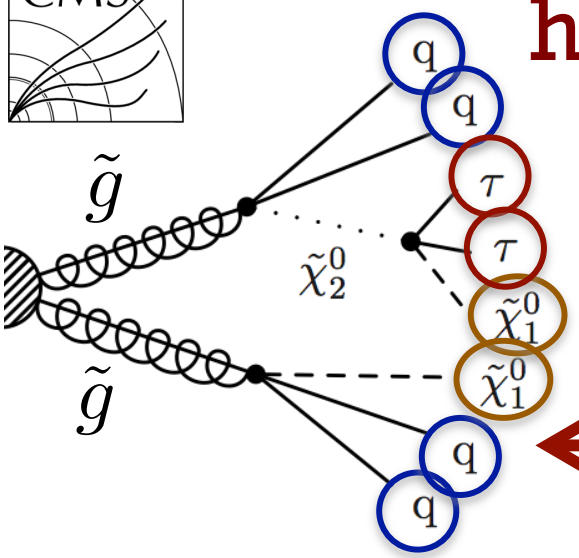


CMS-SUS-11-020

- SMS's also show us that some analyses are not sensitive to the masses and details of intermediate decay particles
- Here, a counting experiment in final states with same sign di-leptons, MET and b-tags is only weakly-dependent on the intermediate details of models yielding 4 W and 4 b-quark final states

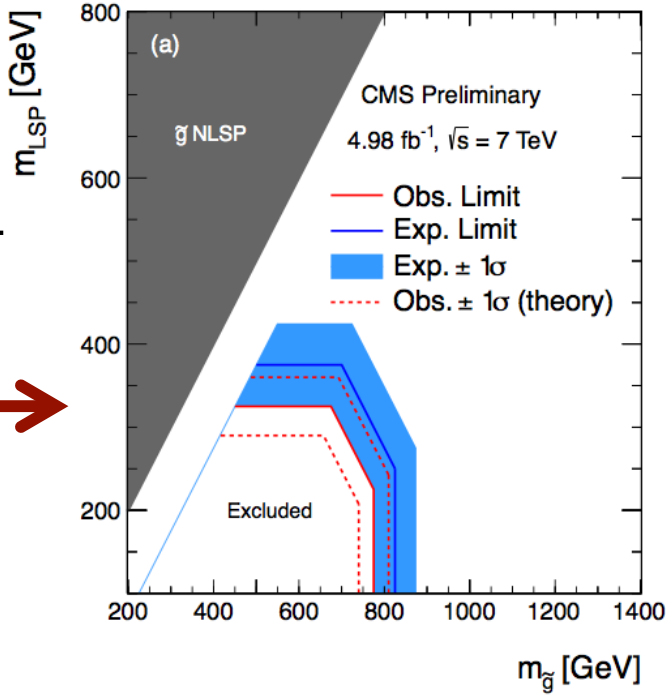


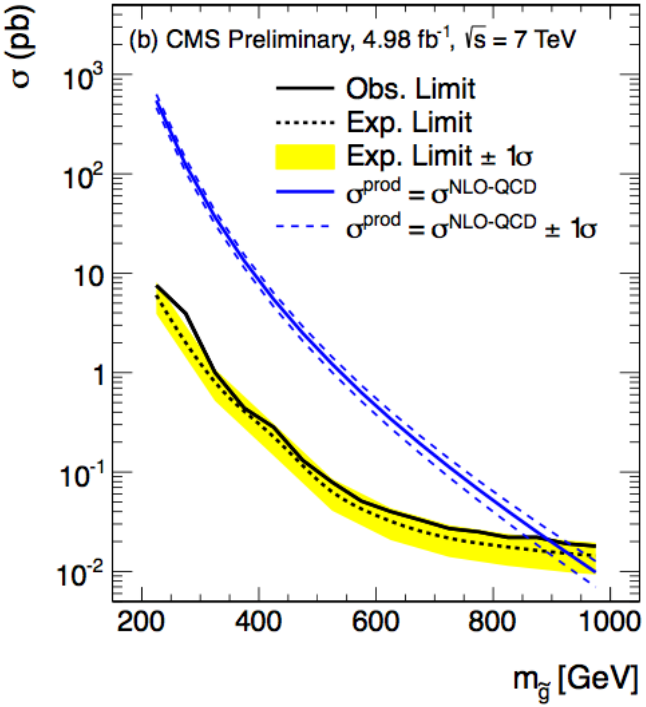
hadronic taus+jets+MET



CMS-SUS-12-004

- Can interpret search in hadronic tau final states in context of SMS to the left



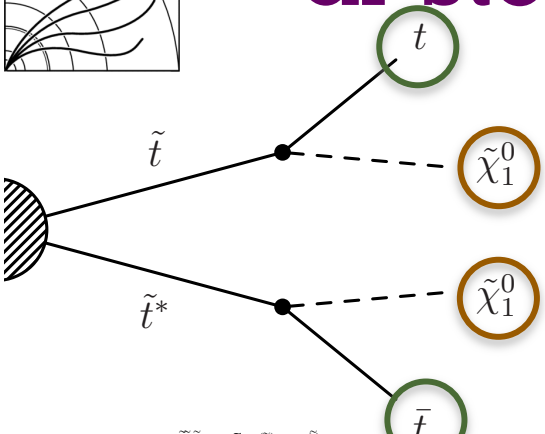


- Can use the same analysis and SMS to confront Gauge Mediated Symmetry Breaking (GMSB) models with stau NLSP and ~keV gravitino:

with $\tilde{\chi}_2^0 \rightarrow \tau\tilde{\tau} \rightarrow \tau\tau\tilde{G}$

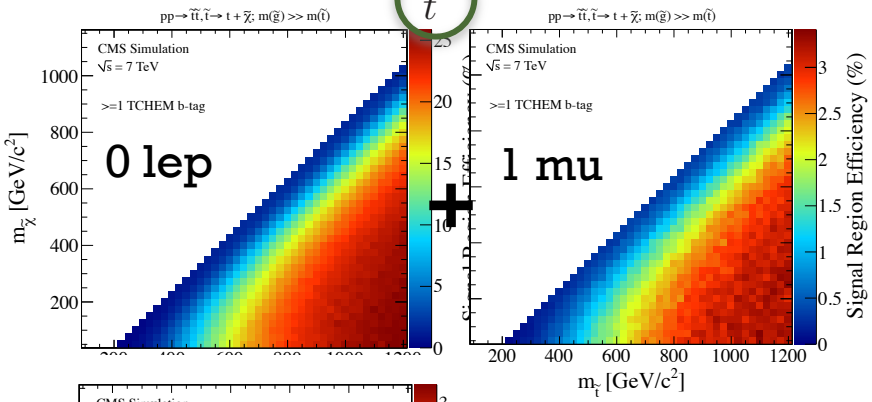
- The existing collection of SMS results covers a significant volume of 'model' space

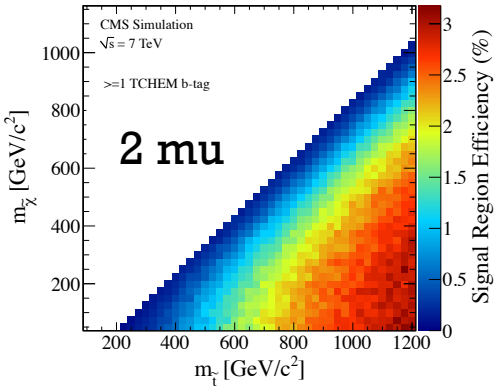
di-stop in multiple final states



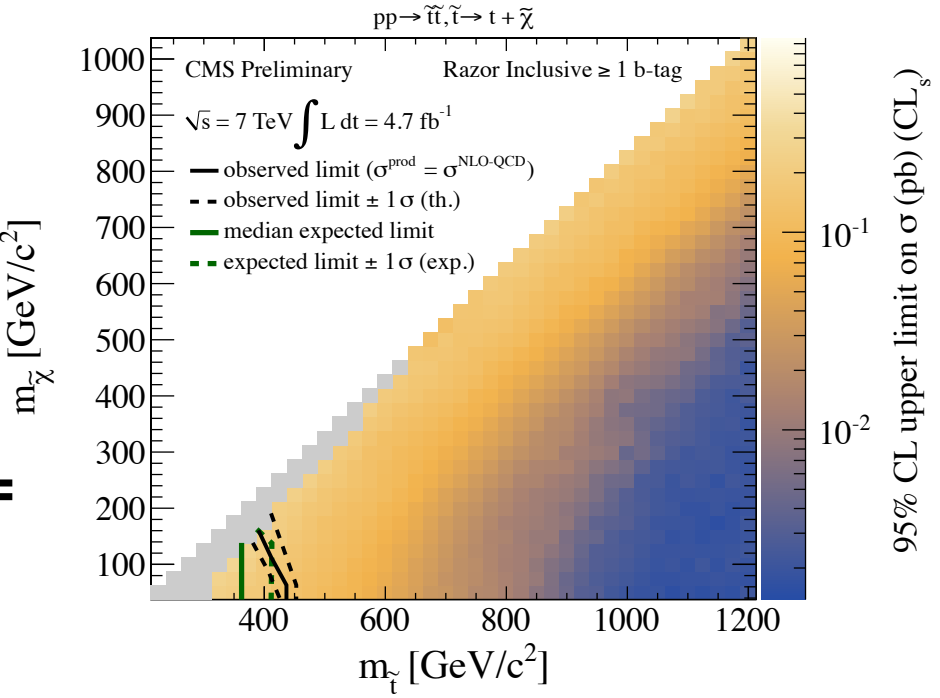
- SMS interpretations don't imply that more than one experimental final state can't be considered simultaneously
- Here, 0, 1 and 2 lepton final states are combined for interpretations in models with SM top quarks coming from di-stop production

CMS-SUS-12-005

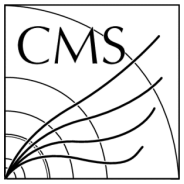




+ other boxes =



See talk by W. Reece for more details on searches using razor variables M_R/R



Outlook (I)

- Simplified models are used to
  - interpret search results over a wide range of 'model' space – spanning different couplings, BR's and mass spectra
  - quantify performance of analyses in a systematic way – identifying complementarities, redundancies and blind spots
- A collection of SMS topologies can be generalized to to other theoretical models
  - SMS's cover many models built to solve hierarchy problem – discrete symmetries result in pair-produced new particles decaying to pairs of weakly interacting particles
  - SMS's provide reference for outside community – along with model efficiency maps and object response functions, theorists can use these results to confront other NP possibilities
- Complete description of CMS SMS effort in CMS-PAS-11-016

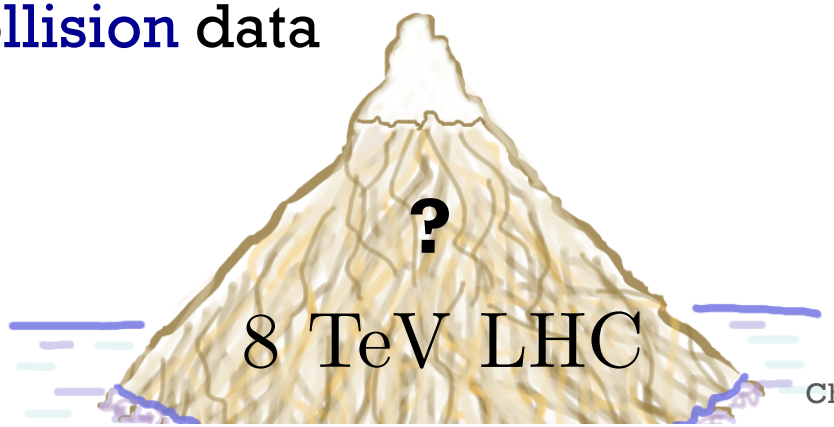
Outlook (II)

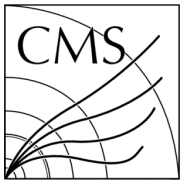
- Still no significant deviations from SM expectations observed – only NULL results

- Many more details about CMS SUSY searches contained in other dedicated ICHEP talks/posters – even more searches and SMS's available on public twiki:

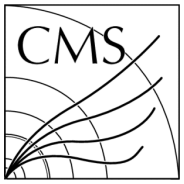
  https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

- STAY TUNED as we continue to map out the space of NP possibilities using an increasing number of SMS's, 7 TeV and now 8 TeV LHC pp collision data





BACK-UP SLIDES



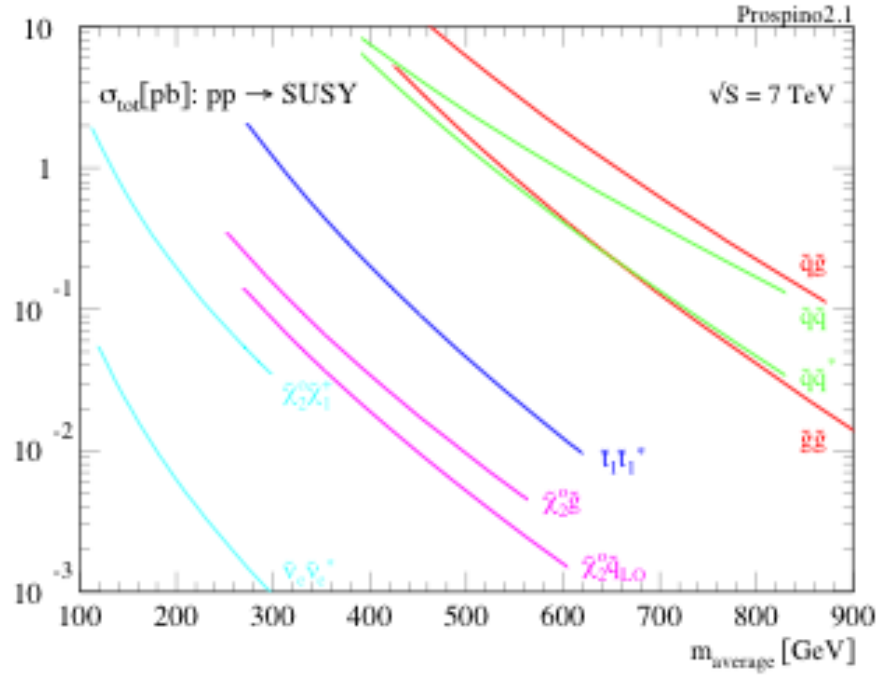
CMS Luminosity

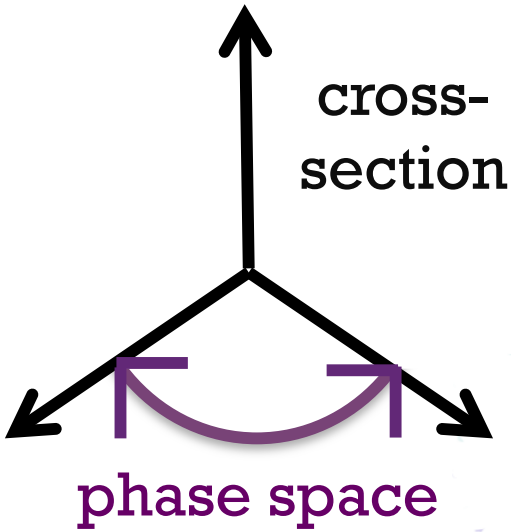
- in the process of precision determination of the luminosity collected by CMS in 2011, a slight time-dependent calibration drift was found in the calorimeter used as a luminometer.
- to remedy this, we developed an independent luminosity determination using the more stable and precise pixel tracker
- preliminary result presented at the LHC Luminosity Days suggests an upward change in the estimated luminosity for 2011 by ~6%, i.e. slightly outside the 1s-band of our original estimate of the luminosity uncertainty
  - the corresponding change for the low-luminosity part of the run (2011A), which is the basis of our new and published precision measurements, is ~3.5%, well within the quoted systematics
- we are finalizing determination of the new luminosity measurement, with significantly better precision
- the anticipated change has a very minor effect on our preliminary results and no visible change in published limits
- instability does not affect the 2010 luminosity determination, as it only affects high-luminosity running

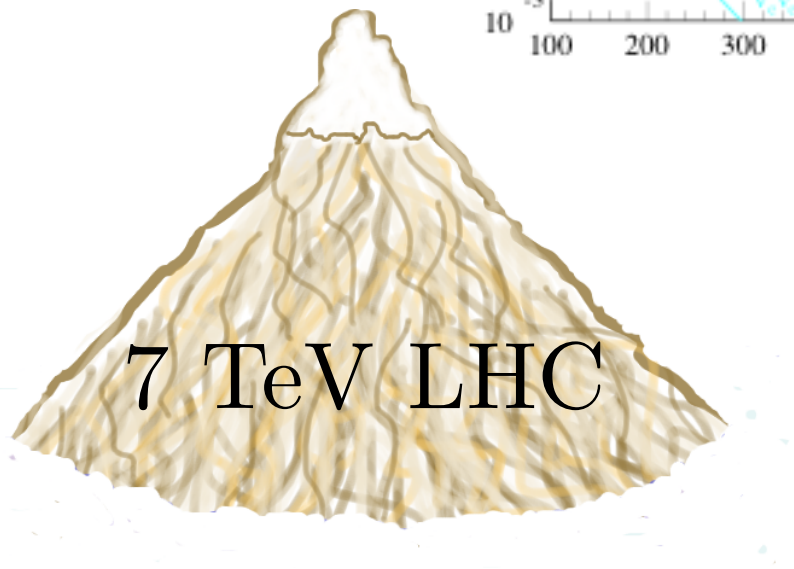
7 TeV LHC Phase Space

The Energy Frontier:

- Large $\sqrt{s}$ introduces the possibility of producing heavier sparticles, at higher rates
- We search in corresponding regions of phase space – often high mass / transverse momenta



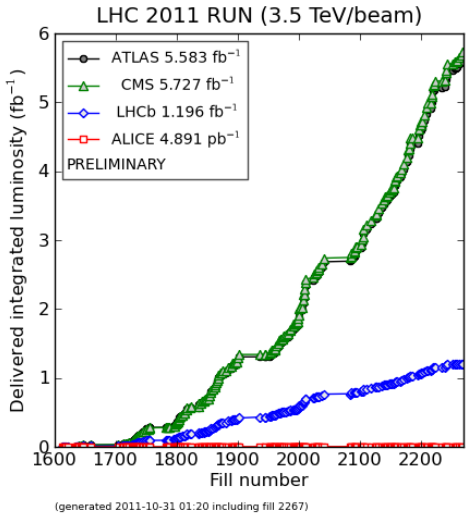




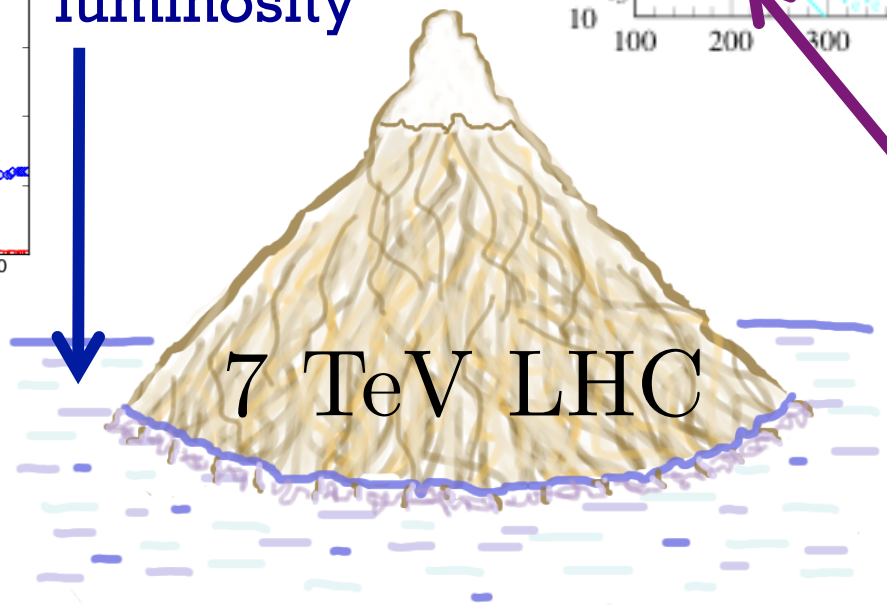
7 TeV LHC Phase Space @ 5 fb^{-1}

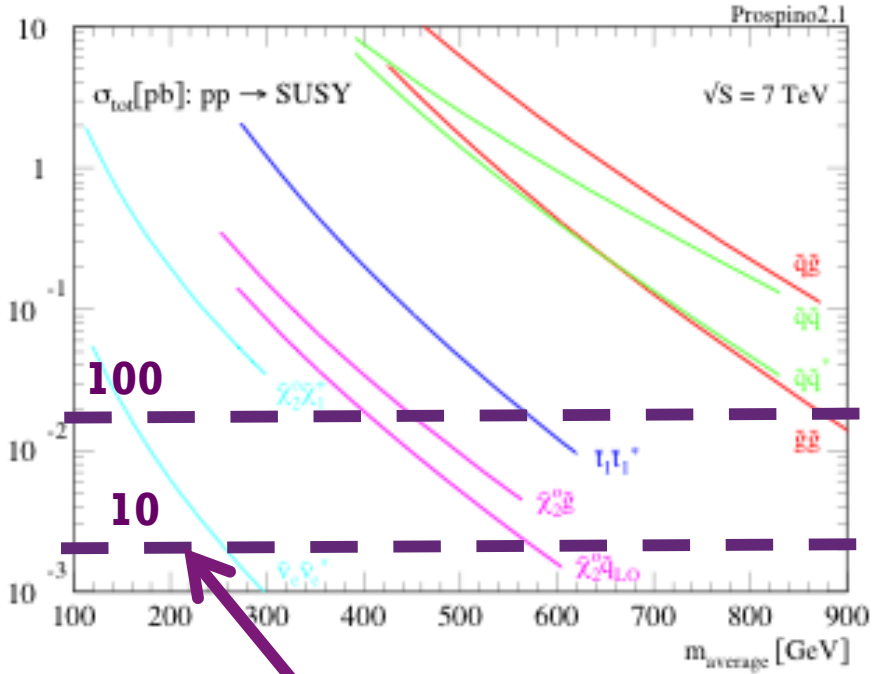
The Intensity Frontier:

- Integrated luminosity dictates how much phase space we can explore – trigger-rate limitations lead to selected phase-space trade-offs



integrated luminosity





10 events produced / 5 fb^{-1}

Searching for deviations

- Nearby regions of phase space are often necessary to contextualize our observations in signal sensitive regions – sidebands, control regions, …
- Many different ways to constrain our SM expectations:
  - sidebands in kinematic variables
  - inversion/loosening of object ID requirements
  - exploiting symmetries of the SM [ex. γ +jets ➔ Z+jets]
  - control samples of leptons/b+jets/photons and even particular kinematic configurations