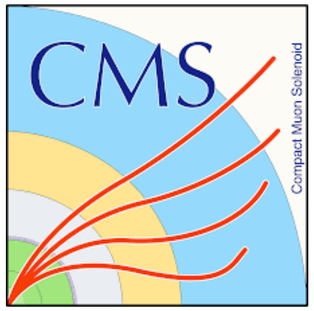
Phenomenological MSSM Interpretation of CMS Run 2 Searches

PHENO 2026

University of Pittsburgh, 11-13th May 2026

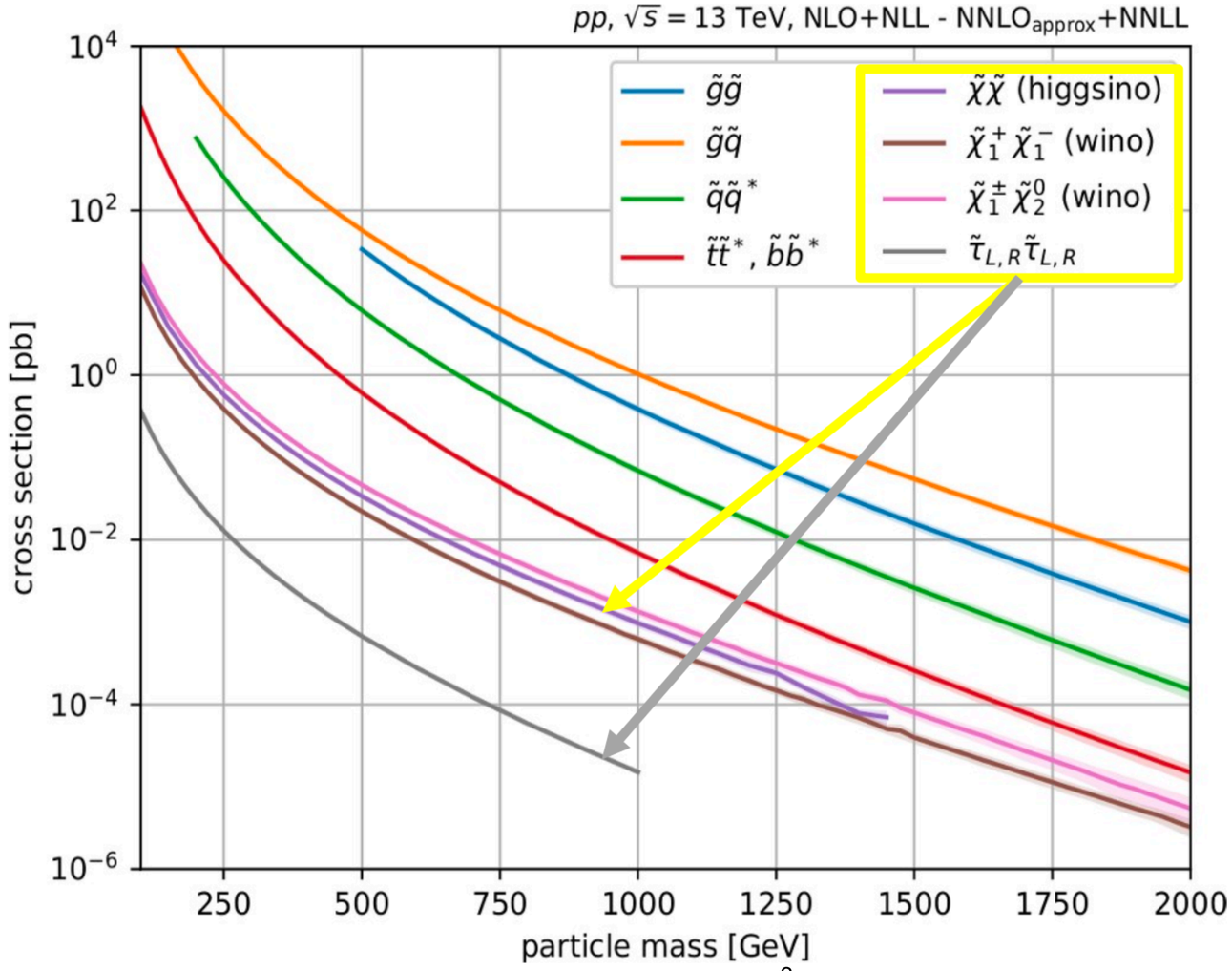
Aleesha KT on behalf of the CMS Collaboration

Carnegie Mellon University



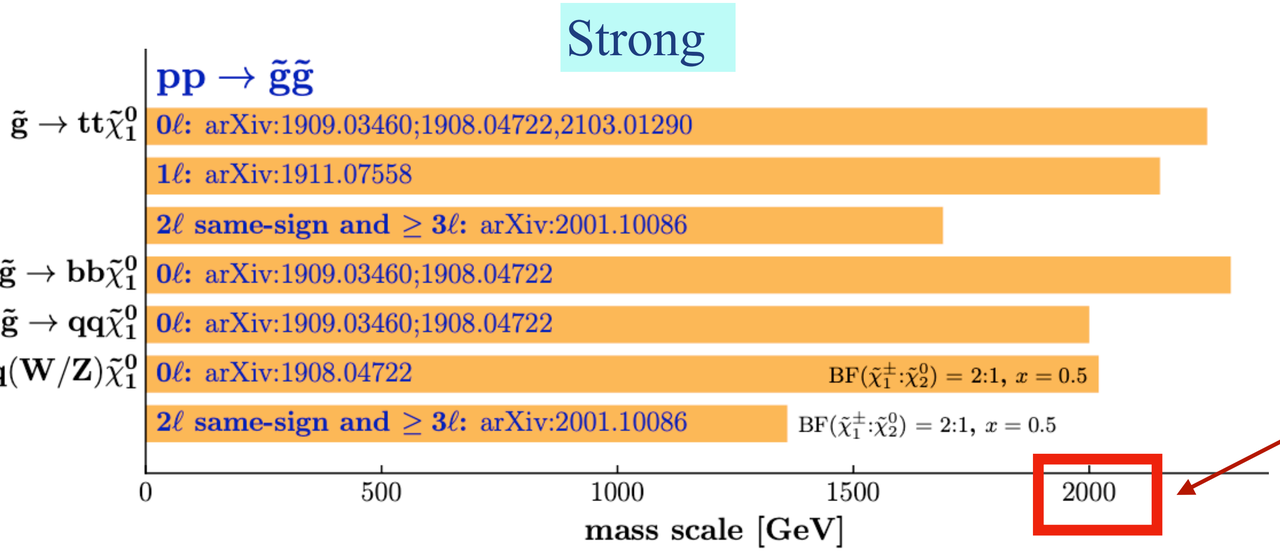
CMS SUSY SEARCHES

- SUSY addresses key SM problems : hierarchy problem, dark matter.
- Previous CMS searches target both strong (gluino, squark) and electroweak (chargino, neutralino, slepton) production.



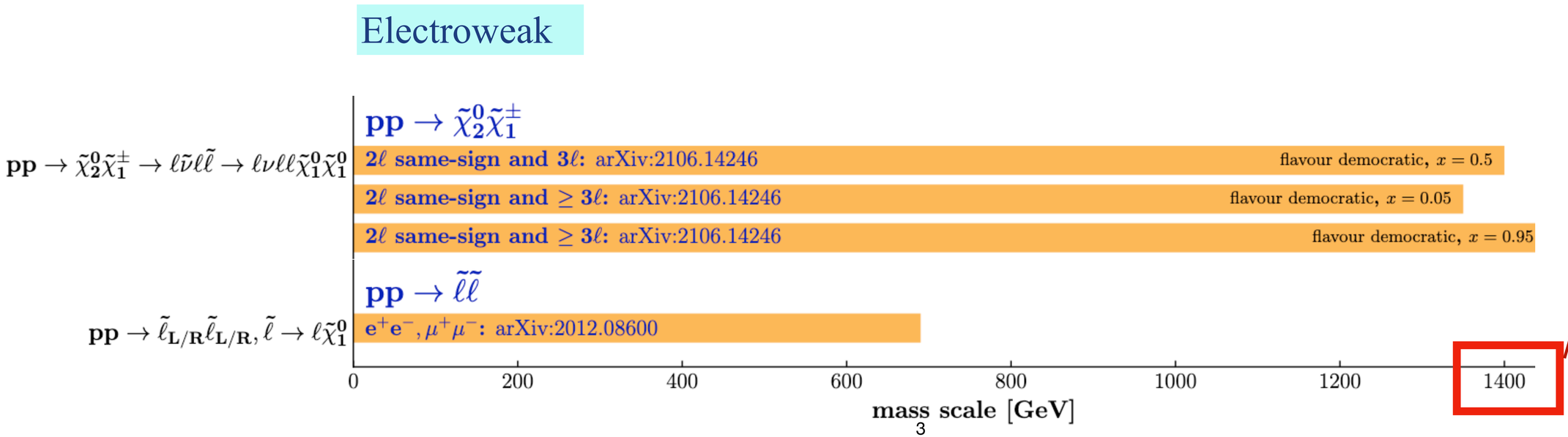
Heavy sparticle -Low xsec

CMS SUSY SEARCHES



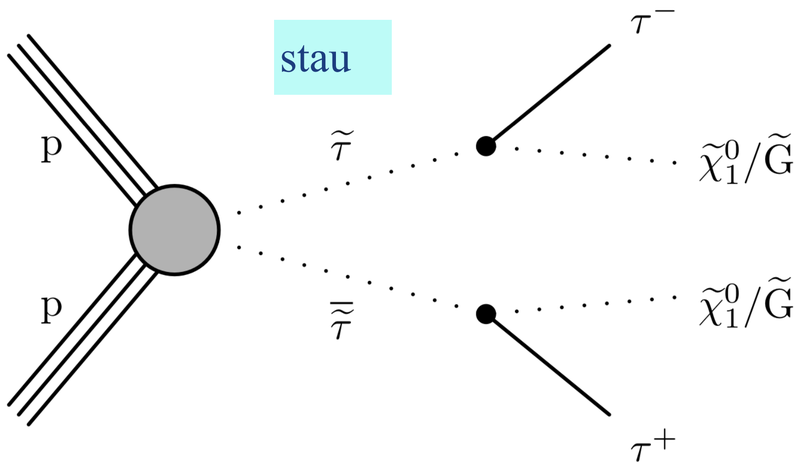
Gluinos excluded upto 2.3 TeV

Weaker bounds on electroweakinos.



Simplified Models (SMS)

- Idealized SUSY scenario ~ 1-3 free parameters.
- Easier to interpret search sensitivity

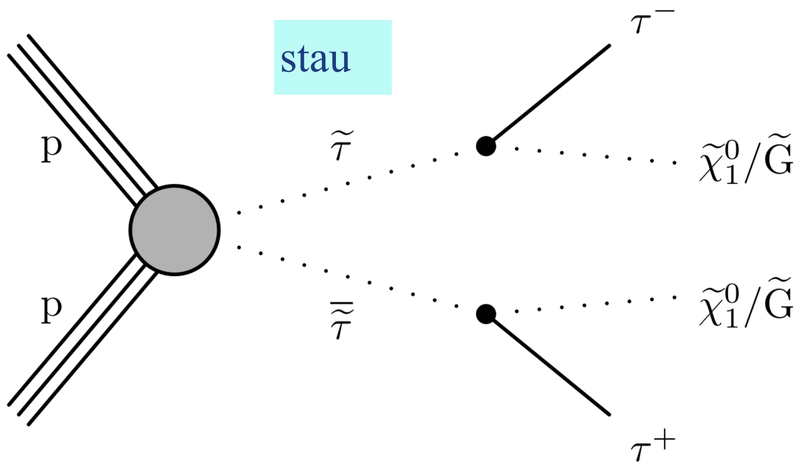


Targets 1 production mechanism
1 decay mode

4

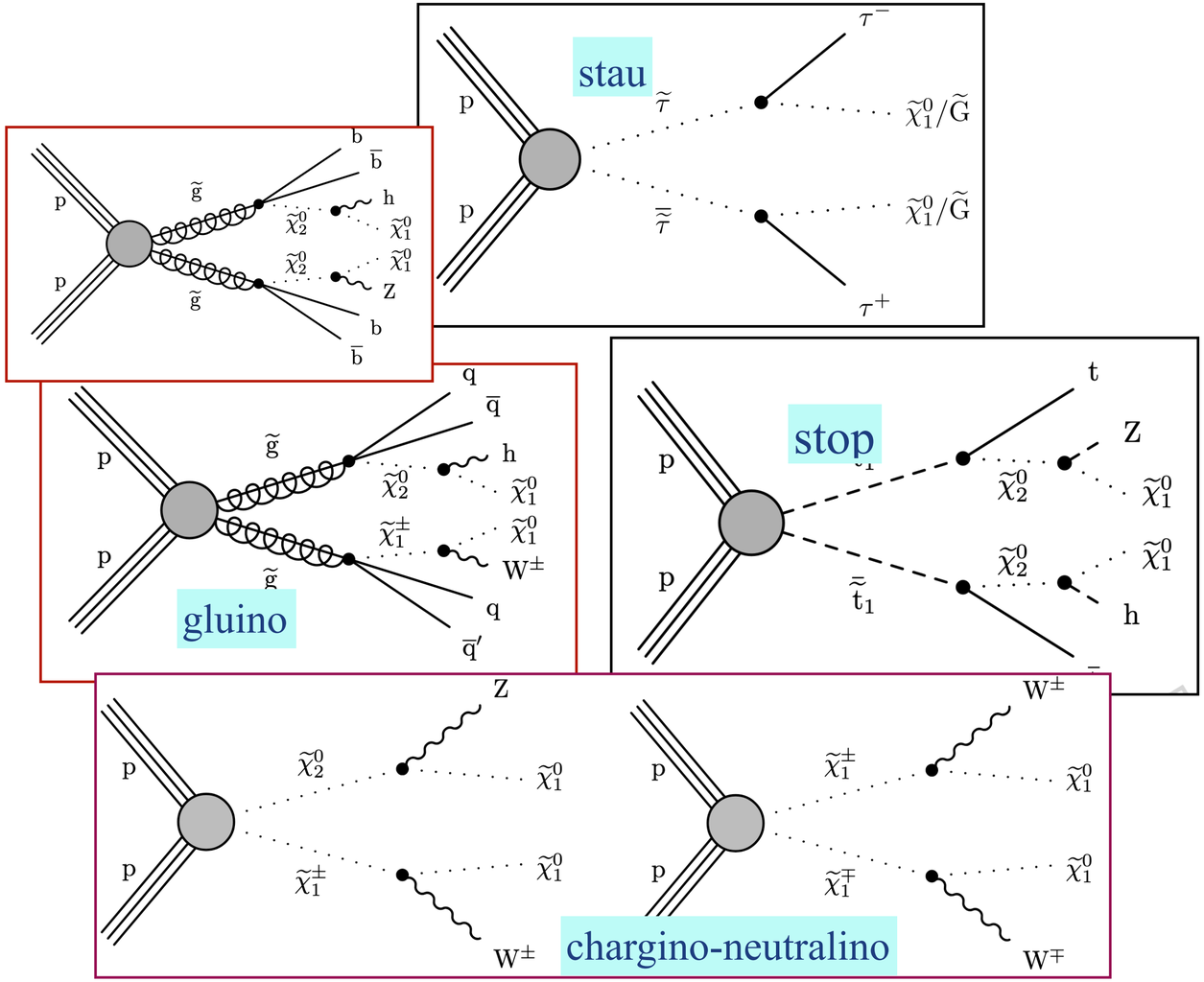
Simplified Models (SMS)

- Idealized SUSY scenario ~ 1-3 free parameters.
- Easier to interpret search sensitivity



Targets 1 production mechanism
1 decay mode

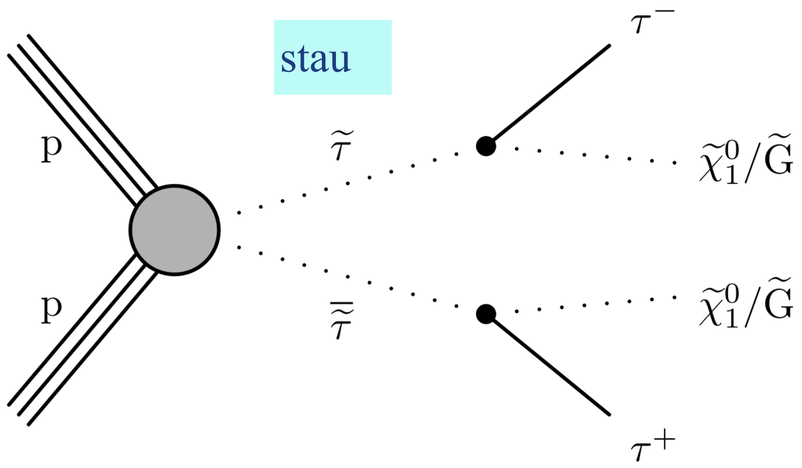
Multiple particle spectra not possible



5

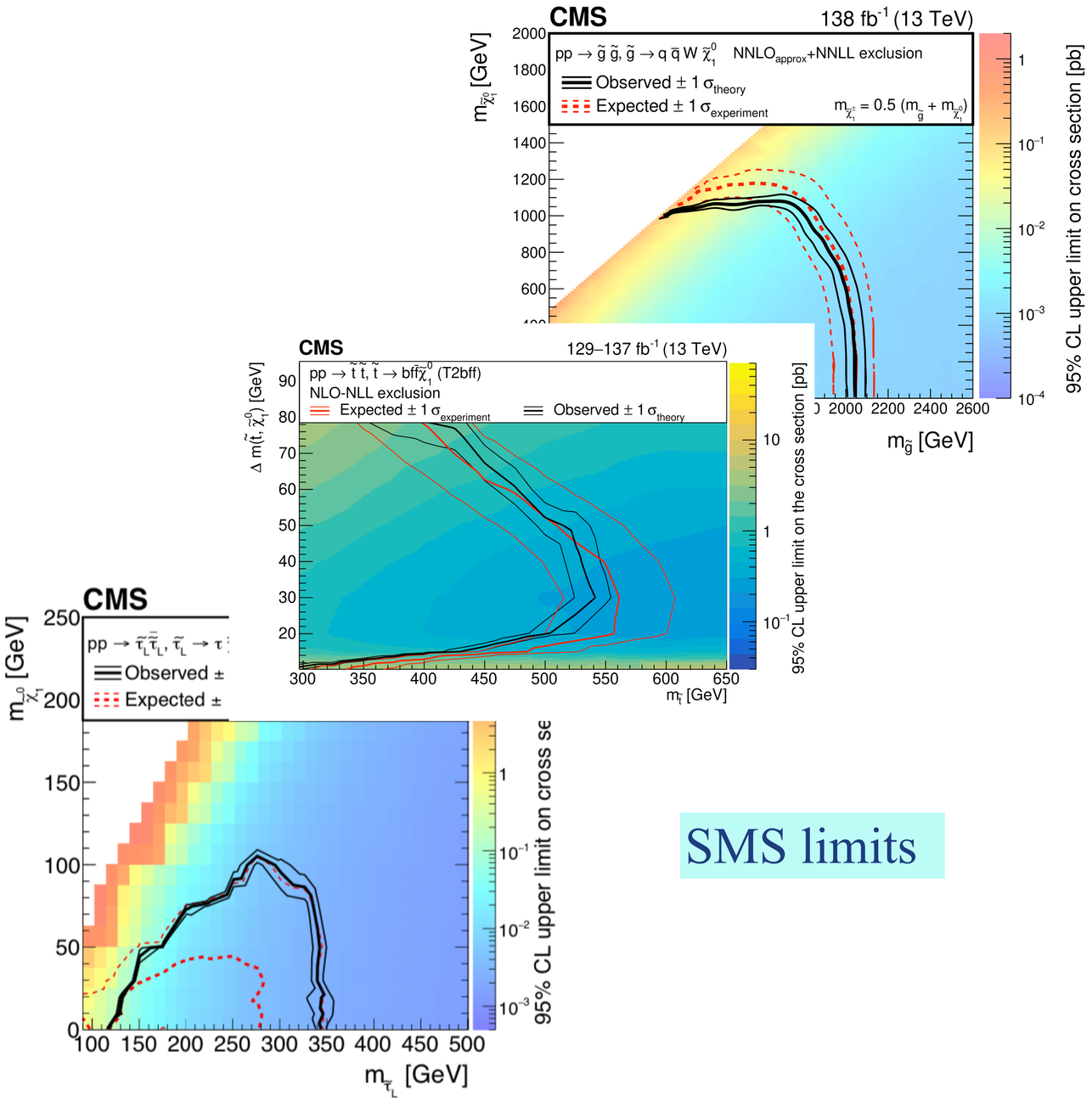
Simplified Models (SMS)

- Idealized SUSY scenario ~ 1-3 free parameters.
- Easier to interpret search sensitivity



Targets 1 production mechanism
1 decay mode

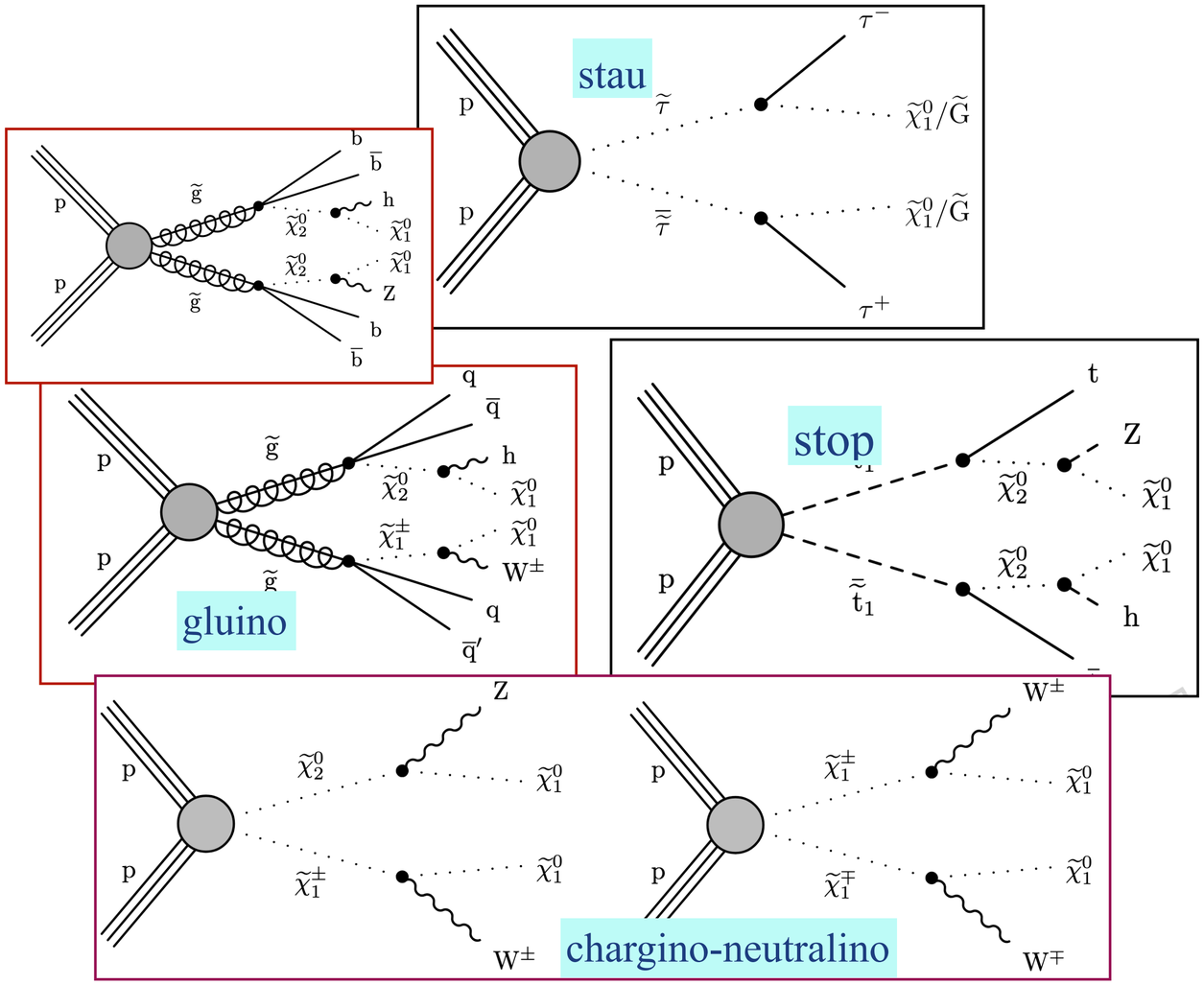
- Drawback: SMS limits may not hold in realistic SUSY scenarios



SMS limits

Phenomenological MSSM (pMSSM)

Multiple particle spectra



- 19- dimensional realization of the MSSM
- Assumes
  - R-parity conservation
  - Weak-scale SUSY
- Captures most phenomenological features of the MSSM

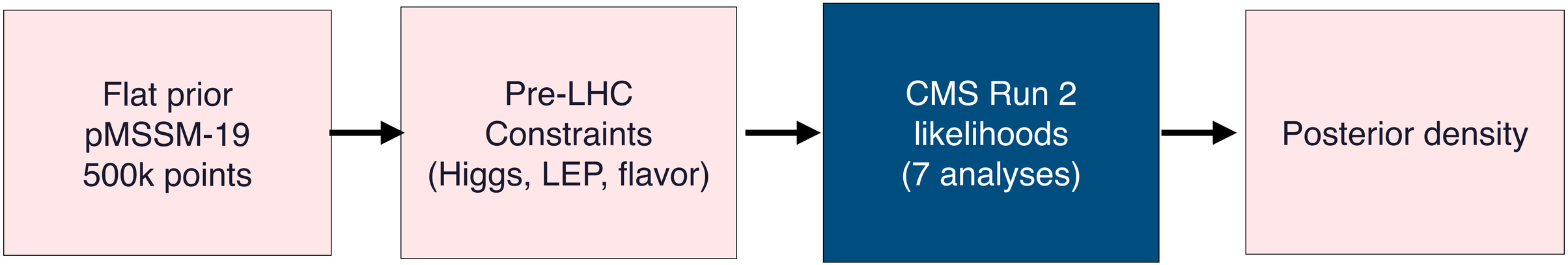
Goal

Re-run the CMS searches originally interpreted in SMS paradigm for each pMSSM model point

Motivation

- Assess how current CMS data constrain the MSSM using pMSSM as a proxy.
- Global Bayesian inference over the pMSSM-19 parameter space

How to reinterpret?



CMS Inputs to the pMSSM combination

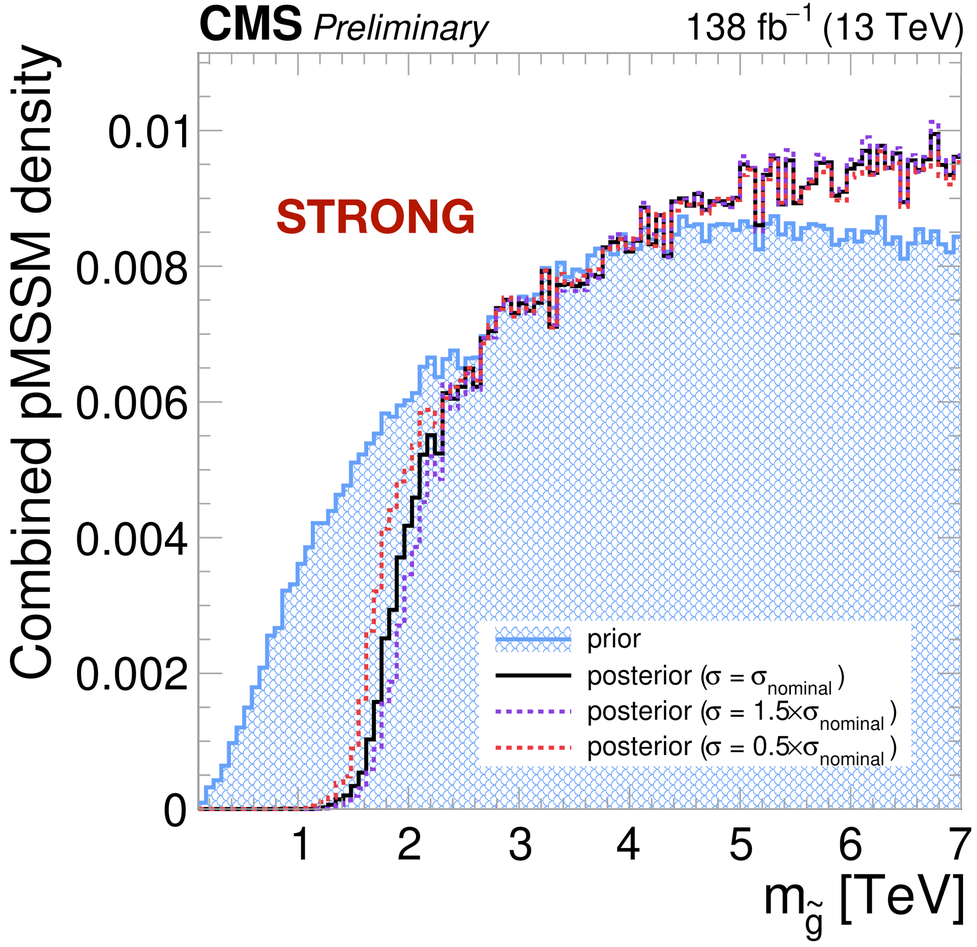
Analysis	Signature	Sensitivity
SUS-18-004 , **SUS-24-003***	Soft Leptons	Compressed EWKinos , **Higgsinos***
SUS-19-006	Jets + MET	Strong production (gluino/squark)
SUS-20-001, **SUS-21-001***	SFOS dileptons	Neutralino decays, **stau***
SUS-21-006	Disappearing tracks	Compressed charginos
SUS-21-007	Single leptons + $\Delta\phi$	Compressed strong

July 2025 update*

Complementary coverage of strong, EWK, and compressed SUSY phase space

What impact does CMS data make?

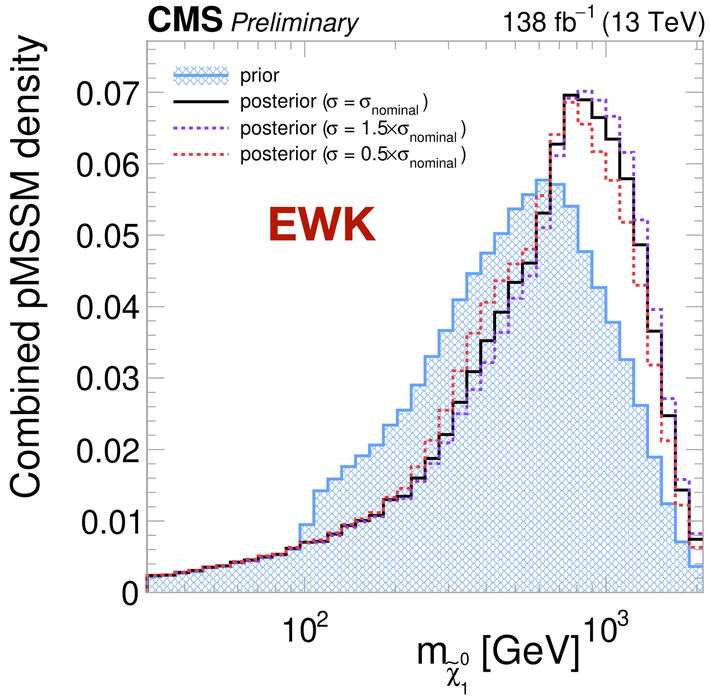
Prior and posterior marginalized distributions -> shows how CMS data updates our knowledge of the MSSM parameter space

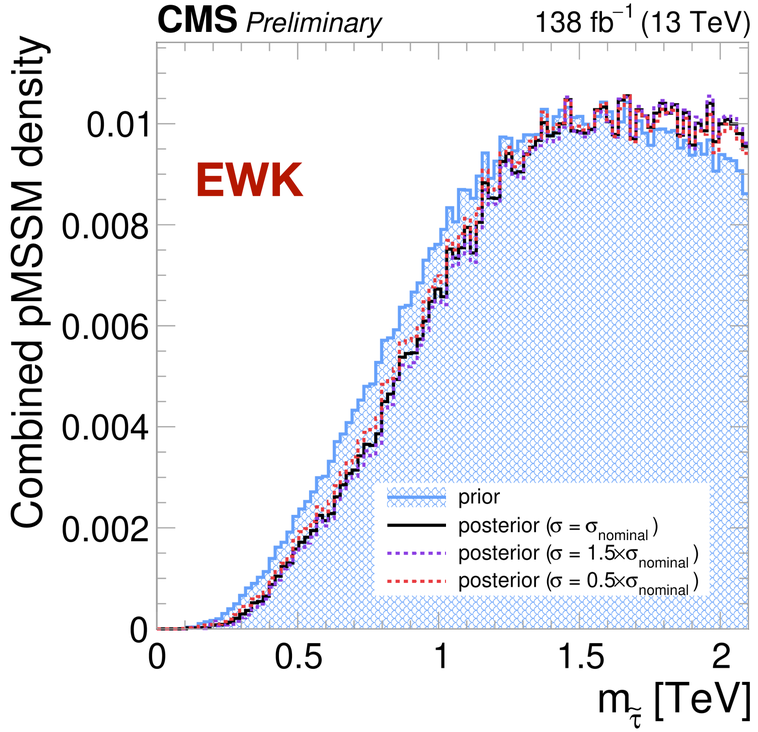


- CMS data heavily disfavors light gluinos
- Direct production of gluinos above 3 TeV is beyond reach of LHC—> CMS has no sensitivity here
- Posterior rises above prior beyond 5 TeV ~ Bayesian consequence of normalization

What impact does CMS data make?

Prior and posterior marginalized distributions -> shows how CMS data updates our knowledge of the MSSM parameter space





- No range of LSP mass is strongly disfavored .
- Denisty at masses below 100 GeV is unchanged by CMS data

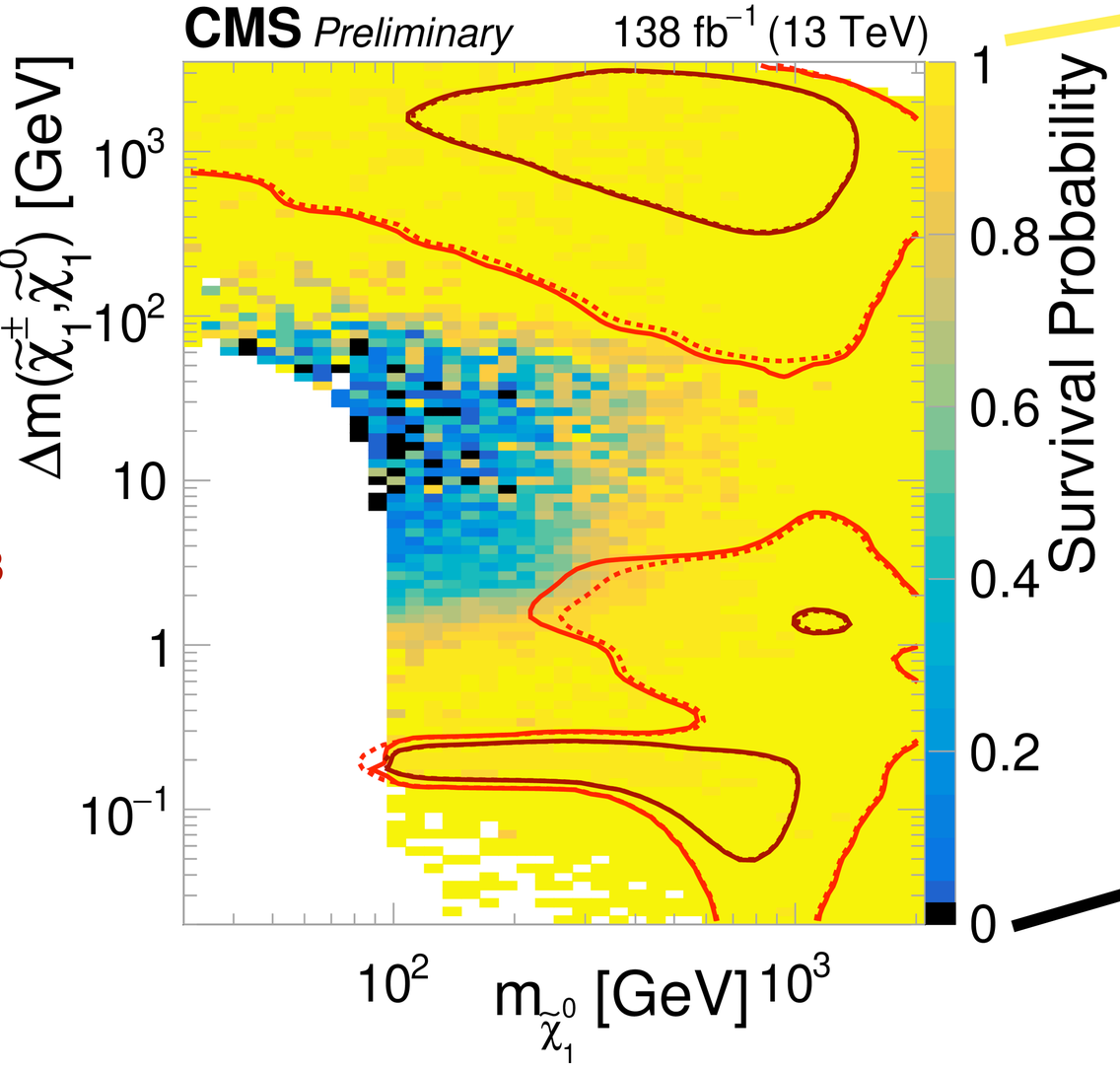
- Stau masses below 1 TeV mildly disfavored , not completely suprressed

stau sector remains largely unconstrained

What fraction of pMSSM survives?

Survival Probability —> measure of parameter space that remains after inclusion of CMS results

SUS-18-004 + SUS+24-003



High survival
CMS search insensitive here

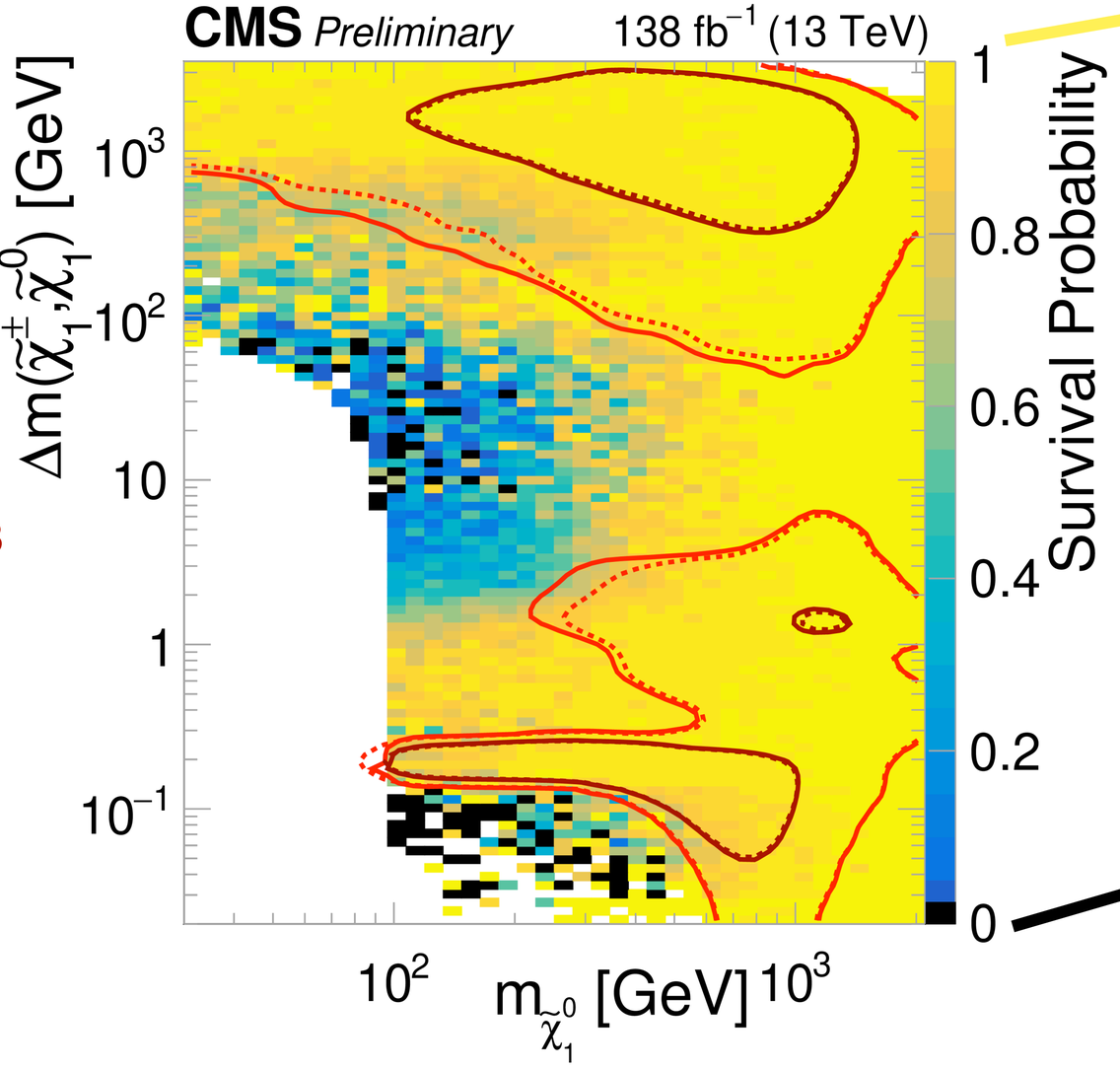
Zero survival
Fully Excluded

Nominal CMS prior

What fraction of pMSSM survives?

Survival Probability —> measure of parameter space that remains after inclusion of CMS results

SUS-18-004 + SUS+24-003 + SUS-20-001 + SUS-21-001



High survival
CMS search insensitive here

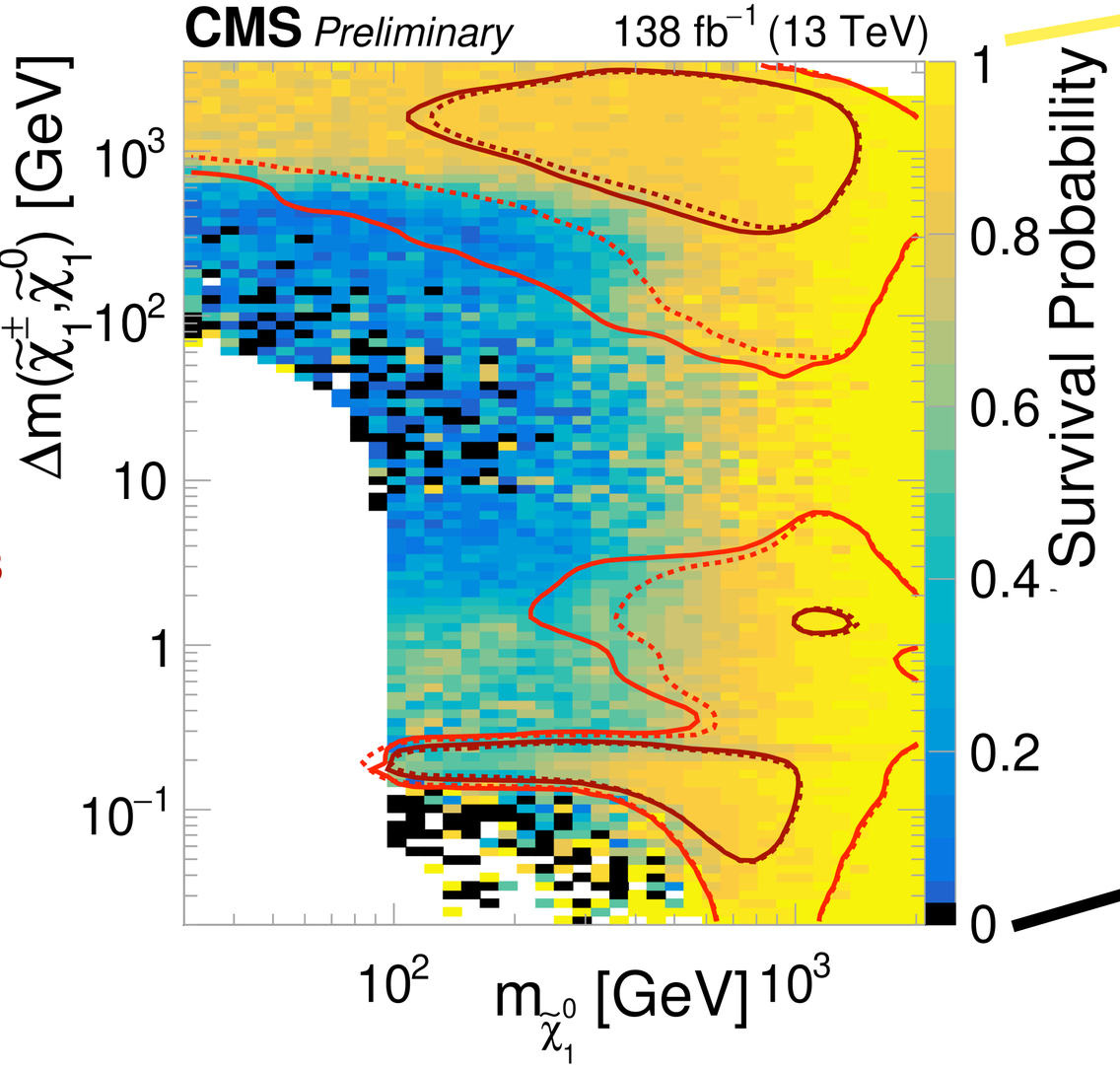
Zero survival
Fully Excluded

Nominal CMS prior

What fraction of pMSSM survives?

Survival Probability —> measure of parameter space that remains after inclusion of CMS results

SUS-18-004 + SUS+24-003 + SUS-20-001 + SUS-21-001 + SUS-21-007



High survival
CMS search insensitive here

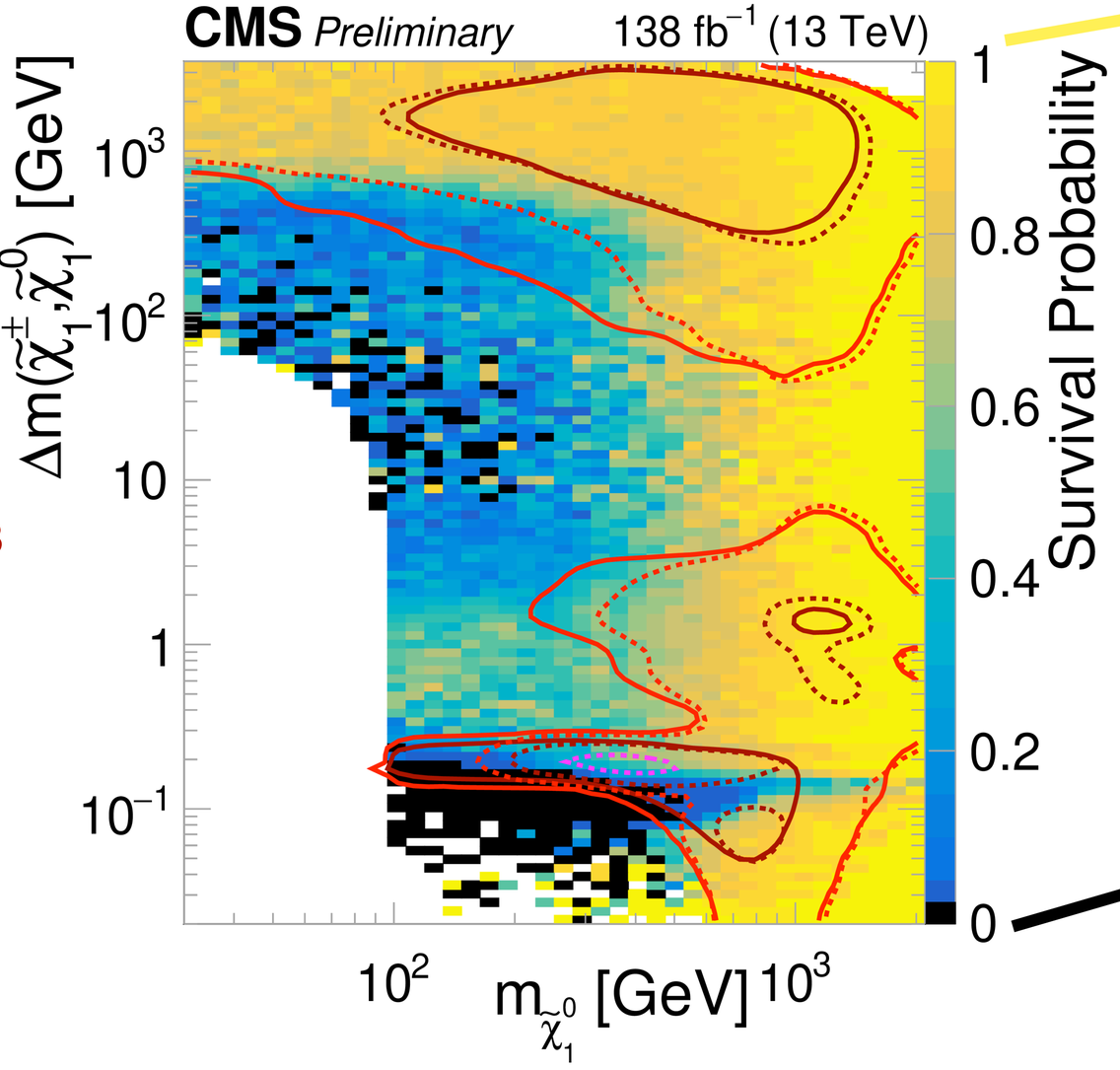
Zero survival
Fully Excluded

Nominal CMS prior

What fraction of pMSSM survives?

Survival Probability —> measure of parameter space that remains after inclusion of CMS results

SUS-18-004 + SUS+24-003 + SUS-20-001 + SUS-21-001 + SUS-21-007+ SUS-21-006



High survival
CMS search insensitive here

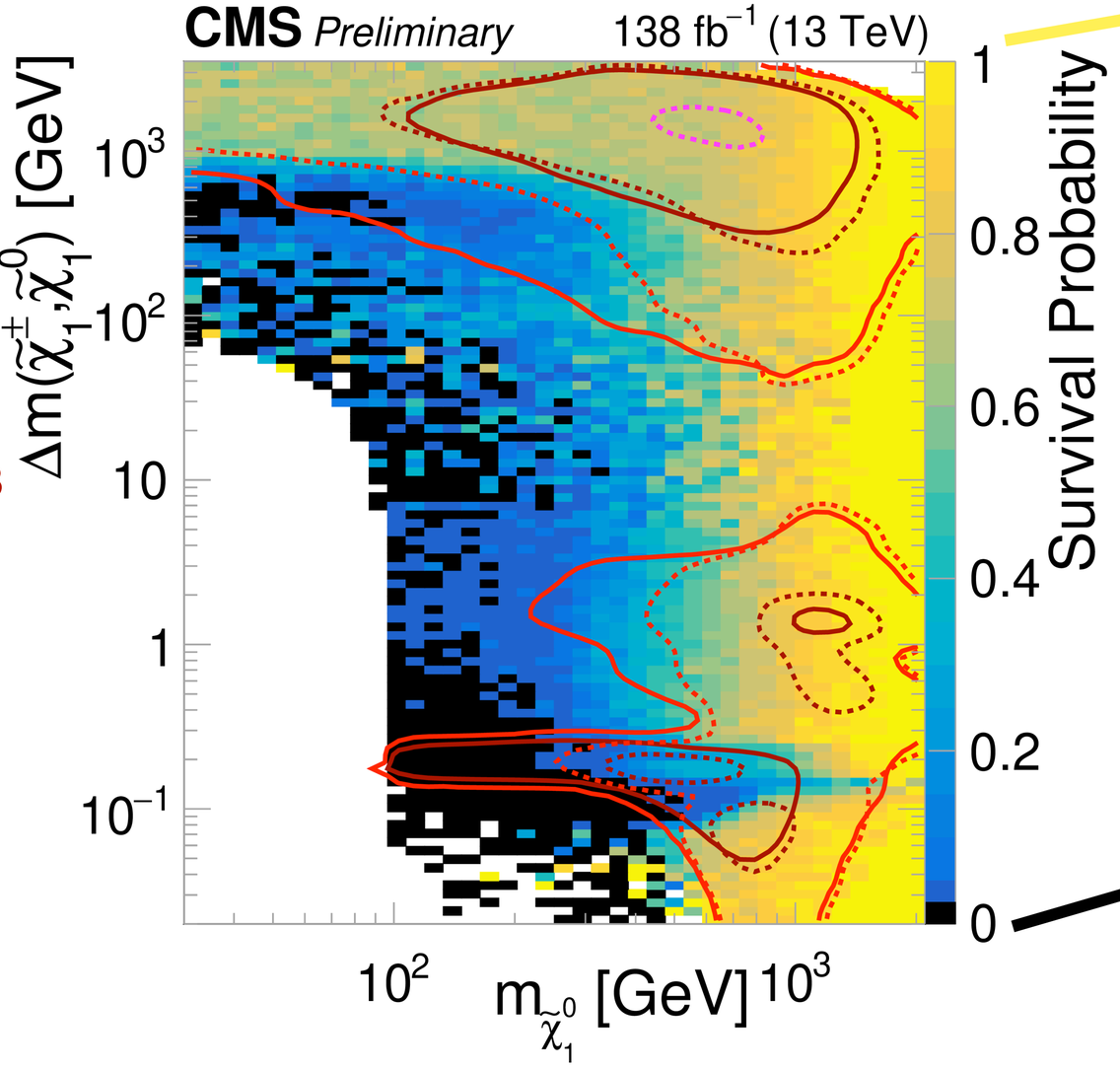
Zero survival
Fully Excluded

Nominal CMS prior

What fraction of pMSSM survives?

Survival Probability —> measure of parameter space that remains after inclusion of CMS results

SUS-18-004 + SUS+24-003 + SUS-20-001 + SUS-21-001 + SUS-21-007+ SUS-21-006 + SUS-19-006



High survival
CMS search insensitive here

Zero survival
Fully Excluded

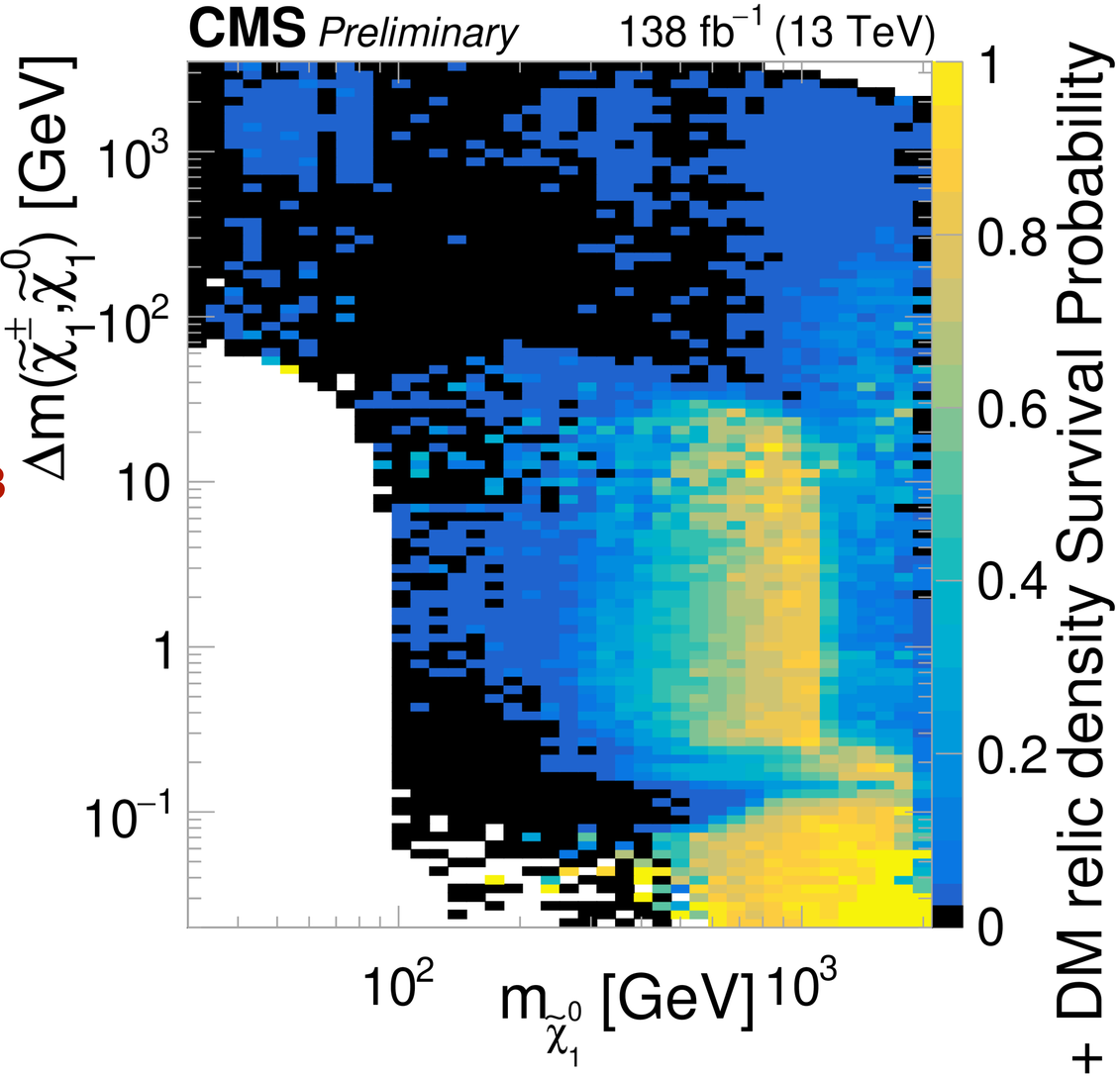
Nominal CMS prior

What fraction of pMSSM survives?

Prior constrained
by DM-related data

SUS-18-004 + SUS+24-003 + SUS-20-001 + SUS-21-001 + SUS-21-007+ SUS-21-006 + SUS-19-006

+ DM Constraint —>
Predicted relic density to be less than 110% of Planck measurement

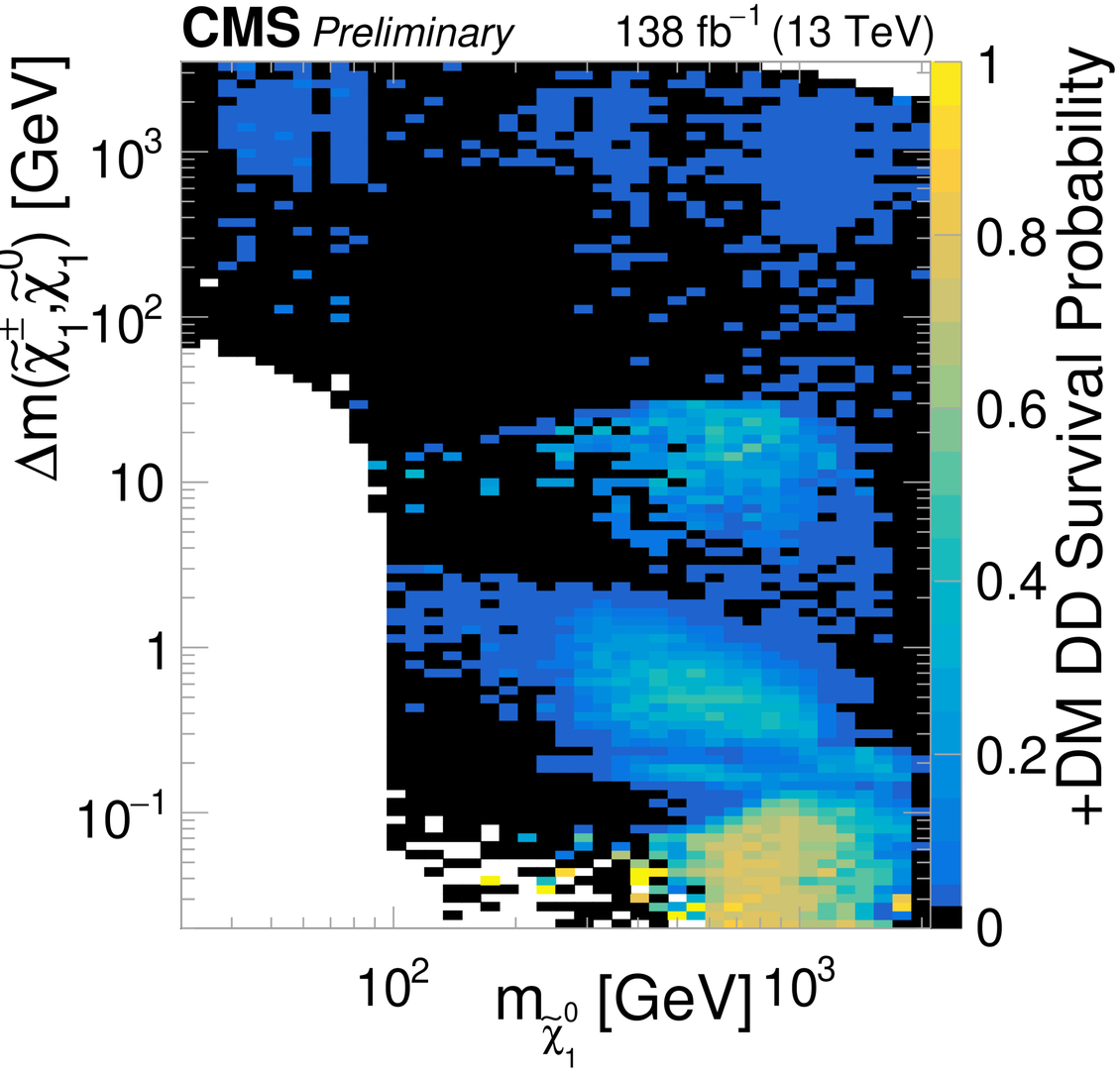


What fraction of pMSSM survives?

Prior constrained
by DM-related data

SUS-18-004 + SUS+24-003
+ SUS-20-001 +
SUS-21-001 +
SUS-21-007+ SUS-21-006
+ SUS-19-006

\+ DM constraint
\+ from DD



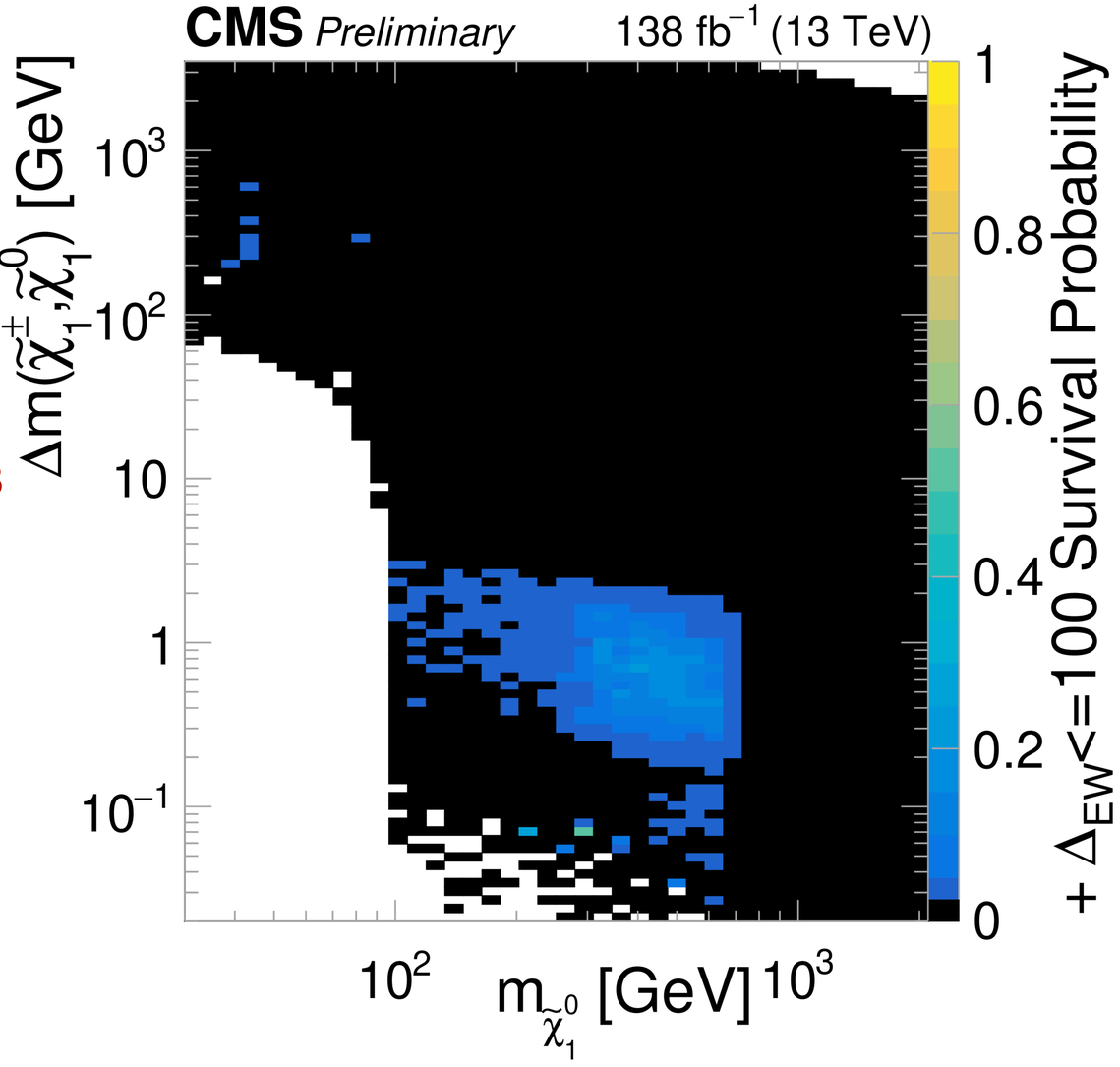
Model cannot be ruled out at 95% CL by Direct Detection experiments (DD)

What remains post Run 2?

Prior constrained
by DM-related data

SUS-18-004 + SUS+24-003 + SUS-20-001 + SUS-21-001 + SUS-21-007+ SUS-21-006 + SUS-19-006

\+ DM constraints
\+ Naturalness criterion



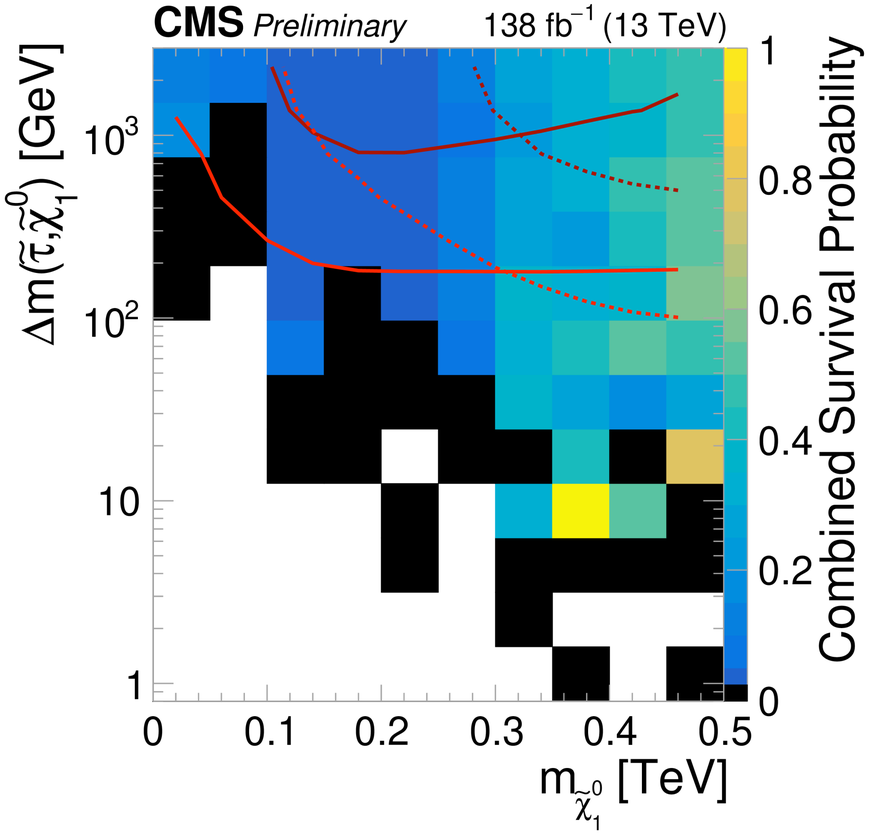
Concentrates at neutralino mass ~ 100-400 GeV with light Higgsino-like spectrum

What's Next ?

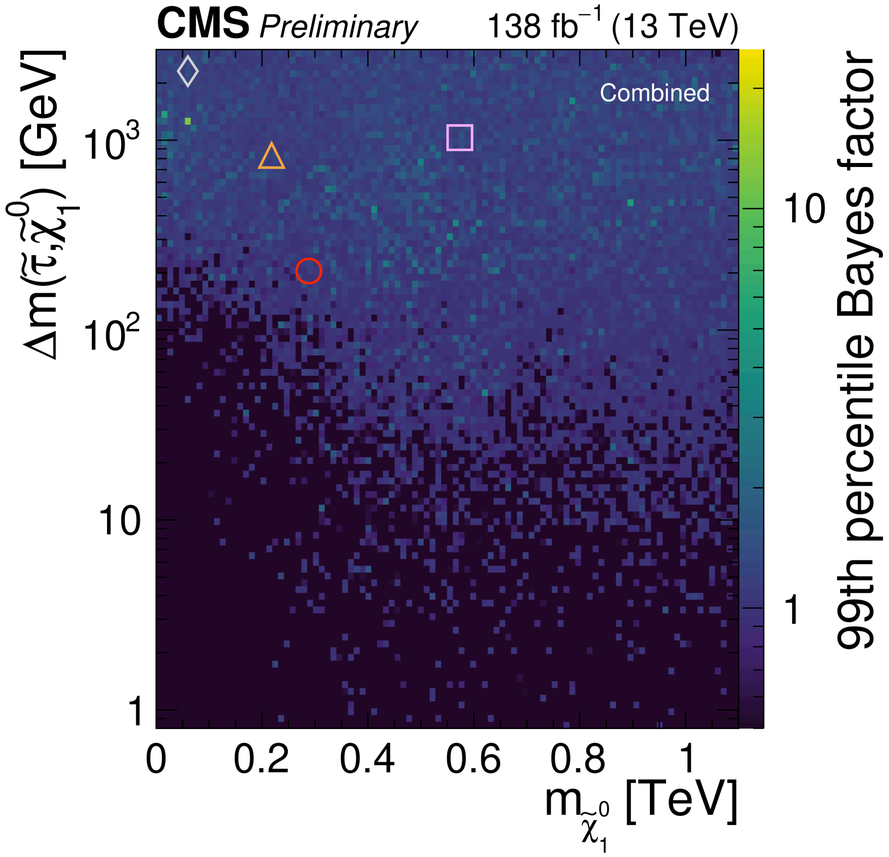
- No single search covers the full pMSSM phase space
- Combined limit excludes regions that would otherwise survive when analyses are considered independently, exploiting complementary sensitivities across the strong, EWK, and stau sectors
- Premature to conclude weak-scale SUSY is on the verge of exclusion
- Stau sector in pMSSM is wide open post - Run 2
- Active Run 3 search for direct stau production

Where to focus?

stau sector remains largely unconstrained



Nominal CMS prior + DM constraint + Naturalness criterion



- Bayes factor of the most data-consistent model point in each bin
- Reveals the phase-space regions that align most closely with the data —> indicates regions of interest for future studies