Electroweak SUSY in Leptonic Final States with the CMS Detector

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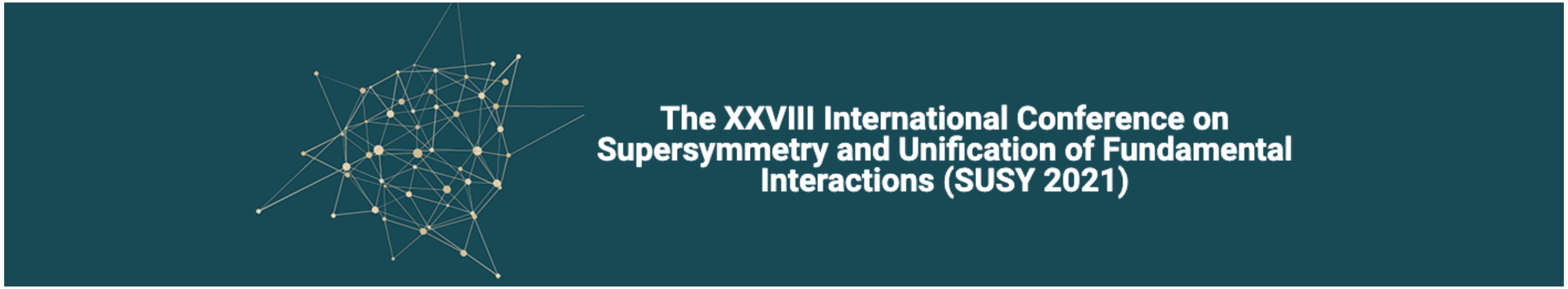
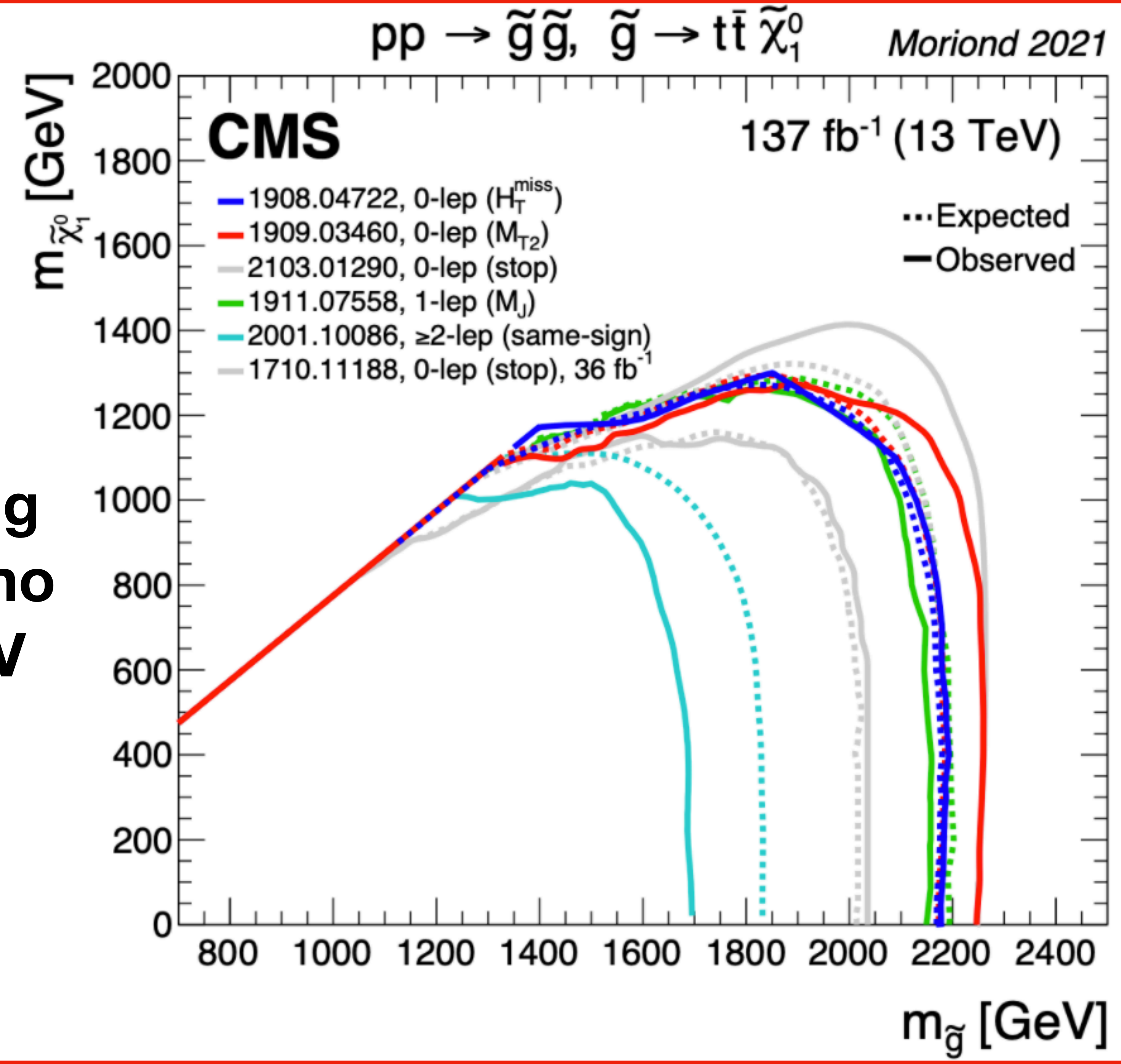
on behalf of the CMS Collaboration

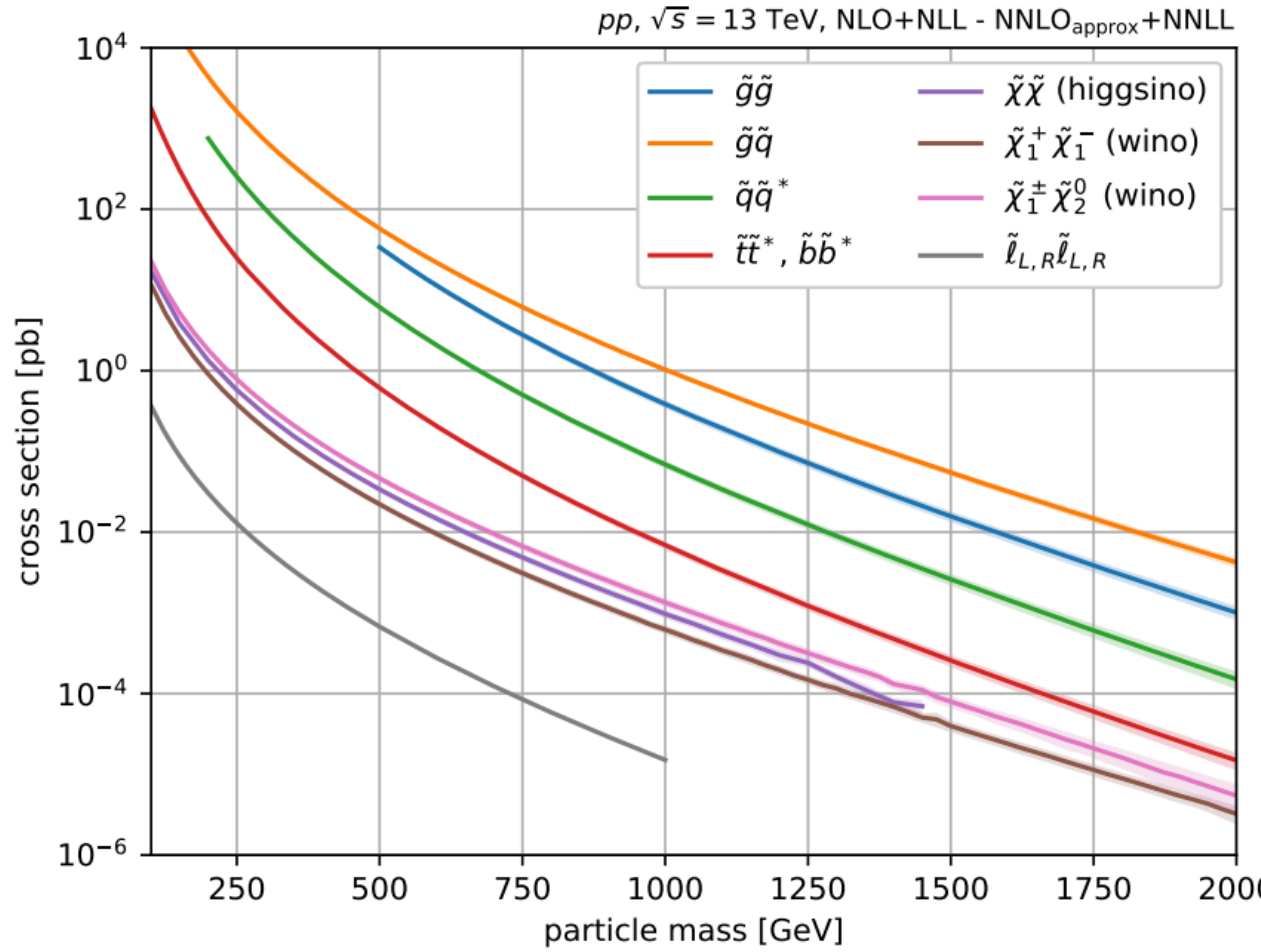


Motivation

- Extensive exclusion limits on strongly interactive superpartners→too heavy to be produced at LHC? Mass spectra too compressed to be observed?
- EWK production of SUSY particles has lower x-secs, lower exclusion limits
  - May still be observable at LHC→Interesting method to search for SUSY
- **Searches for direct production of charginos/neutralinos, which decay to SM particles + MET from LSPs**

Searches for strongly-interacting SUSY exclude gluino mass up to 2.2 TeV





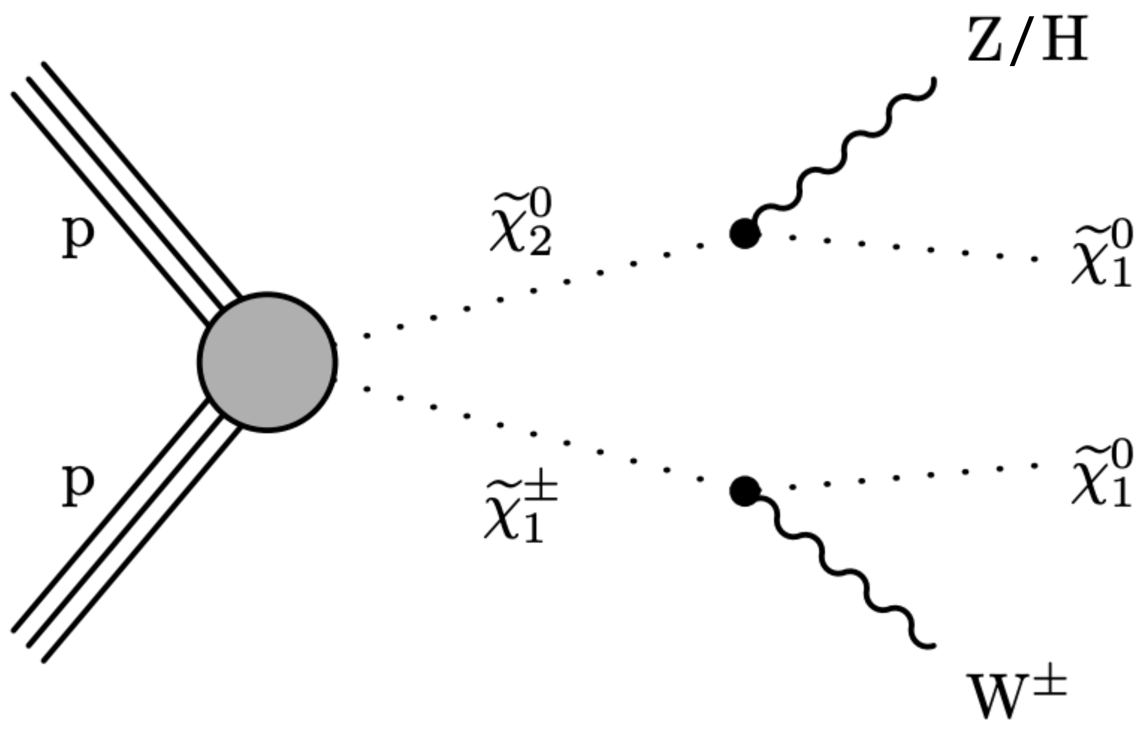
While EWK cross sections are lower, large Run2 dataset allows for searches probing EWK SUSY

SS + Multilepton

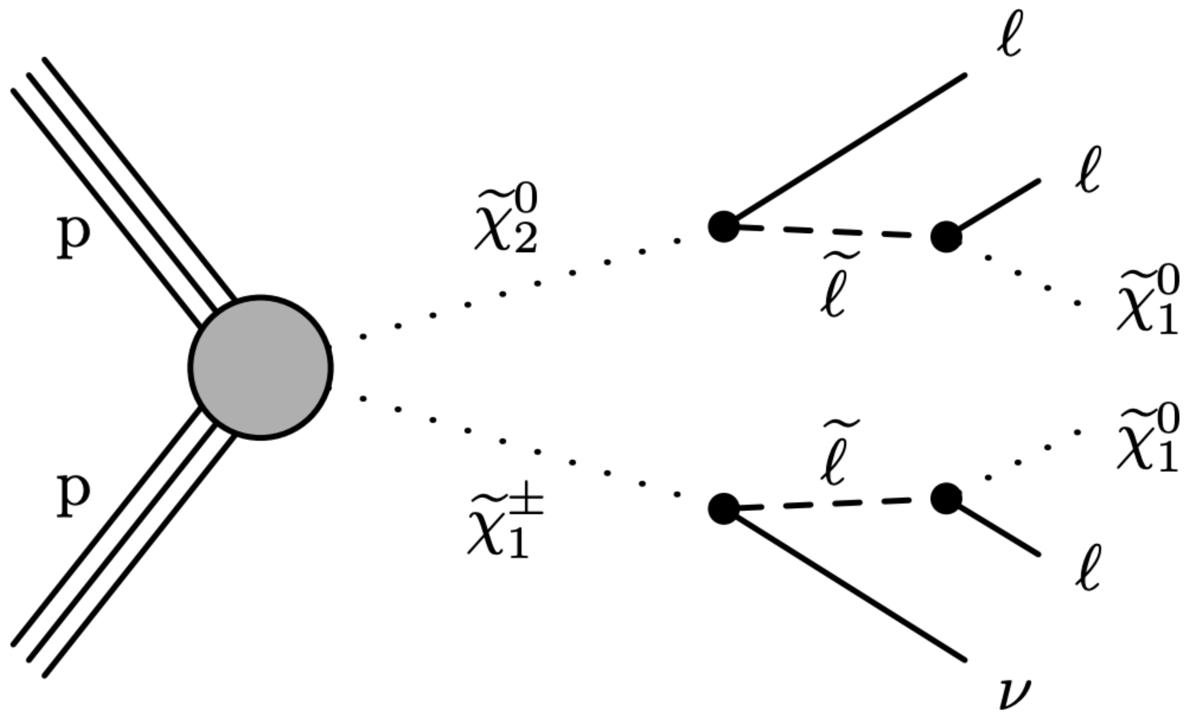
arXiv: 2106.14246

- Consider **SS dilepton final states** and **events with 3/4 leptons** (up to 2 hadronic taus)
- Target 3 simplified models:
  - Chargino/neutralino pair production with direct decay
  - Light sleptons which decay to LSP
  - Near massless gravitino as LSP (GMSB)
- Search sensitivity strengthened by use of **parametric neural networks**

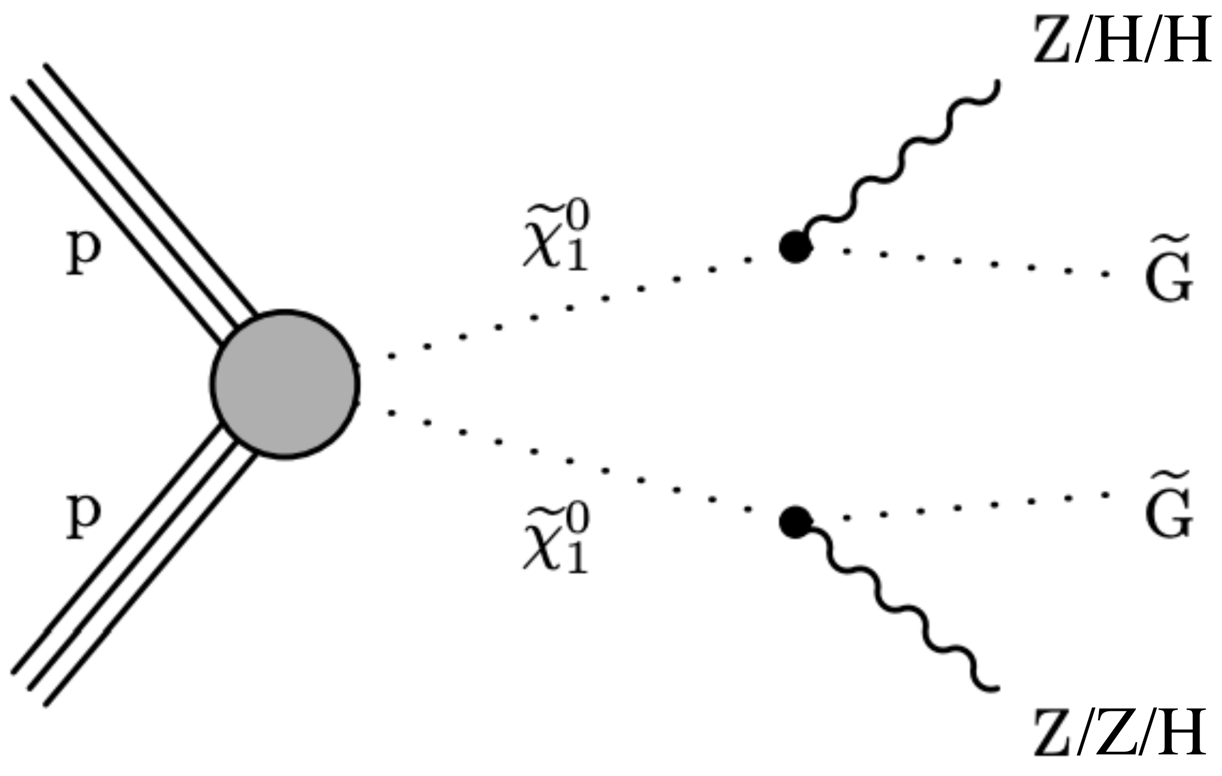
Model with heavy sleptons



Model with light sleptons

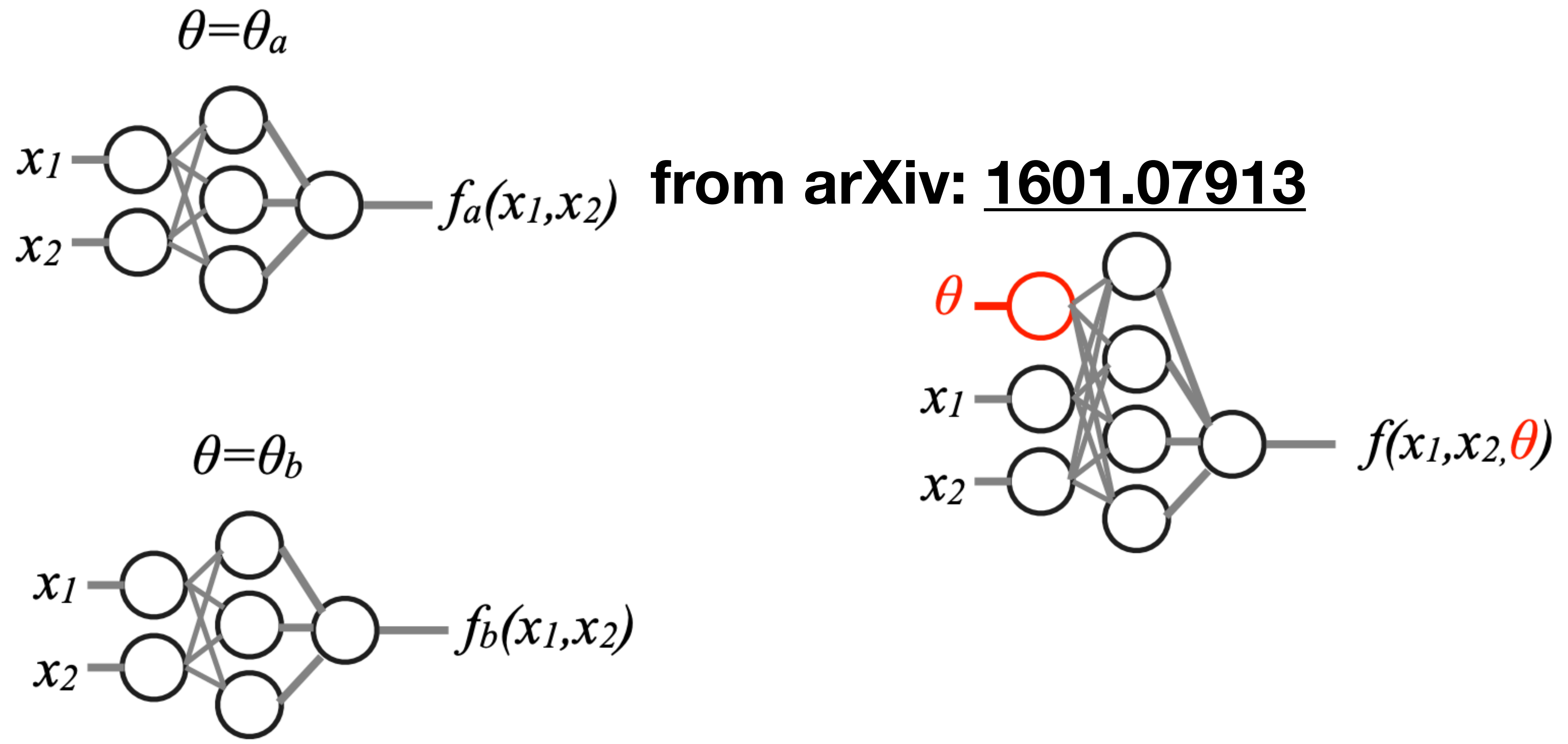


Model with gravitino as LSP

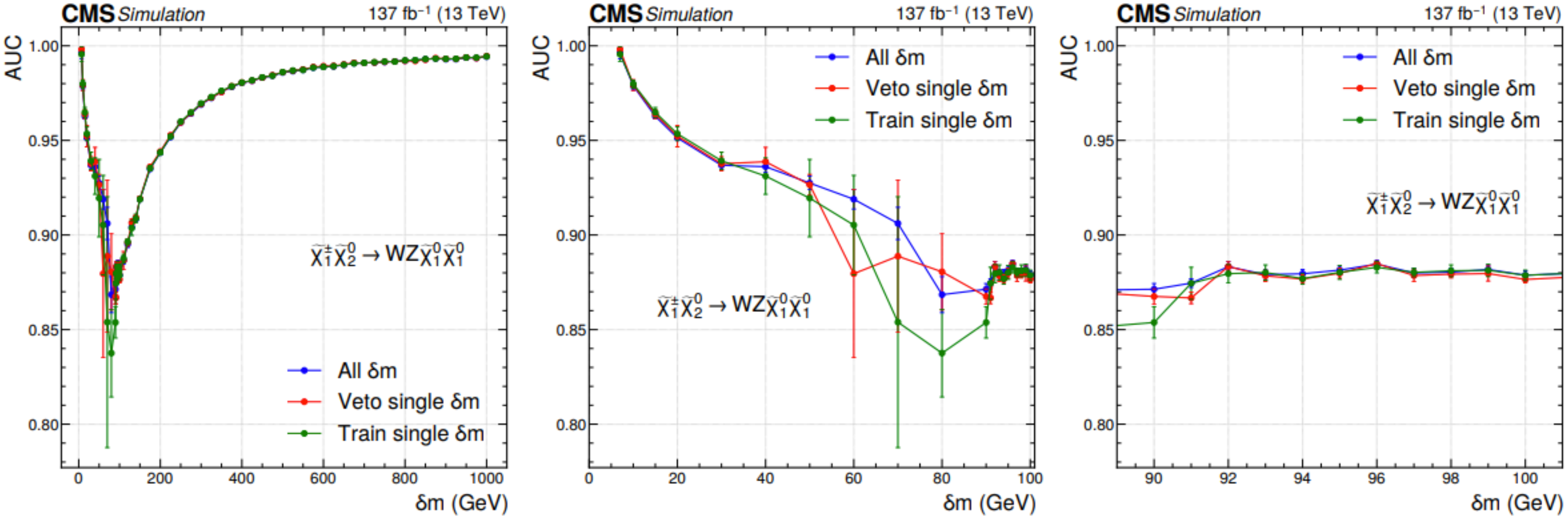


Parametric NN

- Used for increased sensitivity in multilepton events with an OSSF pair→a background-heavy region
- To allow for interpolation across many signal points, parametric NN takes one or more signal parameters as additional input features
  - In training on background events, given a random value from parameter's distribution
- NN parametric in δm: mass splitting between chargino and LSP

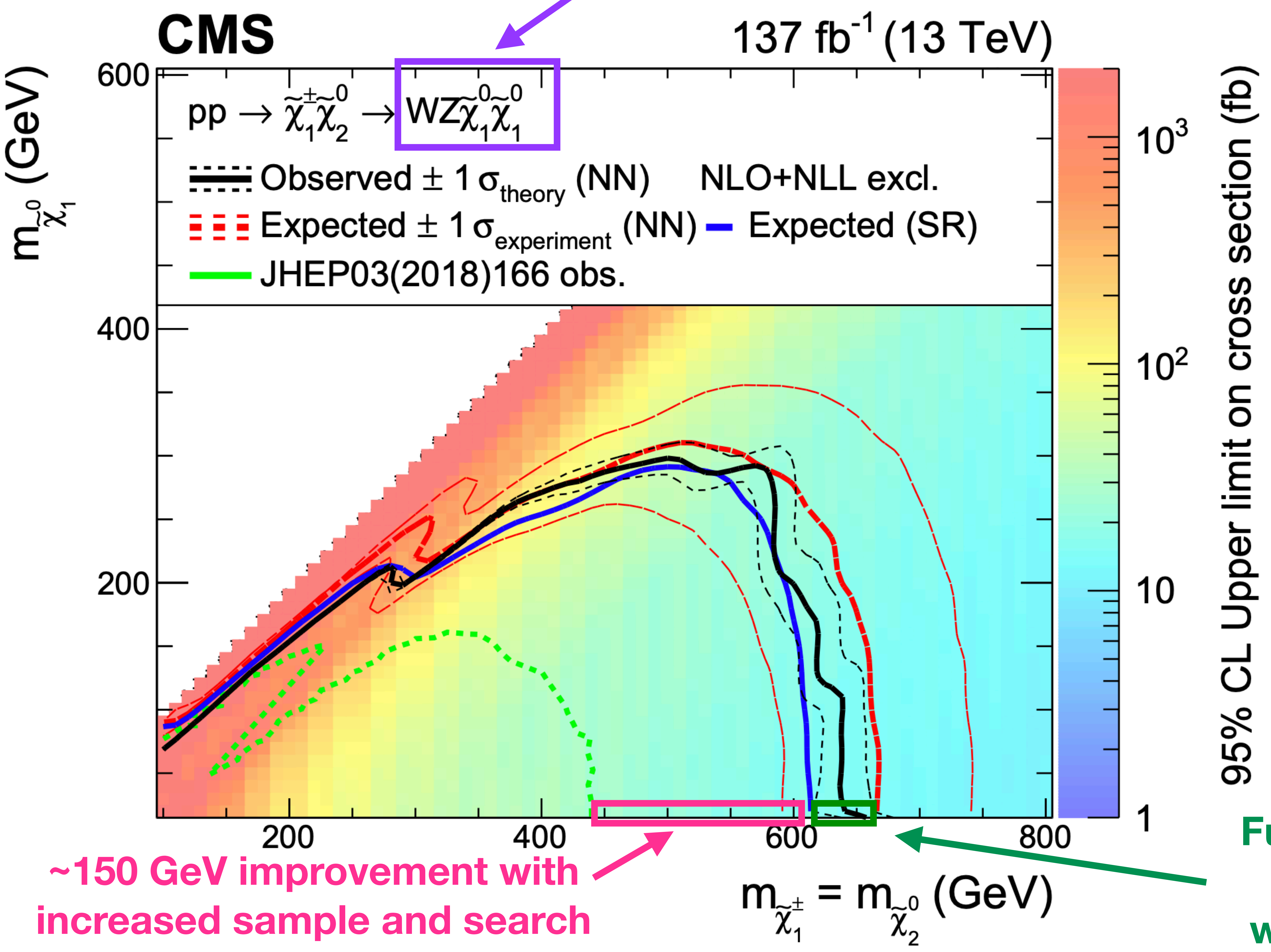


from arXiv: 1601.07913



Results

WZ mediated model

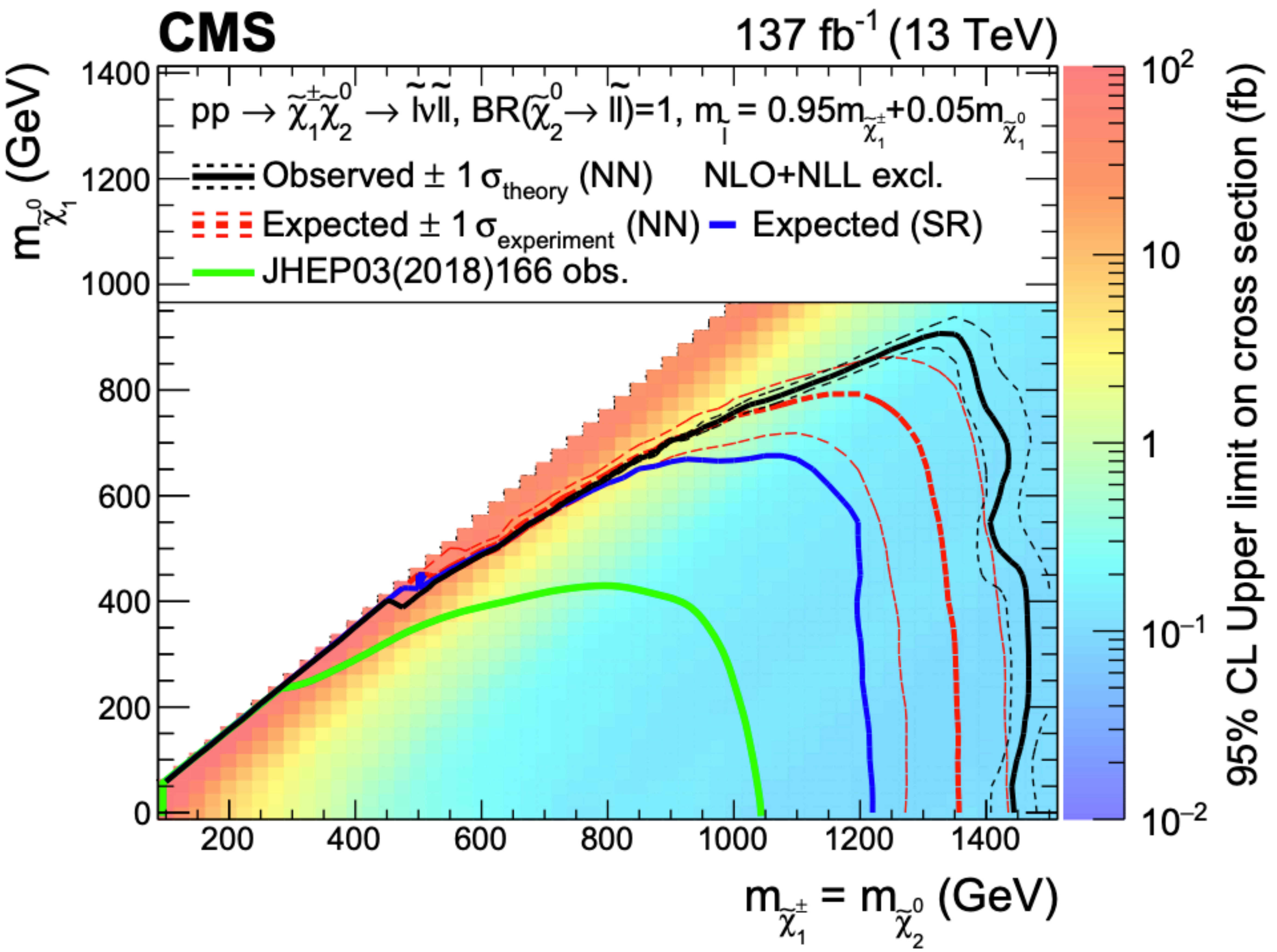


~150 GeV improvement with increased sample and search region optimization alone!

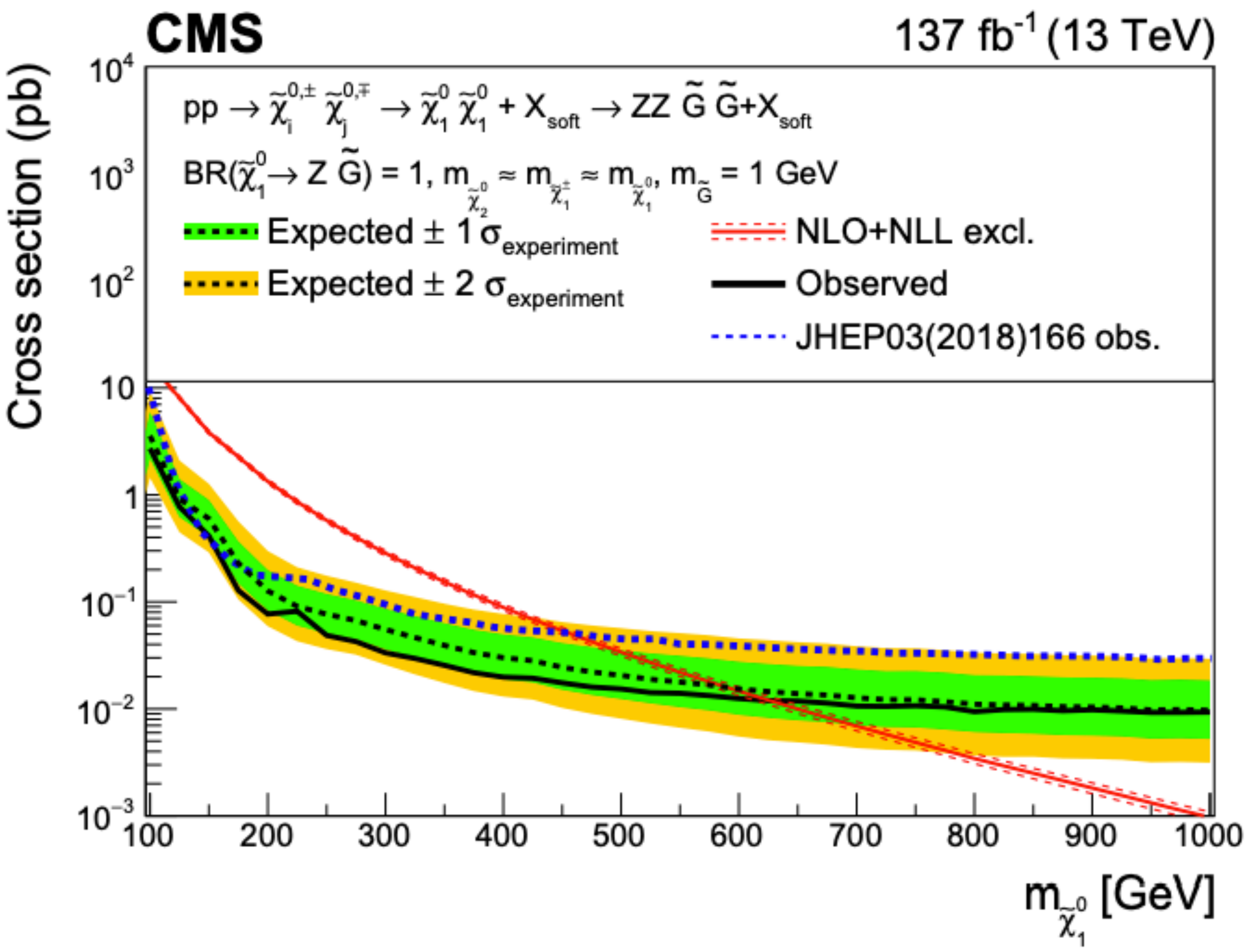
Further ~50 GeV improvement with use of NN!

Results

slepton mediated model

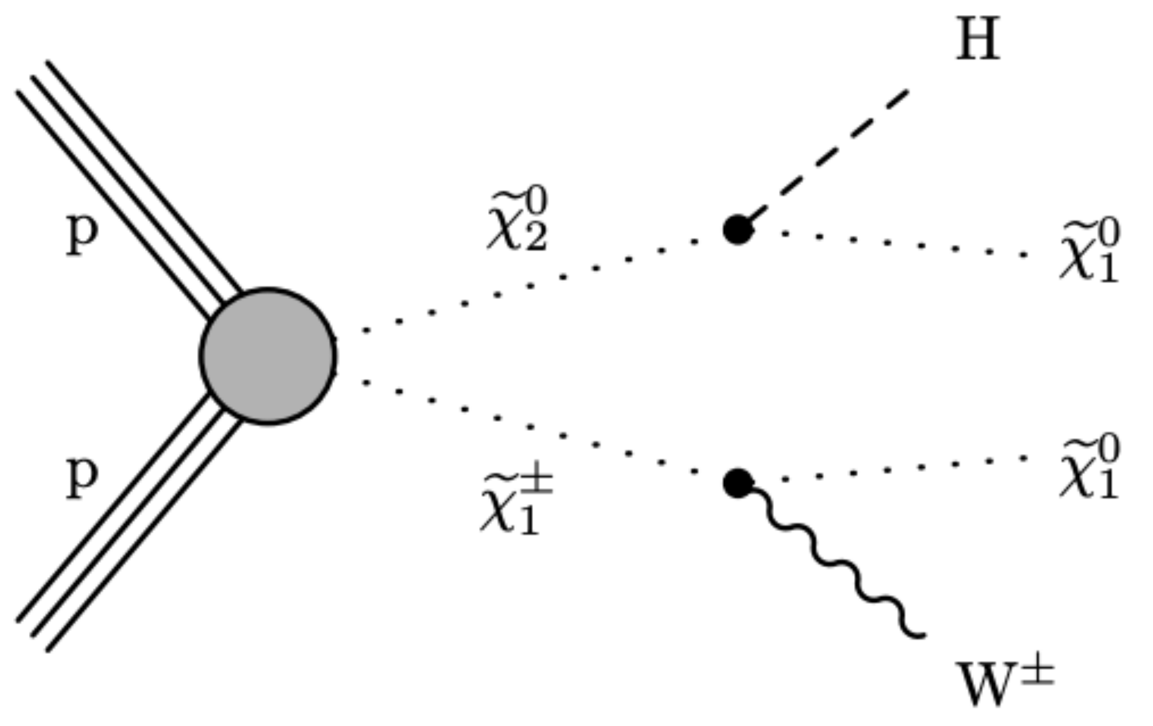


GMSB model

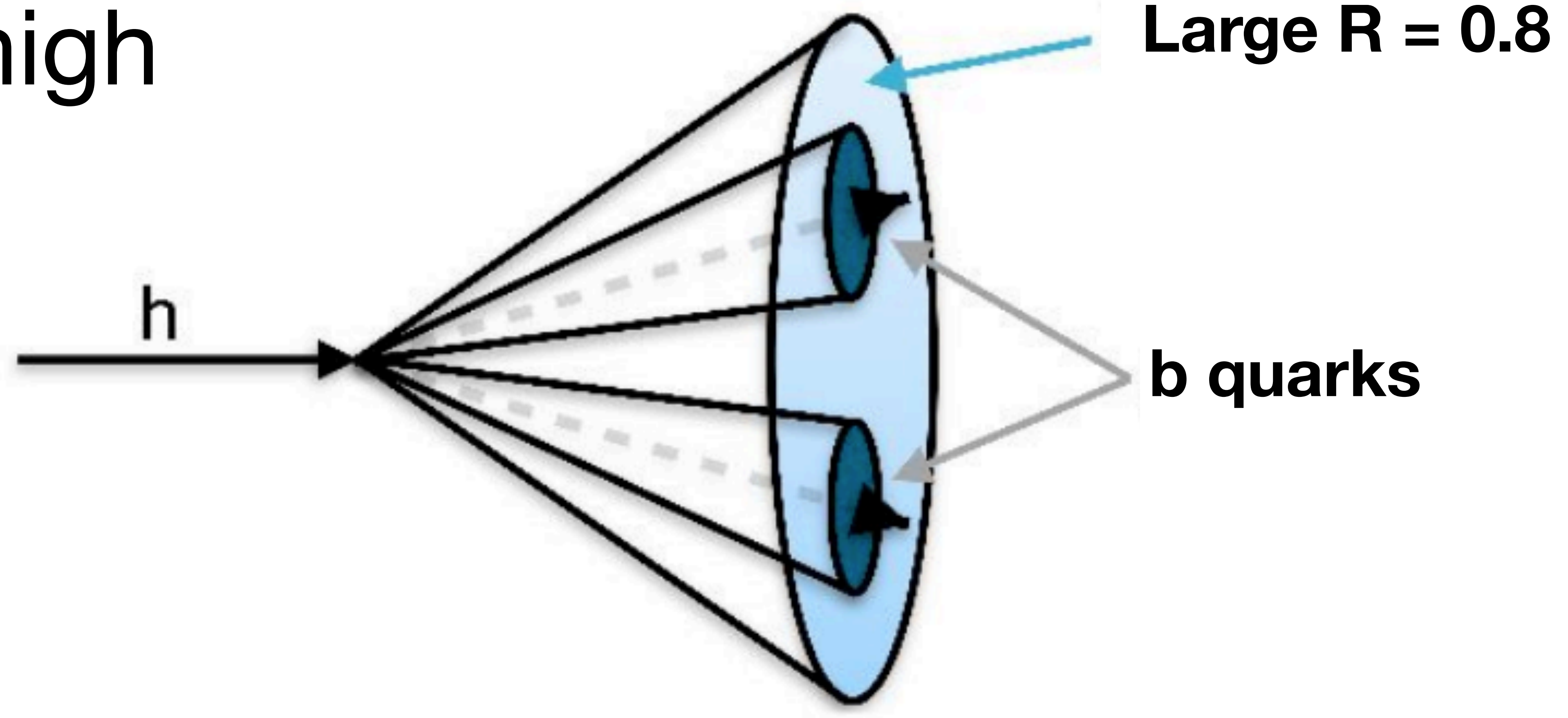


Semileptonic

arXiv: 2107.12553

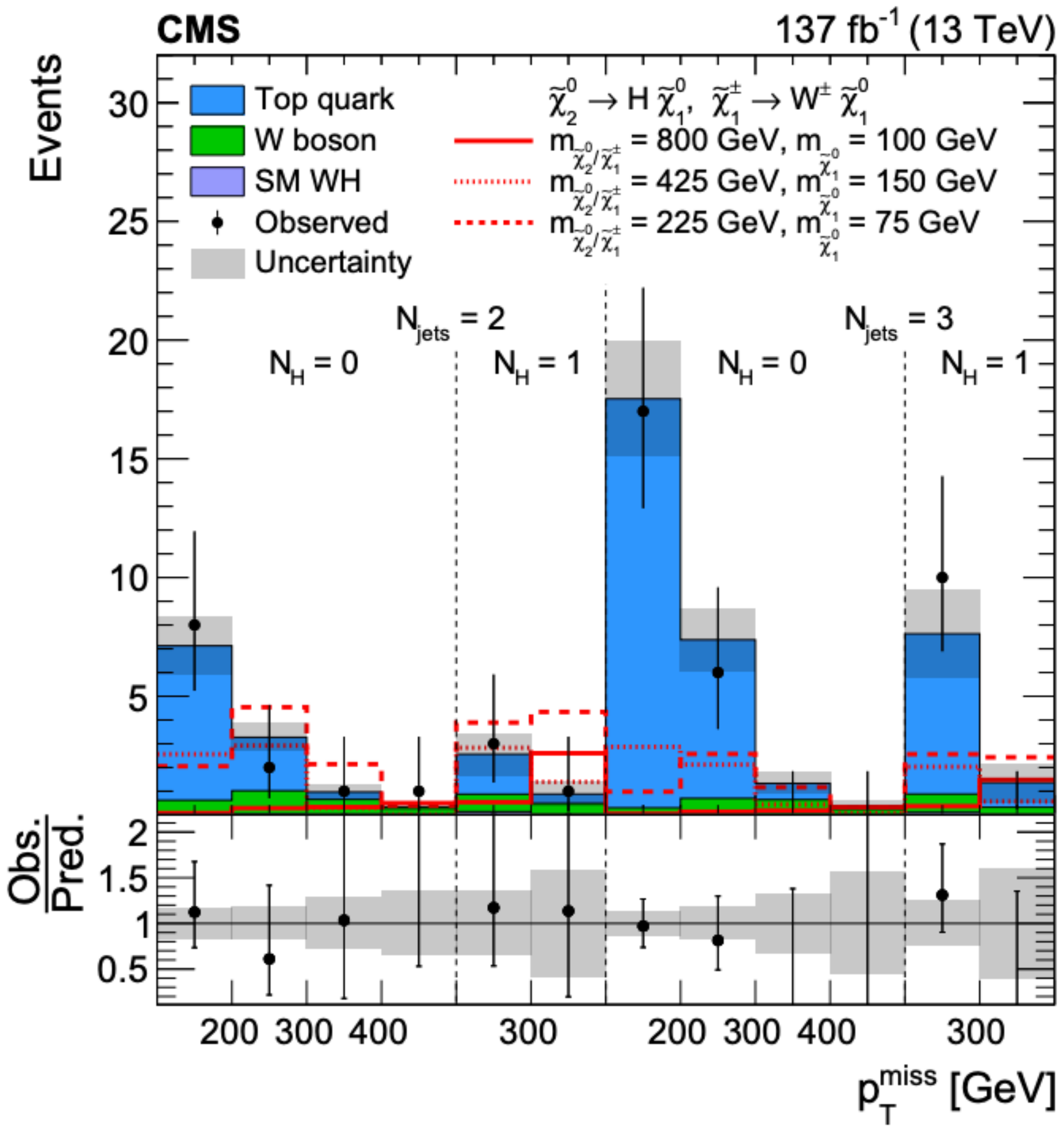


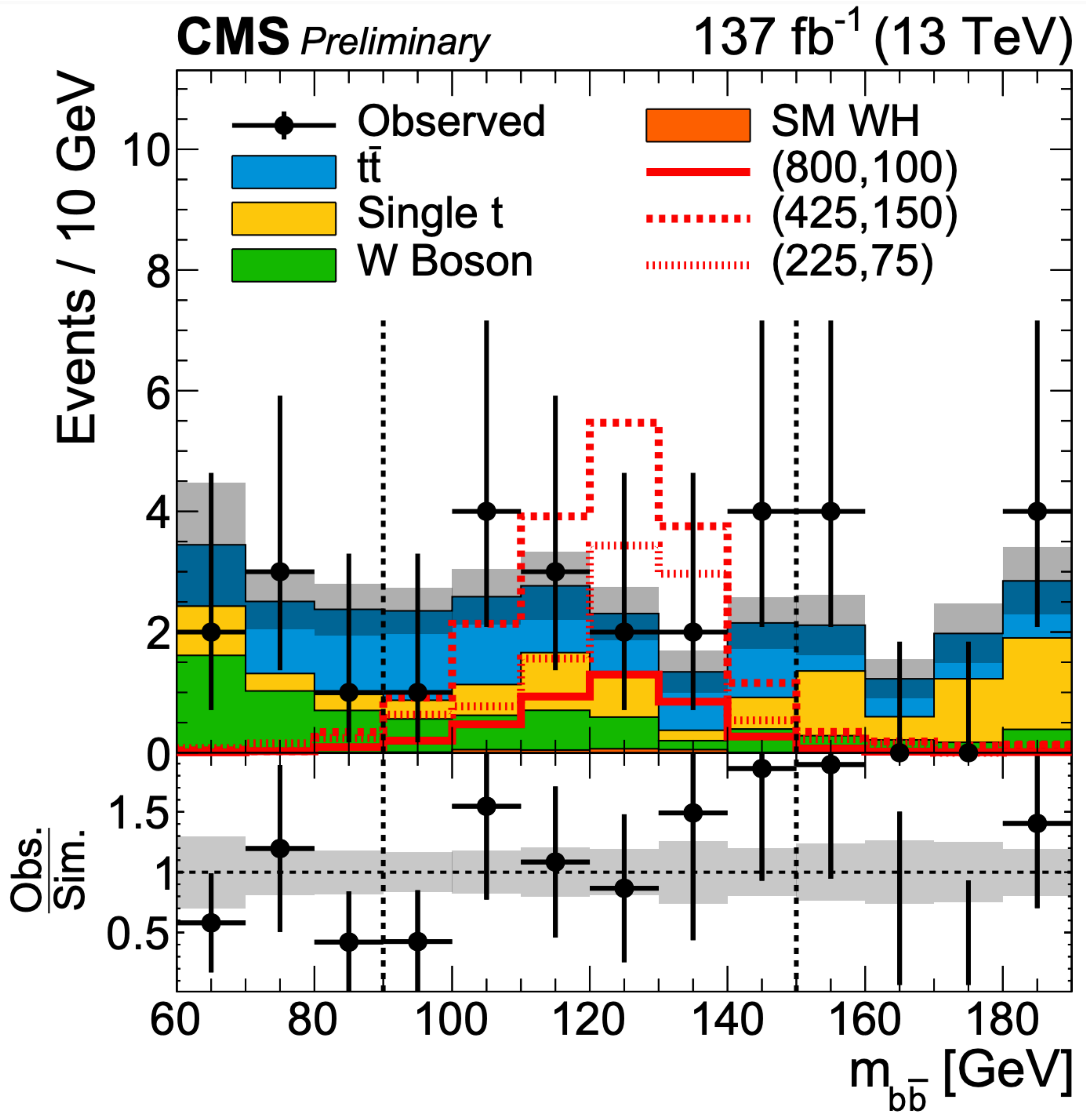
- Consider signatures with leptonic W, H→bb
- Increased sensitivity from
  - Additional search regions with ISR jet
  - Use of novel **boosted Higgs tagging discriminator** to identify models with high mass splittings
- **Use of Higgs to probe BSM**
- **Data-driven background estimates**



Background Estimation

- Data-driven estimates for largest backgrounds (top and W boson decays)
- Give very accurate prediction!

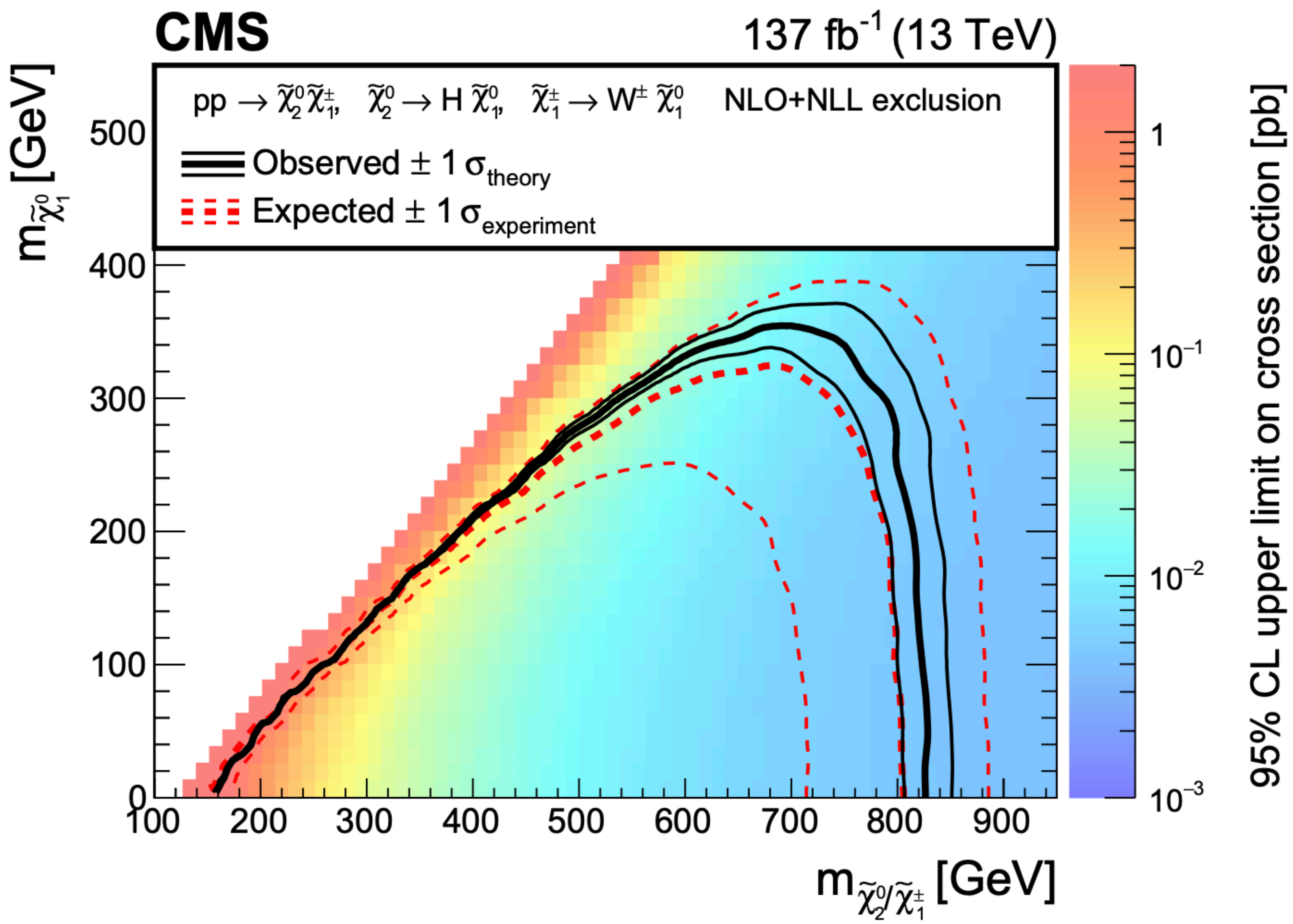




- m_{bb} distribution (not representative of background estimate) does show that even in region where signal peak expected, no deviation from SM

Results

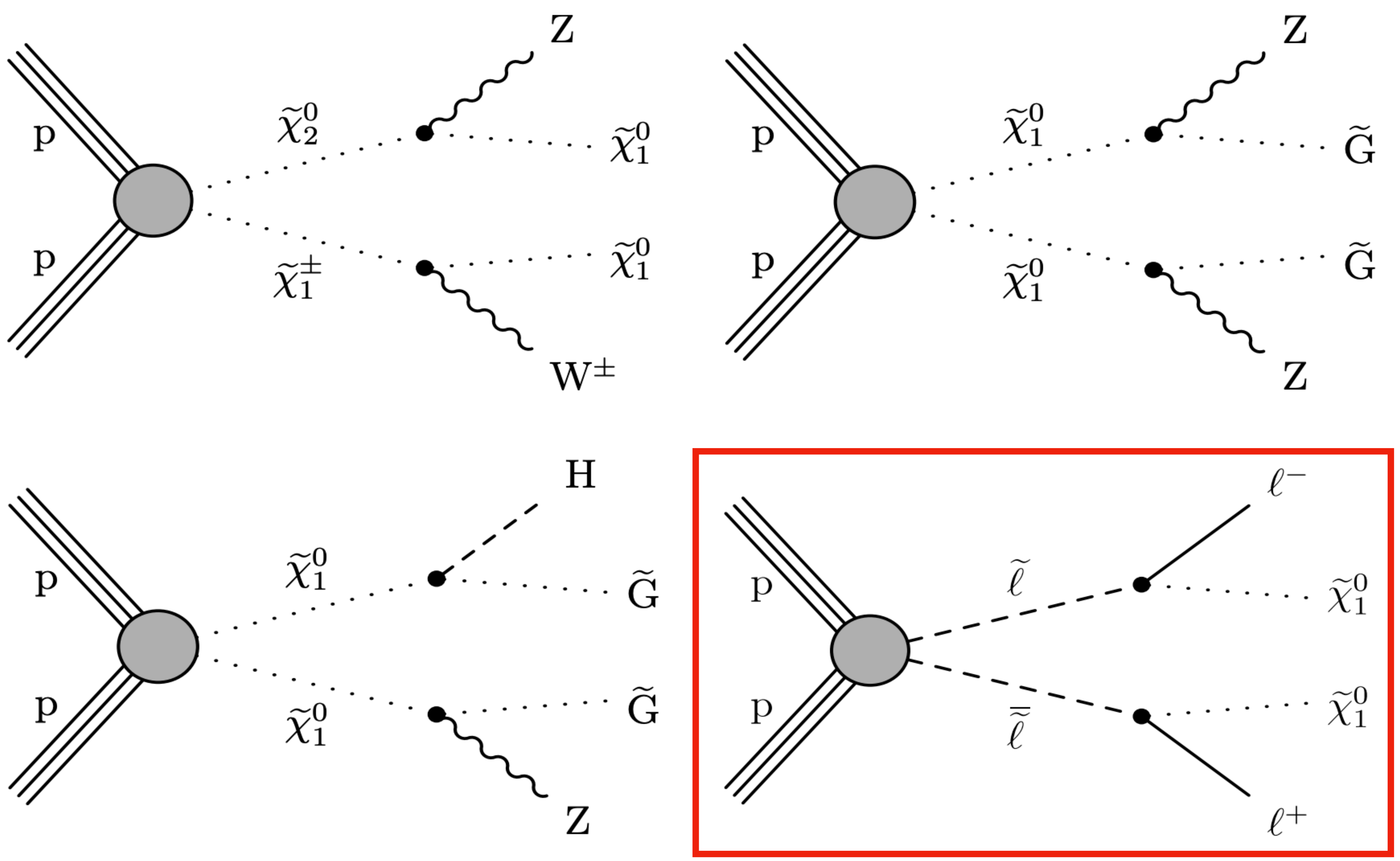
- Previous CMS search with 2016 data excluded chargino up to 490 GeV for low mass LSP
- With extra data, reoptimized search regions, and inclusion of boosted topologies, pushed limits to 820 GeV for low mass LSP!



OSSF

arXiv: 2012.08600

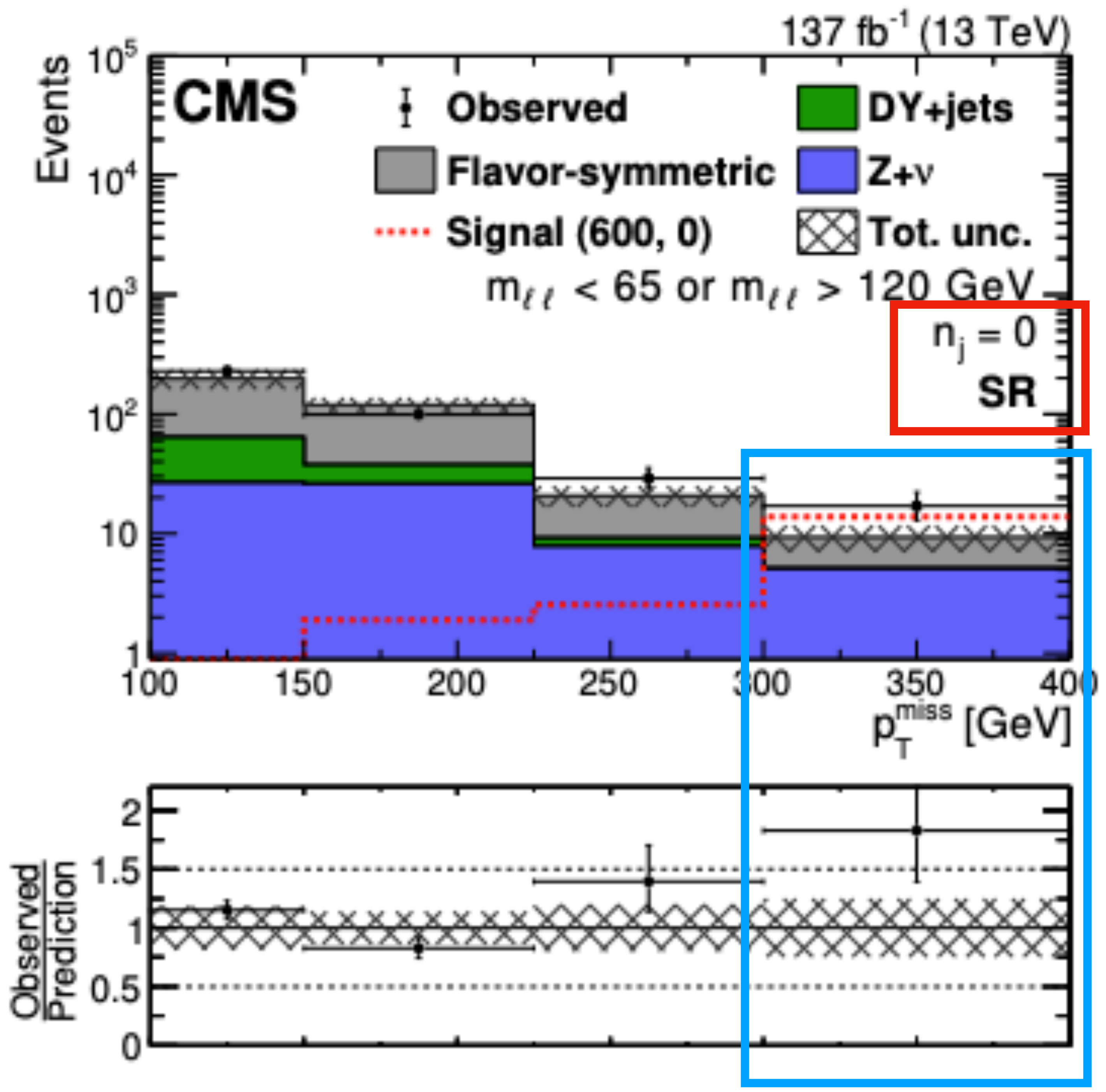
- Target decay modes with on- or off-shell Z bosons and to SM leptons
- Consider GMSB models with gravitino as LSP and models with lightest neutralino as LSP
- **Inclusion of direct slepton pair production simplified model**



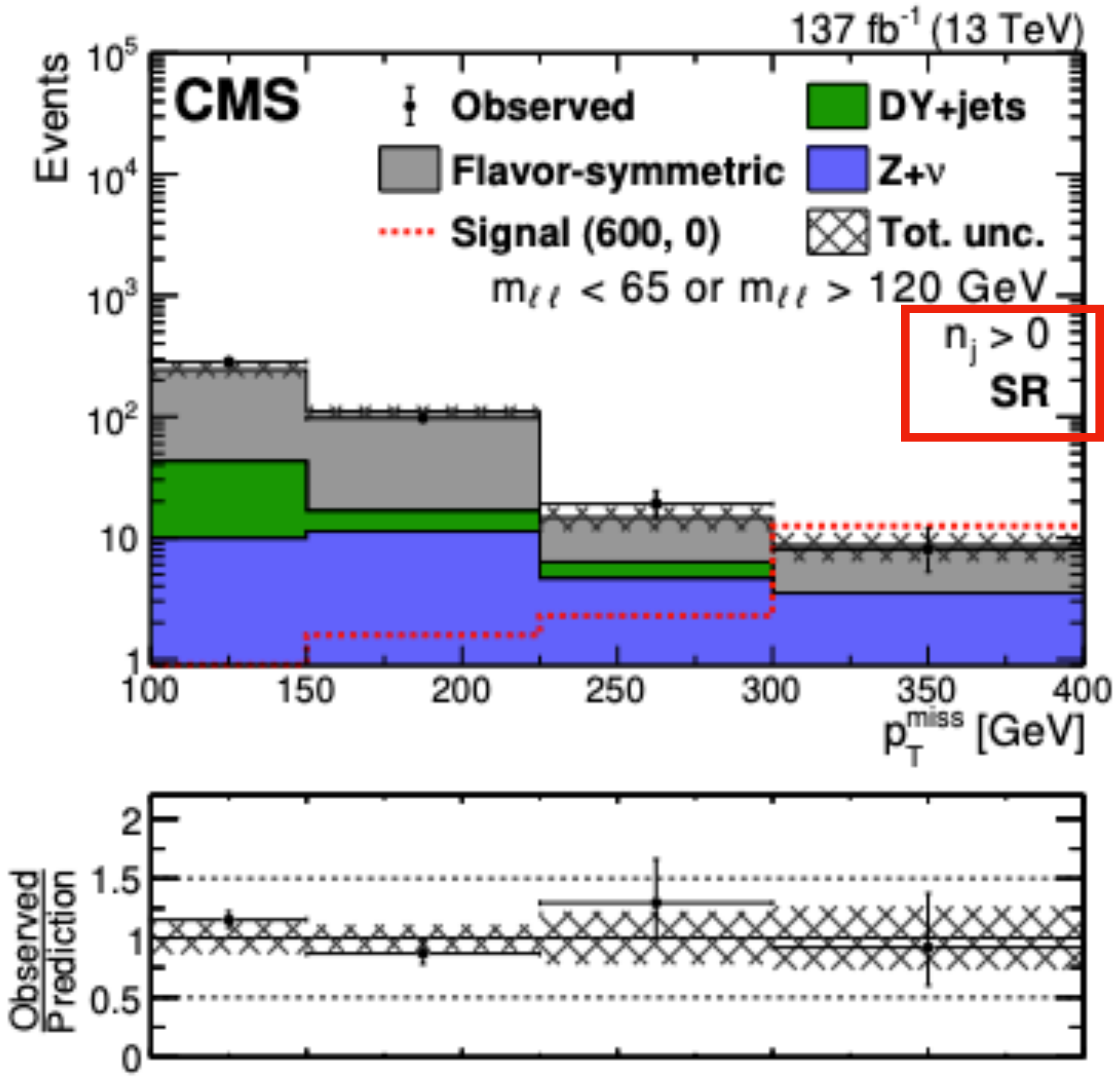
Results in Slepton Regions

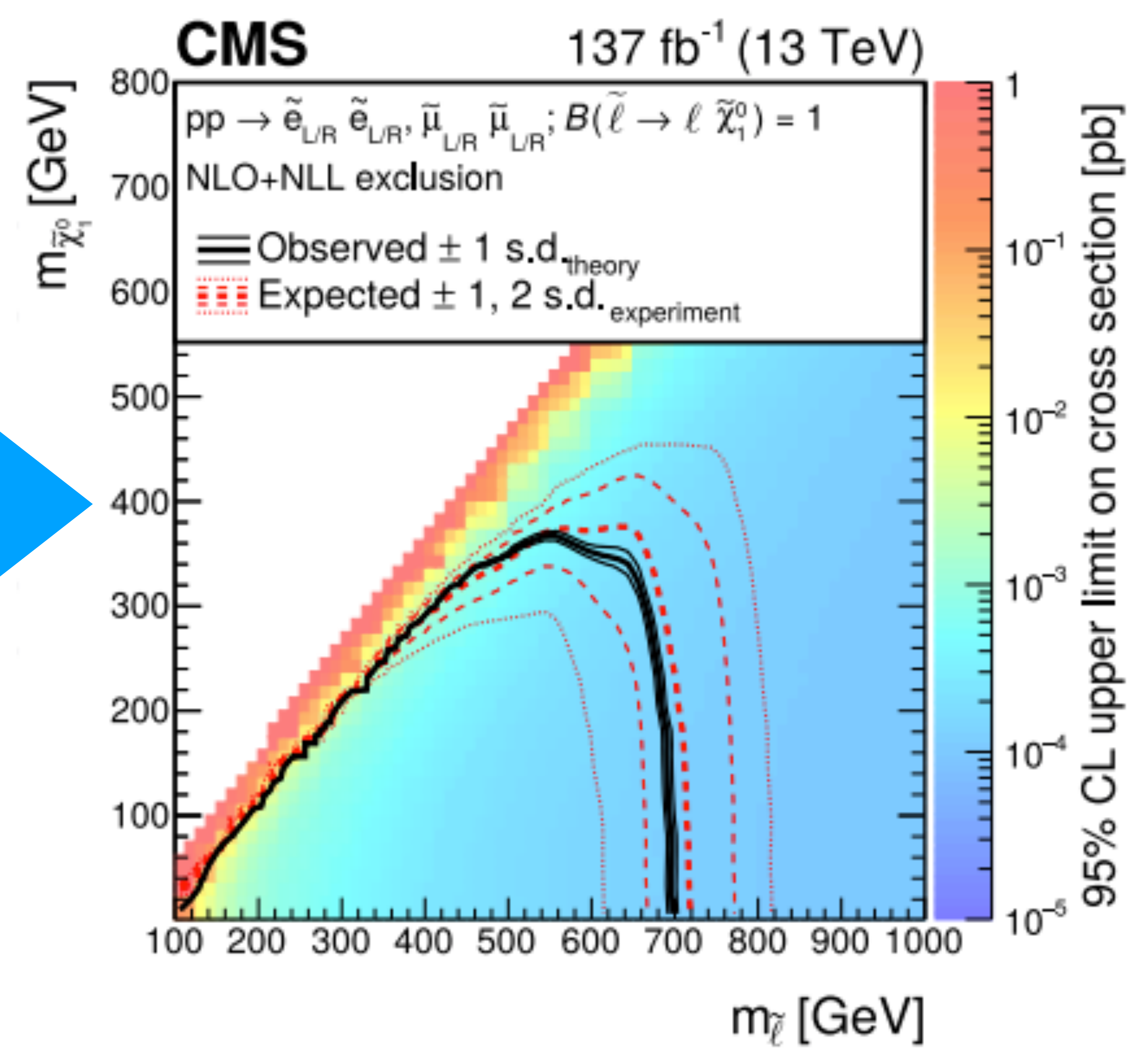
No significant excesses observed

region with 0 jets



region with >0 jets



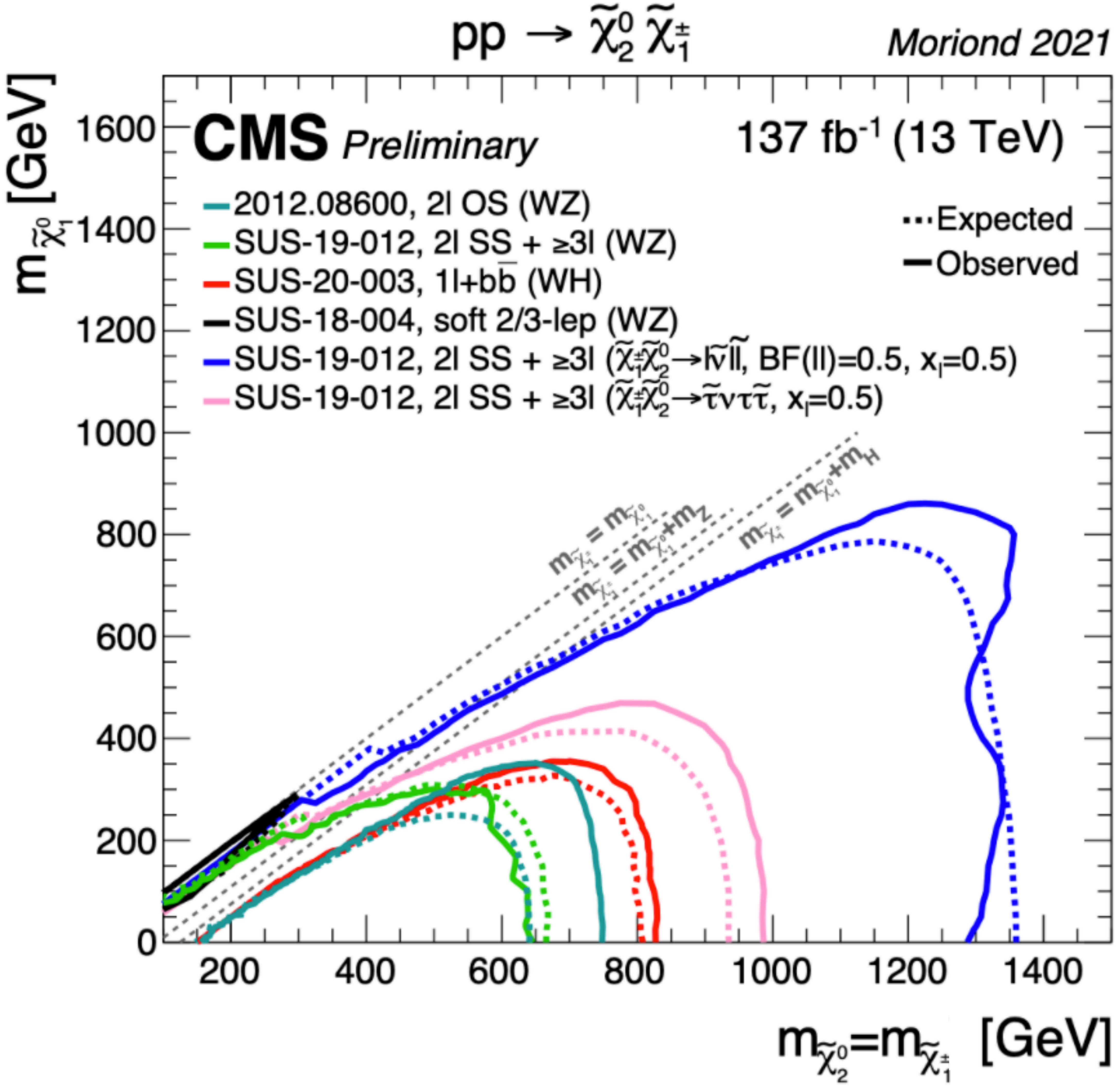


Highest discrepancy: local significance of 1.6 s.d.

exclude slepton mass up to 700 GeV for low mass LSP

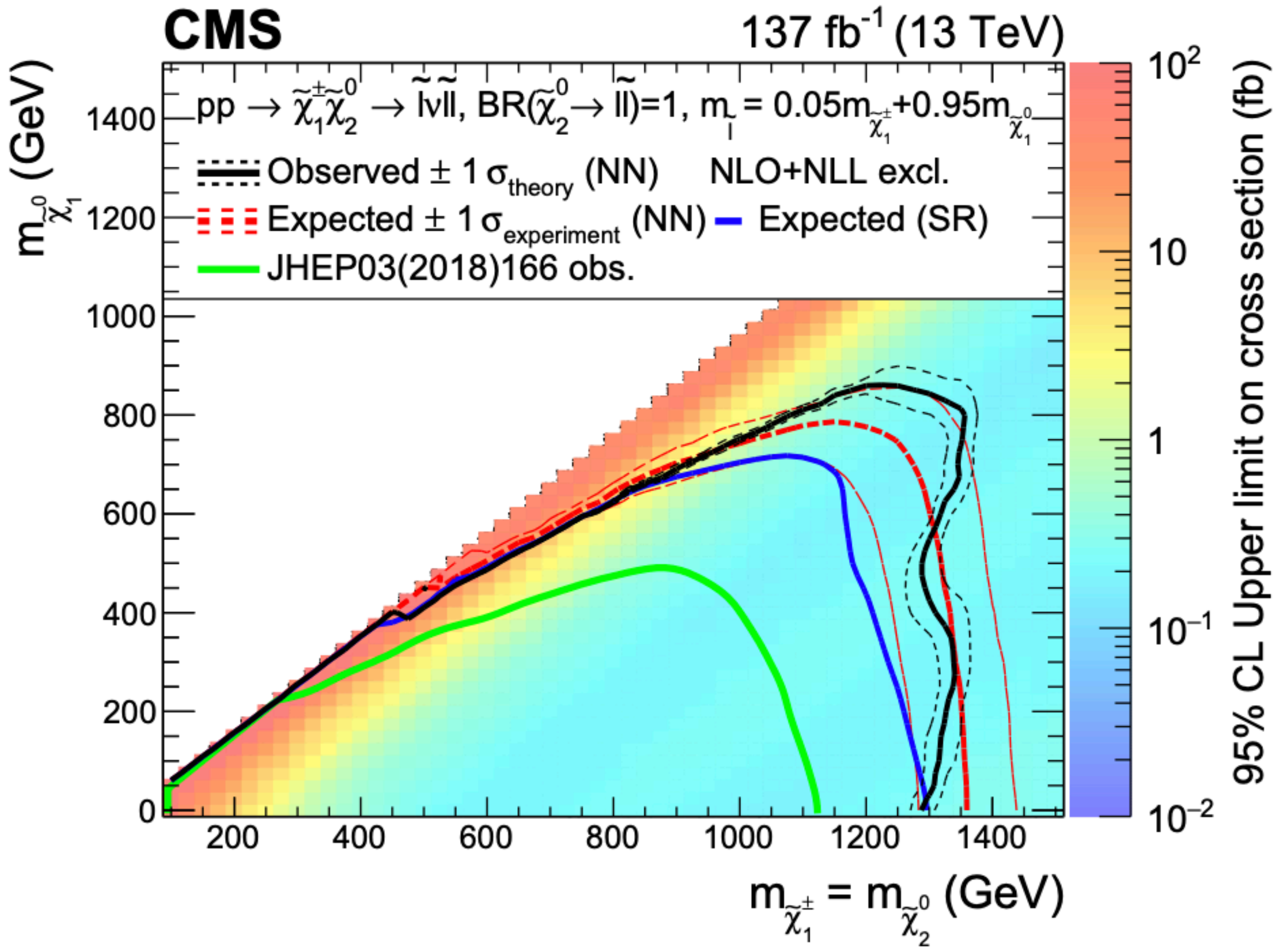
Summary

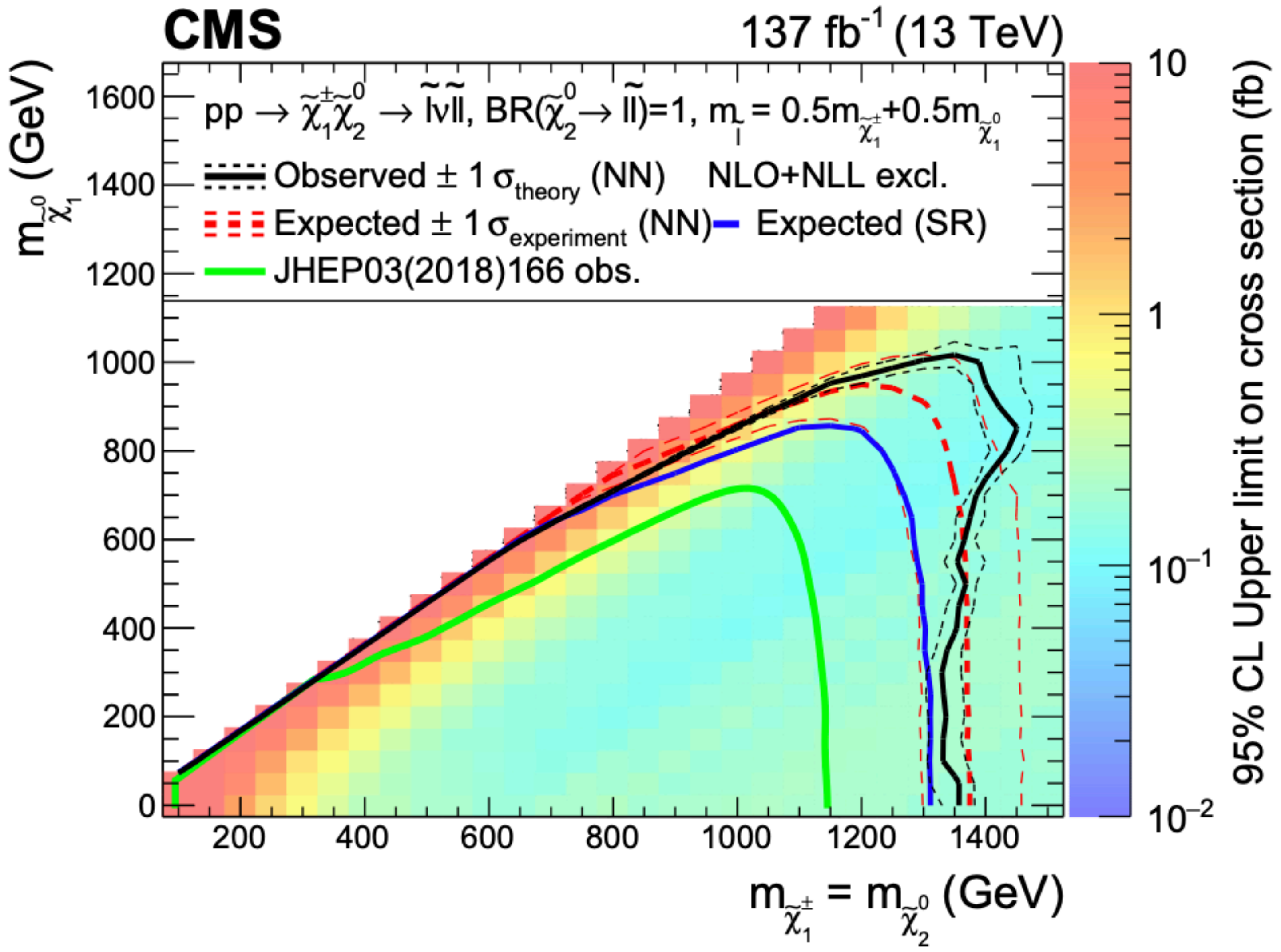
- Wide range of EWK SUSY searches at CMS: Varied signatures and simplified models probed
- Exclusions on EWKino masses as high as 1450 GeV, depending on model
- Exclusions on slepton masses up to 700 GeV

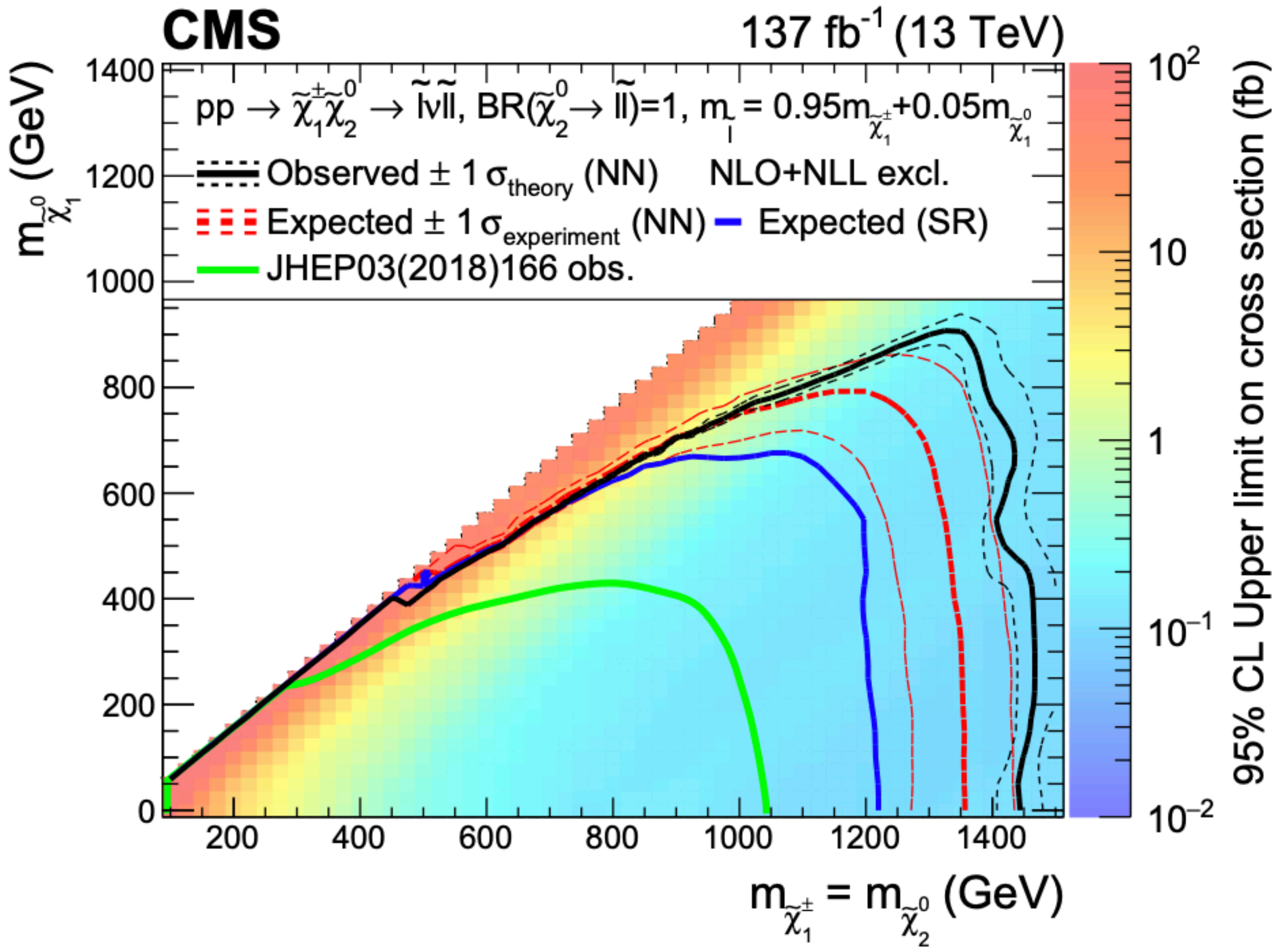


backup

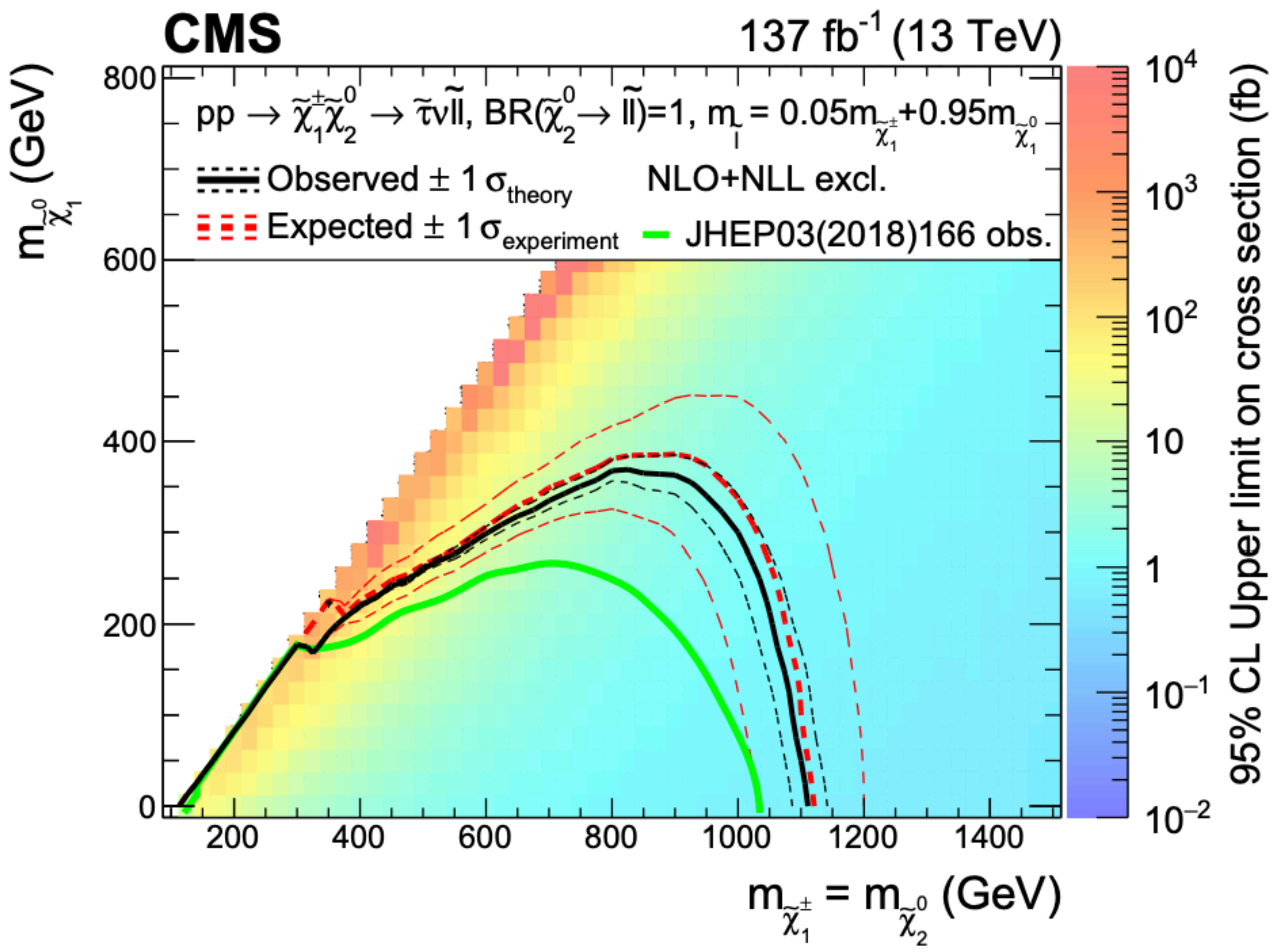
Slepton Mediated

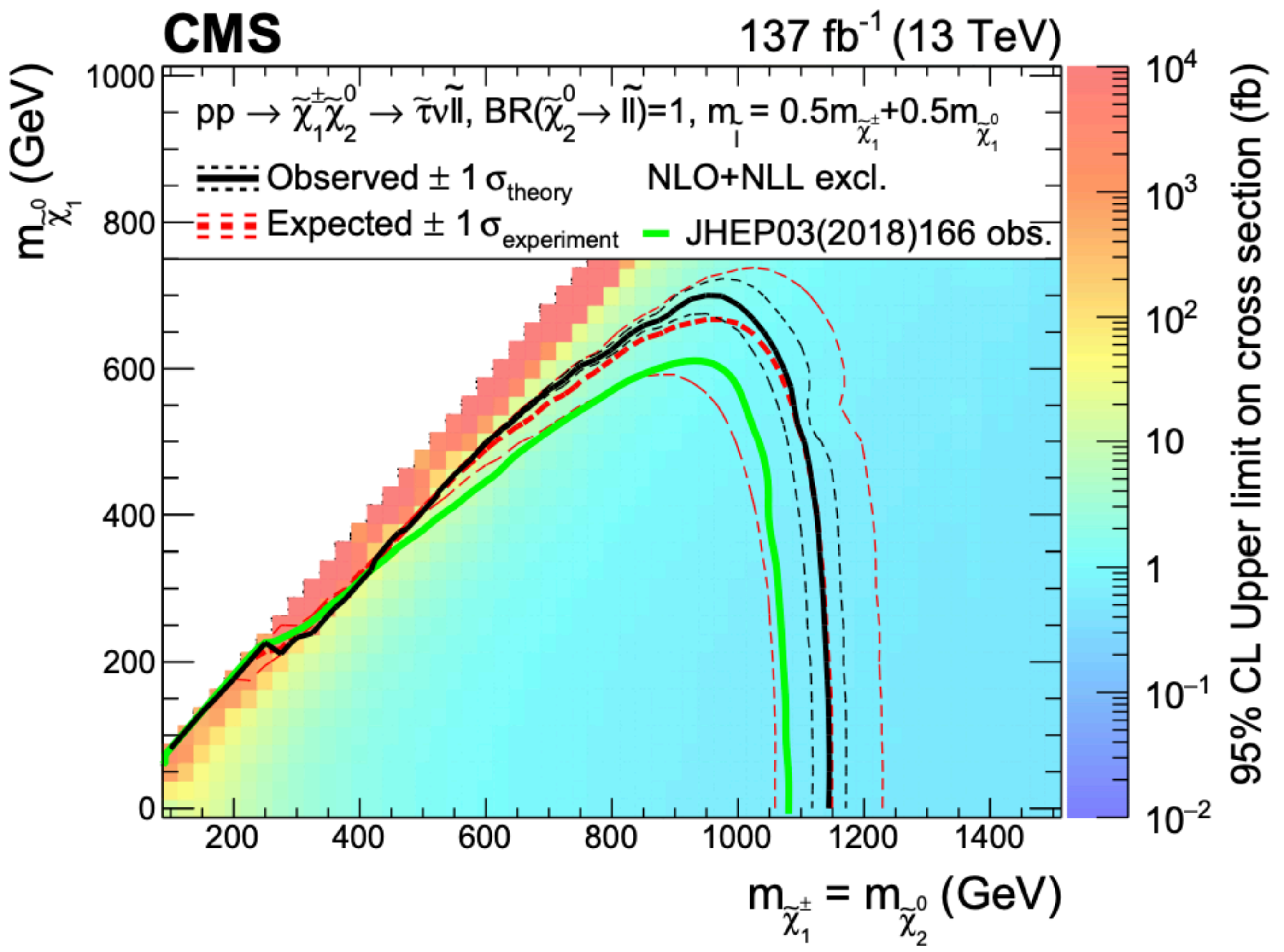


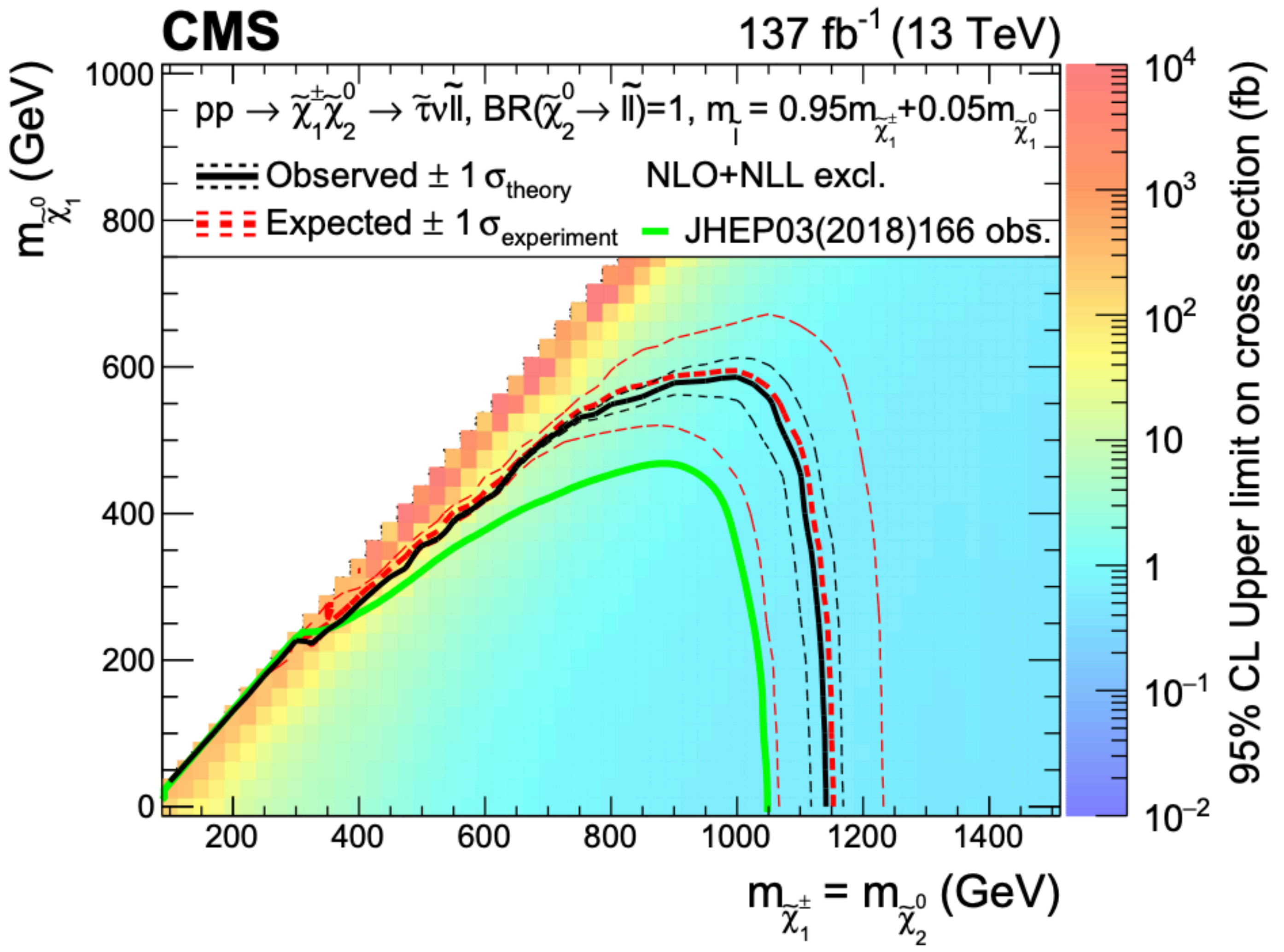




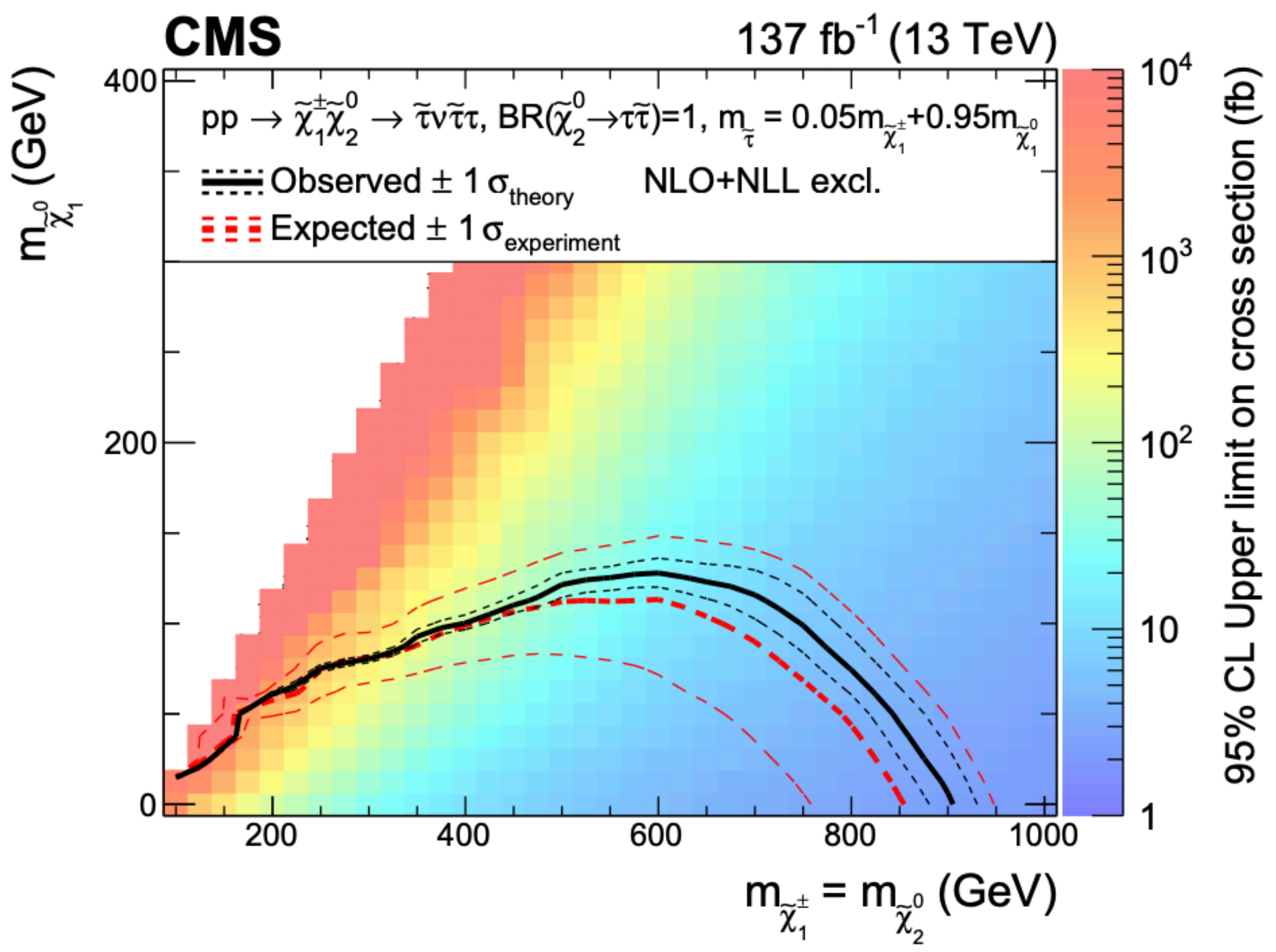
Slepton Mediated

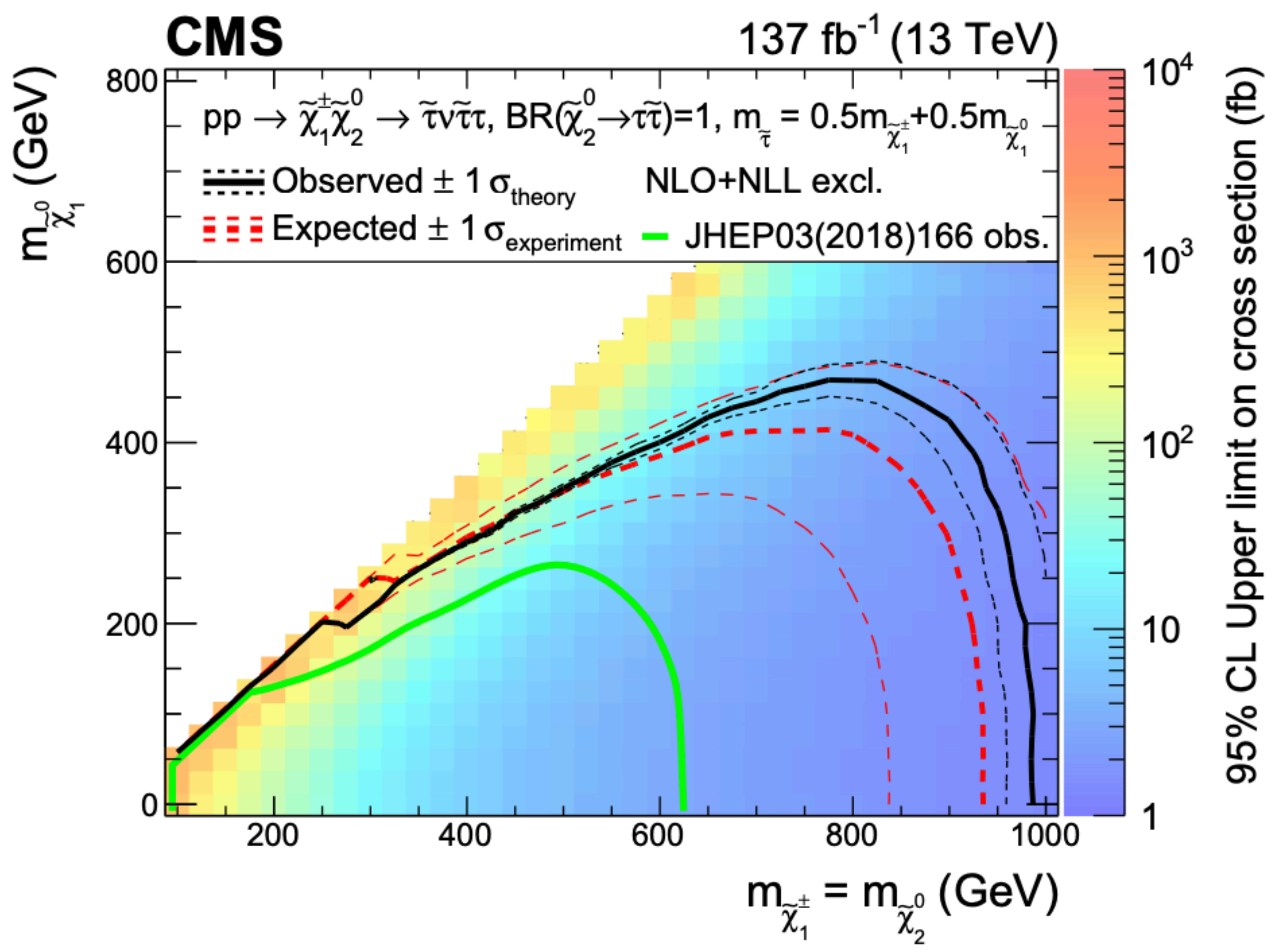


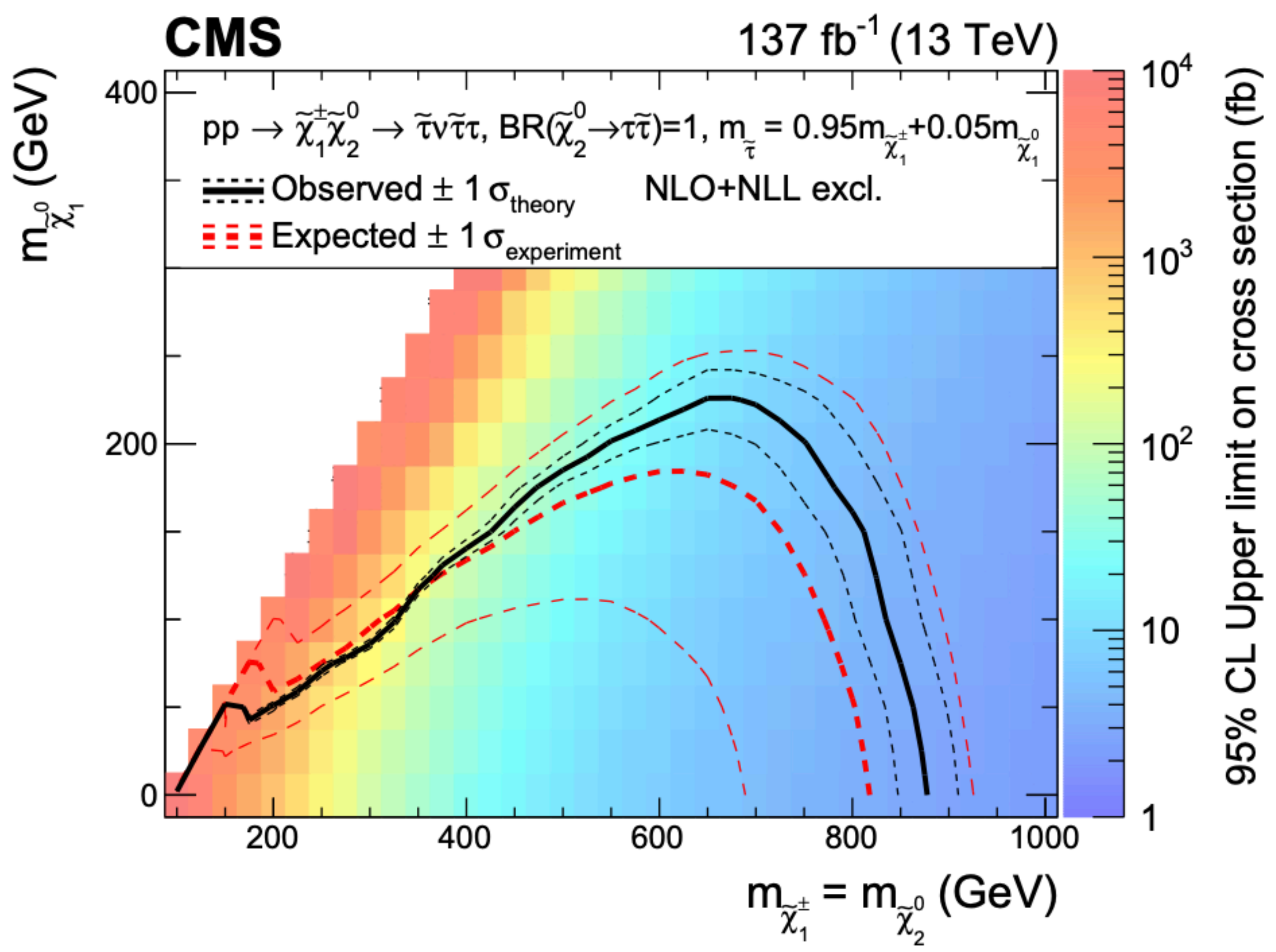




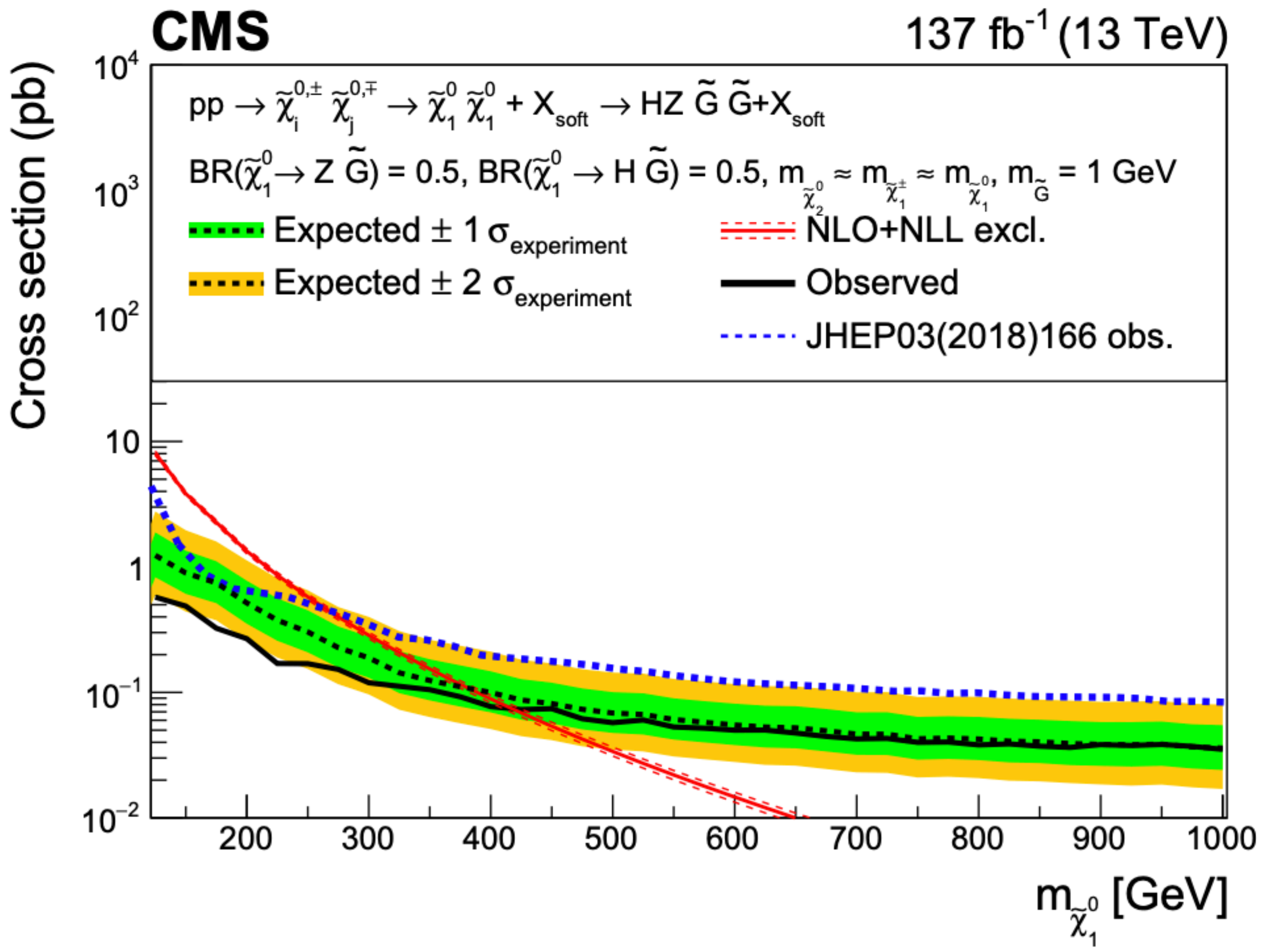
Slepton Mediated

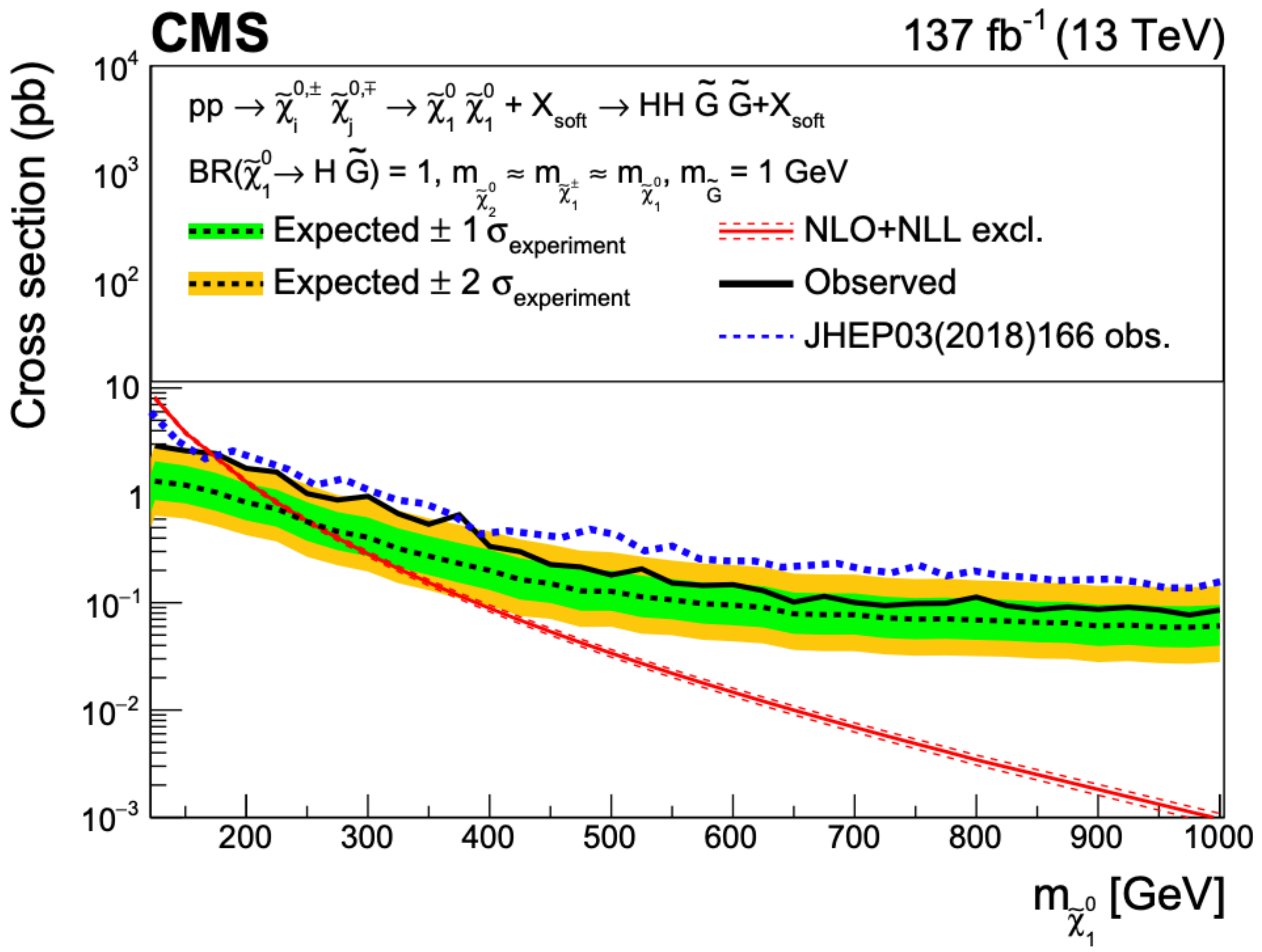




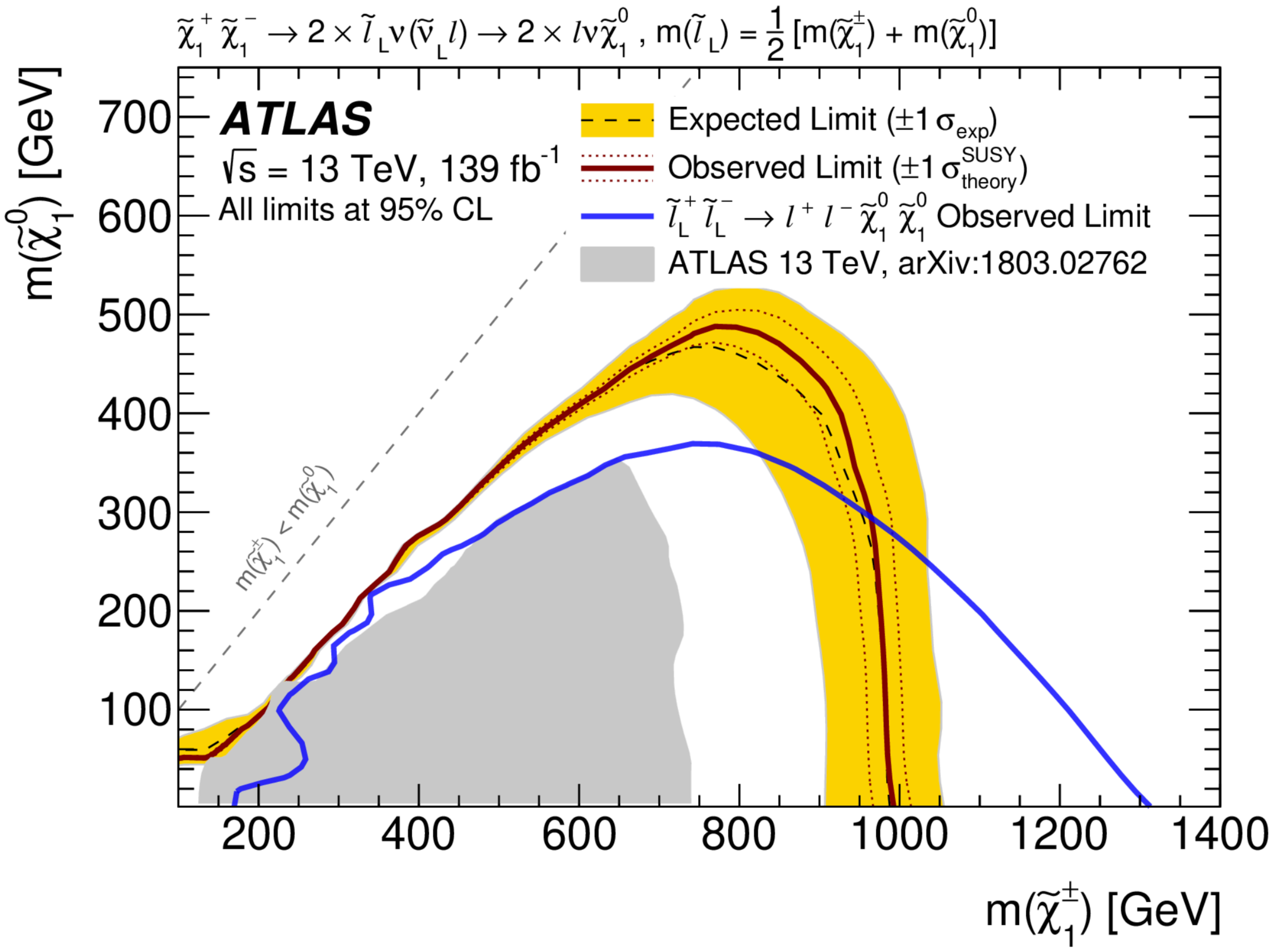


GMSB

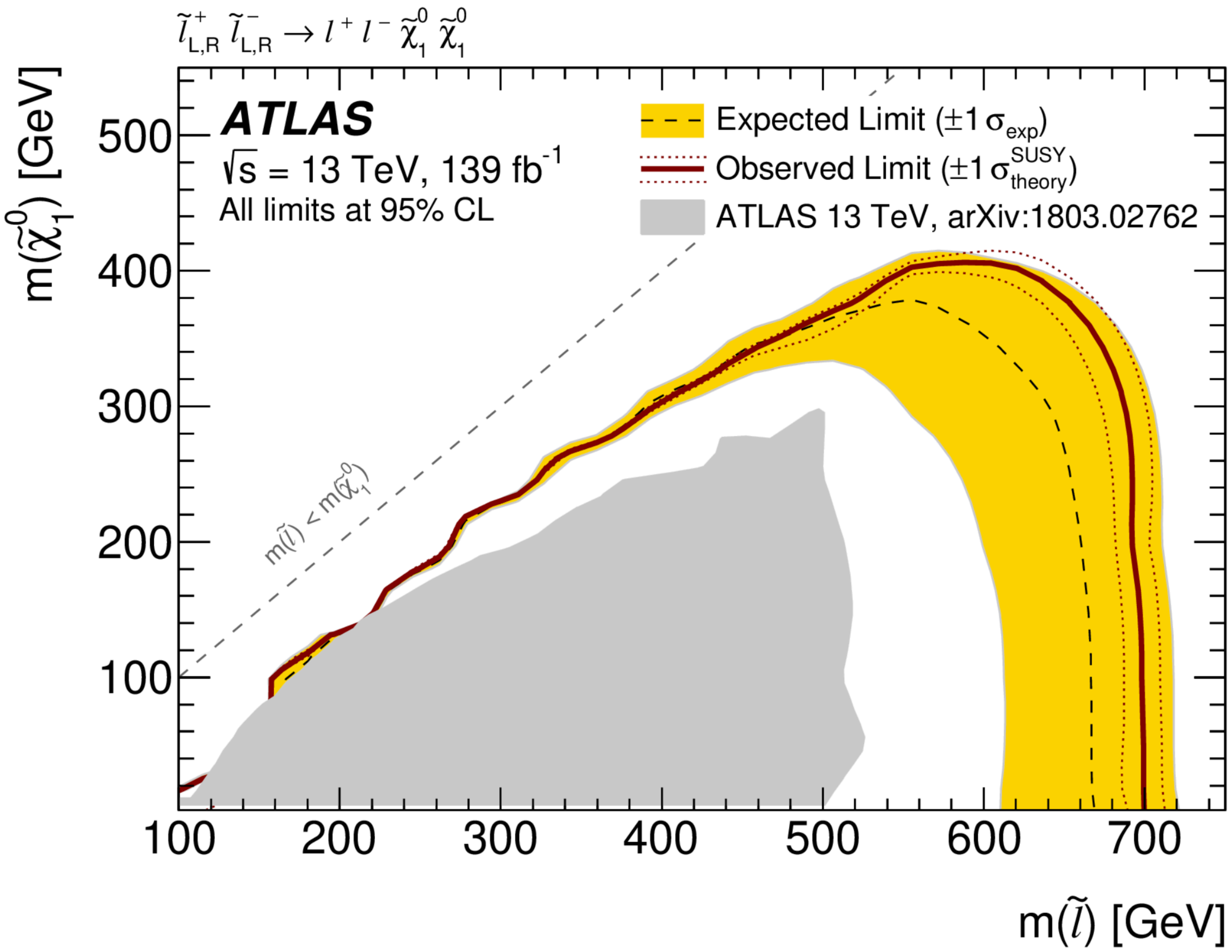

CMS
137 fb-1 (13 TeV)
pp → χ̃i0,± χ̃j0,∓ → χ̃10 χ̃10 + Xsoft → HZ G̃ G̃+Xsoft
BR(χ̃10→ Z G̃) = 0.5, BR(χ̃10 → H G̃) = 0.5, mχ̃20 ≈ mχ̃1± ≈ mχ̃10, mG̃ = 1 GeV
Expected ± 1 σexperiment
Expected ± 2 σexperiment
NLO+NLL excl.
Observed
JHEP03(2018)166 obs.
Cross section (pb)
mχ̃10 [GeV]


CMS
137 fb-1 (13 TeV)
pp → χ̃i0,± χ̃j0,∓ → χ̃10 χ̃10 + Xsoft → HH G̃ G̃+Xsoft
BR(χ̃10→ H G̃) = 1, mχ̃20 ≈ mχ̃1± ≈ mχ̃10, mG̃ = 1 GeV
Expected ± 1 σexperiment
Expected ± 2 σexperiment
NLO+NLL excl.
Observed
JHEP03(2018)166 obs.
Cross section (pb)
mχ̃10 [GeV]

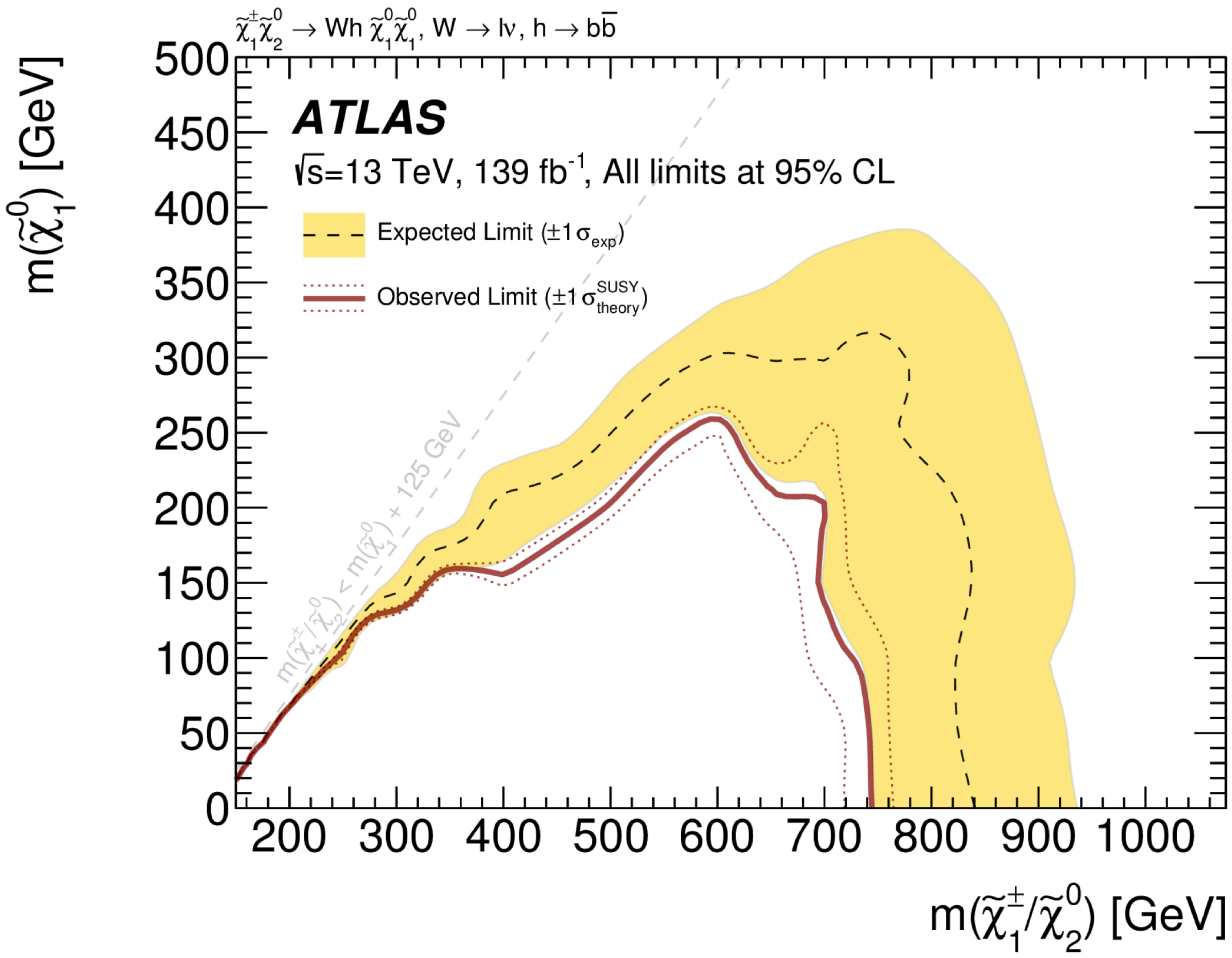
ATLAS Slepton Mediated



ATLAS Slepton Limit



ATLAS WH1l



$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \to Wh\ \tilde{\chi}_1^0\tilde{\chi}_1^0$, $W \to l\nu$, $h \to b\bar{b}$
ATLAS
$\sqrt{s}$=13 TeV, 139 fb^{-1}, All limits at 95% CL
Expected Limit ($\pm 1\sigma_{exp}$)
Observed Limit ($\pm 1\sigma^{SUSY}_{theory}$)
$m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0) < m(\tilde{\chi}_1^0) + 125$ GeV
$m(\tilde{\chi}_1^0)$ [GeV]
$m(\tilde{\chi}_1^{\pm}/\tilde{\chi}_2^0)$ [GeV]
0
50
100
150
200
250
300
350
400
450
500
200
300
400
500
600
700
800
900
1000