



SUSY searches at the LHC

Ligang Xia

Nanjing University

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- How to search at LHC?
- Summary plots from ATLAS/CMS
- Some highlights in 2021
 - many leptons
 - many jets
 - disappearing track
 - same-sign dilepton
- Summary

Useful links:

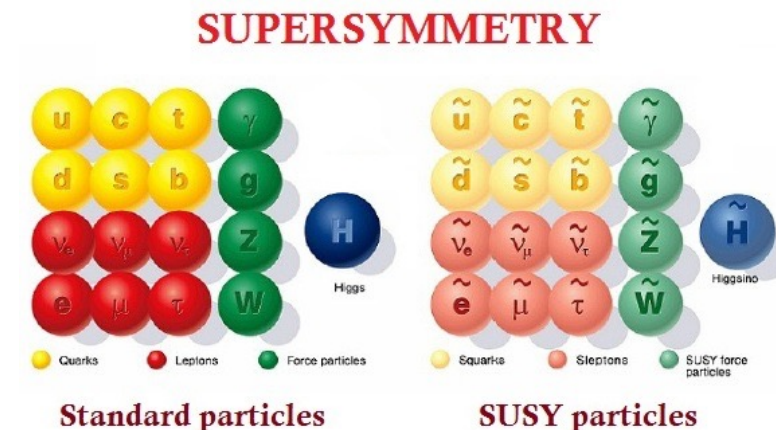
A most recent review: [2111.10180](#)

[ATLAS public SUSY results](#)

[CMS public SUSY results](#)

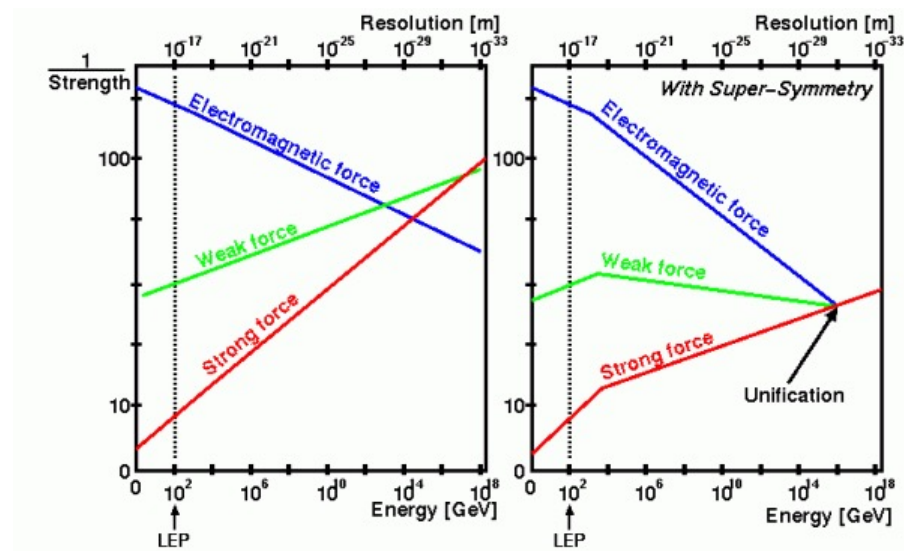
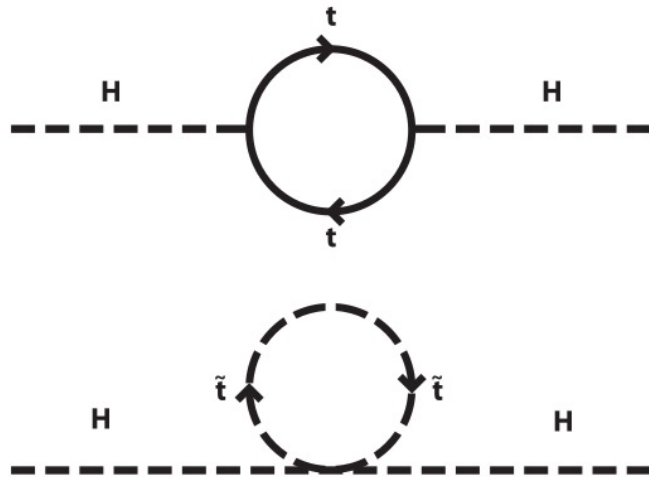
Introduction to Supersymmetry

- Internal symmetry VS spacetime symmetry
- Supersymmetry is a spacetime symmetry.
 - Introduce a fermionic (bosonic) **superpartner** for each SM boson/fermion
 - lepton $\leftrightarrow$ slepton, quark $\leftrightarrow$ squark
 - gluon $\leftrightarrow$ gluino, higgs $\leftrightarrow$ higgsino, graviton $\leftrightarrow$ Gravitino
 - Superpartners share the **same quantum numbers**



Introduction to Supersymmetry

- Charming theory:
 - **Hierarchy** problem: Higgs mass $\ll$ Planck scale?
 - **Gauge coupling unification**: $\sim 10^{16}$ GeV
 - Lightest Supersymmetry Particle: **dark matter** candidate
 - “Naturalness” predict **top squark**: $0.1 \rightarrow 1\text{TeV}$ within LHC accessibility



How to search at LHC ?

- Minimal Supersymmetry extension of the Standard Model (MSSM):

- Huge dimension of parameter space: 105 parameters
- Use simplified models: only few sparticles contribute
- Many assumptions: naturalness ... (stop cannot be too heavy!)

- Experimentalists only need care about LSP(NLSP) and RPC/V:

- Lightest Supersymmetry Particle: W/Z/H/G $\tilde{}$ ($\chi_1^\pm, \chi_1^0, G\tilde{}$):

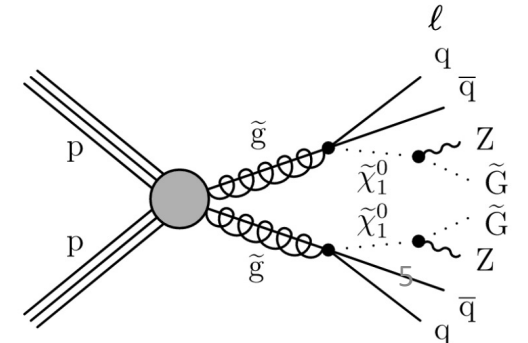
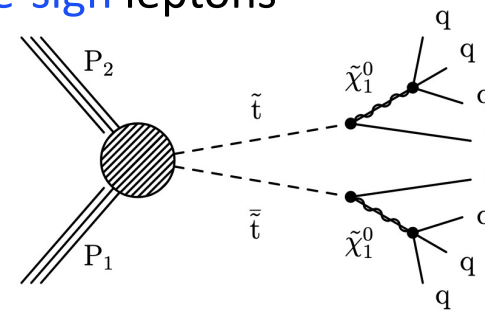
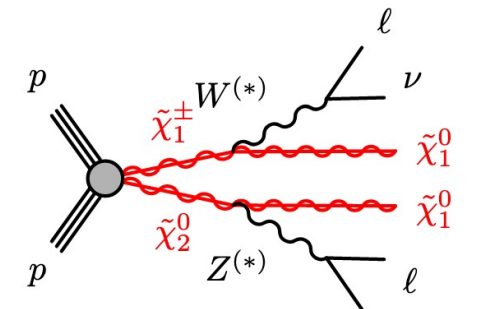
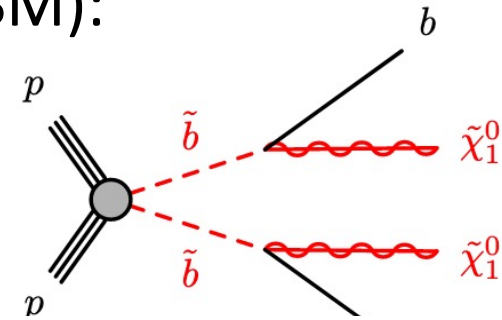
- Large missing transverse momentum
- Significant lifetime/long lived (stopped track, displaced vertex, ...)

- Next-to Lightest Supersymmetry Particle (χ_2):

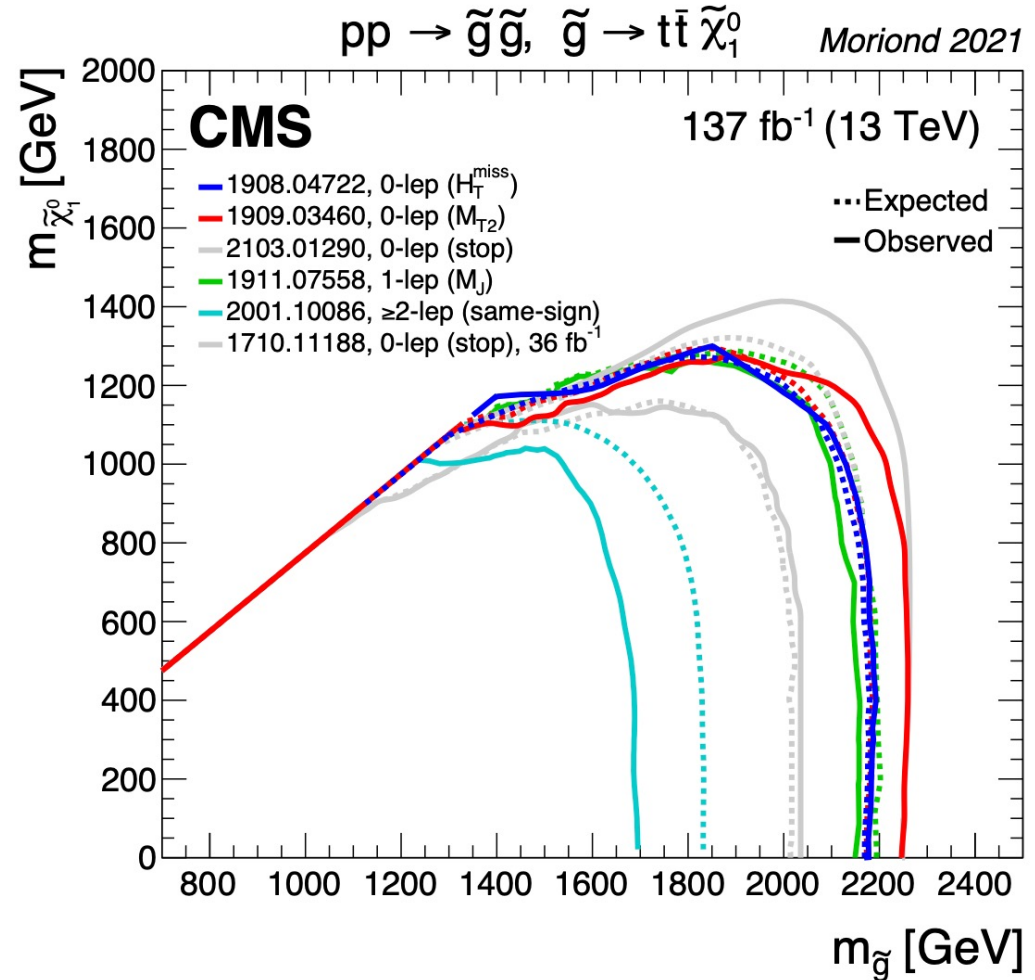
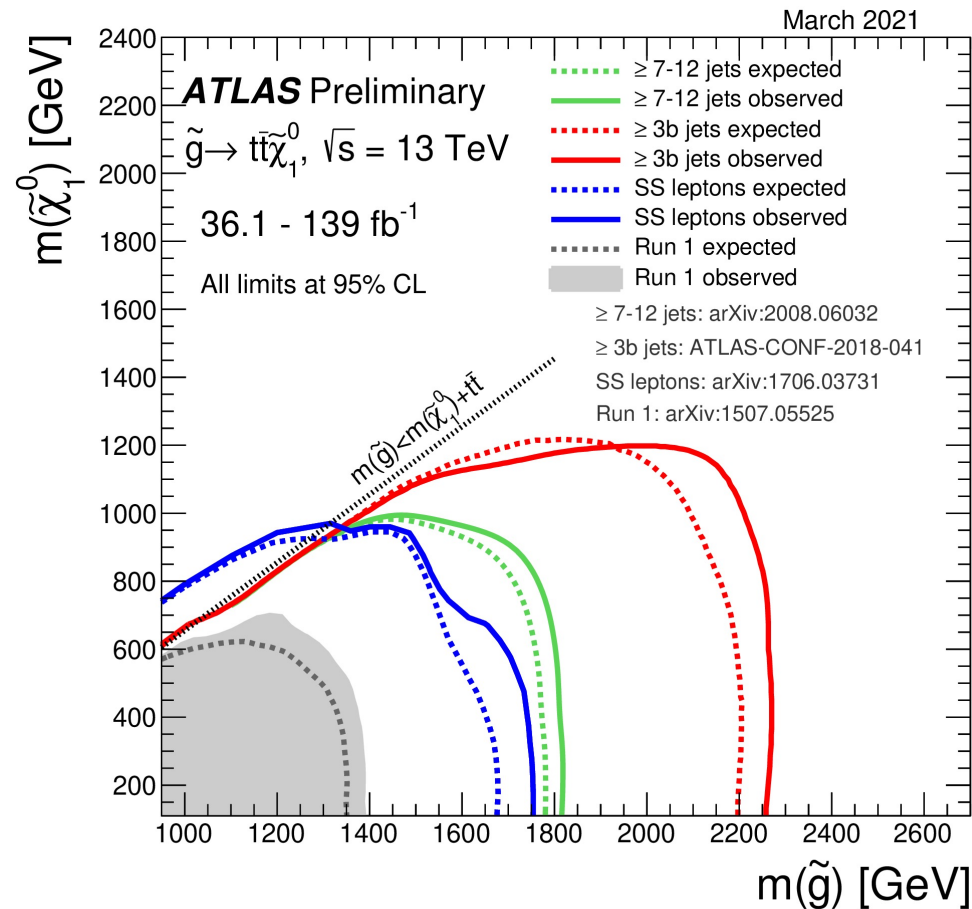
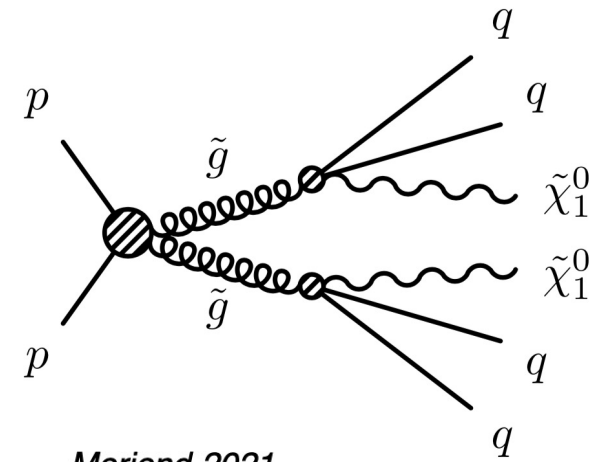
- create many possible decay chains
- High jet multiplicity/lepton multiplicity: Same-sign leptons

- R-parity conservation/violation:

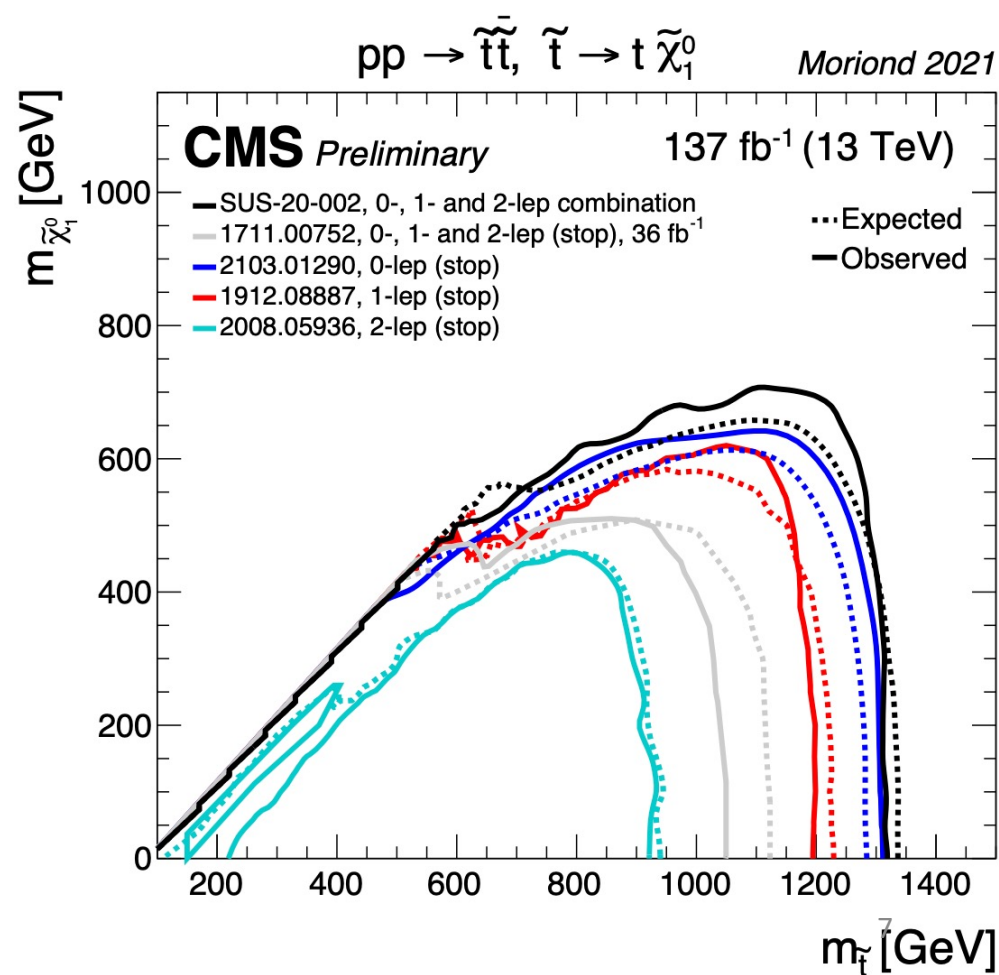
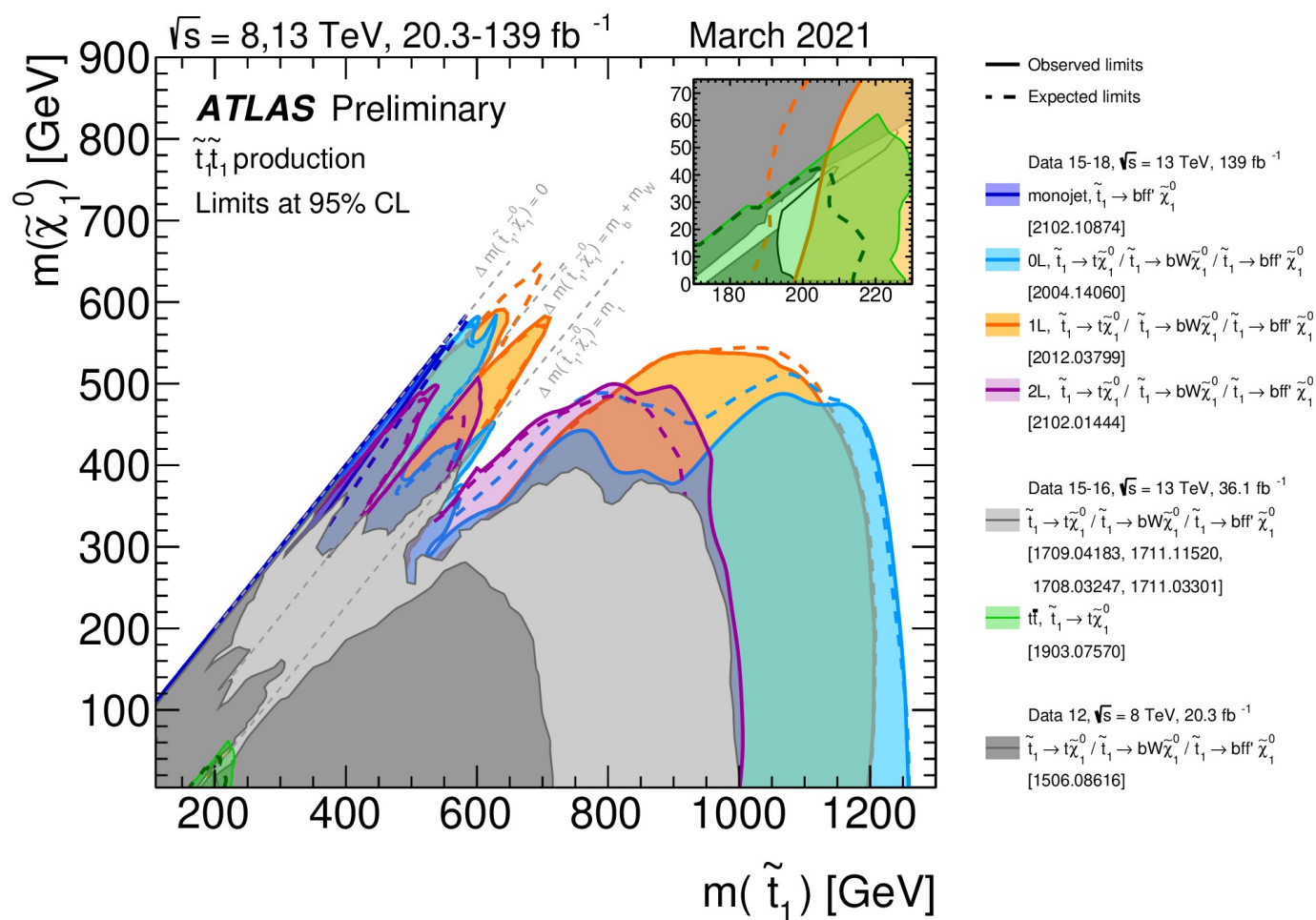
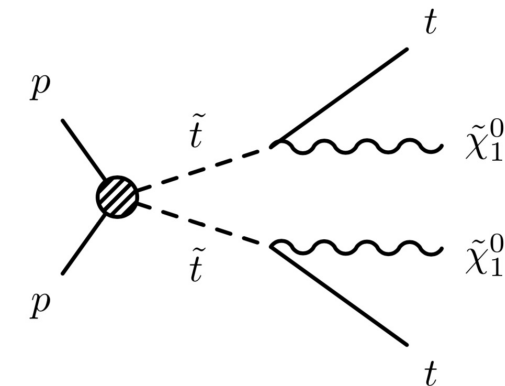
- Supersymmetry/Lepton/baryon number



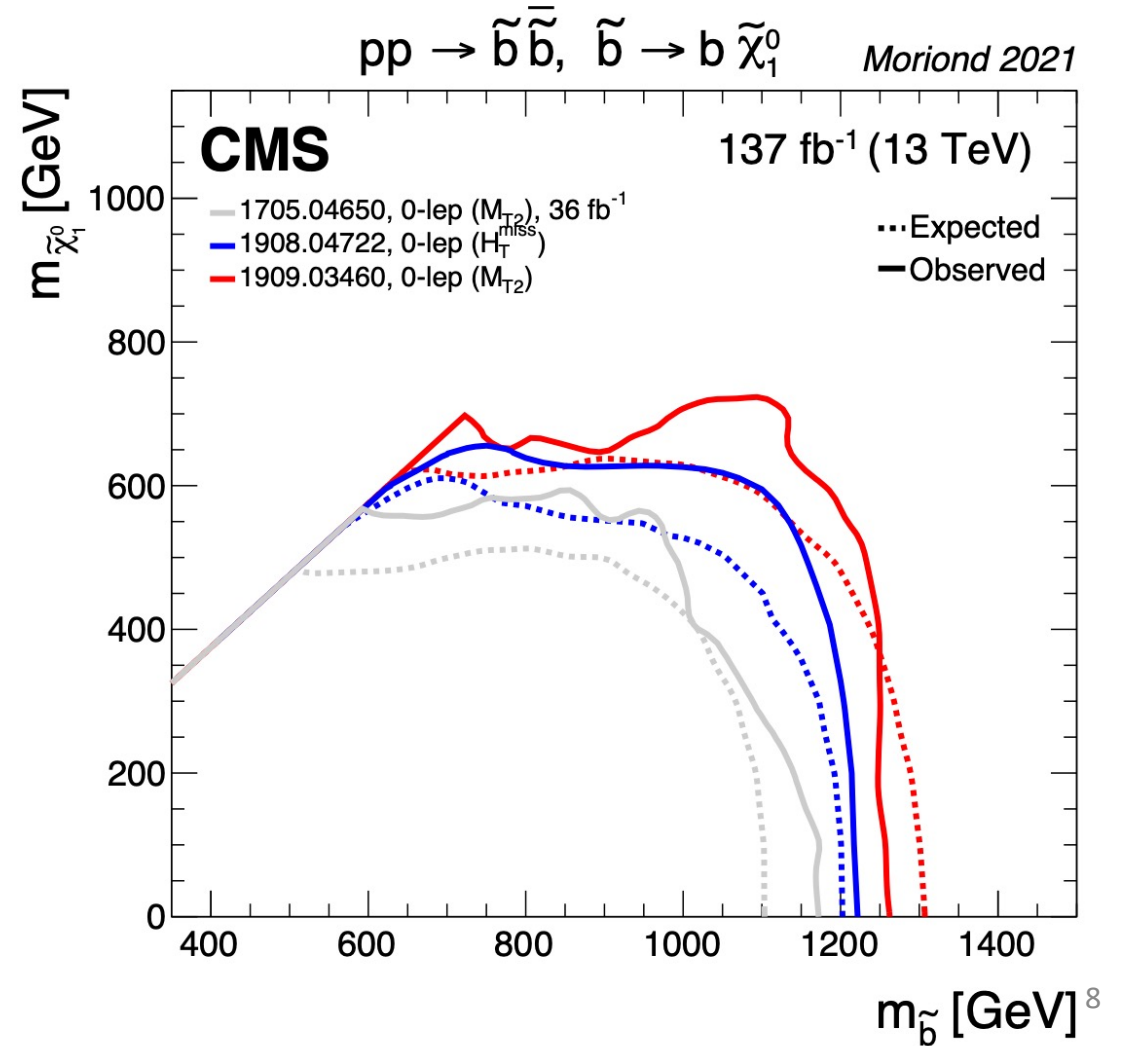
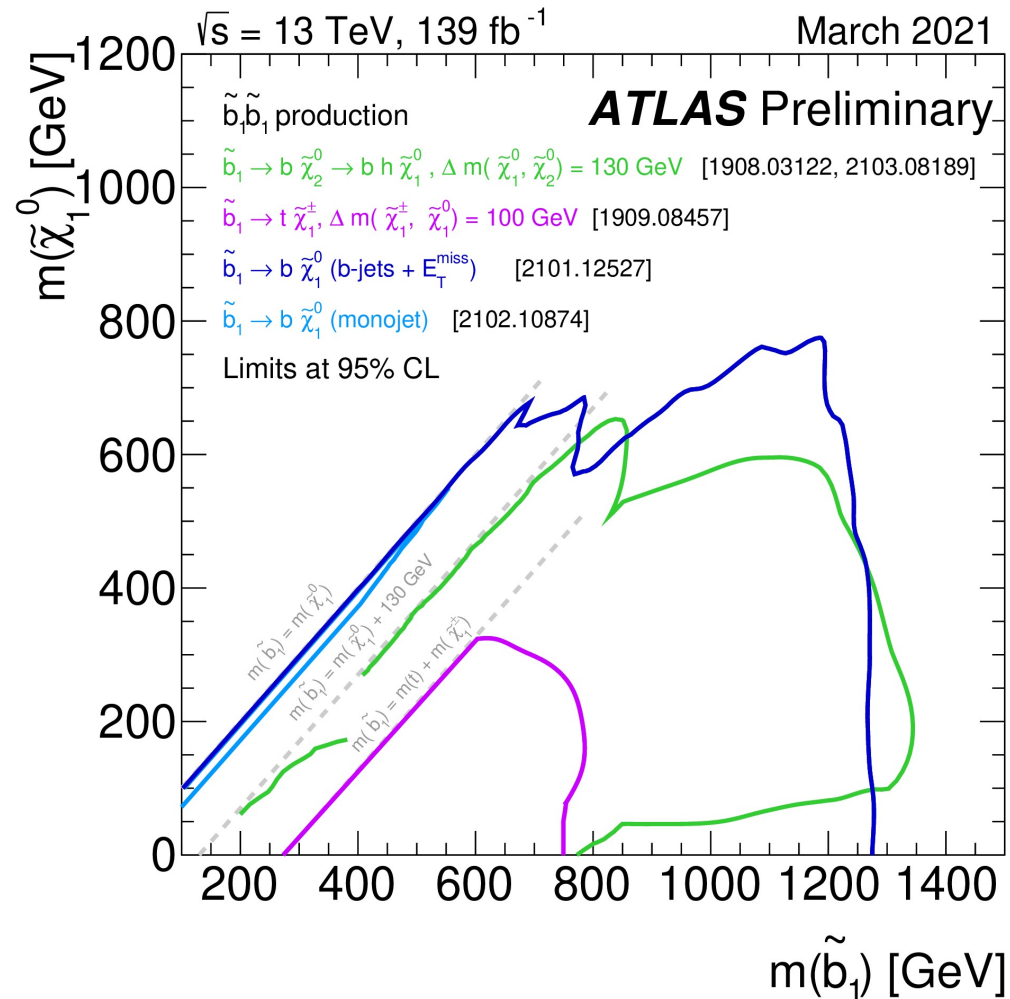
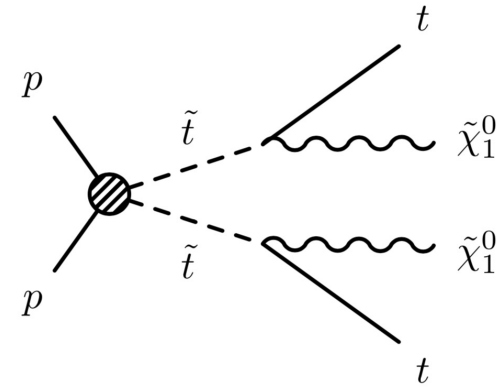
Summary plots: Gluino



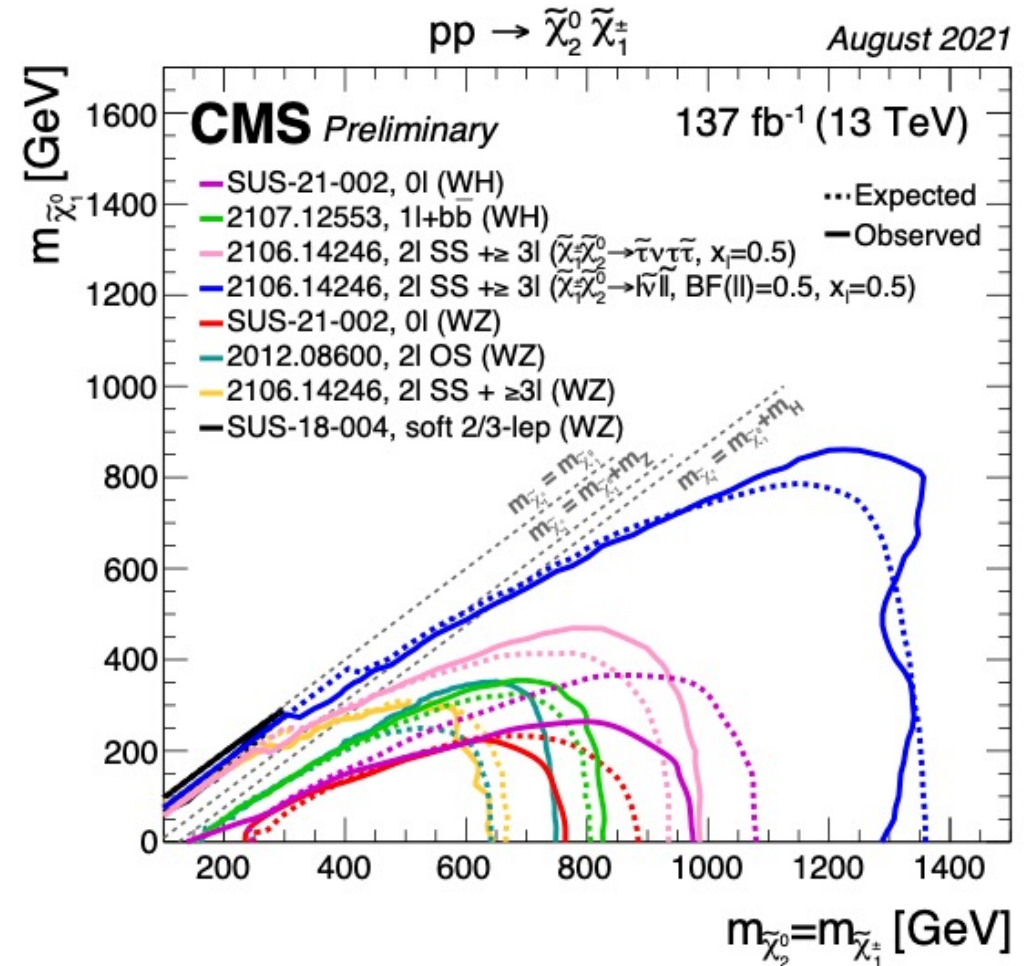
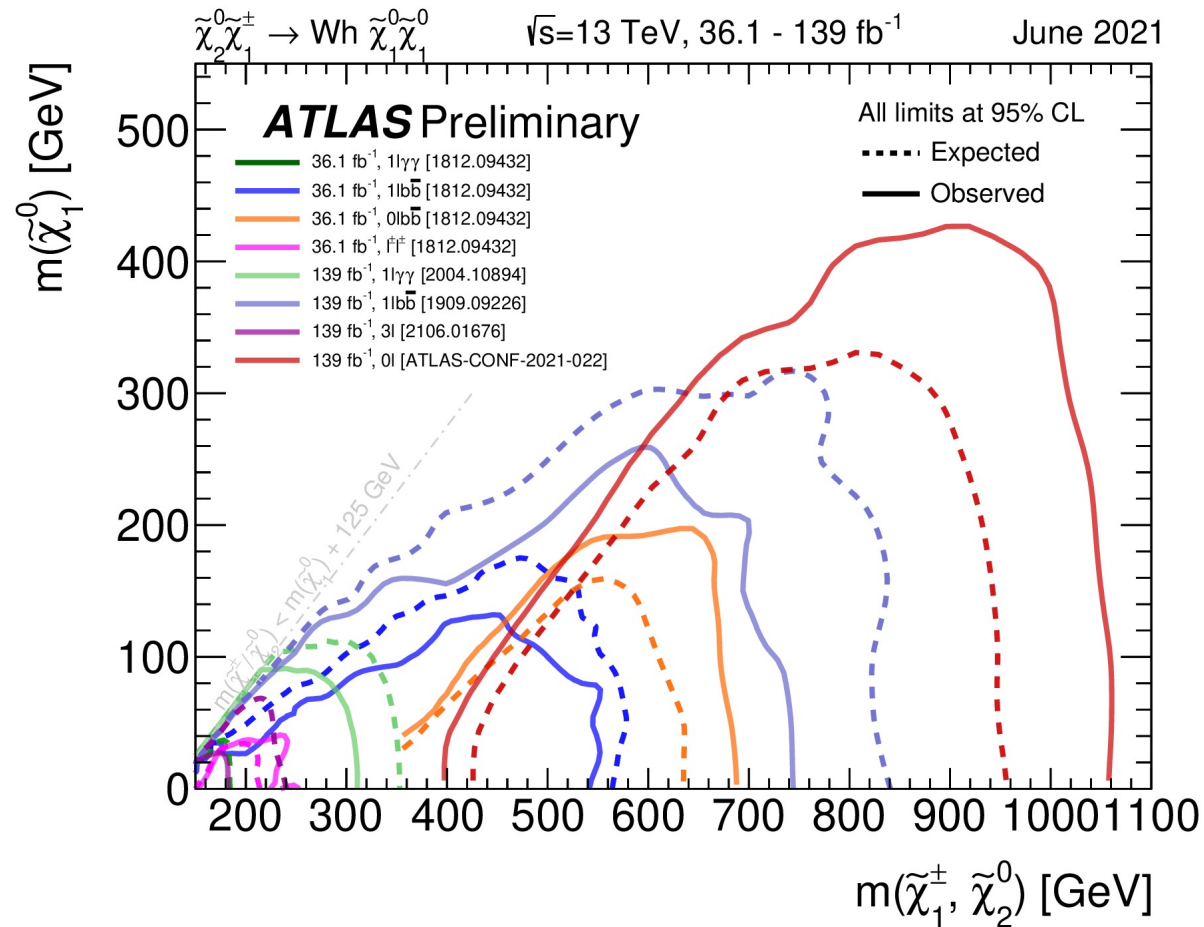
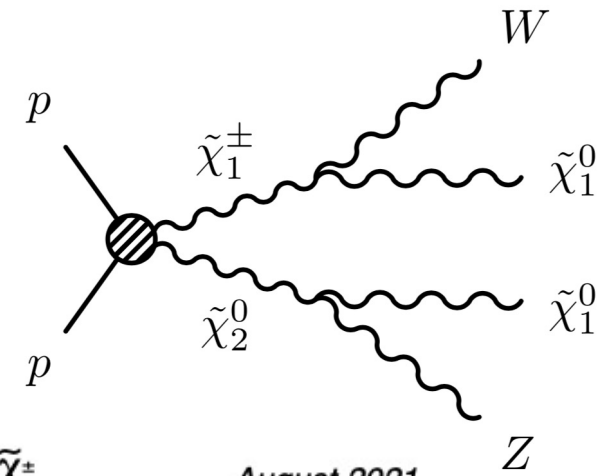
Summary plots: stop



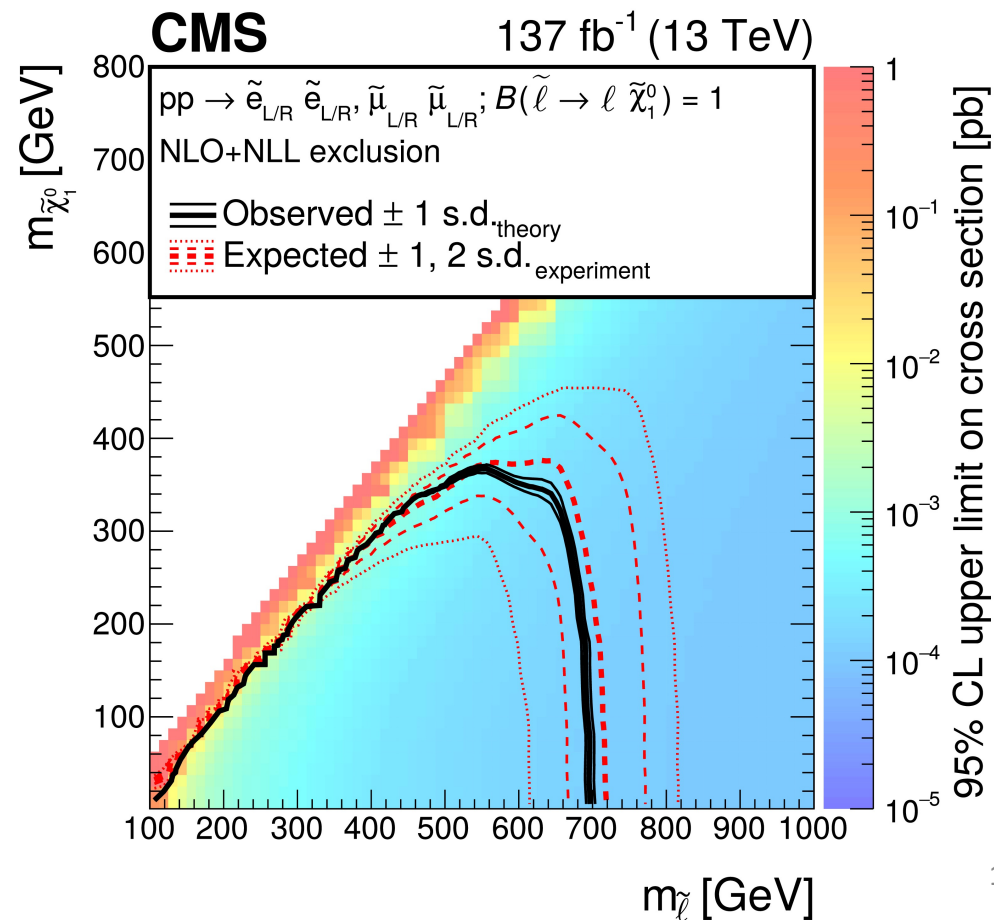
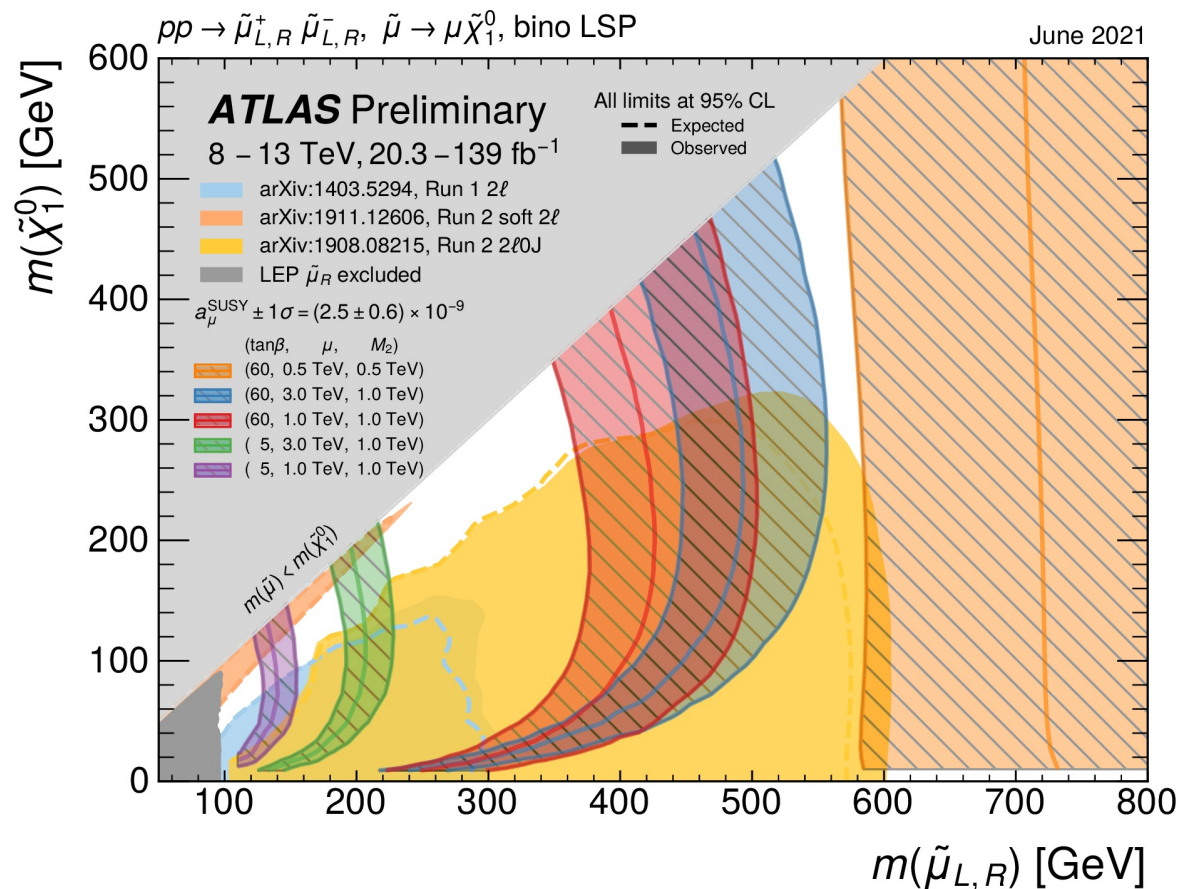
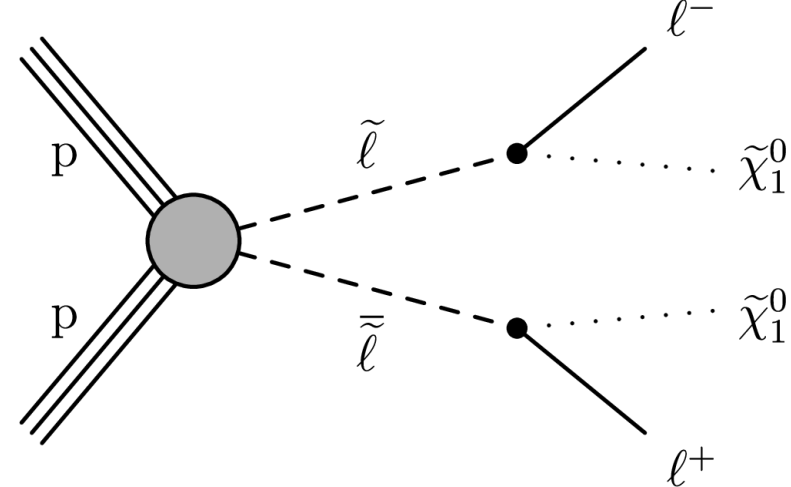
Summary plots: b squark



Summary plots: EWK production



Summary plots: slepton

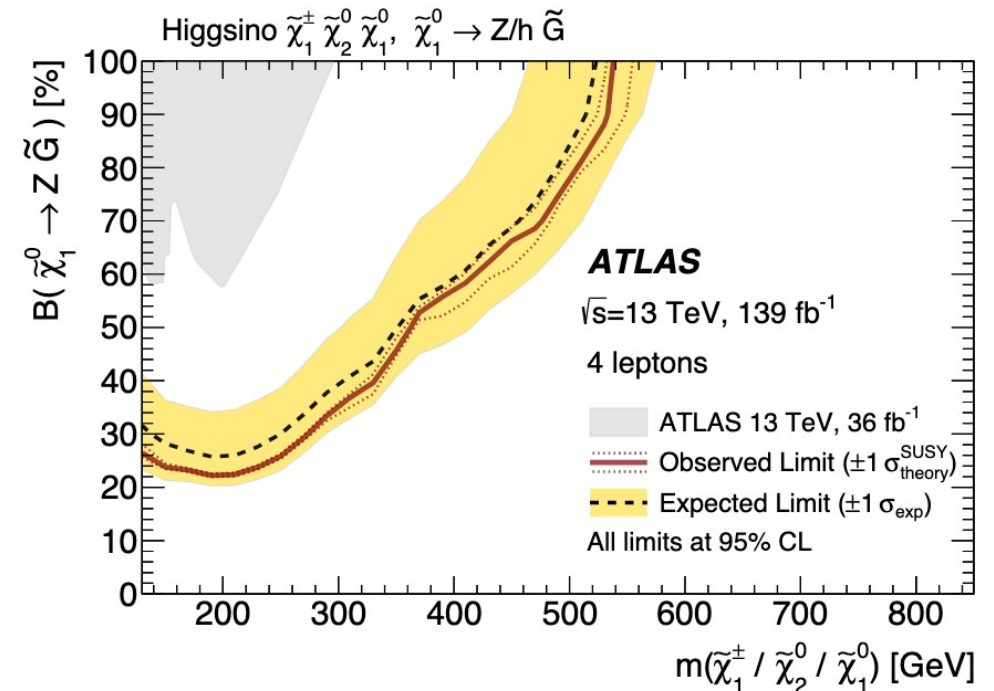
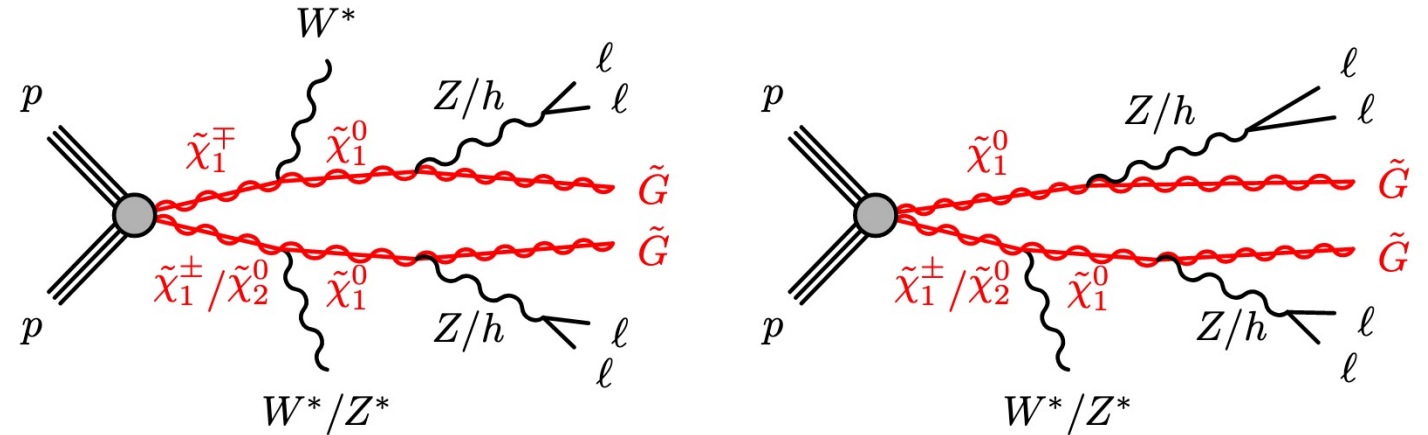
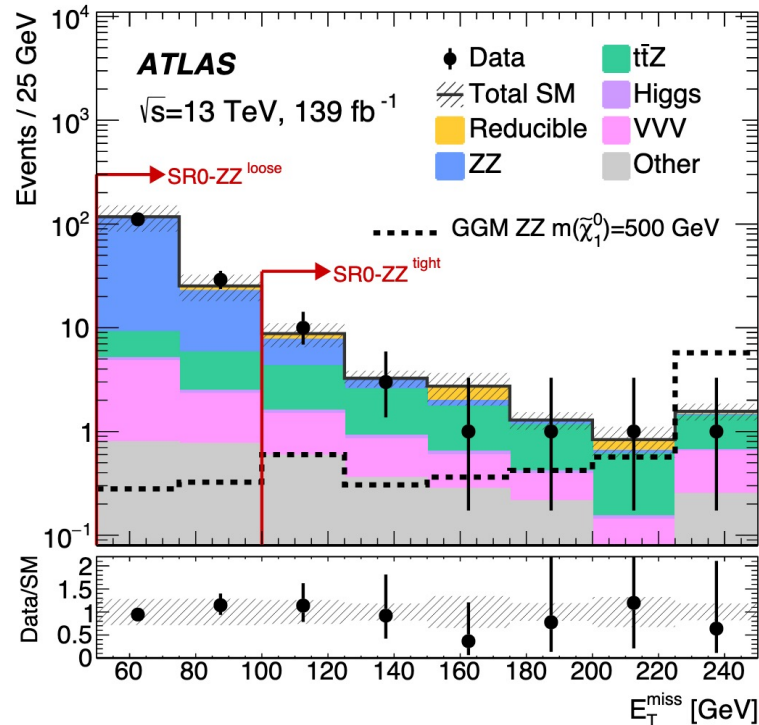


Highlights: many leptons

Ref: 2103.11684 (ATLAS)

Features:

- four or more leptons
- large missing ET

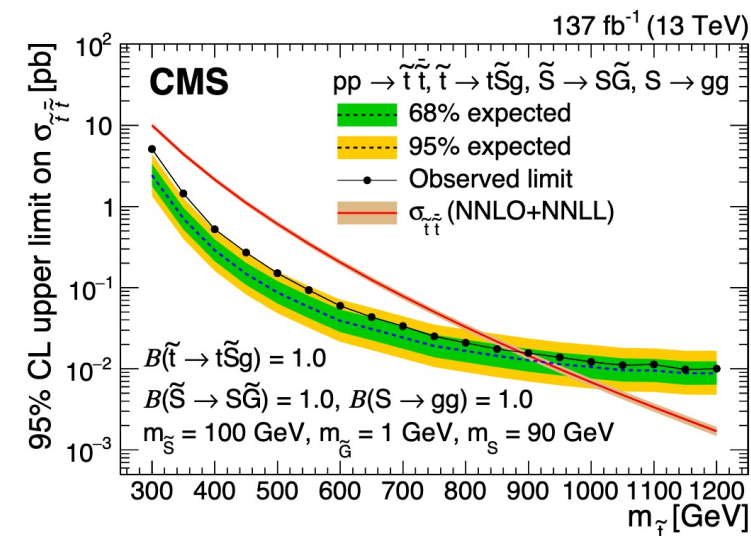
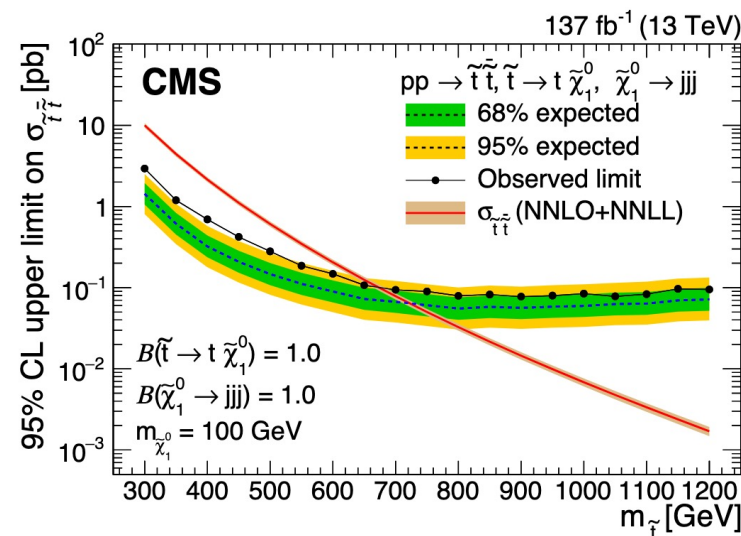
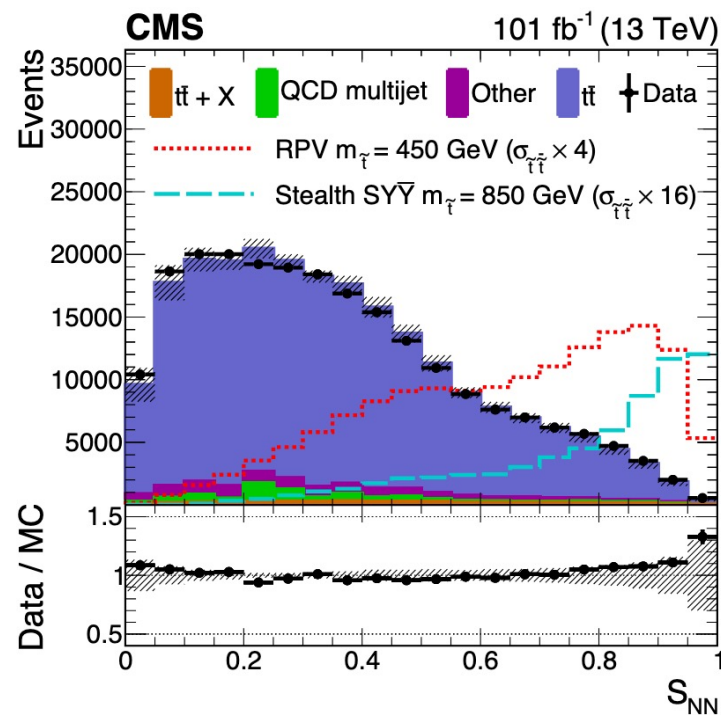
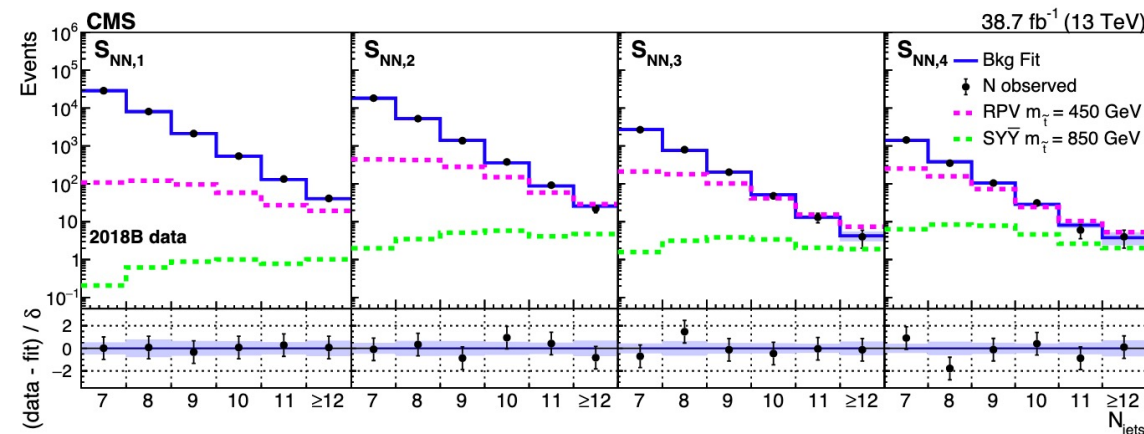
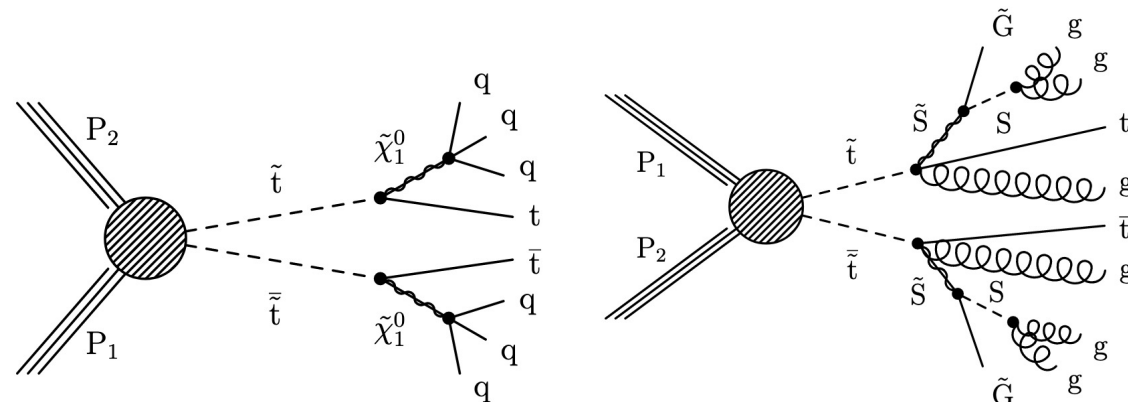


Highlights: many jets

Ref: 2102.06976 (CMS)

Features:

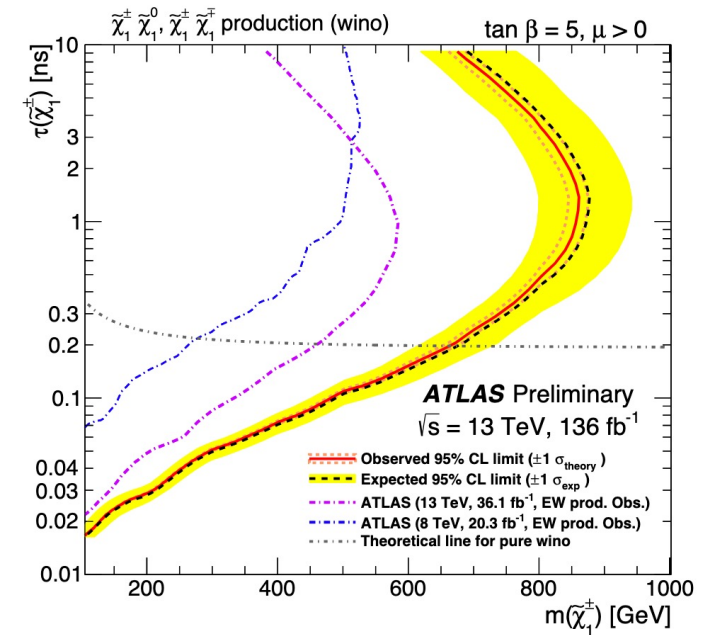
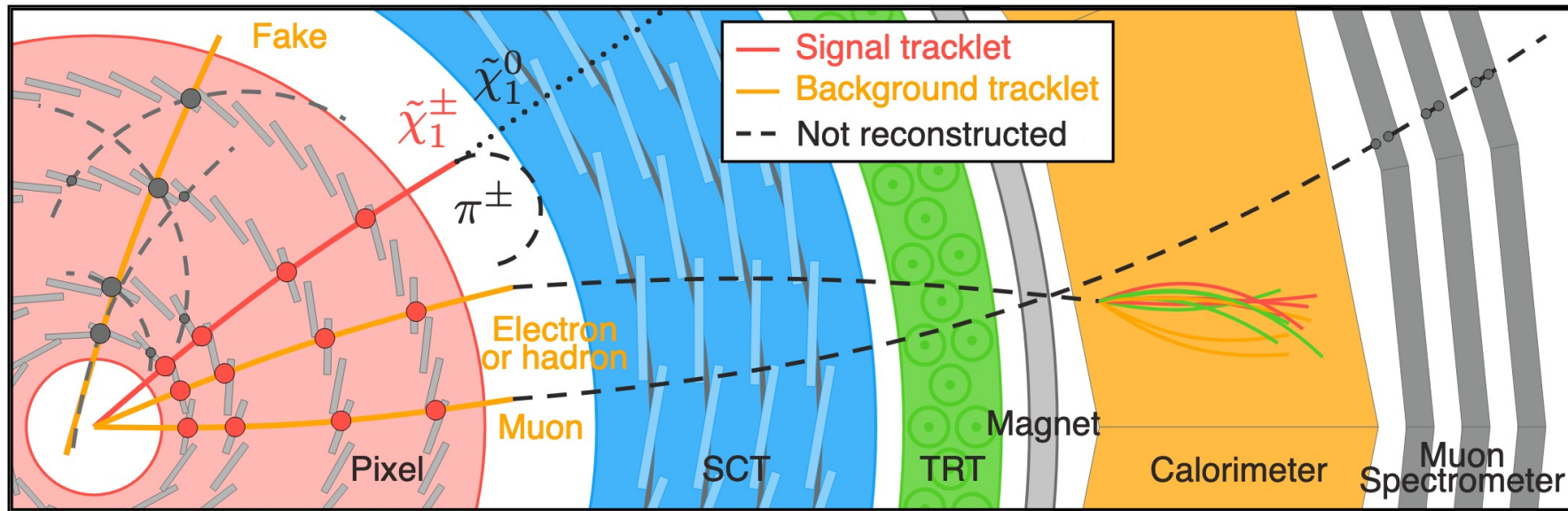
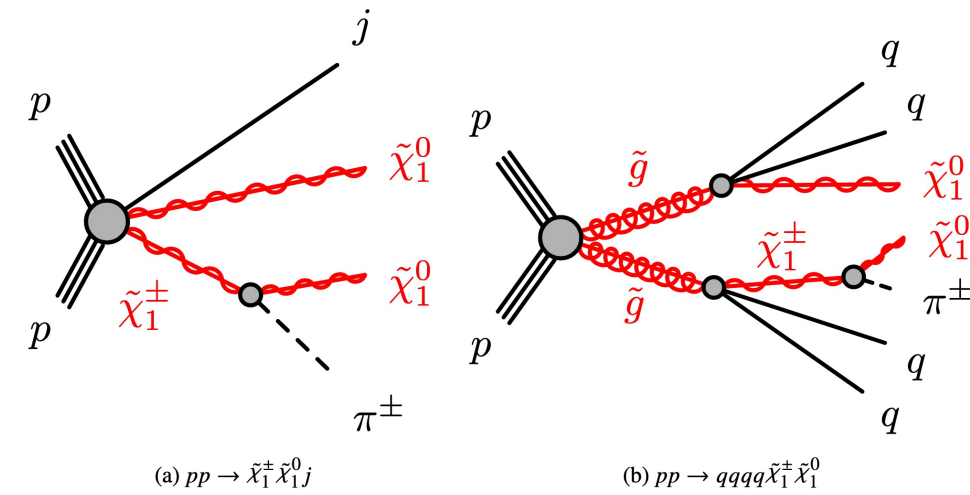
- ≥ 7 jets
- neutral network



Highlight: disappearing track

Ref: ATLAS-CONF-2021-015
(ATLAS)

Features: disappearing track

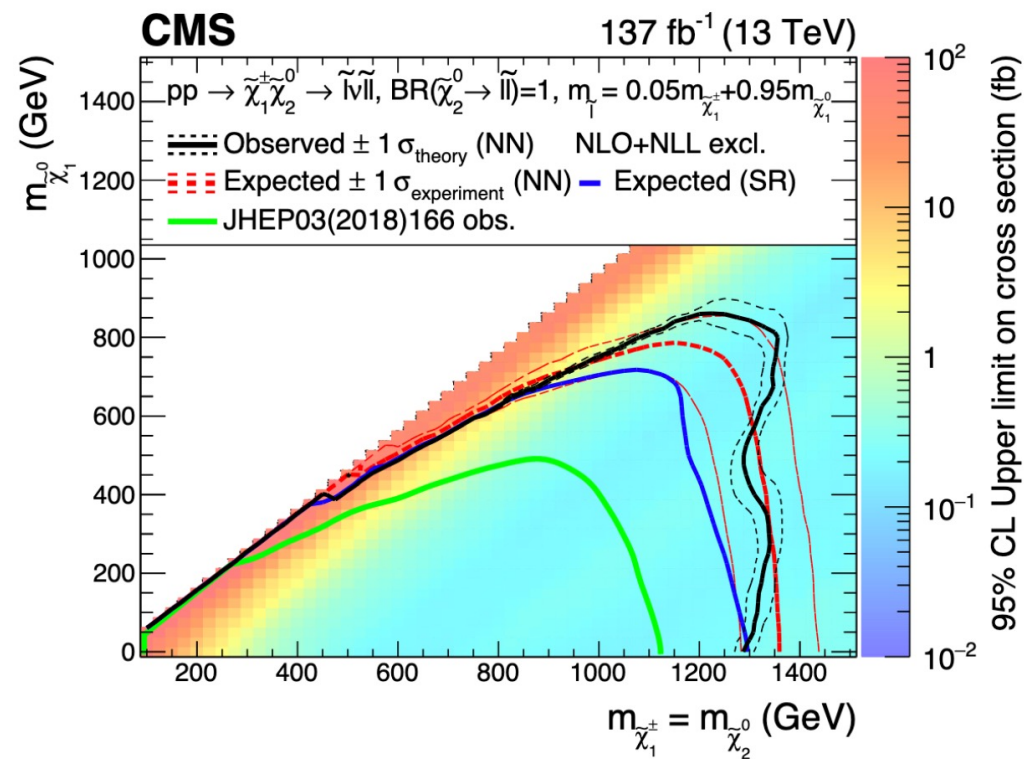
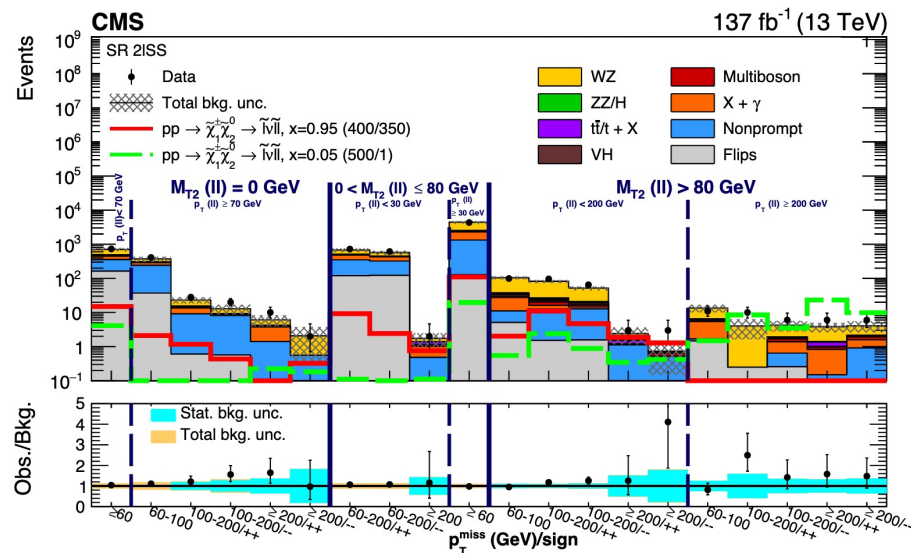
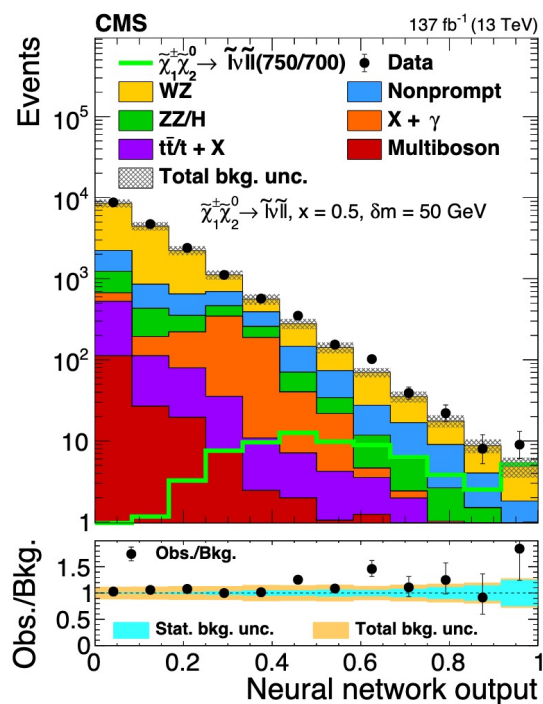
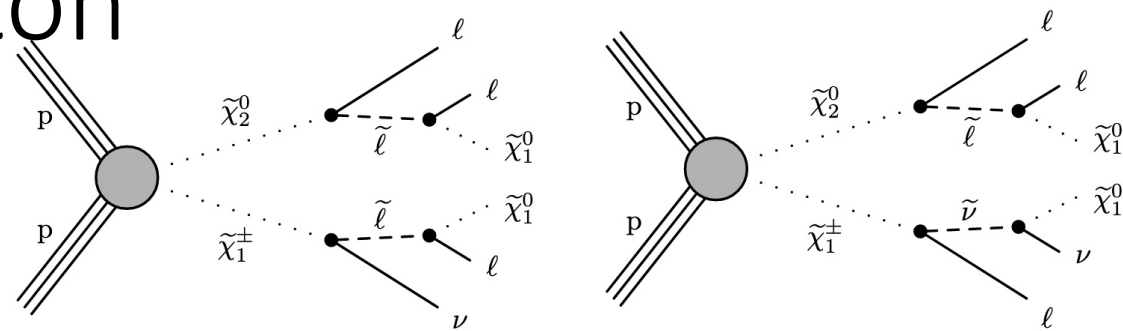


Highlight: same-sign dilepton

Ref: 2106.14246 (CMS)

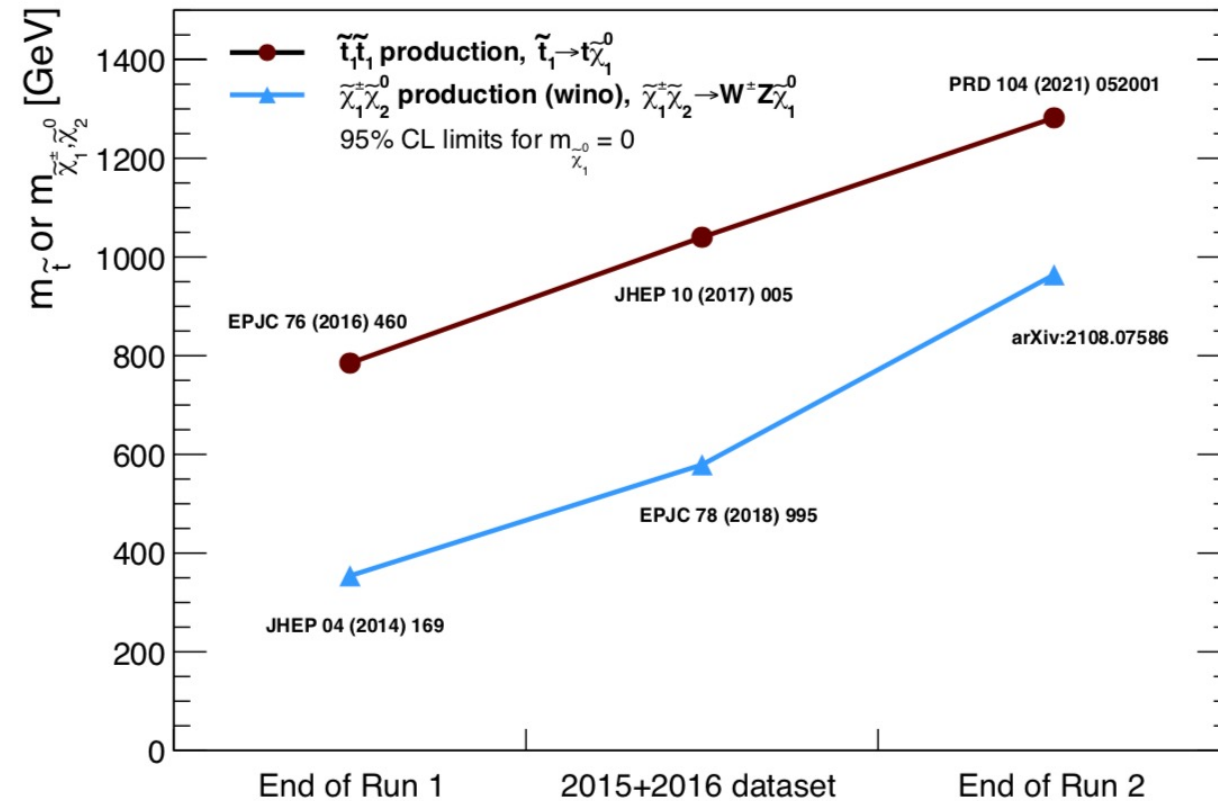
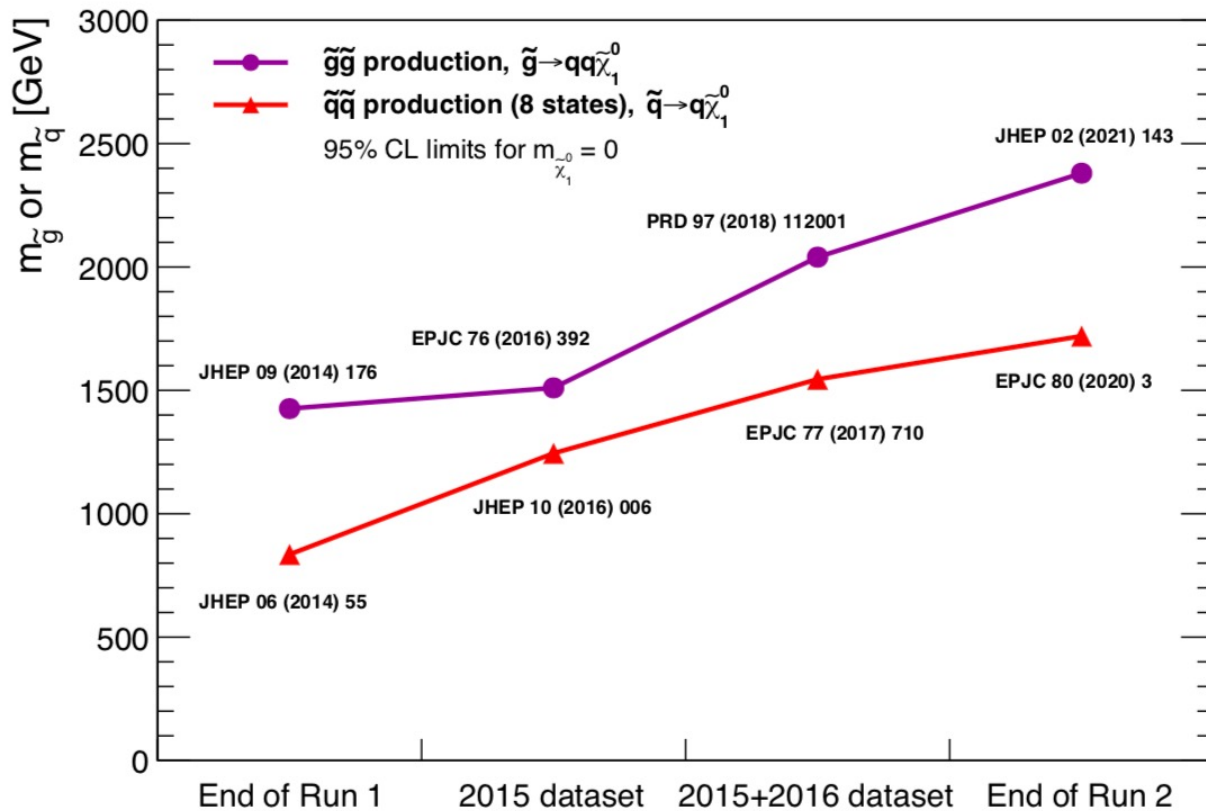
Features:

- same-sign dilepton
- large missing ET



Evolution of mass limits since Run 1

From a most recent review: [2111.10180](https://arxiv.org/abs/2111.10180)



Summary

- Gluino/Stop/Squark with mass $\sim 1\text{-}2$ TeV excluded
- Electroweakino (W,B,H) with mass ~ 1 TeV excluded
- Se/mu with mass ~ 0.7 TeV excluded
- Stau with mass ~ 0.39 TeV excluded
- Many more interesting results to come: higgsino, stau ...
- Exclusive searches with simplified models
- A global fit still looks unlikely
- No SUSY? No, we need more experimental efforts!