LHXSG WG3: NMSSM topics

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The 14th Workshop of the
LHC Higgs Cross Section Working Group

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NMSSM in WG3: *Activities and structure*

The goal

To further exploit the search potential of the NMSSM"

The main focus

- *Shaping ideas through theory-experiment live discussions*
- *Provide benchmark points/planes for NMSSM searches*

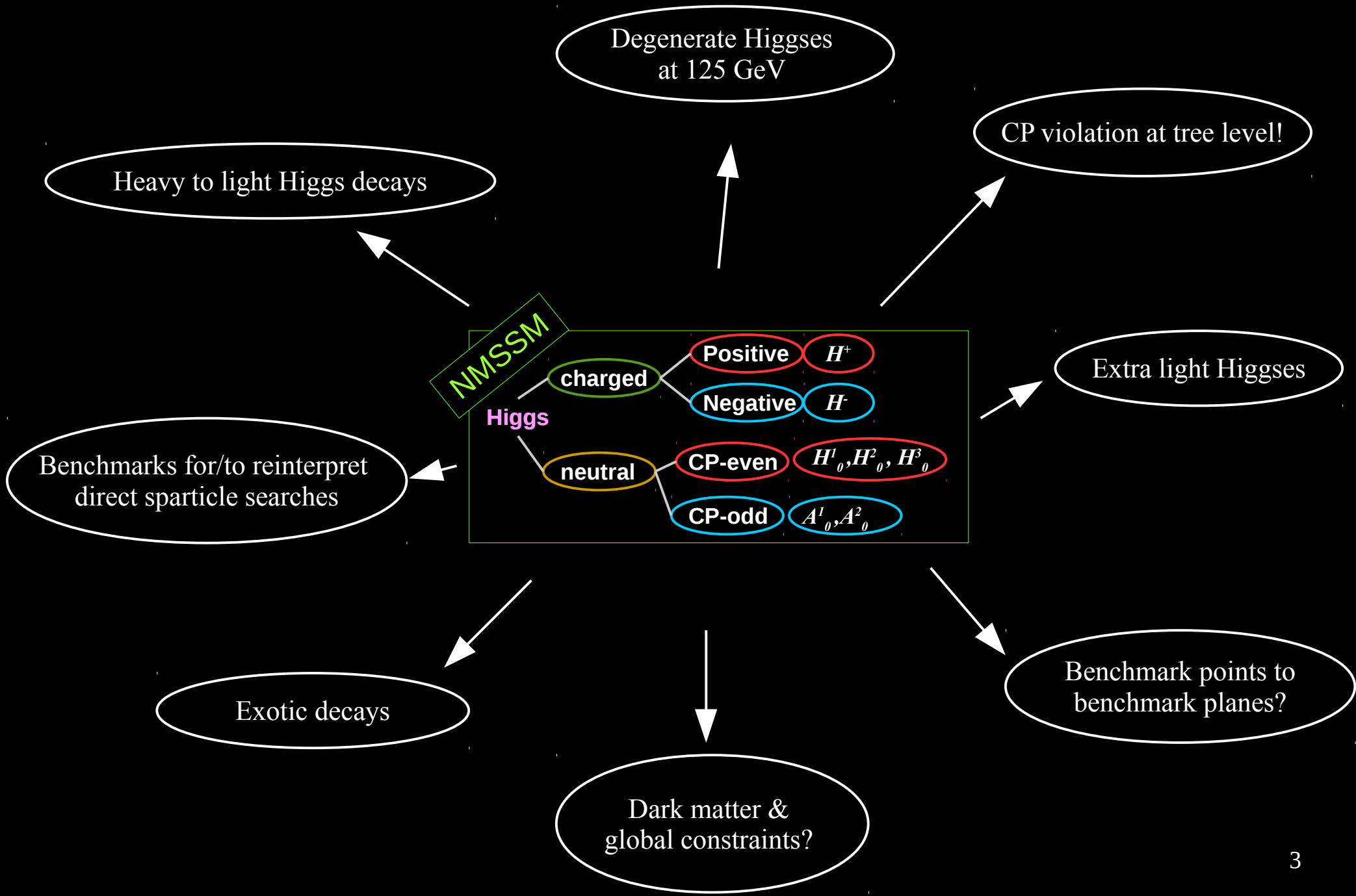
Latest meeting https://indico.cern.ch/event/709119/

Join us on lhc-higgs-nssm@cern.ch

Your contribution is more than welcome

Following our main goal, this talk is meant to provide food for thought and material for discussion

Diversity in ideas and search topics



From the theory corner: *ideas and proposals*

Degenerate Higgses at 125 GeV

CP violation at tree level!

Heavy to light Higgs decays

If a new scalar resonance is discovered, there are several decays that offer insights on its CP nature:

- CPV in the Higgs sector if we observe $H \rightarrow Zh$ and e.g. $H \rightarrow ZZ$ at the same time!
- Offers various final states for simultaneous searches

Nucl. Phys. B901 (2015) 526

Benchmarks for/to reinterpret direct sparticle searches

- Some existing experimental searches could be reinterpreted in NMSSM
- *NMSSM-specific scenarios* with singlet LSP would involve $\tilde{t}$ cascade decays:

  $\tilde{t}_1 \rightarrow t + \tilde{\chi}^0_2$ (higgsino-like) $\rightarrow$ top + Z/h(125) + $\tilde{\chi}^0_1$ (singlino)
- Couplings of the singlino to (s)quarks & (s)leptons are small
  - used for decays only if this is the only available decay channel
- None of existing searches with Z/h(125) seems optimised for this scenario

ark points to
ark planes?

From the theory corner: *ideas and proposals*

Degenerate Higgses at 125 GeV

CP violation at tree level!

e.g. JHEP11 (2017) 008

Heavy to light Higgs decays

H/A (MSSM-like) → h(125)+ h/a (singlet-like)

Cover a significant range of NMSSM parameter space in 4b and bbγγ

Benchmarks for/to reinterpret direct sparticle searches

A possible large BR(H/A → h(125)+h/a → 4b/bbγγ) may weaken the existing MSSM limits from "H/A → ττ" in (m_A,tanβ) plane

Exotic decays

Benchmark points to benchmark planes?

Dark matter & global constraints?

From the theory corner: *ideas and proposals*

- Specialized searches and limits from the experimental side
- Benchmark planes will facilitate:
  - Testing the limits
  - Improving the search
  - Expanding the covered parameter space

A non-trivial task!

Many parameters in NMSSM affecting the Higgs sector at tree-level: λ,κ, A_λ,A_κ, μ_{eff}, tanβ

Experimental results in terms of measurable quantities, i.e. mass, cross section, BR …
→ Theorists recast these results in terms of NMSSM parameters including radiative corrections.

What model parameters affect the measurable quantities the most?
- More than two parameters? Then several planes!

Would be good to include examples in theory papers …

Benchmark points to benchmark planes?

Discussions via Sven's talk here

From the theory corner: *ideas and proposals*

Find more *here*

pNMSSM race for 125 GeV Higgs boson

Shehu AbdusSalam, arXiv:1710.10785

The first global fit of weak-scale pNMSSM with 26 parameter
- Similar approach as pMSSM

⟺

Experimental inputs for observed limits in HepData or similar

Two Higgs bosons near 125 GeV in the NMSSM: beyond NWA

S. Munir et al, EPJ C77 (2017) 544

Interfering Higgses with degenerate mass
- ggF($\gamma\gamma$) is analysed
- can contribute up to 40% of total observed rate

⟺

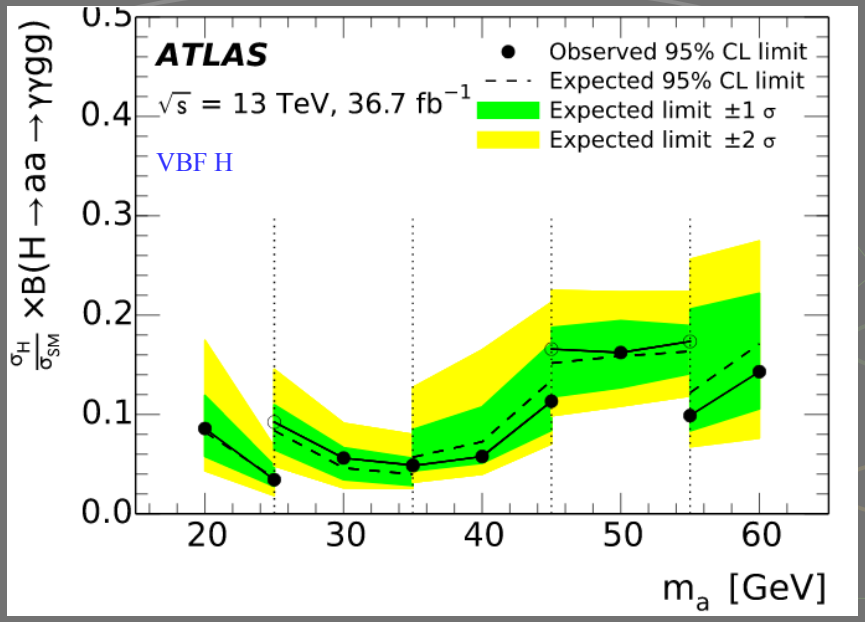
Work ongoing to define benchmarks: can have BR($H_i \to \tau\tau$) ~ 12%, poor resolution ...

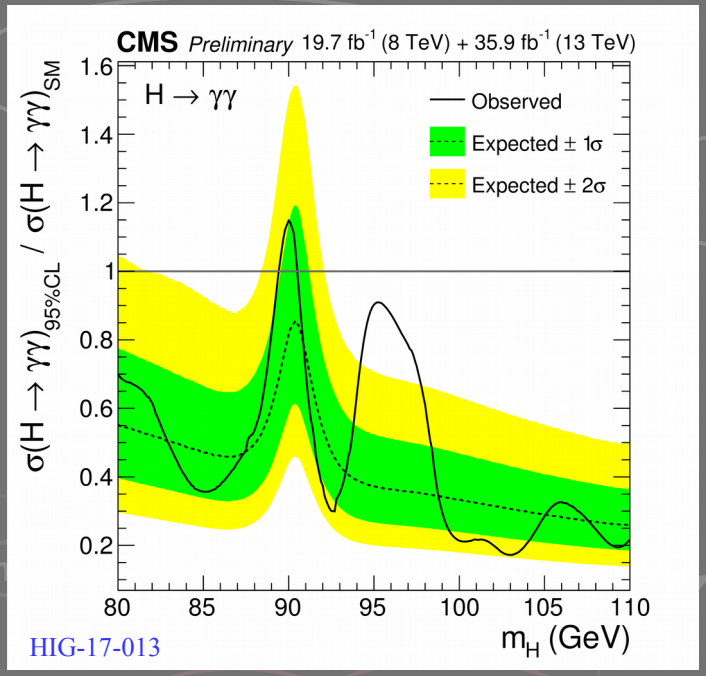
Can we discover a light singlet-like NMSSM Higgs boson at the LHC?

W. de Boer et al, arXiv:1712.02531

- Novel scanning techniques for the whole parameter space
- Determine the range of cross sections and branching ratios

The experiment side: *direct searches*

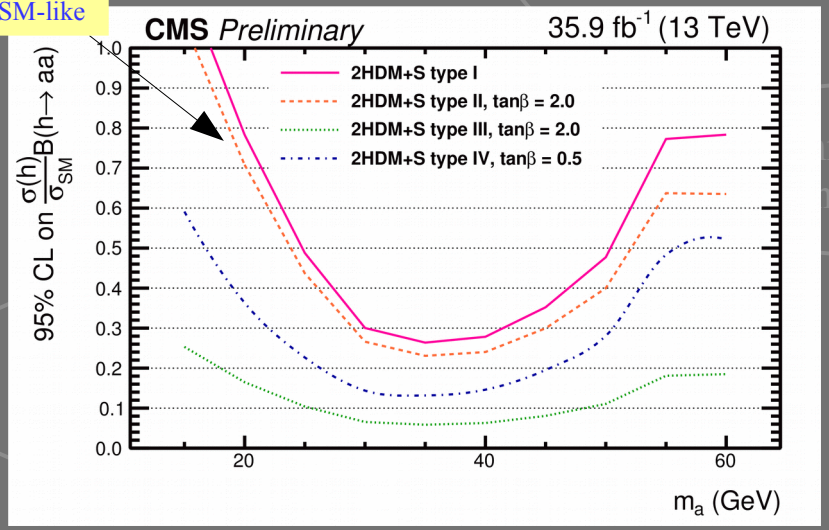




Extra light higgses

Exotic decays

NMSSM-like



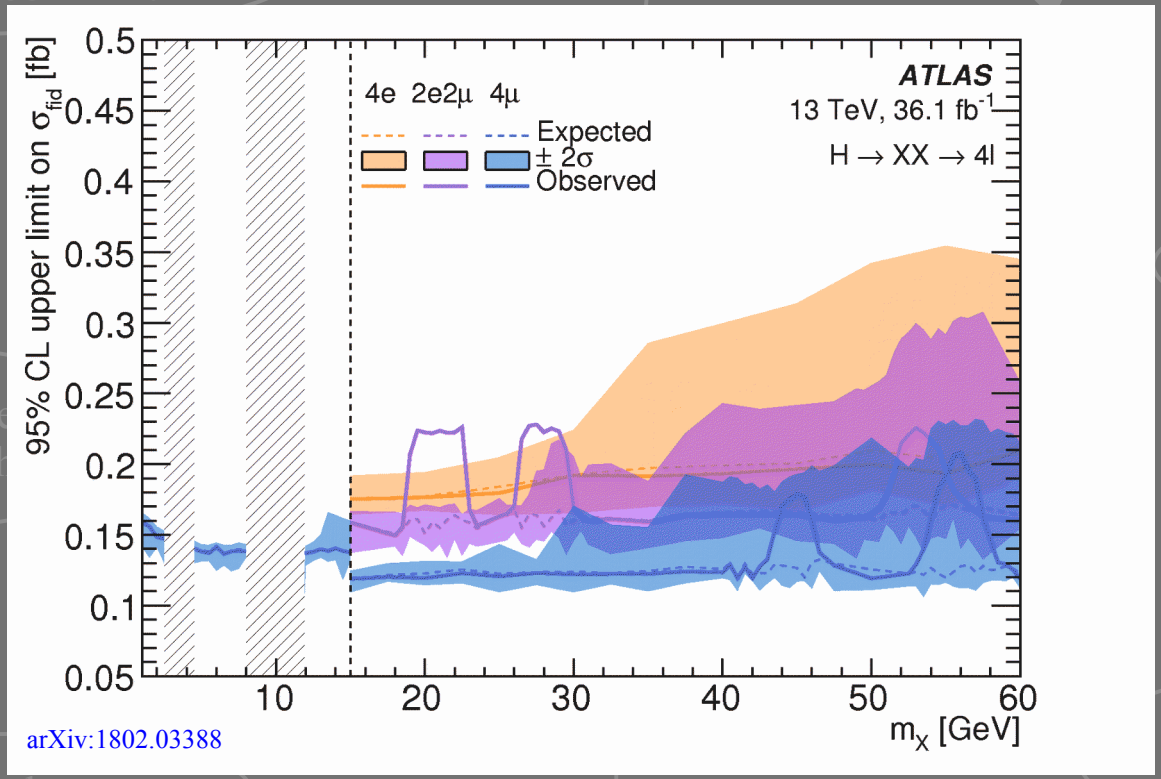
The experiment side: *possible NMSSM interpretation*

Degenerate Higgses at 125 GeV

CP violation at tree level!

Heavy to light Higgs decays

Fiducial cross sections



Extra light Higgses

Benchmarks for/to reinte
direct sparticle search

Benchmark points to benchmark planes?

Exotic decays

A model independent measurement from an interesting phase space!

global constraints?

The experiment side: *possible NMSSM interpretation*

Degenerate Higgses at 125 GeV

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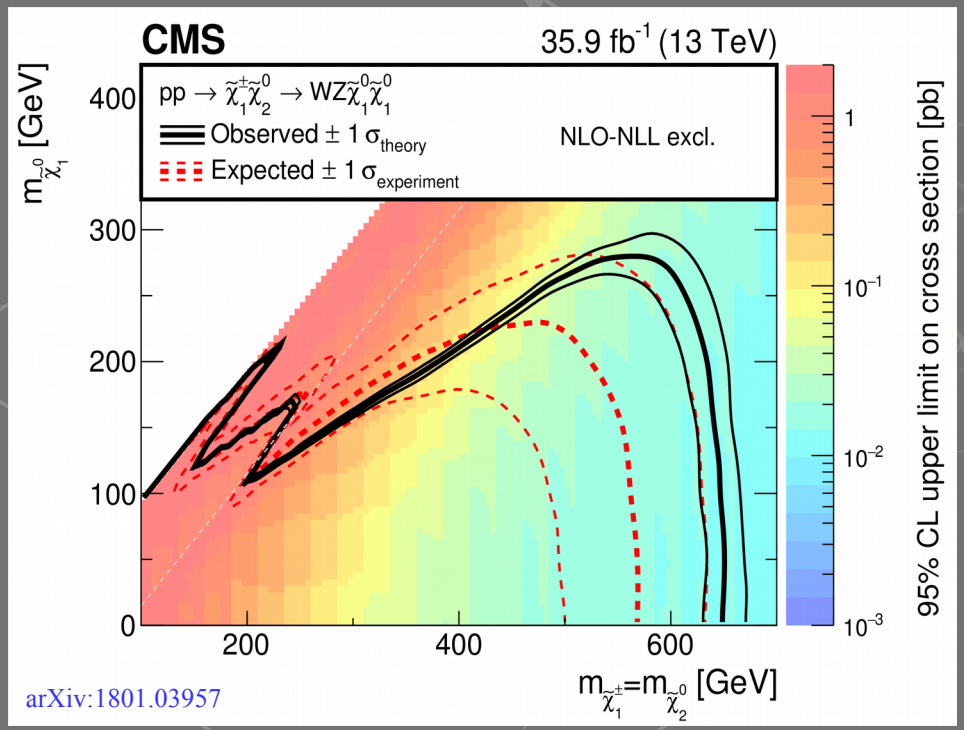
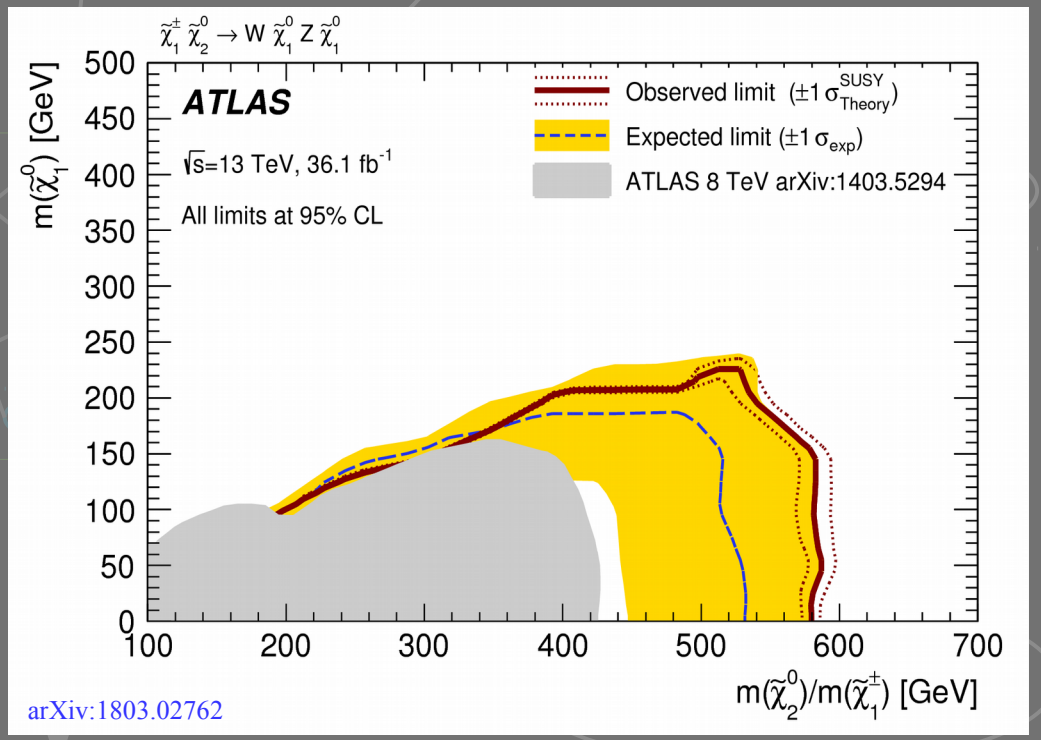
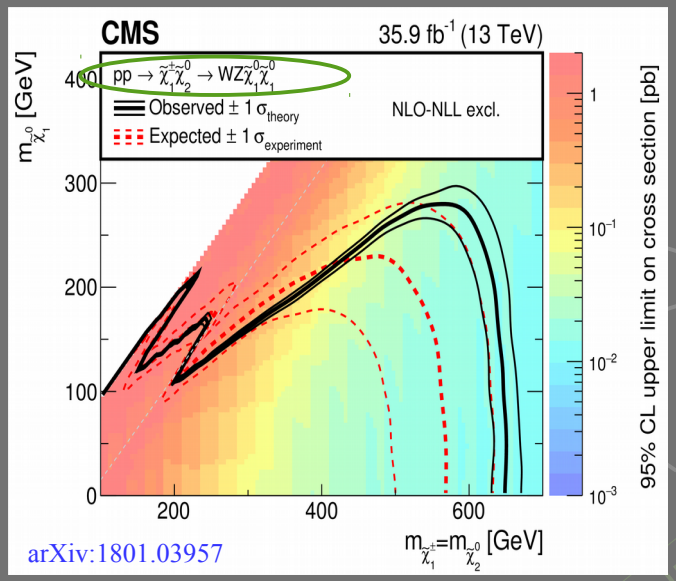
Direct sparticle searches





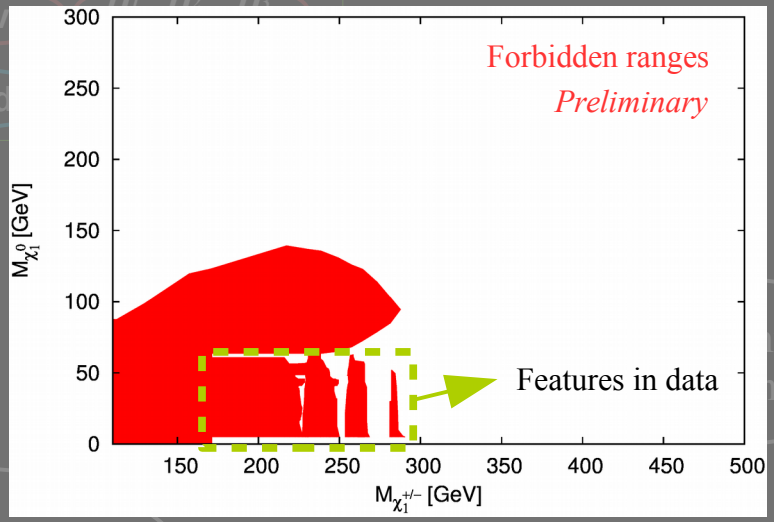
Dark matter & global constraints?

The experiment side: *possible NMSSM interpretation*



- Can be reinterpreted to relevant constraints on NMSSM "light higgsino + light singlino" scenario:
  - $\tilde{\chi}^{\pm}_1/\tilde{\chi}^0_{2(3)}$ ⟷ higgsino
  - $\tilde{\chi}^0_1$ ⟷ singlino
- Constraints can be added from dark matter relic density, spin-dependent and spin-independent direct detection experiments

Ongoing by C. Hugonie & U. Ellwanger



- For $m(\tilde{\chi}^0_1) \leq 5$ GeV constraints from direct detection experiments fade away;
- The resulting freedom in NMSSM allows for $m(\tilde{\chi}^{\pm}_1) \sim 170$ GeV.
- Results from ATLAS has also appeared recently, 1803.02762
- Benchmark planes will be provided

The experiment side: *seeking for theory inputs*

Multiple search proposals in the market from theory

- **A rough estimate on the sensitivity**
  - Reinterpretation of existing results with similar final states?
  - Providing benchmarks that could be tested even at gen. level?

- **MC implementation of the models**
  - Correct angular properties, useful in searches for CPV scenarios
  - Going beyond the usual use of "SM-like Higgs production" and introduce new decays: H(heavy) → h(125) + φ

- **Effect of sparticles on h(125)**
  - What are the recommendations on a tool to estimate the effect of a new Higgs state on h(125) cross section, BR's and kinematics?

Summary

NMSSM has a rich phenomenology and provides a wide range of search topics

Physicists in theory and experiment are actively working to make sure we have no stone unturned

- Search for a NMSSM signal in data in different phase spaces
- Use available results to constrain the NMSSM parameter space, also via a pNMSSM approach
- Shape and propose new topics for analyses

A joint theo-exp effort is ongoing to provide benchmark points/lines /planes for NMSSM analyses

Join us and bring your ideas …

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHXSWGNMSSM

BACKUP

The experiment side: *possible NMSSM interpretation*

Additional comments:

- The production cross section for higgsinos is smaller than for winos as assumed in 1709.05406
- BM points are not necessary as limits on σ×BR on this final state are already useful.

Effect on $\tilde{t}/\tilde{b}$ searches:

- Possible to have $\tilde{t} \rightarrow t + \tilde{\chi}^0_{2(3)}$ or $\tilde{t} \rightarrow b + \tilde{\chi}^{\pm}_1$ with consequent decays of higgsinos to W/Z and $\tilde{\chi}^0_1$.
- Considering possible BRs and masses in such $\tilde{t}$ decays, BM points/lines/planes can be defined for $\tilde{t}/\tilde{b}$ searches.