# Electroweakino SUSY search with Wh

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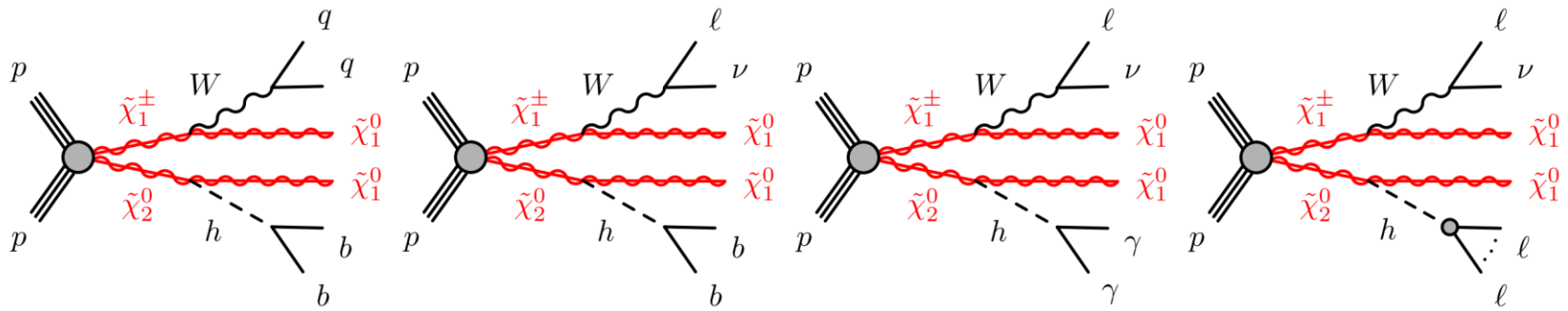
# Introduction

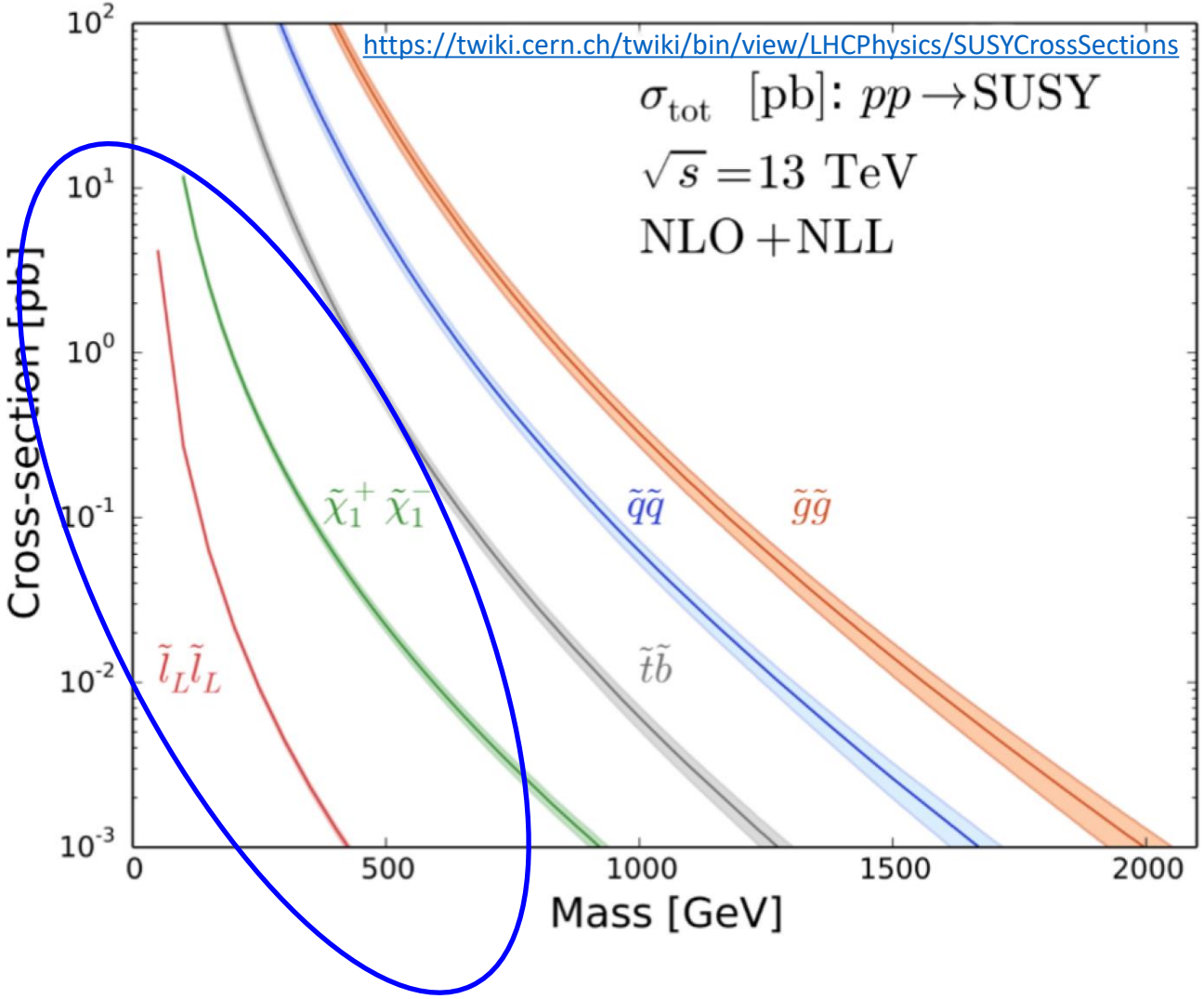
- **Several analyses searching for chargino and neutralino pair production via Wh are performed in both ATLAS and CMS**
- **Different final states considered:**
  - W → lν or qq
  - H → bb, γγ, or ll (from WW/ZZ/ττ)
  - IHEP group is contributing to **1lbb**, **2lSS/3l**, **1lττ** analyses



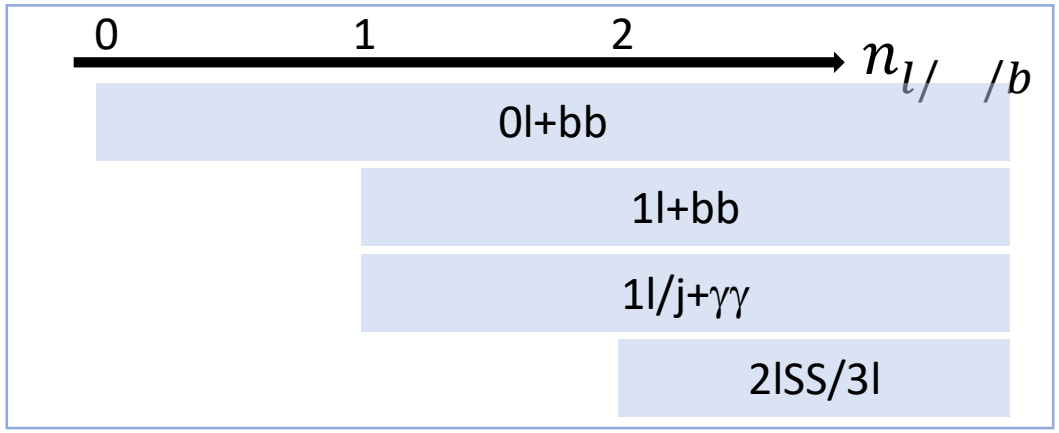

(a) $0\ell b\bar{b}$ (b) $1\ell b\bar{b}$ (c) $1\ell\gamma\gamma$ (d) $\ell^{\pm}\ell^{\pm}$,$3\ell$

# Motivations

- If the coloured sparticles are too heavy for LHC, electroweak productions will be dominant.
- Smaller cross sections, limits are less stringent, and motivated by naturalness.
- Decay via **Higgs boson** is dominant for many choices of the parameters
- Observation of a Higgs boson in a SUSY-like process would provide evidence that SUSY particles couple to the Higgs field.



# Common Strategy - I




- Analyses target final states with **different object multiplicities**
- Interpretation performed with simplified SUSY models,
  - 100% BR for targeted decay
  - $\tilde{\chi}_1^{\pm}$ (C1)/$\tilde{\chi}_2^0$ (N2) and $\tilde{\chi}_1^0$ (N1) masses as free parameters
- Higgs mass set to 125 GeV, and BR assumed to be the same as in the SM
- R-parity-conserving (RPC) assumed, $\tilde{\chi}_1^0$ as the LSP

$$\mathrm{R_P} = (-1)^{3(\mathrm{B-L})+2S}$$

# Common Strategy - II

- SUSY searches rely on accurate modelling of the Standard Model backgrounds
  - Control/validation regions (CR/VR) are defined to study the background modeling
  - Data-driven/sideband/fit methods developed for some irreducible backgrounds
- Discriminating variables are used to separate signals from backgrounds:


Object counting, momenta, energies

e.g. $N_{jet,bjet,l,r}$, $p_T$

Scale variables, event-wise variables

e.g. $H_T = \Sigma P_T$, $E_T^{miss}$, $m_{eff} = \Sigma P_T + E_T^{miss}$

Angular variables

e.g. $\Delta\varphi(jet, E_T^{miss})$, $\Delta R(l, l)$

Mass variables

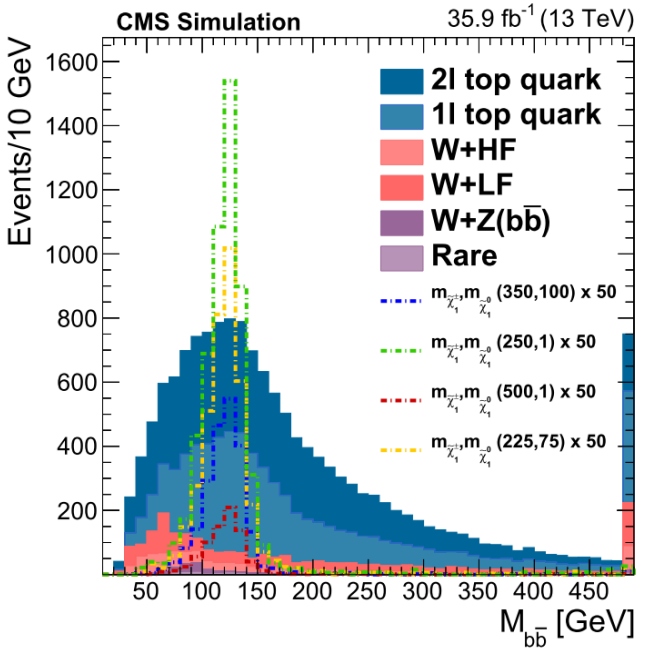
e.g. $m_{ll}$, $\mathrm{m_T}\left(\mathrm{l}, E_T^{miss}\right)$

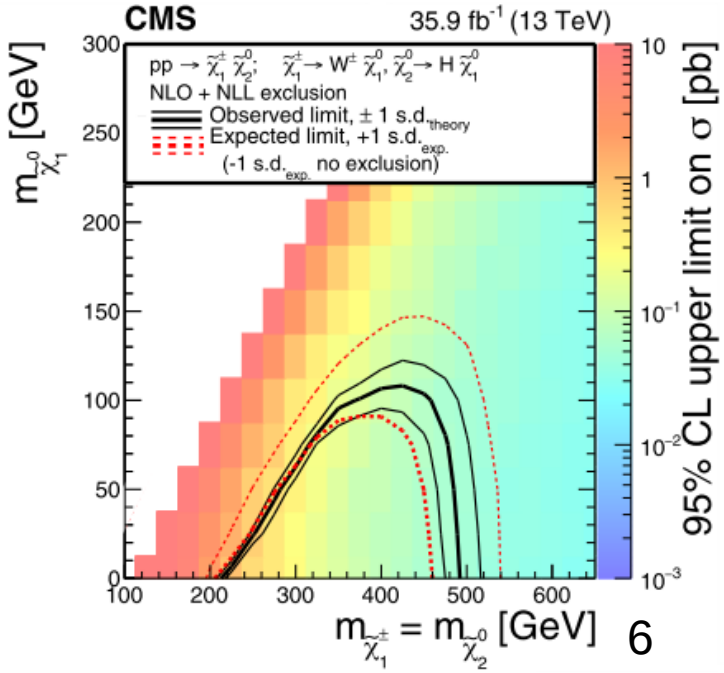
Hypothesis based event variables

e.g. $m_{T2}$, razor

# 1l + bb scenario

- **H → bb** (**most dominant** channel) and W → lν
- Dominant SM background: ttbar, W+jets, single top (Wt channel)
  - CR defined by inverting the SR selections
  - Derive scale factor from CRs and apply to SRs
- MET, $m_T$, $m_{bb}$ and $m_{CT}$ are very efficient variables to separate events in signal from backgrounds
- Results from CMS experiment: **JHEP 11 (2017) 029**
- Results from ATLAS experiment based on 36.1 $fb^{-1}$ data will be submitted to PRD soon



# 0l + bb scenario

- **H → bb** (**most dominant** channel) and W → qq
- Dominant SM background: ttbar, W+jets, single top (Wt channel)
- MET, $m_T$, $m_{bb}$ and $m_{CT}$ are very efficient to discriminate events from signal and backgrounds
- Results from ATLAS experiment based on 36.1 $fb^{-1}$ data will be submitted to PRD soon

# 1j + γγ scenario

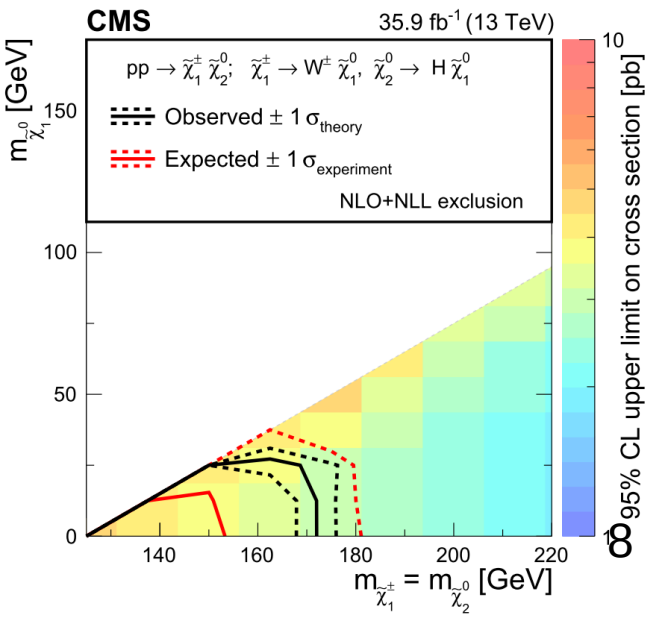
- **H → γγ** (results in very clean isolated Higgs peak)
- Dominant SM background: SM Higgs and non-resonant γ production
  - Non-resonant γ production fitted in $m_{\gamma\gamma}$ sideband regions
  - SM Higgs background estimated from MC simulation
- Razor variables ($M_R$, $R^2$) provide discrimination between SUSY signals and SM background processes, used to define binning SRs

$$M_R \equiv \sqrt{(|\vec{p}^{j_1}| + |\vec{p}^{j_2}|)^2 - (p_z^{j_1} + p_z^{j_2})^2},$$

$$R^2 \equiv \left(\frac{M_T^R}{M_R}\right)^2,$$

$$M_T^R \equiv \sqrt{\frac{p_T^{miss}(p_T^{j_1} + p_T^{j_2}) - \vec{p}_T^{miss} \cdot (\vec{p}_T^{j_1} + \vec{p}_T^{j_2})}{2}}.$$

- Results from CMS experiment: **PLB 779 (2018) 166**

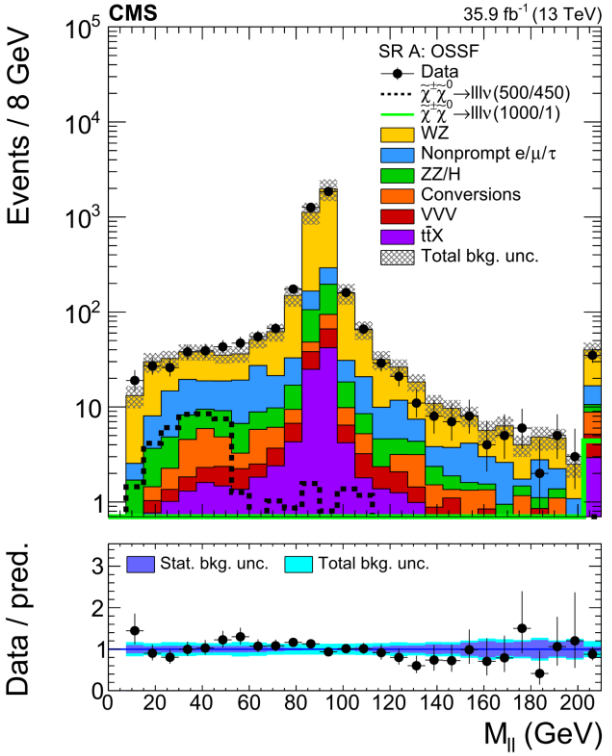


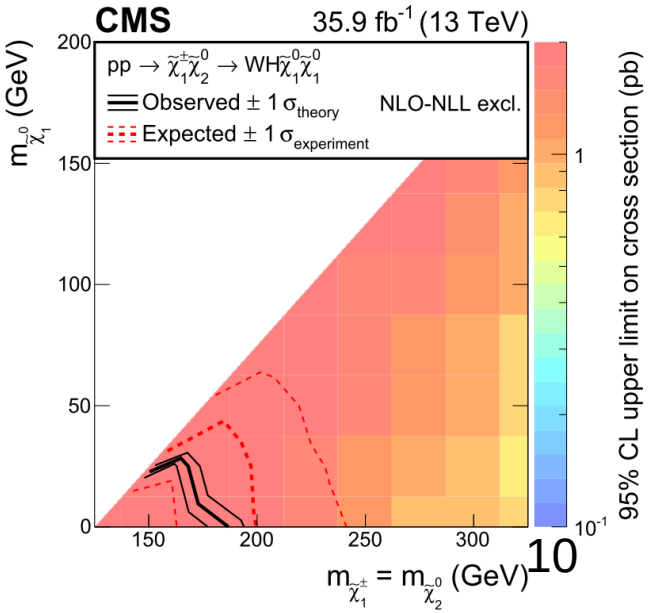
# 1l + γγ scenario

- **H → γγ** (results in very clean isolated Higgs peak) and **W → lν** (1 lepton can suppress hadronic backgrounds)
- Dominant SM background: SM Higgs and non-resonant γ production
  - Non-resonant γ production fitted in $m_{\gamma\gamma}$ sideband regions
  - SM Higgs background estimated from MC simulation
- MET, $m_T$, $m_{bb}$ and $\Delta\varphi_{W,h}$ can provide discrimination between events from signal and backgrounds
- Results from ATLAS experiment based on 36.1 $fb^{-1}$ data will be submitted to PRD soon

# 3l scenario

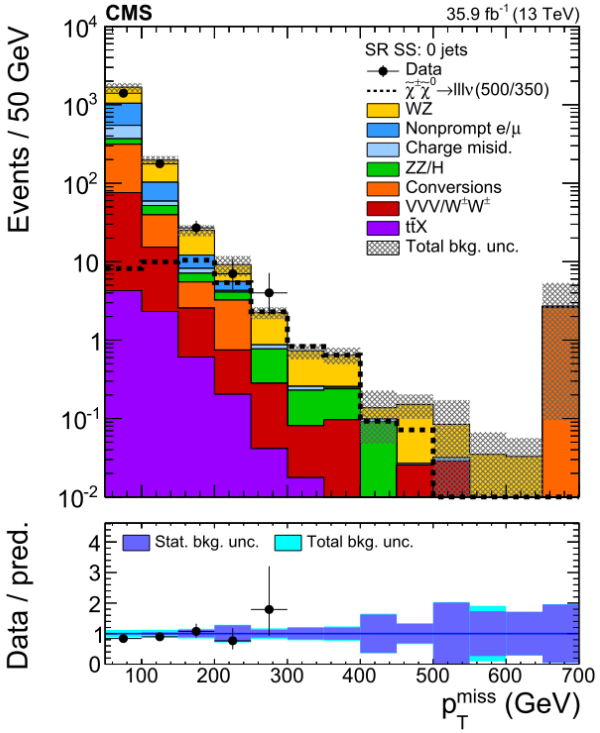
- **H → WW, ZZ or ττ → ll** and **W → lν**
- Main backgrounds:
  - **Reducible background**: at least one fake or non-prompt lepton (data driven method)
  - **Irreducible backgrounds**: real leptons, dominated by diboson (MC estimation)
- Events classified by number of leptons and their flavor
  - $m_{ll}$, $m_{T2}$, MET, $n\tau_h$, $n_{OSSF}$ are very efficient variables
- Results from CMS experiment: **JHEP 03 (2018) 166**
- Results from ATLAS experiment based on 36.1 $fb^{-1}$ data will be submitted to PRD soon

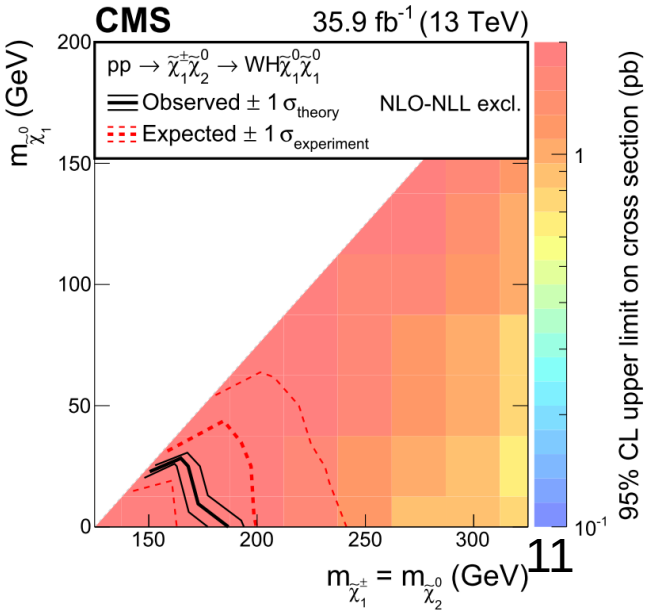


# 2lSS scenario

- **H → WW, ZZ or ττ → l(l)** and **W → lν**
- **2lSS requirement** to cover compressed scenarios with soft lepton while keeping the SM background small
- Main backgrounds (similar as 3l scenario):
  - **Reducible background**: fake + charge-flip backgrounds
  - **Irreducible backgrounds**: real leptons
- Similar SR categorization as 3l scenario
- Results from CMS experiment: **JHEP 03 (2018) 166**
- Results from ATLAS experiment based on 36.1 $fb^{-1}$ data will be submitted to PRD soon



# Summary

- Several analyses searching for C1N2 production via Wh in different final states using 13 TeV data collected by ATLAS and CMS are ongoing
- The strategy and current results of these analyses are presented
- No SUSY observed yet with 35.9 $fb^{-1}$ data from CMS
- More results (more scenarios, more data!) are coming soon, stay tune!


The End

# Backup