



# Weakly-interacting and 3<sup>rd</sup> generation SUSY searches at the LHC

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Particle physics and cosmology  
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on behalf of the CMS and ATLAS collaborations



# Introduction

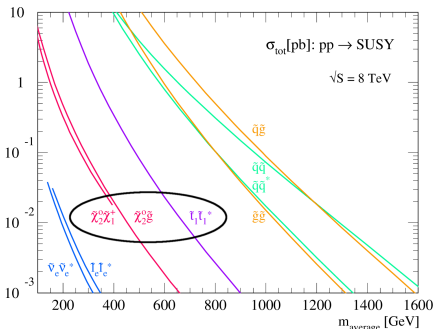
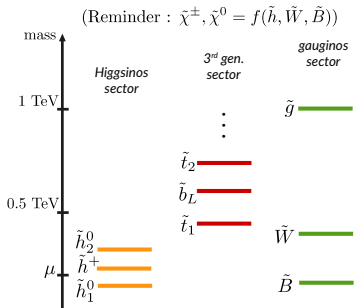
## Some of the main motivations for SUSY

### Naturalness

- Cancel divergences in Higgs mass, seek low fine-tuning
- Imply light gauginos/higgsinos and stop

### Dark matter candidate

- In  $R$ -parity conserving models, the LSP is a good DM candidate



# Outline

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- ① **Search for 3<sup>rd</sup> gen**
- ② **Search for electroweak-inos**
- ③ **Prospects for Run II and beyond**

# Outline

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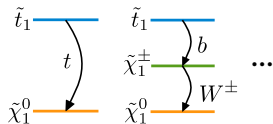
①

**Search for 3<sup>rd</sup> gen. SUSY**

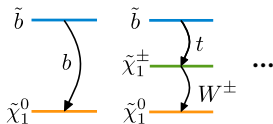
# Third generation SUSY searches

## Typical searches for third generation SUSY

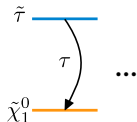
### Stop pair production



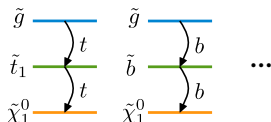
### Sbottom pair production



### Stau pair production



### Glino-mediated 3<sup>rd</sup> gen.

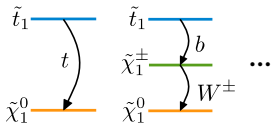


NB : but also many less-typical scenarios/signatures :  
GMSB, RPV, mono-stop, ...

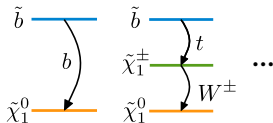
# Third generation SUSY searches

In this talk, focus on :

**Stop** pair production



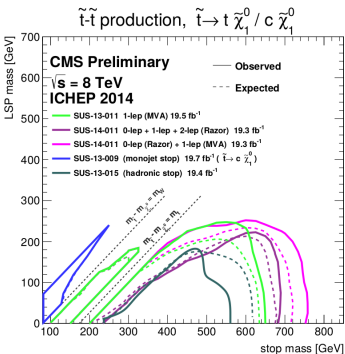
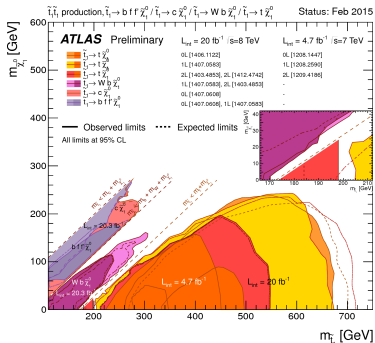
**Sbottom** pair production



# Third generation SUSY searches : stop

## The big picture on stop after Run I

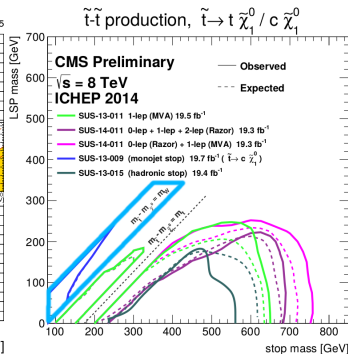
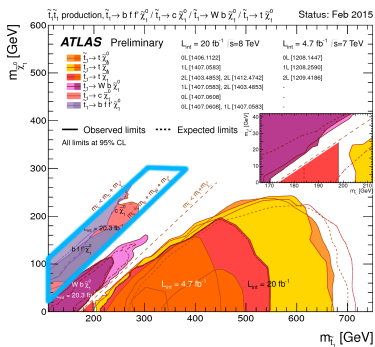
- NB : assuming BR = 100%
- No  $\tilde{t}$  up to  $\sim 700$  GeV for a light  $\tilde{\chi}_1^0 \rightarrow$  not so good for naturalness
- But let's focus here on some interesting corner of the phase space



# Search for compressed $\tilde{t}_1/\tilde{\chi}_1^0$

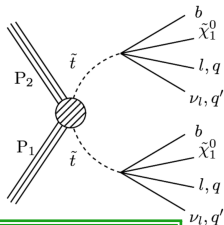
## Compressed spectra ( $\tilde{t}_1$ quasi-degenerated with $\tilde{\chi}_1^0$ )

- Cosmologically motivated to get the right DM relic density
- $\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0$  (monojet analysis) or  $\tilde{t}_1 \rightarrow bff'\tilde{\chi}_1^0$  (soft leptons analysis)





# Search for compressed $\tilde{t}_1/\tilde{\chi}_1^0$



CMS SUS-14-021

## Signature/selection

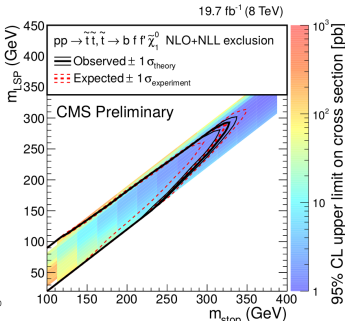
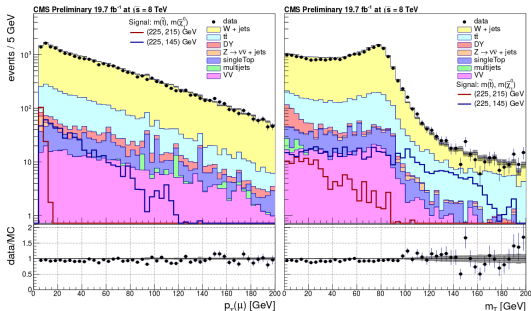
- 1 or 2 soft  $e/\mu$  ( $5 \sim 30$  GeV),  $E_T^{\text{miss}}$ , ISR-jet

## Dominant backgrounds : $W$ +jets, $t\bar{t}$ , DY

- Different strategies : keep only  $\mu^-$  (1 $\ell$  chan.), veto  $Z$ -peak (2 $\ell$  chan.), veto  $b$ -tags, ...

## Uncertainties

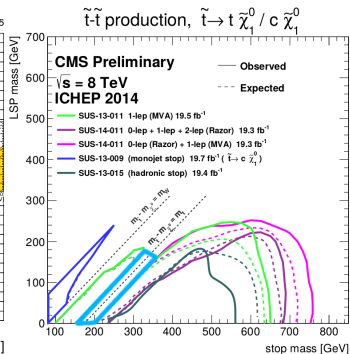
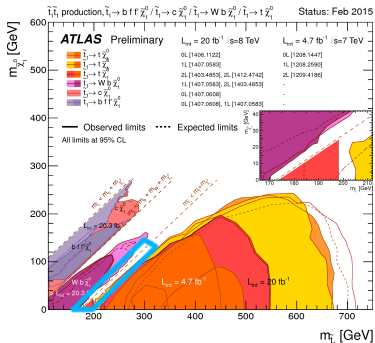
- Mainly  $W$ +jets control and stat



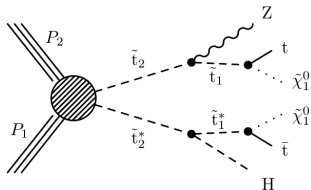
# Search for stealth $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$

Stealth scenario ( $\Delta m \sim m(\text{top})$ )

- Signal looks almost like SM  $t\bar{t}$  production
- Workaround 1 : constrain from  $t\bar{t}$  cross-section measurements
- Workaround 2 : look for the second stop  $\tilde{t}_2 \rightarrow \tilde{t}_1 H/Z$ .



# Search for stealth $\tilde{t}_1 \rightarrow t\tilde{\chi}_1^0$



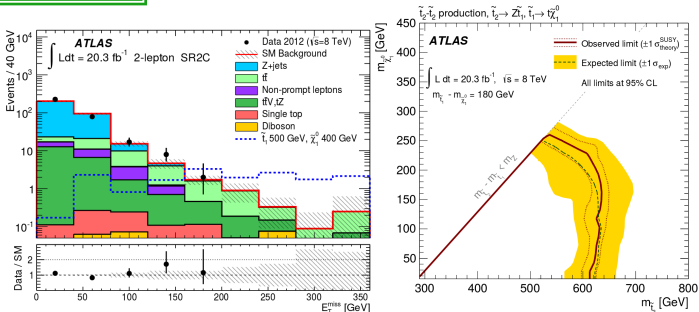
## Signature/selection

- $(Z \rightarrow \ell^+ \ell^-)$  with large  $p_T(Z)$ ,  $\geq 1$   $b$ -tag,  $\geq 5$  jets,  $E_T^{\text{miss}}$ , possibly more leptons.

**Backgrounds :**  $t\bar{t}$ ,  $t\bar{t}V$ , non-prompt  $\ell$   
**Main uncertainties**

- JES/JER,  $t\bar{t}V$  cross-sections

ATLAS 1403.5222



(Results can be put in perspective to [constraints on  \$m\_S \equiv \sqrt{m\_{\tilde{t}\_1} m\_{\tilde{t}\_2}}\$](#) )

# Search for $\tilde{b} \rightarrow b\tilde{\chi}_1^0$

## Signature/selection

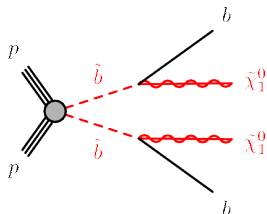
- 2  $b$ -tag,  $E_T^{\text{miss}} > 150$  GeV, veto leptons.

## Backgrounds : $t\bar{t}$ , DY

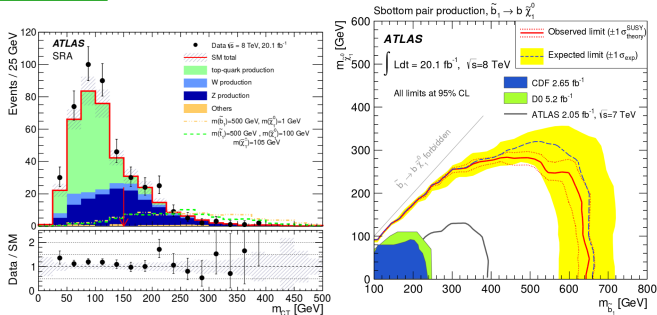
- Strategy : use several angular, kinematic variables such as  $\Delta\phi(j, E_T^{\text{miss}})$

## Main uncertainties

- JES/JER,  $t\bar{t}V$  cross-sections



ATLAS 1308.2631



# Outline

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②

**Search for electroweakinos production**

# Search for electroweakinos

## The big picture on electroweakinos after Run I

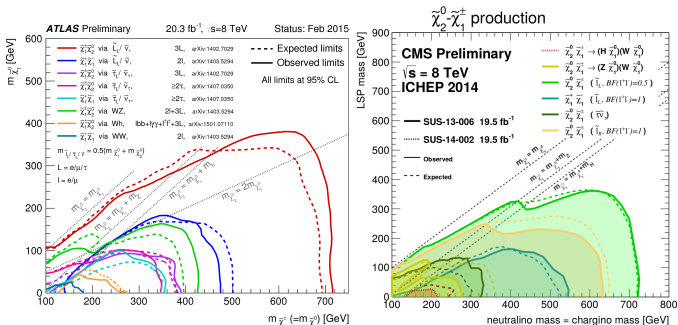
Main searches :  $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$  with  $m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$ , and  $\tilde{\chi}_1^\pm \tilde{\chi}_1^\mp$

### Make your own decay chain !

- $\tilde{\chi}$  nature : mainly wino, mainly higgsino ?
- Mass splitting : compressed or large ?
- Intermediate decay to sleptons / sneutrinos ?
- ...

$\leftrightarrow$  relates to  $M_1, M_2, \mu, \beta$

$\Rightarrow$  Here, also focus only on two specific analysis



# Search for $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ VBF production

**Motivation** : low  $\Delta m$ , or multiple  $\tau$ s in decays

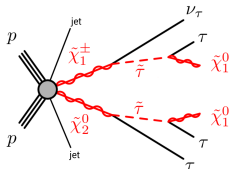
- VBF-oriented analysis makes it possible to probe these difficult scenarios

**Signature/selection**

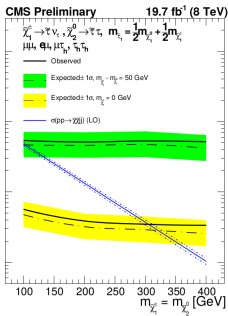
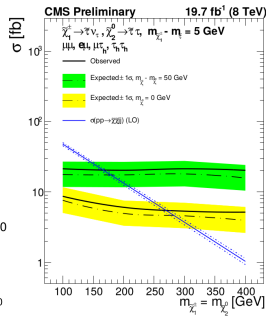
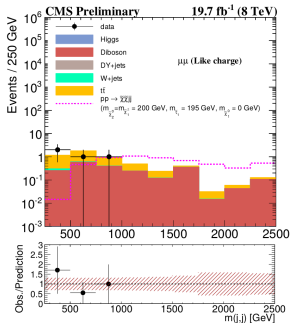
- Two VBF jets, 2 leptons (including  $\tau_h$ ),  $E_T^{\text{miss}}$

**Backgrounds** :  $t\bar{t}$ , DY, diboson

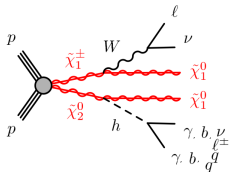
- $\rightarrow$  veto  $b$ -tag, look for same-sign leptons



CMS SUS-14-005



# Search for $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ decay via Higgs



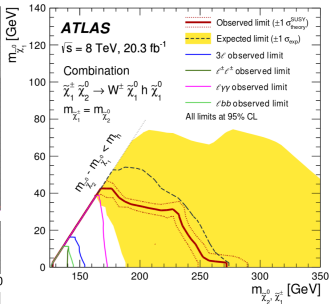
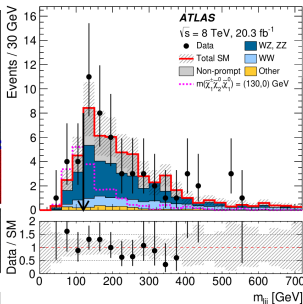
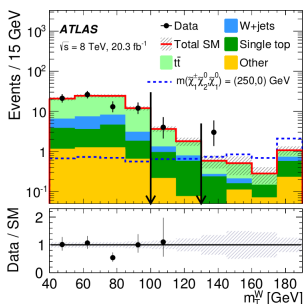
## Signature/selection

- $(W \rightarrow \ell\nu) + (h \rightarrow \gamma\gamma, bb, \ell\nu q\bar{q}) + E_T^{\text{miss}}$
- One sub-analysis per  $h$  channel

**Backgrounds :**  $t\bar{t}$ , diboson, non-prompt  $\ell$

**Statistical combination to obtain a single limit**

ATLAS 1501.07110





# Outline

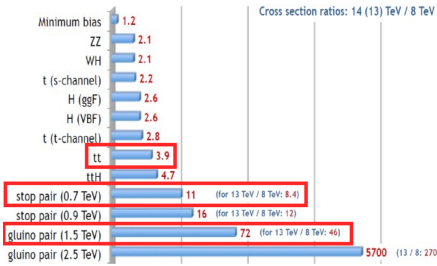
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3

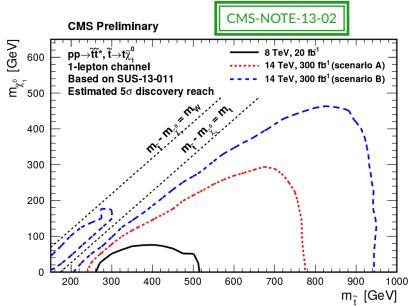
**Prospects for Run II and beyond**

# Prospect for Run II and beyond

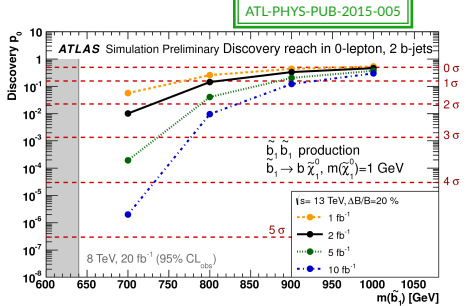
- $\tilde{g}$  searches quite hot at the beginning
- $\tilde{t}$  search update expected with  $5 \sim 10 \text{ fb}^{-1}$
- Run II and Phase 2 will definitely constrain tightly 3<sup>rd</sup> gen. and ewkinos, therefore naturalness



## Stop searches



## Sbottom searches



# Conclusion

- Third gen and electroweak SUSY is well motivated by naturalness and DM
- Presented the big picture, legacy from Run I searches  
(NB : a lot more on the [CMS](#) and [ATLAS](#) public SUSY pages)
- Growing interest in stealthy/compressed scenarios that may hide SUSY in current data
- And much phase space awaiting us for Run II!



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Thank you!