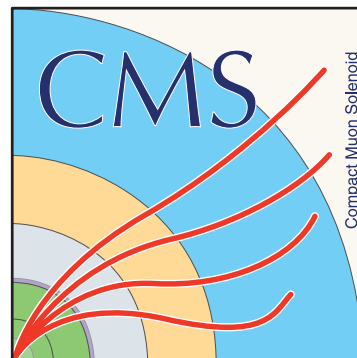


SUSY SEARCHES AT THE HL-LHC

Marco Rimoldi

on behalf of the ATLAS and CMS Collaborations



Marco Rimoldi - LHEP AEC, Universität Bern

u^b

^b
UNIVERSITÄT
BERN

AEC
ALBERT EINSTEIN CENTER
FOR FUNDAMENTAL PHYSICS

WG3 Contributions

■ Generic searches for SUSY

- Prospects for realistic SUSY models at the HL-/HE-LHC (*S. Heinemeyer et al.*)
- Probing SUSY at HL- and HE-LHC (*T. Han et al.*)
- Supersymmetry at a 28 TeV hadron collider: HE-LHC (*A. Aboubrahim, P. Nath*)

■ SUSY strong production

- SUSY strong - improved searches for squark and gluinos (*ATLAS*)
- Prospects for third generation squark production at the HL-LHC and HE-LHC (*ATLAS*)
- Same-sign di-lepton SUSY (*CMS*)
- Implications of a Stop Sector Signal at the LHC (*A. Pierce et al.*)

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HLHEFWG3>

WG3 Contributions

■ SUSY EWK production

- Prospects for C1N2 via WZ and Wh in multilepton at the HL-LHC and HE-LHC (*ATLAS*)
- Prospects for chargino pair production at HL- and HE-LHC (*ATLAS*)
- Search for chargino-neutralino in Wh channel using 1Lbb final states (*ATLAS*)
- Prospects for direct stau production at the HL-LHC (*ATLAS and CMS*)
- Compressed electroweakinos at HL- and HE-LHC (*ATLAS and CMS*)
- Prospects for radiative natural SUSY at HL- and HE-LHC (*H. Baer et al.*)
- Constraining slepton and chargino through compressed top squark search (*P. Konar et al.*)

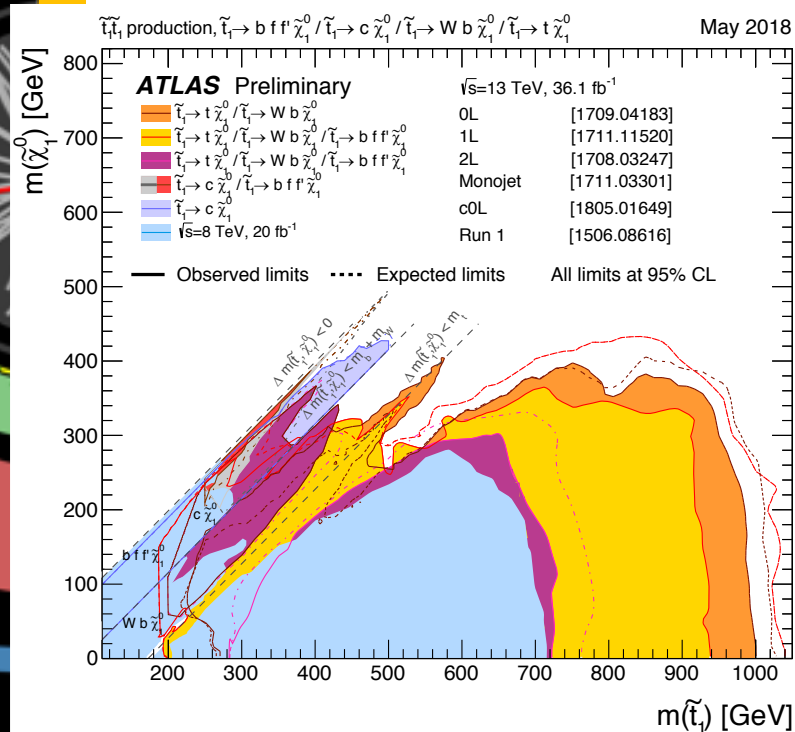
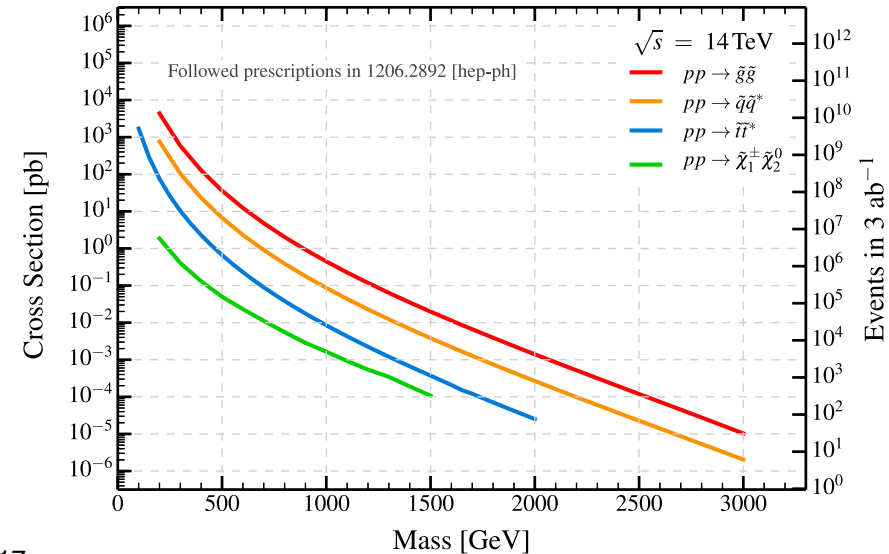
■ Long Lived particles signature in Carlos's Talk

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HLHEWG3>

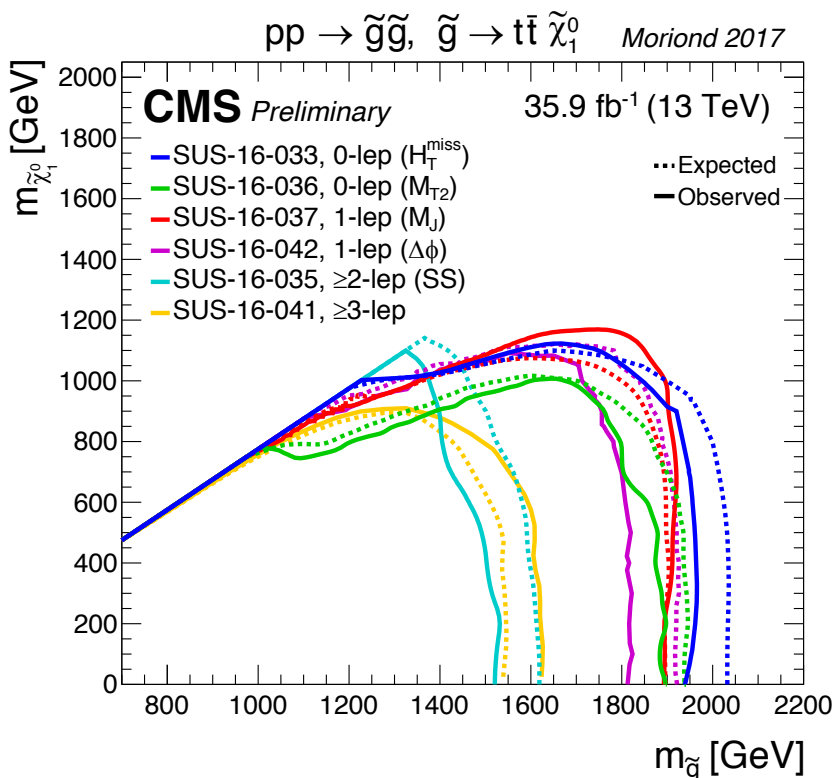
Introduction

Run 2 searches have set stringent limits on **Simplified Model** in both **Strong** (squark and gluino) and **Electroweak** (chargino, neutralino and slepton) productions.

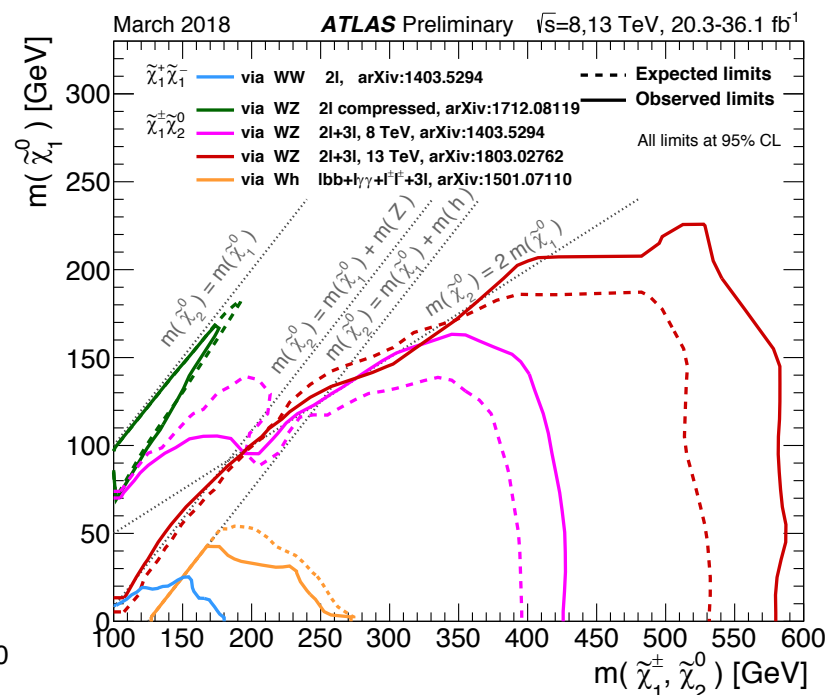
- ✓ 1 TeV for **Stop**
- ✓ 1.5-2 TeV for **Gluino**, 1.5 TeV for **Squark**
- ✓ 600 GeV for **C1N2**



ATLAS SUSY Public Results



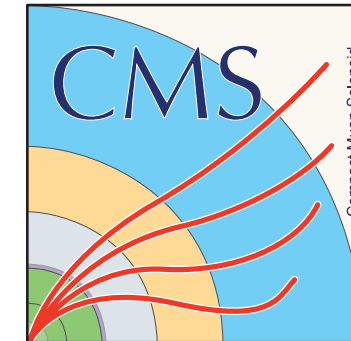
CMS SUSY Public Results



Introduction

In this talk, I will present the expected ATLAS and CMS contributions to the Yellow Report for the European Strategy for Particle Physics.

Different analysis approaches for HL-LHC have been used by the two collaborations.



- Based on truth-level events + smearing of the detector:
 - Reconstruct particles (e , μ , jets, MET) from truth + overlay and smear their energy and p_T using appropriate smearing functions based on full simulation of the detector
 - Jets from a pileup library
 - Cross checked with some of the 'real' data analyses
- Full simulation
- Analysis with parameterized detector performance: DELPHES with up-to-date phase-2 detector performance
- Projections using 13 TeV signal and background samples scaled at 14 TeV (foreseen to be mixed with the previous two)

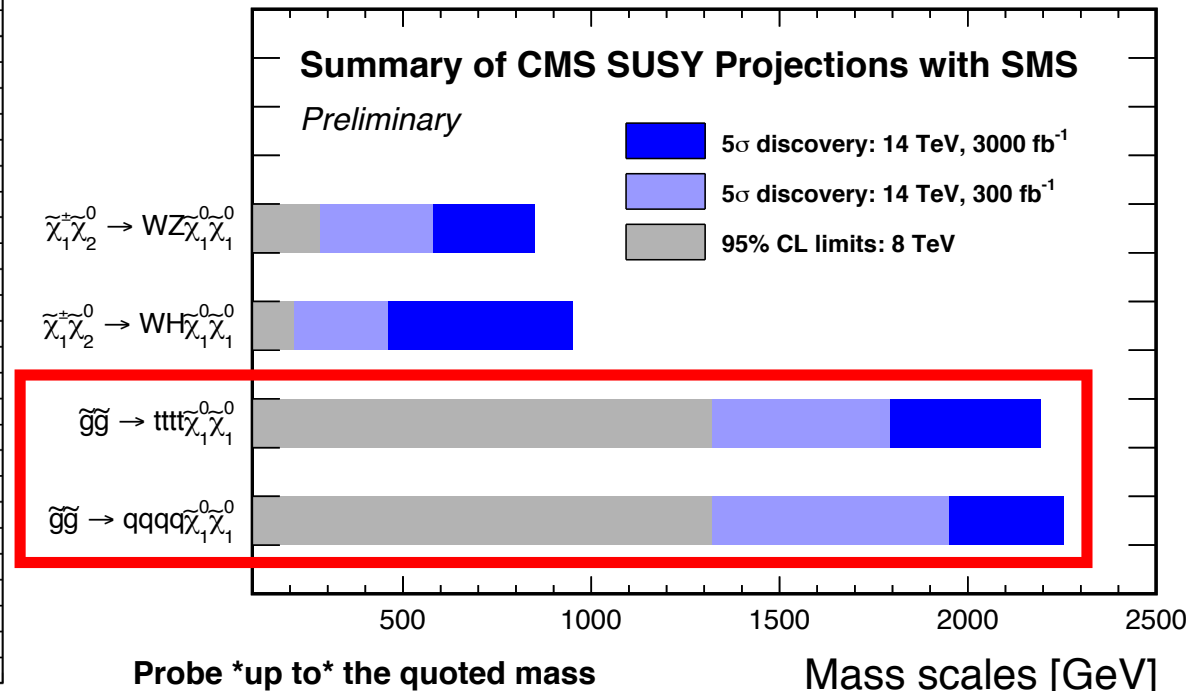
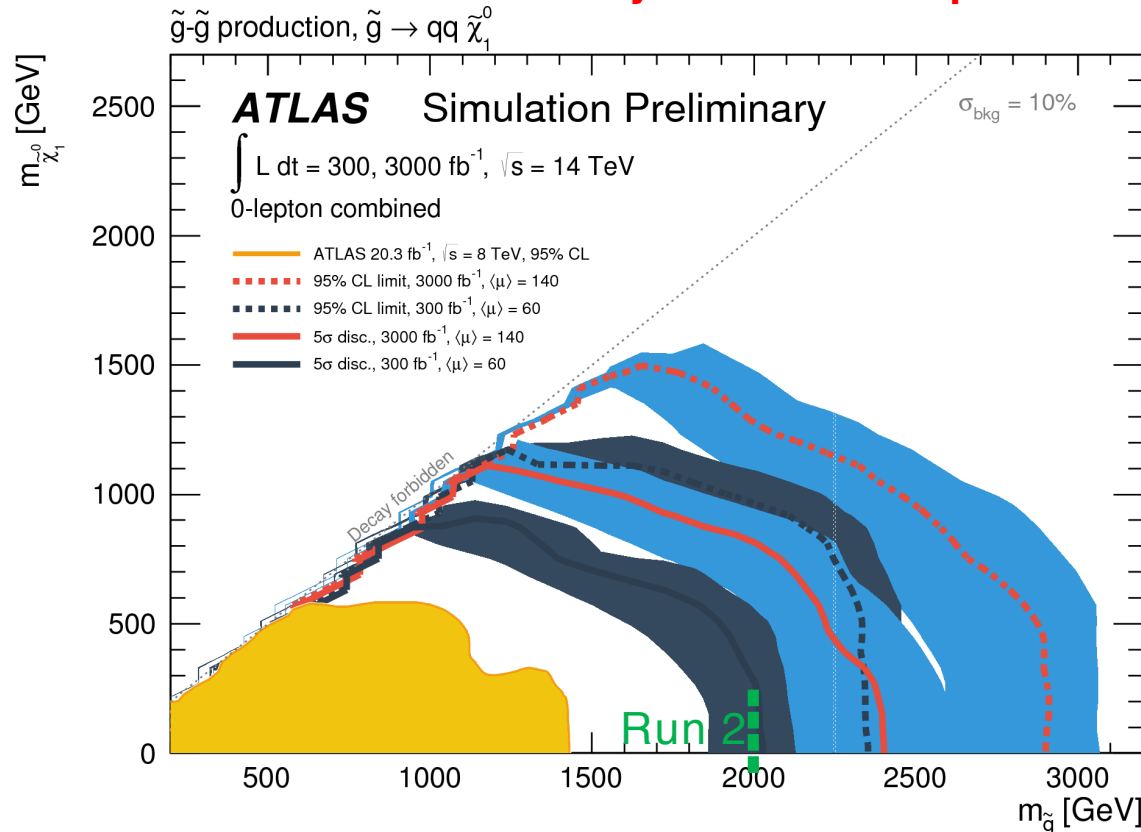
u^b

^b
UNIVERSITÄT
BERN

Squark and Gluino

- Previous prospects show 5σ discovery reach at ~ 2.5 TeV (~ 1.3 TeV) for g (q) for massless neutralino simplified models.
- Discoverable squark pair production models are already excluded using the 36.1 fb^{-1} Run 2 data. (ATLAS-CONF-2017-022, CMS-SUS-17-006).

ATLAS might update the prospects in the multijet channel.
Theory studies are expected for the YR (cross section calculation)

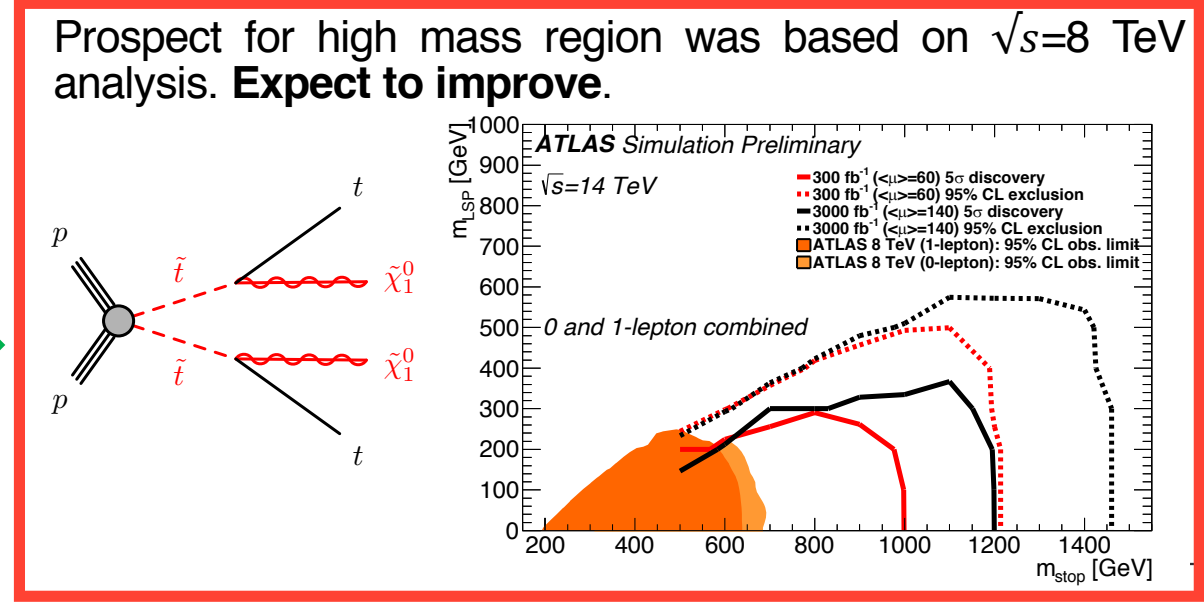
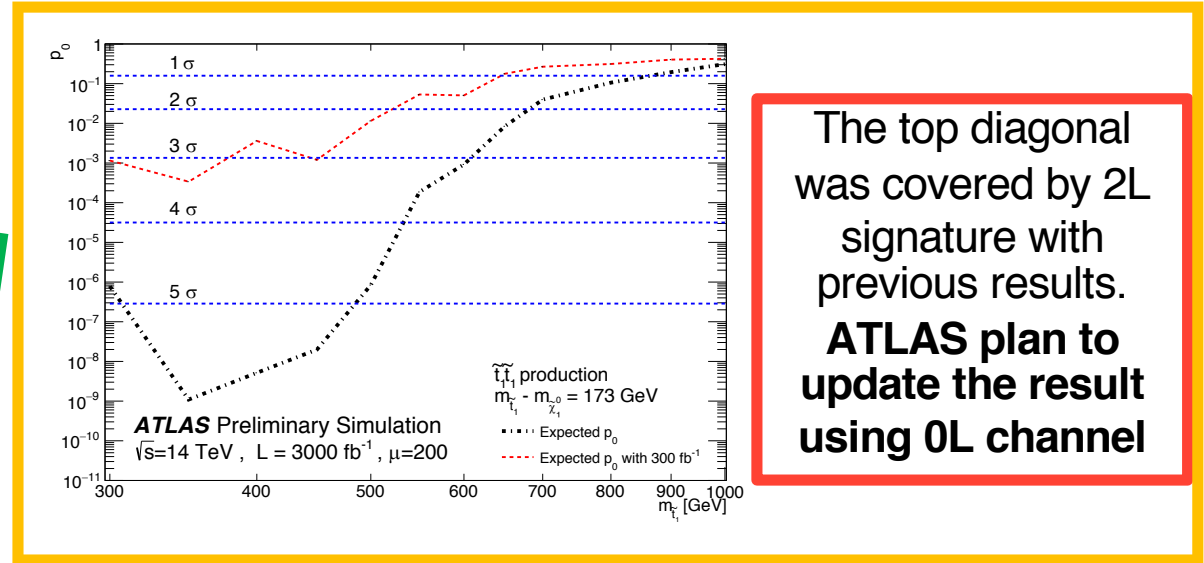
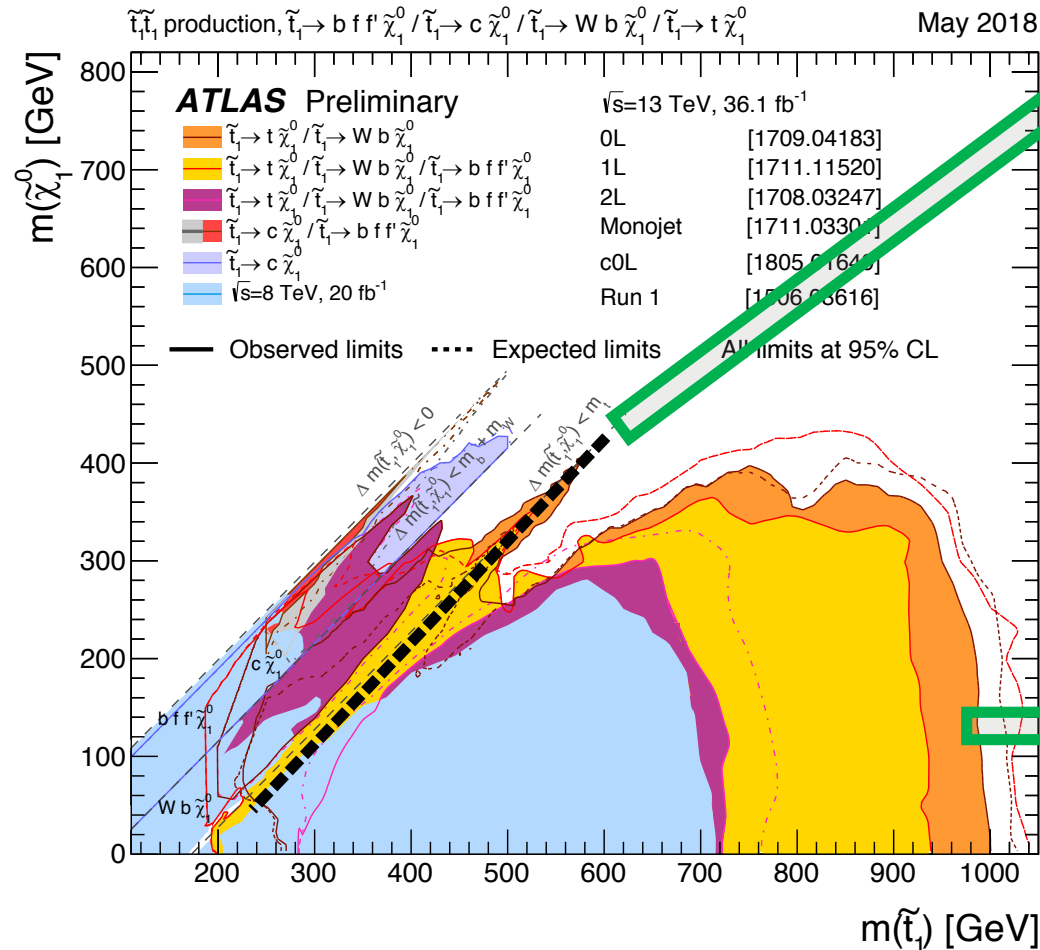


If discovered, HE-LHC will be needed to study in detail their properties

u^b

Stop and Sbottom searches

1 TeV stops excluded in simplified models.
Limits can get significantly worse in more complex scenarios

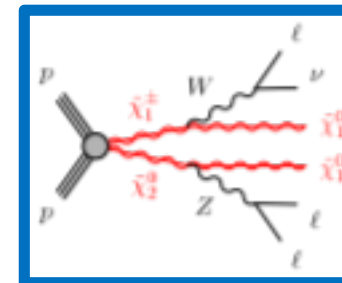


Electroweak SUSY: Chargino-Neutralino

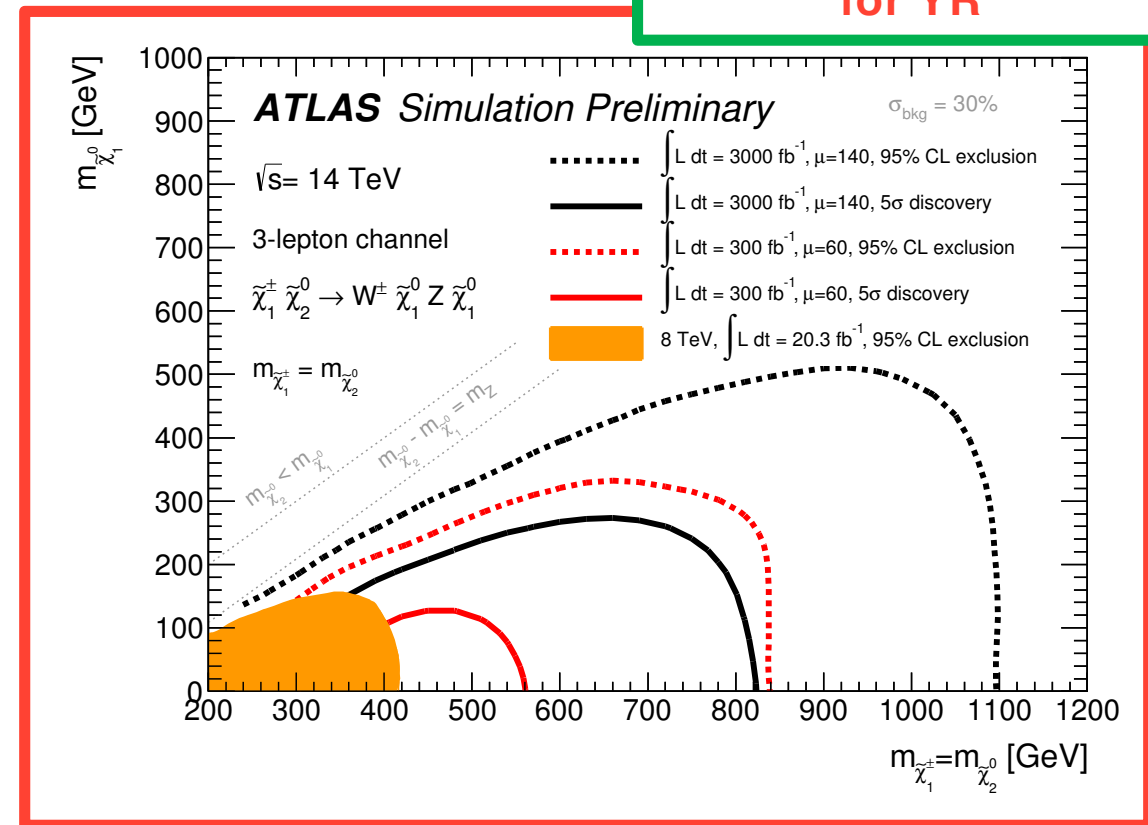
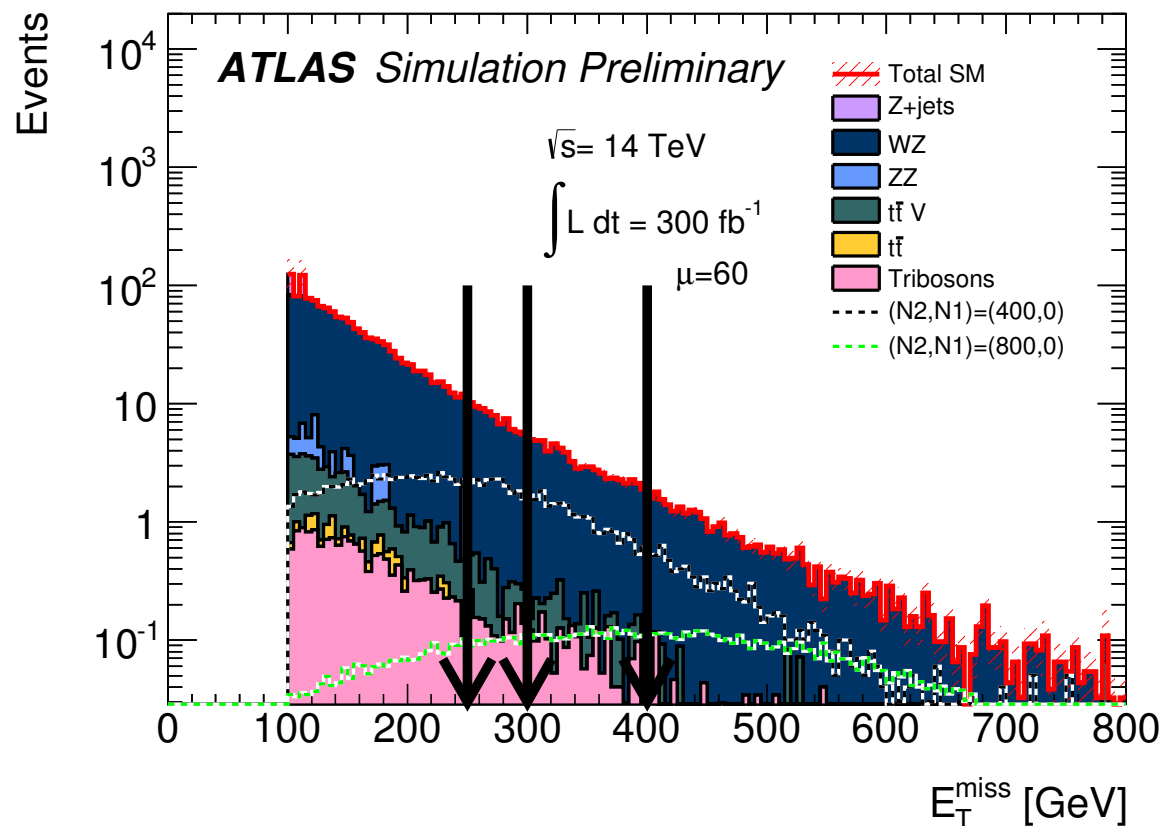
- Targets WZ and Wh-mediated decay of Charginos and Neutralinos
- Different final state, $W(\ell\nu)Z(\ell\ell)$ or $W(\ell\nu)h(bb)$

Exclusion limit extends above 1 TeV for massless LSP.

Current Run 2 analysis already better than 300 fb⁻¹ projection



Results to be updated for YR



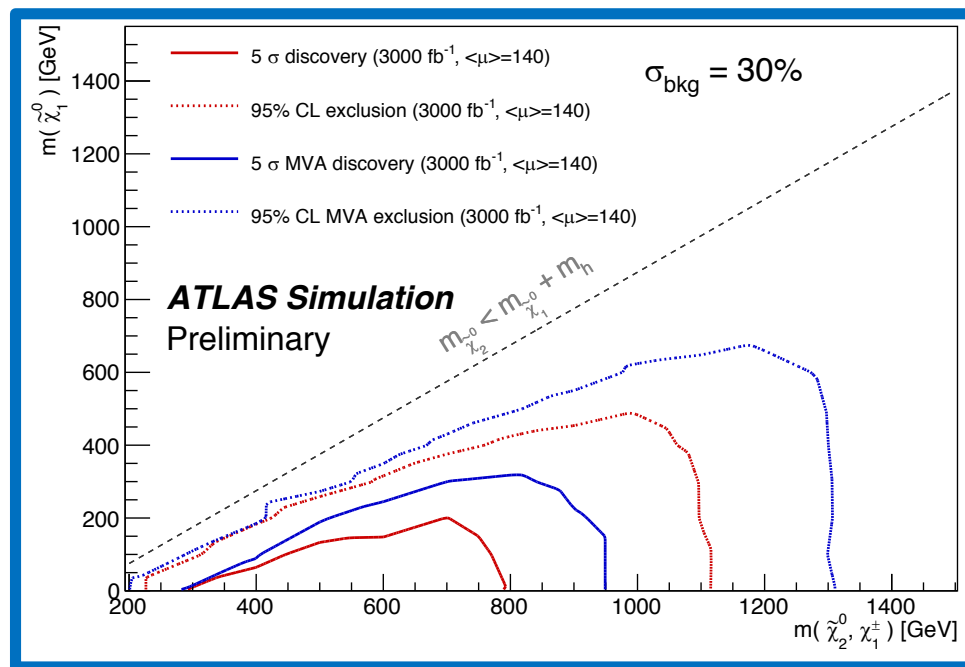
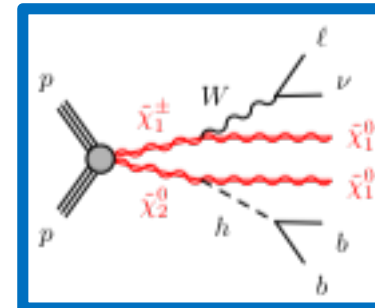
ATL-PHYS-PUB-2014-010

Electroweak SUSY: Chargino-Neutralino

- Targets WZ and Wh-mediated decay of Charginos and Neutralinos
- Different final state, $W(\ell\nu)Z(\ell\ell)$ or $W(\ell\nu)h(bb)$

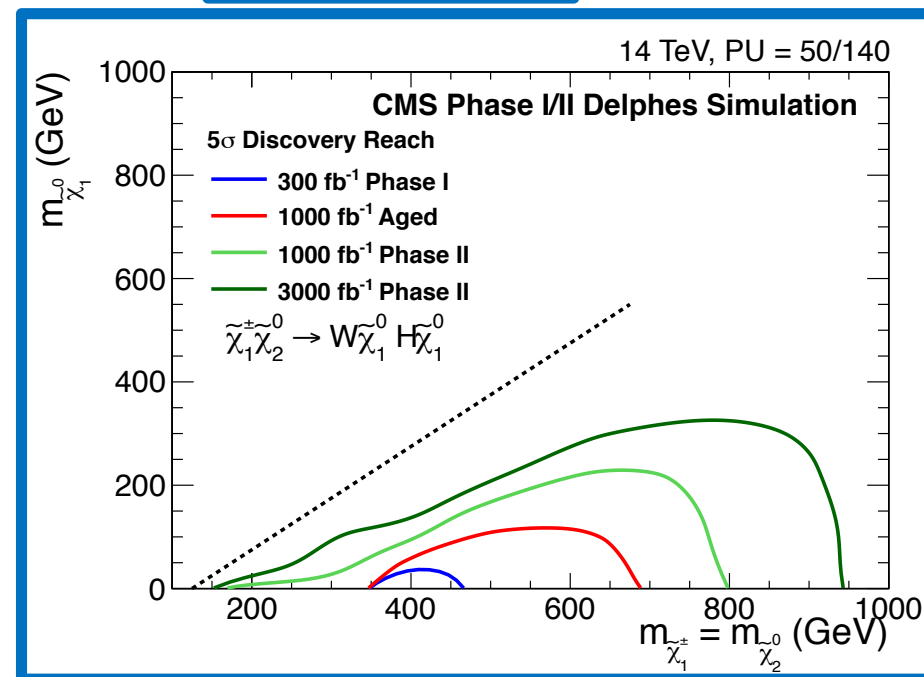
Exclusion limit extends above 1 TeV for massless LSP.

Current Run 2 analysis already better than 300 fb⁻¹ projection



ATL-PHYS-PUB-2015-032 - CERN-LHCC-2015-020

ATLAS Results to be updated for Summer with new detector parametrisation

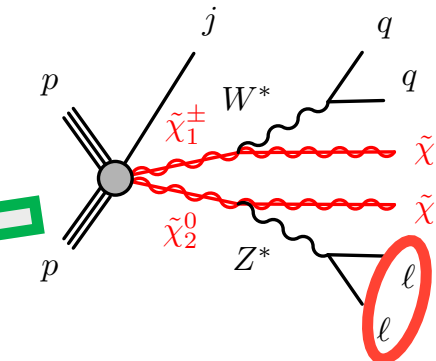
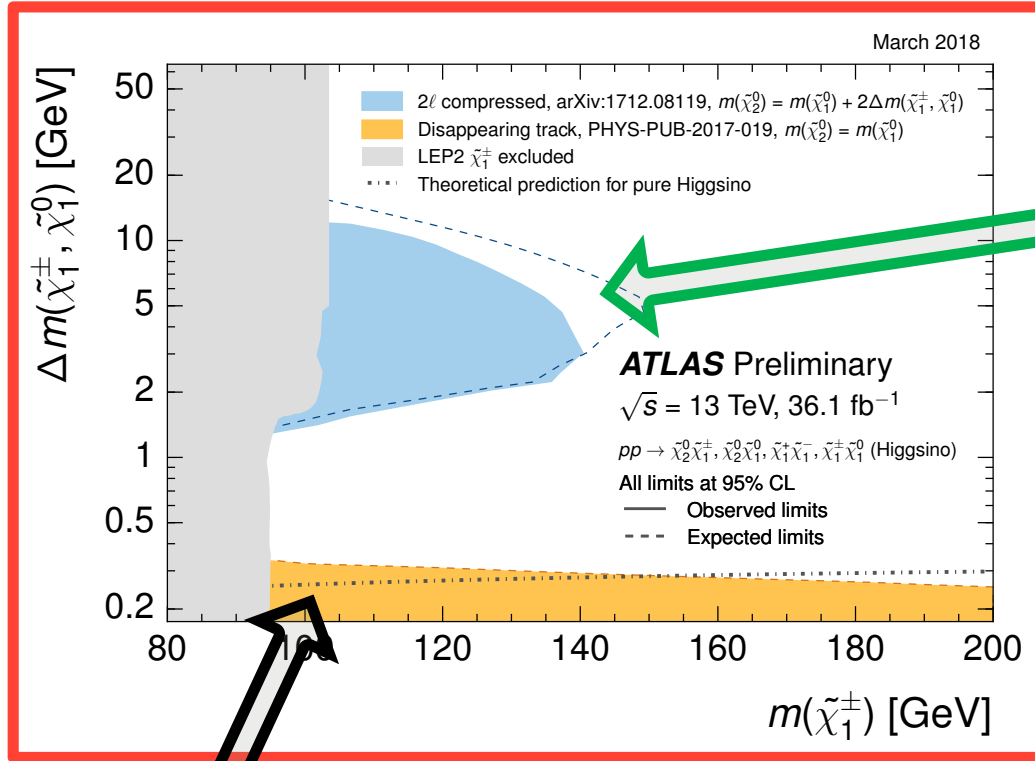


CMS Expected improvement: MET resolution using timing information Boosted tagger for $h(bb)$

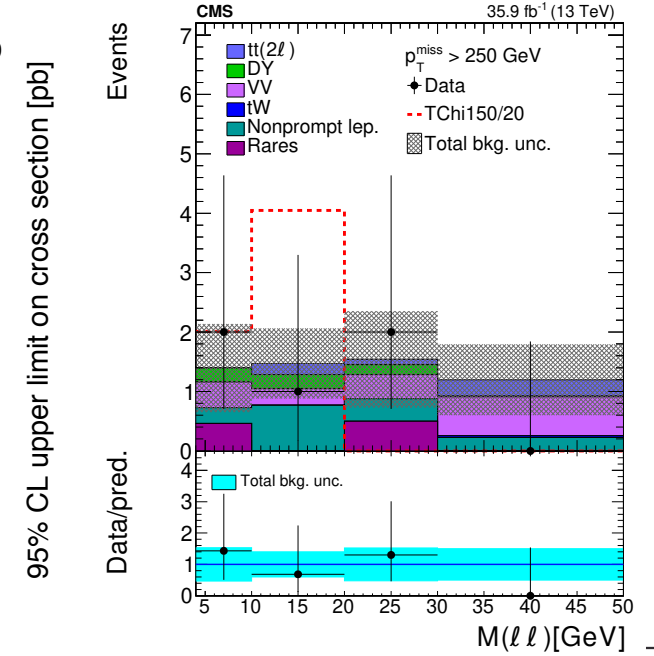
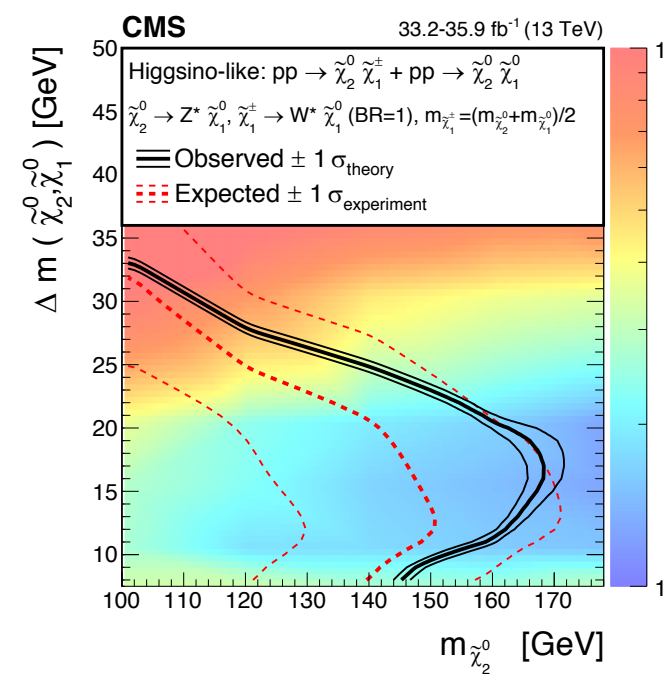
Compressed Ewkinos

In the limit of low- μ the two lightest neutralino and lightest Chargino are Higgsino-like, and nearly mass degenerate.

For splitting larger than a GeV, soft leptons can be reconstructed



- Low- p_T lepton reconstruction is crucial
- Analysis fit on low value m_{ll} and MET
- Potential improvement from adding 3L final state and VBF production.
- Expected results for YR by CMS and ATLAS**

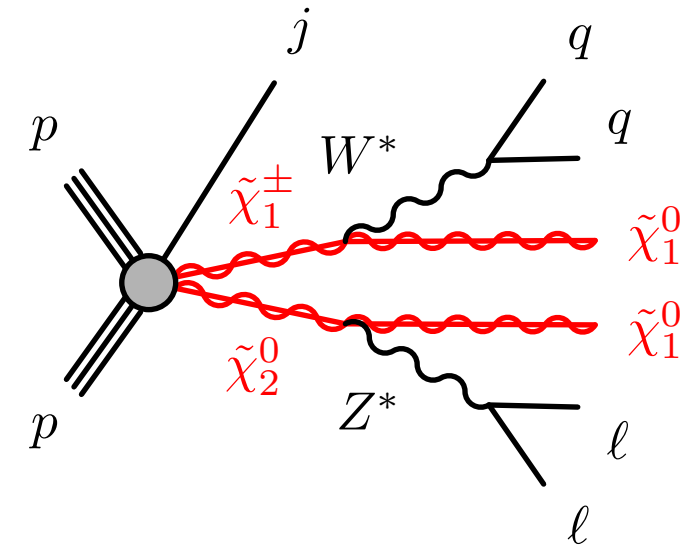


For very low mass splitting, Charginos can give **disappearing track signature**

Compressed Ewkinos

Discussion between the ATLAS and CMS collaborations:

- Check the cross section for C1N2 Higgsino like (i.e. compare Resummino input, pdf sets etc.)
- Add 30% uncertainties on signal (due to ISR modelling)
- Add 30% uncertainties data driven fakes
- Fake leptons estimation will be compared between the ATLAS and CMS. Different approach are used.



C2N4: Same sign leptons signature

M2 → C2, N4

M1 → N3

μ → C1, N1, N2

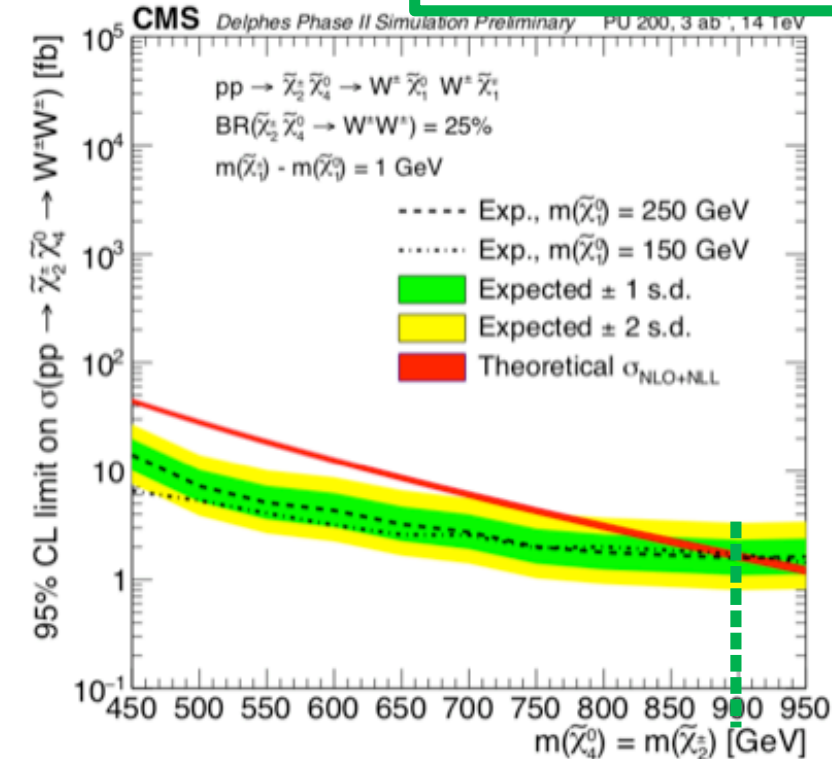
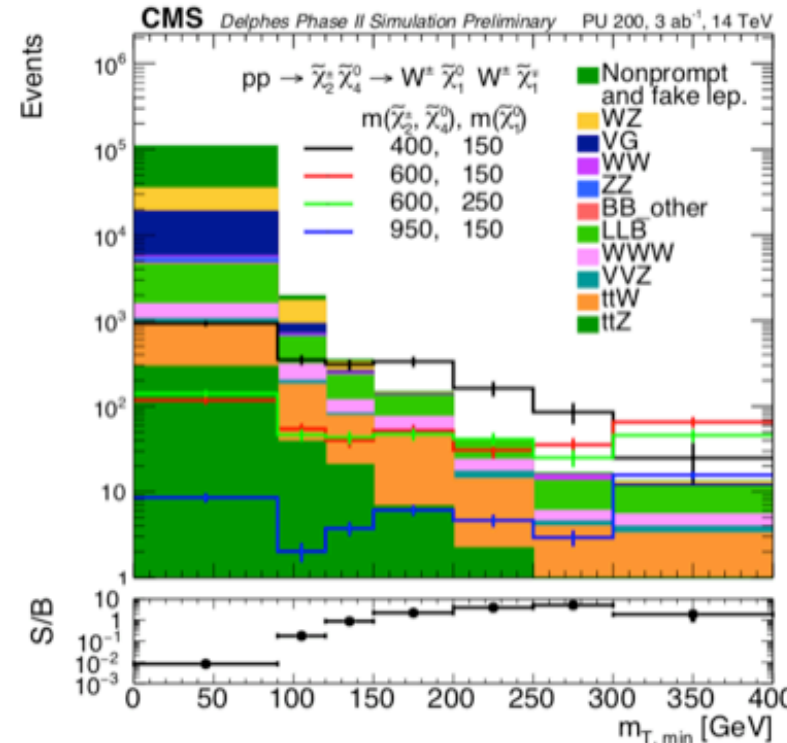
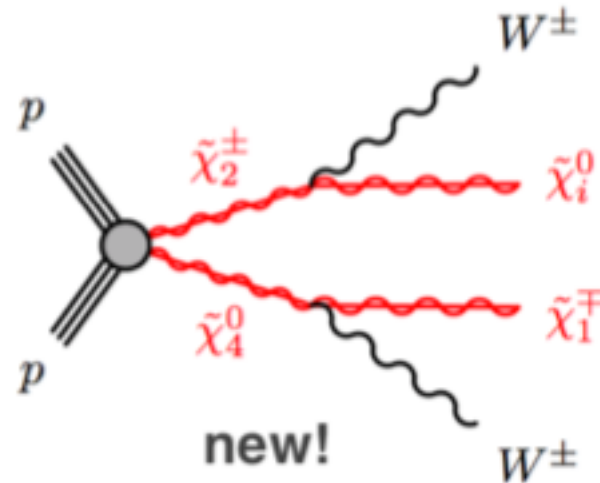
RNS Model → Naturalness oriented model → Higgsino LSP
 C1-N1-N2 are compressed, Unique signature in C2N4 decay:

Largest visible cross-section

25% BR into Same Sign W .

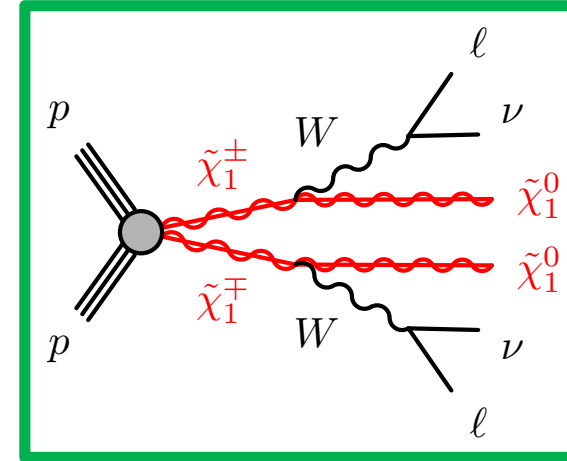
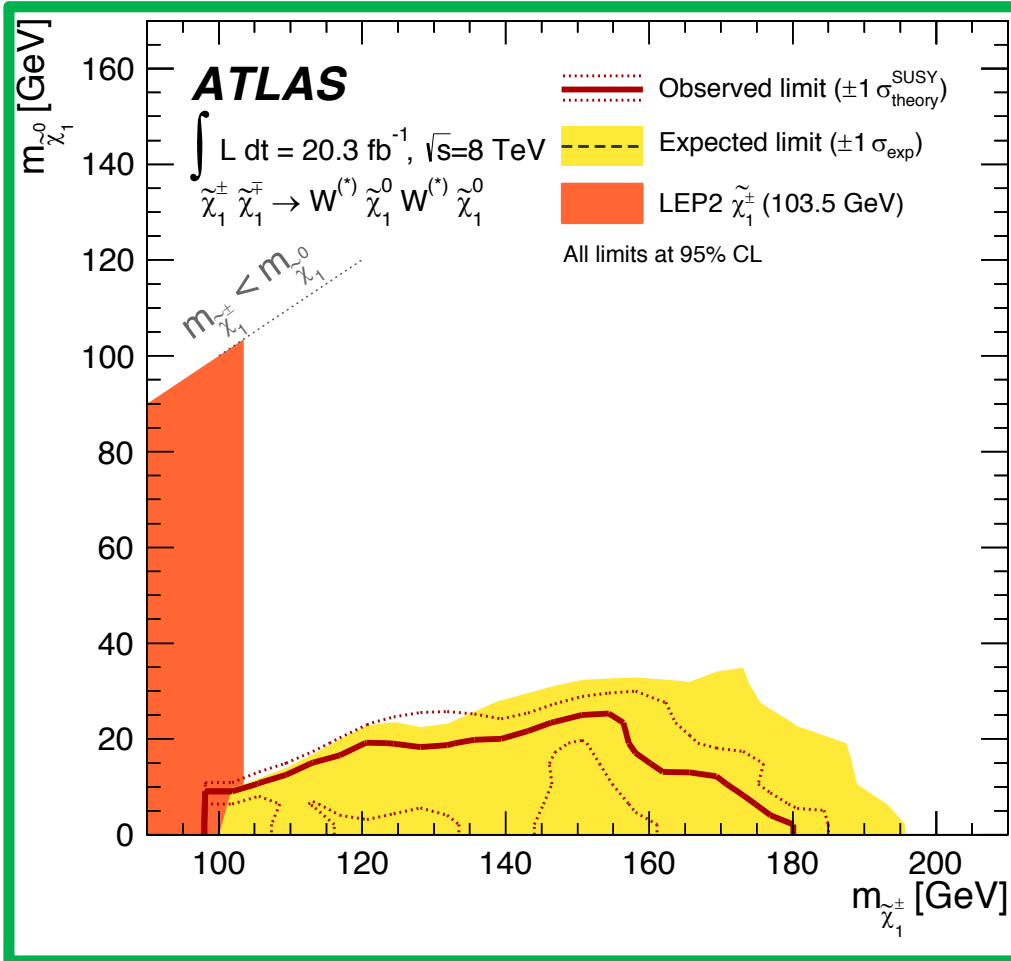
- Powerful probe complementing direct searches for higgsinos

Expected results for the YR



Electroweak SUSY: chargino-chargino to WW

Challenging signature with low sensitivity during Run 1 analysis.
Very interesting channel for HL-LHC



- Analysis based on E_T^{miss} and m_{T2} with jet veto
- Sensitivity also in function of the different WW background assumption.
 - **Update results for the Yellow report.**

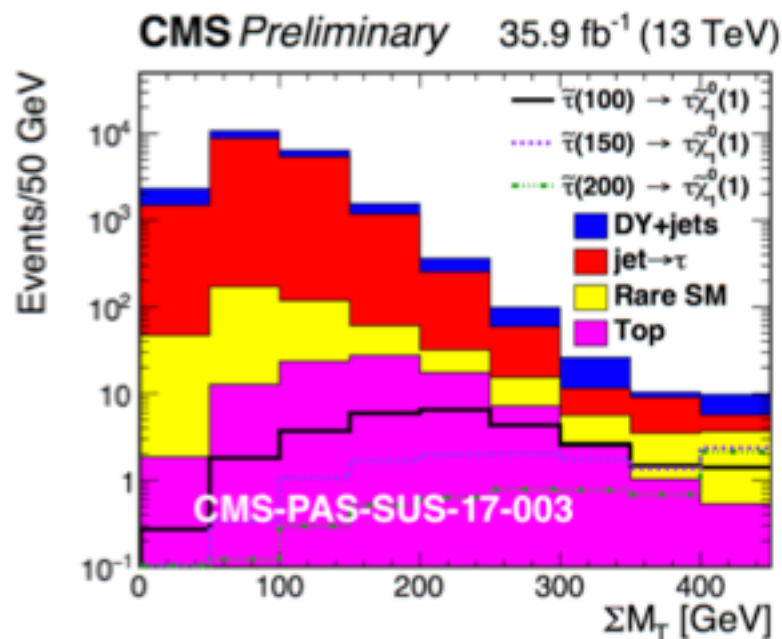
u^b

^b
UNIVERSITÄT
BERN

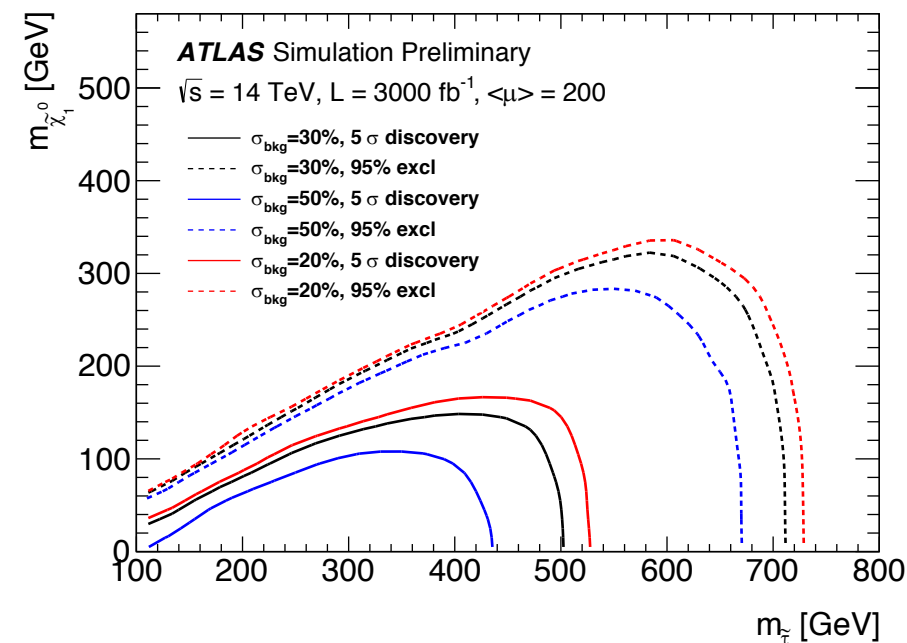
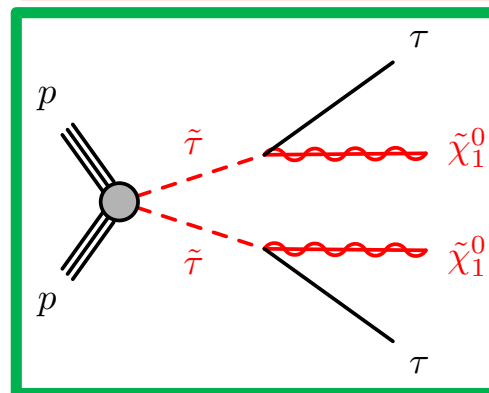
AEC
ALBERT EINSTEIN CENTER
FOR FUNDAMENTAL PHYSICS

Direct stau production

- Direct stau production become dominant if charginos and NLSP neutralinos are heavy.
- Very challenging search due to low cross-section for producing stau pair and low acceptance



**Both results
planned for YR**



- Both $\tau_{had}\tau_{had}$ and $\tau_{had}\tau_{lep}$ will be targeted.
- Information from timing detector expected to significantly impact tau ID performance
- Expect sensitivity up to 500-600 GeV for current assumption on Phase2 detector.

- Current Run 1 limits excludes $\widetilde{\tau}_R$ only up to 109 GeV.
- Discovery sensitivity 400 GeV for $\widetilde{\tau}_L$
- No discovery sensitivity for pure $\widetilde{\tau}_R$
- Update with improved tau performance parameterisation

Conclusion

- The current plan for the Yellow Report mostly focused on EW SUSY due to low expected low cross-section. High statistic is needed.
- Discussion on common items between ATLAS and CMS (e.g. Higgsino). Working also on having common plots to give a LHC wide view.
- Particular attention needed for coherent cross-sections and uncertainties assessment.

WG3 Contribution

■ Long Lived particles

- Prospects for disappearing track analysis at HL-LHC (*J. Anders et al. ATLAS*)
- Prospects for disappearing track analysis at HE-LHC (*M. Saito et al.*)
- displaced vertex
 - Prospects for LLP->DV+MET (*L. Jeanty et al. ATLAS*)
 - displaced muons (*CMS*)
 - Prospects for LLP->mu+jets at the HL-LHC (*X. Cid Vidal et al. LHCb*)
 - Prospects for LLP->dijets at the HL-LHC (*X. Cid Vidal et al. LHCb*)
- heavy stable charged particles (dE/dx and TOF) (*CMS*)
- fast timing signatures for long-lived particles (*CMS*)
- various interpretations
 - Searching for Confining Hidden Valleys at the LHCb and ATLAS/CMS (*A. Pierce et al.*)

<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HLHEWG3>