

# Long lived chargino in the MSSM and impact of LHC searches

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**FWF**

Der Wissenschaftsfonds.

# Team members

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- A truly Snowmass project: discussions started after last EF10 ino meeting
  - Amit Adhikary
  - Biplob Bhattacharjee
  - Rohini Godbole
  - Suchita Kulkarni
  - Rakhi Mahbubani
  - Rhitaja Sengupta
- Includes four aspects:
  - Review of theoretical loop calculations for chargino lifetimes
  - Comparison of theory calculations with predictions from spectrum generators
  - Reinterpretation for LHC DT/HSCP searches for chargino LLP
  - Demonstration of validity of ‘effective’ simplified models

# Review theory calculations

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- Long lived particles result either from small mass splitting (chargino in MSSM) or from suppressed couplings (heavy neutrino in neutrino mass models)
- Lifetime crucially depends on mass splitting

$$c\tau \propto \frac{1}{\Delta M}$$

- Mass splitting dictates ‘hardness’ of final state objects at the experiments and therefore controls the search design
- **Question: For long lived chargino in the MSSM what is the correct theory prediction for mass splitting?**
- Loop corrections are very important to accurately answer this question

# Chargino in MSSM

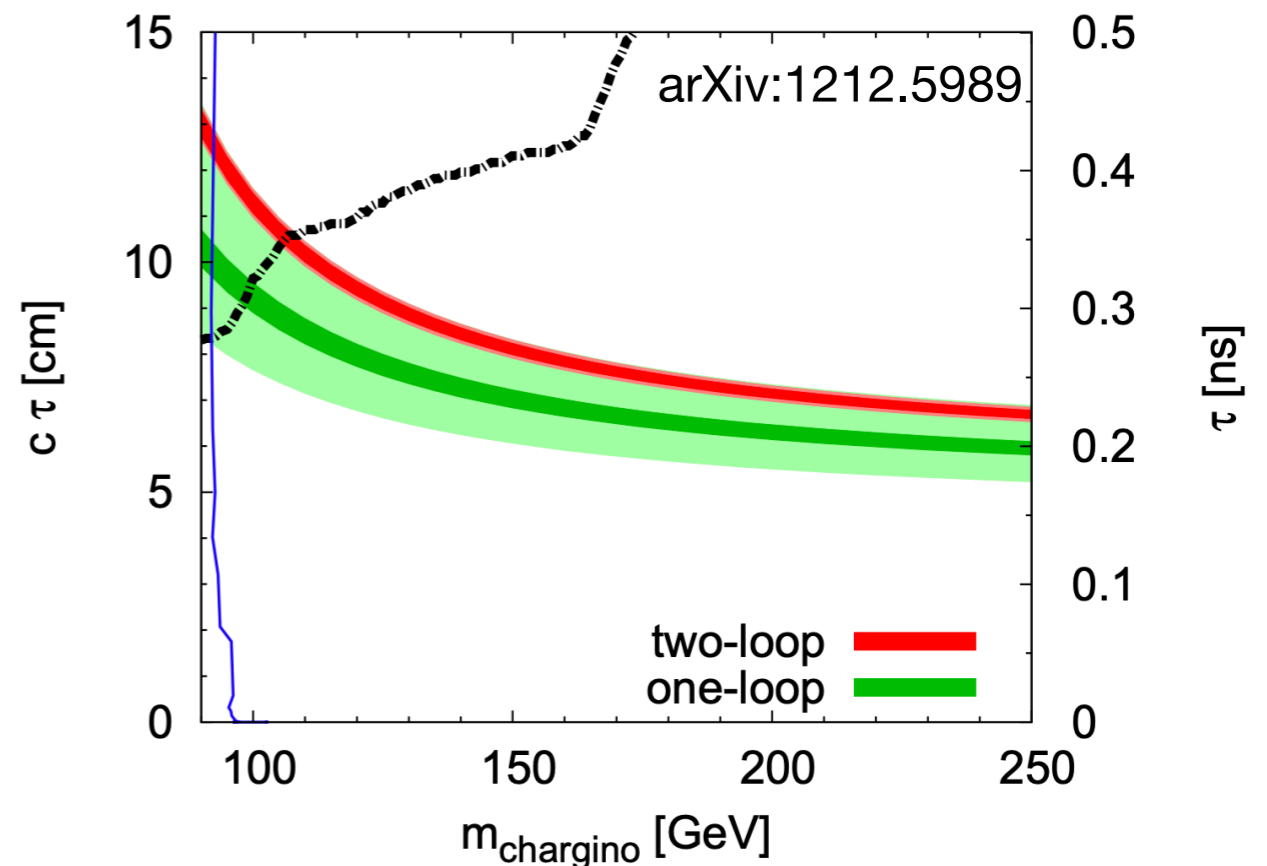
- Long lived particles result either from small mass splitting (chargino in MSSM) or from suppressed couplings (heavy neutrino in neutrino mass models)
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$$M_{\tilde{C}} = \begin{pmatrix} 0 & X^T \\ X & 0 \end{pmatrix} \quad \text{where} \quad X = \begin{pmatrix} M_2 & \sqrt{2}s_\beta m_W \\ \sqrt{2}c_\beta m_W & \mu \end{pmatrix}$$

$$\delta m_{\text{tree}} = m_{\tilde{C}_1} - m_{\tilde{N}_1} = \frac{m_W^4}{\mu^2 M_1} \sin^2 2\beta \tan^2 \theta_W$$

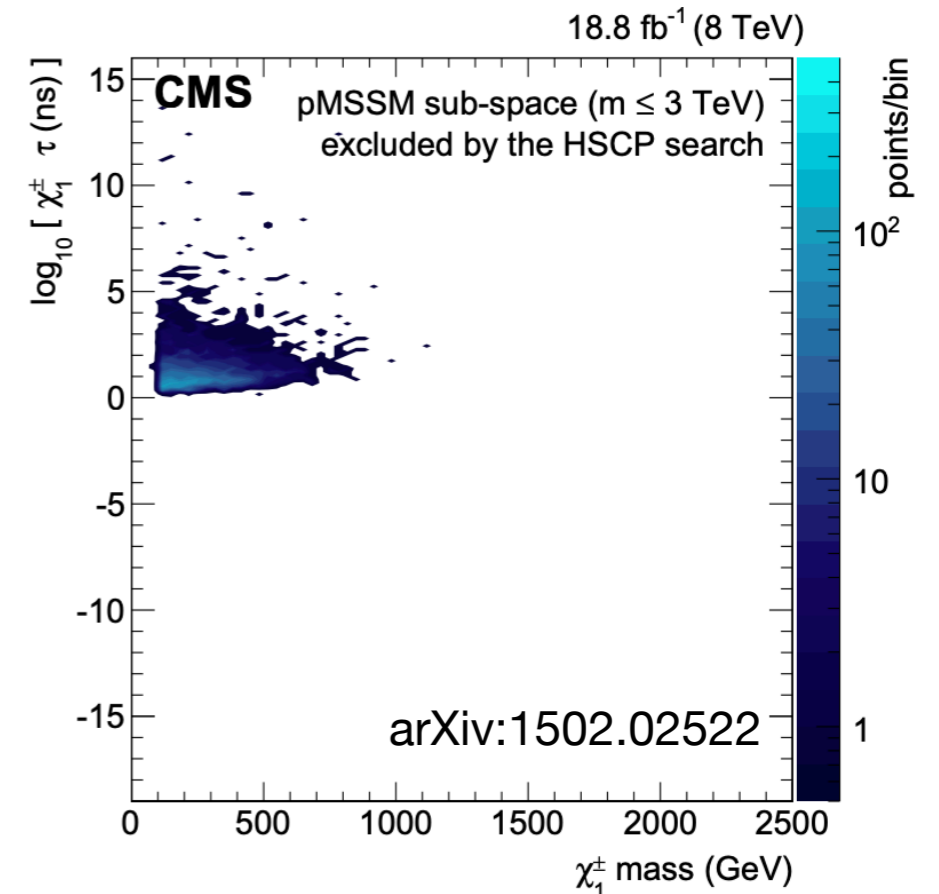
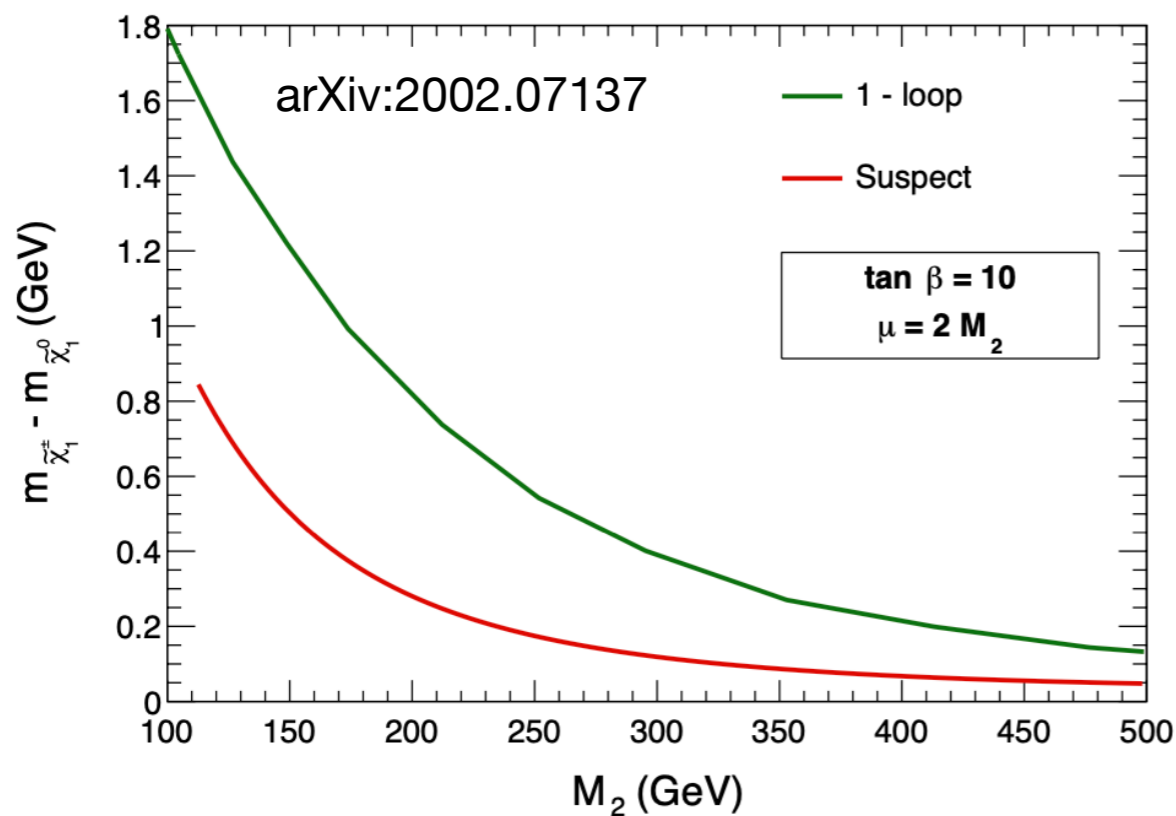
- Two loop corrections for pure wino scenarios can be pretty relevant
- How do these corrections generalise to pure higgsino case and mixed scenarios?

hep-ph/9606211  
arXiv:1712.00968  
arXiv:1212.5989



# Compare spectrum generators

- Analytical calculations for pure Wino-like chargino LLP exist up to two loops
- Question: How correct are the chargino - LSP mass splitting prediction in spectrum generators?
  - Review spectrum generators; compare with theory predictions
- Understand if parameter space e.g. shown by CMS interpretation is feasible

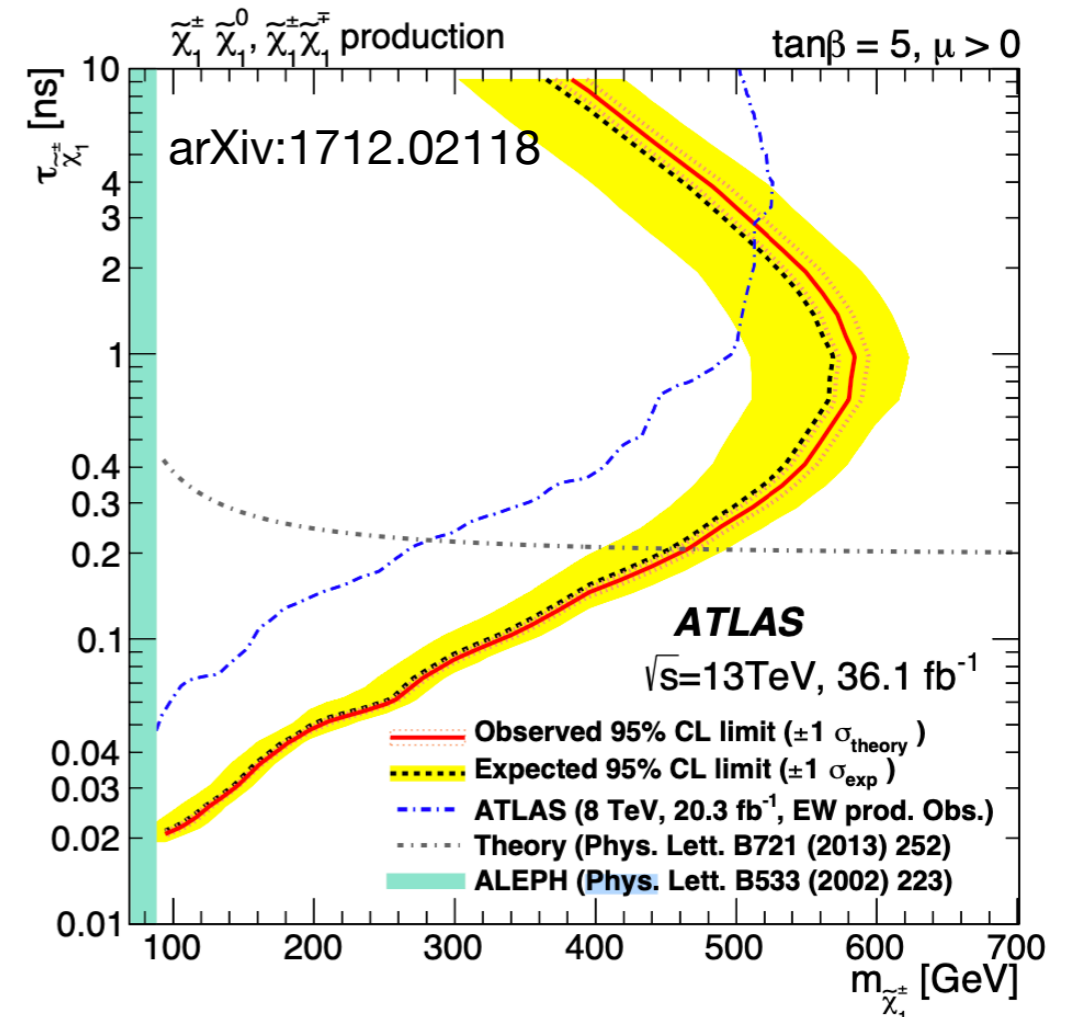


- Lifetimes as predicted by the popular suspect2 spectrum generator demonstrate noticeable difference to theory prediction

# Reinterpret searches

- Question: What is the true reach of these DT and HSCP searches for MSSM parameter space?
  - Reinterpret the LHC DT and (if applicable) HSCP analysis for chargino LLP within MSSM to correctly identify the reach of searches
- Searches are also applicable for simplified EW models
- Simplified EW models: loop corrections only arise from high dimensional operators
- Understand if the lifetime predictions are correctly calculated.

arXiv:1903.00013  
arXiv:1410.4549



# Conclusions

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- As LHC searches become a powerful tool to explore new physics parameter space it becomes relevant to correctly predict features of the new physics parameter space
- These involve lifetimes and mass splittings of degenerate particles and it in turn affects our understanding of the impact of LHC searches
- We will investigate the impact of these loop corrections some of which are documented in the literature on the chargino parameter space within the MSSM
- We will demonstrate the effect of model dependent exclusion of DT analyses
- We will investigate the effect also for simplified EW models