Tops, charms and invisibles

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About Myself

- MSc at University of Melbourne working on Cosmic ray simulations for SABRE south
- Currently undergoing PhD at University of Adelaide
- Have performed work on SUSY analyses, as well as hardware work at CERN (QuestNP for FastTracKer)
- Will be talking about current and previous qc+MET searches as ATLAS

SUSY – Brief overview

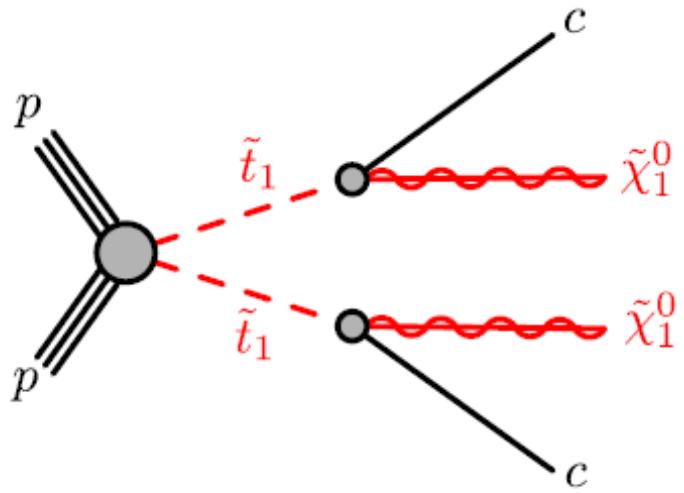
- The premise of SuperSymmetry (SUSY) is that every Standard Model particle has a superpartner particle with a half-integer spin difference
- Electroweak gauge bosons have superpartners which mix to form mass eigenstates, Charginos and Neutralinos which are charged and neutral respectively
- Neutralinos in certain models are dark matter candidates

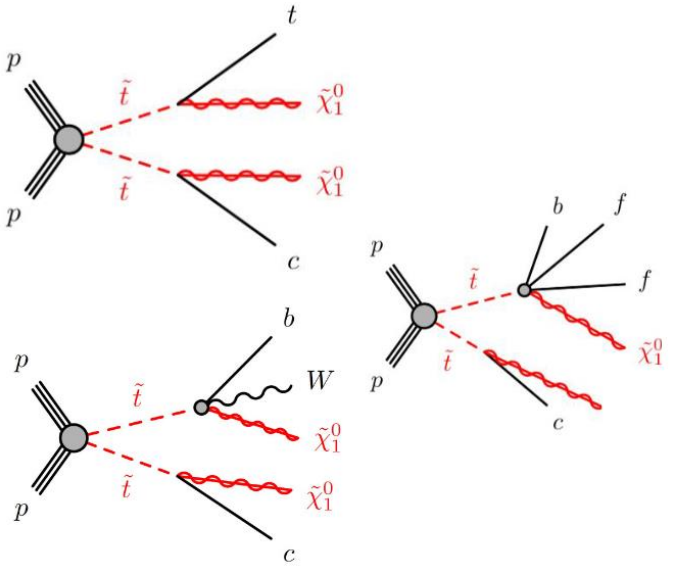
Searching for Flavour Violation in top and charm squarks at the LHC

- Motivated by non-Minimally Flavour Violating (nMFV) extensions to Minimal Supersymmetric Standard Model (MSSM).
  - https://arxiv.org/pdf/1808.07488.pdf
- Current published SUSY searches sensitive to small mixing of 2nd and 3rd generation, not to large mixings.
- Assuming maximal mixing, we assume branching ratios $Br(t_1 \rightarrow tX_0) = Br(t_1 \rightarrow cX_0) = 50\%$
  - 50% tc+MET, 25% cc+MET, 25% tt+MET

qc+MET searches

- cc+MET
  - t_1t_1->cX_0cX_0
  - Previous cc+MET using 36.1 fb^{-1} Run II data
    - https://arxiv.org/pdf/1805.01649.pdf
  - Current cc+MET to use full 139 fb^{-1} data.
- tc+MET
  - 2-body: t_1t_1-> tX_0cX_0
  - 3-body: t_1t_1-> bWX_0cX_0
  - 4-Body: t_1t_1-> $bffX_0cX_0$
- The main background contributions for tc/cc+MET analyses are:
  - Z+jets ~55% total background
  - W+jets ~10%
  - diboson ~10%
  - ttbar ~5%
  - Other < 5%
- Possibilities of combining results further down the line





Charm tagging

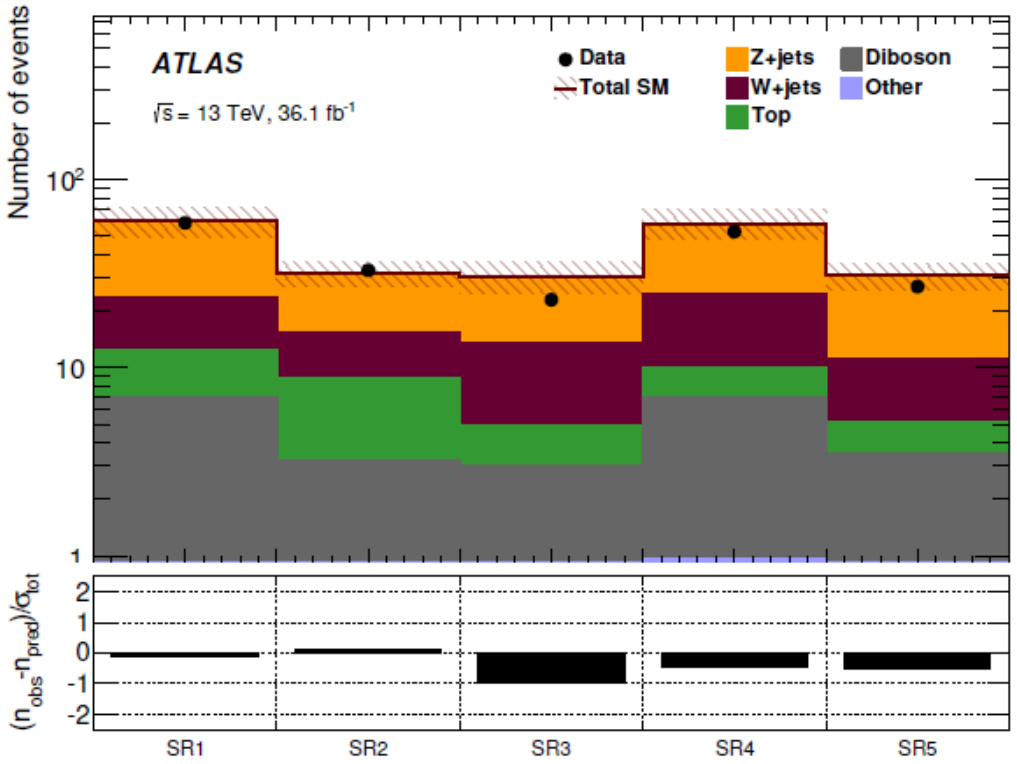
- Charm tagging reconstructed jets is one of the main challenge of any qc+MET analysis
  - More difficult that b-tagging experimentally
- Currently no charm tagger is recommended by FTAG group, nor calibration
- Different approaches have been used:
  - Past cc+MET search have used multivariate discrimination based on MV2 algorithm
  - Other approaches also are possible

Other challenges

- Z+jets is difficult to remove from signal regions, mainly through Z->νν decays with associated c-jets (or mis-tagged light jets)
- ttbar is a similar concern in compressed regions where it can mimic signal
- Initial state radiation is an issue where it can be difficult to separate from the signal system

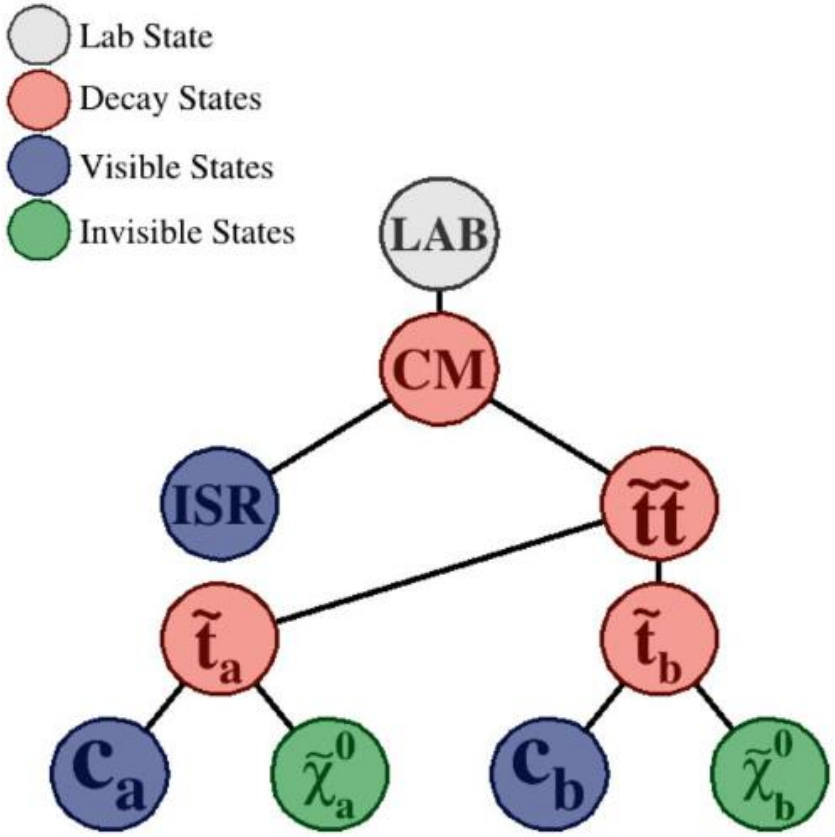
2018 cc+MET analysis

- No significant excess above SM
- Top and Charm squarks with masses up to 850 GeV are excluded at 95% CL with a massless lightest neutralino
  - For m_{t1}-m_{X0} < 100GeV t_1/c_1 squarks with masses up to 500GeV excluded



2021 cc+MET analysis – University of Adelaide/Argonne National Laboratory

- Using full Run II dataset
  - 139fb^{-1}
- Investigating charm tagging solutions and WPs
- Implementing Recursive Jigsaw Reconstruction alongside conventional analysis
  - Can use RJR to reconstruct particle decays with the presence of combinatoric and kinematic ambiguities, imposing specific decay topology
  - Apply mass minimization jigsaw rules for invisible objects to split MET based on c-jet and parent state properties
  - Possibly use imposed topologies to isolate background in signal regions.



Conclusion

- qc+MET analyses are designed to test nMFV MSSM models, where 2nd and 3rd generation mixing is maximal
- There are multiple topologies encompassing different projects
- It presents multiple interesting challenges to overcome regarding background contamination of signal, as well as the requirement of effective c-tagging for which there are no official recommendation.