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Disappearing track search at a 100 TeV *pp* collider

Eur. Phys. J. C 79, 469 (2019), arXiv:1901.02987

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EF09 BSM-General: Long-lived particles

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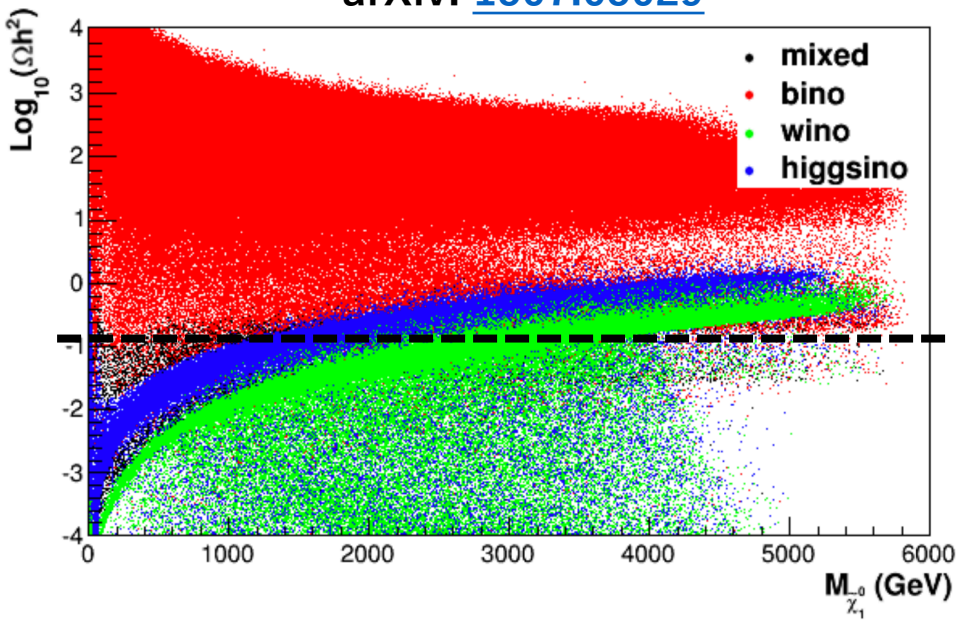
Motivation

- Neutralino (SUSY) is a good candidate as DM.
  - In a thermal scenario, the DM relic density constrains the upper bound of DM mass
    - Pure wino ~ 3 TeV
    - Pure higgsino ~ 1 TeV
    - Pure bino : coannihilation scenario possible

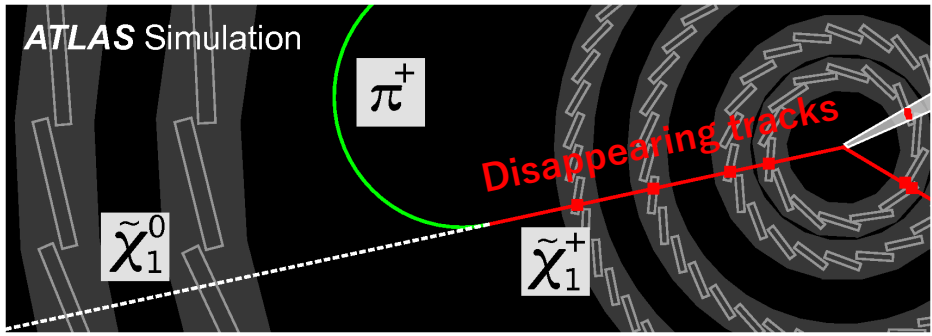
- Focused on the nearly pure wino/higgsino LSP case
  - Hard to detect the secondary objects from the chargino decay due to the tiny mass difference (Δm = O(100) MeV)
  - A chargino becomes long-lived
    - Wino : τ = 0.2 ns, $c\tau$ ~ 6 cm
    - Higgsino: τ = 0.023 ns, $c\tau$ ~ 7 mm
  - Observed as a disappearing track signature

- Future Circular Collider (FCC)
  - FCC-hh is a 100 TeV *pp* collider (CDR)
  - Integrated luminosity : 30 ab^{-1} (collected by 30-years run)
  - Pileup : $< \mu > = 200\ or\ 1000$ (depending on bunch space)
    - $< \mu > = 200, 500$ is assumed in this study

arXiv: 1507.05029



arXiv: 1712.02118

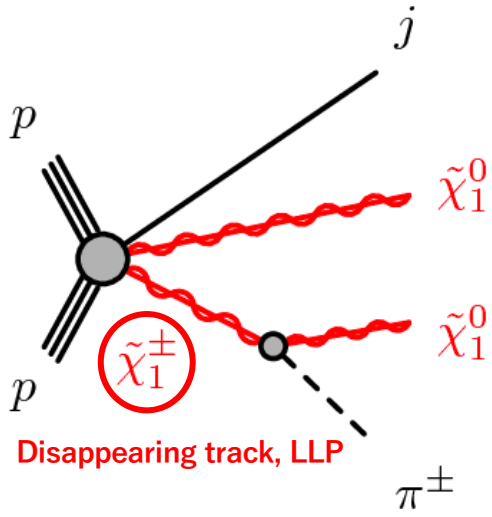


$$\tilde{\chi}_1^{\pm} \rightarrow \pi^{\pm} \tilde{\chi}_1^0$$

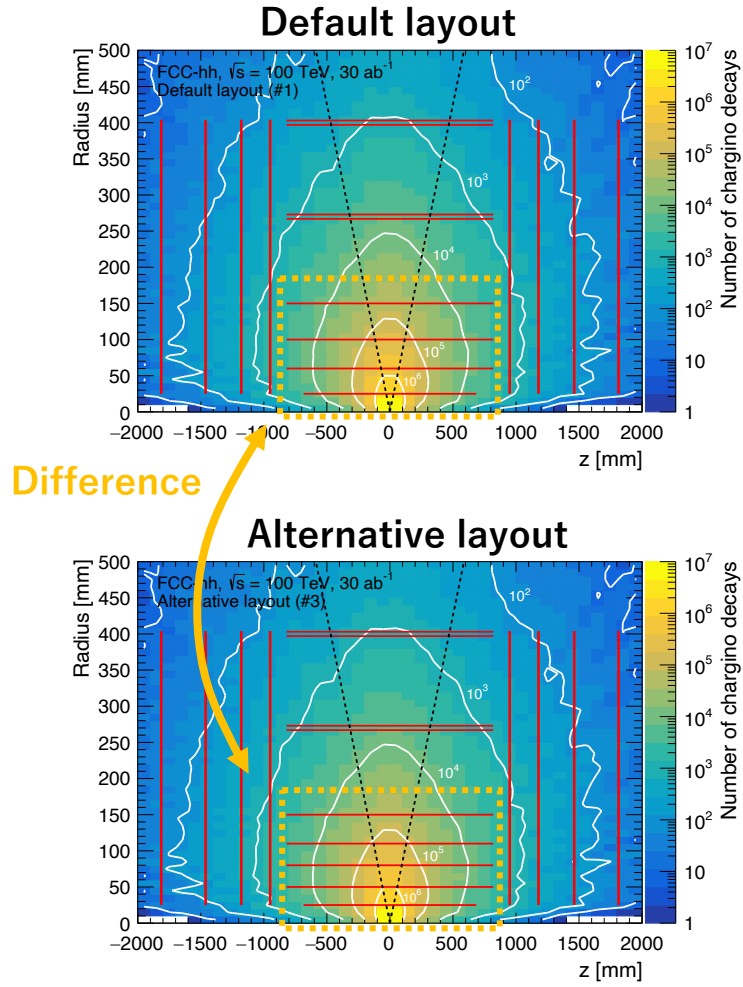
very low pT undetectable

Analysis strategy

- Based on ATLAS disappearing track search
  - Jet + MET + short disappearing tracklet



- Tracker layouts
  1. Default layout: used in CDR by default
  2. Alternative layout: additional pixel layer
  - Signal efficiency is sensitive to the tracker layout

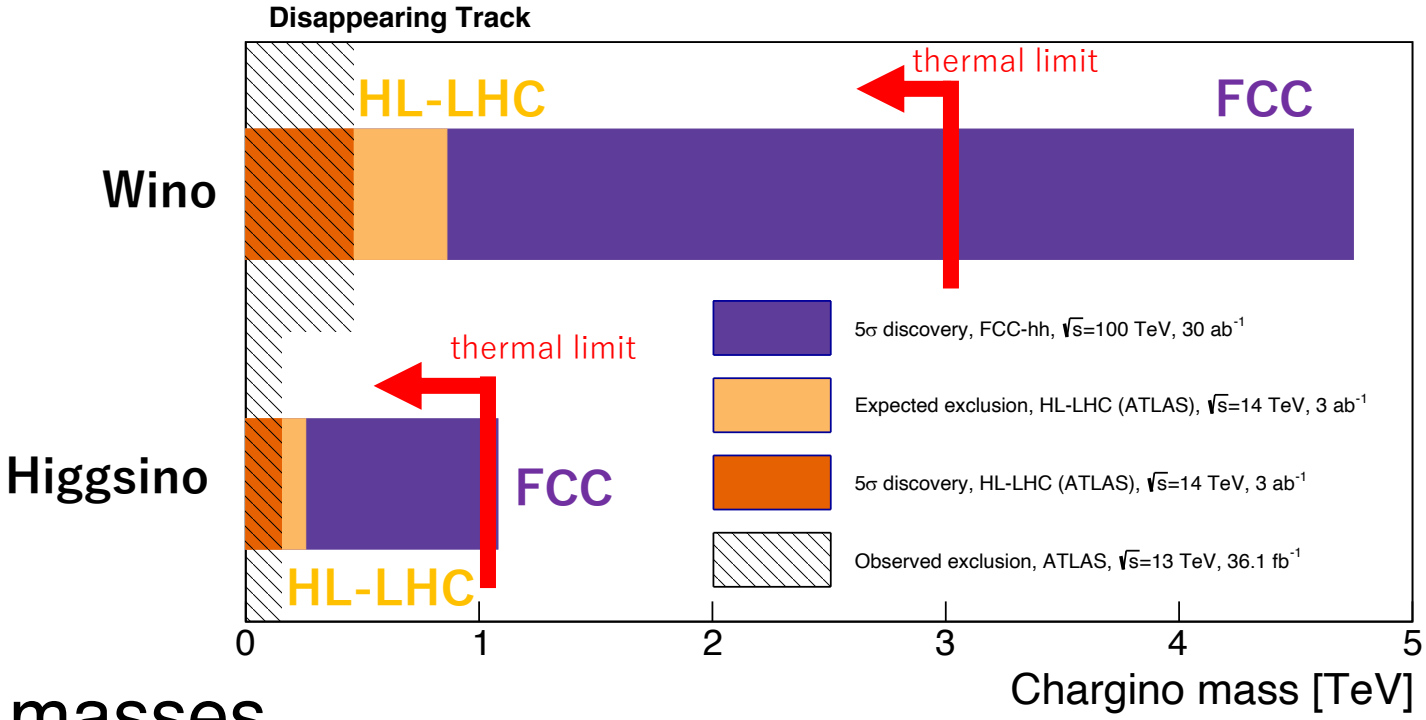


- Background (combinatorial fake)
  - Estimated using Geant4 simulation and simple tracking
  - Fake rate depends on the required number of hits on a tracks and pileup
    - Better to require at least 5 hits to reject fake tracklets

- Time information
  - 50 ps hit-level time resolution of the tracker is assumed
    - Low Gain Avalanche Detector (LGAD) already achieve < 30 ps time resolution (arXiv: 1703.09004)
  - >95% of fake tracklets can be removed with 50 ps hit-level time info
  - Chargino velocity β : accuracy of ~ 6% at $\beta < 0.8$
    - enable to measure the BSM after the discovery

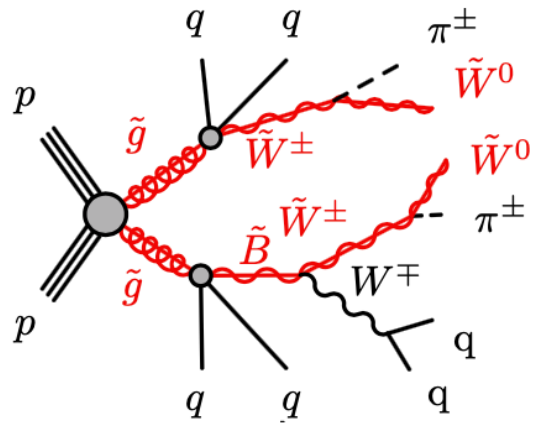
Results

- FCC-hh has the potential to cover the full mass range for discovery for thermal Wino/Higgsino DM



After discovery

- Determination of other gaugino masses
  (JHEP **05** (2019) 179, arXiv:1901.10389)
  - Considering $\tilde{g} \to qq\tilde{B}$, $\tilde{g} \to qq\tilde{W}$, $\tilde{B} \to qq\tilde{W}$ process
  - Determined Wino/Bino/Gluino masses
  - Implications to SUSY breaking scenario



- Determination of wino lifetime (Phys. Lett. B **803** (2019) 135260, arXiv:1912.00592)
  - ~O(10) % accuracy

Comments from UTokyo group

- FCC-hh can discover the thermal Wino/Higgsino DM
  - or reject nearly pure wino/higgsino LSP scenario

- In the disappearing track search
  - Tracker layout is important
    - Signal efficiency drastically changes in higgsino cases.
  - Time information at each sensor gives us a various extension
    - Background rejection and measurements of signal velocity, resulting in implication for the BSM model
  - Expected to be in common with other LLP searches and other colliders!

- We may not be possible to contribute much to the Snowmass process due to limited person-power, but we are happy to be involved in the discussion for preparing material