Direct Searches for new physics at FCC ee

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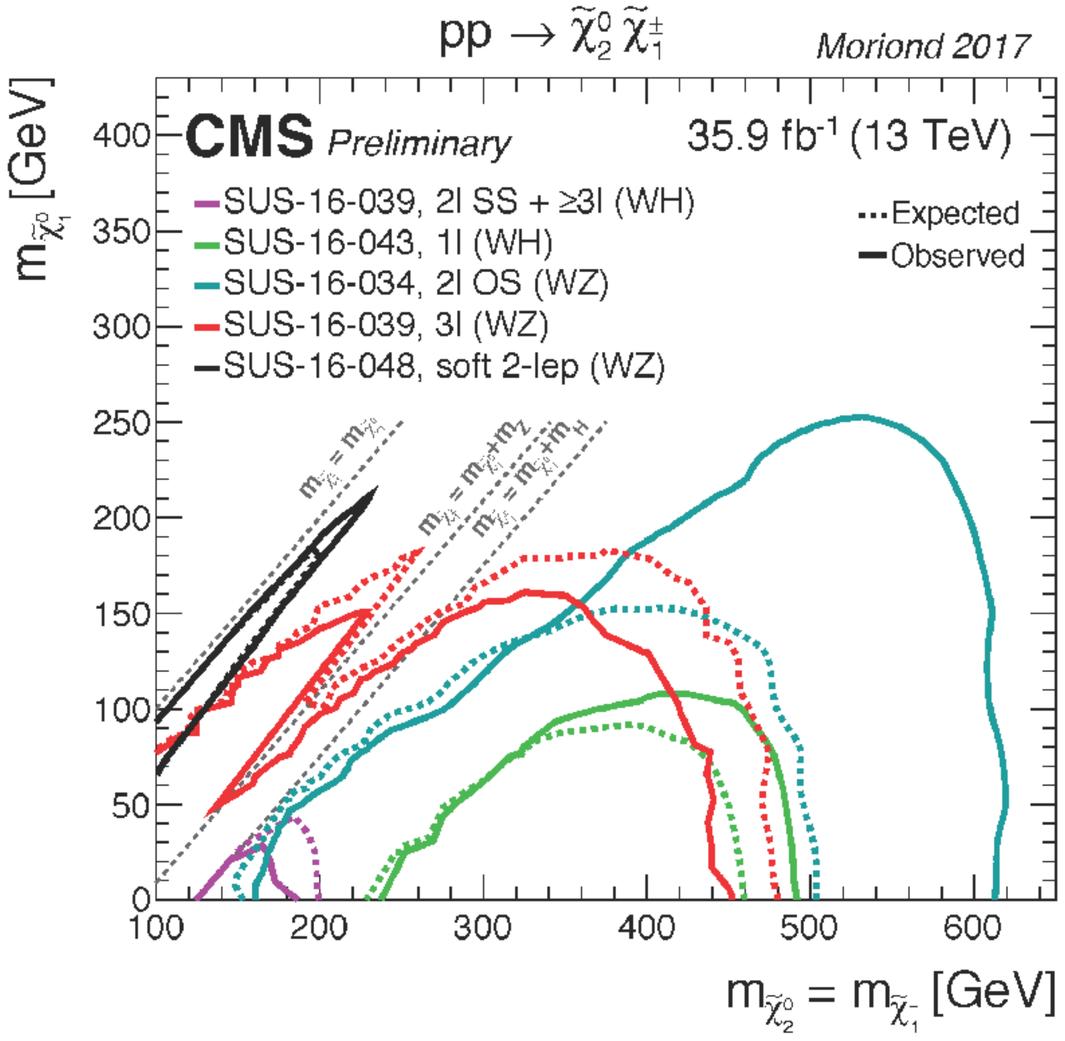
Overview

- New Physics searches for decades at colliders
  - Wide range of topics (too many for this talk)
  - String bounds from previous colliders (LEP, Tevatron, LHC)
- FCCee could complement this program
  - Clean experimental environment
  - Can probe complicated signatures (displaced signatures, disappearing tracks, non-pointing photons, etc)

Prompt Gauginos: LHC corners

- LHC probed large portion of parameter spaces for many models
- Notable example: SUSY limits pushed to TeV level
- Despite the effort, many tricky regions are still to be probed
  - compressed spectra, "stealthy" regions (Mass split ~ Mass of SM particles), etc.



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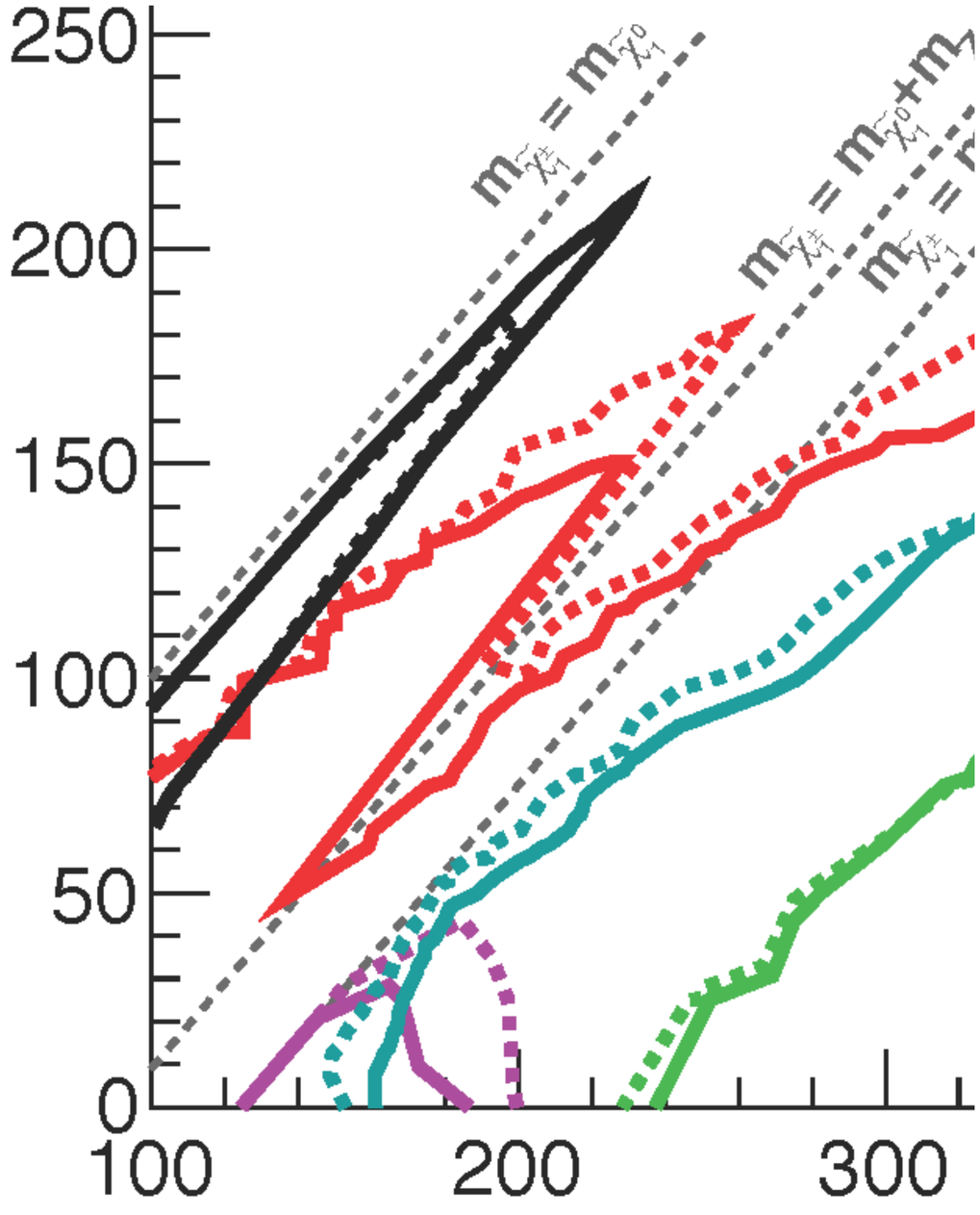
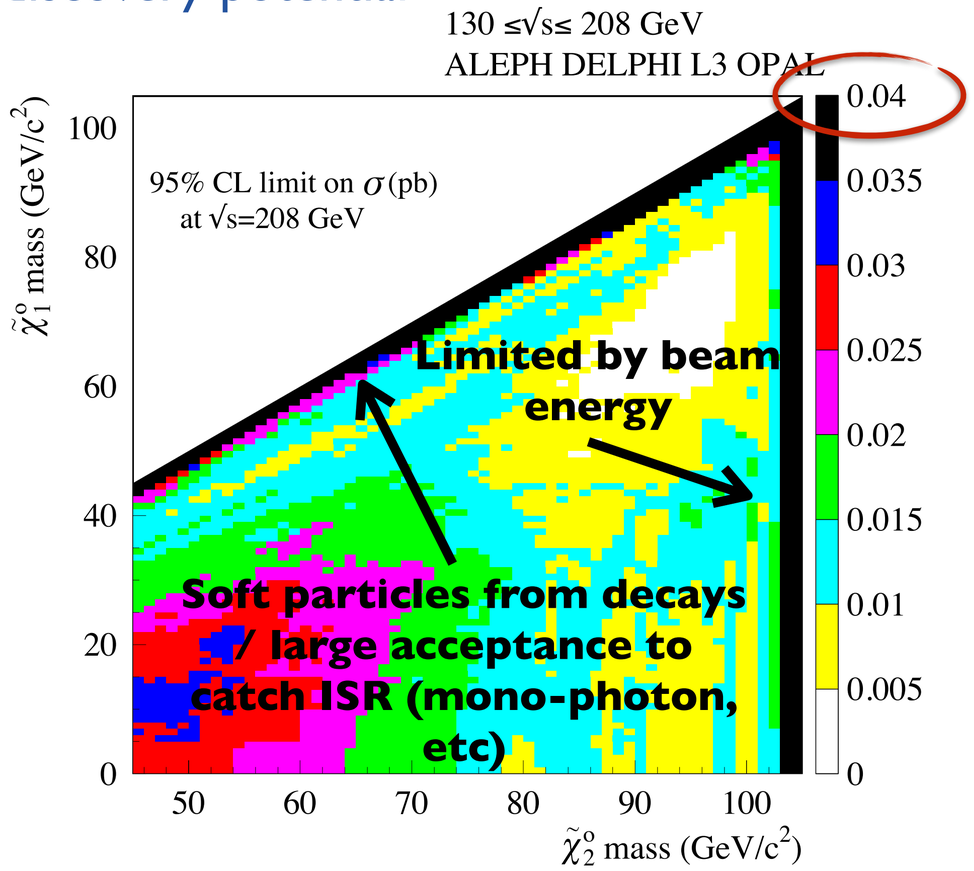
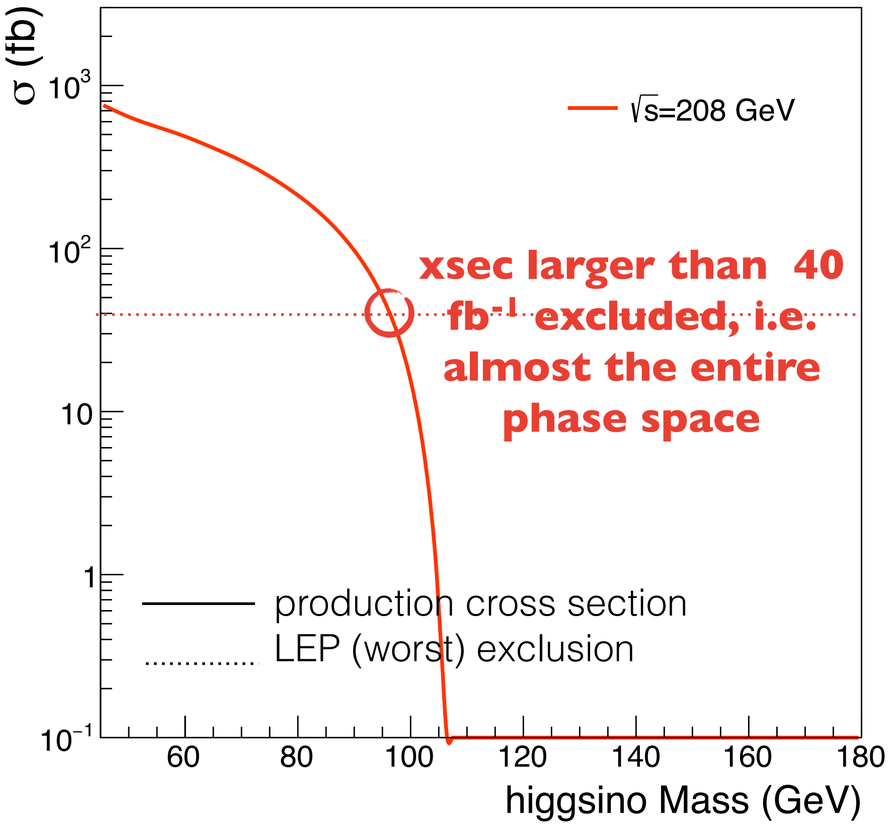


Prompt Gauginos: LEP legacy

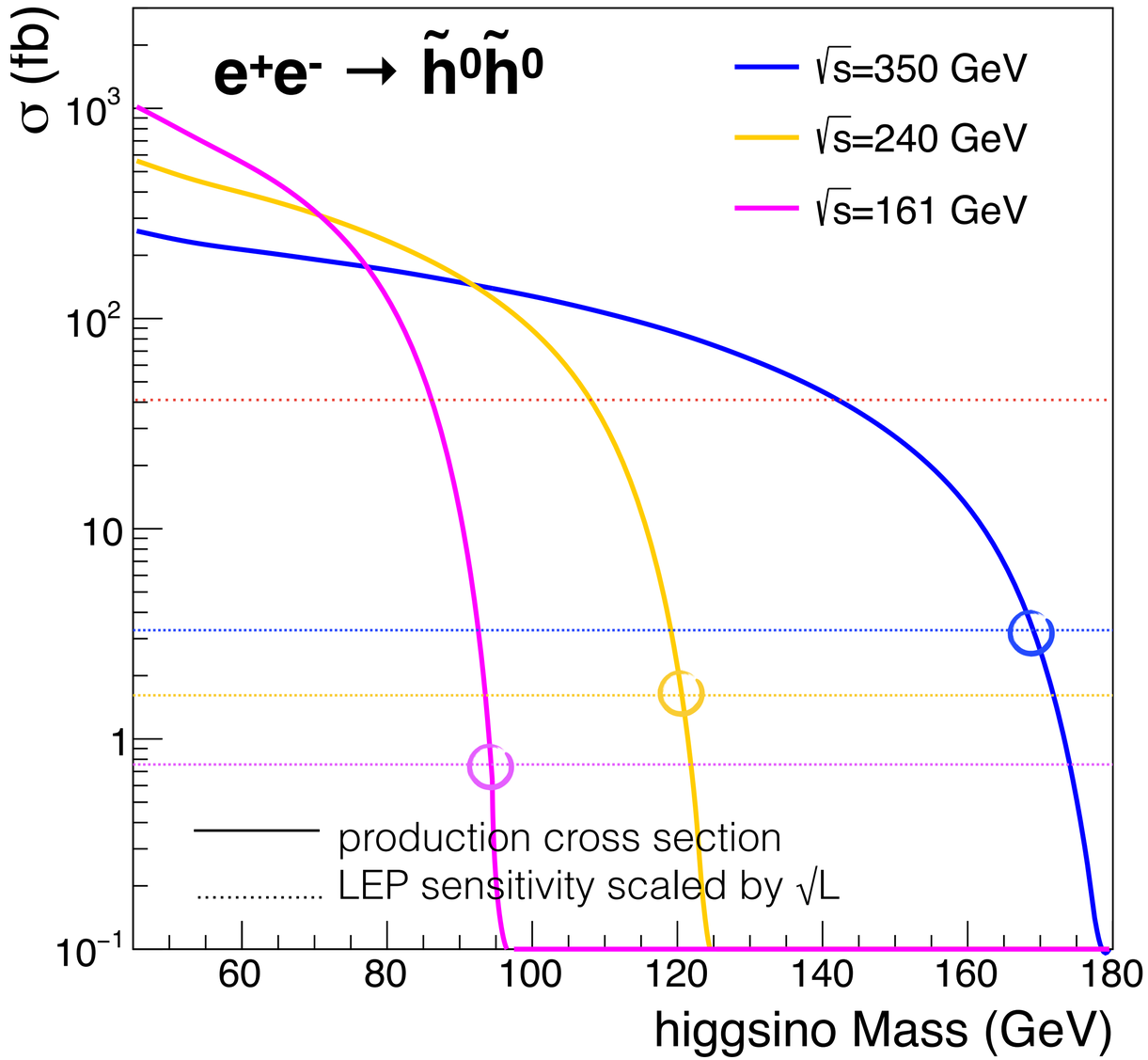
- LEP already probed SUSY compressed spectra with no blind spot
- Experimental challenges similar at FCCee (i.e., the path to follow is clear)
- The statistics increase in statistics translates into better limits / more discovery potential





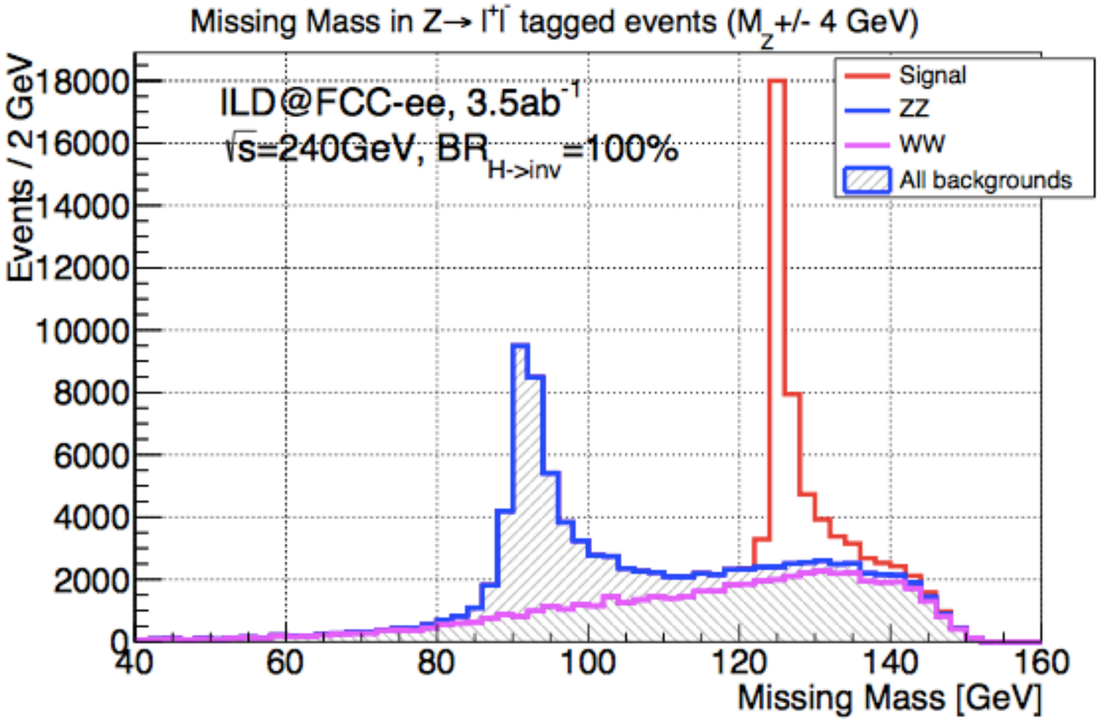
Prompt Gauginos: FCCee reach

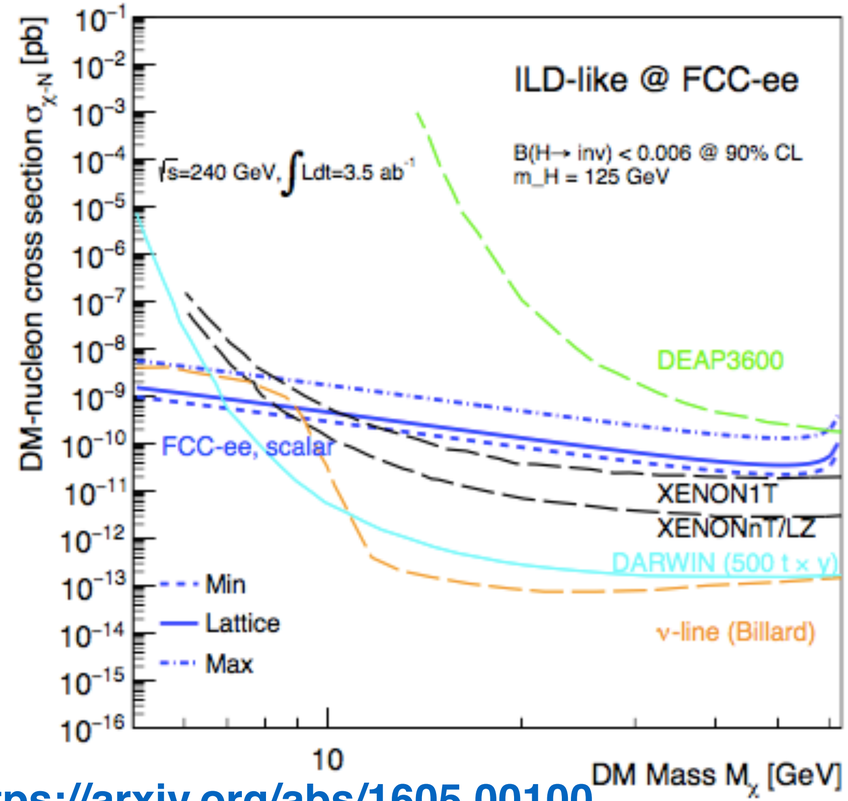
- As for LEP, the foreseen runs at different sqrt(s) have the statistical power to probe the full phase space
- The limitation is at large masses (= beam energy), and not for compressed spectra (= soft particles)
- Similar conclusions hold for other final states: leptons (for sleptons), Ws and Zs (for other gaugino decay modes)



Missing Mass

- Search for invisibles already exploited @LEP
  - mono-photon, diphoton, etc
- Interesting for modern New Physics models, e.g. Higgs-portal Dark Matter scenarios
- Good sensitivity thanks to the large statistics of H bosons

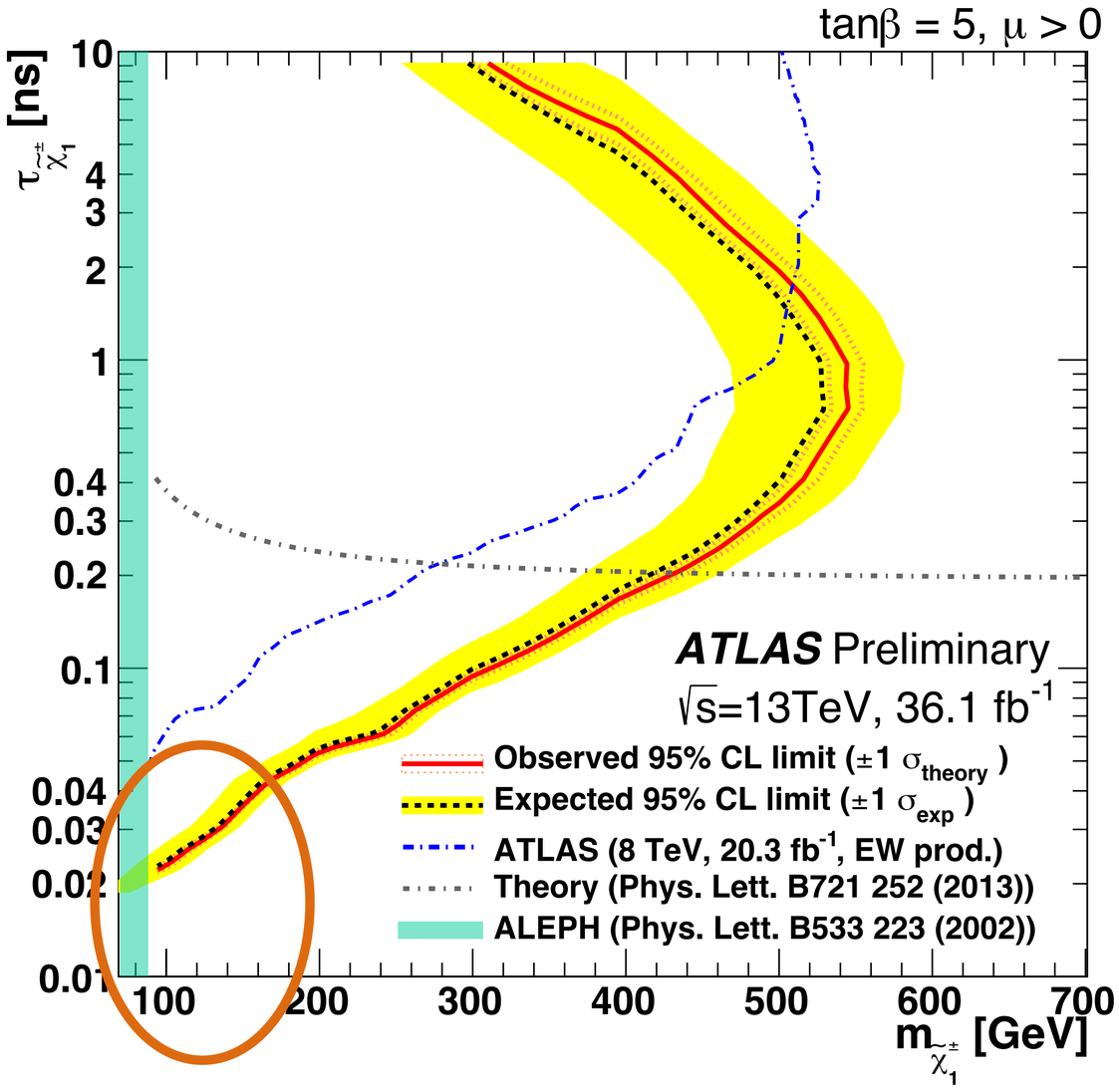




https://arxiv.org/abs/1605.00100

Flying gauginos: LHC corners

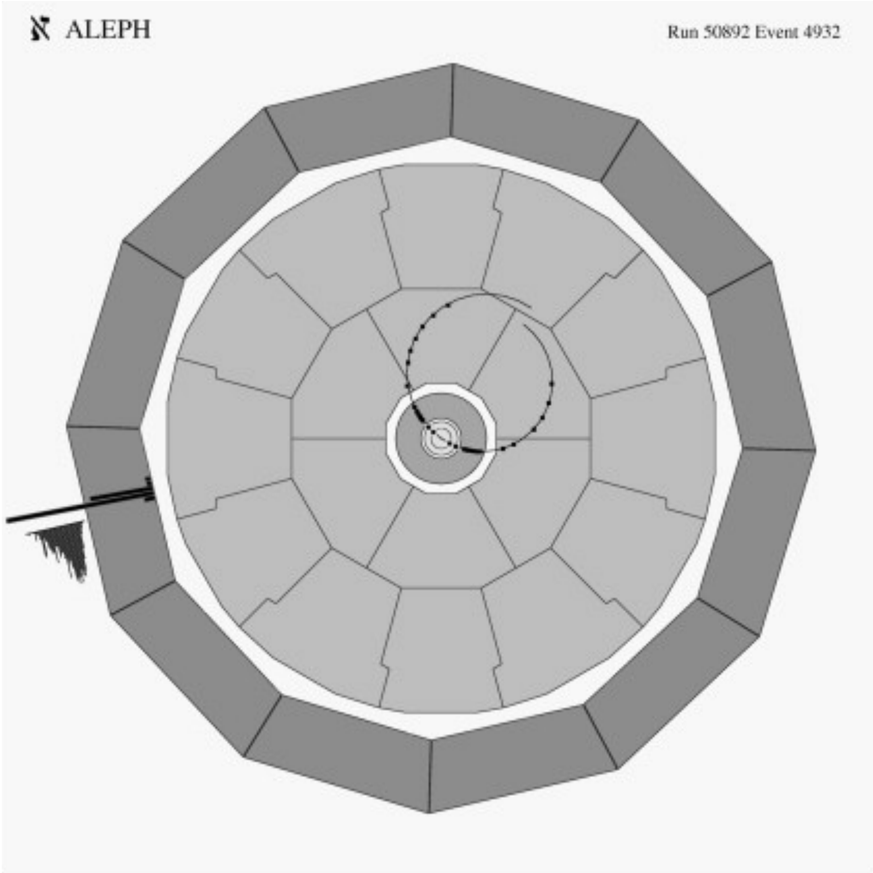
- LHC experiments are searching for long-living particles. Typical example: chargino decaying to almost-degenerate neutralino
- Search limited not only by beam/statistics
  - difficult to probe short lifetimes in a hadronic environment
  - FCCee can probe the small-mass/small-lifetime scenario (motivated by naturalness for many BSM models)

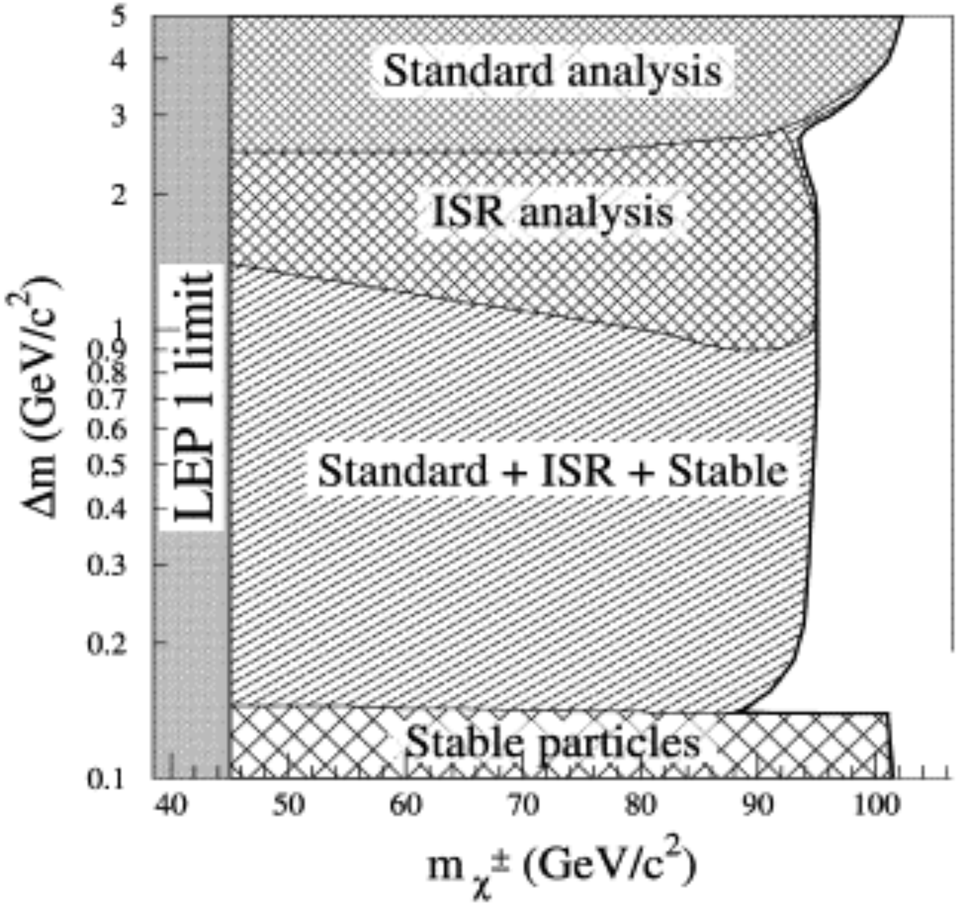


Flying gauginos: LEP legacy

- Signature at FCCee is extremely clean: track segments recoiling vs a photon

- Combining prompt to long-living search strategies, one can cover the low-mass corner for small life times / small mass gaps





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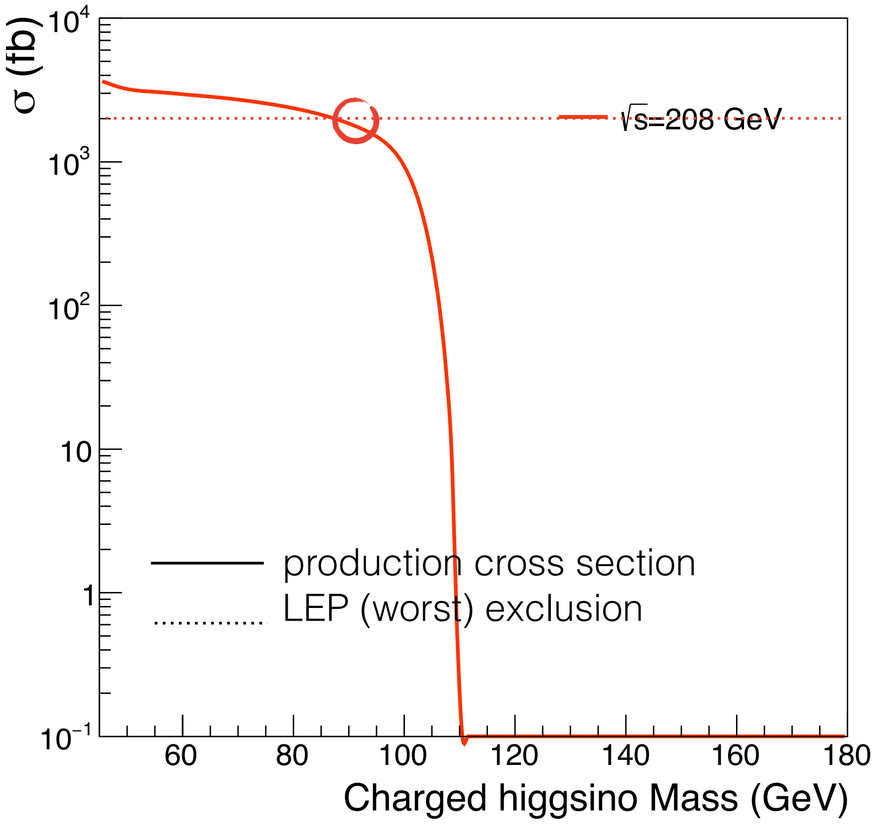
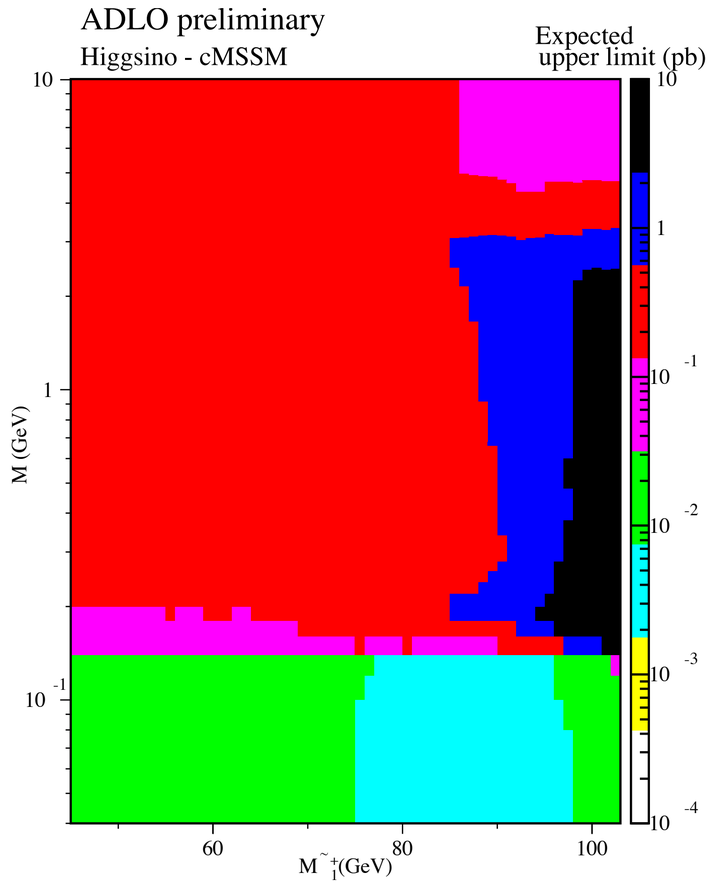
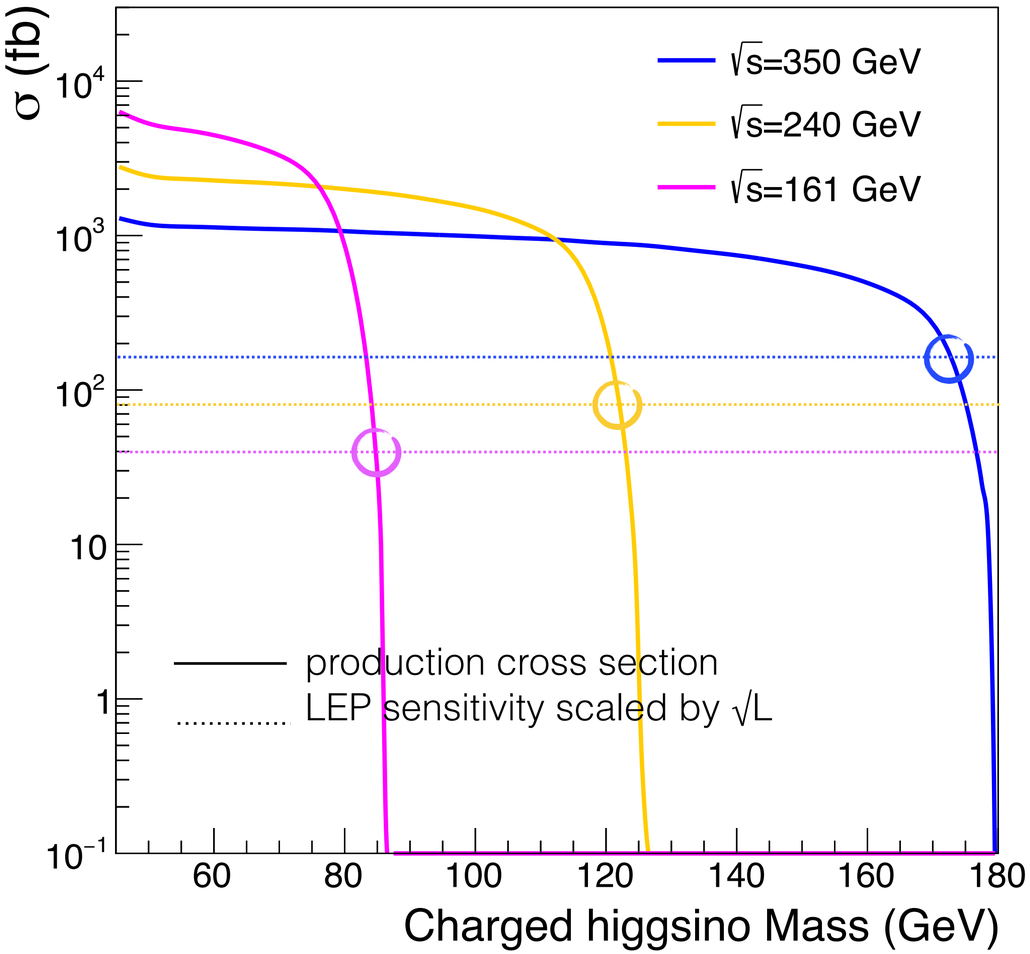




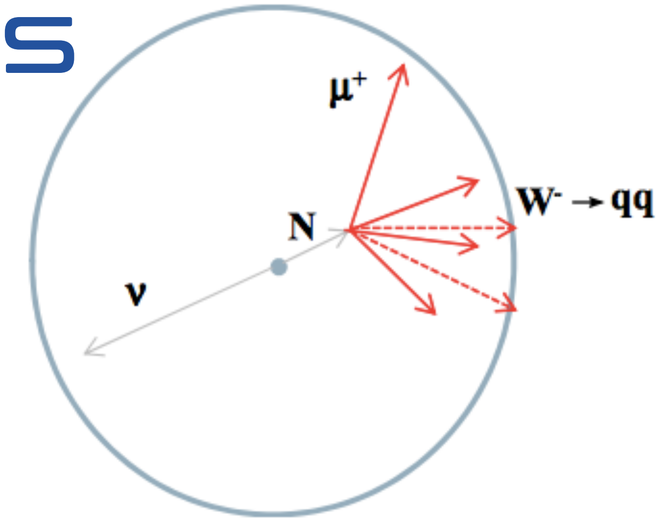
Flying gauginos: FCCee reach

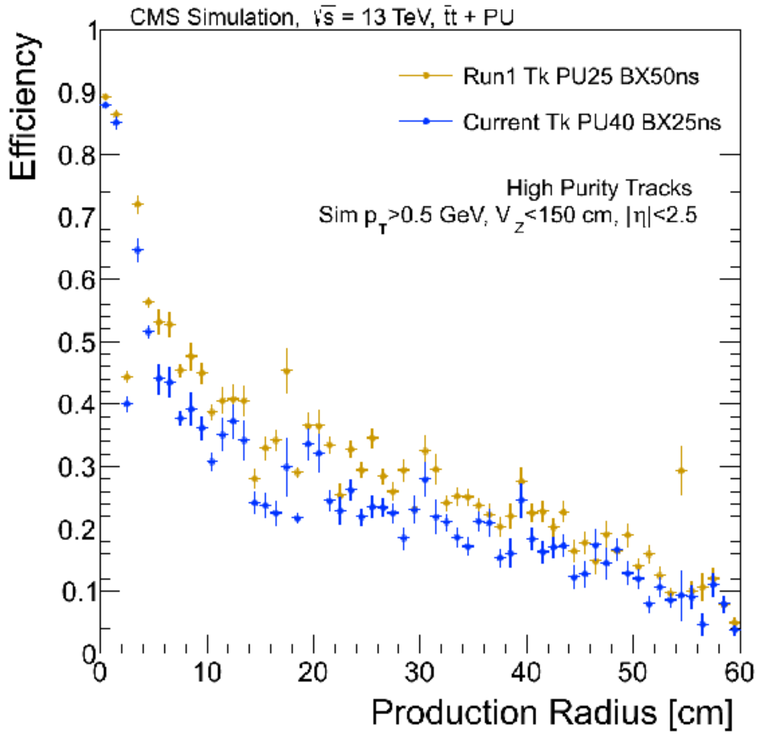
- At LEP, almost the entire phase space was covered, for very small mass splits
- The FCCee foreseen luminosity will allow to cover almost entirely the parameter space at any considered energy
- Dedicated studies to come, to assess in details the sensitivity to long-living particles (see also next slides)



Displaced Vertices

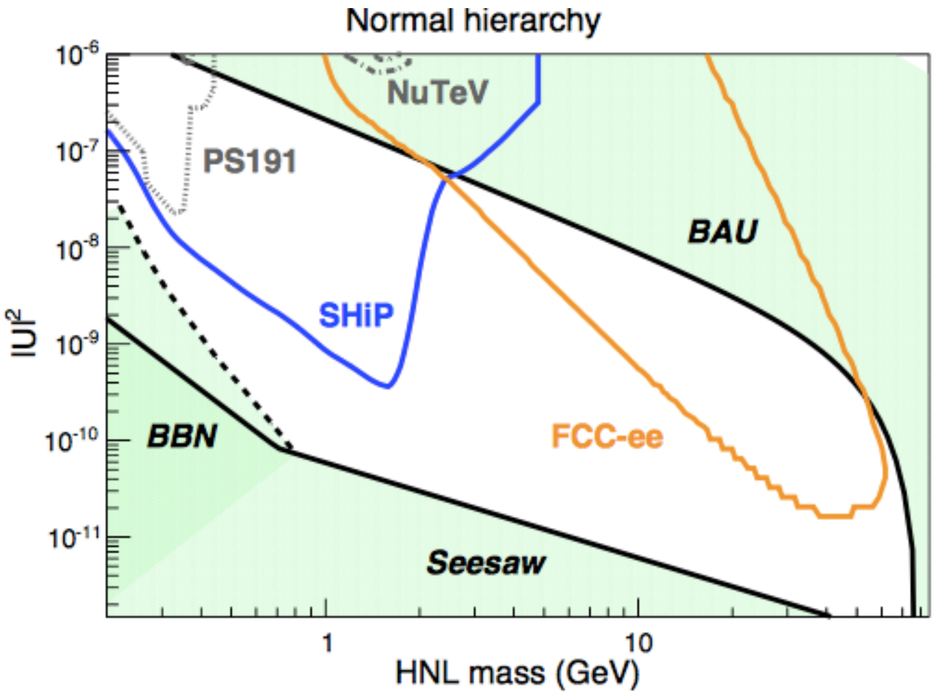
- Displaced-vtx signatures emerge in many BSM scenarios
  - SUSY compressed spectra
  - right-handed neutrinos, as in νMSM
  - resonances with small couplings, e.g., some dark-photon scenario
- FCCee clean experimental environment (vs LHC) offers possibility to probe untested scenarios
  - Requirements on tracking capabilities for displaced objects



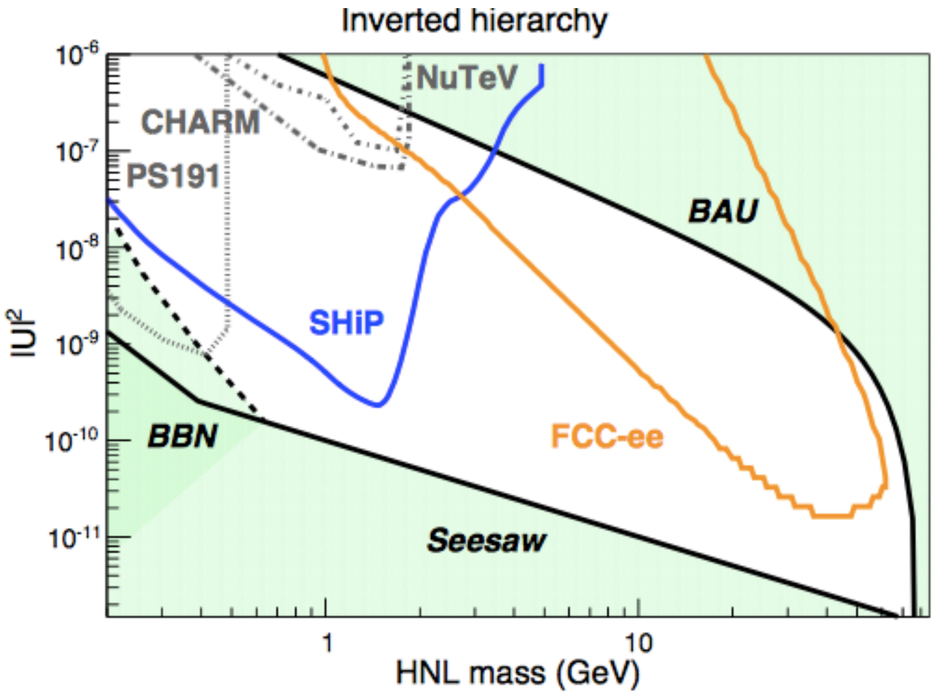


Displaced Vertices

- Preliminary studies show good potential
- Confirmation needed, based on accurate detector simulation
- Complementarity with other CERN projects (e.g., SHiP)



(a) Decay length 10-100 cm, 10^{12} Z^0



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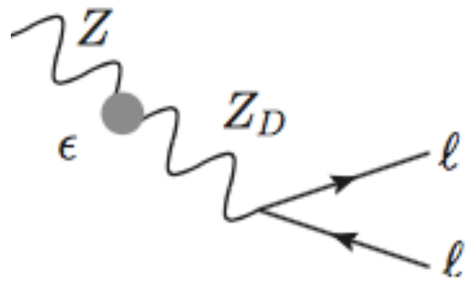
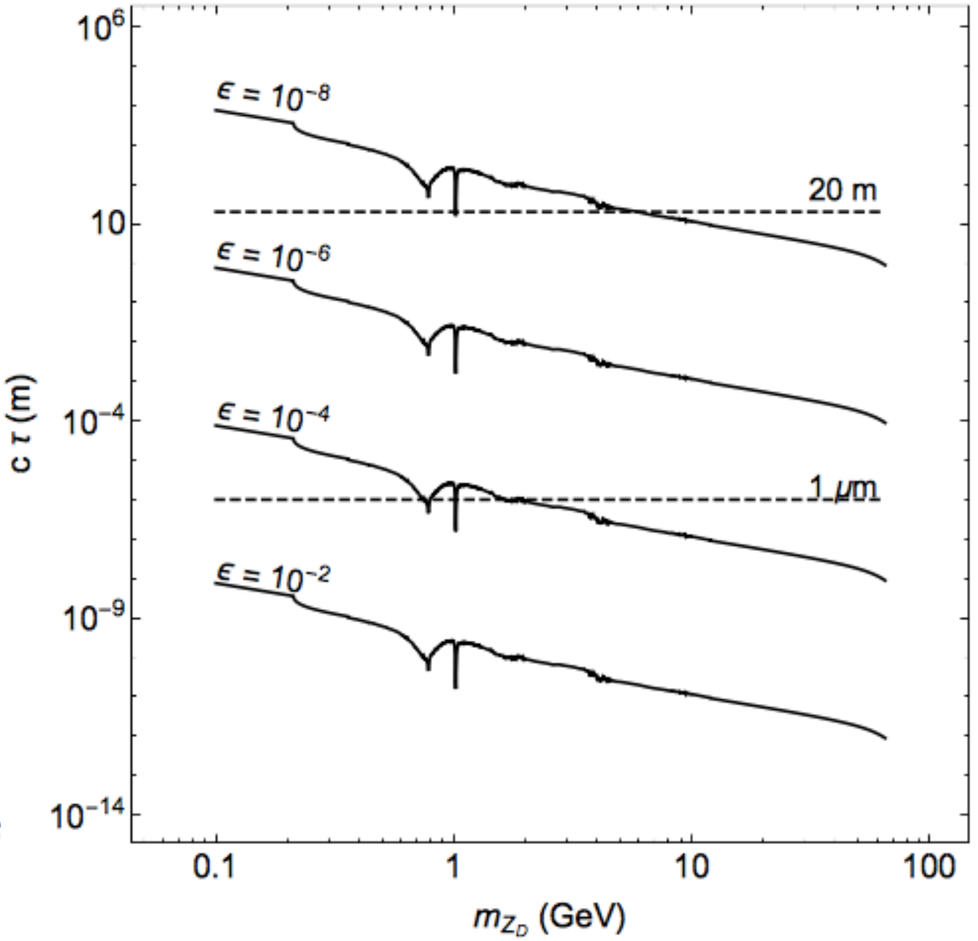
https://arxiv.org/abs/1411.5230v2

Dark Sector



- Many future experiments to probe dark photons, massive photon-like particles with small couplings with SM
  - Mass values expected to be small
  - Due to small coupling, could be long-living
- Challenging signatures for FCCee
  - small coupling implies small cross section
- Sensitivity from EWP observables @Z pole



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Dark Sector

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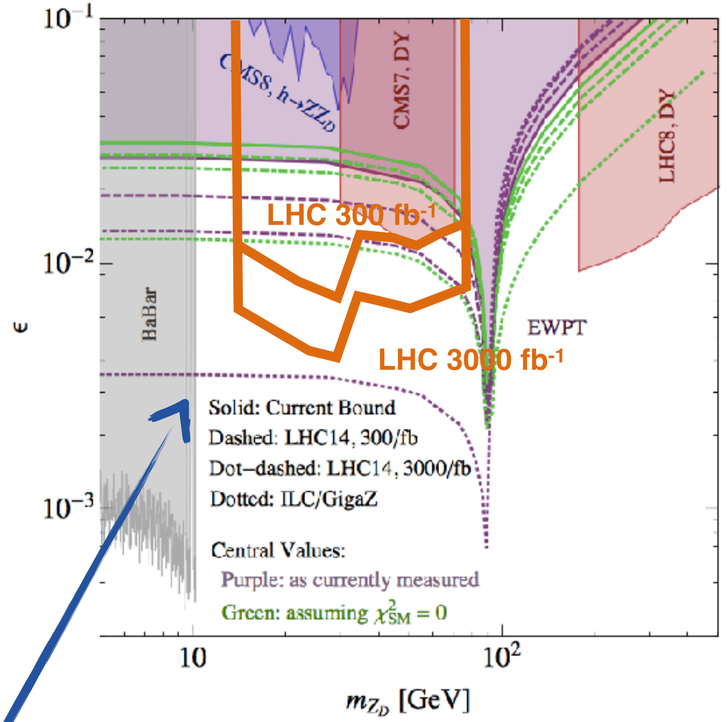
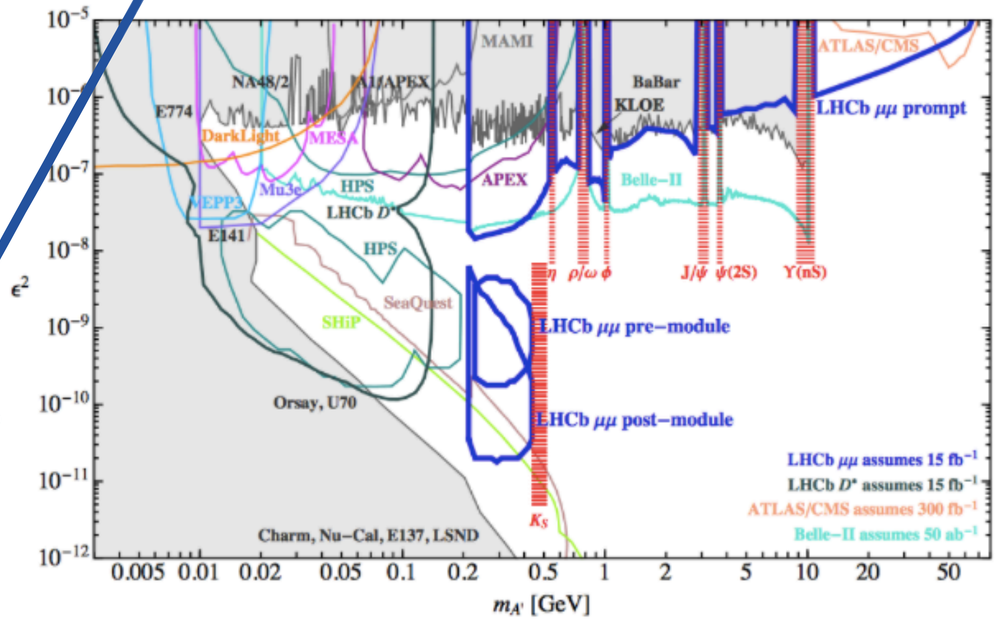
  - Mass values expected to be small
  - Due to small coupling, could be long-living
- Challenging signatures for FCCee
  - small coupling implies small cross section
- Sensitivity from EWP observables @Z pole, direct production via photon ISR, etc (to be quantified)





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Implications on Detector Geometry

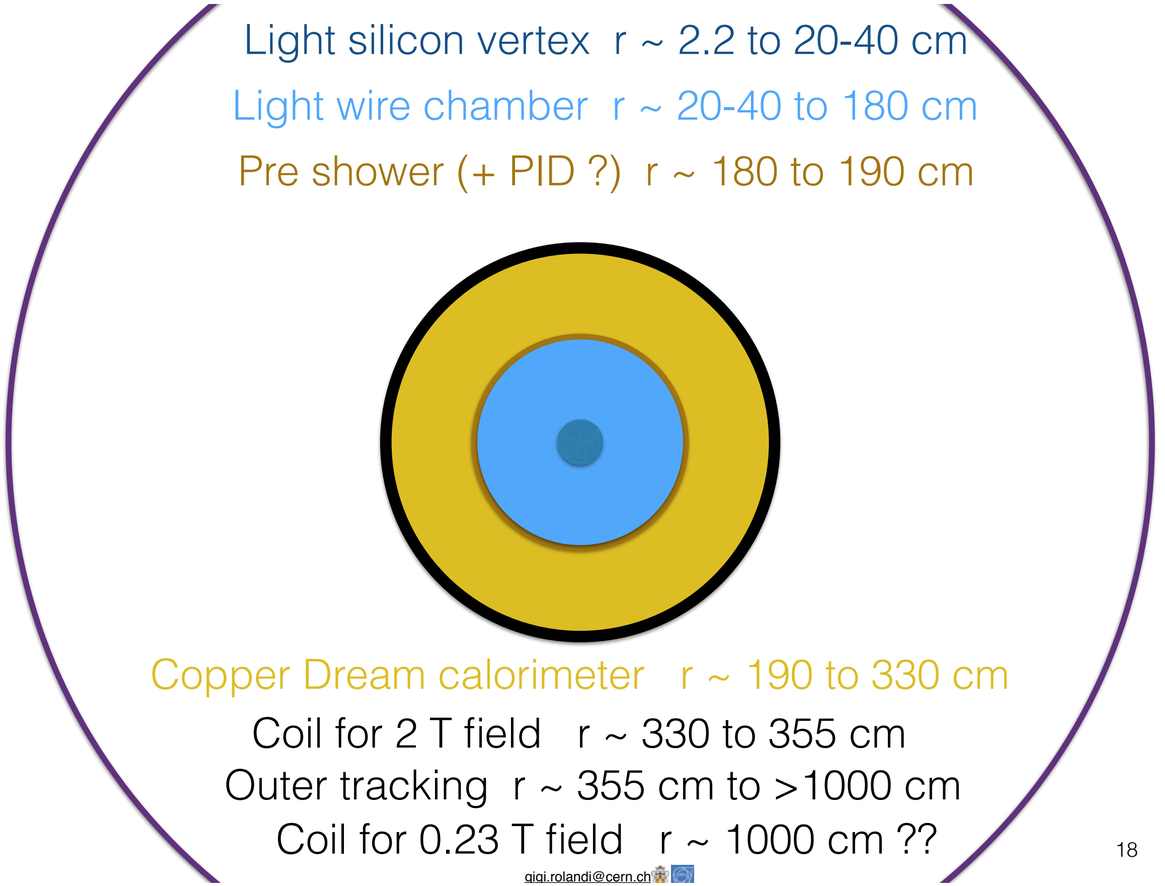
- Much of the BSM program at reach with a detector optimized for EW/ Higgs/Flavor physics (b- and c-tagging, good resolution on missing mass, etc)

- But some exotic signature comes with special requirements

  - PID in the inner tracker (through dE/dx)

  - Good track resolution at large displacements

  - Large tracking volume (to probe large values of cτ)



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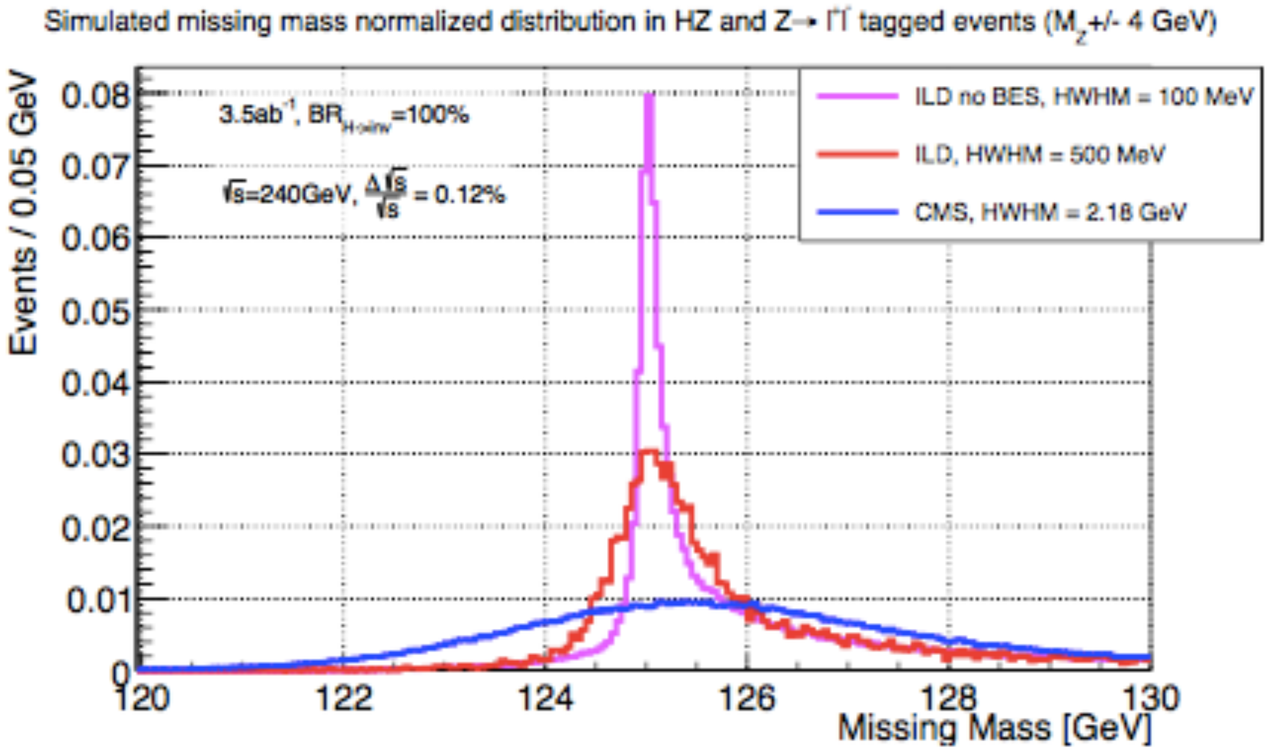
Implications on Detector Resolution

- FCCee experimental conditions are optimal to search for invisibles particles
  - known initial state
  - small impact of beam energy spread
- This calls for good tracking performances
  - Missing-mass resolution dominated by tracker resolution → ILC-like tracking resolution is mandatory



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Moving Forward

- FCCee has a big potential to probe BSM models in a complementary way to past, present and (other) future machines
- Clean environment + high luminosity allows to probe tricky scenarios (e.g., for the LHC) with good precision
- Only a few examples presented here. Many more possible, depending on people interest & commitment
  - Accurate simulation software for many exotic signatures (e.g., instrumental background to displaced signatures)
  - People to commit to a detailed exploration of the vast landscape of BSM possibilities