

# Direct Searches for new physics at FCC<sub>ee</sub>

Maurizio Pierini



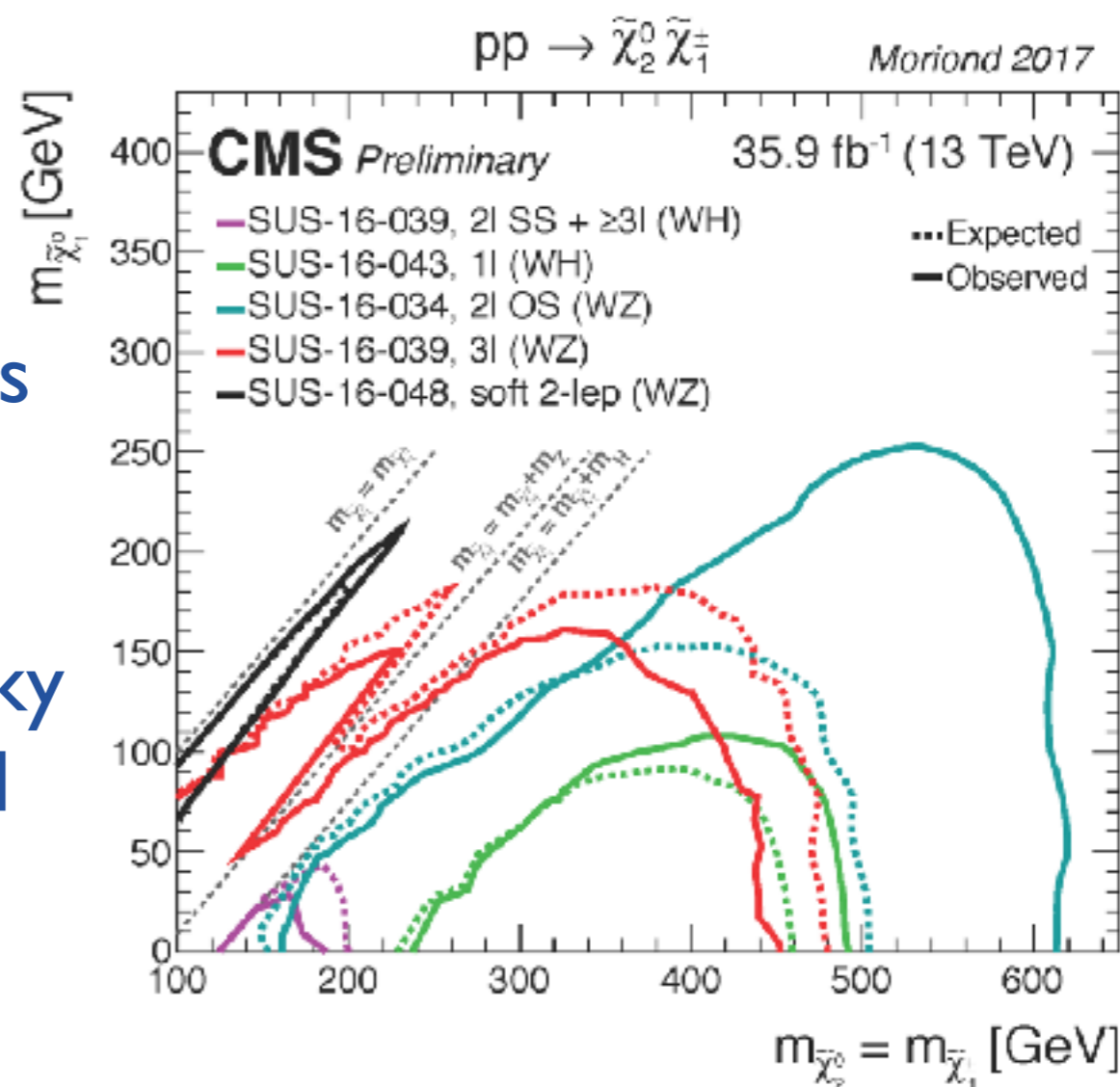


# Overview

- 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  $\sim$  Mass of SM particles), etc.



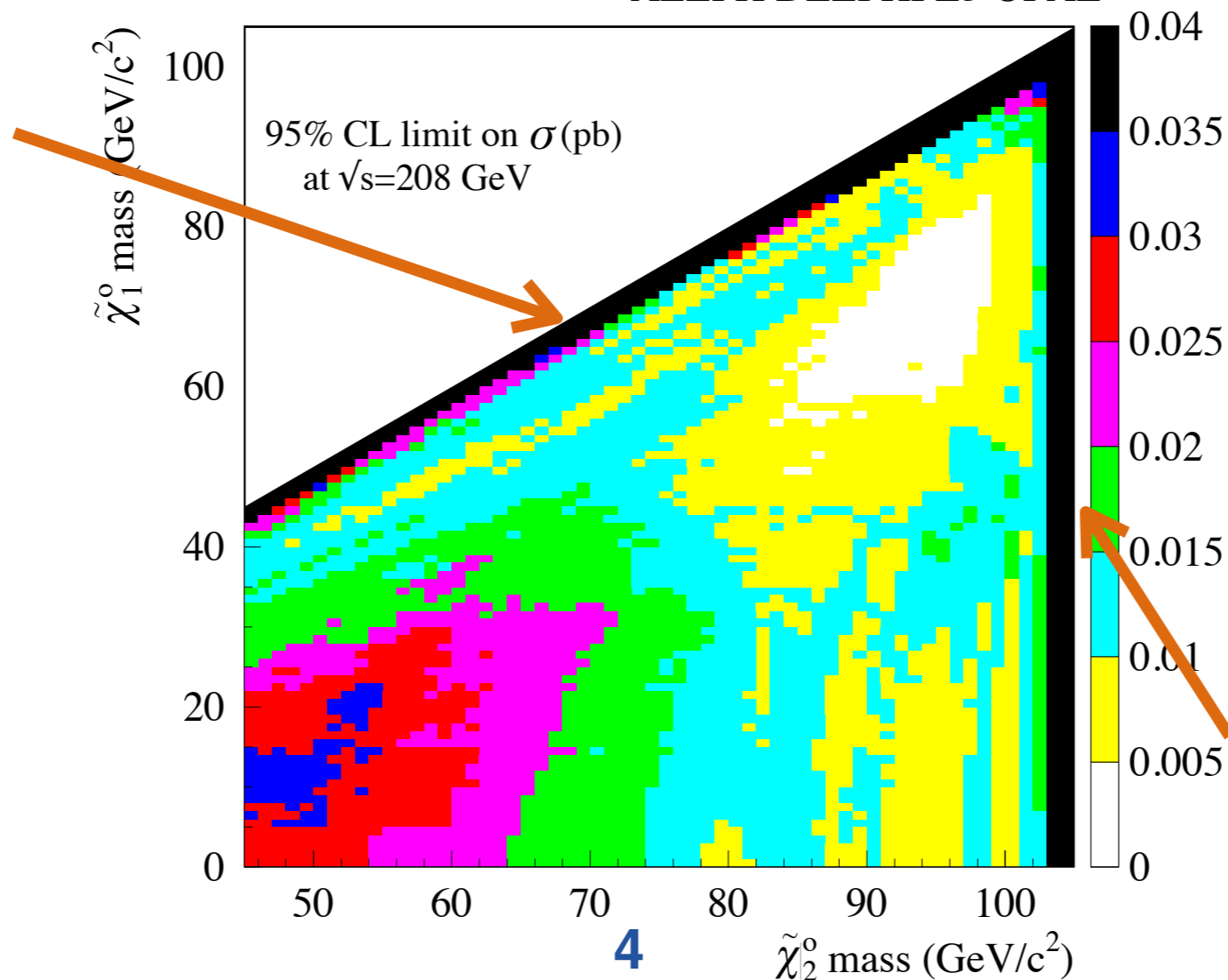


# Prompt Gauginos: LEP legacy

- 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

**Soft particles from decays / large acceptance to catch ISR (mono-photon, etc)**

130  $\leq \sqrt{s} \leq$  208 GeV  
ALEPH DELPHI L3 OPAL



**Limitation here comes from beam energy**



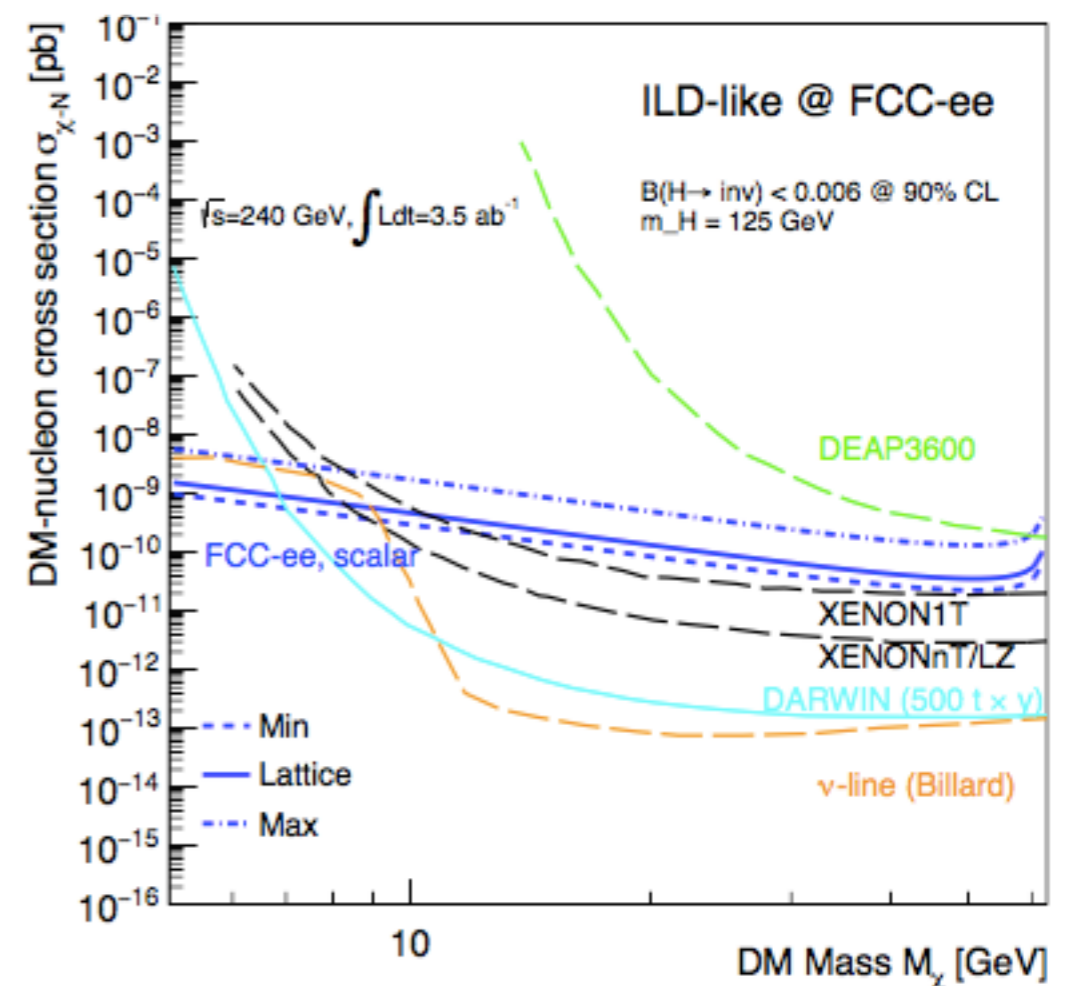
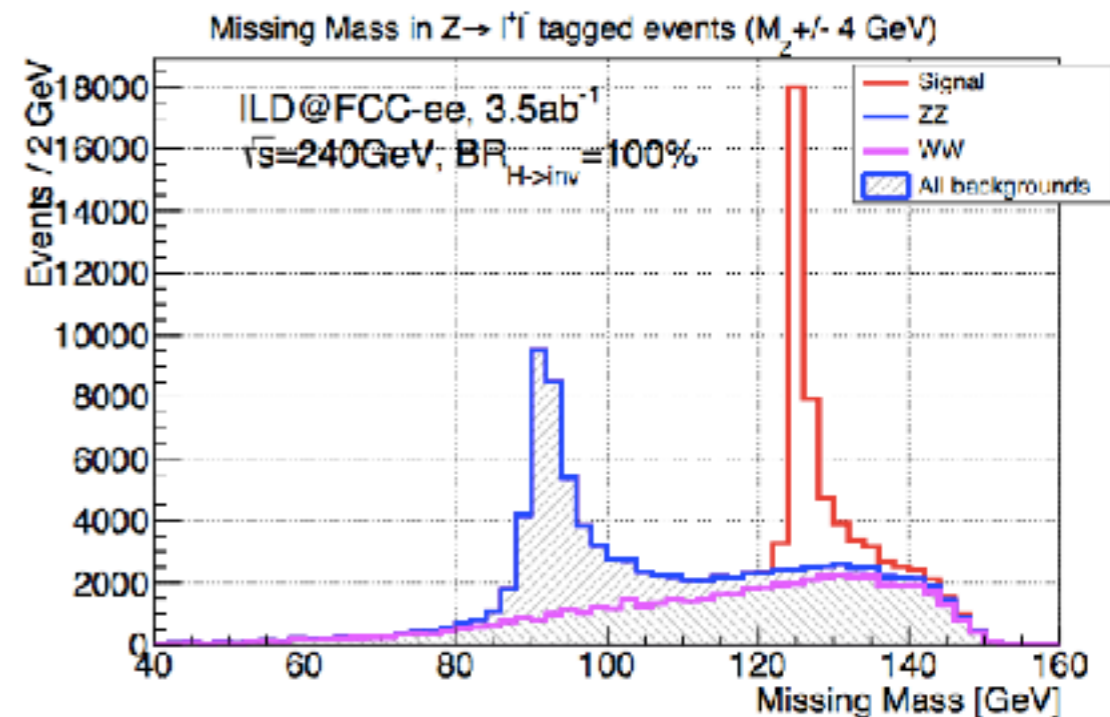
# Prompt Gauginos: FCCee reach

**TO BE DONE : here I would like a plot like the one above, scaled by  $\sqrt{L}$  ratio. To draw a line, I need a prediction for the production xsec. Might come in time for Berlin**



# Missing Mass

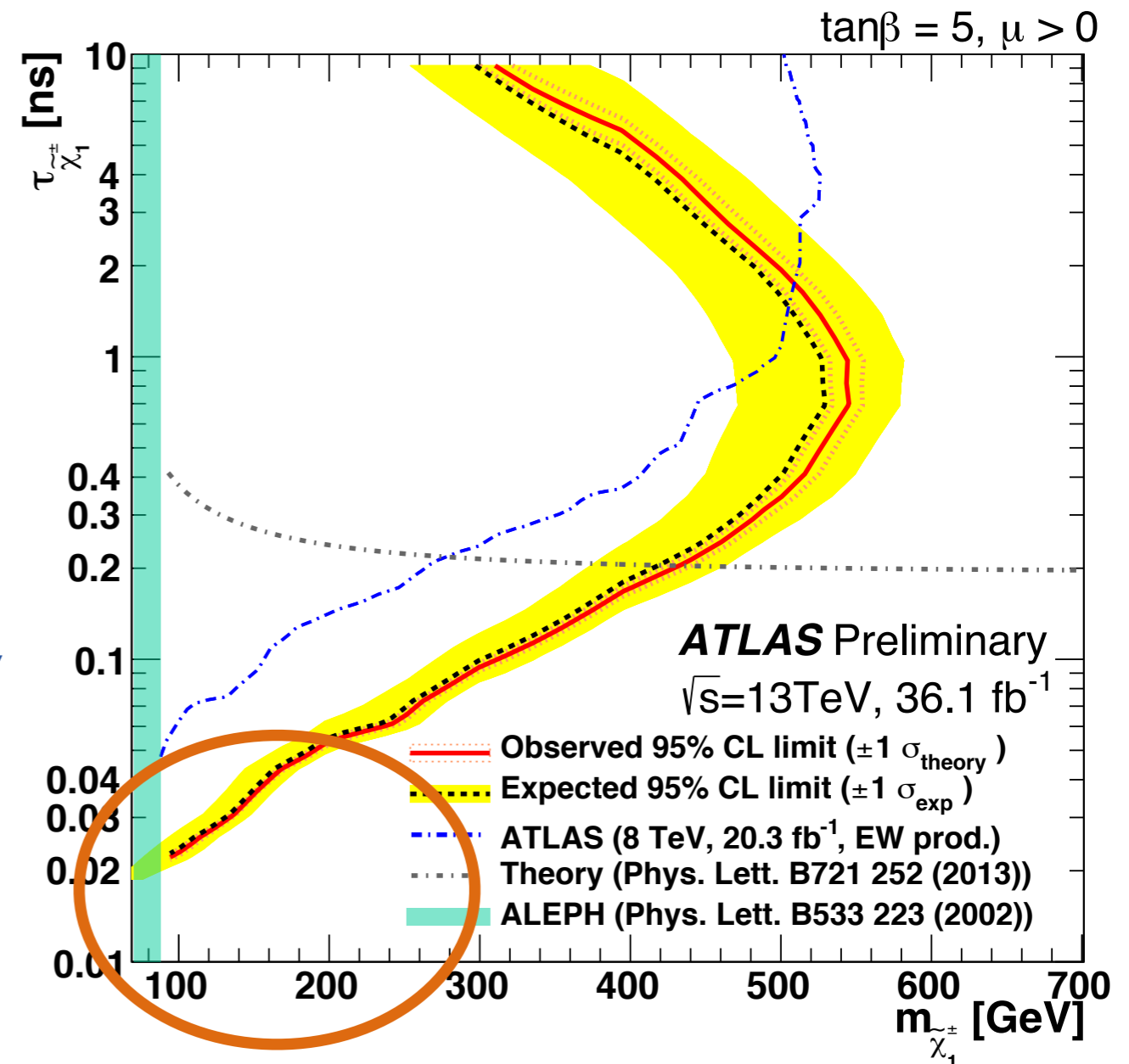
- Search for invisibles already exploited @LEP
- mono-photon, diphoton, etc
- Interesting for modern New Physics models, e.g. Higgs-portal Dark Matter scenarios
- Good sensitivity thanks to the large statistics of H bosons





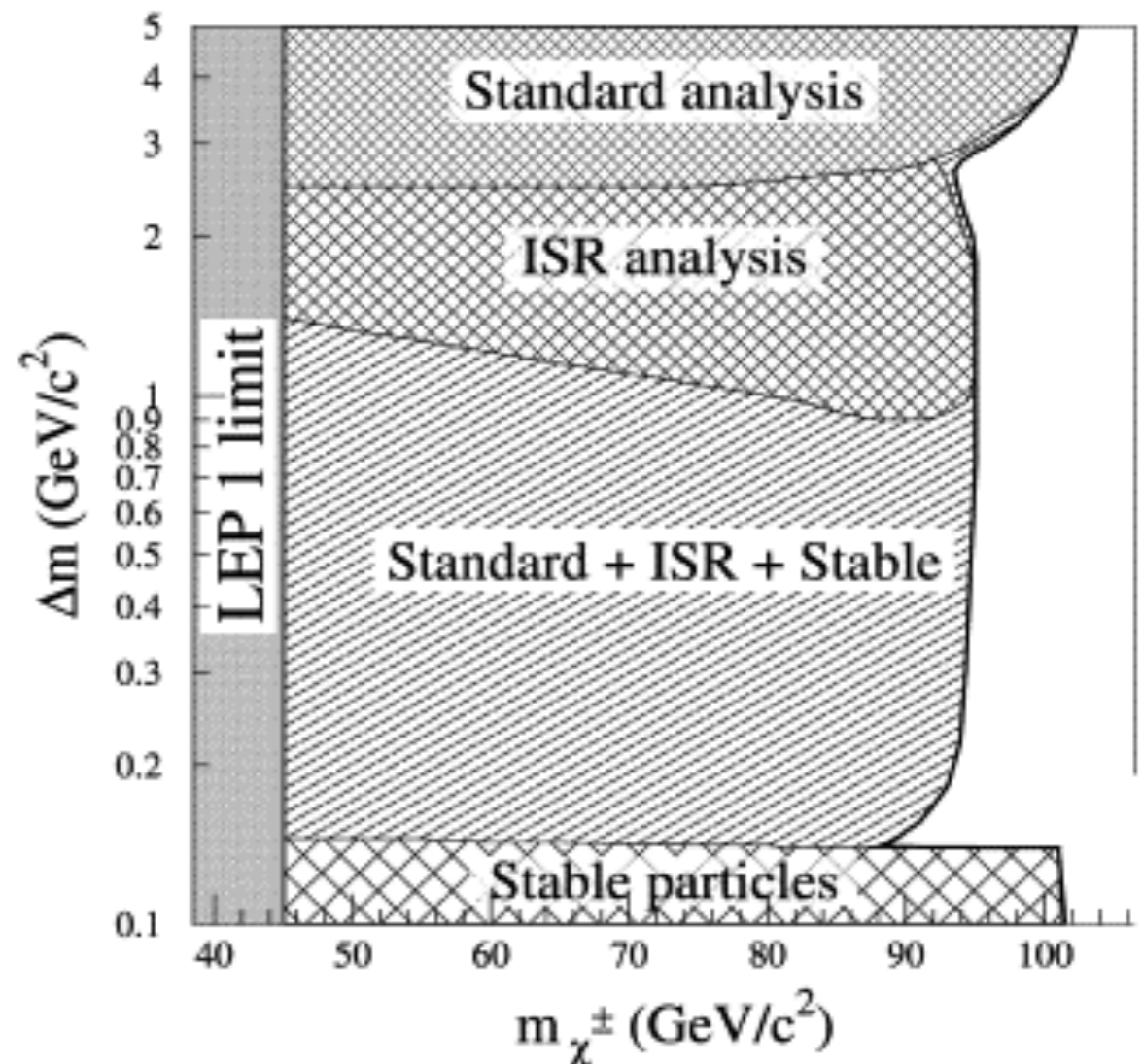
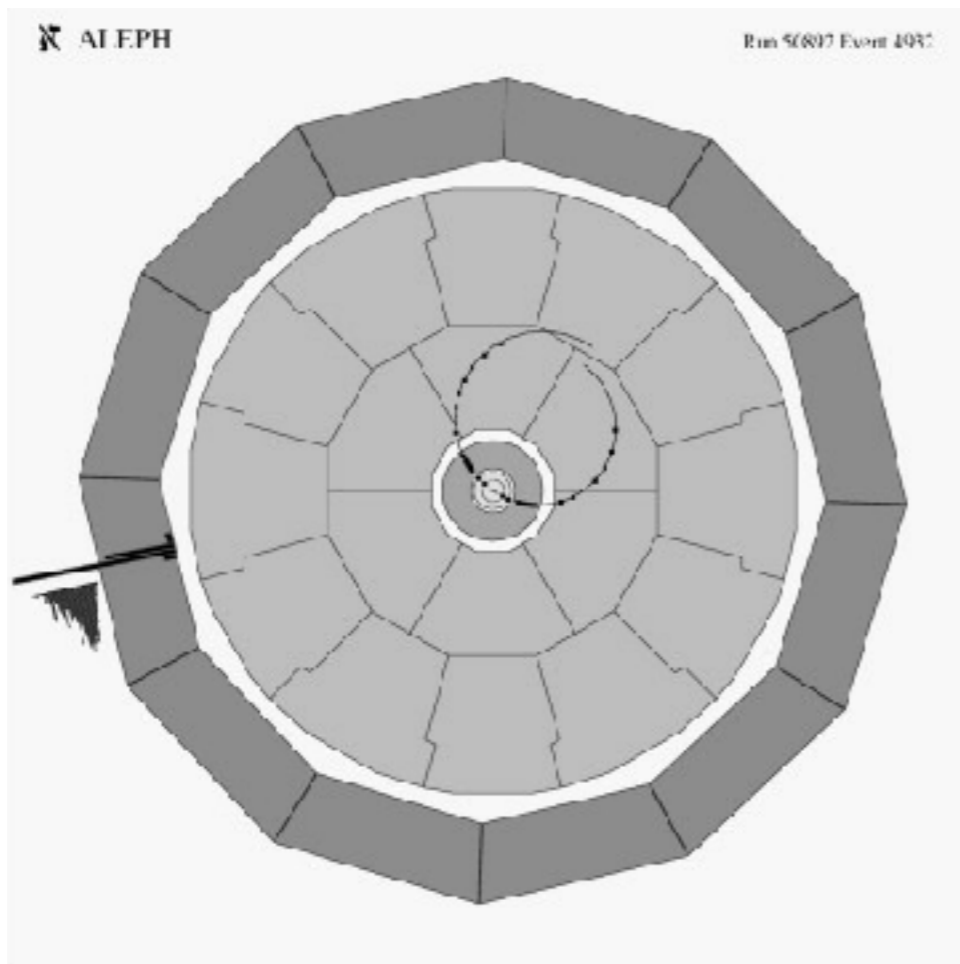
# Flying gauginos: LHC corners

- 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





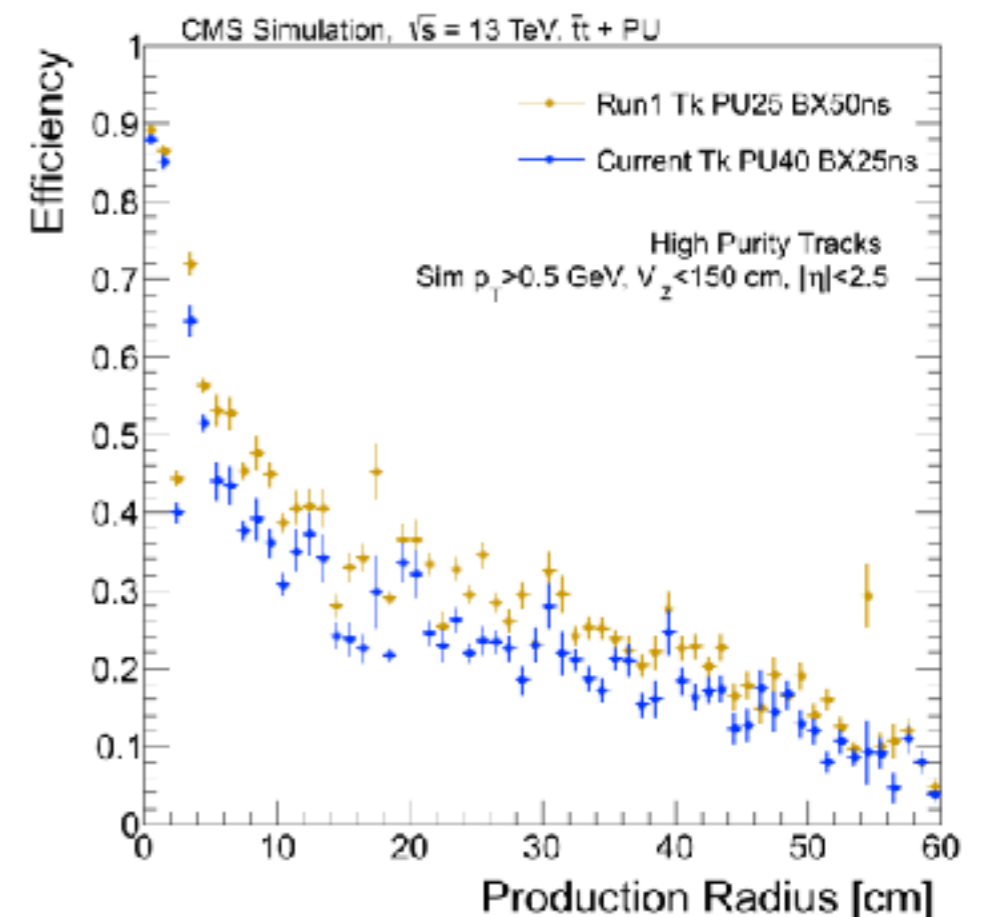
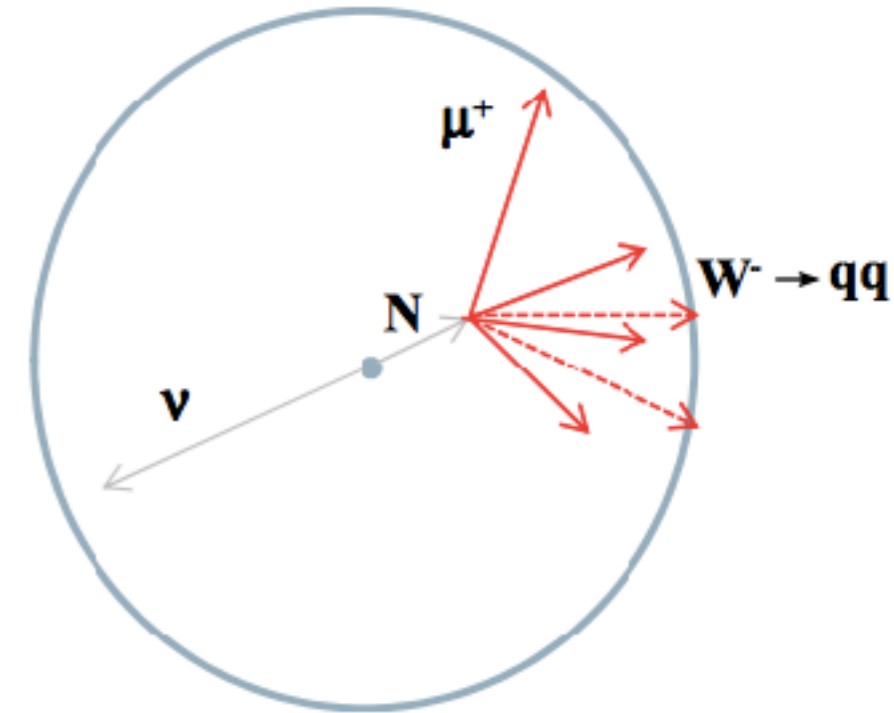


# Flying gauginos: FCCee reach

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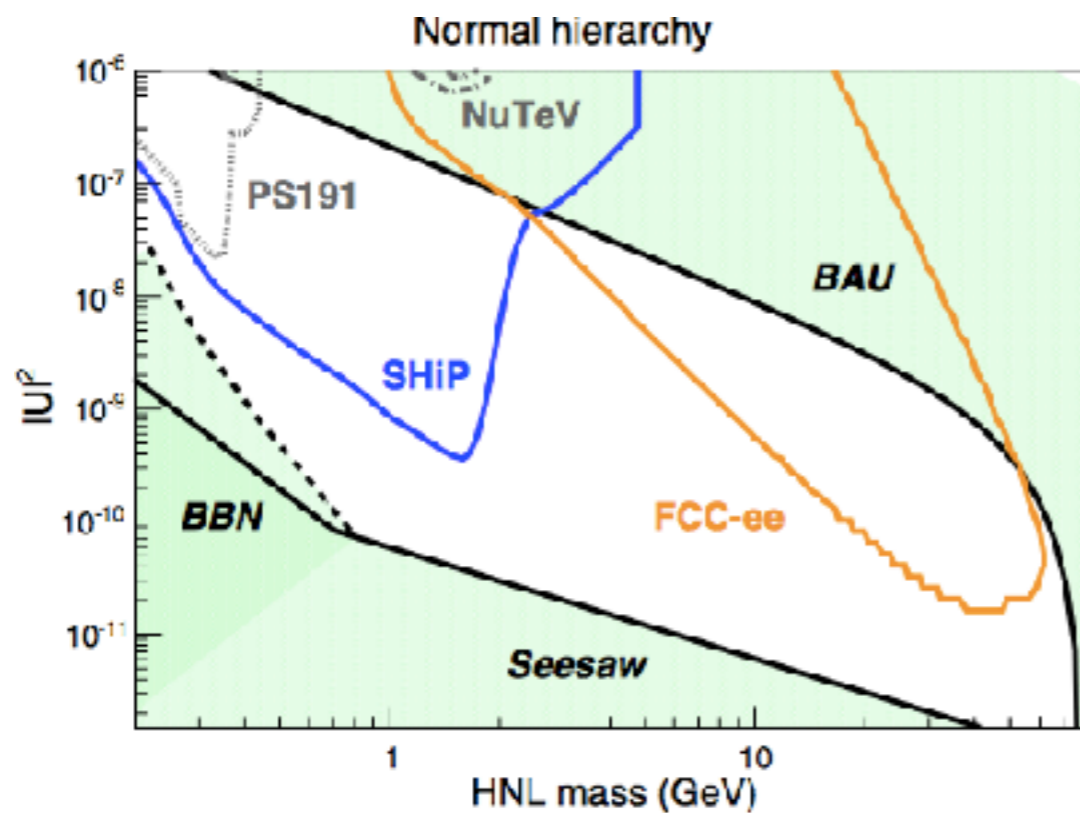
# Displaced Vertices

- Displaced-vtx signatures emerge in many BSM scenarios
  - SUSY compressed spectra
  - right-handed neutrinos, as in  $\nu$ MSSM
  - 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

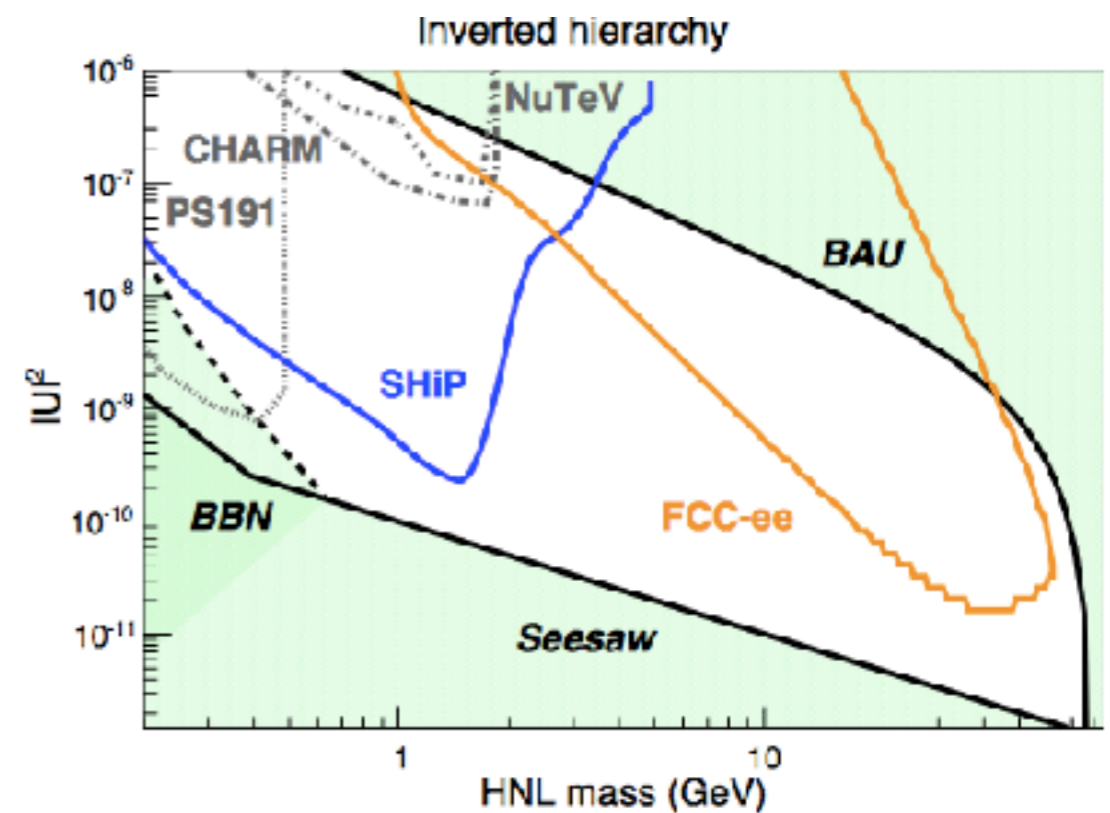


# Displaced Vertices

- Preliminary studies show good potential
- Confirmation needed, based on accurate detector simulation
- Complementarity with other CERN projects



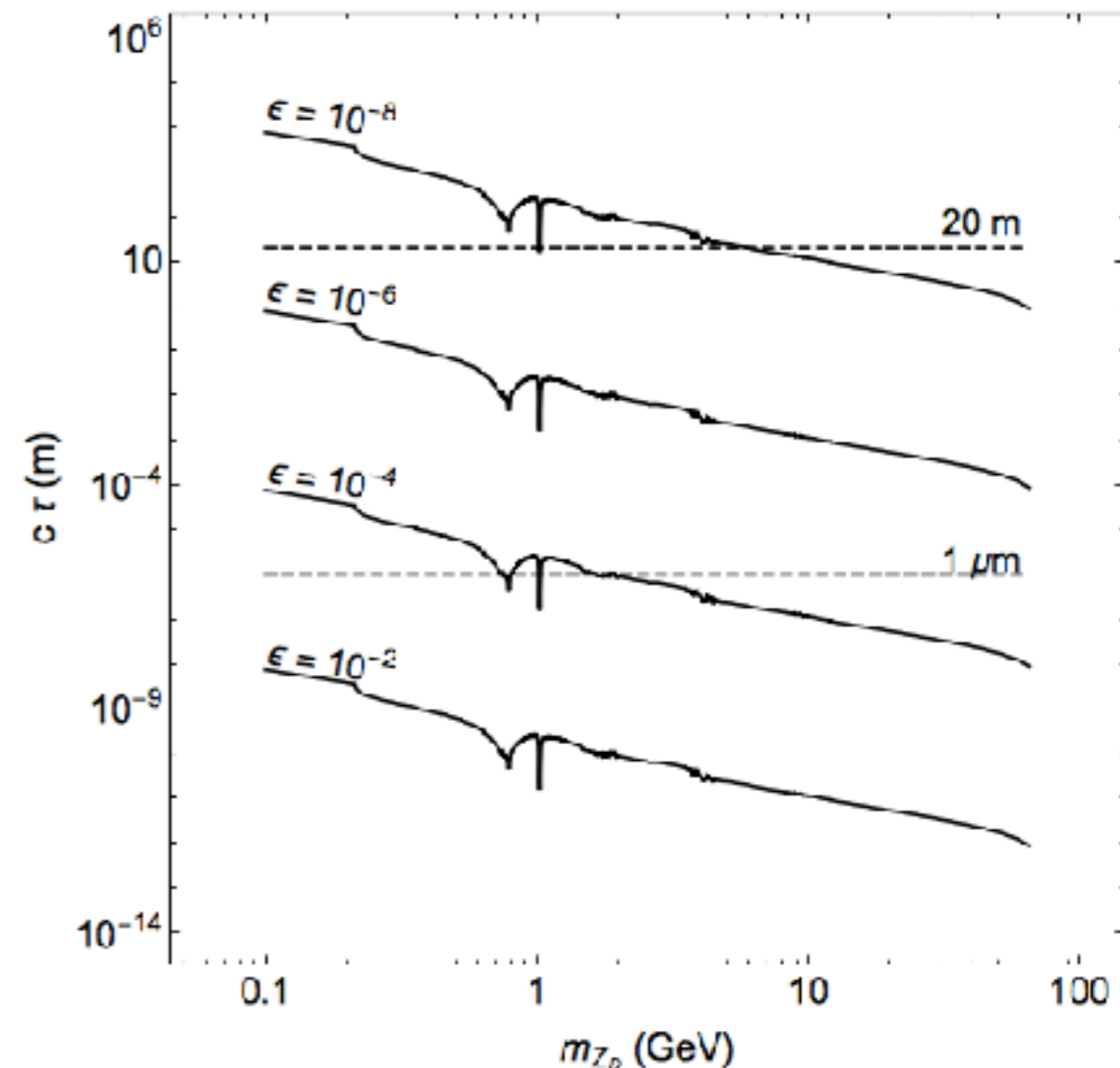
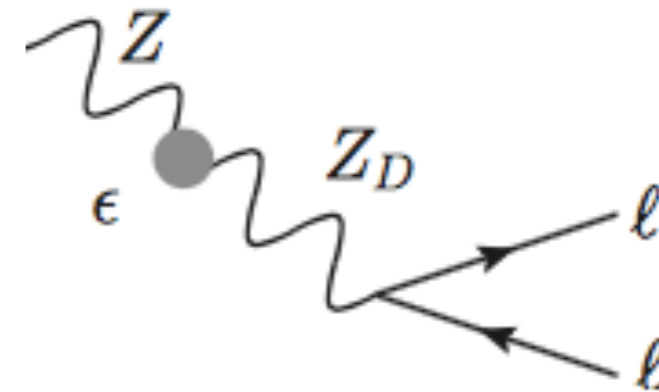
(a) Decay length 10-100 cm,  $10^{12} Z^0$



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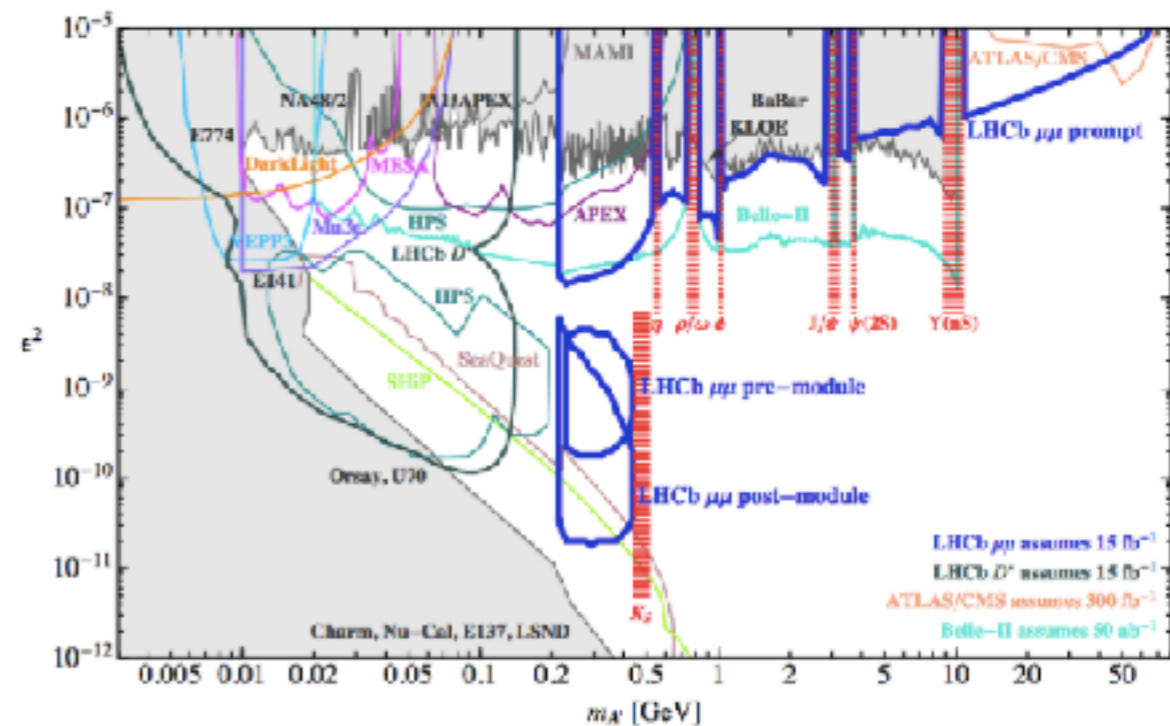
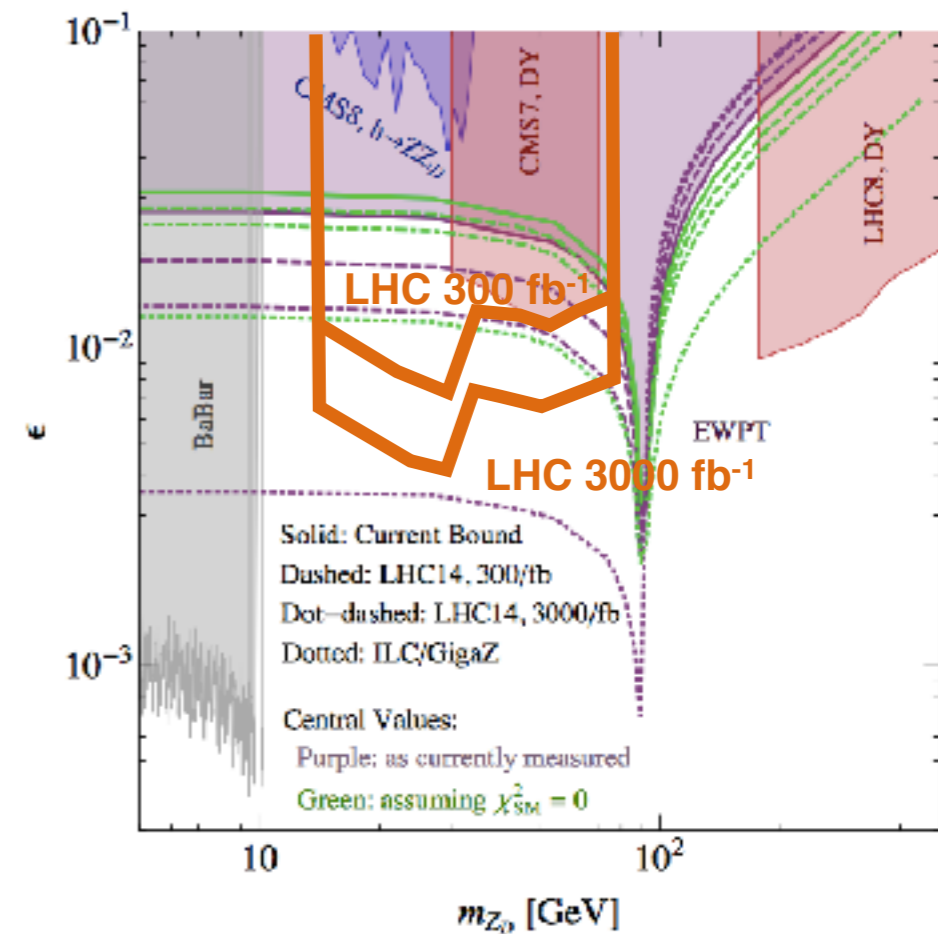
# Dark Sector

- 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



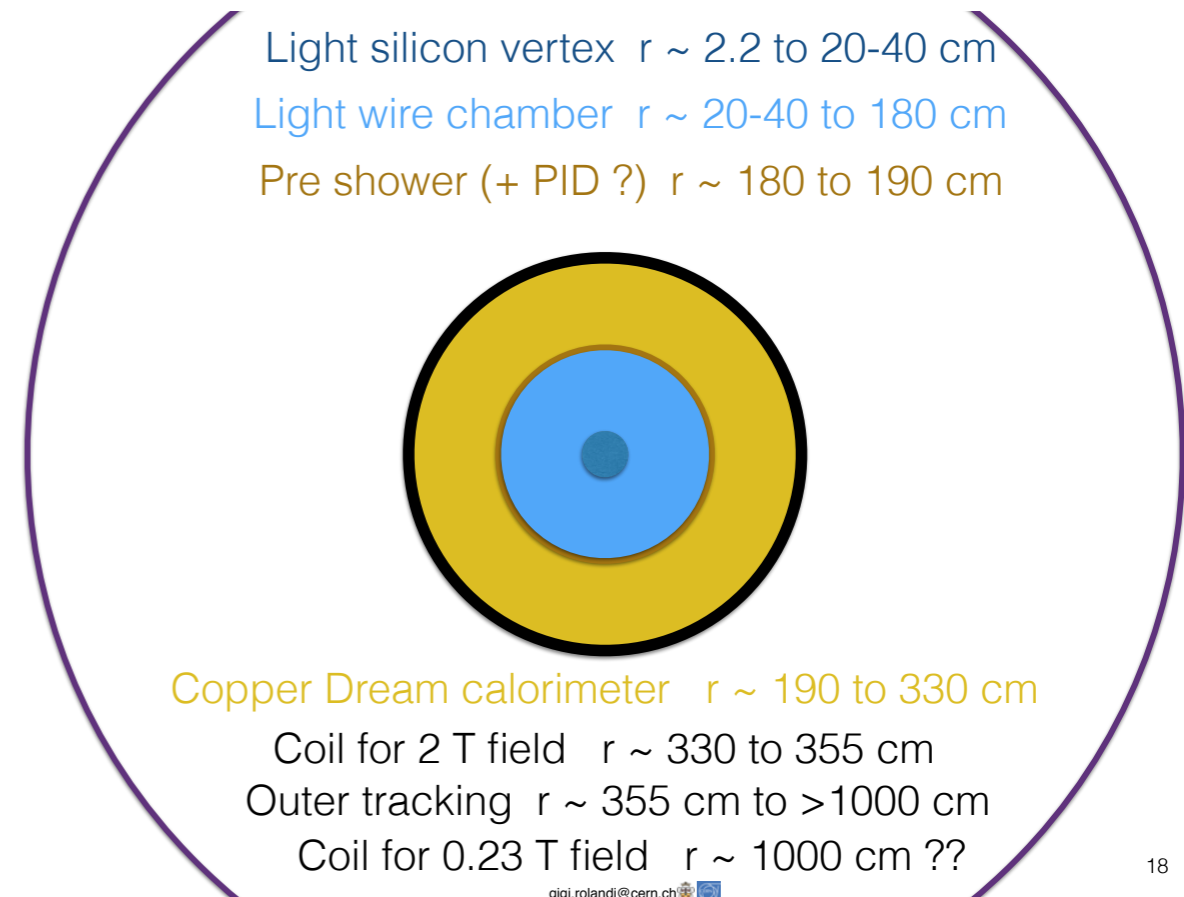
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  - Sensitivity from EWP observables @Z pole
  - Need to study sensitivity to small masses (prompt or displaced)



# Implications on Detector Geometry

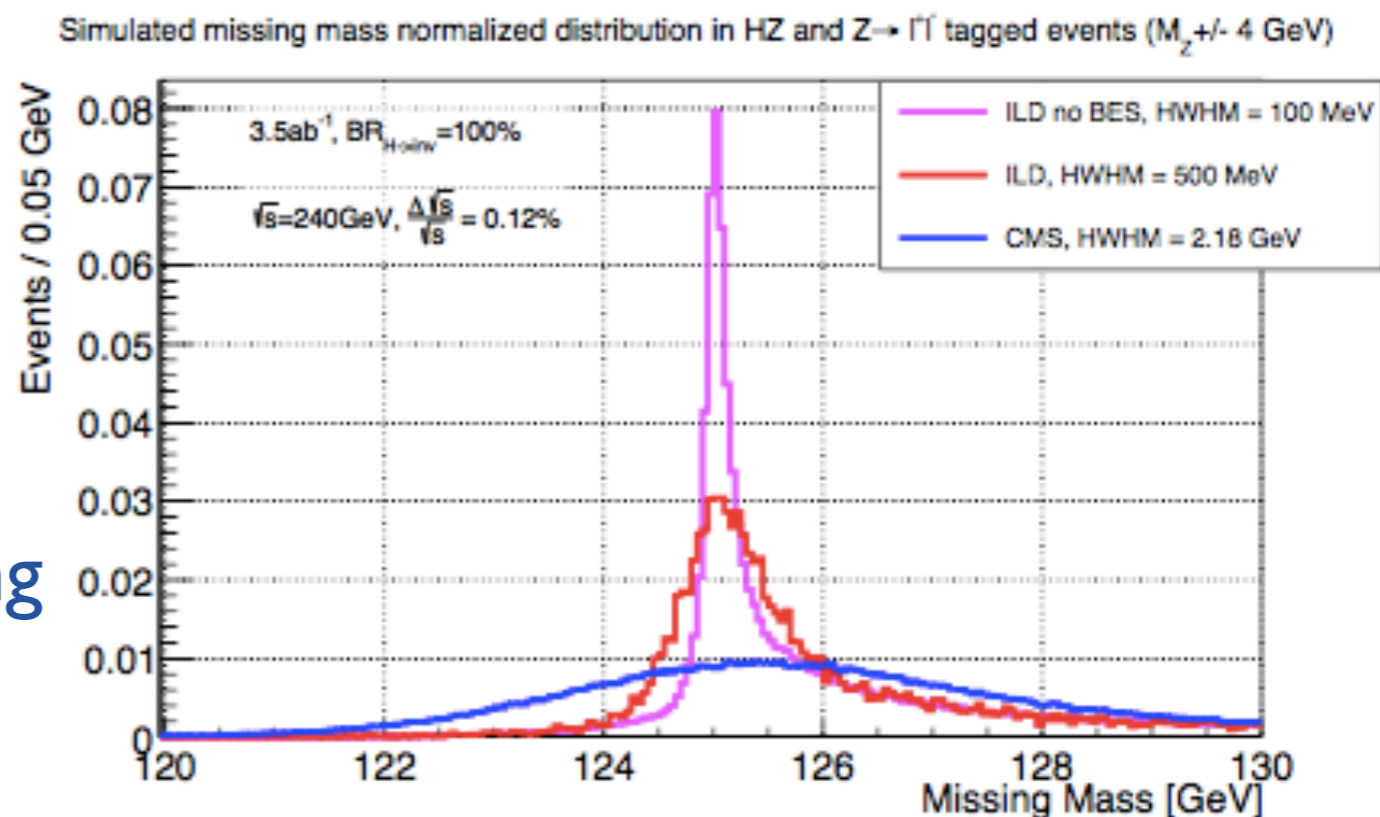
- Much of the BSM program at reach with a detector optimized for EW/Higgs/Flavor physics (b- and c-tagging, good resolution on missing mass, etc)
- But some exotic signature comes with special requirements
  - PID in the inner tracker (through  $dE/dx$ )
  - Good track resolution at large displacements
  - Large tracking volume (to probe large values of  $c\tau$ )





# 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





# 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 with good precision
- Only a few examples presented here. Much more work ahead
  - Need accurate simulation software for many of these signatures
  - Need to attract more people to explore the vast BSM landscape in a systematic way