Long-Lived Particle Search with Lepton Colliders

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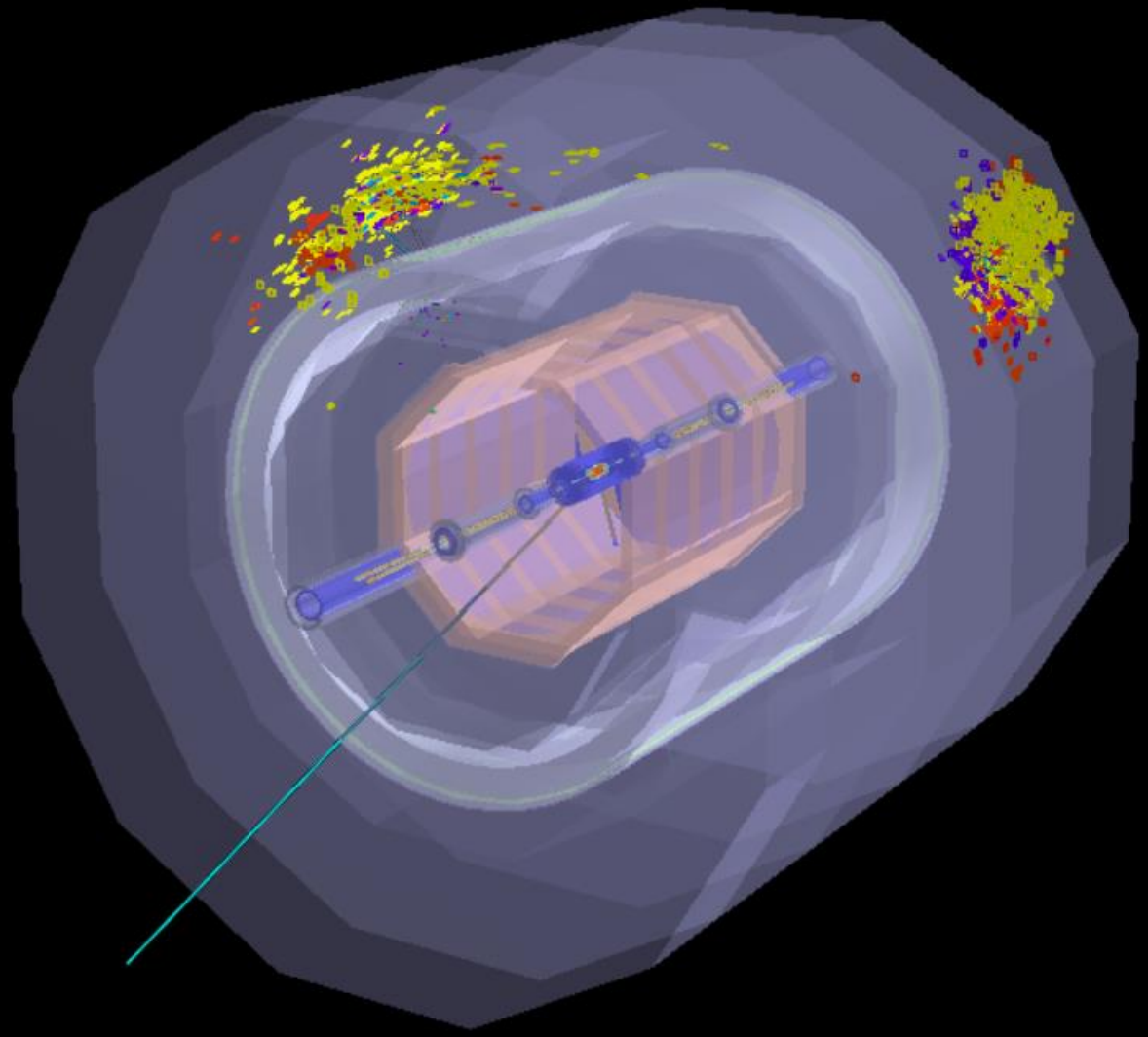
$$e^+e^- \to Zh \to \nu\bar{\nu} + SS1 + SS2 \to \nu\bar{\nu}q\bar{q}q\bar{q}$$



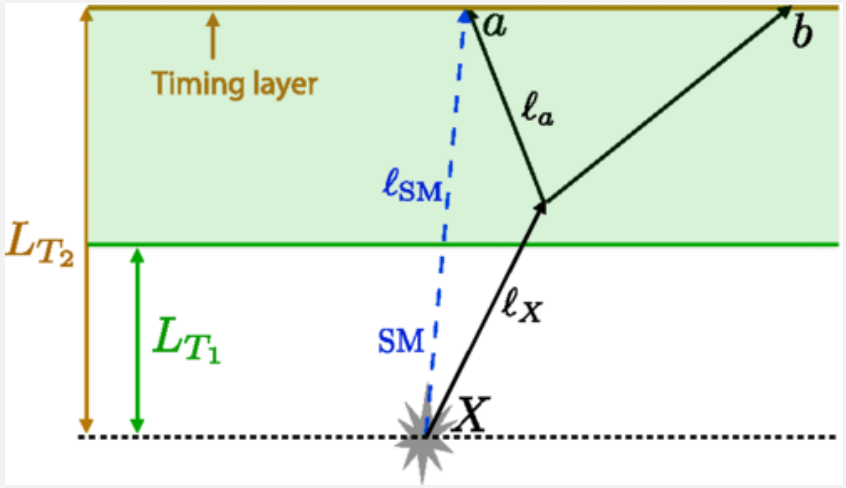
What is a long-lived particle?

Particle lifetimes span a very wide range and long lifetimes can generically appear in the BSM theories.

*Object (neutral or charged) decaying a **macroscopic** and **reconstructible** distance from IP*

Signal signature of a long-lived particle:

Neutral LLP decays are a spectacular signature, and the burst of energy appearing out of nowhere sets it apart from the collision point.



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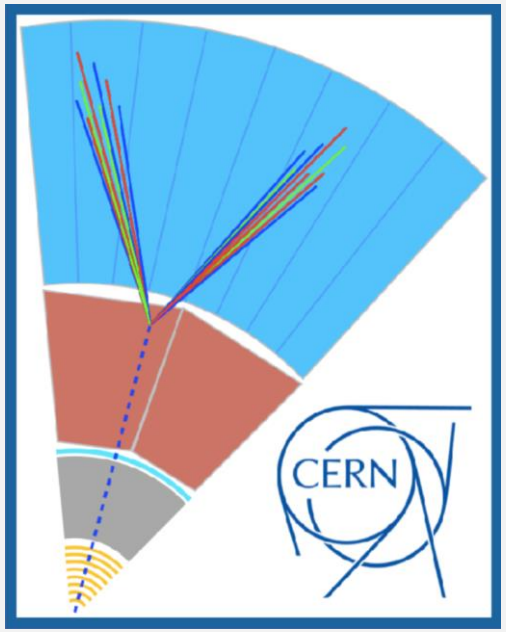
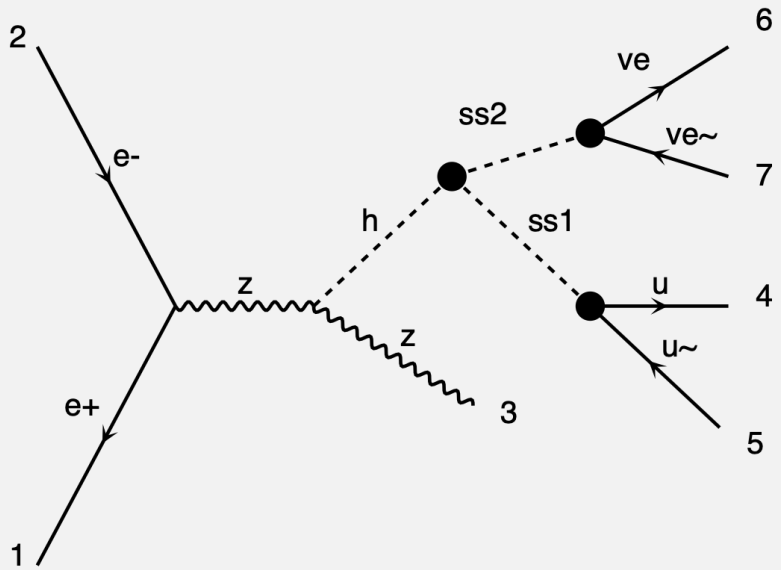
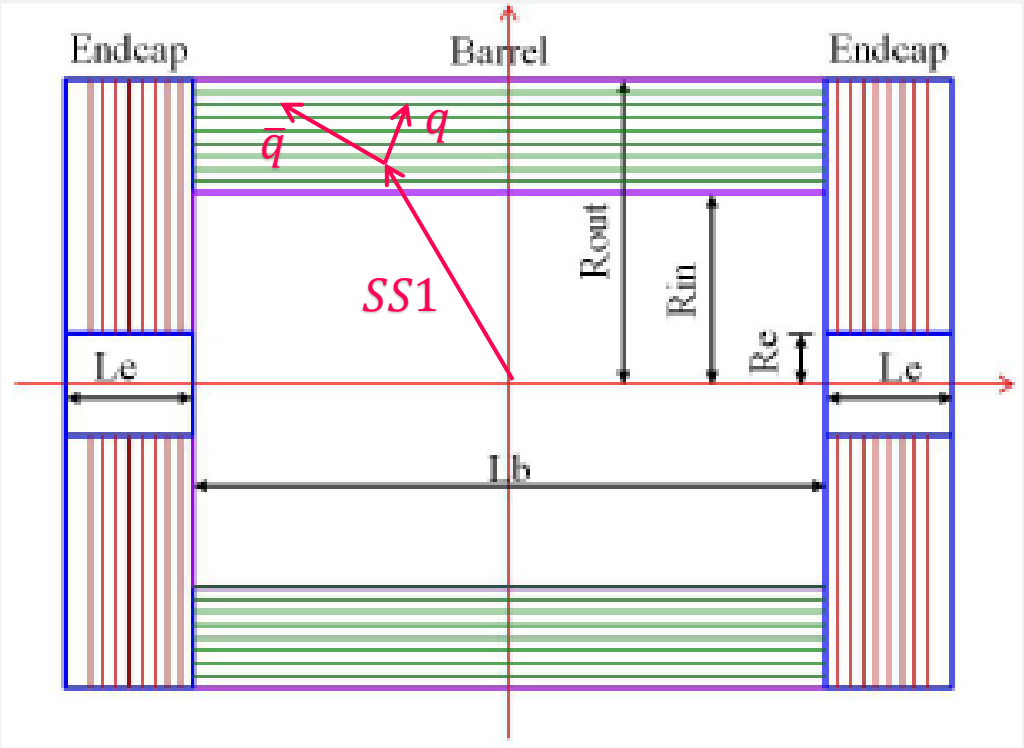


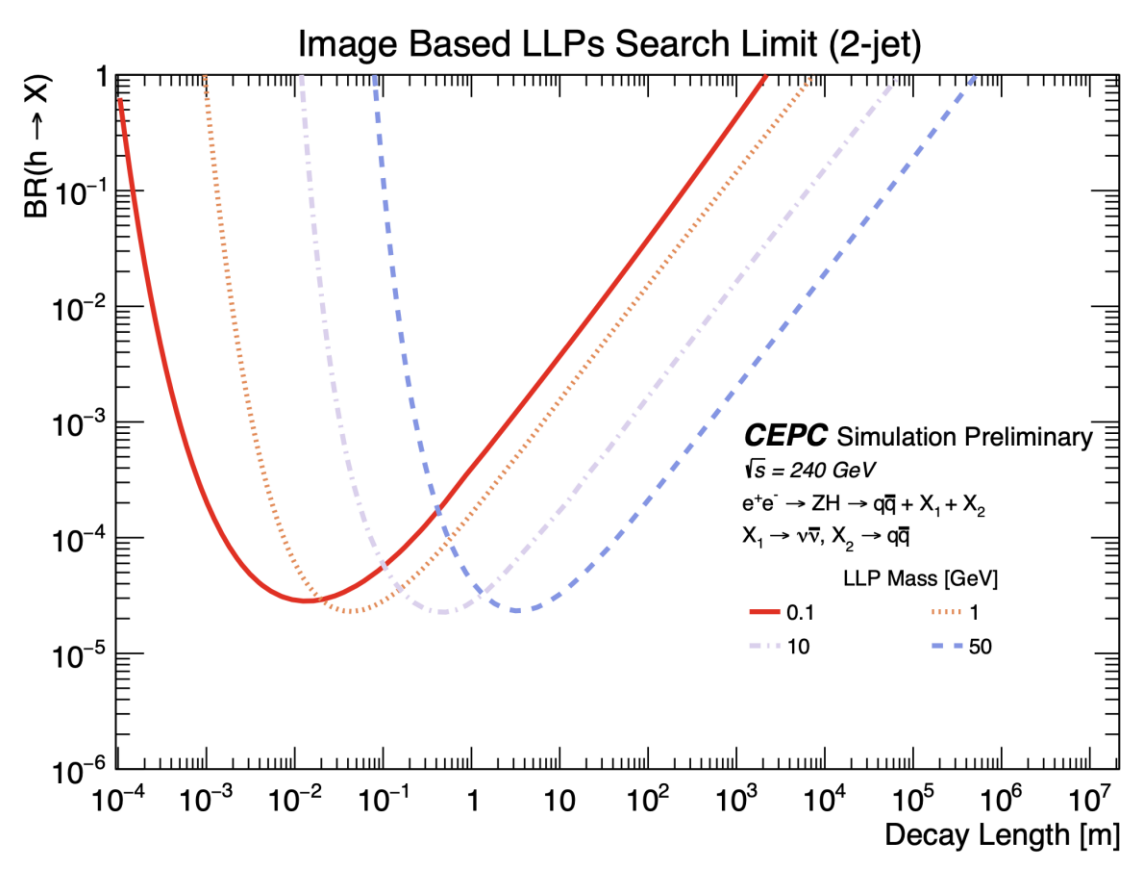
LLP Searches at Lepton Colliders



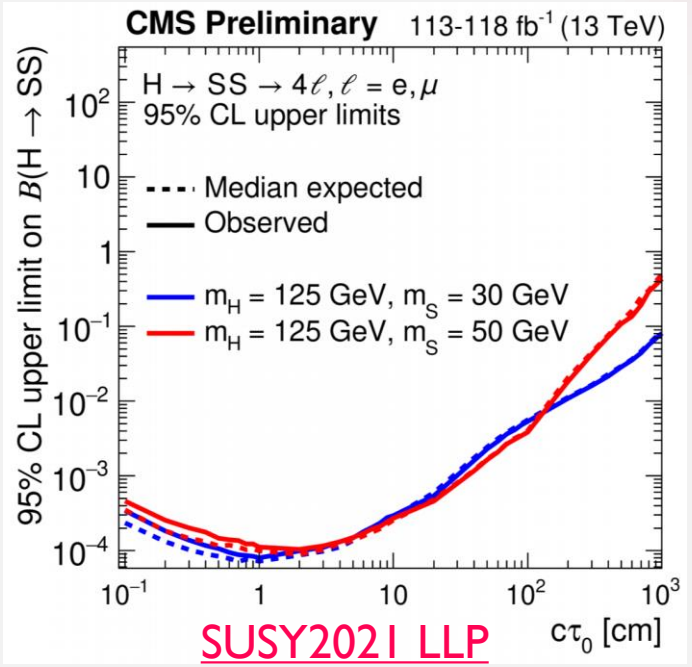


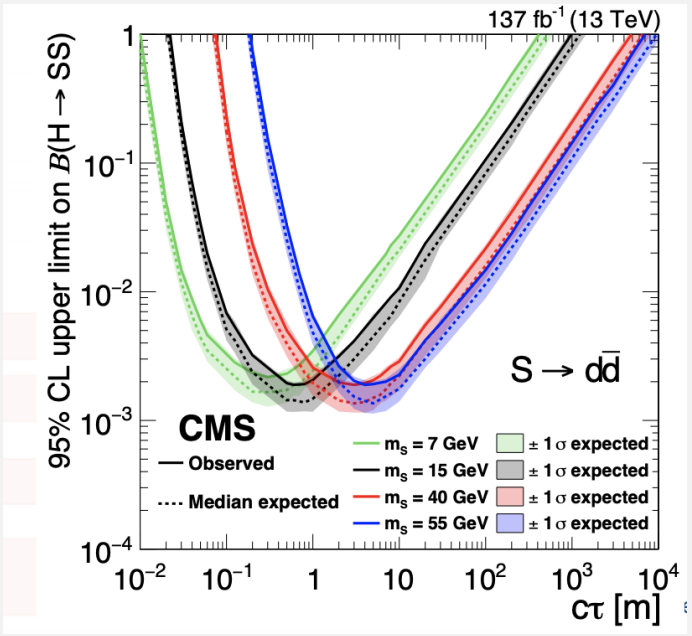
- Energy: 240 GeV
- Mass of SS1: 0.1-50 GeV
- Mass of SS2: 0.1-50 GeV
- SS1, SS2's lifetime $\tau = R_{\text{out}}/c \ = 6m/c = 20\ ns$

Sensitivity (Inner detector)

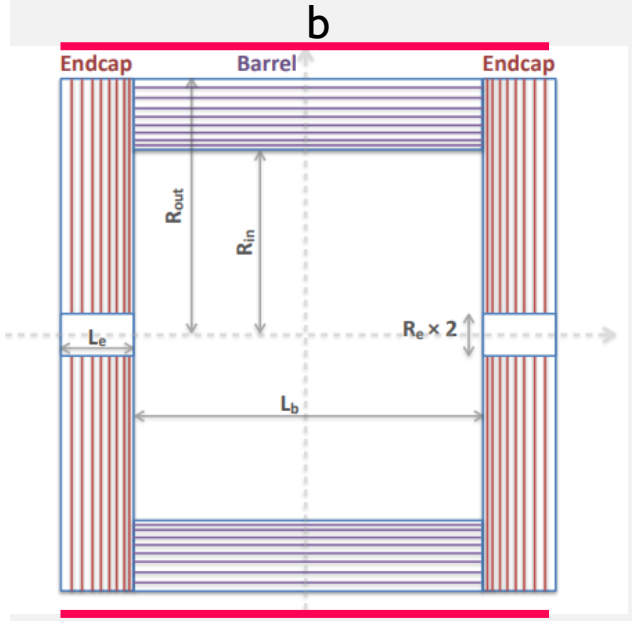


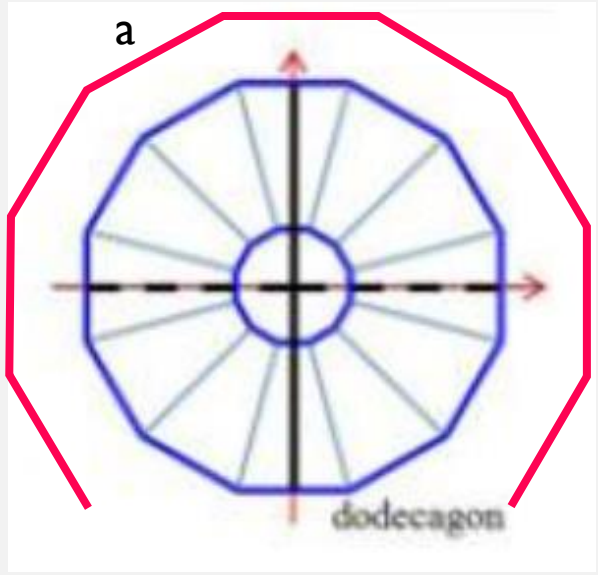
- Best branching ratio exclusion limit at decay length around a few meters: $BR(h \rightarrow XX) > \sim 10^{-5}$ for most LLP masses
- Good sensitivity for low LLP mass (as low as 0.1 GeV)

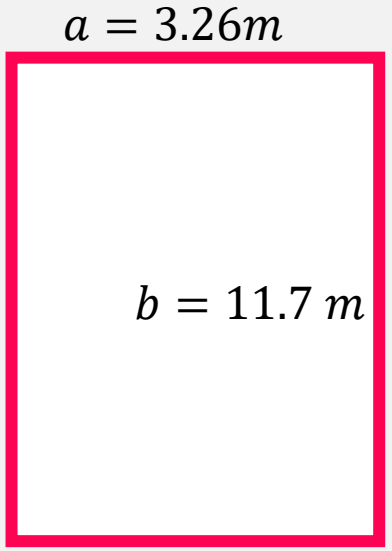


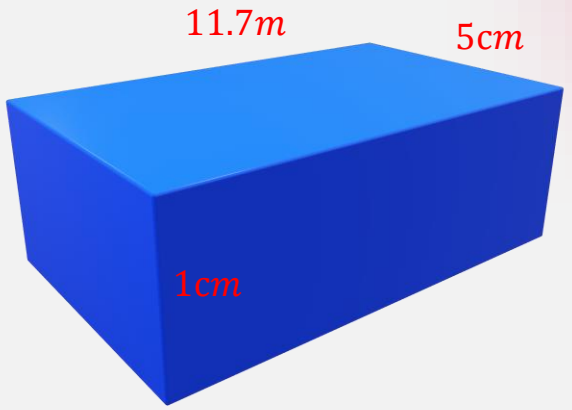


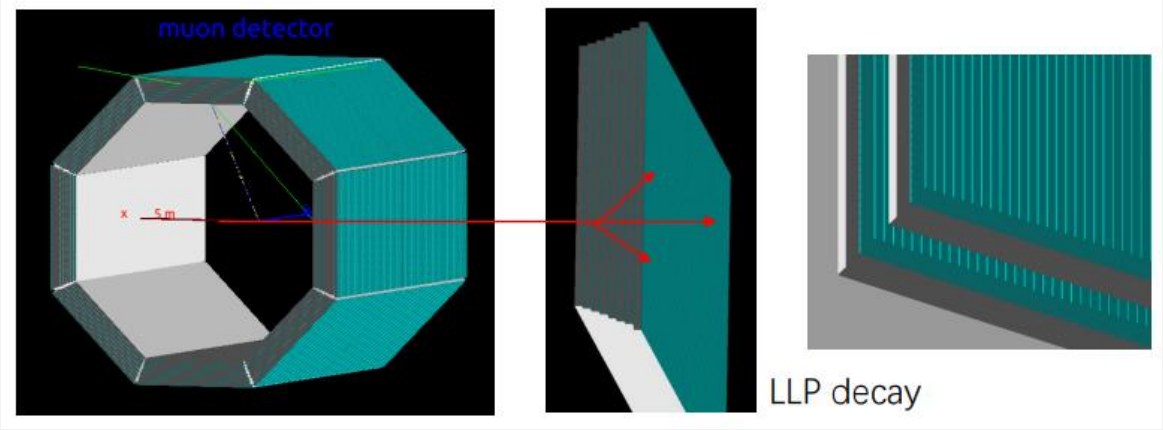
Outer Detector Design





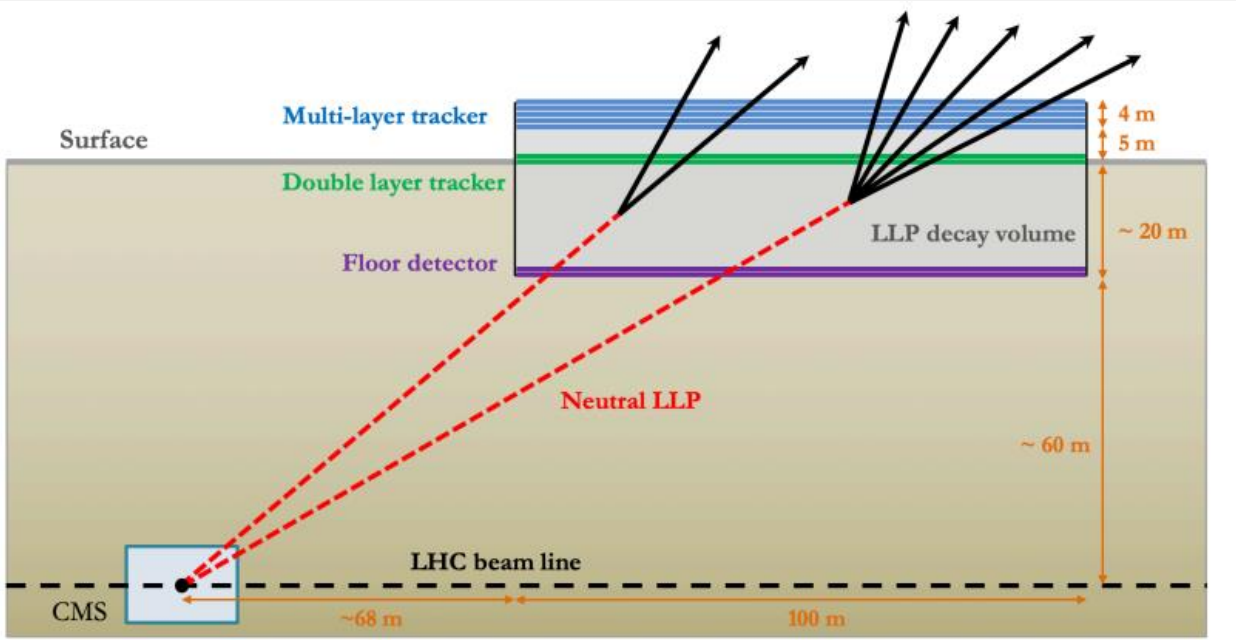


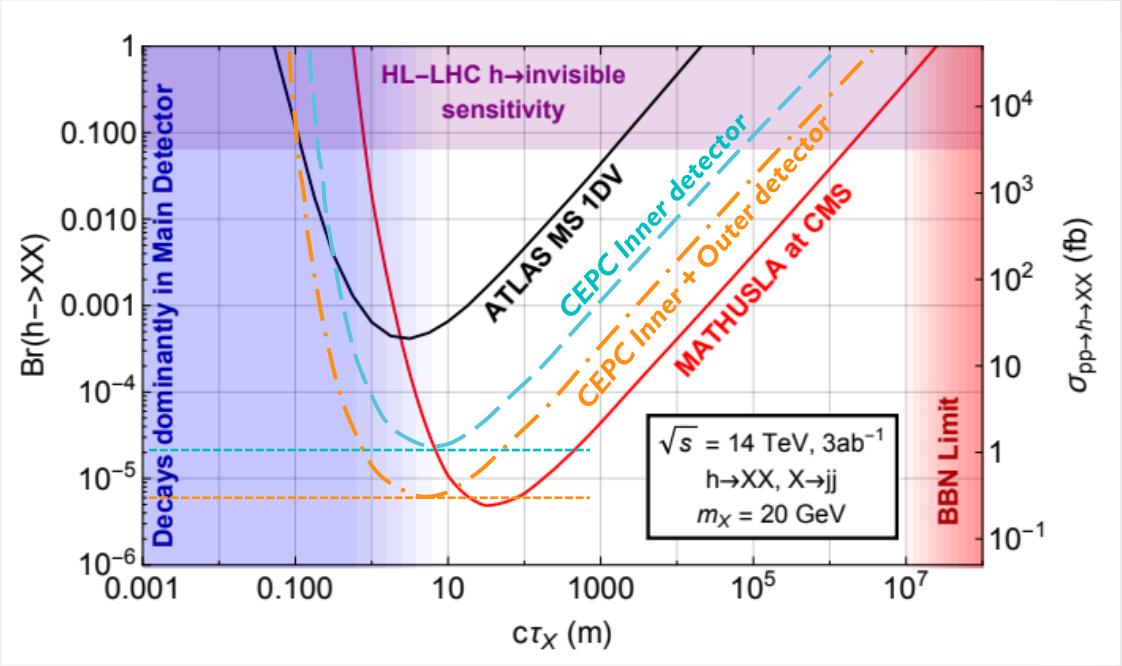




- Outside muon detector to track LLPs
- Same detector structure in Xiaolong's report
  - scintillator strip + WLS fiber +SiPM
- 8 layers scintillator with good timing
- geometry acceptance $\epsilon_{\text{geo}} \approx 0.65$
- 65 strips per cell, 4680 strips in total

Comparison with MATHUSLA





LLP @ MATHUSLA based on **HL-LHC**: $> 1 \times 10^8$ Higgs bosons

Summary

- Long-Lived Particle ($h \to q\bar{q}\nu\bar{\nu}$) study done with future lepton collider
  - current results based on CEPC_v4 geometry setup
- First attempt to apply AI image recognition techniques to raw detector hits
  - Very good sensitivity reached ($\sim 10^{-5}$) with (expected) 10^6 Higgs statistics compared to current LHC limits ($\sim 10^{-4}$).
- Exploring the possibility of external detector outside muon detector.
  - Comparable sensitivity as MATHUSLA@HL-LHC.

Thanks

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