Long-lived scalars from Exotic Higgs decays at FCC-ee

EFCA focus topic: LLPs - Roundtable

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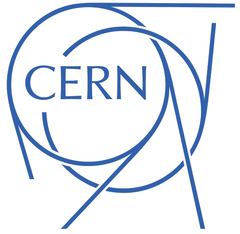

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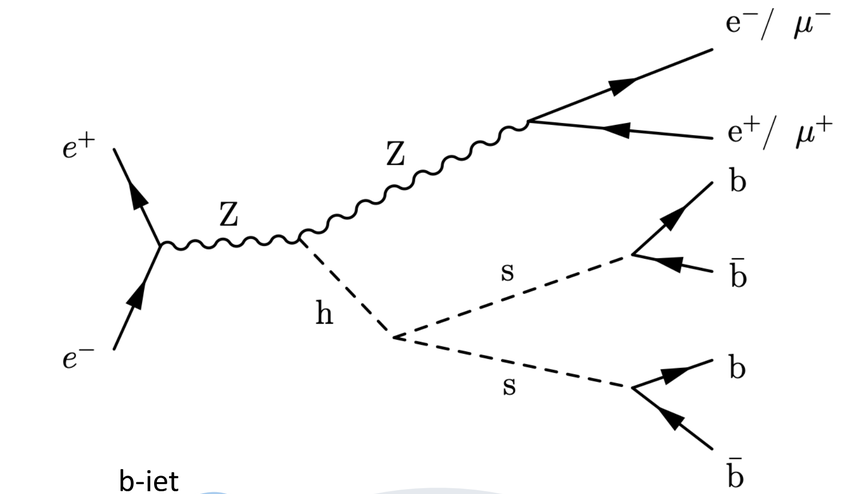
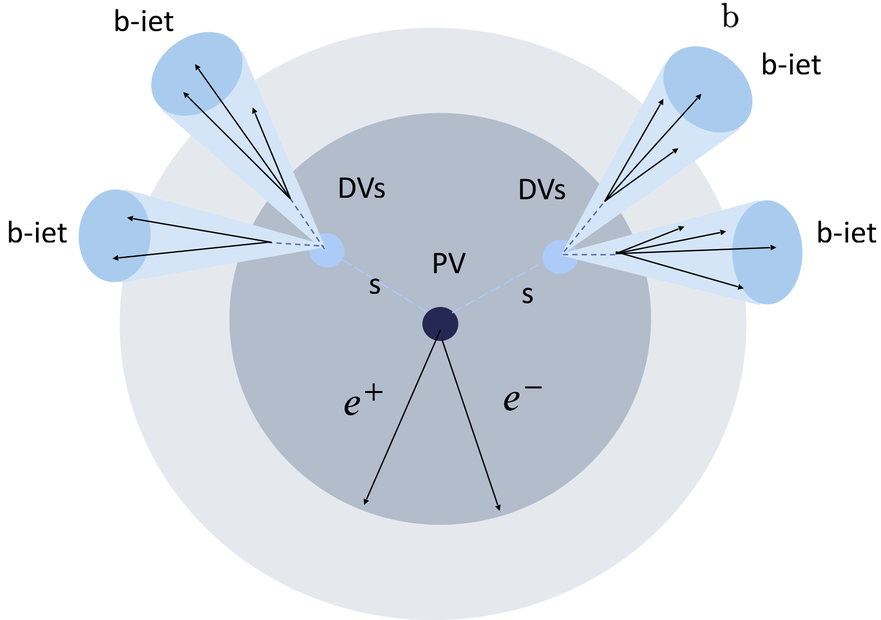
Overview of our studies

$$\mathcal{L}_{SM} \ni \underbrace{\frac{1}{2}\mu_S^2 S^2 - \frac{1}{4!}\lambda_s S^4}_{\text{scalar potential}} - \underbrace{\frac{1}{2}\kappa S^2 |H|^2}_{\text{portal term}} + \underbrace{\mu^2 |H|^2 - \lambda |H|^4}_{\text{Higgs potential}}$$

- We are studying the FCC-ee sensitivity towards **long-lived scalars** from exotic Higgs decays
  - SM+S extension using the Hidden Abelian Higgs Model arXiv:1312.4992, arXiv:1412.0018
  - Long-lived scalars for sufficiently small mixing between the Higgs and the scalar
- Targeting the **FCC-ee Zh** stage and the signal process:

  $e^+e^- \rightarrow Z\,h$ with $Z \rightarrow e^+e^-$ or $\mu^+\mu^-$ and $h \rightarrow ss \rightarrow b\bar{b}b\bar{b}$
- Experimental signature:
  - A **displaced vertex (DV)** from the long-lived scalar decay
  - A reconstructed **Z boson from ee or μμ**
- The topic for Magdalena's master thesis at Uppsala Diva entry
- Study summarised in an FCC note CDS entry (restricted)
- We are currently working on turning the note into a paper
- More in Magdalena's talk at the ECFA WG1-SCRH topical meeting





Status of our studies

- Signal is simulated with the MadGraph5 HAHM model
- MadGraph v3.4.1 + Pythia8 + Delphes, with the spring2021 IDEA Delphes card
- DV reconstruction using current tools in the FCCAnalyses framework with extra constraints and functions
  - LCFI+ algorithm for secondary vertexing arXiv:1506.08371
- Generator-level studies show sensitivity to the signal points with ms=20GeV and sin θ = 1e-5, 1e-6 → cτ ≈ 3 mm and 30 cm
  ms=60GeV and sin θ = 1e-6, 1e-7 → cτ ≈ 9 cm and 9 m
- Event selection: 1 Z-boson + at least 2 DVs:

Vertex Selection	Min r_{DV-PV}	4 mm
	Max r_{DV-PV}	2000 mm
	Min $M_{charged}$	1 GeV

- Currently working on a refined background study with the FCCee Winter2023 campaign samples
- Many ideas for future studies on the scalars, e.g to add neutral energy in the calorimeter pointing to each of the DVs to improve DV mass