

LLPs from Exotic Higgs Decays at FCC-ee

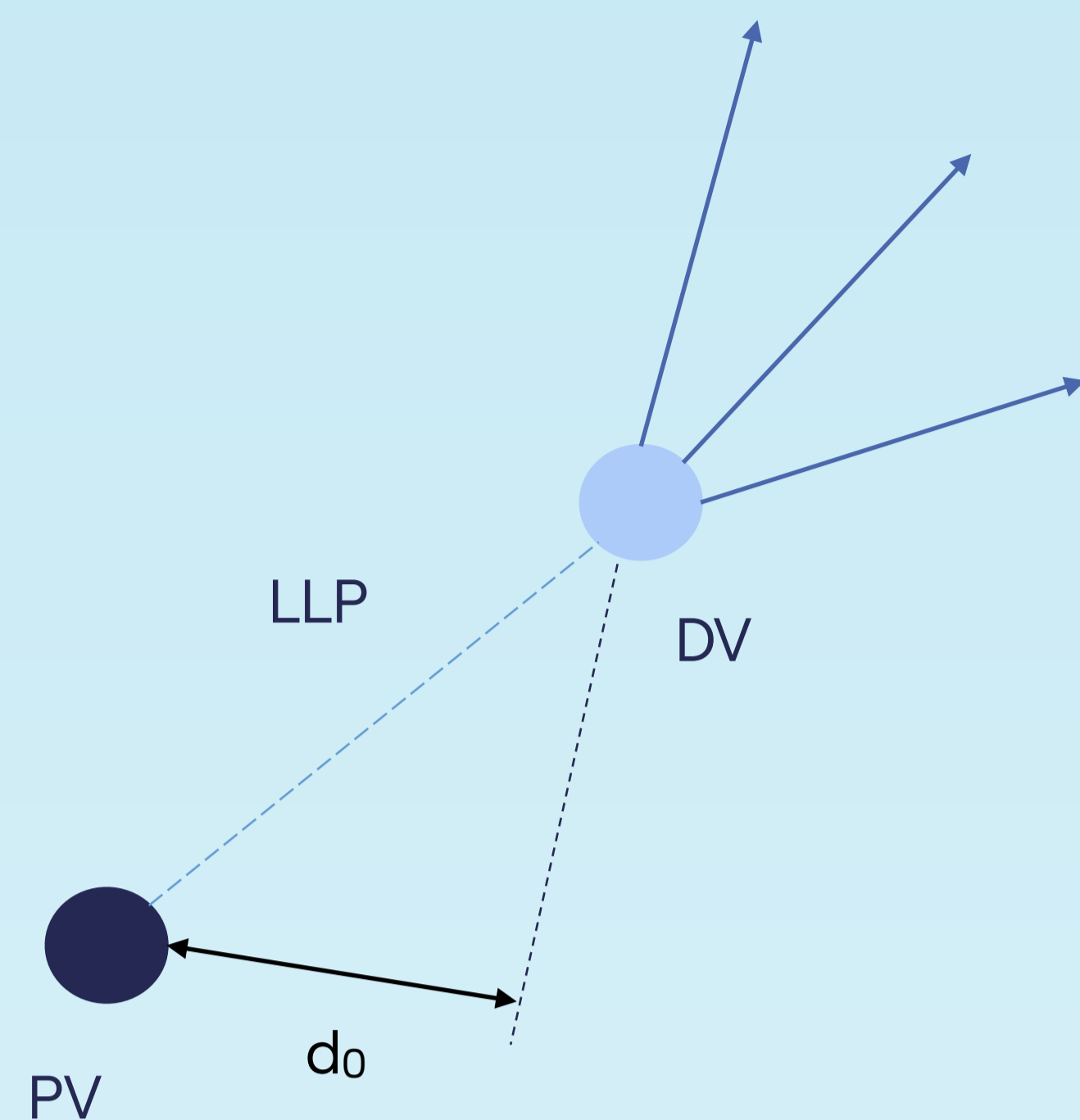
A sensitivity study regarding Long-Lived Particles at the Future Circular Collider

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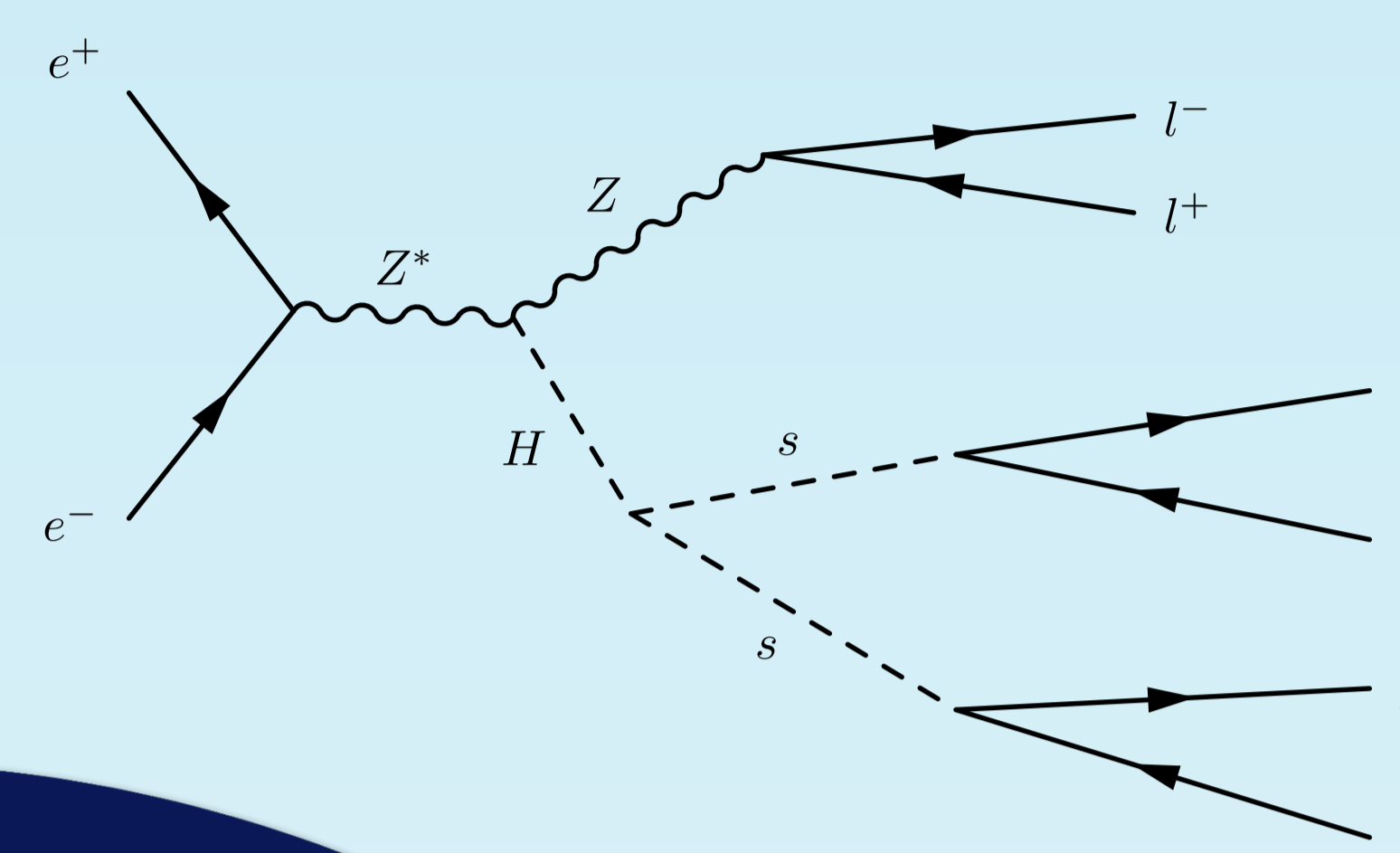
Long-Lived Particles

- Long-Lived Particles (LLPs) are featured in many BSM models
- Distinct experimental signatures
- Small background from SM processes
- Technically challenging
- LHC detectors not designed for LLPs
- Could have evaded detection so far
- Room for improvement at future colliders



New Physics Model

- Extended SM with scalar sector → new scalar "s" could be a portal to the dark sector [1,2]
- New scalars very feebly coupled to SM Higgs, via $\sin\theta$
- Higgs boson decaying into two long-lived new scalars that further decay to b -quarks
- Higgs boson produced at ZH stage (240 GeV) of FCC-ee



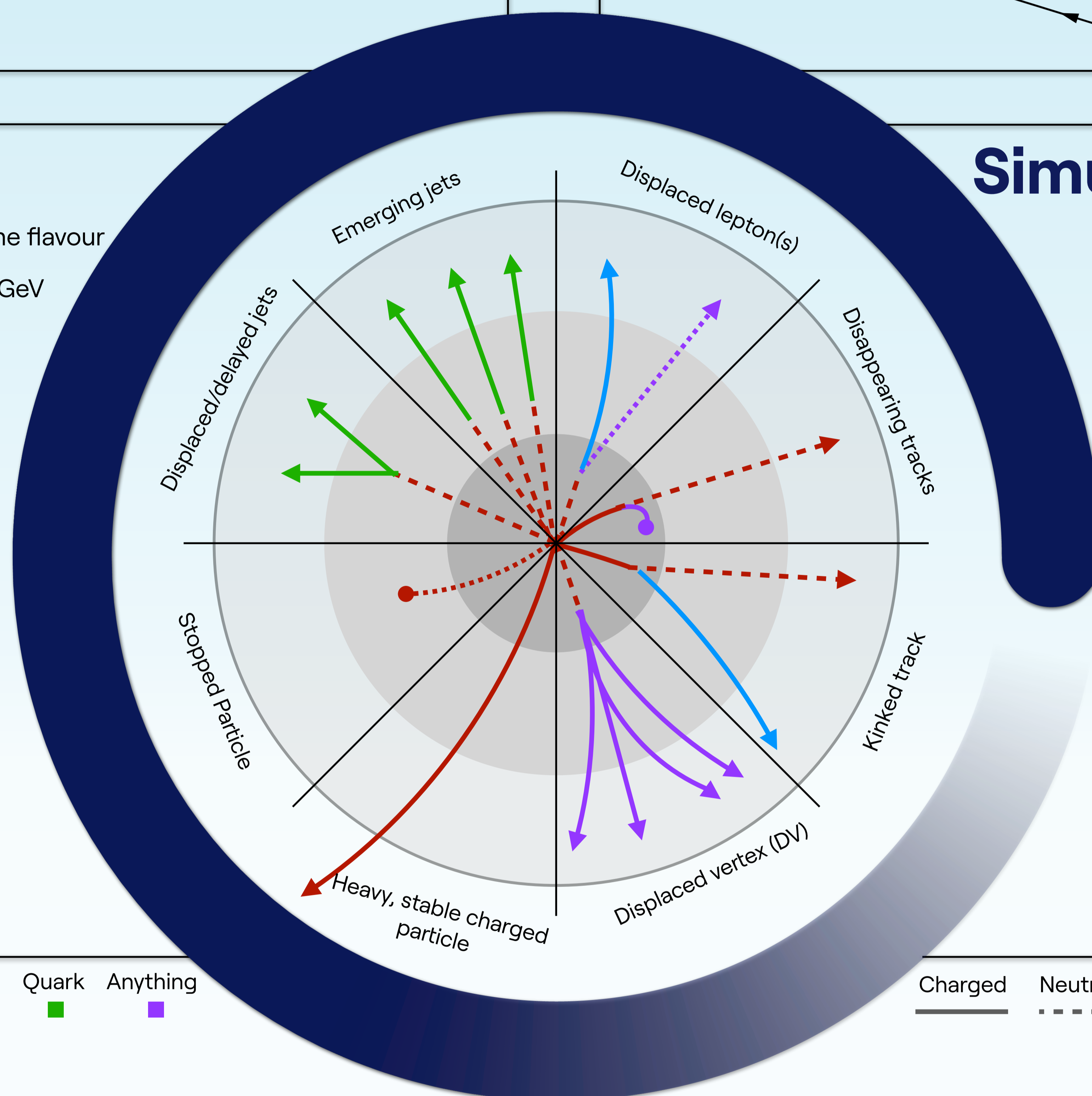
- Signal Signature:
 - 2 isolated leptons (e, μ)
 - 2 displaced vertices (DVs) from the scalar decay
- Sources of backgrounds considered:
 - ZH, $H \rightarrow SM$
 - ZZ
 - WW

Event Selection

- Exactly 2 leptons (e or μ), opposite-sign, same flavour
- m_{ll} compatible with a Z decay: $70 < m_{ll} < 110$ GeV
- At least 2 reconstructed DVs:
 - Inside the tracker volume but outside of the innermost region: $4 \text{ mm} < r_{DV-PV} < 2000 \text{ mm}$
 - With invariant mass > 1 GeV
- To reconstruct DVs we use:
 - At least 3 non-primary tracks
 - $p_T > 1$ GeV
 - $|d_0| > 2$ mm
 - $r_{DV-PV} > 50$ mm
- LCFI+ algorithm [5]

Simulation & Software

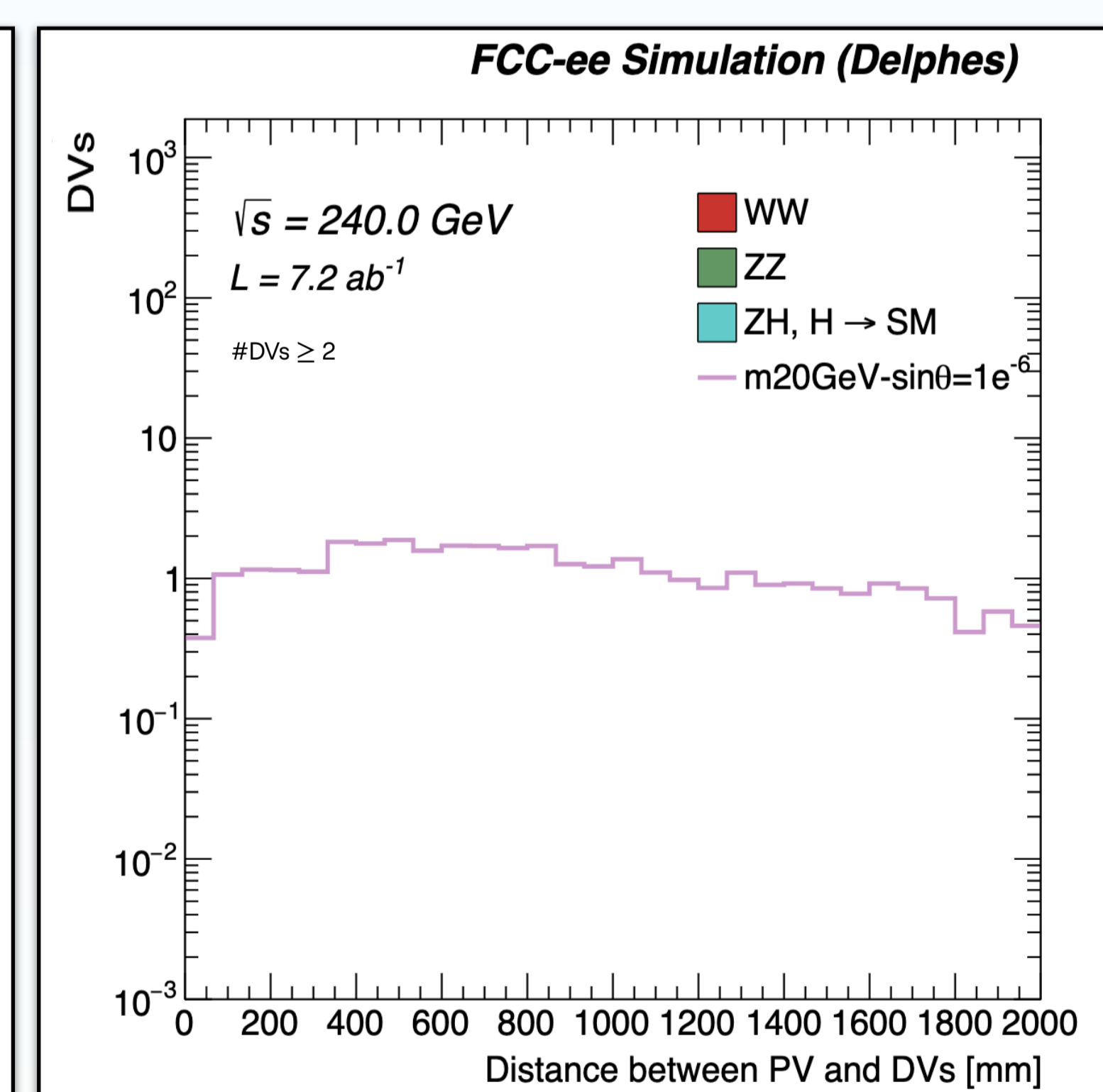
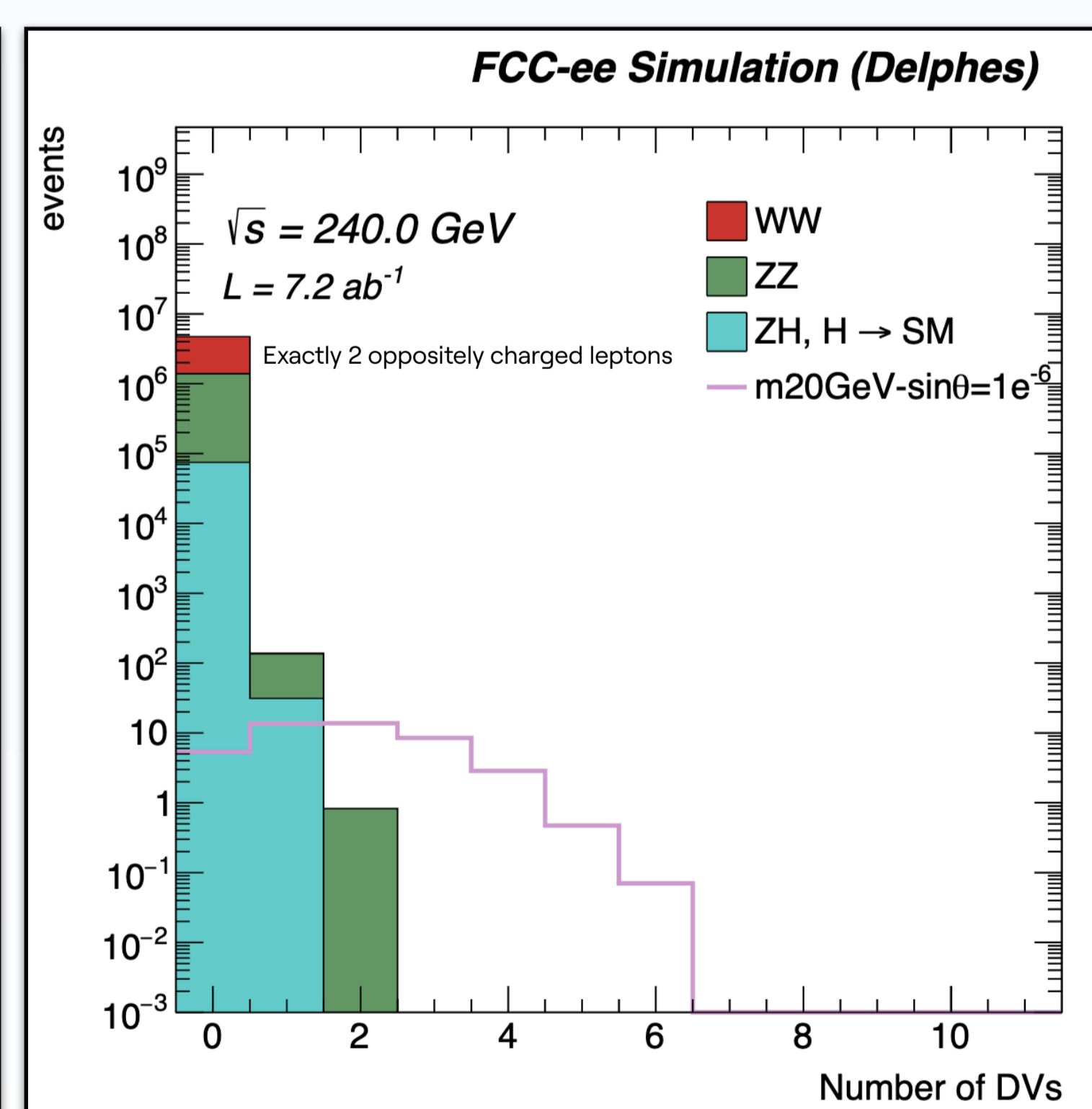
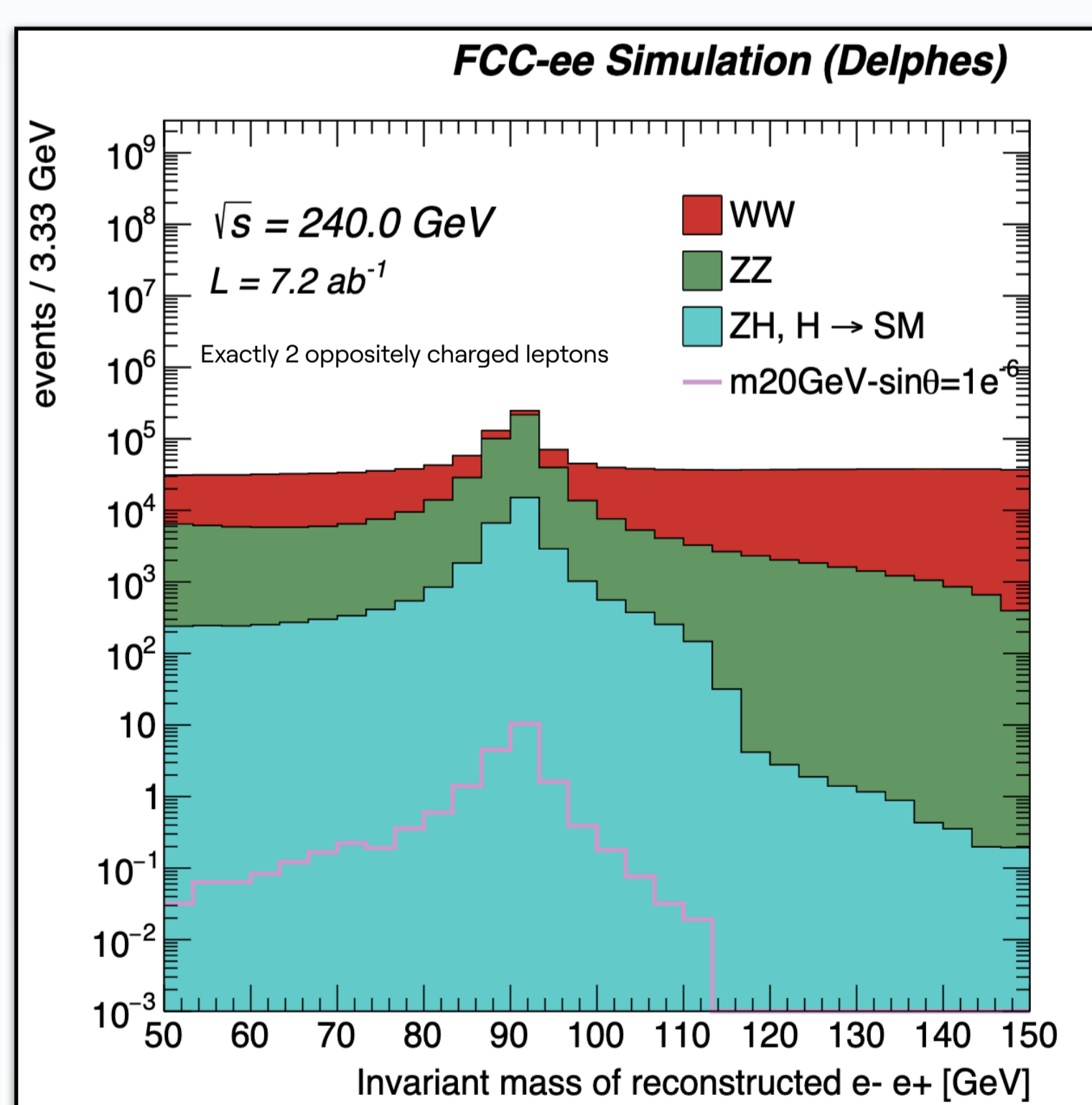
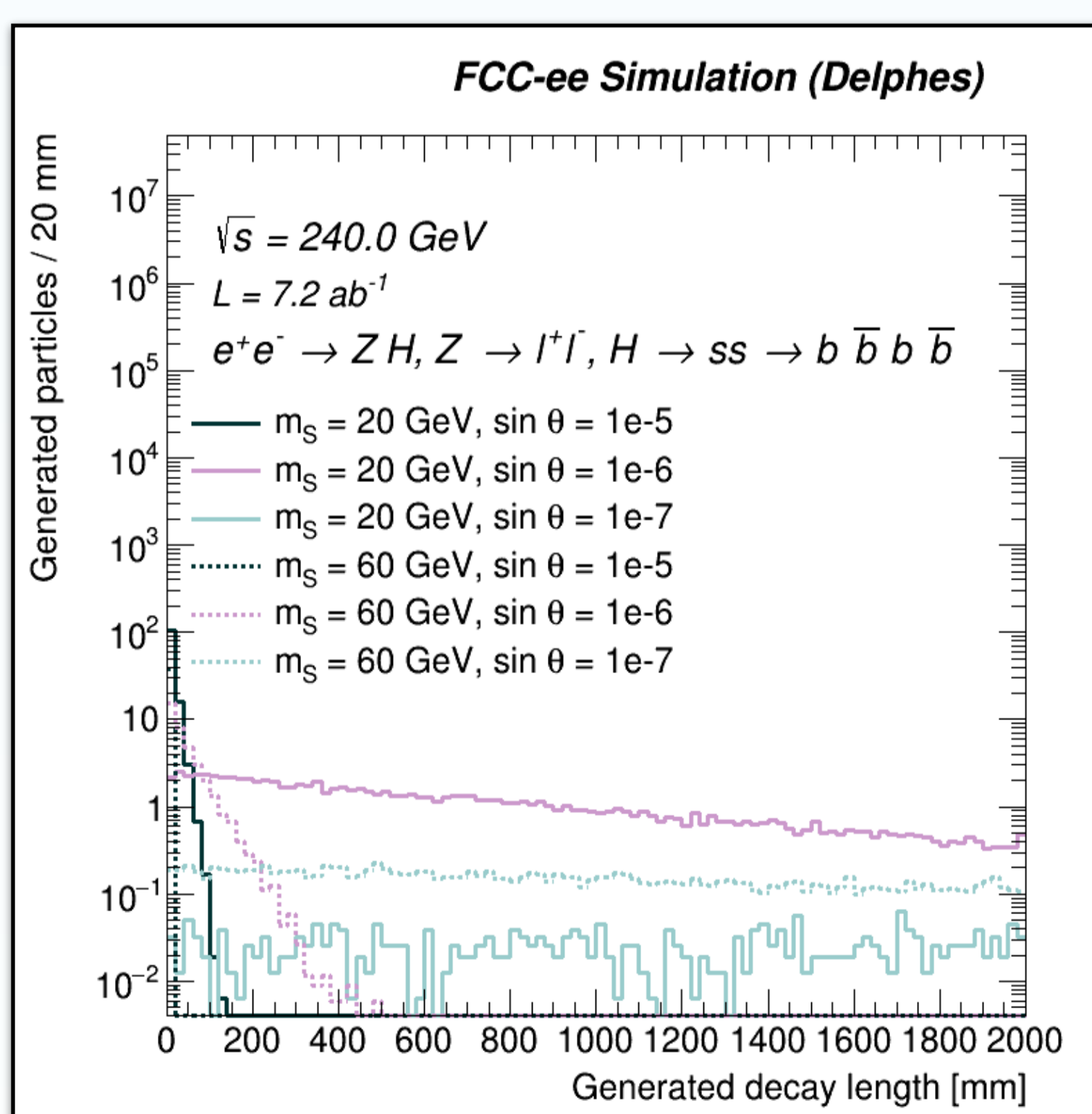
- Signal:
 - MadGraph v3.4.1 + PYTHIA8 + DELPHES tag 3.5.1.pre05 IDEA card [3]
 - 6 different signals generated: $m = [20,60]$ GeV & $\sin\theta = [1e^{-5}, 1e^{-6}, 1e^{-7}]$
- Background:
 - Centrally produced: **winter2023** samples
 - ZH, $H \rightarrow SM$: WHIZARD + PYTHIA6
 - WW: PYTHIA8
- Analysis performed using FCCAnalyses v0.9.0 framework [4]



BSM Lepton Quark Anything

Charged Neutral Either

Results



Process	Before selection	Exactly 2 oppositely charged leptons	$70 < m_{ll} < 110$ GeV	#DV $s \geq 2$
ZH, $H \rightarrow SM$	$938,471 \pm 527$	$74,931 \pm 66$	$68,871 \pm 51$	$0 (\leq 51)$
WW	$118,357,200 \pm 3876$	$3,324,843 \pm 1082$	$746,749 \pm 513$	$0 (\leq 513)$
ZZ	$9,784,730 \pm 430$	$1,319,337 \pm 426$	$908,730 \pm 353$	$0 (\leq 353)$
All background	$129,080,401 \pm 3930$	$4,719,111 \pm 1162$	$1,724,350 \pm 625$	$0 (\leq 625)$
60 GeV, 10^{-5}	18.85 ± 0.01	12.2 ± 0.2	12.4 ± 0.2	0.004 ± 0.003
60 GeV, 10^{-7}	18.85 ± 0.01	14.5 ± 0.2	14.5 ± 0.2	6.9 ± 0.1
20 GeV, 10^{-6}	63.78 ± 0.05	44.6 ± 0.5	45.1 ± 0.5	15.5 ± 0.3

Conclusions & Outlook

- Prospective search for exotic Higgs boson decays to LLPs at FCC-ee
- 15 events in the strongest signal in a background 0 search
- Journal publication in preparation

