

Rare Higgs Decay at the FCCee:

$$H \rightarrow aa \rightarrow 4K$$

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Overview

Goal

- Feasibility study to determine the measurement of this rare Higgs decay

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Motivation

- Exploring new parameter space with the specific chosen signal process at 240 GeV centre-of-mass energy

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Motivation

- Exploring new parameter space with the specific chosen signal process at 240 GeV centre-of-mass energy
 - Interesting since this study has not been done before

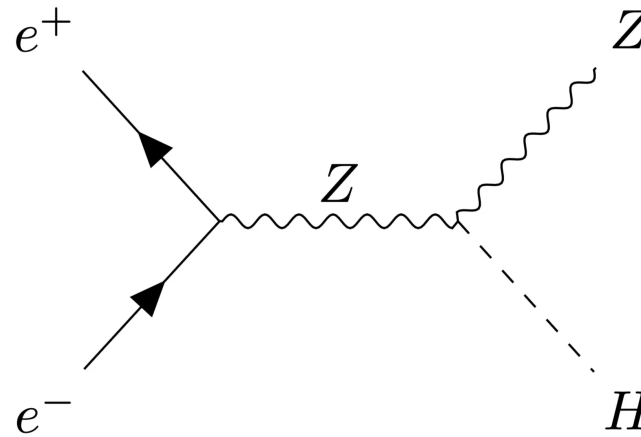
Overview

Processes

One signal (*500,000 events*)

- $ee \rightarrow Z \rightarrow ZH$
 - $Z \rightarrow ee$
 - $H \rightarrow aa$
 - $aa \rightarrow 4 K^+$

“p8_ee_eeH_Hpsps_ecm240”



Overview

Processes

Three backgrounds

- $ee \rightarrow WW$ ($\sim 3.7 * 10^8$ *events*)

“p8_ee_WW_ecm240”

- $ee \rightarrow ZZ$ ($\sim 5.6 * 10^7$ *events*)

“p8_ee_ZZ_ecm240”

- $ee \rightarrow Zqq$ ($\sim 1 * 10^8$ *events*)

“p8_ee_Zqq_ecm240”

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Sample generation

- Signal events are generated with Delphes+Pythia8

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- Definition of new pseudo-scalar from Pythia card
 - spin type: 0
 - Nominal mass: 1.5 GeV
 - Γ_{BW} : $1.9732 * 10^{-12}$ GeV (very prompt)
 - One decay channel $\rightarrow$ 2 charged kaons $\rightarrow$ 100%

```
! Definition of new pseudoscalar
9000006:all = ps psbar 0 0 0 1.5 1.9732e-12 1.0 75.0 0
9000006:oneChannel = 2 1.000 101 321 -321
9000006:mayDecay = on
9000006:isResonance = on
9000006:onMode = off
9000006:onIfAny = 321
```

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Reconstruction of the Higgs

- Filtered out events that did not have exactly 4 kaons
- Individual masses of the 4 kaons were then summed up

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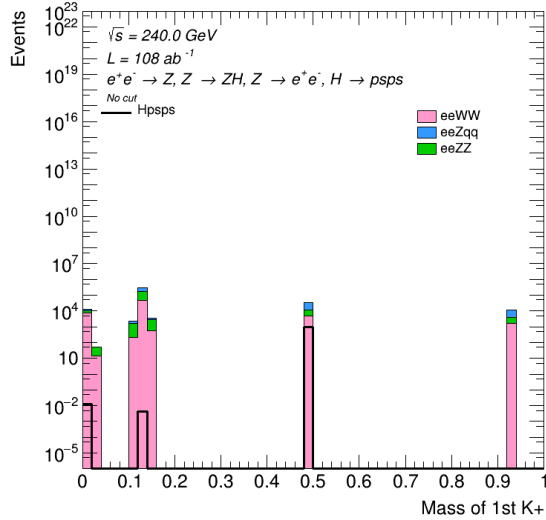
Selections

- $0.2 < K+_{mass} < 0.7 \text{ GeV}$
- $K+_{energy} > 2 \text{ GeV}$
- $H_{mass} > 120 \text{ GeV}$

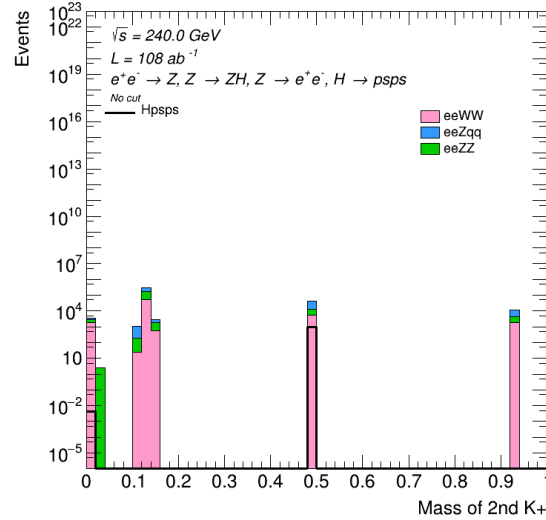
Note: it seems like Delphes cannot differentiate between kaons and pions so reco. kaon mass is the pion mass

Plots

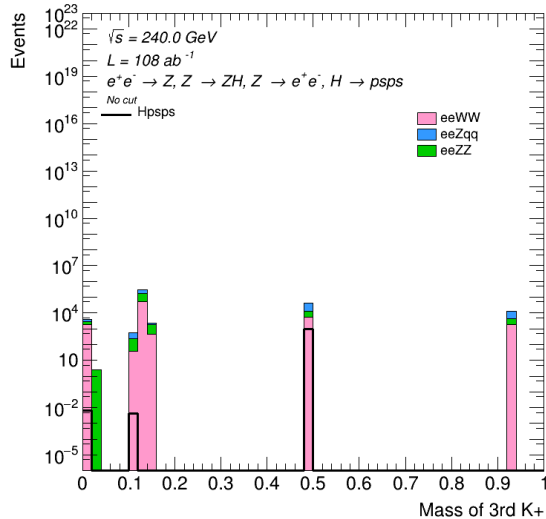
FCCAnalyses: FCC-ee Simulation (Delphes)



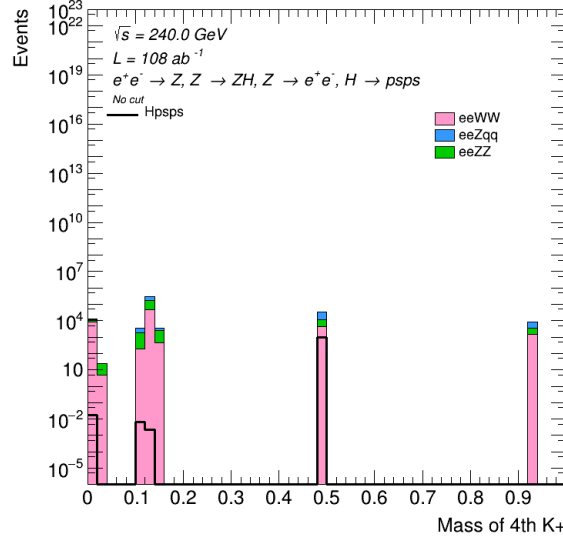
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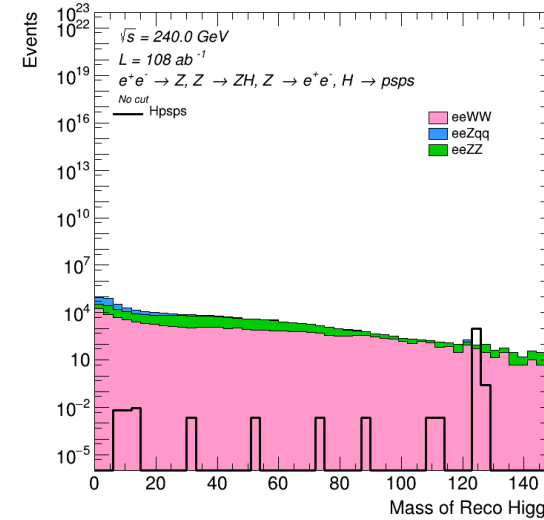


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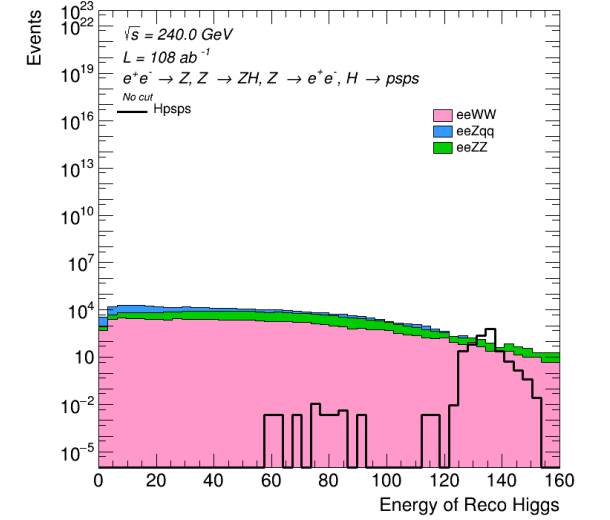


No cut

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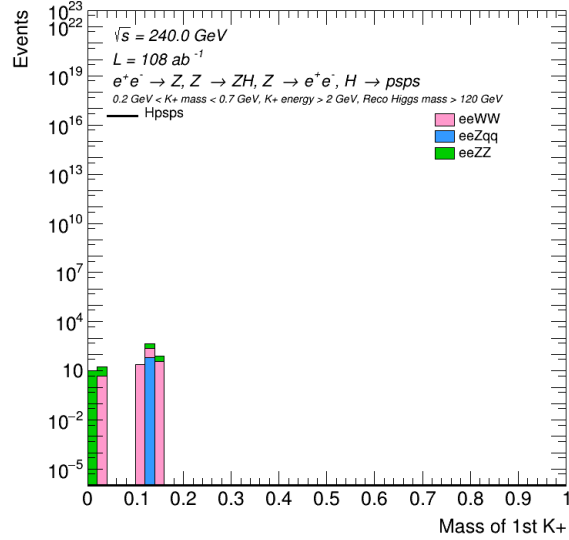


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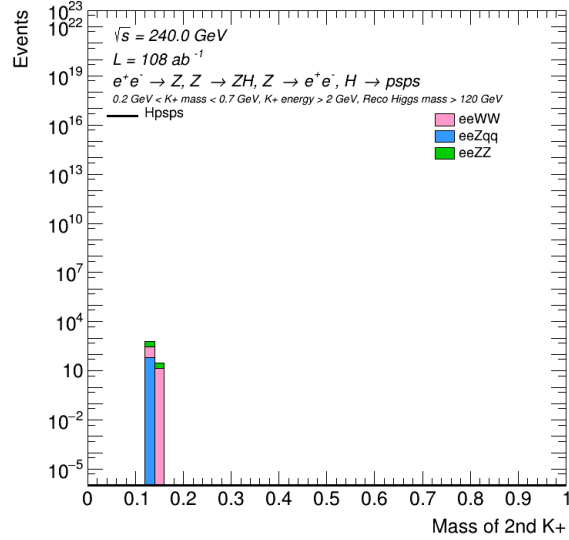


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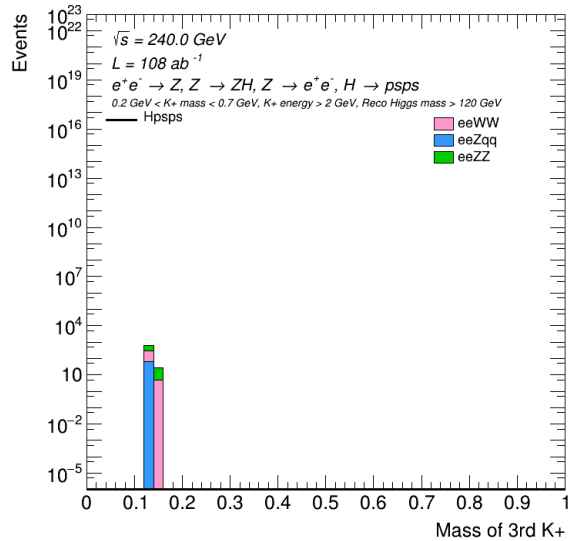


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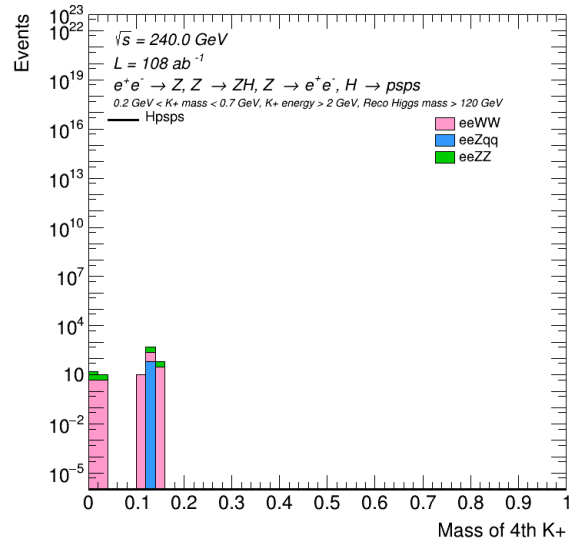


Kinematic cut

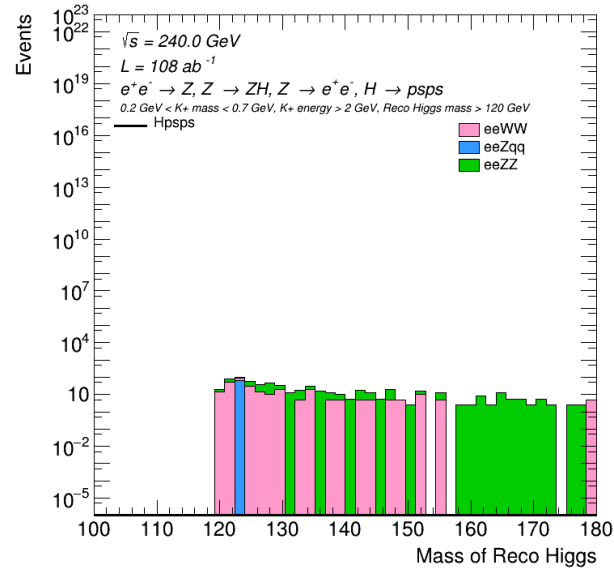
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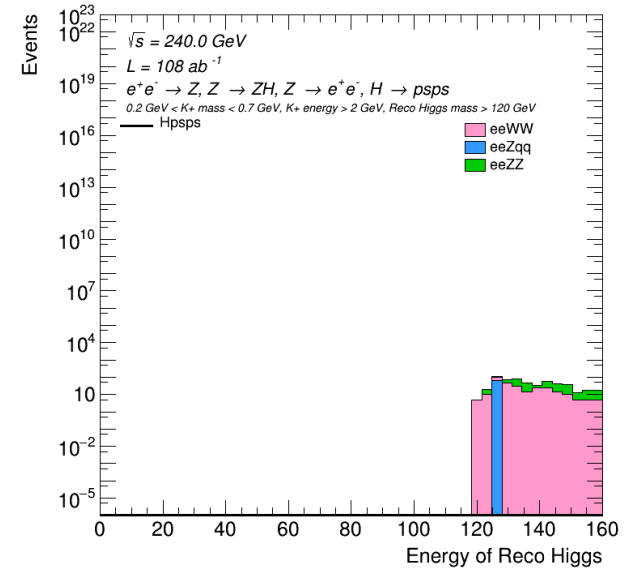
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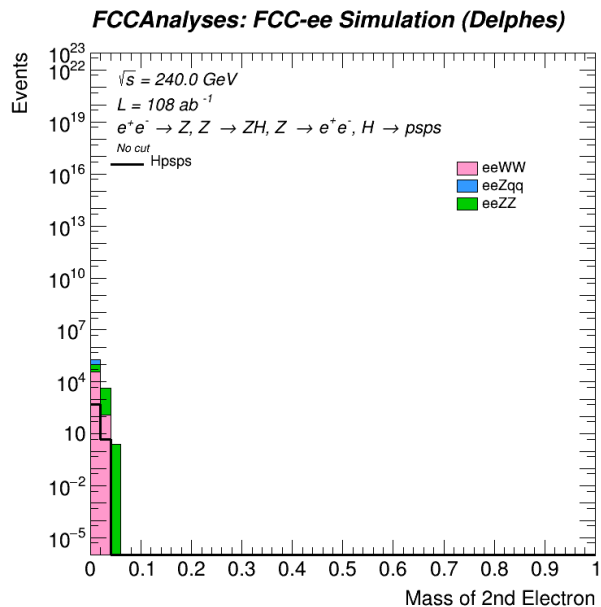
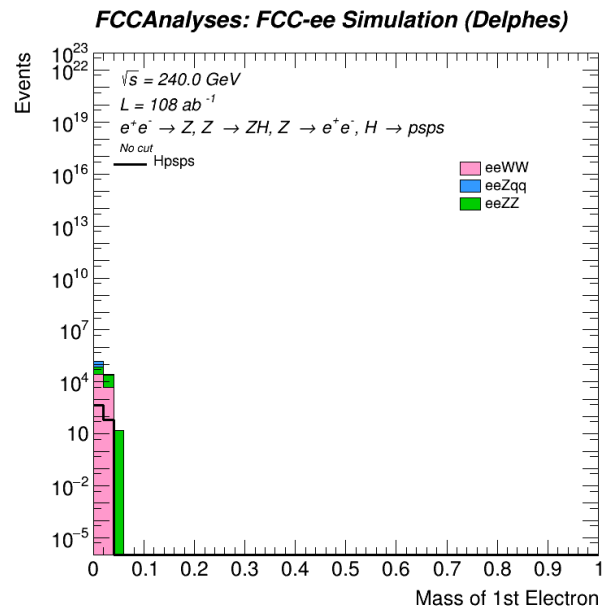
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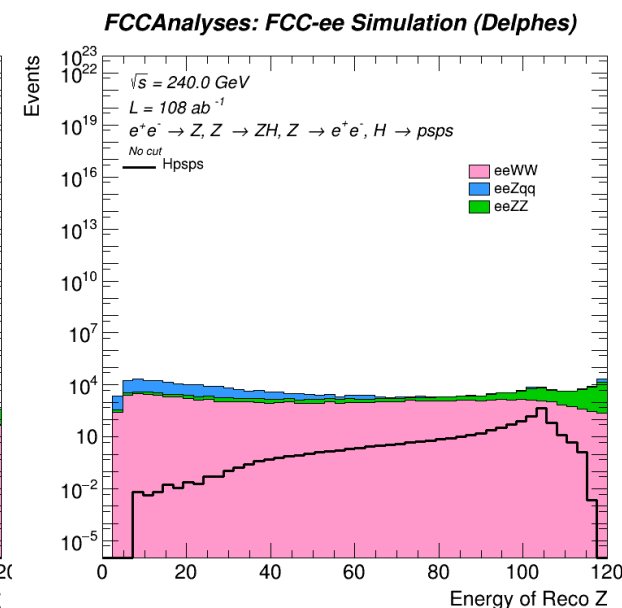
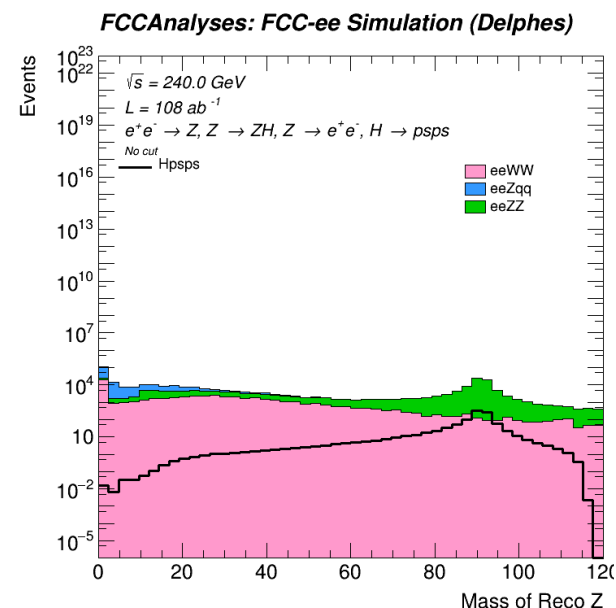
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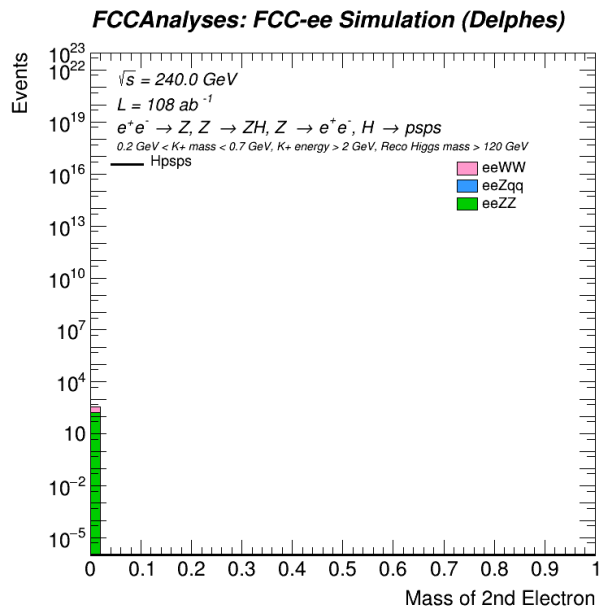
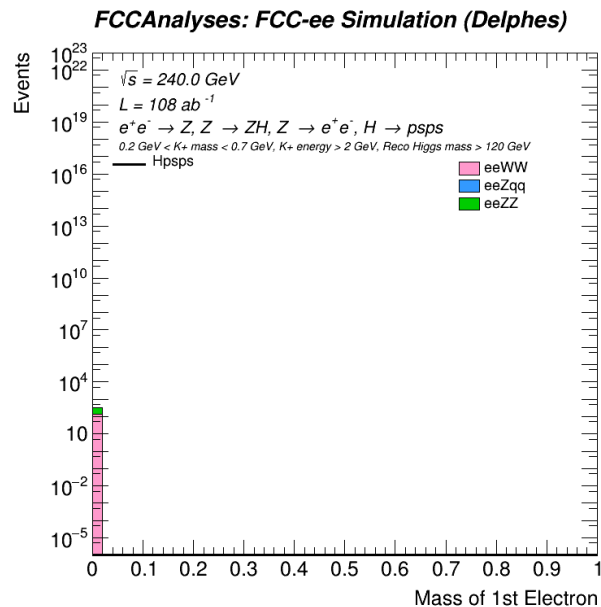
Plots



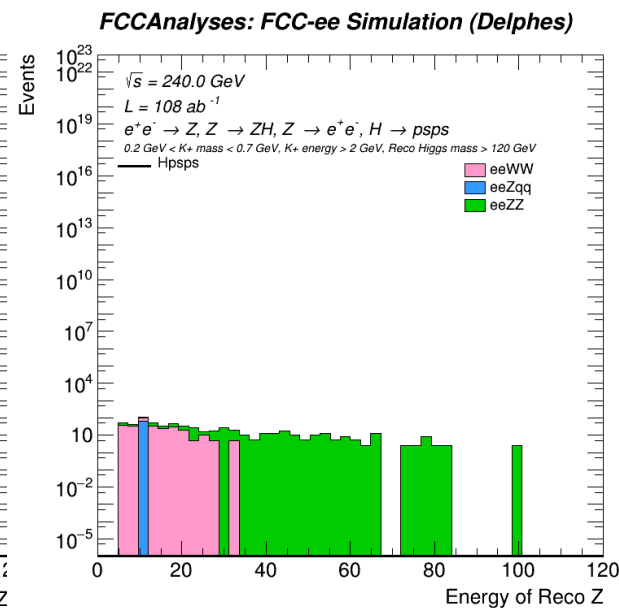
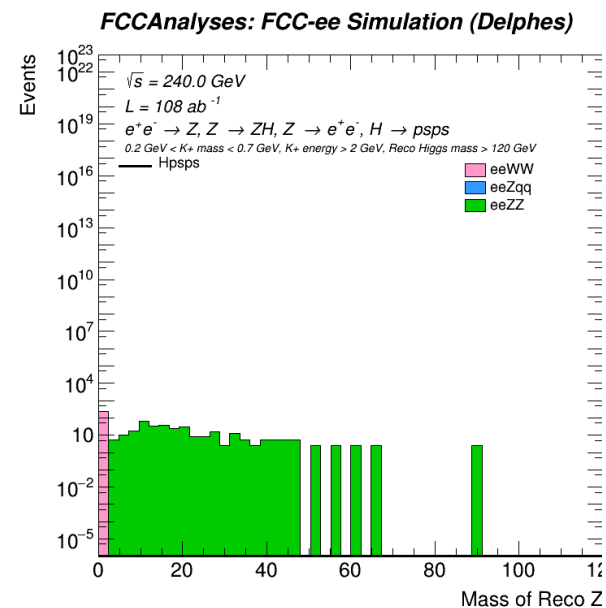
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Next steps

- Add missing energy for the Z
- Increase number of generated sample events using Pythia card
- Include more background processes
- Probe parameter space where ALP is long-lived?