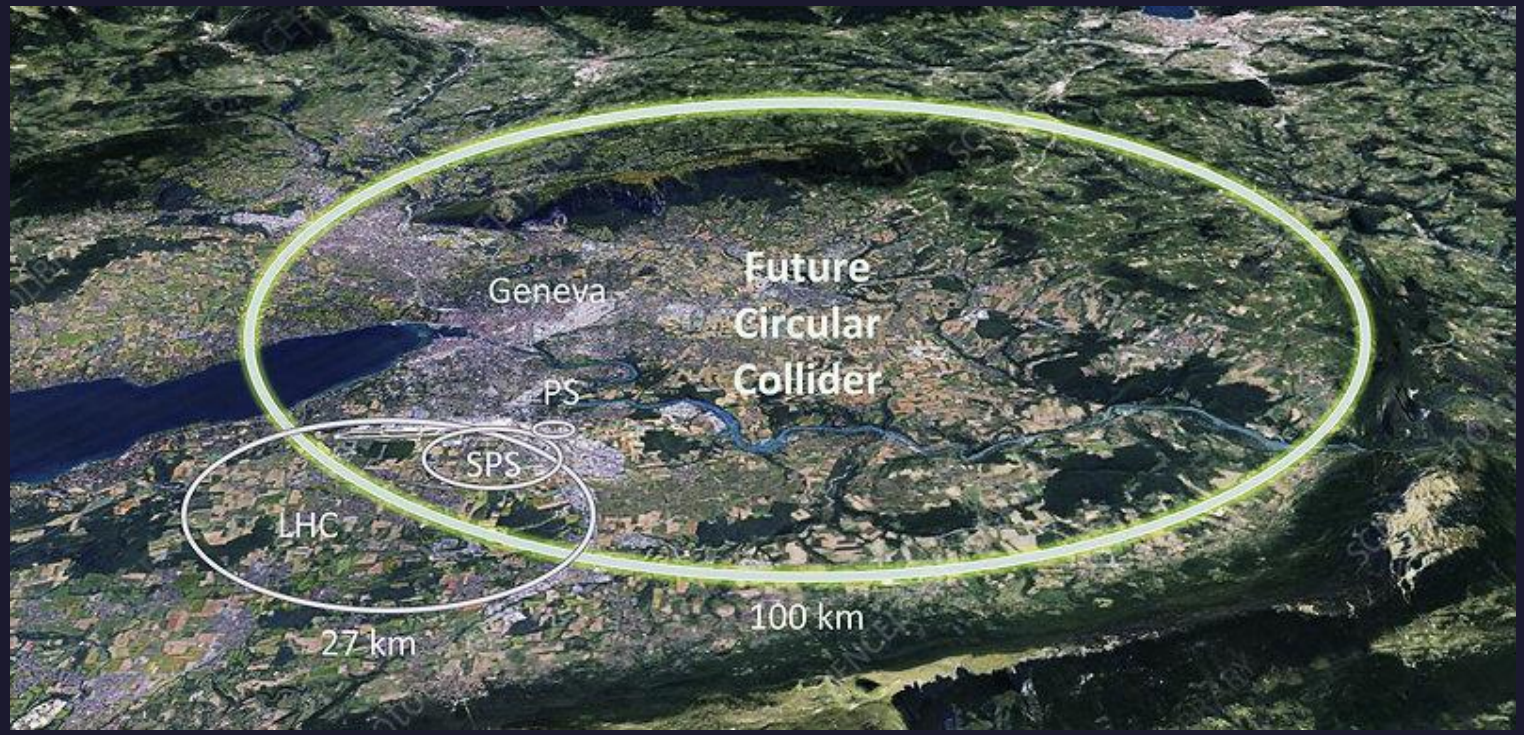
Long-lived axion-like particles at the FCC-ee

Weekly meeting with Juliette



HELMHOLTZ

Freya Blekman, Juliette Alimena, Lovisa Rygaard, **Elnura Bakhishova**

29.01.25

DESY.

New variable: Invariant mass and total momentum of photons coming from the ALP

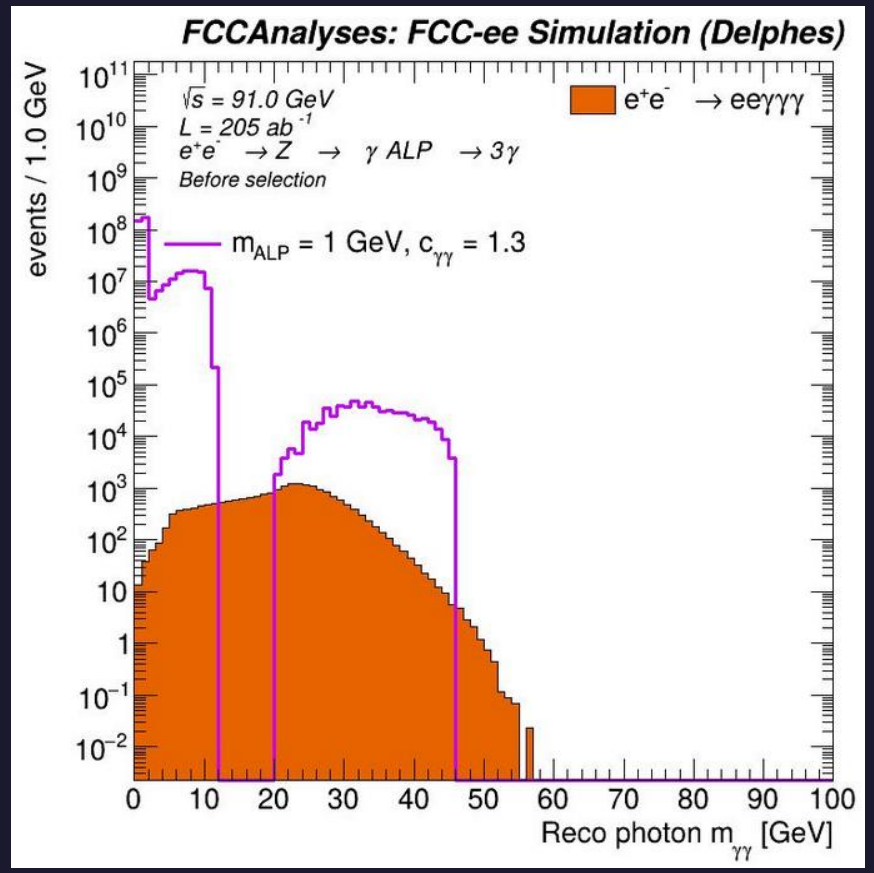
2 ways of doing it:

1) **Use RecoPhoton indices [1] and [2] --> should ideally correspond to the ALP photons**

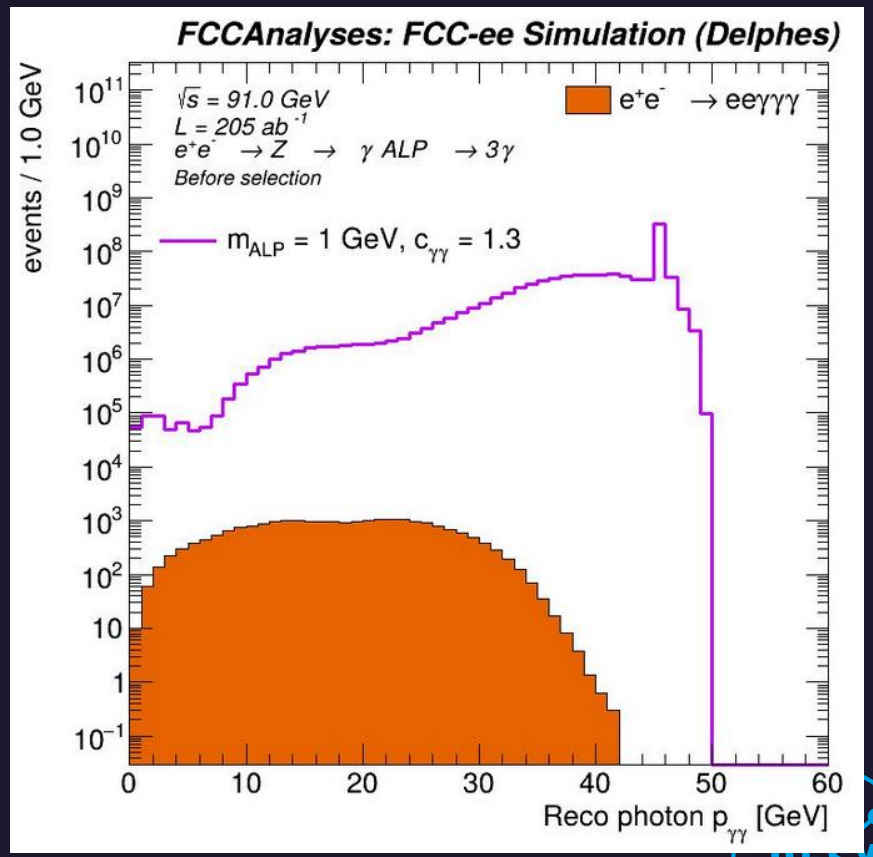
2) **Use that pair of photons with smallest angular separation (mindeltaR) --> define new function in ReconstructedParticle.cc that collects the corresponding photon indices, in stage1 apply that function on RecoPhotons and work with the new collection of photons**

New variable: Invariant mass and total momentum of photons coming from the ALP

1) **Use RecoPhoton indices [1] and [2] --> should ideally correspond to the ALP photons**



With object selections from MG
(photon pt>10GeV, eta < 2.5)



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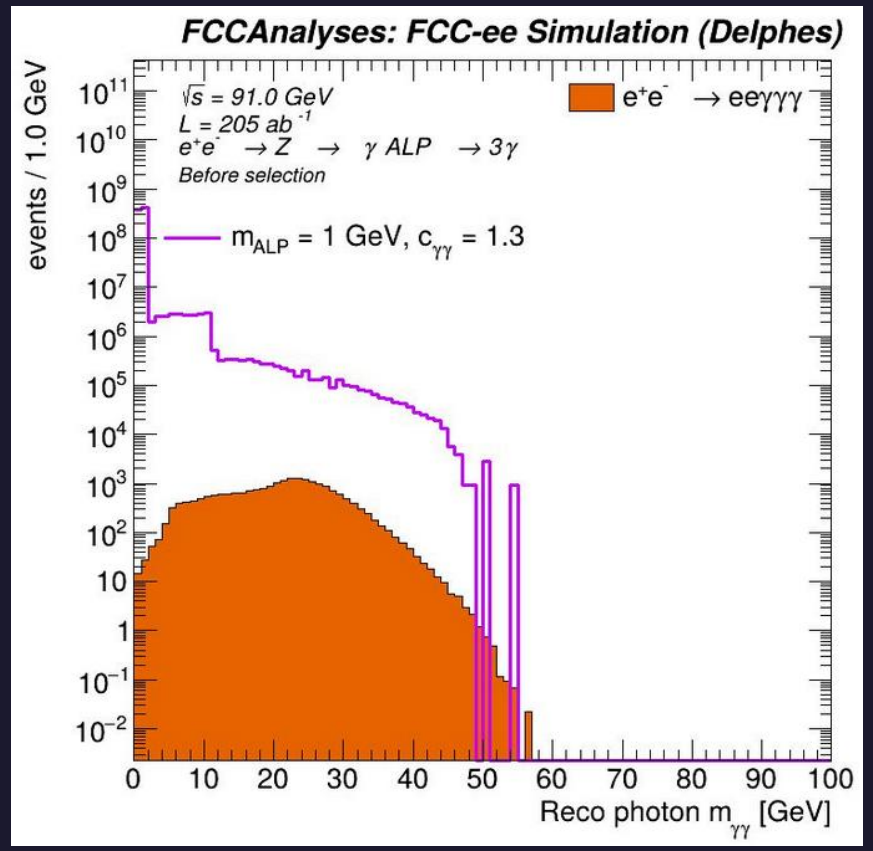
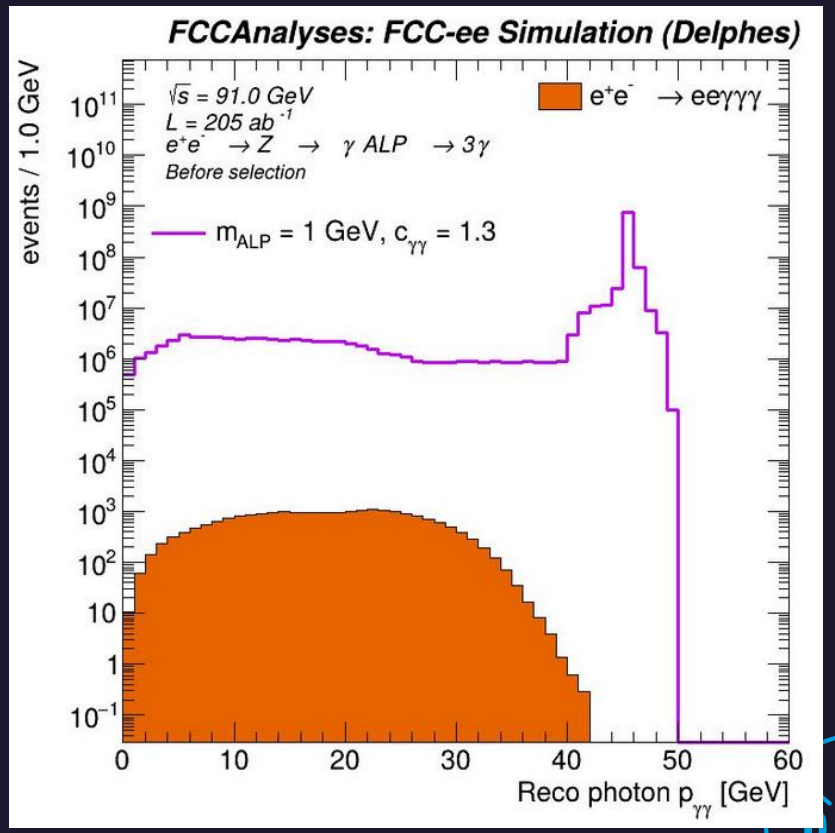
New variable: Invariant mass and total momentum of photons coming from the ALP

1) **Use RecoPhoton indices [1] and [2] --> should ideally correspond to the ALP photons**



Without object selections from MG



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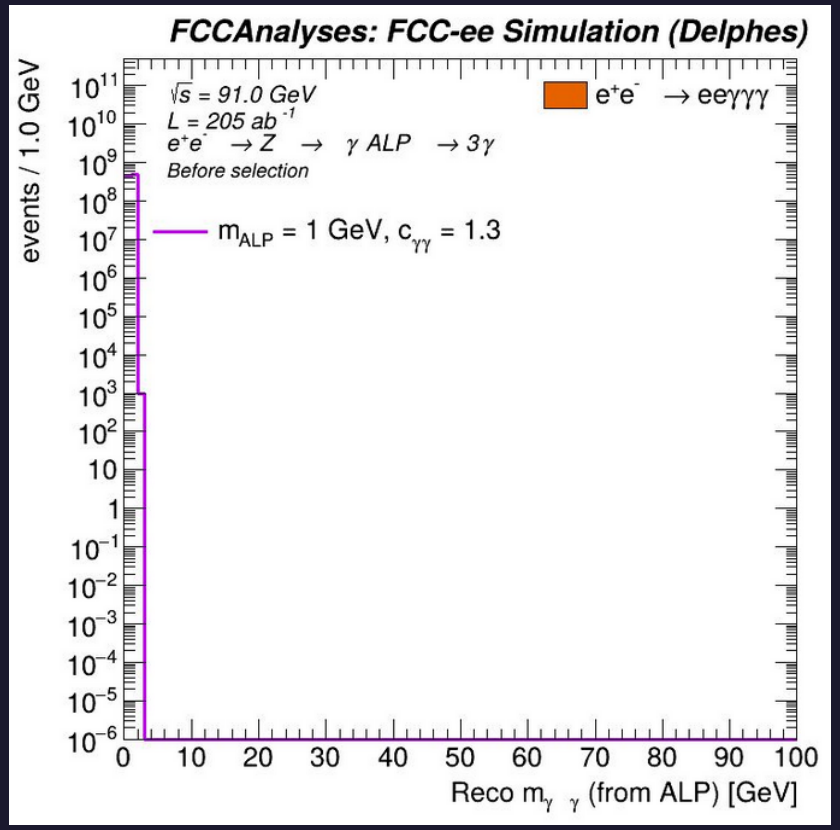
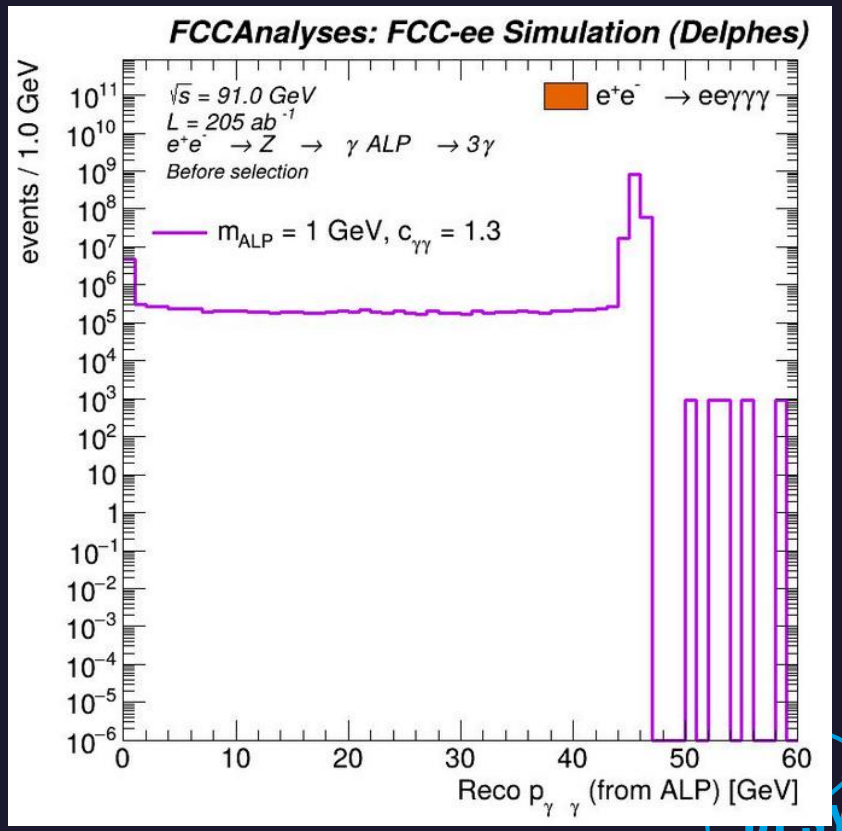
New variable: Invariant mass and total momentum of photons coming from the ALP

Compare to RecoALPPhoton's invariant mass and total momentum





Without object selections from MG

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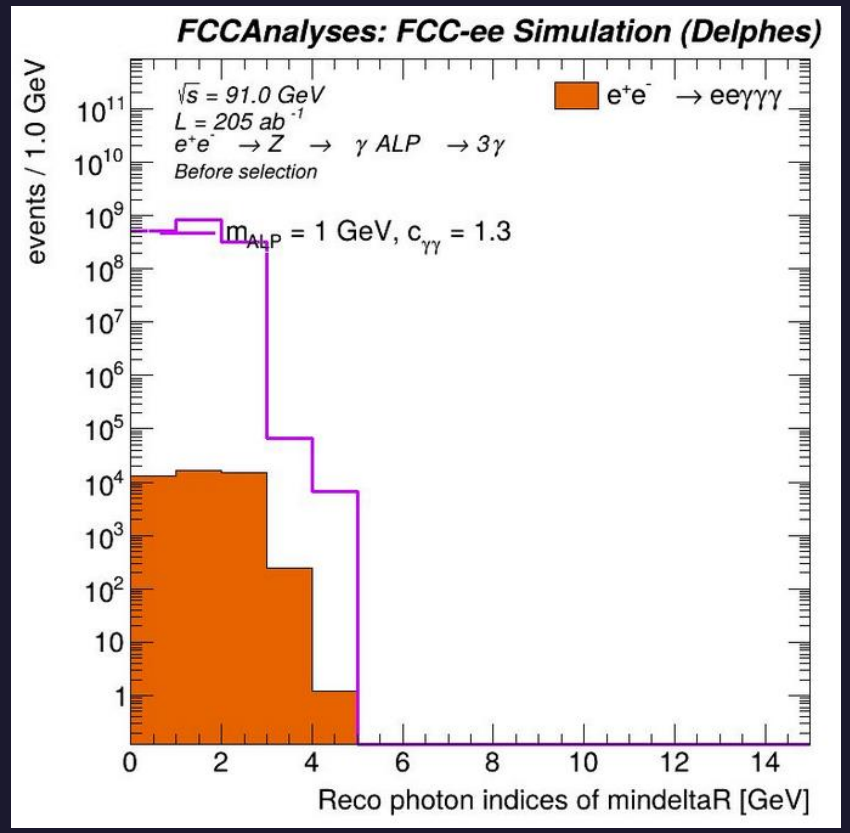
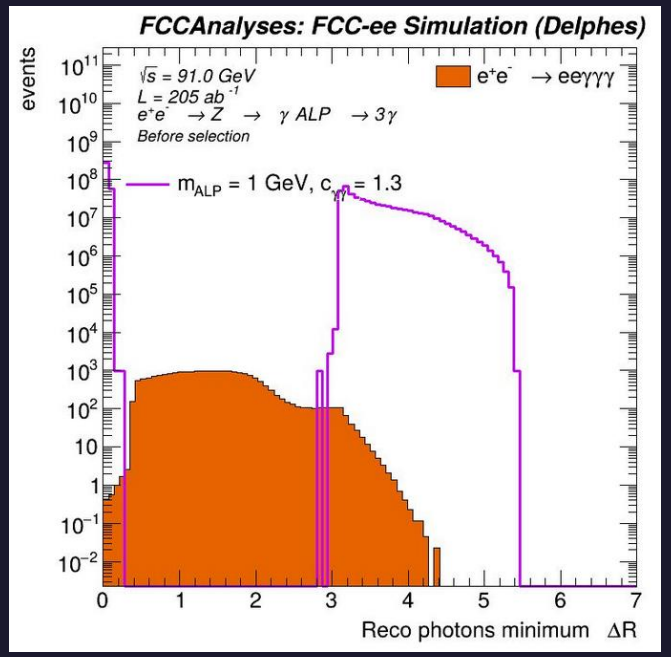
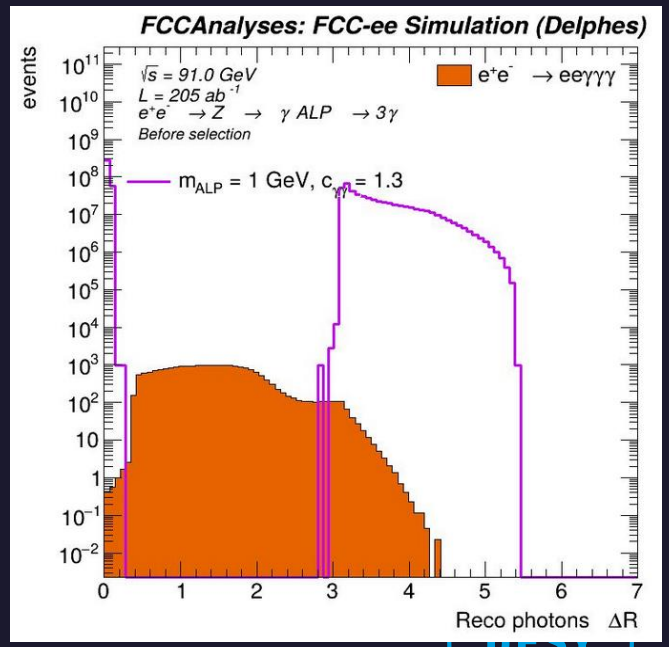
New variable: Invariant mass and total momentum of photons coming from the ALP

2) Use that pair of photons with smallest angular separation (mindeltaR) --> define new function in ReconstructedParticle.cc that collects the corresponding photon indices



Verify that these photon indices actually return the mindeltaR distribution: calculate deltaR for those photons





MindeltaR of reco photons = deltaR of photons with previously calculated indices

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With object selections from MG (photon pt>10GeV, eta < 2.5)

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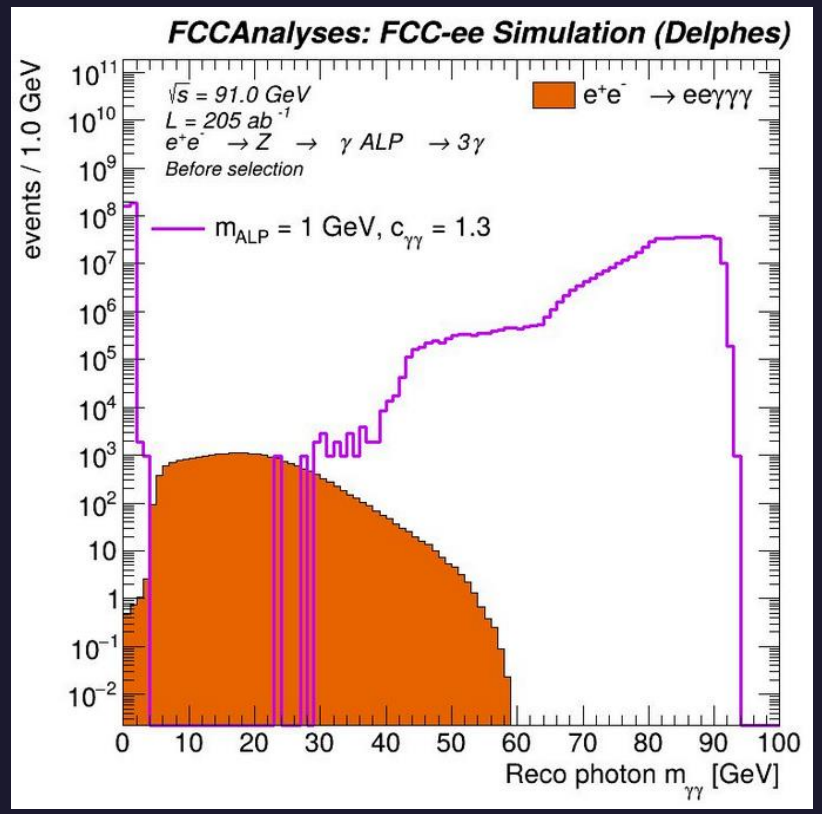
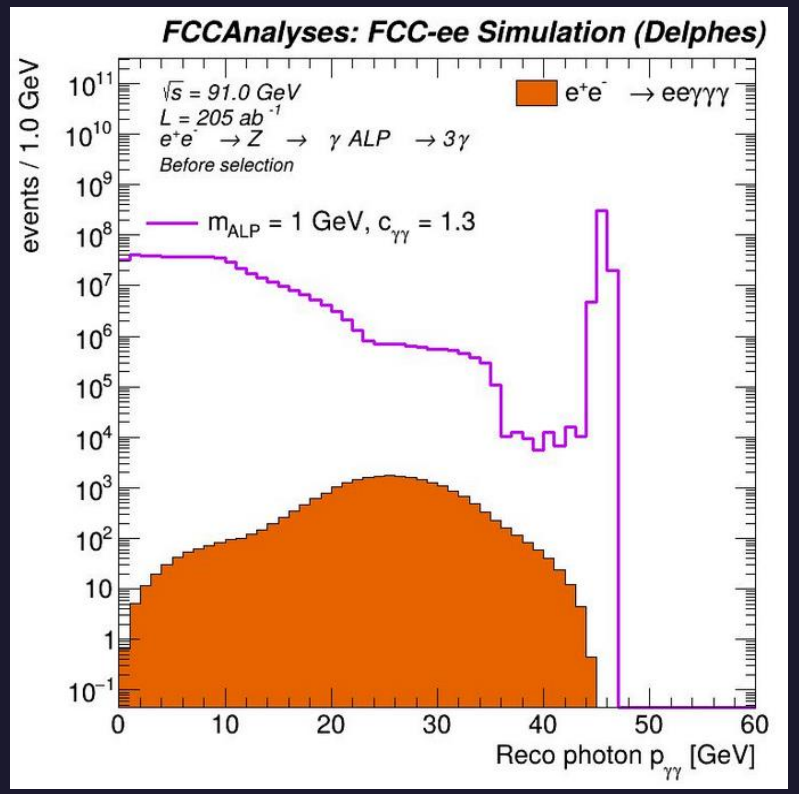
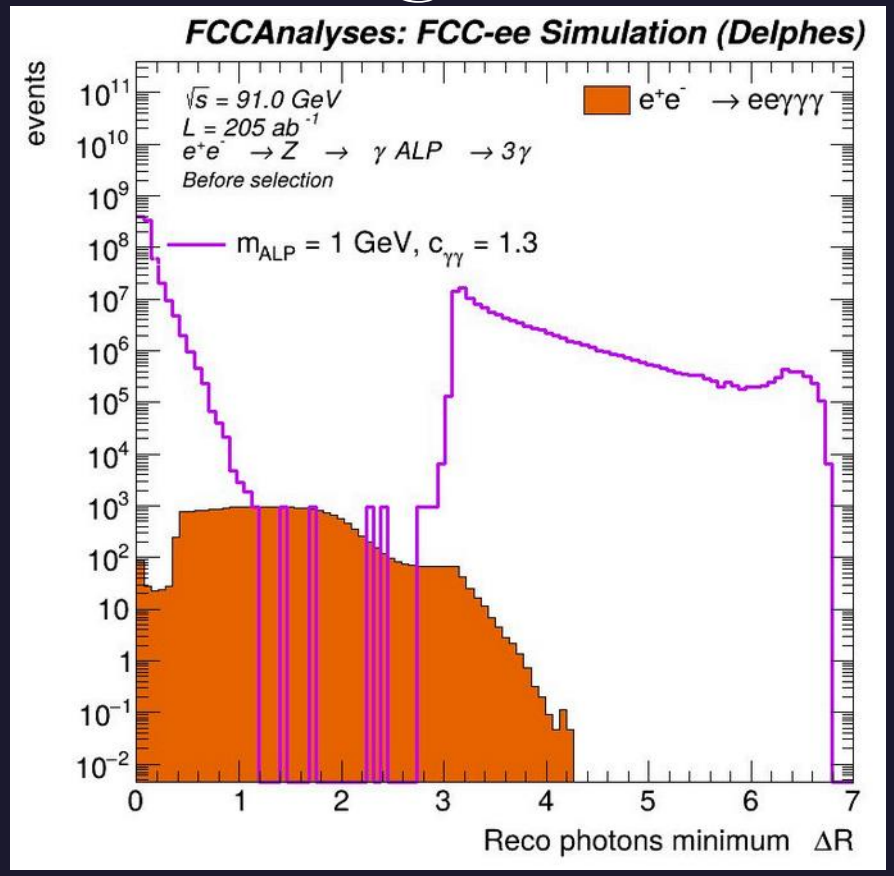


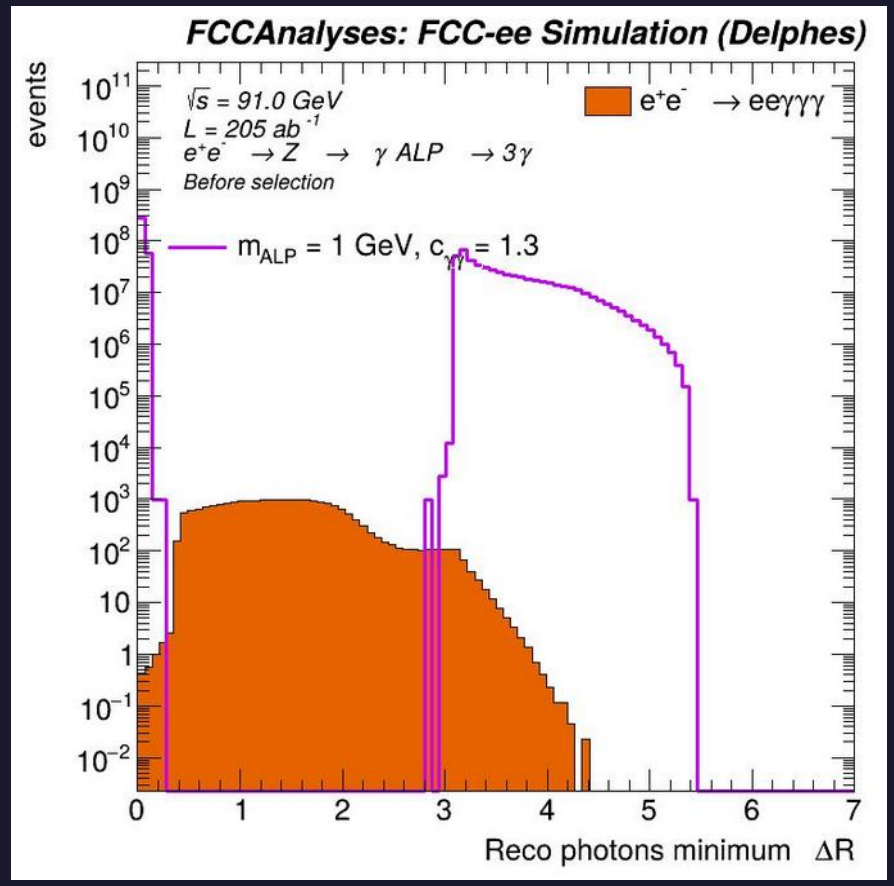


With object selections from MG (photon pt>10GeV, eta < 2.5)

Checking deltaR



Without object selections from MG (pt, eta)



With object selections from MG

First peak for signal should be from the two photons decaying from the ALP, however MG does cut on photons with deltaR < 0.4 !!! If that peak is from pythia photons- where is the peak from the MG ALP photons??

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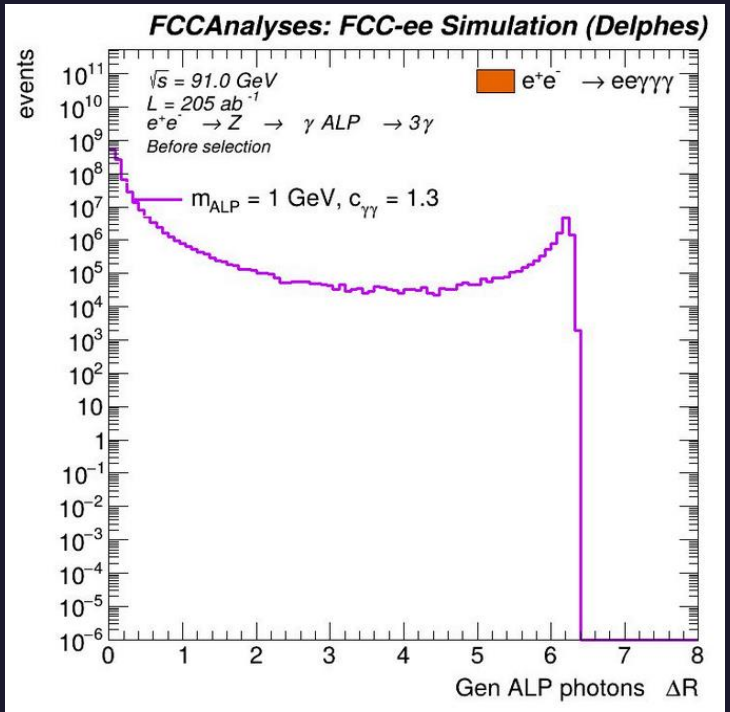
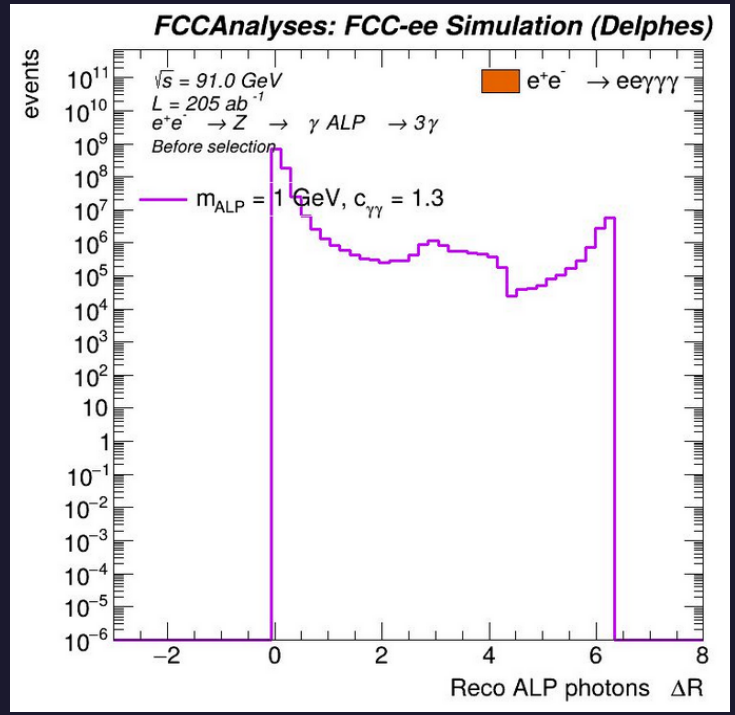
Checking deltaR

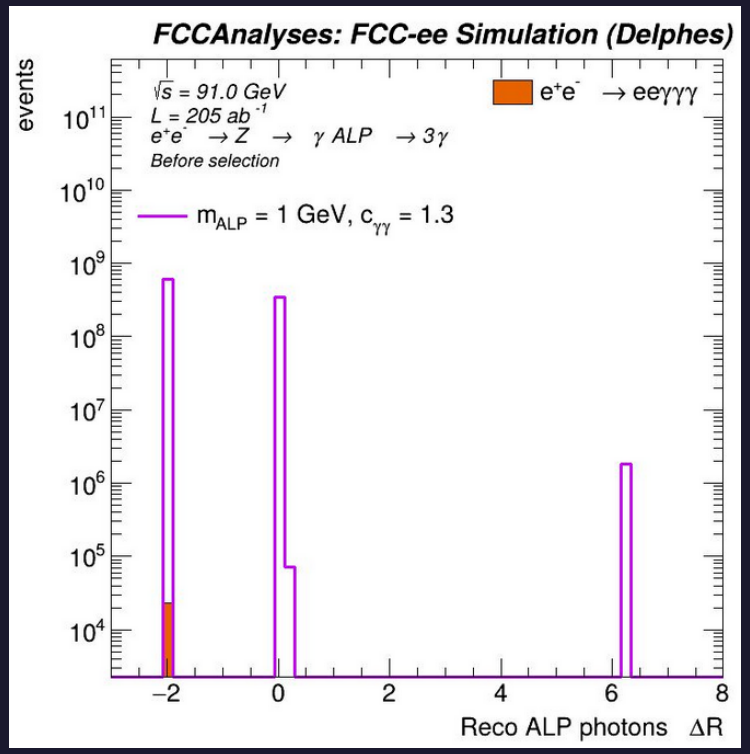
Without object selections from MG





These are photons from the ALP (matched to gen level)
Why is there deltaR < 0.4 when MG has a cut for those values?

With object selections from MG (pt, eta)



With the additional deltaR > 0.4 selection we would have no signal at all!

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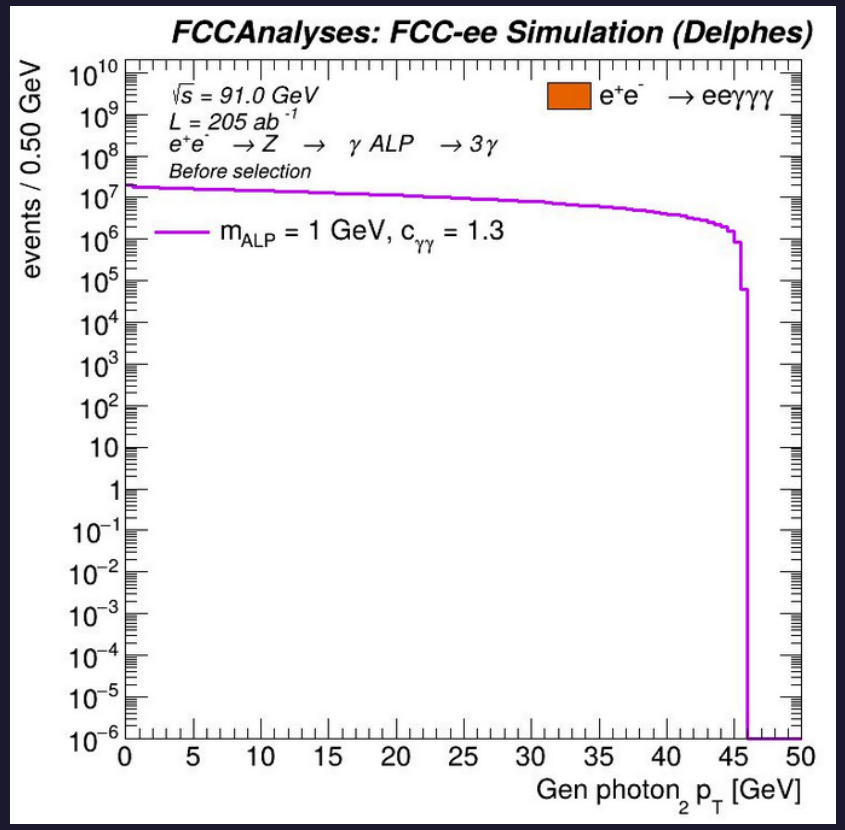
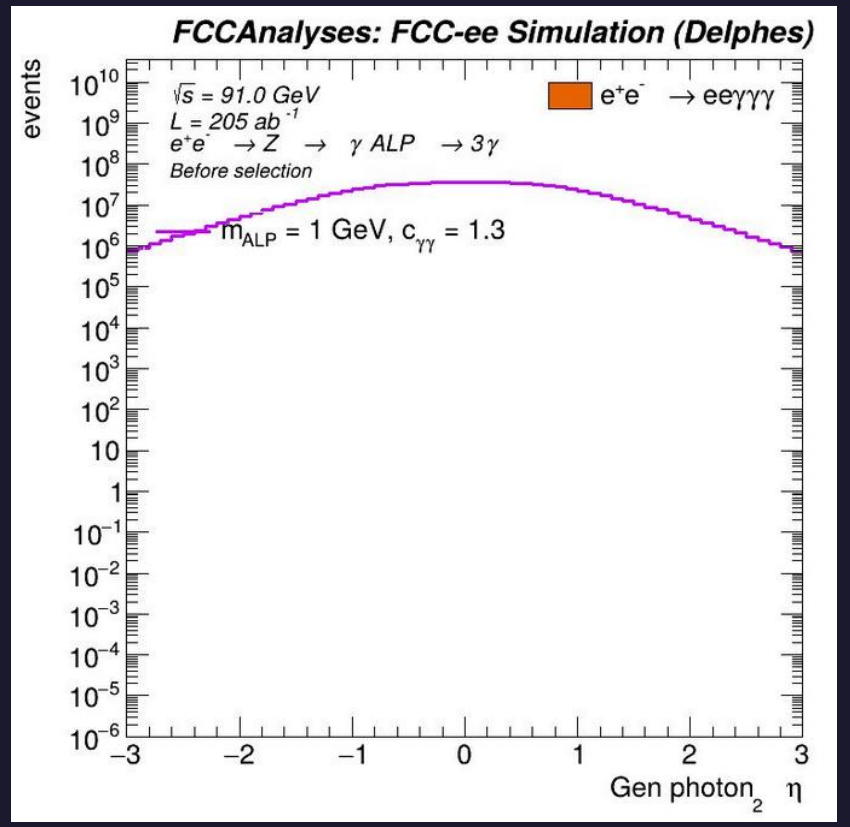
Checking deltaR

Without object selections from MG



Photons from ALP



Photons from ALP

Eta and pt cut not there

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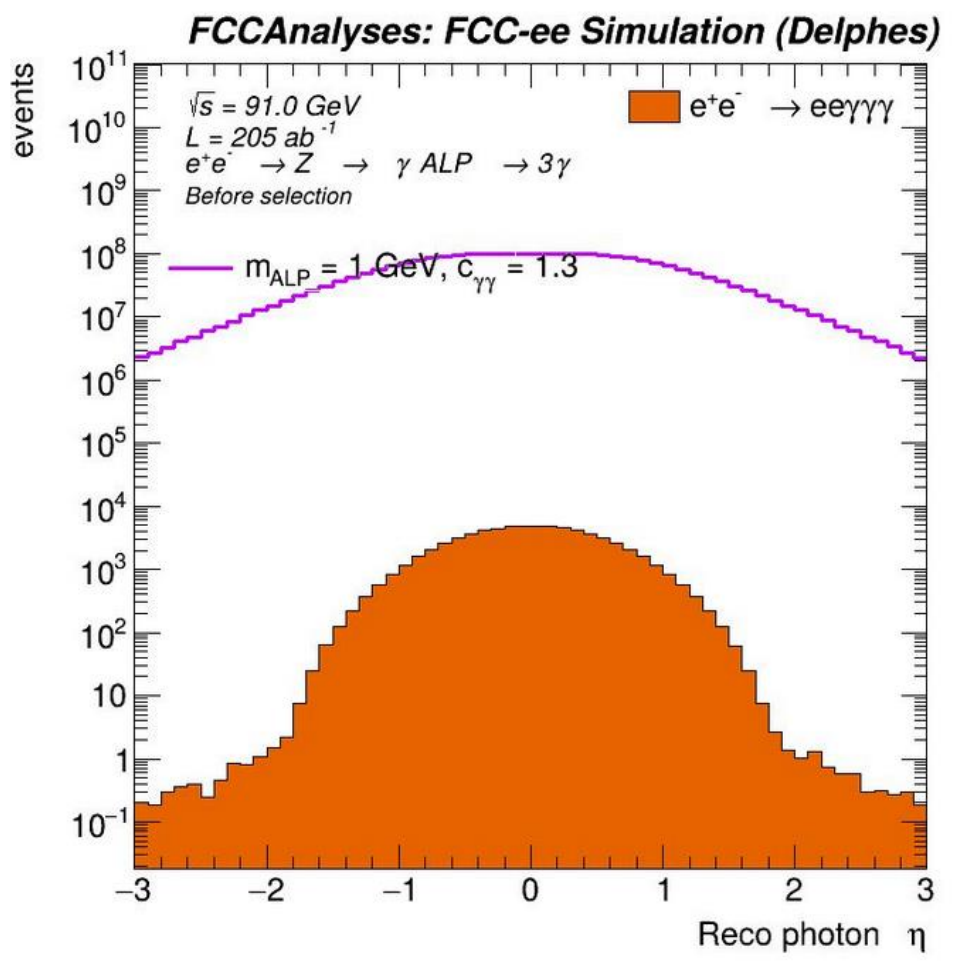
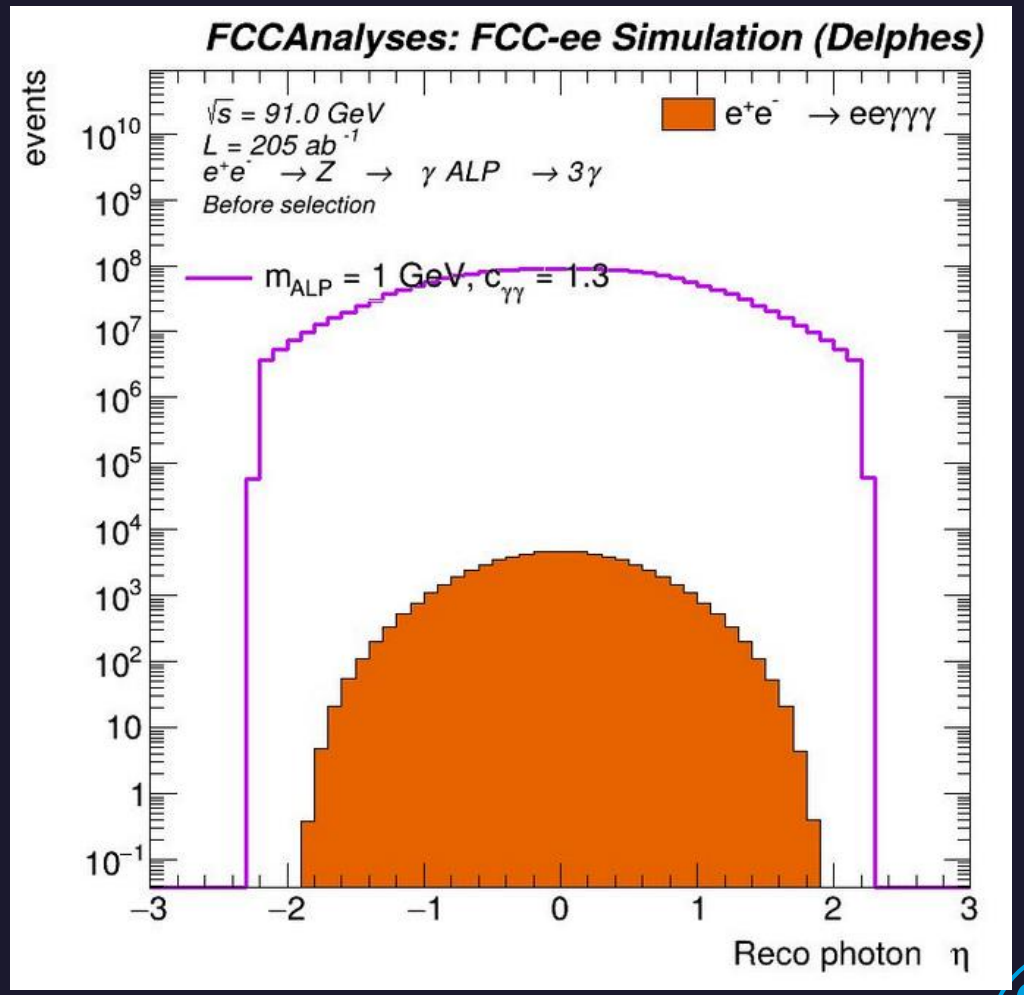
Checking deltaR

Without object selections from MG



With obj selections from MG



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Checking deltaR

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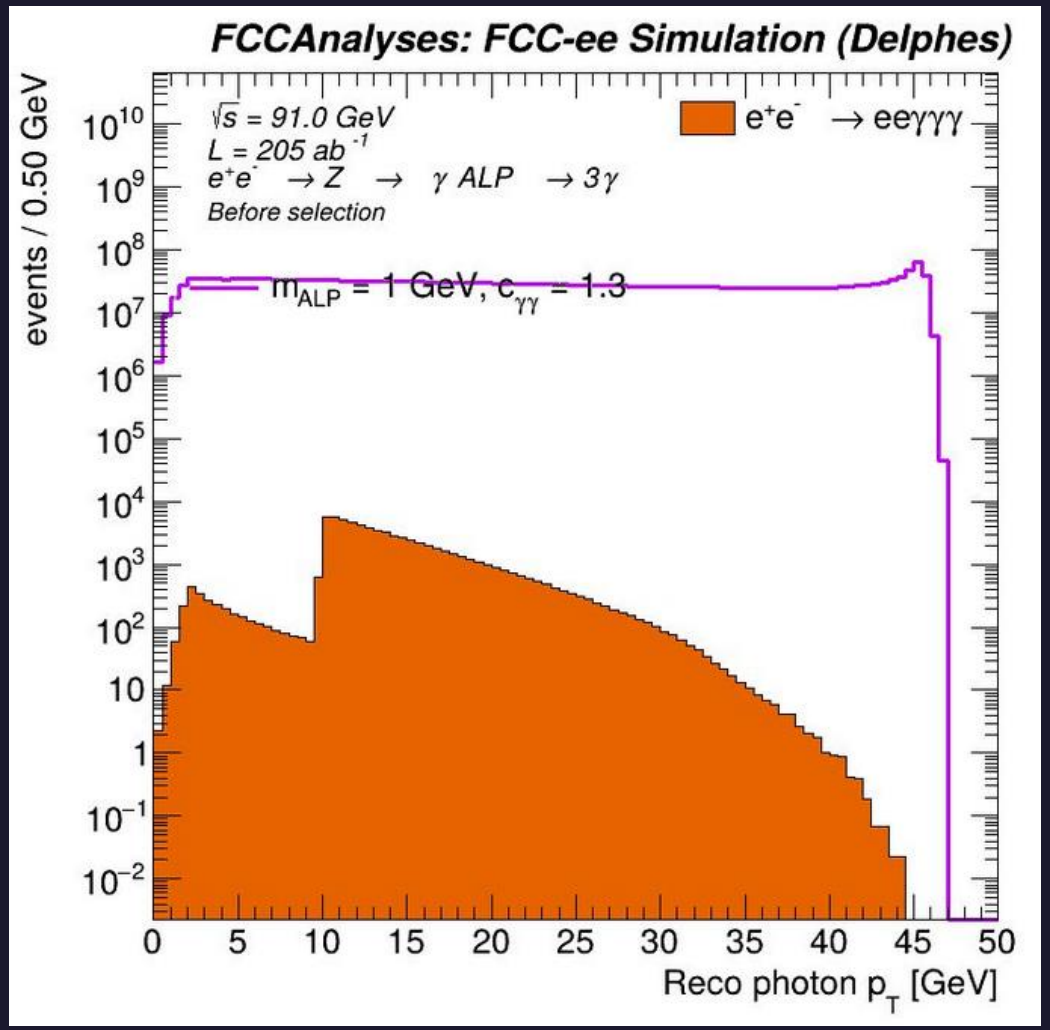
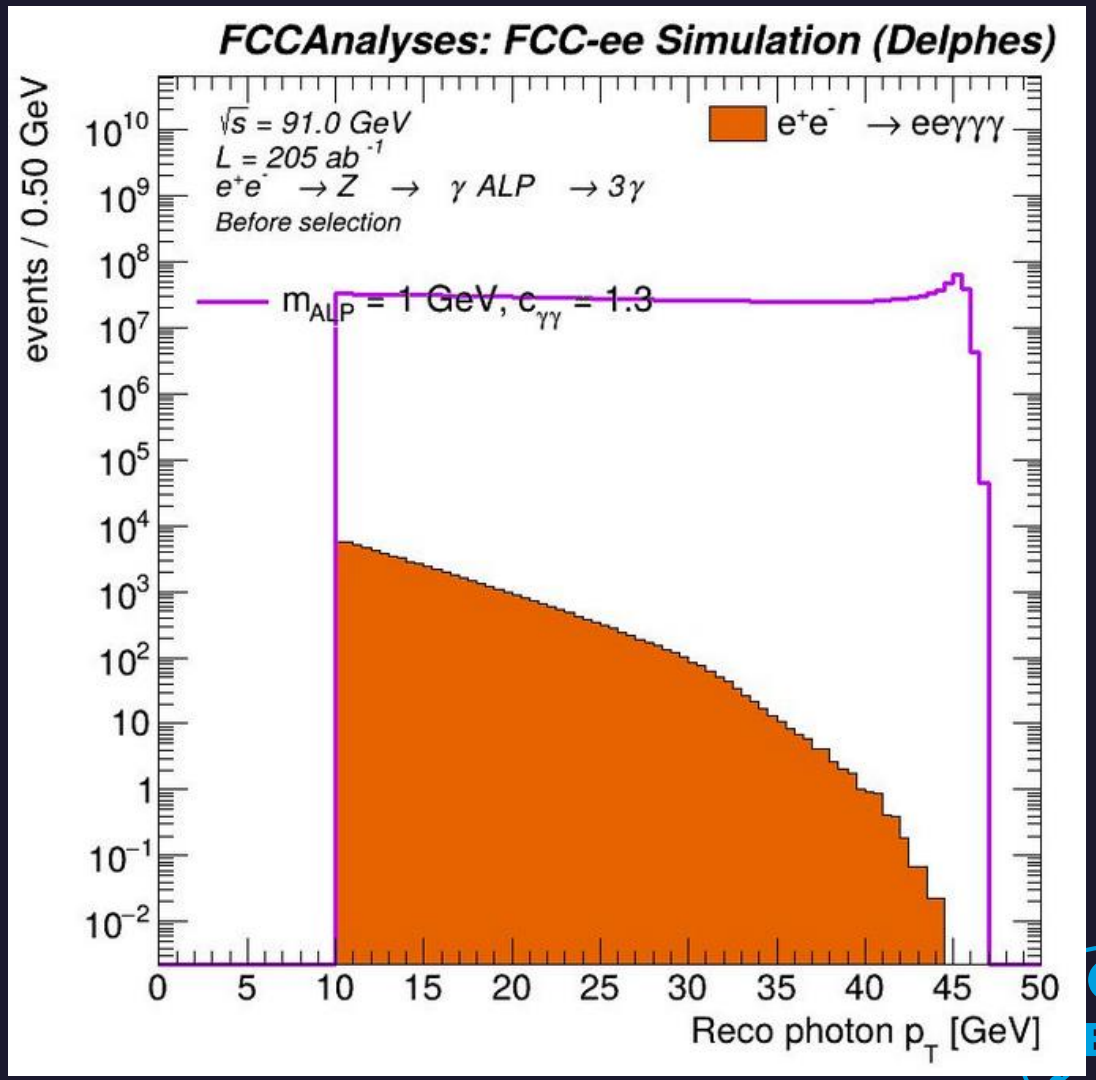


With obj selections from MG



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Conflicting information from MadGraph

In the MG output .lhe file events and the settings of the run_card are listed

px py pz Energy

```
<event>
 7      1 +4.6287000e+00 9.11880000e+01 7.81860800e-03 1.18400000e-01
      -11 -1    0    0    0    0 +0.0000000000e+00 +0.0000000000e+00 +4.5593999997e+01 4.5594000000e+01 5.1100000000e-04 0.0000e+00 1.0000e+00
       11 -1    0    0    0    0 -0.0000000000e+00 -0.0000000000e+00 -4.5593999997e+01 4.5594000000e+01 5.1100000000e-04 0.0000e+00 -1.0000e+00
       23  2    1    2    0    0 +0.0000000000e+00 -2.2204460493e-16 +0.0000000000e+00 9.1188000000e+01 9.1188000000e+01 9.4641e-14 0.0000e+00
  9000005  2    3    3    0    0 +4.7522996978e+00 +1.2477957495e+00 +4.5322969007e+01 4.5599483175e+01 9.9999977695e-01 7.7043e-05 0.0000e+00
       22  1    3    3    0    0 -4.7522996978e+00 -1.2477957495e+00 -4.5322969007e+01 4.5588516825e+01 0.0000000000e+00 0.0000e+00 -1.0000e+00
       22  1    4    4    0    0 +3.9514113532e+00 +1.3940197171e+00 +3.6831149641e+01 3.7068727070e+01 0.0000000000e+00 0.0000e+00 1.0000e+00
       22  1    4    4    0    0 +8.0088834459e-01 -1.4622396754e-01 +8.4918193659e+00 8.5307561056e+00 0.0000000000e+00 0.0000e+00 1.0000e+00
</event>
```

--> For photon (22) sometimes total momentum (=energy) of less than 10 GeV, although card settings shows pt >10 GeV

```
#*********************************************************************
# Standard Cuts                                                      *
#*********************************************************************
# Minimum and maximum pt's (for max, -1 means no cut)                *
#*********************************************************************
  10.0  = pta ! minimum pt for the photons
  -1.0  = ptamax ! maximum pt for the photons
  {}    = pt_min_pdg ! pt cut for other particles (use pdg code). Applied on particle and anti-particle
  {}    = pt_max_pdg ! pt cut for other particles (syntax e.g. {6: 100, 25: 50})
#*********************************************************************
# Minimum and maximum E's (in the center of mass frame)              *
#*********************************************************************
  0.0   = ej ! minimum E for the jets
  0.0   = eb ! minimum E for the b
  0.0   = ea ! minimum E for the photons
  0.0   = el ! minimum E for the charged leptons
```

```
#*********************************************************************
# Inclusive cuts                                                     *
#*********************************************************************
  0.0   = xpta ! minimum pt for at least one photon
#*********************************************************************
# maximal pdg code for quark to be considered as a light jet         *
```

Whats that?

run_card.dat

```
#*********************************************************************
# Maximum and minimum absolute rapidity (for max, -1 means no cut)   *
#*********************************************************************
 2.5  = etaa    ! max rap for the photons
 0.0  = etajmin ! min rap for the jets
 0.0  = etaamin ! min rap for the photons
 {} = eta_min_pdg ! rap cut for other particles (use pdg code). Applied on particle and anti-particle
 {} = eta_max_pdg ! rap cut for other particles (syntax e.g. {6: 2.5, 23: 5})
#*********************************************************************
# Minimum and maximum DeltaR distance                                *
#*********************************************************************
 0.4 = draa    ! min distance between gammas
 -1.0  = draamax ! max distance between gammas
#*********************************************************************
```