Search for exotic decays of the 125 GeV Higgs boson to light pseudoscalars decaying to two photons

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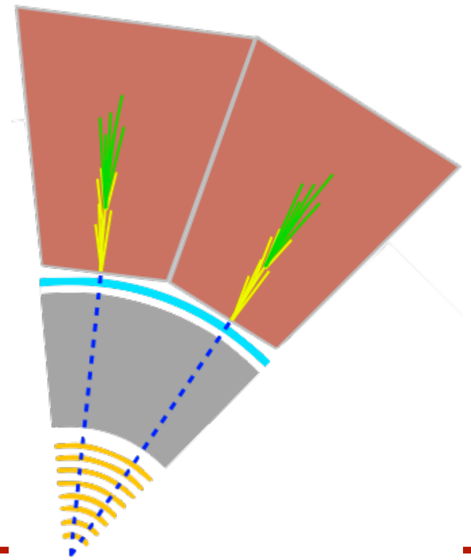
Higgs Exotic decays : Multi Photon Signatures

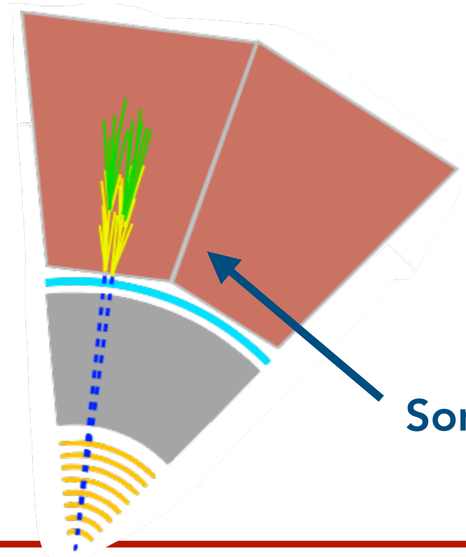
- Photons leave no signature other than their energy deposit in ECAL
- Standard isolation calculated based on some fixed **ΔR** cone size
- If there is a lot of extra energy in the cone => Jet faking a photon
- Distinguish photons from jets-faking-photons by requiring stringent isolation
  - Straightforward for high mass diphoton resonance search
  - Challenging for low-mass resonances with highly boosted states (consider m(a) < 15 GeV)

$$\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

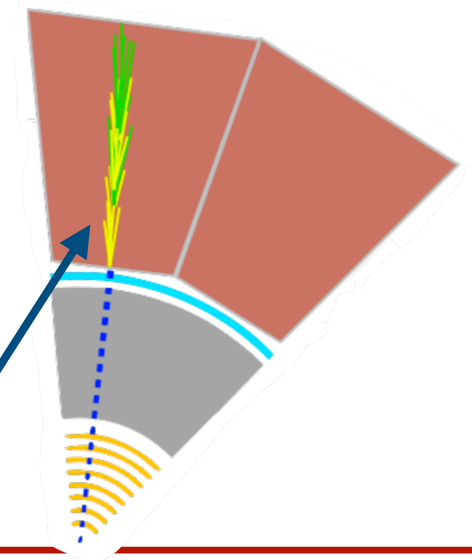
Two well-separated photons



Two (or more) nearly-merged photons

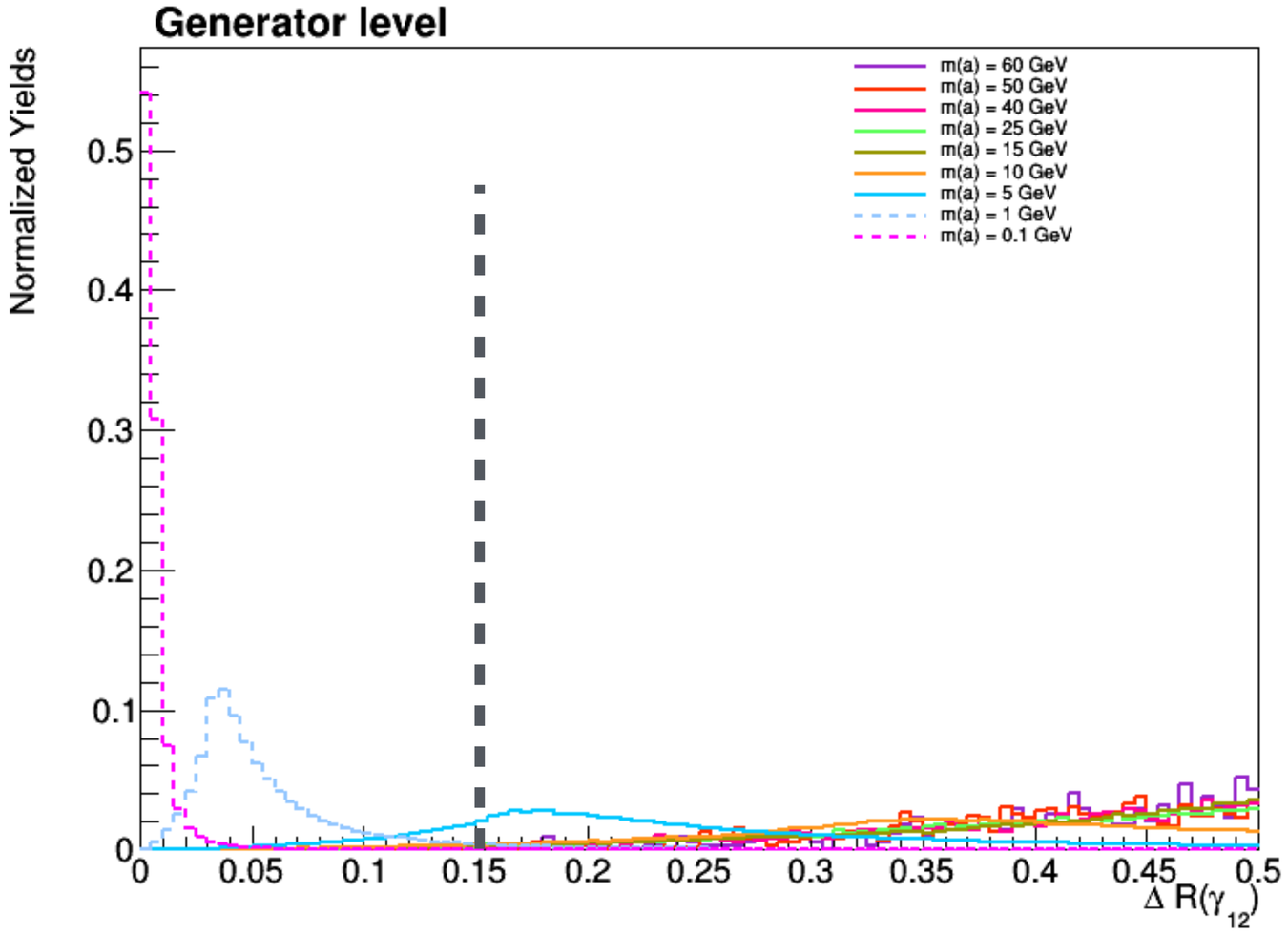


Two completely overlapping photons



Sometimes referred to as "photon-jets"

Motivation to perform a Generator level study

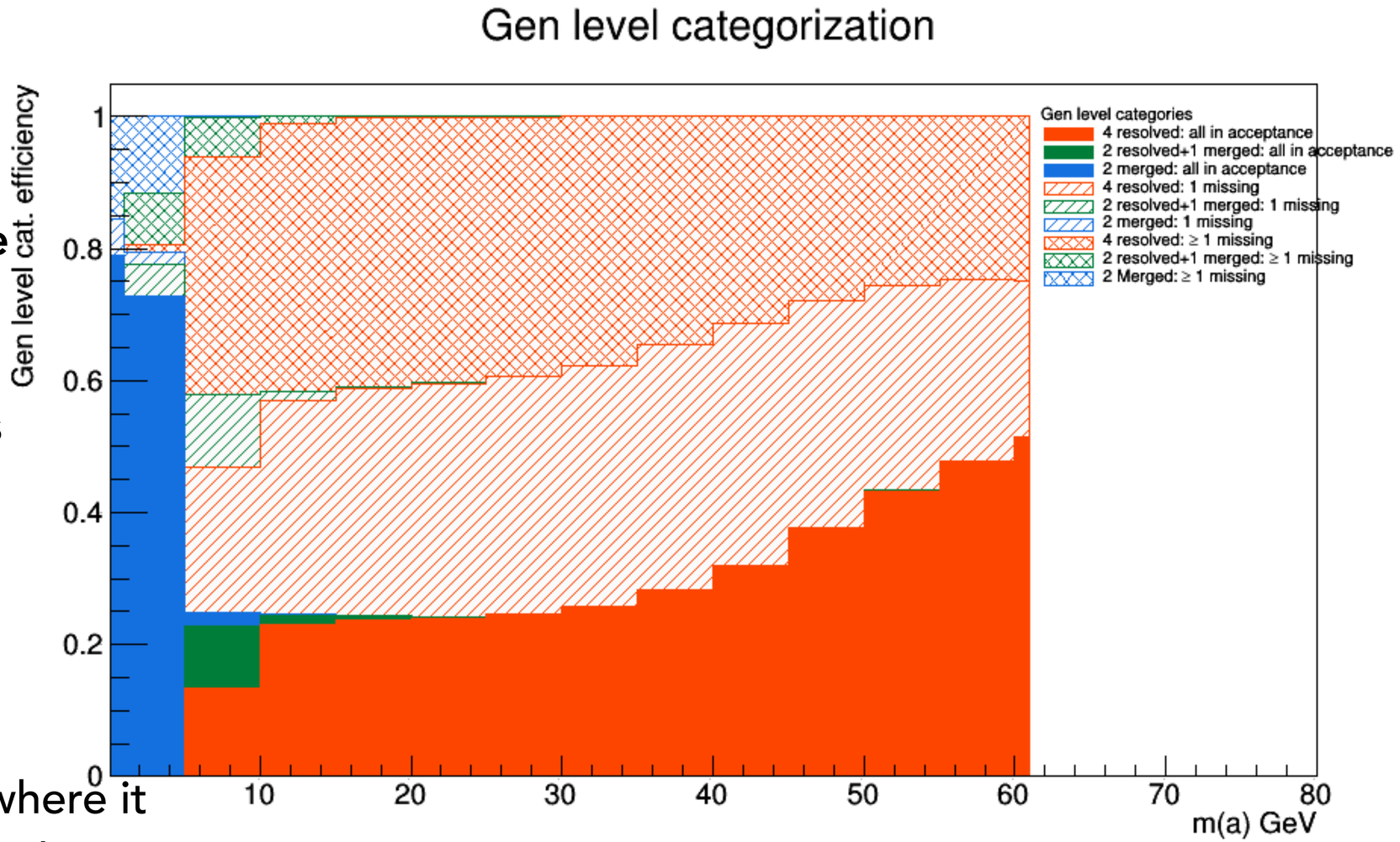


- For a cluster of 5x5 crystals in ECAL, **ΔR ~ 0.123**
- ΔR between photons from the same "a"
- Consider **γ**'s to be isolated if ΔR > 0.15

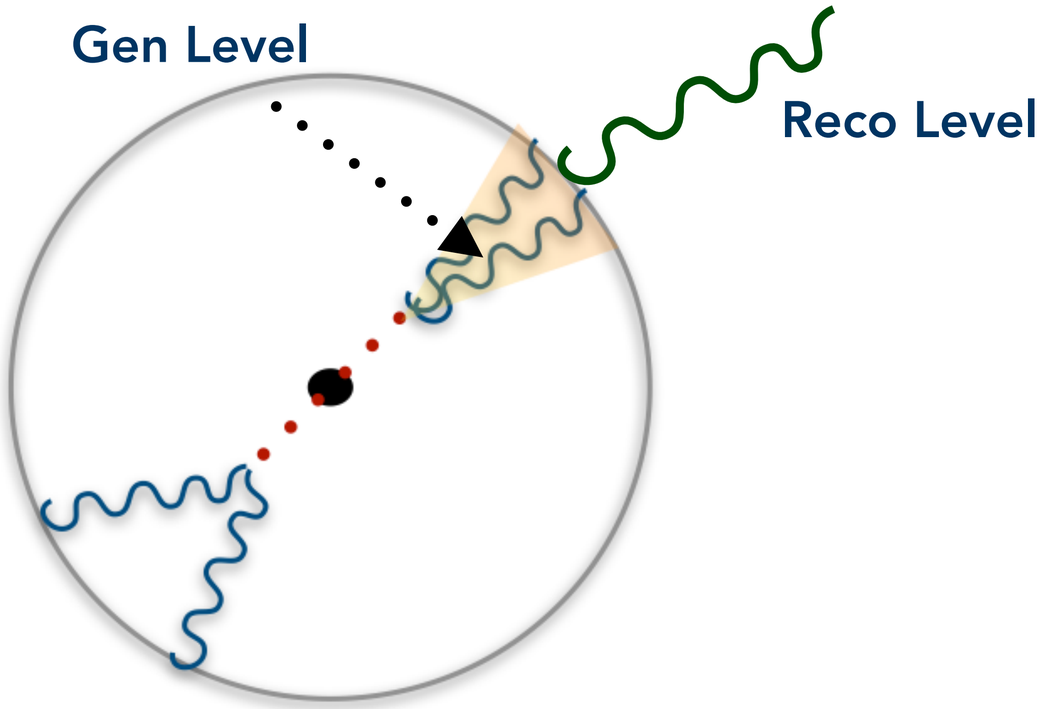
- For m(a) < 5 GeV, most **γ**'s (coming from the same "a") are merged, i.e cannot be reconstructed as two separate photons

Generator level study

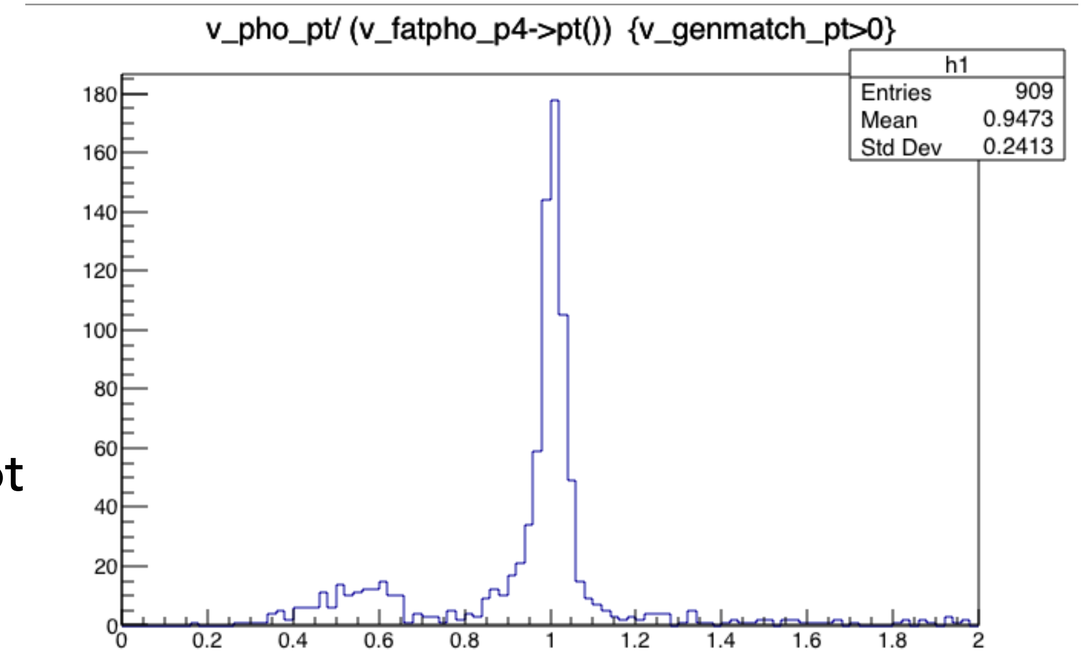
- If no pairs found with $\Delta R < 0.15$
  - **4 resolved γ's case**
- 1 pair with $\Delta R < 0.15$
  - **2 resolved + 1 merged γ's case**
- 2 pairs with $\Delta R < 0.15$
  - **2 pairs of merged γ's case**
- Detector acceptance requirements
  - P_T **γ**1 > 30 GeV
  - P_T **γ**2 > 18 GeV
  - P_T **γ**3 > 10 GeV
  - P_T **γ**4 > 10 GeV
  - |**η**| < 2.5
- The solid colors represent events where it is possible to reconstruct the tetra-photon mass peak



Gen-Reco Matching



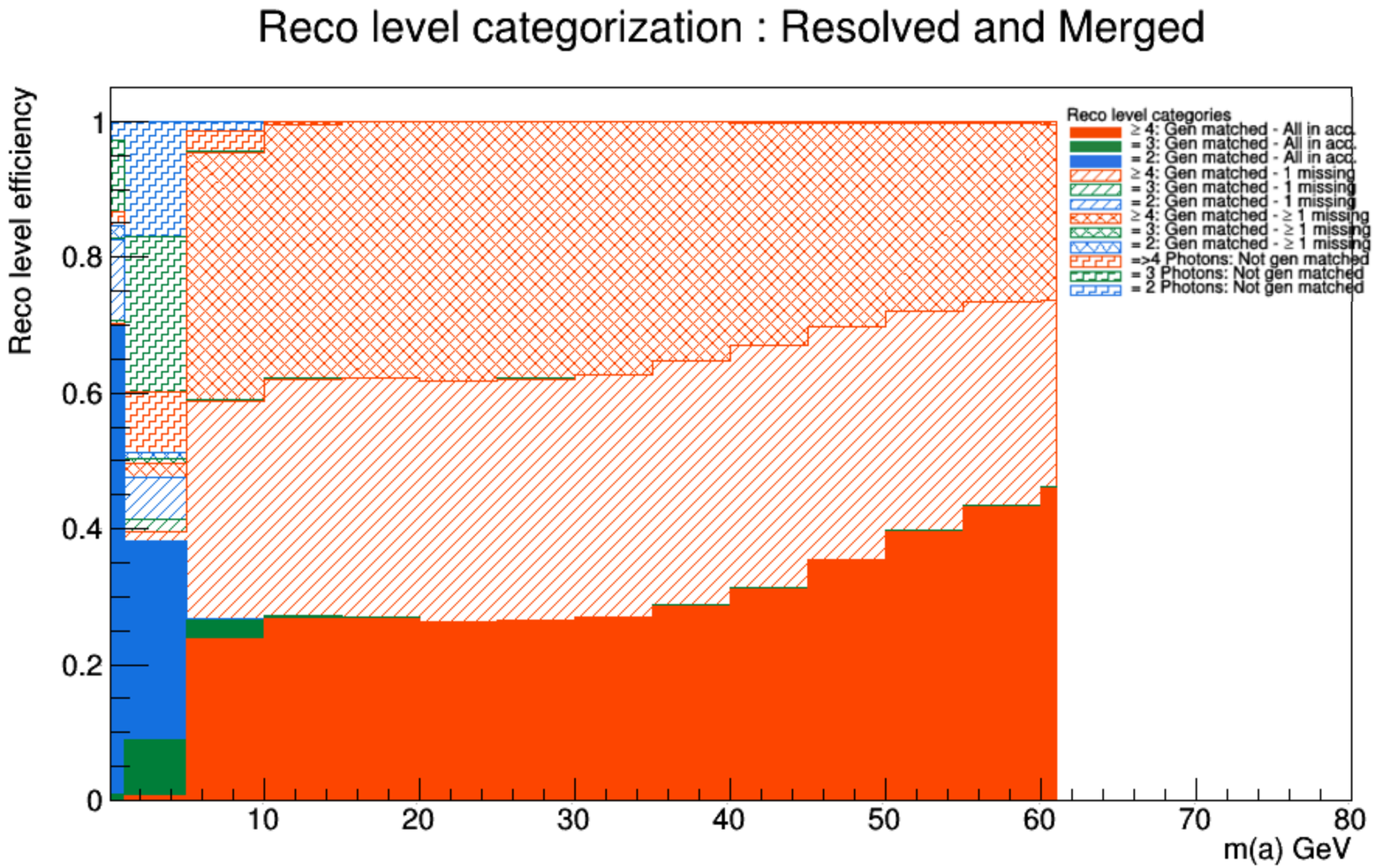
- If the Reco level photon is close to two Gen photons within a cone of $\Delta R = 0.15$, then its said to be matched to a Merged photon
- Closure test for this Gen-Reco matching
- Plot ratio of P_T of Reco photon (has been gen-matched) / P_T of gen-level merged photon



- Peaks around 1 most times
- Why the small peak around 0.5? (Maybe the definition of merged photon @ gen level is not optimal?)

Reco level categorization

- Mimic the same categories at Reco level with the existing gen-reco matching algorithm
- Like the categories at the Gen-level, for m(a) > 5 GeV, most events are of the kind with 4 resolved photons
- There are also events where Reco photons are not correctly Gen-matched (being investigated)



Conclusion

- In agreement with HGG convenors we have decided to concentrate on the 4 resolved photon category until the end of this year — Most pieces of the analysis machinery exists for this category

- Next meeting — present a full picture of this category (along with new work on background and signal modeling)