"Photon-jet" search

"Photon-jet": A highly collimated grouping of multiple photons which leads to one EM cluster, comparable to the size of that of a single photon ($\Delta \phi \times \Delta \eta = 0.075 \times 0.175$ for photon reconstruction in barrel)

They arise from BSM models with multiphoton final states. (e.g. extended Higgs sector, axions) Decay products of a high-mass resonance will be boosted. When these boosted particles decay to multiple photons, they form photon-jets.

Analysis overview

Event selection:
- At least 2 reconstructed photons with high $E_T$
- Loosely defined photon ID criteria
- Tight isolation cut

Categorization:

**Category 1: Low-$\Delta E$**
- 2 selected reco photons with $\Delta E \leq 200$ MeV
- Photon-jets with $\frac{m_a}{m_X} \leq 0.002$
- Background: Mostly SM $\gamma\gamma$ events

**Category 2: High-$\Delta E$**
- At least 1 selected reco photon with $\Delta E \geq 200$ MeV
- Photon-jets with $0.002 < \frac{m_a}{m_X} < 0.01$
- Background:
  - ~50% SM $\gamma\gamma$ events
  - ~50% hadronic-jet events ($\gamma j$ and $jj$)
- Less (~1/8) background yield compared to the other category
  \[ \Rightarrow \text{Good sensitivity for } 0.002 < \frac{m_a}{m_X} < 0.01 \]

Diphoton mass distribution

Statistical method:
- $S + B$ unbinned fit
- Signal: Crystal Ball function (i.e. Gaussian + power-law tails)
- Resolution $\sim 1\% \times m_X$ (Narrow width approximation)
- Background: Function fit
  \[ N (1 - x)^{\alpha} x^{\beta + c \log x} \quad (x = \frac{m_\gamma \gamma}{13 TeV}) \]
- Systematic uncertainty evaluation with Spurious Signal method

Results

Reinterpretation