

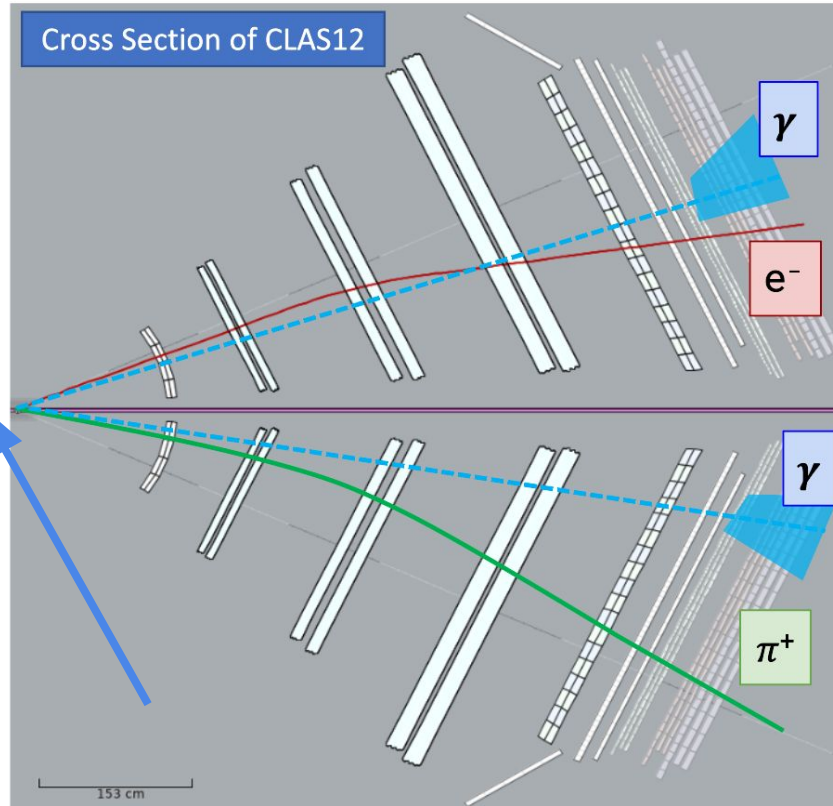
# Photon Classification with Gradient Boosted Trees at CLAS12



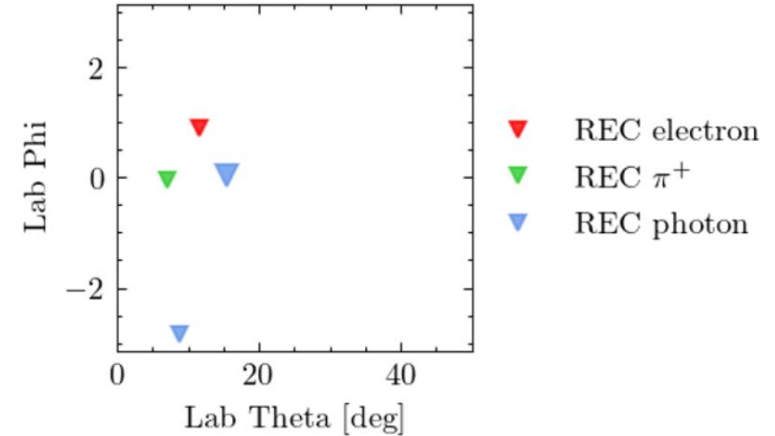
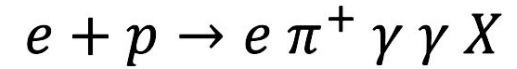
Gregory Matousek



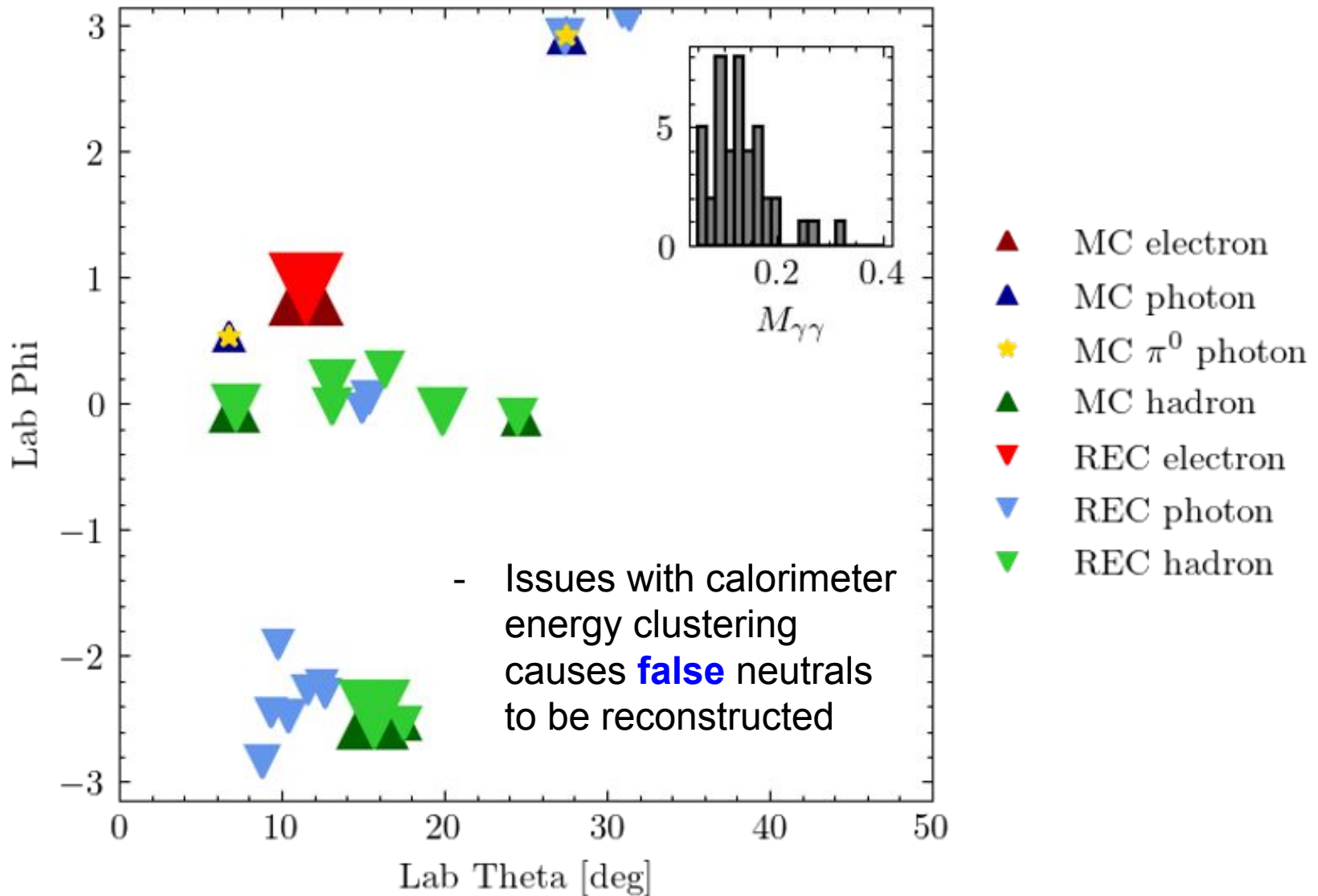
# Ideal $\pi^\pm\pi^0$ dihadron event @ CLAS12



Fixed proton target



# Typical $\pi^{\pm}\pi^0$ dihadron event @ CLAS12



# Photon GBT Classifier

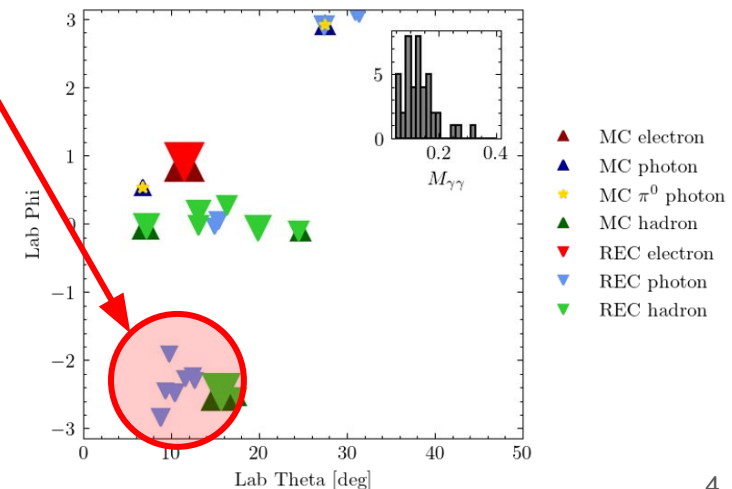
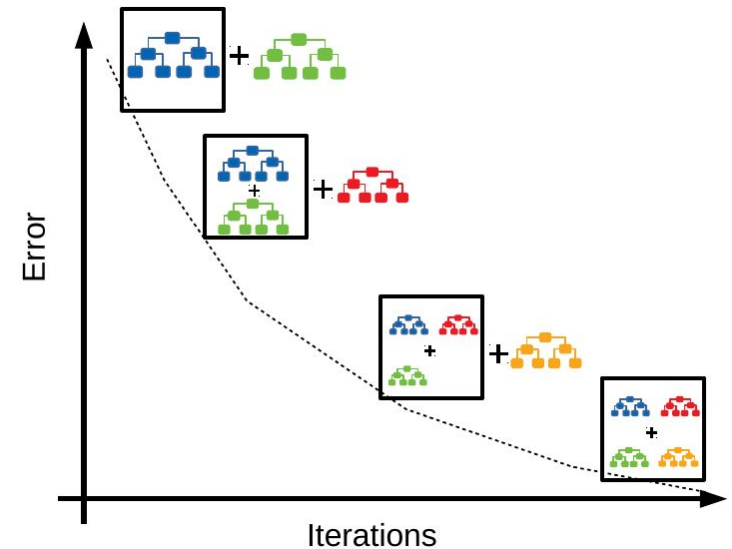


## CatBoost

- Using Gradient Boosted Trees architecture handled by **CatBoost**
  - Many weak learner trees → strong classifier
  - Handles empty inputs (useful for nearest neighbor structure)

### *Model Structure*

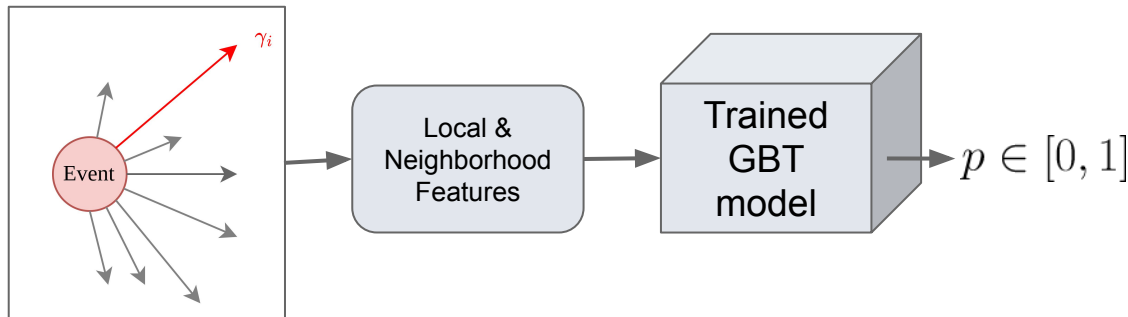
- N Trees: 1000
- Tree Depth: 10
- Learning Rate = 0.1
- Symmetric Growth Policy
- 16 inputs (5 intrinsic, 9 nearest neighbor)



# Photon GBT Classifier

Train on intrinsic ( $E_{\text{dep}}$ ,  $\theta$ , calo-shape, etc. ) and nearest neighbor ( **angular separation with N-nearest charged hadron, neutral particle, etc.**) features

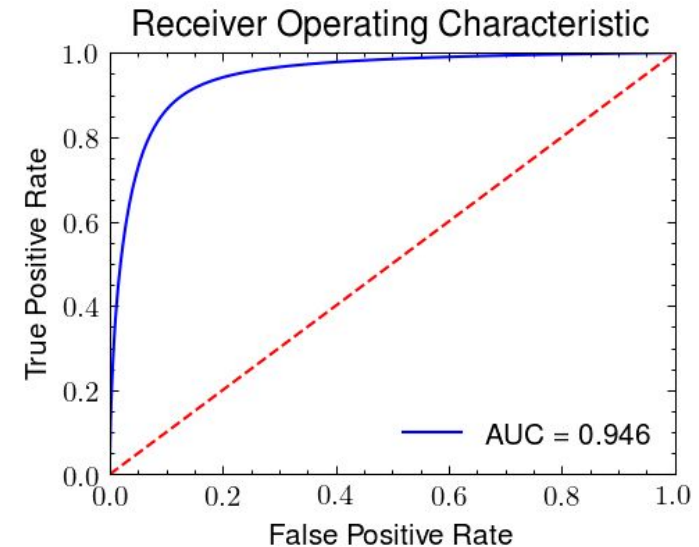
photon of interest (POI)



$p \approx 0 \rightarrow$  Photon does not have a MC match (background)

...

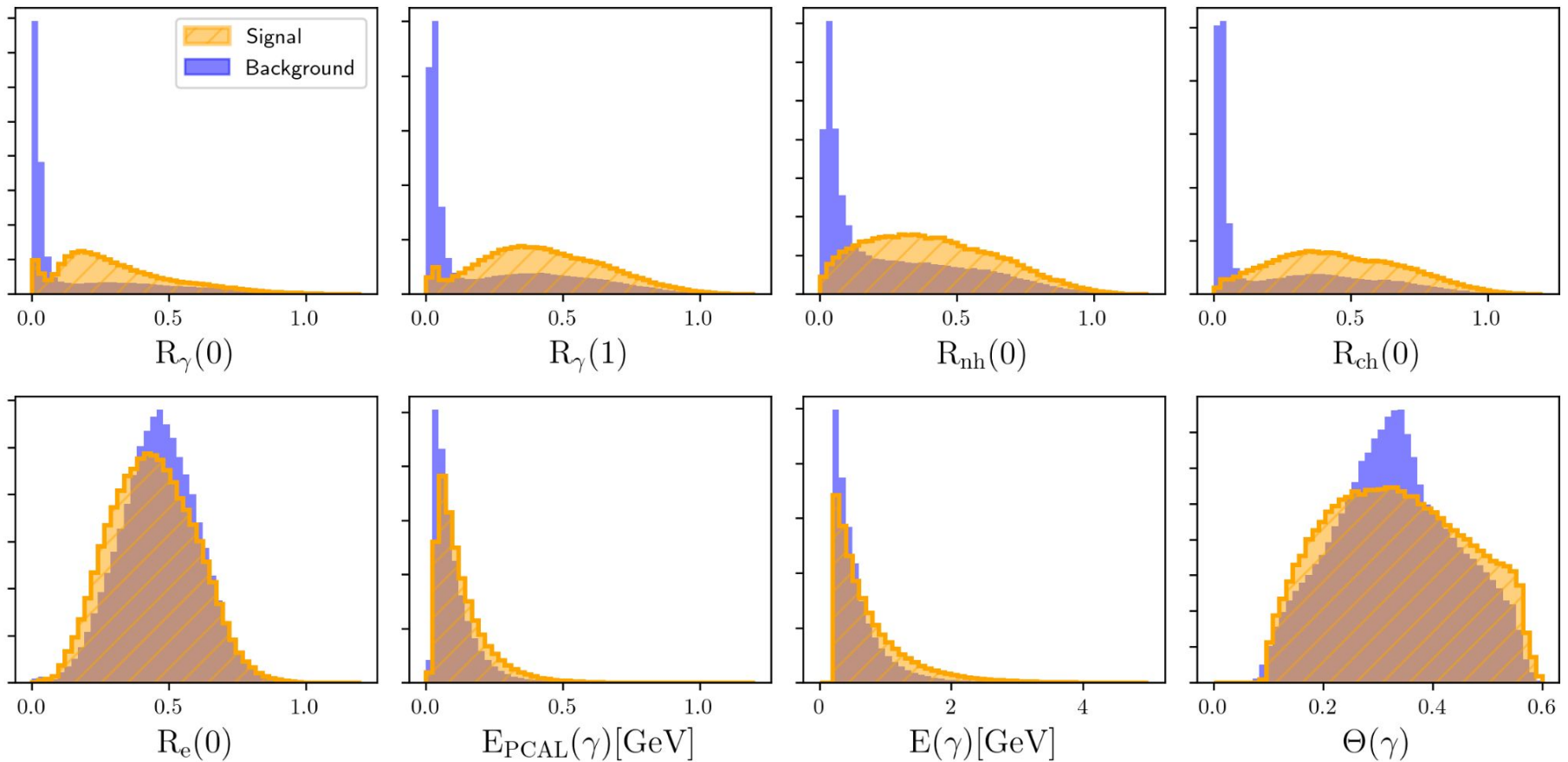
$p \approx 1 \rightarrow$  Photon likely has MC match (signal)



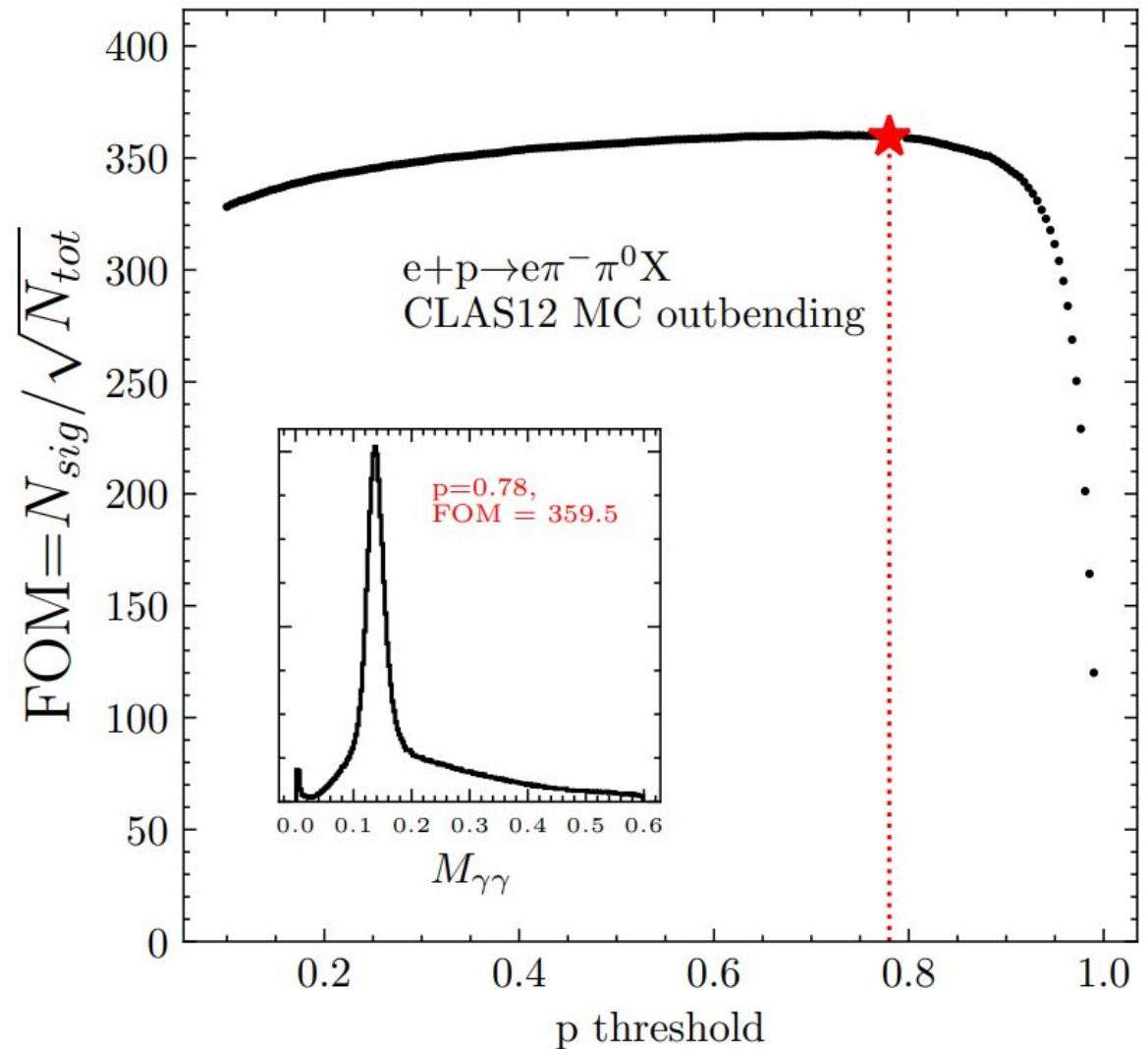
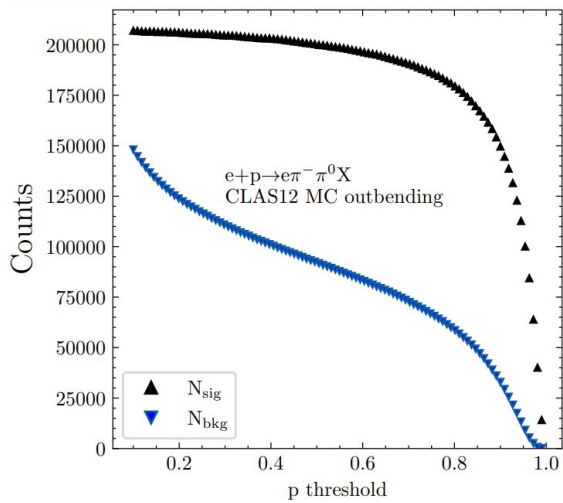
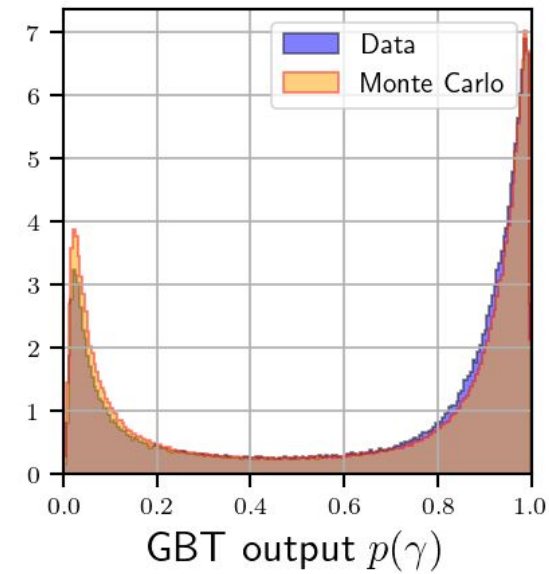
**Avoids learning resonant structure**

# Sample Set of Model Parameters

$R_a(n) \rightarrow$  Angular distance to  $(n+1)$ th nearest particle 'a'

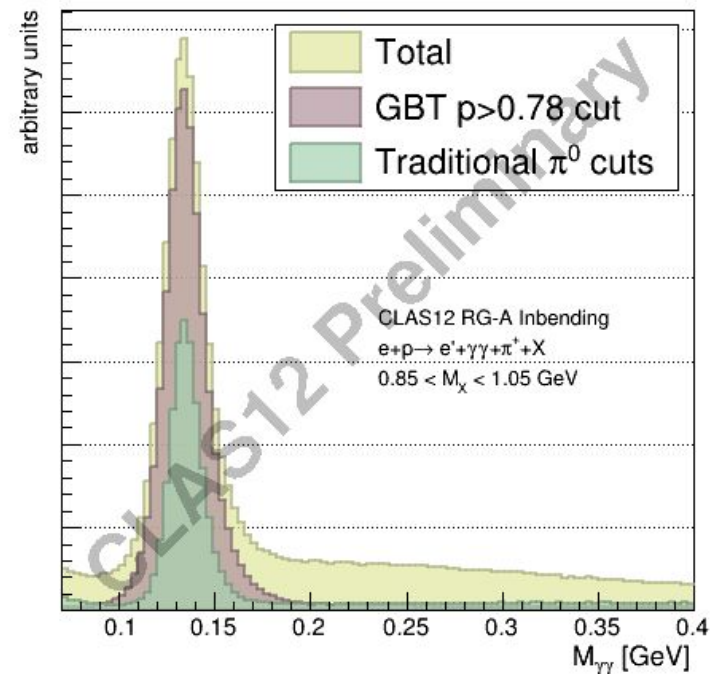
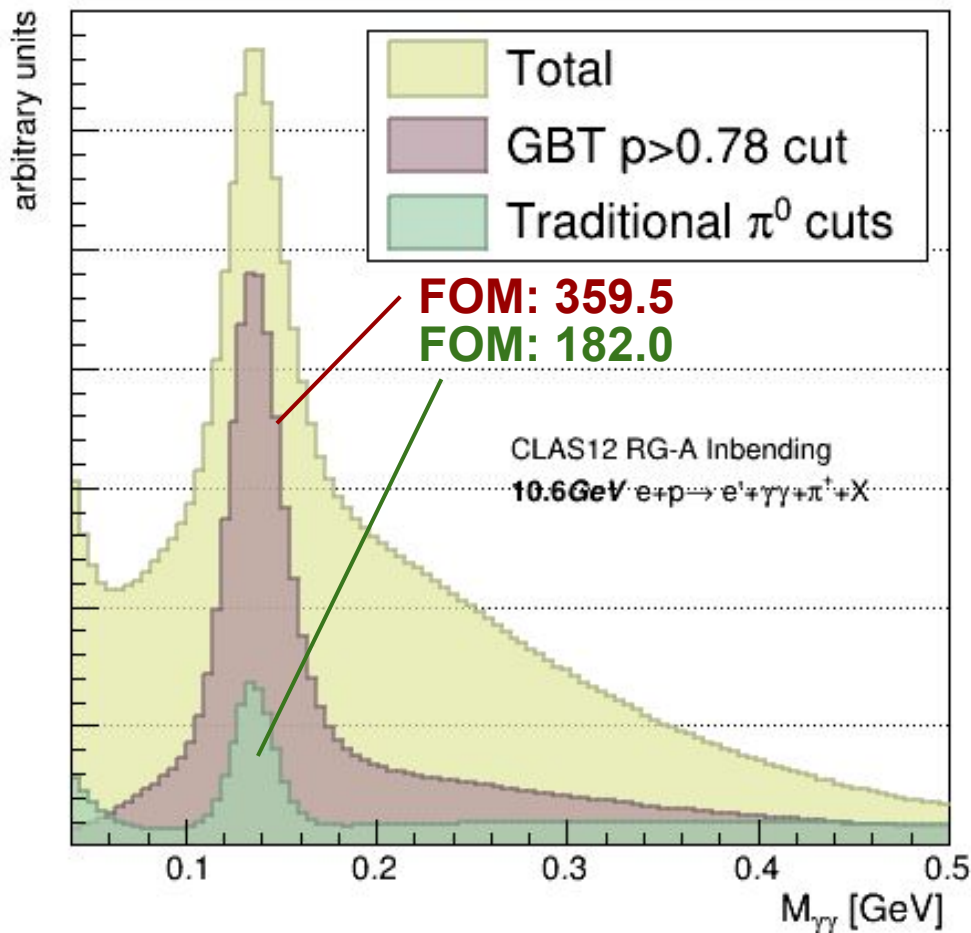


# Model Performance



# Conclusion

- Photon classifier targets **false photons** at CLAS12 → purifies  $\pi^0$  signal w/o training on  $\gamma\gamma$  resonance → Applicable for many  $\pi^0$  studies
- Tutorial @ [https://github.com/Gregtom3/clas12\\_photon\\_classifier](https://github.com/Gregtom3/clas12_photon_classifier)



Exclusive  $\rho^+ \rightarrow \pi^+\pi^0$  channel