Weekly report

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Working status

Analysis:

- HGTD: conveners have no reply to the result. Not sure about the progress.
- VBF Higgs CP: Branching ratio calculation.

QT: Photon ID optimization

- Previous study shows some contribution from photon TopoCluster variables.
- Add those variables to Z->llg framework, to get known of them.

Shift:

- Twice a week in future 2 weeks.

Photon ID optimization

Motivation:

- Present photon ID is derived from shower shape variables only, from Run1 period.
- Plan to add some variables describing superclusters, to improve identification.

Approach:

- Start with HGamSinglePhotons package, plot distributions for signal(γ+jets) and background(fake jet) for new variables, and data-MC comparison.(Finished by Tyler previously)
- Repeat it in Radiative-Z framework, for MC modelling with Z->llg process. (My first step)
- Re-optimize the photon ID menu and check the improvement.

Photon ID optimization

Topo Clusters

Formation

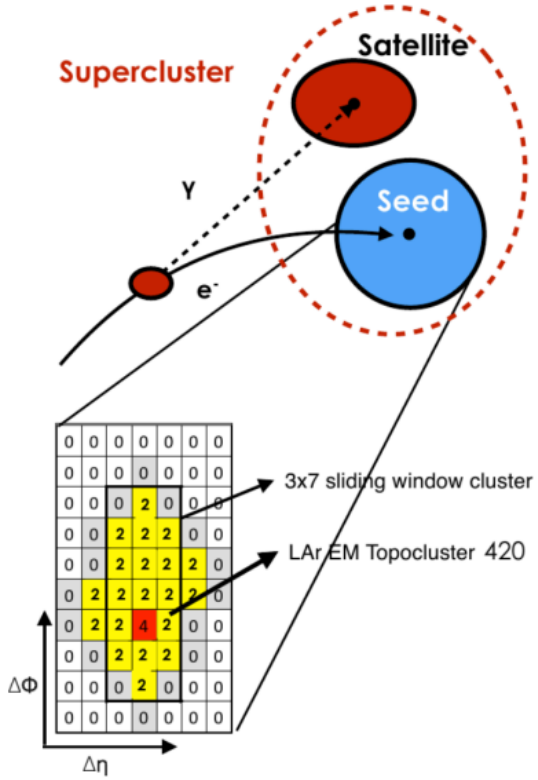
Find “seeds” - cells with signal significance > 4σ
- Order by significance

Grow by scanning neighbor cells
- If significance > 2σ, then add cell+neighbors to cluster
- Continue until all cells are grouped

In the case two seeds grow into each other, clusters are merged

Note - happens in a 3d space, depth is important too!

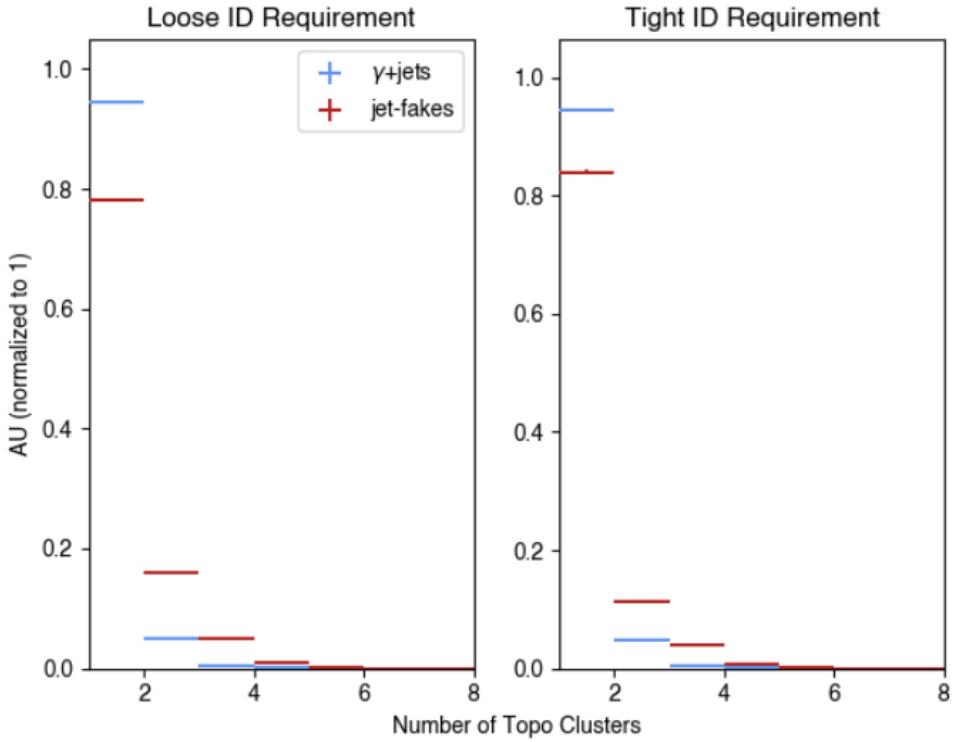
*“neighboring cell” in depth = partial overlap in (η,ϕ) plane



Photon ID optimization

Note

Topo clusters are **not** one-to-one with photon objects - have seen as many as 8 clusters/ photon, however, overwhelmingly one cluster/photon.



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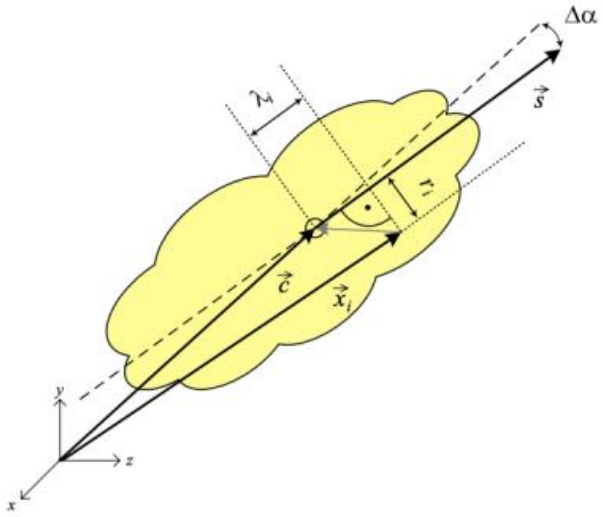
Photon ID optimization

Cluster shape

https://arxiv.org/pdf/1603.02934.pdf



- $\vec{c}$ *centre of gravity of cluster, measured from the nominal vertex* $(x = 0, y = 0, z = 0)$ *in ATLAS*
- $\vec{x}_i$ *geometrical centre of a calorimeter cell in the cluster, measured from the nominal detector centre of ATLAS*
- $\vec{s}$ *particle direction of flight (shower axis)*
- $\Delta\alpha$ *angular distance* $\Delta\alpha = \angle(\vec{c}, \vec{s})$ *between cluster centre of gravity and shower axis* $\vec{s}$
- λ_i *distance of cell at* $\vec{x}_i$ *from the cluster centre of gravity measured along shower axis* $\vec{s}$ $(\lambda_i < 0$ *is possible)*
- r_i *radial (shortest) distance of cell at* $\vec{x}_i$ *from shower axis* $\vec{s}$ $(r_i \geq 0)$

$$r_i = |(\vec{x} - \vec{c}) \times \vec{s}|$$

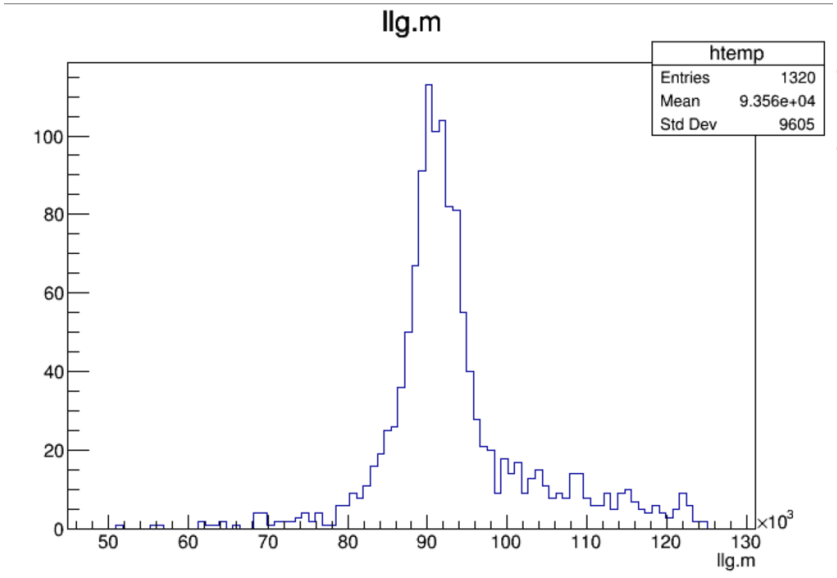
$$\lambda_i = (\vec{x_i} - \vec{c}) \cdot \vec{s}$$

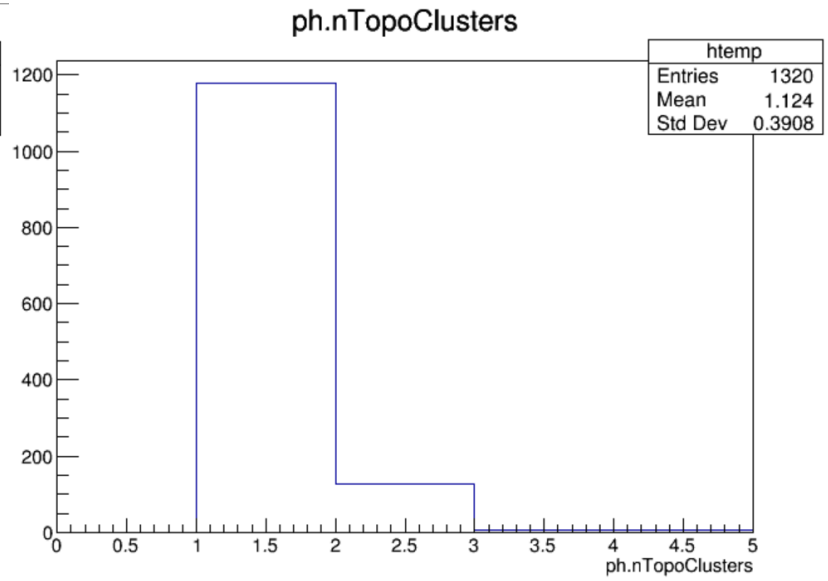
Photon ID optimization

Variables extracted from cluster shape:

- y_ntopoCluster: number of topo clusters associated to photon object
- y_topoCluster0_secondR: Semi-major axis in width for the leading topo cluster associated to each photon.
- y_topoCluster0_secondLambda: Semi-major axis in depth for the leading topo cluster associated to each photon.
- y_topoCluster0_centerLambda:Depth of leading topo cluster at its centroid.
- y_topoCluster0_isolation: Energy weighted fraction of non-clustered perimeter cells

Photon ID optimization



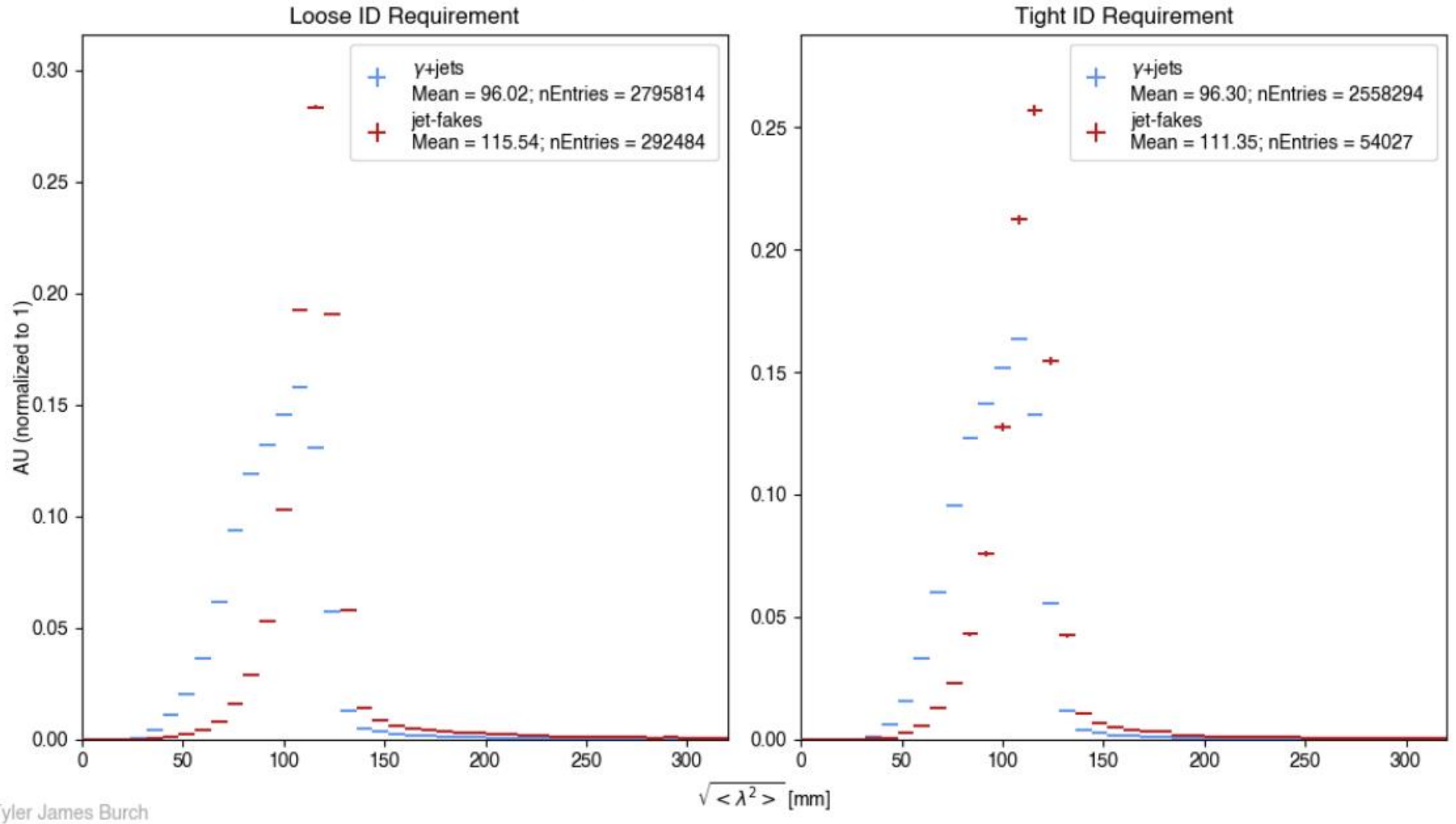


Left: $m_{ll\gamma}$ right: nTopoClusters.

Present progress:
Only nTopoClusters is successfully implemented in Radiative-Z framework.
Code crashed when calling xAOD::EgammaHelpers:getAssociatedTopoClusters().

Backup

Cluster Shape Information, λ



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Topo clusters associated with photons on average are less long in the calorimeter depth direction than jet-fakes

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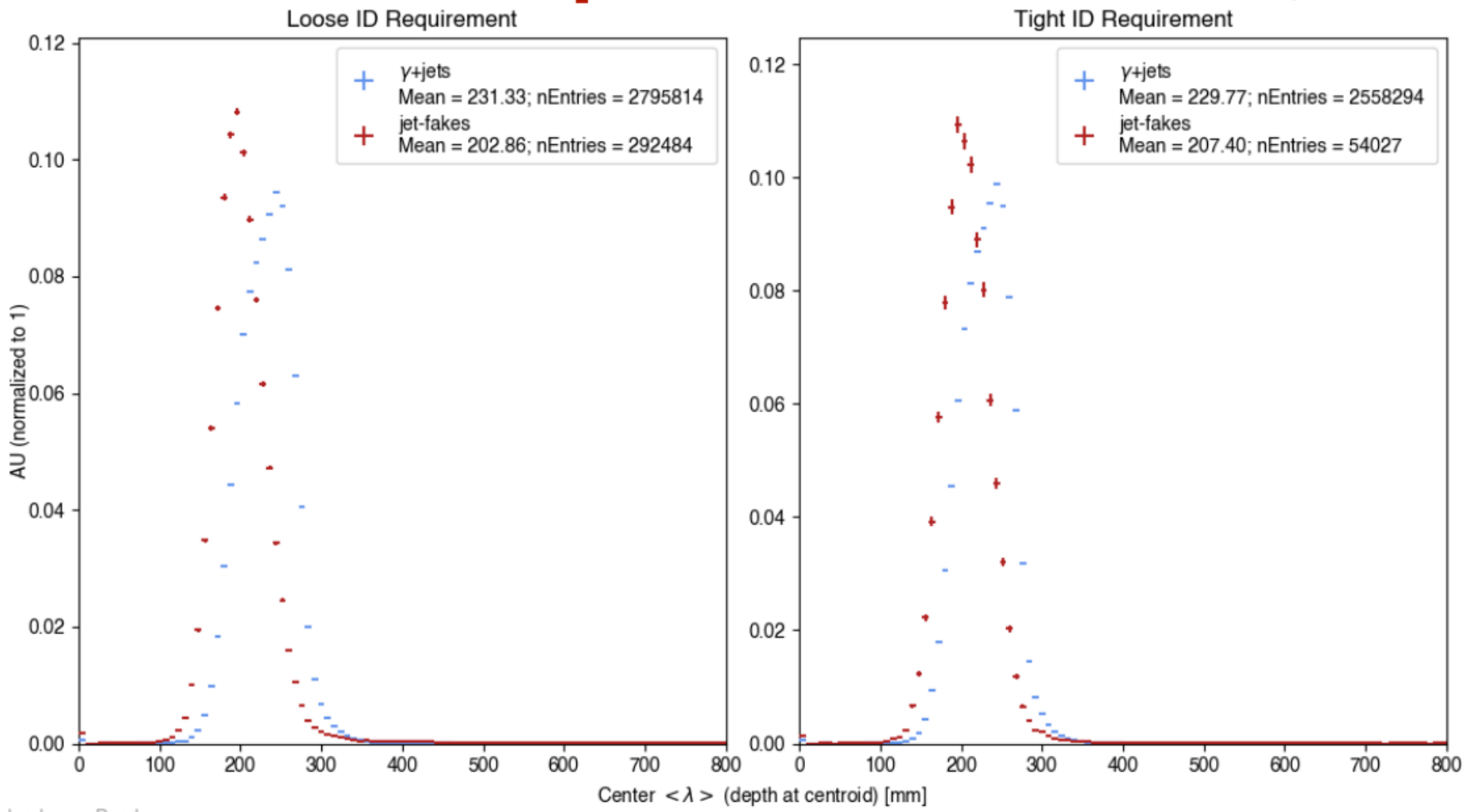
Cluster Shape Information, λ



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Can also look at the depth at cluster centroid - photons are slightly deeper at the centroid than jet-fakes

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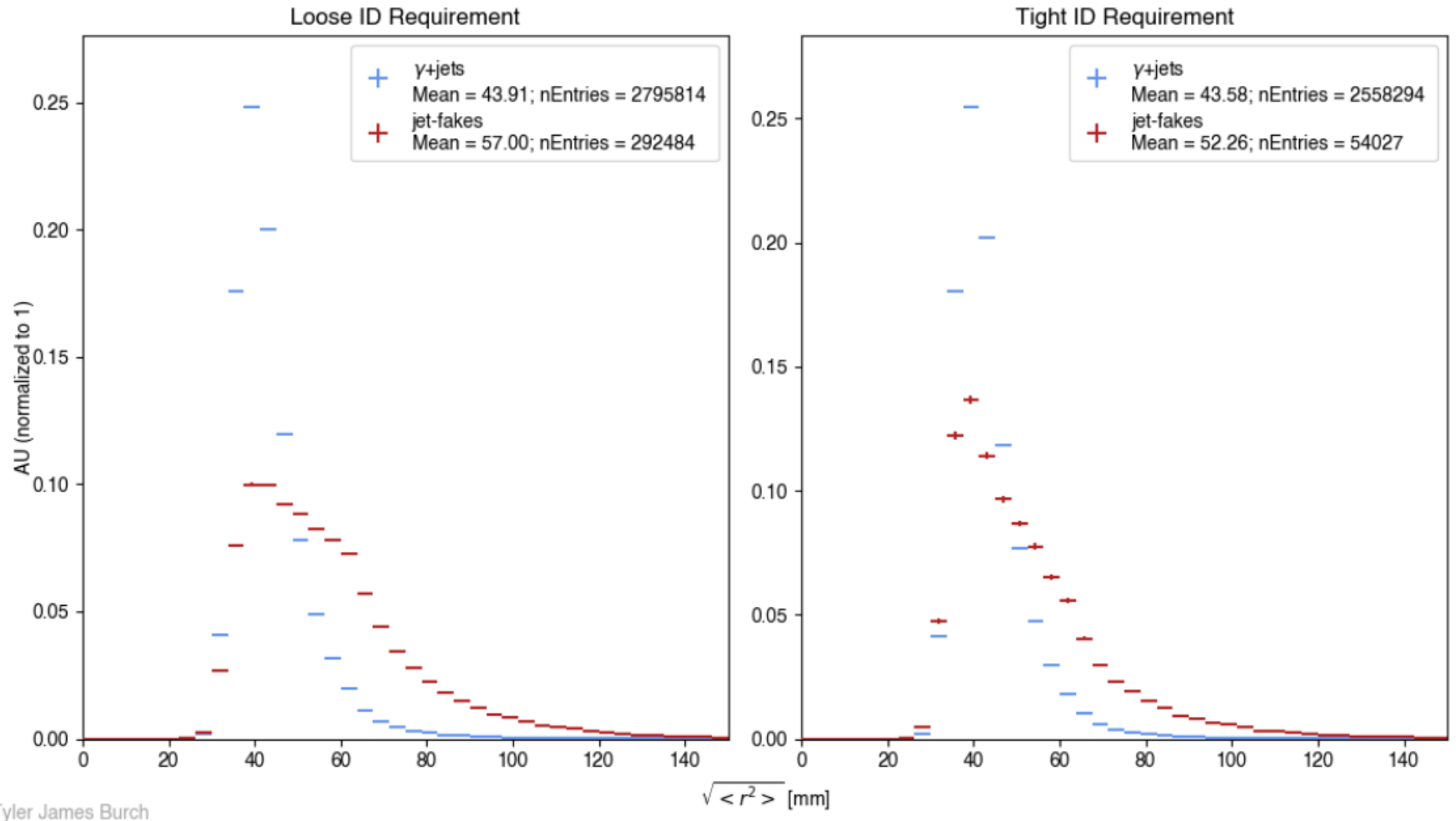
Cluster Shape Information, R



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Jet fakes are notably wider than photons. Difference is slightly less once applying tight ID requirement, but still some separation

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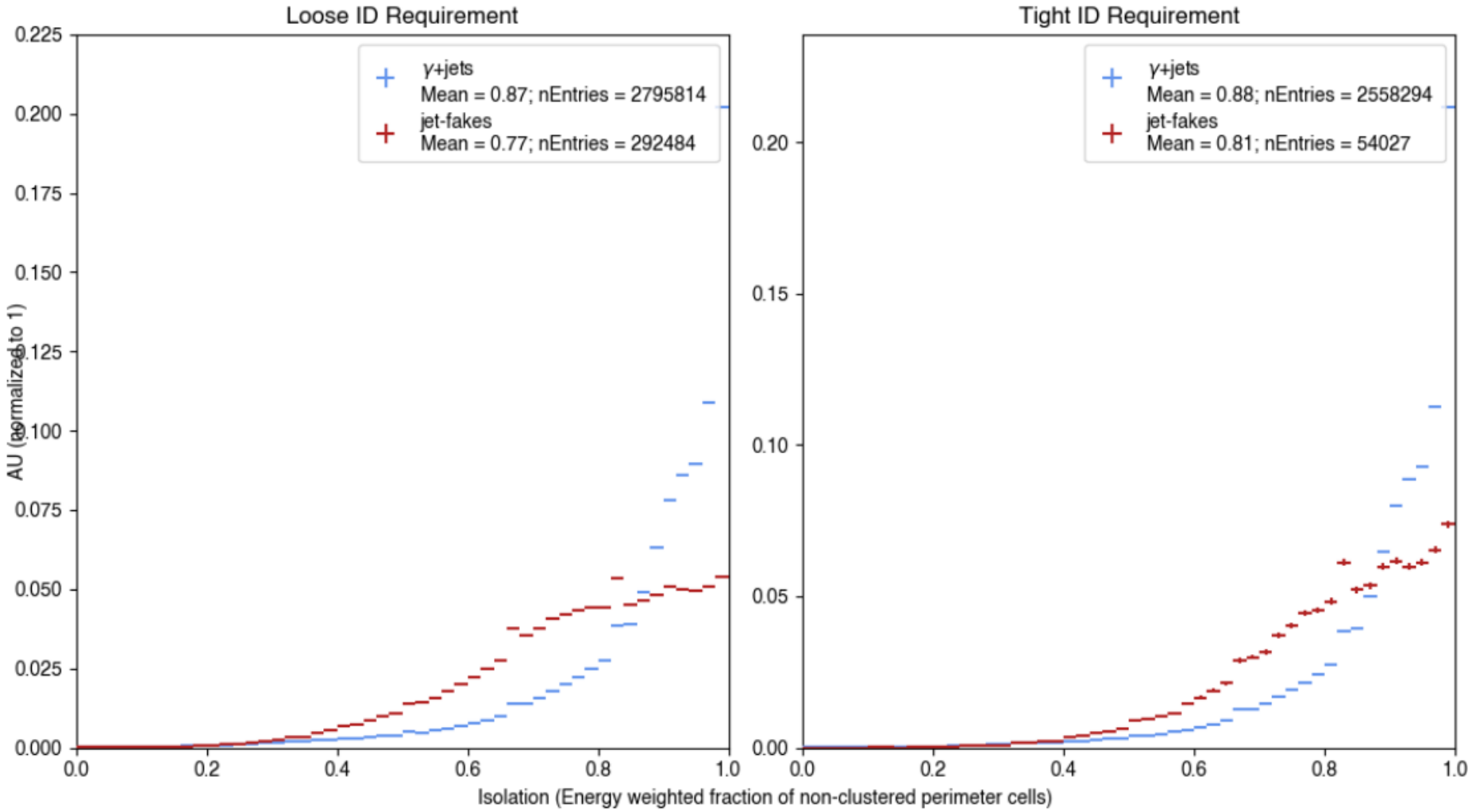
Isolation



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Good separation observed… but should do further looking into correlation with calo/track isolation

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BDT Studies

Starting point: mirroring studies by Jan-Hendrik presented earlier this year

- Compared BDT to established cuts-based optimization using same inputs
- Attempted to replicate this using the same inputs, then add topo-cluster variables
- Preselection and cuts listed below, working from locally produced SinglePhoton ntuple (containing topo cluster information)

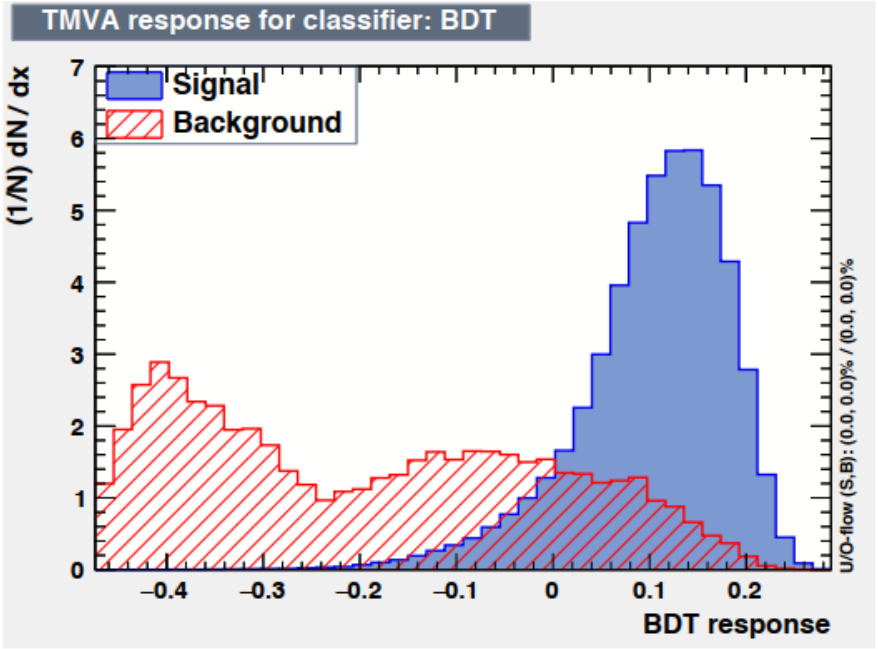
Topo-Cluster variables considered:

y_topoCluster0_secondLambda - semi-major axis in depth (for leading topo-cluster)
y_topoCluster0_centerLambda - depth of cluster centroid (for leading toro-cluster)
y_topoCluster0_secondR - semi-major axis in width (for leading topo-cluster)
y_topoCluster0_emProbability - Likelihood (leading) topo-cluster originated from an EM shower
y_topoCluster0_isolation - Energy weighted fraction of non-clustered perimeter cells (for leading topo-cluster)
y_nTopoClusters - Number of topo-clusters associated to photon object

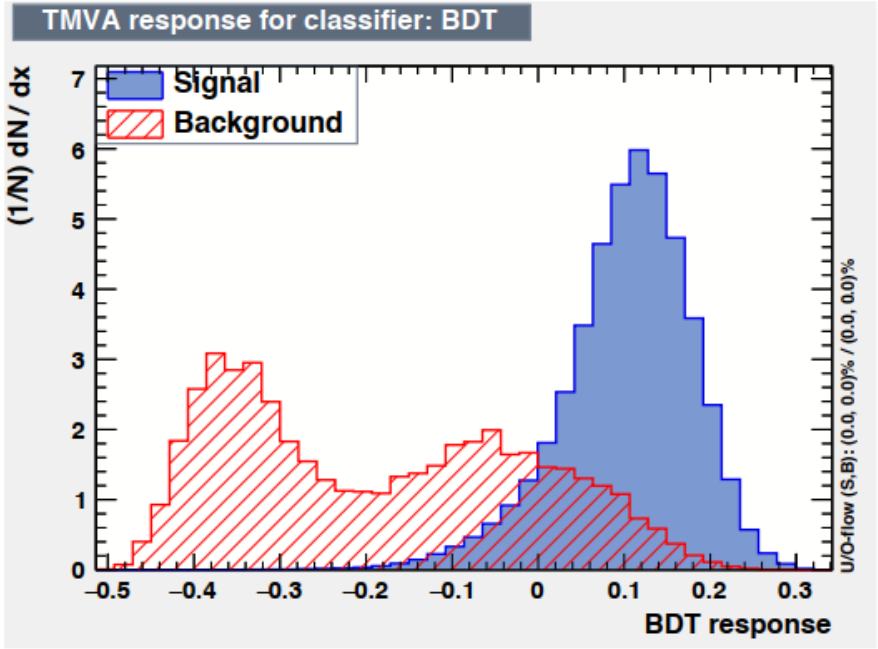
	Signal	Background
y_isTruthMatchedPhoton	True	False
acceptEventPtBin	True	
y_isLoose	True	
y_f1	>0.005	
y_wtots1	>-10	
y_weta1	>-100	

Additional cuts:
- Lowest pT and Eta bins
  - |eta| < 0.6
  - 25 < pT/GeV < 60
- FixedCutLoose isolation
- Unconverted photons

BDT Studies



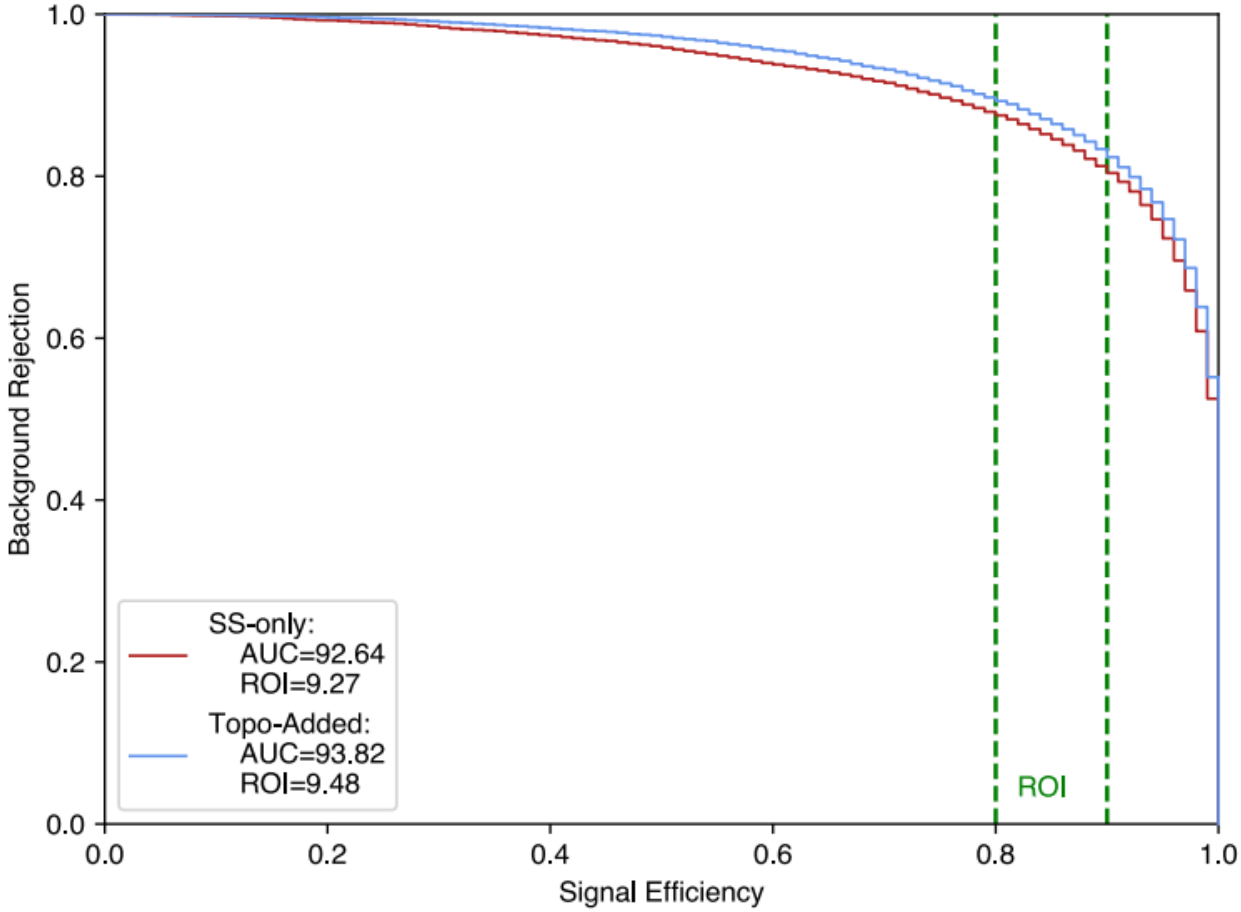
without topo-clusters



with topo-clusters

Slightly better separation observed when adding the topo-clusters

BDT Studies



Comparison to prior study:

N-1 variable	$0.00 \leq \lvert\eta\rvert < 0.60$ full	ROI
all	84.06	7.66

ROI: $0.8 < \varepsilon_{sig} < 0.9$

Nominal BDT, matched settings listed, expect ~similar performance

Background Rejection	SS-Only ε_{sig}	Topo-Added ε_{sig}
0.80	0.905	0.925
0.85	0.845	0.875
0.90	0.745	0.785
0.95	0.545	0.635

Few % increase in signal efficiency at the same background rejection by including topo-cluster variables

Improvement over preliminary look at cuts method (AUC = 0.897, formal study to follow)

(Only lowest pT/eta bin, certainly will change in different bins)

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