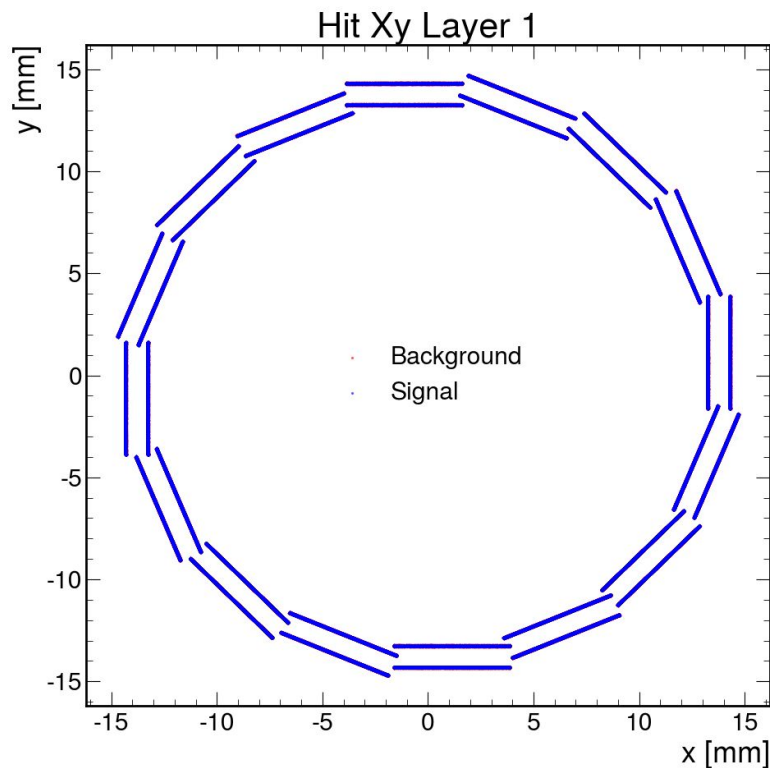


FCCEe Geometric Clustering Characterization

1



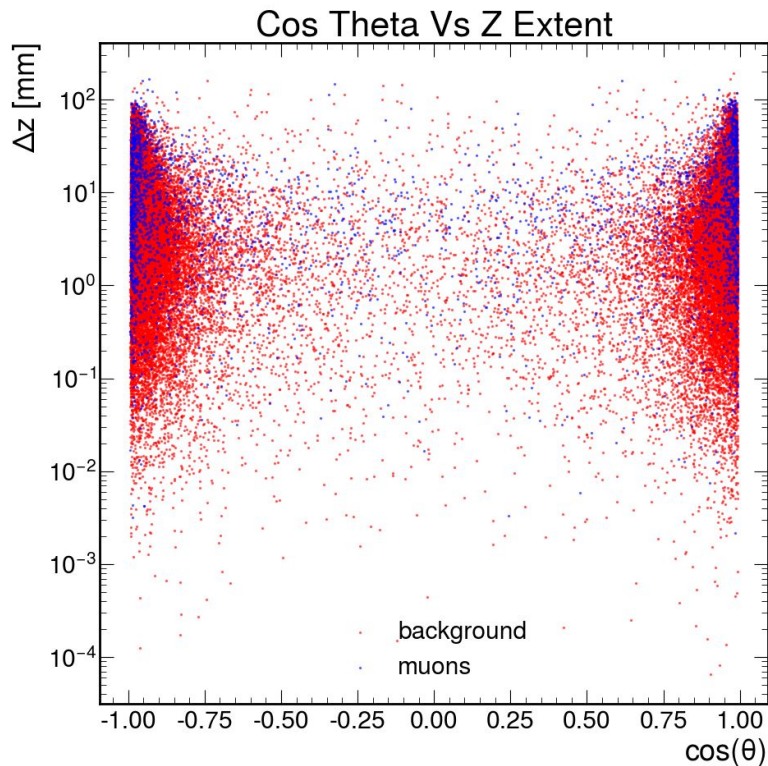
Layer 1 X vs. Y



- We see two readout layers. The outer I refer to as, layer 1B, the inner as layer 1A.
- Conservative classifier presumes readout is only possible per module, optimistic classifier considers crosstalk between concentric modules.

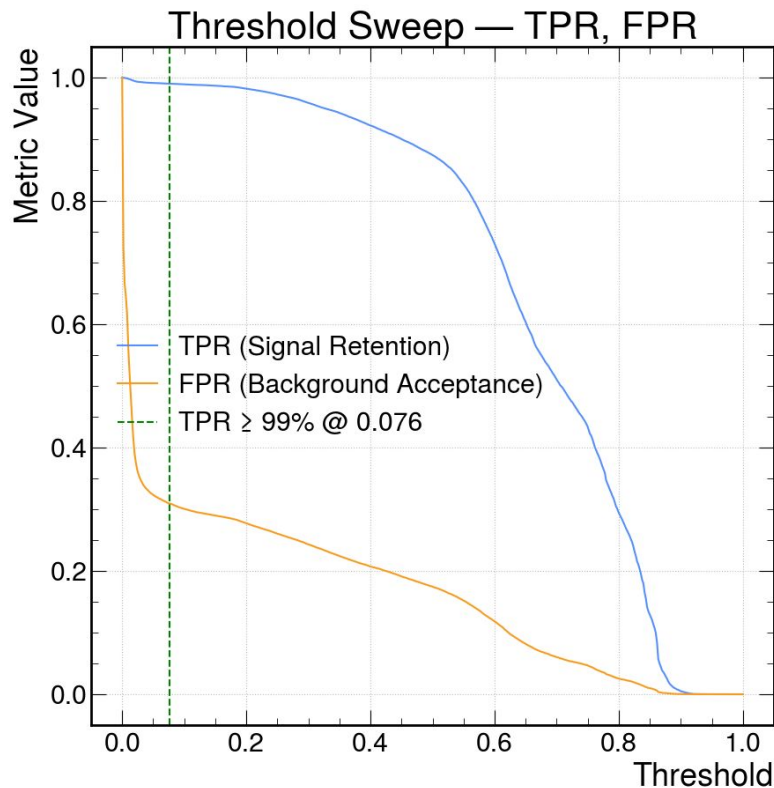
Conservative Separation

Conservative Separation Testing



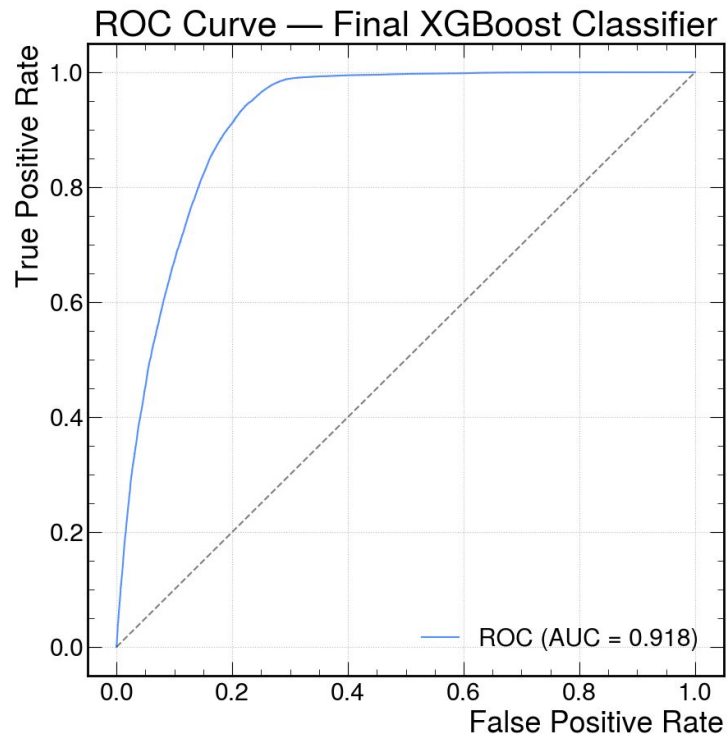
- Seeking to separate $Z \rightarrow q\bar{q}$ and muons from beam background, while preserving at least 99% of signal clusters.
- More conservative approach, only considering module level readout on layer 1A, thus no Δz relationship.
- Using gradient boosted decision tree with input features including: $\cos(\theta)$, e_{dep} , Δz , etc.

Method



- Grid search across hyper parameters for XGBoost, settling on: max depth = 8, learning rate = 0.1, positive weight = 0.5.
- Swept TPR/FPR thresholds to achieve $\geq 99\%$ signal retention and maximal background rejection.
- Final TPR/FPR threshold 0.0762.

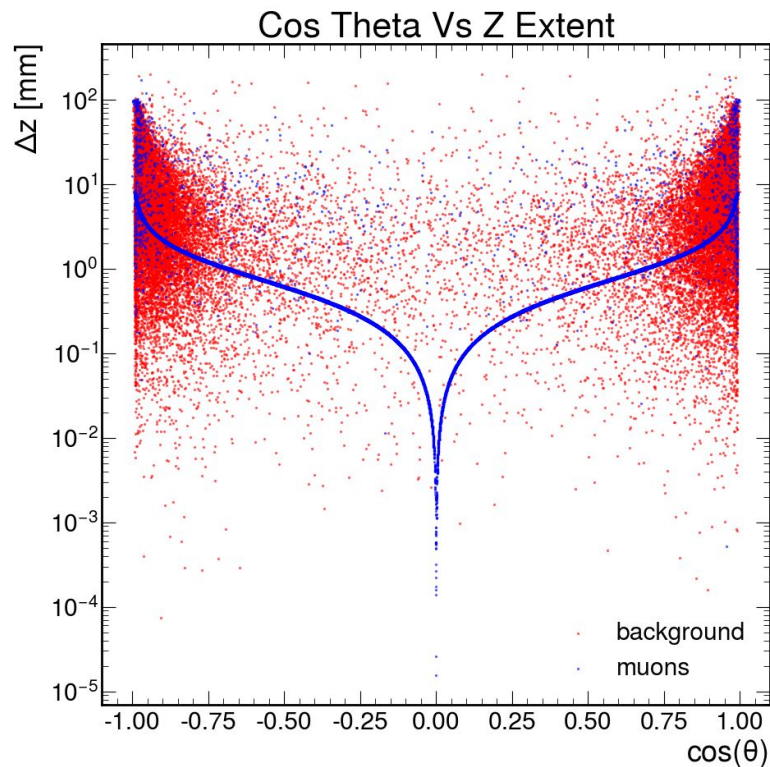
Final Conservative Classifier



- Final decision rule becomes:
 $\hat{y} = \mathbb{1} [P(\text{signal} \mid \mathbf{x}) \geq 0.0762]$
- Final classifier results in:
 - a. Signal retention = 99.0%
 - b. Background rejection: 69.1%
 - c. ROC AUC: 0.9177
 - d. Accuracy: 84.0%
 - e. Precision (signal): 76.3%

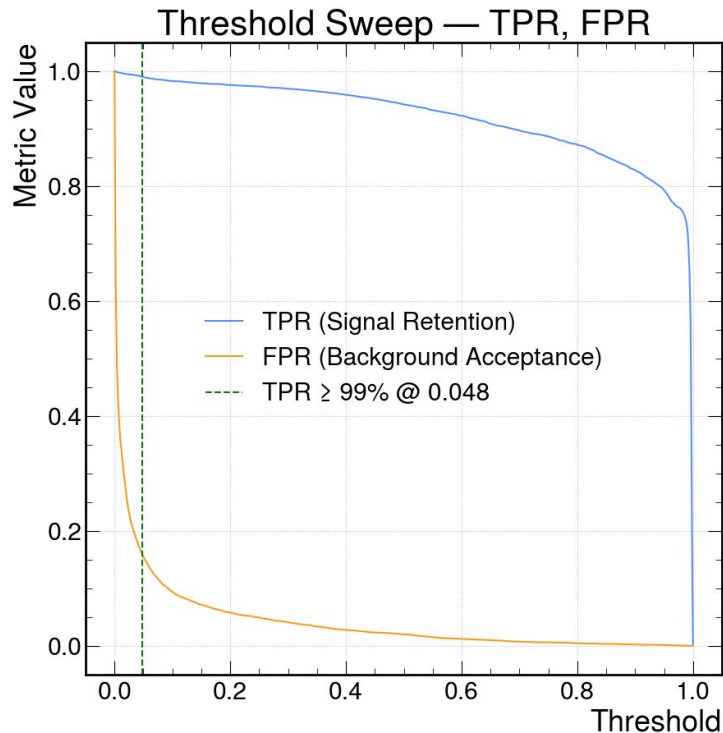
Optimistic Separation

Optimistic Separation Testing



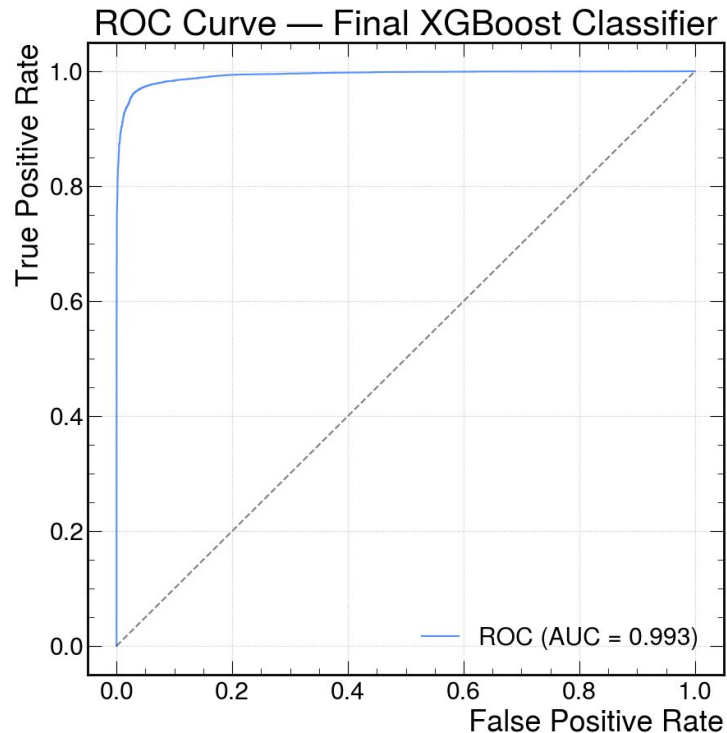
- Considers possibility of crosstalk between module pair on layers on 1A and 1B.
- With this crosstalk enabled: $\ln(\Delta z) = \ln(\Delta r * |\cot(\Theta)|)$ available to classifier (shown for muons & background).
- Using gradient boosted decision tree with input features including: $\cos(\theta)$, edep, $\log(\Delta z)$, etc.

Method



- Grid search across hyper parameters for XGBoost, settling on: max depth = 10, learning rate = 0.1, positive weight = 0.25.
- Swept TPR/FPR thresholds to achieve $\geq$ 99% signal retention and maximal background rejection.
- Final TPR/FPR threshold 0.0481.

Final Optimistic Classifier



- Decision rule becomes:
 $\hat{y} = \mathbb{1} [P(\text{signal} \mid \mathbf{x}) \geq 0.0481]$
- Final classifier gives:
 - a. Signal retention = 99.0%
 - b. Background rejection: 84.0%
 - c. ROC AUC: 0.9934
 - d. Accuracy: 91.0%
 - e. Precision (signal): 86.0%

Next Steps

- Further test optimistic classification algorithms besides XGBoost, (SVM, random forest).
- Run classifier across more physics besides muons and $Z \rightarrow qq$.
- Analyze radius of curvature vs. MC particle energy to verify curling in ϕ .