FCAL Shower Identification: True Photons vs SplitOffs

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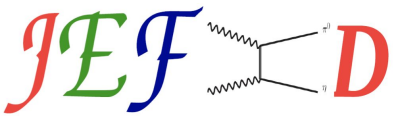
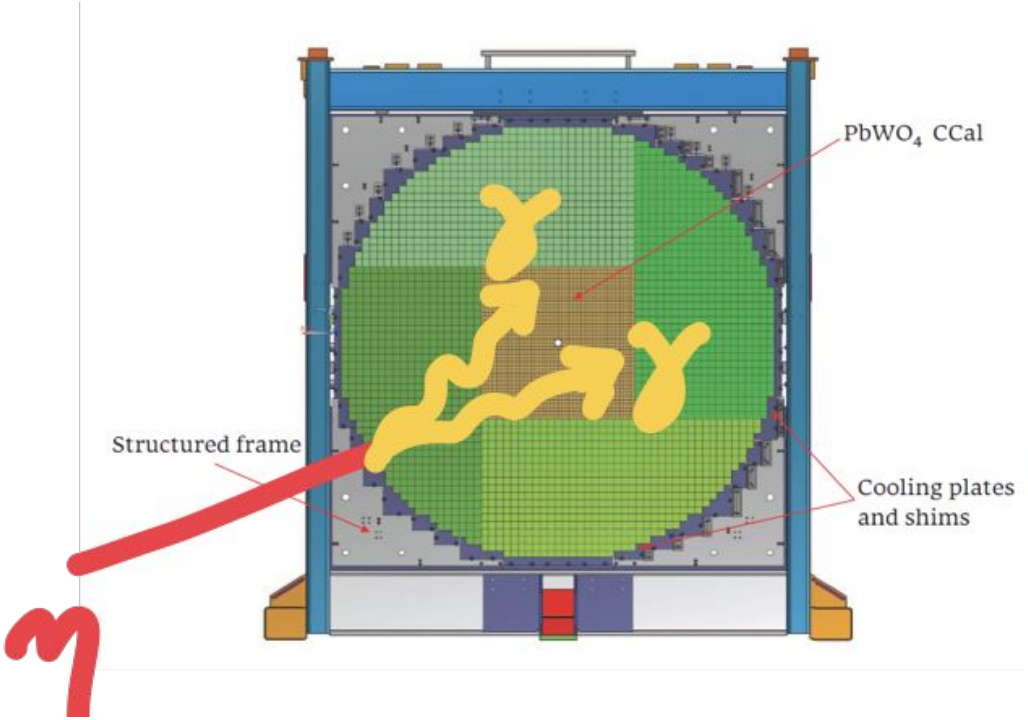
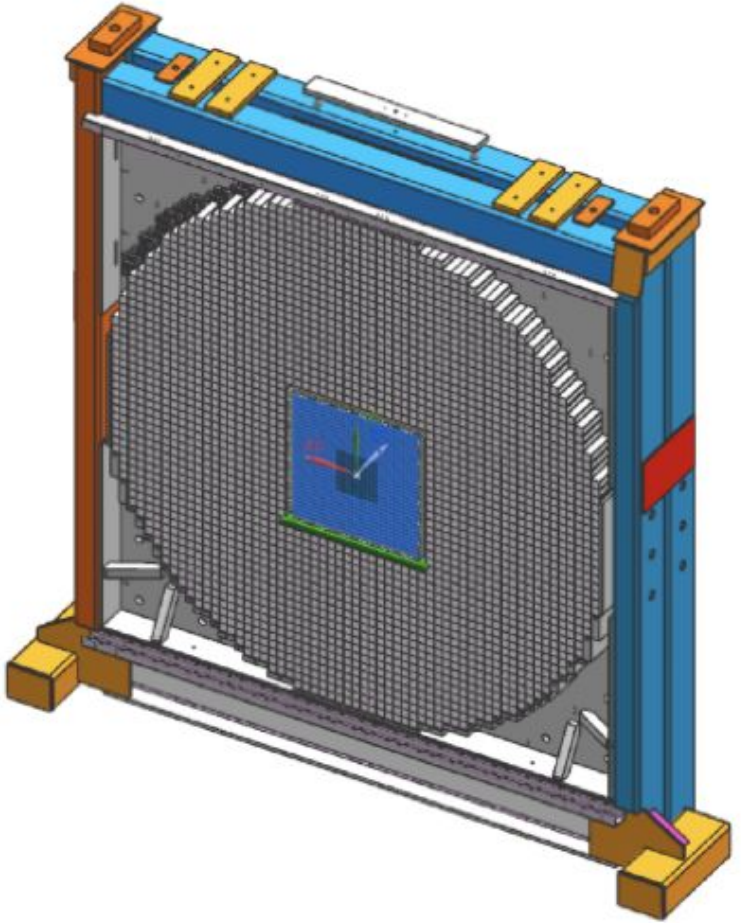


FCAL-II Showers





Types of FCAL Showers

Using machine learning to separate hadronic and electromagnetic interactions in the GlueX forward calorimeter

Rebecca Barsotti and Matthew R. Shepherd
Department of Physics, Indiana University, Bloomington, IN 47405

Following classification scheme set for FCAL by :

Type 0 : True Photon Showers : photons of interest produced from hadron decays

Type 1 : Charged Particle Showers : charged particles interacting with FCAL

Type 2 : Other Showers : from hadronic splitoffs or background

Problem in distinguishing between Type 0 and Type 2 showers as Type 1 showers can be identified by considering any associated tracks in the drift chambers.

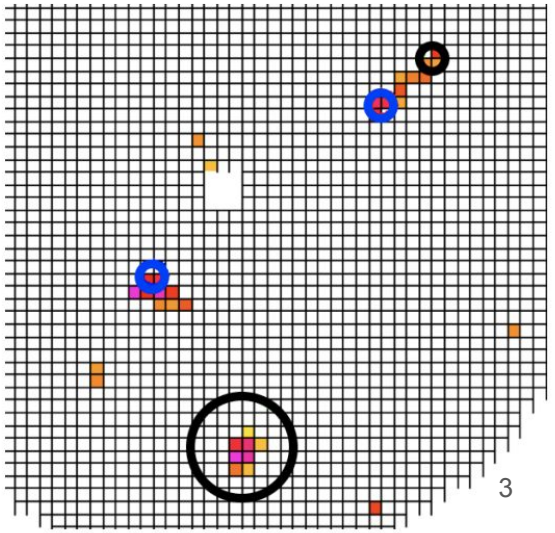


Fig 2 : IU

Generating labeled photons from omega decay

Use genr8 to create omega production with the decay :

$\gamma p \rightarrow \omega p$

$\omega \rightarrow \pi^+ \pi^- \pi^0$

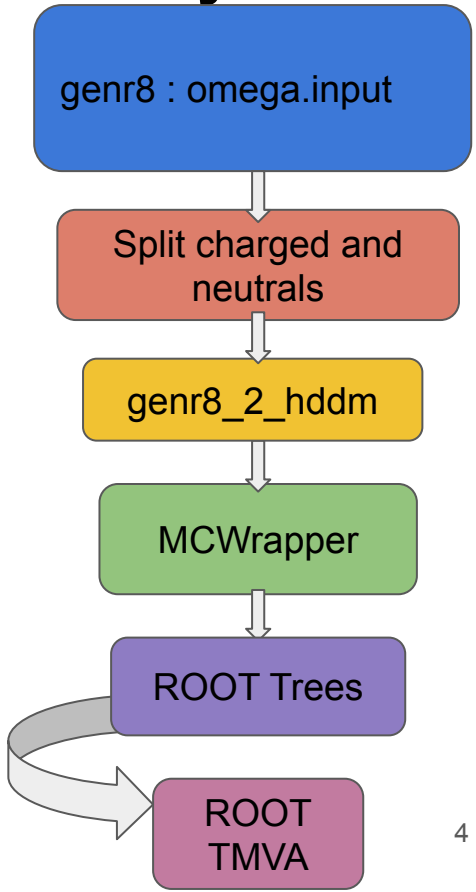
$\pi^0 \rightarrow \gamma \gamma$

Charged Data : $p\ \pi^+\ \pi^-$

Neutral Data: $\gamma\ \gamma$

Have two separate data sets (charged and neutral) and therefore can create a labeled dataset of FCAL showers (photons) such that true photons and splitoffs are known.

As opposed to reconstructing and separating later

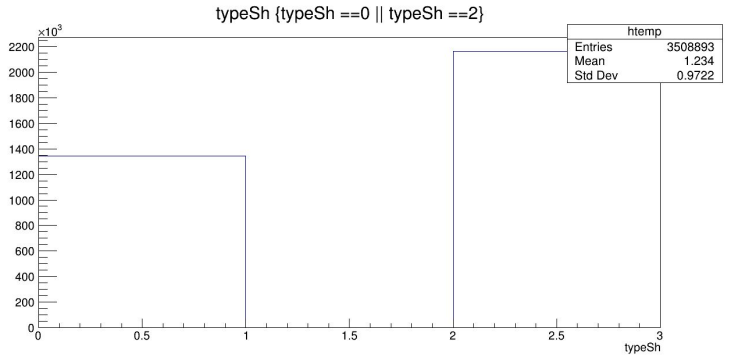


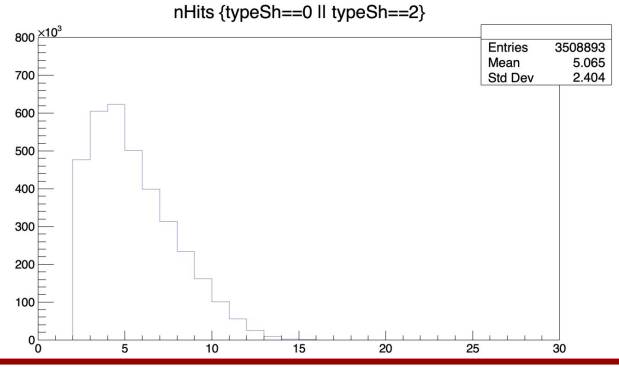
Data Cuts

True Photons	Splitoffs
Neutral Hypothesis == 22 : must be properly reconstructed as a photon	Neutral Hypothesis == 22 : must be mistaken as a photon
BCAL Energy < 0.05	BCAL Energy < 0.05
Number of Photons == 2 : properly reconstruct the number of photons	Number of Photons > 0
trajDeath > 550 cm : the thrown photon must have reached the FCAL before interacting	N/A

Comparison - number and type of shower

IU





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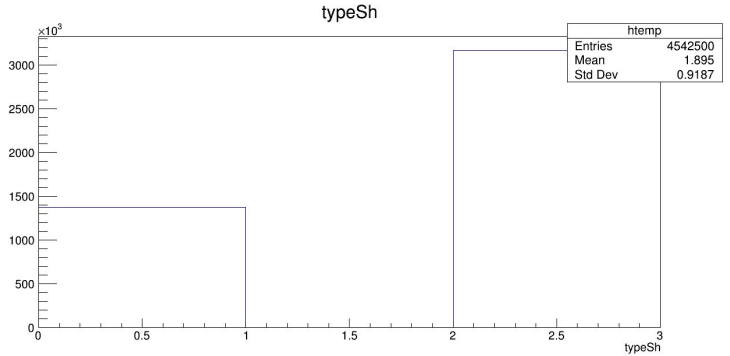

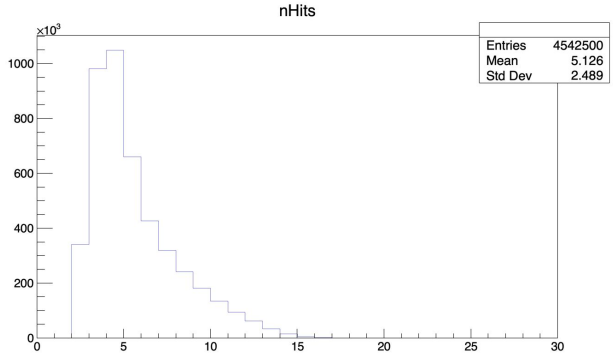

Comparison - Position of Shower

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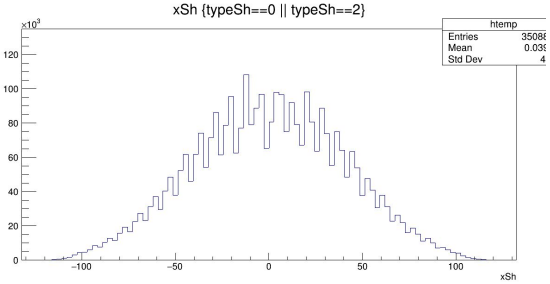

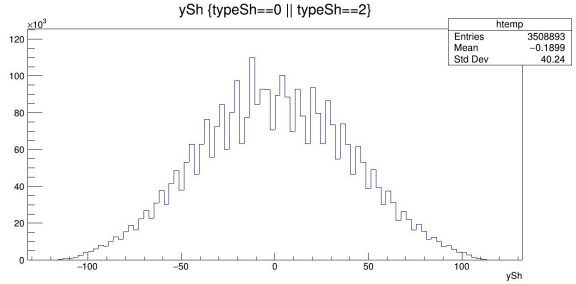

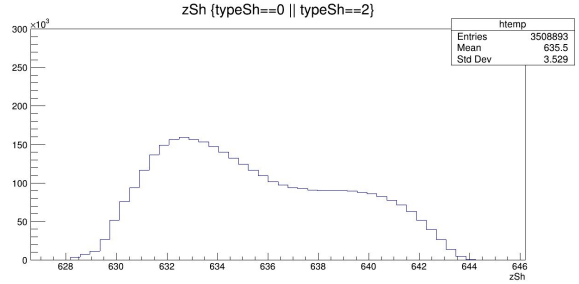

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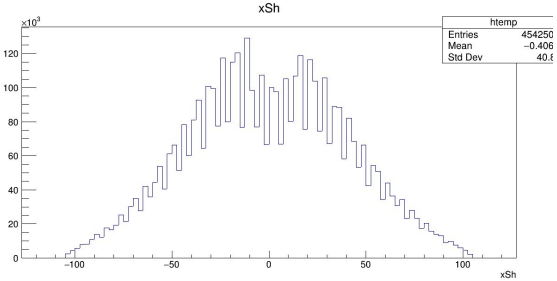

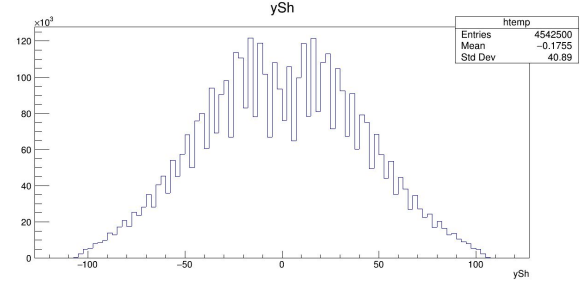

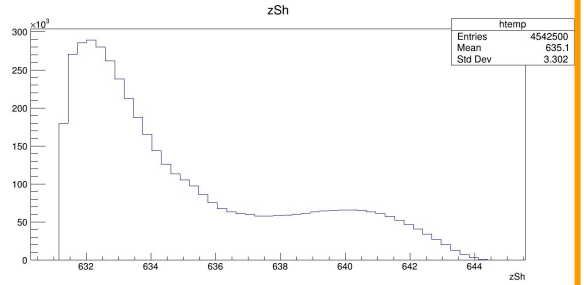

Comparison - Energy, speed and time of shower

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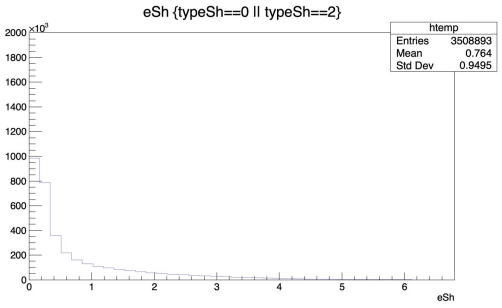

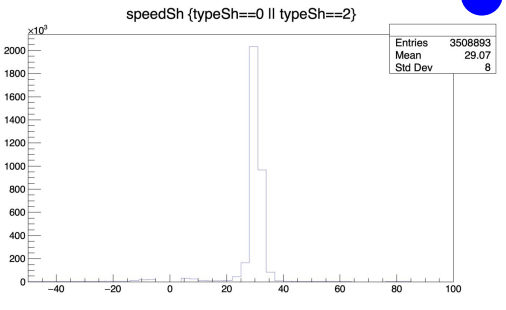

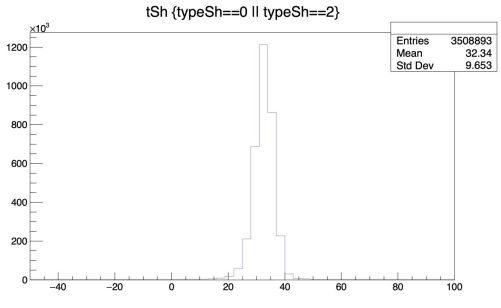

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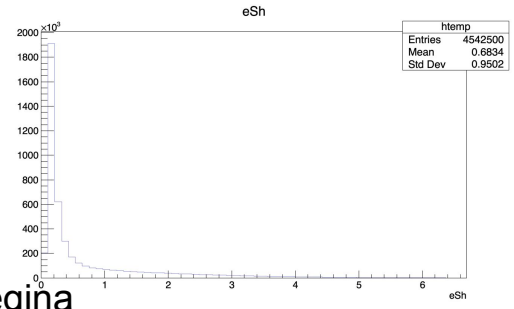
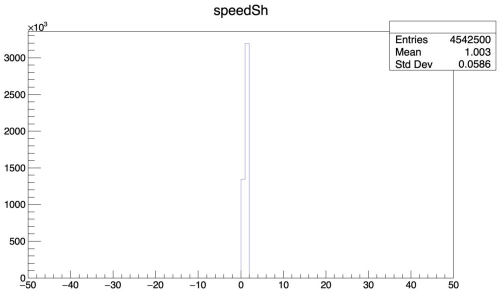
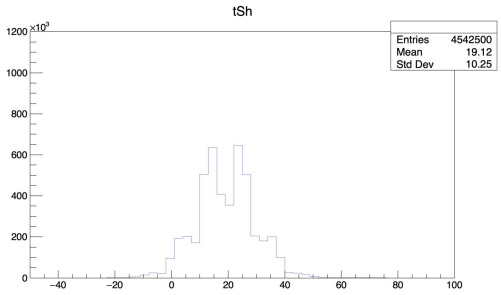


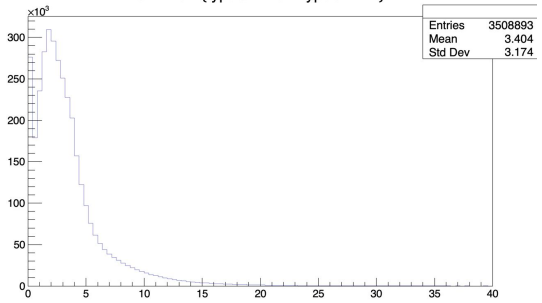


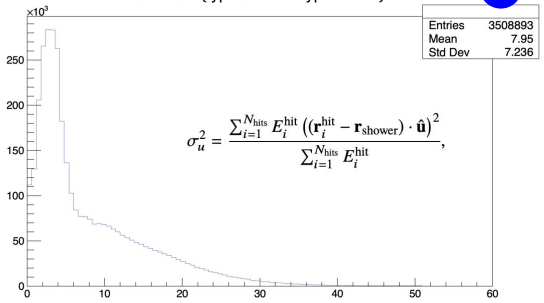


Comparison - Second moments

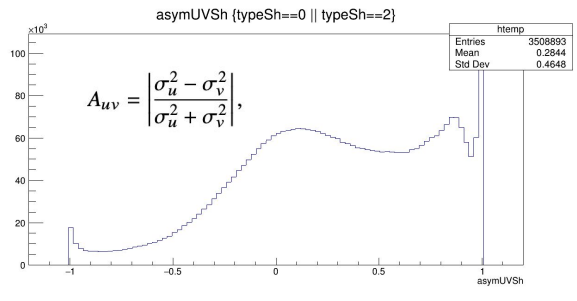
$$\hat{\mathbf{u}} = \frac{\mathbf{r}_{\text{shower}} - \mathbf{r}_{\text{track}}}{|\mathbf{r}_{\text{shower}} - \mathbf{r}_{\text{track}}|},$$
$$\hat{\mathbf{v}} = \hat{\mathbf{u}} \times \hat{\mathbf{z}},$$

IU





$$\sigma_u^2 = \frac{\sum_{i=1}^{N_{\text{hits}}} E_i^{\text{hit}} \left((\mathbf{r}_i^{\text{hit}} - \mathbf{r}_{\text{shower}}) \cdot \hat{\mathbf{u}}\right)^2}{\sum_{i=1}^{N_{\text{hits}}} E_i^{\text{hit}}},$$



$$A_{uv} = \left|\frac{\sigma_u^2 - \sigma_v^2}{\sigma_u^2 + \sigma_v^2}\right|,$$

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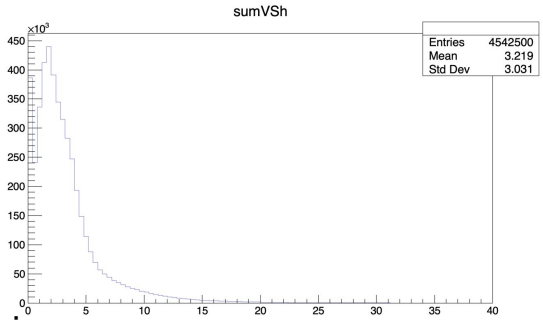

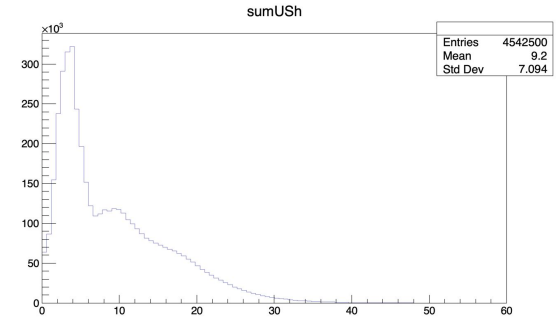

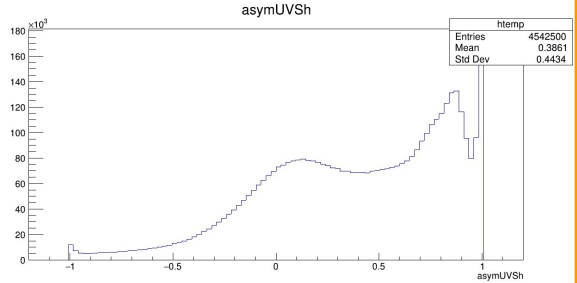

Comparison - Energy block ratios

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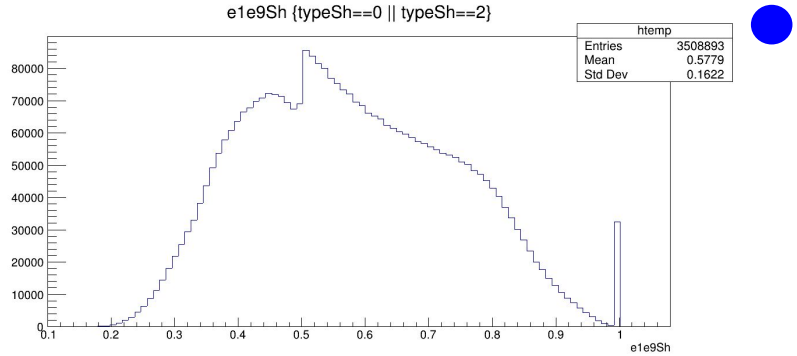

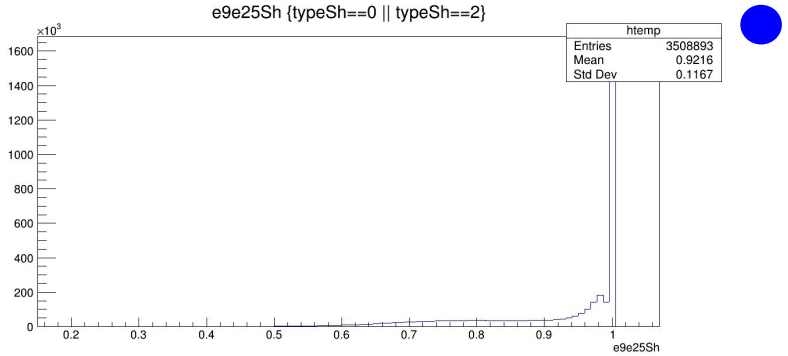

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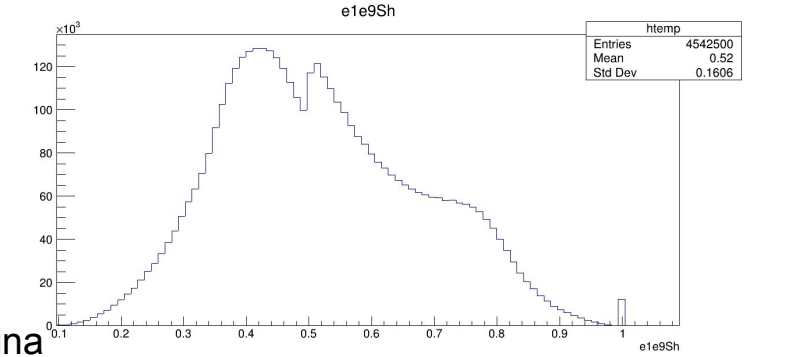
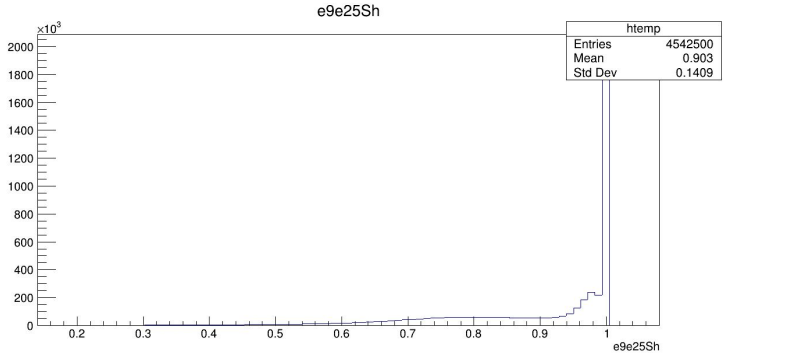
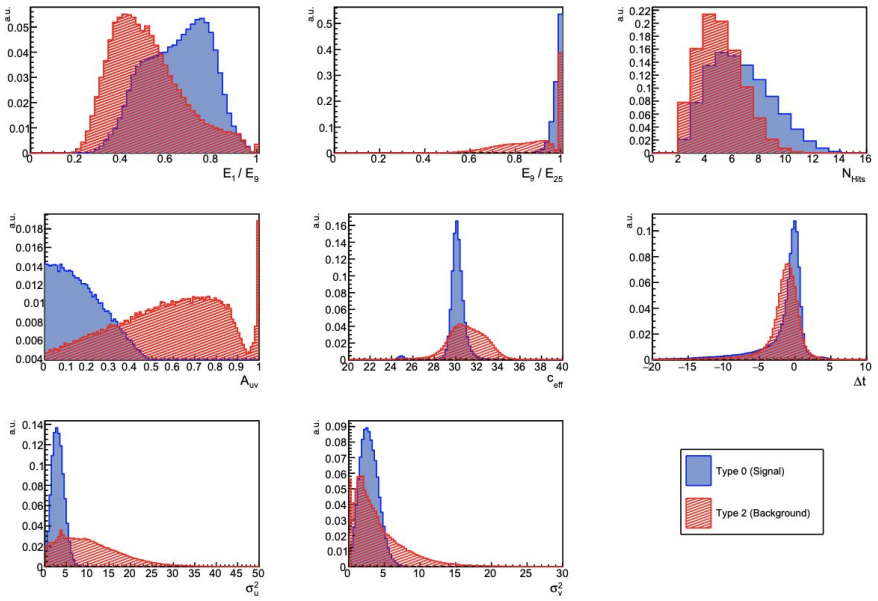




Future MVA training

- Data cuts and Selection
- Find the feature importance (TMVA) , and feature analysis
- Repeat on FCAL-II



True photons and Mergers (Varun)

Initial goal: Label a “Merger”

- MC - GenEtaRegge Sample
- $\eta \rightarrow \pi^0 \pi^0 \pi^0$ 6 photons
- Other reactions : $\pi^0 \pi^0 \gamma$, $\gamma \gamma \gamma \gamma \gamma$: 5 photons
- 6 photons thrown, 5 photons Reconstructed -> look for features to label “Merger”

Later : Machine Learning