Calorimetry Meeting:
July 13, 2017

Rebecca Barsotti

Omega decay

- $\gamma \mathrm{p} \rightarrow \omega \mathrm{p}$

- $\omega \rightarrow \pi^{+} \pi^{-} \pi^{0}$
  $\rightarrow \pi^{+} \pi^{-} \gamma \gamma$

Definitions

- Type 0 showers:
  - Photon showers originating from a π^0 decay

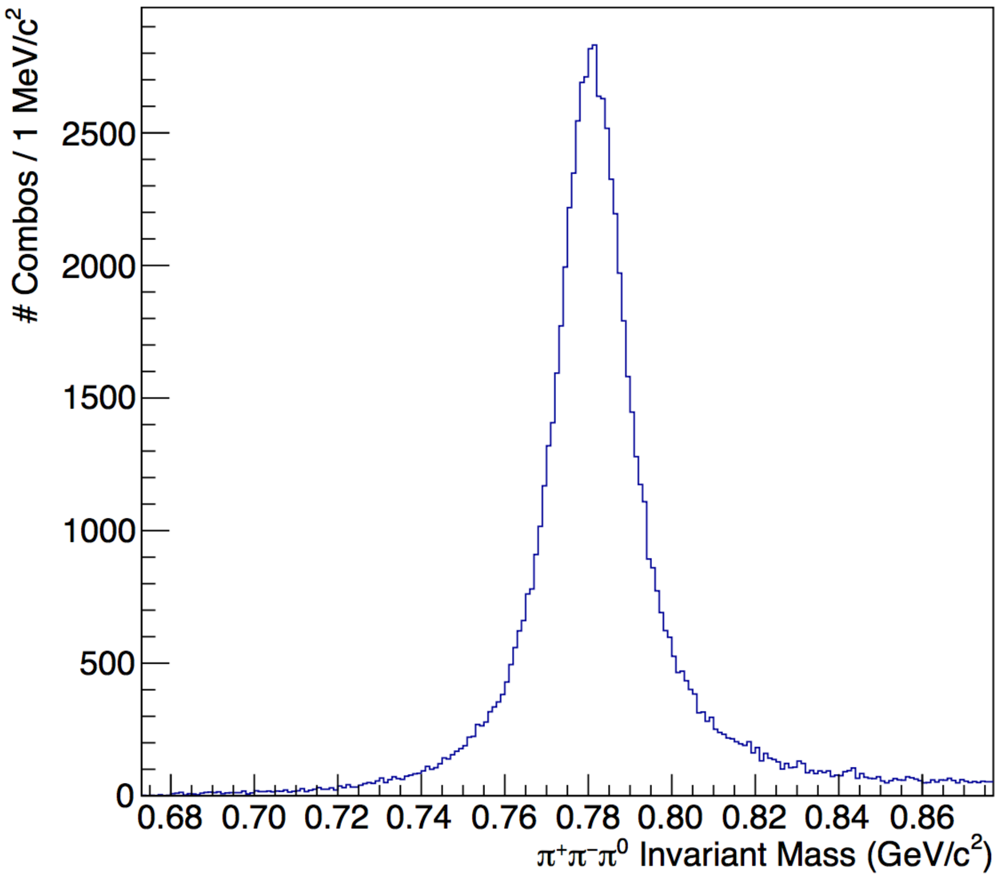
- Type 1 showers:
  - Showers originating from a charged particle for which there is a track
  - Easy to identify by simple geometry

- Type 2 showers:
  - All other showers
  - Noise, split-offs from Type 1 showers, etc.
  - These cause backgrounds for true photons

Project Background

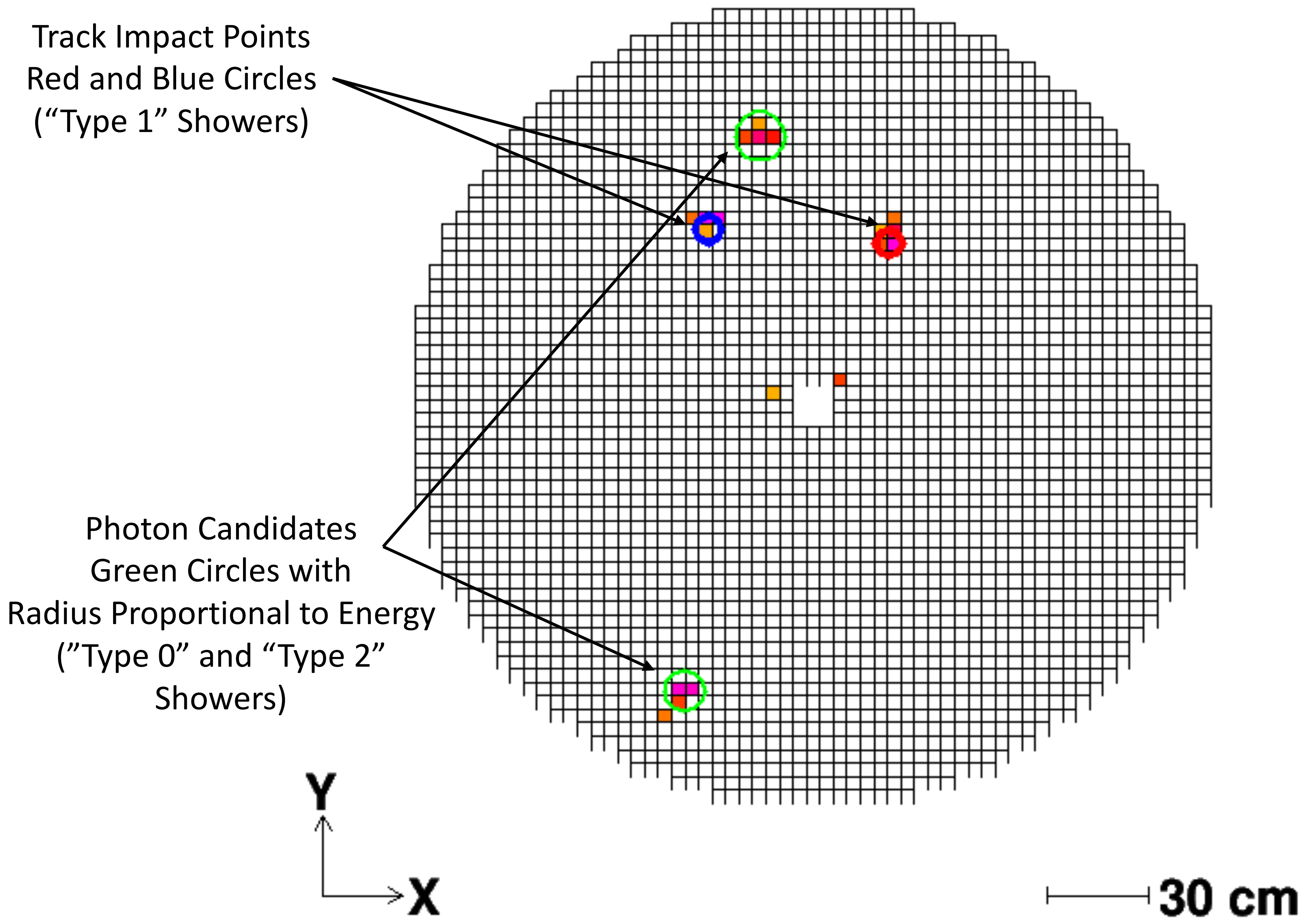
- **Goal:**
  Algorithmically differentiate between Type 0 and Type 2 showers
- **Zeroth Stage:**
  Create a set of data cuts to isolate omega decays to identify Type 0 showers
- **First Stage:**
  Isolate variables that can be used to differentiate between Type 0 and Type 2 showers
- **Second Stage:**
  Identify algorithms that can use these variables to create clear distinctions
- **Third Stage:**
  Implement algorithm to differentiate between shower types

Data cuts on $\omega \rightarrow \pi^{+} \pi^{-} \pi^{0}$

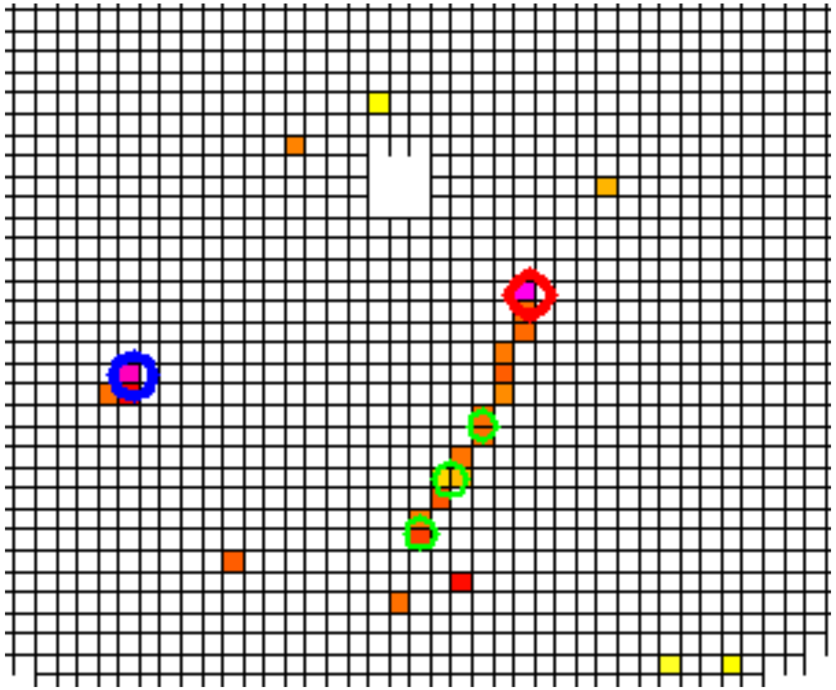


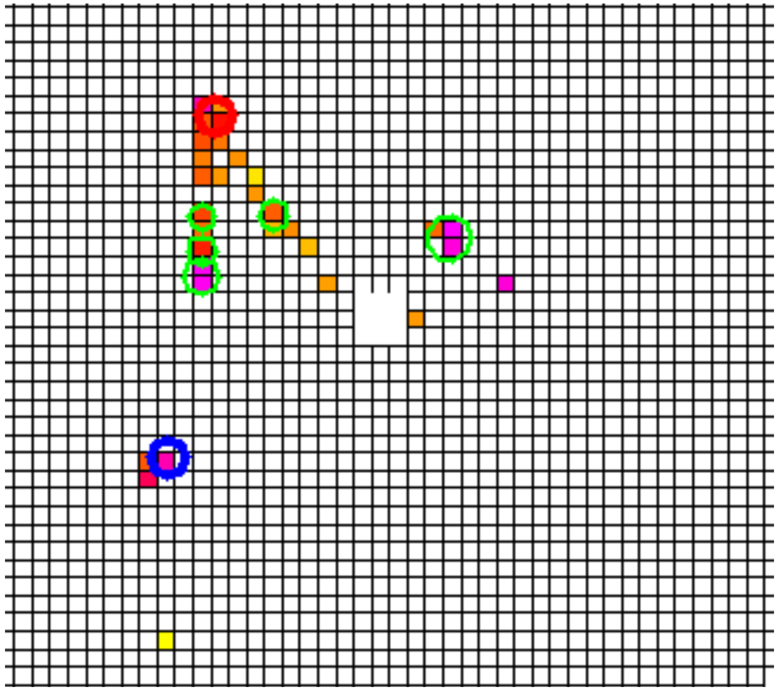
Cuts made on kinematic chi-squared value, beam energy

FCAL view from downstream looking upstream



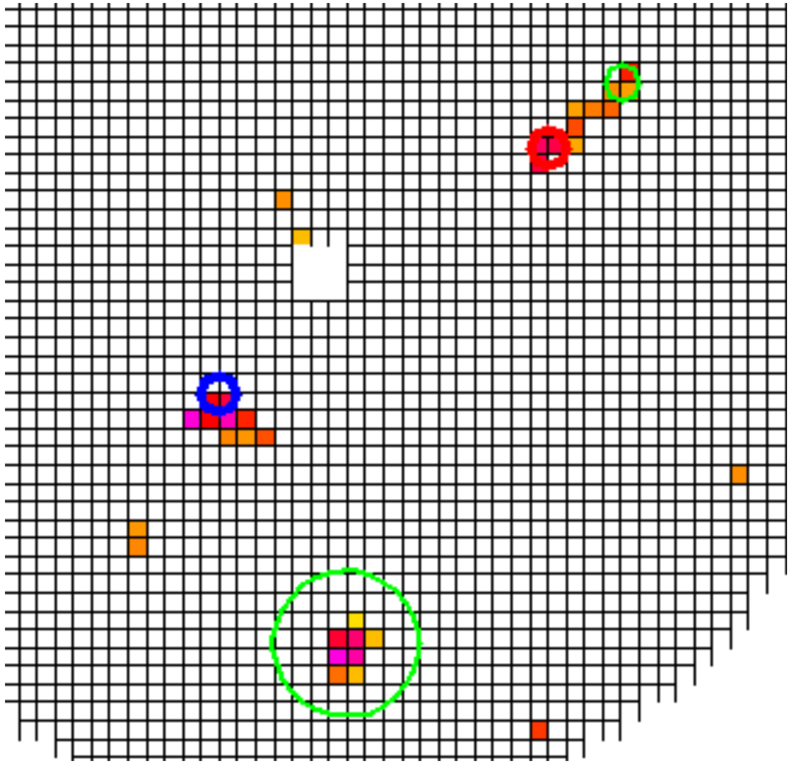
Shower examples: Type 2

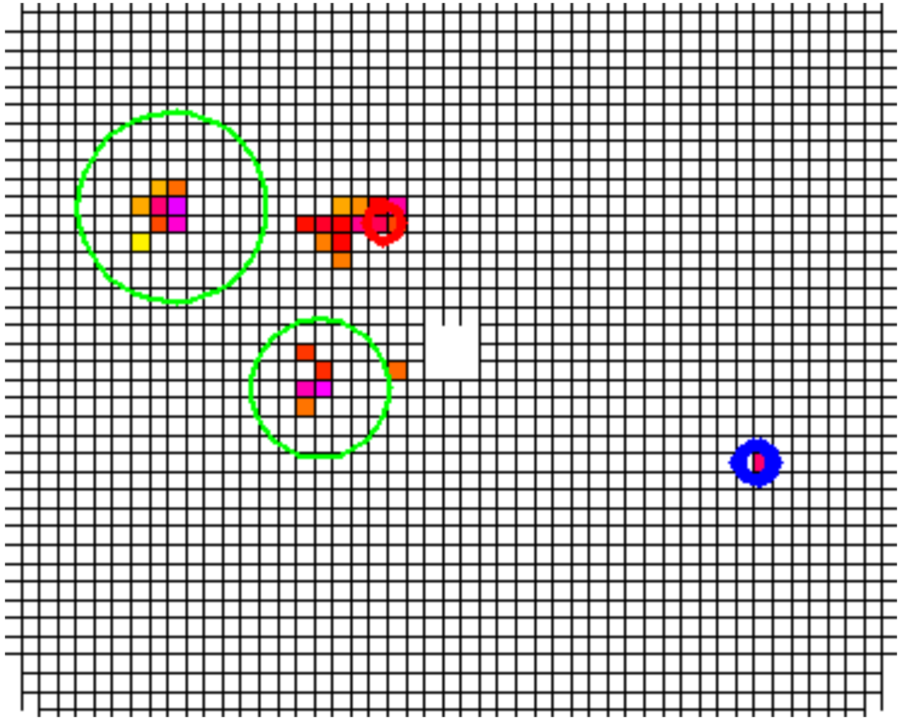




Photon candidates emanating from charged track impacts

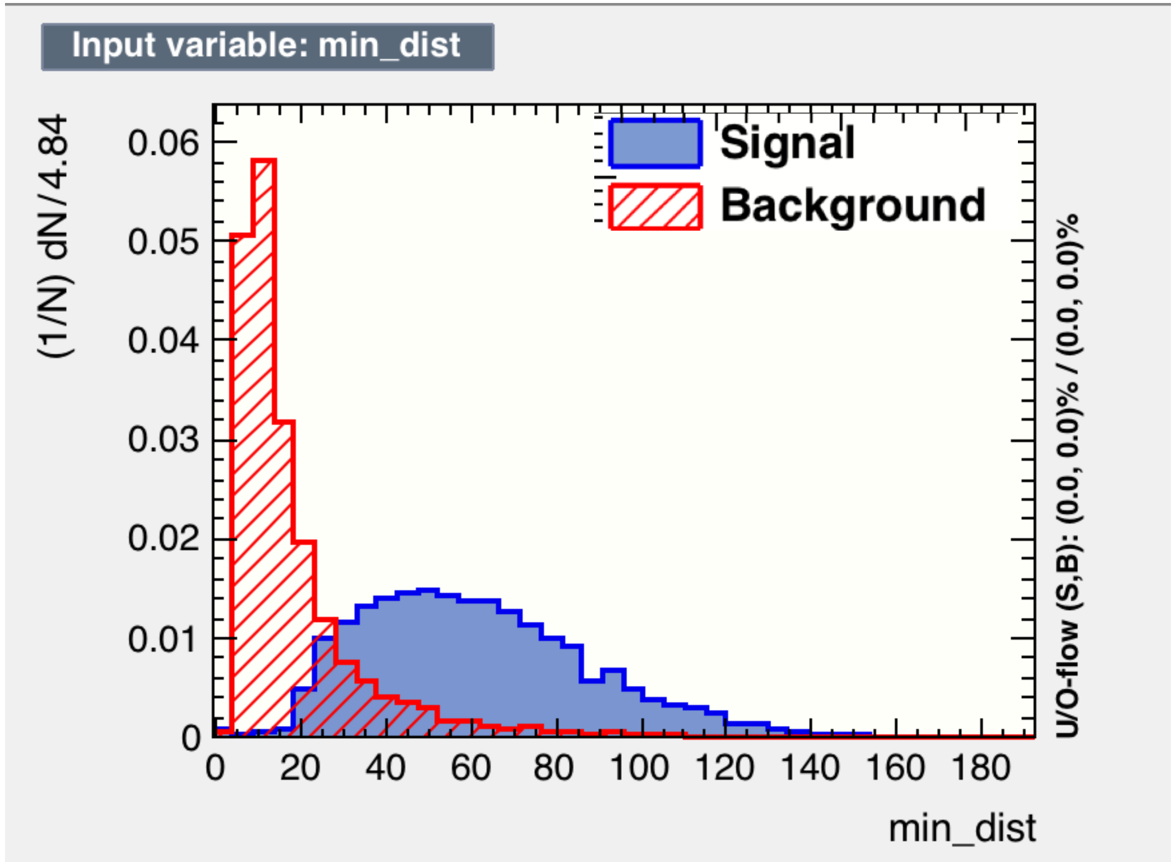
Shower examples: Type 0



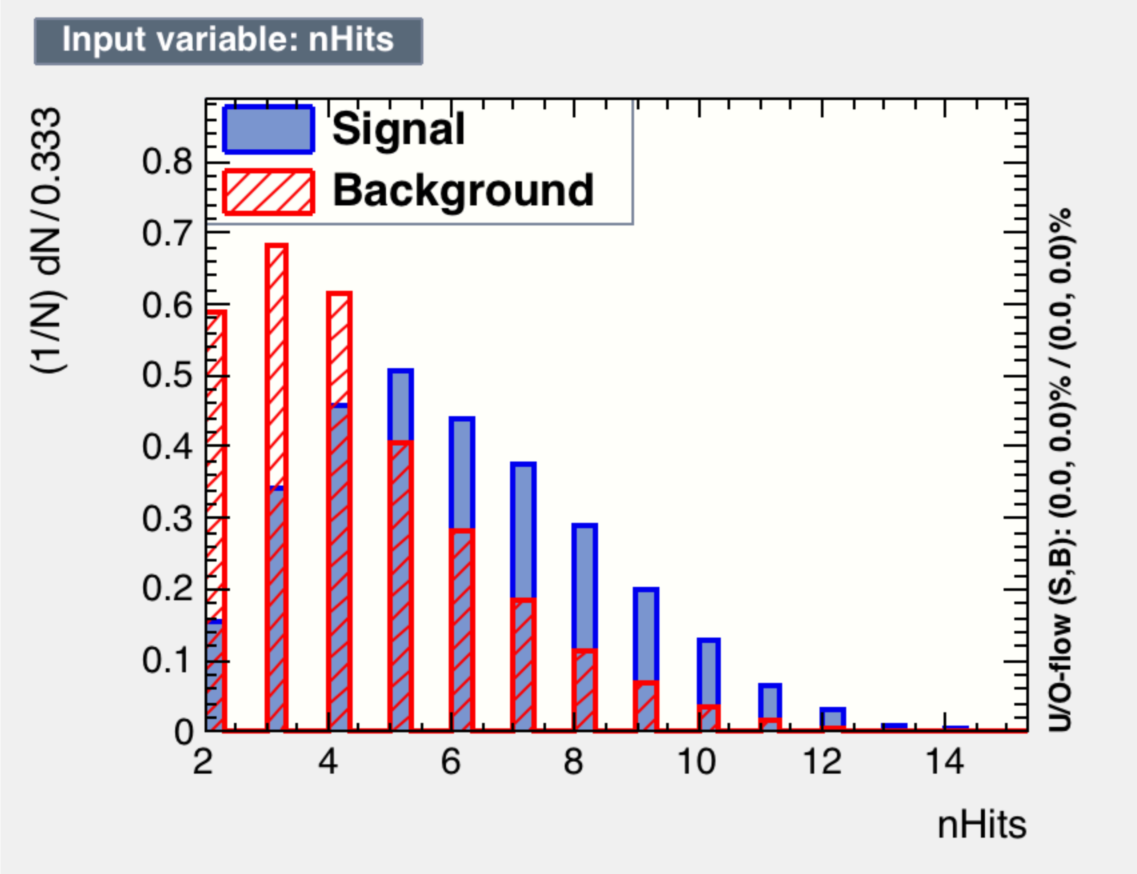


True photon showers: compact in size and more uniformly distributed

Input variables

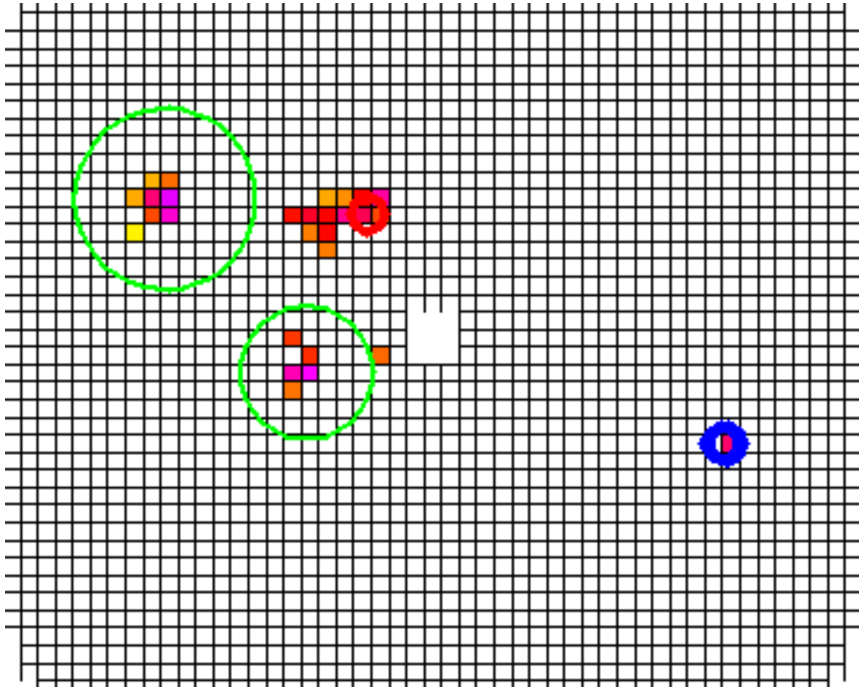


Shortest distance to nearest Type 1 Shower

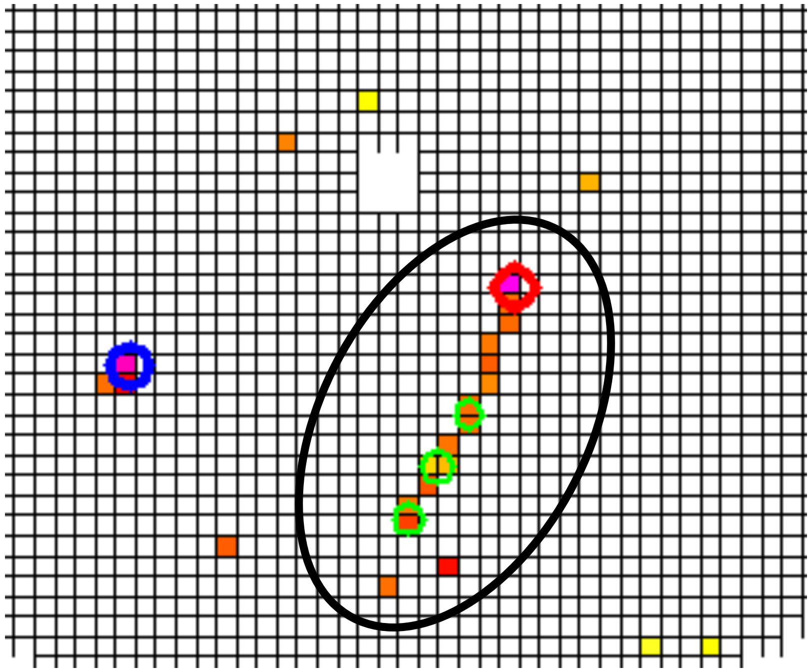


Number of Hits per shower

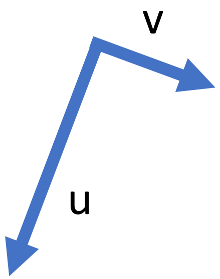
Principal axes of a shower



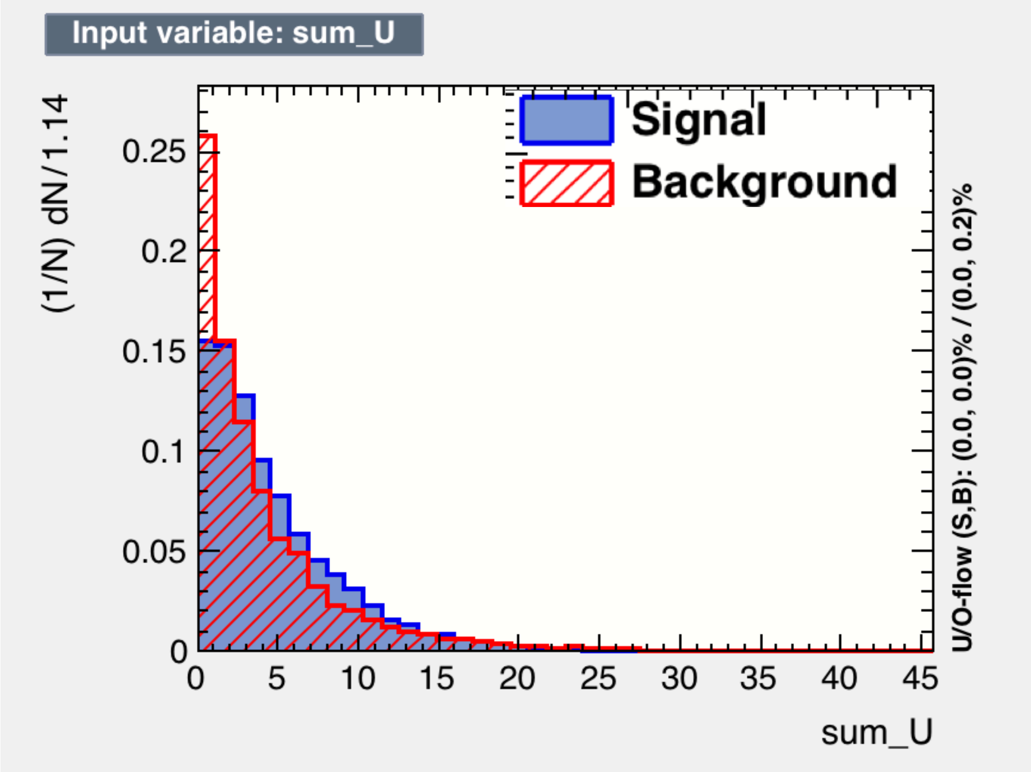
Type 0 shower

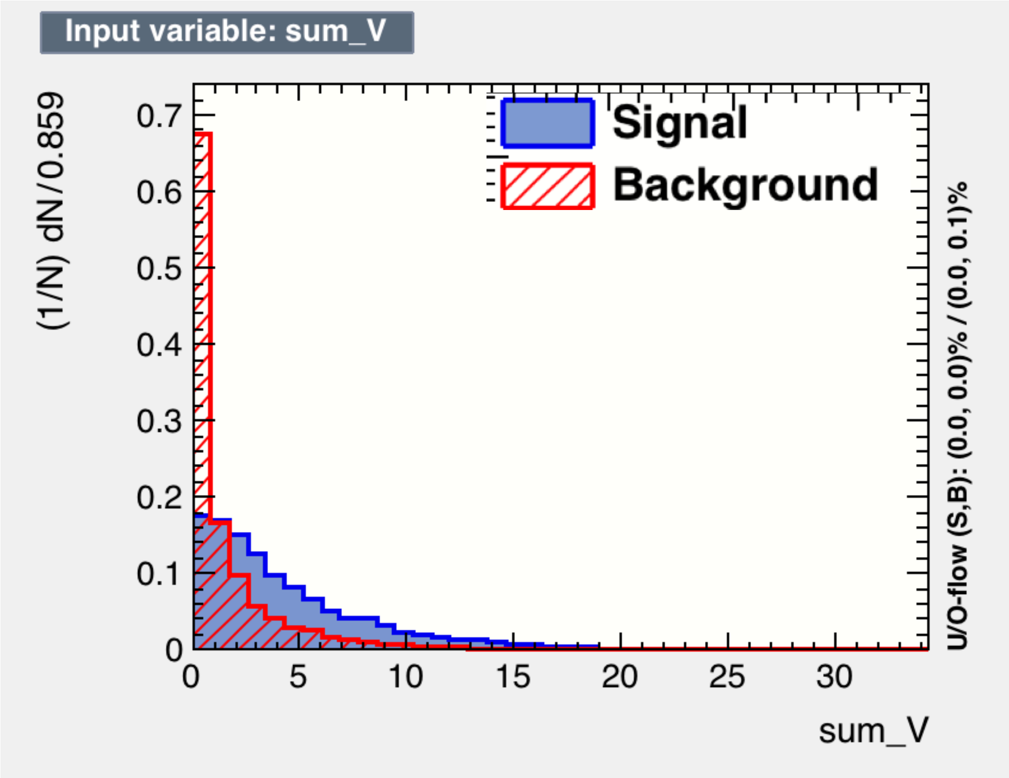


Type 2 shower



Input variables





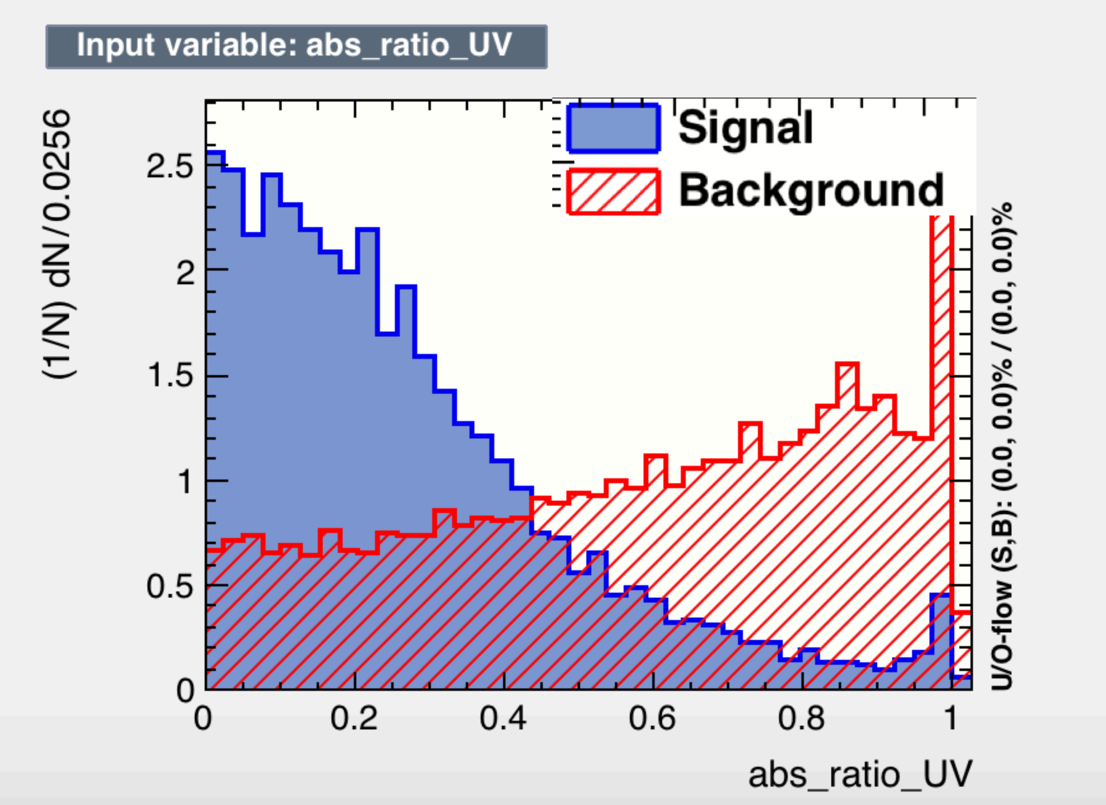
Energy weighted width of the shower along principal shower axes

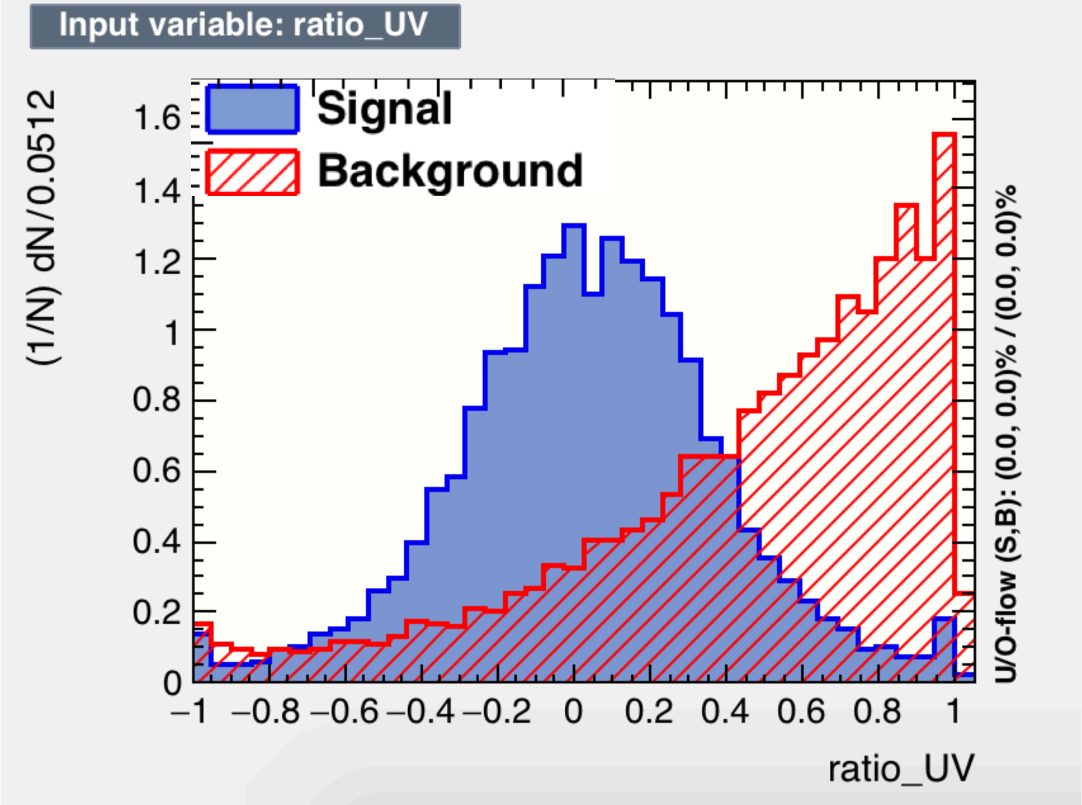
sum_U $=\sum_i E_i \, (\boldsymbol{h_i} \cdot \boldsymbol{u})^2 \, / \, \sum_i E_i$

$\boldsymbol{h}$ is the vector from the shower center to the hit block in the shower

$\boldsymbol{u}$ is the principal axis

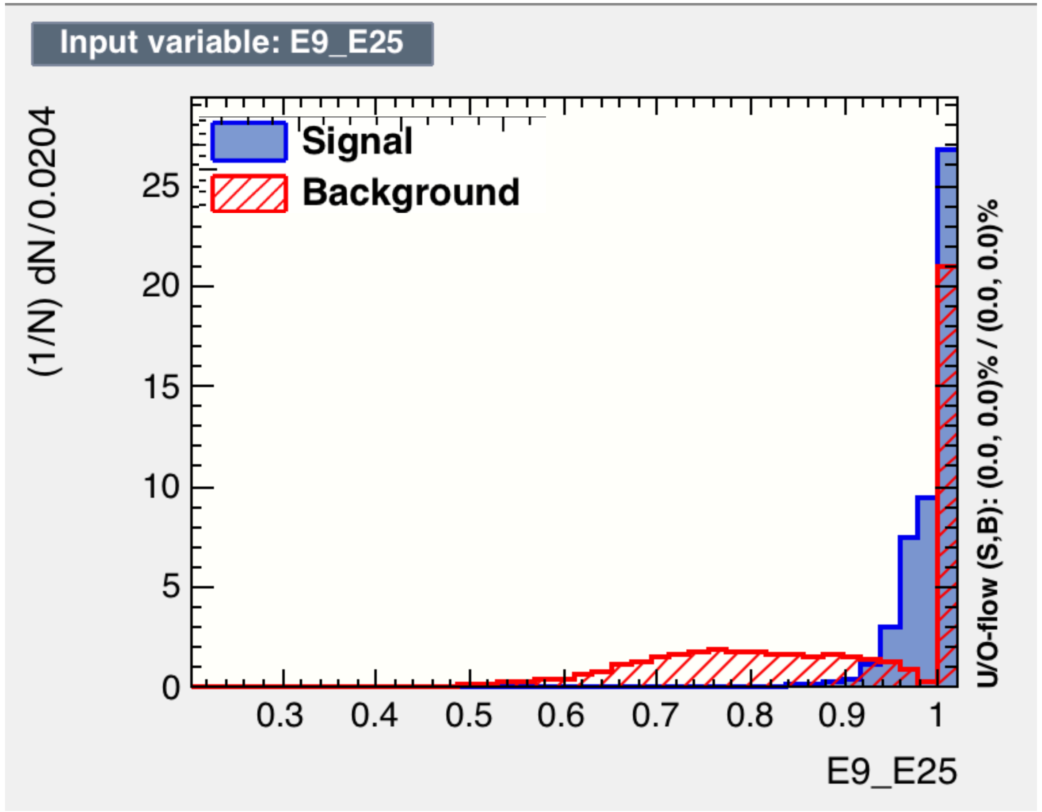
Input variables



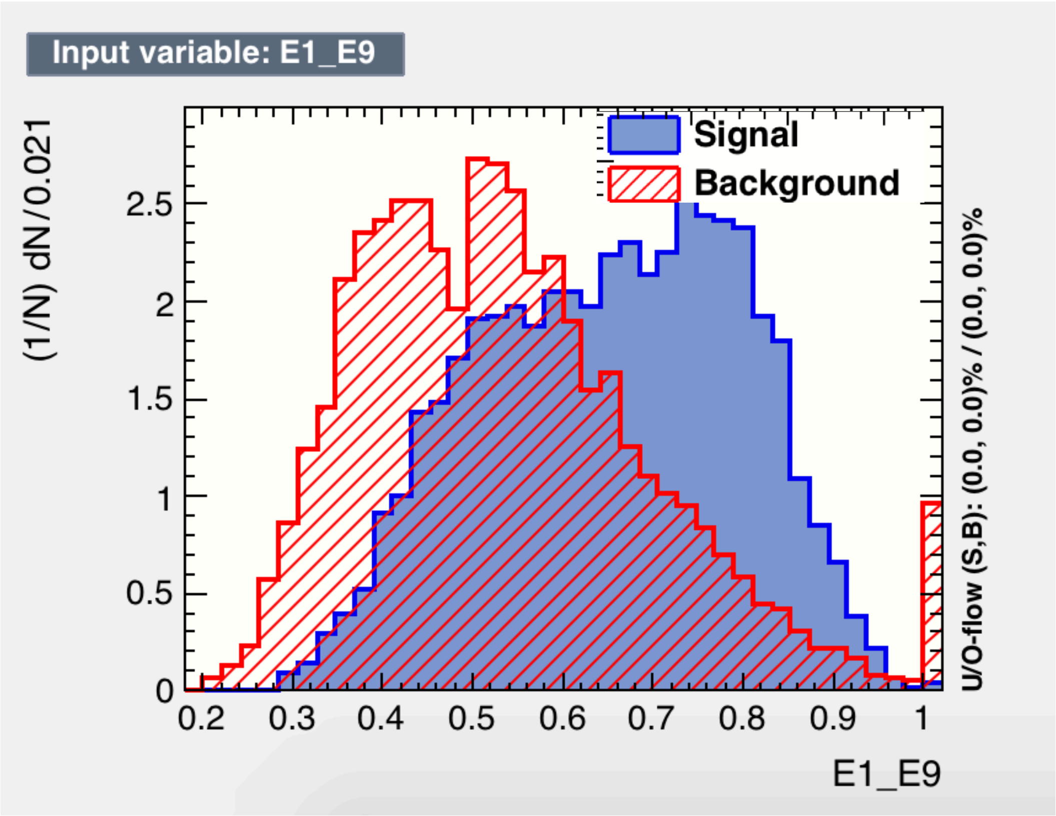


Ratio of energy weighted shower widths along principal shower axes

Input variables

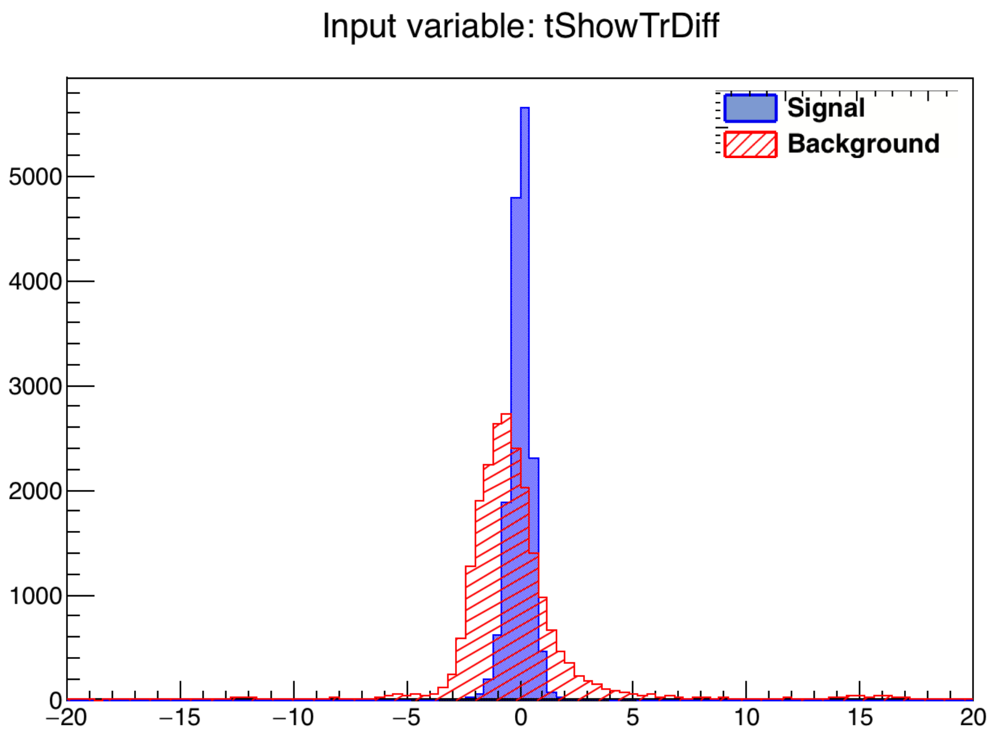


Energy in the nearest 9 blocks over the energy in nearest 25

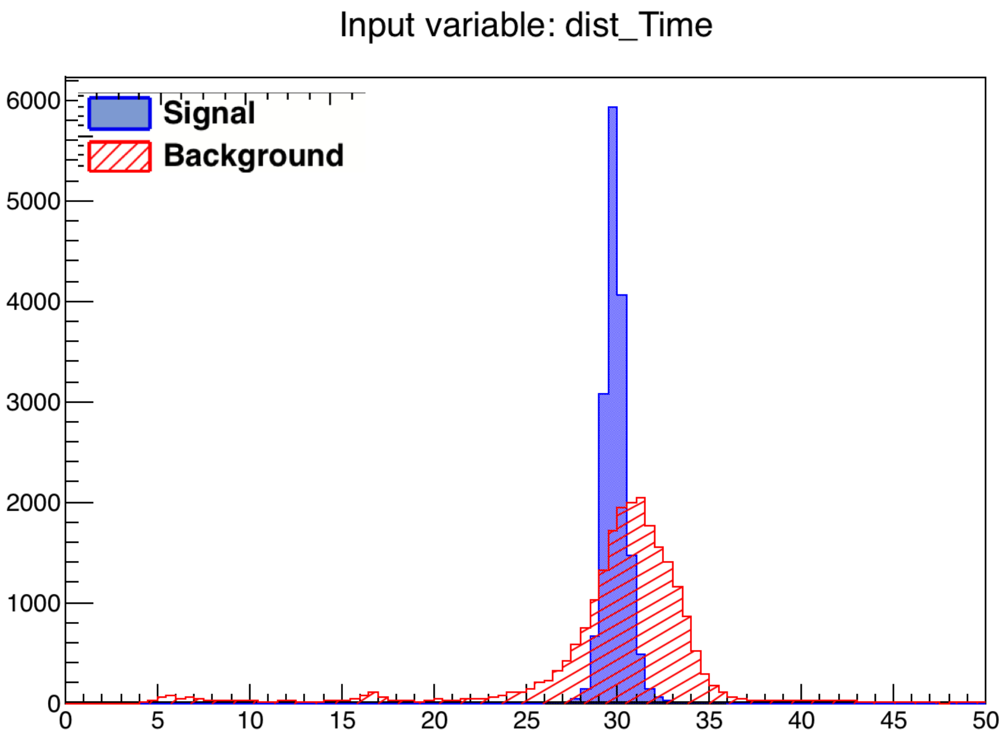


Energy in central block over energy in the nearest 9 blocks

Input variables

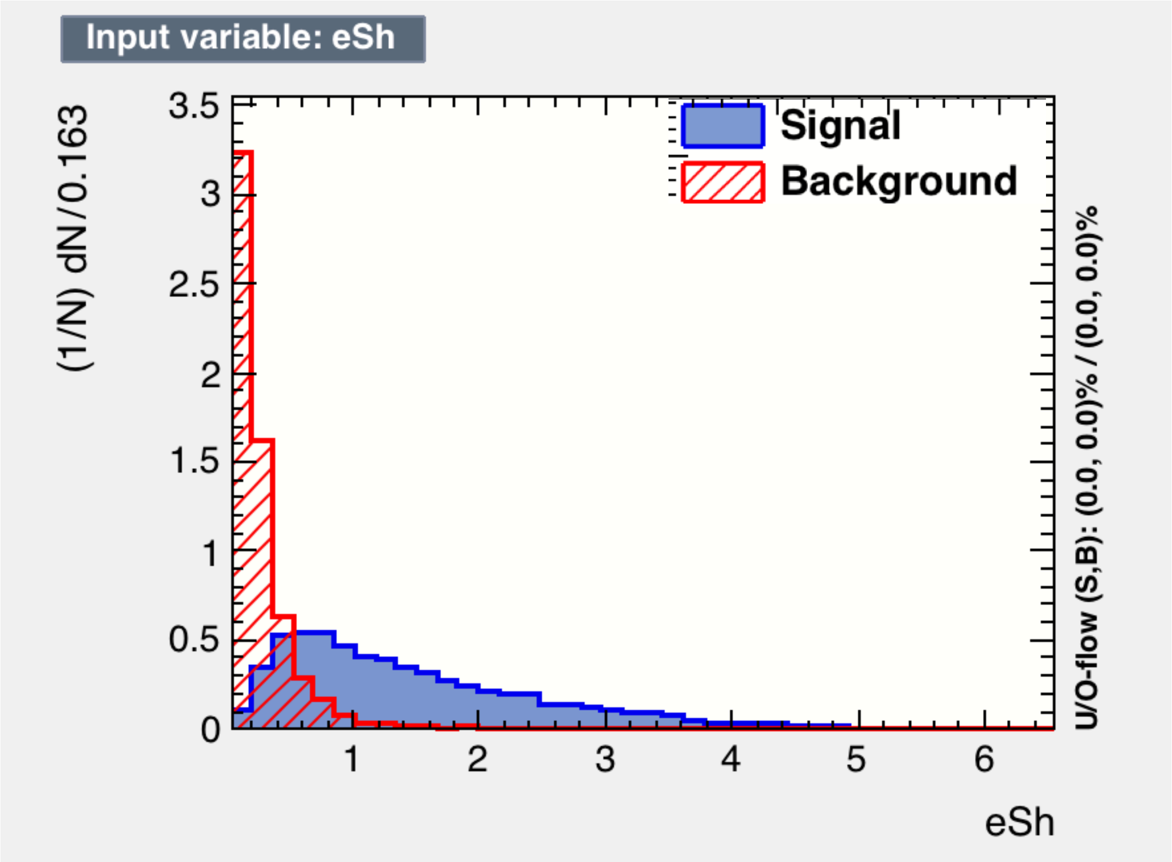


Difference between Time of Shower and Time of Track



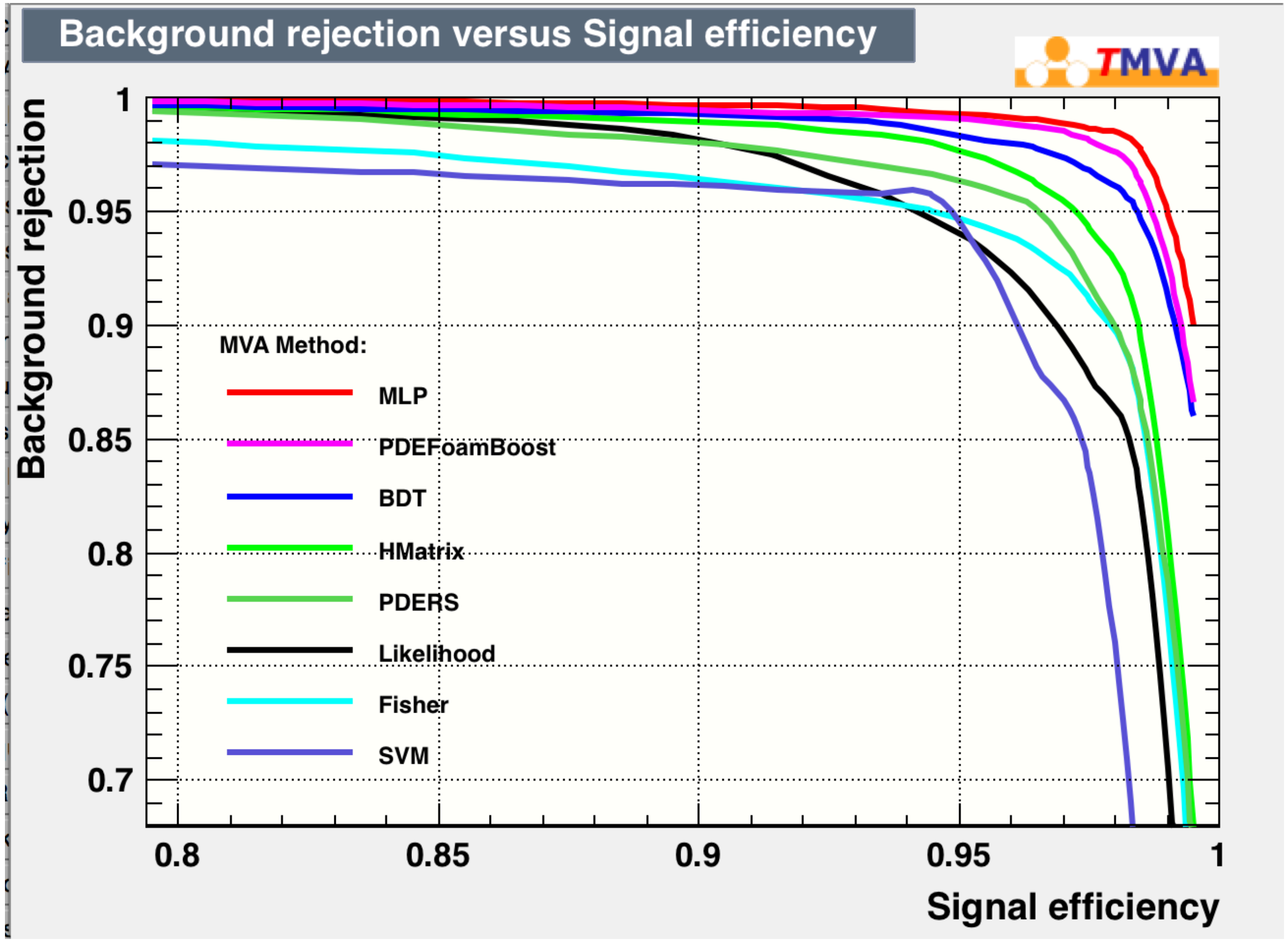
Effective velocity

Input variables



Energy of the shower

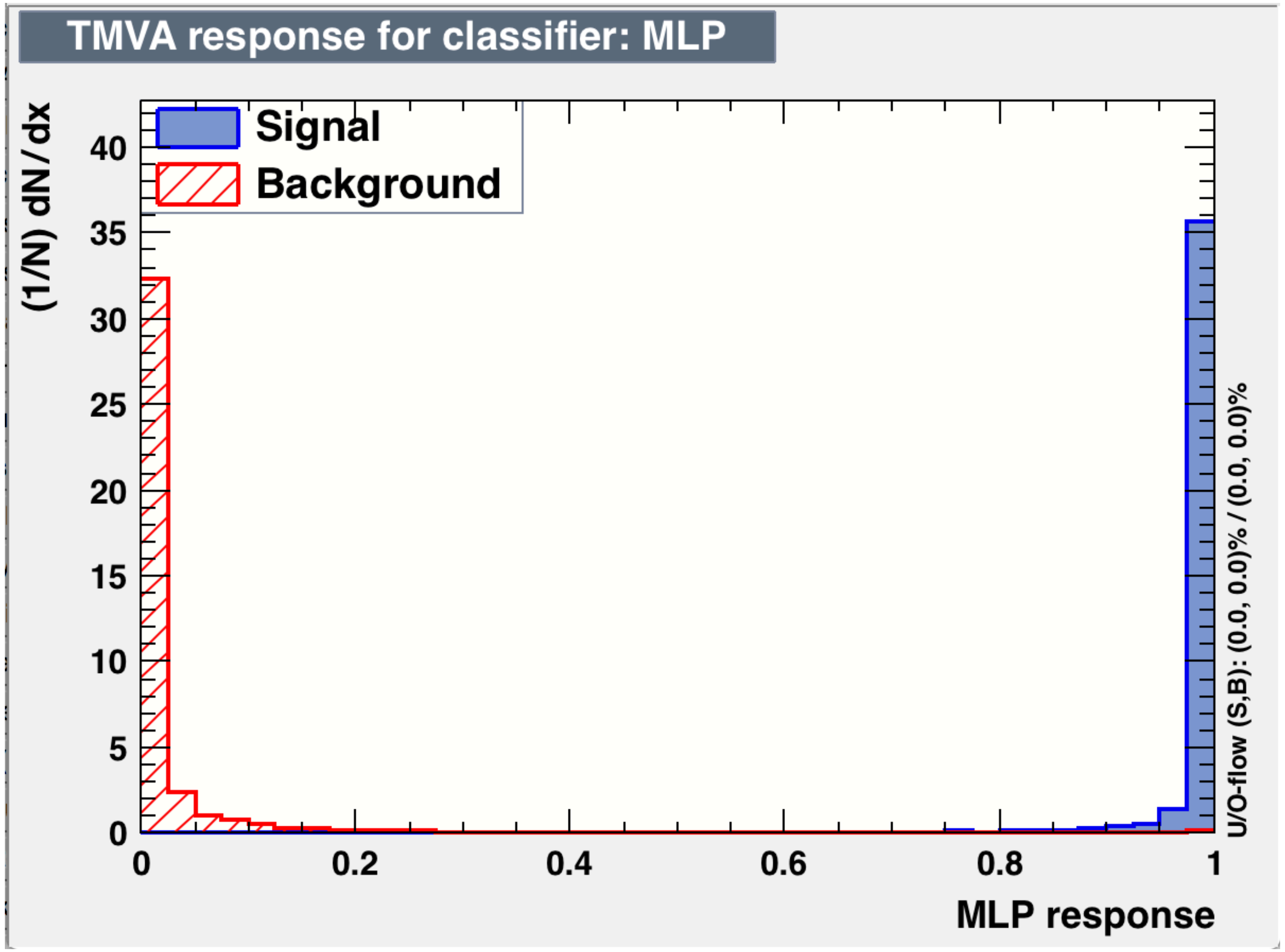
Algorithms: first glance



Algorithms

- **Performance:** Multi-layer perceptron (MLP)
- **Implementation Difficulty:** MLP
- **Runtime:** PDE Foam Boost
  - .5 ms per event as compared to 1 ms per event

Classifier Output Distribution



Summary

- Most important thing is good signal efficiency to avoid discarding good photons
- The Multi-Layer Perceptron algorithm offers a promising option with good signal efficiency and background rejection
- Lot of useful input variables and parameters that can also be tweaked to serve individual purposes
- Currently working to implement the MLP algorithm separate from TMVA