Photon Fragmentation studies

CLIC Meeting

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Outline

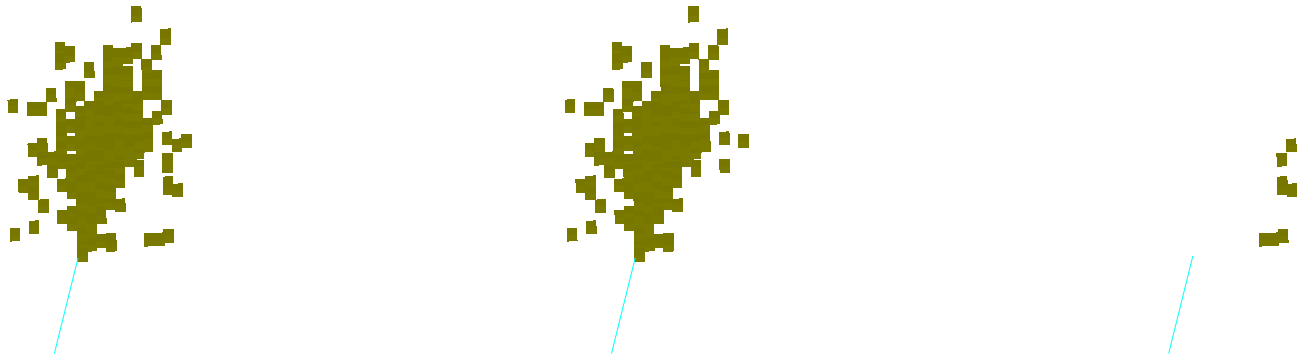
Introduction

Photon Fragmentation studies

- Aim: Improve photon reconstruction
- Importance: physics studies like τ decay reconstruction relying on accurate photon reconstruction
- Current Pandora photon identification-well documented
- Issues when photons are close:
- A photon is split into:
- A Photon + photon fragments
- A Photon + neutral hadron fragments

Issue

- Event display of a 20GeV photon split into a true photon/photon fragment pair
- From left to right, graphs are the true photon/photon fragment pair, the true photon and the photon fragment.



Plan

- Identify close pairs of photon/photon and photon/hadron
- Categorise into true photon/photon pairs and true photon/photon fragments pairs, and similarly for photon/neutral hadron pair
- Categories: should-not-be-merged pairs:
- - true photon/true photon pairs,
- - true photon/true hadron pairs
- And should-be-merged-pairs:
- - true photon/photon fragment pairs,
- - true photon/neutral hadron fragment pairs

Plan

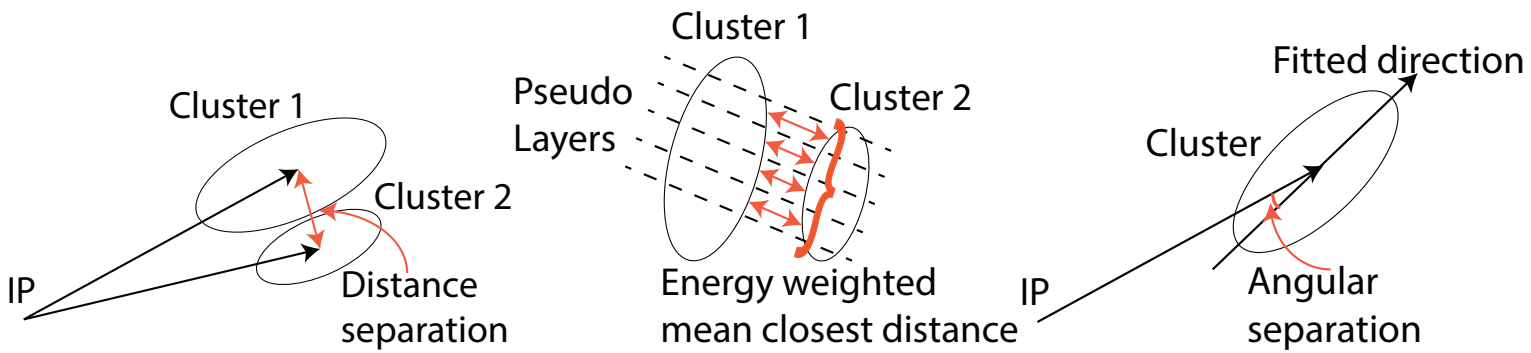
- Also Categorise into high and low energy pairs depending on energy of low energy part in a pair
- Separating should-be-merged-pairs: from should-not-be-merged pairs
- Merge photon/neutral hadron fragments with true close-by photons.
- Decide whether to split merged photons
- Consider photon pairs with distance separation < 500mm without duplicates

Setup

- Sample using: Z' uds Jet
- Lastest Marlin
- Stand alone photon clustering algorithm applied. (PandoraSettingsDefault)

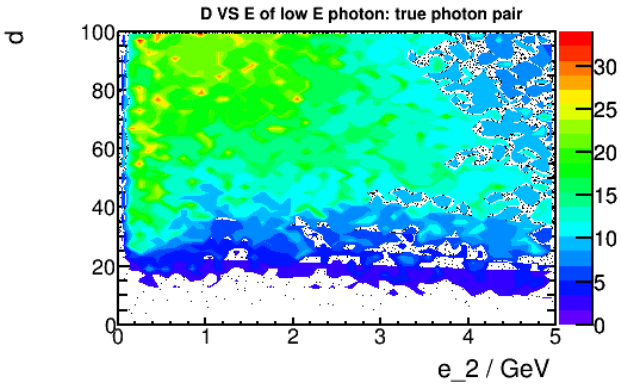
Parameters
Definitions

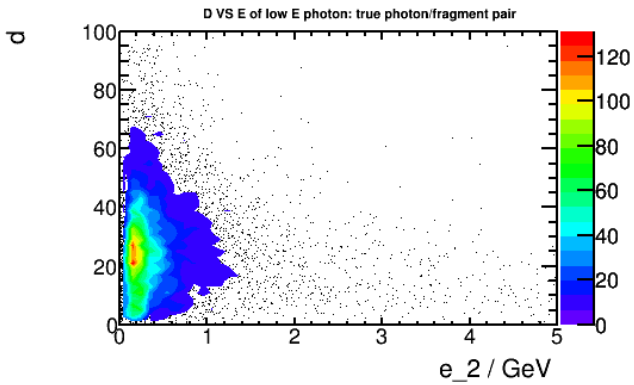
- e_2: Energy of low energy part in a pair
- d: Distance separation - distance between centre position of two clusters
- d_{Layer}: Energy weighted mean closest distance separation over layers
- Ang: Angular separation of a cluster- difference in direction to IP and fitted direction
- Please see back-up slides for full list

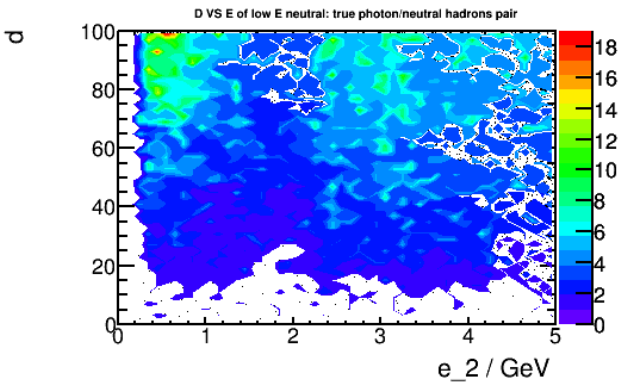


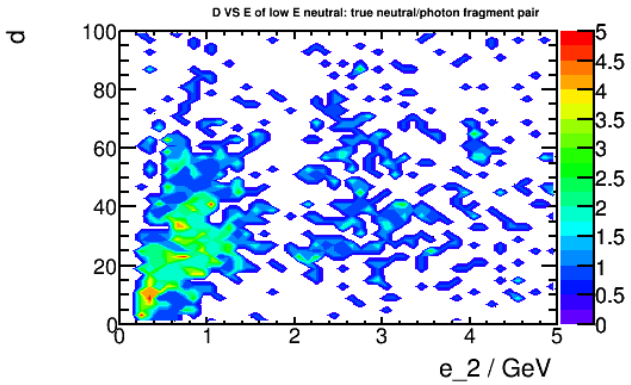
Categorisation

- Categorised photon/photon or photon/neutral hadrons into high energy (>1GeV) and low energy(<1GeV) pairs
- Based on energy of low energy part in the pair, motivated by top right plot







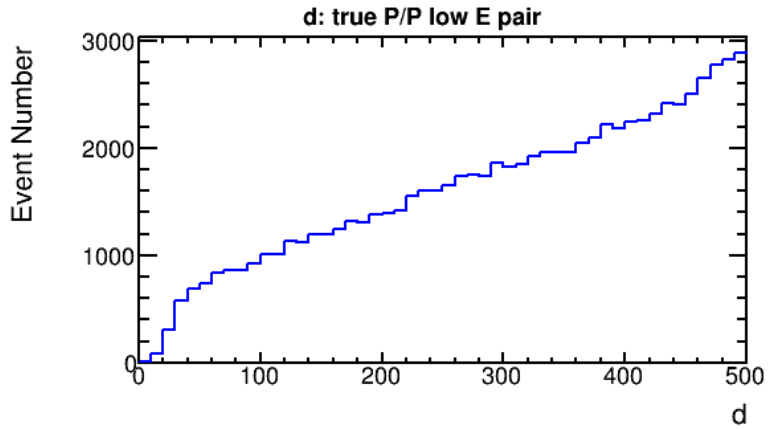


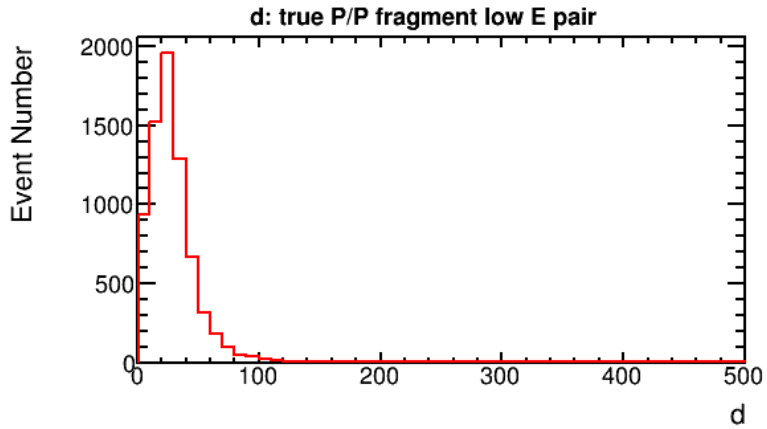
Categorisation

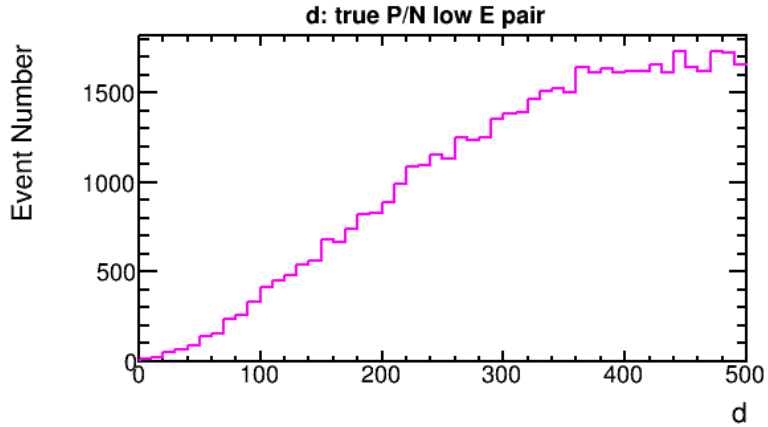
- We could look at distributions of various parameters for different categories.
- Categories: should-not-be-merged pairs:
- - true photon/true photon pairs,
- - true photon/true hadron pairs
- And should-be-merged pairs:
- - true photon/photon fragment pairs,
- - true photon/neutral hadron fragment pairs
- Low and high energy pairs based on energy(1GeV) of low energy part in pair
- P for photon, N for neutral hadron, E for energy

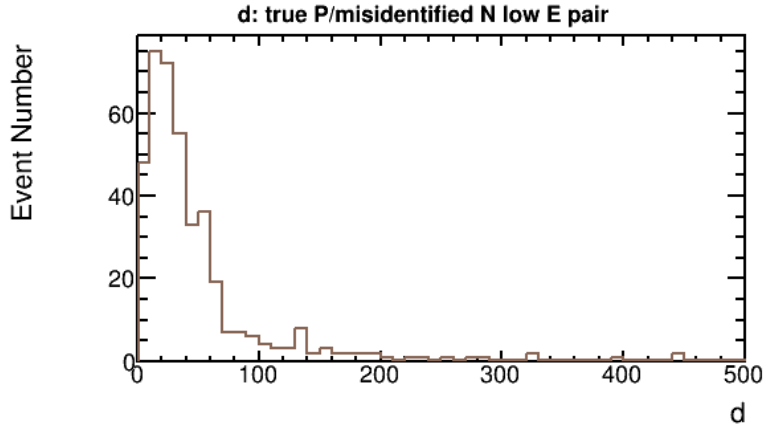
Distributions

- Distance separation for low energy pairs. Clear differences for true P/P and P/P fragments



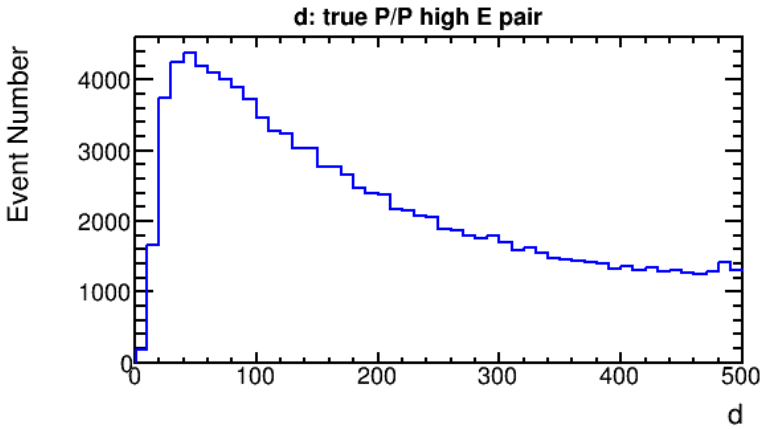


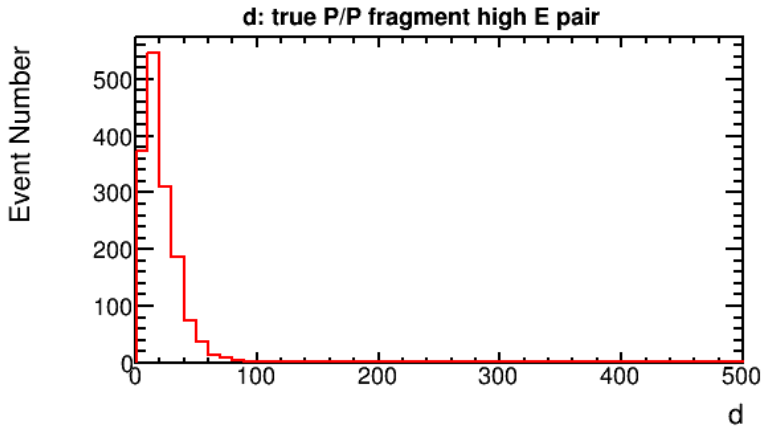


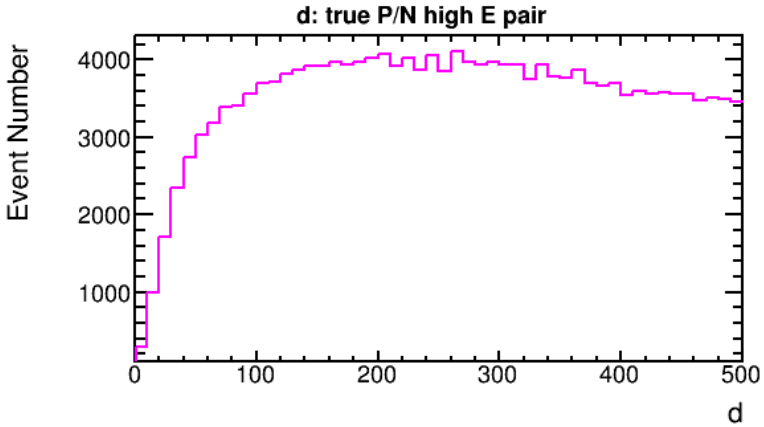


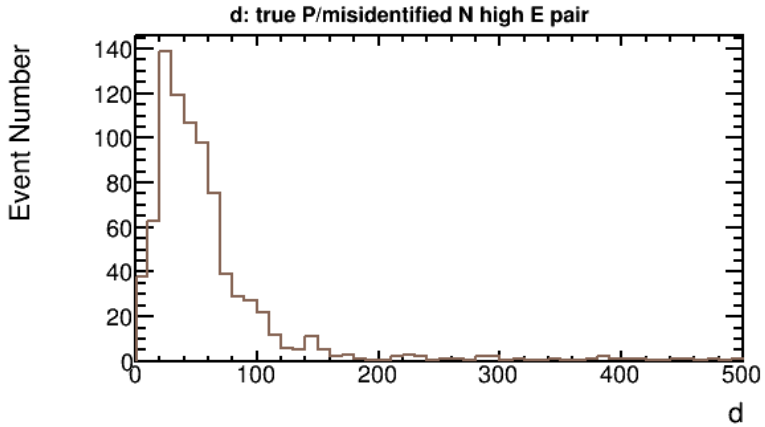
Distributions

- Distance separation for high energy pairs. Differences for true P/P and P/P fragments



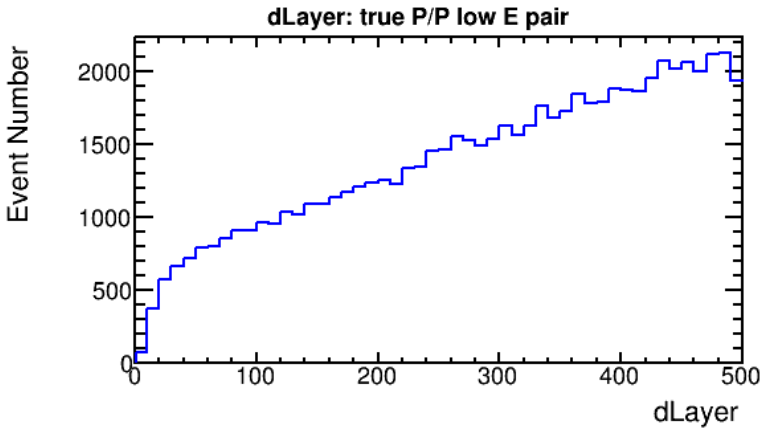


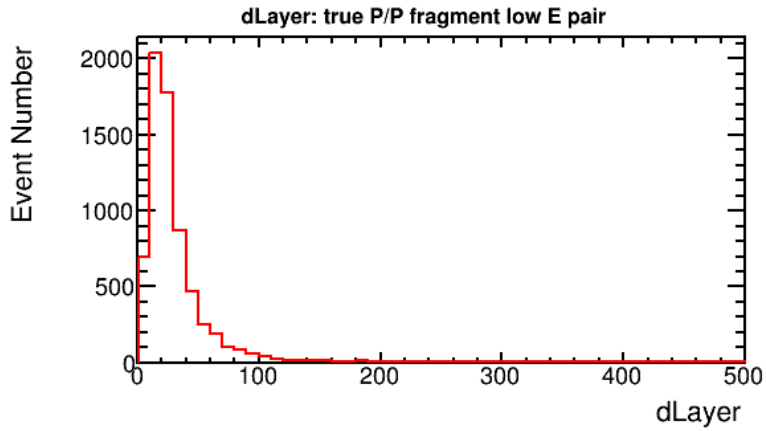


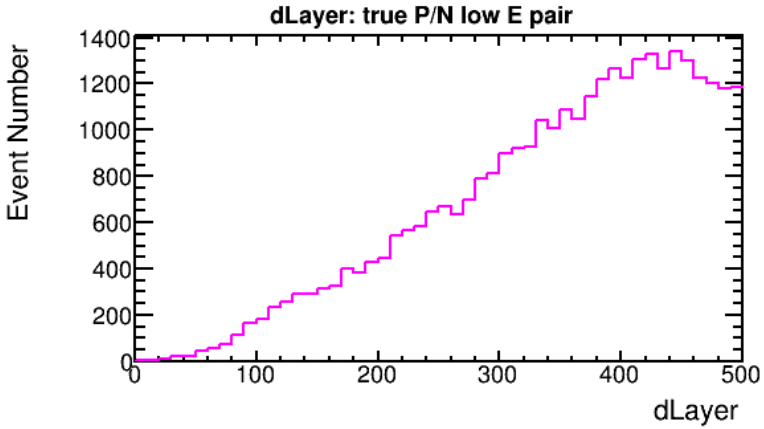


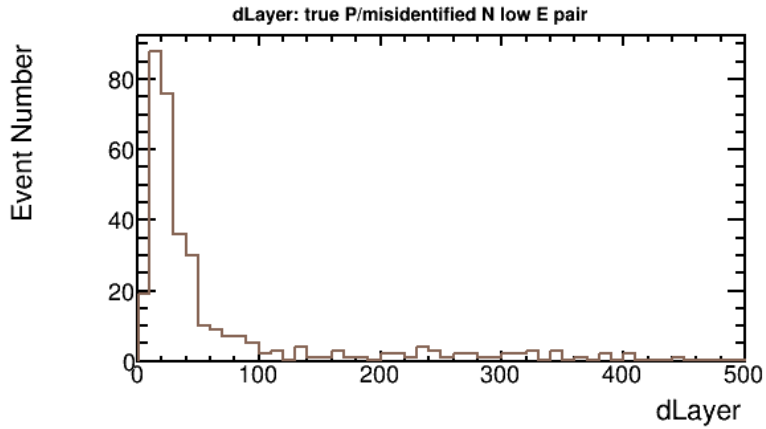
Distributions

- d_{layer} for low energy pairs. Again Clear differences for true P/P and P/P fragments









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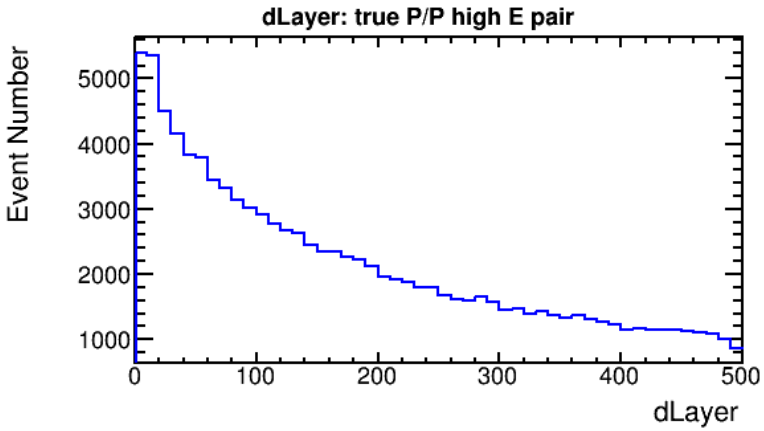
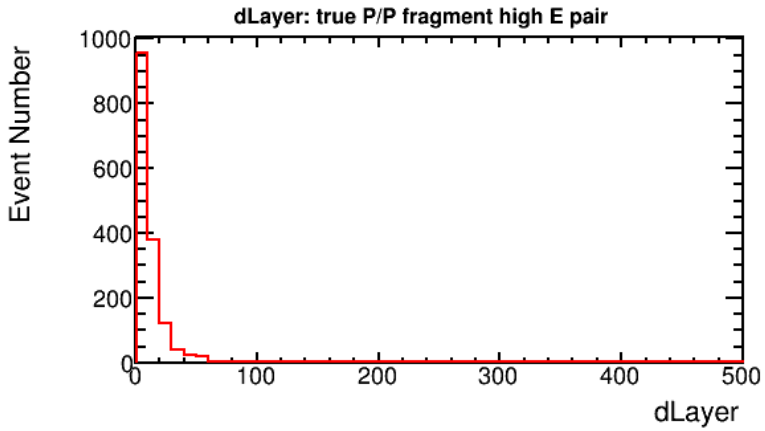
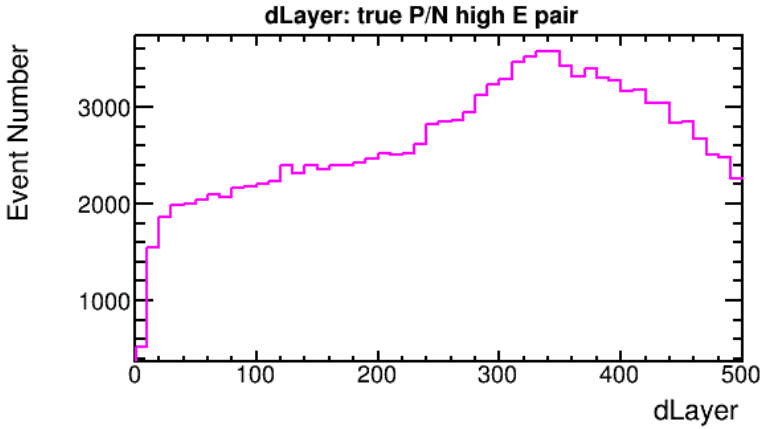
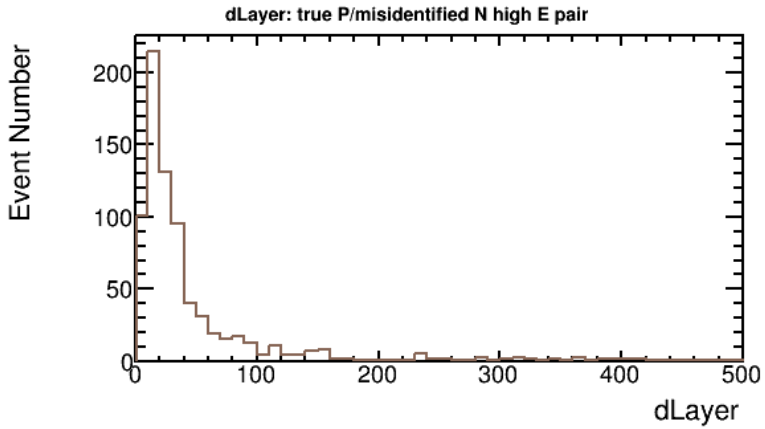


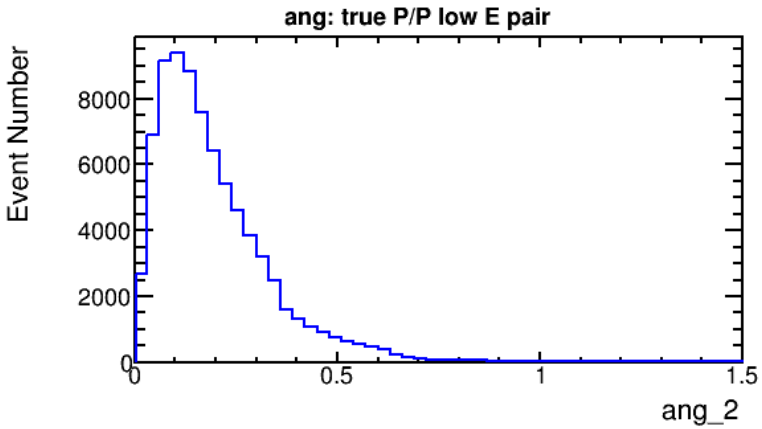


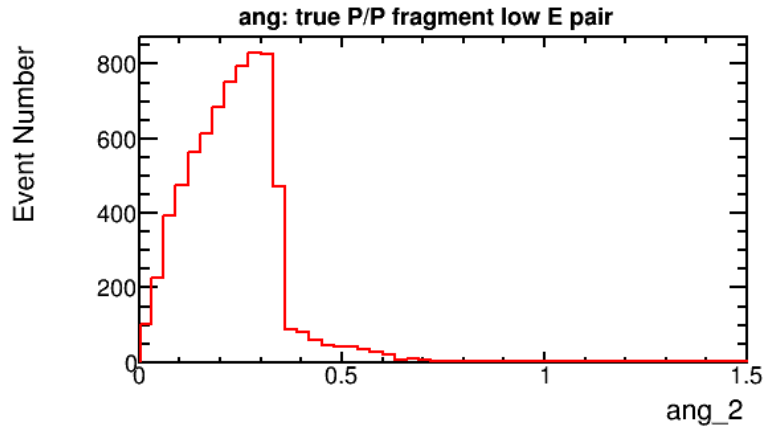


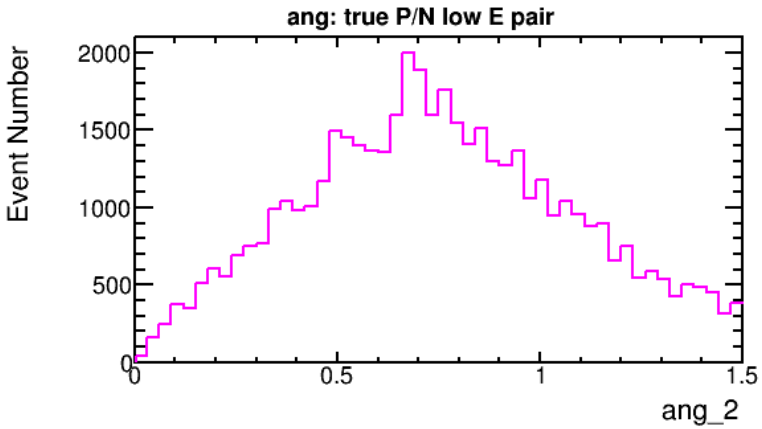


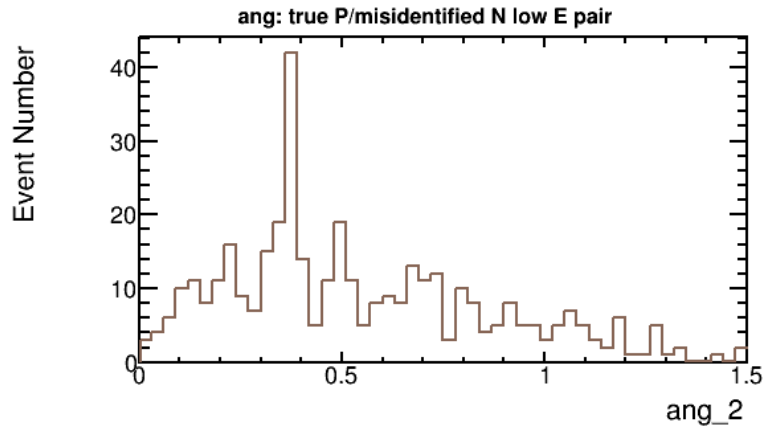
Distributions

- *Ang* of low E part for low energy pairs. Differences, no clear separation









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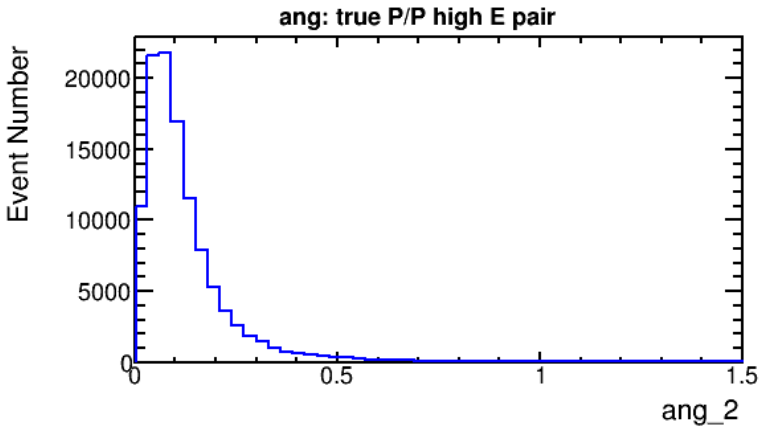
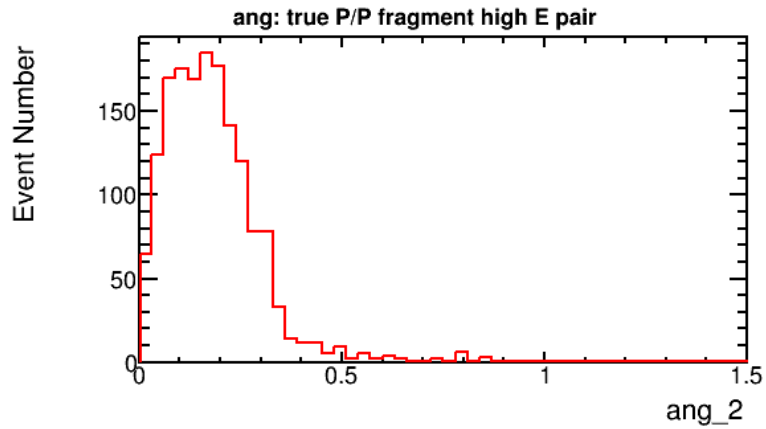
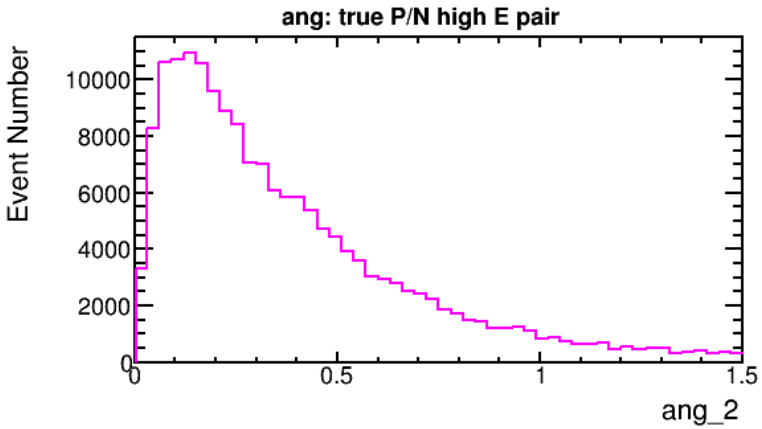
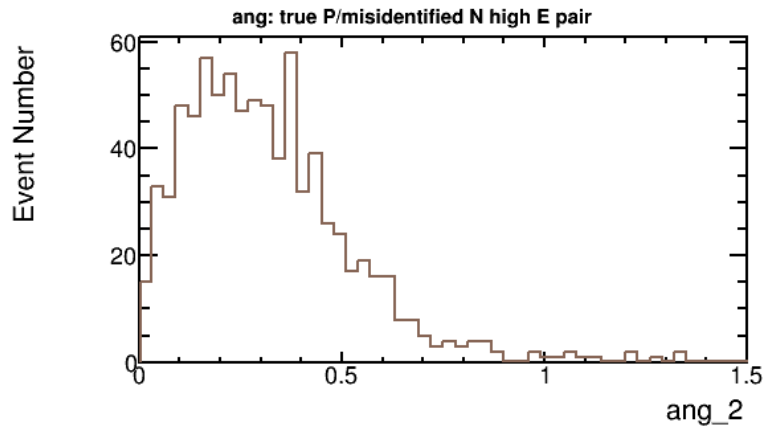








Simple cuts

- Clear cuts in d and d_{layer}, values selected to keep most fragments and fewest true photons
- The fragments(F%) and photons(P%) selection efficiency: defined as number of fragments/photons passed the cut over the number before the cut
- Fragments can be photon fragments or neutral hadron fragments, which should be merged

Cuts	**Cuts**	**F%**	**P%**
E Low P cut	d_{Layer} <100mm	0.96	0.09
E Low N cut	d<150mm	0.96	0.09
E High P cut	d_{Layer} <50mm	0.95	0.13
E High N cut	d<150mm&&d_{Layer} <200mm	0.90	0.16

Simple cuts

- Selection efficiency was high, yet many true photons left.
- With MVA, ratio of fragments to true photons could increase substantially.
- Numbers of fragments (Frag Left) and true photons(Photon Left) after selection cut are shown

Cuts	Frag Left	Photon Left
E Low P cut	6942	6852
E Low N cut	378	3803
E High P cut	1524	23249
E High N cut	740	28191

Summary and future work

- **On-going work:**
- Trying projection of a cluster on the direction of flight
- Identified fragmentation caused by clustering and likelihood test in Photon Reconstruction
- Minor clusters contribute to fragments
- MVA for better separation of photons and fragments
- Simple cuts preserve most fragments.

Summary and future work

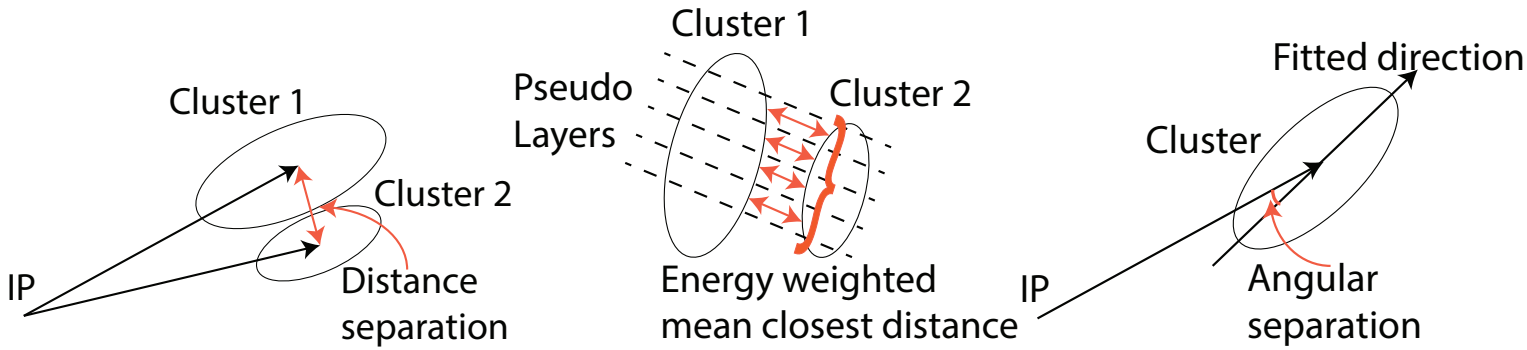
- **Next step:**
- Improving clustering in Photon Reconstruction by matching photon EM shower shape
- Also merge photon/neutral hadron fragments with true photon after pre-selection
- Then decide whether to split the merged clusters
- Will improve Pandora photon identification. Improve studies like τ reconstruction

Back-up

All Parameters

Definitions

- Here is a full list of parameters tried
- and showed differences in should-be-merged and should-not-be-merged groups
- d: Distance separation - distance between centre position of two clusters
- d_{Dlayer}: Energy weighted mean closest distance separation over layers
- Ang: Angular separation of a cluster- difference in direction to IP and fitted direction



All parameters
Definitions

- e_2: Energy of low energy part in a pair
- $layer_{mean,2}$: Energy weighted mean layer number of low energy part in a pair
- $d_{transverse,fitted}$: Energy weighted mean transverse separation of a cluster, wrt to its fitted direction
- cos_2: cosine of low energy part in a pair wrt to z axis
- $shapeDifference_{longitudinal}$: The difference of a cluster' longitudinal shape to a EM shower profile

Thank you!

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