Status of the SiD-Iowa PFA: New developments and plans

Garabed Halladjian, Remi Zaidan

SiD PFA meeting

The general plan

- Likelihood: should include maximum possible information

- Scoring & shower building:
  - First iteration:
    - Skeleton (simultaneous building of tracks)
    - Tight criteria
    - High purity
    - Reasonable efficiency
  - Second iteration:
    - Criteria can include information based on the first iteration
    - Increasing the efficiency
    - Adding the isolated sub-clusters
    - Adding the ambiguous sub-clusters

- The criteria of the score depends from the way that it is used in the shower building

- Both should be optimized at the same time

Remi Zaidan

Shower Reconstruction:
First Iteration

How does the first iteration work

- **Start from each track matched to a seed:**
  - Order does not matter.
  - All linkable clusters are available to all tracks.
- **Build charged showers for each track:**
  - Start from a seed.
  - Add all links fulfilling a certain criteria.
  - Treat each newly added cluster as a seed and iterate.
- **Criteria:**
  - Cut on a likelihood-based score.
 - Accept only outgoing links.

Likelihood training: good vs bad links

- **What is a good link:**
  - According to MC truth, a link from A to B is a good link.
  - However, a bad link from A to C will look more "good" in terms of the discriminating variables we have been using in the likelihood!
 - Need to somehow train the likelihood not to link directly from A to B, but instead go through X, Y and Z.

B: good

C: bad

Z

Y

X

A: seed

center of the detector
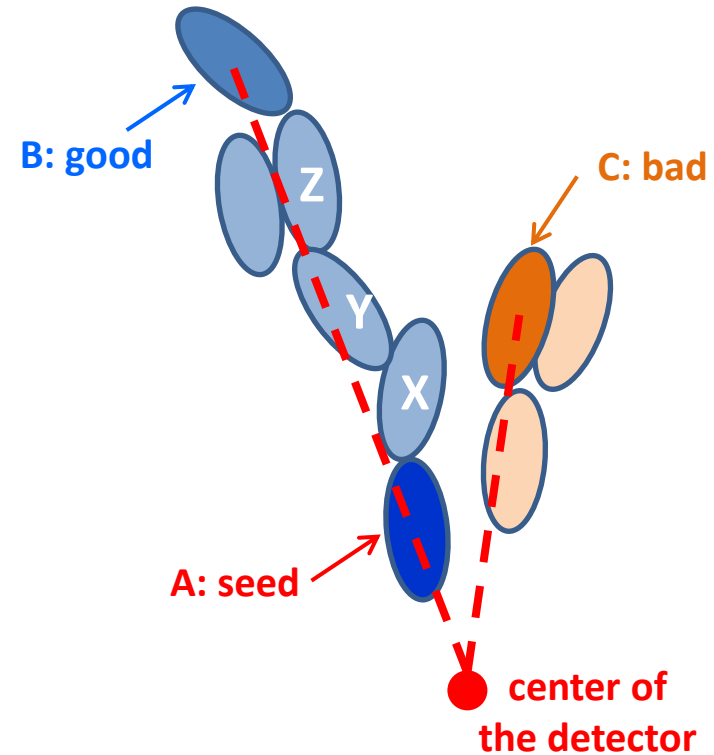
Definition:
negative and positive poles

- **Calculating distances:**
  - Calculating the minimal distance between two clusters is quadratic with the number of hits per cluster.
  - Instead, we define for each cluster a negative and a positive pole which are the closest and the farthest hits to the center of the detector.
  - Compute the distance between the positive pole of a cluster to the negative pole of the next cluster.
 - Calculating the new distance is linear with the number of hits per cluster.

Positive pole Farthest hit

Negative pole Nearest hit

center of the detector
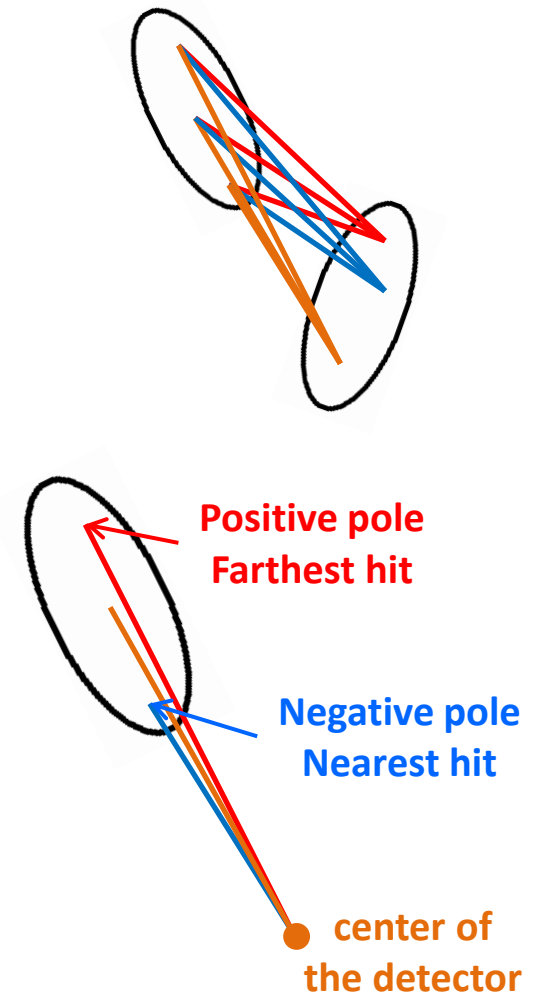
Definition: Interaction field

- **We define an "interaction" field between clusters:**
  - Positive "attracts" negative.
  - The "force" decrease with distance and angles: the "view field" is from inside out.
  - Two parameters to optimize:
    - How fast the force decrease with distance
   - How fast the force decrease with angle.
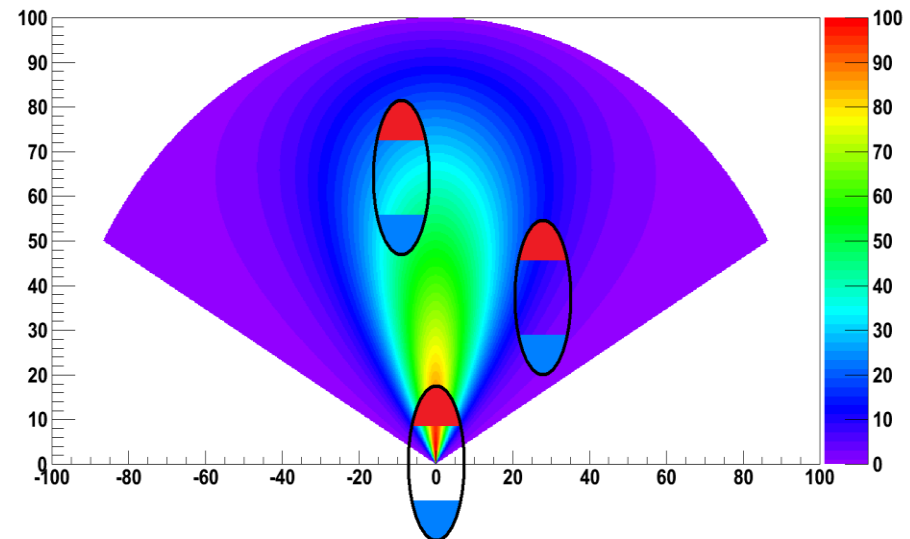
Likelihood training: using the "force"

- **Use the force to train the likelihood to favor direct links:**
  - A link from A to X is a good link if:
    - A and X originate from the same MC particle.
    - X is "attracted" by A more strongly than any other cluster.
- **We don't use the force during reconstruction:**
  - We only use the force to train the likelihood to link directly to X rather than to B.

B: bad

Z

C: bad

Y

X

X: good

A: seed

center of the detector
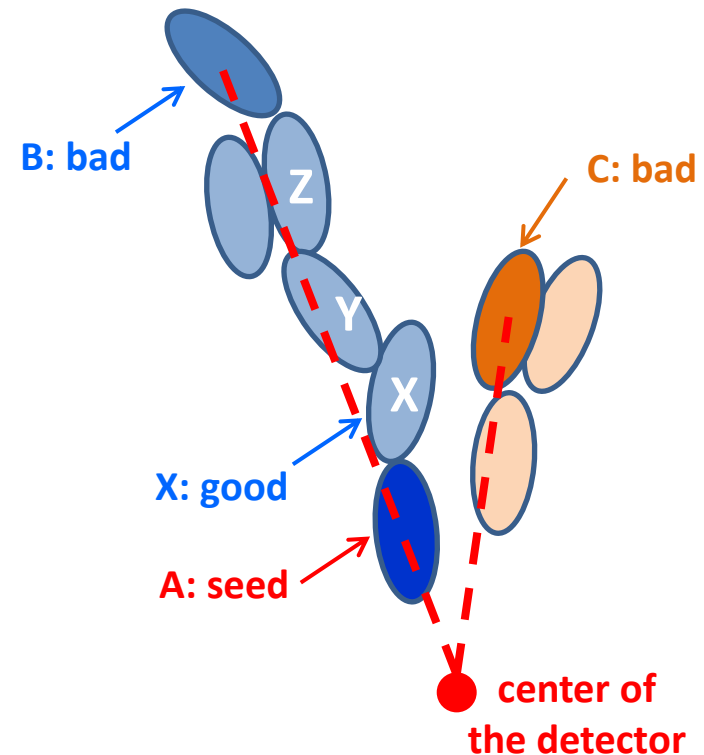
Likelihood training: Ecal vs Hcal

- **The scales in the Ecal and the Hcal are very different:**
  - Use separate likelihoods for Ecal and Hcal.
  - Clusters in the Muon detector are treated as in Hcal:
    - The reason: lack of statistics to create a separate category
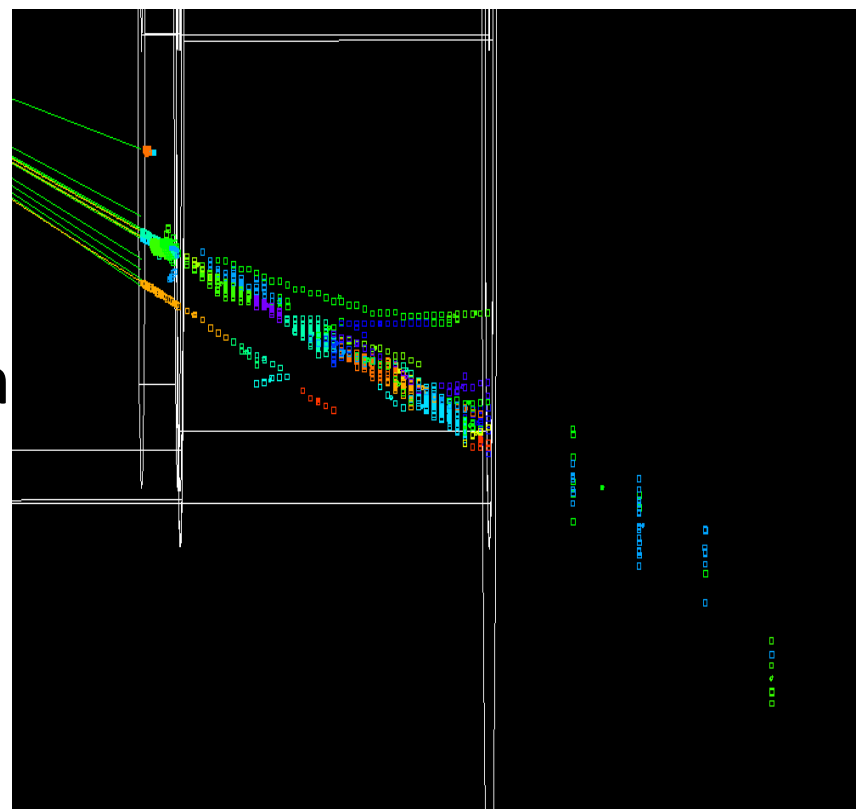
Likelihood training: Ecal vs Hcal

- **A concrete example:**
  - Distance of closest approach (mm)
  - Most of the bad links between Ecal-Ecal clusters are within the good peak of the Hcal-Hcal links.
  - Mistakes made in the Ecal are most likely to propagate along with the shower building all the way through the Hcal.
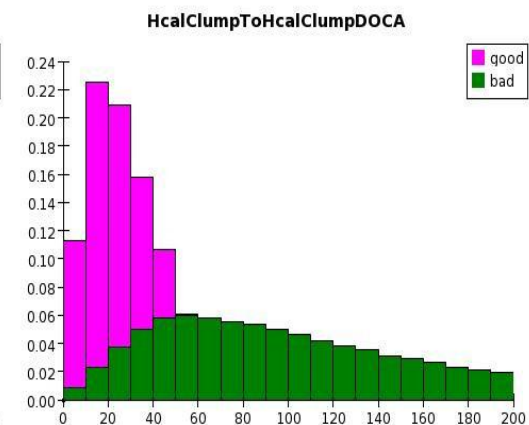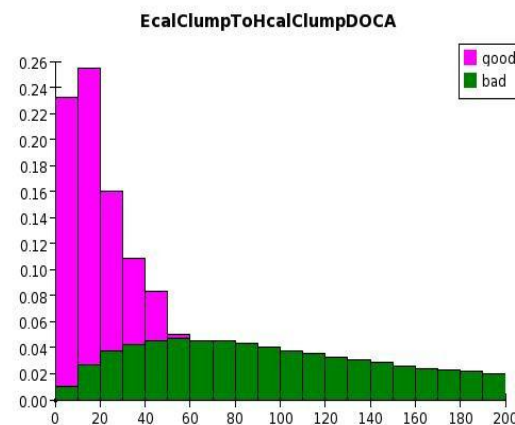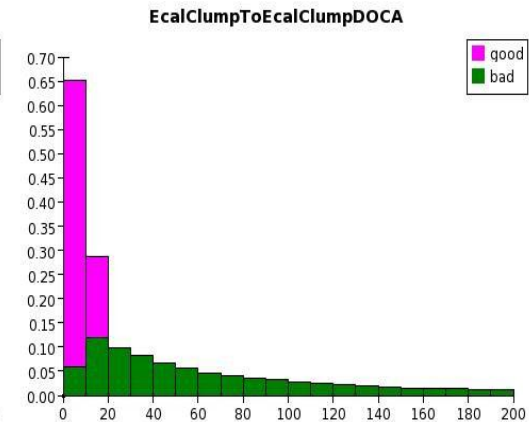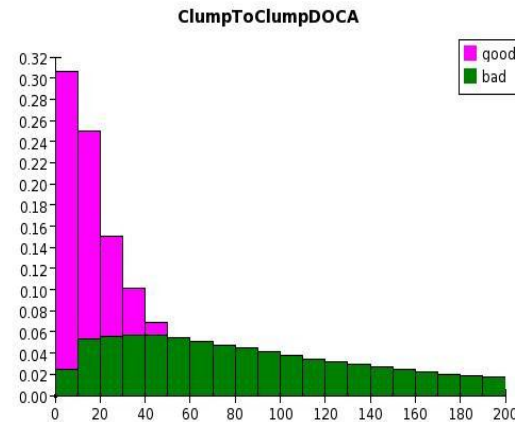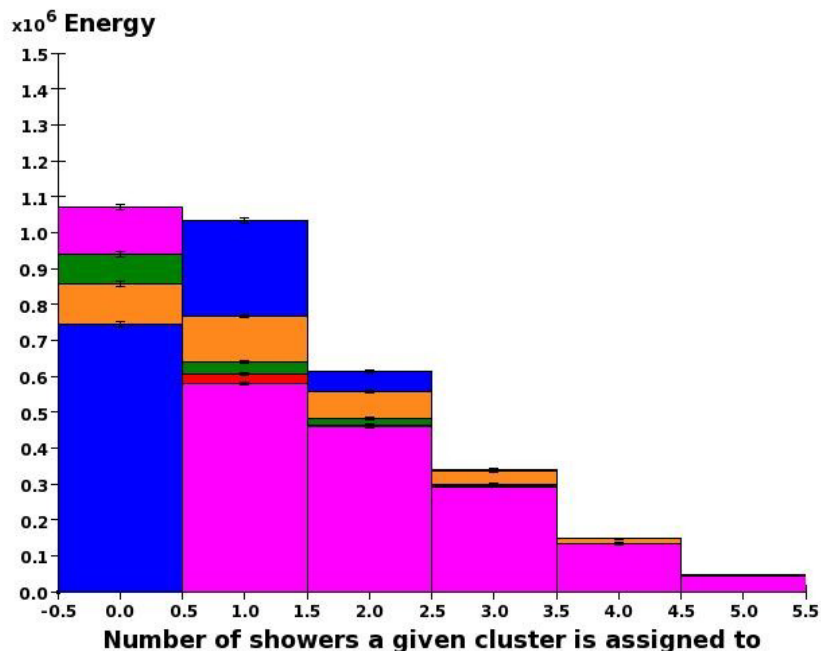
First results of the first iteration

- Too many neutral energy assigned to charged hadrons.
- Especially photons!

Assigned to neutral particles (bin 0) but in reality are from:

Photons
Neutral hadrons
Charged hadrons with no reconstructed track
Charged hadrons

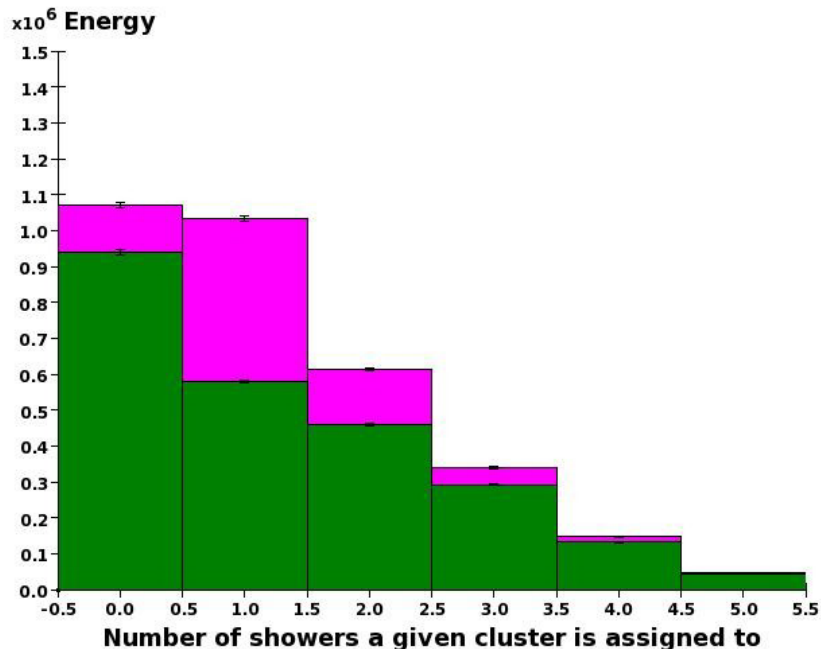**Assigned to charged particles (bin ≥ 1) but in reality are from:**

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A different charged hadron than all the ones assigned to
One of the charged hadrons assigned to

x10^6 Energy

Number of showers a given cluster is assigned to

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Same as the slide before with two colors for clarification:

Correct Assignment
Confusion

x10^6 **Energy**

Number of showers a given cluster is assigned to

Using 2-dimensional PDF's for the likelihood

- Reduced photons confusions.
- More unassigned charged energy

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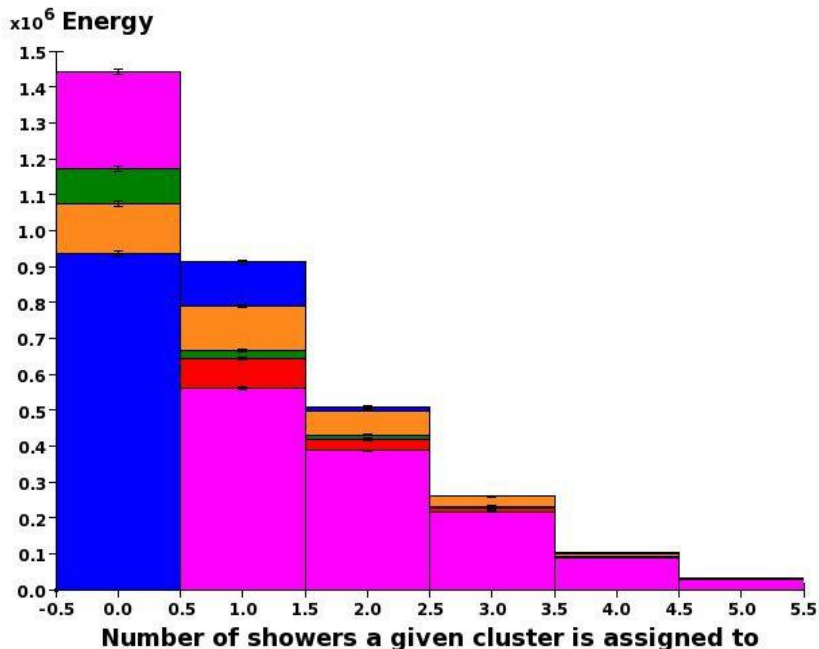**Assigned to charged particles (bin ≥ 1) but in reality are from:**

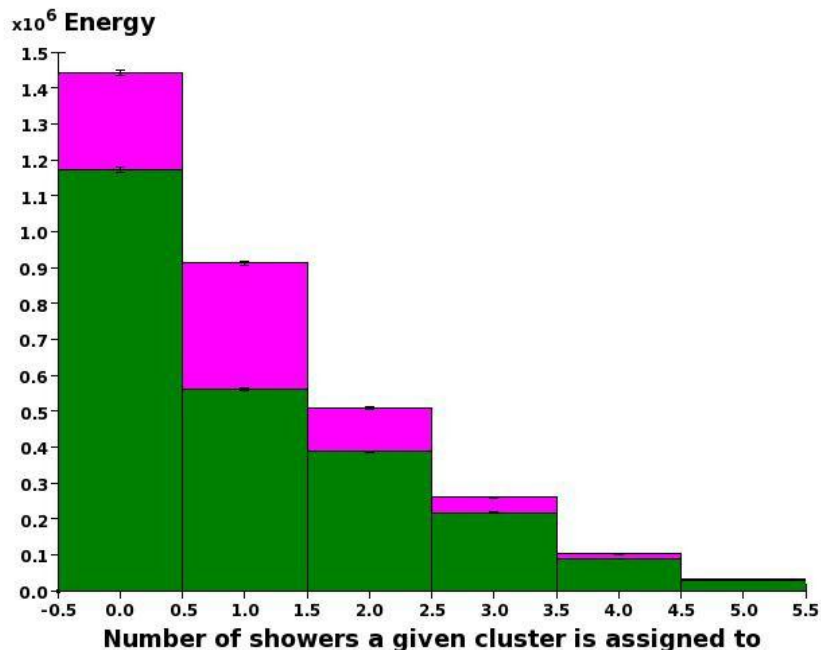| |
|---|
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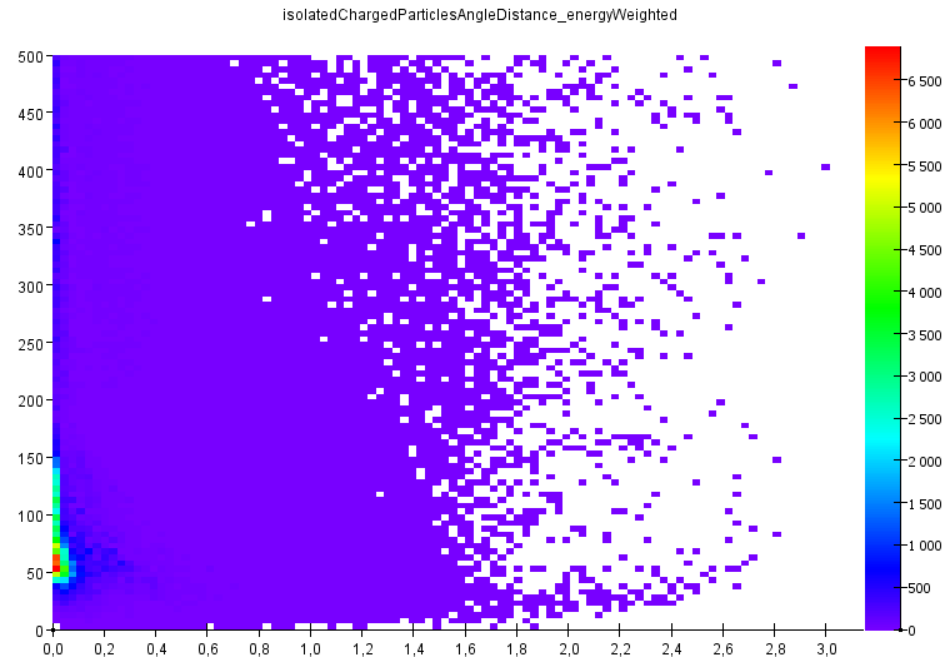
Missing charged energy in the Ecal

- **We looked at the unassigned charged energy:**
  - Many of these missed clusters are situated along the extrapolation of a track and at a distance of 60-70 mm from the extrapolation of the track to the Ecal entrance.
  - This might be due to a problem at the crossing from thin to thick Ecal layers.
  - Need to investigate, but for now we decided to pick up those clusters by hand.

isolatedChargedParticlesAngleDistance_energyWeighted

Missing charged energy in the Ecal

- Recovered most of the unassigned charged energy.
- Slightly more photons assigned to charged energy.

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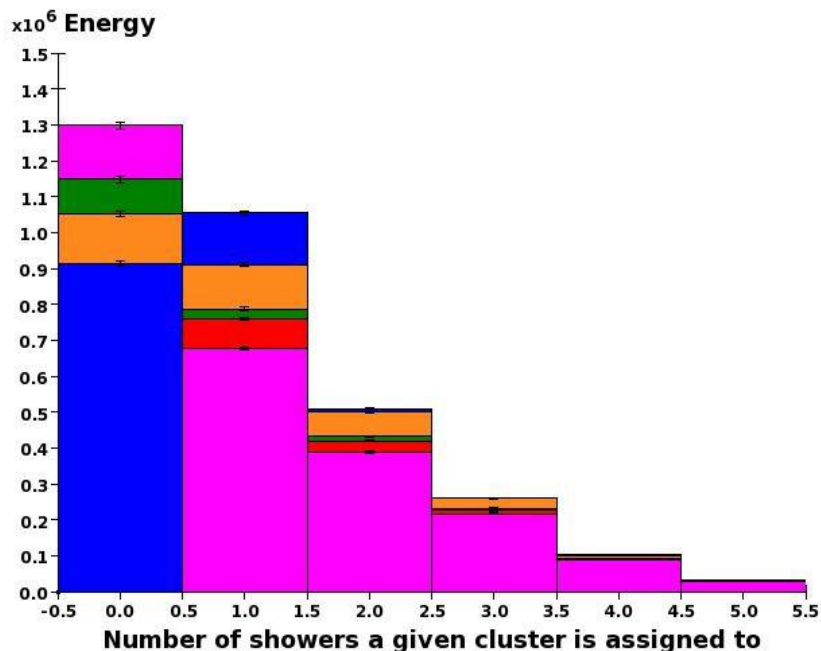**Assigned to charged particles (bin ≥ 1) but in reality are from:**

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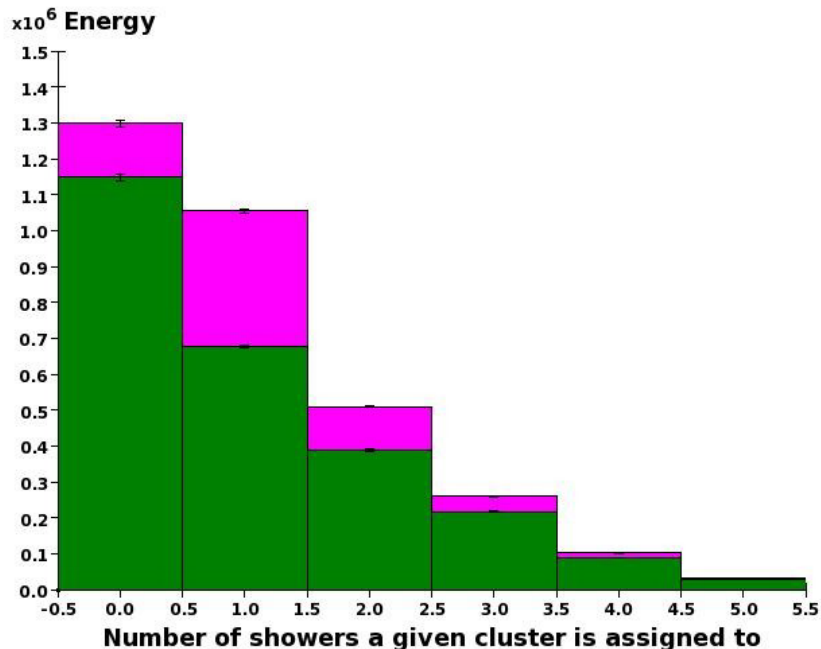
Dealing with photons.

- **Resolving overlap between photons, muons and initial MIP's:**
  - Reconstructed photons which have common hits with muons of initial MIP's are removed from the photon pool and put into the hadron pool before starting the shower building:
  - Seems to be too strong a criterion as this puts 1/3rd of the (real) photons back among the hadrons.
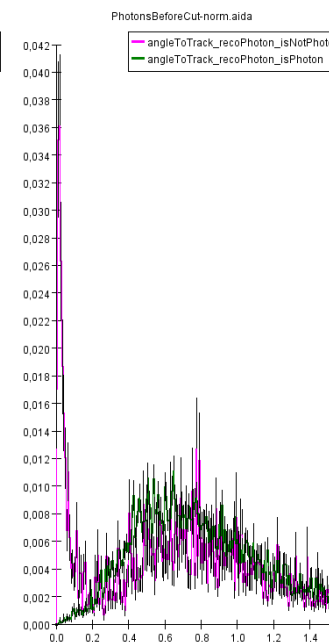
Called hadrons

Called photons

Called photons then hadrons

Real photons

Real hadrons
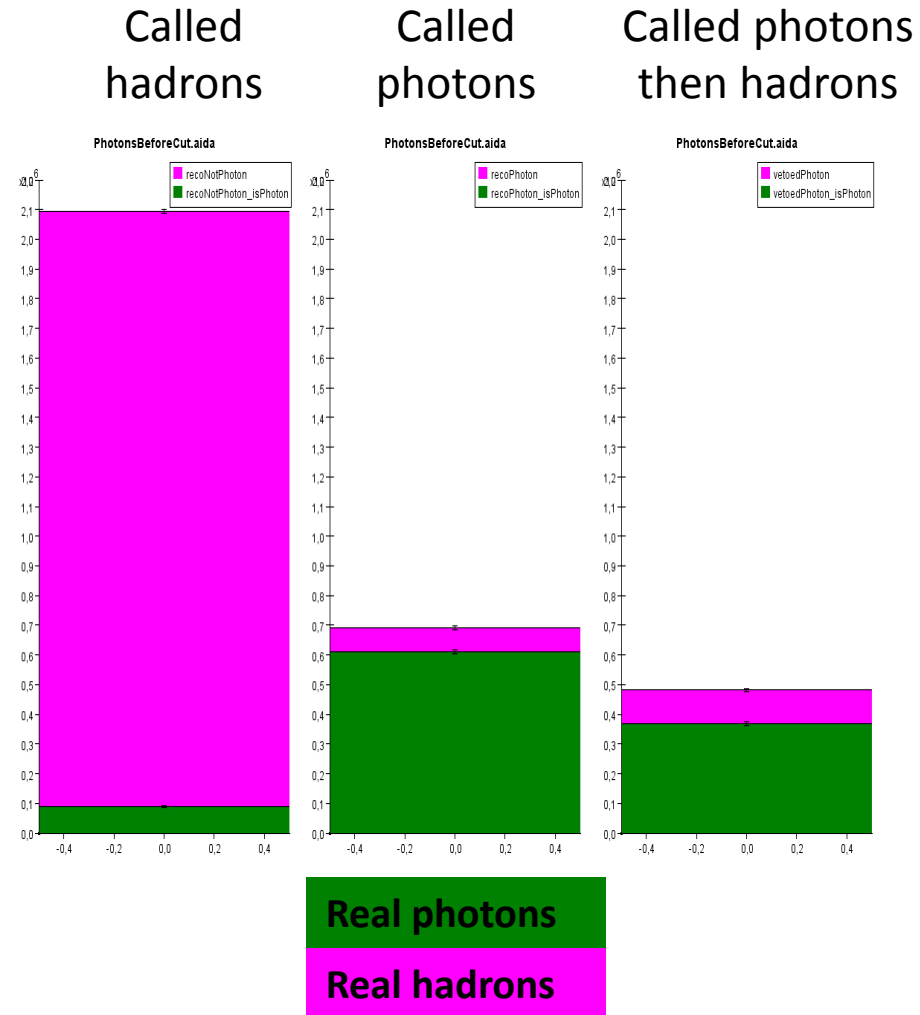
Dealing with photons

- **Looked at several variables, one was ineteresting:**
  - The angle to the closest track.
  - Only call a reconstructed photon a photon if there is no charged track within an angle of 0.1.
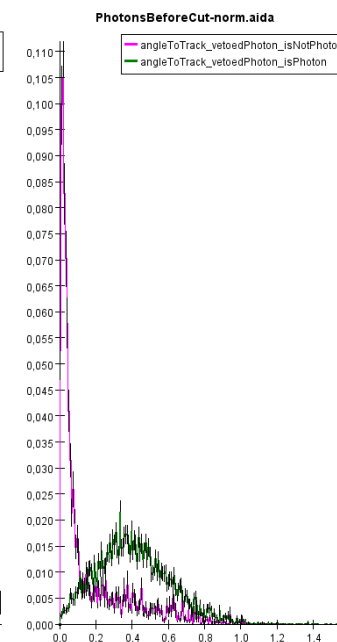
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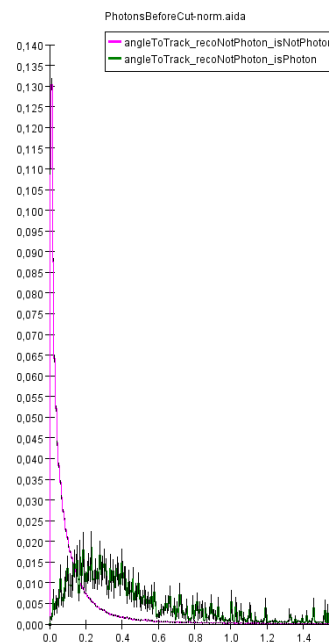
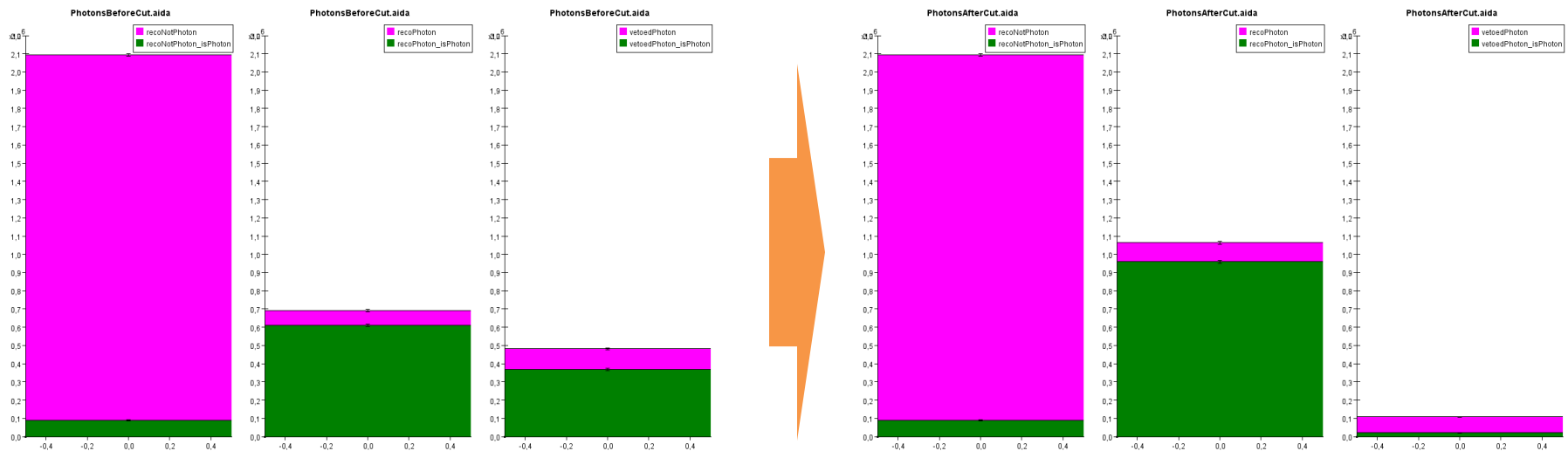Called photons

Called photons then hadrons

Real photons

Real hadrons

Dealing with photons.

- **Performance is rather good.**
  - Still small rate of photon/hadron confusion.
  - Now limited by the Photon ID reconstruction.
  - Need to estimate how the remaining confusion affects the PFA

Dealing with photons

- Removed most photons from being candidate to hadron shower reconstruction.
- Significantly improved on the photon side

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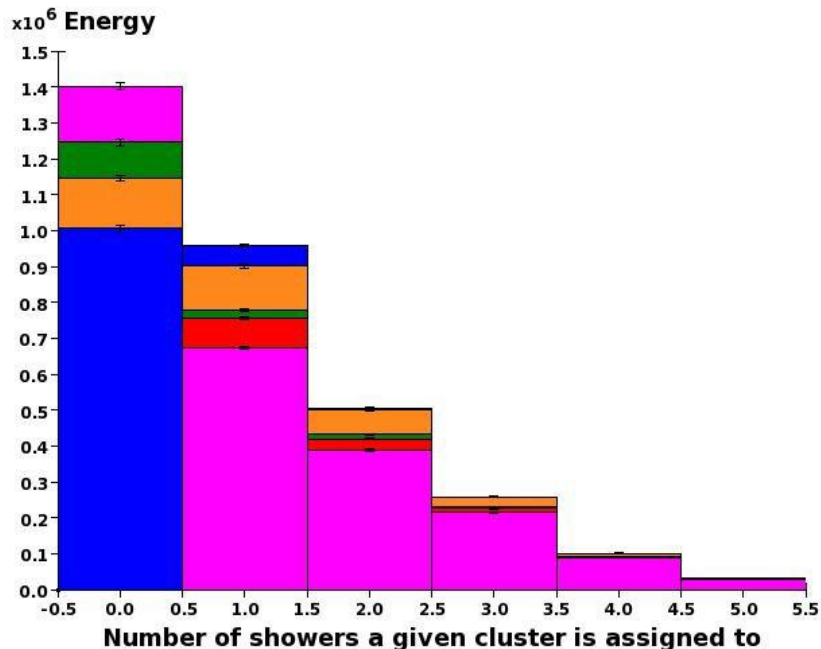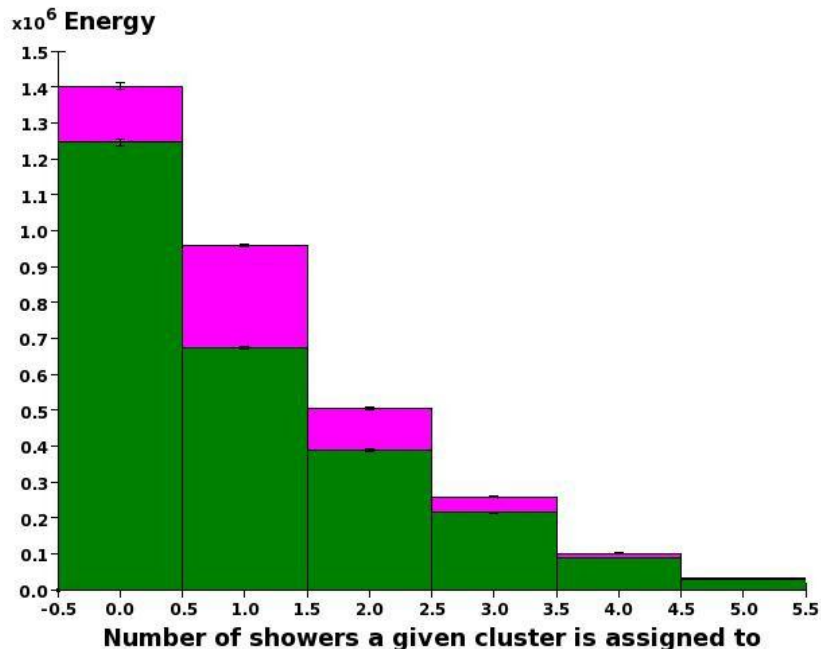**Assigned to charged particles (bin ≥ 1) but in reality are from:**

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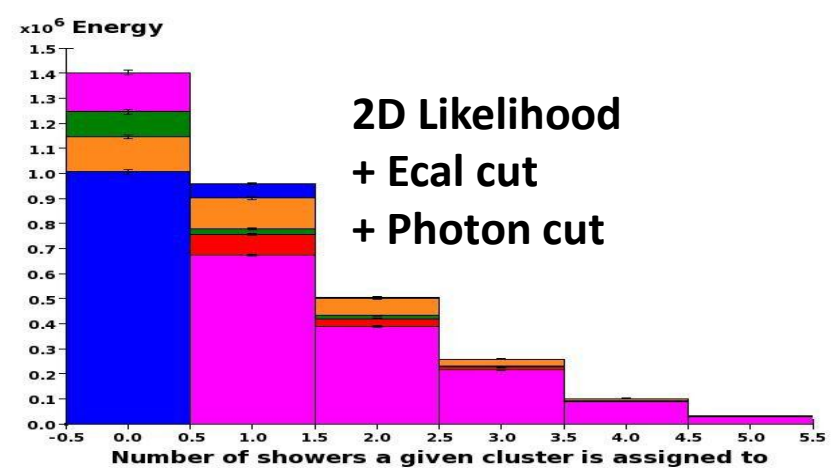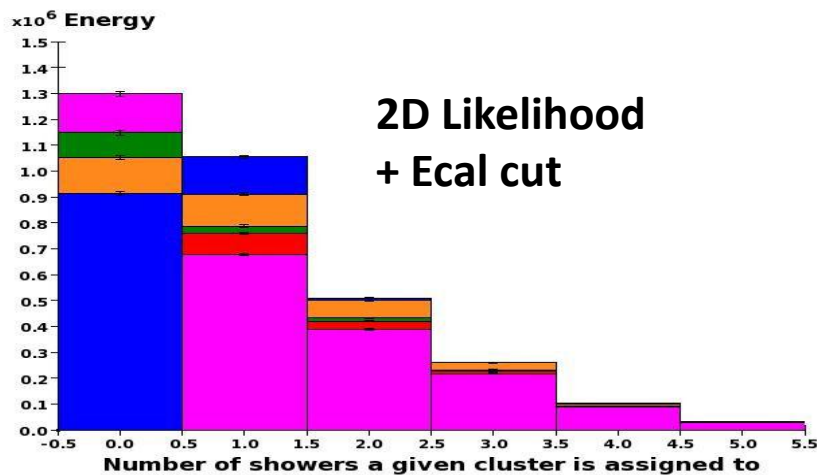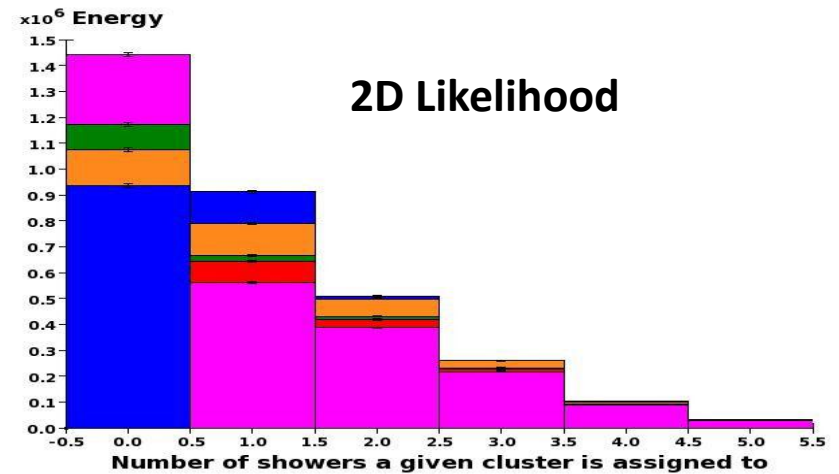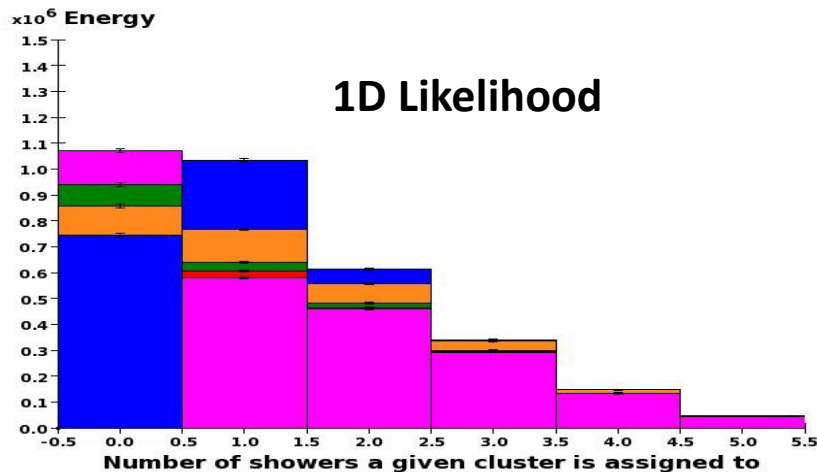**Same as the slide before with two colors for clarification:**

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Summary at this point

- **Showing steady improvement so far...**

1D Likelihood

2D Likelihood

2D Likelihood
+ Ecal cut

2D Likelihood
+ Ecal cut
+ Photon cut

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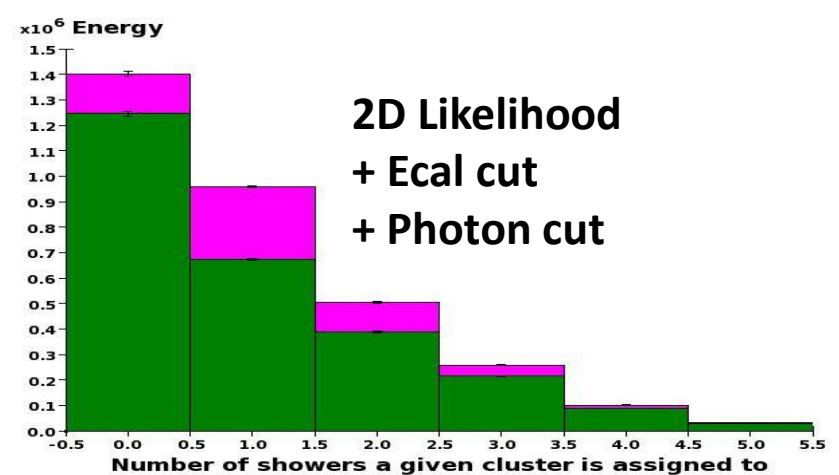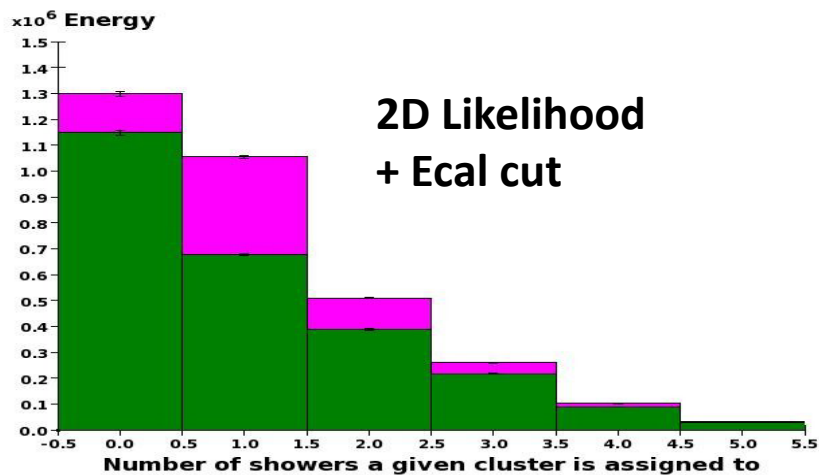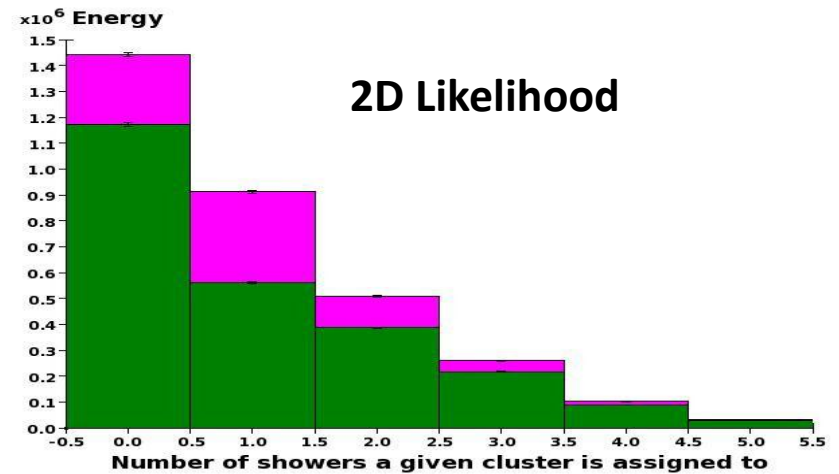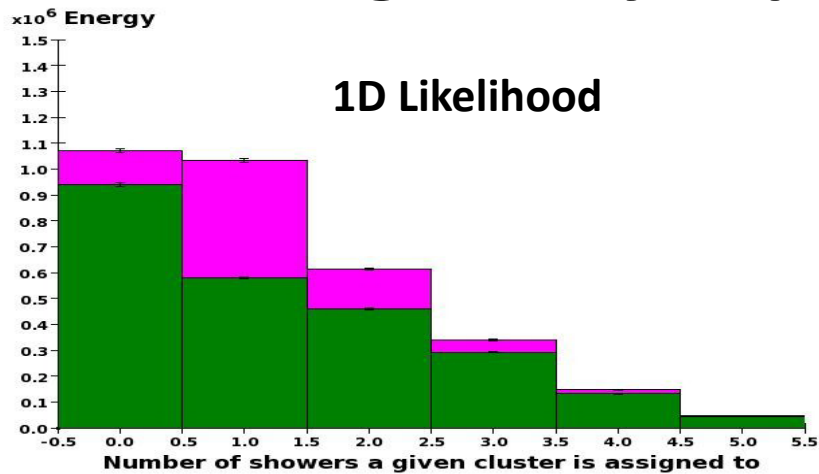
Thinking about next steps

Remi Zaidan

Building neutral hadrons shower prototypes.

We believe that a first pass on neutral hadron showers would help the neutral/charged separation...

If we are aware of the presence of a nearby neutral shower, we can be smarter in the charged shower building.

center of
the detector