

PFA(Particle Flow Algorithm) at University of Iowa

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Outline

0. Code location
1. Initial clustering and photon ID
2. Tracking, track extrapolation and seed clusters
3. Building charged showers
4. Fixing mistakes
5. Reconstructed Particle output

Where to find it

Where is it?

- Location
org.lcsim.pfa.structural
- The class name
RunAndWriteOutPFA →
- It will write out "full.slcio"
- cvs update and build it

```
//setup track
add(new CheatReconDriver());
//setup Photon and DirectedTree
add(new SetUpDTreeForReclustering());
//run PFA
add(new ReclusterDTreeDriver(...));
//output
add(new FlushReconstructedParticlesDriver(...));
writeOutMini("full.slcio")
```

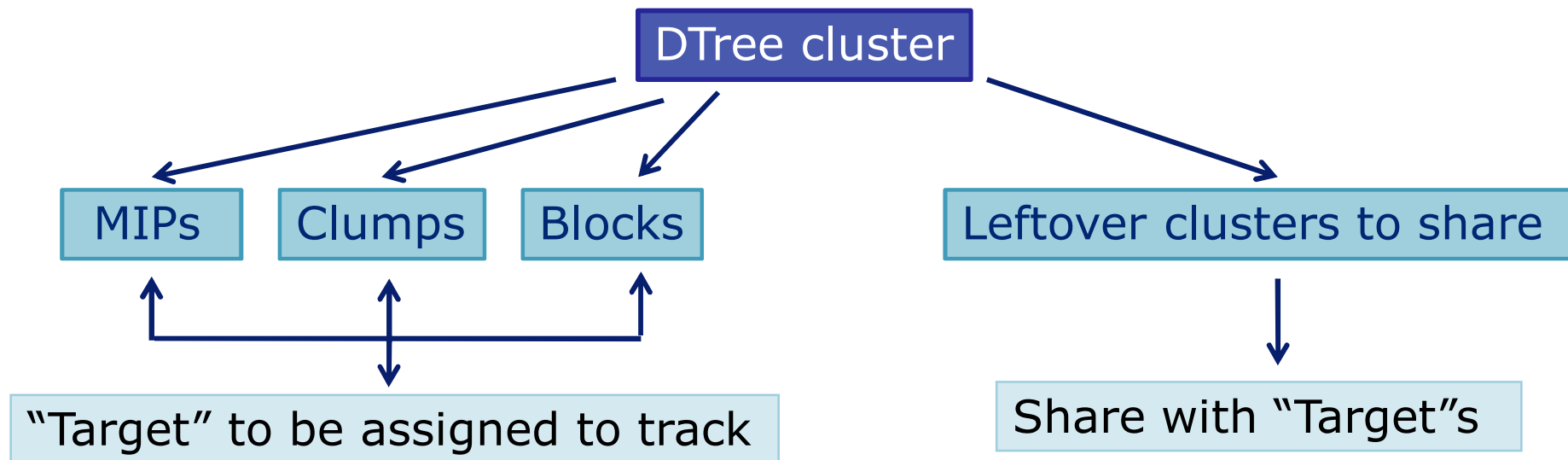
Example

- In *ExampleReadPFA*
add(new MassPlots("FlushedDTreeReclusteredParticles", "xxx.aida"));
- You are going to get output file as "xxx.aida"
- If you need any help, don't hesitate to get in touch with us.
(TJ, Mat, Ron also can help with the output file)

DTree Clusters

Structure

ECal Digi Hits (Barrel, Endcap)			HCal Digi Hits (Barrel, Endcap)	
Photon	DTree cluster (ECal Barrel)	DTree cluster (ECal Endcap)	DTree cluster (HCal Barrel)	DTree cluster (HCal Endcap)



Leakage problem

- Some of high energy shower escapes HCal, reaching Muon Detector.
- If you can add the energy in Muon Detector, you will get better resolution since it means a more correct assignment for high energy jet.
- Use Muon Endcap System. (Not Muon Barrel due to solenoid material)

substructure in DTree

MIP A continuous sequence of single hits

Clump Group of hits with high density

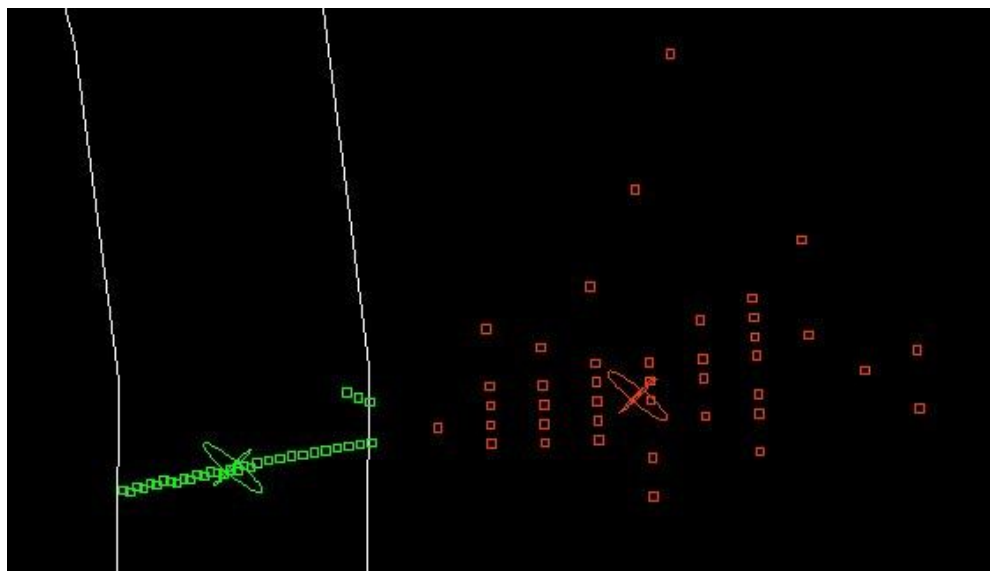
Block No structure,
if (≥ 20 hits in ECAL, ≥ 15 hits in HCAL)

Leftover No structure, small number of hits

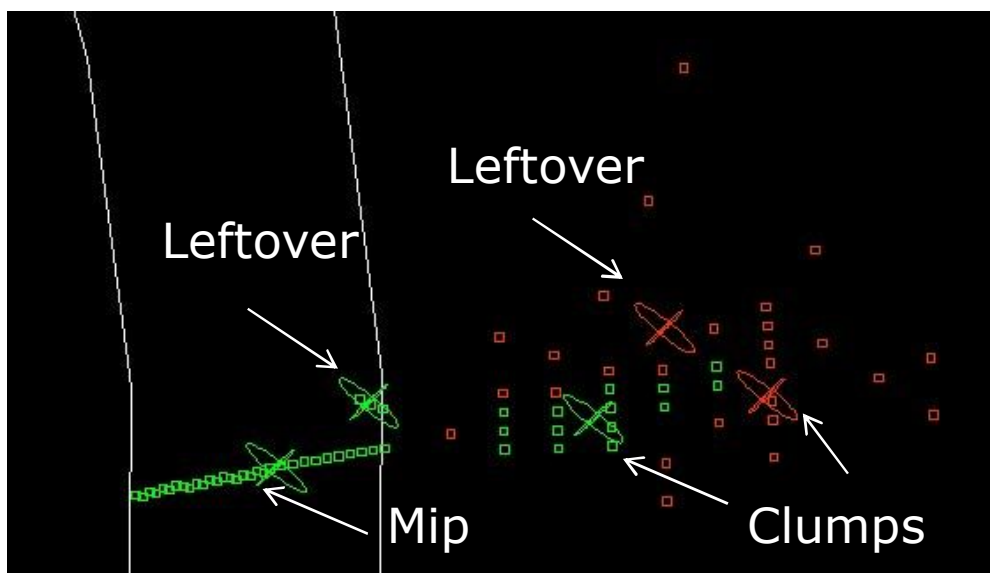
Leftover clusters are shared with target (mip, clump, block, seed) : Fuzzy clustering

- Give weight based on distance
- Inside same DTree cluster, give bonus : +0.05
- Outside of the DTree cluster, give penalty : x0.2

Example



2 DTree clusters
in ECal and HCal

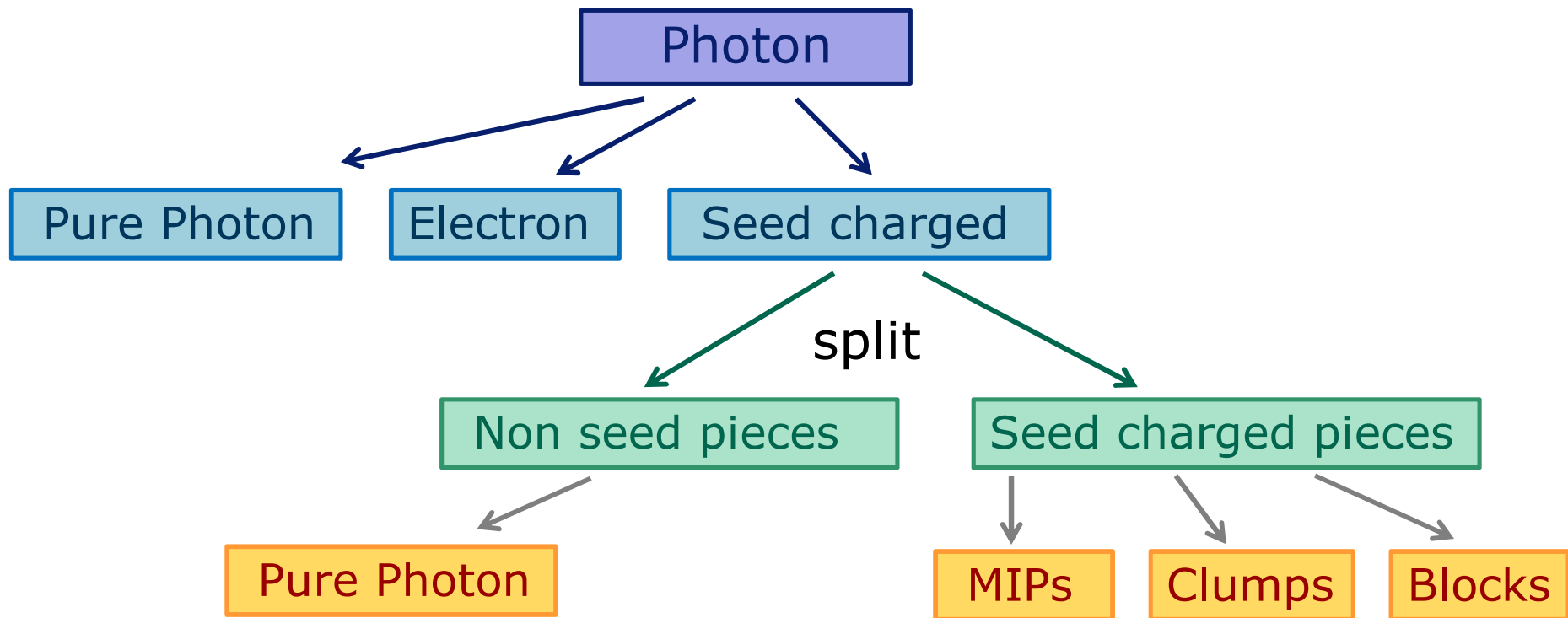


DTree cluster in ECal has
one mip and one leftover
cluster.

DTree cluster in HCal has
two clumps and one
leftover cluster.

Photon separation

- Photon is given by Ron's photon finder
- Separate it more.
 - Pure photon cluster if the cluster has no track matched.
 - Electron cluster if the cluster has track matched and survives E/p.
 - Charged cluster : Seed corresponding to track.



Tracking

Currently we use Ron's tracks, cheating track

- Find the 3 outermost hits in tracker using MC truth with *LocalHelixExtrapolator*.
- Extrapolate track with the 3 hits position
- Can fail when low momentum tracks loop over

PFA with real track list is under investigation.

- This study is just beginning.
- Make extrapolated track given by tracking group
- The track is extrapolated with *HelixSwimmer*.
- Resolution with real track can be worse.
- But this will be improved.

Track matching to seed cluster

Candidate clusters for matching

- Mip, clumps, blocks, leftover, photon
- It is important to assign clusters to track accurately

If the track has no cluster matched,

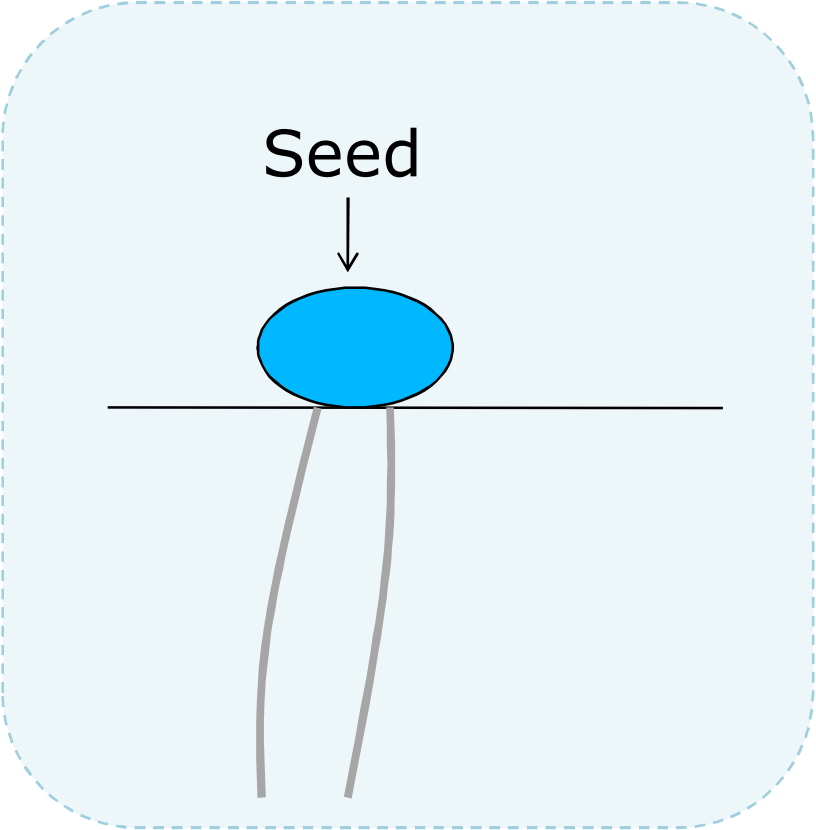
- If track doesn't reach calorimeter (e.g. low angle or p_T), then add particle with track's 3 momentum.
- If track does reach calorimeter, something failed : ignore the track since its energy made it to ECal somewhere.

Seed : Each track has one seed.

- Break up if the seed is too big with $(E-p) > 3\sigma$
- If the seed is flagged as photon, break it up (slide 7)
- We want to avoid the case where the seed is mixed with photon or neutral hadron clusters.

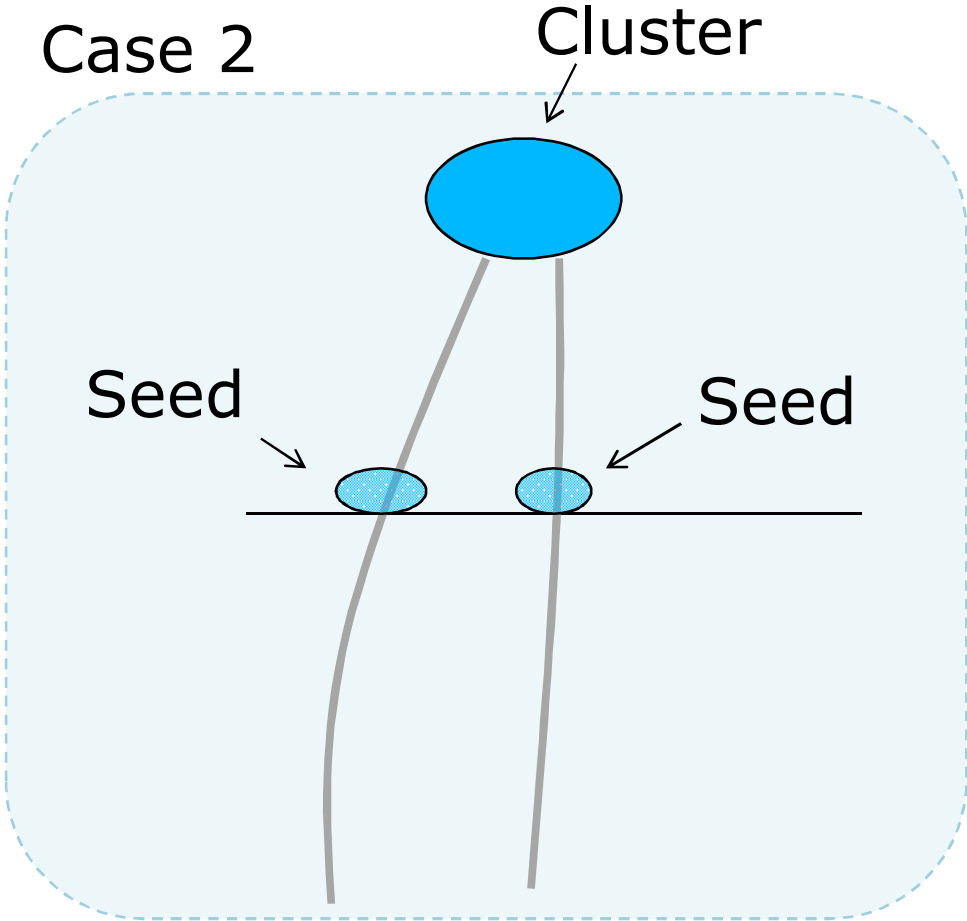
Merging tracks into one

Case 1



Make "multiple track" for E/p check. Written out as 2 separate charged particles in the end.

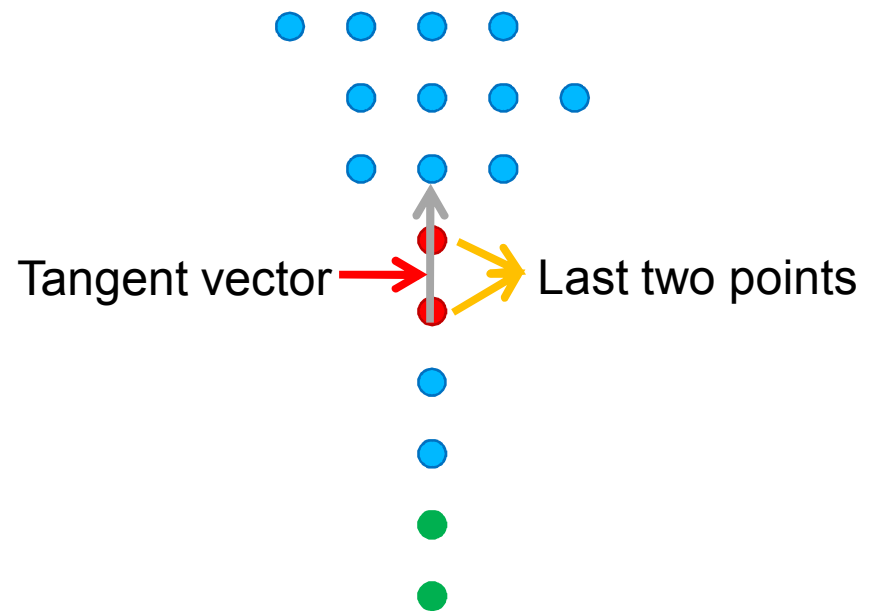
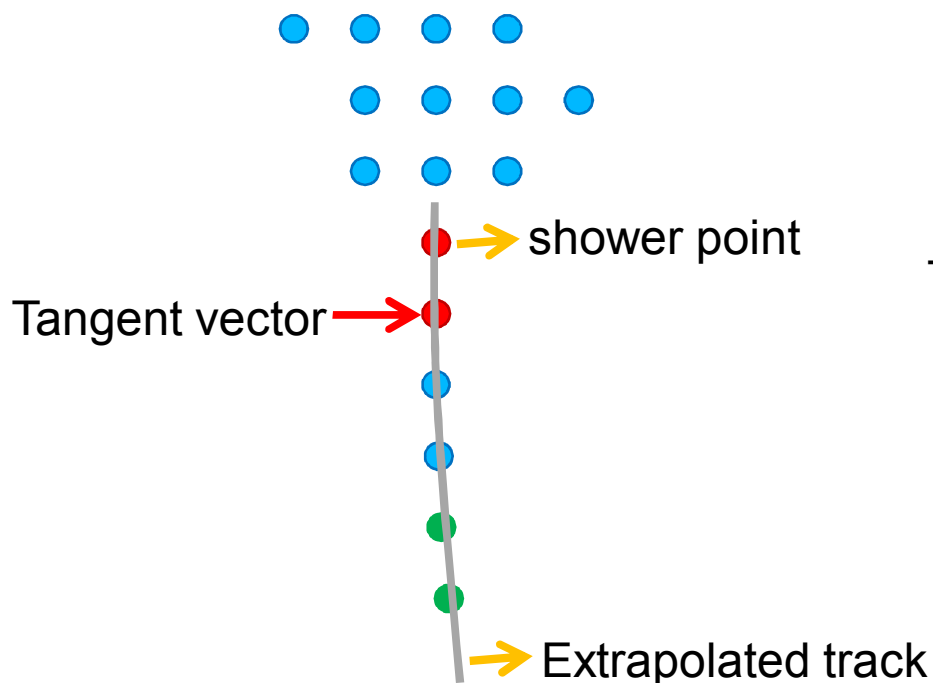
Case 2



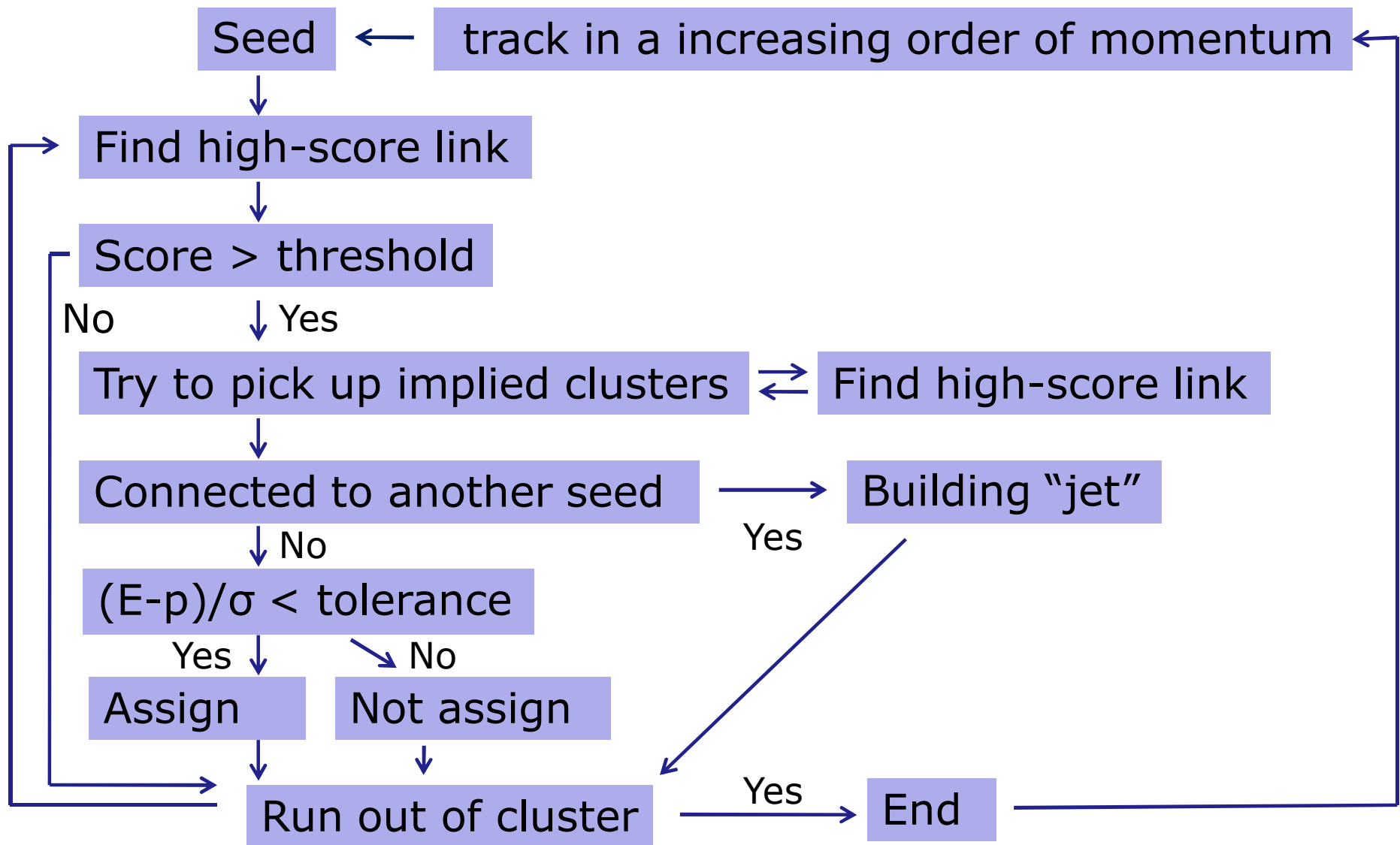
Put it together for E/p check
This case is called "jet" in a PFA code, doesn't have physics meaning.

Shower point and tangent direction

- Extend the mip by finding closest hit in next layer
- Stop when hits have neighbours 3 layers in a row.
- Two ways to get the tangent direction
 - Using extrapolated track
 - Using last two hits before shower starting
- Look at the angle from the showering point for scoring and reassignment later.



Building charged cluster



If incomplete track ($E \ll p$), adjust tolerance/threshold and go back

Fixing mistakes

Mistakes

- If E is too small compared to track momentum, there is still room in charged shower.
- Find unassigned cluster and add it.

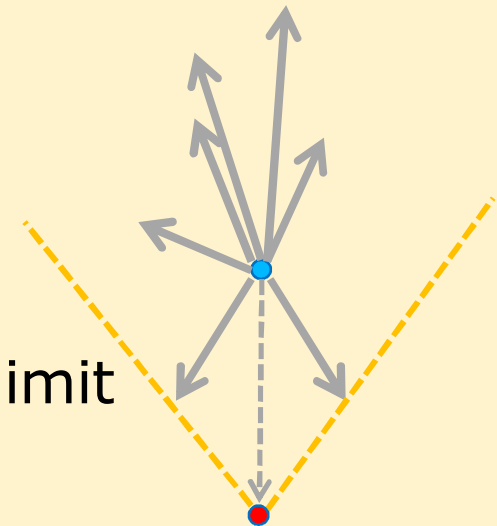
How to solve: Method 1. Override

- Find high score link to the unassigned cluster
- Check if the corresponding cluster has track matched.
- Add this cluster only if it survives E/p requirement when we add it to charged shower components.

Fixing mistakes

How to solve: Method 2. Reassignment

- There are clusters which are not assigned to any track due to E/p fail or score too low
- We want to recover those clusters by adding it to track (if that's the right thing to do).
 - Make unassigned cluster list
 - Get an angle for each cluster with track
 - Veto if score < 0.7
 - Add clusters in angular order
 - Add clusters until E/p meet tight upper limit
 - Veto if the cluster is too huge ($E \gg p$)



Neutral Hadron Shower

- The remaining cluster after assigning as charged and photon clusters are going to be neutral hadron clusters.
- Make neutral shower by looping over unassigned clusters in the same way we did for charged clusters.
- But in this case, there is neither E/p cut or any adjusting threshold for score.
- Each set of shower clusters is going to be one neutral particle.
- If the whole shower is deposited in ECAL, treat it as photon, instead.

Reconstructed Particle

Make reconstructed particle

- Photon has one cluster and no mass. 4-vector is based on position and energy of the cluster.
- Electron has one cluster and one track. 4-vector is based on the track momentum and electron mass.
- Charged particle is reconstructed with 4-vector based on the track momentum and pion mass.
- Neutral particle is reconstructed with 4-vector based on the position and energy of the cluster and kaon mass.

FlushedDTreeReclusteredParticles

- This is the output list of reconstructed particles.
- Currently it contains final state particles.

Summary

- For barrel region with ZZ(nunuqqbar) event sample, RMS90: 3.8 GeV for sid01 rpc and 3.3 GeV for sid01 scint. For more details, see Mat's talk
- What we have been doing for last several months has improved the resolution. We still have lots of thing to try, e.g.
 - Energy dependent optimization is needed.
 - Muon Identification in a simple way.
 - Study with the new real track list
 - How to recover the cluster stolen by low momentum track earlier.
- Things are moving in the right direction.