PFA et reconstruction

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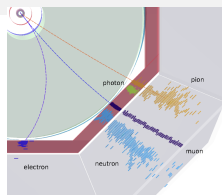
IP2I Lyon

18 octobre 2023
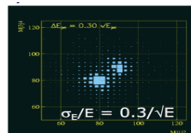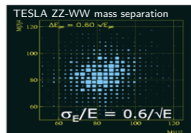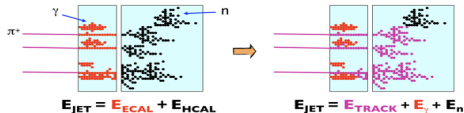
Particle flow calorimetry

Particle Flow Algorithm (PFA)

- ILC physics program requires $W/Z \to q\bar{q}$ mass separation.
- $\Rightarrow$ jets resolution $[50, 500]$ GeV better than $\sim 3 - 4$ % $\sim 30\%/\sqrt{E}$.
- Use optimal sub-detector for jet energy estimation :
  tracker ($\sim 60\%$), ECAL ($\sim 30\%$), HCAL ($\sim 10\%$).
- Separate energy depositions from close-by particles :
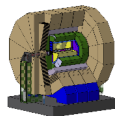
  high granularity is key point.

High granularity calorimeters : ILD baselines example

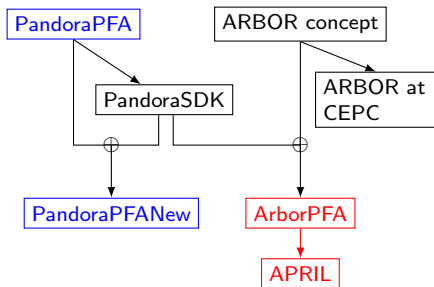|		
SiWECAL	29 layers, 2 to 4 mm thick, 5×5 mm^2 cells.
AHCAL	48 layers, 25 mm thick, 30×30 mm^2 cells.
SDHCAL	48 layers, 26 mm thick, 10×10 mm^2 cells.

PFA and ILD
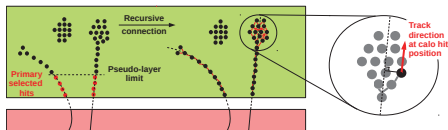
ILD PFA reconstruction

PFA strategy

Both PandoraPFA and ArborPFA, construct many small clusters then merge them.

The APRIL algorithm

APRIL : Algorithm for Particle Reconstruction at ILC from Lyon.

The clustering strategy

- start from tracks (track driven clustering) extrapolate tracks in calorimeters $\rightarrow$ cluster hits close to the tracks.

- Perform Arbor Clustering with all hits.
- $\rightarrow$ Clusters containing track cluster define charged clusters.
- Arbor parameters set to avoid making big clusters.
- $\rightarrow$ Some hits remain unclustered.
- Nearby hits merging : remaining unclustered hits are clustered with mlpack DBSCAN (efficient Nearest Neighbour clustering)
- If $E_{track} > E_{cluster}$, merge nearby cluster.

Arbor clustering

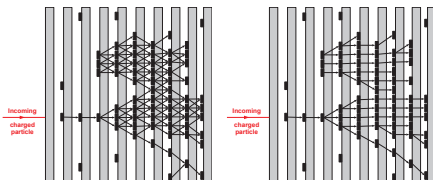Graph theory : a shower is an oriented tree.

Orientation

- Rearrange hits in virtual nested cylinders (= pseudo layers)
- Count them from the inside.
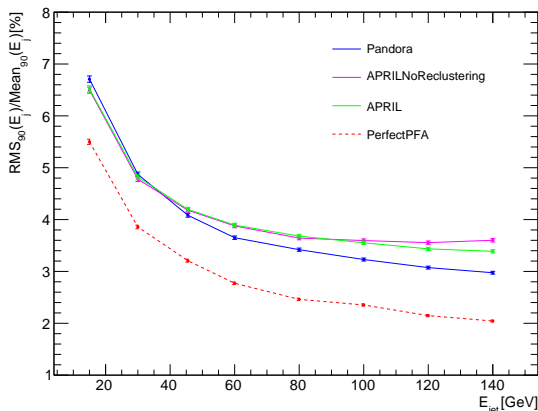- Forward direction = increase pseudo layer number.

Arbor

1. Connect all neighbouring hits (use mlpack NeighborSearch).
2. Clean connectors = keep max one backward connection per hit.

Incoming
charged
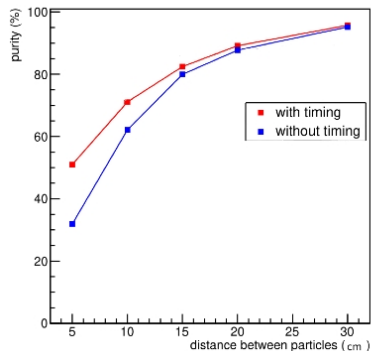particle

Incoming
charged
particle

- (PandoraPFA without reclustering) $\lesssim$ APRIL performance < (PandoraPFA with reclustering)
- A simple reclustering algorithm is tried for APRIL : If $E_c > p_t$, remove hits from cluster until $E_c \simeq p_t$ and make a neutral hadron cluster with the removed hits.
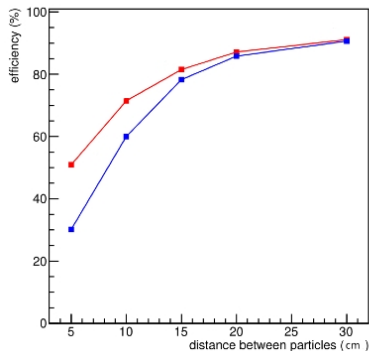
Next steps

- Replace reclustering by cluster cutting algorithm.
- Add time precision to PFA reconstruction.

purity for neutral particle

efficiency for neutral particle

- ML based clustering (GNN).