Calorimeter Reconstruction Inventory

ORNL Calorimeter Workfest

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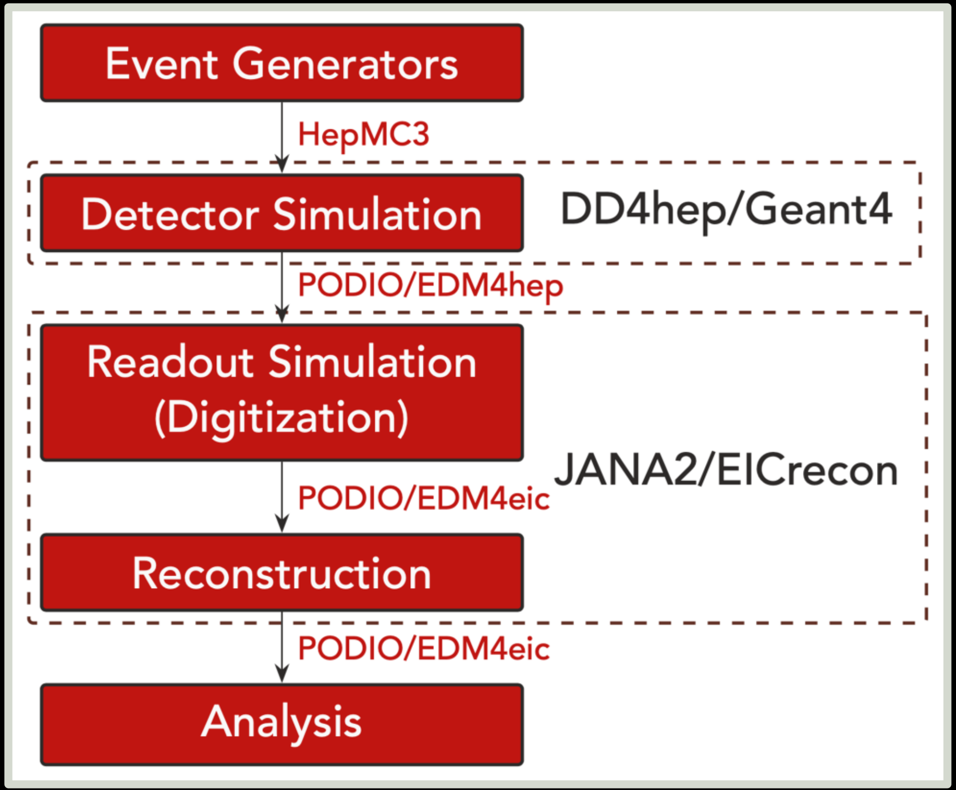
Overview | EICrecon Structure



From [Dima's slides] on 06.02

Algorithms
- Process data
- As generic as possible
  - not constrained to a particular geometry or detector
- Aim for minimal dependencies
  - e.g. JANA2 independence required

Data Model
- EDM4eic + EDM4hep, managed by PODIO
- Defines overall flow of simulation + reconstruction

Factories
- Lightweight interface between interface between an algorithm and JANA2

Plugin
- Defines what sequence of algorithms (incl. parameters + inputs/outputs) to run
- Currently grouped into 2 categories
  - **detector:** NHCal, FHCal, BHCal, EEEMCal, BIC, etc.
  - **global:** tracking, event-wise PID, particle reco

Overview | General Calorimeter Workflows

Data Model

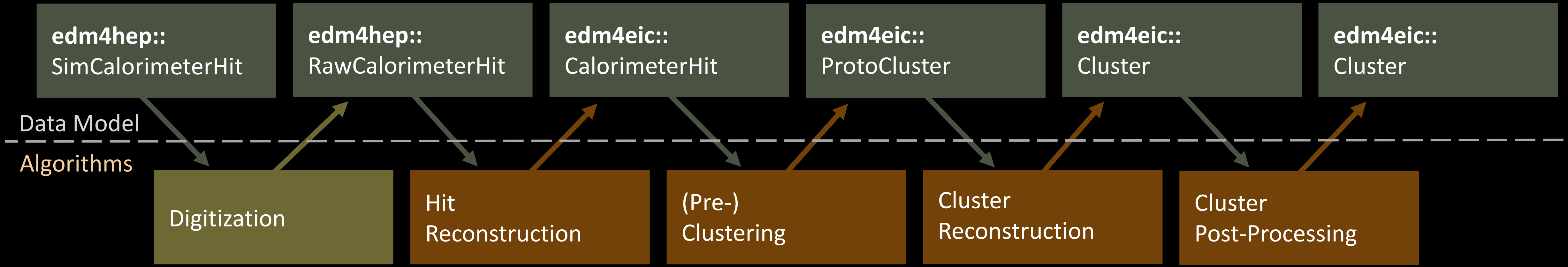
edm4hep:: SimCalorimeterHit	edm4hep:: RawCalorimeterHit	edm4eic:: CalorimeterHit	edm4eic:: ProtoCluster	edm4eic:: Cluster	edm4eic:: Cluster

Algorithms

Digitization	Hit Reconstruction	(Pre-) Clustering	Cluster Reconstruction	Cluster Post-Processing
Calorimeter Hit Digi	Calorimeter Hit Reco	Calorimeter Island Clustering	Calorimeter Cluster Reco CoG	Calorimeter Cluster Shape
	Calorimeter Hits Merger*	Imaging Topo-Cluster	Imaging Cluster Reco	Energy-Position Cluster Merger
		HEXPLIT		Truth-Energy Position Cluster Merger
		Calorimeter Truth Clustering		Track-Cluster Merge Splitter

* Should be under (pre-) clustering

Algorithm Details | Digitization



Calorimeter Hit Digi: used by every calorimeter

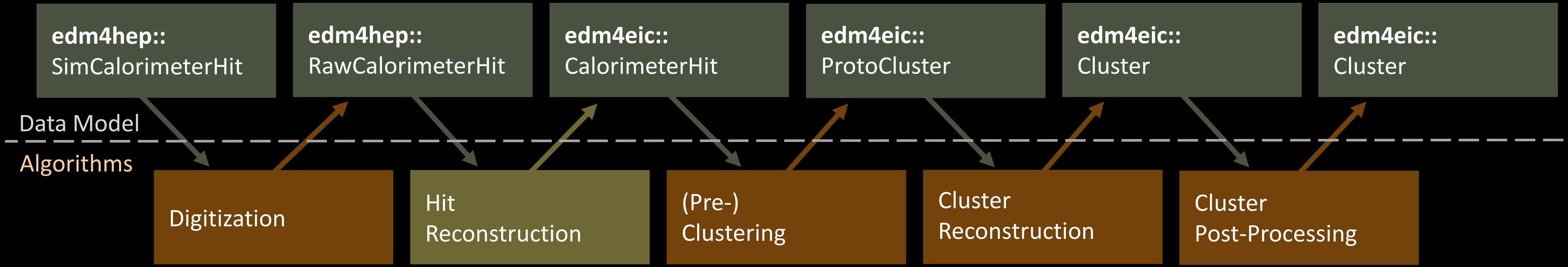
Gist

1. Sums hits over specified fields
2. Smears summed energy by parameterized resolution & converts to ADC
3. Determines & smears time of hit

Inputs/Outputs

- **Inputs:**
  - SimCalorimeterHit
- **Outputs:**
  - RawCalorimeterHit,
  - Sim-RawCalorimeterHit Association

Algorithm Details | Hit Reconstruction



Calorimeter Hit Reco: used by every calorimeter

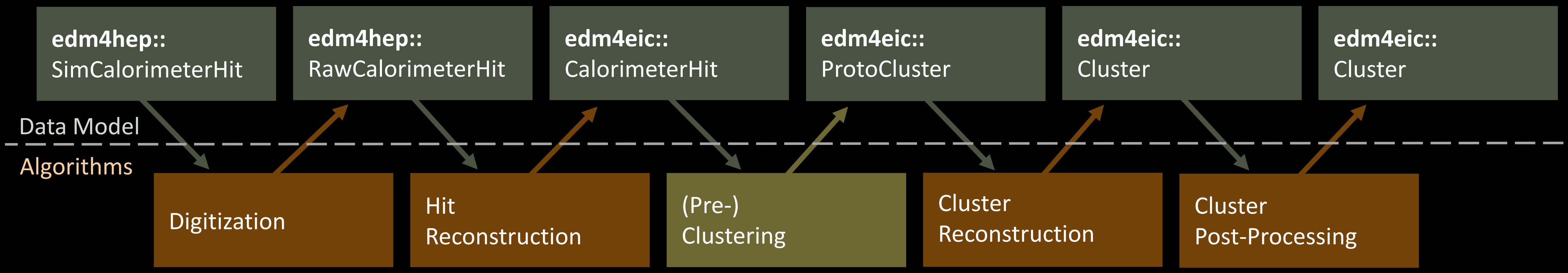
Gist

1. Convert ADC value to energy & TDC to time
2. Can be used to mock-up dead channels by adjusting sampling fraction

Inputs/Outputs

– **Inputs:**
  › RawCalorimeterHit
– **Outputs:**
  › CalorimeterHit

Algorithm Details | (Pre-) Clustering (1/5)



Calorimeter Hits Merger: used by NHCal, BHCal (sort of), FHCal Insert

Gist

1. Merges rec calo hits based on provided transformations
2. Energy is summed, and hit position/relations set to that of "reference cell"

Inputs/Outputs

- **Inputs:**
  - CalorimeterHit
- **Outputs:**
  - CalorimeterHit

Algorithm Details | (Pre-) Clustering (2/5)

Data Model

edm4hep:: SimCalorimeterHit → edm4hep:: RawCalorimeterHit → edm4eic:: CalorimeterHit → edm4eic:: ProtoCluster → edm4eic:: Cluster → edm4eic:: Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

<u>Calorimeter Island Clustering:</u> used by every calorimeter except BIC (Imaging)

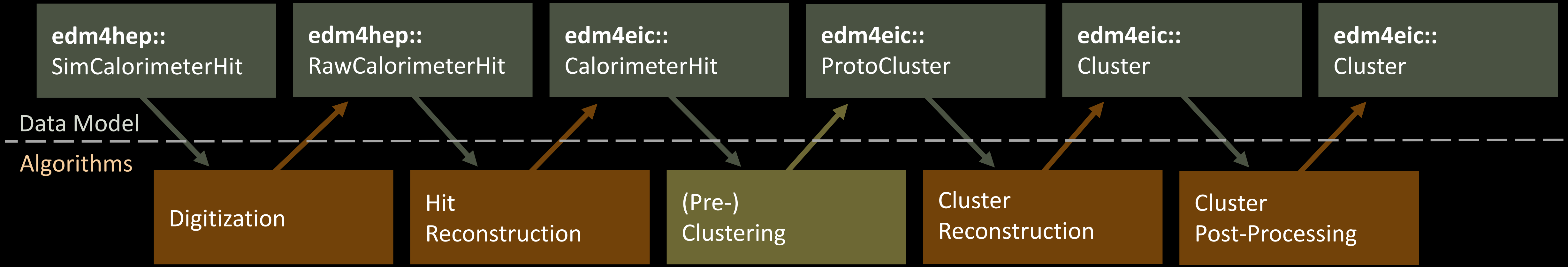
Gist

1. Combines hits into continuous deposits of energy
2. Identifies neighbors based on either selected distance metrics or based on "adjacency matrix" (cell ID comparisons)

Inputs/Outputs

- **Inputs:**
  - CalorimeterHit
- **Outputs:**
  - ProtoCluster

Algorithm Details | (Pre-) Clustering (3/5)



Imaging Topo Cluster: used by BIC, FHCal Insert, ZDC (HCal)

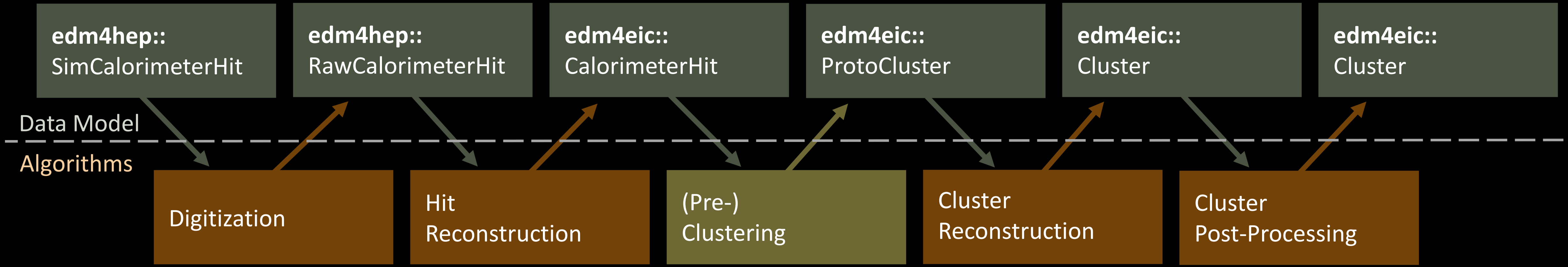
Gist

1. Combines hits into continuous deposits of energy across layers of a radially segmented calo
2. Identifies neighbors based on selected distance metric
3. Likely can merge with island clustering…

Inputs/Outputs

- **Inputs:**
  - CalorimeterHit
- **Outputs:**
  - ProtoCluster

Algorithm Details | (Pre-) Clustering (4/5)



HEXPLIT: used by FHCal Insert, ZDC (HCal)

Gist

1. Divides hits into “subhits” based on the overlap of hits in previous layers
2. Divides energy proportional to overlap

Inputs/Outputs

- **Inputs:**
  - CalorimeterHit
- **Outputs:**
  - CalorimeterHit

Algorithm Details | (Pre-) Clustering (5/5)

Data Model

edm4hep:: SimCalorimeterHit → **edm4hep::** RawCalorimeterHit → **edm4eic::** CalorimeterHit → **edm4eic::** ProtoCluster → **edm4eic::** Cluster → **edm4eic::** Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

Calorimeter Truth Clustering: used by every calorimeter

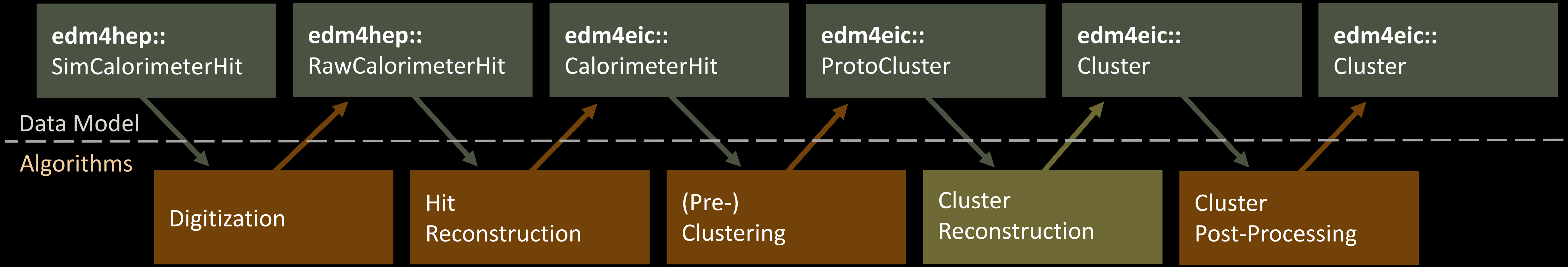
Gist

1. Groups hits into clusters based on “first” contributing particle
   - ☞ Nominally should get a cluster of all hits caused by particle
2. Needs update to match how sim-rec associations are handled

Inputs/Outputs

- **Inputs:**
  - CalorimeterHit
  - SimCalorimeterHit
- **Outputs:**
  - ProtoCluster

Algorithm Details | Cluster Reconstruction (1/2)



Calorimeter Cluster Reco CoG: used by every calorimeter except BIC (Imaging)

Gist

1. Reconstructs cluster w/ energy set to be weighted sum of hits
2. Position set to be barycenter of cluster using selected weighting scheme
3. Associates cluster to primary particles

Inputs/Outputs

- **Inputs:**
  - ProtoCluster
  - Sim-Rec Hit Associations
- **Outputs:**
  - Cluster
  - Sim-Rec Cluster Assoc.s

Algorithm Details | Cluster Reconstruction (2/2)

Data Model

edm4hep:: SimCalorimeterHit → **edm4hep::** RawCalorimeterHit → **edm4eic::** CalorimeterHit → **edm4eic::** ProtoCluster → **edm4eic::** Cluster → **edm4eic::** Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

Imaging Cluster Reco: used by BIC

Gist

1. Same functionality as Cluster Reco CoG
2. But also performs weighted sum/barycenter calculation over all hits in a given layer of a radially segmented calorimeter

Inputs/Outputs

- **Inputs:**
  - ProtoCluster
  - Sim-Rec Hit Associations
- **Outputs:**
  - Cluster (x2)
  - Sim-Rec Cluster Assoc.s

Algorithm Details | Cluster Post-Processing (1/4)

Data Model

edm4hep:: SimCalorimeterHit → **edm4hep::** RawCalorimeterHit → **edm4eic::** CalorimeterHit → **edm4eic::** ProtoCluster → **edm4eic::** Cluster → **edm4eic::** Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

Calorimeter Cluster Shape: used by every calorimeter

Gist

1. Computes cluster shapes (radius, eccentricity, etc.) on reconstructed clusters
2. Outputs copy of clusters + associations but now with shapes

Inputs/Outputs

- **Inputs:**
  - Cluster
  - Sim-Rec Cluster Assoc.s
- **Outputs:**
  - Cluster
  - Sim-Rec Cluster Assoc.s

Algorithm Details | Cluster Post-Processing (2/4)

Data Model

edm4hep:: SimCalorimeterHit → **edm4hep::** RawCalorimeterHit → **edm4eic::** CalorimeterHit → **edm4eic::** ProtoCluster → **edm4eic::** Cluster → **edm4eic::** Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

Energy-Position Cluster Merger: used by BIC

Gist

1. Merges energy of a cluster with the position of another
2. Clusters matched based on eta-phi distance

Inputs/Outputs

- **Inputs:**
  - Cluster (x2)
  - Sim-Rec Cluster Assoc.s (x2)
- **Outputs:**
  - Cluster
  - Sim-Rec Cluster Assoc.s

Algorithm Details | Cluster Post-Processing (3/4)

Data Model

edm4hep:: SimCalorimeterHit → **edm4hep::** RawCalorimeterHit → **edm4eic::** CalorimeterHit → **edm4eic::** ProtoCluster → **edm4eic::** Cluster → **edm4eic::** Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

Truth Energy-Position Cluster Merger: used by BIC

Inputs/Outputs

- **Inputs:**
  - MC particles
  - Cluster (x2)
  - Sim-Rec Cluster Assoc.s (x2)
- **Outputs:**
  - Cluster
  - Sim-Rec Cluster Assoc.s

Gist

1. Same as previous energy-position cluster merger, but does so based on truth information

Algorithm Details | Cluster Post-Processing (4/4)

Data Model

edm4hep:: SimCalorimeterHit → **edm4hep::** RawCalorimeterHit → **edm4eic::** CalorimeterHit → **edm4eic::** ProtoCluster → **edm4eic::** Cluster → **edm4eic::** Cluster

Algorithms

Digitization → Hit Reconstruction → (Pre-) Clustering → Cluster Reconstruction → Cluster Post-Processing

Track-Cluster Merge/Splitter: used by NHCal, EEEMCal, BHCal, LFHCAL, FEMC

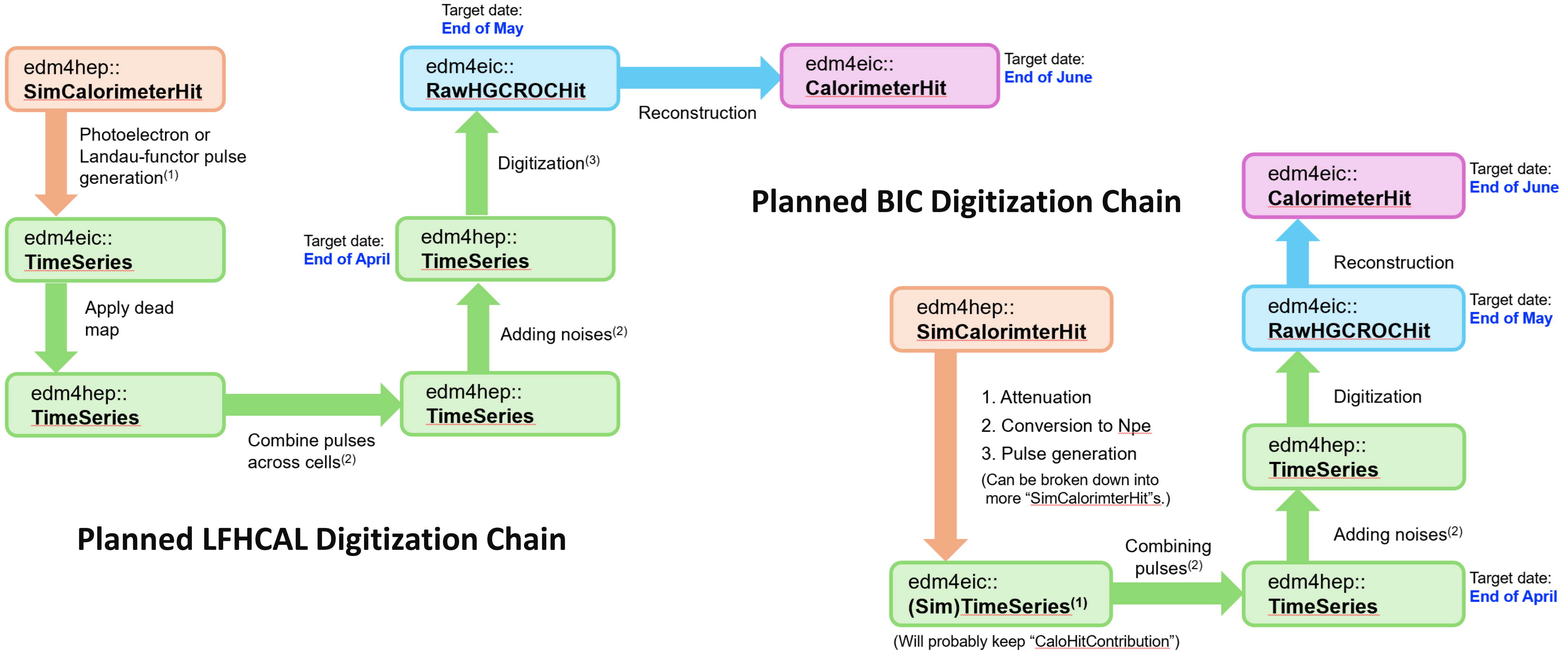
Inputs/Outputs

- **Inputs:**
  - ProtoCluster
  - TrackSegment
- **Outputs:**
  - ProtoCluster

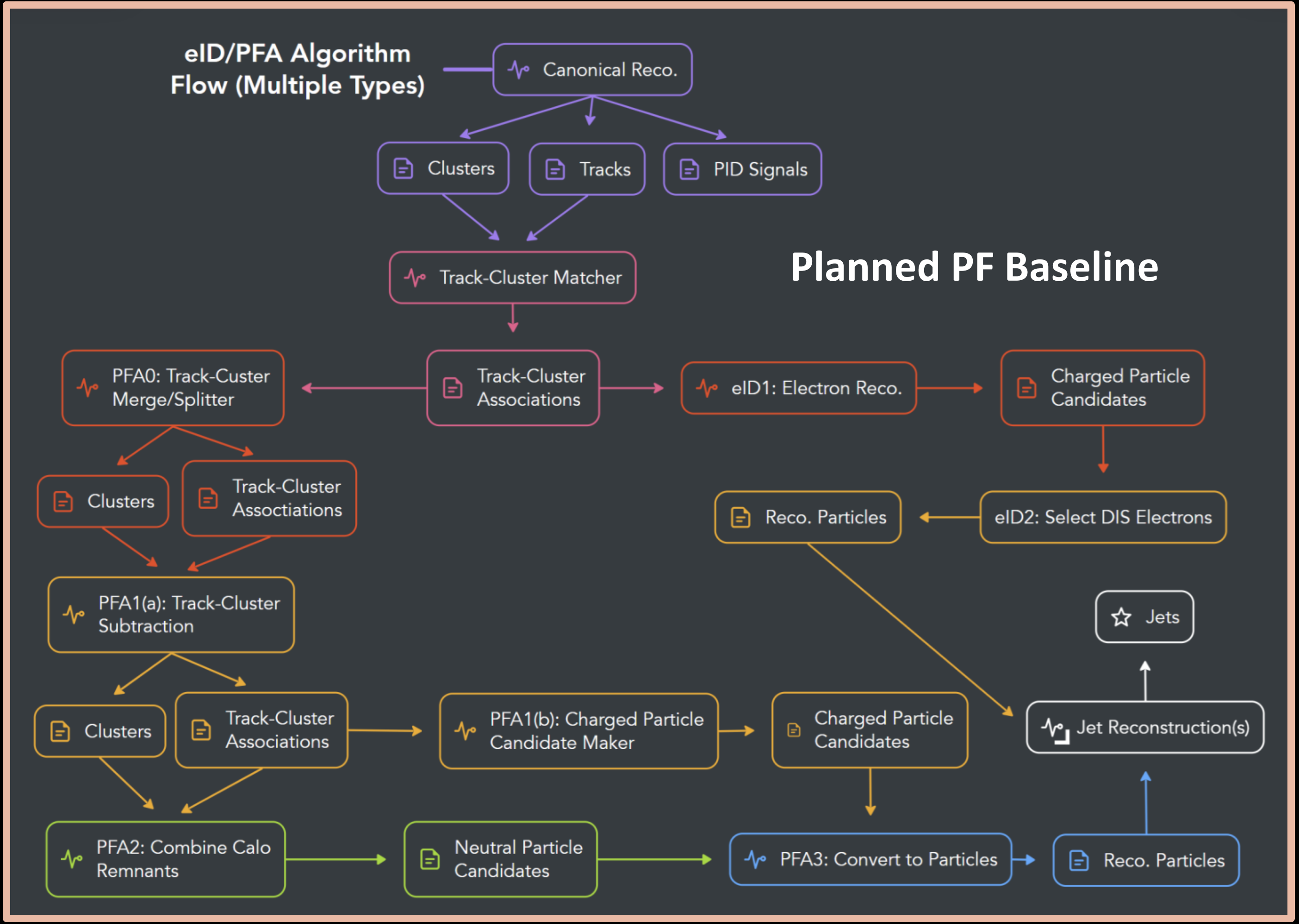
Gist

1. Sums all clusters within a provided window based on if E/p of projected track falls within provided tolerance
2. Then divides clusters if multiple tracks pointing to same one
   - ☞ Energy attenuated proportional to track momentum

Ongoing Work | Enhancing Digitization



Ongoing Work | Particle Flow



Thanks!