Brainstorm | Next Reconstruction Priorities

- Open discussion on future physics + reconstruction priorities will be part of this week's Phyiscs Readiness WS
  - Scheduled for Wednesday, Sep. 17th at 1:40 UK time
  - ☞ So want to brainstorm some possible priorities/to-do's from reconstruction side

Some thoughts:

- PID development/integration (eg. upcoming TIC discussion)
- Evolution of PF/eID after baseline
  - Expanding topoclustering (clustering across calorimeters)
  - Integration of PFAlpha and eID
- Generalized resonance reconstruction

More thoughts:

- Expansion of kinematic/inclusive algorithms
  - Eg. The "Reaction Hypothesis" floated on Aug. 4th
  - Tighter integration of central & FF/FB regions
- Timeframe integration
- Background impact on holistic reconstruction

Clustering Inventory | First Steps (1/2)

- **By itself:** not necessarily a *physics + reconstruction* priority, **but tangentially related**
  - Some degeneracies in our suite of calorimeter clustering algorithms
    - Eg. Dima noted duplication b/n ImagingClusterReco and ClusterRecoCoG in EICrecon#1658
    - And *some* similarities between ImagingTopocluster and CalorimeterIslandCluster
  - Some areas we might be able to improve
    - Eg. CalorimeterTruthClustering might need an update (cf. EICrecon#2072)
- **So now starting inventory of clustering**
  - ☞ Building on some slides I did for the June ORNL Calorimeter workfest (in backup)

Clustering Inventory | First Steps (2/2)

Algorithm	Description
Island Clustering	Clusters hits into continuous deposits of energy; incl. distance metric, adjacency matrix, and cluster splitting
Imaging Topocluster	Clusters hits into continuous deposits of energy across several layers; incl. distance metric
HEXPLIT	Divides hits into sub-hits based on overlap in previous layers
Truth Clustering	Groups reconstructed hits by contributions' MC particles
Cluster Reco CoG	Calculates weighted sum of hit energy, barycenter
Cluster Shape Calculation	Calculates cluster radius, eccentricity, etc.
Imaging Cluster Reco	Calculates weighed sum of hit energy, barycenter across several layers
Energy-Position Merger	Merges energies of one set of clusters with positions of another
Truth Energy-Position Merger	Same as above, but with truth info
Track-Based Merge/Splitter (PF)	Merges nearby clusters if E/p with a matched track is below tolerance, splits clusters between multiple tracks if need be

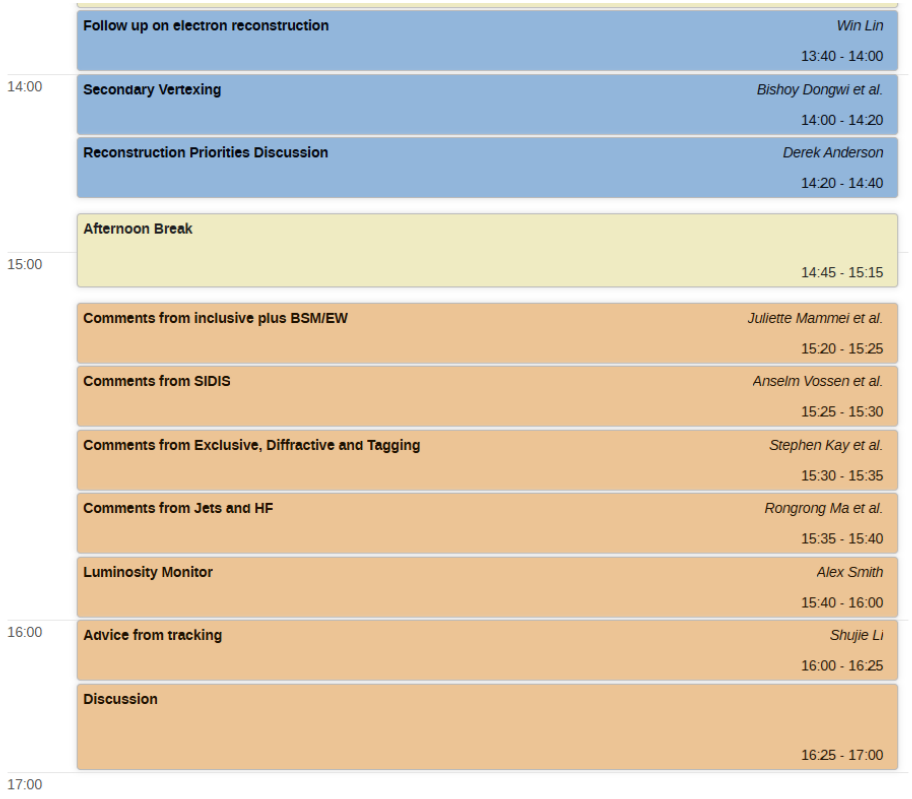
Tracking | Could Talk Be Divided?

- Last portion of 1st day dedicated to discussion of systematics
  - Scheduled for Wednesday, September 17th at 3:15 pm UK time
  - Includes talk on tracking
    - See agenda on left, and charge below

- **Would it make sense to move some of tracking talk to the reconstruction block?**

as you know, we are investigating possible sources of systematic uncertainty that we should account in the analyses. In order to evaluate them in the most educated way, we need your help.
Can you please help us with the following points/questions:

- Uncertainty on electron polar angle due to misalignment of detector planes.
- Uncertainties due to Material map.
- Are detector efficiencies correctly reproduced by current simulation? Do they account for Impact of Noise, beam backgrounds?
- Reconstruction code efficiency for raw yield.



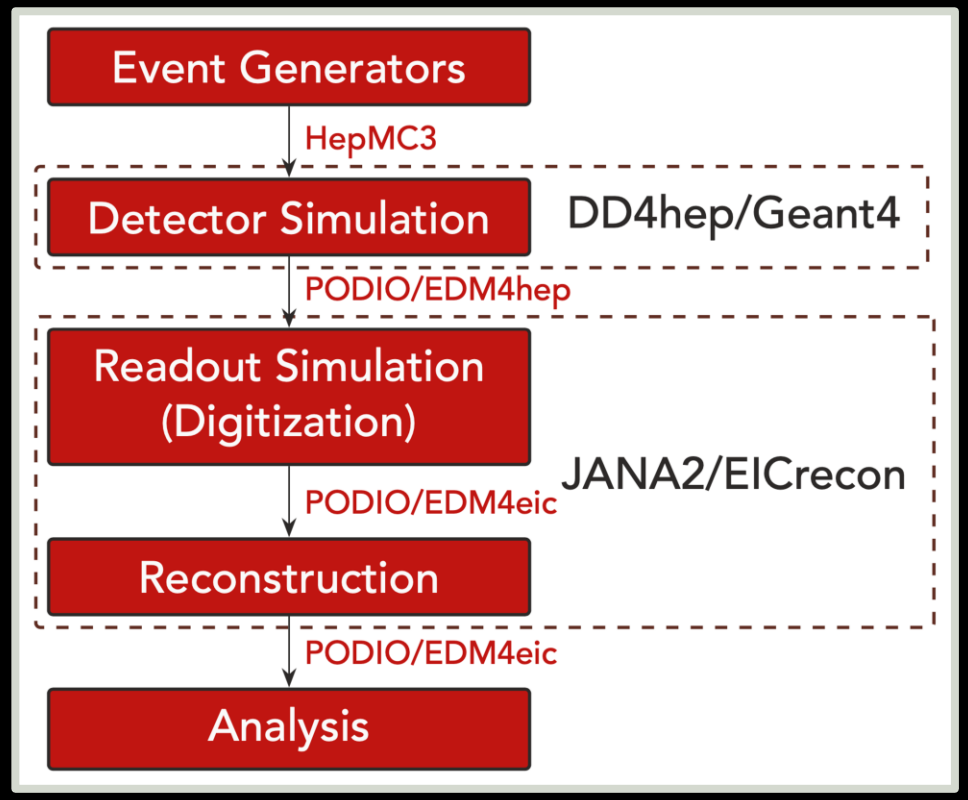
Calorimeter Reconstruction Inventory

ORNL Calorimeter Workfest

Derek Anderson (ISU)

June 4th, 2025

Overview | EICrecon Structure



From Dima's slides on 06.02

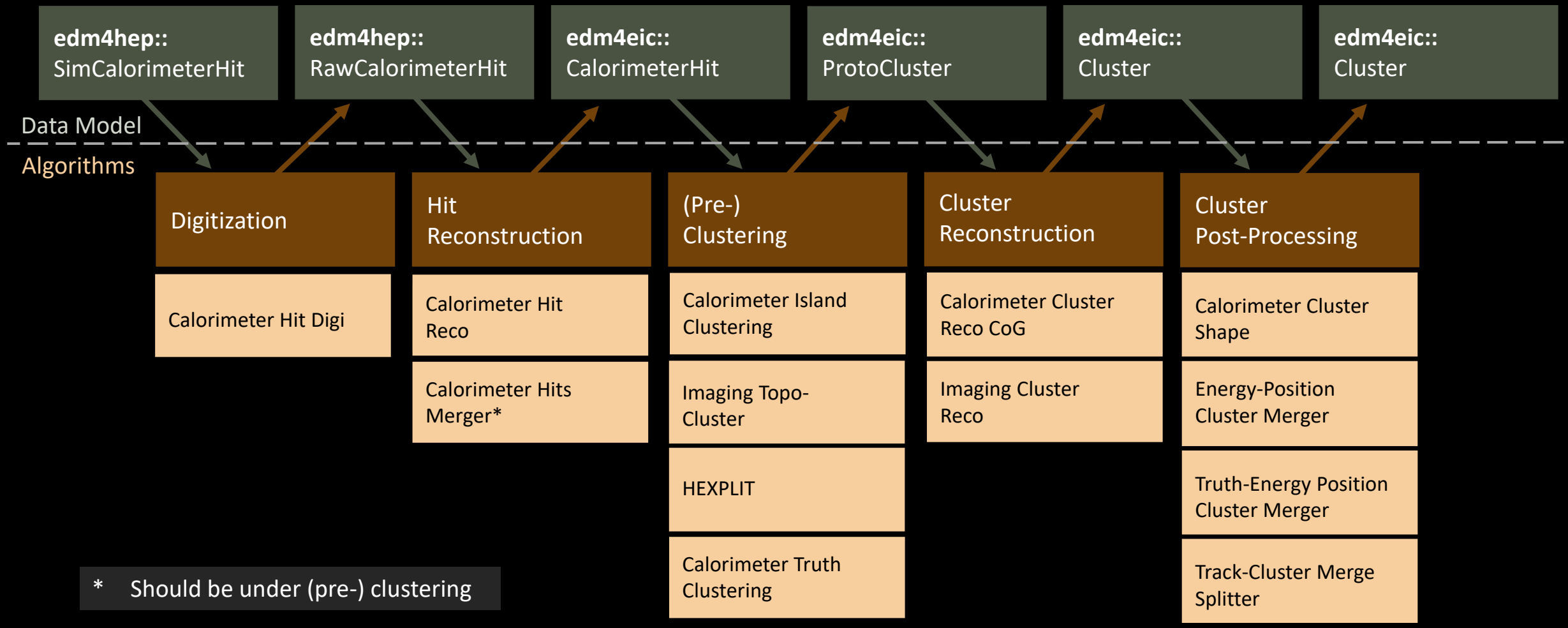
Algorithms
- Process data
- As generic as possible
  - not constrained to a particular geometry or detector
- Aim for minimal dependencies
  - e.g. JANA2 independence required

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

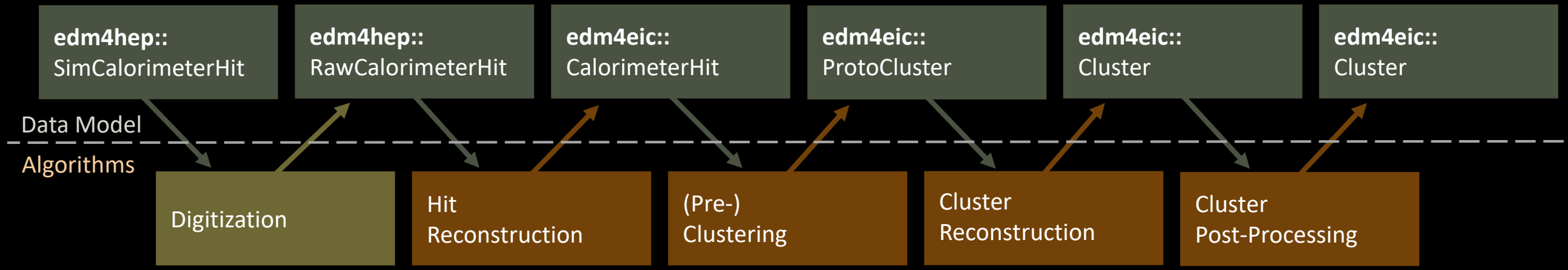
Data Model
- EDM4eic + EDM4hep, managed by PODIO
- Defines overall flow of simulation + reconstruction

Overview | General Calorimeter Workflows



* Should be under (pre-) clustering

Algorithm Details | Digitization



Calorimeter Hit Digi: used by every calorimeter

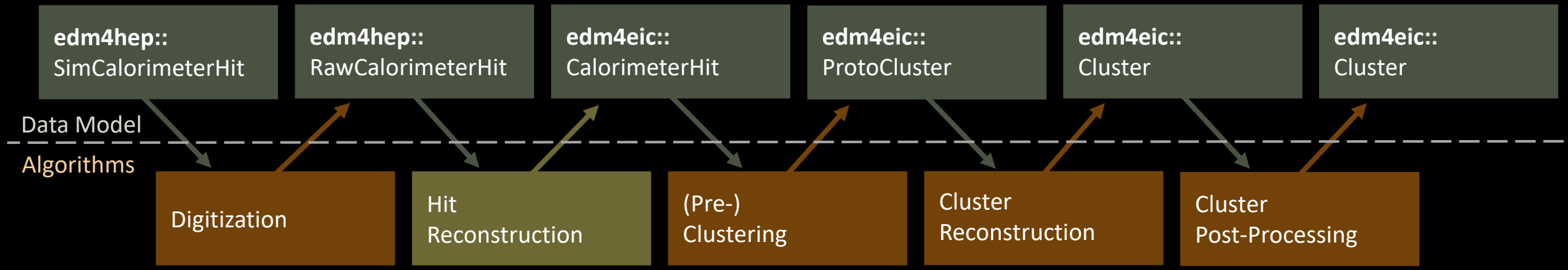
Gist

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



<u>Calorimeter Hit Reco:</u> used by every calorimeter

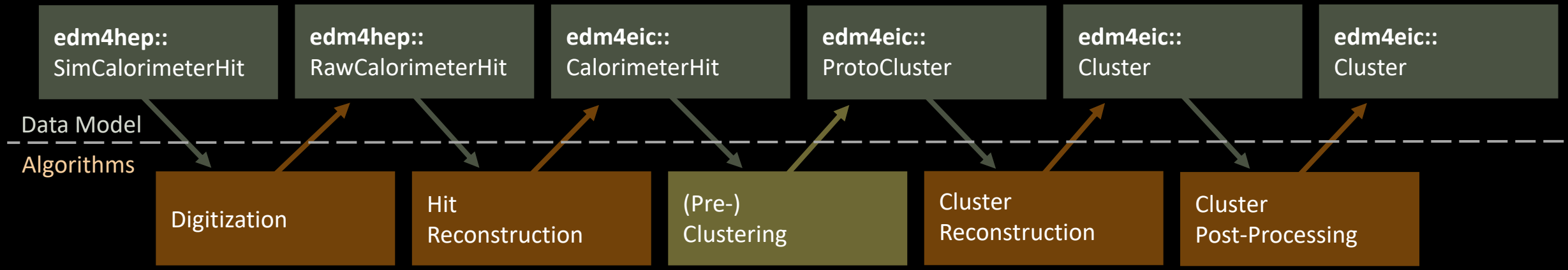
Gist

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

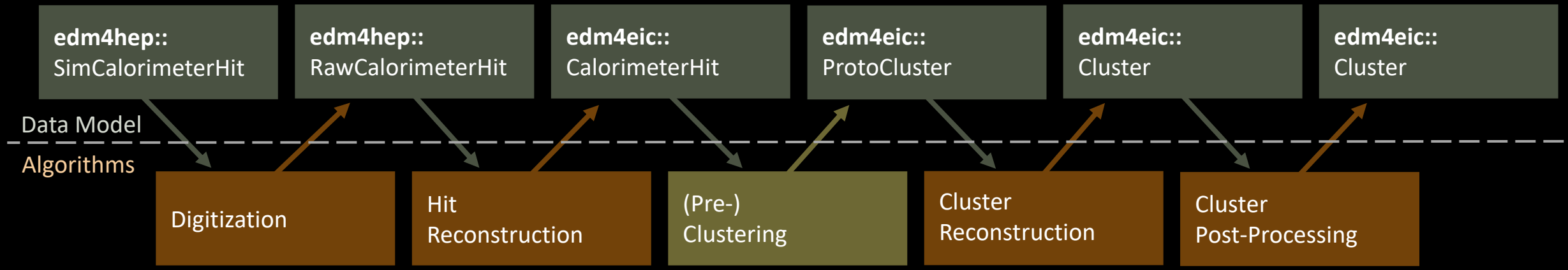
Gist

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)



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

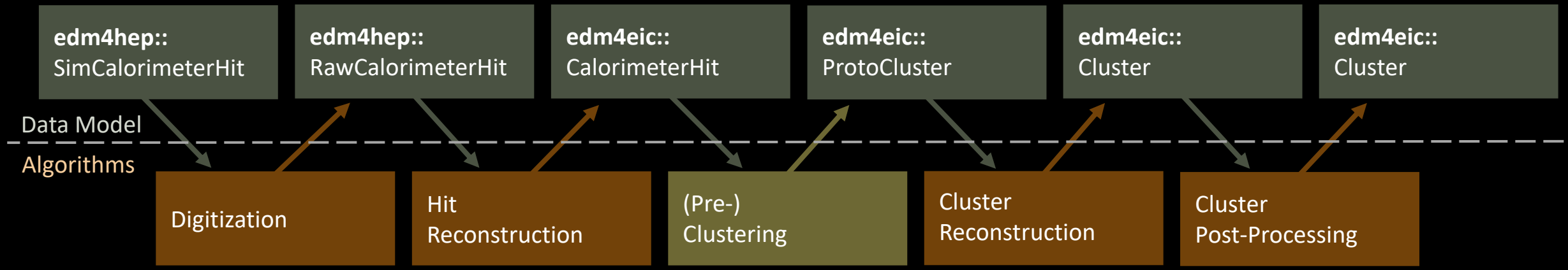
Gist

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)



<u>Imaging Topo Cluster:</u> used by BIC, FHCal Insert, ZDC (HCal)

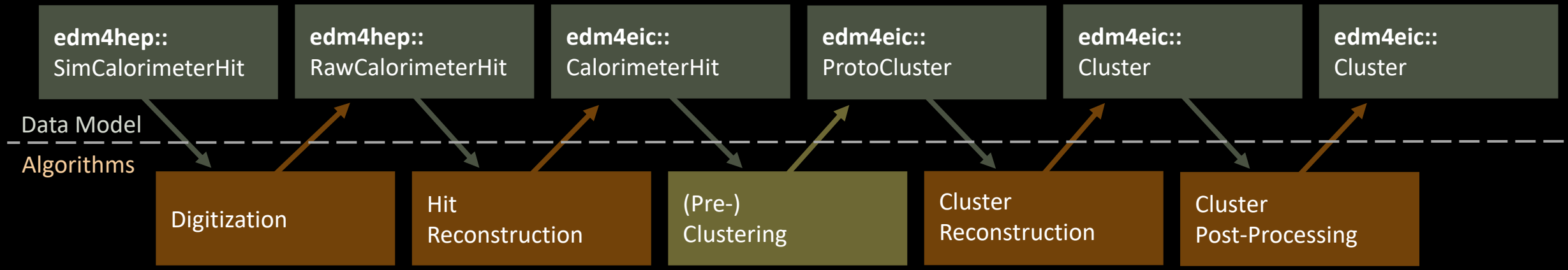
Gist

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)

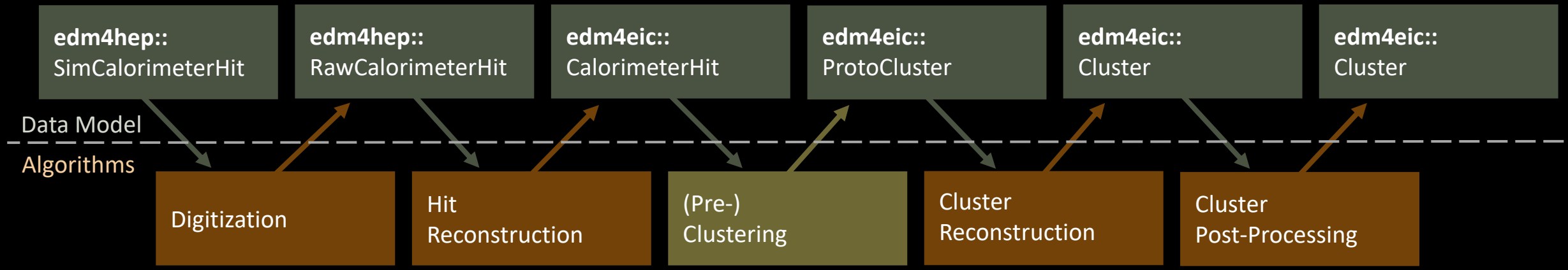
Gist

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)



<u>Calorimeter Truth Clustering:</u> used by every calorimeter

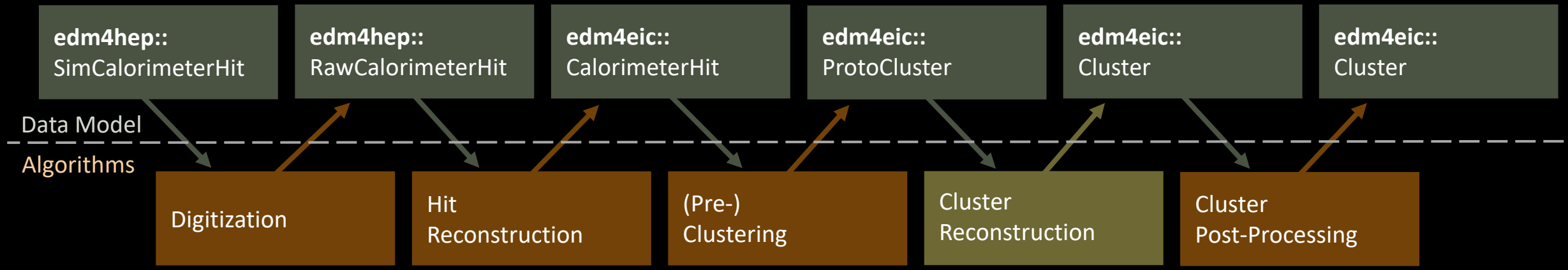
Gist

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)



<u>Calorimeter Cluster Reco CoG:</u> used by every calorimeter except BIC (Imaging)

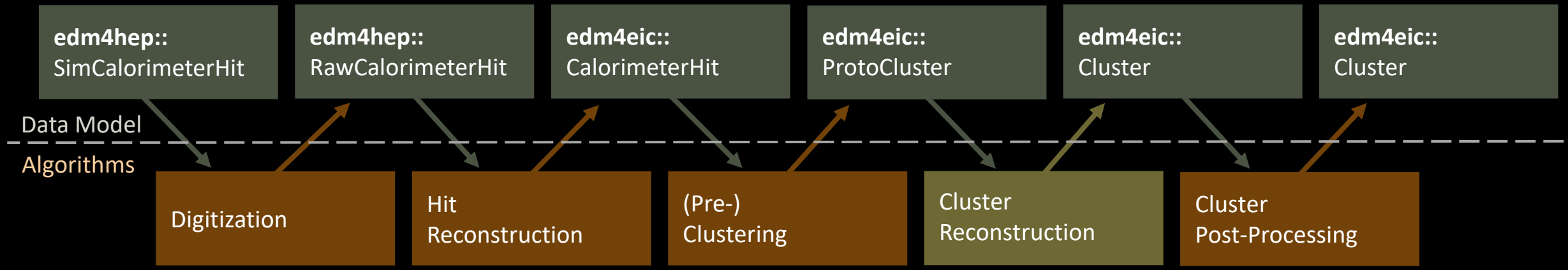
Gist

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)



<u>Imaging Cluster Reco:</u> used by BIC

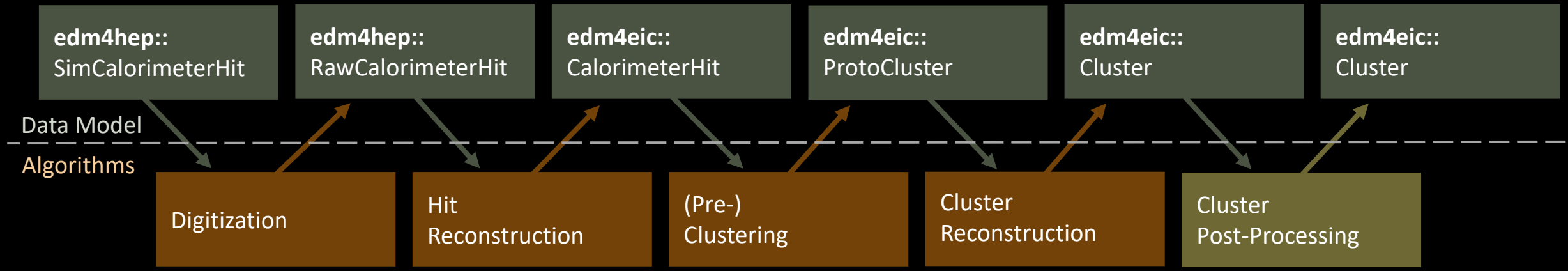
Gist

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)



<u>Calorimeter Cluster Shape:</u> used by every calorimeter

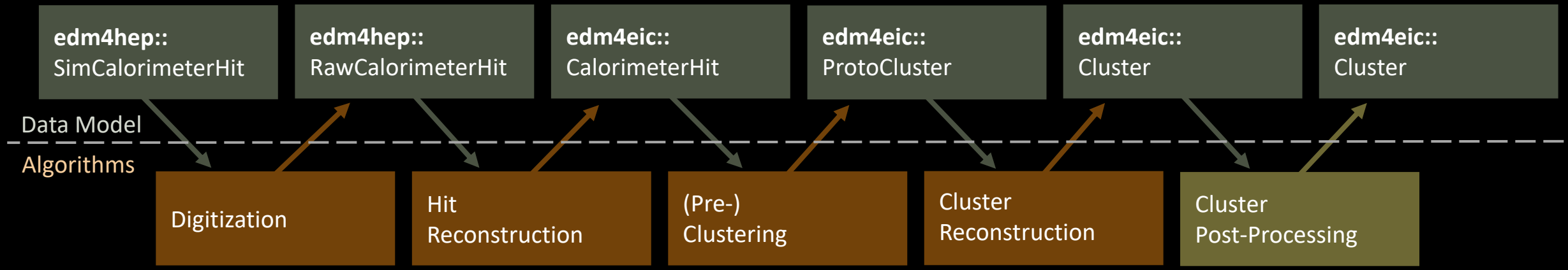
Gist

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)



<u>Energy-Position Cluster Merger:</u> used by BIC

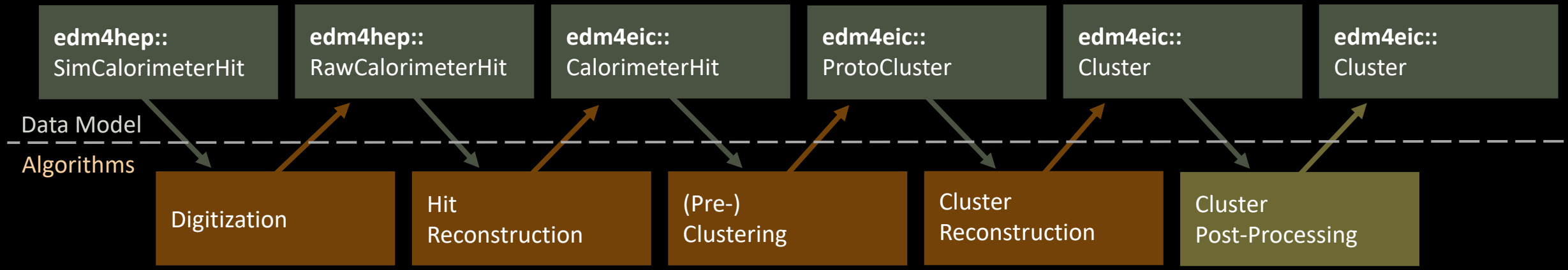
Gist

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)



<u>Truth Energy-Position Cluster Merger:</u> used by BIC

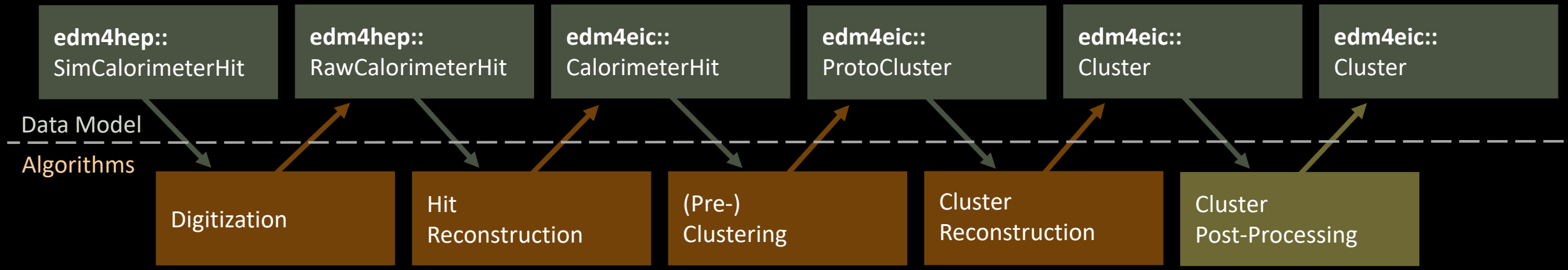
Inputs/Outputs

- **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)



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

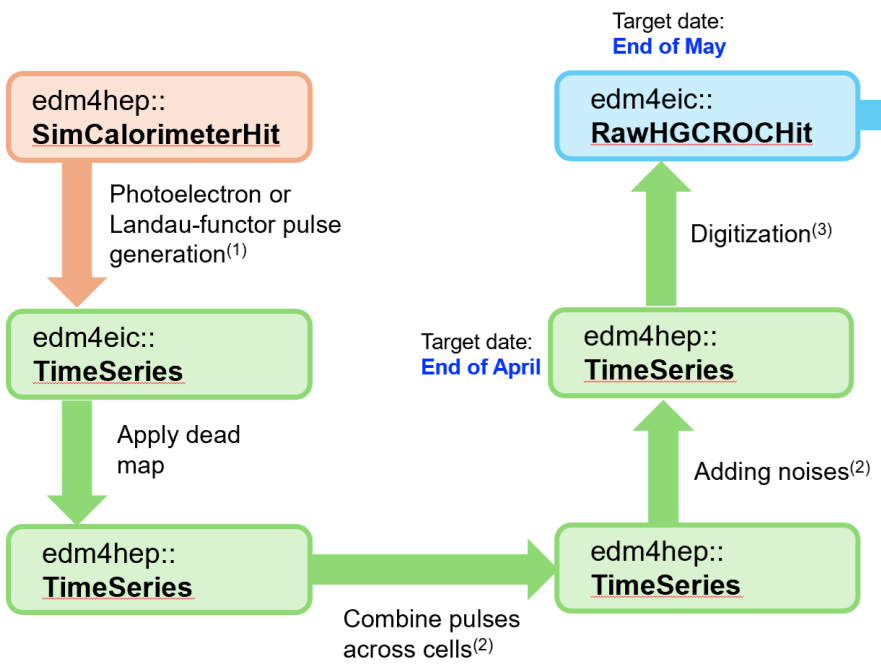
Inputs/Outputs

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

Gist

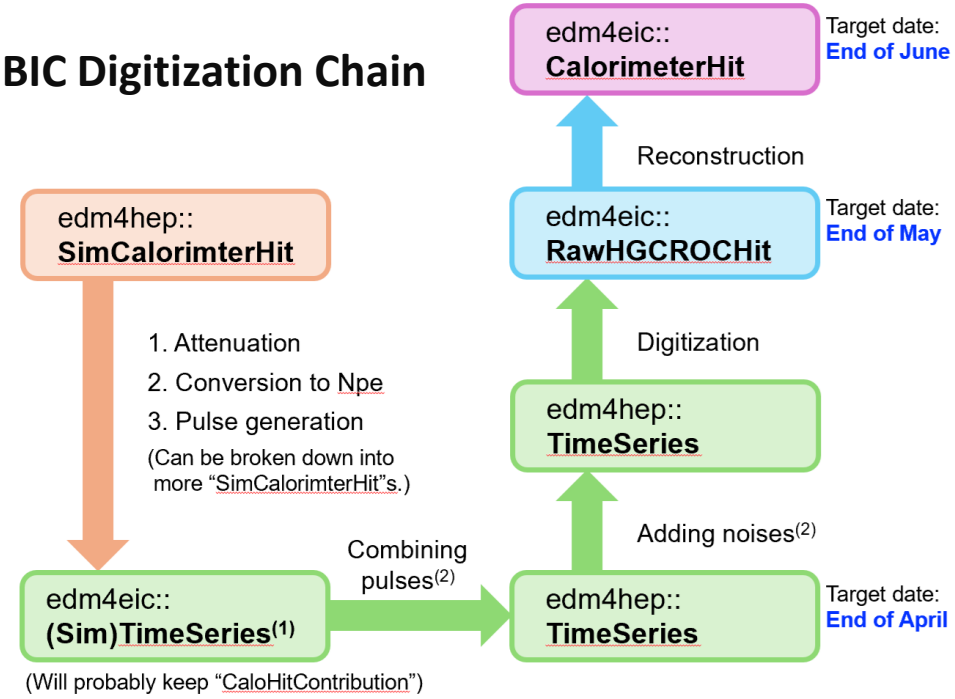
1. Sums all clusters within a provided window based on if E/p of projected track falls within provided tolerance
2. Then divides clusters if multiple tracks pointing to same one
   - ☞ Energy attenuated proportional to track momentum

Ongoing Work | Enhancing Digitization

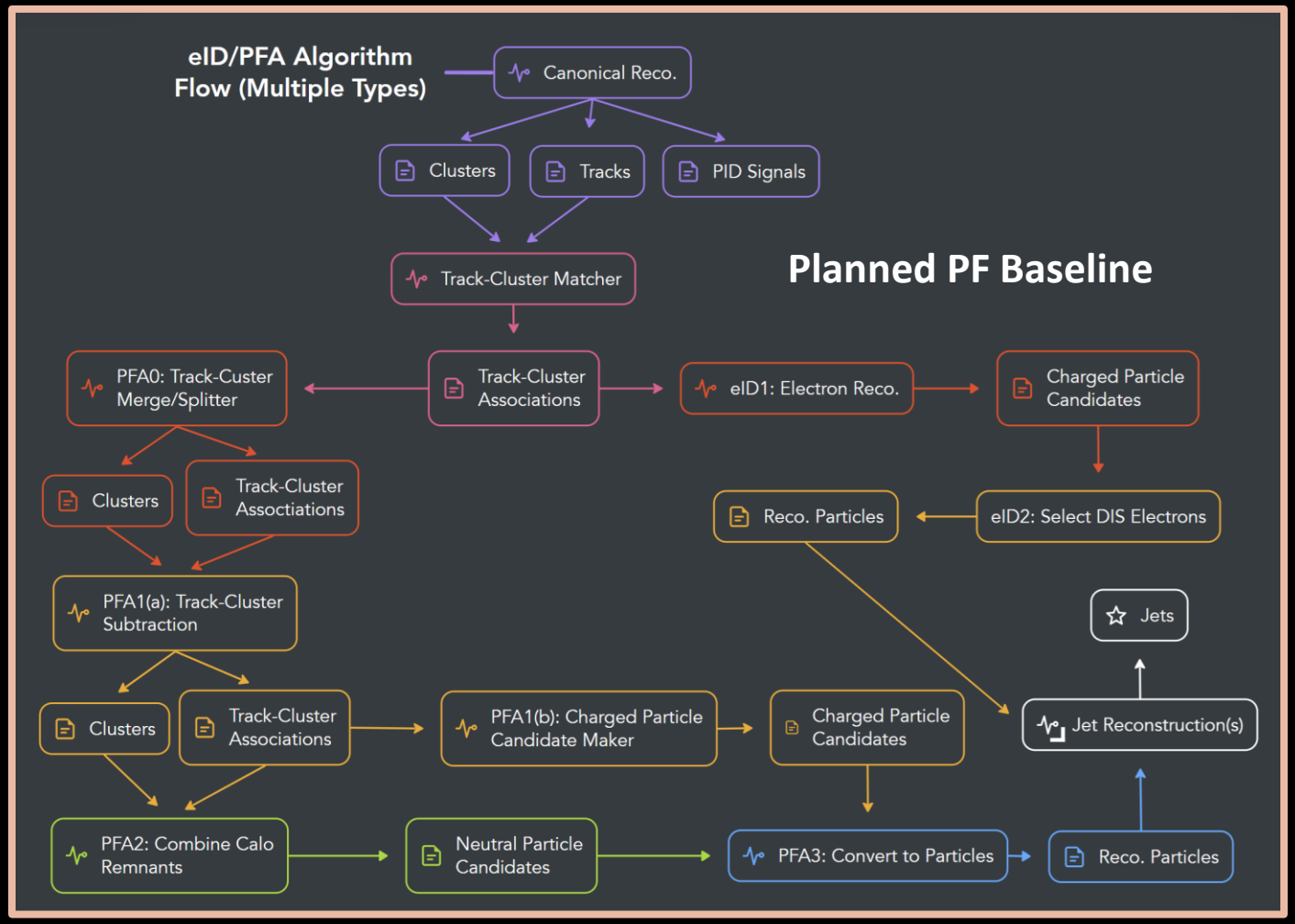


Planned LFHCAL Digitization Chain

Planned BIC Digitization Chain



Ongoing Work | Particle Flow



ePIC
STATE
Thanks!