

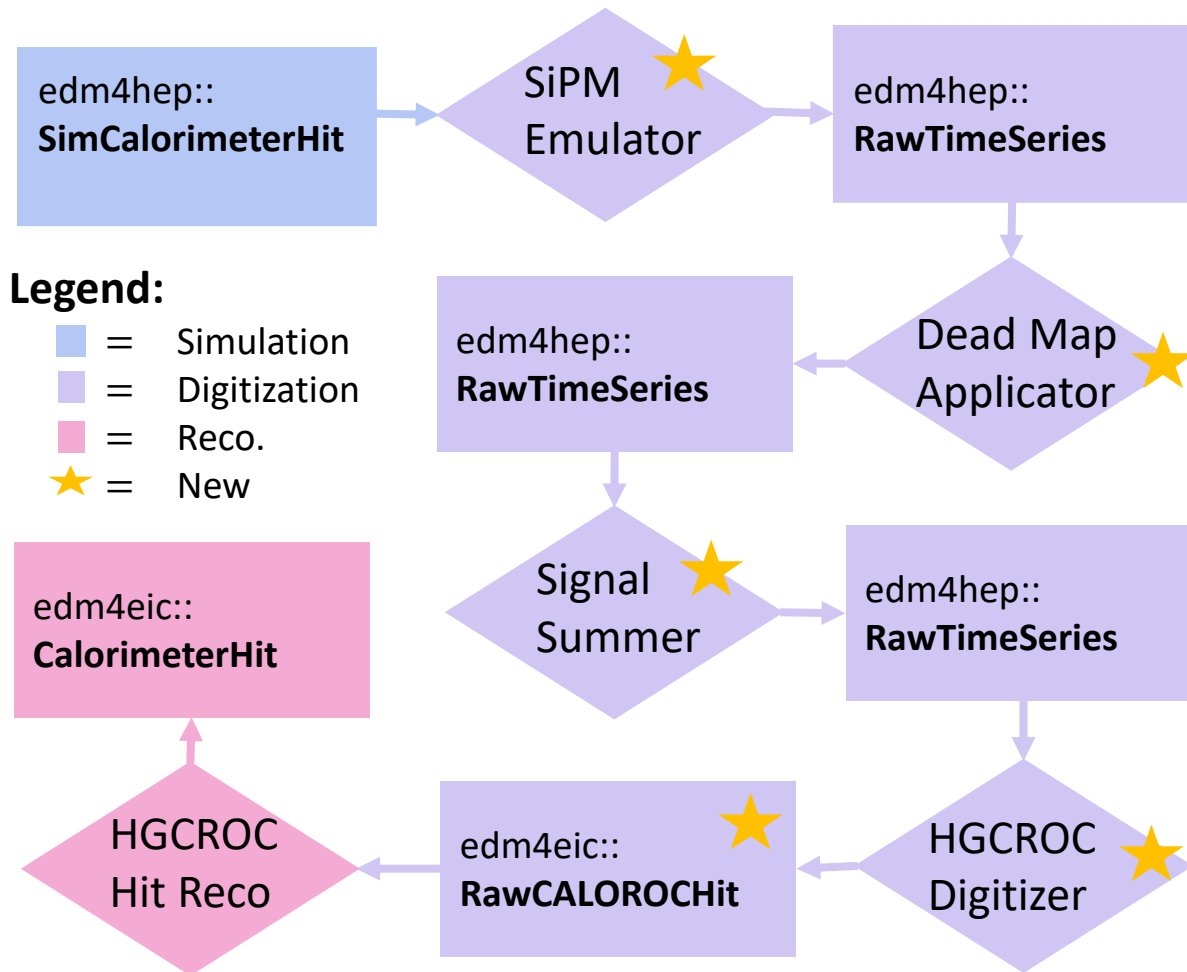
LFHCAL Digitization Software Plans

Derek Anderson

03.19.2025

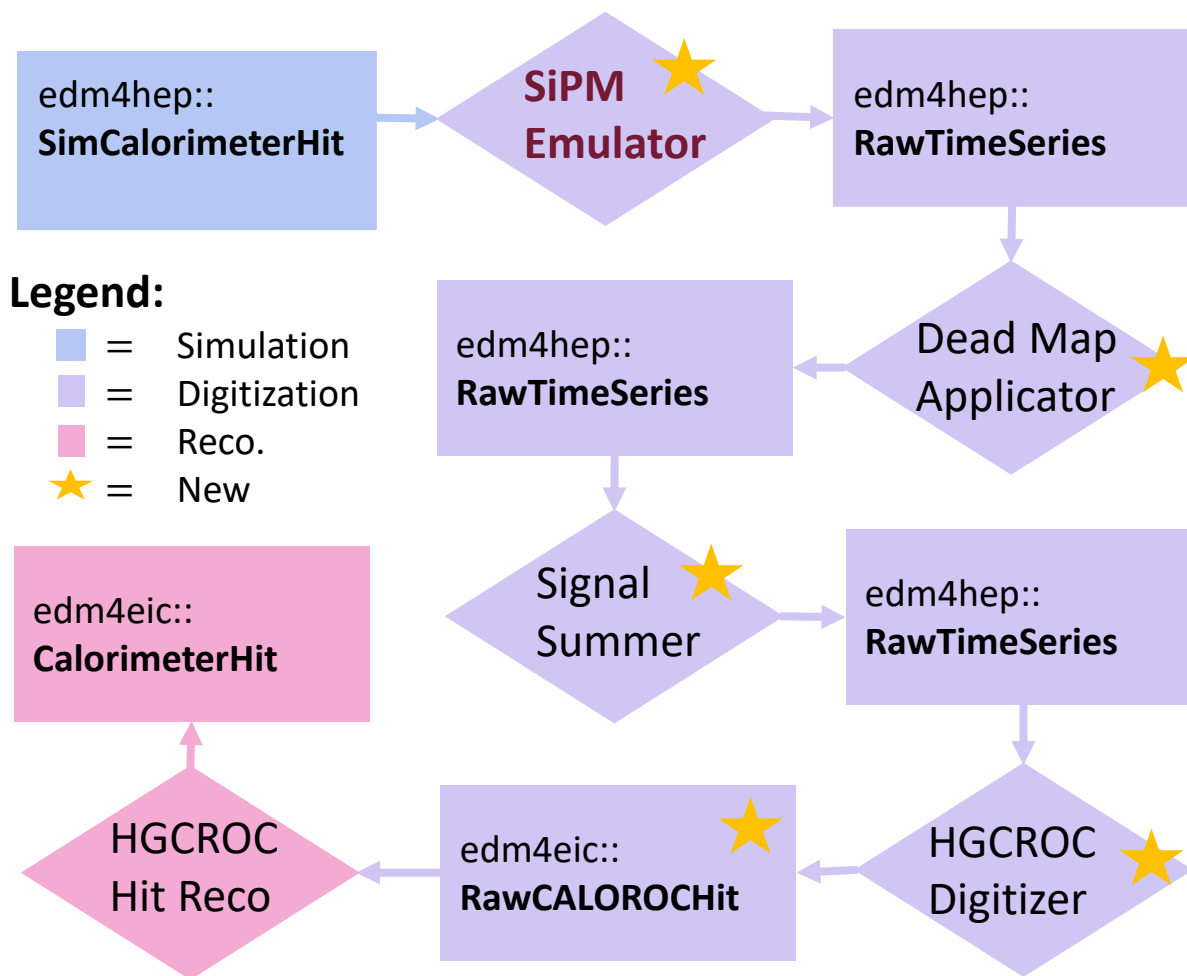
**Join the HGCROC Digitization
[Mattermost Channel!](#)**

HGC/CALOROC Digitization | Overview



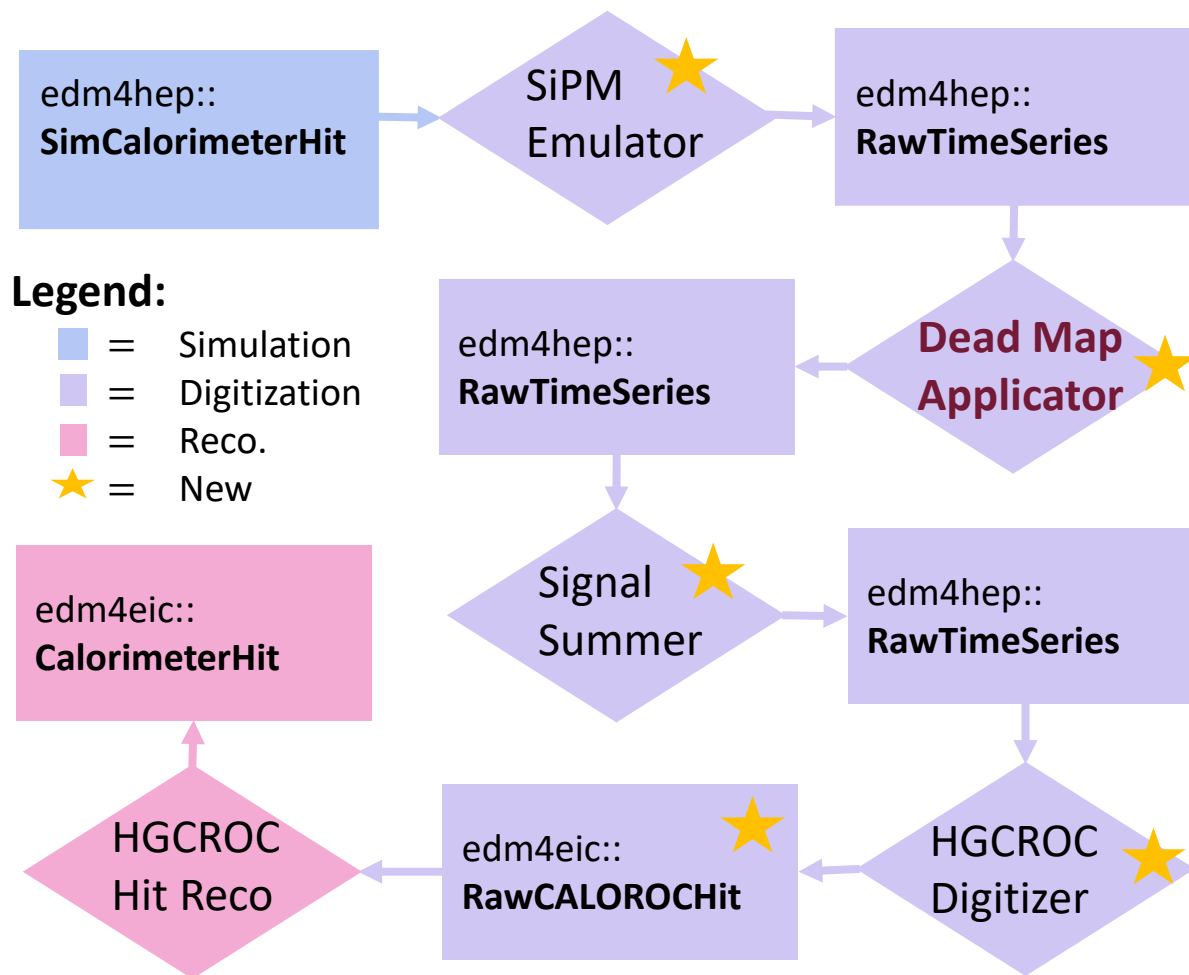
- **Left:** proposed algorithmic flow for LFHCAL HGCROC digitization
 - Looks complicated, but goal is to ensure modularity
 - Will help support multiple workflows
- **Past discussions:**
 - [\[02.28.2024\] LFHCAL mtg.](#)
 - [2024 EIC UGM](#)
 - [\[03.05.2025\] Calo CCWG mtg.](#)

HGC/CALOROC Digitization | Details (1/6)



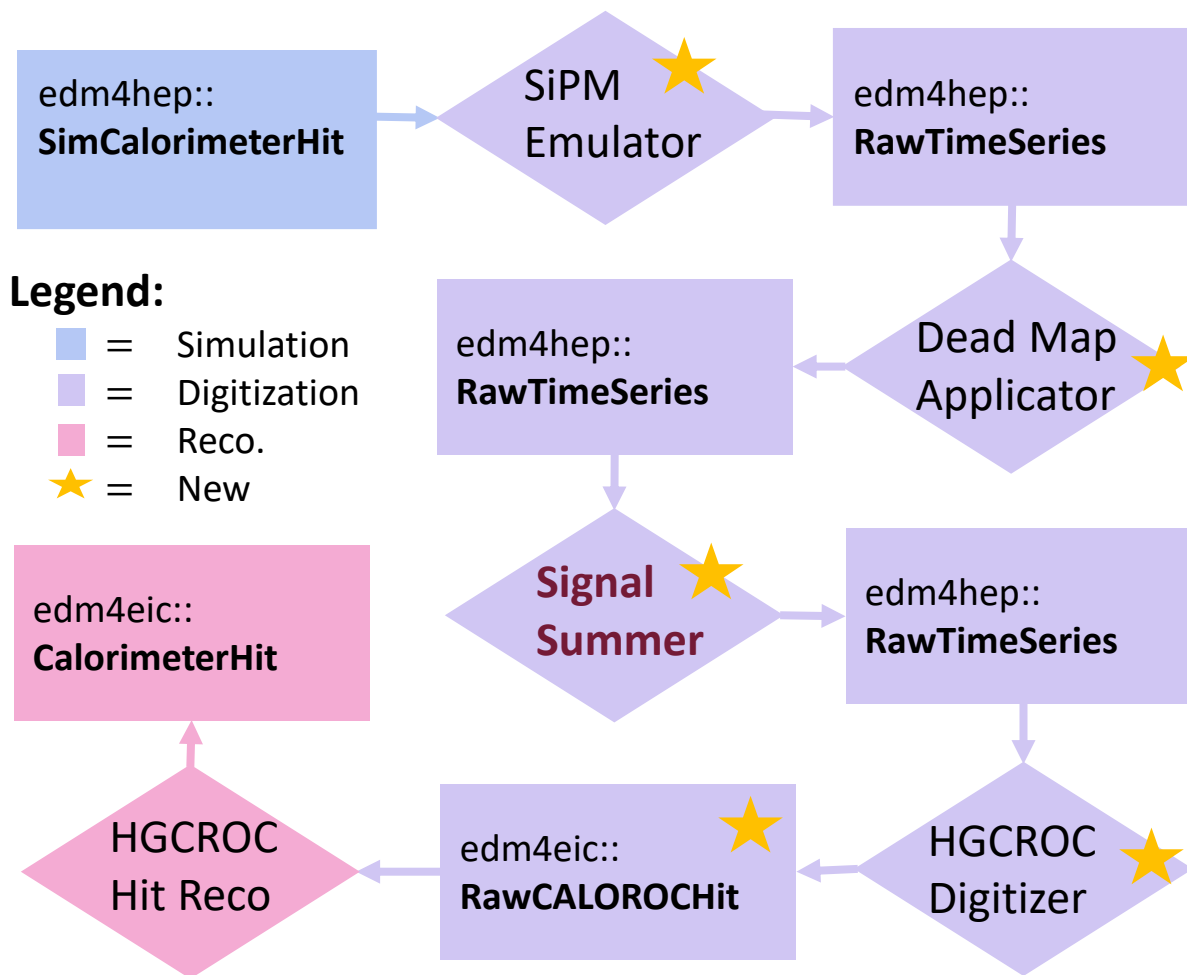
- **SiPM Emulator/SiPM Waveform Generator:** ingests sim hits and generates appropriate waveform *for each channel*
 - **Input:** Sim calorimeter hits
 - **Output:** Raw time series (i.e. waveforms)
- **Plan:** use [SimSiPM](#) package to generate waveforms
 - Needs to be vetted, though!
 - See WIP branch [here \(EICrecon#1761\)](#)
 - **Alternative:** generate a waveform similar to TOF approach, [LGADPulseGeneration](#)

HGC/CALOROC Digitization | Details (2/6)



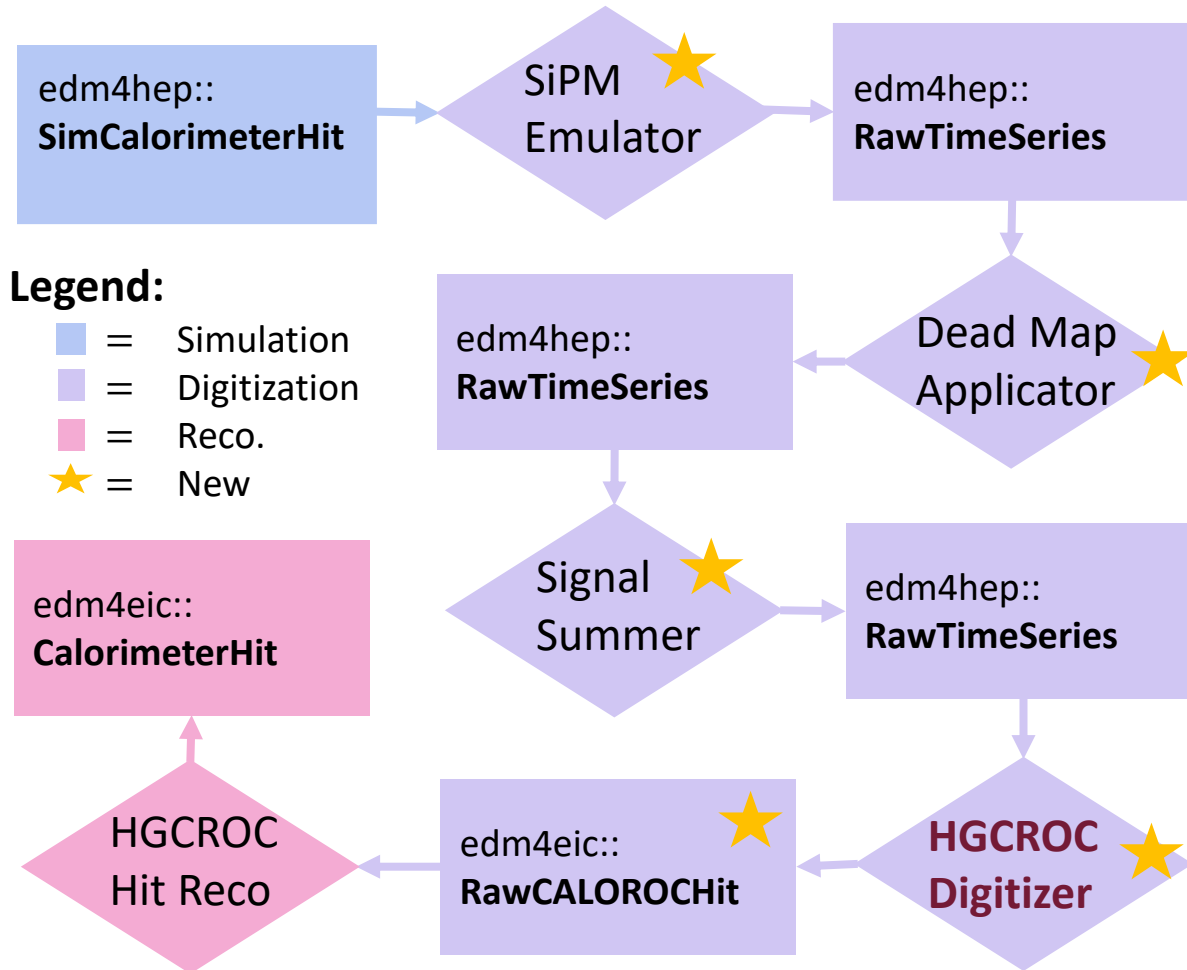
- **Dead Map Applicator:** applies a provided dead map to remove specific channels
 - **Input:** Raw time series
 - **Output:** Raw time series (but only for alive channels)
- **Plan:** could take a couple approaches
 - a) Allow for adjacency-matrix-style specification of dead channels
 - b) Or provide a LUT a la PID

HGC/CALOROC Digitization | Details (3/6)



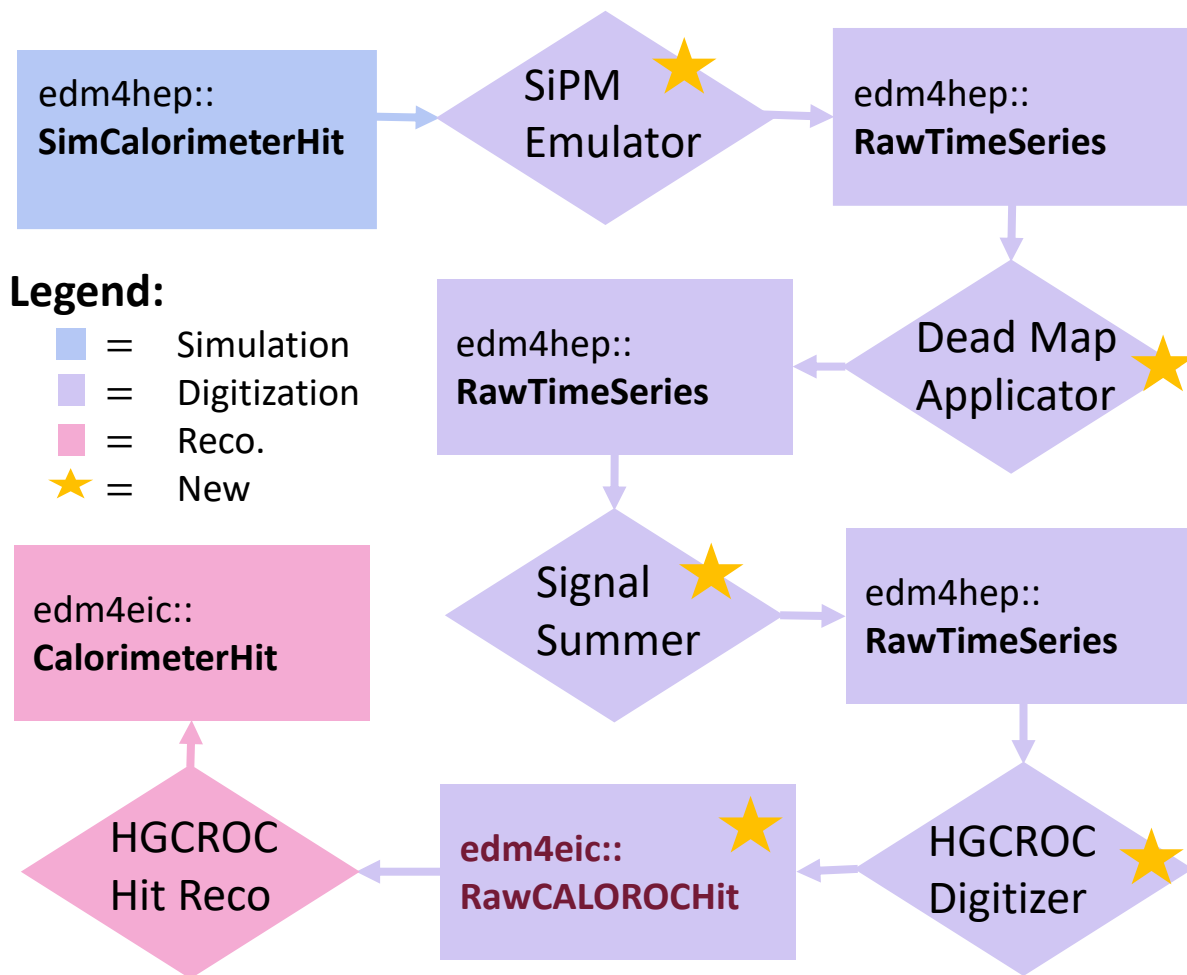
- **Signal summer:** at its most simple, combines signals (waveforms) in specified channels
 - ☞ But will need to also *synchronize* channels
 - **Input:** Raw time series
 - **Output:** Raw time series (but summed and synchronized)
- **Plan:** for the summing, could take a similar tack to the calo hit merging algorithm
 - ☞ But the synchronization piece will need quite a bit of thought...

HGC/CALOROC Digitization | Details (4/6)



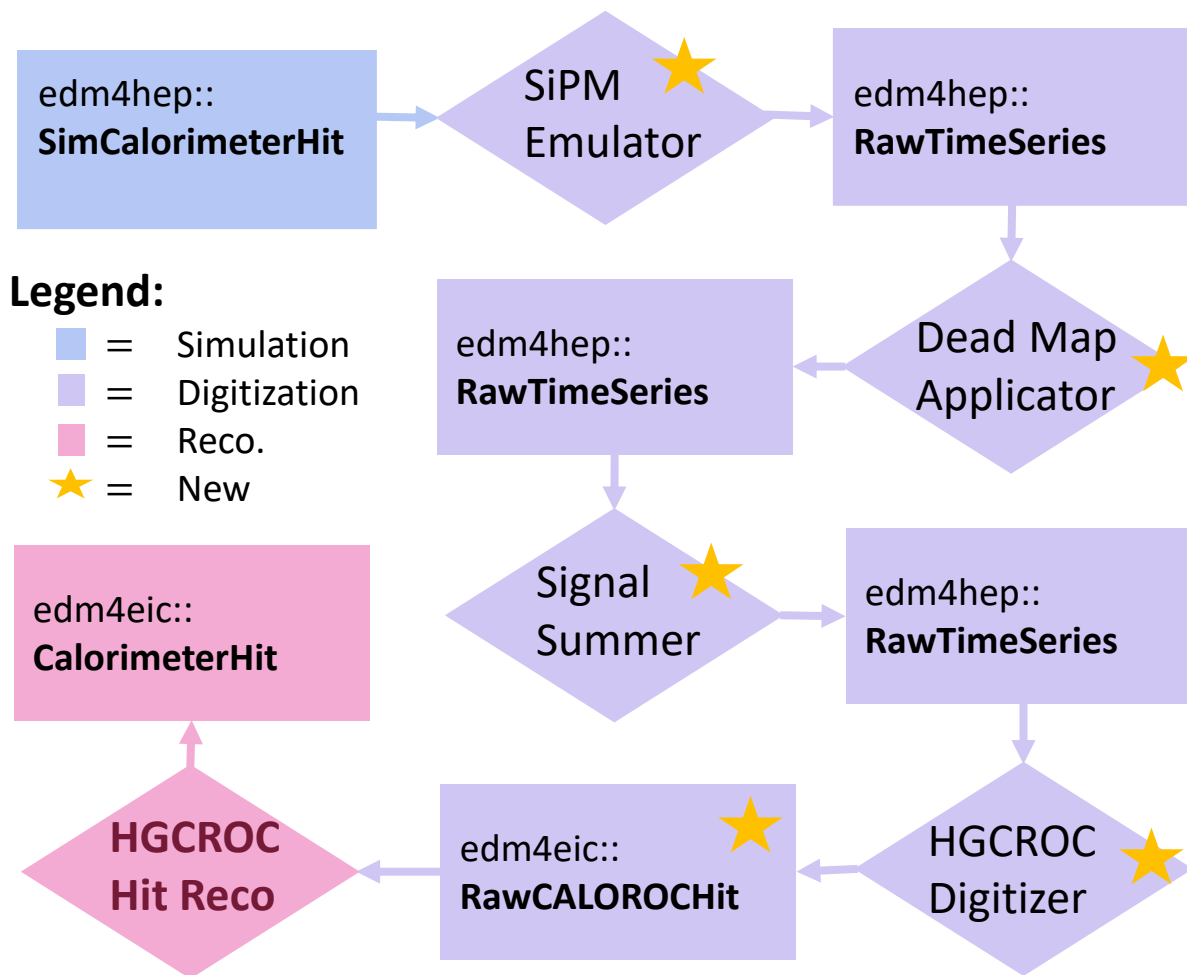
- **HGCROC Digitizer:** turns summed waveforms into digitized hits
 - ☞ But will need to also *synchronize* channels
 - **Input:** Raw time series
 - **Output:** Raw CALOROC hits (see next slide)
- **Plan:** existing CMS code will be a good reference (see discussion [here](#))
 - But also can take a “bare bones” approach initially
 - ☞ i.e. simple extraction of ToT, ToA, amplitude(s), etc.
 - **Note:** SimSiPM also can do this “bare bones” extraction

HGC/CALOROC Digitization | Details (5/6)



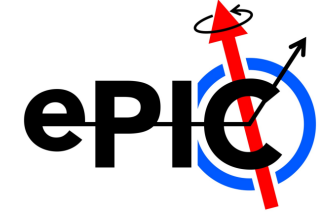
- **Raw CALOROC hit:** new datatype
 - Similar to [edm4hep::RawCalorimeterHit](#)
 - But w/ extensions to reflect additional info from HGC/CALOROC chips
- **Plan:** see draft PR @ [edm4eic#101](#)
👉 (and please give feedback!)

HGC/CALOROC Digitization | Details (6/6)



- **HGCROC hit reco:** turns raw hits into reconstructed hits
 - Parallels existing [hit reco algorithm](#)
 - ☞ Sans pieces of algorithms handled earlier in chain...
 - **Input:** Raw CALOROC hits
 - **Output:** Rec. calo hits, rec-sim hit associations
- **Plan:** again, existing CMS code will be a good reference (see discussion [here](#))

Backup | Preliminary Task List



Item	PR/Issue	Assignee/Interested	Target	Notes
Add SiPM++ to shell	n/a	Wouter D. (UM)	Done	See here in eic/spack
SiPM waveform generation algo	To-Do	Afnan S. (LLR), Deepa T. (UT)	TBD	i.e. run SiPM++
HGCROC raw hit type	EDM4eic#101	Derek A. (ISU)	April	Under discussion
Waveform summation algo	To-Do	Fredi B. (ORNL)	TBD	
HGCROC digitization algo	To-Do	Derek A. (ISU)	TBD	
HGCROC reconstruction algo	To-Do	Matt Ng. (LLR)	TBD	

- **Above:** preliminary list of tasks as sketched out during 2024 Lehigh discussion

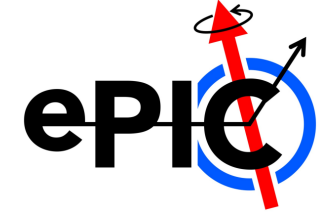
Backup | Current Draft of Raw CALOROC Hit



```
247 +
248 + edm4eic::RawCALOROCHit:
249 +   Description: "Raw hit from a CALOROC/HGCROC chip"
250 +   Author: "D. Anderson"
251 +   Members:
252 +     - uint64_t cellID           // Detector specific (geometrical) cell id
253 +     - int32_t  samplePhase     // Phase of samples in [# samples], for synchronizing across chips
254 +     - int32_t  timeOfArrival   // [adc counts]
255 +     - int32_t  timeOverThreshold // Total time over threshold [adc counts]
256 +     - int32_t  timeStamp      // [adc counts]
257 +   VectorMembers:
258 +     - int32_t  amplitude       // Amplitude of waveform at specific samples in [adc counts]
259 +
```

- **Above:** current draft (c.a. 03.19.2025) of proposed RawCALOROC Hit type
 - See [edm4eic#101](#) for more discussion

Backup | The Infamous Blackboard



- **Right:** picture of notes from LFHCAL/NHCal discussion at the 2024 Lehigh UGM
 - Sketches out individual tasks/path towards implementation
 - But we need to find the time to actually do it :/
- **Note:** other tasks specified in list
 - Check impact of high-precision physics lists on LFHCAL response
 - Implement BHCal, LHFCAL test beam geometries in DD4hep

