TOF simulation summary

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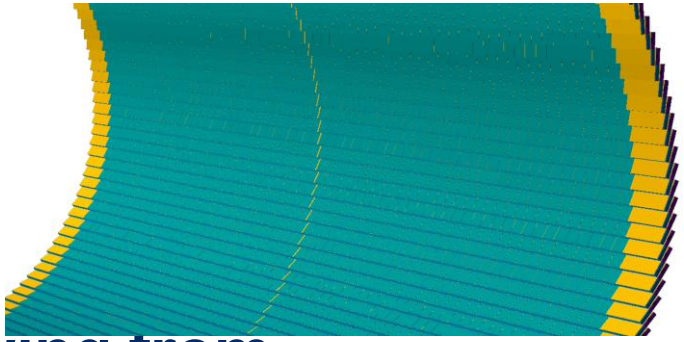
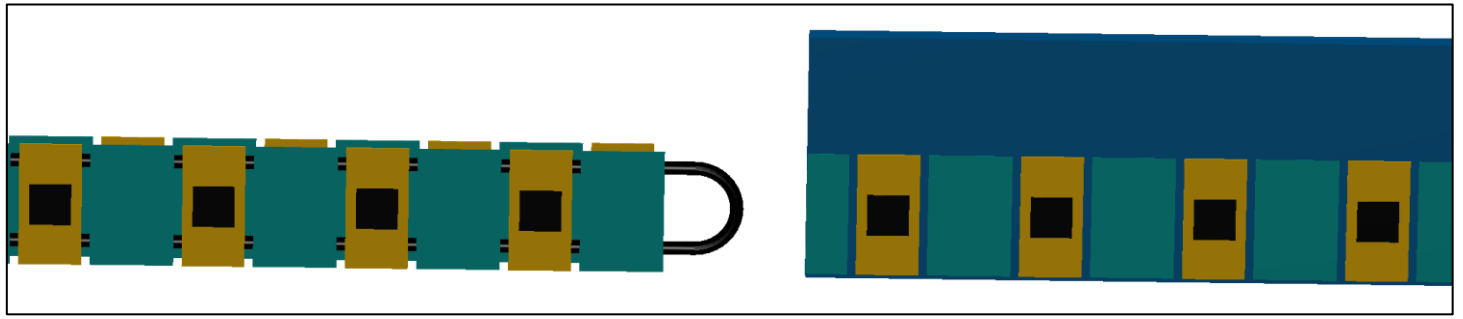
TOF geometry update

BTOF geometry (update May 17 2025)

- **Before: Sensor on one side:**

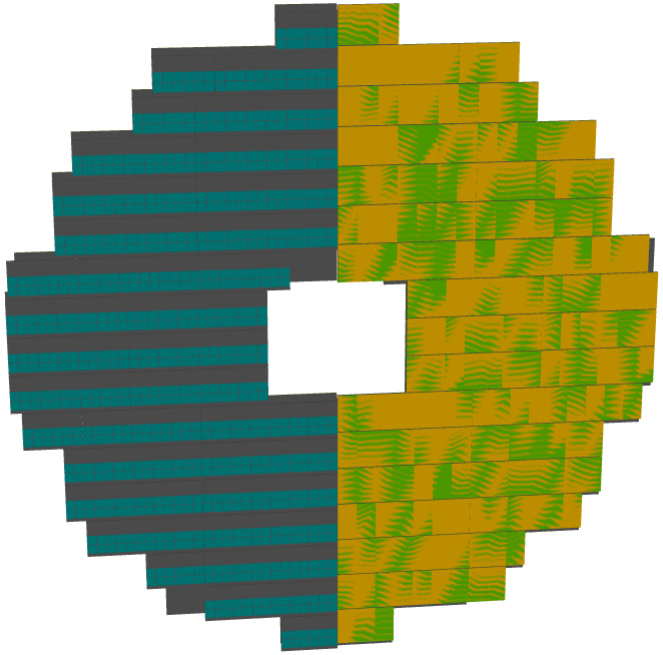


- **Updated to match proposed drawing from** https://indico.bnl.gov/event/27154/contributions/104363/attachments/60759/104362/2025%2003%2024%20Mechanics%20Workshop%20TOF%20Presentation.pdf
- **Design: (Sensors on both sides)**



FTOF geometry (July 9, 2025)

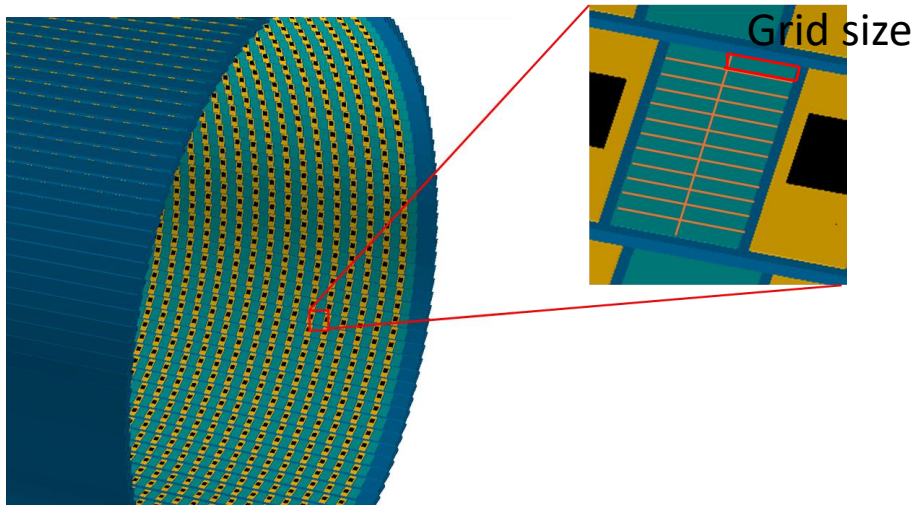
- **ACTS is unable to use tracking information on the back side of FTOF.**
  - https://indico.bnl.gov/event/27986/contributions/106788/attachments/61537/105677/tracking_050125.pdf
- **Error with FTOF geometry implementation.**
- **Fixed in https://github.com/eic/epic/pull/887**



Cover on the left removed to show sensors.

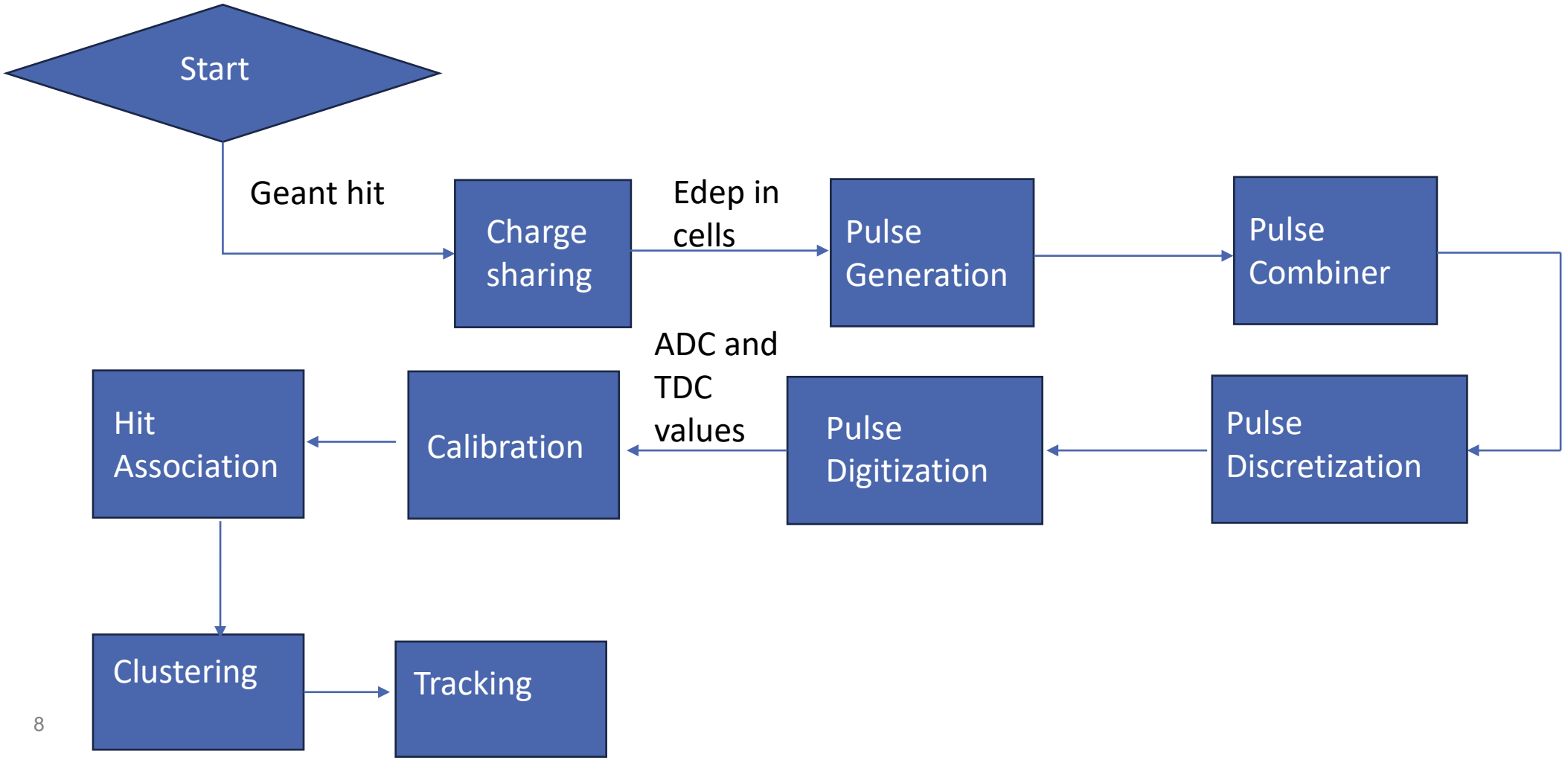
FTOF and BTOF strip size update (June 30, 2025)

- Realistic BTOF grid size: 0.5 cm * 0.5 mm
- Realistic FTOF grid size: 0.5 mm * 0.5 mm
- However, position better than 0.5 mm because of charge sharing (not yet implemented).
- Reduced BTOF grid size to 0.5 cm * 0.1 mm
- Reduced FTOF grid size to 0.1 mm * 0.1 mm

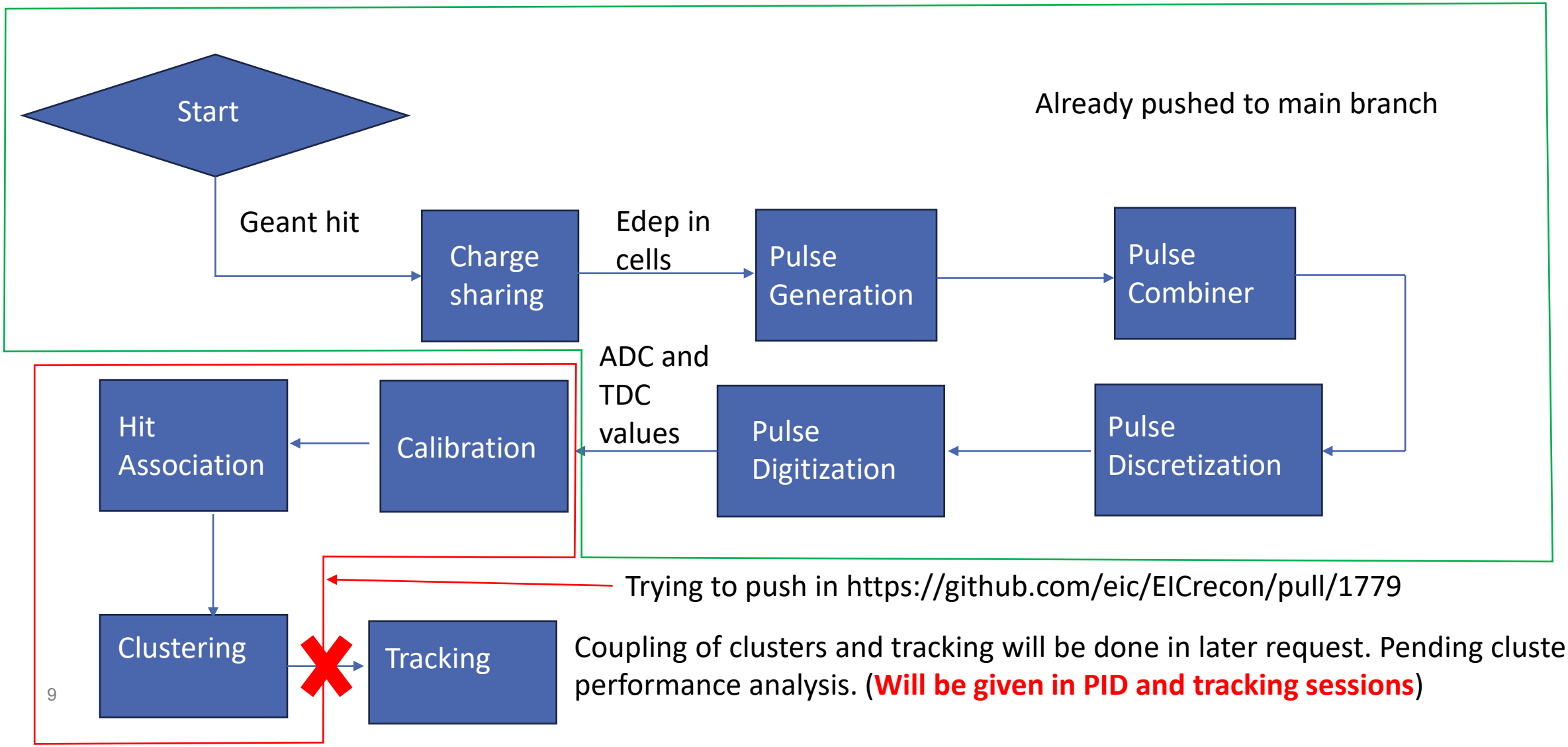


TOF digitization update

Digitization work-flow

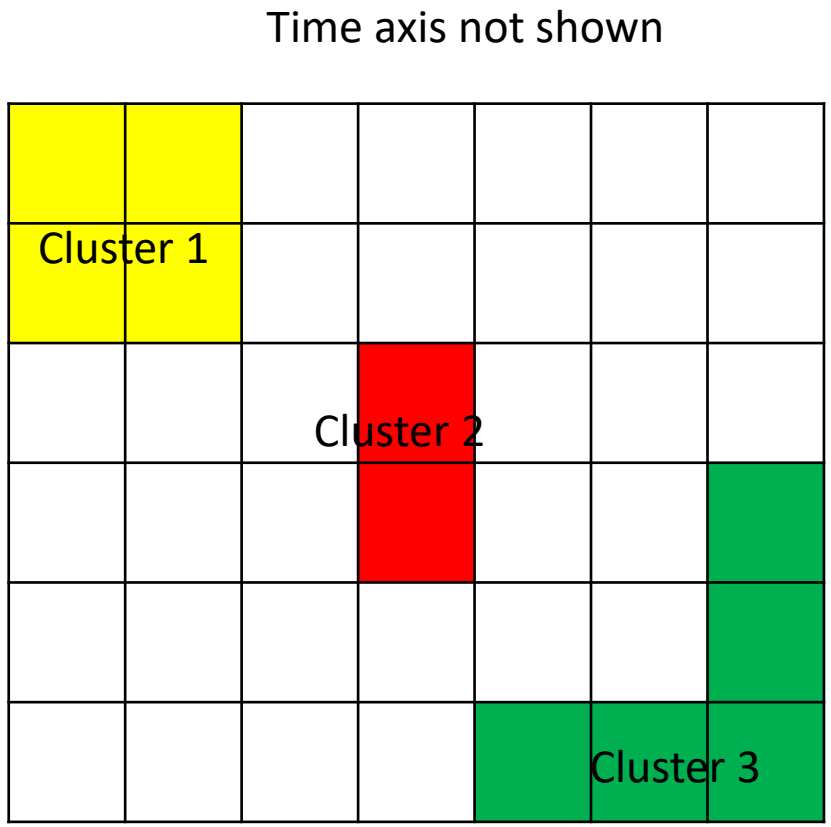


Digitization work-flow (as of July 11)



Calibration and clustering

- **Calibration of TDC to time is just a linear transformation.**
  - Same for ADC.
  - **No time walk (slewing) correction.**
- **Clustering is just weighted average of neighbors.**
  - Group connected neighbors together.
    - Hits are neighbors if $\Delta t < 1ns$.
  - Weighted by Edep.
  - Time of a cluster = time of the earliest hit.
  - **No Edge correction.**

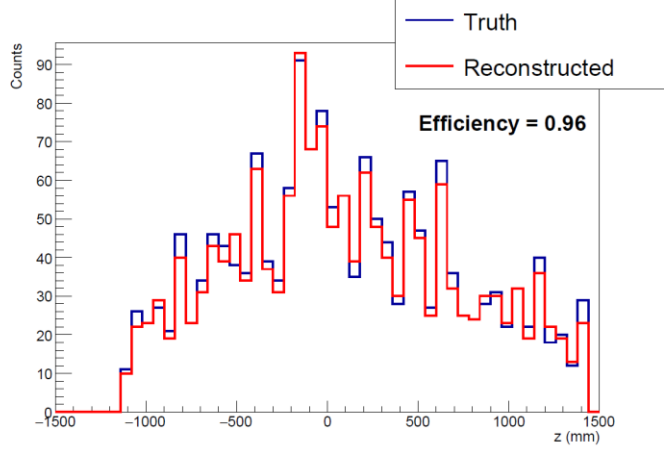


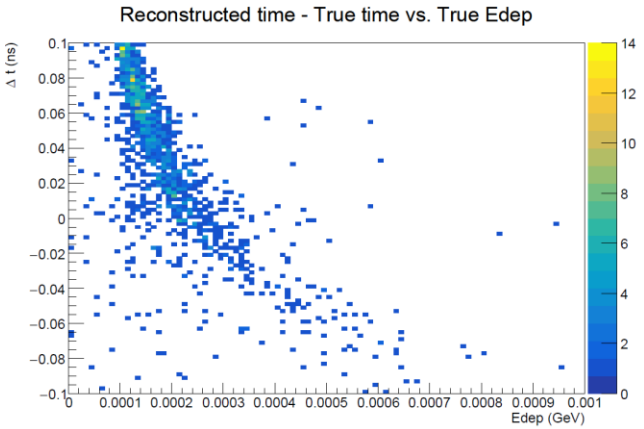
Hit association

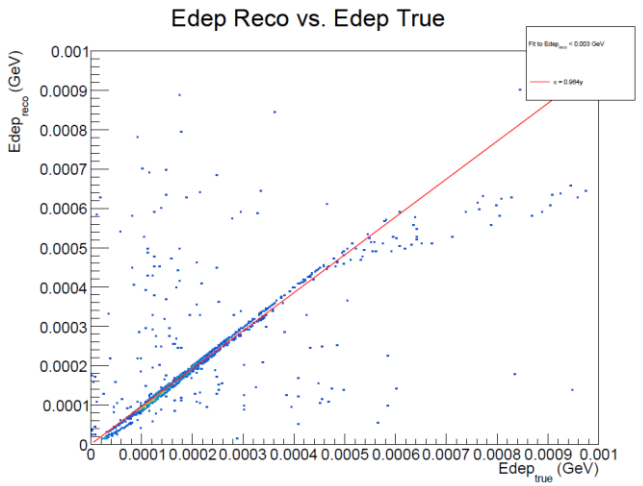
- **Associate reconstructed hit with true hits if:**
  1. They come from the same sensor.
  2. Time difference between the two hits < 1 ns.
  3. If there are multiple hits within 1 ns, choose the one with the smallest Delta t.

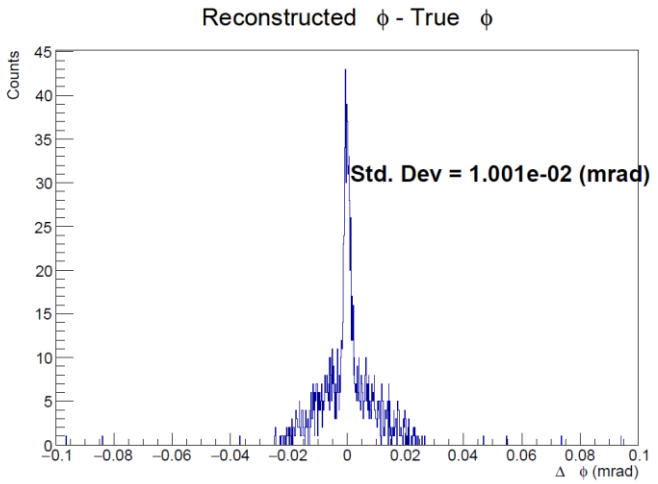
Clustering performance
Charge sharing sigma_x = 0.01 cm
Gain/threshold settings from #1779

- **96% Efficiency for Edep > 5e-5 GeV (After #1945).**
- **Time slewing (as expected).**
- **Phi resolution = 0.01 mrad.**
  - Expected resolution = 0.045 mrad with no charge sharing
- **Edep reconstructed correctly.**









Reduce charge sharing spread

- https://github.com/eic/ElCrecon/pull/1779 also reduces charge sharing sigma 0.1 cm -> 0.01 cm
- Speed improvement:

#1779

eicrecon-dis (clang++, 18x275, 0, craterlake_18x275, ASAN)
succeeded 5 hours ago in 14m 34s

Search logs

Run ElCrecon

```
1310  15:03:28.248  [info] Final report: 100 events processed at 0.9 Hz
1311  15:03:28.908  [info] Finalized JEventProcessor JEventProcessorPODIO
1312  Links:
1313  100 calls, 4.01 s (  4.6%) edm4hep::RawTimeSeries:TOFBarrelPulses ->
      edm4eic::SimPulse:TOFBarrelCombinedPulses
1314  100 calls, 4.44 s (  5.0%) JEventProcessorPODIO ->
      edm4eic::TrackSegment:CalorimeterTrackProjections
1315  100 calls, 5.76 s (  6.5%) edm4eic::Cluster:HcalFarForwardZDCClustersWithoutShapes ->
      edm4eic::ProtoCluster:HcalFarForwardZDCImagingProtoClusters
1316  100 calls, 7.99 s (  9.1%) edm4eic::RawTrackerHit:TOFBarrelADCTDC ->
      edm4hep::RawTimeSeries:TOFBarrelPulses
1317  100 calls, 8.00 s (  9.1%) JEventProcessorPODIO -> edm4eic::RawTrackerHit:TOFBarrelADCTDC
1318  100 calls, 8.39 s (  9.5%) JEventProcessorPODIO ->
      edm4eic::ReconstructedParticle:GeneratedCentauroJets
1319  100 calls, 8.42 s (  9.6%) JEventProcessorPODIO ->
      edm4eic::ReconstructedParticle:ReconstructedCentauroJets
1320  100 calls, 9.57 s ( 10.9%)
      edm4eic::MCRecoClusterParticleAssociation:HcalFarForwardZDCClusterAssociations ->
      edm4eic::Cluster:HcalFarForwardZDCClustersWithoutShapes
1321  100 calls, 9.63 s ( 10.9%) JEventProcessorPODIO ->
      edm4eic::MCRecoClusterParticleAssociation:HcalFarForwardZDCClusterAssociations
1322  100 calls, 21.42 s ( 24.4%) JEventProcessorPODIO ->
      edm4eic::CherenkovParticleID:DRICHAerogelIrtCherenkovParticleID
```

eicrecon-dis (clang++, 18x275, 0, craterlake_18x275, ASAN)
succeeded 2 weeks ago in 13m 47s

Search logs main

Run ElCrecon

```
947  18:49:08.005  [info] Finalized JEventProcessor JEventProcessorPODIO
948  Links:
949  100 calls, 5.55 s (  5.0%) edm4eic::Cluster:HcalFarForwardZDCClustersWithoutShapes ->
     edm4eic::ProtoCluster:HcalFarForwardZDCImagingProtoClusters
950  100 calls, 6.61 s (  5.9%) edm4eic::SimPulse:TOFBarrelCombinedPulses ->
     edm4eic::SimPulse:TOFBarrelSmoothPulses
951  100 calls, 6.64 s (  6.0%) edm4hep::RawTimeSeries:TOFBarrelPulses ->
     edm4eic::SimPulse:TOFBarrelCombinedPulses
952  100 calls, 8.35 s (  7.5%) JEventProcessorPODIO ->
     edm4eic::ReconstructedParticle:ReconstructedCentauroJets
953  100 calls, 8.39 s (  7.5%) JEventProcessorPODIO ->
     edm4eic::ReconstructedParticle:GeneratedCentauroJets
954  100 calls, 8.82 s (  7.9%)
     edm4eic::MCRecoClusterParticleAssociation:HcalFarForwardZDCClusterAssociations ->
     edm4eic::Cluster:HcalFarForwardZDCClustersWithoutShapes
955  100 calls, 8.88 s (  8.0%) JEventProcessorPODIO ->
     edm4eic::MCRecoClusterParticleAssociation:HcalFarForwardZDCClusterAssociations
956  100 calls, 23.59 s ( 21.2%) JEventProcessorPODIO ->
     edm4eic::CherenkovParticleID:DRICHAerogelIrtCherenkovParticleID
957  100 calls, 31.68 s ( 28.4%) edm4eic::RawTrackerHit:TOFBarrelADCTDC ->
     edm4hep::RawTimeSeries:TOFBarrelPulses
958  100 calls, 31.71 s ( 28.4%) JEventProcessorPODIO -> edm4eic::RawTrackerHit:TOFBarrelADCTDC
```

Future

- **Time walk/edge correction.**
- **Use CFD instead of EICROC for BTOF (Pull request #1974).**
  - EICROC uses constant threshold, not fraction.
  - BTOF uses CFD, FTOF uses EICROC.
- **Add noise to pulses.**
- **Add cooling tubes to FTOF.**

Backup: CFD implementation