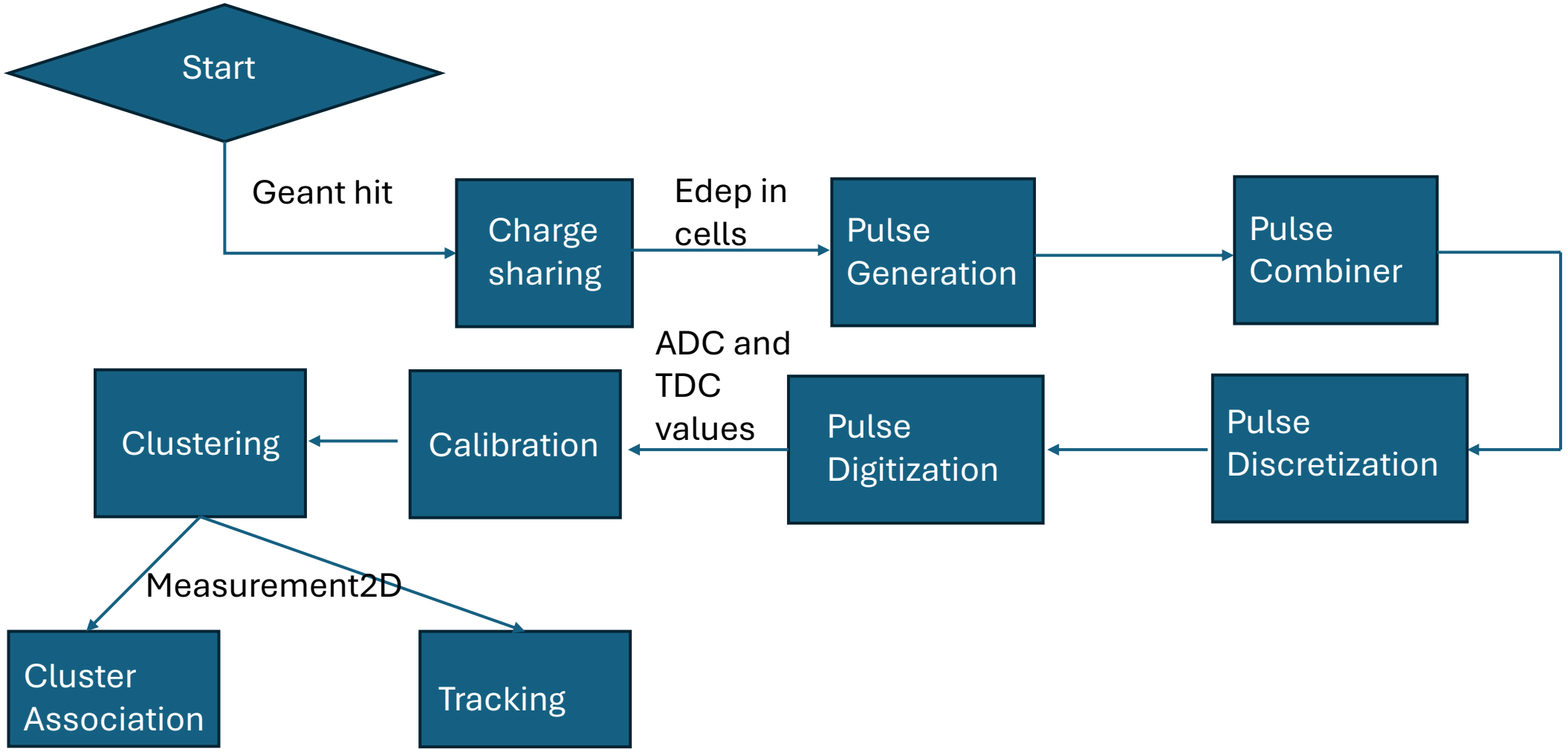
Proposed update to clustering algorithm

4/13/2026

Why change

- Issue: BTOF and ECTOF pixel size is 1/5 the realistic size.
  - Was done to emulate position resolution with charge sharing.
- Proposed change: Revert pixel size back to physical size.
- Challenge back then: Need to implement charge sharing for the correct position resolution.
  - Efficiency lost due to charge sharing routine was NOT understood.
  - Now we think we do.

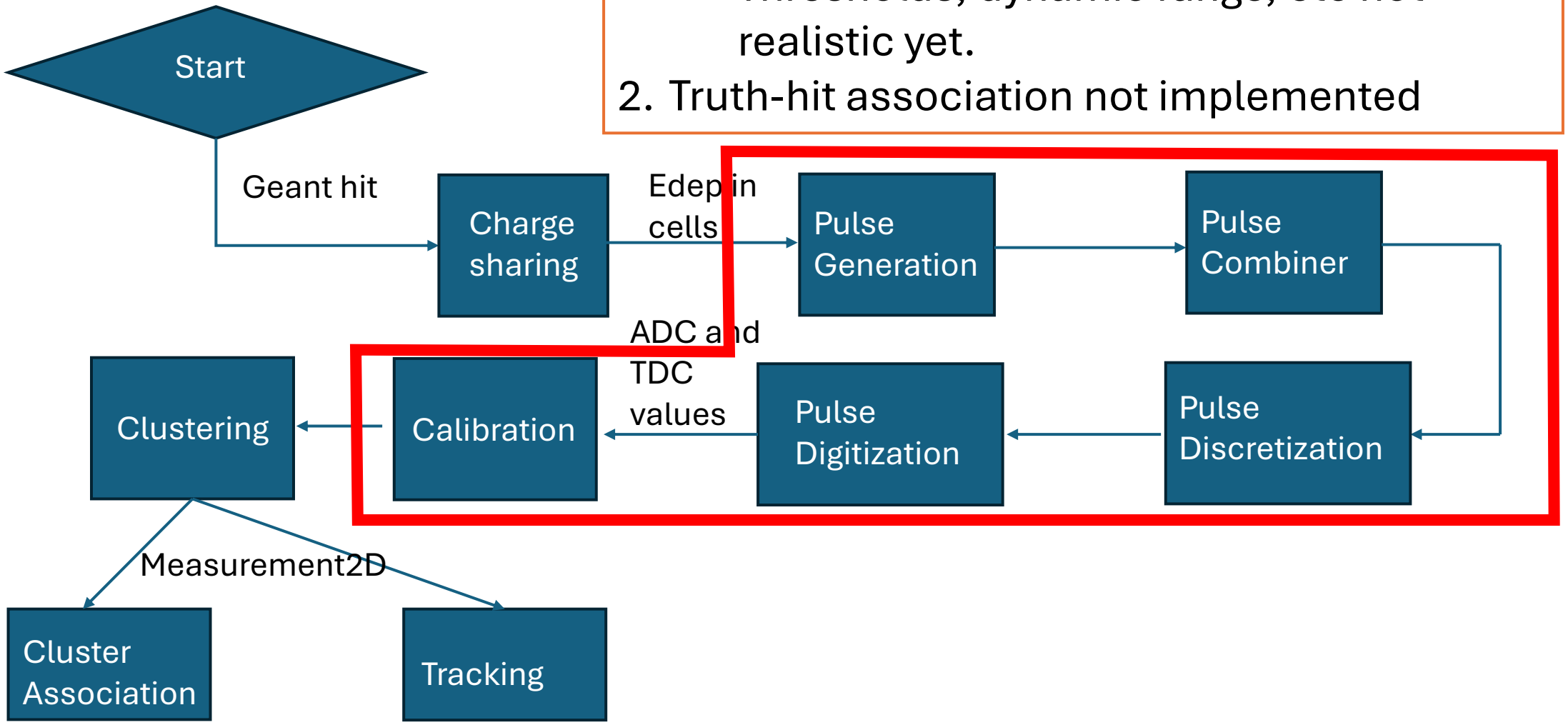
Charge sharing and digitization work-flow



Charge sharing

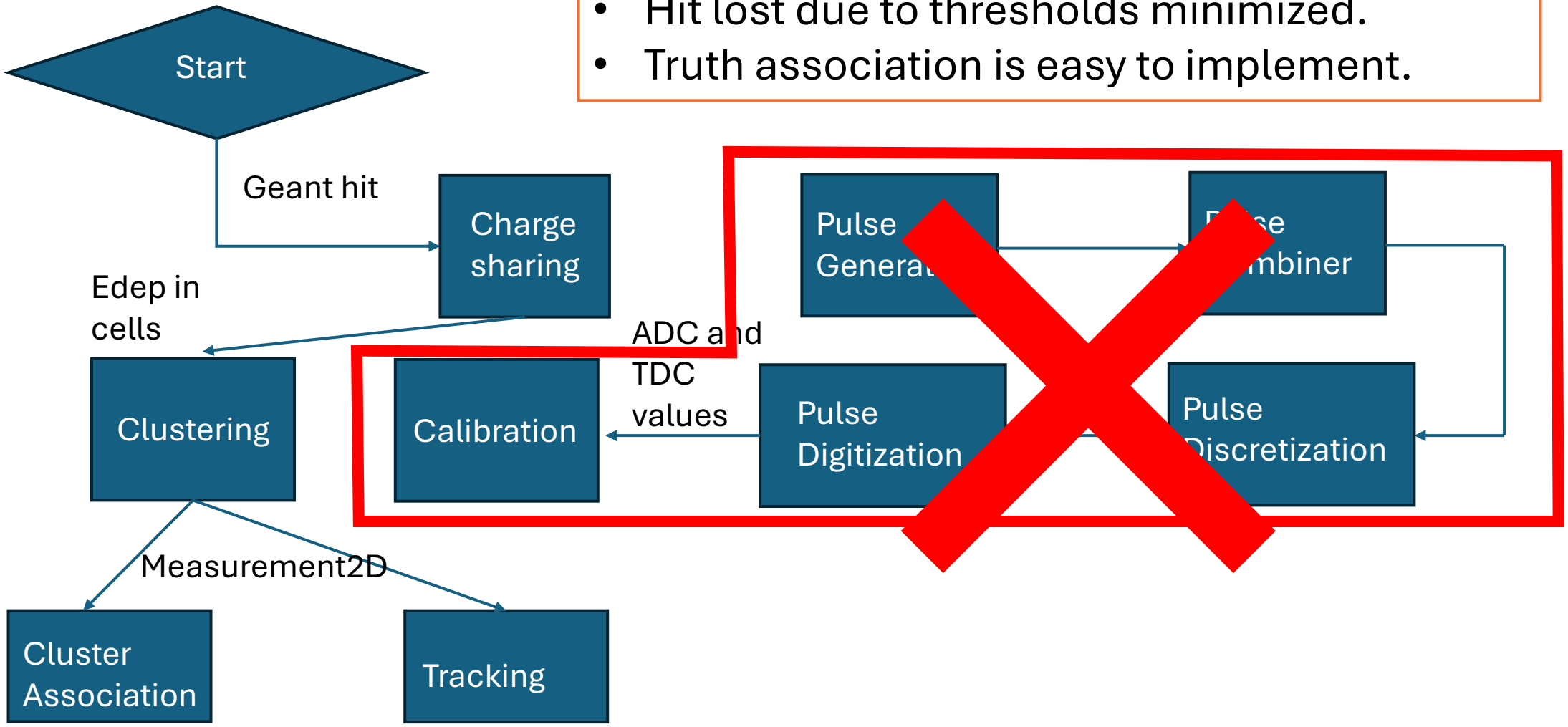
Challenges:

1. Efficiency lost due to digitization not yet understood.
   - Thresholds, dynamic range, etc not realistic yet.
2. Truth-hit association not implemented



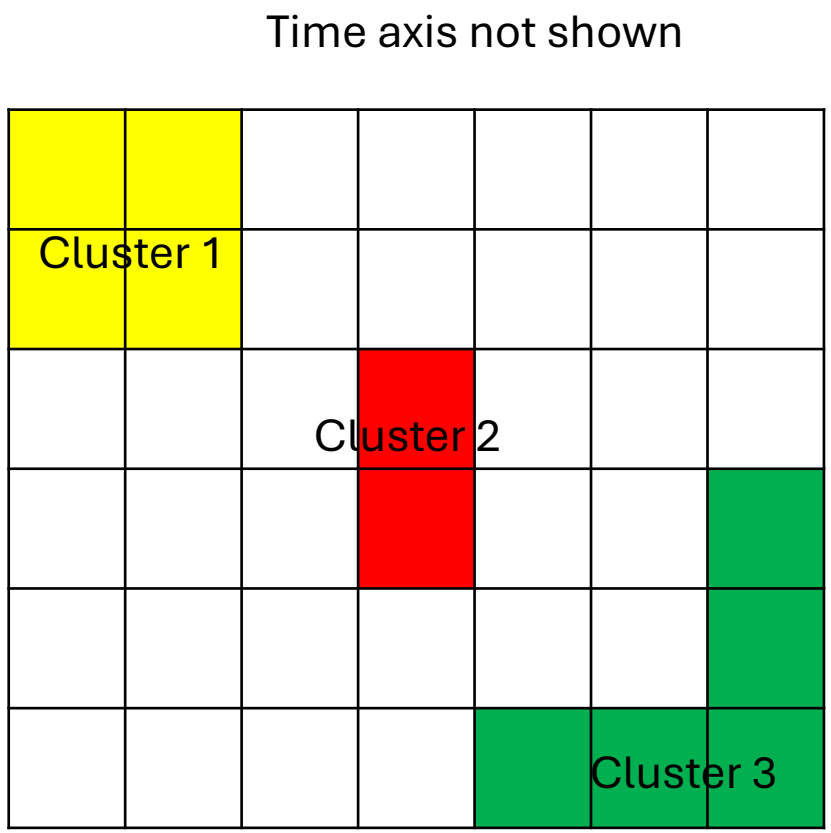
Proposed update: Bypass all digitization routine

Without digitization steps,
- Hit lost due to thresholds minimized.
- Truth association is easy to implement.



Clustering algorithm

- Clustering: weighted average of neighbors.
  - Group contiguous neighbors.
    - Hits are contiguous in time if $\Delta t < 1ns$.
  - Weighted by Edep.
  - Time of a cluster = time of the earliest hit.
  - **No Edge correction.**



Settings for performance study

- MC particle gun:
  - 0 < theta < 2
  - 2pi azimuth uniform
  - 0.1 < |p| < 1 GeV/c
  - Pi+ only

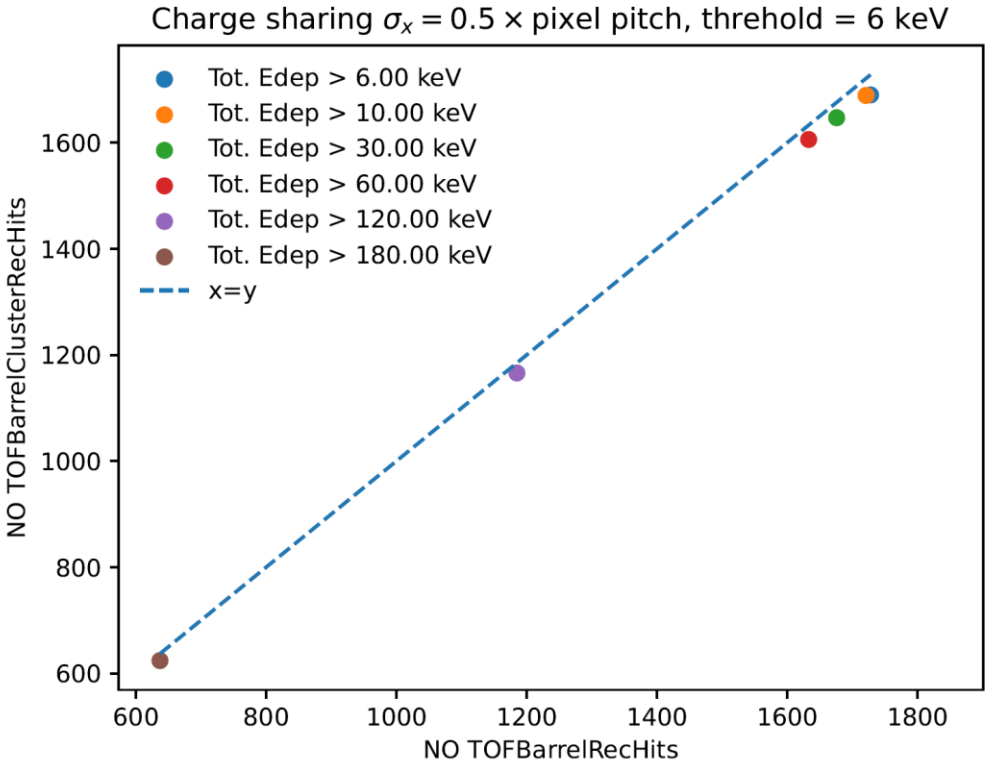
- Reco thresholds:
  - Edep < 6 keV not recorded.
  - Same default settings for current main branch.

BTOF before and after comparison

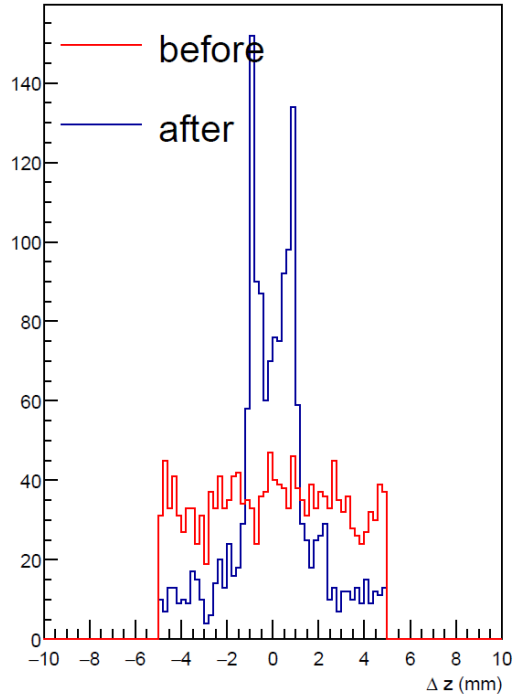
- Before: Small pixel size, NO charge sharing.
- After: Realistic pixel size, WITH charge sharing.

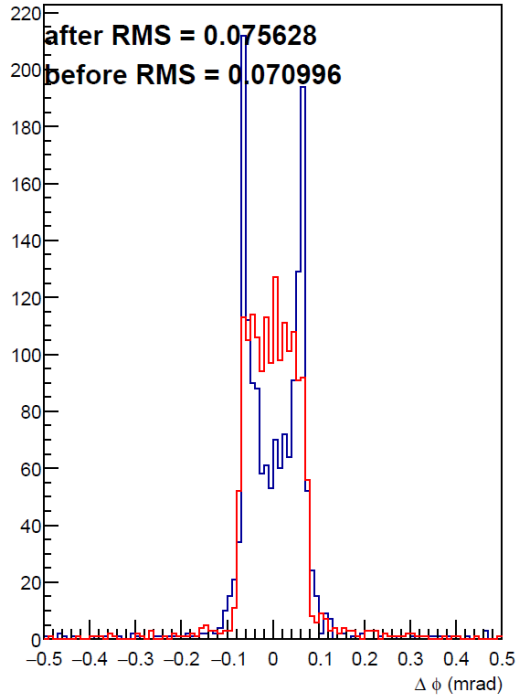
Charge sharing:
Sigmax = 0.5 mm = pixel pitch
Sigmay = 0.5 cm = 0.5*pixel width

Similar efficiency (NO Rec Hits after vs before)



Similar resolution (reco-truth distributions)



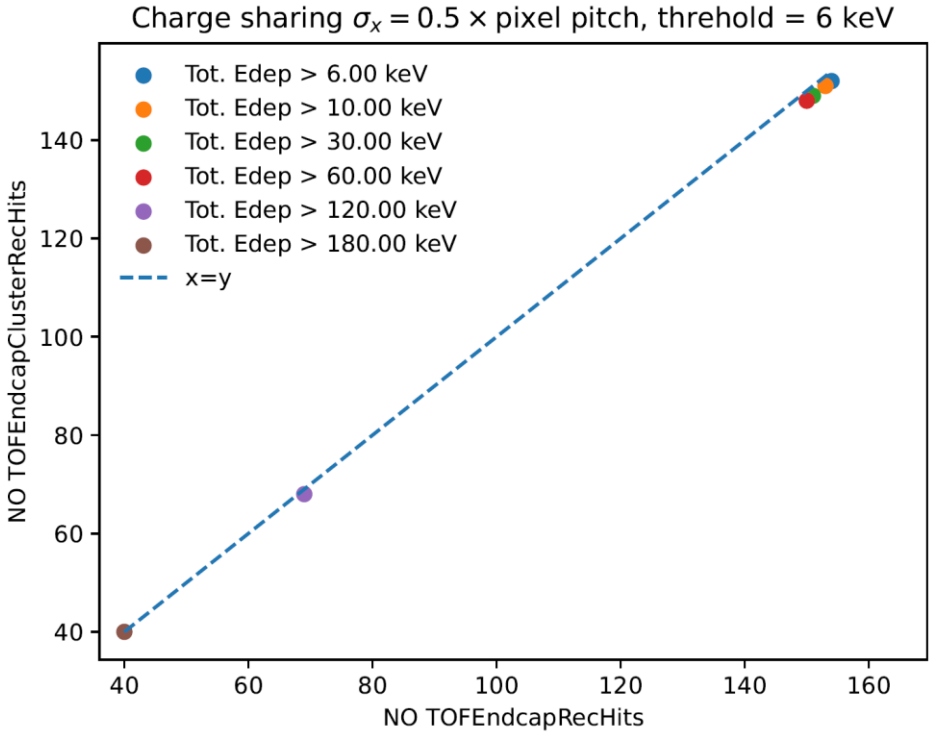


ETOF before and after comparison

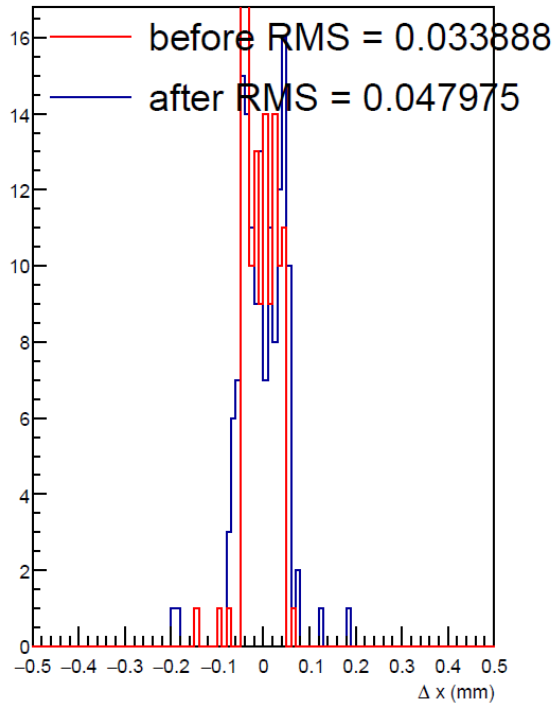
Charge sharing:
Sigmax = 0.25 mm = 0.5*pixel width
Sigmay = 0.2515 mm = 0.5*pixel heig

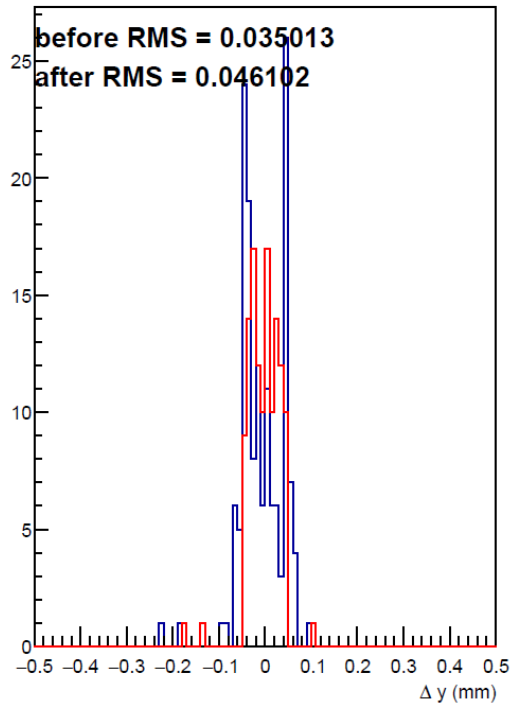
- Before: Small pixel size, NO charge sharing.
- After: Realistic pixel size, WITH charge sharing.

Similar efficiency (NO Rec Hits after vs before)



Similar resolution (reco-truth distributions)





Conclusion

- Clustering algorithm with realistic pixel size gives us:
  - Similar efficiency,
  - Similar resolution to what we currently have in main branch.

- Proposal: Will replace TOFBarrelRecHits with output from cluster algorithm for track reconstruction.

Things to discuss

Format of reco-truth association

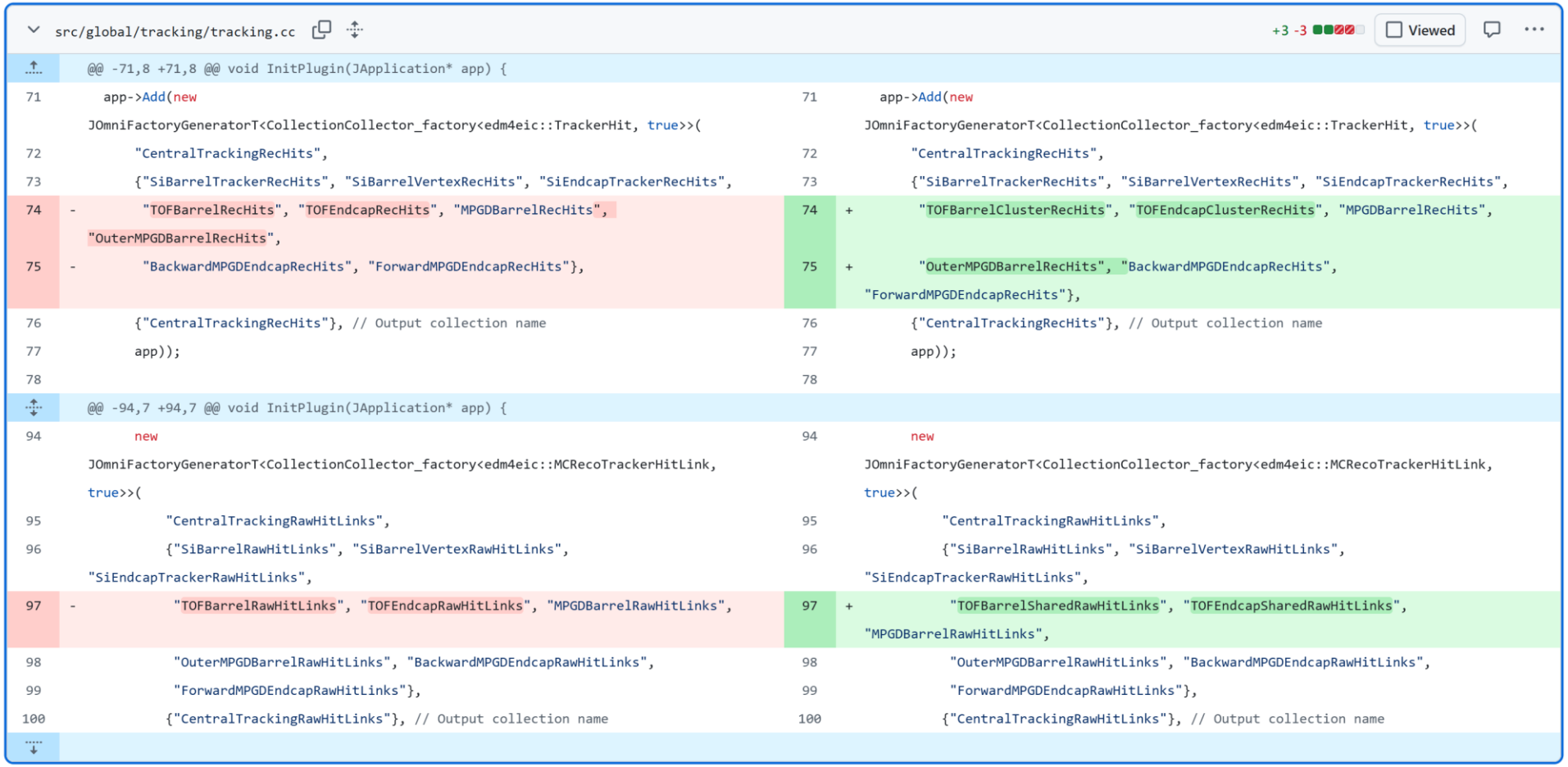
- In my pull request:
  - TOFBarrelSharedHitLink: Link all hits spawned by the charge sharing class to the simhit.
  - TOFBarrelSharedRawHitLink: Link Rec hit to raw hits spawned by the charge sharing class.

- Advantage: Minimal modifications to existing class. (SiliconTrackerDigi class is used to make TOFBarrelSharedRawHitLink).

- Disadvantage: Now you need 2 links for reco-truth association

Input for tracking algorithm

- In my pull request:
  - LGADHitCluster generates both TrackerHits and Measurement2D. Tracking algorithm takes TrackerHits as input.
- Advantage: Easy substitution from TOFBarrelRecHits (which is also of type TrackerHit).
- Disadvantage: I knew the group wanted Measurement2D directly, but we may need to write some more boiler plate code.



src/global/tracking/tracking.cc +3 -3 Viewed

```
@@ -71,8 +71,8 @@ void InitPlugin(JApplication* app) {
71   app->Add(new JOmniFactoryGeneratorT<CollectionCollector_factory<edm4eic::TrackerHit, true>>(
72       "CentralTrackingRecHits",
73       {"SiBarrelTrackerRecHits", "SiBarrelVertexRecHits", "SiEndcapTrackerRecHits",
74 -      "TOFBarrelRecHits", "TOFEndcapRecHits", "MPGDBarrelRecHits", "OuterMPGDBarrelRecHits",
75 -      "BackwardMPGDEndcapRecHits", "ForwardMPGDEndcapRecHits"},
74 +      "TOFBarrelClusterRecHits", "TOFEndcapClusterRecHits", "MPGDBarrelRecHits", "OuterMPGDBarrelRecHits",
75 +      "BackwardMPGDEndcapRecHits", "ForwardMPGDEndcapRecHits"},
76       {"CentralTrackingRecHits"}, // Output collection name
77       app));
78
@@ -94,7 +94,7 @@ void InitPlugin(JApplication* app) {
94       new JOmniFactoryGeneratorT<CollectionCollector_factory<edm4eic::MCRecoTrackerHitLink, true>>(
95           "CentralTrackingRawHitLinks",
96           {"SiBarrelRawHitLinks", "SiBarrelVertexRawHitLinks", "SiEndcapTrackerRawHitLinks",
97 -          "TOFBarrelRawHitLinks", "TOFEndcapRawHitLinks", "MPGDBarrelRawHitLinks",
97 +          "TOFBarrelSharedRawHitLinks", "TOFEndcapSharedRawHitLinks", "MPGDBarrelRawHitLinks",
98           "OuterMPGDBarrelRawHitLinks", "BackwardMPGDEndcapRawHitLinks",
99           "ForwardMPGDEndcapRawHitLinks"},
100          {"CentralTrackingRawHitLinks"}, // Output collection name
```

Pull request

- Enlarge pixel size in epic: https://github.com/eic/epic/pull/1080

- Enable cluster algorithm: https://github.com/eic/EICrecon/pull/2616