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Tracker Hits to Trajectory

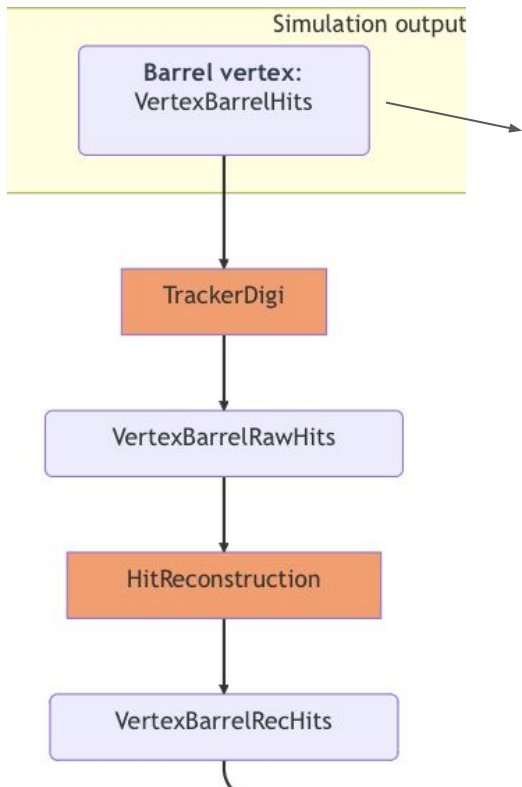
Shujie Li

With lots of help from Wouter and Dmitry

EIC-ePIC track recon meeting

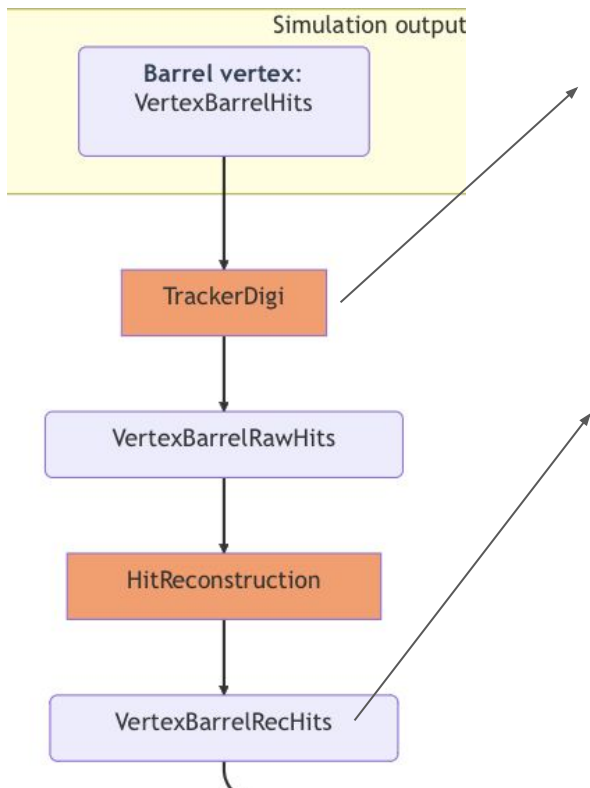
Oct 19, 2023





```

#----- SimTrackerHit
edm4hep::SimTrackerHit:
  Description: "Simulated tracker hit"
  Author: "F.Gaede, DESY"
  Members:
    - uint64_t cellID      //ID of the sensor that created this hit
    - float EDep          //energy deposited in the hit [GeV].
    - float time          //proper time of the hit in the lab frame in [ns].
    - float pathLength    //path length of the particle in the sensitive material that resulted in the hit
    - int32_t quality     //quality bit flag.
    - edm4hep::Vector3d position //the hit position in [mm].
    - edm4hep::Vector3f momentum //the 3-momentum of the particle at the hits position in [GeV]
  OneToOneRelations:
    - edm4hep::MCParticle MCParticle //MCParticle that caused the hit.
  MutableExtraCode:
  
```



eicd::RawTrackerHit:

Description: "Raw (digitized) tracker hit"

Author: "W. Armstrong, S. Joosten"

Members:

- uint64_t cellID // The detector specific (geometrical) cell id.
- int32_t charge // ADC value
- ## @TODO: is charge appropriate here? Needs revisiting.
- int32_t timeStamp // TDC value.

eicd::TrackerHit:

Description: "Tracker hit (reconstructed from Raw)"

Author: "W. Armstrong, S. Joosten"

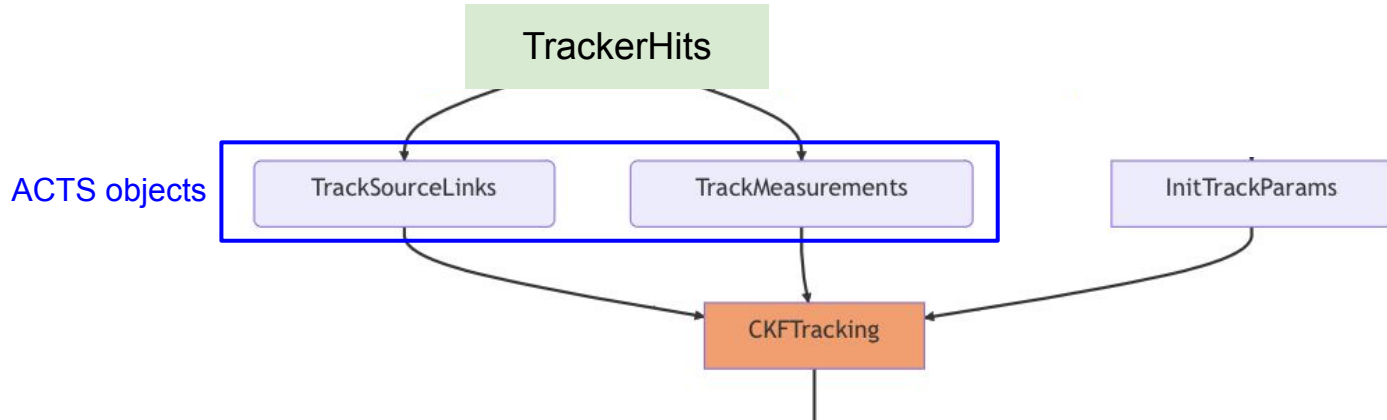
Members:

- uint64_t cellID // The detector specific (geometrical) cell id.
- edm4hep::Vector3f position // Hit (cell) position and time [mm, ns]
- eicd::CovDiag3f positionError // Covariance Matrix
- float time // Hit time
- float timeError // Error on the time
- float edep // Energy deposit in this hit [GeV]
- float edepError // Error on the energy deposit [GeV]

Previous:

```
// Create source links
auto sourceLink = std::make_shared<ActsExamples::IndexSourceLink>(surface->geometryId(), hit_index);
sourceLinks.emplace_back(sourceLink);

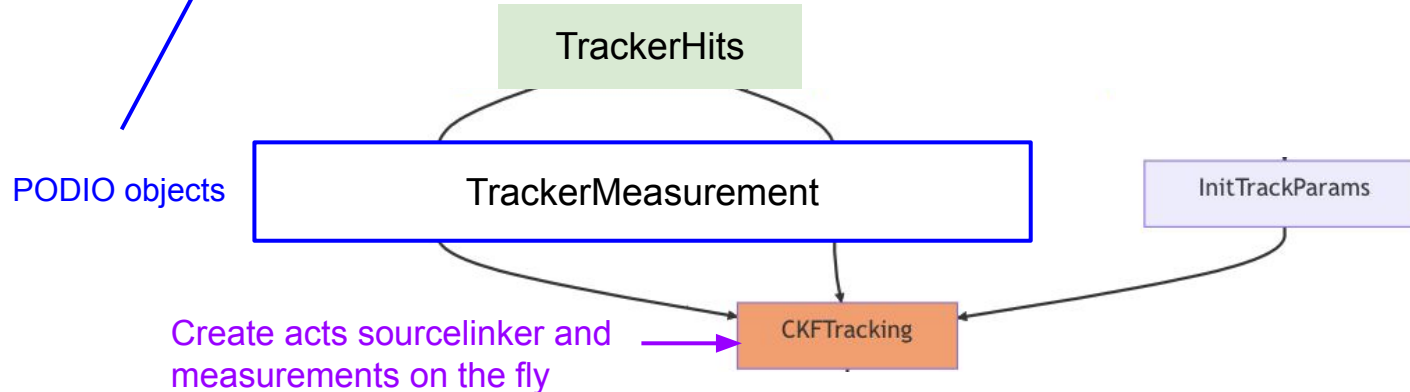
auto measurement = Acts::makeMeasurement(*sourceLink, loc, cov, Acts::eBoundLoc0, Acts::eBoundLoc1);
measurements->emplace_back(std::move(measurement));
```



Now:

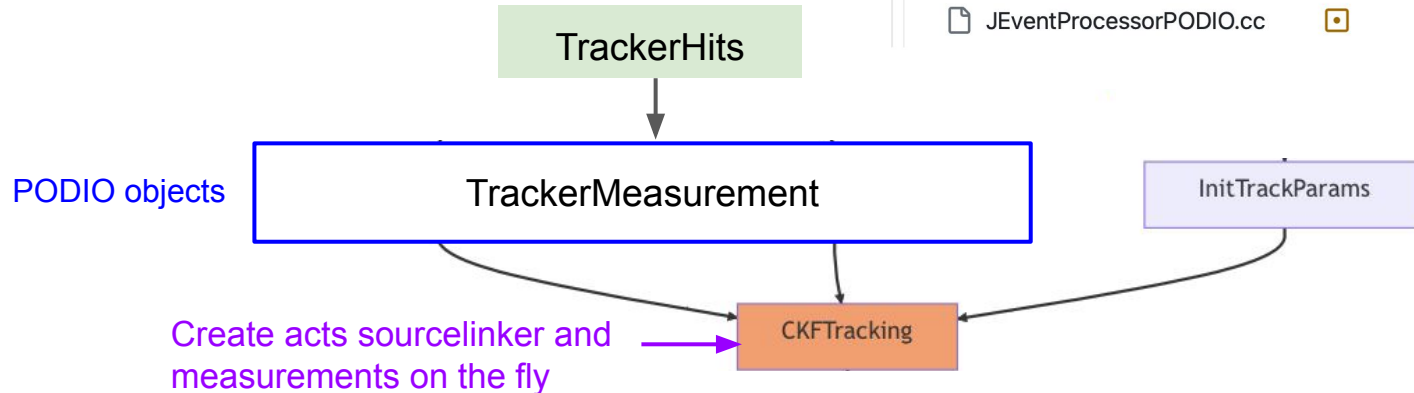
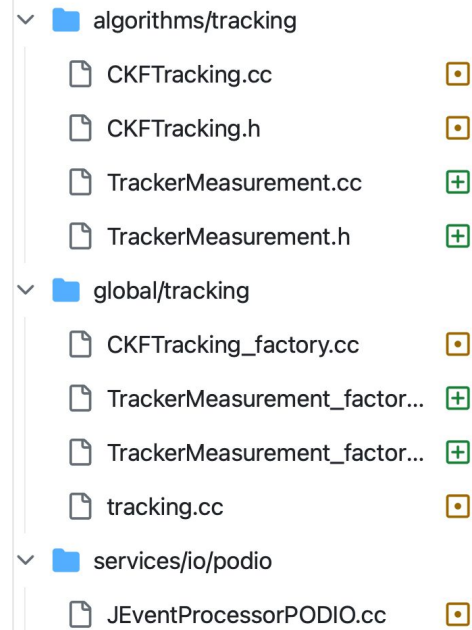
New data structure proposed by Wouter, [link](#)

```
edm4eic::Measurement2D:  
  Description: "2D measurement (on an arbitrary surface)"  
  Author: "W. Deconinck"  
  Members:  
    - uint64_t      surface      // Surface for bound coordinates (geometryID)  
    - edm4hep::Vector2f loc      // 2D location on surface  
    - float         time         // Measurement time  
    - edm4eic::Cov3f covariance  // Covariance on location and time  
  VectorMembers:  
    - float         weights      // Weight for each of the hits, mirrors hits array  
  OneToManyRelations:  
    - edm4eic::TrackerHit hits   // Hits in this measurement (single or clustered)
```

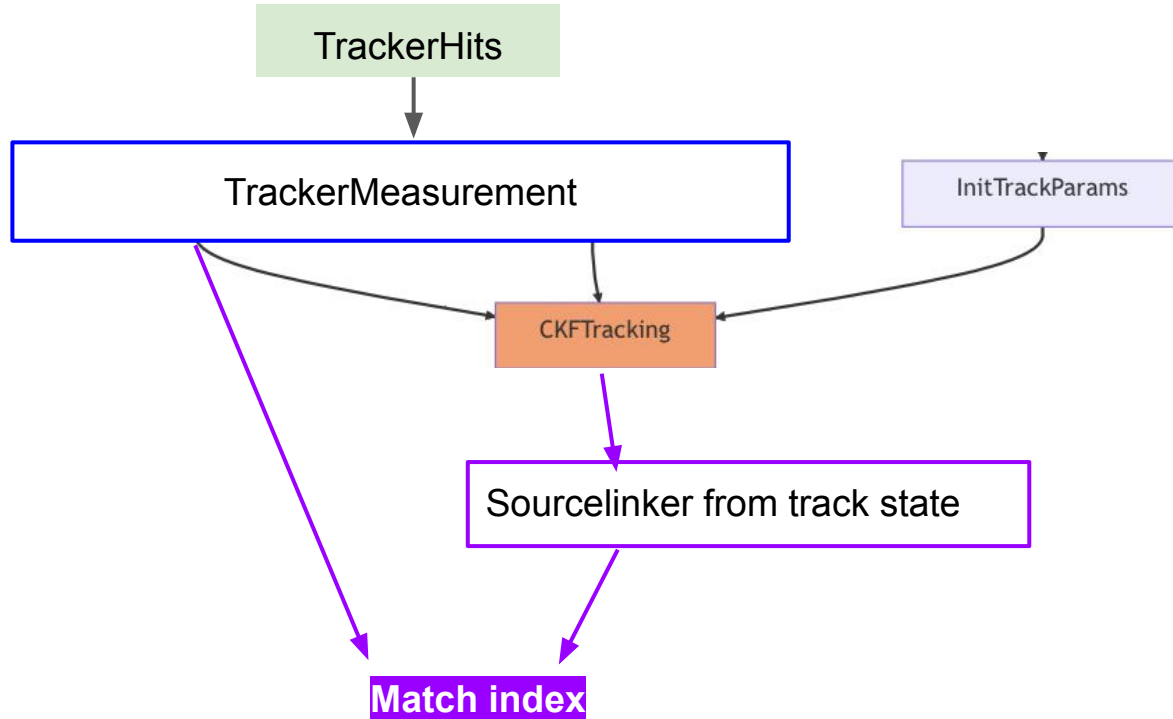


Now:

New factory, PR almost ready
<https://github.com/eic/EICrecon/pull/1076>



Associate Hits/TrackerMeasurement to Trajectory



geometryID (uint64_t) can be converted to volume and surface ID

<https://acts.readthedocs.io/en/latest/core/geometry.html#geometry-identifier>

3 trajectories reconstructed from exactly the same group of hits

```
[tracking:CentralTrackerMeasurements] [debug]
[tracking:CentralTrackerMeasurements] [debug] All hits processed. Hits size: 8 measurements->size: 8
Create sourcelink:
2017612907939913759 0
2017612770500960287 1
2594073522804362575 2
2377900740690578766 3
2161727958576794957 4
3026419087031961180 5
2810246304918170429 6
3098476681069859392 7
} Hit index
trajectory state,measurement, outlier, hole: 11 4 3 0
visit backward
Measurement: GeoID=3026419087031961180 index=5
Outlier: GeoID=2810246304918170429 index=6
Outlier: GeoID=2594073522804362575 index=2
Outlier: GeoID=2377900740690578766 index=3
Measurement: GeoID=2161727958576794957 index=4
Measurement: GeoID=2017612907939913759 index=0
Measurement: GeoID=2017612770500960287 index=1
trajectory state,measurement, outlier, hole: 11 4 3 0
visit backward
Measurement: GeoID=3026419087031961180 index=5
Outlier: GeoID=2810246304918170429 index=6
Outlier: GeoID=2594073522804362575 index=2
Outlier: GeoID=2377900740690578766 index=3
Measurement: GeoID=2161727958576794957 index=4
Measurement: GeoID=2017612907939913759 index=0
Measurement: GeoID=2017612770500960287 index=1
trajectory state,measurement, outlier, hole: 11 4 3 0
visit backward
Measurement: GeoID=3026419087031961180 index=5
Outlier: GeoID=2810246304918170429 index=6
Outlier: GeoID=2594073522804362575 index=2
Outlier: GeoID=2377900740690578766 index=3
Measurement: GeoID=2161727958576794957 index=4
Measurement: GeoID=2017612907939913759 index=0
Measurement: GeoID=2017612770500960287 index=1
```


Trajectory info in EICrecon output

_begin / _end: index range of the corresponding vector
e.g. measurementChi2[8...15] gives hit chi2 for the 2nd trajectory

_0: the first scalar
vector in this data
structure, e.g.
measurementChi2

```
CentralCKFSeededTrajectories.measurementChi2_begin = 0, 8, 16
CentralCKFSeededTrajectories.measurementChi2_end = 8, 16, 24
CentralCKFSeededTrajectories.outlierChi2_begin = 0, 0, 0
CentralCKFSeededTrajectories.outlierChi2_end = 0, 0, 0
CentralCKFSeededTrajectories.trackParameters_begin = 0, 1, 2
CentralCKFSeededTrajectories.trackParameters_end = 1, 2, 3
CentralCKFSeededTrajectories.measurementHits_begin = 0, 8, 16
CentralCKFSeededTrajectories.measurementHits_end = 8, 16, 24
CentralCKFSeededTrajectories.outlierHits_begin = 0, 0, 0
CentralCKFSeededTrajectories.outlierHits_end = 0, 0, 0
CentralCKFSeededTrajectories#0 = (vector<podio::ObjectID>*)0x6000030251a0
CentralCKFSeededTrajectories#0.index = 0, 1, 2
CentralCKFSeededTrajectories#0.collectionID = 59, 59, 59
CentralCKFSeededTrajectories#1 = (vector<podio::ObjectID>*)0x600003025380
CentralCKFSeededTrajectories#1.index = 7, 5, 6, 0, 1, 2, 3, 4, 7, 5, 6, 0, 1, 2
CentralCKFSeededTrajectories#1.collectionID = 57, 57, 57, 57, 57, 57, 57, 57, 57
CentralCKFSeededTrajectories_0 = (vector<float>*)0x6000030257a0
CentralCKFSeededTrajectories_1 = (vector<float>*)0x600003025860
```

#0: the first vector of
pointer (relation) in
this data structure,
e.g. trackParameters

To do:

1. Finalize PR (developed with local version of EDM4EIC, pending CI test)
2. Prepare analysis scripts to convert geometry ID to surface, 2D position to 3D (Beatrice, Shujie)
3. Next step: matching tracks and particles?