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Tracking and Vertexing Data Structure Update

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ePIC Software and Computing Meeting
02.07.2024



edm4eic version update

The screenshot displays a vertical timeline of GitHub commits for the edm4eic project. The commits are listed from top to bottom, with the most recent at the top. Each commit entry includes a title, the author's name, the time since the commit, and the commit count (3/3). The commits are: 1. 'feat: update vertex edm to 4d quantities (#61)' by an unnamed user, committed 4 days ago. 2. 'create TrackSeed structure to store the seed info (#69)' by ShujieL and wdconinc, committed last week. 3. 'bring measurements back to trajectory (#60)' by ShujieL and wdconinc, committed 2 weeks ago. 4. 'fix: Cov6f operator(i,j) must be const (#67)' by wdconinc, committed 2 weeks ago. 5. 'fix: only compile edm4eic_merge for podio < 0.17.4 (#64)' by wdconinc, committed 2 weeks ago. 6. 'fix: next version will be 5.0.0 (#66)' by wdconinc, committed 2 weeks ago. 7. 'Update track fit EDM (#58)' by osbornrd, committed 4 months ago. Vertical arrows on the left indicate the commit dates: Jan 30, 2024; Jan 25, 2024; Jan 23, 2024; Jan 20, 2024; and Nov 2, 2023.

feat: update vertex edm to 4d quantities (#61) ...
3 people committed 4 days ago · ✓ 3 / 3

Commits on Jan 30, 2024

create TrackSeed structure to store the seed info (#69) ...
ShujieL and wdconinc committed last week · ✓ 3 / 3

Commits on Jan 25, 2024

bring measurements back to trajectory (#60) ...
ShujieL and wdconinc committed 2 weeks ago · ✓ 3 / 3

Commits on Jan 23, 2024

fix: Cov6f operator(i,j) must be const (#67) ...
wdconinc committed 2 weeks ago · ✓ 3 / 3

Commits on Jan 20, 2024

fix: only compile edm4eic_merge for podio < 0.17.4 (#64) ...
wdconinc committed 2 weeks ago · ✓ 3 / 3

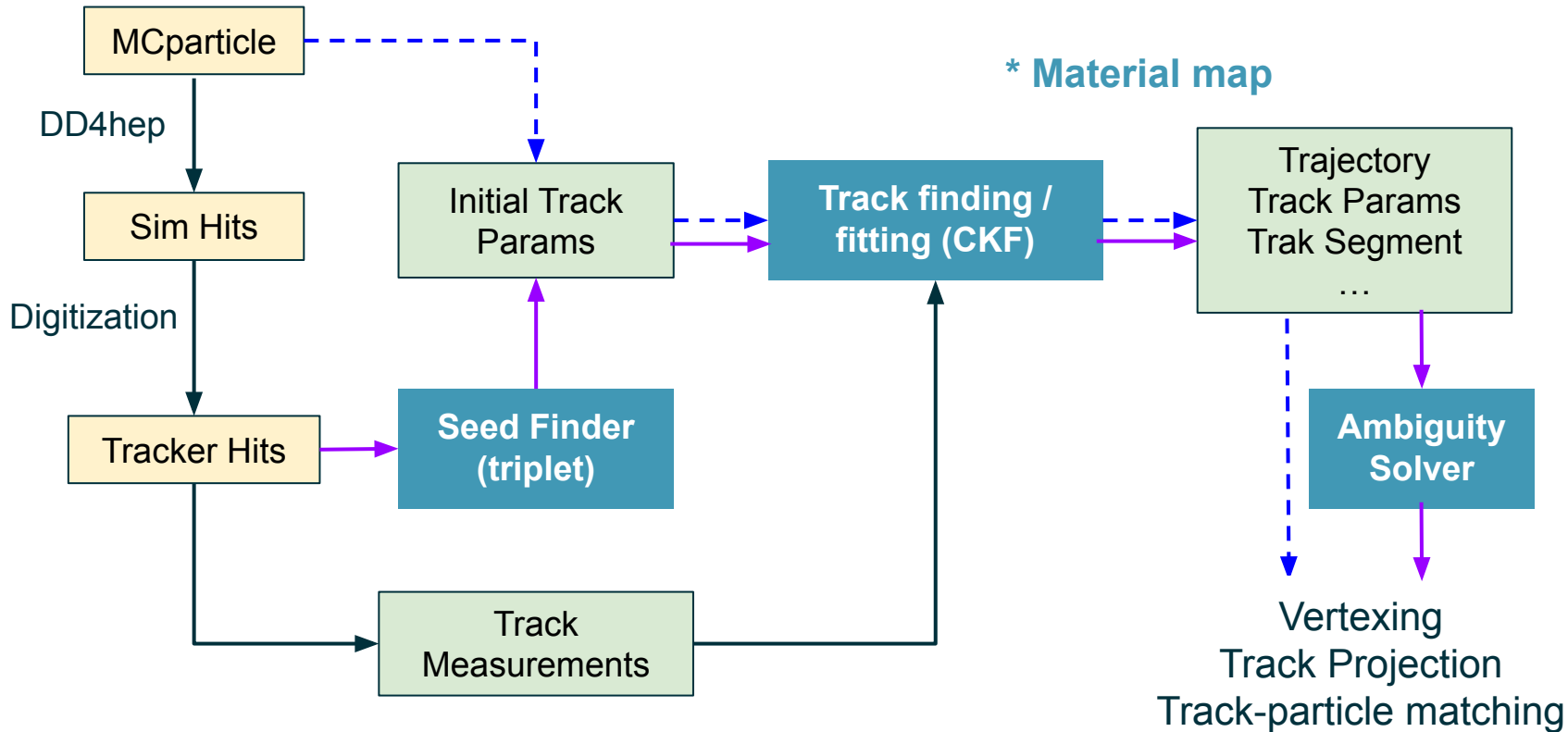
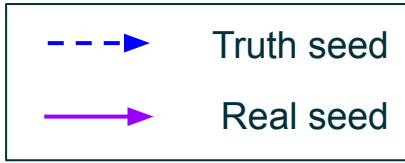
fix: next version will be 5.0.0 (#66) ...
wdconinc committed 2 weeks ago · ✓ 3 / 3

Commits on Nov 2, 2023

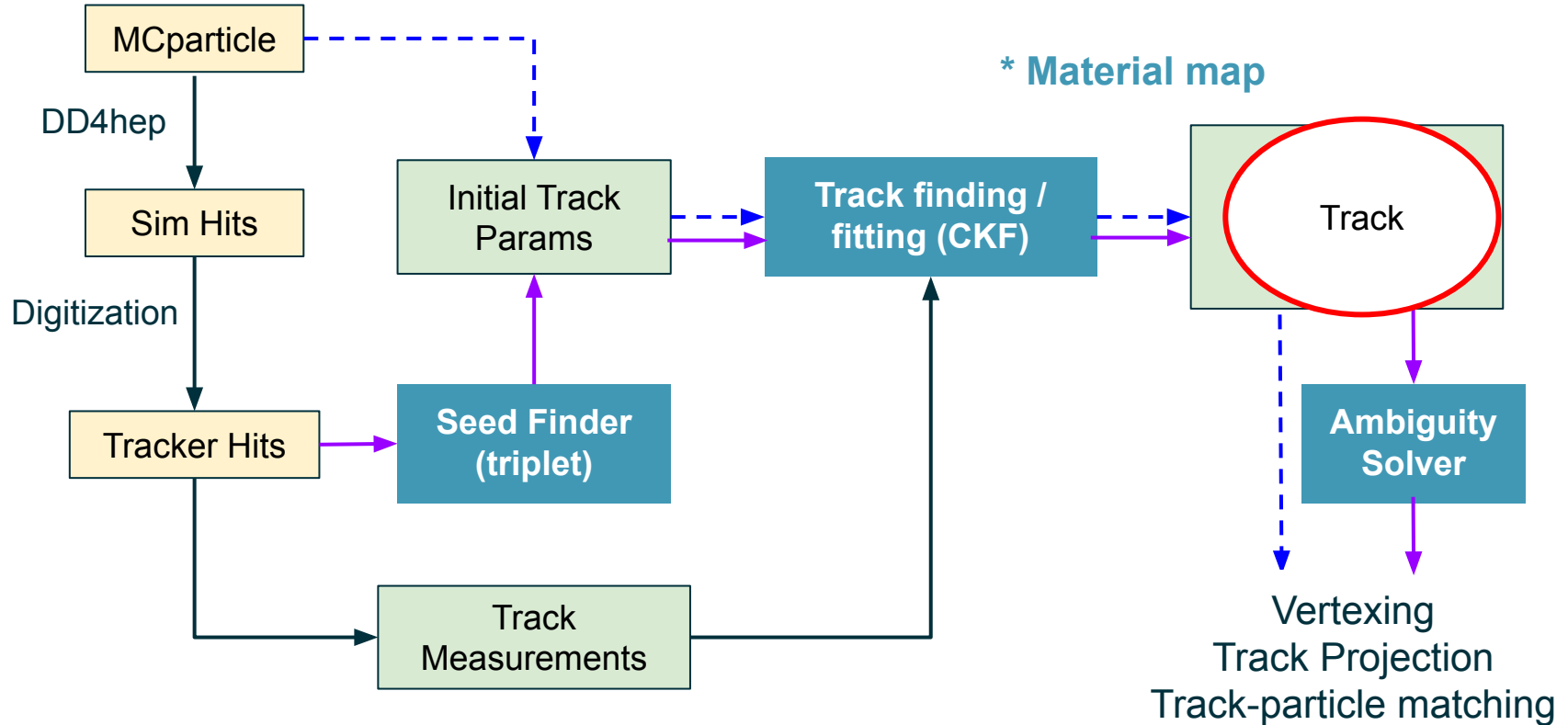
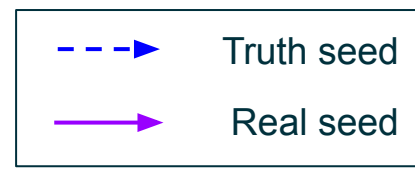
Update track fit EDM (#58) ...
osbornrd committed 4 months ago · ✓ 3 / 3

- v4.0.0 (Nov 2023):
 - measurement2D to allow trajectory to hits association
- v5.0.0 (Feb 2024)
 - Track, TrackSeed, Vertex
- Pending:
 - Sim hits to TrackerHit association?

Track Reconstruction Workflow



Track Reconstruction Workflow



“Track” should be the single output of CKF.

Need workforce across different WG to coordinate this change

edm4eic::Track:

Description: "Track information at the vertex"

Author: "S. Joosten, J. Osborn"

Members:

```
- int32_t           type           // Flag that defines the type of track
- edm4hep::Vector3f position      // Track 3-position at the vertex
- edm4hep::Vector3f momentum     // Track 3-momentum at the vertex [GeV]
- edm4eic::Cov6f   positionMomentumCovariance // Covariance matrix in basis [x,y,z,px,py,pz]
- float           time           // Track time at the vertex [ns]
- float           timeError      // Error on the track vertex time
- float           charge         // Particle charge
- float           chi2           // Total chi2
- uint32_t        ndf            // Number of degrees of freedom
- int32_t         pdg            // PDG particle ID hypothesis
```

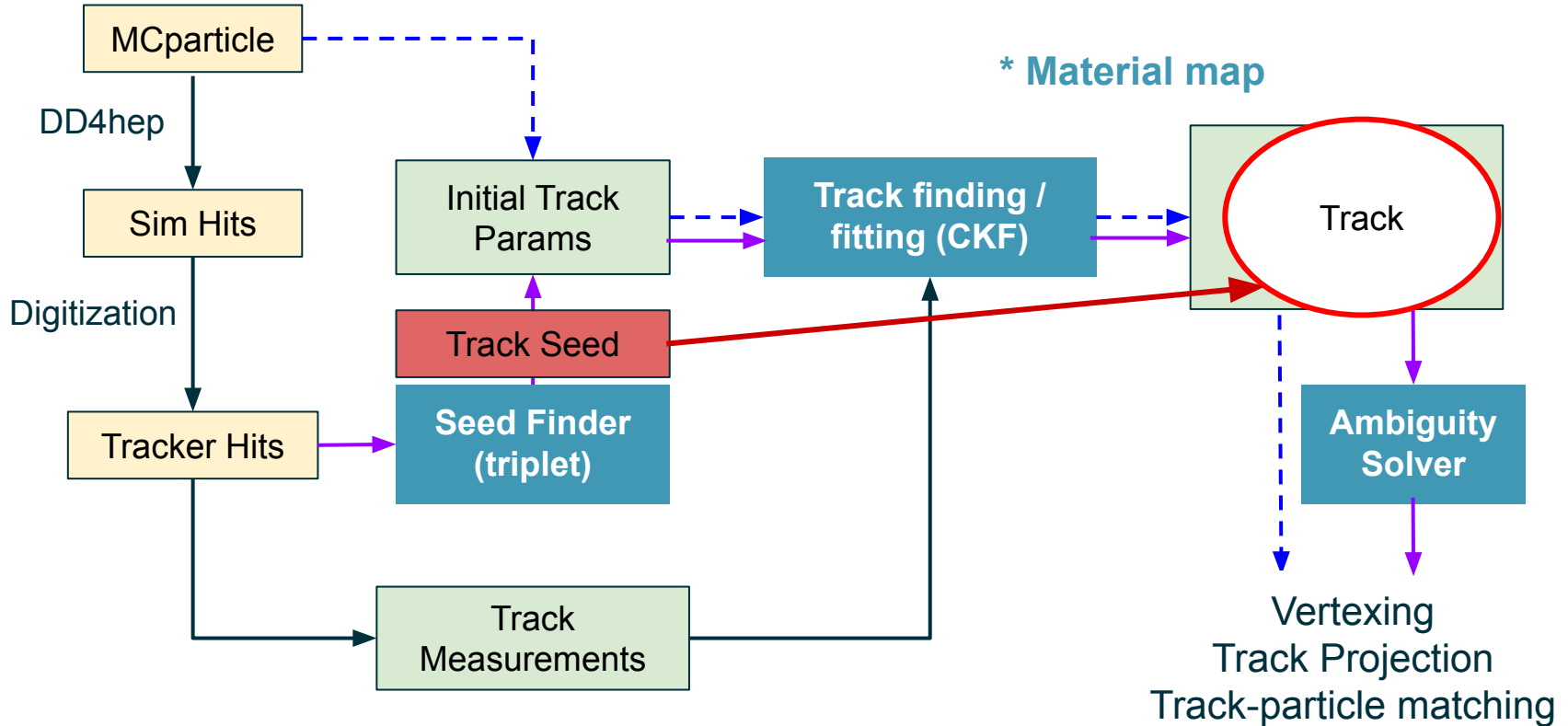
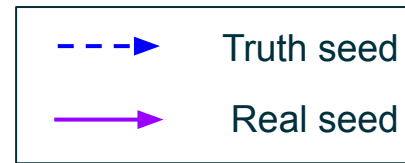
OneToOneRelations:

```
- edm4eic::Trajectory trajectory // Trajectory of this track
```

OneToManyRelations:

```
- edm4eic::Measurement2D measurements // Measurements that were used for this track
- edm4eic::Track         tracks       // Tracks (segments) that have been combined to create this track
```

Track Reconstruction Workflow



“TrackSeed” allows inspection of seed finder algorithm to understand e.g. trajectories with less than 3 measurements.

Also, a reference to seed is added to trajectory

```
edm4eic::TrackSeed:
  Description: "Seed info from the realistic seed finder"
  Author: "S. Li, B. Schmookler, J. Osborn"
  Members:
    - edm4hep::Vector3f      perigee    // Vector for the perigee (line surface)
  OneToManyRelations:
    - edm4eic::TrackerHit    hits      // Tracker hits triplet for seeding
  OneToOneRelations:
    - edm4eic::TrackParameters  params  // Initial track parameters
```

Vertex EDM Status

```
Description: "EIC vertex"
Author: "J. Osborn"
Members:
- int32_t      type          // Type flag, to identify what type of vertex it is (e.g
- float       chi2          // Chi-squared of the vertex fit
- int         ndf           // NDF of the vertex fit
- edm4hep::Vector4f position // position [mm] + time t0 [ns] of the vertex. Time is 4
## this is named "covMatrix" in EDM4hep, renamed for consistency with the rest of edm4eic
- edm4eic::Cov4f positionError // Covariance matrix of the position+time. Time is 4th c
OneToManyRelations:
- edm4eic::ReconstructedParticle associatedParticles // particles associated to this vertex.
```

- edm4eic::Vertex recently updated as of edm4eic v5.0.0
 - edm4eic [PR](#)
- IterativeVertexFinder in EICrecon updated to accommodate changes
 - EICrecon [PR](#)
- Outstanding issues, dependent on other data model issues
 - Vertex points to ReconstructedParticles - suitable for now but not really for the long term
 - Vertexing will run right after tracking, so this should really point to edm4eic::Tracks
 - Opens additional issue that truth vertices will not be able to be stored in this object upon making that change

Question: link TrackerHits to MCparticles

```
#----- 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
- float pathLength //path length of the particle in the
- int32_t quality //quality bit flag.
- edm4hep::Vector3d position //the hit position in [mm].
- edm4hep::Vector3f momentum //the 3-momentum of the particle at

```
OneToOneRelations:
```

- edm4hep::MCParticle MCParticle //MCParticle that caused the hit.

DD4hep

ElCrecon

```
edm4eic::TrackerHit:
```

```
Description: "Tracker hit (reconstructed from Raw
```

```
Author: "W. Armstrong, S. Joosten"
```

```
Members:
```

- uint64_t cellID // The de
- edm4hep::Vector3f position // Hit (c
- edm4eic::CovDiag3f positionError // Covari
- float time // Hit ti
- float timeError // Error
- float edep // Energy
- float edepError // Error

```
edm4eic::MCRecoTrackerHitAssociation:
```

```
Description: "Association between a RawTrackerHit and a SimTrackerHit"
```

```
Author: "C. Dilks, W. Deconinck"
```

```
Members:
```

- float weight // weight of this association

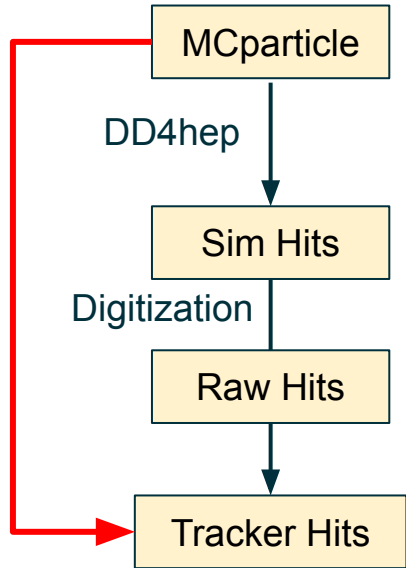
```
OneToOneRelations:
```

- edm4eic::RawTrackerHit rawHit // reference to the digitized hit

```
OneToManyRelations:
```

- edm4hep::SimTrackerHit simHits // reference to the simulated hits

Question: link tracker hits to MCparticles



What we have:

Sim hits \rightarrow MCparticle

Sim hits \longleftrightarrow Raw Hits

Options:

1. TrackerHit \rightarrow MCparticle:

- direct reference is not feasible b/c it makes recon object depend on simulation

2. Provide an analysis script or ask the user to trace from TrackerHit \rightarrow RawHit \rightarrow SimHits \rightarrow MCparticle offline:

- It's too complicated and requires processing EICrecon output locally
- The script will not be maintained within EICrecon

3. Add an EICrecon factory (plugin) to produce TrackerHit \longleftrightarrow MCparticle association

- Requires dedicated data structure which can be redundant
- People may use the output blindly without knowing the process