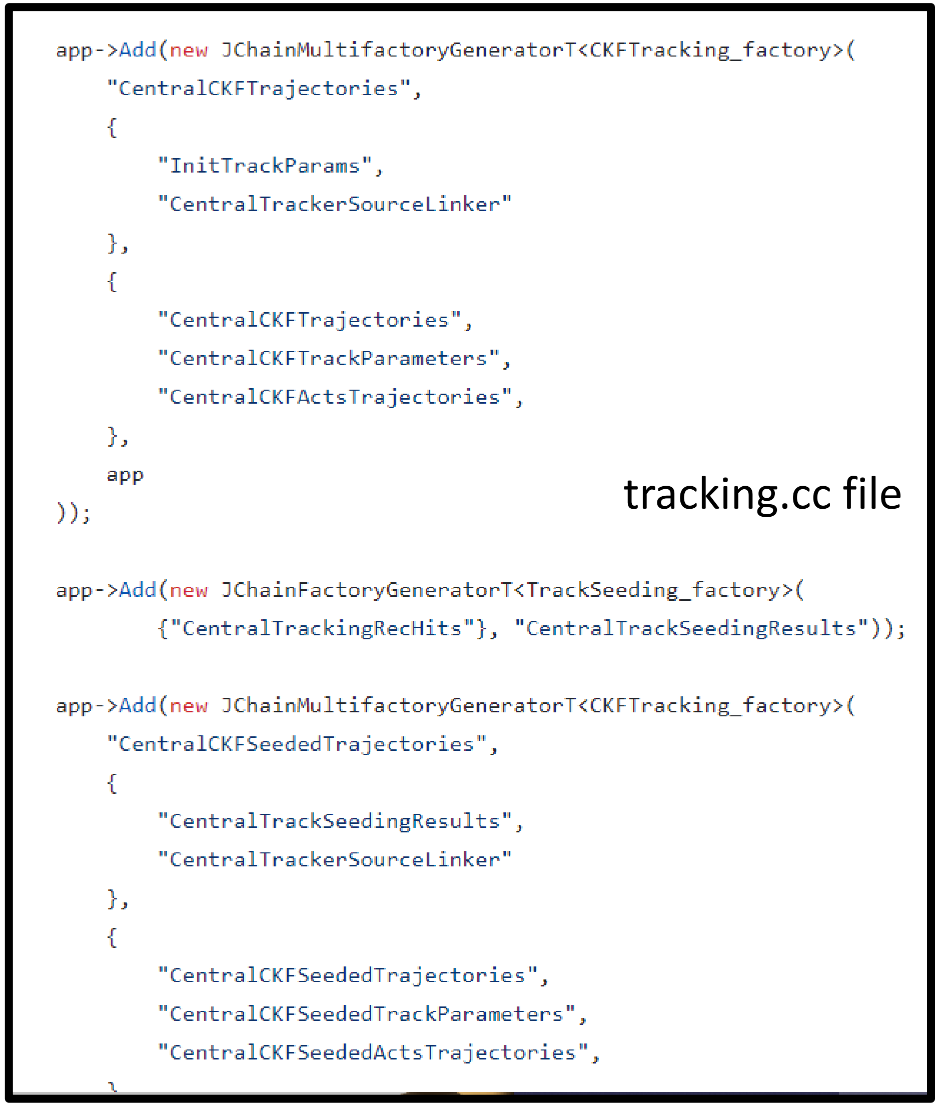
Updates to EICRecon output

Barak Schmookler

(much of the work done by Wouter and Minjung)

Recent updates to EICRecon

- ➢PRs #859, #860, #872 have been merged into the main repository.
- ➢These PRs update the tracking-related factories to mostly pass podio collections as input/output.
- ➢They also move some code from the factories to the algorithms.
- ➢Lastly, edm4eic::Trajectory and edm4eic::TrackParameters data types are added to the output.

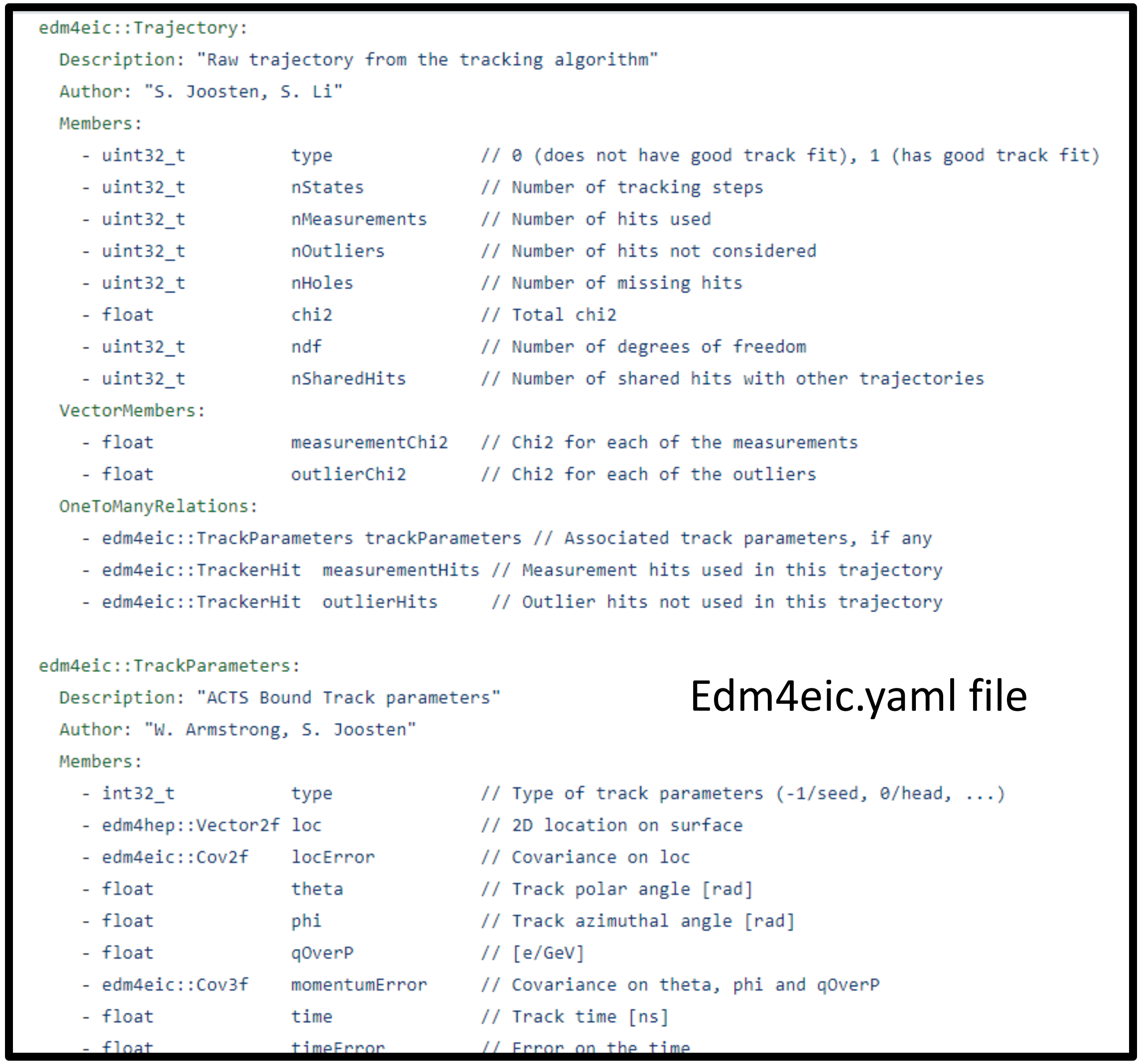


```
app->Add(new JChainMultifactoryGeneratorT<CKFTracking_factory>(
    "CentralCKFTrajectories",
    {
        "InitTrackParams",
        "CentralTrackerSourceLinker"
    },
    {
        "CentralCKFTrajectories",
        "CentralCKFTrackParameters",
        "CentralCKFActsTrajectories",
    },
    app
));

app->Add(new JChainFactoryGeneratorT<TrackSeeding_factory>(
        {"CentralTrackingRecHits"}, "CentralTrackSeedingResults"));

app->Add(new JChainMultifactoryGeneratorT<CKFTracking_factory>(
    "CentralCKFSeededTrajectories",
    {
        "CentralTrackSeedingResults",
        "CentralTrackerSourceLinker"
    },
    {
        "CentralCKFSeededTrajectories",
        "CentralCKFSeededTrackParameters",
        "CentralCKFSeededActsTrajectories",
    }
```

tracking.cc file

Recent updates to EICRecon

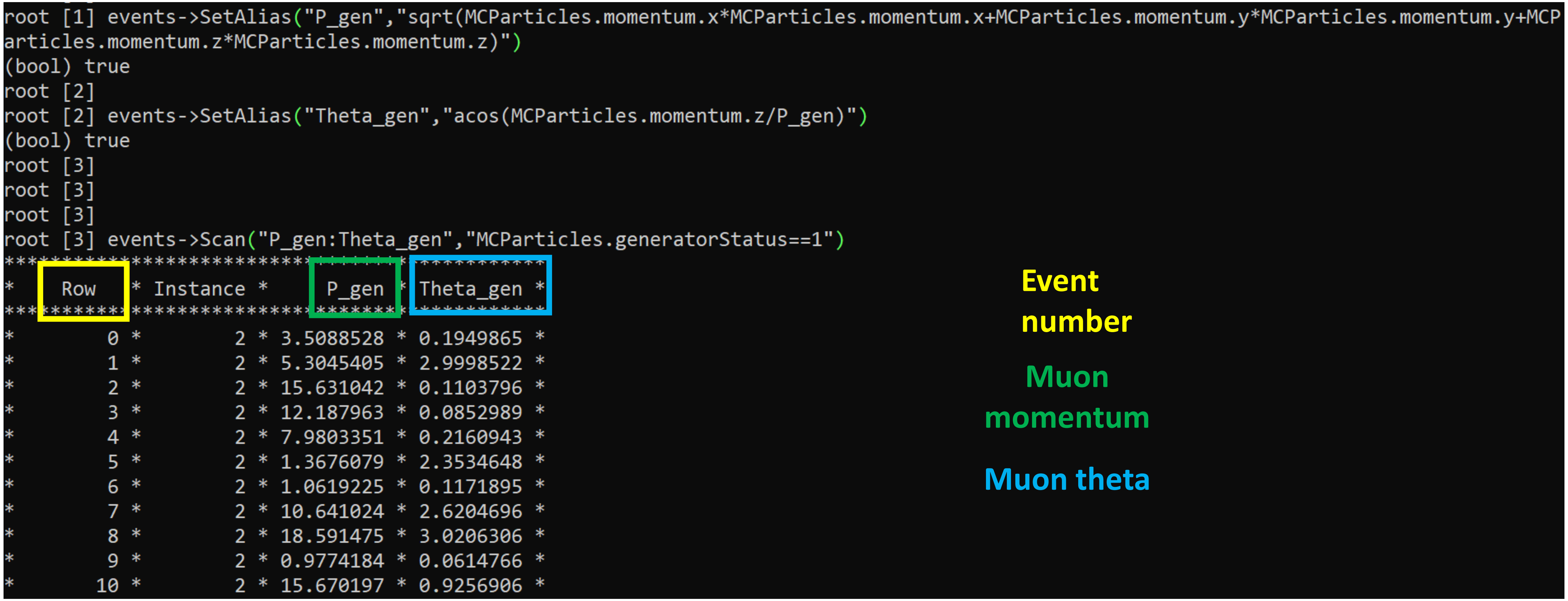
- ➢PRs #859, #860, #872 have been merged into the main repository.
- ➢These PRs update the tracking-related factories to mostly pass podio collections as input/output.
- ➢They also move some code from the factories to the algorithms.
- ➢Lastly, edm4eic::Trajectory and edm4eic::TrackParameters data types are added to the output.



```
edm4eic::Trajectory:
  Description: "Raw trajectory from the tracking algorithm"
  Author: "S. Joosten, S. Li"
  Members:
    - uint32_t          type              // 0 (does not have good track fit), 1 (has good track fit)
    - uint32_t          nStates           // Number of tracking steps
    - uint32_t          nMeasurements     // Number of hits used
    - uint32_t          nOutliers         // Number of hits not considered
    - uint32_t          nHoles            // Number of missing hits
    - float             chi2              // Total chi2
    - uint32_t          ndf               // Number of degrees of freedom
    - uint32_t          nSharedHits       // Number of shared hits with other trajectories
  VectorMembers:
    - float             measurementChi2   // Chi2 for each of the measurements
    - float             outlierChi2       // Chi2 for each of the outliers
  OneToManyRelations:
    - edm4eic::TrackParameters trackParameters // Associated track parameters, if any
    - edm4eic::TrackerHit  measurementHits // Measurement hits used in this trajectory
    - edm4eic::TrackerHit  outlierHits     // Outlier hits not used in this trajectory

edm4eic::TrackParameters:
  Description: "ACTS Bound Track parameters"
  Author: "W. Armstrong, S. Joosten"
  Members:
    - int32_t           type              // Type of track parameters (-1/seed, 0/head, ...)
    - edm4hep::Vector2f loc               // 2D location on surface
    - edm4eic::Cov2f    locError          // Covariance on loc
    - float             theta             // Track polar angle [rad]
    - float             phi               // Track azimuthal angle [rad]
    - float             qOverP            // [e/GeV]
    - edm4eic::Cov3f    momentumError     // Covariance on theta, phi and qOverP
    - float             time              // Track time [ns]
    - float             timeError         // Error on the time
```

Edm4eic.yaml file

Looking at the results with single muons



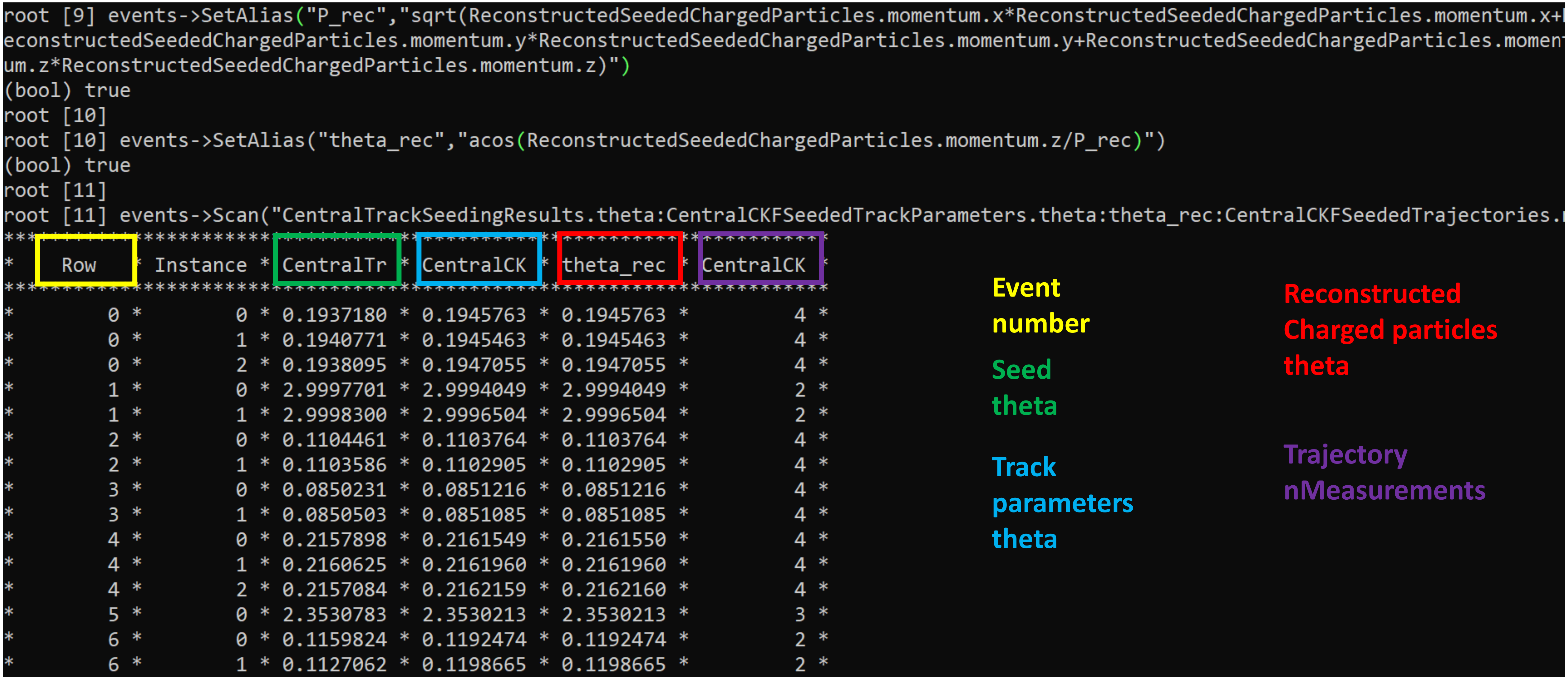
```
root [1] events->SetAlias("P_gen","sqrt(MCParticles.momentum.x*MCParticles.momentum.x+MCParticles.momentum.y*MCParticles.momentum.y+MCP
articles.momentum.z*MCParticles.momentum.z)")
(bool) true
root [2]
root [2] events->SetAlias("Theta_gen","acos(MCParticles.momentum.z/P_gen)")
(bool) true
root [3]
root [3]
root [3]
root [3] events->Scan("P_gen:Theta_gen","MCParticles.generatorStatus==1")
***********************************************
*    Row   * Instance *     P_gen * Theta_gen *
***********************************************
*        0 *        2 * 3.5088528 * 0.1949865 *
*        1 *        2 * 5.3045405 * 2.9998522 *
*        2 *        2 * 15.631042 * 0.1103796 *
*        3 *        2 * 12.187963 * 0.0852989 *
*        4 *        2 * 7.9803351 * 0.2160943 *
*        5 *        2 * 1.3676079 * 2.3534648 *
*        6 *        2 * 1.0619225 * 0.1171895 *
*        7 *        2 * 10.641024 * 2.6204696 *
*        8 *        2 * 18.591475 * 3.0206306 *
*        9 *        2 * 0.9774184 * 0.0614766 *
*       10 *        2 * 15.670197 * 0.9256906 *
```

Event number

Muon momentum

Muon theta

Looking at the results with single muons



```
root [9] events->SetAlias("P_rec","sqrt(ReconstructedSeededChargedParticles.momentum.x*ReconstructedSeededChargedParticles.momentum.x+R
econstructedSeededChargedParticles.momentum.y*ReconstructedSeededChargedParticles.momentum.y+ReconstructedSeededChargedParticles.moment
um.z*ReconstructedSeededChargedParticles.momentum.z)")
(bool) true
root [10]
root [10] events->SetAlias("theta_rec","acos(ReconstructedSeededChargedParticles.momentum.z/P_rec)")
(bool) true
root [11]
root [11] events->Scan("CentralTrackSeedingResults.theta:CentralCKFSeededTrackParameters.theta:theta_rec:CentralCKFSeededTrajectories.
*************************************************************************
*    Row   * Instance * CentralTr * CentralCK * theta_rec * CentralCK *
*************************************************************************
*        0 *        0 * 0.1937180 * 0.1945763 * 0.1945763 *         4 *
*        0 *        1 * 0.1940771 * 0.1945463 * 0.1945463 *         4 *
*        0 *        2 * 0.1938095 * 0.1947055 * 0.1947055 *         4 *
*        1 *        0 * 2.9997701 * 2.9994049 * 2.9994049 *         2 *
*        1 *        1 * 2.9998300 * 2.9996504 * 2.9996504 *         2 *
*        2 *        0 * 0.1104461 * 0.1103764 * 0.1103764 *         4 *
*        2 *        1 * 0.1103586 * 0.1102905 * 0.1102905 *         4 *
*        3 *        0 * 0.0850231 * 0.0851216 * 0.0851216 *         4 *
*        3 *        1 * 0.0850503 * 0.0851085 * 0.0851085 *         4 *
*        4 *        0 * 0.2157898 * 0.2161549 * 0.2161550 *         4 *
*        4 *        1 * 0.2160625 * 0.2161960 * 0.2161960 *         4 *
*        4 *        2 * 0.2157084 * 0.2162159 * 0.2162160 *         4 *
*        5 *        0 * 2.3530783 * 2.3530213 * 2.3530213 *         3 *
*        6 *        0 * 0.1159824 * 0.1192474 * 0.1192474 *         2 *
*        6 *        1 * 0.1127062 * 0.1198665 * 0.1198665 *         2 *
```

Event number

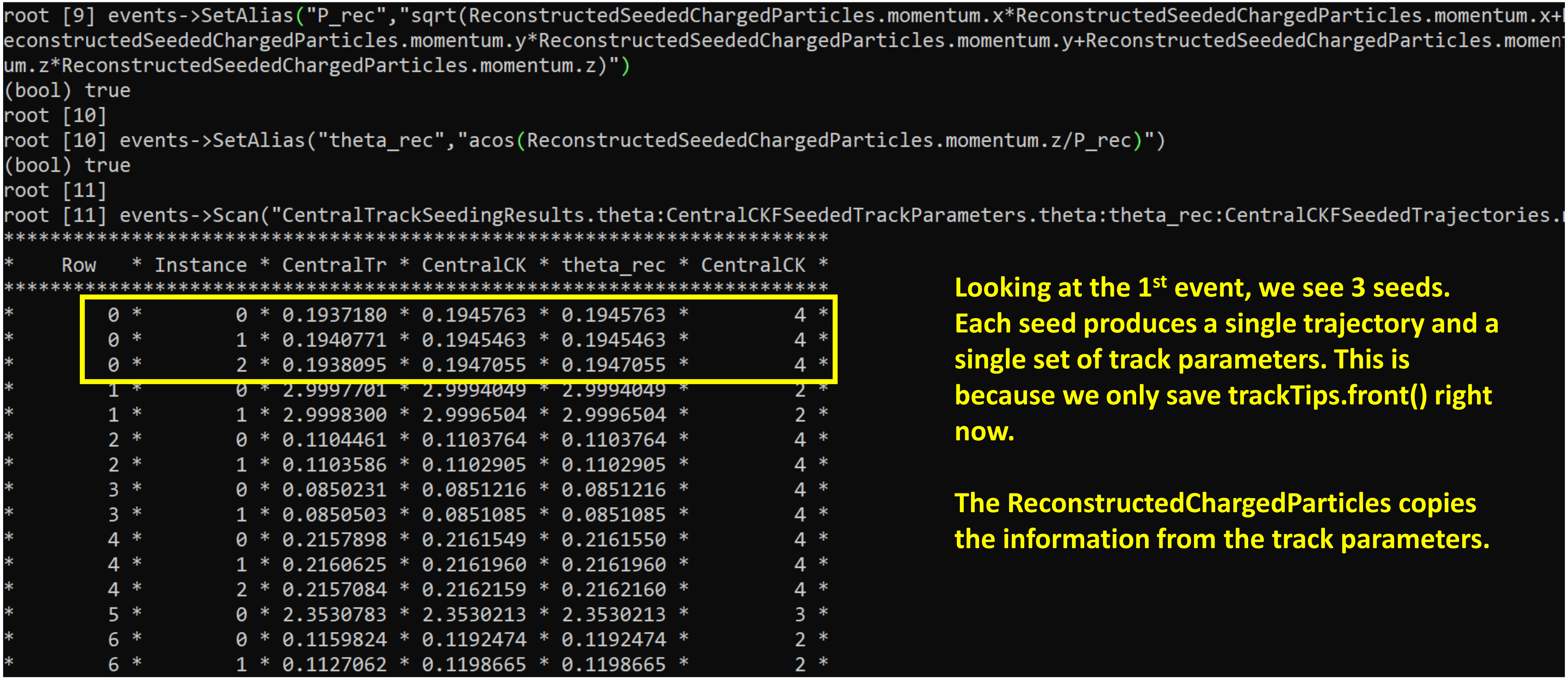
Seed theta

Track parameters theta

Reconstructed Charged particles theta

Trajectory nMeasurements

Looking at the results with single muons

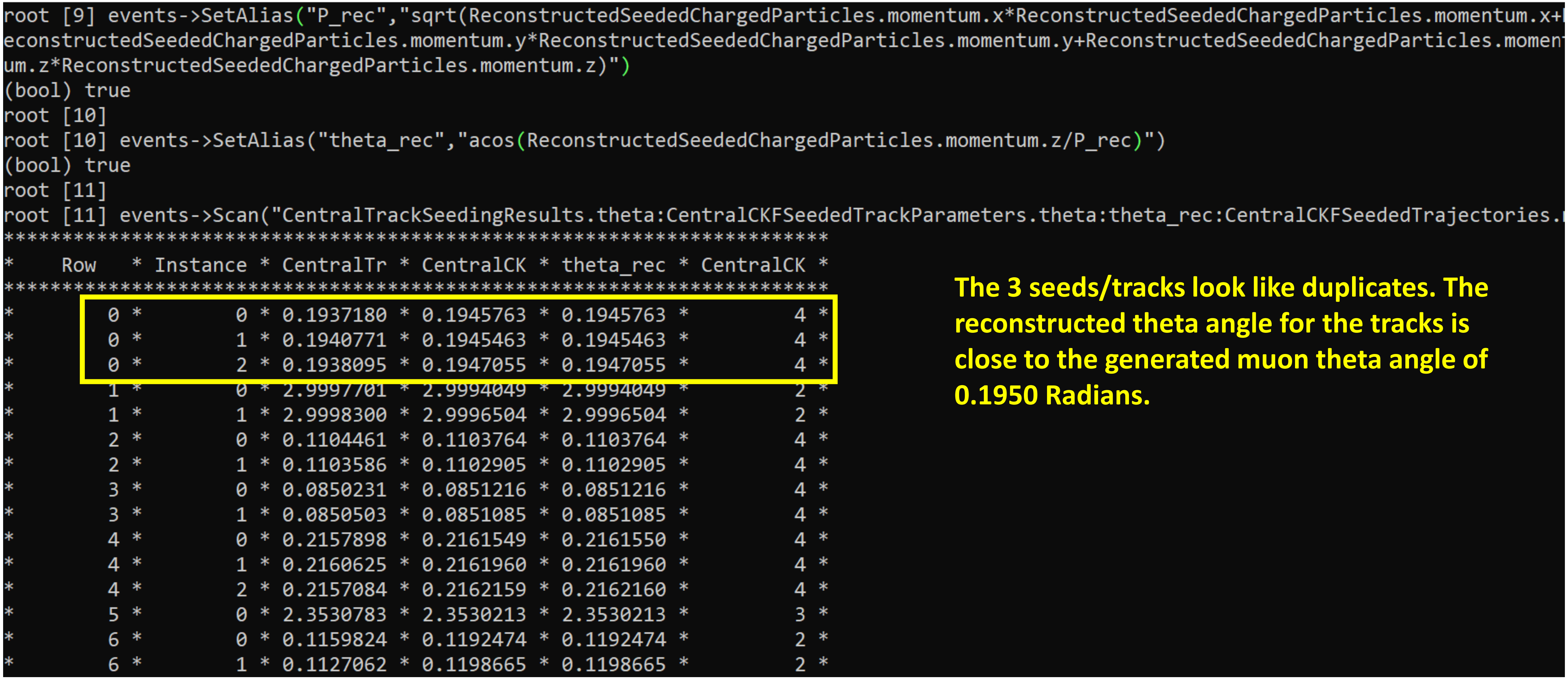


```
root [9] events->SetAlias("P_rec","sqrt(ReconstructedSeededChargedParticles.momentum.x*ReconstructedSeededChargedParticles.momentum.x+
econstructedSeededChargedParticles.momentum.y*ReconstructedSeededChargedParticles.momentum.y+ReconstructedSeededChargedParticles.momen
um.z*ReconstructedSeededChargedParticles.momentum.z)")
(bool) true
root [10]
root [10] events->SetAlias("theta_rec","acos(ReconstructedSeededChargedParticles.momentum.z/P_rec)")
(bool) true
root [11]
root [11] events->Scan("CentralTrackSeedingResults.theta:CentralCKFSeededTrackParameters.theta:theta_rec:CentralCKFSeededTrajectories.
***********************************************************************
*    Row   * Instance * CentralTr * CentralCK * theta_rec * CentralCK *
***********************************************************************
*        0 *        0 * 0.1937180 * 0.1945763 * 0.1945763 *         4 *
*        0 *        1 * 0.1940771 * 0.1945463 * 0.1945463 *         4 *
*        0 *        2 * 0.1938095 * 0.1947055 * 0.1947055 *         4 *
*        1 *        0 * 2.9997701 * 2.9994049 * 2.9994049 *         2 *
*        1 *        1 * 2.9998300 * 2.9996504 * 2.9996504 *         2 *
*        2 *        0 * 0.1104461 * 0.1103764 * 0.1103764 *         4 *
*        2 *        1 * 0.1103586 * 0.1102905 * 0.1102905 *         4 *
*        3 *        0 * 0.0850231 * 0.0851216 * 0.0851216 *         4 *
*        3 *        1 * 0.0850503 * 0.0851085 * 0.0851085 *         4 *
*        4 *        0 * 0.2157898 * 0.2161549 * 0.2161550 *         4 *
*        4 *        1 * 0.2160625 * 0.2161960 * 0.2161960 *         4 *
*        4 *        2 * 0.2157084 * 0.2162159 * 0.2162160 *         4 *
*        5 *        0 * 2.3530783 * 2.3530213 * 2.3530213 *         3 *
*        6 *        0 * 0.1159824 * 0.1192474 * 0.1192474 *         2 *
*        6 *        1 * 0.1127062 * 0.1198665 * 0.1198665 *         2 *
```

Looking at the 1st event, we see 3 seeds. Each seed produces a single trajectory and a single set of track parameters. This is because we only save trackTips.front() right now.

The ReconstructedChargedParticles copies the information from the track parameters.

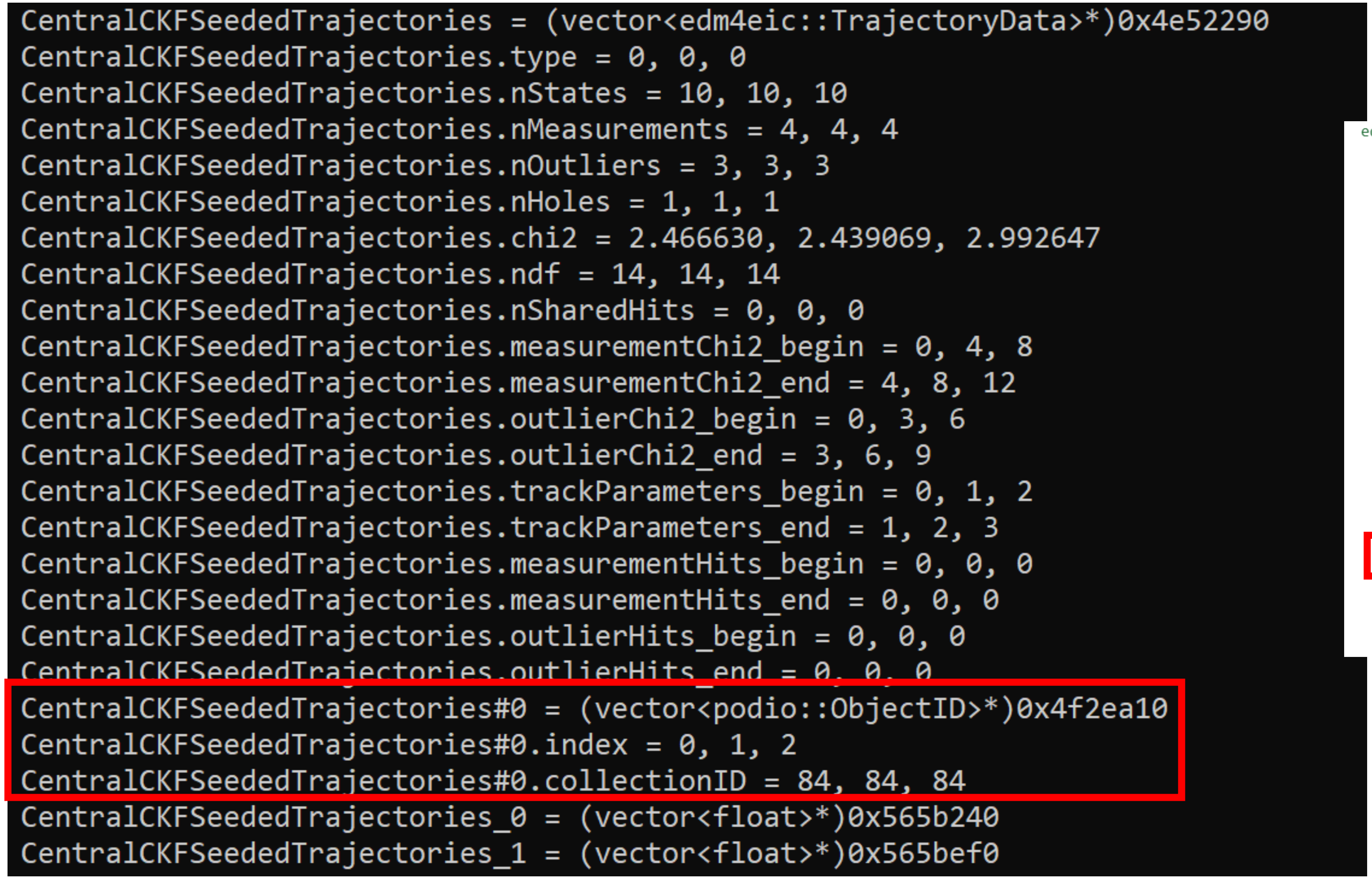
Looking at the results with single muons



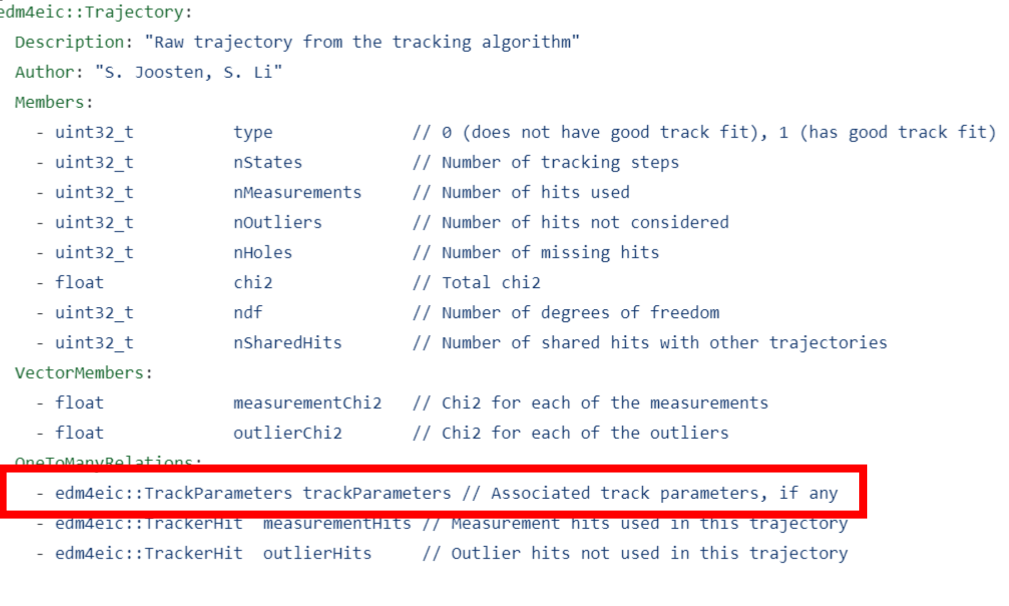
```
root [9] events->SetAlias("P_rec","sqrt(ReconstructedSeededChargedParticles.momentum.x*ReconstructedSeededChargedParticles.momentum.x+
econstructedSeededChargedParticles.momentum.y*ReconstructedSeededChargedParticles.momentum.y+ReconstructedSeededChargedParticles.momen
um.z*ReconstructedSeededChargedParticles.momentum.z)")
(bool) true
root [10]
root [10] events->SetAlias("theta_rec","acos(ReconstructedSeededChargedParticles.momentum.z/P_rec)")
(bool) true
root [11]
root [11] events->Scan("CentralTrackSeedingResults.theta:CentralCKFSeededTrackParameters.theta:theta_rec:CentralCKFSeededTrajectories.
***********************************************************************
*    Row   * Instance * CentralTr * CentralCK * theta_rec * CentralCK *
***********************************************************************
*        0 *        0 * 0.1937180 * 0.1945763 * 0.1945763 *         4 *
*        0 *        1 * 0.1940771 * 0.1945463 * 0.1945463 *         4 *
*        0 *        2 * 0.1938095 * 0.1947055 * 0.1947055 *         4 *
*        1 *        0 * 2.9997701 * 2.9994049 * 2.9994049 *         2 *
*        1 *        1 * 2.9998300 * 2.9996504 * 2.9996504 *         2 *
*        2 *        0 * 0.1104461 * 0.1103764 * 0.1103764 *         4 *
*        2 *        1 * 0.1103586 * 0.1102905 * 0.1102905 *         4 *
*        3 *        0 * 0.0850231 * 0.0851216 * 0.0851216 *         4 *
*        3 *        1 * 0.0850503 * 0.0851085 * 0.0851085 *         4 *
*        4 *        0 * 0.2157898 * 0.2161549 * 0.2161550 *         4 *
*        4 *        1 * 0.2160625 * 0.2161960 * 0.2161960 *         4 *
*        4 *        2 * 0.2157084 * 0.2162159 * 0.2162160 *         4 *
*        5 *        0 * 2.3530783 * 2.3530213 * 2.3530213 *         3 *
*        6 *        0 * 0.1159824 * 0.1192474 * 0.1192474 *         2 *
*        6 *        1 * 0.1127062 * 0.1198665 * 0.1198665 *         2 *
```

The 3 seeds/tracks look like duplicates. The reconstructed theta angle for the tracks is close to the generated muon theta angle of 0.1950 Radians.

Association between trajectories and track parameters



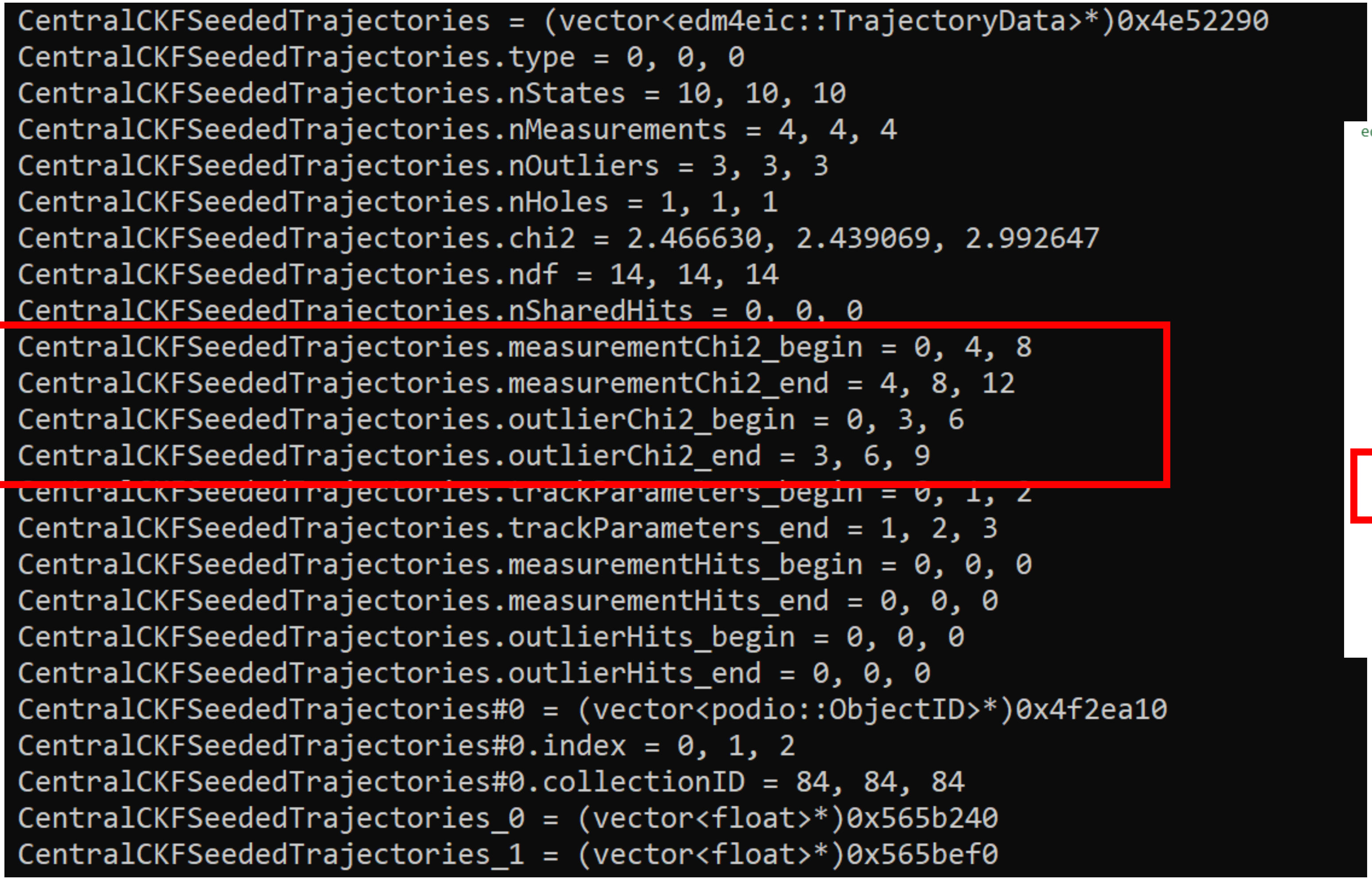
```
CentralCKFSeededTrajectories = (vector<edm4eic::TrajectoryData>*)0x4e52290
CentralCKFSeededTrajectories.type = 0, 0, 0
CentralCKFSeededTrajectories.nStates = 10, 10, 10
CentralCKFSeededTrajectories.nMeasurements = 4, 4, 4
CentralCKFSeededTrajectories.nOutliers = 3, 3, 3
CentralCKFSeededTrajectories.nHoles = 1, 1, 1
CentralCKFSeededTrajectories.chi2 = 2.466630, 2.439069, 2.992647
CentralCKFSeededTrajectories.ndf = 14, 14, 14
CentralCKFSeededTrajectories.nSharedHits = 0, 0, 0
CentralCKFSeededTrajectories.measurementChi2_begin = 0, 4, 8
CentralCKFSeededTrajectories.measurementChi2_end = 4, 8, 12
CentralCKFSeededTrajectories.outlierChi2_begin = 0, 3, 6
CentralCKFSeededTrajectories.outlierChi2_end = 3, 6, 9
CentralCKFSeededTrajectories.trackParameters_begin = 0, 1, 2
CentralCKFSeededTrajectories.trackParameters_end = 1, 2, 3
CentralCKFSeededTrajectories.measurementHits_begin = 0, 0, 0
CentralCKFSeededTrajectories.measurementHits_end = 0, 0, 0
CentralCKFSeededTrajectories.outlierHits_begin = 0, 0, 0
CentralCKFSeededTrajectories.outlierHits_end = 0, 0, 0
CentralCKFSeededTrajectories#0 = (vector<podio::ObjectID>*)0x4f2ea10
CentralCKFSeededTrajectories#0.index = 0, 1, 2
CentralCKFSeededTrajectories#0.collectionID = 84, 84, 84
CentralCKFSeededTrajectories_0 = (vector<float>*)0x565b240
CentralCKFSeededTrajectories_1 = (vector<float>*)0x565bef0
```



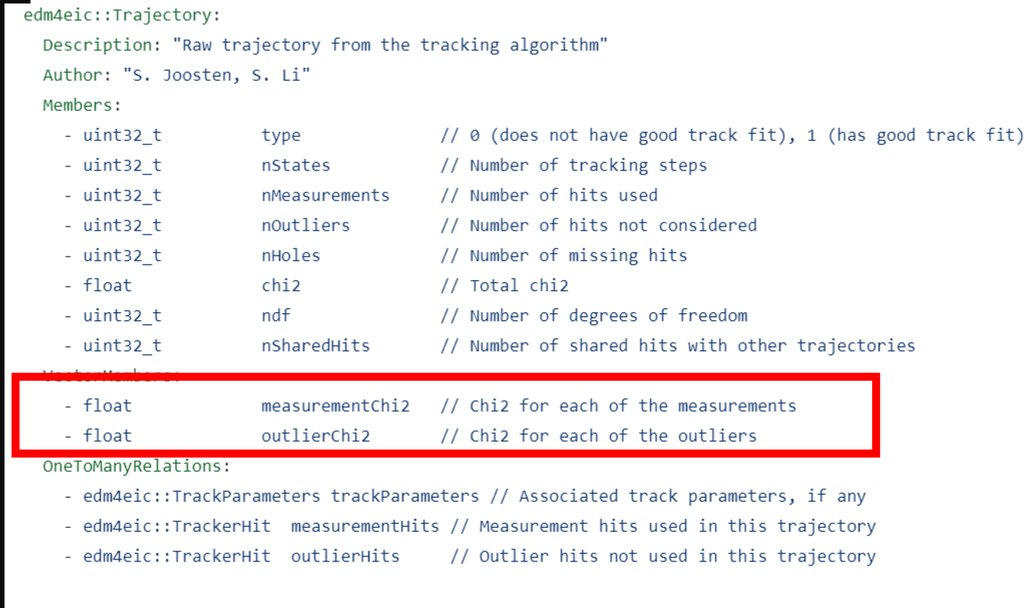
```
edm4eic::Trajectory:
  Description: "Raw trajectory from the tracking algorithm"
  Author: "S. Joosten, S. Li"
  Members:
    - uint32_t          type            // 0 (does not have good track fit), 1 (has good track fit)
    - uint32_t          nStates         // Number of tracking steps
    - uint32_t          nMeasurements   // Number of hits used
    - uint32_t          nOutliers       // Number of hits not considered
    - uint32_t          nHoles          // Number of missing hits
    - float             chi2            // Total chi2
    - uint32_t          ndf             // Number of degrees of freedom
    - uint32_t          nSharedHits     // Number of shared hits with other trajectories
  VectorMembers:
    - float             measurementChi2   // Chi2 for each of the measurements
    - float             outlierChi2       // Chi2 for each of the outliers
  OneToManyRelations:
    - edm4eic::TrackParameters trackParameters // Associated track parameters, if any
    - edm4eic::TrackerHit  measurementHits // Measurement hits used in this trajectory
    - edm4eic::TrackerHit  outlierHits     // Outlier hits not used in this trajectory
```

If we allow the (Multi)Trajectory to have multiple sets of track parameters, we can use this association to link the data types.

A couple issues



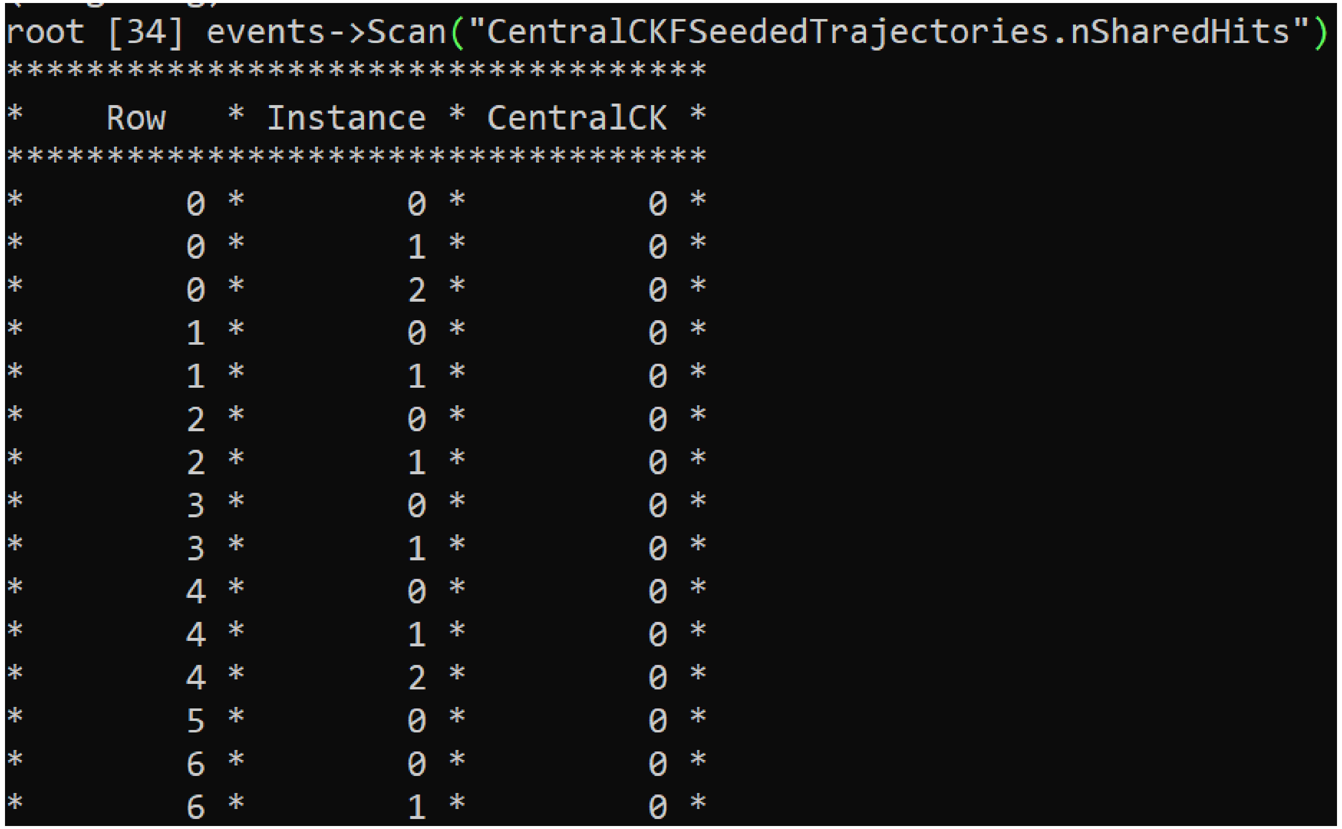
```
CentralCKFSeededTrajectories = (vector<edm4eic::TrajectoryData>*)0x4e52290
CentralCKFSeededTrajectories.type = 0, 0, 0
CentralCKFSeededTrajectories.nStates = 10, 10, 10
CentralCKFSeededTrajectories.nMeasurements = 4, 4, 4
CentralCKFSeededTrajectories.nOutliers = 3, 3, 3
CentralCKFSeededTrajectories.nHoles = 1, 1, 1
CentralCKFSeededTrajectories.chi2 = 2.466630, 2.439069, 2.992647
CentralCKFSeededTrajectories.ndf = 14, 14, 14
CentralCKFSeededTrajectories.nSharedHits = 0, 0, 0
CentralCKFSeededTrajectories.measurementChi2_begin = 0, 4, 8
CentralCKFSeededTrajectories.measurementChi2_end = 4, 8, 12
CentralCKFSeededTrajectories.outlierChi2_begin = 0, 3, 6
CentralCKFSeededTrajectories.outlierChi2_end = 3, 6, 9
CentralCKFSeededTrajectories.trackParameters_begin = 0, 1, 2
CentralCKFSeededTrajectories.trackParameters_end = 1, 2, 3
CentralCKFSeededTrajectories.measurementHits_begin = 0, 0, 0
CentralCKFSeededTrajectories.measurementHits_end = 0, 0, 0
CentralCKFSeededTrajectories.outlierHits_begin = 0, 0, 0
CentralCKFSeededTrajectories.outlierHits_end = 0, 0, 0
CentralCKFSeededTrajectories#0 = (vector<podio::ObjectID>*)0x4f2ea10
CentralCKFSeededTrajectories#0.index = 0, 1, 2
CentralCKFSeededTrajectories#0.collectionID = 84, 84, 84
CentralCKFSeededTrajectories_0 = (vector<float>*)0x565b240
CentralCKFSeededTrajectories_1 = (vector<float>*)0x565bef0
```



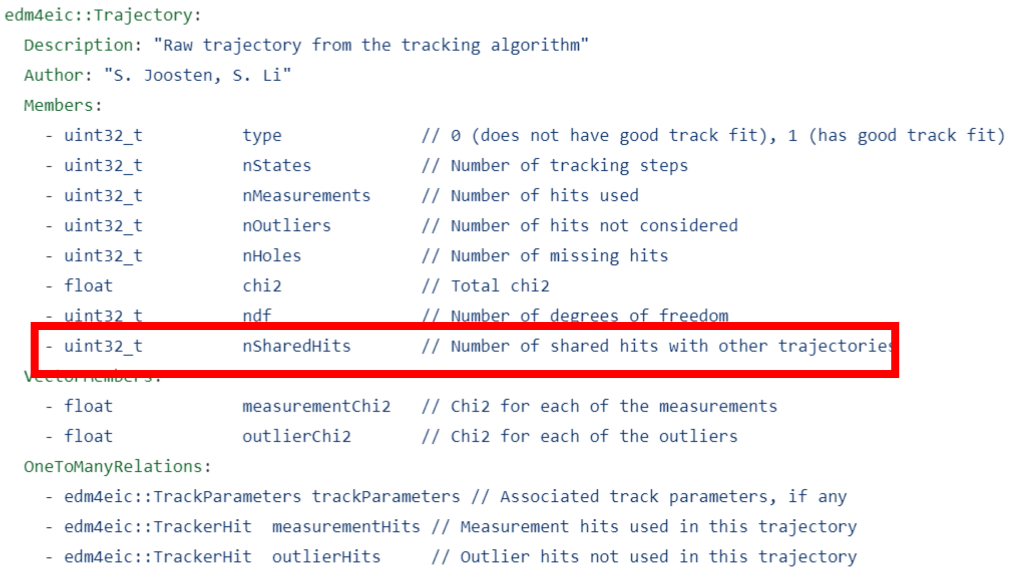
```
edm4eic::Trajectory:
  Description: "Raw trajectory from the tracking algorithm"
  Author: "S. Joosten, S. Li"
  Members:
    - uint32_t         type            // 0 (does not have good track fit), 1 (has good track fit)
    - uint32_t         nStates         // Number of tracking steps
    - uint32_t         nMeasurements   // Number of hits used
    - uint32_t         nOutliers       // Number of hits not considered
    - uint32_t         nHoles          // Number of missing hits
    - float            chi2            // Total chi2
    - uint32_t         ndf             // Number of degrees of freedom
    - uint32_t         nSharedHits     // Number of shared hits with other trajectories
  VectorMembers:
    - float            measurementChi2   // Chi2 for each of the measurements
    - float            outlierChi2       // Chi2 for each of the outliers
  OneToManyRelations:
    - edm4eic::TrackParameters trackParameters // Associated track parameters, if any
    - edm4eic::TrackerHit  measurementHits // Measurement hits used in this trajectory
    - edm4eic::TrackerHit  outlierHits     // Outlier hits not used in this trajectory
```

We have a list of indices for the individual hit chi-squares, but I can't find the values in the file.

A couple issues



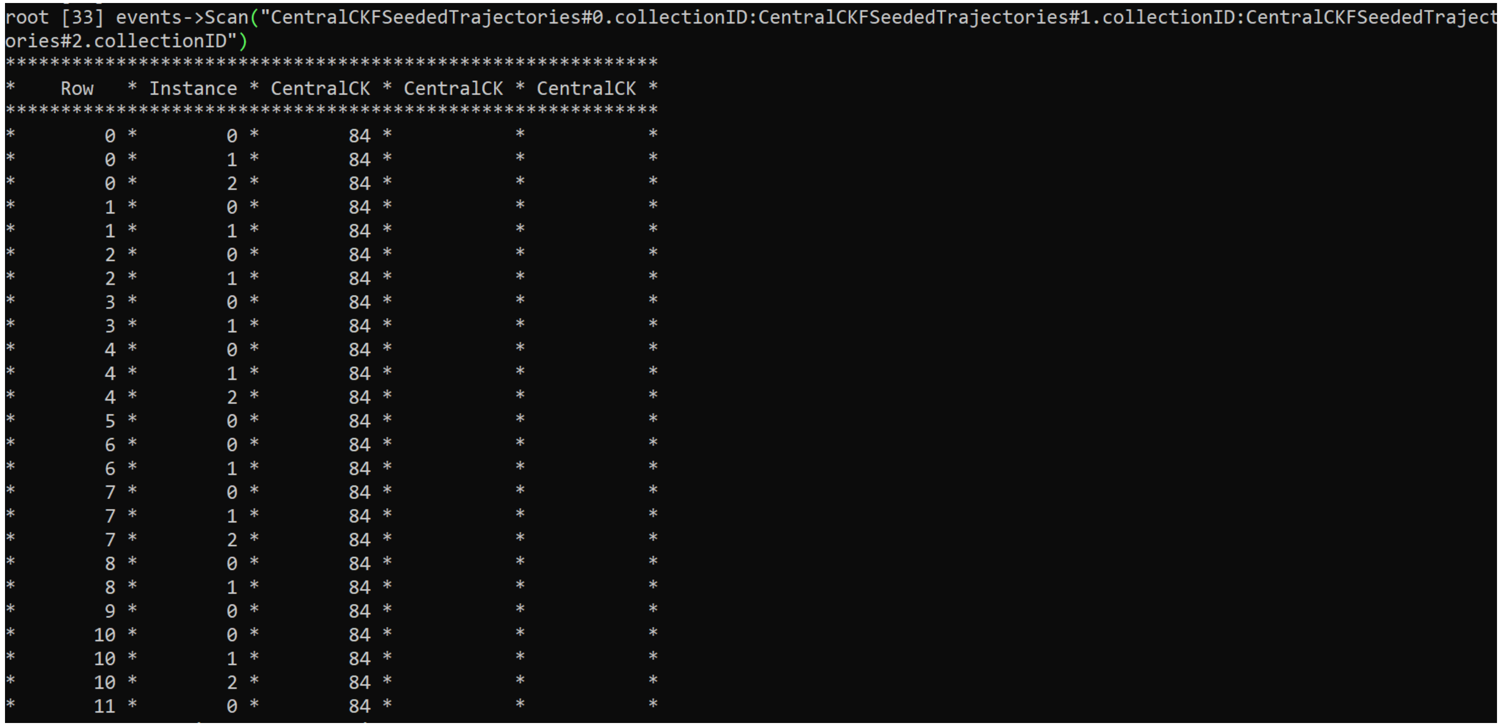
```
root [34] events->Scan("CentralCKFSeededTrajectories.nSharedHits")
***********************************
*    Row   * Instance * CentralCK *
***********************************
*        0 *        0 *         0 *
*        0 *        1 *         0 *
*        0 *        2 *         0 *
*        1 *        0 *         0 *
*        1 *        1 *         0 *
*        2 *        0 *         0 *
*        2 *        1 *         0 *
*        3 *        0 *         0 *
*        3 *        1 *         0 *
*        4 *        0 *         0 *
*        4 *        1 *         0 *
*        4 *        2 *         0 *
*        5 *        0 *         0 *
*        6 *        0 *         0 *
*        6 *        1 *         0 *
```



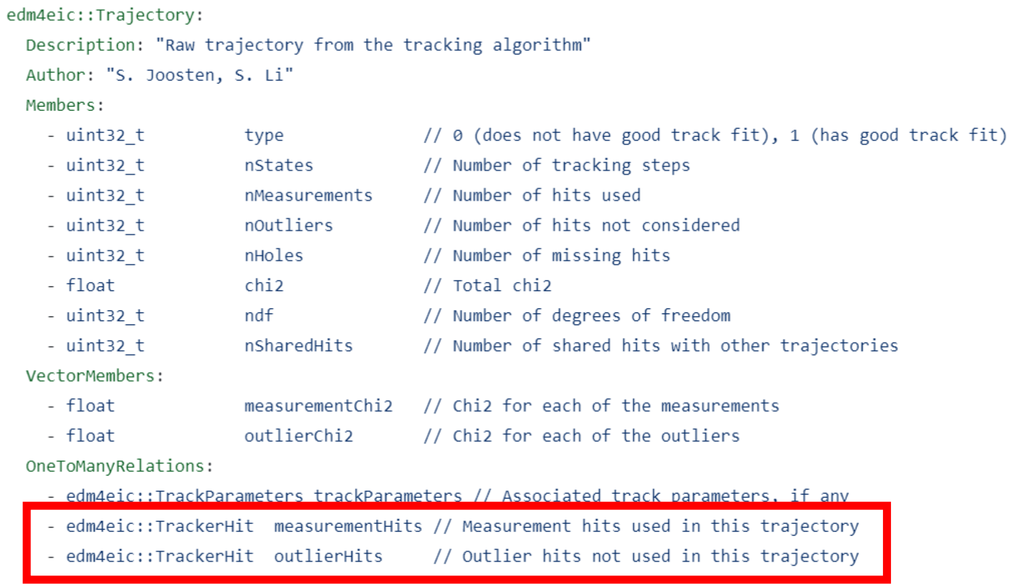
```
edm4eic::Trajectory:
  Description: "Raw trajectory from the tracking algorithm"
  Author: "S. Joosten, S. Li"
  Members:
    - uint32_t          type            // 0 (does not have good track fit), 1 (has good track fit)
    - uint32_t          nStates         // Number of tracking steps
    - uint32_t          nMeasurements   // Number of hits used
    - uint32_t          nOutliers       // Number of hits not considered
    - uint32_t          nHoles          // Number of missing hits
    - float             chi2            // Total chi2
    - uint32_t          ndf             // Number of degrees of freedom
    - uint32_t          nSharedHits     // Number of shared hits with other trajectorie
  VectorMembers:
    - float             measurementChi2  // Chi2 for each of the measurements
    - float             outlierChi2      // Chi2 for each of the outliers
  OneToManyRelations:
    - edm4eic::TrackParameters trackParameters // Associated track parameters, if any
    - edm4eic::TrackerHit  measurementHits // Measurement hits used in this trajectory
    - edm4eic::TrackerHit  outlierHits     // Outlier hits not used in this trajectory
```

The nSharedHits for all the trajectories seems to always be zero, even when we have the duplicated tracks.

A couple issues



```
root [33] events->Scan("CentralCKFSeededTrajectories#0.collectionID:CentralCKFSeededTrajectories#1.collectionID:CentralCKFSeededTraject
ories#2.collectionID")
************************************************************
*    Row   * Instance * CentralCK * CentralCK * CentralCK *
************************************************************
*        0 *        0 *        84 *           *           *
*        0 *        1 *        84 *           *           *
*        0 *        2 *        84 *           *           *
*        1 *        0 *        84 *           *           *
*        1 *        1 *        84 *           *           *
*        2 *        0 *        84 *           *           *
*        2 *        1 *        84 *           *           *
*        3 *        0 *        84 *           *           *
*        3 *        1 *        84 *           *           *
*        4 *        0 *        84 *           *           *
*        4 *        1 *        84 *           *           *
*        4 *        2 *        84 *           *           *
*        5 *        0 *        84 *           *           *
*        6 *        0 *        84 *           *           *
*        6 *        1 *        84 *           *           *
*        7 *        0 *        84 *           *           *
*        7 *        1 *        84 *           *           *
*        7 *        2 *        84 *           *           *
*        8 *        0 *        84 *           *           *
*        8 *        1 *        84 *           *           *
*        9 *        0 *        84 *           *           *
*       10 *        0 *        84 *           *           *
*       10 *        1 *        84 *           *           *
*       10 *        2 *        84 *           *           *
*       11 *        0 *        84 *           *           *
```

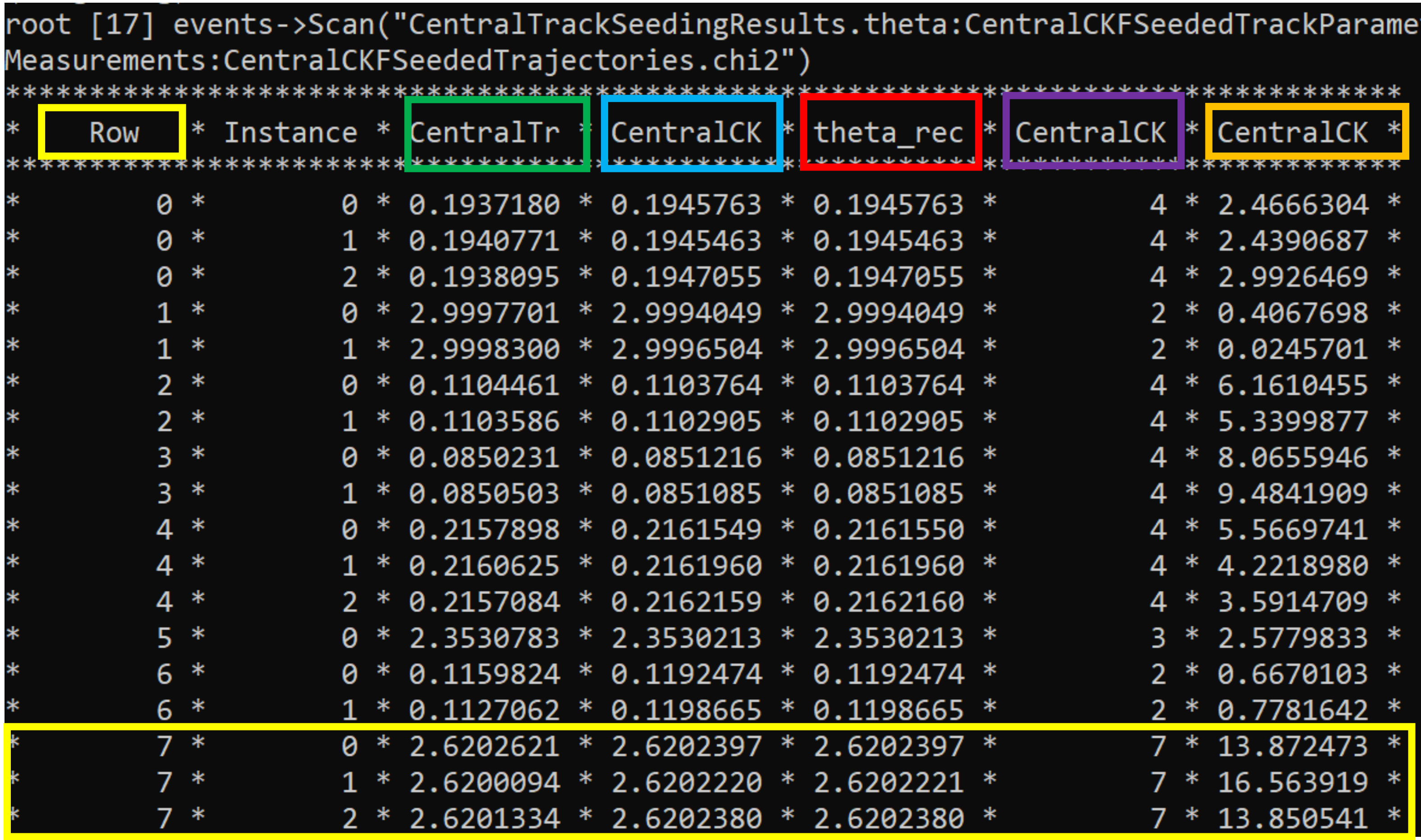


```
edm4eic::Trajectory:
  Description: "Raw trajectory from the tracking algorithm"
  Author: "S. Joosten, S. Li"
  Members:
    - uint32_t         type              // 0 (does not have good track fit), 1 (has good track fit)
    - uint32_t         nStates           // Number of tracking steps
    - uint32_t         nMeasurements     // Number of hits used
    - uint32_t         nOutliers         // Number of hits not considered
    - uint32_t         nHoles            // Number of missing hits
    - float            chi2              // Total chi2
    - uint32_t         ndf               // Number of degrees of freedom
    - uint32_t         nSharedHits       // Number of shared hits with other trajectories
  VectorMembers:
    - float            measurementChi2   // Chi2 for each of the measurements
    - float            outlierChi2       // Chi2 for each of the outliers
  OneToManyRelations:
    - edm4eic::TrackParameters trackParameters // Associated track parameters, if any
    - edm4eic::TrackerHit  measurementHits // Measurement hits used in this trajectory
    - edm4eic::TrackerHit  outlierHits     // Outlier hits not used in this trajectory
```

The associations to the digitized hits are missing. This is expected right now, since we are not extracting the used hits after the CKF fit.

Maybe we need to add an index to the source linker to keep track of the hits as we convert back and forth from edm4eic to ACTS format?

A couple issues



```
root [17] events->Scan("CentralTrackSeedingResults.theta:CentralCKFSeededTrackParameters.theta:theta_rec:CentralCKFSeededTrajectories.nMeasurements:CentralCKFSeededTrajectories.chi2")
***********************************************************************************
*    Row   * Instance * CentralTr * CentralCK * theta_rec * CentralCK * CentralCK *
***********************************************************************************
*        0 *        0 * 0.1937180 * 0.1945763 * 0.1945763 *         4 * 2.4666304 *
*        0 *        1 * 0.1940771 * 0.1945463 * 0.1945463 *         4 * 2.4390687 *
*        0 *        2 * 0.1938095 * 0.1947055 * 0.1947055 *         4 * 2.9926469 *
*        1 *        0 * 2.9997701 * 2.9994049 * 2.9994049 *         2 * 0.4067698 *
*        1 *        1 * 2.9998300 * 2.9996504 * 2.9996504 *         2 * 0.0245701 *
*        2 *        0 * 0.1104461 * 0.1103764 * 0.1103764 *         4 * 6.1610455 *
*        2 *        1 * 0.1103586 * 0.1102905 * 0.1102905 *         4 * 5.3399877 *
*        3 *        0 * 0.0850231 * 0.0851216 * 0.0851216 *         4 * 8.0655946 *
*        3 *        1 * 0.0850503 * 0.0851085 * 0.0851085 *         4 * 9.4841909 *
*        4 *        0 * 0.2157898 * 0.2161549 * 0.2161550 *         4 * 5.5669741 *
*        4 *        1 * 0.2160625 * 0.2161960 * 0.2161960 *         4 * 4.2218980 *
*        4 *        2 * 0.2157084 * 0.2162159 * 0.2162160 *         4 * 3.5914709 *
*        5 *        0 * 2.3530783 * 2.3530213 * 2.3530213 *         3 * 2.5779833 *
*        6 *        0 * 0.1159824 * 0.1192474 * 0.1192474 *         2 * 0.6670103 *
*        6 *        1 * 0.1127062 * 0.1198665 * 0.1198665 *         2 * 0.7781642 *
*        7 *        0 * 2.6202621 * 2.6202397 * 2.6202397 *         7 * 13.872473 *
*        7 *        1 * 2.6200094 * 2.6202220 * 2.6202221 *         7 * 16.563919 *
*        7 *        2 * 2.6201334 * 2.6202380 * 2.6202380 *         7 * 13.850541 *
```

Event number

Seed theta

Track parameters theta

Reconstructed Charged particles theta

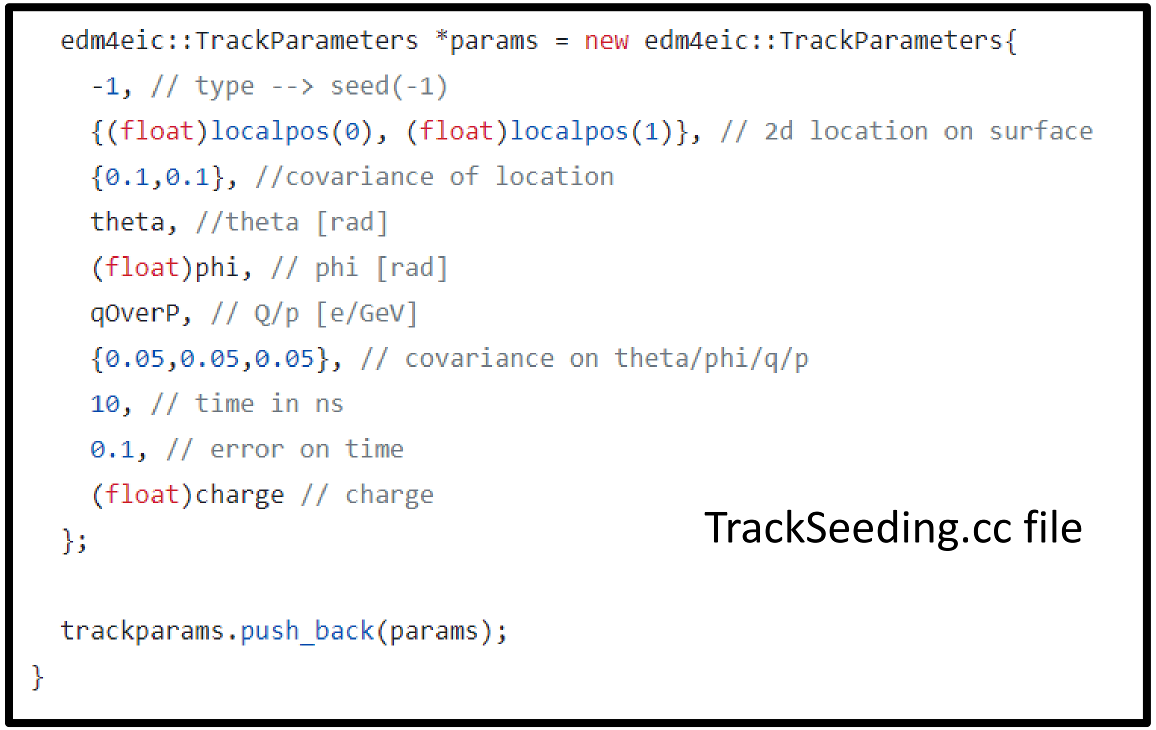
Trajectory nMeasurements

Total chi-square

One strange thing is that even though the tracks all have the about same parameters as the generated particles and the same number of measurement, there chi-suare can differ substantially.

A couple issues

- A guess for why we may see this chi-square difference is that our initial covariance matrix has too small uncertainties.
- We can adjust this and check the effect.



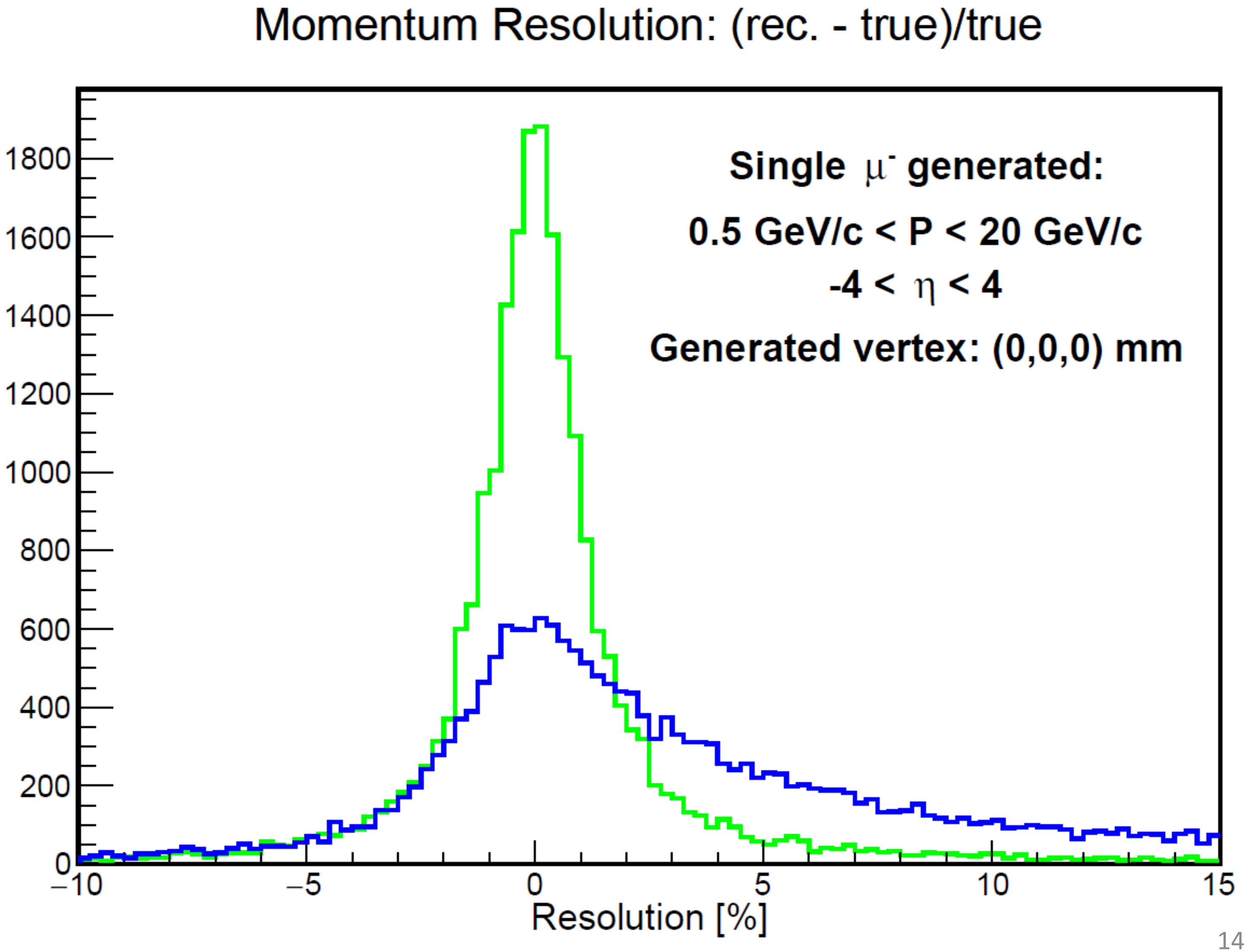
```
  edm4eic::TrackParameters *params = new edm4eic::TrackParameters{
    -1, // type --> seed(-1)
    {(float)localpos(0), (float)localpos(1)}, // 2d location on surface
    {0.1,0.1}, //covariance of location
    theta, //theta [rad]
    (float)phi, // phi [rad]
    qOverP, // Q/p [e/GeV]
    {0.05,0.05,0.05}, // covariance on theta/phi/q/p
    10, // time in ns
    0.1, // error on time
    (float)charge // charge
  };

  trackparams.push_back(params);
}
```

TrackSeeding.cc file

Resolution comparison at seed and track parameter level

Seed level

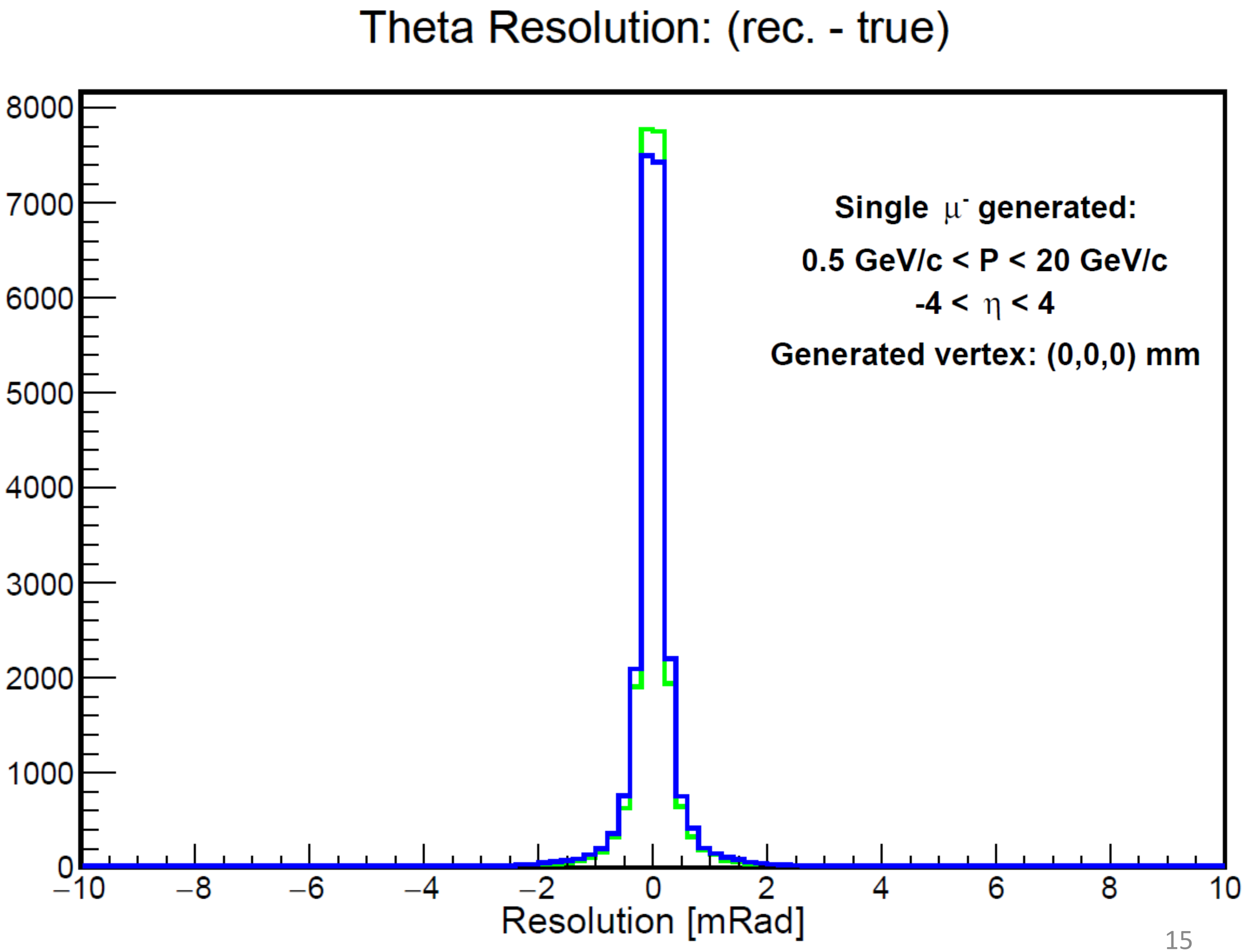
Track parameter level



Resolution comparison at seed and track parameter level

Seed level

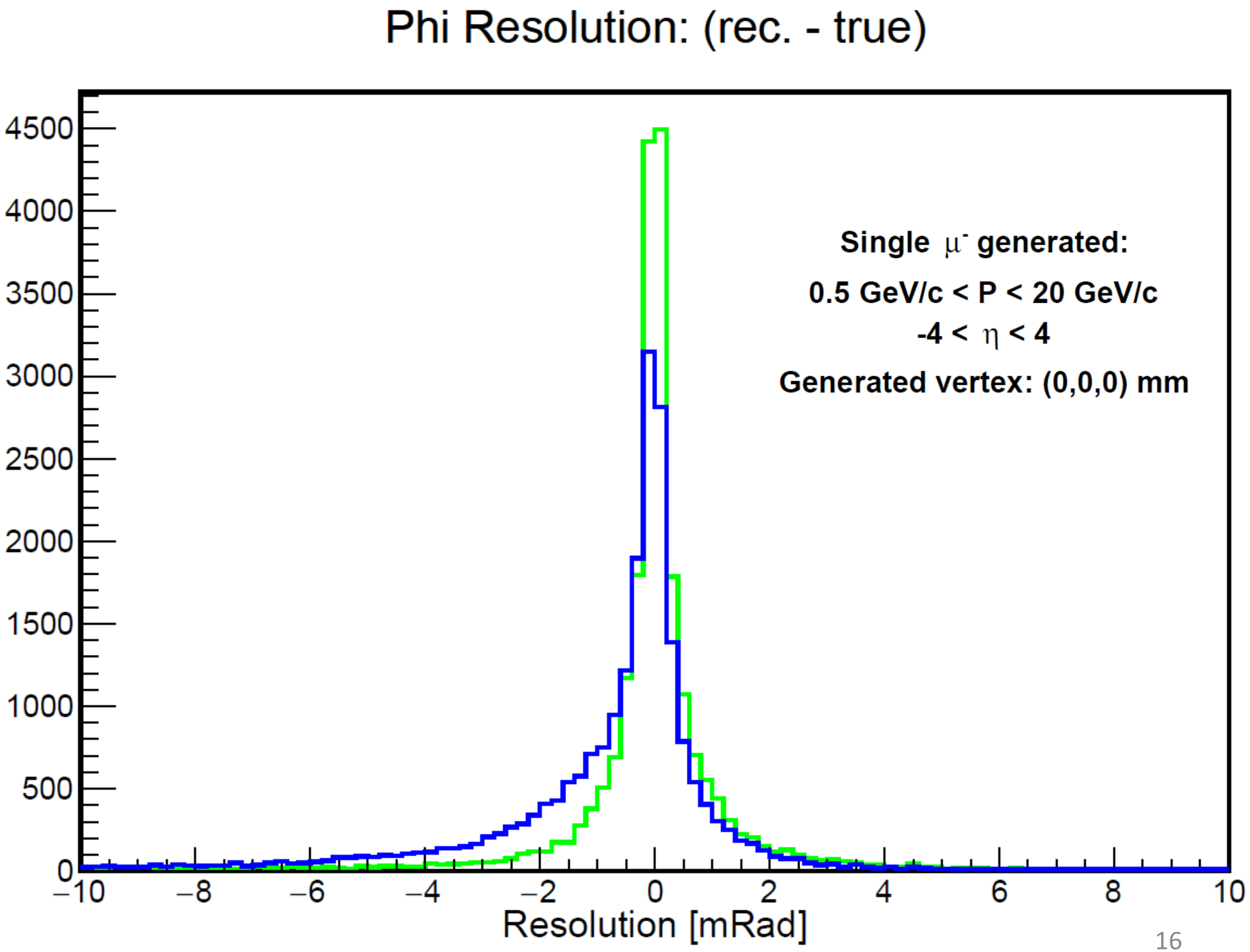
Track parameter level



Resolution comparison at seed and track parameter level

Seed level

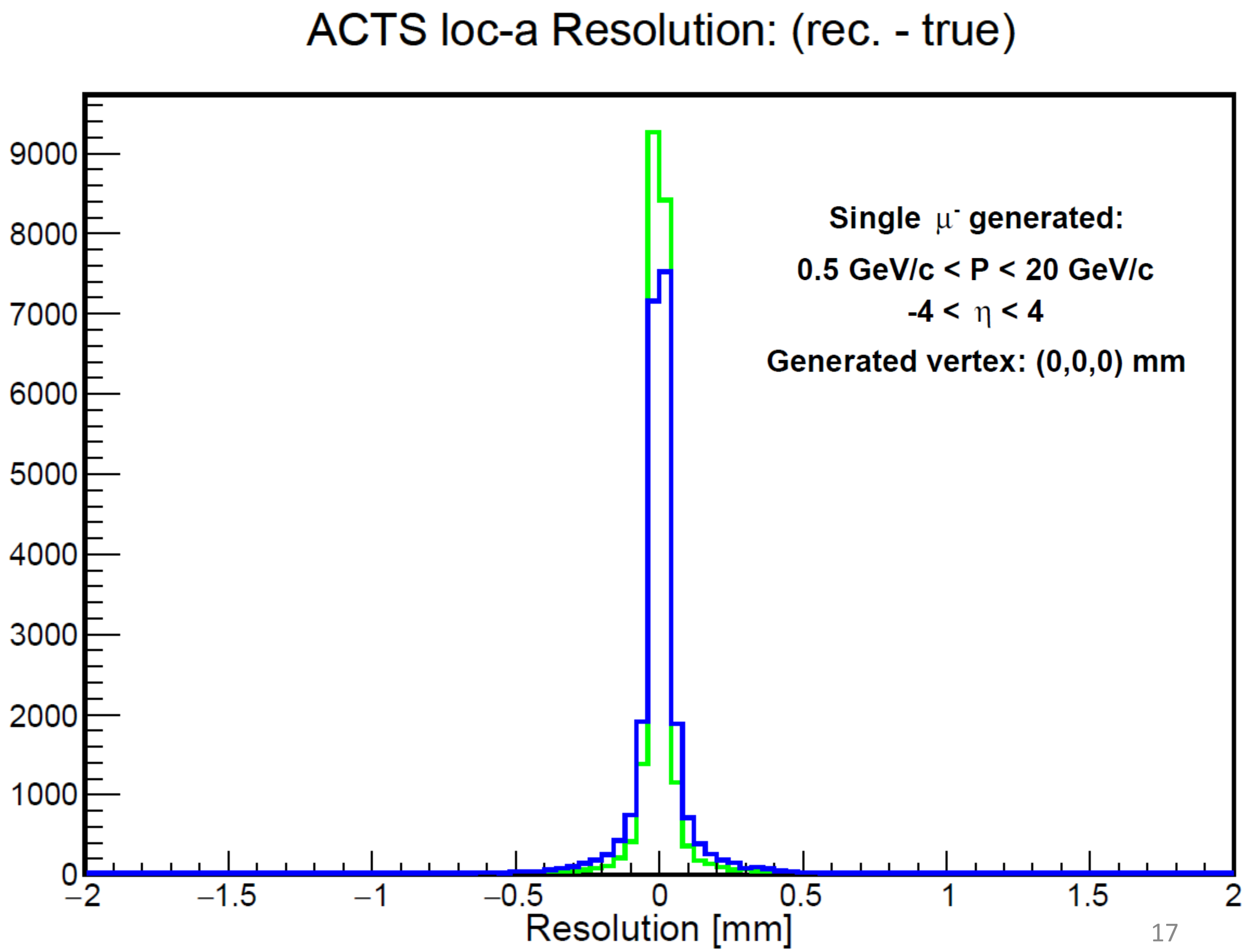
Track parameter level



Resolution comparison at seed and track parameter level

Seed level

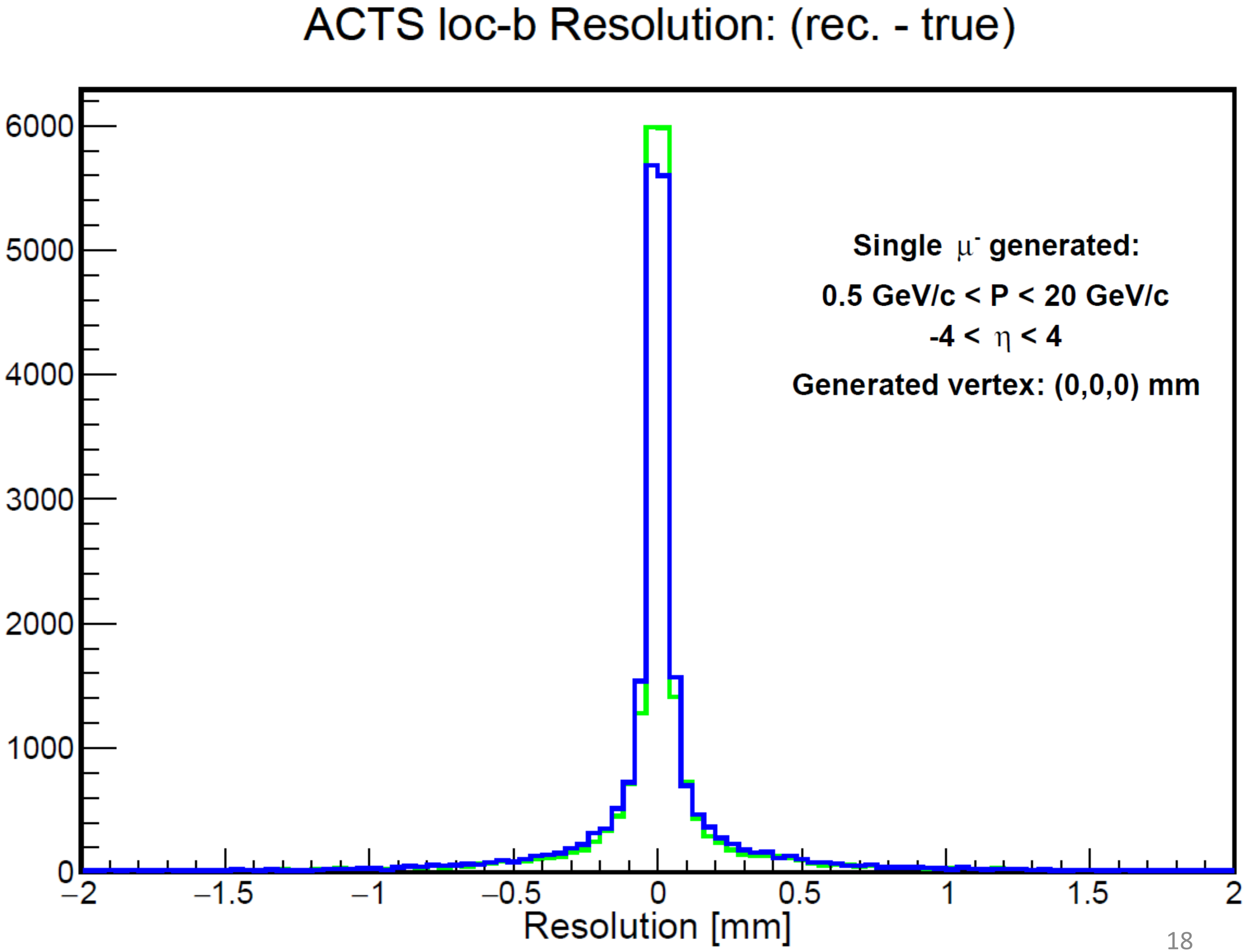
Track parameter level



Resolution comparison at seed and track parameter level

Seed level

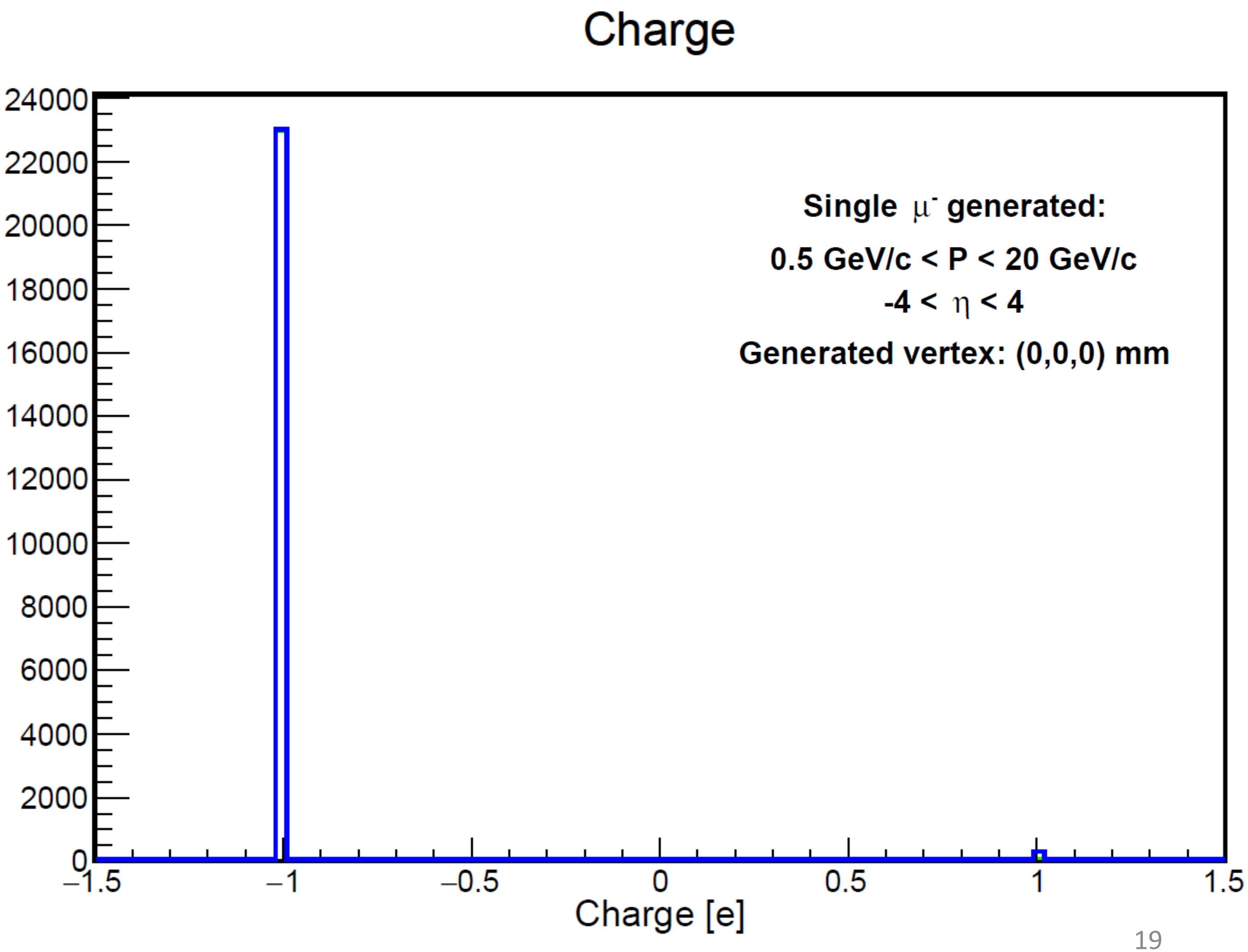
Track parameter level



Resolution comparison at seed and track parameter level

Seed level

Track parameter level



Backup

Seed multiplicity – why do we see many events with 3 seeds?

ACTS seed finder and filter parameters

If we have a particle at mid-rapidity which hits layers L0, L1, L2, L3, and L4, then we can make the following combinations:

1. L0,L1,L2
2. L0,L2,L3
3. L0,L3,L4

✖ 4. L0,L1,L3

✖ 5. L0,L1,L4

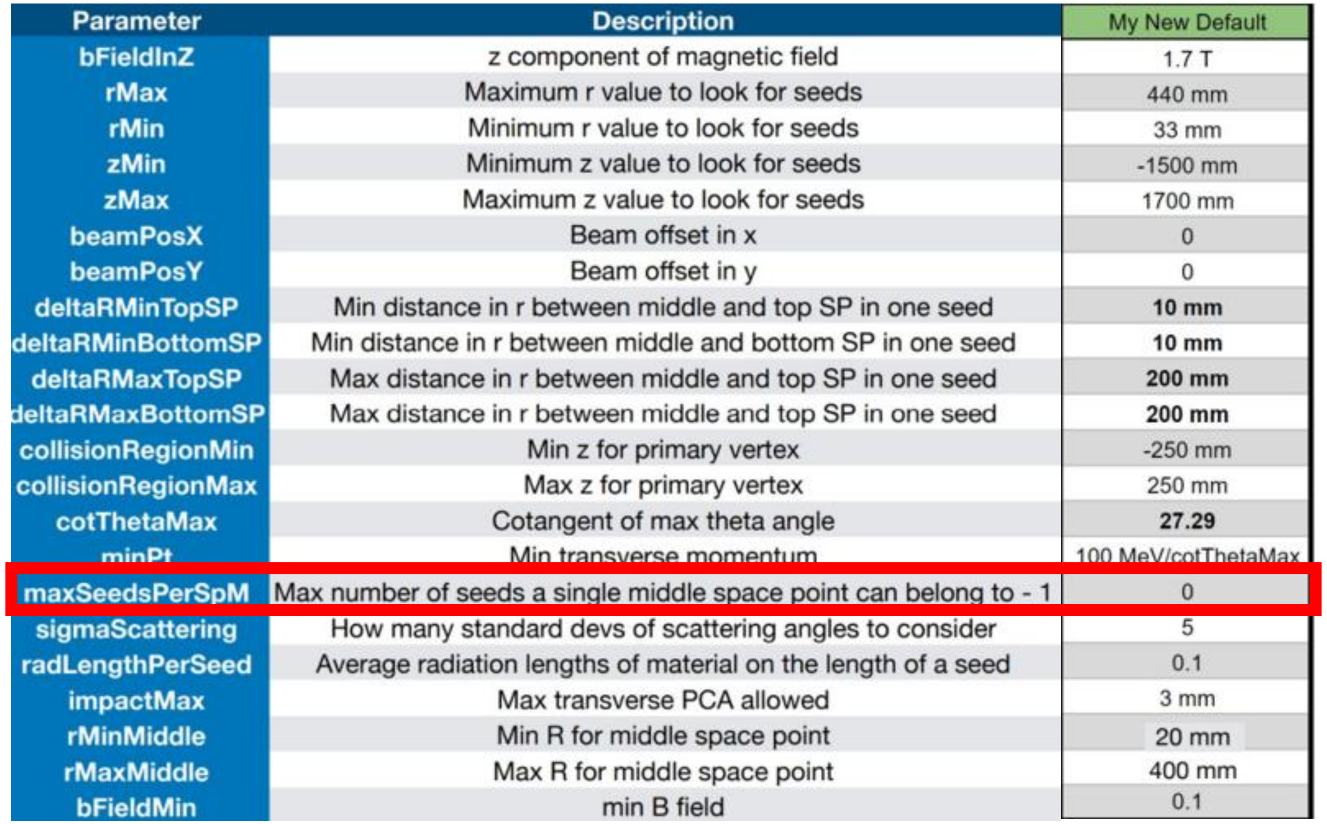
✖ 6. L0,L2,L4

✖ 7. L1,L2,L3

✖ 8. L1,L2,L4

✖ 9. L1,L3,L4

✖ 10. L2,L3,L4



Parameter	Description	My New Default
bFieldInZ	z component of magnetic field	1.7 T
rMax	Maximum r value to look for seeds	440 mm
rMin	Minimum r value to look for seeds	33 mm
zMin	Minimum z value to look for seeds	-1500 mm
zMax	Maximum z value to look for seeds	1700 mm
beamPosX	Beam offset in x	0
beamPosY	Beam offset in y	0
deltaRMinTopSP	Min distance in r between middle and top SP in one seed	**10 mm**
deltaRMinBottomSP	Min distance in r between middle and bottom SP in one seed	**10 mm**
deltaRMaxTopSP	Max distance in r between middle and top SP in one seed	**200 mm**
deltaRMaxBottomSP	Max distance in r between middle and top SP in one seed	**200 mm**
collisionRegionMin	Min z for primary vertex	-250 mm
collisionRegionMax	Max z for primary vertex	250 mm
cotThetaMax	Cotangent of max theta angle	**27.29**
minPt	Min transverse momentum	100 MeV/cotThetaMax
maxSeedsPerSpM	Max number of seeds a single middle space point can belong to - 1	0
sigmaScattering	How many standard devs of scattering angles to consider	5
radLengthPerSeed	Average radiation lengths of material on the length of a seed	0.1
impactMax	Max transverse PCA allowed	3 mm
rMinMiddle	Min R for middle space point	20 mm
rMaxMiddle	Max R for middle space point	400 mm
bFieldMin	min B field	0.1