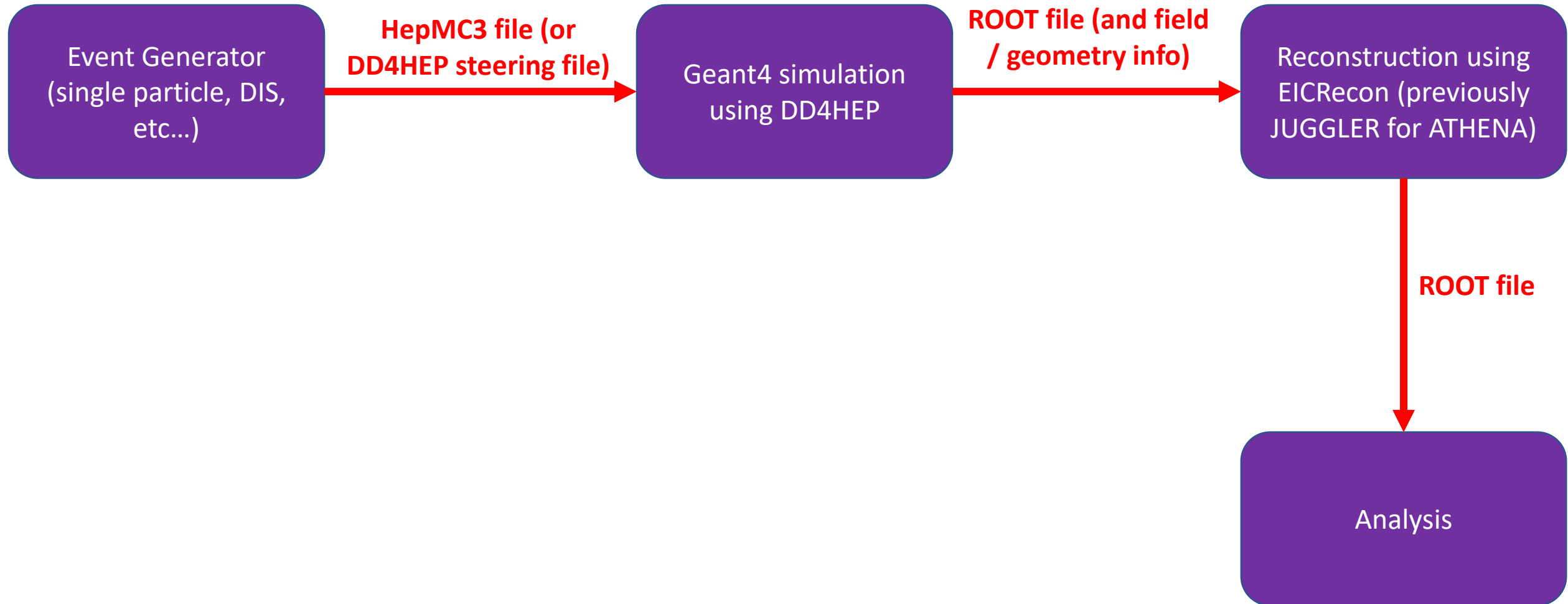


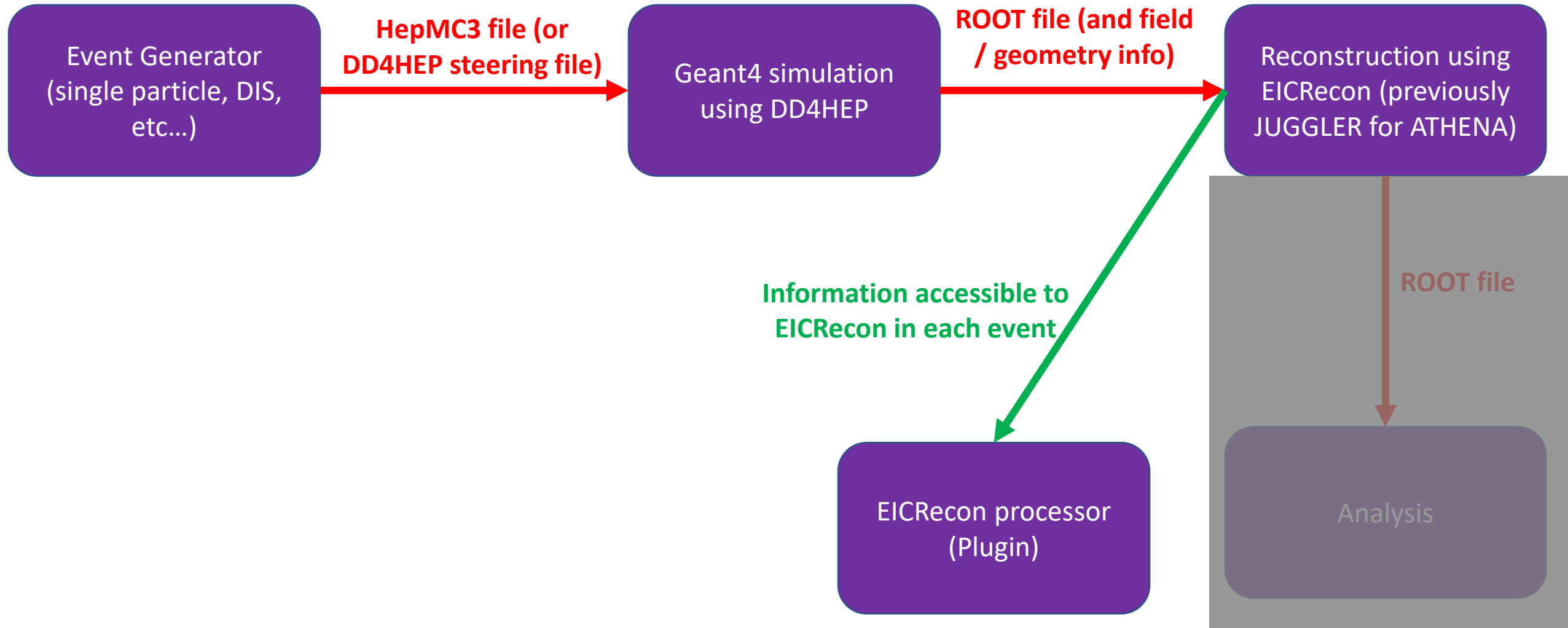
# Track QA processor for EICRecon

Barak Schmookler

# Simulation workflow for ePIC



# Simulation workflow for ePIC



# Simulation workflow for ePIC

Event Generator  
(single particle, DIS,  
etc...)

**HepMC3 file (or  
DD4HEP steering file)**

Geant4 simulation  
using DD4HEP

**ROOT file (and field  
/ geometry info)**

Reconstruction using  
EICRecon (previously  
JUGGLER for ATHENA)

**ROOT file**

Analysis

**Information accessible to  
EICRecon in each event**

EICRecon processor  
(Plugin)

All the information that can be used by an EICRecon processor should eventually be written to the standard EICRecon output ROOT file. The challenge is that this ROOT file uses a data model (edm4hep/edm4eic) to set its output format. Changing this data model or adding additional information to the standard output requires coordination with the ePIC software group, which can take some time. So, the processor (Plugin) approach is a good temporary analysis method.

# What tracking QA information do we need?

- In the EICRecon output ROOT file, we have access to the following:
  1. Digitized hits (positions) in the tracking detectors
  2. Track momentum vector at vertex for each track
- Other tracking information can currently only be accessed by an EICRecon processor:
  1. Number of measurements for a track
  2. Track chi-square and covariance matrix
  3. Track state information at tracking detector surfaces. This allows for the calculation of hit residuals, for example.

# Track QA processor for EICRecon

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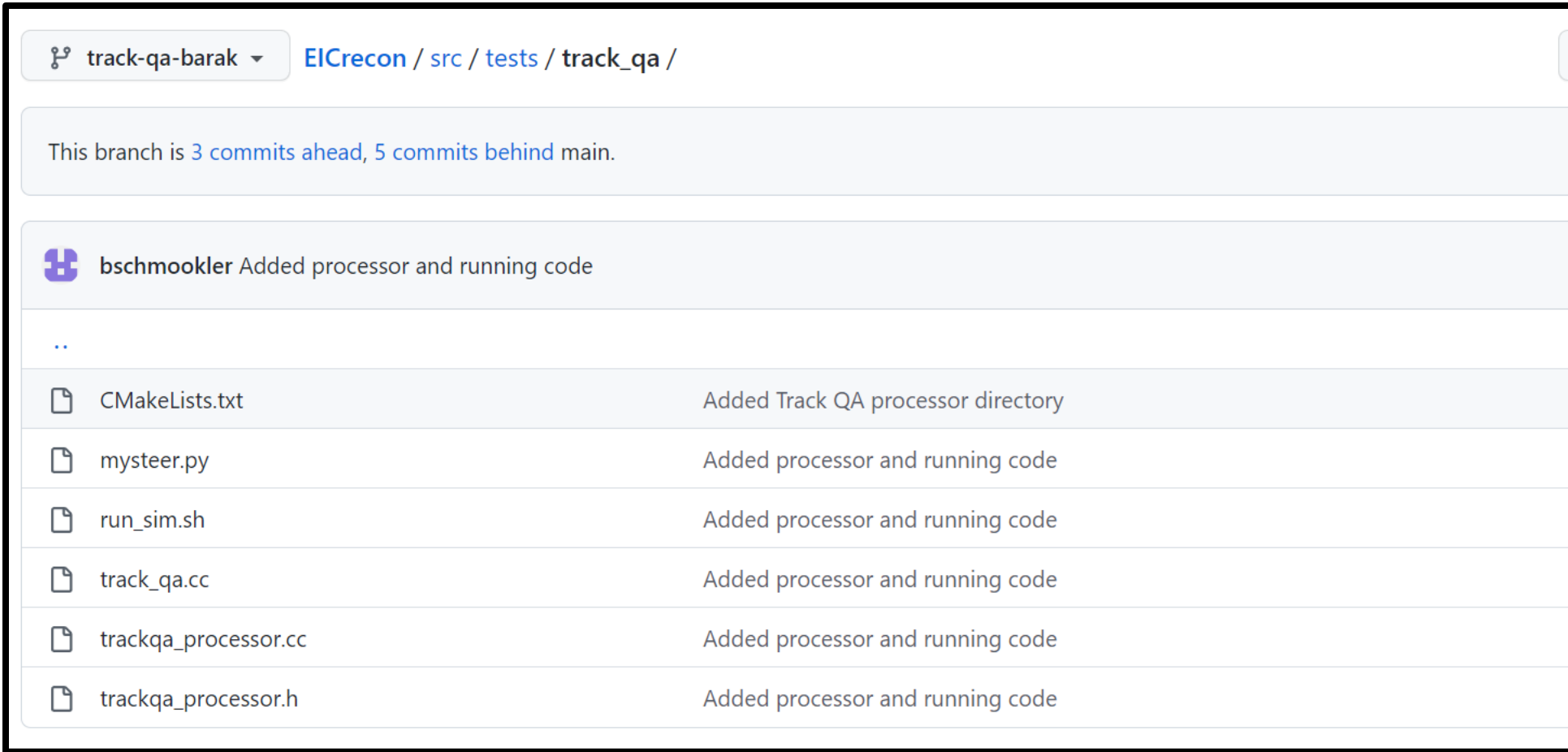
track-qa-barak 36 branches 23 tags Go to file Add file <> Code

This branch is 3 commits ahead, 5 commits behind main. Contribute

bschmookler Merge branch 'main' into track-qa-barak ccd0f50 15 hours ago 1,205 commits

.github/workflows	Merge branch 'main' into ci-add-debug-release-in-cache-key	last week
cmake	Current requirement is Acts-20.2.0 or later (within 20 series)	last month
docs	Remove old flags from sidebar	2 months ago
src	Merge branch 'main' into track-qa-barak	15 hours ago
.clang-format	.clang-format based on LLVM	last month
.clang-tidy	.clang-tidy; disabled a few likely heavy hitters	last month
.gitignore	Add .run directory from IDE to gitignore	2 weeks ago

# Track QA processor for EICRecon



The screenshot shows a GitHub commit page for the repository `track-qa-barak` at the path `EICrecon / src / tests / track_qa /`. The page indicates that the current branch is 3 commits ahead and 5 commits behind the main branch. A commit by user `bschmookler` is shown, titled "Added processor and running code". The commit message is followed by a list of files added:

File	Commit Message
..	
CMakeLists.txt	Added Track QA processor directory
myster.py	Added processor and running code
run_sim.sh	Added processor and running code
track_qa.cc	Added processor and running code
trackqa_processor.cc	Added processor and running code
trackqa_processor.h	Added processor and running code

# Example event: single electron with $p = 2$ GeV, $\eta = 0$

## Truth seeded tracking

**The Plugin first accesses the generated  
particle information**

```
[2023-01-23 21:47:08.745] [track_qa] [trace] trackqa_processor event
[2023-01-23 21:47:08.745] [track_qa] [trace] -----
[2023-01-23 21:47:08.745] [track_qa] [trace] Number of primary generated particles:
[2023-01-23 21:47:08.745] [track_qa] [trace]          1
[2023-01-23 21:47:08.745] [track_qa] [trace] Generated particle id, eta, p, E:
[2023-01-23 21:47:08.746] [track_qa] [trace]          11          -0.00          2.00          2.00
```



# Example event: single electron with $p = 2 \text{ GeV}$ , $\eta = 0$

## Truth seeded tracking

Then it gets the digitized tracker hit information

```
[2023-01-23 21:47:08.746] [track_qa] [trace] Detector SiBarrelTrackerRecHits has 2 digitized hits.  
[2023-01-23 21:47:08.746] [track_qa] [trace] For digitized hit number 1:  
[2023-01-23 21:47:08.746] [track_qa] [trace] Hit x, y, z, r, eta:  
[2023-01-23 21:47:08.746] [track_qa] [trace]   -421.71      80.18      0.26      429.26      0.00  
[2023-01-23 21:47:08.746] [track_qa] [trace] For digitized hit number 2:  
[2023-01-23 21:47:08.746] [track_qa] [trace] Hit x, y, z, r, eta:  
[2023-01-23 21:47:08.746] [track_qa] [trace]   -267.56      45.23      0.11      271.36      0.00
```

```
Detector SiBarrelVertexRecHits has 3 digitized hits.  
For digitized hit number 1:  
Hit x, y, z, r, eta:  
  -118.69      17.72      0.04      120.00      0.00  
For digitized hit number 2:  
Hit x, y, z, r, eta:  
  -47.54       6.66     -0.00      48.00      0.00  
For digitized hit number 3:  
Hit x, y, z, r, eta:  
  -35.66       4.94     -0.00      36.00      0.00
```

```
Detector SiEndcapTrackerRecHits has 0 digitized hits.  
  
Detector MPGDBarrelRecHits has 0 digitized hits.  
  
Detector MPGD DIRC RecHits has 0 digitized hits.  
  
Detector TOFBarrelRecHit has 1 digitized hits.  
For digitized hit number 1:  
Hit x, y, z, r, eta:  
  -623.21      135.96     -0.00      637.87      0.00  
  
Detector TOFEndcapRecHits has 0 digitized hits.
```

```
[2023-01-23 21:47:08.746] [track_qa] [trace] Total number of tracker hits is 6
```

# Example event: single electron with $p = 2$ GeV, $\eta = 0$

## Truth seeded tracking

Then, for each ACTS track, it finds general track information and the track parameters at the vertex

```
[2023-01-23 21:47:08.746] [track_qa] [trace] -----
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of ACTS Trajectories: 1
[2023-01-23 21:47:08.746] [track_qa] [trace]
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of elements in trackTips 1
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of measurements in trajectory: 5
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of states in trajectory      : 11
[2023-01-23 21:47:08.746] [track_qa] [trace] Total chi-square of trajectory      :    6.18
[2023-01-23 21:47:08.746] [track_qa] [trace] [loc 0] [loc 1]   [phi] [theta]   [q/p] [err phi] [err th] [err q/p]
[2023-01-23 21:47:08.746] [track_qa] [trace]   -0.01  -0.02   3.01   1.57   -0.50   0.00043   0.00042   0.0009
[2023-01-23 21:47:08.746] [track_qa] [trace] Trajectory p, eta:
[2023-01-23 21:47:08.746] [track_qa] [trace]           2.00     0.00
```

# Example event: single electron with $p = 2 \text{ GeV}$ , $\eta = 0$

## Truth seeded tracking

Then, for each ACTS track, it finds general track information and the track parameters at the vertex

```
[2023-01-23 21:47:08.746] [track_qa] [trace] -----
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of ACTS Trajectories: 1
[2023-01-23 21:47:08.746] [track_qa] [trace]
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of elements in trackTips 1
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of measurements in trajectory: 5
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of states in trajectory      : 11
[2023-01-23 21:47:08.746] [track_qa] [trace] Total chi-square of trajectory      :    6.18
[2023-01-23 21:47:08.746] [track_qa] [trace] [loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
[2023-01-23 21:47:08.746] [track_qa] [trace]      -0.01  -0.02  3.01  1.57  -0.50  0.00043  0.00042  0.0009
[2023-01-23 21:47:08.746] [track_qa] [trace] Trajectory p, eta:
[2023-01-23 21:47:08.746] [track_qa] [trace]          2.00    0.00
```

**General information about the track**

# Example event: single electron with $p = 2 \text{ GeV}$ , $\eta = 0$

## Truth seeded tracking

Then, for each ACTS track, it finds general track information and the track parameters at the vertex

```
[2023-01-23 21:47:08.746] [track_qa] [trace] -----  
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of ACTS Trajectories: 1  
[2023-01-23 21:47:08.746] [track_qa] [trace]  
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of elements in trackTips 1  
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of measurements in trajectory: 5  
[2023-01-23 21:47:08.746] [track_qa] [trace] Number of states in trajectory      : 11  
[2023-01-23 21:47:08.746] [track_qa] [trace] Total chi-square of trajectory      :    6.18  
[2023-01-23 21:47:08.746] [track_qa] [trace] [loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]  
[2023-01-23 21:47:08.746] [track_qa] [trace] -0.01 -0.02 3.01 1.57 -0.50 0.00043 0.00042 0.0009  
[2023-01-23 21:47:08.746] [track_qa] [trace] Trajectory p, eta:  
[2023-01-23 21:47:08.746] [track_qa] [trace] 2.00 0.00
```

**Track parameters at vertex**

# Example event: single electron with $p = 2 \text{ GeV}$ , $\eta = 0$

## Truth seeded tracking

For the track, it then steps through each track state and accesses the track parameters at that location

```

Now at State number 1
This is a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
 7.05 -0.35 2.84 1.57 -0.50 0.0014 0.0014 0.0011
State global x, y, z, r and pathlength:
-622.27 128.82 0.02 635.46 638.52

Now at State number 2
This is NOT a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
1844.65 0.34 2.85 1.57 -0.50 0.00049 0.00041 0.0011
State global x, y, z, r and pathlength:
630.00 -0.01 -0.02 630.00 630.67
    
```

...

```

Now at State number 7
This is a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
 0.14 -0.00 2.98 1.57 -0.50 0.004 0.00034 0.1
State global x, y, z, r and pathlength:
-118.70 17.60 0.02 120.00 120.00
    
```

...

```

Now at State number 10
This is NOT a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
105.14 -0.01 3.00 1.57 -0.50 0.05 0.01 0.1
State global x, y, z, r and pathlength:
35.00 -0.01 -0.02 35.00 35.00

Now at State number 11
This is NOT a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
84.89 -0.01 3.00 1.57 -0.50 0.05 0.01 0.1
State global x, y, z, r and pathlength:
28.25 -0.01 -0.02 28.25 28.25

Number of calibrated states: 6
-----|
    
```

# Example event: single electron with $p = 2 \text{ GeV}$ , $\eta = 0$

## Truth seeded tracking

For the track, it then steps through each track state and accesses the track parameters at that location

```

Now at State number 1
This is a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
 7.05 -0.35 2.84 1.57 -0.50 0.0014 0.0014 0.0011
State global x, y, z, r and pathlength:
-622.27 128.82 0.02 635.46 638.52

Now at State number 2
This is NOT a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
1844.65 0.34 2.85 1.57 -0.50 0.00049 0.00041 0.0011
State global x, y, z, r and pathlength:
630.00 -0.01 -0.02 630.00 630.67
    
```

...

```

Now at State number 7
This is a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
 0.14 -0.00 2.98 1.57 -0.50 0.004 0.00034 0.1
State global x, y, z, r and pathlength:
-118.70 17.60 0.02 120.00 120.00
    
```

```

...
Now at State number 10
This is NOT a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
105.14 -0.01 3.00 1.57 -0.50 0.05 0.01 0.1
State global x, y, z, r and pathlength:
35.00 -0.01 -0.02 35.00 35.00

Now at State number 11
This is NOT a calibrated state.
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]
84.89 -0.01 3.00 1.57 -0.50 0.05 0.01 0.1
State global x, y, z, r and pathlength:
28.25 -0.01 -0.02 28.25 28.25

Number of calibrated states: 6
-----|
    
```

**Number of calibrated states is equal to number of digitized tracker hits and is close to number of measurements in the track**

# Example event: single electron with $p = 2 \text{ GeV}$ , $\eta = 0$

## Truth seeded tracking

Using the above information, we can compare the digitized tracker hits to the track parameters at that detector surface.

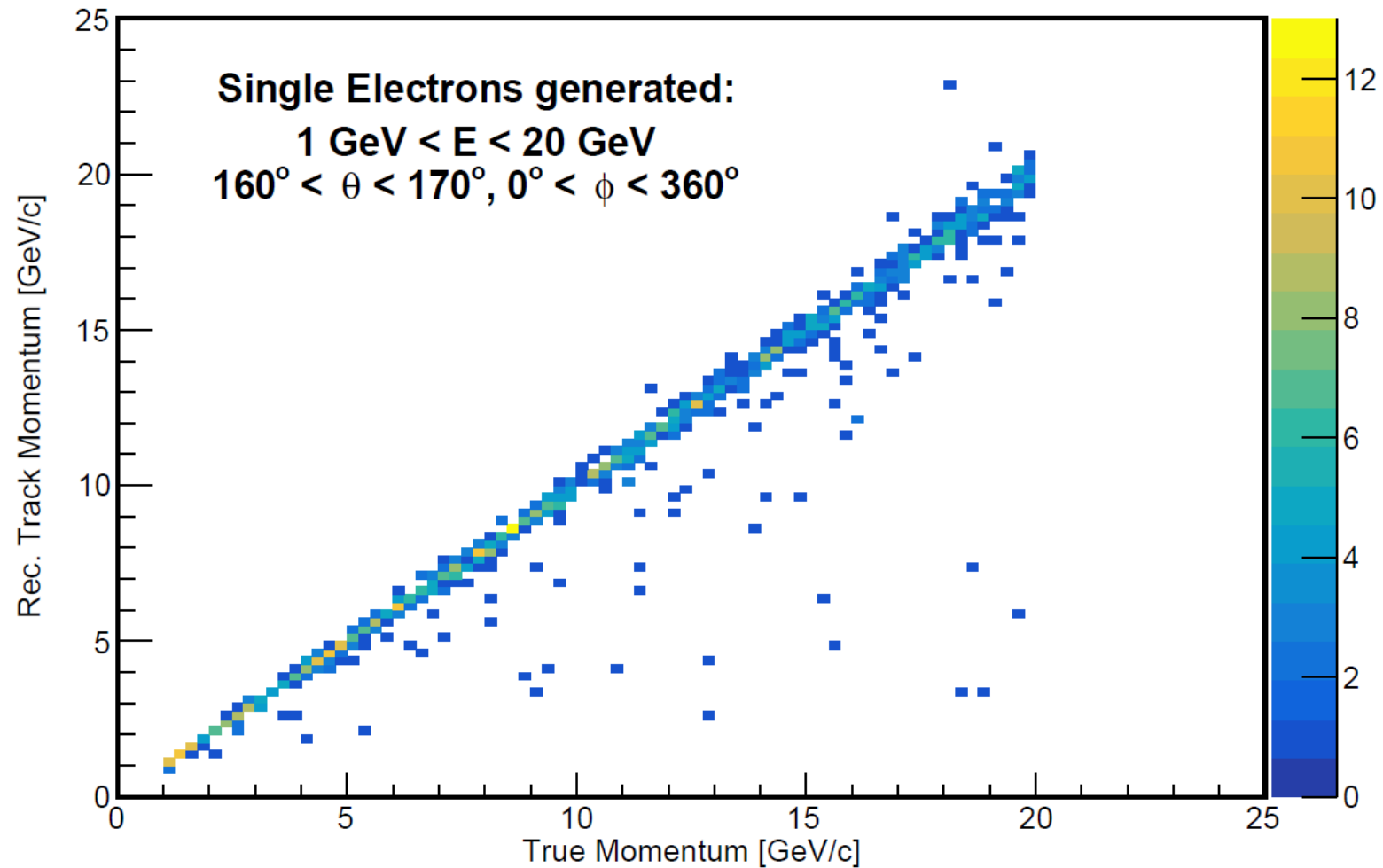
### Digitized hits

```
Detector SiEndcapTrackerRecHits has 0 digitized hits.  
Detector MPGDBarrelRecHits has 0 digitized hits.  
Detector MPGDDIRCRHits has 0 digitized hits.  
Detector TOFBarrelRecHit has 1 digitized hits.  
For digitized hit number 1:  
Hit x, y, z, r, eta:  
-623.21 135.96 -0.00 637.87 0.00  
Detector TOFEndcapRecHits has 0 digitized hits.
```

### Track parameters

```
Now at State number 1  
This is a calibrated state.  
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]  
7.05 -0.35 2.84 1.57 -0.50 0.0014 0.0014 0.0011  
State global x, y, z, r and pathlength:  
-622.27 128.82 0.02 635.46 638.52  
Now at State number 2  
This is NOT a calibrated state.  
[loc 0] [loc 1] [phi] [theta] [q/p] [err phi] [err th] [err q/p]  
1844.65 0.34 2.85 1.57 -0.50 0.00049 0.00041 0.0011  
State global x, y, z, r and pathlength:  
630.00 -0.01 -0.02 630.00 630.67
```

We can make plots directly in this processor





## Summary / Next steps

- We have written an EICRecon processor (Plugin) which can access additional information compared to the standard reconstructed ROOT file.
- We need to better understand some of the variables and decide what plots we want to make.
- Then we can use this processor for our track seeding studies.