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ACTS Efforts for the EIC-ePIC detector

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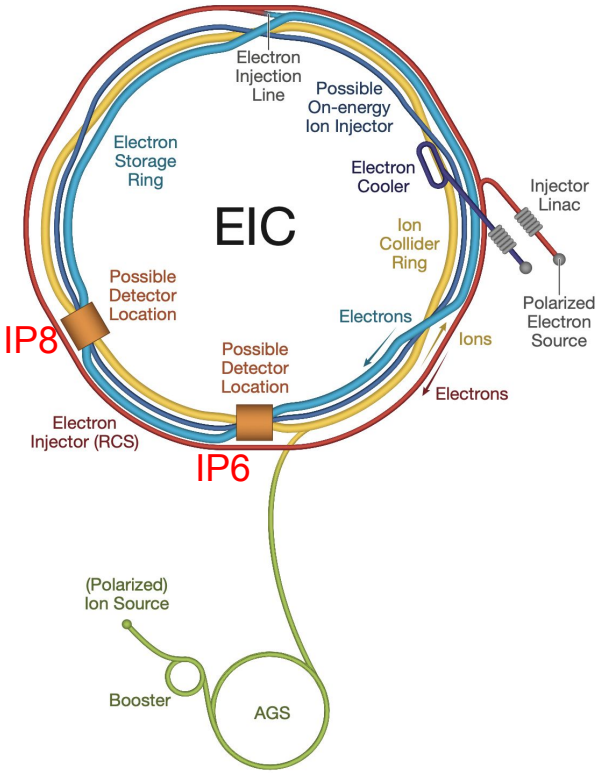
Berkeley Lab

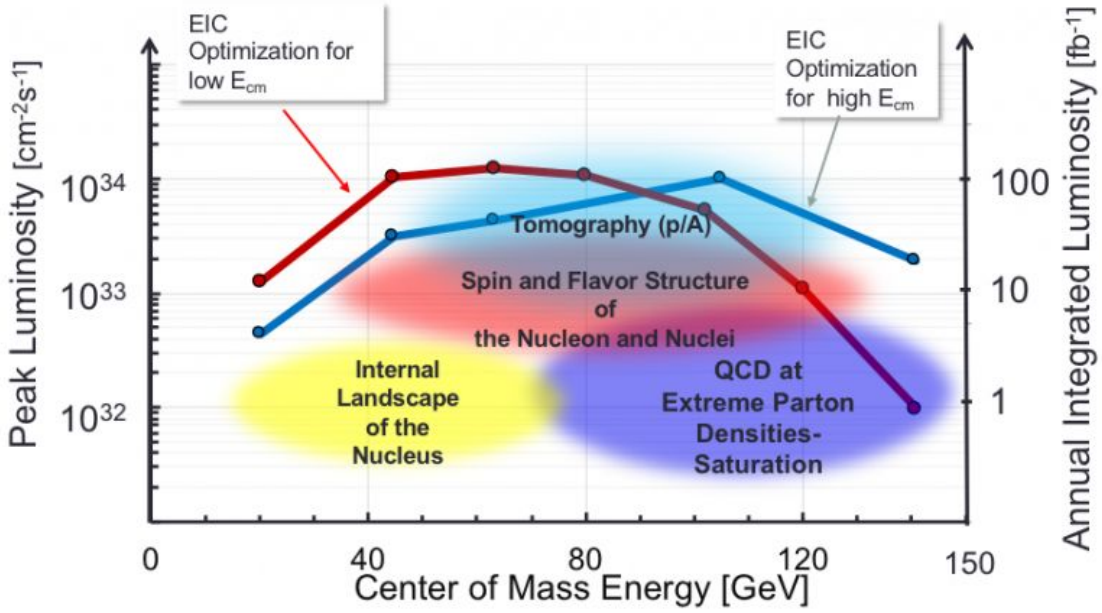
September 26 @ ACTS Developer Workshop 2022

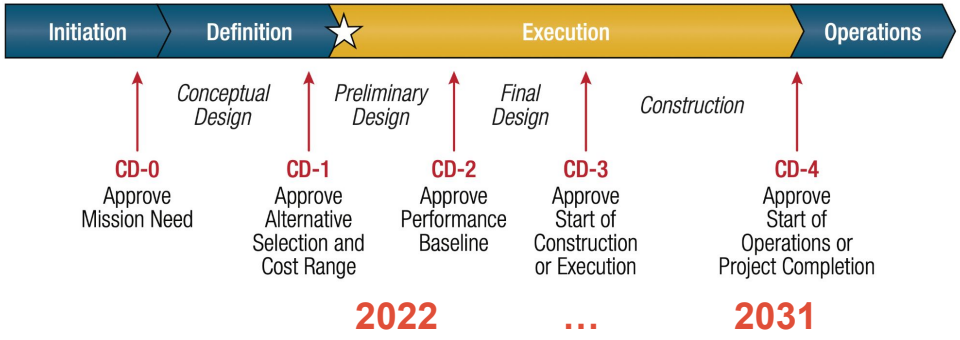
Electron-Ion Collider Overview

https://www.bnl.gov/eic/
http://eicug.org

- Beam properties:
  - Electron: 2.5 - 18 GeV
  - Hadron: 40 - 275 GeV
  - Crossing angle: 25 mrad
  - Collision rate: 500 kHz - 1 MHz

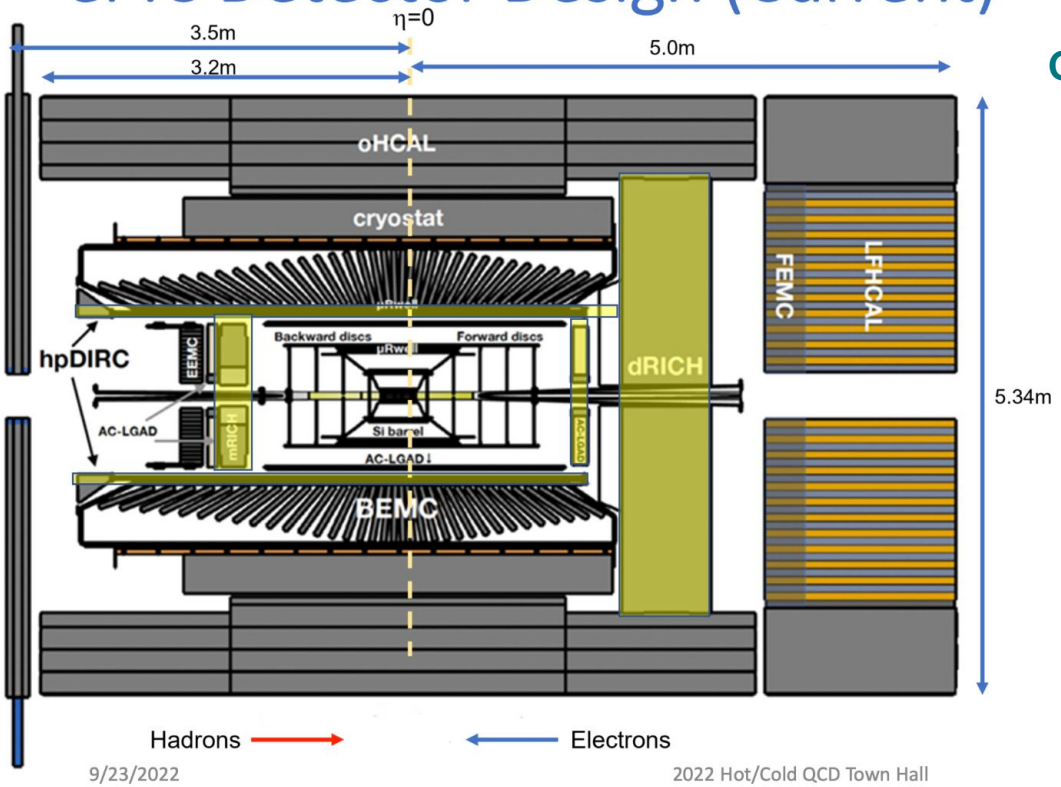






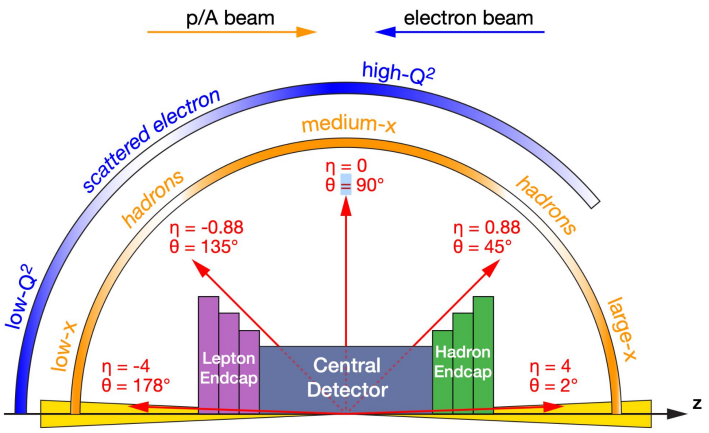
Courtesy of John Lajoie

ePIC Detector Design (Current)



Goal:

- Meet physics requirements as listed in the EIC yellow report (arxiv: 2103.05419)
- Cost, schedule, and risk



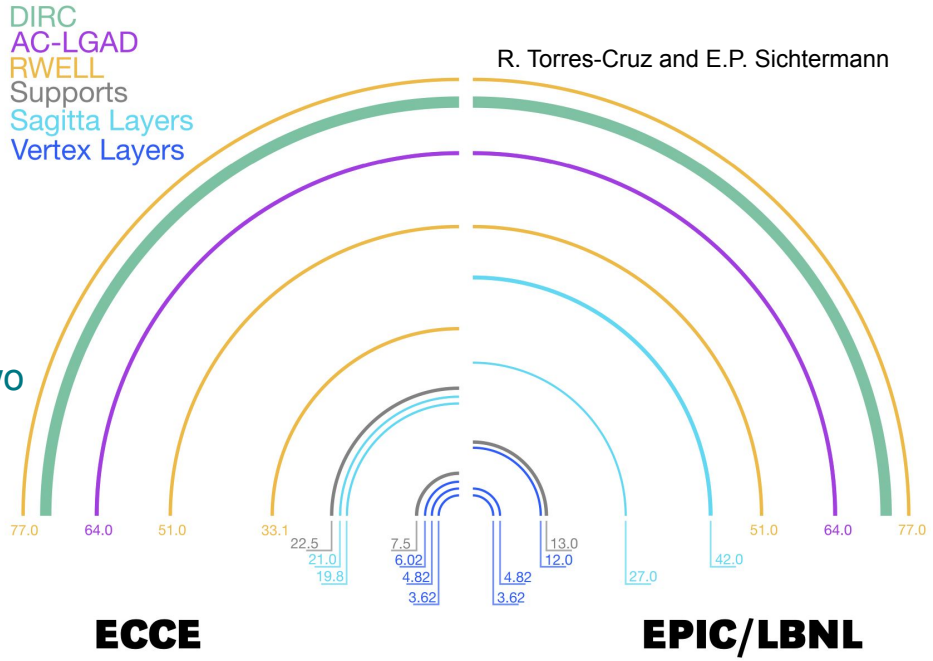
Current Status:

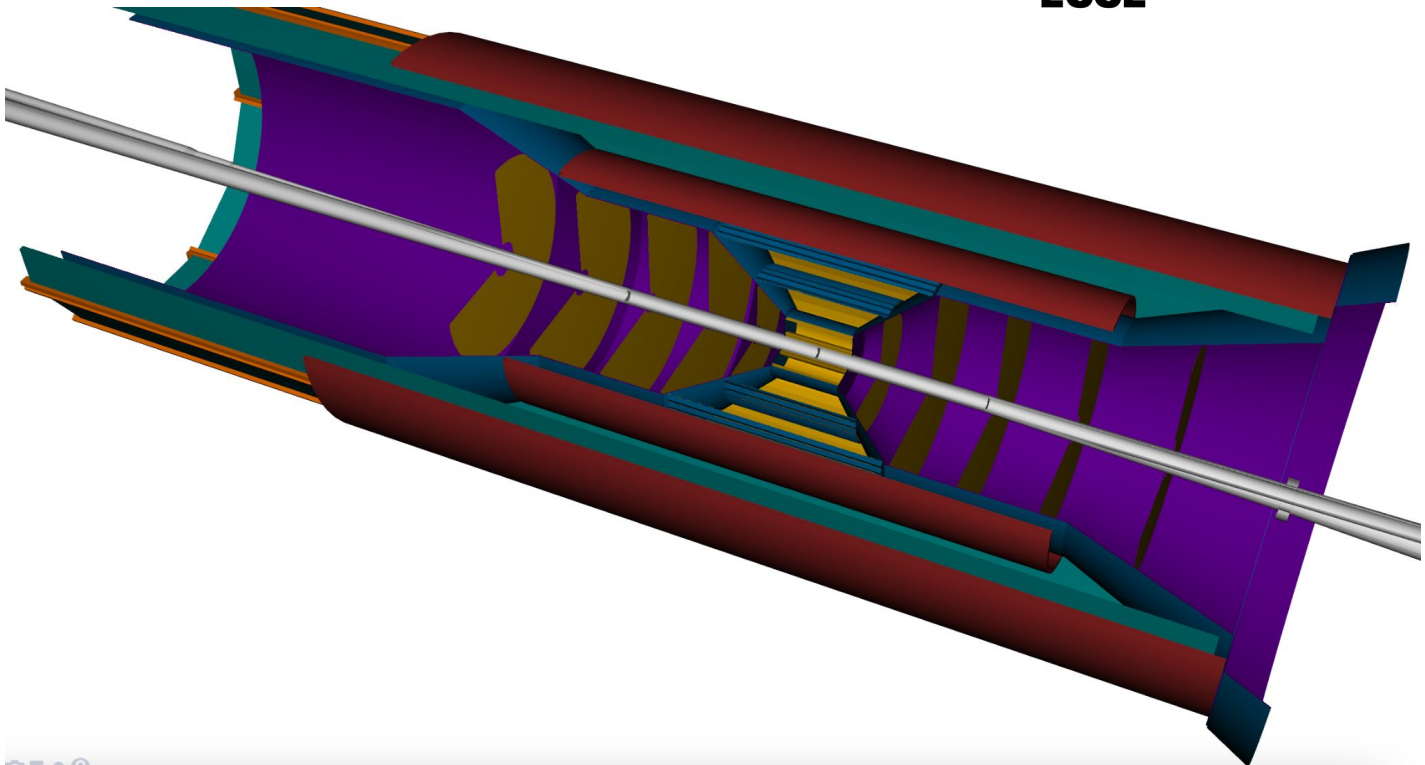
- Detector optimization with existing software stack
- developing new software framework for the October simulation campaign

In-progress

EPIC Tracker Optimization

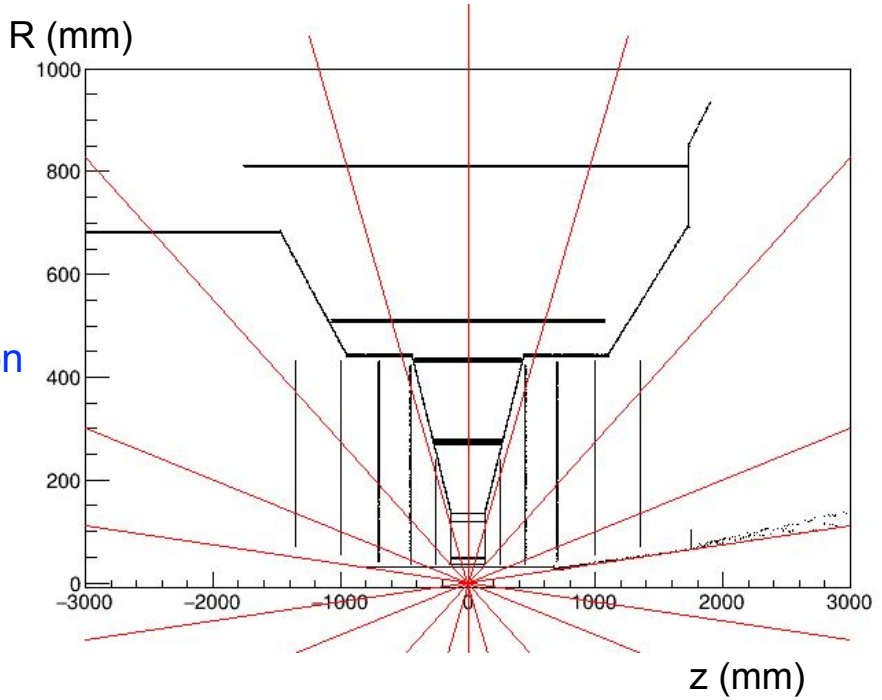
- Silicon tracker:
  - Three inner vertex barrel layers (ITS3)
  - Two sagitta barrel layers (ITS2 stave-like)
  - five disks each direction
- Micromega outer barrels (two barrels, each has two layers)
- AC-LGAD, and DIRC
- projective cone for services and support
- 1.7T new magnet





In-progress

EPIC Tracker Optimization



Optimization are primarily studied in the existing software framework, while the new geometry is implemented in the new EPIC framework for validation

To support future detector development (simulation + reconstruction in iteration) in the new framework, need to

1. speed up the material map generation

   – this feature is already in ACTS 20 and backported to ACTS 19. Will pick it up in the next release

2. integrate this process in to CI.

refactor: Improve material mapping speed #1458

Merged paulgessinger merged 27 commits into acts-project:main from Corentin-Allaire:fast

Conversation 36 Commits 27 Checks 37 Files changed 16

Corentin-Allaire commented on Aug 22 • edited

This PR improve the speed of the material mapping :

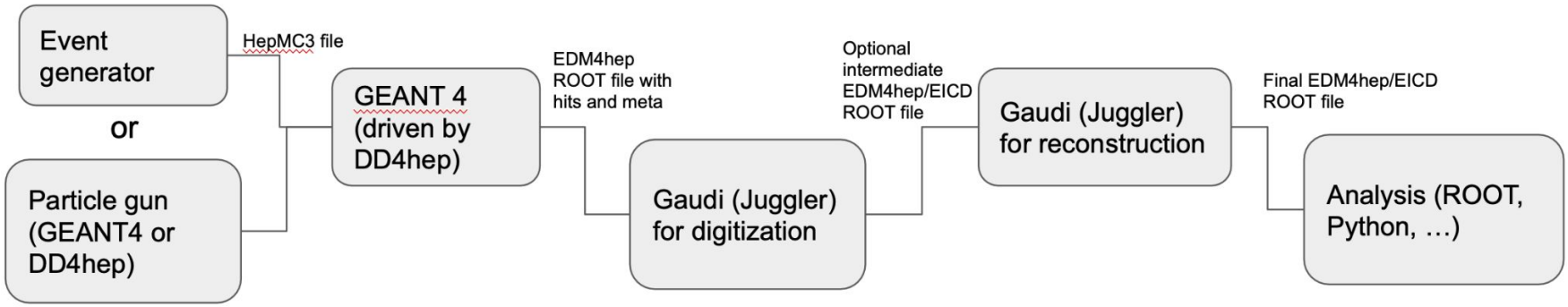
Existing Framework from ATHENA Detector Proposal

DD4Hep:

- Geant4-based full detector description
  - detailed beampipe, supporting structures, and material budget
  - use segmentation to handle pixel sensor resolutions
  - detector volumes are constructed for later use (by ACTS).

Juggler: 

- Gaudi-based digitization and reconstruction
- **ACTS** for track finding/reconstruction



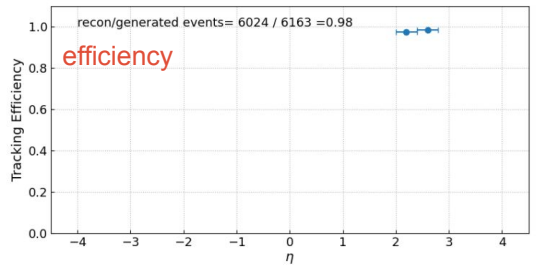
Benchmarked

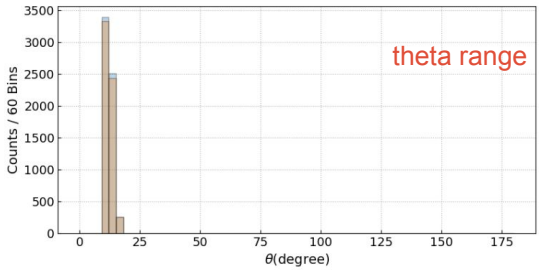
Single Particle Track Reconstruction with Juggler

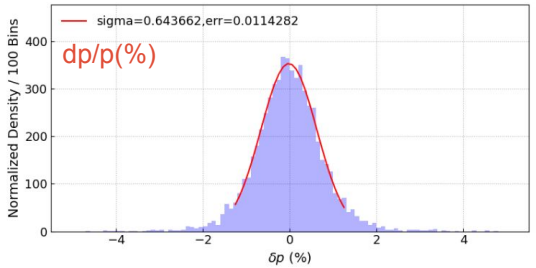
- single pion events
- vertex at 0
- CKF with truth seeding (use truth initial particle info to generate seeds)

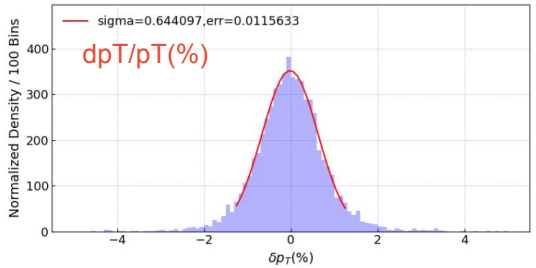
resolution = (init - rec) / init

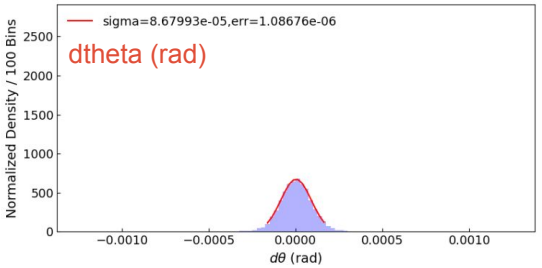
efficiency cuts:
dpp: 5%
theta: 0.005 rad
phi: 0.03 rad
DCA: 3 mm

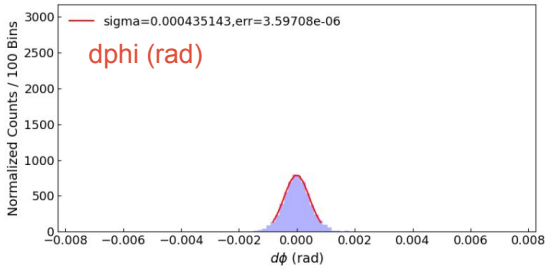


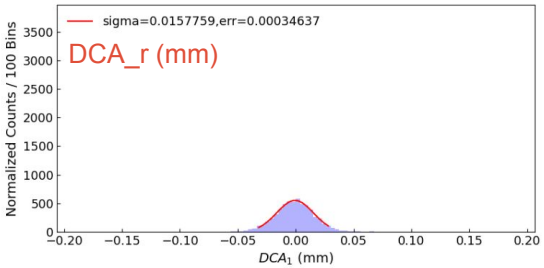


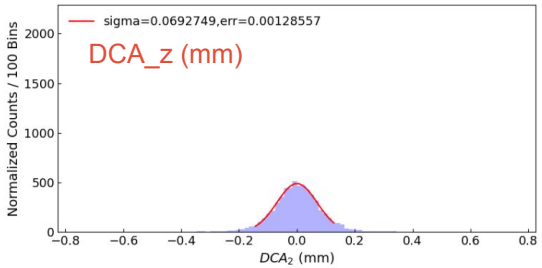






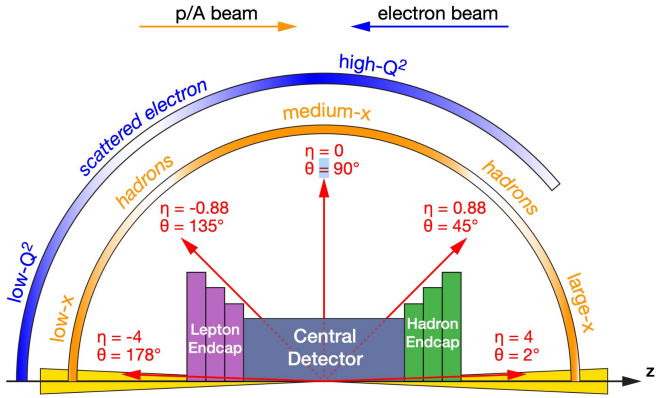






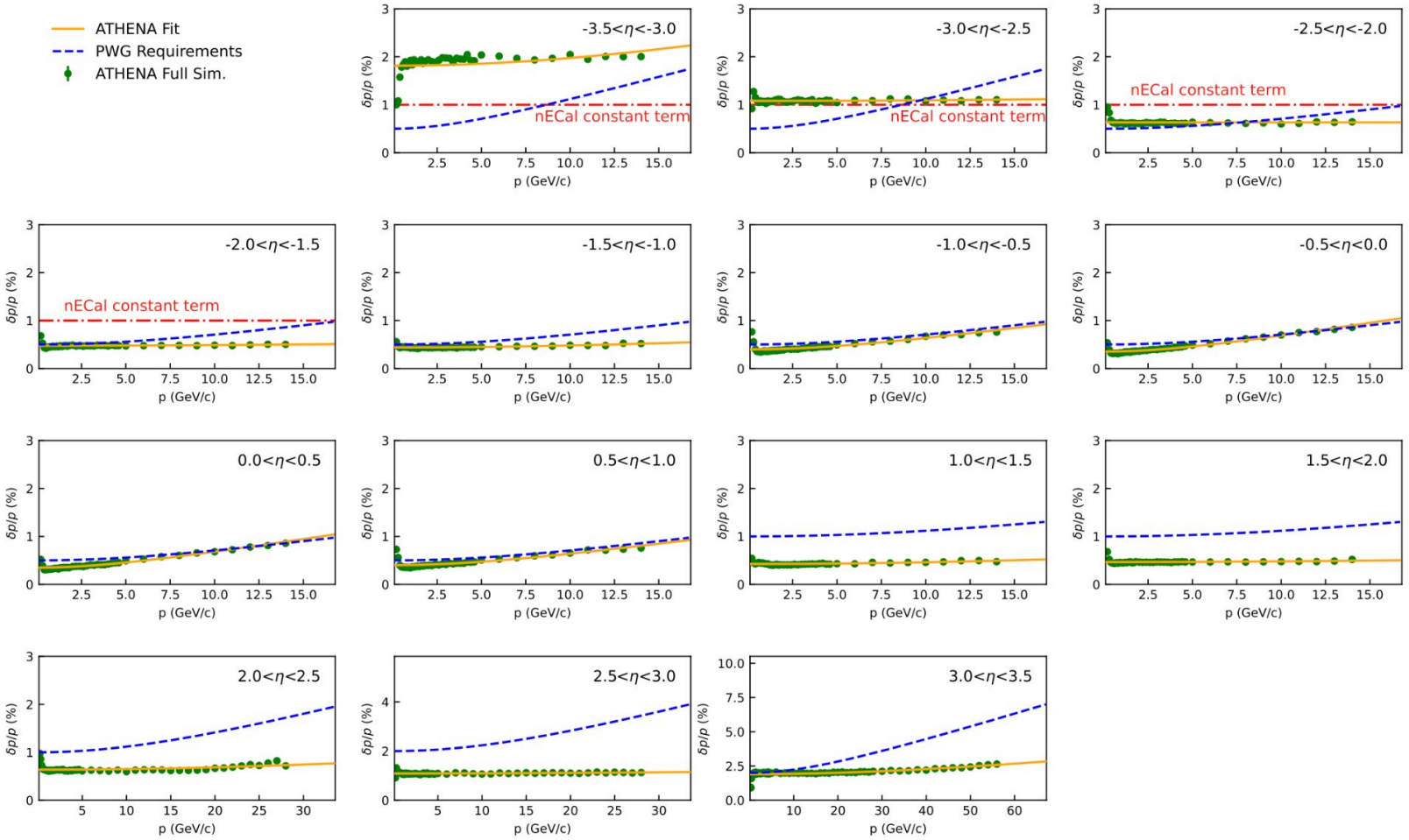
Benchmarked

Single Particle Track Reconstruction



Performance check against physics requirements from the EIC Yellow Report

dp/p:



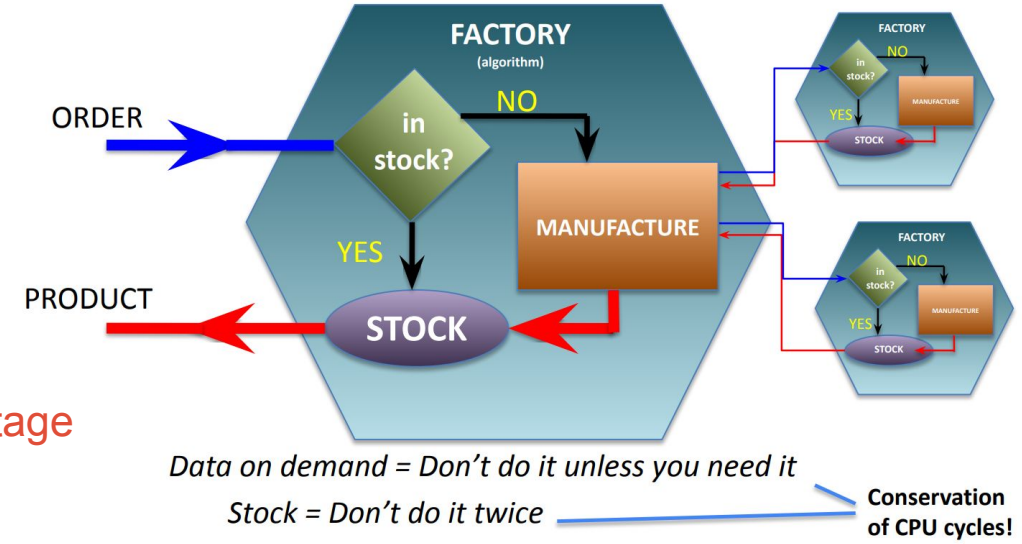
In-progress

EPIC Software Framework

https://eicweb.phy.anl.gov/EIC
https://github.com/eic
https://jeffersonlab.github.io/JANA2/index.html

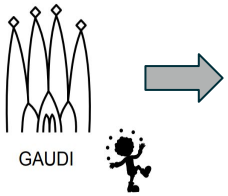
Component	Software Decisions
Geometry	DD4hep
Data model	PODIO/EDM4hep
Reconstruction Framework	Gaudi → JANA2
Code repo and CI	Github + Gitlab for CI/CD

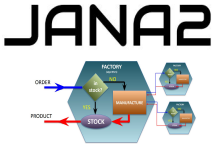
JANA2: cpp based multi-threaded event reconstruction tool form Jefferson Lab



- stay with ACTS 19 at this transition stage

Juggler/Gaudi algorithms wired together with python options scripts





JANA2 tries to automate wiring, while manual wiring is possible

EPIC Software Taskforce

https://eicweb.phy.anl.gov/EIC
https://github.com/eic

EPIC CompSW
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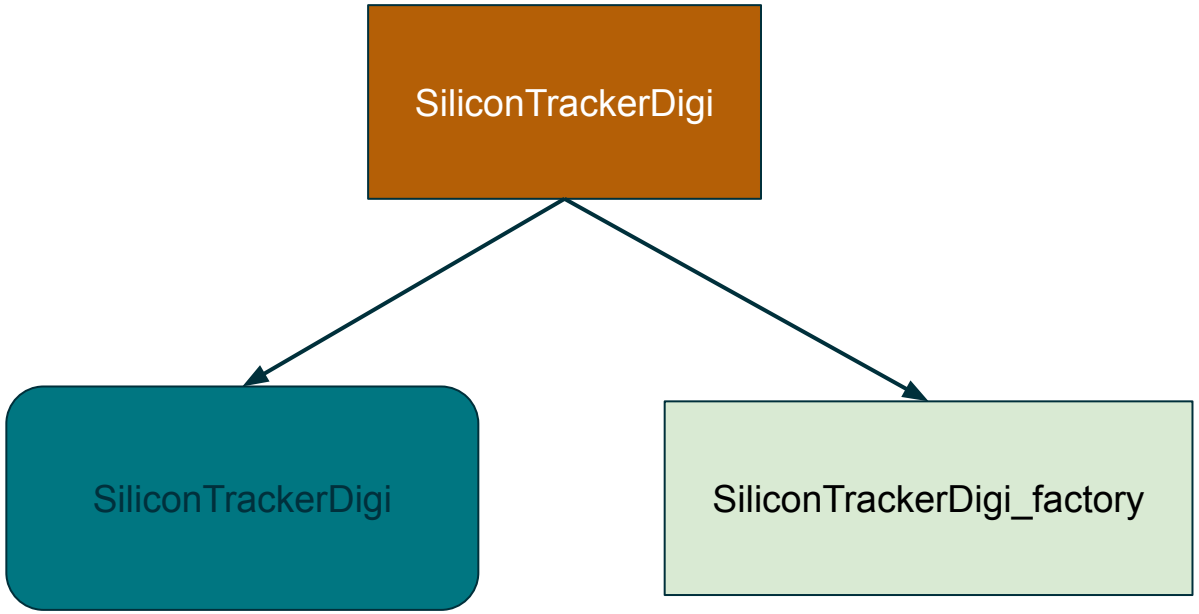
- EPIC Software and Computing WG
  - detector sub-system liaisons
- EPIC Simulation, Production, and Quality Assurance WG
- EPIC developer meeting
- EPIC-ACTS meeting: https://indico.bnl.gov/category/436/
- AI4EIC: https://eic.ai

Splitting algorithms to framework independent parts

Gaudi Algorithm with Gaudi properties, services, includes, etc.



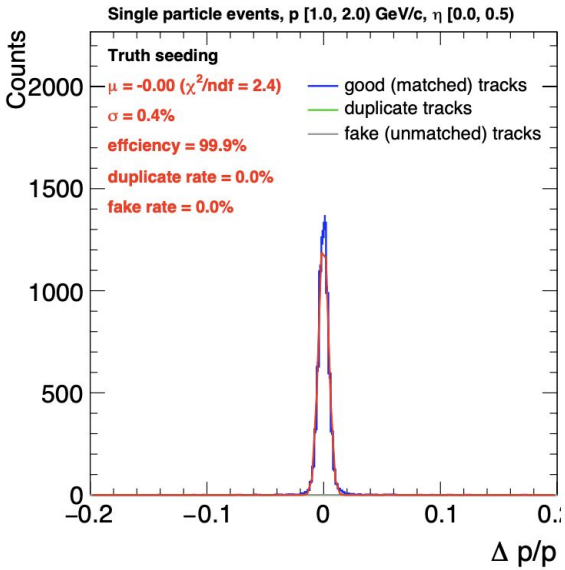
Framework independent, relying only on event model, libraries (like dd4hep) and other non framework related files

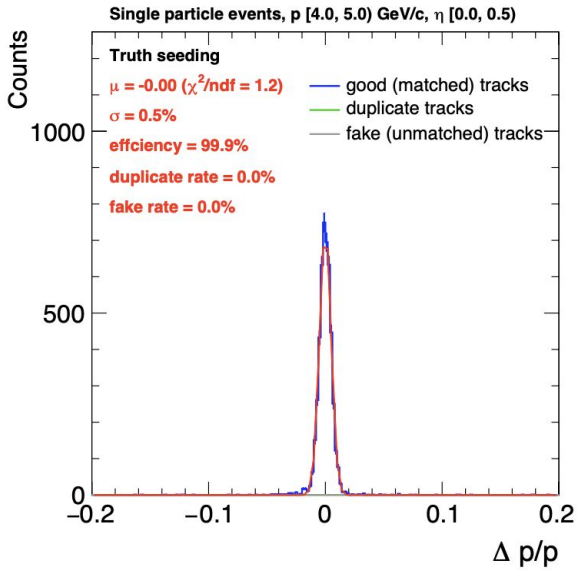
Framework related: JANA factories, parameters, services etc - framework related parts invoking algorithms

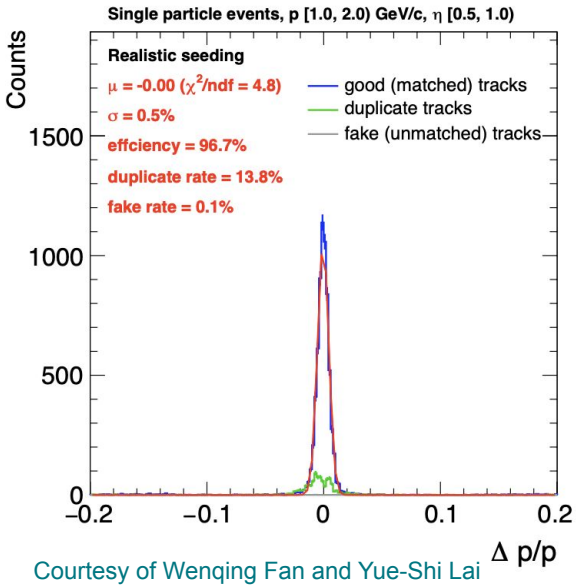
courtesy of Dmitry Romanov

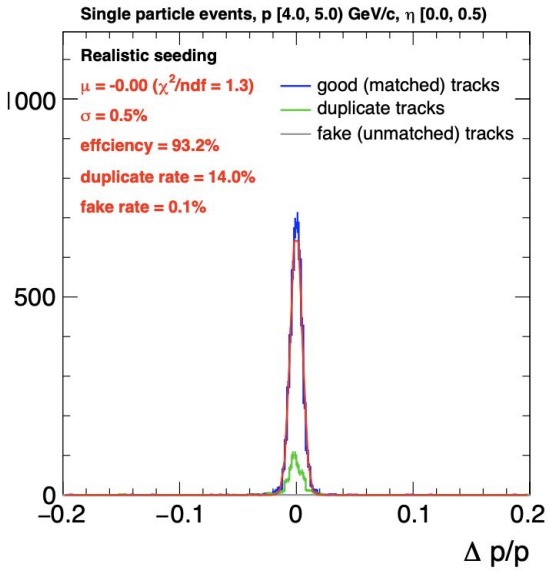
In-progress

Pattern Recognition for CKF Seeding









mid rapidity:

good performance with single pi+ event.

maxSeedsPerSpM=1

Forward/backward:

need to tweek search window

Courtesy of Wenqing Fan and Yue-Shi Lai

In-progress

Far-forward Tracking

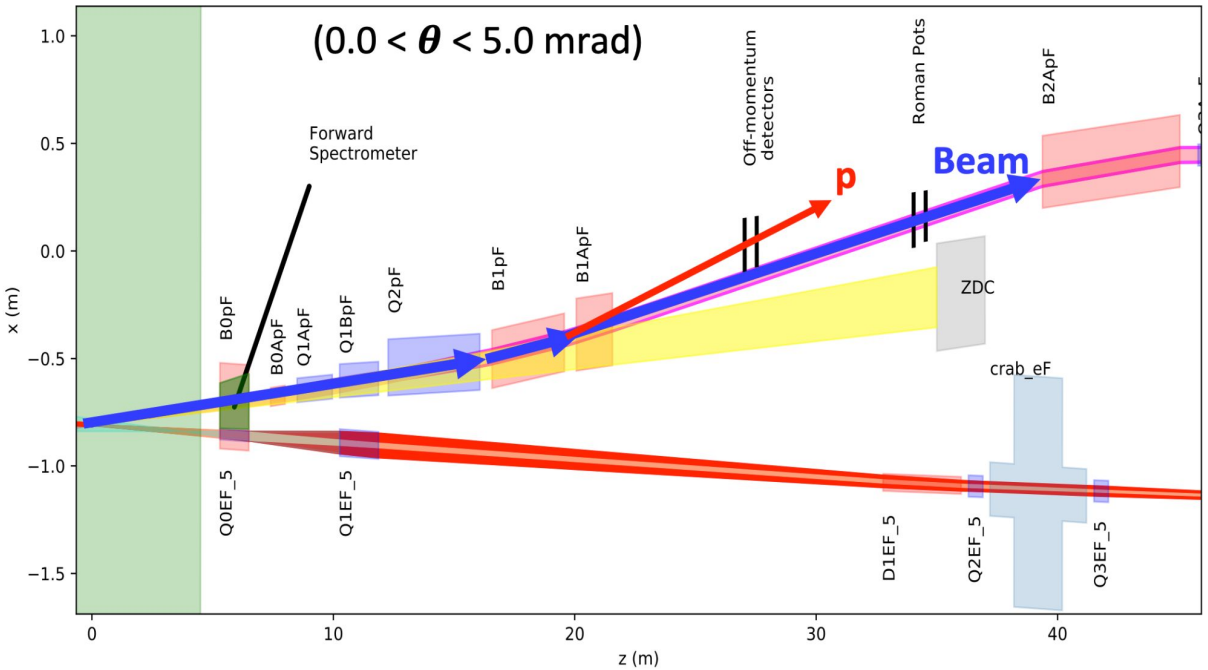
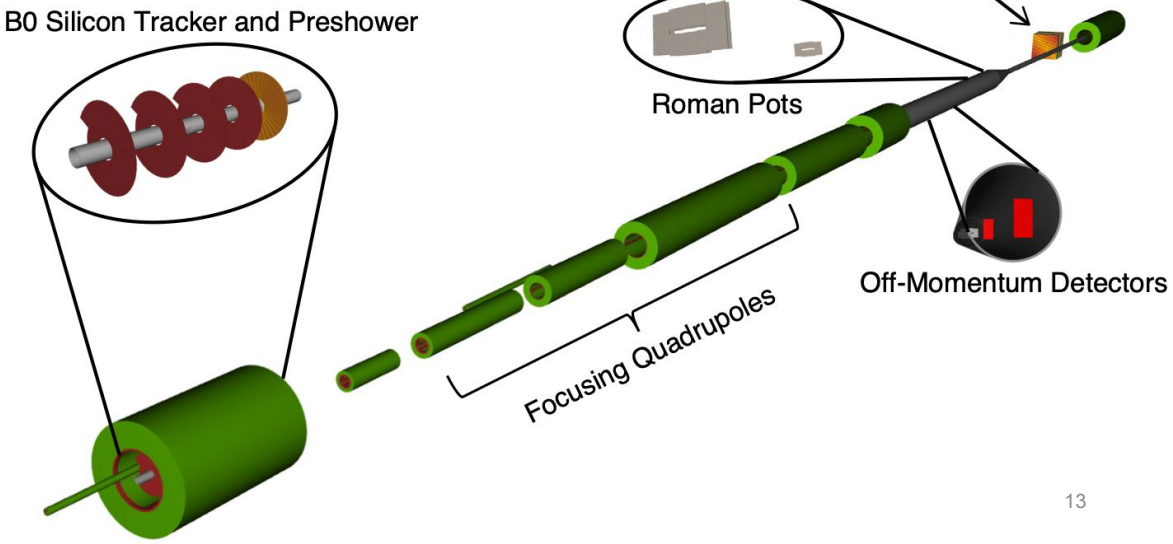


figure by A. Jentsch



In-progress

Far-forward Tracking

- silicon disks inside the B0 magnet in the hadron (forward) direction
- need the boundary description for non-trivial cut cylinders to describe the electron beampipe (off-axis at an angle).

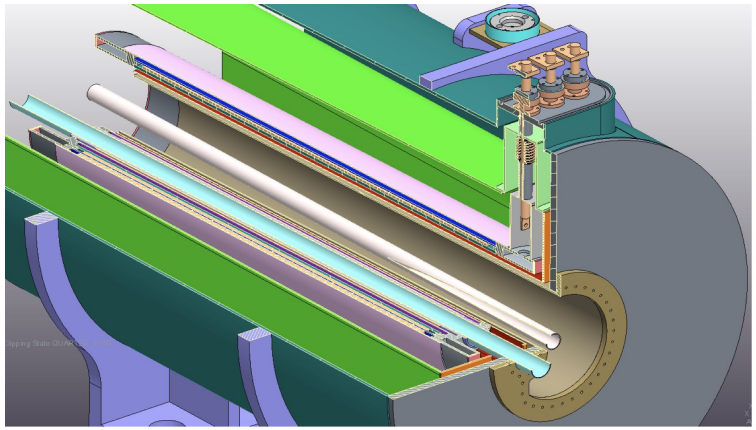
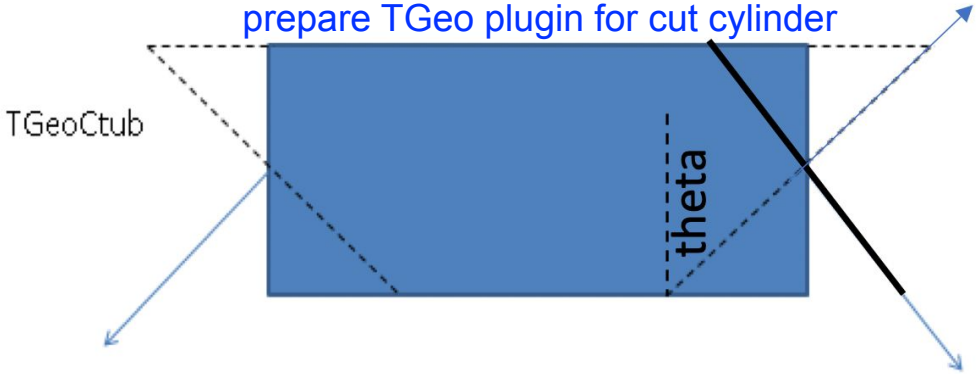
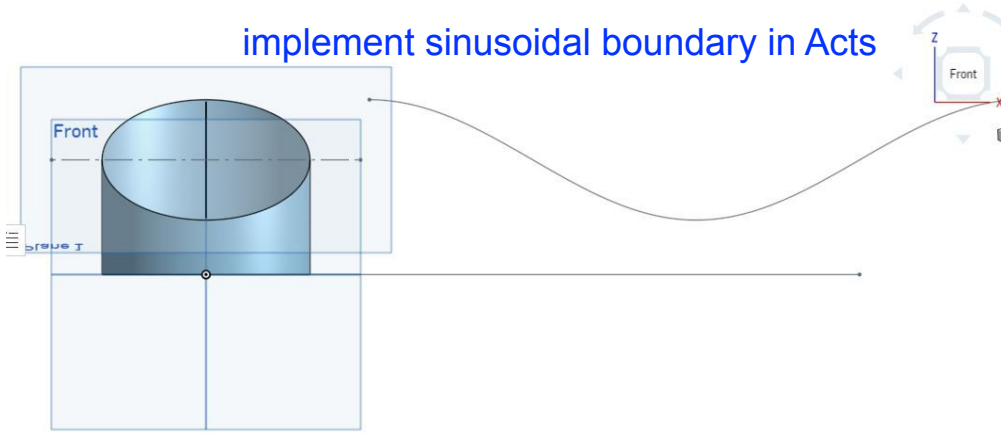


figure by A. Jentsch

prepare TGeo plugin for cut cylinder



implement sinusoidal boundary in Acts



Summary

The EIC-ePIC collaboration are developing a new software framework. The CKF from Acts is used for track finding/fitting. Ongoing efforts including material map auto-generation, realistic seeding, and special geometry implementation.

We are thankful for the tremendous support provided by ACTS developers.

Looking forward, we plan to:

- continue the EIC-ACTS meeting, and work closely with ACTS developers on track reconstruction. Also study background noise, vertex reconstruction, trajectory projection and cluster matching.
- make sure ACTS works fully with JANA2.
- start transition to ACTS 20 after the simulation campaign in October. Backporting of new features to v19 would be appreciated until then.
- follow the integration of ACTS tracking structure in EDM4hep
- explore SYCL and other multi-core/GPU parallelization strategies.

Thank You