



Track finding summary

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Seeding for EPIC

- Essential ingredient of a tracking pipeline
- Even in detector study, needed for realistic performance
 - Efficiency, fake rate, multiple reconstruction, etc.
 - Beam condition (synchrotron radiation, beam gas interaction)
- Old Juggler has a seeder using the “traditional” binned ACTS seeding algorithm
 - Has reasonable parameters for EIC and most ACTS pitfalls are fixed upstream or worked around
 - Performance was studied and within $\approx 1-2\times$ of the $\Delta p/p$ of truth seeding
 - Performance unfortunately ACTS version dependent (best/truth seeding-like performance with 19.9, but since deteriorated), unfortunately not understood (and require some major effort understanding ACTS subtleties)
 - Produces multiple seeds/truth track, and occasional seeding failure due to ACTS binning

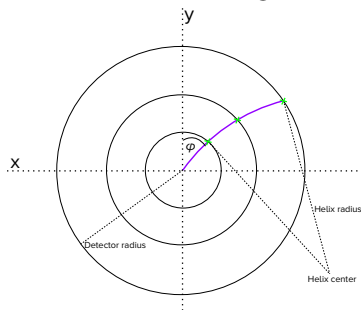
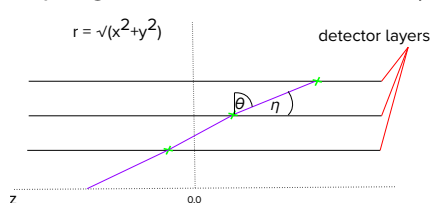
Seeding for EPIC

- “Orthogonal” seeder in EICrecon
 - Not ready
 - An experimental version that I use to understand ACTS behavior
- sPHENIX derived “orthogonal” seeder in EICrecon
 - (Sorry being critical) was advertised as “worry-free”, but with the very simplistic sPHENIX tracker
 - Pitfalls (≈ 6 seeds/track, $|\eta| < 3$ cutoff) very reminiscent of the binned seeder visible once running on EPIC geometry
 - A version uses ported parameters from the binned seeder, but still has ununderstood performance issues (e.g. the hard cutoff at $|\eta| < 3$)
 - Has own helix fit code

ACTS Seeding

<https://acts.readthedocs.io/en/latest/core/seeding.html>

- Triplet generation (not limited to 3 layers, and works for forward configuration)



- Triple-loop filtering based on reasonable curvature, compatible η , backprojection to the vertex z range, etc.
- Double-loop filtering, weighting seeds based on mergeability of seed groups (ideally merge to seeds with 5 space points), backprojection to the lowest vertex z and ρ possible
- Single-loop filtering to only retain the highest quality N seeds per middle space point

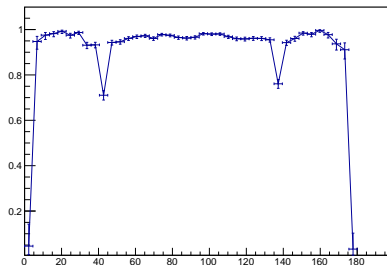
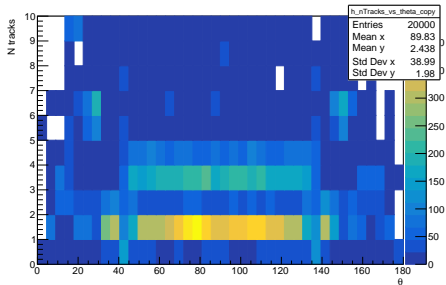
— Particle path within detector
— Particle measurement on detector surface

Binned seeding PR

The screenshot shows a GitHub pull request (PR) page. At the top, there's a search bar and a 'Sign in / Register' button. The PR title is 'Updated ACTS seeding code fixing multiple issues'. The author is Yue Shi Lai, who requested to merge the 'seeding-epic' branch into 'main' one week ago. The PR has 1 unresolved thread and 2 overview items. The description states: 'Avoid NaN and std::bad_alloc inside ACTS during the grid creation, due to specific pseudorapidity coverage, field strength, and minimum pT; custom association of hit to tracking surfaces; additional memory debugging checks'. It lists three issues addressed: 1. std::bad_alloc inside ACTS for virtually any EIC acceptance coverage, field strength and minimum pT (!). 2. Inefficient and sometimes incorrect hit-surface association, fixed by (re-)determine the hit-surface association through geometry service. 3. Removed eicd/edm4eic inheritance, which appears to have side-effects impacting seeding efficiency at 40 degrees angle. The right sidebar shows the assignee (Wouter Deconinck), reviewer (Wouter Deconinck), labels (None), milestone (None), time tracking (No estimate or time spent), lock merge request (Unlocked), and 2 participants.

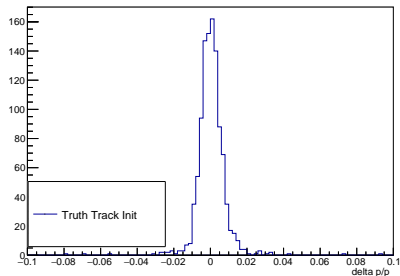
- https://eicweb.phy.anl.gov/EIC/juggler/-/merge_requests/494
- Drop-in replacement for TrackParamTruthInit
- Uses raw (global) hits and will query geometry/magnetic field by itself
- First version merged into Juggler \approx summer 2022, updated again December

Binned seeder performance

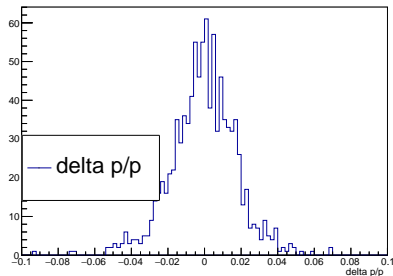


- Again 1–2 GeV/c
- Maximum seeds per space point middle set to 2 (minimum not yielding a poor efficiency)
- Mostly 1 seed/track, but some 3 or 4 seeds/track
- Can potentially be optimized at the cost of forward and intermediate region performance
- Observation is that this is a moving target from ACTS to ACTS version, maybe a issue with binned seeding

Midrapidity/forward performance



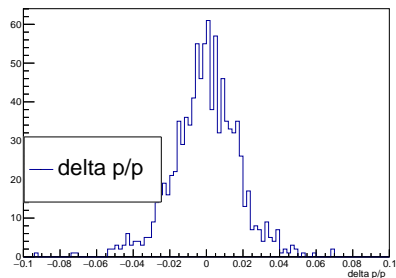
- 1–2 GeV/c and $|\eta| < 0.88$
- $\Delta p/p < 1\%$



- 1–2 GeV/c and $2 < \eta < 2.5$
- $\Delta p/p \approx 2\%$

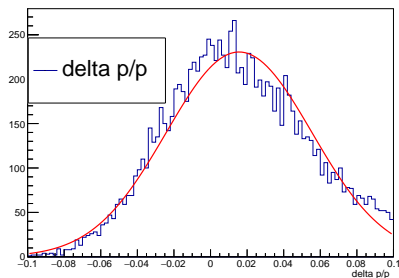
ACTS 19.9

ACTS version impact



$1 < p < 2 \text{ GeV}/c, 2 < \eta < 2.5$

ACTS 19.9, $\approx 2\%$

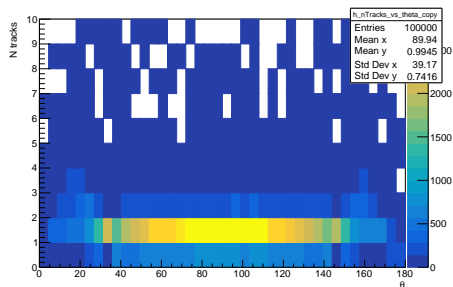


$1 < p < 2 \text{ GeV}/c, 2 < \eta < 2.5$

ACTS 20.3, $3.98 \pm 0.03\%$

- The code is prepared for ACTS 21.x, and I ran it earlier today
- There are visible seed filter changes, and the performance/additional parameter tunings has to be understood

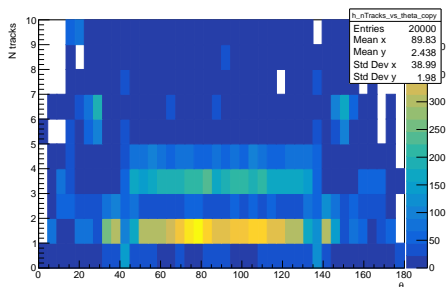
ACTS version impact



$1 < p < 2 \text{ GeV}/c$

ACTS \approx 15-16

- Also N_{track} used to be much more “normal”
- 19.9 infact retuned to maximally reduce duplicate seeds



$1 < p < 2 \text{ GeV}/c$

ACTS 19.9

Summary

- 3 implementations of seeder (not fully “decorrelated”)
- At least 1 existing working point for seeding
 - Caveat 1: Multiple seeds
 - Caveat 2: Performance difference to truth seeding
- Painful to track ACTS version changes and associated performance differences
 - ⇒ Ongoing effort, requires deep understanding of the ACTS interna
- Naïve port of an sPHENIX seeder shows similar behavior/worry with N_{track} at EPIC
 - Challenges inherent to EPIC and performance for simpler hadron collider experiments do not translate
 - ⇒ Understanding of ACTS inner working will be crucial