

# Joint tracking + Jets/HF Workfest – Vertexing Session

Xin Dong (LBNL)

Olga Evdokimov (UIC)

Brian Page (BNL)

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# Topics studied

We had presentations and studies on three topics:

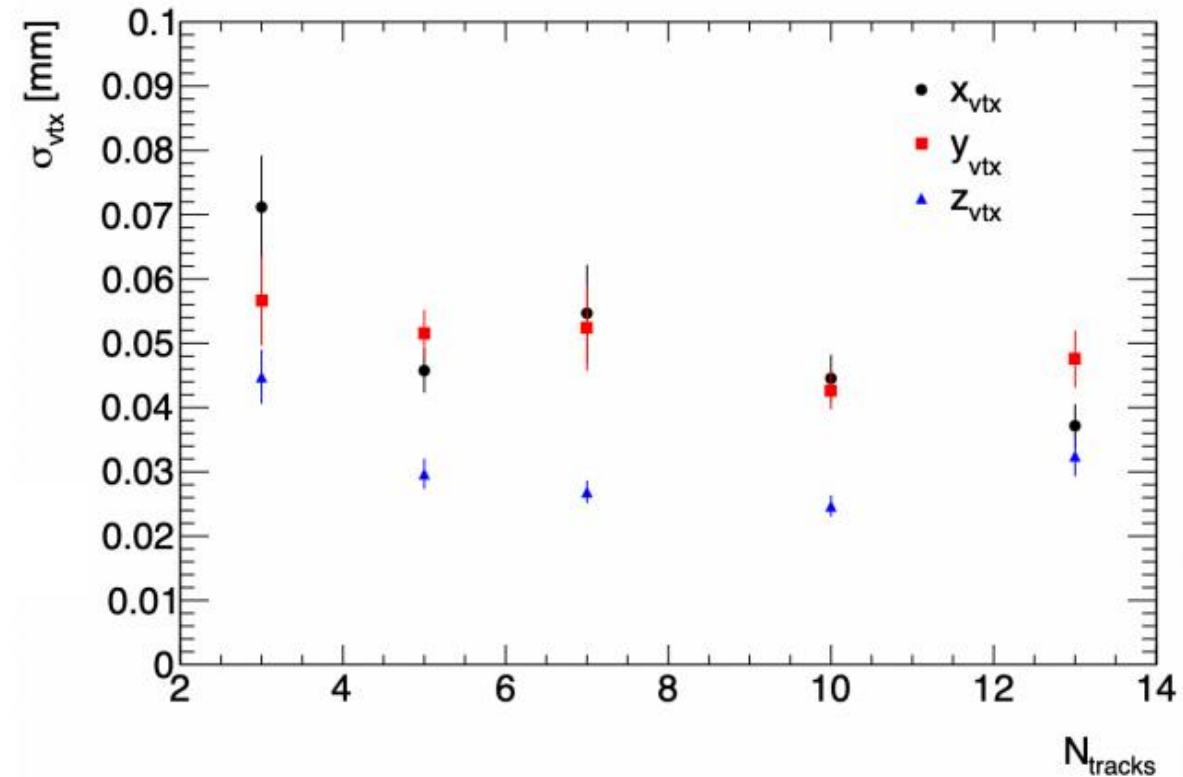
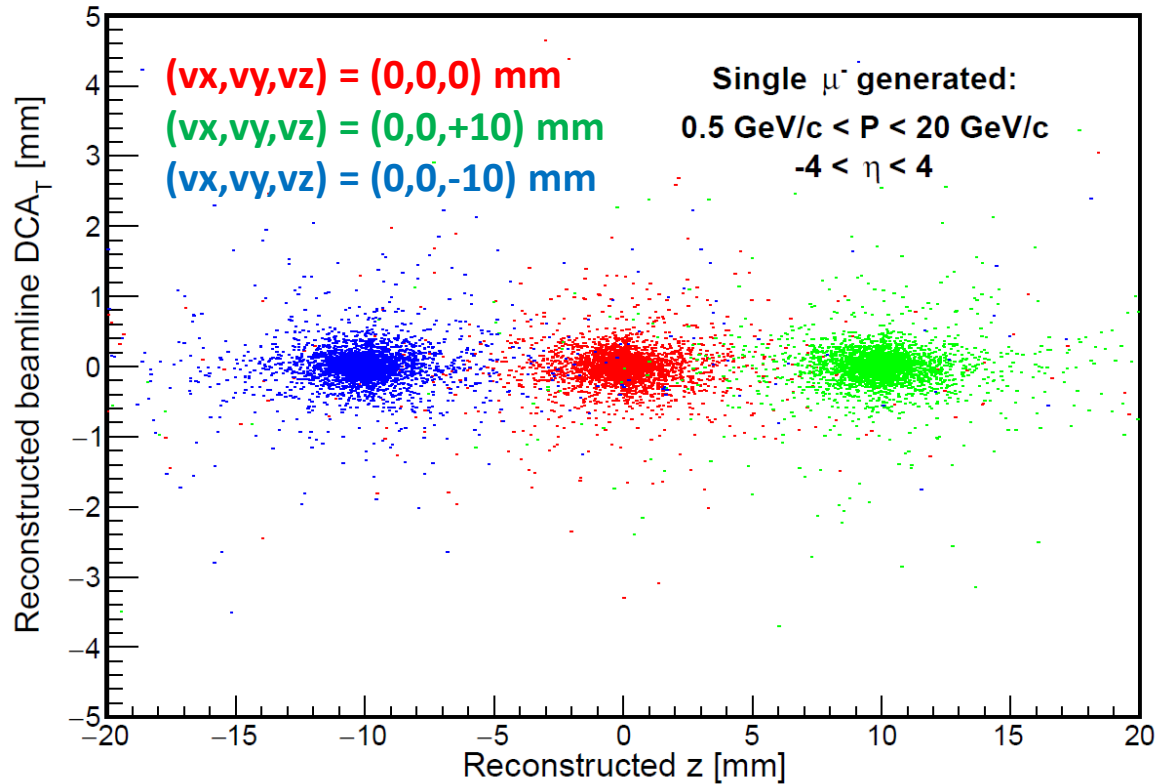
1. Primary vertex reconstruction resolution performance
2. Real-seeded tracking with single particles
3. Tracking efficiencies for DIS events

# Single and few-particle performance tests

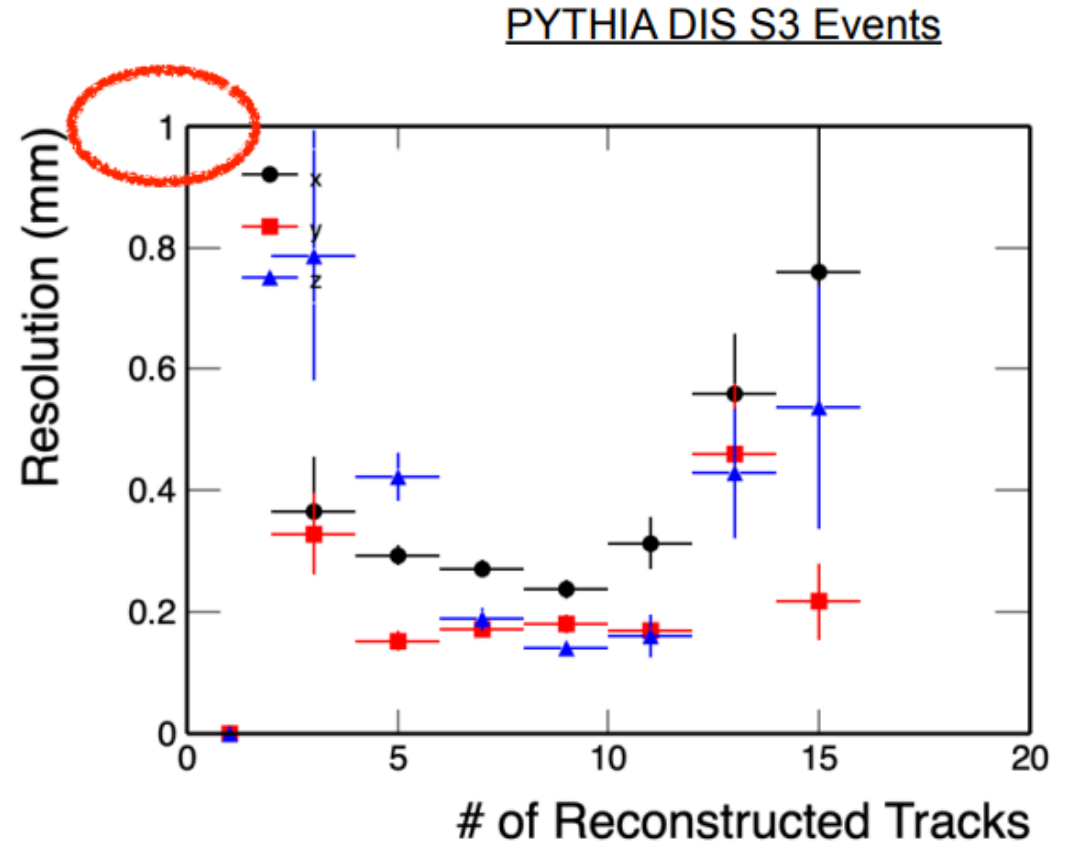
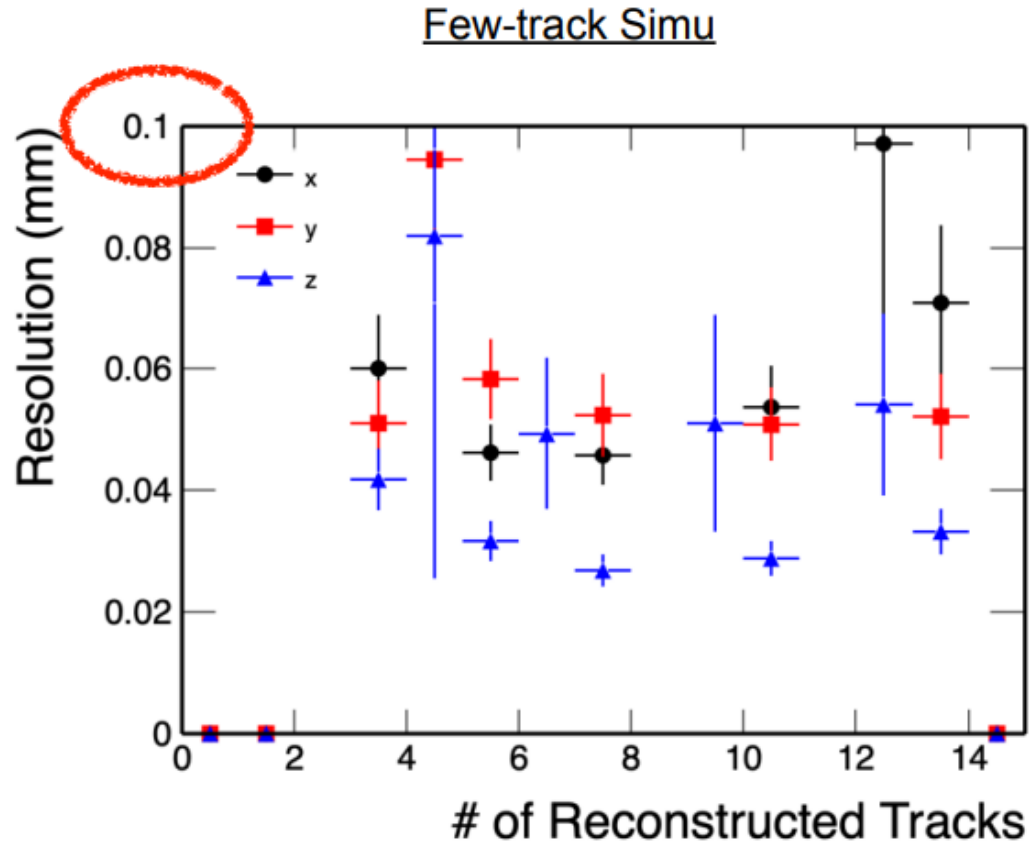
Single particle thrown

N pions thrown flat in acceptance and flat in  $0.2 < p_T < 5$  GeV at a fixed vertex  $(0,0,20)$  mm

Truth-seeded tracking



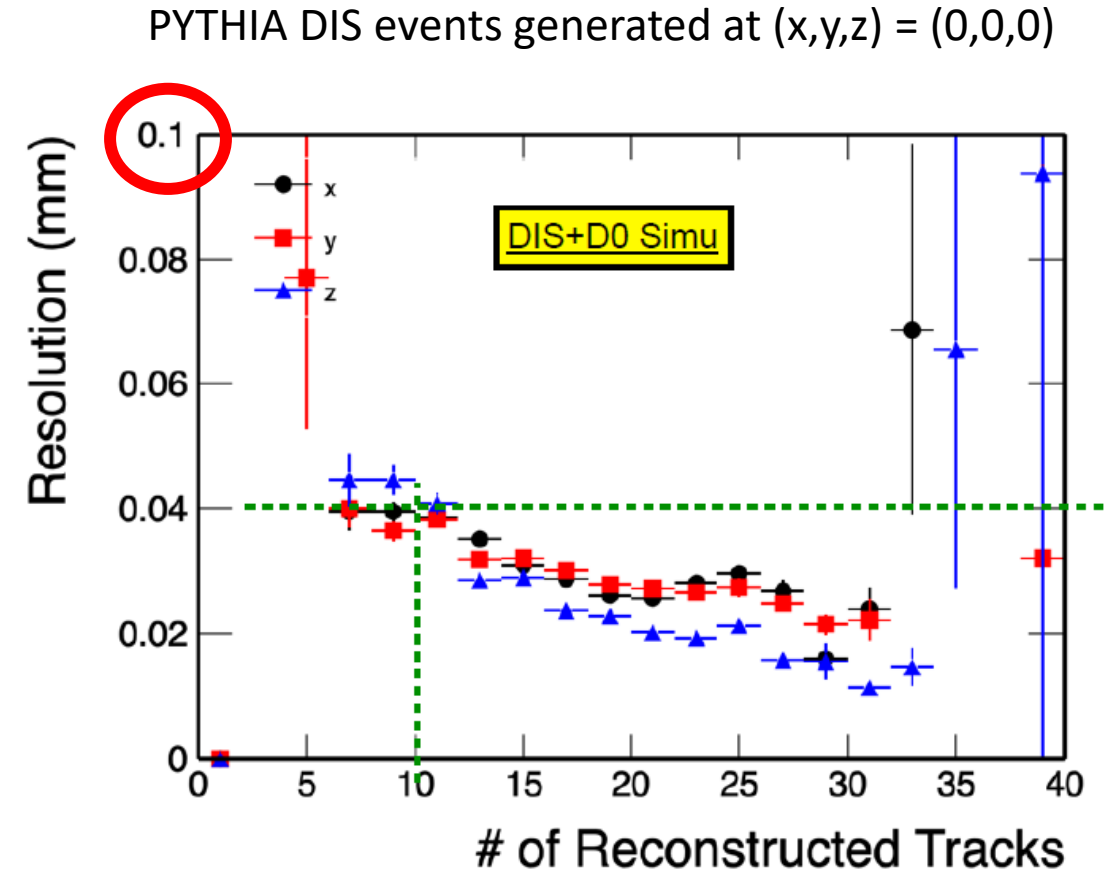
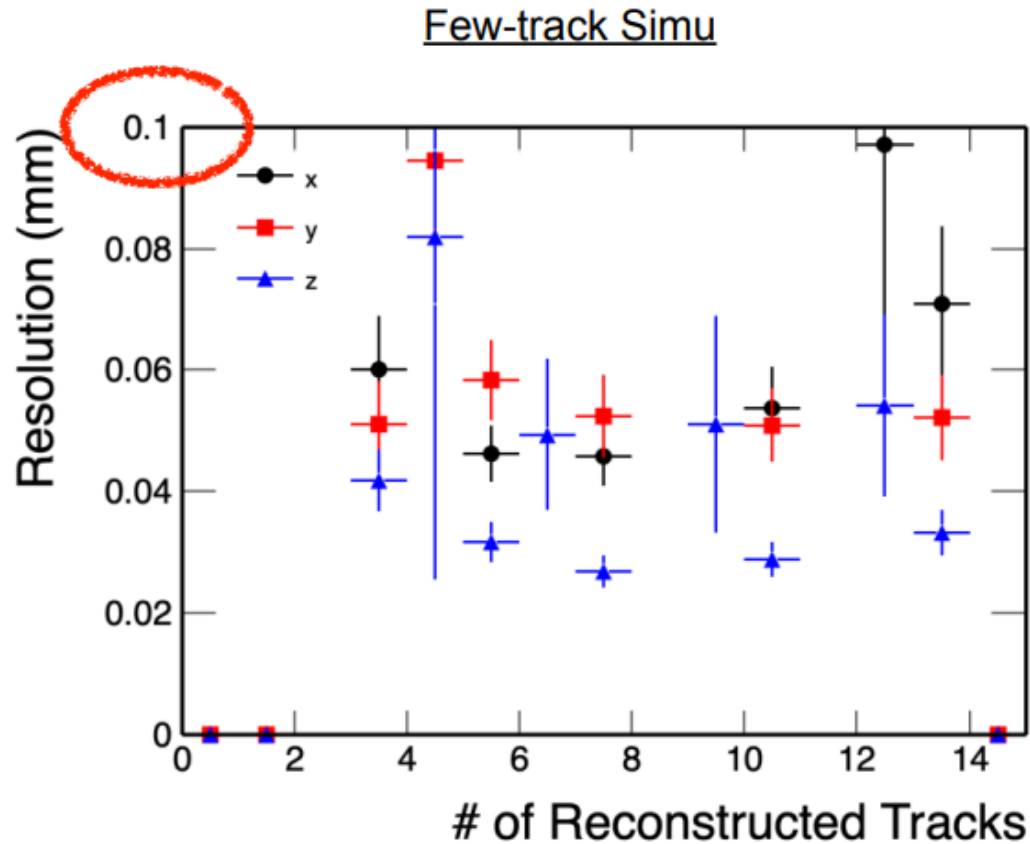
# Few-particle simulation vs. DIS events



**Few-track simulation** – truth-seeded tracking with all particles generated at a fixed point on the z axis.  $(x,y) = (0,0)$ .

**PYTHIA DIS S3 Events** – truth-seeded tracking including realistic beam effects, crossing angle and beam spot size

# Few-particle simulation vs. DIS events

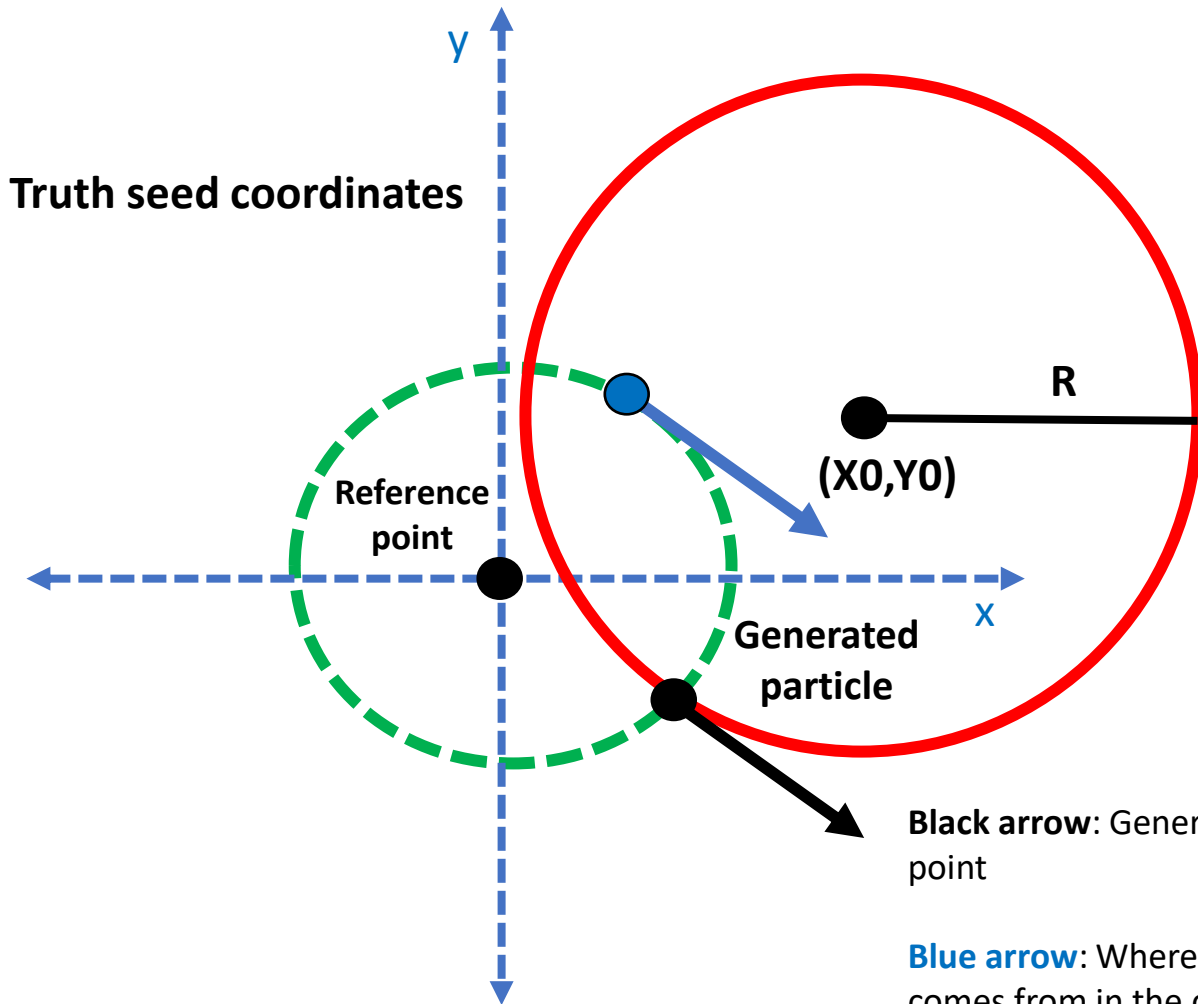


**Few-track simulation** – truth-seeded tracking with all particles generated at a fixed point on the z axis.  $(x,y) = (0,0)$ .

**PYTHIA DIS Events** – truth-seeded tracking not including realistic beam effects, crossing angle and beam spot size

# Potential issue in coordinate transformations

<https://acts.readthedocs.io/en/latest/core/geometry/surfaces.html#line-surface>



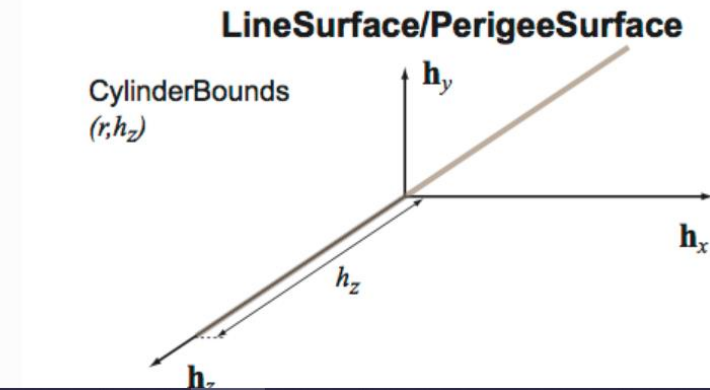
**Black arrow:** Generated particle at its creation point

**Blue arrow:** Where the CKF will think the particle comes from in the current truth seeding implementation.

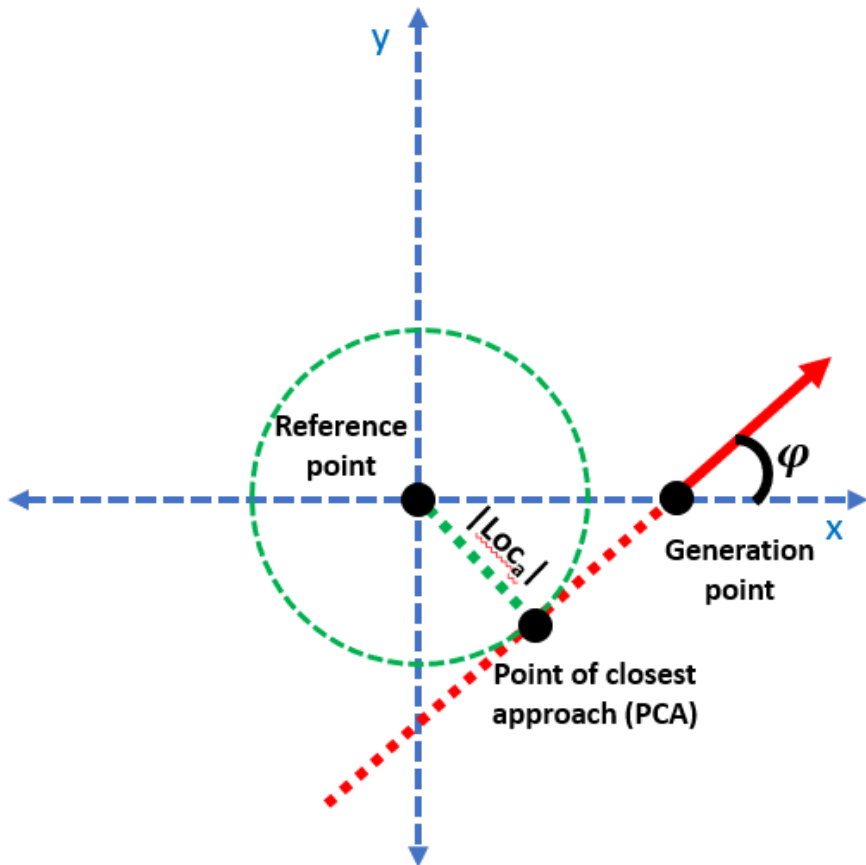
`Acts::LineSurface` is a special kind of surface that depends on a reference direction, typically the unit momentum direction  $\vec{d}$  of a particle. A point in space is considered *on surface* if and only if it coincides with the point of closest approach between the direction vector  $\vec{d}$  and the line direction vector  $\vec{z}$ . As such, the function `Acts::LineSurface::globalToLocal()` can fail, if the argument position and direction do not fulfill this criterion. It is pure-virtual, meaning that it can not be instantiated on its own.

```
class LineSurface : public Acts::Surface
```

Base class for a linear surfaces in the TrackingGeometry to describe dirft tube, straw like detectors or the Perigee It inherits from Surface.

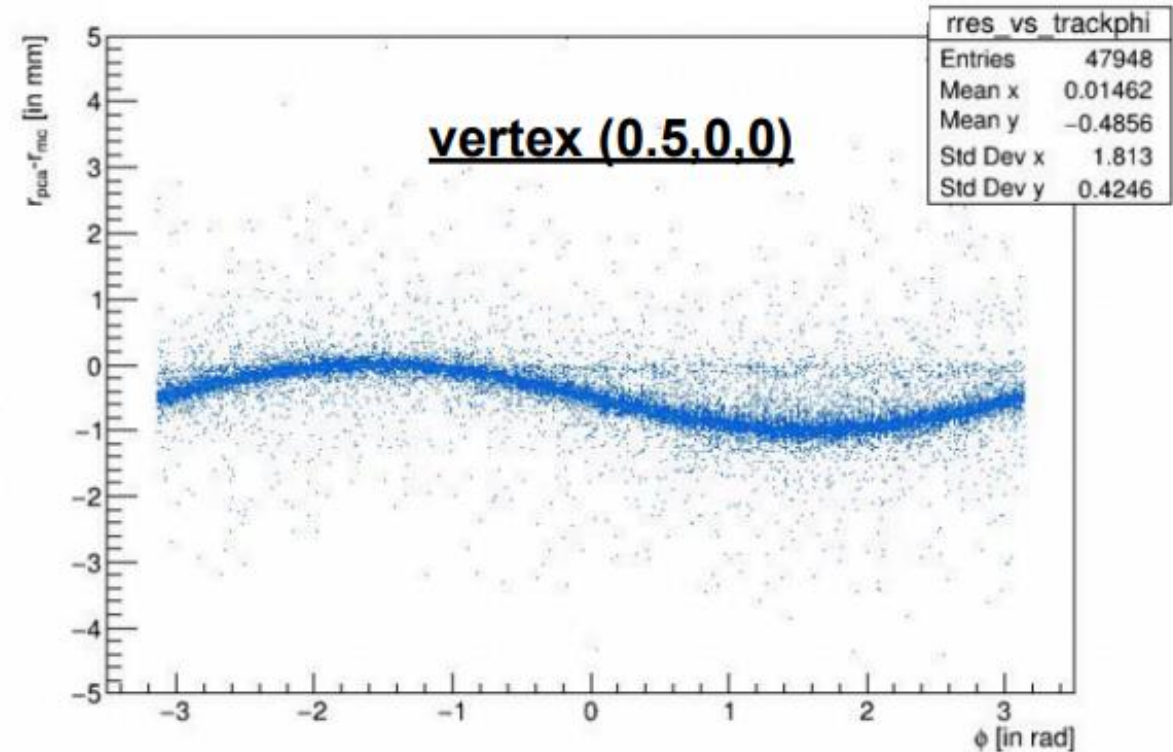


# Implementing a simple fix

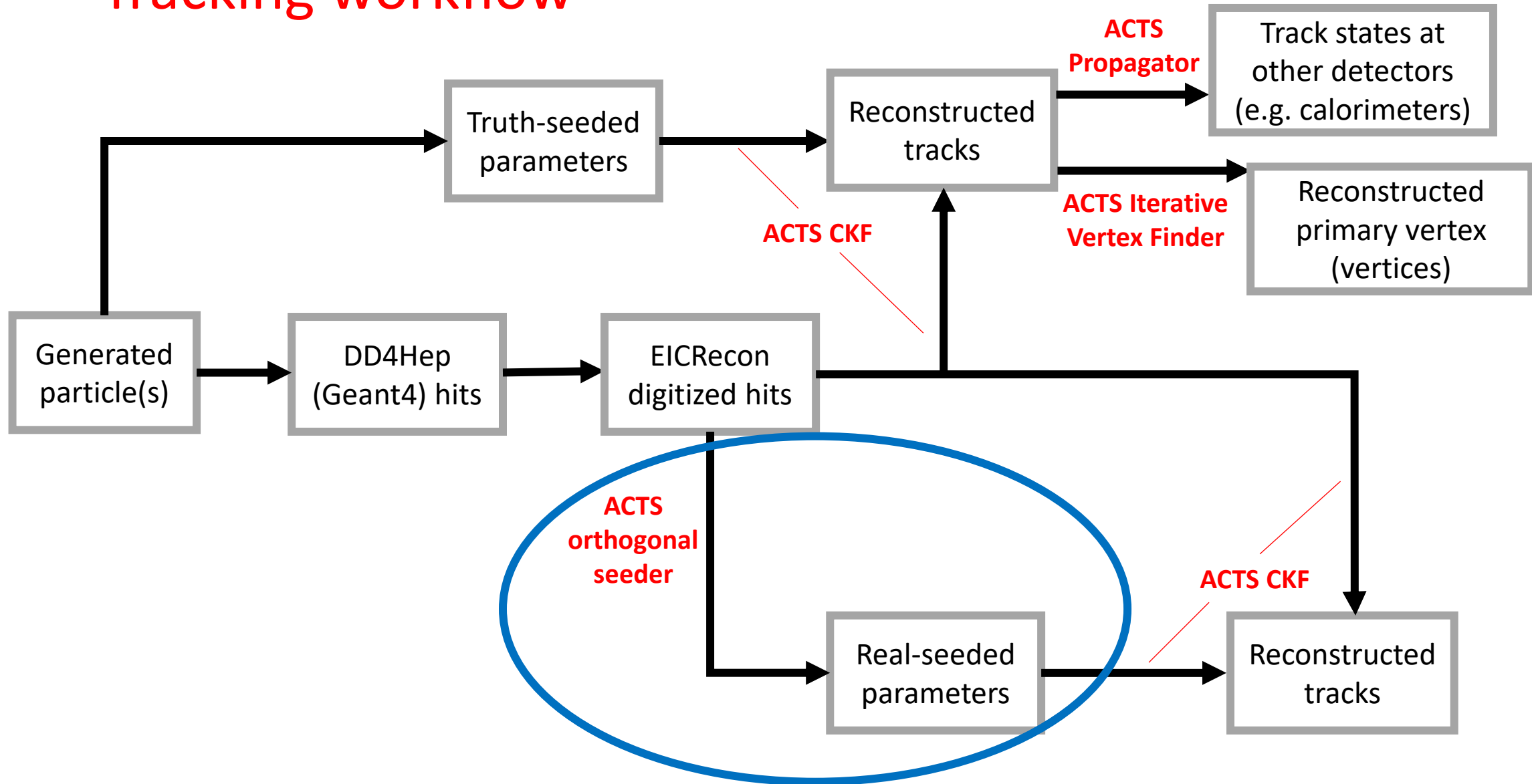


Single particle thrown after applying fix

Harsimran Singh



# Tracking workflow

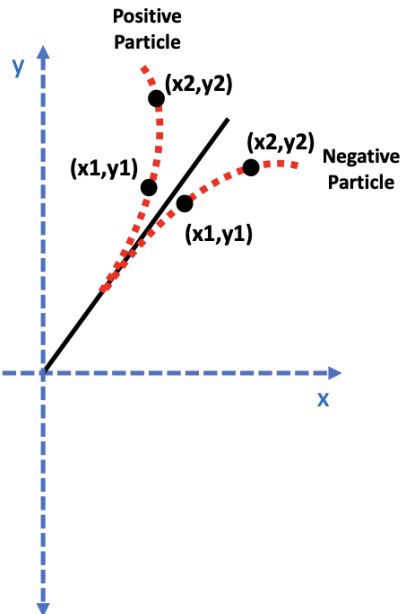




# Updates to realistic seeder based on single-particle simulation

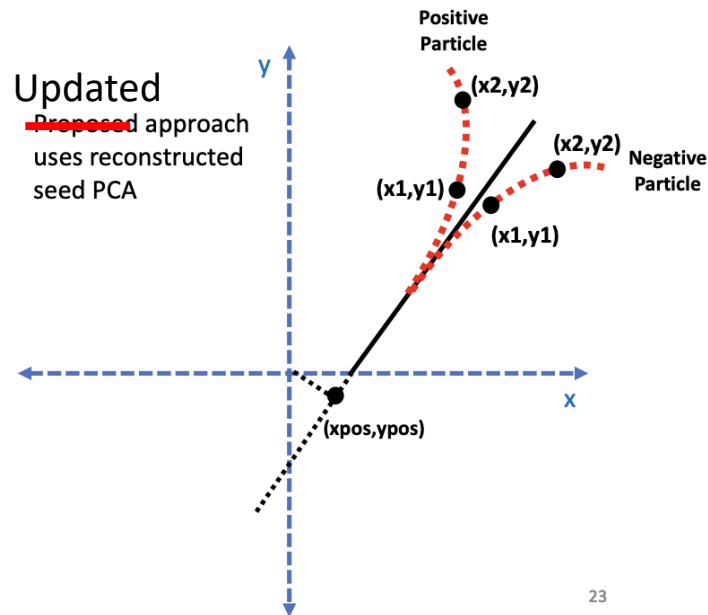
- ❑ Fix to globalToLocal seed conversion. EICRecon PR [#1185](#)
- ❑ Fix to seed charge calculation. EICRecon PRs [#1213](#), [#1214](#)

Previous  
~~Current~~  
approach does  
comparison with  
respect to (0,0)



1/10/2024

Updated  
~~Proposed~~  
approach  
uses reconstructed  
seed PCA



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Here is some statistics to validate this request:

N=10k events, muon with eta -4 to 4, and momentum 0.5 to 20 GeV

Negative muon at (0,0,0)  
Total seeds: 25774  
Wrong charge seeds (pre-fix): 301 (1.2%)  
Wrong charge seeds (post-fix): 224 (0.87%)

Negative muon at (1,0,0) mm  
Total seeds: 25521  
Wrong charge seeds(pre-fix): 5407 (21.1%)  
Wrong charge seeds(post-fix): 230 (0.9%)

Positive muon at (1,0,0) mm  
Total seeds: 27688  
Wrong charge seeds(pre-fix): 5376 (19.4%)  
Wrong charge seeds(post-fix): 368 (1.3%)

This shows that the results are stable for particle generated at z=0.  
for particles generated off the beam axis, the results improve  
significantly for both positive and negative muon.

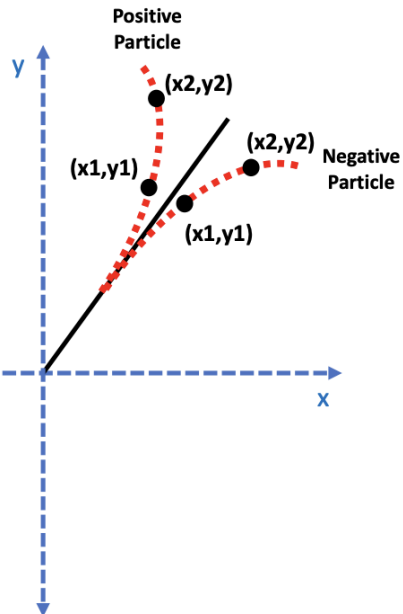
Jeetendra Gupta

1/13/2024

# Updates to realistic seeder based on single-particle simulation

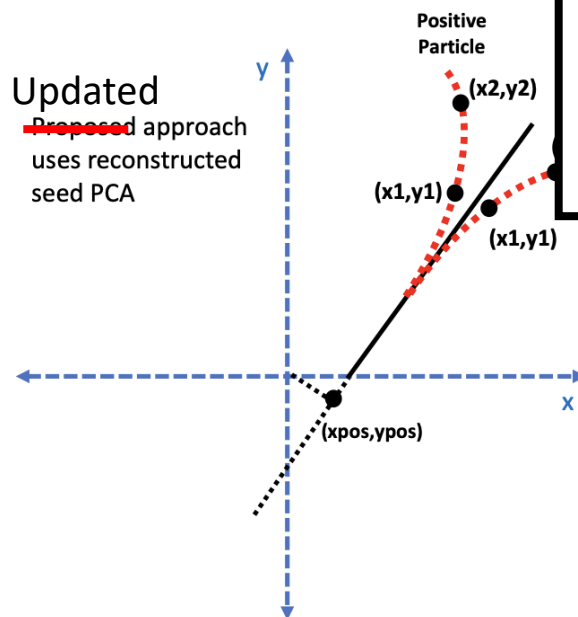
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Previous  
~~Current~~  
approach does comparison with respect to (0,0)



1/10/2024

Updated  
~~Proposed~~  
approach uses reconstructed seed PCA



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Ongoing efforts with real seeder:

- ❑ Additional checks with single-particle simulations
- ❑ Removal of duplicate seeds. [Minjung Kim](#)
- ❑ Then we can study vertexing with the real-seeded tracking.

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Jeetendra Gupta

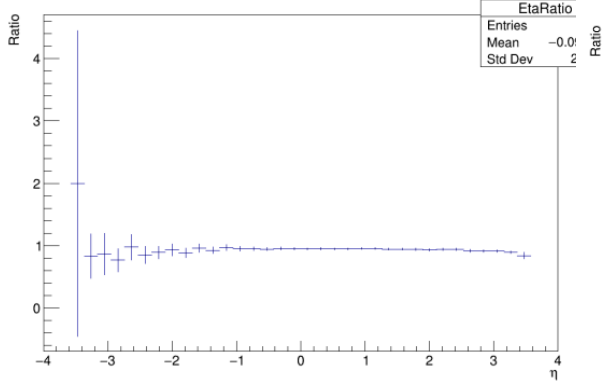
# (Truth-seeded) Track efficiency in DIS events

PYTHIA DIS S3 events

Tracking and/or matching  
inefficiency observed for protons

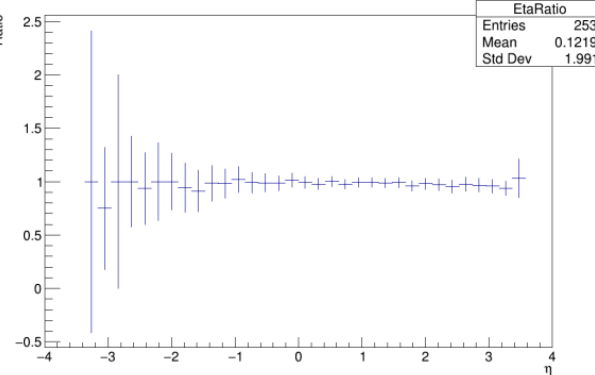
**Pions**

Ratio Eta, 0.0 GeV/c < pT < 20.0 GeV/c



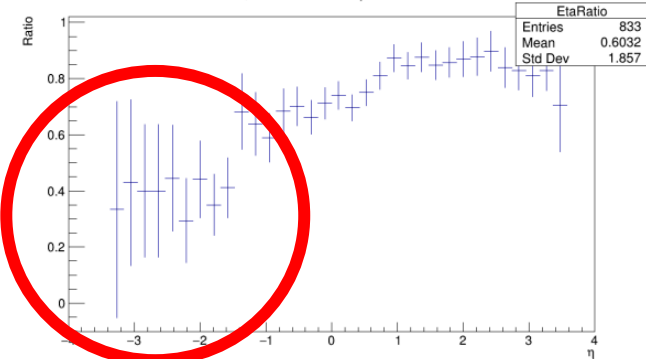
**Kaons**

Ratio Eta, 0.0 GeV/c < pT < 20.0 GeV/c



**Protons**

Ratio Eta, 0.0 GeV/c < pT < 20.0 GeV/c

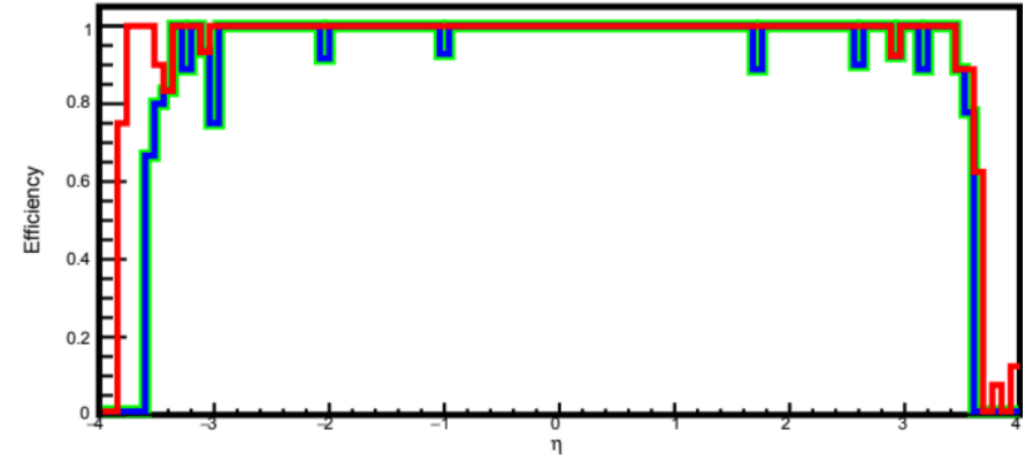


Efrain Alvarado

Single-particle proton simulation

No inefficiency observed

Tracker Efficiency vs. generated particle  $\eta$



Jeetendra Gupta

More studies are needed to understand this difference.

# Summary

Overall, this session was very successful at identifying some ongoing issues with the vertexing and track reconstruction, and then implementing/planning some fixes for these issues.

# Joint Particle Flow + Jets/HF Workfest

Derek Anderson (ISU)

Olga Evdokimov (UIC)

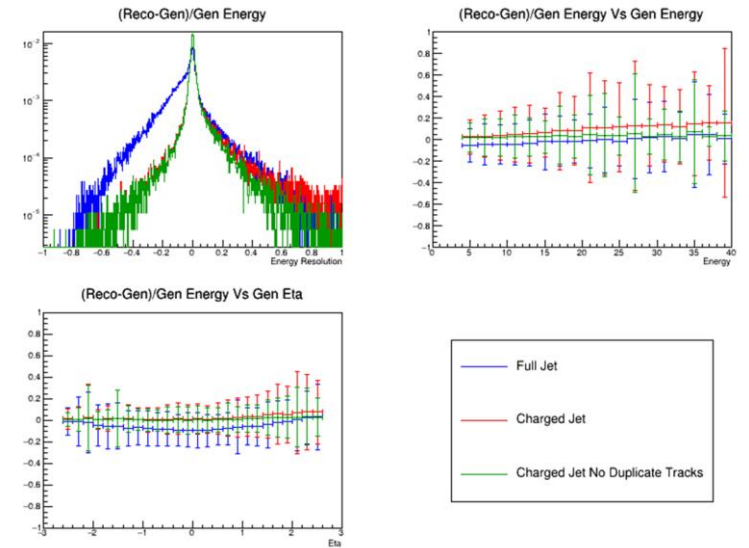
Brian Page (BNL)

# Particle Flow / Jet & HF Session

- ❑ Second day of Jet & HF sessions focused on development of the particle flow algorithm
  
- ❑ Introductory talks:
  - ❑ Jet benchmarks
  - ❑ Particle flow algorithm / factory status
  - ❑ Backward Hcal
  
- ❑ Identified a set of tasks to work on in open session:
  - ❑ Particle Flow
    - ❑ Visualizer
    - ❑ Downstream validation
    - ❑ Code review and debugging
  
  - ❑ Jet Factory Maintenance
    - ❑ Migrate to OmniFactory
    - ❑ Implement PODIO functionality
  
  - ❑ Begin work on physics benchmarks

# Talk Highlights

- ❑ Brian discussed the status of jet benchmarks
  - ❑ Have been doing benchmarks manually
  - ❑ Need to go through Dima's tutorial to get these in the official framework 😊



- ❑ Derek gave an overview of the status of the Particle Flow Algorithm
  - ❑ Served as a good introduction for defining workfest tasks

Particle Flow Discussion | To-Do

**Missing Infrastructure (Major):**

- PF Framework
  - › Factories
  - › Algorithm + configuration files
- Improved track-cluster associator
  - › Extend to include Hcals
  - › However, truth-based implementation may work for interim

**Missing Infrastructure (Minor):**

- PFObject Visualizer:
  - › Plugin (or service?) to visualize clusters, tracks, etc.
  - › Crucial for debugging
- Downstream analysis:
  - › Code to look at impact of changes
  - › Existing jet benchmarks are good starting place

**Open Questions:**

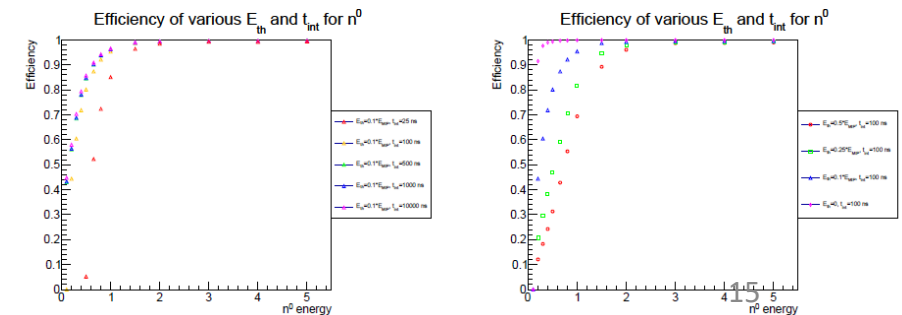
- Does implemented cluster splitting work in non-enabled\* detectors?
- How well do existing MC-cluster associations work?
  - › Currently handled by MatchClusters algorithm
  - › Would a separate MC-cluster associator be better?

**Legend:**

- Major** = necessary for implementation
- Minor** = can be pursued in parallel with implementation
- Yellow** = connection with other groups
- \* = existing implementation enabled for central ECals and ECalLumiSpec (not enabled for Imaging/SciFi)

July 13<sup>th</sup>, 2023 | Derek Anderson, ePIC, JET/IF WG | 10/10

- ❑ Leszek gave an update on the status of the backward HCal
  - ❑ Good discussion on where we should focus effort to validate its use in jet reconstruction



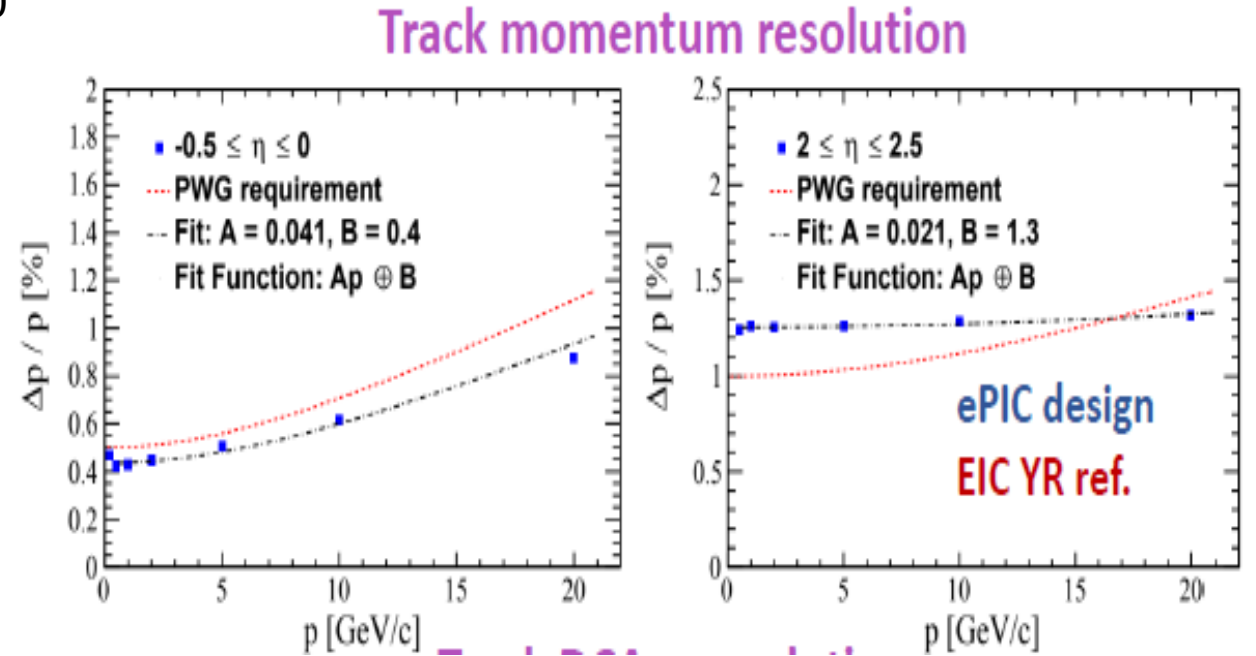
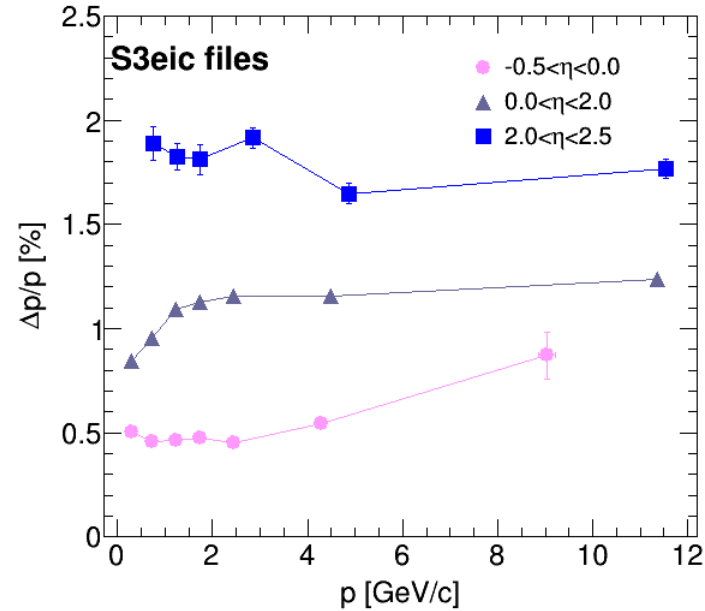
# Workfest Highlights

- ❑ Virginia Bailey (GSU) began work on developing Particle Flow visualization tools, but progress is impeded by lack of hit-cluster associations in PODIO output.
  - ❑ Issue opened on Github: (Issue #1223) [<https://github.com/eic/ElCrecon/issues/1223>]
  - ❑ **Just resolved today (PR #1224) Big thanks to Dima and Wouter!**
- ❑ Settled on plots for PF algorithm validation (JES/JER, PES/PER, Kinematics, Multiplicity, performance of cluster splitting, performance of track/cluster matching, angular resolution)
- ❑ Tristan Protzman (Lehigh) resolved a serious memory bug preventing work on initial Particle Flow algorithm from continuing
  - ❑ PR associated with implementation of initial PFAlpha is (PR# 1186) [<https://github.com/eic/ElCrecon/pull/1186>]
- ❑ The PRs associated with implementing PODIO relations and converting the jet factories to JOmniFactory's are:
  - ❑ (PR #1217) [<https://github.com/eic/ElCrecon/pull/1217>]
  - ❑ (PR #1067) [<https://github.com/eic/ElCrecon/pull/1067>]



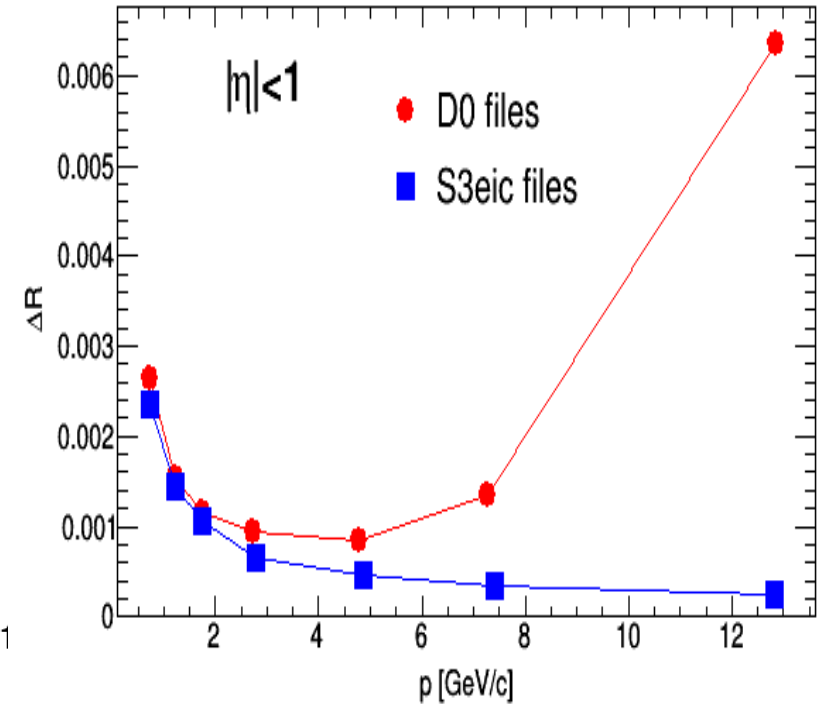
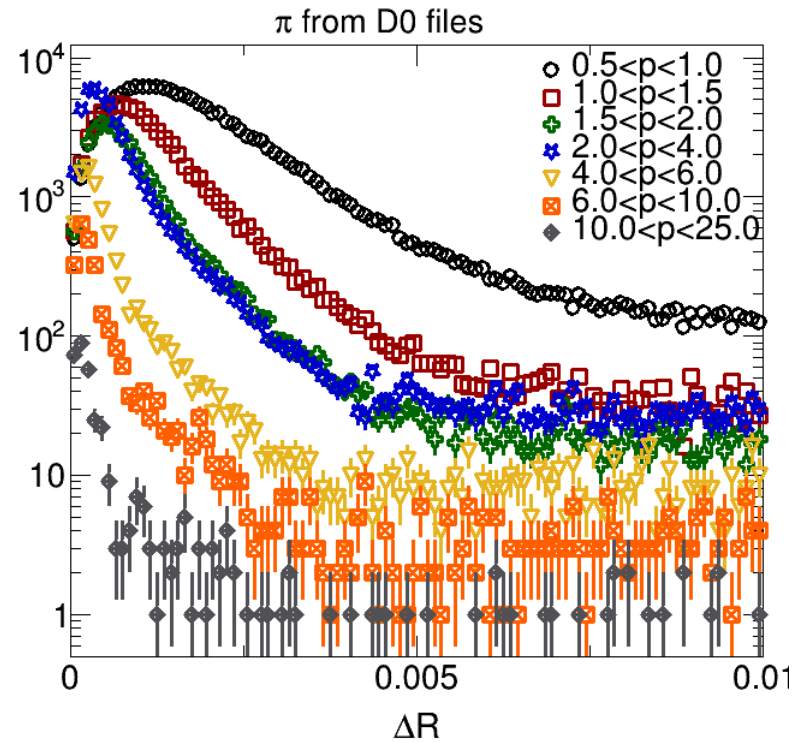
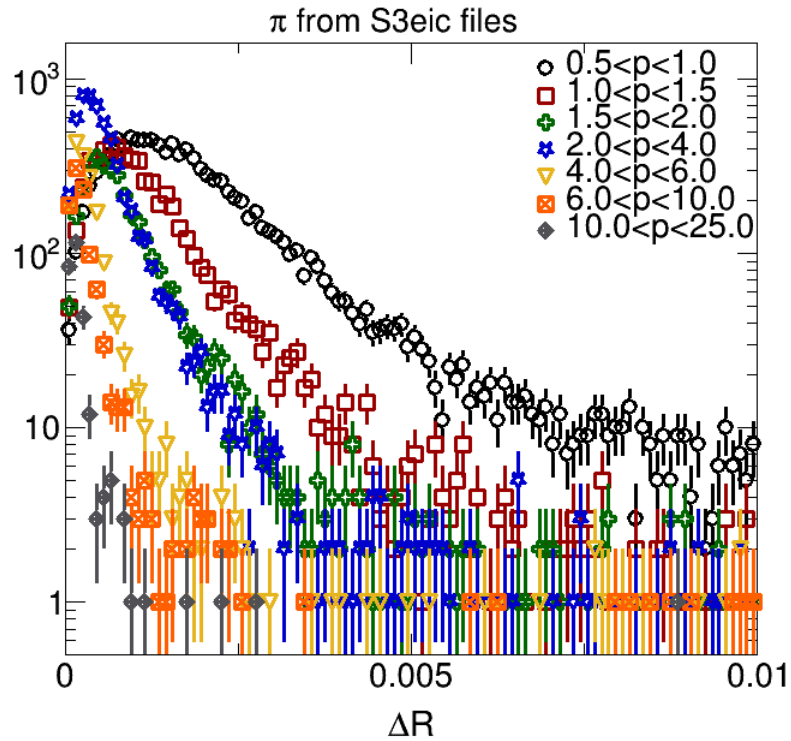
# HF Topics: Momentum Res for Primary Tracks

23.12.0/epic\_craterlake/DIS/NC/18x275/minQ2=100



- Resolution in forward rapidity region below expected/needed performance benchmark
- Mismatch between RecoPartciles and Tracks information?

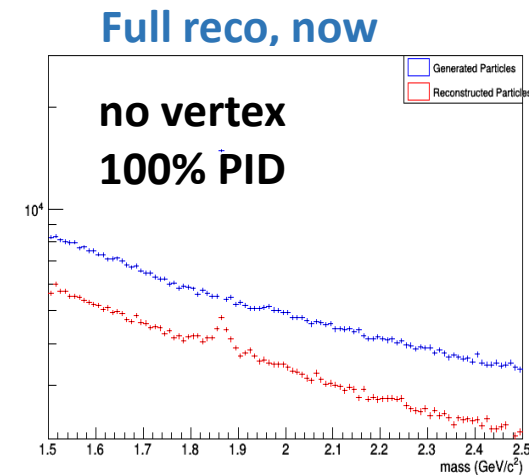
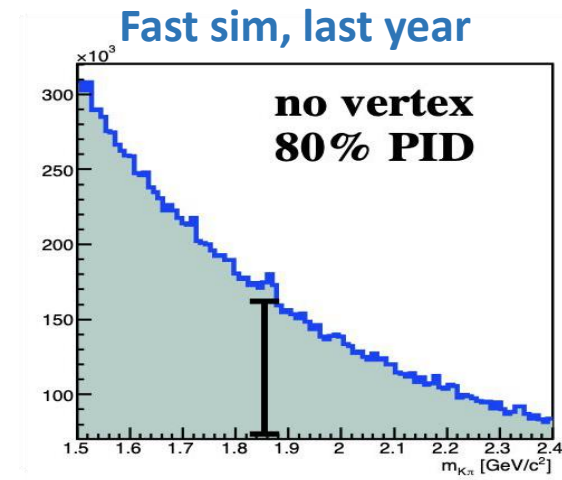
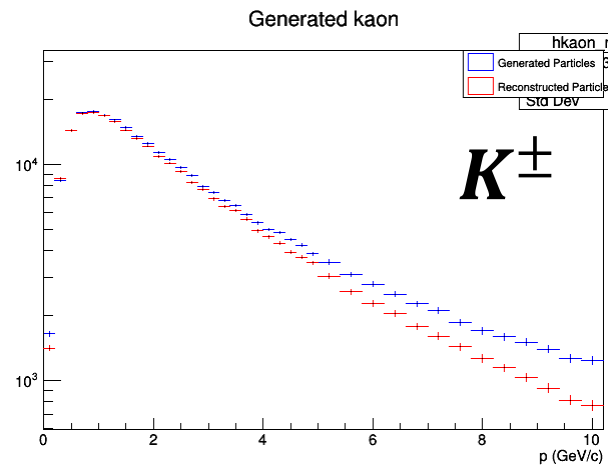
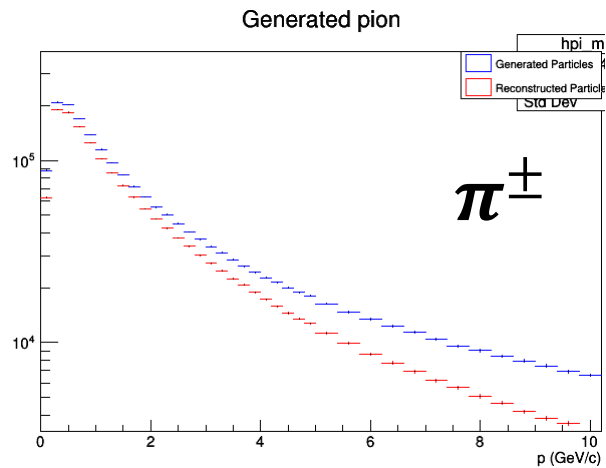
# HF Topics: Geometric Matching of Reco to MC Tracks



Increase of the decay distance impacts secondary track reconstruction performance

# HF Topics: Open Charm Reconstruction

- Where are we now:
  - S/B is too bad to start tuning on standard production
  - hepMC filtered sample is created; no official MC yet; private version ran by Brian
  - First look at eicRecon with ideal PID, no vertex

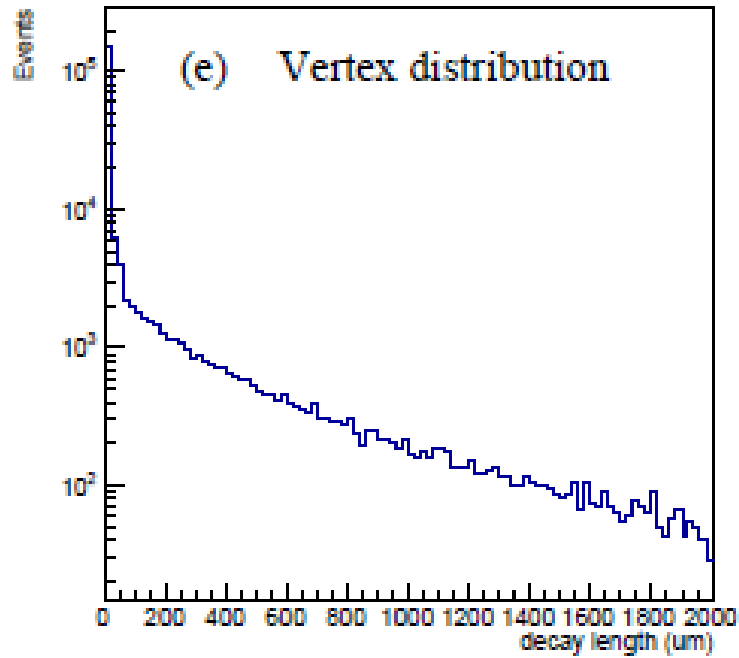


Again, loss of secondary track reconstruction efficiency with growing displacement

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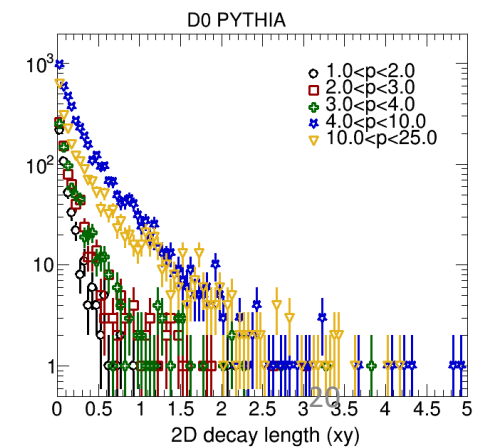
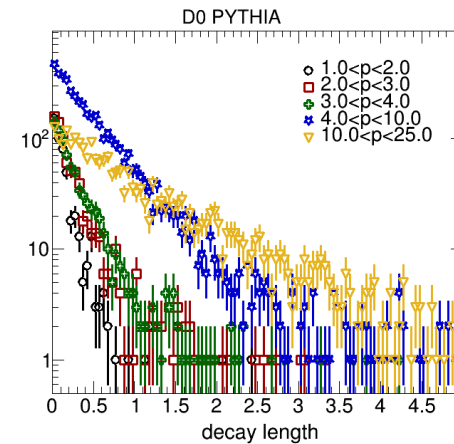
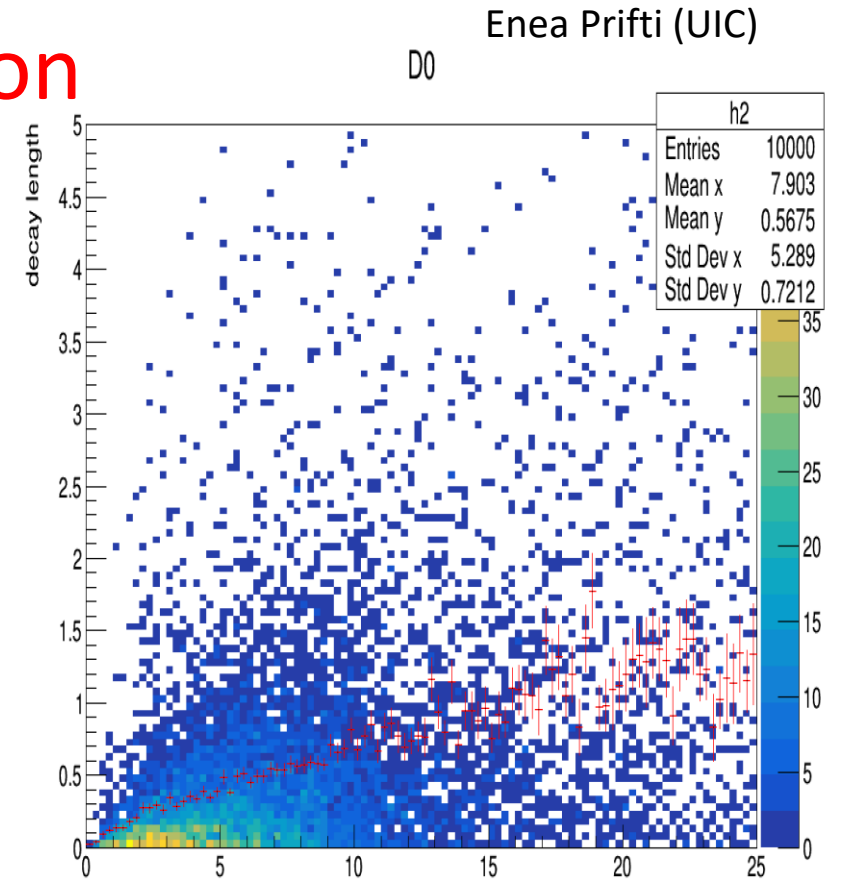
# HF Topics: Open Charm Reconstruction

- Decay kinematics:



$D^0$  decay in the sample from *JPCS* 770 (2016) 1, 012042

1/13/2024



# Final (Personal) Thoughts

- ❑ Overall, the sessions were quite successful – several issues identified and resolved in a relatively short time
- ❑ Successfully on-boarded two+ new people
- ❑ Pairing inexperienced people with experts greatly eased the learning curve associated with using the software
- ❑ A review of the output trees to ensure all associations which are defined are being filled would be helpful
- ❑ Documentation on what associations are and how they relate would be helpful – maybe as analyzers work these things out, they can document – need a centralized area where this documentation could be stored