

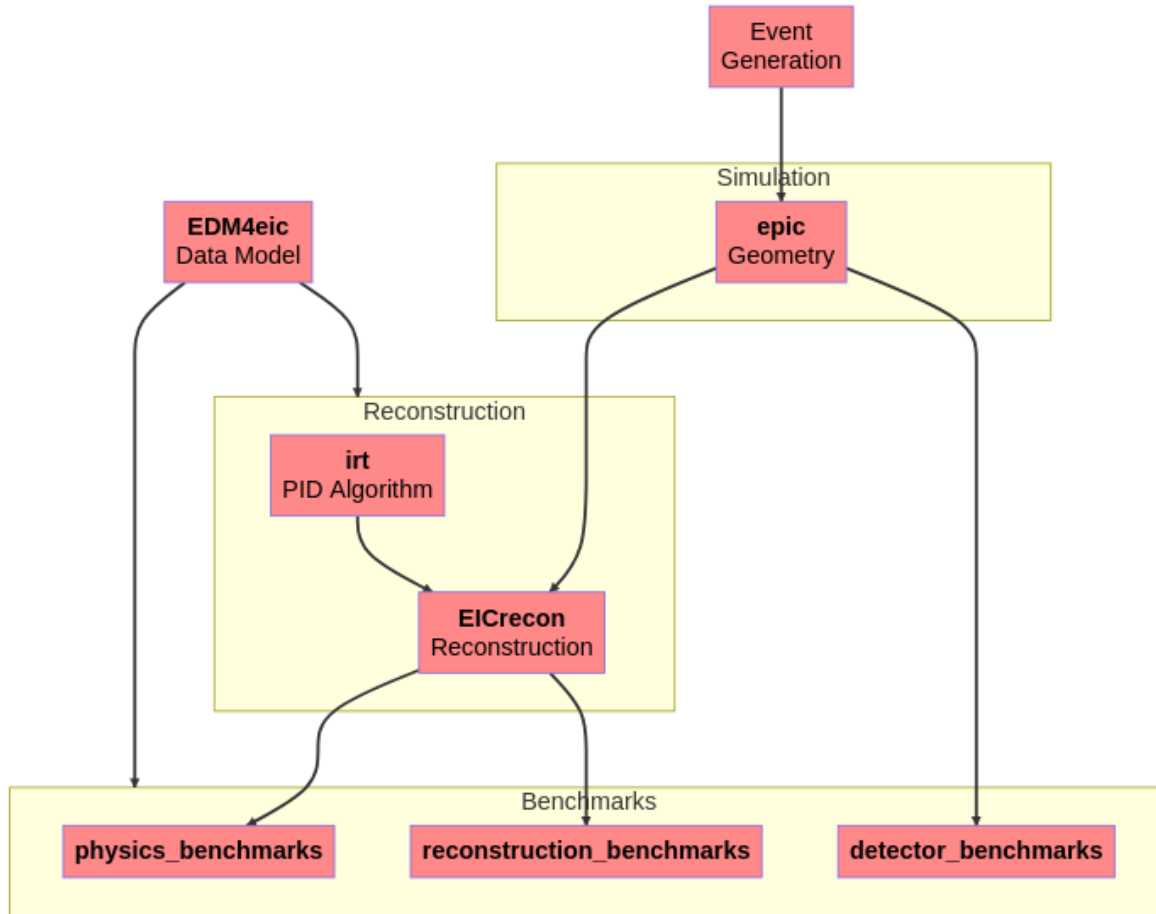
# **dRICH Benchmarks and Bug Fixes**

**Christopher Dilks**

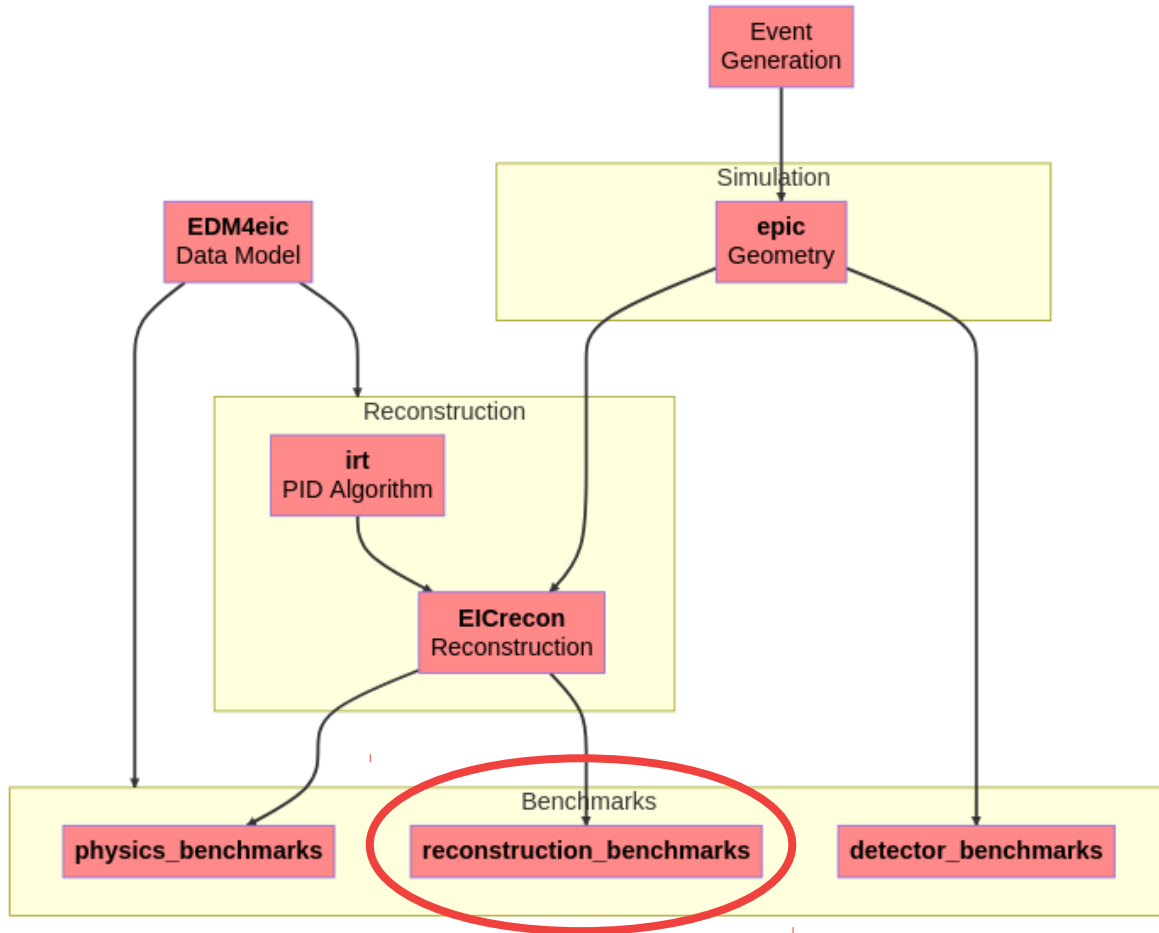
dRICH Simulation Meeting

29 June 2023

# Overview of ePIC Software

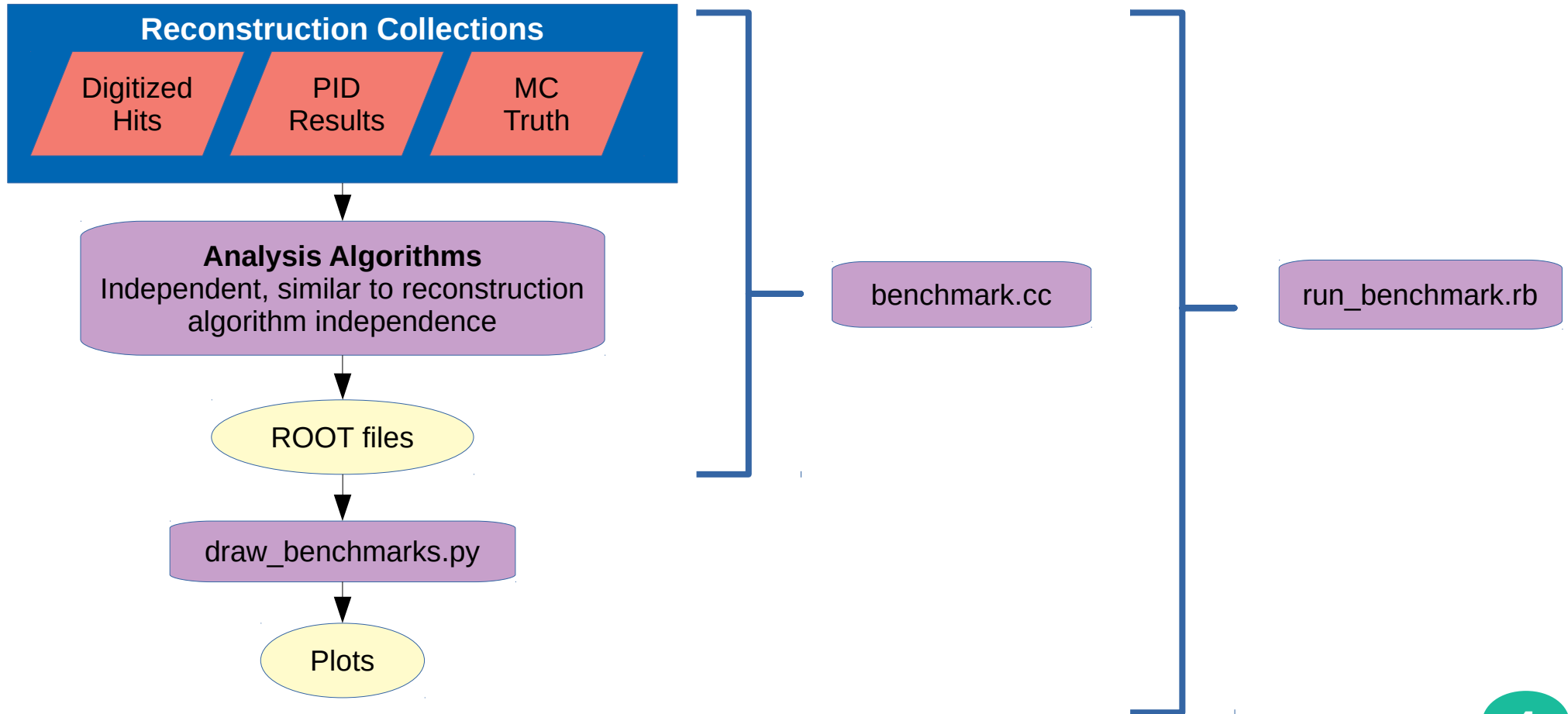


# Overview of ePIC Software



# Our Benchmark Design\*

\* Not standard! But well-aligned with software principle of modularity!



# Analysis Algorithms

## ◆ SimHitAnalysis

- Number of incident photons (pre-digitization and QE)
- Incident photon spectrum

## ◆ RawHitAnalysis

- ADC
- TDC
- Photon spectrum for digitized hits

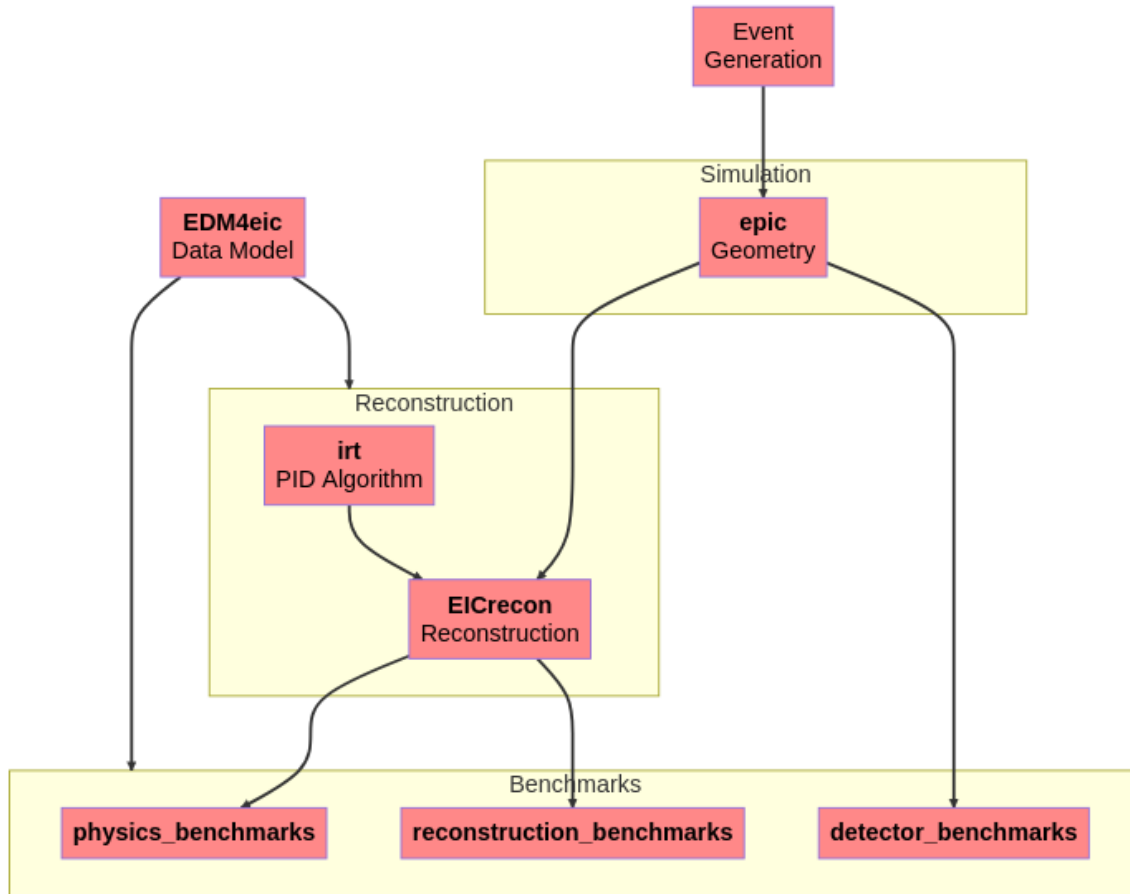
## ◆ CherenkovPIDAnalysis

- NPE
- Cherenkov angles and residuals
- Refractive index
- PDG with highest weight
- Dependence on  $p$  and  $\eta$

## ◆ ReconstructedParticleAnalysis

- Fraction with PID PDG == true PDG

# Continuous Integration Everywhere



Examples:

- ◆ **Geometry**
  - GDML Production
  - Overlap checks
- ◆ **Reconstruction**
  - Coverage
  - Unit tests
- ◆ **Benchmarks**
  - Detector Performance
  - Physics Performance

**Triggered by Pull Request commits**

# Continuous Integration in drich-dev

## ◆ Pull request review and approval has been much slower than development

- Not many available reviewers...
- We've been prioritizing developing features and fixing bugs...

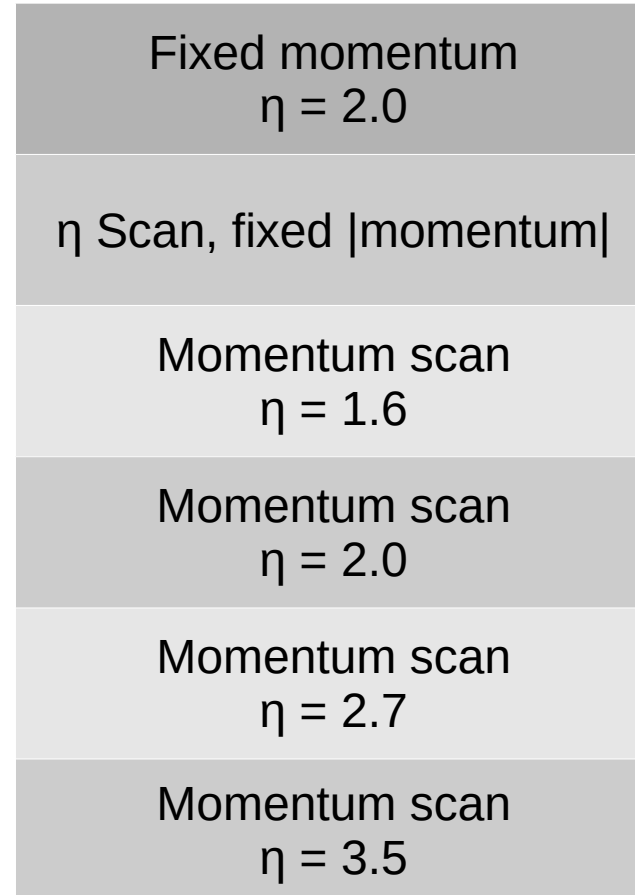
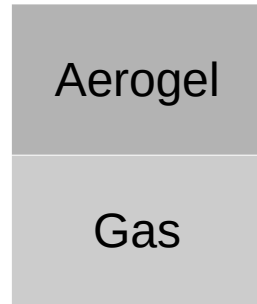
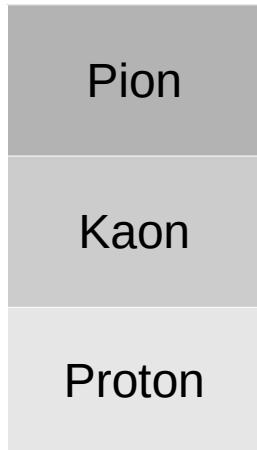
## ◆ Continuous Integration in drich-dev allows:

- Full control over which versions of each repository is used
  - Namely, EICrecon and reconstruction\_benchmarks have separate, unmerged branches for IRT
  - Allows quick testing of ideas without waiting for PR approval in each repository
- Allows for testing of things which are not easy to test in a single repository
  - Example: pixel gap cuts
    - Need high-stats simulation + dRICH (standalone) geometry → too much for a unit test?
    - Dependent on an EICrecon library → may not be accepted as a benchmark
    - Easiest solution: test regularly in drich-dev and hope for a better approach in the future
- Allows us to launch moderate statistics jobs for performance studies
  - Though this should really be done in reconstruction\_benchmarks (TODO after IRT is fully approved in EICrecon)

# dRICH-dev Continuous Integration Matrix

## “Pipeline”:

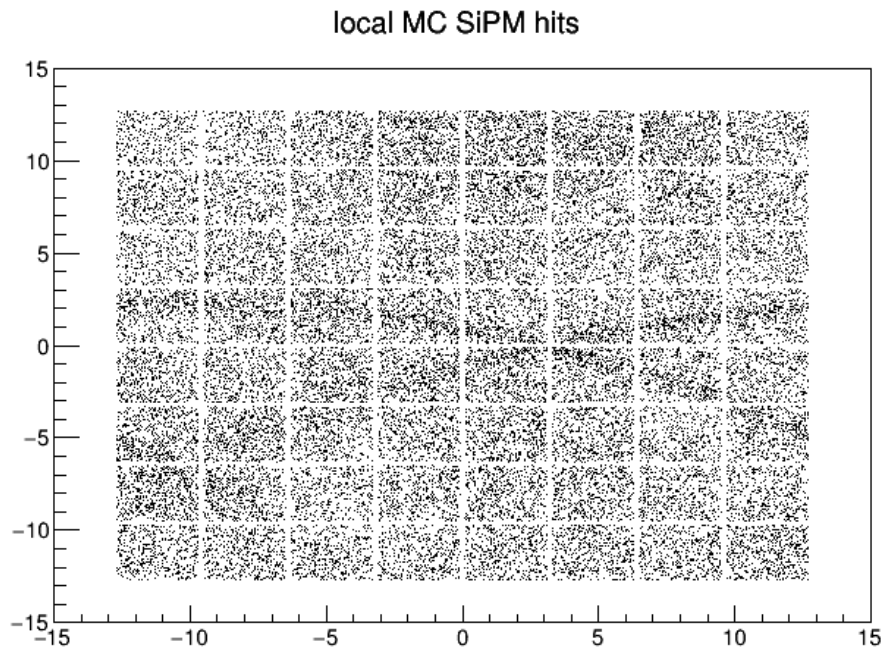
Simulation → Reconstruction → Benchmarks



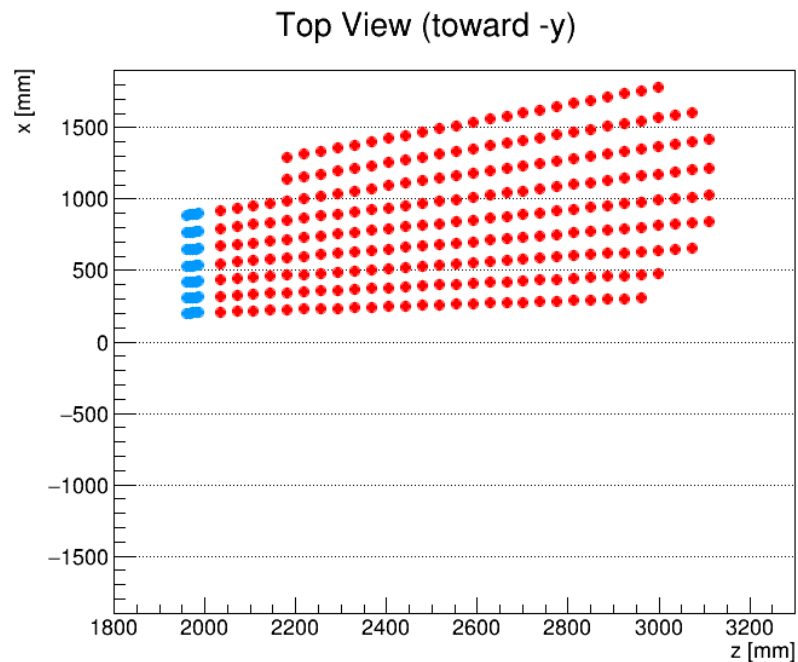


# dRich-dev Continuous Integration: Additional Tests

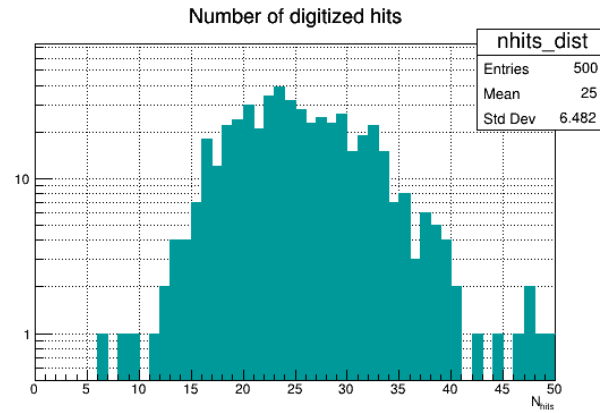
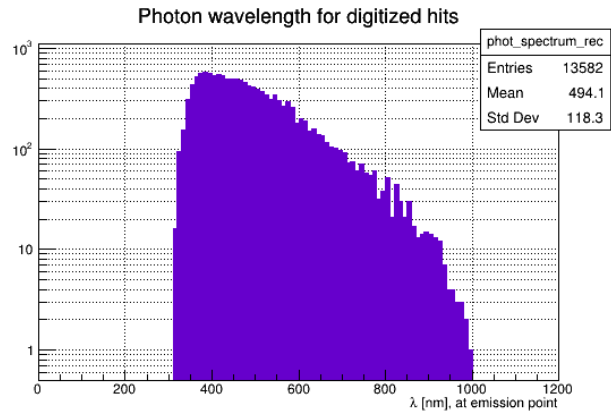
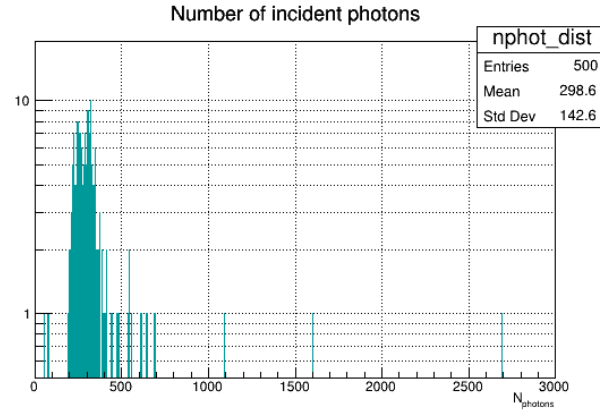
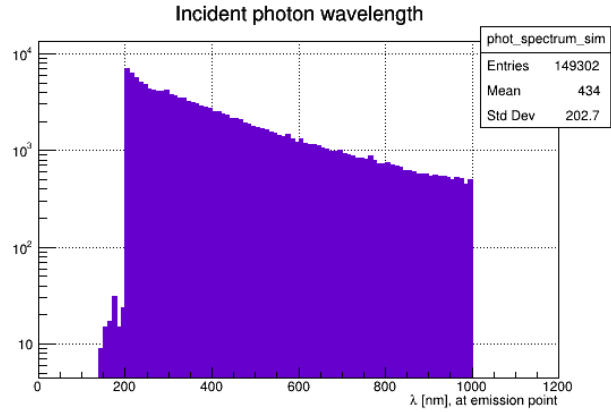
## Pixel Gaps



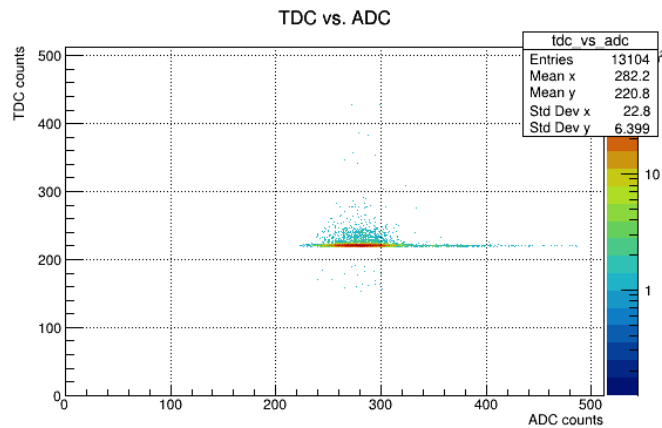
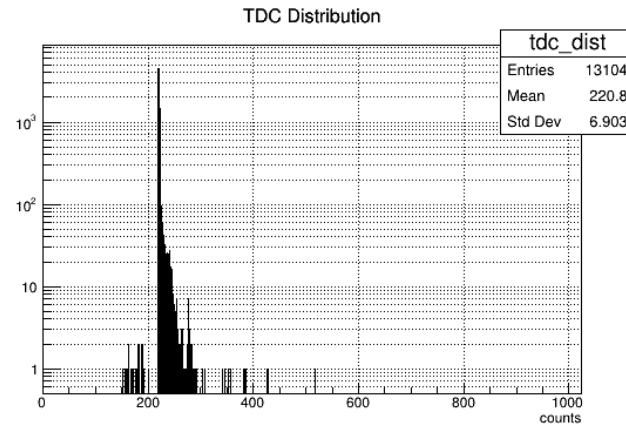
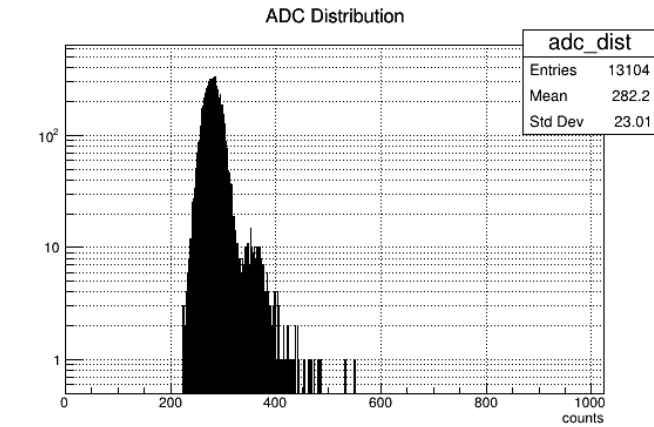
## Track Propagation



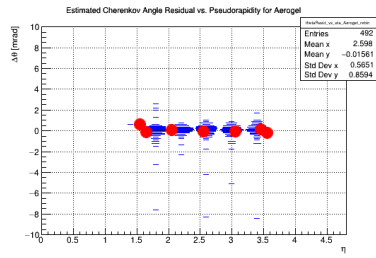
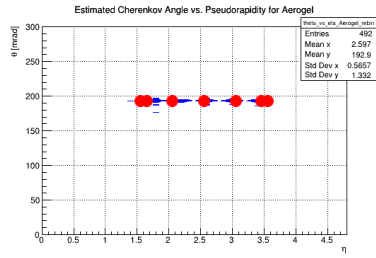
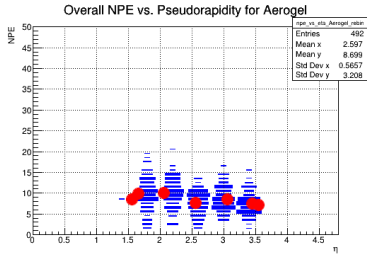
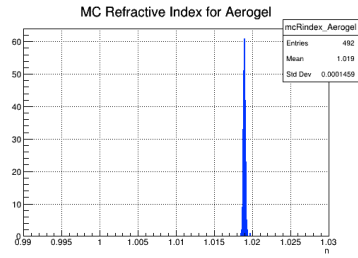
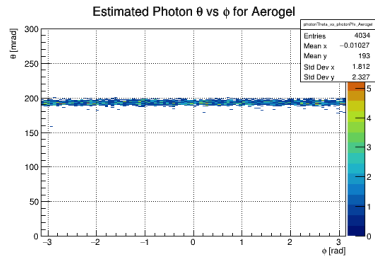
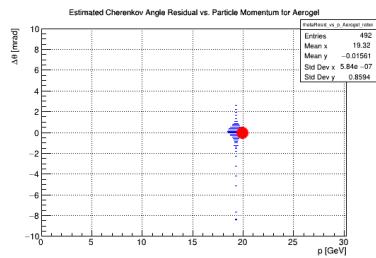
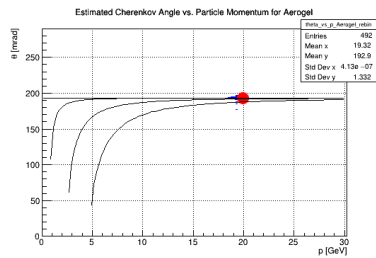
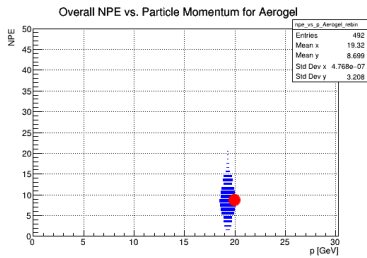
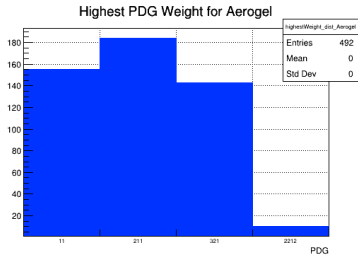
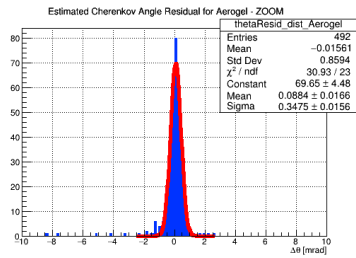
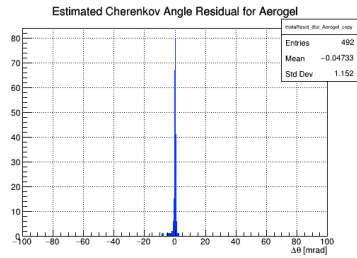
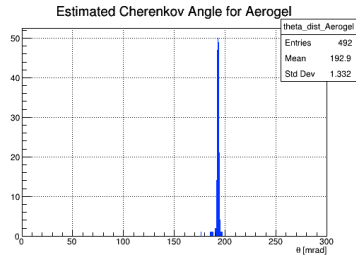
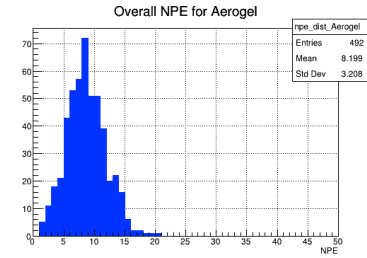
# Benchmark: Photon Spectra



# Benchmark: Digitization



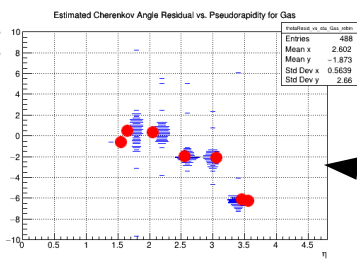
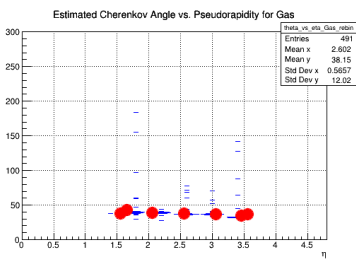
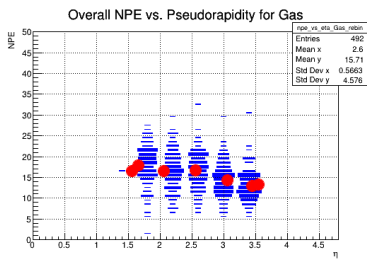
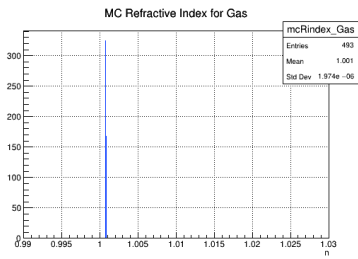
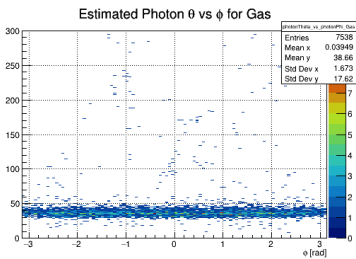
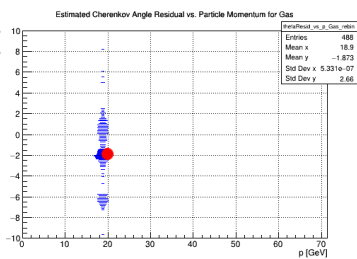
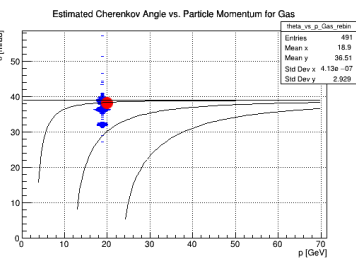
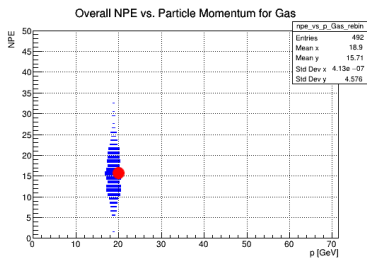
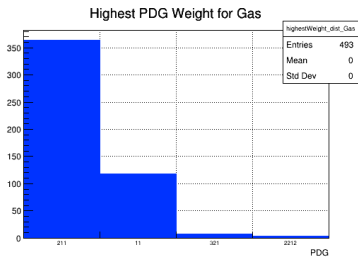
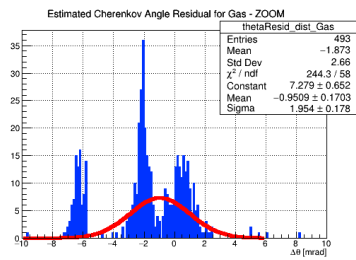
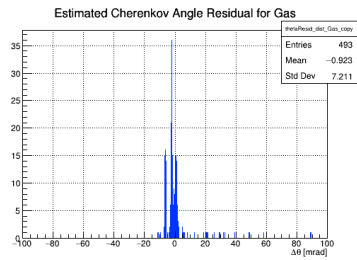
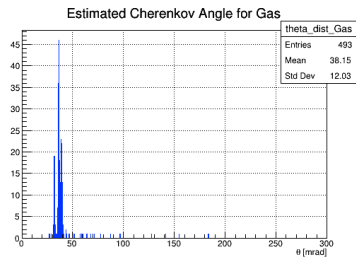
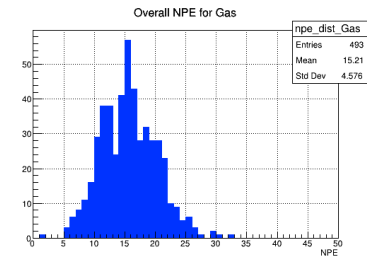
# Benchmark: Aerogel PID



Focusing on example  $\eta$  scan

NOTE: all of this is **after** the updates for PDUs and service material

# Benchmark: Gas PID



PROBLEM!

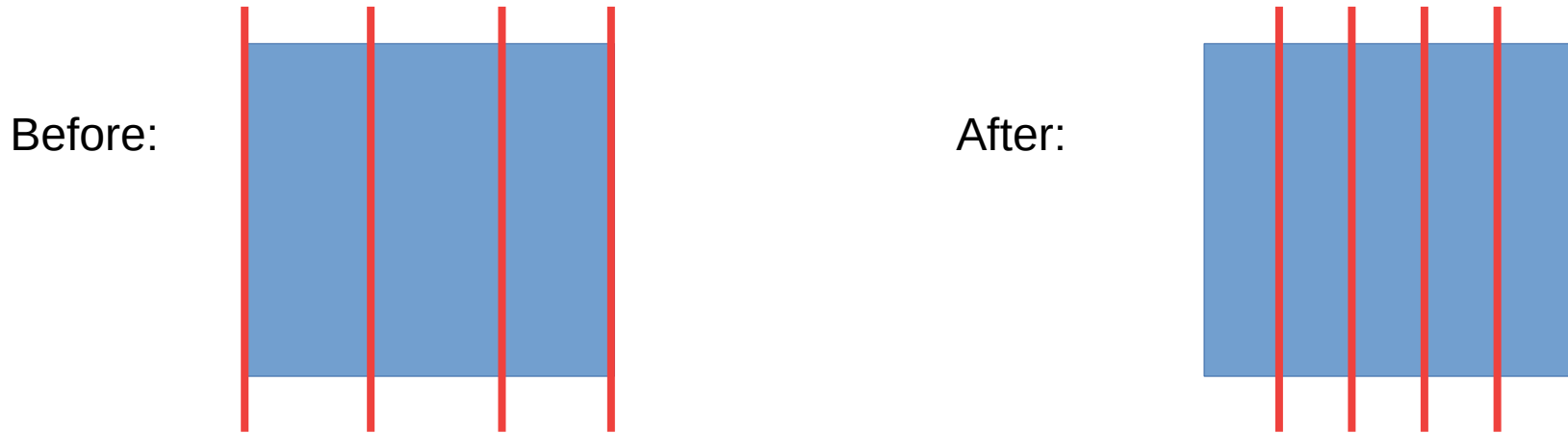
# Bug Fixes

## ◆ Number of Propagated Track Points

- Aerogel: 5 → leave as is
- Gas: 10 → increase to 30

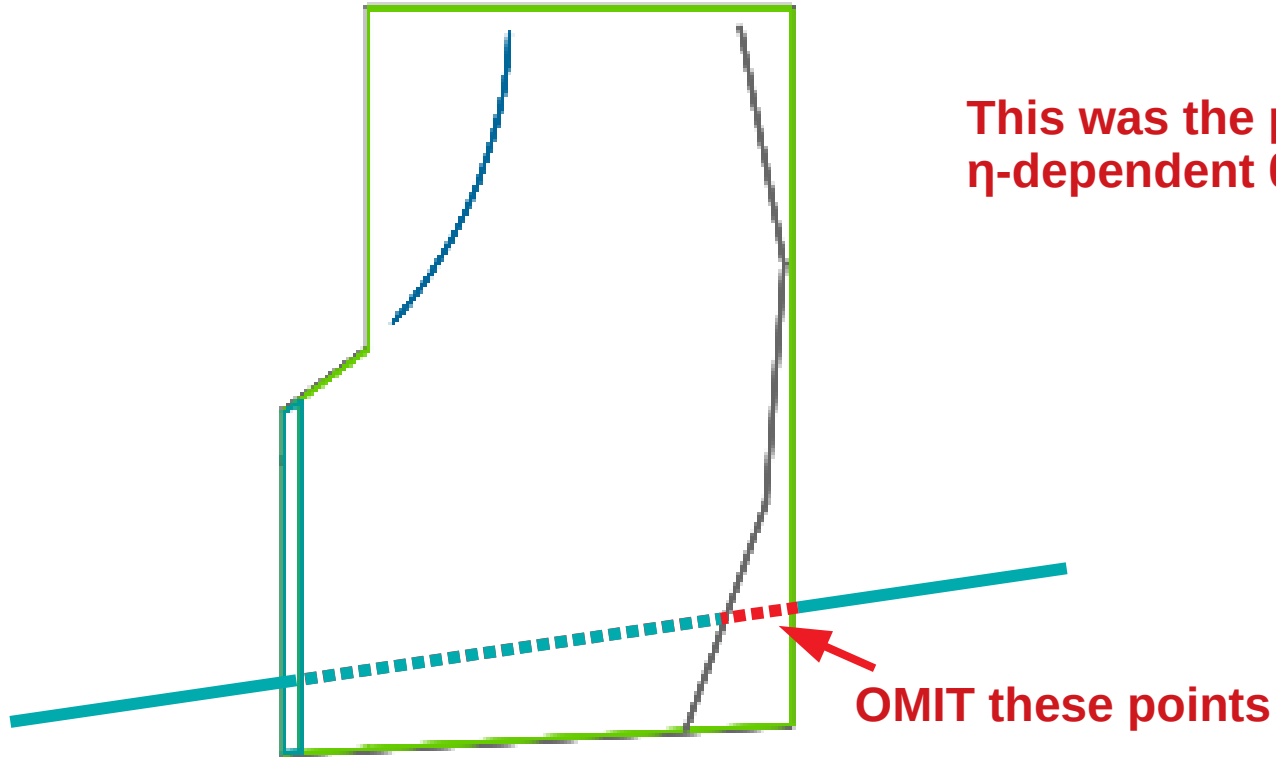
## ◆ Avoid Propagation to Optical Boundaries

- Example for 4 planes:

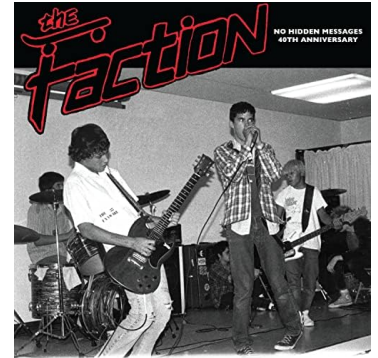


# Bug Fixes

## ◆ Do Not Propagate Beyond the Mirror



This was the primary cause of the  $\eta$ -dependent  $\theta$  residual in gas!!!



Beyond the Mirror

# An Outstanding Issue...

<https://github.com/eic/ElCrecon/issues/564>

Tracks which miss the dRICH cause a lot of error pollution and unnecessary propagation attempts

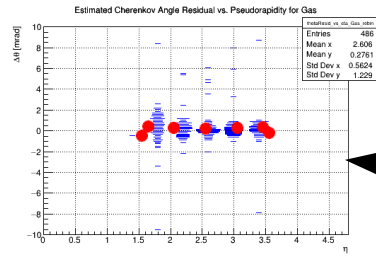
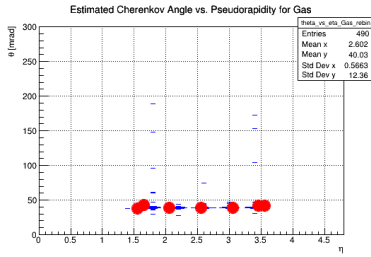
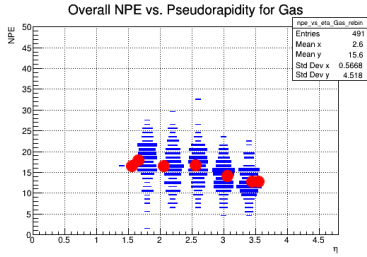
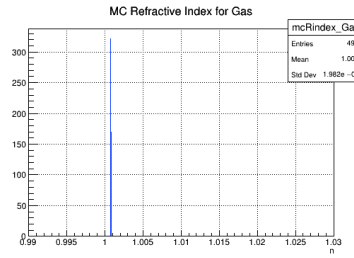
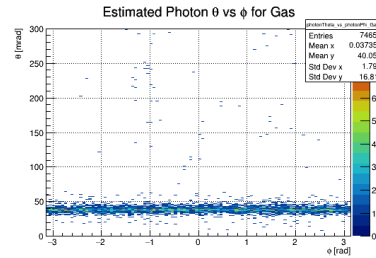
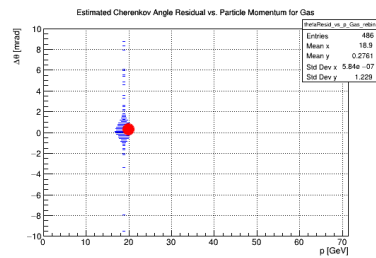
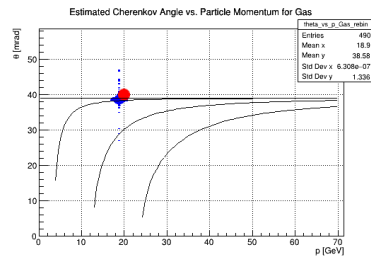
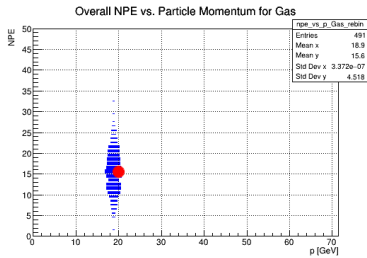
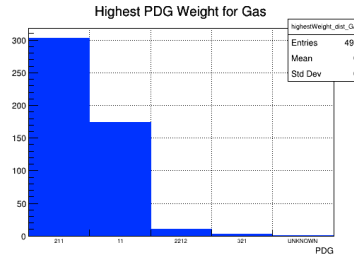
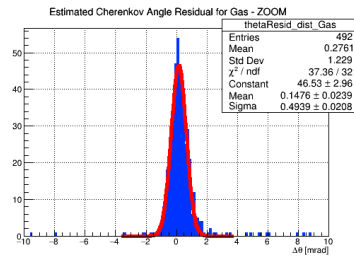
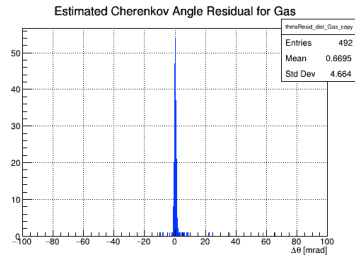
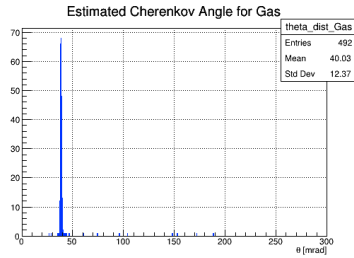
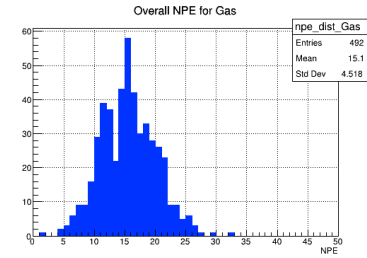
```
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
ProjectTrack ERROR Propagation reached the step count limit of 1000 (did 1000 steps)
```

Possible solution: see linked Github issue

**A good entry-level task**

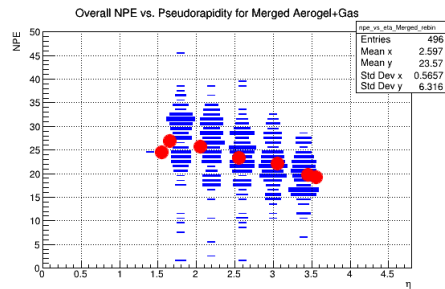
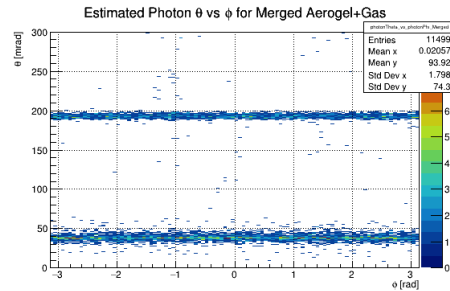
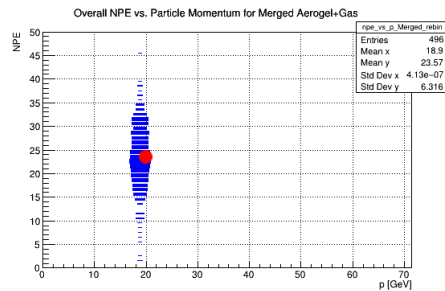
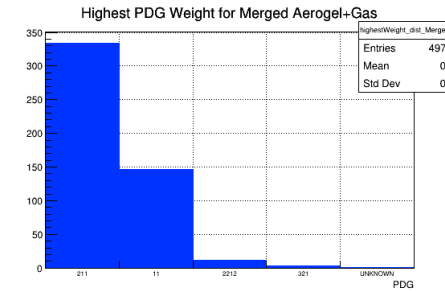
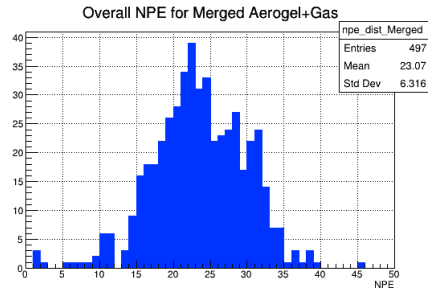


# Benchmark Gas PID after Bug Fixes



FIXED!

# Benchmark: Merged Aerogel + Gas PID



# Next Steps

## ◆ Initial IRT in EICrecon PR

- <https://github.com/eic/EICrecon/pull/707>

## ◆ Open PRs for

- Track propagation bug fixes
- PID Merging of Aerogel and Gas
- Linking PID to Reconstructed Particles
- Updates for PDUs
  - Geometry: Marco, should we keep vessel thickness and filter thickness? Are the service dimensions okay?
  - Reconstruction