dRICH – Status on Simulation and Reconstruction software

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On behalf of dRICH simulation team

Outline

- A quick recap on simulation status
- Upcoming changes in dRICH geometry
- IRT: Quick recap
- Hints on IRT V-2 Improvement
- Requirement of an improved ray tracing
- Upcoming plans on IRT v-2 and data model
- Summary

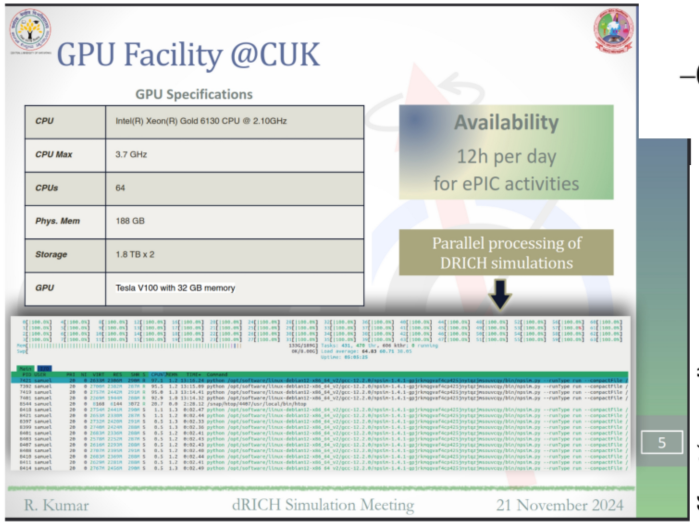
A quick recap

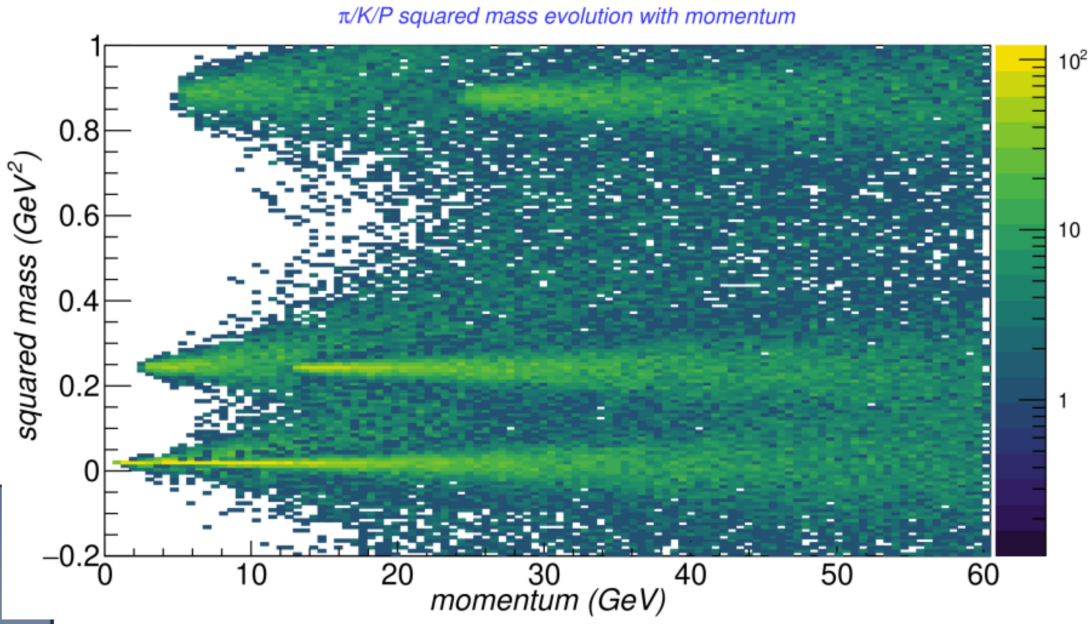
Towards larger dRICH simulation community

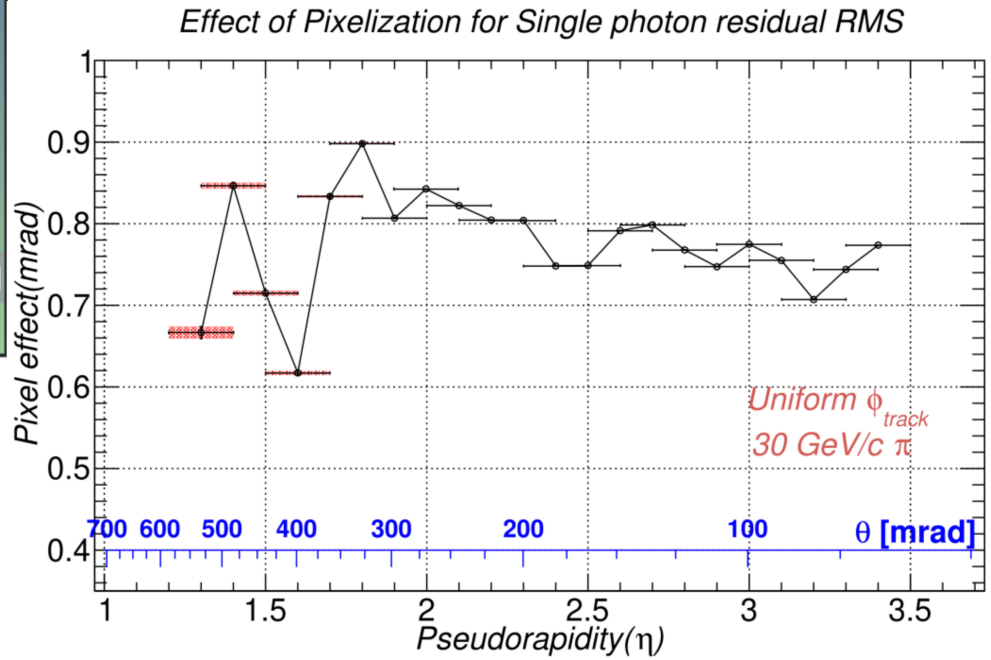
- Current team:
- Central University of Karnataka, India
  - Deepak Samuel
  - A. Rajan
  - N. George
- Central Universtiy of Haryana, India
  - Ramandeep Kumar
  - Meenu Thakur
  - R. Jangid
  - Taniya
  - T.Tanvi
  - G.Laishram
- Ramaiah University of applied sciences, India
  - Tapasi Ghosh
  - Rohit Sigh
- INFN Trieste
  - Jinky Agarwala
  - Gabriele Furlani (Tirocino)
  - Chandradoy Chatterjee
- INFN Cosenza & University of Calabria
  - Luisa Occhiuto

Constant guidance and helps from Marco and Silvia.

In future new collaborations are foreseen.



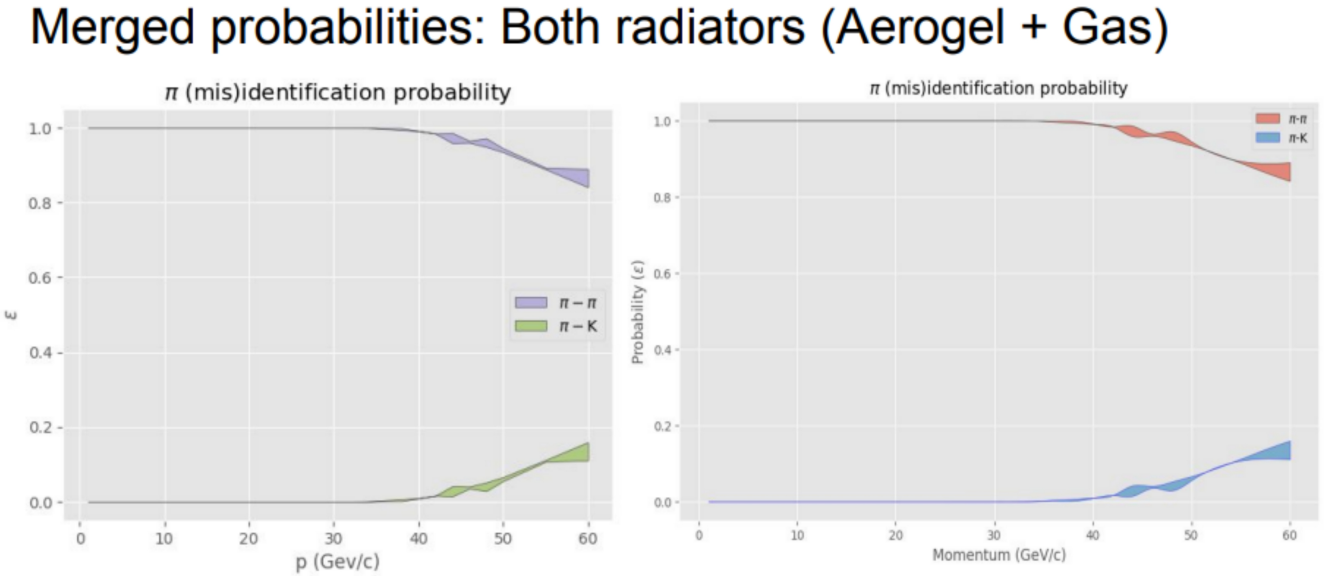




A community has been formed dedicated for dRICH simulation studies. Currently, we can extract high level information (e.g. squared mass of charged particle from both radiators) and microscopic effects like pixelization using full ePIC software scheme.

A quick recap

Over entire psudorapidity and momentum ranges the PID (mis-) identification efficiencies are computed using DELPHES. Results are compatible with number of sigma separation.



After suggestion: only in higher eta-region (3.2-3.5)

AFTER SUGGESTIONS

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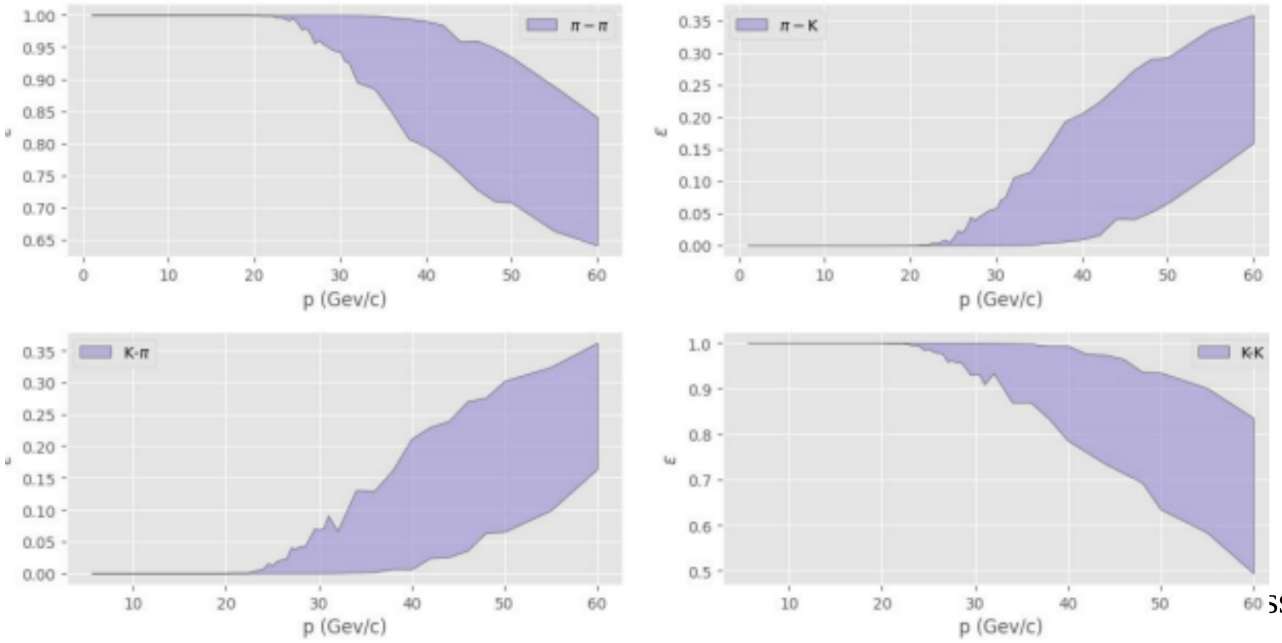
eta: 1.5-3.5 (full range)



The dRICH geometry is very similar to the mechanical model.

However, some changes will be implemented.

Benchamark plots like N-sigma separation, resolution, number of photons will be monitored.

Upcoming changes in dRICH geometry

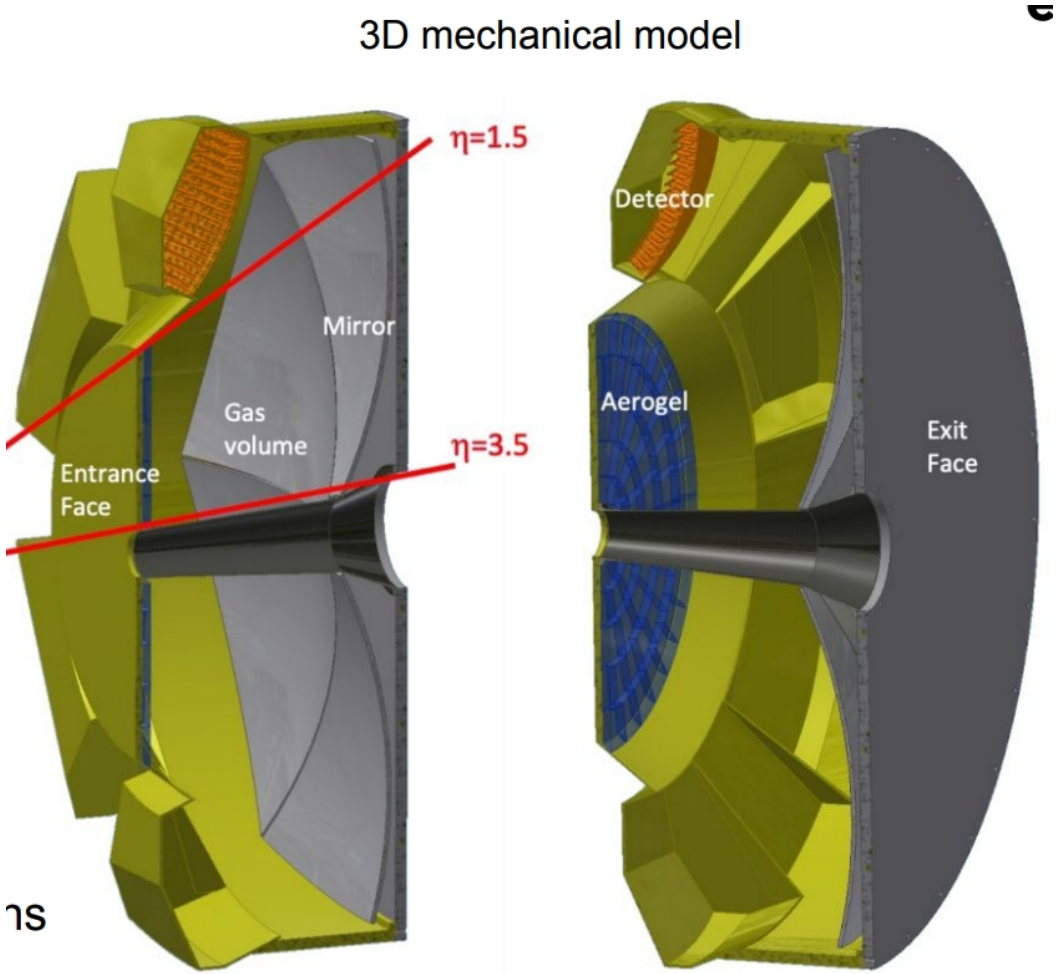
1. Basic implementation of the titled mirror exists (not in main branch). Will be placed in the main branch. Connor tried to test different radii configurations.

2. Currently Aerogel is a single piece, tiling will be made. (Luisa, Annalisa)

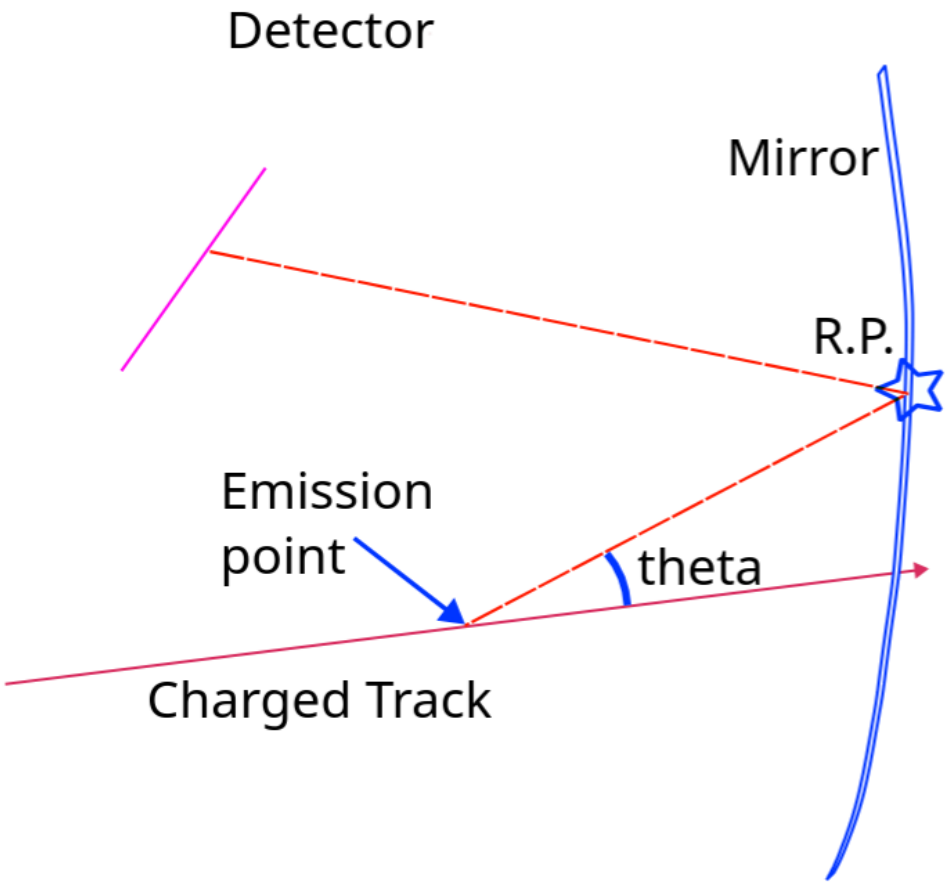
3. Implemented beam pipe geometry is under study reshaping and dRICH reorientation (wrt hadron beam) will be studied. (Rohit)

4. Sensor shaping has effect on triple point (snout outer-edge, sensor-box lower edge and quartz window), more realistic design is foreseen.

All these effects have implication to acceptance. Acceptance studies will be performed for every changes.



A quick recap of the IRT



1) An indirect ray tracing estimates the Cherenkov angle from pure geometric consideration.

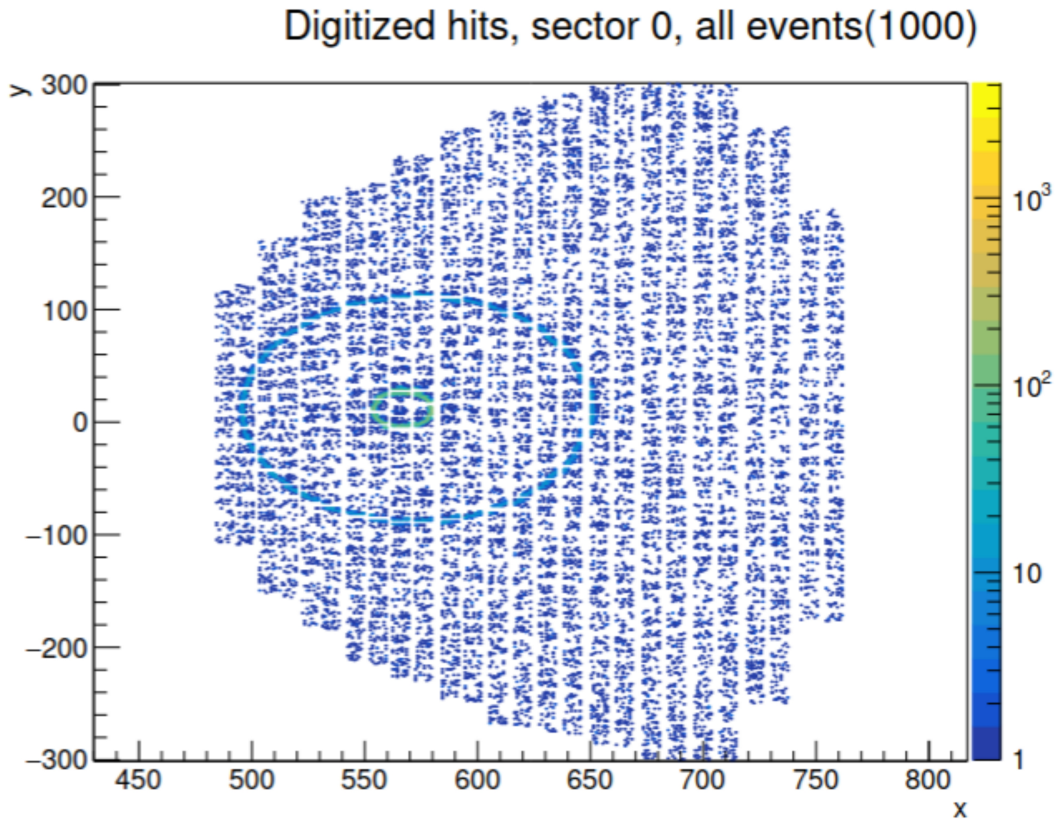
2) Essential input: coordinates of hit points.
assumption on point of emission, geometry. No discrimination between signal and noise hits. **No model (noise or signal) dependent event reconstruction!**

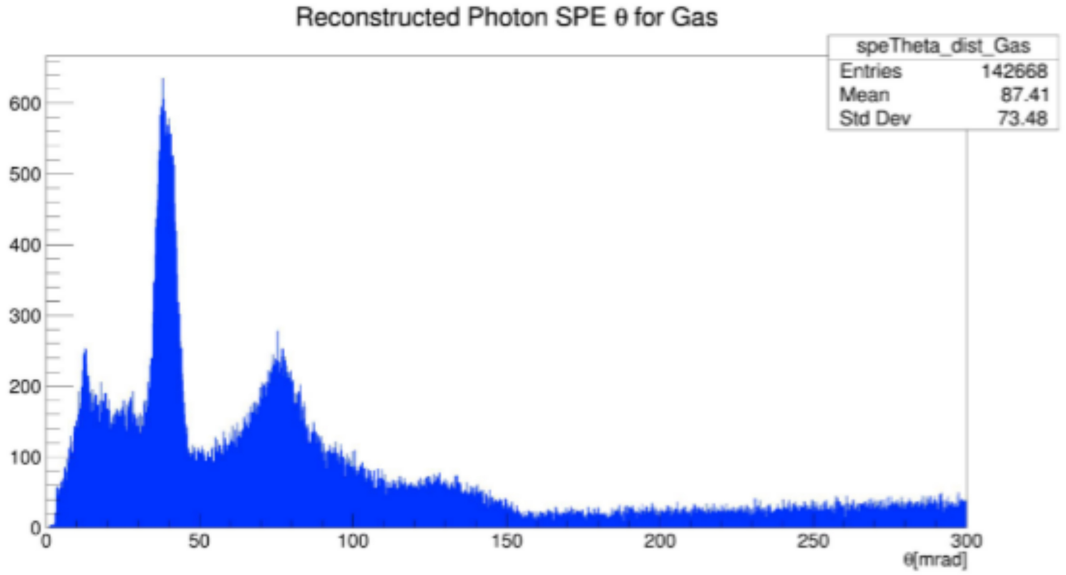
3) Multiple optical path contributes to non-trivial handling of geometry.

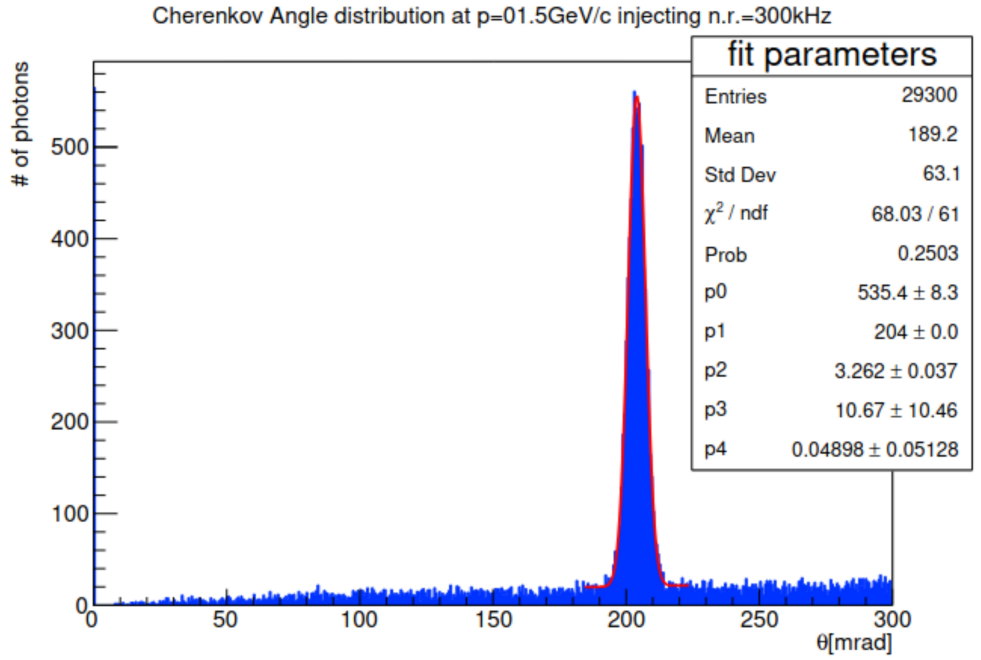
4) In EICRecon: Currently we assign a photon weighted value, to identify the number of photons favor one hypothesis over the other.
In Stand-alone: A event based chi-squared extendable to timing incorporation is made.

5) Above all, the stand-alone version is capable to correctly reconstruct the Cherenkov angles for single photon and track level assignment for a [particle,hypothesis] pair in extremely complicated event topology.

Issues with the reconstruction IRT-v1

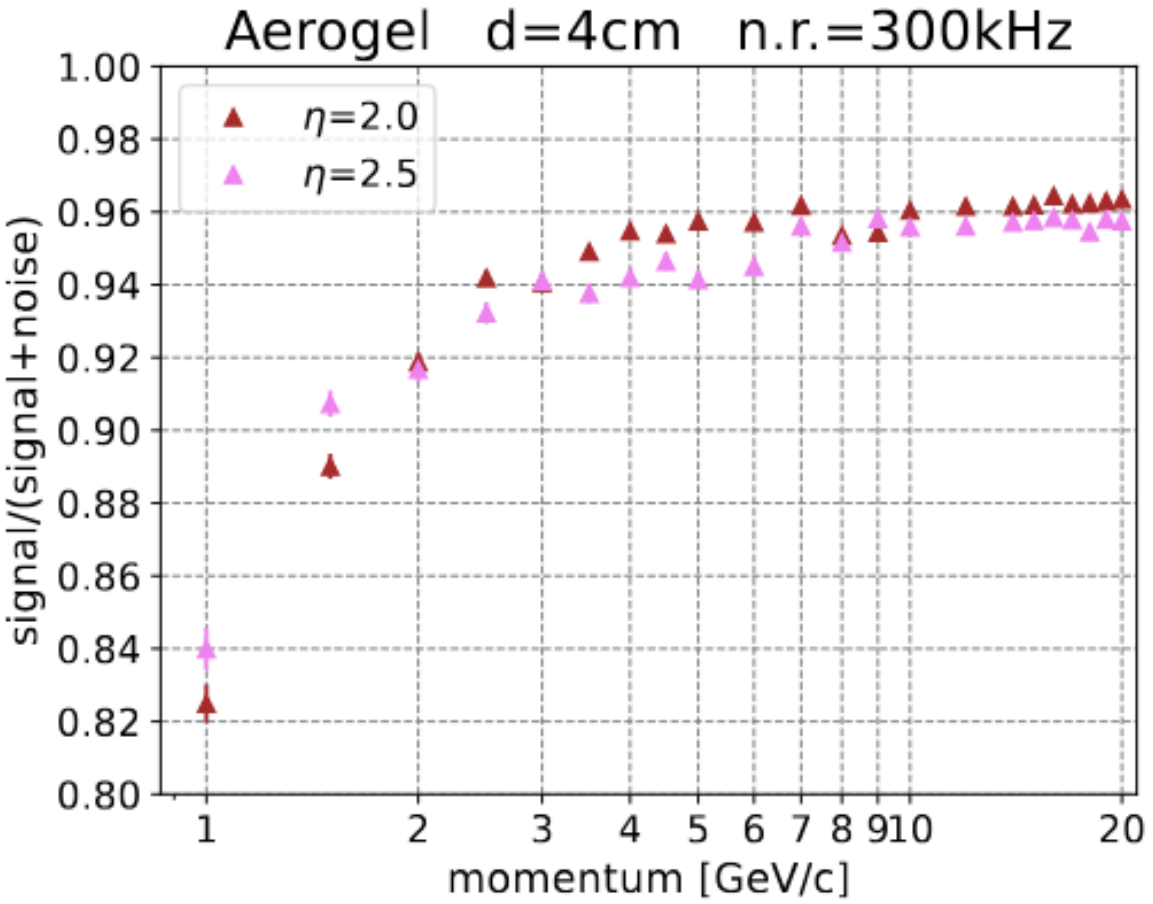


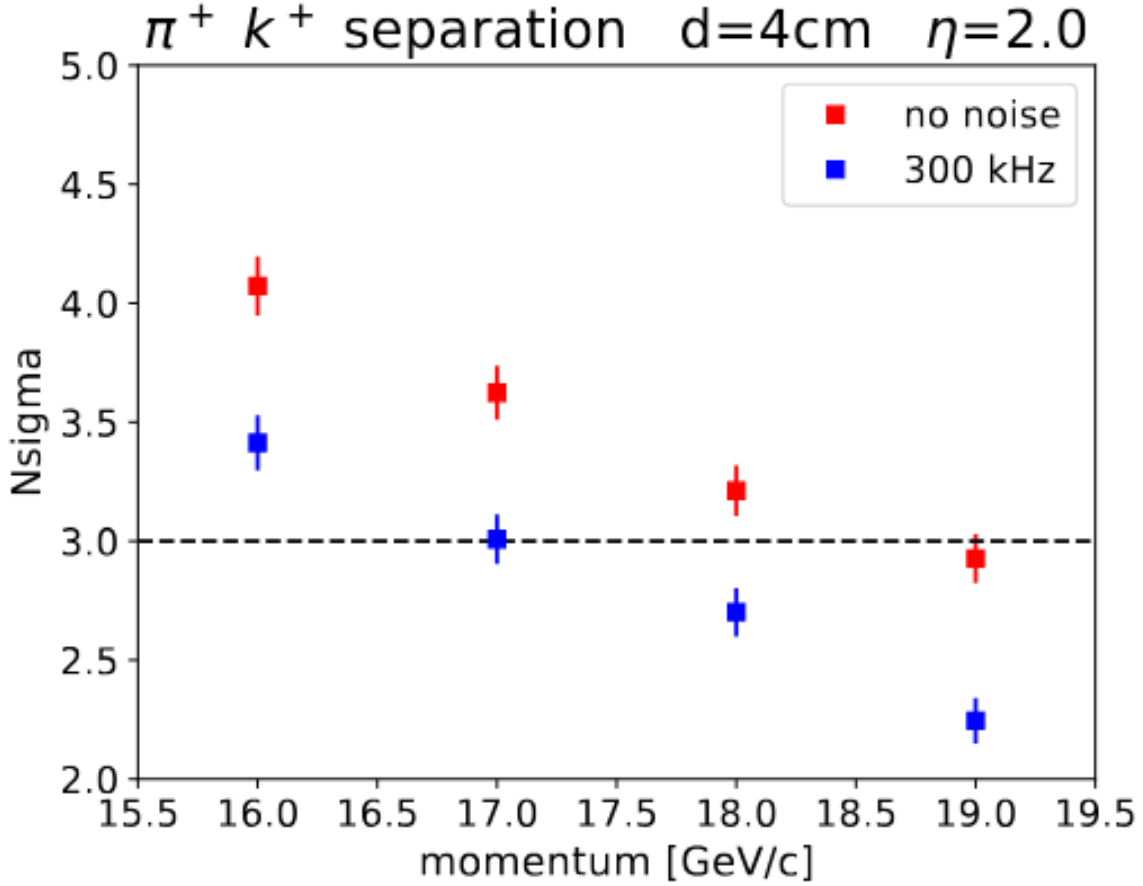




The first indication was unrealistic angle reconstruction while handling SiPM noise hits! Hits of other sectors limits the IRT V-1 performance.
Interim solution was to shoot particles in one sector at a time to estimate the noise under the signal peak.

Issues with the reconstruction IRT-v1 (spot fix)



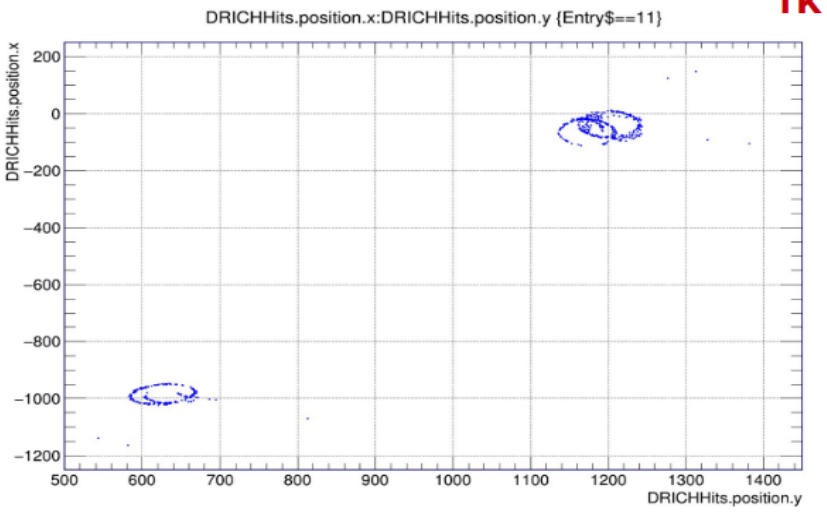


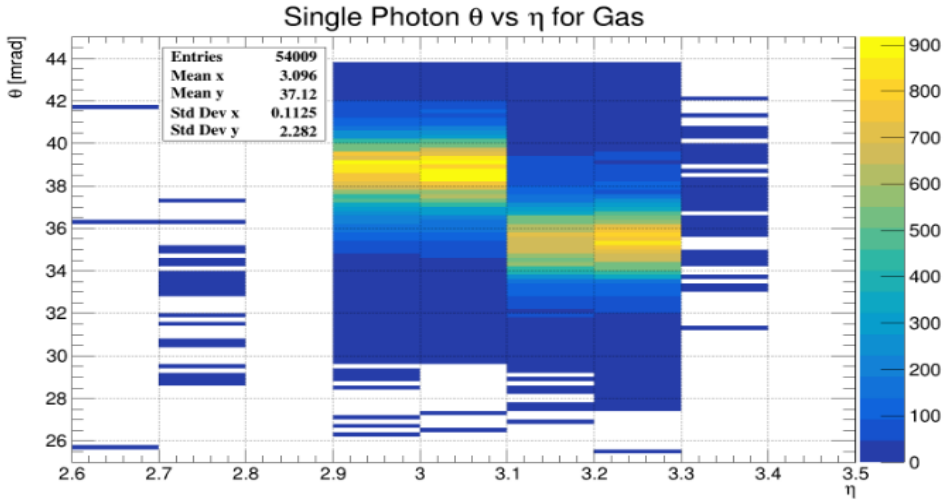
Issues with the reconstruction IRT-v1

Aerogel removed!

30 GeV/c	η	ϕ
Pion	3.0	90^0 to 180^0
Kaon	3.3	90^0 to 180^0

1k events





Multiple charged tracks in an event.

IRT in EICRecon correctly identifies and estimates Cherenkov angle properly.

However, IRT in EICRecon mixes up things when aerogel rings are split!

Issues with the reconstruction IRT-v1

Aerogel Added!

30 GeV/c	η	ϕ
Pion	3.0	90^0 to 180^0
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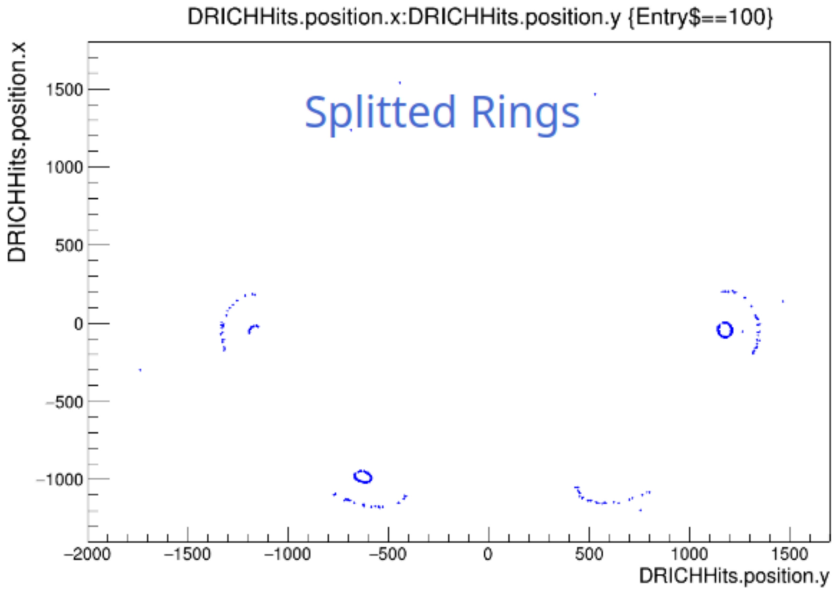
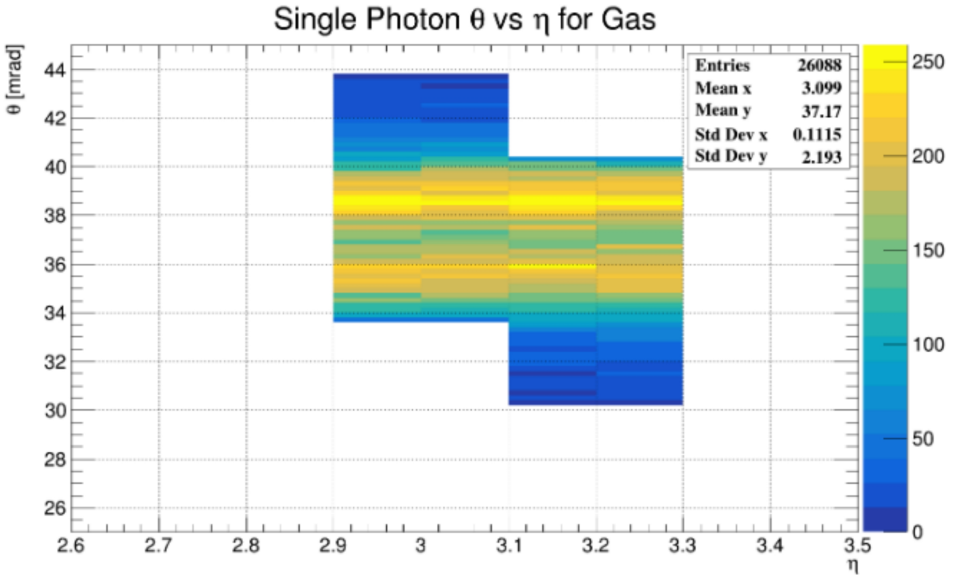
Multiple charged tracks in an event.

However, IRT in EICRecon mixes up things when aerogel rings are split!

A sector which holds split rings, and multiple tracks the “other possible” photon path is not considered. Tries to find a solution which is closer to one hypothesis. To assign a weight!

1k events

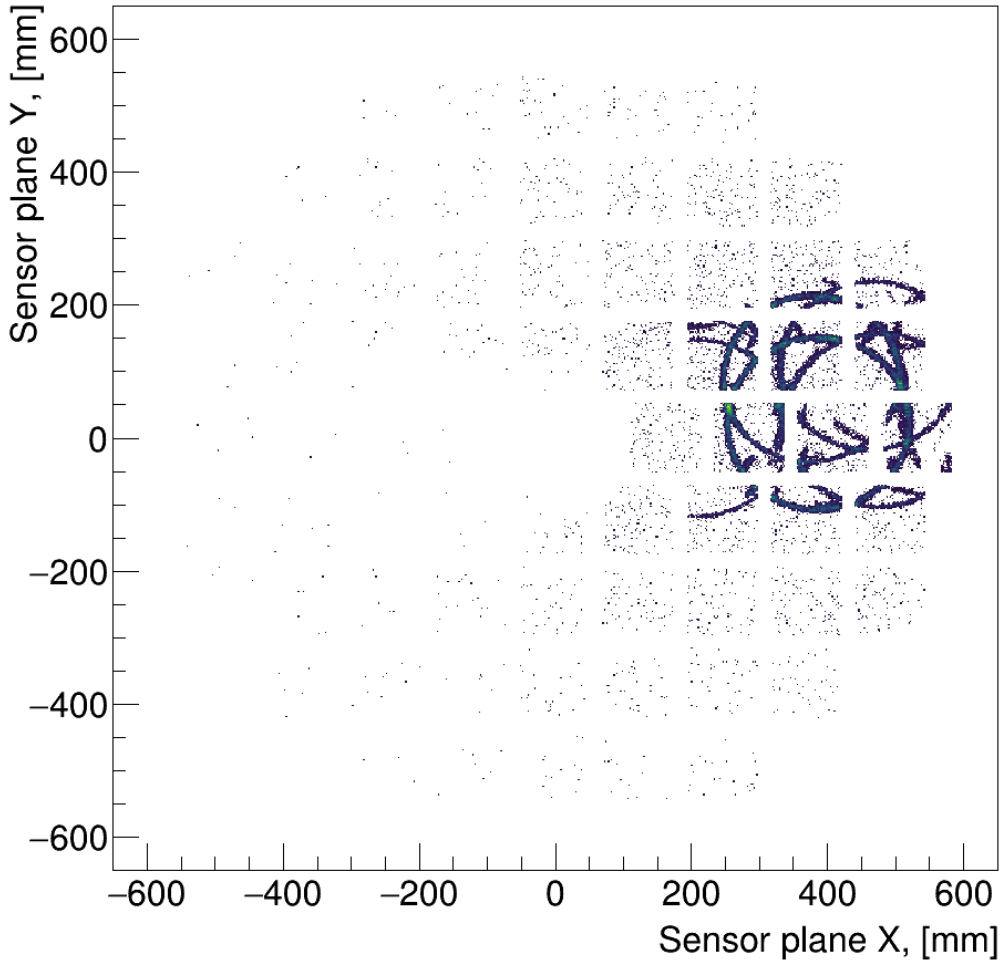




This situation is somewhat similar to pfRICH case. The mixed tracks and photons must be considered that one HRPPD tile may have contribution from either direct or reflected light.

Stand-alone IRT handles this

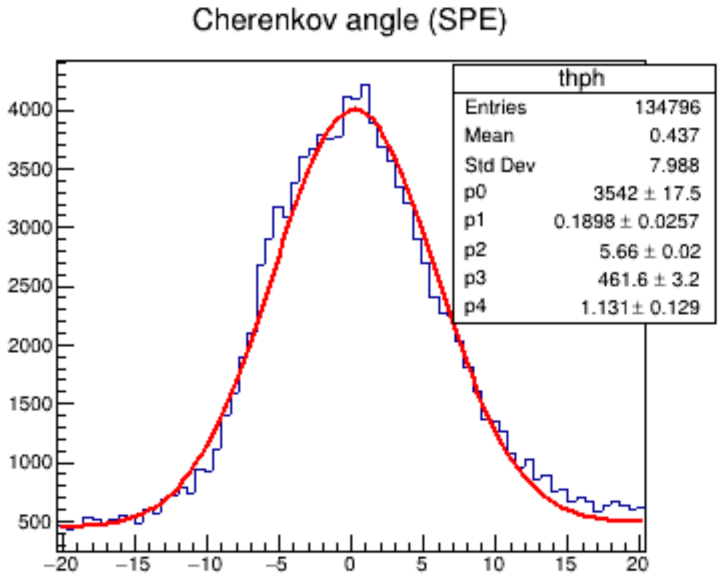
Hints of improvement with IRT v-2

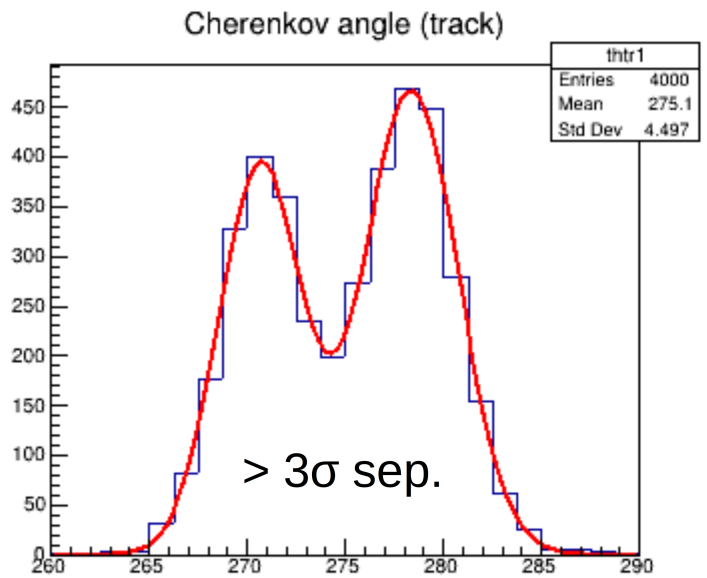


a) Each event is comprised of 4 particles (pion kaon mixture) at 7 GeV/c (consider that at pfRICH we are at PID limit).

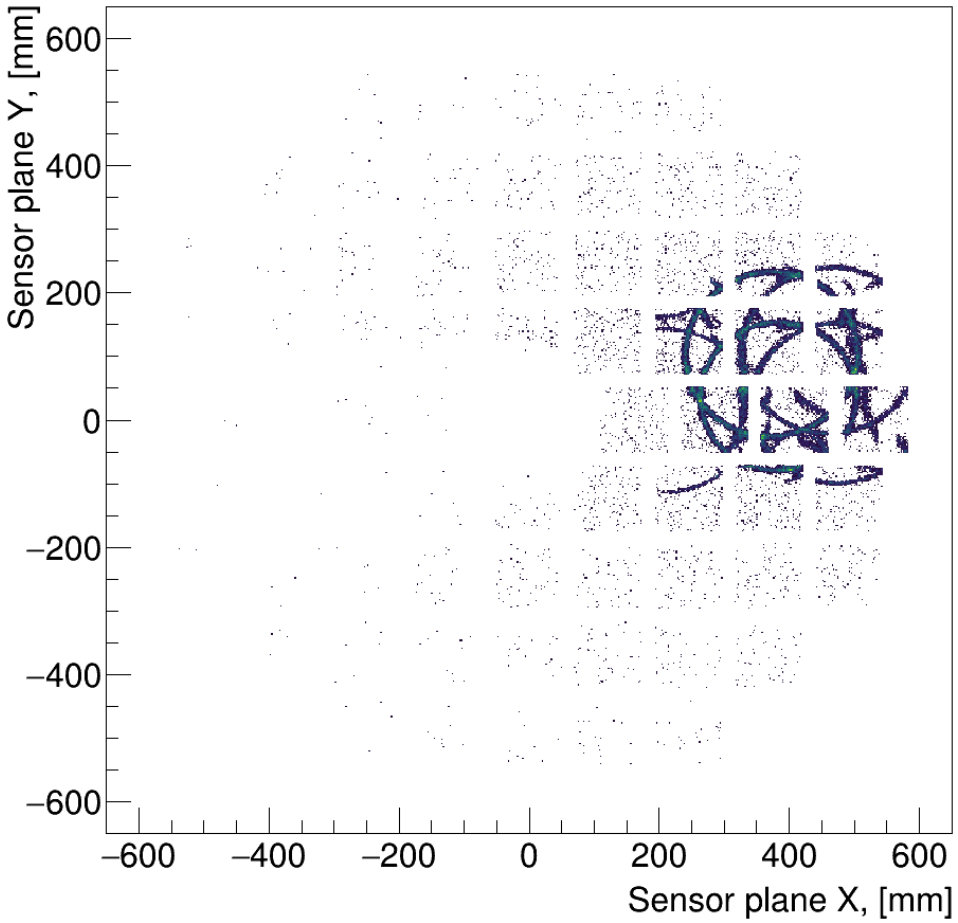
b) We are deliberately overcomplicating ring and photon topology.

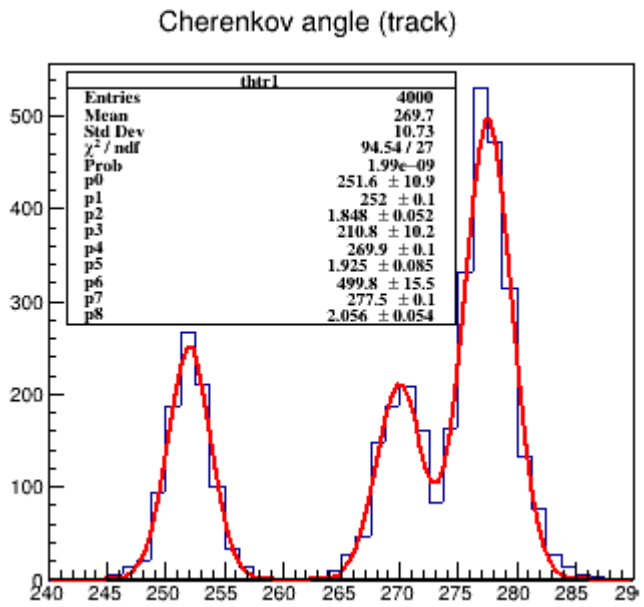
c) Still we obtain slightly larger than 5.5 mrad SPE resolution and better than 3σ track level separation

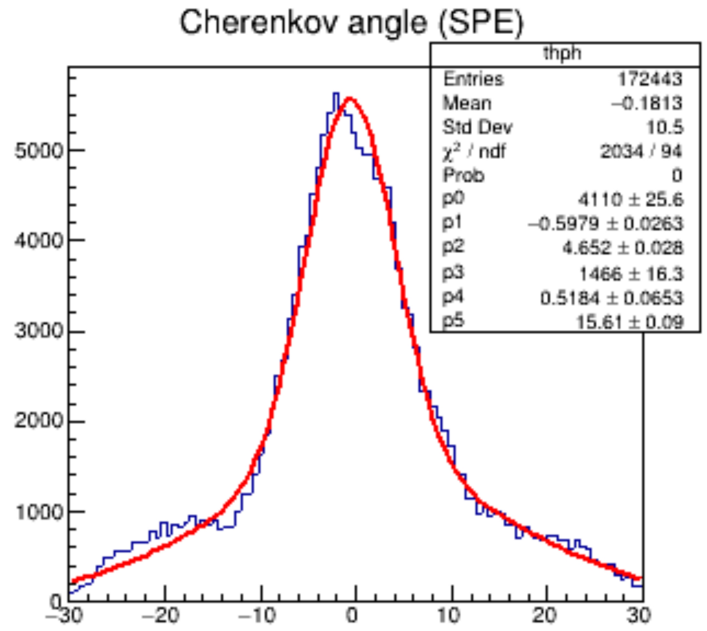


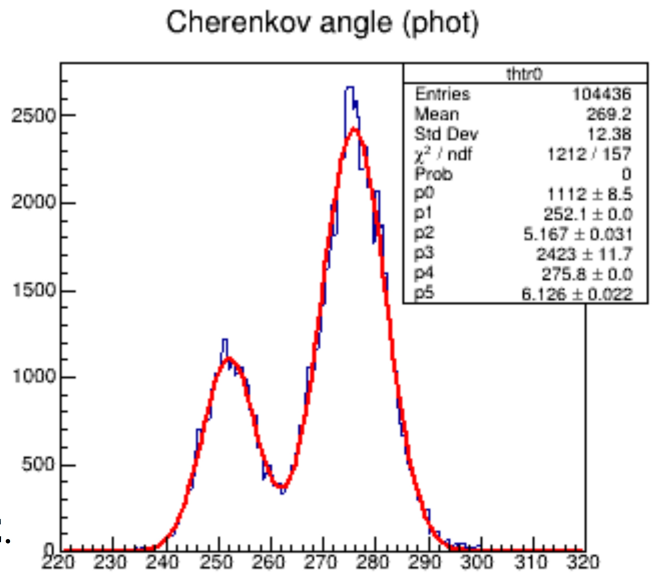


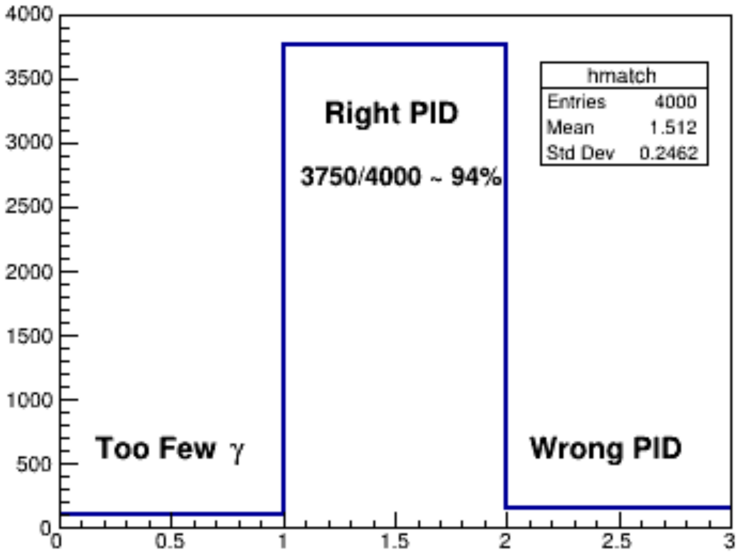
Hints of improvement with IRT v-2









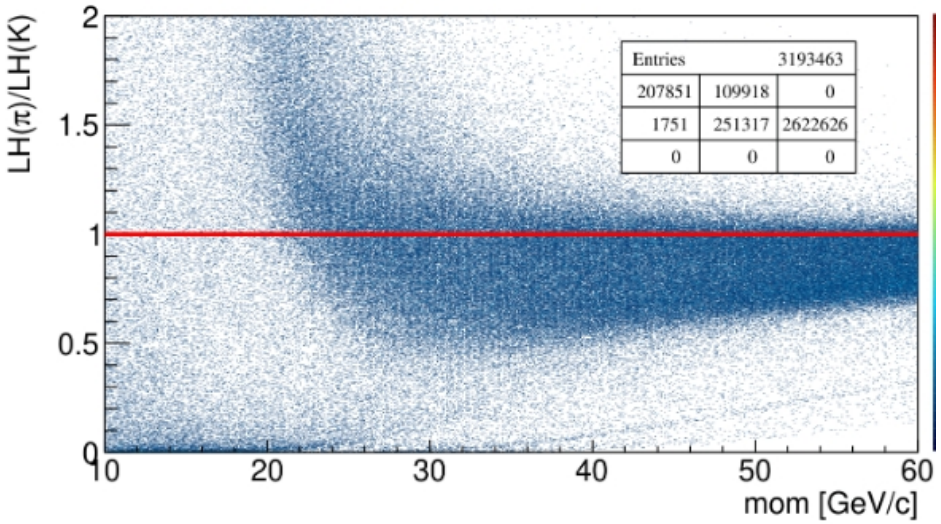


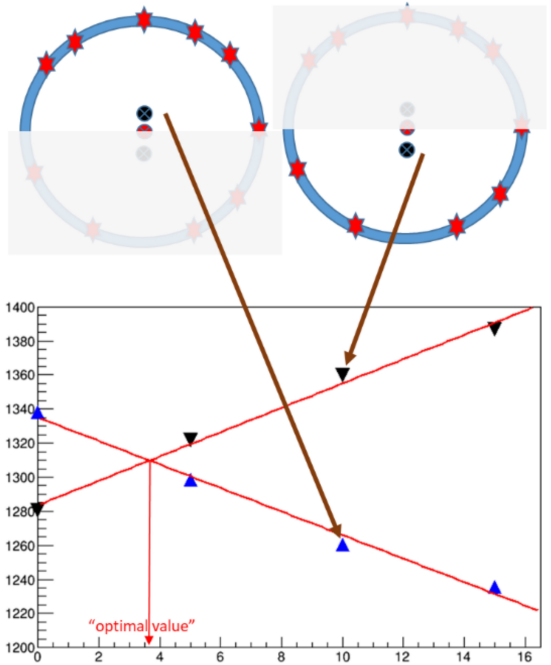
4 particles an event 4 GeV and 7 GeV pi/K mixture. Ensured overlapping

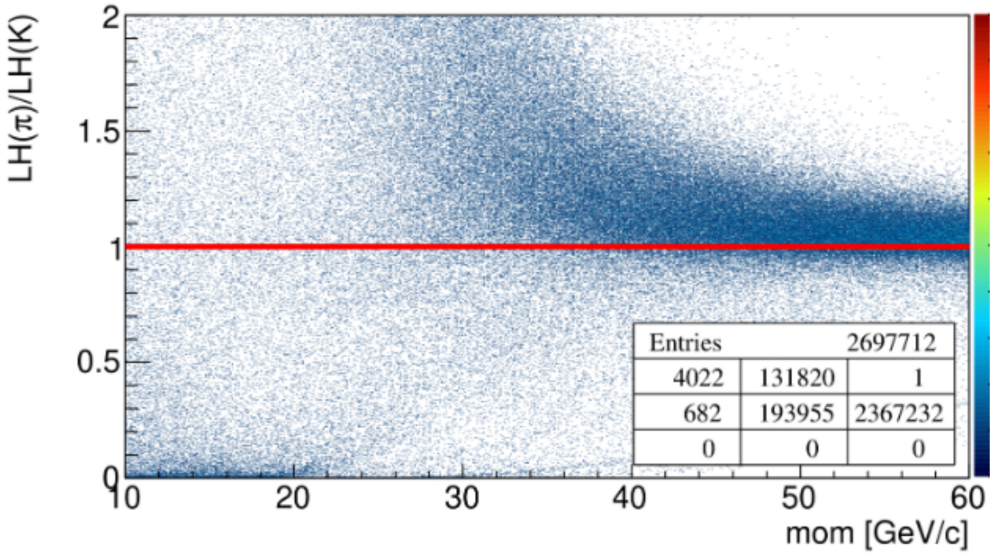
C.

Requirement of an improved ray tracing

- Ray tracing methods have potential advantages. It gives access to single photon angle and resolutions.
- Important intermediate stage: From the data to the final PID analysis. The accuracy of a multivariate likelihood based PID highly depends on pre-analysis.
- Large synergy between pf/dRICH over IRT based approach. A common PID platform. Global LH to include TOF information. Under the PID CC-WG umbrella?
- Initial testing to import IRT-v2 in EICRecon has been started. Substantial change in PID part of the data model will be made.







Upcoming plans on IRT v-2 and data model

- A dummy RICH detector is being locally implemented by Alexander to check hits and test at the level of meaningful EICRecon output. More on his talk.

- We will discard all weight based particle selection, capable to identify single particles and initially replace an event-level chi-squared PID. Large combinatorial overhead, a event level likelihood maybe a solution?

- Data model has to be revised. Initial idea is to fork the official data-model, and keep track of the changes. Deepak Sammuel from CUK, India agreed to take this responsibility.

- For the common pf/dRICH reconstruction (RICH-reconstruction) team, contact person to communicate and represent to the Software and Reconstruction working group.

- Alternative algorithm can also be explored later. KEEPING THE INTUITIVE ALGORITHM UNHARMED!

Summary

- We are aware of delivering PID to the physics WG. PhD students working on dRICH also require an algorithm to provide PID.

- Handling complicated event topology is a limit for IRT v-1, currently in EICRecon. An algorithm that can handle multiple optical path choices is robust from the principal point of view. Our initial studies suggest that IRT v-2 is capable of that. We therefore will bring it to EICRecon.

- PID Output: currently (stand-alone) an event based chi-square algorithm is in place. Large combinatorial overhead due to particle-hypothesis pair. A global (event-based) likelihood has to be implemented. Likelihood compatibility to incorporate other PID detectors requires a global coordination.

- From the reconstruction point of view, a common RICH algorithm platform is imagined to work closely with the global reconstruction collaboration.

Back ups

IRT-DRT

ELSEVIER
Nuclear Instruments and Methods in Physics Research A 502 (2003) 294–299
Section A
www.elsevier.com/locate/nima

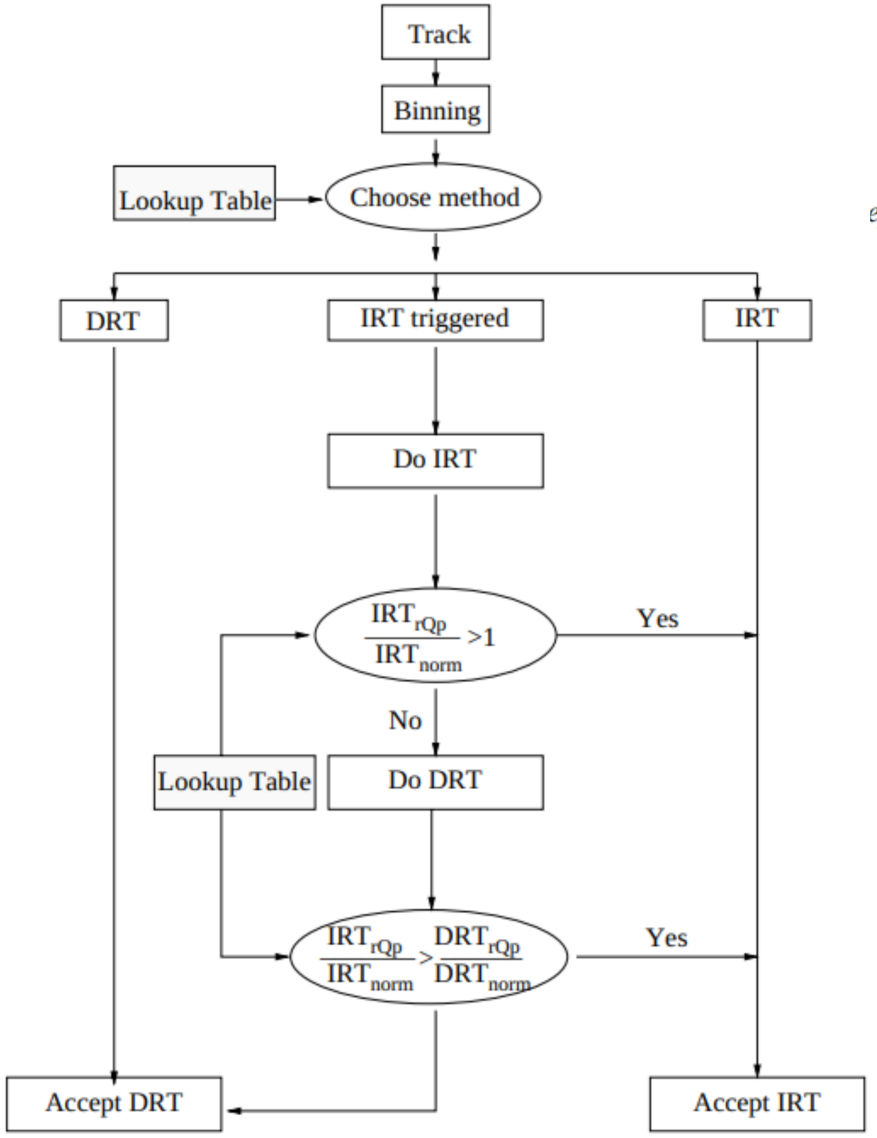


Fig. 2. The decision flowchart for the RPS.

Hadron identification with the HERMES RICH

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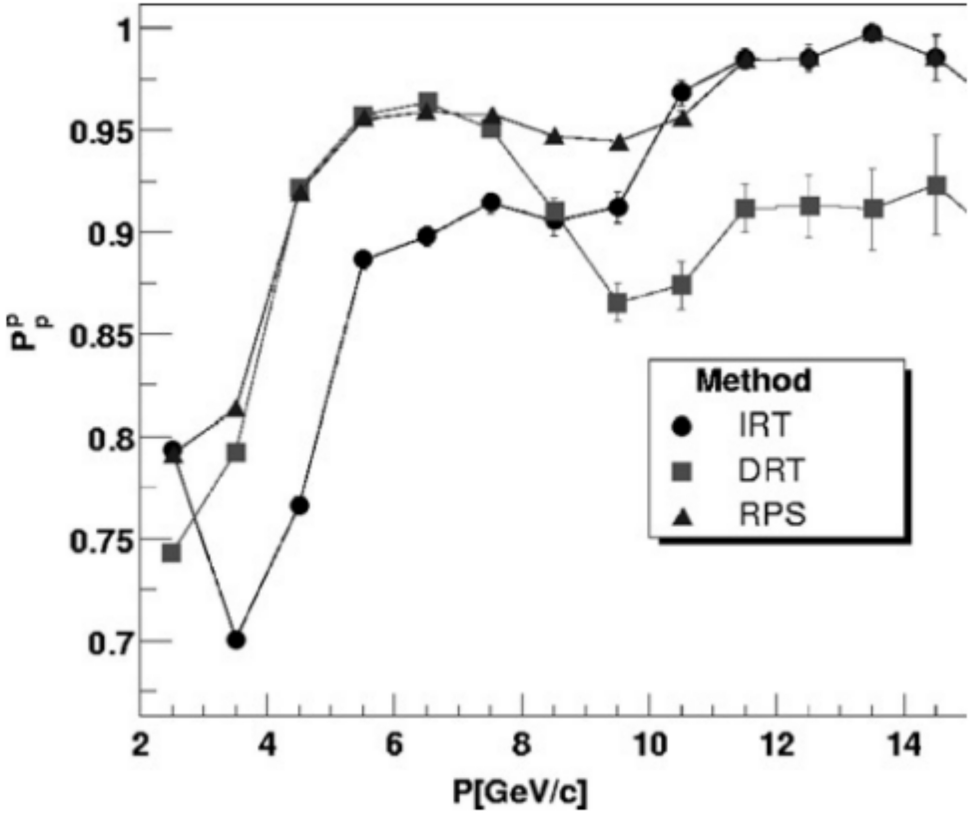

Fig. 3. Proton efficiency as a function of momentum for IRT, DRT and RPS.

IRT-v1

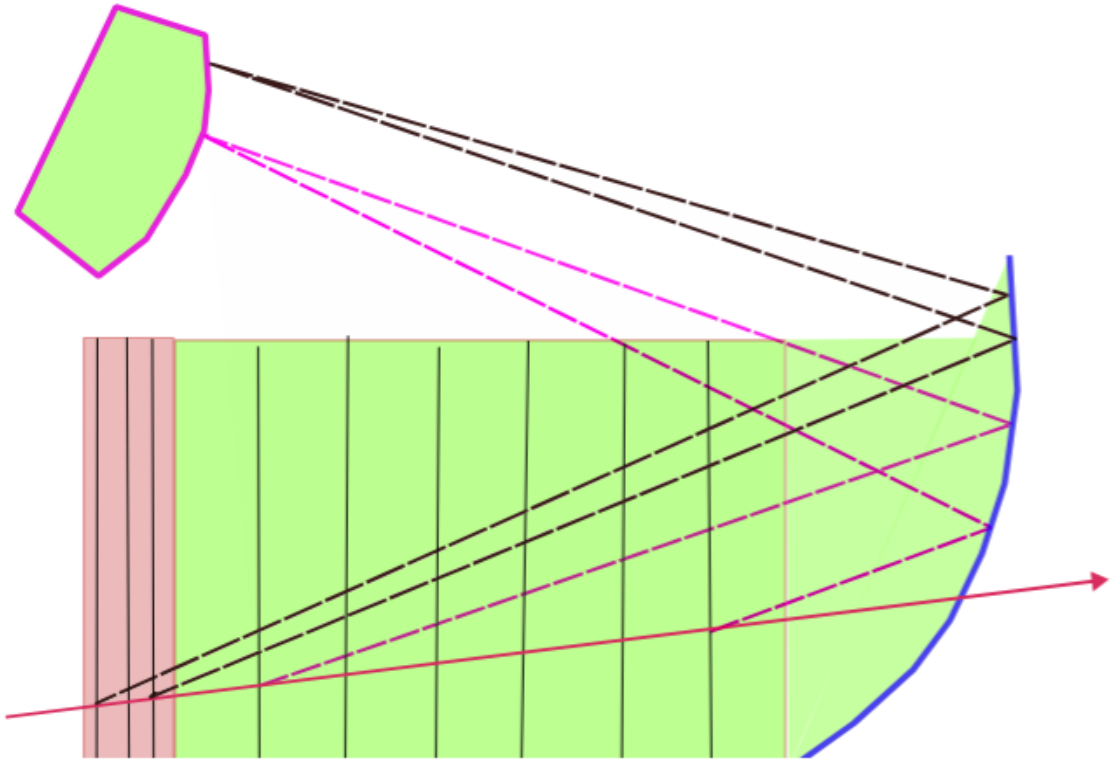

Figure: IRT working principle

- Currently we are using the IRT v1.0. So called ATHENA IRT or dRICH IRT.
- Surfaces are parametric: e.g. Flat surface, spherical surface.
- Optical boundaries have specific surface and refraction/reflection are taken accordingly.
- Given the detection point, the reflection point around the mirror can be guessed.
- Average of the converged solution for a set of assumed emission points are passed as the Cherenkov polar and azimuthal angle.
- Currently we are using 5 points for aerogel and 10 points for gas tracks.
- Based on each photon's angle an weight is assigned with 3σ window for different hypotheses. Brute PID performance.