hpDIRC Simulation Status in ePIC Software
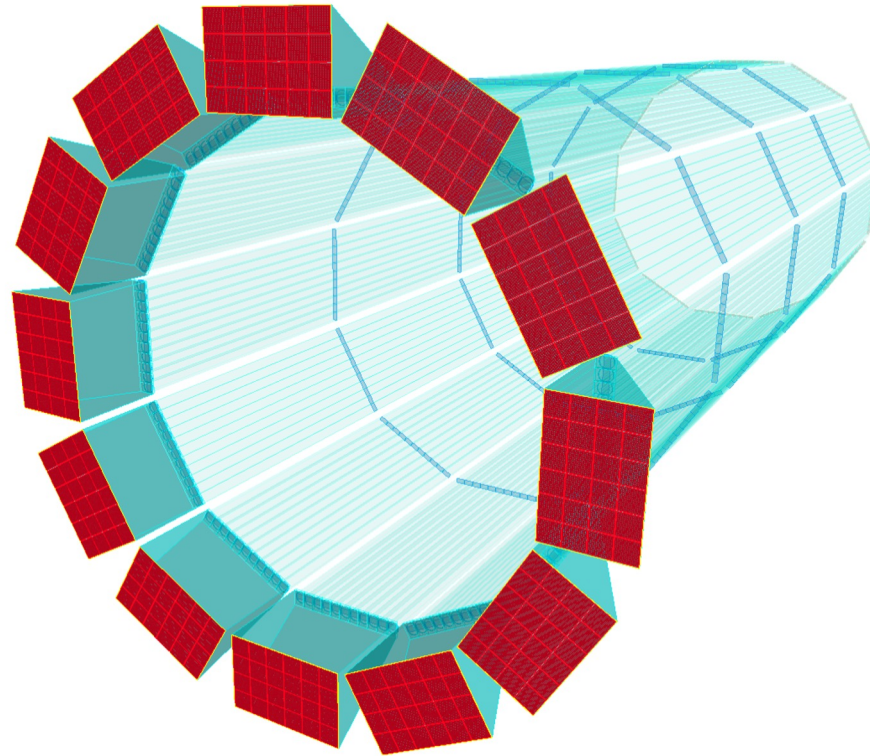
Greg Kalicy — CUA

ePIC TIC Meeting

September 22nd, 2025

CUA GSI JAZAN UNIVERSITY Jefferson Lab OLD DOMINION UNIVERSITY Stony Brook University UNIVERSITY OF South Carolina WAYNE STATE UNIVERSITY WILLIAM & MARY UNIVERSITY of GLASGOW
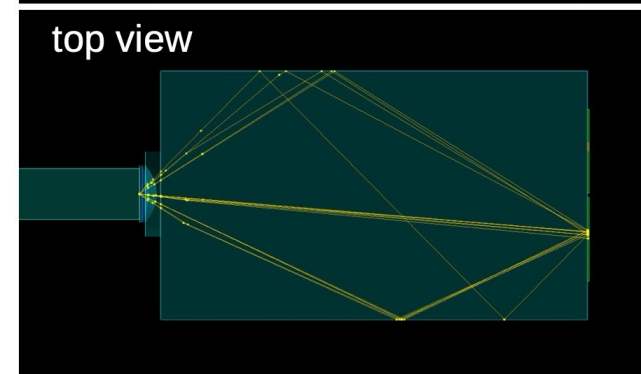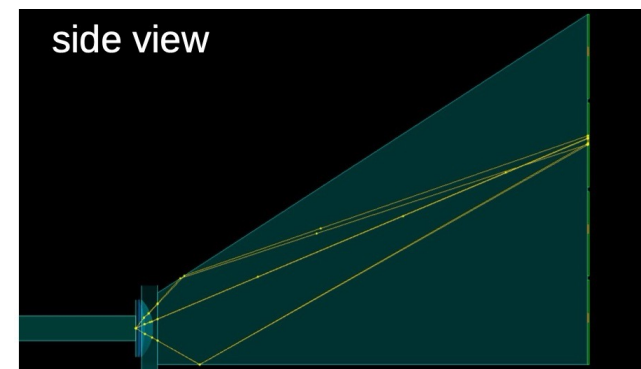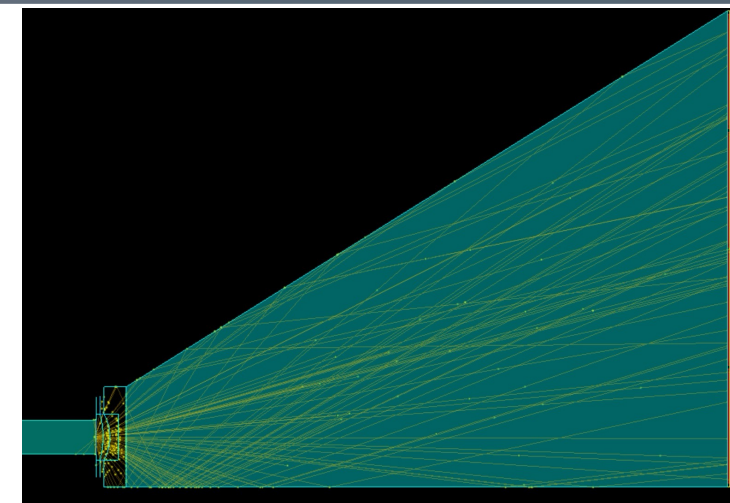
HPDIRC RECONSTRUCTION

hpDIRC PID methods:

➤ Geometrical (BABAR-like), robust and fast method based on Look-Up Tables, delivers Cherenkov angle per particle and Single Photon Resolution (useful for calibration and in prototype tests), does not depend on precise time measurement

➤ Time Imaging (Belle II TOP-like), uses Probability Density Functions (analytical or simulation-based), makes optimum use of precision of position and time information

➤ Neural Network Reconstruction, directly using binned time and channel id to provide PID (under development)

High-precision angular track resolution is crucial for reaching required hpDIRC performance for all reconstruction methods

➤ Key features:
  ➤ BaBar-like
  ➤ uses Look-Up Tables
  ➤ delivers Cherenkov angle per particle and
     Single Photon Resolution (useful for calibration)
  ➤ does not depend on precise time measurement

➤ Pixel position + bar location define
  photon direction at bar end, stored
  in Look-Up Table (LUT), combined with particle
  track to calculate Θ_C.

➤ Path pixel – bar not unique
  combinatorial background in Θ_C
  requires careful treatment.

➤ Arrival time information is used to resolve
  ambiguities

➤ Will be the first implemented reconstruction
  method in EICrecon

side view

top view

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  - ➤ BaBar-like
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  - ➤ delivers Cherenkov angle per particle and Single Photon Resolution (useful for calibration)
  - ➤ does not depend on precise time measurement

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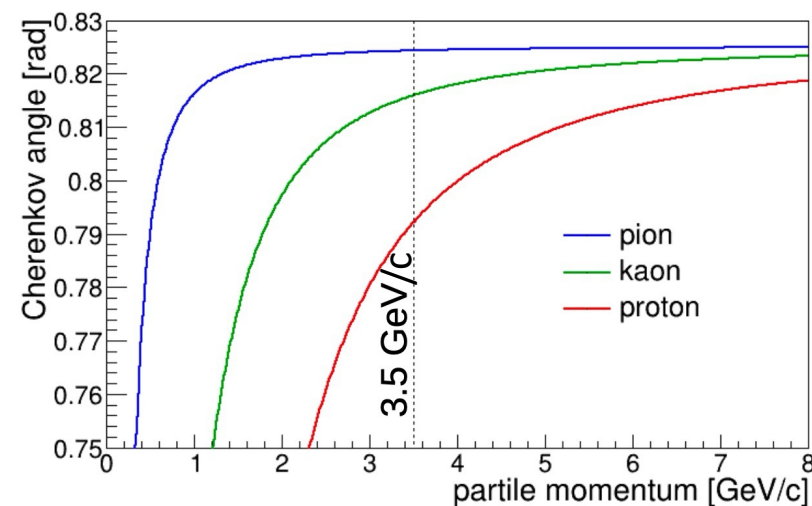
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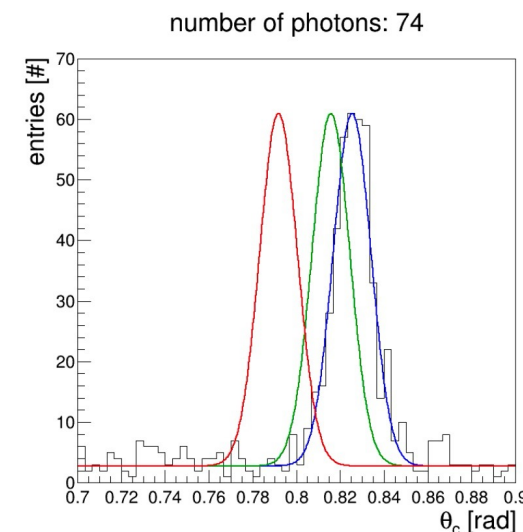
- ➤ Will be the first implemented reconstruction method in EICrecon

$$\log \mathcal{L}_h = \sum_{i=1}^{N} \log(S_h(c_i) + B_h(c_i)) + \log P_h(N)$$
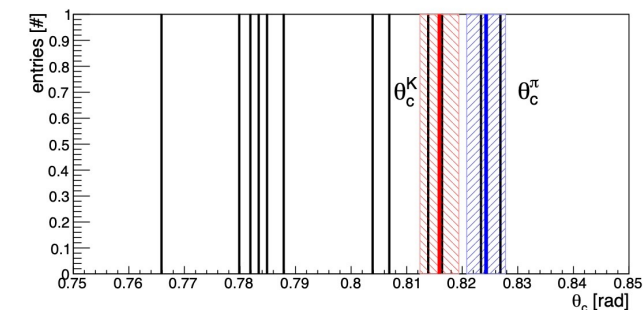
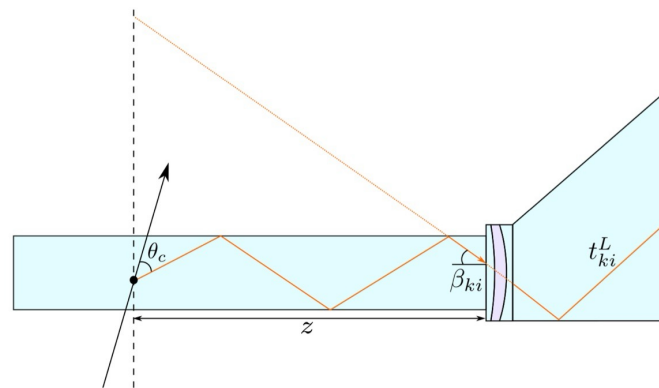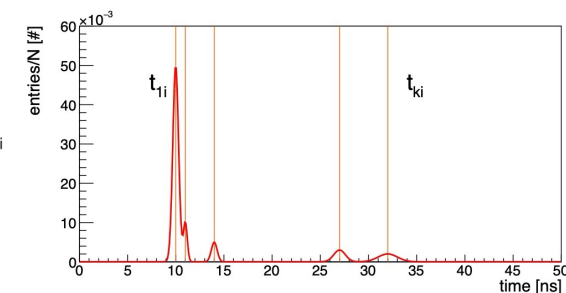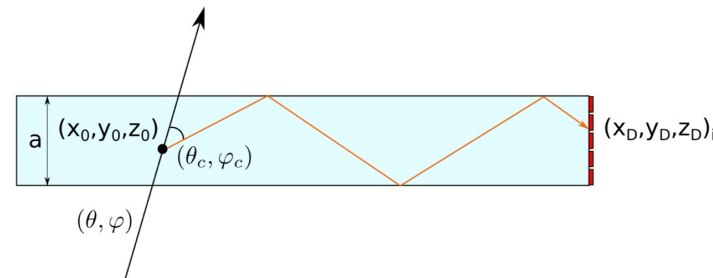signal   combinatorial background

➤ **Key Features:**

➤ Belle II TOP-like

➤ uses **P**robability **D**ensity **F**unctions

➤ optimal use of position and time information

$$\log\mathcal{L}_h = \sum_{i=1}^{N}\log(S_h(c_i,t_i) + B_h(c_i,t_i)) + \log P_h(N)$$

➤ **Probability density functions (PDFs):**

➤ **From data:** best PID, requires a large amount of data in whole angular and momentum acceptance

➤ **Simulated:** full Geant4 simulation of every possible particle type direction and momentum

➤ **Analytical:** fast, low memory footprint initially developed for Belle II TOP, modified to account for spherical lens focusing (PDFs using LUT)

➢ Implemented:

  ➢ All optical components of the geometry are implemented (radiator, focusing system, EV, mirror)

  ➢ Wave-length dependent material properties

  ➢ Quantum and collection efficiencies of PMTs are implemented (stacking action class)

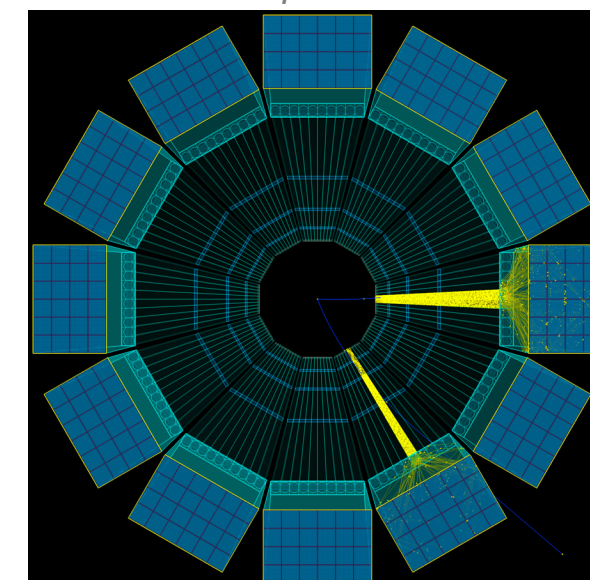 ➢ Digitization: DIRCRawHit (RawTrackerHit) → celd Id → position → PMT Id, pixel Id → DIRC tree

➢ Reconstruction:

  ➢ Initial approach using plug-in DIRC tree (see https://github.com/eic/snippets/tree/main/PID/hpDIRC) does not work anymore

  ➢ Geometrical reconstruction: LUT was created using standalone Geant4 simulation to be directly imported into ePIC's simulation.

  ➢ Time-imaging reconstruction: PDFs were created using standalone macros using simulated data.

hpDIRC in ePIC simulation
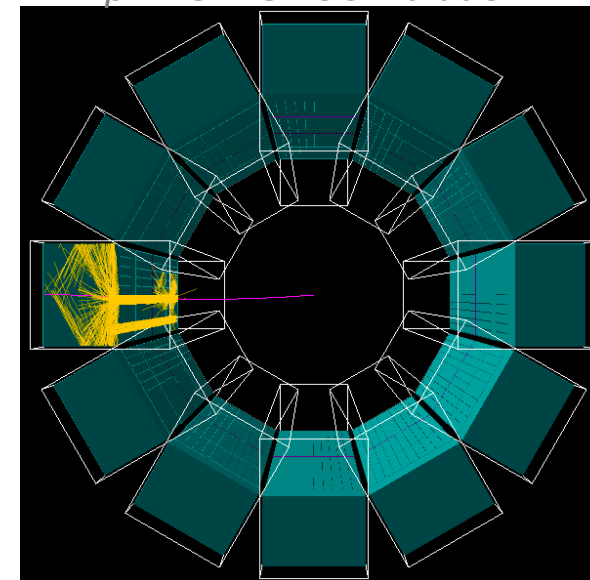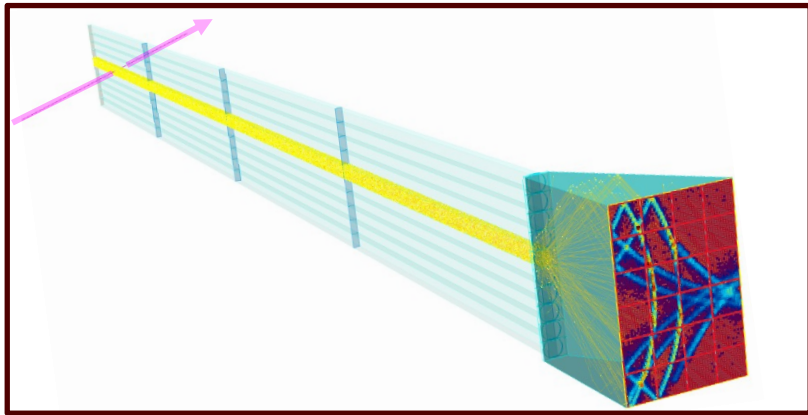

Stand-alone hpDIRC simulation

- ➤ Integration of hpDIRC Reconstruction into Full ePIC Simulation restarted

- ➤ Collaborative work between WSU and SBU teams.

- ➤ Shubham will work with support from Roman and Bill to adopt stand alone code according to ePIC tutorials and dRICH examples. He will start with Geometric reconstruction.

- ➤ Coordination with the Reconstruction Working Group has started. Chandra's involvement will help strengthen collaboration and support the development and integration of the algorithms in EICrecon.

Bill Llope (WSU)
Shubham Dutta (SBU)
Julio Barrantes (SBU)

hpDIRC in ePIC and stand-alone simulation

Single particle gun events to map hpDIRC performance