

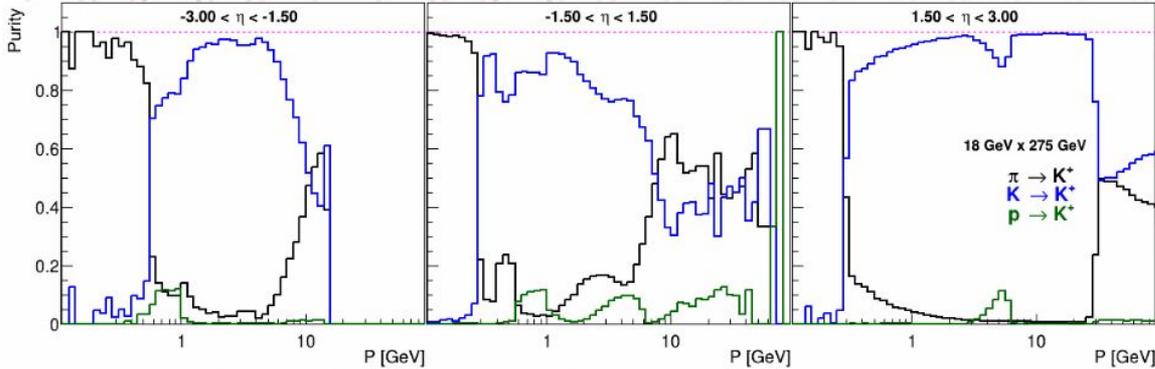
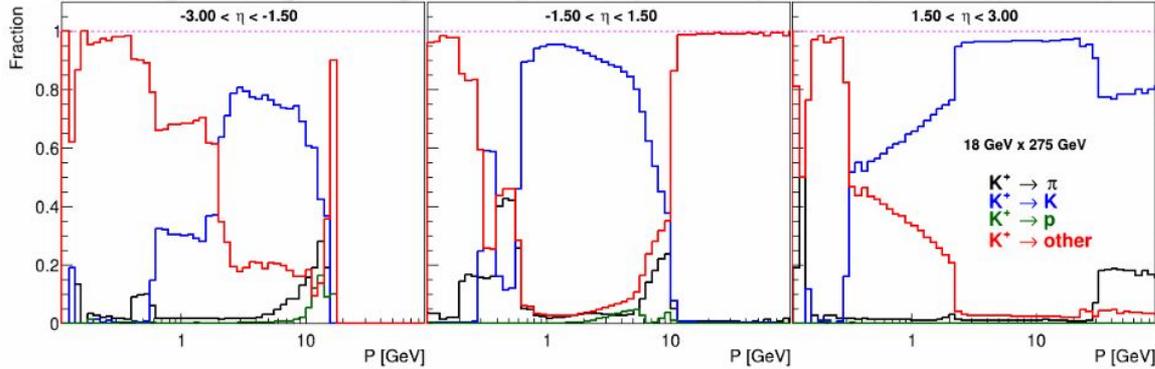
PID Algorithms: Status and Plans

Chandradoy Chatterjee

with

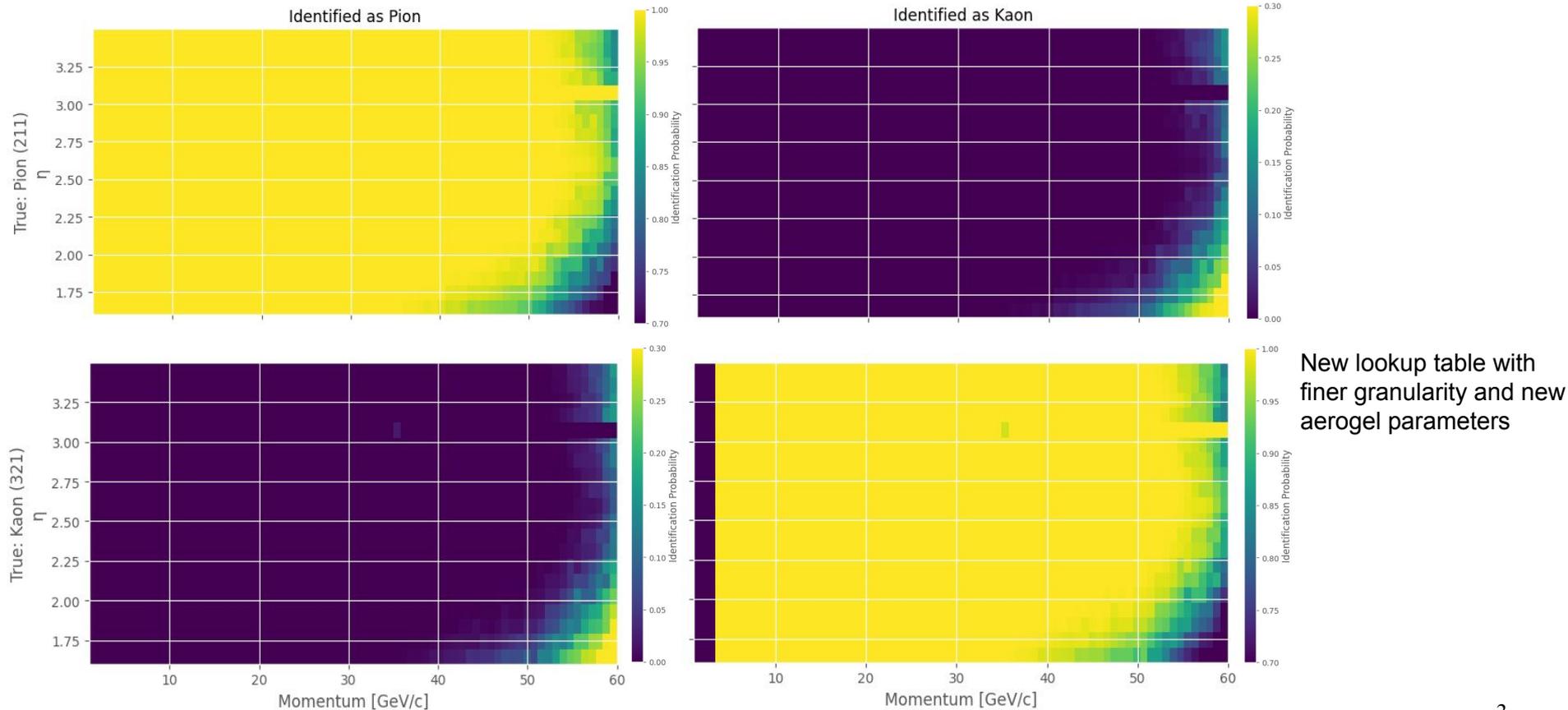
Brian Page, Derek Anderson, Shujie Li, Surabhi Tarafder

Requirements from SIDIS WG

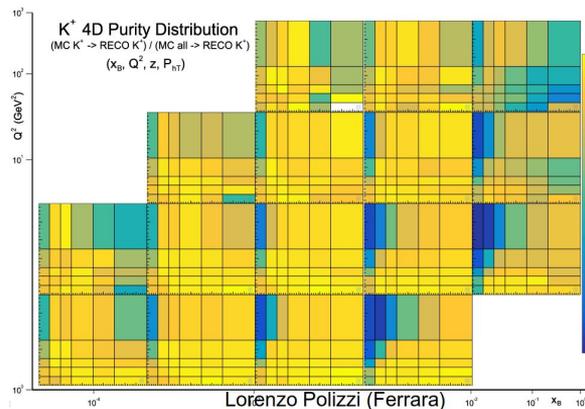
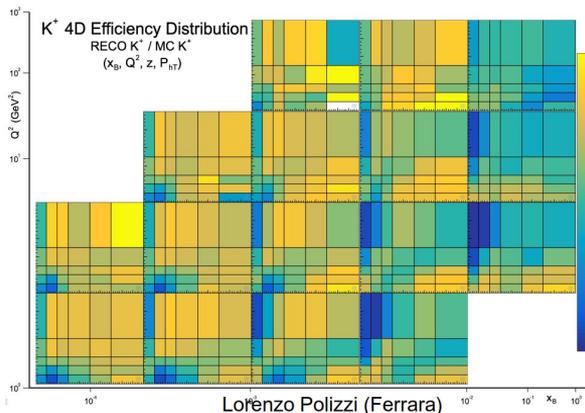


- ❑ pion/Kaon/Proton PID efficiency and purity versus momentum in three rapidity ranges:
 - ❑ Currently based on LUT generated either in standalone or single particle gun in ePIC simulation stack.
 - ❑ Would need likelihood (with tunable cuts).
- ❑ Coarse binning:
 - ❑ dRICH has large pseudorapidity dependence due to single mirror configurations.
- ❑ Flexibility to tune between efficiency and purity.

Fine binned LUT (dRICH example)



Requirements from SIDIS WG



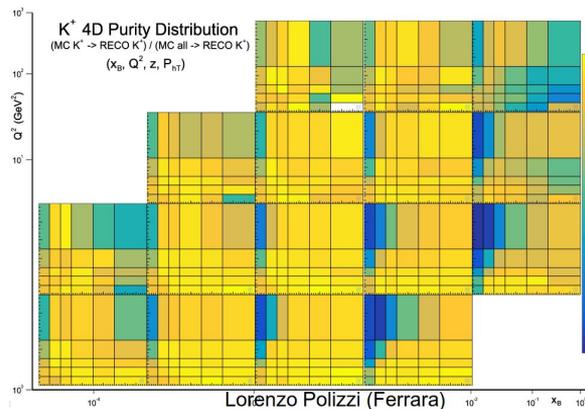
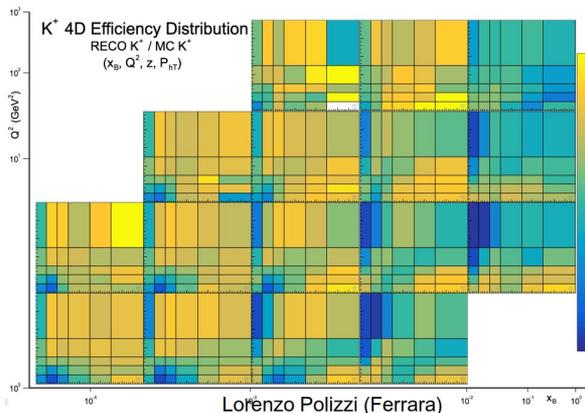
Needed aspects of SIDIS WG:

- Flexibility: Tune PID efficiency and purity based on physics case.
- Unfolding capability: Unfold PID matrices in fine phasespace bins.
- Holistic PID: not only pi/K/p separation from dedicated PID detectors, but also include e/h and e/pi ID information from calorimeter (+tracking).
- Systematics: Assignment of systematics for the efficiency matrices.

- Detector calibration using physics samples.
 - Known decay samples to validate algorithm and detector performance.
 - Inclusion of realistic background and impact can only be studied via pythia samples.
- We know all these! But where do we stand?



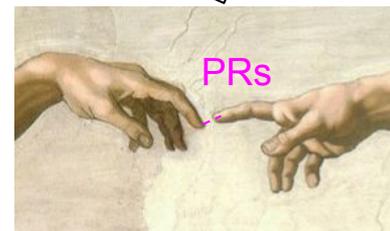
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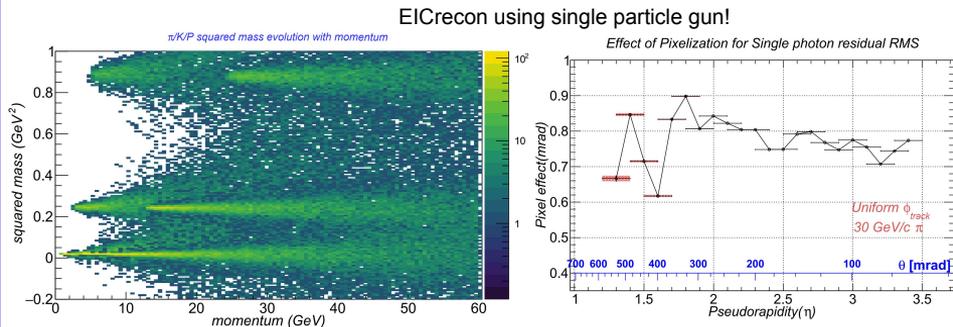
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Cherenkov PID algorithms in ePIC (EICrecon)

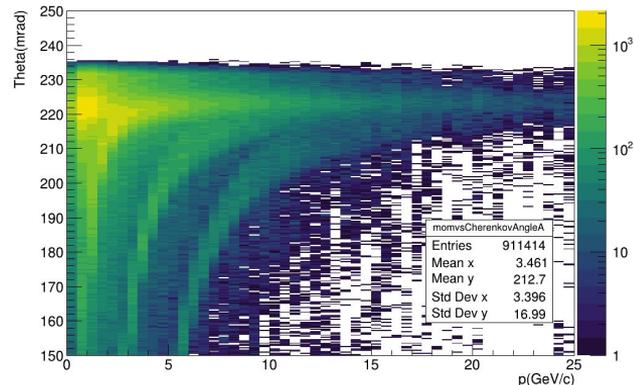
- We have three Cherenkov detectors:
 - pFRICH
 - **dRICH** (currently in official SW releases)
 - hpDIRC
- IRT1 in EICRecon:
 - dRICH currently uses Inverse Ray Tracing to estimate the Cherenkov angle of single detected photons (First part of the algorithm). Single photon information for a given mass hypothesis to assign weight to a favorable hypothesis (Second Part of the Algorithm relevant for PID).
 - Confusion arises for high multiplicity events, added noise with split rings etc. An updated version resolves this. Event based chi-squared. Not yet log-likelihood.
- An update of IRT (IRT2) handles this multi-trajectory confusions. Integration to EICRecon ongoing.
- hpDIRC has a *standalone* algorithm. Tested in simulation and beam test. Integration to EICRecon is ongoing.
- Efforts towards AI/ML : dRICH, pFRICH, hpDIRC



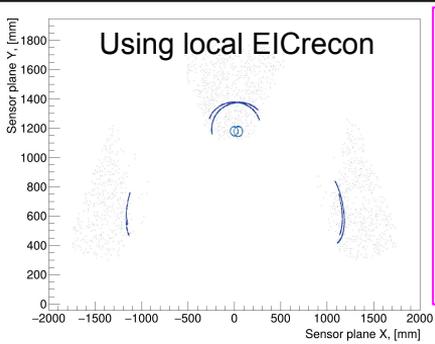
Aerogel photons from october campaign:

root://dtn-eic.jlab.org/volatile/eic/EPIC/RECO/25.10.1/epic_craterlake_without_zdc/DIS/BeAGLE1.03.02-1.0/eAu/10x100/q2_10to100/

Cherenkov Angle (Aerogel) as Momentum

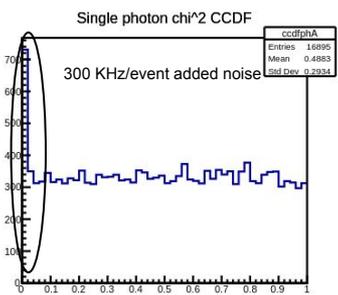
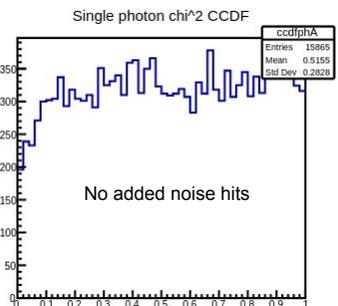
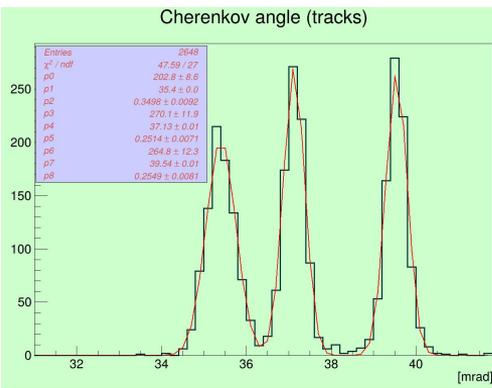


IRT 2 integration status



- ❑ IRT 2 uses same class to reconstruct single Cherenkov photon angles.
- ❑ Uses a calibration file with tabulated emission point as a function of momentum and pseudorapidity.
- ❑ Hit, track and event based chi-square.
- ❑ Uses hit position and timing information to perform PID.
- ❑ Subject to combinatorics for large multiplicity events → Can be eliminated with track-level log likelihood.

Expected (reconstructed) angles:
 30 GeV kaon: 35.34 mrad (35.40 mrad);
 50 GeV kaon: 37.71 mrad (37.13 mrad);
 50 GeV pion: 38.87 mrad (39.54 mrad).



Work is ongoing to port IRT v2 into EICRecon.

- ❑ Rebased against EDM4eic, epic and EICRecon repositories.
- ❑ Generalized: no pFRICH/dRICH/mock RICH specifications.
 - ❑ ACTS tracking interface.
 - ❑ Without any standalone scripts.
 - ❑ IRT reconstruction within generic EICRecon IrtInterface.
- ❑ Open Pull Requests :
 - ❑ epic: <https://github.com/eic/epic/pull/1025>
 - ❑ EDM4eic: <https://github.com/eic/EDM4eic/pull/155>
 - ❑ EICrecon: <https://github.com/eic/EICrecon/pull/2379>

Reviewers' comment are being addressed.

- ❑ Optics file eliminated
 - ❑ Tested for dRICH : Works
 - ❑ pFRICH still to be tested.

Ongoing or soon to be started:

- Incorporation of photon level information in IRT2 data model.
- PODIO style association (like existing dRICH benchmark)
- Background effects

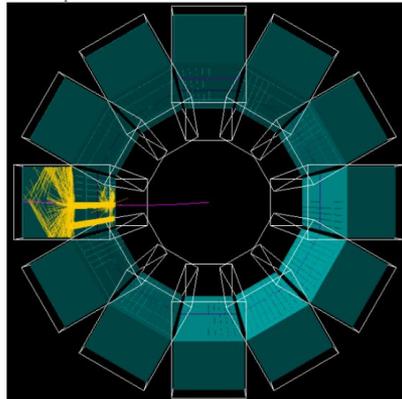
Tentative time scale:

- To address the issues flagged in the PR (end of this month)
- Validation of IRT 2 with some physics samples (~ two months)
- Implementation of Likelihood (at least at a preliminary level: Before next CM)

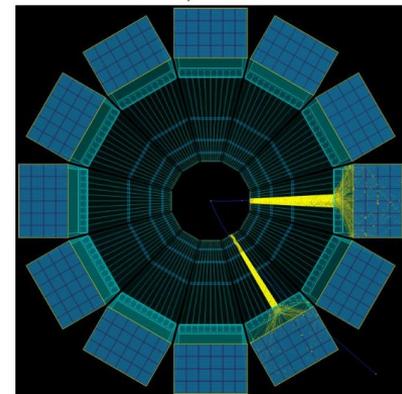
hpDIRC status

- ❑ Cross-check between mechanical design and DD4hep implementation are ongoing by Bill and Shubham
- ❑ Comparison of observables between standalone and ePIC stack.
- ❑ Measured PDE with HRPPD are implemented and tests are being made. Digitization is under discussion.
- ❑ First Pull Requests after these sanity checks are done.
- ❑ Pythia events (without background from other systems) is under study to compare stand-alone test made by Bill.
- ❑ PID output : limited to log likelihood. Discussions can be made on most relevant information (single photon resolution, timing information etc).

hpDIRC in ePIC simulation

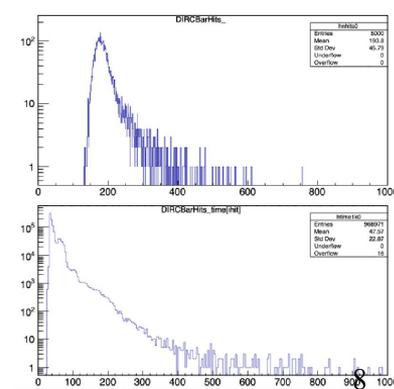
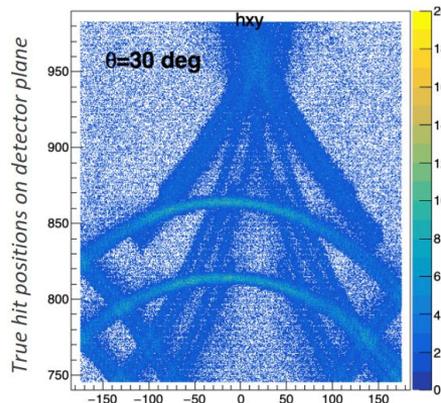


Stand-alone hpDIRC simulation



- Workforce is limited:
 - **Shubham and Bill are trying to identify the major obstacles.**
 - **In about a month of time, hpDIRC colleagues would be able to reassess what kind of assistance is mostly needed.**
 - **Software related issues are not the only needed help. People with deeper knowledge in RICH-type detector would be needed to address some specific issues.**
- A realistic timescale for much matured hpDIRC reconstruction:
 - Before the next collaboration meeting
- AI/ML : W&M involvement, interesting, difficult to project a timescale.

Shubham's talk in Joint Reco PID-CC Workfest

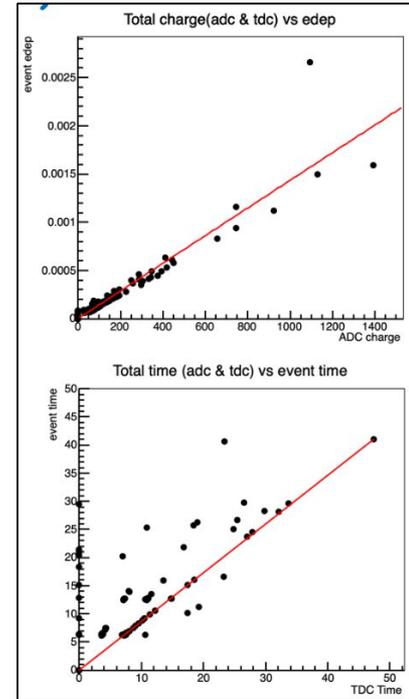
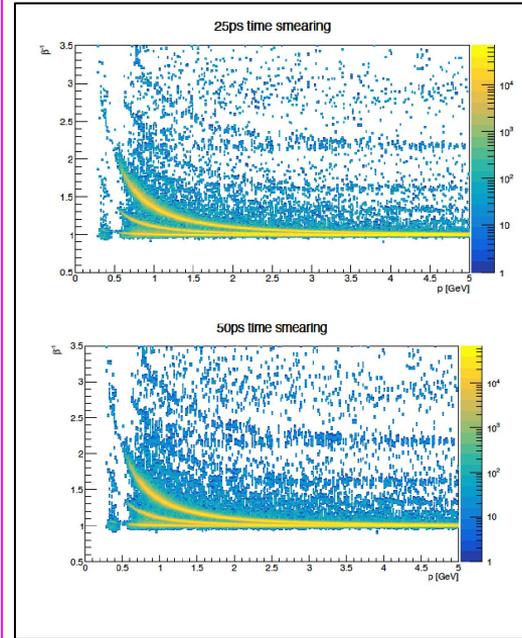


hits per track photons propagation time

Time of Flight

- B/F-TOF has up-to-date Geometry
- Digitization, Material Budget, PID performance has been done for BTOF.
 - BTOF Digi ready, needs synchronization with performance studies.
- PID performance of FTOF has been shown in Joint Reco-PID CC Workfest.
- Material budget, effect on tracking, Digitization are either started or ongoing.
 - FTOF digitization needs further development.
- Limited human resource:
 - Expected a new student.
 - Helps can be appreciated:
 - Integration of Digitization and performance.
 - Proper benchmarking.

- ❑ Presented results use particle gun, needs extension to Pythia events.
- ❑ Uses ePIC simulation chain.



[See Kentaro's talk](#)

Summary of Joint PID-CC & Reco WG meeting

- ❑ Demonstrated that Work is ongoing despite shortage of workforce.
- ❑ SIDIS working group has clearly mentioned the requirements.
 - ❑ New look up table available for dRICH with new aerogel parameters.
 - ❑ Level zero systematic studies will be made.
- ❑ Next collaboration meeting has been largely agreed upon as a timeline to demonstrate PID in EICRecon.
- ❑ IRT v2 integration into EICRecon is getting large support from Dmitry (not only review but also EICRecon integration).
- ❑ Incorporation of particle data-flow towards holistic PID and required data-model was largely discussed. Support from SIDIS WG would be appreciated.

Take home messages

- Currently implementations of algorithm into EICRecon are ongoing. Despite not always with an open PR.
 - Requests to DSCs and developers:
 - Please open PRs even if in draft mode. Certain aspects can be readily resolved.
 - Long approval time compromised performance studies (Example TOF)
 - Optimization of review process is a SW priority. Improvement expected.
- A general consensus to report progress before/at next CM.
- RICH-IRT in close collaboration with Dmitry.
- hpDIRC and TOF in transition phase.
 - hpDRIC expects in one month to identify potential helps from SW team, but support with colleague knowledgeable in RICH-type detector is needed.
 - TOF might seek help from Tracking colleagues.
- Holistic PID:
 - Involvement from SIDIS WG
 - Algorithm should give flexibility to analyzers