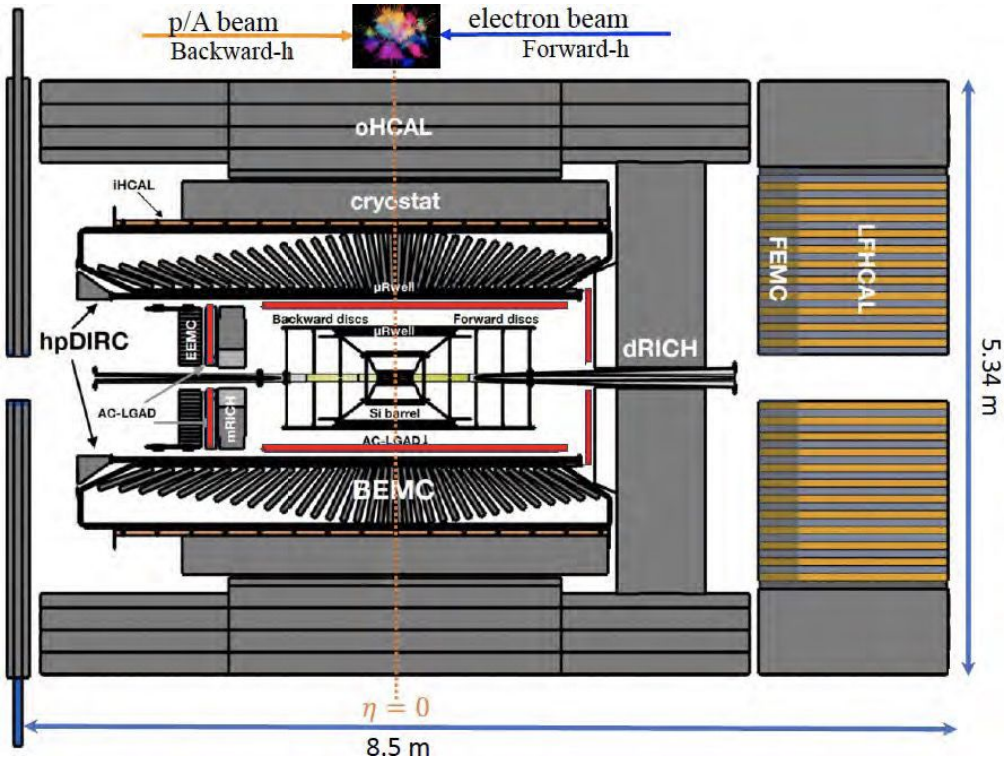
TOF-PID Report: simulation and optimization

ePIC GD/I meeting
November 7, 2022

AC LGADs TOF Overview



	PID coverage
Forward (1.5<η<3.5)	0.15 < p < 2 GeV
Barrel (|η|<1.4)	0.15 < p_T, p < 1.5 GeV
Backward (-3.7<η<-1.74)	0.15 < p < 2 GeV

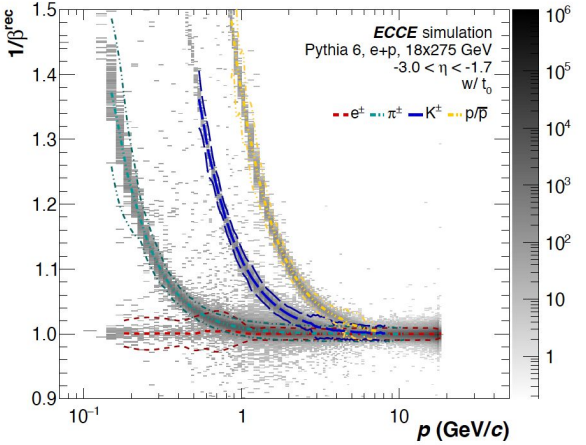
Note: backward TOF is currently taken out of the reference design as a backup option

Baseline design:

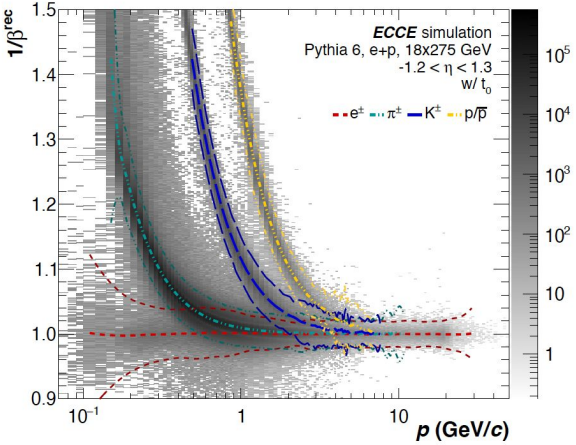
- 500 micron x 1cm strips for barrel
- 500 micron x 500 micron pixels for endcap
- 25ps time resolution

Studies prior to ePIC stack - PID

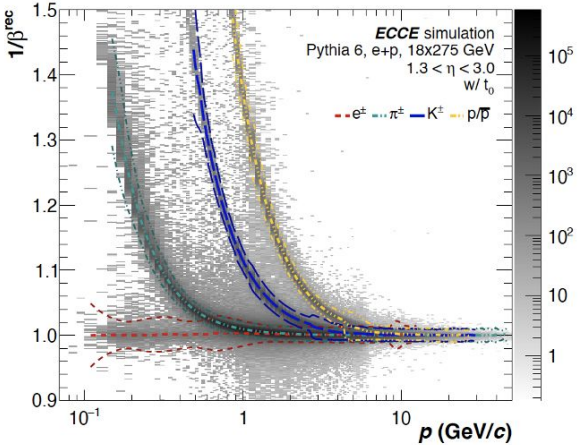
Backward



Barrel



Forward



$1/\beta=(t-t_0)/L$

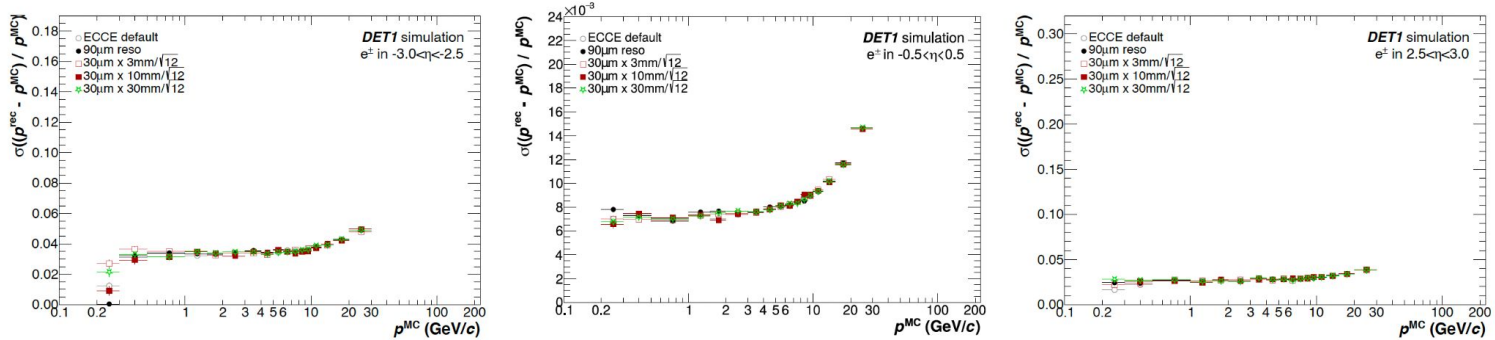
F. Bock (ORNL)
S. Yang (SCNU)

- σ_t~25 ps for single hits (optimal scenario)
- start time (t_0) determined by scattered *e*- and/or fitted with all detected hadrons

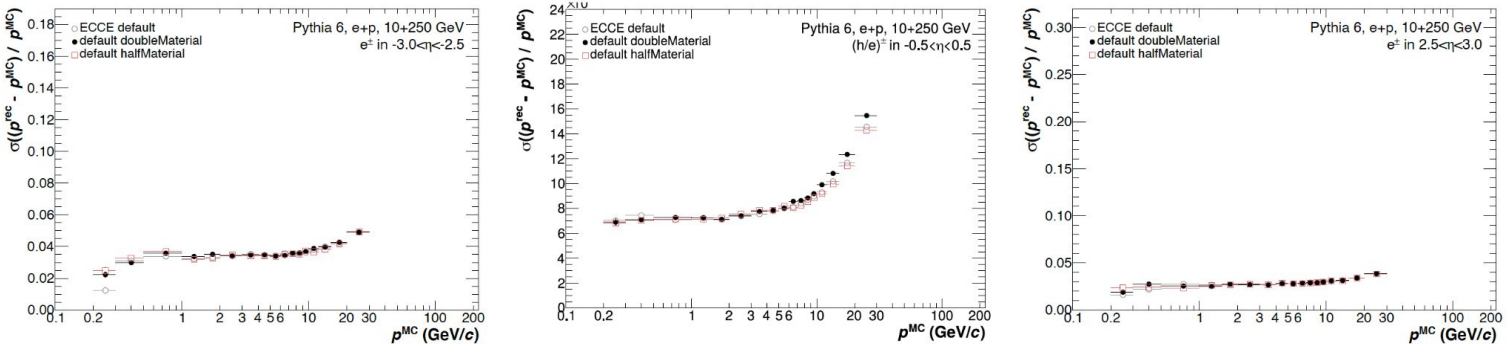
Full PID of π, K, p, and even *e*- (p<0.5 GeV) down to ~0.15 GeV

Studies prior to ePIC stack - tracking

No significant impact observed when varying position resolution (e.g., 30 vs 90 microns)



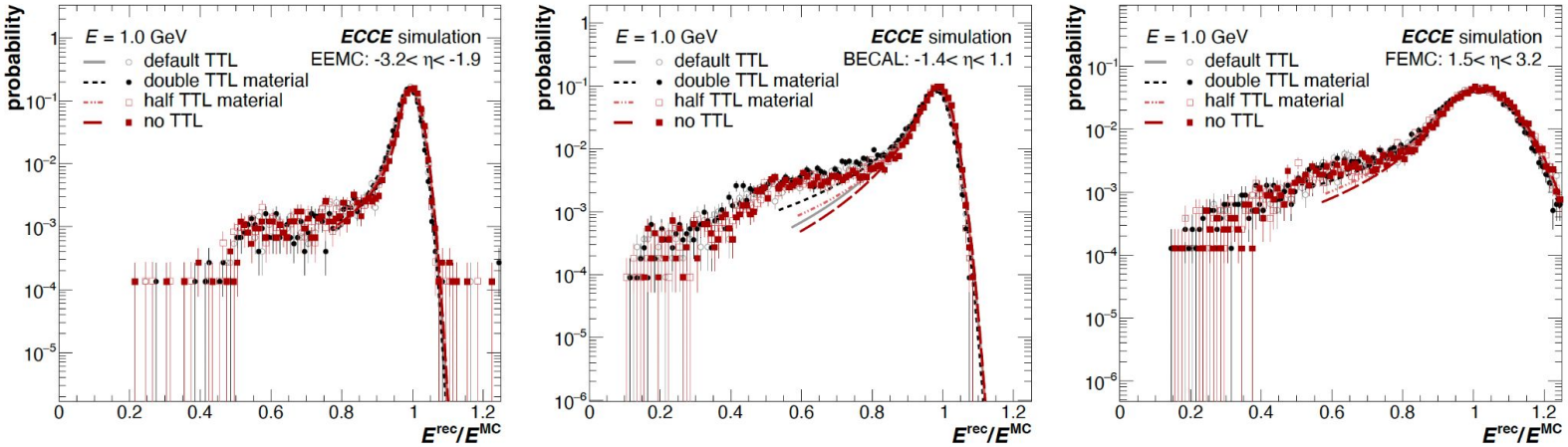
No significant impact observed even when doubling the material budget



Also studies on track pointing angle resolution, tracking efficiency, etc.

Studies prior to ePIC stack - impact on ECAL

No significant impact observed even when doubling the material budget

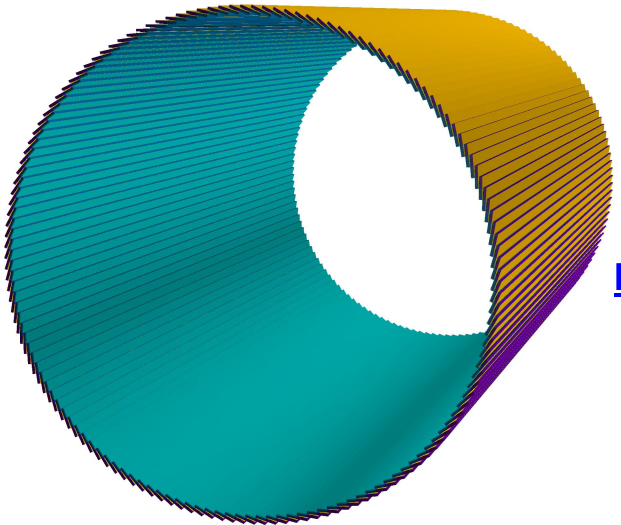


The WG has started making the transition to ePIC software stack over the past few months and poised to repeat all studies using the state-of-the-art tools to converge on the design parameters of TOF.

Detailed plan: https://wiki.bnl.gov/EPIC/index.php?title=TOFPID

TOF in ePIC stack: Geometry

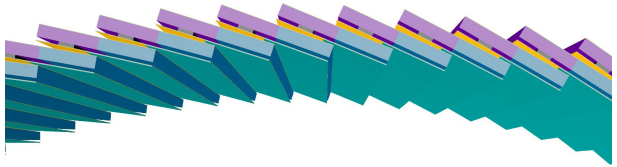
- Realistic geometry implemented in dd4hep
- On-detector services and cooling accounted for
- Average material budget of ~8% X/X_0 (fwd) and ~1% (barrel)
  - Dominated by supports and cooling
- Proposed R&Ds to further optimize the design



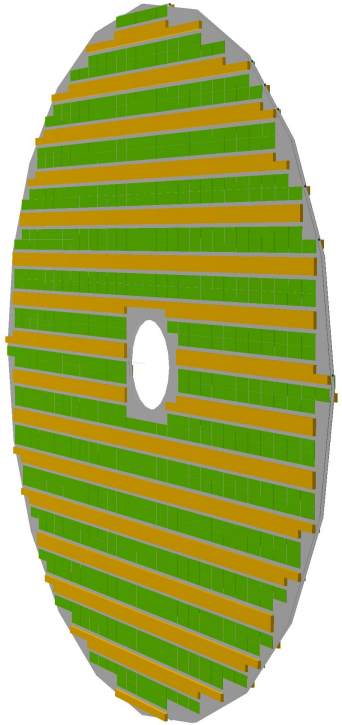
Flexible and easily adjustable implementation

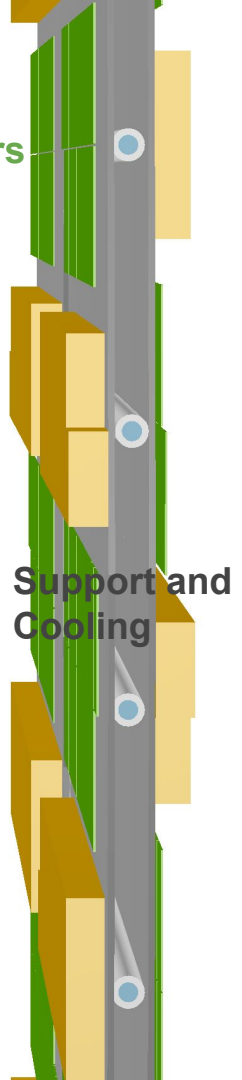
➔ Quick turn-around with engineer suggestions for porting to dd4hep

Barrel Staves



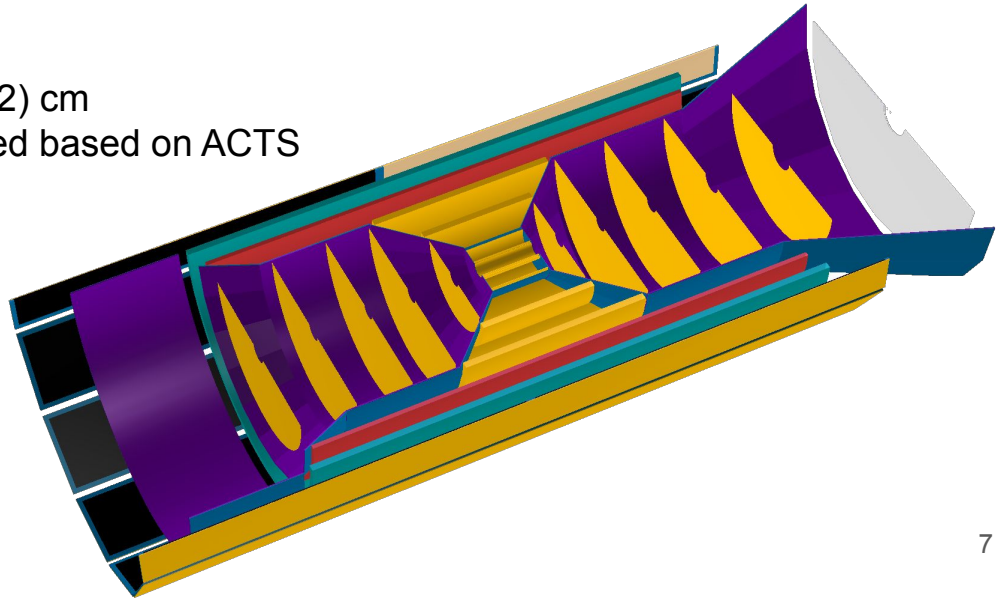
Forward disk





TOF in ePIC stack: SIM, DIGI, and RECO

- Detector geometry fully implemented in DD4hep
  - Based on latest concepts, including services etc.
- TOF layers (barrel and fwd) fully integrated in ACTS tracking
- Digitization infrastructure in place in eicrecon
  - Single MIP time resolution 25ps
  - Position resolution:
    - Endcap: 30 microns
    - Barrel: 30 microns x 1/sqrt(12) cm
- Time-of-flight determination to be finalized based on ACTS track length and TOF detector hits



Tutorial presentation by Dmitry at TOF meeting later today:
https://indico.bnl.gov/event/17691/

TOF in ePIC stack: next steps

Repeat and extend studies previously done :

- Finalization of time-of-flight reconstruction in eicrecon
  - Studies of time resolution for PID performance and impact to physics
    - Determination of final TOF requirements in EPIC
- Position resolution for tracking performance (momentum and angular + pointing resolution) with latest tracker and RICH configuration(s)
  - Impact of TOF layers on pattern recognition with ACTS
  - TOF layer performance with beam backgrounds and detector noise
- Material impact to other detectors

-> determine optimal sensor parameters (e.g., relaxing requirement on position resolution)

Poised to make progress in coming weeks!

Detailed overview of ongoing studies and determined detector parameters: https://wiki.bnl.gov/EPIC/index.php?title=TOFPID