Hadron PID Considerations in ePHENIX concepts

For seeding the discussion on eRD14 integration options

Jin Huang

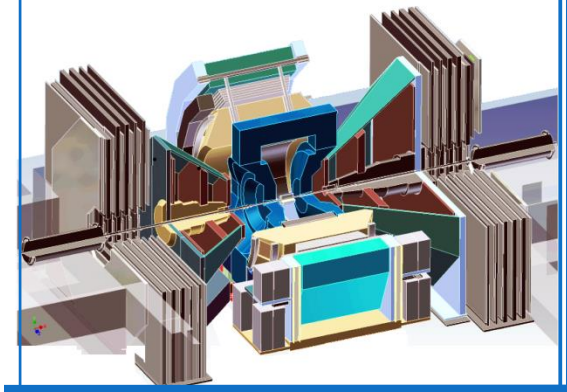
Brookhaven National Lab

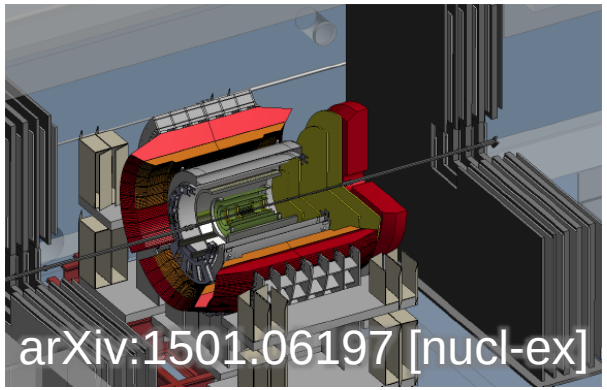
PHENIX

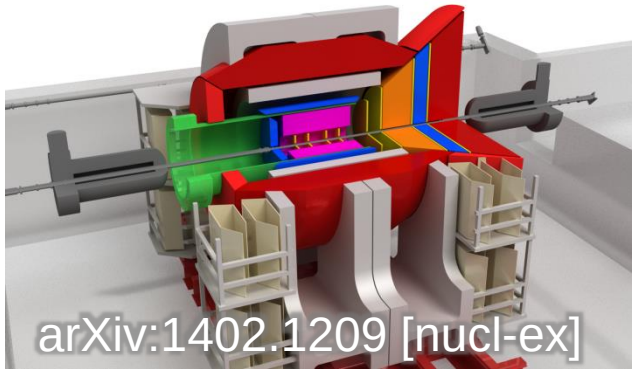
Evolution of the PHENIX experiment

Documented: http://www.phenix.bnl.gov/plans.html

Current PHENIX	*s*PHENIX (+fsPHENIX)	An EIC detector
14y+ operation 100+M$ investment	Comprehensive central upgrade base on BaBar magnet	Path of PHENIX upgrade leads to a capable EIC detector
Broad spectrum of physics (QGP, Hadron Physics, DM)	Rich jet and beauty quarkonia physics program → nature of QGP	Large coverage of tracking, calorimetry and PID
140+ published papers to date	fsPHENIX : forward tracking, Hcal and muon ID → Spin, CNM	Open for new collaboration/new ideas
Last run in this form 2016		







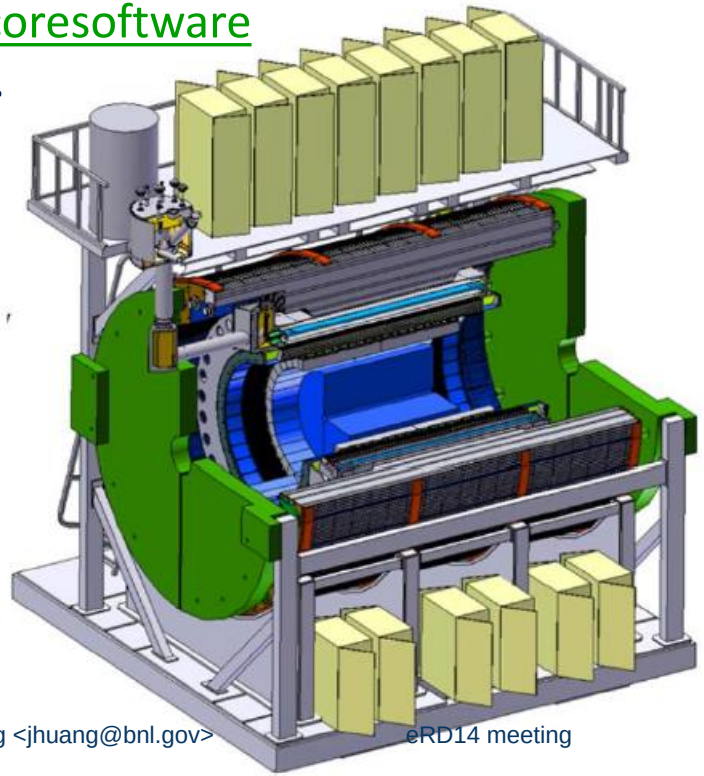
~2000 | 2017→2020 | ~2025 | Time

RHIC: A+A, spin-polarized p+p, spin-polarized p+A

EIC: e+p, e+A

sPHENIX
– quick summary and look "forward"

- sPHENIX: major upgrade to the PHENIX experiment aim for data @ 2020
- Physics Goals: detailed study QGP using jets and heavy quarks at RHIC energy region
- Baseline consists of new large acceptance EMCal+HCal built around recently acquired BaBar magnet. Additional tracking also planned
- Detailed performance simulation. Simulation/analysis software open access: https://github.com/sPHENIX-Collaboration/coresoftware
- Very positive DOE scientific review Apr 2015.
- Forming new scientific collaboration: https://www.bnl.gov/lajudr2015/
- Nov 2015: Cost schedule review
- Dec 2015: first collaboration meeting as new scientific collaboration
- A good foundation for future detector upgrade



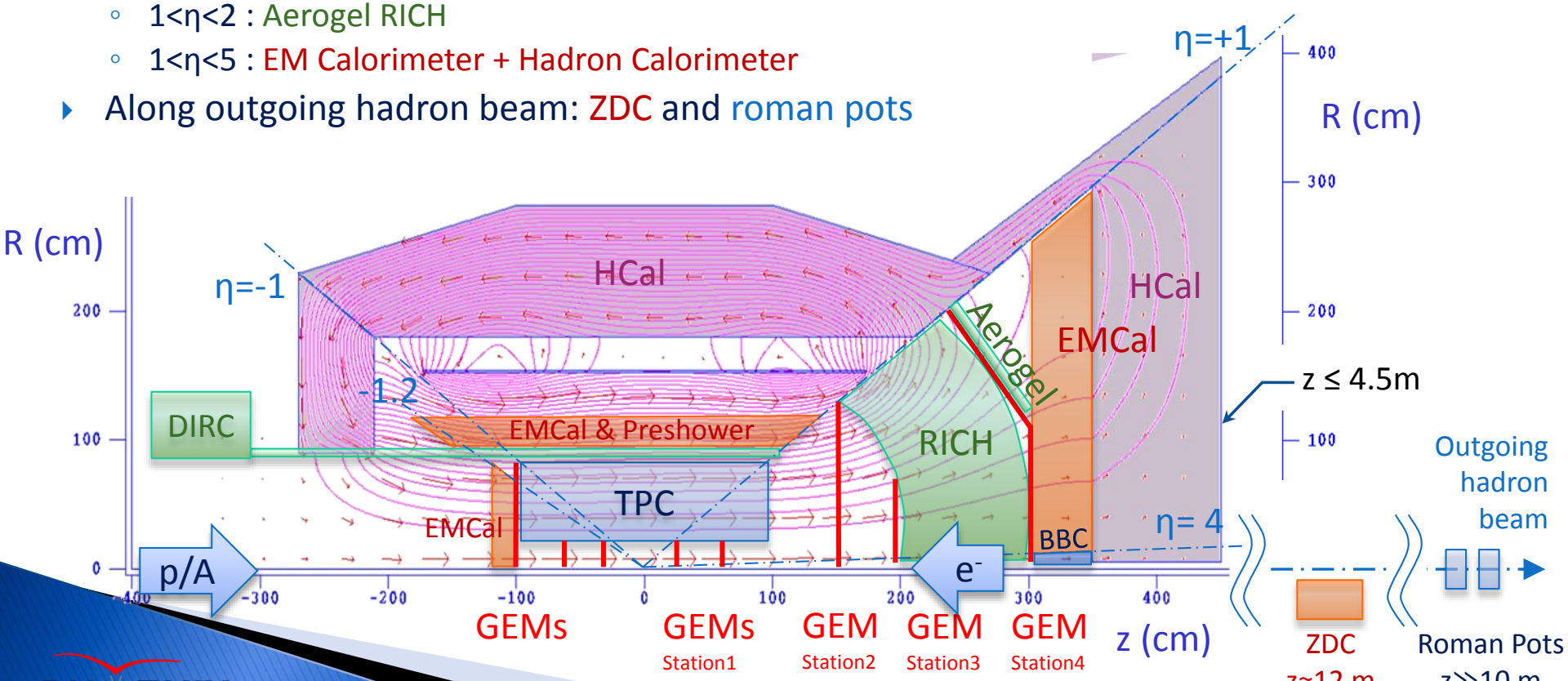
Baseline detectors for sPHENIX

sPHENIX MIE, arXiv:1501.06197 [nucl-ex]

In EIC era: concept for an EIC Detector

- -1<η<+1 (barrel) : sPHENIX + Compact-TPC + DIRC
- -4<η<-1 (e-going) :
  High resolution calorimeter + GEM trackers
- +1<η<+4 (h-going) :
  - 1<η<4 : GEM tracker + Gas RICH
  - 1<η<2 : Aerogel RICH
  - 1<η<5 : EM Calorimeter + Hadron Calorimeter
- Along outgoing hadron beam: ZDC and roman pots

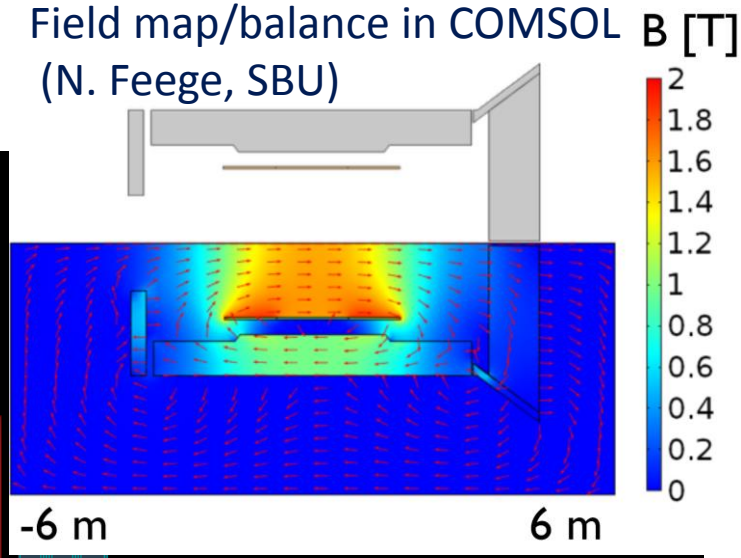
Working title: "ePHENIX"
LOI: arXiv:1402.1209
Review: "good day-one detector"
"solid foundation for future upgrades"



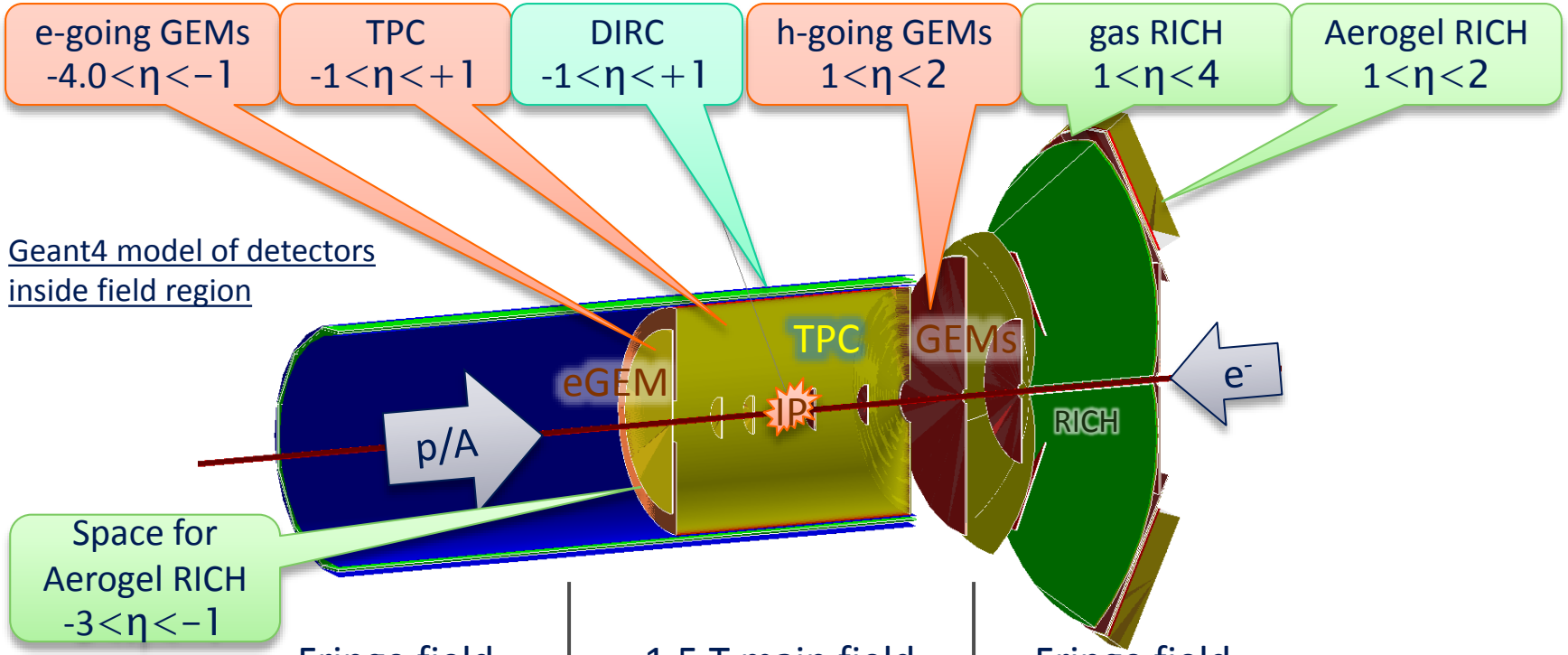
Recent evolving of ePHENIX with sPHENIX

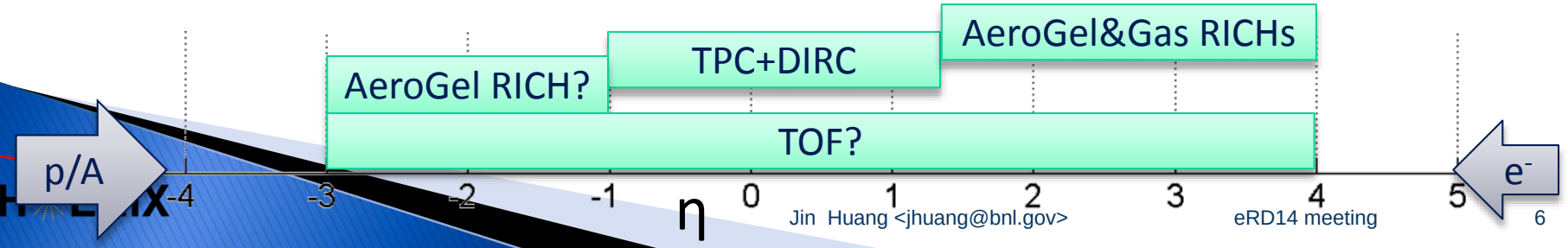
Available under GitHub/EIC-Detector:
coresoftware-eic/macros/Fun4All_G4_ePHENIX.C

Field map/balance in COMSOL
(N. Feege, SBU)

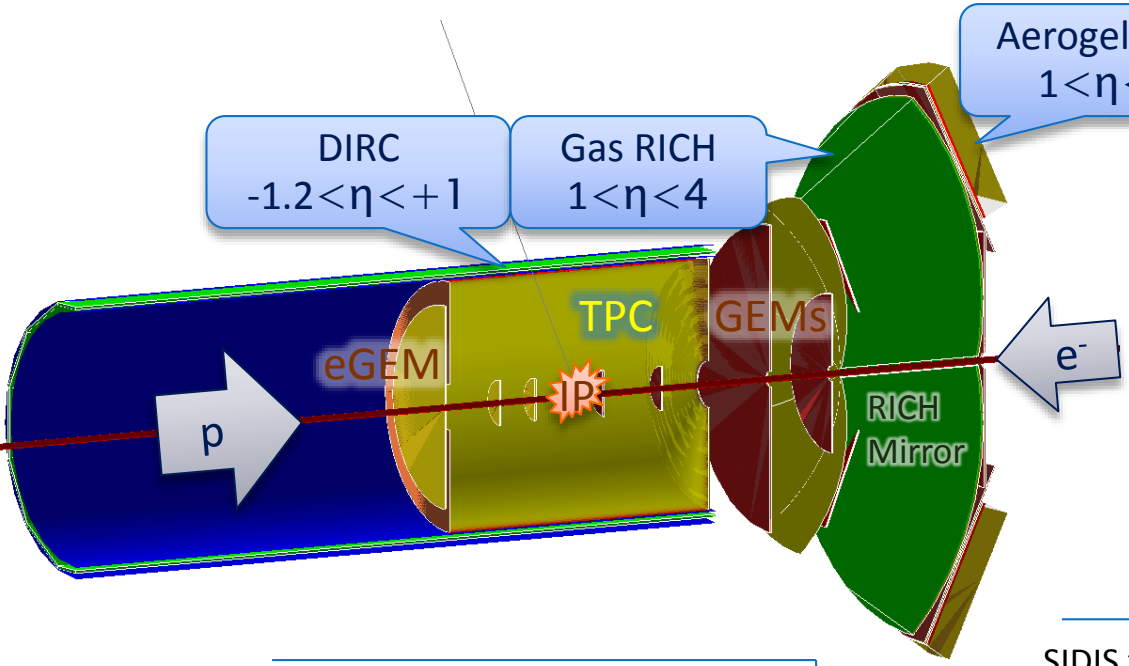


Tracking and PID detectors

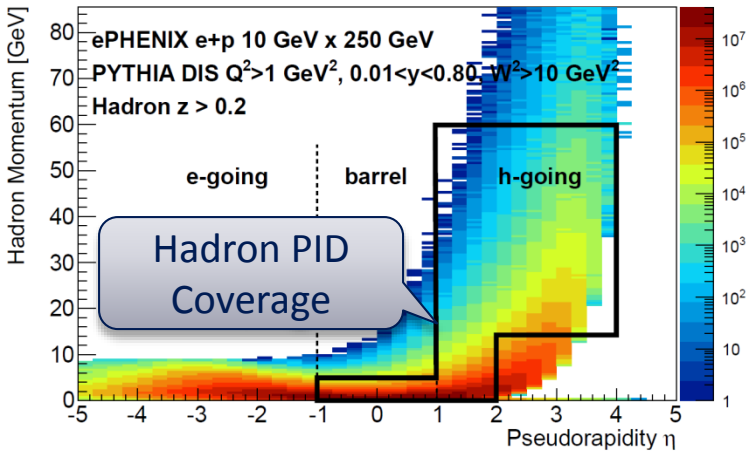




Hadron PID Overview

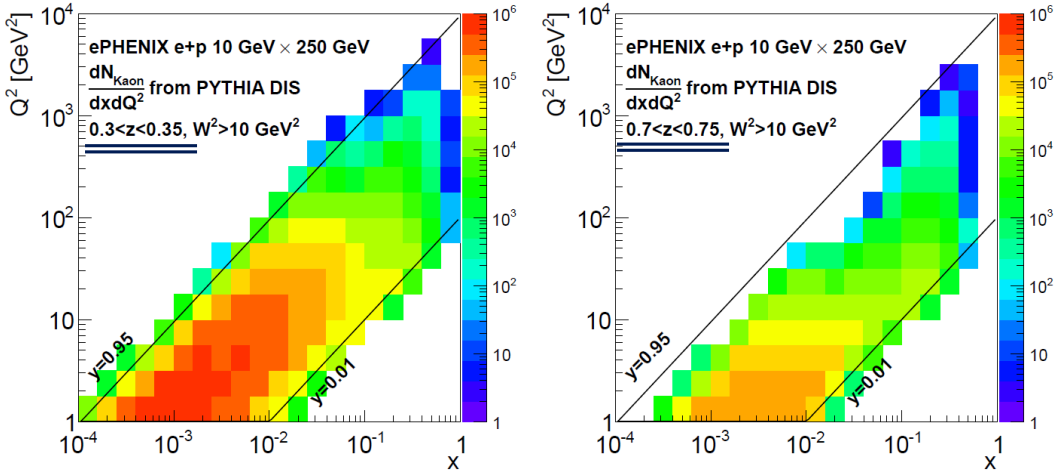


One configuration for hadron PID
10 x 250 GeV beam

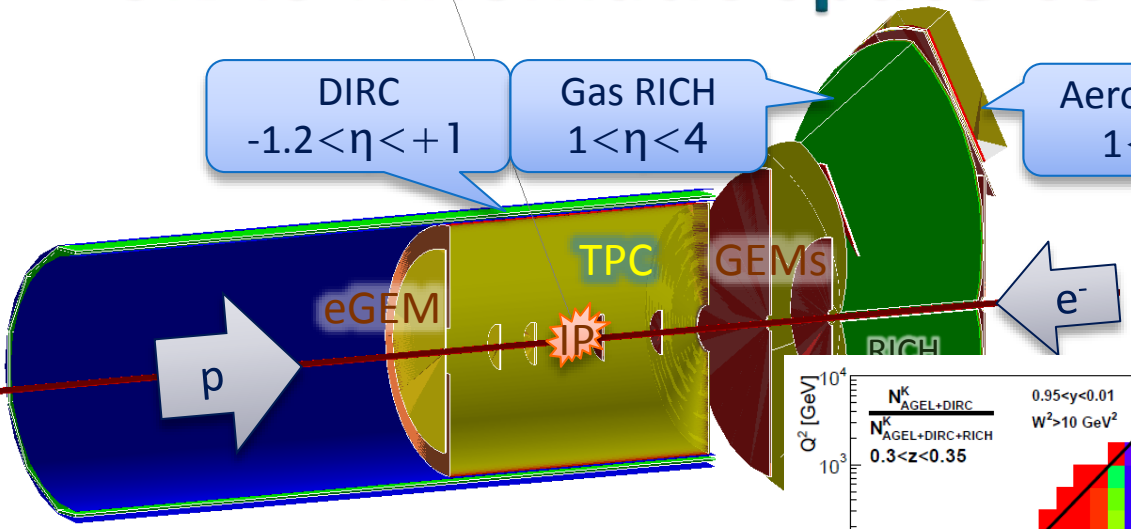


- DIRC
  - Based on BaBar DIRC design plus compact readout
  - Collaborate with TPC dE/dx for hadron ID in central barrel
- Aerogel RICH
  - eRD11 modular design should work well
  - Collaborate with gas RICH to cover 1<η<2
  - PID in e-going direction for higher e-beam
- Gas RICH: eRD6 single gas radiator
- TOF solution: next few slides

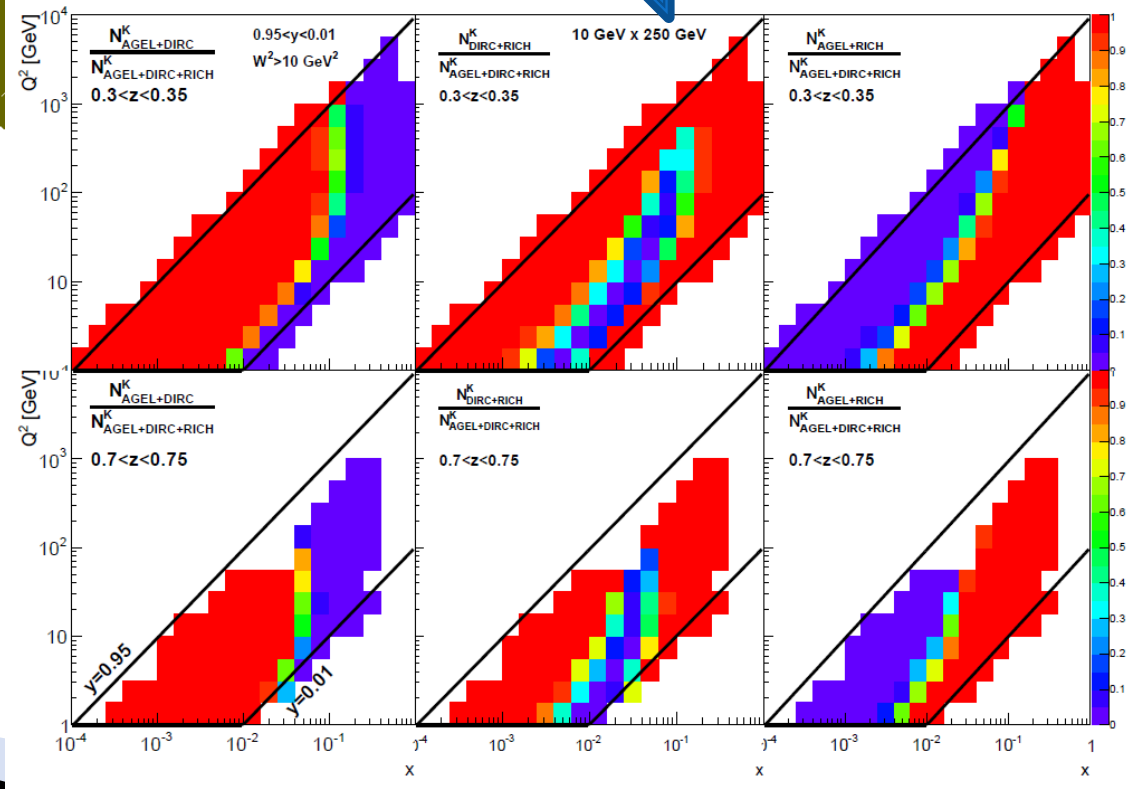
SIDIS x-Q^2 coverage with hadron PID in two z-bins



Coverage of each subsystem quantized in SIDIS kinematic space coverage (x, Q2, z)



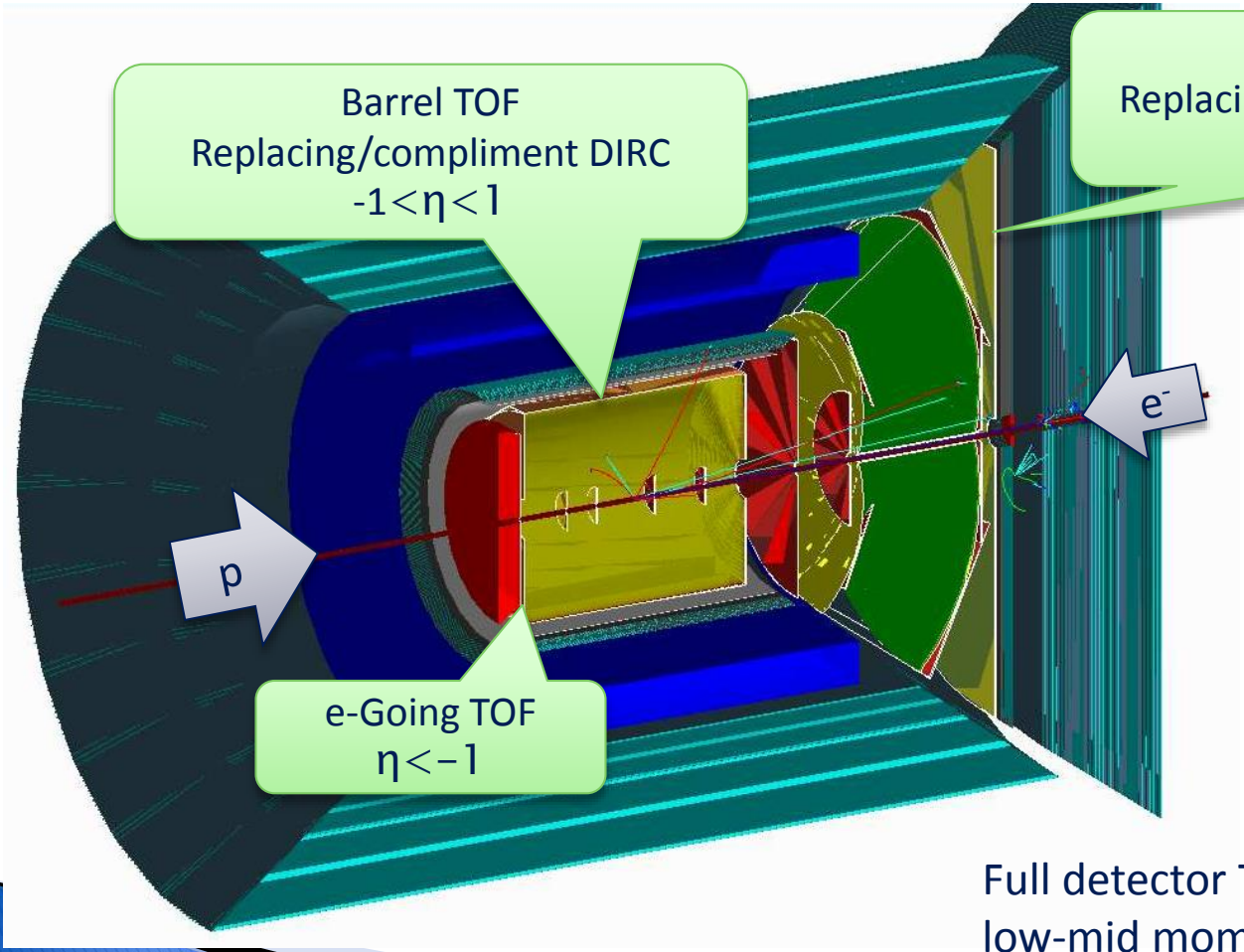
Evaluated for one possible configuration



Missing PID coverage, IF any single subsystem is removed

PHENIX

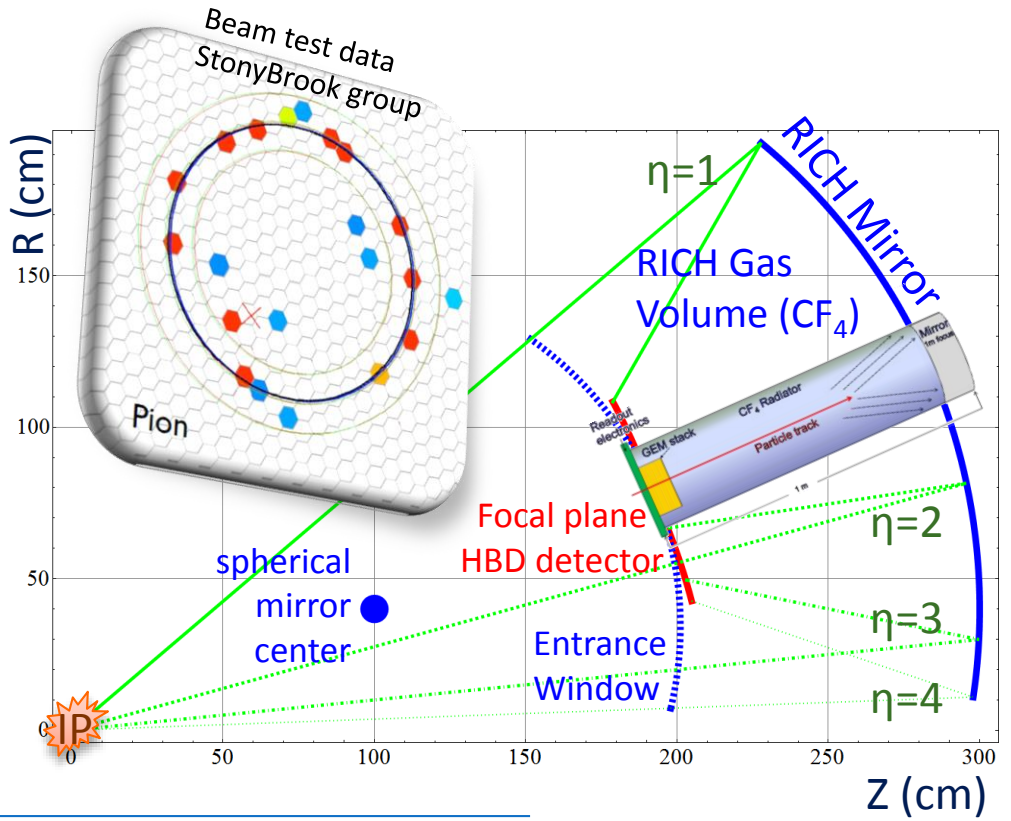
Another PID detector configuration
Full detector TOF solution, eRD10



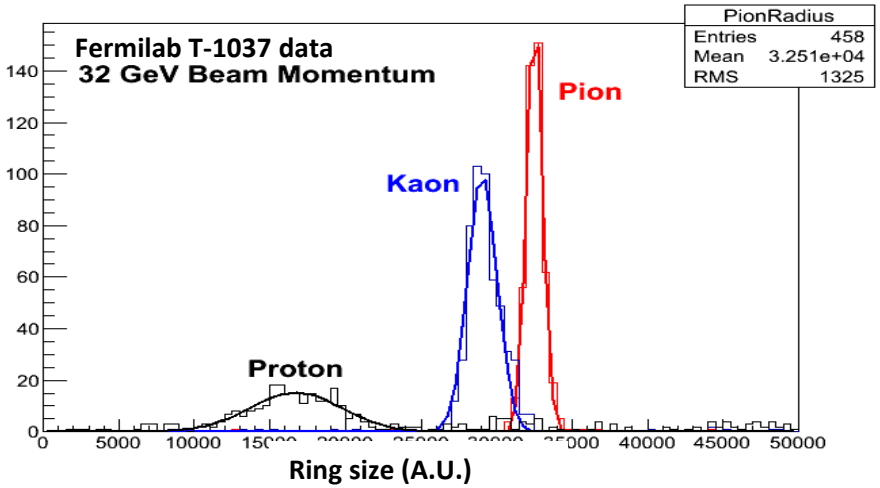
Full detector ToF system to cover low-mid momentum range PID

Gas RICH - The Design

- Hadron ID for p>10GeV/c require gas Cherenkov
  - CF_4 gas used, similar to LHC_b RICH
- Beautiful optics using spherical mirrors
- Photon detection using CsI–coated GEM in hadron blind mode
  - thin and magnetic field resistant
- Active R&D:
  - Generic EIC R&D program
  - recent beam tests by the stony brook group

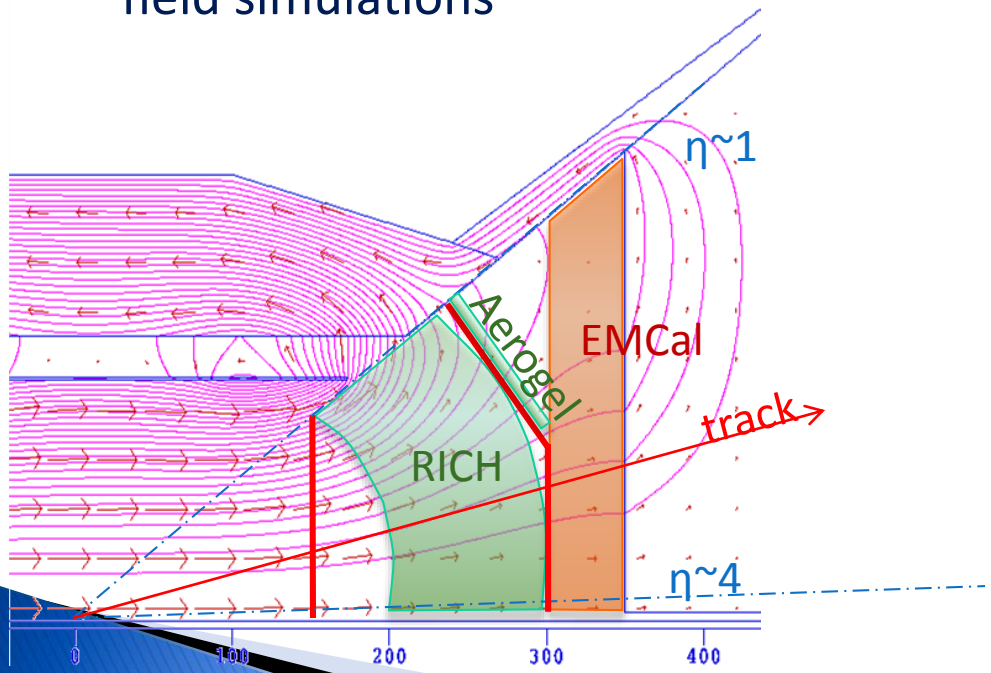


Courtesy : EIC RD6 TRACKING & PID CONSORTIUM



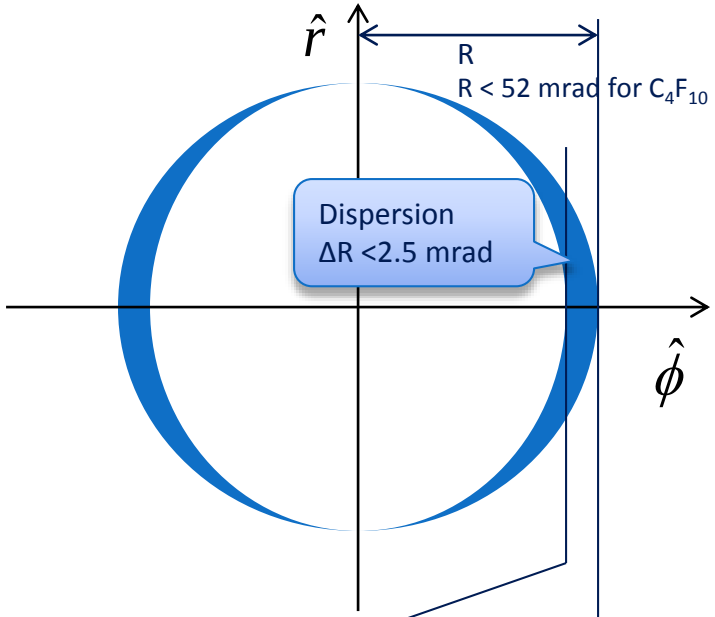
Field effect - distortion for RICH

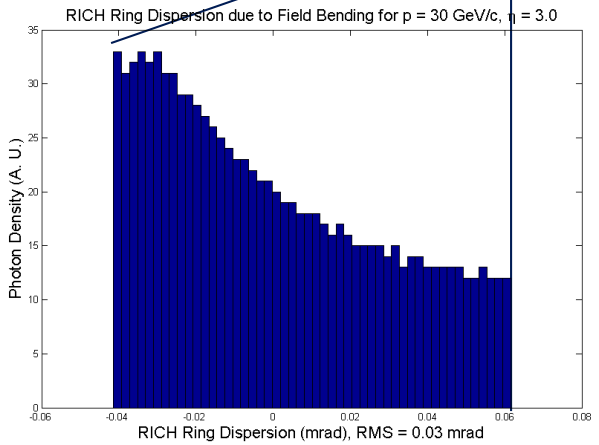
- Field calculated numerically with field return
- Field lines mostly parallel to tracks in the RICH volume with the yoke
- We can estimate the effect through field simulations



A RICH Ring:

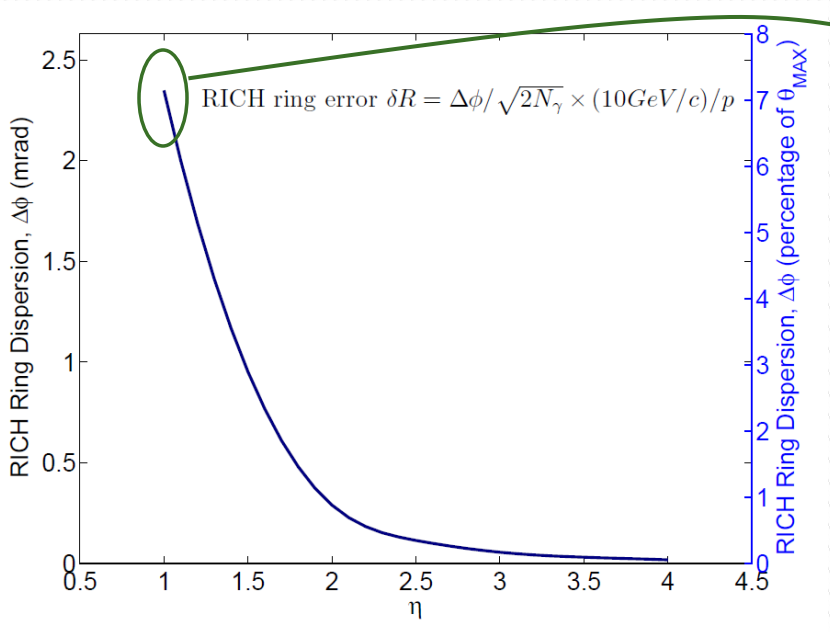
Photon distribution due to tracking bending only

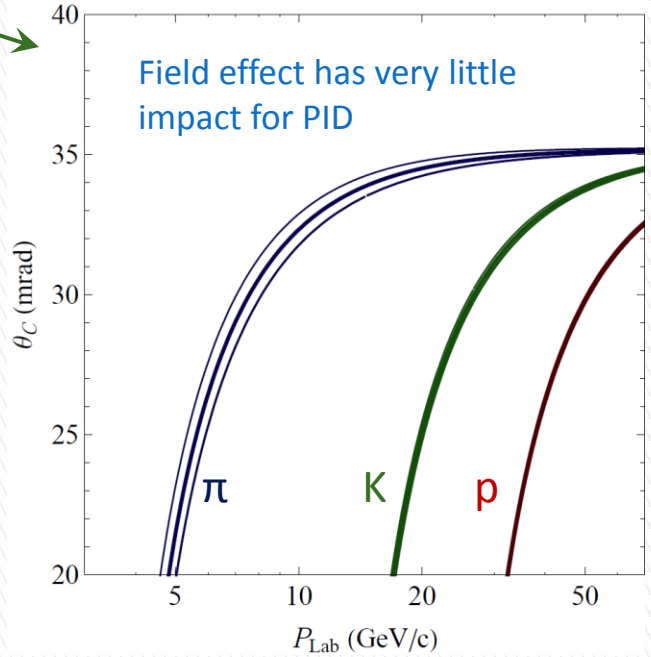




Field effect – Radius uncertianty of RICH Ring

Ring radius ± 1σ field effect (for worst η=1)

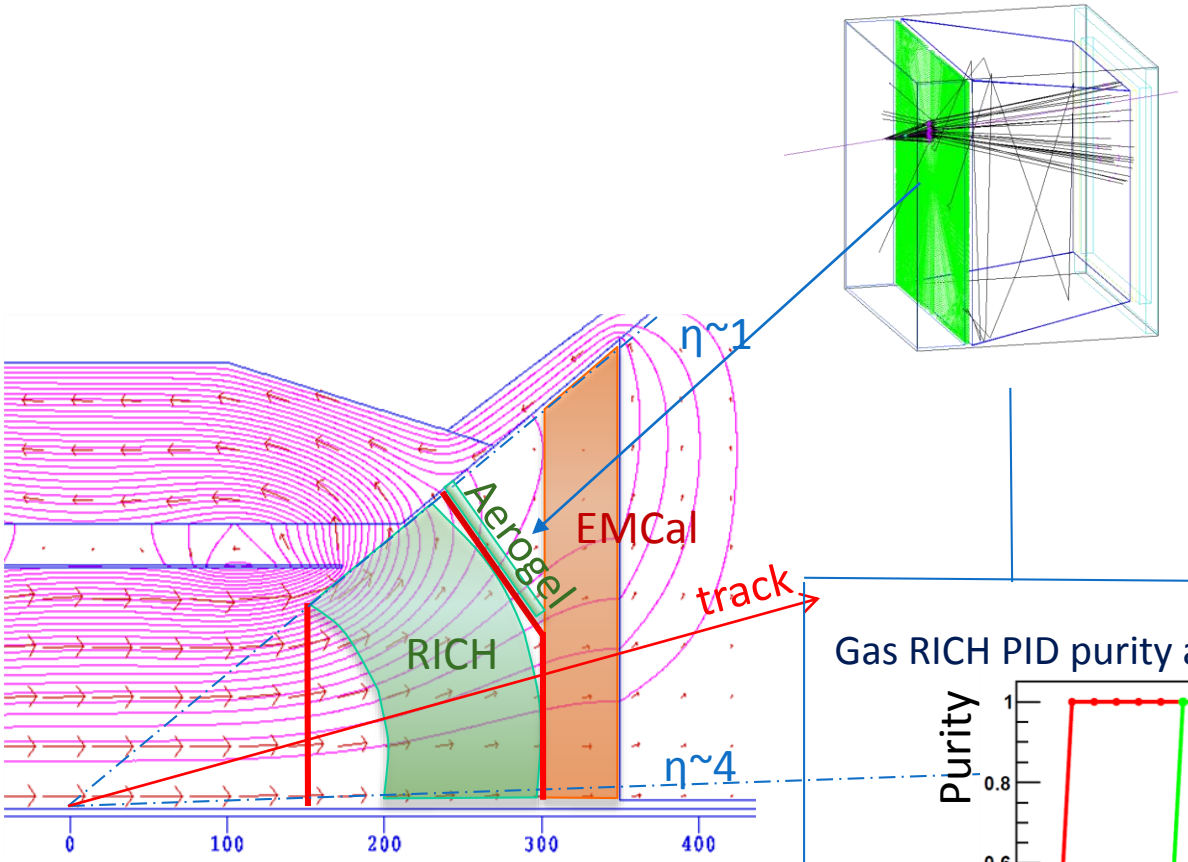




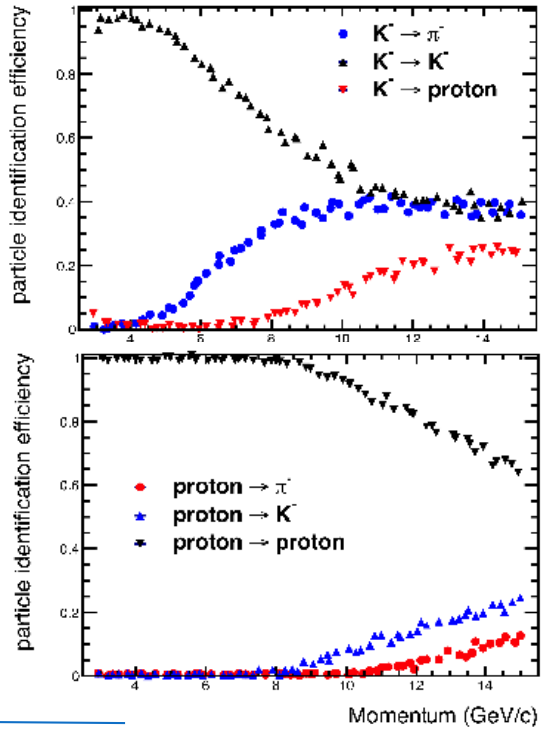
Quantify ring radius error

In the respect of PID: minor effect

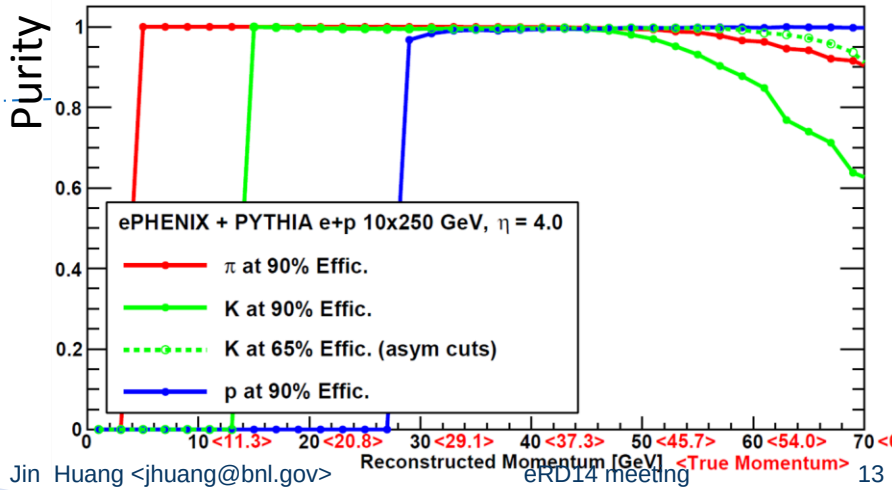
H-going side - performance



AeroGel RICH PID eff.

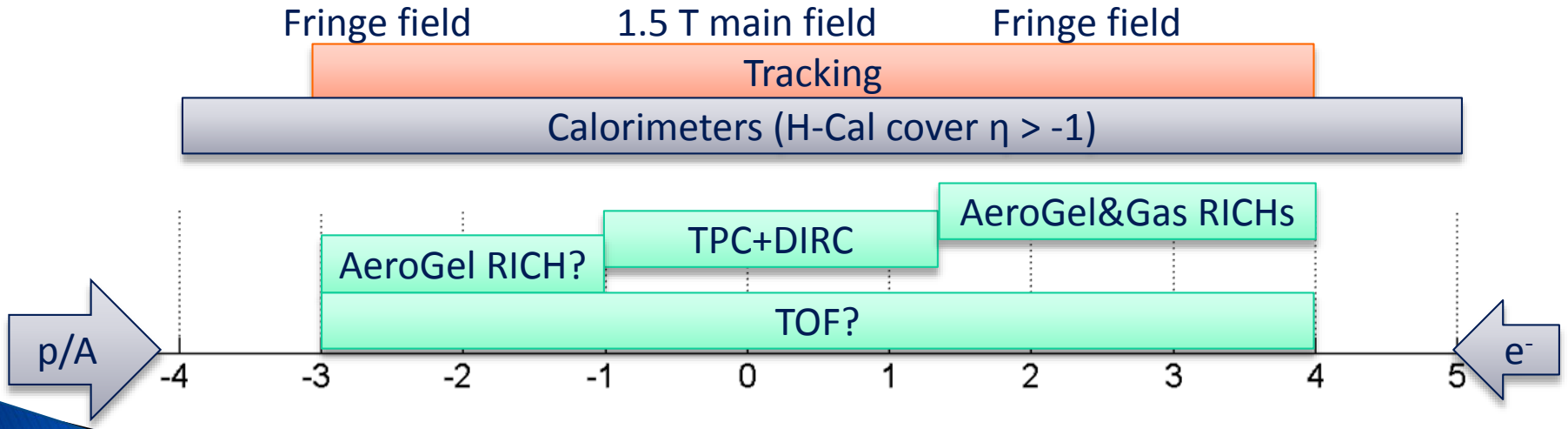


Gas RICH PID purity at η=4 (most challenging region w/ δp)



Summary

- "ePHENIX" concept based on sPHENIX upgrade
- Evolving concepts of full detector hadron PID
  - H-going: AeroGel RICH (medium momentum range) + Gas RICH (high-p range)
  - Barrel : TPC (low momentum range) + DIRC (medium momentum range)
  - E-going: AeroGel RICH
  - Full detector TOF solution also considered



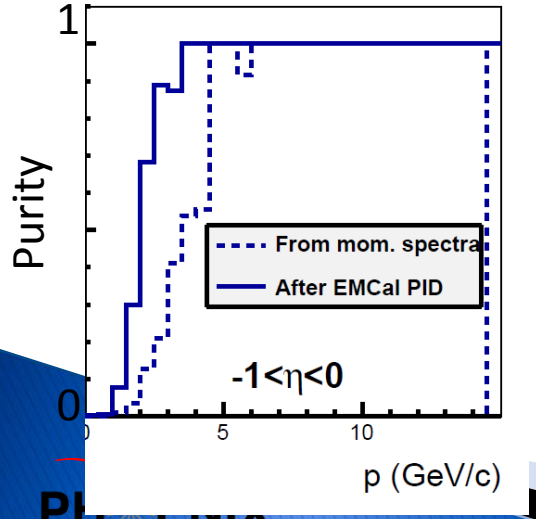
Extra Information

Use of calorimeter for EIC physics

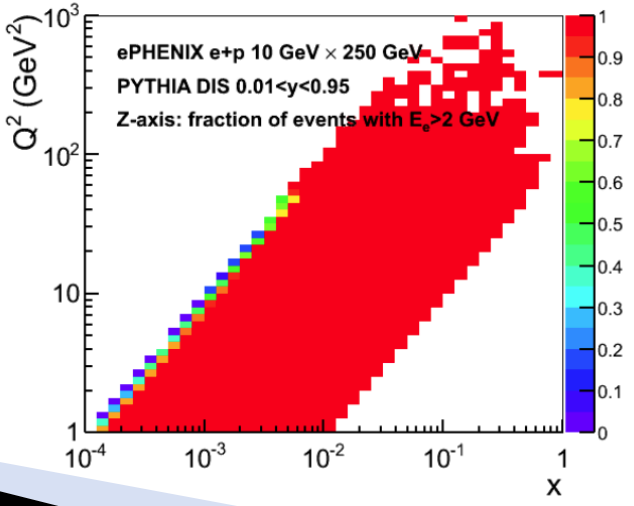
- Electron identification (e-EMC, barrel EMC)
- Electron kinematics measurement (e-EMC, barrel EMC)
- DIS kinematics using hadron final states (barrel EMC/HCal, h-EMC/HCal)
- Photon ID for DVCS (All EMC)
- Diffractive ID (h-HCal)
- High momentum track energy measurement (h-HCal)

From Sasha and Karen using parameterized performance

Electron purity after EMCal PID



Fraction of DIS event with good electron ID



DIS kinematics survivability Electron kinematic method