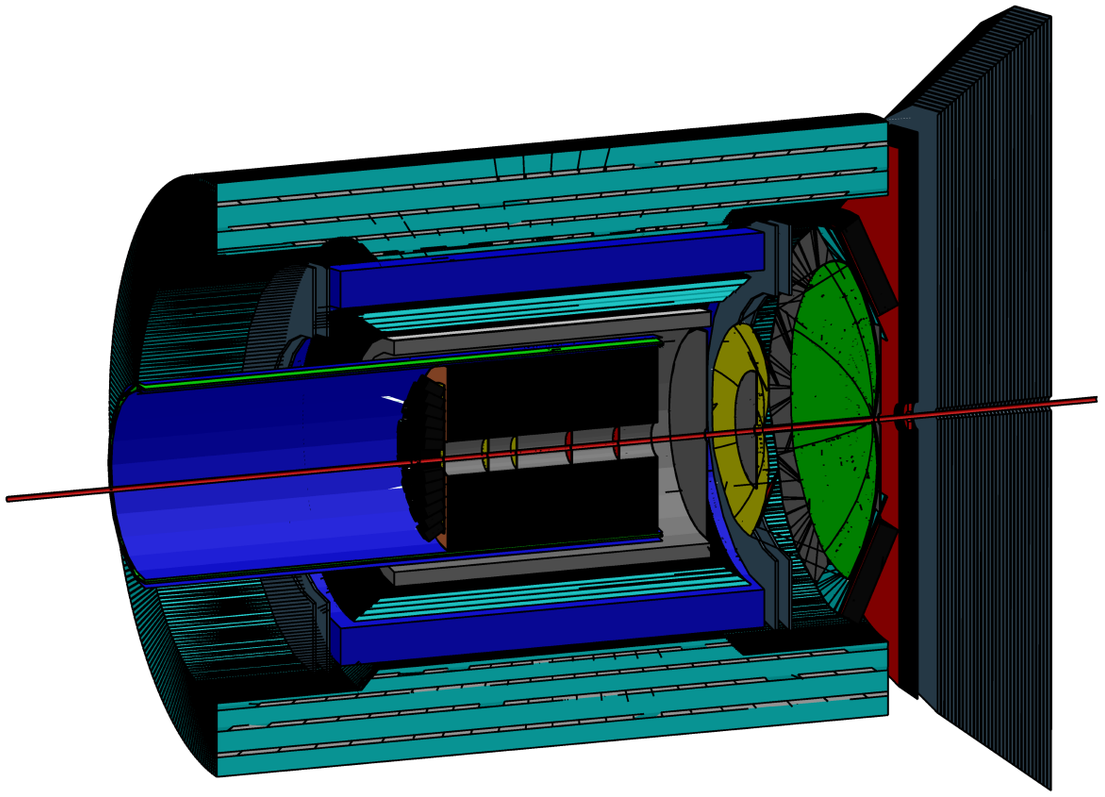
Stony Brook University

An EIC Detector based on sPHENIX

(Working titles ‘ePHENIX’ / ‘CELESTE’)

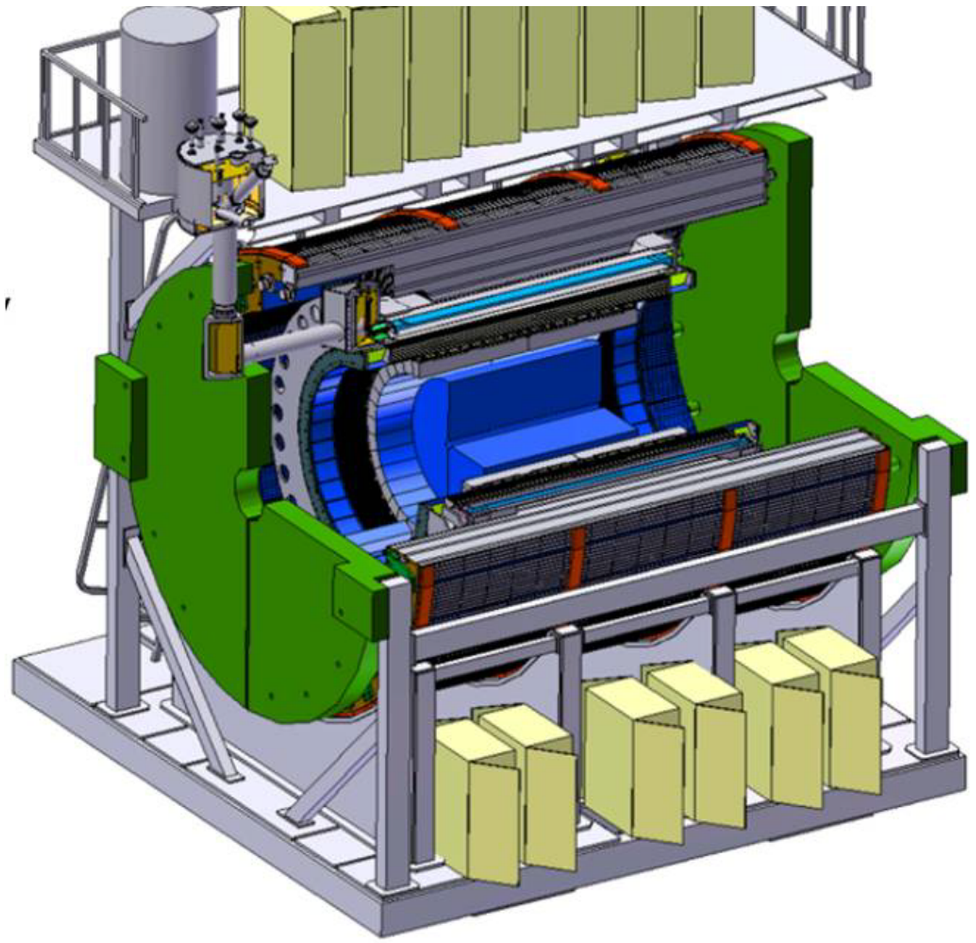


- Current detector concept
- Acceptance and performance

Nils Feege

Electron Ion Collider User Group Meeting 2016
UC Berkeley, January 6 - January 9 2016

sPHENIX - the new RHIC IP8 experiment

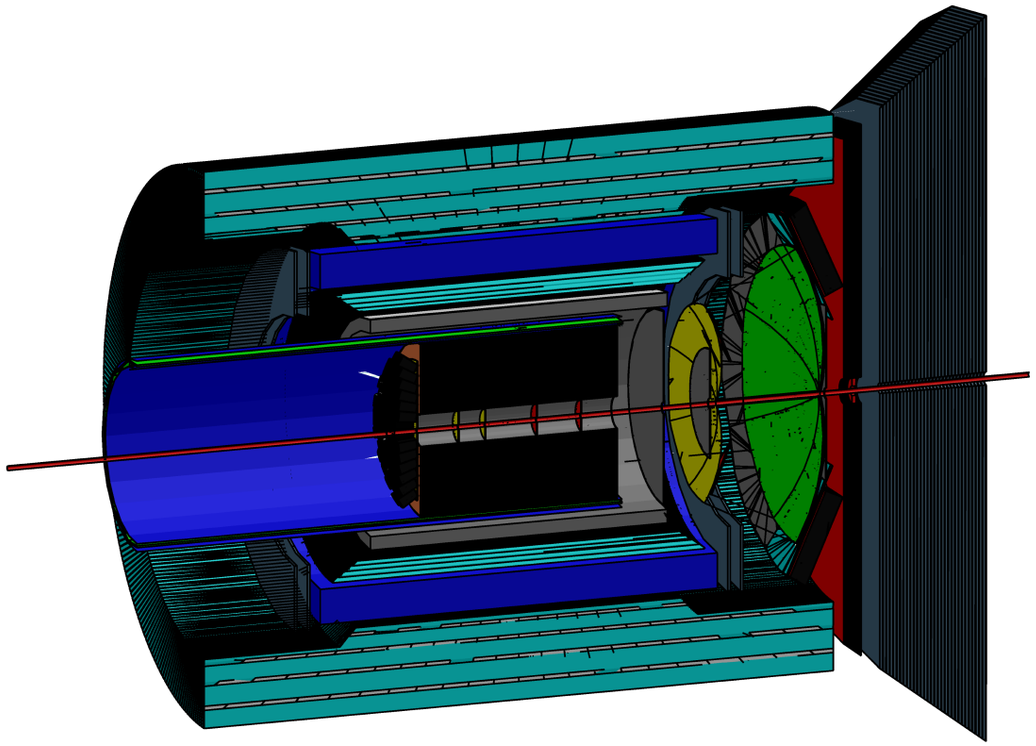


- Objective: Study Quark Gluon Plasma with jet and Upsilon probes
- 1.5 T BaBar solenoid magnet with tracking, ECAL, and HCAL coverage $|\eta| < 1.1$
- Passed DOE Scientific Review in April 2015
- Completed preCDR document
- Collaboration formed in December 2015

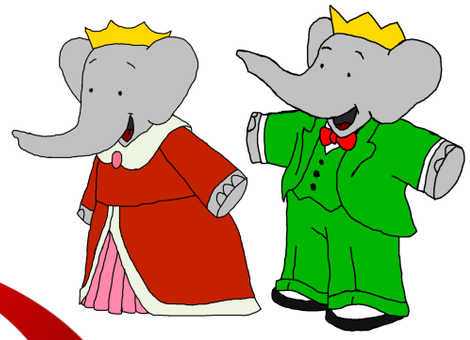
Evolution of an EIC Detector

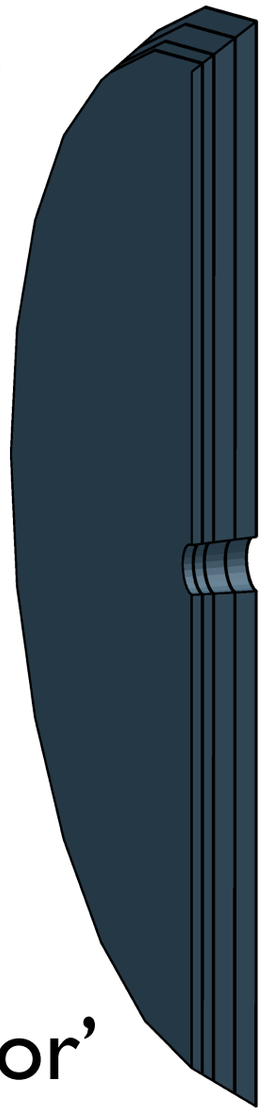
eRHIC / JLEIC

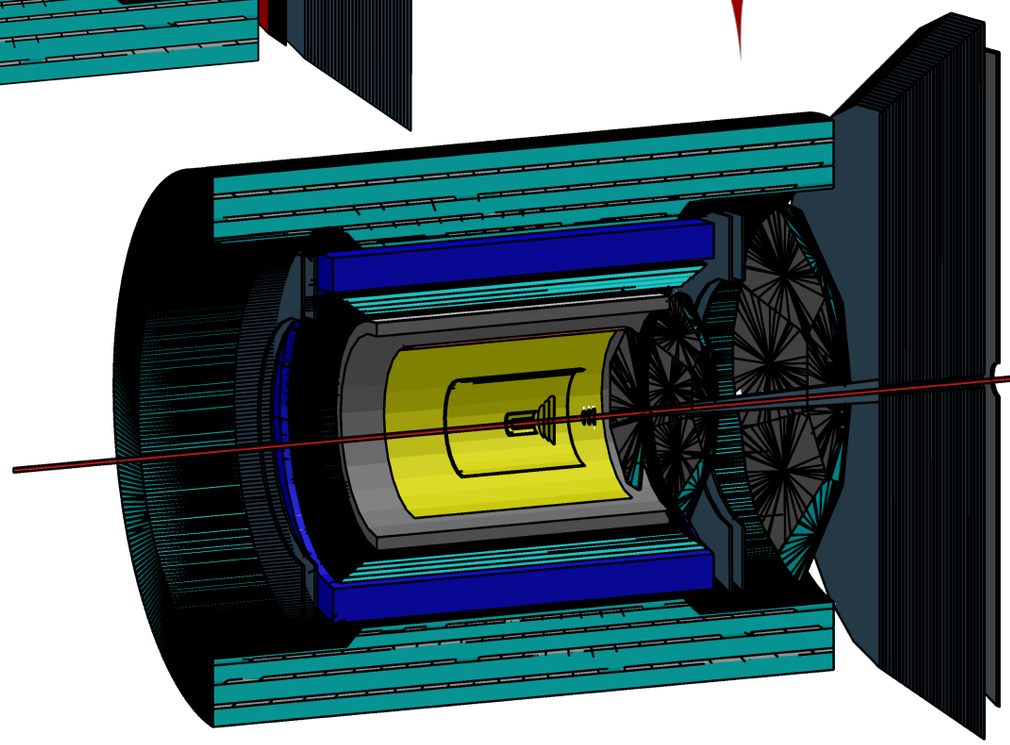
RHIC

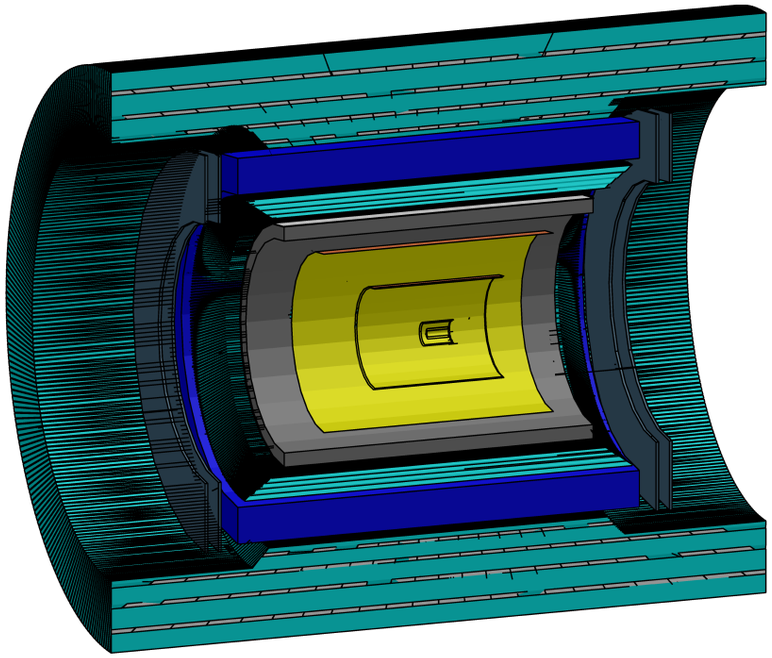


‘CELESTE’?



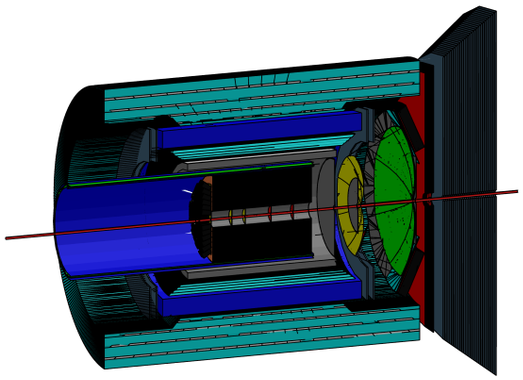






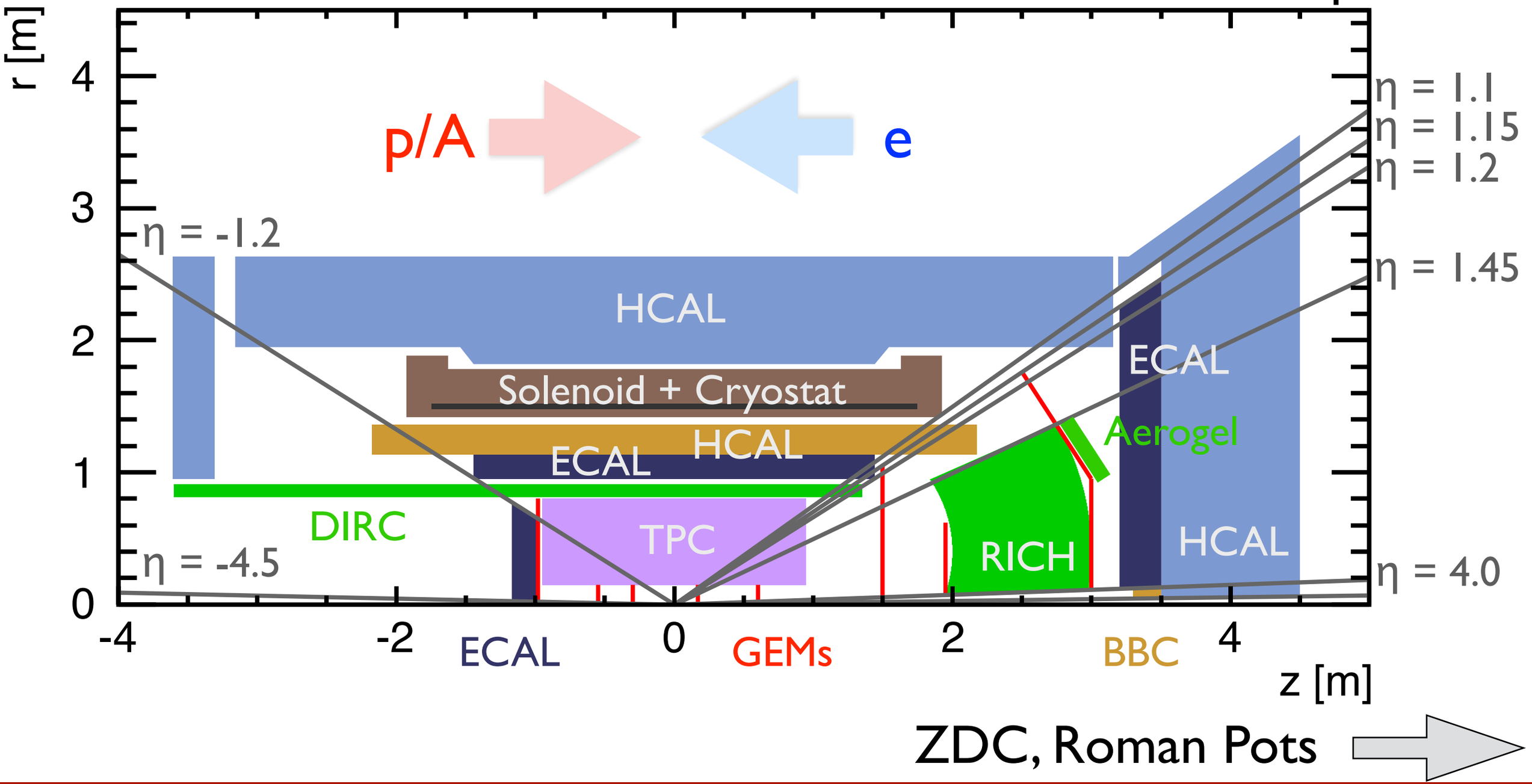
sPHENIX ‘barrel detector’

‘forward detector’



EIC Detector Concept

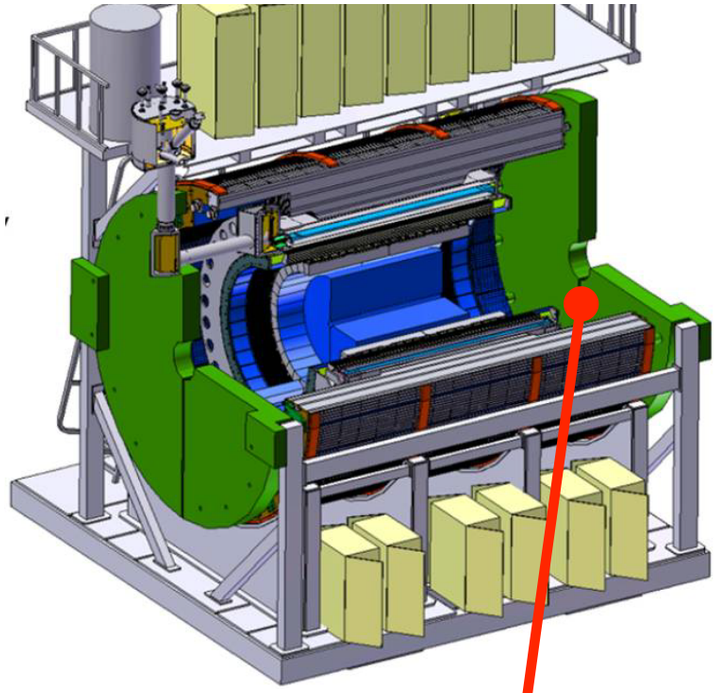
'2015 revised concept'

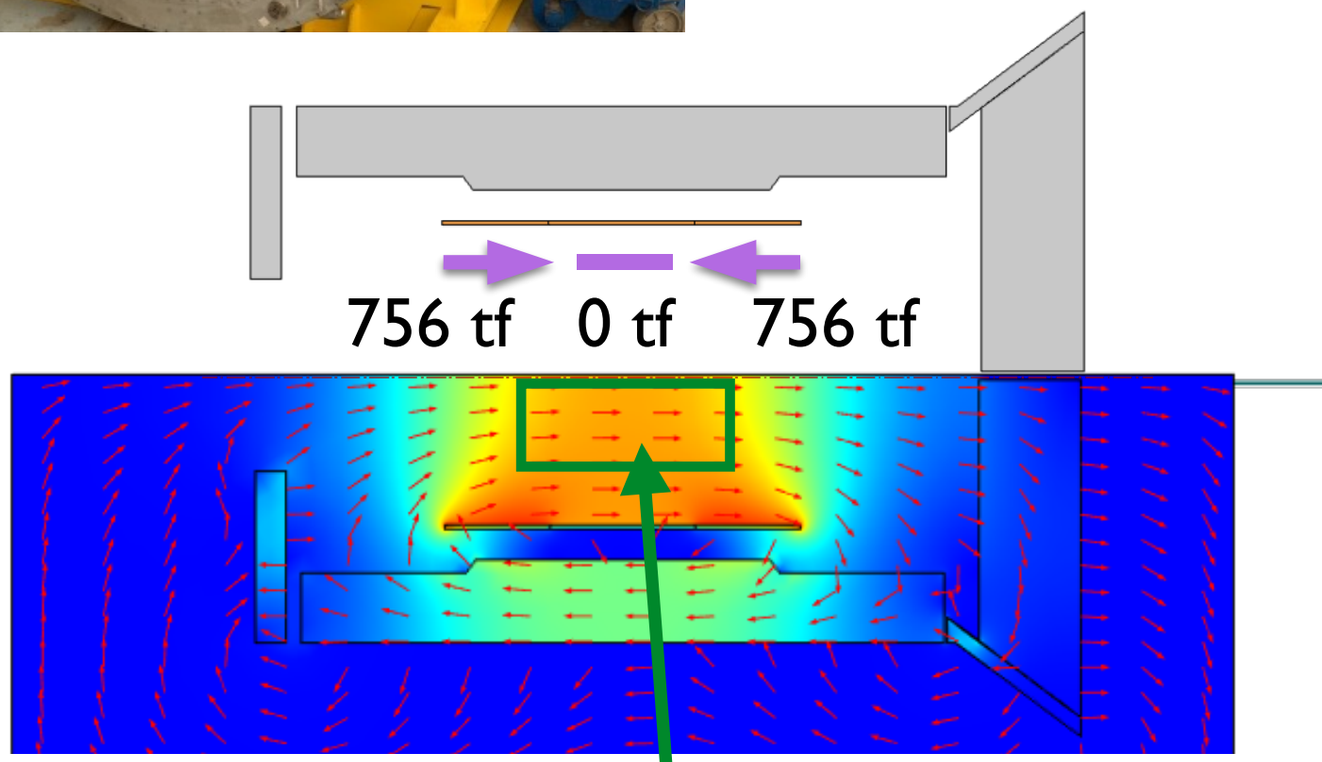


ZDC, Roman Pots

The BaBar Magnet and Flux Return

- ✓ Superconducting Solenoid
- ✓ Field: 1.5T
- ✓ Inner radius: 140 cm
- ✓ Outer radius: 173 cm
- ✓ Length: 385 cm

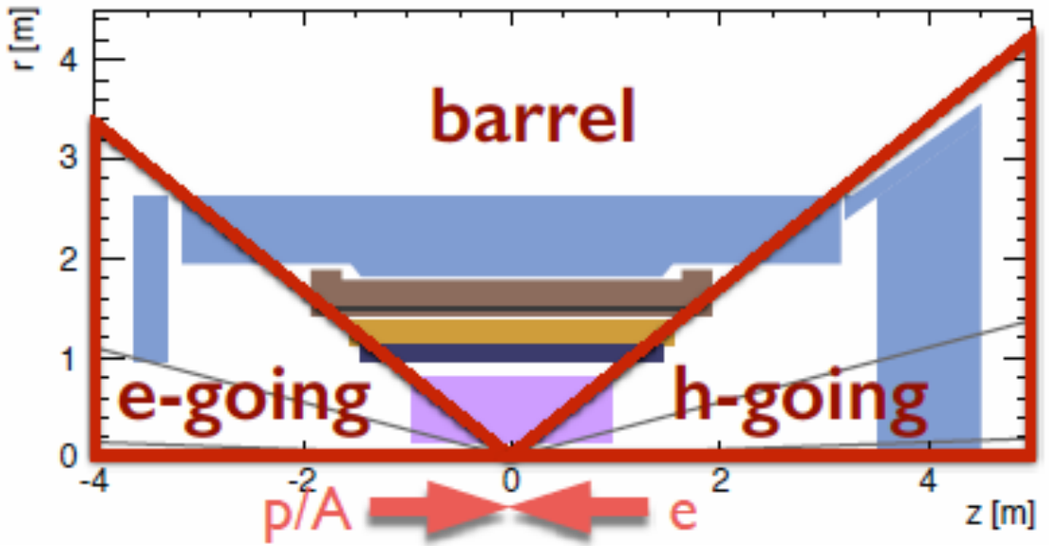


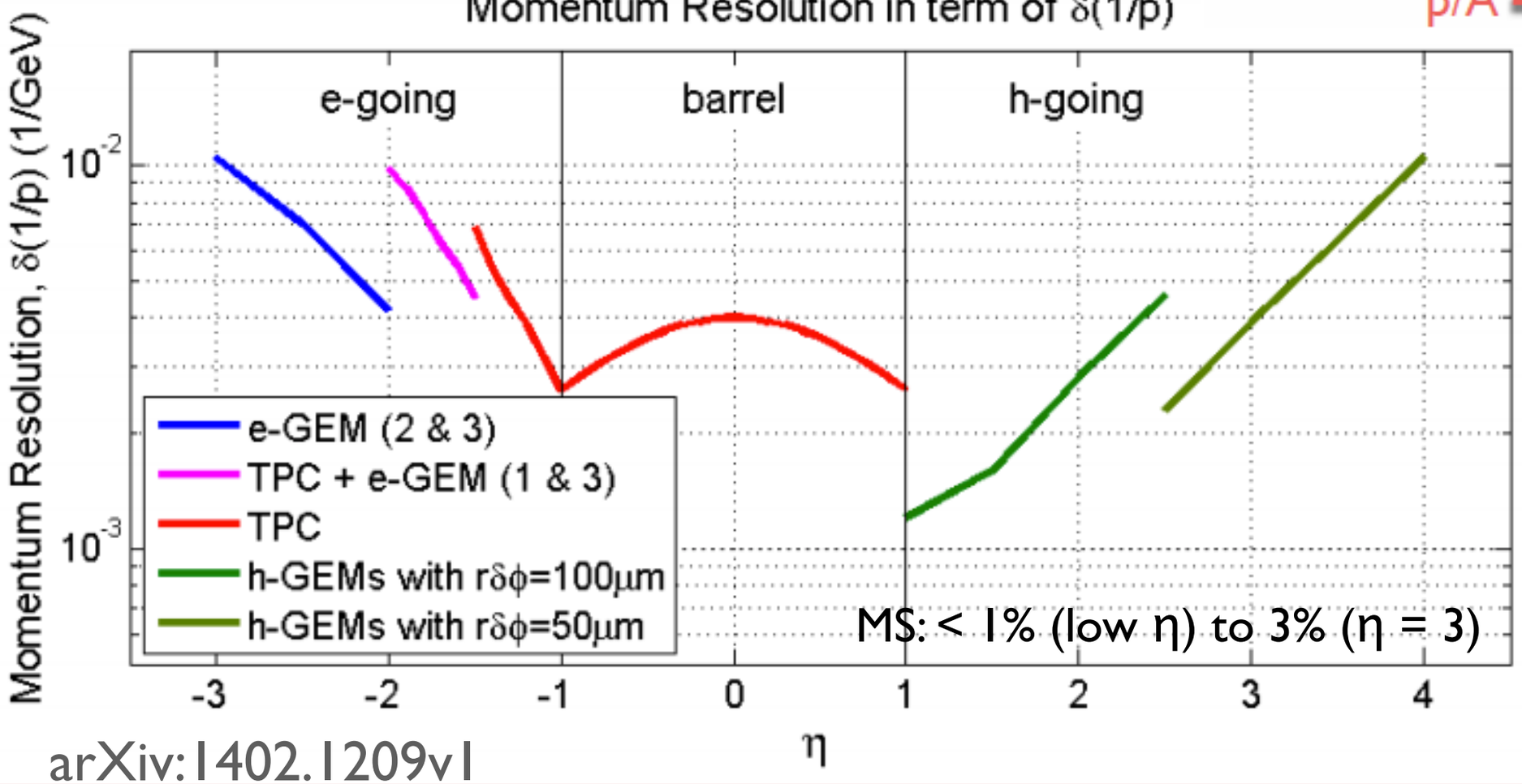


Tracking System

sPHENIX Options: Silicon, MAPS, TPC

EIC Detector: TPC and GEM's

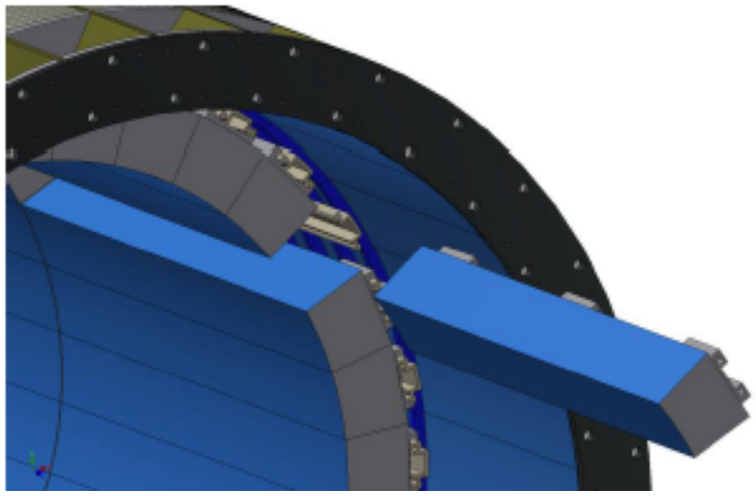


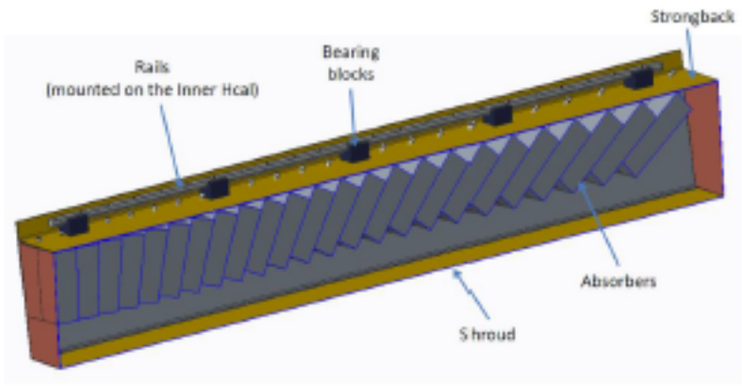


MS: < 1% (low η) to 3% (η = 3)

arXiv:1402.1209v1

Electromagnetic Calorimeter





sPHENIX preCDR

eRD1

Tungsten-fiber (18 X_0)

12%/$\sqrt{E}$ energy resolution

~3x3 cm^2 segmentation

Lead-scintillator (18 X_0)

12%/$\sqrt{E}$ energy resolution

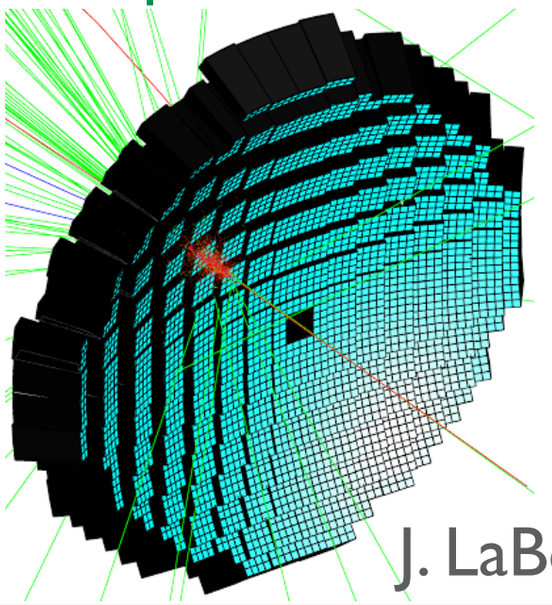
~3x3 cm^2 segmentation

Lead-tungstate (20 X_0)

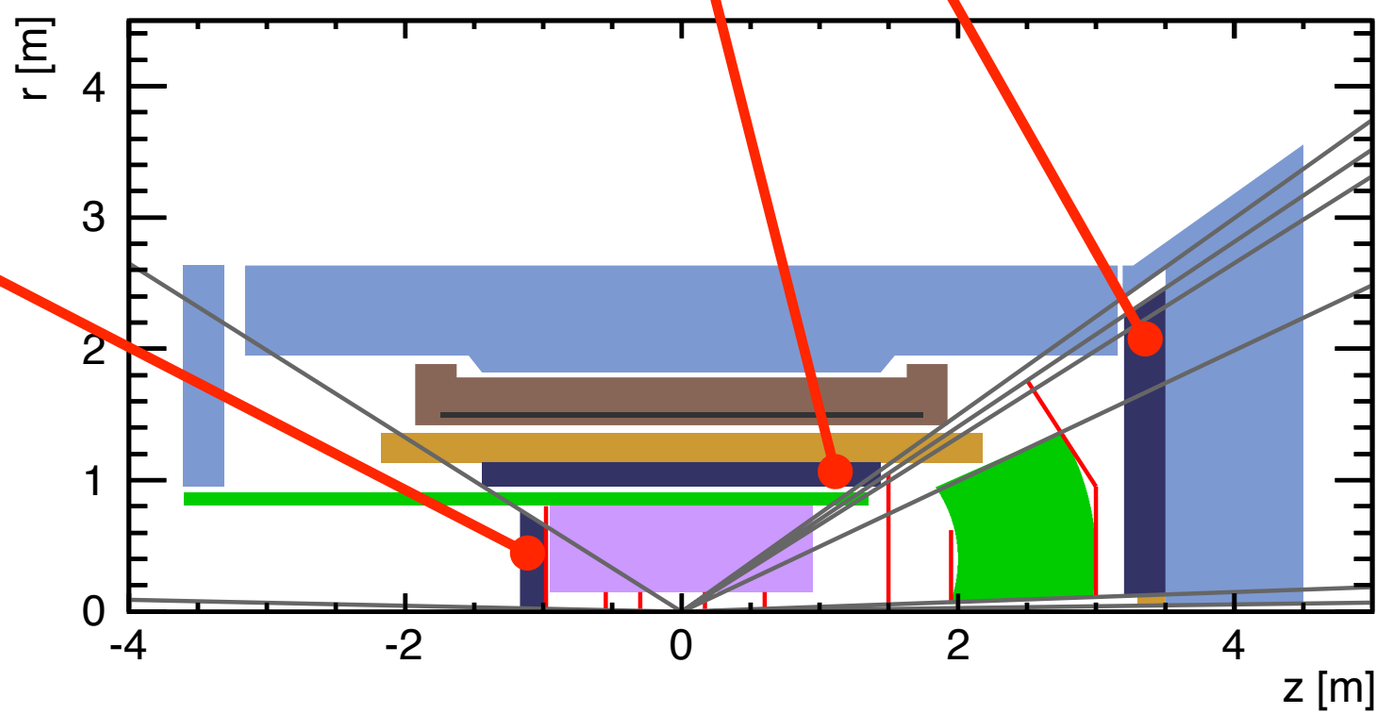
2%/$\sqrt{E}$ energy resolution

2x2 cm^2 segmentation

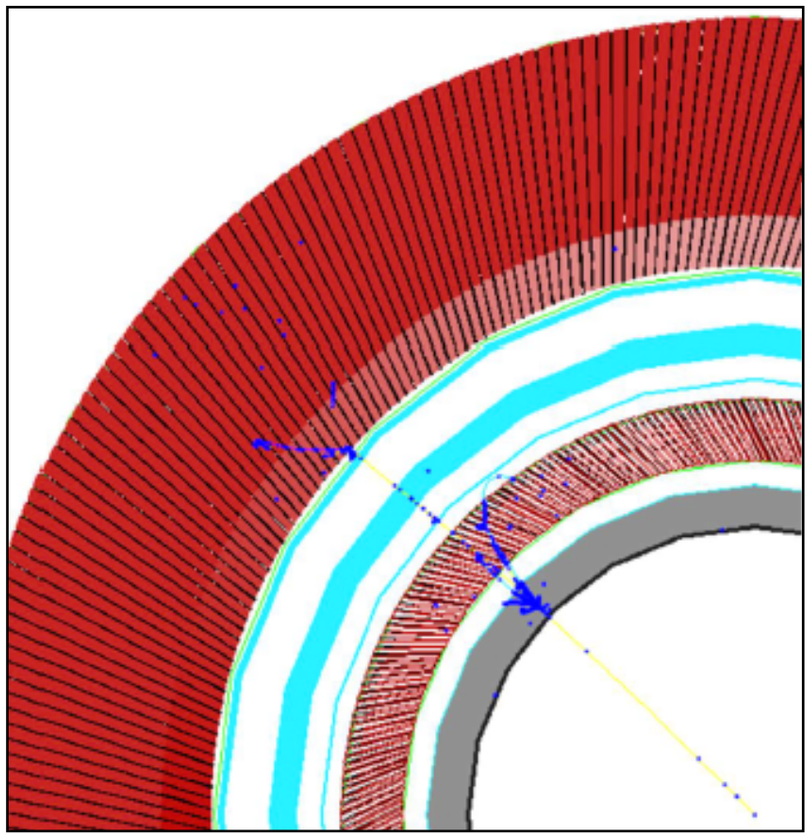
3mm/$\sqrt{E}$ position resolution



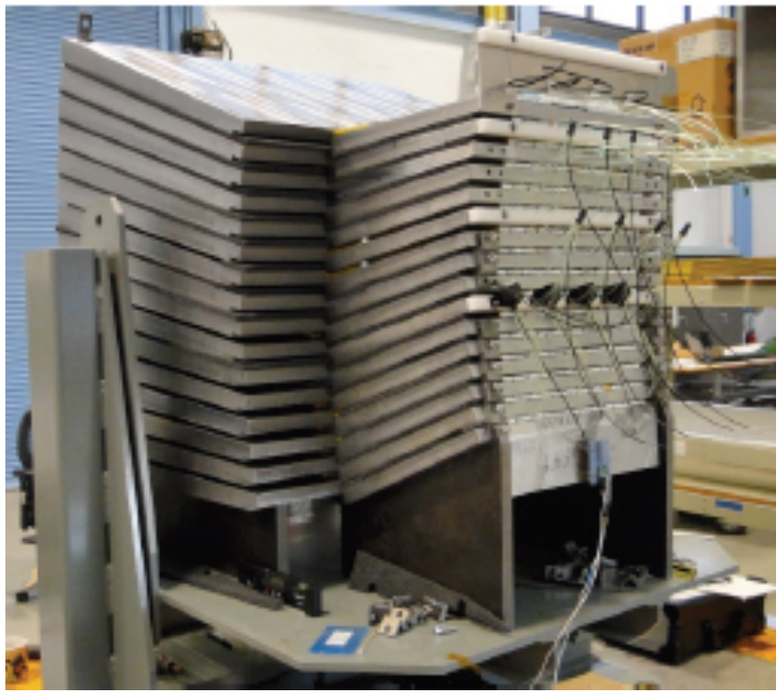
J. LaBounty



Hadron Calorimeter



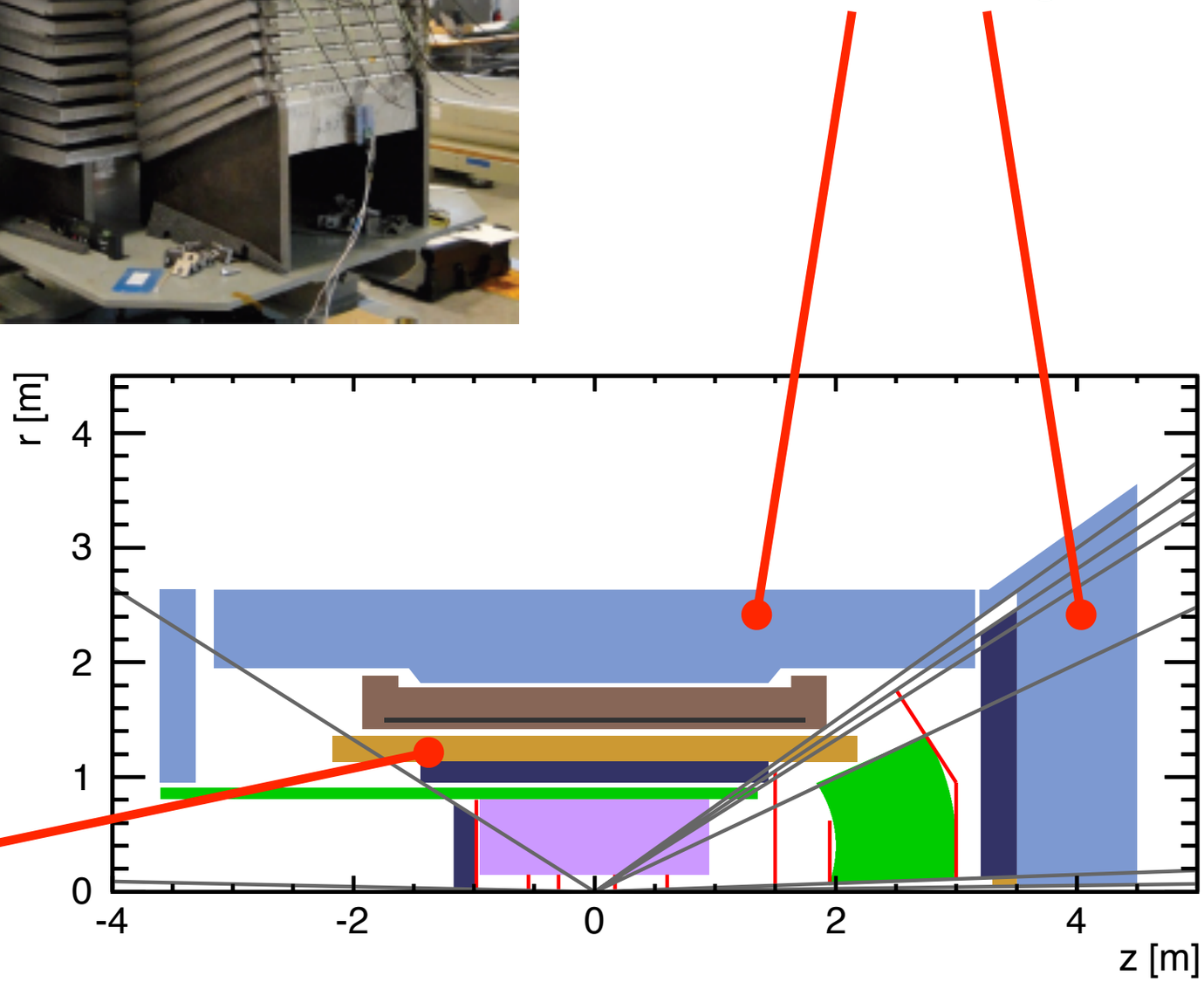
sPHENIX preCDR



Steel-scintillator (5 λ_{int})

100%/$\sqrt{E}$ energy resolution

~ 10 × 10 cm^2 segmentation

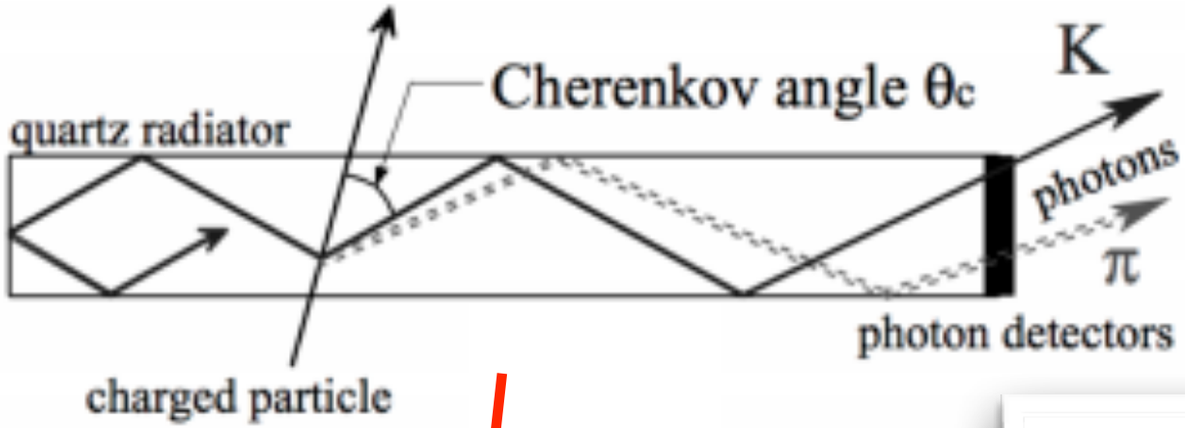


Steel-scintillator (1 λ_{int})

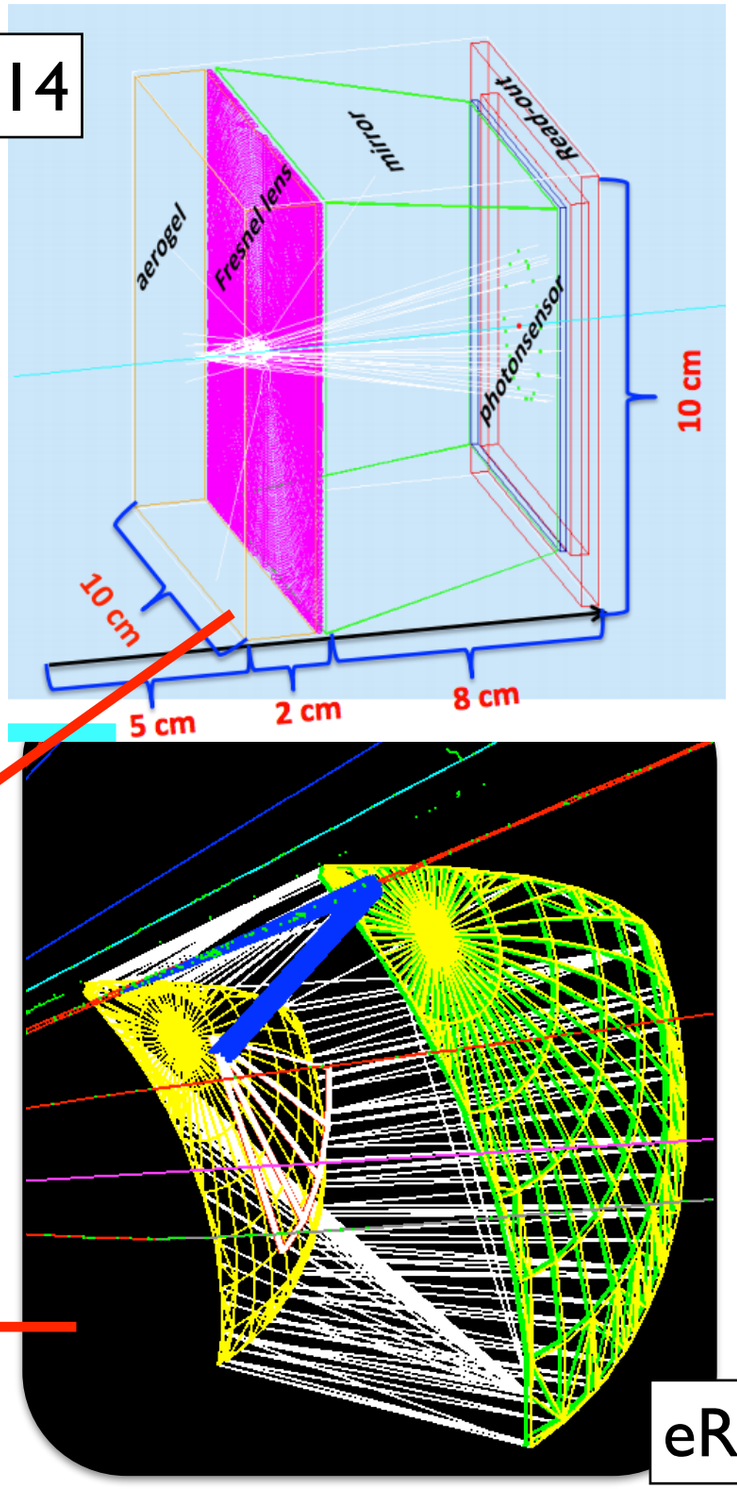
100%/$\sqrt{E}$ energy resolution

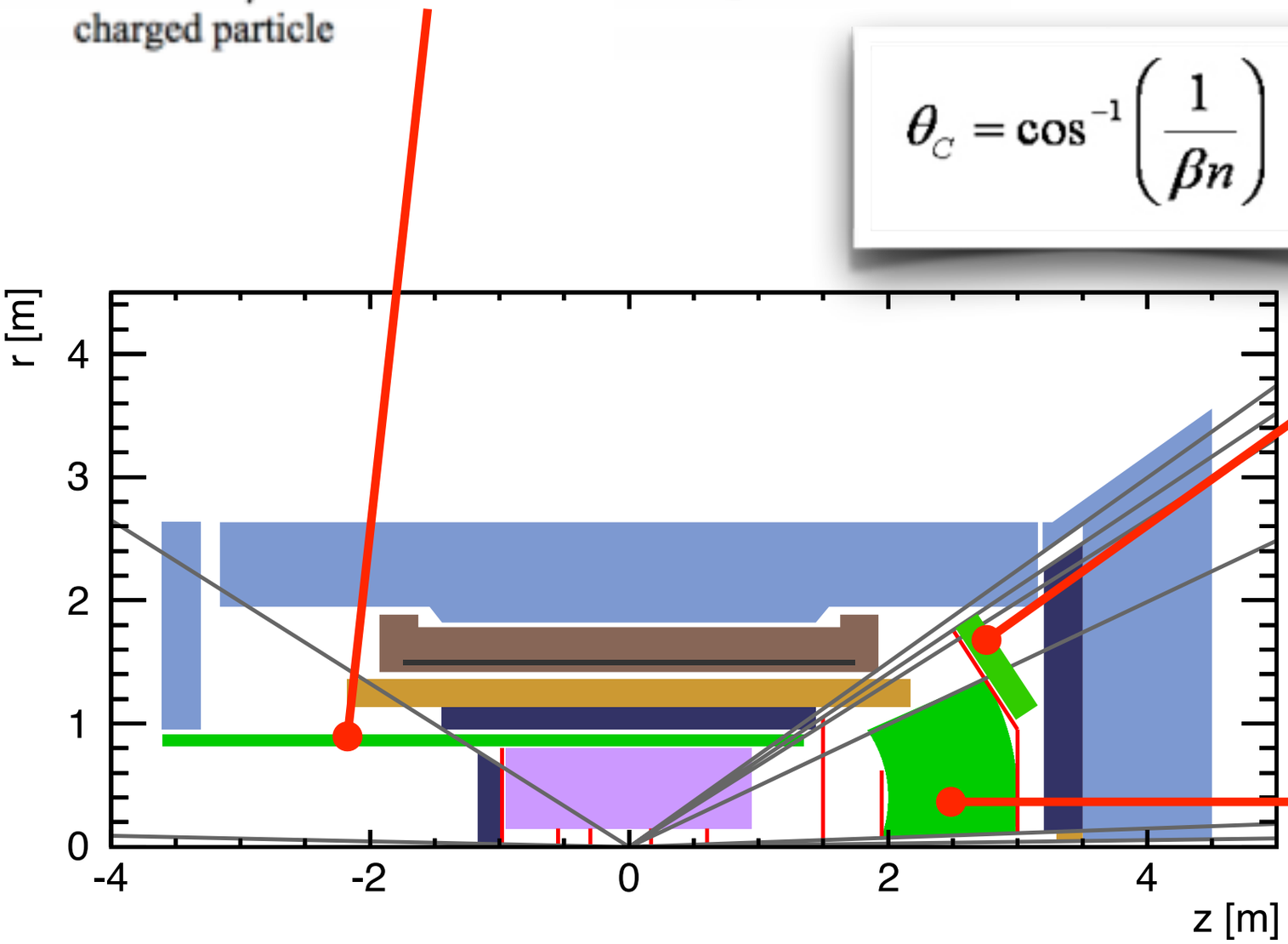
~ 10 × 10 cm^2 segmentation

RICH Detectors for Hadron ID



$$\theta_C = \cos^{-1}\left(\frac{1}{\beta n}\right)$$



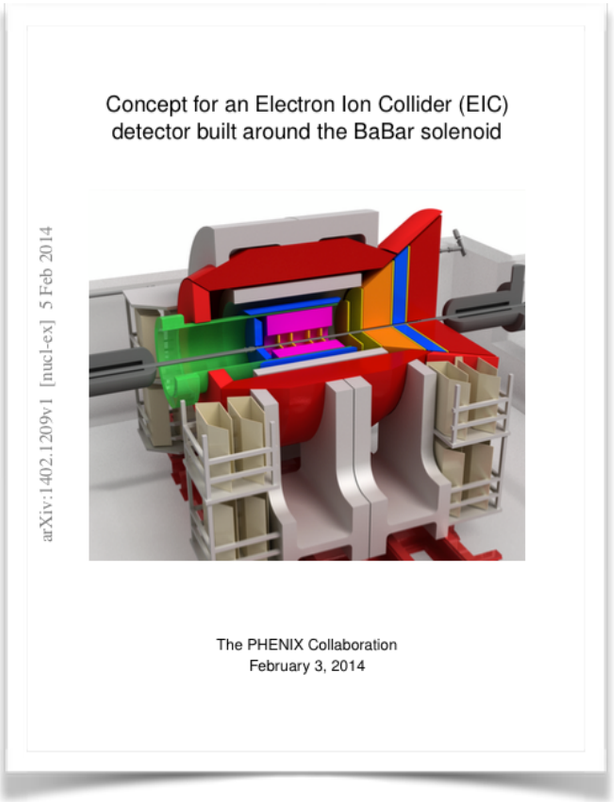


Setting the stage for the LOI studies

Maximum beam energies

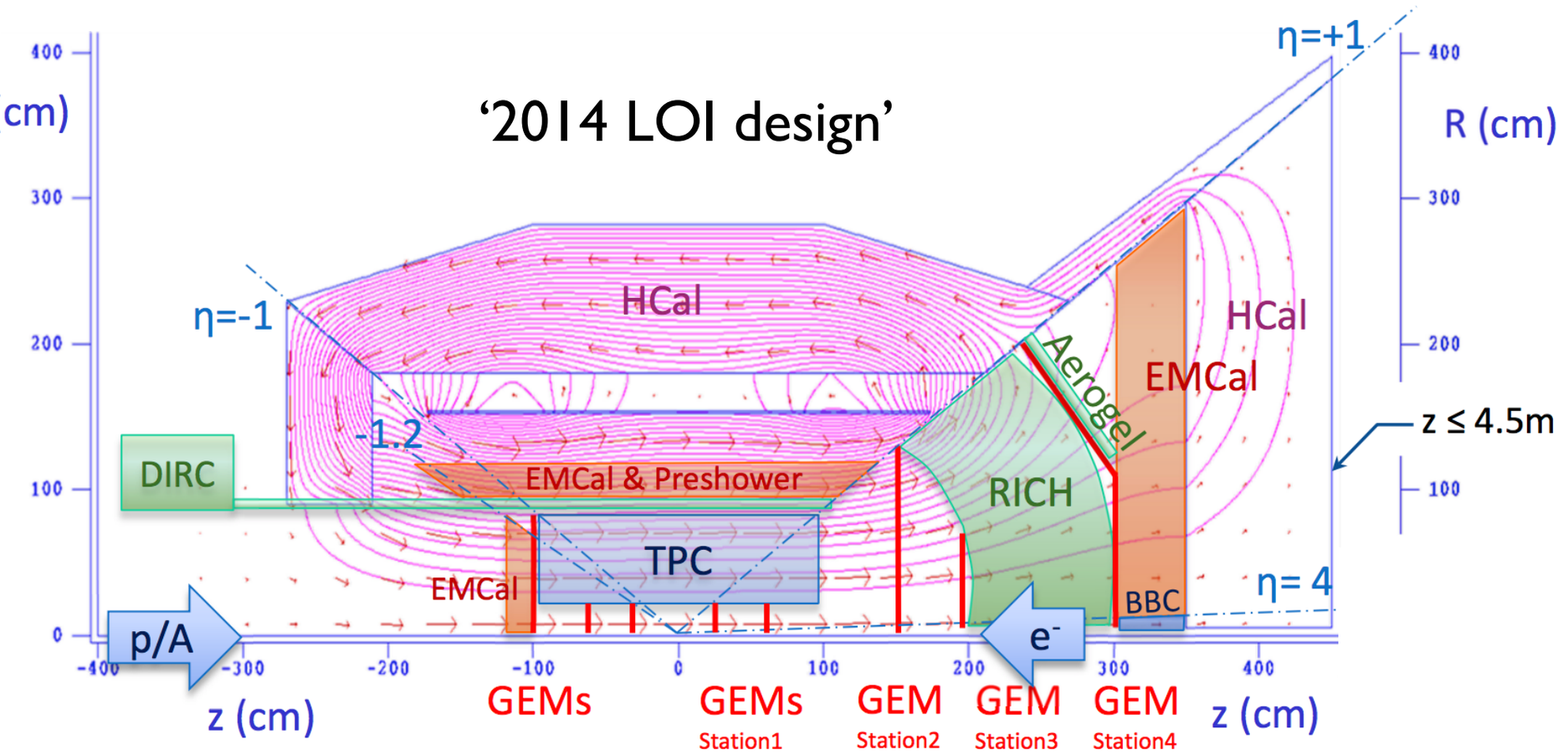
e	10 GeV
p	255 GeV
Au	100 GeV / nucleon

e+p Design luminosity (10 GeV on 255 GeV)
10^{33} $cm^{-2}s^{-1}$

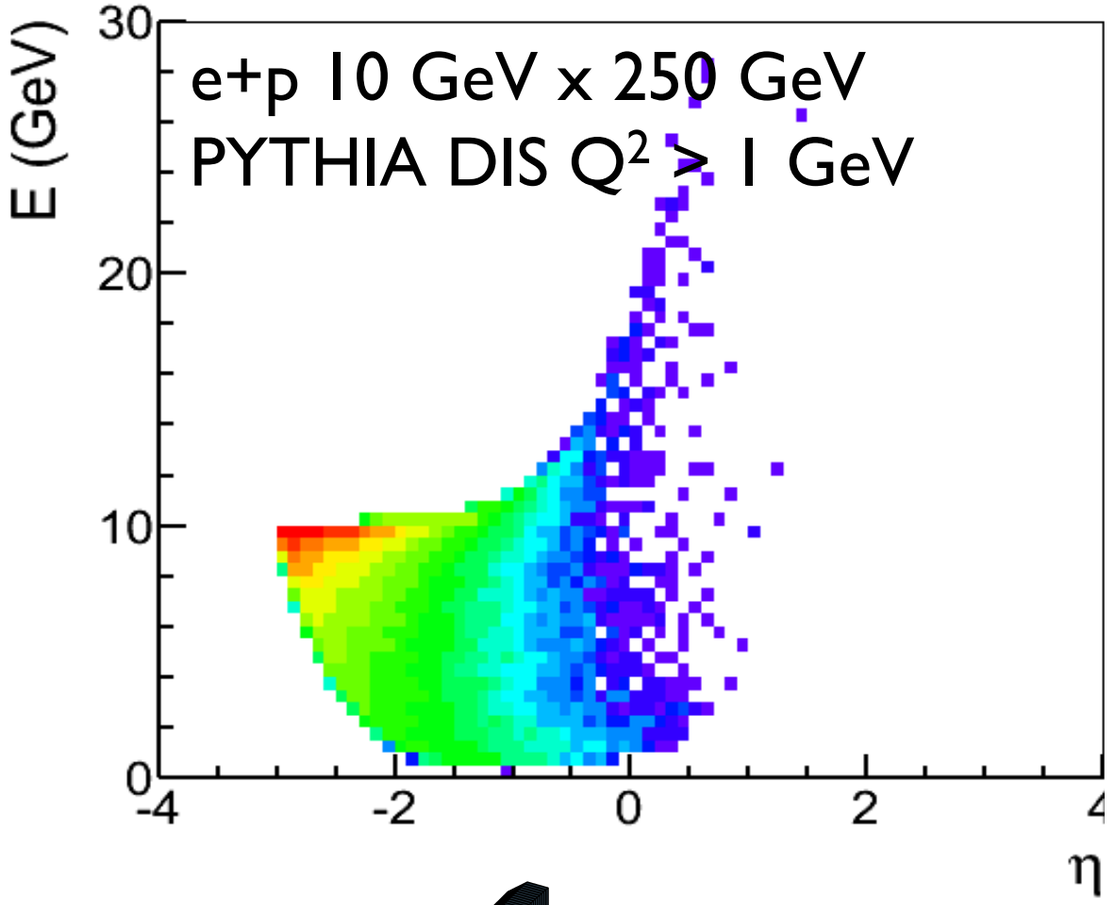


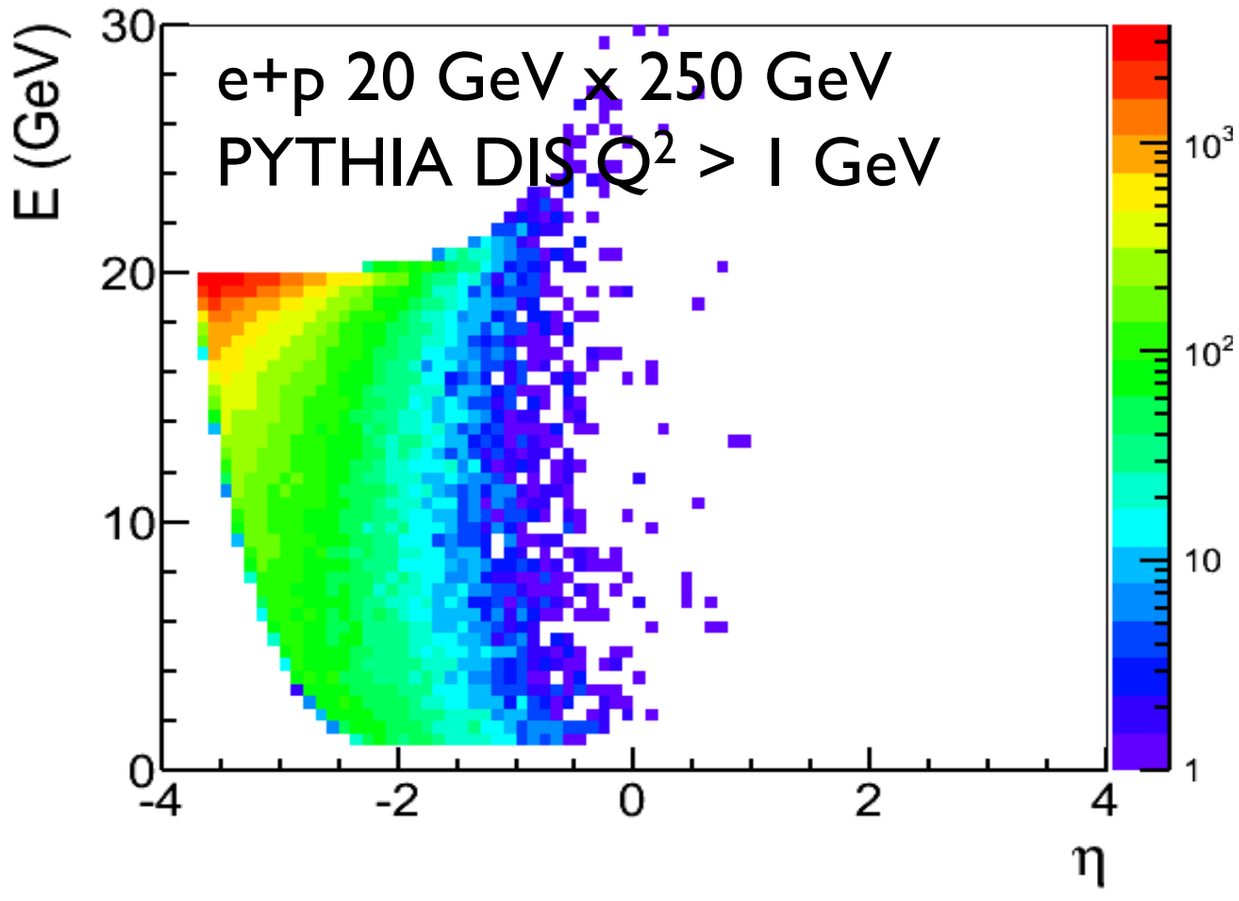
[arXiv:1402.1209v1]

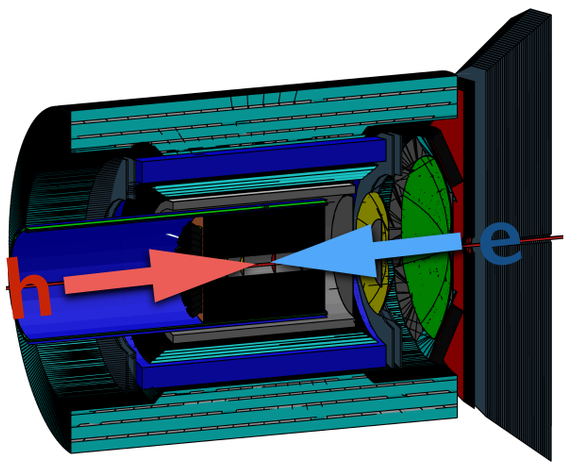
‘2014 LOI design’



DIS electron measurement





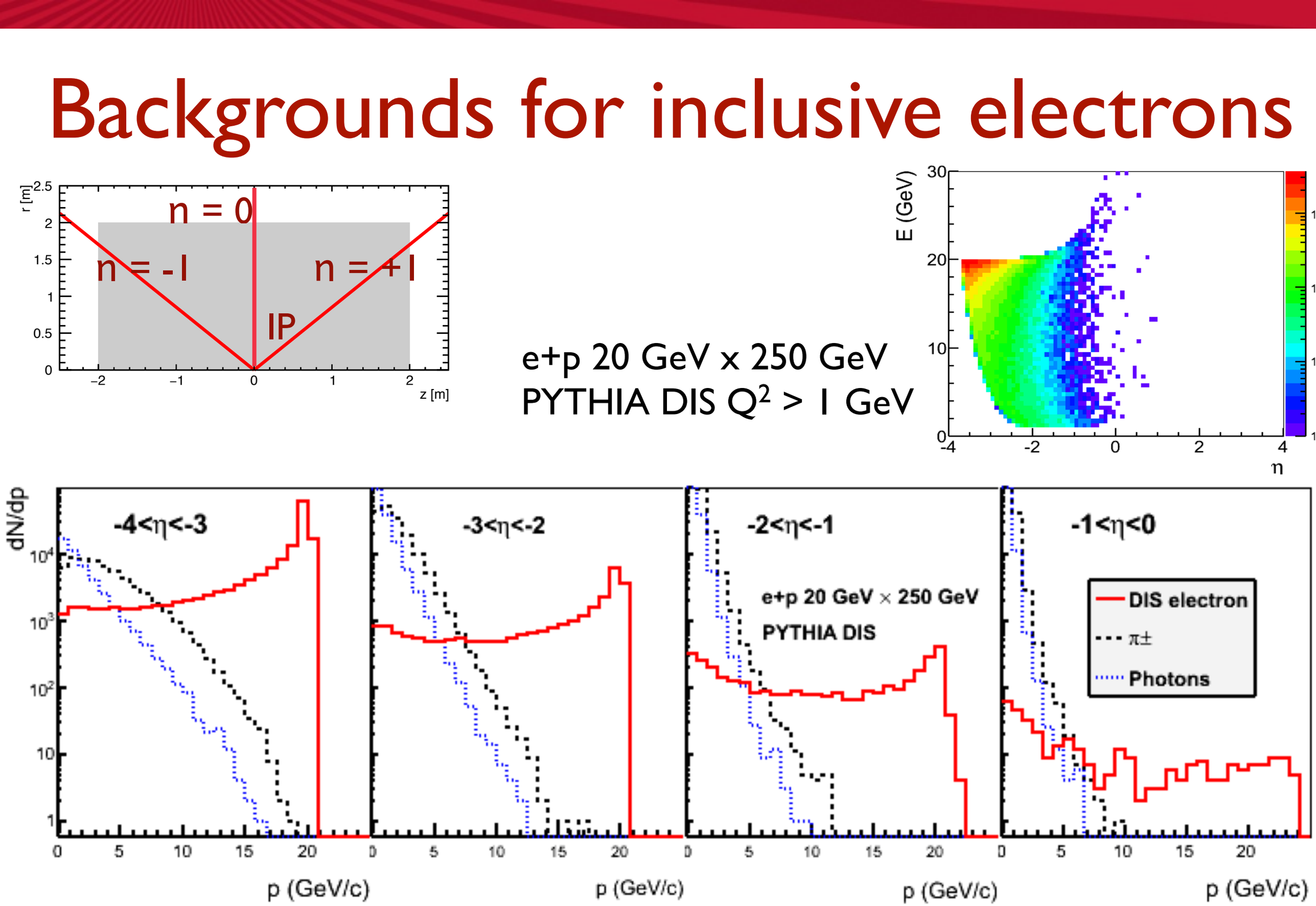


Need:
- Electron ID
- energy
- angle

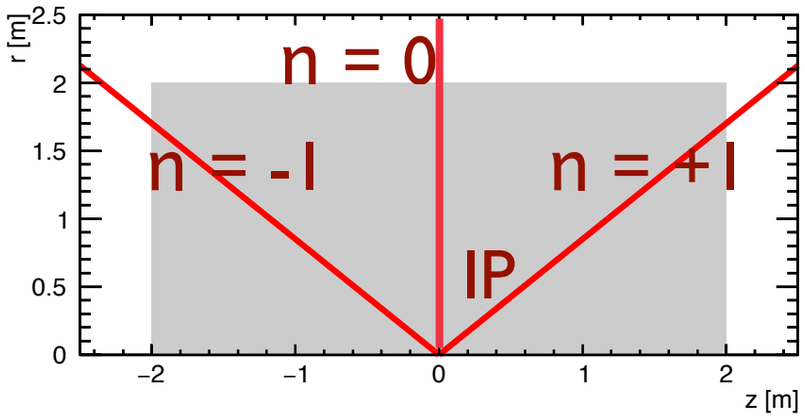
Solution:
- ✓Tracking
- ✓Calorimeter

Backgrounds for inclusive electrons

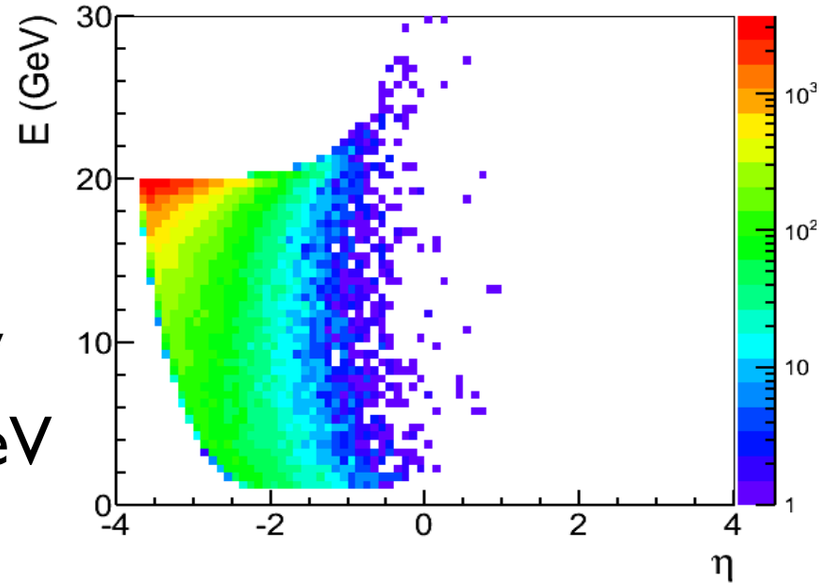
e+p 20 GeV x 250 GeV
PYTHIA DIS Q^2 > 1 GeV



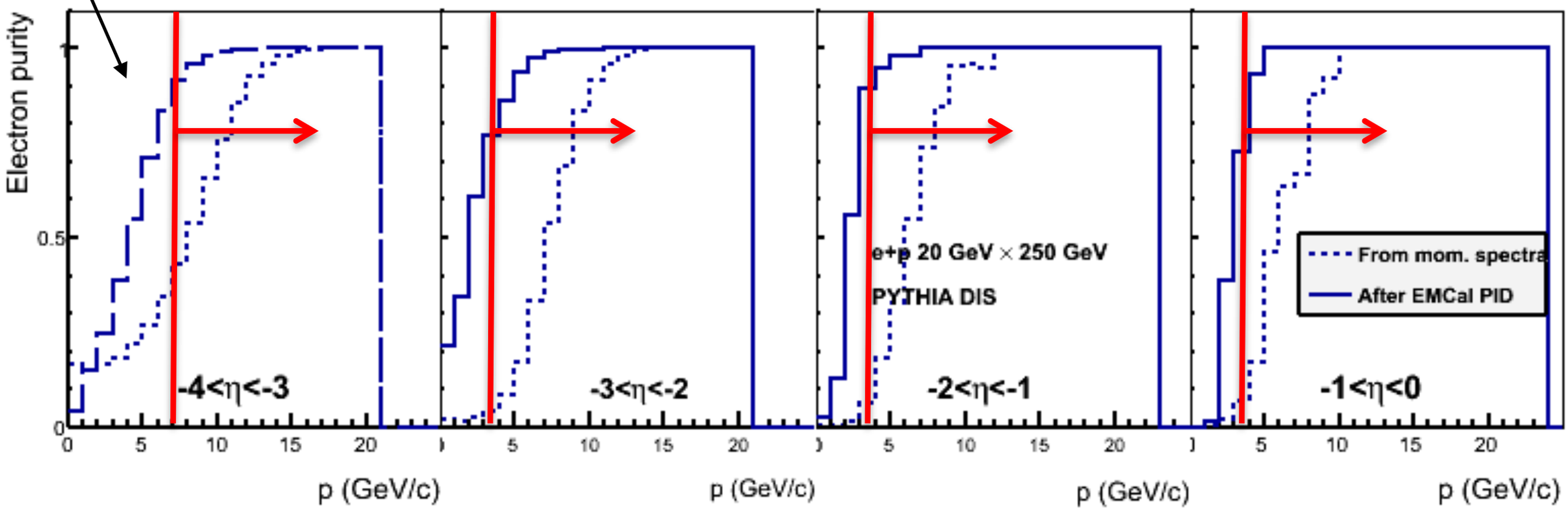
Electron identification



e+p 20 GeV x 250 GeV
PYTHIA DIS $Q^2 > 1$ GeV



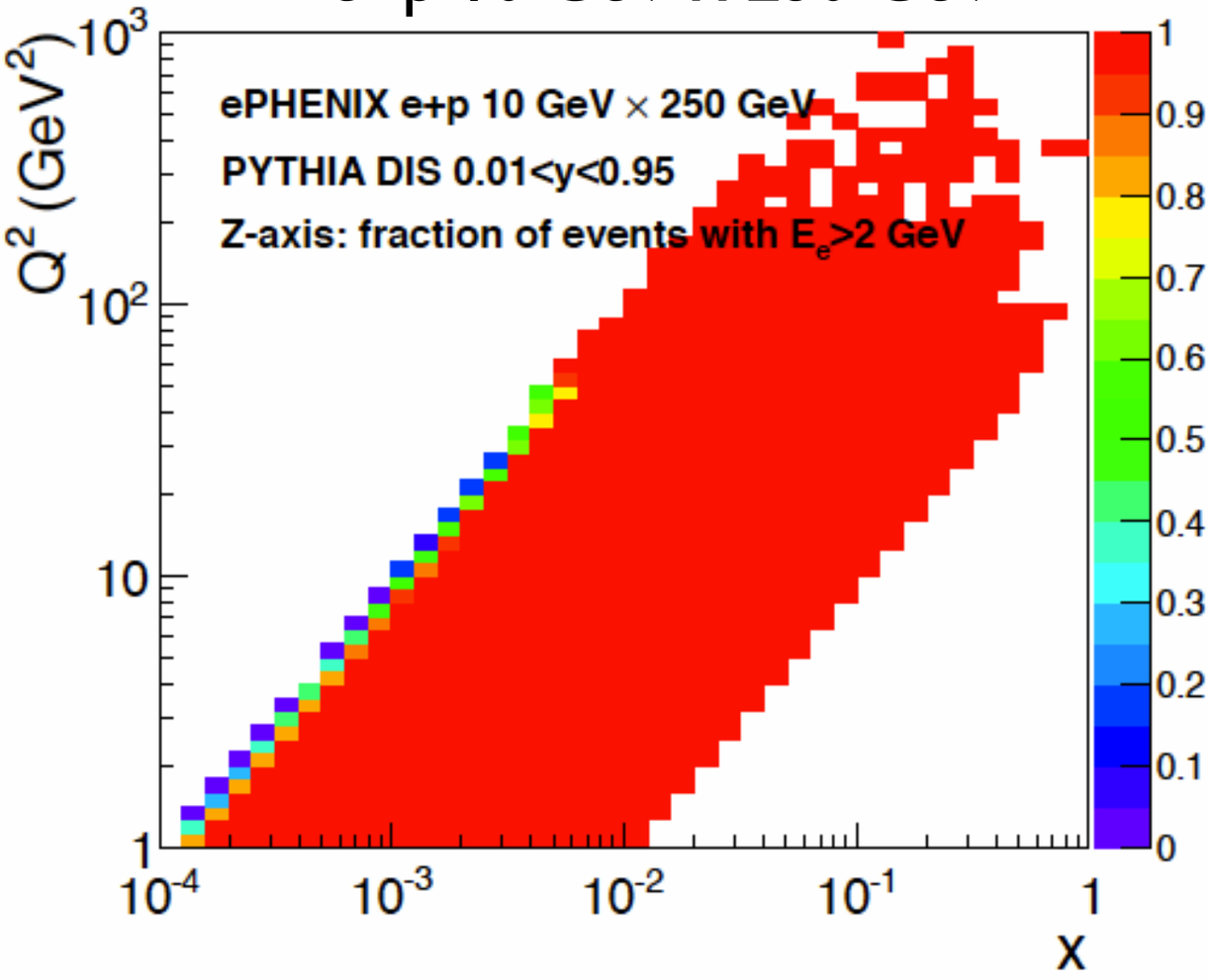
No tracking or E/p



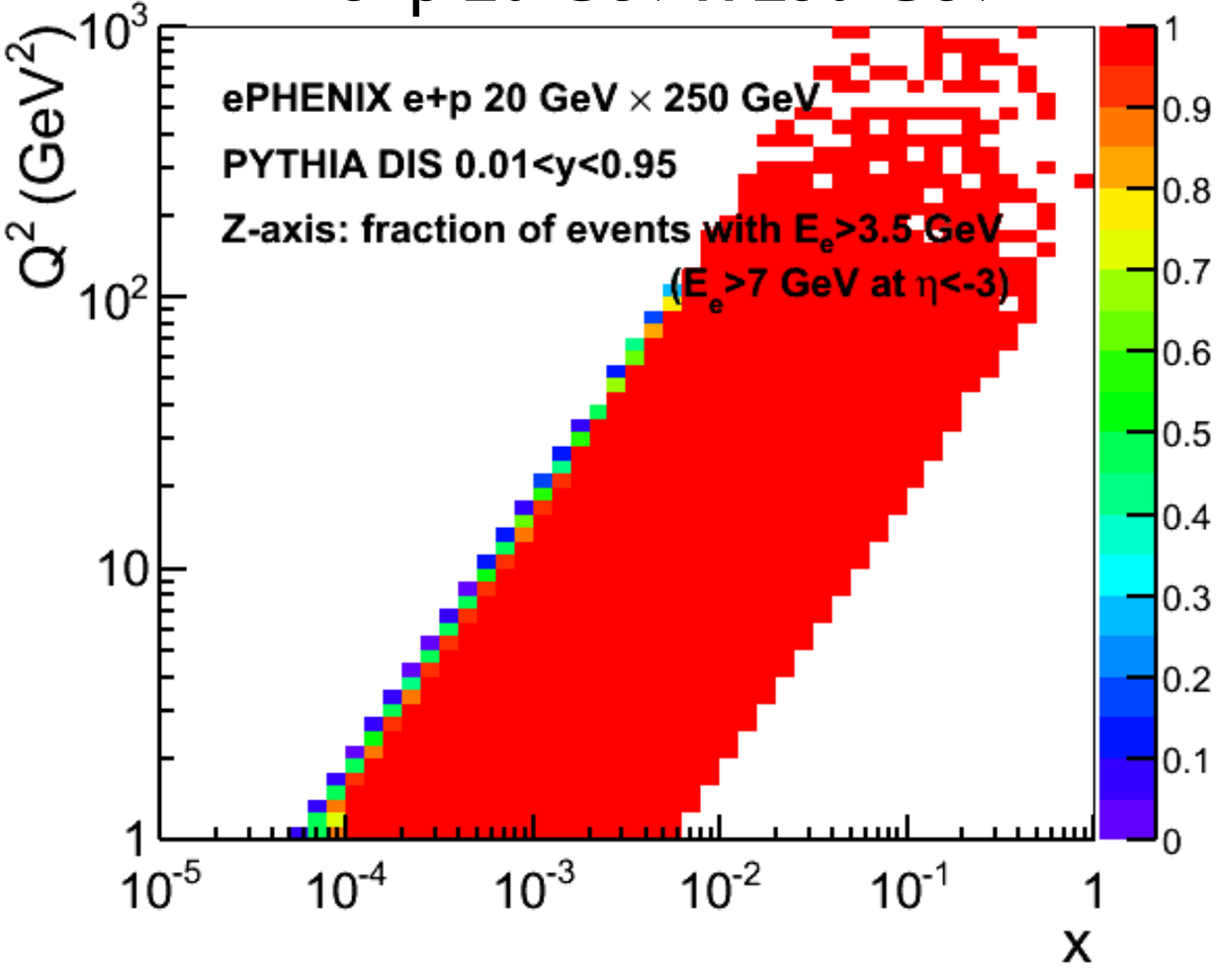
A. Bazilevsky

Cut on electron energy only marginally reduces x-Q^2 coverage

e+p 10 GeV x 250 GeV



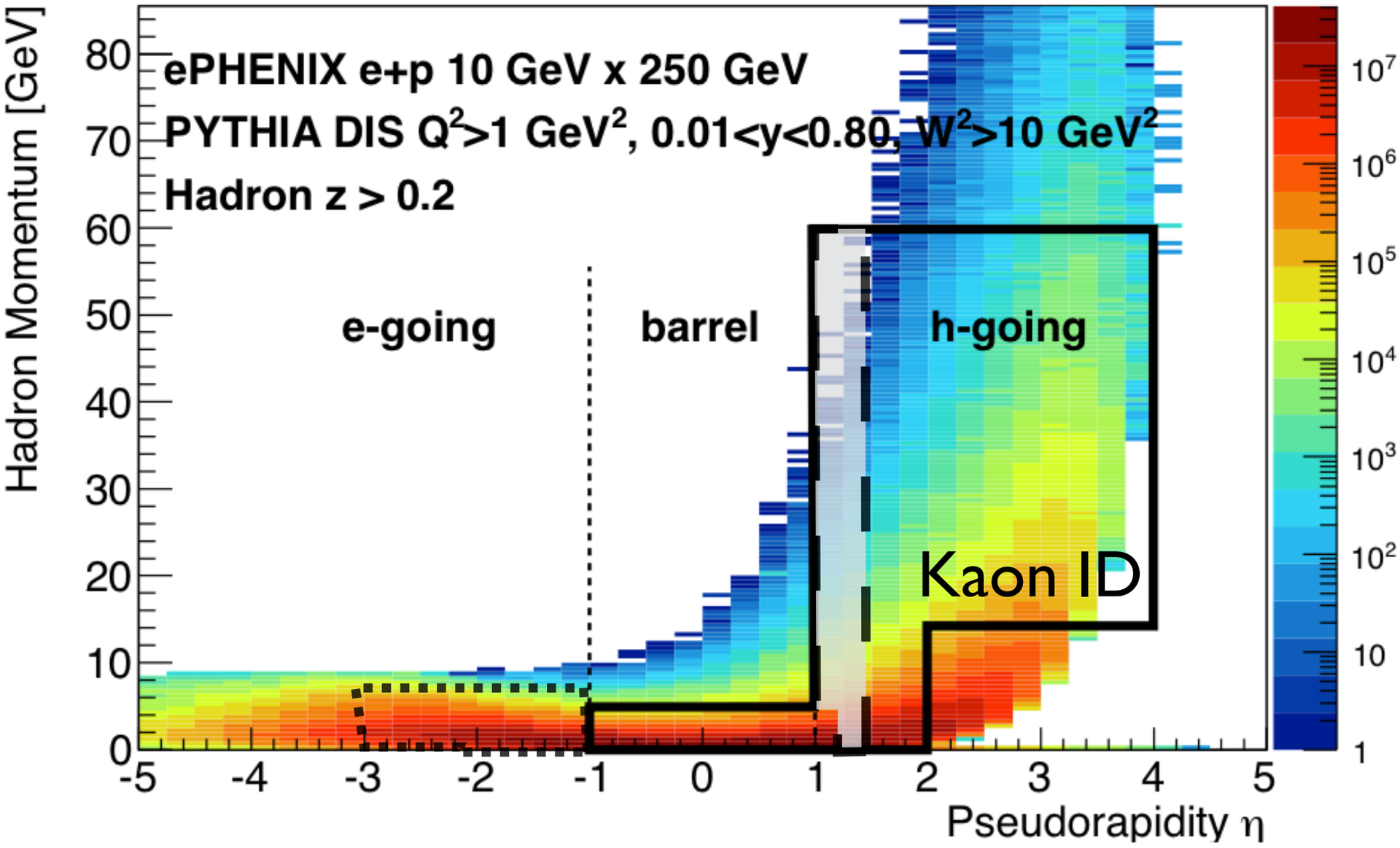
e+p 20 GeV x 250 GeV

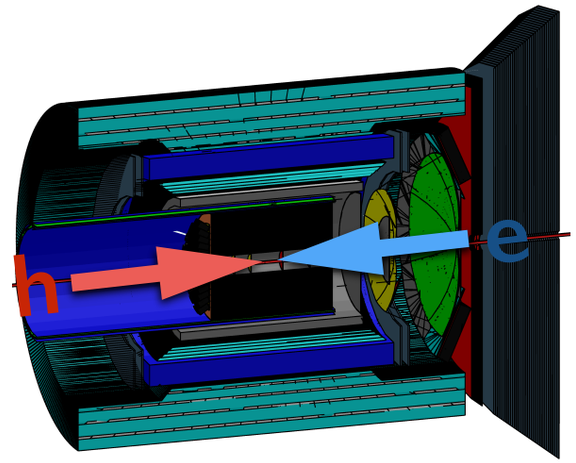


LOI arXiv:1402.1209v1

A. Bazilevsky

SIDIS: Hadrons from DIS events





Need:

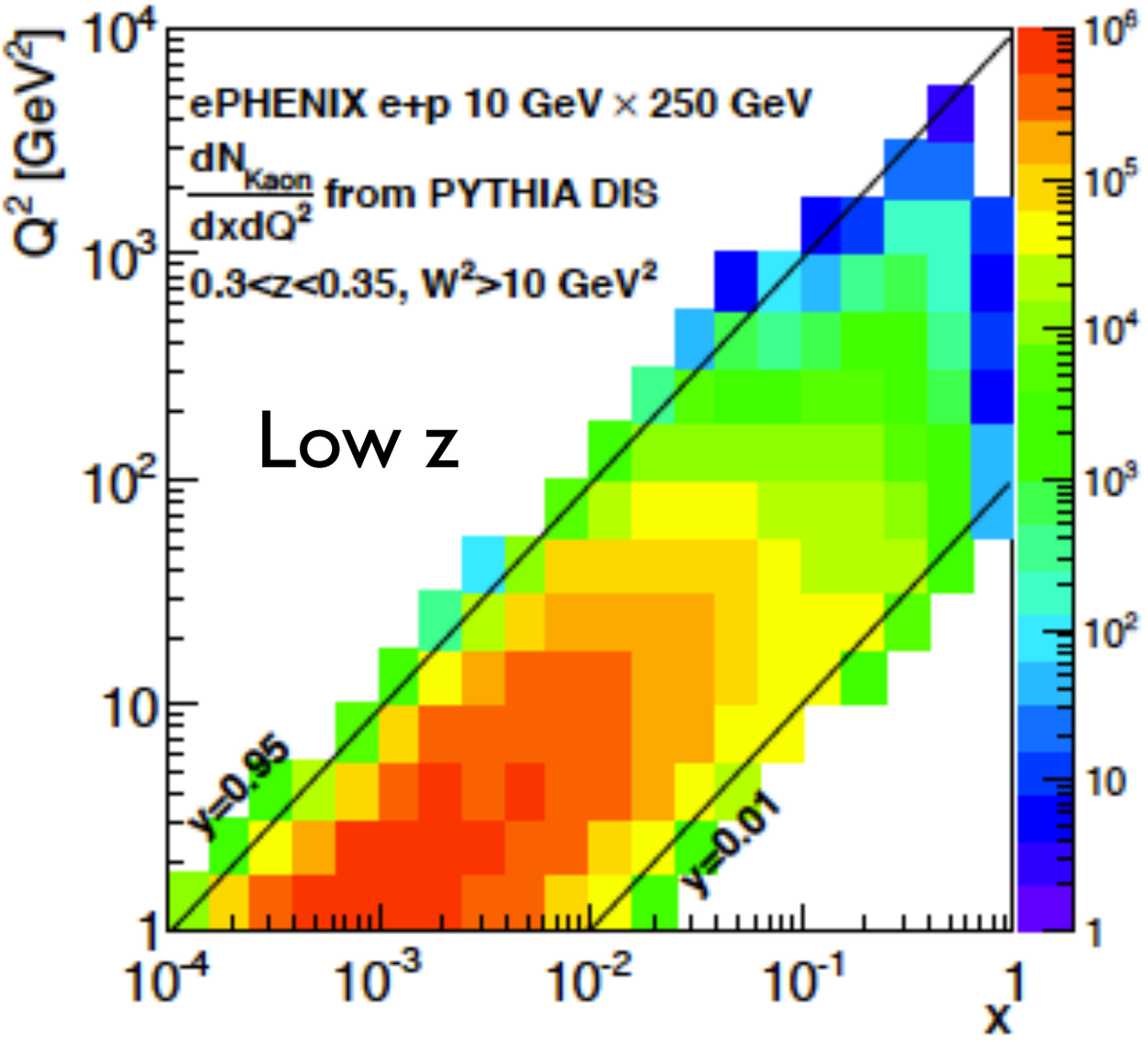
- Hadron ID

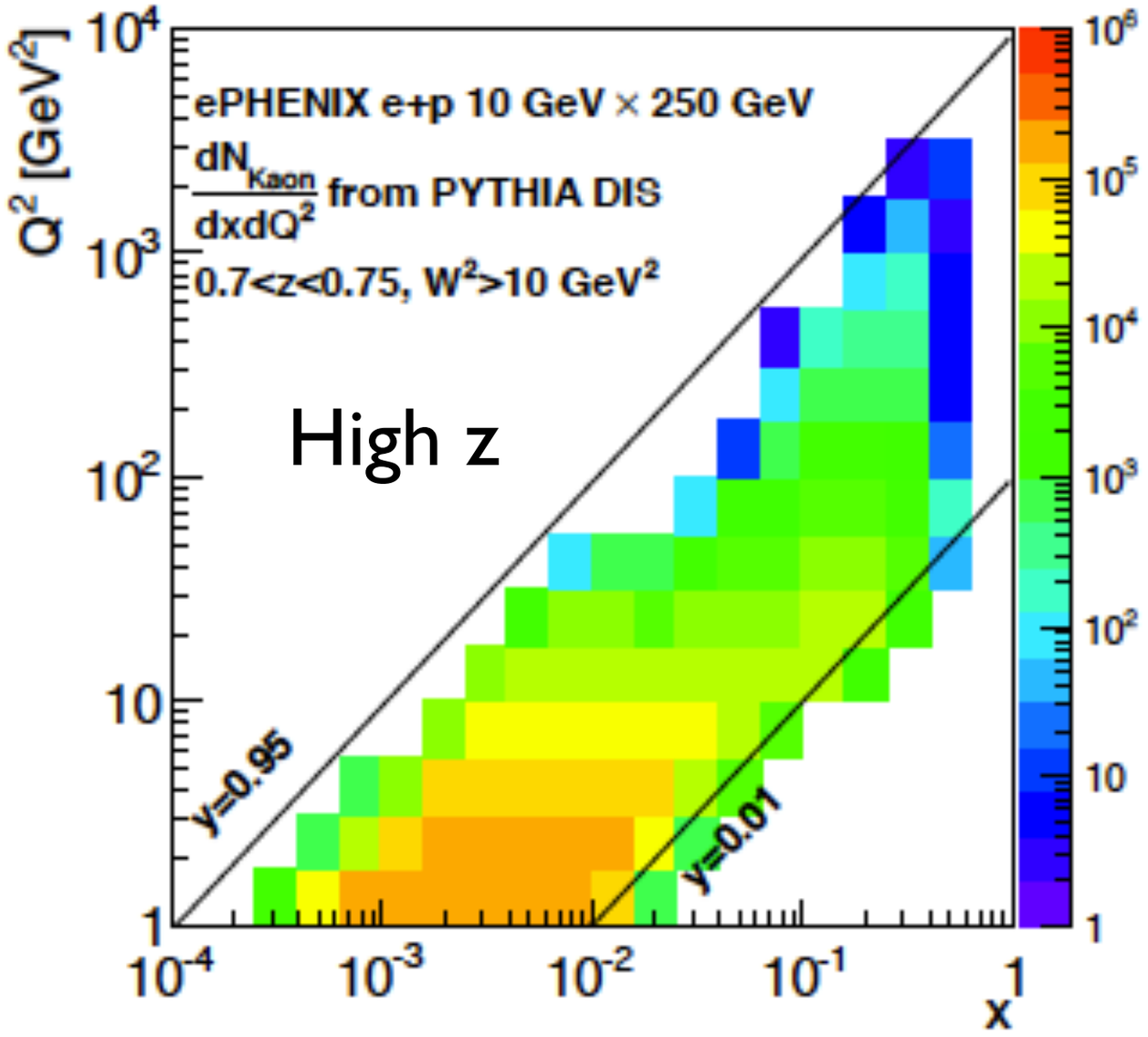
Solution:

- ✓RICH

arXiv:1402.1209v1

Identified kaons kinematics coverage



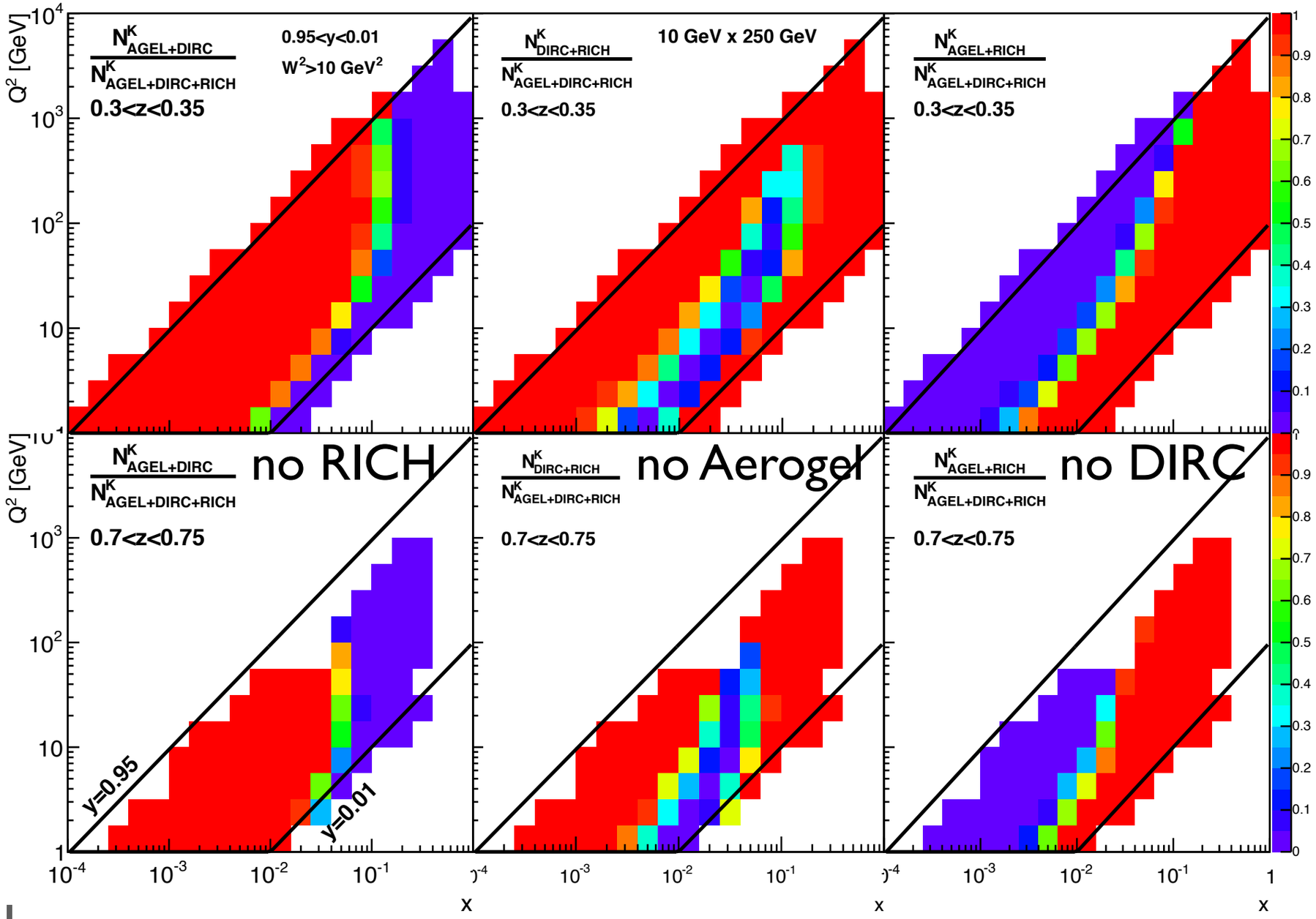


arXiv:1402.1209v1

All three RICH detectors are needed to cover full x-Q^2 range

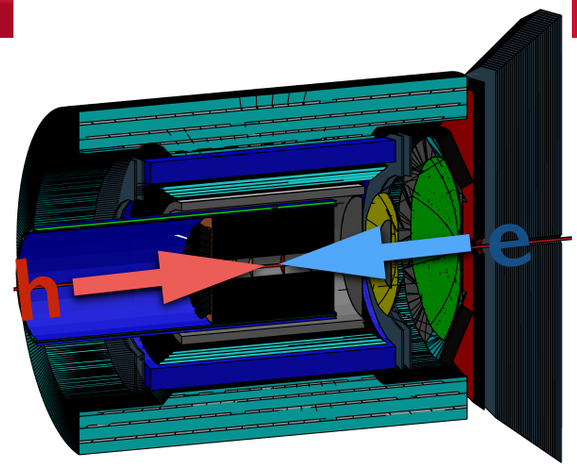
low z

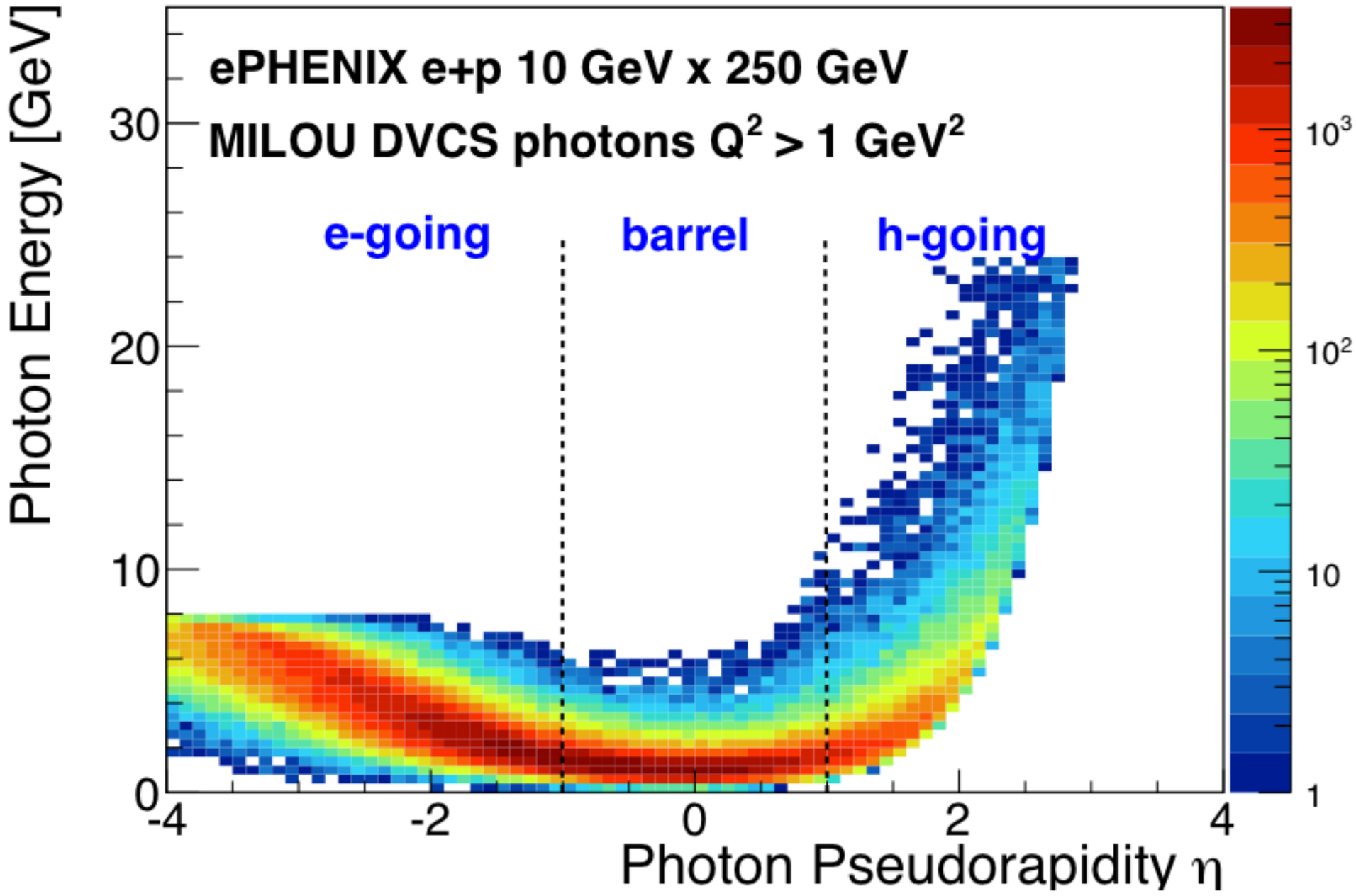
high z



arXiv:1402.1209v1

DVCS photons





arXiv:1402.1209v1

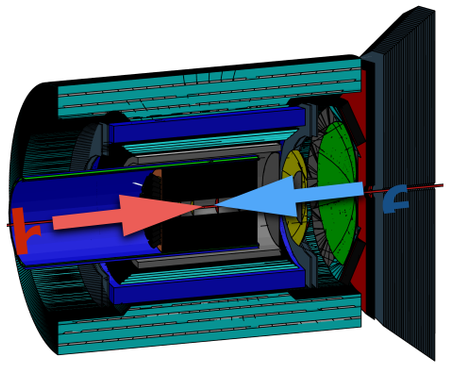
Need:

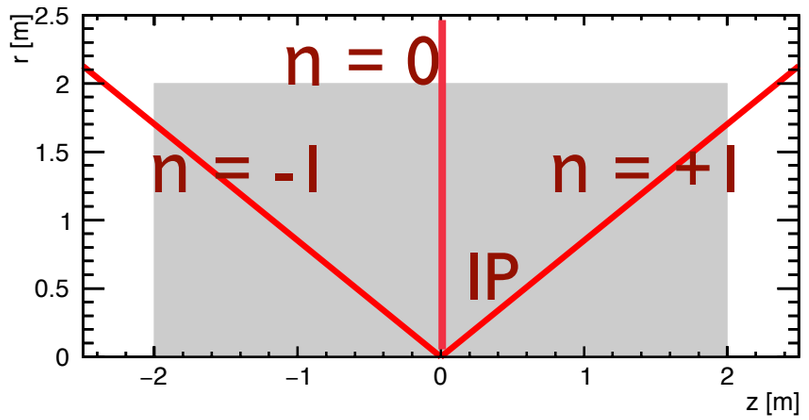
- Electron / photon separation
- Confirm exclusiveness

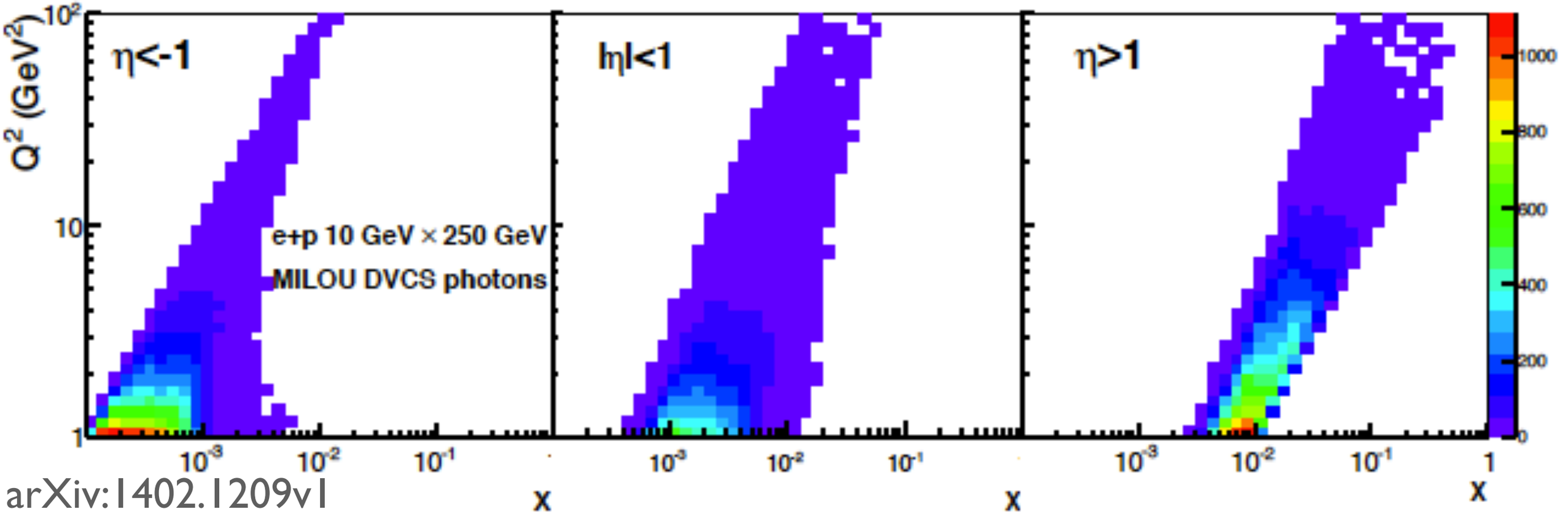
Solution:

- ✓Granular EMCal
- ✓Roman Pots (ZDC for eA)

DVCS photon acceptance: Need to cover wide rapidity range





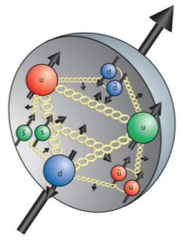


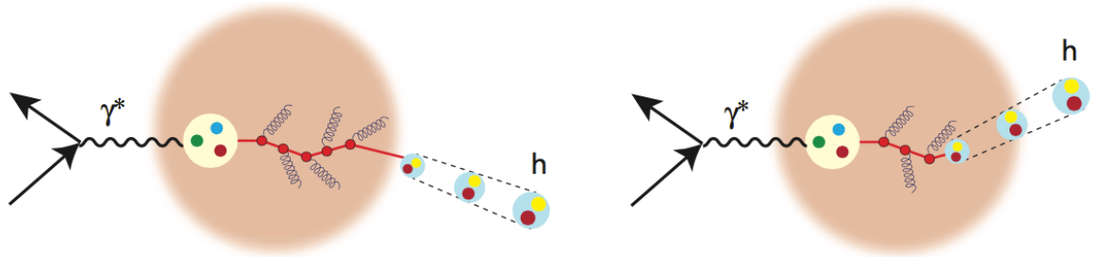
arXiv:1402.1209v1

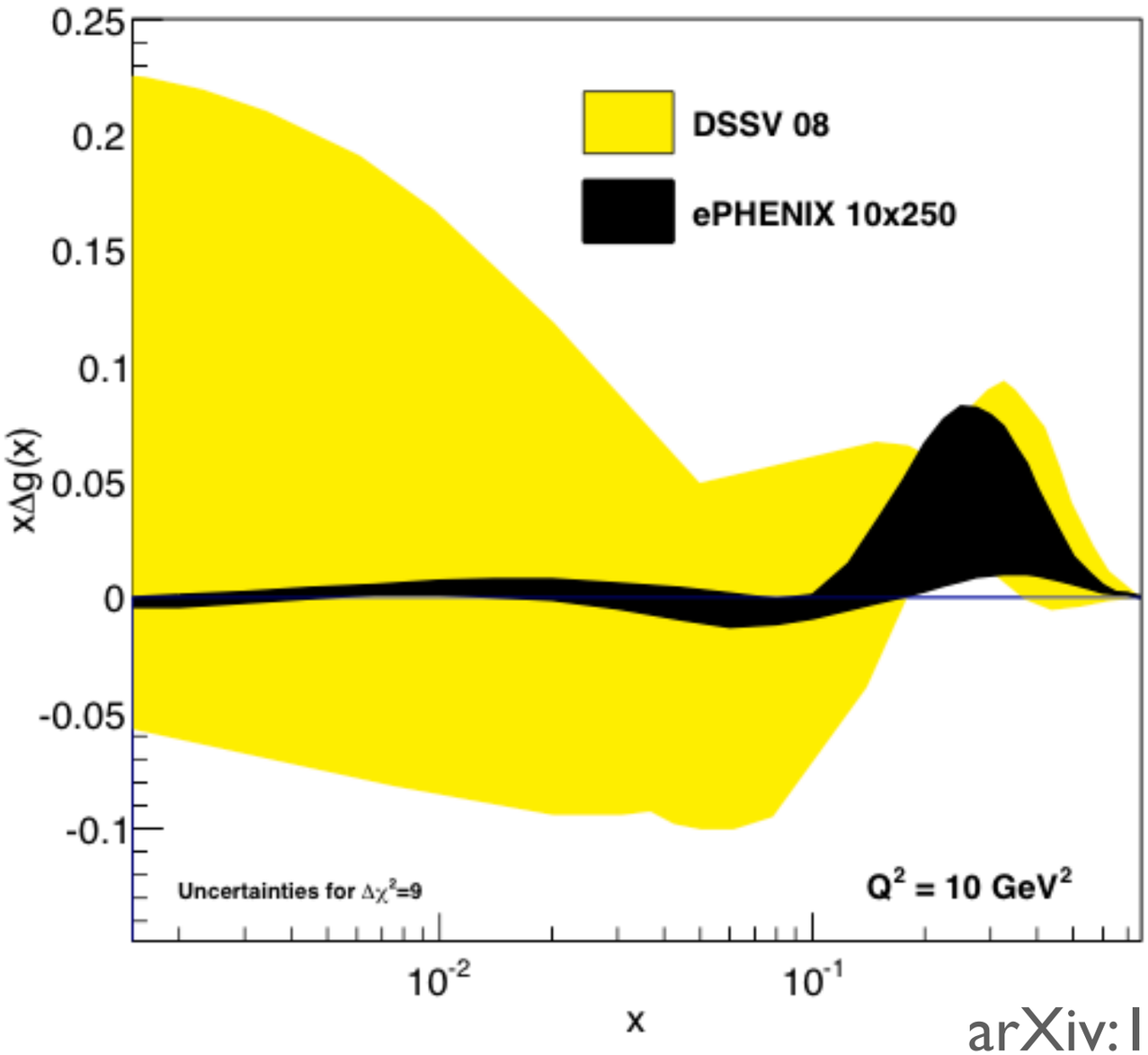
Expected physics performance

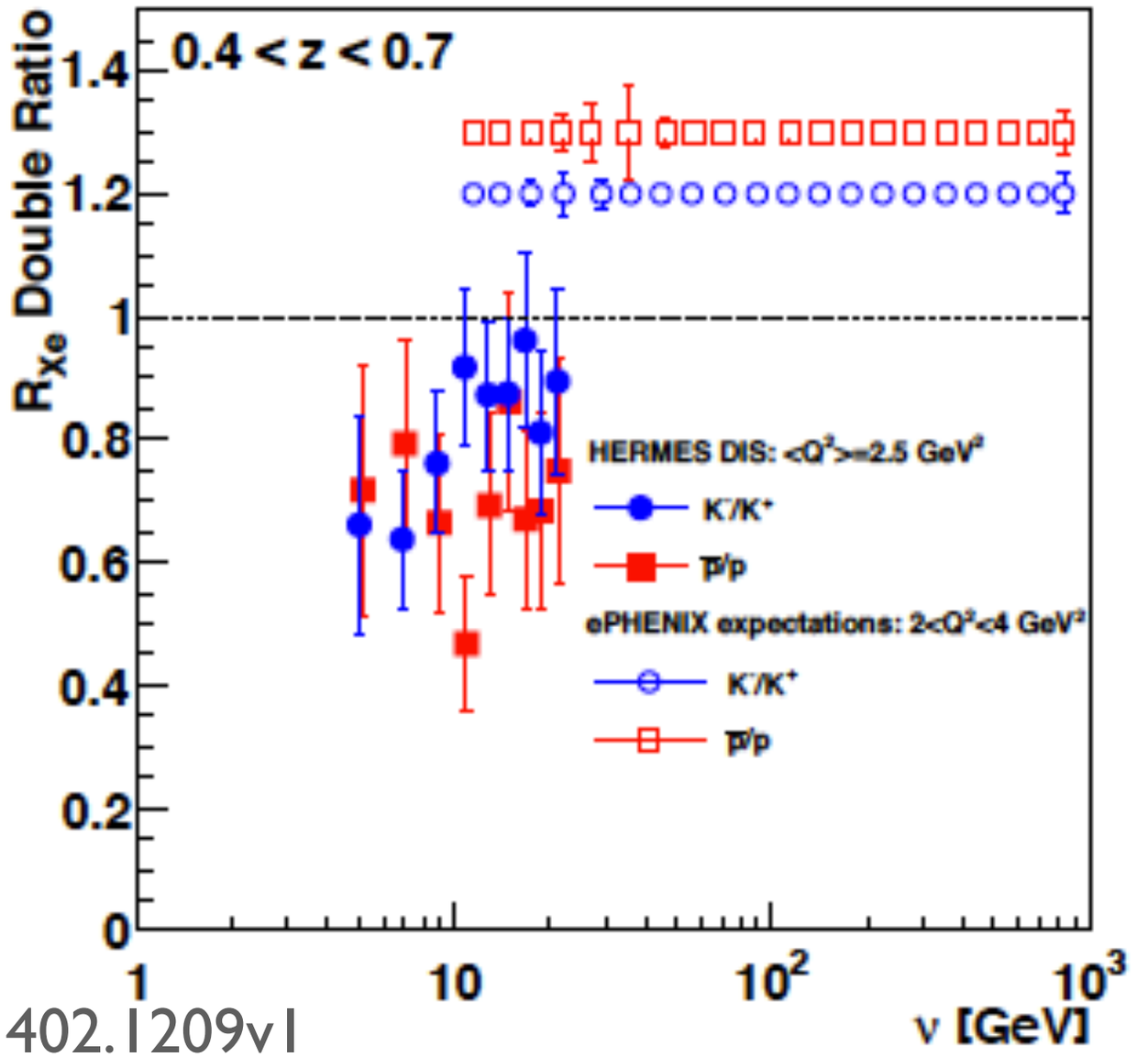
PHYTHIA generator and ePHENIX acceptance/efficiencies

10 fb^{-1} at 10GeV×250GeV





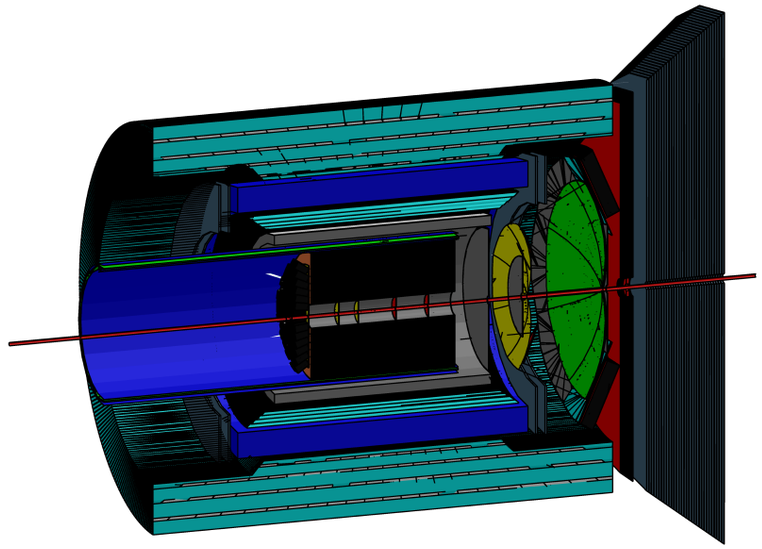




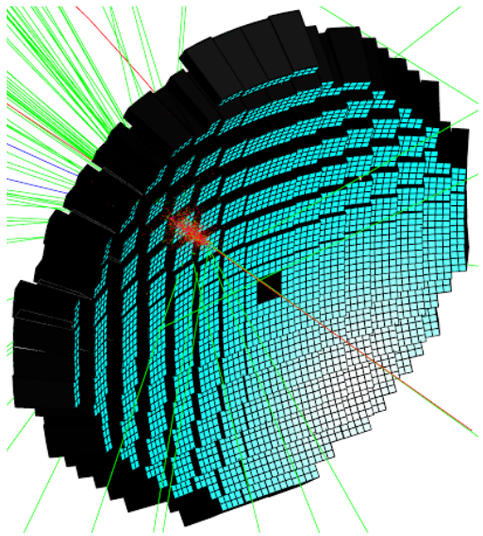
arXiv:1402.1209v1

Current / future simulation activities

- Further advance the GEANT4 detector simulation (include readout and digitization effects for all systems),



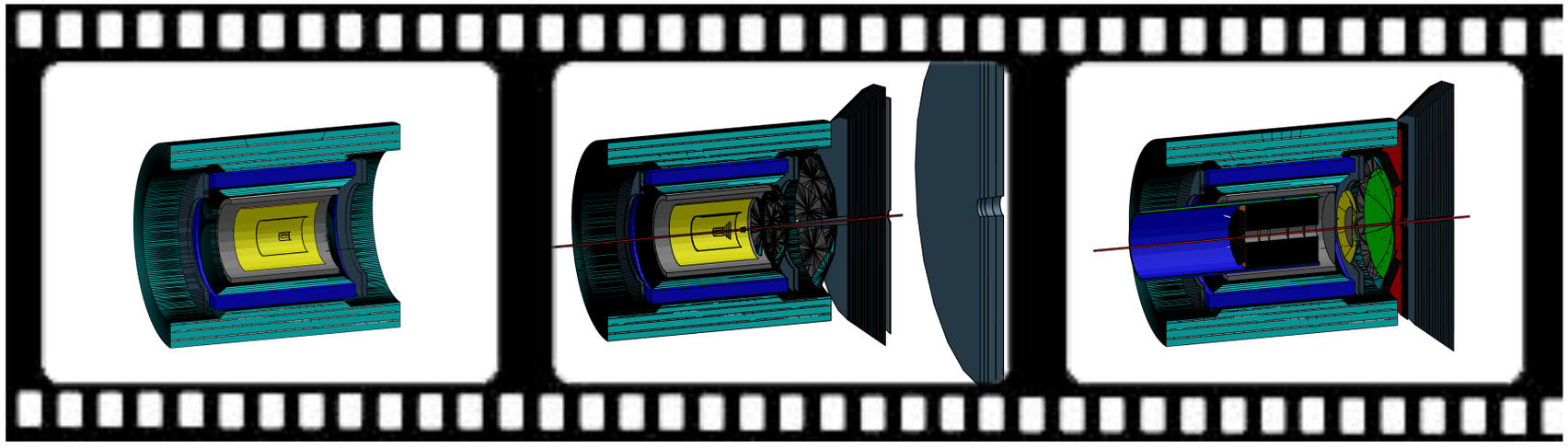
- Evaluate the performance of the latest design options for EIC core measurements and explore various physics topics.



https://github.com/sPHENIX-Collaboration
https://github.com/EIC-Detector

Strong involvement of SBU undergraduate students (J. LaBounty, T. Krahulik, R. Bruce)

Summary

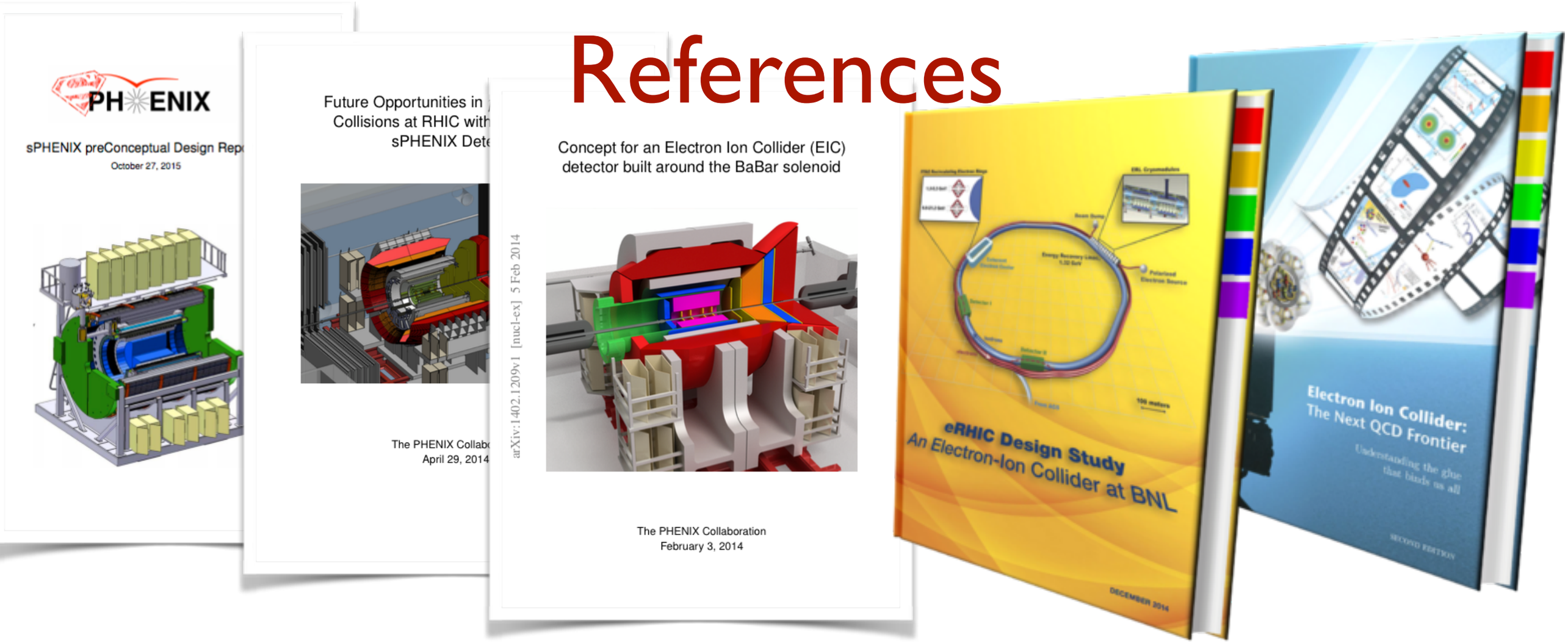


- The EIC detector design based on sPHENIX
  - ✓ evolves naturally from sPHENIX,
  - ✓ capitalizes on major sPHENIX investments,
  - ✓ covers critical acceptances,
  - ✓ addresses much of the EIC physics potential,
  - ✓ has compact length compatible with IRs at eRHIC or JLEIC.

- Ongoing simulation and detector R&D activities keep advancing this design, incorporate sPHENIX updates, and offer lots of opportunities for novel ideas, new collaborators, and students.

ADDITIONAL SLIDES

References



- Concept for an Electron Ion Collider (EIC) detector built around the BaBar solenoid [arXiv:1402.1209v1]
- sPHENIX preConceptual Design Report [https://indico.bnl.gov/getFile.py/access?resId=0&materialId=11&confId=1483]
- Future Opportunities in p+p and p+A Collisions at RHIC with the Forward sPHENIX Detector
- Electron Ion Collider: The Next QCD Frontier [arXiv:1212.1701v3]
- eRHIC Design Study [arXiv:1409.1633]

Current Simulation Efforts

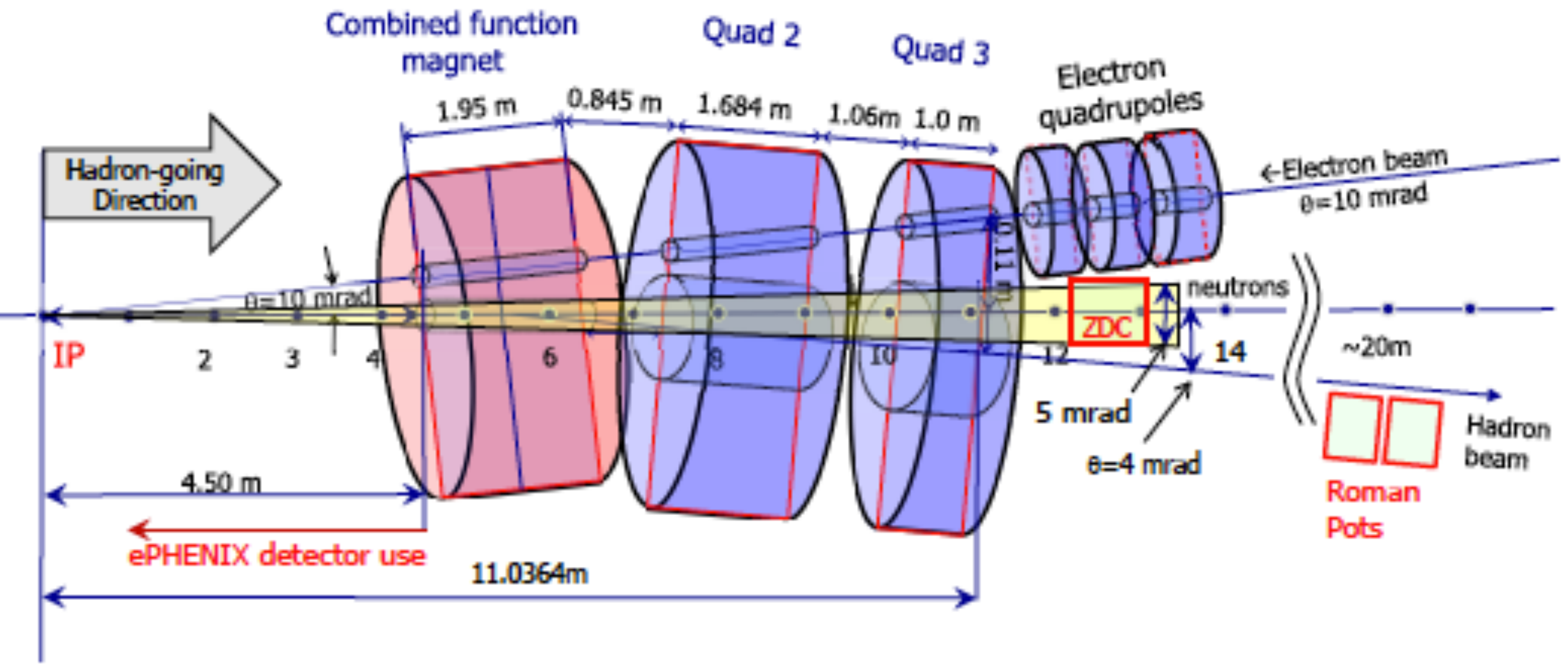
- Joint EIC detector / fsPHENIX meeting (BlueJeans) every other Tuesday 9 pm EST; **Next meeting: January 12, 2015**
  https://indico.bnl.gov/categoryDisplay.py?categId=93

- Mailing list:
  sphenix-eic-l@lists.bnl.gov

- Wiki:
  http://zwarg.physics.sunysb.edu/mediawiki/eic

- GitHub:
  https://github.com/sPHENIX-Collaboration
  https://github.com/EIC-Detector

Beamline Detectors

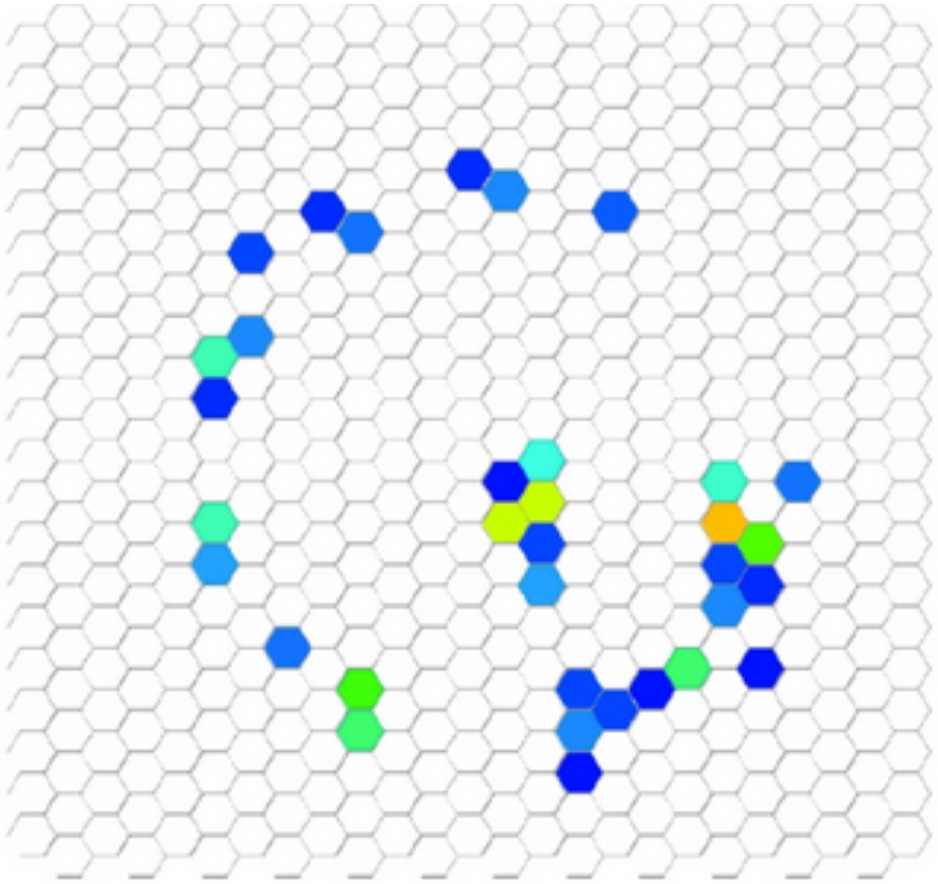


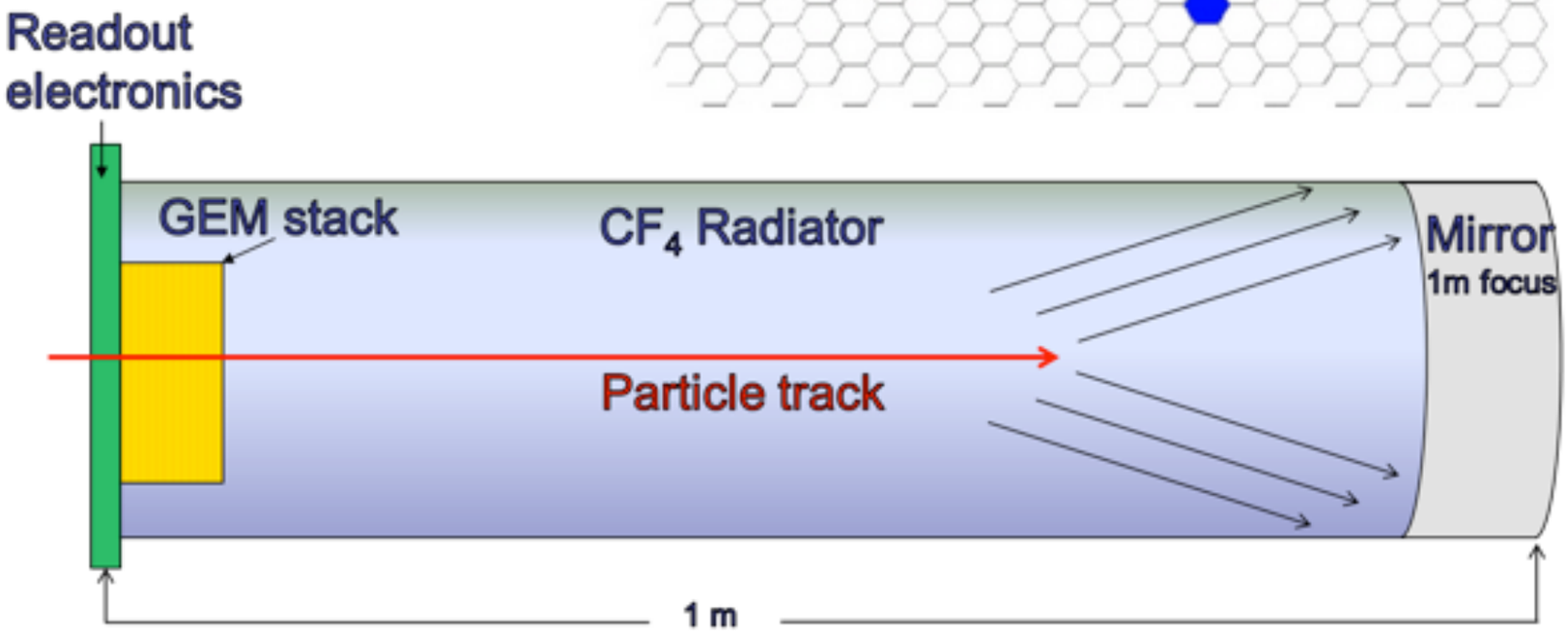
arXiv:1402.1209v1

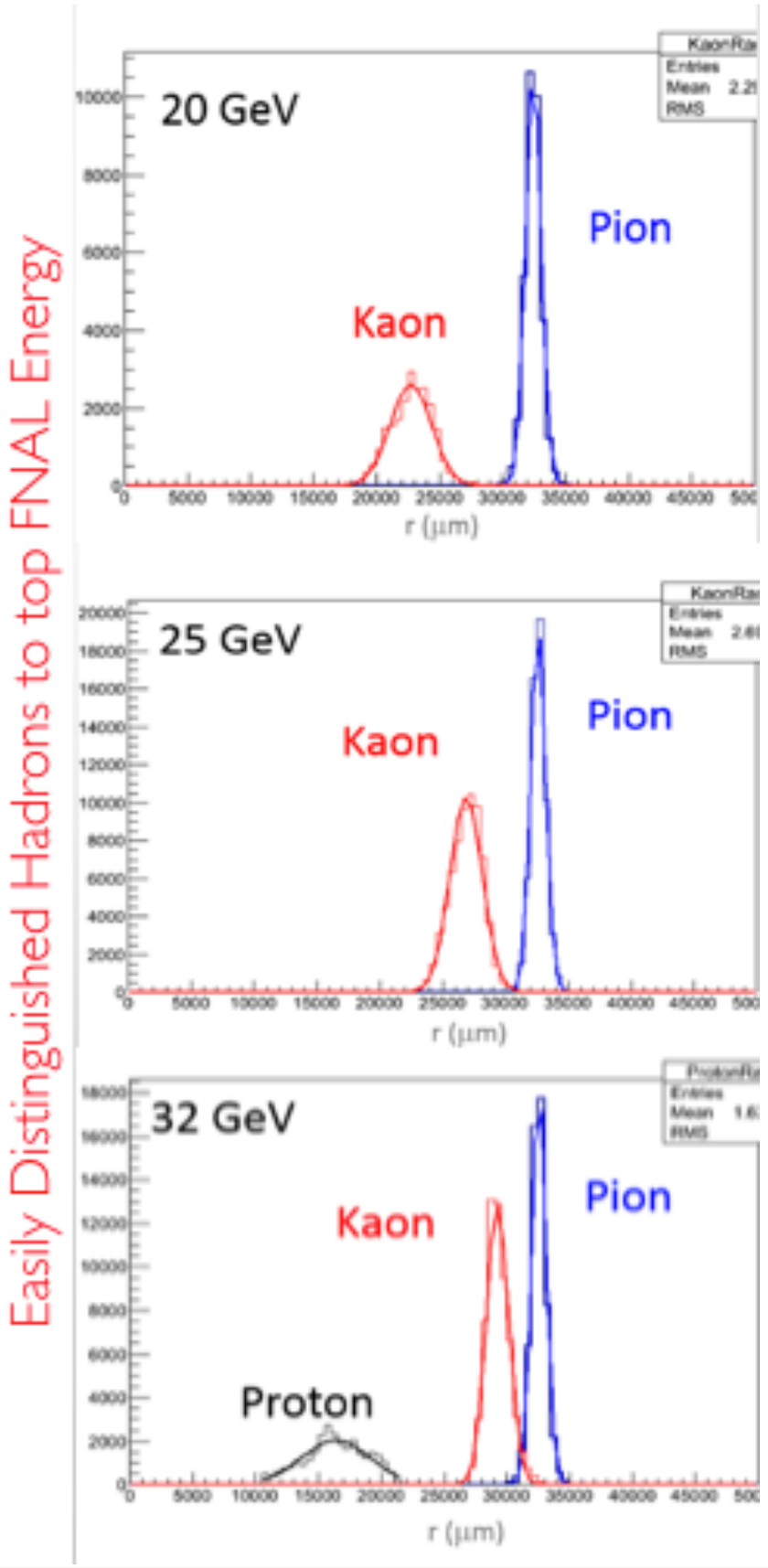
EIC R&D: Gas RICH

EIC R&D project eRD6

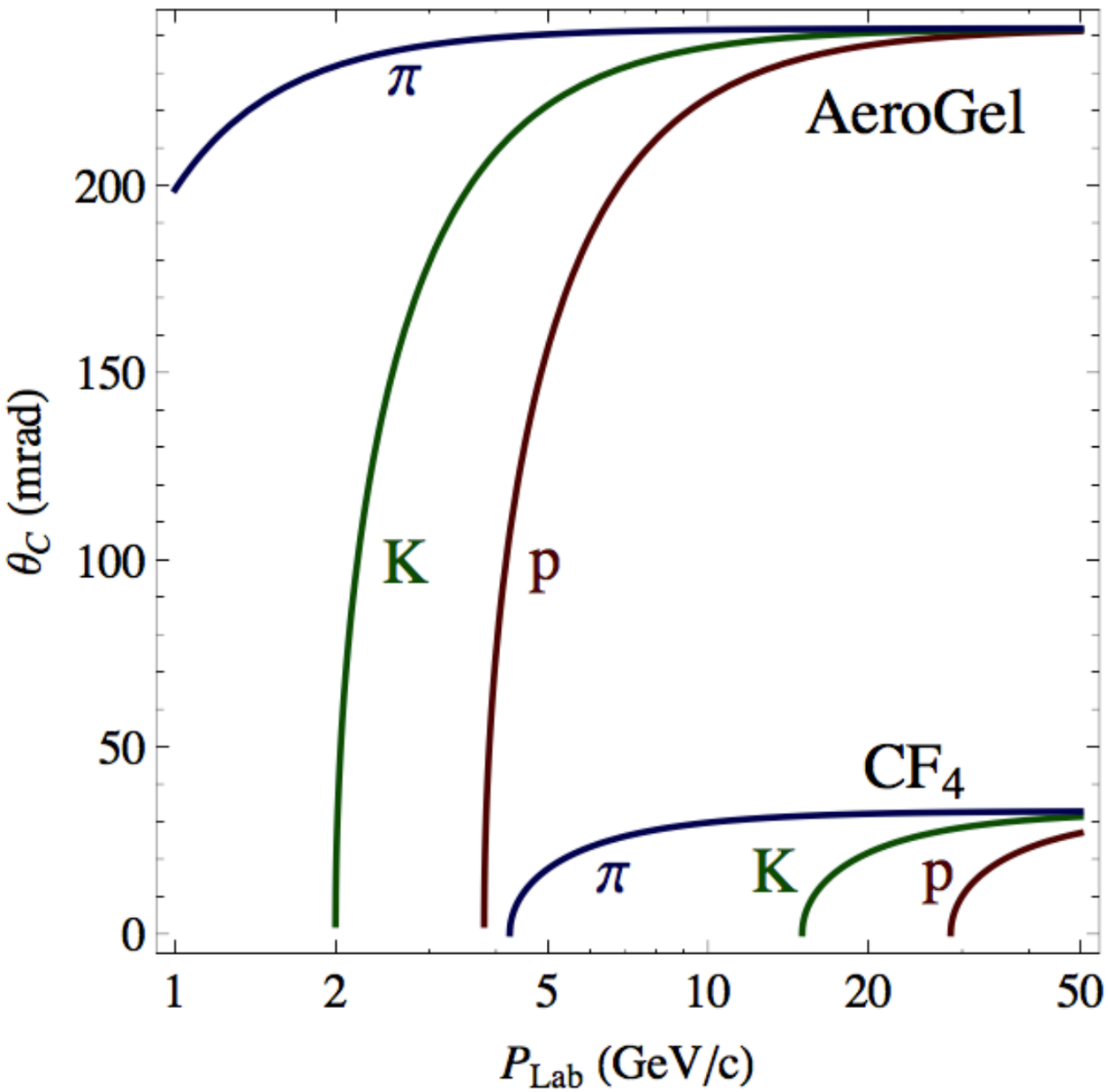
SBU Students:
Thomas Videbaek
Stefanie Zajac
Marie Blatnik
and others



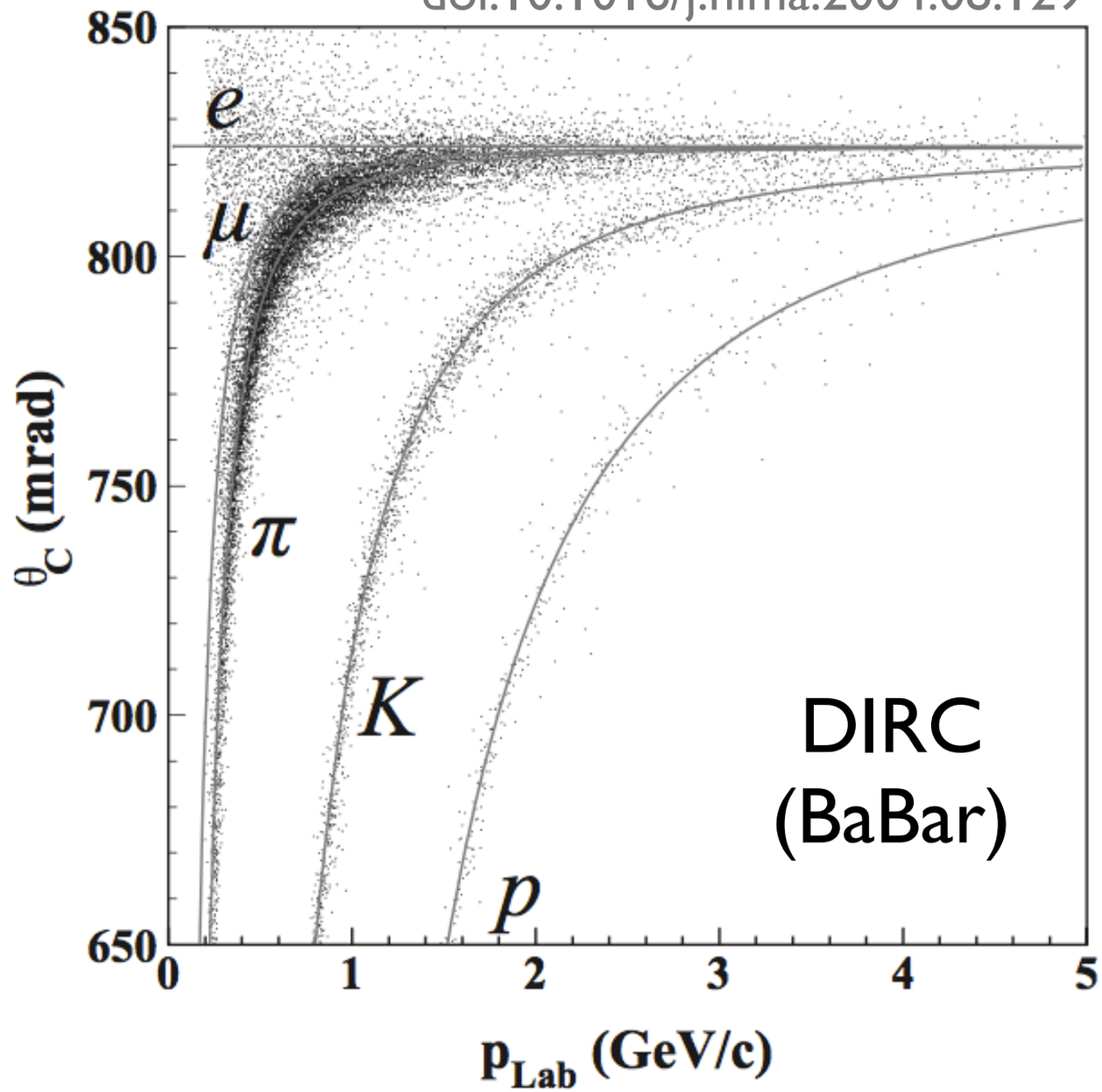




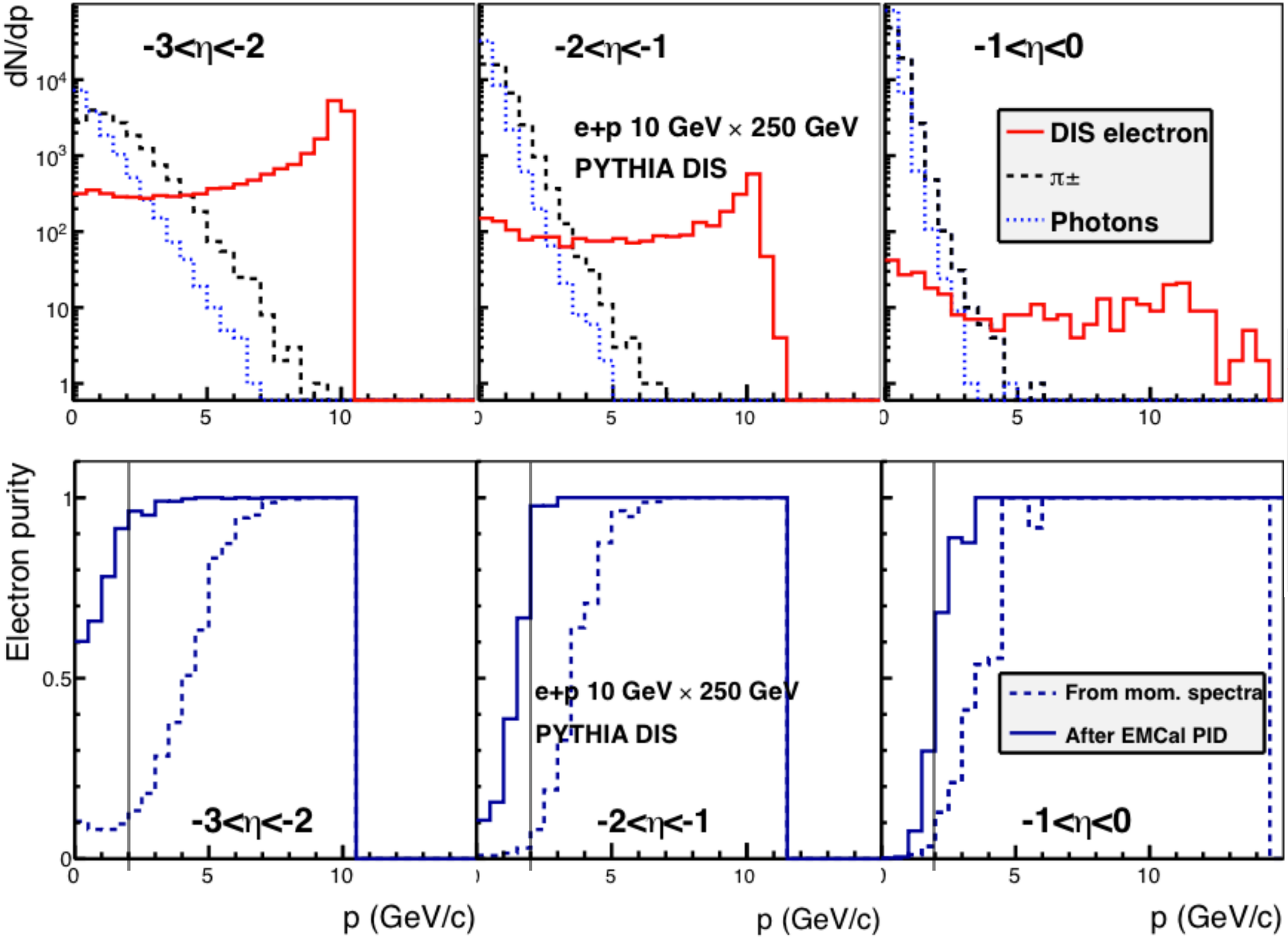
Hadron ID Performance for EIC

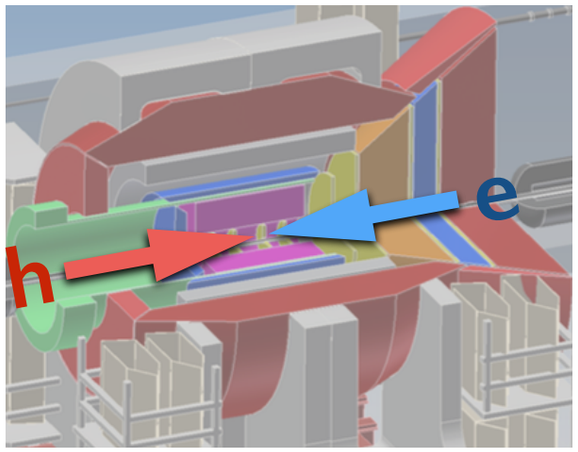


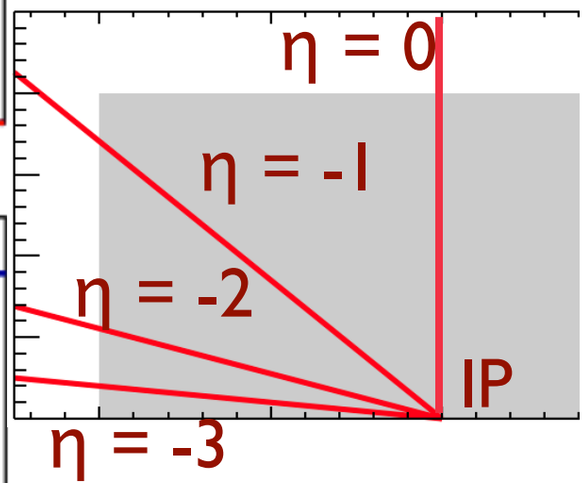
doi:10.1016/j.nima.2004.08.129



Electron ID via E/p matching







2 Calorimeter:

$\sigma_E/E = 1.5\%/\sqrt{E}$

$\sigma_E/E = 12\%/\sqrt{E}$

arXiv:1402.1209v1