Gluons with Charm: JLabFY2016-2017 LDRD Project

DETECTOR OVERVIEW OF THE JLAB EIC (JLEIC)

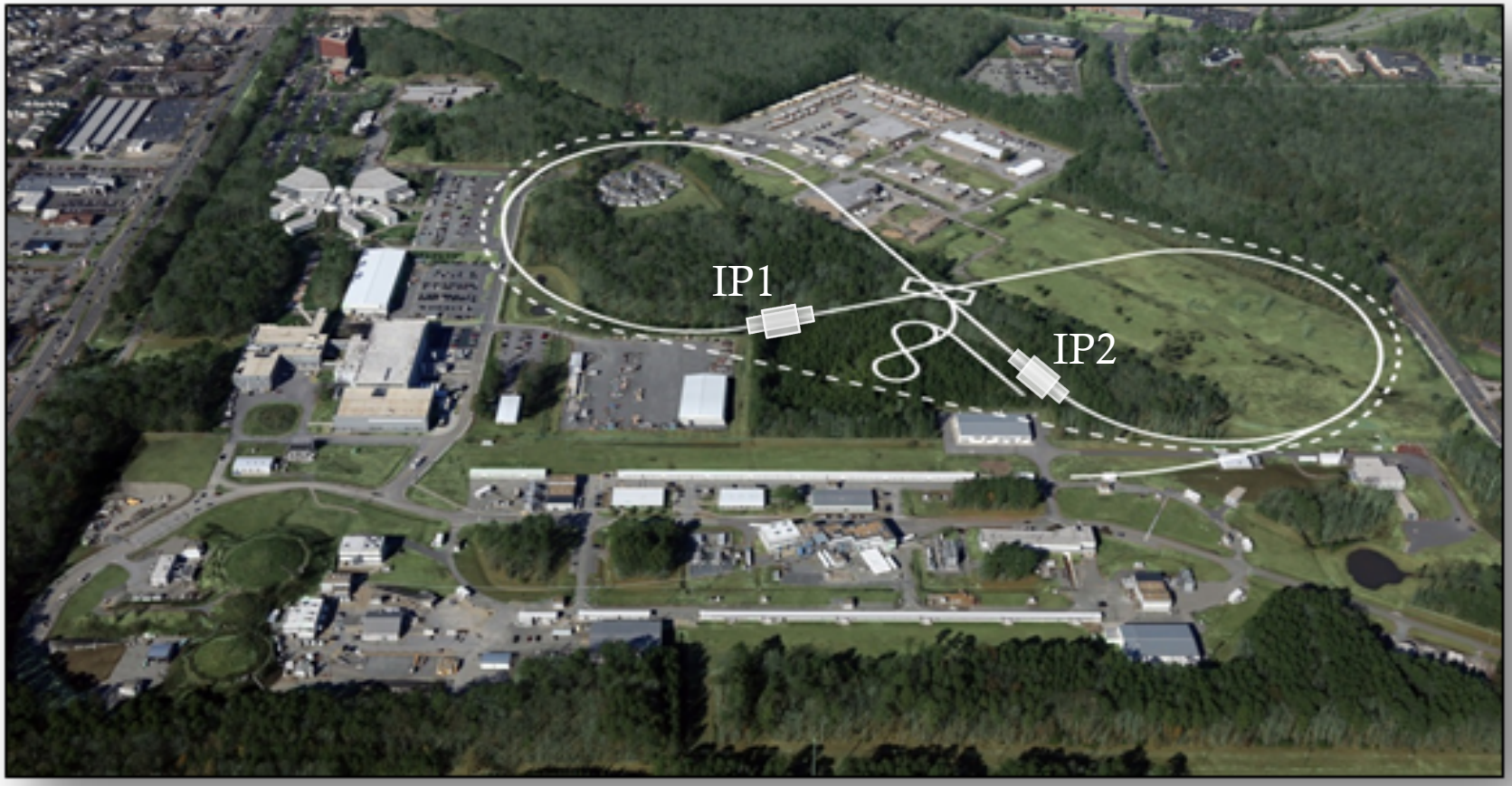
Charles Hyde

Old Dominion University

Norfolk VA, USA

20 Oct 2015

EIC@JLAB SITE PLAN



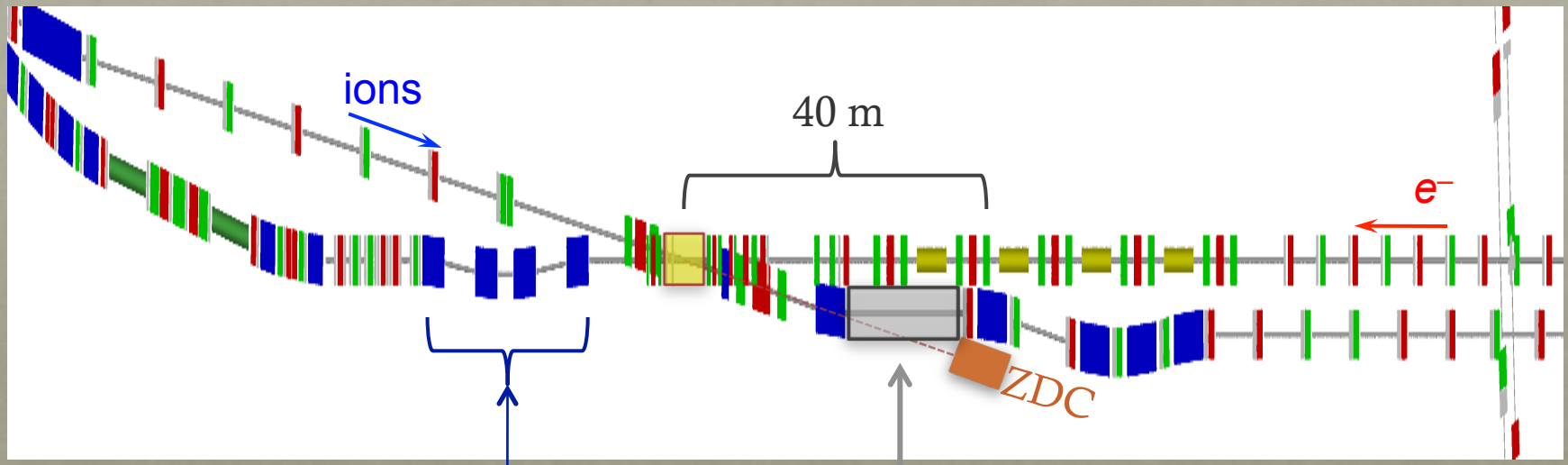
IP1: Full Acceptance Detector

IP2: Jets, ePHENIX Detector

Interaction Point Optics

- Horizontal Focus Quad
- Vertical Focus Quad
- Dipole;
- IP Solenoid/Central Detector

Figure-8 Crossing



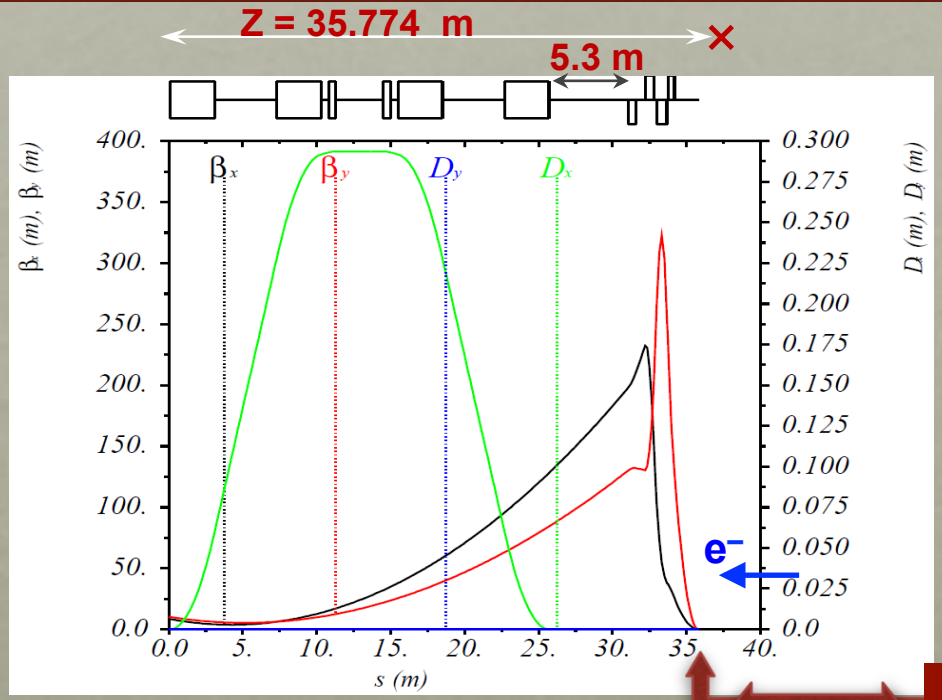
Compton Polarimeter Chicane & 0° e^- Tagger

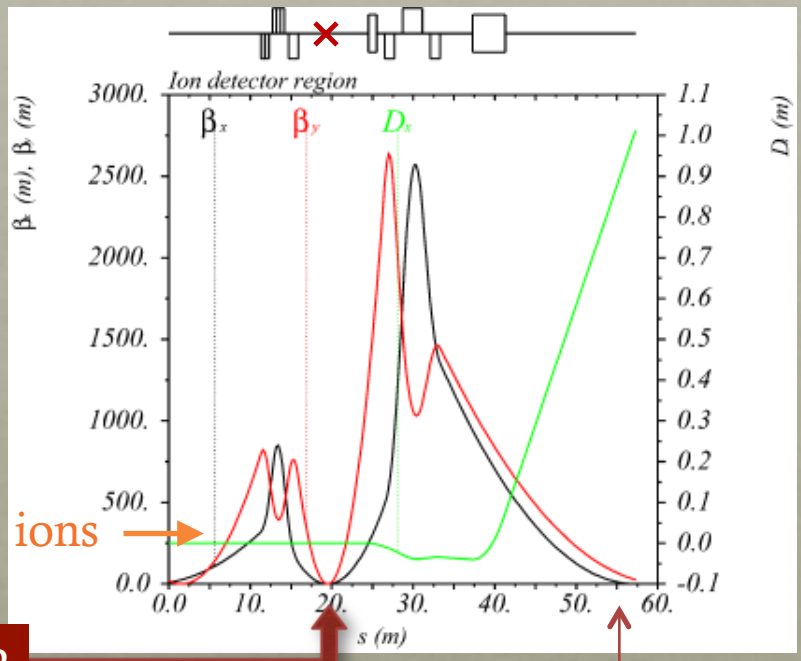
Far Forward Tracker:
- Exclusive Reactions,
- Projectile (Baryon) Fragments

FOLLOWING J. BJORKEN'S VISION:

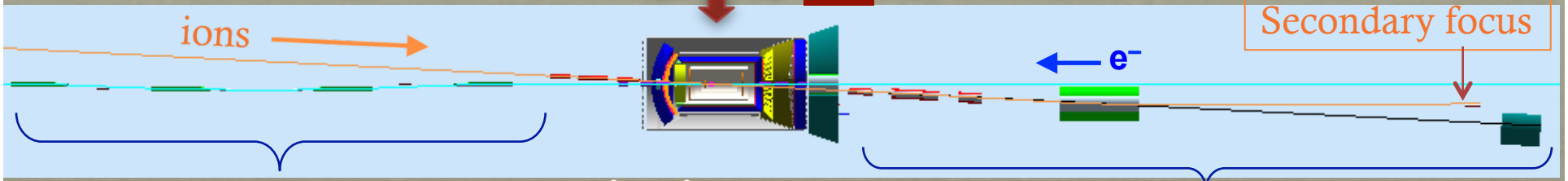
Full Coverage: ion rapidity to e^- rapidity

Uniform detector density per unit rapidity





IP



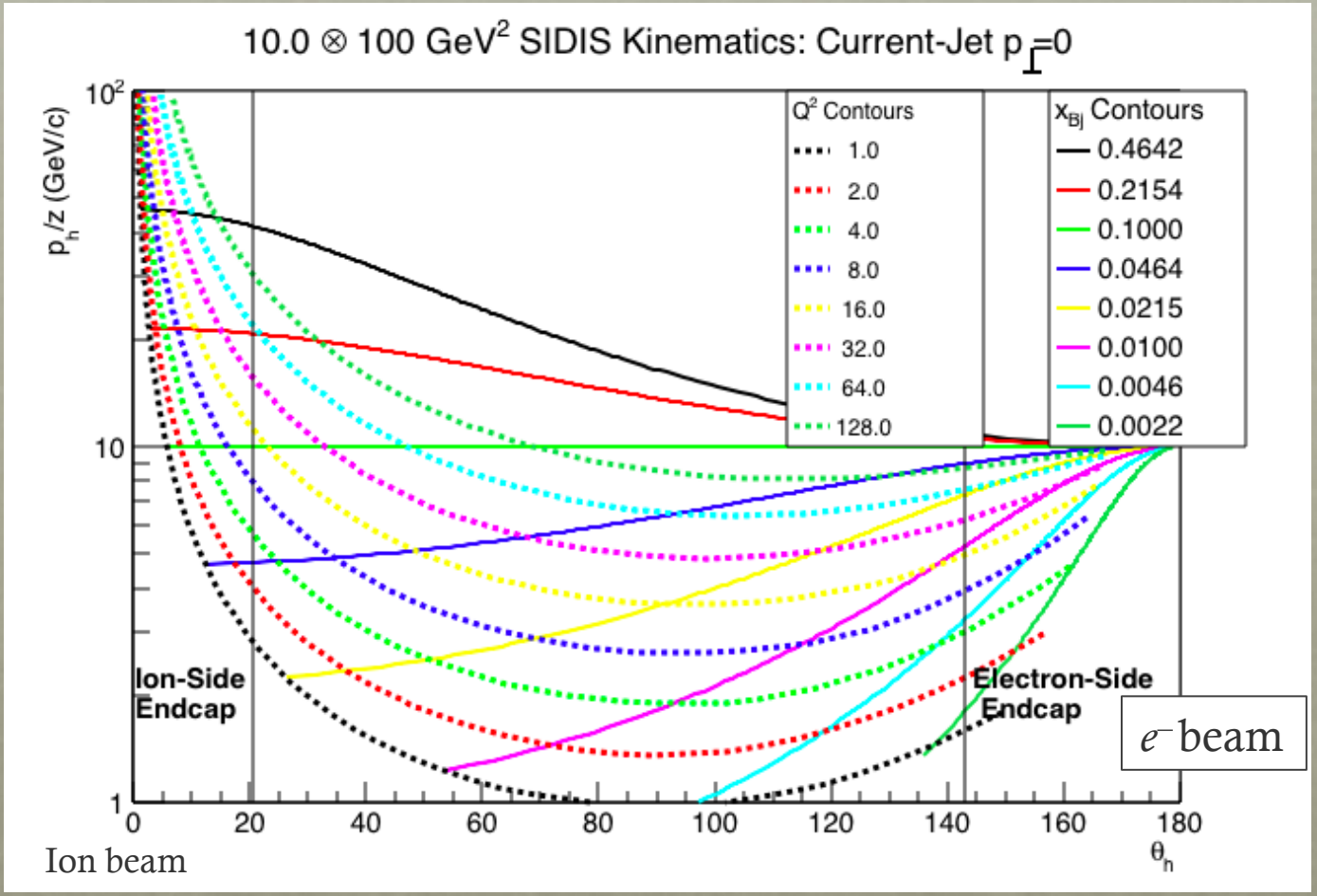
Compton Polarimeter Chicane, 0° e^- Tagger ($Q^2 \sim m_e^2$)
A.Camsonne, Friday: Future Facilities

Far-Forward Spectrometer
K.Park, Friday: Future Facilities

ZDC

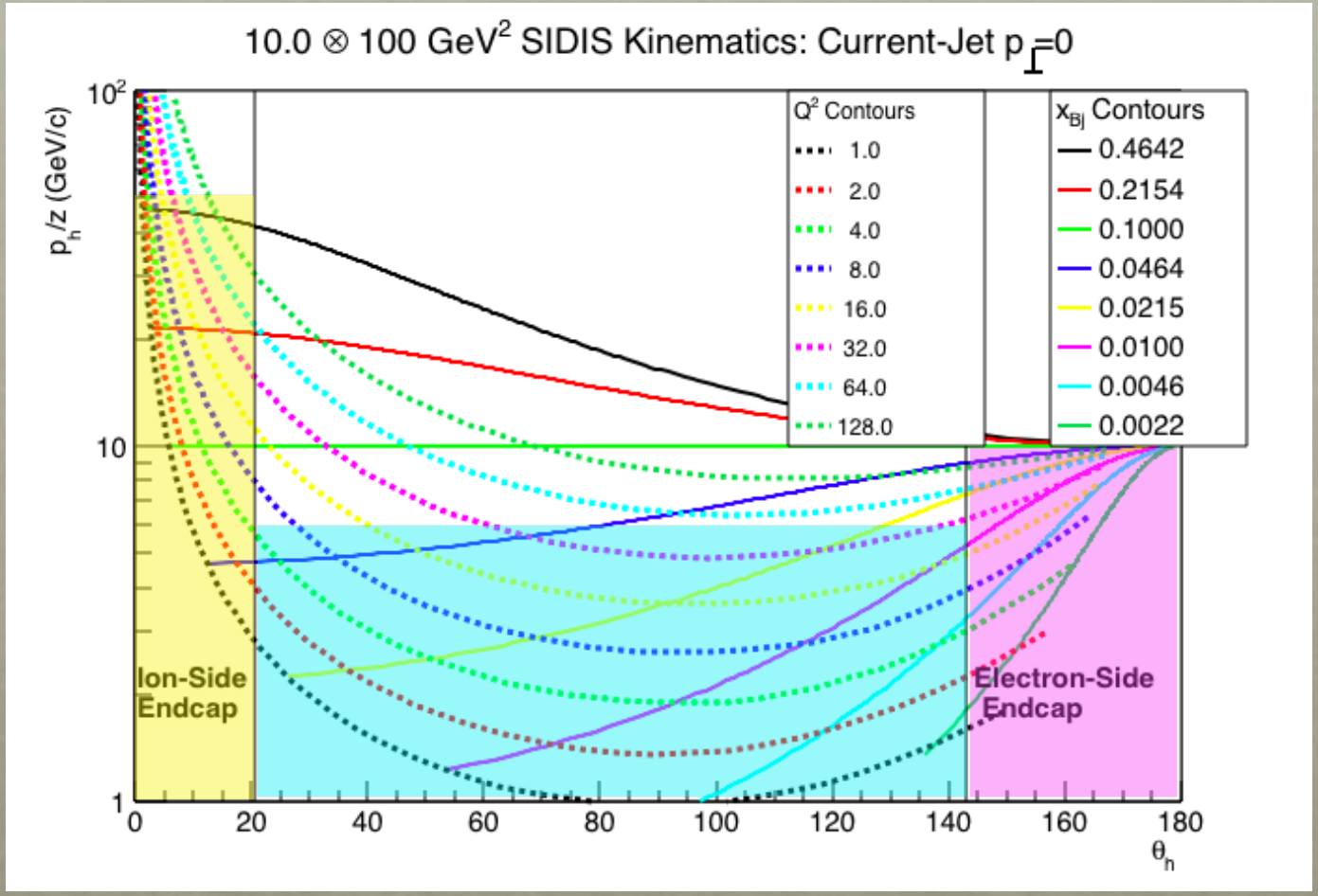
DIS HADRONIC KINEMATICS: $xP+q$

- Maximum hadron momentum *vs* hadron angle in contours of constant Q^2 or x_{Bj}
- Hadron momentum scales with *z*



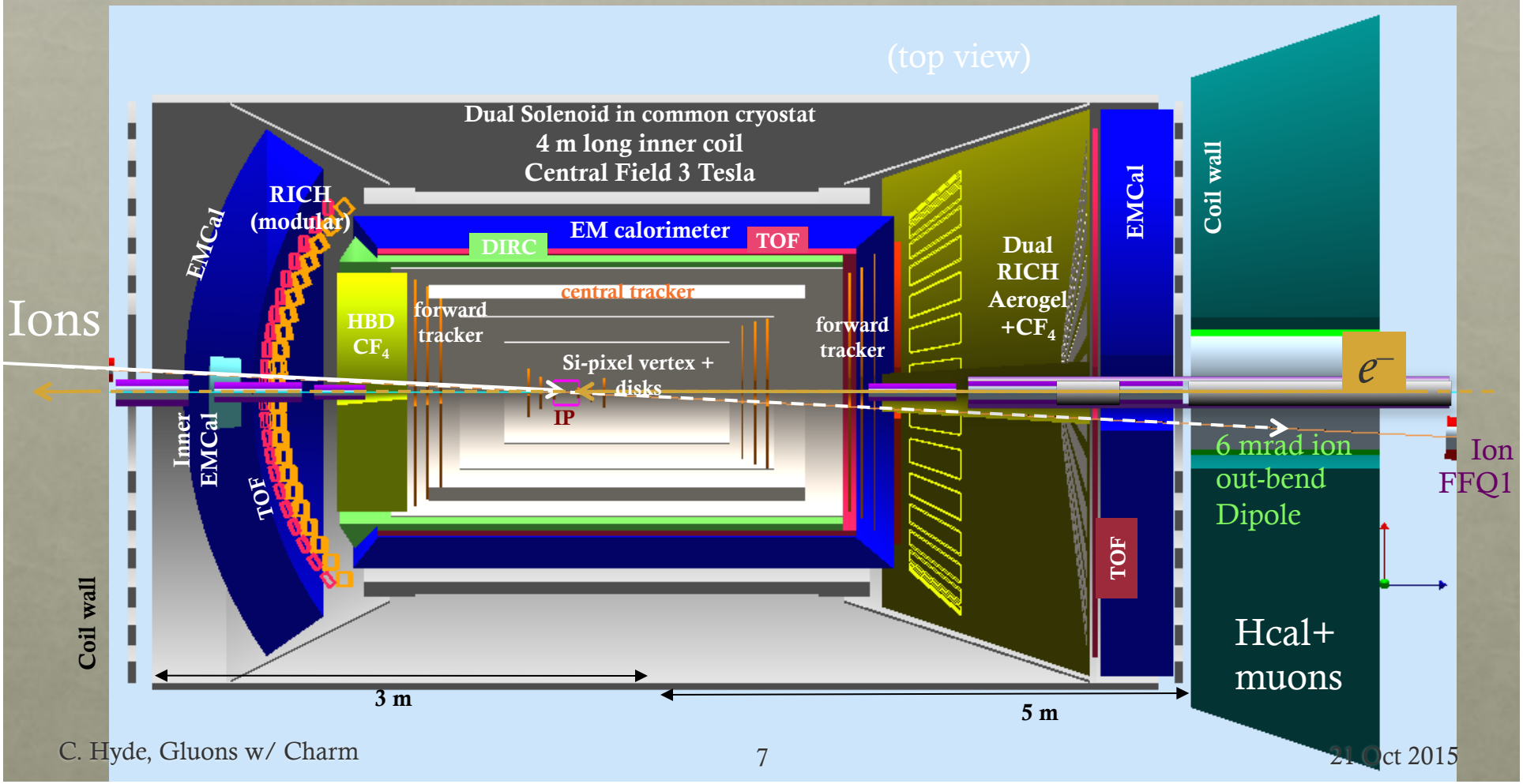
DIS HADRONIC KINEMATICS: $xP+q$

- Projected π/K PID.
- 2 decades in x_B, Q^2.
- Kinematic points outside PID region are accessible for $z < 1$.



MEIC CENTRAL DETECTOR
WITH DUAL SOLENOID MAGNET
(Geometrically compatible with 1.5 T CLEO Solenoid)

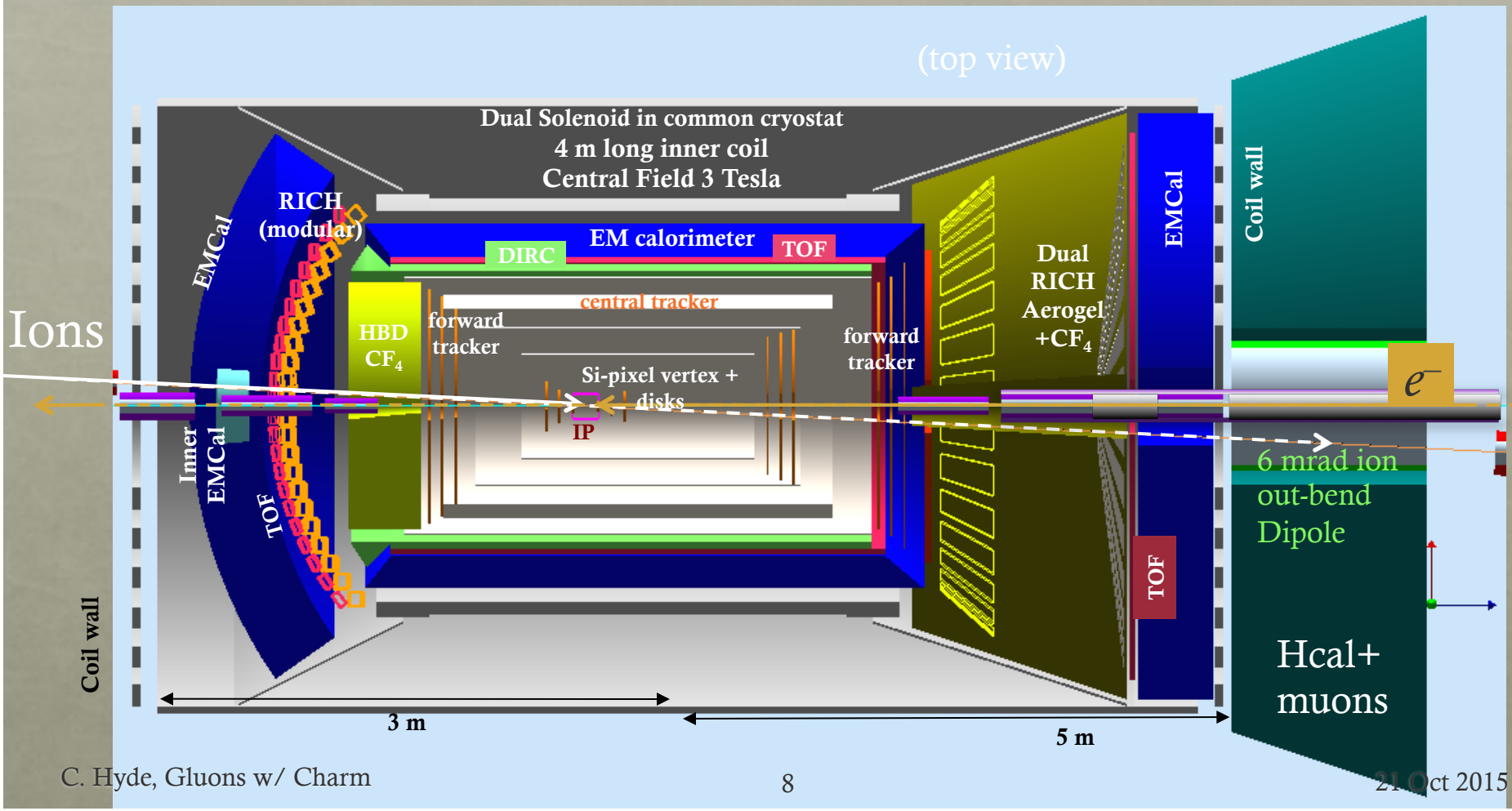
Electron End-Cap: •HBD (CF_4+UV-GEM) or TRD, •Aerogel RICH (Modular), •TOF(MRPC), •EMCal (Shashlyk+ inner $PbWO_4$)



MEIC CENTRAL DETECTOR
WITH DUAL SOLENOID MAGNET
(Geometrically compatible with 1.5 T CLEO Solenoid)

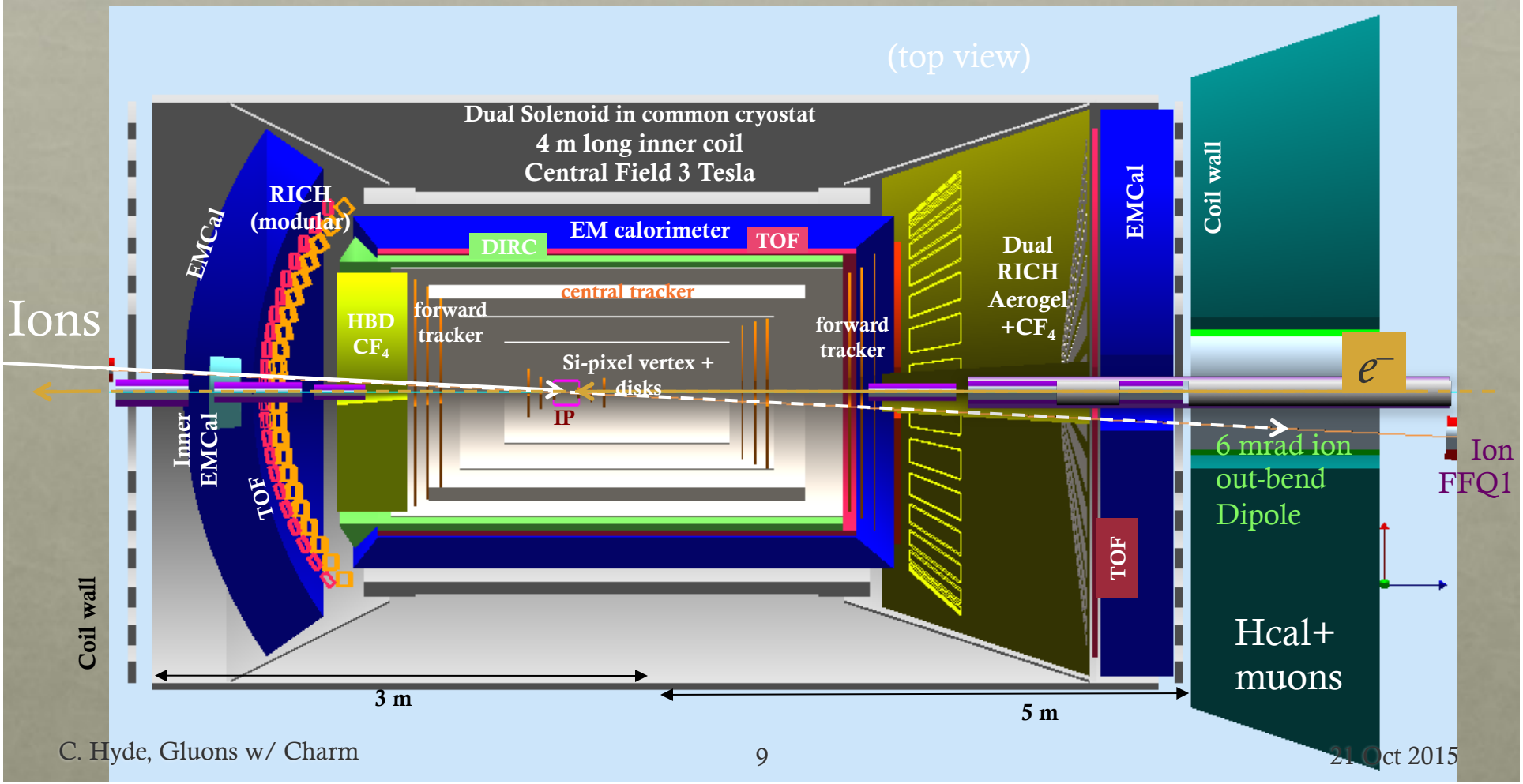
Barrel Region:

•DIRC (π,K,p to ≤6 GeV/c), •TOF(MRPC), •EMCal (W or Pb sampling)



MEIC CENTRAL DETECTOR
WITH DUAL SOLENOID MAGNET
(Ion End-Cap Detectors)

- Dual RICH: Aerogel + CF_4 (Out-focussing 1- or 2-bounce mirror)
- TOF(MRPC), •sampling EMCal, Hcal/Muon Tracker (CLEO)

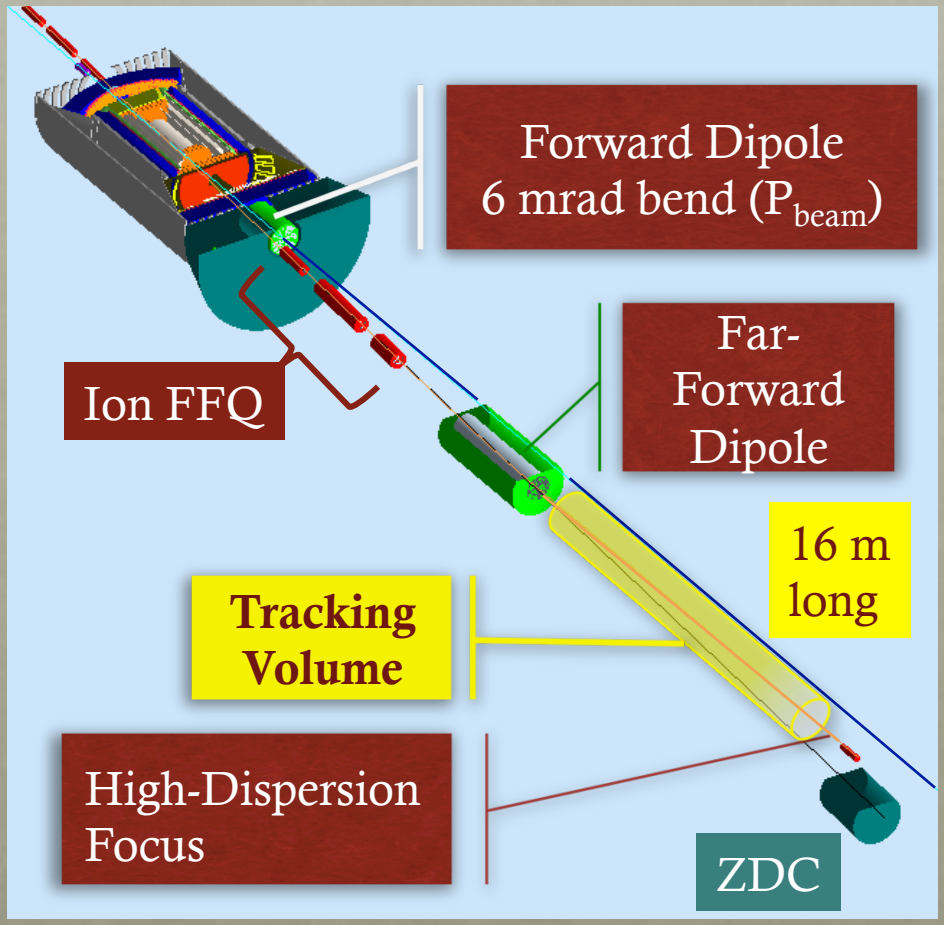


ION FORWARD AND FAR-FORWARD REGIONS

- **Forward Dipole (z=5.5m)**
  - **2 T-m (scaled to 100GeV/c proton)**
    - **Flux exclusion for *e*-Beam**
  - **Acceptance $25 < \theta \leq 80$ mr (relative to electron axis)**
  - **> 50cm Tracking space after magnet**
- **FFQ triplet acceptance:**
  - **$\pm$ 10 mr horiz, $\pm$14 mr vert, for $|\Delta p/p| \leq 0.5$**
  - **25 mrad cone (full opening) line-of sight to ZDC**
- **High Dispersion Focus @36m**
  - **Full Acceptance:**

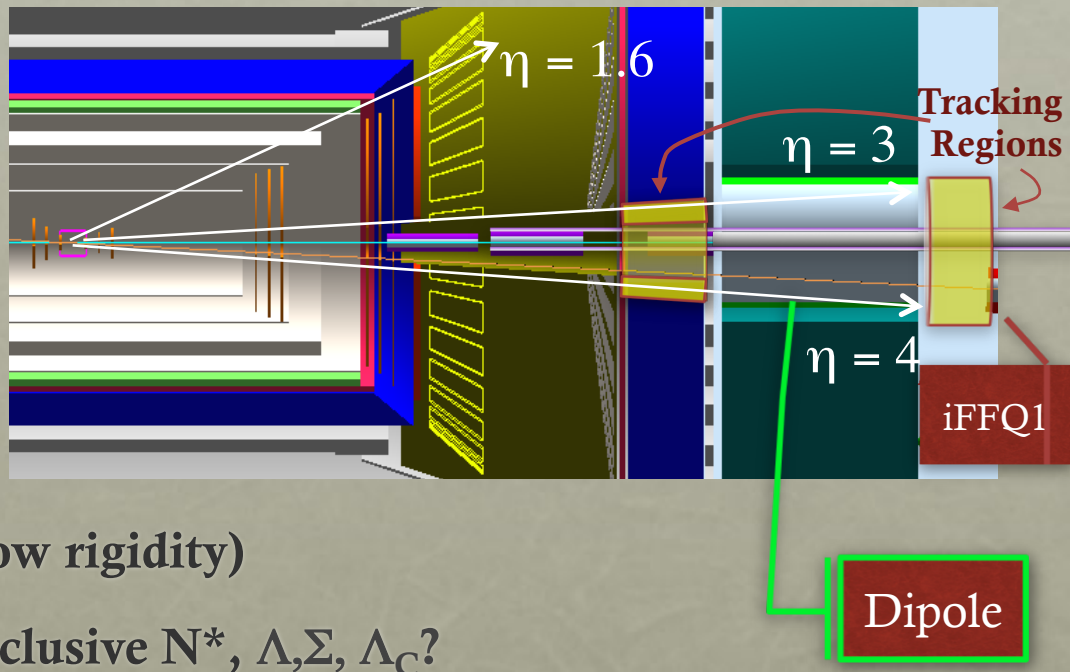
    $0.5 > |\Delta P/P| > 0.005$

    or $\theta_{IP} > 4$ mrad

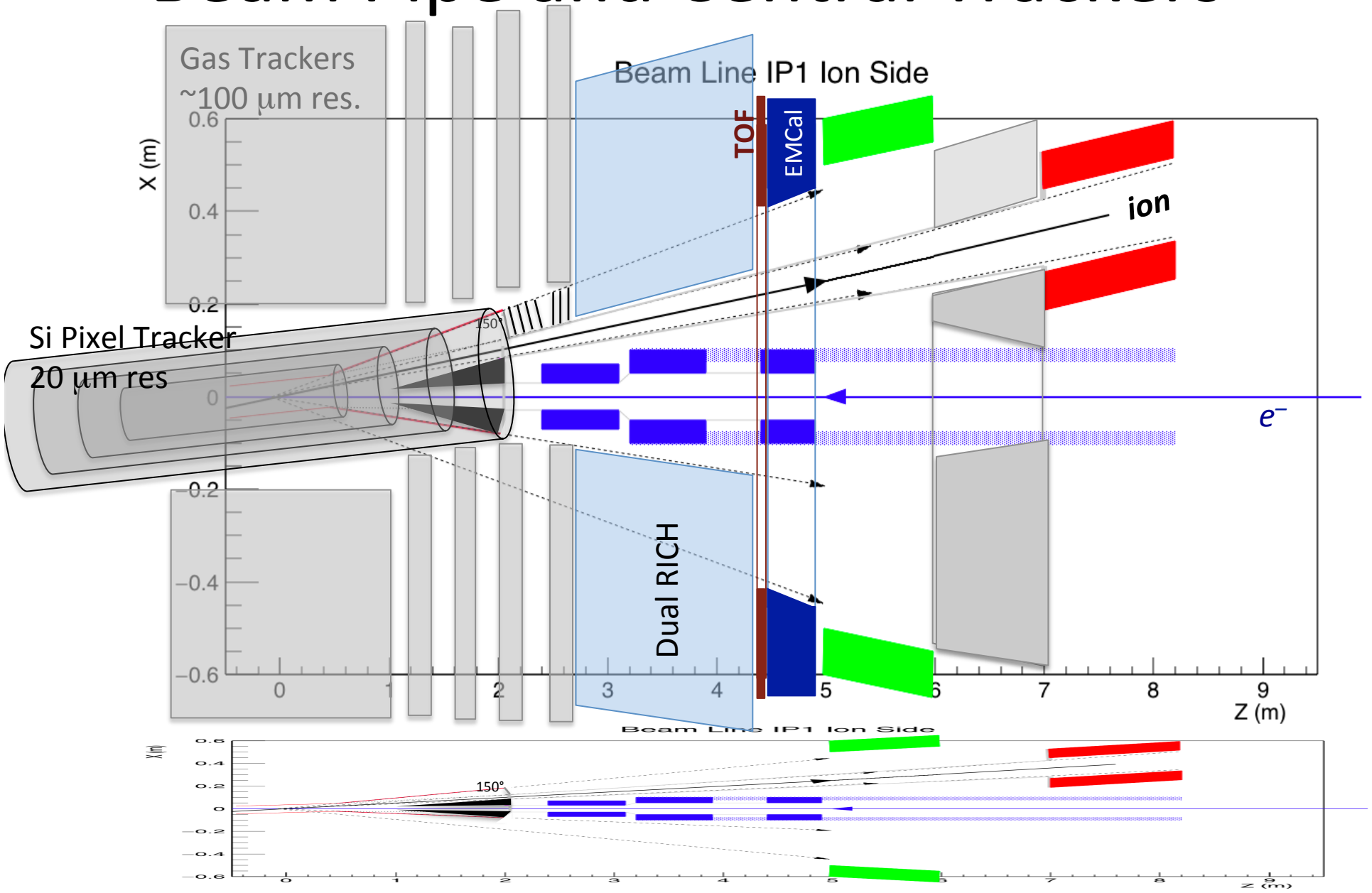


END-CAP & FORWARD REGIONS

- 2 Tesla-m Dipole (z=5.5m)
  - (*cf.* For θ < 80 mrad, Solenoid Bdl < 0.6 T-m)
  - Acceptance ± 90 mrad (relative to electron) (+40, –140 mrad to ion)
- Full Reconstruction of Projectile Fragmentation
  - High-P_T , and/or small $-x_F$ (low rigidity)
  - $3.5 < \eta < 5$
  - Mesons from decay of near exclusive N*, Λ,Σ, Λ_C?
- NN correlations in heavy nuclei
  - $P_T/P_{||}$ < (1 GeV/c)/(40 GeV/c) = 25 mrad relative to ion-beam < 75 mrad relative to electron axis



Beam Pipe and Central Trackers

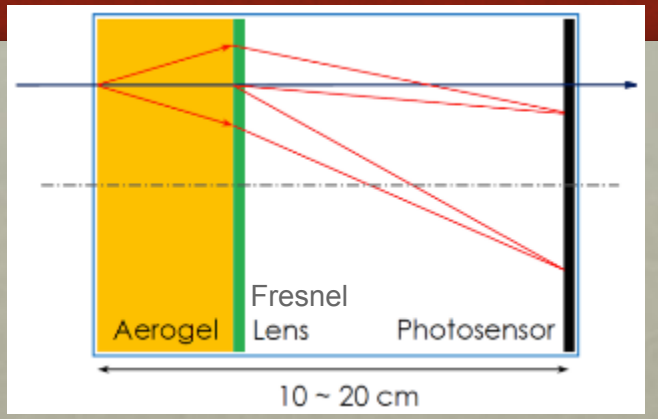


DETECTOR SUBSYSTEMS

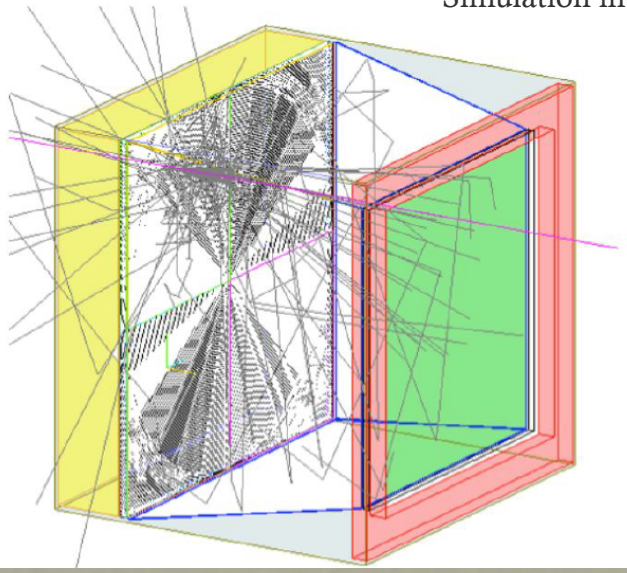
AND R&D EFFORTS

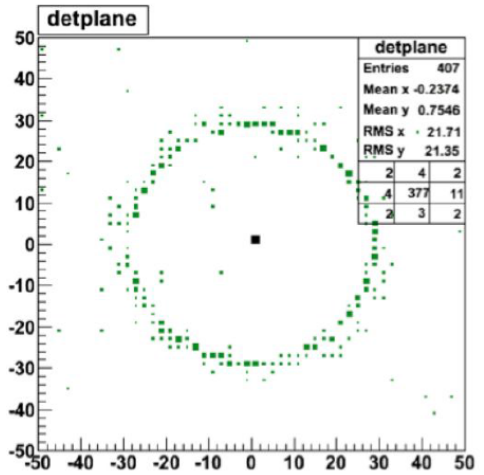
MODULAR RICH

Conceptual Design



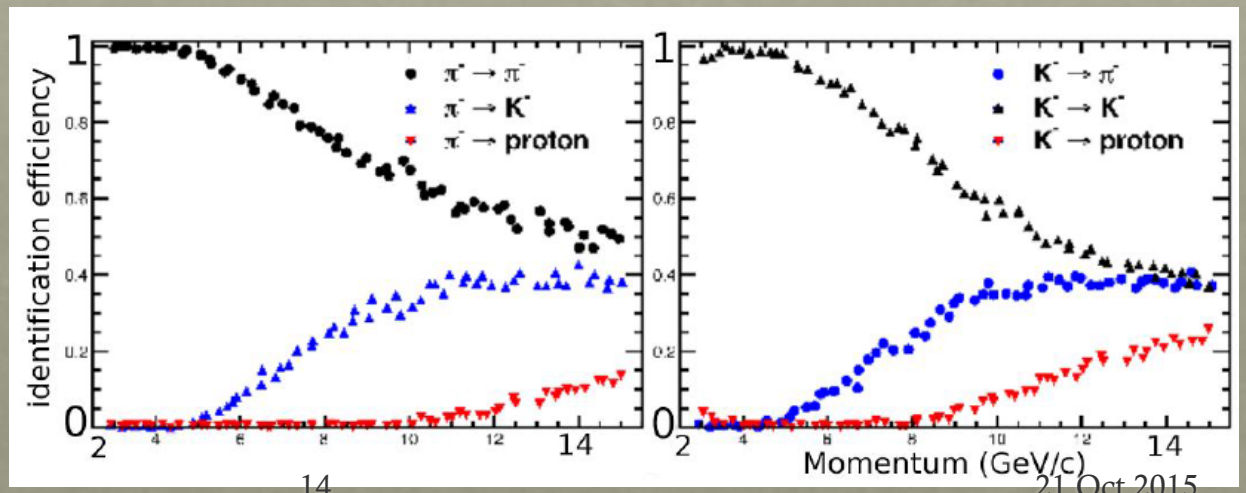
Simulation in **GEMC**





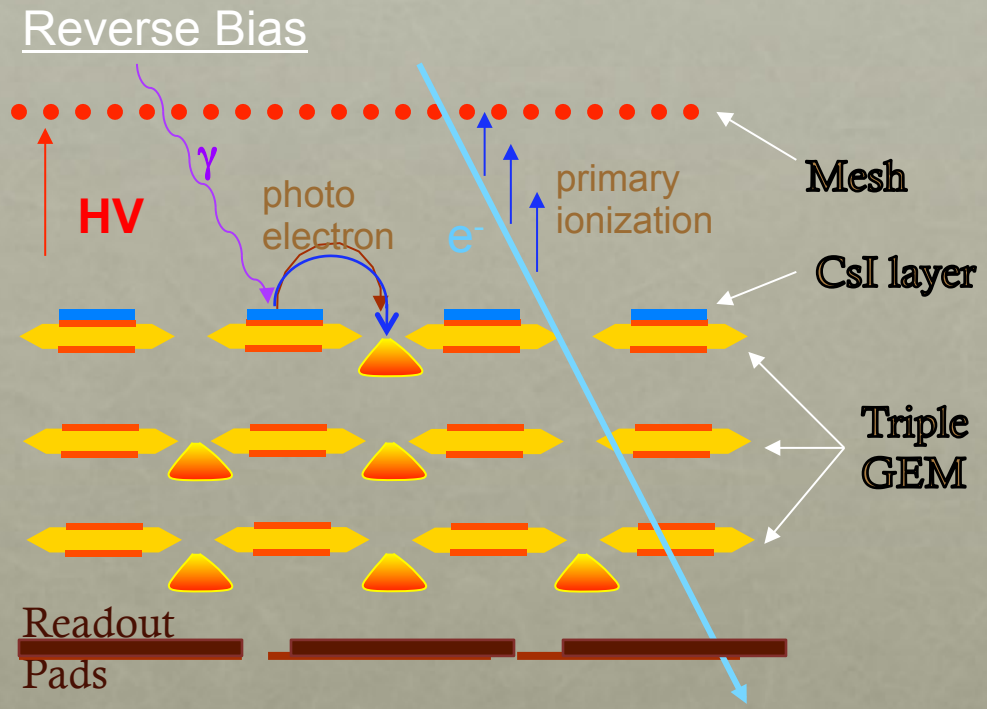
- Compact π/k PID
  $p \leq 10$ GeV/c
- Flexible arrangement, can be projective to IP

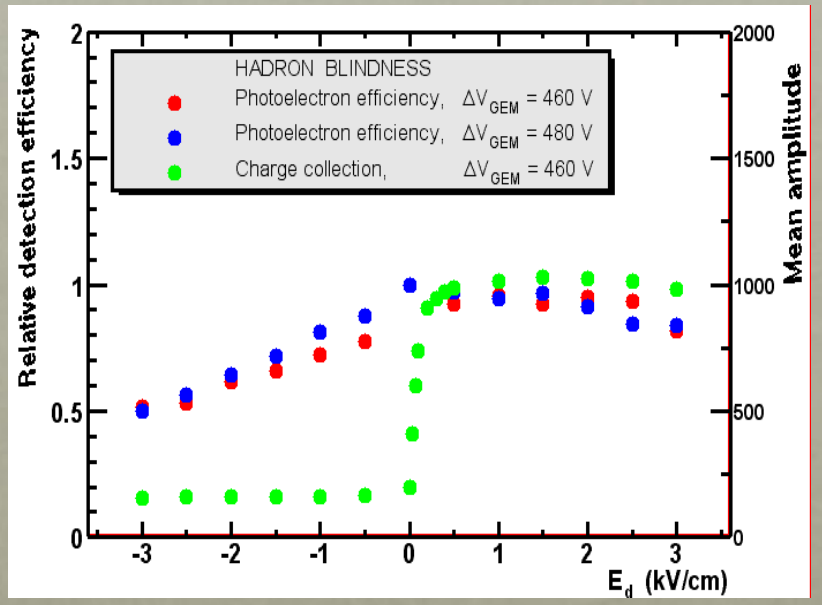
Final performance simulation : Efficiency and mis-ID VS momentum



EIC R&D eRD11

HADRON BLIND DETECTOR(HBD)



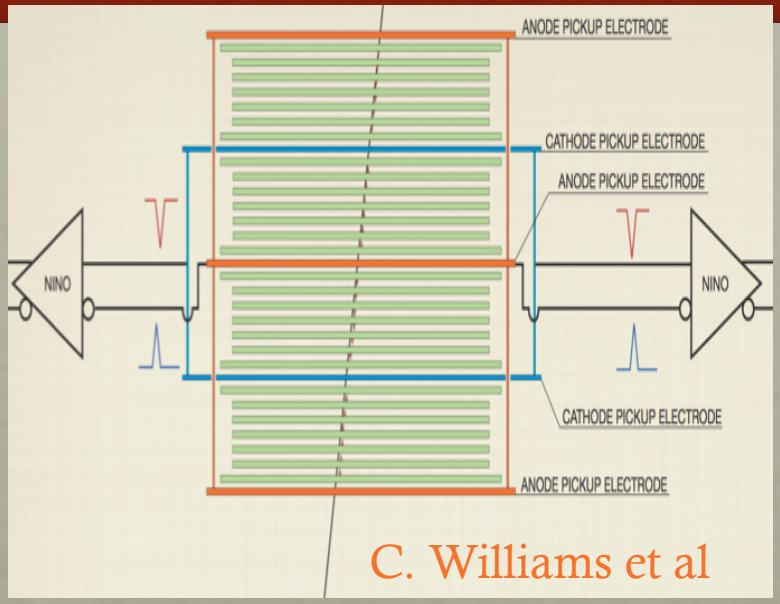


- compact e/π PID detector
- Blind to hadron <4GeV with CF_4 gas at PHENIX

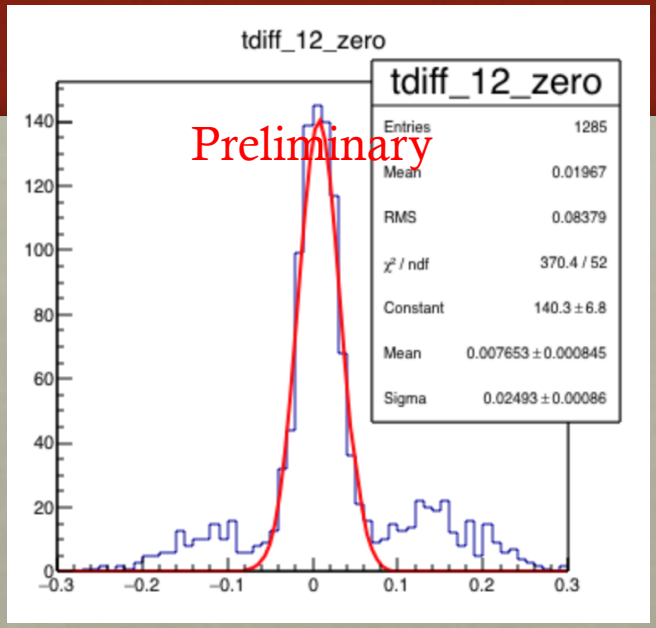
Tom Hemmick

TOF (MRPC)

mRPC TOF



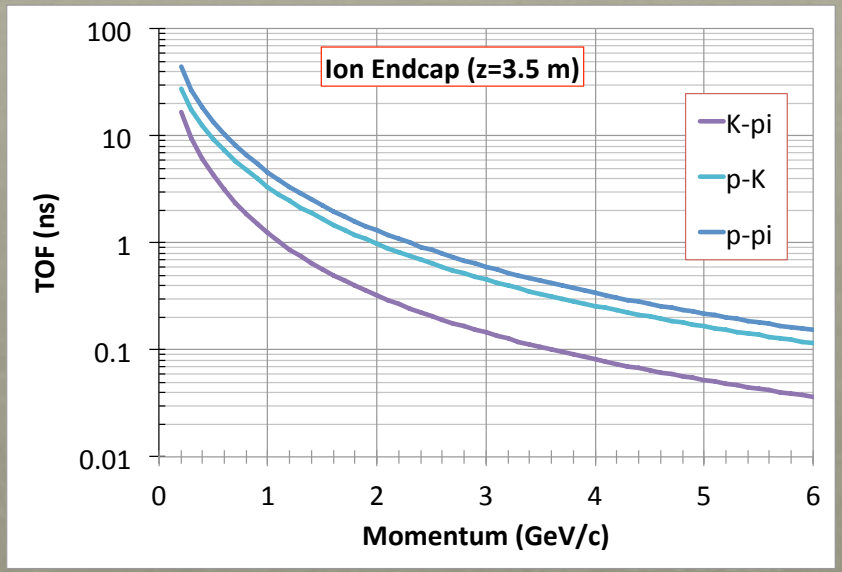
C. Williams et al



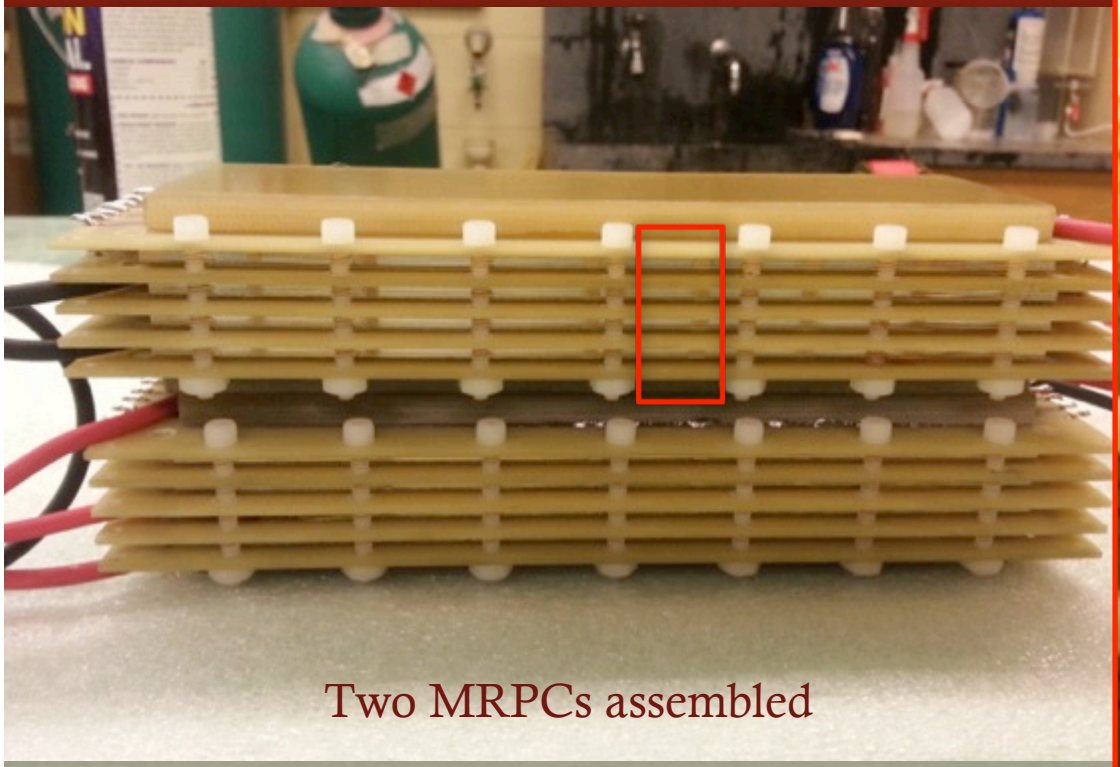
$\Delta t = t_2 - t_1$
$= 25$ ps
$\sigma_t = \Delta t/\sqrt{2}$
$= 18$ ps

EIC R&D
UIUC
eRD14

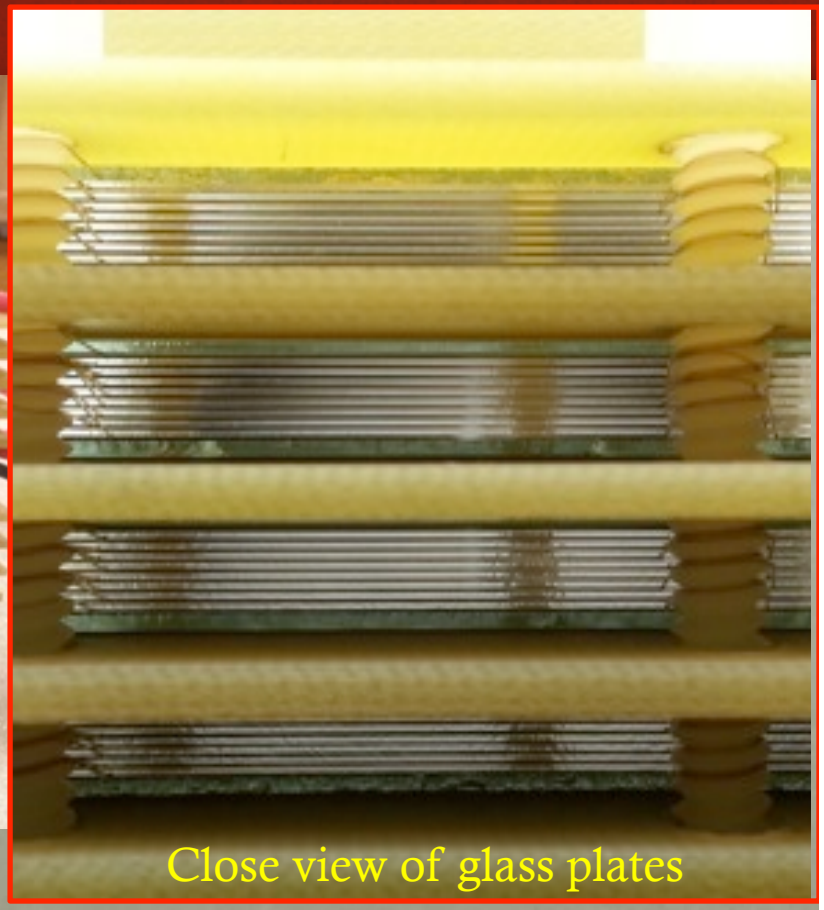
- compact PID detector
- Flexible arrangement, can be projective to IP and at barrel



MRPC PROTOTYPES ASSEMBLED

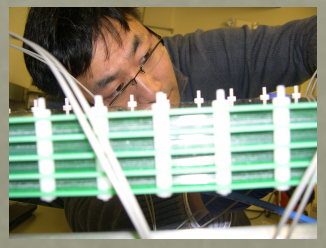


Two MRPCs assembled



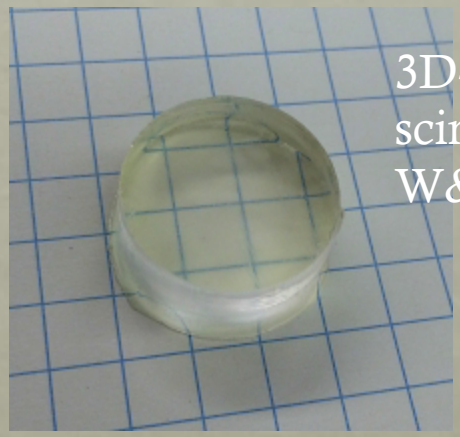
Close view of glass plates

All done at UIUC by eRD10 post-doc Ihnjea Choi

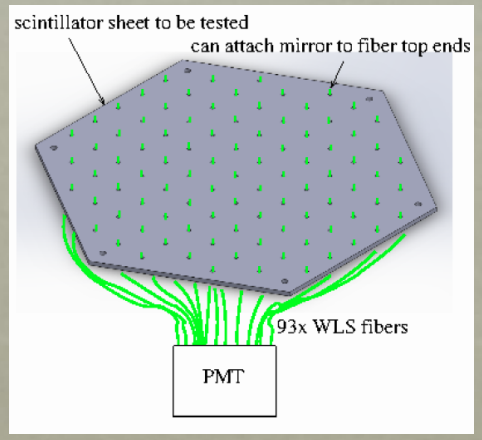


EMCAL (SHASHLIK+CRYSTAL)

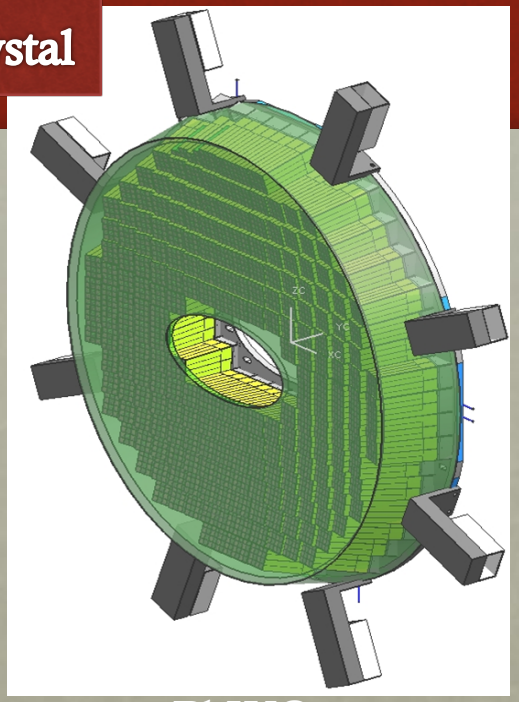
IHEP, COMPASS Shashlik, 2010



3D-printed scintillator at W&M



Panda Crystal endcap



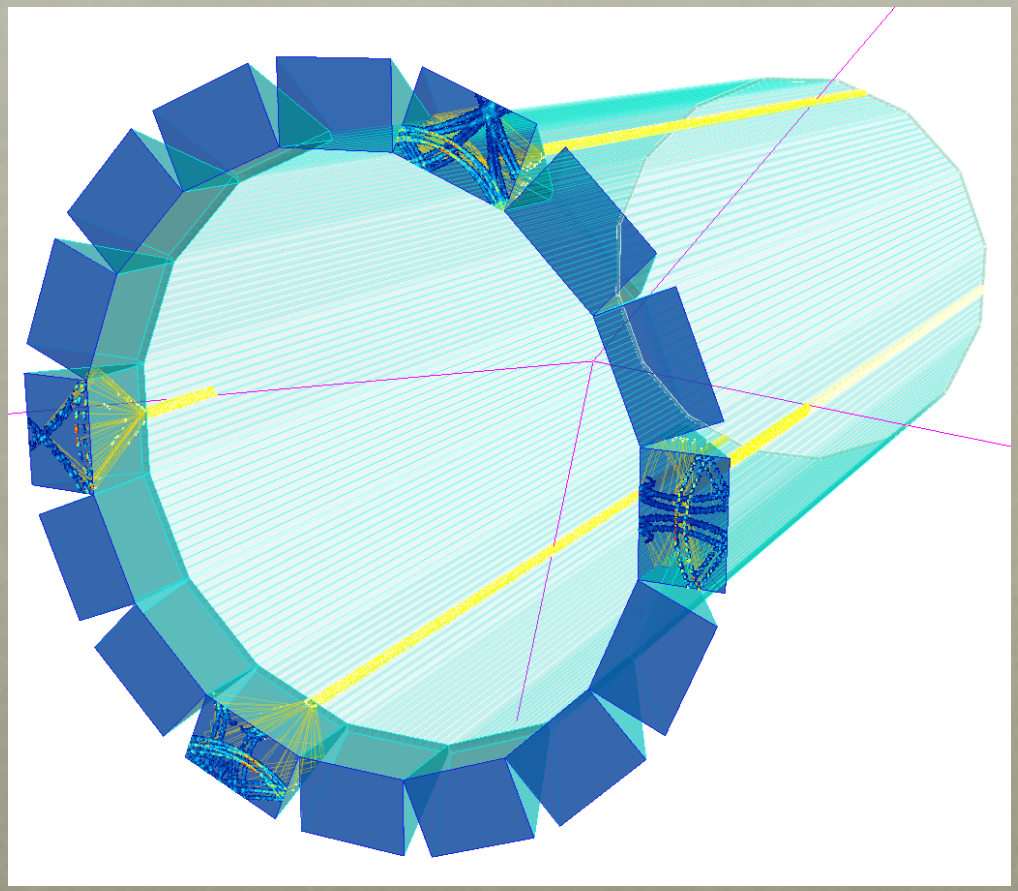
$PbWO_4$

- **Projective can help PID performance**

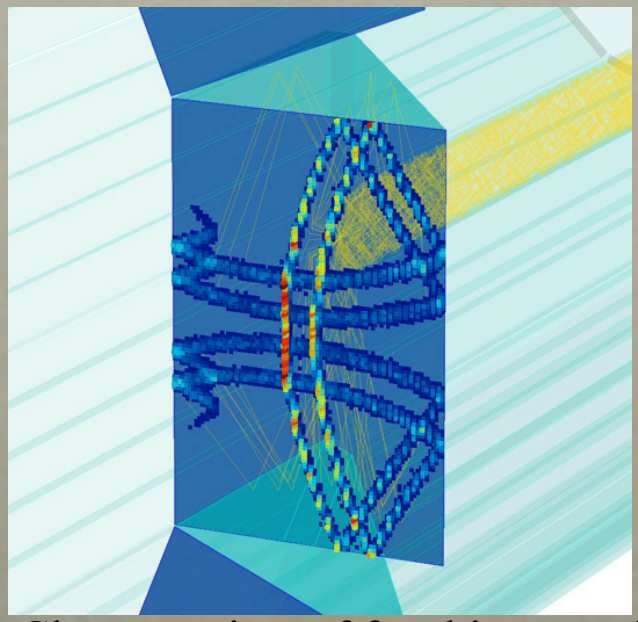
- **Crystal calo near 180° (electron endcap) compensates lower tracking resolution**
- **Working with Crytur and SICCAS to qualify $PbWO_4$ production**

EIC R&D eRD14

GEANT4 DIRC Simulation: Narrow radiator bars grouped to common prism/photosensor array

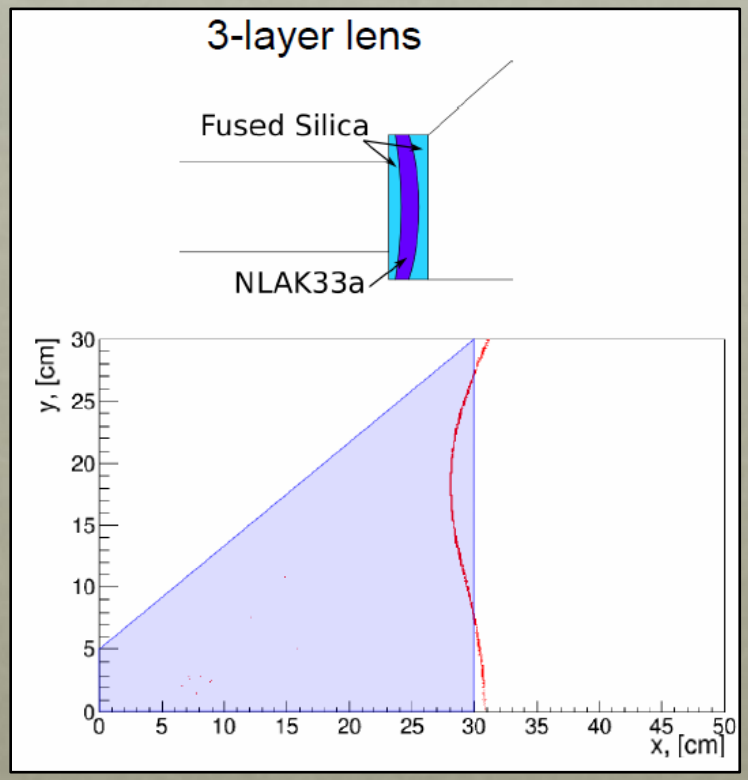


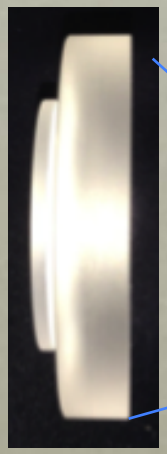
- Standalone Geant4 simulation
  - Developed at GSI
  - Installed at JLab
  - Can be integrated with various frameworks (GEMC, eicROOT)

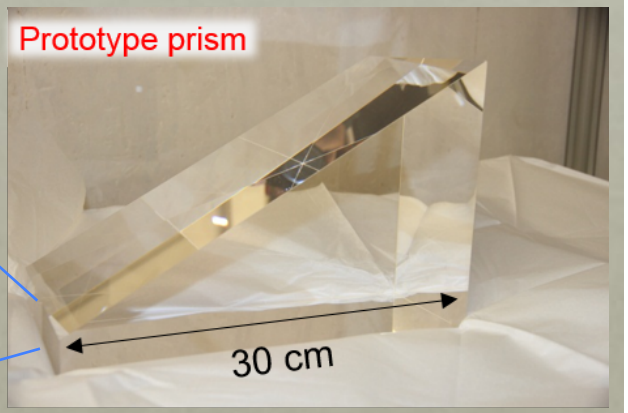


- Close-up view of focal image with spherical 3-layer lens (no air gap)

DIRC imaging: 3-Layer spherical Lens with Flat Focal Plane

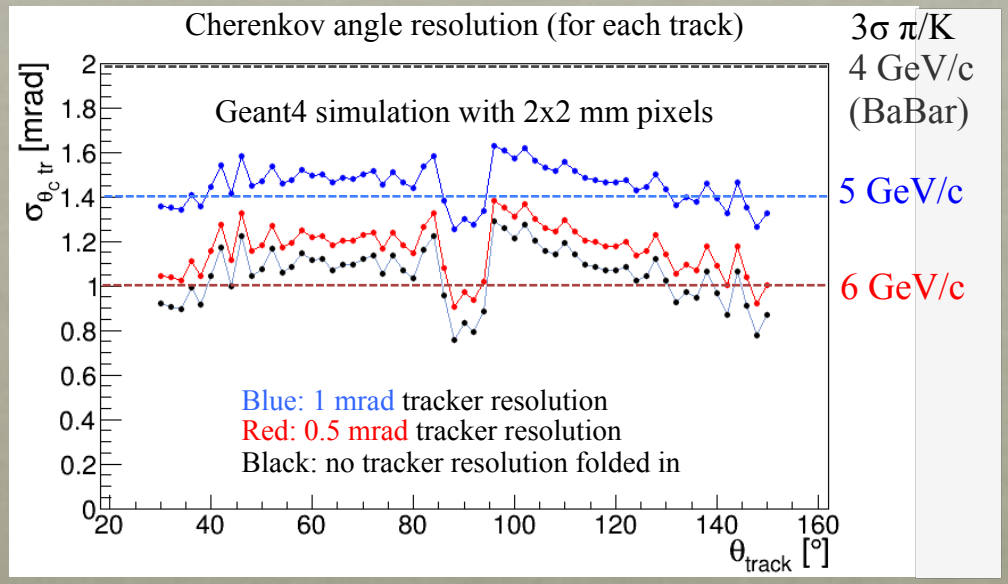






- The prototype lens was matched to the existing GSI prototype prism
  - The focal plane can canted to align the sensors with perpendicular to the B-field.
- In the simulation, a wider prism is used, covering an entire bar box

FULL SYSTEM DIRC CHERENKOV ANGLE RECONSTRUCTION



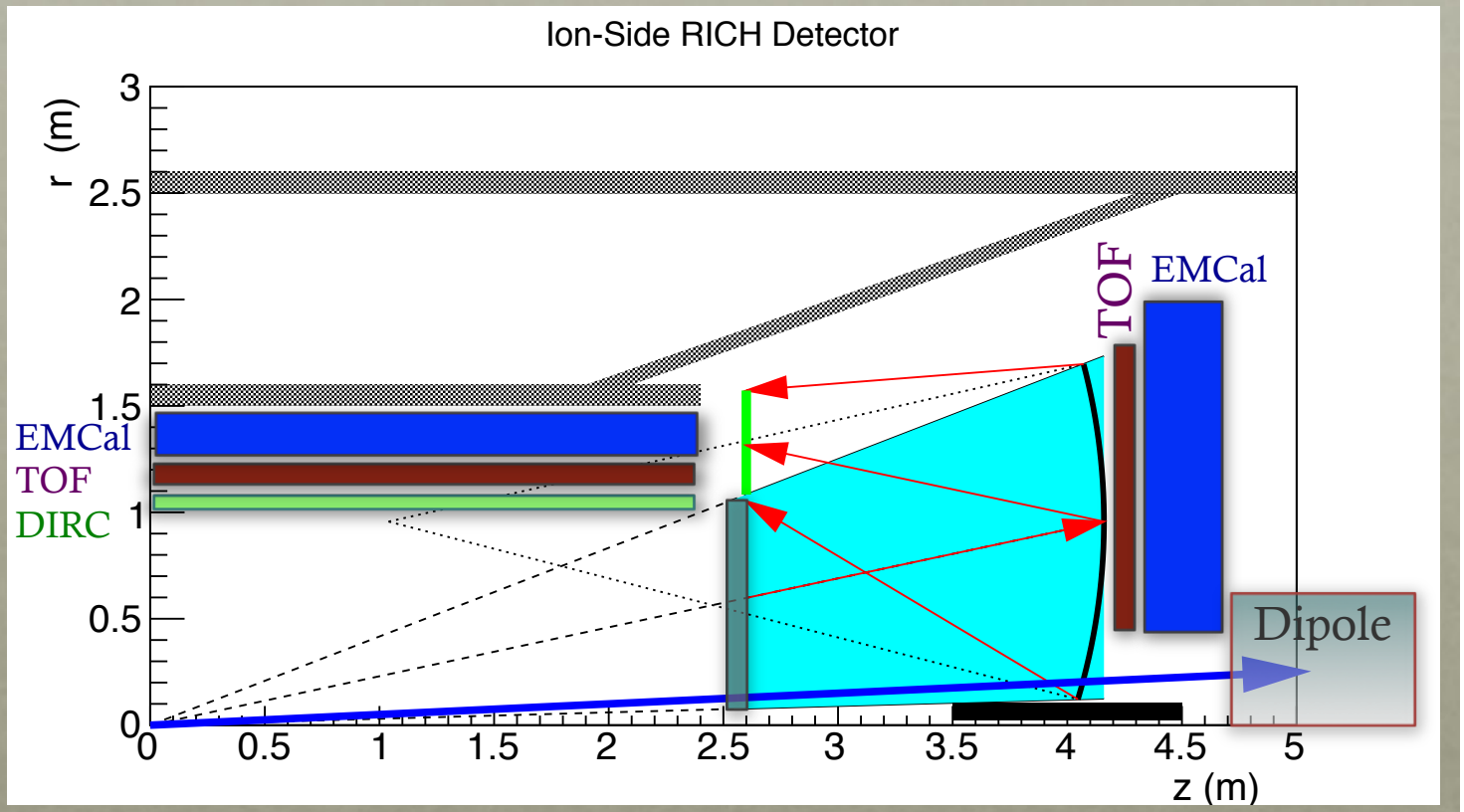
- The per-track resolution *vs* track polar angle, for three assumptions of track incidence angular resolution.

- With a tracker angular resolution of 0.5-1.0 mrad and a sensor pixel size of 2-3 mm, the lens-based EIC DIRC will reach Cherenkov angle resolution close to 1 mrad corresponding to a 3σ π/K separation up to 6 GeV/c.

EIC R&D Milestone reached: The feasibility of a high-performance EIC DIRC has been demonstrated and using a compact readout "camera."

SINGLE BOUNCE DUAL RICH:

- **Aerogel with Fresnel lens ~75 cm focal length: image at focal point of mirror (also filter UV)**
- **CF_4 gas (visible + UV)**
- **2nd mirror to place photo sensors in weaker field?**



In contrast, ePHENIX and BEAST concept have in-focussing mirrors