The Status of the EIC

An Unique General-Purpose Facility & Detector

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New Opportunities for Beyond-the-Standard Model Searches at the EIC

CFNS, SBU

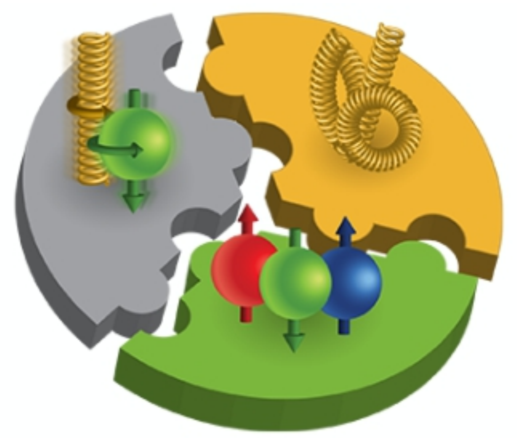
July 21, 2025

Brookhaven National Laboratory

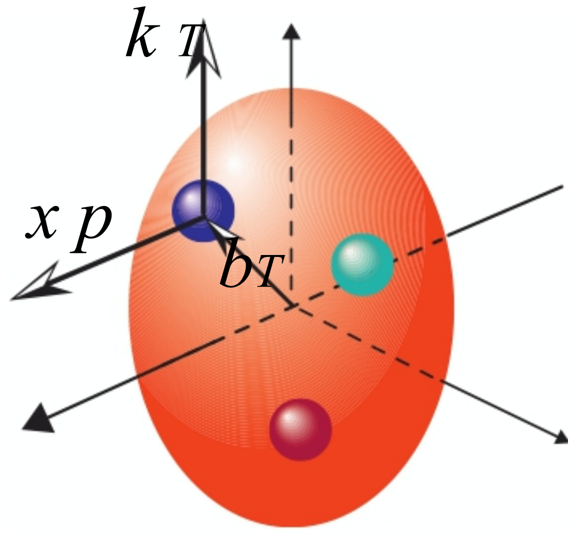
EIC Physics (= QCD Physics)

Investigate with precision the universal dynamics of gluons to understand the emergence of hadronic and nuclear matter and their properties

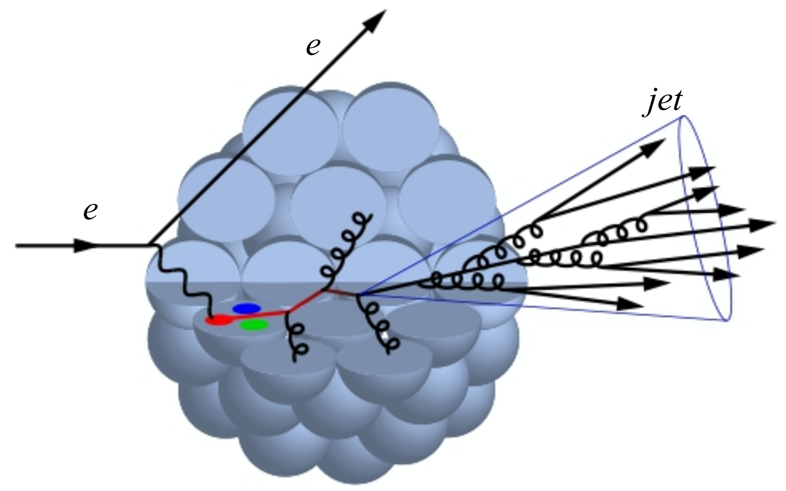
Central Questions:



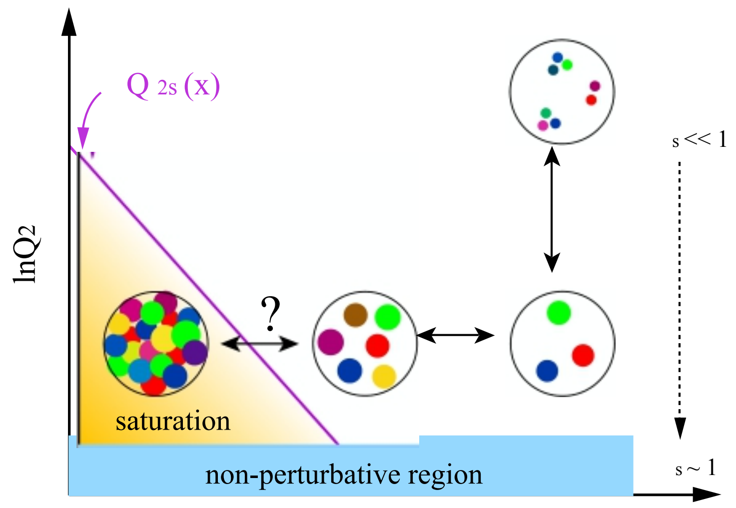
- How are sea quarks and gluons, and their spins, distributed in space and momentum inside the nucleon? How do the nucleon properties emerge from them and their interactions?



- How do color-charged quarks and gluons, and colorless jets, interact with a nuclear medium? How do confined hadronic states emerge from these quarks and gluons?

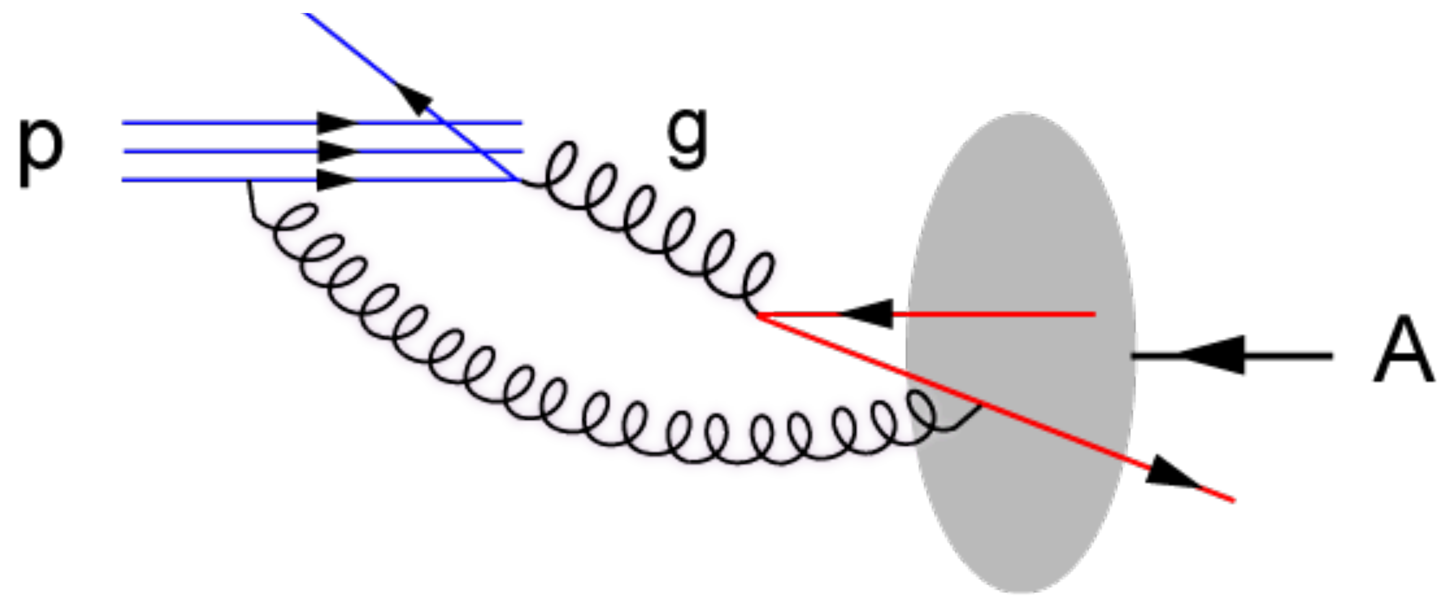


- What happens to the exploding gluon density at low-x in hadronic matter? Does it saturate at high energy, giving rise to a gluonic matter with universal properties?



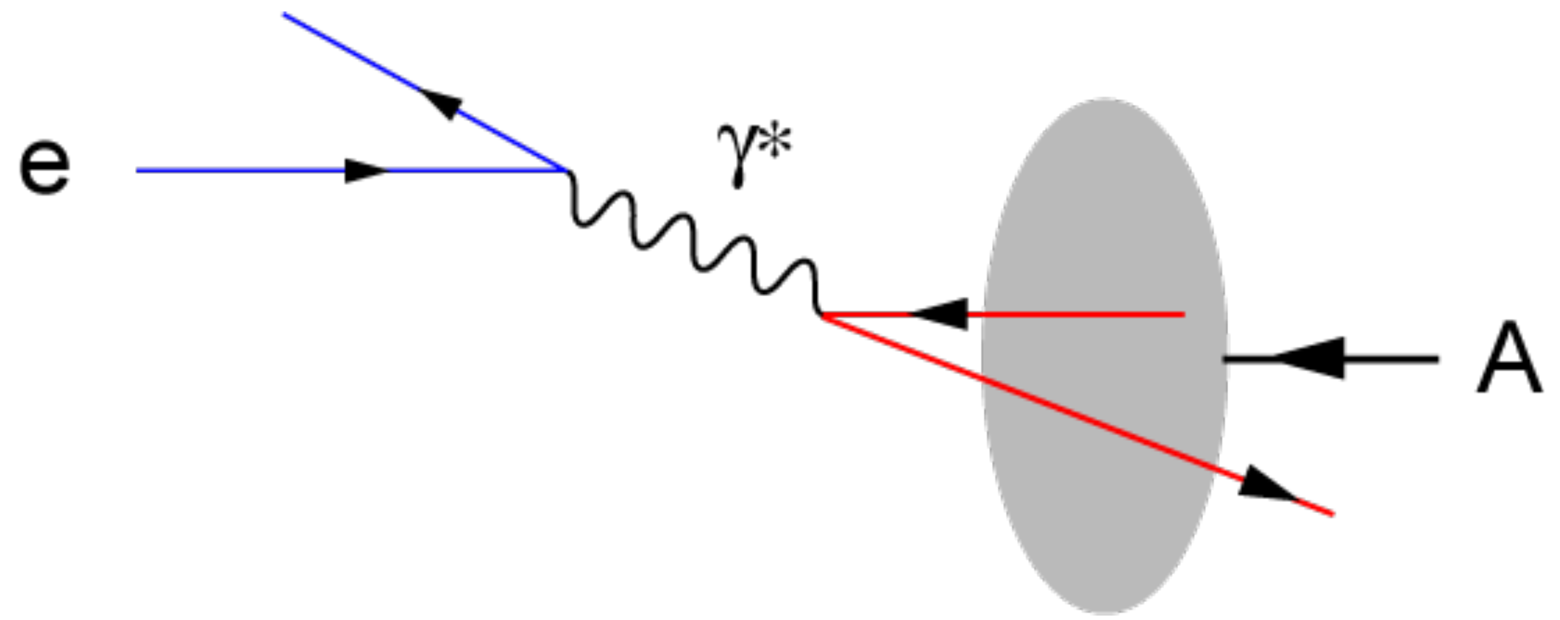
What Can Provide Answers?

Hadron-Hadron



- Test QCD
- Probe/Target interaction directly via gluons
- lacks the direct access to x, Q^2

Electron-Hadron (DIS)



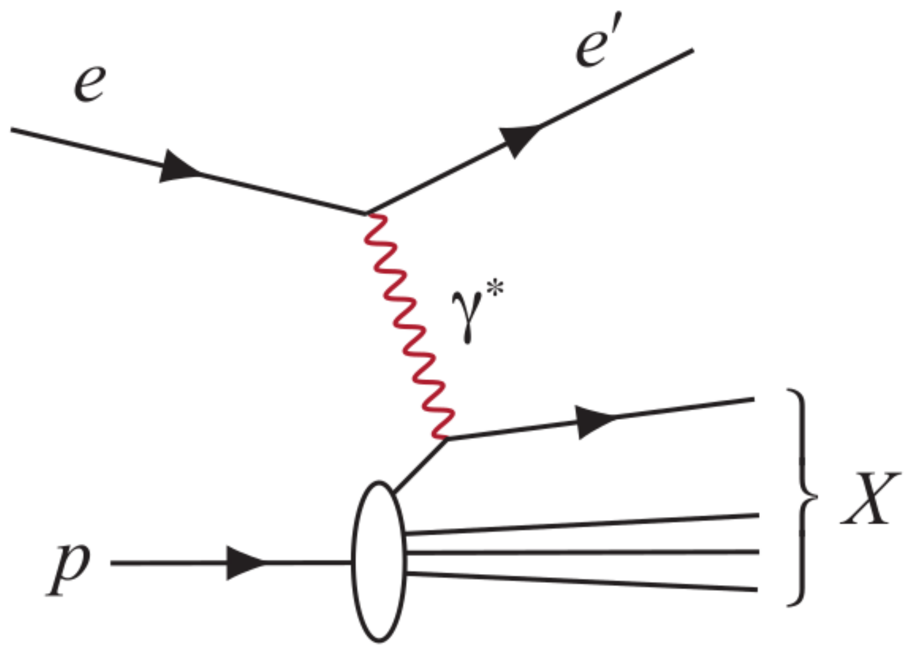
- Explore QCD & Hadron Structure
- Indirect access to glue
- High precision & access to partonic kinematics

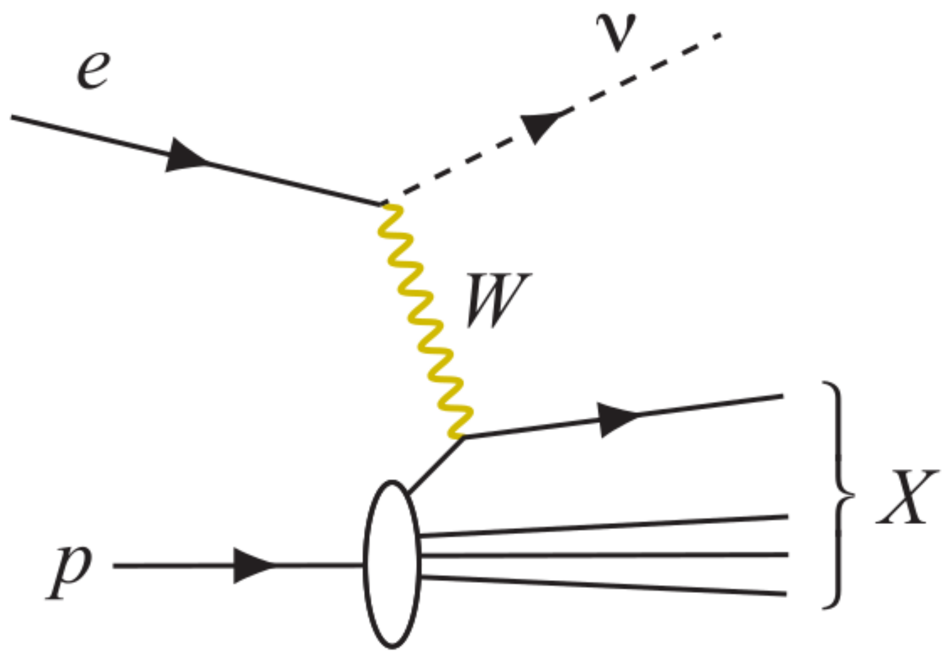
Both are complementary and provide excellent information on properties of gluons in the nuclear wave functions

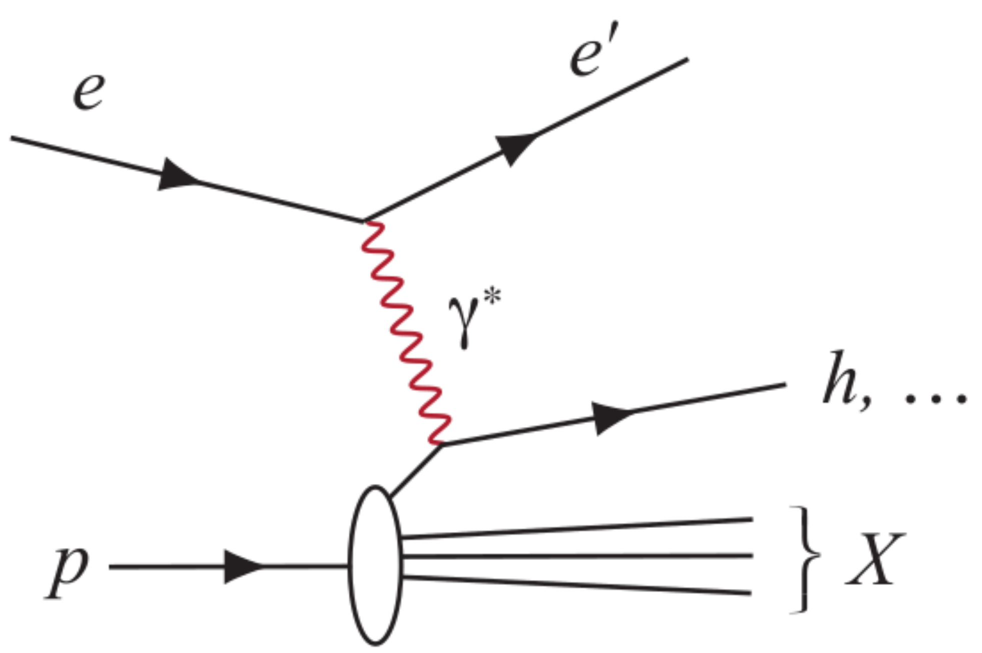
Precision measurements ⇒ **DIS** due to unprecedented exact knowledge of QED

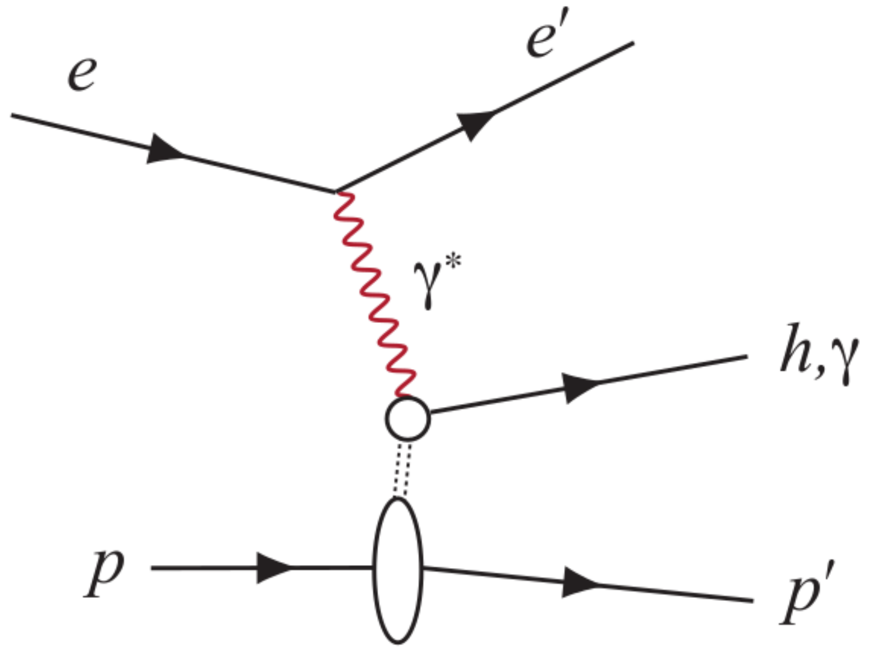
General: Category of Processes to Study

DIS event kinematics - scattered electron or final state particles (CC DIS, low y)









Neutral Current DIS

- Detection of scattered electron with high precision - event kinematics

Charged Current DIS

- Event kinematics from the final state particles (Jacquet-Blondel method)

Semi-Inclusive DIS

- Precise detection of scattered electron in coincidence with at least 1 hadron

Deep Exclusive Processes

- Detection of all particles in event

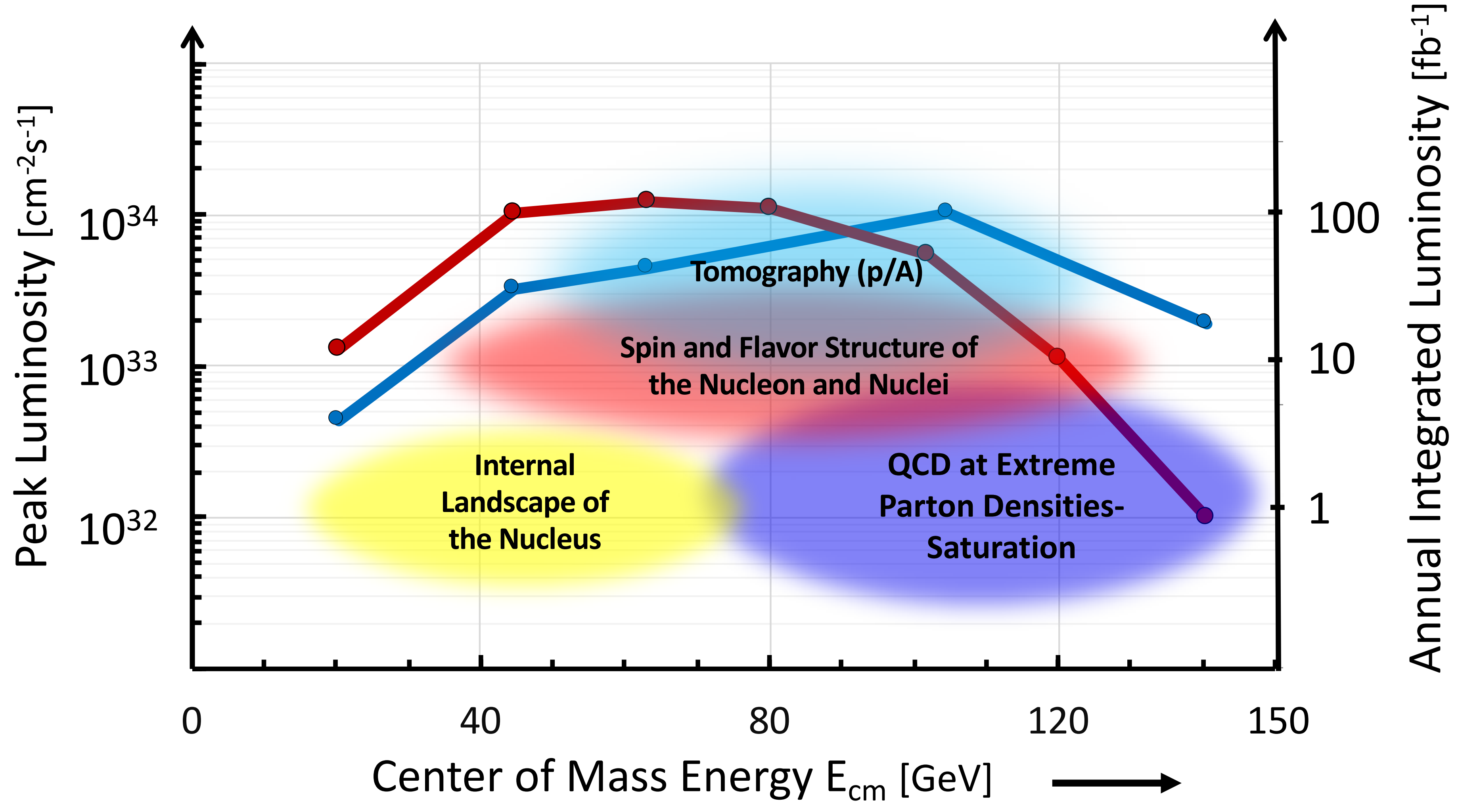
Parton Distributions in nucleons and nuclei

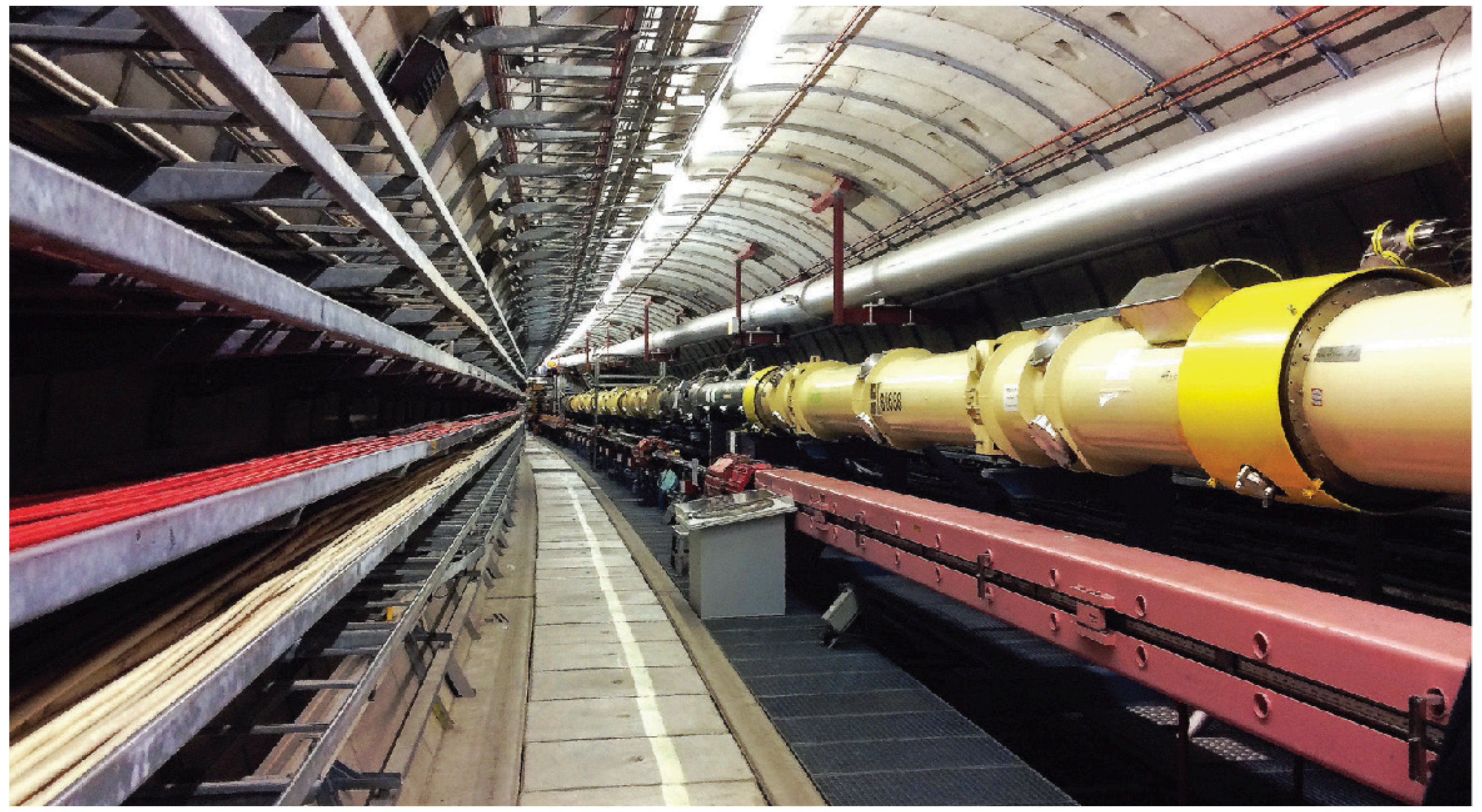
Spin and Flavor structure of nucleons and nuclei | **Tomography Transverse Momentum Dist.**

QCD at Extreme Parton Densities - Saturation | **Tomography Spatial Imaging**

What Do We Need?

- Access to gluon dominated region and wide kinematic range in x and Q^2
  - ➡ Large center-of-mass energy range $\sqrt{s}$ = 20 -14000 GeV
- Access to spin structure and 3D spatial and momentum structure
  - ➡ Polarized electron and proton and light nuclear beams ≥ 70% for both
- Accessing the highest gluon densities ($Q_S^2 \sim A^{1/3}$)
  - ➡ Nuclear beams, the heavier the better (up to U)
- Studying observables as a fct. of x, Q^2, A, etc.
  - ➡ High luminosity (100x HERA): 10^{33-34} cm^{-2} s^{-1}





HERA@DESY

Siberian Snakes, RHIC

Reality Check

Designing a dream machine is easy but

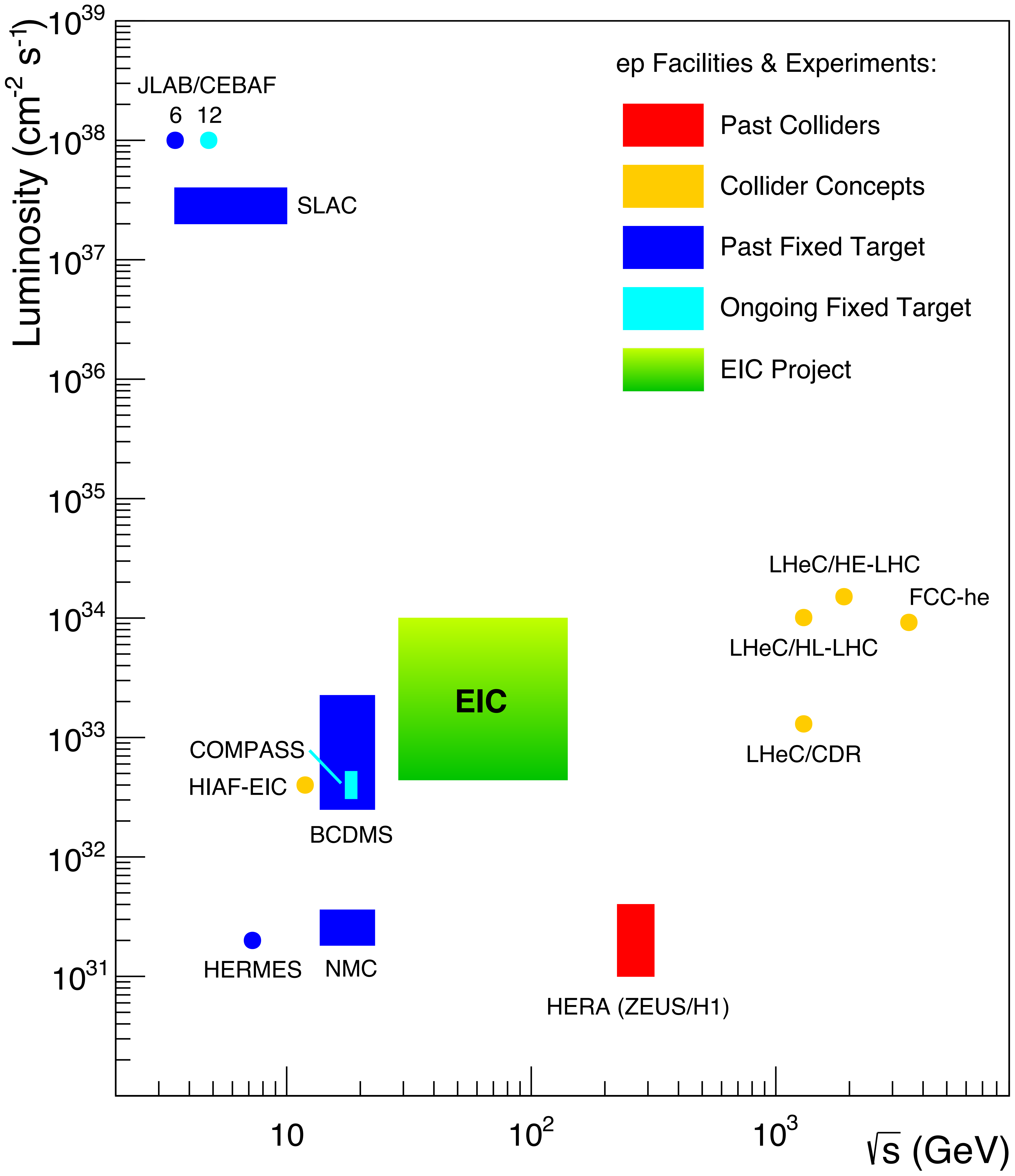
- It has to be fundable
- The technology has to be available
- Path of failed efforts is long: Isabelle, SSC, …

Find the parameters that do the job and that actually can be realized!

EIC:

- Highly polarized (70%) e- and p beams
- Ion beams from D to U
- Variable center-of-mass energies from $\sqrt{s}$=20-140 GeV
- High collision luminosity $10^{33\text{-}34}$ $cm^{-2}s^{-1}$ (HERA ~ 10^{31})
- Possibilities of having more than one interaction region

Landscape of DIS: The Uniqueness of EIC



- EIC cannot compete with e+p at HERA ($\sqrt{s}$ = 318 GeV)
- EIC's strength is polarized e↑+p↑ and e+A collisions
- Here the kinematic reach extends substantially compared to past (fixed target) coverage
  - Q^2×20, x/20 for e+A
  - Q^2×20, x/100 for polarized e↑+p↑

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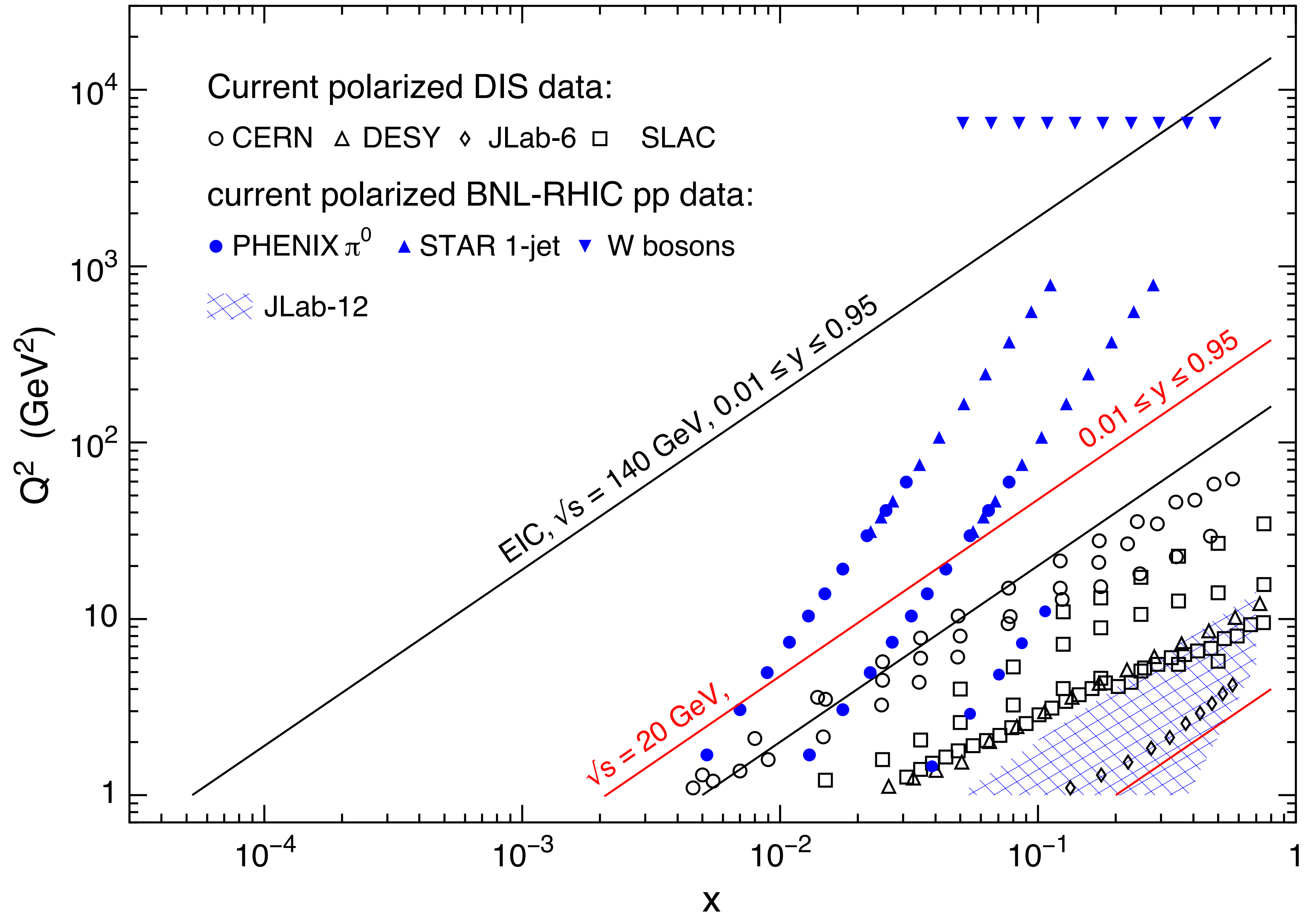

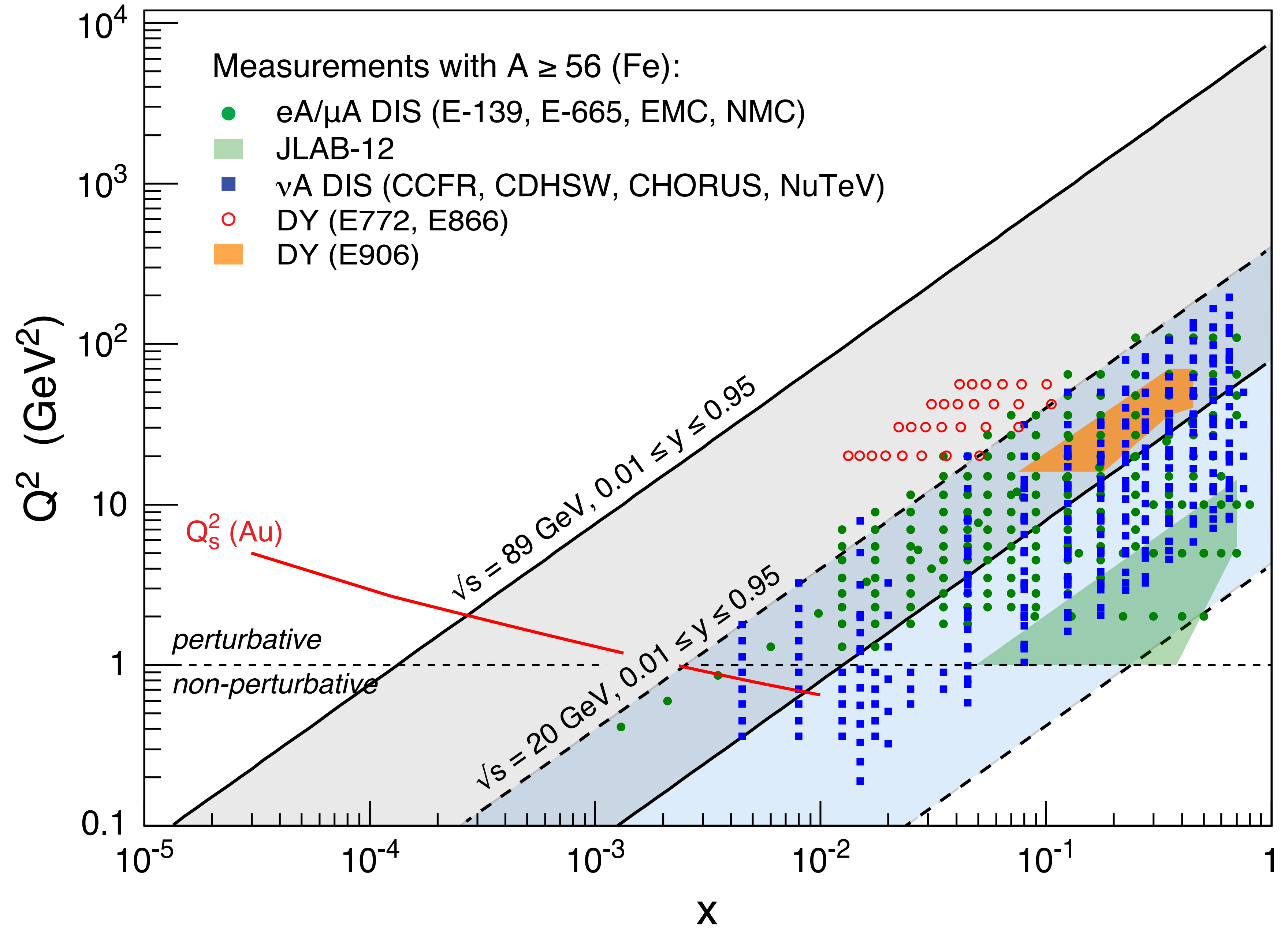

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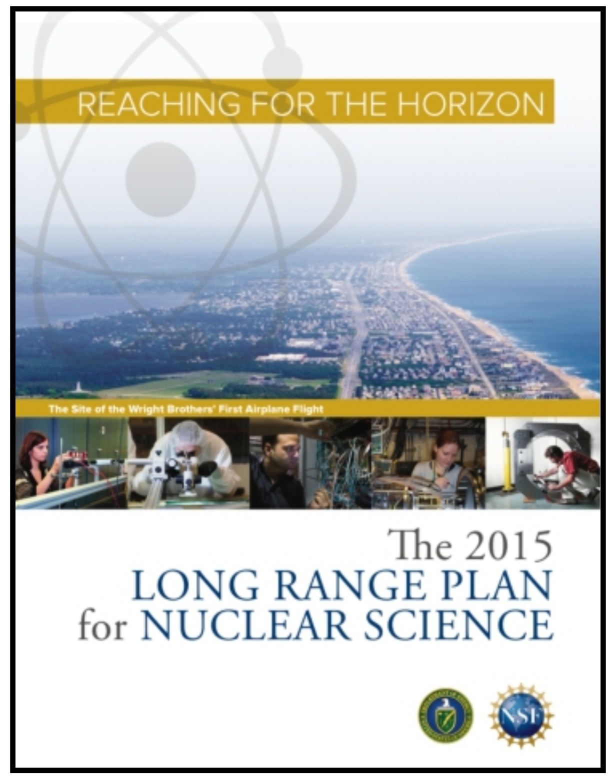
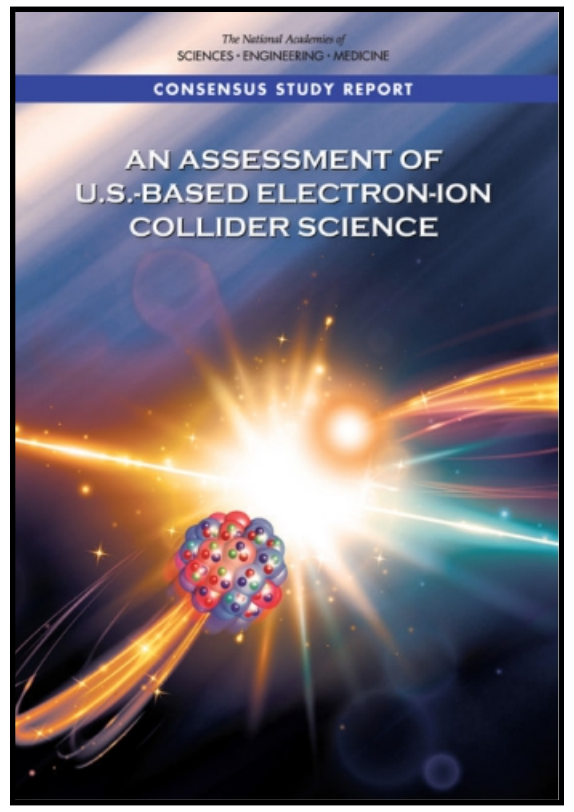
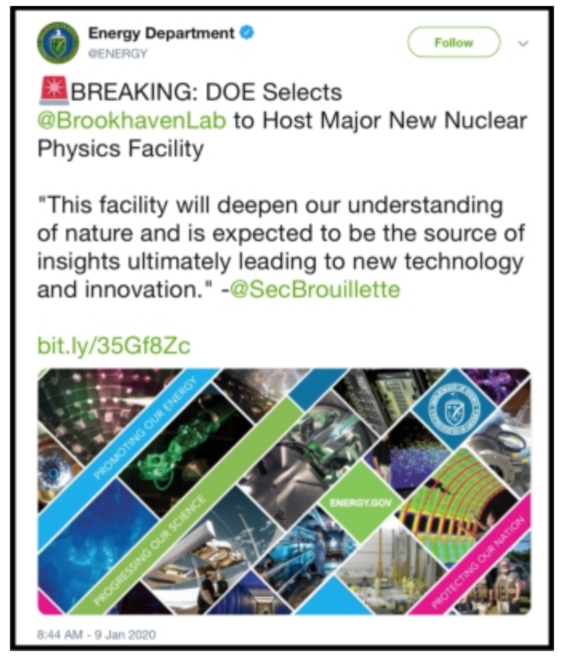
Status of EIC



2015: US Nuclear Physics Long Range Plan:
"We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB."

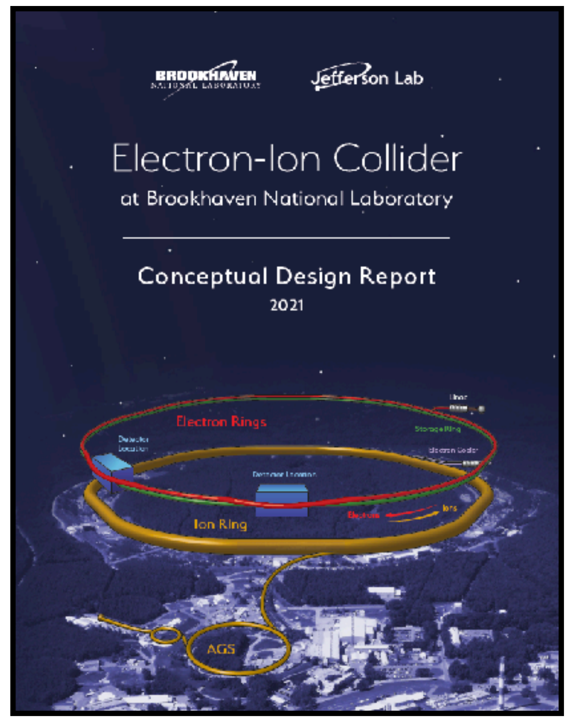


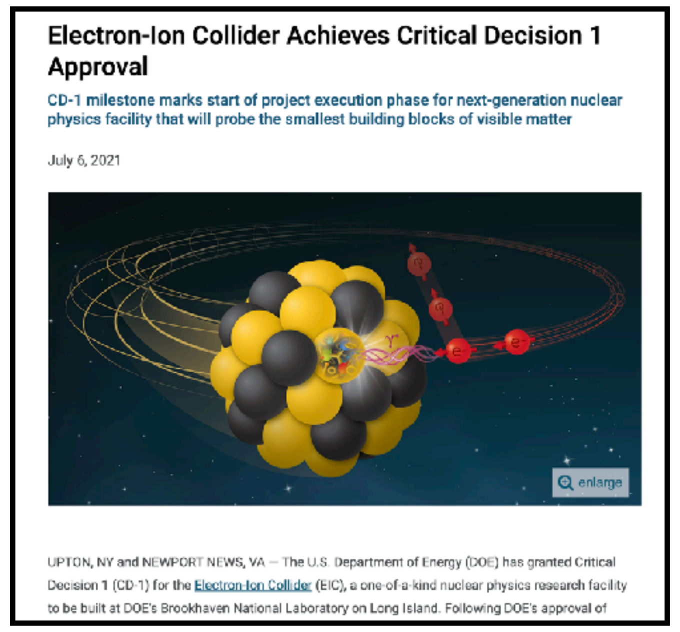
2018: National Academy EIC Review
"The committee finds that the science that can be addressed by an EIC is compelling, fundamental and timely."



December 2019/January 2020:
After science, cost, and host review DoE gives EIC CD-0 (*Approve Mission Need*) and selects BNL as the hosting site. BNL and JLab are the hosting labs. Project management officially started 4/1/2020.

January/February 2021: Release of CDR, CD-1 Review



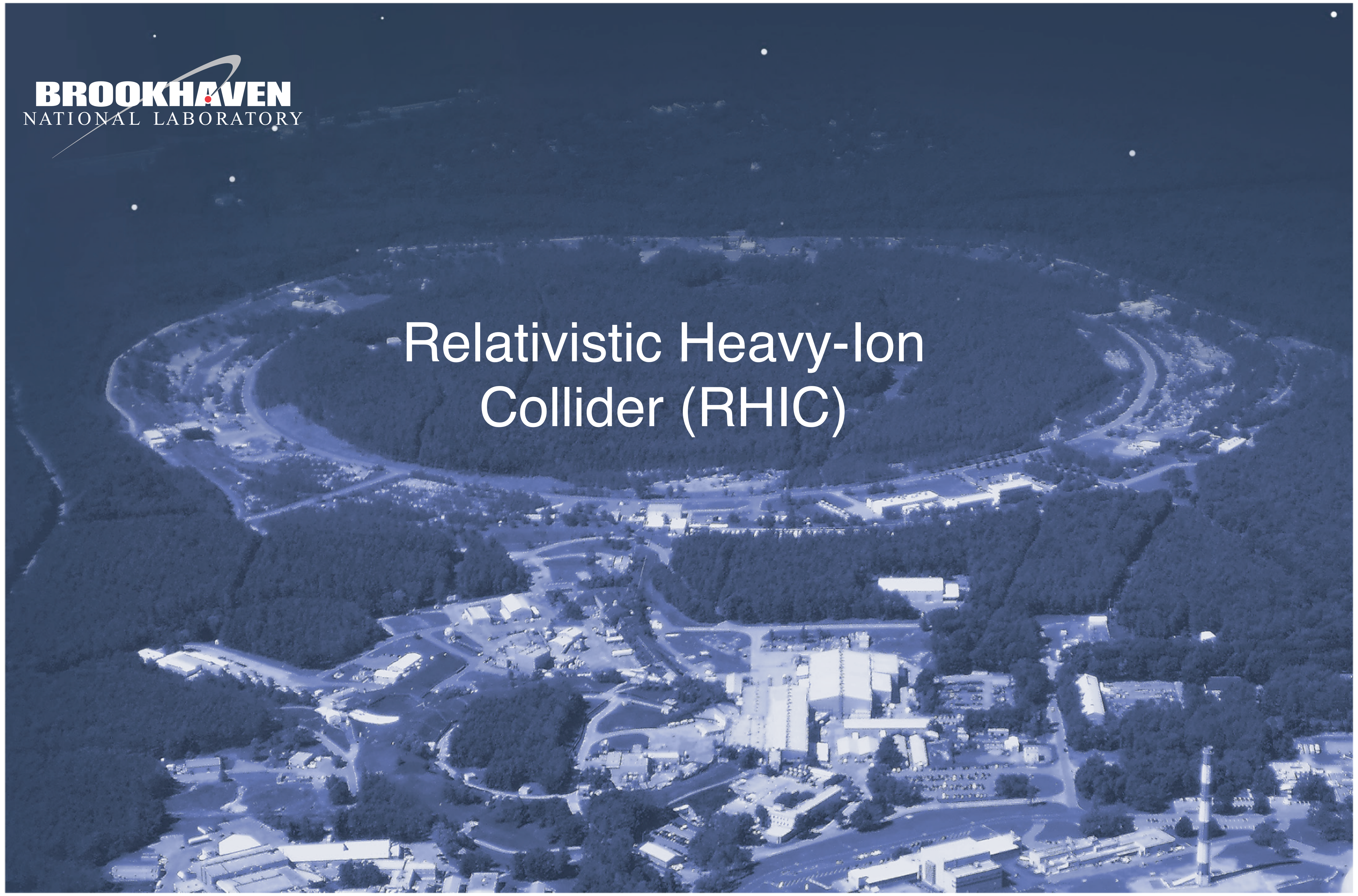


July 2021: CD-1 (*Approve Alternative Selection and Cost Range*) received.
Original cost estimate: $2 - 2.6 B
$100M from New York State towards infrastructure

April 2024: EIC project passes CD-3A for Long-Lead Procurements

EIC Machine Overview

EIC is using part of RHIC facility at BNL which is operating at its peak



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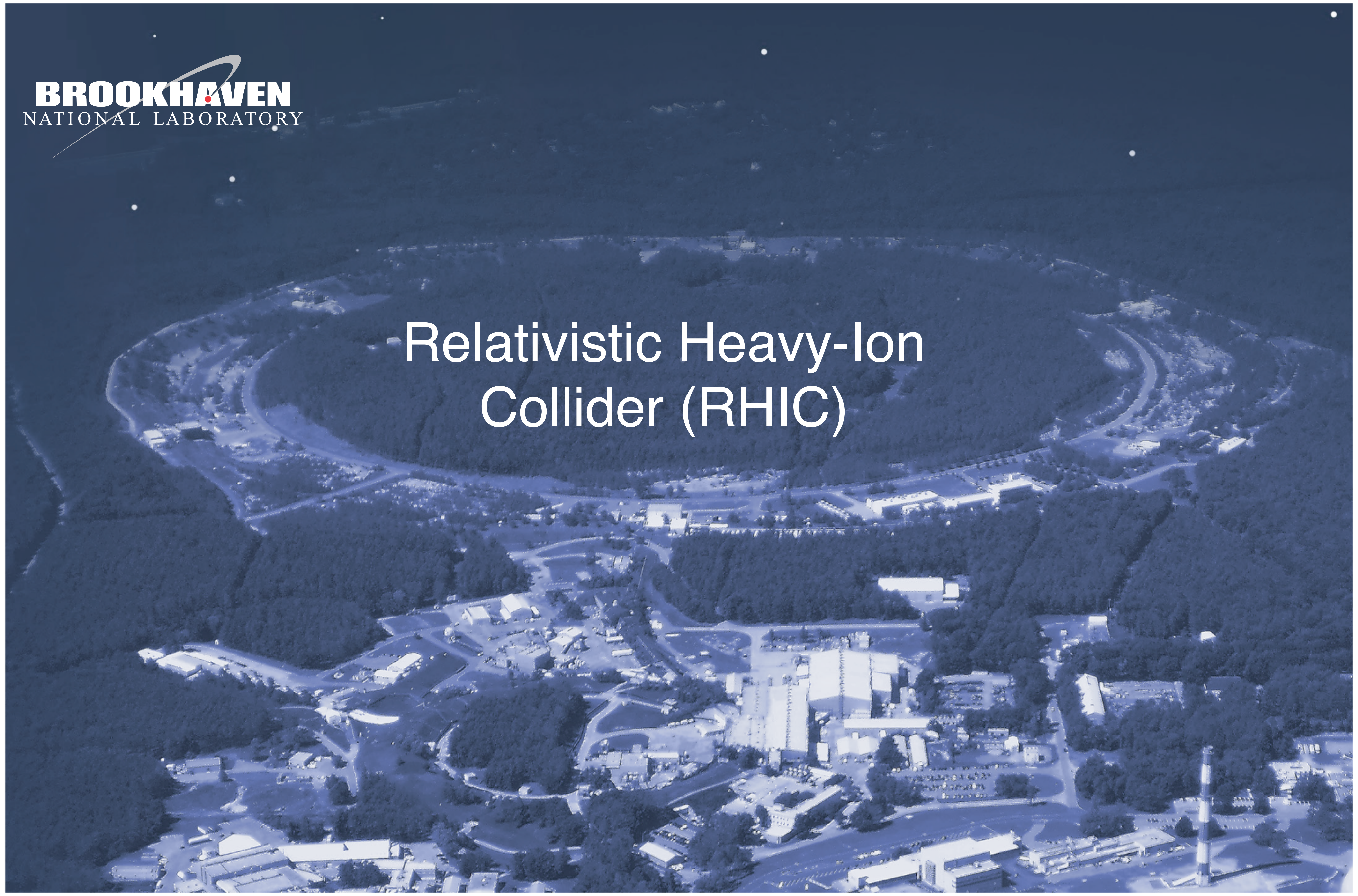

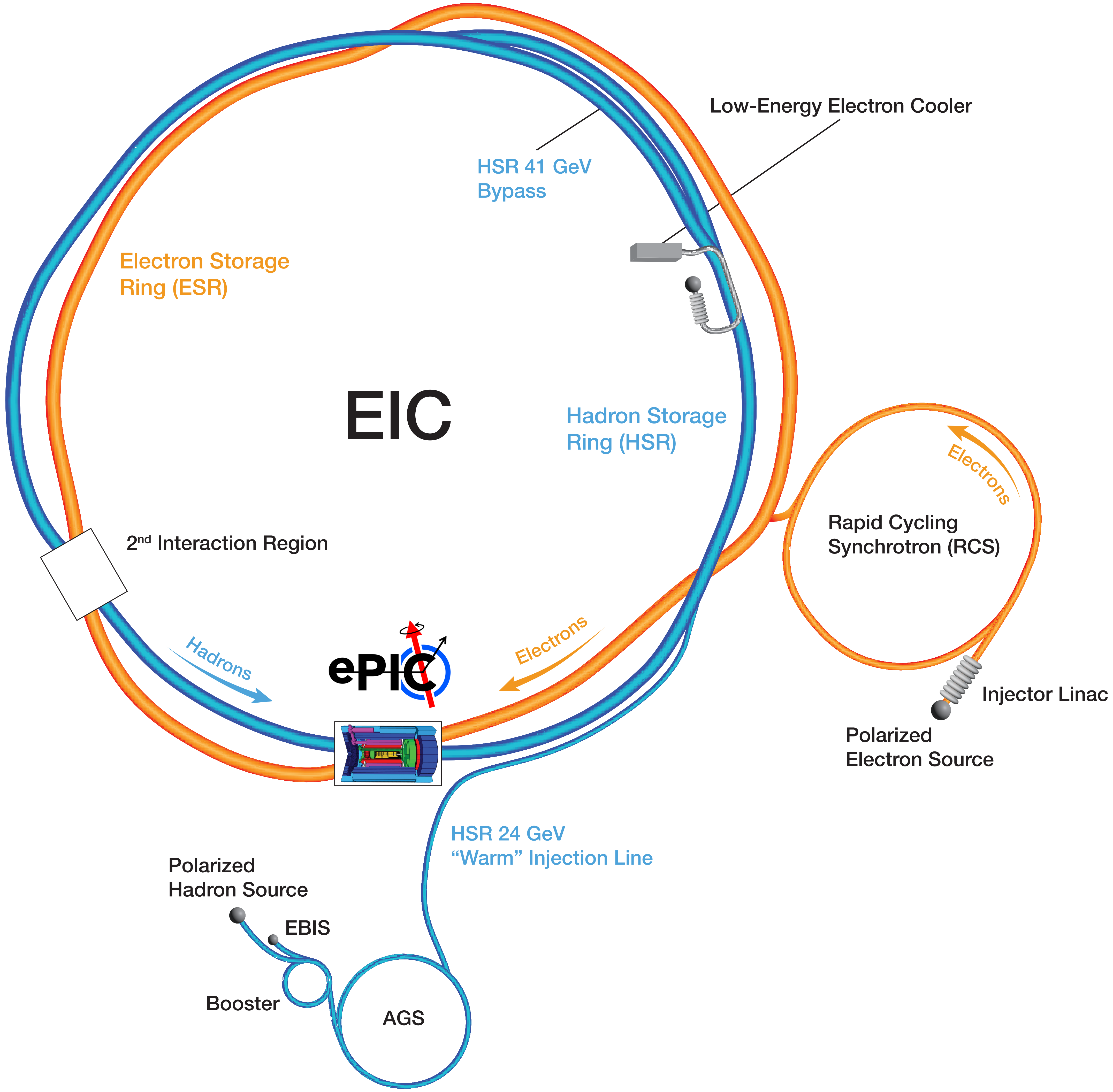

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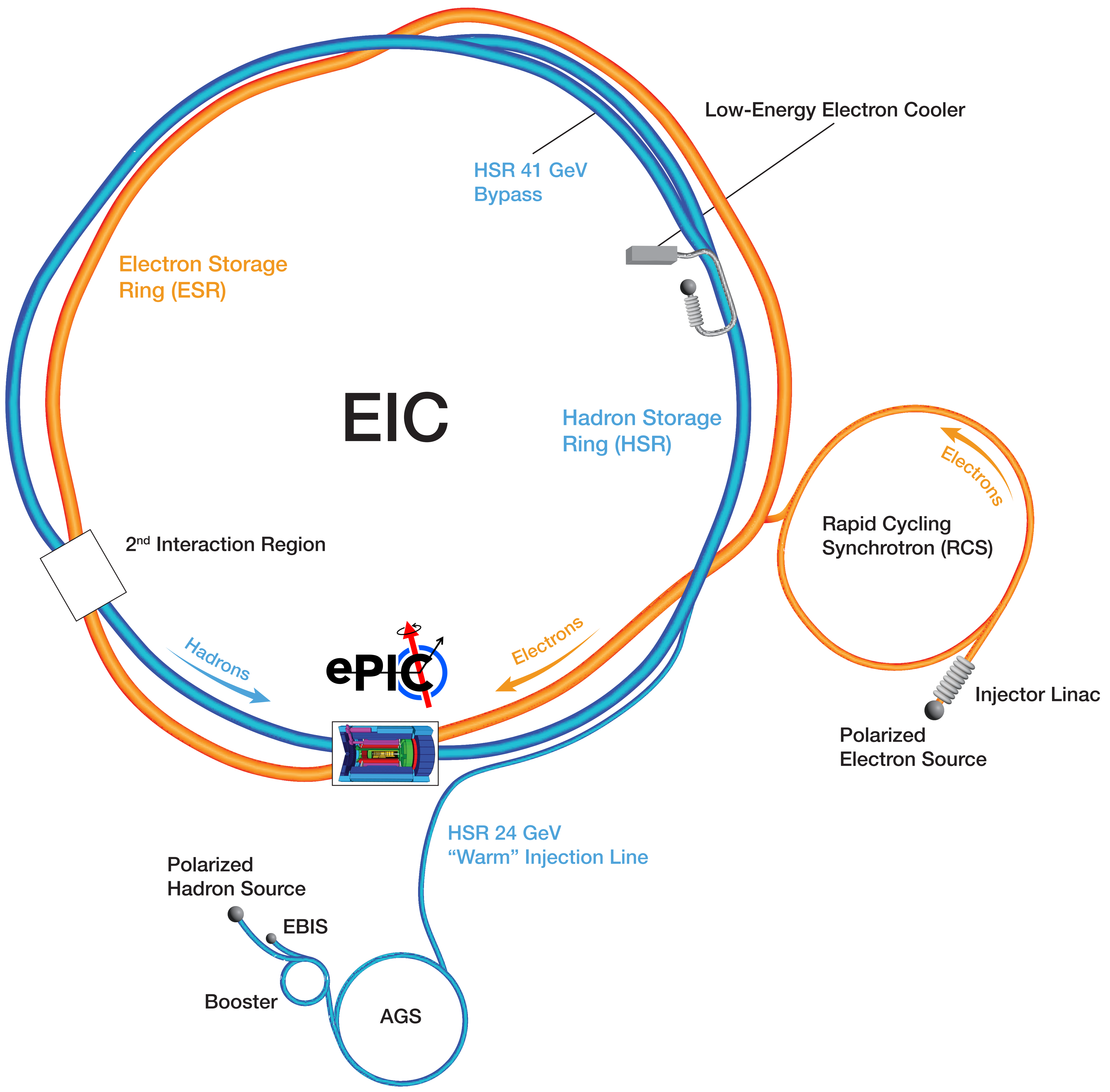
Three Ring Design

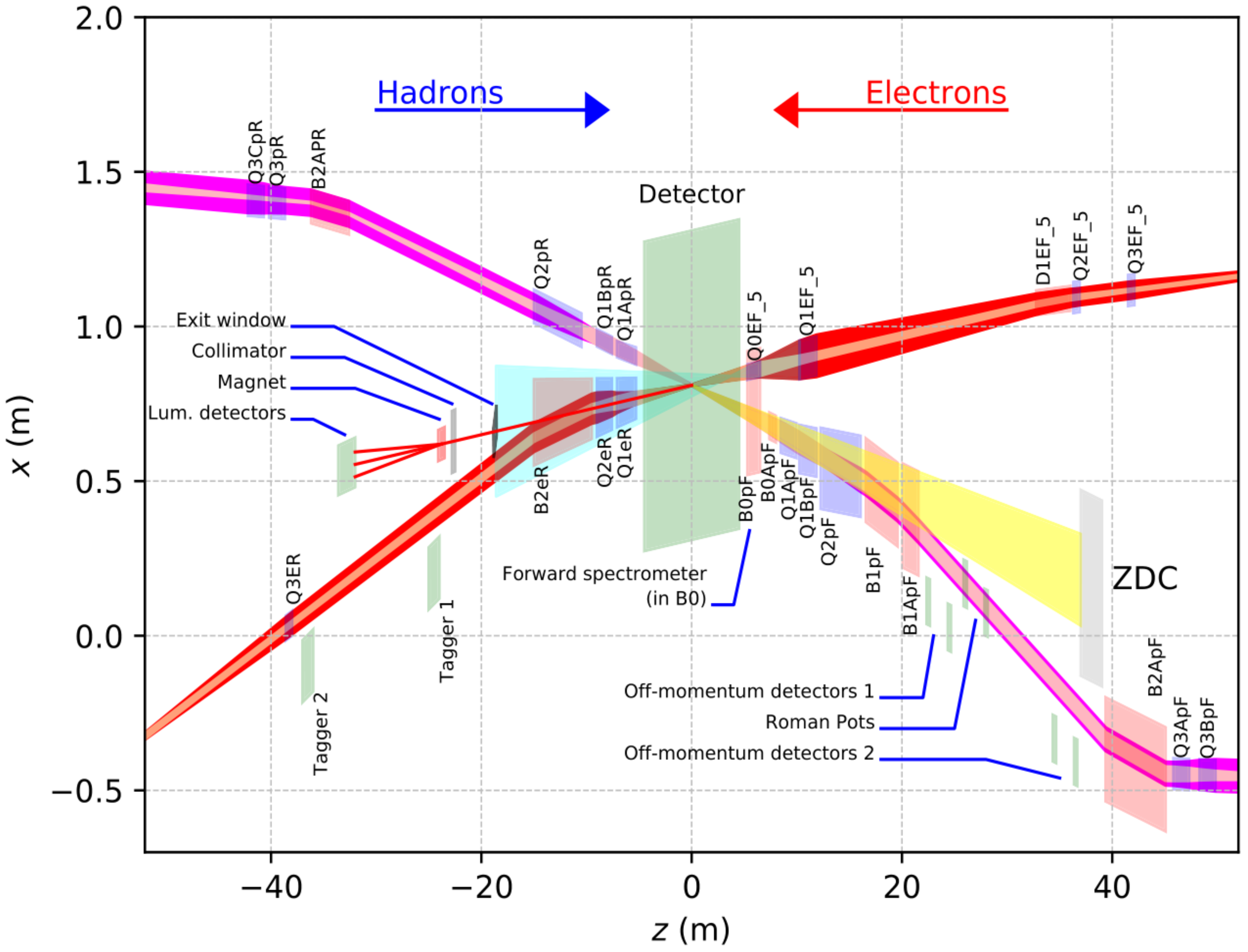
- Hadron storage ring 40-275 GeV (existing)
  - Many bunches, 1160 @ 1A beam current
  - Need strong cooling
- Electron rapid cycling synchrotron (new)
  - 1-2 Hz
  - Spin transparent due to high periodicity
- Electron storage ring (2.5–18 GeV, new)
  - Many bunches
  - Large beam current (2.5 A) ➔10 MW S.R. power
  - S.C. RF cavities
- High luminosity interaction region(s) (new)
  - $L = 10^{34} cm^{-2} s^{-1}$
  - Superconducting magnets
  - 25 mrad crossing angle with crab cavities

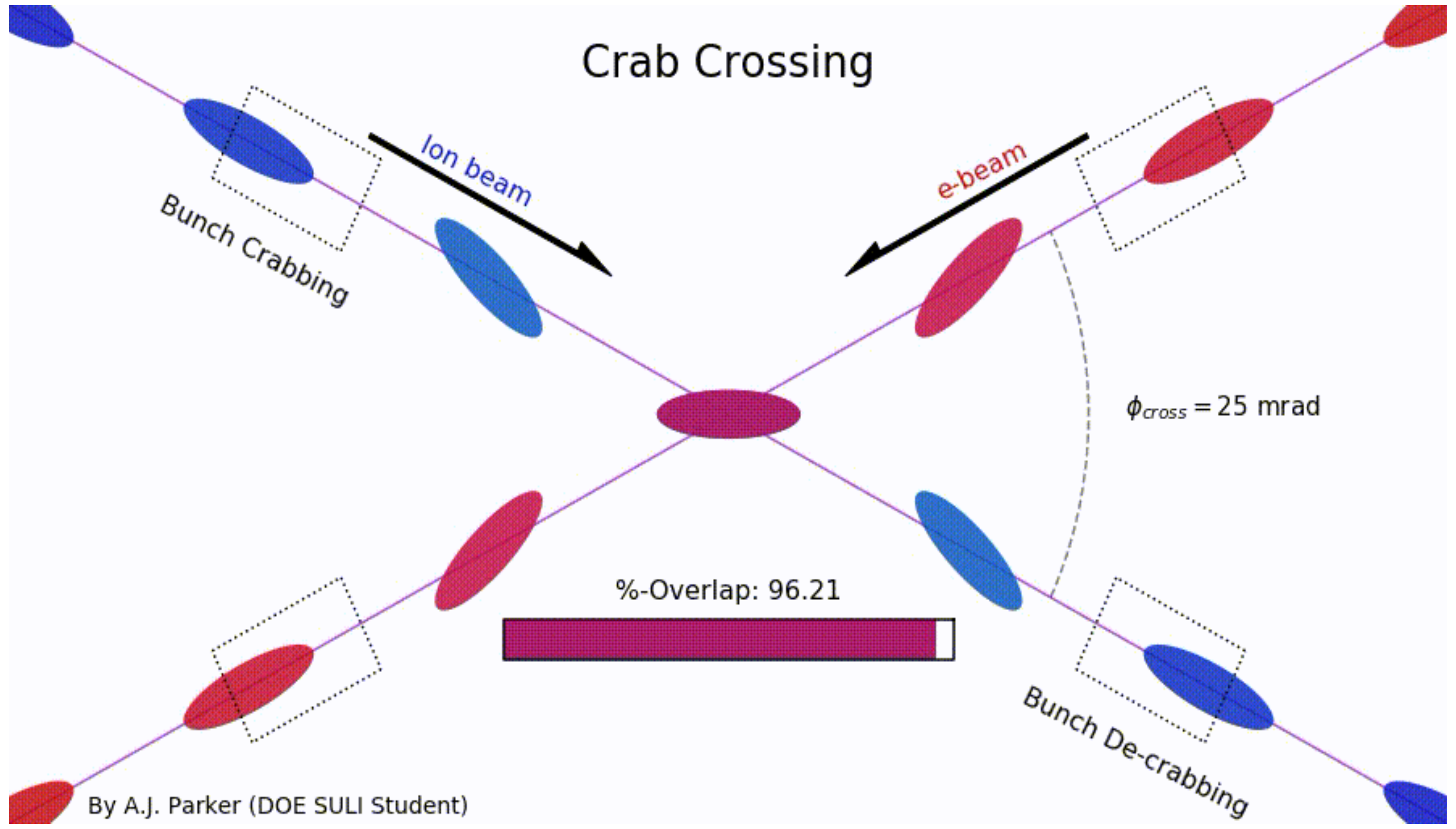


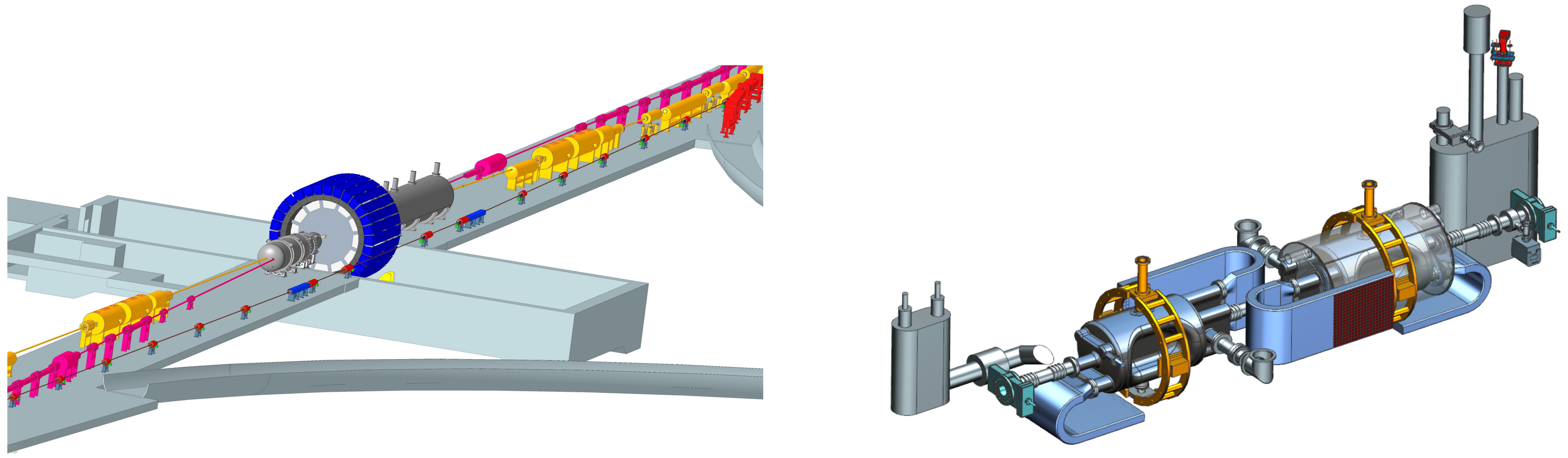
EIC IR Layout

High luminosity:
- 25 mrad crossing angle
- Small β* for high luminosity
  with limited IR chromaticity contributions
- Large final focus quadrupole aperture

Machine Detector Interface
- Large detector acceptance
- Forward spectrometer
- No magnets within - 4.5 / +5 m from IP
- Space for luminosity detector, neutron detector, “Roman Pots







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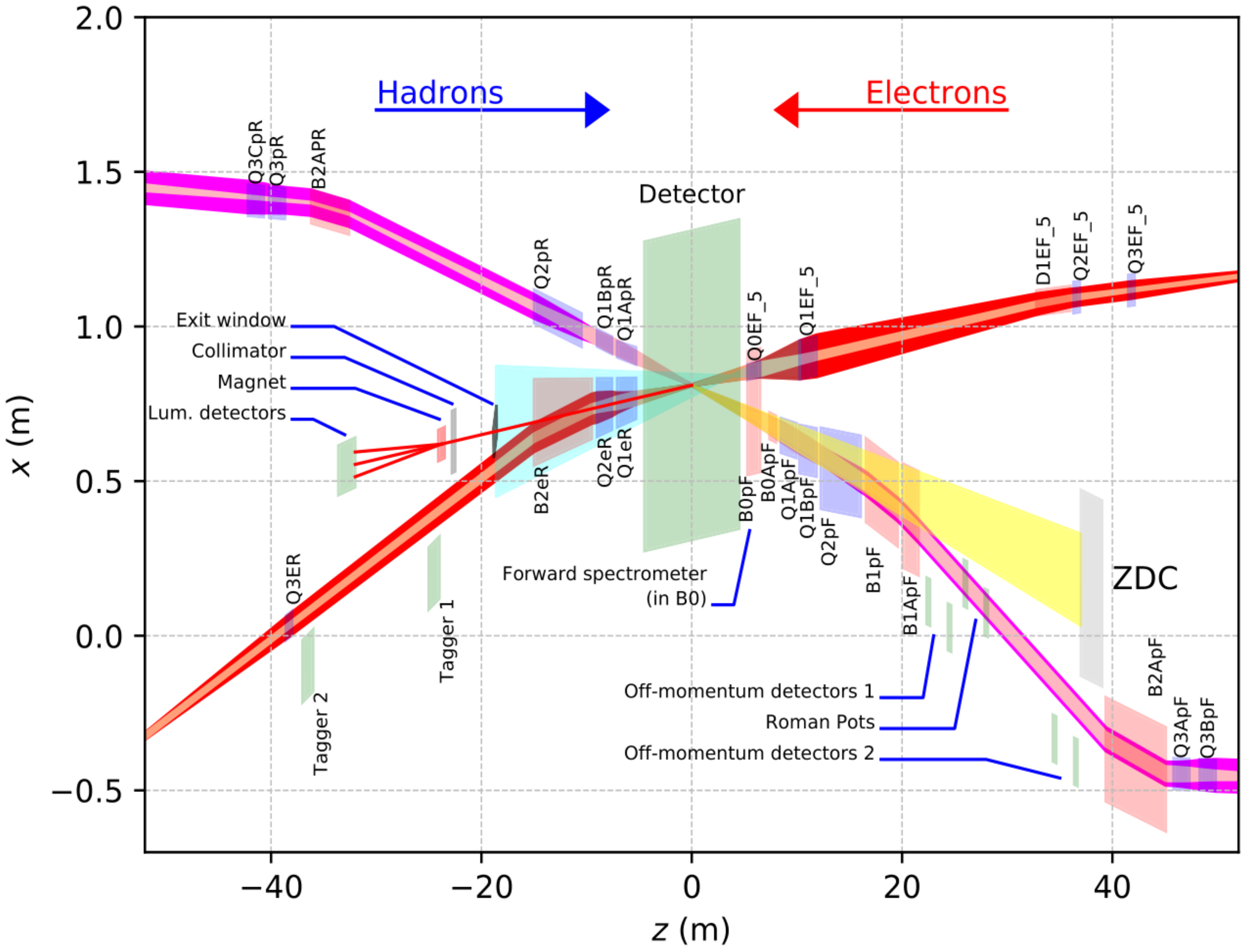
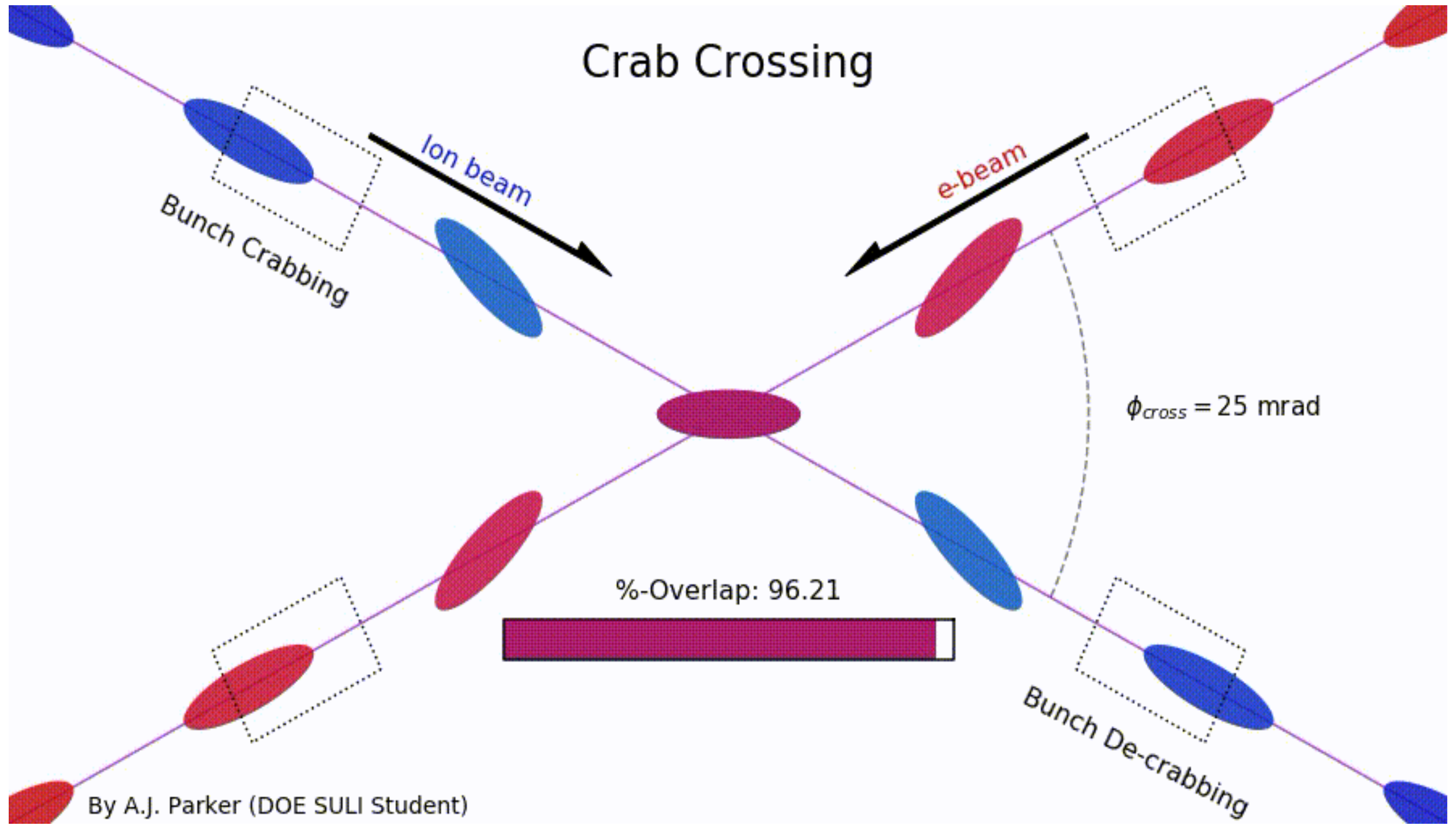
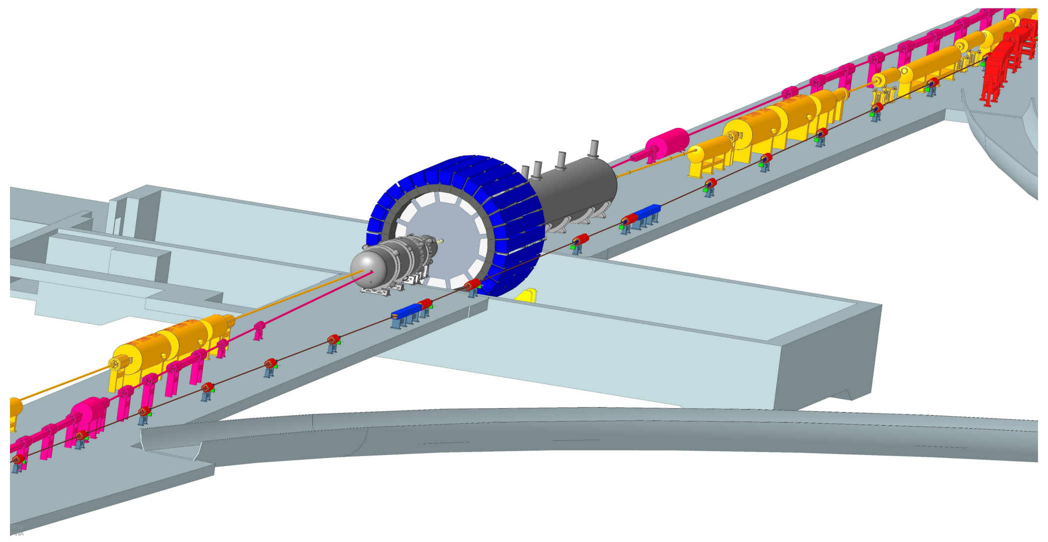
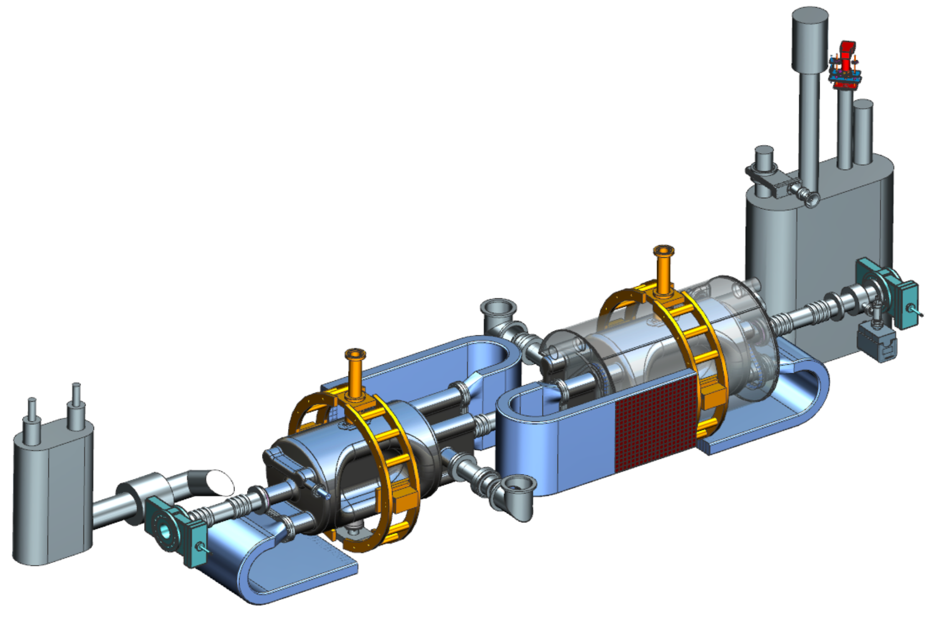


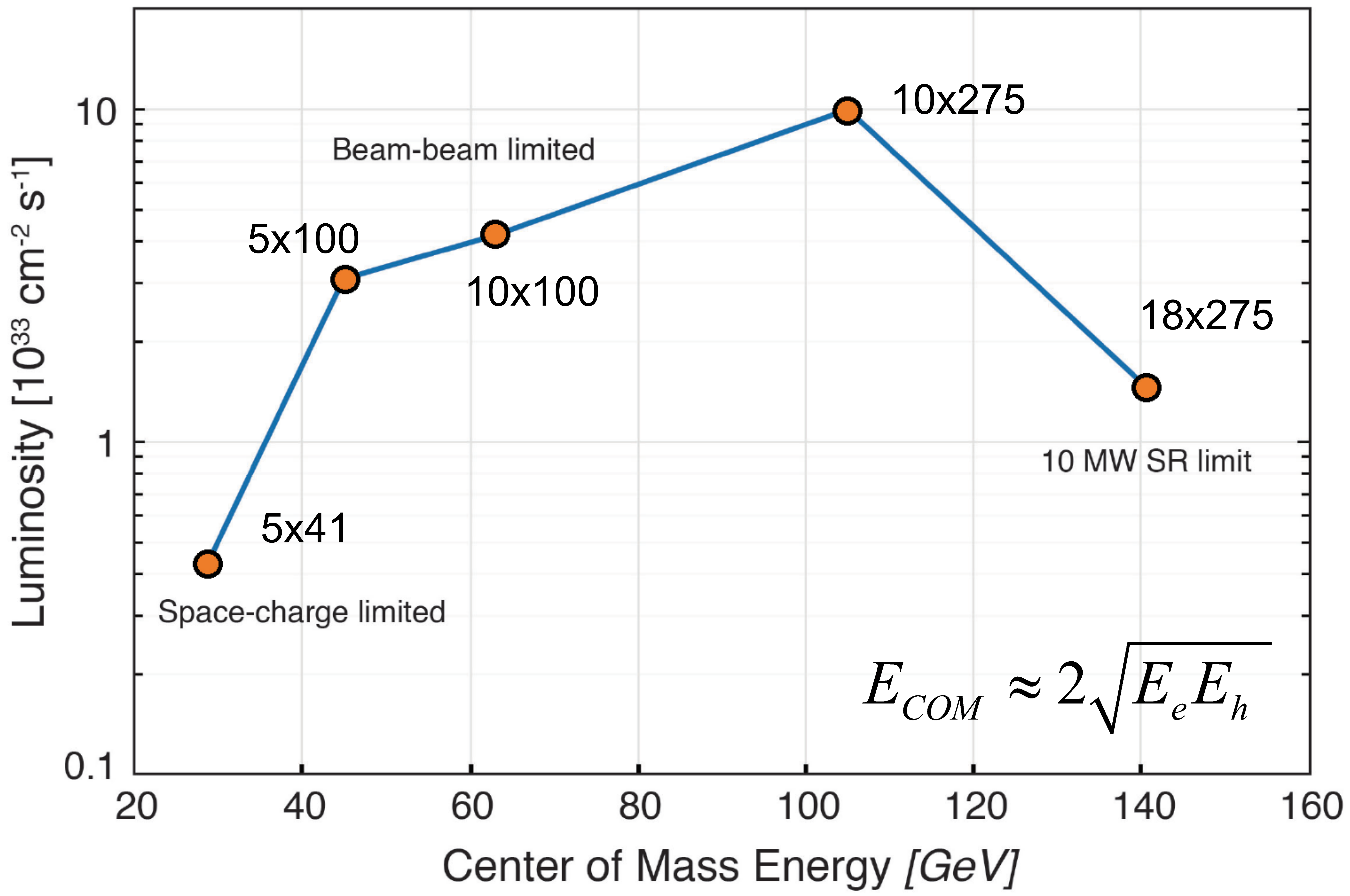






e+p Luminosity versus Center-of-Mass Energy

EIC peak luminosities (CDR)

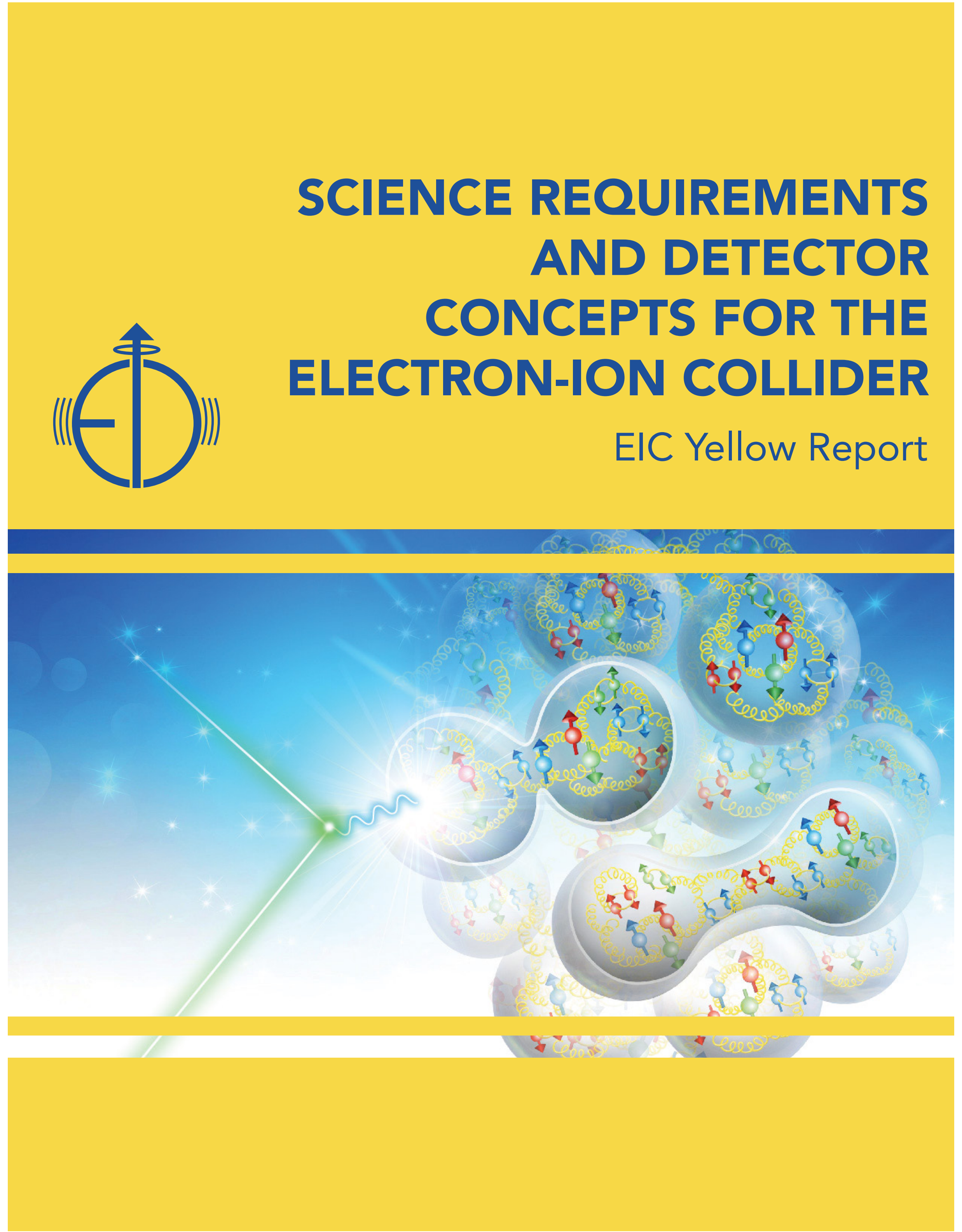


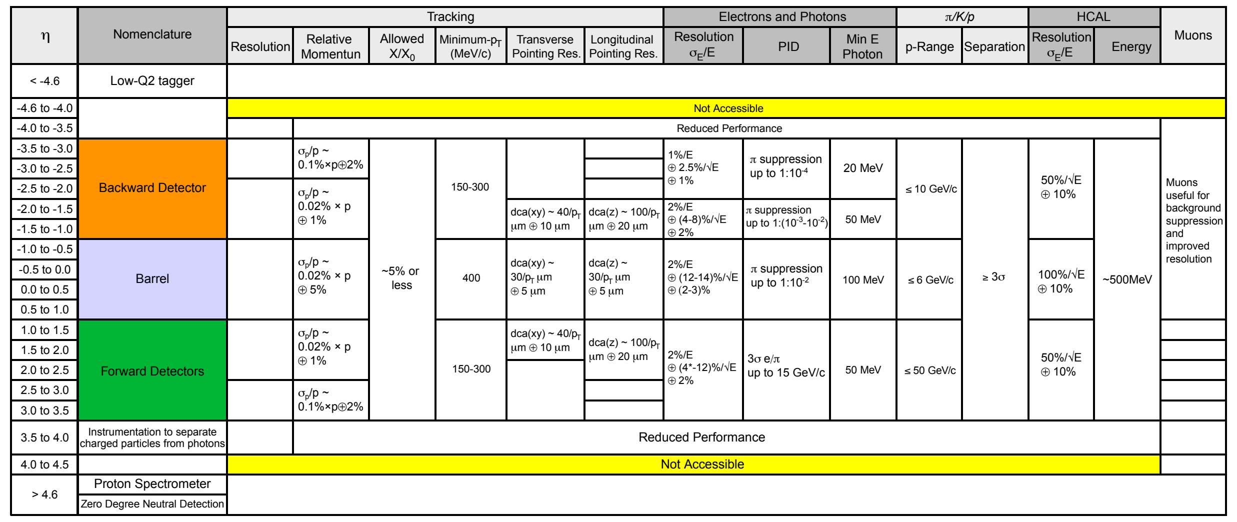
- Planning of beam use will be critical to increase physics output
  - Balance: $\mathscr{L}, \sqrt{s}, A$
- Electron-nucleon luminosities in e-A collisions are similar within a factor of 2 to 3

Recall in pp colliders: $\mathscr{L} \propto \sqrt{s}$

Detector Planning

- The DOE-NP supported EIC Project includes **one** detector and **one** IR in the reference costing
- The EIC is capable of supporting a science program that includes **two** detectors and **two** interaction regions.
- The community (EIC User Group) is strongly in favor of two general purpose detectors
  - Complementarity, cross-checking, cross-calibration/reduction of systematics (see HERA), mitigating of overall risk
- **EIC User Group "Yellow Report" Effort**
  - Initiative to advance the state and detail of requirements and detector concepts in preparation for the realization of the EIC.
  - 1 year effort concluded in March 2021 with a comprehensive "Yellow" Report
  - 902 Pages, 414 authors from 121 institutions, 675 figures
  - Nucl. Phys. A 1026 (2022) 122447, arXiv:2103.05419

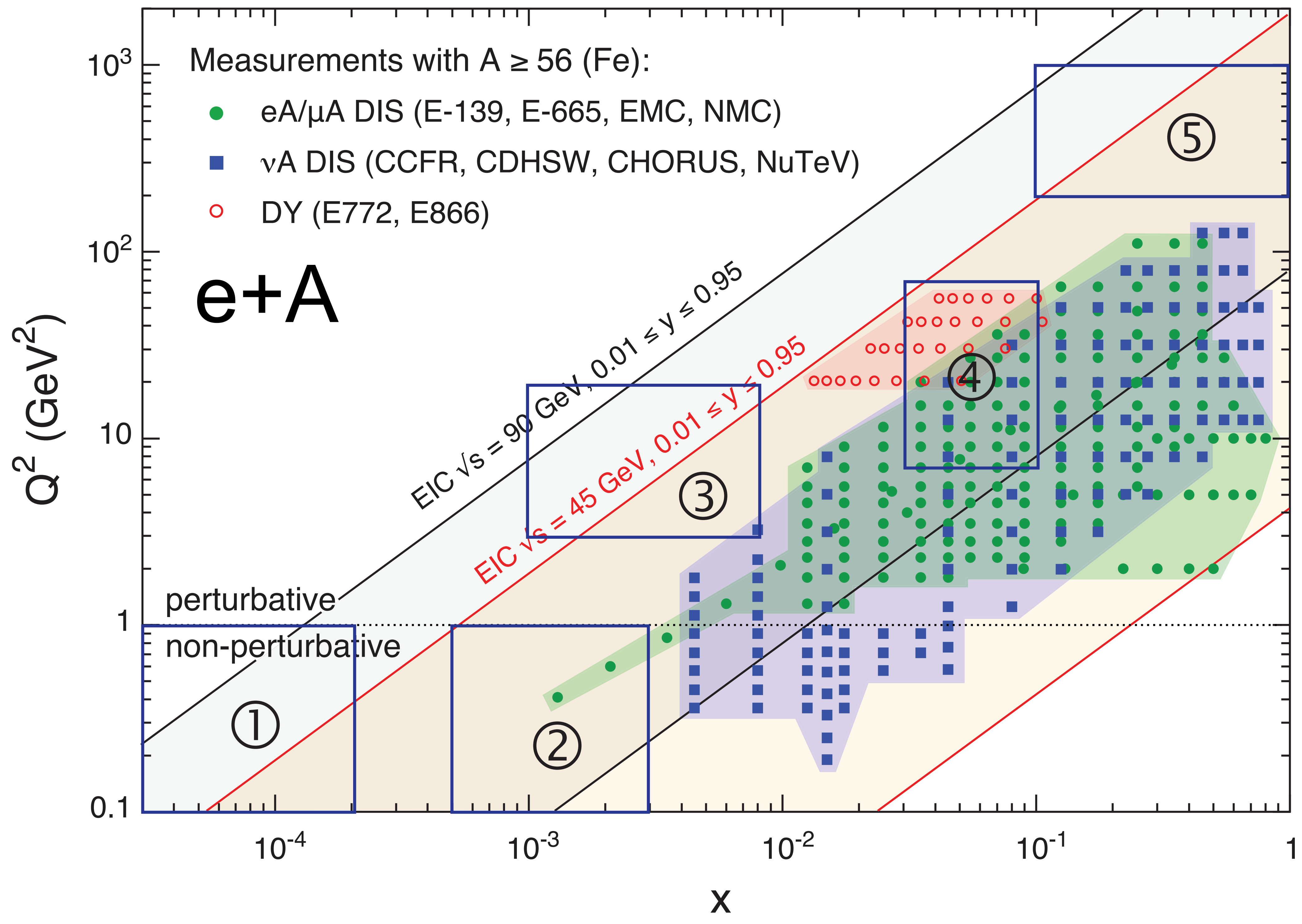




η	Nomenclature	Tracking						Electrons and Photons			$\pi/K/p$		HCAL		Muons
		Resolution	Relative Momentun	Allowed X/X_0	Minimum-p_T (MeV/c)	Transverse Pointing Res.	Longitudinal Pointing Res.	Resolution σ_E/E	PID	Min E Photon	p-Range	Separation	Resolution σ_E/E	Energy	
< -4.6	Low-Q2 tagger														
-4.6 to -4.0		Not Accessible													
-4.0 to -3.5			Reduced Performance												
-3.5 to -3.0	Backward Detector		$\sigma_p/p \sim 0.1\% \times p \oplus 2\%$	~5% or less	150-300			$1\%/E \oplus 2.5\%/\sqrt{E} \oplus 1\%$	π suppression up to $1{:}10^{-4}$	20 MeV	≤ 10 GeV/c	≥ 3σ	$50\%/\sqrt{E} \oplus 10\%$	~500MeV	Muons useful for background suppression and improved resolution
-3.0 to -2.5															
-2.5 to -2.0			$\sigma_p/p \sim 0.02\% \times p \oplus 1\%$												
-2.0 to -1.5						dca(xy) ~ $40/p_T$ µm ⊕ 10 µm	dca(z) ~ $100/p_T$ µm ⊕ 20 µm	$2\%/E \oplus (4\text{-}8)\%/\sqrt{E} \oplus 2\%$	π suppression up to $1{:}(10^{-3}\text{-}10^{-2})$	50 MeV					
-1.5 to -1.0															
-1.0 to -0.5	Barrel		$\sigma_p/p \sim 0.02\% \times p \oplus 5\%$		400	dca(xy) ~ $30/p_T$ µm ⊕ 5 µm	dca(z) ~ $30/p_T$ µm ⊕ 5 µm	$2\%/E \oplus (12\text{-}14)\%/\sqrt{E} \oplus (2\text{-}3)\%$	π suppression up to $1{:}10^{-2}$	100 MeV	≤ 6 GeV/c		$100\%/\sqrt{E} \oplus 10\%$		
-0.5 to 0.0															
0.0 to 0.5															
0.5 to 1.0															
1.0 to 1.5	Forward Detectors		$\sigma_p/p \sim 0.02\% \times p \oplus 1\%$		150-300	dca(xy) ~ $40/p_T$ µm ⊕ 10 µm	dca(z) ~ $100/p_T$ µm ⊕ 20 µm	$2\%/E \oplus (4^*\text{-}12)\%/\sqrt{E} \oplus 2\%$	3σ e/π up to 15 GeV/c	50 MeV	≤ 50 GeV/c		$50\%/\sqrt{E} \oplus 10\%$		
1.5 to 2.0															
2.0 to 2.5															
2.5 to 3.0			$\sigma_p/p \sim 0.1\% \times p \oplus 2\%$												
3.0 to 3.5															
3.5 to 4.0	Instrumentation to separate charged particles from photons		Reduced Performance												
4.0 to 4.5		Not Accessible													
> 4.6	Proton Spectrometer														
	Zero Degree Neutral Detection														

Inclusive (All): Scattered Electron Requirements

The energy and angle of scatter electron gives key variables x, y, Q^2



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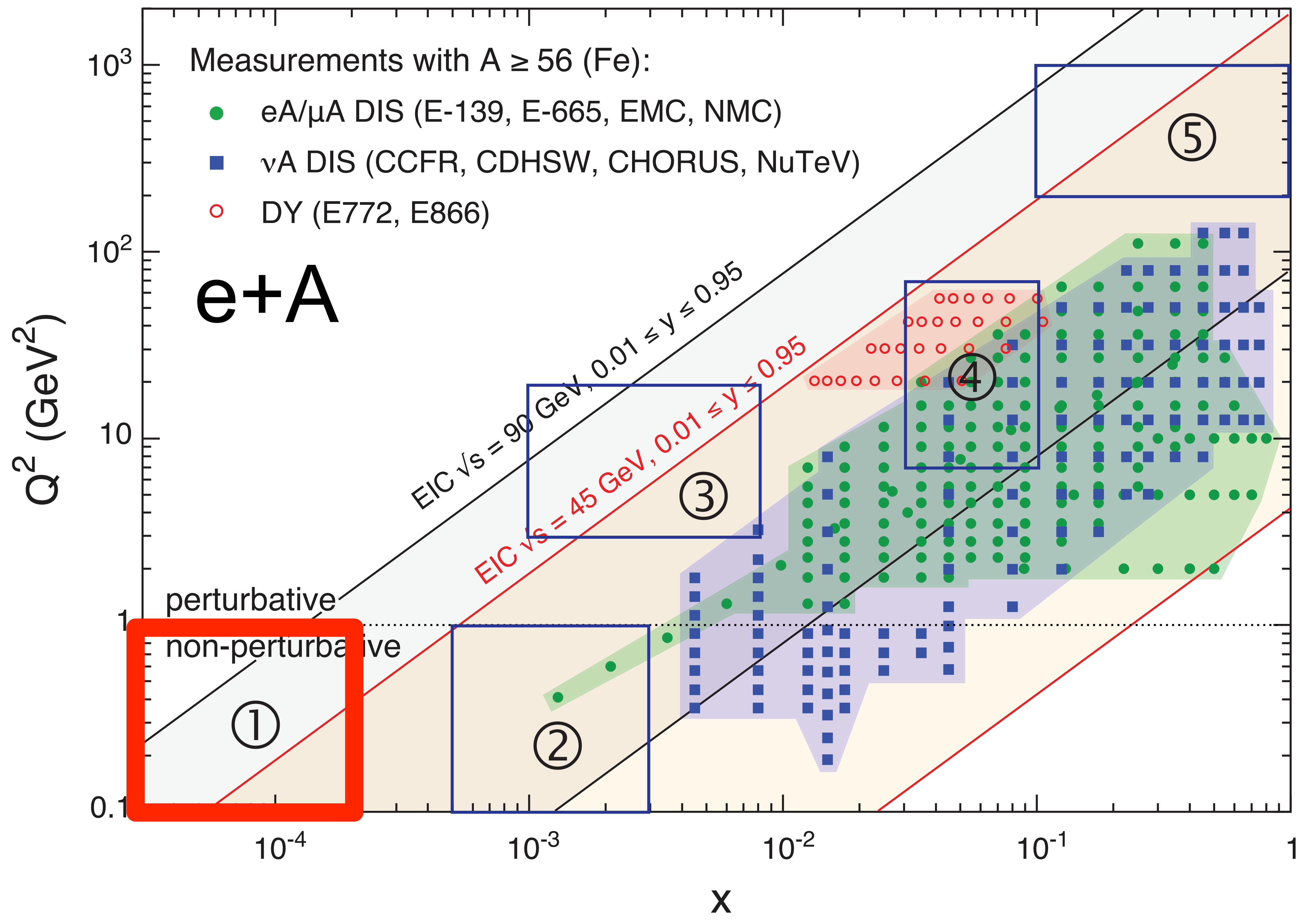
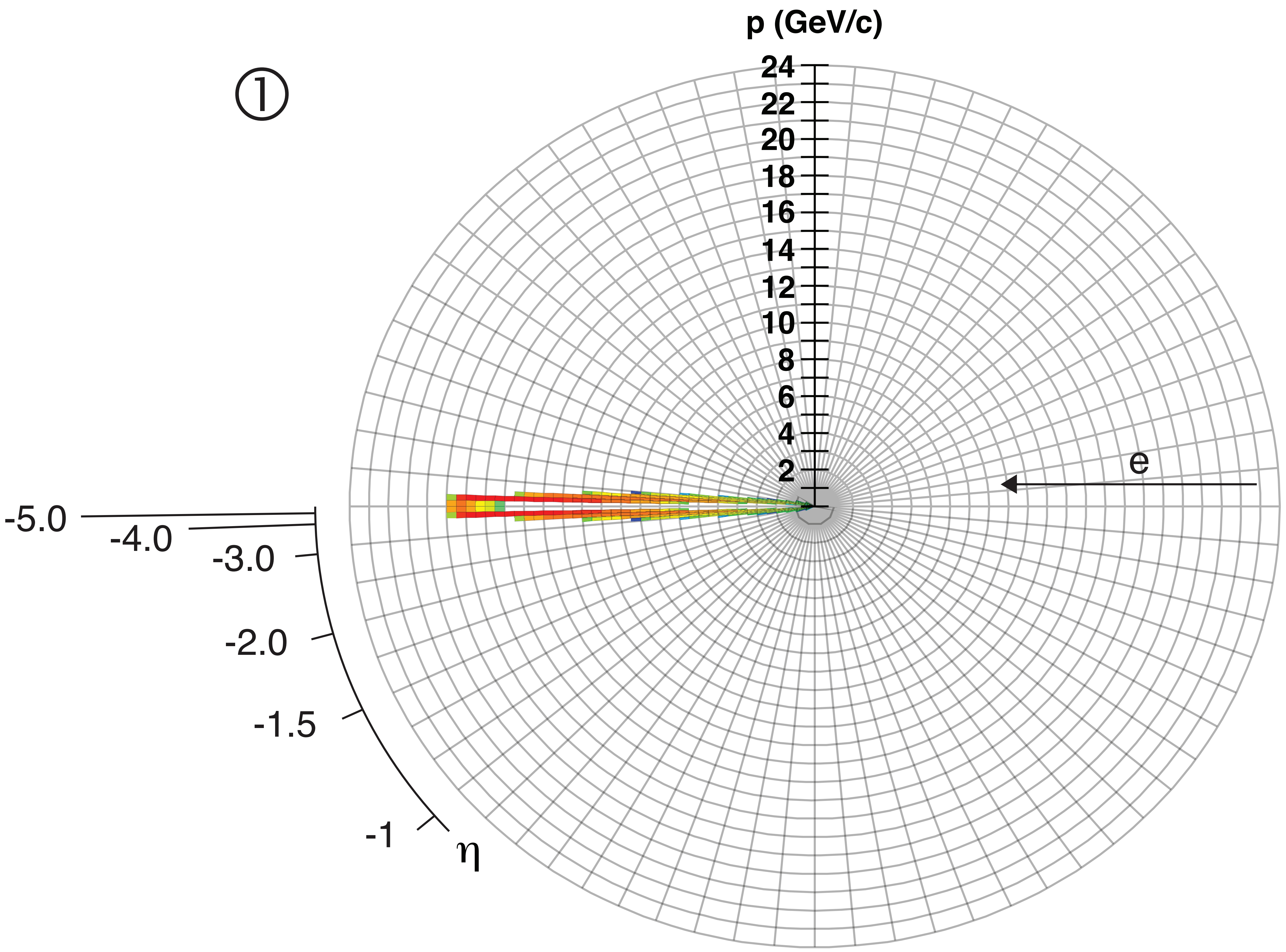


20 GeV on 100 GeV, $0.1 < Q^2 < 1$ GeV^2, $3{\cdot}10^{-5} < x < 2{\cdot}10^{-4}$



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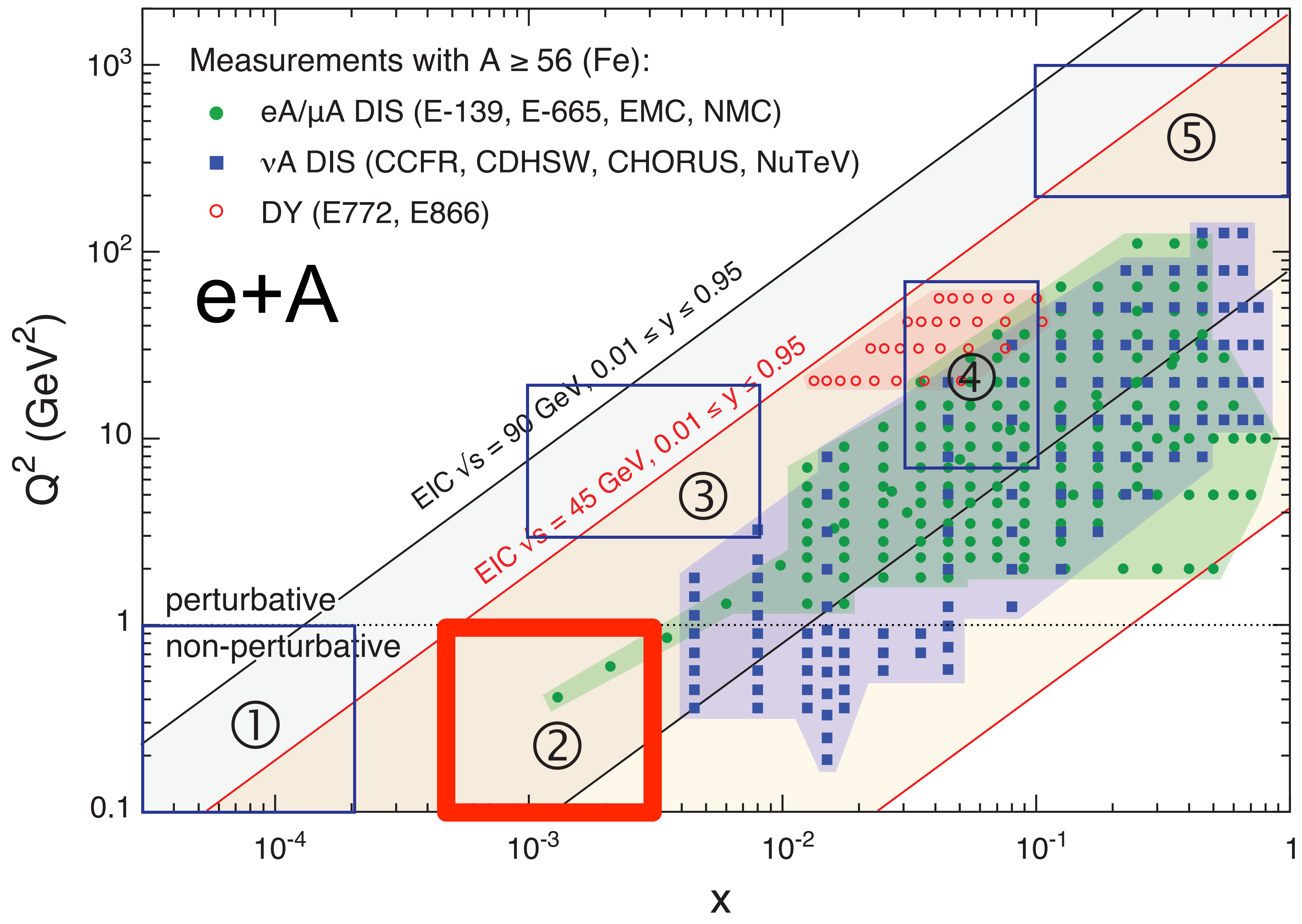
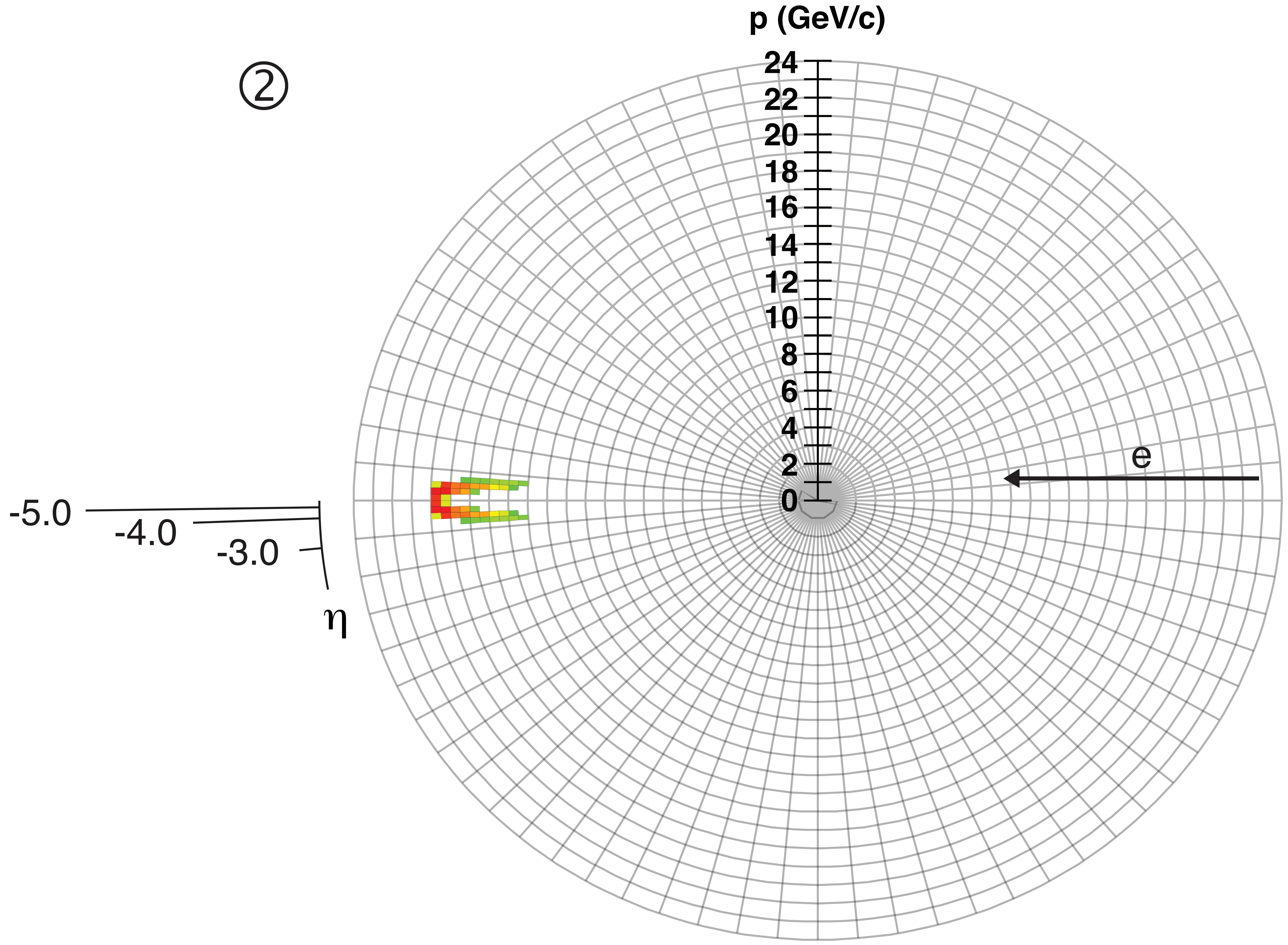


20 GeV on 100 GeV, $0.1 < Q^2 < 1$ GeV^2, $5\cdot10^{-4} < x < 3\cdot10^{-3}$



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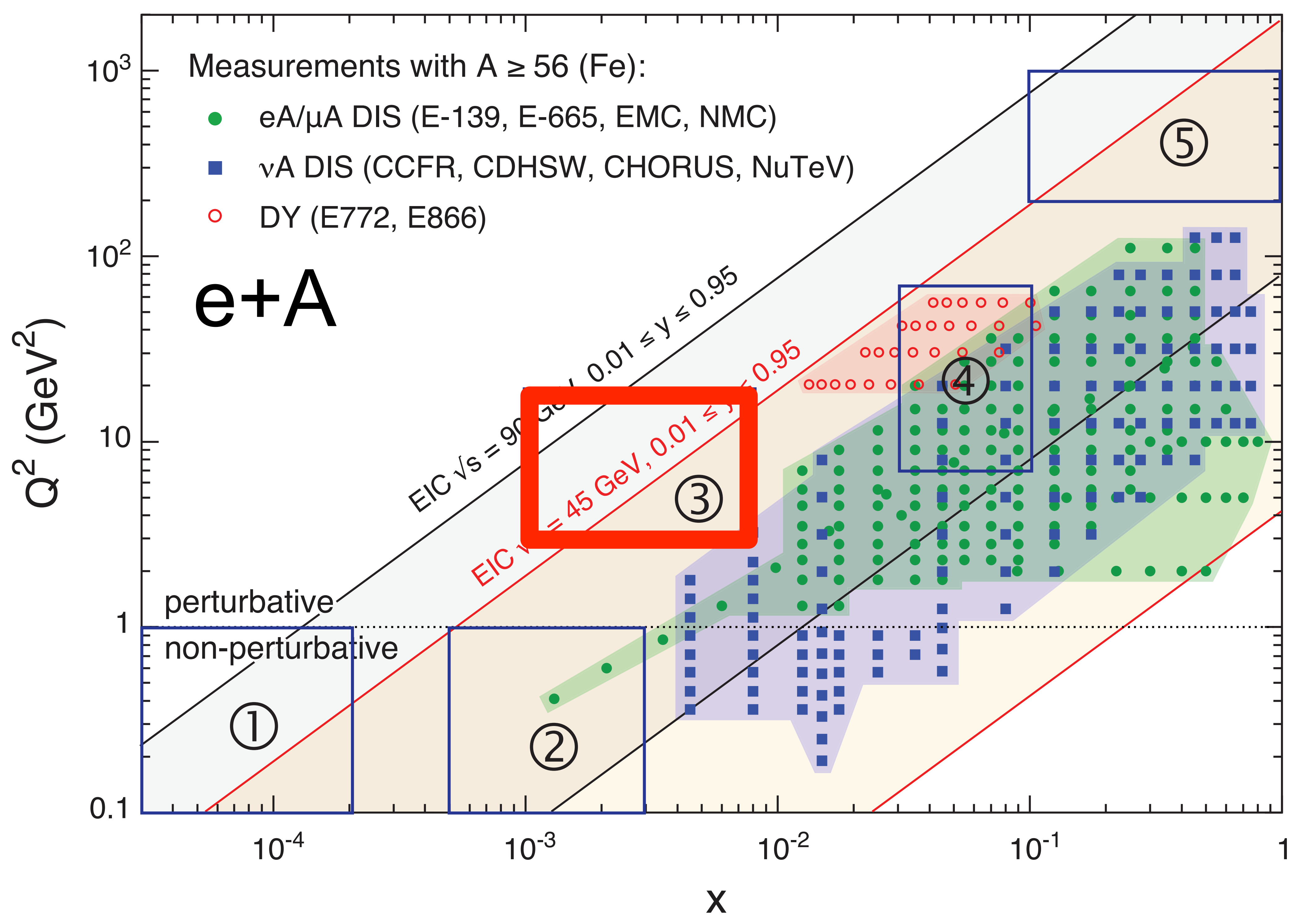
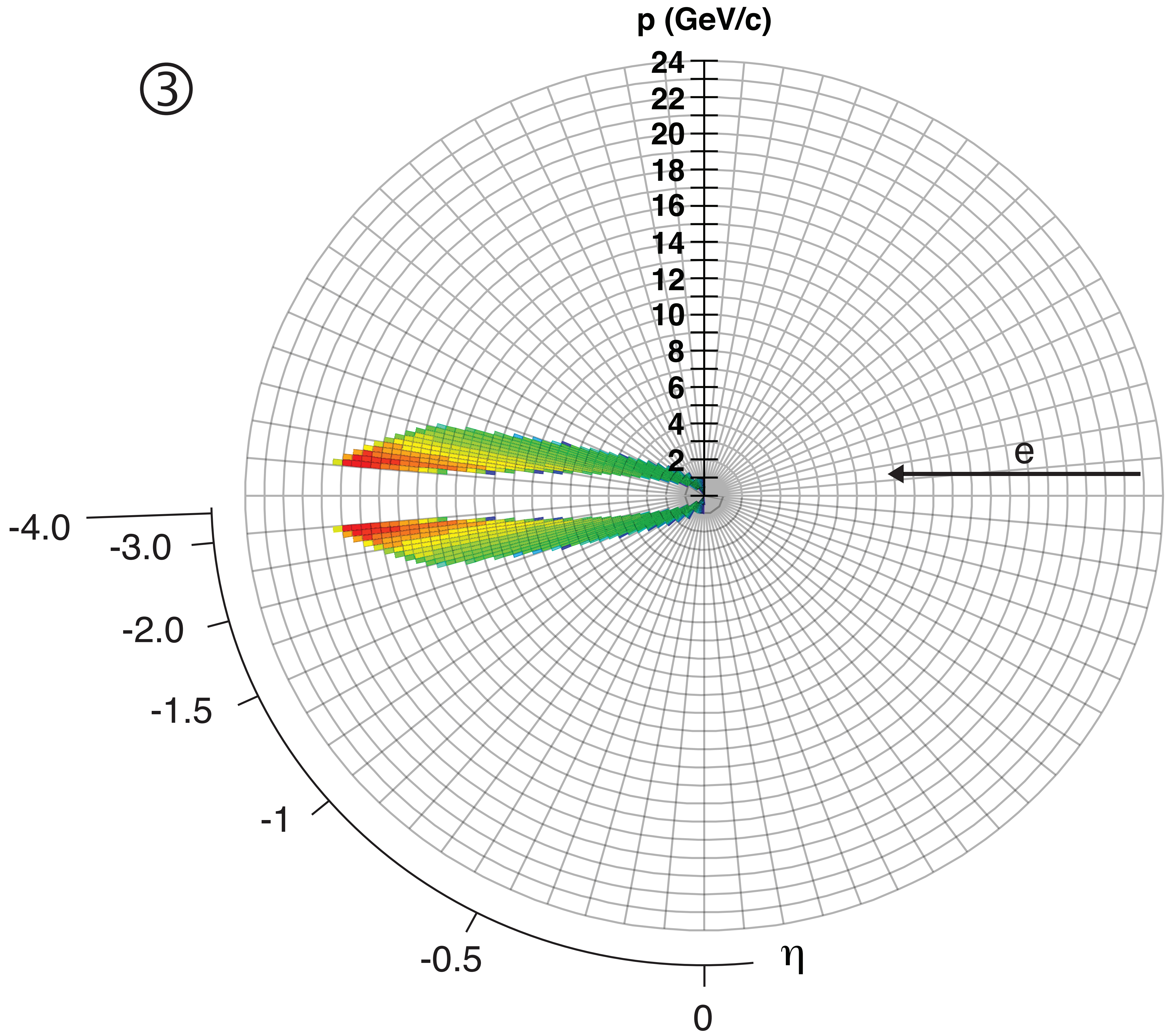


20 GeV on 100 GeV, $3 < Q^2 < 20$ GeV^2, $1\cdot10^{-3} < x < 8\cdot10^{-3}$



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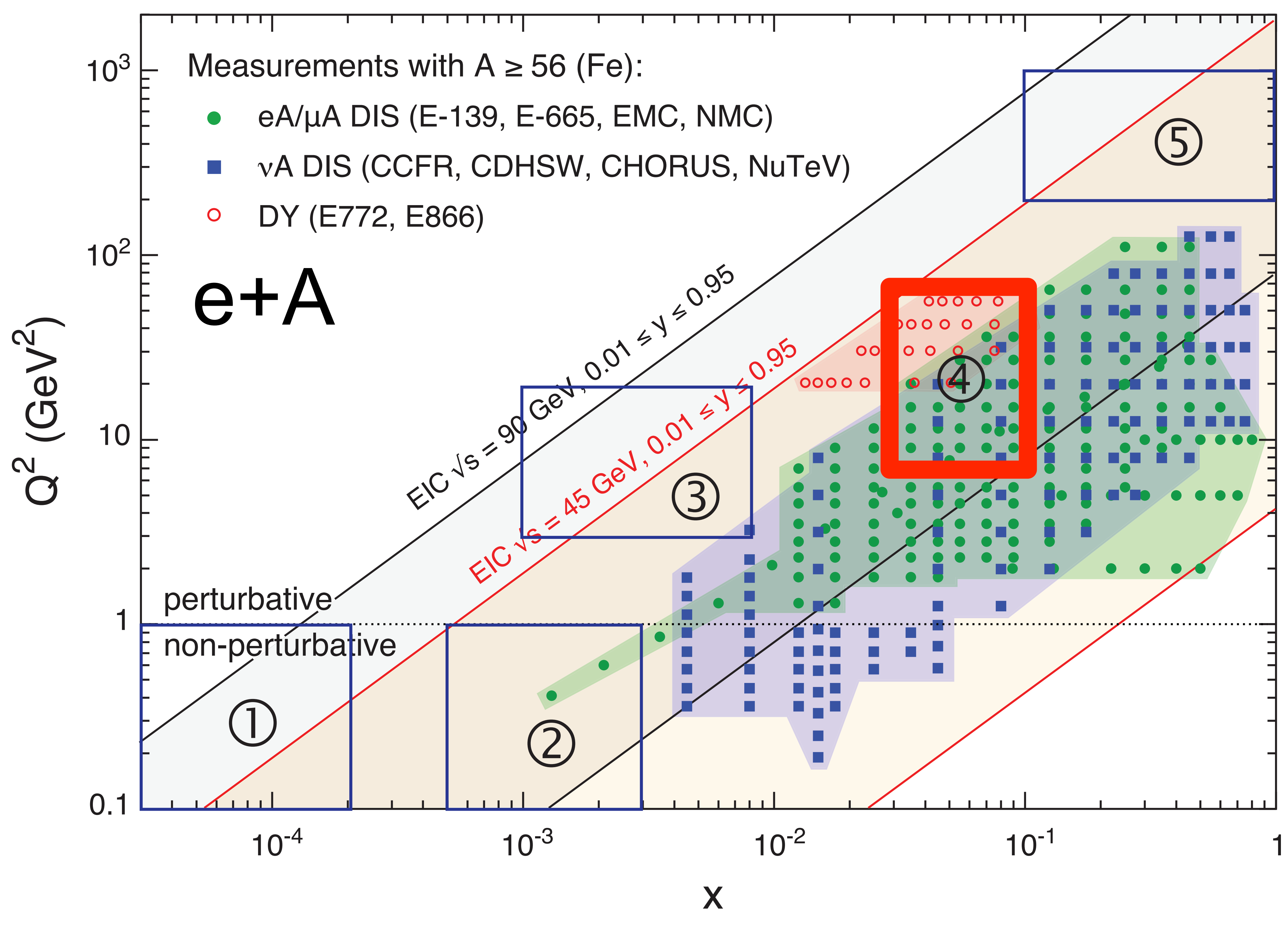
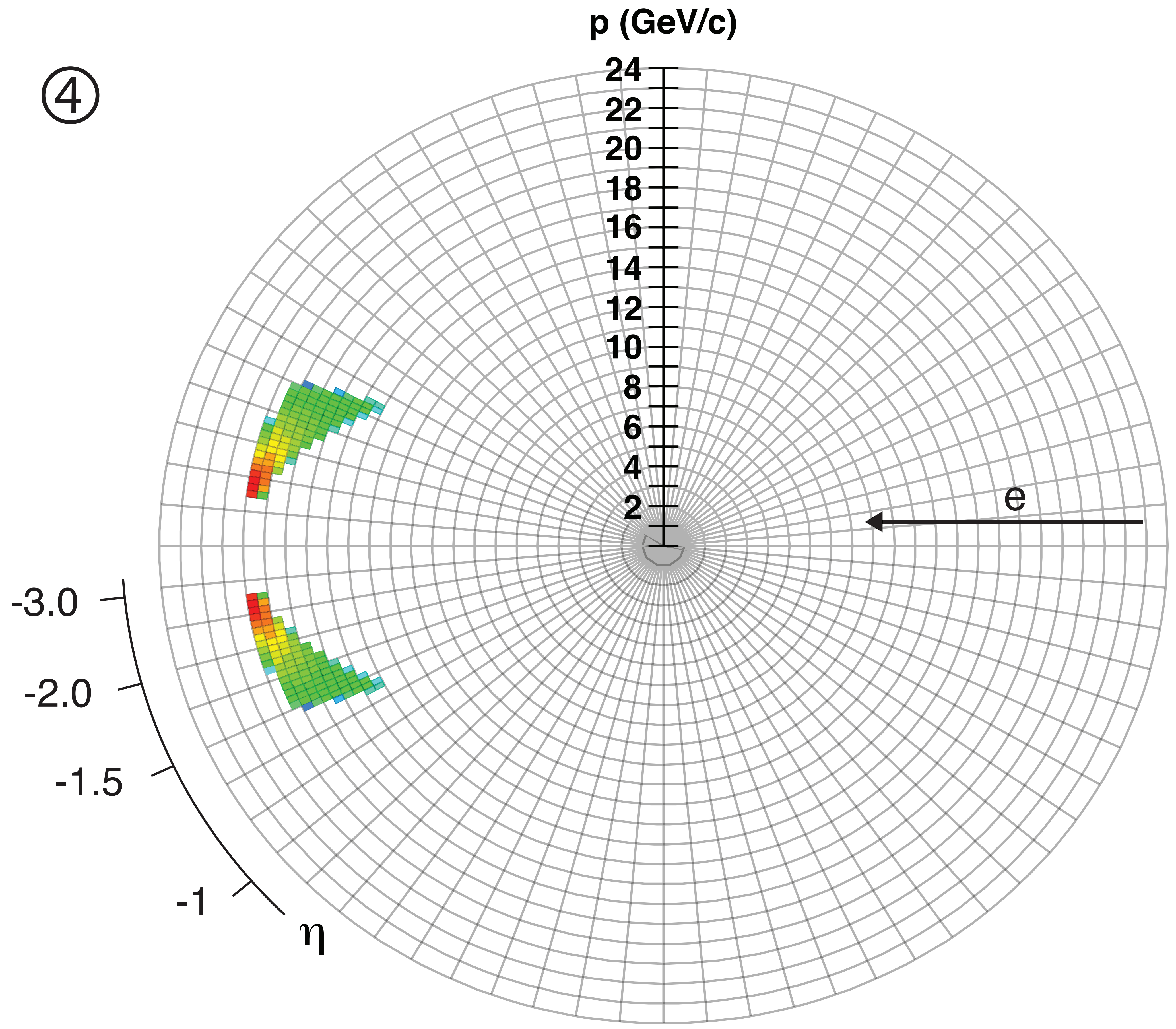


20 GeV on 100 GeV, $7 < Q^2 < 70$ GeV^2, $3{\cdot}10^{-2} < x < 1{\cdot}10^{-1}$



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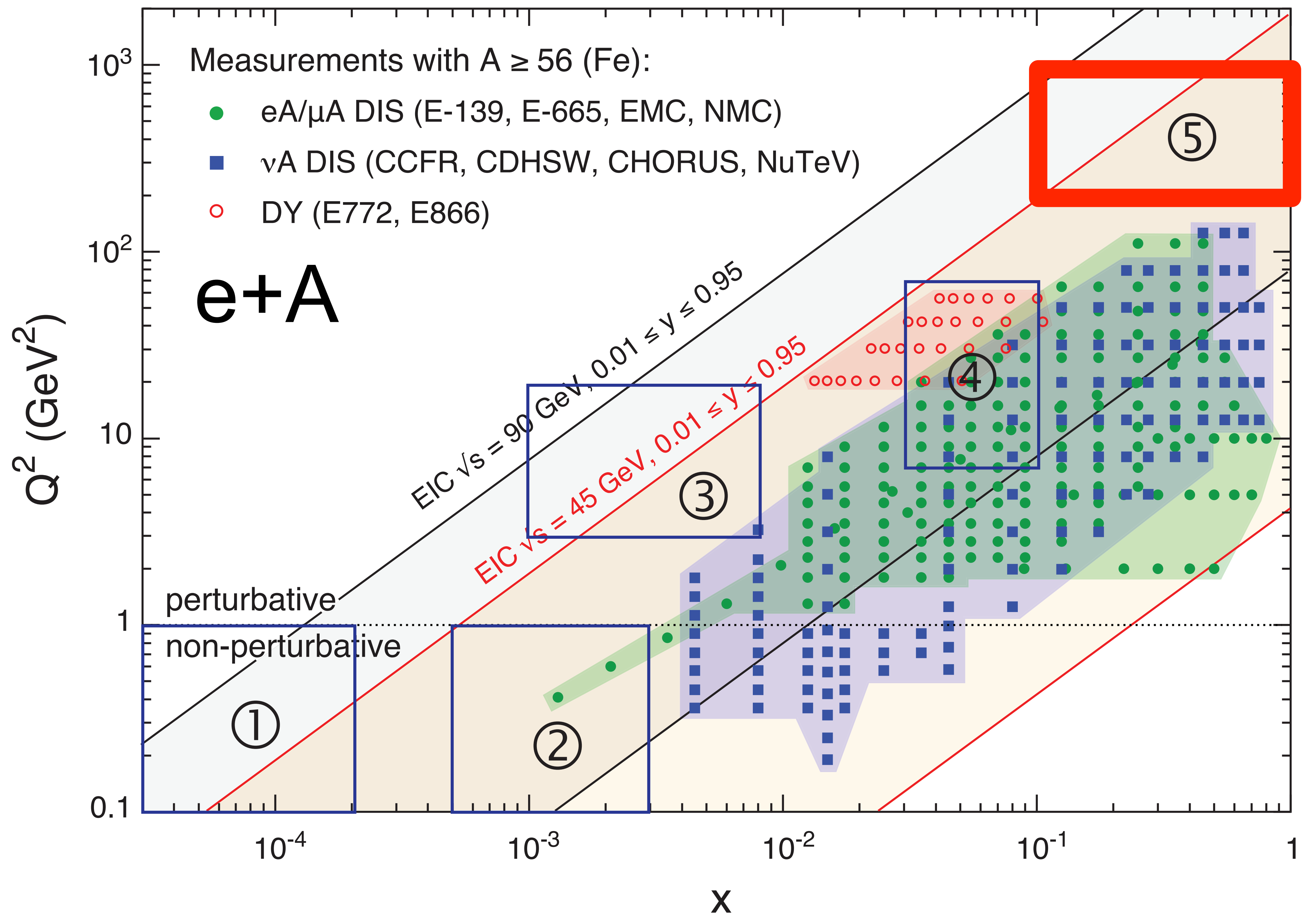
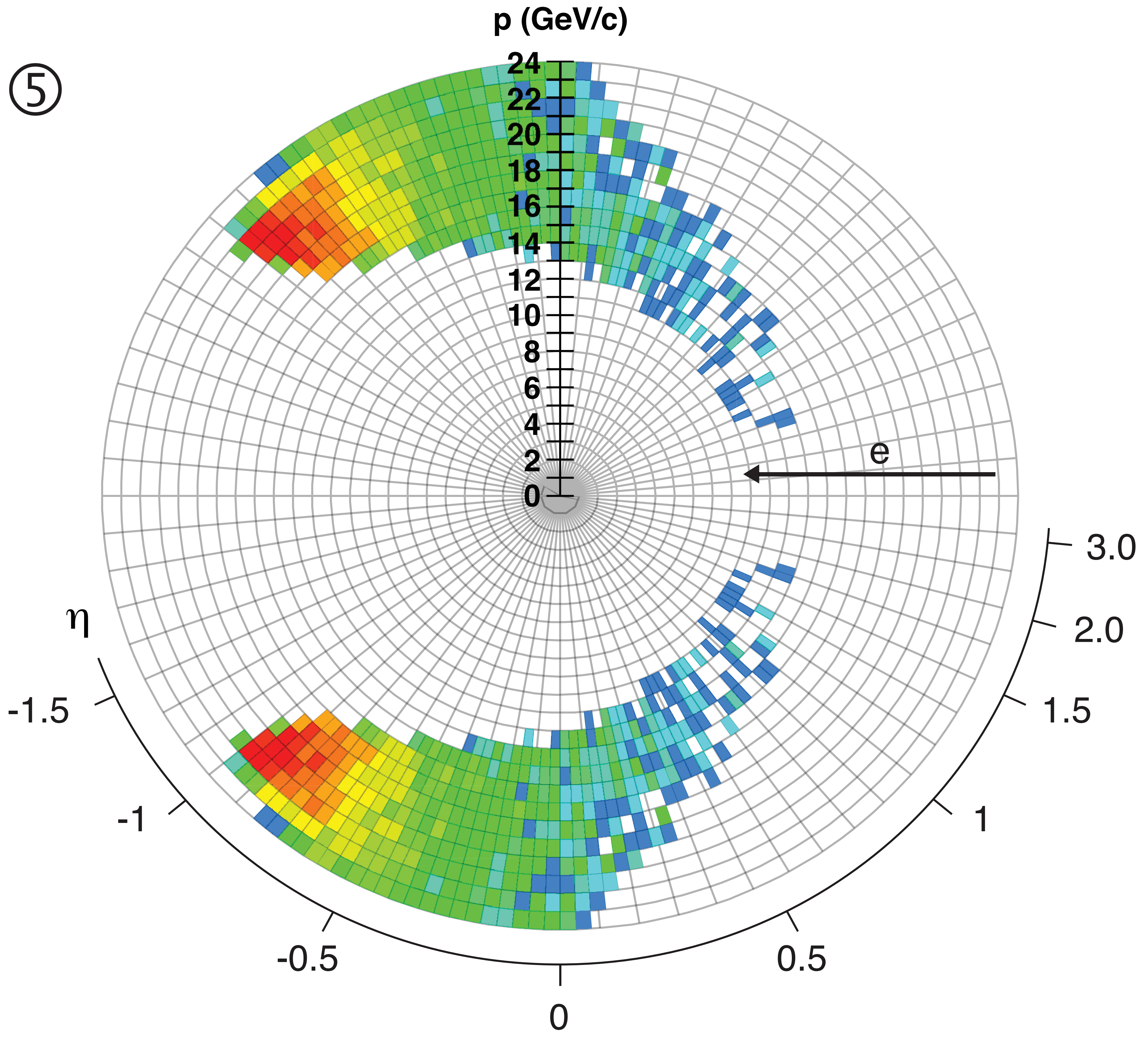


20 GeV on 100 GeV, 200 < Q^2 < 1000 GeV², 0.1 < x < 1



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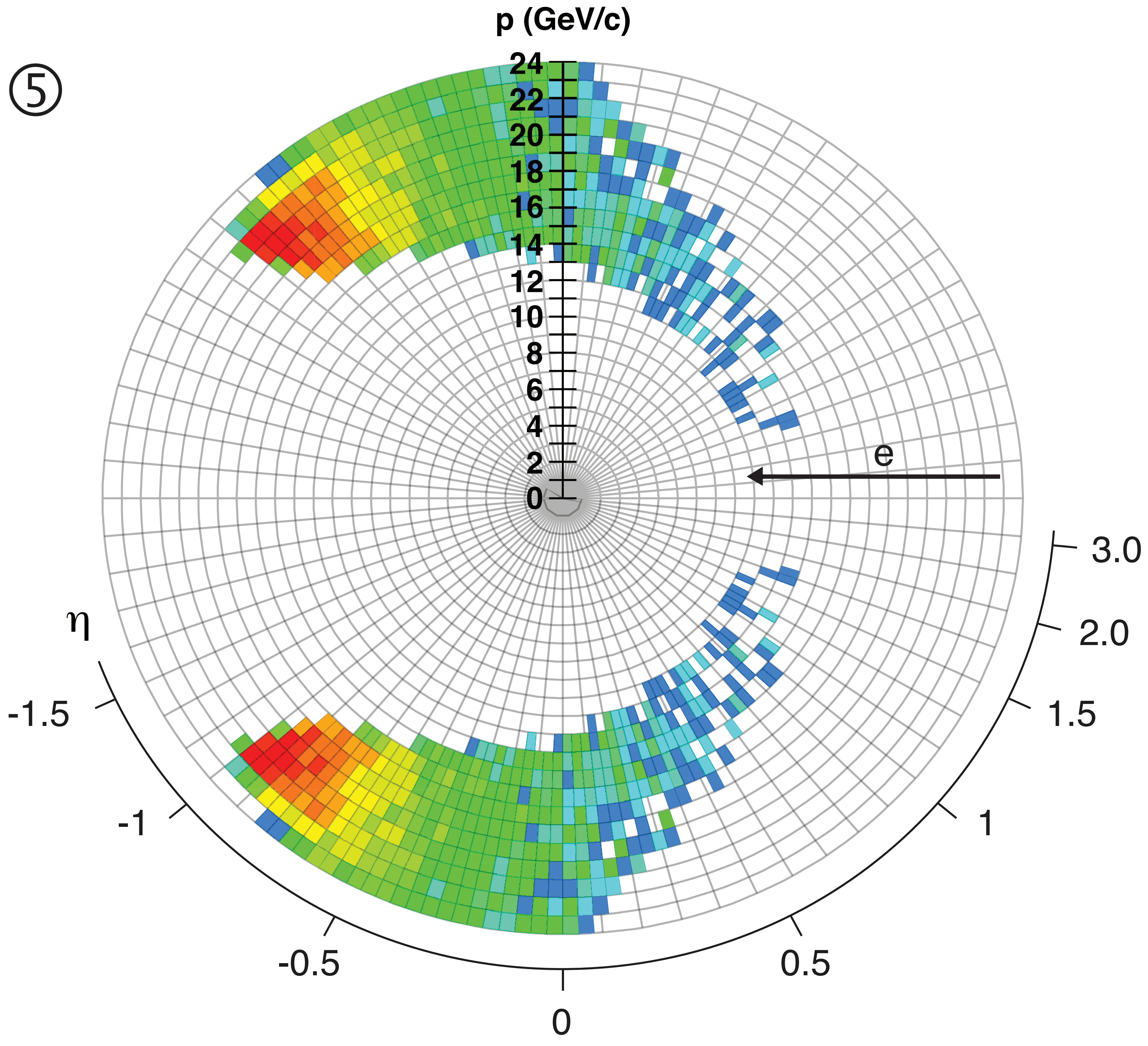
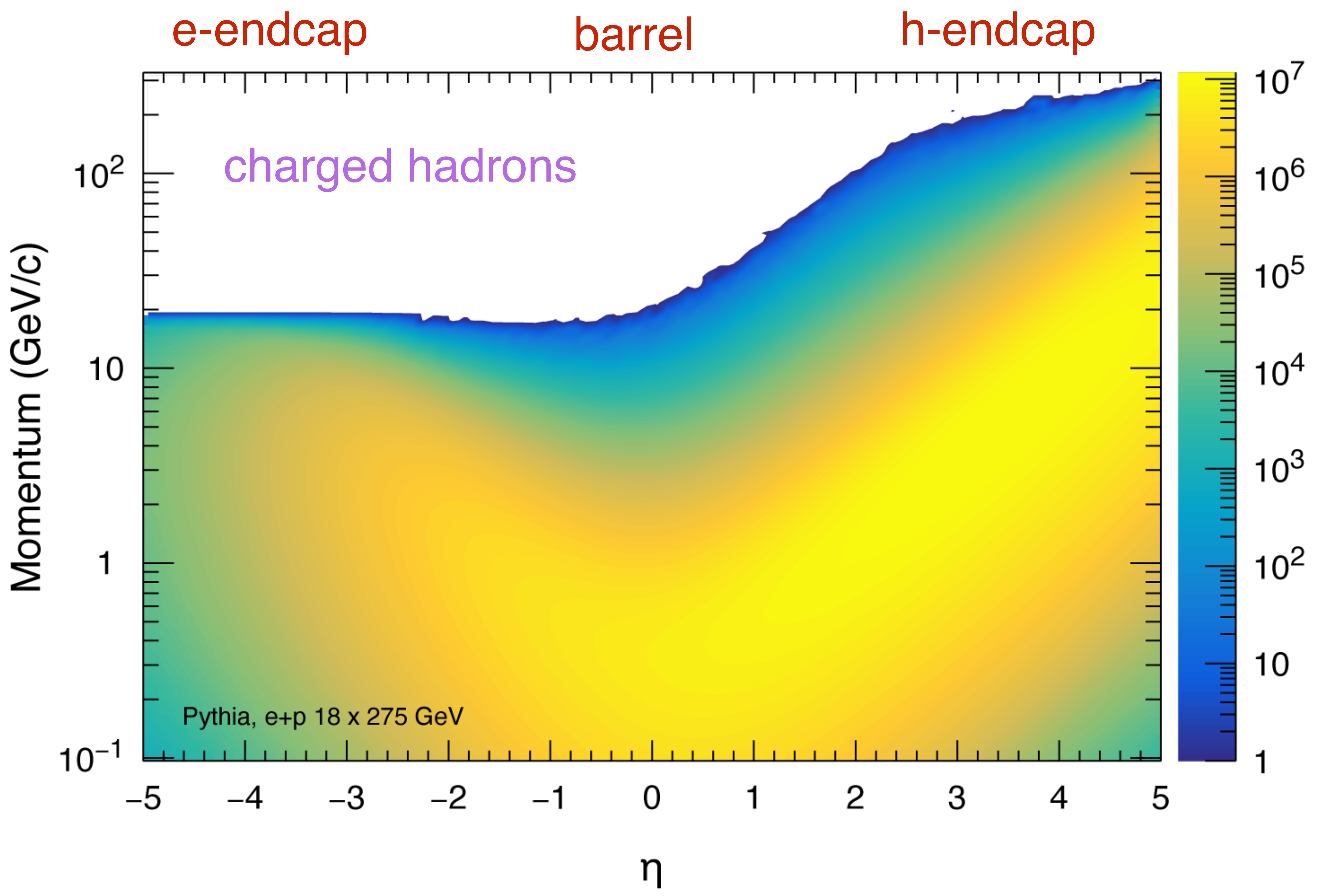
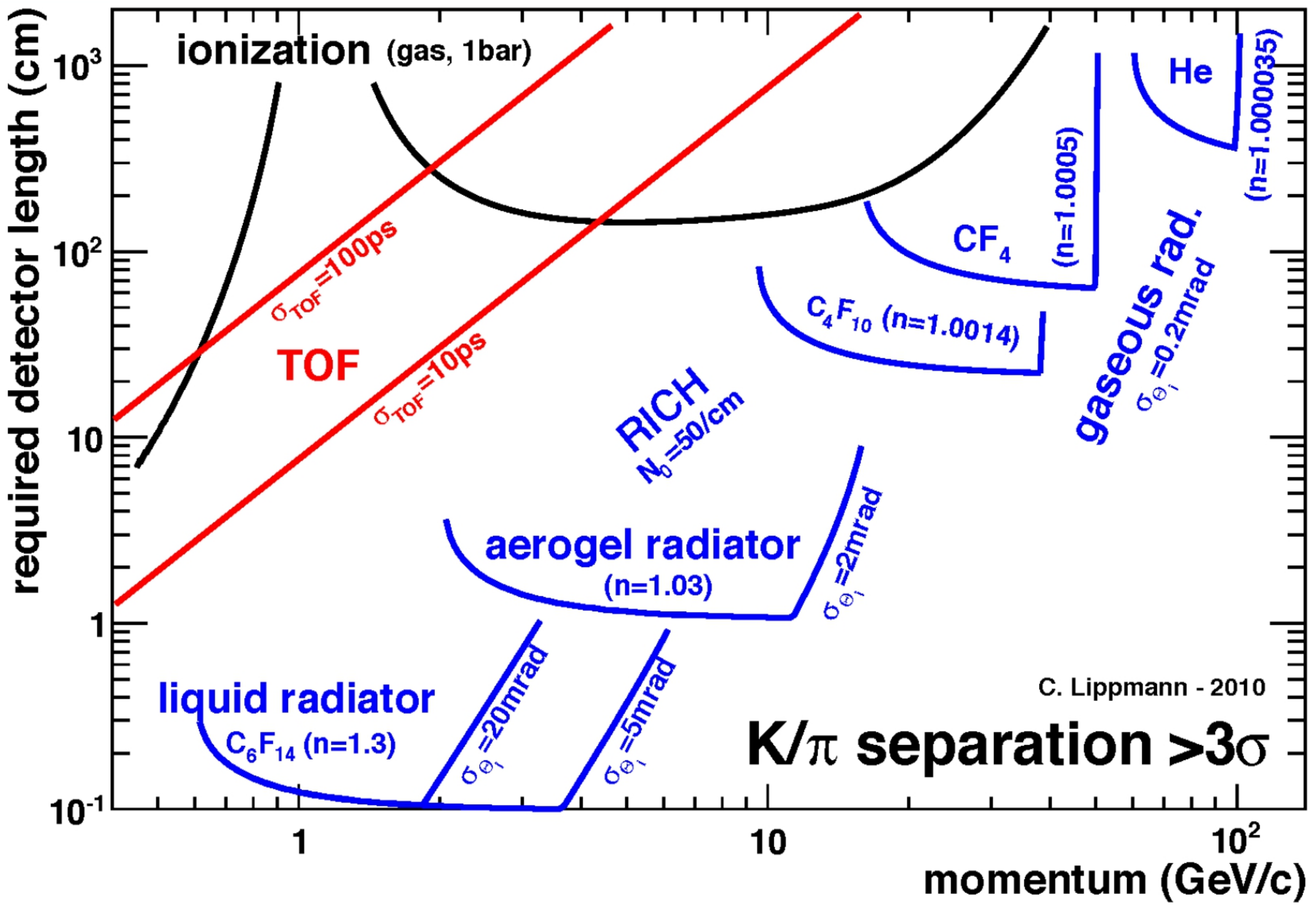
20 GeV on 100 GeV, $200 < Q^2 < 1000$ GeV^2, $0.1 < x < 1$

- e' Measurement Requires:
  - excellent electron identification (e/h)
  - equal rapidity coverage for tracking and calorimeter
  - low material budget to reduce bremsstrahlung
  - momentum/energy and angular resolution are critical



SIDIS: Hadron Identification Requirements





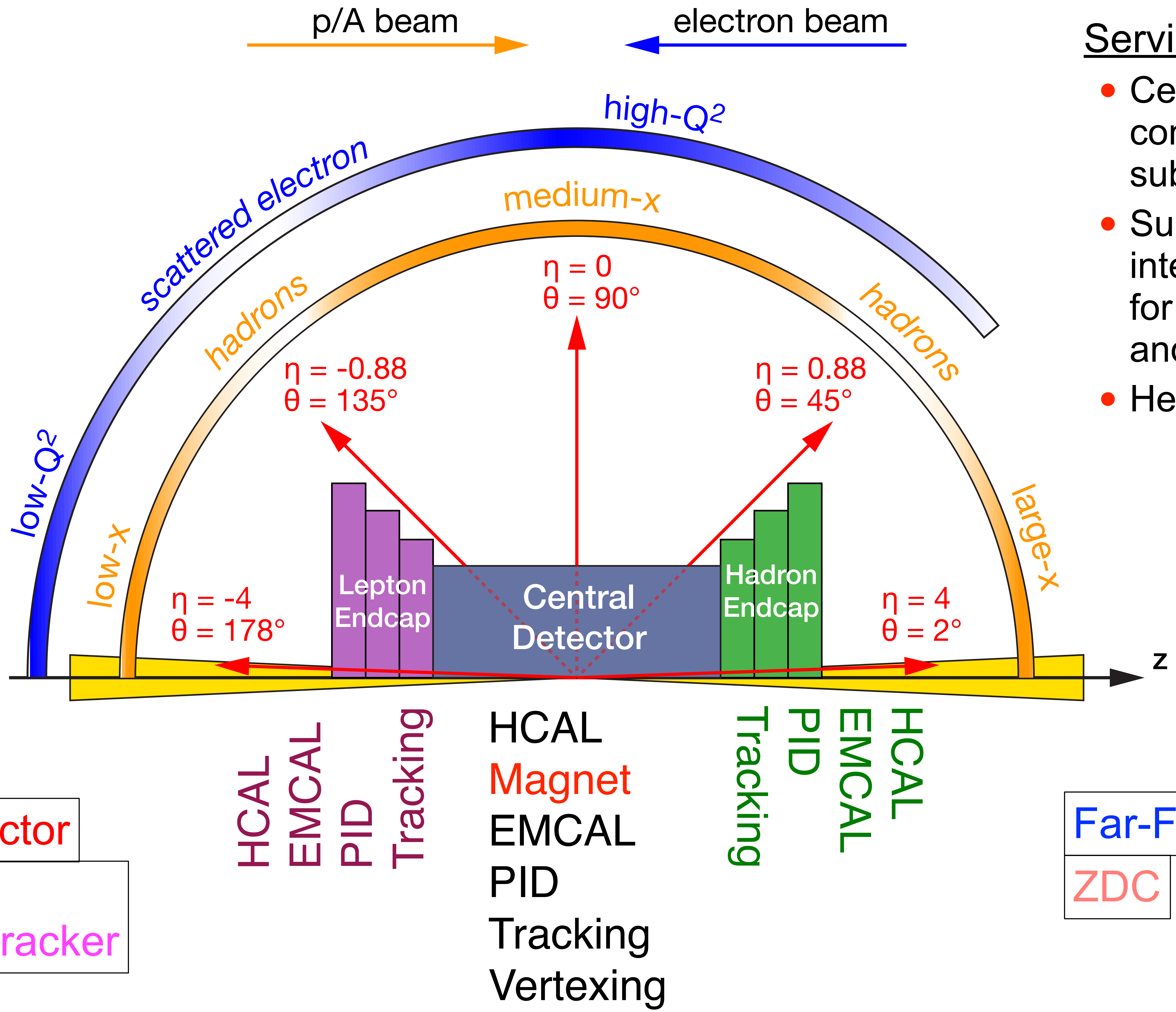
- Physics Requirements
  - $\pi^{\pm}, K^{\pm}, p^{\pm}$ separation over a wide range $|\eta| \leq 3.5$
- Strong Momentum–η correlation
  - -5 < η < 2: 0.2 < p < 10 GeV/c
  - 2 < η < 5: 0.2 < p < 50 GeV/c

- Need absolute particle numbers at high purity and low contamination
- Require more than one technology to cover the entire range
- EIC PID needs are more demanding then at most collider detector

EIC General Purpose Detector Concept

Magnet

- Cannot affect the *e* beam to avoid synchrotron radiation ⇒ Solenoidal Field (common in HEP)
- Downside is missing bending power $\int B \cdot dl$ in forward and backward region putting extreme requirements on tracking (h) and calorimetry (e)



Services

- Central detector will contain ~25 different subsystems
- Substantial integration challenge for power, cooling, and data services
- Hermeticity?!

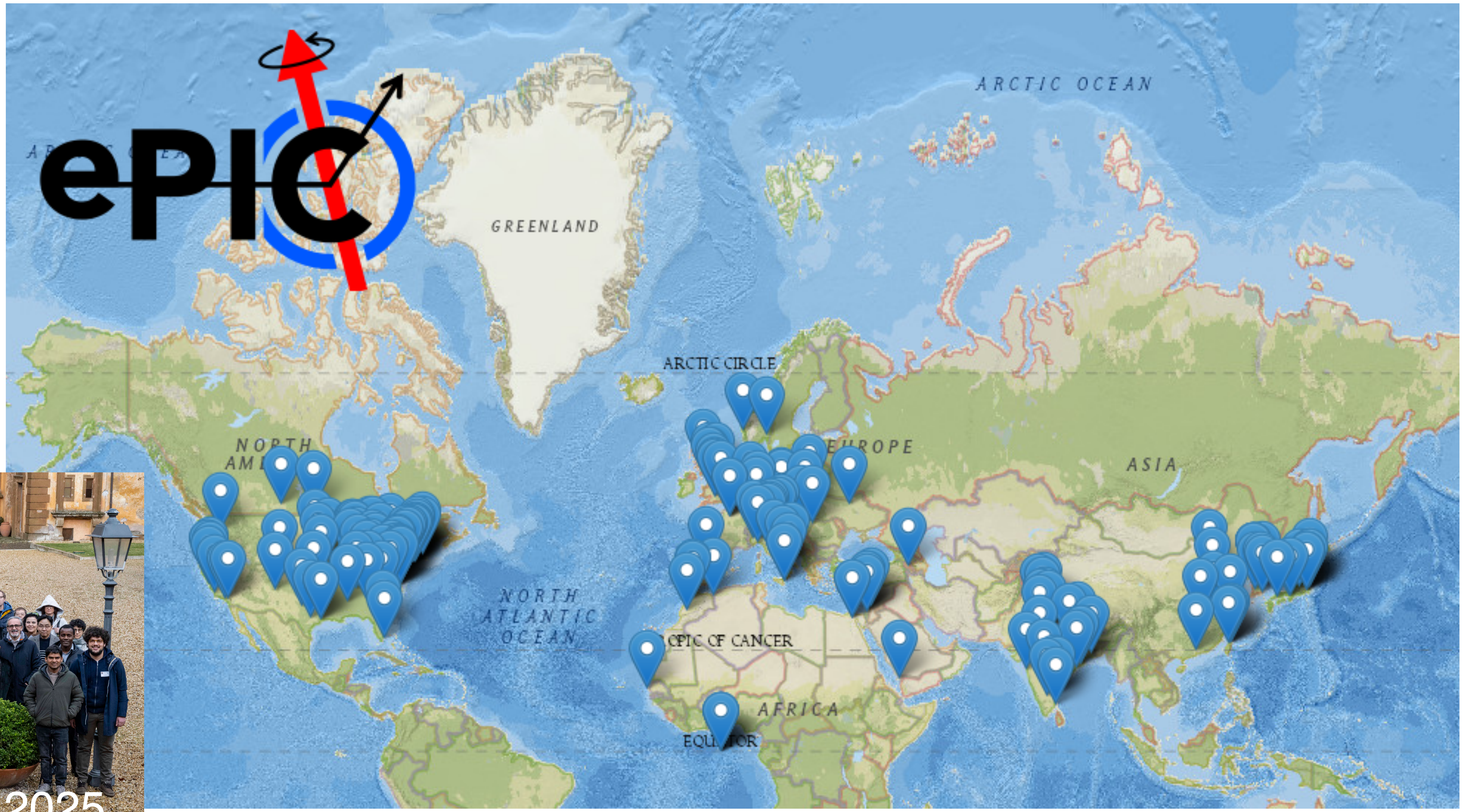
Brief Review of Requirements (see Yellow Report)

- Hermetic detector, low mass inner tracking
- Moderate radiation hardness requirements
- Electron measurement & jets in approx. -4 < η < +4
- Good momentum resolution
  - central: $\sigma(p)/p = 0.05\,\%\,p \oplus 0.5\,\%$
  - fwd/bkd: $\sigma(p)/p = 0.1\% \oplus 0.5\,\%$
- Good impact parameter resolution:
  - $\sigma = 5 \oplus 15/p\sin^{3/2}\theta\ (\mu\text{m})$
- Excellent EM resolution
  - central: $\sigma(E)/E = 10\,\%/\sqrt{E}$
  - backward: $\sigma(E)/E < 2\,\%/\sqrt{E}$
- Good hadronic energy resolution
  - forward: $\sigma(E)/E \approx 50\,\%/\sqrt{E}$
- Excellent PID π/K/p
  - forward: up to 50 GeV/c
  - central: up to 8 GeV/c
  - backward: up to 7 GeV/c
- Low pile-up, low multiplicity, data rate ~500kHz (full lumi)

Hermeticity, low mass, and PID requirements make EIC detector design challenging

electron Proton and Ion Collider experiment ePIC

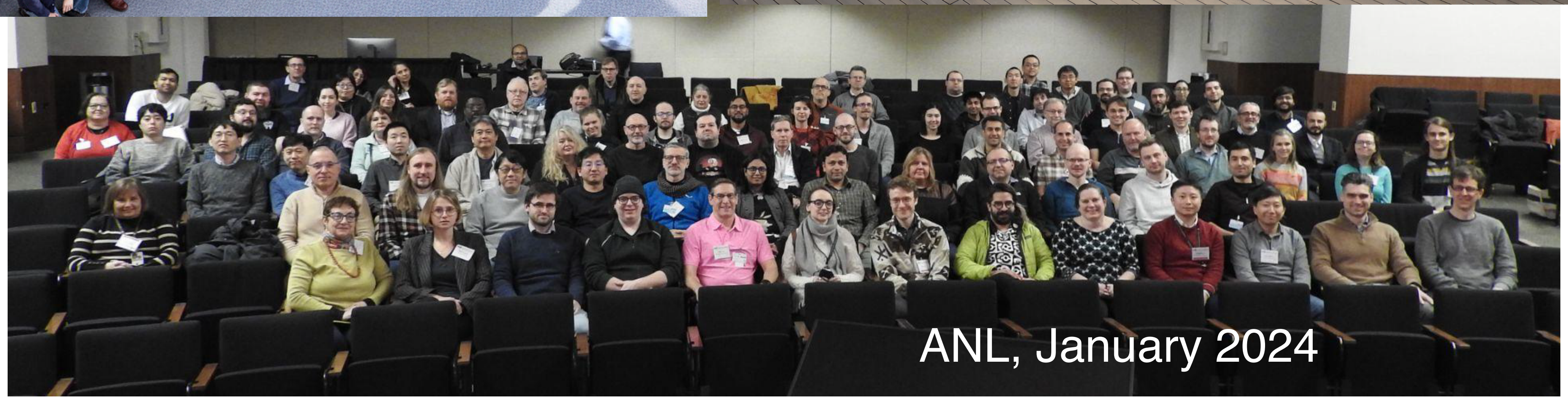
- ePIC was founded in July 2022
- ePIC is a community of scientists dedicated to realizing the EIC science mission
- They work closely with the EIC Project formed by the two host labs, BNL and JLab
- ePIC is international:
  - 1054 Members
  - 180 Institutions
  - 26 Countries




Frascati, January 2025

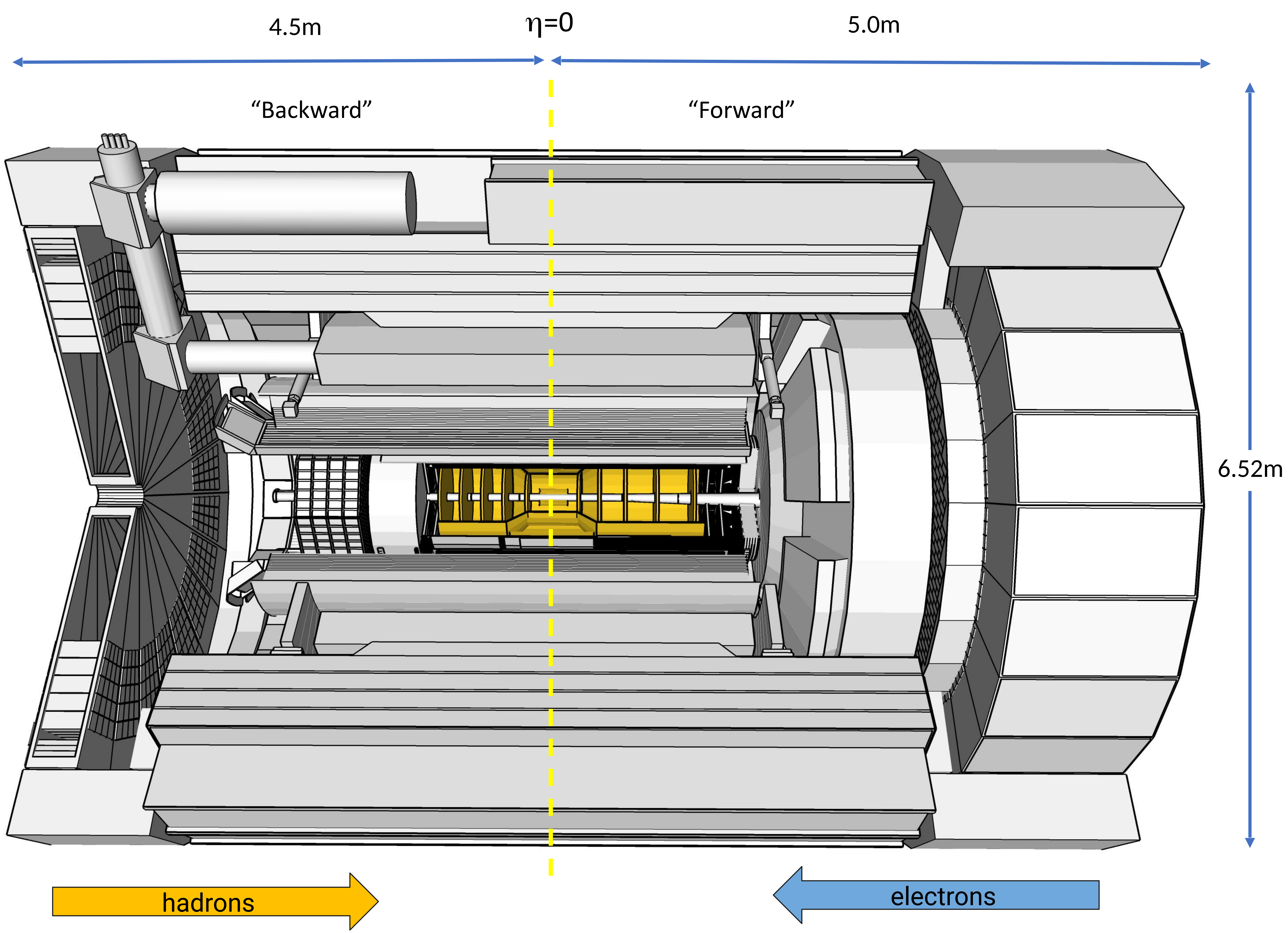

JLab, Jan. 2023


Warsaw, July 2023


ANL, January 2024


Lehigh, July 2024

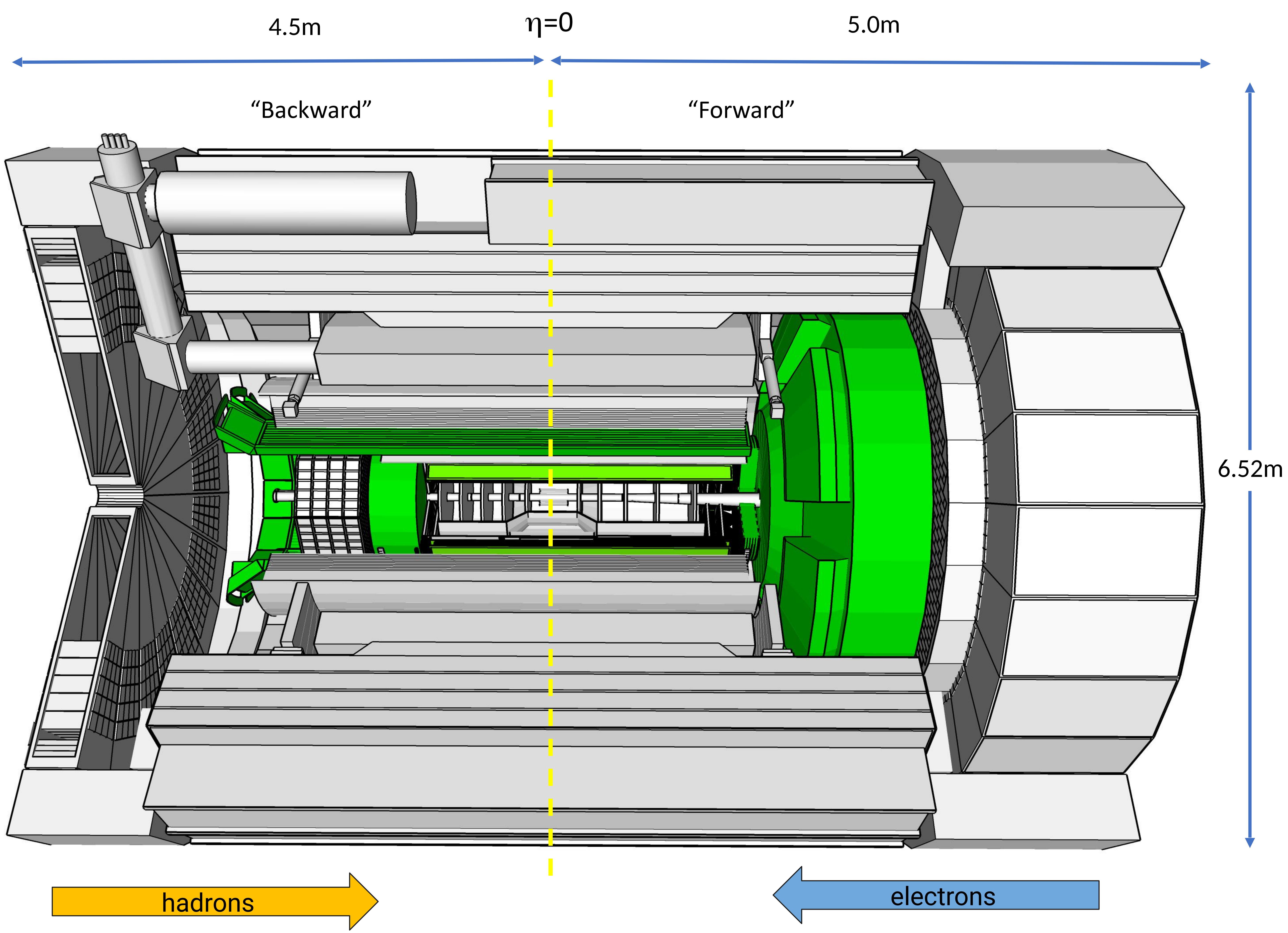
ePIC Overview



Tracking:

- New 1.7T (2.0T) solenoid
- Si MAPS Tracker
- MPGDs (μRWELL/μMegas)

ePIC Overview



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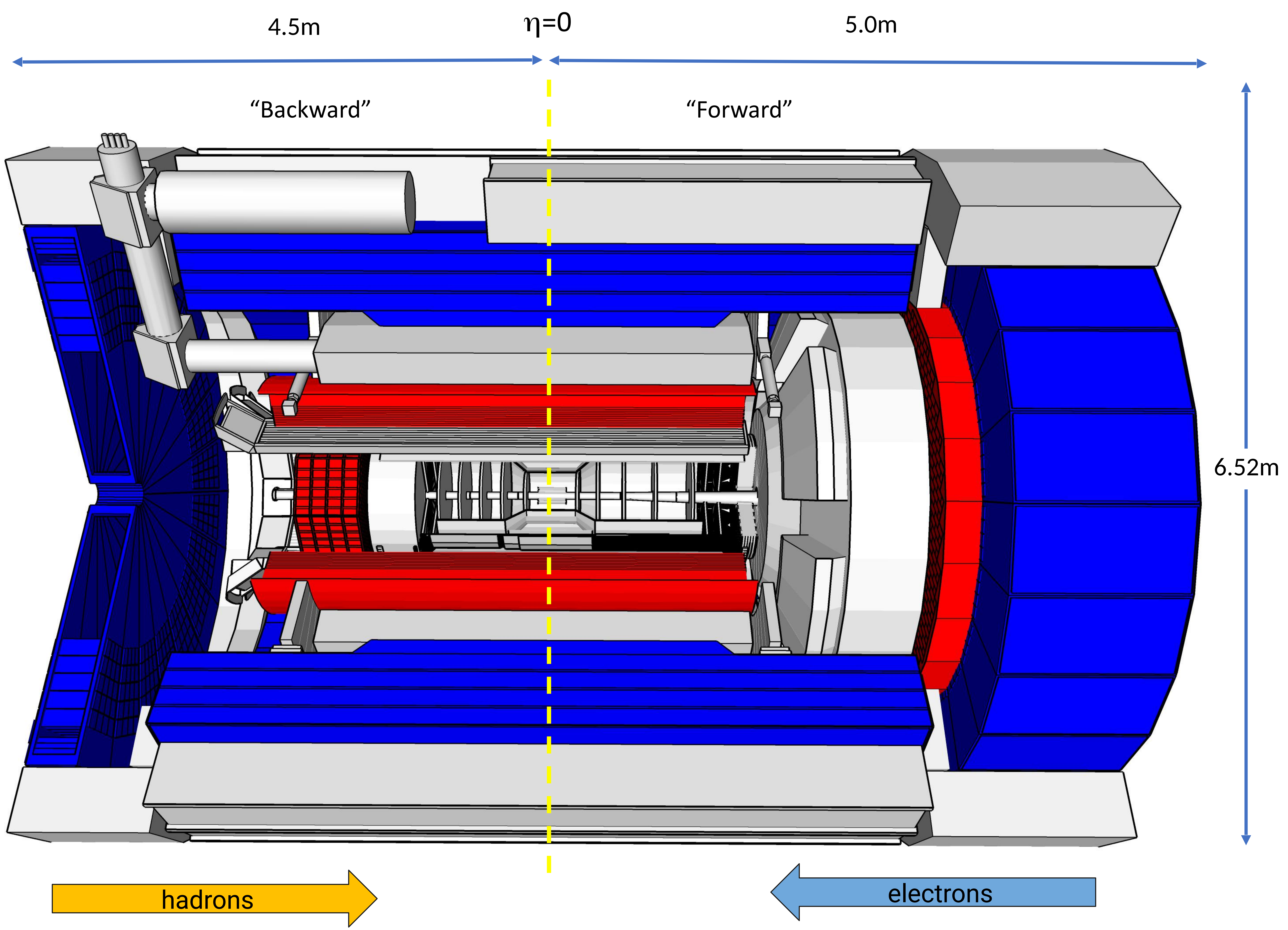
PID:

- high-performance DIRC
- proximity-focused RICH
- dual-radiator RICH
- AC-LGAD (~30ps TOF)

ePIC Overview



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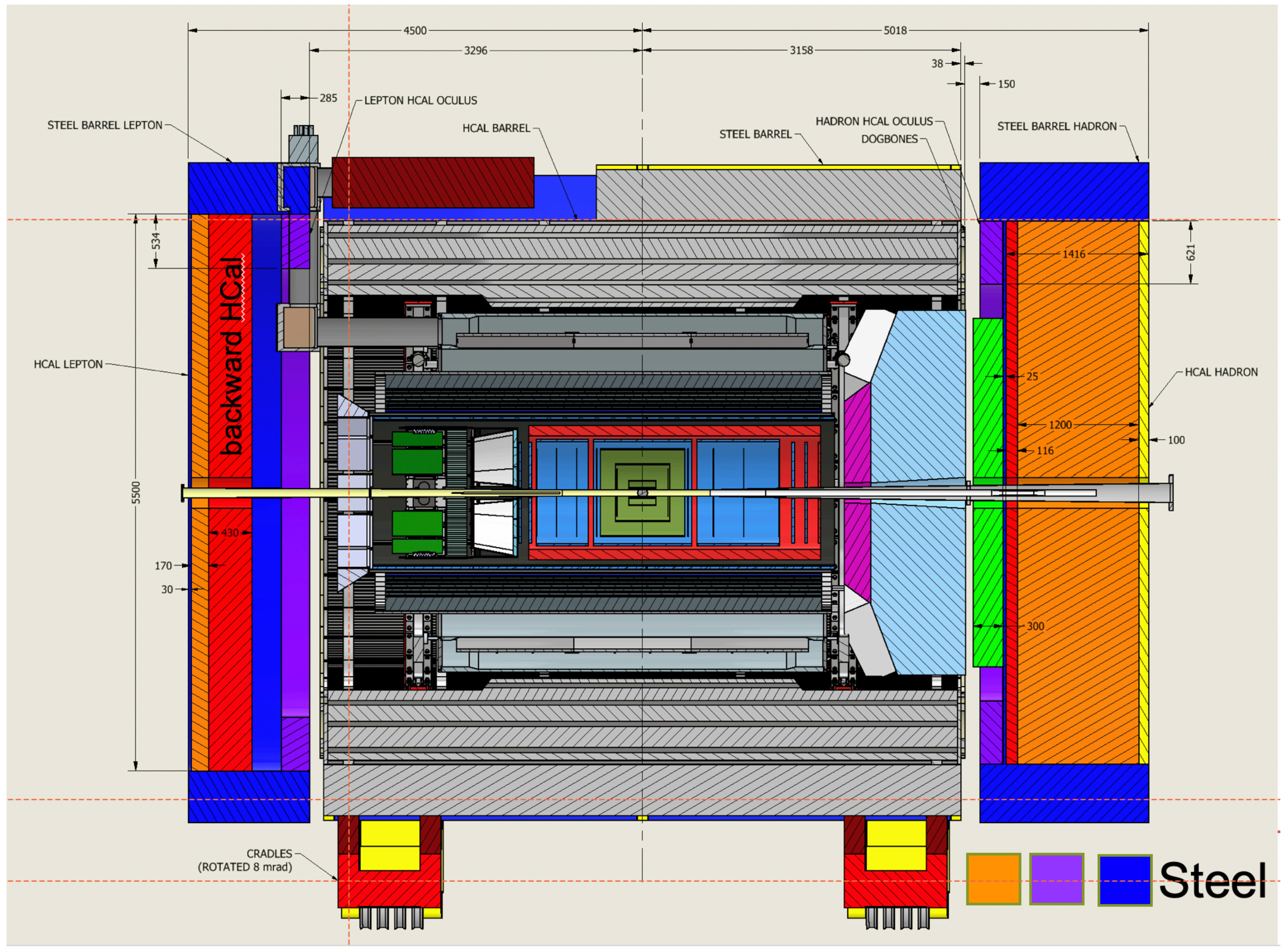
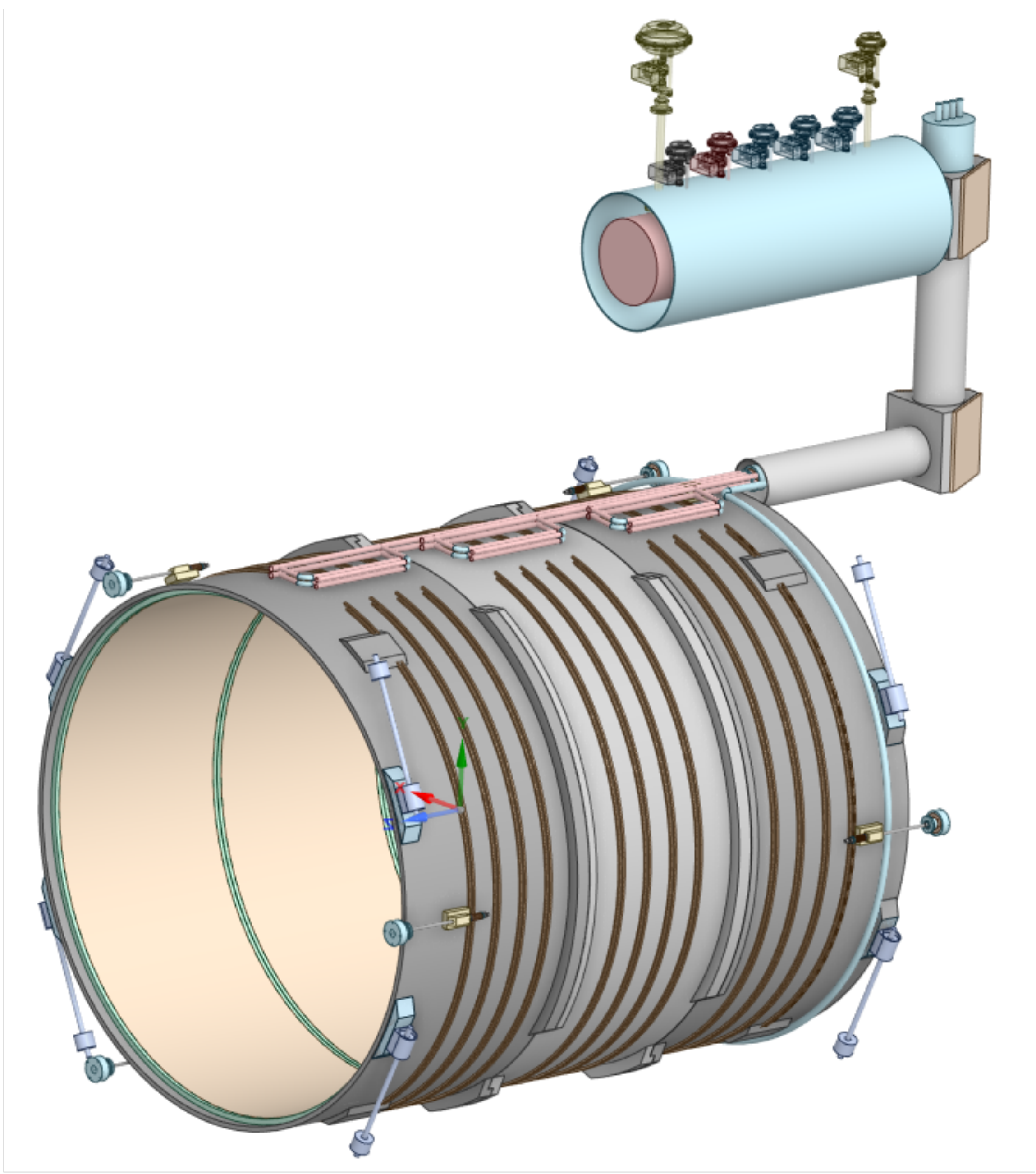
Calorimetry:
- Imaging Barrel EMCal
- PbWO4 EMCal (backwards)
- Finely segmented EMCal +HCal in forward direction
- Outer HCal (sPHENIX re-use)
- Backwards HCal (tail-catcher)

MARCO Magnet

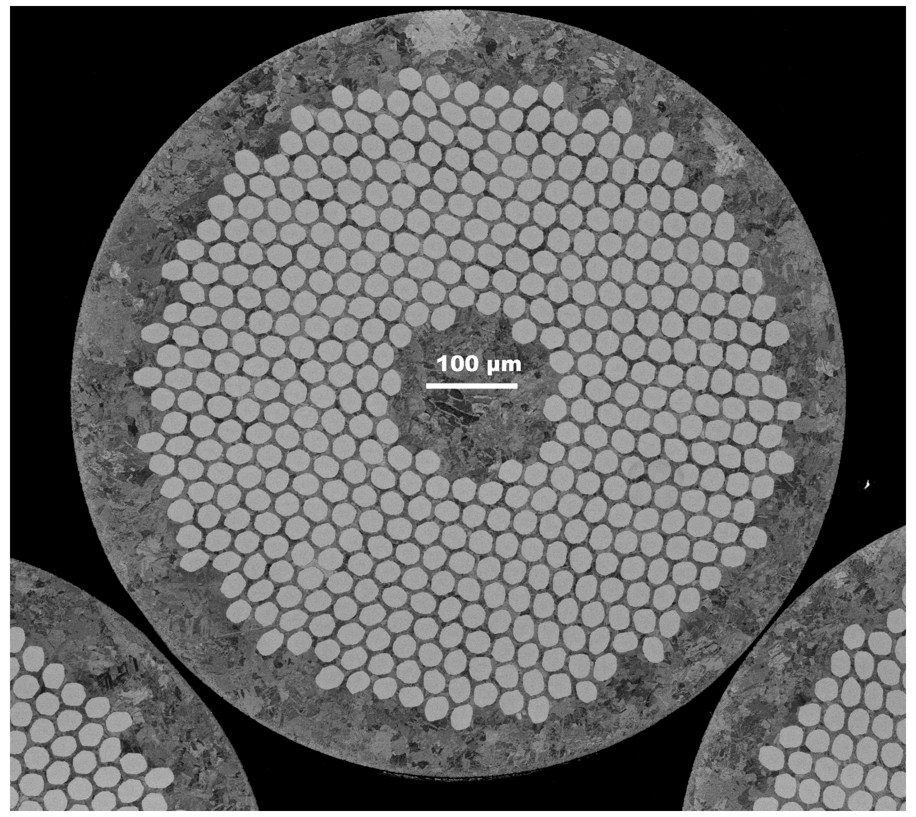




- New solenoidal SC magnet
- Coil is divided in 3 modules with 6 layers each. This is done mainly to accommodate possible conductor length.
- Flux return steel layout fully defined to minimize forces and fringe fields (~10G)

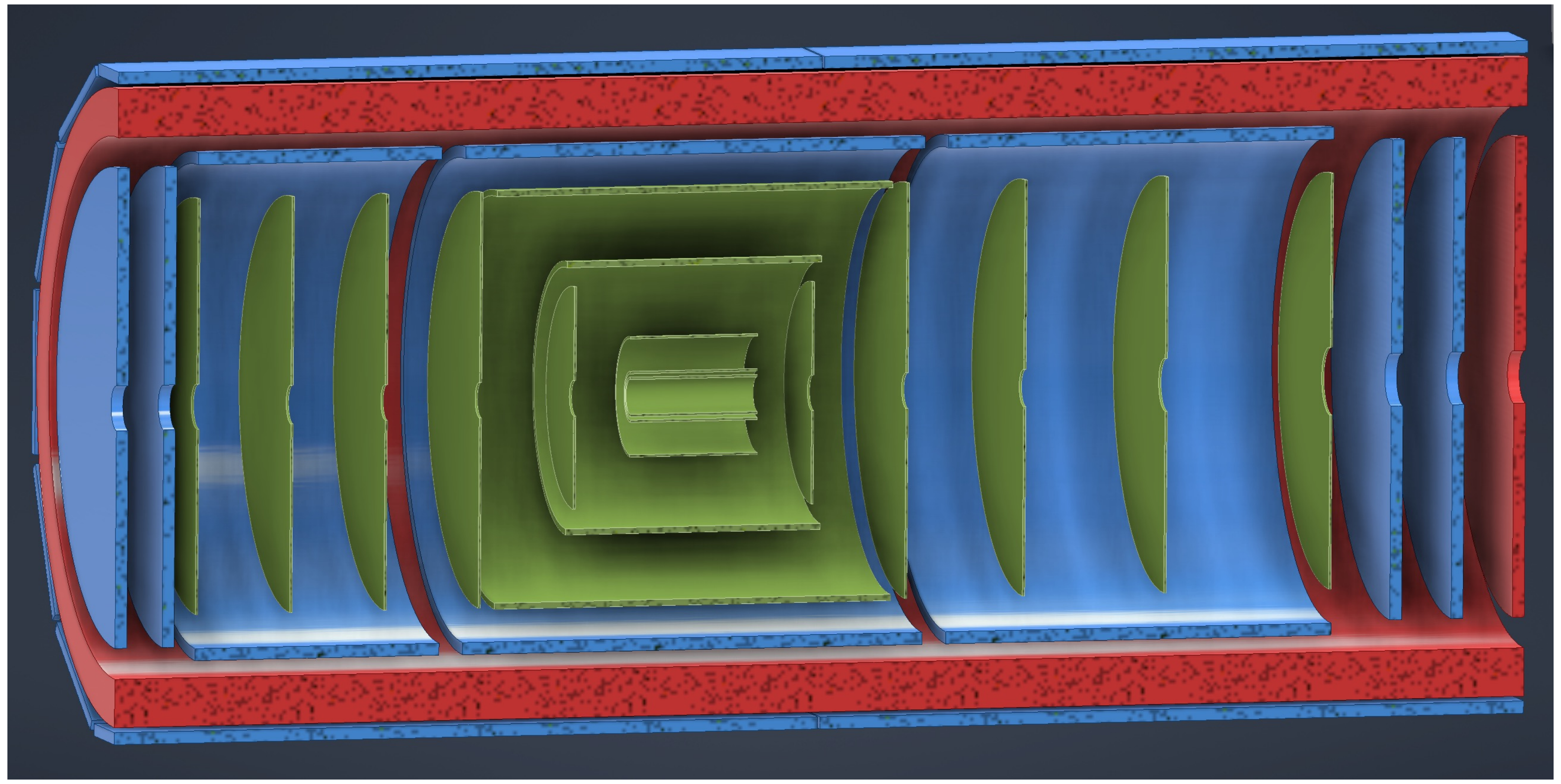
Robust and safe operating parameters

B_0	1.5 T	1.7 T	2.0 T	Units
Current	2942	3335	3924	A
T_{op}	4.7	4.7	4.7	K
B_{peak}	2.00	2.27	2.67	T
Temp. margin	3.06	2.82	2.45	K
Load line margin	59.6	54.2	46.1	%
$I / Ic(T,B_{peak})$	17.9	22.1	29.3	%

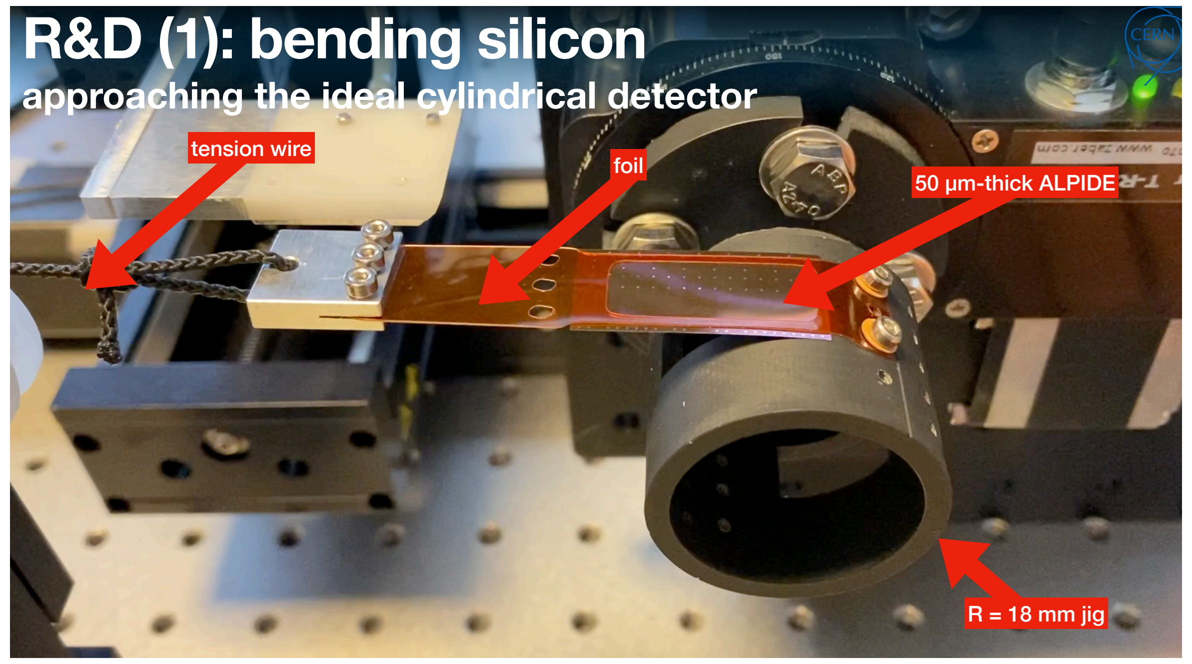


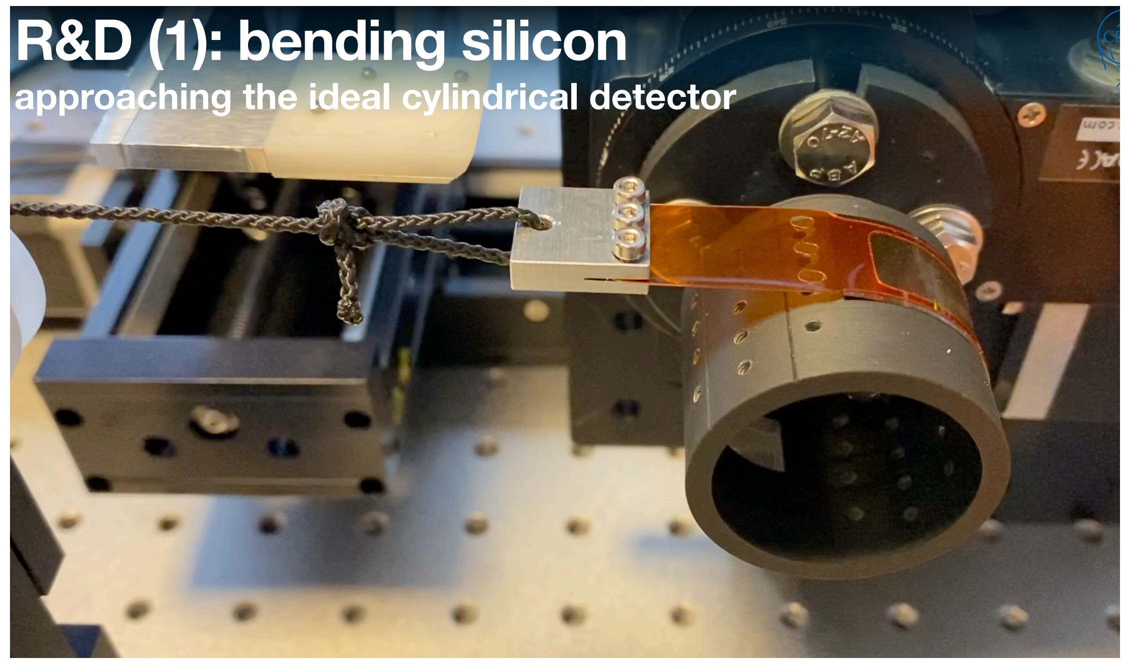
Magnet – strands for sample tests, the filaments are beautifully arranged – These are the final quality assurance tests before starting the long-lead procurement for conductor

Barrel Tracking

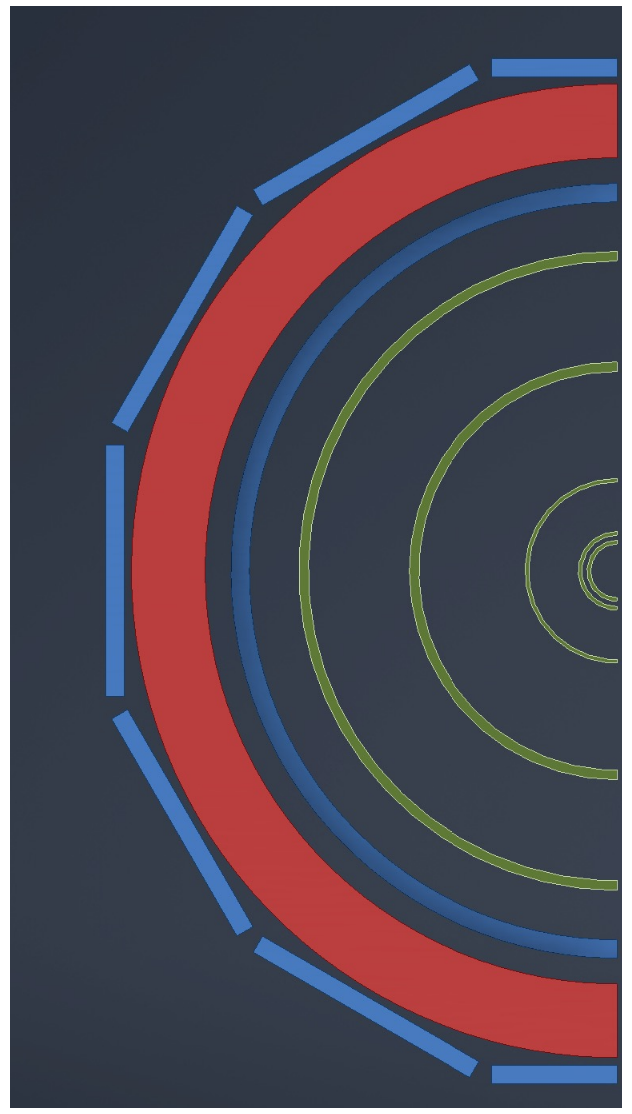


SVT MPGDs ToF (fiducial volume)





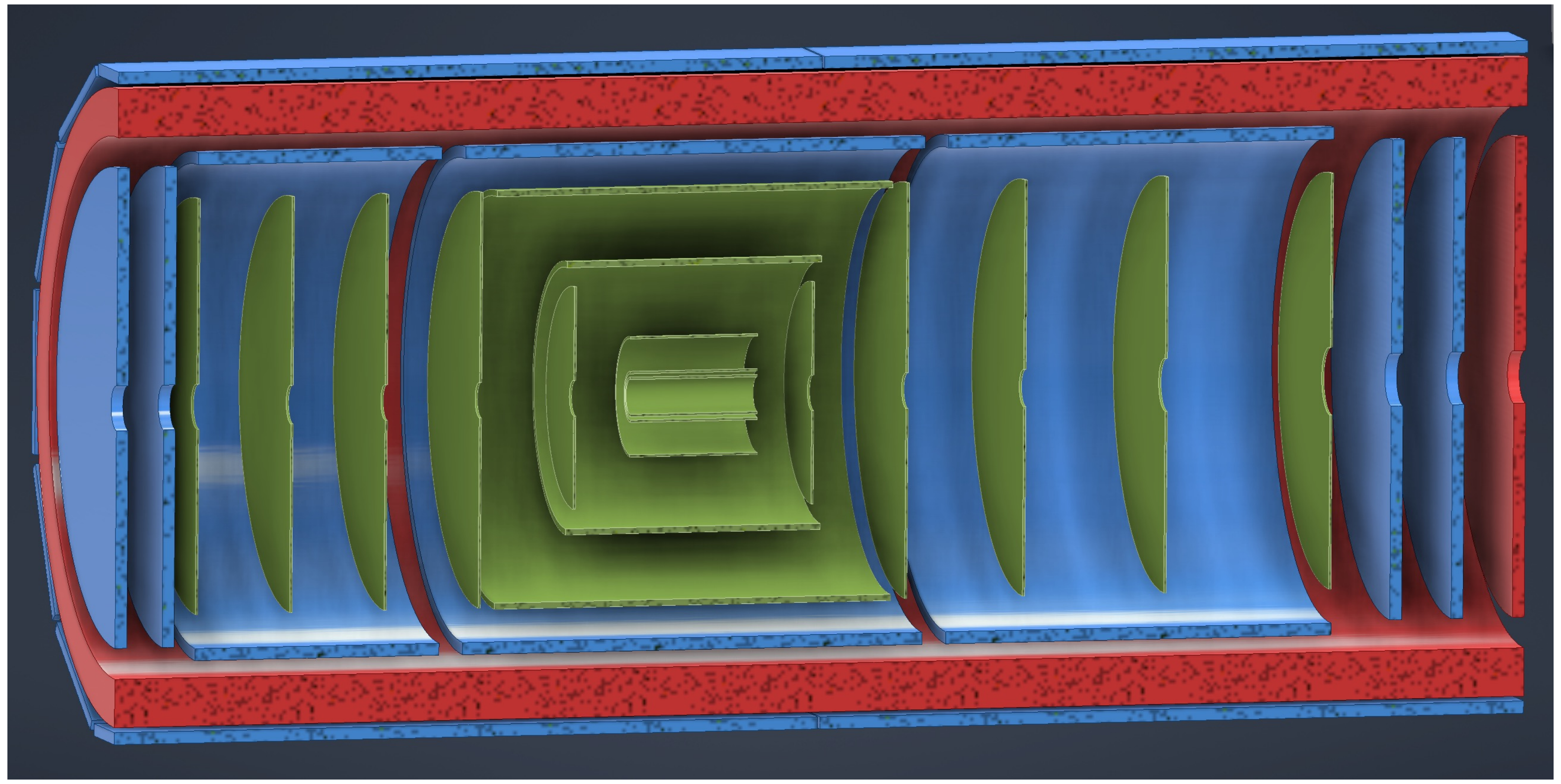
Bending 20 μm silicon



Si Vertex/Inner Barrel (3 layers)

- ITS3/sensor: Joint effort with ALICE/CERN (SVT Consortium)
- Large-area, wafer-scale, stitched sensors bent around beam pipe using latest 65 nm MAPS technology
- Small pixels (20 µm), low power consumption (<20 mW/cm^2) and material budget (~0.05% X/X_0) per layer
- Vertex layers optimized for beam pipe bake-out and ITS-3 sensor size

Barrel Tracking



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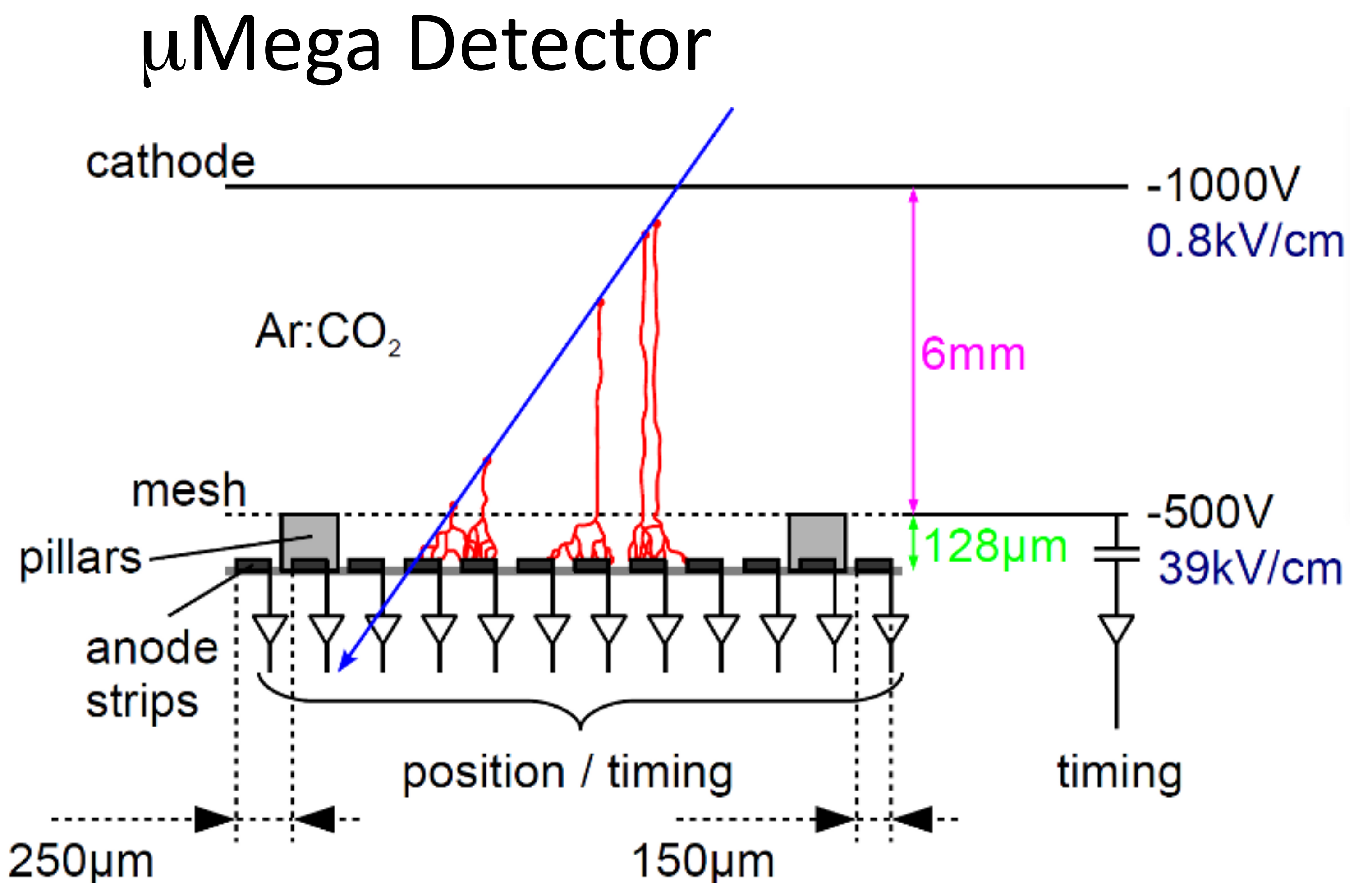
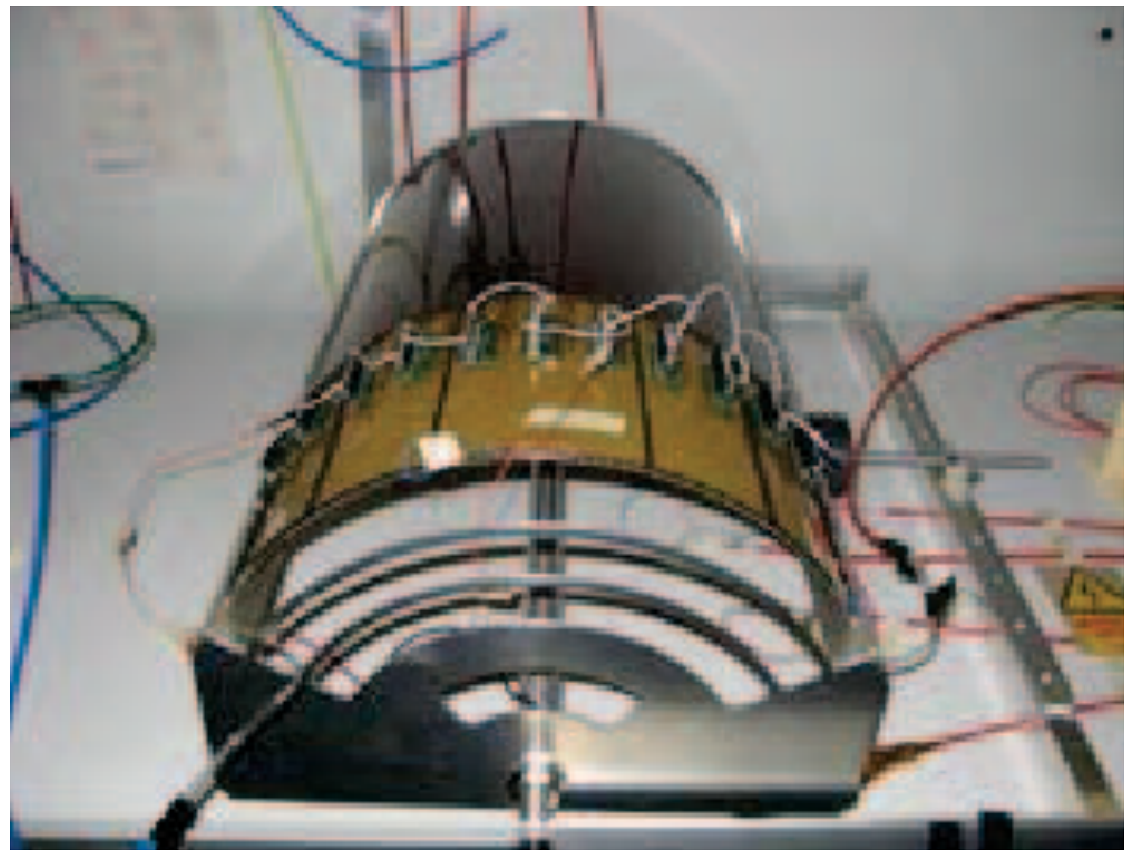
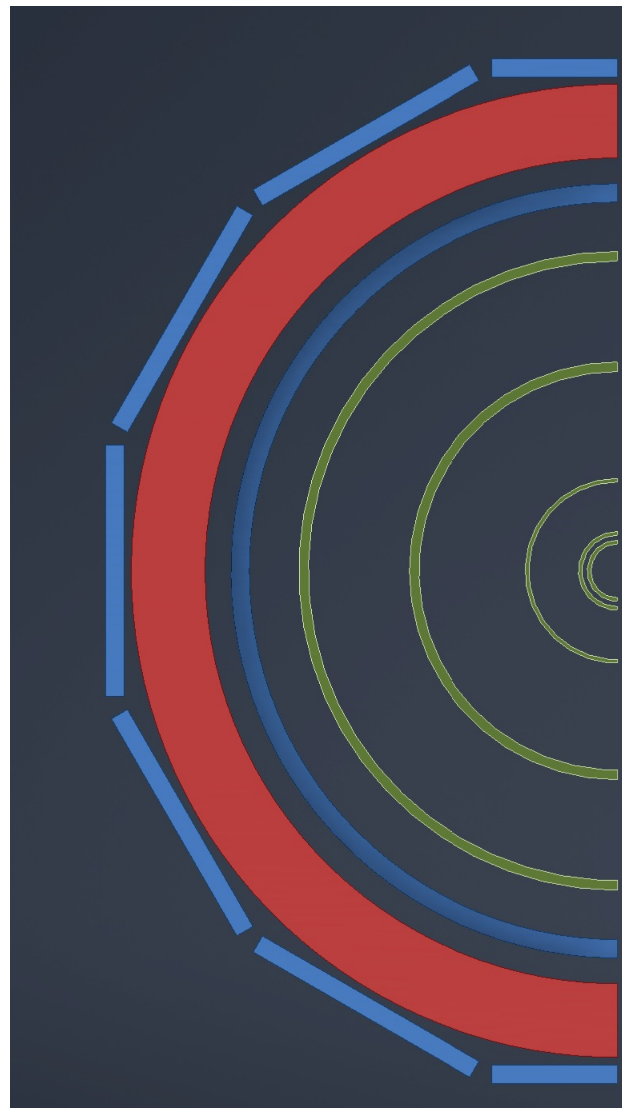


Cylindrical μMega



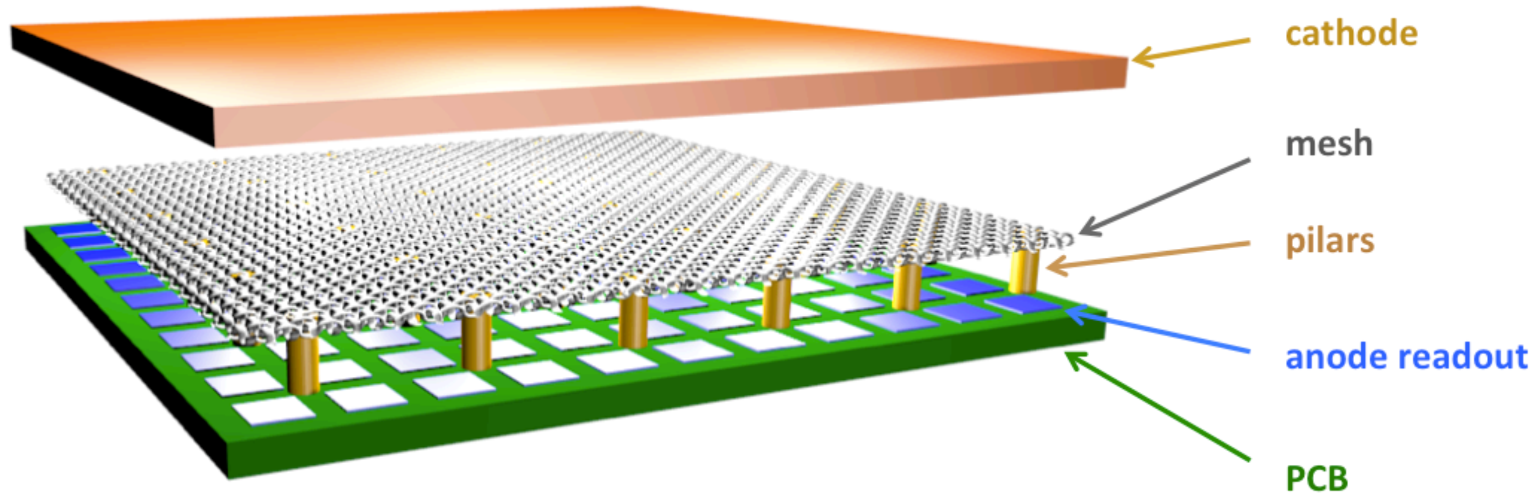


Si Tracking/Outer Barrel (2 layers)

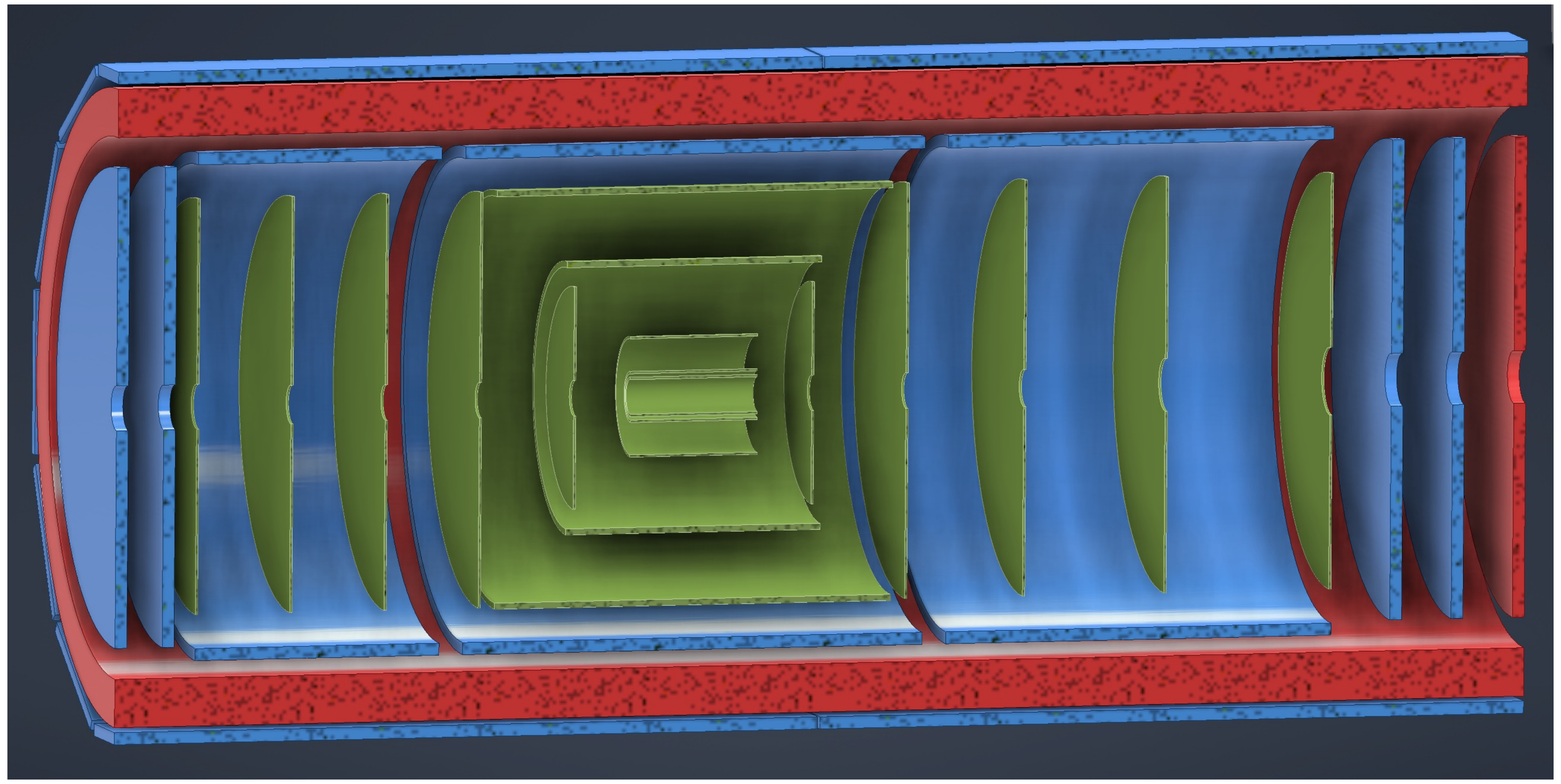
- EIC sensors derived from ITS3
  - not wafer-stiched: too expensive for large area (8 m2) due to low yield

Cylindrical MPGD Layer

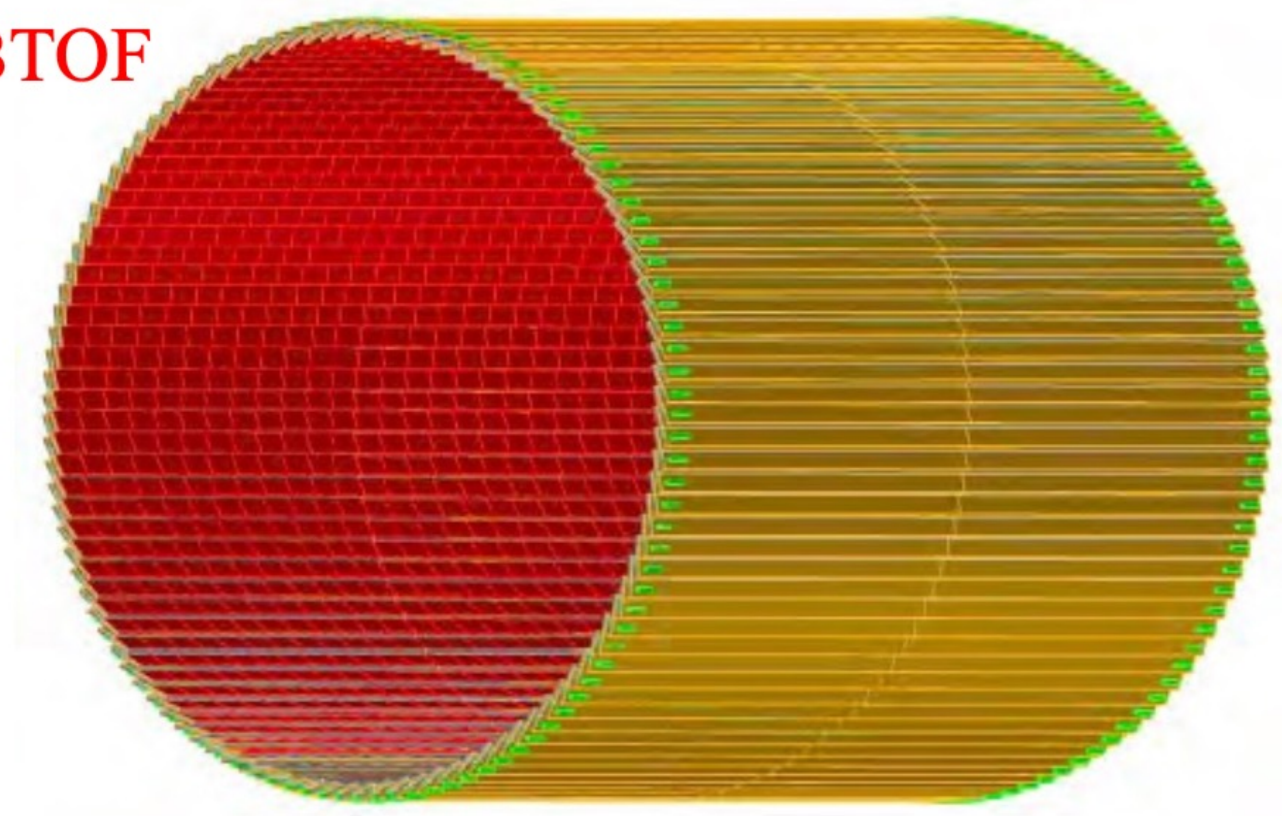
- Either Micromegas or Thin Gap MPGDs
- Important for pattern recognition



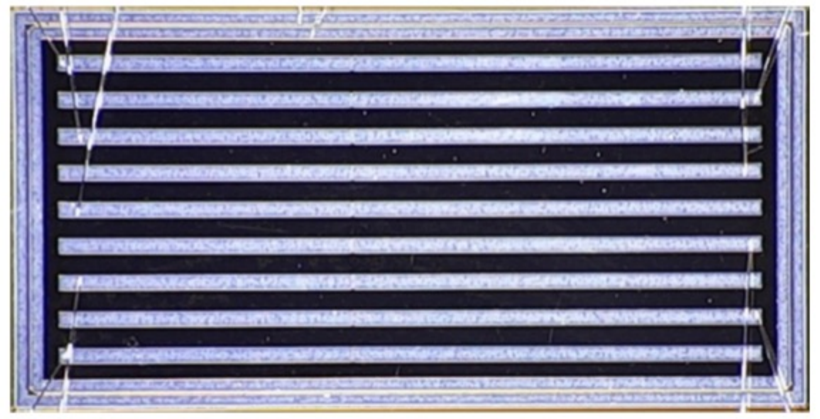
Barrel Tracking



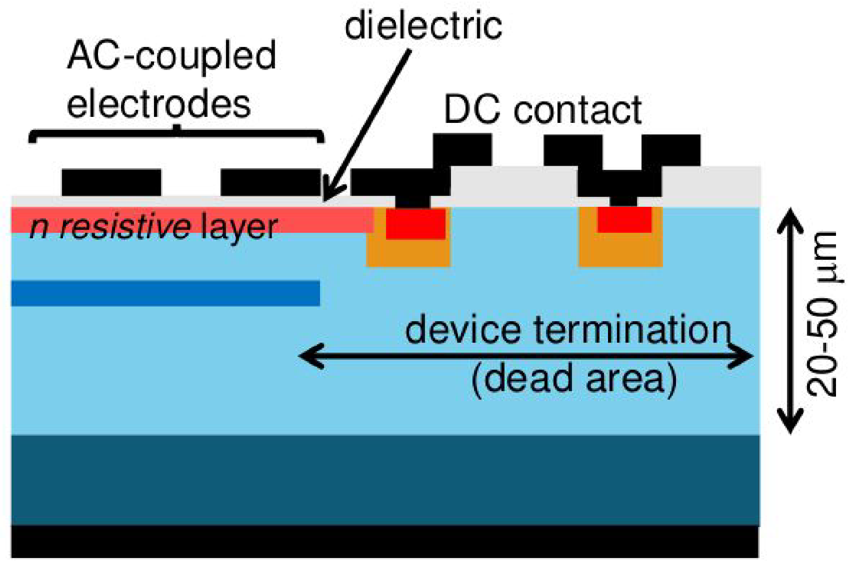
SVT MPGDs ToF (fiducial volume)

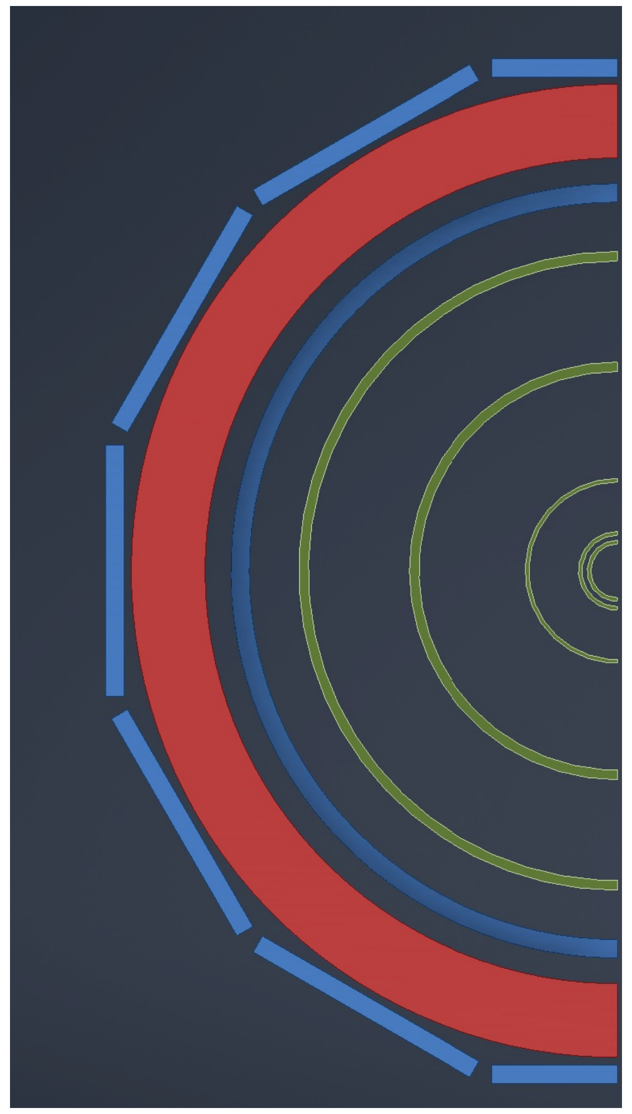


HPK Strip Sensor (4.5x10 mm^2)



	Area (m^2)	Channel size (mm^2)	# of Channels	Timing Resolution	Spatial resolution	Material budget
Barrel TOF	10	0.5*10	2.4M	35 ps	30 μm in $r \cdot \varphi$	0.01 X_0

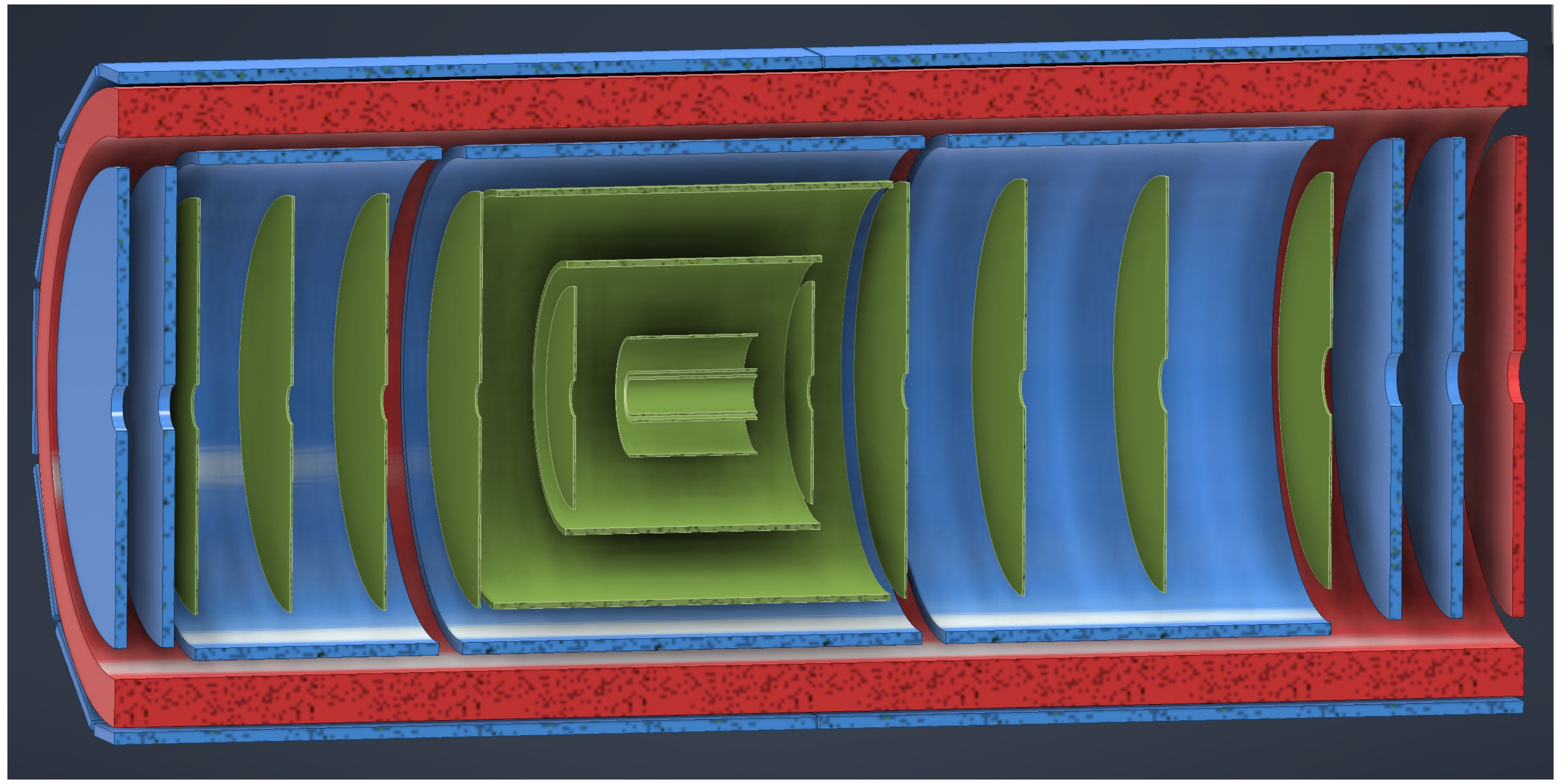




AC-LGAD TOF

- Serves for tracking and low-p_T PID
- Additional space point for pattern recognition / redundancy

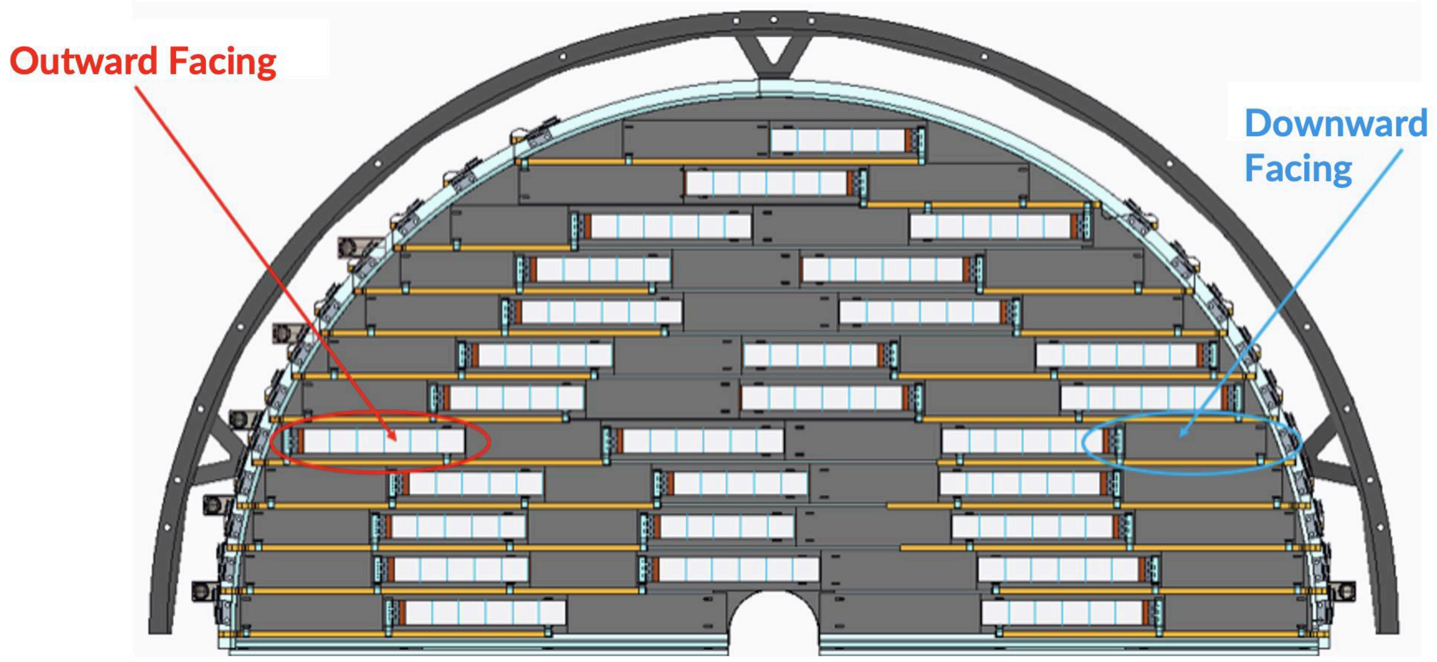
Forward-Backward Tracking



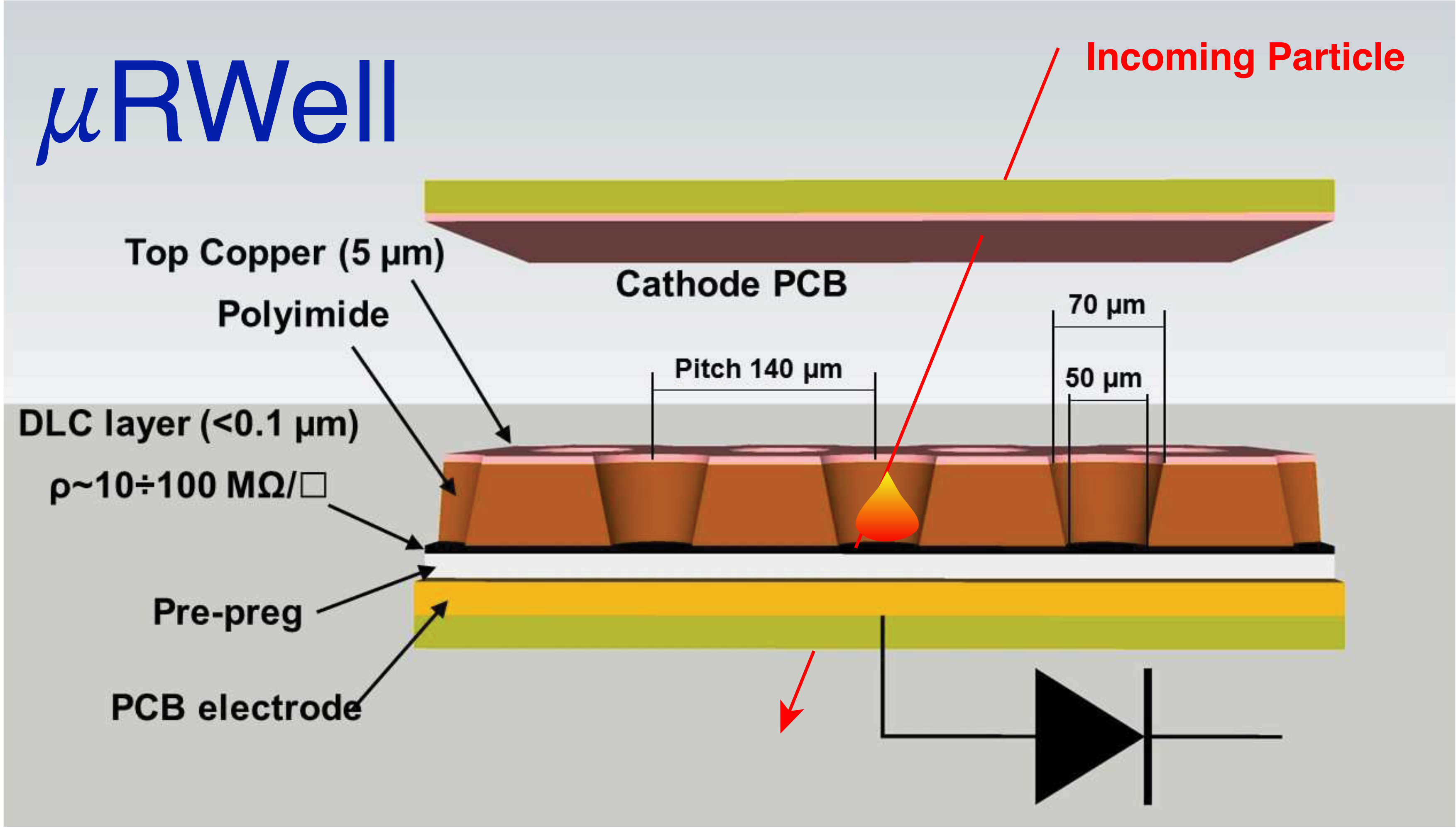
SVT MPGDs ToF (fiducial volume)

Disk	-z	+z	X/X_0
Si 1	250	250	0.24
Si 2	450	450	0.24
Si 3	650	700	0.24
Si 4	850	1000	0.24
Si 5	1050	1350	0.24
MPGD	1100	1480	~1
MPGD	1200	1610	~1

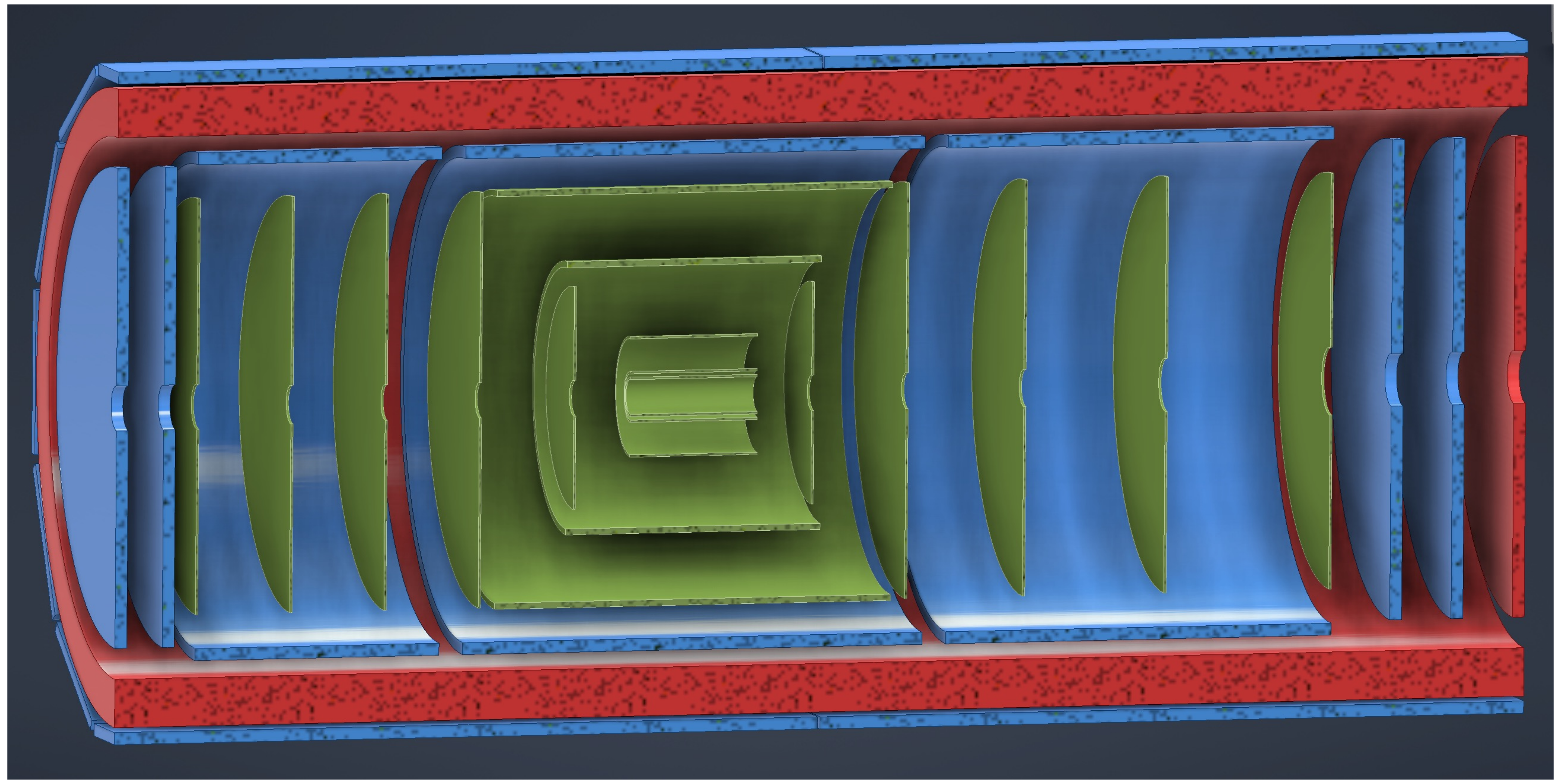
Disk layout design in progress



- 5 Si + 2 μRWell discs in forward/backwards direction (ITS-3 based large area sensor design)
- High resolution requirements hard to meet
  - Increase lever arm by maximizing tracker extent in z
  - Pattern recognition with realistic background studied
  - Ongoing optimization
  - Can potentially impact *t* measurement in e+A

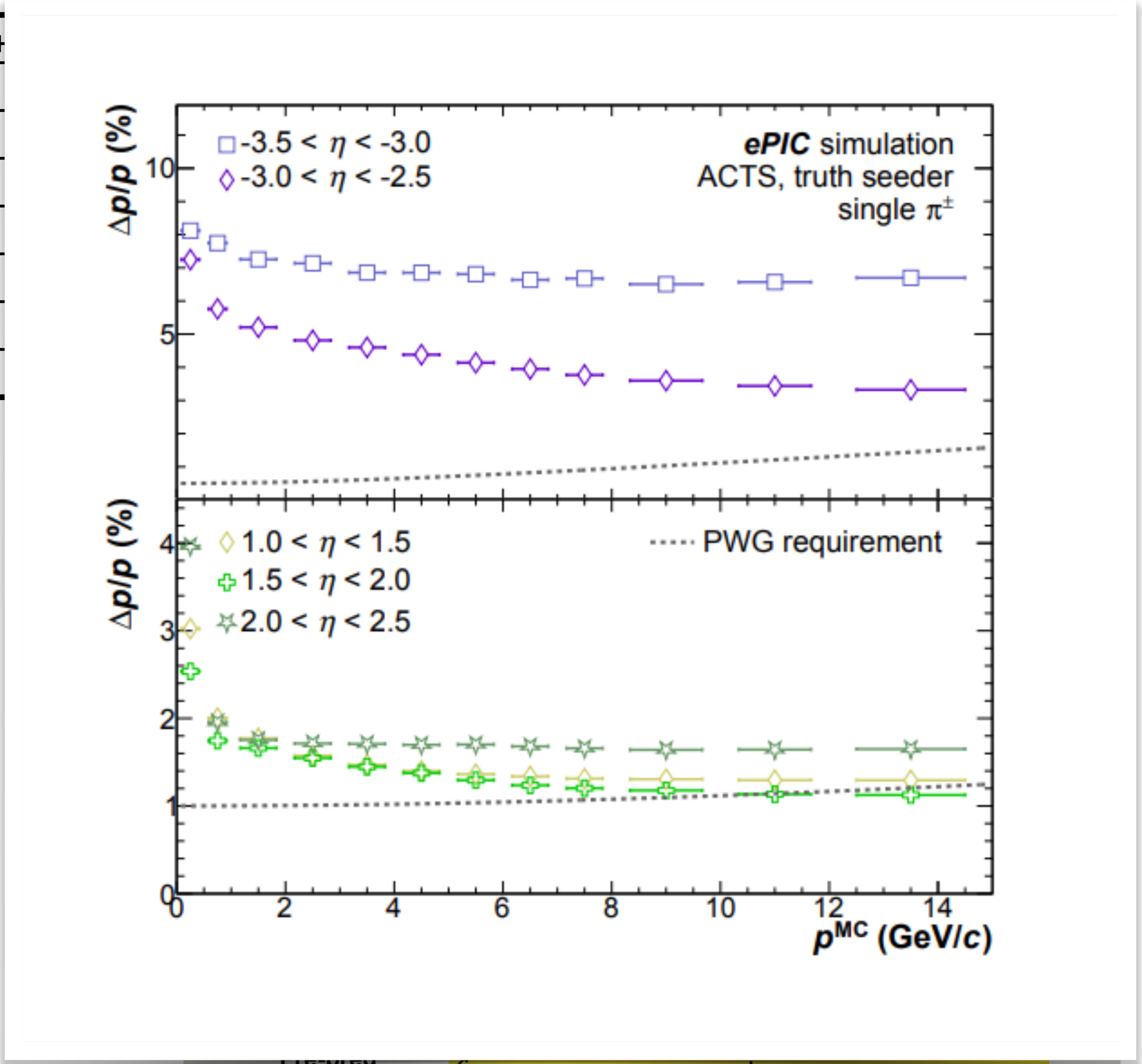


Forward-Backward Tracking



SVT MPGDs ToF (fiducial volume)

Disk	-z	+
Si 1	250	
Si 2	450	
Si 3	650	
Si 4	850	
Si 5	1050	
MPGD	1100	
MPGD	1200	



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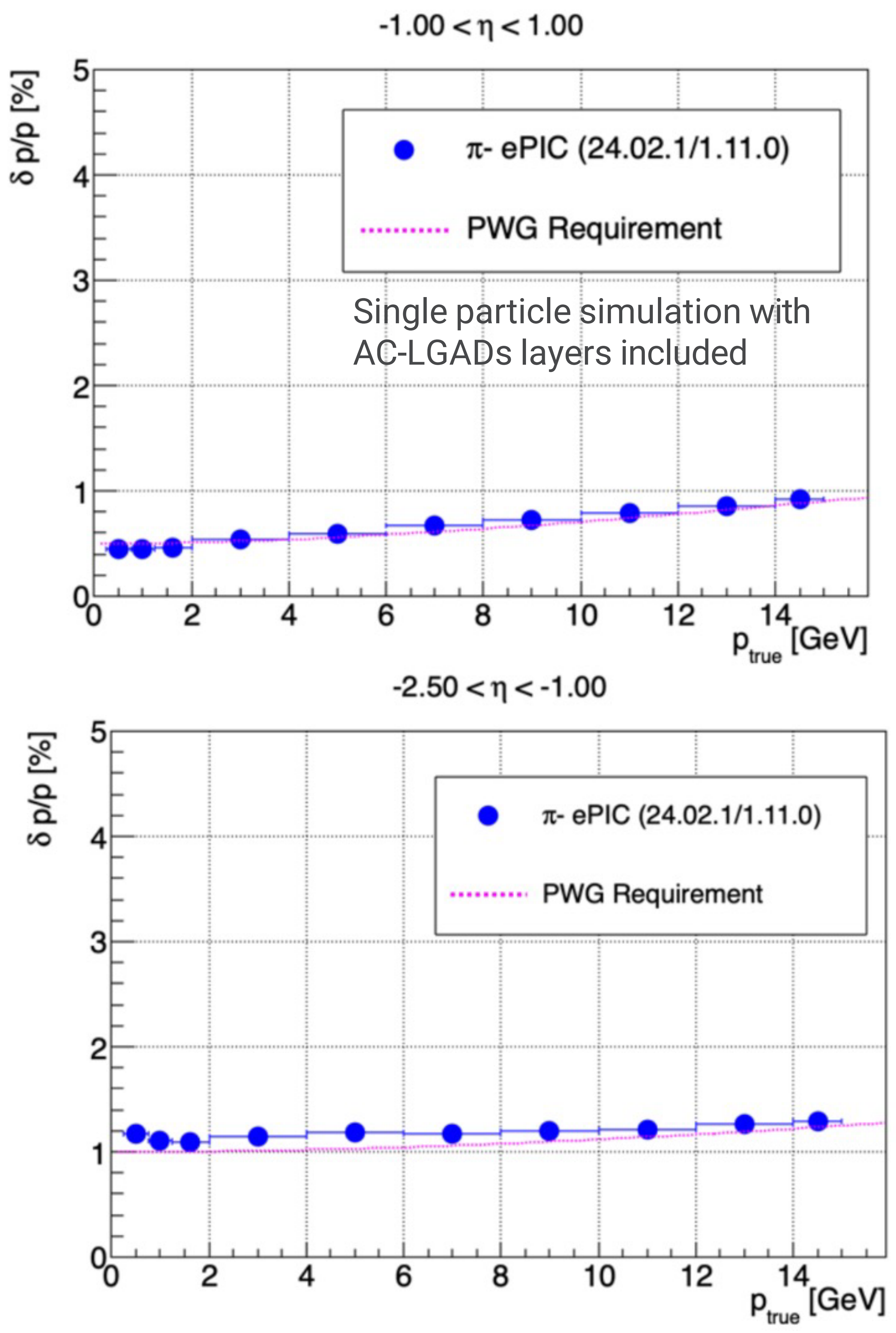
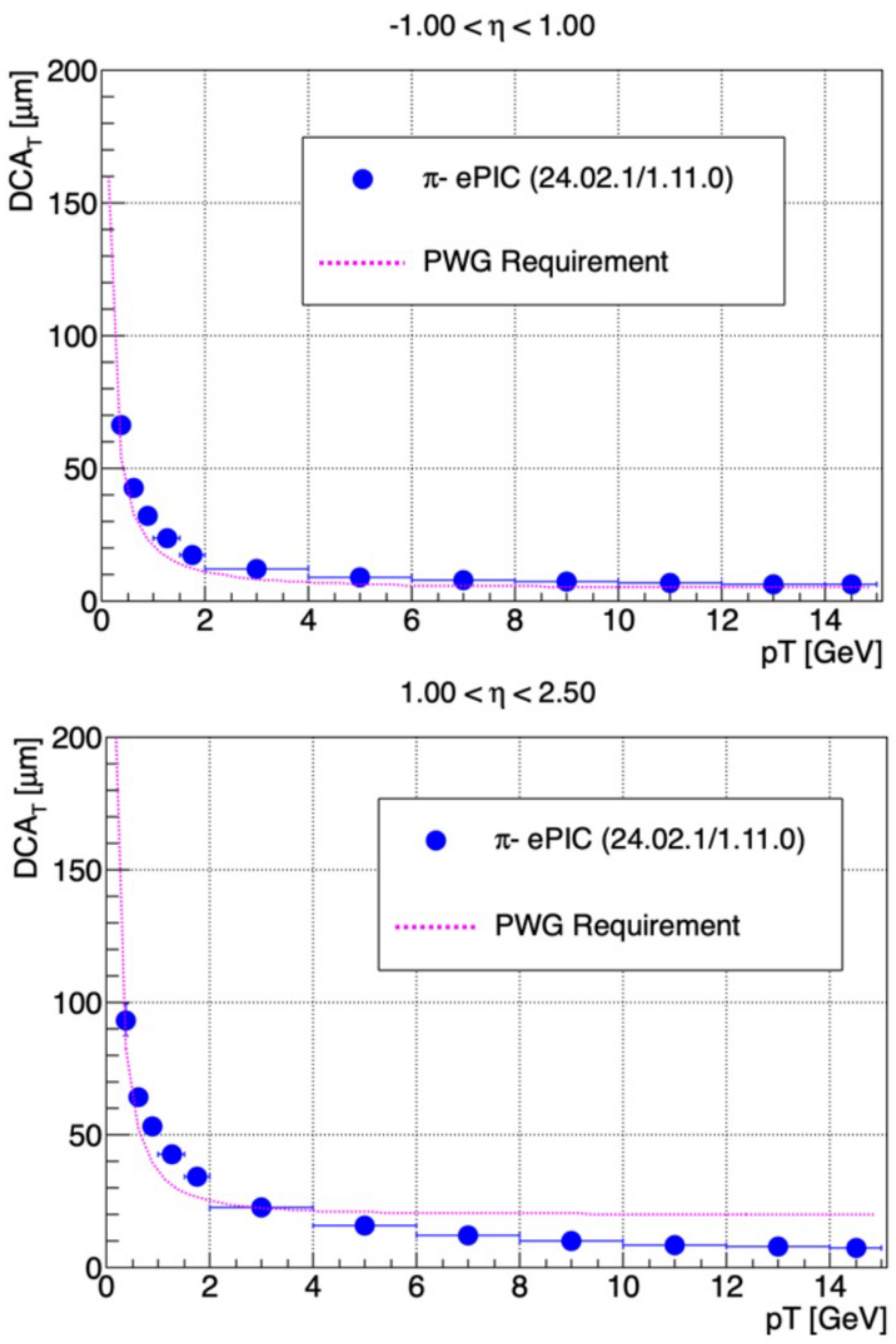
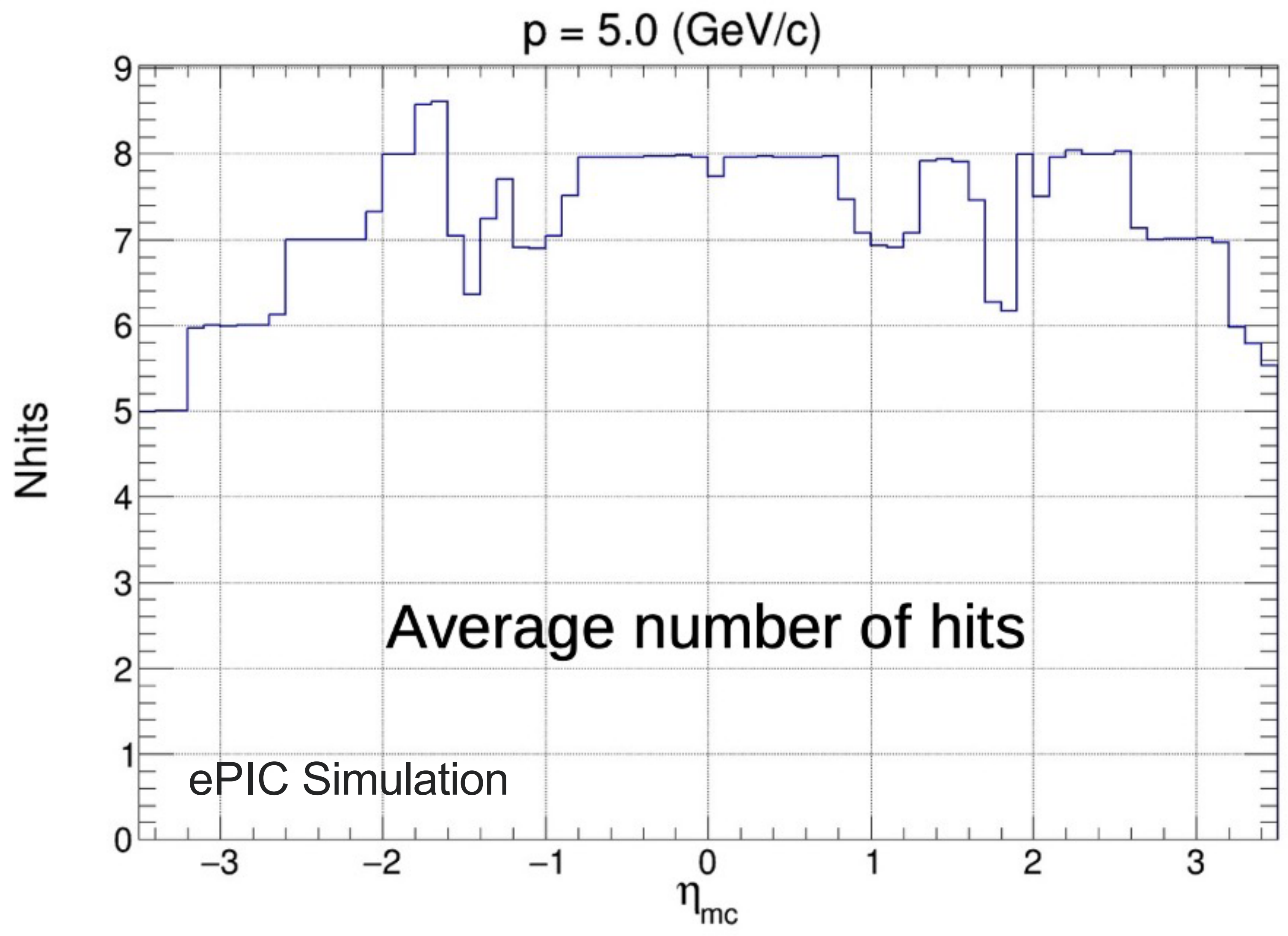
Tracking Performance

Momentum



Distance of Closest Approach (DCA_T)

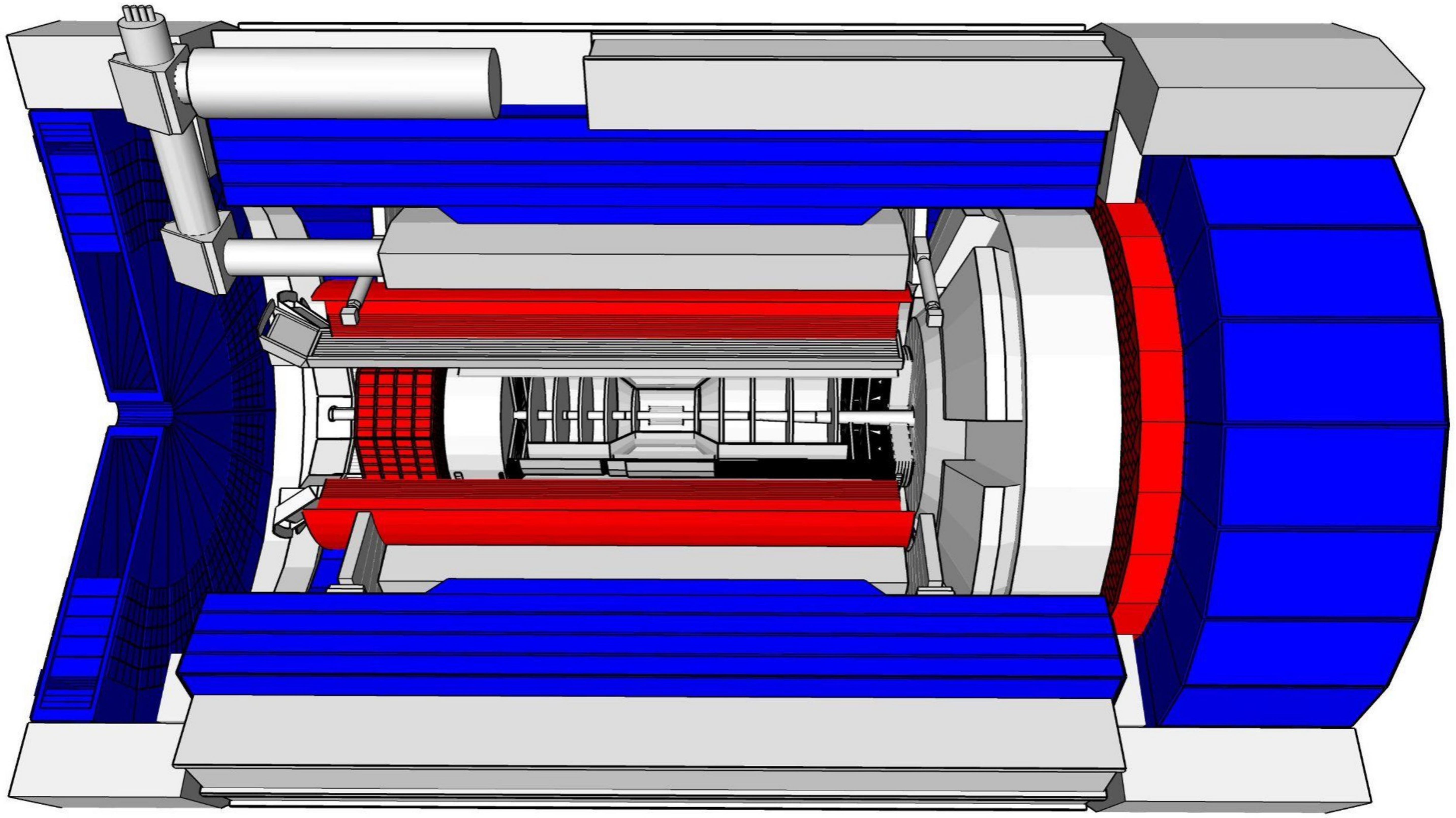




	Momentum Resolution	Spatial Resolution
Backward (-3.5 to -2.5)	~0.10%×p⊕2.0%	~ 30/pT μm ⊕ 40 μm
Backward (-2.5 to -1.0)	~ 0.05%×p⊕1.0%	~ 30/pT μm ⊕ 20 μm
Barrel (-1.0 to 1.0)	~0.05%×p⊕0.5%	~ 20/pT μm ⊕ 5 μm
Forward (1.0 to 2.5)	~0.05%×p⊕1.0%	~ 30/pT μm ⊕ 20 μm
Forward (2.5 to 3.5)	~0.10%×p⊕2.0%	~ 30/pT μm ⊕ 40 μm

- Backward/Forward momentum resolution in extreme η regions complemented by calorimetric resolution
- Meets PWG requirements elsewhere

Calorimetry



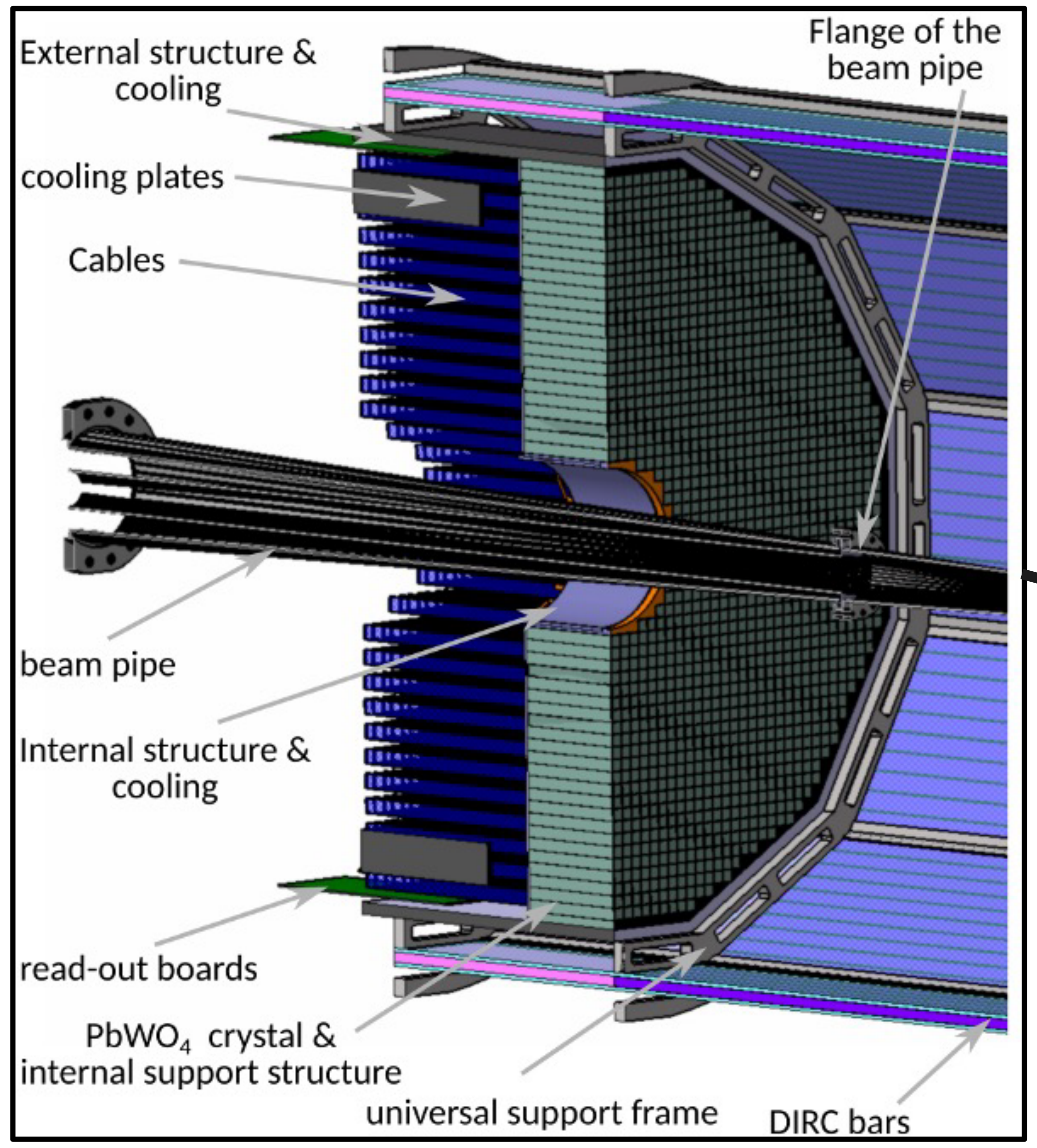
Calorimeters with wide range of acceptances (backward, barrel, forward) and different technologies:

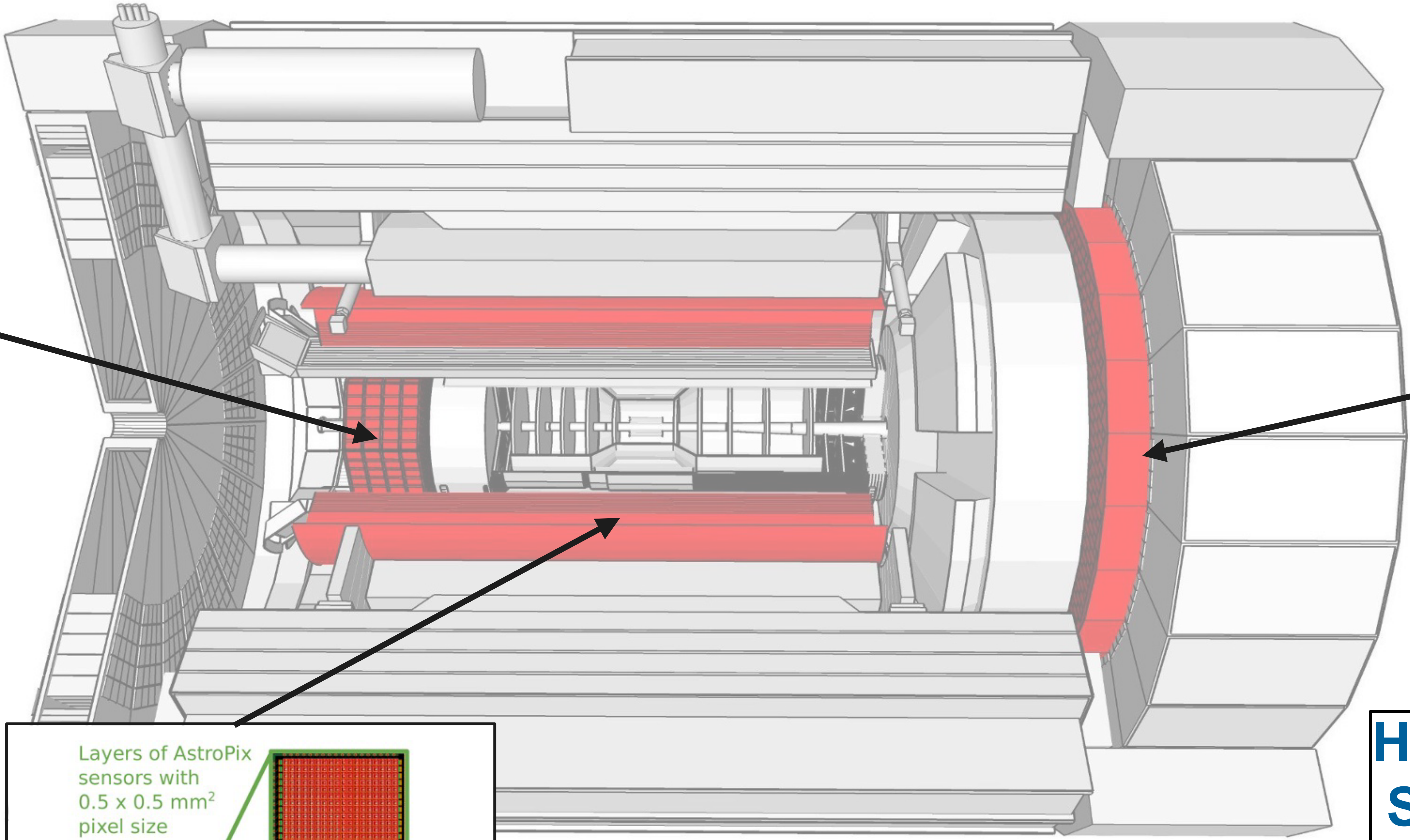
- Electromagnetic Calorimeter.
- Hadronic Calorimeter.

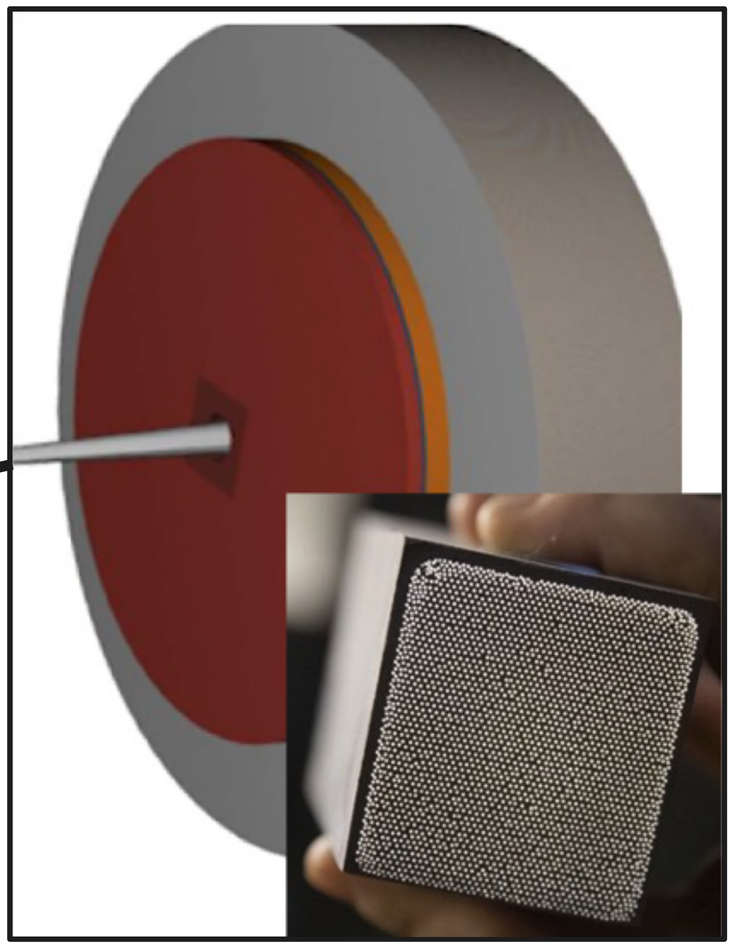
Purpose:

- Detect the scattered electron and separate them from π (up to 10^{-4} suppression factor in backward and barrel ECal)
- Improve the electron momentum resolution at backward rapidities (2-3%$/\sqrt{E} \oplus (1-2)$% for backward ECal)
- Provide spatial resolution of two photons sufficient to identify decays $\pi^0 \to \gamma\gamma$ at high energies from ECals
- Contain the highly energetic hadronic final state and separate clusters in a dense hadronic environment in Forward ECal and HCal

Electromagnetic Calorimetry



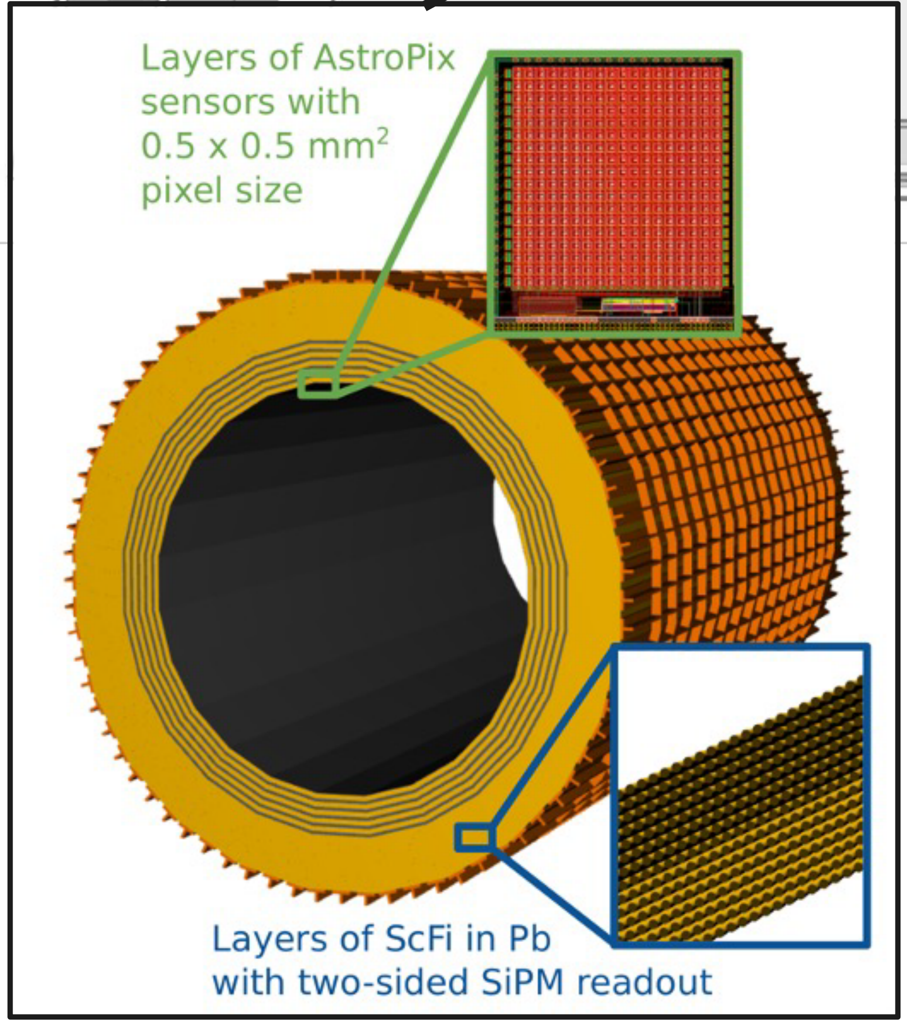




Backward EMCal

$PbWO_4$ crystals

- 2 × 2 × 20 cm³ crystals
- Readout: SiPMs 10μm pixel
- Depth: ~20 X0
- Cooling to keep temperature stable within ± 0.1 °C



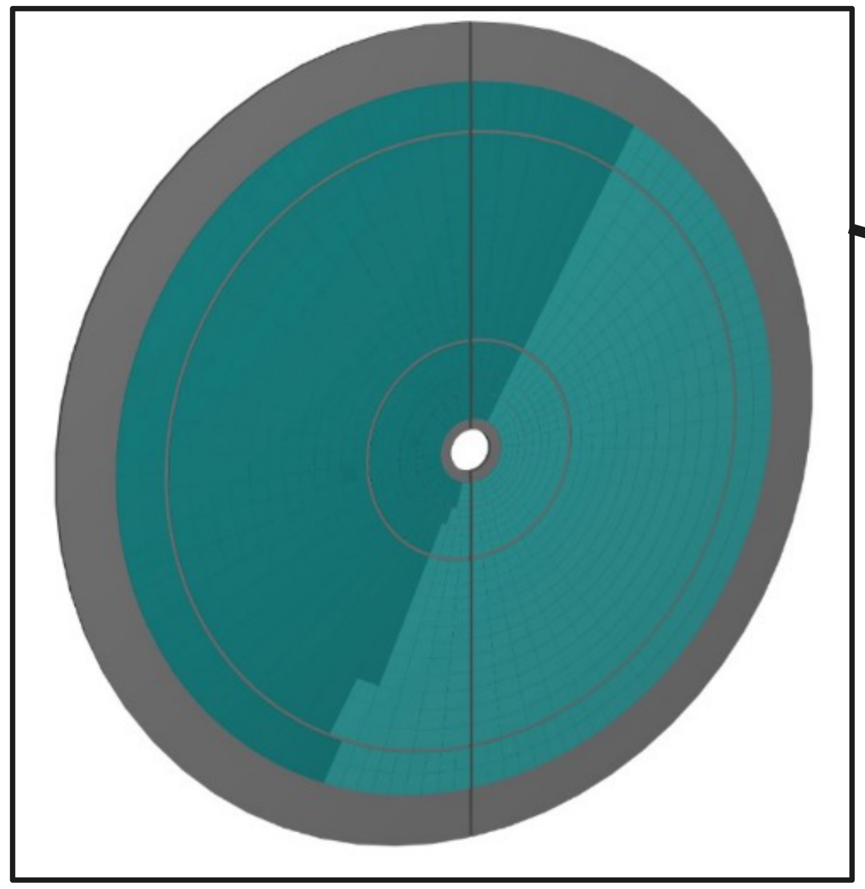
Imaging Barrel Calorimeter

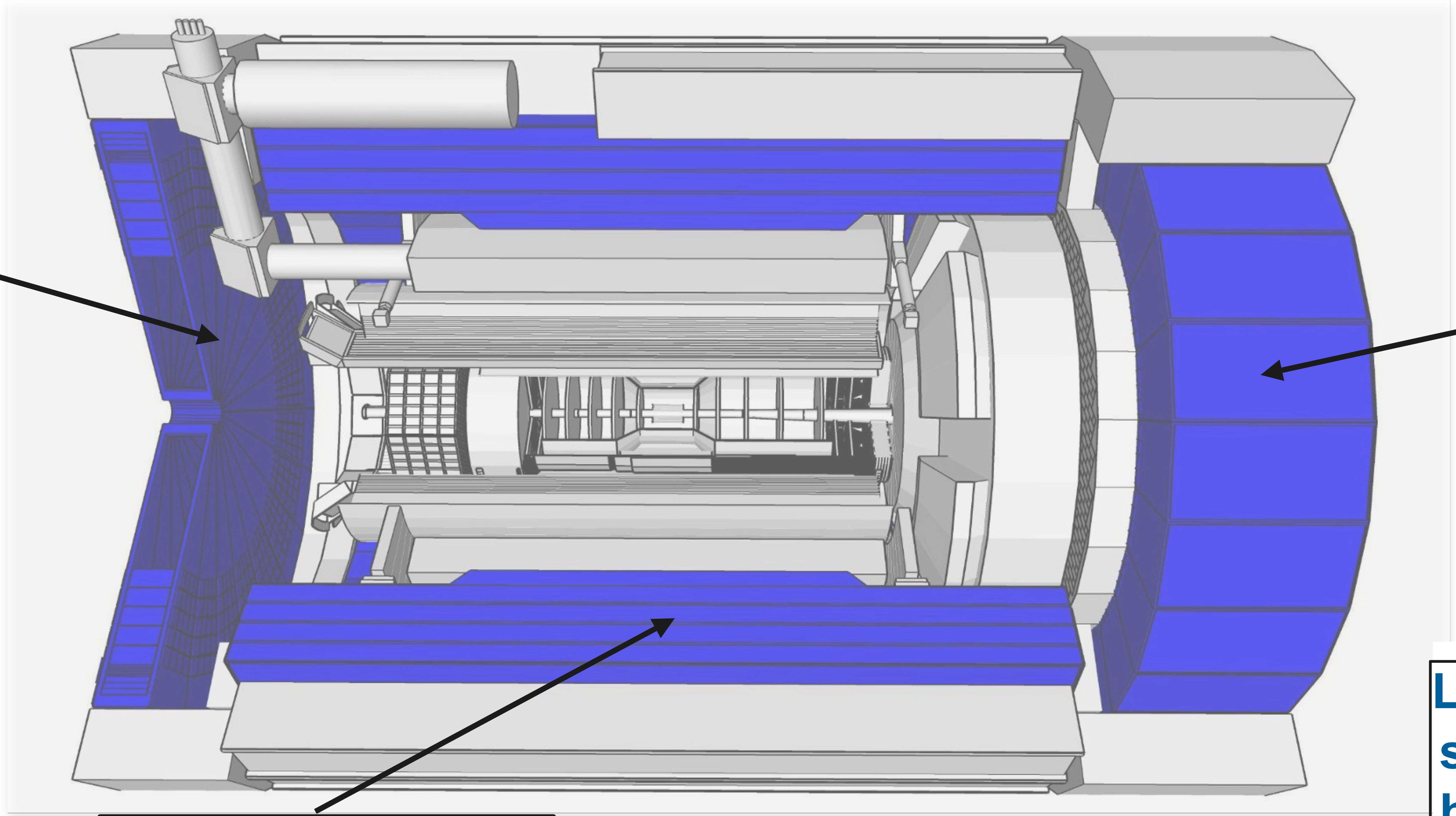
- 4(+2) layers of AstroPix MAPS sensor, 500x500 μm
- Interleaved with scintillating fiber/Pb layers
  - 2-side SiPM readout, 50 μm pixel
- Depth: ~17.1 X0

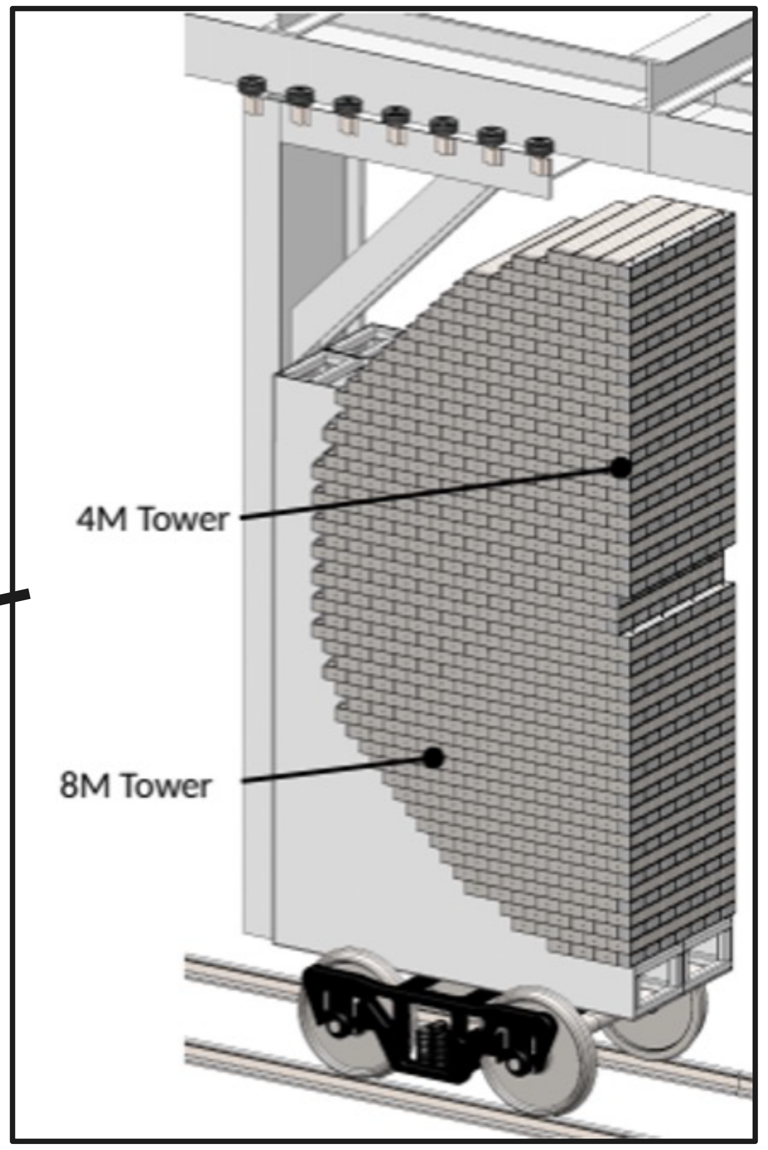
High granularity W/ SciFi EMCal

- Tungsten powder mixed with epoxy + scintillating fibers
- 5 cm x 5 cm x 17 cm blocks
- 4 independent towers per block
- Readout: 4 SiPM per tower, 50 μm pixel
- Depth: ~23 X0

Hadronic Calorimetry







Backwards HCal

- Steel + large scintillator tiles sandwich
- SiPM readout
- Exact design still in progress

Barrel HCAL (sPHENIX re-use)

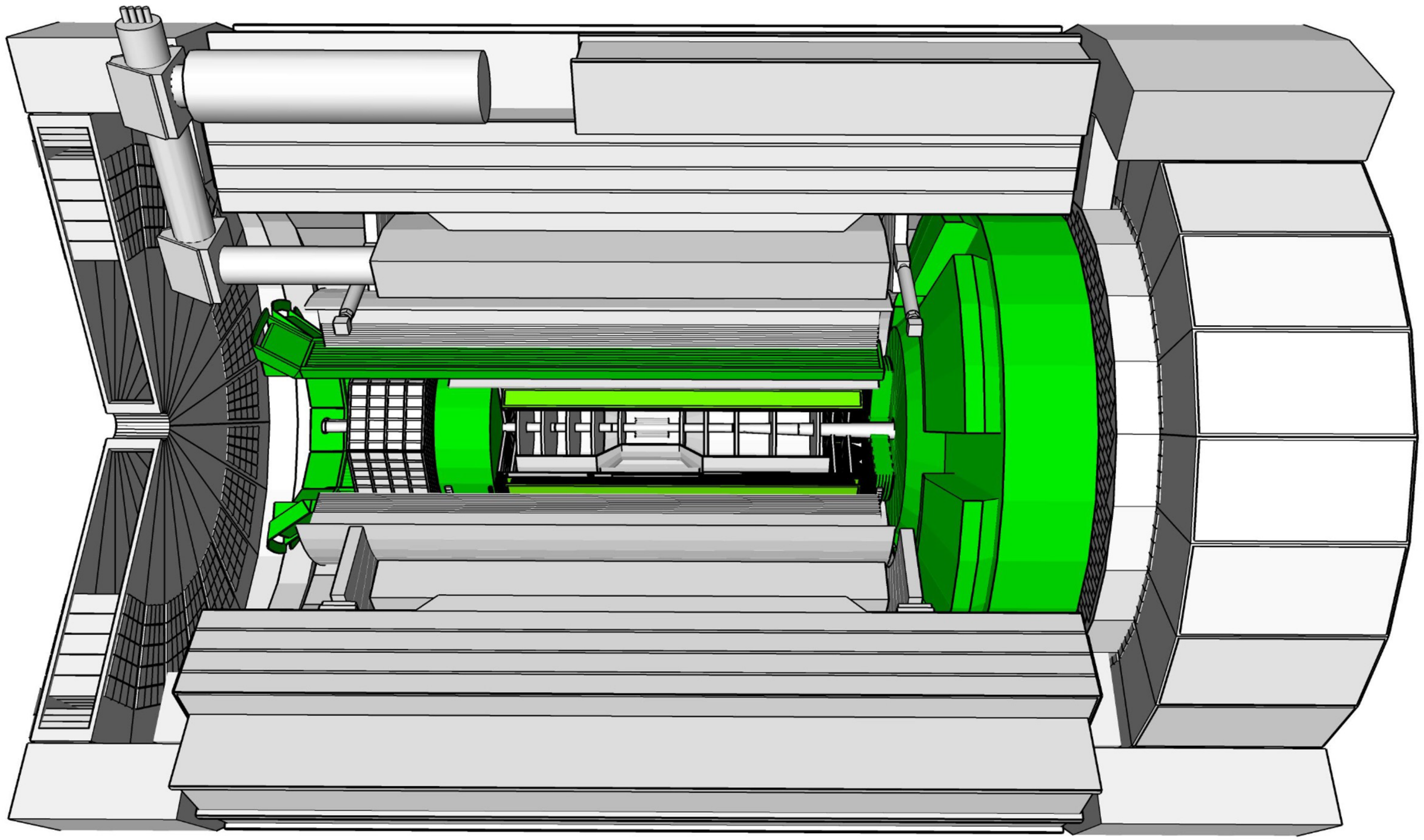
- Tilted Steel/Scintillator plates with SiPM readout

Refurbish for EIC
- Minor radiation damage replace SiPMs
- Upgrade electronics to HGCROC
- Reading out each tile individually

Longitudinally separated HCAL with high-η insert

- Steel + Scintillator SiPM-on- tile
- Highly segmented longitudinally
- 65 layers per tower
  - 565,760 SiPMs
- Stackable for “easy” construction

Particle ID (PID)



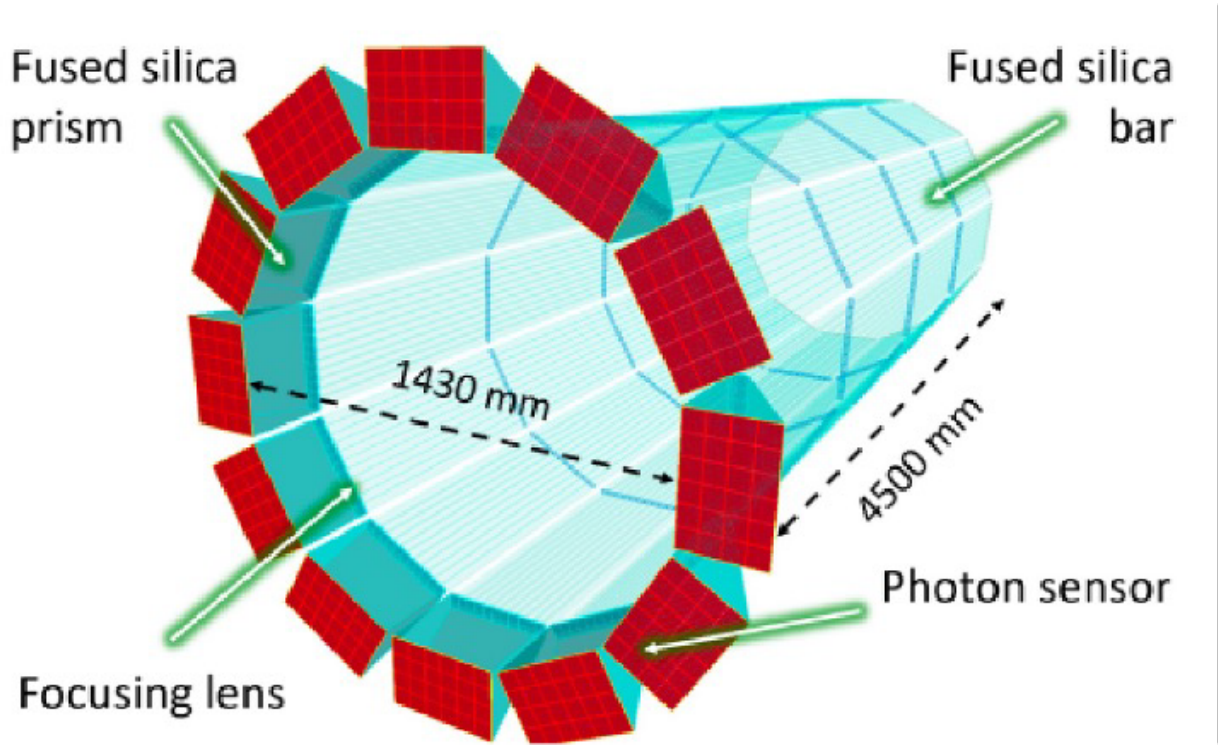
Rapidity	$\pi/K/p$ and π^0/γ	e/h	Min p_T (E)
-3.5 – -1.0	7 GeV/c	18 GeV/c	100 MeV/c
-1.0 – 1.0	8-10 GeV/c	8 GeV/c	100 MeV/c
1.0 – 3.5	50 GeV/c	20 GeV/c	100 MeV/c

Particle Separation Needs

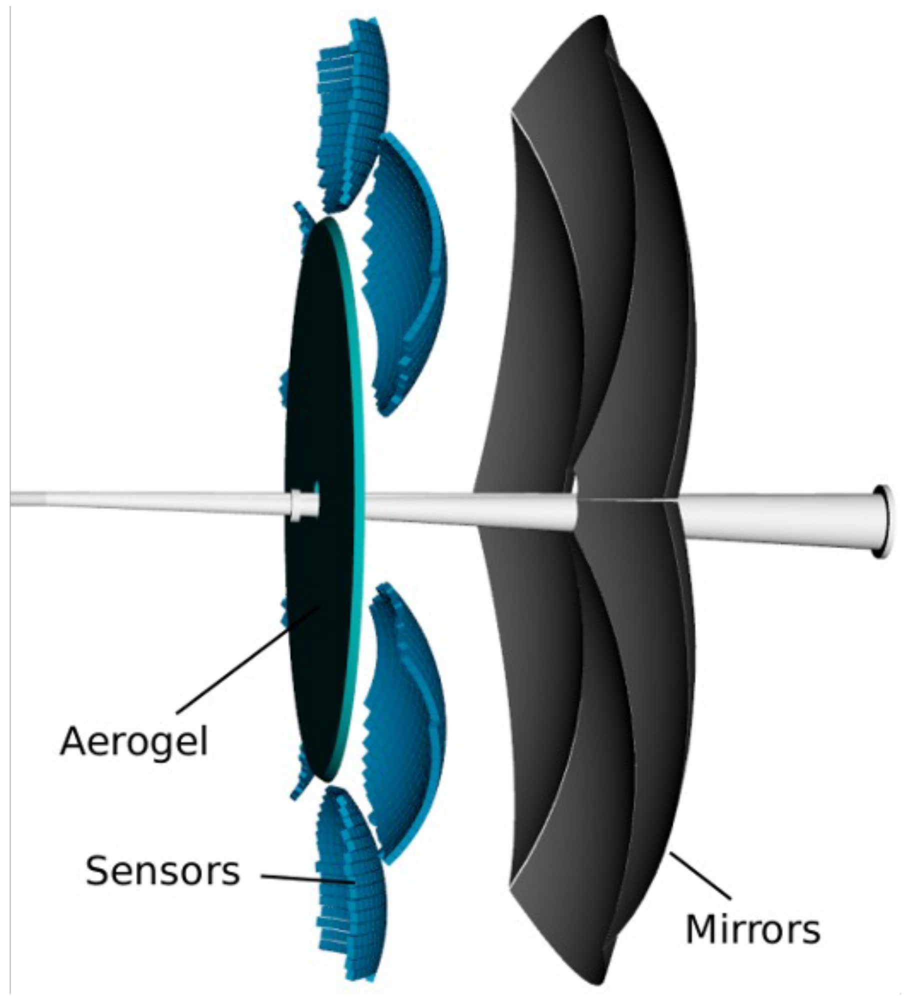
- Electrons from photons ⟶ 4π coverage in tracking
- Electrons from charged hadrons ⟶ mostly provided by calorimetry and tracking, PID detectors at low p
- Charged pions, kaons and protons from each other on track level ⟶ Cherenkov detectors
- Cherenkov detectors, complemented by other technologies at lower momenta: ToF
- Demands on PID are unique to ePIC

Particle ID (PID)

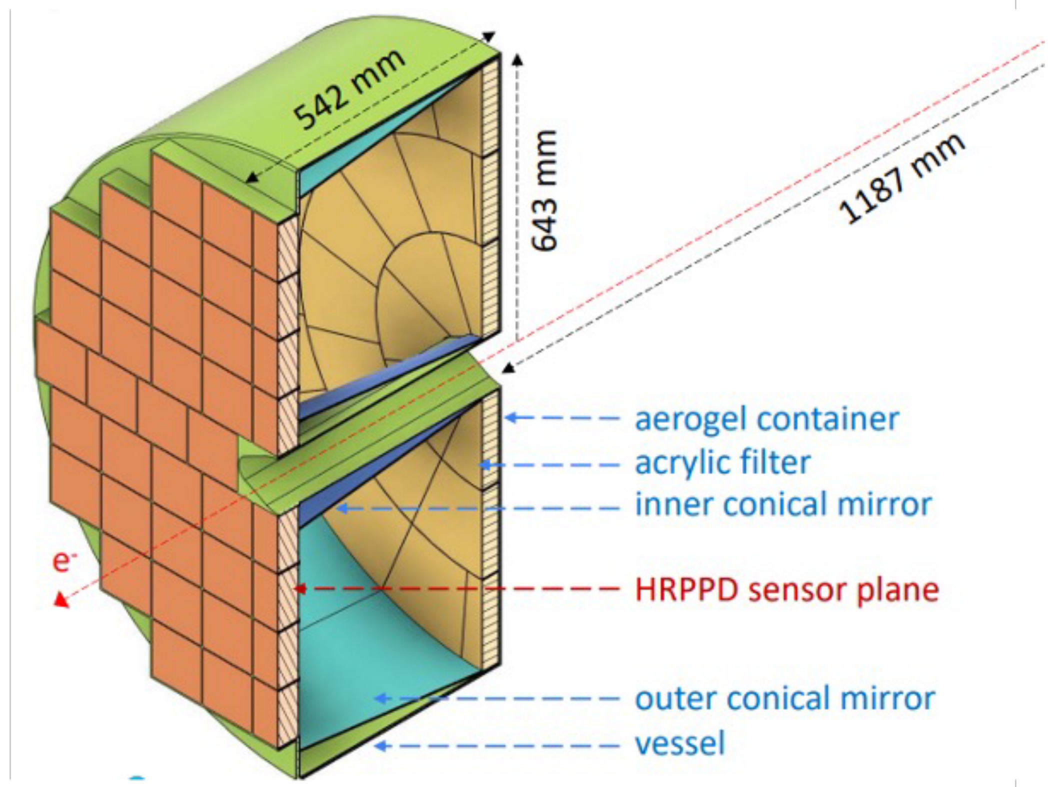
High-Performance DIRC (hpDIRC)

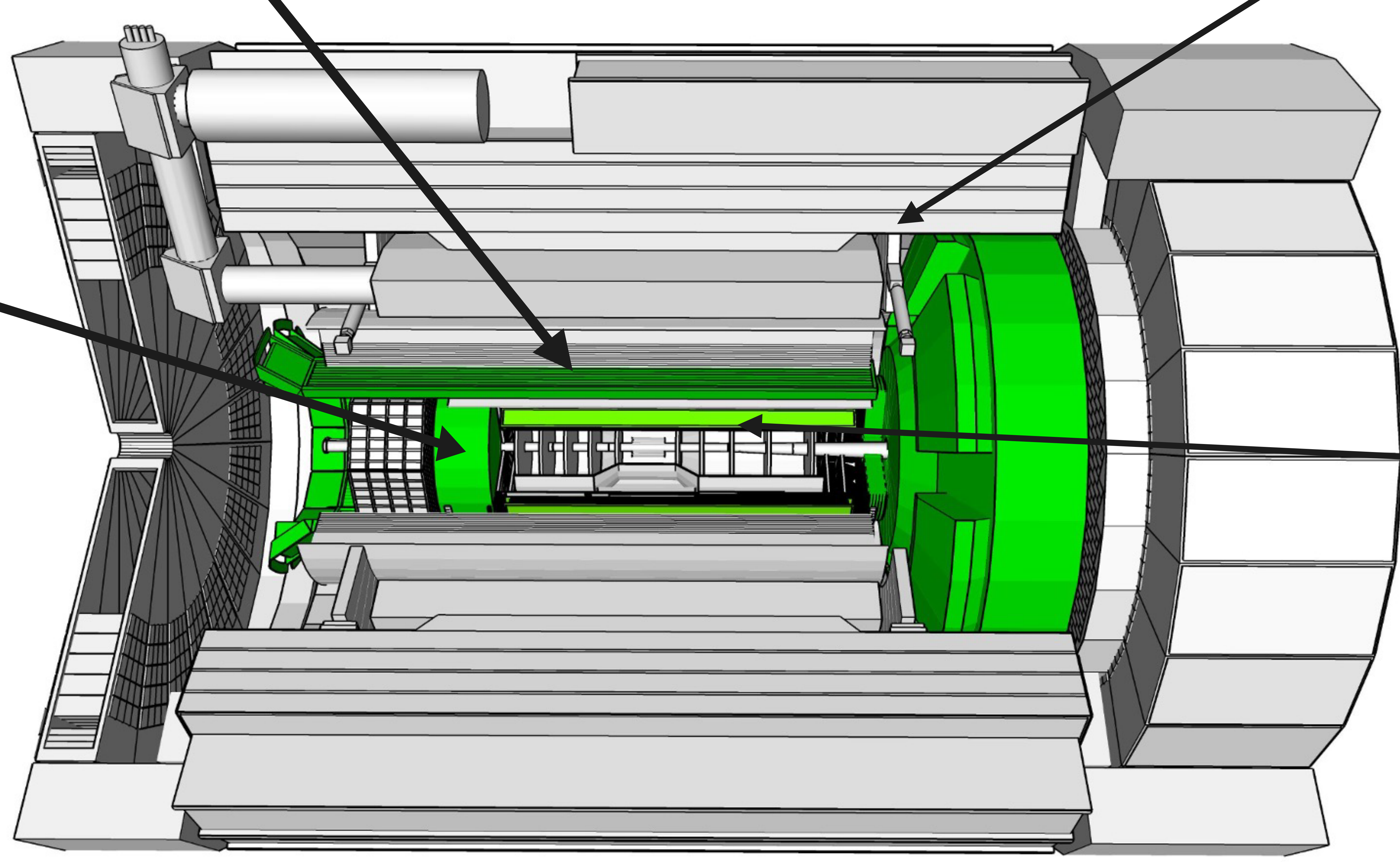


Dual-Radiator RICH (dRICH)

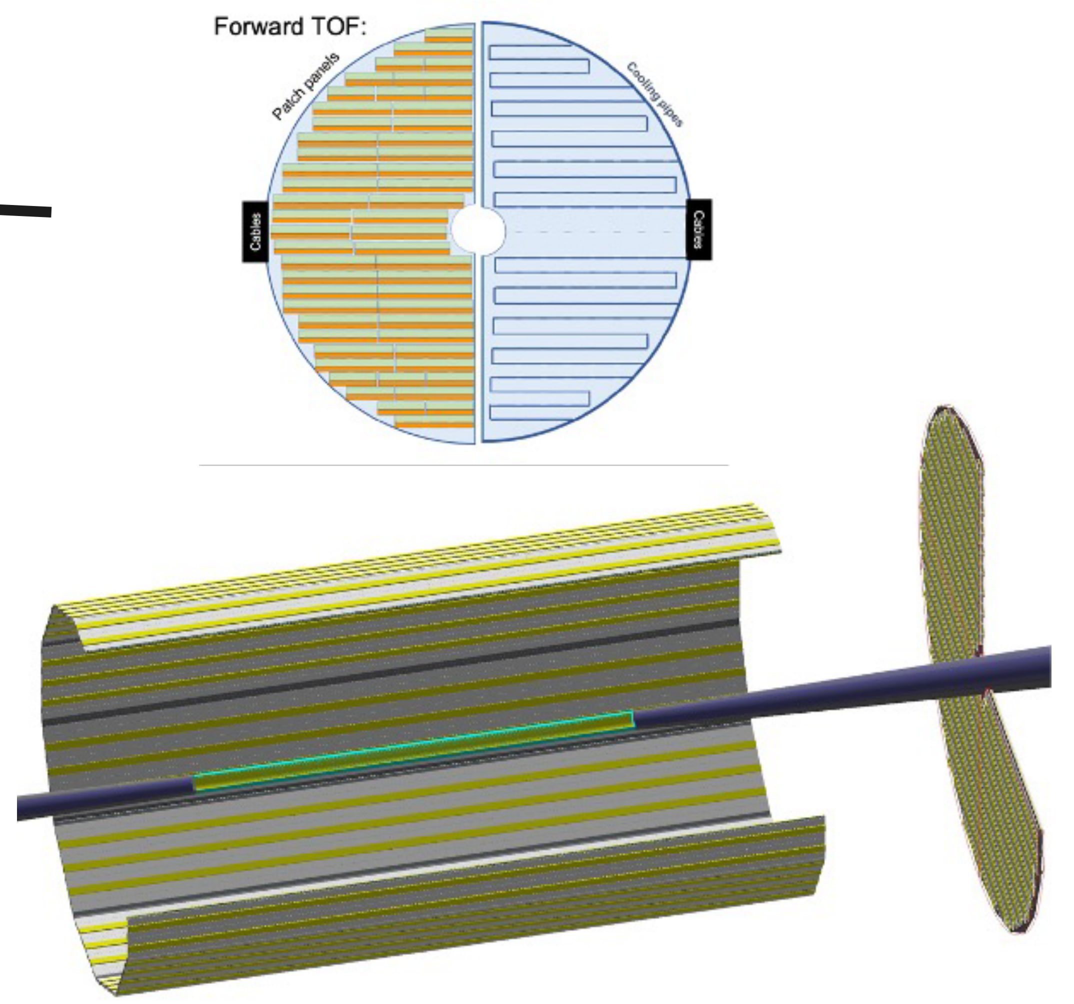


Proximity Focusing RICH (pfRICH)

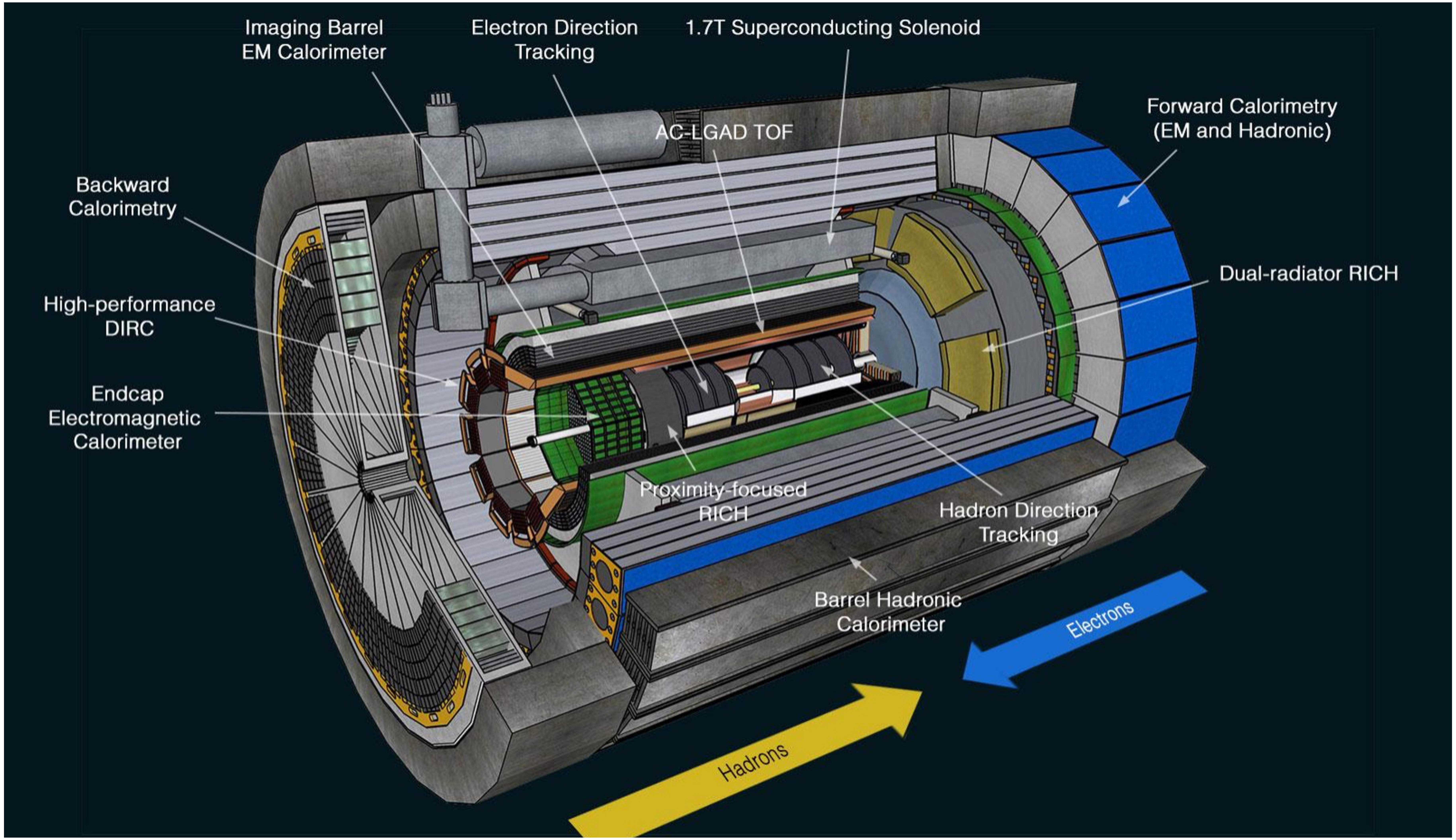




Time-of-Flight (ToF)

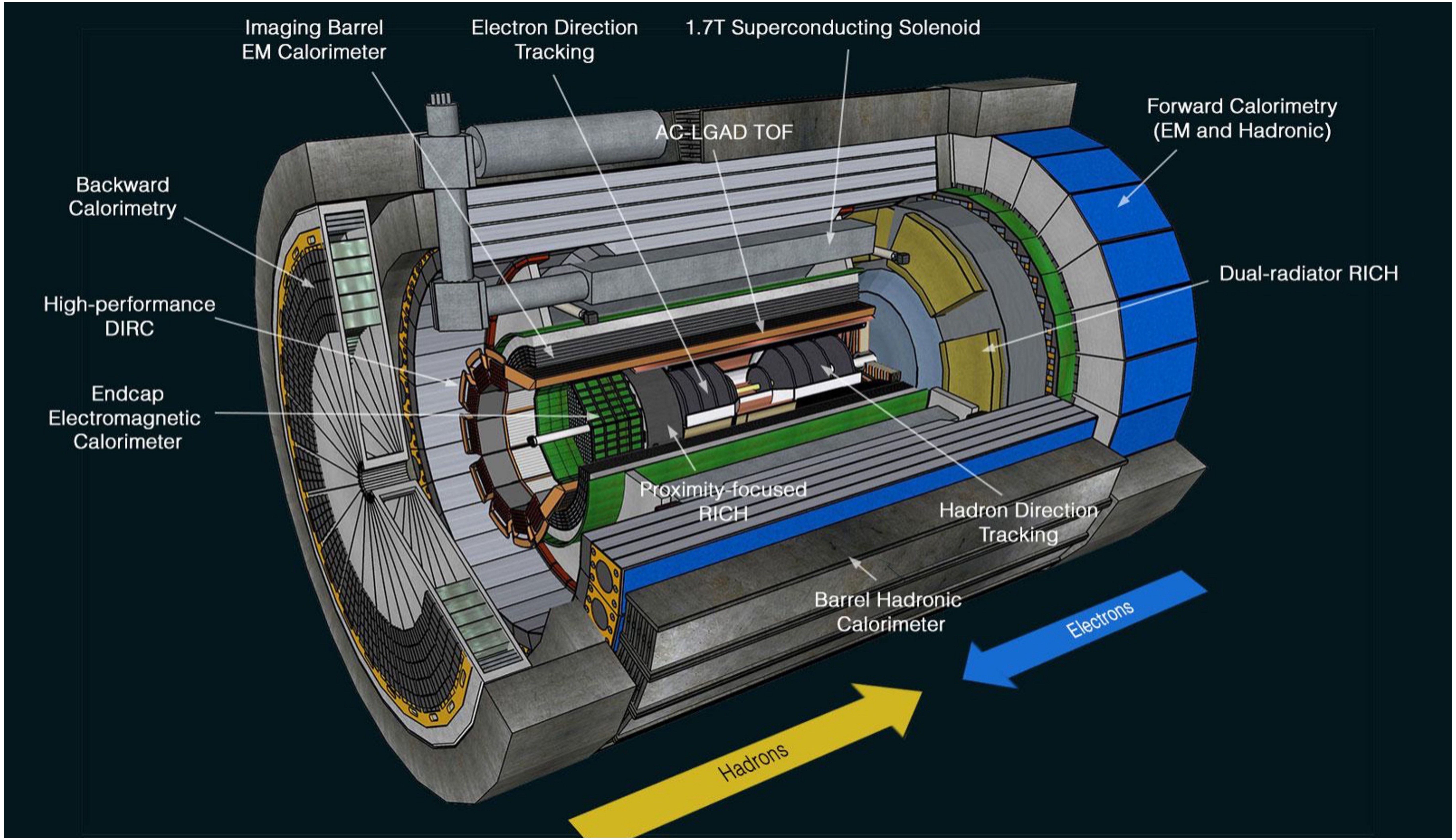


Are we done?



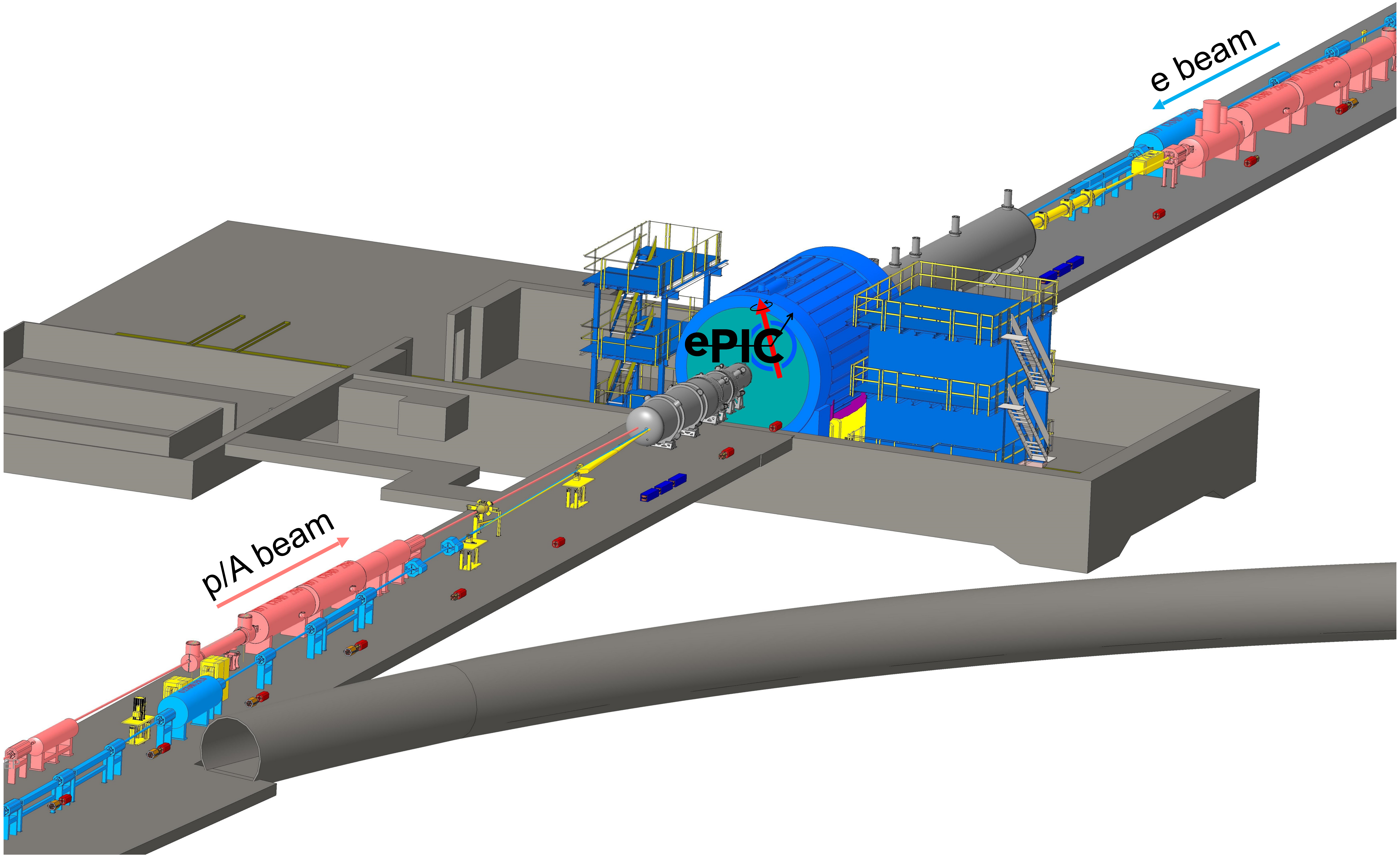
Imaging Barrel
EM Calorimeter
Electron Direction
Tracking
1.7T Superconducting Solenoid
AC-LGAD TOF
Forward Calorimetry
(EM and Hadronic)
Backward
Calorimetry
Dual-radiator RICH
High-performance
DIRC
Endcap
Electromagnetic
Calorimeter
Proximity-focused
RICH
Hadron Direction
Tracking
Barrel Hadronic
Calorimeter
Electrons
Hadrons

Are we done?



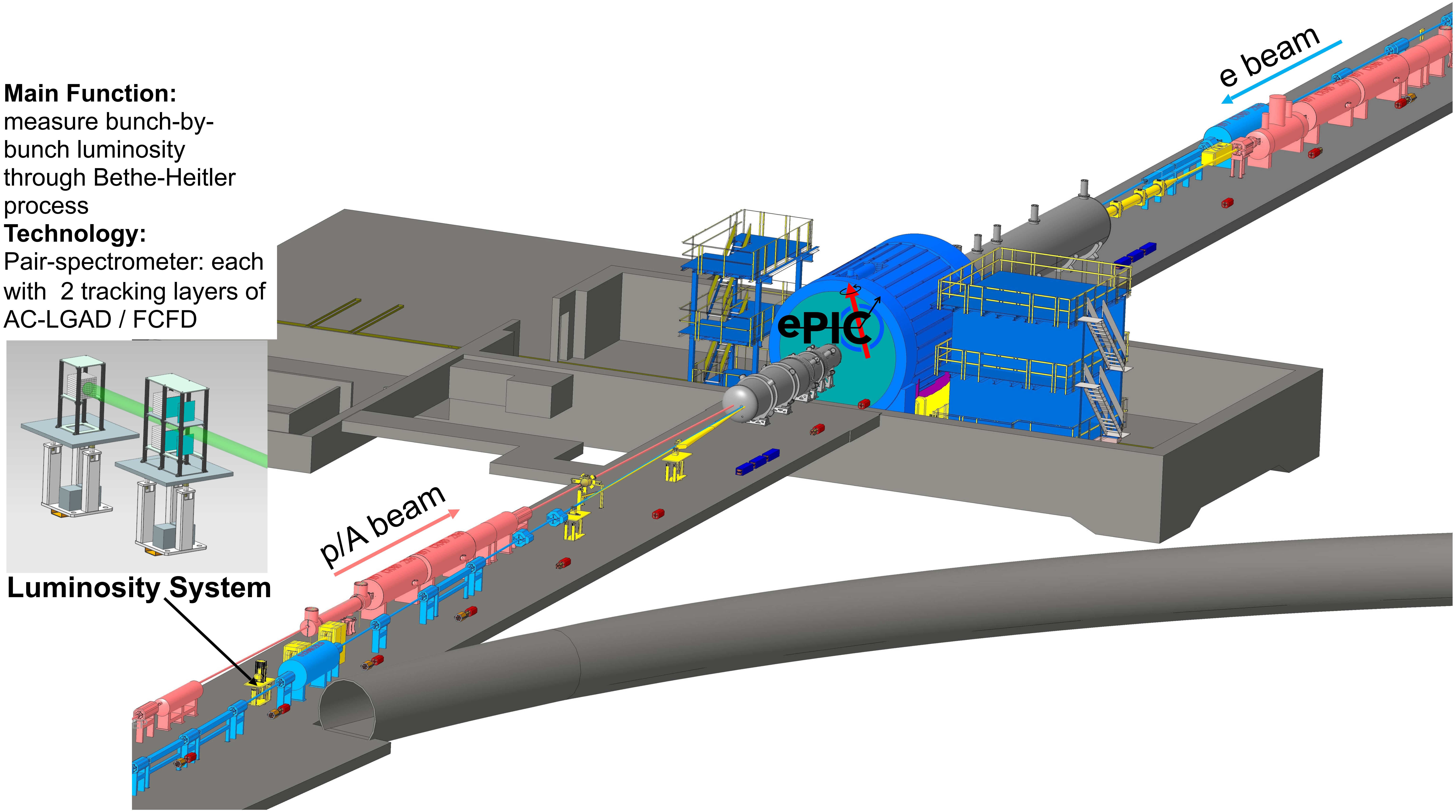
Perfect and necessary, but not sufficient …

ePIC Far-Forward/Far-Backward Detectors



ePIC Far-Forward/Far-Backward Detectors

Main Function:
measure bunch-by-bunch luminosity through Bethe-Heitler process
Technology:
Pair-spectrometer: each with 2 tracking layers of AC-LGAD / FCFD



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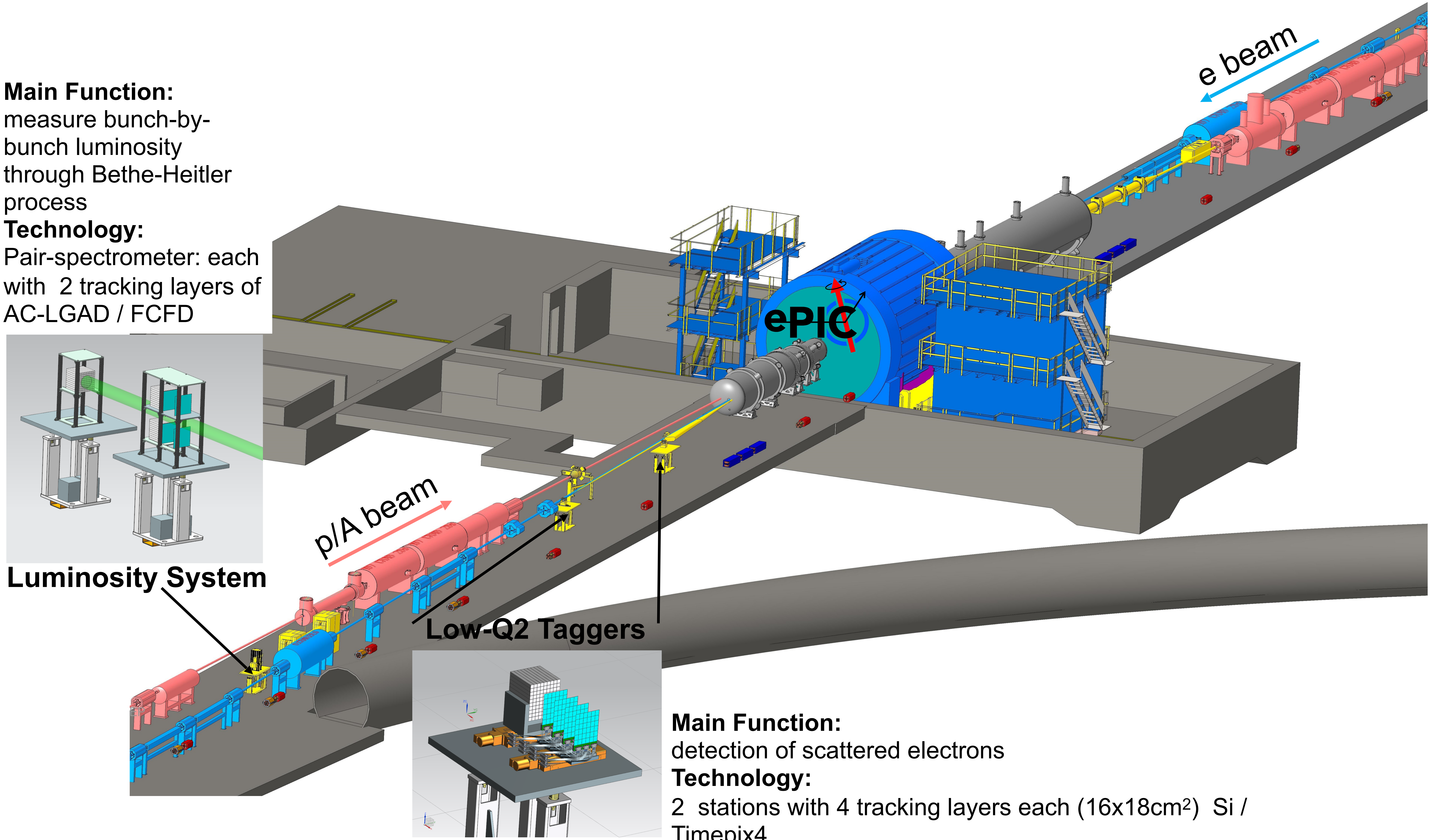


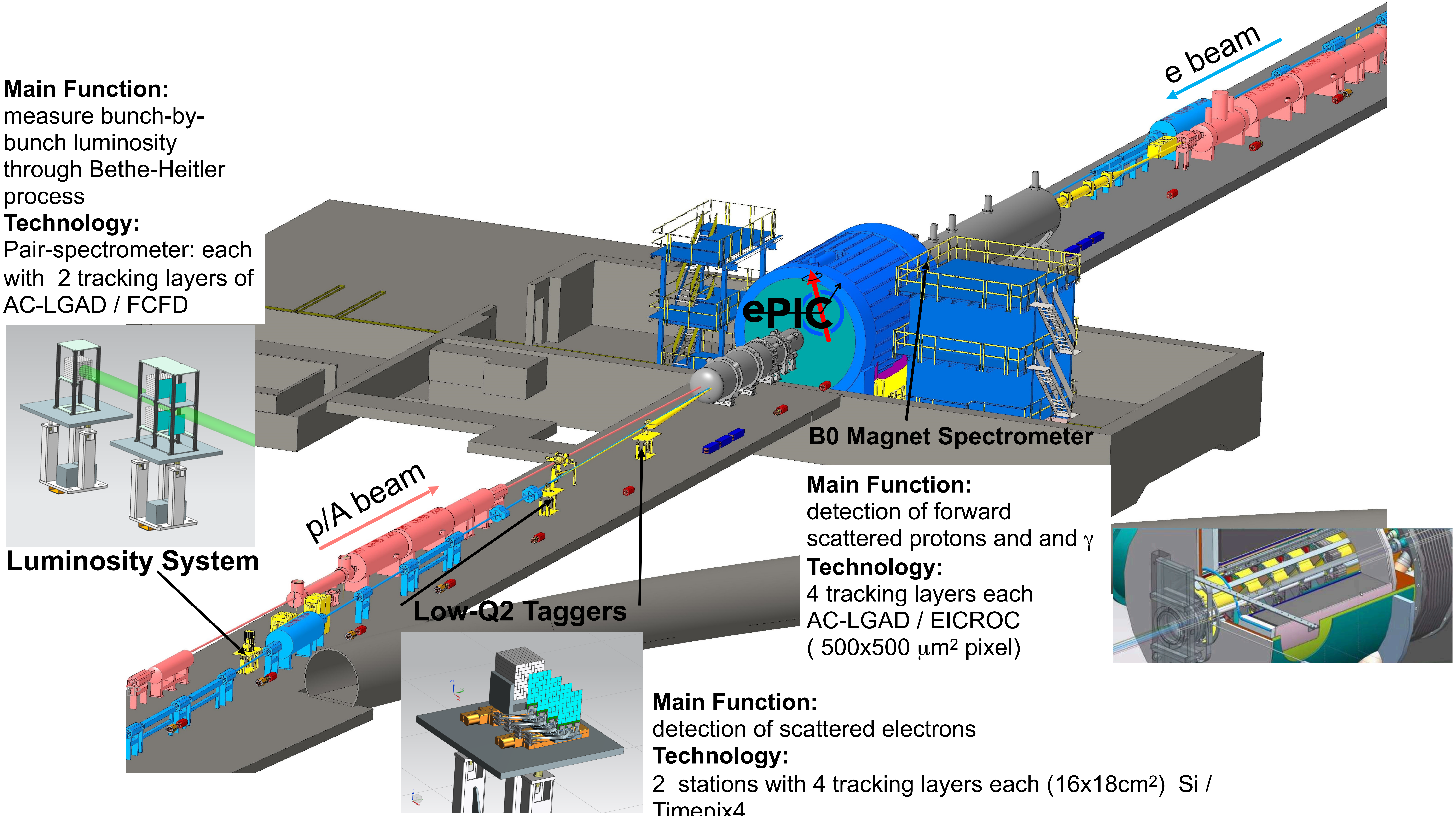
Luminosity System

Low-Q2 Taggers

Main Function:
detection of scattered electrons
Technology:
2 stations with 4 tracking layers each (16x18cm^2) Si / Timepix4

ePIC Far-Forward/Far-Backward Detectors

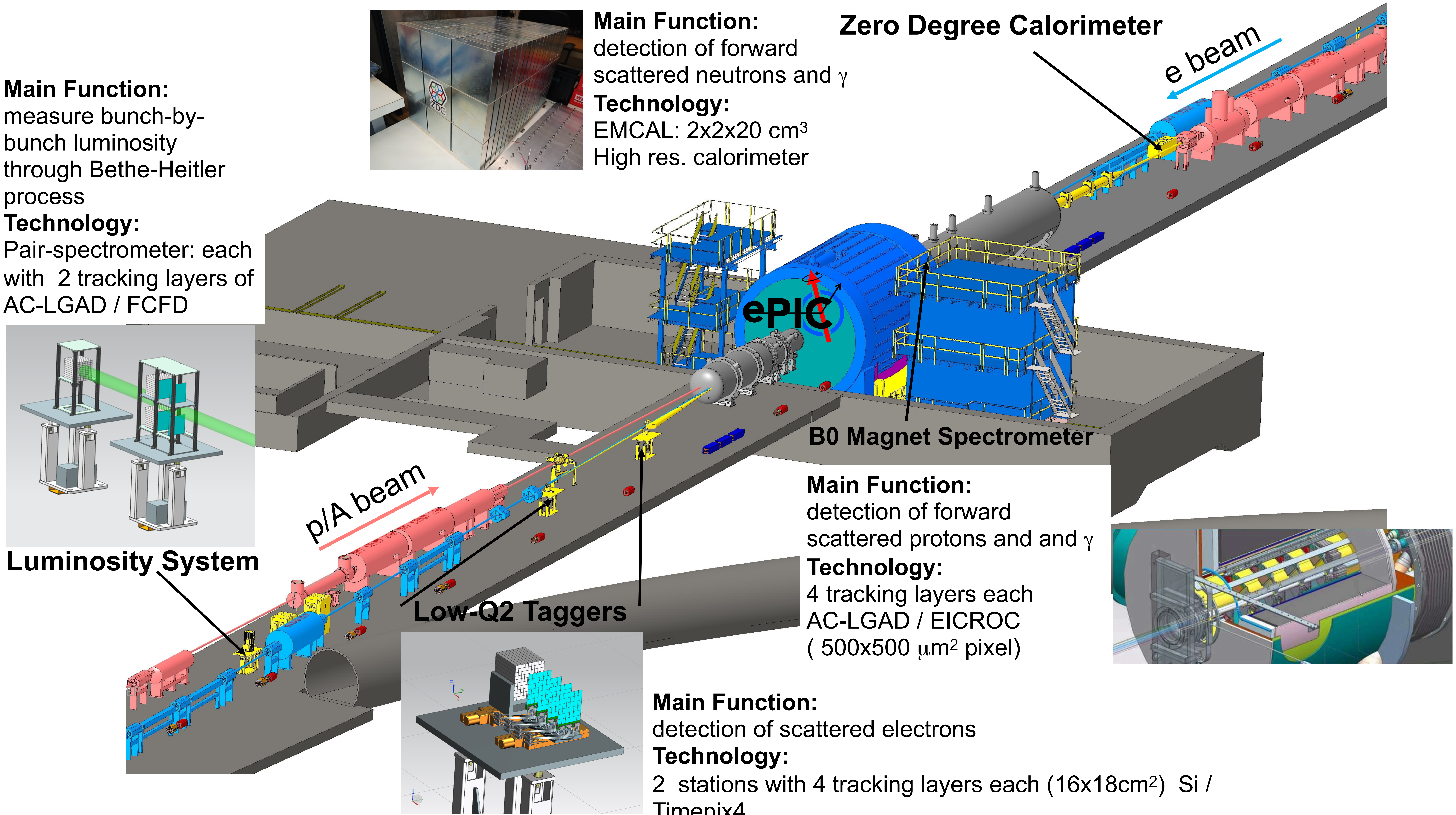
Main Function:
measure bunch-by-bunch luminosity through Bethe-Heitler process
Technology:
Pair-spectrometer: each with 2 tracking layers of AC-LGAD / FCFD



Main Function:
detection of forward scattered protons and and γ
Technology:
4 tracking layers each AC-LGAD / EICROC
(500x500 μm^2 pixel)

Main Function:
detection of scattered electrons
Technology:
2 stations with 4 tracking layers each (16x18cm^2) Si / Timepix4

ePIC Far-Forward/Far-Backward Detectors



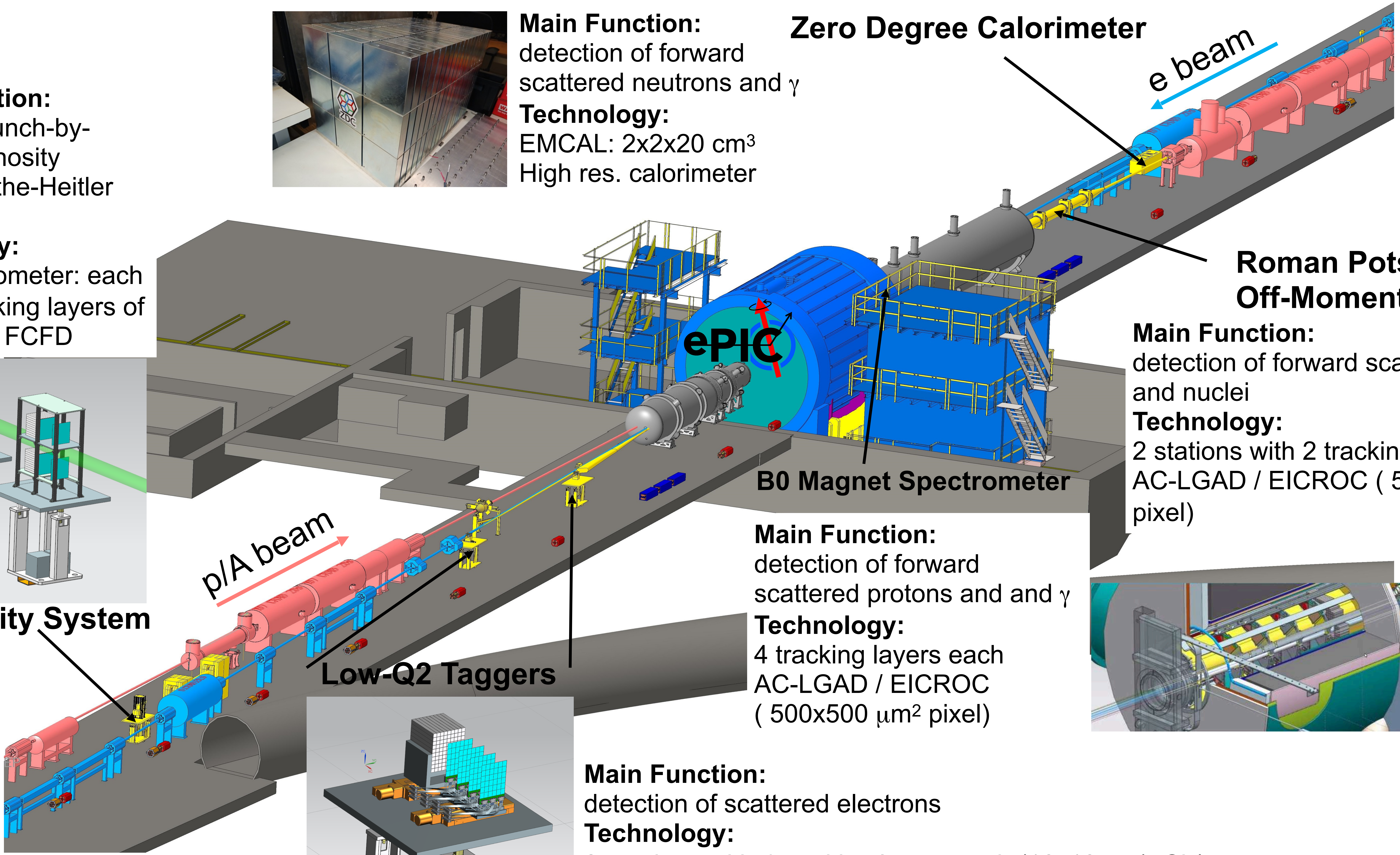
Main Function:
detection of forward scattered neutrons and γ
Technology:
EMCAL: 2x2x20 cm^3
High res. calorimeter

Main Function:
measure bunch-by-bunch luminosity through Bethe-Heitler process
Technology:
Pair-spectrometer: each with 2 tracking layers of AC-LGAD / FCFD

Main Function:
detection of forward scattered protons and and γ
Technology:
4 tracking layers each AC-LGAD / EICROC
(500x500 μm^2 pixel)

Main Function:
detection of scattered electrons
Technology:
2 stations with 4 tracking layers each (16x18cm^2) Si / Timepix4

ePIC Far-Forward/Far-Backward Detectors



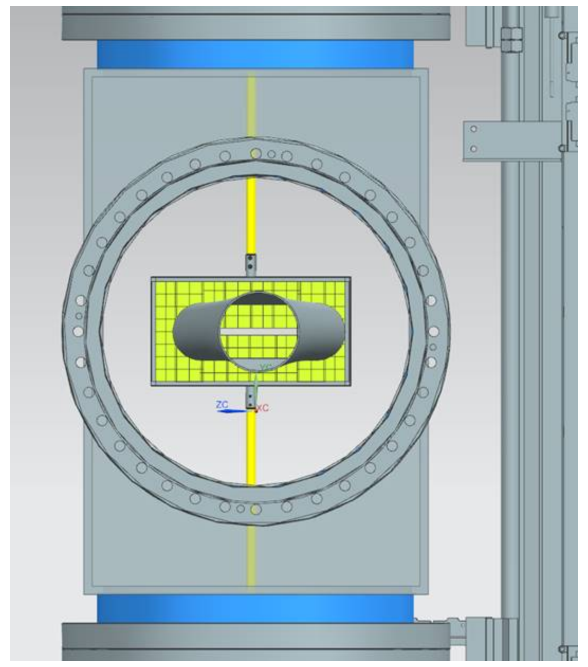
Luminosity System

Main Function:
measure bunch-by-bunch luminosity through Bethe-Heitler process
Technology:
Pair-spectrometer: each with 2 tracking layers of AC-LGAD / FCFD

Zero Degree Calorimeter

Main Function:
detection of forward scattered neutrons and γ
Technology:
EMCAL: 2x2x20 cm^3
High res. calorimeter

Roman Pots and Off-Momentum Detectors



Main Function:
detection of forward scattered protons and nuclei
Technology:
2 stations with 2 tracking layers each AC-LGAD / EICROC (500x500 μm^2 pixel)

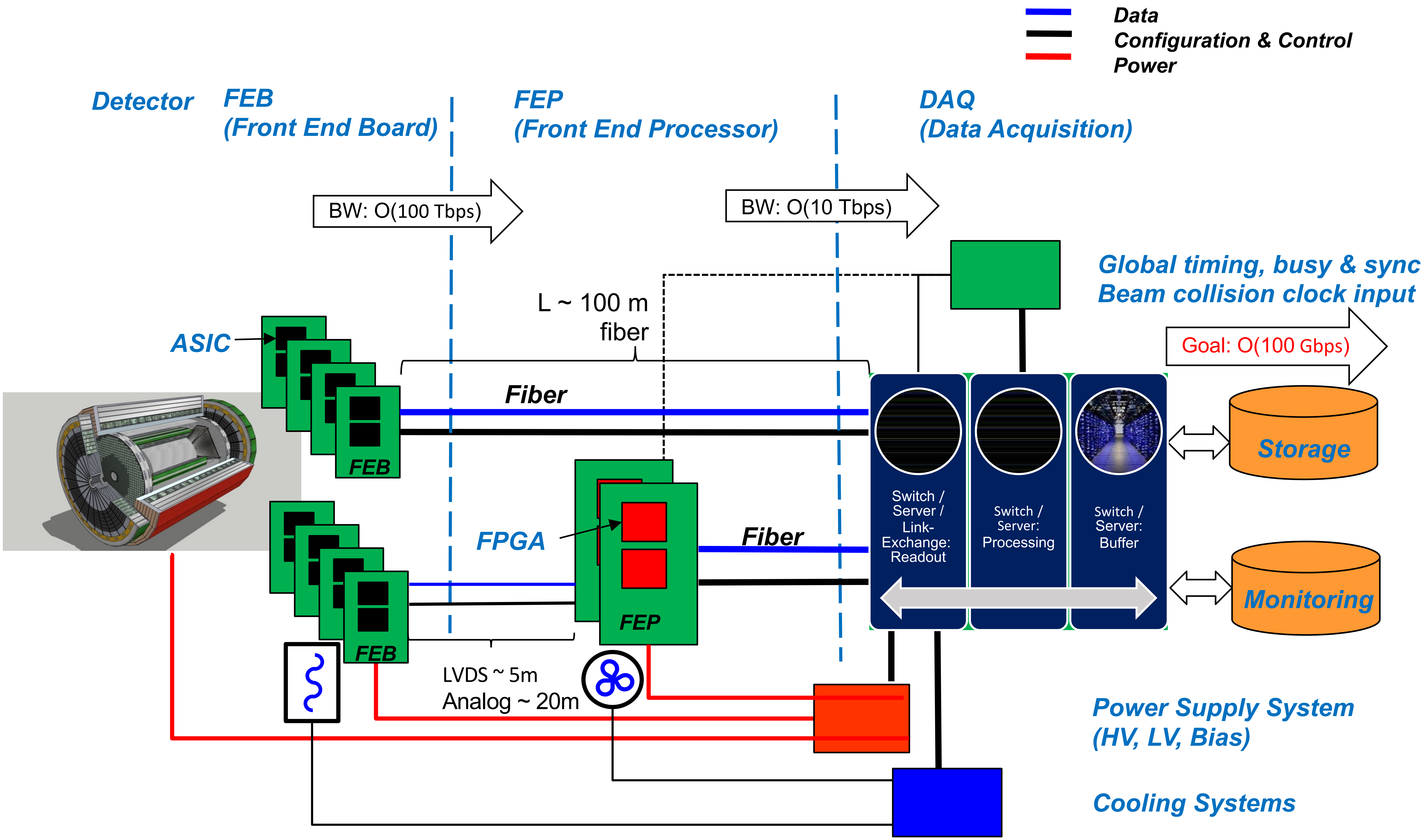
B0 Magnet Spectrometer

Main Function:
detection of forward scattered protons and and γ
Technology:
4 tracking layers each
AC-LGAD / EICROC
(500x500 μm^2 pixel)

Low-Q2 Taggers

Main Function:
detection of scattered electrons
Technology:
2 stations with 4 tracking layers each (16x18cm^2) Si / Timepix4

Streaming DAQ



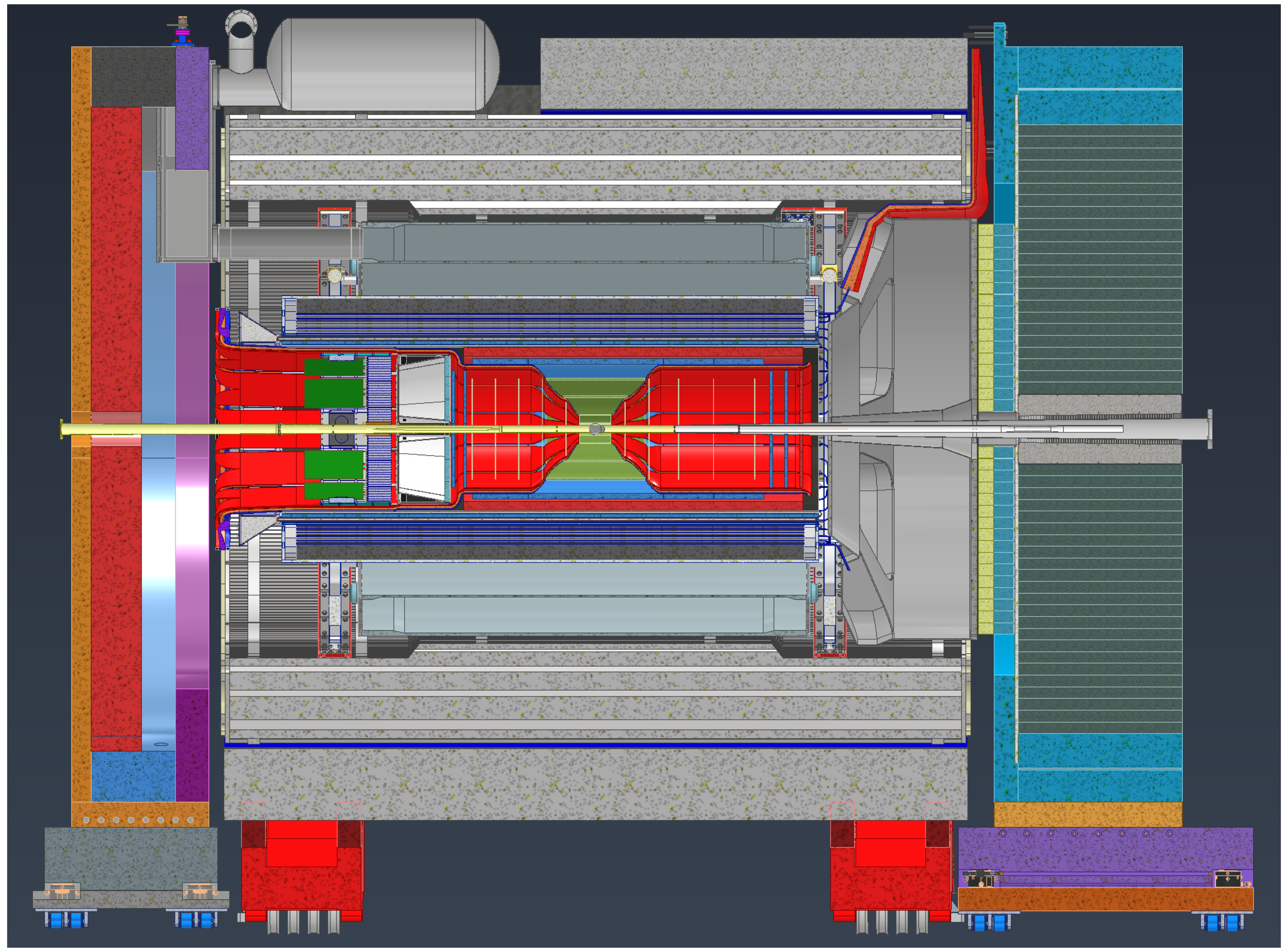
Benefits from low multiplicity/occupancy even in eA.
Background impact under study.
At full $\mathscr{L}$ ➟ ~0.5 MHz interaction rate.

- No external trigger
- All collision data digitized but aggressively zero suppressed at FEB
- Low / zero deadtime
- Event selection can be based upon full data from all detectors (in real time, or later)
- Collision data flow is independent and unidirectional ➟ no global latency requirements
- Avoiding hardware trigger avoids complex custom hardware and firmware
- Data volume is reduced as much as possible at each stage

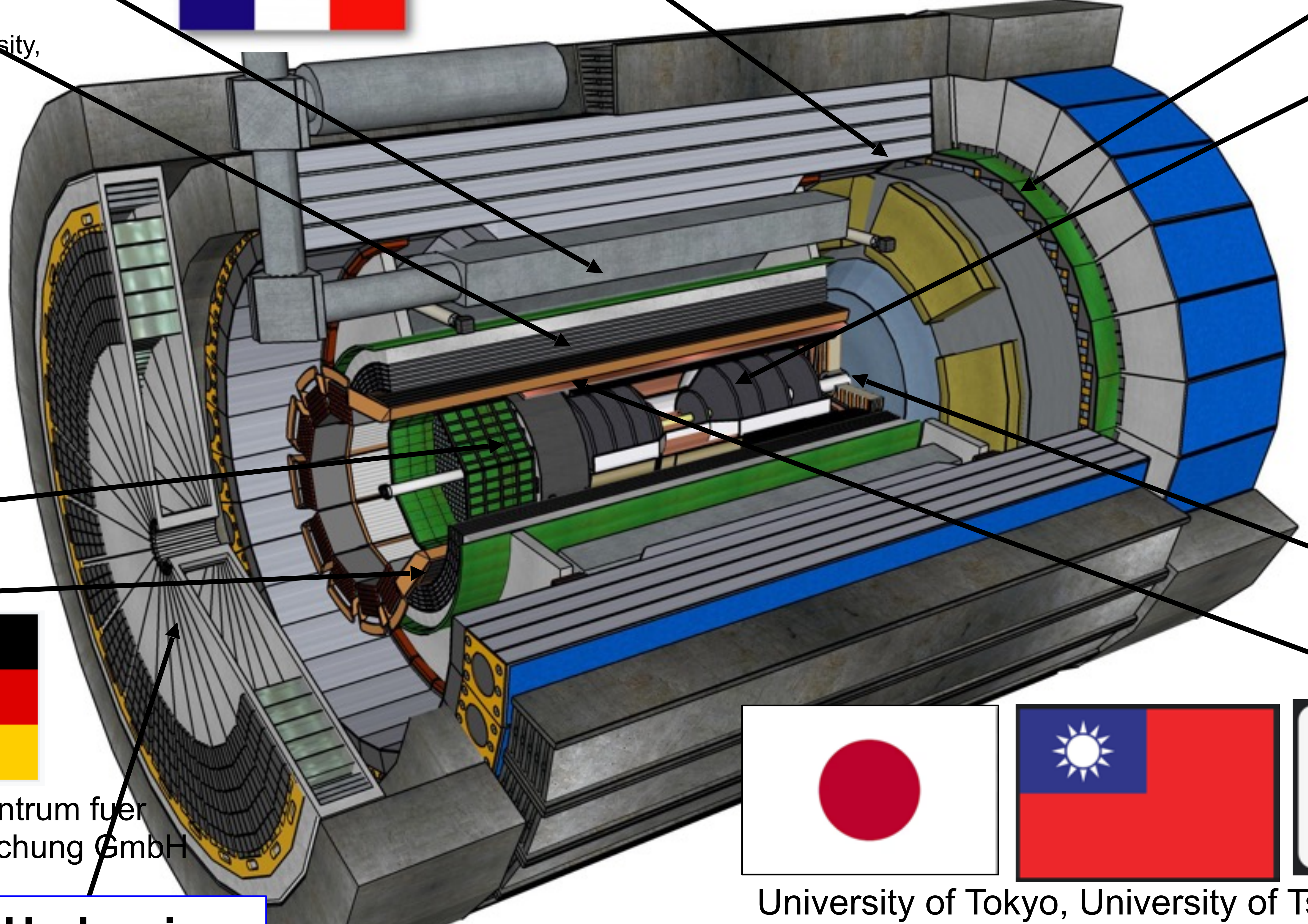
Integration

Integration Challenges

- All subdetectors and services into the main detector volume
- Installation of detector and accelerator components
- Integrate main detector and ancillary detectors into the IR and electron and hadron beam lattice
- Moving ePIC of hall for maintenance critical
- RCS beam line is limiting lateral dimension



ePIC: A True International Detector (30% In-Kind)



Barrel Electromagnetic Calorimeter

Karlsruhe Institute of Technology

Yonsei University,
Gangneung-Wonju National University,
Hanyang University
Jeonbuk National University
Korea University
Kyungpook National University
University of Seoul
Pusan National University
Sungkyunkwan University
Sejong University
Hanyang University
Yonsei University

University of Regina
University of Manitoba

Superconducting Solenoid

Dual-radiator RICH

INFN Sezione di Bologna
Università di Bologna
INFN Sezione di Ferrara,
Università di Ferrara
INFN Sezione di Trieste
Universita di Trieste

Forward Electromagnetic Calorimeter

Tracking Detectors

University of Birmingham,
Daresbury Laboratory,
INFN Sezione di Bari,
Università di Bari,
Università di Foggia,
INFN Sezione di Padova,
Università di Padova,
INFN Sezione di Pavia,
INFN Sezione di Trieste,
Universita di Trieste,
Czech Technical University in Prague,
Rutherford Appleton Laboratory
University of Liverpool,
CEA-Saclay,
Seoul National University,
INFN Sezione di Roma Tor Vergata,
Universita di Roma Tor Vergata

Backward Electromagnetic Calorimeter

IJClab (Orsay)
A. Alikhanian National Laboratory, Armenia,
Charles University (CUNI), Prague

DIRC

GSI Helmholtzzentrum fuer Schwerionenforschung GmbH

Backward Hadronic Calorimeter

Czech Technical University in Prague,
NPI The Czech Academy of Sciences

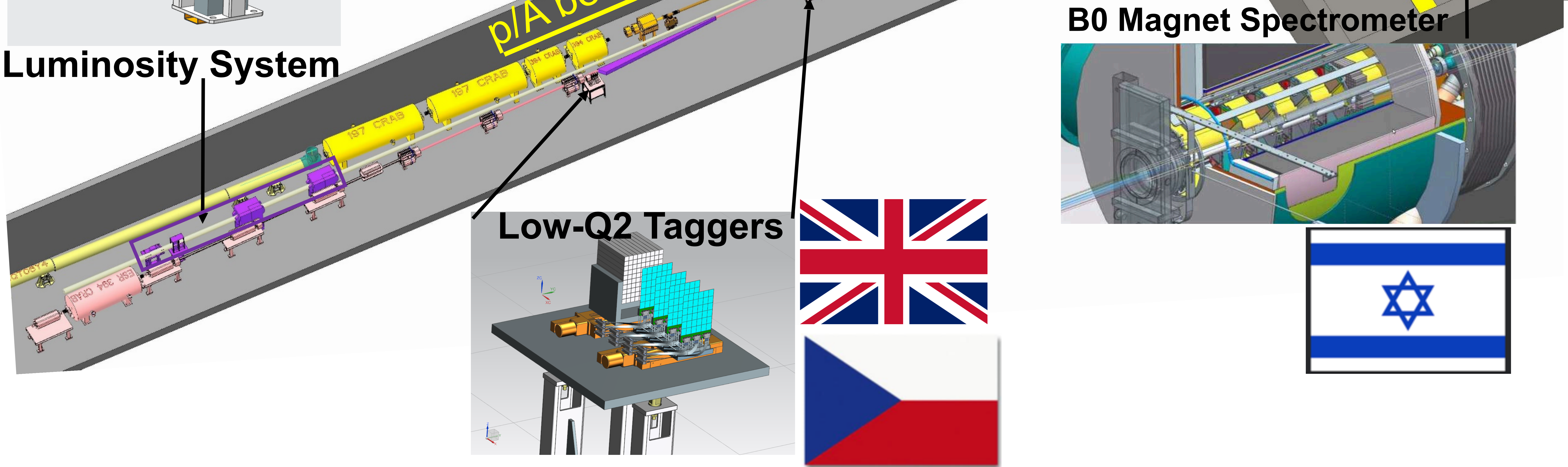
Time-of-Flight

University of Tokyo, University of Tsukuba, Hiroshima University
Kobe University, Nara Women's University, Nihon University, Shinshu University
National Central University, National Cheng Kung University
National Taiwan University, National Tsing Hua University

Data-Acquisition Electronics

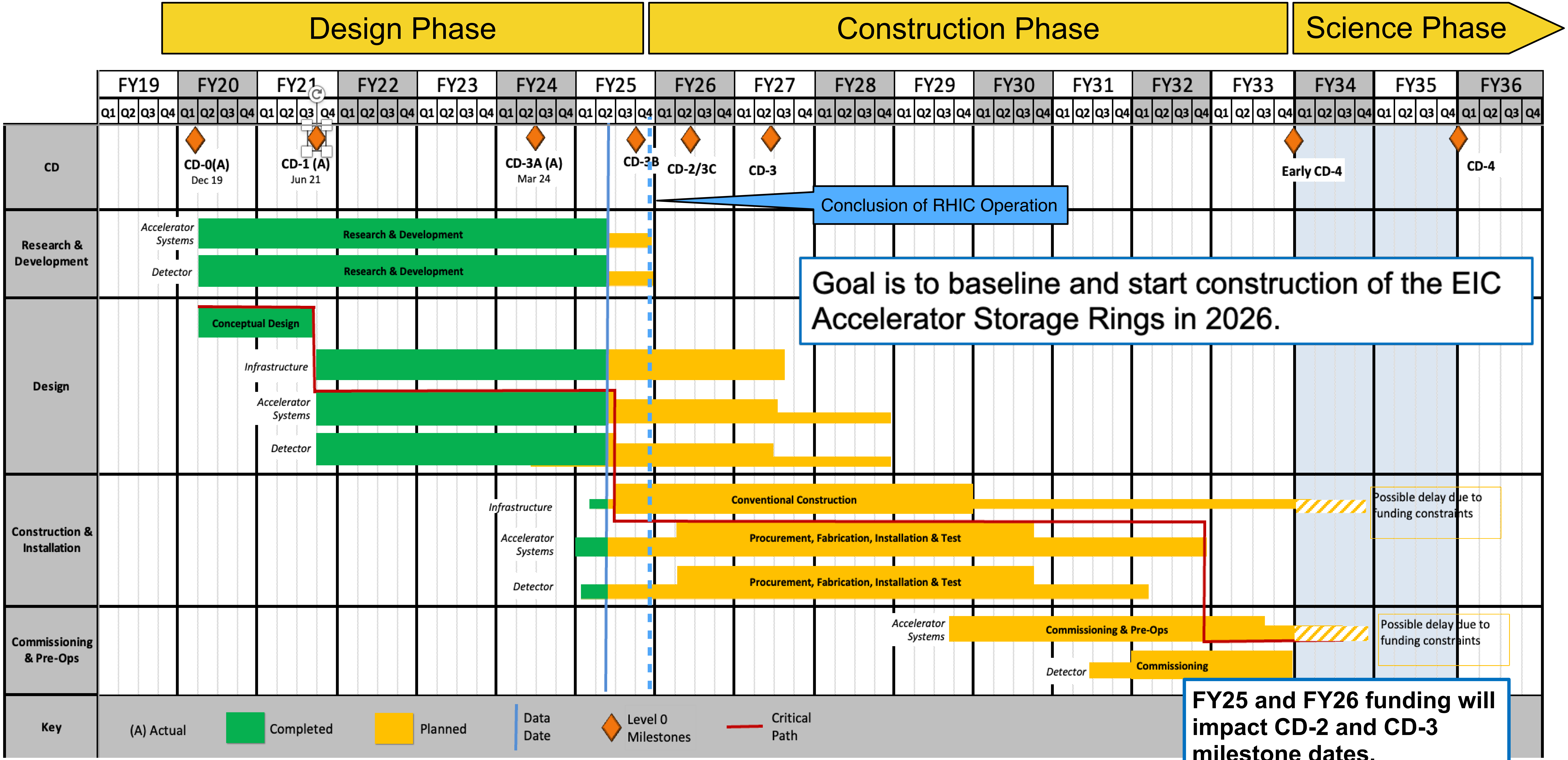
Far-Forward/Far-Backward Detectors Non-DOE Interest & In-kind

IR vacuum – crucial interface for detectors



RIKEN Nishina Center
University of Glasgow
AGH University of Krakow
Ben Gurion University of the Negev
Institute of Nuclear Physics Polish Academy of Sciences (IFJ PAN)
Institute of Physics, Academia Sinica
Tel-Aviv University
Warsaw University of Technology, Faculty of Physics
University of York

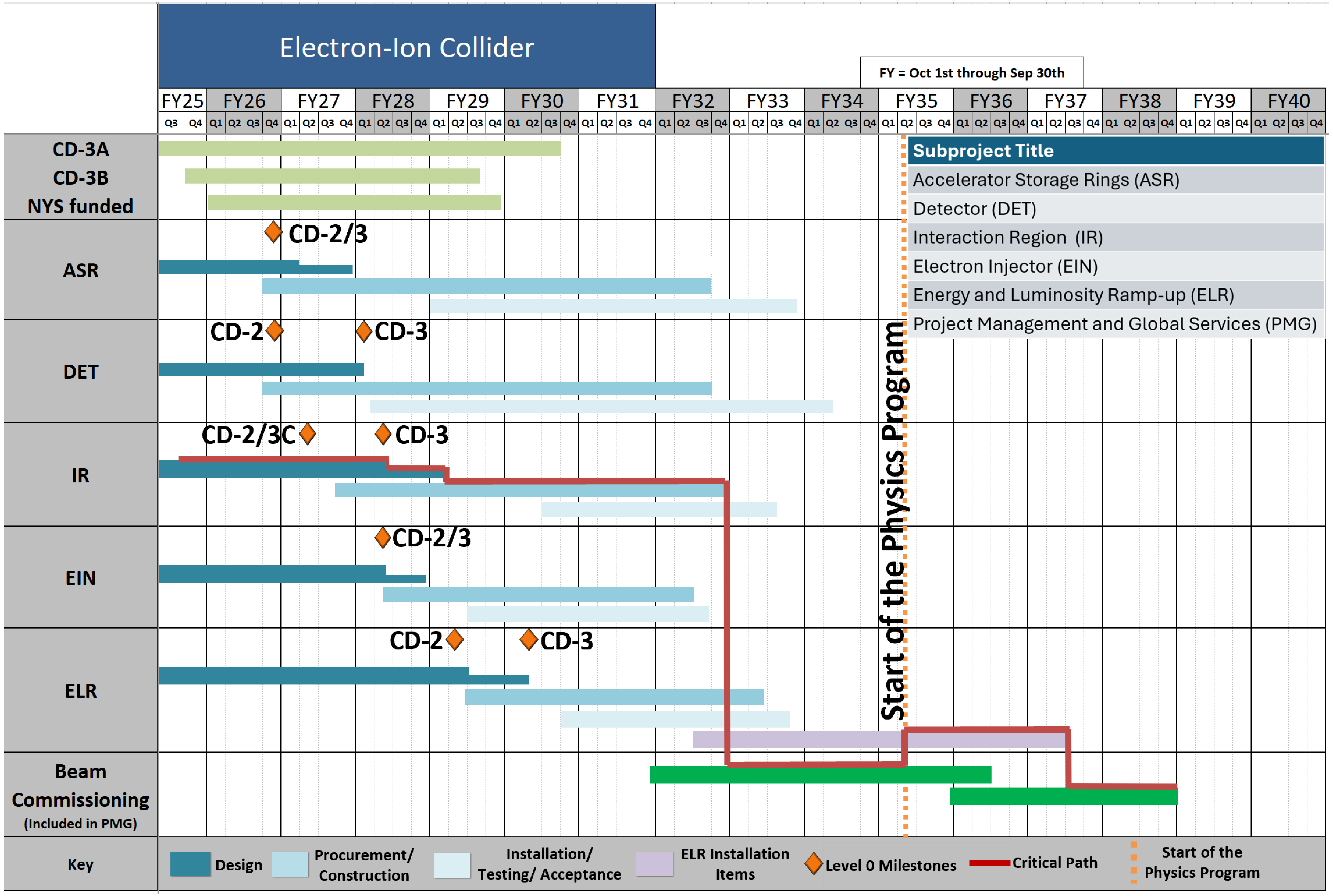
Quo Vadis EIC: Overall Schedule



Goal is to baseline and start construction of the EIC Accelerator Storage Rings in 2026.

FY25 and FY26 funding will impact CD-2 and CD-3 milestone dates.

New: Split into Subprojects



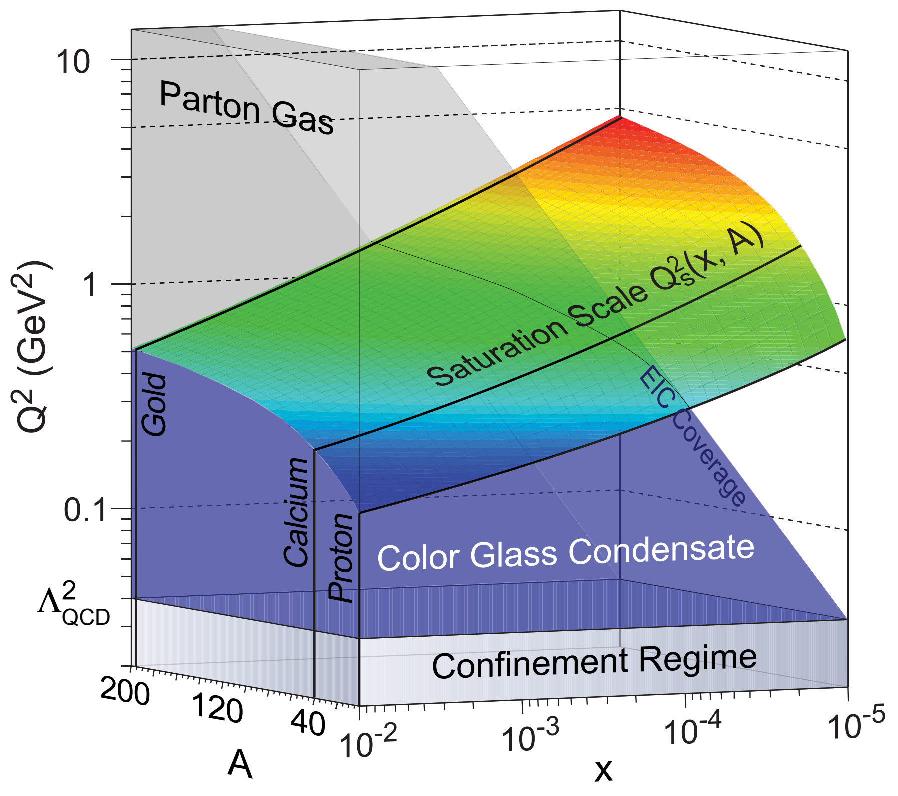
Project Delivery Strategy

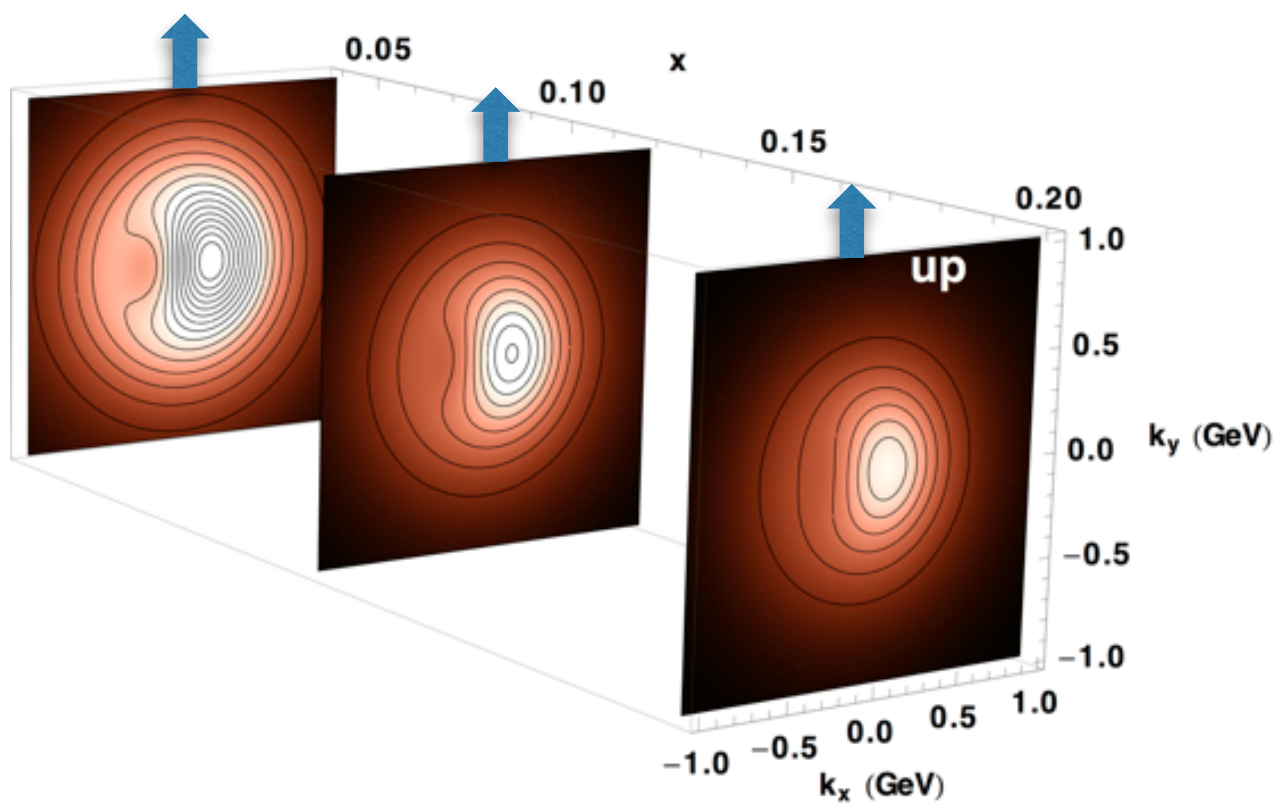
- Deliver the full EIC facility scope using subprojects and the phased implementation of the EIC project scope.
- The strategy enables the start of the EIC construction when the first subproject is ready and the start of the EIC science program during collider commissioning, concurrent with the final subproject equipment installation.

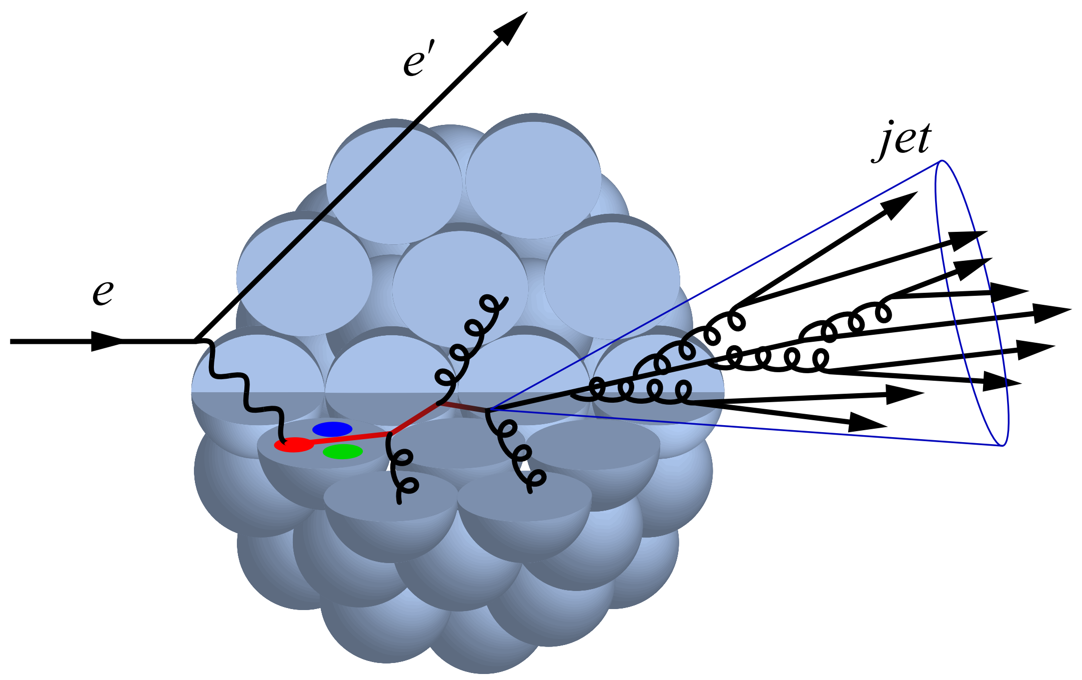
Closing Comments

EIC will provide answers to profound questions in QCD

- **ep:** Precision studies of structure functions, TMDs, and GPDs will lead to the most comprehensive picture of the nucleon ever: its flavor, spin, and spatial structure
- **eA:** Unprecedented study of matter in a new regime of QCD. New capabilities open a new frontier to study the saturation region, measure the gluonic structure of nuclei, and investigate color propagation, and fragmentation using the nucleus as analyzer.







There is precedent for surprises in nature, provided you look


Event #4
0.0 ns


Event #4
0.0 ns


Event #4
0.0 ns