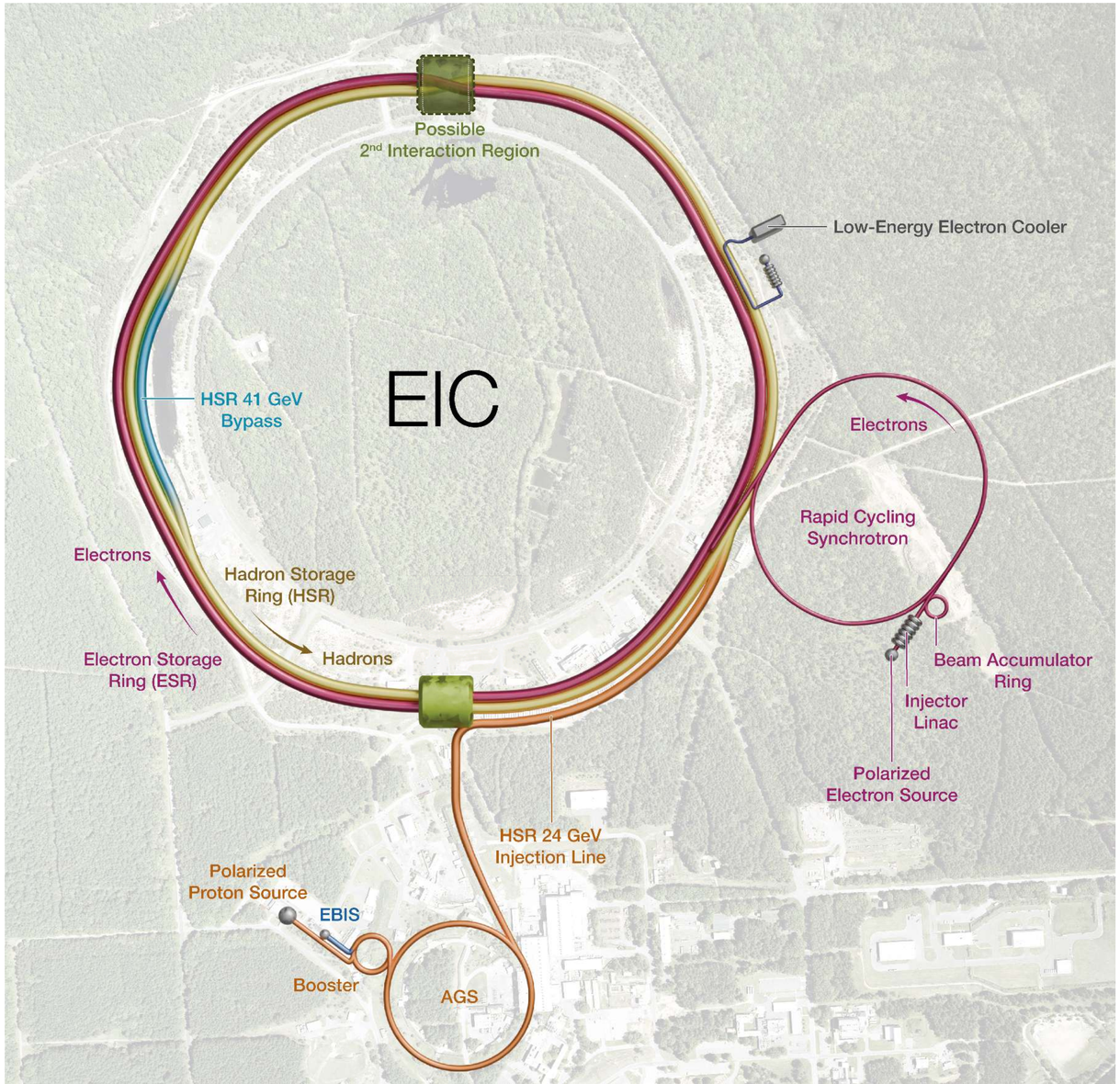
Towards a detector for the future EIC

Charlotte Van Hulse, on behalf of the ePIC collaboration
VUB

ODYSSEUS Top science in Flanders fwo

NSTAR26
07 to 11 September 2026
Sevilla, Spain

Future: the electron-ion collider (EIC)



- Based on RHIC:
  - use exiting hadron storage ring
    energy: 41, 100–275 GeV
  - add electron storage ring in RHIC tunnel
    energy: 5–10 GeV

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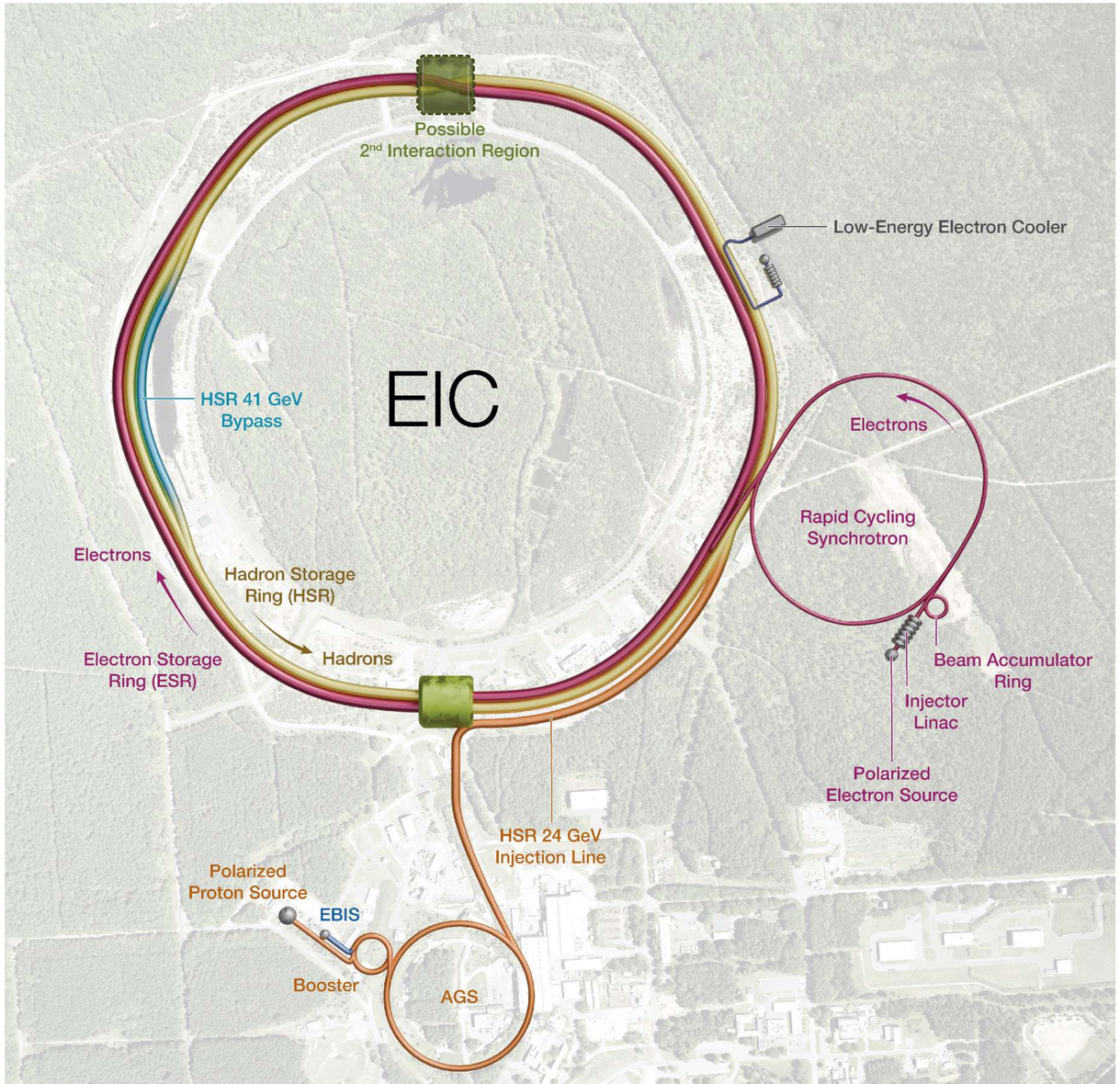

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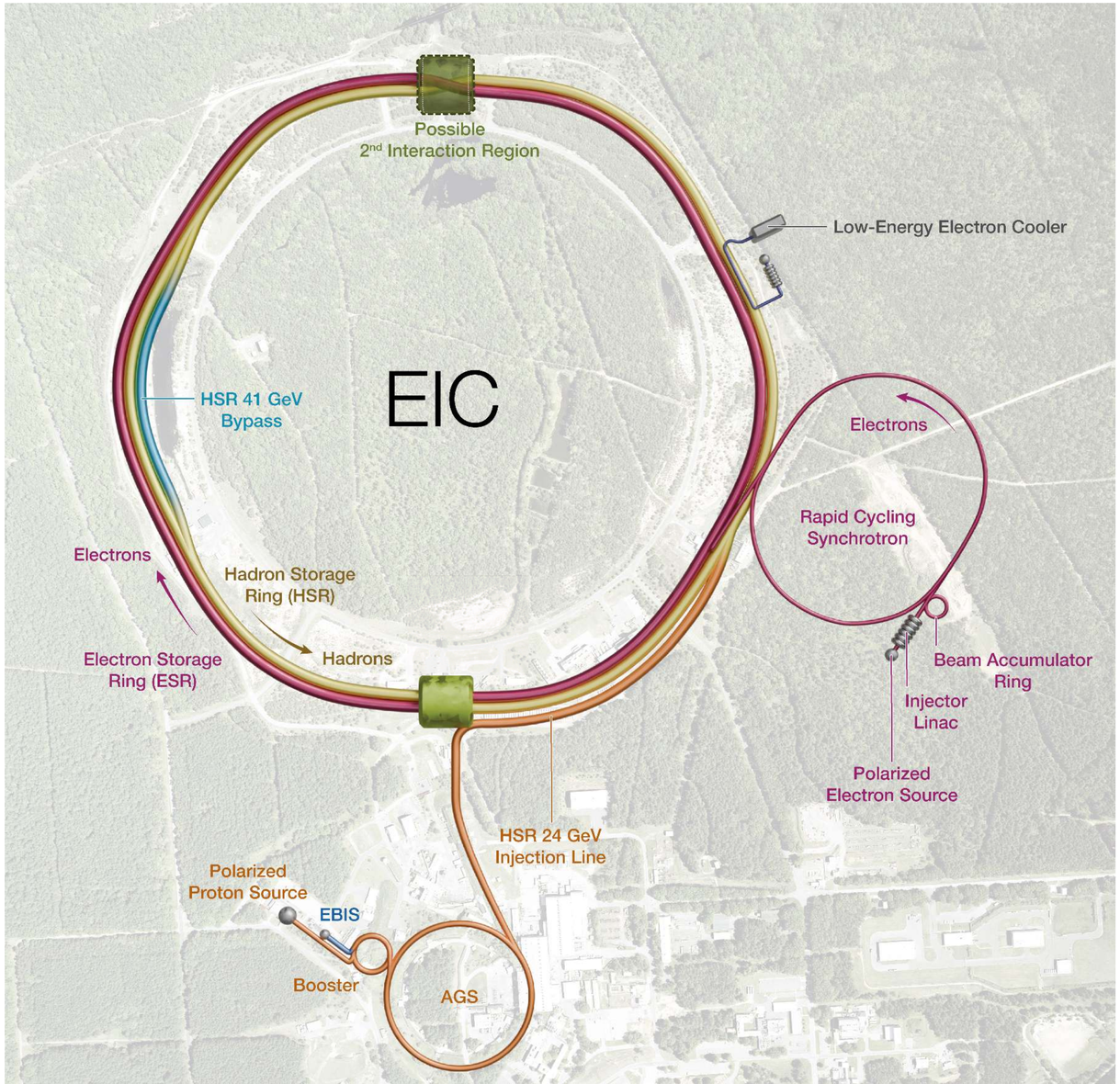

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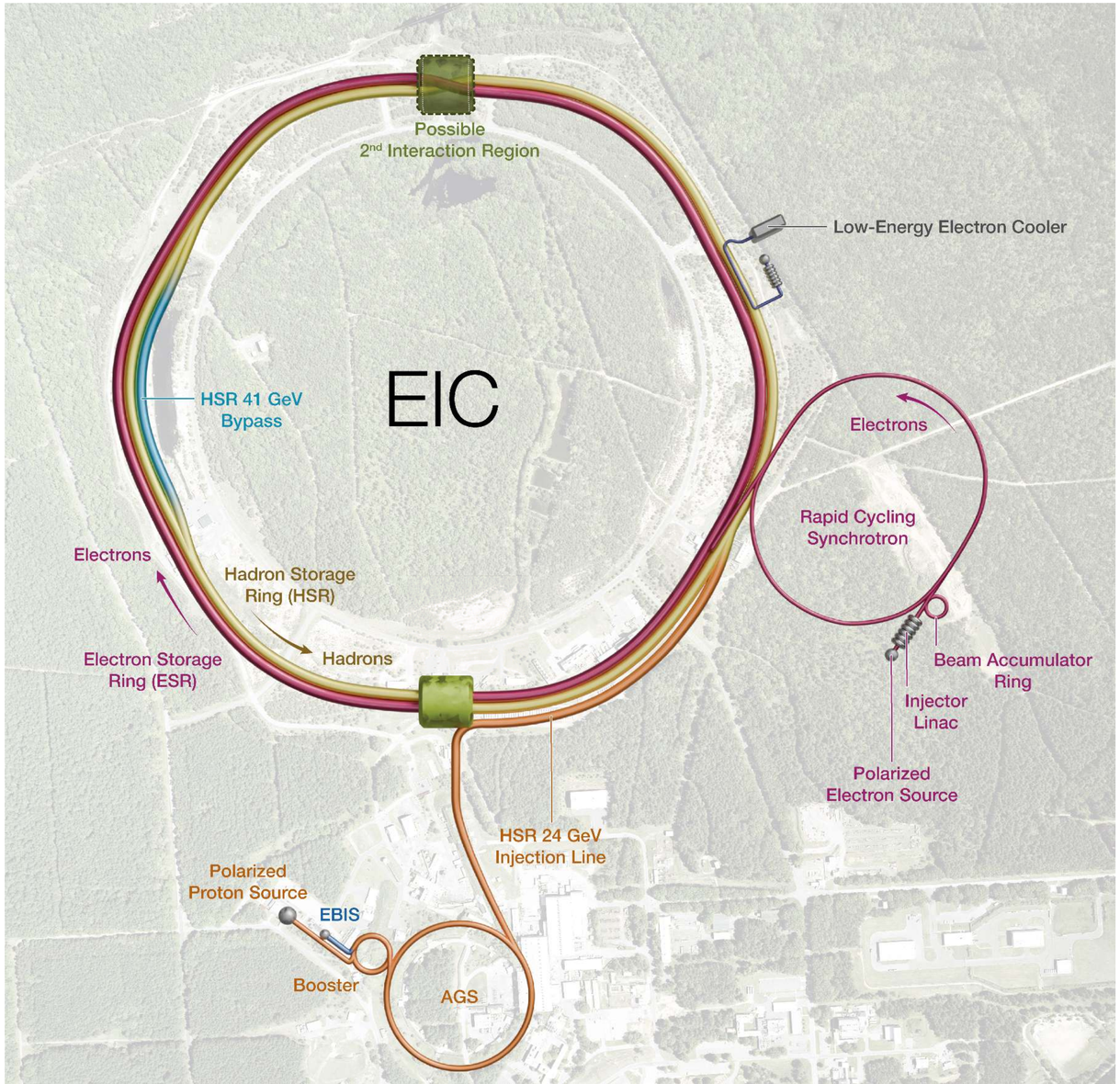

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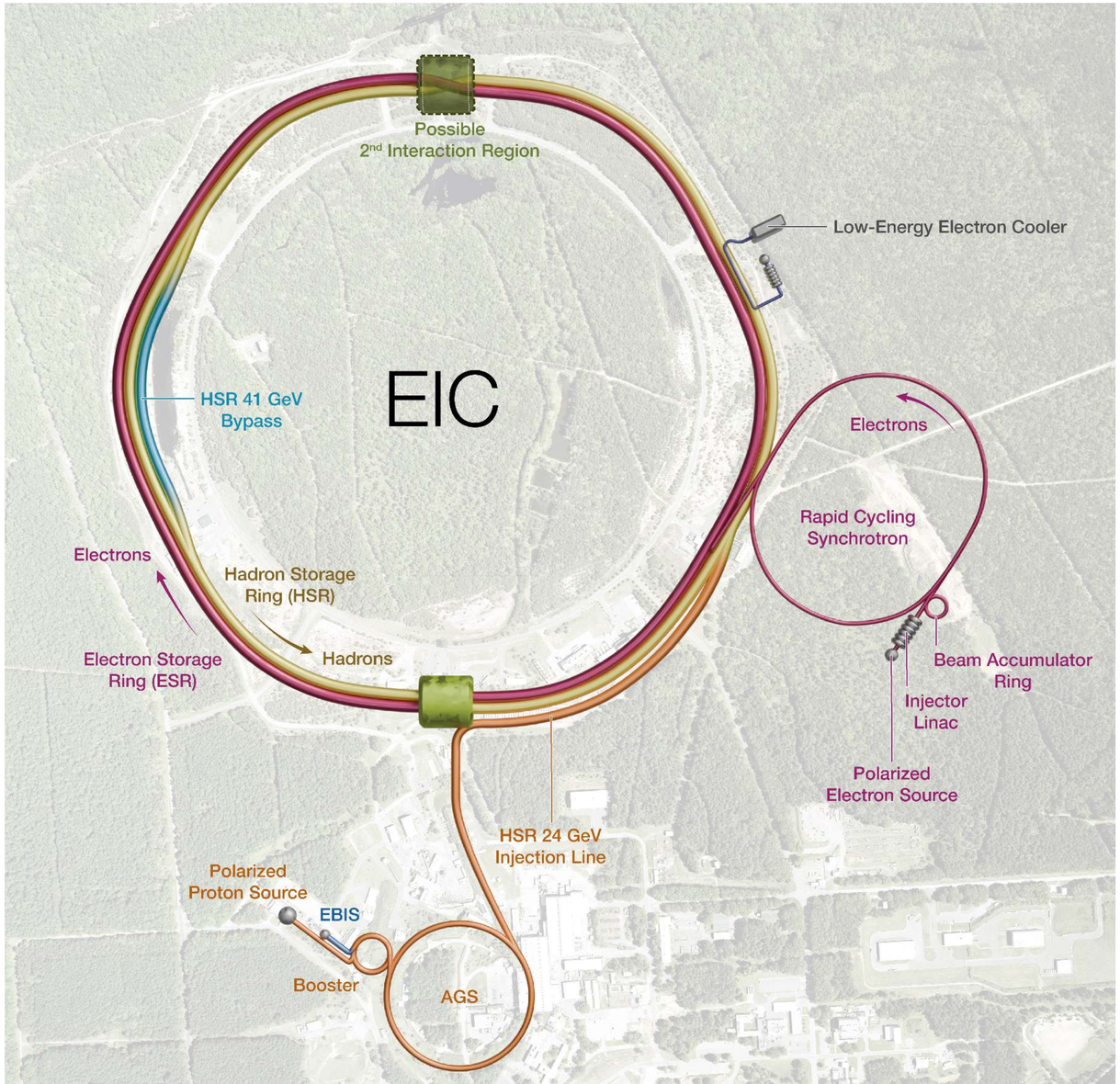

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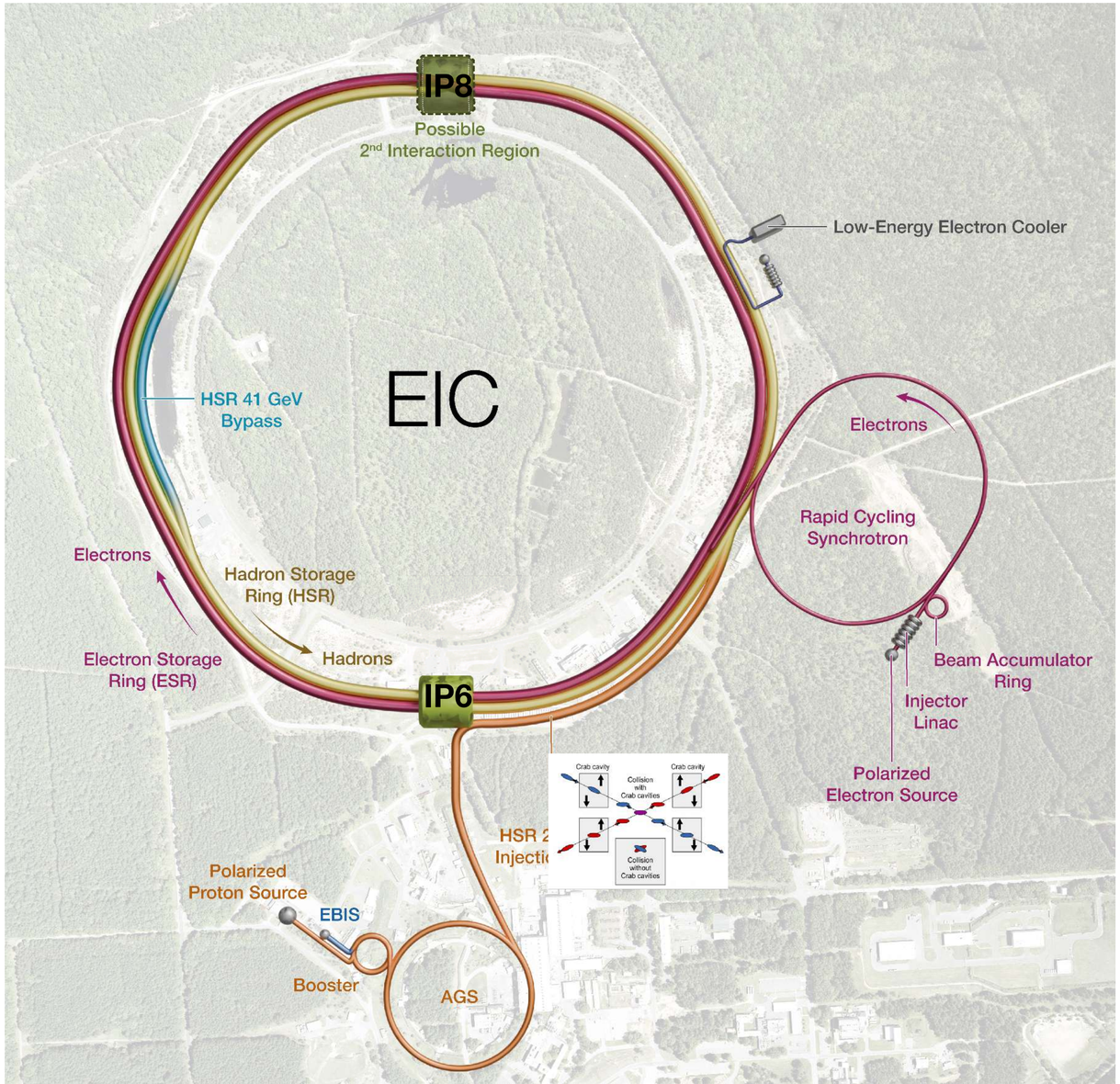

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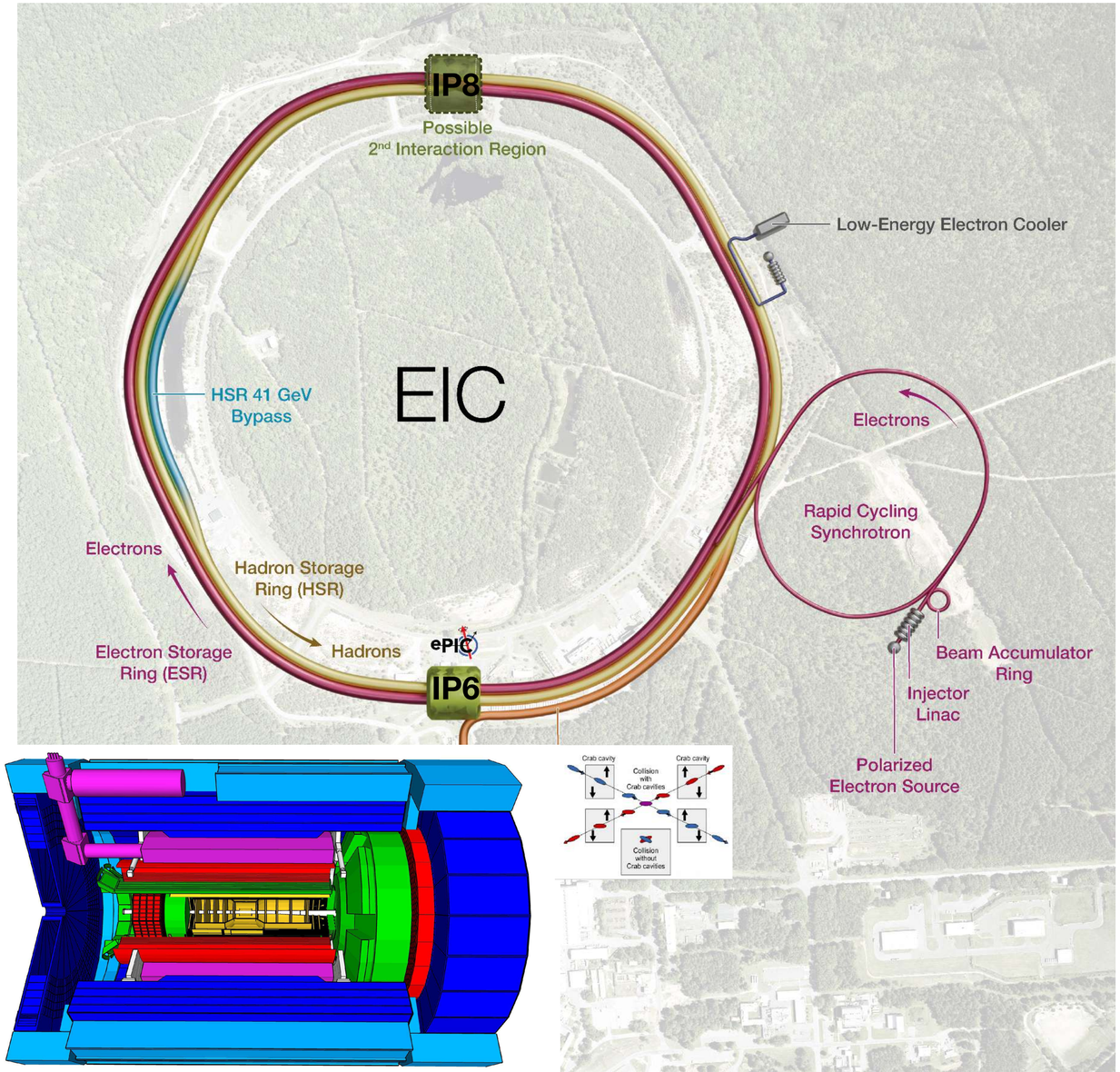

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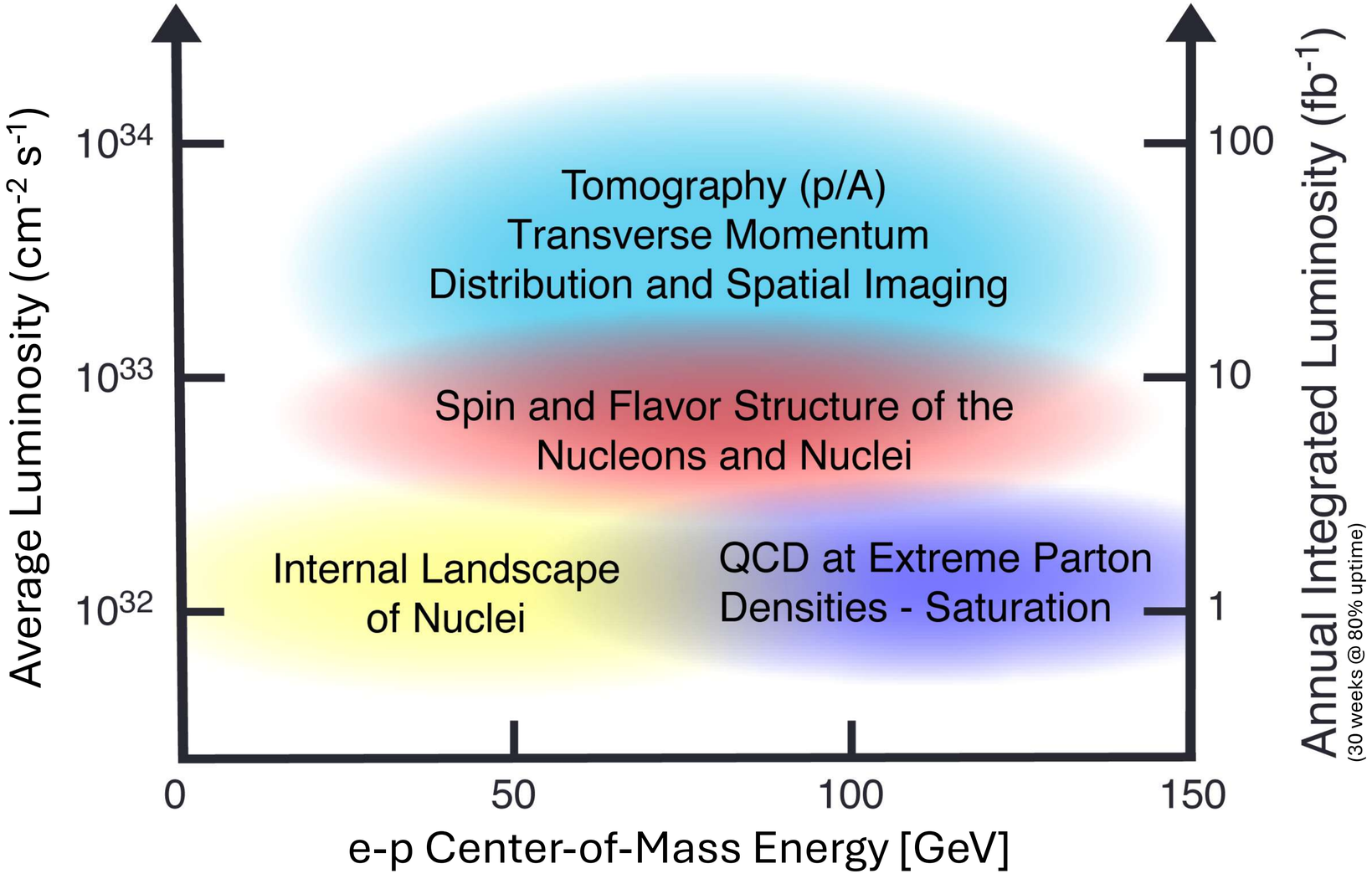
The various data-collection stages



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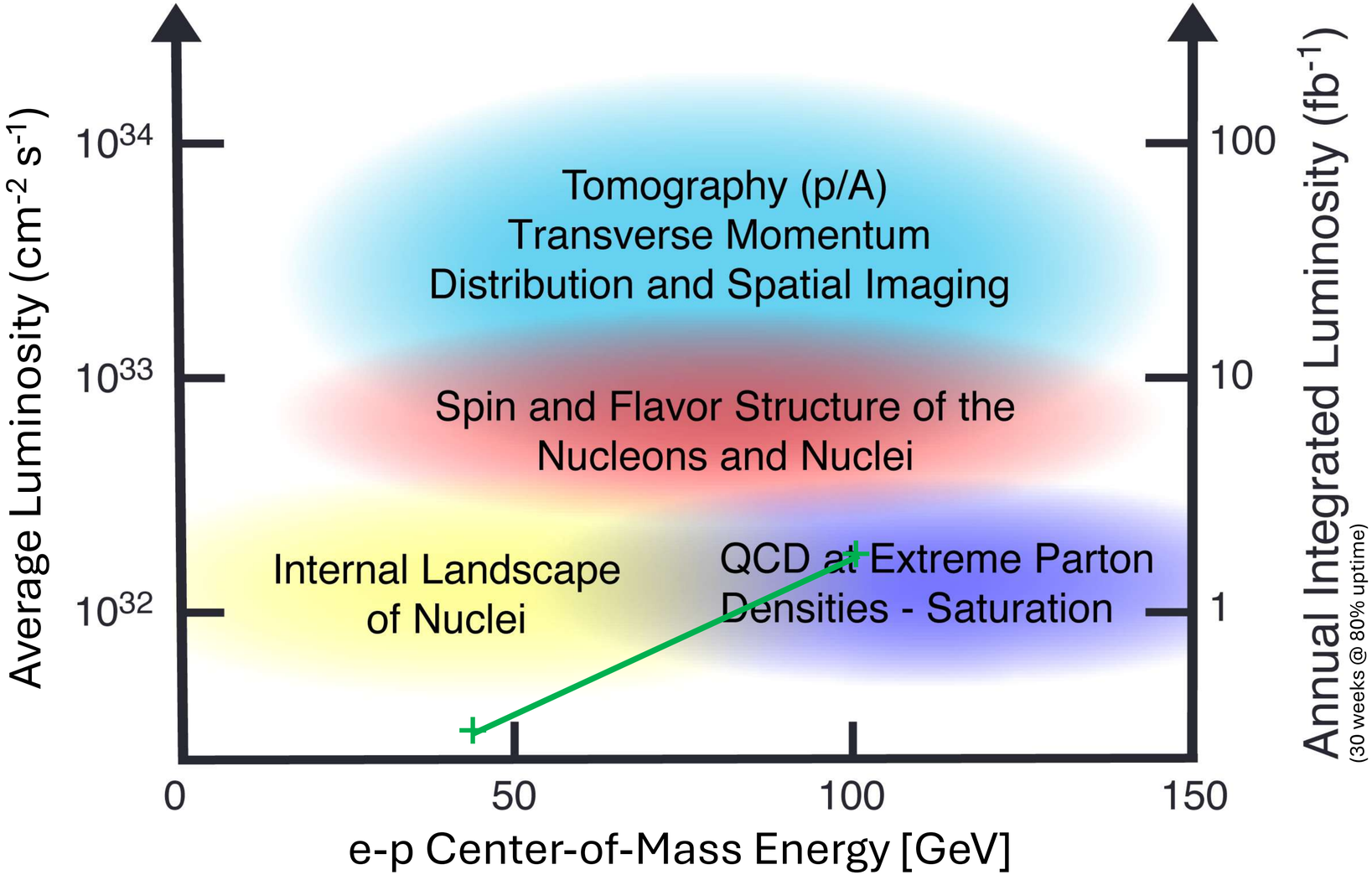

+ EIC
  - SRF for 7nC/bunch
  - no 394 MHz crab cavities
  - no low energy cooling
  - no 41 GeV bypass

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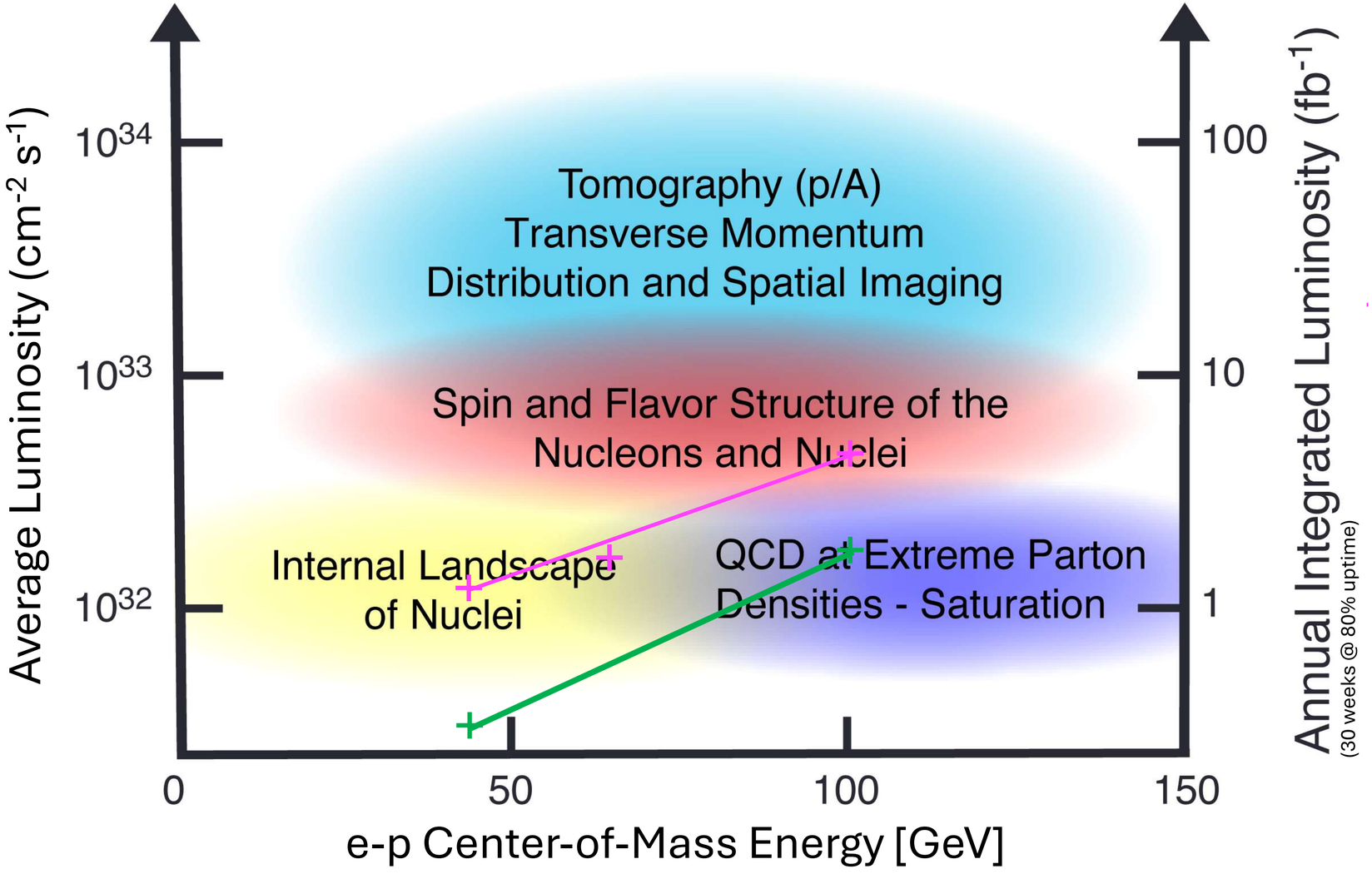

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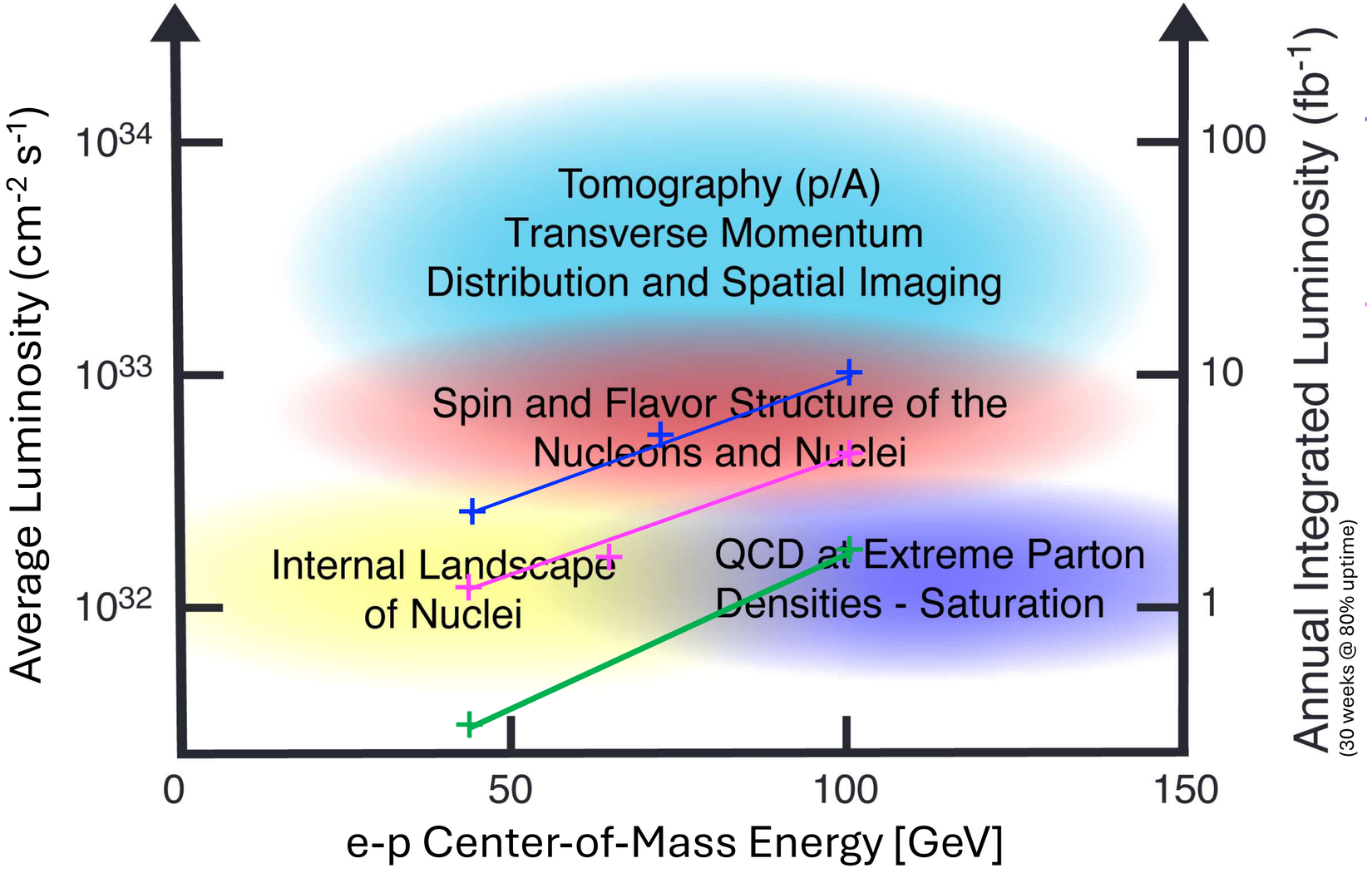

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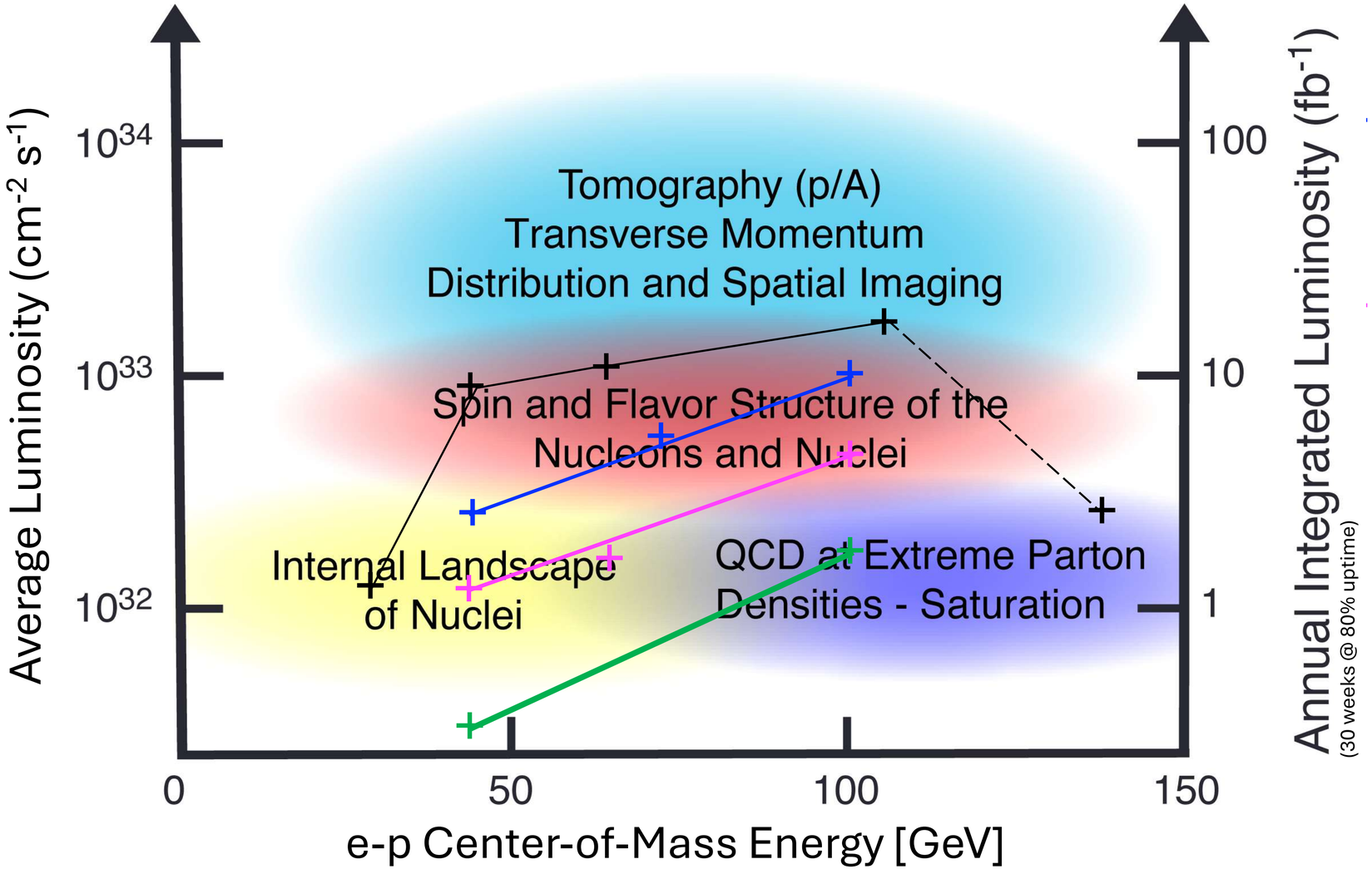

+ EIC Full Capability
  - - - 140 GeV (upgrade)

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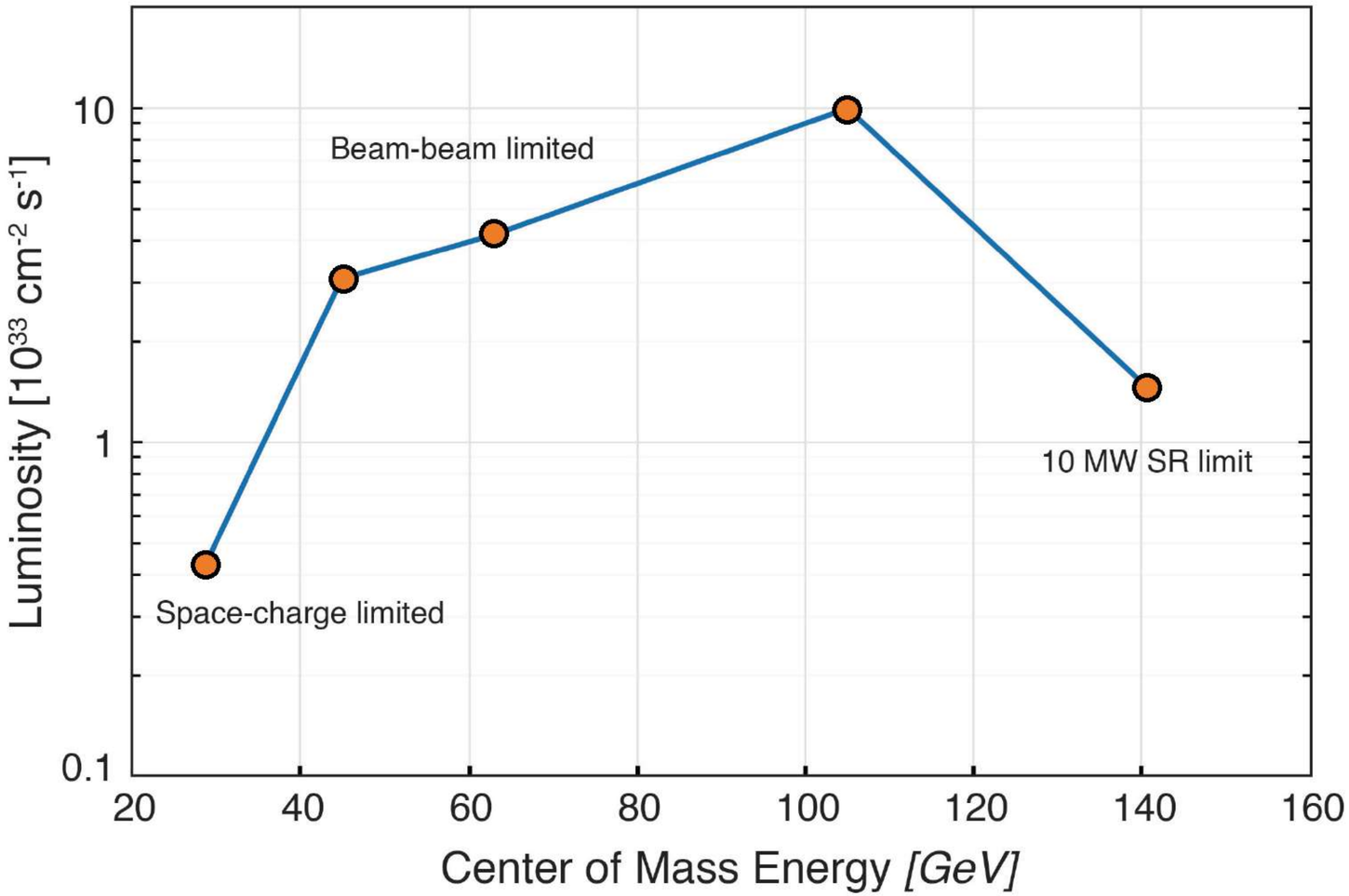
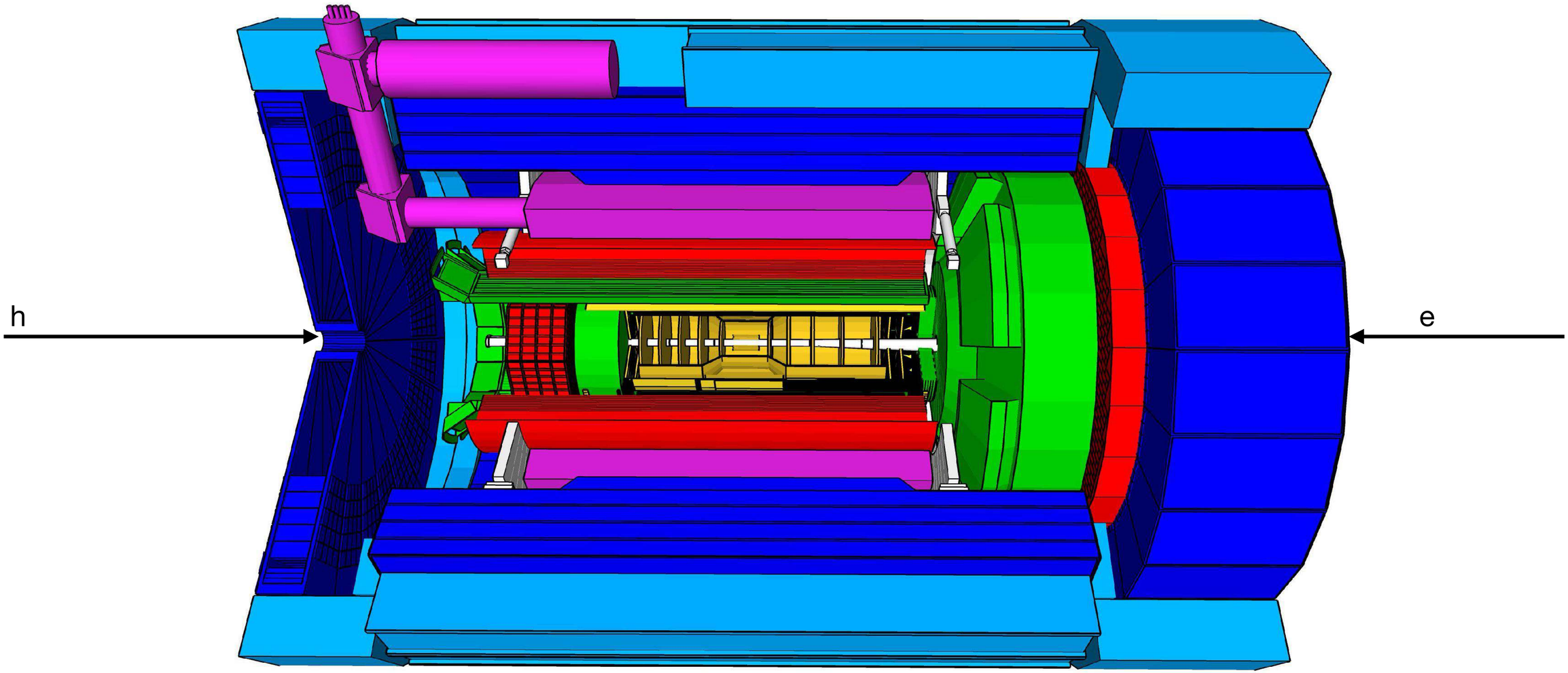
Luminosity and centre-of-mass energy: ep collisions



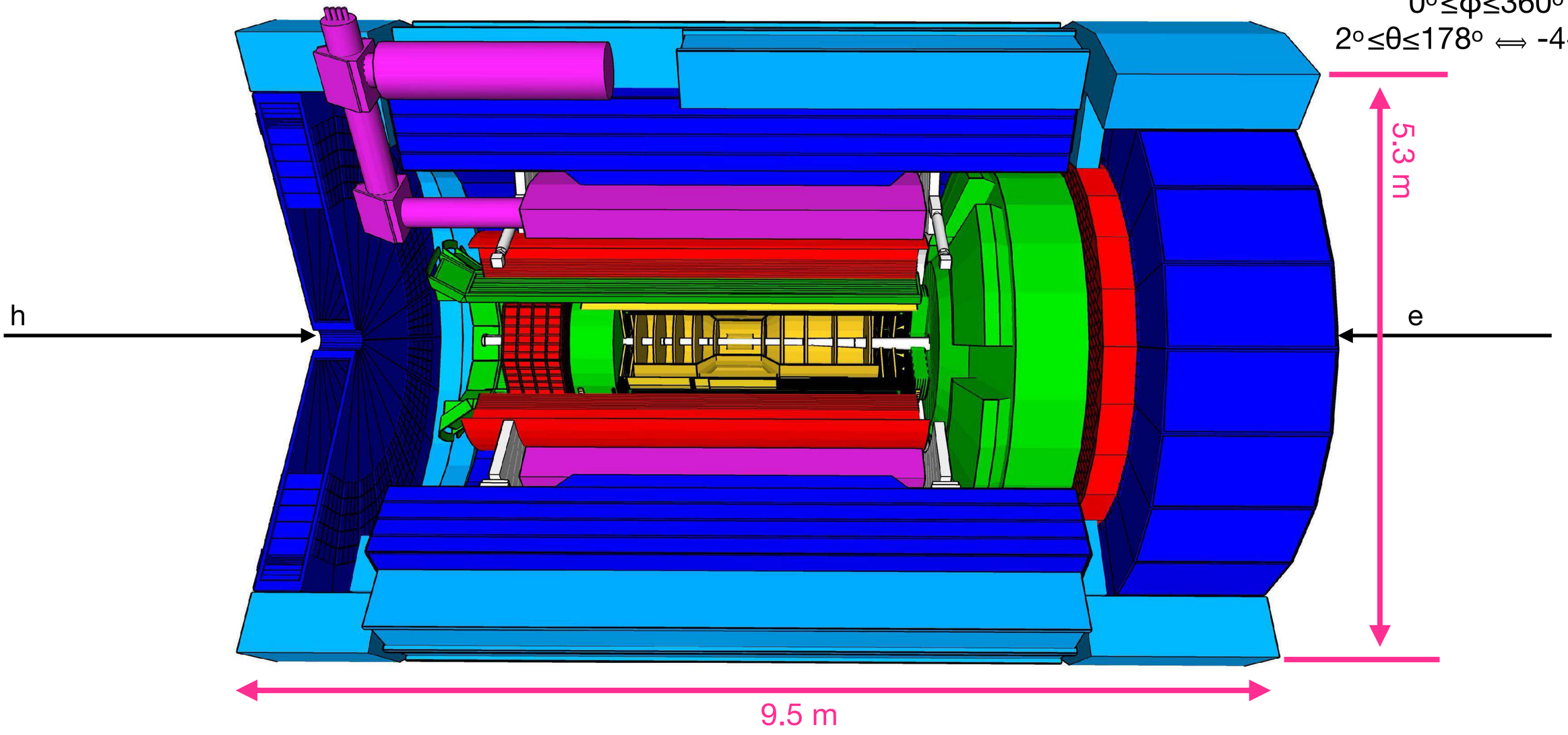
Luminosity for eA similar within factor 2–3

The electron-proton/ion collider (ePIC) detector



The electron-proton/ion collider (ePIC) detector

hermetic coverage:
$0^o \leq \phi \leq 360^o$
$2^o \leq \theta \leq 178^o \iff -4 < \eta < 4$



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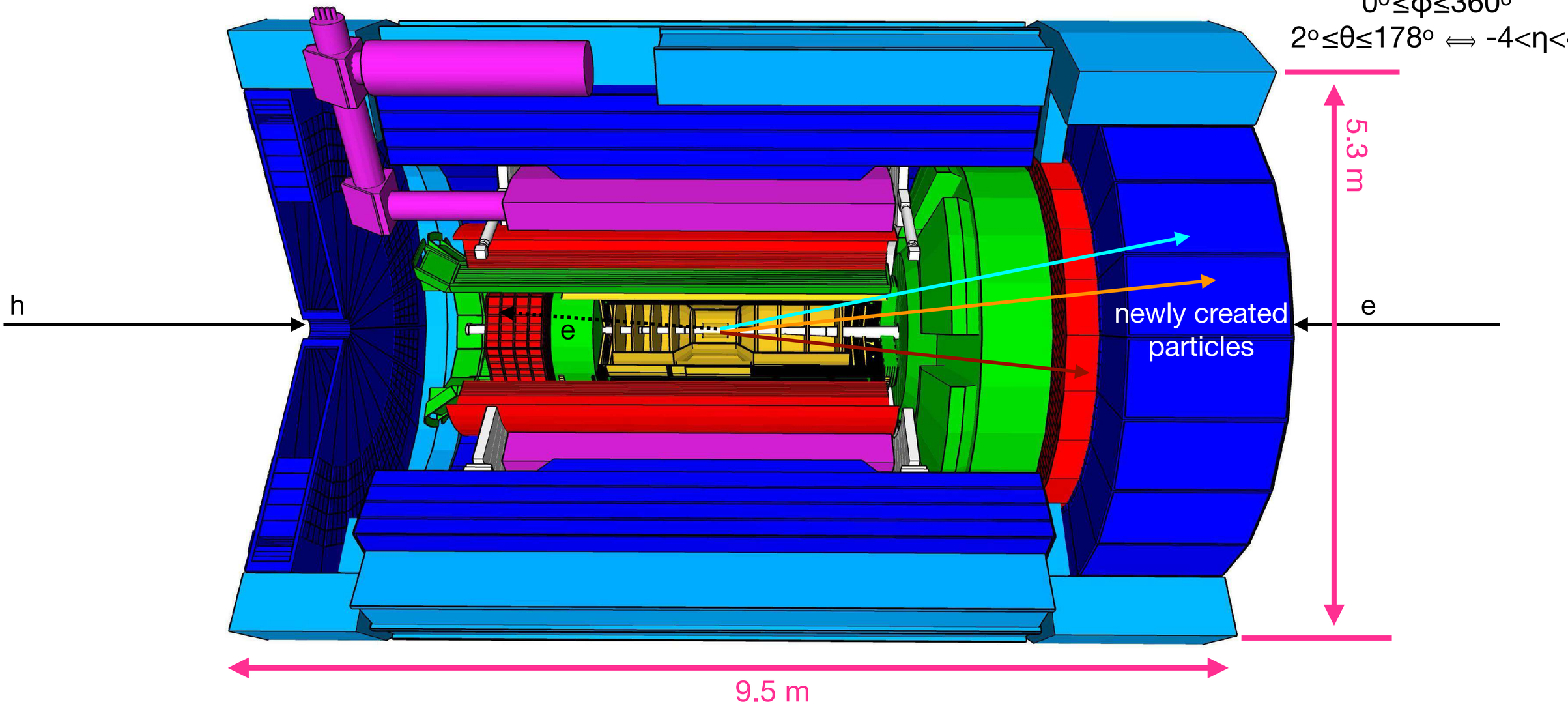

The electron-proton/ion collider (ePIC) detector

- **Tracking**
- **PID**
- **Electromagnetic calorimeter**
- **Hadronic calorimeter**

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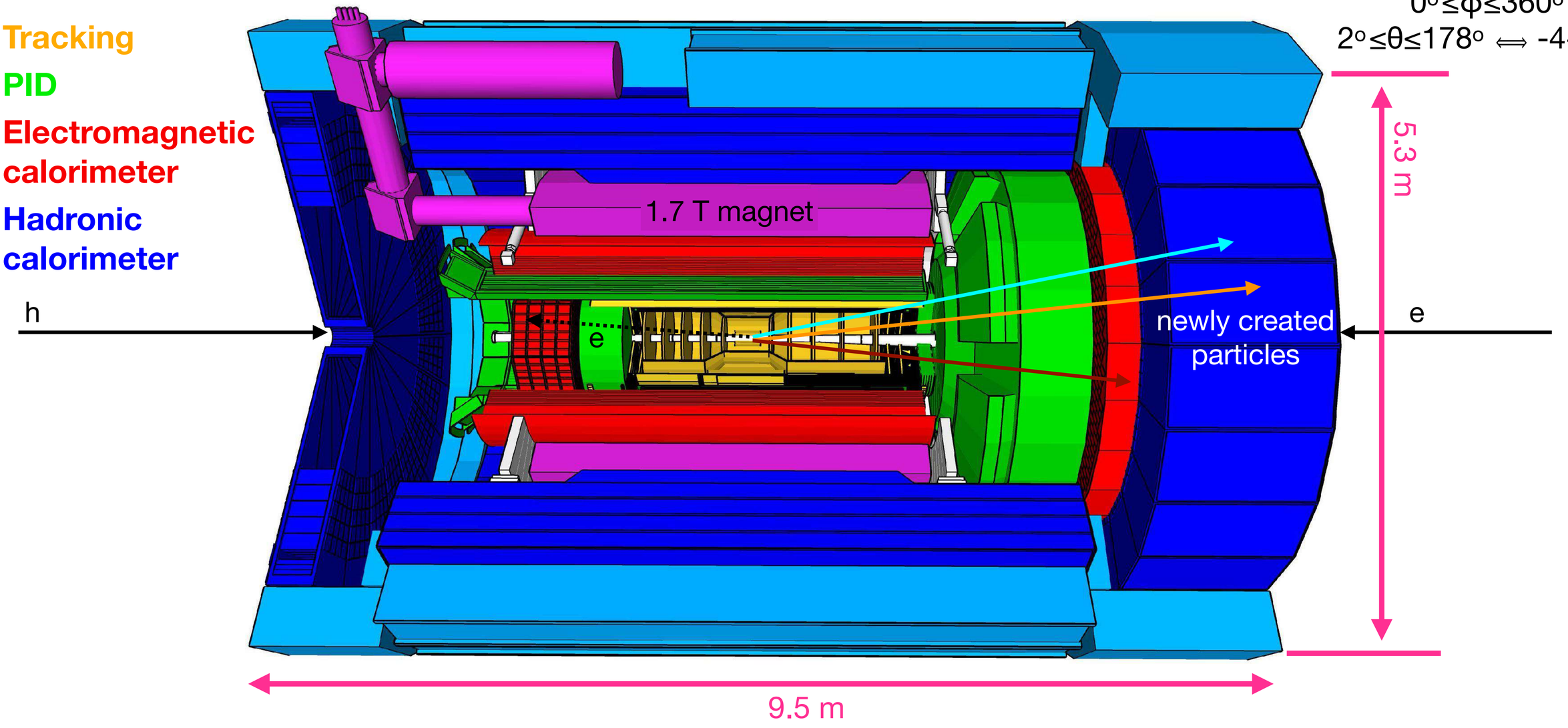

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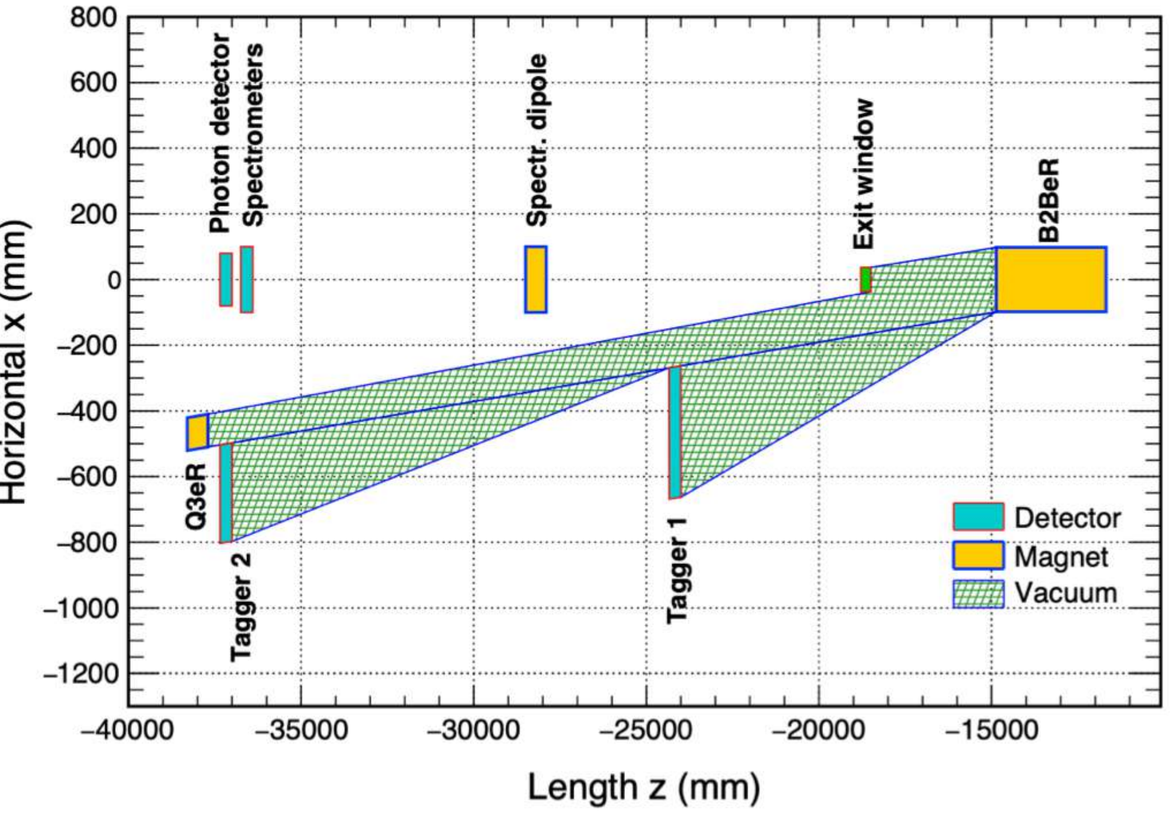

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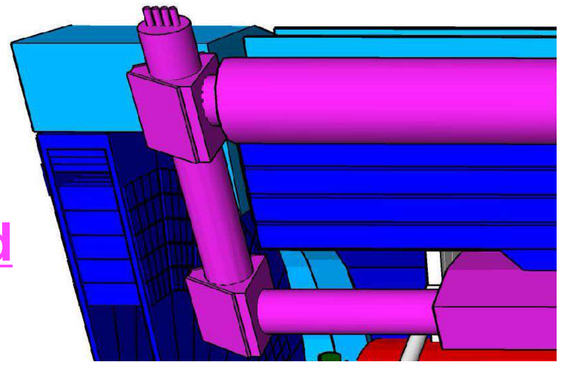

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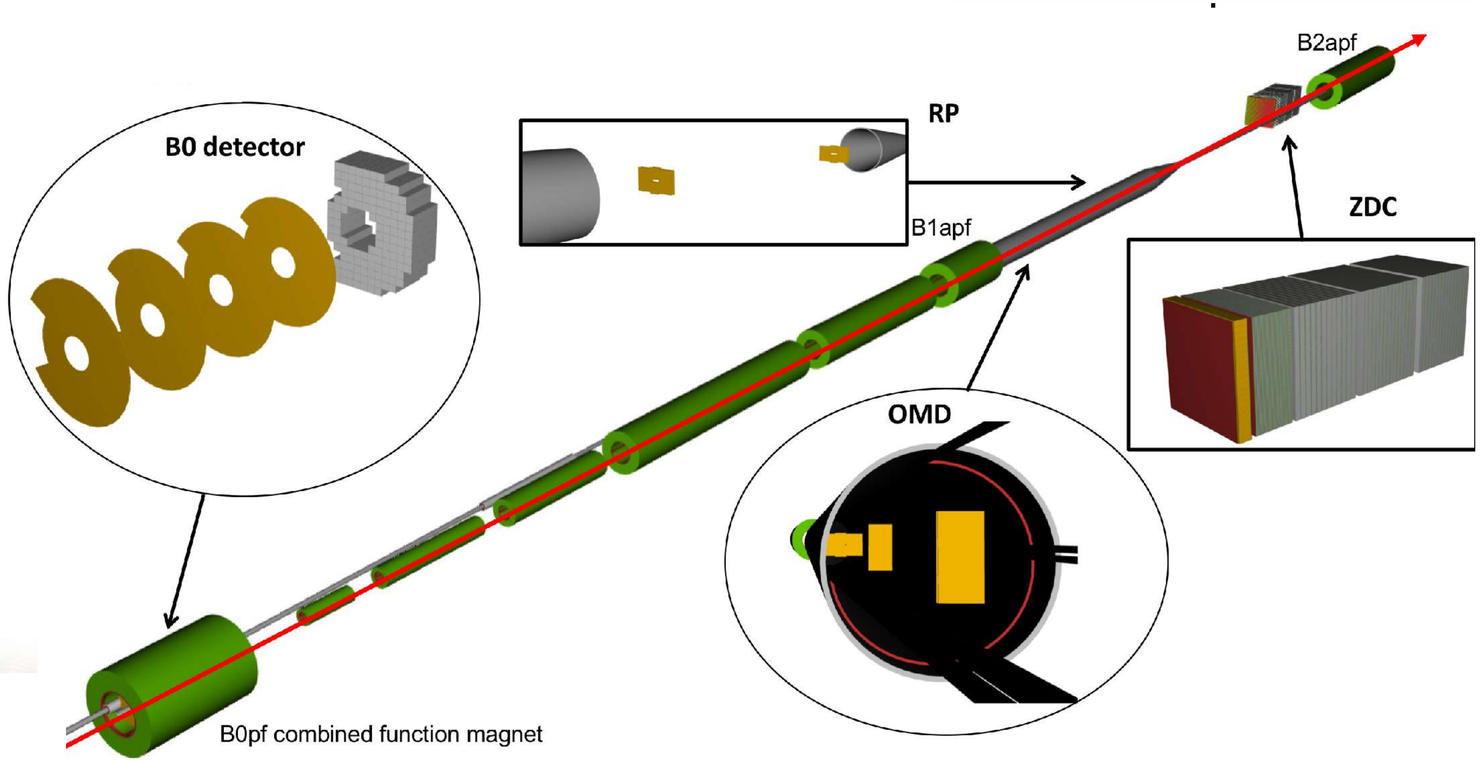

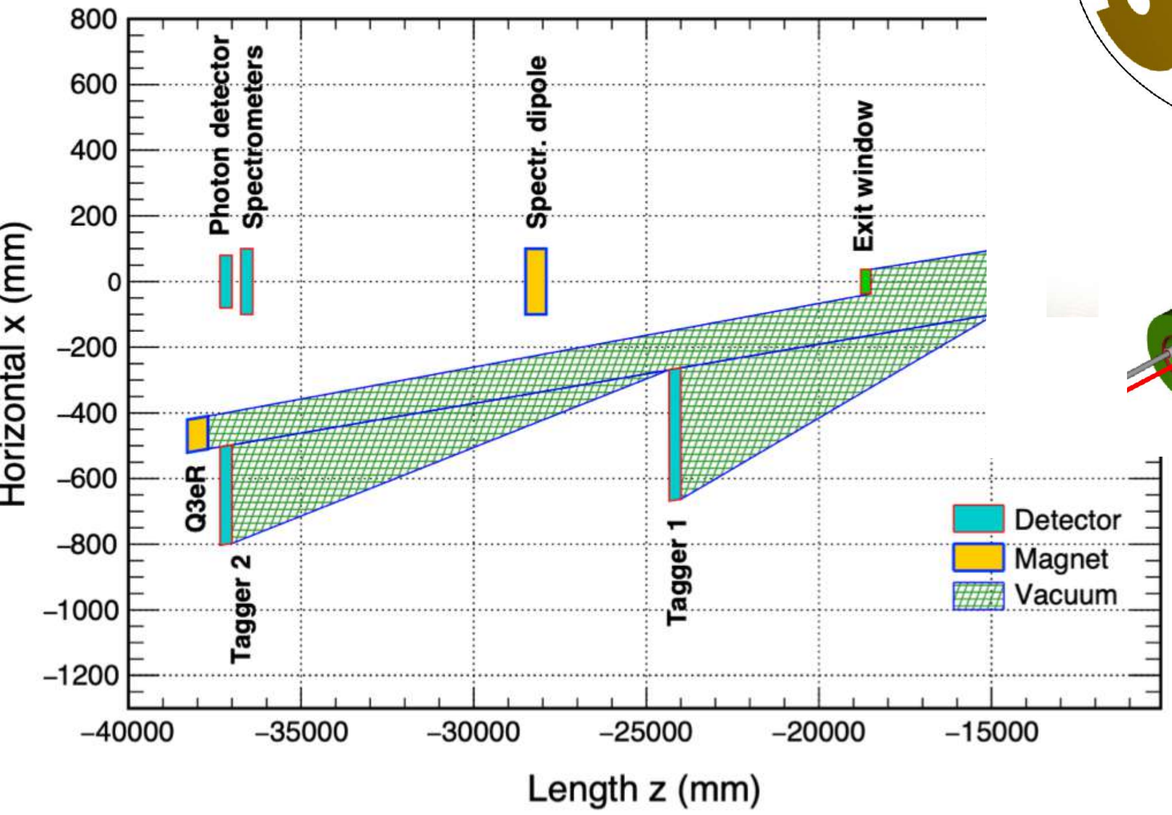

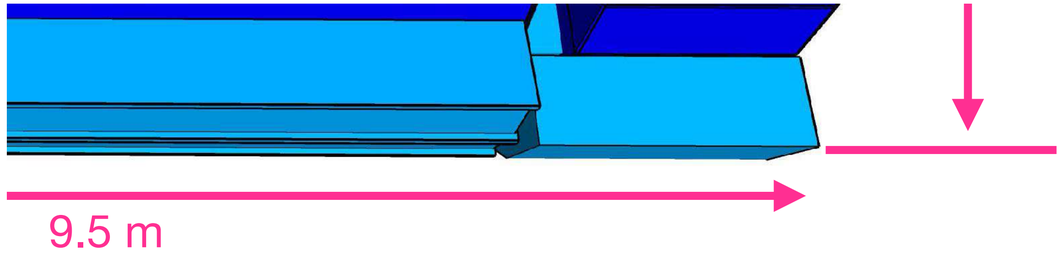

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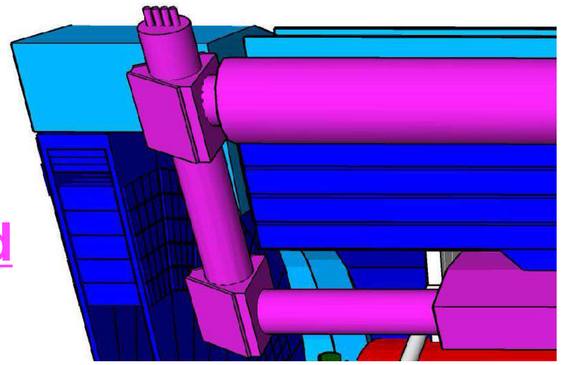

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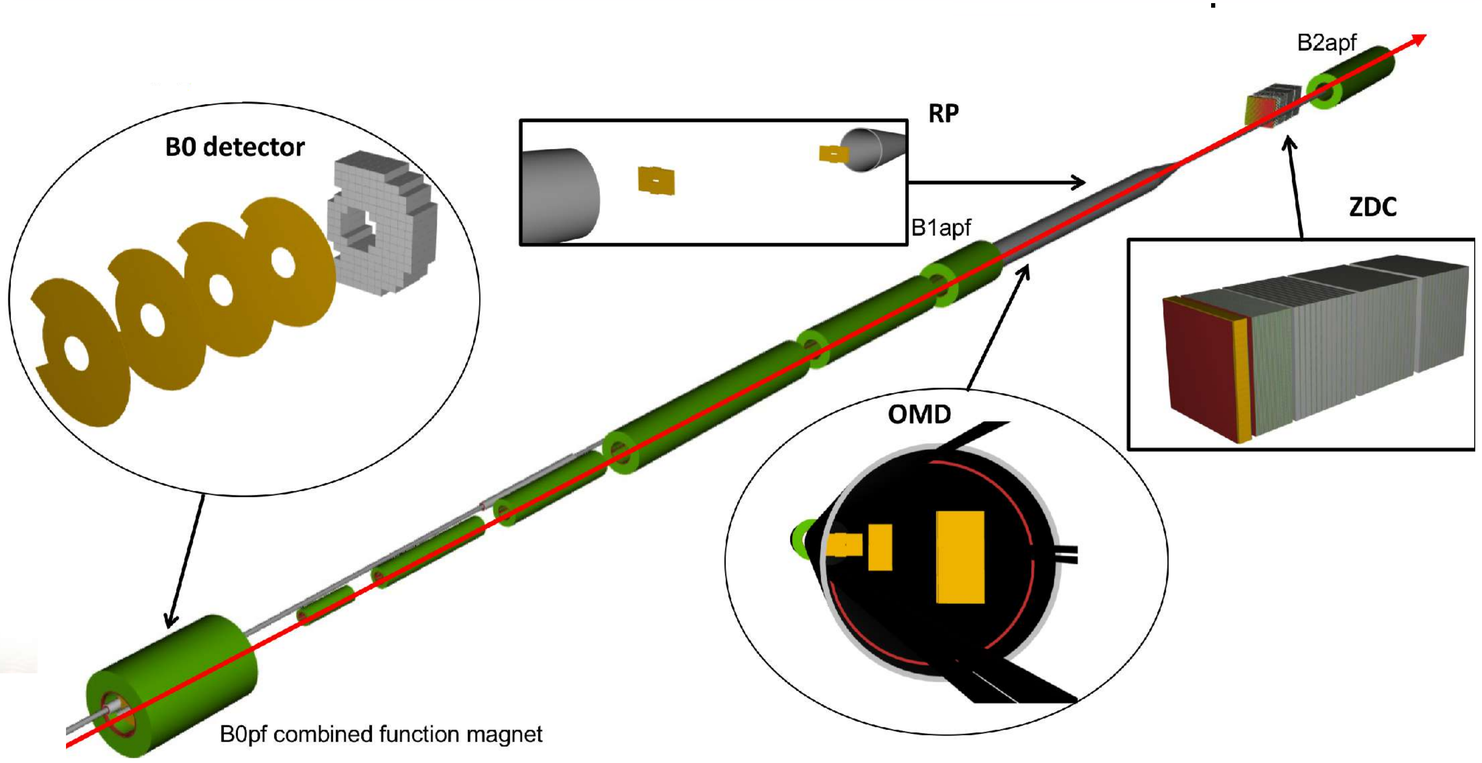
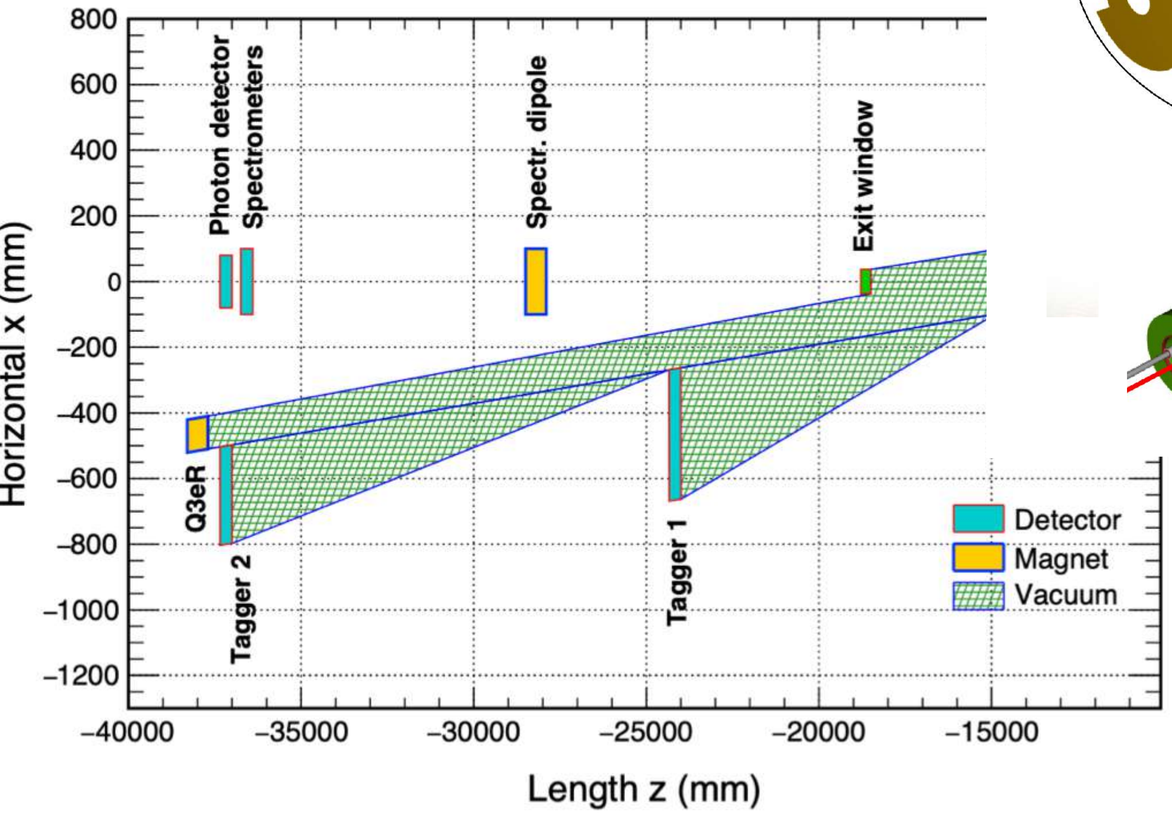
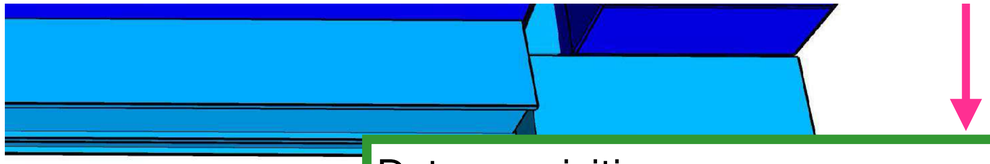


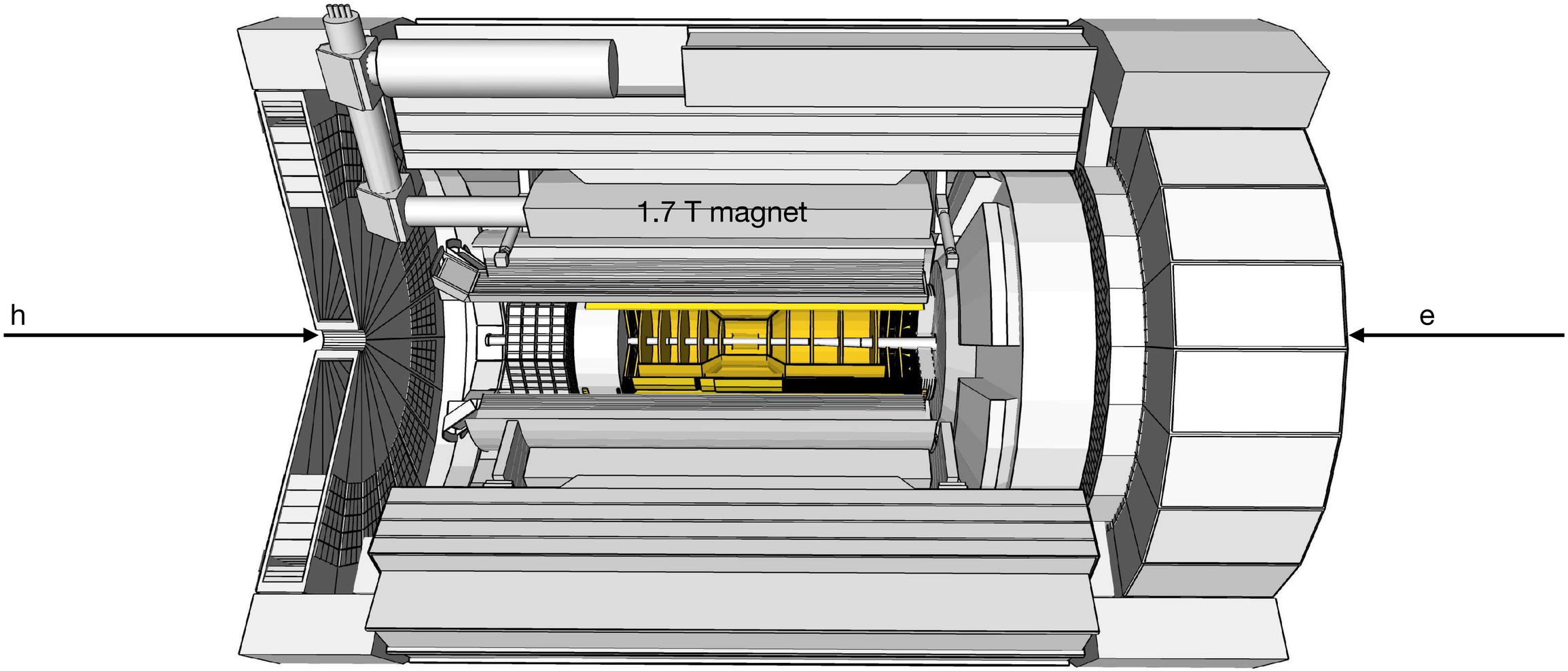




9.5 m

Data acquisition:
- no trigger
- all collision data is digitised
- with strong zero-suppression at front-end electronics

Tracking system



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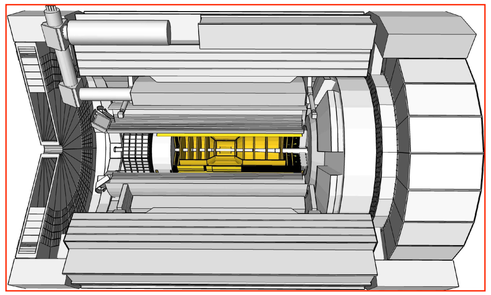
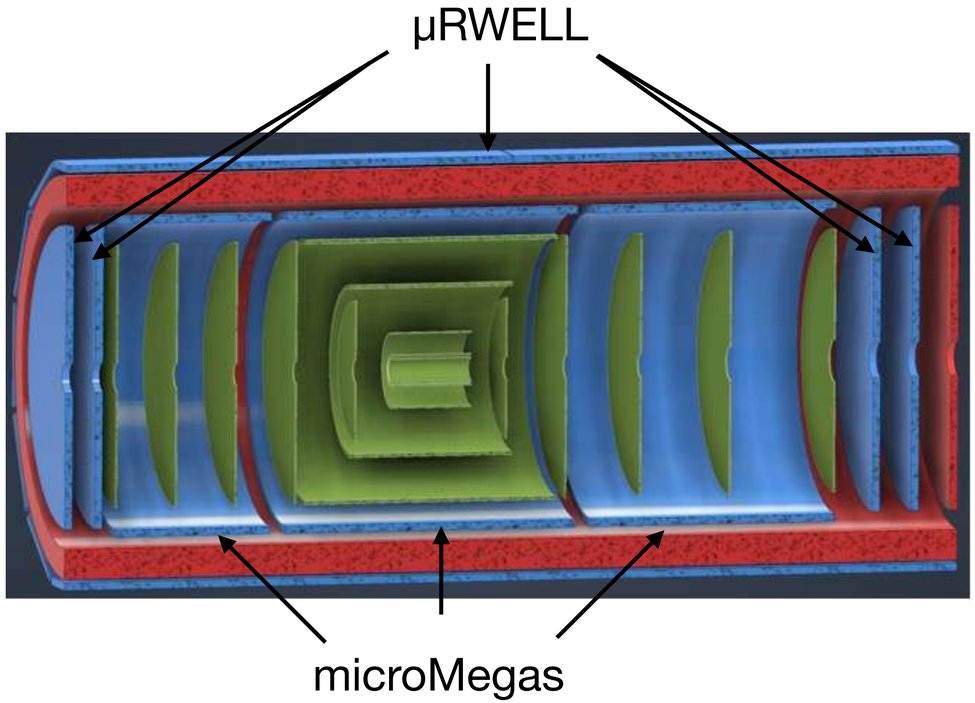




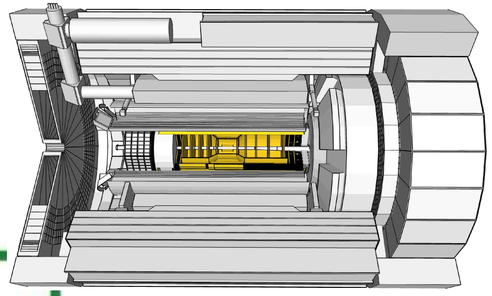
1.7 T magnet

- Monolithic Active Pixel Sensor (MAPS) Silicon vertex tracker
  - 3-layer inner barrel (IB) and 2-layer outer barrel (OB)
    - IB X/X_0 : 0.05%/layer
      OB X/X_0 : 0.25%+0.55%
  - End-cap disks: 5 electron and 5 hadron side
    - X/X_0: 0.25% per layer
  - 20 μm pitch
  - Small material budget, with carbon-based structure
  - Room temperature operation, with air cooling

- AC-LGAD based TOF:
  - PID & additional tracking point
  - 20-35 ps time resolution for ToF

- Micro-pattern gaseous detectors: µRWELL and microMegas
  - timing resolution: 10–20 ns
  - additional space-point for track reconstruction

Tracking resolution



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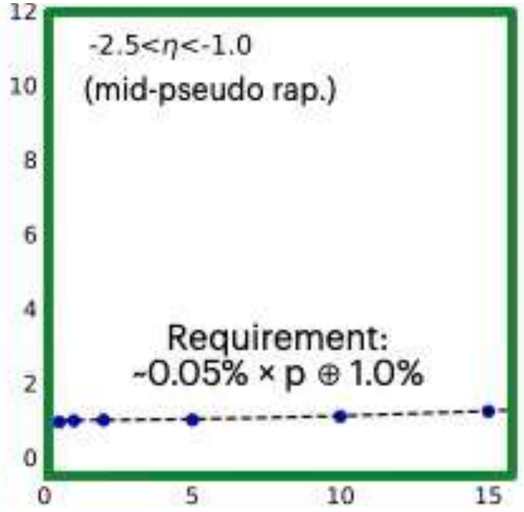
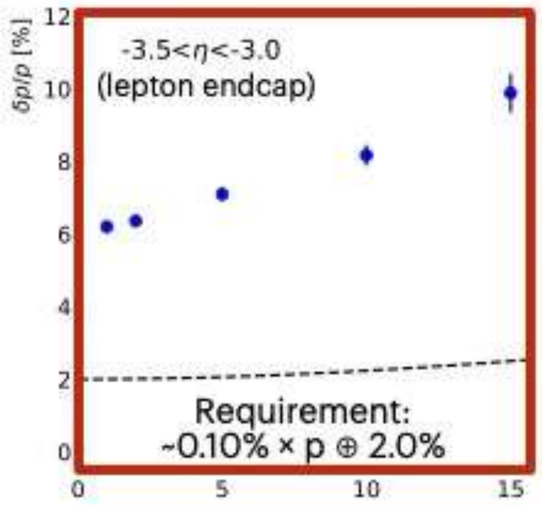
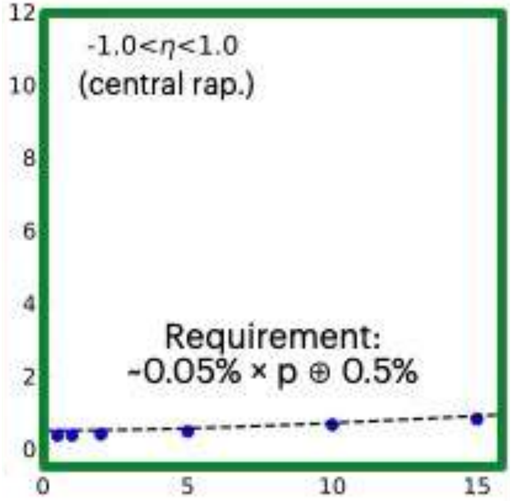
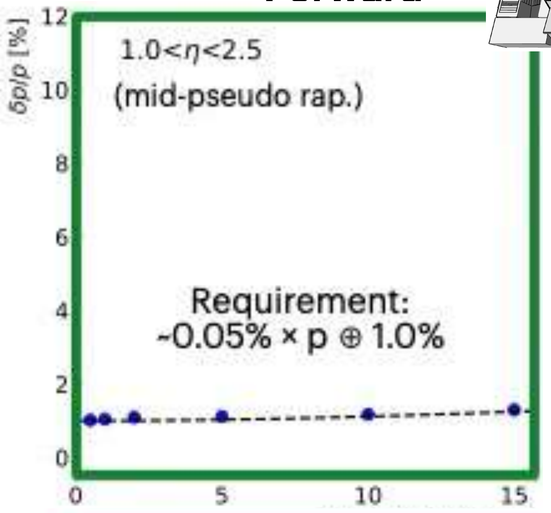


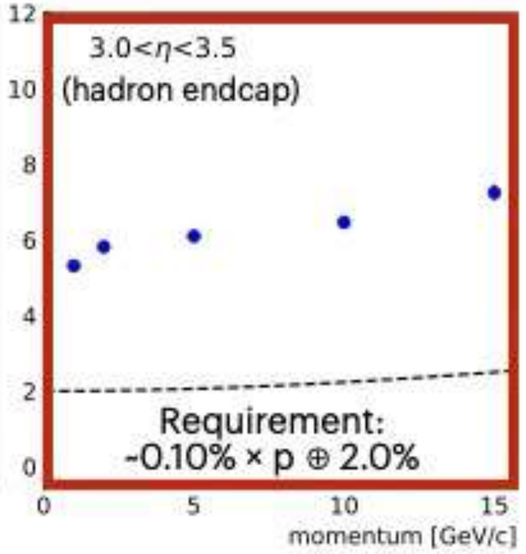


Central

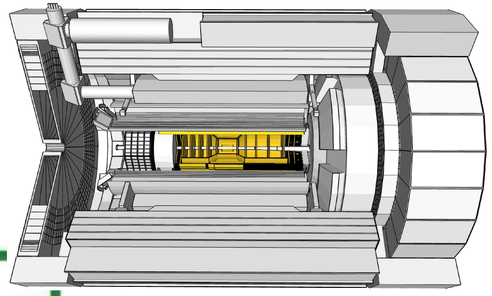


Forward





Tracking resolution



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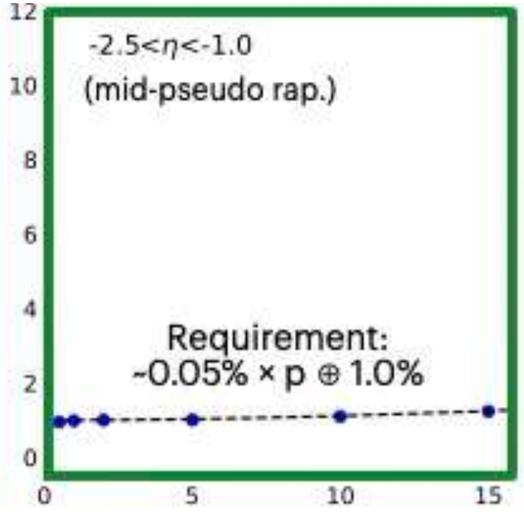

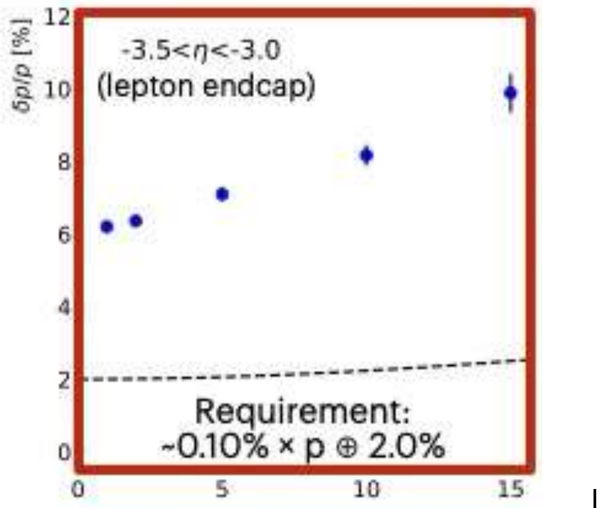

complemented with electromagnetic calorimeter

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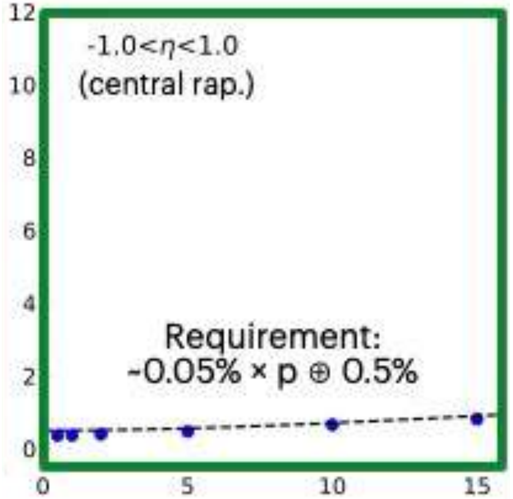

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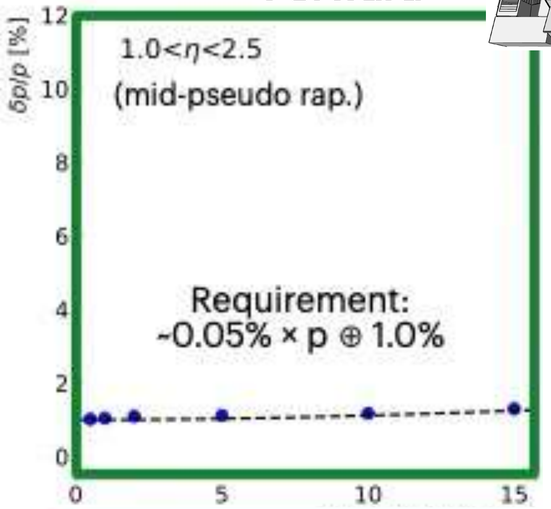
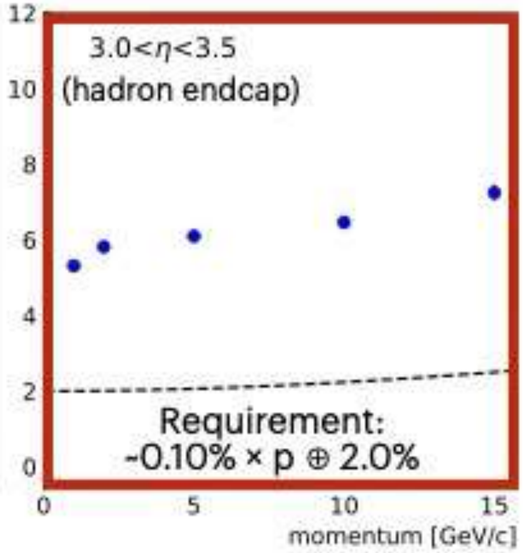
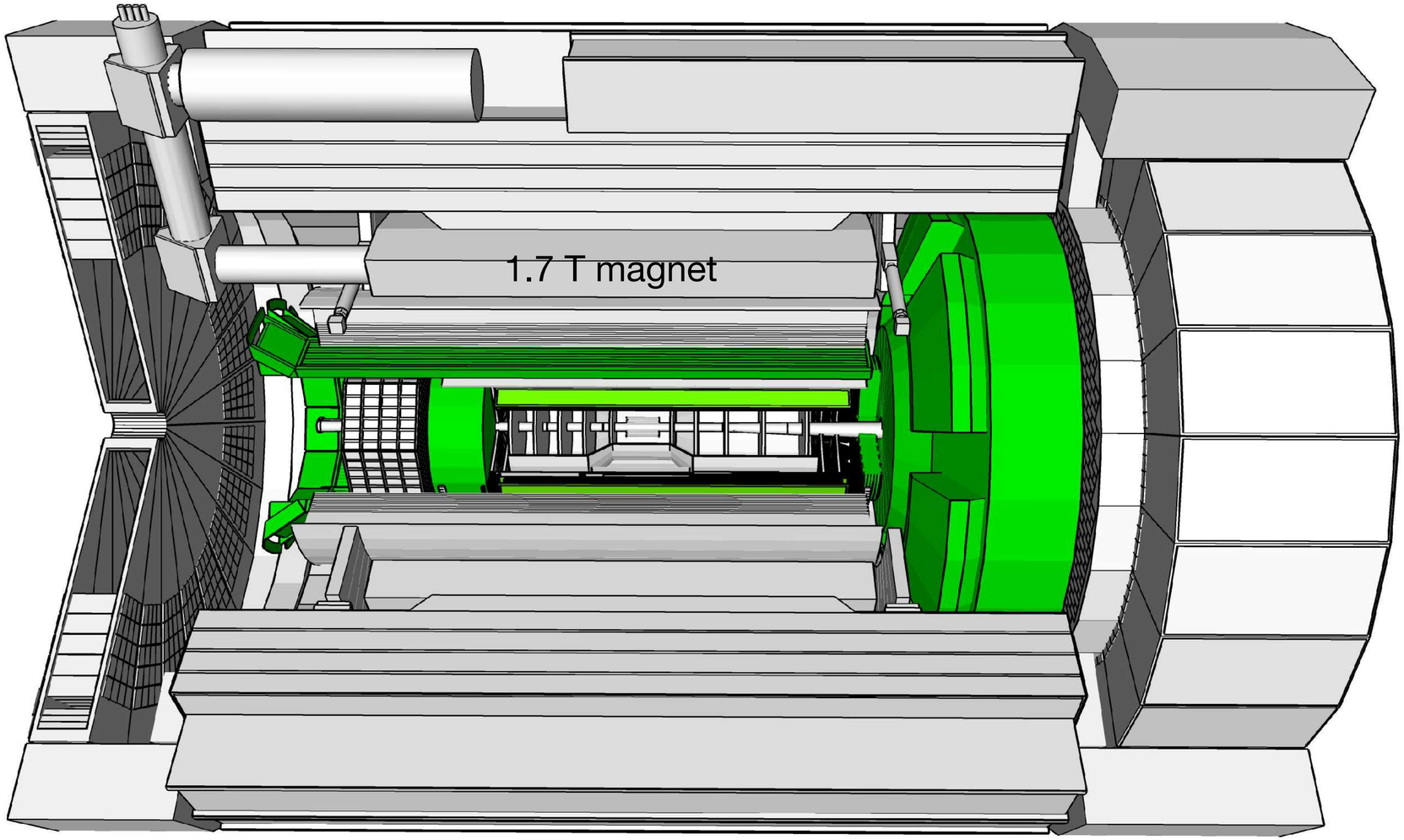


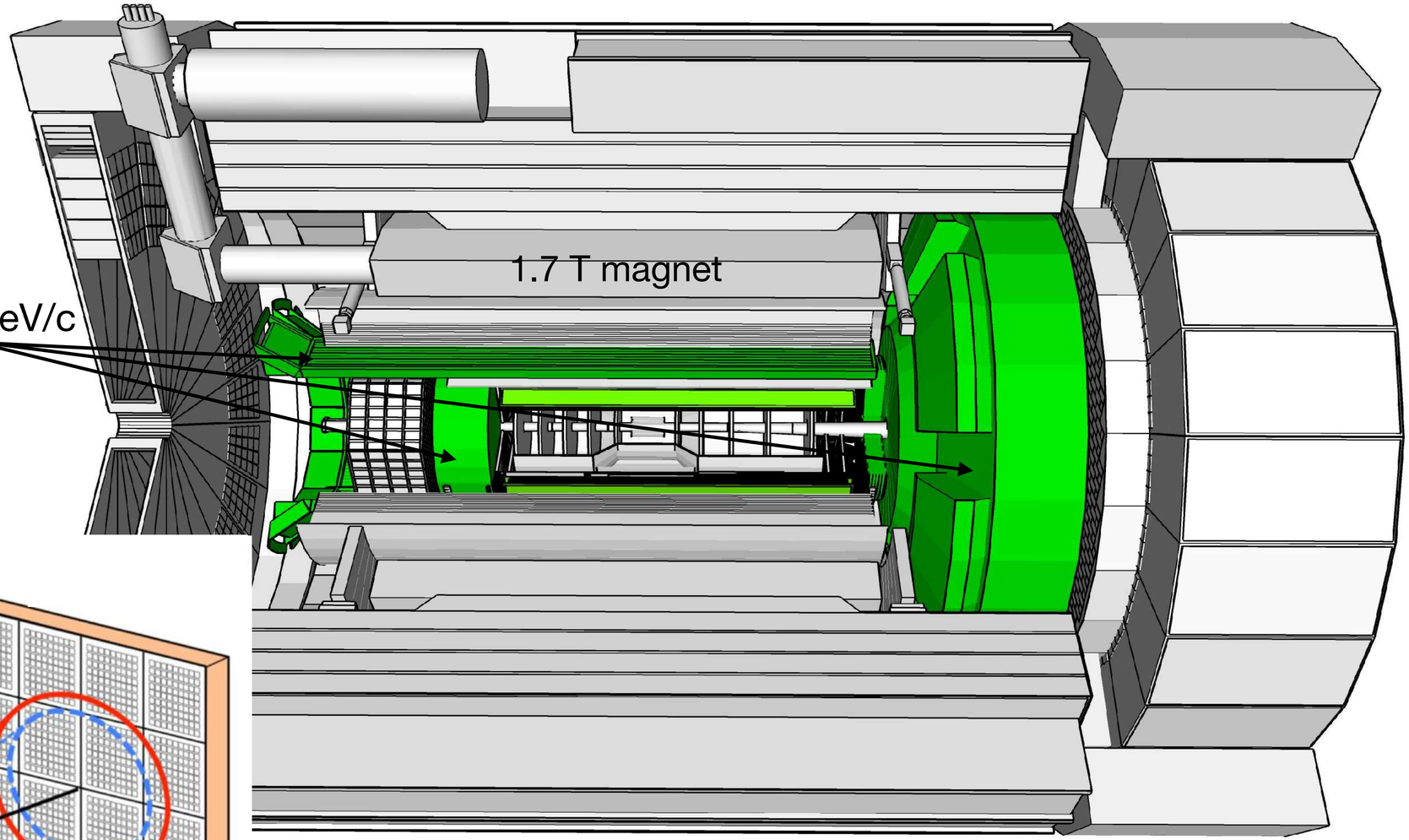


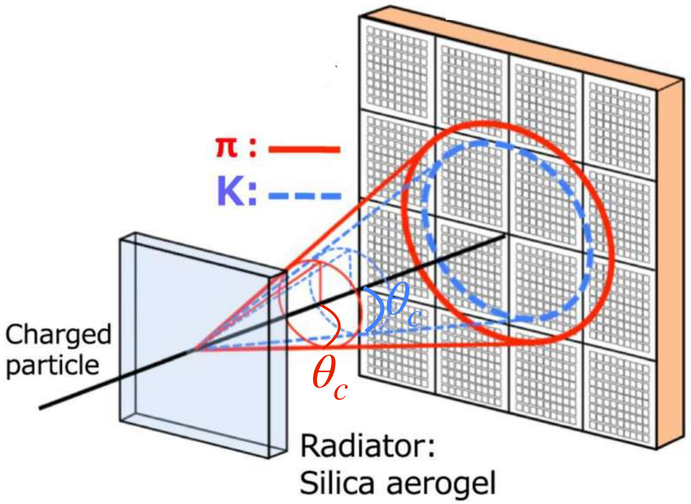
Particle identification



Particle identification

detectors based on
Cherenkov radiation
for 1 GeV/c<p<50 GeV/c





$$\cos\theta_c \propto \frac{1}{v}$$

Particle identification

AC-LGAD based TOF, for p < 0.5 – 3 GeV/c

$$v = \frac{L}{t_{stop} - t_{start}}$$

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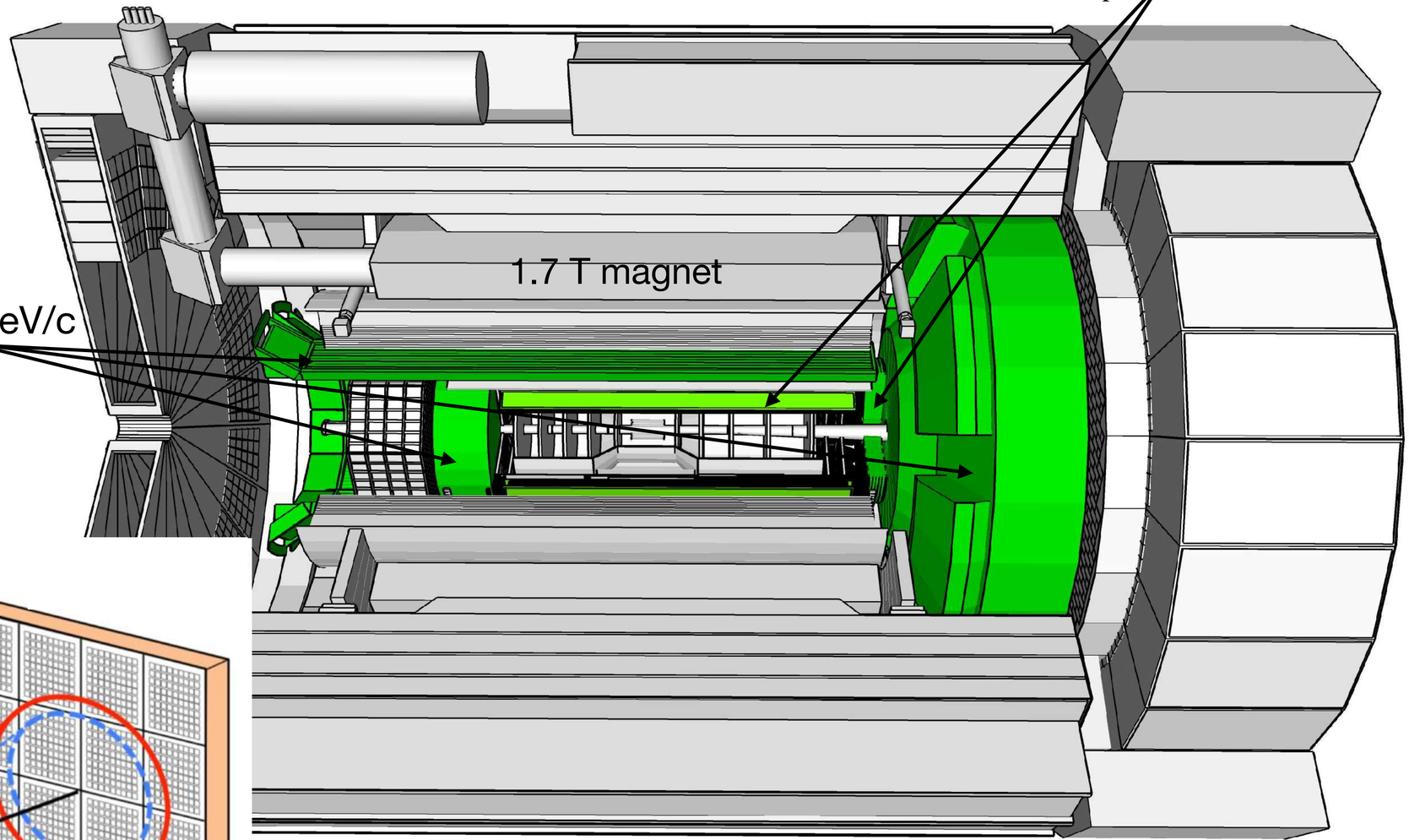
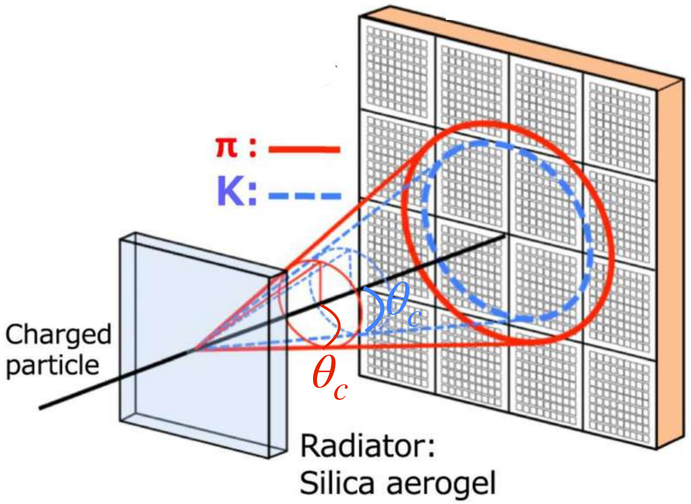
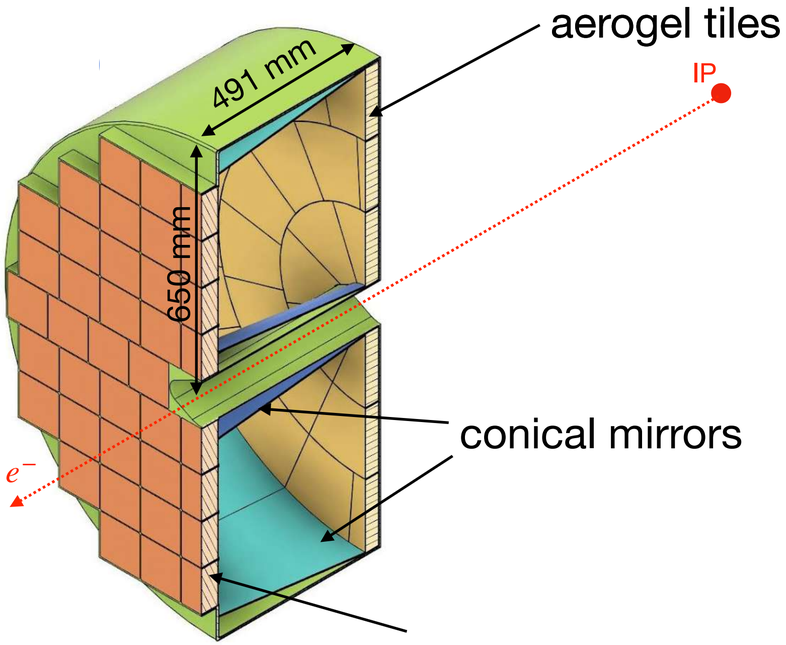
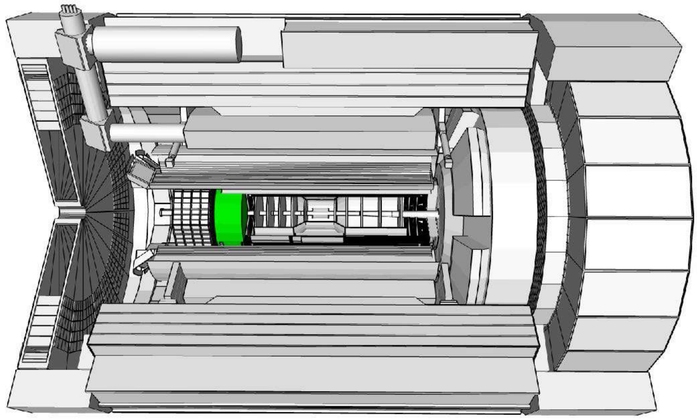




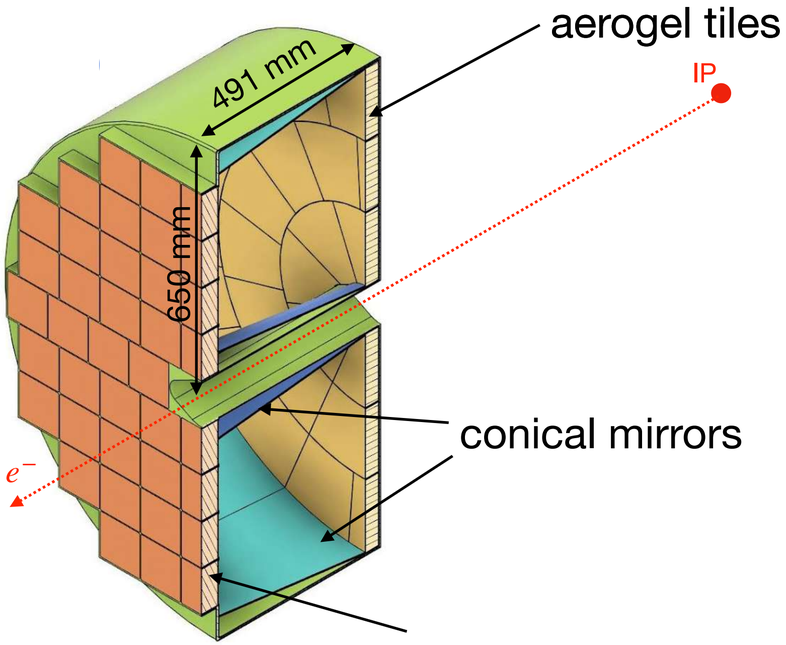
$$\cos\theta_c \propto \frac{1}{v}$$

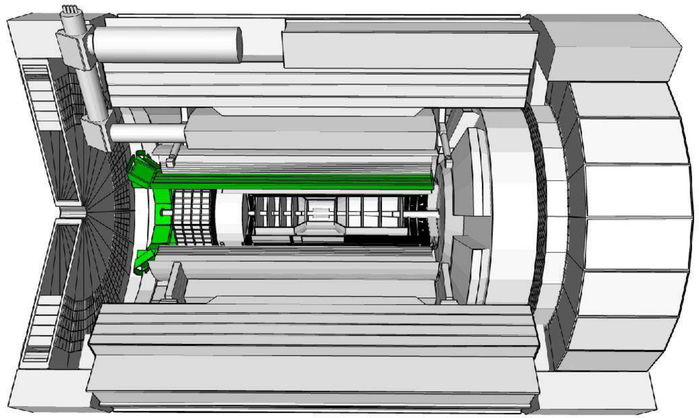
Cherenkov detectors



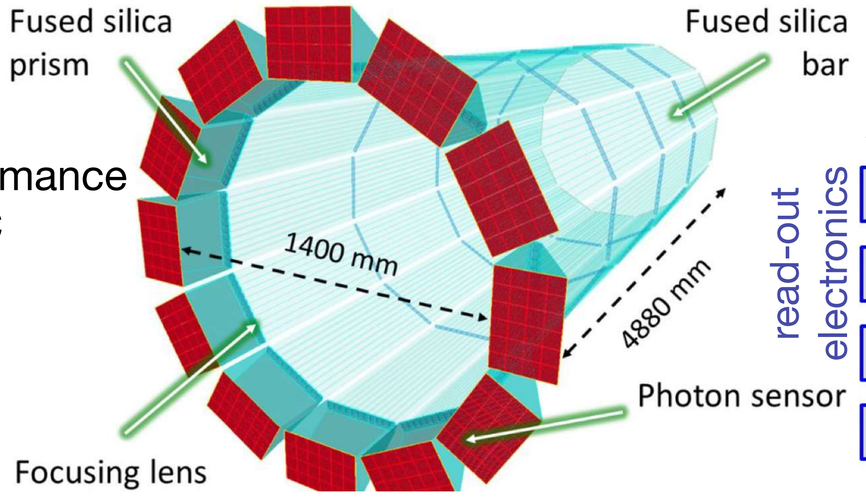


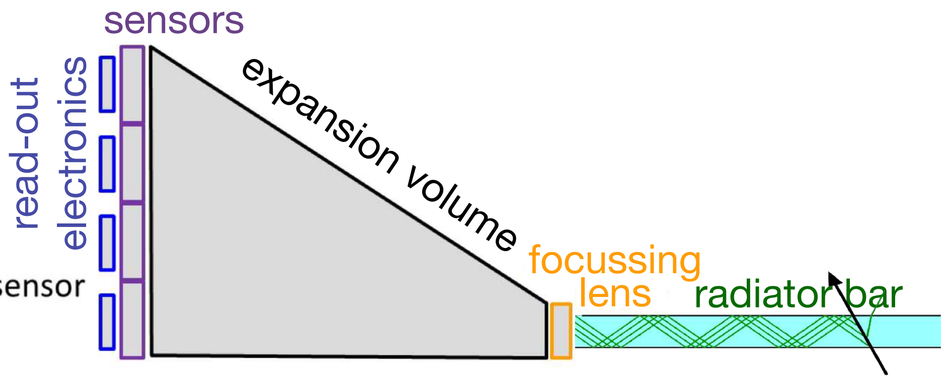
Cherenkov detectors



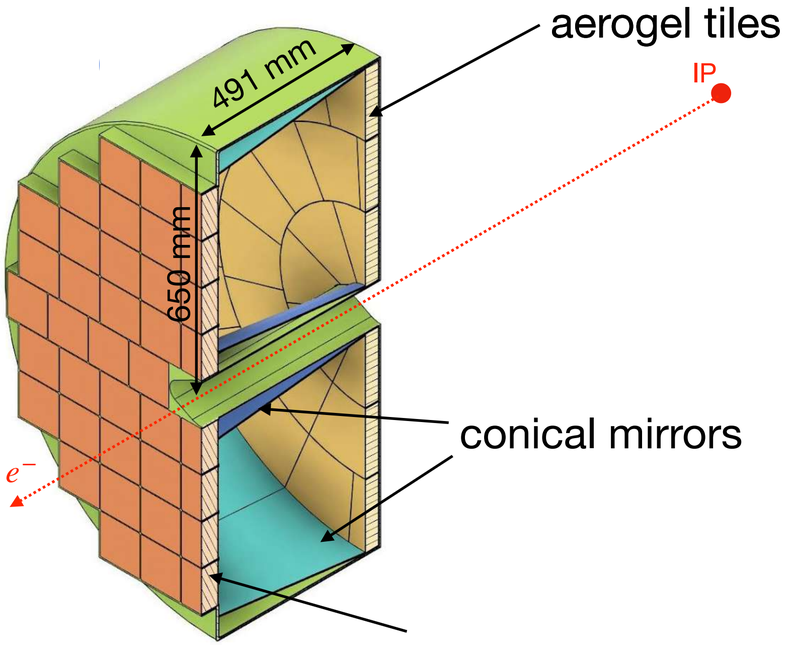


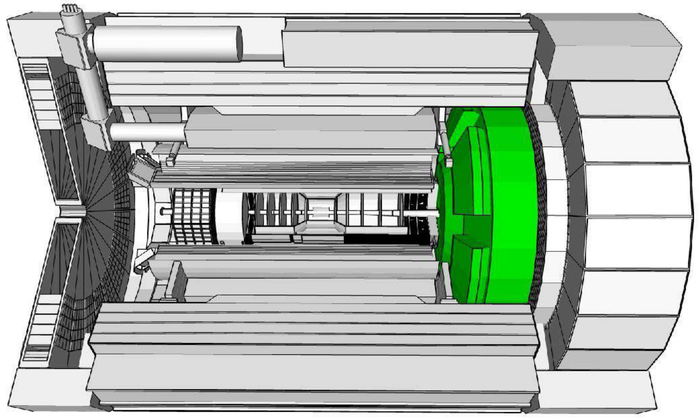
High-performance DIRC



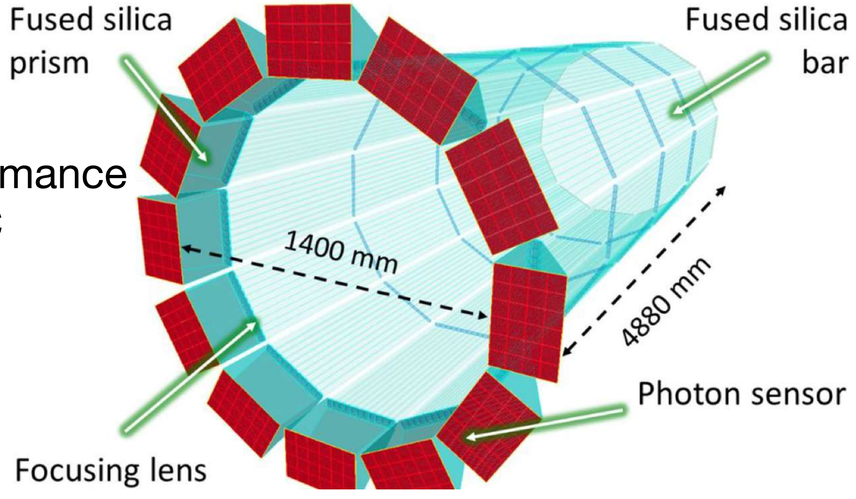


Cherenkov detectors

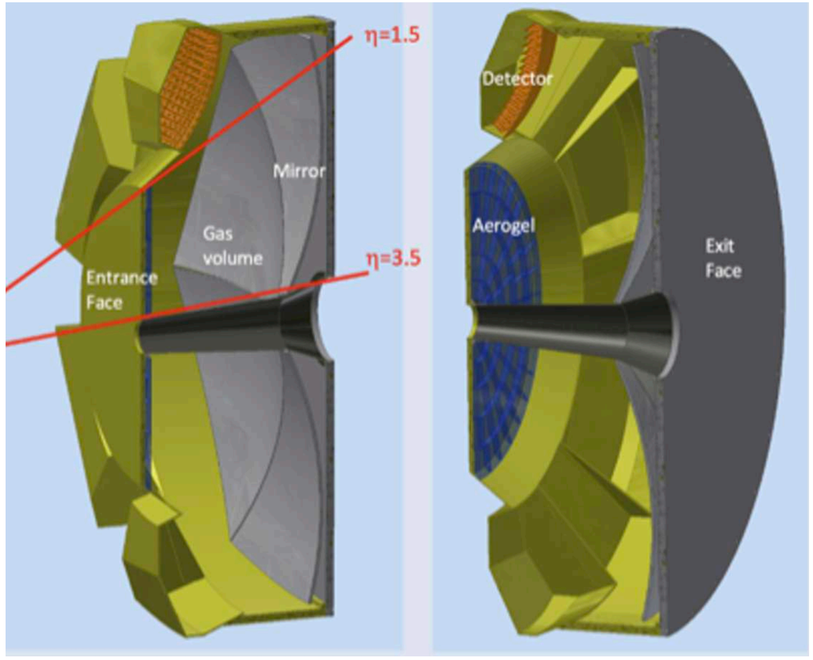




High-performance DIRC



dual RICH

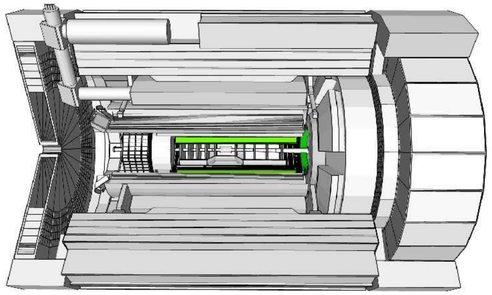


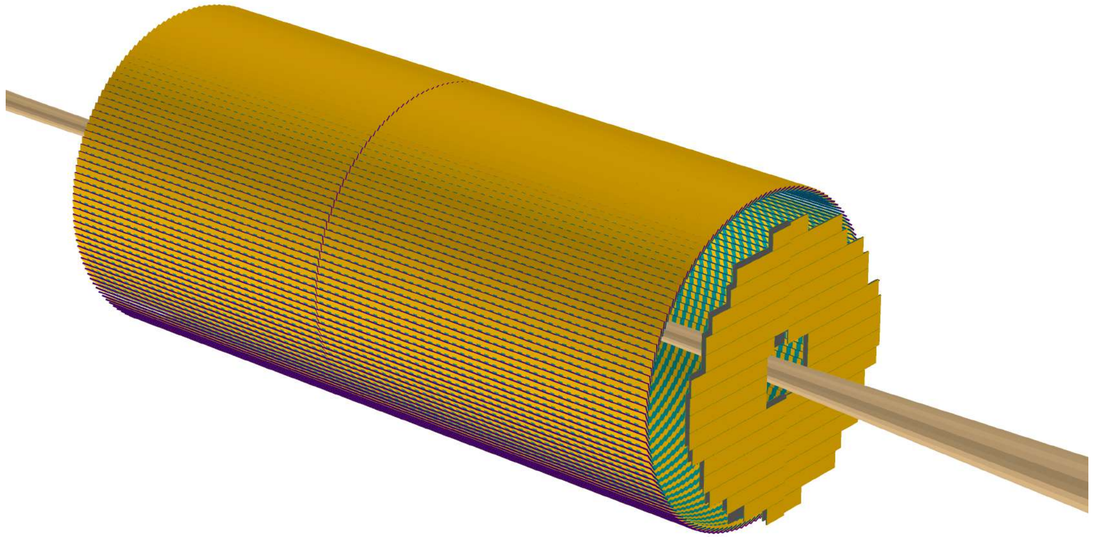
- radiators: C_2F_6 gas and aerogel
- SiPMs as photosensors

Time of flight

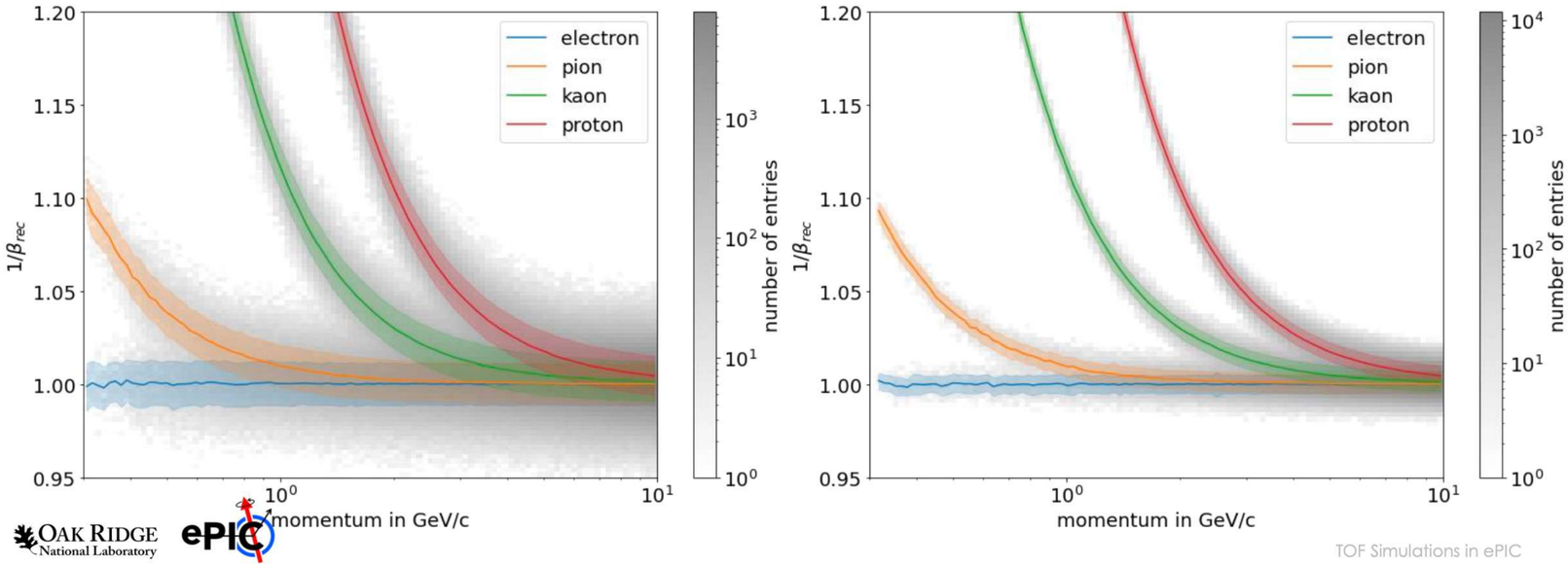
AC-LGAD based TOF

30 μm space resolution
25-35 ps time resolution



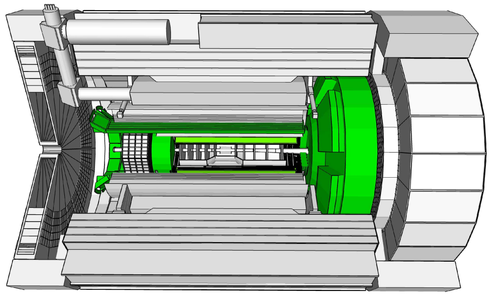


Barrel Region
- e/pi up to 0.5 GeV/c
- pi/K up to 1.9 GeV/c
- K/p up to 3.1 GeV/c

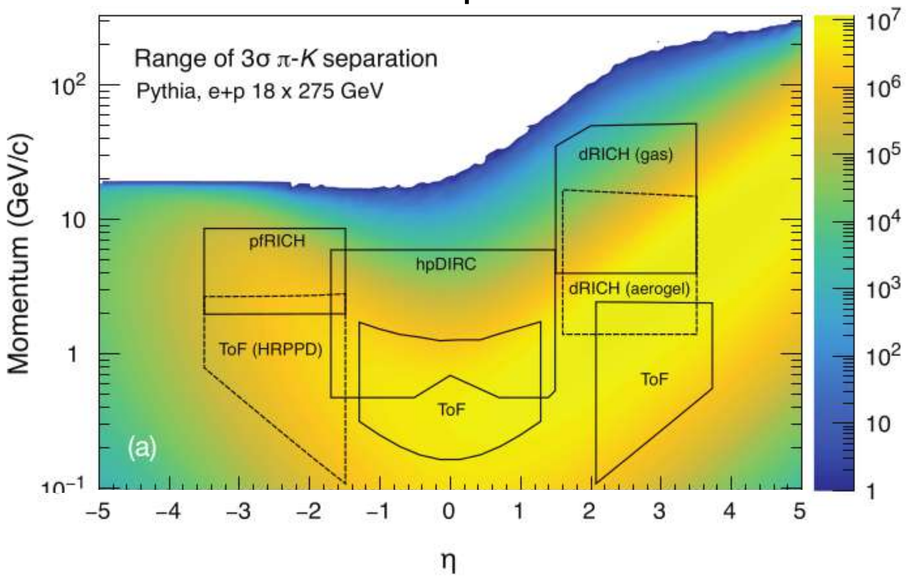


Endcap Region
- e/pi up to 0.8 GeV/c
- pi/K up to 2.7 GeV/c
- K/p up to 4.6 GeV/c

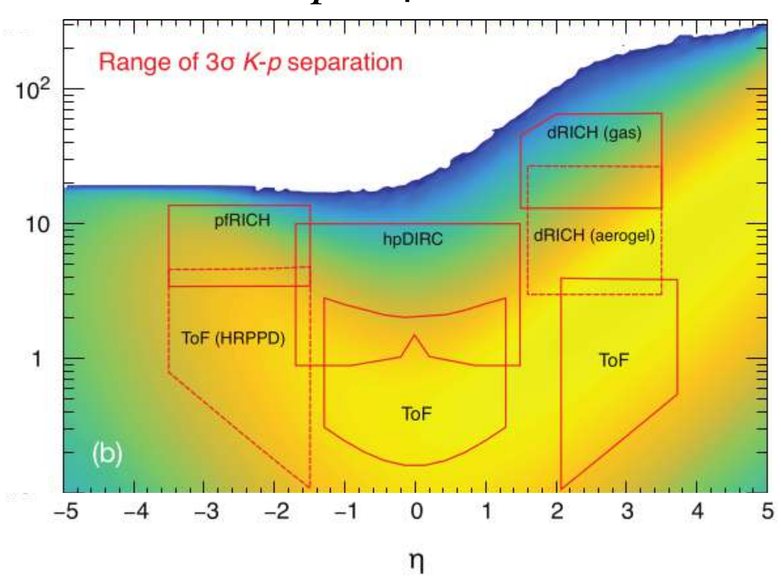
Particle identification: coverage



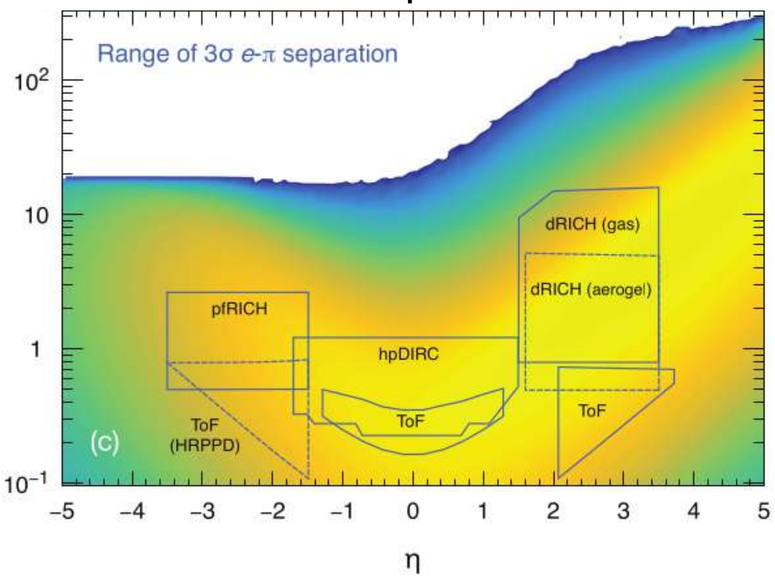
π/K separation



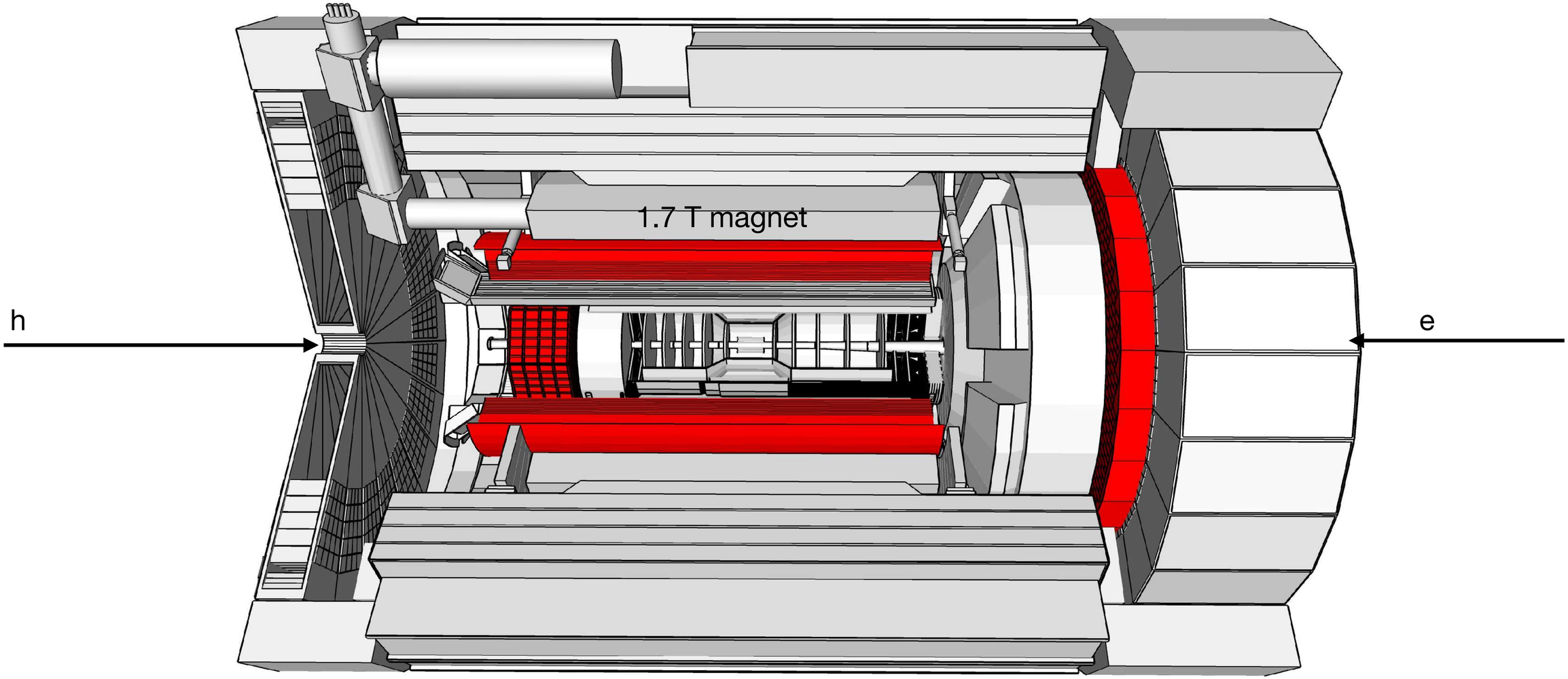
K/p separation



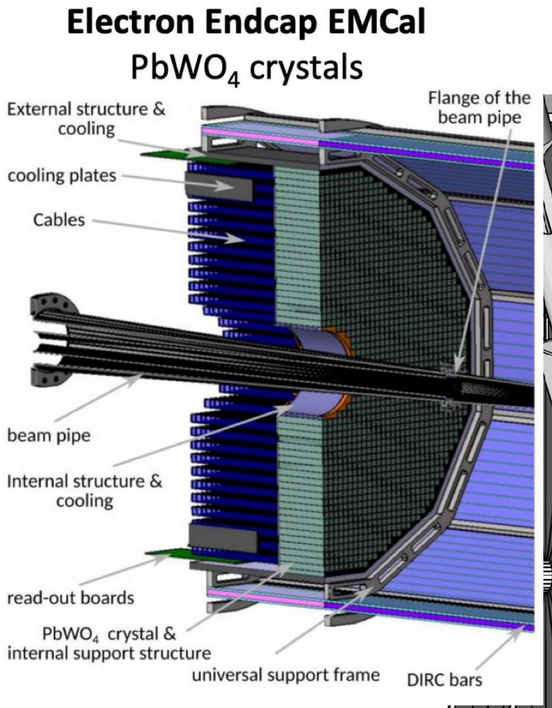
e/π separation

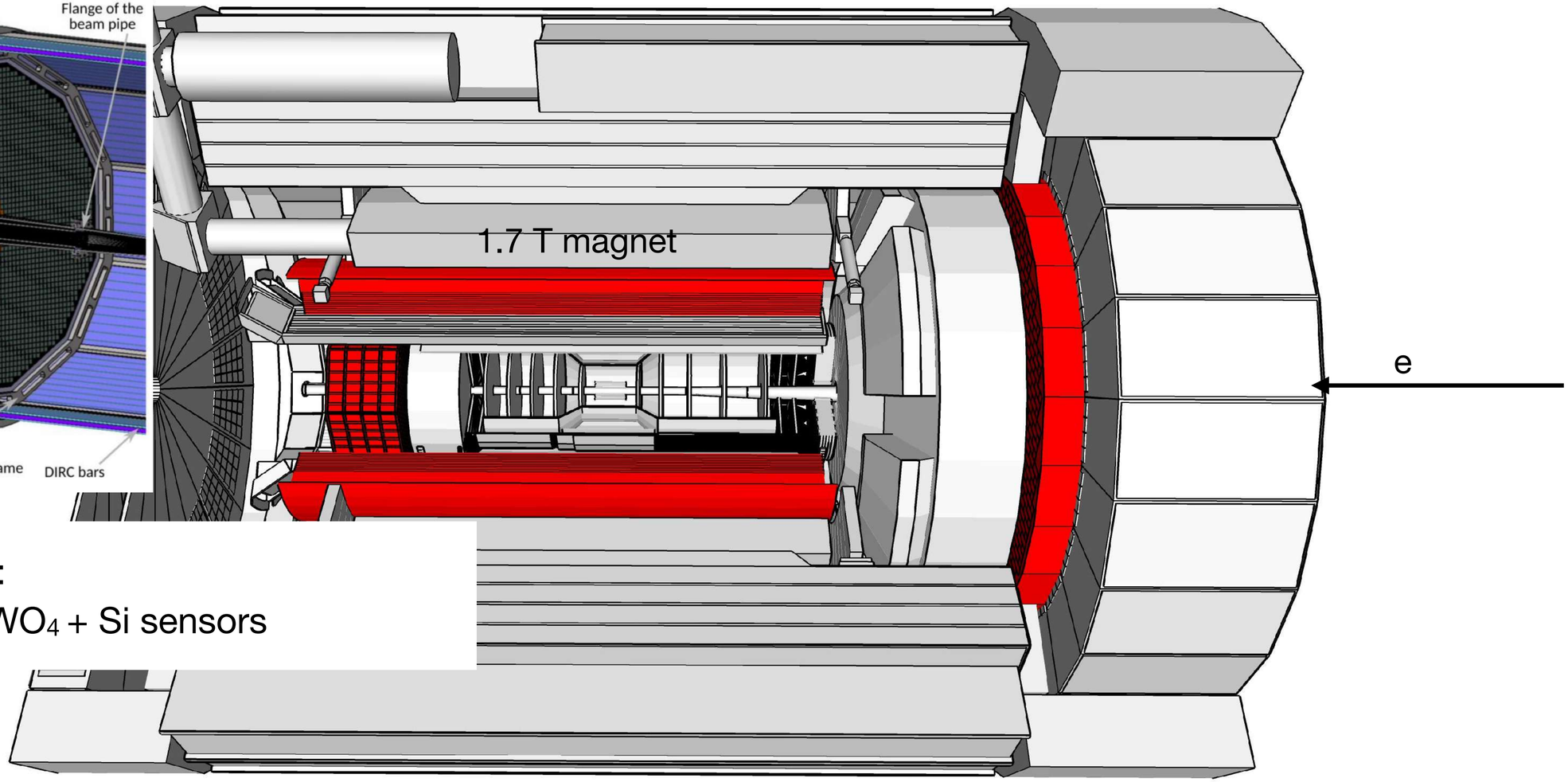


Electromagnetic calorimeter



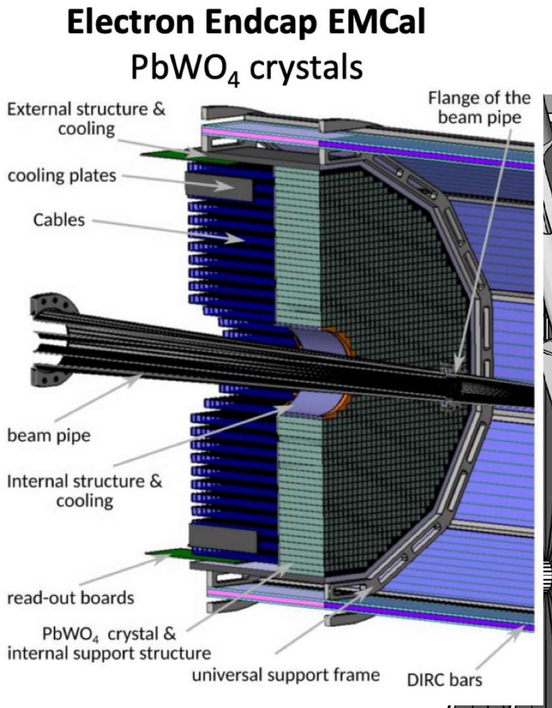
Electromagnetic calorimeter

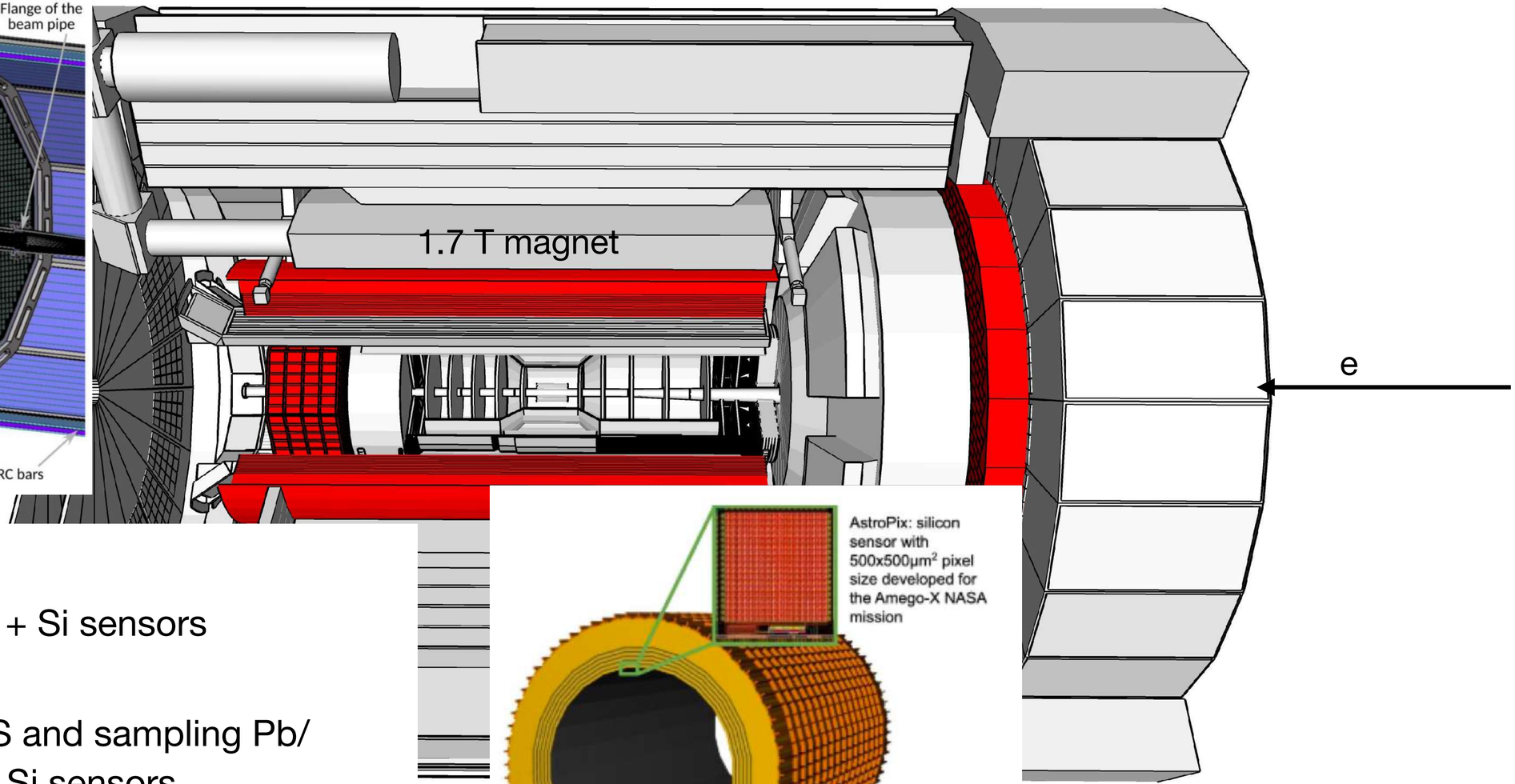




- Backward EMCAL:
  high-precision $PbWO_4$ + Si sensors

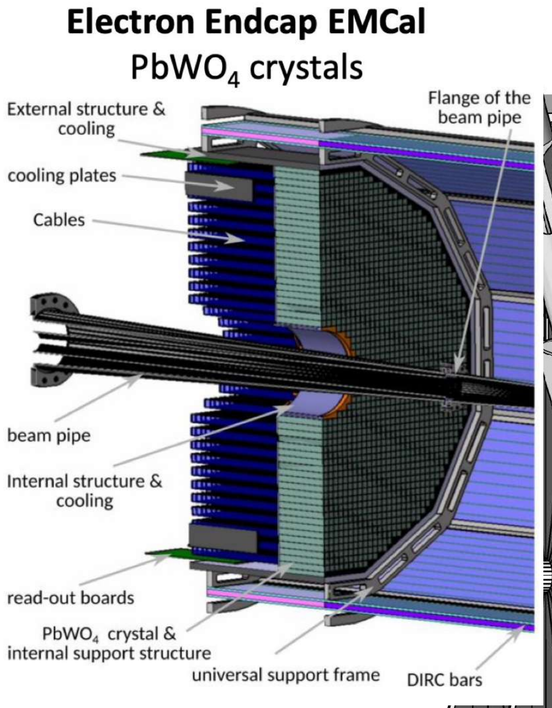
Electromagnetic calorimeter

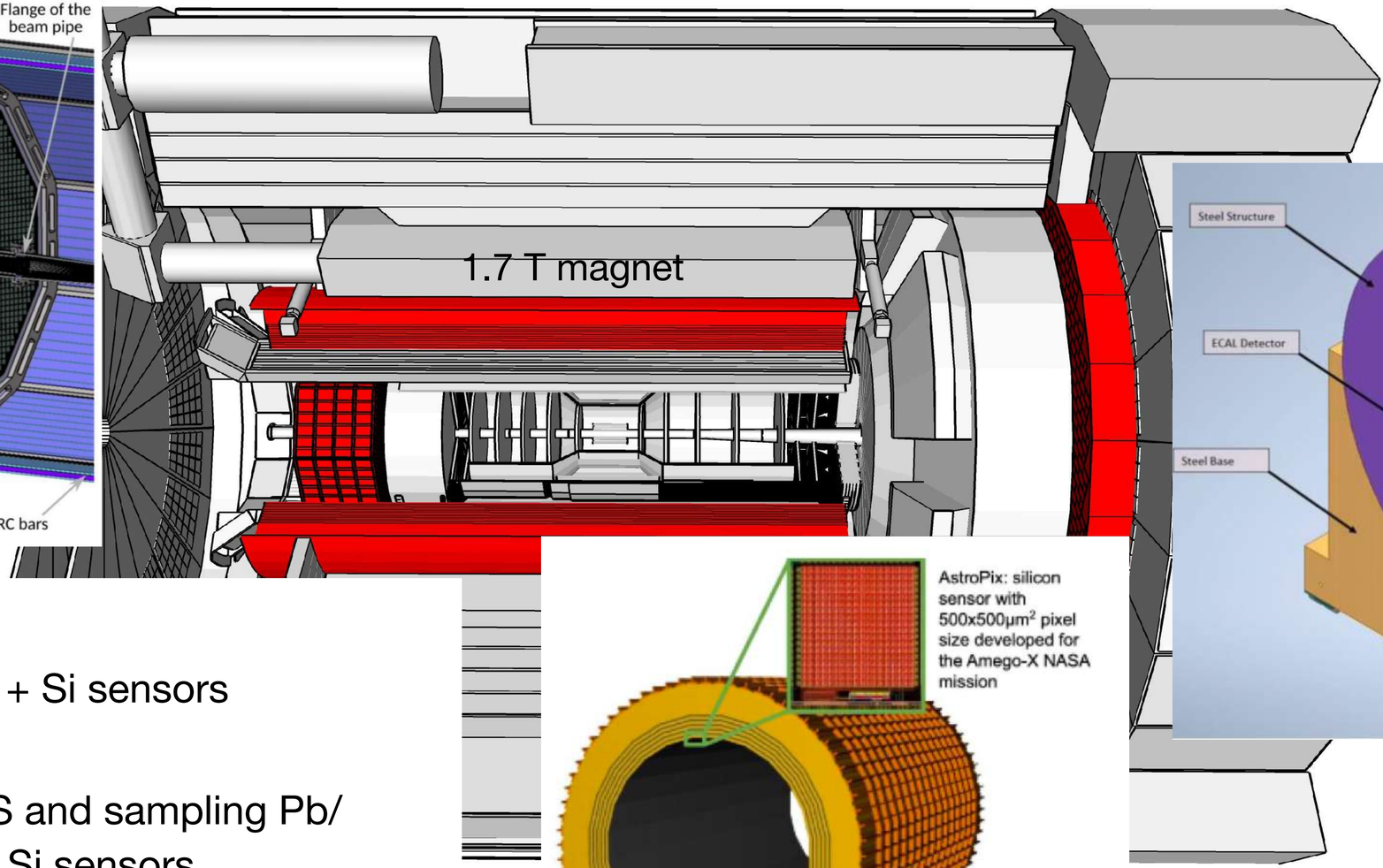


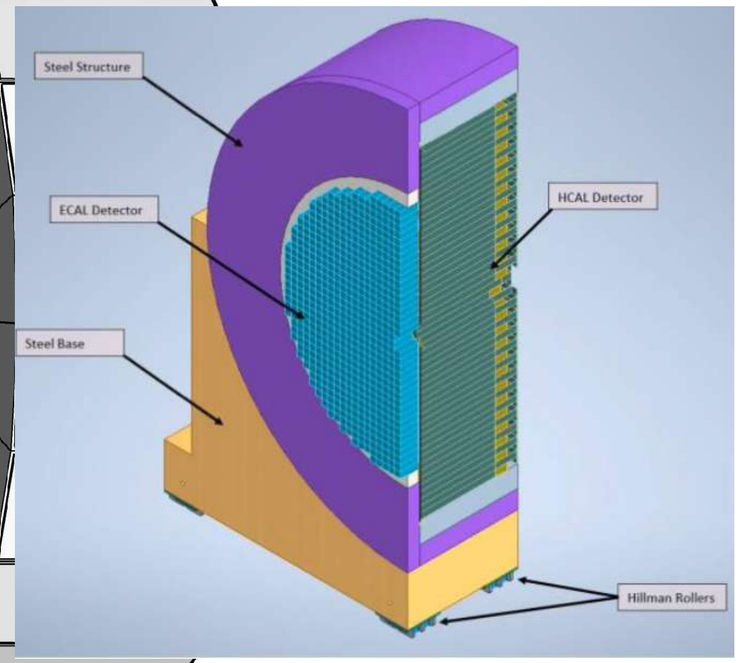


- Backward EMCAL:
  high-precision $PbWO_4$ + Si sensors
- Barrel EMCAL:
  3D imaging with MAPS and sampling Pb/ scintillating fibres with Si sensors

Electromagnetic calorimeter

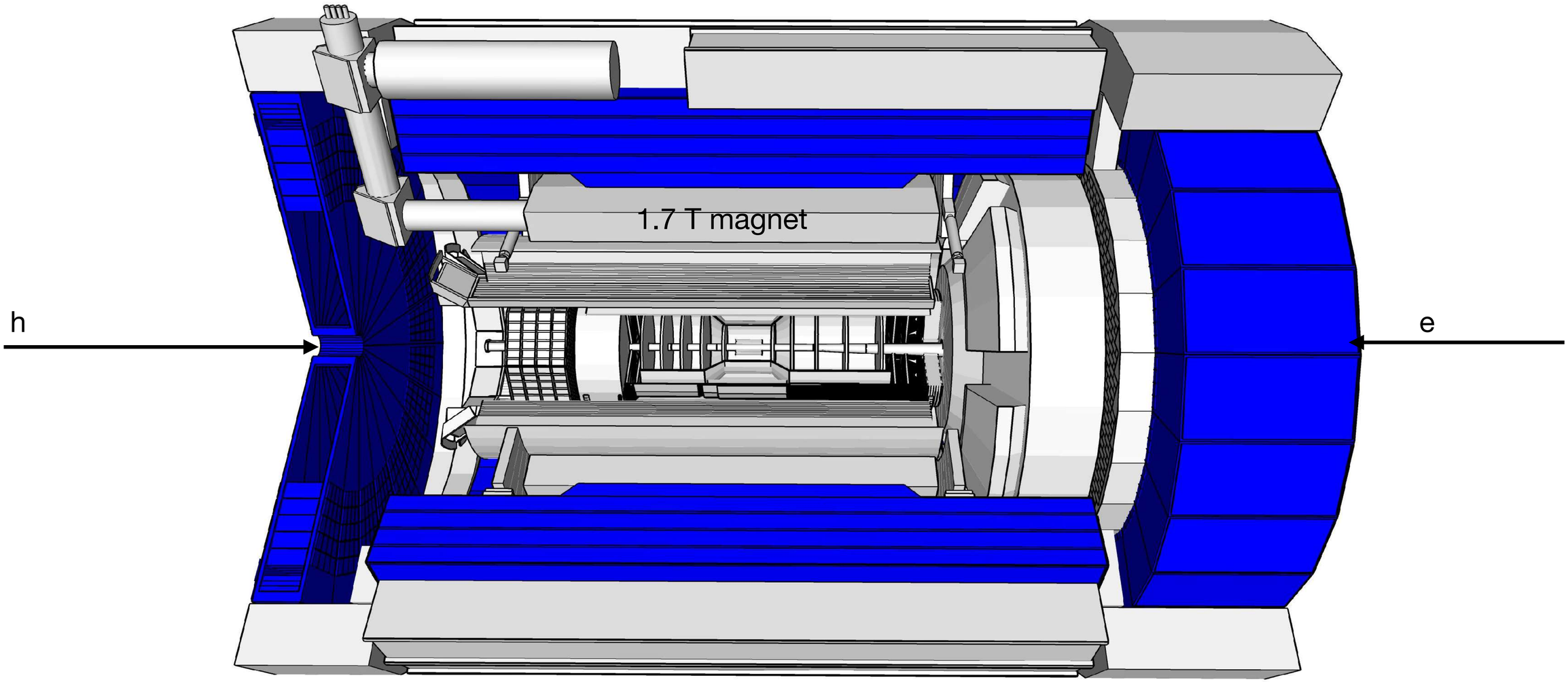




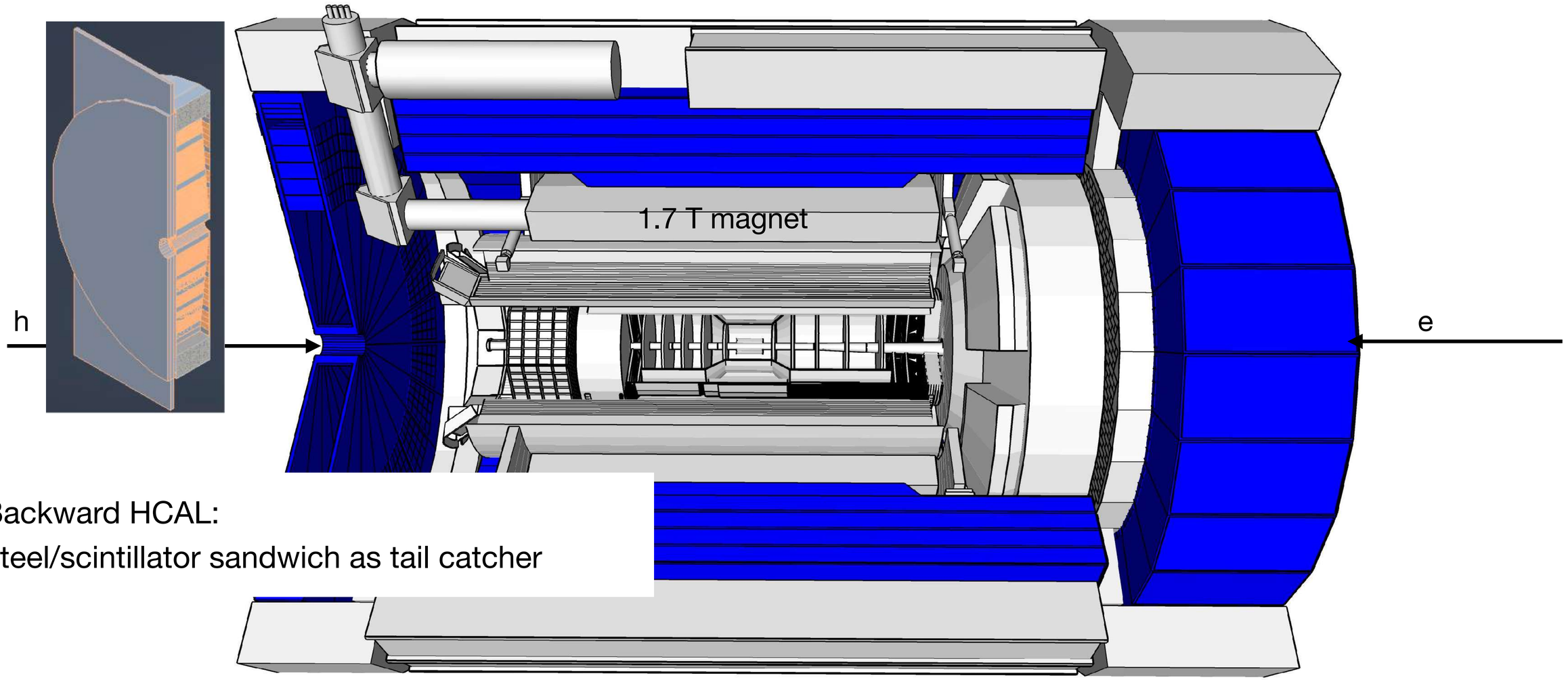


- Backward EMCAL:
  high-precision $PbWO_4$ + Si sensors
- Barrel EMCAL:
  3D imaging with MAPS and sampling Pb/ scintillating fibres with Si sensors
- Forward EMCAL:
  finely segmented W powder/scintillating fibres

Hadronic calorimeter

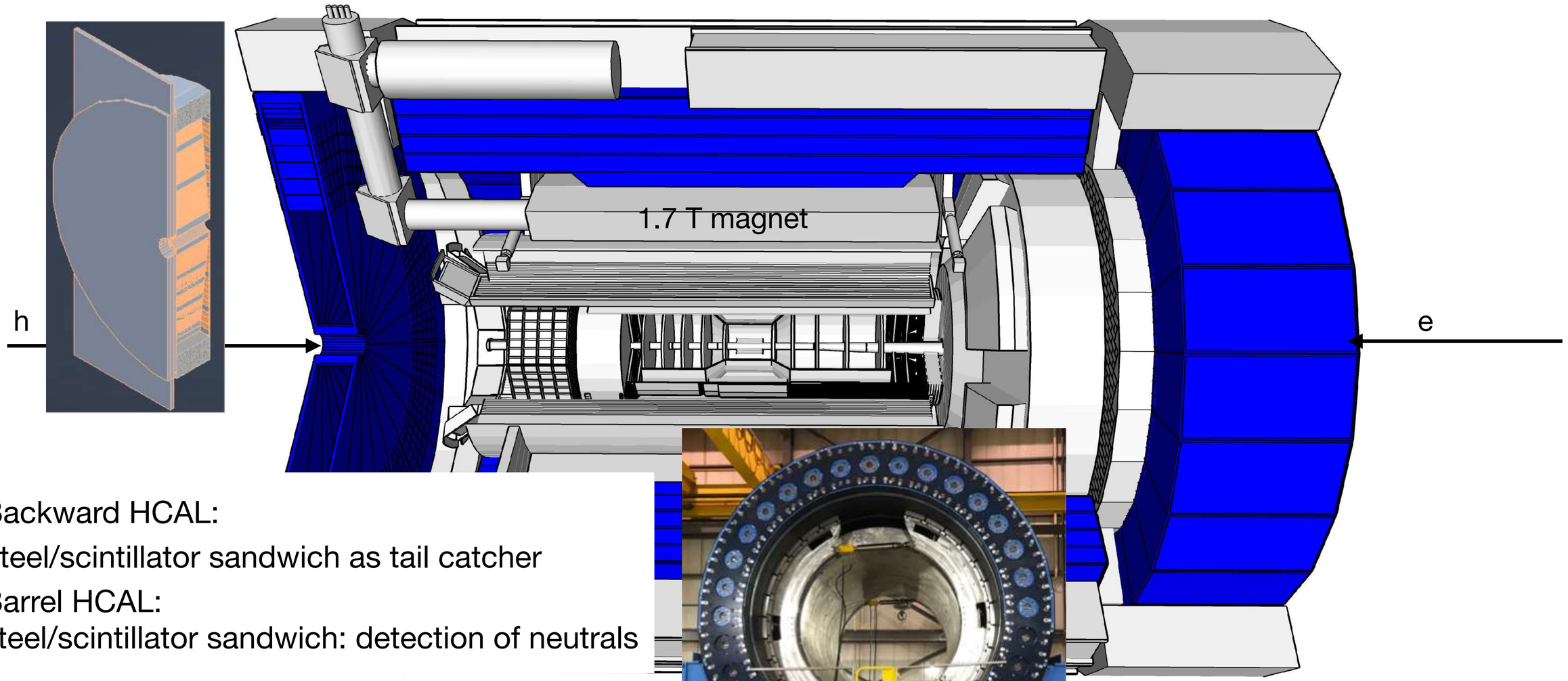


Hadronic calorimeter



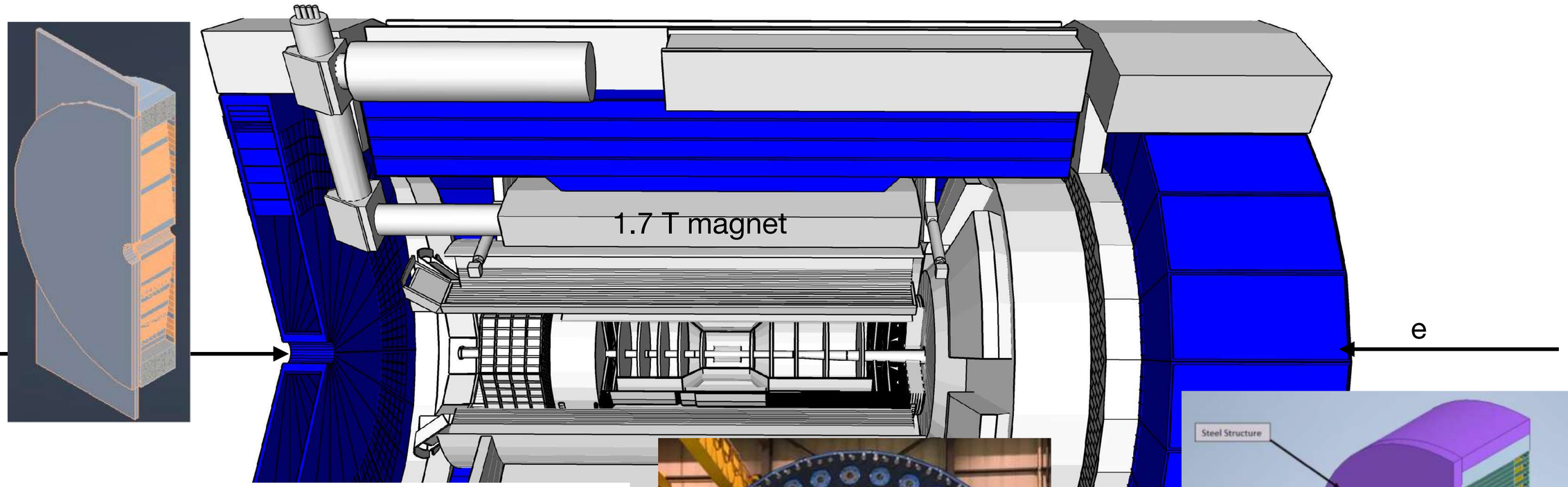
- Backward HCAL:
  steel/scintillator sandwich as tail catcher

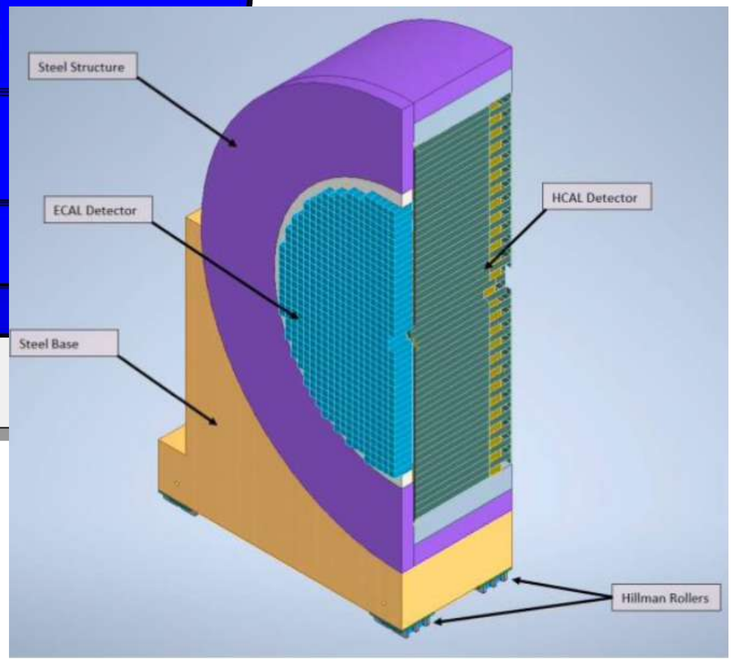
Hadronic calorimeter



- Backward HCAL:
  steel/scintillator sandwich as tail catcher
- Barrel HCAL:
  steel/scintillator sandwich: detection of neutrals

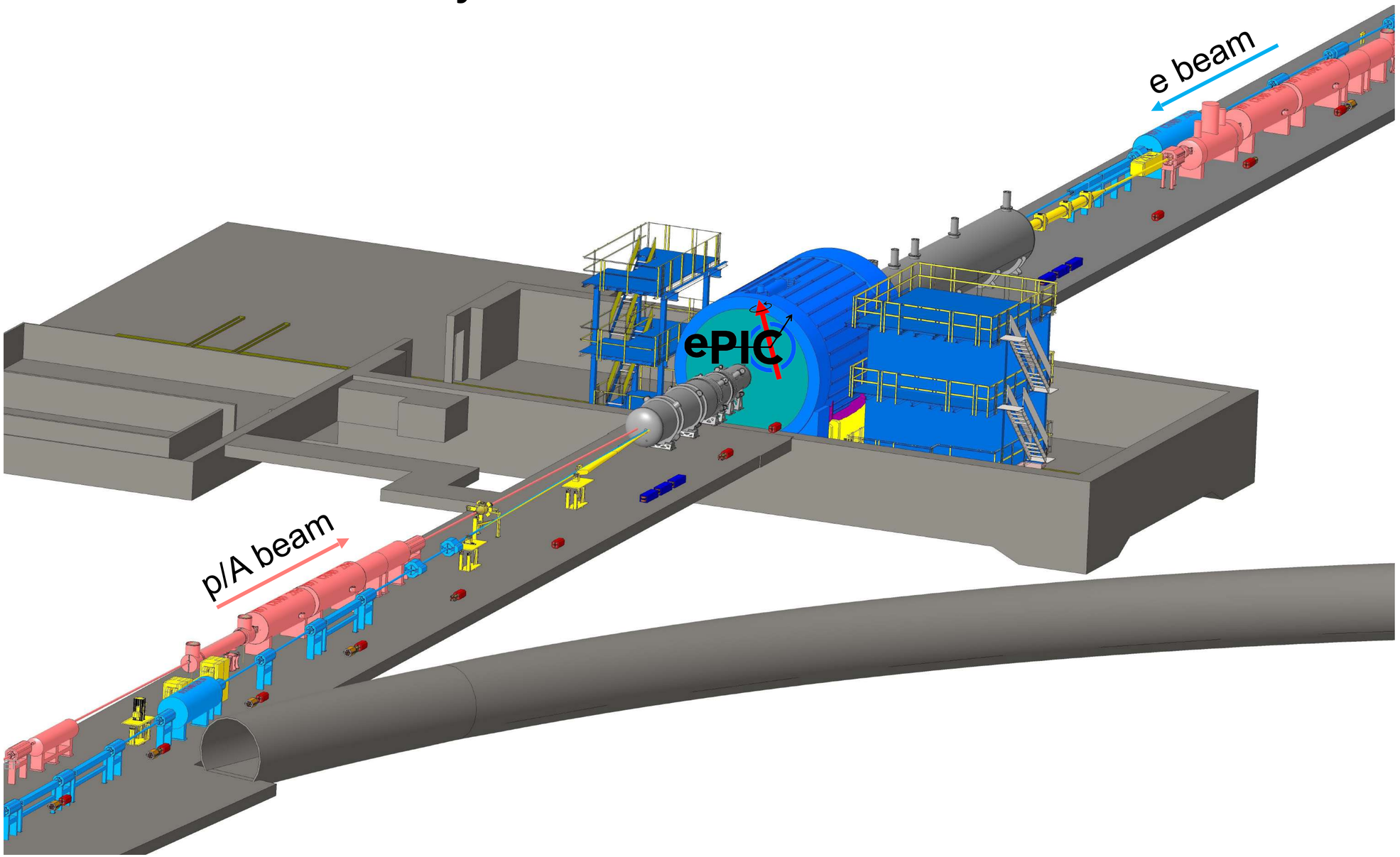
Hadronic calorimeter



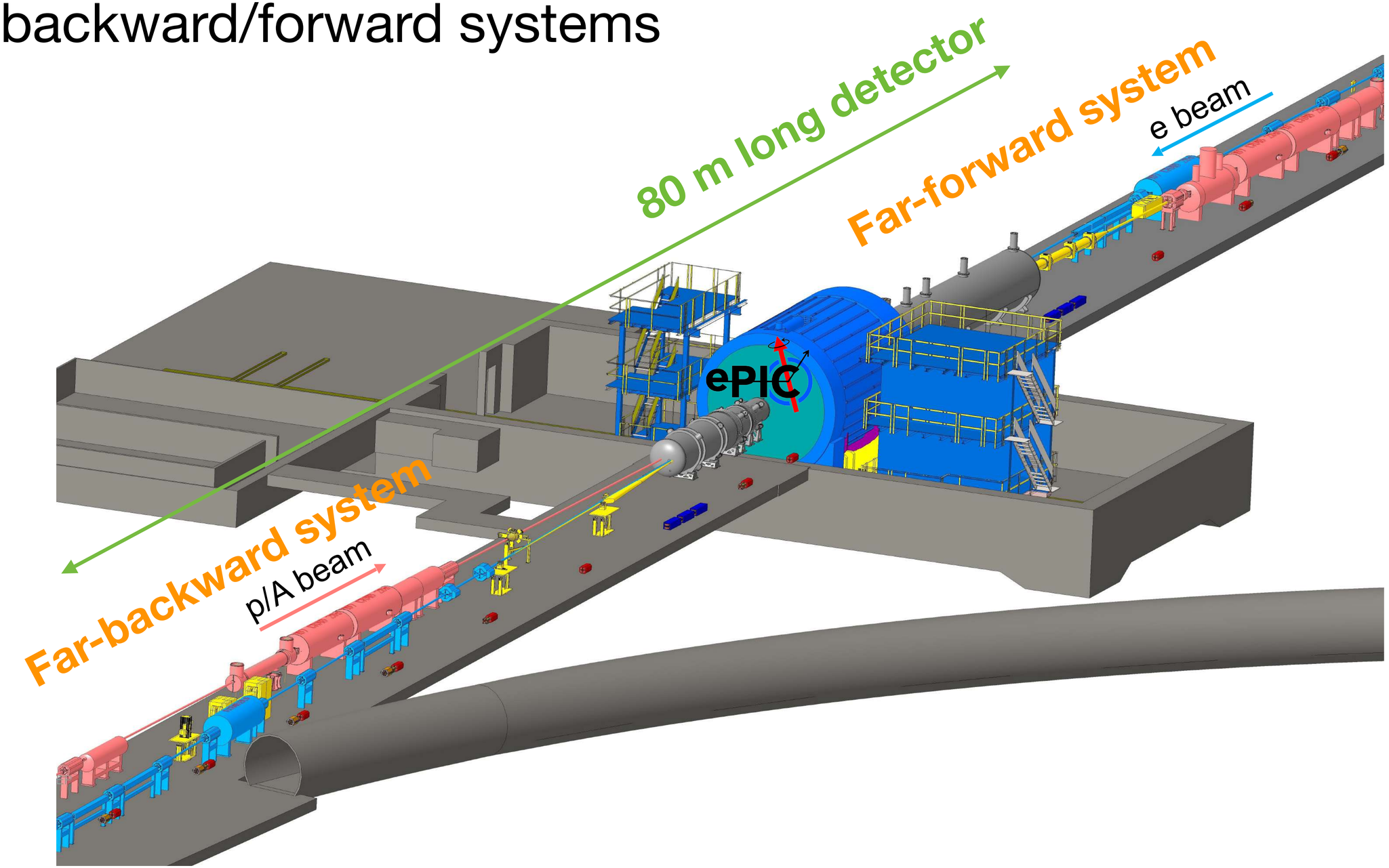


- Backward HCAL:
  steel/scintillator sandwich as tail catcher
- Barrel HCAL:
  steel/scintillator sandwich: detection of neutrals
- Forward HCAL:
  steel/scintillator sandwich longitudinally segmented, high granularity: good E resolution

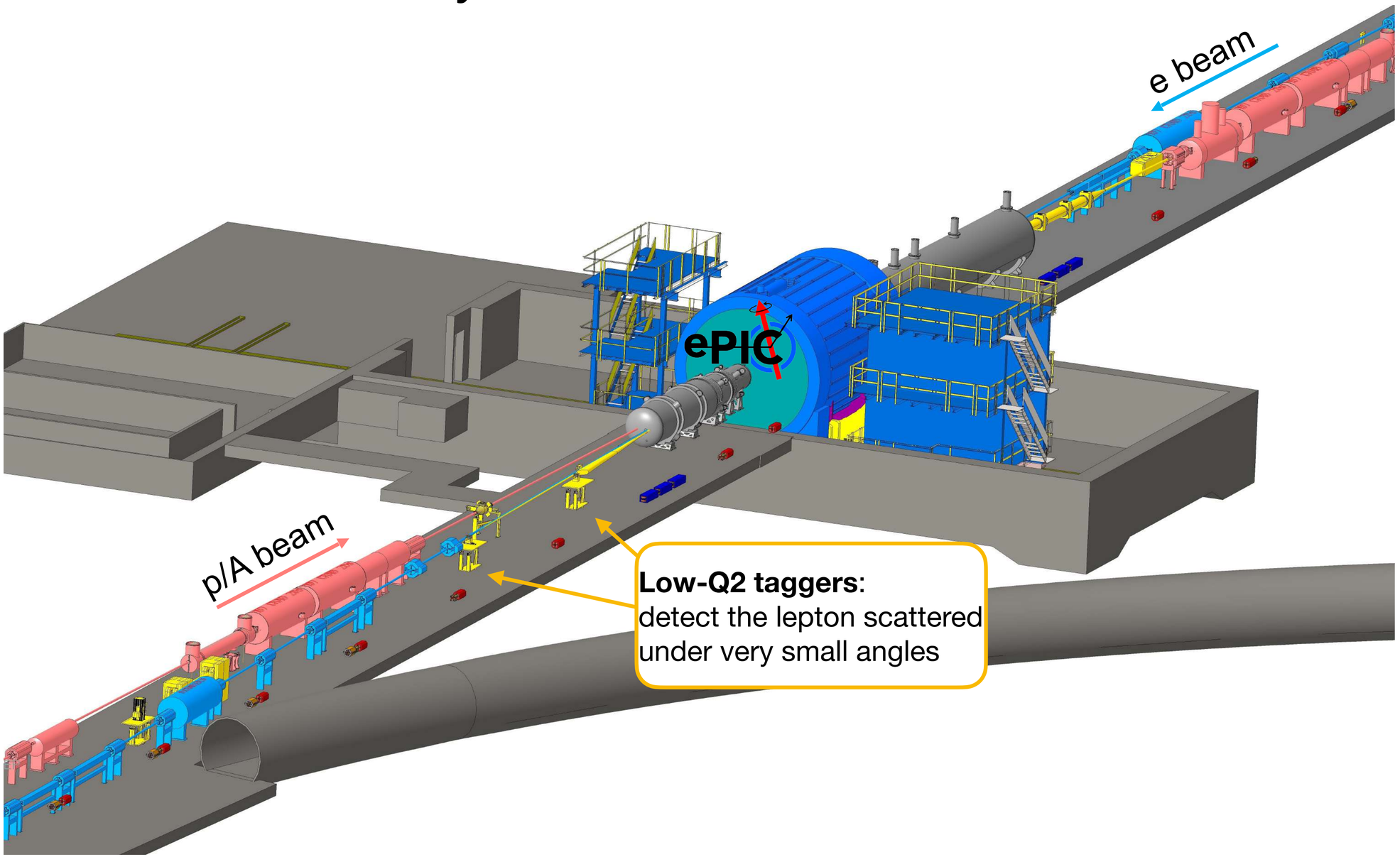
Far backward/forward systems



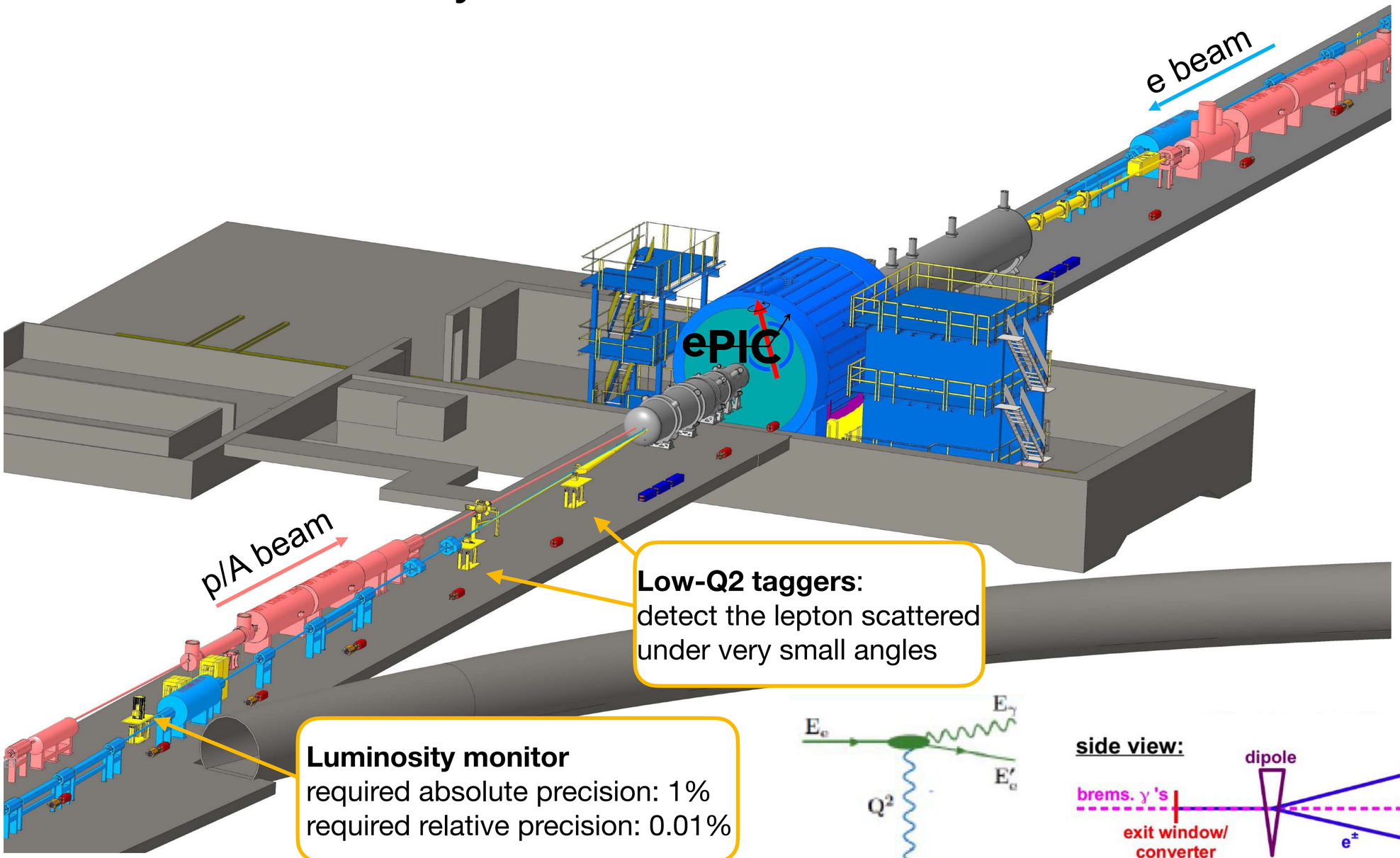
Far backward/forward systems



Far backward/forward systems



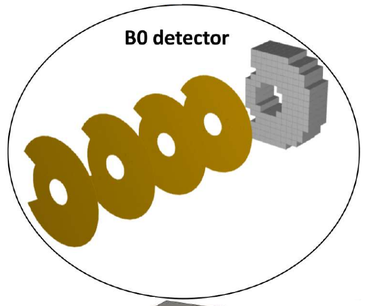
Far backward/forward systems



Low-Q2 taggers:
detect the lepton scattered under very small angles

Luminosity monitor
required absolute precision: 1%
required relative precision: 0.01%

Far backward/forward systems



B0 system: trackers+electromagnetic calorimeters inside magnetic field to detect **protons and photons**

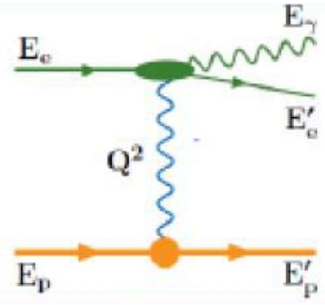
e beam

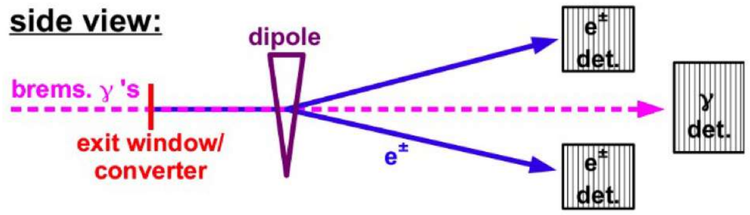
ePIC

p/A beam

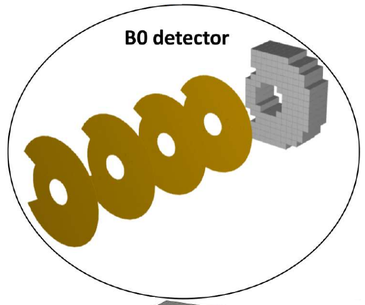
Low-Q2 taggers:
detect the lepton scattered under very small angles

Luminosity monitor
required absolute precision: 1%
required relative precision: 0.01%





Far backward/forward systems



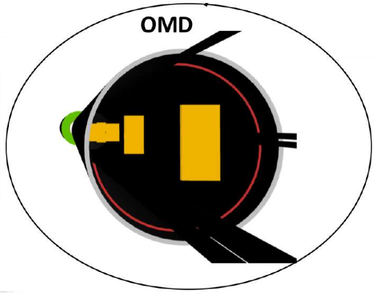
B0 system: trackers+electromagnetic calorimeters inside magnetic field to detect **protons and photons**

e beam

Roman pots and off-momentum detectors: reconstruct **far-forward protons** (and other charged particles+light ions)

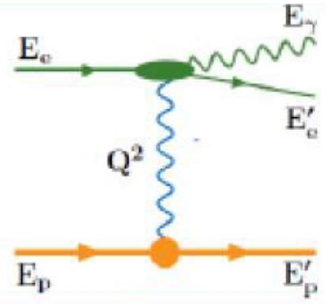
ePIC

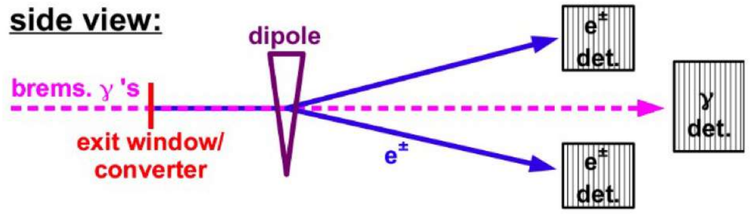
p/A beam



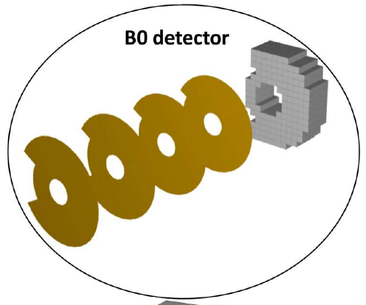
Low-Q2 taggers: detect the lepton scattered under very small angles

Luminosity monitor
required absolute precision: 1%
required relative precision: 0.01%



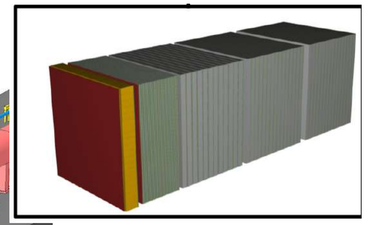


Far backward/forward systems

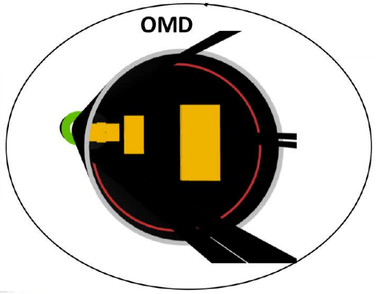


B0 system: trackers+electromagnetic calorimeters inside magnetic field to detect **protons and photons**

Zero-degree calorimeters: detection of **neutrons and photons**



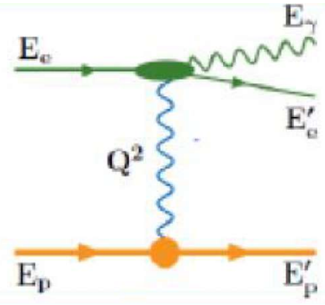
Roman pots and off-momentum detectors: reconstruct **far-forward protons** (and other charged particles+light ions)

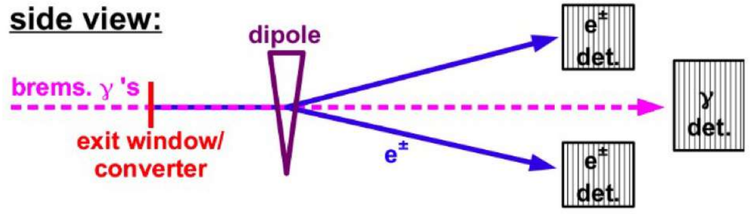


p/A beam

Low-Q2 taggers: detect the lepton scattered under very small angles

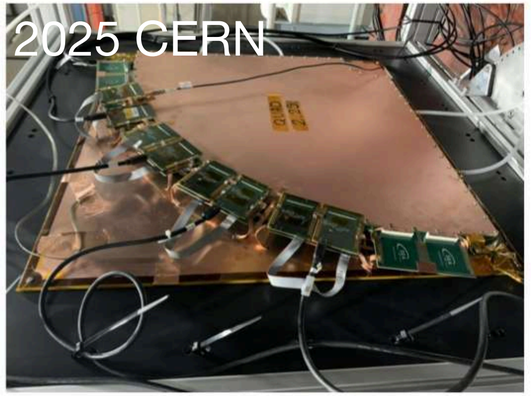
Luminosity monitor
required absolute precision: 1%
required relative precision: 0.01%



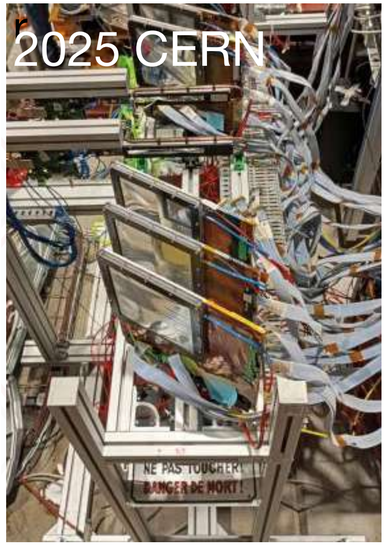


Test-beam measurements

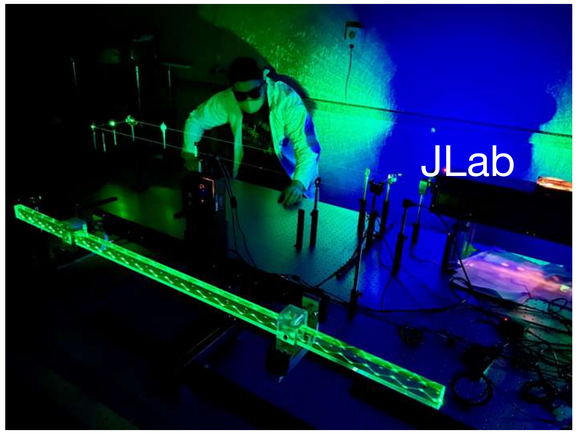
µRWELL-ECT ETAs



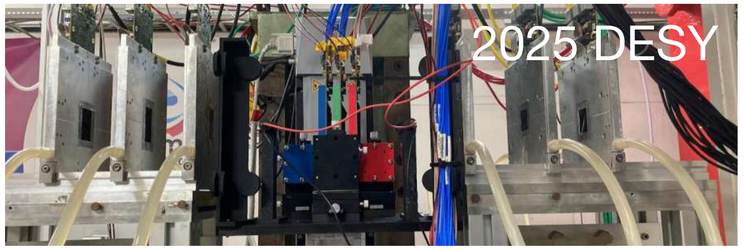
microMegas

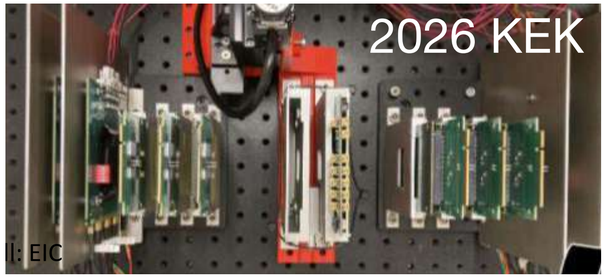


Optical test of
refurbished DIRC

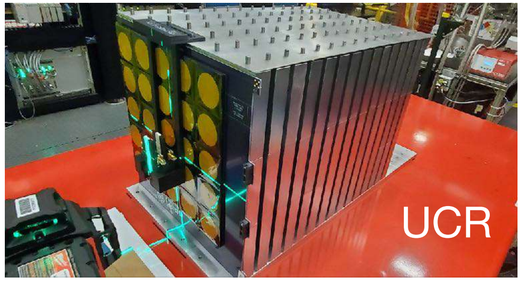


TOF detectors



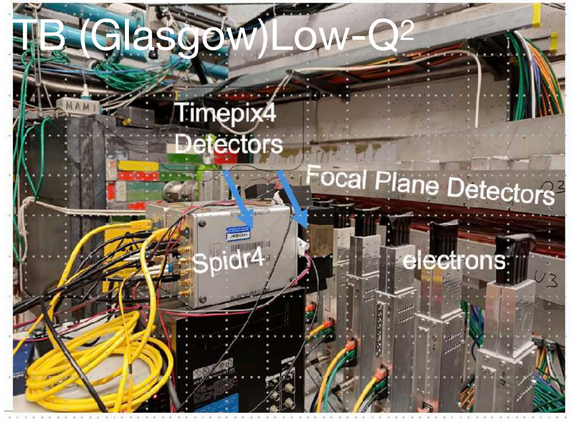


ZDC



Forward HCAL

Low-Q^2 Tagger



Summary and outlook

- EIC with ePIC will address various open and key aspects of QCD via
  - high luminosity
  - collisions of polarised electron and polarised proton/large variety of unpolarised ions
  - Fully-instrumented detecrtor
- Efforts started 20 years ago, with continuously increasing activity
- Over the next decade building and commissioning of ePIC: very exciting times ahead!