Discovery through Complementarity – The EIC 2nd Detector

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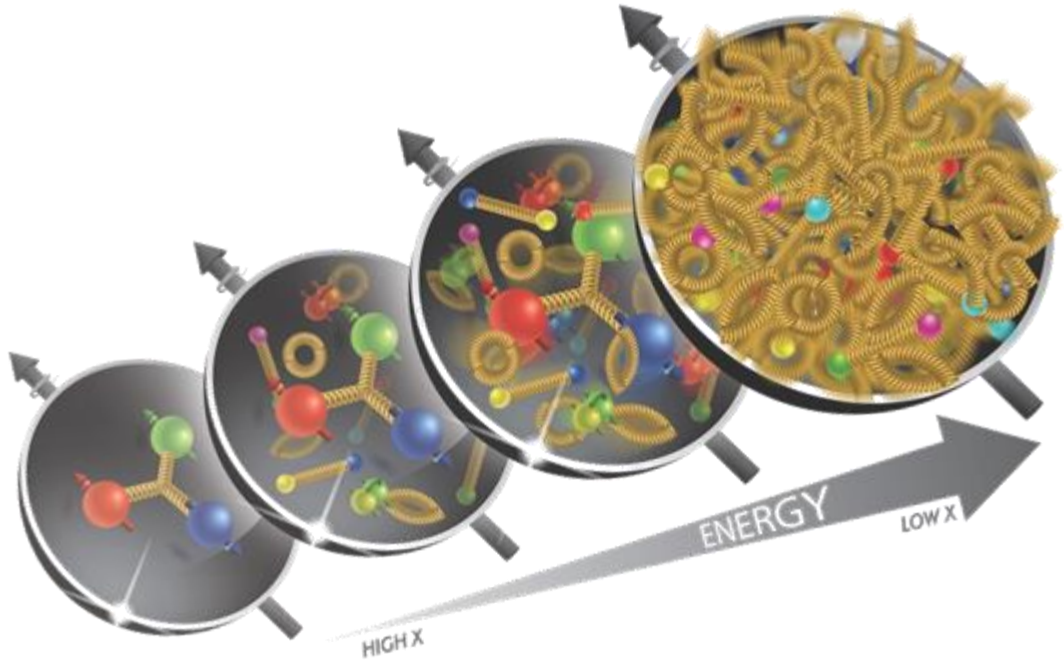
09-19-2024

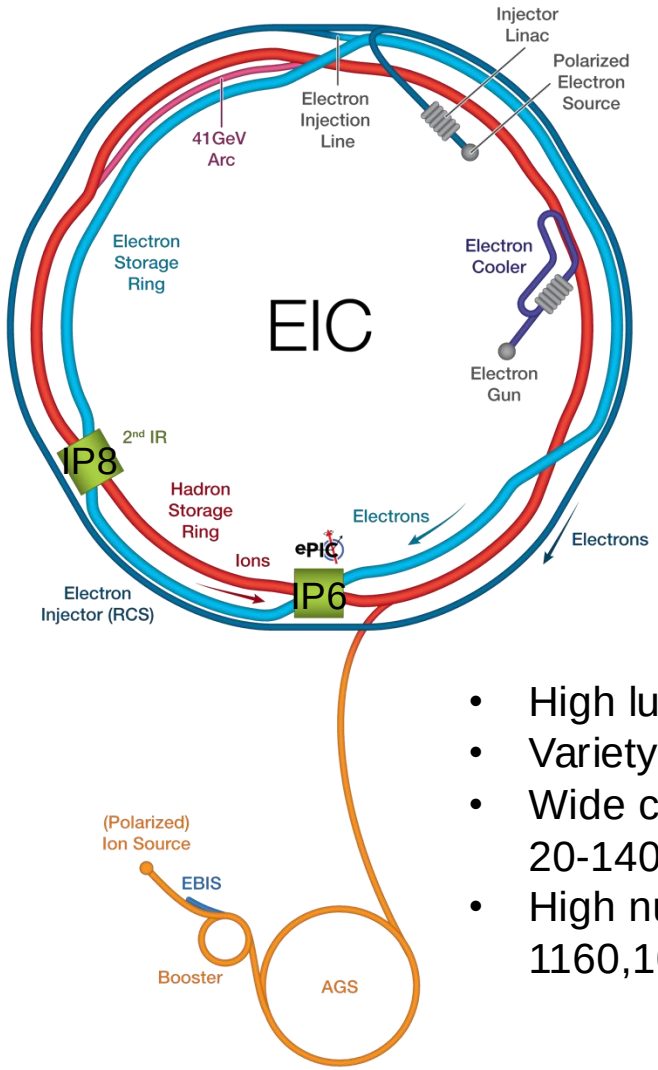
The Physics of EIC

The **finest microscope** to look inside the nucleons using electromagnetic-induced virtual photons

1. Origin of proton mass and spin
2. Quark and gluon distributions in spatial and momentum space
3. Gluon saturation
4. Hadronization process
5. QCD in a dense nuclear environment
6. Physics beyond the standard model



The Electron-Ion Collider

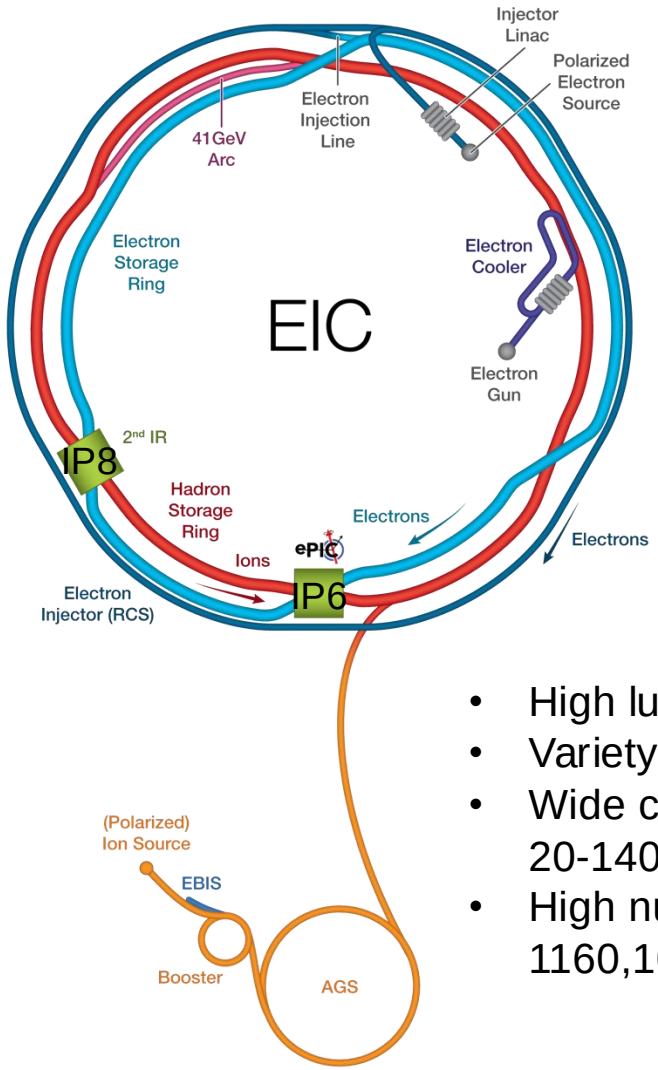


- First collider that provides polarized electron and light ion beams
- Existing hadron storage ring
  41, 100 – 275 GeV
- Electron rapid cycling synchrotron
  1 Hz, 0.4 – 18 GeV
- Electron storage ring 5 – 18 GeV

- High luminosity: 10^{33} – 10^{34} $cm^{-2}s^{-1}$
- Variety of hadron / ion beams: p to Pb
- Wide center-of-mass energy ranging: 20-140 GeV
- High number of bunches: 1160,10ns separation

Brookhaven National Laboratory

The Electron-Ion Collider



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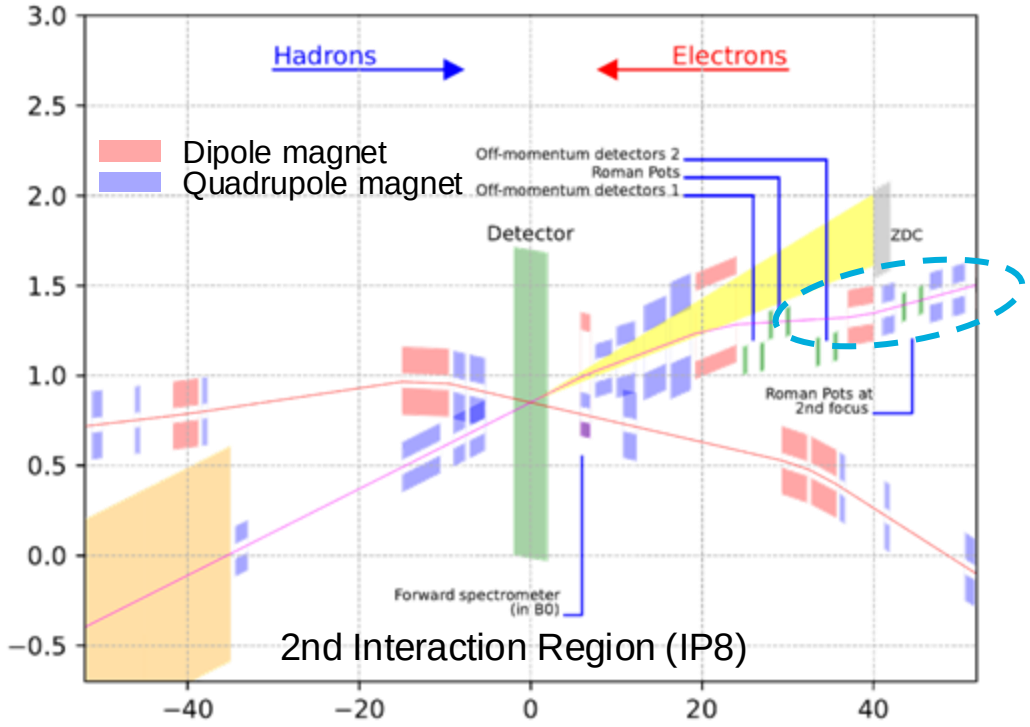

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- Wide center-of-mass energy ranging: 20-140 GeV
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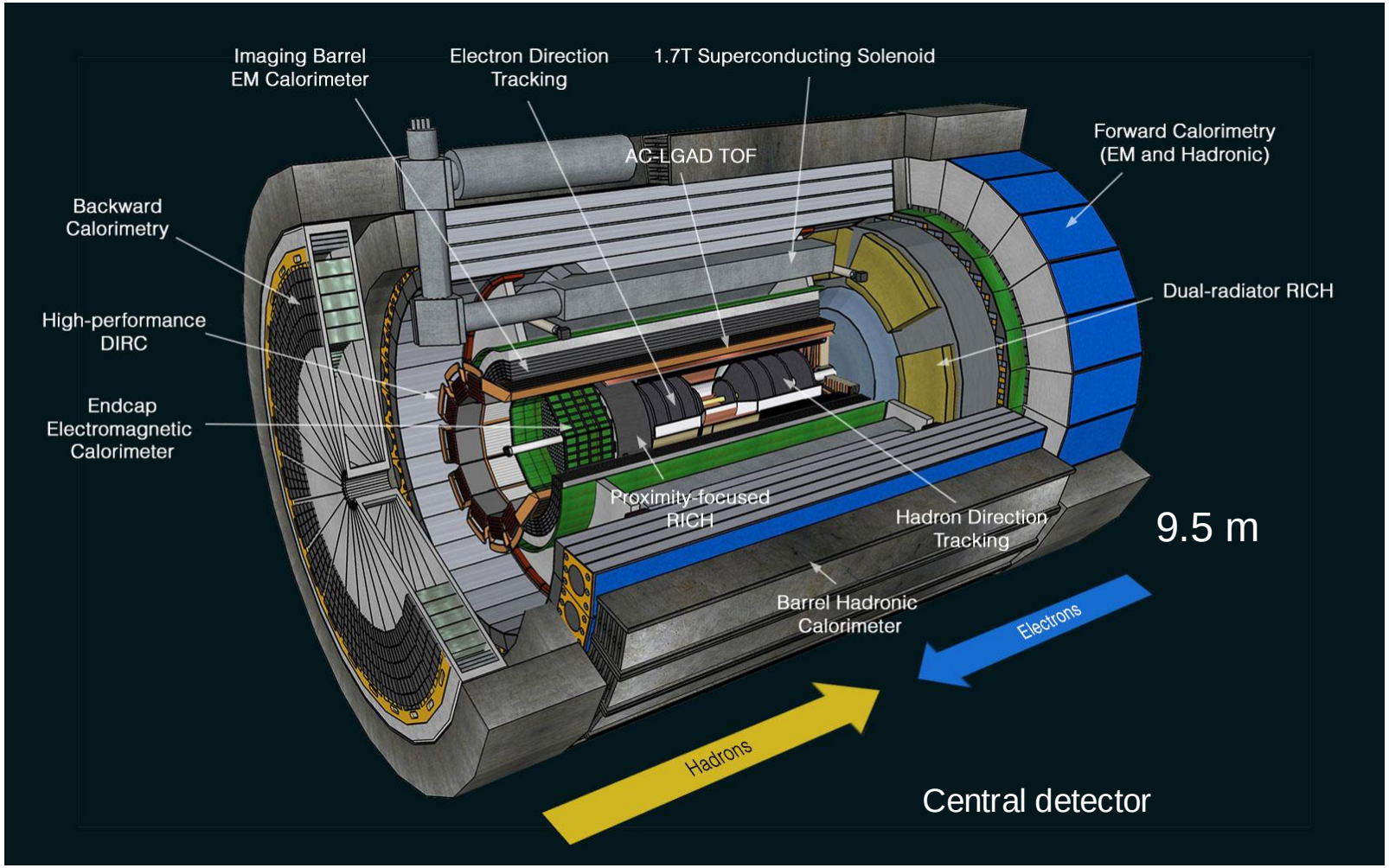
- 25 mrad (35 mrad) crossing angle at the IP6 (IP8)
  → different blind spots
- Crab crossing
  → restore head-on collision of each bunch
- **IP8 with a secondary beam focus**
  → Improve low p_T (~0 GeV) acceptance at far-forward region

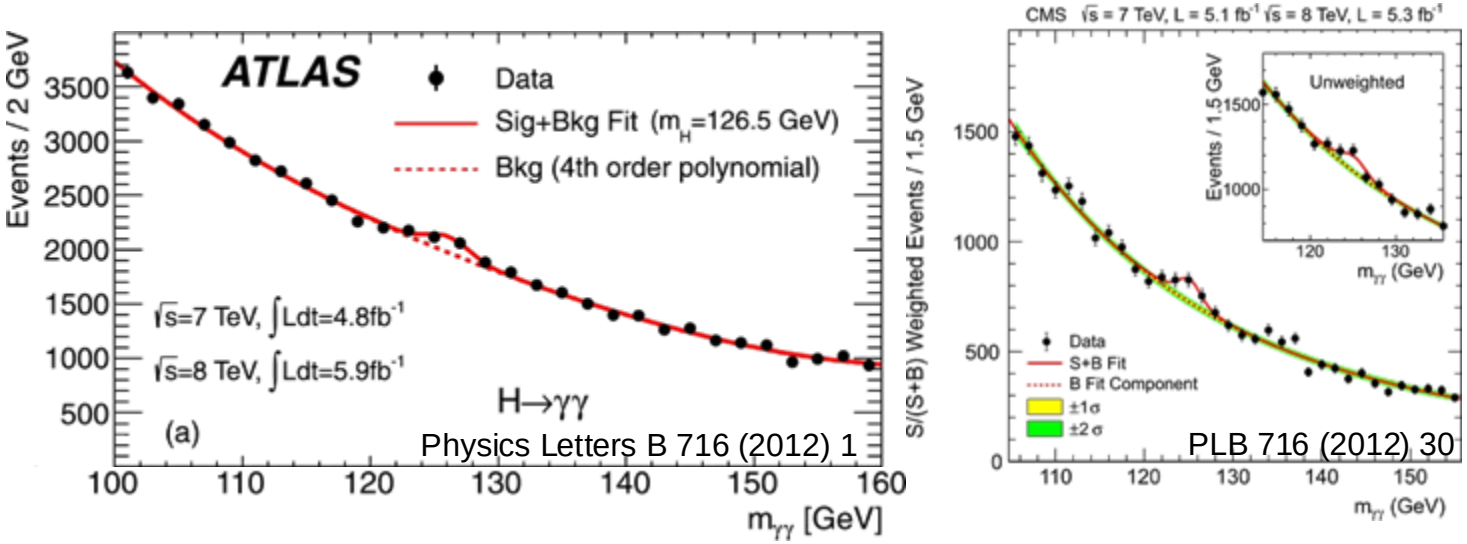
The Project Detector -- ePIC



- **16 subdetectors** in the central region
- **Far-forward and far-backward** detectors for ion fragments and scattered electron measurements
- Using **machine learning** techniques on detector design, operations and data analysis
- 171 institutions from 24 countries and counting

The Needs of a Second Detector

Discovery of Higgs boson from ATLAS and CMS results



- Cross-checking → validate discoveries

The Needs of a Second Detector

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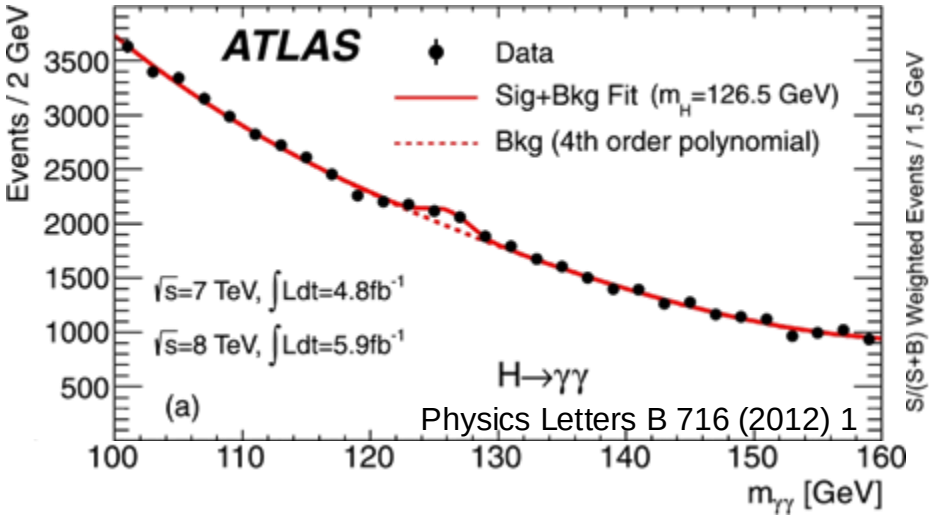

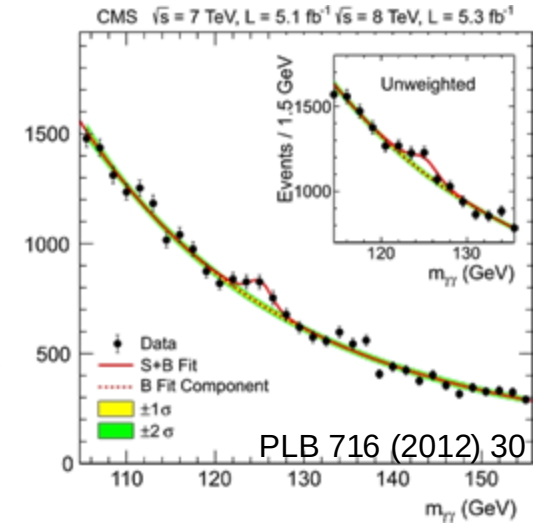

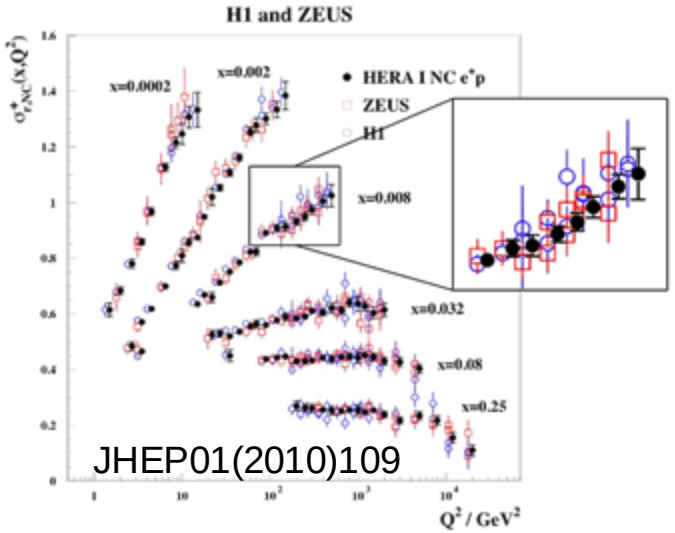

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- Cross Calibration → gives beyond the simple $\sqrt{2}$ statistical improvement

The Needs of a Second Detector

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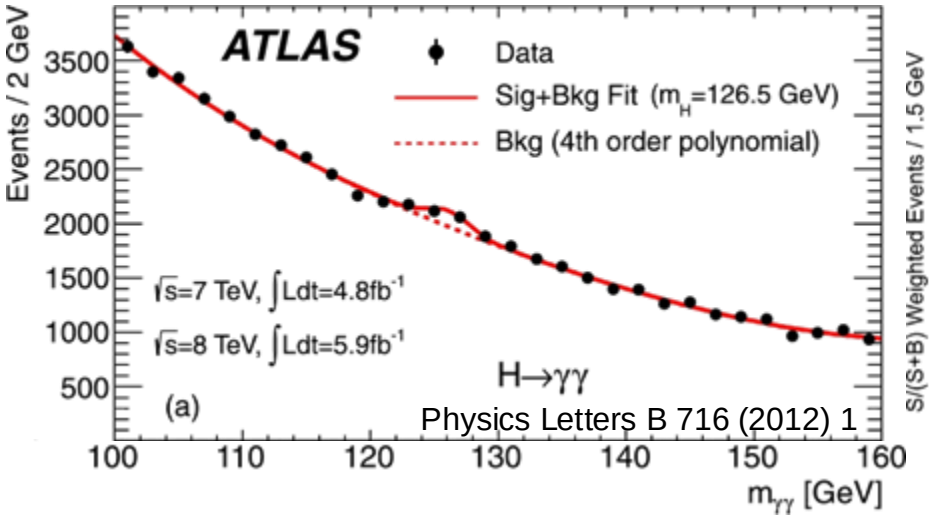
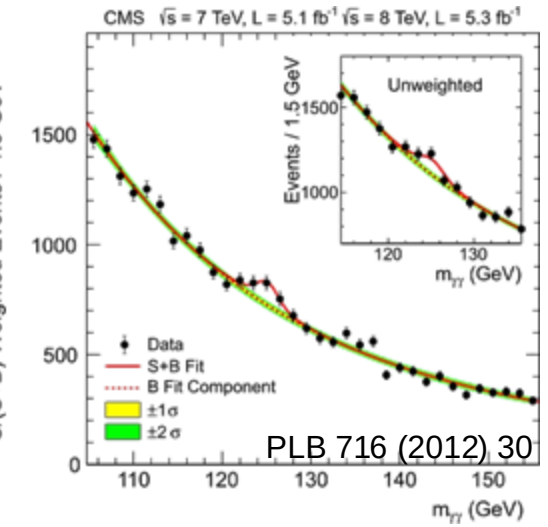


Physics Letters B 716 (2012) 1



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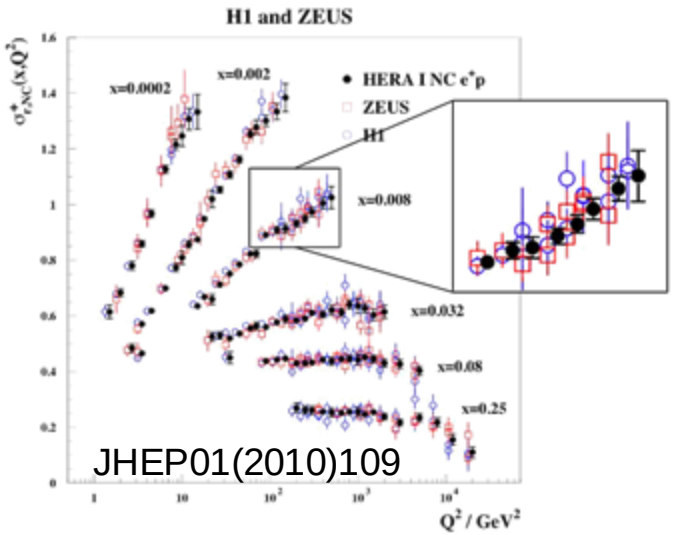
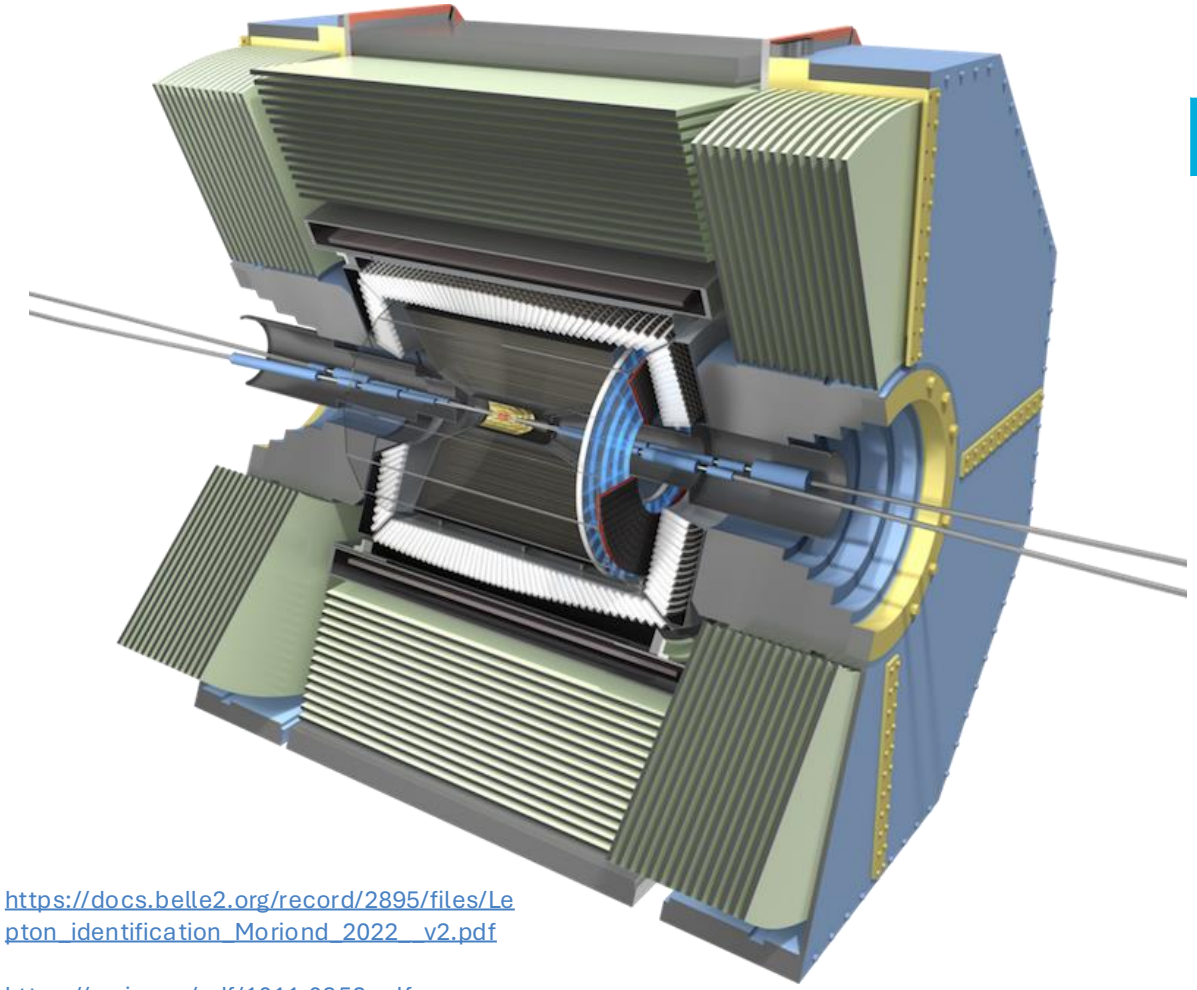


JHEP01(2010)109

- Cross-checking → validate discoveries
- Cross Calibration → gives beyond the simple $\sqrt{2}$ statistical improvement
- Different physics focuses
- Technology Redundancy → mitigate risks

Concepts of the 2nd Detector (Central) – Muon ID

BELLE II KLM (green)



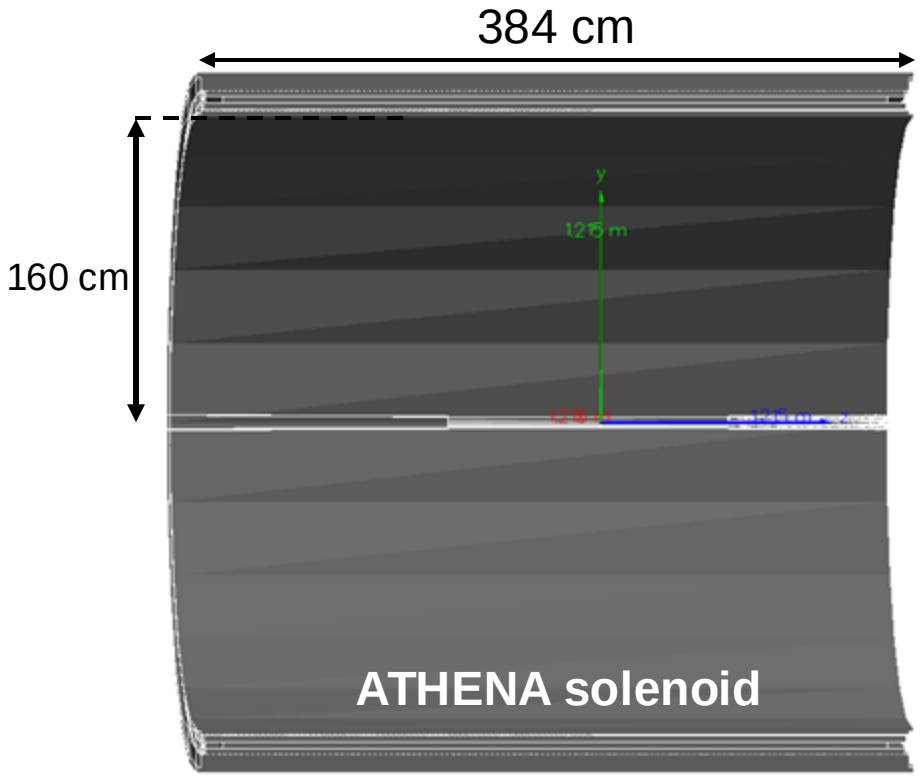
https://docs.belle2.org/record/2895/files/Lepton_identification_Moriond_2022__v2.pdf

https://arxiv.org/pdf/1011.0352.pdf

ePIC	2nd Detector
Hadronic calorimeters in forward, central and backward regions	Muon identification detectors in central and forward
Measures the energy of neutral particles	Reduce ambiguity in quarkonium reconstruction $J/\psi \rightarrow e^+e^-$ v.s. $J/\psi \rightarrow \mu^+\mu^-$

Concepts of the 2nd Detector (Central) – Magnet

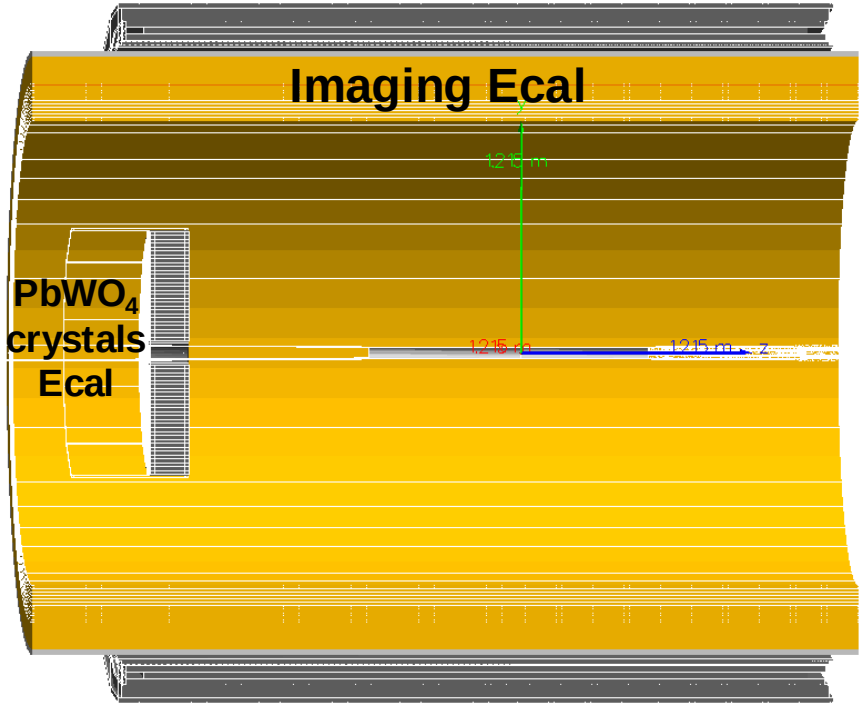
Excluding Hcal/muID



ePIC	2nd Detector
B=1.7 T	B=2T improve momentum resolution
r=1.42 m	r=1.6 m Lager inner volume

Concepts of the 2nd Detector (Central) – Ecal

Excluding Hcal/muID



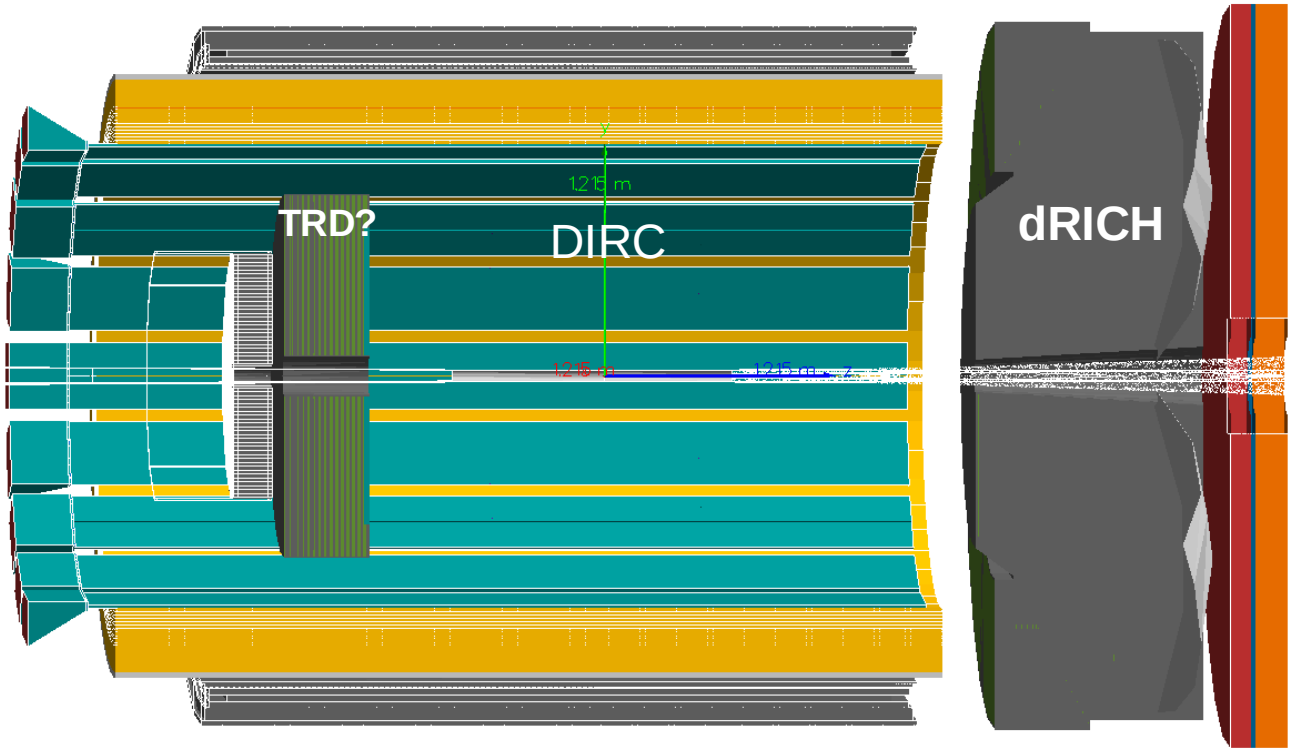
Scintillating Fiber Ecal

Using the ePIC Ecal designs, currently

- Backward
  - Lead-tungsten crystals Ecal
  - Fine energy resolution (1-2%)
    resolution of the probe:
    $\Delta e_{beam} = e'_{beam} - e_{beam}$
  - High pion suppression
- Central
  - 6 layers of imaging silicon sensors interleaved with 5 scintillating fiber/lead layer
  - A large section of scintillating fiber/lead layer at the outer radius
- Forward
  - Scintillating fiber/lead
  - Good pion/photon separation

Concepts of the 2nd Detector (Central) – PID

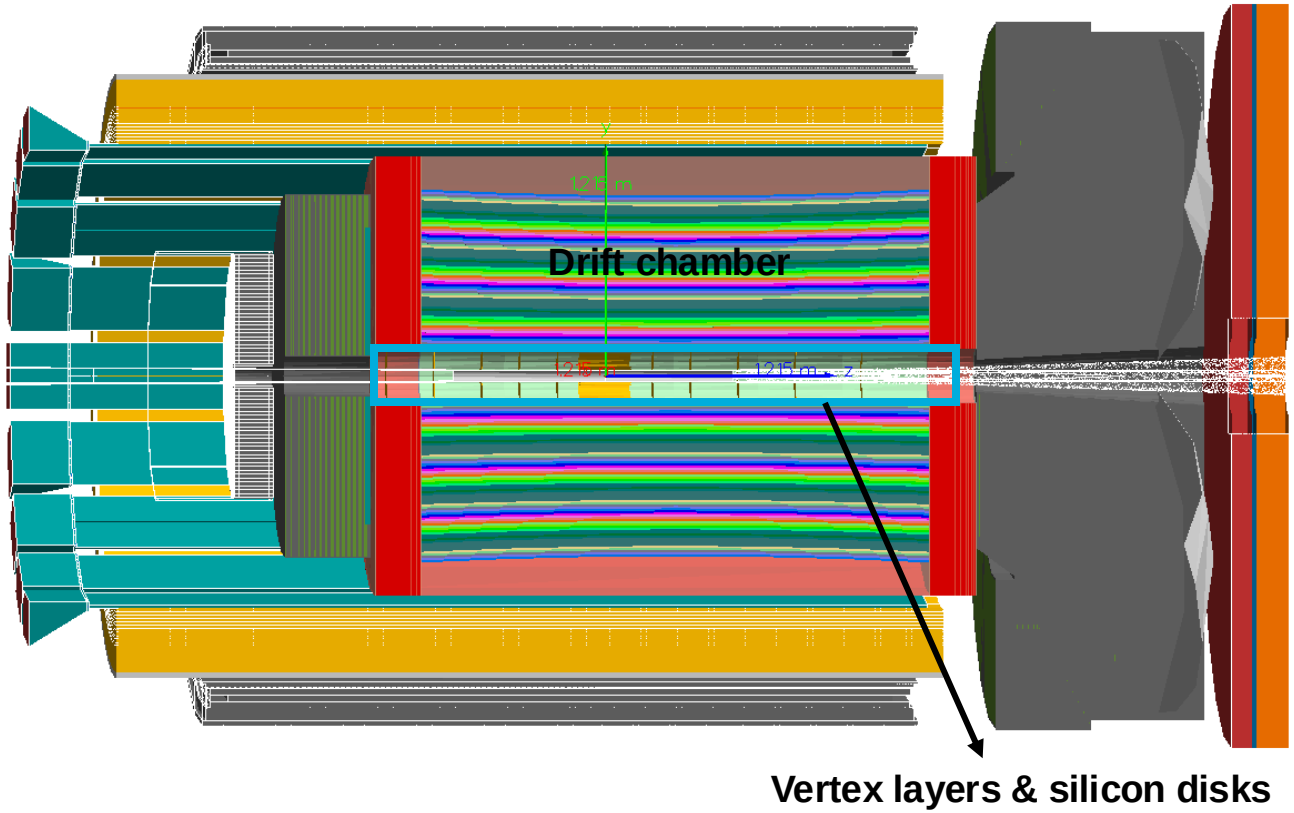
Excluding Hcal/muID



ePIC	2nd Detector
Cherenkov Radiation detector in the forward, central and backward region	Transition Radiation detector for backward particle identification (pfRICH)
Visible photons	x-ray photons

Concepts of the 2nd Detector (Central) – Tracking

Excluding Hcal/muID



ePIC	2nd Detector
Silicon-based tracking system	Non-silicon-based tracking system
5-layers/disks of silicon detector + thin MPGDs (gas detectors)	Inner silicon tracker + large volume of non-silicon tracking technologies. Examples: gas detectors (TPC or drift chamber), scintillating fiber
Fine spatial resolutions	More hits →better pattern recognition →redundancy →resistance against backgrounds

What Do I Do, Actually?

Goals

- Provide a concept of the 2nd Detector
- Suggestion of detector technologies

How: demonstrate the performance of the detector concept

- ✓ J/ψ reconstruction with muon ID smearing
- ❑ Study momentum resolution of a non-silicon-based tracking system
- ❑ PID performance with a transition radiation detector