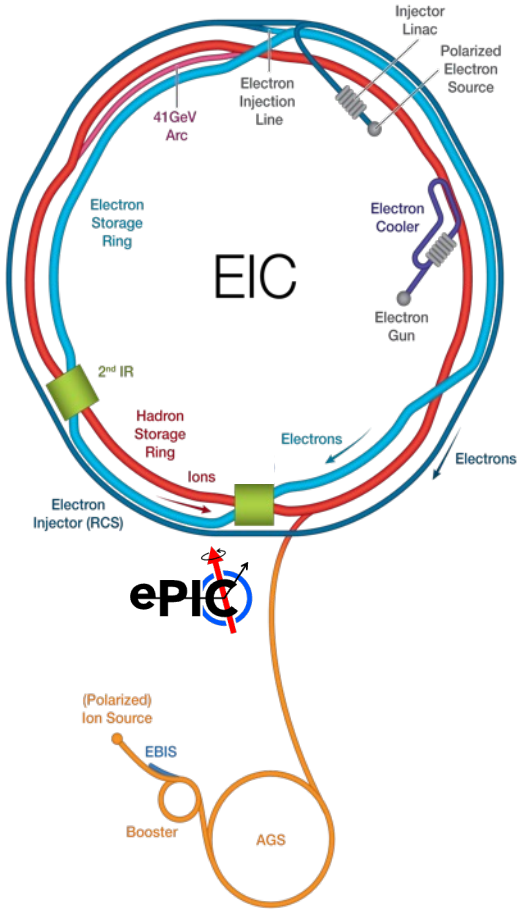
EIC Community in the UK

Peter Jones

University of Birmingham



Daresbury Laboratory
Rutherford Appleton Laboratory

EIC community building in the UK

Community interest spans: nuclear physics, particle physics, accelerator science, theory

- Glasgow (October 2016)

  Workshop on Physics and Engineering Opportunities at the Electron-Ion Collider

- Birmingham – online (July 2020)

  Workshop on Physics, Detector and Accelerator Opportunities at the Electron-Ion Collider

- Cockcroft Institute, Daresbury Laboratory – online (October 2020)

  Accelerator workshop – Promoting Collaboration on the Electron-Ion Collider

- IPPP, Durham – online (September 2021)

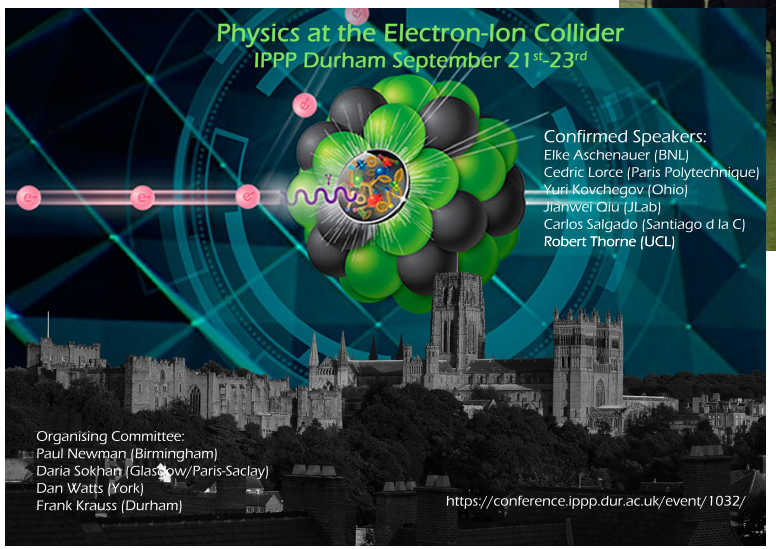
  Physics at the Electron-Ion Collider

- York (March 2024)

  Early Career Workshop

- Birmingham (November 2024)

Loch Lomond – 2016



UK involvement in the EIC

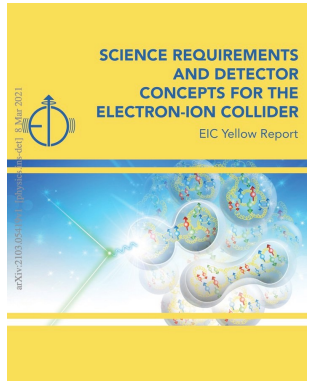
- EIC Generic Detector R&D Programme (Oct 2016 – Sep 2022)

  eRD18 – Precision Central Silicon Tracking and Vertexing at the EIC (Oct 2016 – Sep 2020)
  Birmingham and the Rutherford Appleton Laboratory

  eRD25 – Silicon Tracking and Vertexing (Oct 2020 – Sep 2022)
  Merger with eRD16 (LBNL) working on forward/backward disks

- EIC Yellow Report (Dec 2019 – Mar 2021)

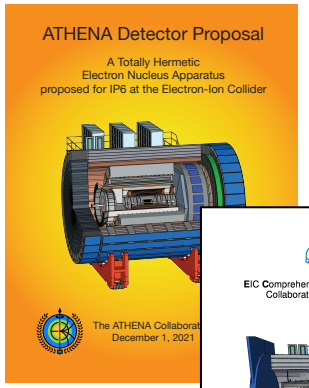
  Peter Jones – Detector WG co-convenor and editor
  Daria Sokhan – convenor Exclusive Physics subgroup
  Paul Newman – convenor of Detector Complementarity subgroup

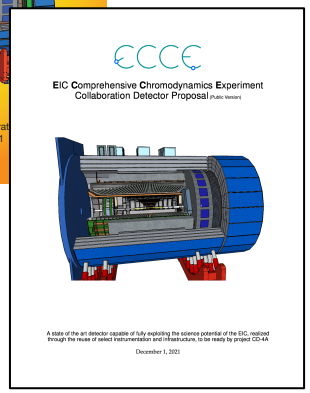


- Detector Proposals (Mar 2021 – Dec 2021)

  ATHENA – Peter Jones (Proposal Committee), Paul Newman (Inclusive PWG convenor),
  Daria Sokhan (Exclusive & Tagging PWG convenor), Laura Gonella (Tracking DWG convenor)

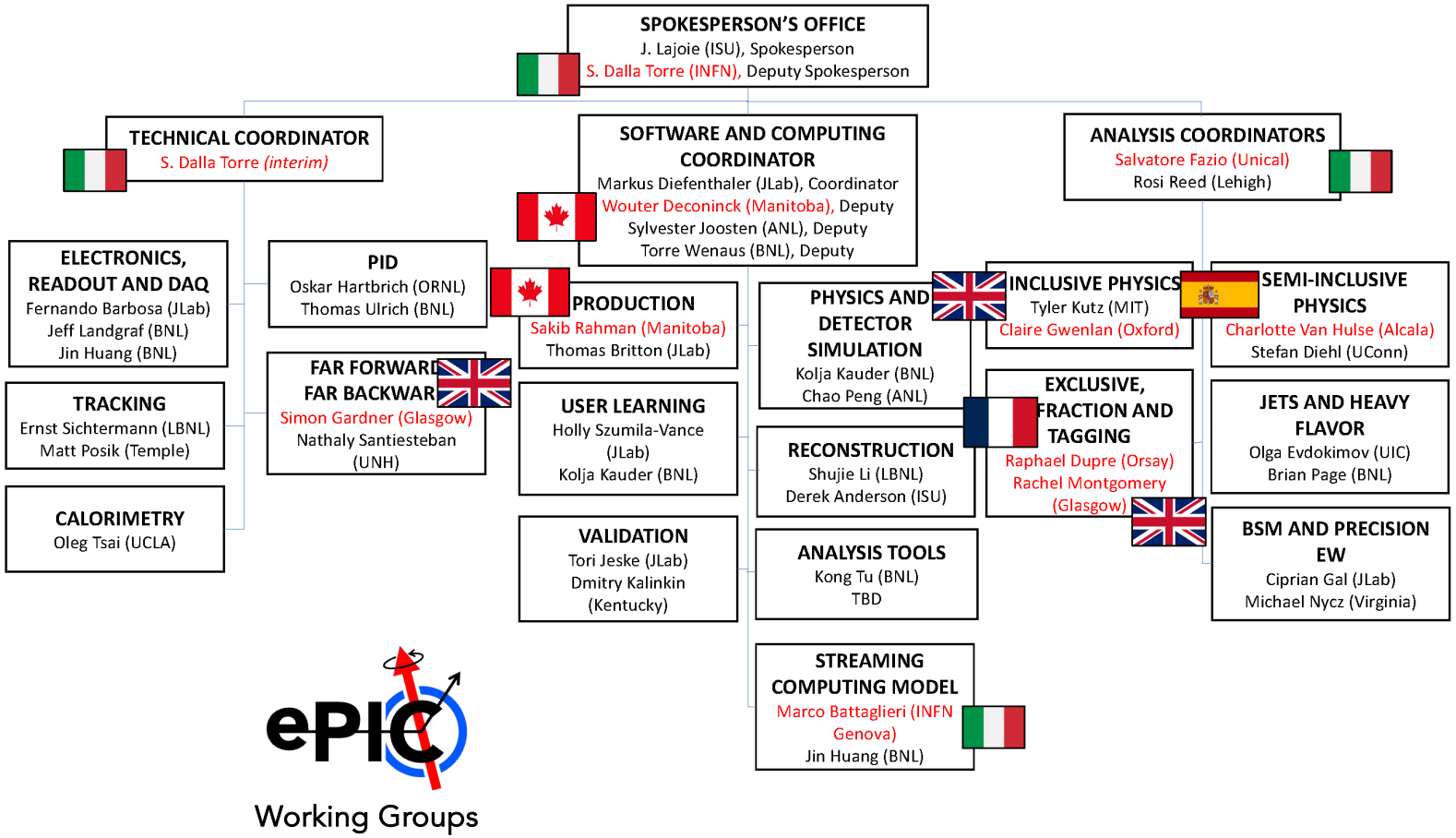
  ECCE – Rachel Montgomery (Exclusive PWG convenor), Claire Gwenlan (Inclusive PWG convenor),
  Nick Zachariou (Far Backward DWG convenor)



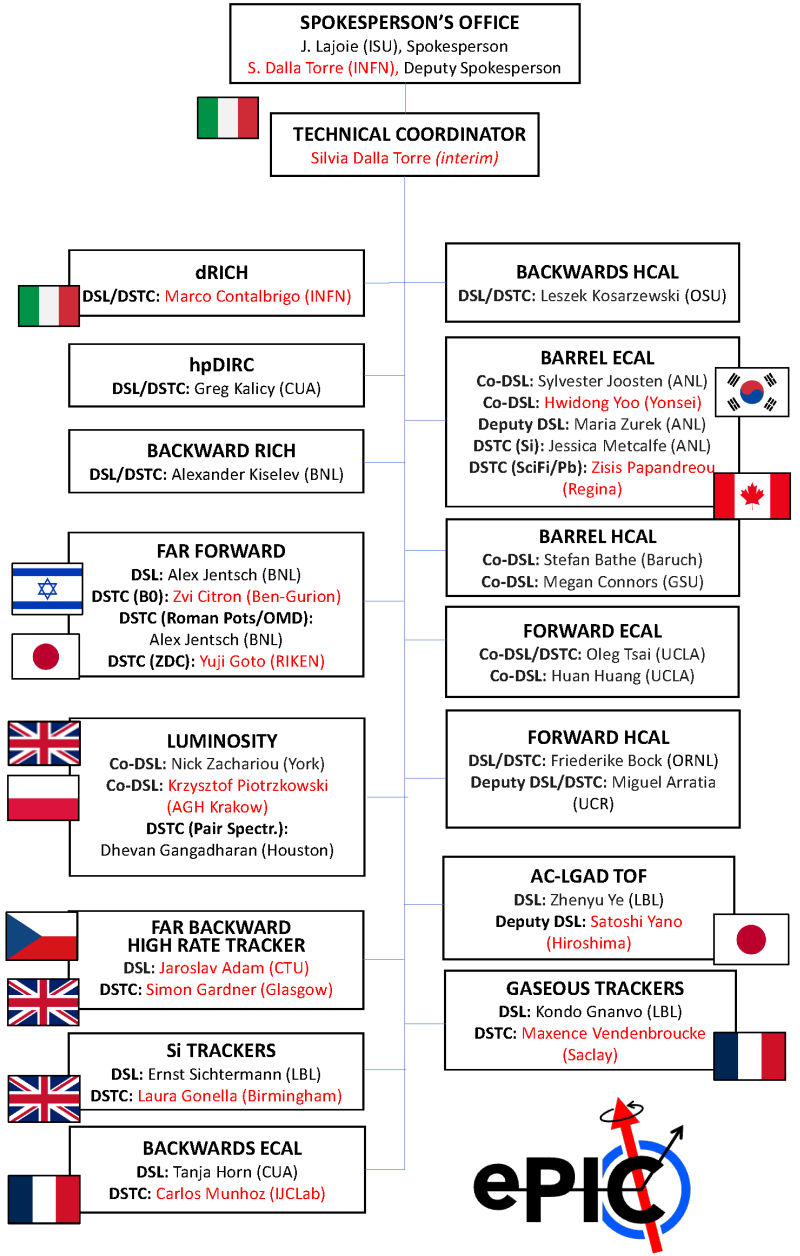


ePIC Collaboration

- International leadership (figures courtesy of John Lajoie)



Working Groups



Detector Subsystem Collaborations

Paul Newman (Birmingham) – Executive Board
Nick Zachariou (York) – Conferences and Talks Committee

UK research funding for the EIC

- UK Research and Innovation (UKRI) – founded in 2018

Nuclear Physics, Particle Physics & Astronomy

Introduced a new approach to identifying and funding large infrastructure projects
Outline proposal submitted – EIC shortlisted as potential future project – UKRI Infrastructure Opportunity Report

- UKRI Infrastructure Fund – new funding process for large infrastructure projects

EIC Detector R&D – Preliminary Activity – £2.9m (Oct 2021 – Mar 2024)
EIC Full Infrastructure Project – £58.8m including contingency (Apr 2025 – Mar 2035)

- Funded institutes

Birmingham, Brunel, Glasgow, Lancaster, Liverpool, Oxford, York, Daresbury, Rutherford Appleton Laboratory

EIC-UK Full Infrastructure Project

Hadronic Calorimeters (HCAL)

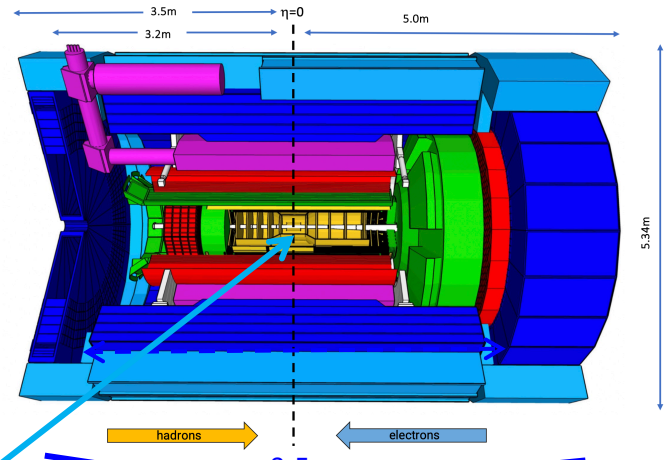
Solenoidal Magnet

E/M Calorimeters (ECal)

Time.of.Flight (ToF), DIRC, RICH detectors

MPGD trackers

MAPS tracker



WP1 – Silicon Tracker

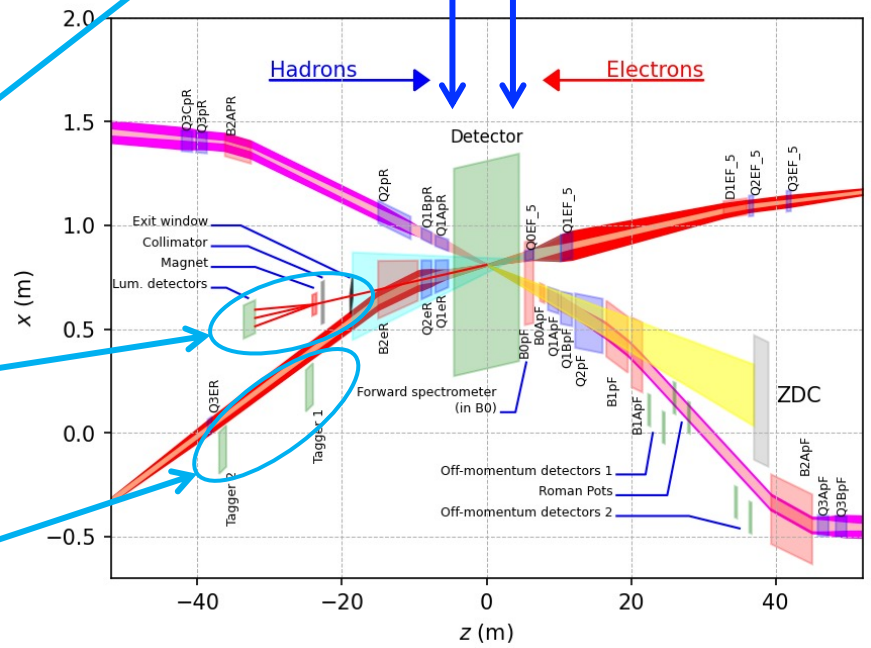
Birmingham, Brunel, Liverpool, Oxford, Daresbury Laboratory, Rutherford Appleton Laboratory

WP3 – Luminosity Monitor

York

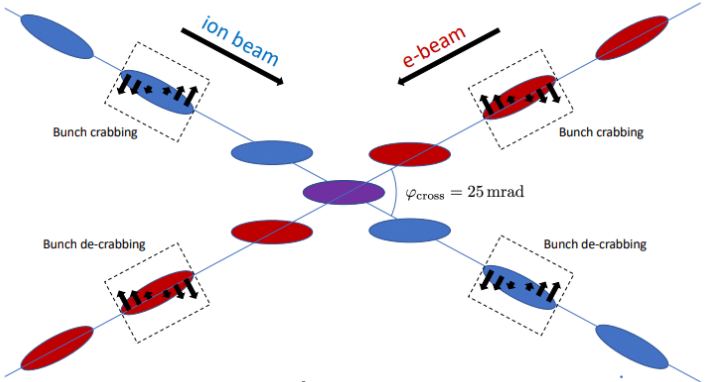
WP2 – Electron Tagger

Glasgow



WP4 – Accelerator

Lancaster, Daresbury Laboratory



Crab cavities

WP1 – Silicon Tracker

- Detector Overview

Proposed ALICE-ITS3 sensor meets EIC needs

65 nm MAPS technology driven by physics requirements and validated with simulations

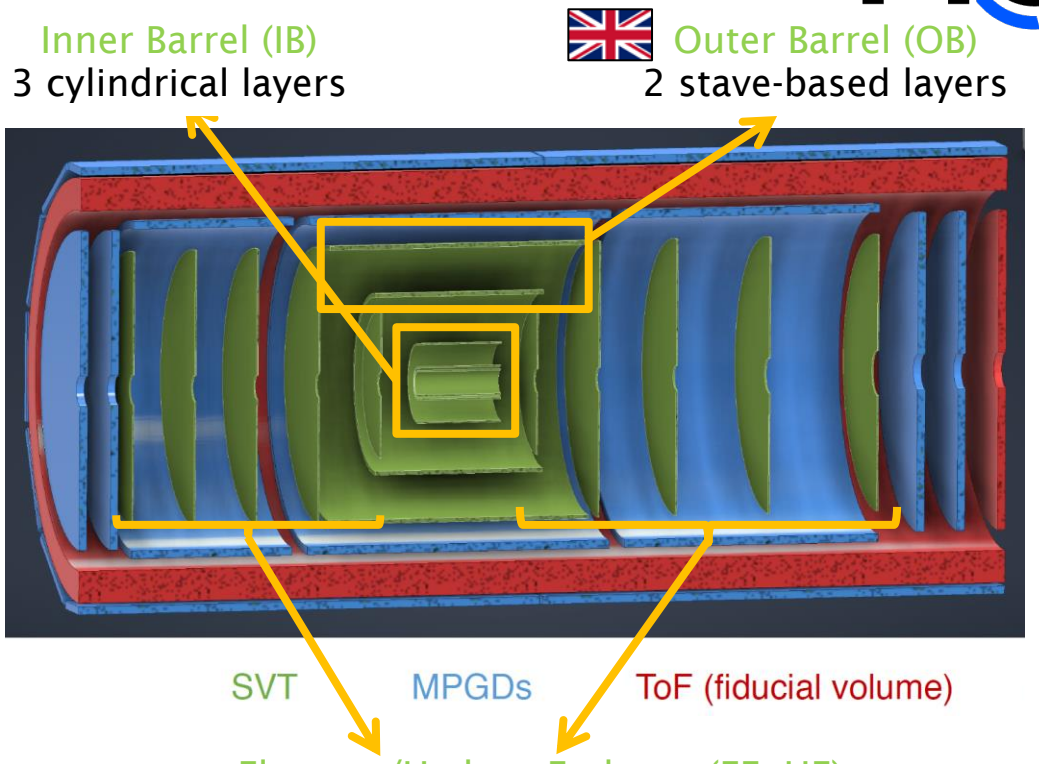
EIC will use same concept for the inner barrel:

- Wafer-scale, stitched sensors, thinned and bent around the beam pipe

EIC specific development needed for the outer barrel layers and disks:

- Large area stitched sensor (but not wafer scale) mounted on a low-mass support

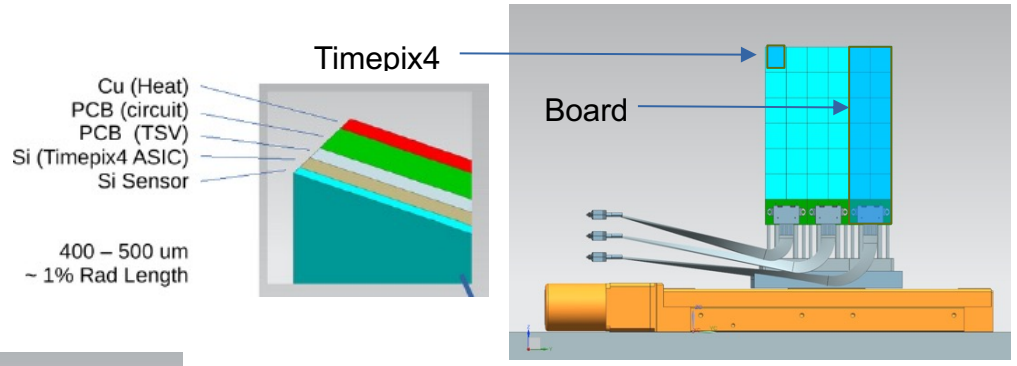
UK contributions: sensor design, serial powering scheme, ancillary ASIC for power distribution, flexible printed circuit design, stave mechanical support structure for the outer barrel layers

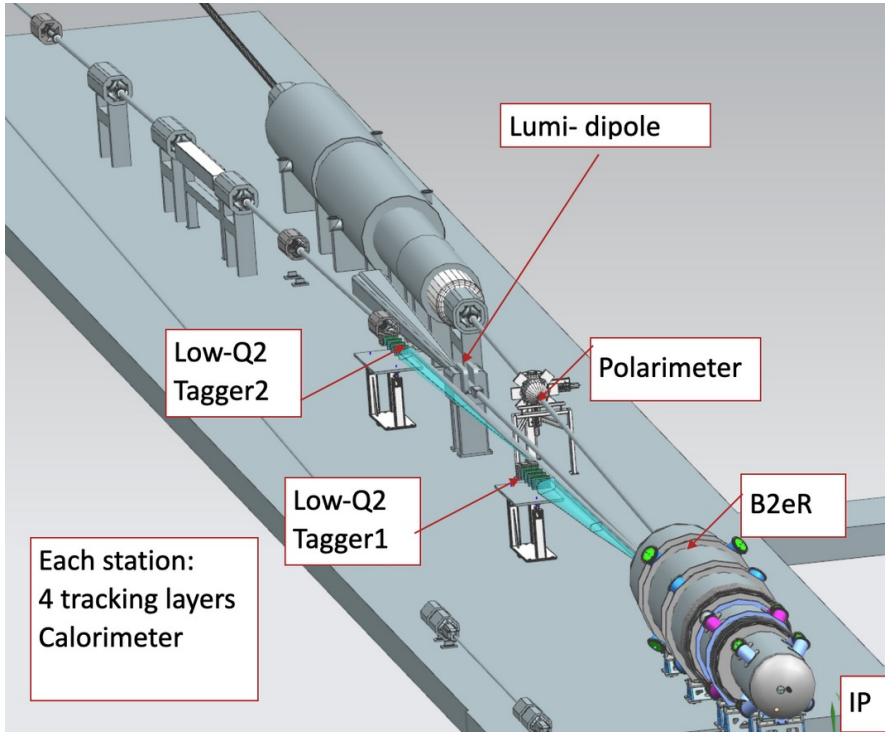


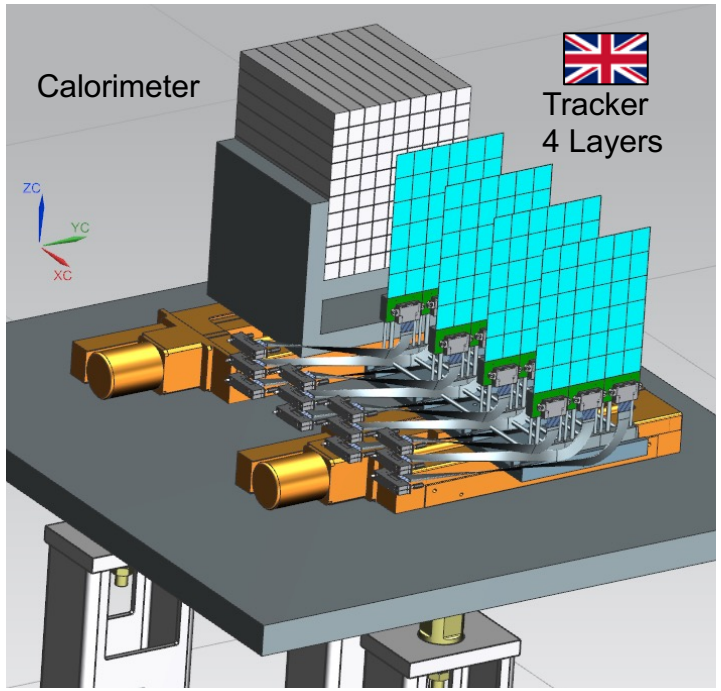
ePIC SVT target specifications	
Spatial resolution	~ 5 μm
Power	< 40 mW/cm^2
Frame rate	≤ 2 μs
Material budget (per layer)	IB: 0.05% X/X_0 OB: 0.25, 0.55% X/X_0 EE/HE: 0.25% X/X_0

WP2 – Electron Tagger

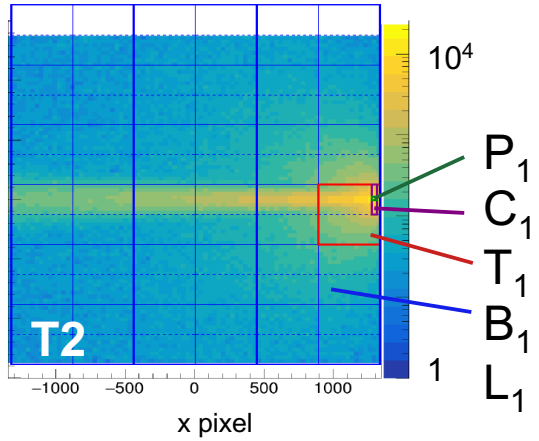
- Tagger design with Timepix4 tracker







Rates dominated by Bremsstrahlung



Maximum rates

Pixel (P1)	70 kHz	
2 column (C1)	8 MHz	
Timepix4 (T1)	600 MHz	38 Gb/s
Board (B1)	1500 MHz	96 Gb/s
Layer (L1)	2500 MHz	160 Gb/s

Total integrated rates

Tagger 1	2 GHz	130 Gb/s
Tagger 2	7 GHz	480 Gb/s
Total	9 GHz	600 Gb/s

WP3 – Luminosity Monitor

- Physics requirements

  Determination of the absolute luminosity to 1% level

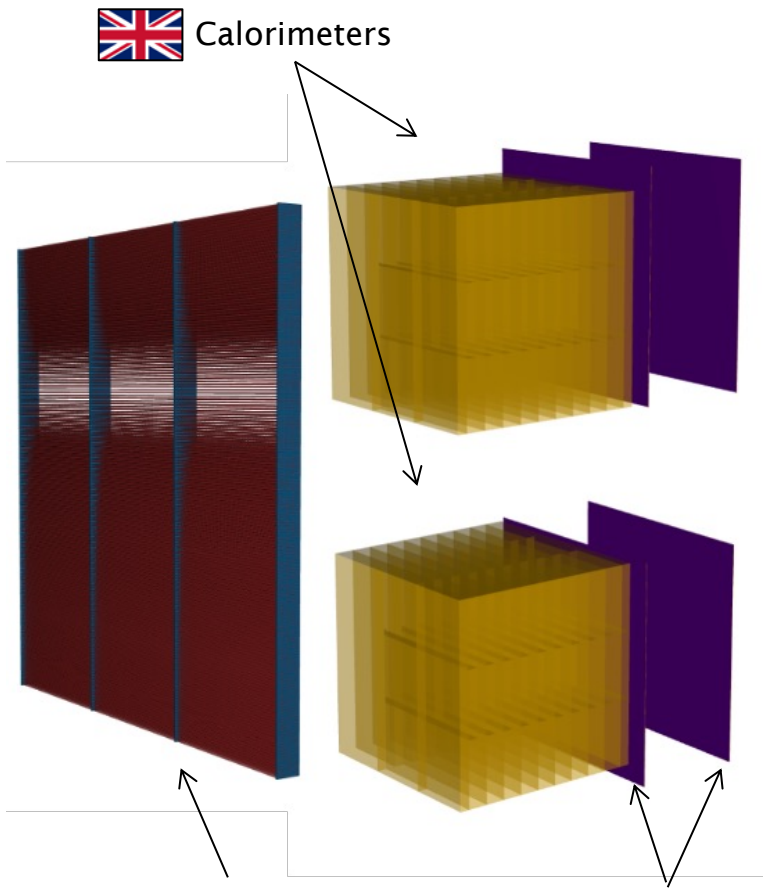
  Determination of the relative luminosity to 10^{-4} level

  Rates 10^3 higher than previous facilities

  Complementarity and redundancy (direct photon detector and pair spectrometer are sensitive to different systematics)

  AI/ML-driven design and analysis to achieve the required shower separation, dynamic range and noise rejection

Pair spectrometer



- Technology choice

  W-powder and epoxy infused with a bundle of scintillating fibers

  Meets all requirements

  Dimensions 18 x 18 x 18 cm^3

  Radiation length ~ 8 mm

  20 layers → 23 X_0

  Scintillating Fibre 0.5 mm diameter (Kuraray or Luxium – samples for tests)

  W-SciFi ratio = 4:1

  Density 10.95 g/cm^3

WP4 – Accelerator

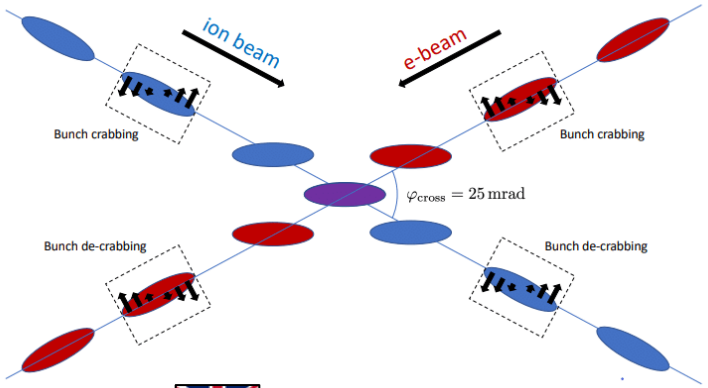
- Superconducting radiofrequency systems

  Builds on experience from HL-LHC, ESS and PIP-II

  Original scope: cavity design and cryomodules for the ERL associated with the hadron beam electron cooler

  New scope (under discussion with the US): cavity design and cryomodules for the beam crabbing system

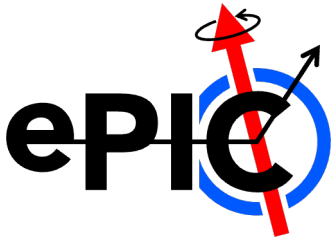
  In collaboration with BNL, JLab and TRIUMF



Crab cavities

HL-LHC cryomodule
at Daresbury Laboratory

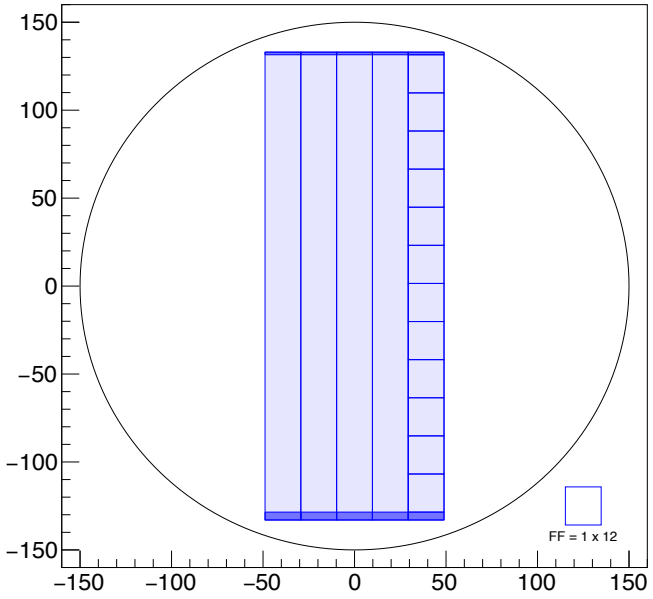
Summary



- EIC Generic Detector R&D Programme was key to early engagement in the project
- Community building through UK national meetings
- Engagement with UKRI infrastructure strategy to establish the EIC project in the UK
- Large-scale funding opportunity through the UKRI Infrastructure Fund
- UK leadership in the international project was key to successful funding bid
- And the breadth of community interest to justify the level of investment

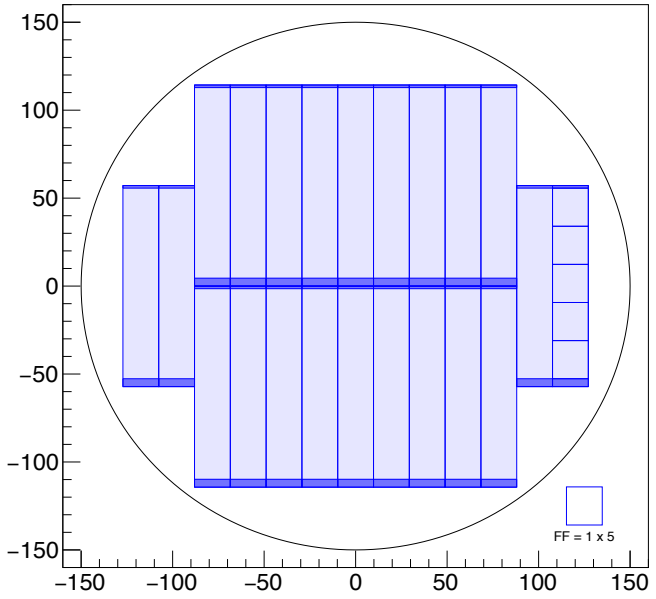
Backup – WP1 – Silicon Tracker – Outer Barrel Layers

ITS3 – Wafer Scale Sensor



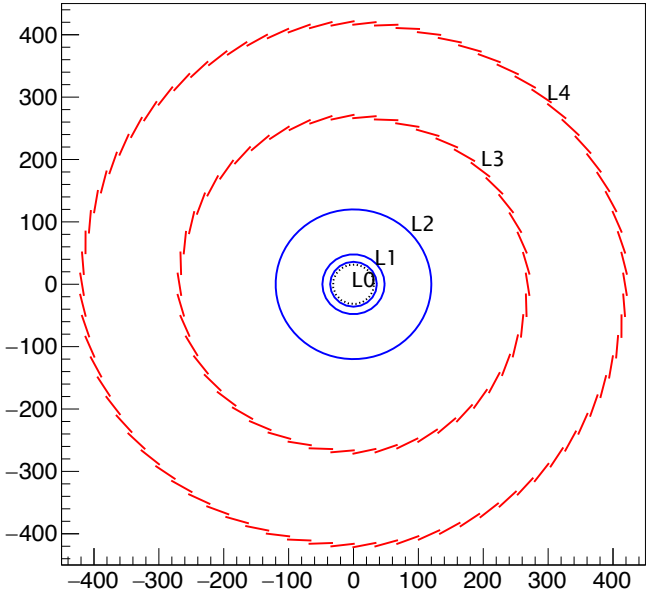
Total 60 RSUs

EIC – Large Area Sensor



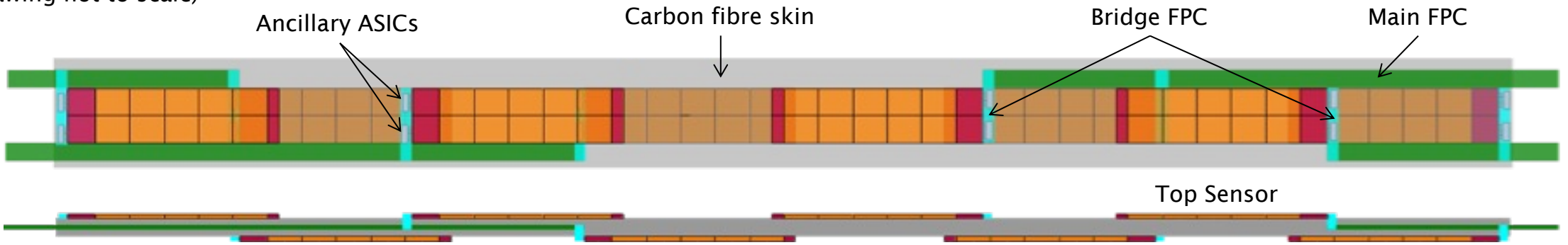
Total 110 RSUs

Outer Barrel Stave Layout



L4 Stave Conceptual Design (length approx. 840 mm)

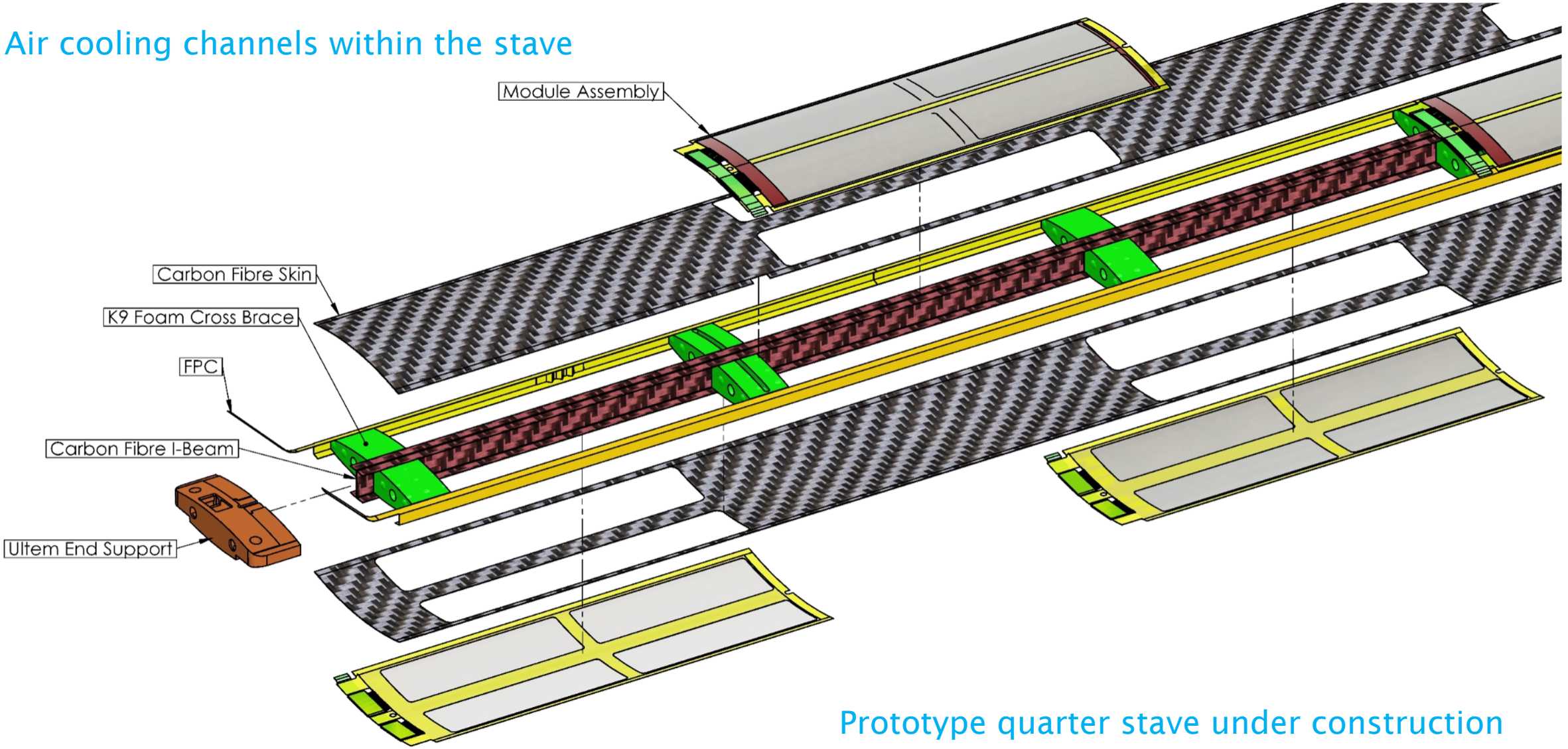
(drawing not to scale)



Backup – WP1 – Silicon Tracker – Outer Barrel Layers

- Stave Structure

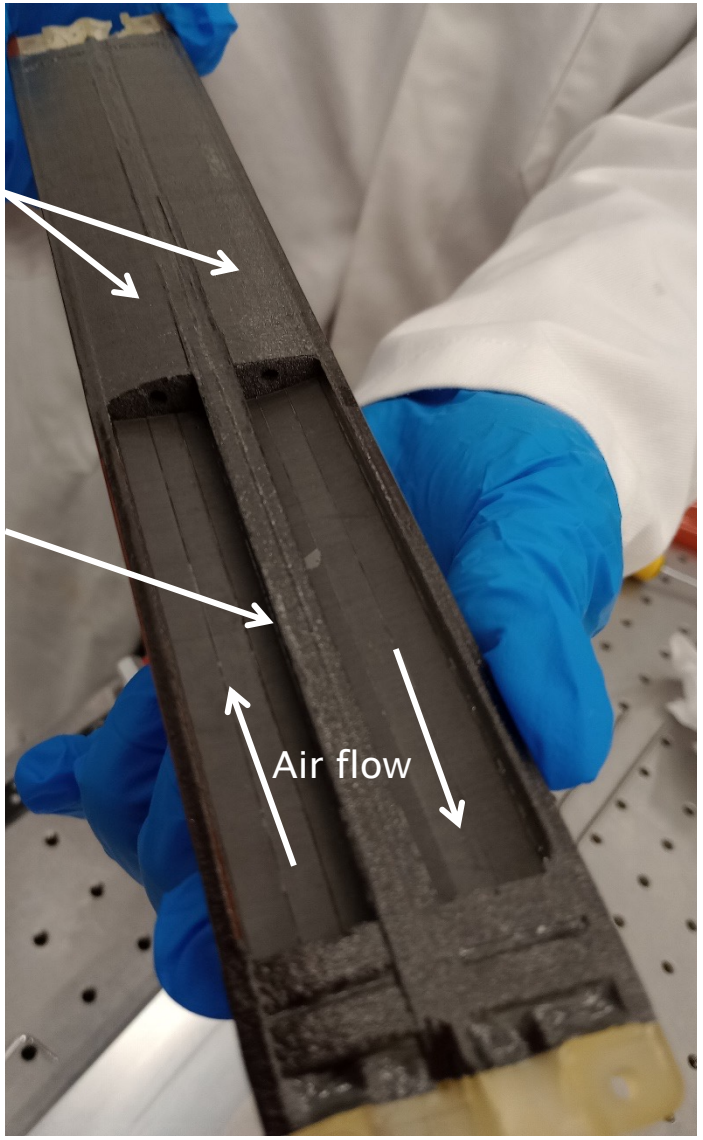
Air cooling channels within the stave

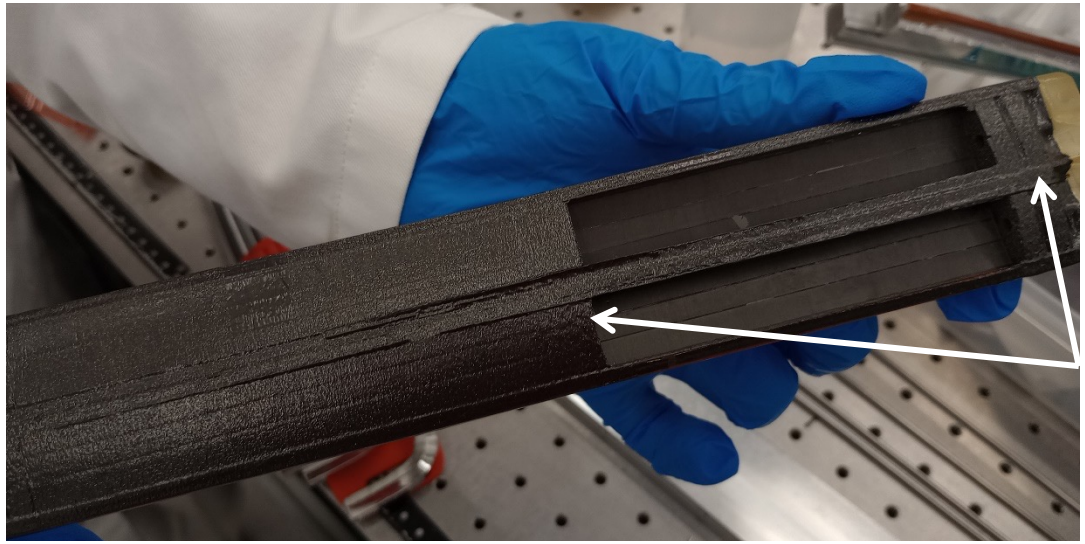


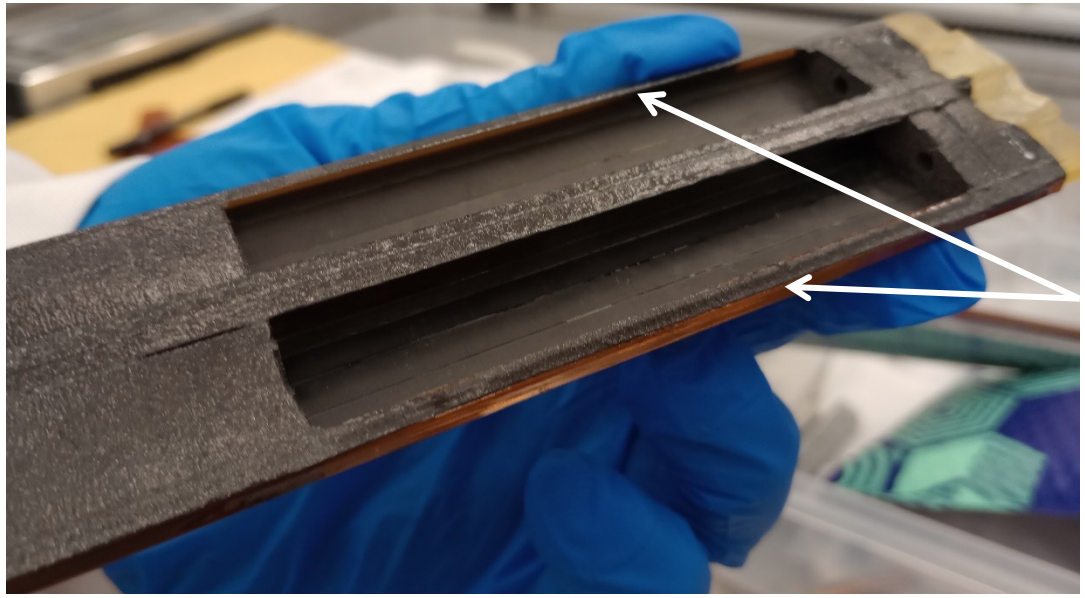
Prototype quarter stave under construction

Backup – WP1 – Silicon Tracker – Outer Barrel Layers

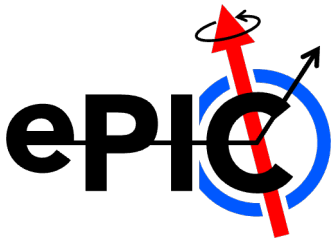
- Quarter-Stave Mechanical Prototype







Backup – EIC-UK Detector and Accelerator Deliverables



- WP1 – Silicon Tracker: Precision tracking and vertexing in the central detector
  Deliverable: the two outer barrel layers of the central silicon tracker (~37% of total active area)
  Institutes: Birmingham, Brunel, Liverpool, Oxford, Rutherford Appleton Laboratory, Daresbury Laboratory

- WP2 – Electron Tagger: Precision tracking of low-Q^2 scattered electrons
  Deliverables: the two tracking stations needed in the far backward region
  Institutes: Glasgow and Lancaster

- WP3 – Luminosity Monitor: Precision bunch-by-bunch measurement of collision luminosity
  Deliverables: the calorimeters needed for the pair spectrometer & low-luminosity direct photon detector
  Institutes: York

- WP4 – Accelerator: Crab cavity design and cryomodule fabrication
  Deliverables: Crab cavities design and cryomodules for the 396 MHz crab cavities (with TRIUMF)
  Institutes: Lancaster and Daresbury Laboratory