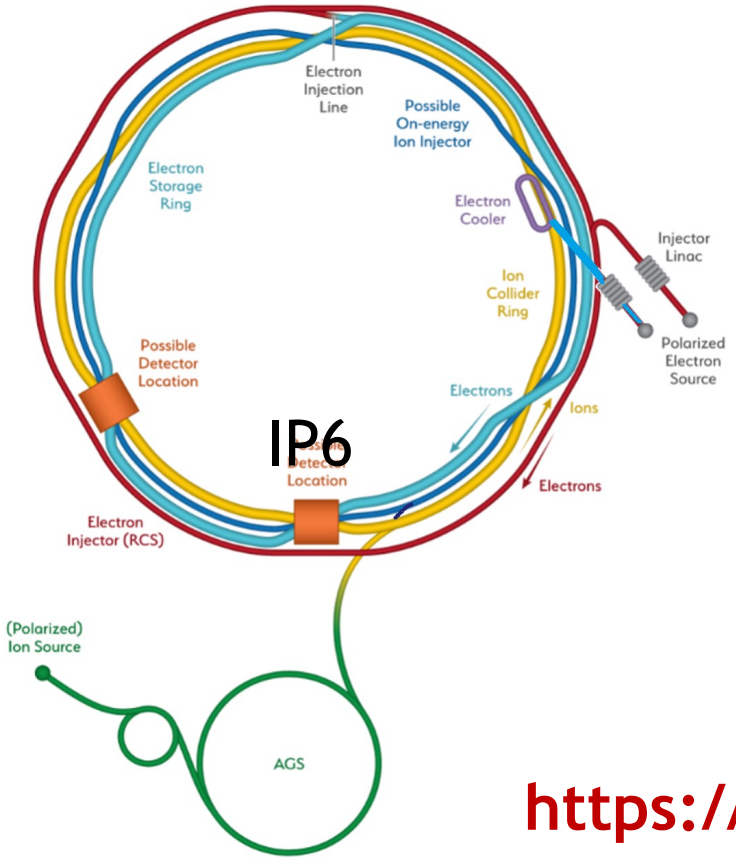
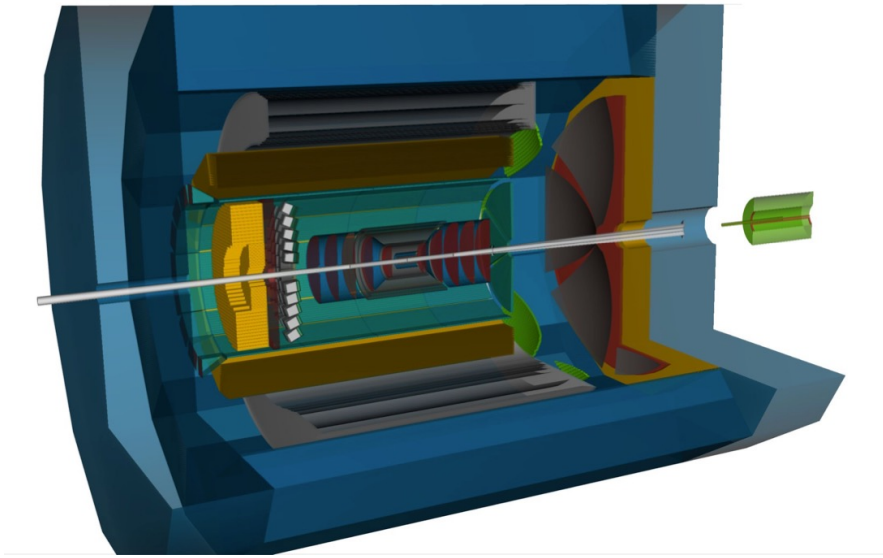
The UK Involvement in ATHENA

IPPP Workshop on
Physics Opportunities at the Electron-Ion Collider

Paul Newman (Birmingham)

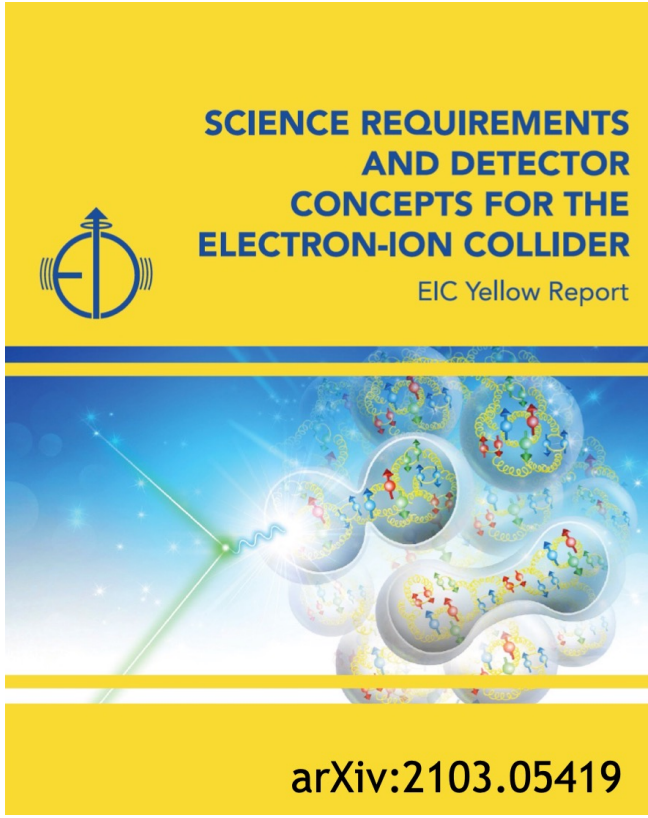


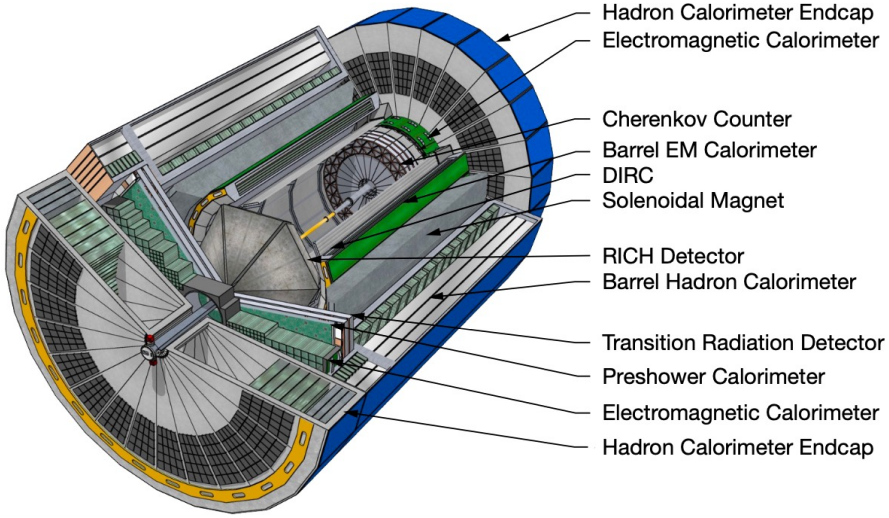


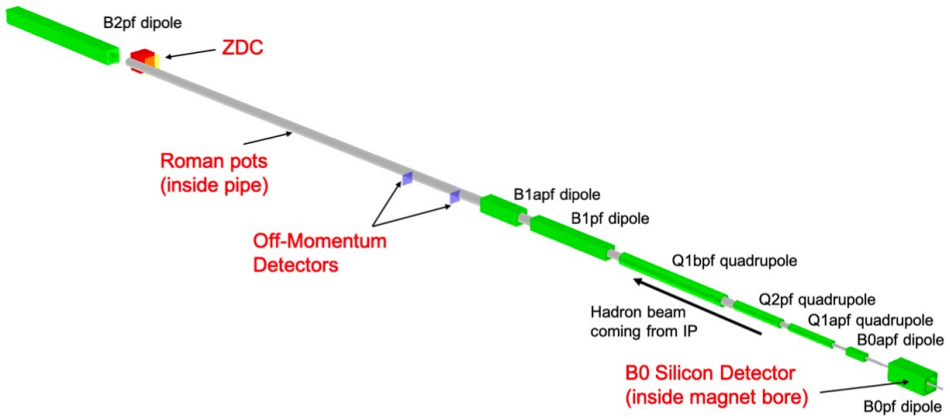
https://sites.temple.edu/eicatip6

Yellow Report Exercise Completed (User Group)

- Over 900 pages!
- Sceince motivation
- Detailed ‘reference’ detector
- Some discussion of case for two detectors
- 3 UK conveners







Experimental Programme Preparation

One “project detector” is funded through the DoE project

BNL and TJNAF Jointly Leading Process to Select Project Detector		
2020	Call for Expressions of Interest (EOI) https://www.bnl.gov/eic/EOI.php	May 2020
	EOI Responses Submitted	November 2020
	Assessment of EOI Responses	On-going
2021	Call for Collaboration Proposals for Detectors https://www.bnl.gov/eic/CFC.php	March 2021
	BNL/TJNAF Proposal Evaluation Committee	Spring 2021
	Collaboration Proposals for Detectors Submitted	December 2021
✓	Decision on Project Detector	March 2022

Very compressed timescale!

ATHENA Proposal

- Aims to be the project detector at IP6
  - → General purpose detector covering all of EIC physics prgramme
  - → Ready from day 1
  - → Located at current STAR location. Largest experimental hall
  - → Based on a 3T solenoid with large bore diameter (1.6m)
  - → Lower field strengths are also possible
  - → Beam crossing angle of 25 mrad

- **A solenoid offering a 3 T field in order to better exploit the EIC potentialities**

Layer	Length	Radial position
Layer 1	420 mm	36.4 mm
Layer 2	420 mm	44.5 mm
Layer 3	420 mm	52.6 mm
Layer 4	840 mm	133.8 mm
Layer 5	840 mm	180.0 mm
TPC start	2110 mm	200.0 mm
TPC end	2110 mm	780.0 mm

(a) Barrel region

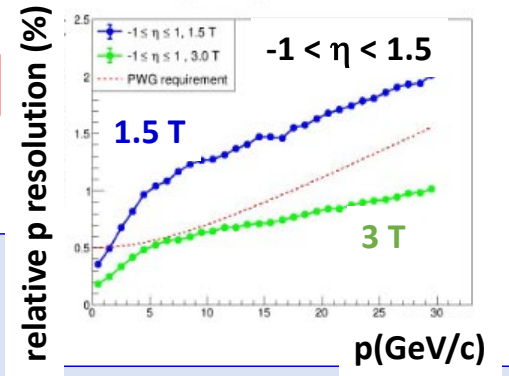
Disk	z position	Inner radius	Outer radius
Disk 1	220 mm	36.4 mm	71.3 mm
Disk 2	430 mm	36.4 mm	139.4 mm
Disk 3	586 mm	36.4 mm	190.0 mm
Disk 4	742 mm	49.9 mm	190.0 mm
Disk 5	898 mm	66.7 mm	190.0 mm
Disk 6	1054 mm	83.5 mm	190.0 mm
Disk 7	1210 mm	99.3 mm	190.0 mm

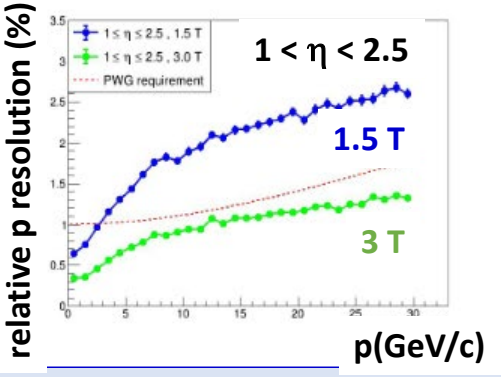
(b) Disk region

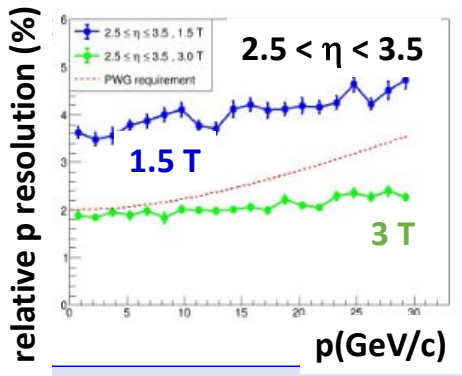
10μm pixel pitch

$x/X_0 = 0.05\%$ per vertexing layer (1 – 3)
$x/X_0 = 0.55\%$ per tracking layer (4 and 5)
$x/X_0 = 0.24\%$ per disk (1 – 7)

Simulations by H. Wennlöf, Birmingham



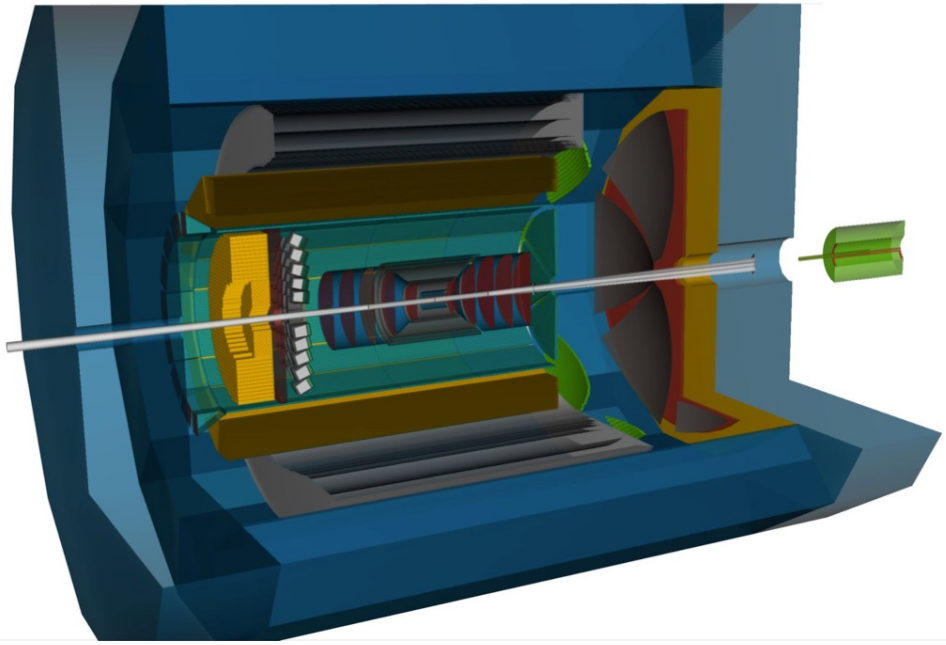




Steps towards Proposal

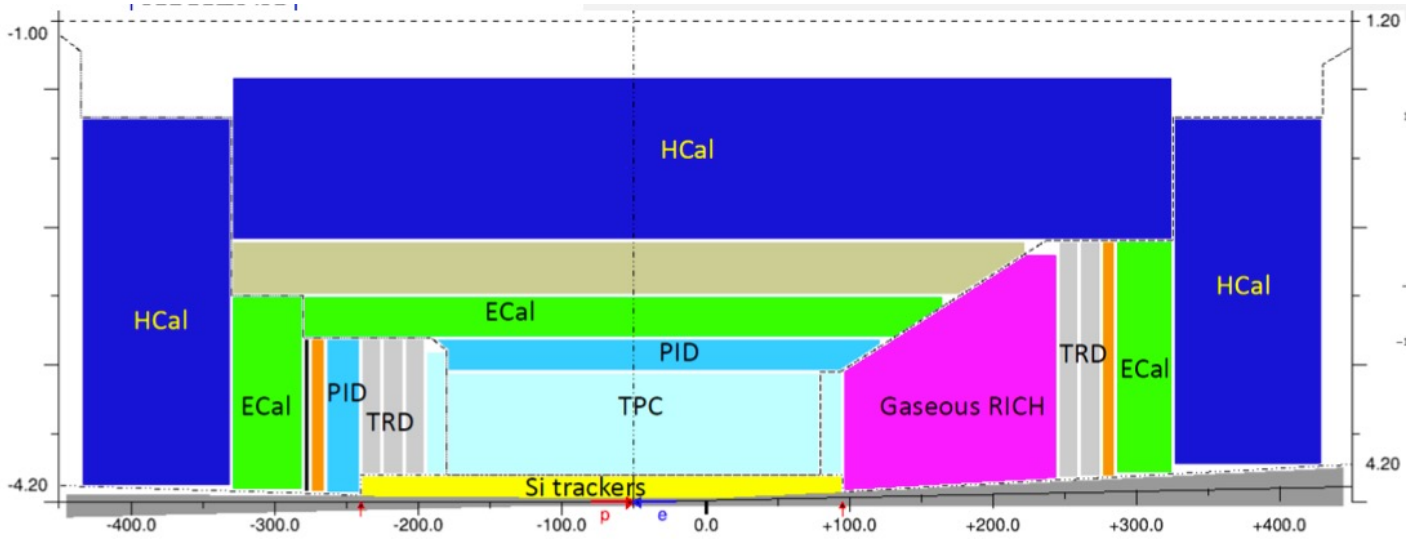
- Conceive and design detector sub-components
- Optimise performance of sub-components
- Integrate sub-components into overall design
- Simulate detector response (DD4HEP)
- Write basic reconstruction tools
- Evaluate physics performance
- Evaluate cost

… and (at least in principle) iterate …

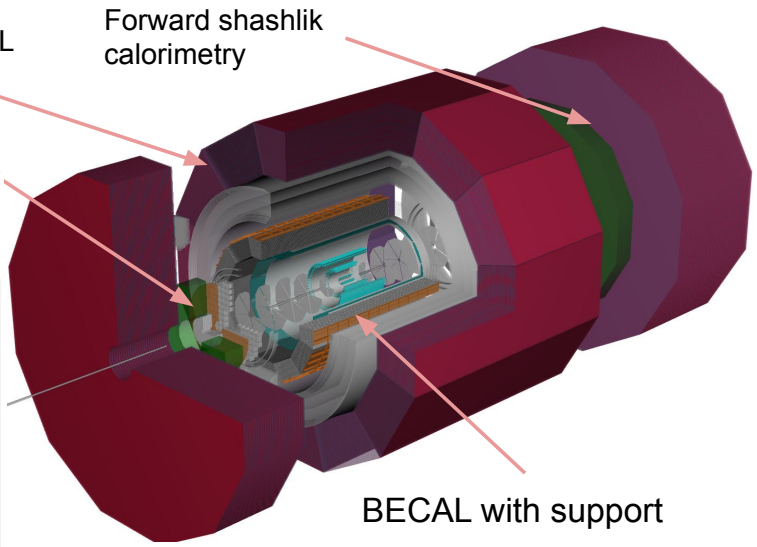


Overview

(follows yellow report)



Calorimetery



central detector, backward

- **ECAL: hybrid, PWO insert and Glass outer ring, EEEMCAL effort**
- **HCAL: Fe/SC, ongoing detector optimization**

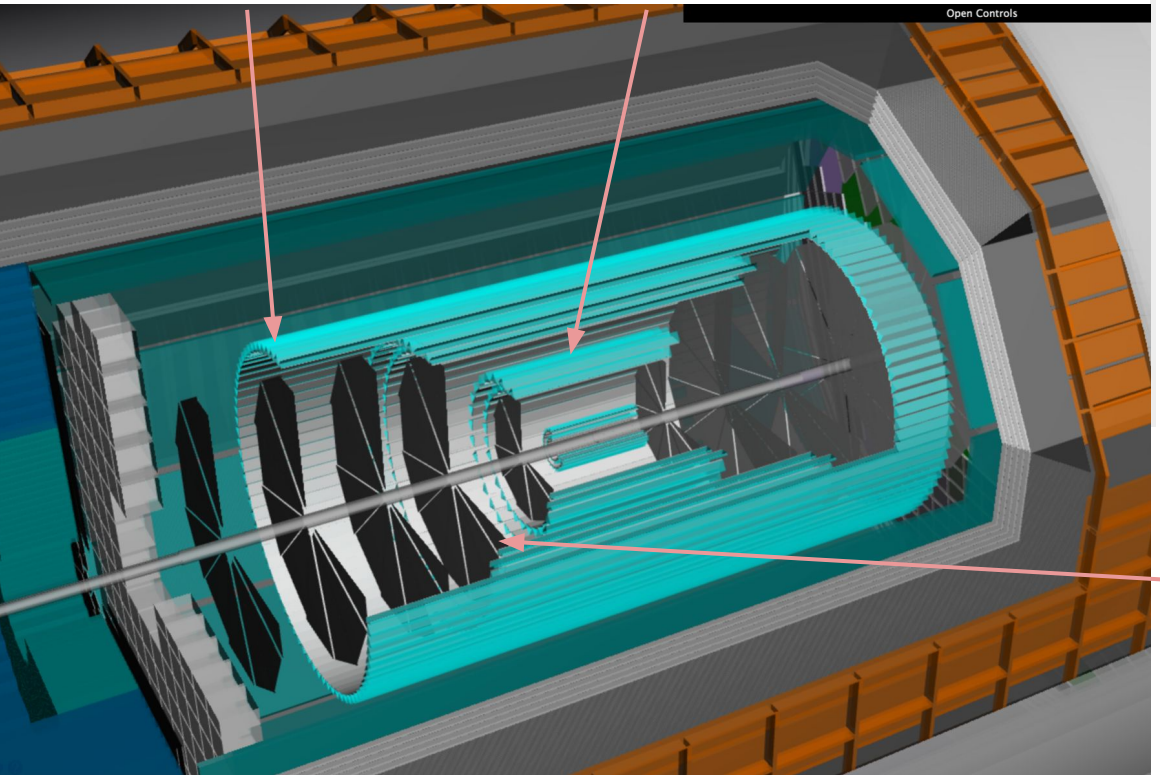
central detector, forward

- **ECAL: W-powder/SciFi**
- **HCAL: Fe/SC, ongoing detector optimization (including total depth, layer thickness and granularity)**

Tracking

Outer LGAD layer not part of the “0-0-0” setup

Barrel staves as in ITS2 TDR



All silicon (MAPS-based) and hybrid silicon / MPGDs have both been evaluated (see Laura’s talk)

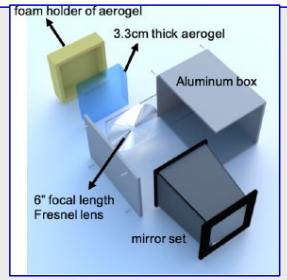
Disks are wedges with sensitive layer and average material backing. Needs better constraints from WG

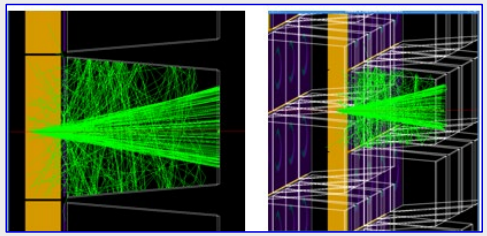
Tracking delegate: Matt Posik
S&C WG contact: Sylvester Joosten

ATHENA PID

The YR PID baseline is still the ATHENA baseline

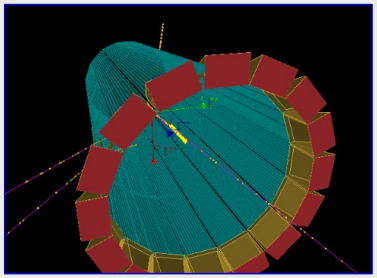
- **Backward: mRICH**





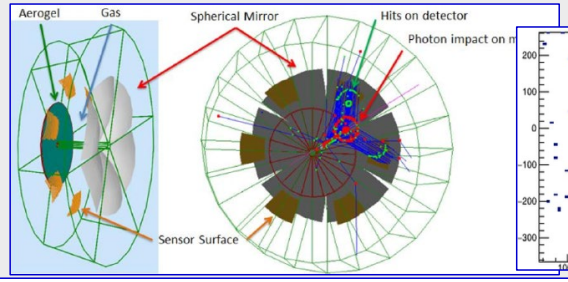
Electron Arm Technology	Range (GeV/c) e - π	π - K
dRICH (aerogel)	0.0025 - 5	2.46 - 16
dRICH (gas)	0.0127 - 18	12.34 - 60
dRICH (overall)	0.0025 - 18	2.46 - 60
HBD	0.0150 - 4.17	-
mRICH	0.0025 - 2	2.00 - 6
TOF (LAPPD 4m, 5ps)	0 - 3	0.00 - 16
TOF (LAPPD 3m, 10ps)	0 - 1.8	0.00 - 10
TRD	1.0 – 270.0	–

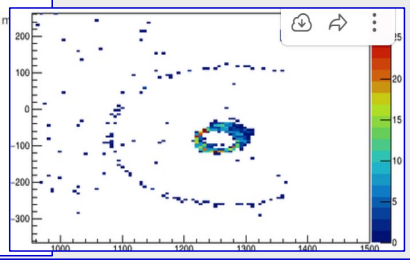
- **Barrel: DIRC**
  - **Important to underline: no longer support from a TPC**



Central Arm Technology	Range (GeV/c) e - π	π - K
$\frac{dE}{dx}$	0 - 2	0 - 3
$\frac{dE}{dx}$ (Cluster Count)	0 - 10	0 - 15
DIRC	0.00048 - 1	0.47 - 6
TOF (LGAD)	0 - 1	0.00 - 5
HBD	0.0150 - 4.17	N/A

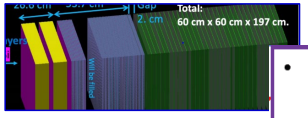
- **dRICH**



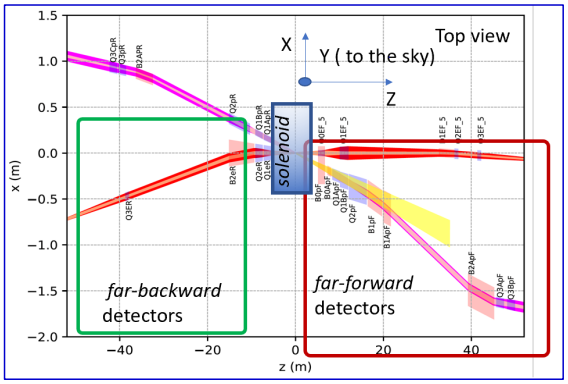


Hadron Arm Technology	Range (GeV/c) e - π	π - K
CsI RICH	0.0150 - 20	14.75 - 50
dRICH (aerogel)	0.0025 - 5	2.46 - 16
dRICH (gas)	0.0127 - 18	12.34 - 60
dRICH (overall)	0.0025 - 18	2.46 - 60
TOF (LGAD)	0 - 1	0.00 - 5
TOF (LAPPD 4m 5ps)	0 - 2.5	0.00 - 16
TRD	1.0 – 270.0	–

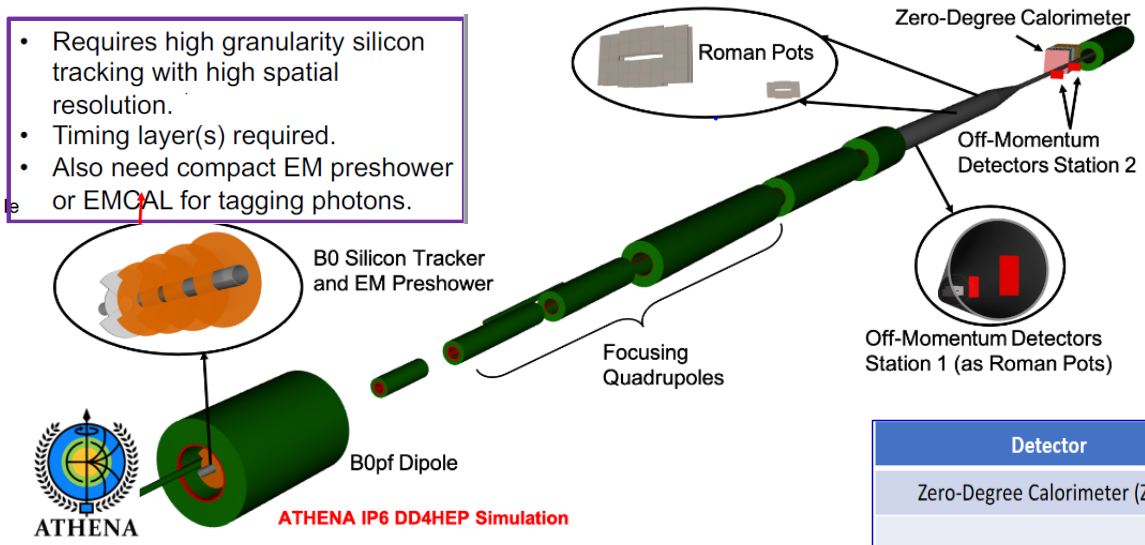
ATHENA far forward detectors



- Combination EMCAL and HCAL with high granularity and resolution.
- Design starting point is ALICE FoCal.



- Requires high granularity silicon tracking with high spatial resolution.
- Timing layer(s) required.
- Also need compact EM preshower or EMCAL for tagging photons.

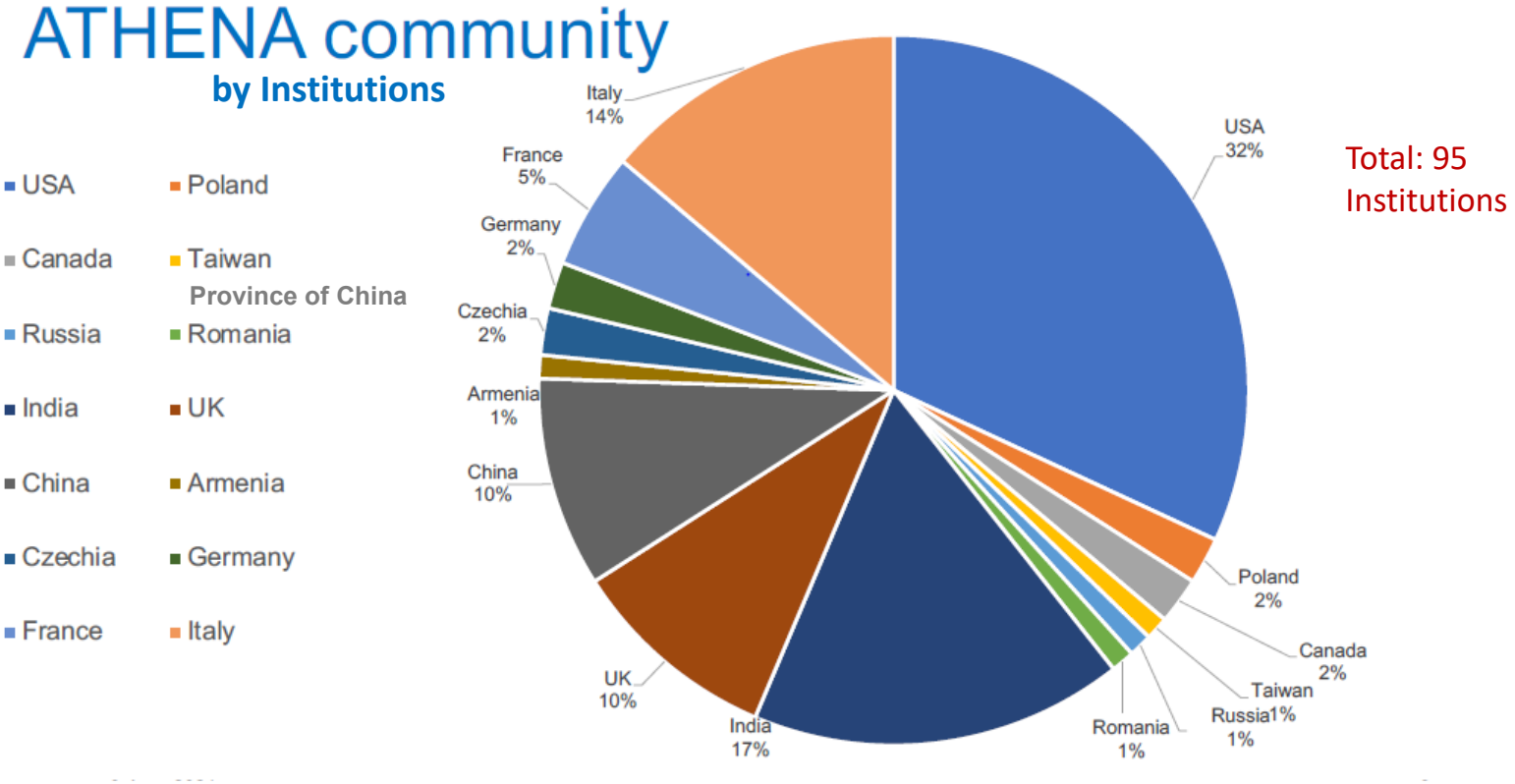


- Both can rely on use of AC-LGAD technology for fast (~20-30ps) timing and good spatial resolution.
- Roman Pots require special care since we plan to go with "potless" design to maximize acceptance.

Detector	Acceptance	Notes
Zero-Degree Calorimeter (ZDC)	$\theta < 5.5$ mrad ($\eta > 6$)	About 4.0 mrad at $\varphi \sim \pi$
Roman Pots (2 stations)	0.0* $< \theta <$ 5.0 mrad ($\eta > 6$)	$0.65 < \frac{p_{z,nucleon}}{p_{z,beam}} < 1.0$ *10σ cut
Off-Momentum Detectors (OMD)	$0.0 < \theta <$ 5.0 mrad ($\eta > 6$)	Roughly $0.3 < \frac{p_{z,nucleon}}{p_{z,beam}} < 0.6$
B0 Sensors (4 layers, evenly spaced)	$5.5 < \theta <$ 20.0 mrad ($4.6 < \eta < 5.9$)	Also looking at photon tagging via EMCAL/preshower.

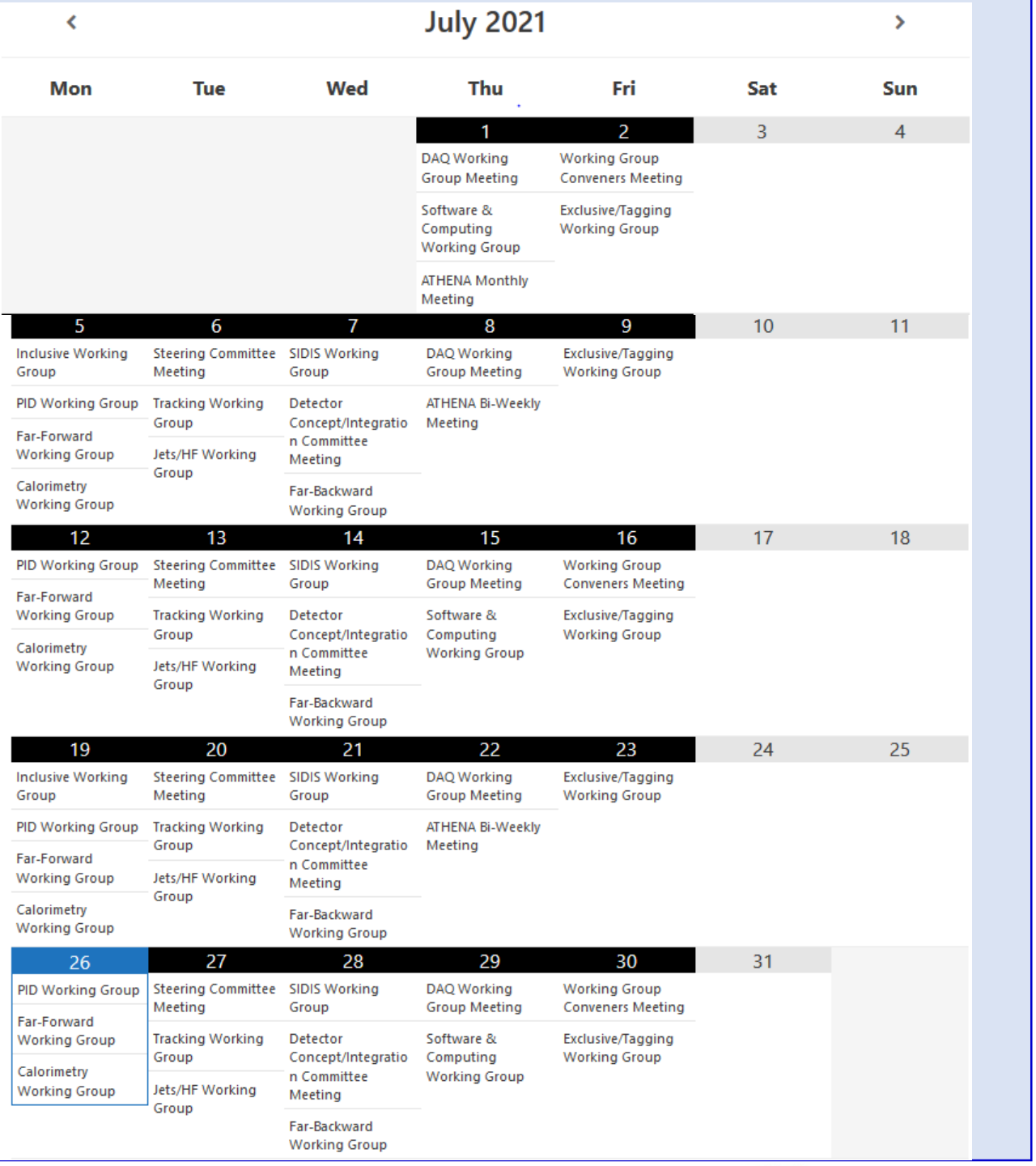
… groups also working on far backward detectors / luminosirty moitooring, polarimetery, (triggerless) DAQ …

ATHENA community



Total: 95 Institutions

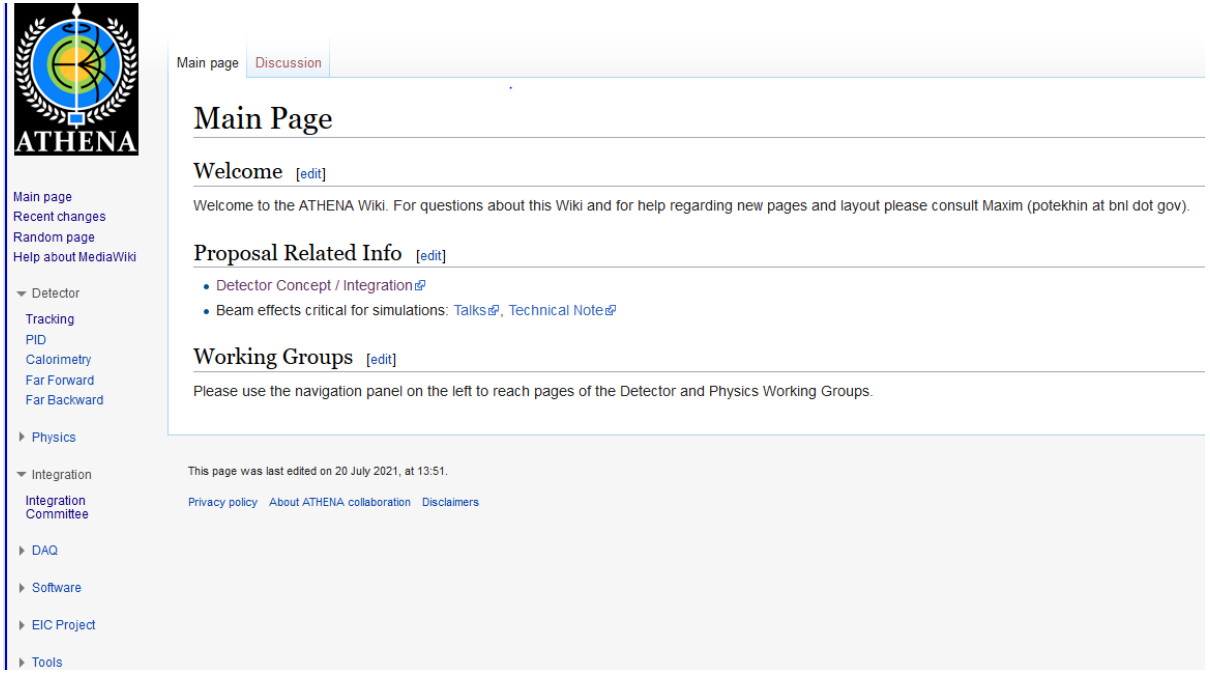
UK is approximately 10% of ATHENA by institutions



Demanding Meeting Schedule!

Ingredients of a Full-scale Experimental Collaboration

Twiki ☺



- The collaboration already has a charter
- It has elected a Collaboration Board Chair (Ernst Sichtermann)
- Spokesperson / Deputy election ongoing …

  → **Note UK interest: Ken Barish + Daria Sokhan**

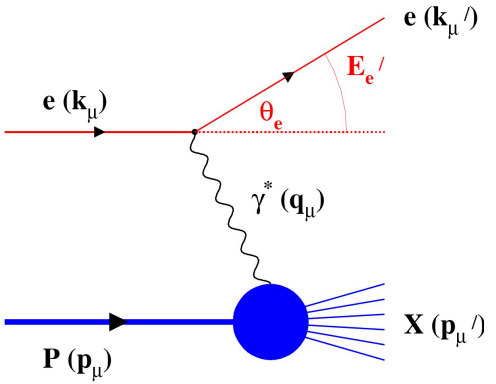
UK Leadership in Physics WGs

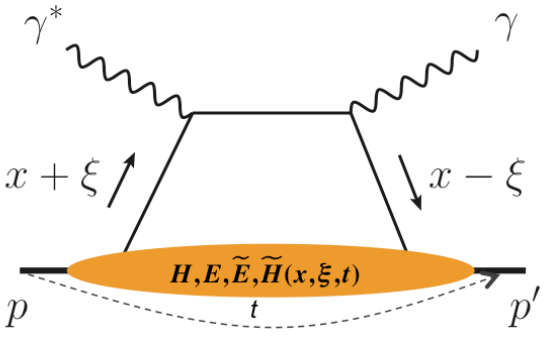
Software & Computing Working Group

CONVENERS: Sylvester Joosten, Dmitry Romanov, Whitney Armstrong, Andrea Bressan, Wouter Deconinck

PHYSICS VALIDATION WGs

- **Inclusive Working Group**
  CONVENERS: Barak Schmookler, Qinghua Xu, Paul Newman
- **Semi-Inclusive Working Group**
  CONVENERS: Marco Radici, Anselm Vossen
- **Jets/HF/EW-BSM Working Group**
  CONVENERS: Ernst Sichtermann, Stephen Sekula, Brian Page, Miguel Arratia
- **Exclusive/Tagging Working Group**
  CONVENERS: Salvatore Fazio, Spencer Klein, Daria Sokhan



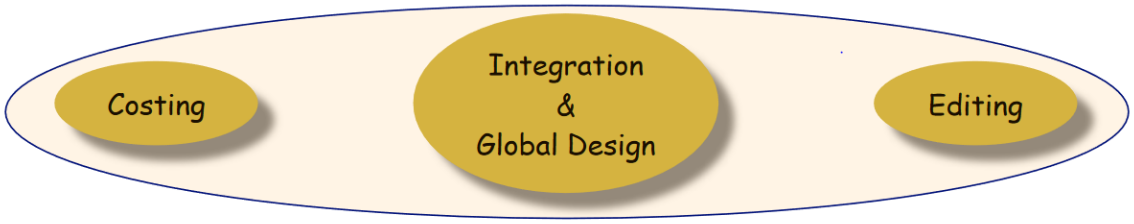


UK Leadership in Detector WGs

- **Tracking Working Group**
  CONVENERS: Laura Gonella, Domenico Elia, Francesco Bossu, Matt Posik
- **PID Working Group**
  CONVENERS: Tom Hemmick, Roberto Preghenella, Franck Guerts
- **Calorimetry Working Group**
  CONVENERS: Oleg Tsai, Paul Reimer, Vladimir Berdnikov
- **Far Forward Working Group**
  CONVENERS: Alexander Jentsch, John Arrington
- **Far-Backward Working Group**
  CONVENERS: Krzyzstof Piotrzkowski, Jaroslaw Adam
- **Polarimetry Working Group**
  CONVENERS: Ciprian Gal, Oleg Eyser
- **DAQ Working Group**
  CONVENERS: Alexandre Camsonne, Jeffery Landgraf

UK Leadership in Proposal Drafting Coimmitte

- Goal: Committee is tasked with coordinating three core proposal elements of the EIC@IP6 proposal effort concerning costing, integration/global design, and editing.



- The proposal committee provides the needed connection between WG's.

- Costing: Bernd Surrow, Olga Evdokimov, Zhangbu Xu, and Yulia Furletova
- Integration / Global Design: Bedanga Mohanty, Franck Sabatie, Alexander Kiselev, Thomas Ullrich, and Silvia Dalla Torre
- Editing: Abhay Deshpande, Barbara Jacak, Zein-Eddine Meziani, and Peter Jones

Ex-officio / Official EIC project contact: Elke Aschenauer

Comments

- EIC overall is a very fast-moving project

- Hard to judge how proposal evaluation will work out, but ATHENA is behaving like it will be around for the long-term (maybe in some future merged format?)

- The UK has developed a strong position and has leadership positions throughout the collaboration's profile (though not yet a senior leadership position)

- The UK also has its first funding (Peter's talk)

- Significant opportunities to engage further as the detector concept and science programme develops