

EPAC ~~Industrial~~ Non-academic Engagements

Rajeev Pattathil



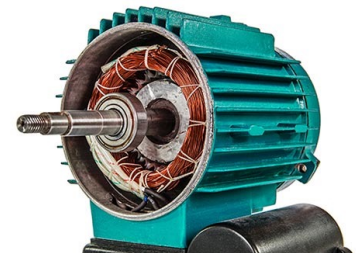
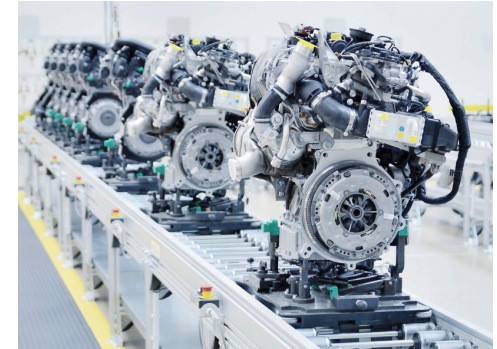


EPAC's key strengths for applications are like to be..

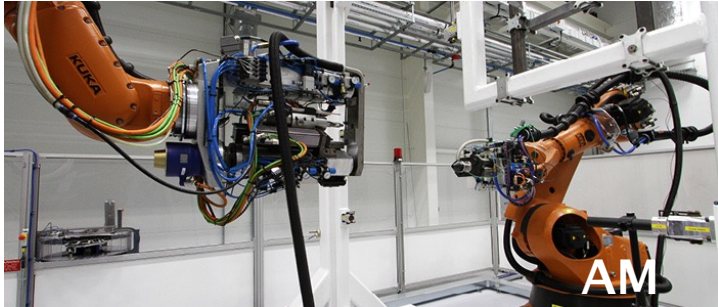
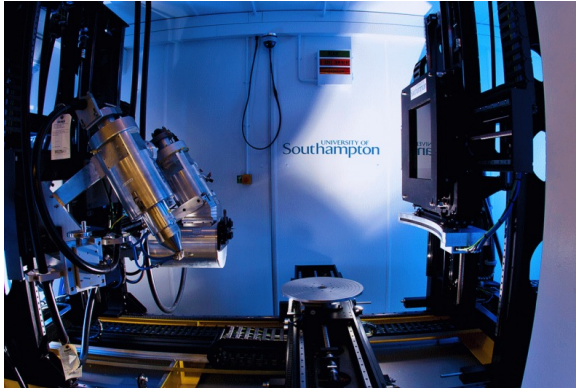
Key Target Techniques

High resolution x-ray radiography & CT imaging

- Specialising in **non-destructive large object analysis and inspection**
- **Fast throughput** CT tomography (screening, QC inspection and cataloguing services)
- **Dynamic** x-ray imaging (in-situ analysis e.g. pumps, turbines, batteries, hydrogen fuel cells)
- **Advanced x-ray analysis techniques** (XAS, XANES...)
- **Multimodal imaging**



To facilitate this, EPAC aims to have



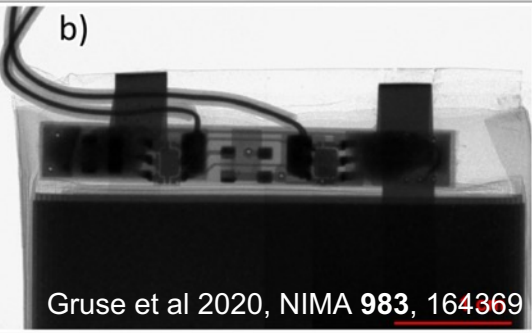
- Sample environments that can withstand large and heavy objects (100kg+ capability)
- Automated sample handling and manipulation systems
- Synchronised high-resolution detectors for dynamic studies
- Imaging as a service
- High throughput of smaller scale samples
- Experience of fast data analysis and compiling
- GUIs for data manipulation
- Relationship managers and experienced support
- Links to wider UK CT community consortia e.g. dXCT, NXCT

Some of these are not for Day 1

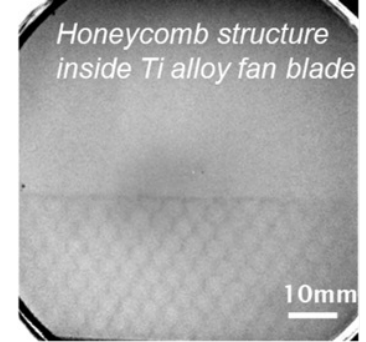
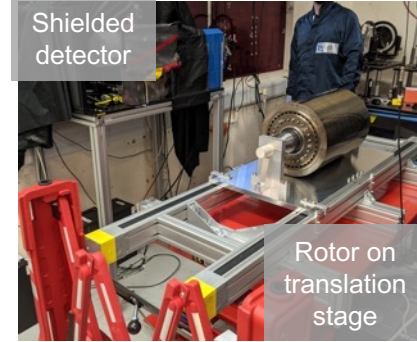
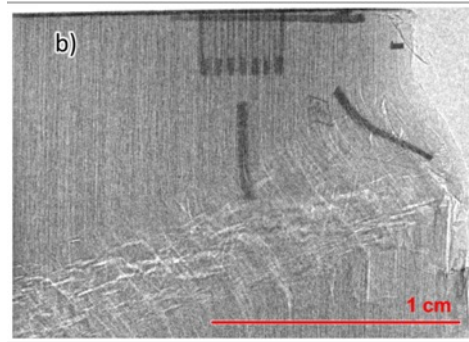


Some key links with industries already exist

X-ray sources in EPAC can enable sub-micron resolution imaging for non-destructive testing
Capability to distinguish small changes in material densities – phase contrast imaging
Material-specific imaging using multi-modal capability (x-rays, protons, neutrons)



Gruse et al 2020, NIMA **983**, 164369



CT for quality control
Phase contrast for graphite electrodes
XAS for product development

Fast, in-process scanning
Better contrast between features
Scaling up to large objects

Radiography to understand fatigue and stress in aerospace and automotive components

Fatigue and stress testing
Brenner 2016, PPCF 58:014039





Access to expert communities is critical

CLF has an extensive network of strategic partners across many disciplines and sectors

- Defence (Dstl, MoD)
- Engineering (Rolls Royce, Edwards)
- Biomedical (NHS, AstraZeneca)
- Nuclear industry (AWE, Sellafield)
- Chemical and pharmaceutical sector (Syngenta, UCB Pharma, Johnson Matthey)
- Manufacturing (MTC, WMG)

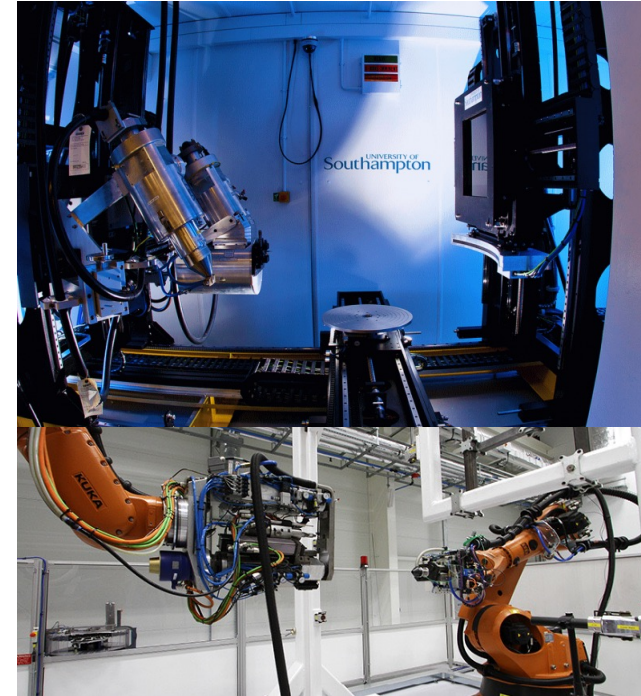
A well-established academic user community across numerous universities





EPAC's industrial (non-academic) engagement plan

- Four major themes
 - **Establishing Access Processes**
Creating a policy for access mechanisms, portal, funding routes, data management
 - **Industry Demonstrators**
Demonstrate the potential of EPAC technology, generate case studies
 - **Industry Engagement**
Increasing interest and potential users of EPAC to generate industry pipeline, engagement materials, workshops etc
 - **Medium-Long term R&D**
Lending expertise, joint studentships, joint funding proposals etc. to address key challenges



CLF's Industrial Partnership and Innovations Group will develop and deliver this plan



Progress affected by recruitment delays

The new IPI group leader has just been offered; likely to join in September

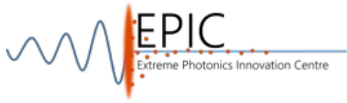
Recruited one application scientist (Band D) a few months ago

Recruitment of a senior (Band E) scientist on hold

Now have a dedicated scientist for DSTL collaborations



Focused on a few key things in the interim



Archit Bhardwaj

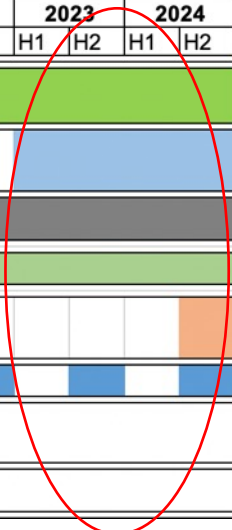
New EPAC application scientist. PhD from TIFR before joining the EPIC Detectors project.





EPAC's industrial engagement strategy

Task	2021		2022		2023		2024		2025		2026		2027		2028		2029					
	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2				
Engagement with key partners to identify quick winners	Green bar																					
Engagement with different sectors of industry to explore requirements and techniques					Blue bar																	
Joint R&D with industrial and strategic partners					Grey bar																	
Optimising EPAC design for applications			Green bar																			
EPAC Industry Networking: conferences, exhibitions, trade shows and sector specific engagements									Orange bar													
Industrial demonstrators: proof of principle experiments		Blue bar		Blue bar		Blue bar		Blue bar		Blue bar		Blue bar		Blue bar		Blue bar		Blue bar				
Establishing EPAC industry network & key industry partners																Grey bar						
EPAC Industry service facility access																		Dark grey bar				



Three-fold approach in the interim period

- Engagement with key collaborators/partners
- Joint proof-of-principle experiments with key partners in Gemini/Vulcan/Other facilities
- Joint R&D with partners



Engagement with key collaborators/partners

- ~90 visits to EPAC in the last 1 year
- Several key engagements:
 - UK Health and Safety Agency, Johnson Matthey, LANL-Manchester, DSTL, AWE, Rolls Royce, UKAEA, First Light Fusion...
- Some of them are developing into new collaborations
 - Several meetings with LANL on x-ray and neutron imaging
 - AWE discussions regarding incorporating long-pulse beamline in EA1 and EA2 – additional funding under discussion
 - AWE discussions regarding x-ray CT imaging
 - Workshops with DSTL –November 23, April 24. Planning for another in Autumn
- Engagement with the wider x-ray CT community in the UK (via CCPI, UCL, Southampton...)



Hosting dXCT 2024 conference in RAL

AN INTERNATIONAL HIGH-PRECISION
METROLOGY CONFERENCE BASED IN THE
UK

DIMENSIONAL X-RAY COMPUTED TOMOGRAPHY (DXCT)

Abstract submission are open from 1st November 2023 and will close 1st March 2024, the deadline has been extended to 29th March 2024.

Registration is open from 5th May 2024

UPCOMING
CONFERENCE

24-25TH

JUNE 2024

- Broad specialist audience from all sectors of XCT metrology landscape
- CLF chosen as hosts to showcase new lightsource technology offered by EPAC





Community engagement for Data/CT solutions

CCPi/CLF workshop with WMG
in June on EPAC CT GUI

Workshop in September-2003
with key (academic) user
groups regarding data
management and analysis
solutions in EPAC, especially
for CT

Good Feedback regarding the
user-friendliness of interfaces

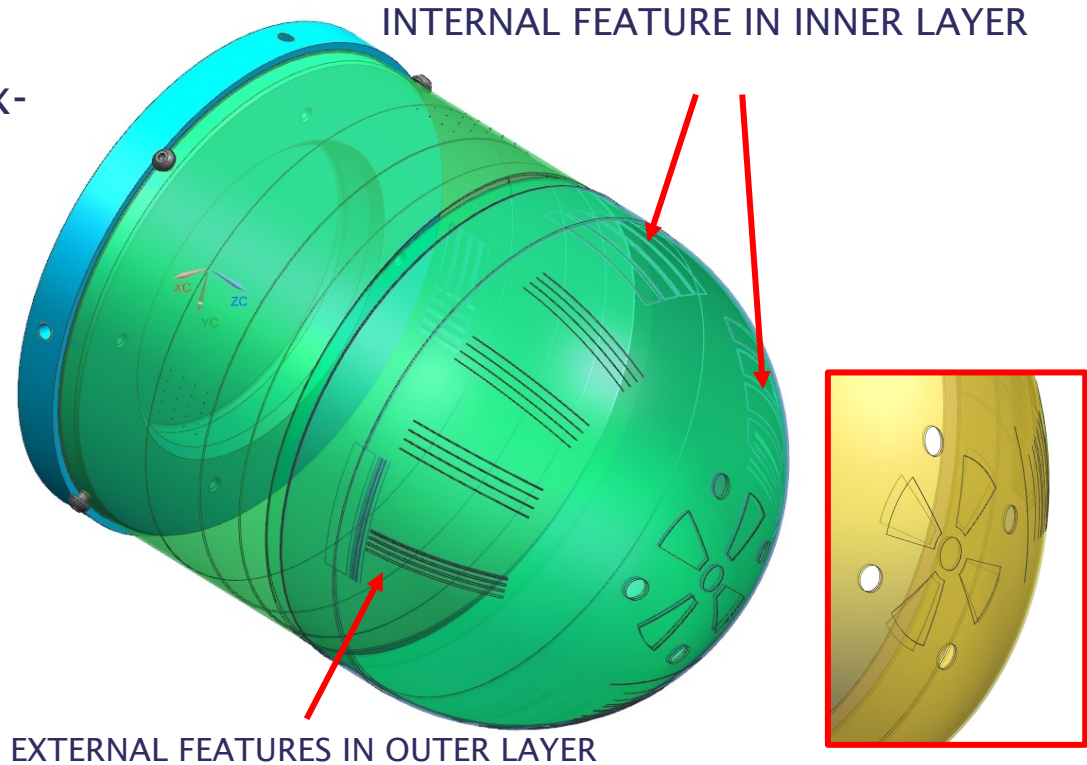
Only minor modifications
suggested



AWE developing plan for testing x-ray imaging capabilities at different energies

Developing IQI's for testing resolution and penetrability

Initial discussions in to test these in CLF (TA2/Gemini and EPAC)





Ongoing engagements

- Significant interest in establishing a strategic collaboration amongst CLF-LANL-U. Manchester
- 3 meetings to explore potential avenues for collaborations
- Planning a joint experimental proposal for Gemini and ELI based on multi-modal probing
- Standing invitation to join LANL experiments in the US
- LANL visiting CLF in July



Multi-probe meeting with Harwell II

A discussion of potential areas of cooperation for mutual benefit by the LANL Multi-probe Radiography team:

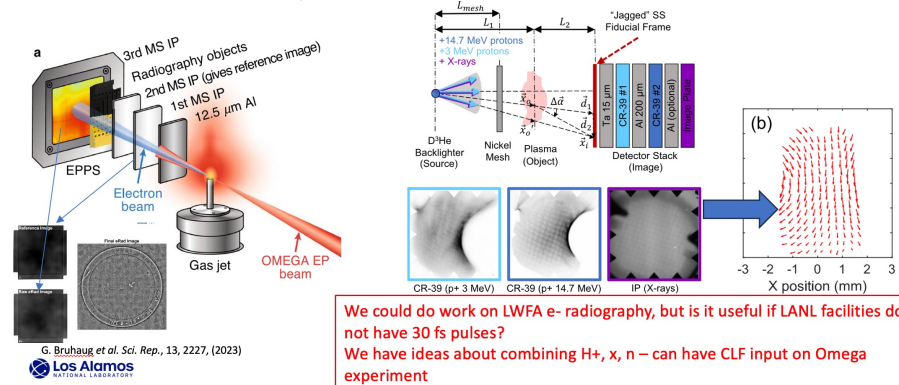
Chengkun Huang (T-5), Joseph Strehlow (P-4), Mariana Alvarado Alvarez (P-4), Chun-Shang (Tim) Wong (P-4),

November 17, 2023

Three potential ideas for LANL/U Manchester-Harwell source development and characterization for multi-probe experiments

Idea 3: (single-shot) Multi-probe radiography

Problem: laser-driven source profile nonuniformity and reproducibility → reference probe



We could do work on LWFA e- radiography, but is it useful if LANL facilities do not have 30 fs pulses?

We have ideas about combining H+, x, n – can have CLF input on Omega experiment

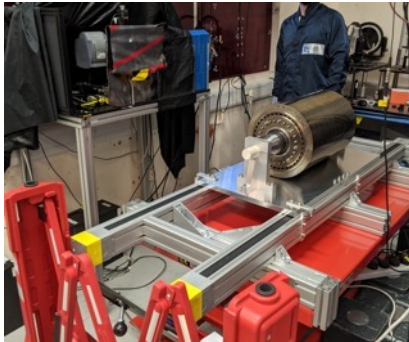


The University of Manchester



Rolls Royce: Developing dynamic high energy XCT for non destructive evaluation

- Several PoC experiments to confirm penetrating power of LWFA x-ray sources
- Proven higher resolution than existing MeV linacs
- Could combine with neutron CT



Radiography to understand fatigue and stress in aerospace and automotive components

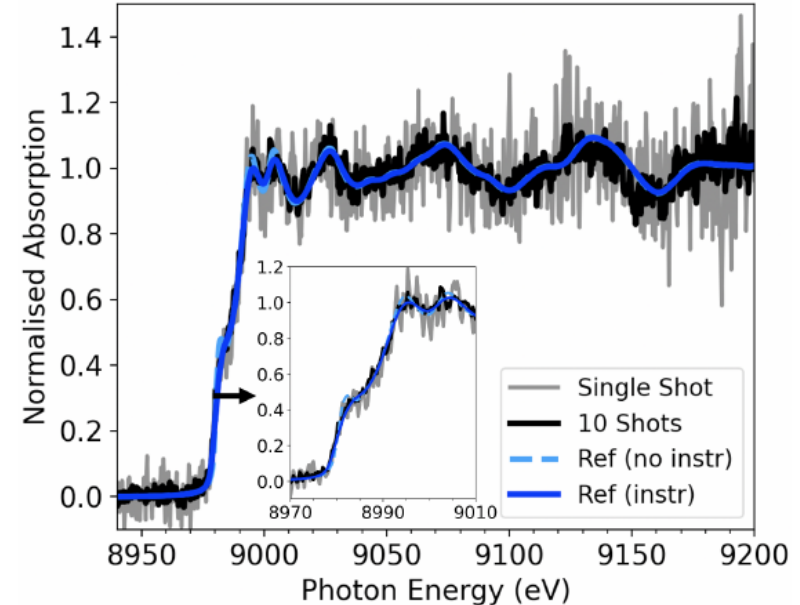
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MeV bremsstrahlung radiography
~ 400 μm resolution

Johnson Matthey: Developing x-ray absorption spectroscopy (XAS) on femtosecond timescales

- Sponsored EPSRC industrial fellowship (2018 – 2021)
- PoC looking at XCT and Cu edge XAS for catalysts.
- Trial projects have been identified for EPAC
- **Joint studentship with Imperial College London**

Workshop with JM in 2023



Single-shot XANES and EXAFS of Cu edge
Kettle 2019, PRL 123, 254801;
Kettle 2023, arxiv 2305.10123



Joint experiments and R&D



WMG: Developing an industrial quality laser-driven XCT beamline

- Working with CiMAT group (Jay Warnett)
- Part of NXCT and HVM Catapult
- Have a range of scanners and huge experience in state-of-the-art XCT
- Critical evaluation of image quality and developing operational protocols
- **Joint PhD studentship (up to Oct 2026)**





Engagements set to increase in the coming years

Task	2021		2022		2023		2024		2025		2026		2027		2028		2029				
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This could be developed/modified by the new IPI group leader



Engagements via conferences

IoP Position Sensitive Neutron Detectors Conference

- Keynote talk at the conference highlighting neutron sources and applications from laser-driven interactions.
- Broad range of interest in pulsed fast neutron sources
- Engagement with NPL Neutron Calibration Facility to develop diagnostics and novel sources
- Discussions with Tokamak energy to support neutron and x-ray diagnostics





Engagement via Eol's

UKRI's Industry Impact Fund (I2F) calls allow SME's to access facilities and capabilities

Themed around
Energy, Net Zero, Security & Defence, Health

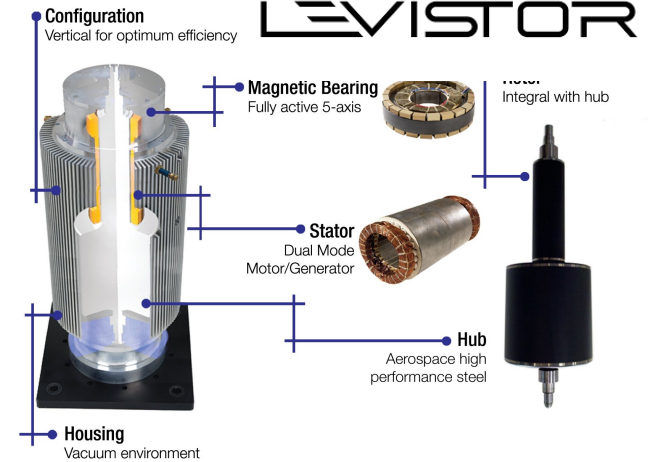
Continuously monitor "Eol challenges"

Arranging meetings with Levistor:

Inspection of Energy storage
flywheel

Arranging meetings with NVH

Inspection of Solid Oxide Electrolyser
Stacked Cell

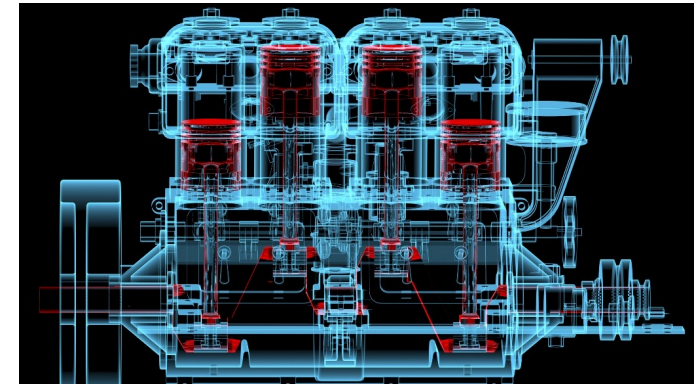




Being part of NXCT can open-up more links

NXCT is the UK's National Research Facility for lab-based X-ray Computed Tomography.

Hosted at the Henry Royce Institute, it is a collaboration between Universities of Manchester, Southampton, Warwick, University College London (UCL) and Diamond Light Source. The NXCT collaboration is funded by EPSRC running from 2022 until 2025.



- **Future opportunity for EPAC – become a partner with next-gen NXCT or the Henry Royce institute?**



Engineering and
Physical Sciences
Research Council



Science and
Technology
Facilities Council

EPAC's (and CLF's) industrial strategy will evolve over the next few years

The aspiration is to have a parity in non-academic engagements – may not be just access to facilities, access to expertise too

We did a 10-year Review of CLF in 2023, which strongly endorsed these plans

With the new IPI group leader in place we plan to accelerate this process

Establish an overall industrial engagement strategy for the CLF, ensuring that the approaches to the different facilities offered by CLF are treated separately based on the operational models of the various instruments

Establish an industrial advisory body covering all CLF activities, including members who are not already fully familiar with the opportunities available, as soon as possible

Accepted. The long term aim is for industrial access to be self sustaining in terms of the people it supports. Additional space in the RC@H is needed to support greater industrial access

Accepted