EUROPEAN
PLASMA RESEARCH
ACCELERATOR
WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA
Preparatory Phase

Incorporating EuPRAXIA into EPAC

Rajeev Pattathil

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EuPRAXIA @ EPAC – site visit: February 2024

Funded by the European Union

Tue 13/02 | Wed 14/02 | All days

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08:00	Taxis from Hotel	
	Arrival	
	Tea, Coffee	
09:00	Introduction to STFC and Harwell Campus	*Alan Partridge*
	EPAC – the big picture	*John Collier*
	EuPRAXIA update	*Massimo Ferrario*
10:00	EuPRAXIA @EPAC	*Rajeev Pattathil*
	The UK Centre of Excellence	*Deepa Angal-Kalinin*
	Coffee Break	
11:00	Round Table Discussion on EuPRAXIA facility model. Chair: Mark Thomson (Alan Partridge if Mark is delayed) — *CR12*, 10:45 - 12:30	*Alan Partridge et al.*
12:00	Lunch — *CR12/13*, 12:30 - 13:30	
13:00	LWFA and FEL in EPAC	*Daniel Symes*
	EPAC- laser architecture	*Paul Mason*
14:00	Towards 100Hz laser drivers	*Mariastefania De Vido*
	X-ray imaging, applications and detectors	*Chris Armstrong*
	Tea, Coffee	
15:00	Closing workshop, transportation to airport — 15:00 - 16:00	
16:00		

Discussions on both technical aspects and funding/governance models

100J pump laser system being commissioned

Funded by the European Union

- Progress has been good across all subsystems : Front End , 10J amplifier and Hundred Joule (HJ) Amplifier
- **Highlight is the *‘completion’* of the Site Acceptance test for the 100J amplifier Diodes**
- Front End beam (both CW and pulsed) has been aligned
- The 10J amplifier is aligned, the debris shields have been installed and passed safety inspections
- The beam transport line between the 10J and 100J has been aligned

EPAC 100 J amplifier

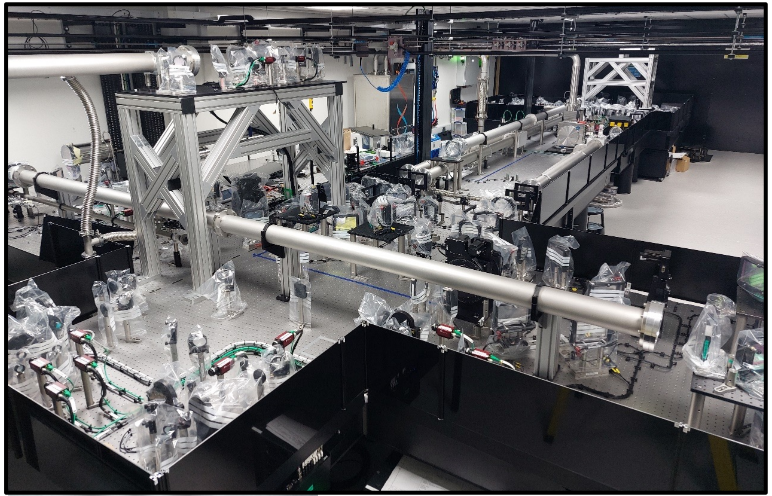
OPCPA front-end being commissioned

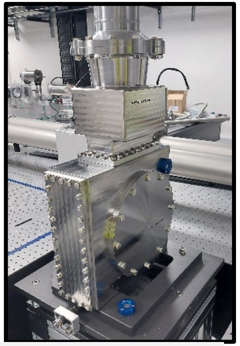
Funded by the European Union

- Progress has been good across all subsystems: picosecond preamplifier, nanosecond amplifier and temporary stretcher
- **Highlight is the *'completion'* of the Site Acceptance Test for the ns amplifier pump laser**
- We have amplified pulses from the ps amplifier, and started to get gain in the ns amplifier

CLF & NG-CEO ns-pump installation team (June 2024)

Main Ti:Sapphire Amplifier being installed





Amplifier head

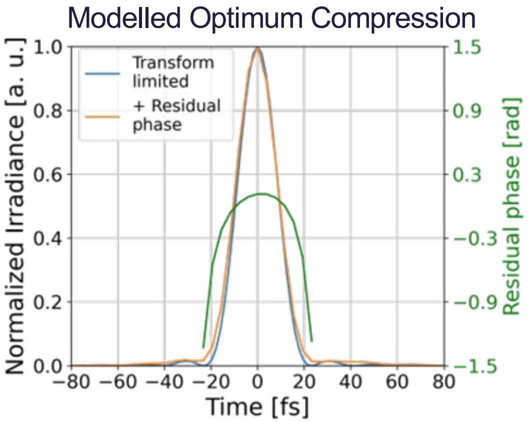
Ti:Sa amplifier

- **Highlight –Commissioning started in June and majority of opto-mechanics & optics installed**
- Laboratory configured for laser operations (interlock & controlled access)
- Beam alignment commenced with low power CW lasers

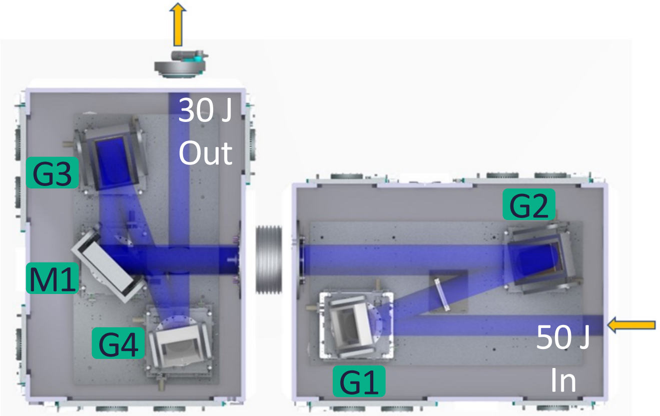
Compressor chambers installed

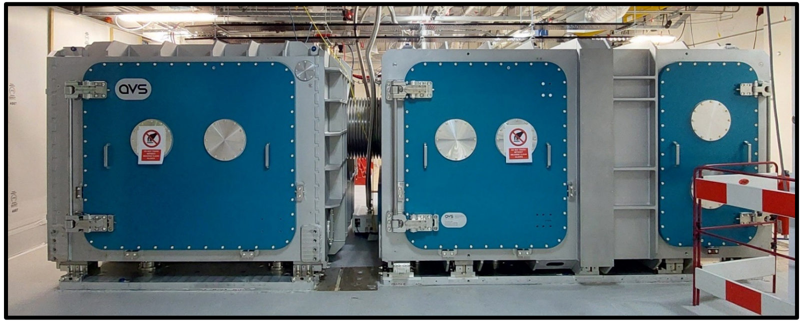
Aim: Compression to 30fs, 30J @ 10Hz.

- 4-grating design @ Littrow (10° out-of-plane angle).
- 300x300 mm^2 (G1&G4), 760x300 mm^2 (G2&G3)
- Peak fluence @ 1 PW = 80 mJ/cm² (30 fs)
- Phase #1 use **gold gratings** @ 1480 line/mm for 1 Hz.
- Phase #2 use **multi-layer dielectric gratings** for 10 Hz.



[1] V. Aleksandrov et al., CLEO/Europe-EQEC 2023





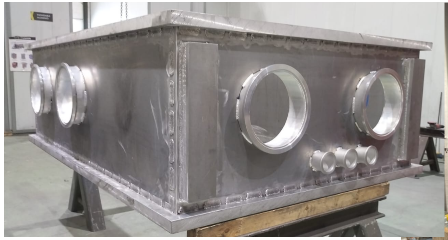
Chambers installed April 2024
Grating installation scheduled Spring 2025.

Beam transport installation underway

Funded by the European Union

- **Highlight -good progress being made on the beam transport. It is complex - spans across 3 floors with multiple chambers**
- **Double mirror chambers (EA1 & EA2)** – In manufacture – expected delivery in October 2024. Support frames installed in August.
- **Beam line mirrors** – Orders placed for final polishing and coating of 16 380 x 270 mm mirrors. Expected by April 2025.
- **EA1 Switchyard Chamber** – In manufacture – expected delivery in November 2024

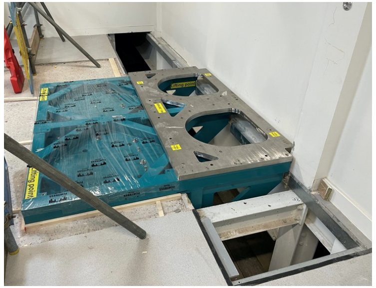
Active beam pointing stabilisation schemes being developed



EA1 Switchyard Chamber

Riser pipework – Ground floor corridor

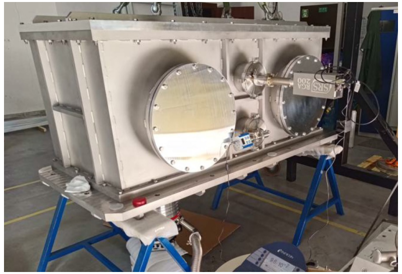
Riser pipework – Plant room 9



Support frame in position

F … ctions installed

EA1 BL1 Riser turning chamber – Pit

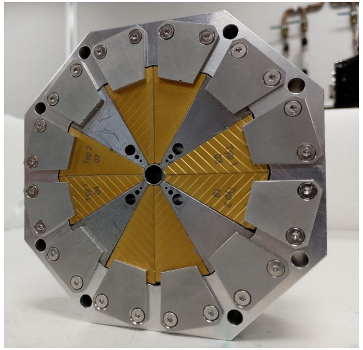


EA1 Double Turning Chamber nearing completion

LWFA area progressing

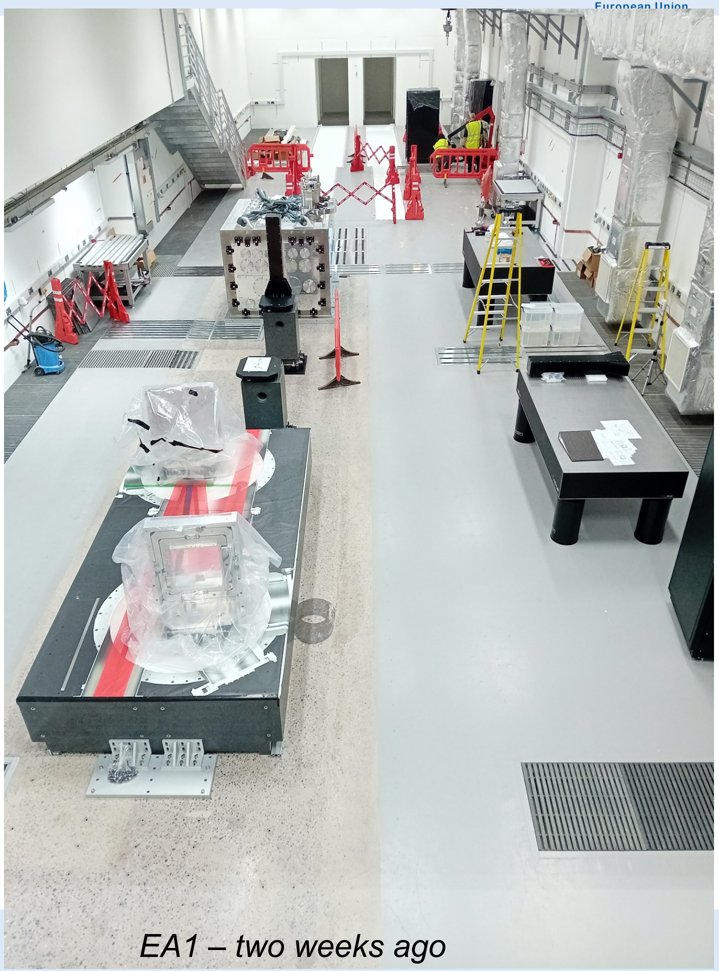
- **All granite blocks in place apart from that of Target chamber**
- **Focusing chamber close to completion**
- Area now prepared for granite delivery next week
- Most optics on order – parabola expected Dec 2024
- 4 x quadrupole magnets being assembled at DL
- Gas jet slot nozzles are being tested – initial applications
- Will move to HOFI later

100 mm gas jet nozzle



PMQ

Focusing chamber



EA1 – two weeks ago

Funded by the European Union

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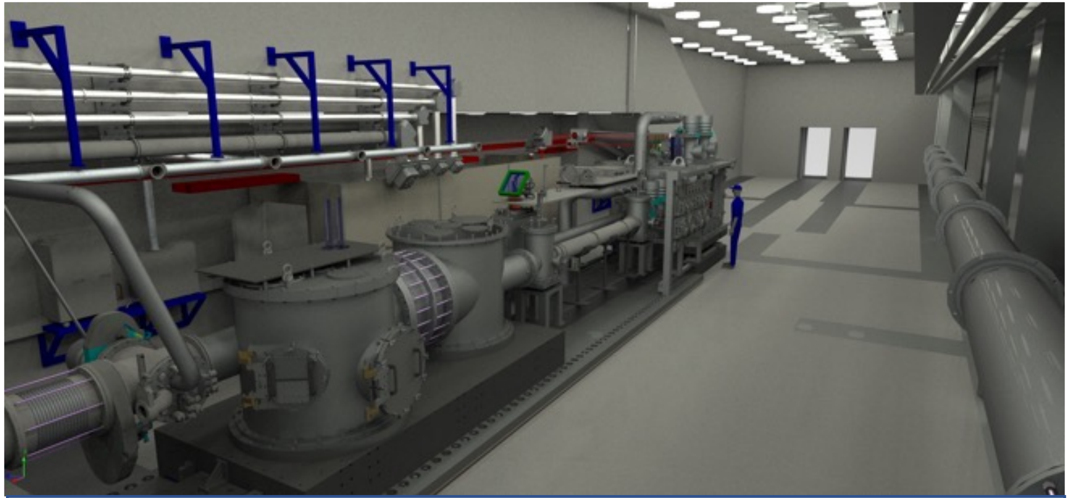
Option 0 – Existing EA1



Space for a second beamline

~~1GeV FEL with user area: >100m (EuPRAXIA CDR)~~
~~Upgradable to 5GeV in Phase 2~~

- Get the few 100TW @100Hz beam into the second beamline in EA1 (internal + PACRI)
- 1GeV beam in the first 5 – 8 m of the area (by middle of the source area)
- ~5m gain length - > 20m to get saturation for 1GeV beam (XUV wavelengths – not x-ray) - ASTeC
- The last 8-10m can be the FEL user area

Pros:

Capital investment needed might be minimal

Cons

Will interfere with EA1 operations

Limited to 1GeV (phase 1)

EuPRAXIA @ EPAC: Options

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Option 1 – Extending EA1

- EA1 is 40m long – but only ~ 20 m after the plasma source for FEL
- ~5m gain length - > 20m to get saturation for 1GeV beam (XUV wavelengths – not x-ray). This doesn't leave any room for FEL user area
- Need extension for 5GeV cases as well as user area

Pros:

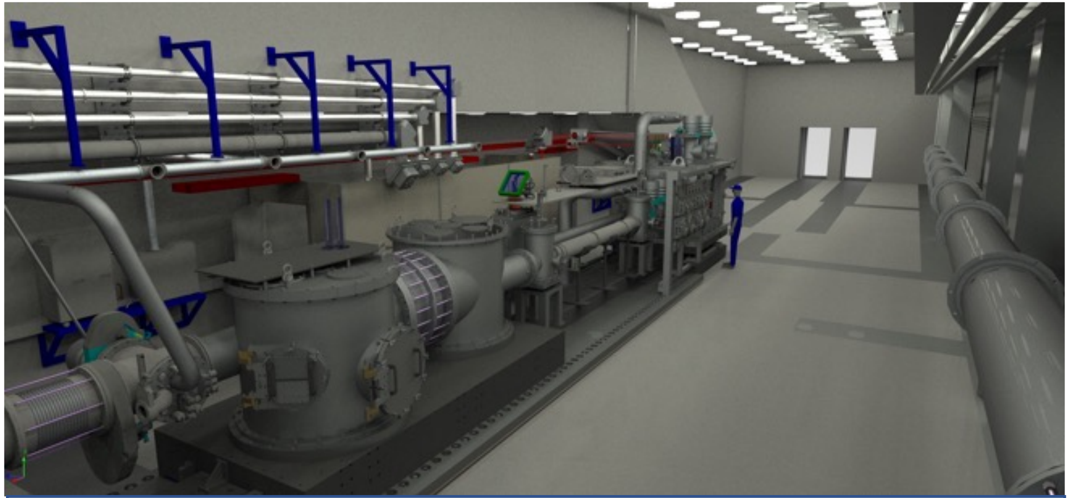
Can use EPAC PW laser for higher energies

Can host multiple phases – good for future-proofing;

Cons

Capital investment (for building) can be high ~ 20-30M

Construction can be disruptive



Space for a second beamline. Building extended further

1GeV FEL with user area: >100m (EuPRAXIA CDR)
Upgradable to 5GeV in Phase 2

EuPRAXIA @ EPAC: Options

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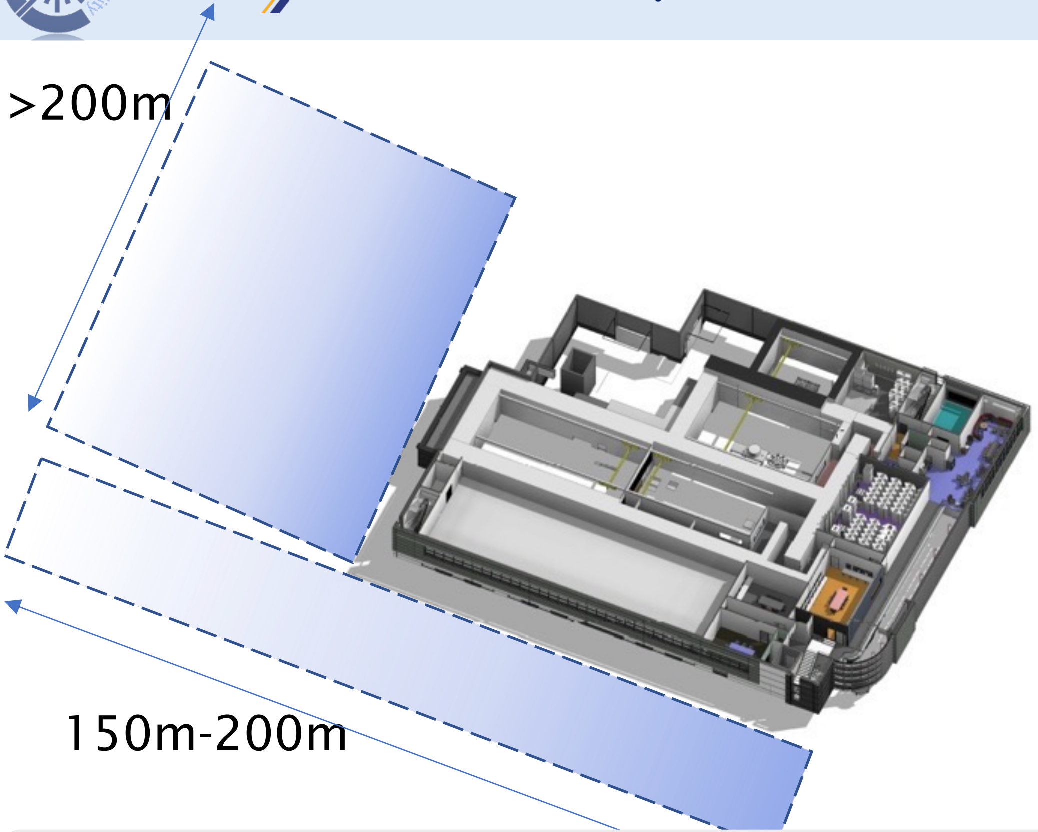


Option 2 – Building an Annex

- Surrounding areas are green/brown fields
- Earmarked for "large science" – so extendable
- More expensive but gives flexibility for future-proofing
- Building works and beamline construction can go in parallel with operation of EPAC

Pros:

Multiple beamlines, full flexibility, futureproofing

Cons

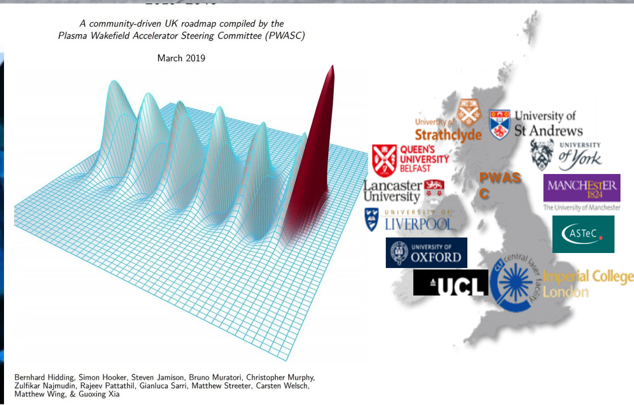
Significant capital investment required

(~60M - 80M)

1GeV FEL with user area: >100m (EuPRAXIA CDR)
Upgradable to 5GeV in Phase 2

EuPRAXIA @ EPAC?

- EPAC's strategy and timescales align with EuPRAXIA well
- Additional space for future laser and experimental areas (eg. a 100Hz system under development, which can be the main driver for 1GeV FEL beamline)
- Has the capacity to expand the EPAC building to house the additional beamlines
- Has an upgrade path to 5GeV and 10GeV with the EPAC PW laser
- Strong expertise within STFC (lasers, accelerators, detectors, targetry, data…) and the academic community (plasma accelerators)
- Applications-oriented program and industry links
- STFC has long history and all the infrastructures required to run a successful user programme
- STFC's Accelerator Strategy now includes development of plasma accelerators



EuPRAXIA @ EPAC: synergies of the campus

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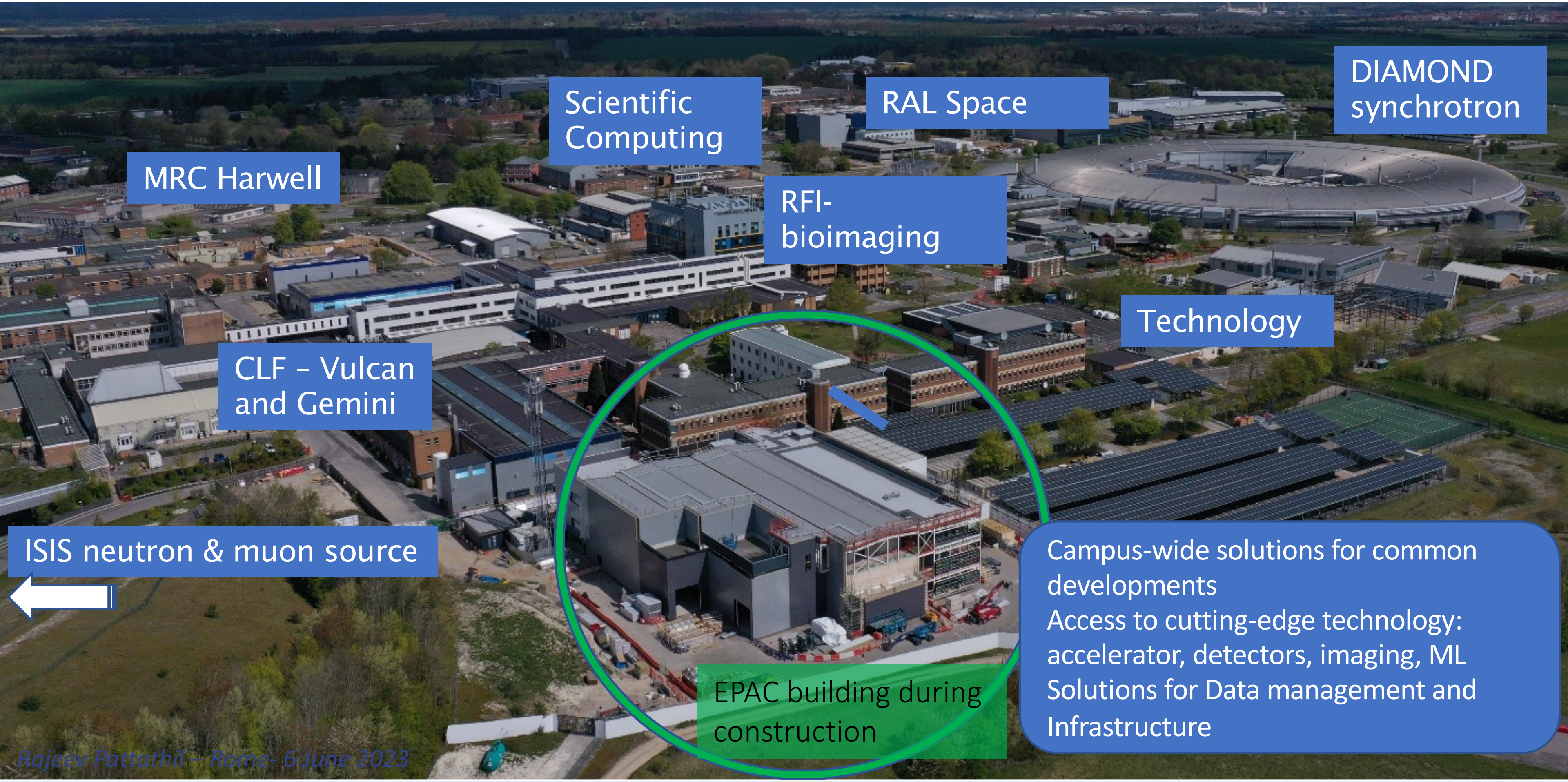

Campus-wide solutions for common developments
Access to cutting-edge technology: accelerator, detectors, imaging, ML
Solutions for Data management and Infrastructure

EuPRAXIA The UK Centre of Excellence

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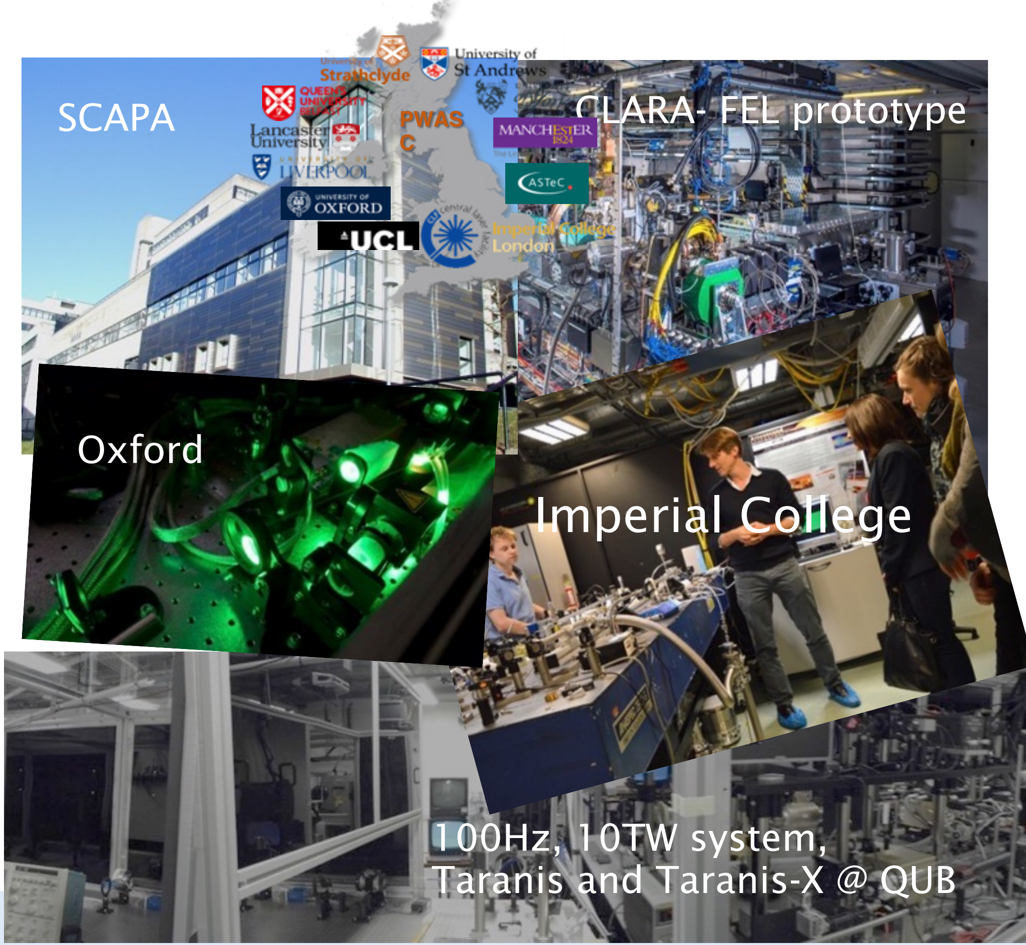
UK CoE will focus of the design and delivery of Applications Beamlines in Sites 1 & 2

The UK University Centers, Accelerator Institutes and the CLF are leaders in the underpinning science and technology

The UK PWASC coordinates activities in this area in the UK

Given the level of management required PWASC recommended that this done via STFC

Since supply to Site 1 is also needed, ASTeC is chosen as the nodal point for the UK Excellence Centre



EuPRAXIA @EPAC: community contributions and collaborations

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Internally developed/coordinated key components
Building design and construction with radiological modeling (CLF)
EPAC 10Hz, 30J system, 100Hz – few 100TW system (CLF)
Laser beam transport (CLF)
Plasma accelerator (UK CoE)
FEL beamline, undulators (UKCoE/ASTeC)
User areas (UK CoE)
Betatron beamline (UK CoE)
Positron beamline (UK CoE)

- Prototypes of amplifier head, solutions for heat management
- Test compressors with gratings with appropriate damage thresholds and heat management solutions

France, Germany, Italy..

- Solutions for wavefront and pointing corrections

France Germany, …

- Plasma accelerator components, Diagnostics, Gas flow control, feedback systems, plasma lens

France, Germany, Italy

- Inputs to end-to-end FEL simulations with laser-driven electrons, undulator design, electron beam transport, photon beamline, diagnostics

France, Germany, Switzerland

- Input to design of user stations, rigs, diagnostics

Germany, Italy, Switzerland

- Physics simulations of LWFA and optimisation of secondary sources for various applications, diagnostics

Germany,France/ Portugal

- Advanced Accelerator schemes (eg. Trojan Horse)

Germany

EuPRAXIA @ EPAC: our perspective

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- A very strong interest in the community to contribute to/host EuPRAXIA
- STFC, UK Accelerator Institutes and the academic community possess a significant expertise critical for EuPRAXIA's success: UK CoE
- Possible to have access slots in EPAC/University centers via existing channels/additional grant funding
- Some key questions/concerns
  - Capital costs and source(s) (host + consortium?)
  - Operational funding and source(s) (host + consortium?)

External funding (capital and/or operational) would be necessary for the business case for hosting a European Infrastructure in the UK

- Long history of running world-class facilities
- Very strong expertise on HPL and plasma accelerator technology
- Strong user community and University facilities
- Campus expertise on detectors/targetry/data management
- Strong links with industrial community

- Governance and funding arrangements need discussions
- Initial funding requirements (for optimised options) are high
- *Requires* external funding
- Lower cost options would involve sharing of "beam time"