EUROPEAN
PLASMA RESEARCH
ACCELERATOR
WITH
EXCELLENCE IN
APPLICATIONS

Incorporating EuPRAXIA into EPAC

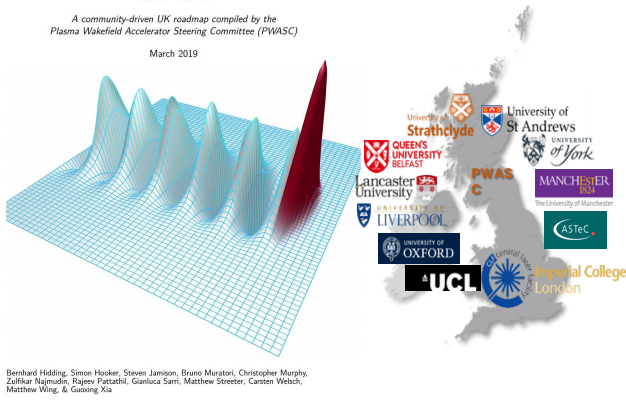
Rajeev Pattathil

This project has received funding from the European Union Horizon Europe research and innovation programme under grant agreement
No. 101079773

EuPRAXIA @ EPAC?

- 10Hz PW laser driving plasma accelerators
- Built for 10GeV beams at 10Hz
- Propose to start with 10Hz PW beam with 100Hz upgrade option (under development)
- 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
- Joining EuPRAXIA is in PWASC Roadmap

EPAC's operations to start in 2026/27 – EuPRAXIA can be built on this – EPAC will be a plasma accelerator facility (not just a laser facility)



EPAC Facility Schematics

Top floor houses

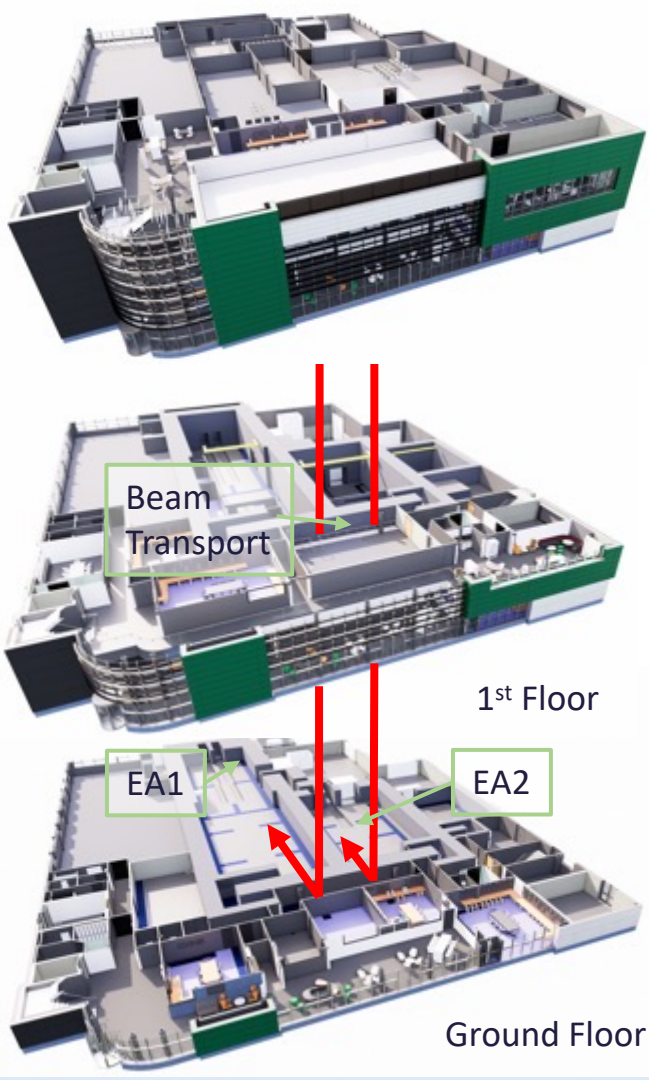
- 1 PW@ 10Hz Laser areas and laser control room.

Space for the addition of new laser systems: 2nd and 3rd synched beamlines

- Office space on 2nd and 1st floors

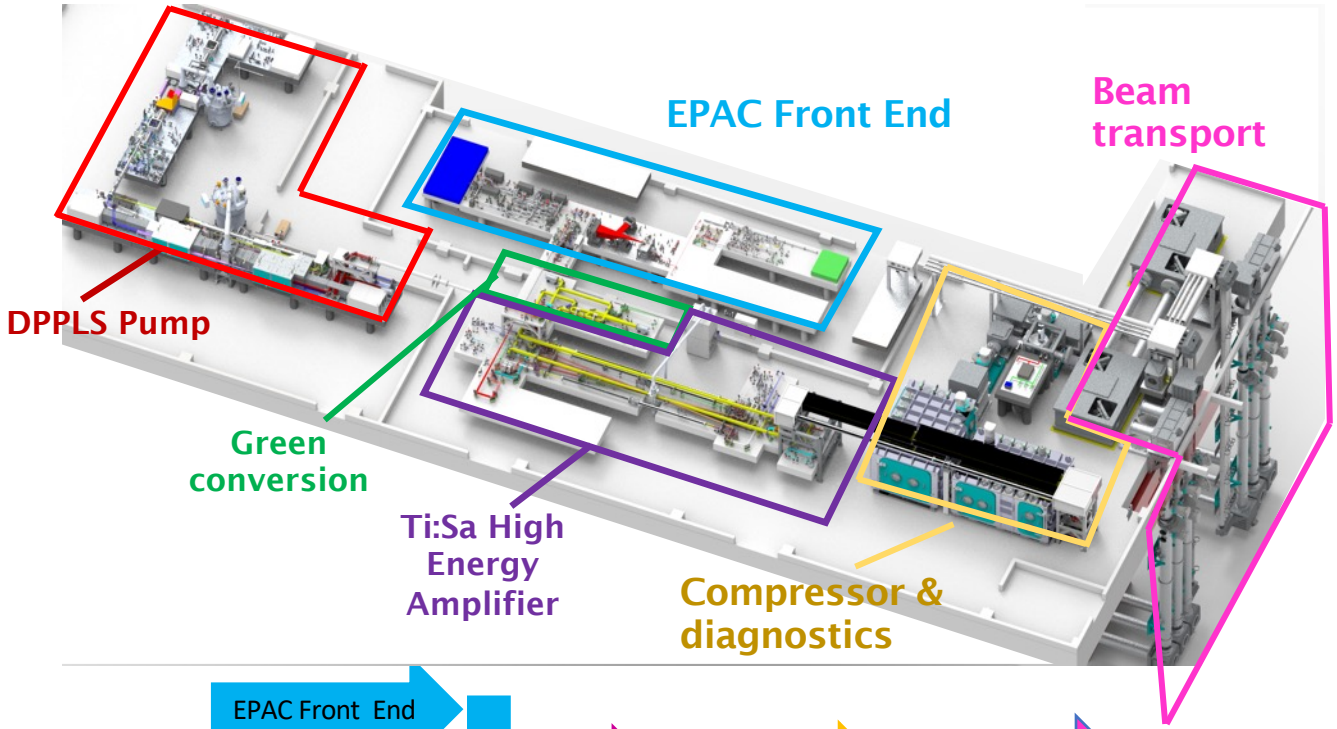
Ground Floor houses three double height radiologically shielded experimental areas

- Experimental area 1 (EA1) ~38 m x 9 m,
- Experimental area 2 (EA2) ~18 m x 10 m
- Future experimental area (EA3)
- Control rooms and auxiliary labs and future cleanroom space and development laser labs



EPAC Laser system

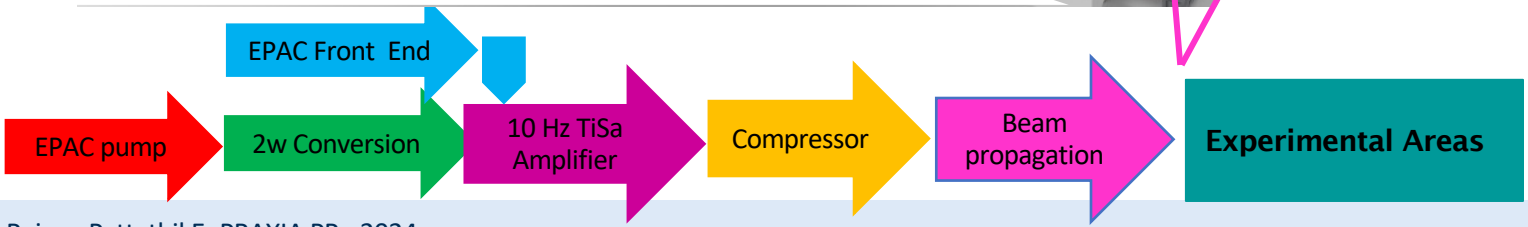
Funded by the European Union



1PW@10Hz

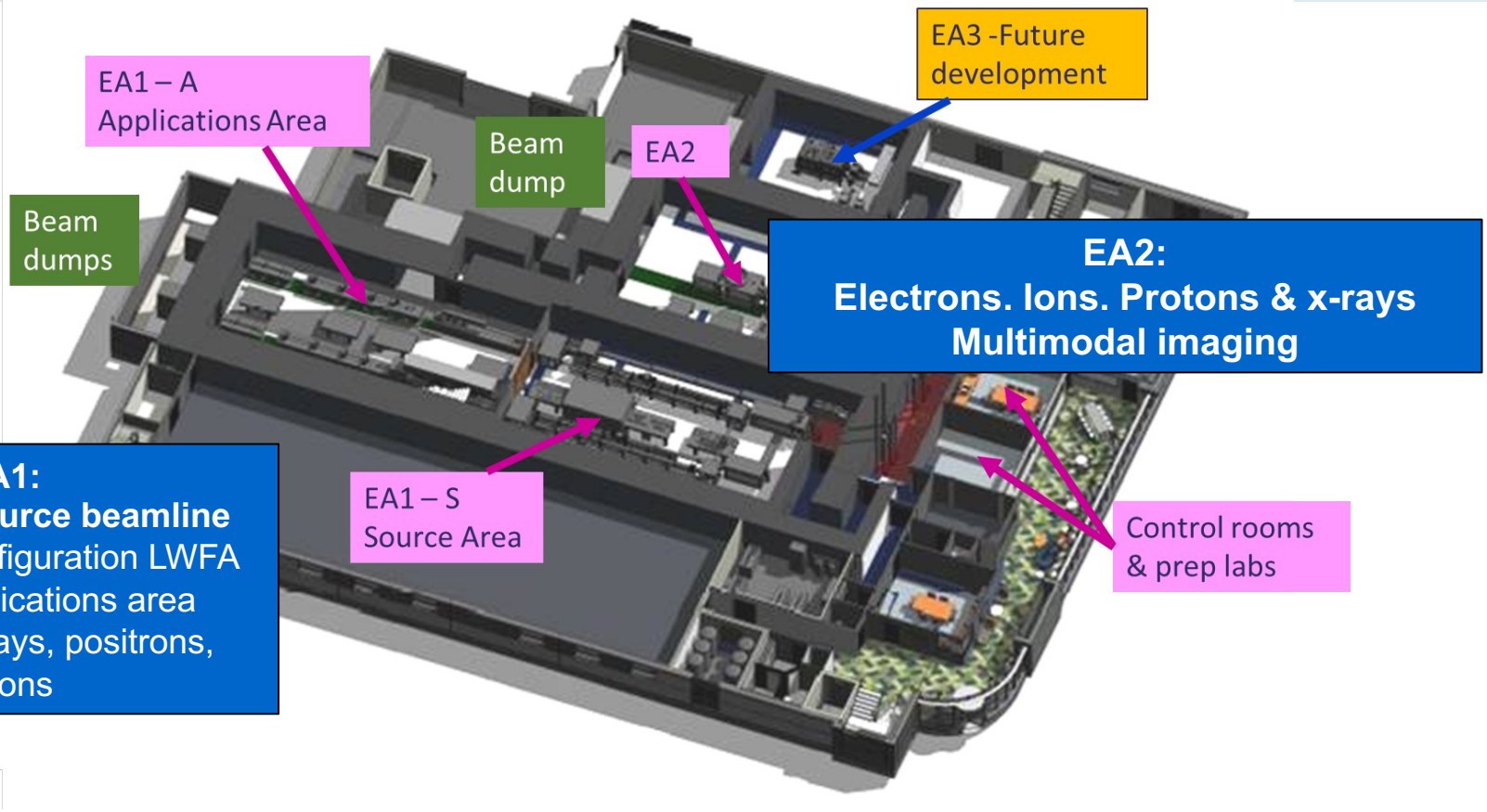
- **Output Energy 30 J**
- **Pulse duration ≤ 30 fs**

  Repetition rate 10 Hz, 1 Hz, Shot on Demand
- Pump for Ti:S is CLF developed 100J DiPOLE system.
- Additional space for future laser and experimental areas (eg. a 100Hz system under development)



Experimental areas on the ground floor

Funded by the European Union

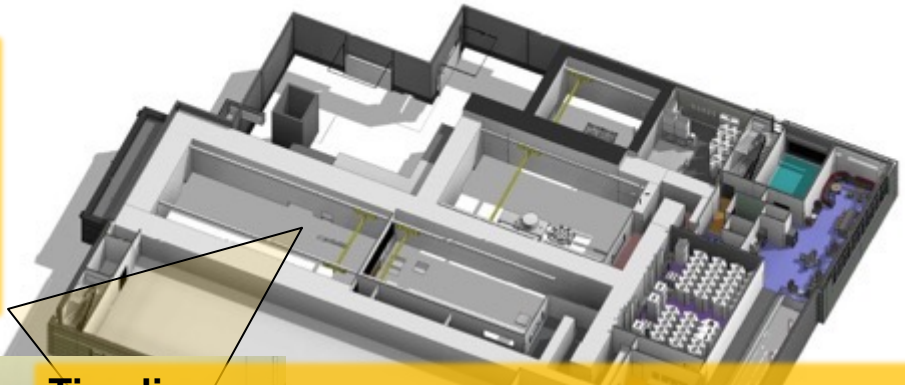


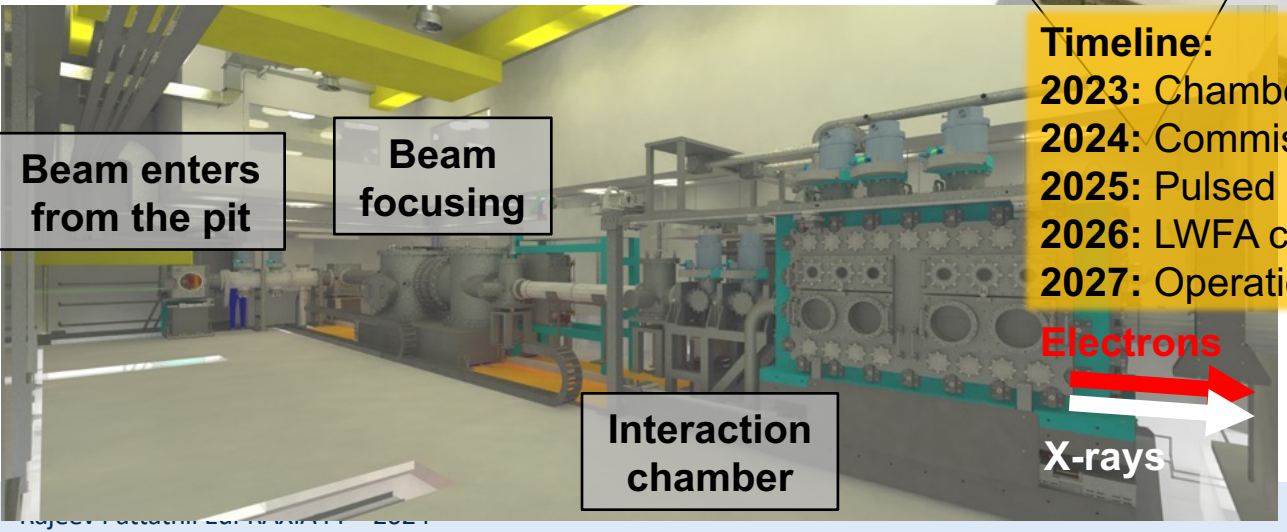
EA1 Configured for plasma accelerator research

Funded by the European Union

EPAC 1 PW drives a laser plasma accelerator

- Focused to relativistic intensity (above 10^{18} Wcm^{-2})
- Target is a few cm of gas
- Creates a plasma with extremely high accelerating fields
- Generates multi-GeV electron beams and x-rays





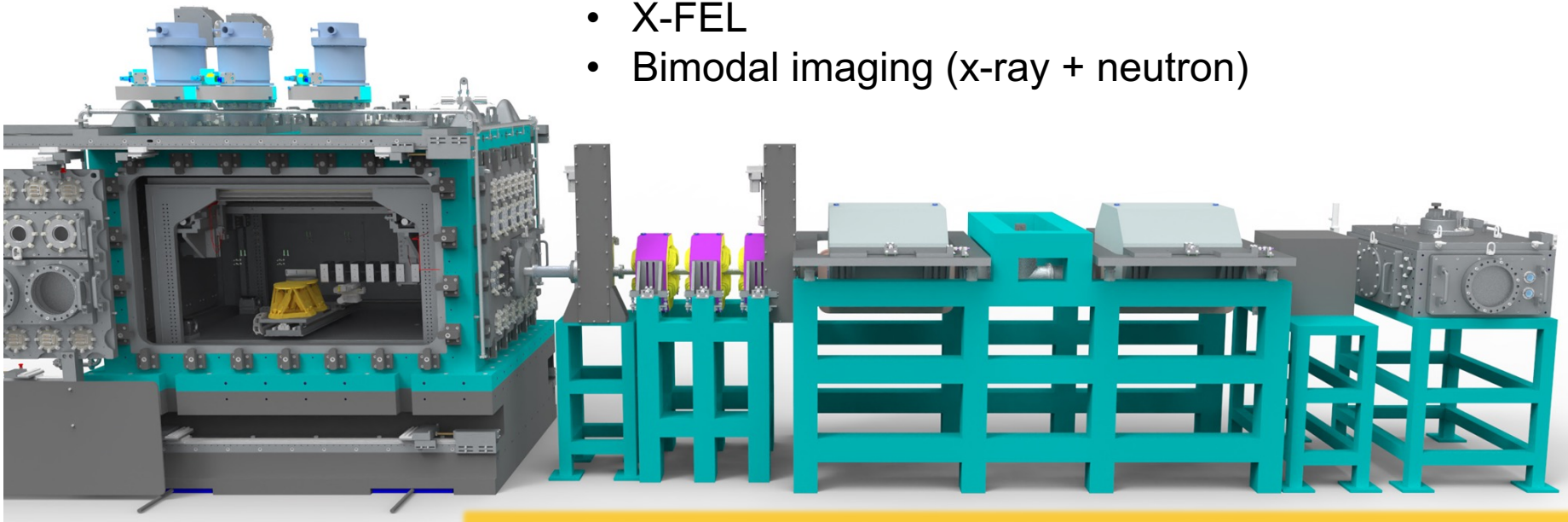
Timeline:

2023: Chambers and large equipment delivered
2024: Commissioning with internal laser
2025: Pulsed beam commissioning
2026: LWFA commissioning
2027: Operational user facility

EA1 sources and applications

Funded by the European Union

- Impact (positrons / muons / bremsstrahlung)
- Collisions (Inverse Compton Scattering & QED)
- X-ray Diffraction and Spectroscopy
- X-FEL
- Bimodal imaging (x-ray + neutron)



Very similar to what EuPRAXIA user-base would need

“Outreach” in EPAC

Funded by the European Union

Harwell open weeks

~18000 visitors

- **Students**
- **Strategic partners**
- **Public**

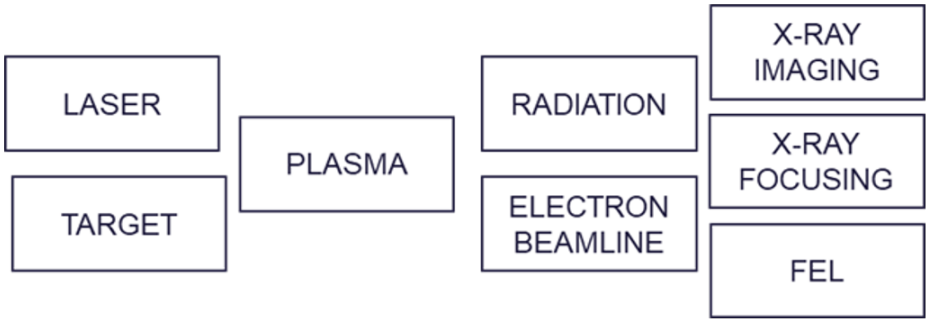
EuPRAXIA @EPAC: requirements from community

Funded by the European Union

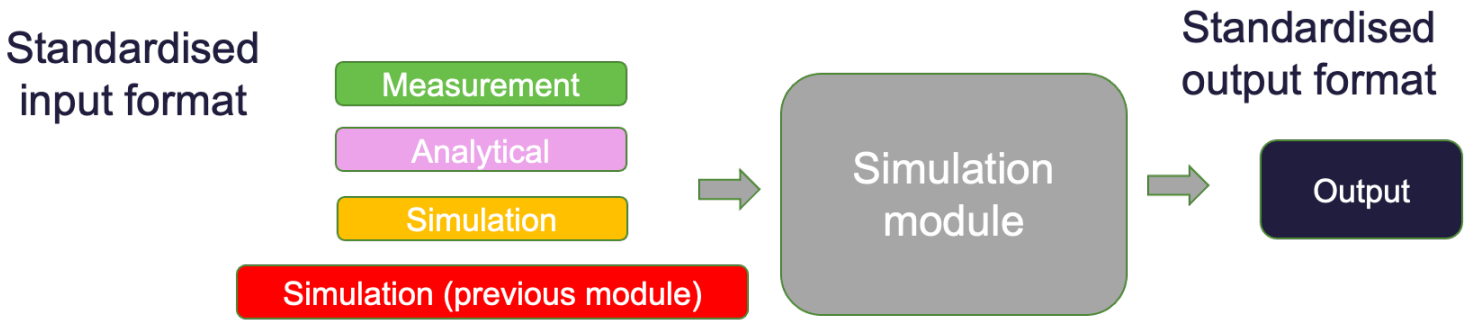
Internally developed/coordinated key components		
Building design and construction with radiological modeling (CLF)		
EPAC 10Hz, 30J system, 100Hz – few 100TW system (CLF)	• Prototypes of amplifier head, solutions for heat management • Test compressors with gratings with appropriate damage thresholds and heat management solutions	France, Germany, Italy..
Laser beam transport (CLF)	• Solutions for wavefront and pointing corrections	France Germany, …
Plasma accelerator (UK CoE)	• Diagnostics, Targets, Gas flow control, feedback systems, ML control, plasma lens	France, Germany, Italy
FEL beamline, undulators (ASTeC)	• Inputs to end-to-end FEL simulations with laser-driven electrons, undulator design, electron beam transport, photon beamline, diagnostics	France, Germany, Switzerland
User areas (UK CoE)	• Input to design of user stations, rigs, diagnostics	Germany, Italy, Switzerland
Betatron beamline (UK CoE)	• Physics simulations of LWFA and optimisation of secondary sources for various applications, diagnostics	Germany, Portugal
Positron beamline (UK CoE)	• Advanced Accelerator schemes (eg. Trojan Horse)	Germany

Funded by the European Union

Built up of modules from front end to end use



This will benefit EuPRAXIA regardless of the site



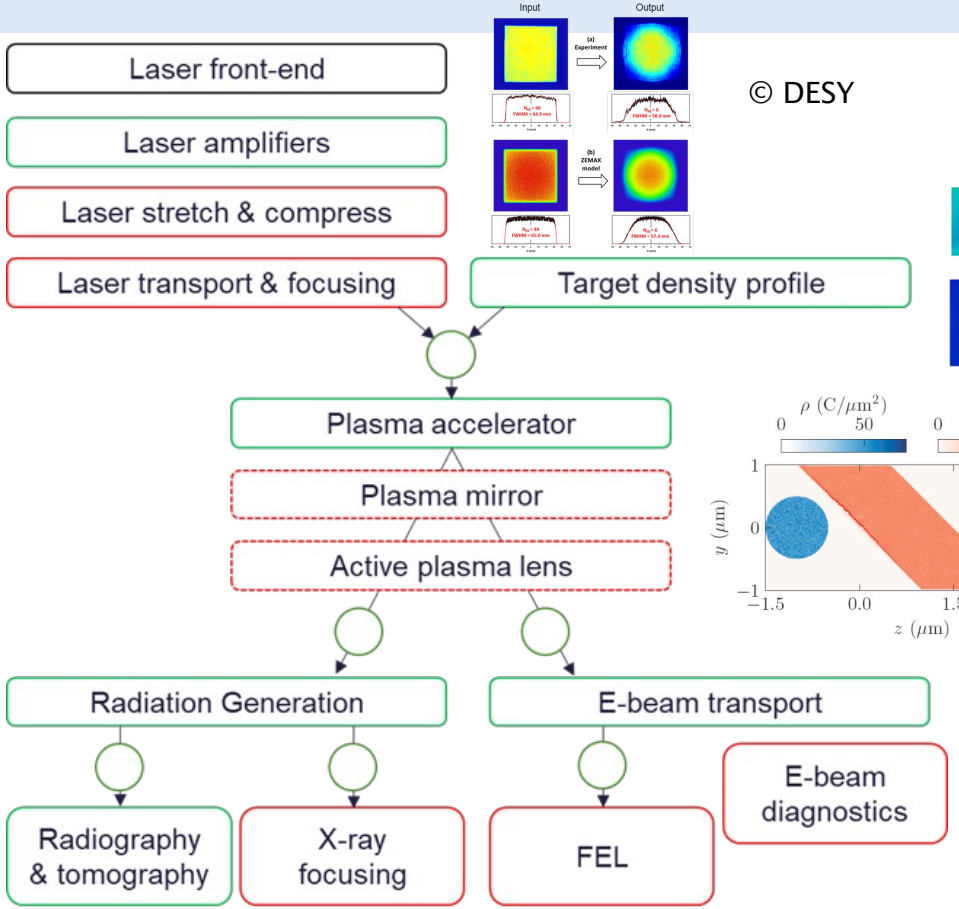
EuPRAXIA @EPAC: collaboration opportunities

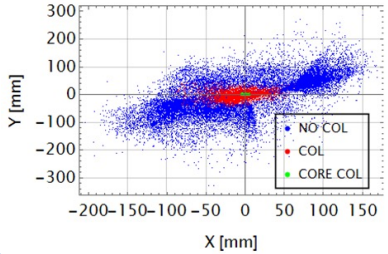
Funded by the European Union

Codes for each box do exist – we have done the green ones, and maybe some of the red.

Circles are *interfaces* between different codes

Dotted edge means optional components

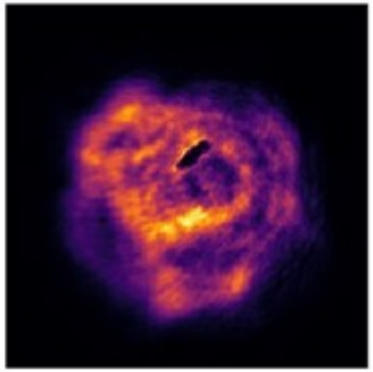




EuPRAXIA @EPAC: collaboration opportunities

Funded by the European Union

- Laser damage is a big issue
- Development of high damage threshold optics
- Studies on laser damage: dependence on
  - Coatings
  - Vacuum levels
  - Cleanliness
  - Humidity and environment control
  - Memory effects
- Integrated machine safety systems



LPA Special Workshop on Intelligent Systems

13–16 Jan 2025

Department of Physics, University of Oxford

Europe/London timezone

Enter your search term