

EUROPEAN  
PLASMA RESEARCH  
ACCELERATOR WITH  
EXCELLENCE IN  
APPLICATIONS



# An Overview of Proposed EuPRAXIA Clusters

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Hamburg (Germany)




This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

- Connected to existing groups and facilities around Europe
  - preparation of technical design
  - study of open technical points
  - definition and execution of validation experiments
  - proof-of-principle studies



- ❑ 10 technical clusters defined
- ❑ In many cases, a cluster is responsible for a specific sub-system with regard to its technical design, testing and implementation / delivery





Theory & Simulation

- 1) **Development and study of new theoretical concepts:** e.g. energy dechirping, external injection, electron injection and acceleration control, radiation generation, thermodynamic studies in plasma capillaries
- 2) **Start-to-end simulations & theoretical modelling of EuPRAXIA beamlines:** LWFA, PWFA & hybrid designs, FEL performance, error and tolerance studies, development of a theoretical machine model
- 3) **Evaluation of machine and components performance:** code benchmarking, measuring hardware performance against theoretical results
- 4) **Development of new codes and computational approaches:** code improvements, robust and realistic modelling tools, HPC, machine learning

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- UOXF
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- WIGNER

*Close connections with: X. Layout & Implementation (on data analysis / computational capabilities)*



Laser  
Technology

**Responsible for development of all laser systems** (drive lasers, photoinjector laser, other laser systems, laser diagnostics, laser transport lines, etc.)

→ **Main scientific & technical challenges:**

- 1) Amplifier configuration
- 2) Pumping technology
- 3) Optical compressor technology
- 4) Pointing stability
- 5) Temporal and spatial shaping
- 6) kHz repetition rate and beyond

**Dedicated talk later!**

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*Close connections with: laser industry*

Plasma  
Components  
& Systems

- 1) **Development of laser plasma injectors (LPIs):** optimised injection schemes and gas cells, high repetition rate targets, laser removal, integrated targets for applications
- 2) **Development of plasma accelerator stages (LPAs & BPAs):** optimised, long plasma targets using discharge capillaries and plasma channels, high repetition rate targets, laser guiding
- 3) **Development of plasma components for laser / electron beam transport and shaping:** active / passive plasma lenses, plasma lenses for laser focusing, energy dechirping, plasma mirrors, feedback loops
- 4) **System integration and prototype development:** multi-stage designs and test experiments

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*Close connections with: VIII. Additional Innovation Paths (on LPA / BPA plasma targets)*



RF  
Technology

- 1) **RF gun technology:** development & optimisation of S-band guns, new cathode materials
- 2) **RF accelerating structures technology:** optimisation of S-band and X-band couplers, structures and systems
- 3) **Synchronisation:** between components within RF system and with laser drivers, design of feedback mechanisms

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*Close connections with: VI. Diagnostics (on synchronisation / feedback systems)*



Magnets &  
Other  
Beamline  
Components

- 1) **Magnets:** further development of magnets, e.g. QUAPEVA design
- 2) **Beam transport & manipulation:** optimisation of transport lines, down-selection of technologies
- 3) **Beam dumps:** conventional designs and plasma-based beam dumps

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*Close connections with:*



  
Diagnostics

- 1) **Electron and positron beam diagnostics:** conventional diagnostics, development of new instruments, esp. single-shot emittance measurement, cBPMs, longitudinal diagnostics
- 2) **Photon diagnostics:** measuring spectra, divergence, emittance of radiation sources, cover all applications (THz to X-ray)
- 3) **Plasma diagnostics:** measurement of plasma density and wakefield structure for both LPA and BPA

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*Close connections with:* *VIII. Additional Innovation Paths (on plasma-based diagnostics)*  
*IV. RF Technology (on synchronisation / feedback systems)*



**Design, prototyping and delivery of all components related to EuPRAXIA flagship applications:**

- 1) FEL beamline with 1-5 GeV electron beam: undulators (TGU, superconducting, etc.), photon beamline
- 2) Low-energy, high-charge positron source
- 3) High-energy, low-emittance positron source
- 4) X-ray betatron source
- 5) Hard X-ray to gamma-ray ICS source
- 6) Two electron test beamlines
- 7) High-field physics beamline

**Preparation of user end stations**

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*Close connections with:*      *X. Layout & Implementation (user infrastructure)*  
    *IX. Training, Outreach & Dissemination (user workshops)*

Additional  
Innovation  
Paths

- 1) **Multi-pulse LWFA:** e.g. high repetition-rate laser drivers, optical tailoring of plasma channels plasma photocathode injector
- 2) **Hybrid LWFA → PWFA**
- 3) **Plasma photocathodes**
- 4) **Plasma-based metrology and diagnostics:** e.g. ionisation- / plasma-based detectors
- 5) **Plasma undulators and advanced radiation sources:** e.g. plasma wigglers, betatron radiation, ICS
- 6) **Plasma-based sources and targets**

**Dedicated talk later!**

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*Close connections with:*

- VI. Diagnostics (on plasma-based diagnostics)*
- III. Plasma Components & Systems (on plasma sources)*

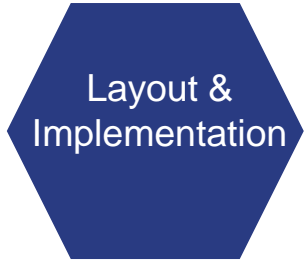
Training,  
Outreach &  
Dissemination

**Raising awareness of EuPRAXIA's research goals and technologies, maximising impact on science and society, promote EuPRAXIA activities for attracting users and collaborators through:**

- 1) Disseminating publications via news, newsletters and social media
- 2) Supporting the organisation of outreach events and providing educational resources for the collaboration to use
- 3) Developing and expanding educational programs & workshops
- 4) Defining a training program for EuPRAXIA users
- 5) Organising workshops for potential and current users

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*Close connections with: VII. Applications (on user training and workshops)  
all partners (on local outreach & public engagement)*



- 1) **Command control system:** design and implementation of control system and control room with local host site groups, integration of laser and accelerator control
- 2) **Data acquisition, analysis and storage:** setup of data infrastructure for operation (with users)
- 3) **Infrastructure:** support with building design, utilities, ventilation, heating, air conditioning, electrical power distribution, etc. for EuPRAXIA sites, vacuum system design, support laboratories and infrastructure for commissioning
- 4) **Safety infrastructure:** support with design & implementation of interlock and access systems, safety procedures for users, radiation safety and monitoring, study of em-effects on instrumentation

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*Close connections with: 1. Theory & Simulation (on data analysis & storage)  
local technical groups at host sites*

- Clusters as a good structure to continue work after end of design study and coordinate studies towards technical design
- Some clusters more self-organised than others
- We currently have an outline of clusters by topic, but details and clear responsibilities are still missing
- **Open points:**
  - In how far should the cluster structure be formalised through a future consortium agreement?
  - Should we aim for common funding or short-term individual funding efforts?
  - How can we organise clusters better with lead partners, deliverables, roadmaps, etc.?

**QUESTIONS? COMMENTS?**

## 16 Participants



## 25 Associated Partners

(as of December 2018)

