

EUROPEAN  
PLASMA RESEARCH  
ACCELERATOR WITH  
EXCELLENCE IN  
APPLICATIONS

*EuPRAXIA PP Technical Review Meeting  
July 15, 2025*



# WP16: EuPRAXIA @ ELI-ERIC TDR current status

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# PP-WP16: EuPRAXIA @ ELI Beamlines TDR

## Current status (Phase-1)

### WP16 in collaboration with WP1&WP3

#### Objectives:

- Evaluation of requirements for potential site of Laser-Driven EuPRAXIA pillar
- Evaluation of a readiness of candidates to accommodate the Laser-Driven EuPRAXIA pillar
- Identification of a site for Laser-Driven EuPRAXIA pillar
- Identification of possible funding resources for the technical realization of the Project
  - Financial Board of Sponsors for guidance on science-political, funding aspects

DONE

DONE

→ M16

DONE

→ March 25, 2025

IN PROGRESS

Now: m32



Start: 11.01.2022	m6	m12	m16	m18	m20	m24	m28	m32	m38	m42
WP16			M16				D16.1		D16.2	

**M16** – Milestone report: Review of candidates sites proposals

→ DONE

**D16.1** - Update on EuPRAXIA plans for selected 2<sup>nd</sup> site (LD-based EuPRAXIA)

→ DONE

**D16.2** - Report on TDR status for the 2<sup>nd</sup> site (LD-based EuPRAXIA)

→ Apr.2026

### LPA-based site SELECTION Process (3 candidates: ELI Beamlines, EPAC,CNR)

#### Bid books and the review panel discussions (WP1+WP3+WP16)

	WHEN		WHAT
3 bid books are submitted	Dec.20, 2024	√	Submission
Review panel meeting 1	Jan.17, 2025	√	Bid book presentations
Review panel meeting 2	Jan.29, 2025	√	Q&A
Review panel meeting 3	Feb.21, 2025	√	Recommendation for CB
Addition review panel meeting	March 21, 2025	√	Recommendation for CB
Consortium Board Meeting	March 25, 2025	√	Voting



March 25, 2025

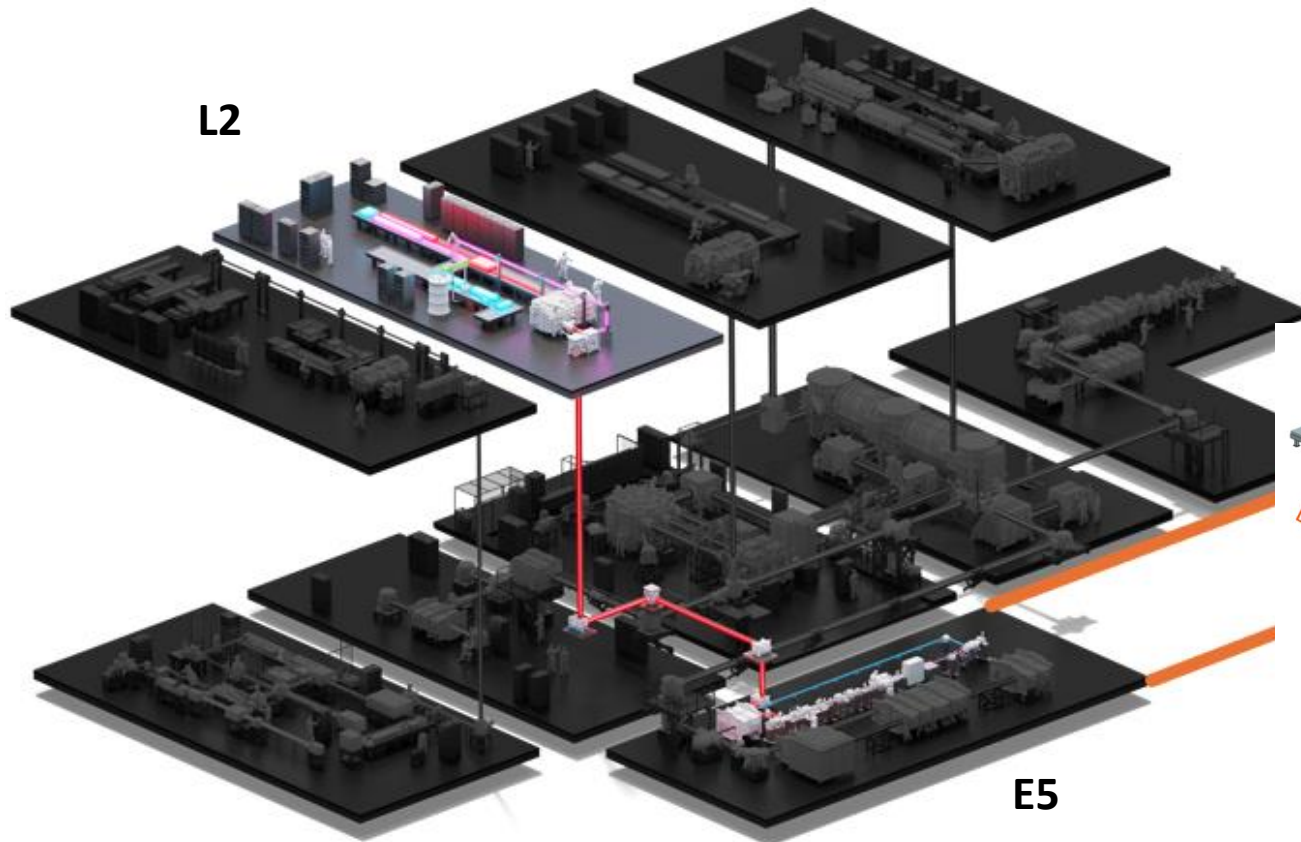


- Adopt the **ELI Beamlines** facility (part of ELI ERIC) as **EuPRAXIA's second user site**. It will be the pillar for a laser driven, plasma-based Free-Electron Laser for users, in accordance with the EuPRAXIA CDR and ESFRI applications. **The facility will launch with an initial stage operating at 1 GeV electron beam energy (EuPRAXIA Phase-1)**
- Support **EPAC's** proposal to act as the **EuPRAXIA Centre for R&D on a 5 GeV electron beam** that is produced in a compact laser-plasma accelerator and that has sufficient beam quality for the FEL application.
- Support **CNR-INO** as the **EuPRAXIA National Node in Italy for Laser R&D**, as a test facility and as an additional formal link between the two EuPRAXIA pillars in Italy and Czech Republic.

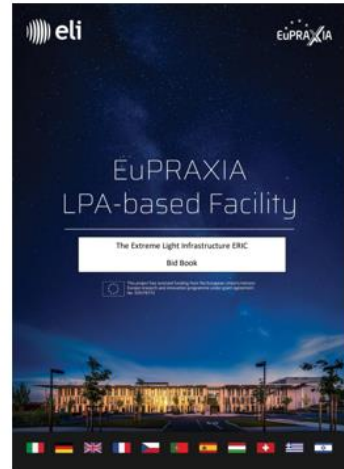
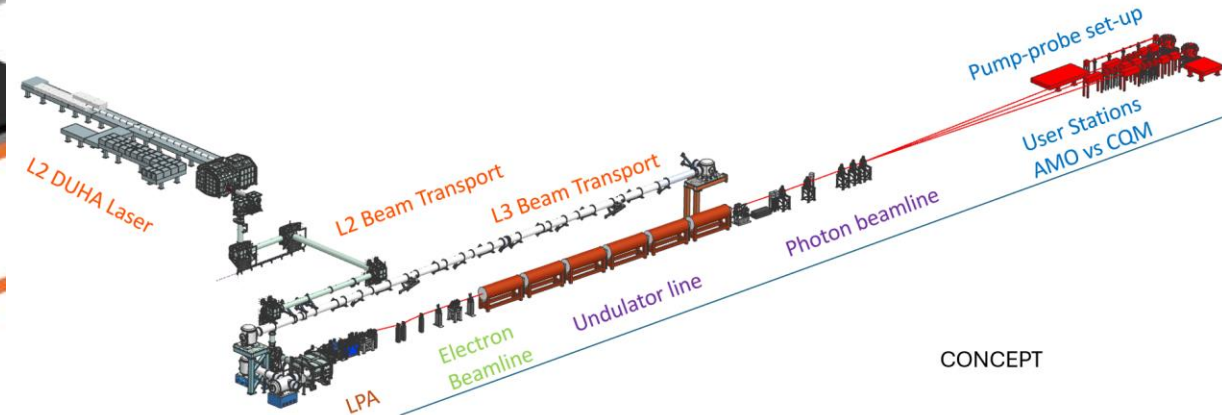
1GeV electron LPA scheme

Subject of the ELI Beamlines bid-book

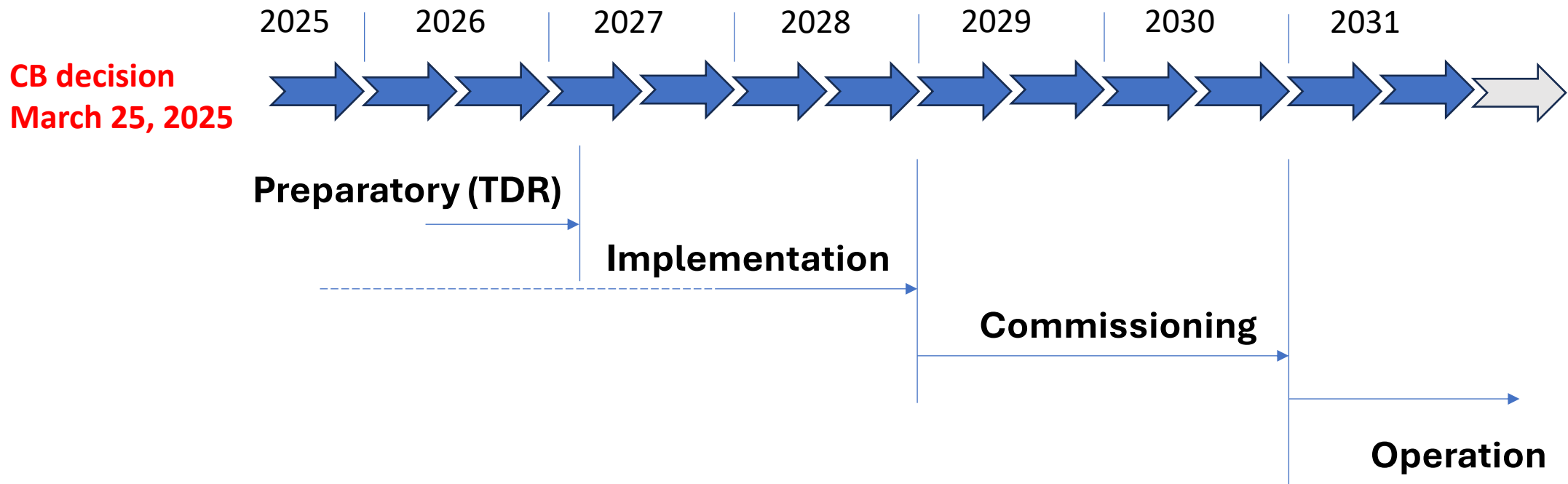
Existing infrastructure



Conceptual solution for Phase-1,  
Integrated into the ELI Beamlines  
infrastructure



## Timescale of the Project (Phase-1) at ELI Beamlines → presented in the bid-book





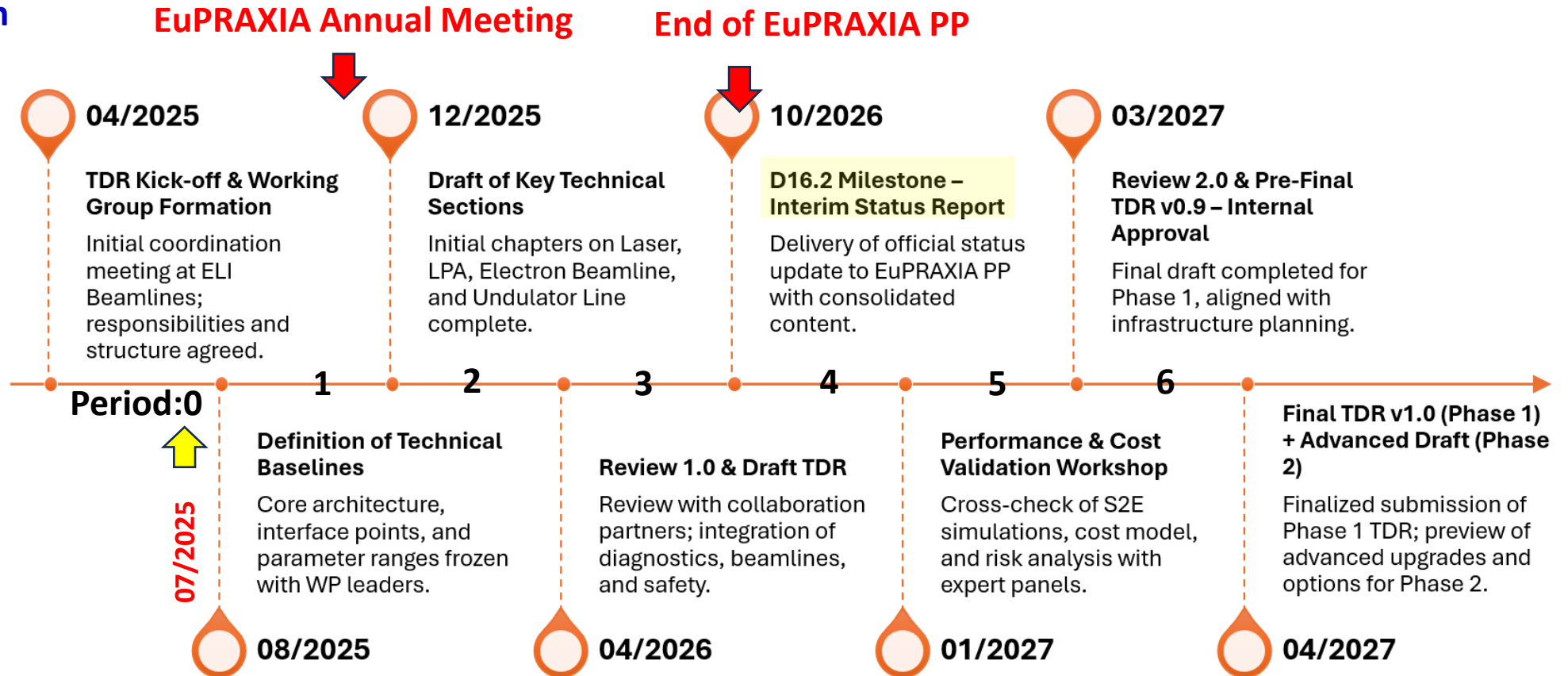
## TDR Timeline for ELI Beamlines

**EuPRAXIA CB decision**  
**March 25, 2025**

**1<sup>st</sup> INFN-ELI meeting**  
**May 15, 2025**

**Assignment of  
the INTERNAL team  
and Project Office**  
**→ August 2025**

**TDR Collaboration &  
Contributions**  
**1<sup>st</sup> online meeting:**  
**→ July 17, 2025**



## TDR PROJECT submitted to ELI Beamlines MB: 2025 (2<sup>nd</sup> half) – 2026 → In order to allocate internal resources

### Executive Summary

This project aims to develop a compact Free Electron Laser (FEL) system driven by a laser-plasma accelerator (LPA) to generate soft X-ray radiation for cutting-edge scientific and industrial applications. It is divided into two main phases:

- **Stage I:** Preparation of a Technical Design Report (TDR), including full system simulations, engineering layouts, and integration planning
- **Stage II - Implementation:** Prototyping of key subsystems and preparatory infrastructure adaptation within existing experimental halls (E5, E6) at ELI Beamlines

**The project is led by ELI Beamlines in collaboration with EuPRAXIA partners**, including European National and Thematic Nodes, leveraging Europe's top expertise in compact accelerator-based light sources.

## PROJECT execution strategy (duration: 18 months from team assignment)

### Phased Work Plan

Phase	Months	Key Outputs
I. Preparatory Phase	1–3	Requirements collected, TRL assessed, feasibility confirmed
II. Prototyping Key Components	3–9	Subsystems tested and benchmarked
III. Technical Design	6–12	Engineering models and integration schemes
IV. Drafting the TDR	12–15	Full report prepared
V. Review & <u>Finalisation</u>	16–18	Reviewed and approved TDR

### Milestones (Check points → Every 3 Months)

Month	Milestone	Checkpoint
M3	Preparatory Phase Complete	C1: TRLs defined, simulations validated
M6	Prototypes in Progress	C2: Conceptual design input gathered
M9	Design Ready	C3: Final engineering updates complete
M12	Design Finalized	C4: Integration model frozen
M15	Draft TDR Submitted	C5: Under review
M18	Final TDR Approved	C6: Project documentation completed

### Timeline and Milestones

Time line	Preparatory	Prototyping	Technical Design	Drafting TDR	TDR Review Finalization	Realization	CTL
M1							
M2							
M3							C1
M4							
M5							
M6							C2
M7							
M8							
M9							C3
M10							
M11							
M12							C4
M13							
M14							
M15							C5
M16							
M17							
M18							C6
M19							
M20							
+++							

D16.2

TDR

## PROJECT risk assessment

Risk Area	Description	Mitigation Strategy
Low TRL Subsystems	Initial TRL 3-4	Raise to >8 via early prototyping
Infrastructure Readiness	E5/E6 halls may need adaptation	Early modelling and facility planning
Simulation-Experiment Gap	Discrepancies between models and reality	Empirical validation and benchmarking
In-kind Contributions	Risk of uneven partner engagement	Formalize through <u>MoUs</u> , and tight coordination
Timeline Pressure	Overlaps or delays	Regular milestone reviews, buffer time

### TRL Assessment Summary

Subsystem	TRL Estimate	Actions to Reach TRL >8	Timeframe
High-Power Laser (L2)	3-4	<u>Demonstration</u> of required parameters, stabilization, timing sync improvements	Month 0-6
LPA Injector	3-4	Test prototype, beam quality tuning	Months 3-9
Electron Beam Transport	5-6	Optics design and validation	Months 6-12
Undulator Module	7	Short module prototype, field tuning	Months 6-12
Soft X-ray Diagnostics	7	Integration, resolution testing	Months 9-15
Control & Synchronization	7	Timing system integration	Months 6-15
Infrastructure (E5/E6)	7	Utility/shielding adaptations	Months 6-18

TRL LEVEL	TRL Description
TRL 1	Basic principles observed – Scientific research begins to be translated into applied research and development (R&D).
TRL 2	Technology concept formulated – The basic principles are explored and practical applications are identified.
TRL 3	Experimental proof of concept – Active R&D is initiated, including analytical and laboratory studies to validate predictions.
TRL 4	Technology validated in lab – Basic technological components are integrated to establish that they work together.
TRL 5	Technology validated in relevant environment – The technology is tested in a simulated or relevant environment
TRL 6	Technology demonstrated in relevant environment – A prototype system is tested in an environment similar to the operational one.
TRL 7	System prototype demonstration in operational environment – A working prototype is demonstrated in a real operational setting.
TRL 8	System complete and qualified – The technology is proven to work in its final form and under expected conditions.
TRL 9	Actual system proven in operational environment – The technology is fully commercialized and operational in its intended setting.

## ELI Beamlines

- 21 experts, 4 FTE for 18 months (TDR phase)
- **Expertise:** lasers, plasma acceleration, electron beam transport, FEL physics, diagnostics, integration, safety, control system and DAQ, project management

## EuPRAXIA and PACRI Partner Contributions

Organized via National and Thematic Nodes, and the PACRI framework:

- **German:** LPA, beam transport, undulators, photon beam transport, control systems, user ops
- **French:** LPA, beam transport, subsystem integration
- **UK:** Laser systems, high-energy accelerator dev, diagnostics
- **Italian:** Laser development, undulator line design, diagnostics
- **Portugal:** LPA modeling, AI/ML tools, plasma source prototyping
- **Thematic Nodes:** dedicated packages
- **PACRI partners:** Plasma module design and prototyping; High repetition rate 100TW-class laser development at ELI Beamlines

## Team & Expertise

**TDR Collaboration: National Nodes & Contributions**  
**1<sup>st</sup> online meeting: July 17, 2025**

## LPA-based FEL / TDR structure ... aligned with INFN-LNF TDR

### Activated already

#### Executive Summary

#### Laser (L2-DUHA) and Laser Diagnostics



ELI /STFC

#### Laser-Plasma e-Accelerator (modelling /plasma source prototyping ) and Plasma Diagnostics



ELI/IST/CNSR/STFC

#### Electron Beam Transport and Relevant Diagnostics



ELI/PSI

#### Undulator Line and FEL performance



ELI/ENEA

#### Photon Beam Transport and Relevant Diagnostics



ELI/DESY(FLASH)

#### User End-Stations



ELI/DESY(FLASH)

#### Safety system

#### Control and DAQ systems

#### Infrastructure (E5+E6) and Technology Integration (3D model)



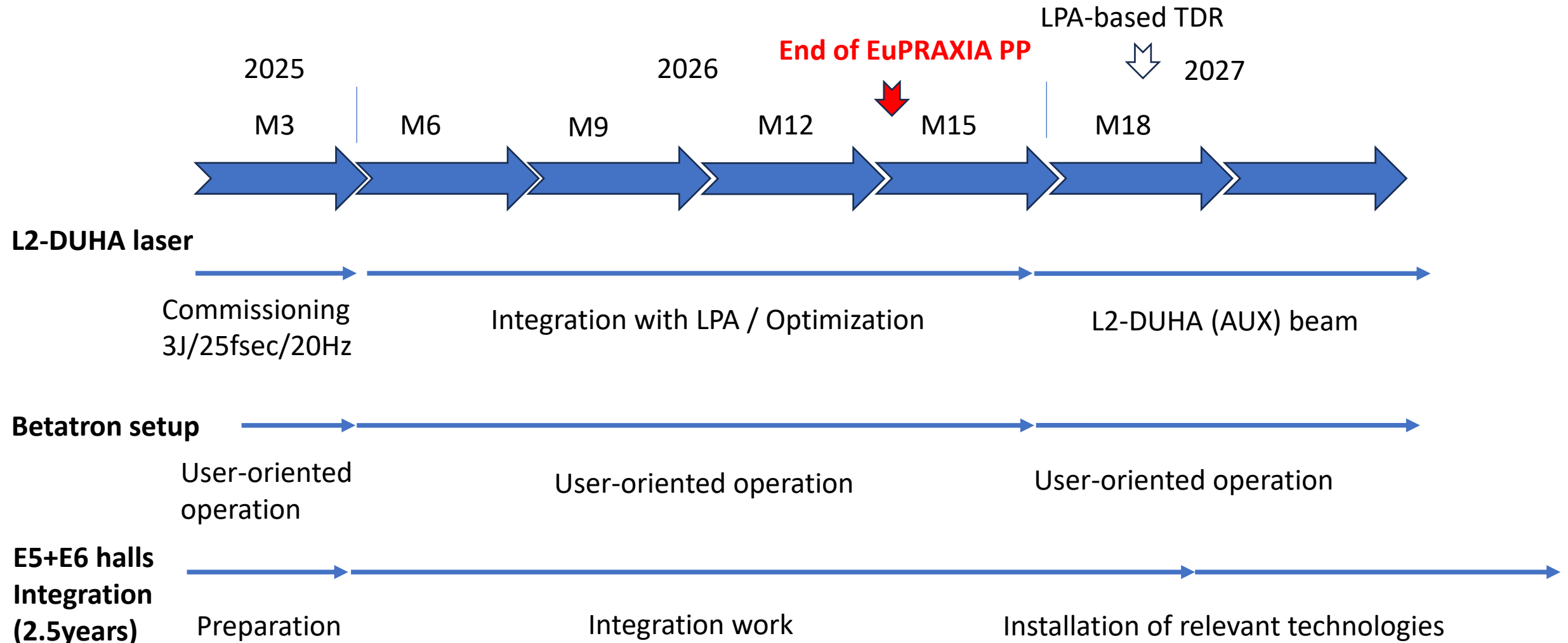
## Implementation phase

- Novel laser system development (L2-DUHA): aiming 5J/25fsec/100Hz
- Betatron setup (E2-hall)
- Infrastructure integration (E5+E6)

**Secure the required budget through the ELI ERIC R&D budget and PACRI.**

- ☐ R&D projects dedicated to the Implementation phase are submitted
- ☐ Assignment of the budget → by November 2025

## Timeline for Implementation phase (18M)



## Implementation / CURRENT status (July 2025)

**L2-DUHA laser system:** UNDER preparation to be commissioned by the end of 2025

**BETATRON** (Gammatron) setup (E2-hall): open for user calls

**E5+E6 integration:** preparation in progress

**Prototyping** of the key sub-systems is in progress

- Both phases of the TDR-oriented Project (Preparation and Implementation) are in progress at ELI Beamlines following the Project timeline.
- Collaboration is being established through the EuPRAXIA PP structure, which will focus on the ELI Beamlines TDR project. This initiative should include additional funding for the early prototyping of key subsystems to attain an acceptable technology readiness level (TRL) for the project's full realization.