EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

cnrs GDR SCIPAC
SCIences of Particle ACcelerators

EuPRAXIA
Preparatory Phase

EuPRAXIA

Journée du GDR SCIPAC
18/12/2024 CEA Saclay

Arnd Specka

Laboratoire Leprince-Ringuet, École polytechnique, Palaiseau

based on presentations by **R. Assmann** (GSI), **Massimo Ferrario** (INFN), Pierluigi Campana (INFN) , Antonio Falone (INFN)

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

A New European High-Tech User Facility

Funded by the European Union

1

Building a facility with very high field plasma accelerators, driven by lasers or beams
1 – 100 GV/m accelerating field

Shrink down the facility size

Improve Sustainability

2

Producing particles and photons to support several urgent and timely science cases

Drive short wavelength FEL

Pave the way for future Linear Colliders

FEATURE EuPRAXIA

A Martinez de la Ossa/DESY

Surf's up *Simulation of electron-driven plasma wakefield acceleration, showing the drive electron beam (orange/purple), the plasma electron wake (grey) and wakefield-ionised electrons forming a witness beam (orange).*

EUROPE TARGETS A USER FACILITY FOR PLASMA ACCELERATION

Ralph Assmann, Massimo Ferrario and Carsten Welsch describe the status of the ESFRI project EuPRAXIA, which aims to develop the first dedicated research infrastructure based on novel plasma-acceleration concepts.

Energetic beams of particles are used to explore the fundamental forces of nature, produce known and unknown particles such as the Higgs boson at the LHC, and generate new forms of matter, for example at the future FAIR facility. Photon science also relies on particle beams: electron beams that emit pulses of intense synchrotron light, including soft and hard X-rays, in either circular or linear machines. Such light sources enable time-resolved measurements of biological, chemical and physical structures on the molecular down to the atomic scale, allowing a diverse global community of users to investigate systems ranging from viruses and bacteria to materials science, planetary science, environmental science, nanotechnology and archaeology. Last but not least, particle beams for industry and health support many societal applications ranging from the X-ray inspection of cargo containers to food sterilisation, and from chip manufacturing to cancer therapy.

This scientific success story has been made possible through a continuous cycle of innovation in the physics and technology of particle accelerators, driven for many decades by exploratory research in nuclear and particle physics. The invention of radio-frequency (RF) technology in the 1920s opened the path to an energy gain of several tens of MeV per metre. Very-high-energy accelerators were constructed with RF technology, entering the GeV and finally the TeV energy scales at the Tevatron and the LHC. New collision schemes were developed, for example the mini "beta squeeze" in the 1970s, advancing luminosity and collision rates by orders of magnitudes. The invention of stochastic cooling at CERN enabled the discovery of the W and Z bosons 40 years ago.

However, intrinsic technological and conceptual limits mean that the size and cost of RF-based particle accelerators are increasing as researchers seek higher beam energies. Colliders for particle physics have reached a

THE AUTHORS
Ralph Assmann *DESY and INFN,* **Massimo Ferrario** *INFN,* **Carsten Welsch** *University of Liverpool/INFN.*

CERN COURIER MAY/JUNE 2023

25

https://www.eupraxia-facility.org/

The EuPRAXIA CDR (2020)

Funded by the European Union

- First ever design of a **plasma accelerator facility**.
- **Conceptual Design Report for a distributed research infrastructure** funded by EU Horizon2020 program. Completed by 16+25 institutes.
- Challenges addressed by EuPRAXIA since 2015:
  - **Can plasma accelerators produce usable electron beams**?
  - **For what can we use those beams** while we increase the beam energy towards HEP and collider usages?
- Next phase consortium, ESFRI: **> 50 institutes**
- Preparatory Phase project: **2022 – 2026** (approved)
- Start of 1st operation: **2029**

http://www.eupraxia-project.eu

The European Physical Journal volume 229 · number 24 · December 2020

EPJ ST

Recognized by European Physical Society

Special Topics

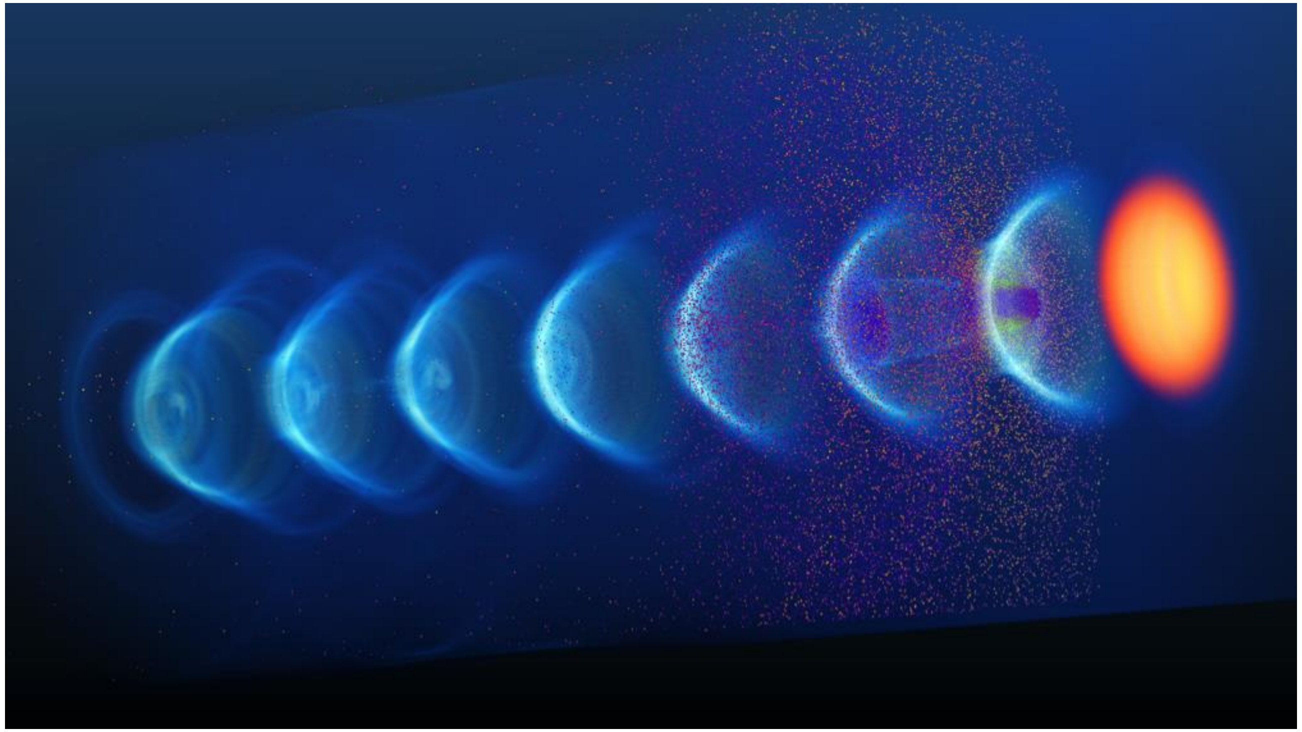
EuPRAXIA Conceptual Design Report

Ralph Assmann and Maria Weikum (Eds.)

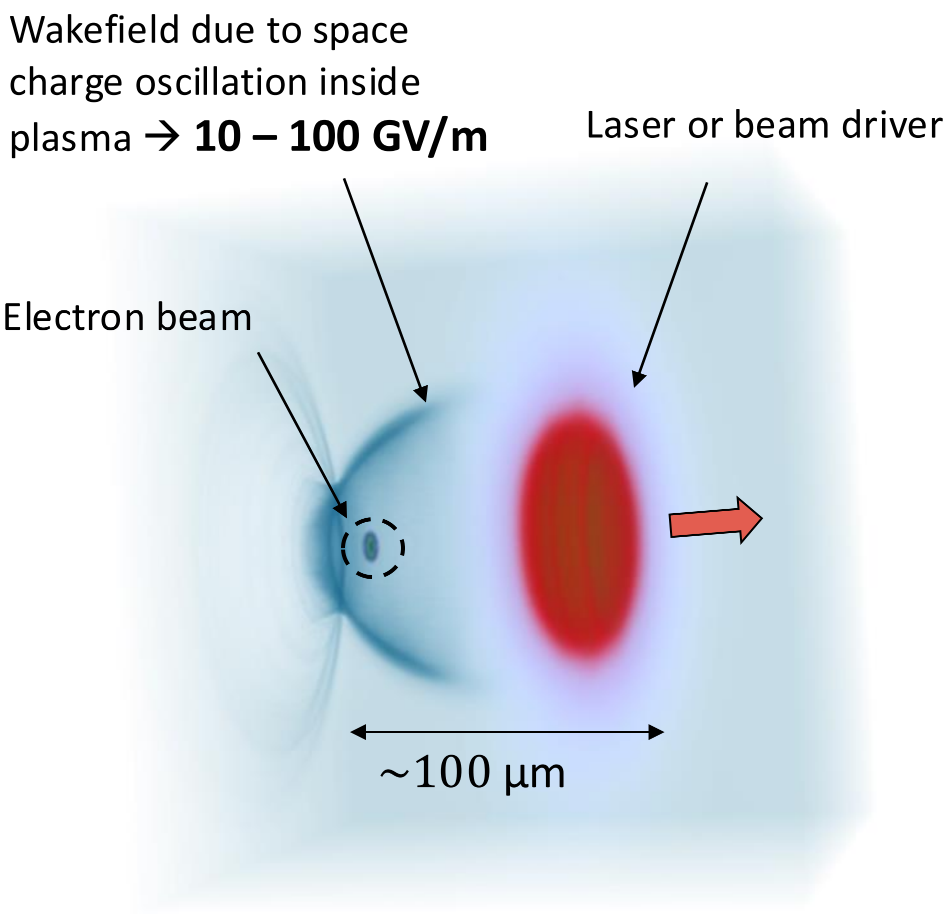
edp sciences Springer

600+ page CDR, 240 scientists contributed

The Plasma Accelerator: The Next Step?



Illustrations from A. Ferran Pousa



Wakefield due to space charge oscillation inside plasma → **10 – 100 GV/m**

Laser or beam driver

Electron beam

Very strong fields can be produced in plasmas and we know how to construct a particle accelerator with them (idea of Tajima & Dawson 1979). **A 1 TeV collider in 10-100 meters?** Not so easy...

Basic beam quality achieved in pilot FEL experiments

Funded by the European Union

2021 Plasma FEL Feasibility Proven: Laser-driven

Horizon Europe

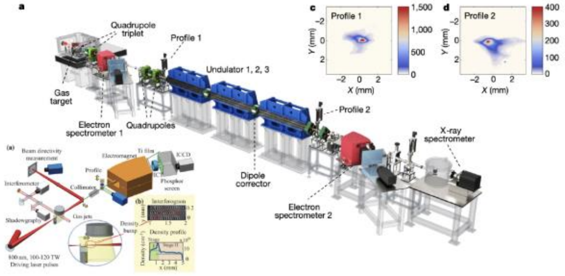
The international journal of science / 22 July 2021

nature

COMPACT SOURCE

Plasma-based acceleration paves way to smaller free-electron lasers

W. T. Wang, K. Feng, *et al.*, *Nature*, **595**, 561 (2021).



Recent ground-breaking result in China

500 MeV electron beam from a laser wakefield accelerator

FEL lasing **amplification of 100** reached at 27 nm wavelength (average radiation energy 70 nJ, peak up to 150 nJ)

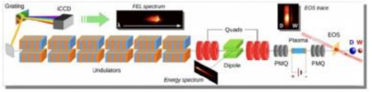
2021 Plasma FEL Feasibility Proven: Electron-driven

Horizon Europe

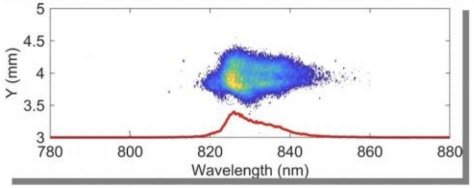
Recent ground-breaking results in Frascati:

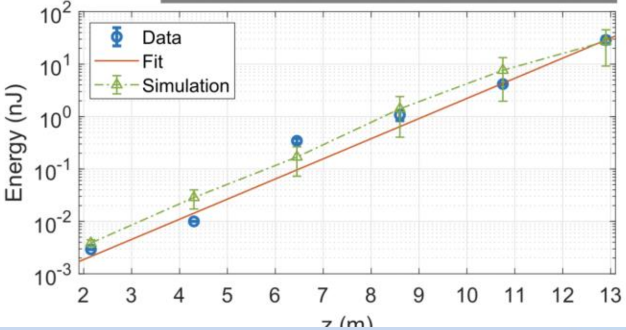
First FEL lasing from a beam-driven plasma accelerator

Pompili et al., Nature **605**, 659–662 (2022)

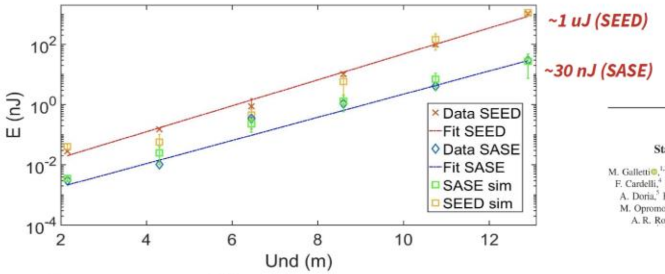


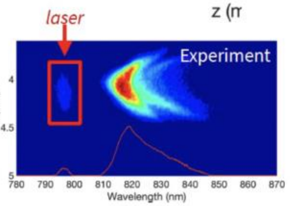
Single Spike SASE spectrum

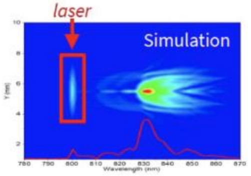




First Beam Driven SEEDED - FEL Lasing at SPARC_LAB (June 2021)







PHYSICAL REVIEW LETTERS **129,** 234801 (2022)

Stable Operation of a Free-Electron Laser Driven by a Plasma Accelerator

M. Galletti,[1,2,3,*] D. Alesini,[4] M. P. Anania,[4] S. Arjmand,[4] M. Behtouei,[4] M. Bellaveglia,[4] A. Biagioni,[4] B. Buonomo,[4] F. Cardelli,[4] M. Carpanese,[5] E. Chiadroni,[4,6] A. Cianchi,[1,2,3] G. Costa,[4] A. Del Dotto,[7] M. Del Giorno,[4] F. Dipace,[4] A. Doria,[5] F. Filippi,[5] G. Franzini,[4] L. Giannessi,[4] A. Giribono,[4] P. Iovine,[8] V. Lollo,[4] A. Mostacci,[6] F. Nguyen,[5] M. Opromolla,[9,10] L. Pellegrino,[4] A. Petralia,[5] V. Petrillo,[9,10] L. Piersanti,[4] G. Di Pirro,[4] R. Pompili,[4] S. Romeo,[4] A. R. Rossi,[10] A. Selce,[5,11] V. Shpakov,[4] A. Stella,[4] C. Vaccarezza,[4] F. Villa,[4] A. Zigler,[4,12] and M. Ferrario[4]

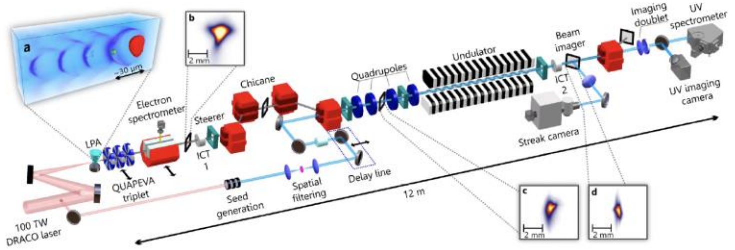
Seeded FEL radiation

- ✓ Pulse energy increased 2 order of magnitude respect to SASE radiation
- ✓ 6% pulse energy RMS fluctuations over 90% of successful shot respect to 17% over 30% of shot for SASE

Seeded UV free-electron laser driven by LWFA

Horizon Europe

Collaboration Soleil/HZ Dresden, published on
Nat. Photon. (2022). https://doi.org/10.1038/s41566-022-01104-w



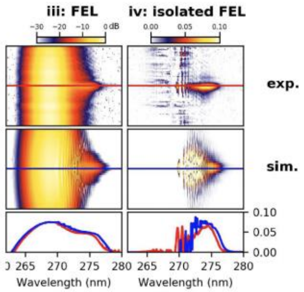


FIG. 1. **Experimental layout.** The electron beam generated in the LPA is first characterized using a removable electron spectrometer and then sent through a triplet of quadrupoles (QUAPEVAs) for beam transport to the undulator and FEL radiation generation. ICTs: Integrated Current Transformers. Non-labelled elements: dipoles (*red blocks*), optical lenses (*blue*), mirrors (*grey circled black disks*). Inset **a**: Particle-in-Cell simulation renders of the accelerating structure driven by the laser pulse (*red*), the electron cavity sheet formed from the plasma medium (*light blue*) is visible in *purple* and the accelerated electron bunch visible in *green*. Insets **b,c,d**: Electron beam transverse distribution measured at LPA exit (**b**), at undulator entrance (**c**) and at undulator exit (**d**).

Intense R&D Program on critical components

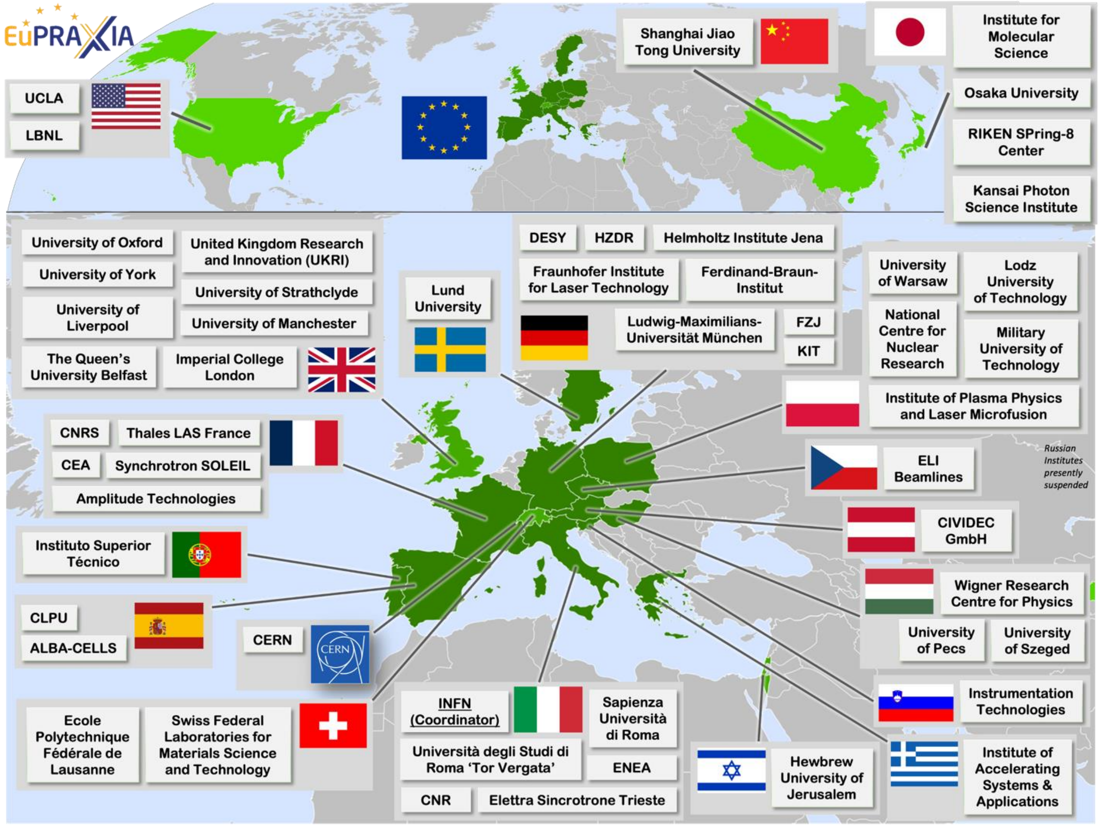
Funded by the European Union

- **Electrons**
  (0.1-5 GeV, 30 pC)
- **Positrons**
  (0.5-10 MeV, 10^{6})
- **Positrons** (GeV source)
- **Lasers**
  (100 J, 50 fs, 10-100 Hz)
- **X-band RF Linac**
  (60 MV/m , up to 400 Hz)
- **Plasma Targets**
- **Betatron X rays**
  (1-10 keV, 10^{10})
- **FEL light**
  (0.2-36 nm, 10^{9}-10^{13})

Wide International Collaboration

Funded by the European Union

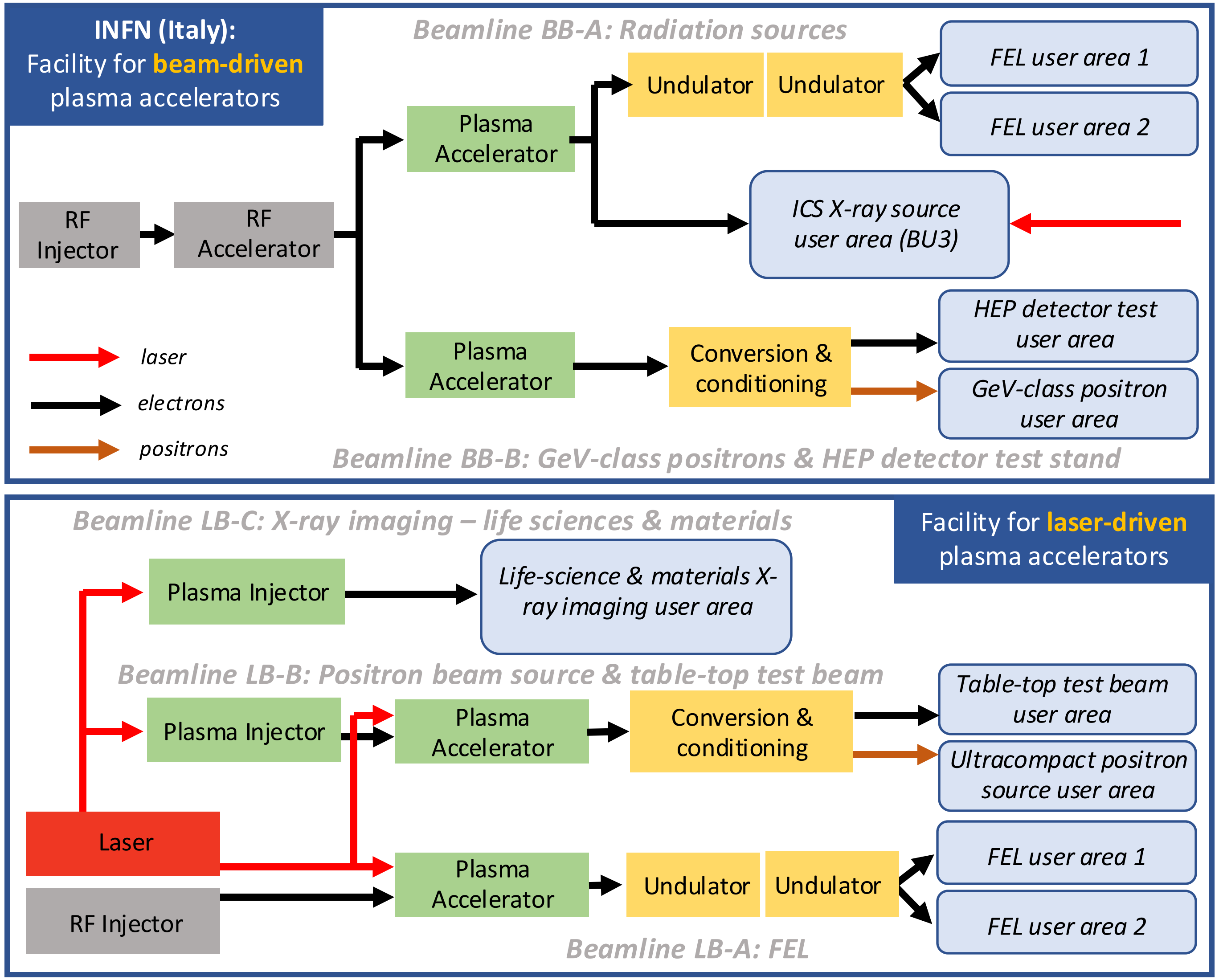
- **The EuPRAXIA Consortium today: 54 institutes** from **18 countries** plus CERN
- Included in the **ESFRI** Road Map
- **Efficient fund raising:**
  - **Preparatory Phase** consortium(2022-26) (funding EU, UK, Switzerland, in-kind)
  - **Doctoral Network** (funding EU, UK, in-kind)
  - **EuPRAXIA@SPARC_LAB** (Italy, in-kind)
  - **EuAPS Project** (Next Generation EU)
  - **PACRI (2025-29)**



Phased Implementation of Construction Sites

Funded by the European Union

	Laser-driven	Beam-driven
Phase 1	✓ FEL beamline to 1 GeV + user area 1 ✓ Ultracompact positron source beamline + positron user area	✓ FEL beamline to 1 GeV + user area 1 ✓ GeV-class positrons beamline + positron user area
Phase 2	✓ X-ray imaging beamline + user area ✓ Table-top test beams user area ✓ FEL user area 2 ✓ FEL to 5 GeV	✓ ICS source beamline + user area ✓ HEP detector tests user area ✓ FEL user area 2 ✓ FEL to 5 GeV
Phase 3	✓ High-field physics beamline / user area ✓ Other future developments	✓ Medical imaging beamline / user area ✓ Other future developments



INFN (Italy):
Facility for **beam-driven** plasma accelerators

Beamline BB-A: Radiation sources

RF Injector
RF Accelerator
Plasma Accelerator
Undulator
Undulator
FEL user area 1
FEL user area 2
ICS X-ray source user area (BU3)
Plasma Accelerator
Conversion & conditioning
HEP detector test user area
GeV-class positron user area

laser
electrons
positrons

Beamline BB-B: GeV-class positrons & HEP detector test stand

Beamline LB-C: X-ray imaging – life sciences & materials

Facility for **laser-driven** plasma accelerators

Plasma Injector
Life-science & materials X-ray imaging user area

Beamline LB-B: Positron beam source & table-top test beam

Plasma Injector
Plasma Accelerator
Conversion & conditioning
Table-top test beam user area
Ultracompact positron source user area

Laser
RF Injector
Plasma Accelerator
Undulator
Undulator
FEL user area 1
FEL user area 2

Beamline LB-A: FEL

EuPraxia Timeline and Rationale

EuPRAXIA
Design Study
2015-19

ESFRI Roadmap
approved VI.2021

EuPRAXIA
PP & DN grants
XI.2022 → XI.2026

EuPRAXIA Consortium
& ESFRI submission
2019 → IX.2020

ESFRI Preparatory
Phase 2021→2026

10 years

Grand design (*R. Assmann et al.*): make EuPRAXIA similar to a HEP-style collaboration, able to setup and manage a Large European Network on advanced particle acceleration technologies (plasma et al.), on lasers and on their industrial and societal applications, thought for academic and industrial users, with two physical sites, and several clusters, *valueing in-kind and cash national contributions*.
Entering ESFRI Roadmap could provide an opportunity to access specific national and EU-based calls for funds.
This design is being throughly pursued from the early Design Phase (2015) to the current Preparatory Phase.

Preparatory Phase Main Goals

Funded by the European Union

- Managerial WP`s
  - **Outreach** to public, users, EU decision makers and industry
  - **Define** legal model (how is EuPRAXIA governed?), financial model, rules, user services and membership extension for full implementation
  - Works with **project bodies and funding agencies** → Board of Financial Sponsors
- Technical WP‘s :
  - **Update of CDR** concepts and parameters, towards technical design (full technical design requires more funding)
  - Specify in detail **Excellence Centers and their required funding**: TDR related R&D, prototyping, contributions to construction
  - Help in defining funding applications for various agencies
- Output defined in **milestones & deliverables** with dates

EuPRAXIA_PP Project Coordinator: Pierluigi Campana (INFN)

Funded by the European Union

Coll. Board
M. Ferrario

Steering Committee

Scientific and Technical Advisory Board

Board of Financial Sponsors

WP1 - Coordination & Project Management
P. Campana, INFN
M. Ferrario, INFN

WP2 - Dissemination and Public Relations
C. Welsch, U Liverpool
S. Bertellii, INFN

WP3 - Organization and Rules
A. Specka, CNRS 🇫🇷
A. Ghigo, INFN

WP4 - Financial & Legal Model. Economic Impact
A. Falone, INFN

WP5 - User Strategy and Services
F. Stellato, U Tor Vergata
E. Principi, ELETTRA

WP6 - Membership Extension Strategy
B. Cros, CNRS 🇫🇷
A. Mostacci, U Sapienza

WP's on coordination & implementation as ESFRI RI (organization, legal model, financing, users)

WP7 - E-Needs and Data Policy
R. Fonseca, IST
S. Pioli, INFN

WP8 - Theory & Simulation
J. Vieria, IST
H. Vincenti, CEA 🇫🇷

WP9 - RF, Magnets & Beamline Components
S. Antipov, DESY
F. Nguyen, ENEA

WP10 - Plasma Components & Systems
K. Cassou, CNRS 🇫🇷
R. Shalloo, DESY

WP11 - Applications
G. Sarri, U Belfast
E. Chiadroni,U Sapienza

WP12 - Laser Technology, Liaison to Industry
L. Gizzi, CNR
P. Crump, FBH

WP13 - Diagnostics
A. Cianchi, U Tor Vergata
R. Ischebeck, EPFL

WP14 - Transformative Innovation Paths
B. Hidding, U Dusseldorf
S. Karsch, LMU

WP15 - TDR EuPRAXIA @SPARC-lab
C. Vaccarezza, INFN
R. Pompili, INFN

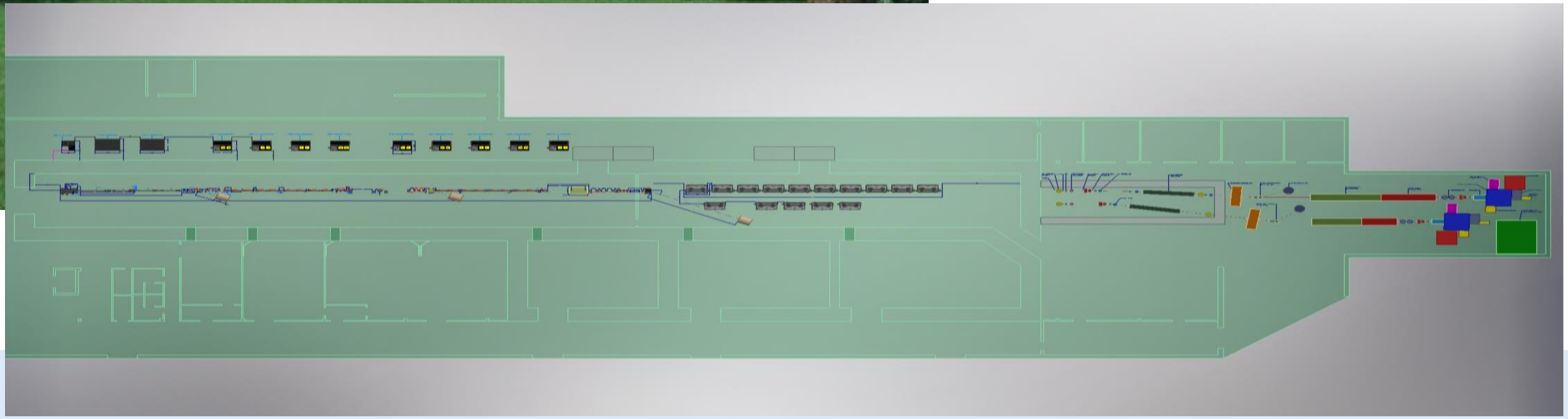
WP16 - TDR EuPRAXIA Site 2
A. Molodozhentsev, ELI-Beamlines
R. Pattahil, STFC

WPs on technical implementation and sites

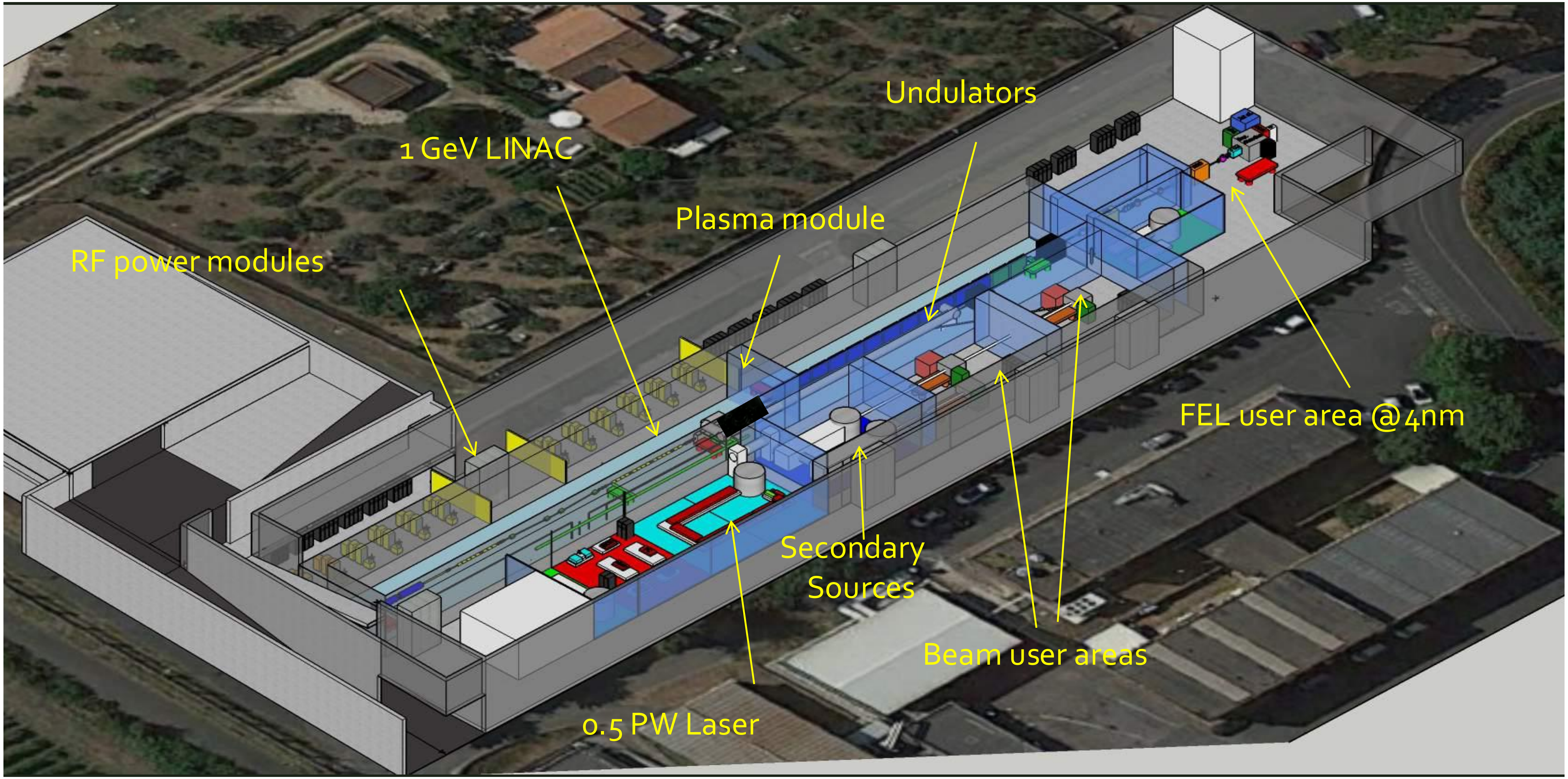
Headquarter and Site 1: EuPRAXIA@SPARC_LAB

Funded by the European Union

- Frascati's future facility
- > 130 M€ invest funding
- Beam-driven plasma accelerator
- Europe's most compact and most southern FEL
- The world`s most compact RF accelerator (X band with CERN)



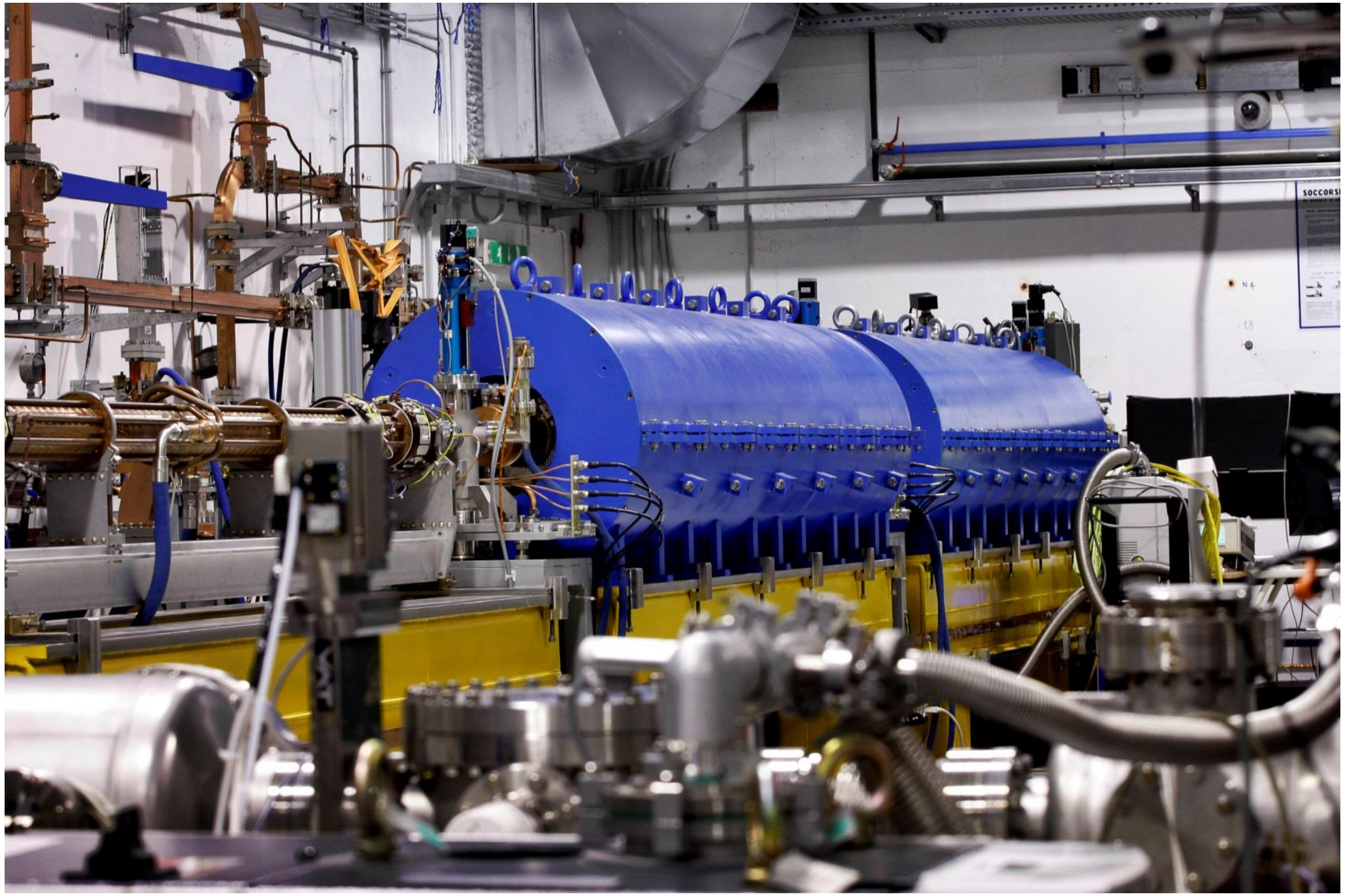
EuPRAXIA@SPARC_LAB



Funded by the European Union

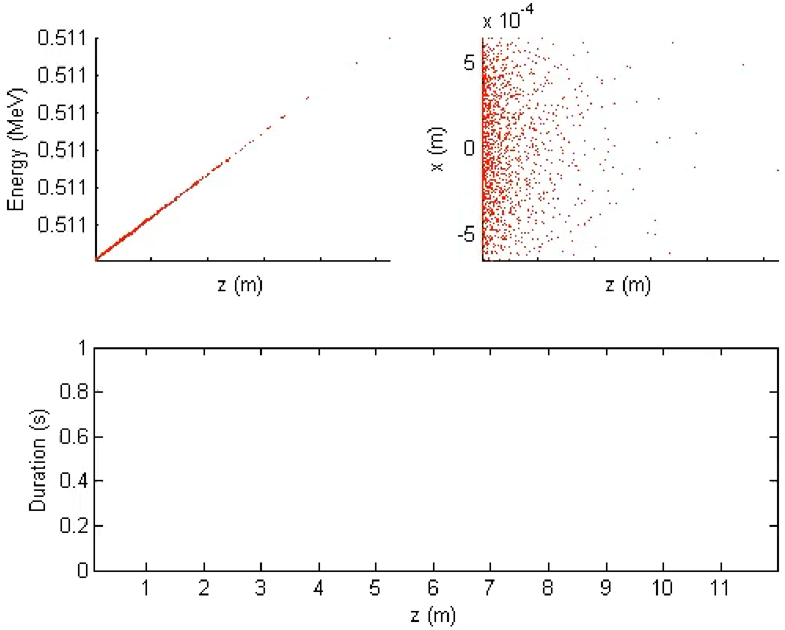
High Quality Electron Beams

Funded by the European Union



Parameter	Unit	Witness	Driver
Charge	pC	30	200
Energy	MeV	101.5	103.2
RMS energy spread	%	0.15	0.67
RMS bunch length	fs	12	20
RMS norm. emittance	mm mrad	0.69	1.95
Rep. rate	Hz	10	10

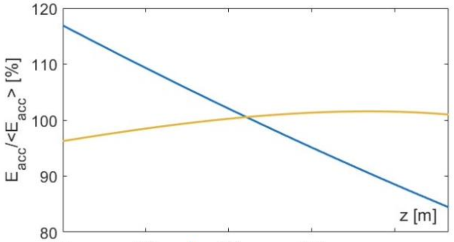
Table 7.2: Driver and witness beam parameters at the end of photo-injector.

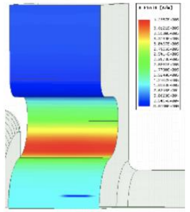


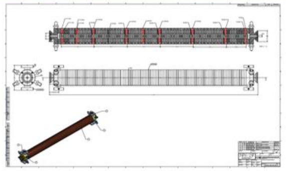
Courtesy E. Chiadroni

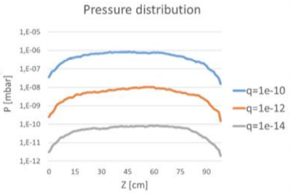
World`s Most Compact RF Linac: X Band

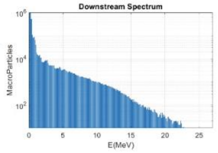
Funded by the European Union





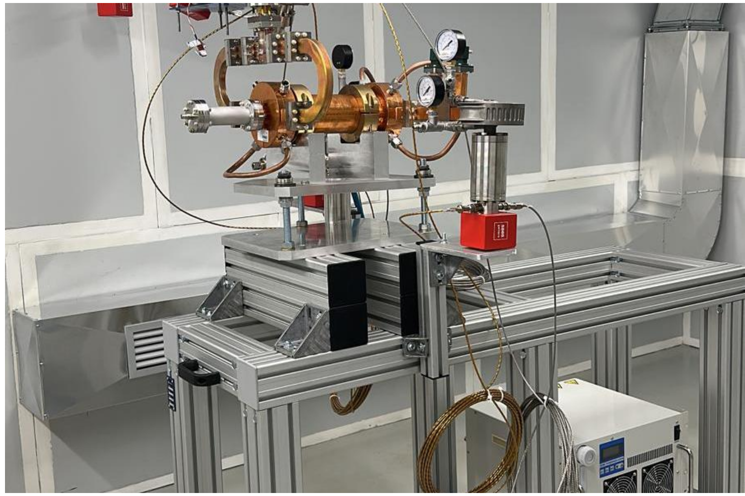




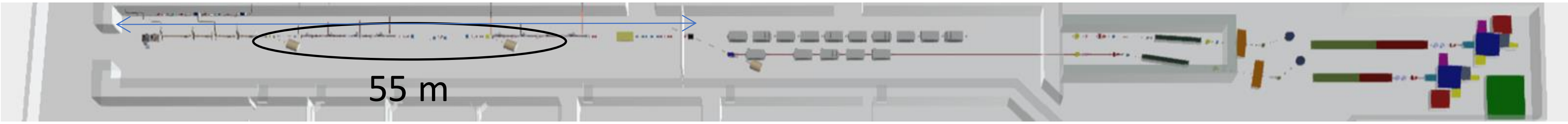


1. **E.m. design**: *done*
2. **Thermo-mechanical analysis**: *done*
3. **Mechanical design**: *done*
4. **Vacuum calculations**: *done*
5. **Dark current simulations**: *done*
6. **Waveguide distribution simulation with attenuation calculations**: *done*

PARAMETER	Value	
	with linear tapering	w/o tapering
Frequency [GHz]	11.9942	
Average acc. gradient [MV/m]	**60**	
Structures per module	2	
Iris radius a [mm]	**3.85-3.15**	**3.5**
Tapering angle [deg]	0.04	0
Struct. length L_s act. Length (flange-to-flange) [m]	**0.94 (1.05)**	
No. of cells	112	
Shunt impedance R [MΩ/m]	93-107	100
Effective shunt Imp. $R_{sh\ eff}$ [MΩ/m]	350	347
Peak input power per structure [MW]	70	
Input power averaged over the pulse [MW]	51	
Average dissipated power [kW]	1	
P_{out}/P_{in} [%]	25	
Filling time [ns]	130	
Peak Modified Poynting Vector [W/μm^2]	3.6	4.3
Peak surface electric field [MV/m]	160	190
Unloaded SLED/BOC Q-factor Q_0	150000	
External SLED/BOC Q-factor Q_E	21300	20700
Required Kly power per module [MW]	**20**	
RF pulse [µs]	**1.5**	
Rep. Rate [Hz]	**100**	

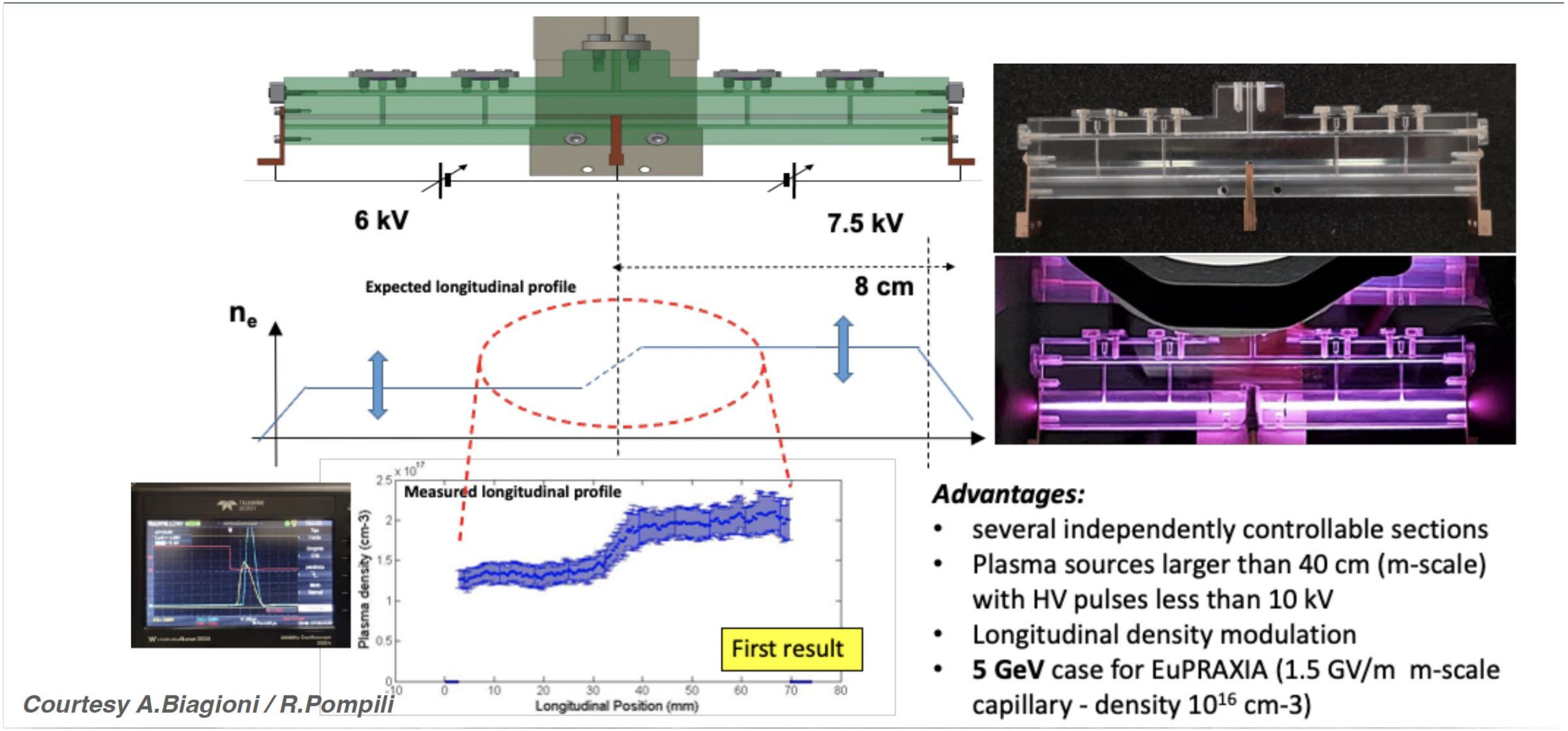


Courtesy D. Alesini



Plasma Module

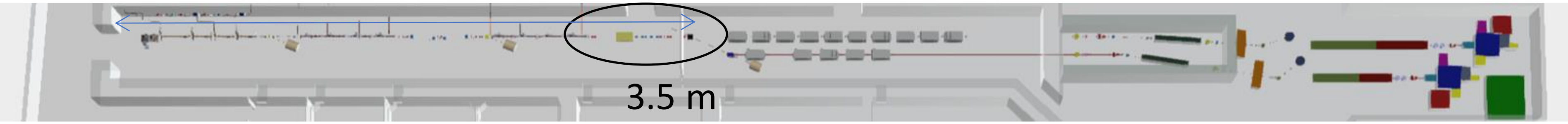
Funded by the European Union



Courtesy A.Biagioni / R.Pompili

Advantages:

- several independently controllable sections
- Plasma sources larger than 40 cm (m-scale) with HV pulses less than 10 kV
- Longitudinal density modulation
- **5 GeV** case for EuPRAXIA (1.5 GV/m m-scale capillary - density 10^{16} cm-3)



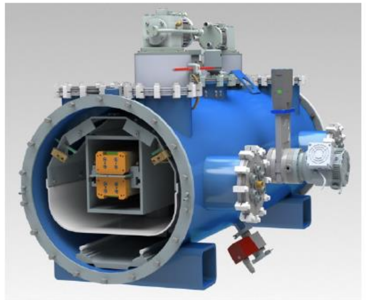
Courtesy A. Biagioni, R. Pompili

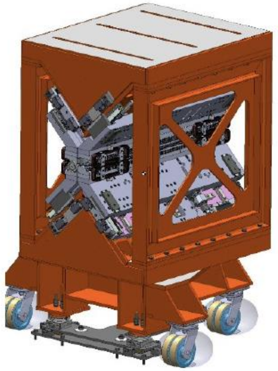
Radiation Generation: FEL

Courtesy L. Giannessi

Two FEL lines:

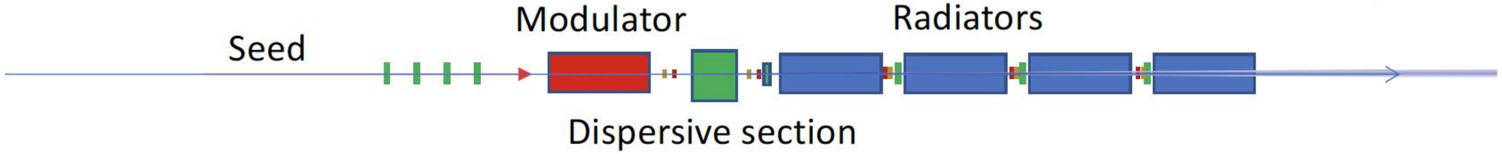
1) *AQUA*: Soft-X ray SASE FEL – Water window optimized for 4 nm (baseline)



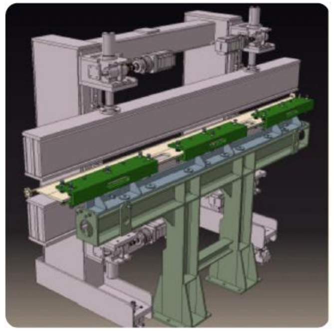


SASE FEL: 10 UM Modules, 2 m each – 60 cm intraundulator sections.
Two technologies under study: Apple-X PMU (baseline) and planar SCU.
Prototyping in progress

2) *ARIA*: VUV seeded HGHG FEL beamline for gas phase

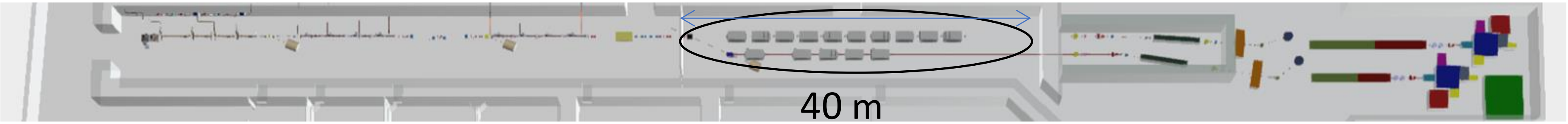


FERMI FEL-1 Radiator



SEEDED FEL – Modulator 3 m + 4 Radiators APPLE II – variable pol. 2.2 m each – SEEDED in the range 50-100 nm (see former presentation to the committee and *Villa et al. ARIA—A VUV Beamline for EuPRAXIA@SPARC_LAB. Condens. Matter 2022, 7, 11.*) – Undulator based on consolidated technology.

Frascati 06/05/23 – EUPRAXIA TDR



Research at EuPRAXIA (Frascati site)

Funded by the European Union

Fundamental research and applications with the EuPRAXIA facility at LNF

4–6 Dec 2024
LNF
Europe/Rome timezone

2nd site candidates (laser-driven PA)


EPAC,Didcot, GB


ELI-Beamlines, Prague, CZc


CNR,Pisa, IT


CLPU,Salamanca, ES

2nd site candidates (laser-driven PA)


EPAC,Didcot, GB


ELI-Beamlines, Prague, CZc

Decision by collaboration targeted in march 2025


CNR,Pisa, IT

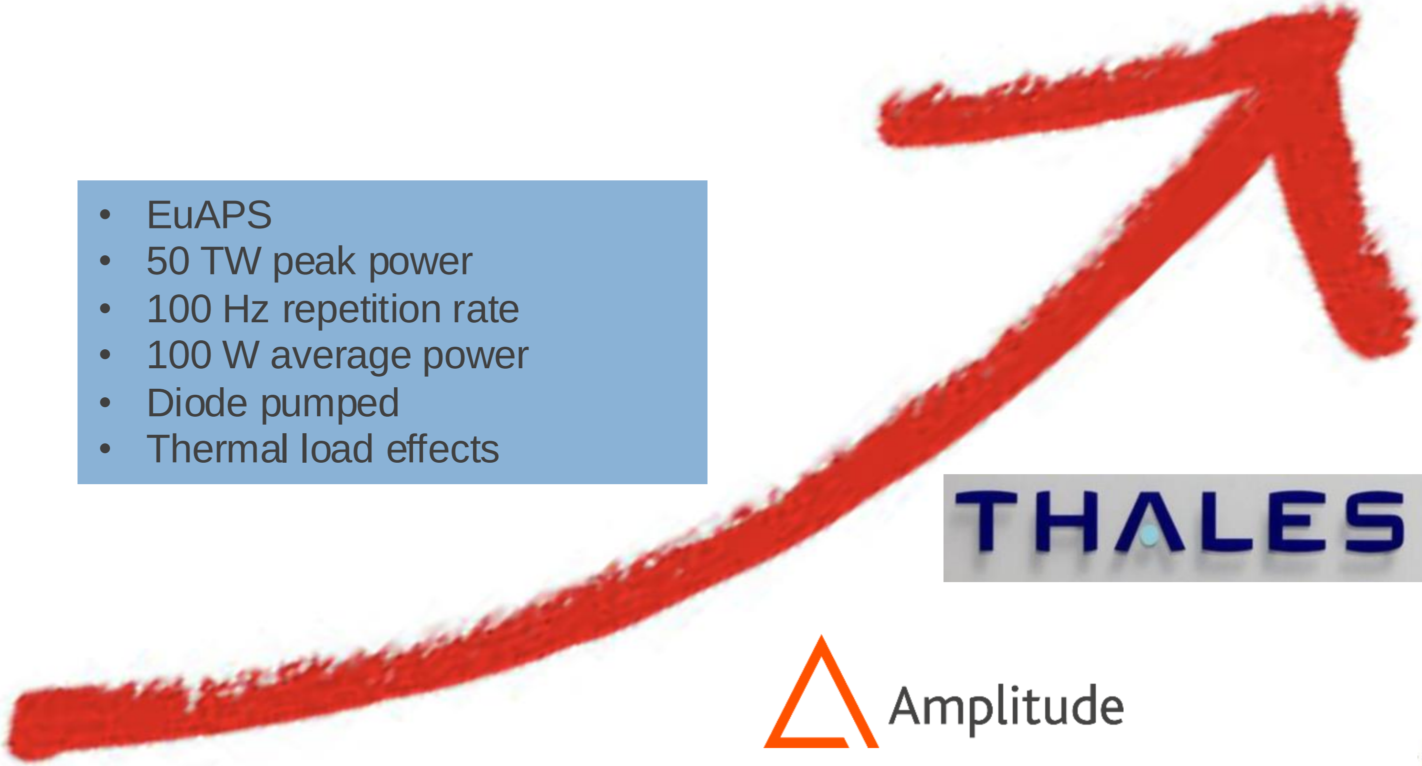

CLPU,Salamanca, ES

Towards EuPRAXIA Laser Specs

- EuPRAXIA
- PW class,
- 100 Hz repetition rate,
- multi kW average power,
- diode pumped
- Full thermal load transport

Eupraxia laser development is aimed at delivering more efficient, kW class PW laser driver for plasma acceleration at >100 Hz rate

EuPRAXIA
Advanced Photon Sources



- EuAPS
- 50 TW peak power
- 100 Hz repetition rate
- 100 W average power
- Diode pumped
- Thermal load effects

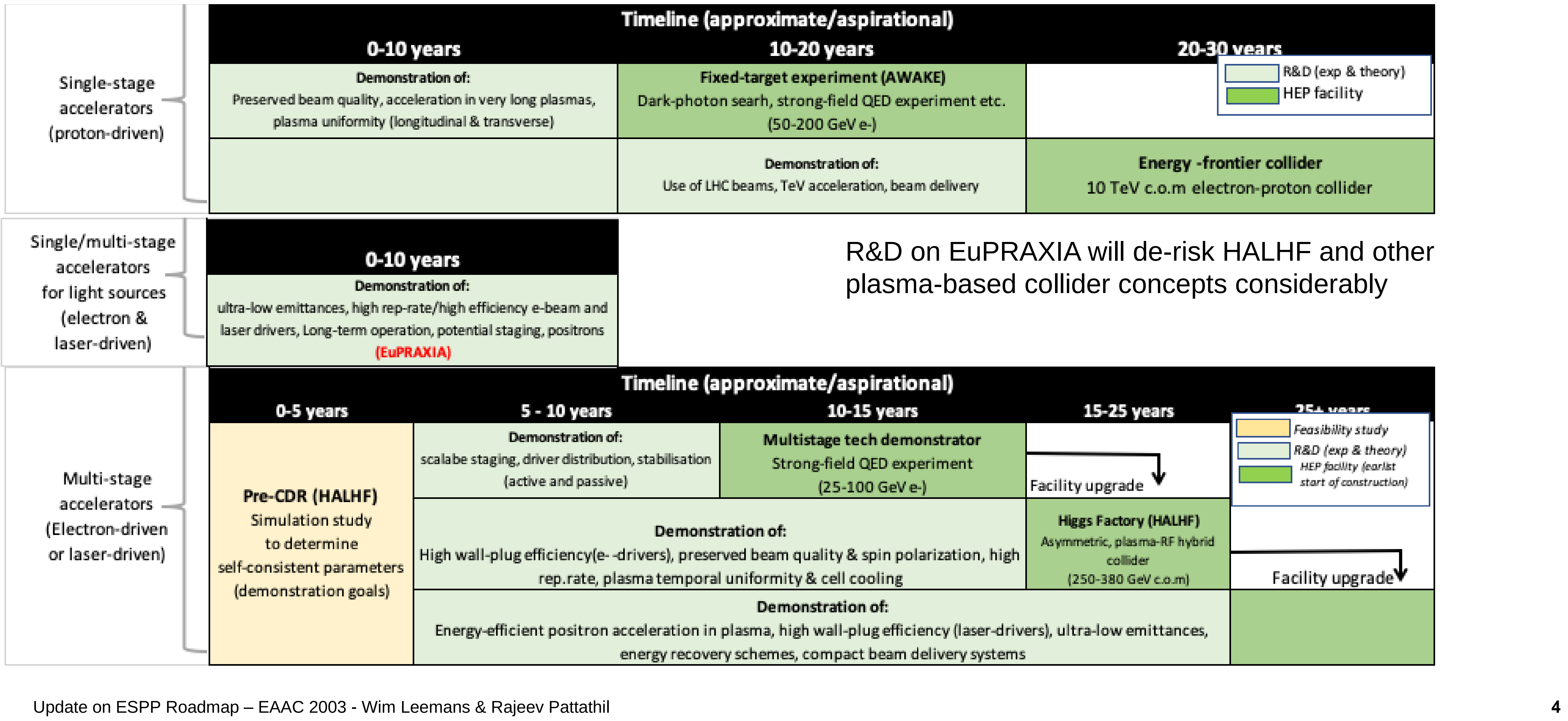
THALES

Amplitude

- CURRENT
- PW class,
- Hz repetition rate,
- ≈10 W average power
- flashlamp pumped
- No thermal load transport

ESPP Roadmap Update – Plasma Accelerators

Funded by the European Union



	Timeline (approximate/aspirational)		
	0-10 years	**10-20 years**	**20-30 years**
Single-stage accelerators (proton-driven)	**Demonstration of:** Preserved beam quality, acceleration in very long plasmas, plasma uniformity (longitudinal & transverse)	**Fixed-target experiment (AWAKE)** Dark-photon searh, strong-field QED experiment etc. (50-200 GeV e-)	
		Demonstration of: Use of LHC beams, TeV acceleration, beam delivery	**Energy -frontier collider** 10 TeV c.o.m electron-proton collider

▭ R&D (exp & theory)
🟩 HEP facility

Single/multi-stage accelerators for light sources (electron & laser-driven)	**0-10 years**
	Demonstration of: ultra-low emittances, high rep-rate/high efficiency e-beam and laser drivers, Long-term operation, potential staging, positrons (EuPRAXIA)

R&D on EuPRAXIA will de-risk HALHF and other plasma-based collider concepts considerably

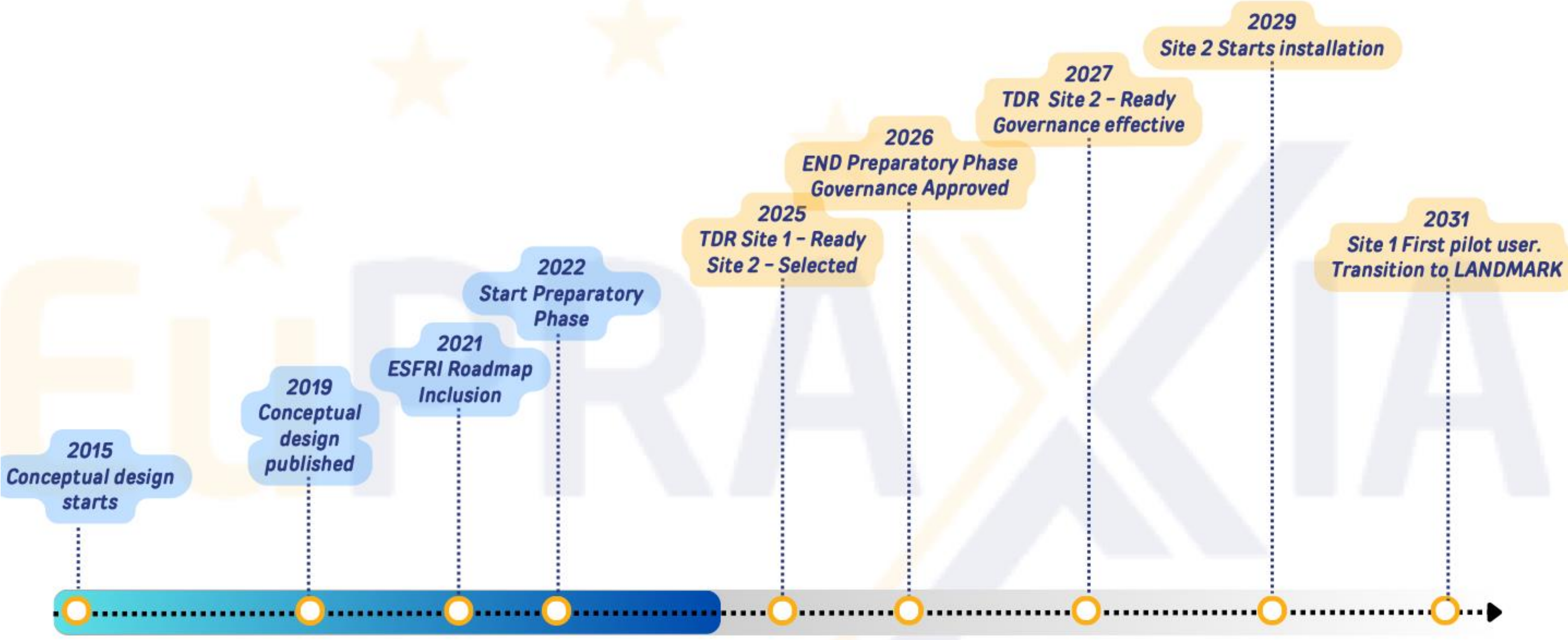
	Timeline (approximate/aspirational)				
	0-5 years	**5 - 10 years**	**10-15 years**	**15-25 years**	**25+ years**
Multi-stage accelerators (Electron-driven or laser-driven)	**Pre-CDR (HALHF)** Simulation study to determine self-consistent parameters (demonstration goals)	**Demonstration of:** scalabe staging, driver distribution, stabilisation (active and passive)	**Multistage tech demonstrator** Strong-field QED experiment (25-100 GeV e-)	Facility upgrade	
		Demonstration of: High wall-plug efficiency(e- -drivers), preserved beam quality & spin polarization, high rep.rate, plasma temporal uniformity & cell cooling		**Higgs Factory (HALHF)** Asymmetric, plasma-RF hybrid collider (250-380 GeV c.o.m)	Facility upgrade
		Demonstration of: Energy-efficient positron acceleration in plasma, high wall-plug efficiency (laser-drivers), ultra-low emittances, energy recovery schemes, compact beam delivery systems			

🟨 *Feasibility study*
▭ *R&D (exp & theory)*
🟩 *HEP facility (earlist start of construction)*

Update on ESPP Roadmap – EAAC 2003 - Wim Leemans & Rajeev Pattathil

4

Timeline



2015
Conceptual design starts

2019
Conceptual design published

2021
ESFRI Roadmap Inclusion

2022
Start Preparatory Phase

2025
TDR Site 1 – Ready
Site 2 – Selected

2026
END Preparatory Phase
Governance Approved

2027
TDR Site 2 – Ready
Governance effective

2029
Site 2 Starts installation

2031
Site 1 First pilot user.
Transition to LANDMARK

EuPRAXIA Consortium Network

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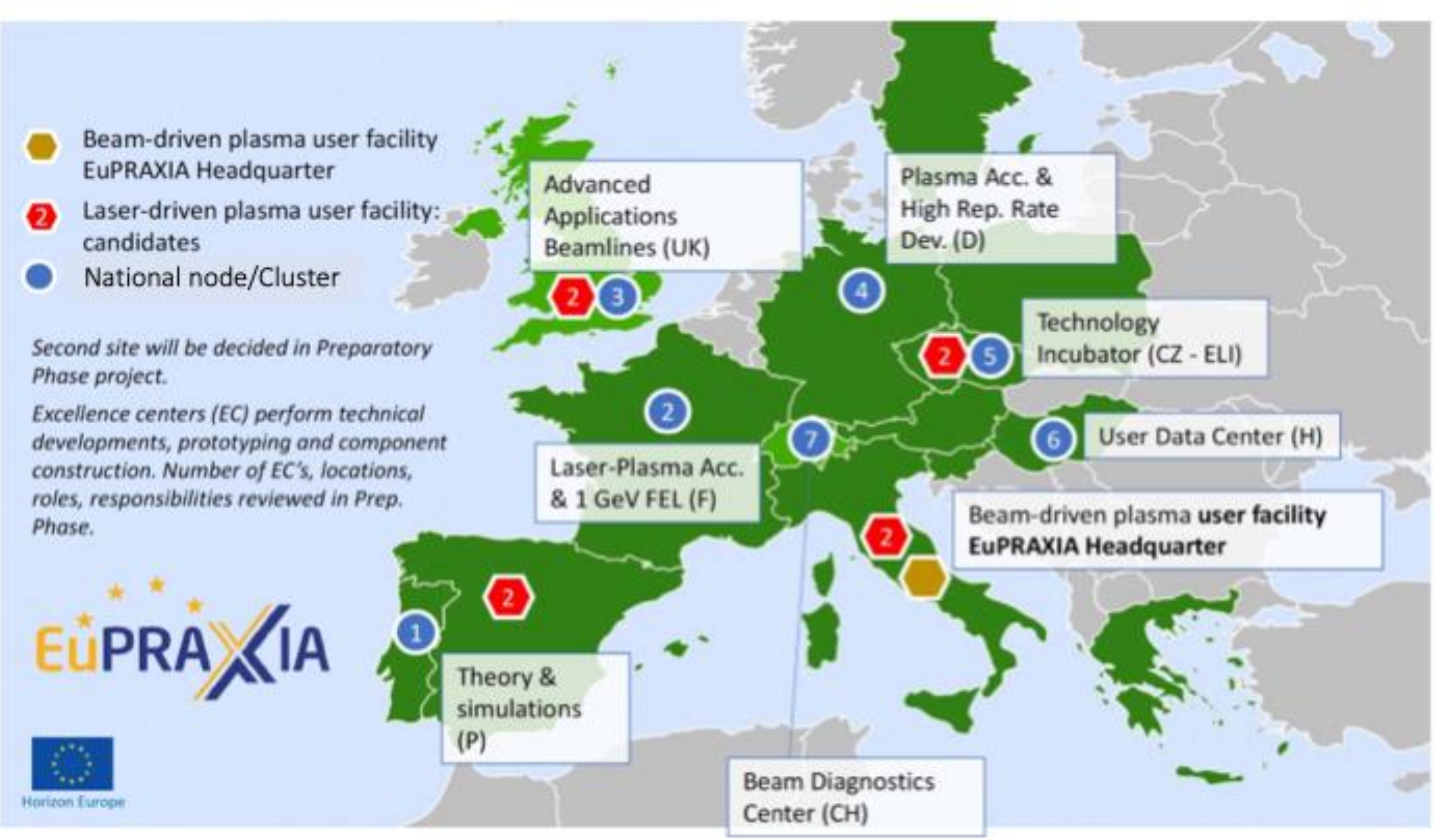


Second site will be decided in Preparatory Phase project.

Excellence centers (EC) perform technical developments, prototyping and component construction. Number of EC's, locations, roles, responsibilities reviewed in Prep. Phase.

A large collection of the best European know-hows in accelerators, lasers plasma technologies

Network organization
- **Sites (PWFA/LWFA)**
- **National nodes**
- **Technology clusters**

4 candidates for LWFA
- CLPU, Salamanca
- CNR-INO, Pisa
- ELI ERIC, Prague
- EPAC-RAL, UK

“Tiered” structure of EuPRAXIA Collaboration

- **Implementation Sites**

  Beam Driven (@LNF) and Laser Driven (to be decided soon)

- **National Nodes**

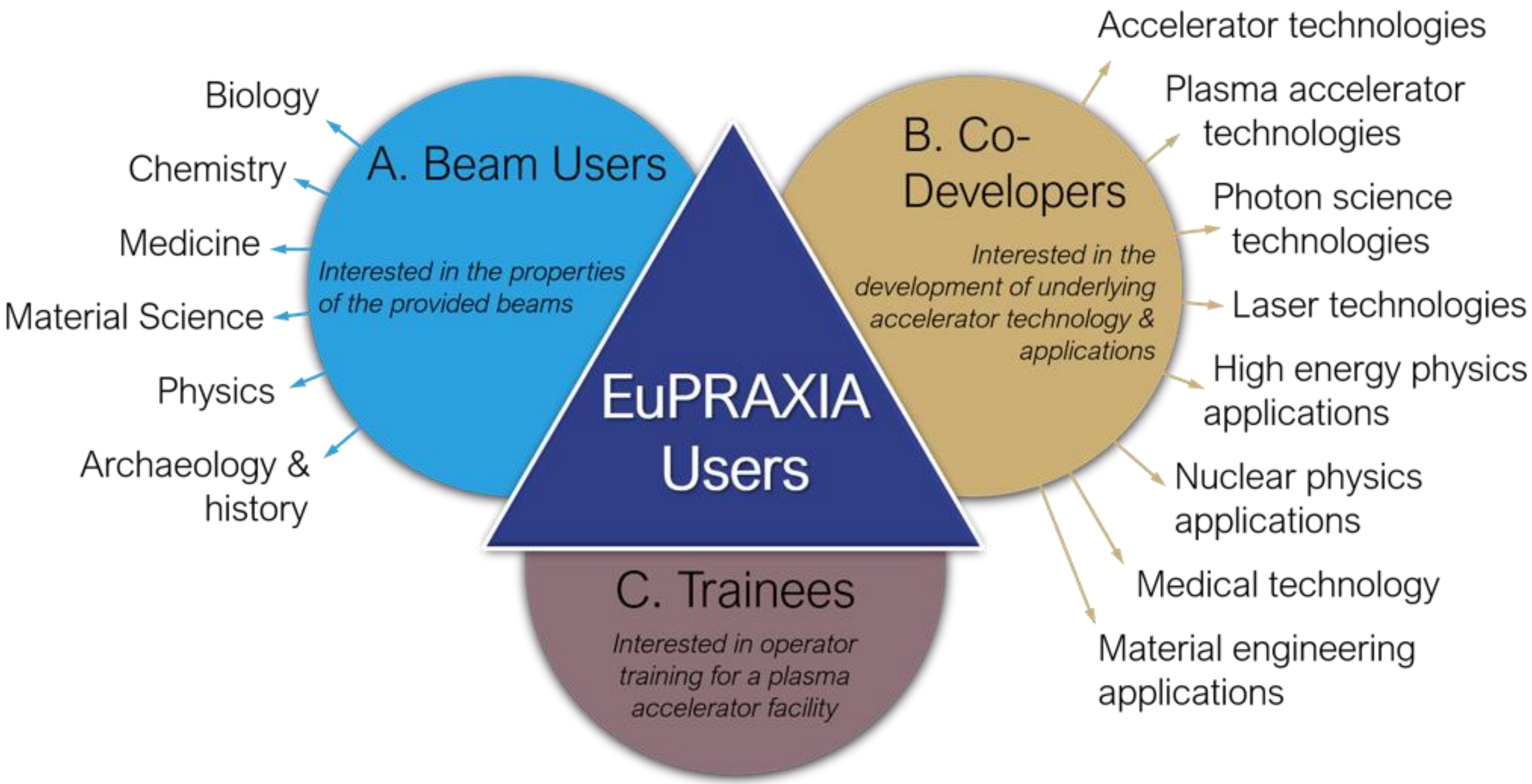
  Technological clusters for development and in-kind contribution

  Coordination at National Level

- **Project Clusters**

  Units that performs dedicated R&D / prototyping / subsystem

User Categories



Contributions françaises potentielles (preparatory phase & au delà)

Funded by the European Union

(Liste non exhaustive, à compléter, excuses pour les oublis)

- collaboration management, organisation (LPGP, LLR)
- 200MeV laser plasma injector proto-type PALLAS(IJC-Lab), EARLI(LPGP)
- Laser (and laser-associated tech) development (LULI)
- Laser guiding in optically formed plasma channels (LOA) ?
- Compact beam capture and diagnostics (LLR)
- simulation of conventional and novel injector schemes (LPGP, LIDYL, LLR)

Conclusions

- EuPRAXIA: ESFRI project (!) for a distributed European Research Infrastructure, **building two plasma-driven FEL´s in Europe**.
- EuPRAXIA FEL site in Frascati LNF-INFN is sufficiently funded for **first FEL user operation in 2029**.
- Second EuPRAXIA FEL site will be selected in next months, among **3 excellent candidate sites**.
- Concept today **works in design and in reality**.
- The facility has to demonstrate solve stability and up-time **for 24/7 user operation**.
- Collaboration and user model will determine 3rd country contributions.
- in-kind contributions and bilateral collaboration agreements to start with
- Opportunity to initiate collaborations at world-class facilities, now.

Funded by the European Union

Thank you for your attention