EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA@Sparc_Lab in the European perspective

M. Ferrario (INFN)

on behalf of the EuPRAXIA collaboration

C&S Review Meeting, LNF, 11 December 2023

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

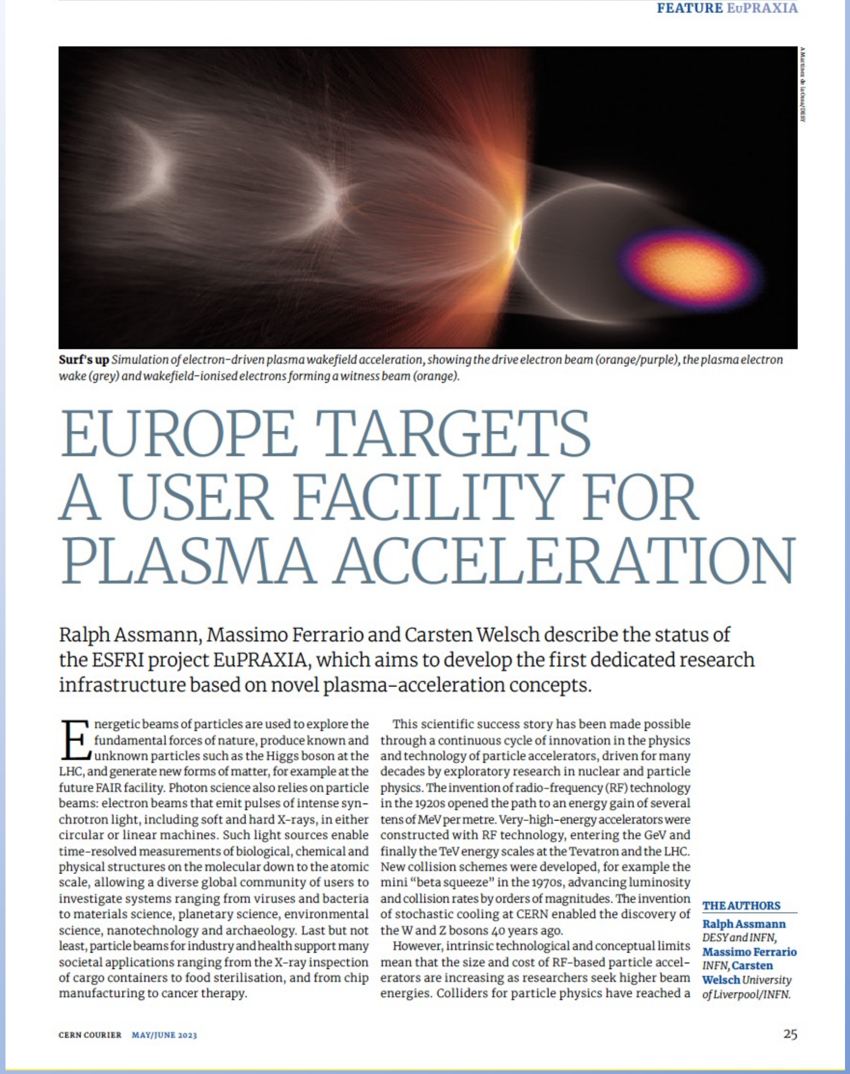
Shrink down the facility size

2

Producing particle and photon pulses to support several urgent and timely science cases

Enable frontier science in new regions and parameter regimes

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



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.

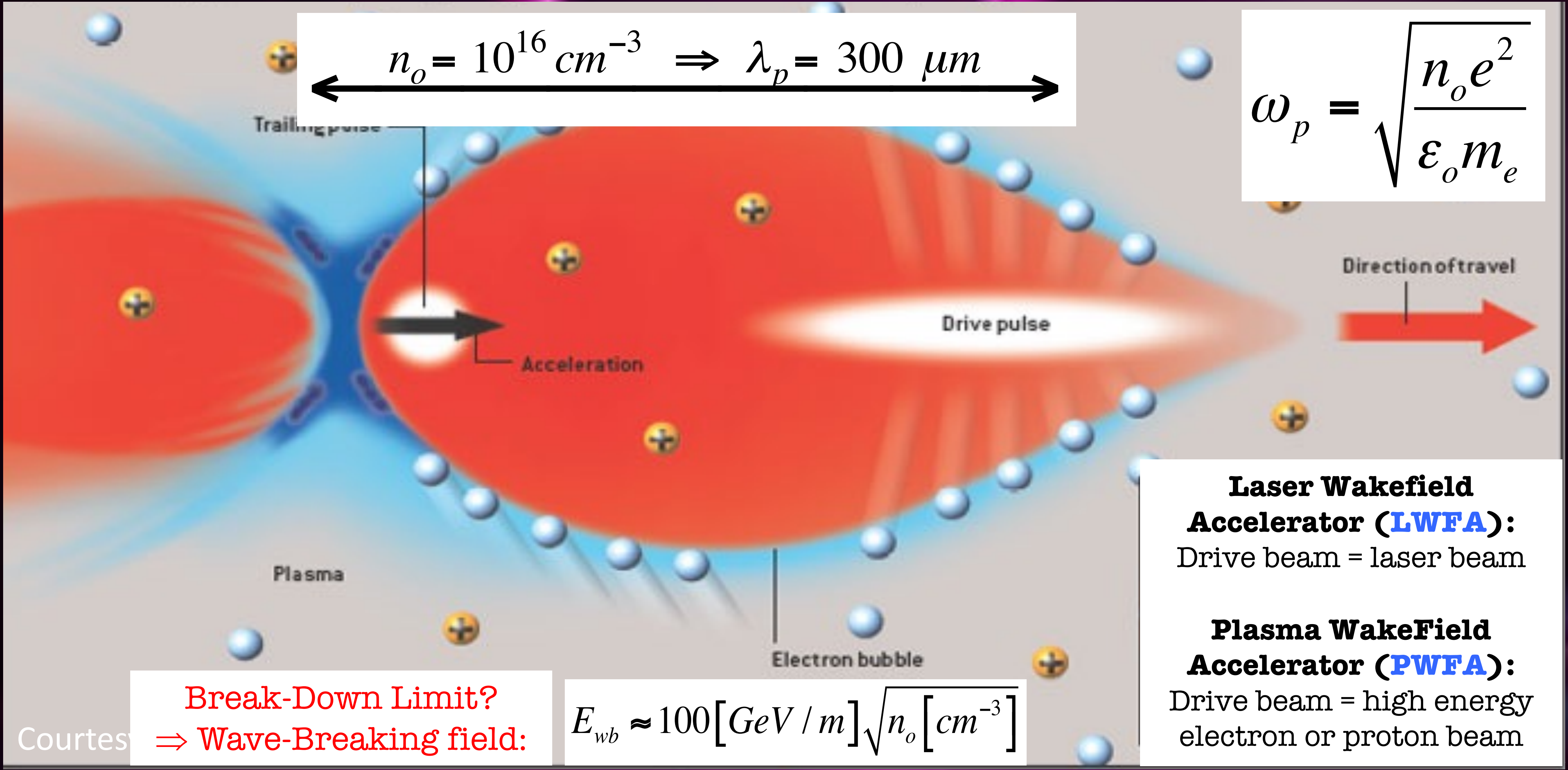
Energetic beams of particles are used to explore the fundamental forces of nature, produce known and unknown particles such as the Higgs boson at the LHC, and generate new forms of matter, for example at the future FAIR facility. Photon science also relies on particle beams: electron beams that emit 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.*

Principle of plasma acceleration



$$n_o = 10^{16}\ cm^{-3} \Rightarrow \lambda_p = 300\ \mu m$$

$$\omega_p = \sqrt{\frac{n_o e^2}{\varepsilon_o m_e}}$$

Laser Wakefield Accelerator (LWFA):
Drive beam = laser beam

Plasma WakeField Accelerator (PWFA):
Drive beam = high energy electron or proton beam

Break-Down Limit?
⇒ Wave-Breaking field:

$$E_{wb} \approx 100\left[GeV / m\right]\sqrt{n_o\left[cm^{-3}\right]}$$

Courtes

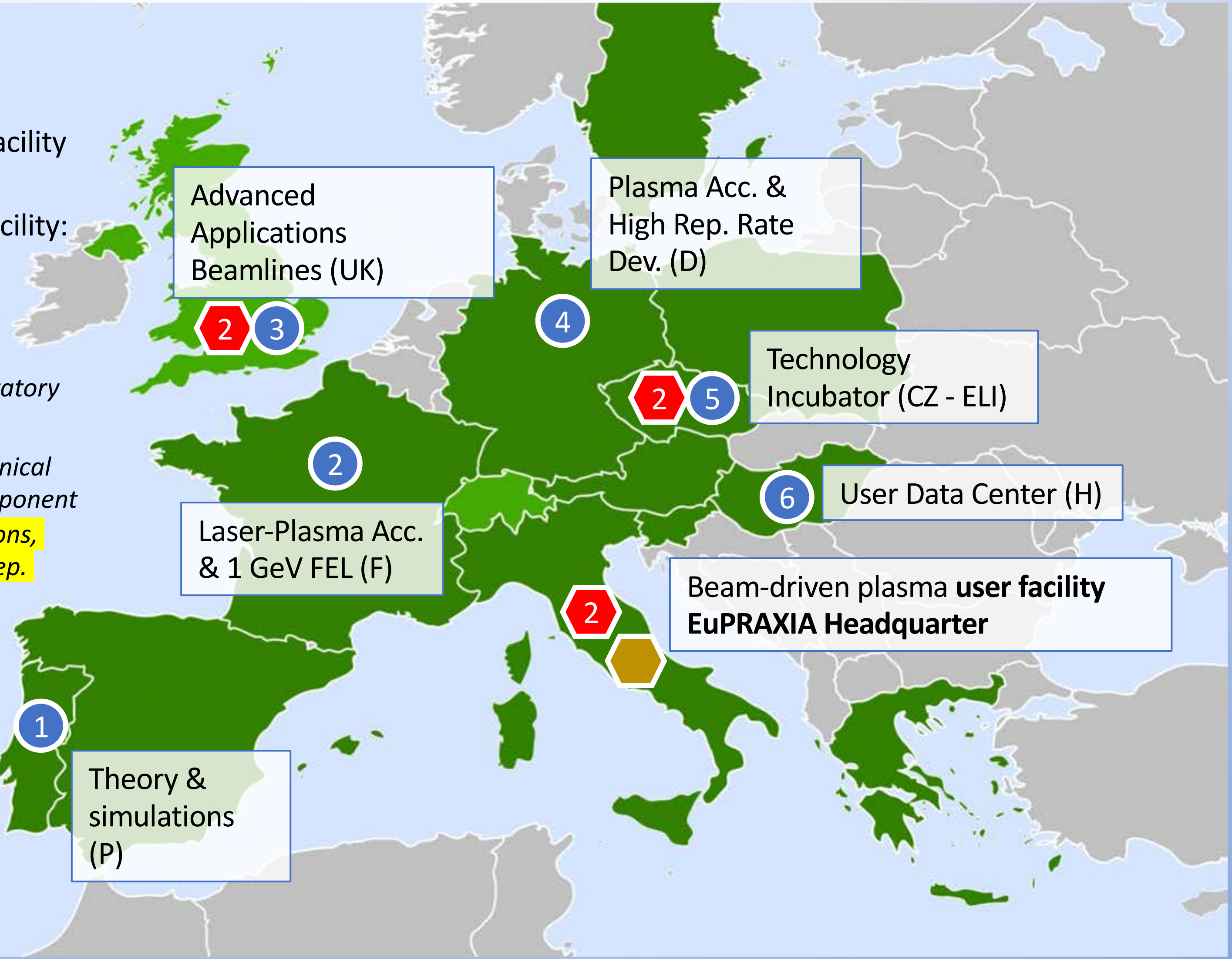
Distributed Research Infrastructure

Funded by the European Union

- ⬢ Beam-driven plasma user facility EuPRAXIA Headquarter
- 2 Laser-driven plasma user facility: candidates
- ● Excellence Center

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.



Advanced Applications Beamlines (UK)

Plasma Acc. & High Rep. Rate Dev. (D)

Technology Incubator (CZ - ELI)

Laser-Plasma Acc. & 1 GeV FEL (F)

User Data Center (H)

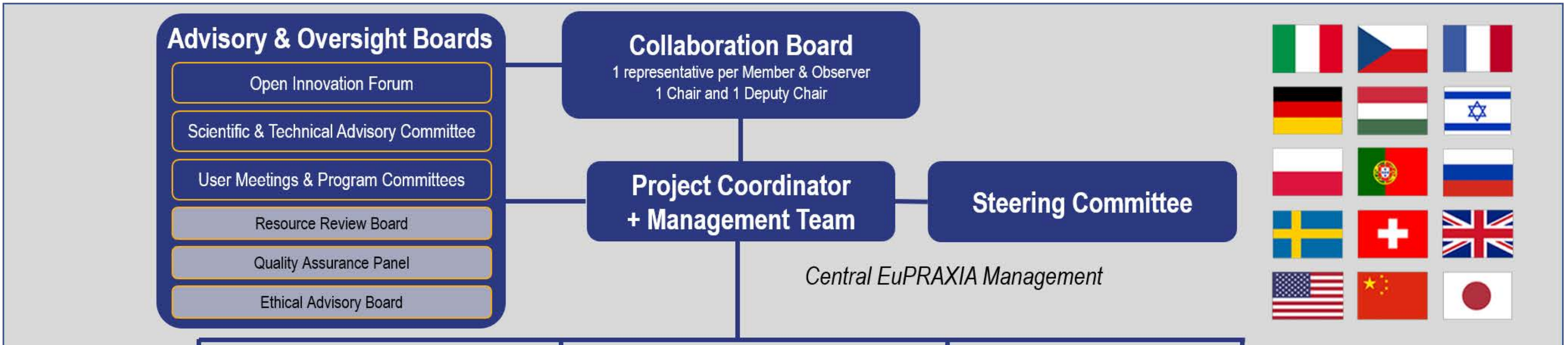
Beam-driven plasma **user facility EuPRAXIA Headquarter**

Theory & simulations (P)

Horizon Europe

EUROPEAN
PLASMA RESEARCH ACCELERATOR WITH
EXCELLENCE IN APPLICATIONS

EuPRAXIA Organisation Chart



Advisory & Oversight Boards

- Open Innovation Forum
- Scientific & Technical Advisory Committee
- User Meetings & Program Committees
- Resource Review Board
- Quality Assurance Panel
- Ethical Advisory Board

Collaboration Board

1 representative per Member & Observer
1 Chair and 1 Deputy Chair

Project Coordinator + Management Team

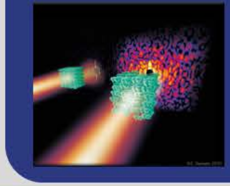
Steering Committee

Central EuPRAXIA Management

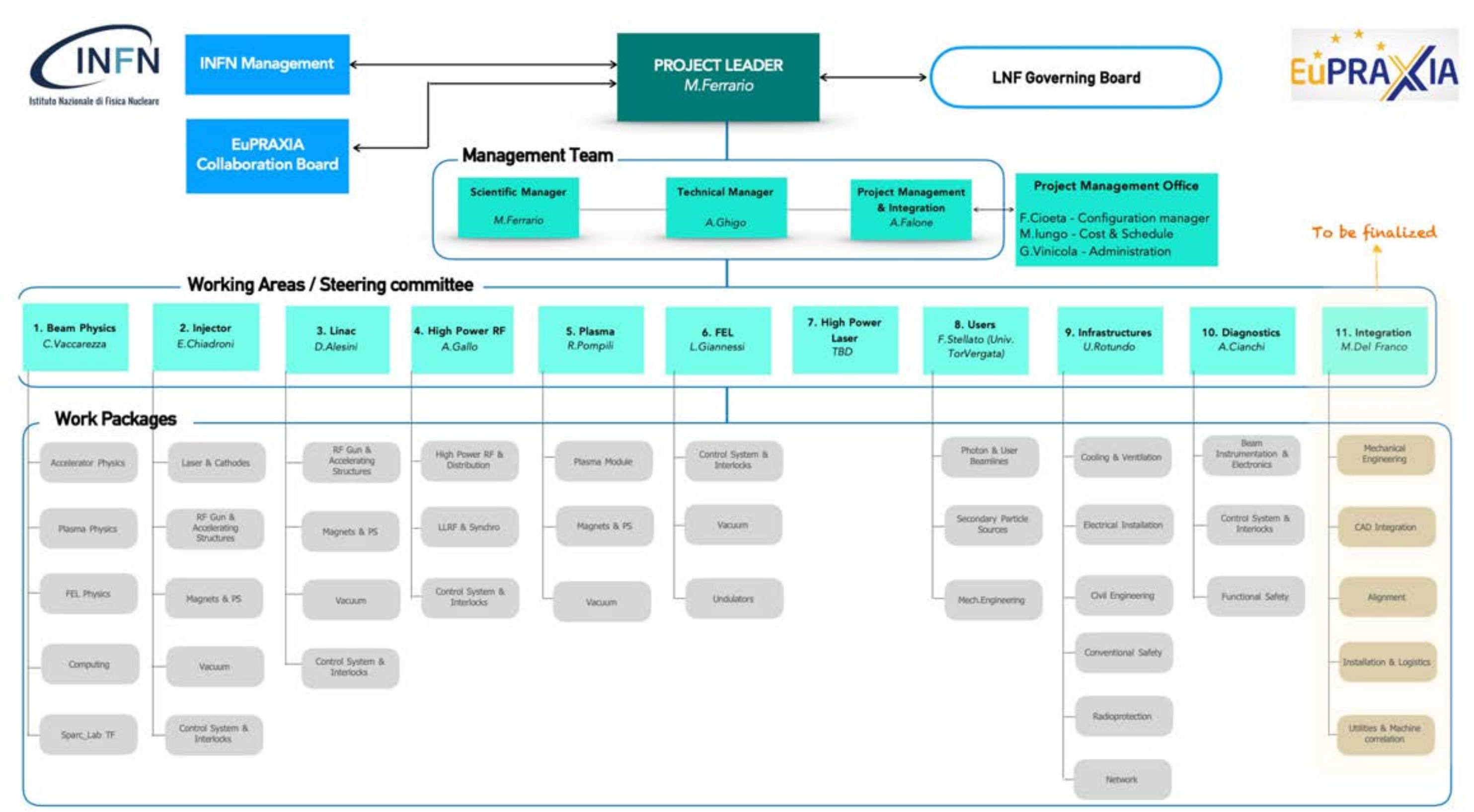
Construction Site Frascati

Local Project Team

Beam-driven plasma accelerator
Delivers FEL light, X rays, electrons, positrons
Life sciences, particle physics, medicine, materials



Location: metropolitan area Rome, Italy



INFN
Istituto Nazionale di Fisica Nucleare

INFN Management

EuPRAXIA Collaboration Board

PROJECT LEADER
M.Ferrario

LNF Governing Board

Management Team

- Scientific Manager – M.Ferrario
- Technical Manager – A.Ghigo
- Project Management & Integration – A.Falone

Project Management Office
F.Cioeta - Configuration manager
M.lungo - Cost & Schedule
G.Vinicola - Administration

To be finalized

Working Areas / Steering committee

- 1. Beam Physics – C.Vaccarezza
- 2. Injector – E.Chiadroni
- 3. Linac – D.Alesini
- 4. High Power RF – A.Gallo
- 5. Plasma – R.Pompili
- 6. FEL – L.Giannessi
- 7. High Power Laser – TBD
- 8. Users – F.Stellato (Univ. TorVergata)
- 9. Infrastructures – U.Rotundo
- 10. Diagnostics – A.Cianchi
- 11. Integration – M.Del Franco

Work Packages

- Accelerator Physics
- Plasma Physics
- FEL Physics
- Computing
- Sparc_Lab TF
- Laser & Cathodes
- RF Gun & Accelerating Structures
- Magnets & PS
- Vacuum
- Control System & Interlocks
- RF Gun & Accelerating Structures
- Magnets & PS
- Vacuum
- Control System & Interlocks
- High Power RF & Distribution
- LLRF & Synchro
- Control System & Interlocks
- Plasma Module
- Magnets & PS
- Vacuum
- Control System & Interlocks
- Vacuum
- Undulators
- Photon & User Beamlines
- Secondary Particle Sources
- Mech.Engineering
- Cooling & Ventilation
- Electrical Installation
- Civil Engineering
- Conventional Safety
- Radioprotection
- Network
- Beam Instrumentation & Electronics
- Control System & Interlocks
- Functional Safety
- Mechanical Engineering
- CAD Integration
- Alignment
- Installation & Logistics
- Utilities & Machine correlation

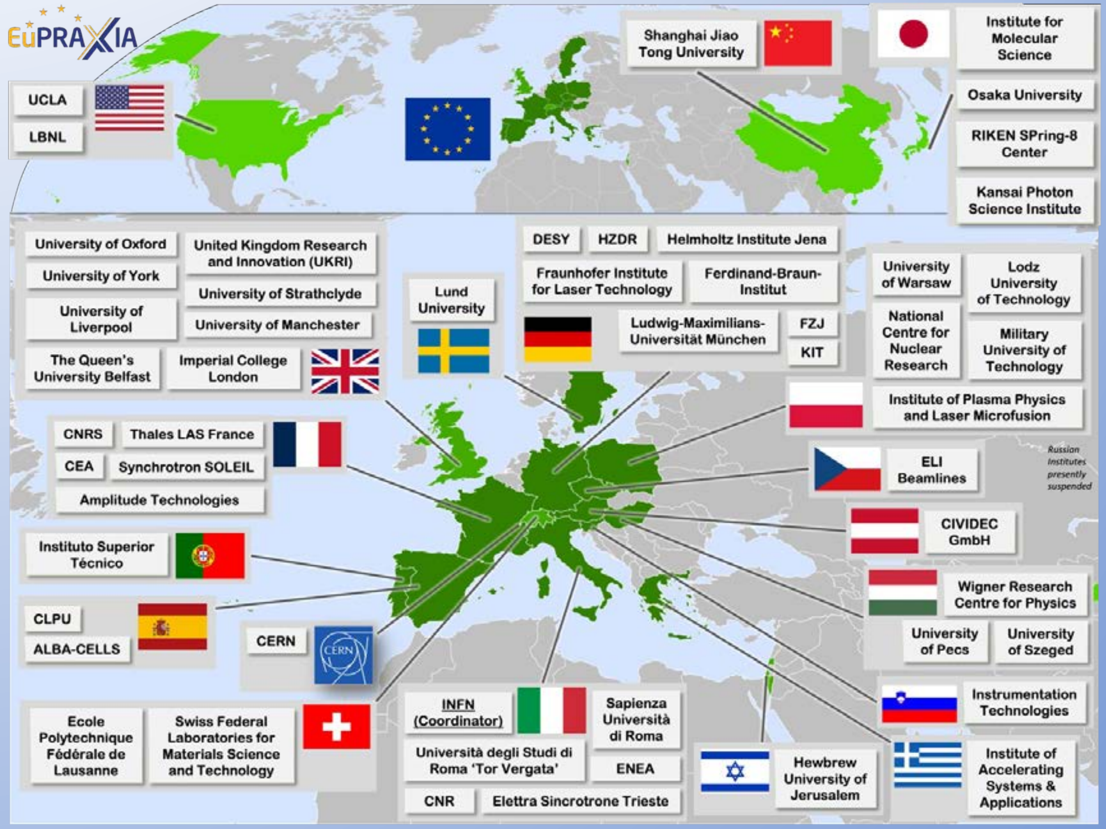
Organization for initial Preparatory Ph

Features to be added with decision or
phases are indicated in lighter shades

Wide International Collaboration

Funded by the European Union

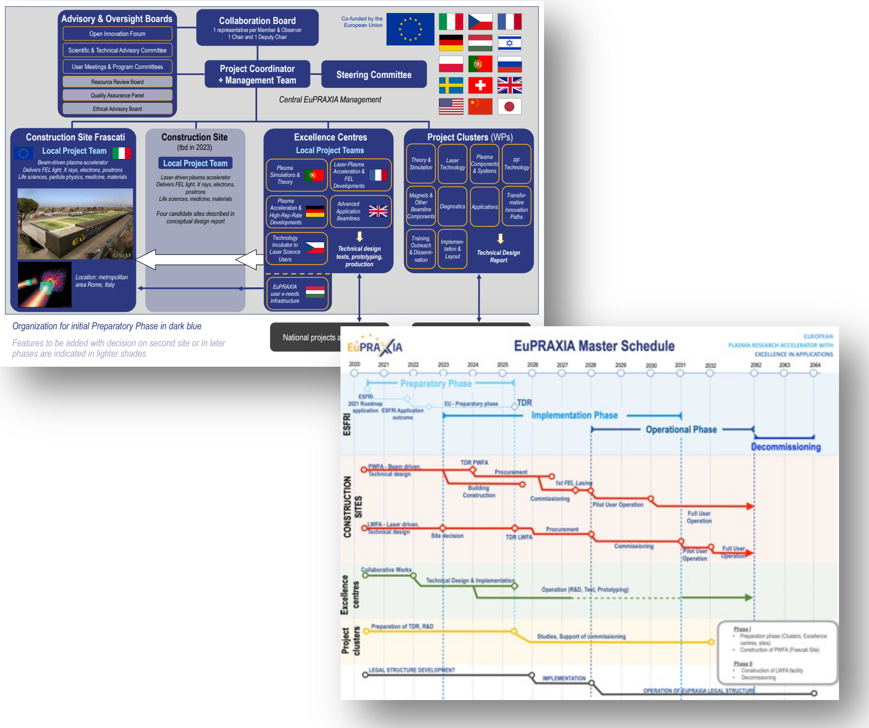
- **The EuPRAXIA Consortium today: 54 institutes** from **18 countries** plus CERN
- Included in the **ESFRI** Road Map
- **Efficient fund raising:**
  - **Preparatory Phase** consortium (funding EU, UK, Switzerland, in-kind)
  - **Doctoral Network** (funding EU, UK, in-kind)
  - **EuPRAXIA@SPARC_LAB**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

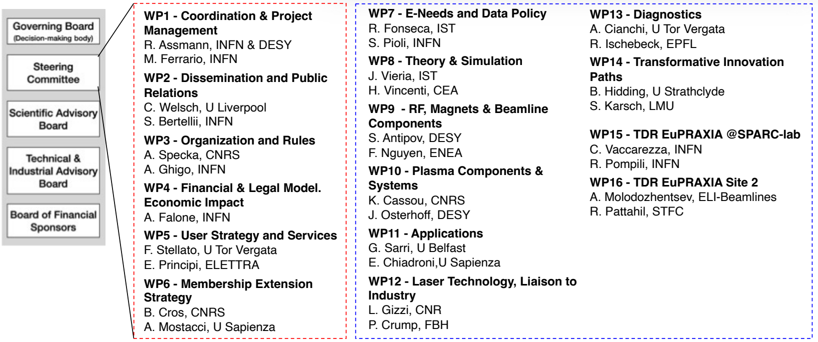


Preparatory Phase Main Goals

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 (correspond to Project Clusters):
  - **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





Governing Board (Decision-making body)
Steering Committee
Scientific Advisory Board
Technical & Industrial Advisory Board
Board of Financial Sponsors

WP1 - Coordination & Project Management
R. Assmann, INFN & DESY
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

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
J. Osterhoff, DESY

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

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

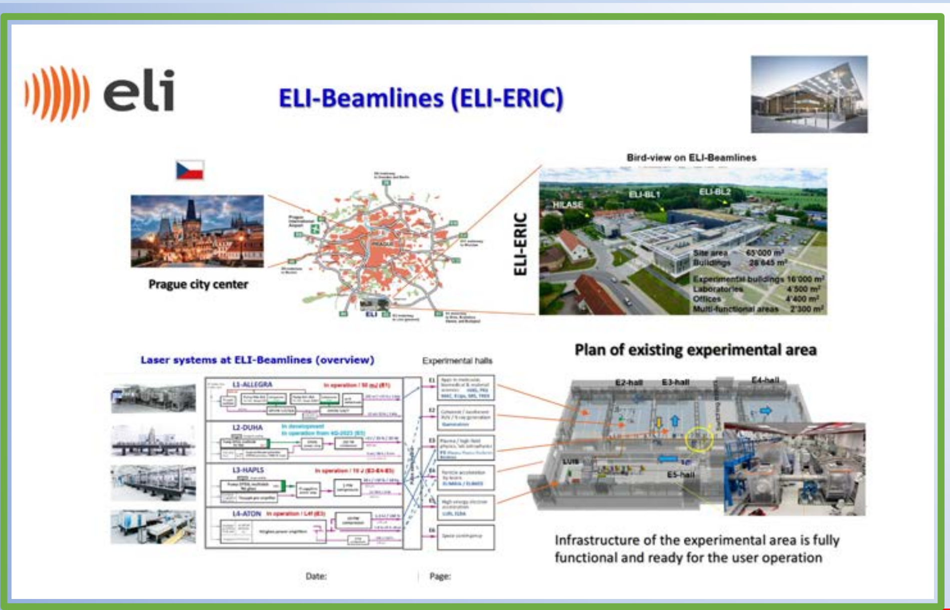
WP13 - Diagnostics
A. Cianchi, U Tor Vergata
R. Ischebeck, EPFL

WP14 - Transformative Innovation Paths
B. Hidding, U Strathclyde
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

Current Candidates for EuPRAXIA Laser Site



ELI-Beamlines (ELI-ERIC)

Prague city center

ELI-ERIC

Bird-view on ELI-Beamlines

HILASE

ELI-BL1

ELI-BL2

Site area 65'000 m^2

Buildings 28'645 m^2

Experimental buildings 16'000 m^2

Laboratories 4'500 m^2

Offices 4'400 m^2

Multi-functional areas 2'300 m^2

Laser systems at ELI-Beamlines (overview)

L1-ALLEGRA In operation / 50 mJ (E1)

L2-DUHA In development In operation from 4Q-2023 (E5)

L3-HAPLS In operation / 10 J (E3-E4-E5)

L4-ATON In operation / L4f (E3)

Experimental halls

Plan of existing experimental area

E2-hall

E3-hall

E4-hall

E5-hall

Infrastructure of the experimental area is fully functional and ready for the user operation

Date:

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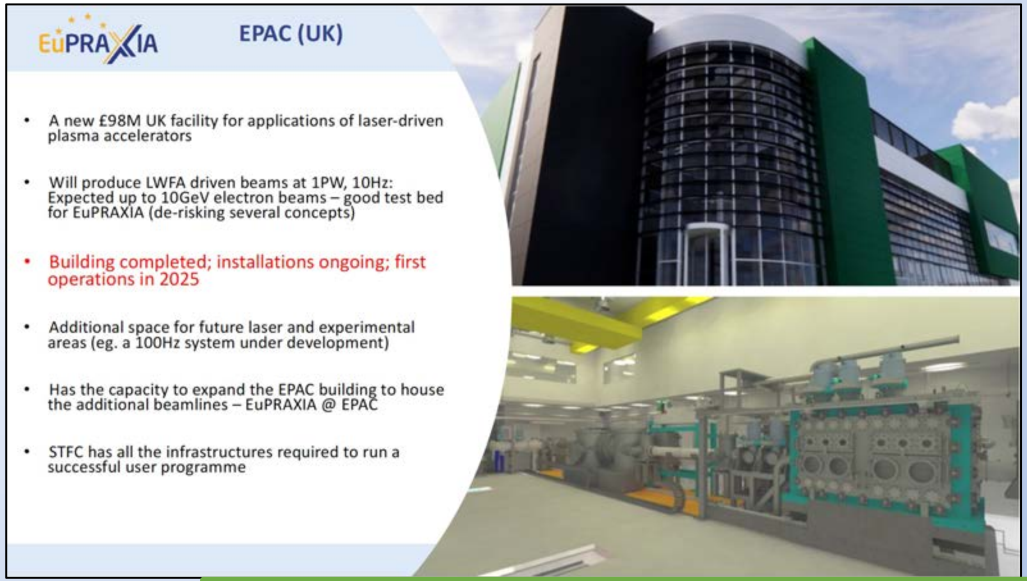
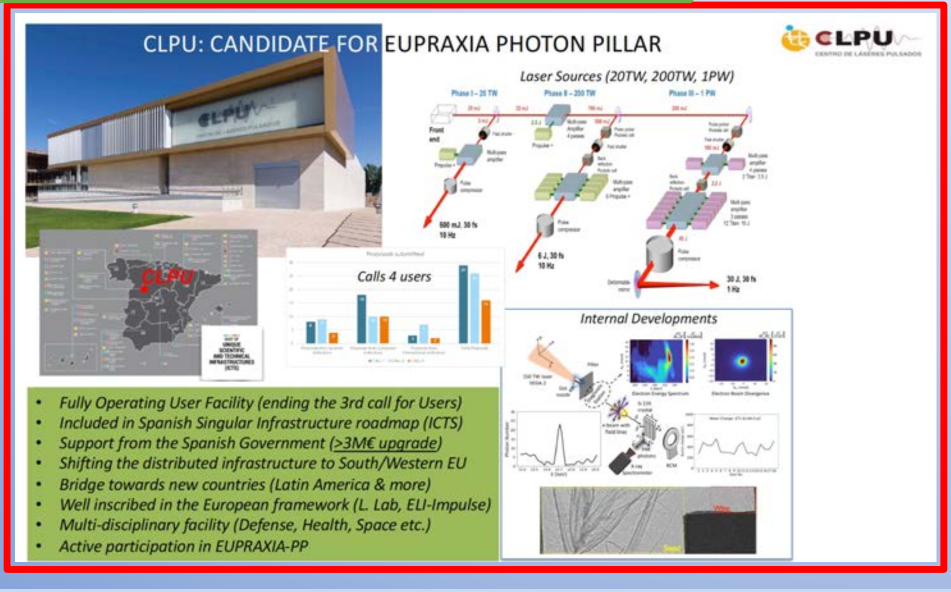


EPAC (UK)

- A new £98M UK facility for applications of laser-driven plasma accelerators
- Will produce LWFA driven beams at 1PW, 10Hz: Expected up to 10GeV electron beams – good test bed for EuPRAXIA (de-risking several concepts)
- Building completed; installations ongoing; first operations in 2025
- Additional space for future laser and experimental areas (eg. a 100Hz system under development)
- Has the capacity to expand the EPAC building to house the additional beamlines – EuPRAXIA @ EPAC
- STFC has all the infrastructures required to run a successful user programme



CLPU: CANDIDATE FOR EUPRAXIA PHOTON PILLAR

CLPU CENTRO DE LÁSERES PULSADOS

Laser Sources (20TW, 200TW, 1PW)

Phase I – 20 TW

Phase II – 200 TW

Phase III – 1 PW

600 mJ, 30 fs 10 Hz

6 J, 30 fs 10 Hz

30 J, 30 fs 1 Hz

CLPU

Calls 4 users

Internal Developments

Electron Energy Spectrum

Electron Beam Divergence

- Fully Operating User Facility (ending the 3rd call for Users)
- Included in Spanish Singular Infrastructure roadmap (ICTS)
- Support from the Spanish Government (>3M€ upgrade)
- Shifting the distributed infrastructure to South/Western EU
- Bridge towards new countries (Latin America & more)
- Well inscribed in the European framework (L. Lab, ELI-Impulse)
- Multi-disciplinary facility (Defense, Health, Space etc.)
- Active participation in EUPRAXIA-PP

PISA for EuPRAXIA@CNR

- CNR campus in Pisa - home to the *Intense Laser Irradiation Laboratory (Est. 2000)*
- PW scale laser facility operational with user collaborative access
- Major upgrade (10 M€ funding) ongoing to enable EuPRAXIA 100 Hz laser milestone and user areas;
- Xtreme photonics node of the IPHOQS (CNR) and EuAPS (INFN) RI networks
- Pioneering group for access to EU Laser Infrastructures (30+ yrs)
- Unique link to multidisciplinary research and technology transfer on site
- Strong link with Pisa University system

CNR-INO ISTITUTO NAZIONALE DI OTTICA CONSIGLIO NAZIONALE DELLE RICERCHE

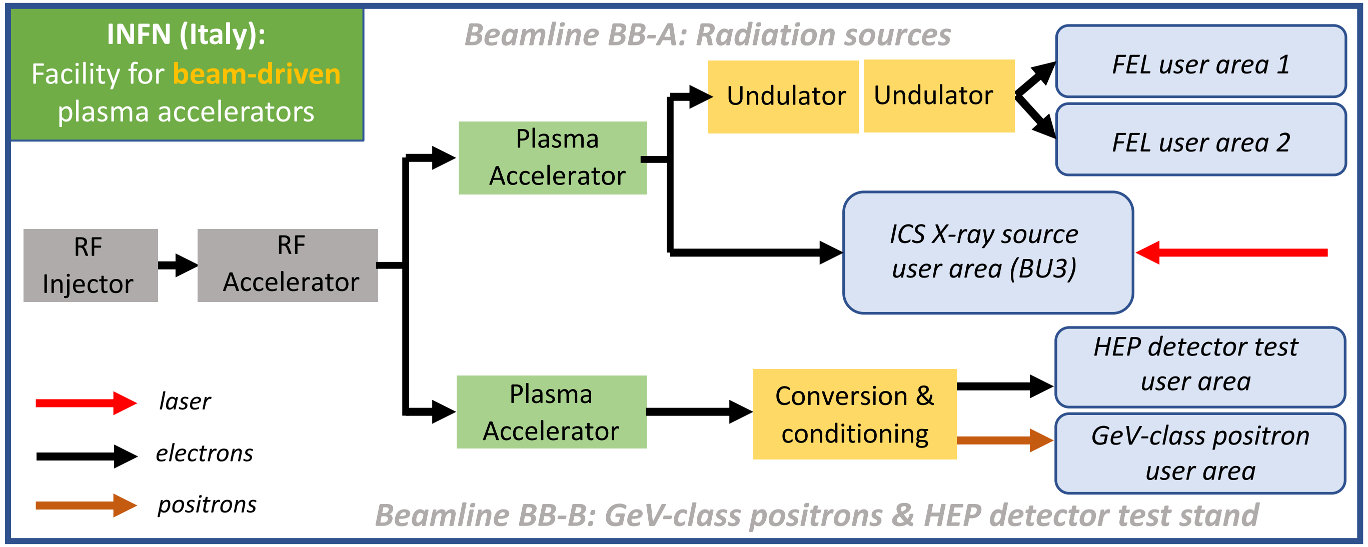
INTENSE LASER IRRADIATION LABORATORY

2nd Sites: Bids from Czech Rep., Italy, UK, Spain

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

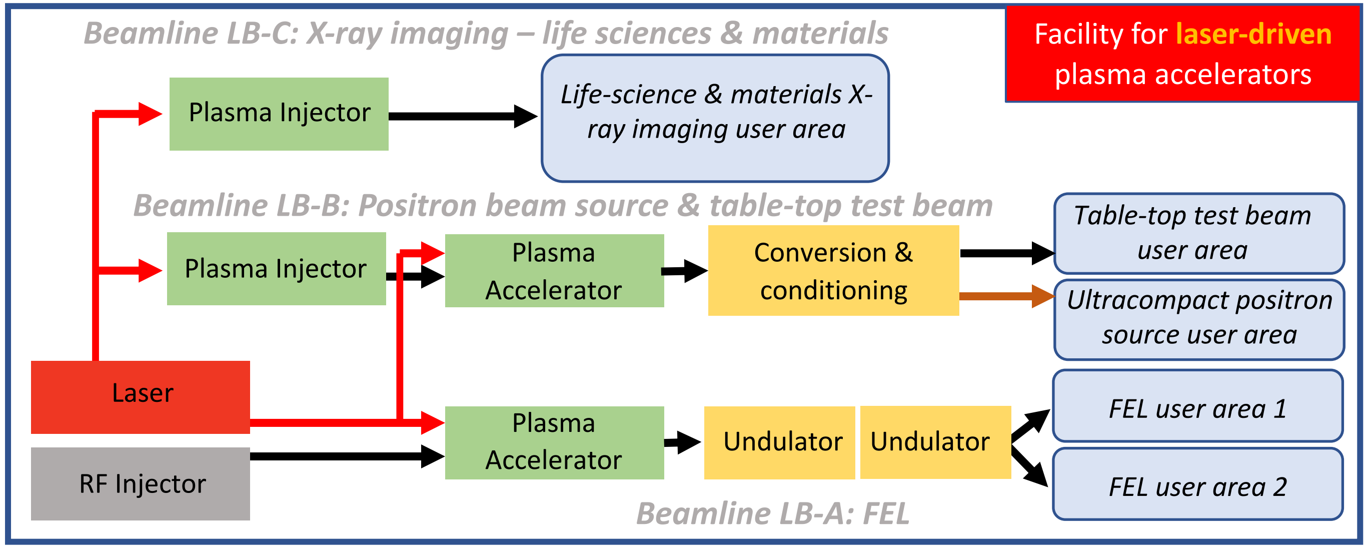
RF Injector → RF Accelerator → Plasma Accelerator → Undulator, Undulator → *FEL user area 1*, *FEL user area 2*

Plasma Accelerator → *ICS X-ray source user area (BU3)*

RF Accelerator → 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



Facility for laser-driven plasma accelerators

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

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

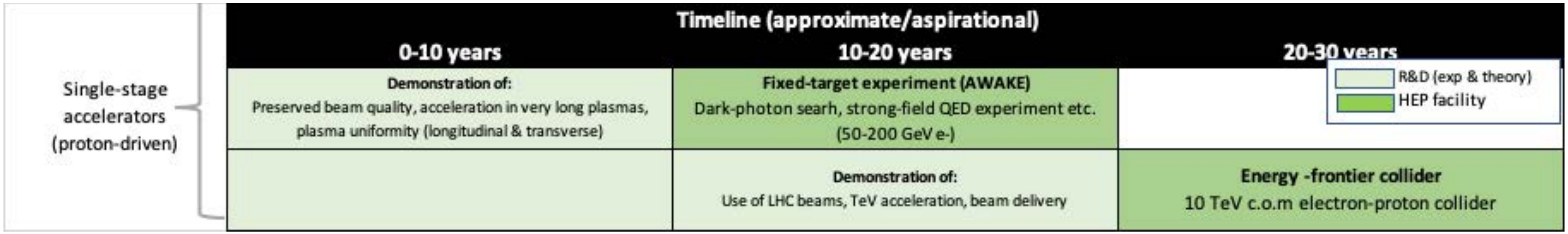
Beamline LB-B: Positron beam source & table-top test beam

Laser → 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*

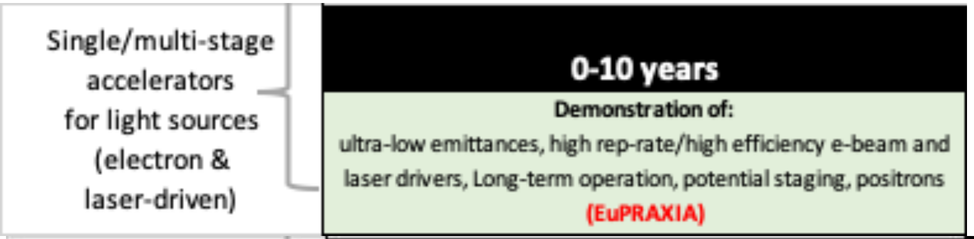
Beamline LB-A: FEL

ESPP Roadmap Update – Plasma Accelerators



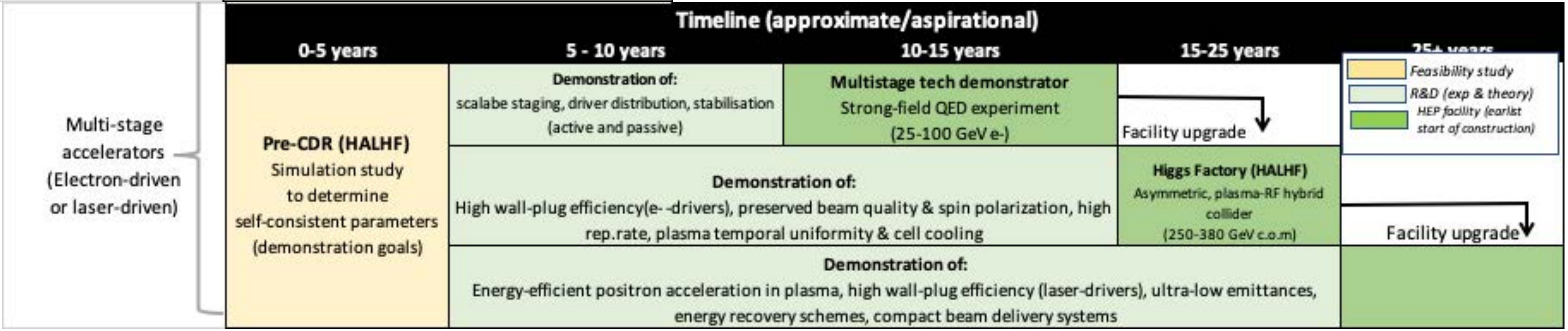
	Timeline (approximate/aspirational)		
	0-10 years	**10-20 years**	**20-30 years**
Single-stage accelerators (proton-driven)	**Demonstration of:** Preserved beam quality, acceleration in very long plasmas, plasma uniformity (longitudinal & transverse)	**Fixed-target experiment (AWAKE)** Dark-photon searh, 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



	0-10 years
Single/multi-stage accelerators for light sources (electron & laser-driven)	**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

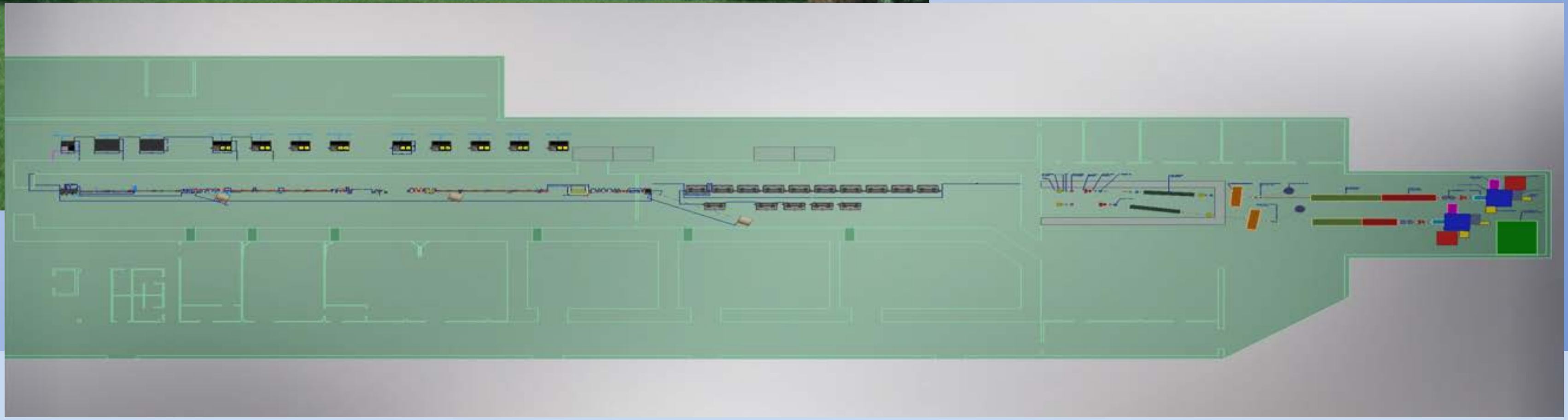


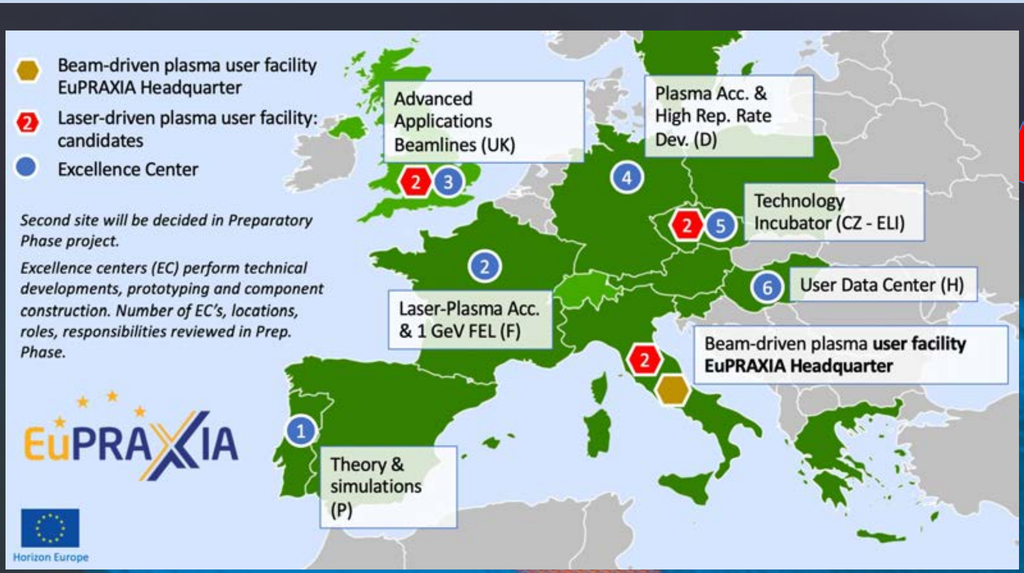
	Timeline (approximate/aspirational)				
	0-5 years	**5 - 10 years**	**10-15 years**	**15-25 years**	**25+ years**
Multi-stage accelerators (Electron-driven or laser-driven)	**Pre-CDR (HALHF)** Simulation study to determine self-consistent parameters (demonstration goals)	**Demonstration of:** scalabe 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)*

Headquarter and Site 1: EuPRAXIA@SPARC_LAB

- 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)





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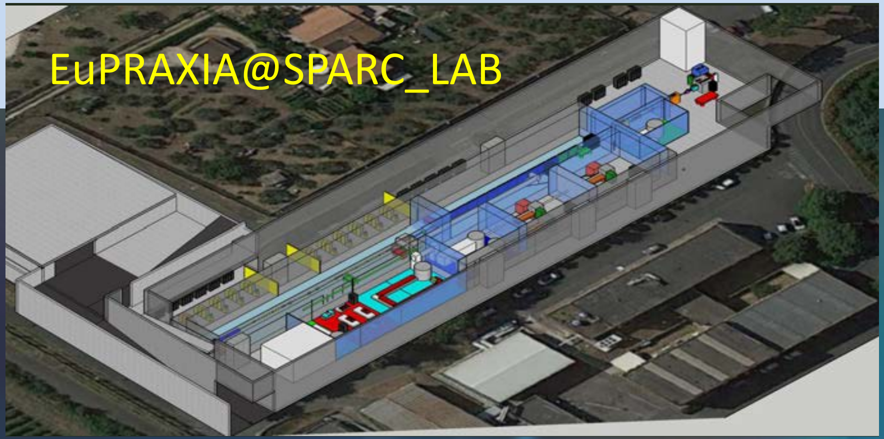
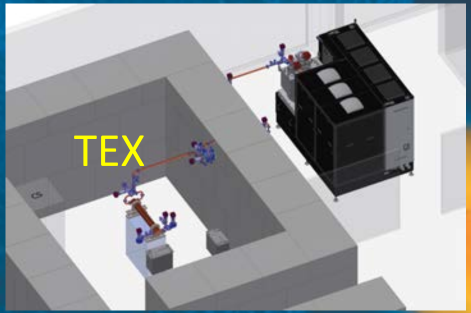
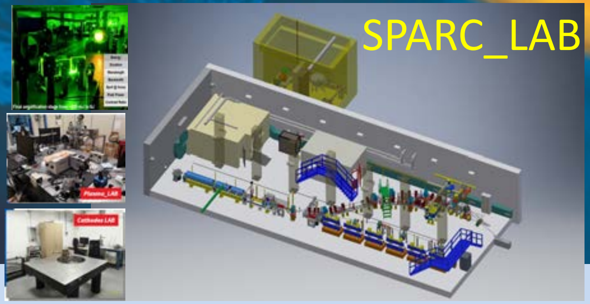




Finanziato dall'Unione europea
NextGenerationEU

REGIONE LAZIO

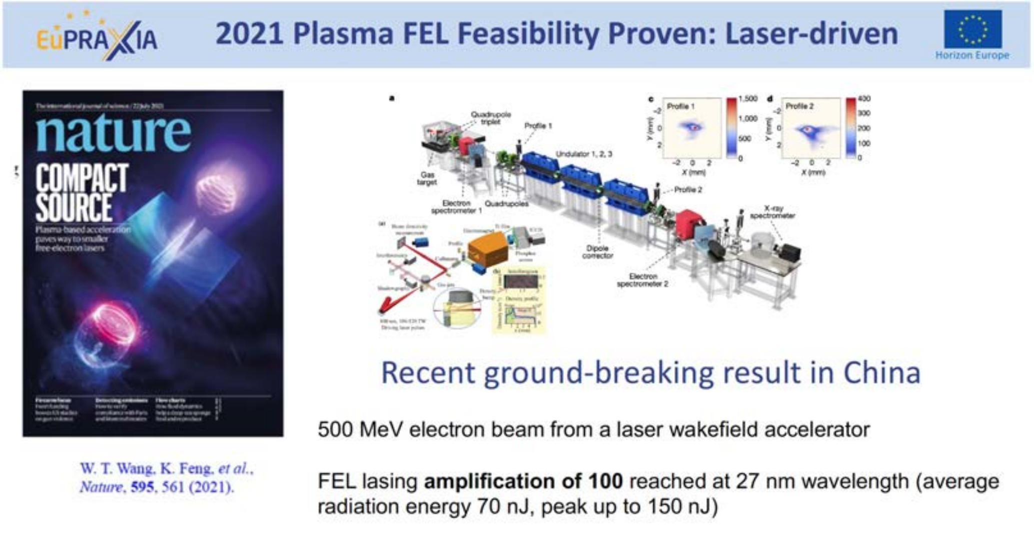



INFN
Istituto Nazionale di Fisica Nucleare

LNF–18/03
May 7, 2018

Technical Design Report

Basic beam quality achieved in pilot FEL experiments



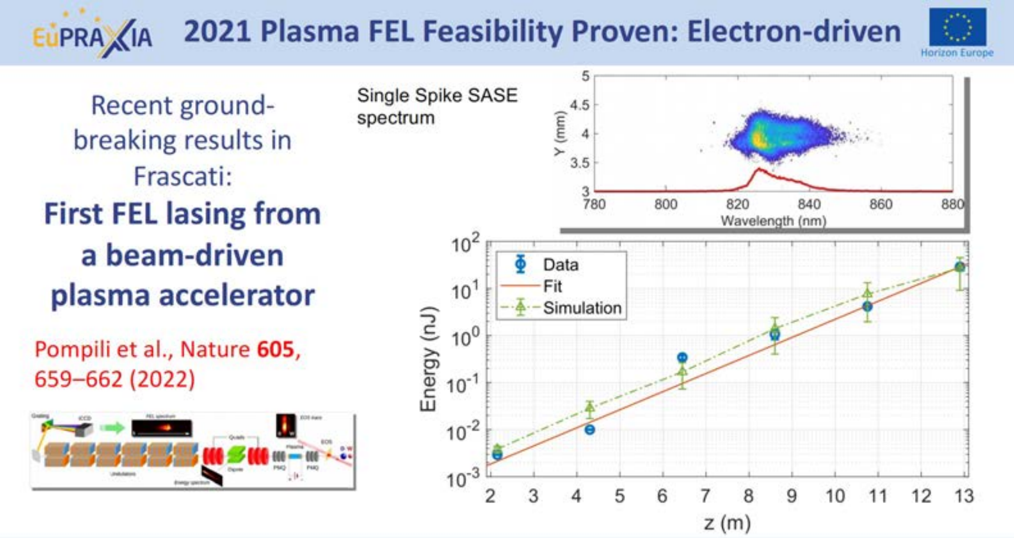
2021 Plasma FEL Feasibility Proven: Laser-driven

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)

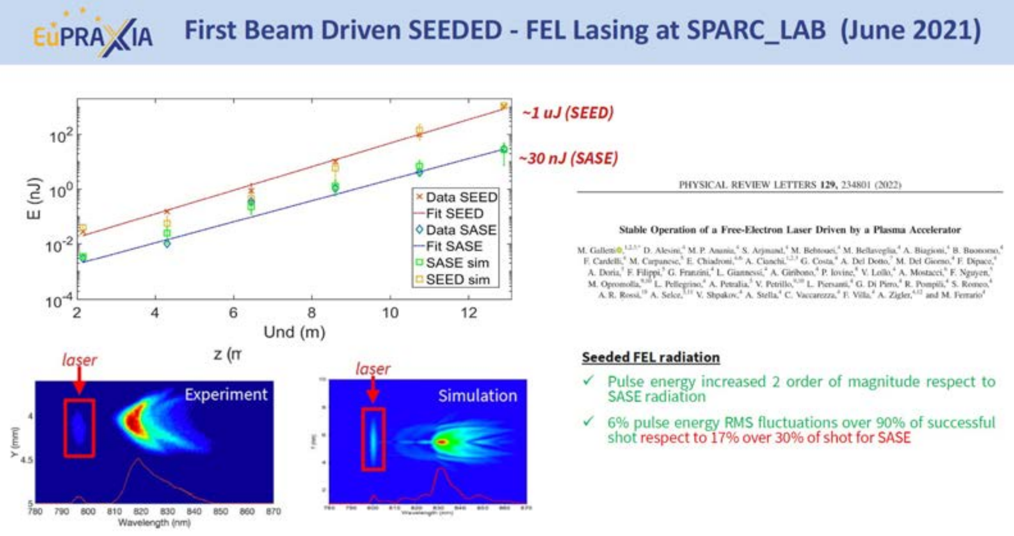


2021 Plasma FEL Feasibility Proven: Electron-driven

Recent ground-breaking results in Frascati:

First FEL lasing from a beam-driven plasma accelerator

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



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

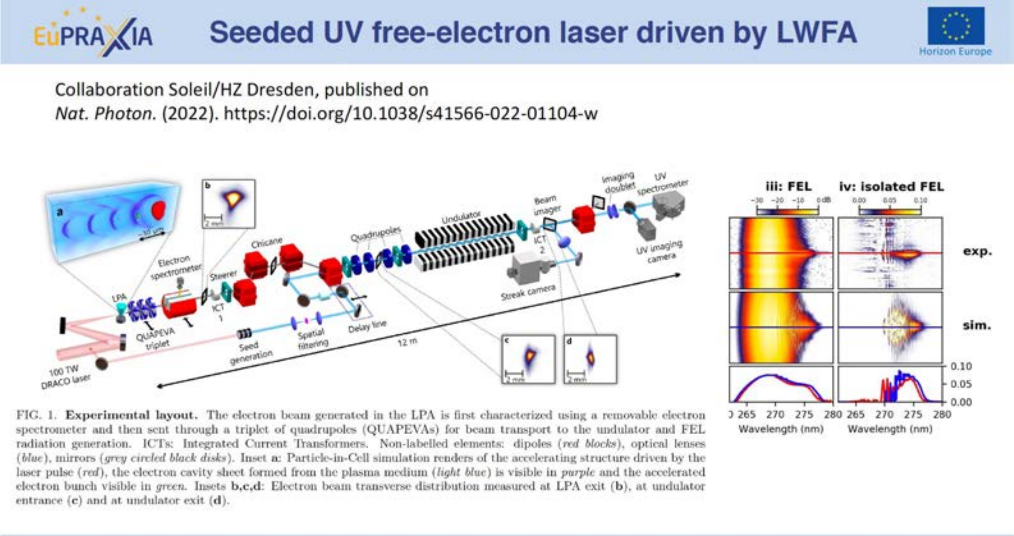
PHYSICAL REVIEW LETTERS **129,** 234801 (2022)

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

M. Galletti, D. Alesini, M. P. Anania, S. Arjmand, M. Behtouei, M. Bellaveglia, A. Biagioni, B. Buonomo, F. Cardelli, M. Carpanese, E. Chiadroni, A. Cianchi, G. Costa, A. Del Dotto, M. Del Giorno, F. Dipace, A. Doria, F. Filippi, G. Franzini, L. Giannessi, A. Giribono, P. Iovine, V. Lollo, A. Mostacci, F. Nguyen, M. Opromolla, L. Pellegrino, A. Petralia, V. Petrillo, L. Piersanti, G. Di Pirro, R. Pompili, S. Romeo, A. R. Rossi, A. Selce, V. Shpakov, A. Stella, C. Vaccarezza, F. Villa, A. Zigler, and M. Ferrario

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

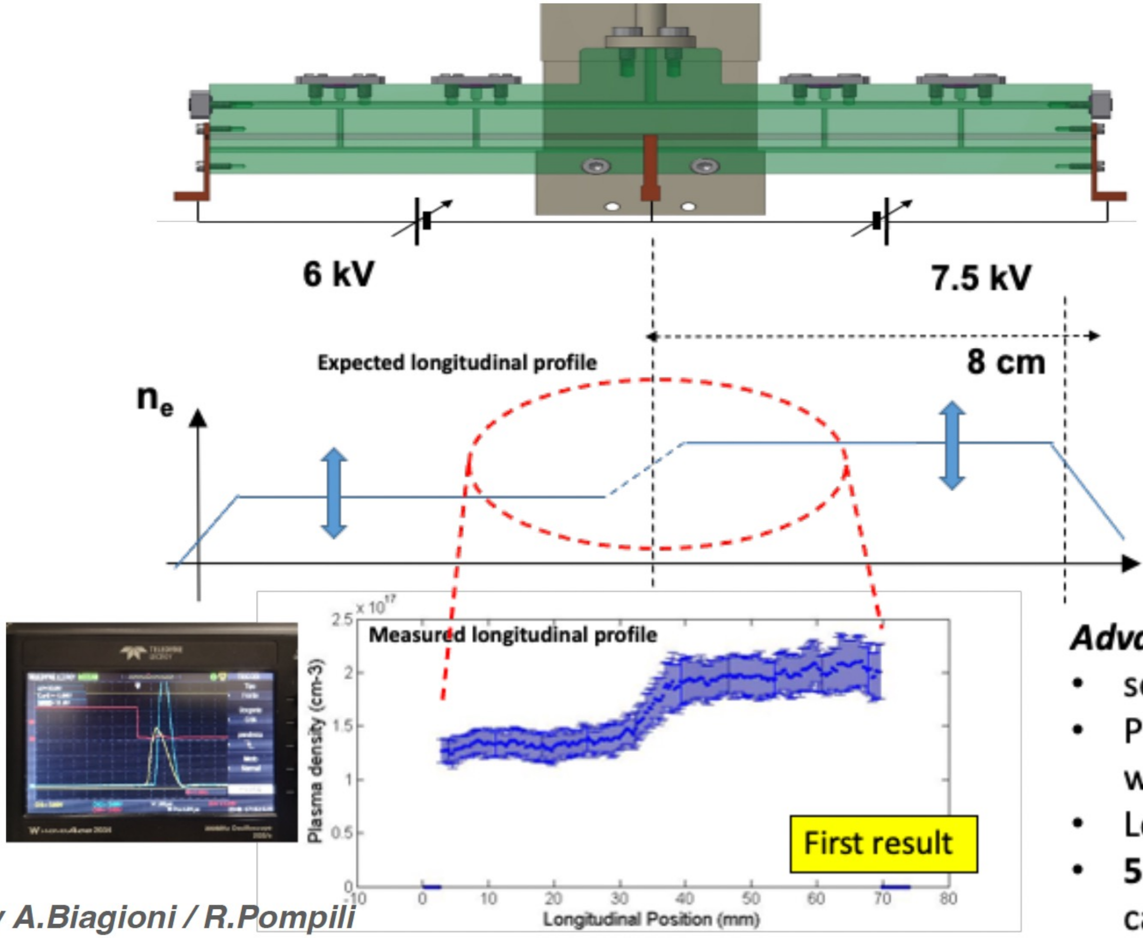


Seeded UV free-electron laser driven by LWFA

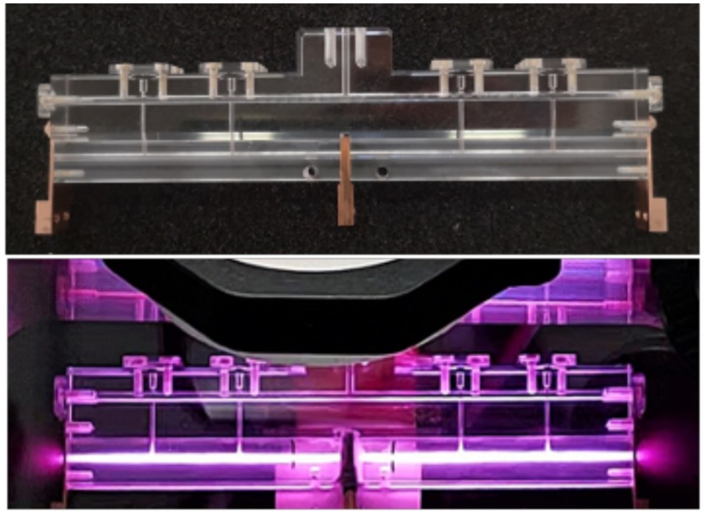
Collaboration Soleil/HZ Dresden, published on
Nat. Photon. (2022). https://doi.org/10.1038/s41566-022-01104-w

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**).

Plasma Module

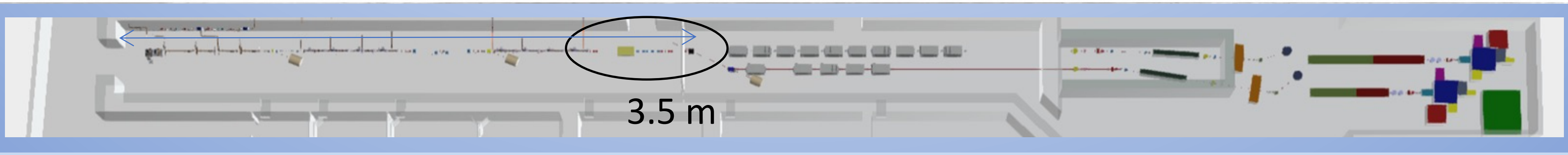


Courtesy A.Biagioni / R.Pompili



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)



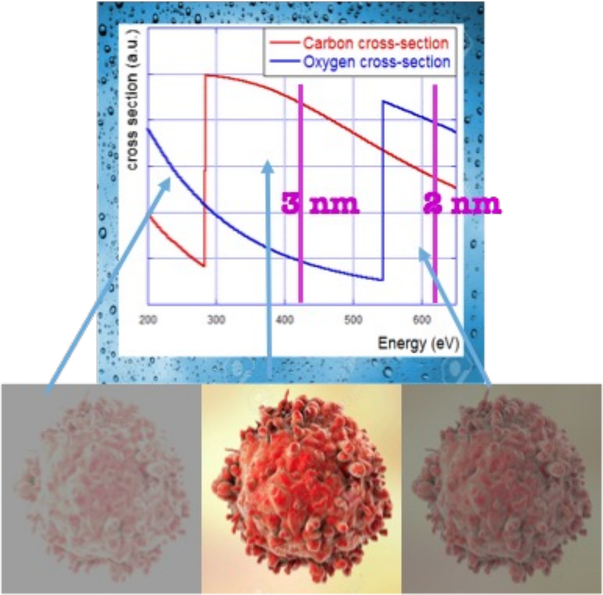
Courtesy A. Biagioni, R. Pompili

Expected SASE FEL performances

Parameter	**Unit**	PWFA	Full X-band
Electron Energy	GeV	**1**-*1.2*	1
Bunch Charge	pC	**30**-*50*	**200**-*500*
Peak Current	kA	1-2	1-2
RMS Energy Spread	%	**0.1**	0.1
RMS Bunch Length	μm	6-3	24-20
RMS norm. Emittance	μm	1	1
Slice Energy Spread	%	≤0.05	≤0.05
Slice norm Emittance	mm-mrad	0.5	0.5

Parameter	**Unit**	PWFA	Full X-band
Radiation Wavelength	nm	**3-4**	**4**
Photons per Pulse	$\times 10^{12}$	**0.1- 0.25**	1
Photon Bandwith	%	**0.1**	0.5
Undulator Area Length	m	30	
ρ(1D/3D)	$\times 10^{-3}$	**2**	2
Photon Brilliance per shot	$s\ mm^2 mrad^2$ $bw(0.1\%)$	$\mathbf{1 - 2 \times 10^{28}}$	1×10^{27}

In the Energy region between Oxygen and Carbon K-edge 2.34 nm – 4.4 nm (530 eV -280 eV) water is almost transparent to radiation while nitrogen and carbon are absorbing (and scattering)



Coherent Imaging of biological samples protein clusters, VIRUSES and cells living in their native state
Possibility to study dynamics
~10 ^{11} photons/pulse needed

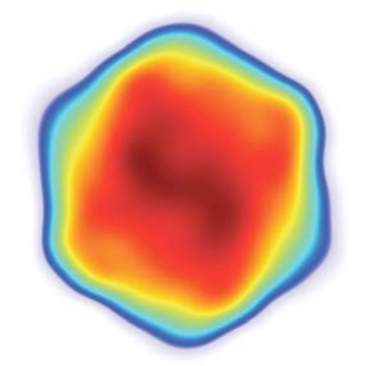
Courtesy F. Stellato, UniToV

Courtesy C. Vaccarezza/L. Giannessi

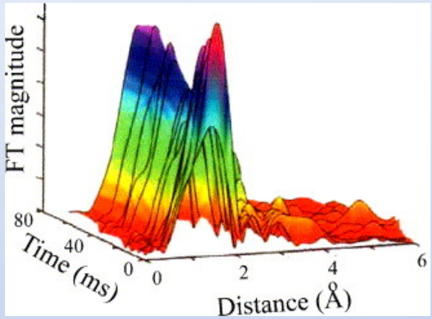
AQUA beamline scientific case

Experimental **techniques** and typology of samples

Coherent imaging



X-ray spectroscopy



Raman spectroscopy

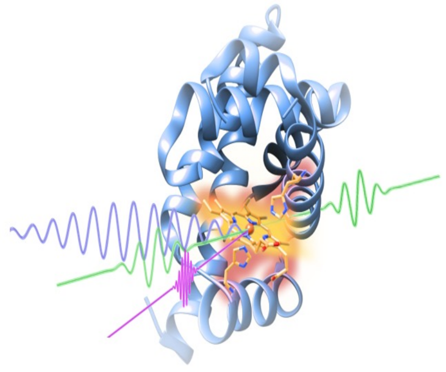
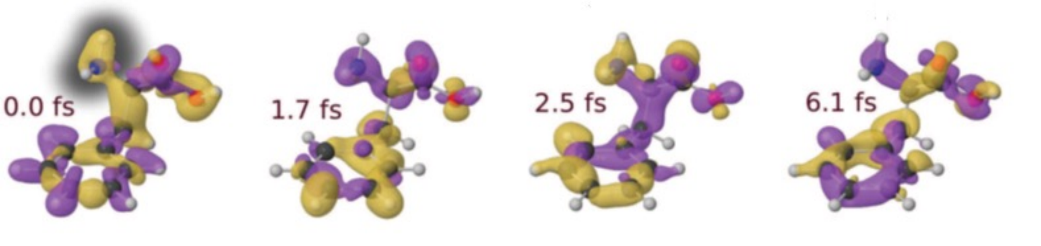


Photo-fragmentation of molecules



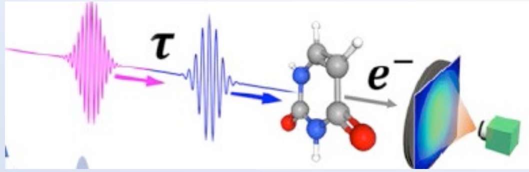
(Large) Viruses
Organelles
Bacteria/Cells
Metals
Semiconductors
Superconductors
Magnetic materials
Organic molecules

Courtesy F. Stellato

ARIA beamline scientific case

Defining experimental **techniques** and typology of samples (and applications)

Photoemission Spectroscopy



Photoelectron Circular Dichroism

Raman spectroscopy

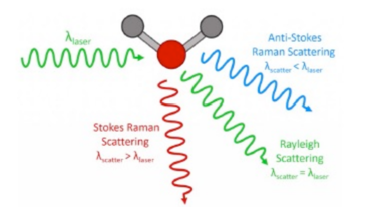
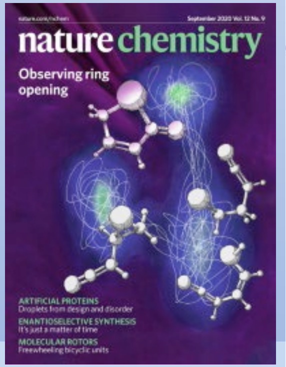
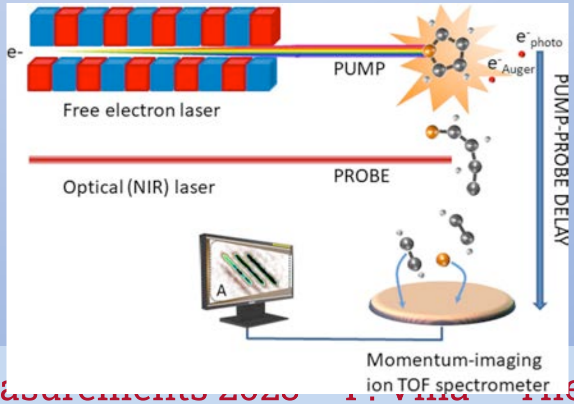


Photo-fragmentation of molecules
Time of Flight Spectroscopy

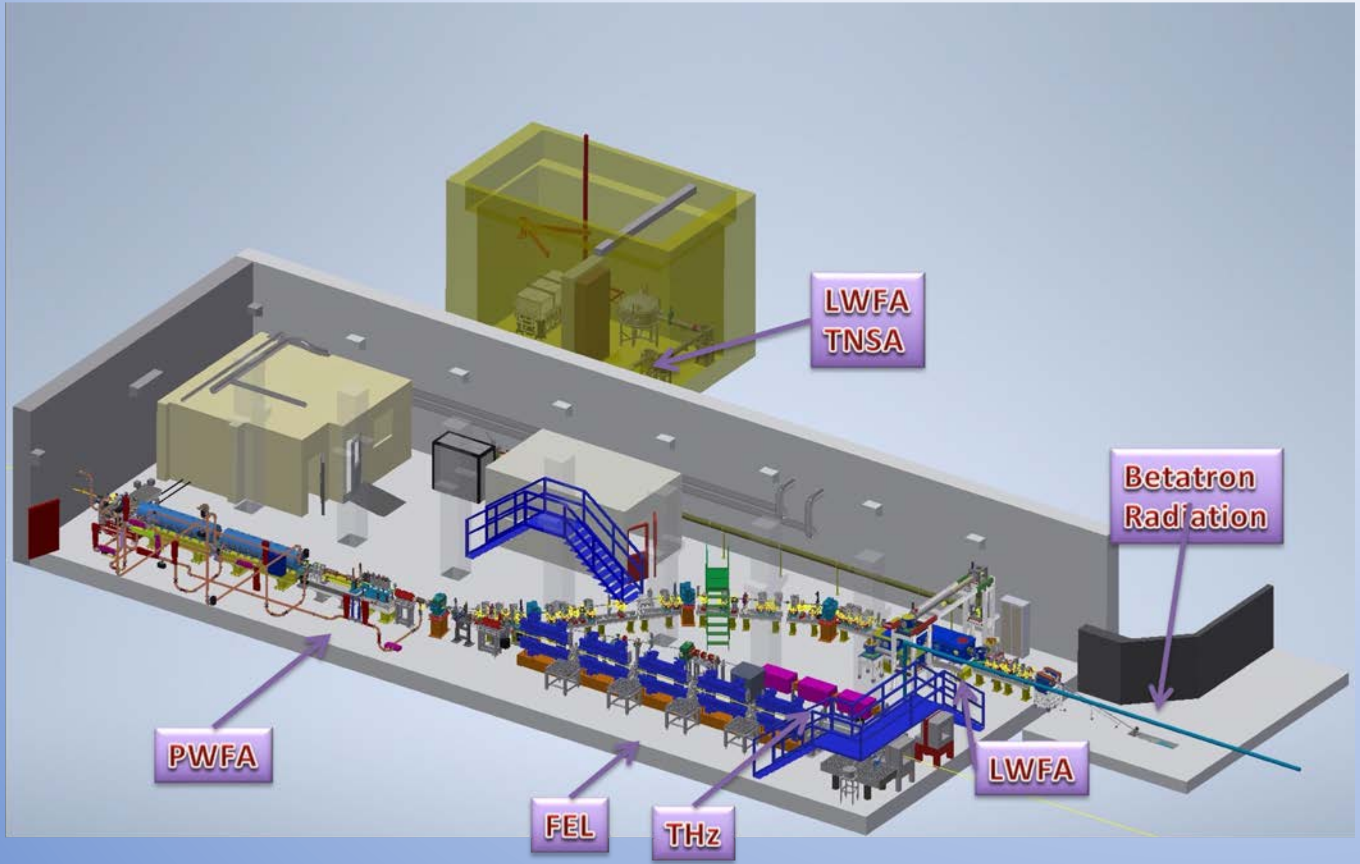


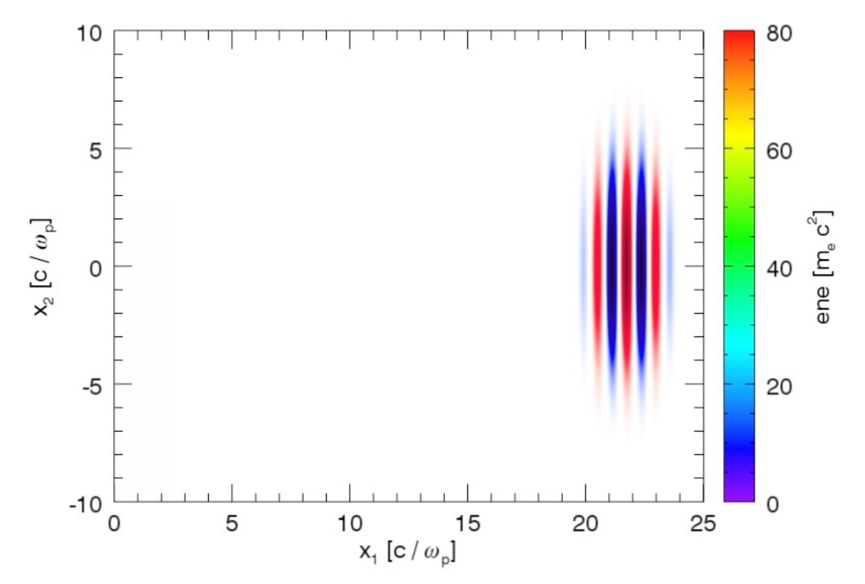


Gas phase & Atmosphere
(Earth & Planets)
Aerosols
(Pollution, nanoparticles)
Molecules & gases
(spectroscopies, time-of-flight)
Proteins
(spectroscopies)
Surfaces
(ablation & deposition)

Courtesy F. Stellato

Betatron Radiation Source at SPARC_LAB





Courtesy J. Vieira, R. Fonseca/GoLP/IST Lisbon

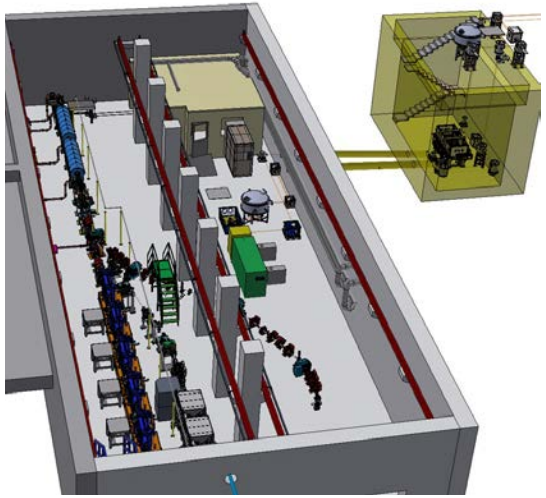
Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
EuPRAXIA Advanced Photon Sources

EuPRAXIA Advanced Photon Sources (EuAPS)

- Supported by PNRR funding
- Collaboration among INFN, CNR, University of Tor Vergata
- EuPRAXIA → *laser-driven betatron radiation source @SPARC_LAB*
  → development of high power (up to 1 PW at LNS) and high repetition rate (up to 100 Hz at CNR Pisa) laser
  → pre-cursor for user-facility

1) **Ultrafast** - laser pulse duration tens of fs useful for **time resolved experiments** (XFEL tens of fs, synchrotron tens to 100 ps).
2) **Broad energy spectrum** - important for **X-ray spectroscopy**.
3) **High brightness** - small source size and high photon flux for **fast processes**
4) **Large market** - 50 synchrotron light sources worldwide, 6 hard XFEL's and 3 soft-ray ones (many accelerators operational and some under construction).

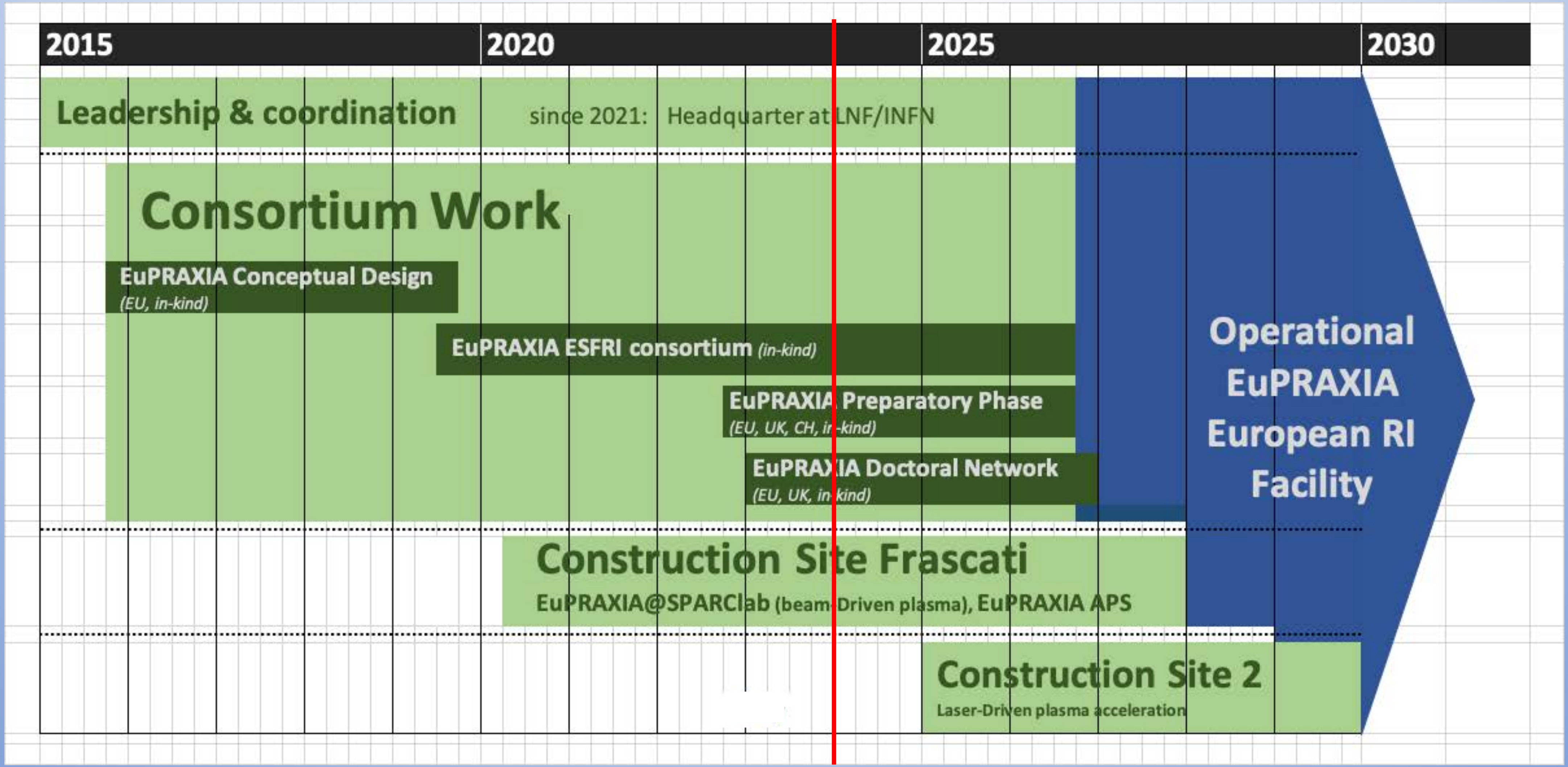
Parameter	Value	unit
Electron beam Energy	100-500	MeV
Plasma Density	10^{18}-10^{19}	cm^{-3}
Photon Critical Energy	1 -10	keV
Number of Photons/pulse	10^{7}-10^{9}	
Repetition rate	1-5	Hz
Beam divergence	3-20	mrad



Courtesy of A. Cianchi

EuPRAXIA Project Timeline

Funded by the European Union



Courtesy A. Falone

Conclusions

Funded by the European Union

- Plasma accelerators have advanced considerably in beam quality, **achieving FEL lasing**.
- EuPRAXIA is a design and an 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 2028**.
- Second EuPRAXIA FEL site will be selected in next 18 months, among **4 excellent candidate sites**.
- Concept today **works in design and in reality**. Expect (solvable) problems in stability for **24/7 user operation**. Facility needed to demonstrate!
- Additional fund raising is continuosly going on

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FEATURE EuPRAXIA

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.

Thank for your attention