Lnf & EuPRAXIA

Fabio Bossi INFN-LNF

ECFA

European Committee for Future Accelerators

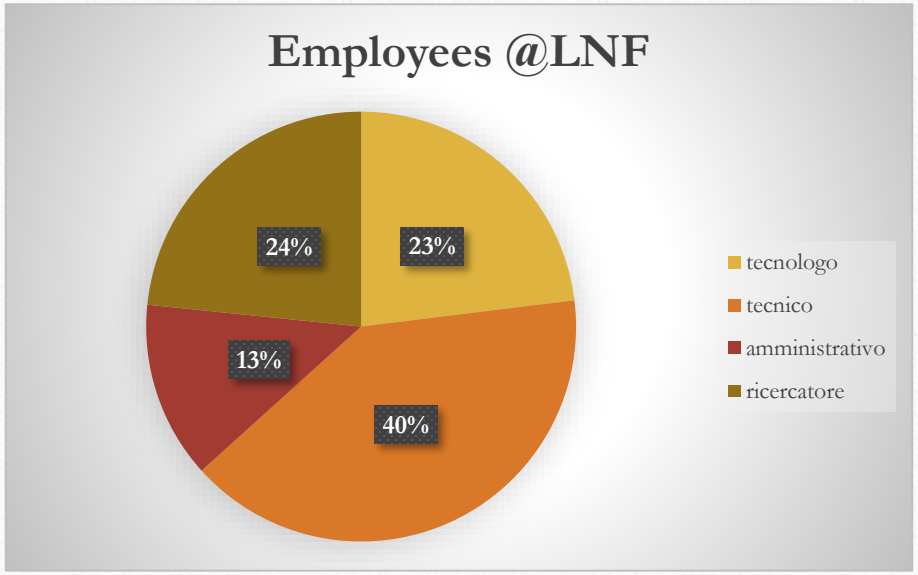
LNF is the oldest and largest national laboratory of INFN.

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Founded in 1954, its main mission has always been the construction and operation of particle accelerators

At present, the laboratory covers an area of about **135,000** sqm and operates the **DAΦNE** e^+e^- collider complex and the **SPARC_LAB** plasma acceleration facility

As of March. 1 2022 there are **305** permanent or fixed-term employees at LNF (researchers, engineers, technicians, administratives) and **39** postdocs



Year 2020 budget

Item	k€
General expenses	12047.00
Research budget	5849.00
External Funds	12034.00
Total	**29930.00**

In 2005 the facility **SPARC_LAB** was put into operation as a test and training facility for advanced accelerator developments

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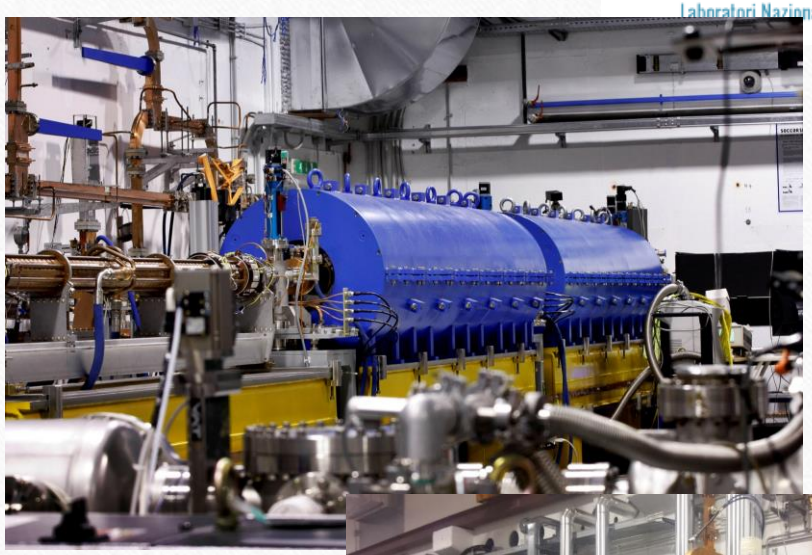
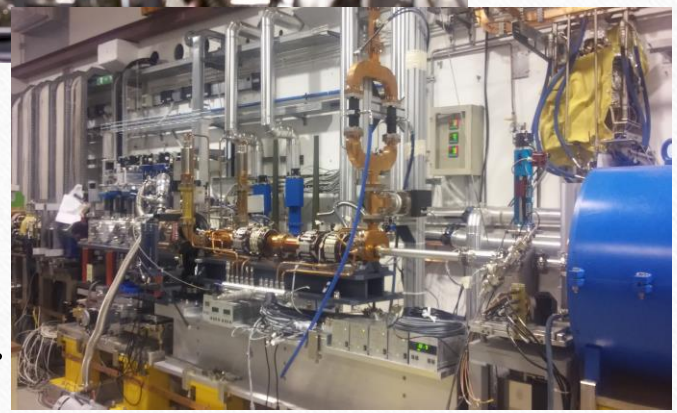
It consists of a high-brightness RF photoinjector, SPARC, and a multi-hundred terawatt laser, FLAME, and was initially focussed on performing FEL experiments and in general on the production of new radiation sources



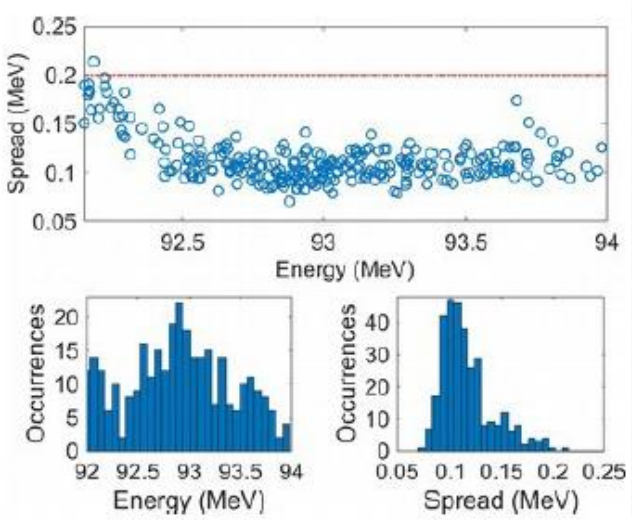
Photoinjector



Plasma Vacuum Chamber

In recent years a dedicated effort has been put in the research on very high acceleration gradients with the **plasma wake field** technique

SPARC_LAB results



Pompili, R., et al. "Energy spread minimization in a beam-driven plasma wakefield accelerator." Nature Physics (2020): 1-5.

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Achieved 4 MeV acceleration in 3 cm plasma with 200 pC driver

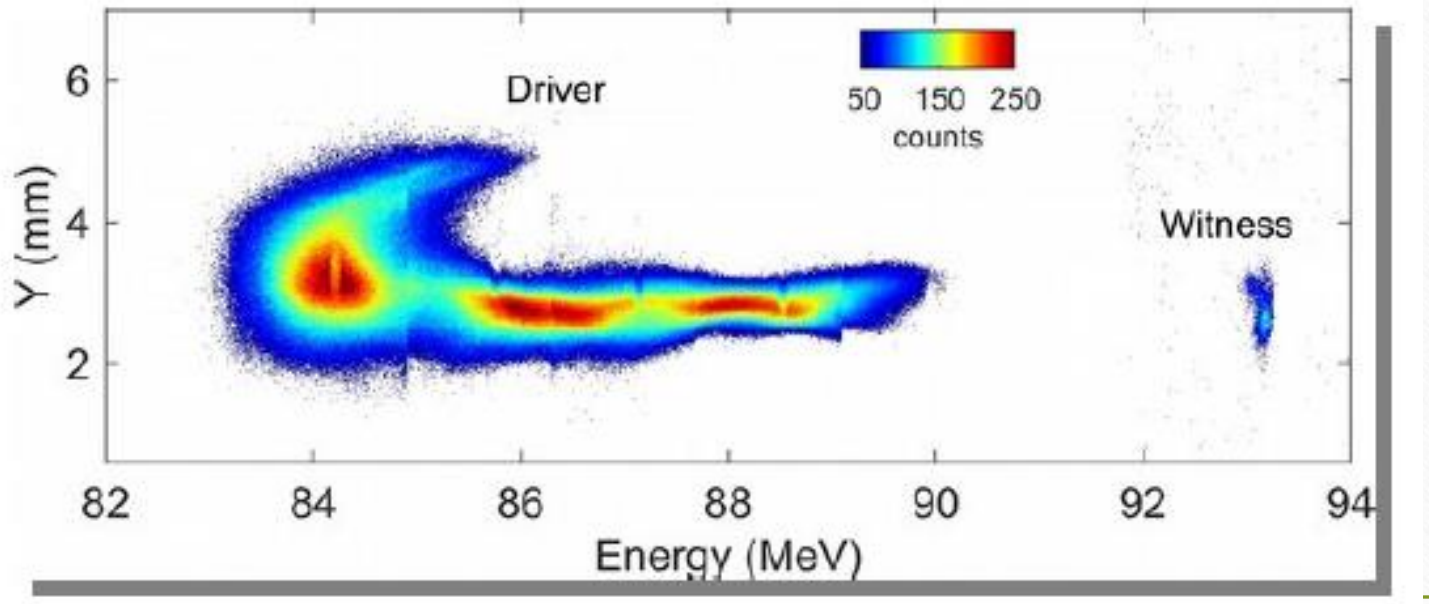
~133 MV/m accelerating gradient

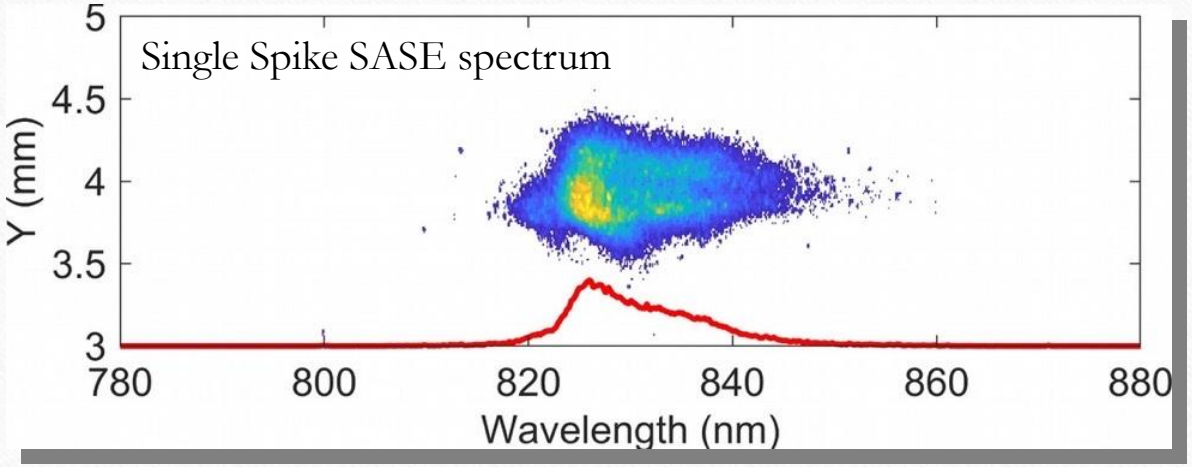
$2x10^{15}$ cm^{-3} plasma density

→ demonstration of energy spread compensation during acceleration

Energy spread reduced from 0.2% to 0.12%

99.5% energy stability





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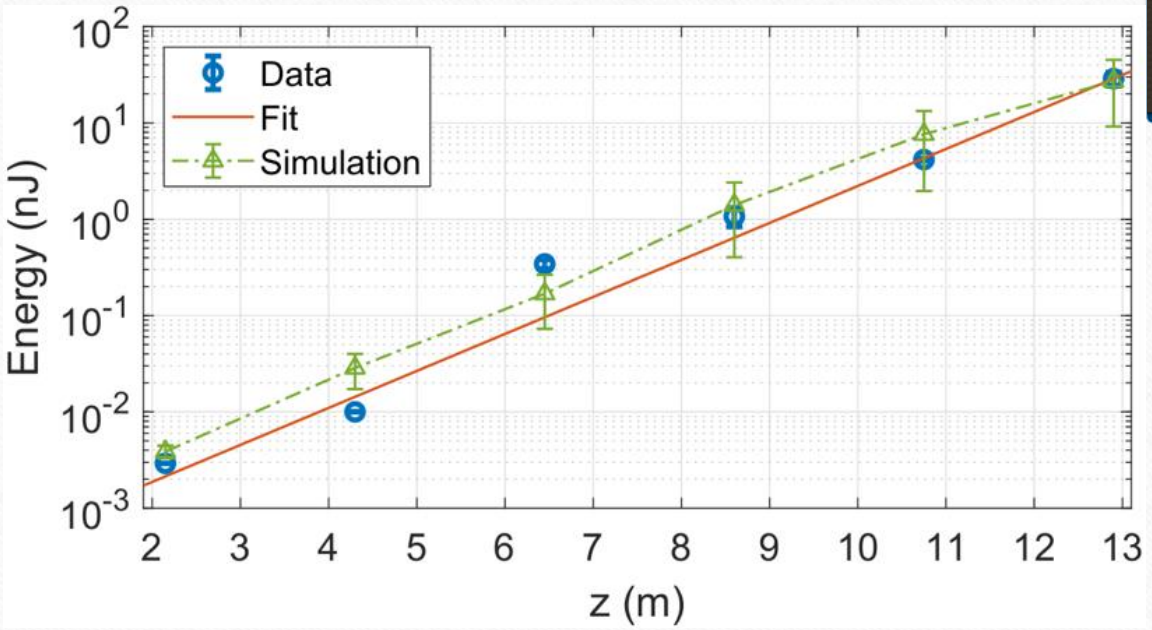
First SASE-FEL Lasing at SPARC_LAB in a beam-driven plasma accelerator

Nature paper coming soon (accepted for publication)

FEL Energy gain along the undulators:

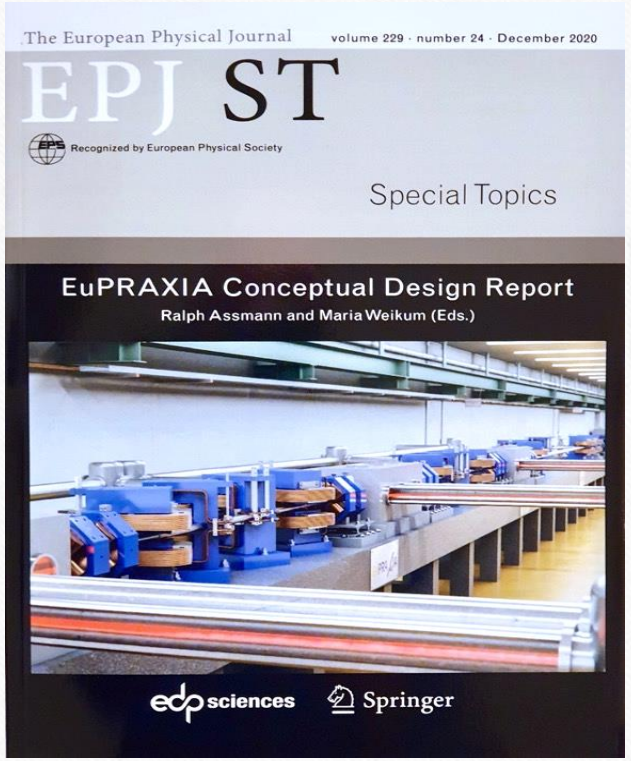


In 2015 the idea of a distributed research infrastructure at the european level **EuPRAXIA** was launched, in the framework of the EU Horizon2020 program

The basic and challenging idea was to arrive at the first ever design of a **plasma accelerator user facility**

The conceptual design report was completed in 2020 by **16** participants+ **25** associated Institutes

The project aims at the construction of two electron machines using laser and beam-driven plasma wakefield acceleration, in the energy range from **1 to 5 GeV**, enabling FEL lasing, compact sources for medical applications etc…



600+ page CDR, 240 scientists contributed

A few important milestones

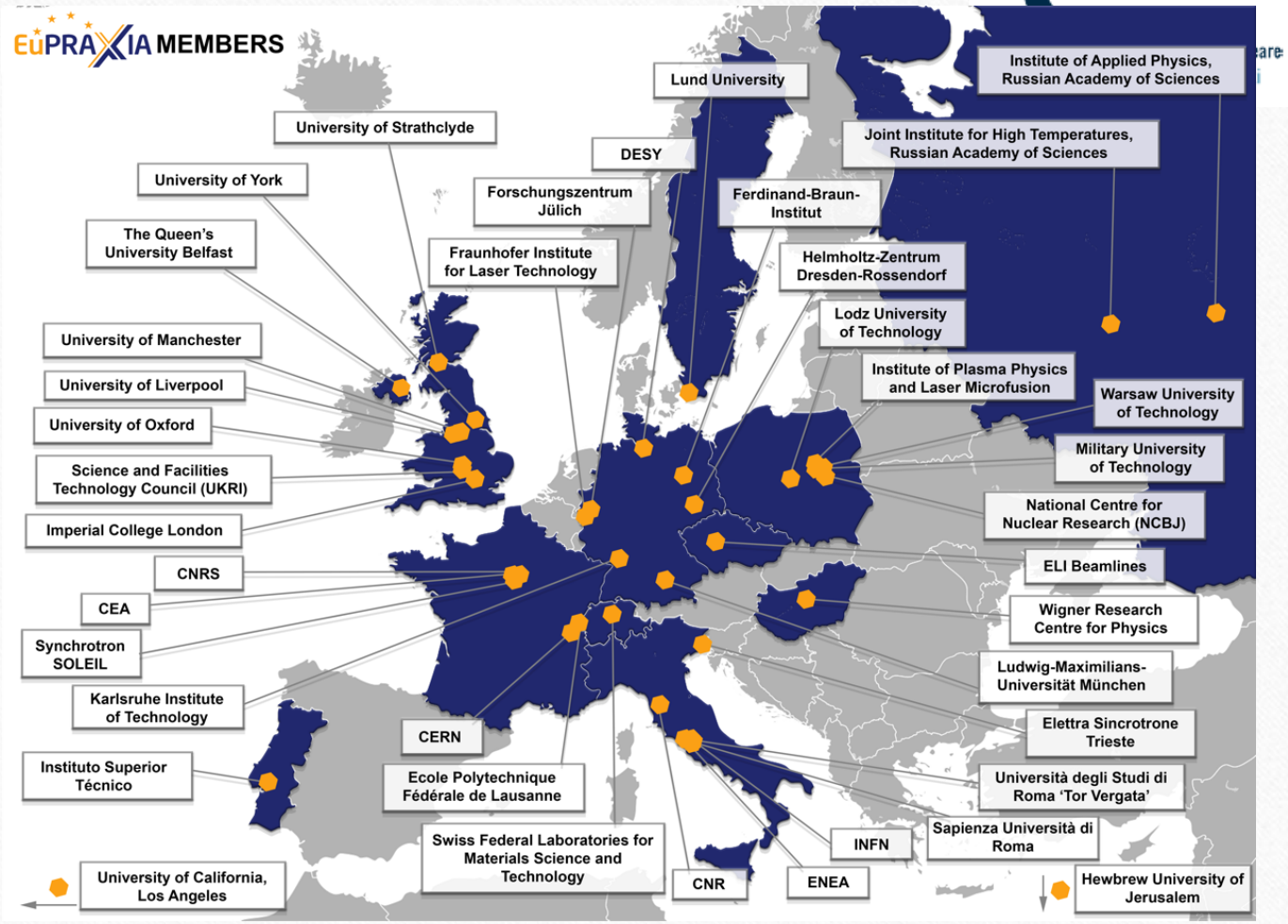
- Approval from the Italian Ministry for University and Research of a **108 M€** grant for the construction of the LNF site (Feb. 2020) ☺
- Application to the **ESFRI** roadmap (Sep. 2020)
- Formation of a new consortium with 40 participant and 10 observer institutions (Dec. 2020)
- EuPraxia inserted in the **ESFRI** roadmap (June 2021) ☺
- Design of the LNF site building finalised (Dec. 2021) ☺
- Application for the **ESFRI** Preparatory Phase Project (Jan. 2022)

The new Consortium

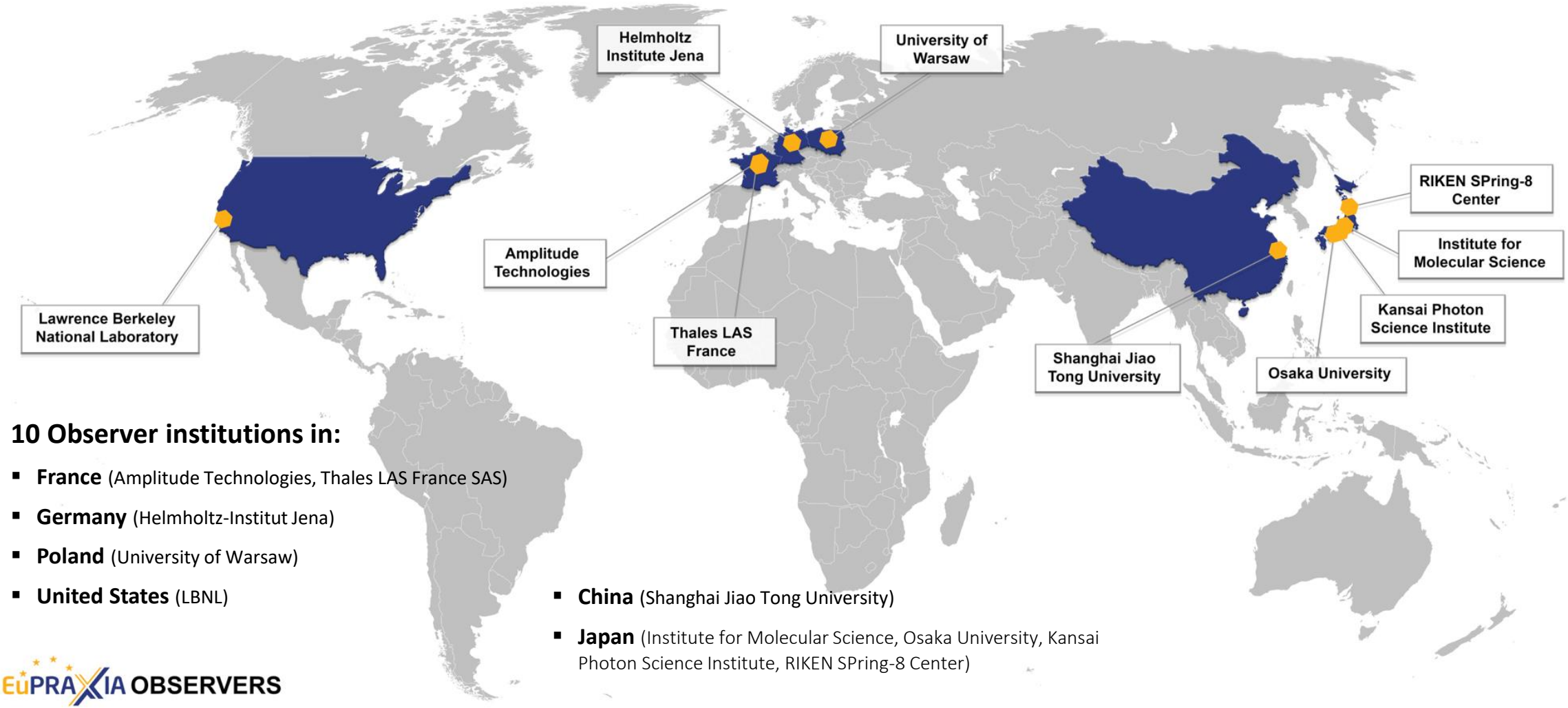
40 Member institutions in:

- **Italy** (INFN, CNR, Elettra, ENEA, Sapienza Università di Roma, Università degli Studi di Roma "Tor Vergata")
- **France** (CEA, SOLEIL, CNRS)
- **Switzerland** (EMPA, Ecole Polytechnique Fédérale de Lausanne)
- **Germany** (DESY, Ferdinand-Braun-Institut, Fraunhofer Institute for Laser Technology, Forschungszentrum Jülich, HZDR, KIT, LMU München)
- **United Kingdom** (Imperial College London, Queen's University of Belfast, STFC, University of Liverpool, University of Manchester, University of Oxford, University of Strathclyde, University of York)
- **Poland** (Institute of Plasma Physics and Laser Microfusion, Lodz University of Technology, Military University of Technology, NCBJ, Warsaw University of Technology)
- **Portugal** (IST)
- **Hungary** (Wigner Research Centre for Physics)
- **Sweden** (Lund University)
- **Israel** (Hebrew University of Jerusalem)
- **Russia** (Institute of Applied Physics, Joint Institute for High Temperatures)
- **United States** (UCLA)
- **CERN**
- **ELI Beamlines**

plus Spain & Greece



The new Consortium (observers)



10 Observer institutions in:

- **France** (Amplitude Technologies, Thales LAS France SAS)
- **Germany** (Helmholtz-Institut Jena)
- **Poland** (University of Warsaw)
- **United States** (LBNL)
- **China** (Shanghai Jiao Tong University)
- **Japan** (Institute for Molecular Science, Osaka University, Kansai Photon Science Institute, RIKEN SPring-8 Center)

EuPRAXIA OBSERVERS

ESFRI Roadmap Announcement (June 30th 2021)

ESFRI

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ESFRI announces new RIs for Roadmap 2021

30.06.2021
PRESS RELEASE

ESFRI announces the 11 new Research Infrastructures to be included in its Roadmap 2021

€4.1 billion investment in excellent science contributing to address European challenges

After two years of hard work, following a thorough evaluation and selection procedure, ESFRI proudly announces the **11 proposals** that have been scored high for their science case and maturity for implementation and will be included as new Projects in the **ESFRI 2021 Roadmap Update**.

The new ESFRI Projects are:

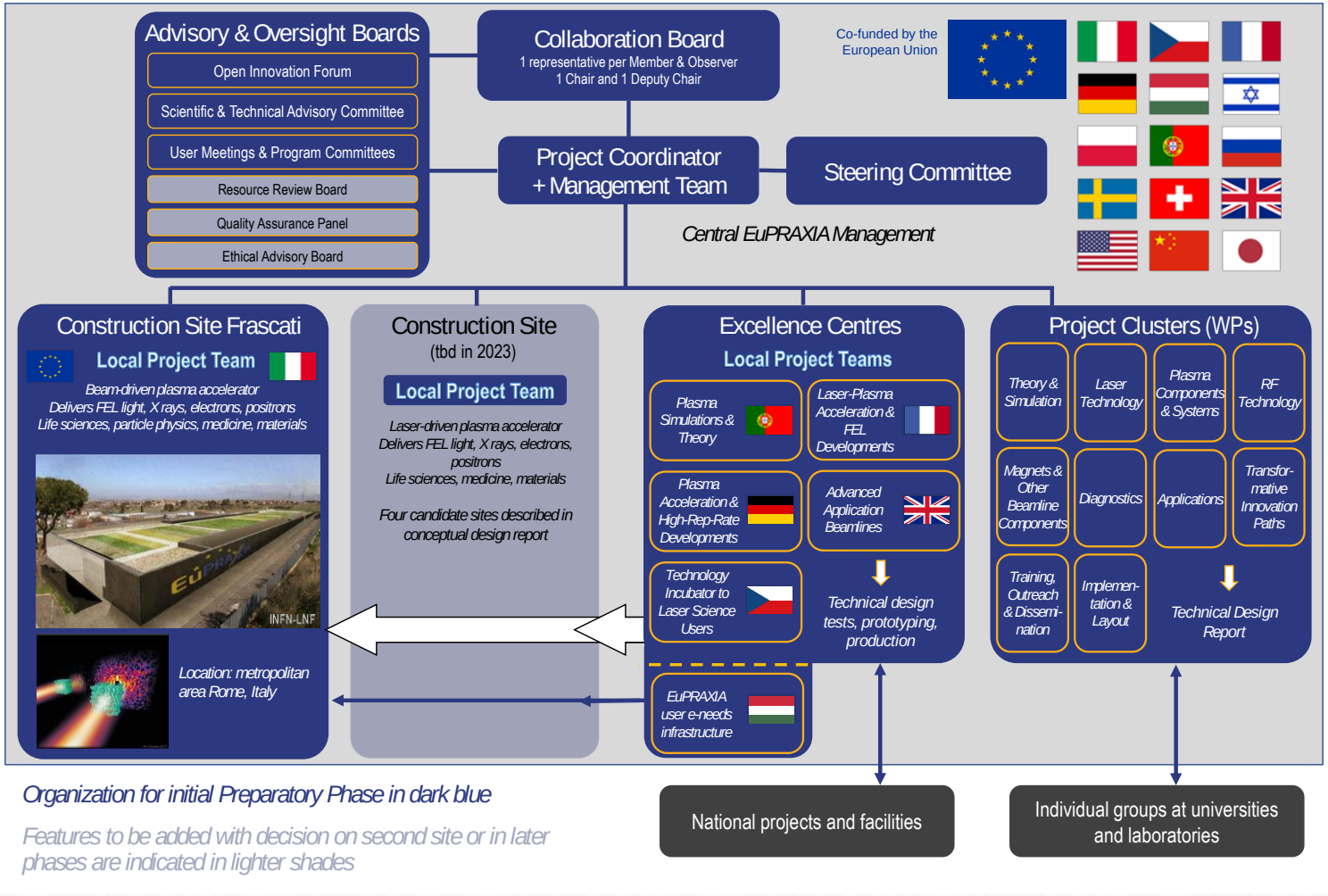
- **EBRAINS** - European Brain ReseArch INfrastructureS, a distributed digital infrastructure at the interface of neuroscience, computing and technology, offering scientists

- There is a **new level of ambition** to develop globally unique, complex facilities for frontier science: Einstein Telescope – highest value project ever on the Roadmap - EUR 1.900 million, and EuPRAXIA – innovative accelerator based on plasma technology - EUR 569 million.

Gravitation Waves research.

- **EuPRAXIA** - European Plasma Research Accelerator with Excellence in Applications, a distributed, compact and innovative accelerator facility based on plasma technology, set to construct an electron-beam-driven plasma accelerator in the metropolitan area of Rome, followed by a laser-driven plasma accelerator in European territory.

Governing structure of the project



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Concept of a distributed research infrastructure

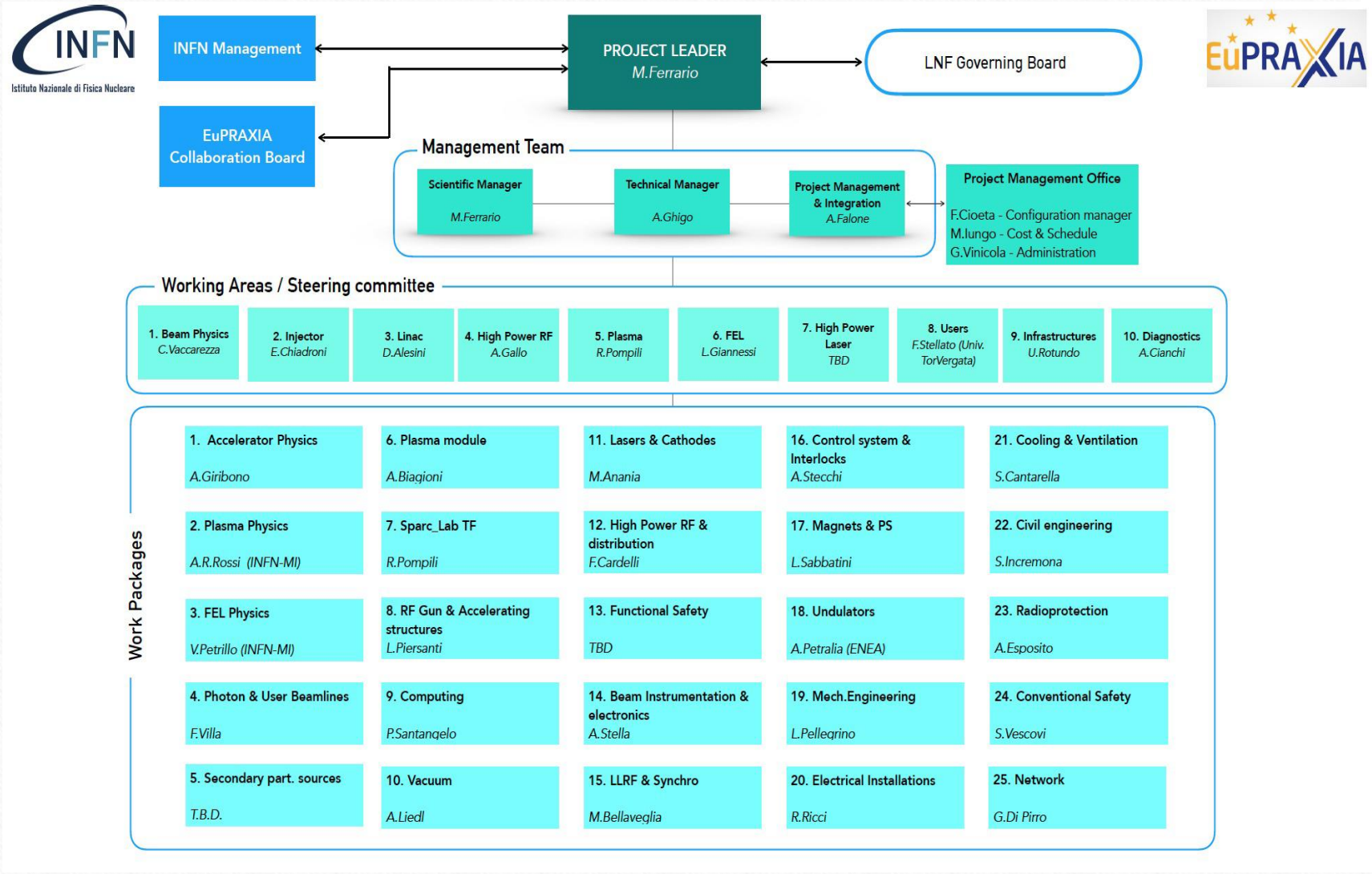
The location of the second construction site yet to be decided

EuPRAXIA at LNF

Besides being the location of the headquarter of the overall european project, LNF is also the site of construction and operation of the beam-driven machine: **EuPraxia@Sparc_Lab**

For this specific project we have produced a local organization chart and governing structure, including a PM office, and delivered a precise WBS and implementation plan

An international advisory board has been formed to scrutinize periodically the progress of the project and provide advise on all the relevant technical issues: P. Muggli (MPP, D, chair), D. Angal-Kalinin (STFC, UK), M. Pedrozzi (PSI, CH), S. Schreiber (DESY, D), L. Scibile (CERN)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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.Iungo - Cost & Schedule
G.Vinicola - Administration
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
Work Packages
1. Accelerator Physics
A.Giribono
2. Plasma Physics
A.R.Rossi (INFN-MI)
3. FEL Physics
V.Petrillo (INFN-MI)
4. Photon & User Beamlines
F.Villa
5. Secondary part. sources
T.B.D.
6. Plasma module
A.Biagioni
7. Sparc_Lab TF
R.Pompili
8. RF Gun & Accelerating structures
L.Piersanti
9. Computing
P.Santangelo
10. Vacuum
A.Liedl
11. Lasers & Cathodes
M.Anania
12. High Power RF & distribution
F.Cardelli
13. Functional Safety
TBD
14. Beam Instrumentation & electronics
A.Stella
15. LLRF & Synchro
M.Bellaveglia
16. Control system & Interlocks
A.Stecchi
17. Magnets & PS
L.Sabbatini
18. Undulators
A.Petralia (ENEA)
19. Mech.Engineering
L.Pellegrino
20. Electrical Installations
R.Ricci
21. Cooling & Ventilation
S.Cantarella
22. Civil engineering
S.Incremona
23. Radioprotection
A.Esposito
24. Conventional Safety
S.Vescovi
25. Network
G.Di Pirro
EuPRAXIA
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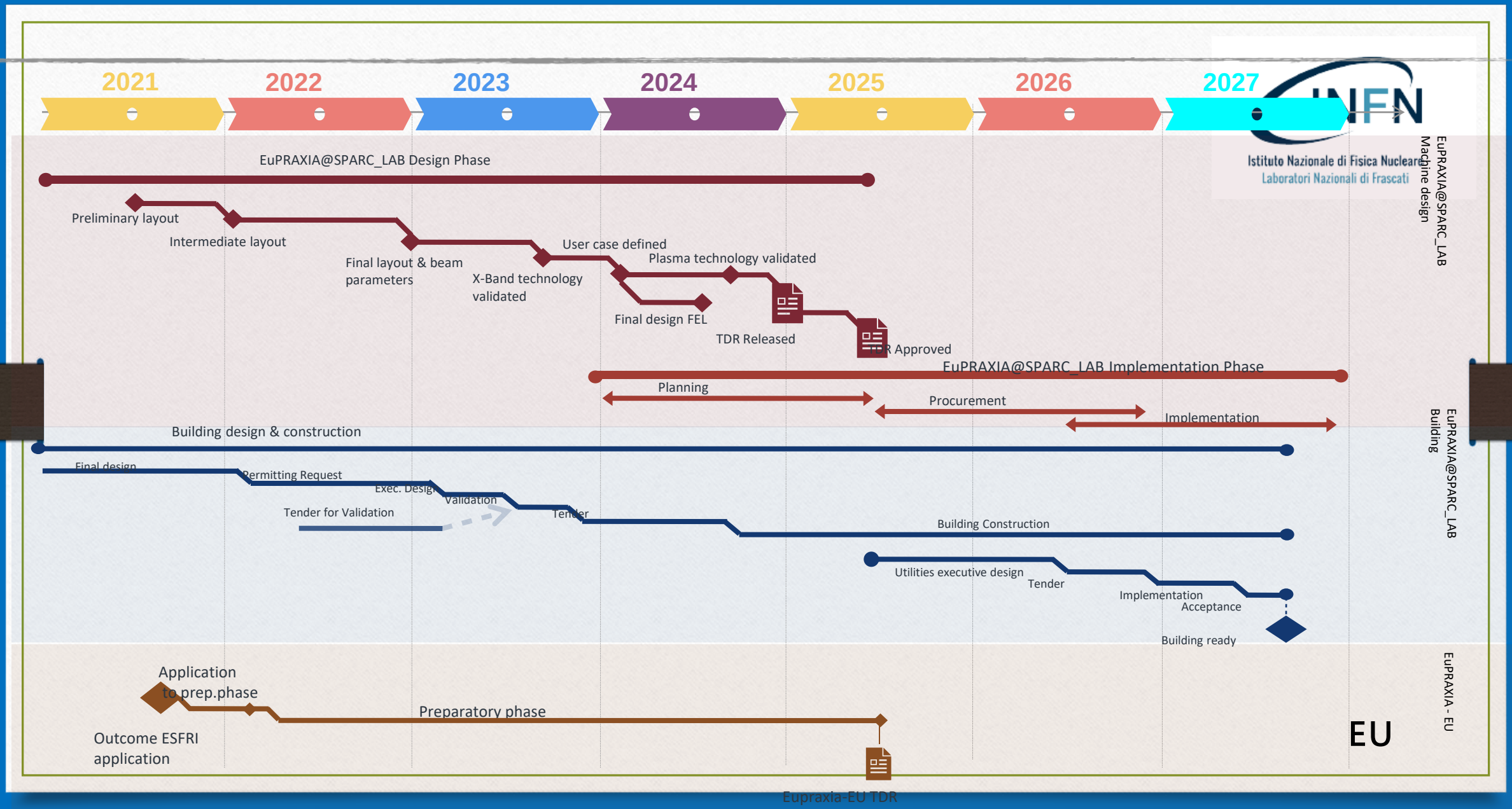
2021
2022
2023
2024
2025
2026
2027
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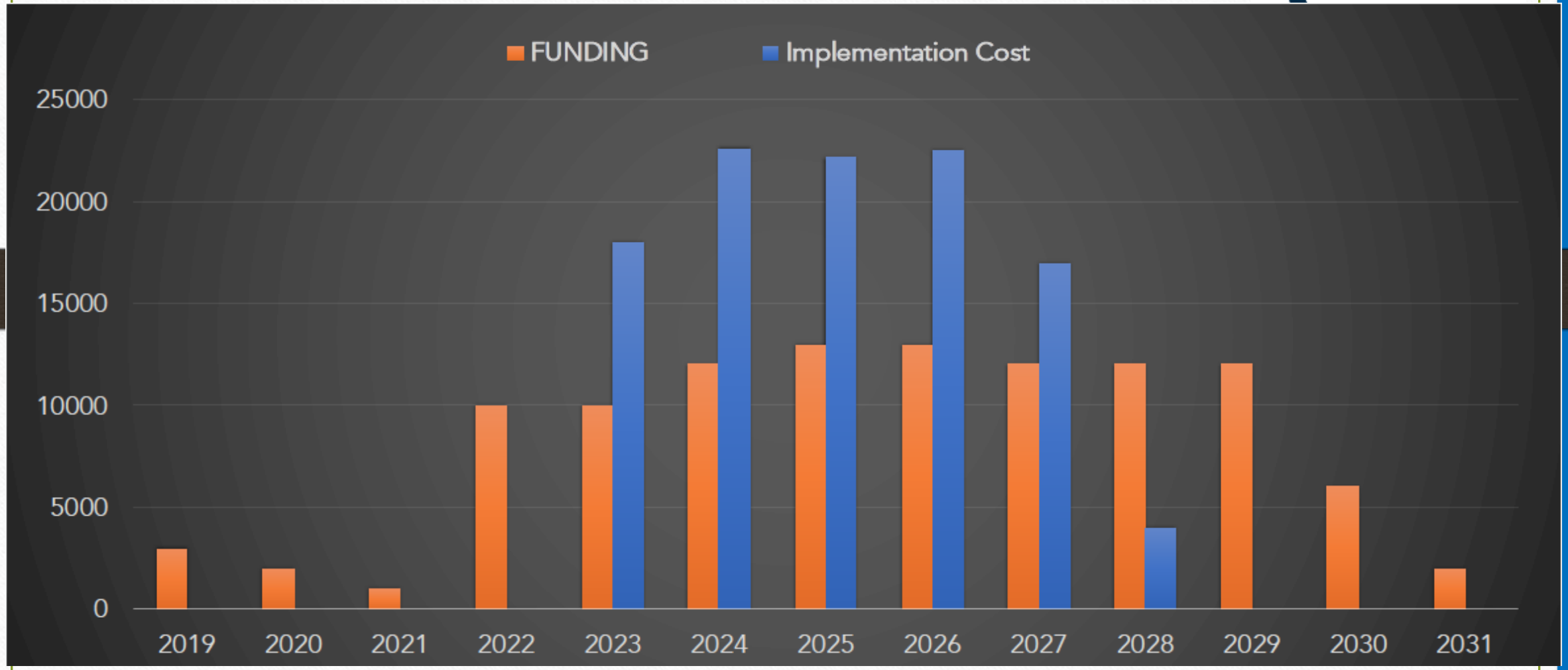
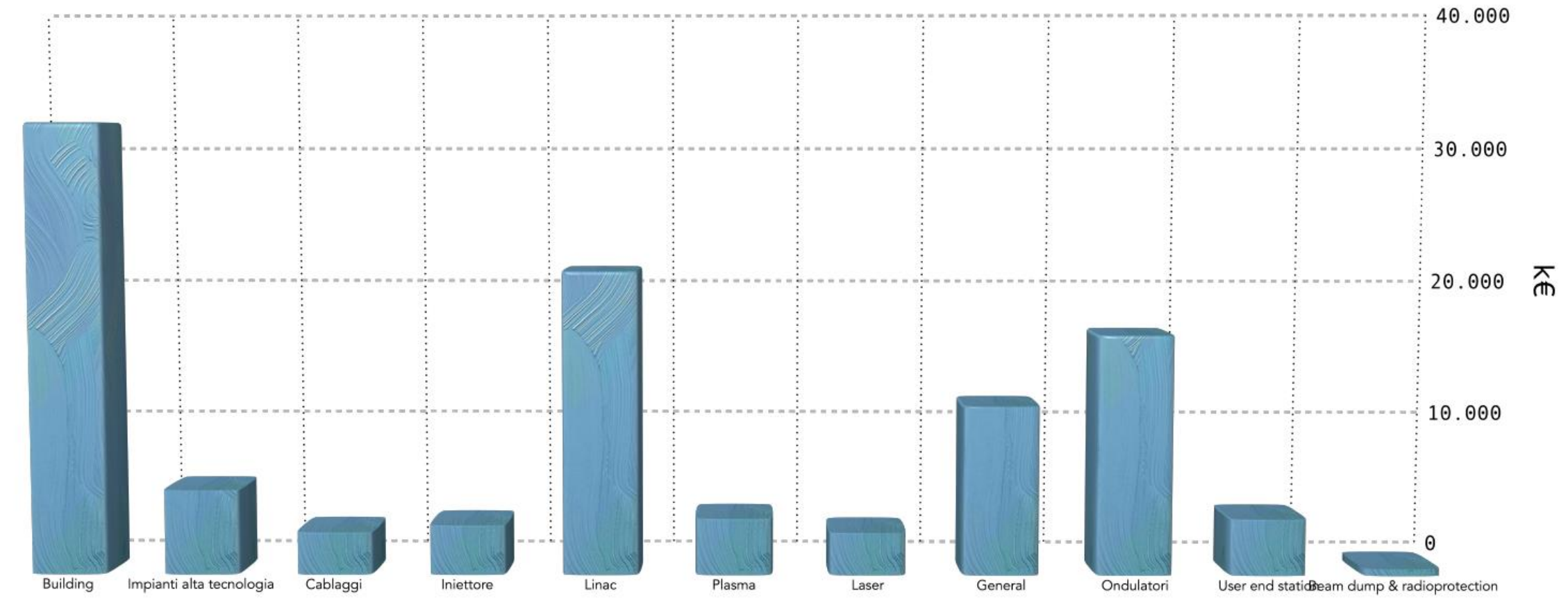
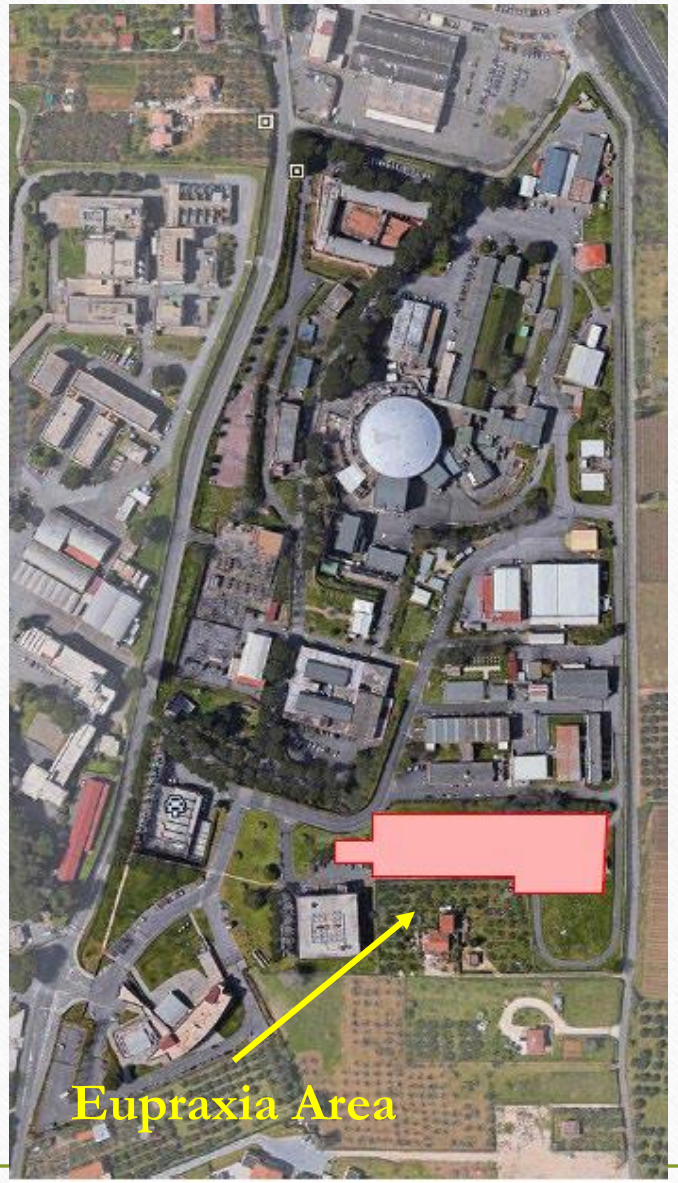
Laboratori Nazionali di Frascati
EuPRAXIA@SPARC_LAB Design Phase
Preliminary layout
Intermediate layout
Final layout & beam parameters
X-Band technology validated
User case defined
Plasma technology validated
Final design FEL
TDR Released
TDR Approved
EuPRAXIA@SPARC_LAB Implementation Phase
Planning
Procurement
Implementation
Building design & construction
Final design
Permitting Request
Exec. Design
Validation
Tender for Validation
Tender
Building Construction
Utilities executive design
Tender
Implementation
Acceptance
Building ready
Application to prep.phase
Preparatory phase
Outcome ESFRI application
Eupraxia-EU TDR
EU
EuPRAXIA@SPARC_LAB Machine design
EuPRAXIA@SPARC_LAB Building
EuPRAXIA - EU

Profile of expenditure (per year)



Profile of expenditure (per item)





The final design for the building has been delivered. We are now starting to work on the authorisation procedures

Overall cost of the building estimated to be **32 M€**, including all the accessory plants

We plan to start the construction in the fall of 2024

Regional funds

In the last years the Lazio Region has contributed resources to the Laboratory's science, through dedicated funding projects

In particular, somehow connected to Eupraxia/Sparc_Lab, two different programs have been issued

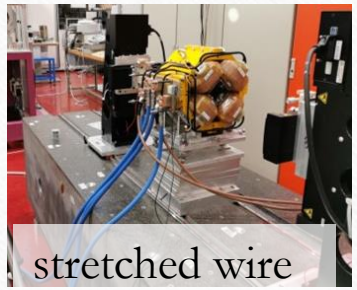
- **LATINO**. An open research infrastructure to provide (also) to private companies the technology developed in the field of accelerators. Funded with **~ 2 M€**
- **SABINA**. Sparc_Lab technical plant consolidation, to allow also accesse to external users. Fundend with **~ 4.5 M€**

We are presently in the phase of negotiations for further investments specifically devoted to EuPRAXIA

old

renewed

Magnetic measurement Lab



stretched wire

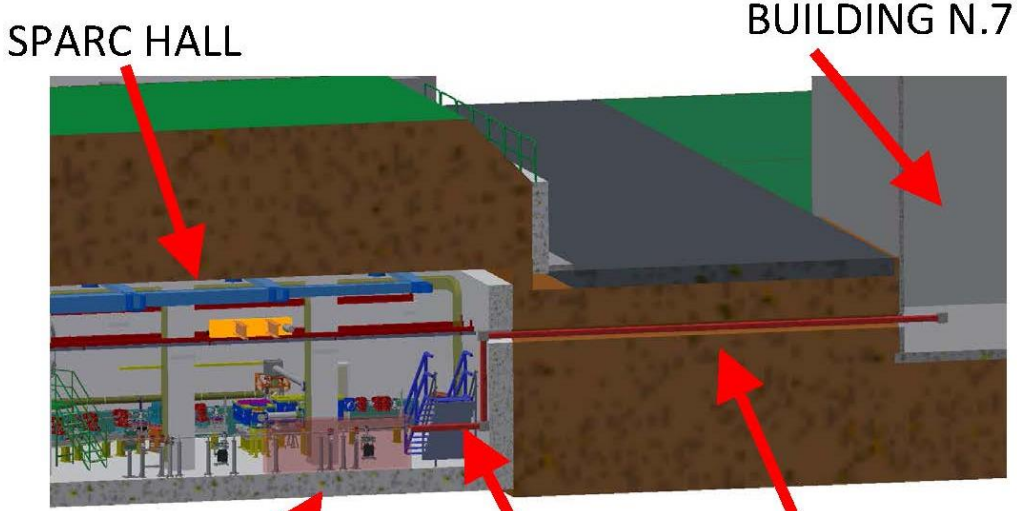
new brazing oven

Examples of LNF infrastructure upgrades based on LATINO project funds

old RF bunker

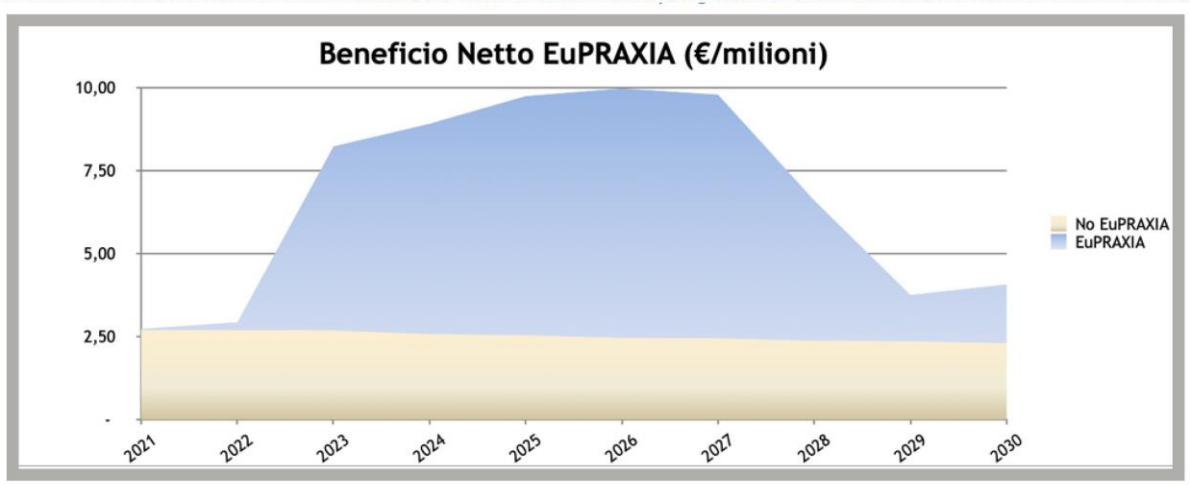
renewed RF bunker - TEX

SABINA: area of interventions



courtesy of Luigi Pellegrino

A regional impact analysis of the Laboratory's activities with some projection on the EuPRAXIA operation has been recently delivered. The incidence of EuPRAXIA in the regional economy is clearly visible



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Application to PNRR funds

An application to the PNRR funds has recently been issued in collaboration with **INFN-LNS**, **CNR-ISM** (Montelibretti (RM)-Potenza), **CNR-INO** (Pisa) and **Tor Vergata University** for:

- The development of a betatron source and all the related diagnostic tools, to be tested at Sparc_Lab, and eventually exploited at EuPRAXIA
- The development of a high power (1 PW) laser at high repetition rate (100 Hz), needed for the operation of the above mentioned instrument

The project, dubbed **EuAPS** (**Eu**praxia-**A**dvanced-**P**hoton-**S**ource) is worth ~ **27 M€**

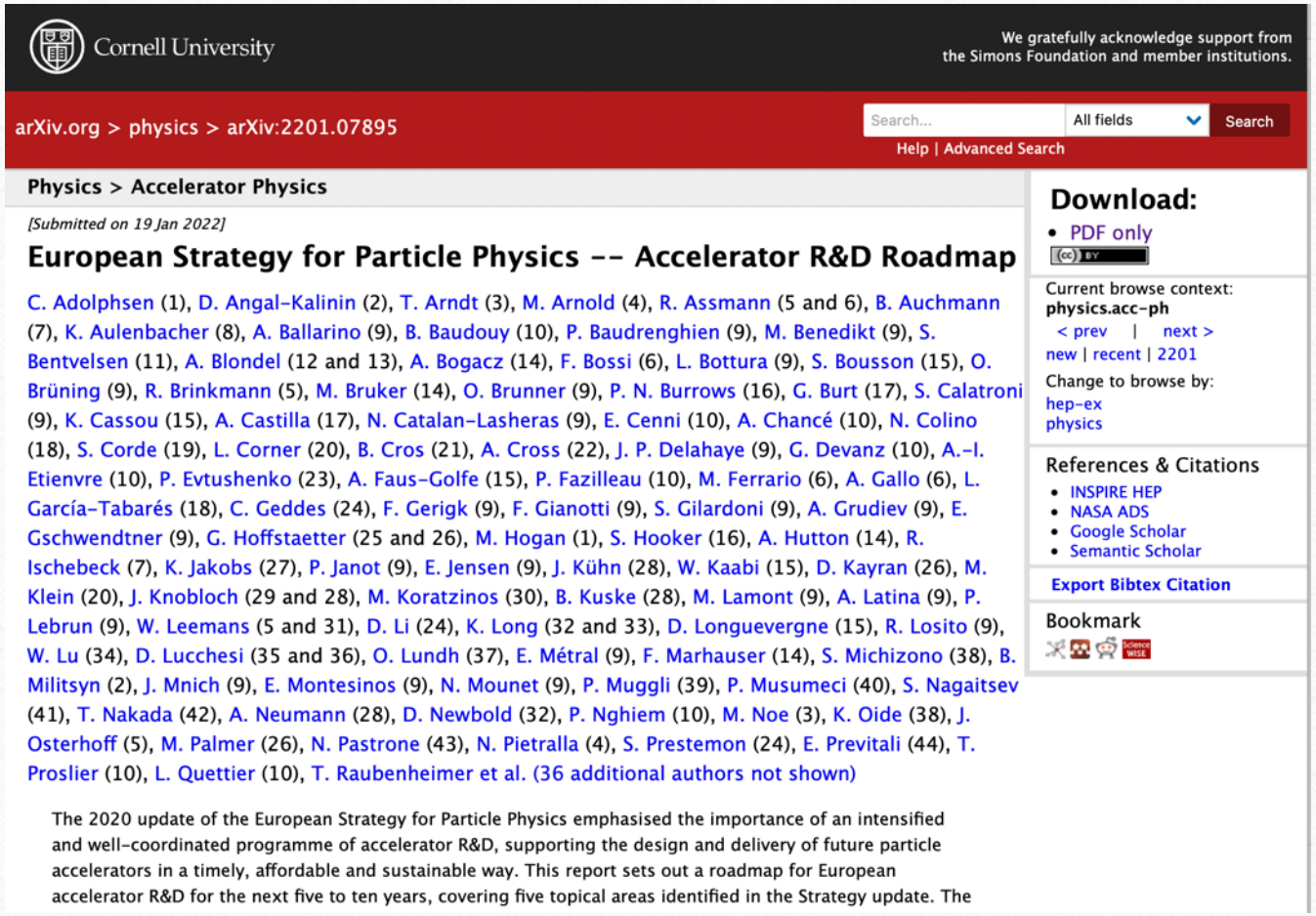
Final considerations

It is clear that EuPRAXIA's end-users will mostly come from different communities wrt HEP. It will serve mostly life science, material science, industrial applications…This is a political and sociolagical issue for the Laboratory that has to be taken properly into consideration. However…

Plasma acceleration is one of the key technologies for the construction of the future HEP colliders, as explicitly recognised by the European Strategy for Particle Physics

We are already part of this process and will continue to contribute to it also in the future

Report on European Accelerator R&D: Includes detailed discussion on plasma and laser accelerators



Cornell University

We gratefully acknowledge support from the Simons Foundation and member institutions.

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Physics > Accelerator Physics

[Submitted on 19 Jan 2022]

European Strategy for Particle Physics -- Accelerator R&D Roadmap

C. Adolphsen (1), D. Angal-Kalinin (2), T. Arndt (3), M. Arnold (4), R. Assmann (5 and 6), B. Auchmann (7), K. Aulenbacher (8), A. Ballarino (9), B. Baudouy (10), P. Baudrenghien (9), M. Benedikt (9), S. Bentvelsen (11), A. Blondel (12 and 13), A. Bogacz (14), F. Bossi (6), L. Bottura (9), S. Bousson (15), O. Brüning (9), R. Brinkmann (5), M. Bruker (14), O. Brunner (9), P. N. Burrows (16), G. Burt (17), S. Calatroni (9), K. Cassou (15), A. Castilla (17), N. Catalan-Lasheras (9), E. Cenni (10), A. Chancé (10), N. Colino (18), S. Corde (19), L. Corner (20), B. Cros (21), A. Cross (22), J. P. Delahaye (9), G. Devanz (10), A.-I. Etienvre (10), P. Evtushenko (23), A. Faus-Golfe (15), P. Fazilleau (10), M. Ferrario (6), A. Gallo (6), L. García-Tabarés (18), C. Geddes (24), F. Gerigk (9), F. Gianotti (9), S. Gilardoni (9), A. Grudiev (9), E. Gschwendtner (9), G. Hoffstaetter (25 and 26), M. Hogan (1), S. Hooker (16), A. Hutton (14), R. Ischebeck (7), K. Jakobs (27), P. Janot (9), E. Jensen (9), J. Kühn (28), W. Kaabi (15), D. Kayran (26), M. Klein (20), J. Knobloch (29 and 28), M. Koratzinos (30), B. Kuske (28), M. Lamont (9), A. Latina (9), P. Lebrun (9), W. Leemans (5 and 31), D. Li (24), K. Long (32 and 33), D. Longuevergne (15), R. Losito (9), W. Lu (34), D. Lucchesi (35 and 36), O. Lundh (37), E. Métral (9), F. Marhauser (14), S. Michizono (38), B. Militsyn (2), J. Mnich (9), E. Montesinos (9), N. Mounet (9), P. Muggli (39), P. Musumeci (40), S. Nagaitsev (41), T. Nakada (42), A. Neumann (28), D. Newbold (32), P. Nghiem (10), M. Noe (3), K. Oide (38), J. Osterhoff (5), M. Palmer (26), N. Pastrone (43), N. Pietralla (4), S. Prestemon (24), E. Previtali (44), T. Proslier (10), L. Quettier (10), T. Raubenheimer et al. (36 additional authors not shown)

The 2020 update of the European Strategy for Particle Physics emphasised the importance of an intensified and well-coordinated programme of accelerator R&D, supporting the design and delivery of future particle accelerators in a timely, affordable and sustainable way. This report sets out a roadmap for European accelerator R&D for the next five to ten years, covering five topical areas identified in the Strategy update. The

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