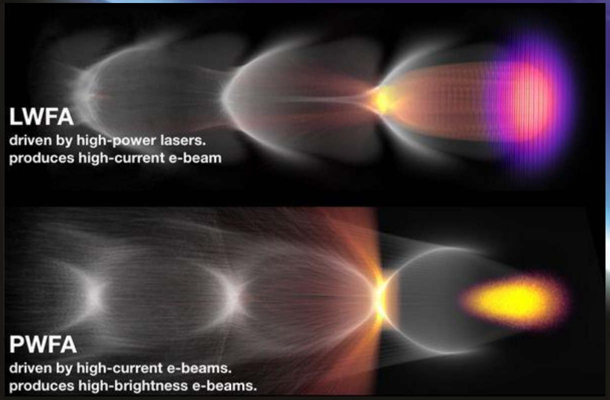
EUROPEAN
PLASMA RESEARCH
ACCELERATOR
WITH
EXCELLENCE IN
APPLICATIONS

The EuPRAXIA project

a plasma based accelerator facility

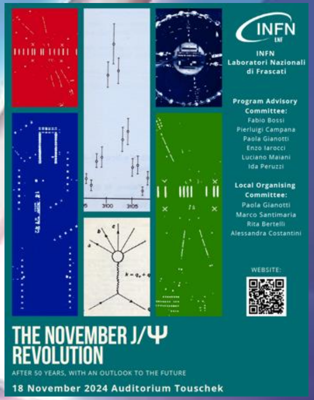
Massimo Ferrario (INFN-LNF)

On behalf of the EuPRAXIA collaboration



LWFA
driven by high-power lasers.
produces high-current e-beam

PWFA
driven by high-current e-beams.
produces high-brightness e-beams.



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Program Advisory Committee:
Fabio Bossi
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Local Organising Committee:
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Rita Bertelli
Alessandra Costantini

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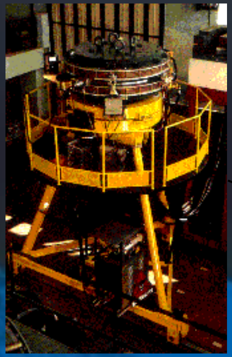
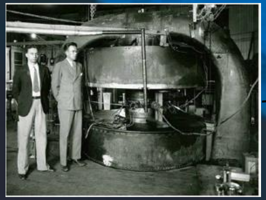
THE NOVEMBER J/Ψ
REVOLUTION

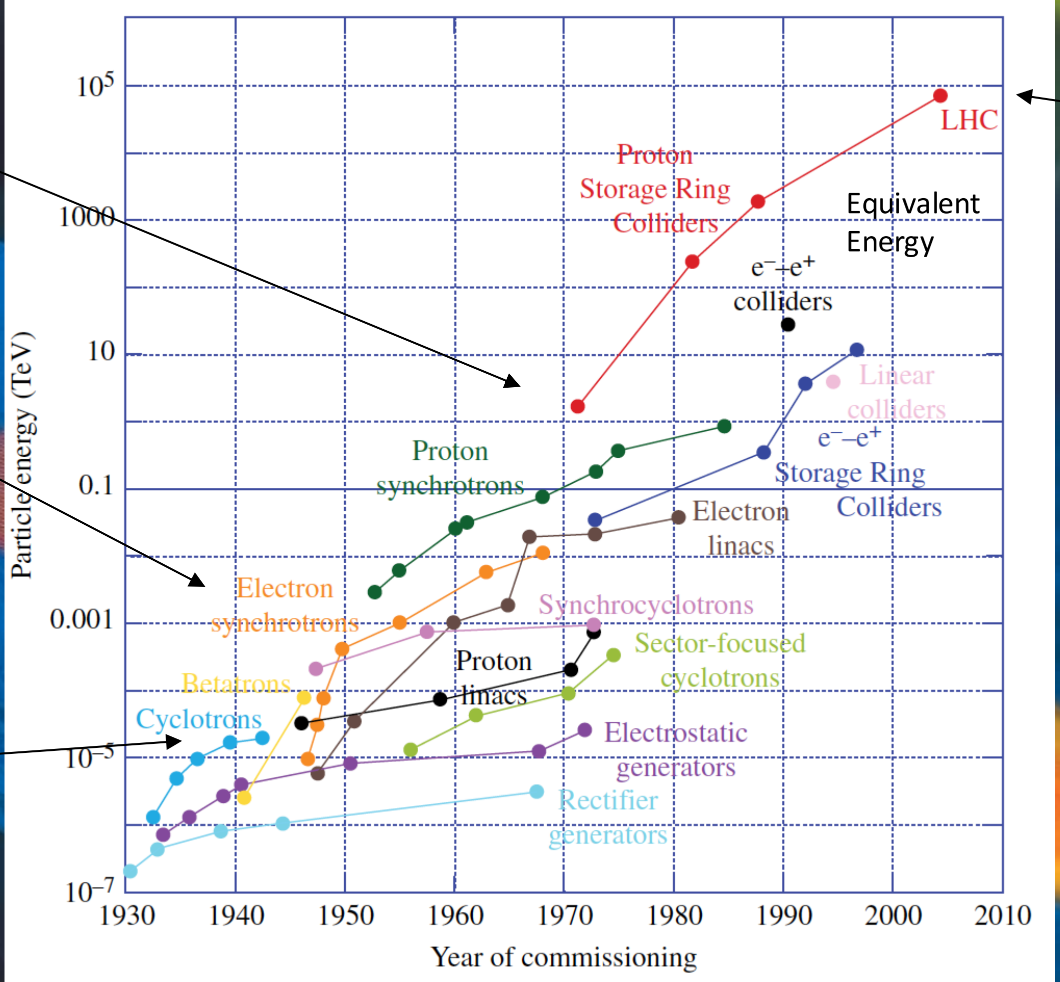
AFTER 50 YEARS, WITH AN OUTLOOK TO THE FUTURE

18 November 2024 Auditorium Touschek

Livingstone Diagram

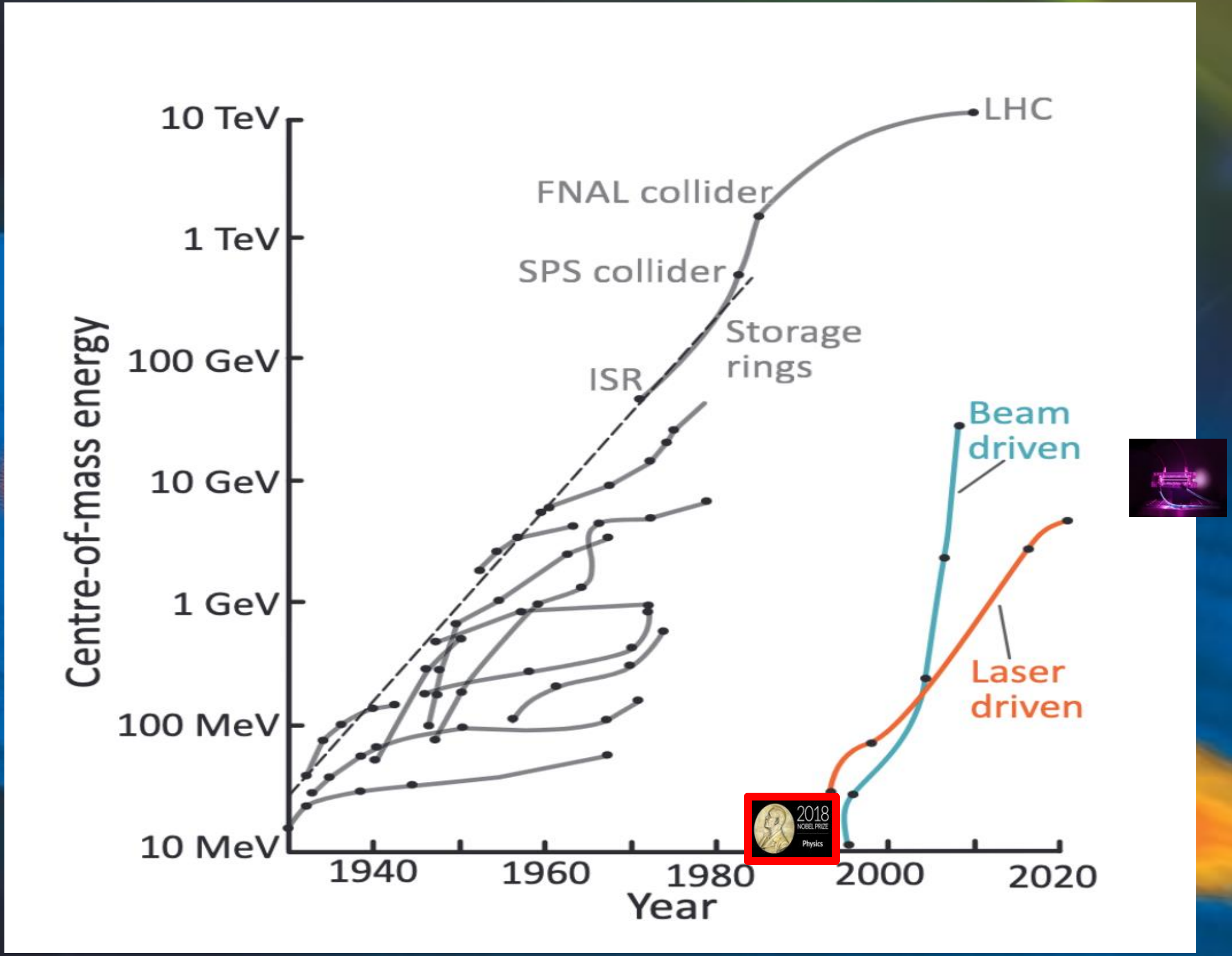






Energy of colliders is plotted in terms of the laboratory energy of particles colliding with a proton at rest to reach the same center of mass energy.

Livingstone Diagram with PWFA



A New European High-Tech User Facility

Funded by the European Union

EuPRAXIA is the first European project that develops a dedicated particle accelerator research infrastructure **based on novel plasma acceleration** concepts **driven by innovative laser and linac technologies**.

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

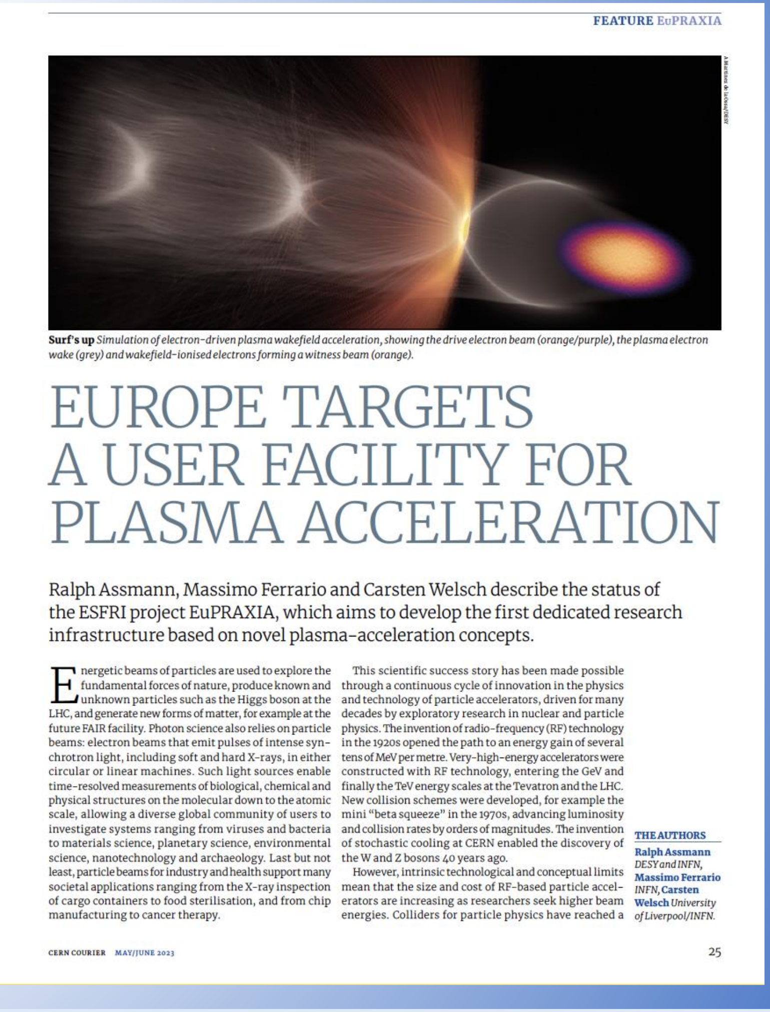
Improve Sustainability

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

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

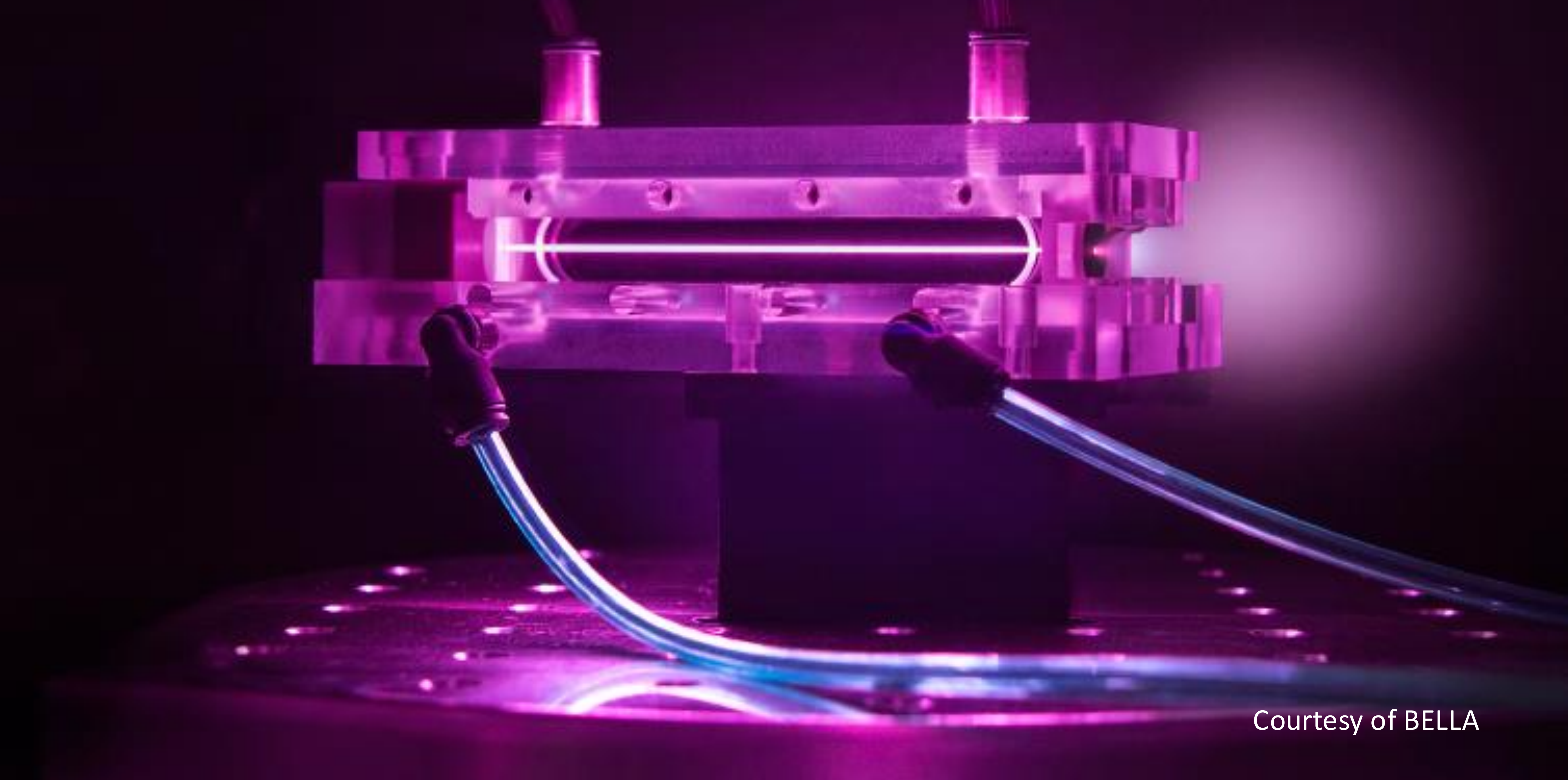
THE AUTHORS
Ralph Assmann *DESY and INFN*, **Massimo Ferrario** *INFN*, **Carsten Welsch** *University of Liverpool/INFN.*

CERN COURIER MAY/JUNE 2023

25

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

Principle of plasma acceleration

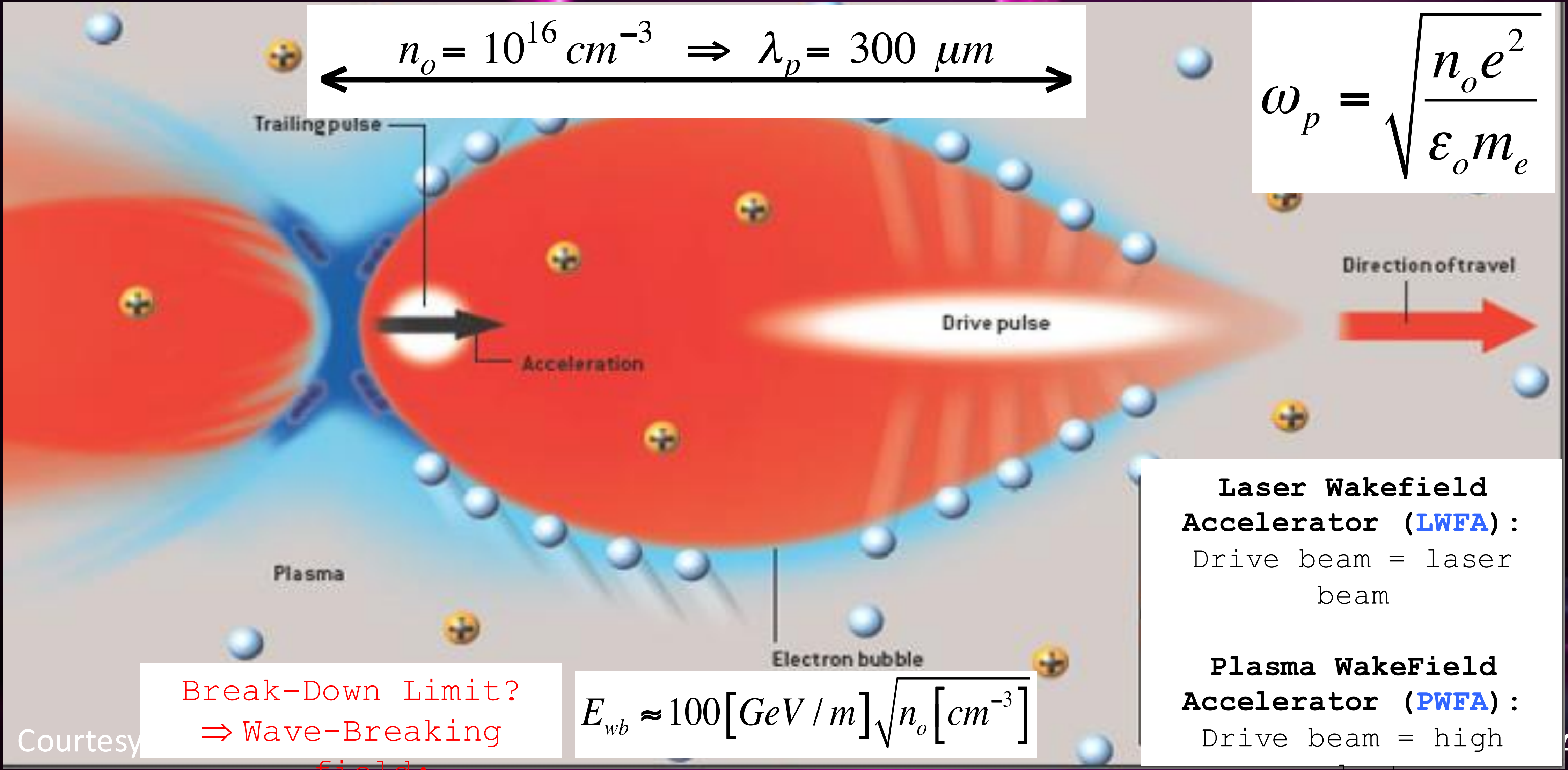


Courtesy of BELLA

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:

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

Courtesy

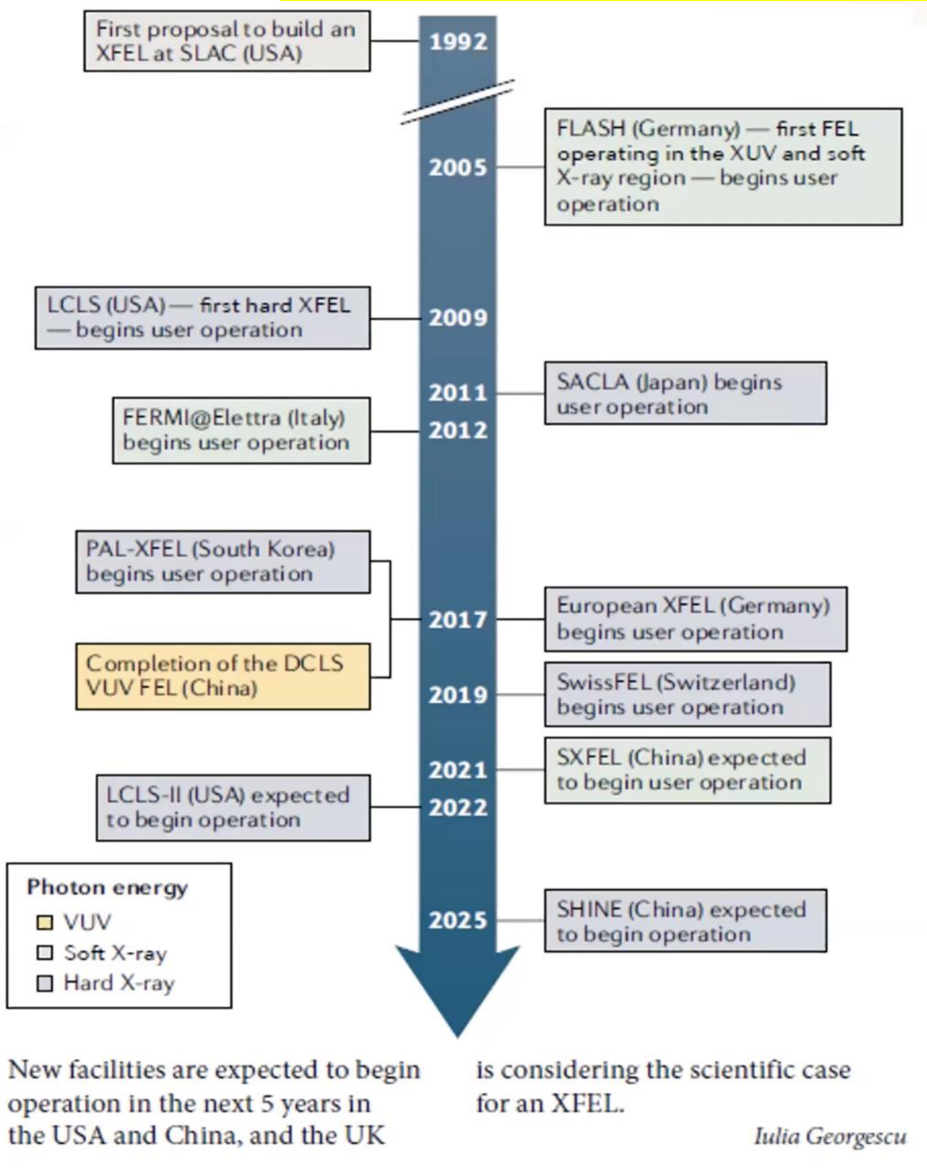
A

EuPRAXIA

FEL is a well established technology

(But a widespread use of FEL is partially limited by its size and costs)

Funded by the European Union

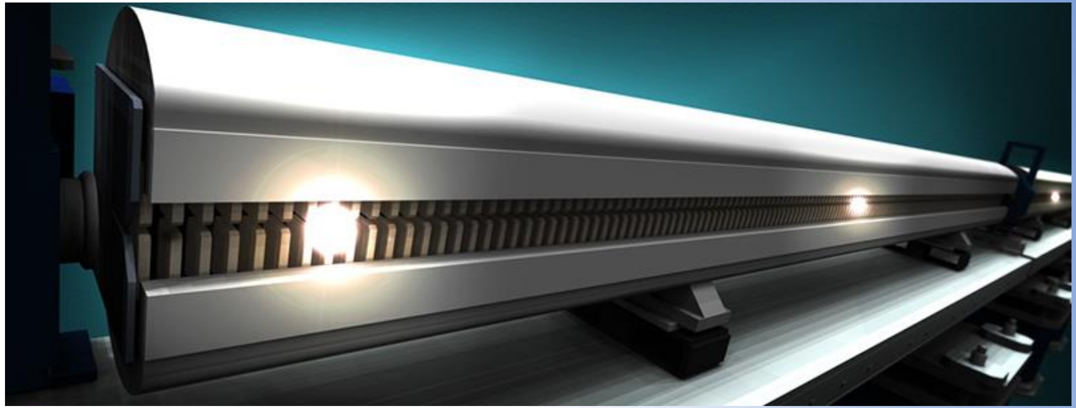


- 1992 – First proposal to build an XFEL at SLAC (USA)
- 2005 – FLASH (Germany) — first FEL operating in the XUV and soft X-ray region — begins user operation
- 2009 – LCLS (USA) — first hard XFEL — begins user operation
- 2011 – SACLA (Japan) begins user operation
- 2012 – FERMI@Elettra (Italy) begins user operation
- 2017 – PAL-XFEL (South Korea) begins user operation
- 2017 – Completion of the DCLS VUV FEL (China)
- 2017 – European XFEL (Germany) begins user operation
- 2019 – SwissFEL (Switzerland) begins user operation
- 2021 – SXFEL (China) expected to begin user operation
- 2022 – LCLS-II (USA) expected to begin operation
- 2025 – SHINE (China) expected to begin operation

Photon energy
☐ VUV
☐ Soft X-ray
☐ Hard X-ray

New facilities are expected to begin operation in the next 5 years in the USA and China, and the UK is considering the scientific case for an XFEL.

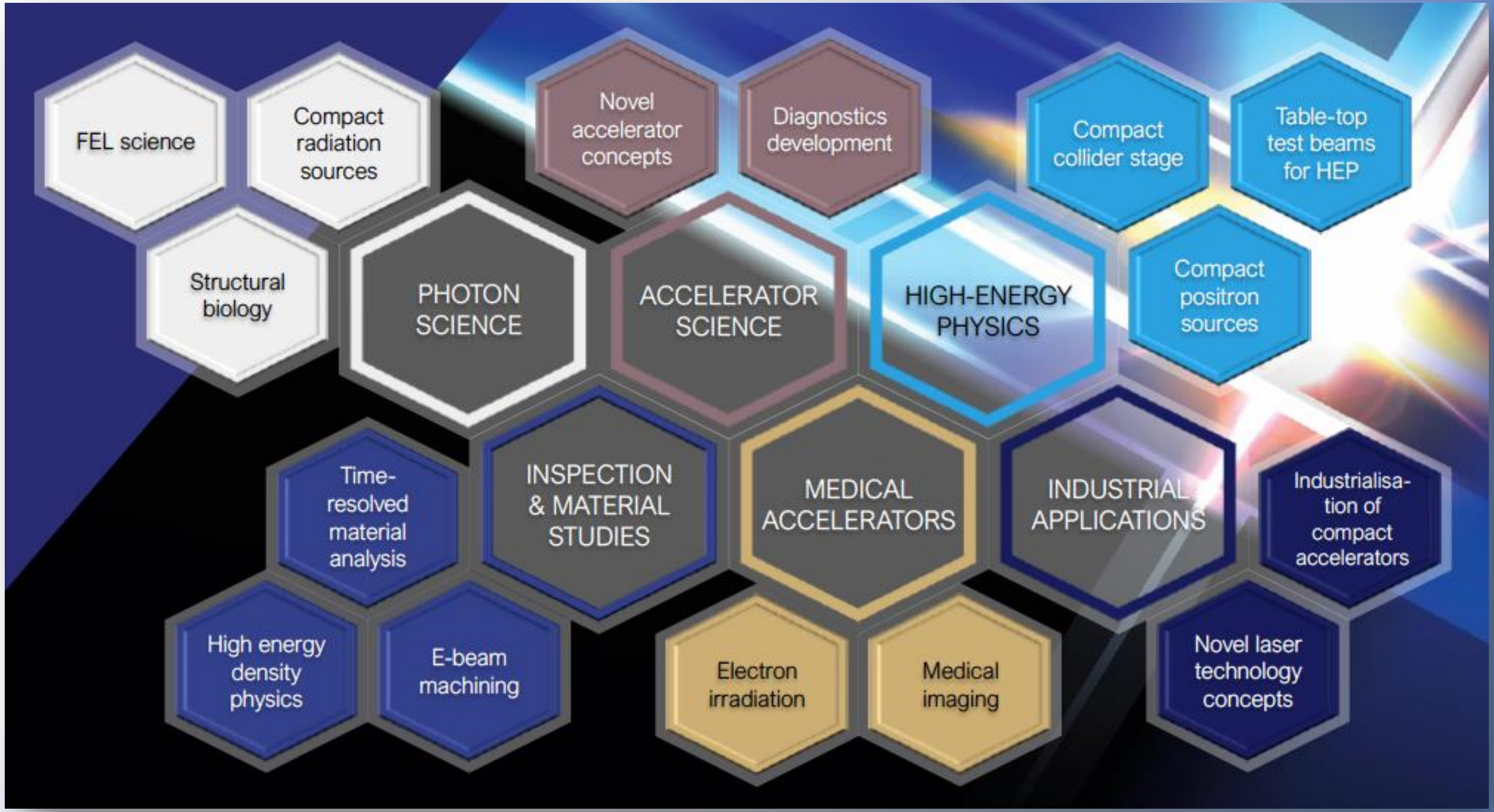
Iulia Georgescu



Intense R&D Program on critical components

Funded by the European Union

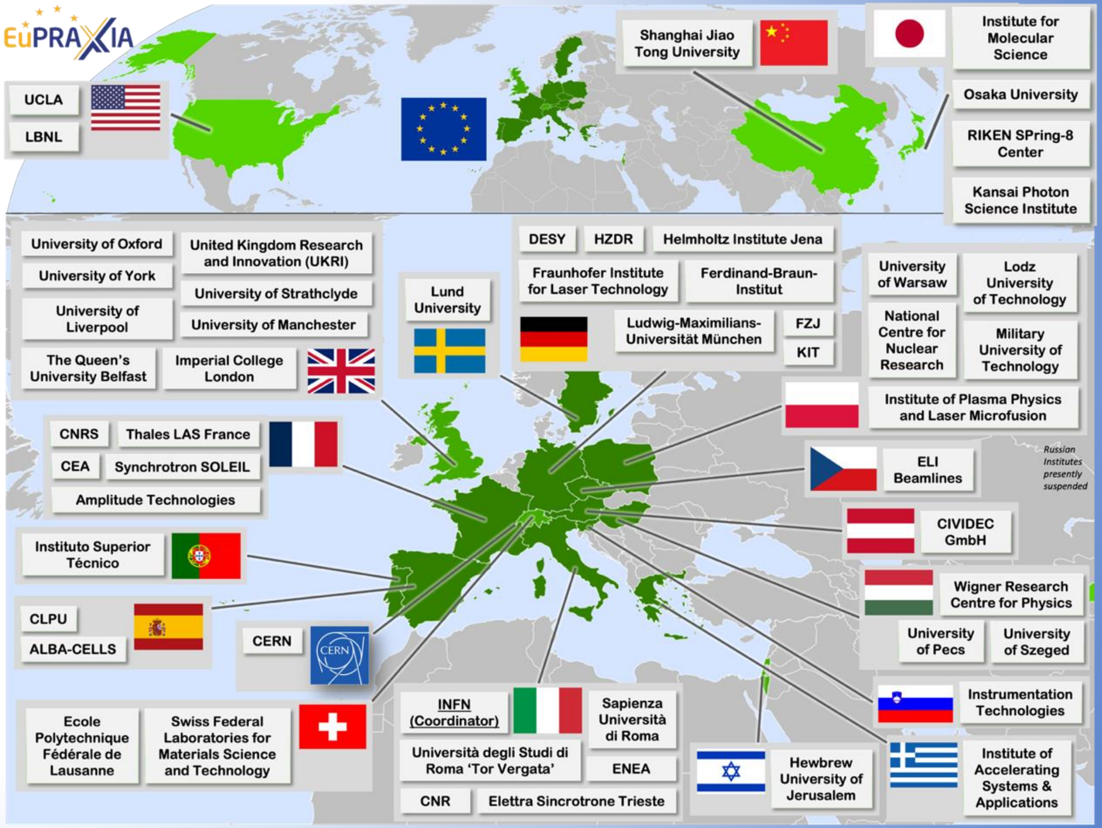
- **Electrons**
  (0.1-5 GeV, 30 pC)
- **Positrons**
  (0.5-10 MeV, 10^6)
- **Positrons** (GeV source)
- **Lasers**
  (100 J, 50 fs, 10-100 Hz)
- **X-band RF Linac**
  (60 MV/m , up to 400 Hz)
- **Plasma Targets**
- **Betatron X rays**
  (1-10 keV, 10^{10})
- **FEL light**
  (0.2-36 nm, 10^9-10^{13})



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 (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? => PACRI !**



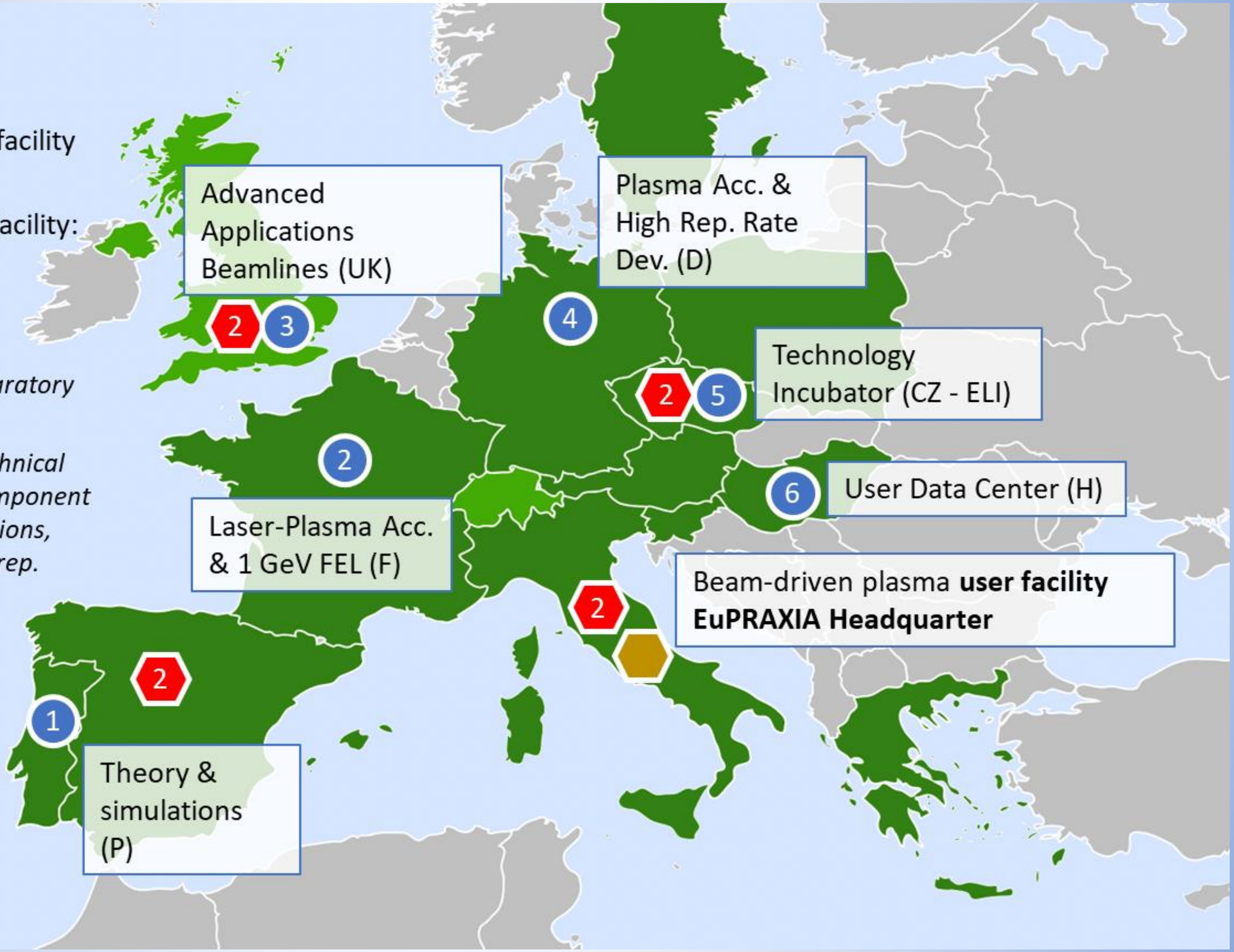
Distributed Research Infrastructure

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.



Horizon Europe

EuPRAXIA Preparatory Phase Organisation

Funded by the European Union

Coll. Board
M. Ferrario INFN

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

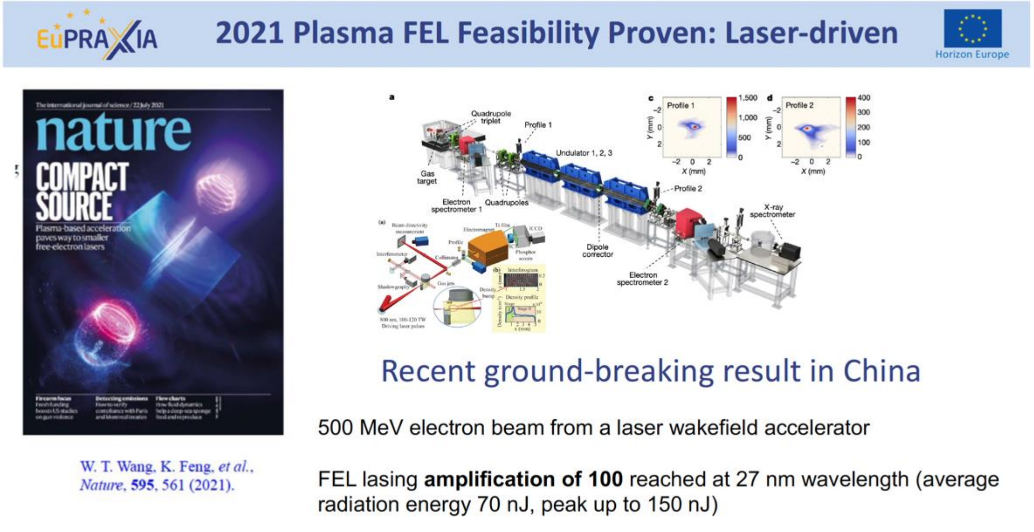
WP14 - Transformative Innovation Paths
B. Hidding, U Dusseldorf
S. Karsch, LMU

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

Basic beam quality achieved in pilot FEL experiments



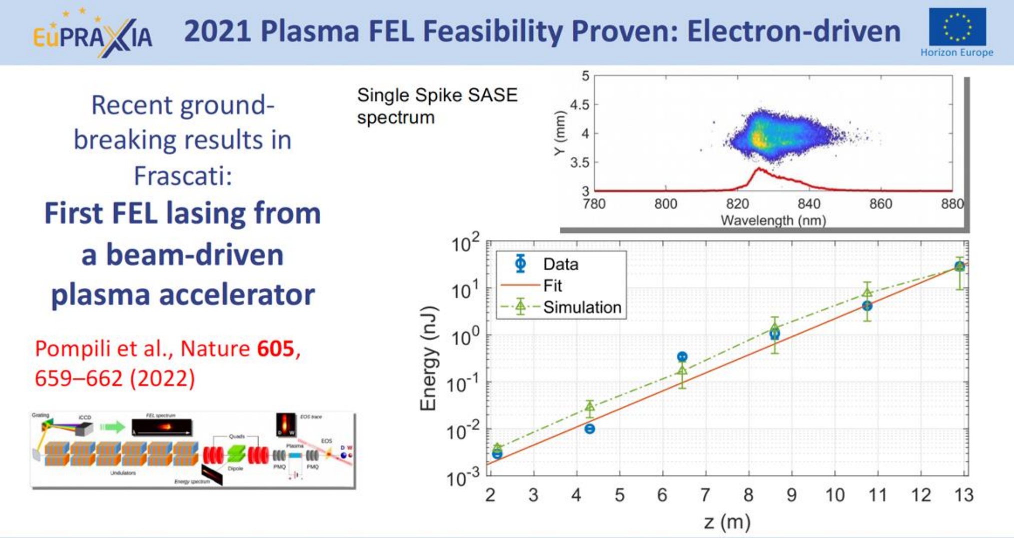
2021 Plasma FEL Feasibility Proven: Laser-driven

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)

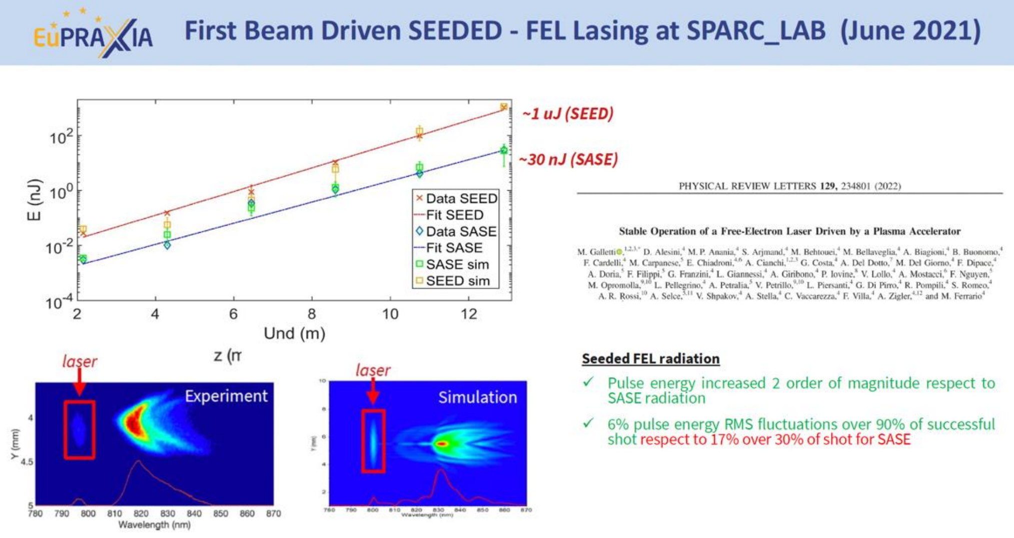


2021 Plasma FEL Feasibility Proven: Electron-driven

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)

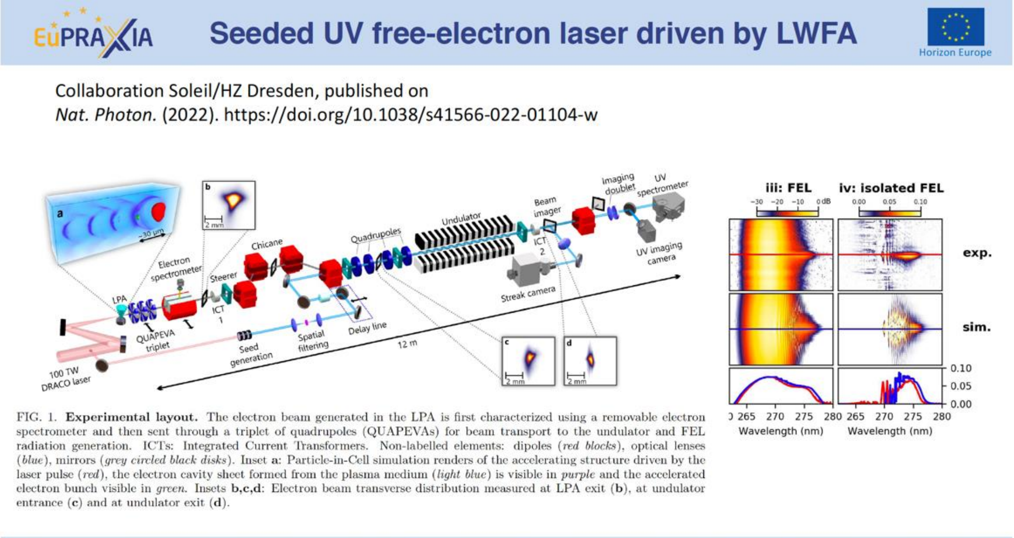
PHYSICAL REVIEW LETTERS **129,** 234801 (2022)

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

M. Galletti,[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



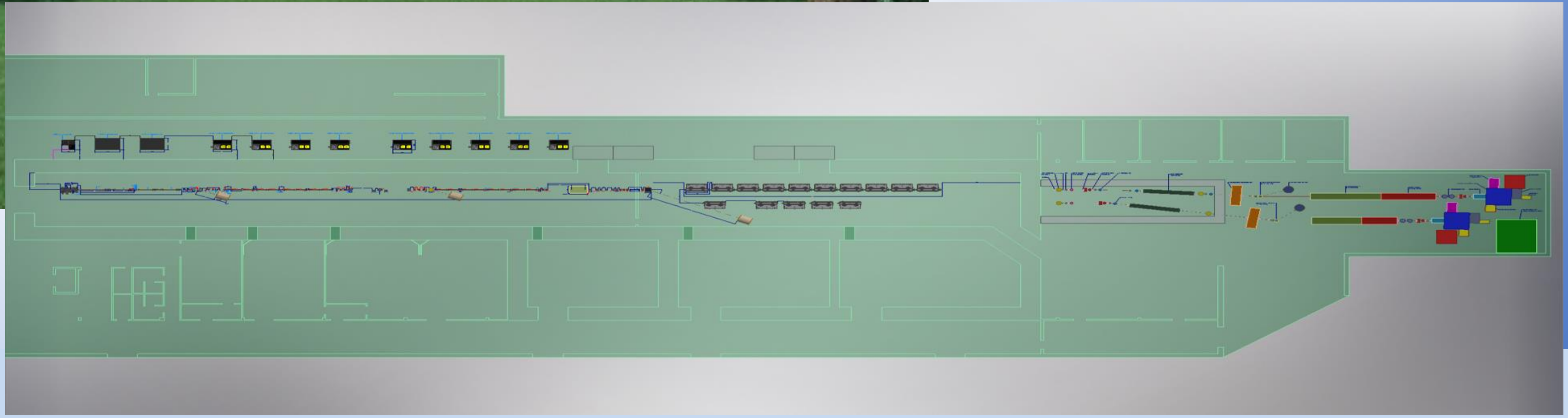
Seeded UV free-electron laser driven by LWFA

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

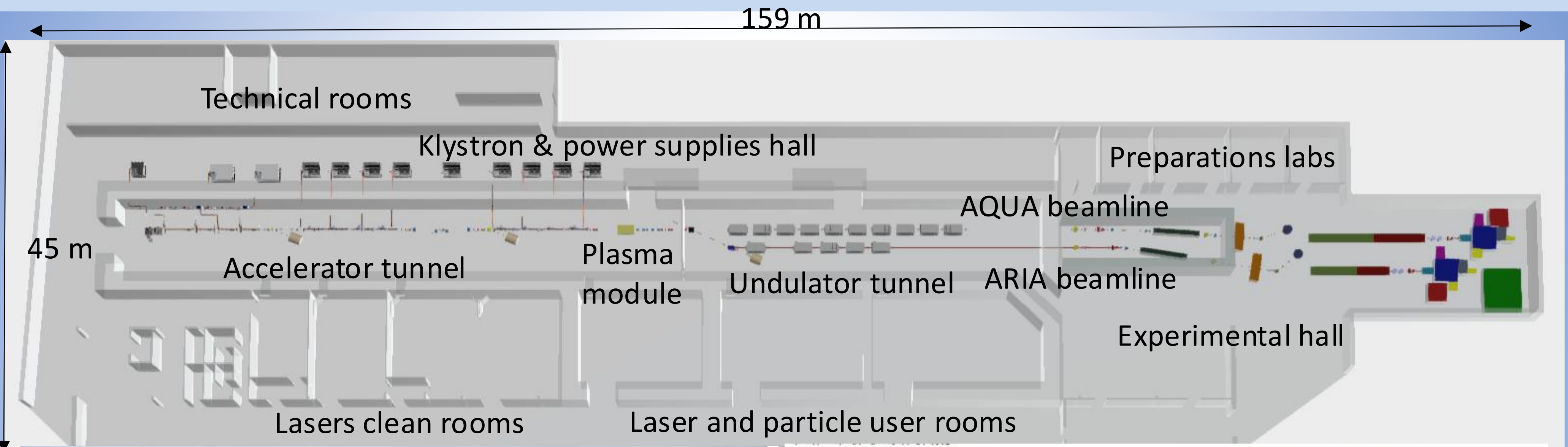
FIG. 1. **Experimental layout.** The electron beam generated in the LPA is first characterized using a removable electron spectrometer and then sent through a triplet of quadrupoles (QUAPEVAs) for beam transport to the undulator and FEL radiation generation. ICTs: Integrated Current Transformers. Non-labelled 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**).

Headquarter and Site 1: EuPRAXIA@SPARC_LAB

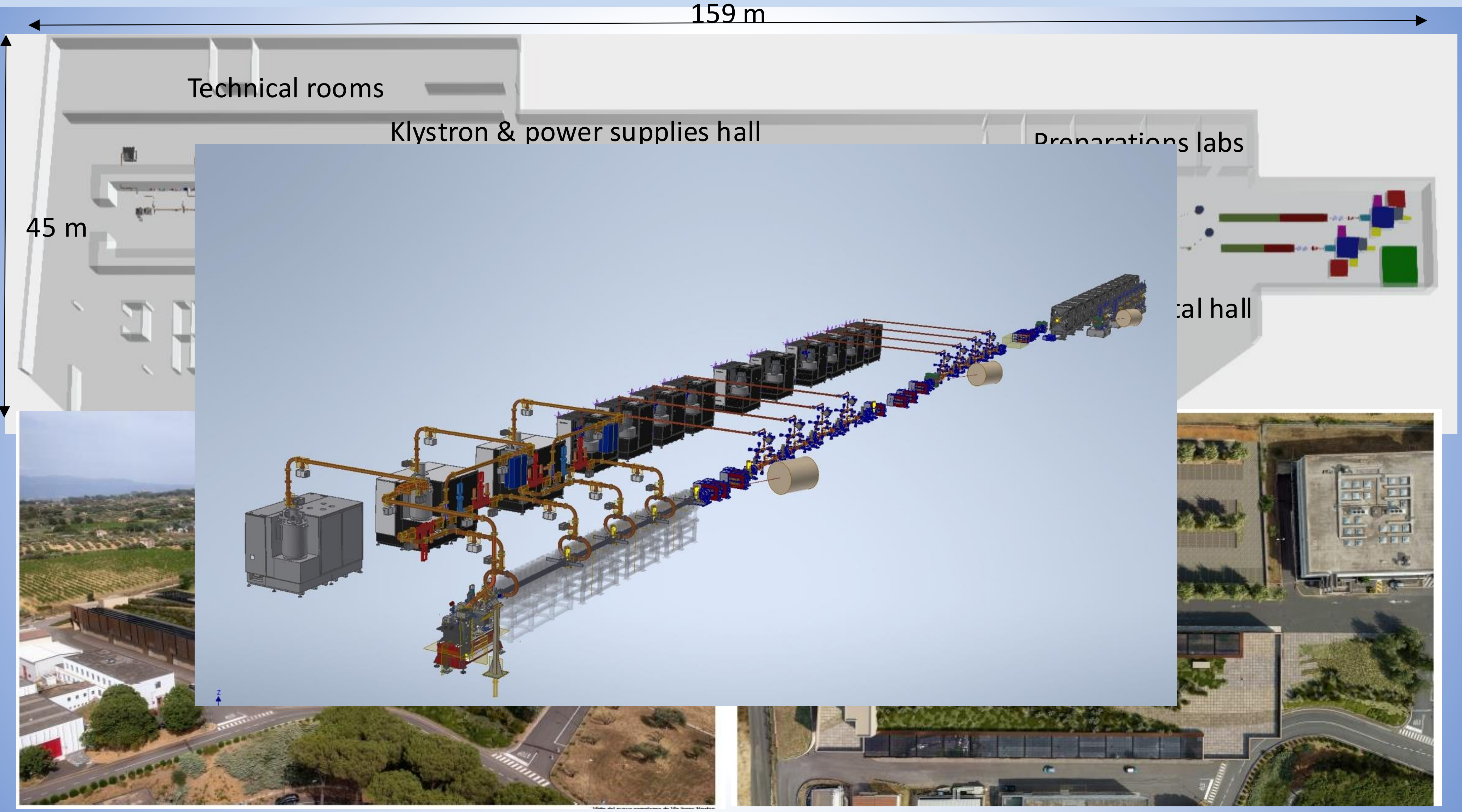
- Frascati`s future facility
- > 130 M€ invest funding
- Beam-driven plasma accelerator
- Europe`s most compact and most southern FEL
- The world`s most compact RF accelerator (X band with CERN)



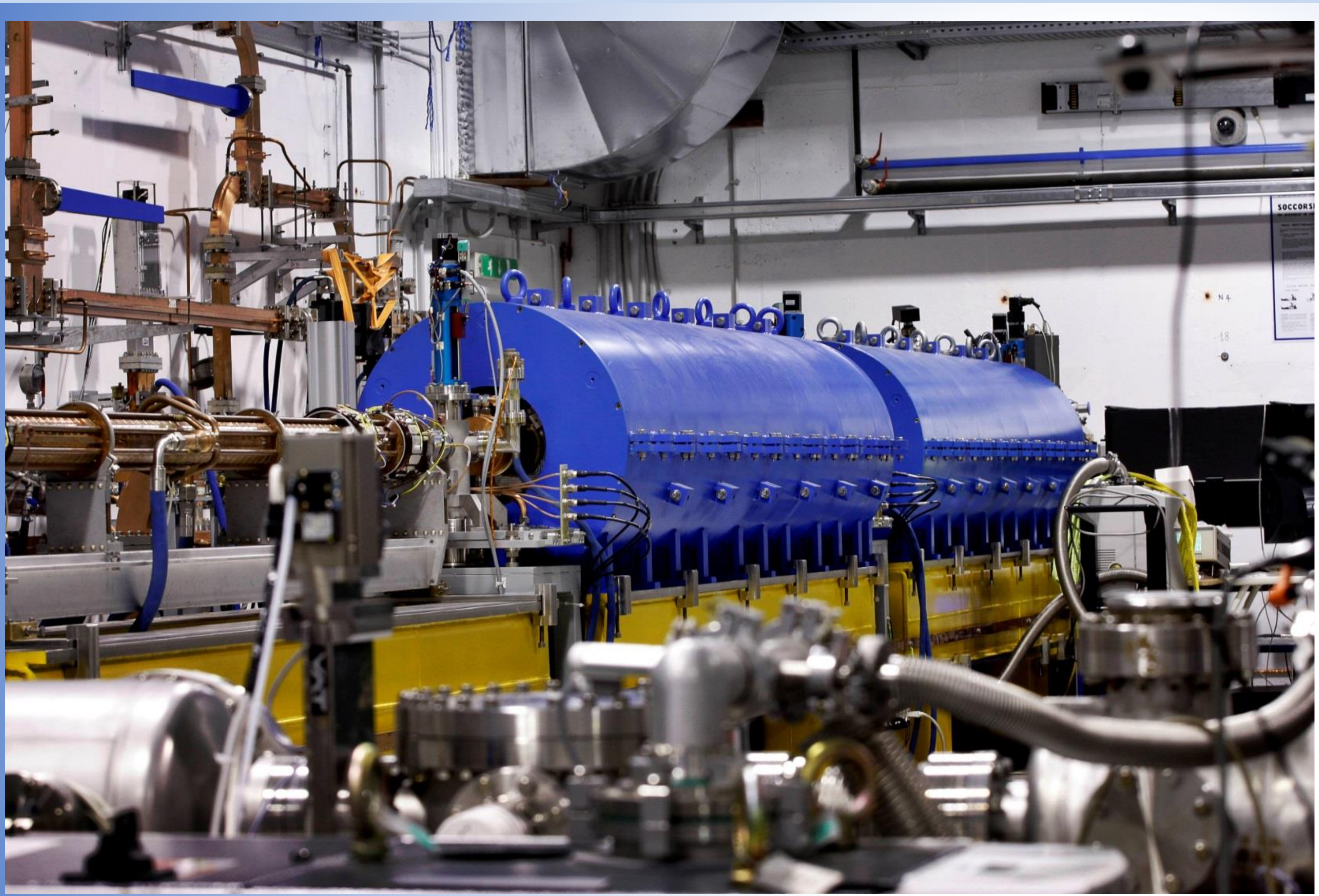
EuPRAXIA@SPARC_LAB Layout

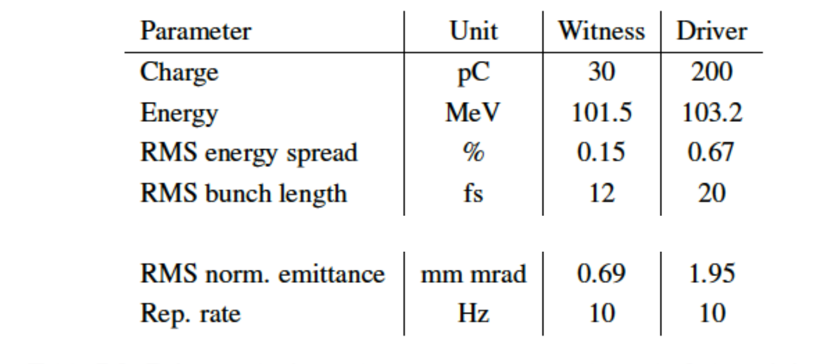


EuPRAXIA@SPARC_LAB Layout



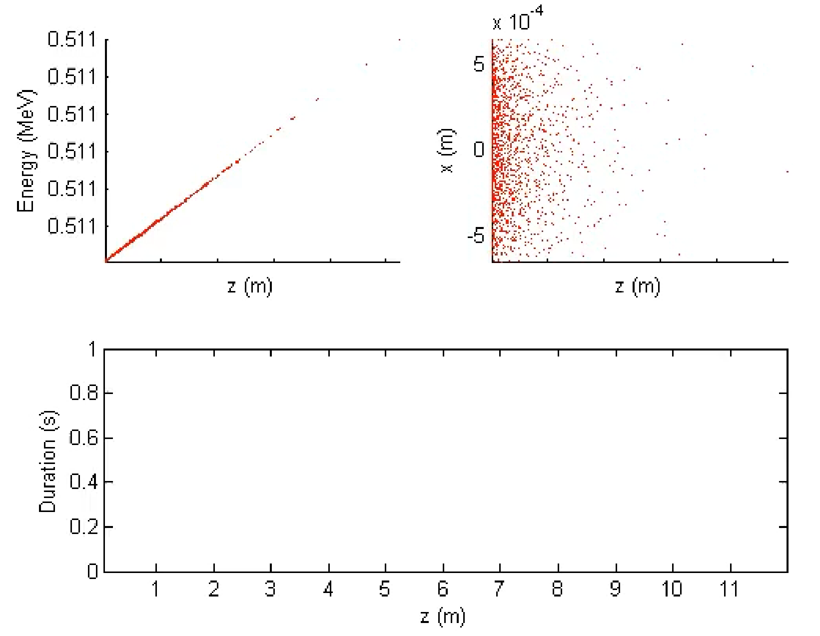
High Quality Electron Beams





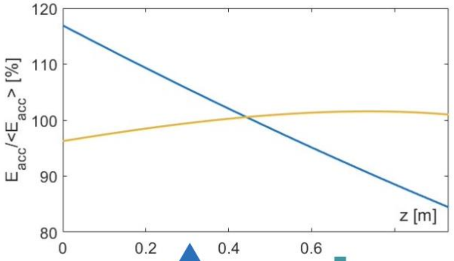
Parameter	Unit	Witness	Driver
Charge	pC	30	200
Energy	MeV	101.5	103.2
RMS energy spread	%	0.15	0.67
RMS bunch length	fs	12	20
RMS norm. emittance	mm mrad	0.69	1.95
Rep. rate	Hz	10	10

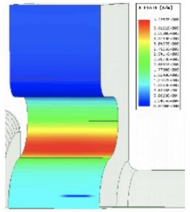
Table 7.2: Driver and witness beam parameters at the end of photo-injector.



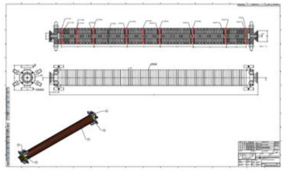
Courtesy E. Chiadroni

World`s Most Compact RF Linac: X Band

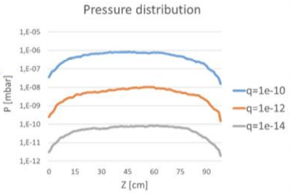




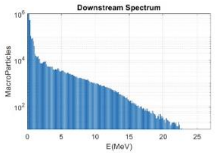
1. **E.m. design**: *done*



2. **Thermo-mechanical analysis**: *done*
3. **Mechanical design**: *done*

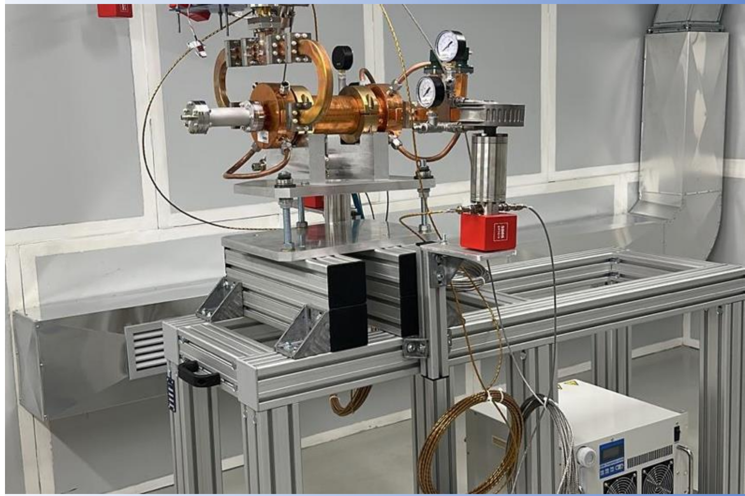


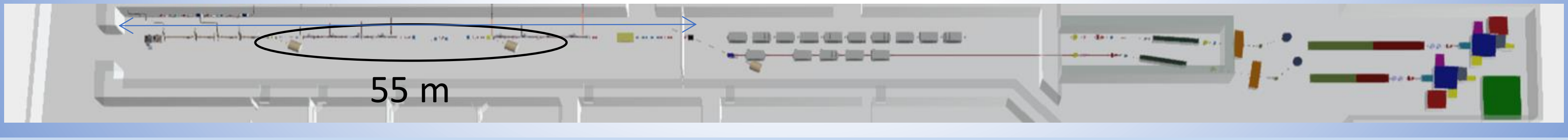
4. **Vacuum calculations**: *done*
5. **Dark current simulations**: *done*



6. **Waveguide distribution simulation with attenuation calculations**: *done*

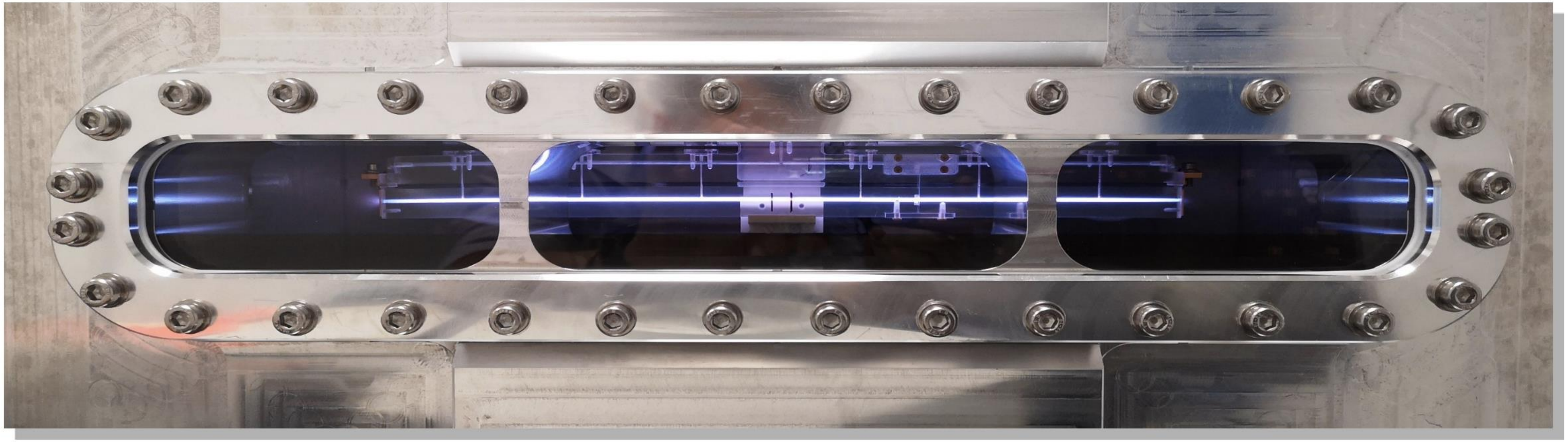
PARAMETER	Value	
	with linear tapering	w/o tapering
Frequency [GHz]	11.9942	
Average acc. gradient [MV/m]	**60**	
Structures per module	2	
Iris radius a [mm]	**3.85-3.15**	**3.5**
Tapering angle [deg]	0.04	0
Struct. length L_s act. Length (flange-to-flange) [m]	**0.94 (1.05)**	
No. of cells	112	
Shunt 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**	





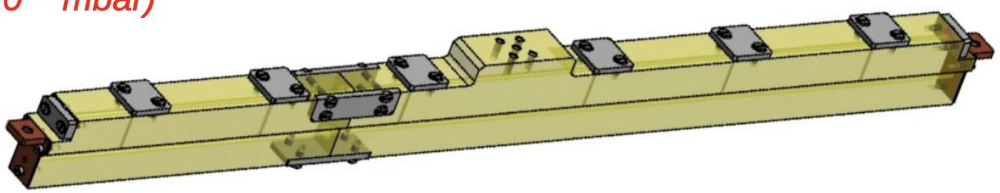
Courtesy D. Alesini

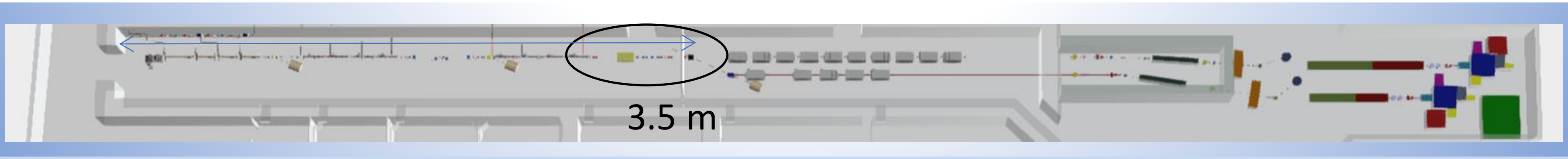
Plasma Module



- 40 cm long capillary → 1st prototype for the EuPRAXIA facility
  - *Made with special junction to allow negligible gas leaks (<10^{-10} mbar)*
- Operating conditions
  - *1 Hz repetition rate (to be increased up to 100 Hz)*
  - *10 kV – 380 A minimum values for ionization*
  - *6 inlets for gas injection. Electro-valve aperture time 8-12 ms*

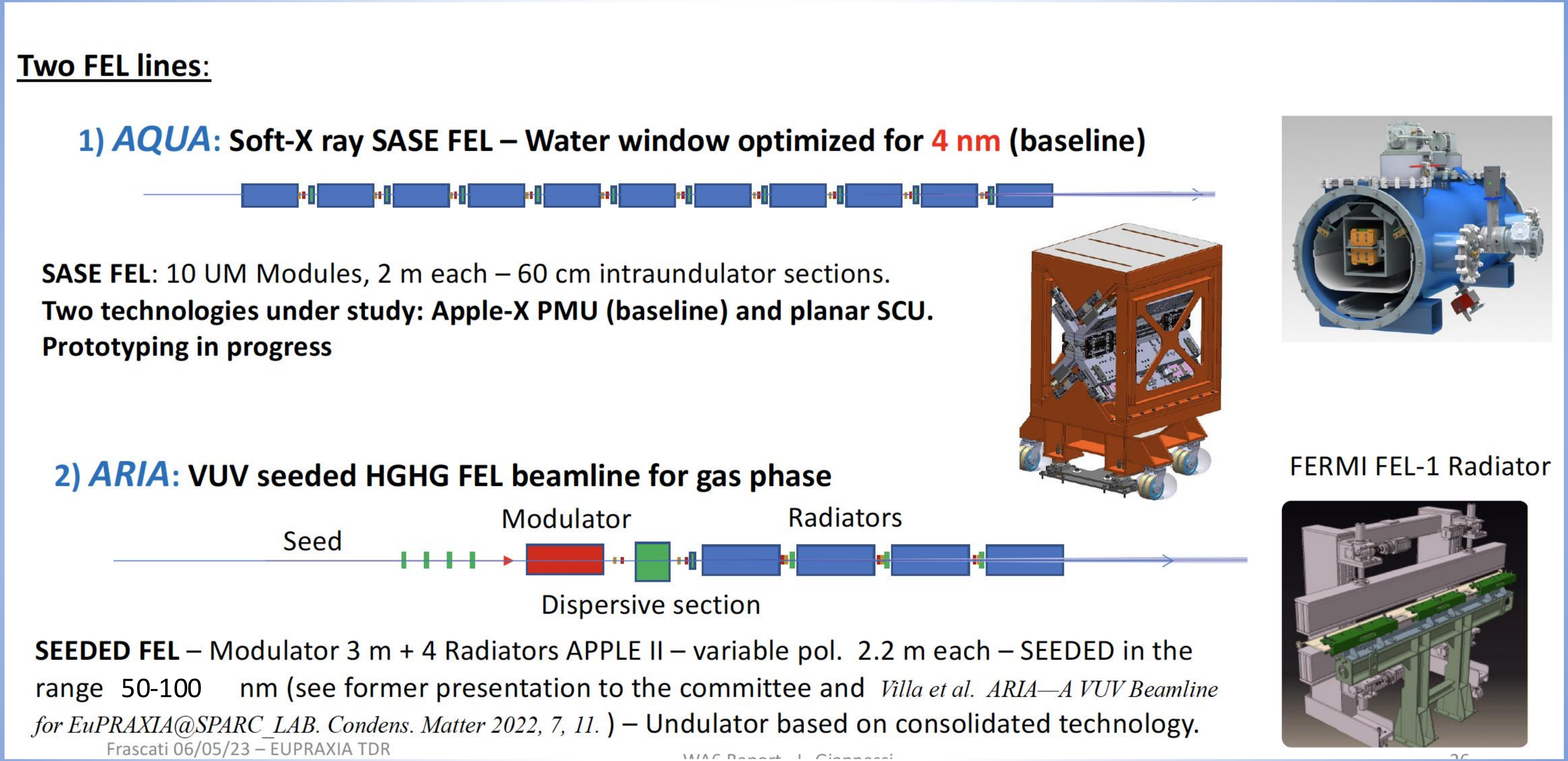
A. Biagioni, V. Lollo





Courtesy A. Biagioni, R. Pompili

Radiation Generation: FEL



Two FEL lines:

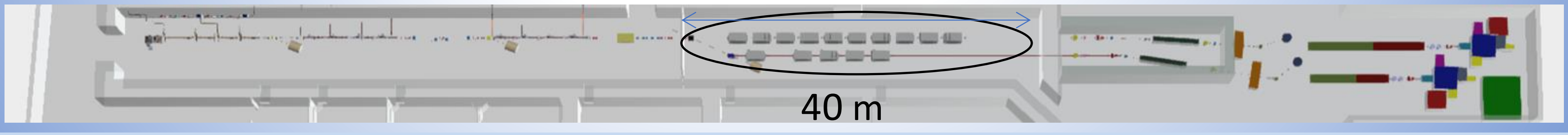
1) ***AQUA*: Soft-X ray SASE FEL – Water window optimized for 4 nm (baseline)**

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.



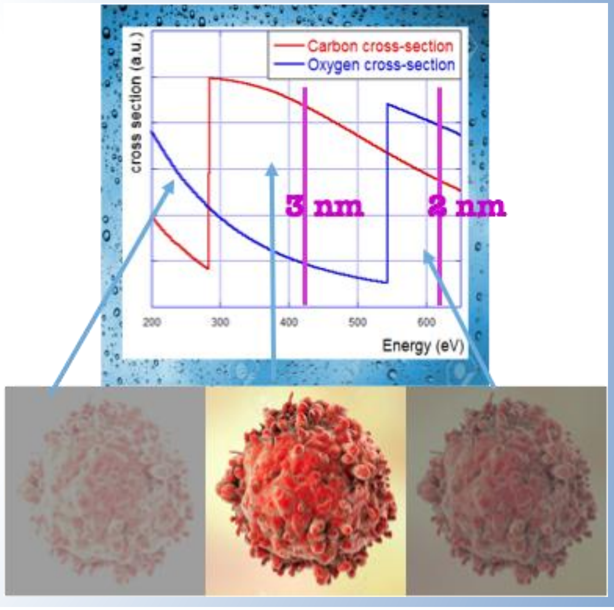
Courtesy L. Giannessi

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	$s\,mm^2mrad^2$ $bw(0.1\%)$	$\mathbf{1{-}2\ \times 10^{28}}$	$1\ \times 10^{27}$

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

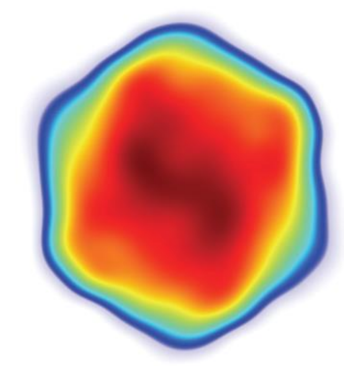
Courtesy F. Stellato, UniToV

Courtesy C. Vaccarezza/L. Giannessi

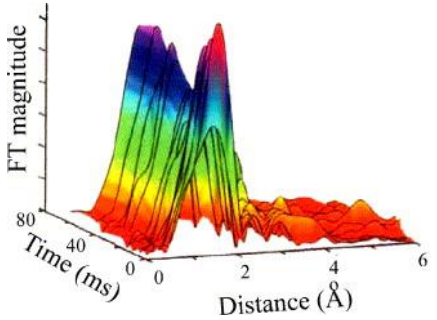
AQUA beamline scientific case

Experimental techniques and typology of samples

Coherent imaging



X-ray spectroscopy



Raman spectroscopy

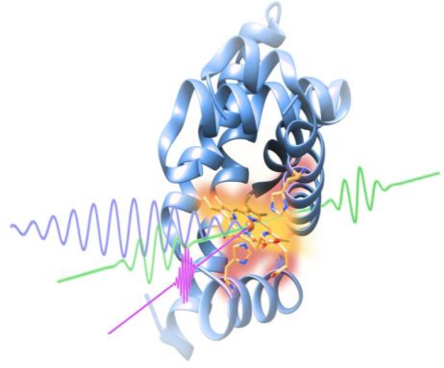
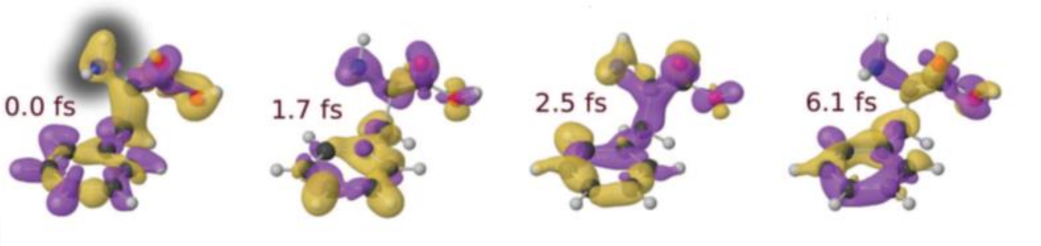


Photo-fragmentation of molecules



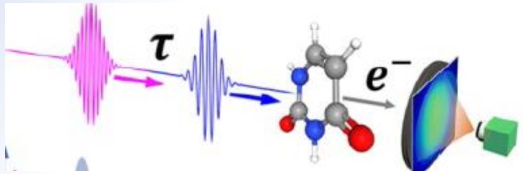
(Large) Viruses
Organelles
Bacteria/Cells
Metals
Semiconductors
Superconductors
Magnetic materials
Organic molecules

Courtesy F. Stellato

ARIA beamline scientific case

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

Photoemission Spectroscopy



Photoelectron Circular Dichroism

Raman spectroscopy

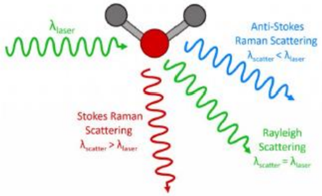
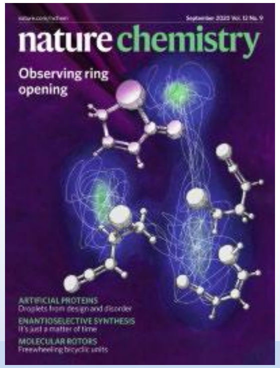
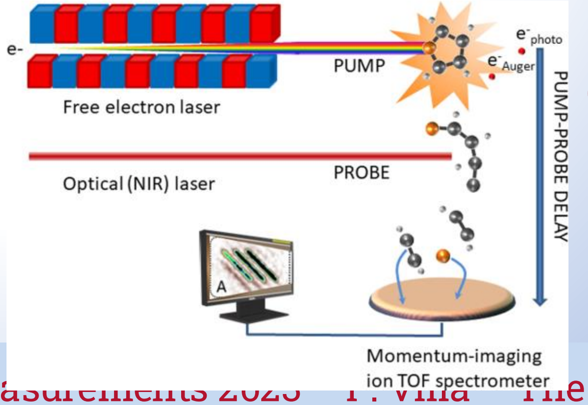


Photo-fragmentation of molecules
Time of Flight Spectroscopy



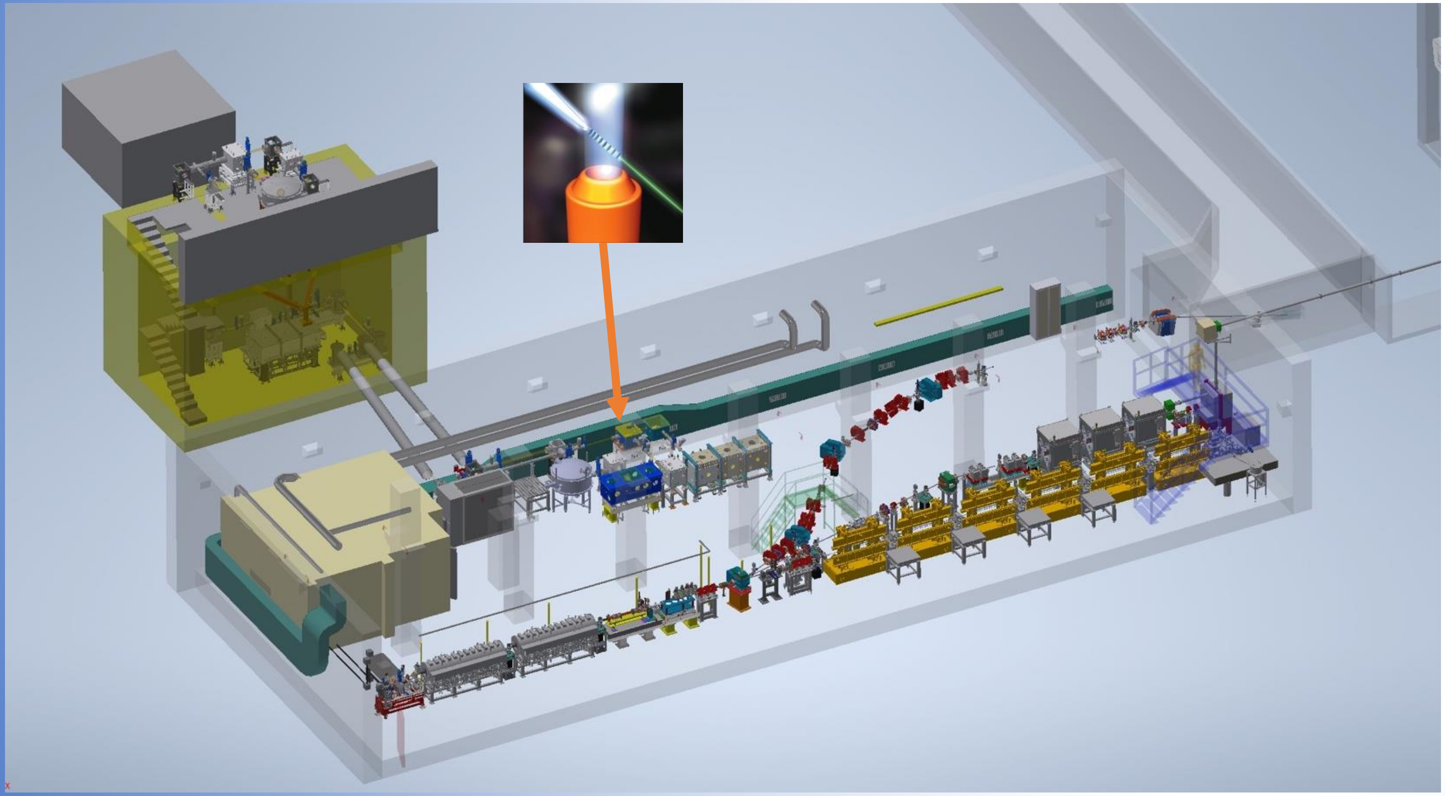


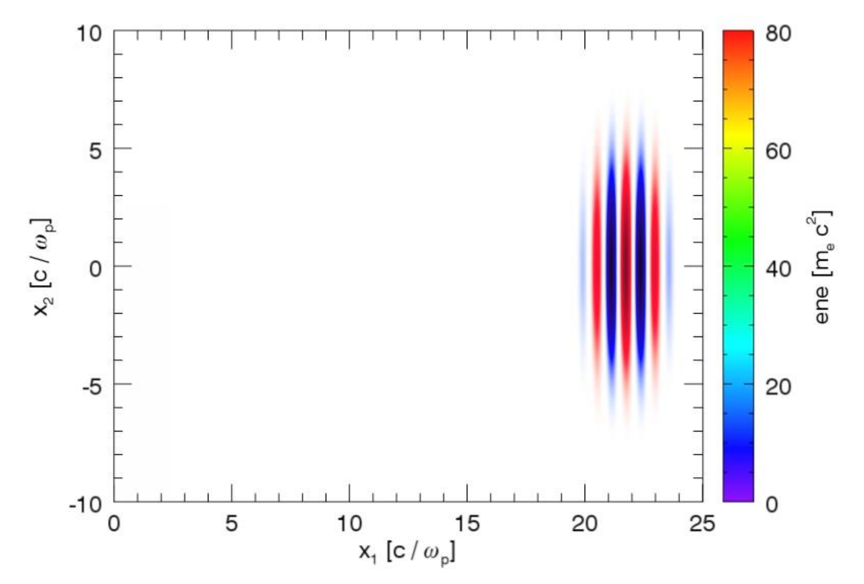
Gas phase & Atmosphere
(Earth & Planets)
Aerosols
(Pollution, nanoparticles)
Molecules & gases
(spectroscopies, time-of-flight)
Proteins
(spectroscopies)
Surfaces
(ablation & deposition)

Courtesy F. Stellato

Betatron Radiation Source at SPARC_LAB

Electron beam Energy [MeV]	50-800
Plasma Density [cm^{-3}]	10^{17} - 10^{19}
Photon Critical Energy [keV]	1 - 10
Nuber of Photons/pulse	10^6 – 10^9

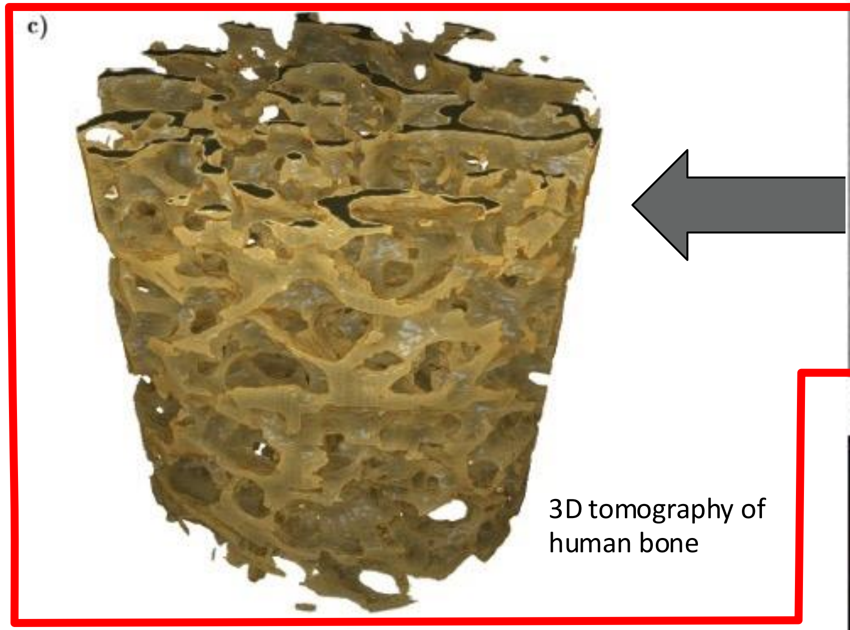


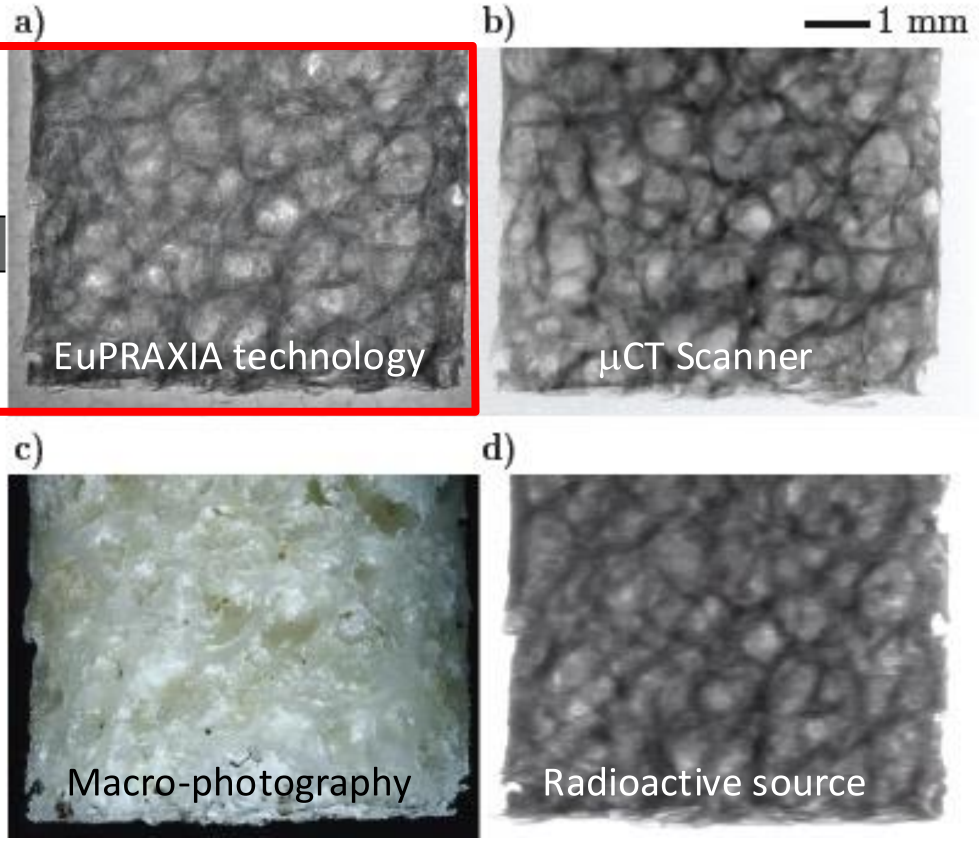


Courtesy J. Vieira, R. Fonseca/GoLP/IST Lisbon

Betatron X Rays: Compact Medical Imaging

J.M. Cole et al, "Laser-wakefield accelerators as hard x-ray sources for 3D medical imaging of human bone". Nature Scientific Reports 5, 13244 (2015)





- **EuPRAXIA laser advance (industry) will push rate from 1/min to 100 Hz.**
- **Ultra-compact source of hard X rays → exposing from various directions simultaneously is possible in upgrades**

Physics & Technology Background:

- Small EuPRAXIA accelerator → small emission volume for betatron X rays.
- **Quasi-pointlike** emission of X rays.
- **Sharper image from base optical principle.**
- Quality demonstrated and published, but takes a few hours for one image.
- Advancing flux rate with EuPRAXIA laser by factor > 1,000!

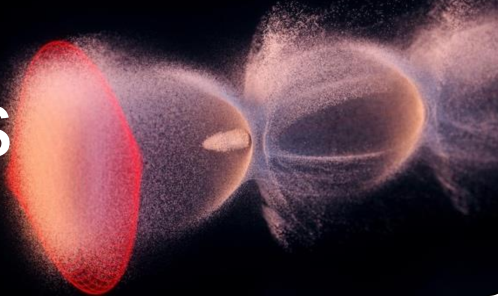
Added value

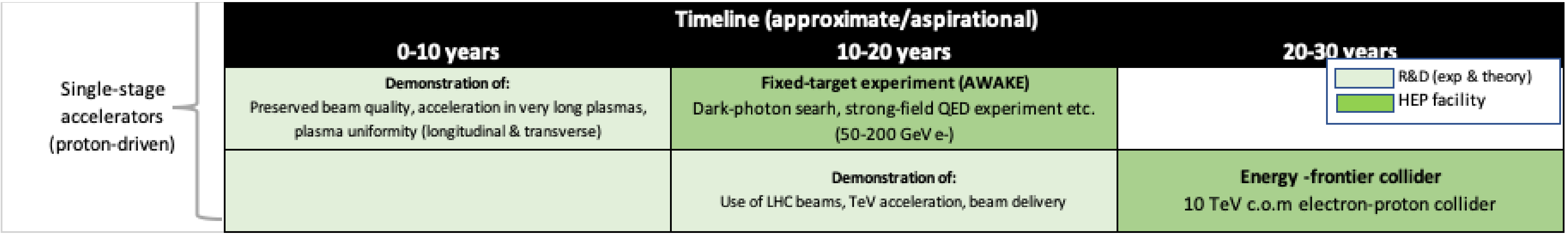
Sharper images with outstanding **contrast**

Identify smaller features (e.g. early detection of cancer at micron-scale – calcification)

Laser advance in EuPRAXIA → **fast imaging** (e.g. following moving organs during surgery)

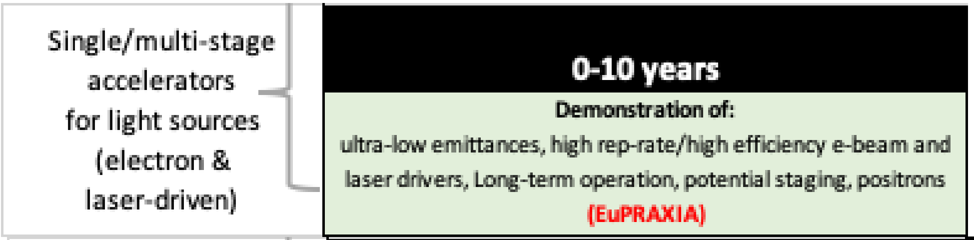
ESPP Roadmap Update – Plasma Accelerators





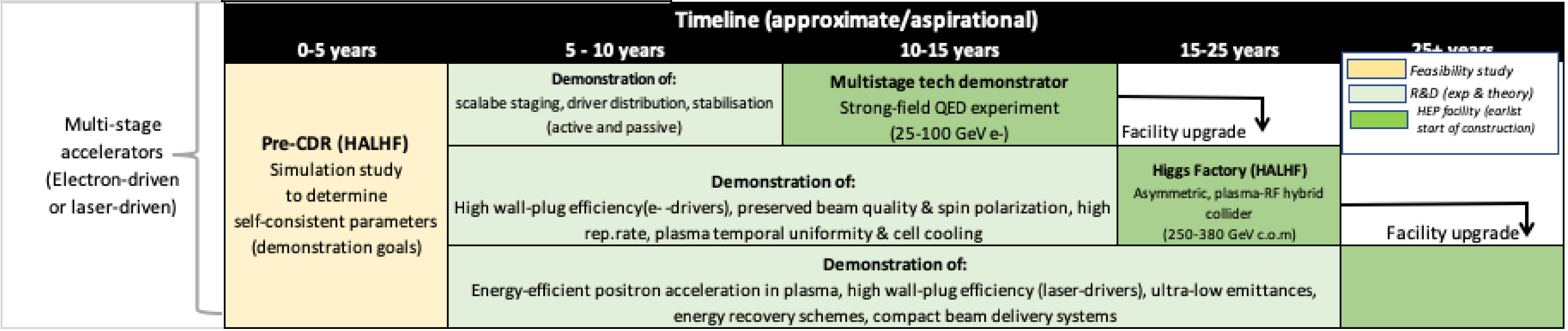
	Timeline (approximate/aspirational)		
	0-10 years	**10-20 years**	**20-30 years**
Single-stage accelerators (proton-driven)	**Demonstration of:** Preserved beam quality, acceleration in very long plasmas, plasma uniformity (longitudinal & transverse)	**Fixed-target experiment (AWAKE)** Dark-photon searh,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

Plasma collider challenges

Beam delivery system

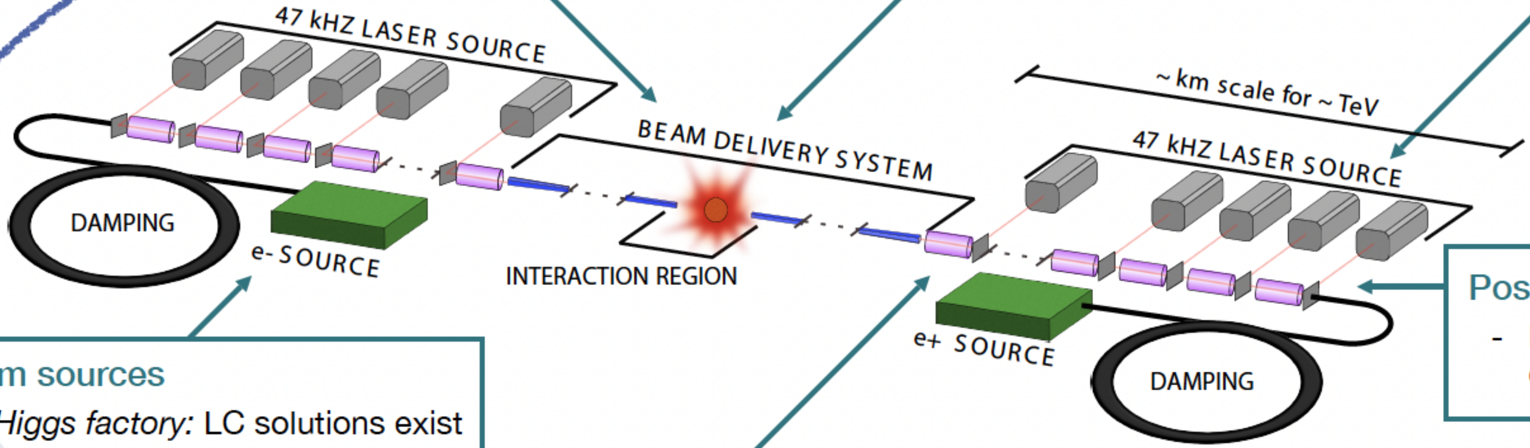
- *Higgs factory:* optimized LC designs exist
  optimizations for plasmas needed/possible?
- *10 TeV collider:* no design exists
  critical - HF designs scale poorly with energy (geo. gradient) → 20 (CLIC) to 90 (ILC) km

Interaction region

- *Higgs factory:* designed for other LCs
- *10 TeV collider:* studies critical to define collider type and machine parameters
  critical - valid codes for beam/beam studies

Driver technology

- *Beams:* technology exists in principle
  cost, gradient, efficiency, distribution optimization
- *Lasers:* do not exist, R&D paths identified
  critical - rep. rate & power, efficiency, robustness, cost
  opportunity - simple energy recovery (photovoltaics)



Positron acceleration

- No concept exists (yet) that fulfills needs
  critical - beam quality, efficiency, resilience

Beam sources

- *Higgs factory:* LC solutions exist
  opportunity - compact (cheaper) sources from plasmas
- *10 TeV collider:* undefined, potentially a key issue

Plasma stages + coupling

- Focus and key charge for our field, no roadblocks known
  critical - beam quality (incl. polarization), efficiency, stability, longevity, resilience to jitter (in time, space, and momentum), resilience to catastrophic errors (one bad shot)
- *Plasma stage:* requires demonstration of collider parameters
  + critical - rep. rates & bunch structure (CW vs. burst), power handling
- *Staging:* requires detailed concepts, additional test facilities
  + critical - driver in-/out-coupling, geometric gradient

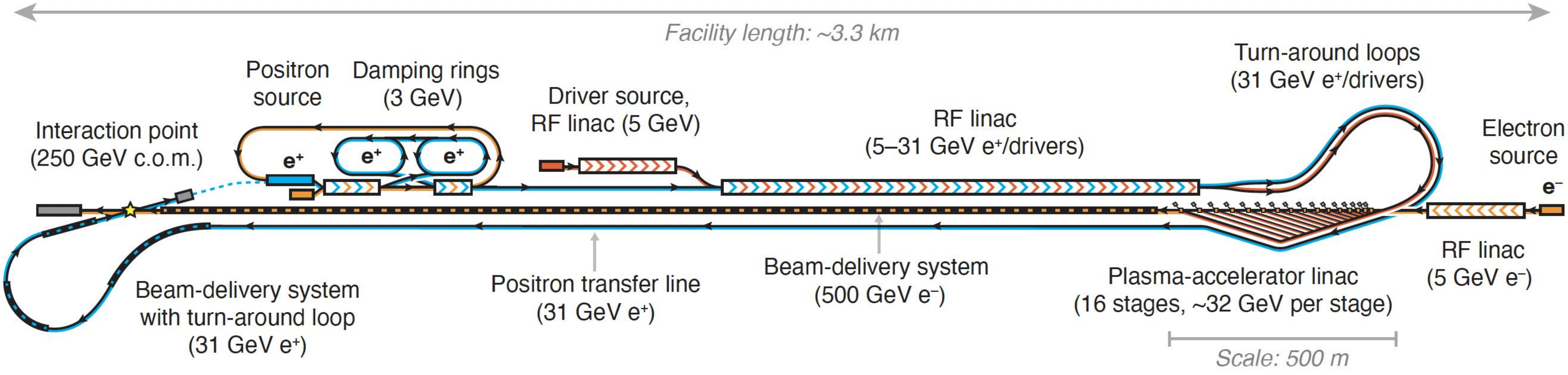
Full system integration

- Turn components into self-consistent machine
- Optimization of the system for cost, efficiency, environmental impact, physics performance, resiliency (jitter budget)

BERKELEY LAB

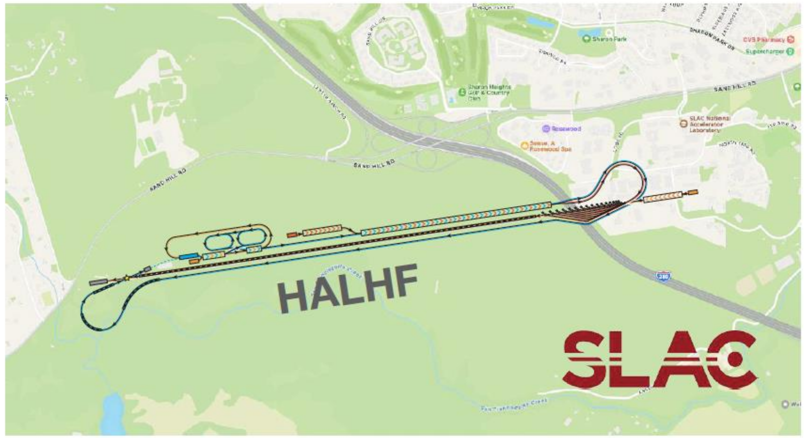
Courtesy J. Osterhoff

HALHF: A Hybrid, Asymmetric, Linear Higgs Factory

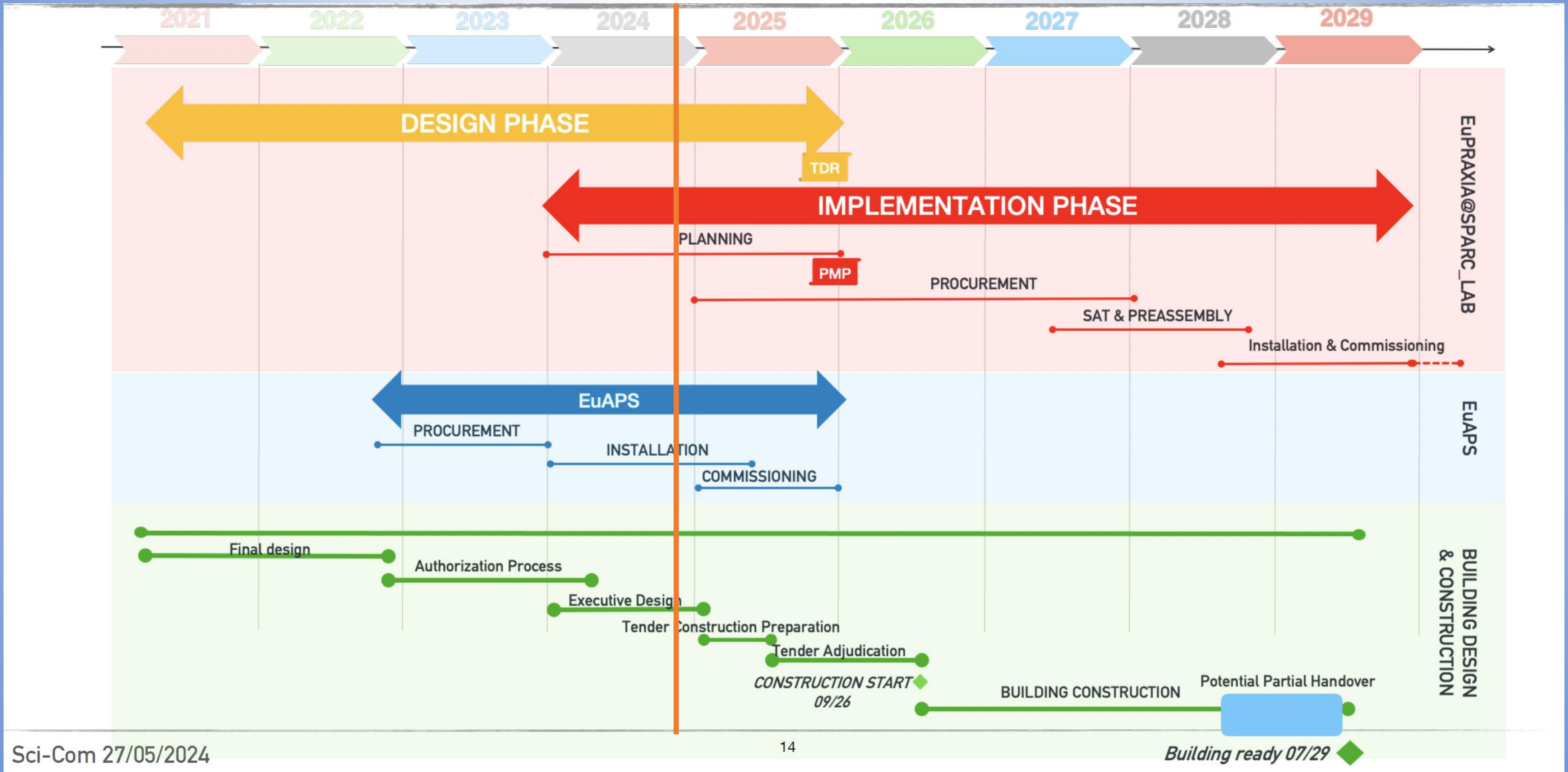


Source: Foster, D’Arcy and Lindstrøm, New J. Phys. 25, 093037 (2023)

- Beam-driven: Use e^+ RF linac for producing e^- drivers
- Overall footprint: ~3.3 km
  - Length dominated by e^- beam-delivery system
  - Fits in most major particle-physics laboratories



EuPRAXIA@SPARC_LAB baseline updating



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 2029**.
- Second EuPRAXIA FEL site will be selected in next 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