EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA
at SPARC_LAB

EuPRAXIA@SPARC_LAB
General Introduction and Project Overview

M. Ferrario, INFN

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

IV EuPRAXIA@SPARC_LAB Review Committee Meeting, LNF November 30, 2022

EuPRAXIA at SPARC_LAB

Funded by the European Union

AGENDA

30/11 Wednesday

14:30 General introduction and project overview - M.Ferrario

15:15 Scientific Case – F. Stellato

16:00 Layout & Infrastructure – A.Ghigo

16:45 Coffee Break

17:15 Sparc_Lab latest results – R.Pompili / V.Shpakov

18:00 Closed Session

01/12 Thursday

9:00 Beam dynamics S2E simulations – C.Vaccarezza

9:45 Plasma module development – A.Biagioni

10:30 FEL & Undulators – L.Giannessi

11:15 Coffee Break

11:45 RF sections & RF Power – D.Alesini

12:30 Electron beam Diagnostics – A.Cianchi

13:15 Lunch Break

14:30 Photon Beam-lines and Diagnostics – F. Villa

15:15 TDR structure and Performance Baseline Structure

16:00 Coffee Break

16:30 Closed Session

02/12 Friday

9:00 Q&A and Outlook of the next meeting

10:00 Closed Session

12:00 Report back

TDR Draft Index

1. Executive Summary
2. EuPRAXIA in the European Context
3. EuPRAXIA@SPARC_LAB
4. Scientific Case
5. Experience with the LNF test facilities

6. Beam Physics
7. Machine layout
8. RF Photo-Injector
9. RF X-band Linac and Compressor system
10. Plasma Accelerating Module
11. Undulators and transfer lines
12. Photon Beam Lines
13. Experimental end-stations
14. Electron and Photon Diagnostics
15. Laser Systems
16. Timing and Synchronisation
17. Control system
18. Vacuum system
19. Magnets and Power Supplies
20. Machine Protection System

21. Civil Infrastructures
22. Radiation Safety and Beam Dumps
23. Integration and Implementation strategy
24. Project Cost and Timeline
25. Project Management structure

EuPRAXIA_PP Kickoff meeting, LNF, November 24-25, 2022

116 participants = > 63 attendance + 53 remote

EuPRAXIA at SPARC_LAB

EuPRAXIA-Preparatory Phase Consortium

34 Institutes from 12 Countries → to be merged with ESFRI Consortium

Funded by the European Union

EuPRAXIA Preparatory Phase

Coordinator

Università di Roma Tor Vergata

Consiglio Nazionale delle Ricerche

SAPIENZA Università di Roma

ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

INFN Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Frascati

Elettra Sincrotrone Trieste

TÉCNICO LISBOA

eli beamlines

IASA

Leibniz Ferdinand Braun Institut

Fraunhofer ILT

Wigner

SZTE University of Szeged

Pécsi Tudományegyetem University of Pécs

cnrs

cea

THALES

DESY.

HZDR Helmholtz Zentrum Dresden Rossendorf

Jülich Forschungszentrum

LMU Ludwig-Maximilians-Universität München

EPFL

Empa Materials Science and Technology

ALBA

CLPU Centro de Láseres Pulsados

UK Research and Innovation

University of Liverpool

CERN

University of Oxford

Queen's University Belfast

University of Strathclyde Glasgow

Imperial College London

The Hebrew University of Jerusalem

The University of California UCLA

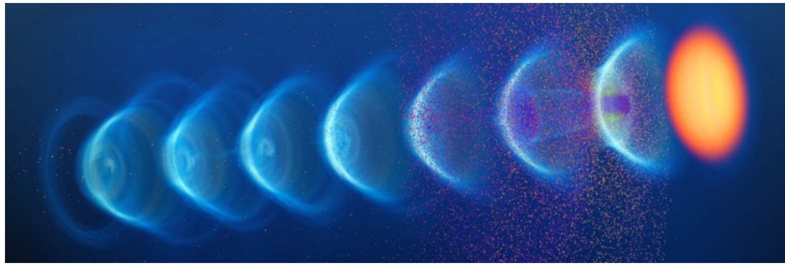
Complemented by institutes in **EuPRAXIA ESFRI consortium: additional 17 institutes** from France, Germany, Poland, Sweden, United Kingdom, China, Japan, United States. Russian institutes presently suspended.

EuPRAXIA-PP (Preparatory Phase) Key Facts

Funded by the European Union

Prepares the implementation of the full RI in Europe

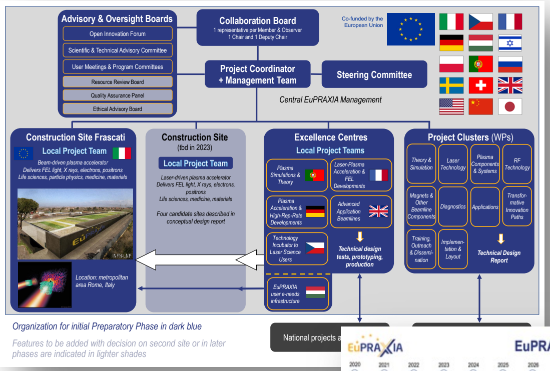
- Total project volume (including in-kind): **8.3 M€**
  - EU funding: **2.49 M€** (EU without in-kind)
  - Outside EU **0.69 M€** (Switzerland)
    0.51 M€ (UK)
- Work organized in 16 Work Packages
- Project dates: **1 Nov 2022 – 31 Oct 2026**
- Coordinator and location of headquarters: **INFN**
- **34** participating organizations from 12 countries
- Will establish a "Board of Financial Sponsors" with representatives of funding agencies.
- So far **~ 25%** of total M&P funding (**569 M€**) secured. Site 1 is essentially financed.

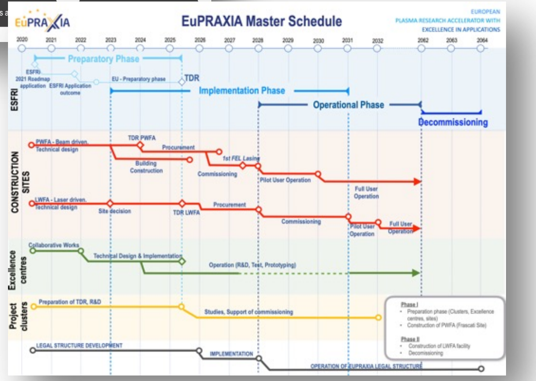


Preparatory Phase Main Goals

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

EuPRAXIA Advanced Photon Sources

- Ranking 1° in ESFRI Research Infrastructure call for Next Generation EU (PNRR).
- Phase 1 EuPRAXIA Implementation Phase
- Betatron Radiation Source for x-ray imaging
- High Power Laser [1 PW]
- High Repetition Rate Laser [100Hz]

Plasma-Generated X-ray Pulses: Betatron Radiation Opportunities at EuPRAXIA@SPARC_LAB

Francesco Stellato [1,2,*], Maria Pia Anania [3], Antonella Balerna [3], Simone Botticelli [2], Marcello Coreno [3,4], Gemma Costa [3], Mario Galletti [1,2], Massimo Ferrario [3], Augusto Marcelli [3,5,6], Velia Minicozzi [1,2], Silvia Morante [1,2], Riccardo Pompili [3], Giancarlo Rossi [1,2,7], Vladimir Shpakov [3], Fabio Villa [3] and Alessandro Cianchi [1,2]

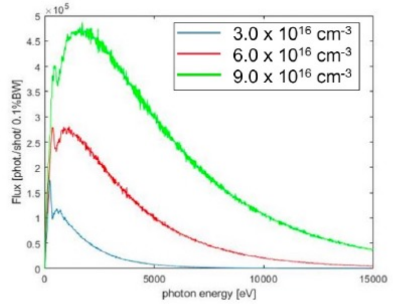


Figure 1. Betatron radiation spectra simulated for a source size of 3 μm and 3 different plasma densities. The total number of photons is 1.7 x 9 for the 9.0 x 10^{16} cm^{-3} density, 9.9 x 8 for the 6.0 x 10^{16} cm^{-3} density and 4.1 x 8 for the 3.0 x 10^{16} cm^{-3} density.

The EuAPS proposal benefits from the preparatory work done in the conceptual design phase of EuPRAXIA, both for the scientific case and the technology. It focuses on an ambitious but technically achievable goal and builds on the pre-existing investments at the SPARC_LAB facilities. As stated in the EuPRAXIA CDR the following EuPRAXIA Flagship Goals will be addressed by the EuAPS Project:

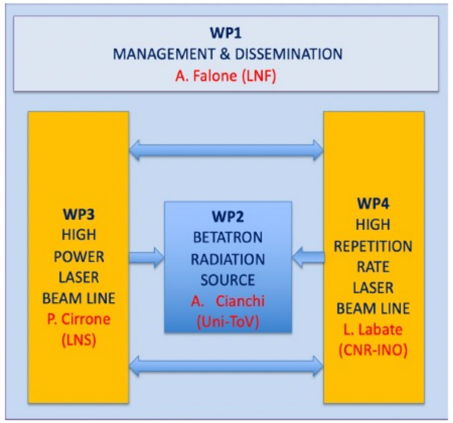
Flagship Innovation Goal 2: EuPRAXIA will develop together with laser industry a **new generation of high peak power lasers**, advancing the presently leading technology into the regime of 20 - 100 Hz repetition rate [...].

Flagship Science Goal 2: EuPRAXIA will deliver **betatron X rays with up to 10^{10} photons per pulse**, up to 100 Hz repetition rate and an energy of 5-18 keV to users from the medical area. [...].

Flagship Science Goal 7: EuPRAXIA will provide access to cutting edge laser technology with **short pulse length in combination with high energy photon pulses** [...].

We expect that the focus on a mature part of the EuPRAXIA project strongly supports project completion on the timescales that are required by PNRR.

EuAPS Scientific Coordinator: M. Ferrario (INFN-LNF)
EuPRAXIA/EuAPS Integration: R. Assmann (DESY & INFN)

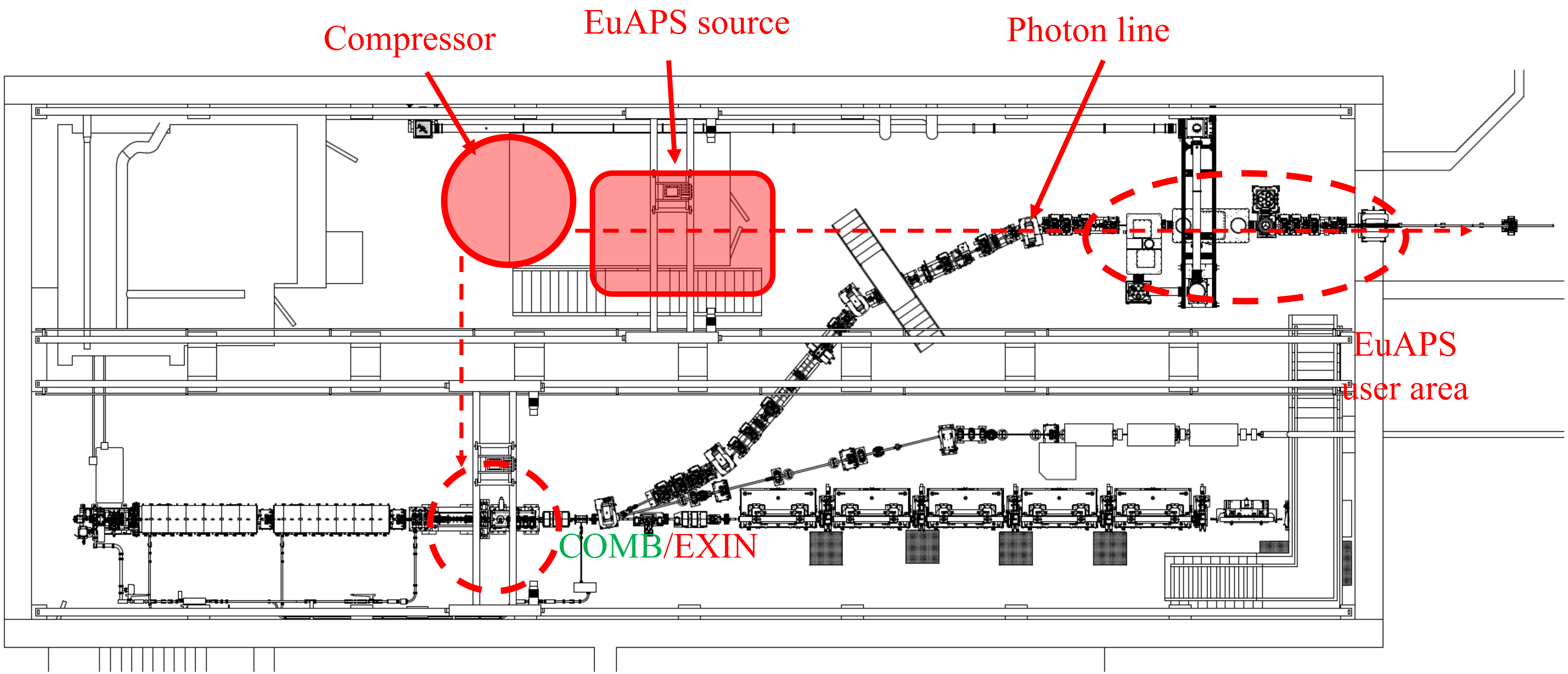


Scientific Advisory Committee

Operating Units Board

Scientific and Technical Board

Project Starting Date : December 1rst


Compressor
EuAPS source
Photon line
EuAPS user area
COMB/EXIN

Recruitment strategy

Several position will be opened soon due essentially thanks to the Next-Generation EU related projects.

There will be:

1. Plasma Scientists
2. Laser engineer
3. Senior scientists in plasma accelerator based as EuAPS infrastructure manager.

Additional positions covering other areas will have to be opened in 2023 → Difficulties in finding candidates.

Welcome 2 new Beam Dynamics Staff members:

- Stefano Romeo
- Alessio Del Dotto

Progress on the EuPRAXIA@SPARC_LAB TDR

Significant progress for ALL working areas and working packages

- Intermediate layout basically frozen (few minor issues to be further studied)
- Realization of X-Band accelerating section mechanical prototype full scale – in house
- Injector layout – Completed
- RF power source strategy concluded and procurement in progress → delay in the administrative procedure. CPI klystron kickoff in few weeks. Canon klystron expected begin 2023.
- Ondulator strategy concluded -> 2 Beamlines in the baseline prototyping activities are ongoing

In general the TDR work is advancing according to the schedule.
Additional Manpower is about to be hired (thanks also to the PNRR Funding).

Milestones Delivered

WA	Milestone	Delivered
WA1	**BEAM PHYSICS**	
M1.1	S2E new layout completed	01/08/2022
M1.2	Photon Number optimization	01/12/2022
WA2	**INJECTOR**	
M2.1	Injector preliminary layout	18/06/2021
M2.2	Injector Layout	03/10/2022
WA4	**RF & POWER SUPPLIES**	
M4.1	S-Band Waveguide design	08/03/2022
M4.2	X-Band Waveguide design	08/03/2022
WA6	**FEL**	
M6.1	FEL Configuration Strategy	03/05/2022
WA10	**DIAGNOSTICS**	
M10.1	BPM prototype validation	28/09/2022
M10.4	High Precision Charge measurement validation	20/05/2022
PO	**PROJECT OFFICE**	
MPO.1	Start Preparatory phase	01/11/2022
BLDG	**Building**	
BLDG.M1	Final design Ready	27/01/2022

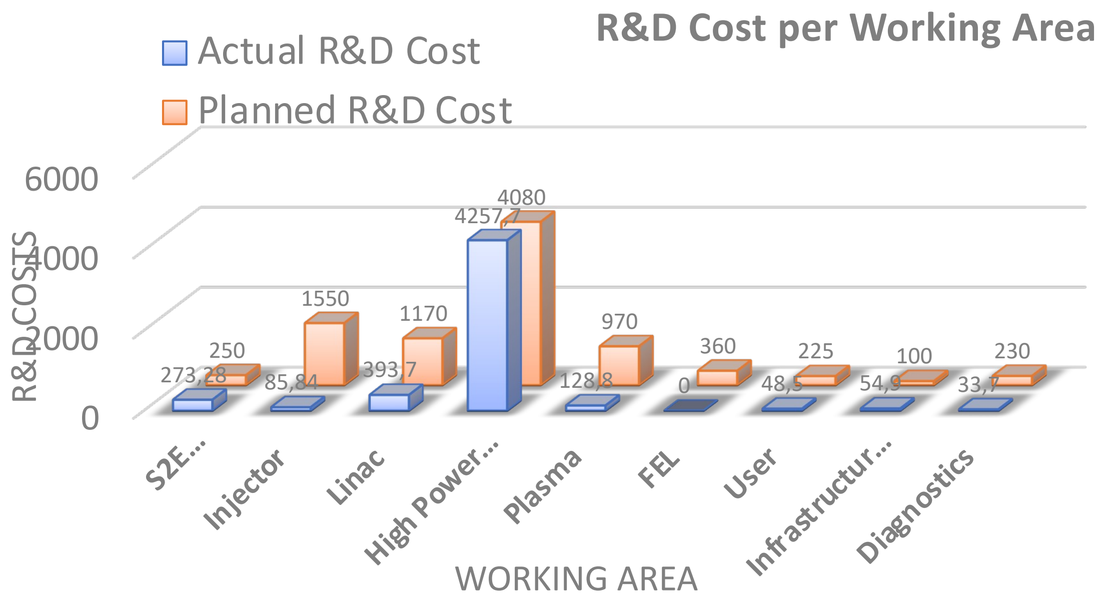
R&D Cost Baseline follow up.

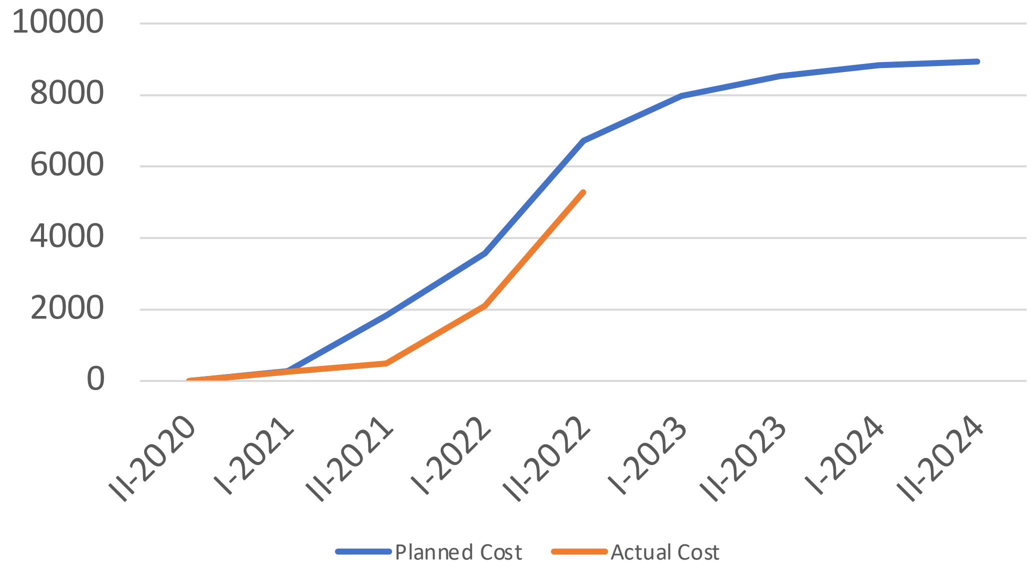
Funded by the European Union

The spending rate for R&D has increased as expected since the definition and the design have reached a more mature level.

In particular the procurement of the most significant items are highlighted below:

- X-Band high efficiency tube
- X-Band high repetition rate RF station (modulator + canon klystron).
- Prototype of X-Band accelerating section





TDR – Beam Dynamics | Machine Layout

Funded by the European Union

Beam Dynamics Studies – Machine Layout

Photoinjector layout concluded (including X-Band 9 cells linearizer)

S2E Finalization for :

30+200pC at 1-1.2 GeV
50+230 pC at 1-1.2 GeV
X-Band @Gun finalization 200-300-500pC Beam

Jitter & Sensitivity analysis will be performed in Spring 2023 – according with the schedule

Courtesy C.Vaccarezza, A.Giribono, S.Romeo

EuPRAXIA@SPARC_LAB Parameter List update 2

Electron Beam parameters from CDR

Parameter	Unit	PWFA	Full X-band
Electron Energy	GeV	1	1
Bunch Charge	pC	30	200
Peak Current	kA	1-2	1-2
RMS Energy Spread	%	1.1	0.1
RMS Bunch Length	μm	6-4	24-20
RMS norm. Emittance	μm	1	1
Slice Energy Spread	%	0.03	0.02
Slice norm Emittance	mm-mrad	0.5	0.3

Electron Beam Parameters Nov 22

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

EuPRAXIA@SPARC_LAB Parameter List update 1

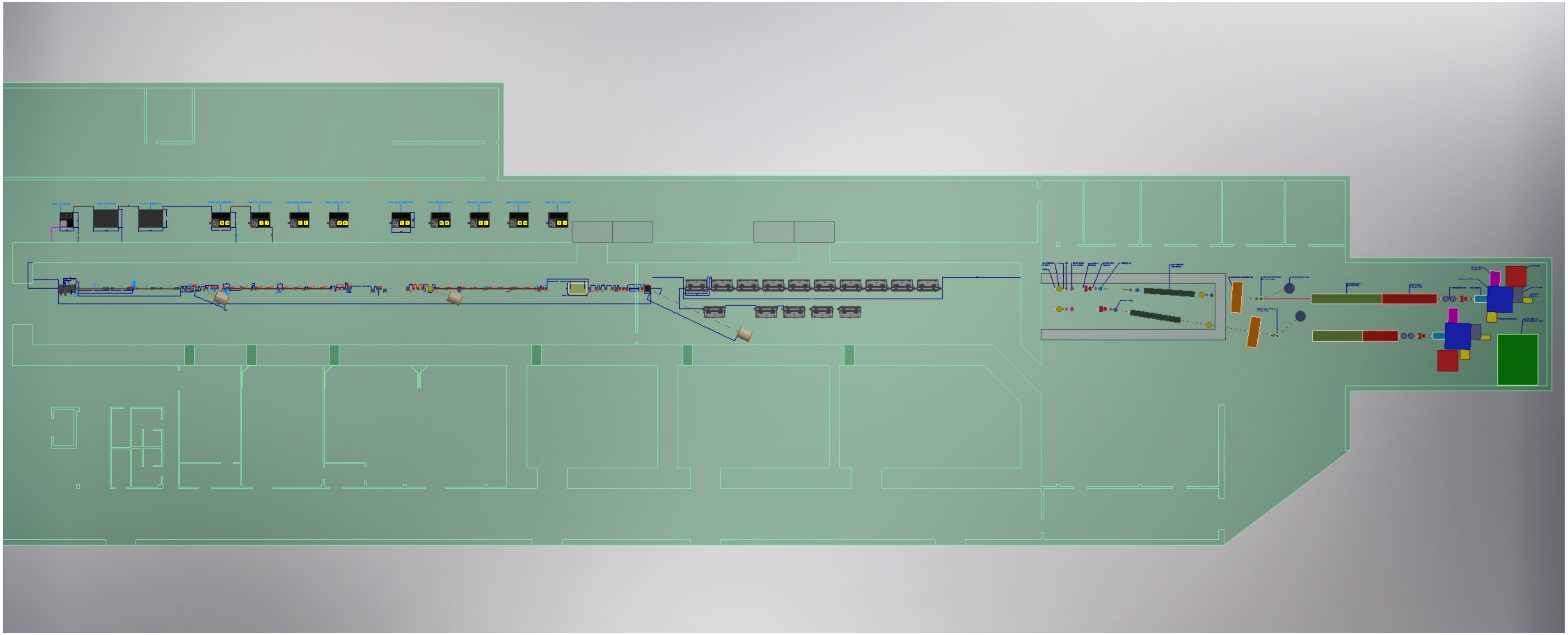
Nominal FEL parameters from CDR

Parameter	Unit	PWFA	Full X-band
Radiation Wavelength	nm	3	
Photons per Pulse	$\times 10^{12}$	0.1	1
Photon Bandwith	%	0.9	0.5
Undulator Area Length	m	30	
ρ(1D/3D)	$\times 10^{-3}$	1	2
Photon Brilliance per shot	$mm^2 mrad^2$ $bw(0.1\%)$	1×10^{27}	

FEL Parameters Nov 2022

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	$\left(\frac{s\ mm^2 mrad^2}{bw(0.1\%)} \right)$	$\mathbf{1\text{–}2 \times 10^{28}}$	1×10^{27}

Machine Layout



Courtesy F.Cioeta & E.Di Pasquale , A.Ghigo

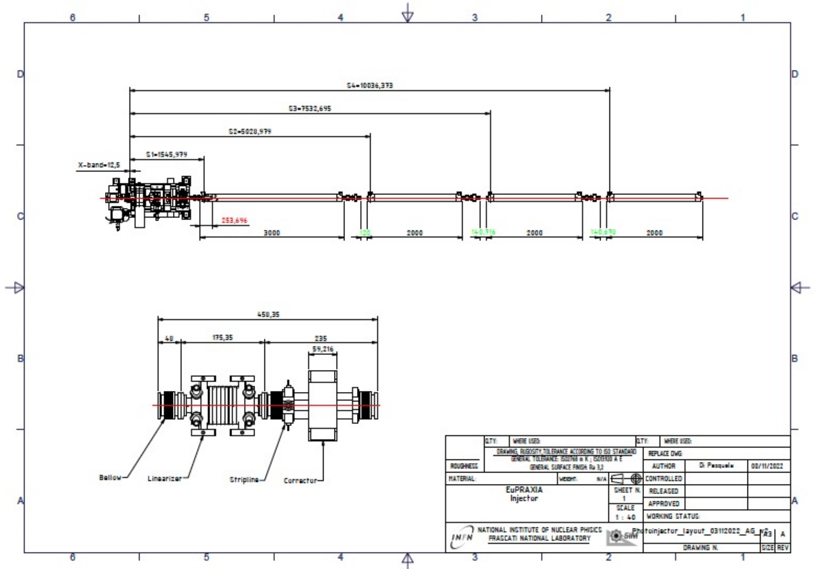
Injector

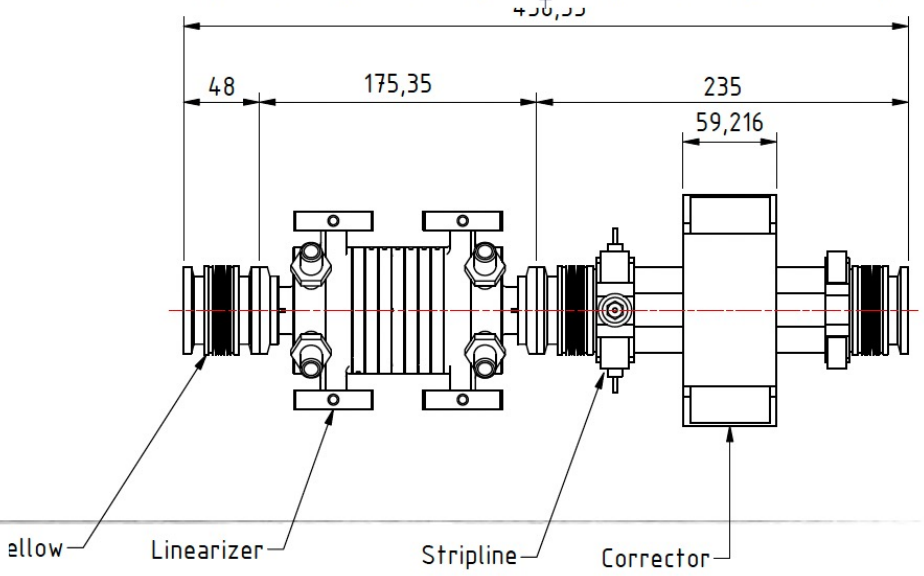
Funded by the European Union

Injector study is now frozen and approved

Optimization of the RF distribution taking into account the X-Band linearizer and the 4 S-Band sections are ongoing

- ✓ Injector layout
- ✓ High charge working point
- ✓ Comb Beam and S-Band optimization (3+2+2+2)
- ✓ RF distribution for the S-Band system (advanced layout agreed but still to be optmized)
- ✓ SW vs TW X-Band linearizer in terms of power distribution
- ✓ Jitter and sensitivity studies





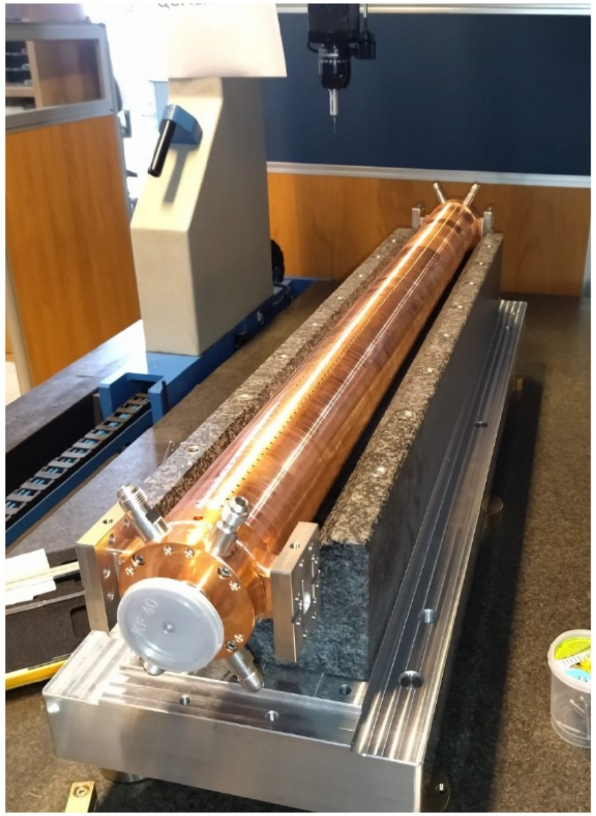
Sci-Com 14/11/2022

9

Linac

Funded by the European Union

- X-Band Accelerating section. Mechanical prototype full scale built.
- Dimensional check and quality control ongoing
- Design of the RF full scale X-Band structure (C.I.) is completed
- Procurement of material for the realization of the RF prototype has started (to be concluded late spring 2023).
- LINAC Layout complete (except Laser heater and bunch compressor design still to be finalized).



Courtesy D.Alesini

RF Power Sources

- ✓ RF design of X-Band waveguide components is completed (e.g. mode converter and pumping port)
- ✓ Procurement High Efficiency High Power CPI Klystron (50MW) – Concluded. Kickoff in the following weeks.
- ✓ Procurement High Repetition Rate Canon Klystron through Scandinova is ongoing – to be finalized begininning of 2023
- ✓ Optimization of the RF Distribution on going (including X-band deflector and linearizer).
- ✓ TEX Facility – Radioprotection authorization process completed. It should be able to start the scientific program soon (waiting for the formalization of the authorization).

Courtesy A.Gallo

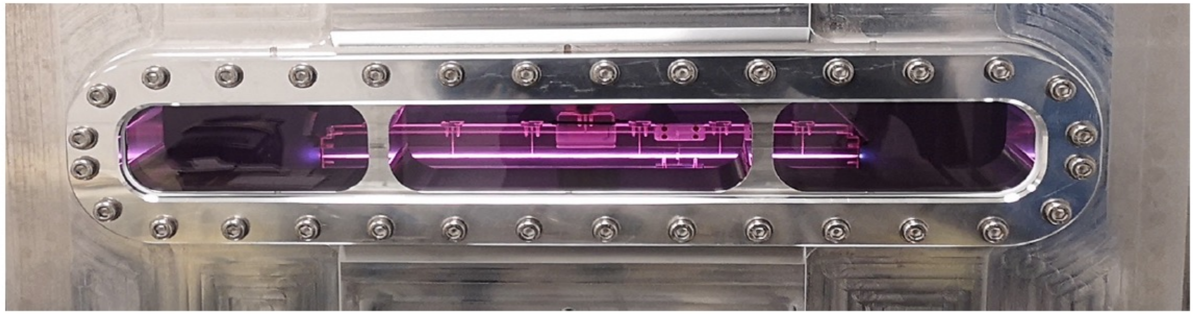
High Efficiency Klystron Specs

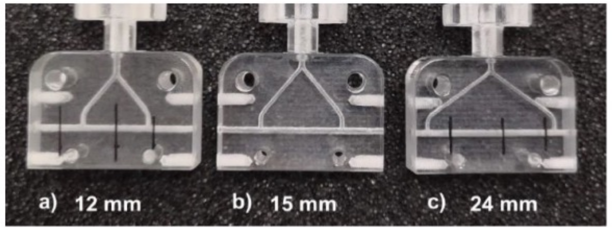
No	Parameter		Unit
		nominal	
1	RF Frequency	11,9942	GHz
2	Peak RF power	50	MW
3	Average RF Power	7,5	
4	RF pulse width (at -3dB)	1,5	µs
5	Pulse repetion rate *	50 / 100	Hz
6	Klystron peak voltage	430	kV
7	Klystron peak current	212	A
8	Perveance	0,75	$\mu A/V^{1.5}$
9	Gain at peak power	50	dB
10	Bandwidth (at -3 dB)	50	MHz
11	Efficiency at saturation	55	%
12	Maximum output VSWR	1.10 : 1	
13	Variation of anodic current (at klystron peak power) within +/- 5% cathode heater power variation		
14	Fraction of RF powr in 2nd harmonic		dBc
15	Pulse failures (arcs etc) during 12 hours continuous test period	< 1	
16	Heater voltage DC	TBD	V
17	Heater current DC	TBD	A
18	Preheating period stable operation full compliant		Hours
19	RF drive power	500	W
20	Magnet current (Main Top)	TBD	A
21	Magnet current (Main Bottom)	TBD	A
22	Magnet current (Gun Coil)	10	A
23	Water flow rate (Collector)	10	GPM
24	Water flow rate (Body)	2	GPM
25	Water flow rate (Magnet)	10	GPM
26	X-ray radiation	0,5	µSv/hr
27	RF output WR-90 flange	TBD	
28	RF input WR-90 flange	TBD	
	* depending on the RF pulse length		

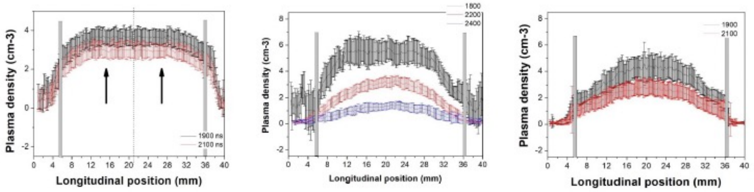
Plasma Module

Production of the first prototype of long capillary (40cm) - Already presented at the last Sci-Com meeting.

- ✓ 40 Cm Discharge was successfully achieved in a plastic capillary.
- ✓ Plasma density completely characterized
- ✓ Vacuum tests with plasma at 100Hz have been reached .
- ✓ Transverse matching tests ongoing
- ✓ 40cm sapphire capillary tests to be performed



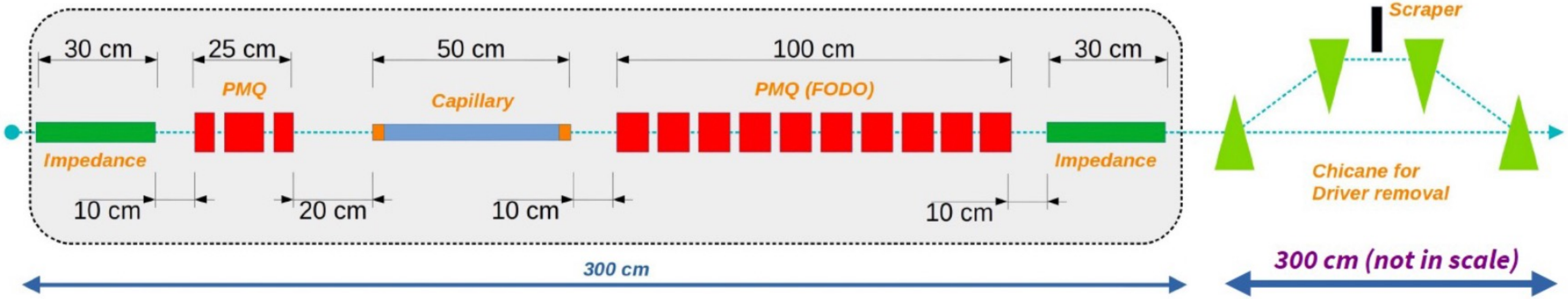




Courtesy R.Pompili, A.Biagioni

Plasma Module

Plasma module layout – Different options under investigations.



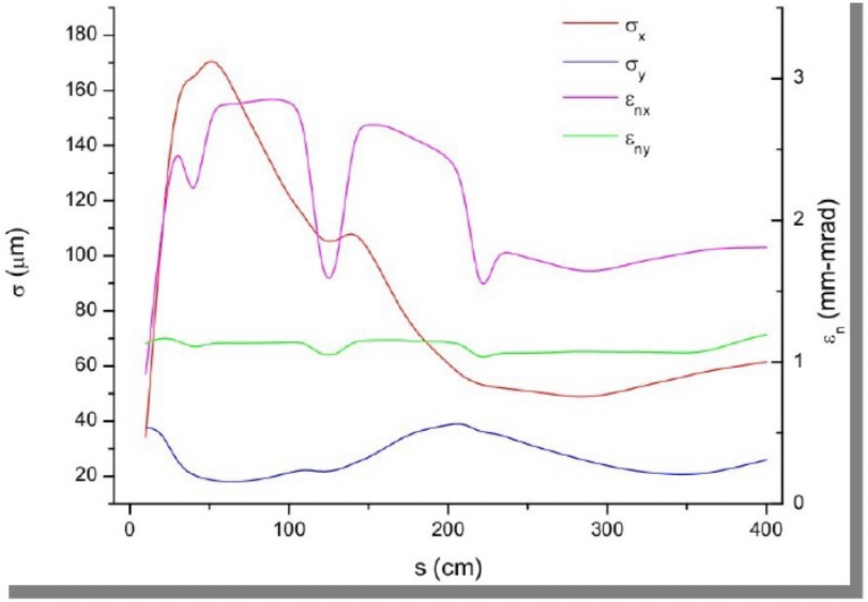
Option 1

From CDR, first idea is to use a long "gentle" FODO to extract the witness.

Major part of the driver is still transported

A magnetic chicane must be used to separate witness and driver in energy and cut the latter with a scraper

Simple solution but require some space and single independent tuning for each PMQ

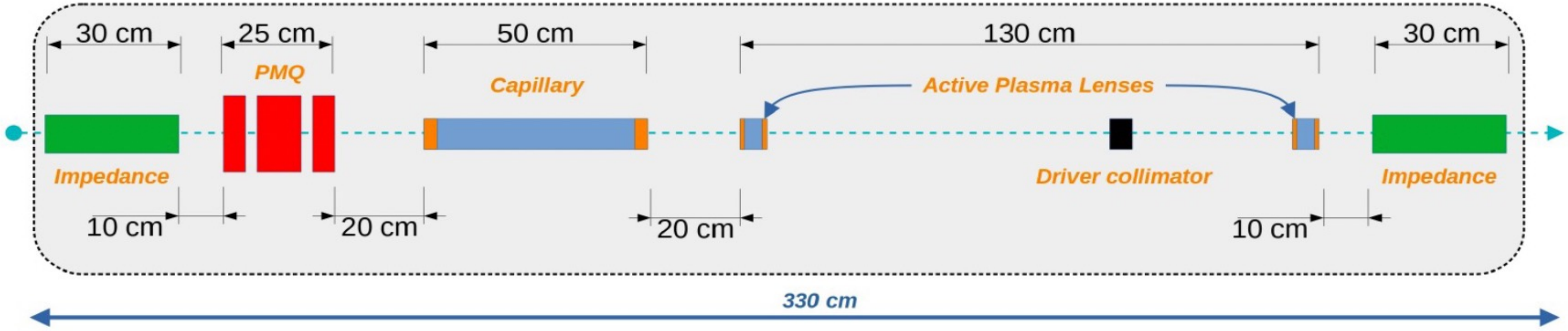


Courtesy R.Pompili, A.Biagioni

Plasma Module

Plasma module layout – Different options under investigations.

Option 2



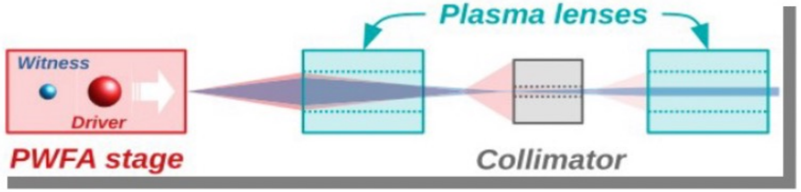
Active-Plasma lenses to extract the witness and remove driver

- Witness is catch and transported without loss of charge
- Driver is over-focused at the collimator entrance and its charge removed

Pompili, R., et al. "Plasma lens-based beam extraction and removal system for plasma wakefield acceleration experiments." Physical Review Accelerators and Beams 22.12 (2019): 121302.

Study performed on the EuPRAXIA@SPARC_LAB reference working point

- It requires two active-plasma lenses and a lead collimator.
- Solution would benefit of compactness and tunability.
- However puts more load on the vacuum



Courtesy R.Pompili, A.Biagioni

FEL and Undulators

- **AQUA**
  - Undulator design – Study of undulator termination and minimization wake fields
  - Undulator prototyping: drawing of a model from the Sabina STEP file in progress. No updates since last meeting (MDF involved in othe activities).
  - Design study of short period undulator. After delivery of SABINA Undulator, to be assigned through contract ?
  - Pulsed wire measurement system under study (A. Selce, A. Petralia)
  - Intrasection design (L. Sabatini, A. Vannozzi, A. Selce, F. Nguyen) Quadrupole field integral defined/discussion ongoing on having correctors embedded in quadrupoles, impedances and feedback frequency cutoff (L. Sabatini, A. Selce, A. Vannozzi)
  - Simulations: testing wake fields models as also suggested by TDR Committee (F. Nguyen & N. Mirian)
  - Recent S2E simulations from WA1 are showing peak currents in excess of 1.9-2kA. FEL simulations show saturation at wavelengths < 4 nm (V. Petrillo). New working point parameters ?

Courtesy L.Giannessi

Users and Beam Lines

Funded by the European Union

- ✓ Proposal for development and characterization of novel optics for focusing X-rays @Elettra

- ✓ Coordination with the corresponding WP for EuPRAXIA- Preparatory Phase

Upcoming Milestones

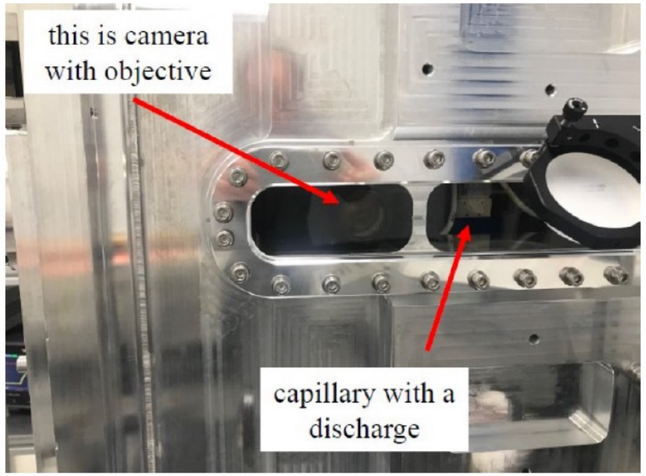
31/12/22 *Preliminary optical simulation of the beamlines*

31/12/22 *Evaluation of Scientific Case for other wavelengths (ARIA)*

Courtesy F.Stellato

Diagnostics

Test on CCD Camera in the plasma chamber - done



Conclusions:

- Camera can work inside the vacuum without problems with the temperature
- Discharge does not create problems with the camera or the trigger

CBPM – PSI Choice for intra ondulator diagnostics

Read-out electronics development under discussion

	PSI CBPM5/8	FMB Oxford
Material	Stainless Steel (outside) – Copper (inside)	Stainless Steel
Length [mm]	100 mm	100 mm
Inner Aperture [mm]	5 / 8 mm	20 mm (custom)
Res. frequency	4.9266 GHz	6.474 GHz
QL	1000	610
Decay Constant	64.6 ns	30 ns
Charge Range	10-200 pC	10-100 pC
Typical Position Range	±1 mm	
Position Sensitivity (CBPM5)	4.5 V/mm/nC	1 V/mm/nC
Charge Sensitivity (CBPM5)	62.8 V/nC	

Stripline prototype

STATUS: Strip-Lines BPM
10cm between flanges and 25mm aperture

- BPM prototype (delivered Feb2022) ✓
- RF Bench tests (march 2022) ✓
- **BPM realization for beam tests including minor modification to design**

Vacuum feedthroughs procurement (qty:16)
Purchase order (PMB, May2022) ✓
Delivery: 4 weeks (estimated)

Tender for mechanical realization (with vacuum group) before 12/2022

Installation @ SPARC (before 03/23)

Beam Tests@ Sparc (before 09/23)

Courtesy Cianchi, Biagioni, Stella, Shpakov, Franzini

Building Status

Progress in the design finalization and authorization process.

- Final design is basically frozen with many further implementations in the last months.

- Informal authorization from different stakeholders to proceed with the formal «Conferenza dei Servizi» (Permitting authority commitee) :
  - ✓ Archeological survey
  - ✓ Landscape
  - ✓ Fire Dept.

- Cost updated (due to current geo-political and macroeconomic scenario) to be discussed at management level

Courtesy S.Incremona, U.Rotundo

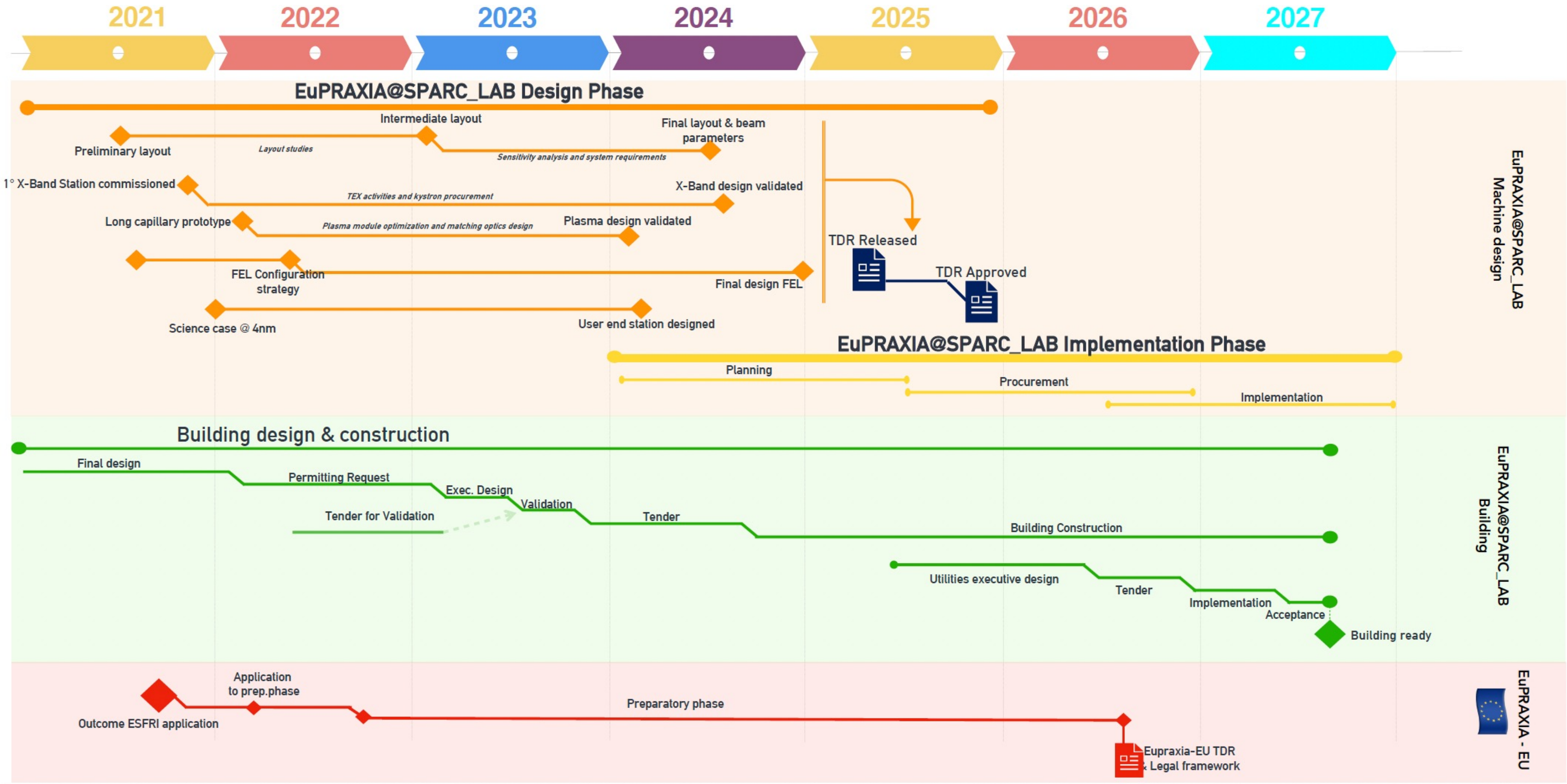
Funded by the European Union

Building Rendering

Vista del nuovo complesso da Via Isaac Newton

Vista aerea del nuovo complesso dalla parte del nuovo parcheggio

Schedule Update



Milestones work in progress

WA	Milestone	Work in progress
WA1	**BEAM PHYSICS**	
M1.3	Machine intermediate layout	06/01/2023
M1.4	RF specifications	06/01/2023
M1.5	Magnets specifications	06/01/2023
WA2	**INJECTOR**	
M2.4	Injector RF Distribution	23/01/2023
M2.5	Photocathode laser design	23/03/2023
WA3	**LINAC**	
M3.1	Linac Design	28/04/2023
M3.2	Vacuum Design	28/04/2023
WA4	**RF & POWER SUPPLIES**	
M4.3	Power supply design validated.	28/04/2023
WA10	**DIAGNOSTICS**	
M10.2	BLM prototype validation	30/01/2023
M10.3	Compact Diag Chamber validation	07/02/2023
M10.5	Diagnostic prototyping validation	07/02/2023
M10.6	Final e-beam diagnostic design	07/02/2023
BLDG	**Building**	
BLDG.M3	Authorization Ready	29/12/2022

Project Office Status

- **The Project Management activities has been carried out as expected.** A lot of effort has been put in defining parallel projects devoted to the consolidation of EuPRAXIA iniative in particular EuAPS, EuPRAXIA Preparatory Phase.
- **The project office of the whole EuPRAXIA iniative is increasing its momentum.** One additional resource has been hired specifically for the management of the EuPRAXIA Preparatory Phase Project. A scientific secretary is about to be hired beginning of 2023.
- **A comprehensive project management plan has been set up for EuAPS** project which is quite demanding from management perspective (bimestral monitoring and a remarkable amount of tender to be issued in a very short time frame).

- **In the next semester the major effort will be put in the definition of a comprehensive configuration and project breakdown structure.** This will help in the estimation of the implementation cost.
- **By the end of 2023 we expect to start the activities for the planning of the Implementation phase and to start the redaction of the TDR itself.**

Conclusions

- Significant progress on the machine layout development
- Still a number of open points to be more investigated
- Prototyping activities on track. X-Band LLRF System prototype is under investigation
- Several other EuPRAXIA related projects to be started soon will reinforce EuPRAXIA@SPARC_LAB activities.
- Additional manpower will hopefully be hired in the next months (3 Through EuAPS Funding + others from funding sources) and hiring for other project can alleviate the workload to EuPRAXIA team.
- In the next weeks we will start the process to structure the TDR chapters and connect them to the intermediate milestones we are performing.