The PACRI Project

Plasma **A**ccelerator systems for **C**ompact **R**esearch **I**nfrastructures

Gerardo D'Auria, Elettra – Sincrotrone Trieste

Massimo Ferrario, INFN Frascati

Leo Gizzi, CNR Pisa

Horizon Europe Call

Horizon Europe Work Programme 2023-2024
INFRA-2024-TECH-01-01
Development of ground-breaking RI Technologies,…..
Including high tech developments for accelerators

- Research and development of new scientific instrumentation, tools and methods for research infrastructures taking into due account **resource efficiency** (e.g. **energy consumption**) and **environmental impact.**
- Their **technology validation and prototyping.**
- **Training of RI staff** for the operation and use of these new solutions.
- The innovative potential for **industrial exploitation** of the solutions and/or for the benefits of the society.

PACRI
Plasma Accelerator systems for Compact Research Infrastructures

EU contribution 10 M€

PACRI areas of interest

1. Compact & efficient plasma accelerators (M. Ferrario - INFN)

With focus on the high rep-rate plasma modules, as required for the EuPRAXIA project.

2. Compact & efficient X-band technology for accelerators (G. D'Auria - Elettra)

With focus on normal conducting RF technology for linear accelerators.

3. Efficient & high repetition rate Lasers (L. Gizzi - CNR)

With focus on high repetition rate laser technology, required to drive high-gradient and high-repetition-rate Laser Plasma Acceleration (LPA) related to the above-mentioned applications.

The project was submitted beginning of March 2024

Evaluation Results

Total score 14.50 (Threshold 10.0/15.0)

Criterion 1 - Excellence

Score: 5 (Threshold 3.0/5.0)

The overall objective of PACRI is to promote the development of new acceleration schemes ad innovative breakthrough technologies for accelerators, Taking energy consuption, resource efficiency, costs and environmental impact into account. ***The overall objective and the specific goals are very clear and pertinent and fully aligned with the overall aim of the INFRA-TECH call as well as with the scope of the TECH-01-01 topic……***

Criterion 2 - Impact

Score: 5 (Threshold 3.0/5.0)

The proposal outlines its expected outputs in an excellent way, including prototypes of high repetition rate plasma modules, a high efficiency klystron and high rep-rate modulator, high power high rep –rate laser systems, and open-source codes for plasma module design……..

Criterion 3 – Quality and efficiency of the implementation

Score: 4.5 (Threshold 3.0/5.0)

The work plan is sound and realistic, albeit ambitious. The breakdown into 14 WPs is logical ……Each WP involves multiple participants: mostly from rather different background which is beneficial for the synergy and coherence…..Milestones and deliverables are generally appropriate: **however, for several tasks there is a lack of intermediate control points, such as milestones or deliverables, which makes it difficult to track the progress of certain tasks throughout the project's lifetime. There is also an occasional lack of interconnection and collaboration between separate WPs, which are not always adequately eplained……..**

Project context

PACRI is a collaborative effort involving 19 International Research Laboratories and Universities, supported by 7 Industrial Partners. It is closely connected to two ESFRI Research Infrastructures:

EuPRAXIA and the Extreme Light Infrastructure, ELI-ERIC

Project duration: 4 Years (2025-2028)

Overall project value 11 M€

10 M€ EU contribution + 1 M€ from PSI

PACRI objectives and ambitions

- Further developments on **high-repetition-rate plasma modules**, as the one foreseen by the **EuPRAXIA project**, extending its scientific domain to high average brightness radiation sources with possible future applications also to high energy physics.
- Improve the performance of normal conducting technology for linacs (**X-band**), aiming at extending their operating capabilities **up to the kHz regime** with the focus on **efficiency and energy consumption**, boosting the diffusion of extremely compact linacs and related X-ray facilities.
- Further developments on **high-power - high repetition rate laser technology,** to support the above-mentioned applications.

Elettra Sincrotrone Trieste

PACRI Collaboration

25 Partners
+
1 Associated Partner

19 Universities and Scientific Labs.
+
7 Industries

#	Partner	Acronym
1	Elettra - Sincrotrone Trieste SCpA (Coordinator)	ST
2	European Organization for Nuclear Research	CERN
3	Istituto Nazionale Fisica Nucleare	INFN
4	University of Liverpool	ULIV
5	Thales-MIS	Th-MIS
6	Scandinova Systems AB	SCND
7	VDL ETG Technology & Development BV	VDL
8	COMEB	COMEB
9	United Kingdom Research and Innovation	UKRI
10	Consiglio Nazionale delle Ricerche	CNR
11	Extreme Light Infrastructure ERIC	ELI-ERIC
12	Centre National de la Recherche Scientifique CNRS	CNRS
13	Thales LAS France SAS	Th-LAS
14	Amplitude	Amplitude
15	Centro de LÁSERES Pulsados	CLPU
16	Ferdinand-Braun-Institut gGmbH, Leibniz-Institut für Hoechstfrequenztechnik	FBH
17	Associacao do instituto superior Tecnico para a Investigacao e Desenvolvimento	IST
18	Università degli Studi di Roma La Sapienza	USAP
19	Heinrich-Heine-Universitaet Duesseldorf	UDUS
20	Deutsches Elektronen-Synchrotron DESY	DESY
21	The Chancellor, Masters and Scholars of the Univ. of Oxford	UOX
22	Ludwig-Maximilians-Universitaet Muenchen	LMU
23	GSI Helmholtz Centre for Heavy Ion Research	GSI
24	Università degli Studi di Roma Tor Vergata	UTOR
25	SourceLAB	SourceLAB
26	Paul Scherrer Institut (Associated partner)	PSI

PACRI work packages

WP No.	Work Package		Lead Partic. Short Name	Person Months	Start Month	End month
1	Coordination and project management	Instit.	ELETTRA	68	1	48
2	Scientific and industrial exploitation		ULIV	49	1	48
3	Plasma accelerator theory and simulations	Plasma	IST	126	1	48
4	High repetition rate plasma structures		INFN	156	1	48
5	Plasma acceleration diagnostics and instrumentation		CNRS	206	1	48
6	High efficiency RF generator	X-band	Thales-MIS	26	1	48
7	High repetition rate modulator		Scandinova	25	1	48
8	X-band RF Pulse Compressor (BOC)		INFN	31	1	48
9	RF tests and validation		CERN	29	1	48
10	High repetition rate high power Ti:Sa amplifier module	Lasers	UKRI	55	1	48
11	Efficient kHz laser driver modules for plasma acceleration		CNR	70	1	48
12	High-rep rate pump sources for laser drivers		ELI-ERIC	51	1	48
13	Prototype of high average power optical compressor		Thales-LAS	40	1	48
14	Laser Driver System Architecture,transport and engineering		CNRS	68	1	48

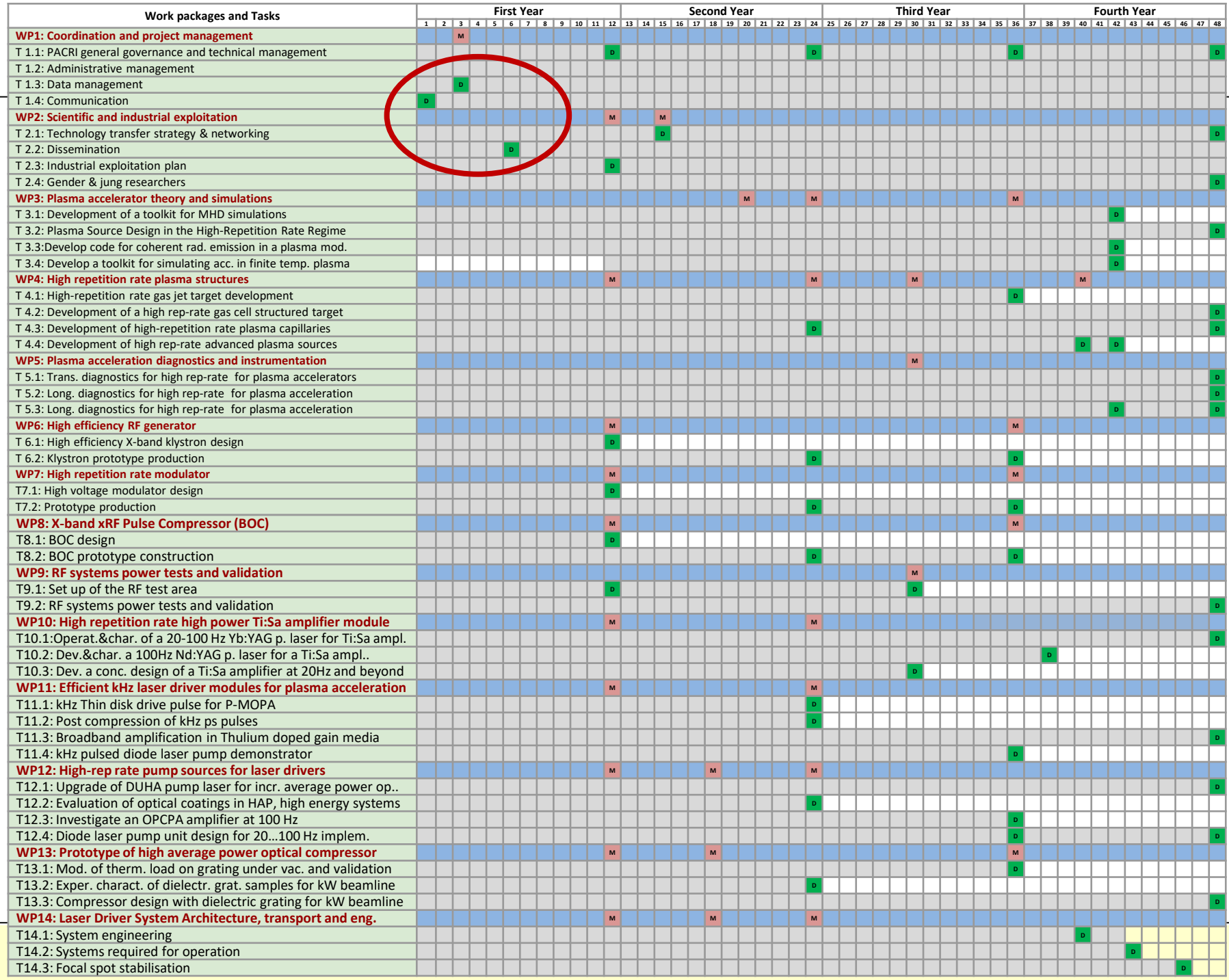
Total 1000 person months

Elettra Sincrotrone Trieste

PACRI Gantt chart

D 54 Deliverables

M 40 Milestones



WPs and Tasks

WP1: Coordination and project management (Elettra):

- Task 1.1: General governance and technical management
- Task 1.2: Administrative management
- Task 1.3: Data management
- Task 1.4: Communication

WP2: Scientific and industrial exploitation (ULIV):

- Task 2.1: Technology transfer strategy & networking
- Task 2.2: Dissemination
- Task 2.3: Industrial exploitation
- Task 2.4: Gender & joung researchers

WPs and Tasks_Plasma

WP3: Plasma accelerator theory and simulations (IST):

- Task 3.1: Development of a toolkit for hydrodynamic simulations
- Task 3.2: Design in the High-Repetition Rate Regime
- Task 3.3: Development of codes for radiation emission in a plasma module
- Task 3.4 Development of a toolkit for simulating acceleration in finite temperature plasma

WP4: High repetition rate plasma structures (INFN):

- Task 4.1: high-repetition rate Gas jet target development
- Task 4.2: Development of a high-repetition rate gas cell structured target
- Task 4.3: Development of high-repetition rate plasma capillaries
- Task 4.4: Development of high-repetition rate advanced plasma sources

WP5: Plasma Accelerator diagnostics and instrumentation (CNRS):

- Task 5.1: Transverse diagnostics for high repetition rate for plasma accelerators
- Task 5.2: Longitudinal diagnostics for high repetition rate for plasma acceleration
- Task 5.3: Development of virtual instrumentation and AI driven control systems

WPs and Tasks_RF

WP6: High efficiency RF generator (Thales-MIS):

- Task 6.1: High efficiency X-band klystron design
- Task 6.2: Klystron prototype production

WP7: High repetition rate modulator (Scandinova):

- Task 7.1: Modulator design
- Task 7.2: Prototype production

WP8: RF pulse compressor (BOC) (INFN):

- Task 8.1: BOC design
- Task 8.2: BOC prototype construction
- Task 8.3: BOC low power RF characterization.

WP9: High power RF tests and validation (CERN):

- Task 9.1: Set up of the RF testing area
- Task 9.2: RF systems power tests

Klystron main operating parameters

RF peak power:	25 MW
Pulse length:	from 2.5 μs to 3.5 μs
RF efficiency:	> 50%
Pulse rep. rate:	400 Hz*

*With the possibility of extending it up to 1 kHz

Modulator main operating parameters

Pulse peak power:	≥ 50 MW
H.V. pulse length:	from 2.5 μs to 3.5 μs
Pulse rep. rate:	400 Hz (up to 1 kHz)

In addition, where possible, training of technical staff in the use of the new systems will be organised during the installation and power tests of prototypes.

WPs and tasks_Laser I

WP10: High repetition rate high power Ti:Sa amplifier module (UKRI):

- Task 10.1: Operation and characterization of a 20-100 Hz Yb:YAG pump laser for a Ti:Sa amplifier.
- Task 10.2: Development and characterization of a 100 Hz Nd:YAG pump laser for a Ti:Sa Amplifier.
- Task 10.3: Developing a conceptual design of a Ti:Sa amplifier at 20 Hz and beyond.

WP11: Efficient kHz laser driver modules for plasma acceleration (CNR):

- Task 11.1: kHz thin disk drive pulse for P-MOPA.
- Task 11.2: Post compression of kHz ps pulses.
- Task 11.3: Broadband amplification in Thulium doped gain media.
- Task 11.4: kHz pulsed diode laser pump demonstrator.

WP12: High-rep rate pump sources for laser drivers (ELI-ERIC):

- Task 12.1: Upgrade DUHA pump laser for increased average power operation.
- Task 12.2: Evaluation of optical coatings in high average power, high energy systems.
- Task 12.3: Investigate an OPCPA amplifier at 100 Hz.
- Task 12.4: Diode laser pump unit design for 20…100 Hz implementation.

WP13: Prototype of high average power optical compressor (Thales-LAS):

- Task 13.1: Modelling of thermal load impact on grating under vacuum and validation with existing systems.
- Task 13.2: Experimental characterization of dielectric grating samples with density power compatible with kW beamline.
- Task 13.3: Compressor design based on dielectric grating technology for kW beamline.

WP14: Laser driver system architecture, transport and engineering (CNRS):

- Task 14.1: System engineering.
- Task 14.2: Systems required for operation.
- Task 14.3: Focal spot stabilisation.

PACRI ongoing activities

- Grant Agreement Preparation completed
  - Signed by the EU and 21 Partners (4 more to go!)

- Consortium Agreement in Preparation

For more info:
Cecilia Blasetti, Elettra Project Management Office (PMO)
cecilia.blasetti@elettra.eu

- Project Web page and logo

Project starting date: 01-03-2025

Acknowledgements

Thanks to all the persons who worked for the preparation and submission of the project.

In particular Massimo Ferrario, Leo Gizzi, Ralph Assmann and my colleague Cecilia Blasetti for their commitment and fundamental support.

Special thanks go to Regina Rochow who worked with us on the earlier version of the PACRI project (CREATE).

There is a lot of work ahead of us, but I hope that PACRI can make a significant contribution to the development of new accelerators.

Thanks for your attention