EuPRAXIA@SPARC_LAB overview and project management

Antonio Falone
On behalf of the EuPRAXIA Team

INFN
Istituto Nazionale di Fisica Nucleare

~~Good~~ Excellent news first!

EuPRAXIA

APPROVED

694

MINISTERO DELLE INFRASTRUTTURE E DEI TRASPORTI

PROVVEDITORATO INTERREGIONALE PER LE OO.PP. PER IL LAZIO, L'ABRUZZO, LA SARDEGNA

* * * * *

VIA MONZAMBANO, 10 – ROMA

AVVISO

ai sensi dell'art. 29 del D.Lgs. 18 aprile 2016, n. 50

OGGETTO: C.d.S. n. 694 - Realizzazione di un nuovo complesso edilizio EuSPARC per ospitare la facility EuPRAXIA presso i Laboratori Nazionali di Frascati INFN.

Amministrazione Proponente: INFN Istituto Nazionale di Fisica Nucleare

Si comunica che ai sensi dell'art. 14-bis comma 5 della L. 241/90 e ss.mm. e ii., è da considerarsi acquisito l'assenso sul progetto in argomento da parte delle Amministrazioni invitate alla Conferenza. Si **DICHIARA**, pertanto, sulla scorta degli atti acquisiti, perfezionata l'intesa per la localizzazione e realizzazione dell'opera indicata in oggetto e, di conseguenza, **AUTORIZZATO** il relativo progetto definitivo.

Gli atti del procedimento sono in visione presso la Segreteria dell'Ufficio Conferenze di Servizi di questo Provveditorato

IL DIRIGENTE	IL RESPONSABILE DEL PROCEDIMENTO	IL PROVVEDITORE
Dott. Ing. Carlo Guglielmi	Dott. Arch. Alessia Costa	Dott. Ing. Vittorio Rapisarda Federico
Firmato digitalmente da CARLO GUGLIELMI O = MiMS C = IT	Alessia Costa MiMS 19.05.2023 13:22:39 GMT+00:00	VITTORIO RAPISARDA FEDERICO Ministero delle Infrastrutture e dei Trasporti 23.05.2023 11:37:37 GMT+01:00

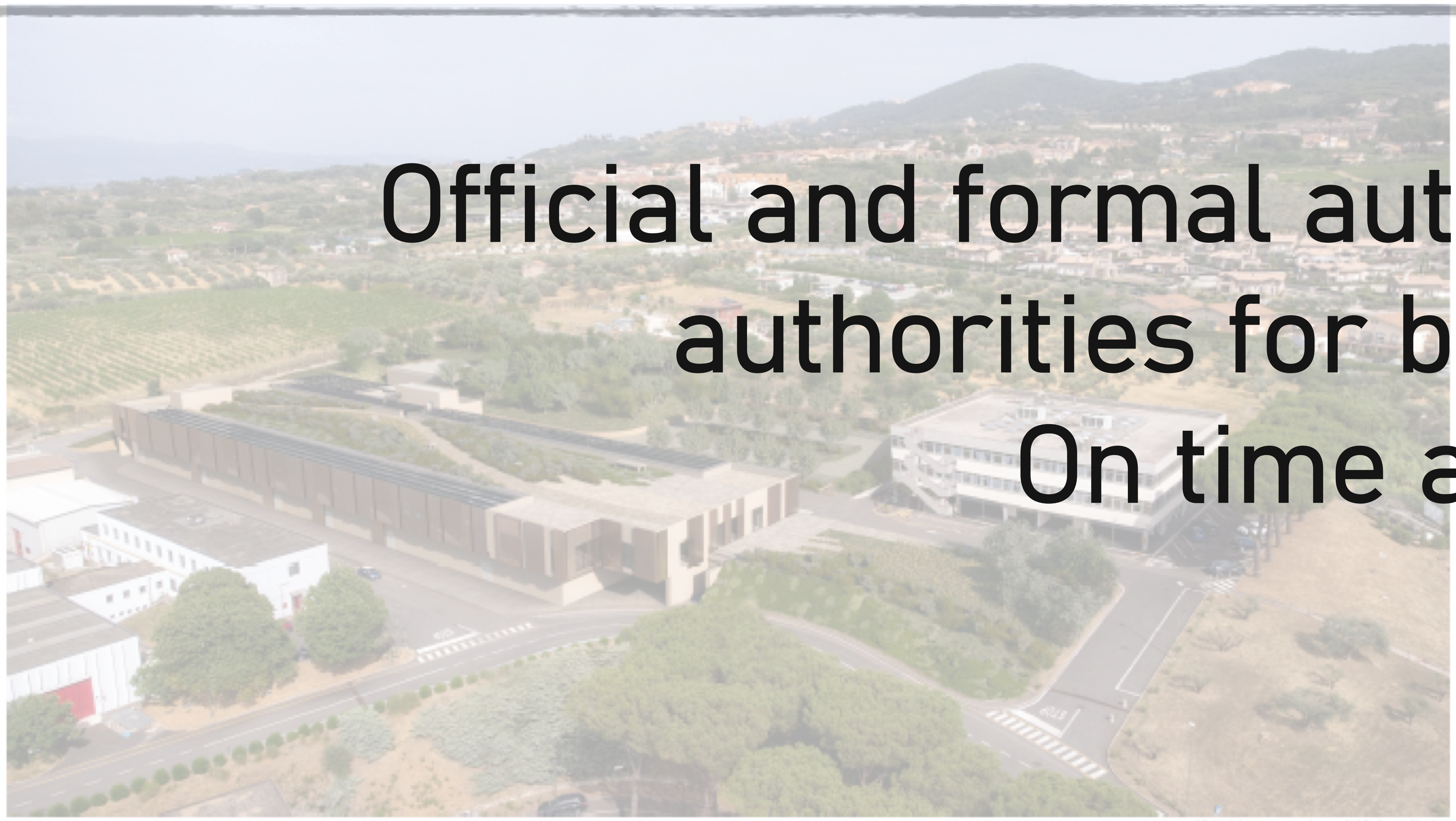
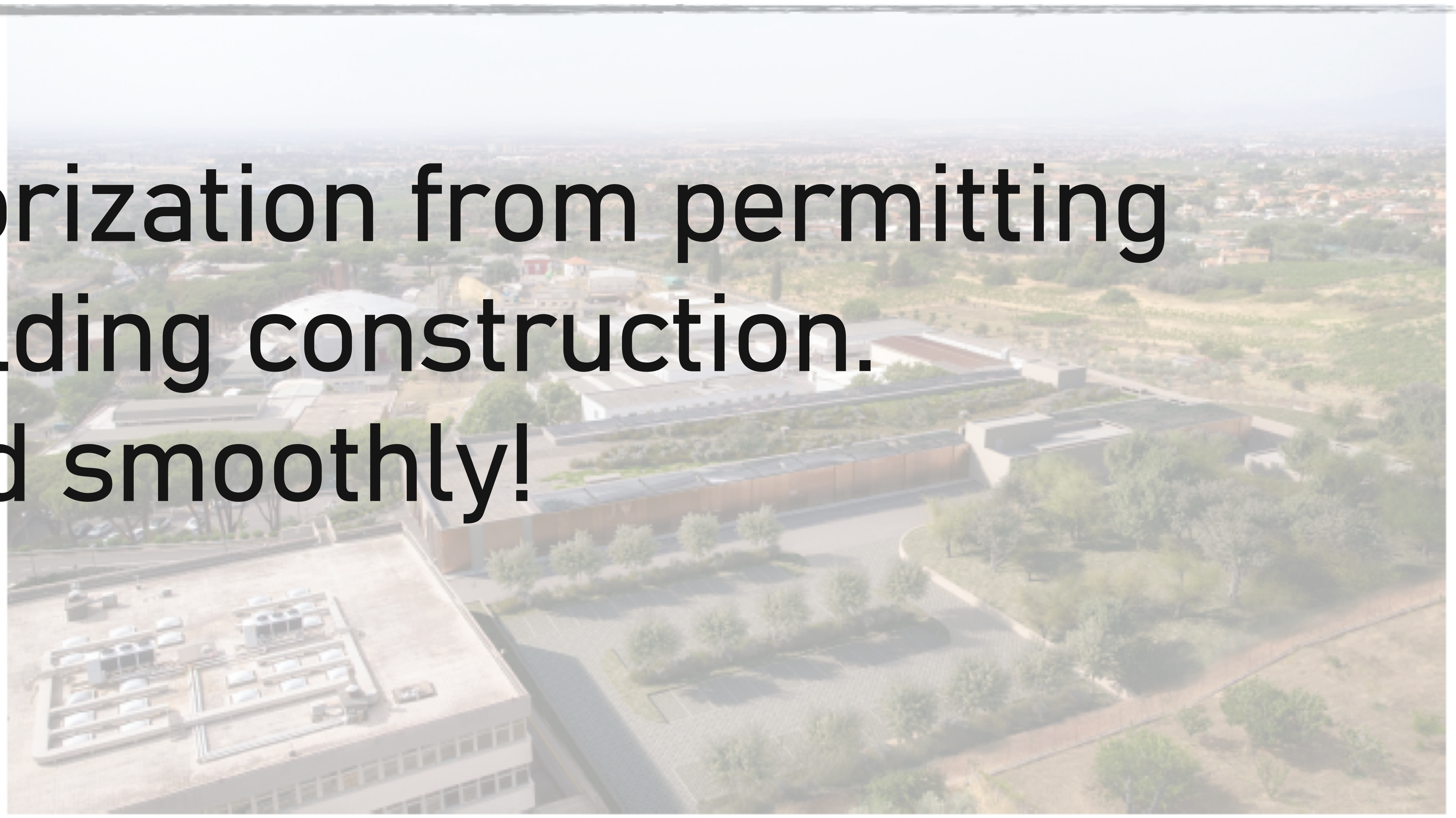
Roma, lì ____________

PUBBLICATO ____________

RITIRATO ____________

ACCREDIA — ISO 9001 BUREAU VERITAS Certification

~~Good~~ Excellent news first!

Official and formal authorization from permitting authorities for building construction.
On time and smoothly!


Thanks Simona, Ugo, Sergio, Ruggero, Andrea and all the technical division for the outstanding work!

Outline

- General overview of EuPRAXIA (wide) – From project to program
- Status EuPRAXIA @ SPARC_LAB from Project Management perspective
- Cost estimation EuPRAXIA@SPARC_LAB

EuPRAXIA Galaxy

EuPRAXIA is naturally evolving from one single project to a program i.e. a set of correlated projects in order to achieve a common goal → Building a Research Infrastructure based plasma accelerators and high power laser. LNF is focusing on the first site – Beam Driven approach.

PROJECT → PROGRAM

A program is a set of related projects and activities, managed in a coordinated fashion and under a structure that allows for the delivery of outcomes and benefits [PMBOK definition]

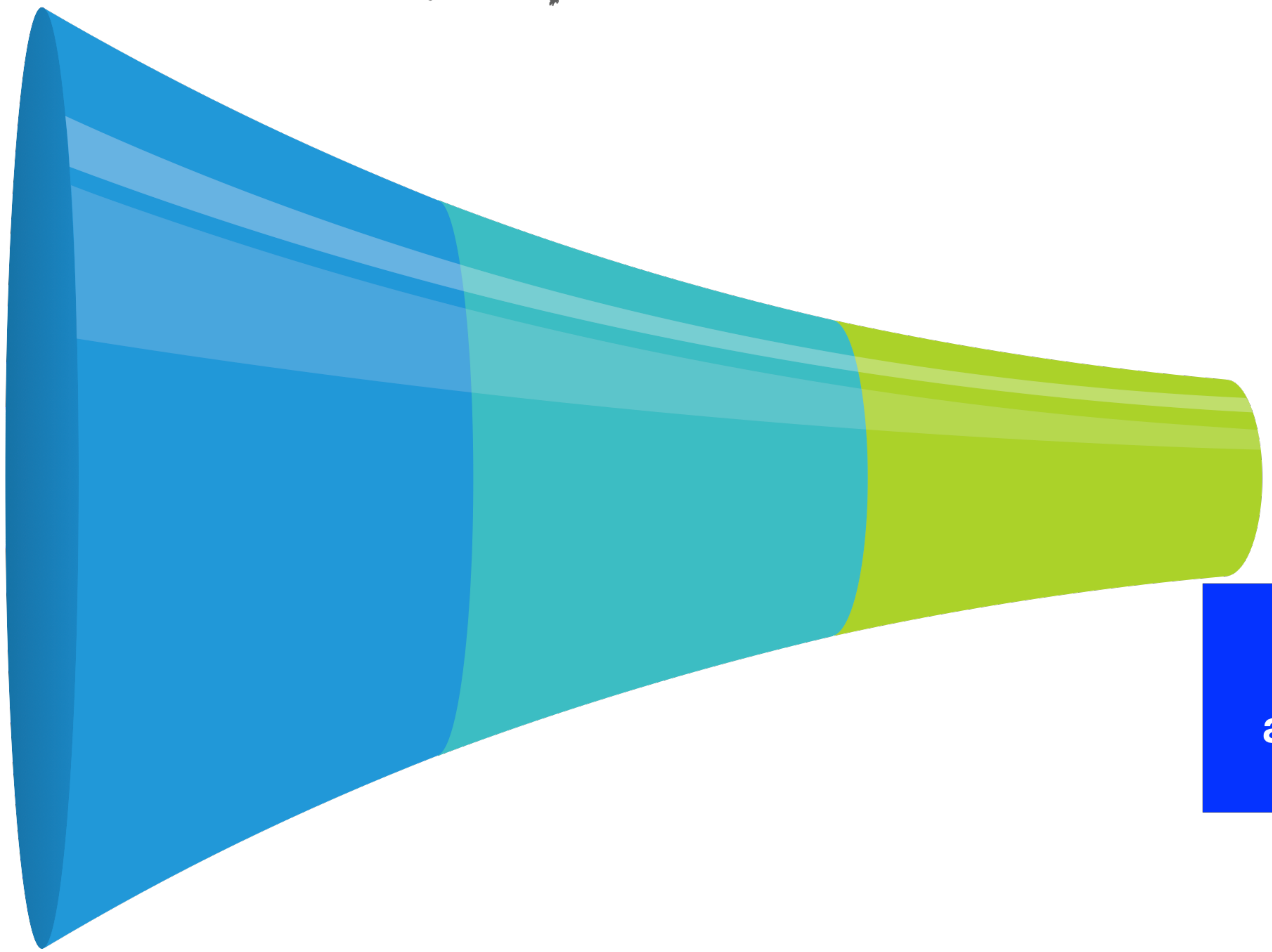
EuPRAXIA Galaxy

Existing facility @ LNF (Correlated with EuPRAXIA)

- SPARC_LAB
- FLAME
- TEX*
- SABINA

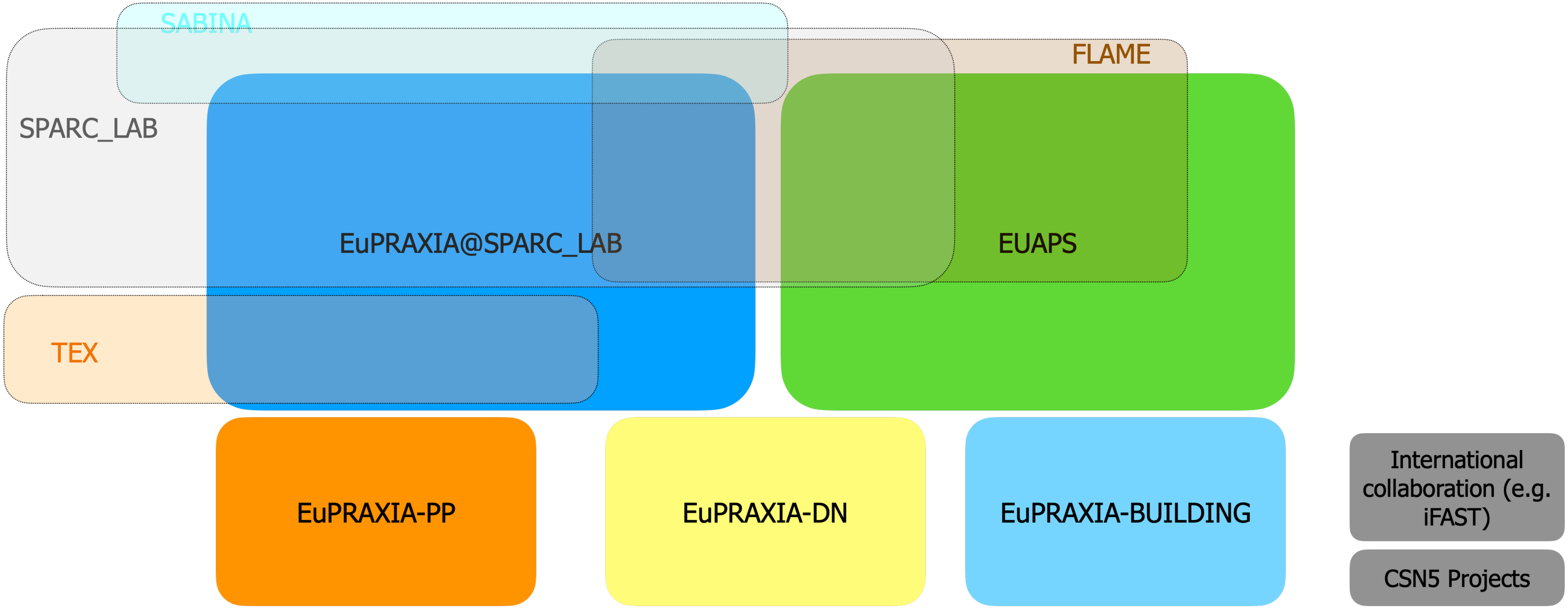
- EuPRAXIA@SPARC_LAB
- EuPRAXIA - Preparatory Phase
- EuPRAXIA - DN
- EuAPS
- EuPRAXIA - Building

EuPRAXIA-projects



Beam Driven Pillar of EuPRAXIA as Distributed Research Infrastructure.

EuPRAXIA Galaxy

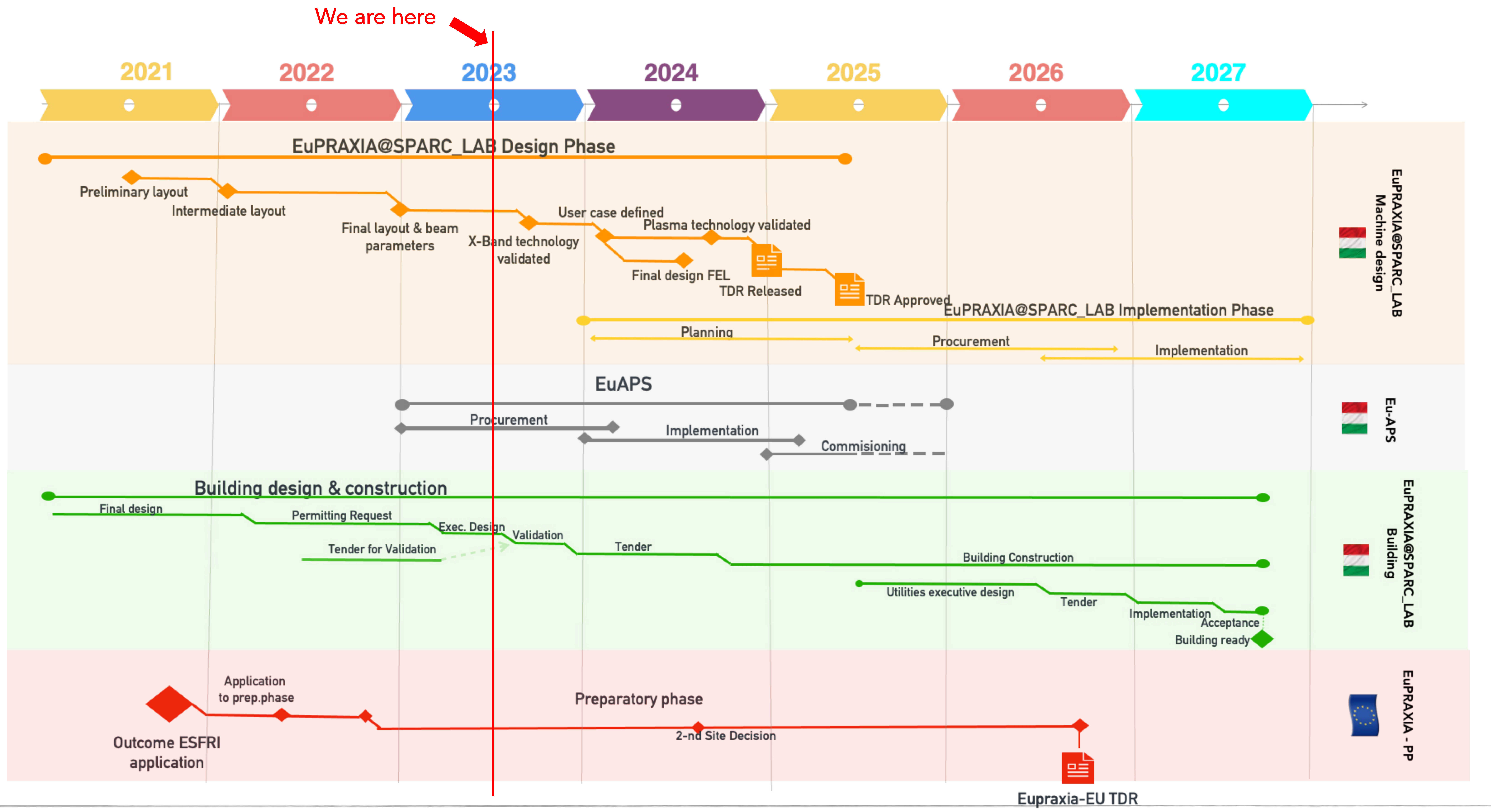


This is just a tentative visualization of the correlation between all EuPRAXIA related activities. The real world is even more complicated, all of them in fact share the same resources and we are not considering here other projects (e.g. STAR, ELI, Rome Technopole, IRIS et.al.) and of course the activities carried out at the DAFNE Complex (Dafne + Linac + BTF).

EuPRAXIA Galaxy

	EuPRAXIA@SPARC_LAB	EuPRAXIA Building	EuAPS	EuPRAXIA-Preparatory Phase	EuPRAXIA - Doctoral network
Scope	Redaction of the TDR of the Beam Driven Pillar	Design and construction of the building that will house the facility	Betatrone Source High Power Laser High Repetition Rate Laser	Definition and design of EuPRAXIA as distributed RI (legal, governance, financial model)	10 PhD programs across Europe on plasma accelerator science
Duration	TDR is expected at the end of 2025	End of 2027 (approx)	30months (+6) Not later than 31/12/2025	48 months 30/10/2026	48 months 31/12/2026
Budget	9 M€	To be assessed. O(40M€)	22,3 M€	2,7 M€ (+ In kind contribution)	2,5 M€ (+ In kind contribution)
Funding source	Internal funding through GE	Internal funding through GE	PNRR	Horizon Europe	Horizon Europe
R&D required	Yes	NO	Some	NO	NO
Partner	Mainly internal LNF with some partnership with Elettra, ENEA UniTOV, Uniroma1, INFN-MI	Internal LNF	LNF, LNS, INFN-MI (INFN) CNR UniTOV	25 Partner + 9 Associated	23 Partner + 15 Associated

EuPRAXIA Galaxy



EuPRAXIA Galaxy

Some main facts:

- EuPRAXIA is in the ESFRI 2021 Roadmap. This gave us a remarkable visibility and credibility among the community and towards funding agencies.
- EuPRAXIA@SPARC_LAB is the first main building block of the future research infrastructure.
- EuPRAXIA@SPARC_LAB is the flagship project of the LAB.
- EuPRAXIA design and implementation requires a huge effort in many areas (R&D, Legal and Management, Technical development, Civil infrastructure, training, collaboration etc…) → Diversification of the funding sources as natural and emerging choice.
- A diversification of the funding schemes helps in the sustainability of the project, however requires a careful management to avoid (or at least mitigate) overlaps within different projects and for resource levelling
- A common governance for all the project helps in this sense although some criticalities remain.

Milestones status

R&D Cost status

Transition to the Implementation Phase

EuPRAXIA@SPARC_LAB is organized on several Working Areas which includes different workpackages.

Each WA has a set of intermediate milestones to be achieved to steer the required R&D towards full maturity for the redaction of a comprehensive Technical Design Report.

The TDR is meant to be the technical baseline for the implementation phase.

Implementation phase starts officially once the TDR is validated by external advisor and approved by the executive board (GE), although some procurement can start earlier for compression schedule issues.

IN PROGRESS:

- **Sensitivity studies for the COMB beam with respect to jitters w/wo X-band at Gun exit:**
  - **No X-band: 50 "machines" from cathode up to the capillary are now being simulated in plasma.**
  - **W X-band : 50 "machines from cathode in preparation**
  - **Estimation of the Energy shot to shot acceptance in the undulator ($\sim 0.1\%$)**
- **cluster upgrade debugging for Power9**
- **LE&HE virtual diagnostics delayed after summer**

UPCOMING MILESTONES

- **May-June 2023**: Stability&jitter sensitivity studies ***plus virtual measurements completion*** : critical for people and computing resources optimization
- Virtual measurements: **Nov 2023**

- **June 2023**: Laser heater parameters w MBI studies for all RF beam: critical for people resources availability

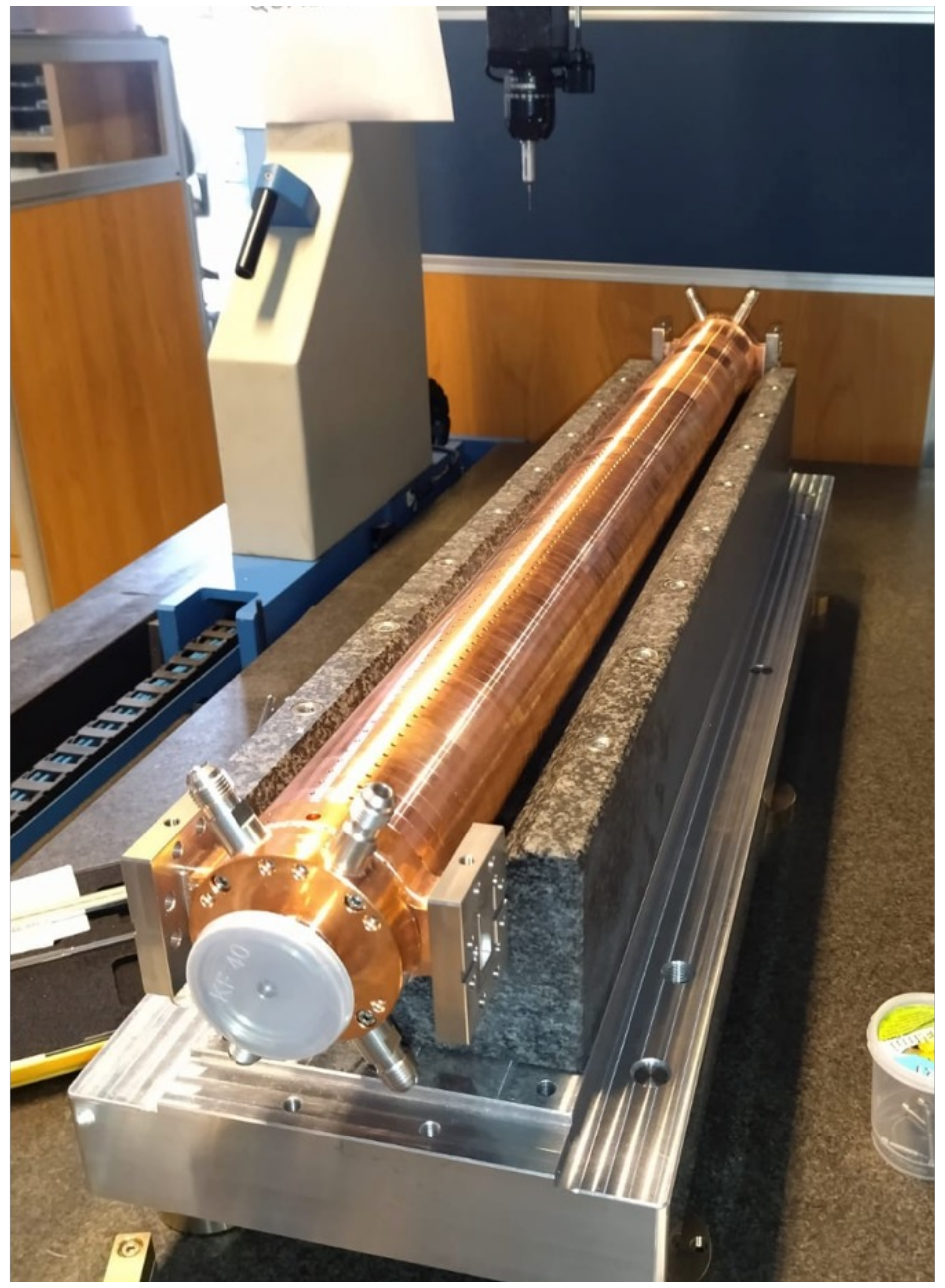
  Oct-Nov 2023

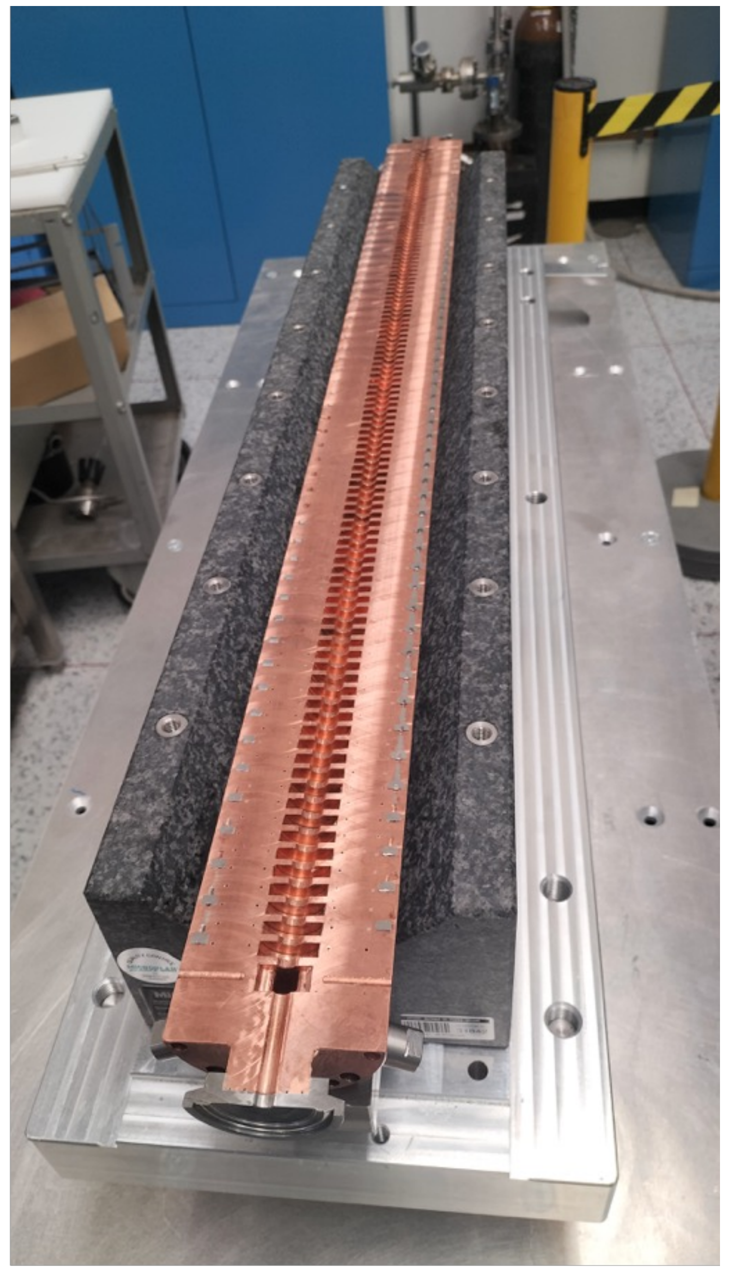
Significant upgrade for the HPC Cluster (also thanks to PNRR Program) is coming soon

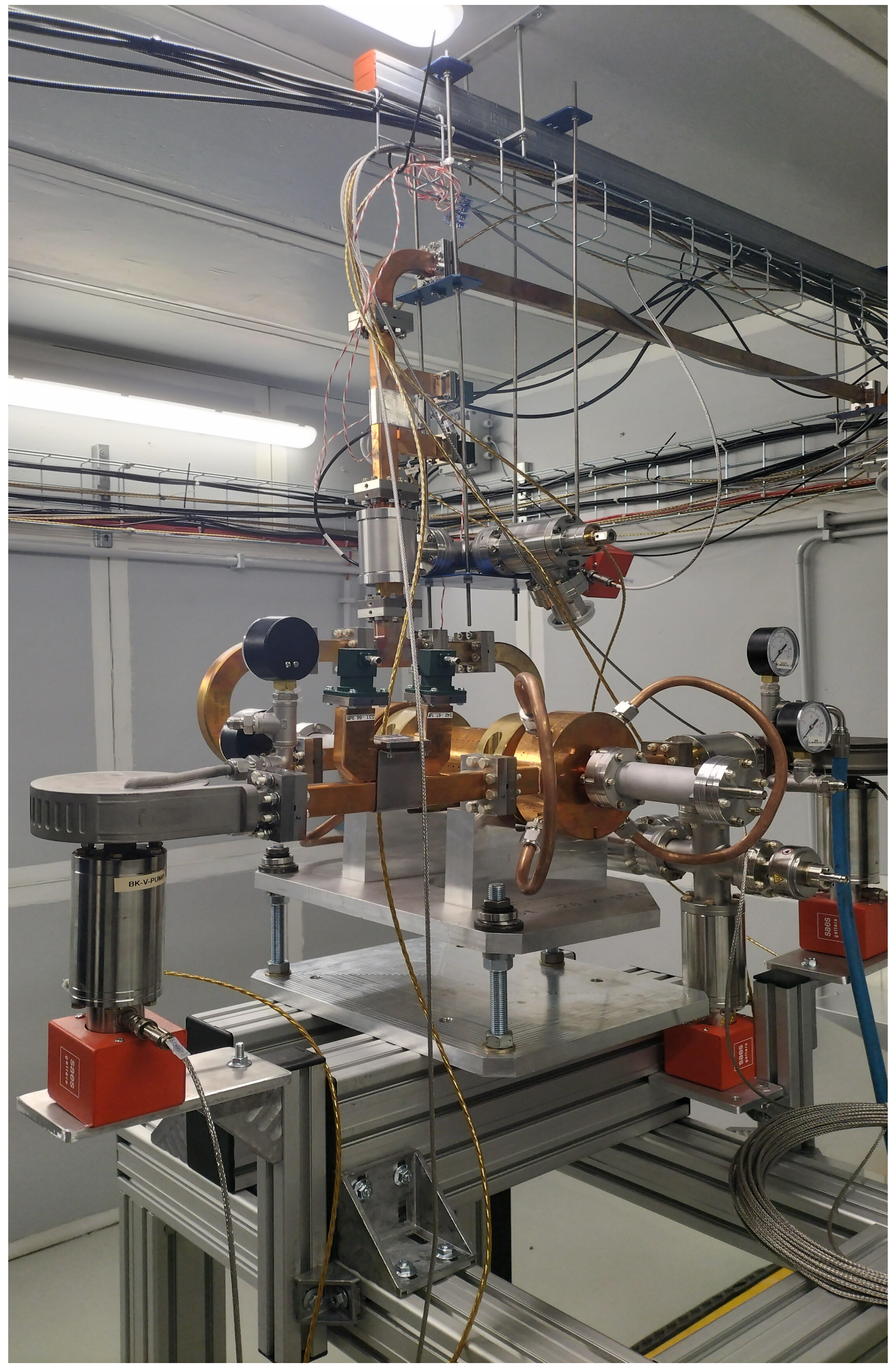
Courtesy C.Vaccarezza, A.Giribono

- Mechanical Prototype X-Band section successfully validated. No significant deformation after brazing and vacuum tightness.

- RF Prototype production in progress (expected in June)







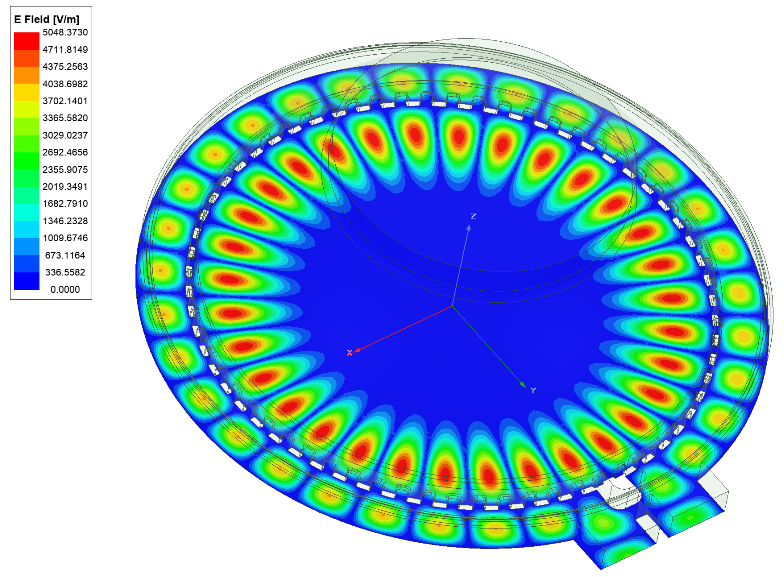
Courtesy D.Alesini, S.Pioli

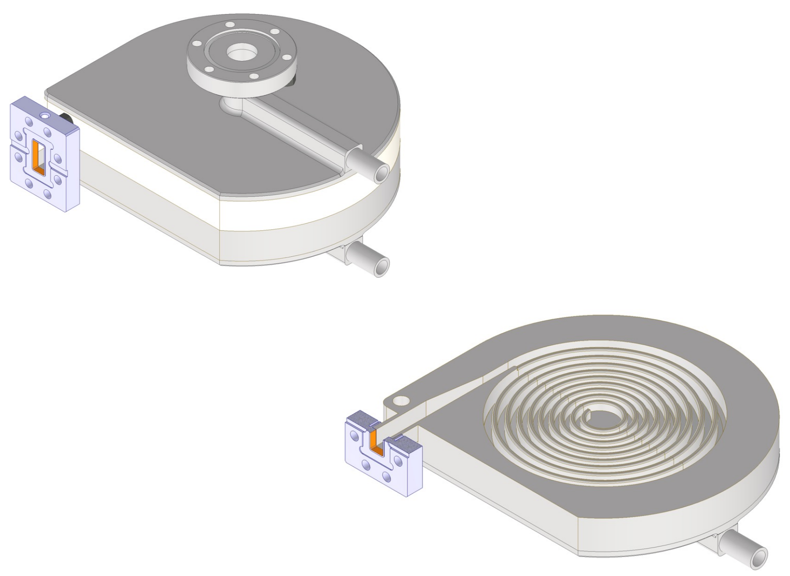
General Status – Acc.sections & WG Components

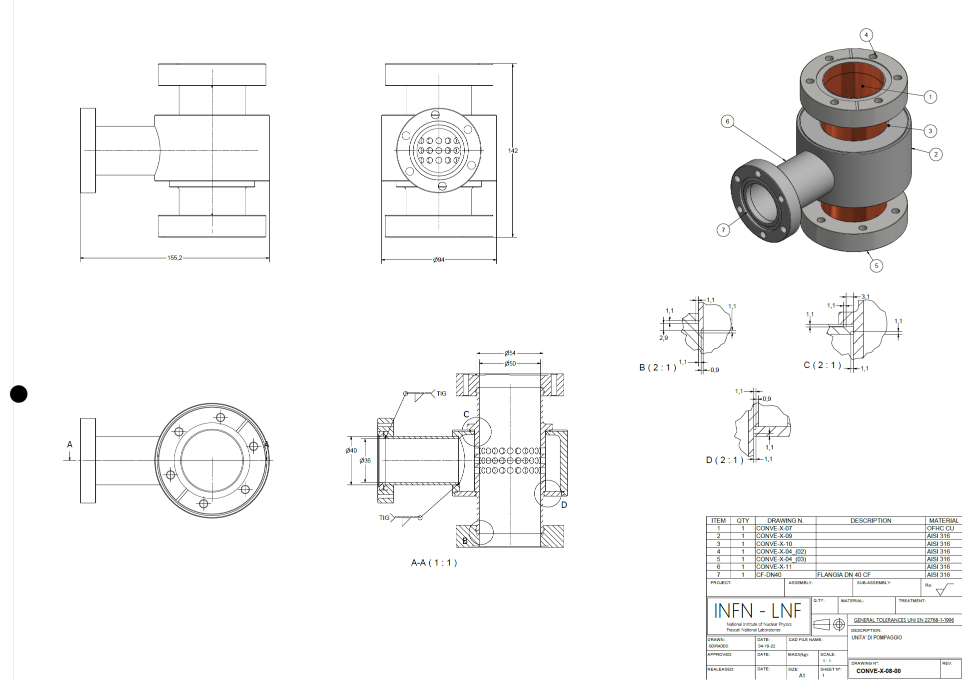
- **Realization of the RF prototype (May 23)**
- **Realization of the vacuum prototype full scale (June 23)**
- **Realization of waveguide components (June 23):**

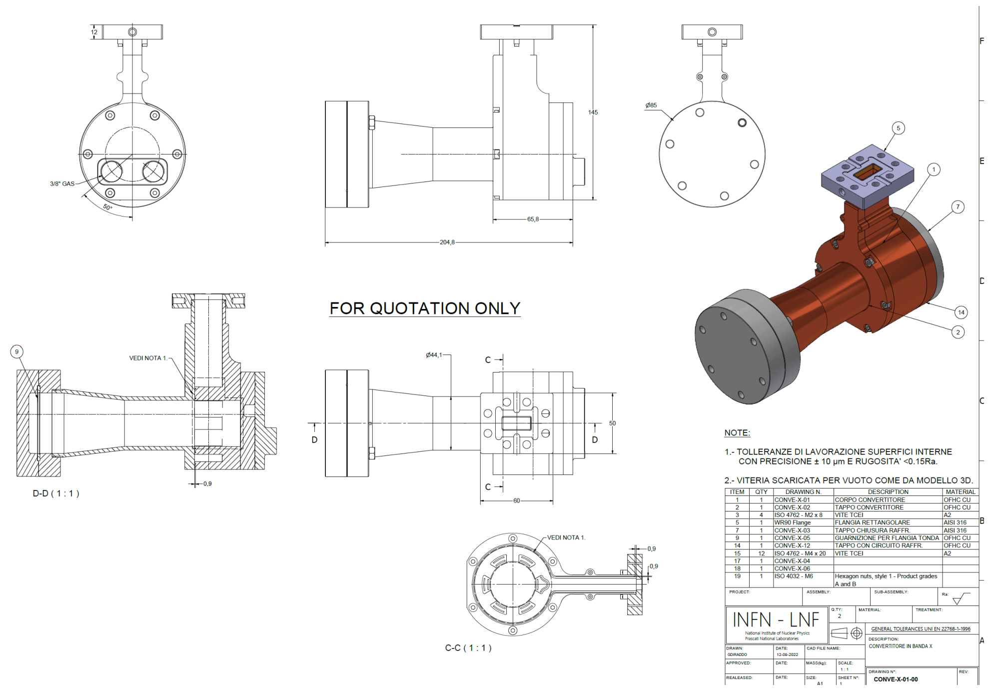
  -mode converter circular/rectangular
  -Rf spiral load (machined)

- **BOC (pulse compressor):**
  - PSI (31/12/23 PNRR tecnopolo)
  - In house (clamped 3/24)







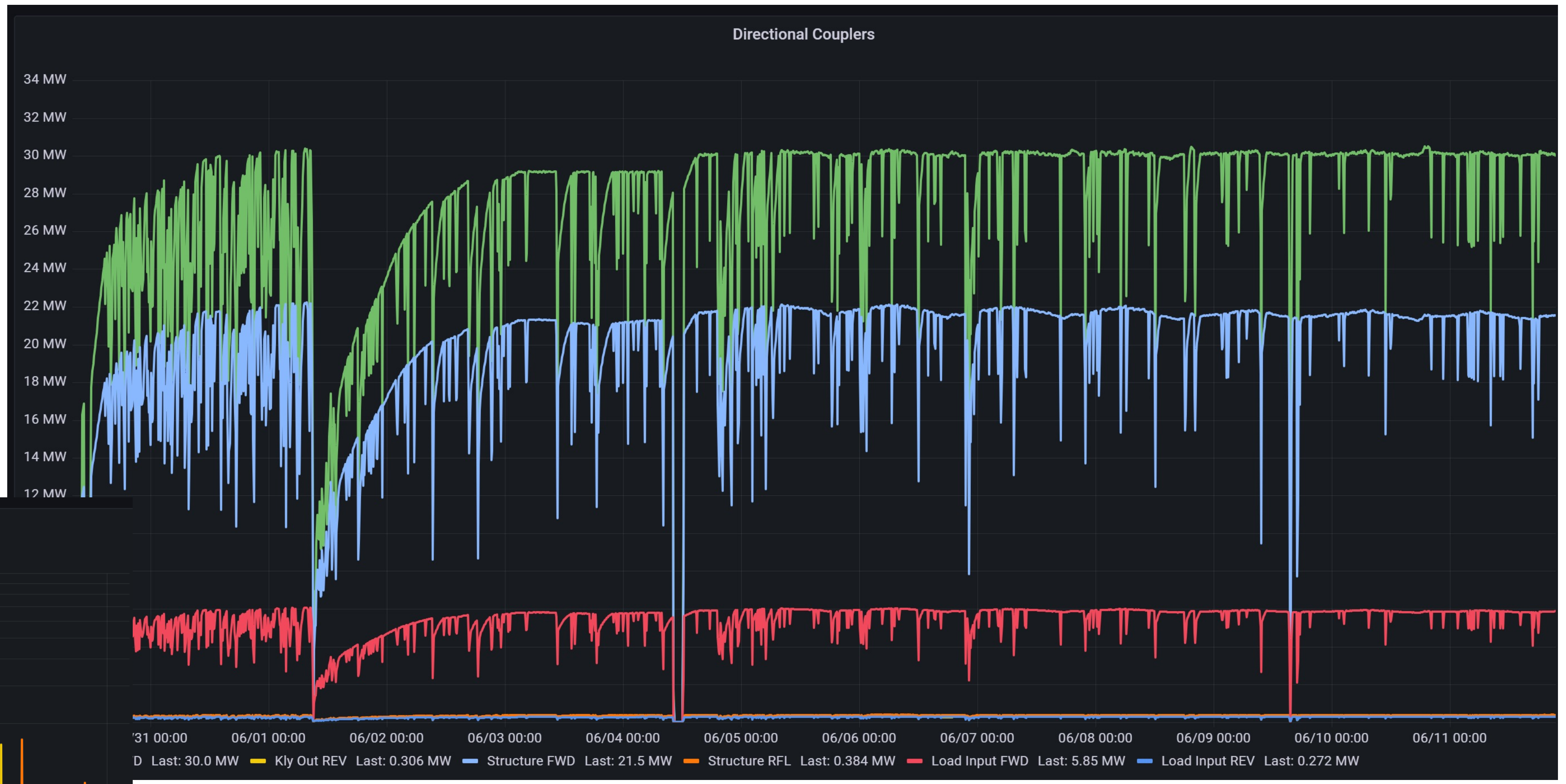


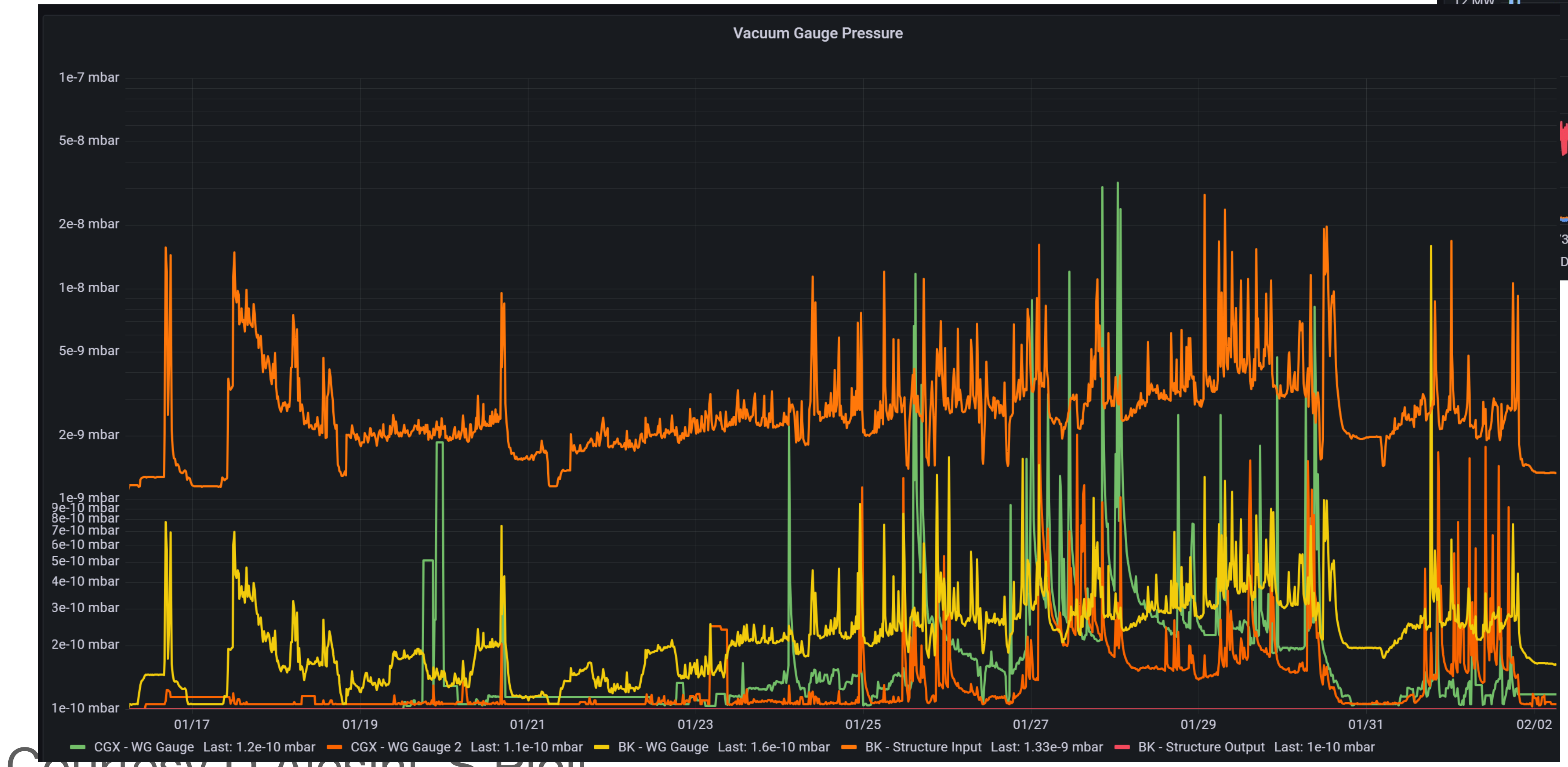
- **Offer requests for final full scale X band structure (May 23)**
- **RF test of Spiral loads**

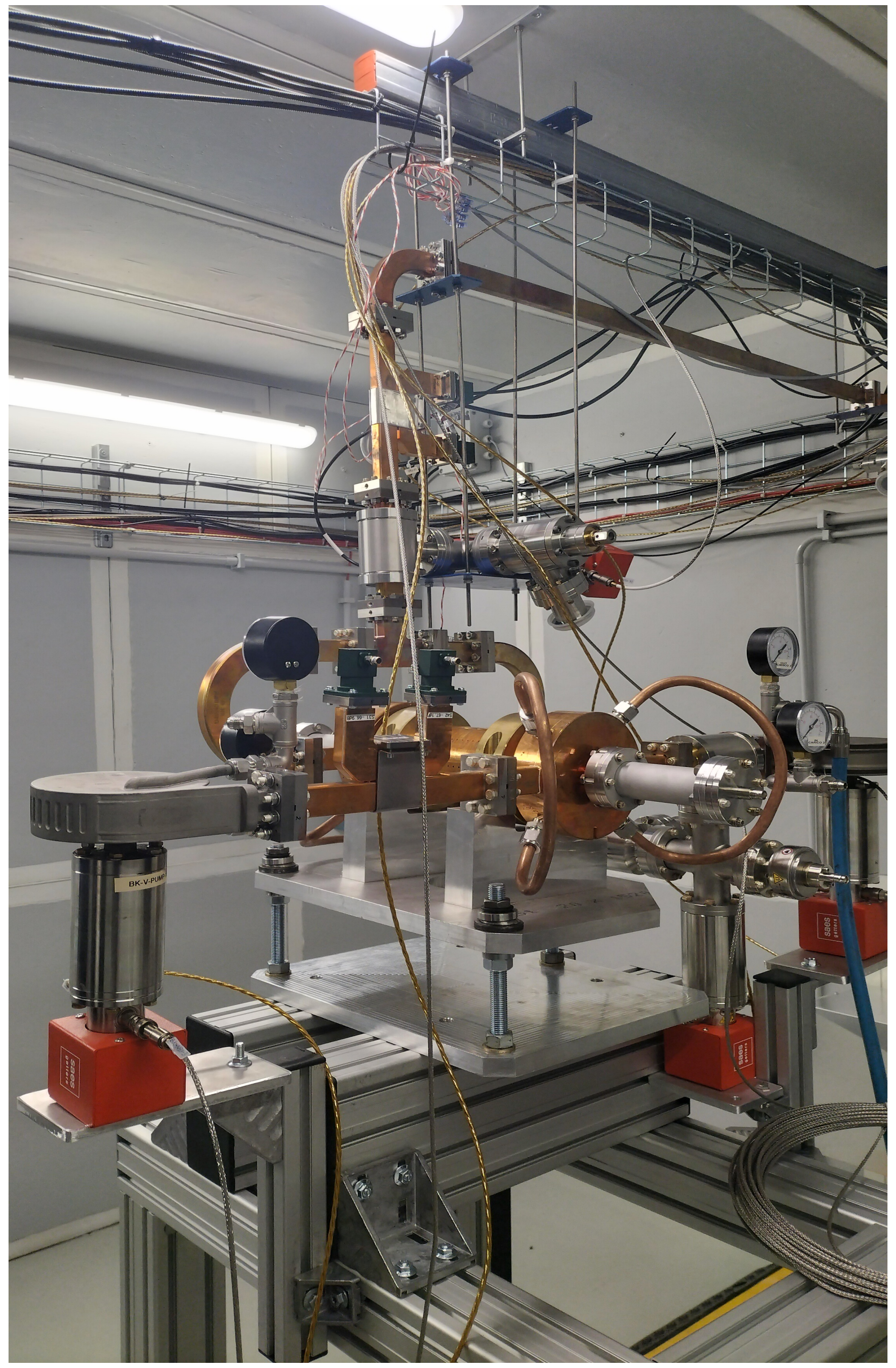
Courtesy D.Alesini, S.Pioli

General Status – High Power RF

- TEX Facility is now fully operating.
- WG network with spiral loads already successfully conditioned.
- RF conditioning of CERN/PSI X-Band section is ongoing.







Courtesy D.Alesini, S.Pioli

TEX Facility is planned to be upgraded;

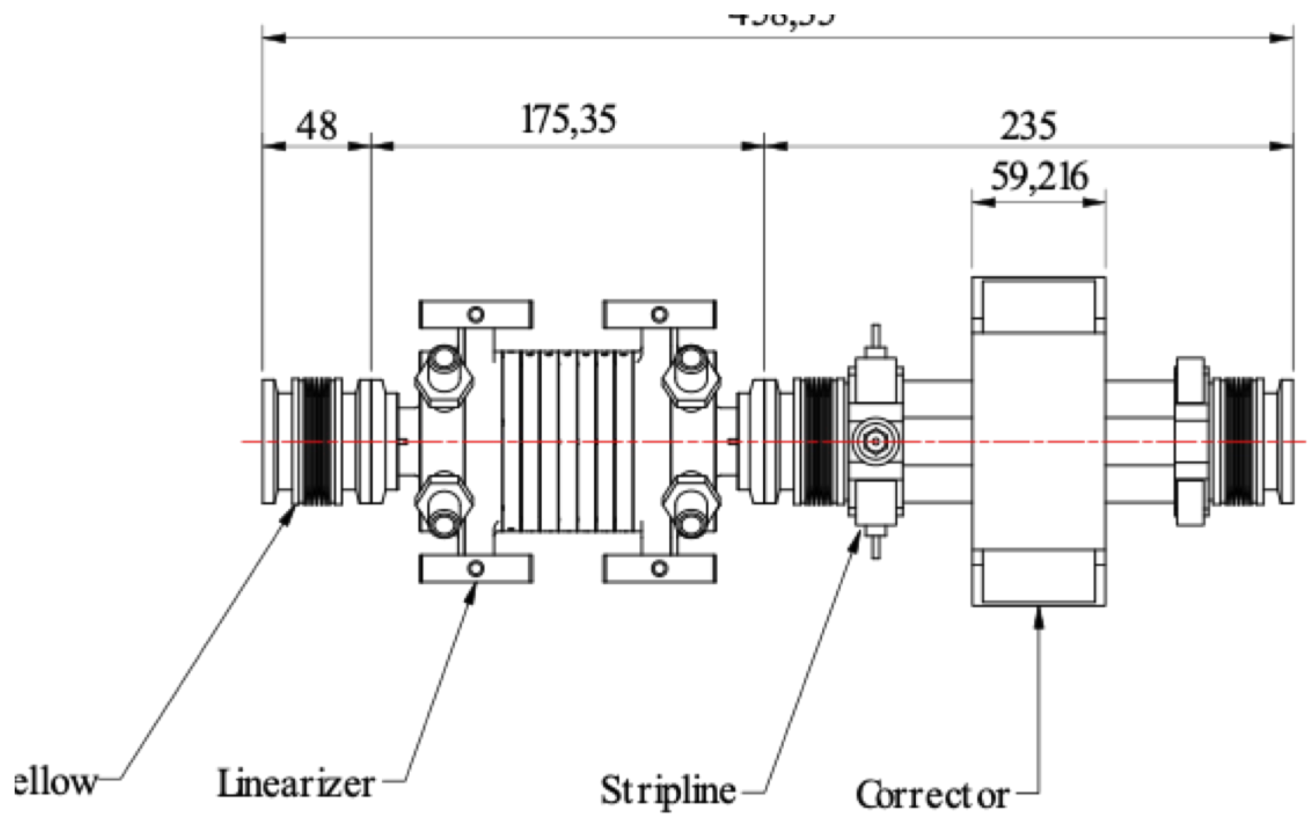
- CPI high efficiency klystron contract is ongoing. Critical Design Report is expected in September. Production should start before the end of 2023. Delivery feb 2025.
- X-Band 400Hz RF Station (Scandinova K300 + Canon tube). FAT is expected in January 2024.
- C-Band 400Hz RF Station (Scandinova K200 + Canon tube) is on going expected early 2024.
- Additional cooling system will be required
- All critical procurement already done (except the cooling system).

Courtesy D.Alesini, S.Pioli

Injector study is now frozen and approved

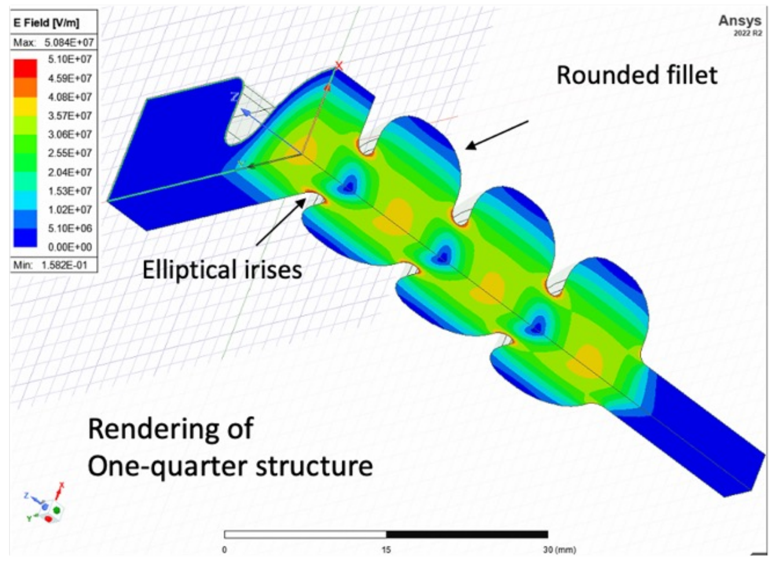
Optimization of the RF distribution taking into account the X-Band linearizer and the 4 S-Band sections are ongoing

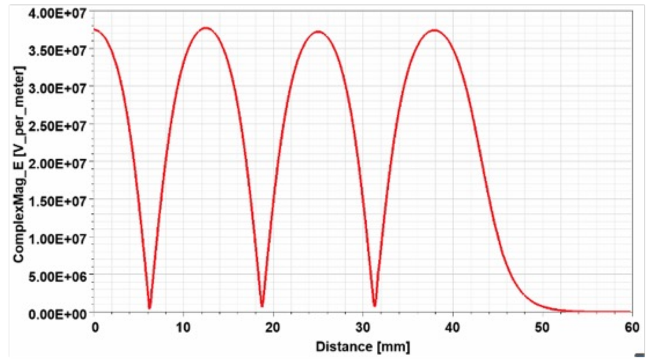
- ✓ Injector layout
- ✓ High charge working point
- ✓ RF distribution for the S-Band system (advanced layout agreed but still to be optmized)
- ✓ Jitter and sensitivity studies
- ✓ Comb Beam and S-Band optimization (3+2+2+2)



- iris aperture radius a = 4 mm
- Number of cells = 7
- Cavity Length (from rendering) = 12 cm
- pi mode
- Accelerating Gradient = 20 MV/m

a = 4 mm	
Resonant frequency, f	11.9942 GHz
Quality factor, Q	9,900
Eff. Shunt Impedance, r	83.5 MΩ/m
Eacc	20 MV/m
Epeak	38 MV/m
Number of cells	7
Coupling coefficient, β	1.23
Field build-up, τ	117 ns
Pin	400 kW





Courtesy E.Chiadroni

General Status - INJECTOR

- **Simulation studies**:
 Jitter studies in comb-like config. with X-band
 High Q comb-like configuration

- **S-band structures**
 Preliminary design and RF param. Defined

- **X-band linearizer**
 Frozen design and RF optimization => SW

- RF Power distribution **completed**

- **LLRF X-band**
 Quotation for a prototype

- **Synchronization**
 Test on intra-pulse phase feedback around Kly with SSM
 Kloop designed and test in RF lab: preliminary results in real environment on C band kly at SPARC: jitter compressed from 60 to 15 fs (rms)
 Mid-June: commissioning of the stabilized link towards FLAME

- **Electronics&Instrumentation**
 Timing System: beam tests in May 2023

Courtesy E.Chiadroni

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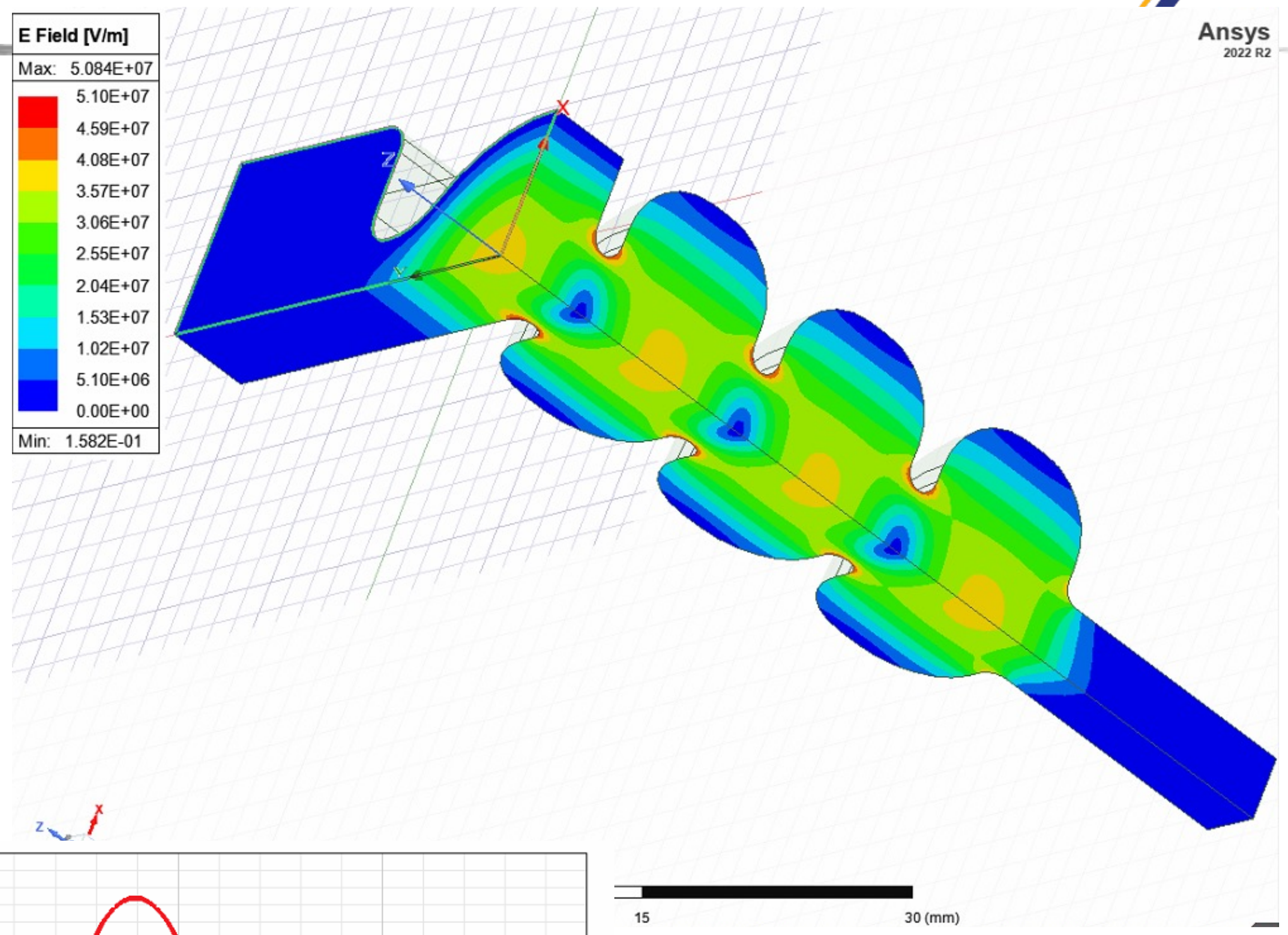

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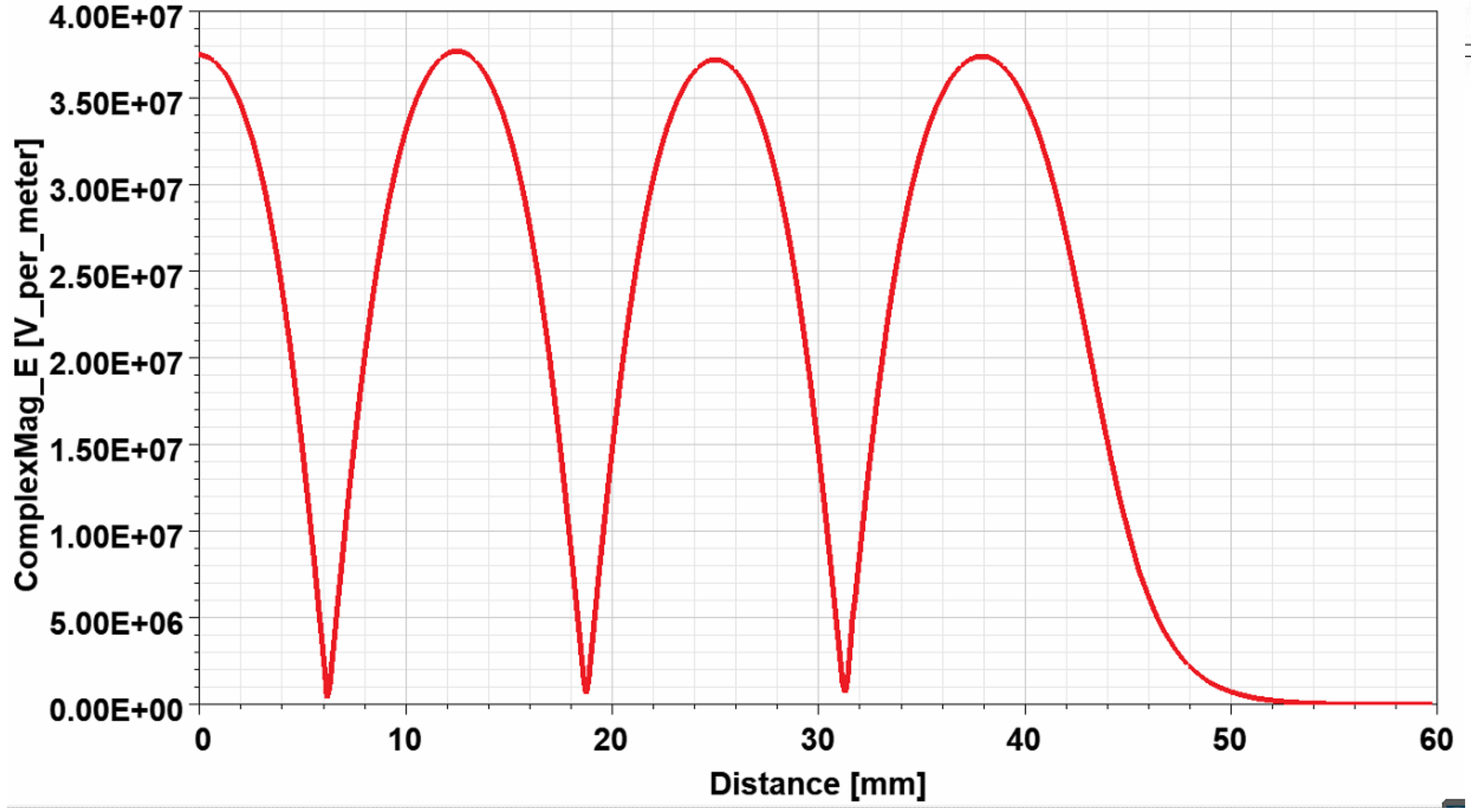

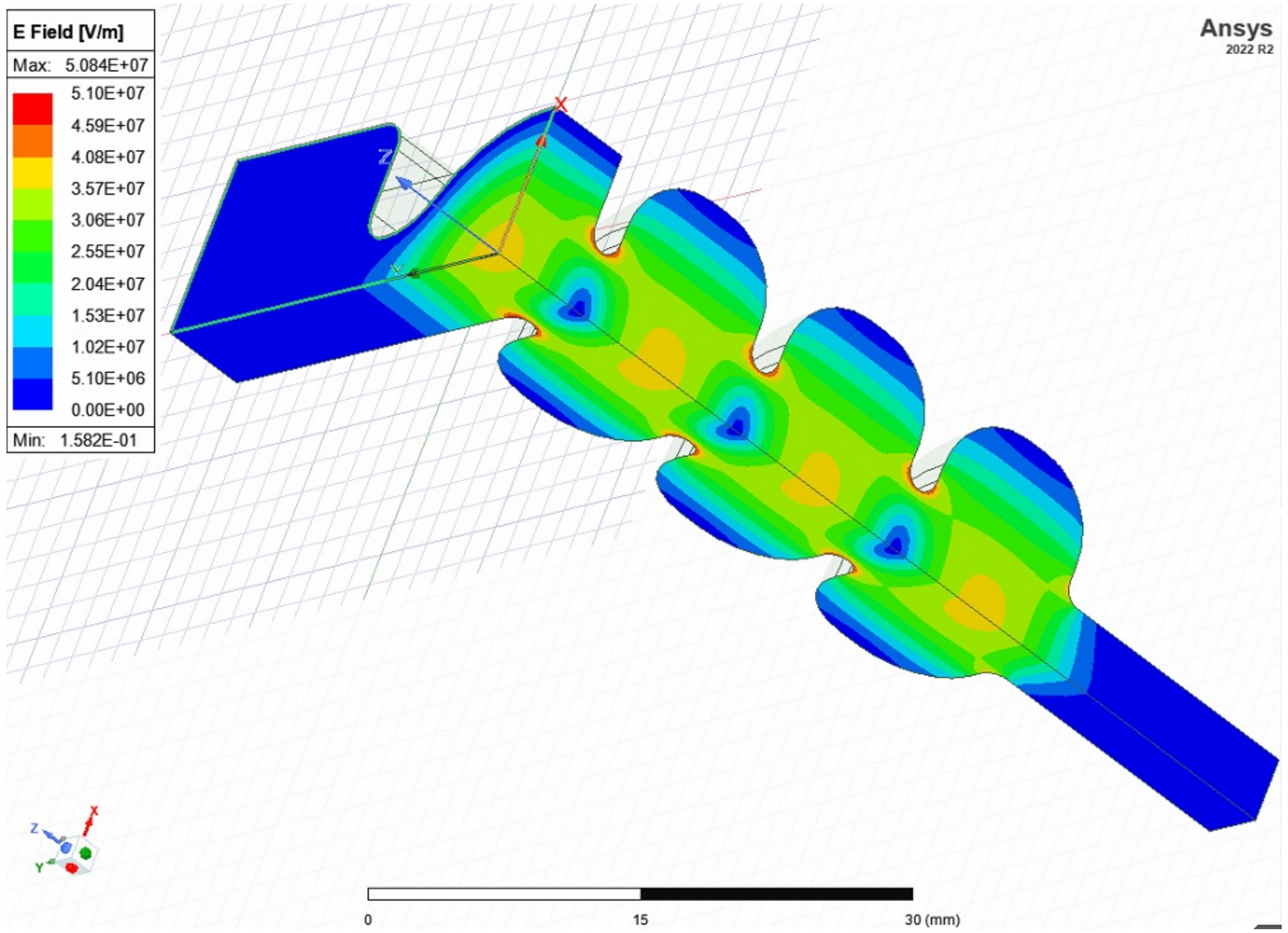

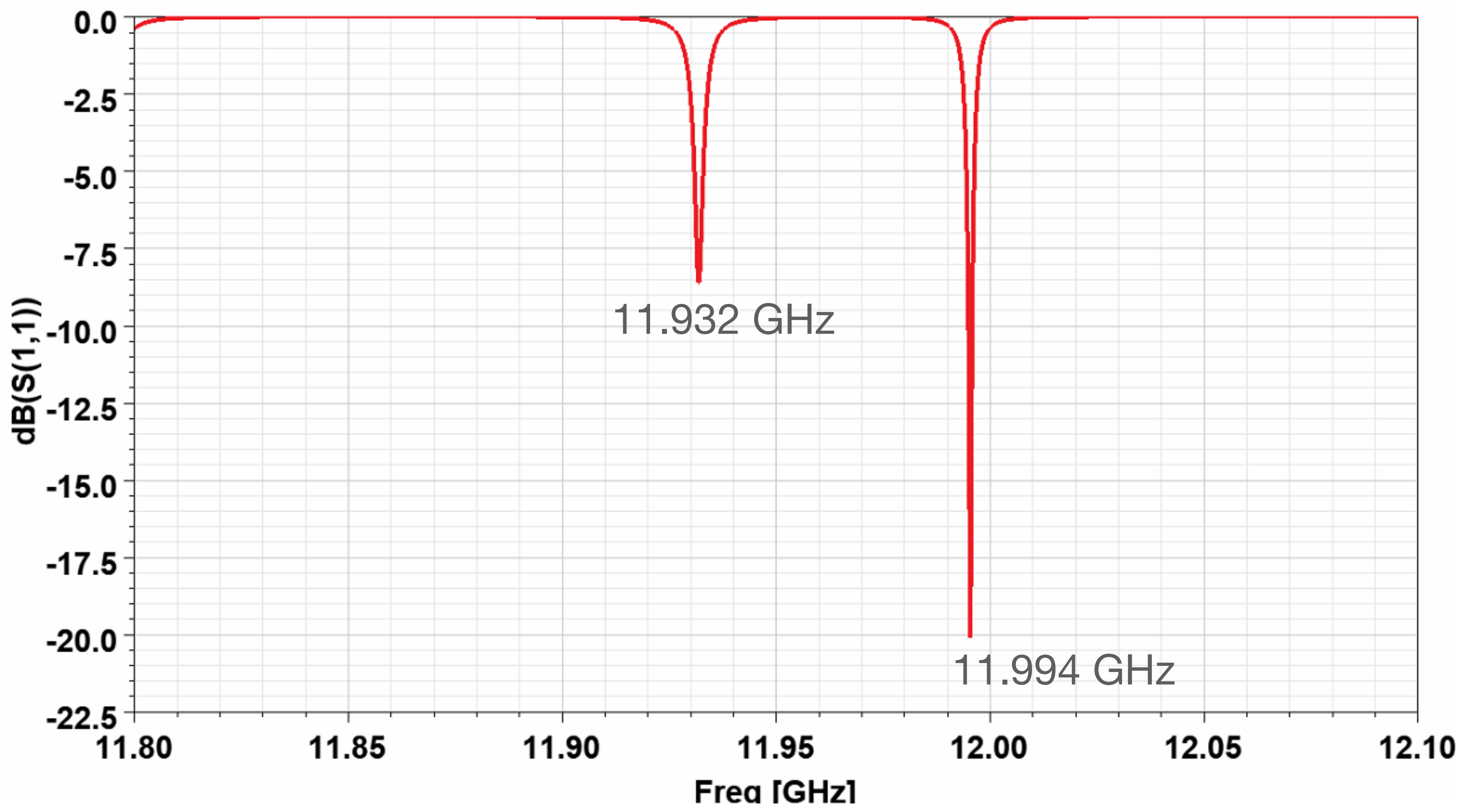

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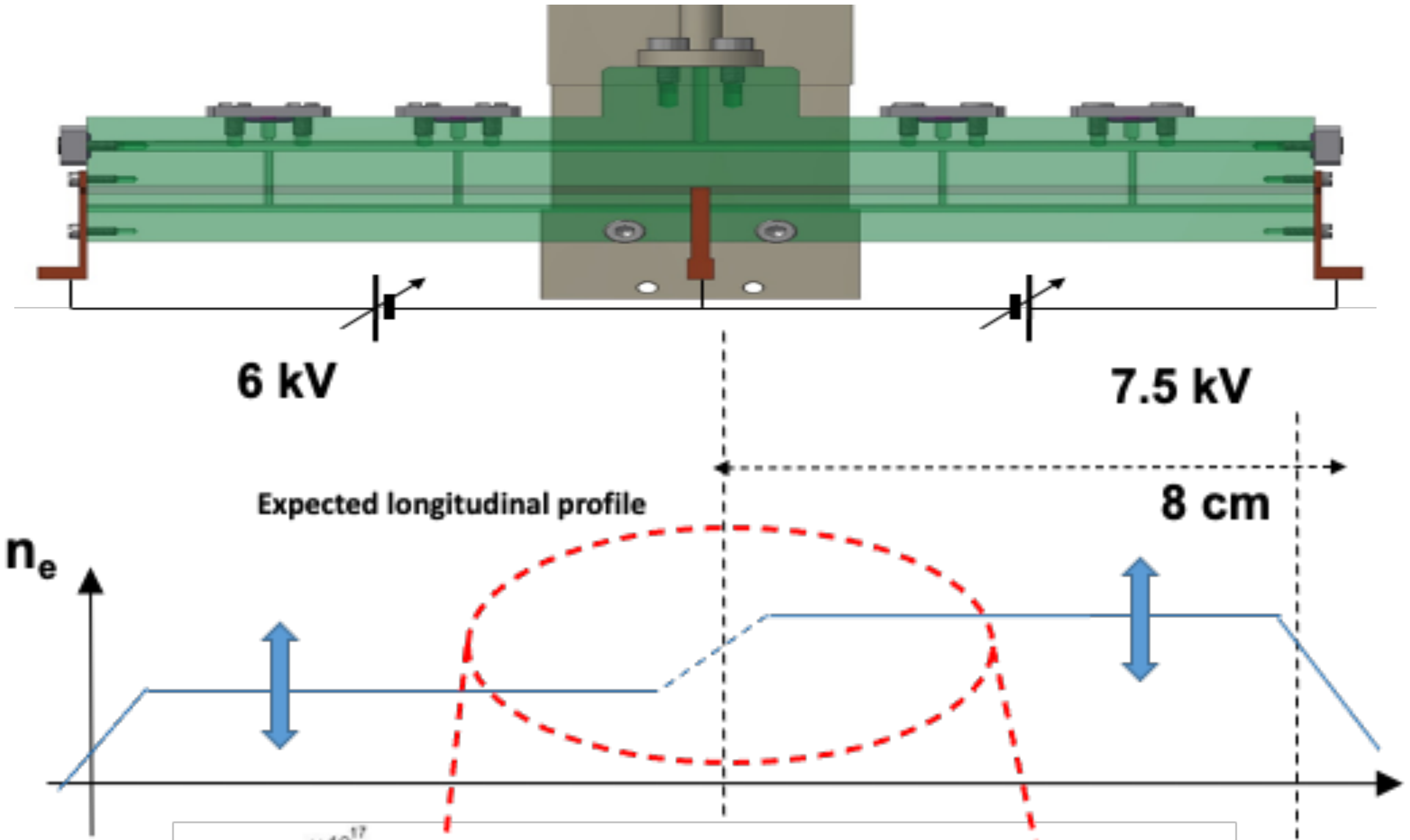
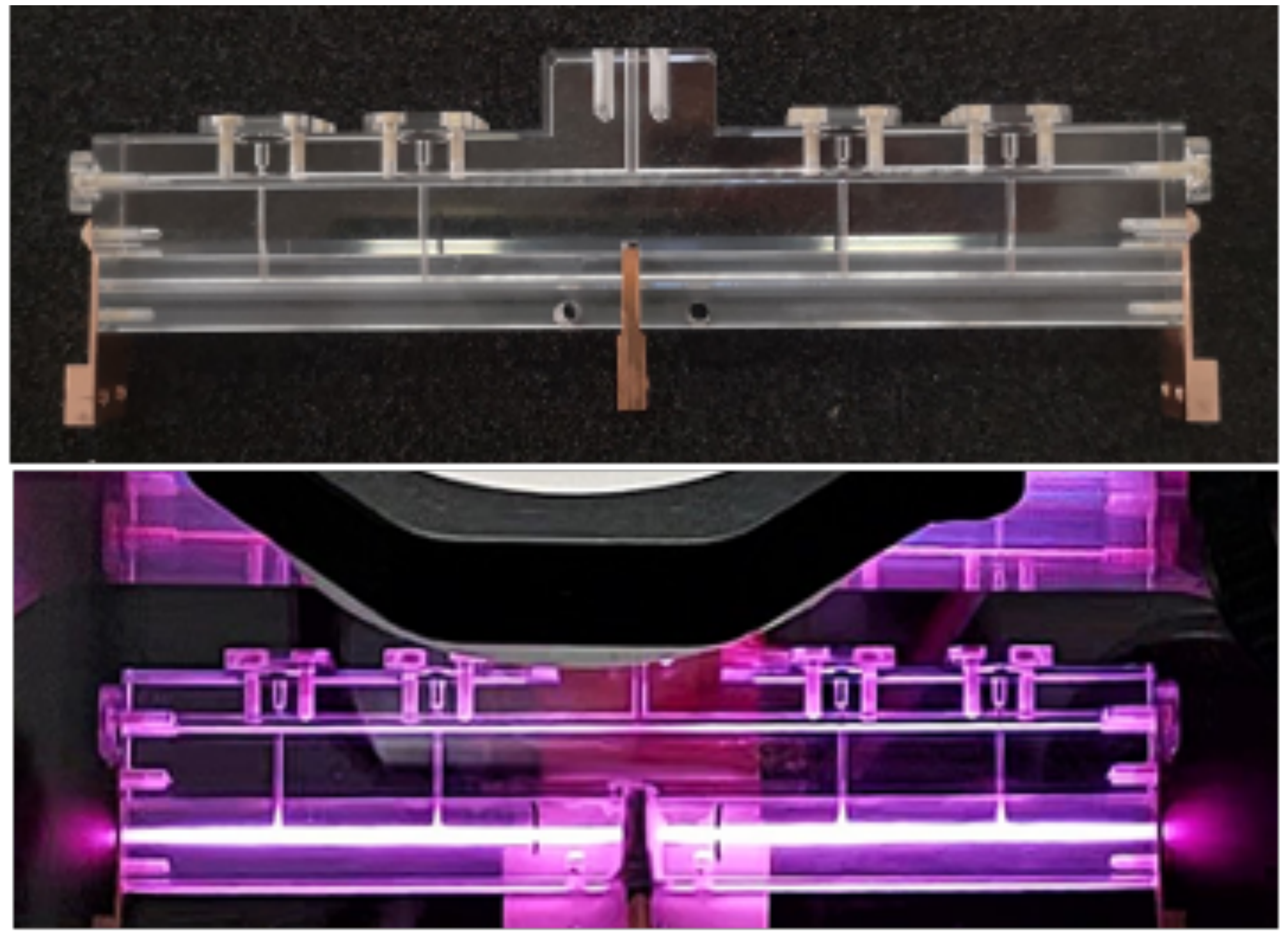
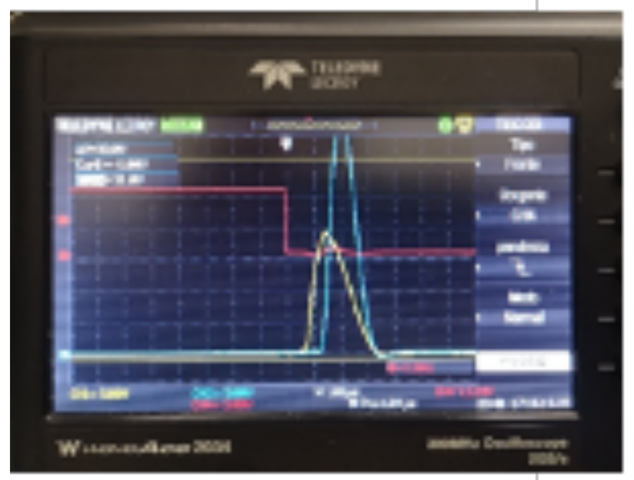
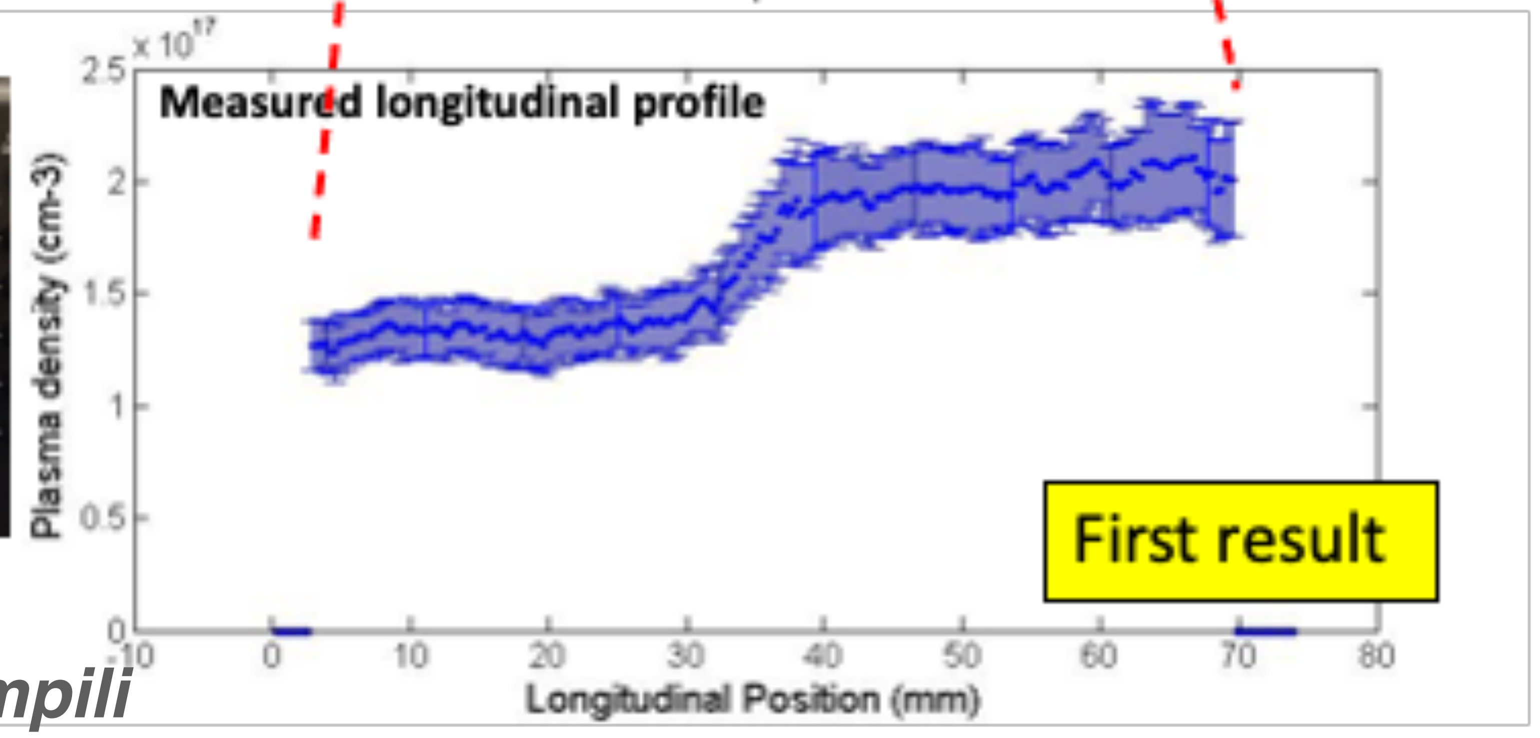








Courtesy A.Biagioni / R.Pompili

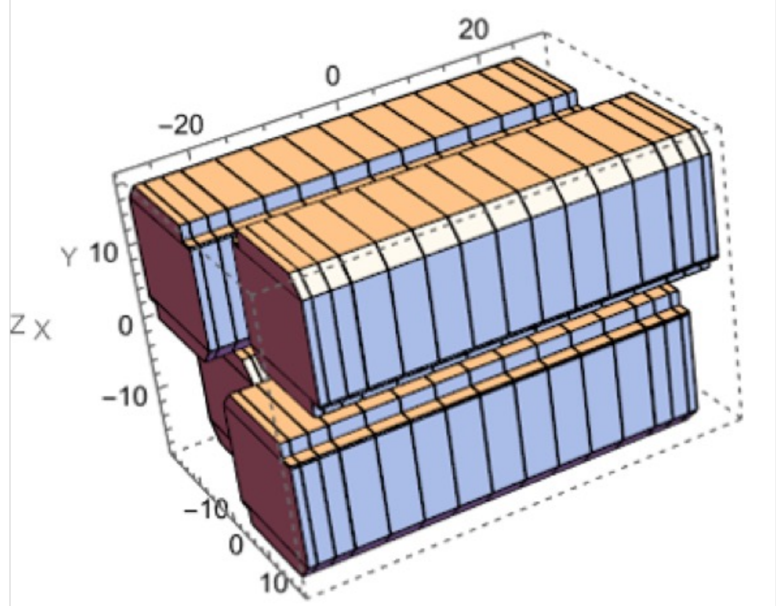
Advantages:

- several independently controllable sections
- Plasma sources larger than 40 cm (m-scale) with HV pulses less than 10 kV
- Longitudinal density modulation
- **5 GeV** case for EuPRAXIA (1.5 GV/m m-scale capillary - density 10^{16} cm-3)

Undulator design and prototyping for AQUA: Apple-X

Defining critical design aspects:
Minimum vacuum chamber size / vacuum - wake-fields (F. Bosco Un. Roma 3 – F. Nguyen, ENEA)
Magnetic field tolerances from prototype of Apple-X module (M. Opromolla, LNF)

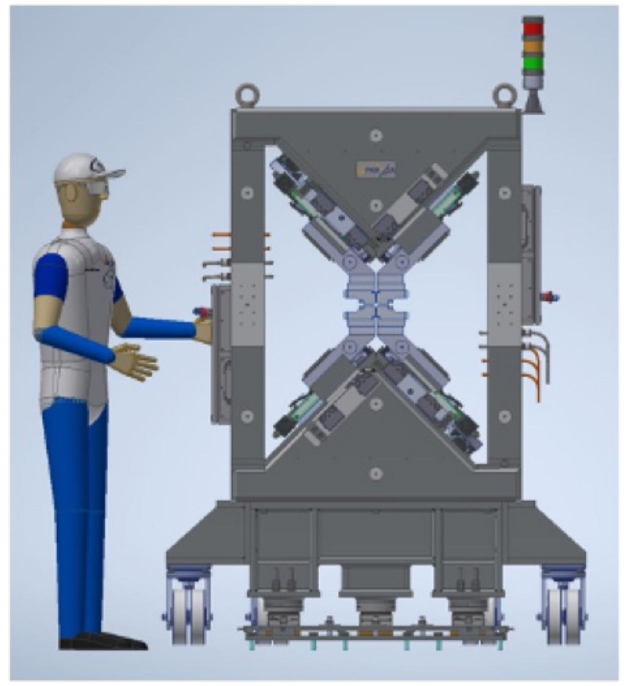
Apple-X undulator for ***SABINA*** (ref. L. Sabbatini) is a first prototype for ***AQUA*** FEL line



Magnetic design A. Petralia (ENEA)

LNF observer in LEAPS-INNOV:
setting up magnetic measurement bench (ref. L. Sabatini A. Vannozzi) in contact with M. Calvi / S. Karabekyan small size Hall probe and Hall probe bench.

Undulator mech. design adapted from KYMA- *SABINA* by M. Del Franco (LNF)



First *SABINA* undulator in FRASCATI March 29, 2023

Courtesy L.Giannessi

Undulator design and prototyping for AQUA 2: SCU

Prototype construction at FNAL (C. Boffo)

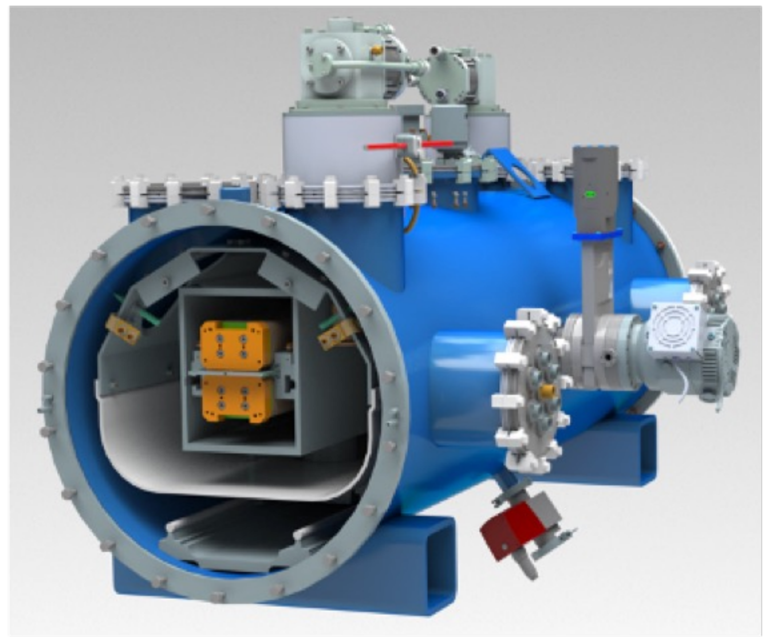
MODULAR DESIGN
Cooling: 2+2 1.8 W GM coolers

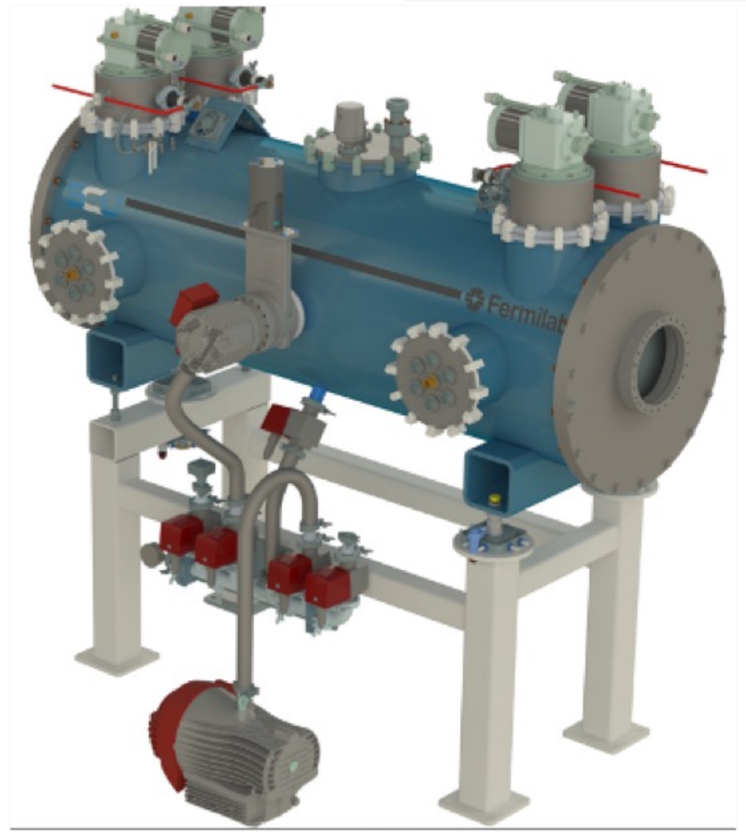
Reduced vessel diameter to minimize: costs, used space and radiation input at 50K

Current leads optimized for higher current/heat load. Hybrid HTS phosphor bronze system

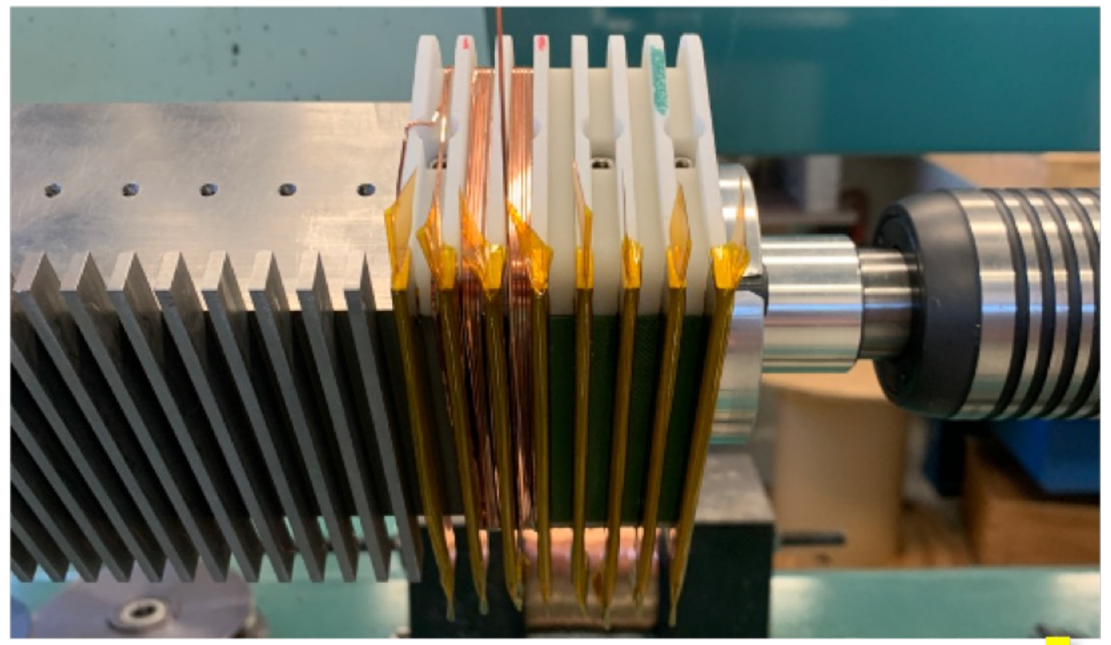
Integrated G11 support posts as in LHC magnets combined with railing system as PIP-II cryomodules

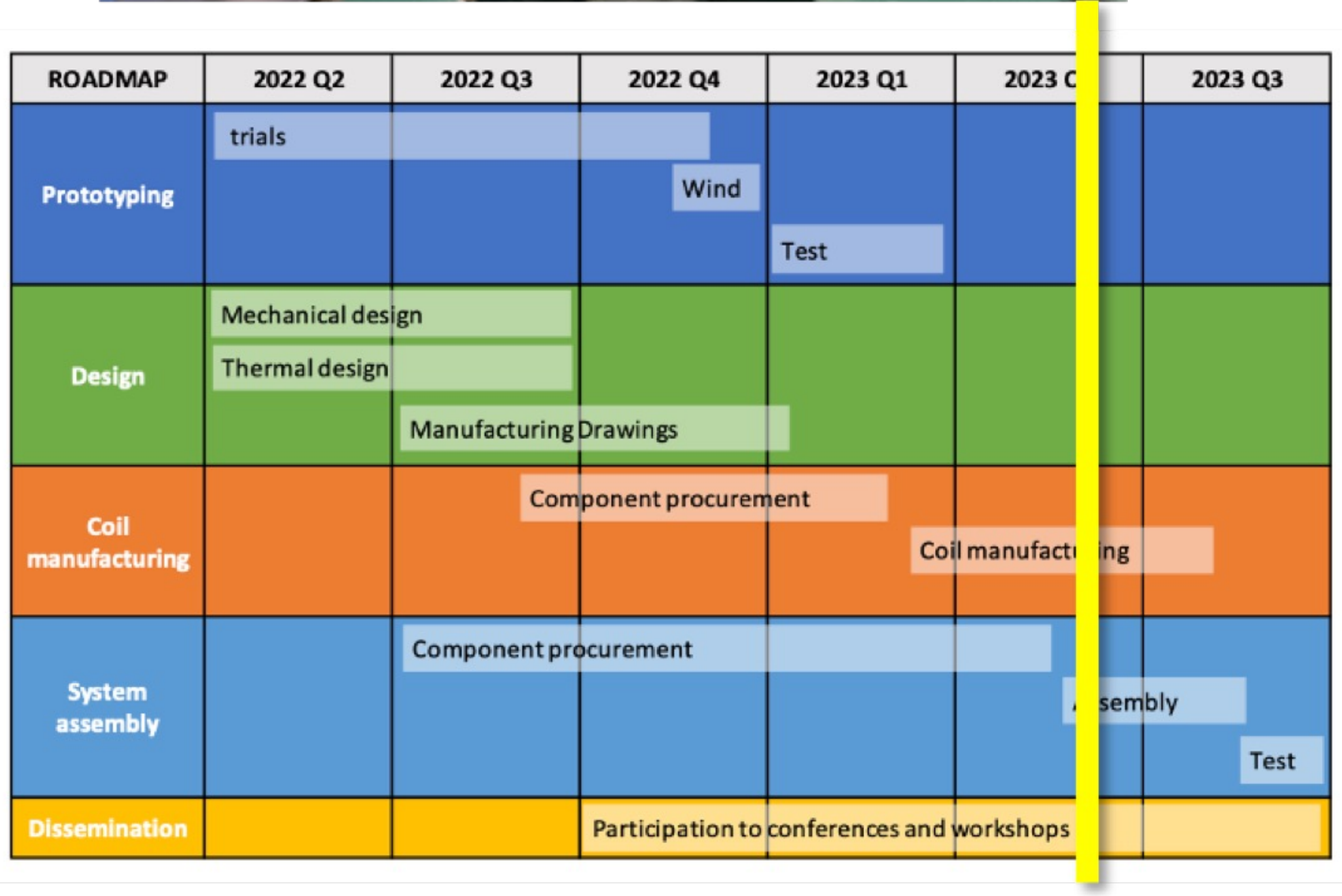
Parameter	Value	Unit
Period	< 16	Mm
Beam stay clear	5	mm
FEL wavelength	~3	Nm
K-value	>1.2	-
Beam heat load	TBD	W
Ramp to operating field	<600	s
Cooling	Cryocoolers	-
Operating temperature	4.2	K
Magnet length	1.5-1.6	m
Flange to flange length	2.0-2.5	m
Beam height	TBD	m
Vacuum vessel diameter	<1	m
Insulation vacuum	$1*10^{-5}$	mbar
Cooldown time	<7	days





Q3 2023 the prototype undulator should be completed – delivery to LNF in 2024





Courtesy L.Giannessi

General Status - Diagnostics

Activity	Completed steps	In progress / Next Steps
Stripline BPMs (tot:14) (Diagnostic/Vacuum/Mechanics groups)	-BPM prototype for Bench Test -Feedthrough procurement -vacuum prototype design -Component List and Costs evaluation	• 1st BPM construction • Usage also in the Sabina beam line, realization of 4 complete BPM (Jan2024) • Beam tests Sept/23 to be verified
BPM Electronics (tot:14 modules) (Diagnostics/Controls groups)	Bench Test of different versions of the Libera BPM module (price vs optional functionalities) Component List and Costs evaluation	• Beam tests (may2023) • Epics control software (Jun2023)
Cavity BPM (tot.10) (Diagnostic group)	Usage in intraondulator Diagnostics Beam test @ Sparc (2021-2022) New Pickups + Electronics Design Draft of a formal INFN-PSI agreement for collaboration on CavBPMs Component List and Costs evaluation	• Started collaboration with PSI (pickup realization) + InstTech (electronics) • Specifications writing (mid 2023) • Signed Agreement INFN-PSI
Timing System (Diagnostic/Controls/RF groups)	Specs identification MRF minimal system procurement System Startup Sparc installation – Bench Performance Tests Epics control software development and test Component List and Costs evaluation	• Beam test (May2023) to compare performance with actual sparc timing

Courtesy A.Cianchi

Milestone Status

WA3	LINAC	Expected date	Status
M1.1	S2E new layout completed	8/1/2022	Done
M1.2	Photon Number optimization	12/1/2022	Done
M1.3	Machine intermediate layout	1/6/2023	Done
M1.4	RF specifications	1/6/2023	Done
M1.5	Magnets specifications	1/6/2023	Done
M1.6	Stability& Jitter studies	6/23/2023	On going
M1.7	Laser heater parameters	7/3/2023	On going
M1.8	Machine final layout	5/24/2024	T.B.D.

WA3	LINAC	Expected date	Status
M3.1	Linac Design	4/28/2023	Done
M3.2	Vacuum Design	4/28/2023	Done
M3.3	Linac RF Distribution	7/4/2024	Done
M3.4	HP Waveguide Validated	6/1/2023	On going
M3.5	X-Band section validated	1/1/2024	On going

WA2	INJECTOR	Expected date	Status
M2.1	Injector preliminary layout	6/18/2021	Done
M2.2	Injector Layout	10/3/2022	Done
M2.3	Injector components design	11/6/2023	Done +
M2.4	Injector RF Distribution	1/23/2023	Done
M2.5	Photocathode laser design	3/23/2023	On going

+ Except X-Band Linearizer which is ongoing

Milestone Status

WA.04	RF & POWER SUPPLIES	Expected Date	Status
M4.1	S-Band Waveguide design	3/8/2022	Done
M4.2	X-Band Waveguide design	3/8/2022	Done
M4.3	Power supply design validated.	4/28/2023	Done
M4.4	X-Band RF power system validation	8/23/2024	On going (LATE)
M4.5	Timing & Synchronization system designed	7/19/2024	On going

WA.05	Plasma	Expected Date	Status
M5.1	Capillary plasma characterization	10/25/2023	On going
M5.2	Plasma section final design	1/17/2024	T.B.D.

WA.06	FEL	Expected Date	Status
M6.1	FEL Configuration Strategy	5/3/2022	Done
M6.2	Final Design Phase 0	11/8/2024	On going
M6.3	AQUA Final Design	3/29/2024	On going

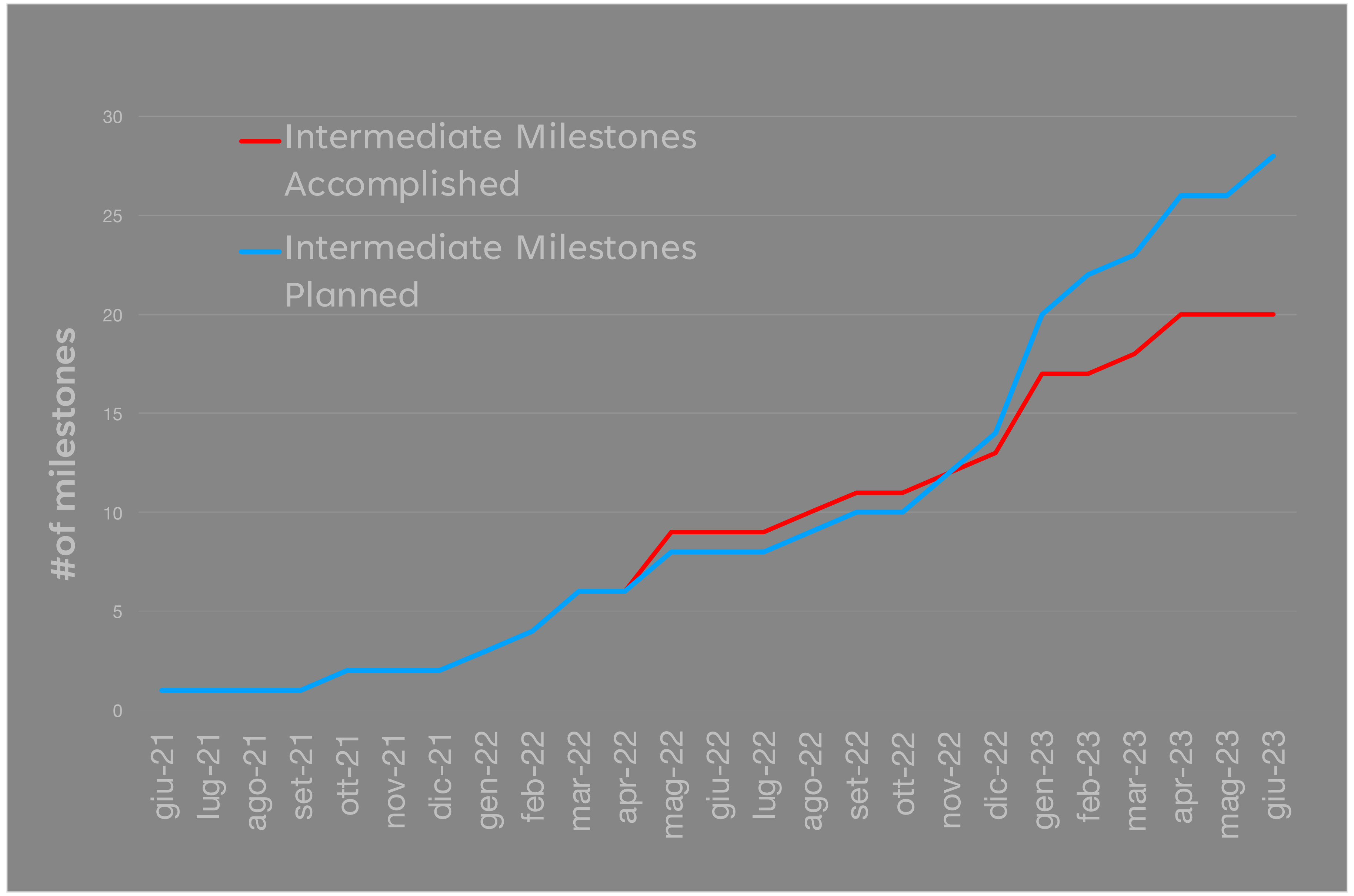
WA.08	USER		
WA8.M1	Design optical elements	11/3/2023	On going
WA8.M2	Final design user end station	4/19/2024	T.B.D.
WA8.M3	TDR Users	10/4/2024	T.B.D.

WA.10	DIAGNOSTICS		
M10.1	BPM prototype validation	9/28/2022	Done
M10.2	BLM prototype validation	1/30/2023	On going
M10.3	Compact Diag Chamber validation	2/7/2023	LATE
M10.4	High Precision Charge measurement validation	5/20/2022	Done
M10.5	Diagnostic prototyping validation	2/7/2023	On going
M10.5	Final e-beam diagnostic design	2/7/2023	On going
M10.6	ML data taking final design	11/6/2023	On going

Some delays accumulated due to several reasons:

- Under staffing. This situation is being mitigated due to a significant number of new colleagues arrived in the last very few months.

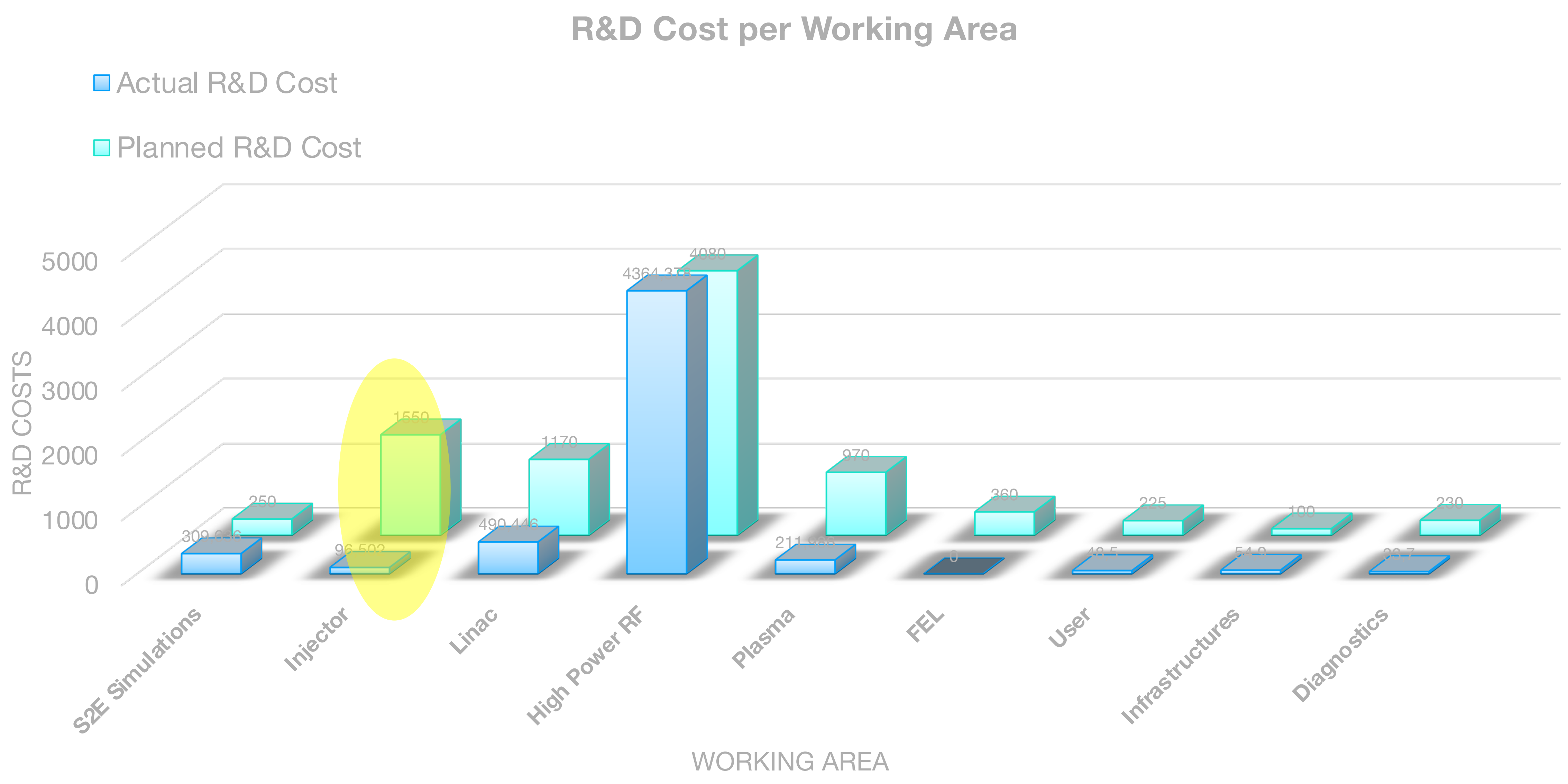
  - **4 Post-Doc:**
    FEL
    Magnets
    Controls
    Virtual RF Diagnostics through ML application
  - **4 Technicians:**
    Magnets (2)
    Diagnostics
    RF
  - **4 Researcher and Technologists in several areas:**
    Project Management support
    Infrastructure Manager
    Plasma Scientist
    Laser Scientists (to be found)
  - **1 Permanent Position** (laser scientist) started few weeks ago.

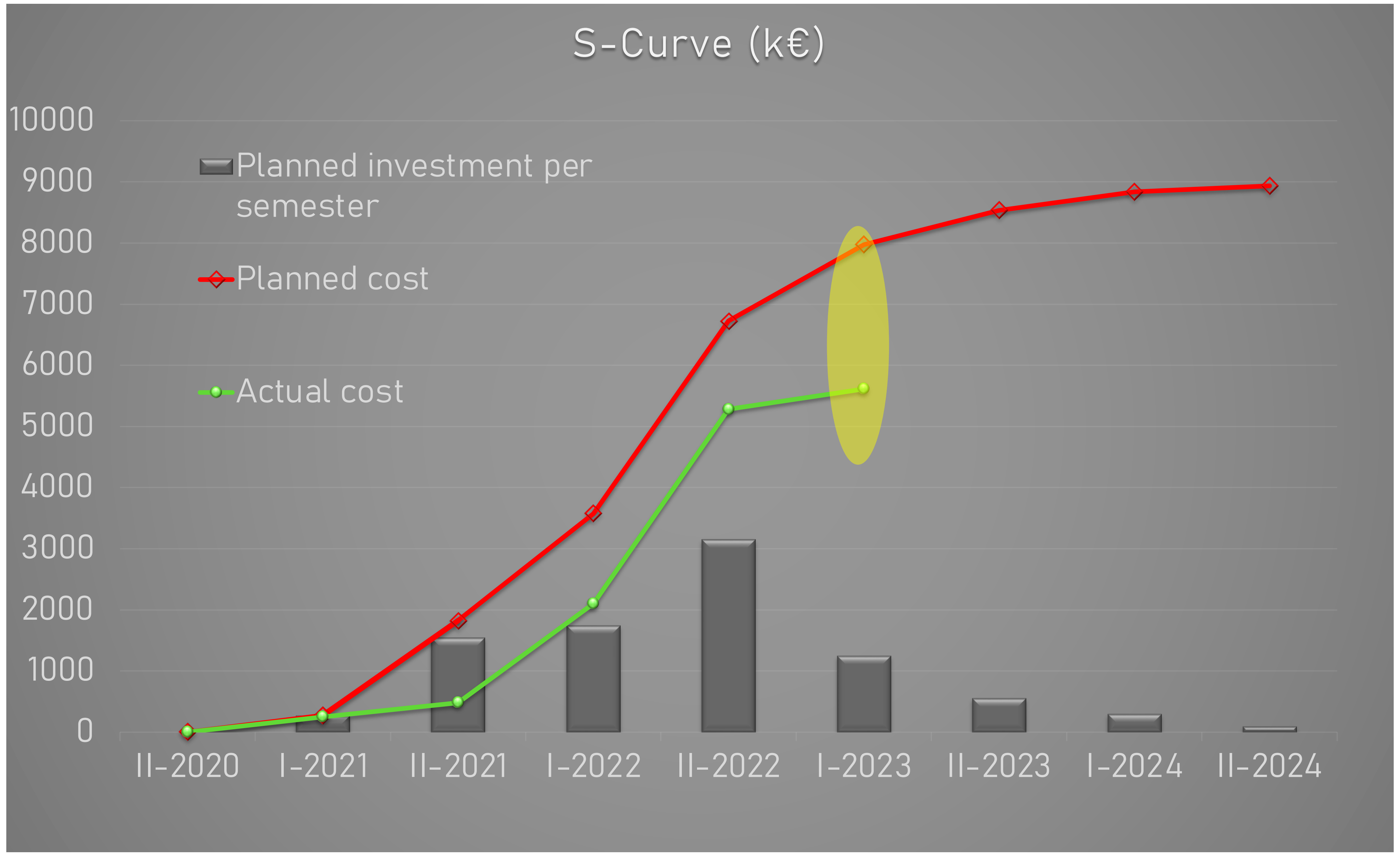


- Delay in the authorization for running the TEX Facility
- A lot of procurement activities for EuAPS
- Milestones missed are indeed at advanced stage and likely will be completed in the next months

In the overall we do not expect a change in the baseline and we believe that the deadline to complete the TDR by 2025 is still achievable. Of course now the detailed design work has to be done

R&D Cost status

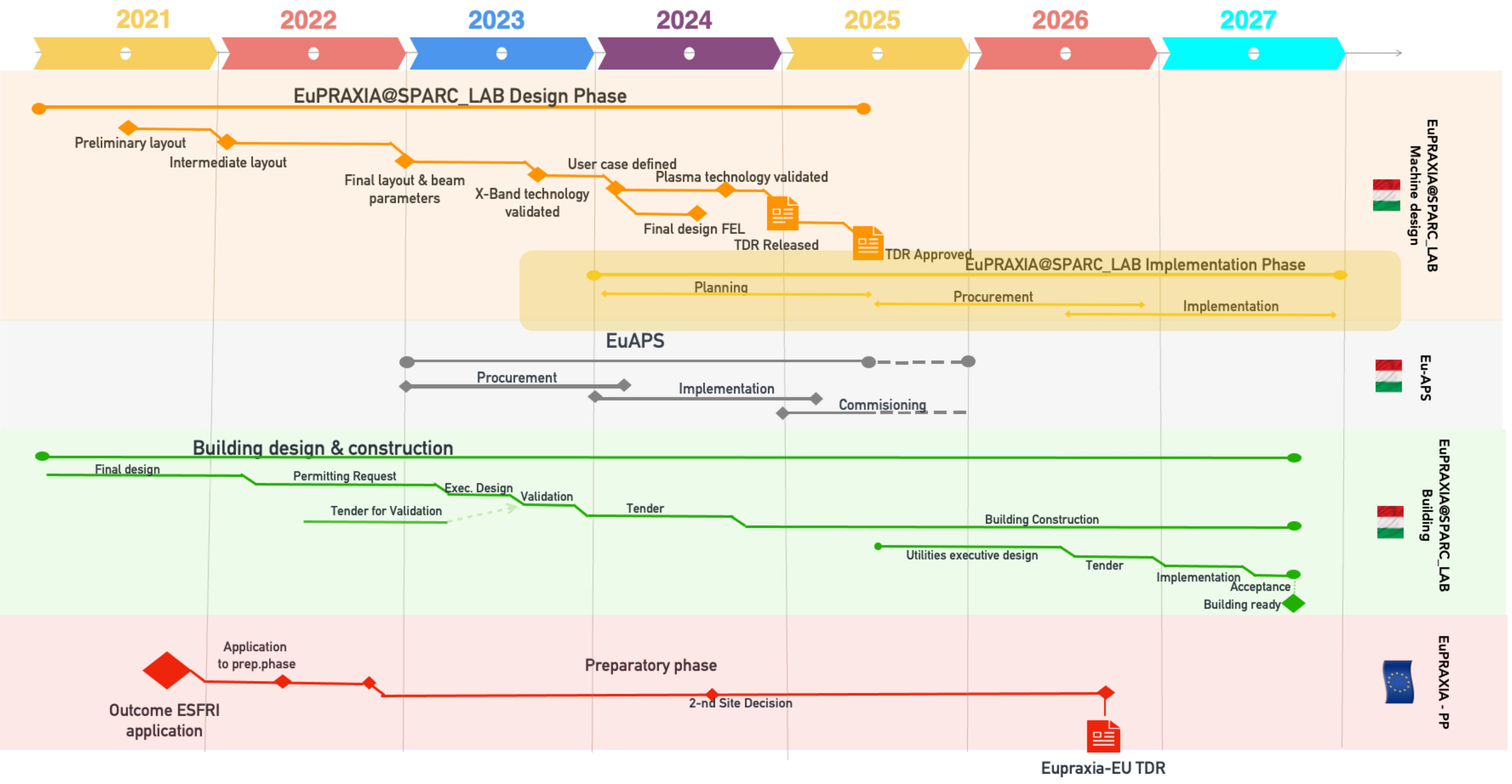




- All expenses are proceeding as expected. Contingencies calculated have not been used.
- Synergy with other projects (e.g. Rome Technopole) allowed a diversification of the funding scheme.
- Discrepancy mainly due to the S-Band Solid State modulator to be procured for SPARC_LAB which is delayed (request for allocation sent).

Transition to the Implementation Phase

The implementation phase planning is due to start in 2024. However some preliminary activities already started.



This will help a smooth transition to the implementation phase.

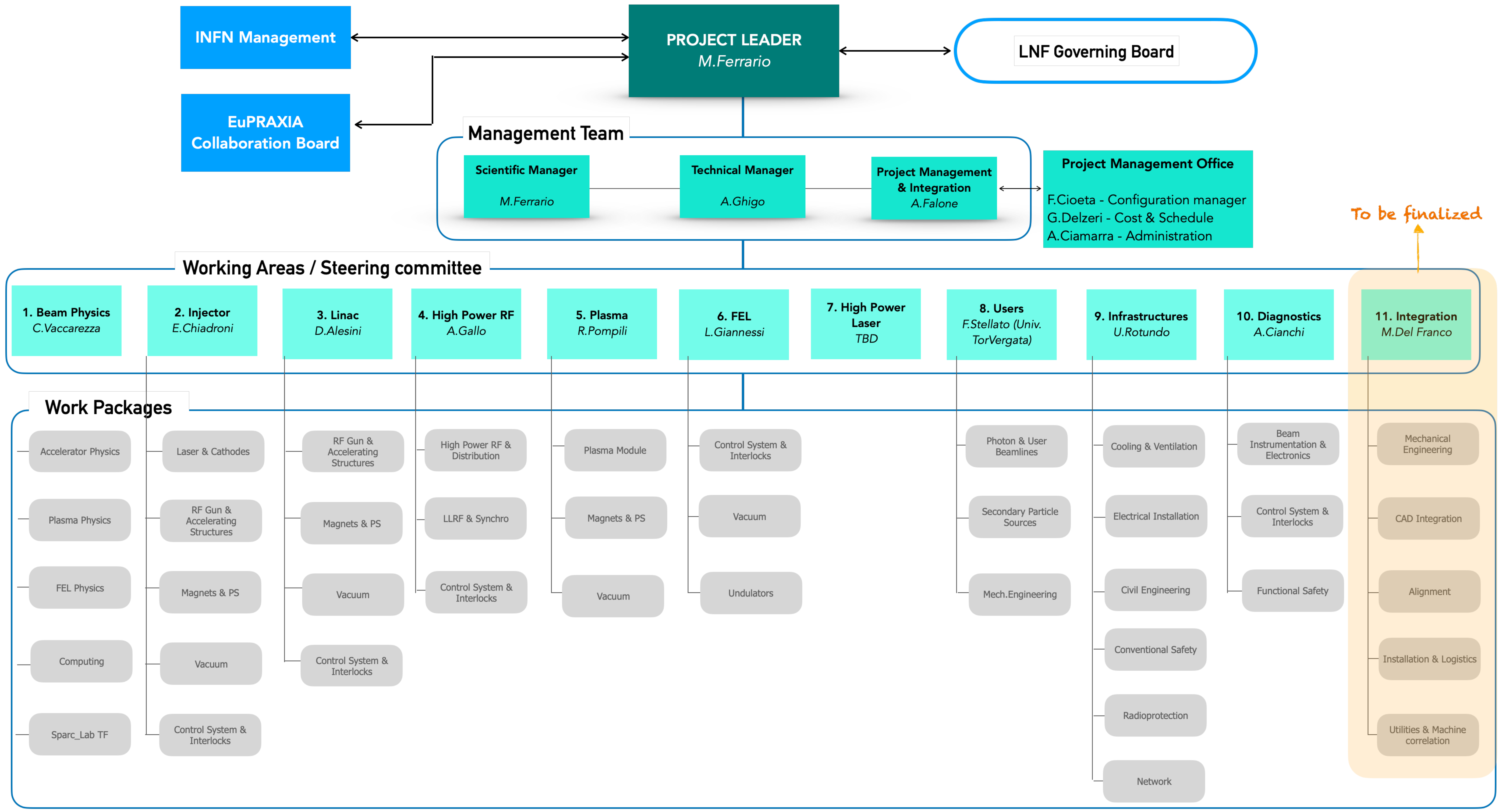
Note that for the EuAPS project, a full monitoring through Earned Value Management techniques are being adopted so far with very remarkable results (out of topic today…).

The experience and the tools developed for EuAPS will be fully implemented and upgraded for EuPRAXIA@SPARC_LAB implementation

Transition to the Implementation Phase

Reformulation of the OBS (to be finalized):

- Clearer rappresentation
- Responsible and tasks unchanged (with some exceptions)
- 1 additional Working Area: Integration to deal with the installation and commissioning planning & preparation



- Note that this is **NOT** the OBS of the implementation phase. This will be defined in the planning phase (2024).

Preamble

- The machine design has reached a level of maturity sufficient to draft a first comprehensive cost estimation.

- The completion of the definitive design of the building allows also a realistic cost estimation for the building construction (which will be refined once the executive design will be completed and the tender open).

- We aim at the definition of a cost-baseline and keep it updated on regular basis following market variation, fine tuning of the design, external assessment and more in general any factor that might imply a change in the baseline.

- Contingencies not considered at the moment – dynamically allocation of contingencies considering savings and extra-cost balance

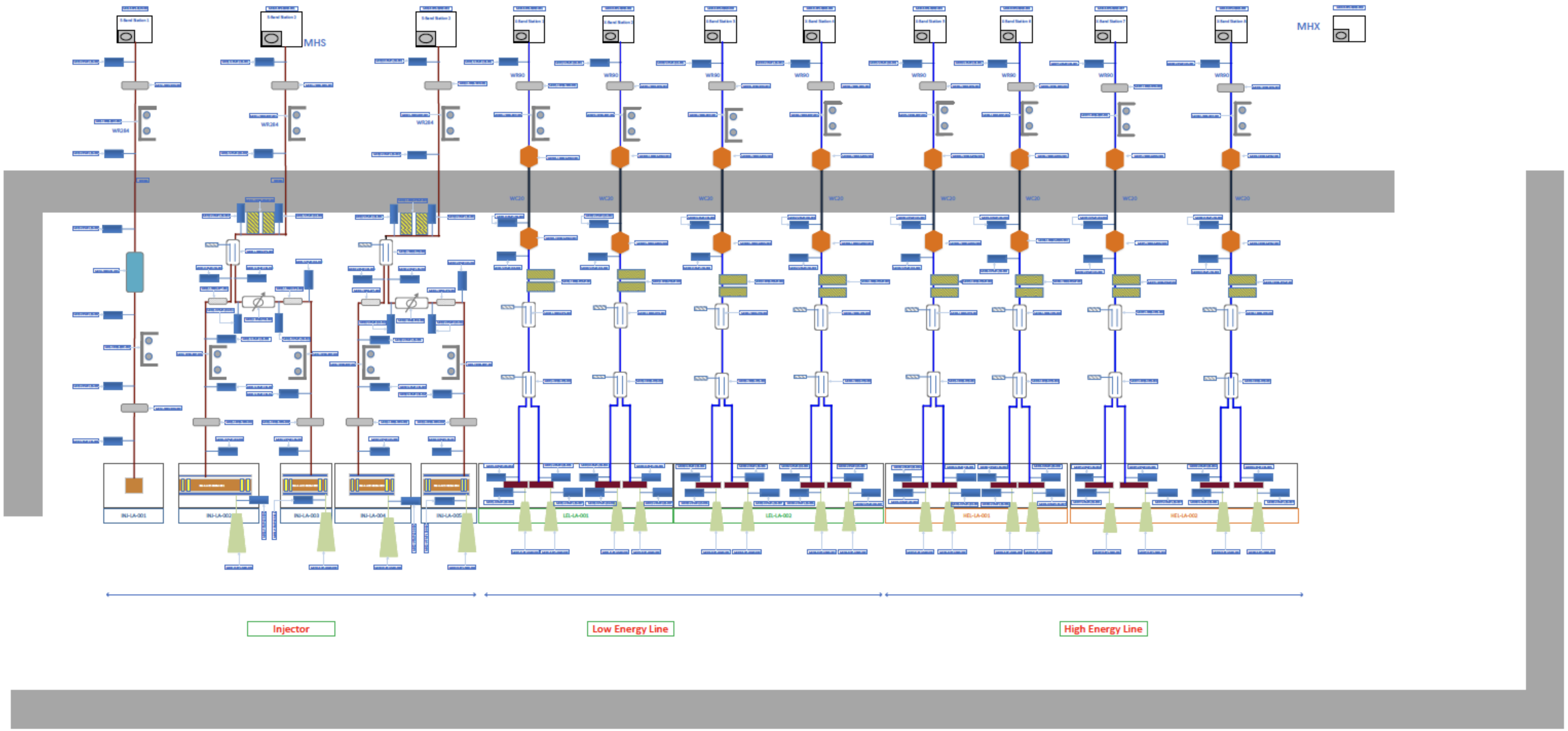
Work done in collaboration with A.Ghigo and F.Cioeta

Methodology

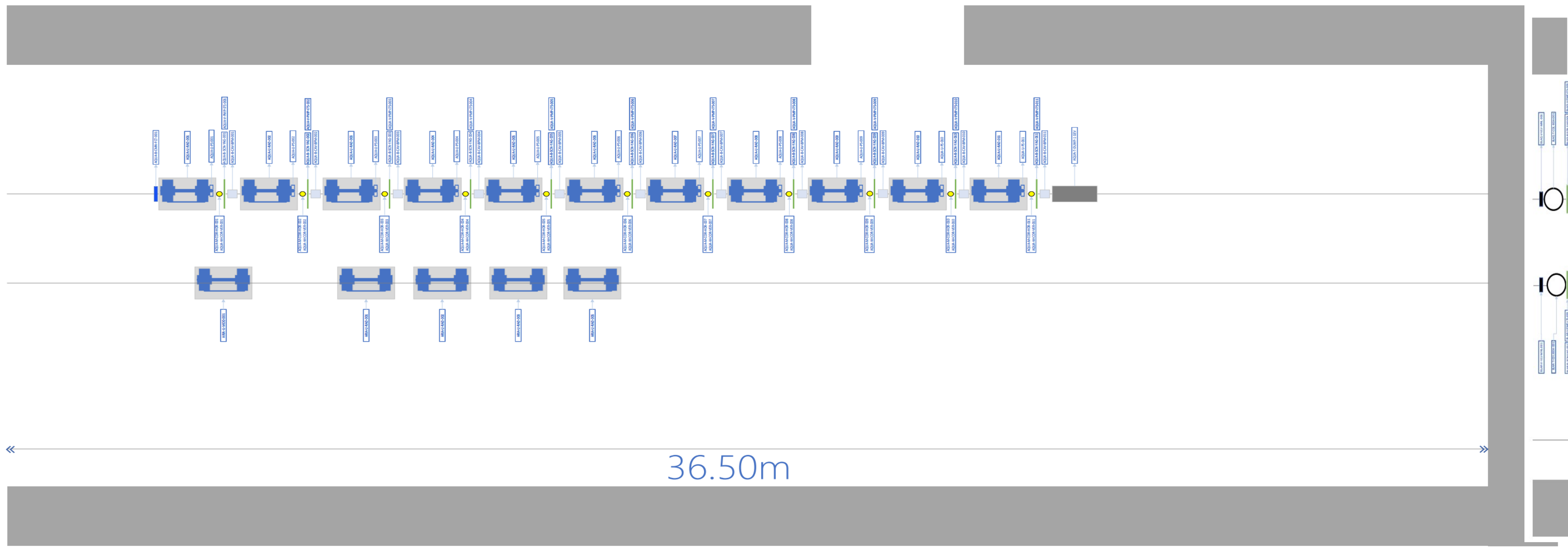
- Each element of the machine design is stored in a database
- Functional layout as basis for the cost – assessment (100% rules)
- Cost are estimated considering market analysis, similar component already procured for similar projects.
- No scale-economies considered. Tot. Cost = #Unit x unit Cost

Linac Functional Layout

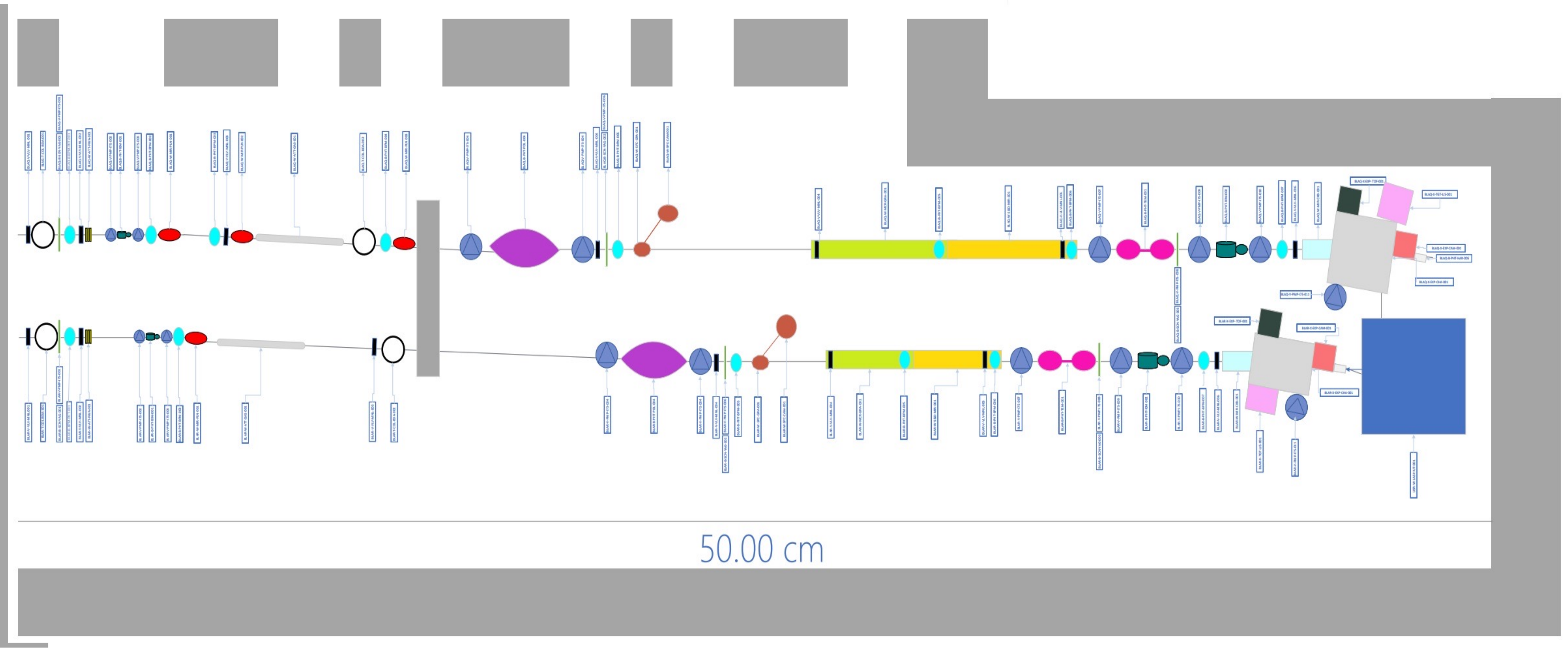
First Draft Cost-Estimation



RF Distribution Functional Layout



Ondulator Functional Layout

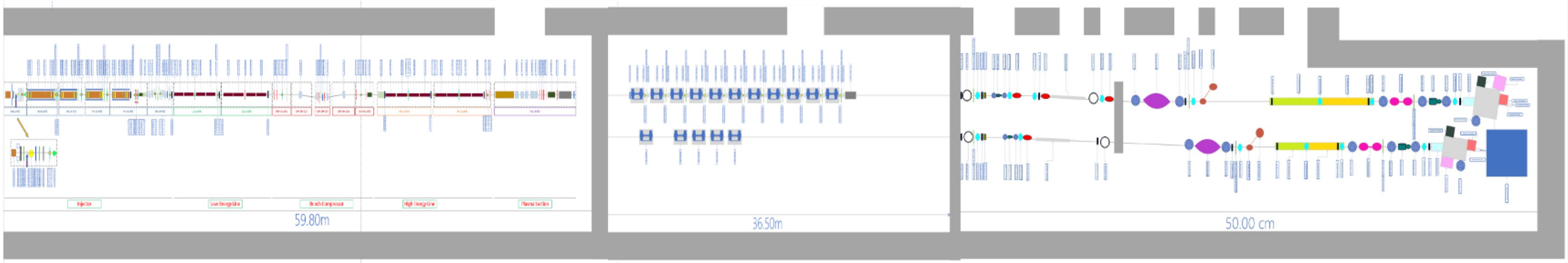


Beam Line Functional Layout

Functional layout / Database

PBS-Machine

ID	WA CODE	WBS Code	Area / Zona	Sistema	Famiglia	Tipo	Numero S	PBS-Code	Descrizione	Z-Cc	Modulo	Connecte
1	WA-02	WP-10	INJ	V	PMP	I20	001	INJ-V-PMP-I20-001	Ion Pump 20 l/s	0	INJ-LA-001	
2	WA-02	WP-10	INJ	V	PMP	I20	002	INJ-V-PMP-I20-002	Ion Pump 20 l/s	0	INJ-LA-001	
3	WA-02	WP-10	INJ	V	PMP	NXT	001	INJ-V-PMP-NXT-001	Next Torr	0	INJ-LA-001	
4	WA-02	WP-08	INJ	A	RF	GUN	001	INJ-A-RF-GUN-001	RF Gun	0	INJ-LA-001	
5	WA-02	WP-10	INJ	V	PMP	NXT	002	INJ-V-PMP-NXT-002	Next Torr	0	INJ-LA-001	
6	WA-02	WP-10	INJ	V	GAU	PIR	001	INJ-V-GAU-PIR-001	Pirani Gauge	0	INJ-LA-001	
7	WA-02	WP-17	INJ	M	SOL	GUN	001	INJ-M-SOL-GUN-001	Gun Solenoid	0	INJ-LA-001	
8	WA-02	WP-10	INJ	V	VLV	MNL	001	INJ-V-VLV-MNL-001	Manual Valve	0	INJ-LA-001	
9	WA-10	WP-14	INJ	B	SCN	YAG	001	INJ-B-SCN-YAG-001	Yag Screen	0	INJ-LA-001	
10	WA-02	WP-10	INJ	V	PMP	I75	001	INJ-V-PMP-I75-001	Ion Pump 75 l/s	0	INJ-LA-001	
11	WA-07	WP-10	INJ	W	MIR	INJ	001	INJ-W-MIR-INJ-001	Mirror Laser Photocathode	0	INJ-LA-001	
12	WA-02	WP-17	INJ	M	COR	HOR	001	INJ-M-COR-HOR-001	Horizontal Corrector	0	INJ-LA-001	
13	WA-02	WP-17	INJ	M	COR	VER	001	INJ-M-COR-VER-001	Vertical Corrector	0	INJ-LA-001	
14	WA-10	WP-14	INJ	B	CMN	FCT	001	INJ-B-CMN-FCT-001	Fast Current Transformer	0	INJ-LA-001	
15	WA-10	WP-14	INJ	B	SCN	YAG	002	INJ-B-SCN-YAG-002	Yag Screen	0	INJ-LA-001	
16	WA-02	WP-10	INJ	V	PMP	I75	002	INJ-V-PMP-I75-002	Ion Pump 75 l/s	0	INJ-LA-001	
17	WA-02	WP-10	INJ	V	VLV	FST	001	INJ-V-VLV-FST-001	Fast Vacuum Valve	0	INJ-LA-001	Residual Gas
18	WA-10	WP-14	INJ	B	BPM	STR	001	INJ-B-BPM-STRP-001	Stripline BPM	0	INJ-LA-001	
19	WA-02	WP-17	INJ	M	COR	HOR	002	INJ-M-COR-HOR-002	Horizontal Corrector	0	INJ-LA-001	
20	WA-02	WP-17	INJ	M	COR	VER	002	INJ-M-COR-VER-002	Vertical Corrector	0	INJ-LA-001	
21	WA-02	WP-08	INJ	A	LNR	SBAND	001	INJ-A-LNR-SBAND-001	Linearizer XBAND	0	INJ-LA-001	
22	WA-02	WP-08	INJ	A	ACC	SBND	001	INJ-A-ACC-SB3M-001	1st S-Band TW Section	0	INJ-LA-002	
23	WA-02	WP17	INJ	M	COR	HOR	003	INJ-M-COR-HOR-003	Horizontal Corrector	0	INJ-LA-002	
24	WA-02	WP17	INJ	M	COR	VER	003	INJ-M-COR-VER-003	Vertical Corrector	0	INJ-LA-002	
25	WA-02	WP-17	INJ	M	SOL	SECT	001	INJ-M-SOL-SECT-001	Long Solenoid S-Band	0	INJ-LA-002	
26	WA-10	WP-14	INJ	B	SCN	YAG	004	INJ-M-COR-HOR-004	Horizontal Corrector	0	INJ-LA-002	
27	WA-02	WP-17	INJ	M	COR	HOR	004	INJ-M-COR-HOR-004	Vertical Corrector	0	INJ-LA-002	
28	WA-10	WP-14	INJ	B	SCN	YAG	003	INJ-B-SCN-YAG-003	Yag Screen	0	INJ-LA-002	
29	WA-02	WP-10	INJ	V	PMP	L75	003	INJ-V-PMP-I75-003	Ion pump 75 l/s	0	INJ-LA-002	
30	WA-10	WP-14	INJ	B	BPM	STRP	002	INJ-B-BPM-STRP-002	Stripline BPM	0	INJ-LA-002	
32	WA-02	WP-17	INJ	M	COR	HOR	005	INJ-M-COR-HOR-005	Horizontal Corrector	0	INJ-LA-002	
33	WA-02	WP-17	INJ	M	COR	VER	005	INJ-M-COR-VER-005	Vertical Corrector	0	INJ-LA-002	
34	WA-02	WP-08	INJ	A	ACC	SBND	002	INJ-A-ACC-SB2M-002	S-Band Accelerating Section	0	INJ-LA-003	
35	WA-02	WP-17	INJ	M	COR	HOR	006	INJ-M-COR-HOR-006	Horizontal Corrector	0	INJ-LA-003	



First Draft Cost-Estimation

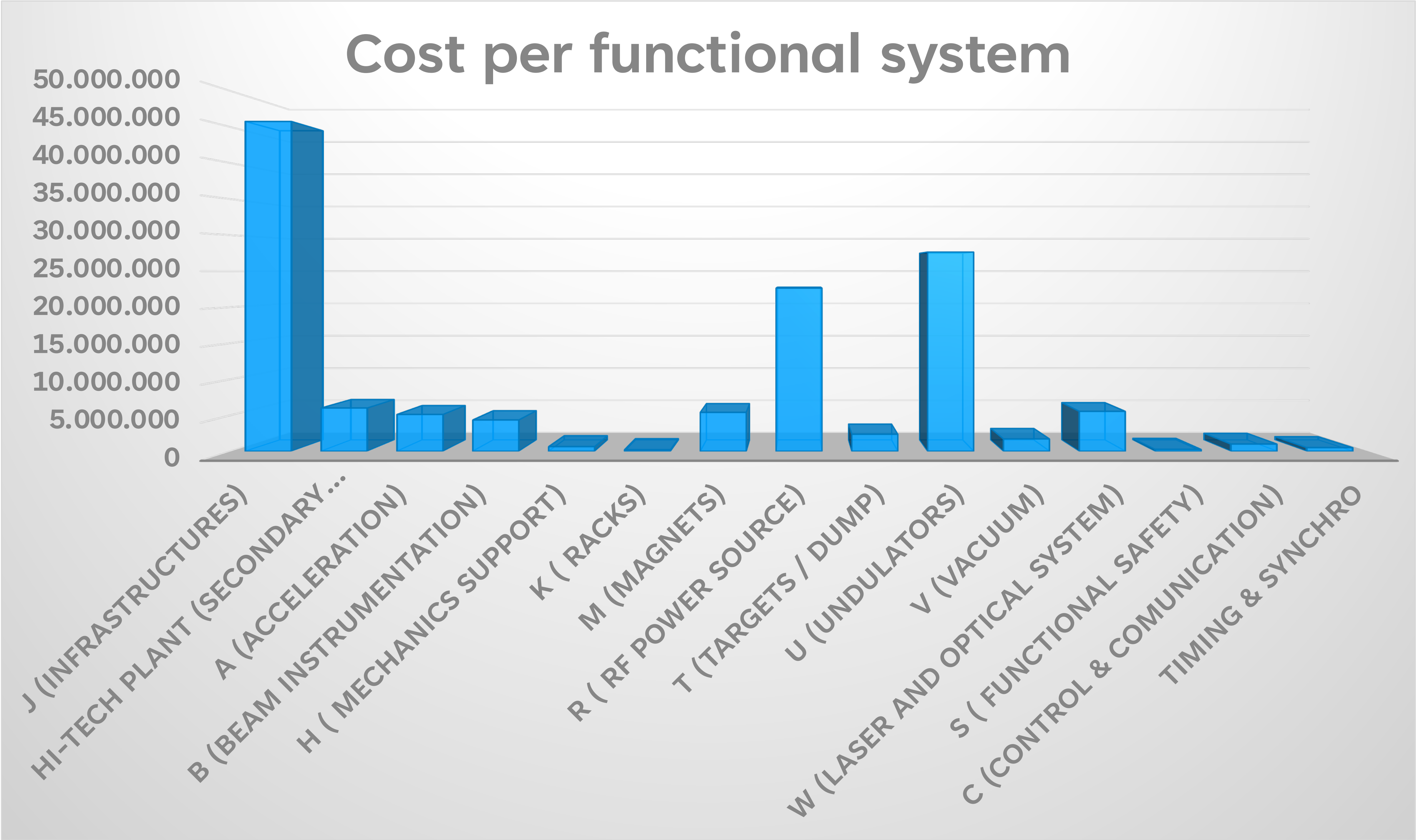
Cost per functional system

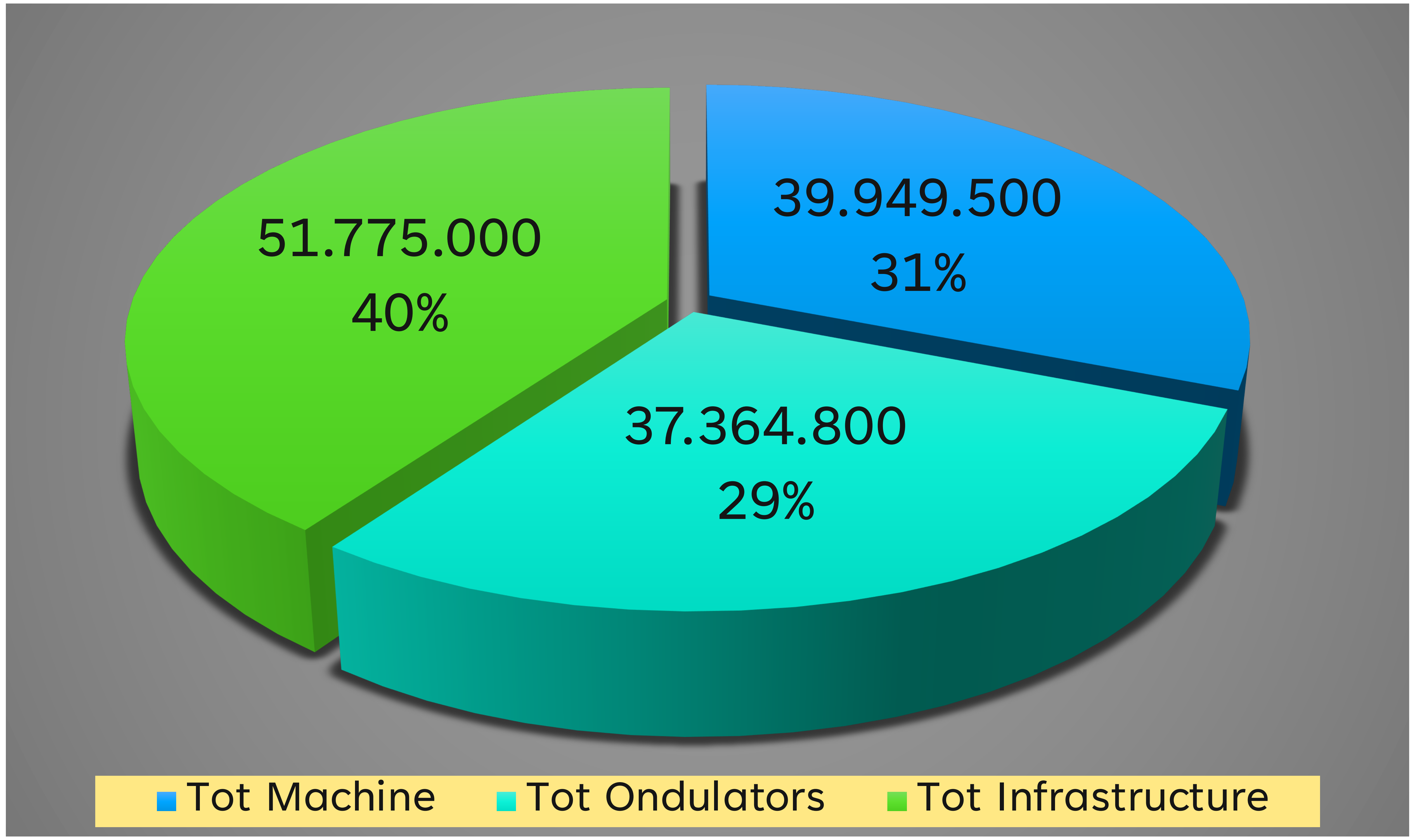
Functional System	Expected cost [€] VAT Included
J (INFRASTRUCTURES)	45.775.000
Hi-Tech Plant (secondary circuit/cabling etc)	6.000.000
A (ACCELERATION)	5.107.000
B (BEAM INSTRUMENTATION)	4.340.000
H (MECHANICS SUPPORT)	637.740
K (RACKS)	200.000
M (MAGNETS)	5.395.000
R (RF POWER SOURCE)	22.631.000
T (TARGETS / DUMP)	2.356.560
U (UNDULATORS)	27.650.000
V (VACUUM)	1.709.000
W (LASER AND OPTICAL SYSTEM)	5.538.000
S (FUNCTIONAL SAFETY)	250.000
C (CONTROL & COMUNICATION)	1.000.000
TIMING & Synchro	500.000
TOT	129.089.300

Cost per functional area

Functional Area	Expected Cost [€] VAT Included
Injector	4.897.100
Low Energy Line	1.918.900
Bunch Compressor	969.500
High Energy Line	2.211.300
Plasma Module	2.137.000
RF Power Station	22.631.000
Control (W/Timing & Synchro)	1.500.000
Photocathode Laser	1.100.000
Tot Machine	37.364.800
ARIA	13.986.800
ARIA BeamLine	5.985.700
AQUA	15.000.000
AQUA BeamLine	4.977.000
Tot Ondulators	39.949.500
Building	45.775.000
Hi-Tech Utilities	6.000.000
Tot Infrastructure	51.775.000
TOTAL	129.089.300

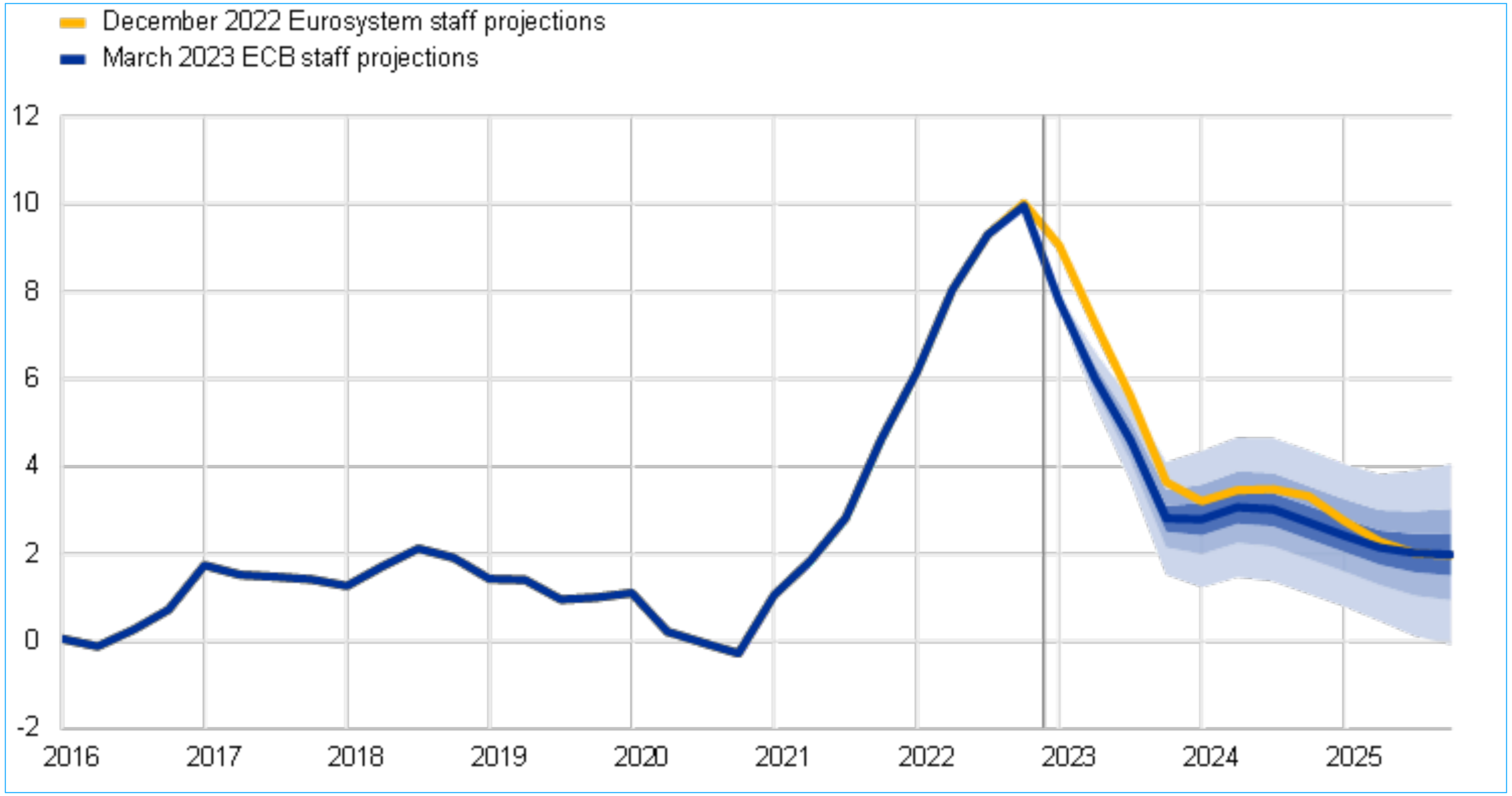
Cost Distribution





40% Infrastructure and 60% overall machine

ECB Inflation projection.



From 2024-2026 on between 2% and 4 %

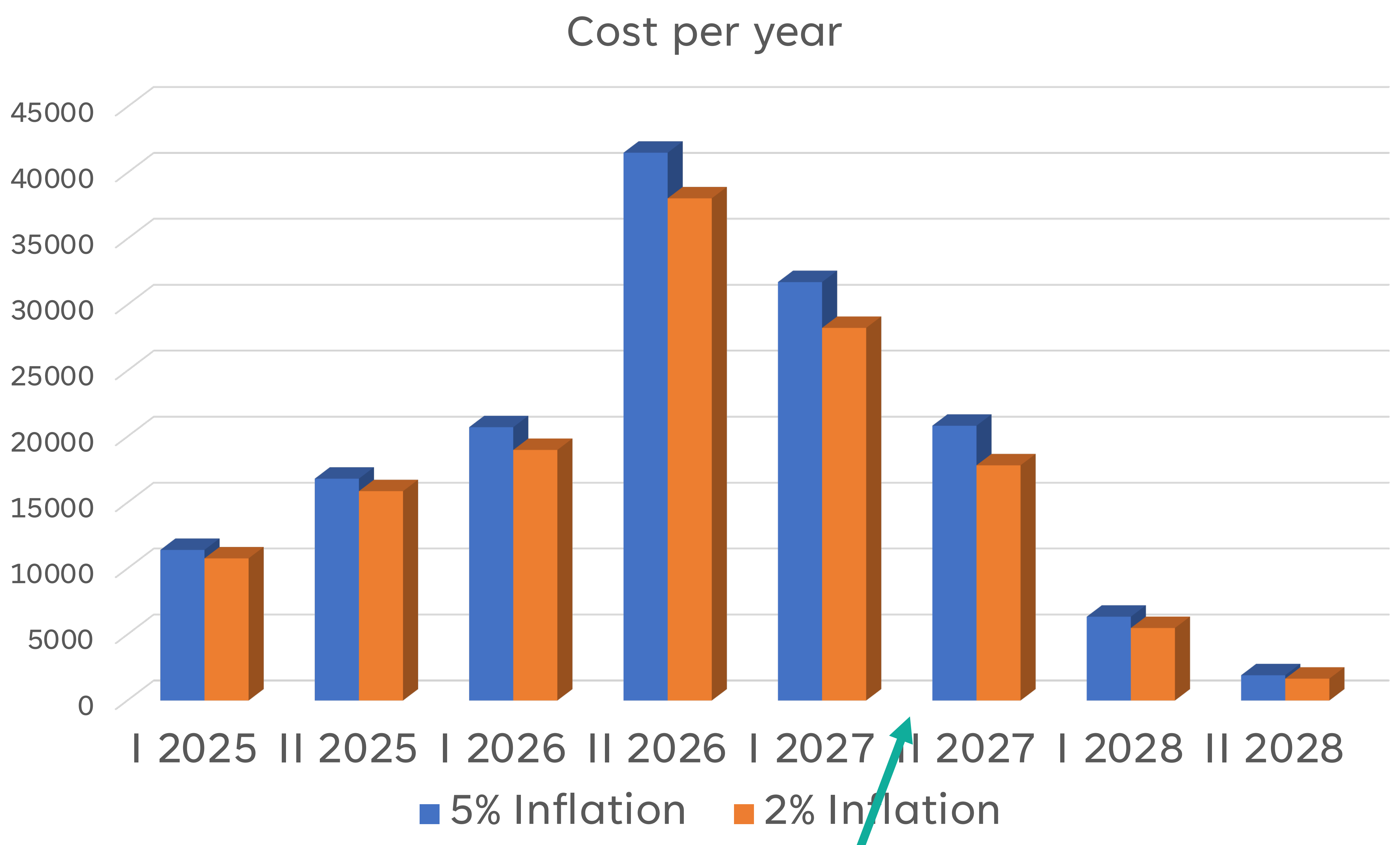
Everything beyond 2026 looks unreasonable and intrinsically unpredictable

The timing of the procurement will be studied in detail during the implementation planning phase (2024 on). It is realistic to estimate that the procurement will start from 2025 to be completed in 2028.

Assuming a reasonable distribution of the procurement over time the Budget At Completion is calculated considering the best and worse scenario of inflation (2% and 5% per year).

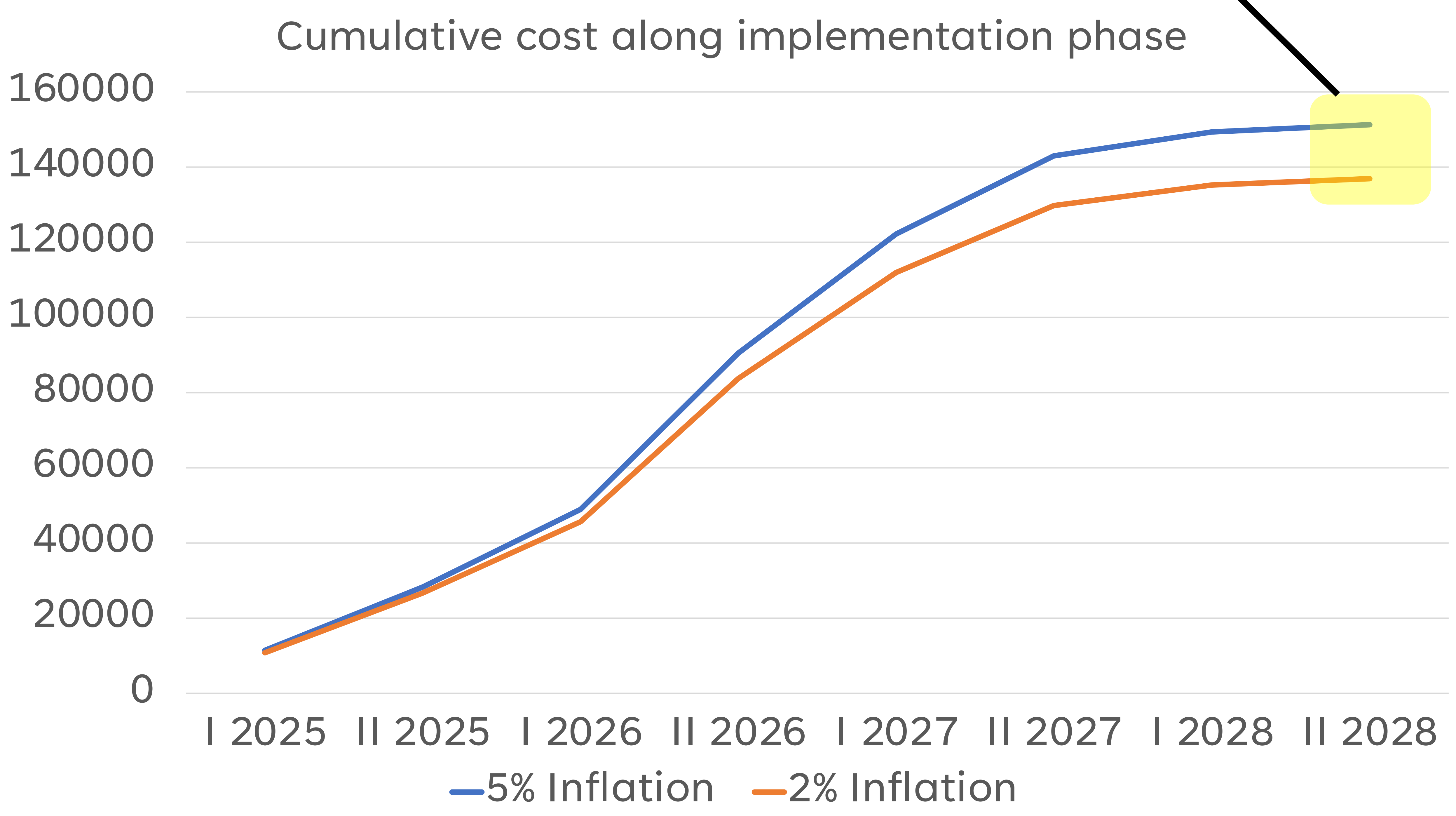
The final BAC should range between 135M€ and 151 M€

First Draft Cost-Estimation



Running costs kick in

136,93M€ < BAC < 151,29 M€



First Draft Cost-Estimation

In 2019 the Italian Government allocated 108M€ until 2030.

In 2021 for the ESFRI Roadmap application we performed a cost estimation (much less accurate though) which is substantially confirmed now.

Considering the current cost estimation as of today the over budget is about 19%, however if we actualize 108M€ to the integrated inflation until today we have that:

108M€ → 125,172 M€*   The actual over budget is therefore just 3%.

However, part of the budget is allocated for R&D (9M€) in addition NO contingencies are included. This would mean that all the risks have been mitigated which is not the case at this moment.

Most importantly it includes 2 beamlines instead of just 1 as originally planned.

* ISTAT Calculator

Conclusions

- EuPRAXIA: Wide range of activities require different funding schemes → Multiple projects. From project to program. Resource allocation and common governance is needed.

- We are half way to the TDR. Overall on time with some delays. Critical steps is the definition of the TDR Chapters which will guide the future work (see contribution this afternoon)

- Authorization from permitting authorities for building construction is a significant milestones accomplished.

- Gradual transition to the implementation phase – organizational aspects & financial needs

- Cost estimation looks reasonable and comparable to the original baseline considering an additional beamline and the inflation correction.