

EUROPEAN
PLASMA
RESEARCH
ACCELERATOR
WITH
EXCELLENCE IN
APPLICATIONS



EuPRAXIA@SPARC_LAB

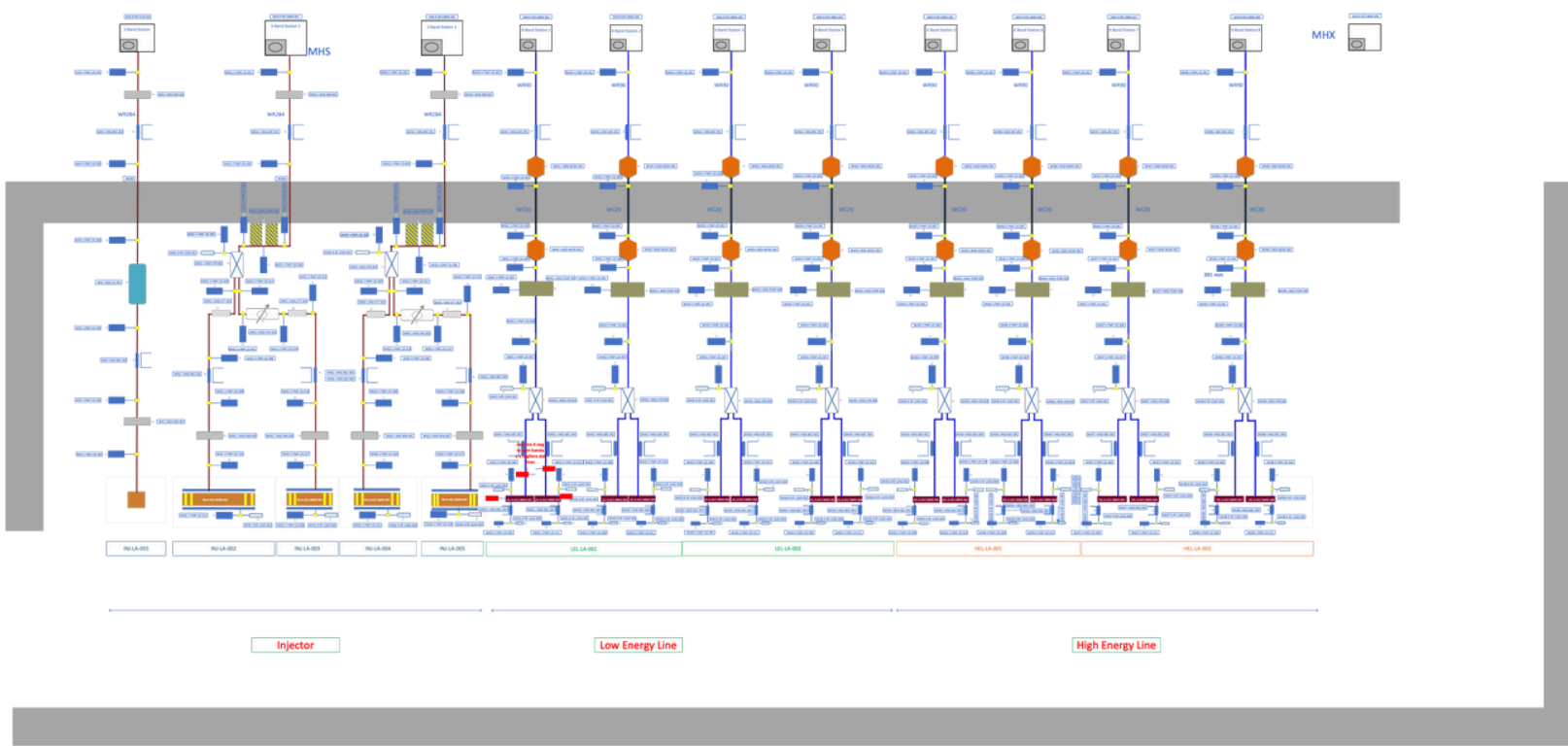
Update cost & schedule baseline
2nd Cost & Schedule Review meeting
22/11/2024



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

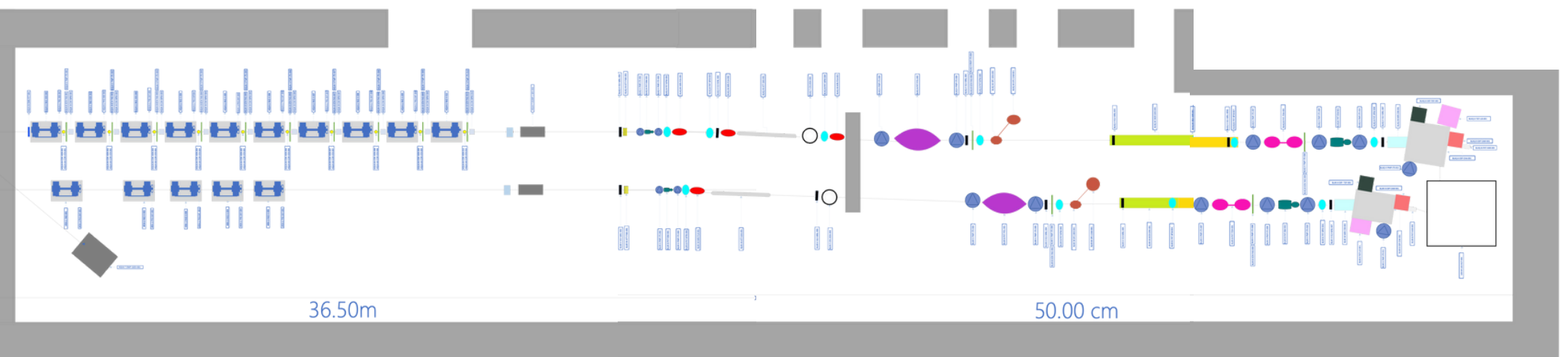
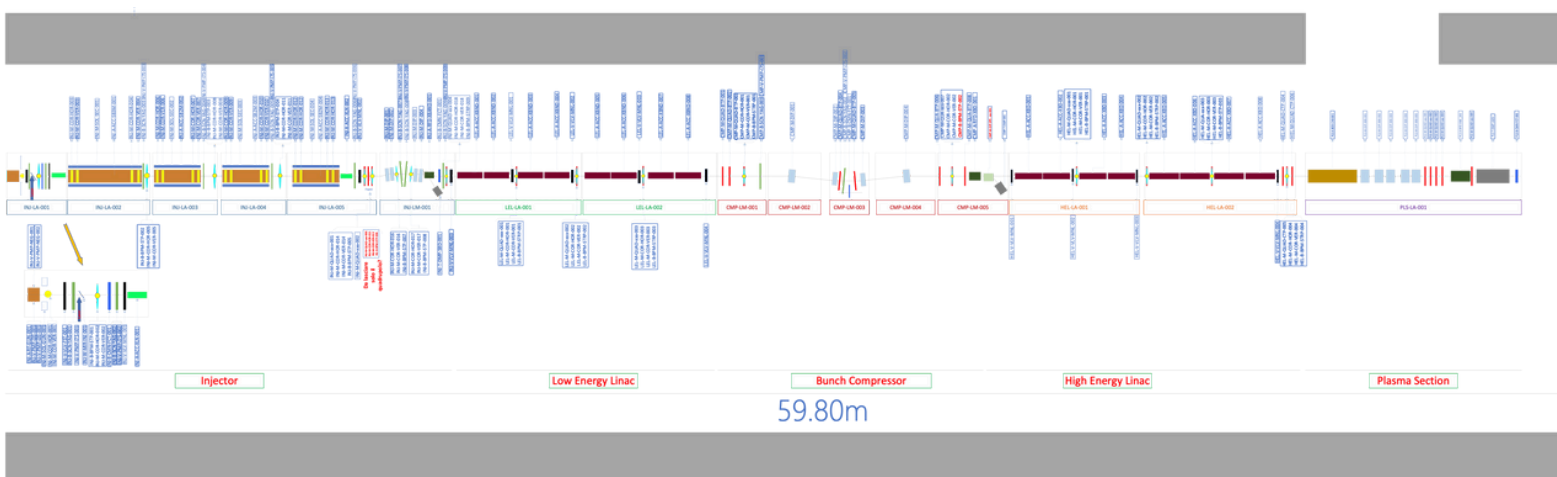
- Scope
- Cost
- Schedule
- WBS and resources
- Risks
- Earned Value Management framework
- The role of PMO

- 1 GEV RF Linac
- Plasma Module for energy doubling (500MeV + 500MeV)
- 2 FEL Lines and associated beamline and user end-stations
- RF distribution
- Ancillary elements (Power Supplies, diagnostics, controls etc.)
- Building and related utilities.

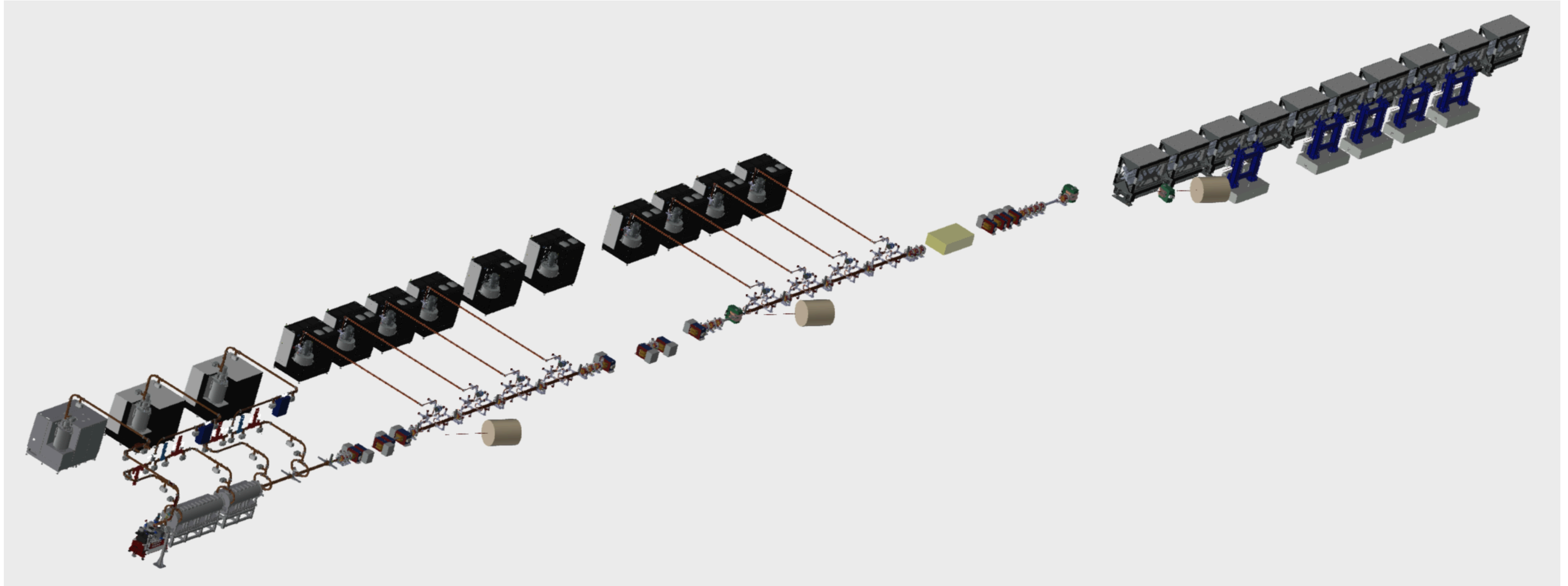


Minimum ESFRI requirement: Facility (almost) operating by 2031 – i.e. at least 1 beamline with pilot experiment / first user

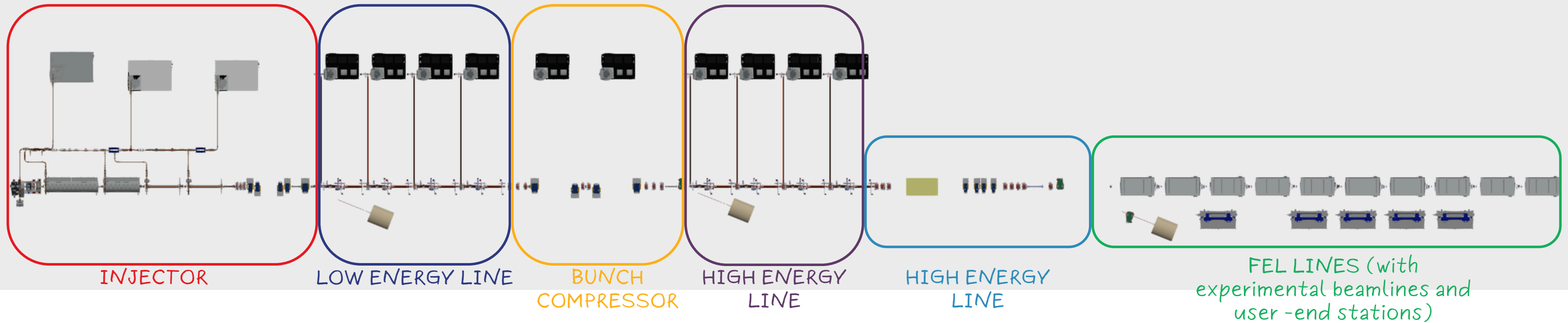
→ **Landmark**







SCOPE remained unchanged.



+ Building (see S. Incremona talk)

W.R.T. the 1st review a comprehensive analysis of the cost has been carried out (at least 2 reviews + ad-hoc adjustments).

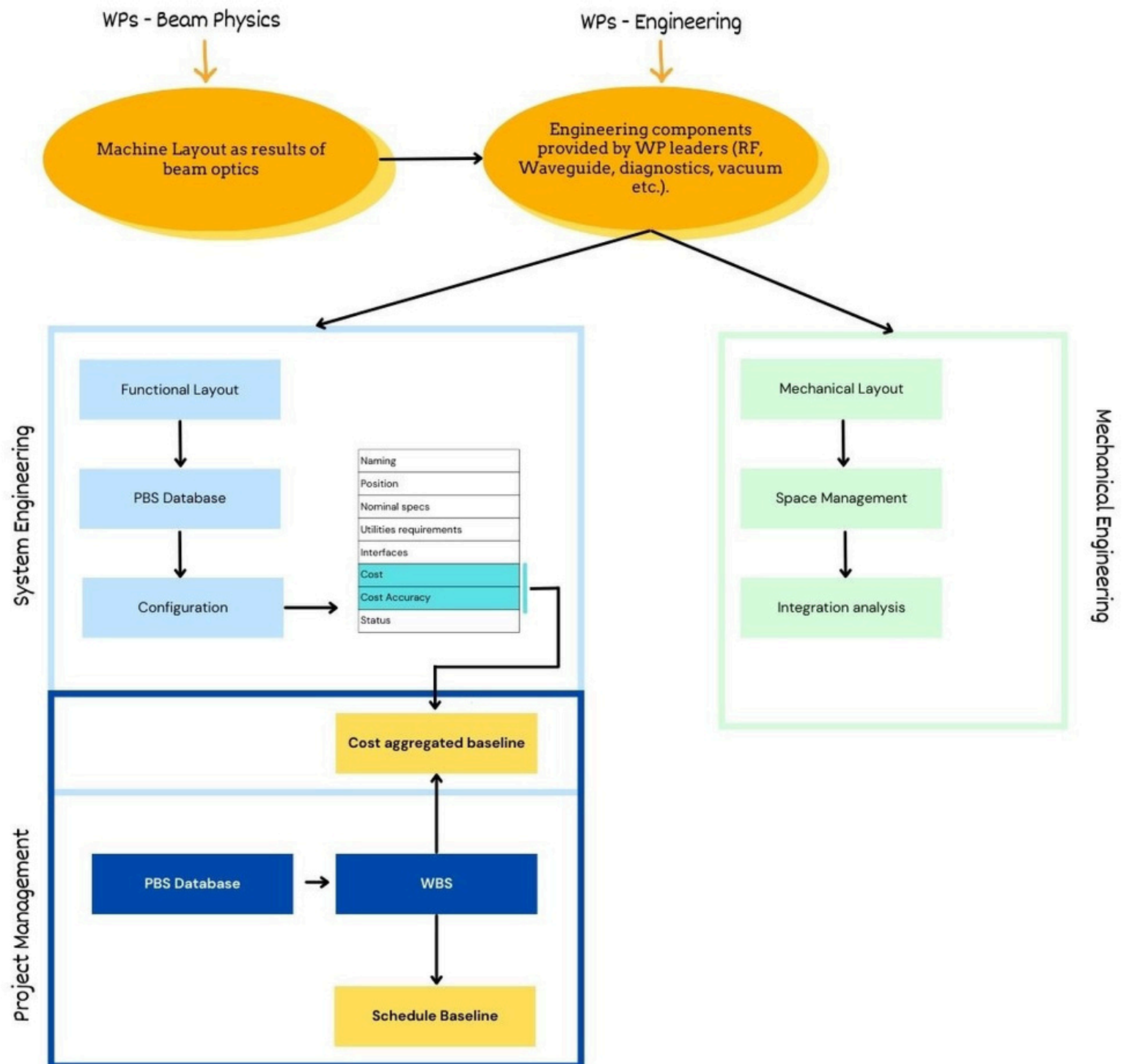
Cost are analyzed bottom-up i.e. from the PBS and WBS based (some subcontracting have been considered). Manpower cost is NOT included in this calculation.

Several changes emerged during these reviews due to a set of reasons:

- Detection of few errors in the estimation (misunderstanding with WP.Leaders).
- Update layout and additional components
- Standardization of some technical choices (e.g. vacuum pumps)
- Newer and more recent quotation for identical items
- Standardization of contingencies.

Methodology:

Cost aggregation



- Aggregation per subsystem (following hierarchic structure of the PBS)
- Aggregation per functional area – logic and consequent evolution of the implementation

Accuracy and contingencies

Accuracy

Inspired by AACE recommendation

Class	Accuracy (%)	Note
1	-5 / +5	<ul style="list-style-type: none"> • Quotation from vendors for identical items recently purchased. • Informal quotation from vendors based on advanced technical design
2	-5 / +10	<ul style="list-style-type: none"> • Comparison with similar items recently purchased • Informal quotation from vendors based on preliminary technical design
3	-10 / +20	<ul style="list-style-type: none"> • Cost incurred in similar activities in the past • Cost incurred in similar items in other facilities
4	-10 / +25	<ul style="list-style-type: none"> • Expert judgement

Contingencies

Cost estimation has been provided by the WP leaders and experts.

In order to get rid of the personal bias a general rule for contingencies have been applied.

- Most probable cost+rounding+ 5%
- Most probable number of items +5%

No spares are included

In all cases no scale economies have been considered.

Considering all of above a reasonable amount of contingencies are now included in the cost-baseline.

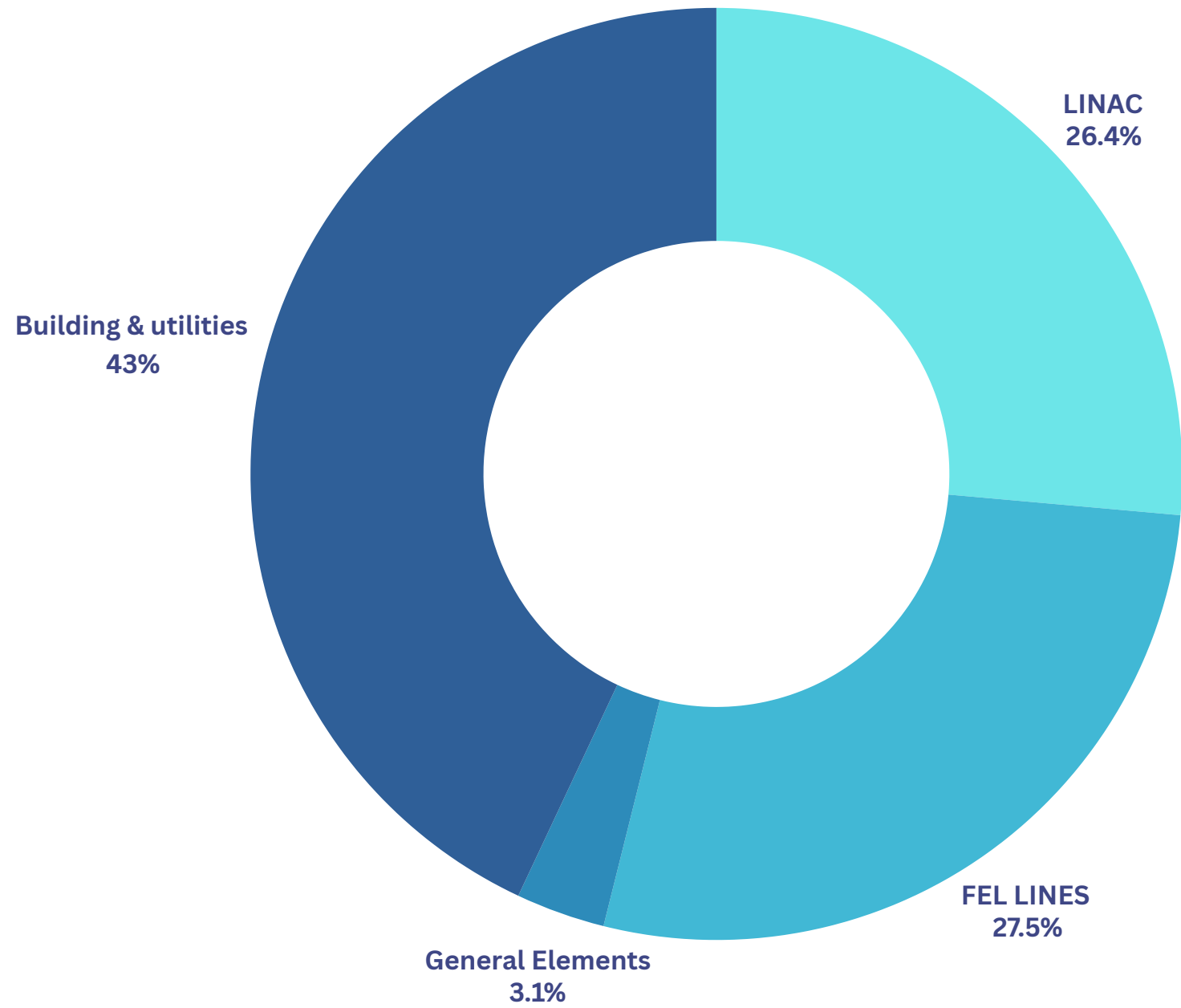
Cost per functional area

Functional Area	Estimated Cost (€)
Injector	10.999.880
Low Energy Line	9.596.380
Bunch Compressor	1.180.400
High Energy Line	9.761.760
Plasma Module	2.096.000
AQUA FEL	15.520.000
AQUA Beam Line	7.095.900
ARIA FEL	6.004.000
ARIA Beam Line	6.374.900
General Elements	3.940.740
Building	48.760.661
High-Tech Utilities	6.000.000
TOTAL	127.330.261

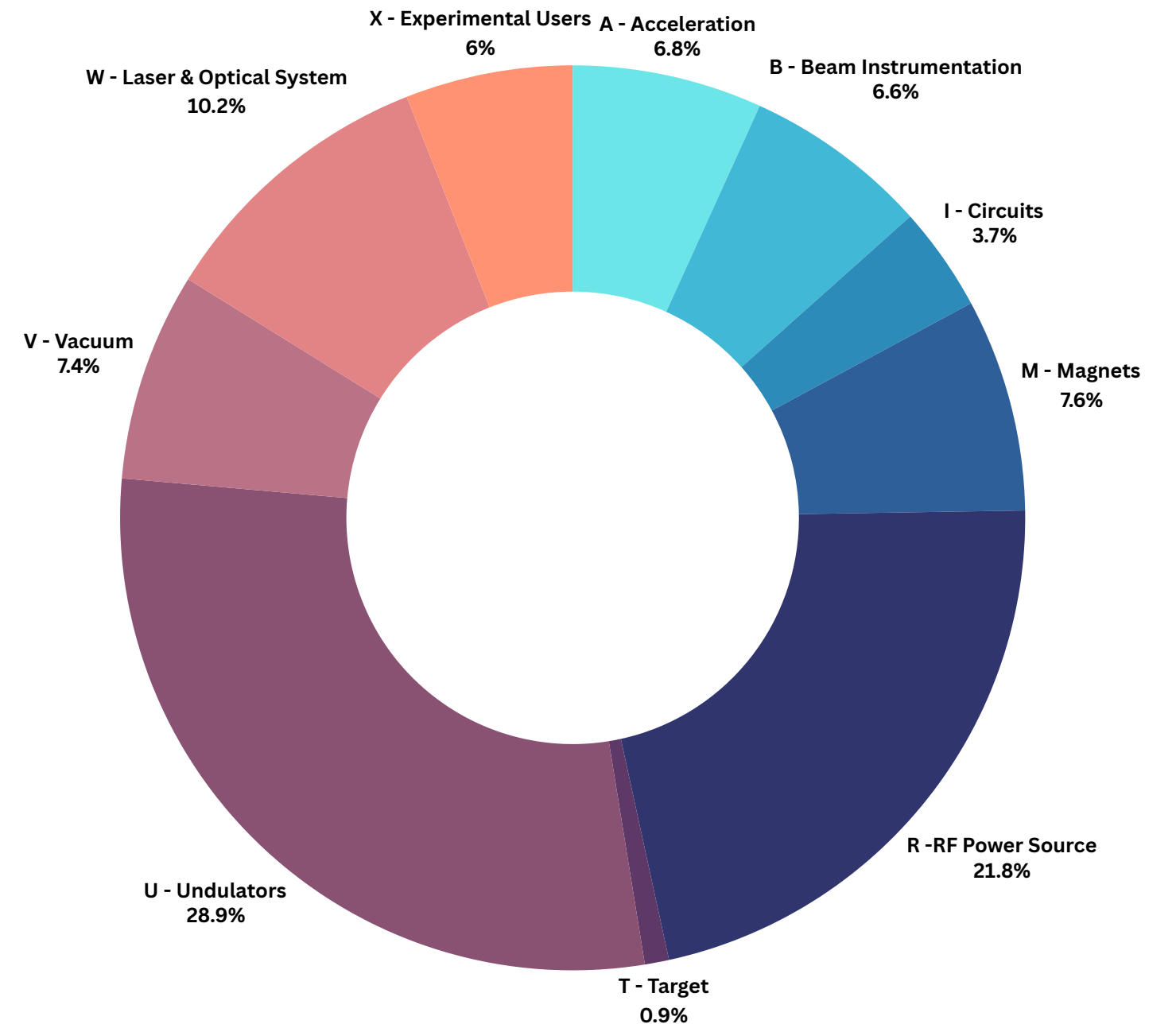
Cost per subsystem

Functional Area	Estimated Cost (€)
A - Accelerating Sections	4.657.000
B - Beam Diagnostics	4.540.000
I - Waveguides elements	2.563.200
M - Magnets	5.219.000
R - RF power Source	14.990.440
T - Beam dumps	592.980
U - Undulators	19.864.000
V - Vacuum	5.112.600
W - Laser & Optical Systems	6.990.000
X - Experimental User beam Lines	4.100.000
General elements	3.940.740
Building & High tech utilities	54.760.661
TOTAL	127.330.261

Cost distribution



Cost distribution machine



In 2019 Italian Government supported ESFRI application with a total funding of 108M€ that was meant to build 1 FEL line, the LINAC and the building with the corresponding utilities.

In the last report it was shown that considering the inflation that was still a sound estimation: 108M€ @ 2019 --> 126,9M€@2024.

In reality this is even better since our current scenario includes 2 beamlines instead of one.

Unfortunately the government funding is not inflation linked therefore a funding gap is there.

Additional Funding

During the last weeks negotiations with local government (Reg.Lazio) have been intensified and we are close to finalize an agreement for an additional 10 M€ funding for the second beam line (ARIA). This is a co-funding (10M€ Reg.Lazio + 10M€ INFN).

This is exclusively for an additional beam line (thus cannot be used for the original baseline) and has some constraints in terms of financial accounting. The second beamline must be completed in 2029 (although is not mandatory to have it fully operational).

This additional funding line makes the overall budget much more realistic and the minimum requirements for ESFRI are fully funded. However imposes additional constraints and complexity to the overall management.

1 Beam Line is fully funded with 7M€ Margin

2 Beam Lines still a gap (but lower than 1 year ago).

Phasing approach considering:

- Savings from building and other items
- Additional funding lines
- Scale economies (especially for the beam lines which have similar or equal components).

INCOME		
Option	Amount (€)	Funding Source
1 FEL Line (AQUA)	108.000.000	IT – Gov.
2 FEL Lines (AQUA+ARIA)	118.000.000	IT-Gov. + Reg.Lazio
R&D for TDR (includes storage area)	-6.500.000	
EXPECTED COSTS		
Option	Amount (€)	Delta €
1 FEL Line (AQUA)	114.951.721	-13.451.721
1 FEL Line (ARIA)	104.714.721	+6.785.279
2 FEL Lines (AQUA+ARIA)	127.330.261	-15.830.261

Building

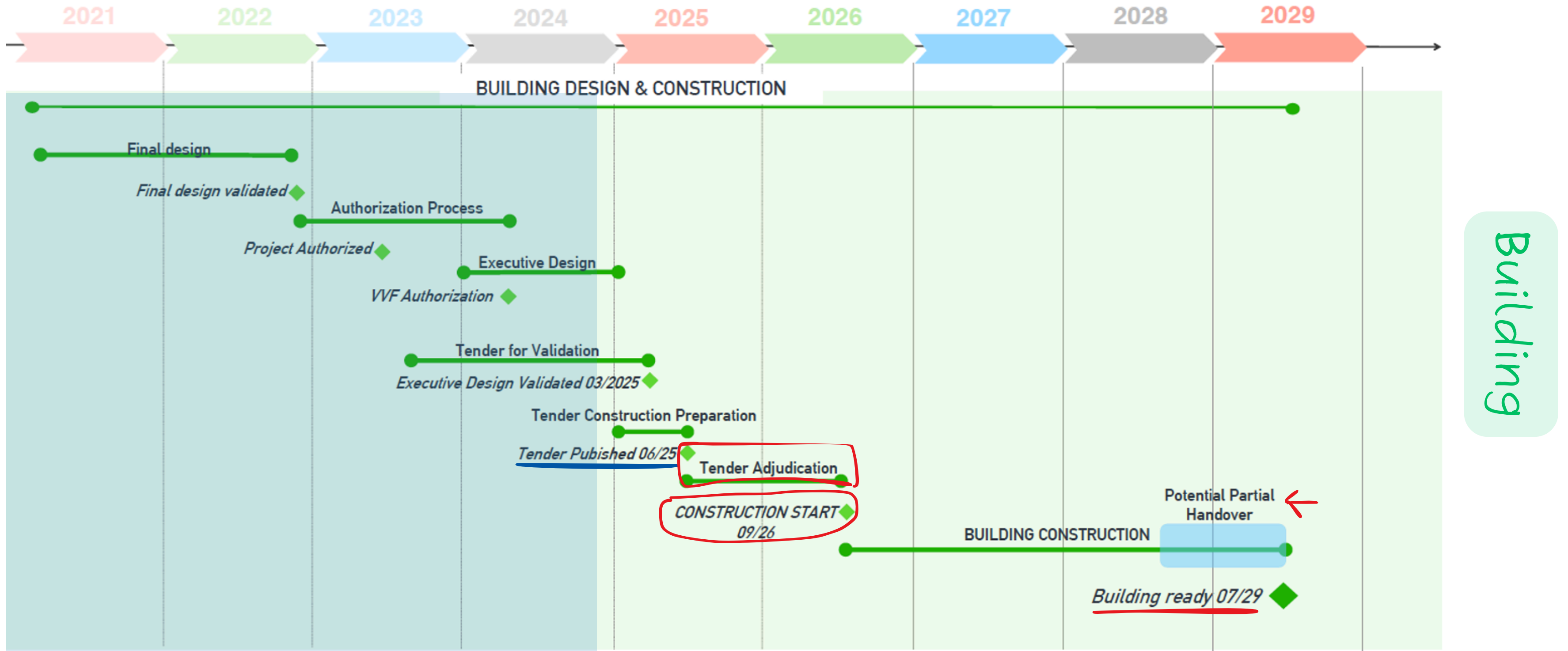
Building is a super critical activity.

TDR completion is a sub-critical activity.

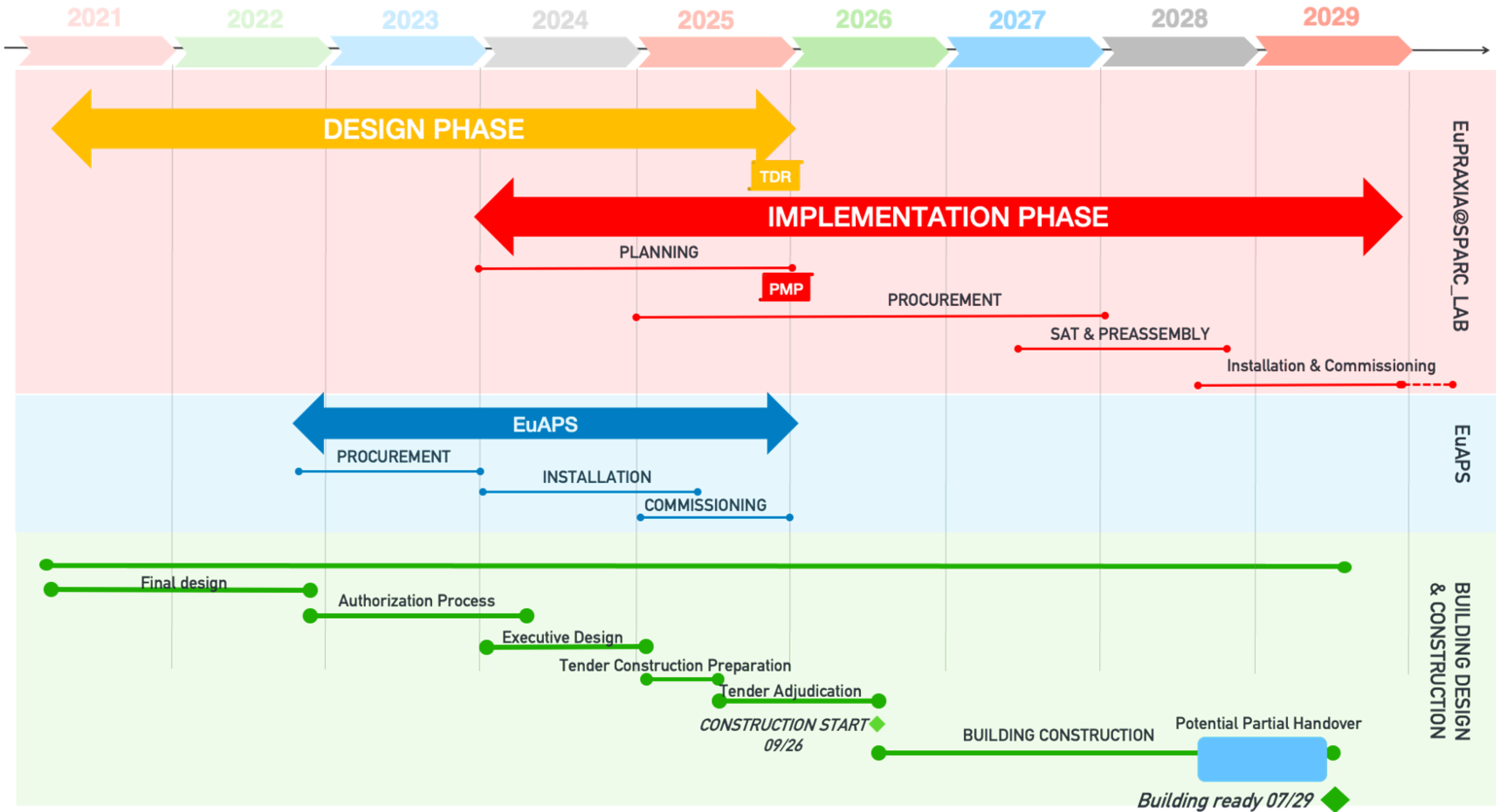
Building availability not only sets the critical milestone for triggering the installation phase but also imposes the constraints on when to start the procurement and implementation.

At beginning of 2024 it was clear that a re-baselining of the building (and as consequence of the whole implementation phase) was required due to a number of delays accumulated.

The new baseline was approved in March based on more awareness of the timing for procurement and other activities and at the moment there are no delays.



W.r.t. the old baseline now we count 1.5 year delay in total and a more refinement in the macro milestones.



Detailed schedule is not yet completed.

Macro areas are considered and a further exercise will be to set up the procurement plan for the subsystem.

Different options will be explored and adopted for the subsystem procurement strategy.

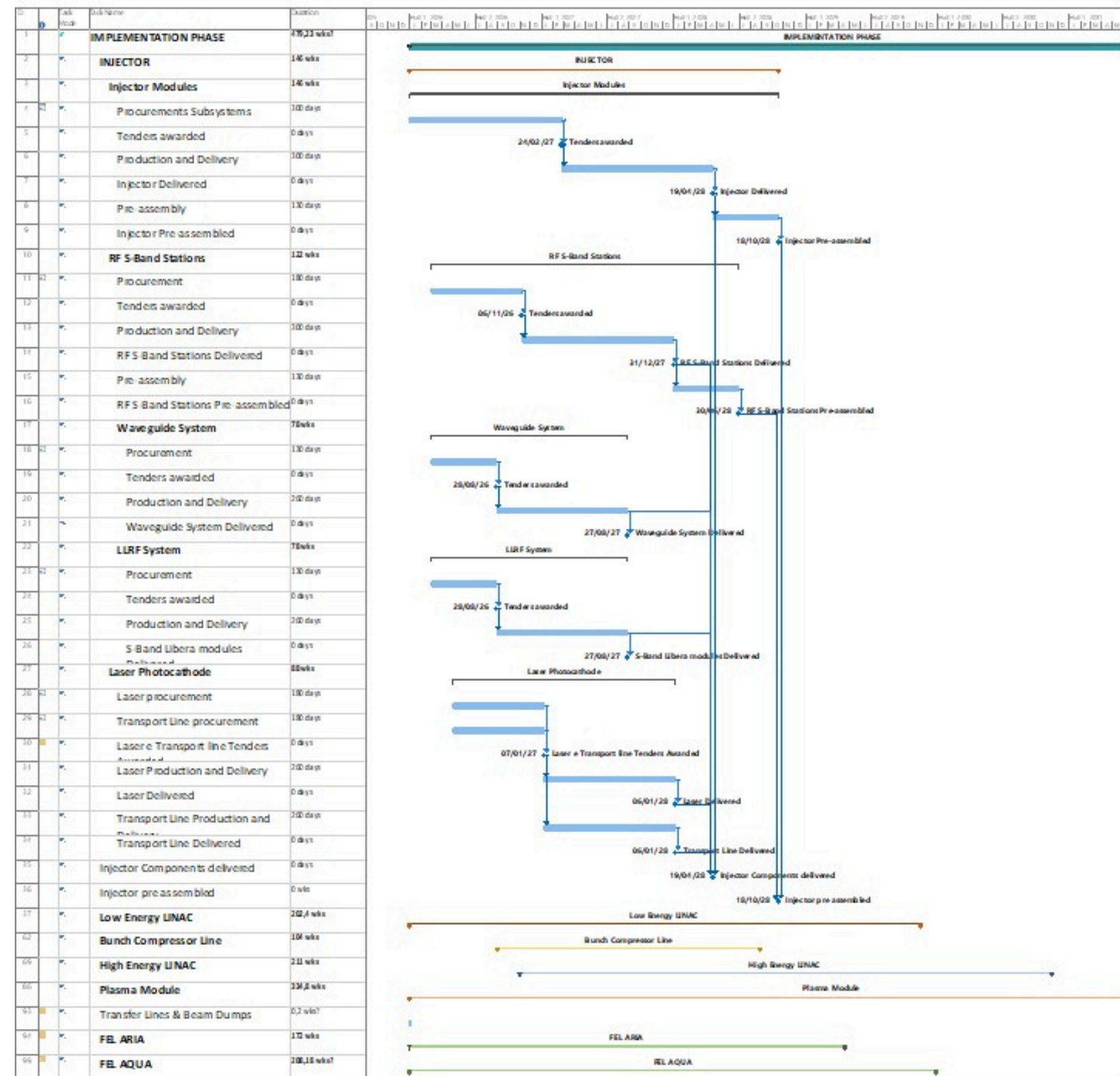
- Large Items single supplier -> 1 tender for the whole machine. different batches for a proper delivery timing. e.g. RF power sources, Undulators
- RF power source tender in principle could start even before the TDR completion. The final validation of the RF supplier is expected to be concluded in Spring 2025.
- LLRF tender is expected to be issued first semester 2025.
- Other elements will be procured based on the upcoming activity. Minimize the risk of early obsolescence and warranty expiring.

Major tenders are expected to start in 2026 after the TDR completion

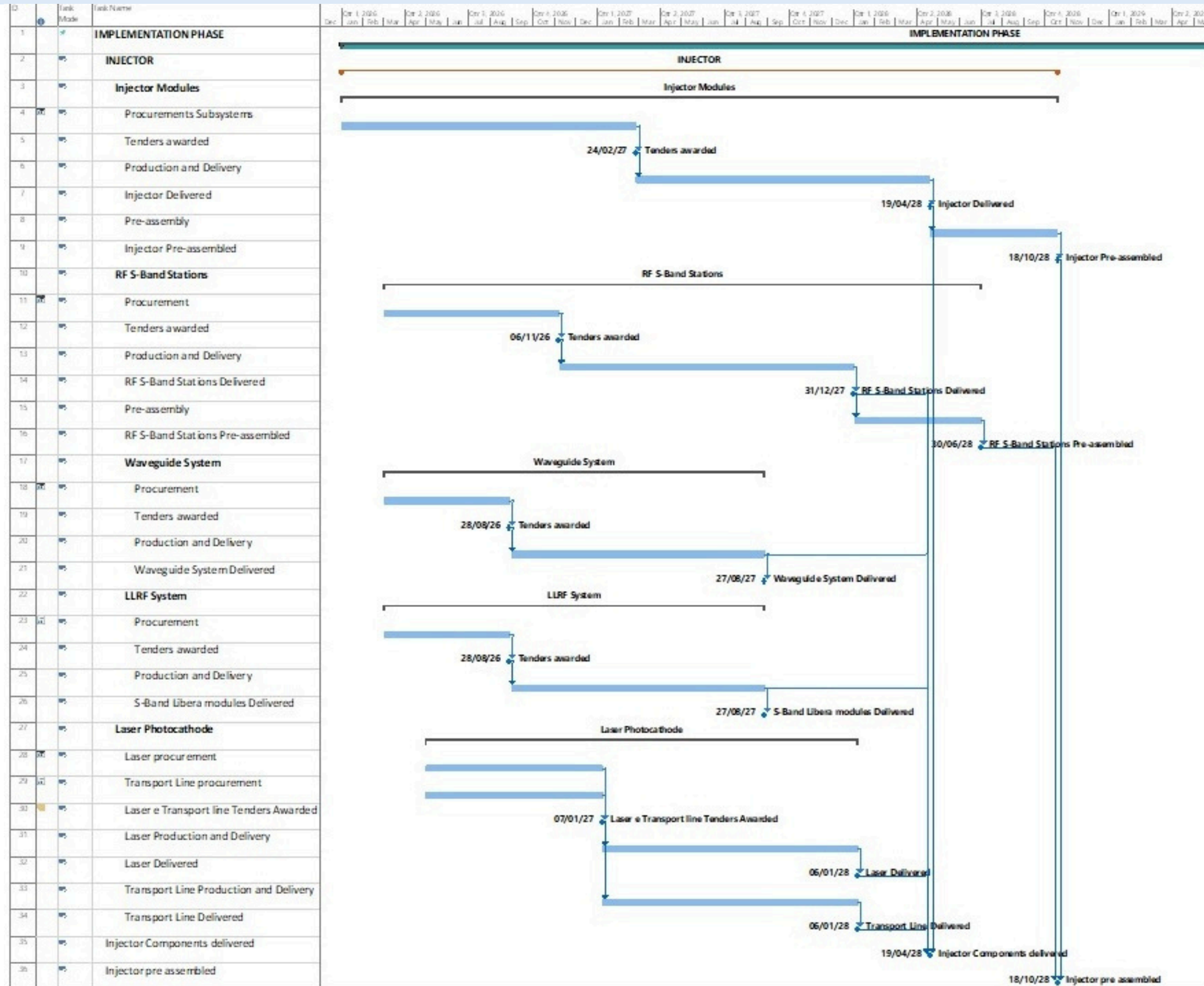
Some tenders can start even earlier:

- LLRF system should start in 2025
- RF power system could start after final validation of X-Band technology (spring 2025)
- Undulators can start in 2026/2027 (risk of lack of suppliers).

The “minor” components are missing in the schedule. This should be handled at WP level.



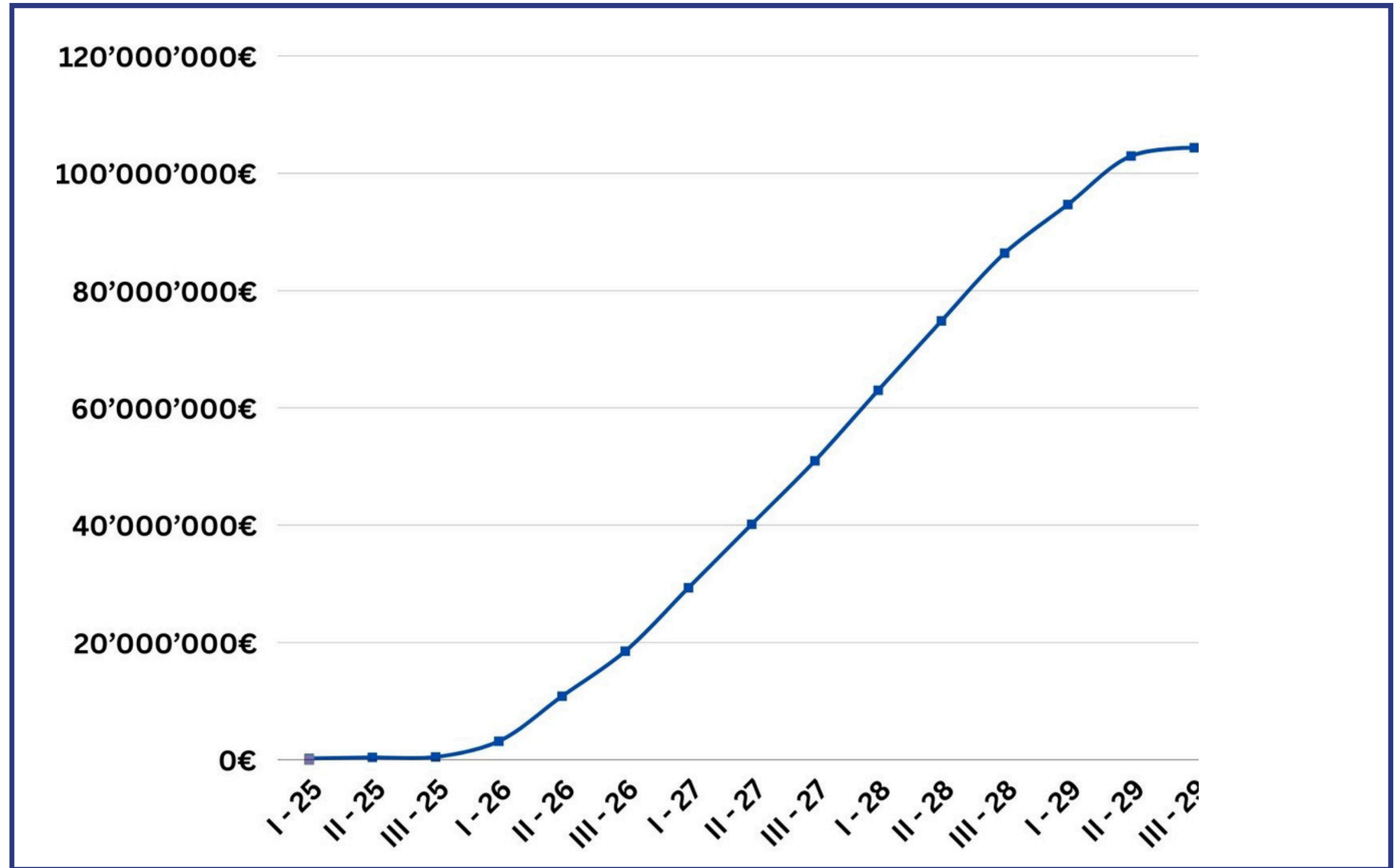
INJECTOR



Planned Value along time considering a linear distribution of the value (an approximation of course but still...).

4-months time based. Maybe for a proper EVM a denser time distribution might be appropriated.

This will be used as baseline for the EVM framework (see next slides).



Following committee recommendation a simplified version of the WBS has been done. Some similar workpackages have been integrated (especially the ones that are carried out by the same group) to reduce the total number of interaction.

For each workpackage an estimation of the total resources integrated along the life cycle has been done.

The current WBS include integration workpackages (2 to 6) and subsystem workpackages (7 to 16) that will be carried out the implementation of the subsystems.

The corresponding organization breakdown structure has to be developed and this process will involve also the management of the Lab and division heads.

The main approach that will be followed is that there will be a project board in order to steer and monitoring the progress of all workpackages and will be in charge to approve/reject changes request acting as final decision maker for the project.

WBS Implementation Phase - Resource Load					
WBS Id	WP Title	FTE R/T	Integrated FTE		Tot.
			FTE Tech		
0	Project Management & System Eng.	5			5
0.1	Cost & Schedule	3			
0.2	Quality & Procurement strategy	1			
0.3	System engineering	1			
1	Beam Physics	6			6
1.1	Simulations	2			
1.2	Virtual Measurements	2			
1.3	Diagnostics tool	1			
1.4	ML Optimization	1			
2	Injector	2			2
2.1	Injector Modules	2			
3	Linac Modules	1,5			1,5
3.1	Low Energy Linac	0,5			
3.2	Bunch Compressor	0,5			
3.3	High Energy Linac	0,5			
4	Plasma	4,5	1		5,5
4.1	Plasma Module	1,5	1		
4.2	Plasma Diagnostics	1,5			
4.3	Plasma Beam Optics	1,5			
5	FEL Line	4			4
5.1	AQUA	2			
5.2	ARIA	2			
6	Beam Line	4			4
6.1	AQUA	2			
6.2	ARIA	2			
7	RF System	6,5	8		14,5
7.1	S-Band RF Station	0,5	1,5		
7.2	X-Band RF Station	0,5	1,5		
7.3	S-Band Waveguide	0,5	0,75		
7.4	Pulse Compressor-SLED	0,5	0,75		
7.5	X-Band Waveguide	1	0,5		
7.6	Pulse Compressor - BOC	1	0,5		
7.7	LLRF S-Band	0,75	1		
7.8	LLRF X-Band	0,75	1		
7.9	Timing & Synch.	1	0,5		
8	Accelerating Sections	4,5	4,75		9,25
8.1	RF Gun	1	2		
8.2	S-Band Sections	0,75	0,75		
8.3	X-Band Sections	2	1		
8.4	Polarix	0,75	1		
9	Diagnostics	3	2		5
9.1	Longitudinal Diag.	1,5	1		
9.2	Transverse Diag.	1,5	1		
10	Laser	6	3		9
10.1	Photo Cathode Laser	2	1		
10.2	Laser heater	2	1		
10.3	Optics and transport line	2	1		
11	Control System	4,75	2		6,75
11.1	EPICS Control Systems	1,5	1		
11.2	Interlocks	1	0,5		
11.3	High Level App.	1,5			
11.4	Machine Protection System	0,75	0,5		
12	Vacuum System	6	4		10
12.1	Vacuum Valves	2	1		
12.2	Vacuum Pumps	2	1		
12.3	Vacuum Chambers	1,5	1		
12.4	Vacuum Gauge	0,5	1		
13	Magnets & Power Supply	5,5	4		9,5
13.1	Solenoids	1	0,5		
13.2	Quadrupoles	1	0,5		
13.3	Dipoles	1	0,5		
13.4	Vertical & Horizontal Correctors	0,75	0,5		
13.5	Permanent Magnets	1	1		
13.6	Power Supplies	0,75	1		
14	Civil Infrastructures	7	4		11
14.1	Building	3			0,5
14.2	Hi Tech Utilities	3	3		0,5
14.3	Conventional Safety	1	1		0,5
15	Radioprotection	1	1		2
15.1	Beam Dumps	0,5	0,5		0,2
15.2	Radioprotection System	0,5	0,5		0,2
16	Mech. Eng. & Integration	5,5	11,5		17
TOT		76,75	45,25		122

Resource estimation at WP level has been done and confirms the previous estimation (with some minor changes).

A more detailed analysis of the time profile of the resource loading has been elaborated.

Resource estimation at WP level has been done and confirms the previous estimation (with some minor changes).

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The first 2.5 years the major resource loading concerns Technologists for tender procedures, executive design etc.
in 2027 technicians start to be fully involved.

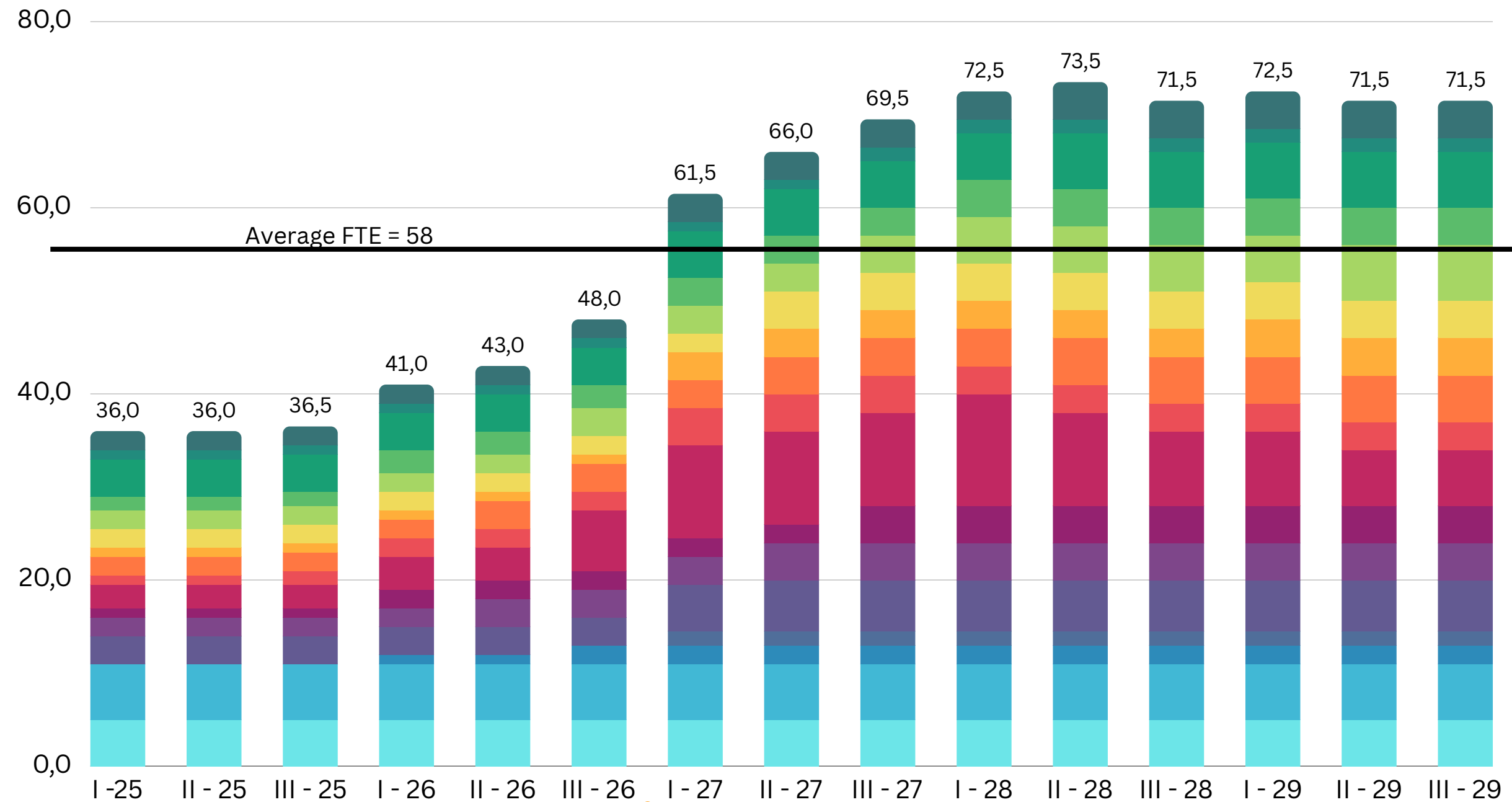
On average 58FTE will be required with a peak in the final part (installation / integration / commissioning) of about 70FTE.

This does not include possible external contributors from partner institutions: UniRoma1, UniRoma2, ENEA, INFN-Mi, Elettra. They can contribute up to 10 FTE in total approximately.

According with the high level schedule a tentative layout of the resource loading along time is done for each workpackage.

Average of about 58 FTE per year will be required.

Resources start increasing in 2027 when the first integration on site kicks in.



Start the first integration on site
(storage and pre-assembly area)

Resource allocation strategy

In principle most of the resources required are available at LNF provided that the current temporary contracts will be confirmed (i.e. transformed into permanent contracts) and no side projects show up.

There's a potential shortage of resources in few groups (controls, magnets, mech.eng., vacuum) to be addressed in the future.

The overall mapping of the resource allocation within the different activities in the Lab. is now monitored by the recently introduced Project Management Office. This will help to assess the real allocation of the resources and in case help decision makers to re-align this allocation with the strategic goals of the Lab.

The recent budget law imposed a restriction of new recruitments (turnover at 75%). This will lead to potential issues concerning the total workforce in the future.

A risk assessment methodology has been adopted based on the quality assurance plan of INFN.

From PMO perspective only cost&schedule risks are considered.

Risk ID	Risk category	Risk owner	Risk Event	P	I cost	I schedule	Risk rating	Mitigation actions
RT1	Time delays	WP leader	Procurement procedures	H	-	M	High	Early Procurement + Follow up of the tender
RT2	Time delays	WP leader	Long delivery time	M	-	M	Medium	Solid Tech. Spec. document + a Dedicated resource
RT3	Time delays	PMO	Resource allocation	L	-	M	Low	Resource allocation + Task monitoring by the Project Office
RC1	Cost increase	Proj.Board	Uncertainty in scope of work	L	L	-	Low	Advanced TDR + Quality control of tender docs
RC2	Cost increase	WP leader	Raw material cost	L	L	-	Low	Monitoring of global developments
RC3	Cost increase	Proj.Board	Additional items not considered in the baseline	L	M	-	Low	Continuous follow-up through periodic meetings with WP-leaders



DocID	Rev.	Validità
INFN-PM-QA-305	1.0	Rilasciato

Data 14/03/2023

Piano Qualità - Procedure

Gestione dei Rischi

In questo documento si stabiliscono le linee guida necessarie per gestire i possibili rischi che potrebbero presentarsi durante il ciclo di vita di un Progetto. L'obiettivo di questo documento è di fornire le procedure per l'identificazione e la valutazione dei rischi, le azioni da intraprendere in caso si manifestasse un rischio e come controllarli nel corso del ciclo di vita.

Autore	Verificato da	Approvato da
L.Leonzi B.Martelli	GdL Project Management	A.Variola

Lista di distribuzione:
- Documento Pubblico

2 main risks can be highlighted.

Procurement Procedure

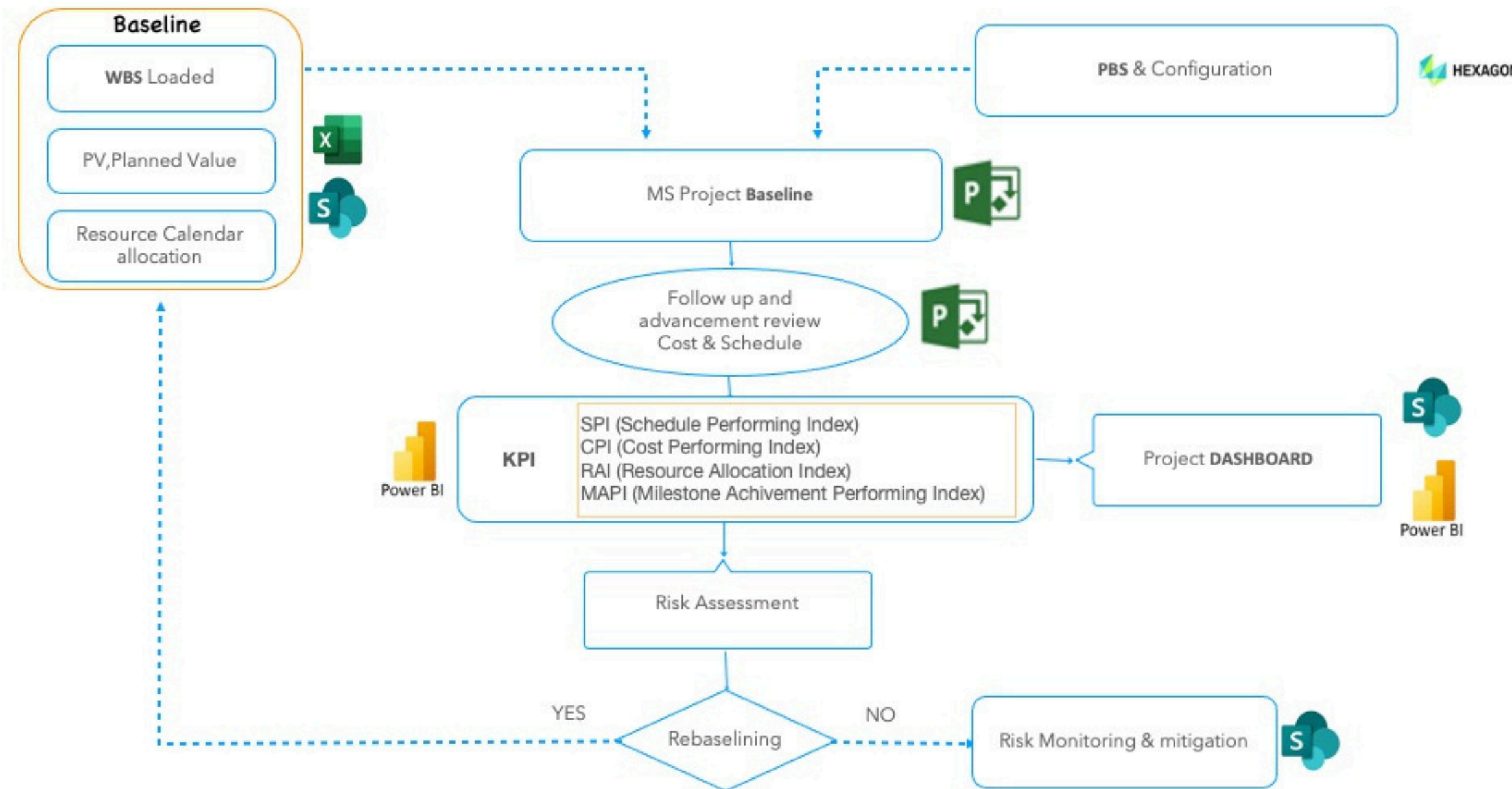
Procurement procedures have become more and more complicated to be handled. The recent experience from PNRR projects show that a large tender can take up to 8-12 months to be finalised. The main mitigation action that can be taken whenever is possible is to anticipate the tender as much as possible. It might be possible that considering the PNRR concluded in 2025 the amount of work to be carried out by the administration will be lower and thus mitigating this risk that still remain consistent.

Supplier issues

For critical items there are only very few suppliers (in some cases only 1) usable. This might imply a weak contractual power and in some cases they are not big companies and the possible amount of work that will be asked will be at the limit of their capabilities (e.g. undulators).

EVM will be the only methodology that will allow an integrated monitoring and control tool for cost & schedule.

Not practical advancement w.r.t. the last meeting. The overall architecture has remained unchanged.



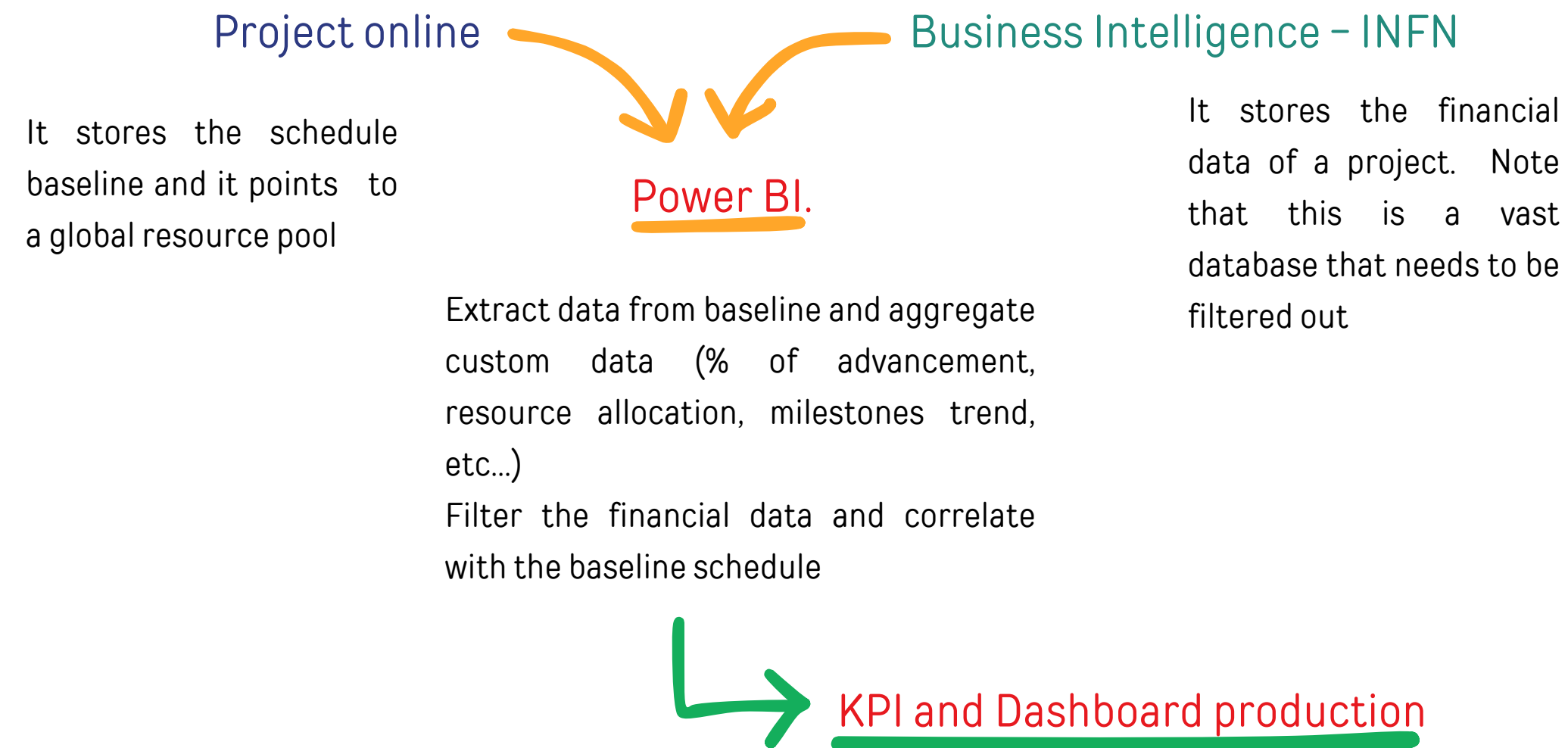
Tools to be used

- Project Online
- Hexagon asset management
- PowerBI

Criteria to be analyzed

- Economic evaluation of the milestones.
- Criteria to assess the % of advancement (25% steps or denser?)

At the moment we have just started an intense program to implement a portfolio management framework for a subset of the project within the Lab. This include also the implementation of an EVM tool to be used in the short term for the EuAPS project as benchmark for EuPRAXIA@SPARC_LAB. This exercise will be ready beginning of 2025. Its deployment is foreseen in spring 2025 and a possible temporary additional resource can help for a fine tuning and/or debugging.

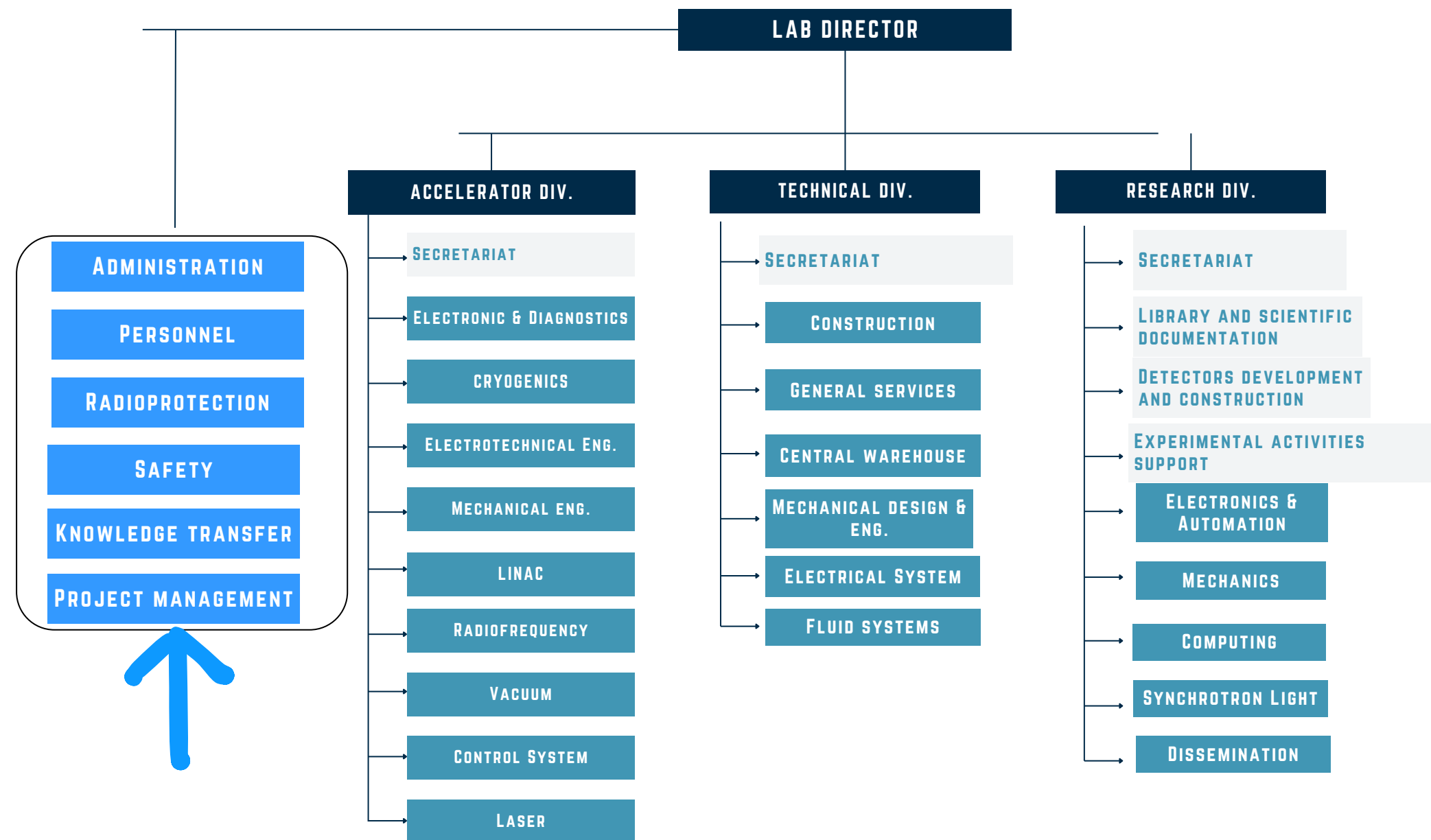


- Note that the financial data cannot (for technical reasons) be associated to a single workpackage.
- It will be possible however to track large tenders (which are easily identifiable) and in any case have a global view of the actual cost divided in different categories
- The EVM methodology therefore can be implemented at macro level. At single WP level there might be some errors.

On the 26th June 2024 the boards of directors (*Consiglio Direttivo*), approved the updated organization structure of Frascati National Laboratory.

MANDATE

- supports LNF Management in the implementation of Project Management best practices and methodologies for the management of the Laboratories projects;
- promotes the constant training and updating on the Project Management methodologies of all the workers in collaboration with the INFN central structure;
- assists the Director, Division heads and Project Managers in the identification of any project risks in terms of availability of human and material resources;
- suggests to the Management of the Laboratories the standards of Project Management and Quality Control to be used for the management of the Laboratory projects (methodologies and software);
- supports the Director and Divisions heads in the harmonization of the different projects of the Laboratories.



and its implication for EuPRAXIA

As consequence of the formal mandate the PMO has to:

- Implement PM best practice.
- Monitor resource allocation and provide quantified information to the decision makers for re-alignment of the allocation with the strategic objectives.
- Implement PM tools
- Training on PM topics.

All of these are aimed to improve the Project Management Maturity Level within the Lab and it certainly will boost the EuPRAXIA@SPARC_LAB project management activities.

This unit has been set up just a couple of months ago and the impact will be (hopefully) measurable in the near future.

DONE

- Update schedule baseline
- Update cost baseline (additional funding and mitigation of the budget gap)
- Some progress on resource allocation
- Risk register implemented

TO DO (among many many other things)

- Detailed schedule and procurement planning
- Finalize decision on the phasing approach for the missing budget
- Full implementation EVM framework
- Redaction of the Project Management Plan (End 2025)