Project Board 05.11.2026

WP STELLARATOR

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High-level objectives of WPSTEL in 2026–2027

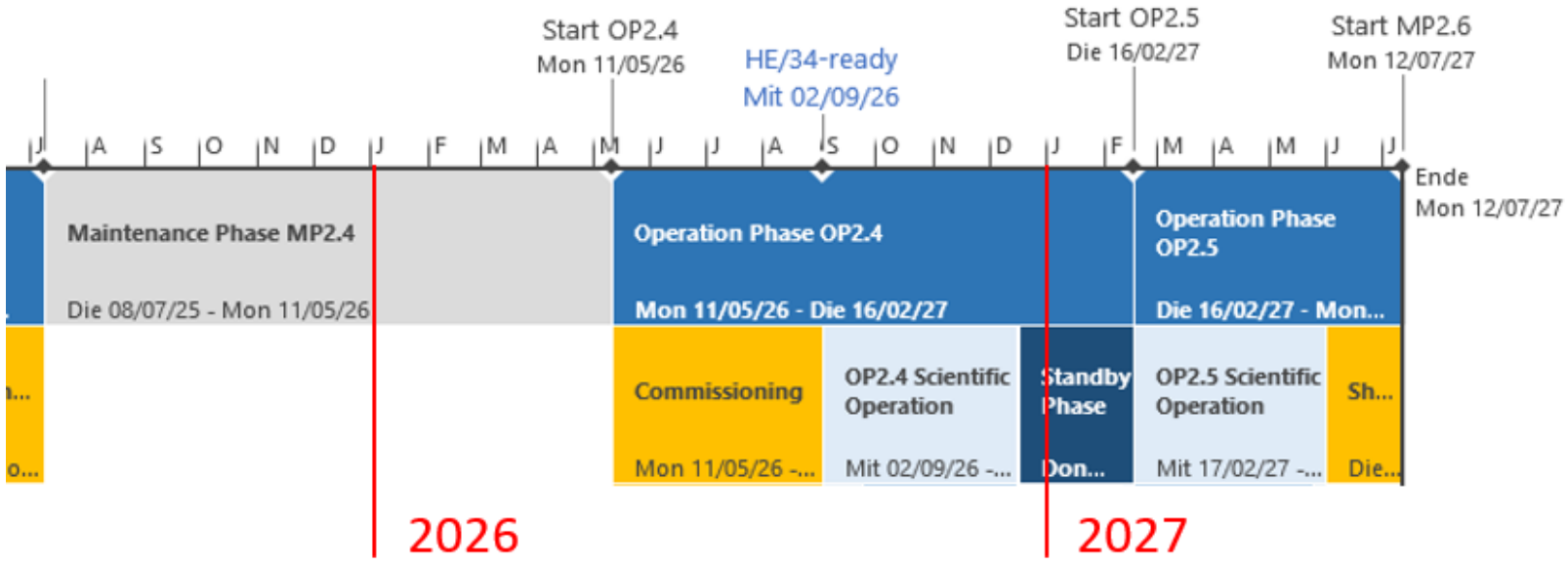
WPSTEL covers the EUROfusion contribution to the exploitation of Wendelstein 7-X and stellarator reactor studies.

- *Overarching goal:* Provide a physics and technology basis for the assessment of stellarators as reactor candidates.

High-level objectives for 2026–2027, grouped into **three main areas, A1, A2 and A3.**

A1. Preparation, execution and exploitation of W7-X campaigns in 2026–2027

- Long pulse, high-performance scenarios based on profile control at reactor-relevant ν and β.
- Assessment of the optimization of the magnetic configuration at reactor relevant parameters on: fast particle behavior, MHD equilibrium and stability, etc.



High-level objectives of WPSTEL in 2026–2027

A2. Assessment on physics gaps for the development of stellarator reactors

- Identification and analysis of key physics uncertainties between present-day stellarators and a future reactor.
- Determination of which ones can be addressed within WPSTEL, and develop recommendations.

A3. Stellarator reactor studies

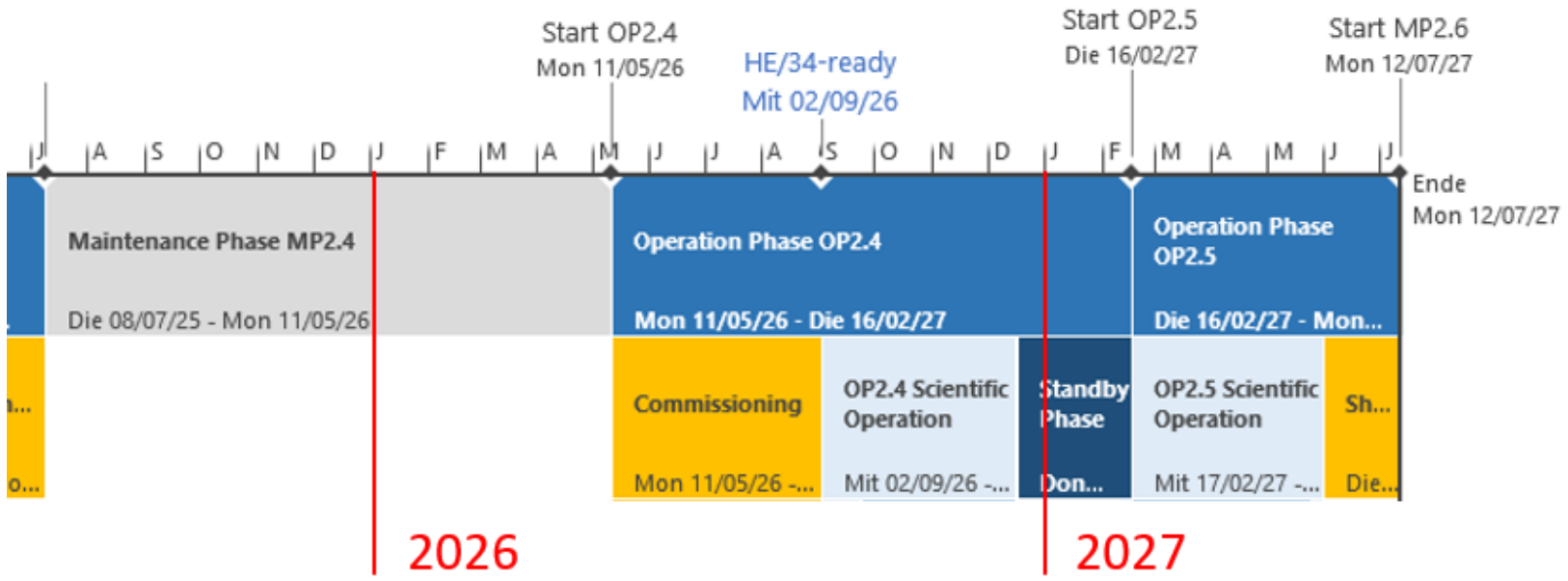
- Identify and further analyse a small set of the most advanced next-generation optimised stellarator configurations and associated coil designs, in close coordination with engineering studies.
- Adapt and assess blanket concepts for 3D stellarator geometries.
- Outline remote maintenance needs and constraints for stellarator reactors.

Current structure of WP STEL

Exploitation of W7-X	Key Physics Gaps	ITER, Enhancements	Stellarator DEMO
Campaign participation incl. missions in 2026 and 2027	Continue work of expert group (EPS talk, paper)	Diagnostic systems for ITER	Coil design for advanced configurations
Preparation of the campaign in 2026 and 2027	Address high priority key physics gaps	High power gyrotrons	Neutronic calculations and tools for neutronic analysis
Exploitation of W7-X aligned with Grand Deliverables	HELIAS physics basis and stellarator database	Large diagnostic projects: MATEO, sFILD	Development of 3D blanket structures

Objectives of WP STEL

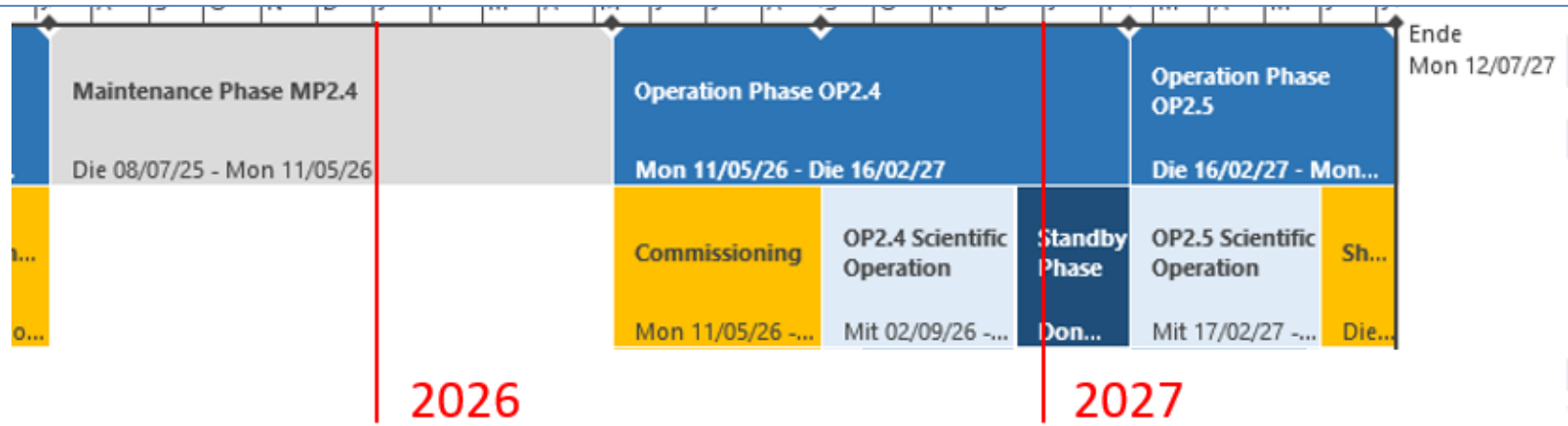
WPSTEL-2026/2027.O1	Conduct and support the 2026/2027 campaigns of W7-X The campaigns in 2026 and 2027 will be implemented involving the responses to the 2026/2027 WPW7X Call for Participation.
WPSTEL-2026/2027.O2	Carry out the development of the diagnostics (spectroscopy systems, reflectometry, video, probes, endoscopes) as a preparation of the campaign.



Objectives of WP STEL

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WPSTEL-2026/2027.O2	Carry out the development of the diagnostics (spectroscopy a

- Two campaigns are planned: OP2.4 in 2026 and OP2.5 in 2027. OP2.4 is scheduled for 12 weeks, while OP2.5 is limited to 9 weeks because it is followed by a longer installation break.
- Contrary to earlier expectations, however, demand for participation from researchers remains at the same level in both years and therefore requires the same level of funding.
- We originally planned to shift some of the resources to 2026, but they were left unused so that they remain available in 2027.



Objectives of WP STEL (continued)

WPSTEL-2026/2027.O3	Analyse and model campaign results. Use other facilities (TJ-II, Uragan-2M) to validate scenarios and tools that can be applied to W7-X
WPSTEL-2026/2027.O4	Address HELIAS physics gaps
WPSTEL-2026/2027.O5	Carry out the development of the system enhancements and ITER support.
WPSTEL-	and continue Prepare IMAS
WPSTEL-	d lay out plans hat can be the
WPSTEL-2026/2027.O8*	Continue the collaboration with TSVV-13 in order to enhance the capabilities of micro-turbulence modelling in W7-X via development of the currently available gyrokinetic codes, their verification and their application to specific transport problems.
WPSTEL-2026/2027.O9	Carry on developments for Stellarator Power Plant Studies as indicated below.

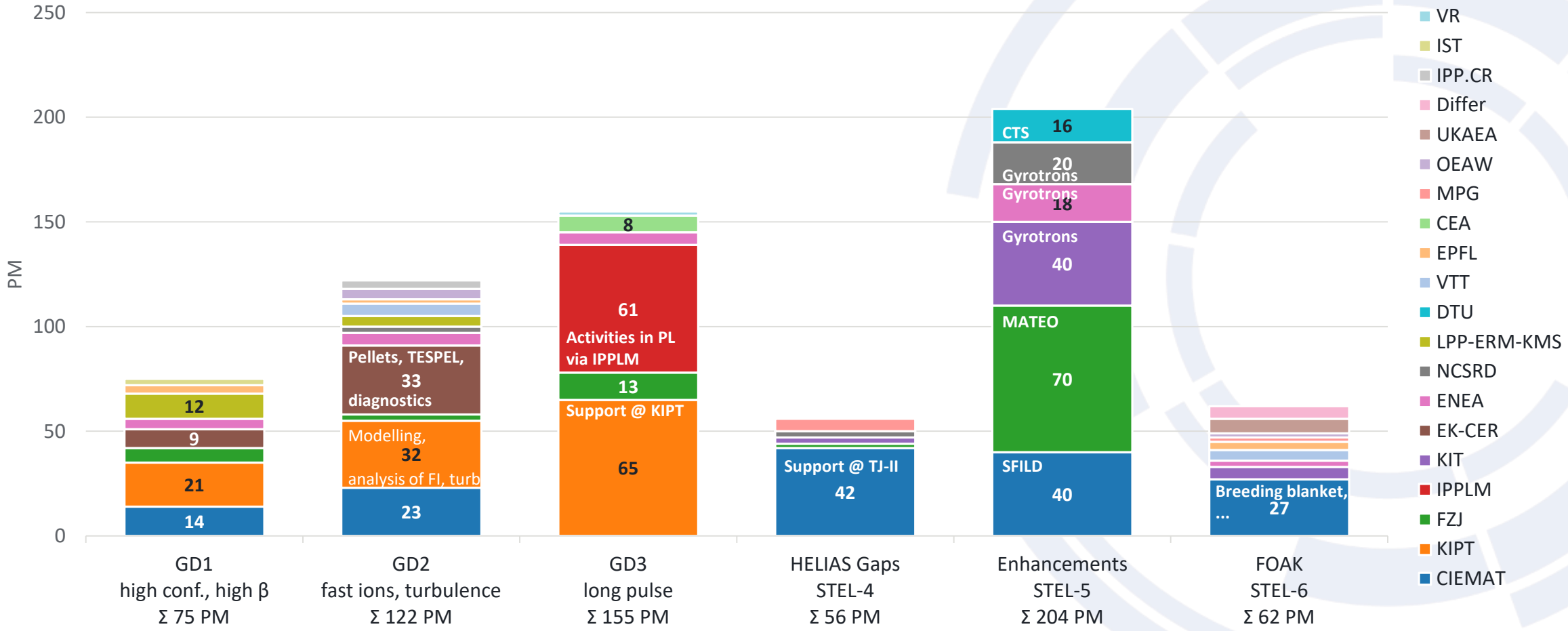
- Deliverable owners report no major delays.
- The SFILD diagnostic is slightly behind because the W7-X constraints turned out to be more complex than expected.
  - This delay will be fully recovered in 2027, and the diagnostic will be ready for installation next year.

Resource allocation for 2026 and 2027

WBS ID	Sub-project	Manpower [PM]	E&GS (incl. use of facilities) [k€]	Missions (actual) [k€]	CC resources [k€]	Total resources [k€]	Related GD/GM
STEL-1	Project Management	28.8	-	325	462	661	
STEL-2	Exploitation of W7-X: GDs + campaign	423 (incl. 50 NA, 22 AR)	-	-	1101	2307	GD1-3
STEL-3	Machine Operation (W7-X)	469.8	4496	-	8324	10406	
STEL-4	HELIAS key physics gaps	76 (incl. 7 AR)	-	-	244	521	
STEL-5	ITER, Enhancements	204		-	881	1762	GD1-3
STEL-6	Stellarator DEMO reactor	58	-	-	206	412	
2026 Total		**789.8 (+469.8)**	**(4496)**	**325**	**11218**	**16068**	
STEL-1	Project Management	28.8	-	325	465	664	
STEL-2	Exploitation of W7-X: GDs + campaign	423 (incl. 50 NA, 22 AR)	-	-	1106	2320	GD1-3
STEL-3	Machine Operation	424.5	4120	-	7633	9541	
STEL-4	HELIAS key physics gaps	68	-	-	244	488	
STEL-5	ITER, Enhancements	157	-	-	678	1357	GD1-3
STEL-6	Stellarator DEMO reactor	58	-	-	209	418	
2027 Total		**734.8 (+424.5)**	**(4120)**	**325**	**10335**	**14788**	
GRAND TOTAL		**1524.6 (+894.3)**	**(8616)**	**650**	**21553**	**30856**	

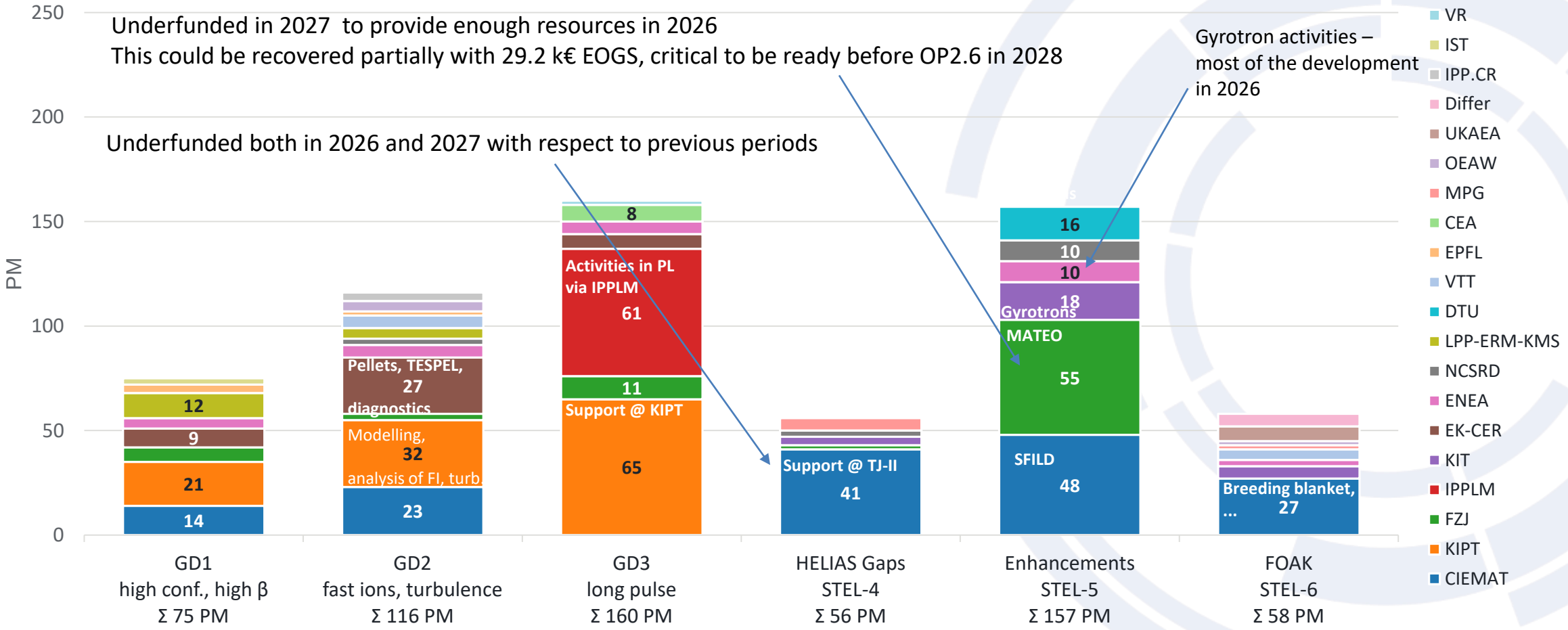
Spending over plan in 2026...

Total 674 PM across GD1–3, HELIAS Key Physics Gaps, Enhancements and FOAK, split by beneficiary



...led to several areas underfunded in 2027

Total 622 PM across GD1–3, HELIAS Key Physics Gaps, Enhancements and FOAK, split by beneficiary



Source: Level-3 structure task specifications 2027 (planning, 28.09.2026). GD1–3 = STEL-2.2 tasks by GD tag; HELIAS Gaps = STEL-4; Enhancements = STEL-5; FOAK = STEL-6. EK-CER "Video GD2 – long pulse" tasks counted as GD3. Not shown: STEL-1 (management), STEL-2.1 (W7-X campaign, not allocated), STEL-3 (machine operation).
Colours per beneficiary as in the 2026 charts.

ITER, Enhancements

Activity	BEN	PM (2026)	PM (2027)
2 MW gyrotron: Resonator	ENEA	16	8
2 MW gyrotron: Exp Testing	KIT	40	18
2 MW gyrotron: MultiPhys	NCSRD	20	10
MATEO	FZJ	70	55
sFILD diagnostics	CIEMAT	40	48
Dual Thomson Scattering	ENEA	2	2
CTS system upgrade	DTU	16	16

Depreciation schedule

Assumptions:

- FZJ depreciation period of 8 years
- Asset values and start dates as informed by FZJ DMA
- Endoscope #4 under construction → estimated

	start date	value	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	FP8	FP9	beyond
ICRH	Sep 2021	1,397				58	175	175	175	175	175	175	175	116		0	757	640
Endos-	Jan 2018	350	44	44	44	44	44	44	44	44						131	219	0
copes	Sep 2019	240		10	30	30	30	30	30	30	30	20				40	150	50
(4)	Oct 2021	317				10	40	40	40	40	40	40	40	30		0	168	149
	Jul 2022?	336					21	42	42	42	42	42	42	42	21	0	147	189
Total		2,640	44	54	74	142	309	330	330	330	286	276	256	188	21	171	1,441	1,028

(HW/Equipment in k€ direct cost)

2026 depreciation costs provided after recent GA meeting.
2027+ not yet provided.

Source: PMU, Petra Haucke | FZJ HW for W7X Enh | Mar 2022 | Page 12

Stellarator DEMO reactor activities in 2026/2027 (58 PM)

- The budget made available by the PMU in April increased from €134k to €204k by reassigning internal resources, this is an important area of research. Overspending encouraged by PMU in 2025.
- Two coordinators were appointed to improve the streamlining of task definition and monitoring.
- The definition of key technological gaps for stellarator reactors (with TRLs) can be carried out in FP9 or at the beginning of FP10.

Activity	PM	BEN
Expert on development of stellarator reactor: Coordinator (Iole Palermo)	2	CIEMAT
Expert on development of stellarator reactor: Coordinator (Felix Warmer)	2	MPG
Remote maintenance in a stellarator	4	UKAEA
3D blanket for a stellarator reactor	25	ENEA, KIT, CIEMAT*
Neutronics, Monte Carlo simulations, high and low fidelity modelling	23	CIEMAT (UNED), KIT, VTT, DIFFER, UKAEA
Advanced optimized configurations and coil systems	2	ÖAW (TU Graz)
Thermo-mechanical analysis of 3D blanket structures (0 PM in 2027, no resources left)	0	EPFL
Total	**58**	

Preparation of FP10

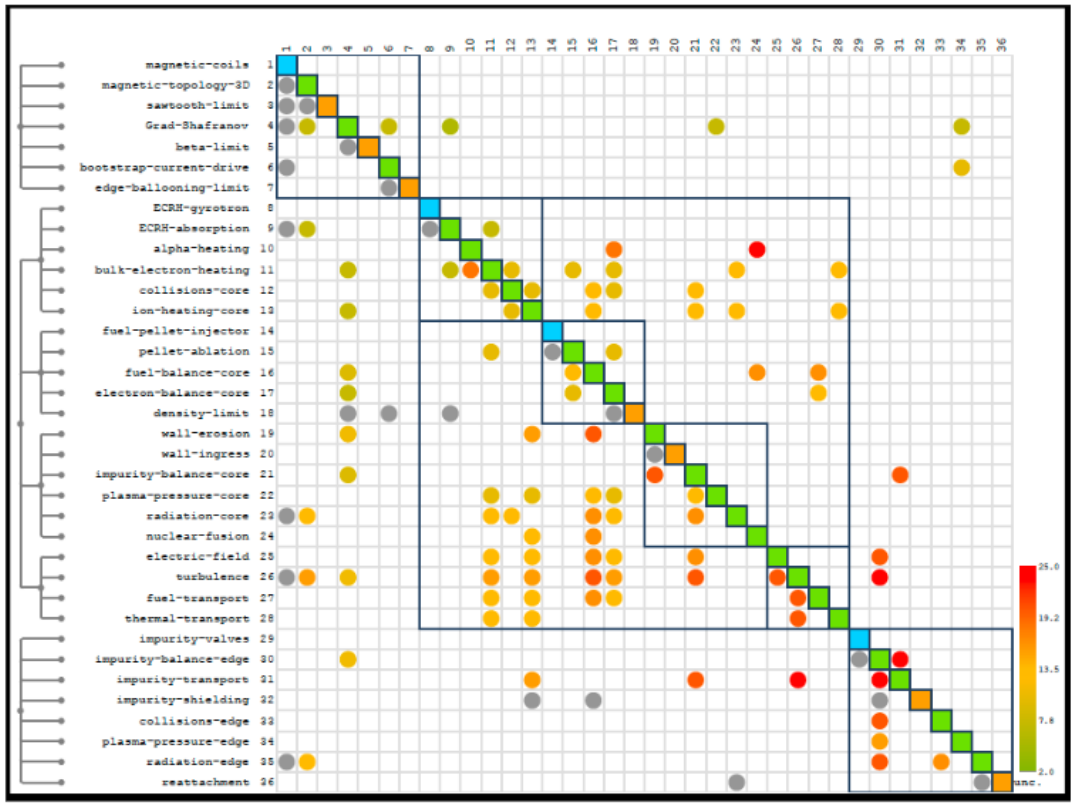


Figure 5 Physics Uncertainty for Stellarators: from W7X to Helias.

- The **fundamental differences** in physics, control strategies, and technology between a stellarator and a tokamak FoAK **require dedicated, stellarator-specific development programs**.

- **At least one intermediate experimental device is required** between W7-X and a stellarator FoAK to resolve critical physics uncertainties under reactor-relevant conditions, in particular:

  - Alpha-particle confinement and turbulence at reactor-relevant parameters.
  - Plasma operation at high magnetic fields.
  - All-metal plasma-facing components under high power density and steady-state conditions.

- **Two major intermediate-step** projects are currently being pursued by EUROfusion beneficiaries towards a stellarator FoAK:

  - **Wendelstein Alpha** (IPP-Proxima, start of operation after FP10)
  - **WISER** (CIEMAT, Spain)

Proposed structure of WP STEL in FP10 towards stellarator FoaK

Four complementary pillars targeting stellarator FoAK readiness

Exploitation of W7-X

- W7-X remains main work horse for stellarator community.
- Support from TJ-II (operating), Uragan-2M (operating) ← can we get specific tasks to be performed
- Preparation, participation, evaluation of campaigns
  1 campaign/year
- Exploitation of W7-X aligned to GD/physics gaps and evaluated based on SRLs/research topics

Reactor Scenarios

- Define stellarator FoAK requirements
- Address physics gaps
- Develop scenarios for intermediate devices (W7-X, W-α, WISER) validating FoAK assumptions
- Scenario control
- Physics models validation: closed divertor, tungsten wall, turbulence optimization, fast ions

Systems & diagnostics

- Develop systems and diagnostics required to close the gaps towards FoaK:
  - W7-X
  - Alpha, WISER
  - ITER, if aligned with stellarator
- For instance:
  - Heating systems
  - Neutron diagnostics
  - microwave diags.
  - maniupulators

Reactor Technology

- Intensify developement on:
  - remote maintenance
  - closed island divertor technology
  - Neutronics
  - 3D blanket
  - Integration of the system components
  - Modular coils
  - 3D Target technology (from WPDIV)

Summary

- Spending above plan in 2026, encouraged by the PMU in 2025, leaves several areas underfunded in 2027: support at TJ-II, exploitation along GDs 1-3, and, most critically, the MATEO activities, which are on the critical path for installation.

- Contrary to earlier statements, the 2026 and 2027 campaigns need the same funding, because demand for participation is equally high in both years.

- Deliverable owners report no major delays. The SFILD diagnostic is slightly behind because the W7-X constraints turned out to be more complex than expected. The delay will be fully recovered in 2027, and the diagnostic will be ready for installation next year.

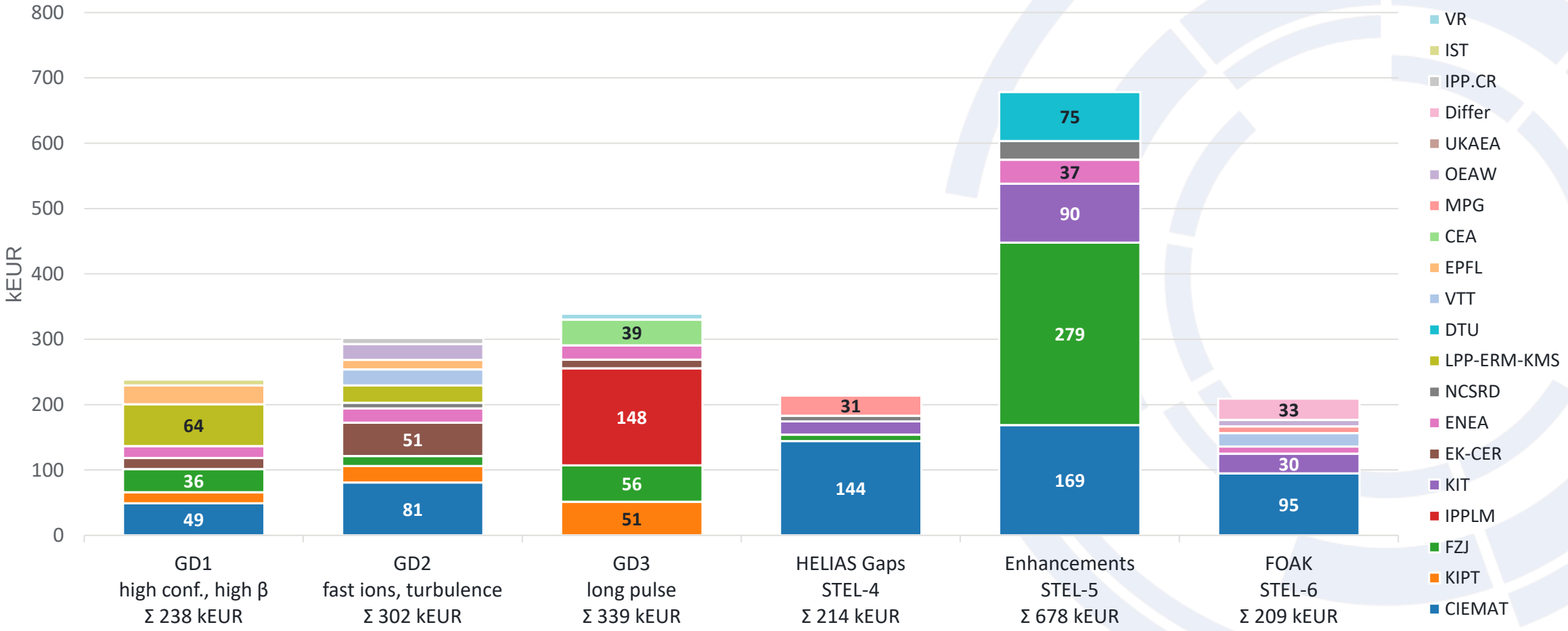
- Depreciation costs for FZJ are still unfunded for 2027 and beyond. Securing them requires action from the PMU and GA.

- Preparation of FP10 is ongoing, with the aim of offering an attractive program for the next framework program.

Backup slides

2027 resources by beneficiary – person-months (PM @ 50%)

Total 622 PM across GD1–3, HELIAS Key Physics Gaps, Enhancements and FOAK, split by beneficiary



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