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WP STEL 2026/2027

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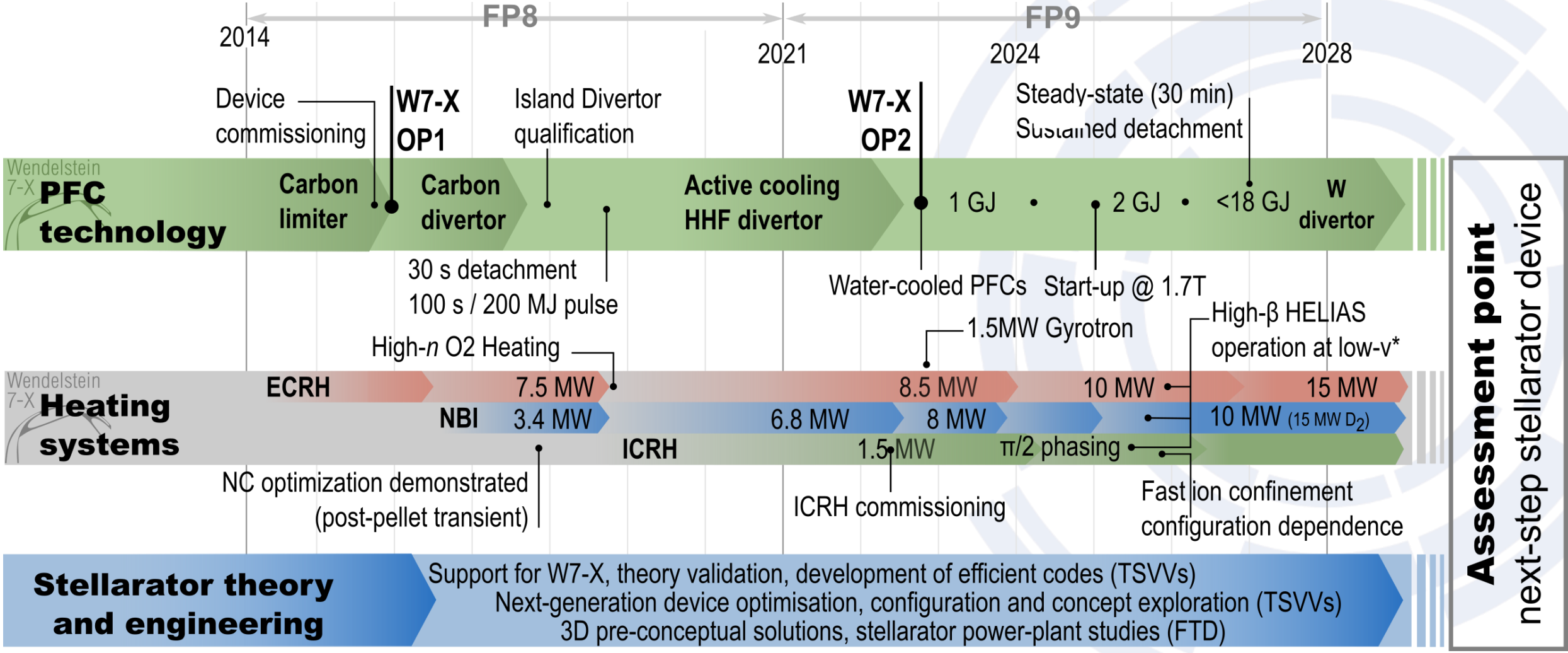
WP W7-X → WP STEL

- Due to structural changes in EUROfusion from 2026, WP W7-X will absorb part of the WP PRD activities related to stellarator reactor research
- As a result, WP STEL will:
  - Further strengthen the scientific exploitation of Wendelstein 7-X in collaboration with European beneficiaries and other WPs (PWIE, DIV, TE)
  - Support European beneficiaries in preparing enhancements for W7-X.
  - Cooperate with TSVVs on further development of modelling tools for HELIAS, their validation and benchmarking.
  - Contribute to ITER developments, if they also align with the broader vision of advancing stellarator reactor concepts.
  - Continue technology development efforts toward a stellarator DEMO, building on WP PRD (SPPS) activities.
    In 2025, 54 PM were allocated to SPPS, whereas only 28 PM shall be inherited from WP PRD in 2026 and 2027, necessitating a refocusing of activities.
- In parallel with efforts in 2025 to address key physics gaps for the HELIAS reactor, which are relevant for future stellarator reactor

Reaching goals of W7-X within FP9



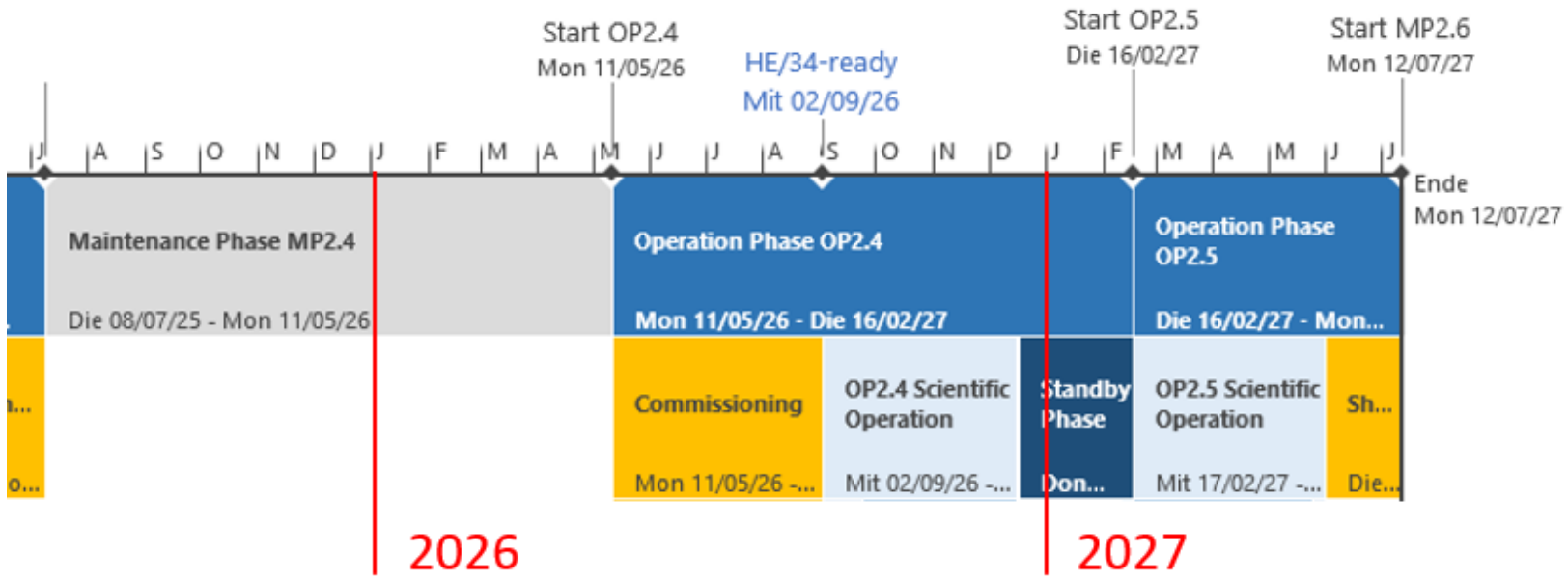
Structure of WP STEL

Exploitation of W7-X*	Key Physics Gaps+	ITER, Enhancements	Stellarator DEMO+
Campaign participation incl. missions in 2026 and 2027	Continue work of expert group (reduced scope)	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

* Engage stronger tokamak community within WP STEL
+ Engage in exchange with TSVVs, DEMO central team, but also stellarator start-ups

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 (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-2026/2027.O6	Ensure information exchange with WPDIV, WPPWIE, WPTE and continue international collaborations in support of the Mission 8 objectives. Prepare IMAS database of the stellarator data.
WPSTEL-2026/2027.O7*	Continue the collaboration with TSVV-12 on stellarator optimization and lay out plans with the goal of producing next-generation optimized configurations that can be the basis of reactor designs.
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.

Grand Deliverables for 2026/2027

ID	Deliverables Table	Gap to be addressed	Priority
STEL. D.01	High confinement scenarios via plasma profile control and high power scenarios at low magnetic field to reach reactor relevant collisionalities ($\nu^* < 0.1$) and high beta ($\langle\beta\rangle \geq 2.5\%$)	(1) Experimental validation of fast ion optimization at high beta discharges. (2) Experimental validation of numerical modelling of the influence of high beta on heat and particle exhaust channels	high
STEL. D.02	Experimentally validated modelling predictions for fast ion physics and turbulent transport	Validate numerical tools developed to predict fast ion physics and turbulent transport	medium
STEL. D.03	Long pulse scenarios with $n\tau Ti >$ 0.1e20 and plasma duration of up to 1000 s	Access to stable, high radiation regimes without decrease in core performance	high

Asignement of financial resources (assumes 28 PM/year from WP PRD for SPPS

		Total amount:	5 586	5 976
Tag	**Year**	**Beneficiary**	**Cons. Contr. (CC)**	**EC (Commission Contr.)**
Campaign participation + preparation	2026 2027	Not_allocated	457	503 503
Missions inside/outside campaign	2026 2027	Not_allocated	269	211 211
Activities to achieve GD 1	2026 2027	Not_allocated	337	371 371
Activities to achieve GD 2	2026 2027	Not_allocated	207	228 228
Activities to achieve GD 3	2026 2027	Not_allocated	290	319 319
HELIAS physics gaps	2026 2027	Not_allocated	252	277 277
ITER, Enhancements	2026 2027	Not_allocated	850	935 935
Stellarator Reactor	2026 2027	Not_allocated	130	143 143

Detailed description of activities

- **STEL.D01:**
  - Conduct **modeling and analysis of fast ion physics and heating**.
  - Optimize the **3D island divertor for high-beta operation**, addressing:
    - Implementation of drifts in EMC3-Eirene.
    - Influence of bootstrap currents and plasma beta on divertor performance.
    - Effects of plasma collisionality.
  - Low-field start-up with ECRH, ICRH
- **STEL.D02:**
  - Conduct **experimental studies of turbulence in the plasma core.**
  - Analyze **scrape-off layer (SOL) transport** and prepare for **2026 experiments**.
  - Conduct **experimental studies of turbulence in SOL** using probe diagnostics.
  - Develop and validate **numerical codes for edge turbulence modelling** (reduced scope).
  - Investigate **drift waves and sawtooth oscillations**.
  - Model and validate **fast ion losses**.
  - Perform **Alfvén mode studies with HIBP at TJ-II**.
- **STEL.D03:**.
  - Advance **wall-conditioning**, including preparatory actions at **Uragan 2-M**.
  - Develop steady-state detachment with seeding impurites.
  - Develop **long-pulse pellet discharges** to enhance performance.

Detailed description of activities (continued)

- ***Address Key Physics Gaps***
  - **Neutral gas modelling** to support metallic divertor integration.
  - **Validation of electromagnetic turbulence results** from TSVV-13 at high beta (with reduced scope).
  - **Data analysis, interpretation, and modeling** to:
    - Complete the **HELIAS physics basis**.
    - Develop experimental scenarios for **OP2.4/OP2.5**, incorporating data from **TJ-II**.
  - Establish an **IMAS database** for stellarator data.
  - Develop fast tools for particle exhaust modelling (reduced scope)
- ***Technological Advancements for W7-X & ITER***
  - Develop a **2 MW gyrotron** for improved heating capabilities.
  - Advance the **MATEO manipulator and observation systems for metallic divertor development and material studies for DEMO**
  - Develop the **SFILD diagnostic system** for fast ion loss detection.
  - Further develop the **ITER dual Thomson scattering system, CTS**.

Detailed description of activities (continued)

- ***Stellarator DEMO Reactor Development***
- Identify a few of the most advanced **next-generation optimized configurations and coil designs**.
- Enhance **neutronic modeling** by:
  - Developing **fast 3D neutron analysis tools**.
  - Performing **Monte Carlo simulations for next-generation optimized configurations**.
- Adapt **DEMO blanket solutions** for **3D stellarators**.
- Conduct **thermal and mechanical analysis** of 3D blanket structures.
- Define **remote maintenance requirements** for the stellarator reactor.

Increased funding will allow to broaden WP STEL important activities (+330 kEUR)

- Increase efforts in Stellarator Reactor to the original level of WP PRD (20 PM), add further development of IR wall monitoring with WP TE(presently in PrIO)

- Increase efforts in Key Physics Gaps to develop tools (not covered by TSVVs), which are critical to develop physics models for the stellarator reactor and are needed before FP10 (24 PM)

- Perform additional intepretative modelling of W7-X resuls to provide better understanind of most recent results (increased budget of GD1, GD2 and GD3 – 36 PM):
  - JOREK modelling of MHD instabilities
  - EMC3-Eirene modelling of high beta plasmas
  - Electromagnetic turbulences in high beta plasmas