EUROfusion

[Update on W transition in JT-60SA (28 April 2026) · Indico]

W related machine enhancements (WPSA)

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JT-60SA Advanced Superconducting Tokamak
BA-Satellite Tokamak Program

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Outlook

- Diagnostics
  - EU proposals (with updates)
  - QST proposals
- Vacuum system
- Cooling system
- Boronization
- ECH upgrade
- EC stray

Proposals for Edge & SOL diagnostics

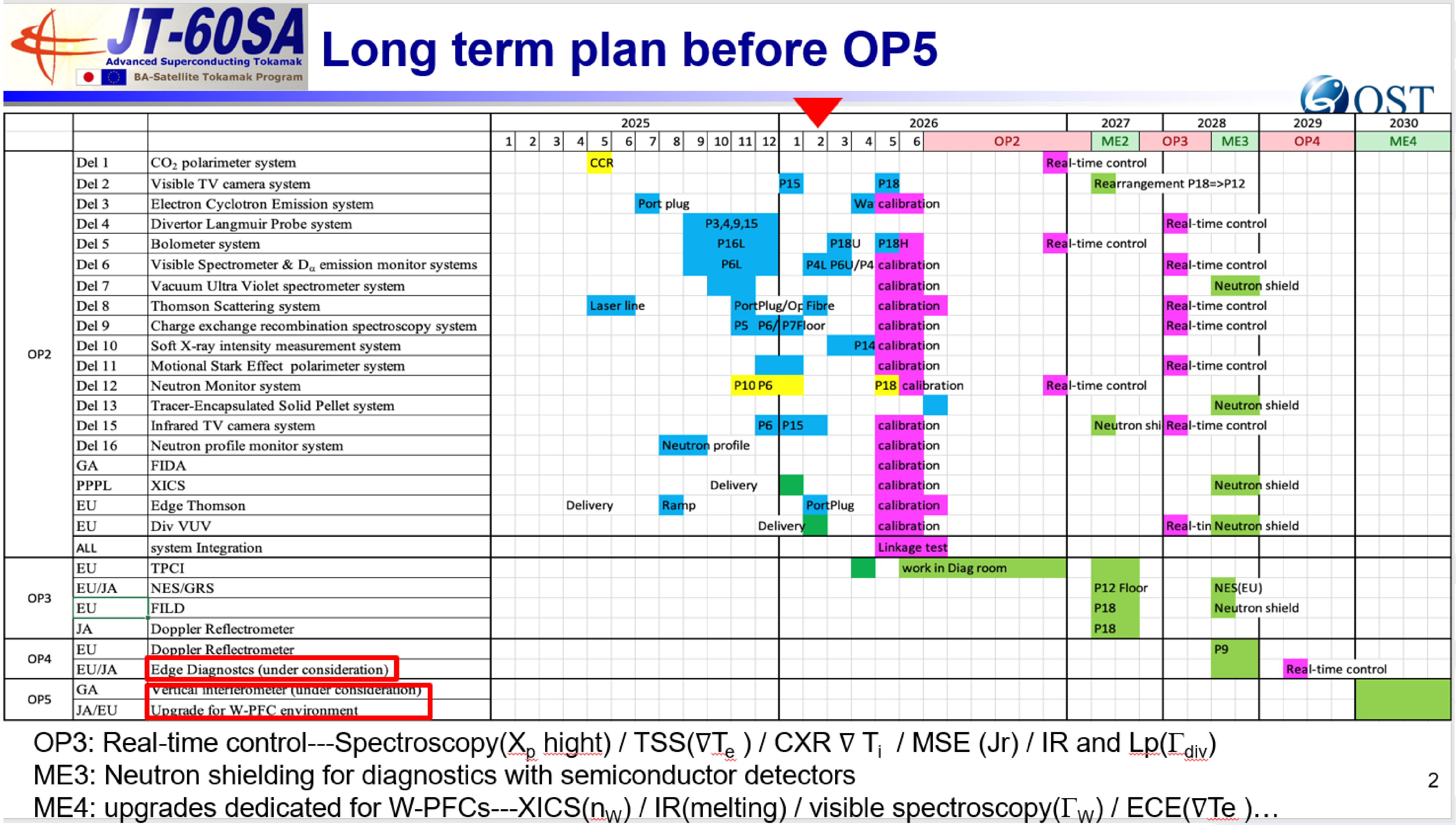
- Status
  - Reports available on DMS (both Eurofusion and JT-60SA)
  - No comments received up to now (except Sebastijan one)
  - No funding in 2026/2027

- Applicability in W traces experiment before the transition
- In general, dedicated modeling to identify the W lines for spectroscopic diagnostics would be very useful

Proposals for Edge & SOL diagnostics (WPSA call in 2025)

Deliverable Title	Author (Beneficiary)	Prov. Priority	W traces exp OP4
Report on the feasibility study for an EU-DEMO like real-time detachment control diagnostics for JT-60SA	Dunai, Daniel (EK-CER)	1	y
Report on the feasibility of the installation in JT-60SA of a runaway electron monitor	Marocco, Daniele (ENEA)	1*	Y (not relevant)
Report on the Enhancement of the fast charge exchange spectroscopy	Liang, Yunfeng (FZJ)	3	-
Report on the feasibility of a MANTIS multispectral visible imaging diagnostics	Perek, Artur (EPFL)	1	W imaging ok, traces partial test
Report on the feasibility study of a high-resolution visible overview camera with real-time and multispectral capabilities	Szepesi, Tamas (EK-CER)	1	y
Quartz Crystal Microbalances	Laguardia, Laura (02-CNR)	1	y
Report on the feasibility of a Thermal Helium Beam diagnostics for electron temperature and density measurement	Ugoletti, Margherita (01-RFX)	1	y
Report on the feasibility of a Neutral Gas Analysis system	Laguardia, Laura (02-CNR)	1	y
Report on the feasibility of a SOL-Pedestal Imaging Vacuum-Ultraviolet spectrometer	Belpane, Andrea (01-RFX)	1	y
Report on the feasibility of a Directional Electron Probe diagnostics	Liang, Yunfeng (FZJ)	1	y
Report on the feasibility of a Collective Thomson Scattering diagnostics	Korsholm, Søren Bang (DTU)	2	-
Update of the feasibility report on Hydrogen/Deuterium Beam Emission Spectroscopy	Dunai, Daniel (EK-CER)	3	-

Expected diagnostics upgrades



QST proposals

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Machine Protection and Operation	Fundamental Parameter Measurement	Physics Understanding
Neutron monitor	YAG laster Thomson scattering	Soft X-ray detector array
Visible TV cameras	CO_2 laser interferometer/polarimeter (Tangential and vertical systems)	Neutron profile monitor
IRTV camera (fist wall and divertor)	ECE	Fast visible TV for pellet monitor
Divertor Langmuir probe	CXRS (toroidal and poloidal)	X-ray Imaging Crystal spectrometer
	Z_{eff} monitor	Visible spectrometer (main and divertor)
	VUV spectrometer	Neutral gas pressure gauge
	MSE polarimeter	DivVUV/FIDA
	Bolometer (main and divertor)	
	Da emission monitor	
		FILD / TPCI / NES/GRS / DR (OP3) Ultra high wavelength accuracy vis spec.
		CIS /LENPA / QMB(OP4)
IRTV / visible (OP5)	XICS / Vis spec (OP5)	LIBS/LIDS (OP5)
	Shunt-current / DivSX / DivTMS(OP5)	FASTCXRS/IPD/Vertical interferometer/Vertical ECE/Burst TMS/CTS

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4. Summary

TCM-44 Naka
20 Nov. 2025

Overall improvements on exhaust system toward the OP2. are ongoing,

- ✓ Failure prevention on dry-pump in the Cryostat exhaust system is designed with two approaches, additional drainage & ballast gas system.
- ✓ VV exhaust system is under improvement for the MGI & Pellet injection operation, and the in-vessel components safety against the overpressure event.
- ✓ Neutron shielding materials for the exhaust system controls are being prepared for the next deuterium operation.

Schedule of Works Onsite

	2025									2026											
	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Cryostat: Drain trap																					
Cryostat: Ballast gas																					
VV: Bypass																					
VV: GV2 replacement																					
VV: Rupture disc																					
VV: Neutron shielding																					

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Cooling system

1. Outline: Upgrade Plan

TCM44 11-02
20 Nov. 2025

Upgrade plan of the cooling water piping and circulation system

Research phase	Initial research phase	Integrated research phase
OP	**OP-2 ~ OP-4**	OP-5
Piping	**Enhanced**	Used (partially upgraded)
Water circulation system	**A part of JT-60U system is re-used** (~ 500 m^3/h ,~1.4 MPa at pump)	**Upgrade to full specification** (Divertor cooling system: ~3000 m^3/h , >2 MPa at divertor inlet)

During the initial research phase,

- the water circulation system in the JT-60U are maintained and re-used.
- Primary water cooling system will be operated from OP-2 with low flow rate and water pressure, and upgraded to full specification from OP-5.

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Cooling system

3.1 Upgrade to full specification: requirements

TCM44 11-02
20 Nov. 2025

Divertor cooling system parameters at full specification

Heat removal capability	• 50 MW for 100 s with 30 minute dwell • 15 MW steady state
Flow rates	• Divertor cooling system : 3000 m³/h
Temperature	• Maximum inlet temperature for divertor: ~40 °C • Δ T < 20 °C
Water pressure	• 2.0 MPa (at inlet of divertor) • ΔP ≤ 1 MPa (between inlet and outlet)

	flowrate (m³/h)	Loss of pressure (MPa)	Maximum heat load (kW)
Lower divertor	1600	1	23200
Upper divertor	489	1	11600
Inboard FW	250	1	12000
Outboard FW	500	1	24000
NBI Port protection plate	210	1	1200

The values above may require checking and reviewing.

- This full specification is required to handle the maximum plasma heating power of ~41 MW for 100 s.

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Boronization system

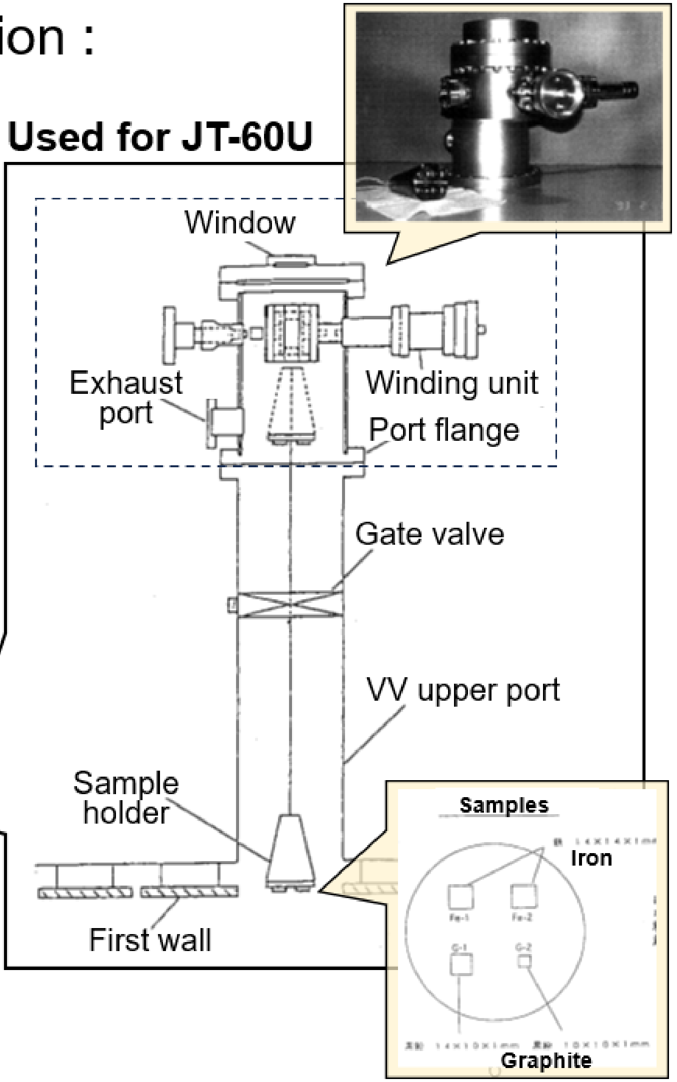
2.3 Diagnostics for JT-60SA Boronization

We require two types of measurement for boronization :

- Measuring **impurity ratio** in VV,
- Observation of **boron film**.

	Measurement	JT-60U	JT-60SA
Impurity Ratio	Effective charge number Z_{eff} Oxygen Impurity ratio n_O/n_e	Measured	Measurable with planned diagnostic.
Impurity Ratio	Mass Spectrometer (Q-Mass)	Measured	Measurable with planned diagnostic.
Impurity Ratio	Residual Gas Analyzer(RGA) in the exhaust system	Measured	**To be installed** (→ amount of decomposition)
Boron Film	First wall tiles observation after the plasma experiment	Observed	**To be observed** (including plasma damages)
Boron Film	Boron film sampling device	Installed at 2 ports	**Under considering**
Boron Film	Real-time thickness monitor	—	(QCM?)

Used for JT-60U



Boronization system

3. Roadmap of Boronization

We would like to discuss the objectives and goals of Boronization for each phase in order to make a system construction plan.

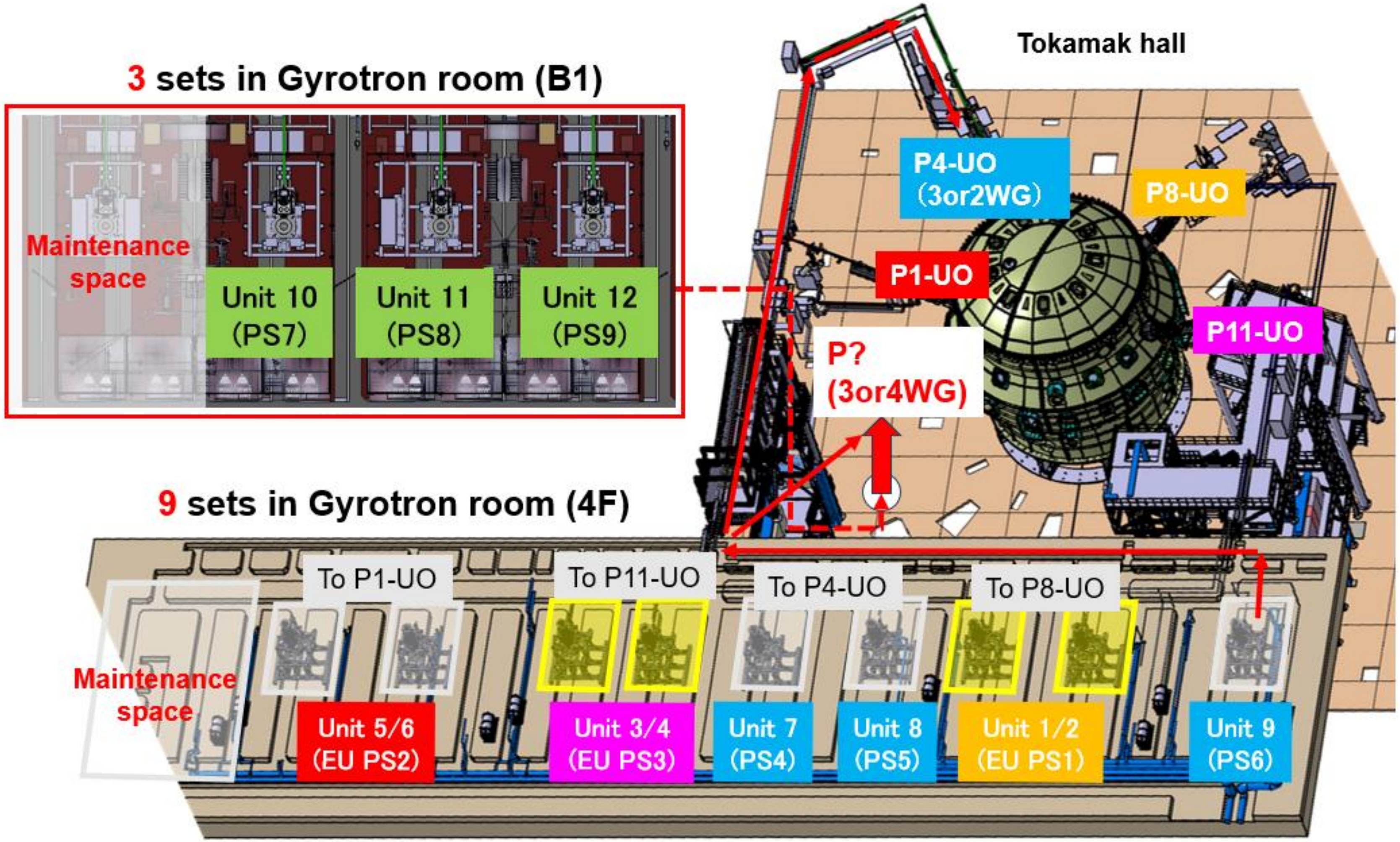
※Our current roadmap

	Op3 Introduction	Op4 Optimization	Op5~ Application to W-wall
Purpose	First introduction of boronization → Confirming **Oxygen reduction**	Optimization Research → Film Thickness Distribution	Application to **W-wall** + Optimization research
Equip-ment	Start with GDC boronization (Compact system at Trus hall)	Operatable ECRF boronization (Move the supply system)	Branching and extension of piping inside VV (Low Priority?)
Measure-ment	Tiles observation after the plasma experiment	Introduction of the boron film sampling device	Real-time thickness monitor

Even after OP5, It will be modified depending on the results.

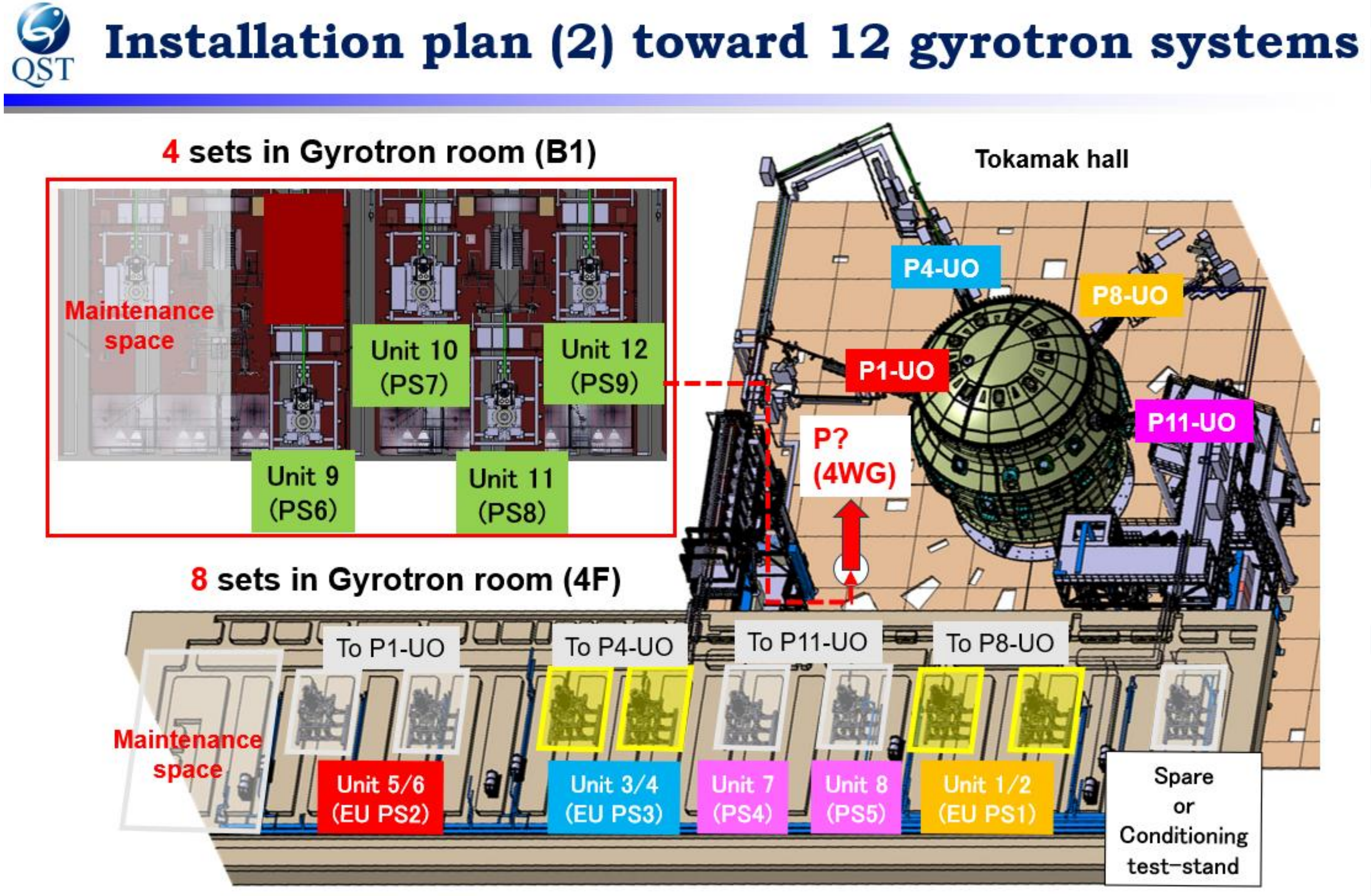
ECRF system

Installation plan (1) toward 12 gyrotron systems



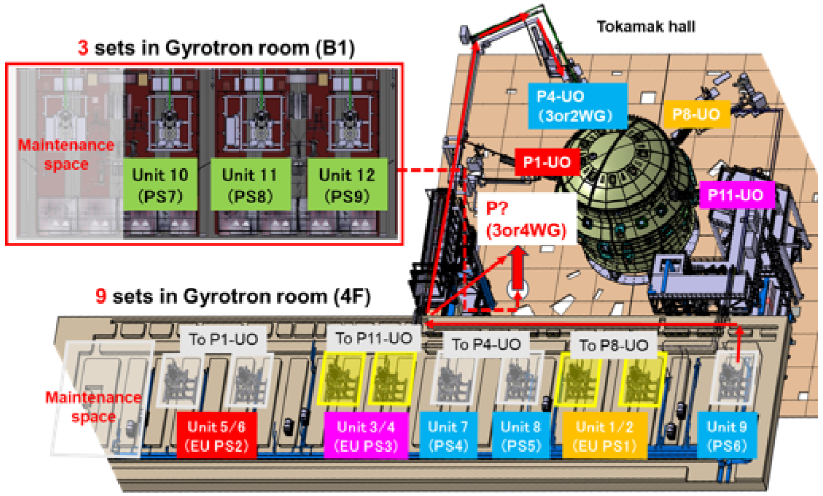
ECRF system

Installation plan (2) toward 12 gyrotron systems



ECRF system

Constraints on ECRF Upgrade



[1] 2WG LA x 3 + 3WG Launcher (LA) x 2

=>Difficulty of design for 3-WG in small port

Need large-size 2 ports

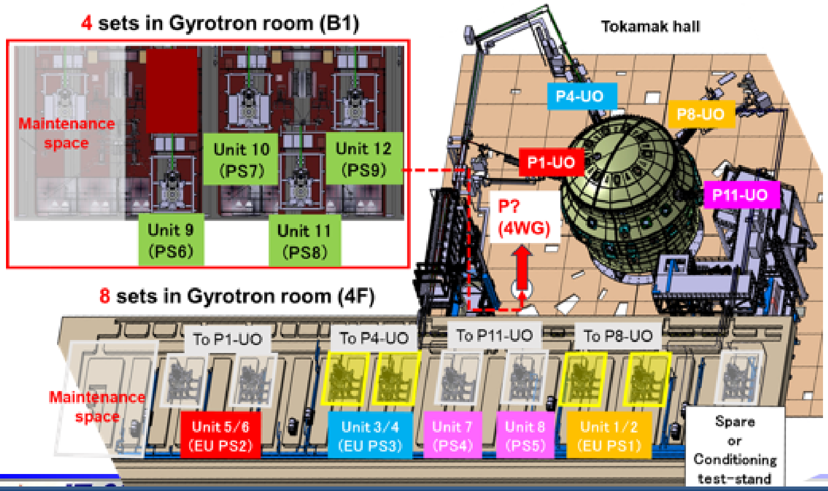
Start manufacturing of One 2WG from 2027

Start of conceptual design for 3WG LA (2026 ~)

[2] 2WG LA x 4 + 4WG LA x 1 (or 2WG LA x2)

TL-layout becomes complex (3 lines + 1line).

EC controllers (address, reflective memory) becomes complex.



[3] 2WG LA x 4 + 4WG LA x 1 (or 2WG LA x2)

TL-layout becomes simple (4 lines)

EC controllers becomes simple.

Need large-size 1 port

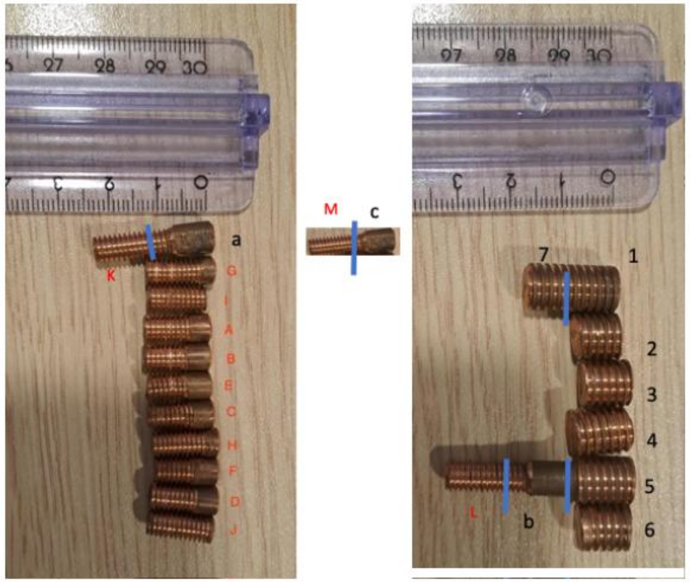
Minimization of PS systems (4 APS/BPS) and gyrotron systems are required.

Start manufacturing of Two 2WG from 2027

Start of conceptual design for 4WG LA (2026 ~)

EC Stray detection

- Preliminary design of dedicated sensor prototypes based on bolometer principle, building on developments for IO, and experimental measurements of Al_2O_3–TiO_2 and Cr_2O_3 coatings performed at ISTP–Milano on samples provided by IO.
- Coating of copper cylinders supplied by ENEA to characterize and qualify the coating process in preparation for the fabrication of the JT-60SA sensor prototypes.
- Design and procurement of microwave components for a simplified three-frequency sniffer probe, based on the antenna probe used on WEST, with the longer-term objective of developing an advanced design similar to that implemented on W7-X.



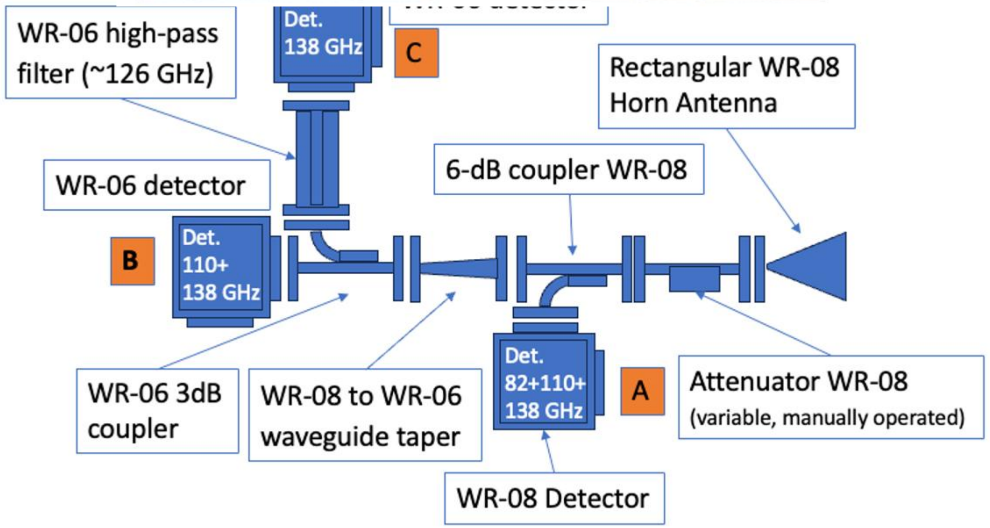


Fig.9: Detection system composed by three detectors (A, B, C), a high-pass filter, two couplers, an attenuator and a rectangular horn antenna.