EUROfusion PSD Management Meeting

WPSA report 2025-05-27

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ME1 status

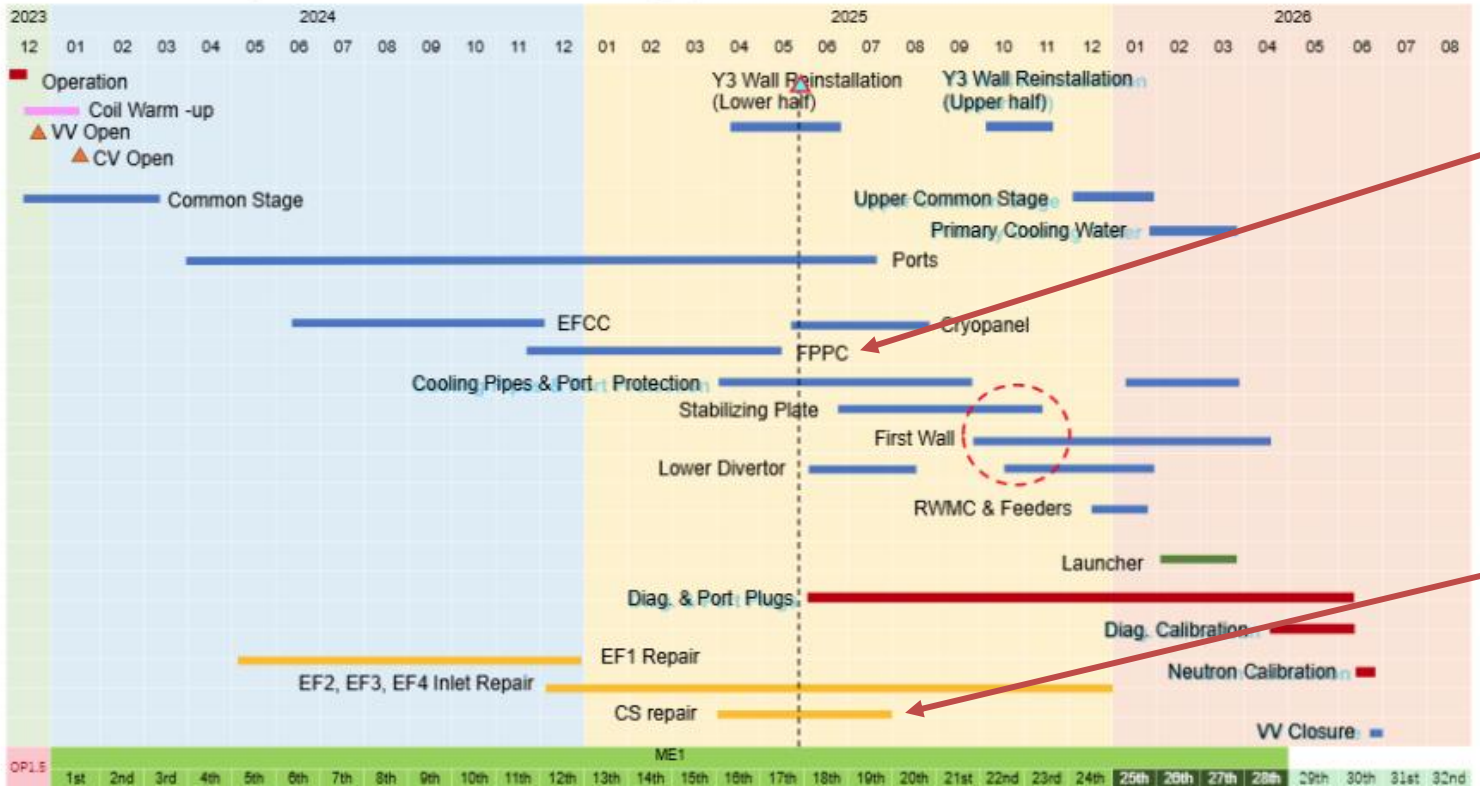
1.1 Overview & Present Status

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

TCM-43 Frascati
21 May 2025

M/E-1 started since Dec. 2023, and assembly preparations were completed.

- Ports are under installation, and NB tanks transportation completed. Joints between the port and tank were carried out accordingly.
- Assembly scenario on in-vessel components are under preparation with related companies, i.e. stabilizing plates & diverter, and so on.



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- upper FPPC HV test after casing work was not passed. Under investigation
- lower FPPC, degradation of resistance investigating the suspicious location of the short-circuit inside winding pack.
- Estimated delay of 6 week

- CS reinforcement mockup result:
  - spray method for insulation of He inlets.
  - High viscosity resin for cable extraction (mockup test ongoing)
- Insulation reinforcement work for CS will be completed in June 2025

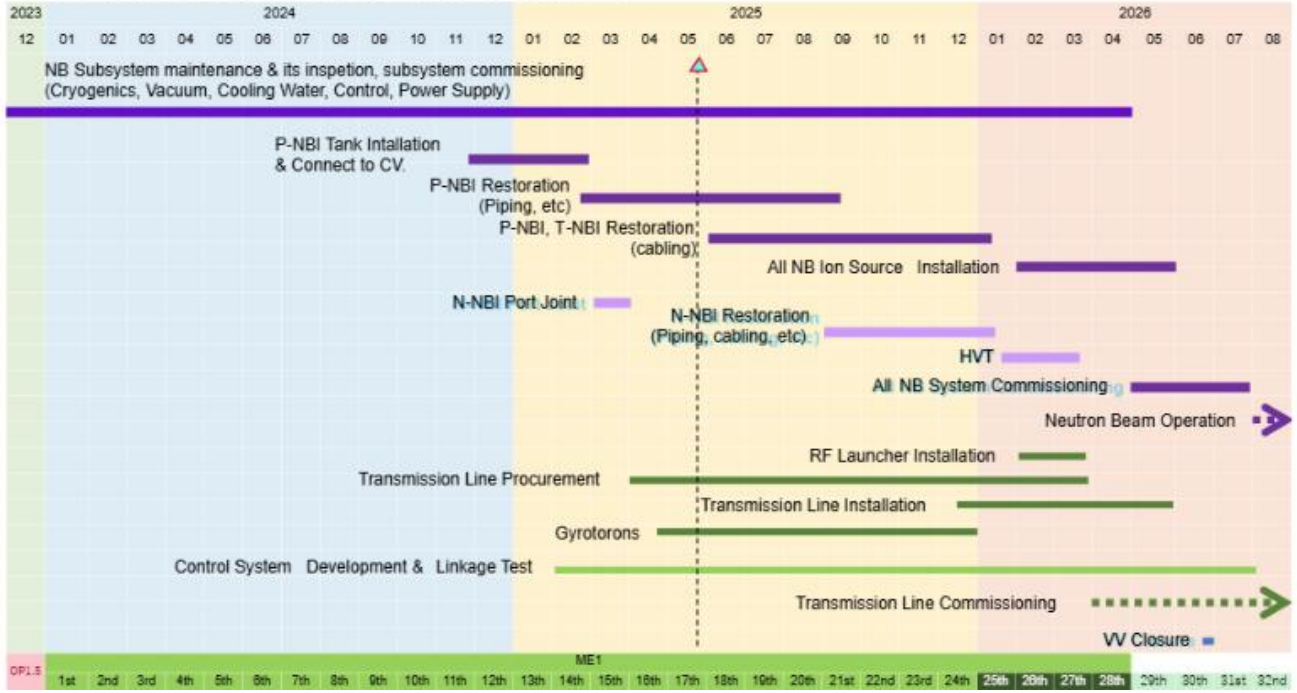
ME1 status

1.2 Schedule on Heating Devices

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

TCM-43 Frascati
21 May 2025

- NBI restoration work is expected to be completed in January 2026. NBI will be ready to start beam operations after installation of ion sources & HVT and system commissioning.
- RF will be ready to start conditioning of the transmission line after installation of the transmission line.



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Op-2	Expected operation schedule:		2026 - 2027		
	Research phase:	**Initial phase I**	Annual neutron limit:	-	**H / D**
Divertor:	Pumped lower inertially cooled carbon divertor Allowable heat flux onto the divertor plate <10MW/m² x ~5s, 15MW/m² x ~3s (Open upper inertially cooled carbon divertor remains available)				
Installed NBI power:	P-NB Perp	P-NB Tang	N-NB	Total installed NBI	Max usable aux. power: **26.5MW**
	4 units 3 MW in H / 6.5 MW in D	4 units 3 MW in H / 7 MW in D	2 units 10 MW	16 MW in H / 23.5 MW in D x 14s duty = 1/30	
Installed ECRF power:	1.5MW x 100s (2 gyrotrons 82 / 110 /138 GHz) with steerable launcher + 1.5MW x5s (1 gyrotron: 82 / 110 /138 GHz, 1 gyrotron 110 GHz only)				
Other equipment	100% inner carbon first wall Stabilizing plates with full carbon armour Fast Plasma Position Control Coils (FPCC) Error Field Control Coils (EFCC) RWM Control Coils (RWMCC)		Active VV and in-vessel cooling Radiation shields Massive gas injection		
Diagnostics	Magnetic sensors C02 interferometer Visible TV camera EDICAM Divertor probes and thermocouples Soft X-ray intensity Brems. intensity Dα emission monitor Visible spectrometer (Z_{eff} monitor) FIDA TESPEL		Infrared TV camera ECE intensity Bolometer Thomson scattering CXRS MSE Neutron monitor VUV spectrometers Crystal spectrometer (XICS) Neutral pressure Neutron profile monitor		

Restart + OP2 overall plan

1.1 Overall Schedule & Milestone

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

TCM-48 Frascati 21-22 May 2025

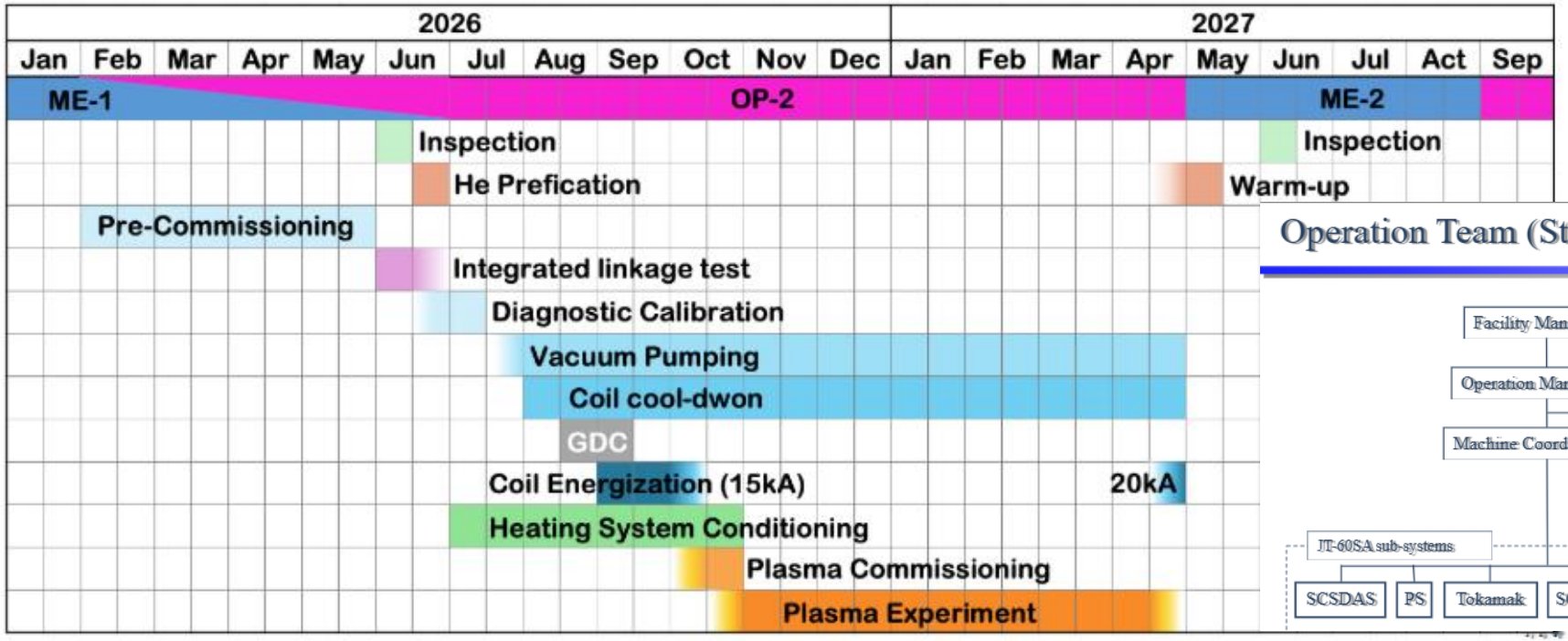
Project Milestone (Machine)

Vacuum pumping : July 2025

20kA PF energization : by end of OP-2

Machine Commissioning : ~90 days

Plasa Commissioning : ~30 days

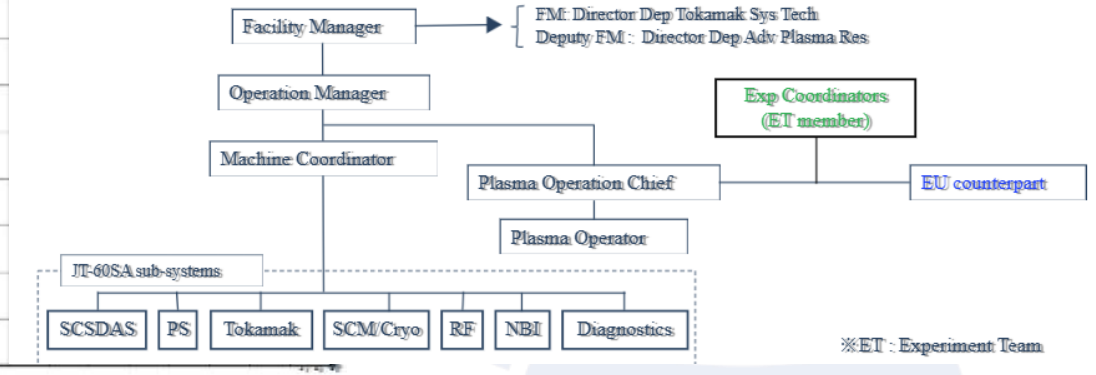


- organization for operations being discussed
- Plasma Operation chief (JA) : decide/coordinate the discharge conditions according to the experiment plan
- EU counterpart : TBD, should be the same as Plasma Operation Chief

Operation Team (Structure)

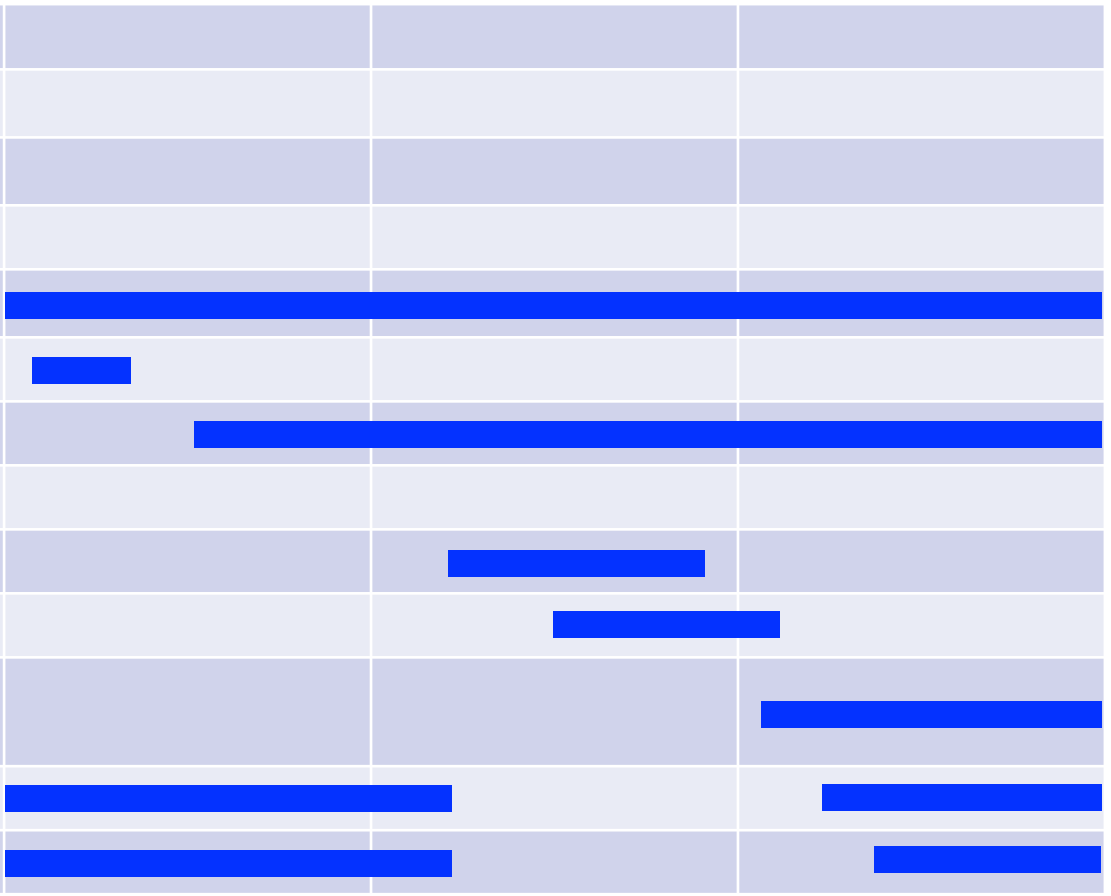
JT-60SA Advanced Superconducting Tokamak, BA-Satellite Tokamak Program

TCM-48 Frascati 21-22 May 2025



COMMISSIONING w/o PLASMA

Topics \ Year/Day	2026
Coolant flow test (atm.)	Dec. ~ Feb.
In-vessel coil energization test (atm.)	Feb. ~ Mar.
Integrated linkage test	May. (24 days)
Calibration of neutron diagnostics	Jun. (20 days)
VV/CV evacuation	Day 0 ~
VV/CV leak check	3 ~ 9 (7 days)
SC cooling down	Day 16 ~
Cryopanel test / operation	TBD
200 deg.C baking of VV	37 ~ 57 (21 ds)
Glow discharge cleaning	TBD
Coil enegization test & QD adjustment	63 ~ 90 (28 ds)
RF conditioning (injection into VV)	
NB conditioning (closed GV)	



Some of commissioning targets are as follows,

- **VV/CV evacuation: 10^{-5}Pa(VV), 10^{-3}Pa (CV), together with VV baking and GDC**
- **SC cooling down: To achieve superconducting transition ~ 37days (previosly 42days)**
- **Energization test: TF(nominal I,V), CS(I<15kA, V<5kV), EF(I<15kA, V<3~4kV)**
- **RF/NB conditioning: nominal power (short pulse)**

COMMISSIONING w/ PLASMA

✓ **Commissioning items w/ plasma is currently being optimized based on the discussion with Exp. Leaders**

Items/Target	Days 10	20	30	40
Achievement of divertor plasma at I_P ~ 1 MA with B_T = 2.25 & 1.7 T		B_T = 2.25 & 1.7 T primarily used during the experiment are planned		
Verification of non-detection of quench signal at I_P ~ 1 MA				
Verification of equilibrium control logic				
Calibration of diagnostics		**Calibration of neutron-related diagnostics is scheduled at the beginning of deuterium operation.**		
Pulse length extension of EC up to 5 s with full injection power (1 MW/launcher)		82 GHz & 138 GHz for B_T = 2.25 T 110 GHz x 2 gyros for B_T = 1.7 T		
Pulse length extension of P-NB up to 5 s with full injection power (1.7 MW/unit)		**Increase of D^0 purity of P-NB & N-NB is scheduled at the transition to D operation.**		
Pulse length extension of N-NB up to 5 s with full injection power (5 MW/unit)				
Facility inspection of JT-60SA based on Regulation of Radioisotopes **(D)**	Facility inspection is scheduled during deuterium operation.			

Enhancements

- Cryopumping system: installation ongoing
- Edge TS: installation starting in July (or August)
- Div VUV: installation in April 2026
- MGI: pre-installation tests OK
- Steady progresses on
  - Fast Ion Loss Detector (J. Ayllon Guerola and FILD team, Univ of Seville) (ME2)
  - Gamma rays spectrometer (M. Nocente and GRS team, UNIMIB, ISTP-CNR, UKAEA) (ME2)
  - Doppler Reflectometry (CIEMAT: E. de la Luna, D. Carralero, T. Estrada, Santiago Cabrera José Martinez) (ME3)
  - Neutron spectrometer and Vertical Neutron Camera (M. Cecconello, J. Eriksson, A. Hjalmarsson (Uppsala) L.Swiderski, (NCBJ), D. Rigamonti (ISTP-CNR) (ME3)
- Progresses on systems under consideration
  - RE monitor (D.Marocco, B.Esposito ENEA) (ME1?)
  - Activation foils (Katarzyna Mikszuta-Michalik, IFPiLM) (ME1?)
  - EC stray radiation (H. Oosterbeek, J. Zimmermann IPP Greifswald, S. Garavaglia, A.Bruschi, F. Fanale ISTP-CNR) (ME2?)

Diagnostics proposals /1

Title or topic	measurement target	comment
EU-DEMO like real-time detachment control diagnostics for JT-60SA	<10 kHz visible (450-750nm) polychromator based divertor spectroscopy systems to detect the loss of detachment defined as a temperature increase above 3 eV of the high density plasma in front of the target (ratio H Balmer lines and C lines); W erosion	stringent requirements on the lines of sight (line integrated measurements). Access from upper port
RE monitor	monitor generation of runaway electrons based on t two BF3 proportional chambers working in count mode and a liquid scintillator working in current mode.	no machine access needed
Enhancement of the fast charge exchange spectroscopy	H, D isotope density profile of the mixture plasma through enhancement of the CXRS diagnostics (Fiber Bragg Grating and Photonic Lantern) to suppress cold H and cold D contribution in the Halpha and D alpha spectra. Ion temperature and rotation velocity could be deduced by the Doppler broadening and Doppler shift of the spectrum	Plug-in device to be installed in the diagnostic room. FBGs, combined with the PLs, installed in the CXRS lab after the light is collected by the multi-mode fiber bundle and before it is directed to the spectrometer, right before the entrance slit
MANTIS multispectral visible imaging	1 kHz radiance and 2D emissivity H, H2, C, N, Ne, Ar… (12 wavelengths) and derived quantities	
High-resolution visible overview camera with real-time and multispectral capabilities	high resolution imaging survey with capabilities for RE synchrotron radiation and spectral analysis (H, C,Fe…) for PWI, pellet ablation, TESPEL, impurities	
SOL-Pedestal Imaging Vacuum-Ultraviolet spectrometer	1D imaging VUV 5-200nm impurity (W) transport in SOL	upper, horizontal, lower oblique considered. Similar to DivVUV
Quartz Crystal Microbalances	Multiple QCMs to monitor erosion, migration and deposition processes in real time	distributed system
Directional Electron Probe	measure scrape-off layer (SOL) current, electron temperature, electron density, ion saturated current and radial electric field along probe's plunge path. SOL current can be used as an indicator of detachment.	Langmuir probe mounted on reciprocating moving system

Diagnostics proposals /2

Title or topic	measurement target	comment
Thermal Helium Beam	2D (4 mm space resolution) electron temperature and density profiles, as well as their fluctuations in edge and SOL through line ratio technique of selected neutral He line intensities, emitted by He gas locally puffed into the plasma. Density range between 1 × 10^18 and 8 × 10^19 m−3, te range 5 eV to 200 eV	mid plane or divertor location 0.95-1.1 rho. Retractable mirror in the vessel
Alkali beam emission spectroscopy	5mm spatial resolution, >100kHz sampling density profiles and density fluctuations simultaneously in the plasma edge and the scrape-off layer. Rotation and ion temperature in principle possible.	stringent port requirements
Deuterium beam emission spectroscopy	10 mm, >100kHz 2D density fluctuations and fast transient events in the core and edge plasma. Flow measurement possible. RT possible	stringent port requirements
Divertor Thomson Scattering	electron density and temperature in the divertor region with a spatial resolution better than 2 cm and a precision better than 10% in the temperature range of 5-200 eV at an electron density of 1×10^{19} m^{-3}.	Laser beam directed into the divertor region through the 3 cm gap between the divertor cassettes (P2 lower oblique) and dumped on the opposite side. Collection optics view the laser beam through the same gap
Neutral Gas Analyser	Development of NGA equipped with RGAs and OGA (with preliminary prototype)	distributed system
Gas Puffing Imaging of turbulent structures	edge density fluctuations and turbulence through imaging of neutrals ionization in the visible spectrum.	line of sight tangential to magnetic field lines, in view of gas nozzle
Collective Thomson Scattering	fast-ion dynamics, isotope ratio, bulk ion rotation velocity, ion temperature	hw requirements not yet clearly defined (in particular: vessel components for signal collection?)

Tungsten transition

- Edge and core heating studies are ongoing
  - Divertor load: well established, PFCs shape ongoing
  - Core progressing including edge (JINTRAC)
  - W tungsten starting
- Technology is advanced on divertor, still lacking on first wall
  - The definition of heat loads on the first wall is not existing yet for the tungsten
  - e.g. shine through from NBI could require areas with higher heat flux capability
- Diagnostics for tungsten operation is being defined
  - Several interesting diagnostics have been proposed and should be studied and developed with the adequate resources
  - Priorities must be set according to scientific interest and efficiency of implementation (e.g. port allocations), while considering human and material resources
- Additional heating needs
  - Preliminary calculations see up to 12 gyrotrons operation being required from OP5 to provide the necessary core heating, start-up assist, instabilities control, etc. (TO BE BENCHMARKED WITH W Transport modeling)
  - QST+F4E preliminary planning for +3 sources (on top of the 9 already under procurement)

Data access

- Inspection concerning cyber attack completed
- Data & analysis server available from this week but only for users on site
- transfer under IFERC network planned for September 2025