



WEST machine news and programme for 2025

A. Ekedahl on behalf of the WEST Team*

The logo for CEA (Commissariat à l'énergie atomique et aux énergies alternatives), featuring the lowercase letters "cea" in white on a red square background.

cea

The logo for IRFM (Institut de Recherches sur les Fusions Magnétiques), featuring the lowercase letters "irfm" in red.

irfm

The logo for WEST (Western European Torus), featuring the word "West" in a stylized, multi-colored font (blue, orange, green).

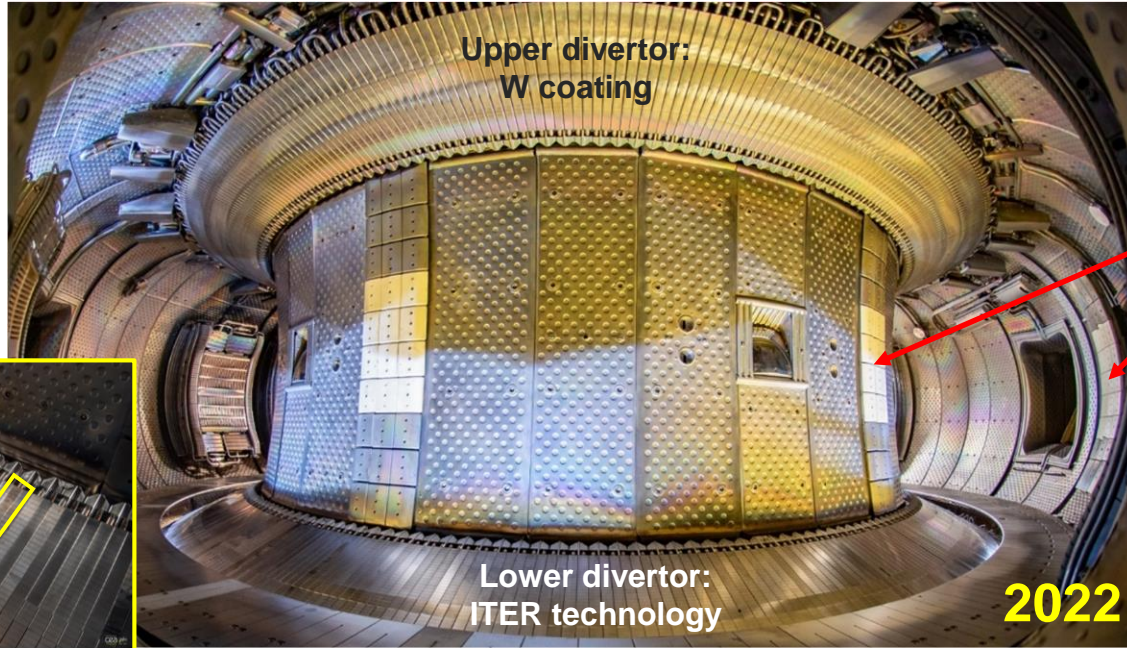
West

[*http://west.cea.fr/WESTteam](http://west.cea.fr/WESTteam)



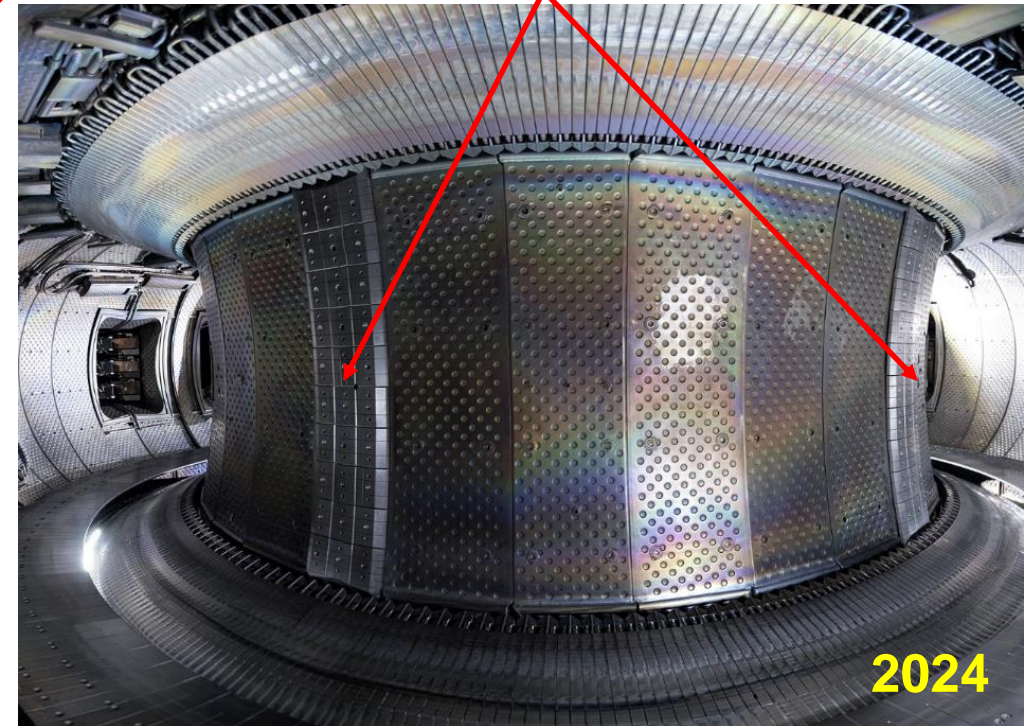
This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

WEST interior evolution



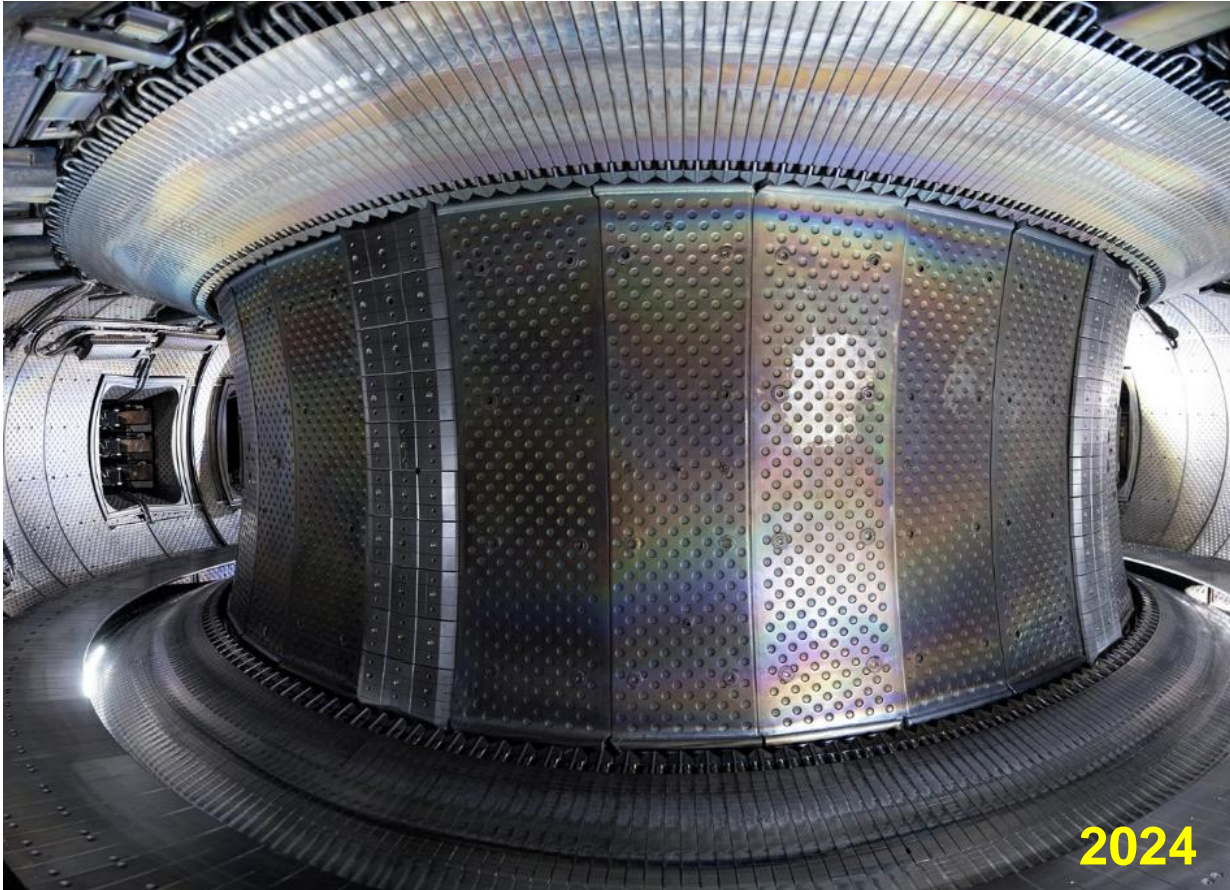
Inner bumpers & outer limiter:

- **2022:** W coating on CFC + Boron-Nitride tiles at mid-plane
- **Summer 2024:** Bulk W tiles



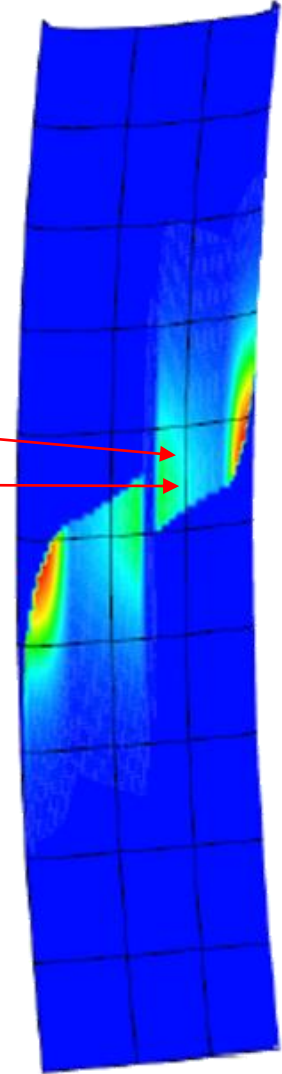
ITER-grade divertor: 456 W divertor units, with 35 monoblocks in each unit

WEST interior: Full tungsten



Start-up on bulk W inner bumpers, with unboronized wall, carried out last week

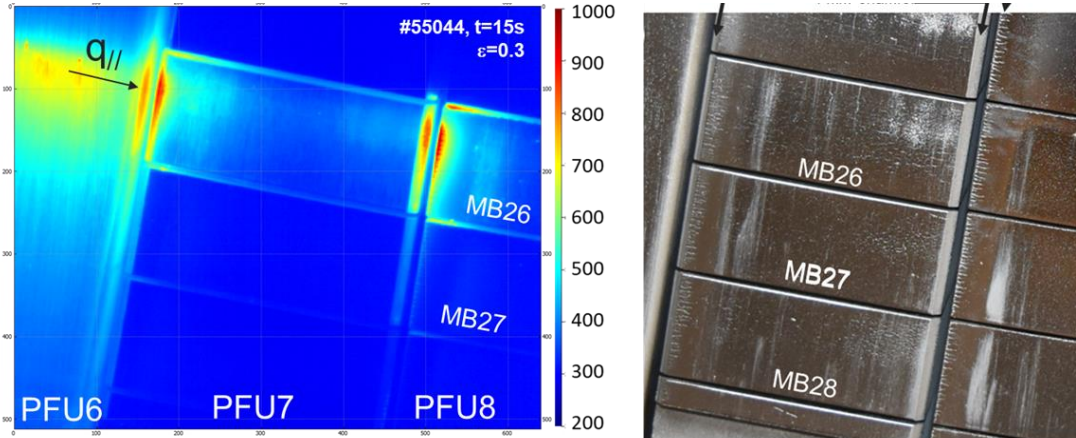
Start-up on bulk W inner bumpers, after non-uniform boronization, will take place tomorrow (boronization today)



- 1 inner bumper equipped with thermocouples at mid-plane
- 1 inner bumper equipped with poloidal array of Langmuir probes

Innovative diagnostics for ITER-grade divertor

Very High Resolution IR camera ($\Delta_x \approx 100\mu\text{m}/\text{pixel}$)

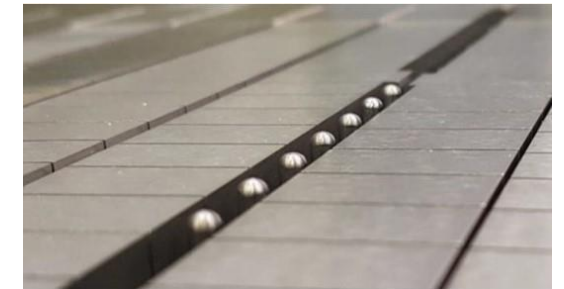


[A. Grosjean et al., FED 2021]

Flush probes bolted on the side of monoblocks

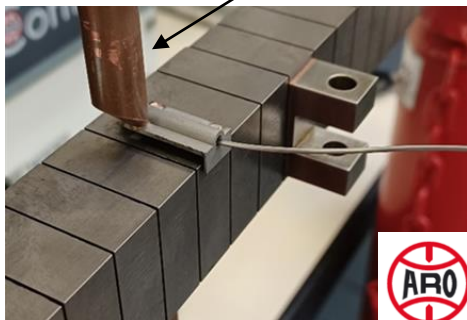


“Popup” probe arrays

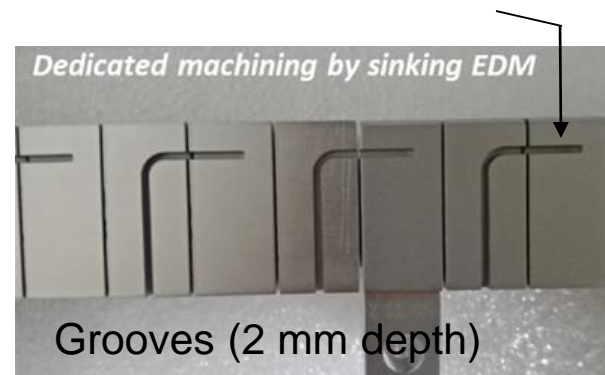


ITER divertor thermocouples (TCs)

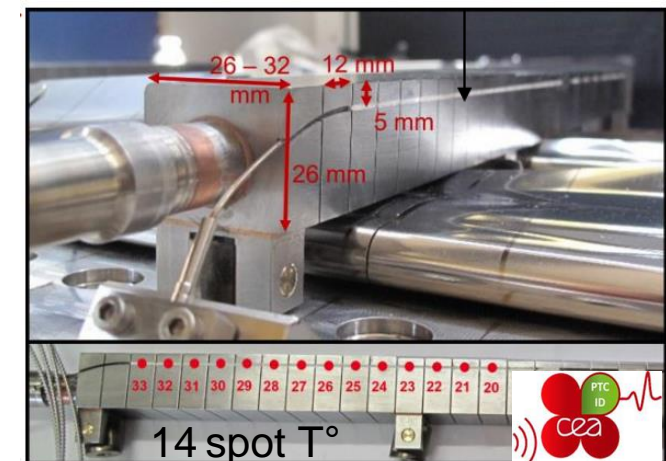
Ni radiative cover
Resistance welding



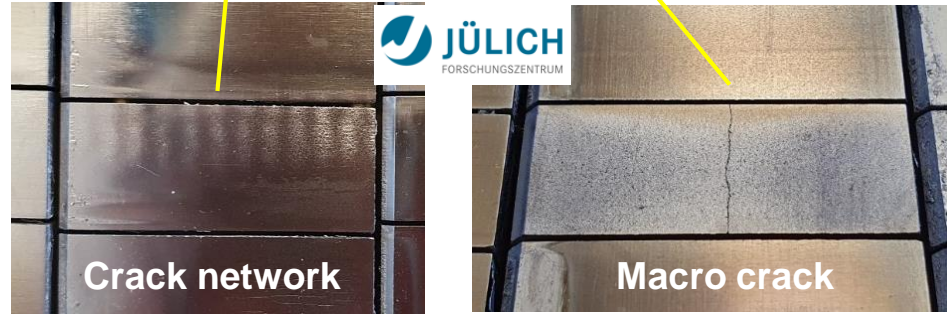
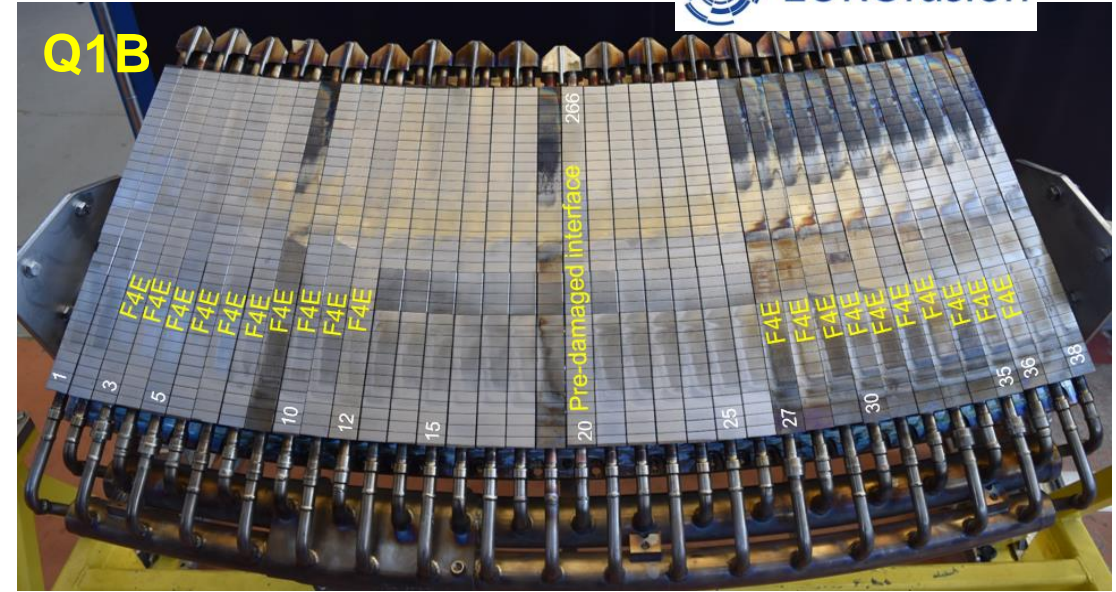
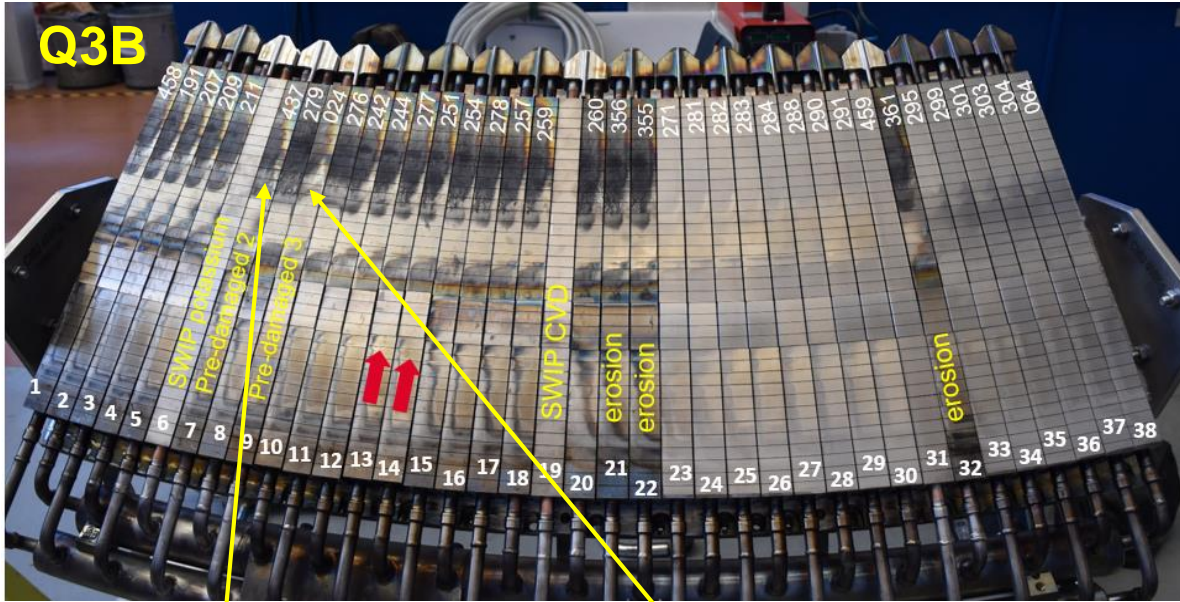
Embedded TCs and Fibre Bragg Gratings (FBG)



[N. Chanet et al., FED 2021]



Divertor sectors for dedicated tests



- Pre-damaged monoblock “Crack network” in place since 2022
- Pre-damaged monoblock “Macro crack” in place since summer 2023
- Pre-damaged monoblocks surveilled by VHR IR camera

- 20 PFU from F4E in place since summer 2023 (RI, Ansaldo, CNIM, Alsymex)
- Sector removed in summer 2024 for analysis (confocal microscopy), then reinstalled

Proof-of-principle cleaning by laser performed on Q1B and Q3B ex-situ in summer 2024 → Method to be developed for using in-situ in 2025

WEST Heating & CD systems

Three radiofrequency systems installed in WEST

■ LHCD system (7 MW)

- 2 launchers, 7 MW / 1000 s
- Key system for long pulse operation

■ ICRH system (9 MW)

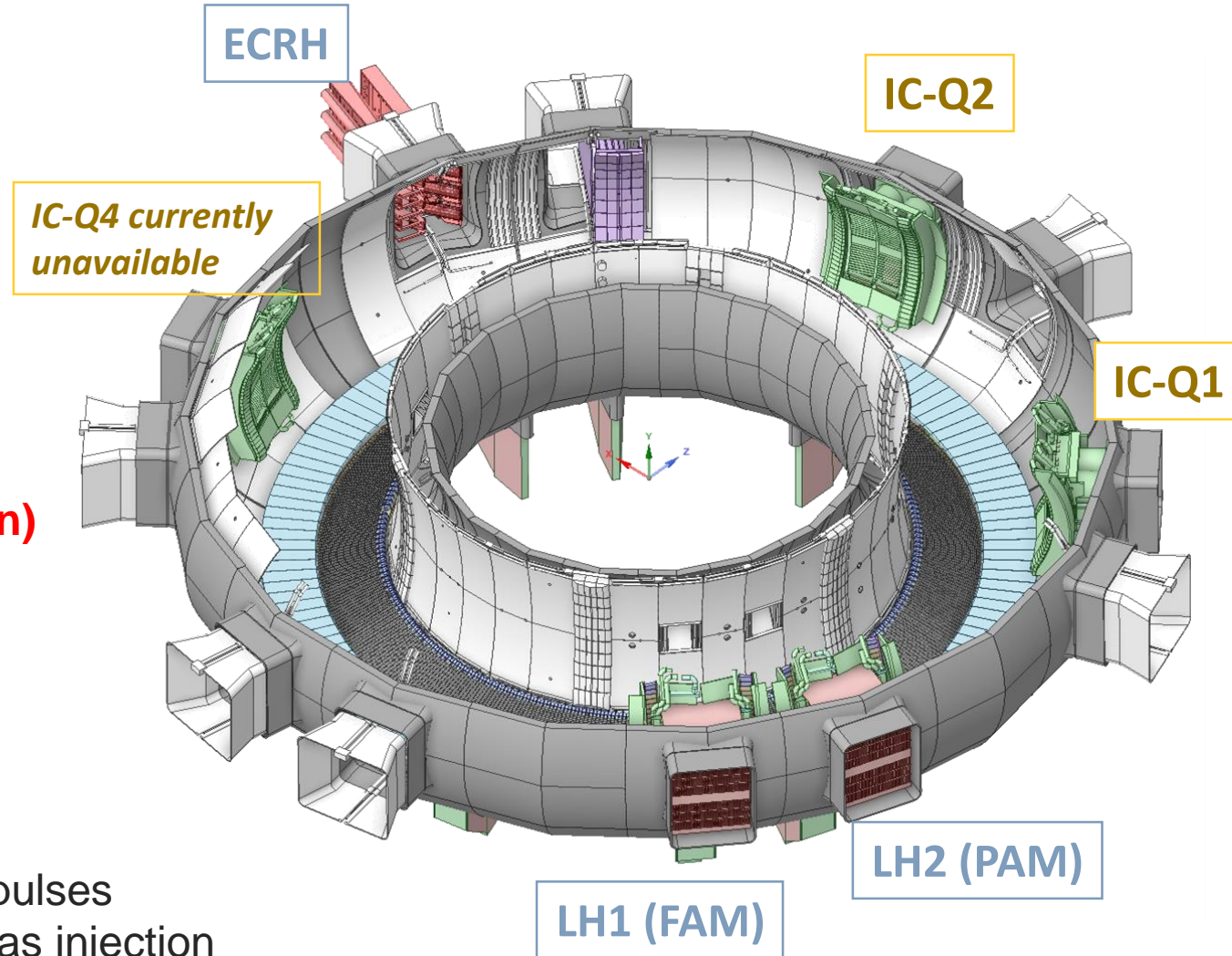
- 3 antennas (9 MW / 30 s, 3 MW / 1000 s)
- IC heating, IC wall conditioning, IC-assisted plasma start-up
- *Only 2 antennas currently available*

■ ECRH / ECCD system (3 MW, staged installation)

- 1 gyrotron (1 MW): commissioning end 2024
- Full system (3 MW) in 2026
- 1 antenna with 3 steerable mirrors

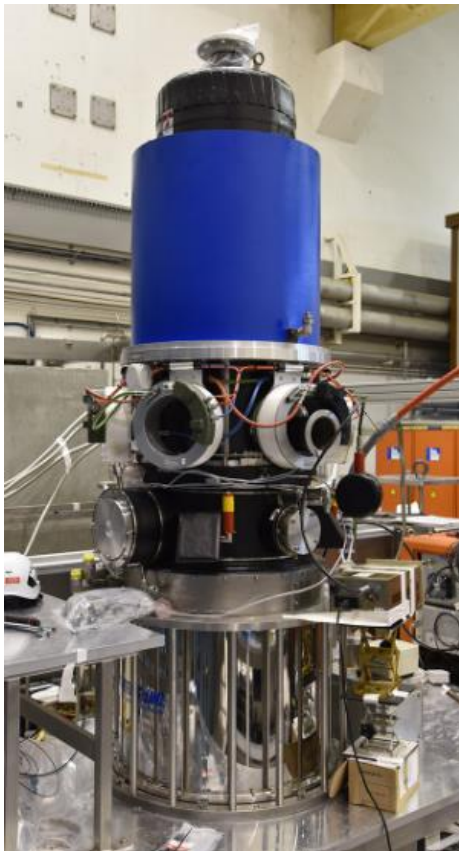
■ ICRH and LHCD limiters

- W coating on CFC
- Antennas / launchers are moveable between pulses
- All antennas / launchers equipped with local gas injection



3 MW ECRH system for WEST

- 3 gyrotrons 105 GHz, 1 MW each / 1000 s
- RF design by KIT, based on THALES W7-X 140 GHz
- Validation of the RF design 1 MW / 5 s at 105 GHz in KIT test stand



1st gyrotron delivered to CEA in September 2024

- Gyrotron installed
- Installation of the auxiliaries ongoing (HV, cooling, cabling, CODAC)
- **Goal: Start commissioning on plasma in December 2024**



ECRH antenna:

- Tore Supra antenna reinstalled in WEST
- Capacity: 3 MW
- 3 steerable mirrors, poloidally & toroidally



[L. Delpéch, SOFT 2024]

THALES



Highlight on recent diagnostics

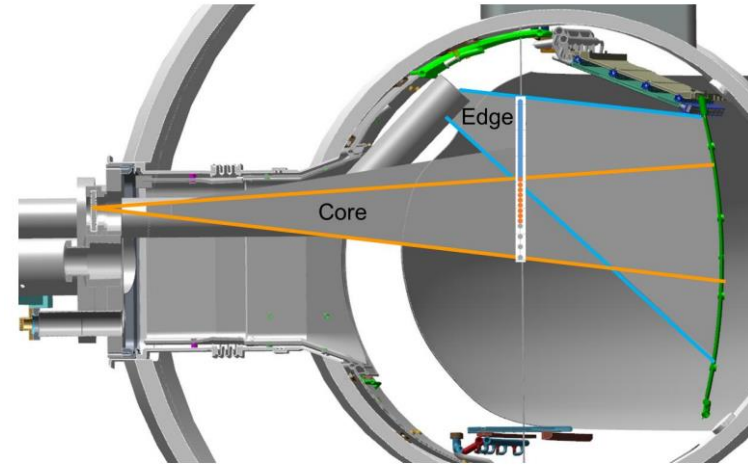
Core Thomson diagnostic

- 18 lines of sight available; 25 mm vertical resolution
- T_e range: 10 eV - 10 keV

Edge Thomson diagnostic

- Actively cooled endoscope installed in 2024
- 28 lines of sight available; 6 mm radial resolution
- T_e range to resolve the pedestal (few eV – few keV)

[G. Colledani, SOFT 2024]



EUROfusion IPP PPPL



Edge Thomson: actively cooled endoscope

ECE imaging



Soft X-Ray GEM detector



Multi Energy Soft X-Ray (ME SXR)



Multi Energy Hard X-Ray (ME-HXR)

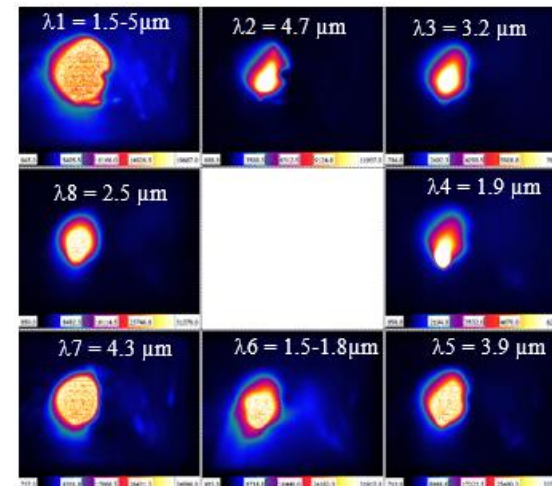
Reciprocating emissive probes



High resolution visible spectroscopy



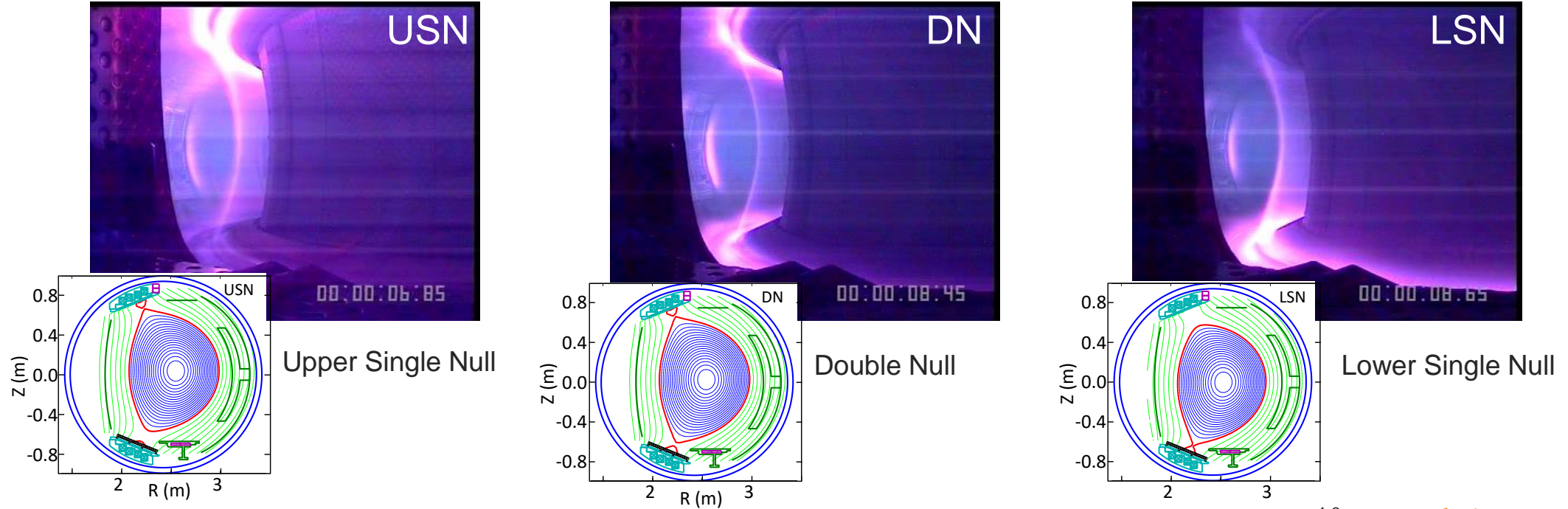
Fast, multi-spectra Infrared (IR) camera



- Installed on wide angle IR view for dedicated RE experiments
- Actively cooled vertical endoscope for 2025

Flexible magnetic configurations and control

Symmetric actively cooled upper and lower target



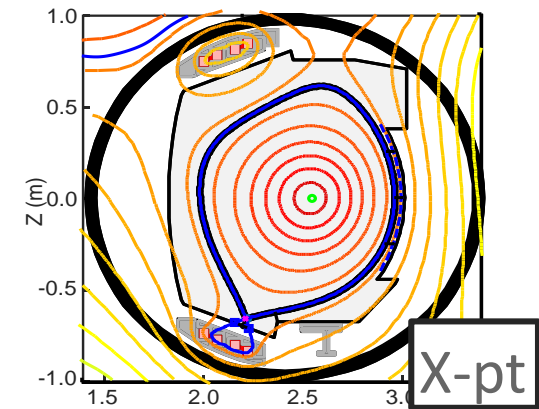
Control schemes

- Loop voltage and I_p for long pulse operation
- Long pulse event handling
- X-point radiation, divertor heat flux, T_{e-div} , etc.

[R. Nouailletas, SOFT 2024]

New for Dec 2024

- Negative triangularity configuration



WEST machine capabilities



$I_p (q_{95} \sim 2.5)$	1 MA
B_T	3.7 T
R	2.5 m
a	0.5 m
$n_{GW} (1MA)$	$1.5 \cdot 10^{20} \text{ m}^{-3}$
P_{ICRH}	6 MW (2 antennas)
P_{LHCD}	7 MW
P_{ECRH}	1 → 2 MW (2025); 3 MW (2026)
$\text{time}_{\text{flattop}}$	1000 s

More info at:

<https://westusers.partenaires.cea.fr>

Capabilities:

- Flexible magnetic configuration (USN, LSN, DN); Negative triangularity in Dec. 2024
- High power RF heating capability
- Large steady-state current drive capability from LHCD
- 3 MW ECRH under installation (1 MW in Dec. 2024)
- Versatile steady state fuelling: gas, pellets, supersonic molecular beam injection (SMBI)
- Boronization system and Impurity powder dropper
- Massive gas injection

Priorities for the WEST programme 2025



ECRH:

- Achieve **sustained H-mode**, using the new **ECRH capability** together with LHCD and ICRH
- 1 MW ECRH available from Dec 2024; 2 MW available in autumn 2025; 3 MW in 2026

Long pulse operation:

- Progress to **1000 s long discharges** (364 s achieved up to now)
- W source in long pulse scenarios

Continue exposure of ITER grade divertor:

- **11 hours of plasma** performed so far; Cumulated fluence of $1 \cdot 10^{27}$ D/m² reached on OSP region
- Spontaneous crack network observed on W monoblocks in Outer Strike Point (OSP) region

High fluence campaign:

- New campaign with **low T_e on divertor** target (5 eV), using Nitrogen seeding
- To be carried out in autumn 2025, after in-situ cleaning of the divertor using laser
- Compare deposit build-up with divertor T_e of 5 eV versus 20 eV

Addressing urgent ITER issues:

- Boronization studies, Runaway impact and mitigation, ICWC

Campaign schedule for 2025







2024			2025																	
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec						
	C10		80 K	C11					Cryo at 300 K				C12							

Vessel closed

- *In-situ laser cleaning of divertor*
- *Remove divertor sector(s) for installation of new W units*

C11 (January – April 2025):

- ECRH 1 MW
- Boronisation probes 
- Gamma ray spectrometer for RE measurements 
- Edge XICS  

C12 (Autumn 2025):

- ECRH 2 MW
- High fluence campaign with impurity seeding

WEST Task Forces

WLTE experiments are integrated into the WEST programme (One team approach)

Two Task Forces in line with European roadmap:

Plasma regimes of operation (M1)

TFL: Patrick Maget (patrick.maget@cea.fr)

Deputy: Pierre Manas (pierre.manas@cea.fr)

→ RT01, RT02, RT03, RT04, RT08, RT09

Heat exhaust systems (M2)

TFL: Jonathan Gaspar (jonathan.gaspar@univ-amu.fr)

Deputy: Alex Grosjean (agrosjea@utk.edu)

→ RT05, RT06, RT07

Commissioning Manager: Philippe Moreau (philippe.jacques.moreau@cea.fr)

Programme Coordinator: Annika Ekedahl (annika.ekedahl@cea.fr)



WEST Reference SL and DC for WPTE expts



WPTE RT	WEST Reference Session Leader	WEST Reference Diagnostic Coord.
RT01	C. Reux (cedric.reux@cea.fr)	R. Sabot (roland.sabot@cea.fr)
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RT06	J. Gaspar (jonathan.gaspar@univ-amu.fr)	N. Rivals (nicolas.rivals@cea.fr)
RT07	R. Nouailletas (remy.nouailletas@cea.fr)	N. Rivals (nicolas.rivals@cea.fr)
RT08	Ph. Moreau (philippe.jacques.moreau@cea.fr)	R. Sabot (roland.sabot@cea.fr)



irfm



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Thank you for your attention

<https://westusers.partenaires.cea.fr>

