# WEST machine capabilities for 2024

WEST (tungsten-W Environment in Steady-state Tokamak) is a superconducting, MA-class tungsten tokamak, targeted at long-pulse operation. To this end, it is equipped with superconducting toroidal field coils, active cooling loop for the plasma facing components (PFCs), and long pulse heating/fuelling systems. WEST allows performing flexible magnetic configurations (upper single null, lower single null and double null), and features a large aspect ratio of 5-6.

For the phase 2 of WEST (which started in 2022), WEST is equipped with a fully actively cooled tungsten ITER-grade lower divertor, designed for 10 MW/m$^2$ steady state heat exhaust and up to 20 MW/m$^2$ for slow transients (limited number of cycles), enabling to reach the full pulse length capability (up to 1000 s). Long pulse operation is also possible on the actively cooled upper divertor (tungsten coating on copper components), but at a lower heat flux (typically < 8 MW/m$^2$).

The divertor Plasma Facing Units (PFUs) consists of tungsten mono-blocks (MBs) bonded on a CuCrZr cooling tube, with ≈ 0.5 mm toroidal gaps between blocks. In WEST phase 2, the shaping consists of a 0.5 mm height toroidal bevel as foreseen in ITER.

A staged introduction of low-Z (boron based) main chamber PFCs started in 2020 to progress in the understanding of the W migration pattern, starting with the central tiles of start-up inner and outer limiters. The low-Z tiles will remain until mid-2024 (for the C9 campaign), then they will be replaced by bulk W-tiles (for the start of the C10 campaign).

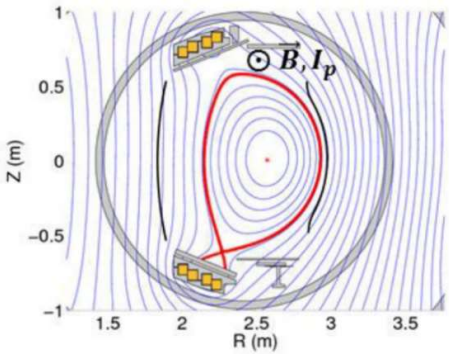
WEST has a versatile fuelling system (gas injection, pellet injection and supersonic molecular beam injection) and can be operated in D and He. An impurity powder dropper (IPD) with four reservoirs for real-time conditioning is also available.

Fixed helicity is required for the lower and upper divertor, so simultaneous $I_p/B_t$ reversal will be required for reversed field operation. As this involves significant hardware modifications, $I_p/B_t$ reversal will not be considered for the 2024 experimental campaigns.

WEST is equipped with a versatile plasma control system (PCS), targeted at handling events for long pulse operation (in particular, a Wall Monitoring System is operational for PFC safety). If interested in applying a non-standard PCS scheme, it is recommended to contact a member of the WEST team beforehand.

## Technical data of WEST:

| | |
|---|---|
| Major/minor radius (m) | 2.5/0.5 |
| Plasma volume (m$^3$) | 15 |
| Elongation | up to 1.35 |
| Triangularity | up to 0.5 |
| Max plasma current (MA) | 1.0 |
| Max toroidal field (T) | 3.7 |
| Discharge duration (s) | From 10 s up to 1000 s (100 s reached in 2023) |
| Discharge frequency (min) | ~20* |




* Longer if pulses > 60 s are performed.

## Fuelling, heating, new diagnostics:

Applied gases in WEST:

- Main plasma: D, He, H
- Other injected gases: $H_2$, $N_2$, Ne, Ar, three impurity lines available simultaneously ($^3$He, Kr, Xe, possible on request)

The plasma of WEST can be heated as follows:

- Ohmic heating up to 1 MW
- Lower Hybrid Current Drive (LHCD), two launchers
  - 7 MW (for 1000 s)
- Ion Cyclotron Resonance Heating (ICRH), three antennas
  - 9 MW for 30 s; 6 MW for 60 s; 3 MW for 1000 s

The LHCD and ICRH antennas can be moved radially between pulses and are equipped with local gas injection systems.

For the second half of 2024 (C10 campaign), the new Electron Cyclotron Resonance Heating (ECRH) system will become available with one gyrotron, providing up to 1 MW for up to 10 s.

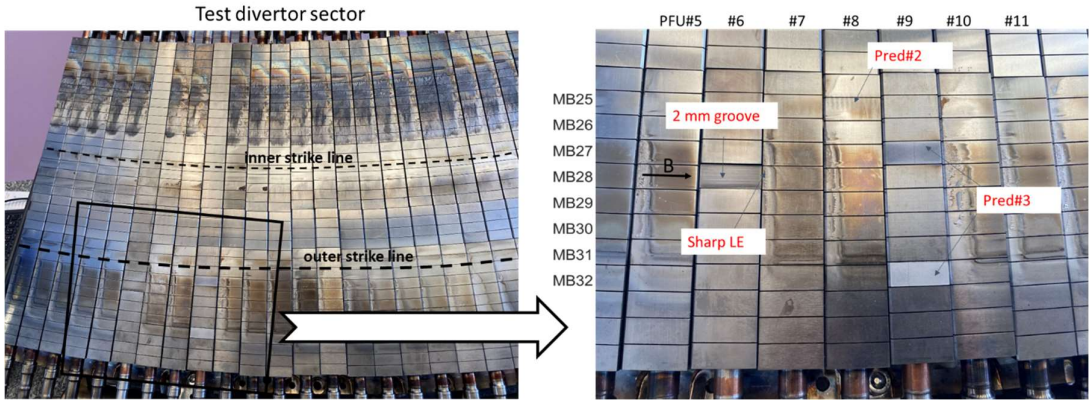
For C9 (first half of 2024), the new Thomson scattering system will provide $n_e$ and $T_e$ measurements in the central plasma with four channels. For C10 (second half of 2024), the central Thomson scattering system will have up to 20 channels and the edge Thomson scattering system for pedestal $n_e$ and $T_e$ will become available.

## Divertor sector for PFU testing:

A test divertor sector located in the field of view of the very high spatial IR camera (PFU#6 to #20) and the visible spectroscopy arrays (PFU#7`and #20) is dedicated to specific experiments. For C9 (first half of 2024), the test divertor sector includes two pre-damaged PFUs and one PFU with a groove in one MB to carry out a W-melting experiment (see table below).

| PFU number | Misalignment* | Description |
|---|---|---|
| #6 | 0 | Groove (2 mm deep, 12 mm width) MB28 |
| #7 | +0.3 mm vertical | Sharp LE (W-melting exp.) – no chamfer |
| #8 | 0 | Pre-damaged #2 (crack network) MB25 |
| #9 | +0.3 mm vertical<br>+1.5 mm poloidal | Pre-damaged #3 (self-castellation) MB27 and MB32 |
| #10 | 0 | |
| #11 | -3 mm poloidal | |
| #12 | 0 | |
| #13 | +3 mm poloidal | |
| #14 | 0 | |
| #14 | -1.5 mm poloidal | |

* The misalignment represents the step between the observed MB with the previous one (upstream).




Individual PFUs can be misaligned with respect to each other in the vertical or radial direction for dedicated experiments. This can be done during a shutdown if the divertor sector is removed from the vessel. PFUs could be moved and assembled on request for the C10 campaign.

**Indicative timeline for 2024:**

| 2024 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
| | C9 | | | | | | | | C10 | | | |

More information on the machine description and the list of available diagnostics can be found on the WEST User Portal, available via https://westusers.partenaires.cea.fr/