

- ✓ Semi continuous operation is then planned from February 2027 onwards, with possibly short breaks to install various baffle configurations, following requests from the experimental programme.
- WEST
 - ✓ A 3.5 months shutdown is planned in early 2026, to allow for removal of dedicated divertor components for post exposure analysis after the 2nd High Fluence campaign planned in C12 by end 2025.
 - ✓ 2 campaigns of ~3 months each are then planned in 2026 (C13 from mid April until July 2026 and C14 from September until end of November 2026), with a short break over the summer, presumably without machine opening.
 - ✓ The same scheme is tentatively planned for 2027, with a 3.5 months shutdown planned from December 2026 until mid April 2027, and 2 campaigns of ~3 months each (C15 from mid April until July 2027 and C16 from September until end of November 2027), with a short break over the summer.

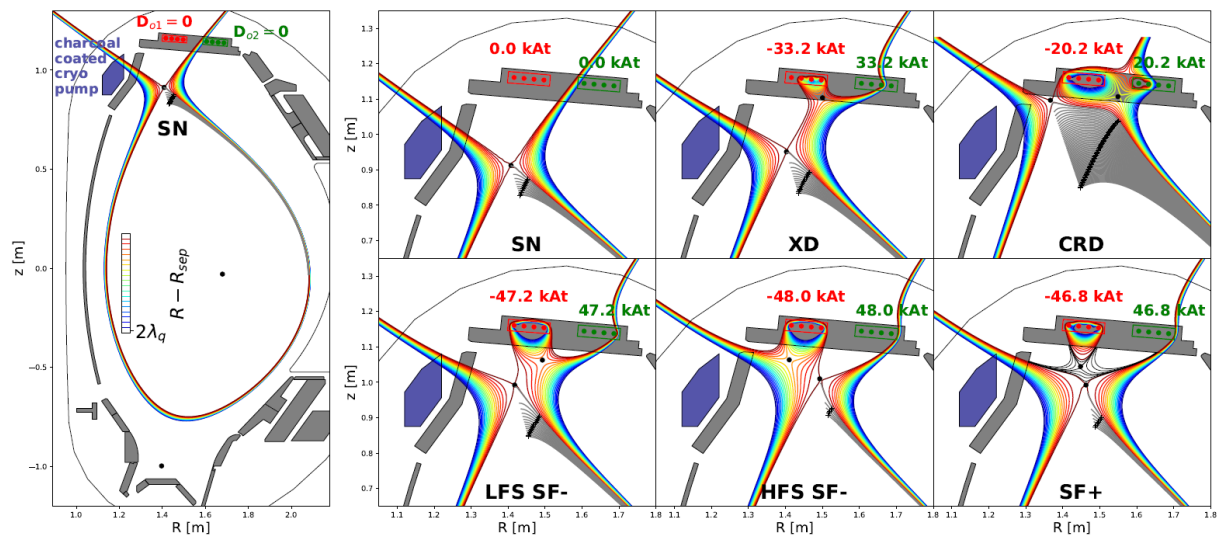
Overview of WP TE devices capabilities

In 2026/27, WPTE will execute experiments on the following devices: AUG, MAST Upgrade (MAST-U), TCV and WEST. A short overview of the various devices, including new capabilities for 2026/27, is found below, but more information is available on the WPTE wiki pages and on the devices intranet sites (credentials required).

AUG

ASDEX (Axially Symmetric Divertor Experiment) Upgrade is a midsize tokamak operating since 1991. From 2007 onwards, the machine has been almost completely equipped with tungsten (W) plasma-facing components (PFCs). The lower divertor configuration, presently DIV III from 2014 onwards, has been optimized to enable ITER and DEMO-relevant physics investigations while upgrading of the upper divertor has been completed for the 2025 experimental campaign. For the 2014 campaign, a divertor manipulator was installed on AUG, allowing the exposure of two full-size divertor PFCs in the low-field side (outer) strike point region during a pre-determined number of discharges. AUG also has manipulators in the outer midplane and in the typical X-point region at the outer divertor. In addition, the machine has an extensive set of in-vessel coils for inducing resonant magnetic perturbations, e.g., for suppressing ELMs.

AUG makes it possible to execute various plasma configurations from lower single null (SN) to upper SN, double null (DN), limiter plasmas, and a number of alternative divertor configurations (ADC) at the upper divertor. The relevant ADC scenarios range from SN to X-point divertor (XD) and from compact radiative divertor (CRD) to various snowflake (SF) varieties. Examples of the possible upper-divertor configurations can be seen in the figure below.



The lower divertor has a fixed helicity and here the directions of the plasma current and toroidal field need to be changed together. Reversing the current requires special efforts, thus typically only 1-2 weeks with reversed current and toroidal field is executed per campaign. In contrast, reversing the toroidal field can be done flexibly for upper SN discharges.

AUG has a variety of non-standard control schemes. If interested in applying such a scheme, direct contact with a member of the AUG control group is recommended. AUG has an operational shattered pellet injection (SPI) system. For sophisticated scenario development, a new discharge program editor *ndpe*, visualisation tools and a flight simulator *fenix* will be deployed for all users with an IPP user id.

Technical data of AUG:

Major/minor radius (m)	1.65/0.5
Max height/width of the plasma (m)	0.8/0.5
Plasma volume (m ³)	13
Triangularity range	-0.35 → 0.6
Max plasma current (MA)	1.4
Max toroidal field (T)	3.2
Discharge duration (s)	<10
Discharge frequency (min)	20

Applied gases in AUG:

- Main plasma: D₂, H₂, He
- Other injected gases: N₂, Ne, Ar, Kr, Xe, Kr+D₂, Xe+D₂, CD₄ (on request)

The plasma of AUG can be heated as follows:

- Ohmic heating: up to 1 MW
- Neutral beam injection (NBI) - 2 boxes, 8 sources. NBI injector II is now fully equipped with variable gap sources, allowing separate changes of power and acceleration voltage
 - ✓ 10 MW @ 60 kV
 - ✓ 10 MW @ 93 kV
- Electron cyclotron resonance heating (ECRH) - 8 gyrotrons, ECRH II + III
 - ✓ 5.5 MW @ 140 GHz
 - ✓ 4 MW @ 105 GHz
- Ion cyclotron resonance heating (ICRH)
 - ✓ 5 MW @ 30 or 36 MHz for 2026, 6.5 MW from 2027
 - ✓ additional frequencies with lower power on request

For the 2026/27 campaign, the main upgrades include the use of upper divertor in-vessel coils for the upper bidirectional divertor with differential currents (2027), refurbished MGI valve(s) (2026) and a number of upgraded diagnostics such as dispersion interferometer for robust, fast density measurements in routine operation and Mantis camera for runaway measurements (2026).

More information of the machine and the list of available diagnostics can be found on <https://www.aug.ipp.mpg.de/wwwaug/>

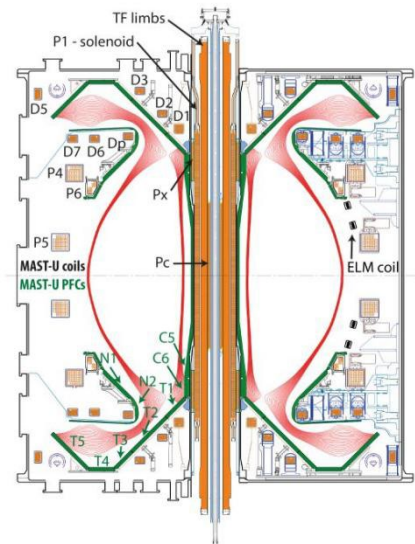
MAST-U

MAST-U is an upgrade to the MAST (Mega Ampere Spherical Tokamak) device in operation since late 2020. As the name says, MAST-U is a spherical tokamak designed for investigating a wide range of alternative divertor configurations, especially the Super-X and comparison with conventional configurations, X-divertor and snowflake configurations are also supported. The machine is equipped with carbon PFCs and features two rows of resonant magnetic perturbation coils for ELM control and error field correction. The produced perturbations have a maximum toroidal mode number up to n=2 with the upper coils and n=4 with the lower coils. Two external pairs of coils are used to provide n=1 and n=2 error field correction.

The MAST-U divertors are up-down symmetric and closed, with lower divertor cryopump available; the upper divertor cryopump is expected in the MU05 campaign (2026). Inter-shot glow discharge cleaning is used between pulses to ensure strong wall pumping and regular boronizations are used to moderate the oxygen content of the plasma. There are separate toroidal chambers for realizing long-legged divertor configurations such as the Super-X. At present only operations in the forward-field configuration (the ion $\mathbf{B} \times \nabla B$ drift points downward) and nominal plasma current direction are supported.

Technical data of MAST-U:

Major/minor radius (m)	0.7/0.5
Max elongation	2.5
Triangularity range	up to 0.6
Max plasma current (MA)	1.0
Max toroidal field (T) on axis	0.65 - 0.72
Discharge duration (s)	<2
Discharge frequency (min)	20-25



Applied gases in MAST-U:

- Main plasma: D_2
- Extrinsic impurities: He, N_2 , CD_4

The plasma of MAST-U can be heated as follows:

- Ohmic heating: 0.2-1 MW
- NBI – 1 on-axis beam, 1 off axis beam
 - ✓ 3.5-4.2 MW total injected power from both beams @75 keV
 - ✓ Beams can be modulated on request

Control capabilities:

- Plasma current control
- Vertical position control
- Equilibrium shape control of the confined plasma and divertors with real-time magnetic measurements
- Detachment control
- Density control

More information on the machine and the list of available diagnostics can be found on https://wiki.euro-fusion.org/wiki/WPTE_MAST-U

TCV

TCV (Tokamak à Configuration Variable) is a midsize tokamak featuring flexible shaping and positioning of the plasma as well as high power-density heating and current drive by ECRH (ECCD), in addition to

NBI. The machine has carbon PFCs and open lower and upper divertors, but since 2019 lower divertor baffles of different sizes are available to be installed for dedicated operation periods.

Owing to the flexibility of the machine, the triangularity (positive and negative), squareness, and elongation of the plasma can be varied over a large range and various alternative divertor configurations can be realized, including snowflake +/-, super-X, X-divertor, and doublet configurations. The installation of the tightly-baffled long-leg divertor (TBLD) for advanced detachment studies is planned in 2026.

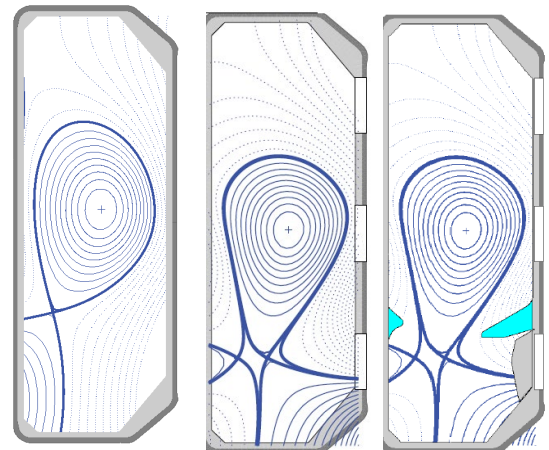
The directions of both the toroidal field and the plasma current can be switched in between discharges.

TCV has a variety of non-standard control schemes. The most notable of these are:

- Multi-parameter integrated control with supervisory actuator management: this can include a combination of beta, current-profile, density-profile, NTM, and sawtooth period control (possibly including realtime modeling, i.e., RAPTOR), and can count on sub-ms full Grad-Shafranov equilibrium reconstruction and on both NBI and ECRH actuators.
- Detachment control through radiation front observation.
- ECRH-assisted breakdown control.

Technical data of TCV:

Major/minor radius (m)	0.88/0.25
Max elongation	2.8
Triangularity range	-0.8 → 0.9
Max plasma current (MA)	1.0
Max toroidal field (T)	1.54
Discharge duration (s)	<4
Discharge frequency (min)	12



Applied gases in TCV:

- Main plasma: D₂, H₂, He
- Other injected gases: N₂, Ne, Ar, Kr
- 10 toroidally and poloidally distributed fueling and seeding valves, 3 GPI valves

The plasma of TCV can be heated as follows:

- Ohmic heating: 0.2-1 MW
- NBI - 2 sources (in opposite directions i.e. 1 source is always counter- I_p)
 - ✓ NBH-1: 1.32 MW @ 25 kV
 - ✓ NBH-2: 1.12 MW @ 45 kV
- ECRH - X2 and X3 configurations (NB! not all powers are available simultaneously)
 - ✓ 2.4 MW + 0.9 MW @ X2 lateral (82.7-84 GHz, 3 launchers (4 in 2027))
 - ✓ 0.9 MW @ X3 lateral (118 GHz, 2 launchers)
 - ✓ 1.8 MW + 0.9 MW (new in 2025) @ X3 top-launched (126 GHz, 2 launchers (3 in 2025))

More information on the machine and the list of available diagnostics can be found on https://wiki.euro-fusion.org/wiki/WPTE_TCV

WEST

WEST (tungsten-W Environment in Steady-state Tokamak) is a superconducting, full-W tokamak, equipped with superconducting toroidal field coils, active cooling loop for the PFCs, and long-pulse heating/fuelling systems. WEST allows flexible magnetic configurations (LSN, USN, DN and NT) and features a large aspect ratio of 5-6.

WEST is equipped with a fully actively cooled tungsten ITER-grade lower divertor, designed for 10 MW/m² steady-state heat exhaust and up to 20 MW/m² for slow transients (limited number of cycles), enabling to reach the full pulse length capability (>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/m²).

The lower divertor Plasma Facing Units (PFUs) consist of tungsten mono-blocks (MBs) bonded on a CuCrZr cooling tube, with \approx 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. The inner bumpers and the start-up limiter (APL) are equipped with W tiles. The BN-tiles used in 2020-2023 have been removed, thus providing a machine with full-W environment.

Negative triangularity (NT) configuration can be achieved by inverting the coil current direction in the upper divertor. This inversion requires one day before the experiment, and one day to reverse back again. Fixed helicity is required for the lower and upper divertor, so experiments with I_p or B_t reversal are not considered for 2026.

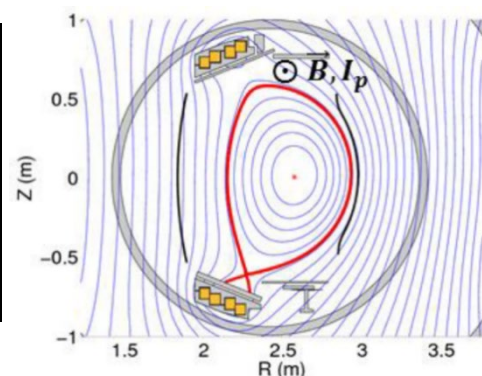
The fuelling of WEST is supplied via gas injection with 21 valves from 11 different locations and pellet injection through 4 injections points (1 LFS equatorial plane + 3 HFS). A massive gas injection system has been implemented to study the disruption and runaway mitigation. An impurity powder dropper (IPD) with four reservoirs for real-time conditioning is also available.

The plasma control system (PCS) is 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
Max elongation	1.35
Triangularity range	up to 0.5
Max plasma current (MA)	1.0
Max toroidal field (T)	3.7
Discharge duration (s)	>1000 s
Discharge frequency (min)	\sim 20*

Applied gases in WEST:



* Longer if long pulses (>60 s) are performed.

- Main plasma: D₂, He, H₂
- Other injected gases: H₂, N₂, Ne, Ar, are fuelled through three impurity lines available simultaneously (³He, Kr, Xe, possible on request)

The plasma of WEST can be heated as follows:

- Ohmic heating: up to ~1.3 MW
- Lower Hybrid (LH) Current Drive – 2 launchers
 - ✓ 6 MW for 1000 s
- ICRH – 3 antennas (the ICQ4 antenna is planned to be reinstalled in early 2026)
 - ✓ Max capacity (3 antennas): 9 MW for 30 s; 6 MW for 60 s; 3 MW for 1000 s
- ECRH and ECCD: The gyrotrons will be successively commissioned in 2026. 3 gyrotrons will be available end 2026.
 - ✓ 1 MW per gyrotron for 10 s

The LHCD and ICRH antennas can be moved radially between pulses and are equipped with local gas injection systems. The EC-wave injection angles can be varied between +25° and -25° in toroidal direction and between +17° and -17° in poloidal direction.

Recent diagnostic upgrades:

- The core Thomson scattering system provides n_e and T_e measurements in the central plasma with up to 20 channels. The edge Thomson scattering system provides pedestal n_e and T_e measurements with up to 32 channels.
- The fast infrared camera (FIRCA) has been installed in a dedicated vertical endoscope in Q4A upper port, viewing the lower divertor sector in Q4A.

Divertor sector for PFU testing:

The test divertor sector (in Q3B) has 30° toroidal extension and is dedicated to technological tests or physics studies on the components. A very high spatial resolution IR system (called VHR IR) enables to monitor the surface temperature of the W MBs with a field of view of 65 mm × 50 mm (0.1 mm / pixel) moveable on an observable area covering a grid of 17 PFUs by 20 MBs, with 20 Hz sampling rate. The VHR IR camera field of view can be changed between pulses to investigate different areas of the test divertor sector and therefore different heat loading conditions with respect to the toroidal ripple field effect.

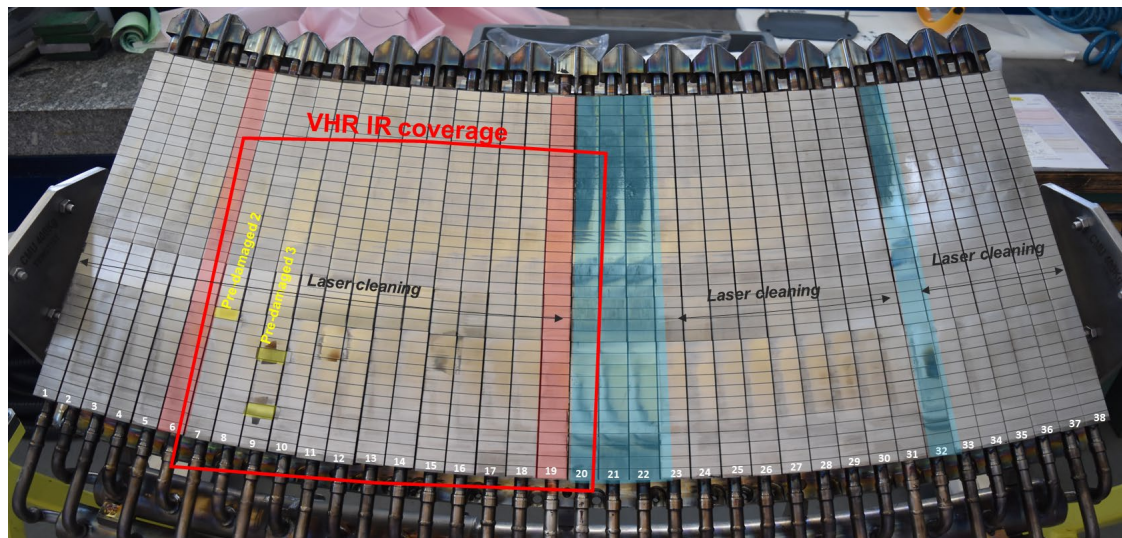
PFUs have been taken out from the production batch and exposed in a HHF test facility (e-beam gun) to generate well-controlled and different type of damages:

- Pre-damaged PFU#2 (featuring crack network on MB25) was exposed in WEST campaigns C6-C7 (PFU location #7), C8-C9 (PFU location #8) and C10-C11 (PFU location #7). Pre-damaged PFU#2 will most likely remain in PFU location #7, in the maximum heat flux area on the low field side.
- Pre-damaged PFU#3 (self-castellation on MB27 and MB31) was exposed in WEST campaigns C8-C11 (PFU location #9). Pre-damaged PFU#3 will most likely remain in PFU location #9, in the maximum heat flux area on the low field side.

Vertical and poloidal misalignments are deliberately introduced to investigate heat load in different configurations. A first series of six consecutive PFUs were installed for the C6-C7 campaigns with misaligned MBs in the poloidal direction (1.5 mm and 3 mm shifts) to generate amplified thermal

signatures of the Optical Hot Spot (OHS) on the 45° inclination chamfer of the adjacent downstream MB. They are situated in PFU locations #10 - #15. This will be kept for 2026.

Two PFUs are dedicated to technological tests, one in PFU location #6 and one in PFU location #19 to reach maximum heat load on the low-field and high-field sides, respectively. Four PFUs have been chosen to assess net erosion and deposition over the campaigns (PFU locations #20, #21, #22 and #32). No surface cleaning or change will be applied during shutdowns, in order to preserve the erosion and deposit history along WEST phase 2. During the summer 2025 shutdown the other PFUs have been cleaned using a laser cleaning method (see figure below).



- Predamaged MBs
- Technological tests
- PFU reference (no cleaning)

In addition to the pre-damaged PFU#2 and PFU#3 described above, a pre-damaged PFU#4 with a native interface default at MB#13 between W and Cu-OFHC is installed in the divertor sector Q1B.

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/>