

WEST shutdown to adjust the magnetic configuration

The summer shutdown was dedicated to the cut of the upper stabilizing ring, the installation of the first ICRH antenna and the improvement of many diagnostics.

The first WEST experimental campaign C1 ended July 28. Very good progresses have been made in the commissioning of the machine sub-systems. While plasma breakdown were routinely achieved, plasma current ramp-up was unexpectedly inhibited by the stray magnetic field produced by the passive structures introduced inside the vessel to improve the plasma vertical control.

The summer shutdown was thus focused on the alteration of the passive structures encouraged by the first experimental results and modelling. The planned

modifications required the removal of the divertor plasma facing components and the emptying of the main cooling loop. The stabilizing plate was split in 6 parts (every 60°) to reduce the induced current during plasma startup.

As initially planned, the new ICRH antenna has been plugged to the torus during this summer break (see below) and new diagnostics were installed.

The new X-ray imaging crystal spectrometer which will provide plasma temperature and rotation profiles has

been connected to the vacuum vessel. Two new lines of sight will enhance the interferopolarimeter with divertor and pedestal measurements. The second vertical reciprocating probe is now operational and finally a prototype of Hall Effect sensor for ITER has been positioned in a specific sleeve for testing.

The objective is to resume plasma experiments in October.

The 1st WEST ICRH Antenna ready to inject power

During the first part of 2017, the numerous pieces of the first WEST ICRH antenna 3D jigsaw, provided by ASIPP (China), were fit together. Then, the antenna endured an extensive qualification campaign before its plugging to the tokamak.

This is the first of a series of three ELM-resilient, actively cooled, antennas designed to provide up to 3MW of plasma RF heating each. The main challenge during the assembly phase lies in the water circuits, since this antenna is fully water-cooled to satisfy the requirement to operate in continuous wave. For each assembly steps involving components welding or sealing, room temperature leak test detections were performed.

At the end of the assembly phase, low level RF characterization were conducted to confirm the RF behavior and find the matching points at nominal frequencies. Then the antenna was introduced into the dedicated vacuum tank TITAN for a global leak test based on three temperature cycles (from room temperature to 200°C, one week per cycle) with its cooling circuit pressurized by helium at 60 bars.

The last step before integrating the antenna into its port plug is the RF commissioning, also performed in TITAN testbed. The objective of this test is to confirm the antenna electrical voltage holding (typically 30 kV) under vacuum conditions. To avoid any damage due to arcing during this delicate phase, specific protection systems are imbedded in the antenna.

The first antenna has successfully passed the preliminary tests and is now installed in WEST waiting for its first plasma.

Flash & watch the
ICRH Antenna road-movie



ICRH Antenna docking on WEST

Temperature is the key parameters to produce fusion reactions: more than 100 million degrees are required in a tokamak. To achieve these unbelievable temperatures heating by radio-frequency wave is used in WEST.

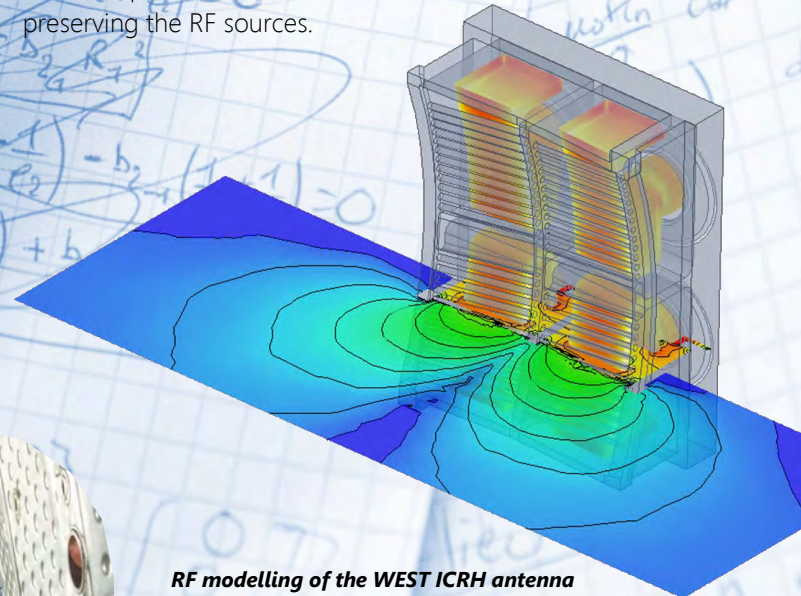
By transferring their energy to the ions (or electrons) of the plasma in a frenetic dance, high power Radio-Frequency waves are used to heat WEST plasma. But launching RF waves into a magnetized plasma is somewhat similar as getting into a fancy nightclub: without respecting certain codes, it can be a delicate process...

In order for the plasma to let the waves in, it is not a matter of wearing the good shoes but a matter of frequency and polarization. At a given frequency, chosen in the range of 30-60 MHz to interact with an ion specie in the plasma center, the magnetized plasma only allows specific kinds of plasma waves to propagate into. The antenna thus must excite some specific waves. For the antenna designer, this leads to dimensional constraints on the orientation, width, spacing and excitation of antenna front face radiating elements.

Thus, before the party gets started, our waves-clubbers must get past the plasma edge gatekeeper. Unfortunately, only a fraction of the RF power reaching the antenna is radiated into the plasma: most of the waves are kicked out from plasma and couple back to the antenna. This reflected power must be diverted from the high power RF sources, in order to avoid damaging them irreversibly.

Different schemes exist for either rerouting this reflected RF power to the dump (into water cooled loads) or back to the plasma. In WEST, the latter approach has been chosen, based on a successful prototype tested on Tore Supra. Capacitors located inside the antenna are tuned in order to create a resonant circuit, which re-circulate the power to the plasma.

However, the plasma variations can be in many cases much faster (submillisecond time scale) than the mechanical systems tuning the capacitors. In the WEST antenna, the choice of the specific 'conjugate-T' electric scheme allows to reduce the reflected power due to these fast transient variations and thus preserving the RF sources.



RF modelling of the WEST ICRH antenna coupling: front-face of the WEST ICRH antenna; four straps, located behind the Faraday screen, are radiating into the plasma facing the antenna.



PICTURE OF THE DAY

**October 2017
WEST vacuum vessel with ICRH antenna plugged in for the first time**

Same player, shoot again

The second experimental C2 will start at the end of October and will run until the end of the year. Having hopefully solved the plasma startup issue, the main objective will be to heat up the plasma with microwaves (Lower Hybrid frequency) to access the so-called H-mode regime of operation (see WNL#15). Heat load patterns on the ITER divertor prototypes will be carefully analyzed with Infrared systems. Besides the new ICRH antenna will be commissioned with plasma.

