Institute for Magnetic Fusion Research

WEST

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Remote ceremony for WEST divertor components delivery

On September 22, SIFFER partners celebrated together, via video, the latest deliveries of the plasma facing components for the new WEST divertor.

From March to October, in China, in spite of the global pandemic, the divertor Plasma Facing Units (PFU) production rate have kept increasing to ensure a timely delivery. All SIFFER (Sino-French Fusion Energy centeR) partners celebrated this achievement on 22 September. It was also the occasion to rejoice in the delivery of the ITER correction coils first batch procured by ITER Chinese Domestic Agency.

On the Chinese side, the celebration gathered researchers and VIP such as the Executive Vice-Governor of Anhui Province, in EAST tokamak control room. On the French side, the researchers and the IRFM director, Jérôme Bucalossi, stood in the WEST premises while CEA high level representative attended remotely.

On the ITER site, the ITER Director General, Bernard Bigot participated from his office.

Bernard Bigot congratulated "*The Chinese Industry, ASIPP and SWIP, for the manufacturing of the 456 actively cooled tungsten Plasma Facing Units of the WEST Tokamak Divertor, and its support to the optimal development of key components of the ITER Divertor*".

Ten thousand kilometers away from each other, the French and Chinese researchers, working jointly on the production of these high-tech components, are looking forward to the next operation phase of WEST.

WEST PFU exposed in EAST control room, China.

WEST PFU mounted on one divertor sector at IRFM, France.

"Winter is coming!"

The magnet cool down has started.

The cool down of the 140 tons superconducting Toroidal Field magnet has started heralding the next experimental campaign. It usually takes about 25 days to reach the superfluid helium temperature of 1.8 K. It includes standby modes at 80 K and 4 K, before integrating the full helium inventory of ~3.5 tons and sending the cryogenic green light signal to the WEST operators. The same sequence will occur on the new superconducting magnets of JT-60SA & ITER with roughly the same duration.

Of course, the involved magnet masses are far from being the same (JT-60SA ≈ 650 tons; ITER ≈ 10.000 tons) resulting in larger cryoplants (electrical power: WEST ≈ 1.1 MW; JT-60SA ≈ 3.8 MW; ITER ≈ 20 MW) in order to keep the same cool down pace of ≈ 1 K/hour.

Coming back to WEST, since the magnet cool down has started, the cryogenic technicians and engineers are on deck to keep an expert eye on the magnet 24 hours a day, 7 days a week.

Cryogenic Team in the control room.

Target TF coil current and temperature for WEST operation.

WEST Science

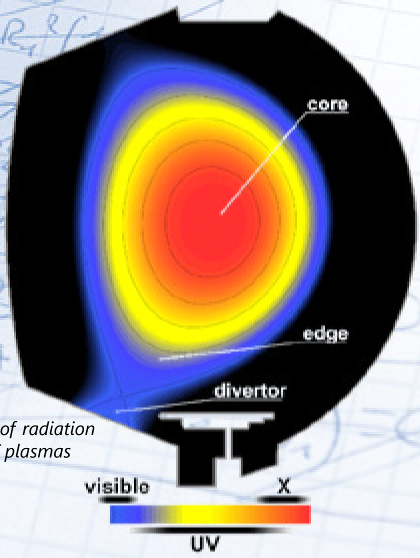
Since the beginning of tokamak research, continuous efforts have focused on plasma radiation.

Plasma radiation defines the ensemble of electromagnetic waves (or photons) emitted by plasma particles.

First, radiation plays an important role in the power balance of plasma scenarios: too much radiation from the hot central plasma will cool the medium and lower the confinement performances. But emitted at the plasma boundary, it lowers the heat loads on plasma facing components and help maintaining the scenario within safety margins.

Second but not least, collecting photons escaping from the extremely hot plasma medium is in most cases simply the only way to diagnose it! So that scientists have learned to use radiation for measurement purposes. Several well-established plasma diagnostics use the collection of radiation emitted by the collective motion of charged particles. The cyclotron motion of magnetised electrons results in a thermalized radiation that depends on electron temperature, which can be inferred from the signals of Electron Cyclotron Emission (ECE) antennas. Using a powerful infrared laser crossing the plasma, beam photons scattered by plasma electrons give access to estimates of local electron density and temperature. This is the basic principle of the Thomson scattering system being implemented in WEST.

The dominant source of radiation in current tokamaks is, by far, the line emissions by atomic electron transitions, which occur when ions are not fully ionised in the plasma. At the plasma boundary, it concerns light impurities like carbon, oxygen or nitrogen. Whereas in the plasma core it comes from heavy metallic impurities like iron, or tungsten as it is the case for WEST. The issue is that the complexity of models for line emission increases dramatically with the number of electrons bound to ions: well established for helium, it is still an active field of research when it comes to tungsten. WEST is currently equipped with several specific spectrometers (sensors providing the radiation as a function of the wavelength) dedicated to tungsten line emission. Experiments and analyses will be part of a global effort to improve tungsten radiation models in view of preparing ITER operation.



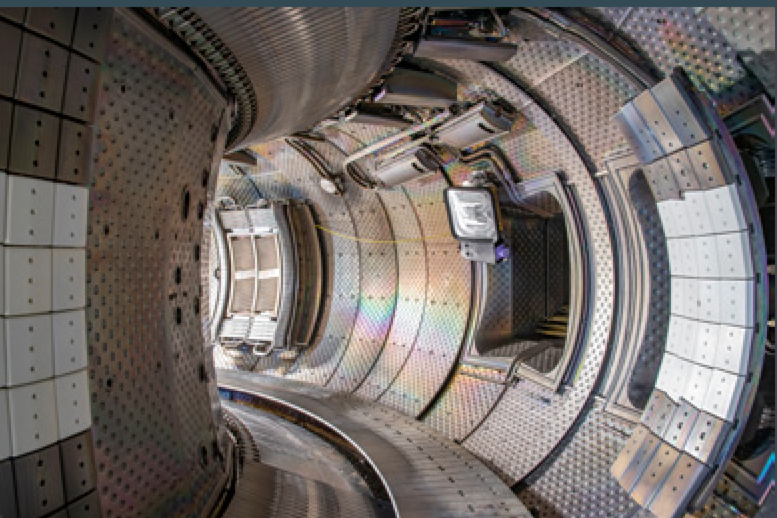
Schematic distribution of radiation wavelength in WEST plasmas

A new look for the WEST limiters for the next campaign!

Tungsten tiles were switched to boron nitride tiles to investigate midplane impurity sources impact.

As expected, tungsten has been identified as one of the main radiating species in the core plasma of WEST (see the WEST Science section above), with deleterious impact on plasma performance.

In particular, the very early phase of the discharge, when plasma is leaning on inner and outer tungsten limiters, has been found to influence subsequent plasma operation.



White components are the boron nitride tiles that replace the tungsten tiles on WEST inner and outer limiters for the next experimental campaign.

In order to investigate the impact of this start up phase, current tungsten tiles of the 6 inner bumpers and the outer limiters have been replaced by boron nitride tiles, a low-Z ceramic material. 92 tiles located in the midplane of the limiters, corresponding to the main contact area with the plasma during start-up phase, will be replaced, while the upper and lower parts of the limiters will remain equipped with tungsten tiles.

In addition to being a low-Z material, boron nitride has attractive thermal properties for a plasma facing material. A tile prototype was successfully tested in mechanical fatigue last June. However, the experience as to its behavior in a tokamak in operation is still scarce. The first weeks of the coming C5 campaign will be decisive for the future of boron nitride in WEST, as one could consider extending its use to RF antennas limiters if proven successful in reducing core tungsten contamination.

The scientific program of C5 will therefore focus on investigating the impact of these new low-Z limiters on plasma performance, in the framework of EUROfusion, as well as on pursuing the effort towards H mode after the first transitions observed last year. Additional features for C5 include two new actively cooled ITER grade divertor sectors (see first article), to be used for dedicated component melting and misalignment experiments, as well as the implementation of an impurity powder dropper and X ray diagnostics provided through a collaboration with US laboratories (PPPL, ORNL and associated universities).

Institut for Magnetic Fusion Research
DRF/IRFM
CEA Cadarache 13108 Saint Paul lez Durance Cedex France

http://west.cea.fr
Contact Newsletter
Sylvie Gibert
sylvie.gibert@cea.fr

+ info