DE LA RECHERCHE À L'INDUSTRIE
cea
Institute for Magnetic Fusion Research
WEST
Newsletter N°27 - May 2020

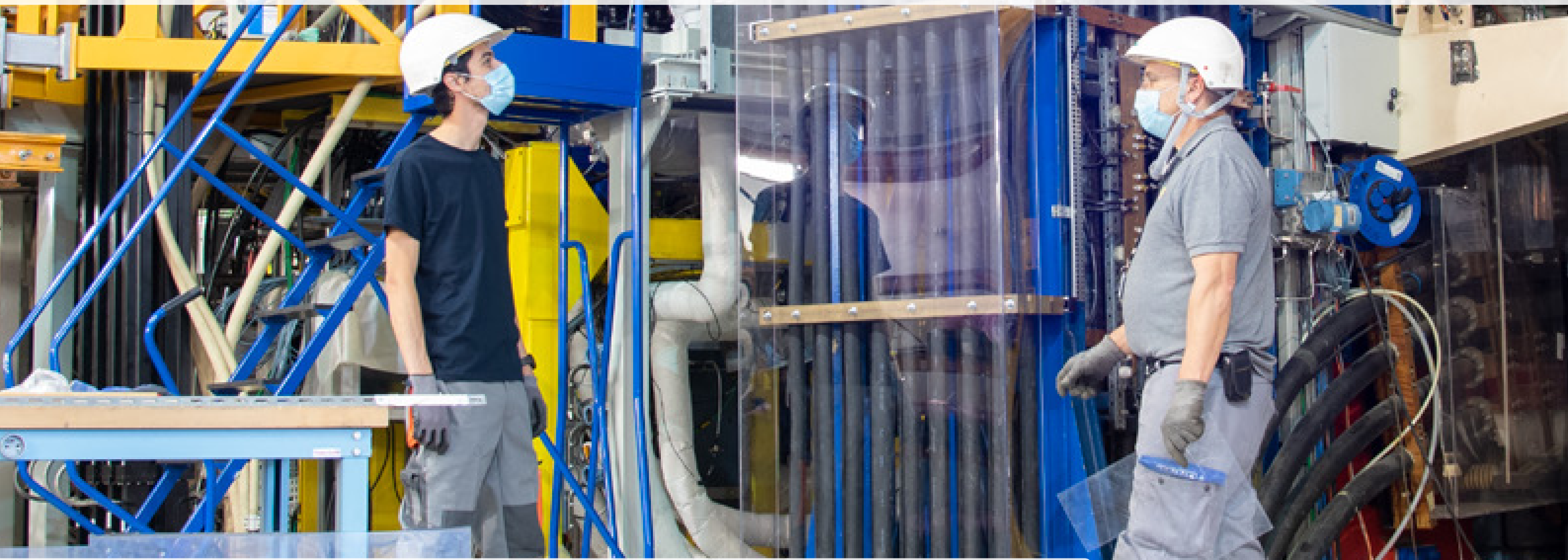
Work resumes on WEST site after COVID-19 lockdown ends

After two months of confinement, activities are progressively restarting in order to prepare the new experimental phase.

The C4 experimental campaign was successfully completed in November 2019. The shutdown focuses now on the installation of a series of ITER-grade Plasma Facing Units (PFU) with the objective to get a fully actively cooled lower divertor. This achievement will give access to nominal plasma discharge durations up to 1000 s and therefore to extensive plasma exposure of components.

The start-up tungsten-coated graphite divertor sectors were removed from the vacuum vessel before the COVID-19 lockdown. Disassembly of the uncooled PFU from their supporting structure and their replacement by ITER-grade PFU had to be stopped in the middle of March.

Since May 25, the first engineers and technicians are back on CEA site to carry on their day-to-day business with great enthusiasm. In parallel to the preparation of the divertor sectors which takes place in a dedicated workshop, various activities are planned inside the torus hall: the modification of the piping network of the divertor cooling system; the doubling of the divertor pumping capability by the installation of turbomolecular pumps in 5 additional ports; the installation of three new X-ray monitors and a boron powder dropper, all provided by Princeton Plasma Physics Laboratory. Naturally, appropriate sanitary measures are in place to protect the workers during these operations.



First batches of ITER-grade PFU received from China.

Despite the COVID-19 pandemic, 80 tungsten Plasma Facing Units were delivered to Cadarache.

Since January 2020, the large-scale industrial production of the WEST divertor PFU with the ITER fully actively cooled technology entered the reception phase. Several technical issues were to be solved during the qualification phase to meet the high-level quality standard required for such components. Afterwards, the first batch of 80 components out of the 456 required to complete the WEST divertor, has just been qualified at IRFM in view of equipping the first two 30° divertor sectors.

Based on ITER divertor vertical target technology (namely, tungsten (W) monoblocks joined to a CuCrZr tube with water cooling), the WEST divertor is being fabricated by Huainam New Energy Research Center in China. The industrial follow-up, performed by IRFM together with WEST Chinese partners (ASIPP and SWIP laboratories), aims at accompanying the industry in manufacturing and qualifying WEST PFU and at gaining relevant experience in the area of large-scale production of actively cooled ITER-grade components. The last batch is expected at Cadarache by the end of July.

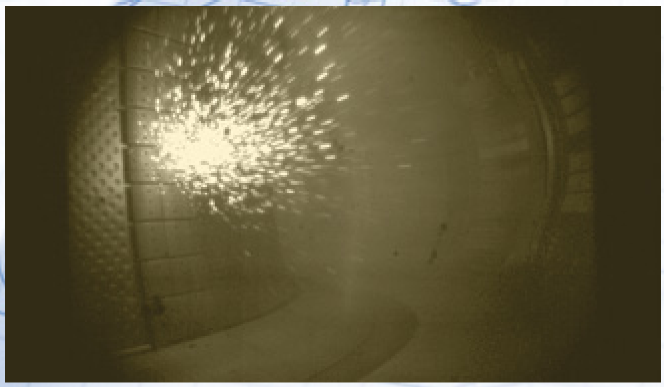
WEST torus hall on 28 May 2020

WEST Science

Electrons from the plasma can be accelerated to relativistic energies during plasma start-up or disruptions.

A tokamak plasma is composed of ions and electrons and is subject to electric fields. These fields are notably used to drive the electric current circulating within the plasma and creating the particle confinement. Electrons are accelerated by those fields but also undergo numerous collisions with other fellow electrons or ions, thus slowing them down. In normal tokamak conditions, these two processes balance each other. But in situations where the electron density is low or the electric field is high, such as plasma start-up or premature terminations (disruptions), an electron may gain more energy than it loses along one turn around the torus. Its speed then increases very quickly up to relativistic energies: it "runs away" from the thermal distribution of the plasma. Furthermore, collisions between runaway electrons and cold thermal electrons may transfer enough kinetic energy from the former to the latter that a runaway avalanche occurs. This process may convert a substantial part of the plasma current into a runaway beam.

Runaway electrons (or simply runaways) are deleterious for tokamak operations because they can deposit large quantities of energy on highly localized regions of plasma facing components and may reduce their lifetime. It is therefore essential for future devices including ITER to understand how to avoid generating them or mitigate them if avoidance is impossible. Many tokamaks in the world including WEST are investigating ways to avoid or mitigate runaways. The most promising method currently consists in injecting large quantities of matter (gas or solid pellets) during the plasma disruption to "brake" them. WEST having produced a lot of runaway electrons during its early phase of experimentation brings insight into this issue for ITER by helping understand conditions to avoid them.



Impact of a runaway beam on the WEST inner wall limiters. Tungsten dust heated and ablated by the beam is seen flying off the tiles.

PPPL X-ray diagnostics

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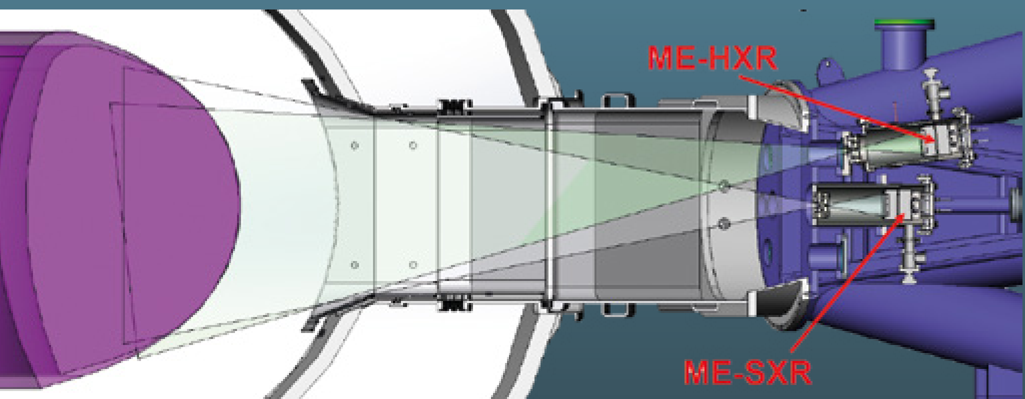
In the context of the DOE-CEA collaboration agreement on "Low Carbon Energy Technologies", these three diagnostics being build are:

• a compact Multi-Energy Hard X-Ray (ME-HXR) camera for measuring the energy- and space-resolved hard X-ray emissivity between 10 and 100 keV, aiming atmeasuring the local electron temperature (Te) and the fast-electron-tail density produced by radio-frequency current drive (LHCD);

• a compact Multi-Energy Soft X-Ray (ME-SXR) camera for energy-resolved measurements between 2 and 20 keV with the goal of measuring Te-profiles and local impurity concentrations (for power balance and transport studies);

• a medium-resolution compact X-ray Imaging Crystal Spectrometer (cXICS) for resolving profiles of spectral line emission which will contribute to estimates of concentrations and transport of medium- (e.g. Ar) and high-Z (e.g. W) impurities.

PPPL's X-ray group has established a robust measurement capability based on 2D pixel array X-ray Si and CdTe detectors. Therefore WEST with its metallic plasma facing components and long-pulse environment is an ideal candidate to deploy this novel technology. LHCD heating and current drive scenarios will serve to test the newly developed ME-HXR camera for identification of the birth of non-thermal runaway-electrons. The compact size of these diagnostics allows for straightforward and flexible deployment including re-entrant configurations that provide a wide field of view. PPPL is in charge of the design, construction, and operation of the diagnostics. Two PPPL post-docs will be located full time on site. CEA is in charge of the installation and implementation of the data acquisition system. A Conceptual Design Review was held in 2019 and a successful Final Design Review followed in January 2020. The diagnostics will be delivered to CEA this summer; the installation is scheduled to be completed before the machine closure so that they will be operative for the next campaign (C5).



Field of view for the ME-HXR and the ME-SXR diagnostics.

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