OVERVIEW OF THE WEST-ITER DIAGNOSTIC INSTRUMENTATION (WIDIA) COLLABORATION ACTIVITIES

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The ITER organization is actively preparing for the implementation of high-performance real-time measurement systems that will monitor and optimize the plasma while ensuring the operational safety of the machine's components. With this in mind, joint activities with the CEA have been carried out for several years, consisting of testing, designing and/or developing often innovative diagnostics in a dedicated CEA laboratory or on the WEST tokamak. All of these activities are grouped under the name WIDIA (WEST-ITER Diagnostic Instrumentation agreement). In the following a review of the main different type of WIDIA activities is presented.

A first set of activities concerns the development of the I&C for the sensors located at the ITER diagnostics port plugs, to avoid overheating and huge mechanical stresses that could occur during disruption. For that purpose, ITER Organization plans installing in different port plugs several thermocouples and accelerometers/strain gauges to monitor in real time both temperatures and mechanical movements to understand and follow the evolution of the port plug deformation, loads and their reactions onto the vacuum vessel port extensions. This will ensure safe operations and behaviours of port plugs all along the vessel lifecycle. By monitoring the temperatures, correlations are made to detect potential hot points in specific locations of the machine and to benchmark the associated modelling. Another application is to estimate the injected Stray Radiation in the plasmas due to power injection during operation. This stray heat can propagate to the ECH window through optical paths and may cause damage. Some thermocouples are used as part of the Electron Cyclotron Heating (ECH) sensors monitoring the ECH stray radiation going through the diagnostic windows. IO and CEA work together to test and optimize these diagnostics in laboratory. For example, different tests were performed to estimate the potential losses in the thermocouple's wires (length and number of junction's impact) and the interactions with high energy cables running beside them (inducted current effect / high frequency perturbation). To synchronize all events, internal TCN (Time Communication Network) is used. Dedicated devices are connected to this Precise Time Network, (PTC, nanosecond) and the optical interrogators (in charge of data acquisition) synchronized with all others real-time devices. The challenge is to define the right architecture to ensure this requirement and to properly synchronize, acquire, timestamp and publish collected data on the network for further analyses. Thermocouples, accelerometers and strain gauges are managed by the same acquisition unit. Reliability and maintenance aspects have deeply been considered to ensure that goals of this diagnostic could be reached in all conditions even in degraded mode.

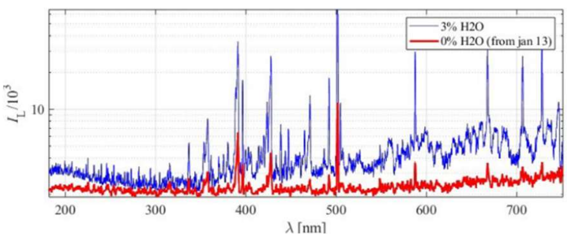

Figure 1: Intensity versus wavelength recorded by visible spectrometer during water leak

ITER requires also a high vacuum (1×10^{-5} Pa) to create and sustain a high-performance plasma. [1]. A leak as small as 10^{-6} Pa·m^3·s^{-1} of either air or water compromise the high-vacuum condition and could impede the operation of a fusion device [2]. Detecting the existence of a leak can be done using pressure gauges but identifying which component is leaking could take several weeks in present day tokamaks like ITER. Hence, there is a pressing need to develop methodologies for fast automatic spatial localization of micro-metric leaks. In order to address this issue, an approach has been devised for the detection and localization leaks using glow discharge cleaning (it is a method of conditioning vacuum vessel walls using a low temperature unmagnetized plasma discharge [3]) together with visible spectroscopy and visible imaging. First encouraging results of the experiments are presented as seen in Figure 1 showing the measured visible spectrum when the calibrated water leak valve is closed and when it is set to the smallest possible leak of about $\Phi_{H2O} = 6 \times 10^{-4}$ Pa$\cdot m^3 \cdot s^{-1}$ (which corresponds to 15 mg/h)

Concerning the primary diagnostics, magnetic diagnostics play a key role for any tokamak operation. Accurate measurements are mandatory to ensure precise magnetic reconstruction of the plasma and, as a result, to perform plasma control and wall protection. On ITER tokamak, 450 mirnov coils (inductive magnetic sensors) will be installed on the inner skin of the vacuum vessel [4], [5]. They constitute the main magnetic systems to recover the plasma magnetic parameters. The full set of sensors was calibrated with a dedicated testbed in the frequency range of 20 Hz up to 2 MHz by measuring their response in terms of amplitude and phase shift. In addition, the integrator [6] associated to any inductive magnetic sensor are crucial element in the magnetic signal measurement chain because, being prone to drift, they may compromise the accuracy of the plasma reconstruction accuracy. One prototype of ITER integrator was qualified on WEST during plasma experiments (800 pulses with duration up to 6'04'') and compared to WEST measurements in order to identify any drift, as seen in Figure 2.

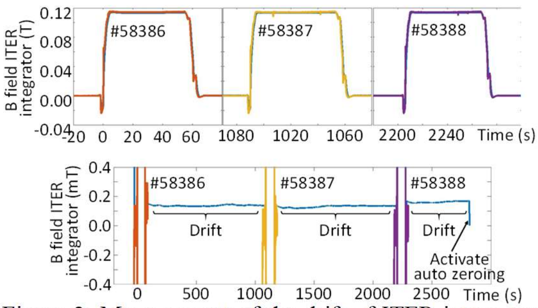

Figure 2: Measurement of the drift of ITER integrator during 3000 s. Top: zoom on pulse performed during the test. Bottom: zoom on integrator signal during and between pulses.

Development of software is also part of the WIDIA activity. For example, CEA demonstrated some year go under CODAC request that the Thermavip software could interface the UDA data servers. The goal of the WIDIA activity in that field is to deploy the Thermavip software in a server located in IT/XPOZ domain and adapt it to read the data required for Tokamak System Monitor (TSM) data analysis activities. This work follows two phases: first to make the necessary developments in a Thermavip plugin to read back UDA data from the CODAC XPOZ archive, stream live data and ensure that ITER 3D CAD models can be open, visualize and manipulated from within Thermavip. Second to demonstrate the use of Thermavip interface for the Tokamak Systems Status and warning panels as implemented in the existing TSM PDR prototype. This dedicated HMI will embed a Python anomaly detection algorithm, display alarms in a list widget, and highlight the linked sensors in a 3D model of the machine.

Finally design and conception complete the WIDIA work. As example the Port Plug Test Facility (PPTF) consists of 4 Test Stands which have been designed for performing environmental tests and providing the environmental conditions and services necessary for the functional tests of the clients (Port Plugs and In-Vessel Components). The conception of a PPTF system capable of acquiring and checking the basic correct behavior of any diagnostic shipped to IO before its installation to the pit is described.

The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

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