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Oral_29: Overview of ITER Diagnostics from JAPAN

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ITER Japan domestic agency (JADA) procures five diagnostics for the ITER project; micro fission chamber (MFC), edge Thomson scattering diagnostics (ETS), poloidal polarimeter (PoPola), divertor impurity monitor (DIM) and divertor infrared thermography (IRTh). JADA has designed each individual diagnostic system taking into account the following: (1) high radiation heat (<1 MW/m2) and high nuclear heat (<10 MW/m3) from the plasma, (2) high acceleration load due to plasma disruptions, (3) effects of neutron and gamma irradiation on optical and electronic devices, (4) minimization of shutdown dose rate (ALARA (as low as reasonably achievable) principle to minimize exposure to humans), (5) containment of activated pressurized cooling water (application of nuclear pressure vessel regulations), (6) ensuring tritium confinement boundaries are maintained in case of accidents such as earthquakes or fires (e.g., vacuum windows and vacuum electrical feedthroughs), (7) structural designs that are based on nuclear safety standards, (8) position alignment, calibration, and maintenance methods that can be implemented in a radiation environment. This overview reports part of solutions and technologies that JADA developed for solving the issues.
ETS injects high power laser (>5 J) into the plasma with repetition rate of 100 Hz. The injected laser is absorbed by a beam dump that is installed into a first wall panel. The number of pulses on the beam dump will be on the order of 109. The beam dump is made of molybdenum alloy and is designed to withstand high heat loads. To reduce the risk of laser damage, the special internal structure called as Chevron has been developed for the beam dump [1]. It has been experimentally shown that a laser-induced damage threshold of this structure is higher than that of a conventional beam dump [2], and the manufacturability has been also demonstrated [3].
PoPola injects far-infrared laser beams to plasma. Since a vacuum window is the first confinement barrier, the size needs to be as small as reasonably possible. It means that the clear aperture size is not large enough comparing to the laser beam size and the laser beam needs to pass through the center of the vacuum window to avoid laser power loss. JADA developed a new laser beam alignment method that can be automated in the radiation environment [4]. The positions of the vacuum windows are identified by using visible laser beam and multiple small retroreflectors that are attached around the vacuum windows. In addition, by using the retroreflectors around the vacuum windows, the automated alignment system learns a special mirror control that can change the laser beam angle without any change of beam position at the vacuum window. Results of the prototyping test show that the beam position displacement at the vacuum window was 2.0 mm or less when the laser beam was tilted within ± 1 mrad for the sake of searching the target inside the vacuum vessel. The alignment error above leads to the laser power loss of 4 % owing to shading at the VW and is acceptable.
IRTh identifies temperature distribution of tungsten divertor surface. One of measurement requirements is the wide temperature range of 200 oC to 3,600 oC with 10 % accuracy. Conventional two-colour thermography identifies temperature from the ratio of the two spectral radiance, and the choice of the two wavelength (λ) has impact on the measurement accuracy. When applying the conventional method to IRTh, two wavelengths are not enough to cover all the required temperature range with 10 % accuracy. To resolve this issue, JADA developed dual two colour method [5], which uses both one single bandpass filter (λ=4.5 μm) and one dual bandpass filter (λ=1.5 and 3 μm). This new method can achieve temperature measurement with higher accuracy than conventional method.
Further solutions and technologies developed for ITER will be presented in this talk.

[1] E. Yatsuka et al., Rev. Sci. Instrum. 84, 103503 (2013)
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[3] E. Yatsuka et al., Fusion Engineering and Design 136 (2018) 1068–1072
[4] R. Imazawa et al., in the proceedings of 27th Fusion Energy Conference, FIP/P1-14, India (2018)
[5] T. Ushiki et al., in the proc. of 37th annual meeting of JSPF, 2P83 (2020). To be submitted to RSI.

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