Laser and microwave diagnostics for ITER and beyond

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ITER diagnostics include an extensive set of laser and microwave diagnostics to give access to a wealth of information on the core and edge plasma and to support high performance operation of ITER [1]. For example, Core and Edge Thomson scattering systems build detailed density and temperature profiles on time scales much faster than τ_E to follow transient events; ECE and reflectometry add time resolution to follow MHD events. Implementing these diagnostics is challenging, needing a panoply of technologies to keep them functioning reliably for thousands of hours despite extreme events such as disruptions and wall conditioning cycles. Shielding, shutters and cleaning systems protect the forward elements of most optical systems from the build-up of deposits and damage. Still, plasma-facing mirrors must survive laser loads and endure erosion, deposition and in-situ RF cleaning. Calibration and monitoring systems ensure accurate and drift-free operation. These support systems are also not straightforward and required specific R&D. Access also drive the design: To deal with the neutron and gamma sources yet allow maintenance of activated components, ITER uses large, multi-purpose ports that couple otherwise distinct systems into modules for maintenance. Machine movement requires provisions to maintain alignment and calibration, from these port plugs, shown in Fig. 1, to the accessible areas 10 – 50 m away. A final complication comes from the difficulty of employing electronics near the plugs. Extensive qualification for radiation resistance is needed. We will examine design adaptations that ITER adopted for its near-reactor environment, consider the lessons learnt from the ITER design activity specifically for laser and active (oscillator driven) microwave systems and lay out some possible evolution paths for the reactor diagnostician that must follow a more industrial approach.

[1] ITER Organization, 'ITER research plan within the staged approach (Level III – Provisional version' report ITR-18-03 (2018) Appendix H, online at: https://www.iter.org/technical-reports

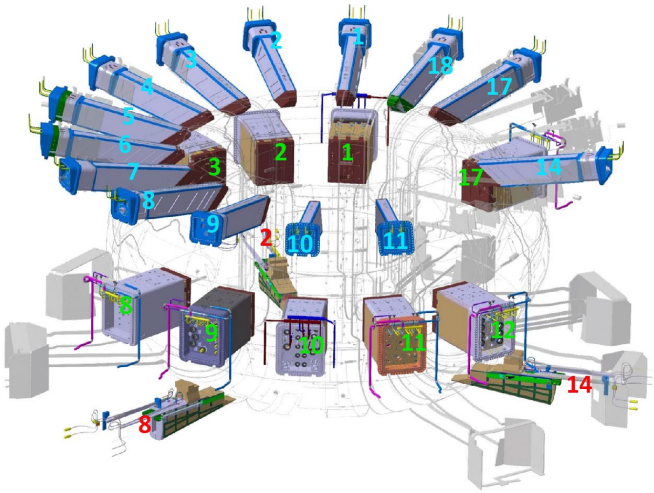

Figure 1. The ITER diagnostic port plus, divertor (3 ports, red numbers), Equatorial (9 ports, green numbers) and upper (14 ports of which 10 have significant payload, cyan numbers). For scale, the flanges of the ports are approximately 15 m from the machine vertical centerline.

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

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