Digital twin of tokamak diagnostics for heat exhaust and confinement prediction

A. Medvedeva[1], I. Kudashev[1], E. Serre[1], M. Schneider[2],
F. Clairet[3], G. Dif-Pradalier[3], N. Fedorzak[3] and the WEST team

[1] *M2P2 Laboratory, CNRS, Centrale Marseille, Aix-Marseille University, Marseille, France*

[2] *ITER Organization, Route de Vinon-sur-Verdon, CS 90 046, St. Paul-lez-Durance, France*

[3] *CEA, IRFM, F-13108 St. Paul-lez-Durance cedex, France*

The major obstacle of experimental studies of fusion plasma is generated by the difficulty of obtaining global and direct measurements in the hostile environment of a tokamak. Existing diagnostics are limited to indirect and local measurements which do not allow a full 3D plasma description nor a detailed comparison with predictive plasma simulations. In this context, a synthetic diagnostic, which models a real one and simulates its signal unambiguously through an accurate physics model, becomes a valuable tool for interpreting measurements as well as validating simulations serving as an input. Obtained synthetic signals can be directly compared to the experimental measurements and processed by usual experimental data analysis routines. Using the standard IMAS Data Model ensures portability as well as supports better traceability and reproducibility of the data generated, providing a robust modelling procedure. This contribution demonstrates recent progress in the development of a digital twin of tokamak diagnostics for heat exhaust and confinement prediction which includes synthetic diagnostics of main plasma measurement systems: interferometry, bolometry, reflectometry, spectroscopy and Langmuir probes. The synthetic signals will be shown for a full WEST discharge simulated with SolEdge3X-HDG [1] transport code based on high-order finite elements (Hybridized Discontinuous Galerkin) scheme [2] and confronted to the experimental measurements. The capabilities of the reflectometry synthetic diagnostic FeDoT will be evaluated for the turbulence dynamics studies, in particular for the detection of transport barriers and sheared flow signatures using simplified fluid model and GYSELA gyrokinetic simulations with staircases [3].

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References

[1] G. Giorgiani et al., Journal of Computational Physics 374 (2018): 515-532
[2] M. Scotto d'Abusco et al., Nuclear Fusion 62.8 (2022): 086002
[3] G. Dif-Pradalier et al., Commun. Phys. 5 (1) (2022): 1-12