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End-to-end intra-pulse data analysis at ITER: first steps from magnetics to live display

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Interpreting diagnostic data as early as possible after a plasma pulse is an important capability of modern tokamaks [1, 2, 3]. This is particularly critical for ITER, since a quick feedback on the plasma performance (shape, confinement, power balance, impurities, ELMs, ⋯) during the pulse is increases efficiency of operation and furthers the implementation of the scientific program that steers its exploitation.

In this work, we present a first implementation of a demonstrator for an intra-pulse processing workflow for ITER, from magnetic measurement data to the live display of equilibrium reconstruction.

Initially, a set of magnetic measurements are artificially created. This requires the use of synthetic poloidal field diagnostic signals from different simulations based on ITER scenarios, together with the corresponding plasma current and the machine description of different components that affect the pulse (like passive structures, wall, and toroidal field coils). We use a Bayesian inference process that adds uncertainties and interpolates the data, ensuring a more realist frequency of the signals. An important aspect of this synthetic diagnostic is the introduction of a frequency-dependent noise (lower power at high frequencies) which closely mimics the usual hardware noise.

This data is written to self-described netCDF file(s). This data will be used as input information to the real-time processes as implemented by the magnetics plant systems. To save network bandwidth, the data is encoded. Then the data is streamed for archiving and stored as HDF5 files. This part is executed in the Plant Operation Zone network (POZ), with the aim to simulate a complete signal acquisition chain of the magnetics diagnostic. From here, they are handled as real plant signals, being transferred to the external plant network (XPOZ), down sampled and used as the initial data for a short intra-pulse analysis workflow. Here, an equilibrium reconstruction is calculated, which is then displayed in the temporary control room Live Display.

We give an analysis of performance, live down sampling, and robustness of the system, with emphasis on extrapolation for real live data. We also perform a validation of the process by comparing the calculated plasma current and equilibrium reconstruction with the synthetic signals used as the input for this process. With this demonstrator correctly validated, we expect to include more complex analysis workflows in order to further develop a full validated intra-pulse processing infrastructure.

[1] D. P. Schissel, et al., Fusion Science and Technology, 58:3, 720-726.
[2] D. Dodt, at al., Fusion Eng. Des. 88 (2013) 79–84.
[3] M. Emoto, et al., Fusion Eng. Des., 89 (2014), p. 758.

Speaker's Affiliation

ITER Organization, St. Paul-lez-Durance

Member State or IGO/NGO

France

Primary author: ABREU, Paulo (ITER Organization)

Co-authors: ABADIE, Lana (ITER Organization); CASTRO, RODRIGO (CIEMAT); MCINTOSH, Simon (ITER Organization); PINCHES, Simon (ITER Organization); Mr MAKUSHOK, Y. (INDRA)

Presenter: ABREU, Paulo (ITER Organization)

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