Contribution ID: **123** Type: **Oral**

End-to-end in-pulse data analysis at ITER: from magnetics measurements to live display

Wednesday, 17 July 2024 13:50 (20 minutes)

Interpreting diagnostic data promptly after it is recorded remains a crucial aspect of modern tokamaks where rapid evaluation of plasma performance during a pulse is essential for operational efficiency and the implementation of the scientific programme. In this work, we present recent progress in developing a demonstrator for an in-pulse processing workflow for ITER, from simulated magnetic measurement data to the live display of equilibrium reconstruction. This demonstrator is a fundamental step in developing a complete in-pulse data analysis and processing workflow that whilst designed for ITER is applicable to any device.

We start with a set of measurements of the magnetic field sources. These are taken from existing ITER scenario simulations and include the description of the magnetic systems (coil position, turns, geometry, etc). This requires knowledge of the poloidal flux from the desired ITER scenarios, together with the corresponding plasma current and the machine description of different components that determine the behavior (like passive structures, wall, and toroidal field coils). We use a Bayesian forward model that add statistical noise to the original signals, ensuring a more realist set of magnetic signals. This is the same model that will be used for inference, thus allowing an accurate comparison of modelling vs real measurements.

This data is used as input information to the real-time processes as implemented by the magnetics plant systems inside the Plant Operation Zone network, 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, down sampled and utilized as the initial input data for a concise in-pulse analysis workflow. This transfer of data from the two networks (Plant Operation Zone and external plant network) is particularly important for testing, since they have different security requirements and performance, and all measured parameters will have to go through this communication channel in order to be analyzed and to contribute to the overall pulse performance analysis. From the external network, an equilibrium reconstruction is calculated, which is then displayed in the control room as a so-called Live Display. This reconstruction can be seen as a foundation step to the complete plasma analysis workflow.

In this work we give an analysis of performance, live down sampling efficiency, and robustness of the system, with emphasis on the Live Display use case. We also perform a validation of the process by comparing the inferred plasma current and equilibrium reconstruction with the synthetic signals used as the input for this process. We also give an overview of limitations and bottlenecks where the process clearly needs improvement before it is deployed in the production environment of a running experiment.

Our ongoing efforts involve expanding to more complete analysis workflows to ultimately develop a fully validated high performance in-pulse processing infrastructure for ITER.

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Session Classification: Data Storage and Retrieval, Distribution and Visulaization

Track Classification: Data Storage and Retrieval, Distribution and Visulaization