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P2.1056 Acceleration of bayesian estimation of temperature and density profiles for W7-X

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Plasma physics experiments often require a fast estimation of plasma parameters for machine control and safety. On the other hand, to do scientific inference a thorough post-processing analysis and uncertainty handling is carried out. The fast parameter estimation can benefit from a more rigorous handling of the uncertainty to have more reliable control of operating conditions. Concurrently, a faster version of the post-processing of inverse problems in parameter estimation can be crucial for rapid decision-making between or during plasma discharges. Besides this, it is not rare that two different plasma diagnostics in an experiment measure the same parameter but their analyses are often carried out separately. This particular scenario describes a great niche for an accelerated version of Bayesian analysis.

Bayesian analysis permits a quantitative estimation of parameters and their uncertainties and allows for a consistent joint data analysis of multiple diagnostics. This comes at the cost of slow processing times typically in the order of minutes or above and a high demand of processing power. The costs are mainly due to the exploration of the resulting non-linear multidimensional parameter distributions with sampling algorithms like Metropolis Hastings Markov Chain Monte Carlo. Faster alternatives like the Kalman filter or sub-optimal Bayesian on-line algorithms are ill-suited for the common time-independent non-linear problems in plasma physics.

This work shows how this analysis can be accelerated through FPGA hardware in order to provide reliable parameter estimations and uncertainties within a time frame useful for modern magnetic confinement devices. It does so by covering representative examples of inverse problems like the joint analysis of the W7-X Thomson scattering and the dispersion interferometer systems. The achieved and not yet optimized design can estimate in less than a second the temperature and density profiles with the data from these two diagnostics that share a near to coincident beam path. Thus, it shows the possibility of using a thorough parameter estimation approach to provide reliable the plasma parameters immediately after a discharge or for a possible operation control during longer discharges. With it, the described data analysis requirements for plasma physics experiments can be met without needing to resort to a speed vs. rigorosity trade-off.

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