Fast and reliable reconstruction of the current distribution at ASDEX Upgrade

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Fast and reliable reconstruction of the current distribution is of particular interest for experimental on-the-fly plasma scenario development. This is of major importance for the development of advanced scenarios where fine-tuning of the q-profile using heating and current-drive actuators is desired. The goal is to reconstruct the most reliable equilibrium achievable from all available experimental data and modelling constraints before the setting of the next plasma discharge has to be decided. The number of plasma discharges for the typically challenging performance optimization is often large but required to be as small as possible for budget reasons. At ASDEX Upgrade the goal is to have the most reliable current and q-profiles within 20 min to be available for plasma parameter optimization before the next discharge.

The first 10 min after the previous discharge are foreseen for kinetic profile reconstruction employing an integrated data analysis (IDA) approach of all profile diagnostics available shortly after the previous plasma discharge (not necessarily in real-time). The second 10 min are dedicated for equilibrium reconstruction with a temporal resolution of 5 ms for a typical plasma discharge of 8 s. The equilibrium reconstruction is based on the coupling of a Grad-Shafranov (GS) solver with the integration of the current diffusion (CD) equation employing a physical coupling of neighboring time points. The ingredients are reliable electron and ion temperature and density profiles from the IDA approach, fast-ion pressure and driven current profiles from the recently developed RABBIT code, the electron-cyclotron driven current from the recently upgraded TORBEAM code, an improved bootstrap-current evaluation, all magnetic data of an extended set of poloidal-field and diamagnetic-loop measurements, internal current measurements from (imaging)MSE and polarimetry, and an automized sawtooth detection algorithm.

The fast and reliable current reconstruction is achieved with the equilibrium code IDE parallelized using an *OpenMP* scheme within the Grad-Shafranov solver, within the RABBIT code of up to 8 NI-beams and within the TORBEAM code. On top of this, an MPI (Message Passing Interface)-based approach is applied for parallel calculations of the GS-solver response matrix and for parallel TORBEAM evaluations of up to 8 EC-beams for the CD-integration. This enables parallel calculations on up to approx. 40 CPU cores of a server-class machine.