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FTP/P1-23: Preparation of Steady State Operation of the Wendelstein 7-X Stellarator

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Wendelstein 7-X has been designed to demonstrate the steady state capability of the stellarator concept. At 10 MW of heating power a pulse duration of 30 minutes is envisaged. Short pulses of additional heating power are foreseen to access beta and equilibrium limits and study fast ion confinement and fast ion driven instabilities. The large variety of time scales is strongly affecting the design of plasma diagnostics, heating and fuelling systems, data acquisition and device control.
For steady state heating ten 1 MW continuous wave gyrotrons are foreseen, operating at 140 GHz second harmonic heating at 2.5 T. Using a system of mirrors, relaying the micro waves through air to Wendelstein 7-X, a very high transmission efficiency has been achieved. Front steering mirrors, one for each gyrotron, individually change the poloidal and toroidal launch angles, thus controlling the radial deposition and current drive. Recent modifications to the gyrotron design include an improved power handling in the collector using a rotating transverse magnetic field. The main heating scenarios are 2nd harmonic X-mode (X2) heating below the cut-off density of 1.2x10ˆ20 mˆ-3 and 2nd harmonic O-mode (O2) heating at higher densities. Owing to non-absorbed power, significant levels of stray radiation are expected for O2-heating, during the transition from X2- to O2-heating, and also during plasma start-up with electron cyclotron resonance waves. Therefore all in-vessel components have to be qualified and if necessary protected to withstand up to 50 kW/mˆ2 of continuous micro-wave power flux.
Many diagnostic techniques require a specific adaptation or even new developments to cope with steady state operation. Besides the measurement of fast events, also the long times scales have to be covered. As a consequence not only data rates increase, but the total amount of data. This requires special efforts for real time plasma control, and for continuous data acquisition and data archiving, and makes new, automated concepts for data processing and analysis indispensable.
The paper summarizes the main technologies required for steady state operation of Wendelstein 7-X, including concepts for integrated data analysis and interpretation, and discusses the possible relevance for other experiments aiming at long pulse operation.

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