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First Results from Protective ECRH Diagnostics for Wendelstein 7-X

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W7-X is a steady state capable optimized stellarator. The main heating system is electron cyclotron resonance heating (ECRH) operating at 140GHz providing up to 9MW microwave power.
A set of diagnostics has been developed to protect the machine from non absorbed ECRH power which can easily damage in vessel components.
The power is launched into the machine by front steerable quasi-optical launchers in X- or O-mode. While in X-mode the first pass absorption is ~99%, it is only 40... 70% in O-mode. The non absorbed power hitting the inner wall is measured by waveguides embedded in the first wall (ECA diagnostic).
In order to prevent the inner wall from overheating or arcing, a near-infra red sensitive video diagnostic with a dynamic range of 450...1200°C was integrated in the ECRH launchers. Thermal calculations for the carbon tiles predict a temperature increase above the detection threshold for scenarios of plasma start-up failure or poor absorption on a time scale of ~100ms and the risk of overheating after ~300ms. However, no temperature rise above the detection threshold could be observed in experiments with failed break down, i.e. poor ECRH absorption for up to 100ms.
The stray radiation level inside the machine is measured by so called sniffer probes which were designed to collect all radiation approaching the probing surface independent of incident angle and polarization. Five sniffer probes are installed at different toroidal positions. They were absolutely calibrated.
The sniffer probes are integrated in the ECRH interlock system. During the first operational phase of W7-X this was the only available plasma interlock system. The signal quality proofed to be high enough for a reliable termination in case of poor absorption. After a breakdown phase of ~10ms, the sniffer probe signals dropped by more than an order of magnitude. However, especially in the very first days of operation, most discharges died by a radiative collapse due to impurity influx. In this case the heating power was reliably switched off due to the increased level of stray radiation. A comparison with the ECA diagnostic clearly showed that the increased level of stray radiation was due to a decay of the plasma performance rather than approaching the cut-off density. In the latter case only the sniffer probe signal would have increased and not both ECA and sniffer probes.

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