

Machine learning-based preemptive control for RMP-driven ELM suppression in KSTAR

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In many tokamaks including KSTAR, resonant magnetic perturbation (RMP) has been considered as a promising candidate for ELM suppression and it is supported by the success of many experiments using the RMP-driven ELM suppression method. The initial large ELM bursts after the pedestal build-up fully in the H-mode transition phase have not yet been suppressed by applying the RMP field, but even a single ELM burst can reduce the lifetime of the plasma facing components (PFCs) severely in a large tokamak such as ITER. Therefore, the ELM bursts, especially initial ELMs, should be fully suppressed. In order to suppress the initial ELM bursts including the first ELM burst, the RMP should be applied in earlier phase than ELMy phase unlike the conventional RMP-ELM suppression manners. We considered an approach to apply RMPs to the ELM-free period right after H-mode transition. For that, we developed a real-time machine learning (ML) algorithm [1] that can classify H-mode transition and ELMy phase in real-time and automatically apply RMPs according to the real-time classification results.

The real-time ML algorithm is implemented in KSTAR plasma control system (PCS) by receiving real-time D-alpha emission diagnostic signals and real-time line-averaged electron density signals. We carried out experiments for the initial ELM bursts suppression using the real-time ML algorithm in the 2020 KSTAR campaign and obtained some promising results. That is, the initial ELM bursts can be fully suppressed with proper safety factor at the edge (q_{95}) and RMP field adjustment. Moreover, there are no significant MHD instabilities, and so we can obtain high confinement performance discharges with a normalized beta 2.

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References

- [1] Giwook Shin et al., Fus. Eng. Des., **157**, 111634(2020)

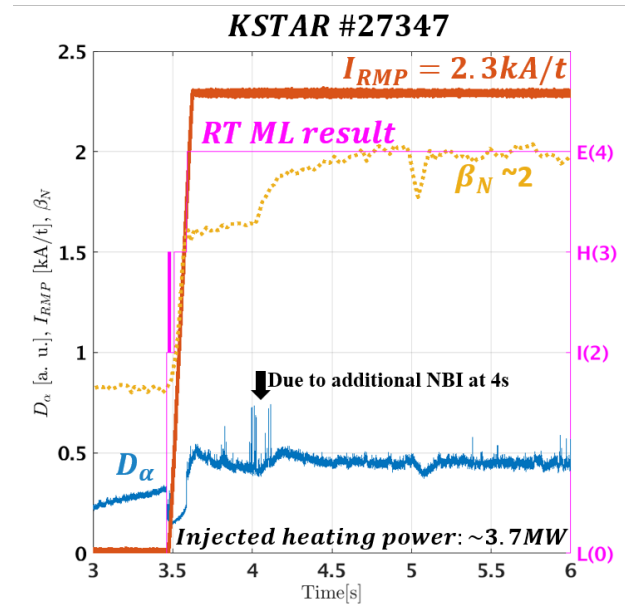


Figure 1. Result for the first ELM crash suppression in KSTAR plasma. The RMP current is applied in the discharge according to the real-time classification result from the ML algorithm. After the RMP current is used, the first ELM crash suppression is achieved.