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A Hybrid Physics/Data-Driven Approach to Disruption Prediction for Avoidance

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Even if the understanding of the tokamak configuration has progressed significantly in the last years, these devices are all plagued by the collapses of the plasma called disruptions. Moreover, devices with metallic plasma-facing components, similar to those foreseen in the next generation of reactors, are also vulnerable in this respect, particularly when operated at q95 around 3. In these machines almost all disruptions are preceded by anomalies in the radiation patterns, which either cause or reveal the approaching collapse of the configuration. Given the influence of these radiation anomalies on the kinetic profiles and the magnetic instabilities, a series of innovative and specific elaborations of the various measurements, compatible with real-time deployment, is required. The data-driven indicators derived from these measurements can be interpreted in terms of physics-based models, which allow determining the sequence of macroscopic events leading to disruptions. The results of a systematic analysis of JET campaigns at high power in deuterium, full tritium, and D-T, for a total of almost 2000 discharges, are very encouraging and prove the potential of the approach. The computational and warning times are such that the control systems of future devices are expected to have more than sufficient notice to deploy effective prevention and avoidance measures.

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