Improving Tokamaks' Diagnostic Capability for Better Disruption Prediction in Metallic Machines with a View on Future Devices

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Disruptions are one of the major problems for the control of Tokamak plasmas, because they . can induce huge heat loads on the plasma facing components, high electromechanical forces on the structures of the devices and runaway electron beams, dangerous for the integrity of the first walls. In the commercial reactors, disruptions will have to be completely avoided. On the other hand, in present Tokamaks, disruptions are unavoidable, particularly in the baseline at low safety factors (around q_{95}=3) in metallic devices. In the perspective of alleviating the disruption problem, the diagnostic outputs and their exploitation will have to be improved in various respects: a) physics content b) reliability c) real time compatibility. The integration of the diagnostic data in more powerful and informative predictors is also essential.

In terms of physical content, particularly for avoidance, profile information has proved to be indispensable; radiation peaking, MARFEs, divertor detachment etc. are being better characterized with new techniques, particularly new tomographic inversion methods. The optimization of mitigation tools, such as shattered pellet injectors, requires proper measurements during the current quench, with the related issues about the difficulties of determining the magnetic topology in rapid evolving conditions. With regard to reliability, in addition to hardware improvements, more robust indicators have been devised, especially for temperature hollowness, and redundancy is achieved by using complementary diagnostics, such as bolometry and cameras. Real time deployment is of course a prerequisite for any practical use of the diagnostics in feedback. New solutions are being developed, particularly for the inverse problems, such as tomography and equilibrium, which typically need excessive computational time in their standard versions. With regard to the integration of all the diagnostic information for coherent decision making, it should be remembered that disruptions are very complex and nonlinear phenomena. Several disruption predictors have been developed during the years, however all of them showed major limitations, from short warning times to the need of a high number of disruptive discharges for the training. New optimization technologies such as genetic programming can provide an estimate of the time to the disruption and a completely innovative approach to training, open world training, has shown that predictors can start operating with very minimal diagnostic information, can adapt to the evolution of the operational space, can identify the disruption types and can be transferred successfully from one device to another.