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Understanding the Physics of Thermal Quench Mitigatio[1]

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This work presents results obtained on DIII-D on thermal quench (TQ) mitigation by massive impurity injection showing that the delivery speed of the particles has a critical effect on the early assimilation of injected impurities in the discharge thus the radiation/conduction balance (which can be improved from 20%-40% up to 90% by massive particle injection) during the TQ: a delivery faster than the TQ timescale (~1 ms on DIII-D) is critical to an efficient TQ mitigation as shown by the comparisons between injection methods as well as mitigated vertical displacement events experiments. TQ mitigation will be required on ITER in the early phase of a disruption when most of the thermal energy of the plasma (~350 MJ on ITER) is lost, inflicting damaging heat loads to the walls of the device. TQ mitigation relies on increasing the balance radiation/conduction to protect the plasma facing components. Injecting impurities through gas or pellet injection has proven an efficient mitigation method on present devices but the extrapolation of thermal quench duration, radiation efficiency, and impurity assimilation to ITER is challenging. But it can generate radiation asymmetries that could induce local melting of the wall on ITER. Strong poloidal flows have been observed during TQ mitigation by impurity injection. These flows that appear not to be driven by $E \times B$ suggest that injecting at different poloidal locations may improve the radiation symmetry. Results enabled by the new multiple locations massive gas puff system designed to study radiation symmetry during the TQ are also presented. They are compared to results obtained on C-Mod with a different poloidal/toroidal configuration (~1/1 on DIII-D, 1/2 on C-Mod) since modeling with the NIMROD code shows that the toroidal asymmetry may be affected by the phase of a strong 1/1 mode with respect to the impurity injection.

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