# MDC-1 Disruption mitigation by massive gas jets

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| **TG priority:** Critical | **Start date:** < 2008 | **Status:**  On-going | **Personnel exchange:**  No |
| **IO priority:**   | **End date:** N/A | **Motivation:** Physics basis for disruption mitigation |

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| **Device /****Association** | **Contact****Persons** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| ITER  | M. Lehnen |   |   |   |   |   |   |
| JET  | S. Jachmich | Desirable | Committed | Committed | Committed | Committed |   |
| TEXTOR  | H. R. Koslowski | Closed | Committed | Committed | Committed | Shutdown |   |
| AUG  | G. Pautasso | Desirable | Committed | Committed | Committed | Committed |   |
| C-Mod  | R. Granetz | Analysis | Committed | Analysis | Analysis | Committed |   |
| DIII-D  | N. Eidietis | Desirable | Committed | Committed | Committed | Committed |   |
| FTU  | B. Esposito | Desirable |   |   |   |   |   |
| MAST  | A. Thornton | Upgrade | Analysis | Committed | Done | Upgrade |   |
| Tore Supra  | C. Reux | Upgrade | Committed | Analysis | Analysis | Upgrade |   |
| KSTAR  | J. Kim | Desirable |   | Committed | Committed | Committed |   |
| HL-2A  | Y. Dong | Desirable |   |   | Committed | Committed |   |
| J-TEXT  | Z. Chen | Desirable |   |   | Committed | Committed |   |

**Purpose in brief:** Provide the physics basis for disruption mitigation and assess mitigation schemes for ITER.

**Results for 2015**

* The mitigation efficiency in degraded plasmas that are about to disrupt has been studied in AUG, DIII-D and JET. A decrease of the pre-TQ time has been observed in AUG with locked modes. A significant impact of pre-disruptive locked modes on the mitigation efficiency has not been observed in the three devices. DIII-D tested the impact of the VDE movement towards or away from the injection location. No significant impact on mitigation efficiency was observed. Note that the quantities used in these experiments were above what is available in ITER when scaled with plasma volume.
* Experiments on MGI into runaway beams have been performed so far at DIII-D, JET, AUG, ToreSupra, TEXTOR, HL-2A and J-TEXT. A much broader database is now available. All machines except JET show a response of the runaway current and energy on the injection of high-Z impurities. No impact on density or runaway current was observed at JET when injecting into the runaway plateau phase. Work will need to focus on understanding the penetration of impurities into runaway background plasmas.
* Saturation in radiated energy fraction at high impurity levels was observed for MGI at JET, AUG and for SPI at DIII-D. It could not be shown that saturation takes place at Erad/Eth > 90%, because of the uncertainties in the measurements. However, saturation sets in at similar quantities for all three devices at comparable stored thermal energies. Comparison to ITER simulations requires identifying suitable parameters for extrapolation. The quantities identified in JET and DIII-D for the lower eddy current limit are - within the uncertainties - in line with DINA simulations for ITER. A more careful comparison requires taking into account the different vessel and VDE timescales of the devices.
* With respect to radiation asymmetries, work on DIII-D and JET focused on controlling the 1/1 mode phase by external fields and by this measuring the impact of the mode on toroidal peaking. TPF’s from these experiments are below 2. These experiments confirm the role of the 1/1 kink mode as predicted by NIMROD. Poloidal peaking of the wall heat flux has been assessed in DIII-D showing PPF’s up to 2.5. Radiation peaking during the thermal quench at DIII-D is less affected by the injection location as it is in JET.

**Plans for 2016**

* Improve understanding of the efficiency of high-Z injection during the current quench or runaway plateau phase with MGI and SPI. Identify relation between impurity quantity and runaway current or energy decay rate.
* Impact of unstable plasmas on mitigation efficiency for more marginal injection quantities like in ITER
* Further quantify the poloidal radiation peaking. Assess the reduction of peaking with increasing thermal energies. Prepare the final report and close WG-8.
* Assess mitigation efficiency with multiple or staggered injections using MGI or SPI (SPI will be staggered in ITER above a certain injection quantity).
* Systematic comparison of MGI and SPI

**Most critical issues:**

1. Identification of a suitable runaway mitigation scheme
2. Assessment of the performance of SPI and extrapolation of SPI (and MGI) parameters to ITER
3. Confirmation of the quantities required for heat load mitigation in ITER and assessment of the compatibility with runaway avoidance and current quench control
4. Assessment of heat loads from radiation asymmetries

**Background:** The ITER disruption mitigation system will consist of multiple hybrid-type injectors that can provide either SPI or MGI. The energies in ITER require that the mitigation scheme is carefully designed to efficiently reduce heat and electro-magnetic loads and to avoid runaway formation. Whereas MGI experiments at many machines and also recent SPI experiments at DIII-D have shown that these loads can be controlled, a suitable runaway mitigation scheme for ITER is not yet identified. Also, a quantitative extrapolation from existing devices is needed for both, MGI and SPI, for all foreseeable disruption scenarios and including an assessment of the simultaneous achievement of all mitigation targets. The understanding of the physics processes is advanced by dedicated modelling efforts including 1D codes like ASTRA or IMAGINE for studies on impurity penetration, 2D/3D fluid simulations with the code TOKES, and NIMROD and JOREK for full 3D MHD simulations. Impact of disruption mitigation on the dynamics of the disruption and especially the current quench phase (incl. runaways) is modelled by the code DINA.

**Closely related work is carried out under several other joint experiments:**

**MDC-15** Disruption database development

**MDC-16** Runaway electron generation, confinement, and loss

**MDC-17** Active disruption avoidance