MDC-17 Active disruption avoidance

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| **TG priority:** Critical | **Start date:** 2009 | **Status:**  On-going | **Personnel exchange:**  Yes |
| **IO priority:** | **End date:** N/A | **Motivation:** Plasma Control, Plasma Operations | |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Device /**  **Association** | **Contact**  **Persons** | **TG Request** | **Activity (from JEX/JA spreadsheet)** | | | | |
| **2012** | **2013** | **2014** | **2015** | **2016** |
| AUG | M. Maraschek | Desirable | Committed | Committed | Committed | Committed |  |
| C-Mod | R. Granetz | Not doing | Not doing | Considering | Considering | Not doing |  |
| DIII-D | R. La Haye | Desirable |  | Considering | Considering | Considering |  |
| FTU | B. Esposito | Desirable | Committed | Committed | Committed | Committed |  |
| JET | S. Jachmich | Desirable | Not doing | Not doing | Committed | Committed |  |
| JT-60U | Y. Kawano | Analysis | Analysis | Analysis | Analysis | Analysis |  |
| NSTX | S. A. Sabbagh | Desirable | Analysis | Analysis | Analysis | Committed |  |
| Aditya | A. Sen (t.b.d.) | Desirable |  |  |  | Considering |  |

**Purpose in Brief**

* (17.1) Quantify the requirements for postponement of disruptions with ECRH and ECCD.
* (17.2) Explore other means of disruption avoidance by avoiding operational limits, or by postponing a disruption while initiating a controlled rampdown (soft stop), or ultimately by recovering the discharge.

**Results for 2015**

* 17.1: AUG performed further experiments on ECCD based disruption avoidance in improved H-mode and started high N density limits and impurity induced disruptions.
* 17.1: DIII-D has reported no dedicated experiments on ECCD based disruption avoidance, but on RMP based experiments (see below).
* 17.1: No further updates from FTU, as no dedicated experiments have been performed. The port of realtime algorithms to AUG and TCV for detecting a still rotating mode is ongoing.
* 17.2: DIII-D has applied electro-magnetic torque by feedback control and avoids TM locking and a possible major disruption. The modes were identified as a low-density high-Ti internal reconnection events taking place on multiple resonant surfaces. Data analysis within MDC-22 has shown that the radial location of the q=2 surface governs the disruptivity.
* 17.2: At JET a new algorithm detecting central W accumulation, which normally leads to a disruption with via a locked mode, has been commissioned. This trigger is being used to initiate an updated discharge termination.
* 17.2: ADITYA is being upgraded from a limiter tokamak towards a divertor tokamak. This upgrade work will last until the end of 2015.
* 17.2: KSTAR (with support from NSTX staff) has proposed a new set of detection coils for RWM experiments. They are expected to allow a mode stabilization closer to the ideal wall limit and a faster, less demanding entrainment of locked modes.

**Plans for 2016**

* 17.1/2: AUG will implement the early detection tools (still rotating 2/1-mode) from FTU, and will concentrate on the high N density limit in H-mode, and impurity induced high N disruptions. A routine inclusion of ECCD based avoidance is considered, which is based on the NTM removal techniques (MDC-8). Within the EUROfusion MST1 framework a huge number of discharges has been allocated on AUG and TCV for disruption avoidance with ECCD and the application of (R)MP’s to control the mode locking or possibly entrain the mode.
* 17.1/2: DIII-D participates at US Transients workshop, and in particular leads the sub-panel on disruption avoidance (T.Strait (GA), D.Gates (PPPL)). In this framework multiple actuators (ECRH/ECCD/RMP/RWM-stabilization/DCS handling) will be used for the disruption avoidance.
* 17.1: No dedicated plans from FTU at present. Input for the early detection of disruptions in realtime at AUG and TCV is provided.
* 17.2: Based on the data analysis for MDC-22, DIII-D is considering to move the radius of the q=2, the radius of the locked mode, inward. This should be achieved by varying Bt and Ip accordingly. Also local variations of the q-profile via ECCD or NBI current drive are foreseen.
* 17.2: At JET a new 3rd MGI valve is installed. For the high Ip and DT experiments in the baseline and hybrid scenarios the realtime control schemes for a save shutdown will further developed. Dedicated disruption avoidance experiments are scheduled for late 2015 / early 2016.
* 17.2: ADITYA will restart operation as a divertor tokamak in 2016.
* 17.2: It is proposed, that other experiments could/should attempt to establish the ICRH based avoidance in different scenarios at larger experiments. Yet no commitment to this approach has been achieved, partially due to technical restrictions.

**Purpose:** This experiment builds on ECRH/ECCD results from FTU and ASDEX Upgrade:

* Quantify the requirements for postponement of disruptions with ECRH and ECCD.
  + Study the effect of heating and torque from tangential NBI and rotating magnetic 3D perturbations on the stabilization of disruption precursors.
  + Extend the technique to H-mode plasmas, and conditions of an H-L transition induced by disruption precursors.
  + Develop criteria to determine the applicability of the technique, and the boundary between the use of disruption avoidance and disruption mitigation.
* Explore other means of disruption avoidance, such as feedback stabilization or forced rotation of disruption precursors with nonaxisymmetric coils and additional momentum input, for example from NBI heating.
* Investigate the combination of mode stabilization and fast current ramp-down, i.e. discharge state dependent ramp-down strategies.

**Background:** This is a continuation of MDC-17, which began in 2009. Avoidance of disruptions is preferable to disruption mitigation, in view of the gas loads, heat loads, etc. associated with a rapid plasma shutdown by gas injection or other means. Recent experiments in FTU and ASDEX Upgrade have shown that disruptions can be avoided or postponed by direct heating of magnetic islands with ECRH/ECCD, applied when a disruption precursor is detected. Such delays could potentially allow a slower, more benign plasma shutdown. Positioning and forced rotation of the island by resonant magnetic perturbations may also improve the effectiveness of ECRH/ECCD or improve the stability directly.