Advances in the development of DIS_tool and first analysis on TCV disruptions.

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I. Introduction

The development of disruptions multi-machine databases [1] is particularly valuable to building a common basis for modelling, to further improving the knowledge of the underlying disruption physics, and to extrapolate to larger next-step fusion devices, such as ITER and DEMO. By processing multiple diagnostics, *DIS_tool* [2] is able to detect fast transient events characterizing the disruptive process, such as thermal quenches and current spikes, and to automatically compute characteristic times and parameters of interest.

II. Processing algorithms and main workflow

The standardization in the definition and the calculation of disruption characteristics times is a difficult task that can benefit from a systematic approach. These aspects have represented the main rationales leading to the implementation of DIS_tool. In Figure 1, an overall scheme of the internal calculations performed by DIS_tool (*DIS_tool calc*) for the determination of the main Thermal Quench (TQ) and Current Quench (CQ) parameters is reported [2]. Core channels and central lines of sight, respectively, of ECE and SXR diagnostics are selected with respect to the position of the magnetic axis and averaged in time. The resulting signals are processed through algorithms based on a median filtering and a Gaussian Sliding Average Smoothed Time Derivative (GSASTD). The same algorithms are exploited also for the detection of the current spikes normally following TQs, being applied to the processing of the plasma current, the toroidal loop voltage and the internal inductance.

Sometimes, the loss of plasma current is not characterized by a single event, but it evolves through a chain of TQs followed by subsequent recovers of the thermal energy, with the plasma current eventually going through “sub-phases” characterized by different decay rates (Figure 2). The detected TQs and current spikes are analyzed with respect to the reference plasma current, bringing to the definition of characteristic times. The latter, according to a

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* *See the author list of “Overview of the JET results in support to ITER” by X. Litaudon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016);* ** *H. Meyer et al., Nuclear Fusion FEC 2016 Special Issue (2017).*

specific “set of rules” (see Figure 3), allow the determination of the relevant disruptive phases and, in the great majority of the cases, the automatic determination of the time of disruption t_D (see [2] for further details).

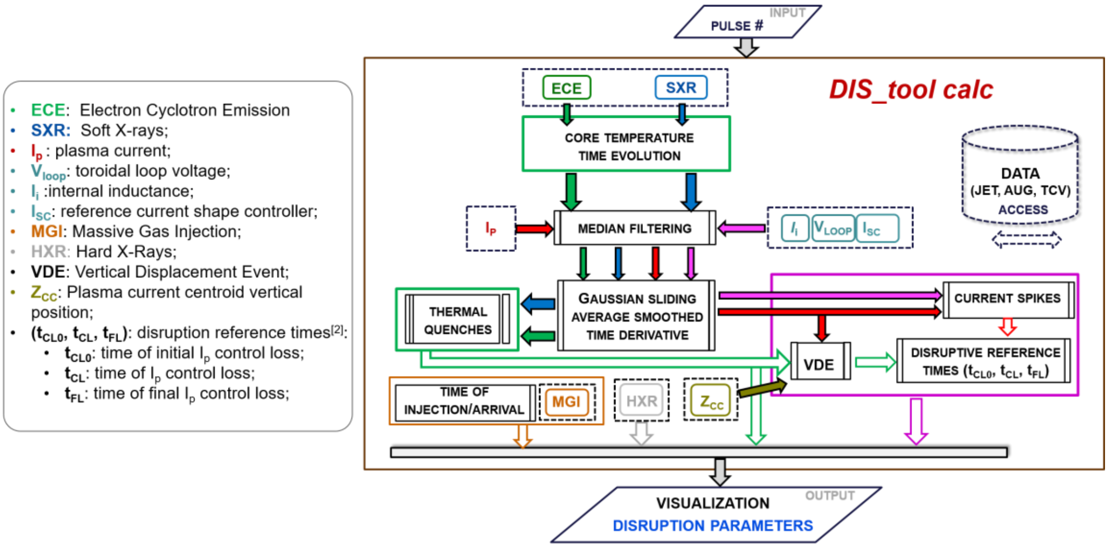

Figure 1: DIS_tool flowchart representing the internal calculations performed for the determination of Thermal Quench (TQ) and Current Quench (CQ) parameters

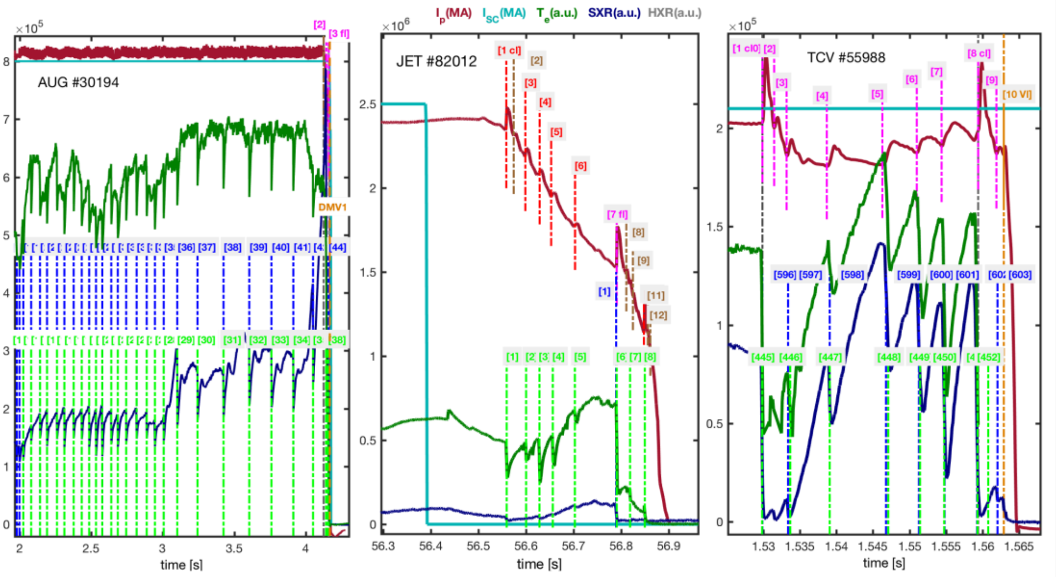

Figure 2: Time evolution of the main quantities analyzed by DIS_tool for TQs and CQs calculations for three disruptive discharges (AUG #30194, JET #82012, TCV #55988.

One of the main advances in the development of DIS_tool is on the side of the management of the information produced by the calculation and in the automatization of the database construction process. The main workflow implemented for the construction of a multimachine disruption database is reported in Figure 3. As shown in the scheme, the block “*DIS_tool calc*” can be run in batch mode, retrieving all the discharges exhibiting a disruptive behavior, in order to build automatically the backbone of the disruption database with all the parameters reported in the output block in Figure 3.

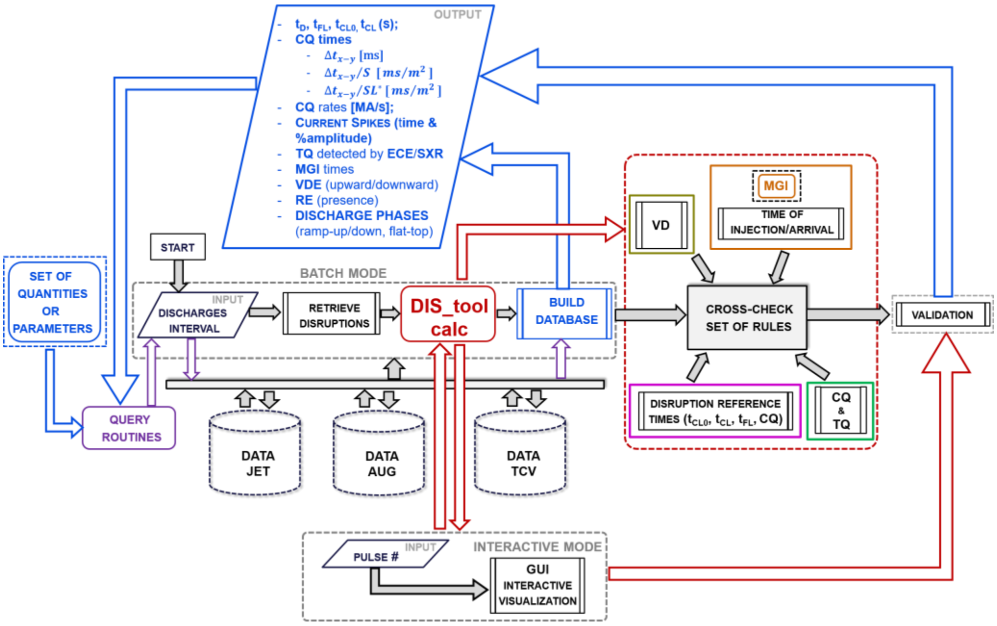

Figure 3: Main Workflow of DIS_tool to support the construction of standardized disruption databases.

The tool is equipped with a Graphic User Interface (GUI) for visualization and for interactive validation of the most critical quantity, that is the time of disruption (t_D). In batch mode, the calculation of the quantities related to the CQ is performed assuming as t_D the time of current loss (t_{CL}), that is the current spike with the largest percentage amplitude (evaluated with respect to the pre-spike plasma current) from which the loss of plasma current starts to take place. In more than 90% of the cases, such a time corresponds exactly to t_D and identifies the start of the edge of the current spike. In almost all the other cases, the time of disruption is one of the characteristics times calculated by the code [2], which can be identified by cross-checking the output parameters, and/or by interactive validation through the GUI. Shared criteria for automatically defining t_D are presently under study in the framework of the EUROfusion Disruption Database, where DIS_tool has been proposed as a part of the workflow for the construction of a European Multi-machine Disruption Database. The set of query routines to access the generated database has been improved as well, allowing to retrieve or write specific parameters in the times of interest, with the possibility to add the corresponding fields to the structured database.

III. Preliminary analysis and perspectives for the construction of a disruption database for TCV

DIS_tool has been initially implemented and tested on JET and AUG local clusters available for data analysis, and, lately, has been implemented also for TCV. A first test has been carried out over the most recent experimental campaigns related to the second part of 2016 and 2017. In the considered range, the total number of discharges with a plasma current reaching 100kA is 1747, out of which 972 disrupted with a plasma current at the time t_{CL} above 100kA. In Figure 4, as an example of parameters automatically calculated by DIS_tool and stored in the generated database, the distribution of the $CQ_{80\text{-}20}$ rate [1] and the plasma current evaluated in t_{CL} with respect to this latter are reported for disruptions occurred in the flat-top, ramp-up and ramp-down phases respectively. TQs and CQs, whose duration is influenced by several parameters, such as the machine size and the type of disruption, are in average faster especially with respect to JET with the ILW, where the effect of the metallic wall resulted in a longer CQs duration [3]. The disruption rate over the considered period is about 56% with about 79% of disruptions occurred in the main/flat-top phase. Such a disruption rate is higher than that in JET with the ILW (~20% in average for currents above 0.8MA), and higher (or almost comparable over some periods) to the disruption rate of AUG for plasma currents above 0.2MA [4]. This is due to the significant effort in the development of new scenarios characterizing the experimental programme of TCV, as well as the extreme shaping freedom, with a vacuum vessel that doesn't fit tightly around most of the plasma shapes. This approach allows supporting an extremely time-consuming activity, providing at the same time the possibility to generalize and standardize the construction of reliable disruption databases. This is particularly important in the definition of a common framework for multi-machine statistical and modelling studies.

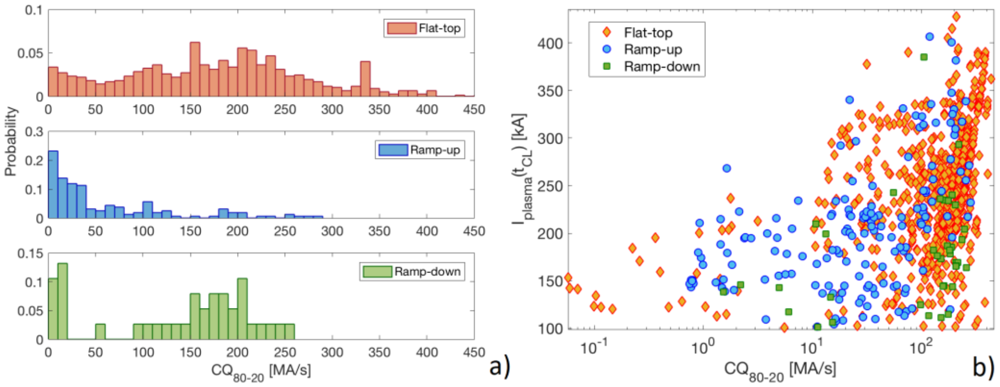

Figure 4: Distribution of CQ rate [MA/s] related to the characteristic time $t_{80\text{-}20}$ [1] for TCV disruptions occurred respectively in the flat-top, ramp-up and ramp-down phases (a) and plasma current at the time t_{CL} with respect to the aforementioned CQ rate.

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