



CIEMAT proposal on 'disruption prediction tools'

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Work carried out by CIEMAT so far



- Test of a potential disruption predictor with adaptive prediction from scratch (**JT-60U database**)
 - Disruption prediction report 2018
 - SOFT contribution
 - J. Vega et al. Fus. Eng. Des. 146 (2019) 1291-1294 (<https://doi.org/10.1016/j.fusengdes.2019.02.061>)
- Predictors trained with scenarios of lower I_p when they are applied to scenarios of higher I_p (**JET database with the ILW**)
 - Three different predictors were tested with good results
 - Disruption prediction report 2019
- Predictors trained with scenarios of lower I_p when they are applied to scenarios of higher I_p (**JET database with the C-wall**)
 - Three different predictors were tested with good results
 - Disruption prediction report 2020

Any of these predictors can be applied to JT-60SA



The objective of disruption predictors (in the most general sense) is to trigger an alarm when a disruptive behaviour is detected

- **Avoidance: actions to remain in a safe operational region**
 - Change of plasma scenario
 - No strong evidence of imminent disruption
 - Time enough for the control system to manage the situation
- **Prevention: actions to terminate the plasma in a safe way**
 - No means to recover non-disruptive conditions
 - No clear root cause
 - No time enough before the disruption
- **Mitigation: actions to alleviate the consequence of a disruption**
 - Unavoidable and imminent disruption



During a running discharge, to put into operation avoidance, prevention or mitigation methods, the ‘warning process’ has to provide either potential root causes or estimations of the time to the disruption

- **Estimation of the time to the disruption**
 - J. Vega et al. Nucl. Fusion. 60 (2020) 026001 (13pp) (<https://doi.org/10.1088/1741-4326/ab5880>)
- **Thermal stability of highly radiative discharges**
 - A. Murari et al. Nucl. Fusion 60 (2020) 046030 (12pp) (<https://doi.org/10.1088/1741-4326/ab7536>)
- **Hollow profiles (avoidance), MARFES (prevention) and mitigation**
 - G. Rattá et al. “A new phase-oriented disruption prediction strategy for mitigation, prevention and avoidance in JET”. JET pin board

Managing the diversity of disruptions and potential remedial actions requires the simultaneous operation of multiple predictor systems with high reliability



- The objective is to develop a specific tool during 2021 to classify disruption types
 - Machine learning methods qualified with confidence measures will be used
- In the future, the classifier can help in the real-time decision of triggering avoidance, prevention or mitigation actions when any predictor identifies an incoming disruption
 - The classifier is a second step after recognising a disruptive behaviour
 - Disruption predictors do not need to include specific logics to determine how to manage the alarm
- An adaptive from scratch approach will be used
 - A very important aspect is to contemplate the addition/removal of quantities not only to improve the classifier but also to take into account the development of new diagnostics and ageing effects
- This adaptive tool could be applied during JT-60SA commissioning before scientific campaigns
 - When the scientific campaigns start, a reliable classifier should be in operation



- To start the work during 2021, JET data can be used
- Deliverables
 - Machine learning procedure to train/upgrade the classifier
 - Tests with JET data
- The adaptive from scratch approach is very important to use at any moment the set of available signals
- The classifier is thought for off-line data analysis
 - The migration under real-time conditions can be considered in the future