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Early identification of disruption paths for prevention and avoidance

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Disruption prevention in the perspective of high performance, high current, long duration plasma discharges requires a substantial evolution of the schemes applied in most of the present tokamaks. An efficient prevention scheme requires the early identification of the nature of the off-normal behavior possibly leading to a disruption and the automatic selection of the appropriated countermeasure, either avoidance or mitigation. The development of such comprehensive scheme is being pursued in a coordinate effort. For the purpose of the avoidance, on which this paper is focused, the disruption can be seen as the result of the interplay of the physical events and of the control system responses to them and to the technical failures. The building blocks of such description should include the integration of several sets of plasma scalar data, plasma profile data, magneto-hydrodynamics indicators and engineering data. Previous work has shown the potential of the Generative Topographic Mapping (GTM) [Bishop C., Neural Comp. 10, 1998] algorithm for identification and discrimination of the disruptive operational space in tokamak devices [Pau A.,Ph.D Thesis, paduaresearch.cab.unipd.it/6664/, 2014; Cannas B., PPCF56, 2014] . In this paper it is shown that the magnetic fluctuations associated with rotating MHD modes can be characterized using a set of observables derived from the Singular Value Decomposition applied to the data collected by an array of pick-up coils. They can provide an input to the GTM analysis such that a clustering separating disruptive and non-disruptive timeslices can be found. A further source of information comes from the analysis of the sequences of events recorded by the machine control system. The analysis of such sequences shows that disruptions and non-disruptive terminations generally follow different paths, i.e. are not populating equally the same sequences. Moreover, the time analysis of the most populated disruptions paths shows that in most of the cases the sequence can be recognized with an advance ranging about from 0.15s to 1.5s with respect to the disruption time. Such information is readily available to the control system and can contribute to the early triggering of the avoidance action. Details of such combined analysis and application to different databases of JET, TCV and AUG tokamaks will be discussed in the paper.

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Primary author: Dr SOZZI, Carlo (Istituto di Fisica del Plasma - CNR, Milano, Italy)

Co-authors: Prof. FANNI, Alessandra (Dip. Ing. Elettrica e Elettronica, Univ. of Cagliari, Cagliari, Italy); Dr PAU, Alessandro (Dip. Ing. Elettrica e Elettronica, Univ. of Cagliari, Cagliari, Italy); Dr MURARI, Andrea (Consorzio RFX, Padova, Italy); Dr TEPLUKHINA, Anna (Swiss Plasma Centre - EPFL, Lausanne, Switzerland); Dr CANNAS, Barbara (Dip. Ing. Elettrica e Elettronica, Univ. of Cagliari, Cagliari, Italy); Dr CIANFARANI, Cesidio (ENEA C. R. Frascati, Dipartimento FSN, Frascati, Italy); Dr GALPERTI, Cristian (Swiss Plasma Centre - EPFL, Lausanne, Switzerland); Dr FERREIRA, Diogo (Inst. de Plasmas e Fusao Nuclear, IST, Lisboa, Portugal); Dr ALESSI, Edoardo (Istituto di Fisica del Plasma - CNR, Milano, Italy); Dr JOFFRIN, Emmanuel (CEA - IRFM, St Paul Les Durance, France); Dr PELUSO, Emmanuele (University of Rome "Tor Vergata", Roma, Italy); Dr LERCHE, Ernesto (Laboratory for Plasma Physics, ERM/KMS, Brussels, Belgium); Dr PAWELEC, Ewa (Inst. of Physics, University of Opole, Opole, Poland); Dr FELICI, Federico (Swiss Plasma Centre - EPFL, Lausanne, Switzerland); Dr RIMINI, Fernanda (Culham Centre for Fusion Energy, Abingdon, United Kingdom); Dr KOECHL, Florian (Culham Centre for Fusion Energy, Abingdon, United Kingdom); Dr STAKUNAS, Gediminas (Lithuanian Energy Institute, Kaunas, Lithuania); Dr SIAS, Giuliana (Dip. Ing. Elettrica e Elettronica, Univ. of Cagliari, Cagliari, Italy); Dr RATTÀ,

Giuseppe (Lab. Nacional de Fusión, CIEMAT, Madrid, Spain); Dr IVANOVA-STANIK, Irina (Inst. of Plasma Phys. and Laser Microfusion, Warsaw, Poland); Dr VOITSEKHOVITCH, Irina (Culham Centre for Fusion Energy, Abingdon, United Kingdom); Dr VEGA, Jesus (Lab. Nacional de Fusión, CIEMAT, Madrid, Spain); Dr MARASCHEK, Marc (Max-Planck-Institut für Plasmaphysik, Garching, Germany); Dr BARUZZO, Matteo (Consorzio RFX, Padova, Italy); Dr BERNERT, Matthias (Max-Planck-Institut für Plasmaphysik, Garching, Germany); Dr GELFUSA, Michela (University of Rome "Tor Vergata", Roma, Italy); Dr LUNGARONI, Michele (University of Rome "Tor Vergata", Roma, Italy); Dr SAUTER, Olivier (Swiss Plasma Centre – EPFL, Lausanne, Switzerland); Dr KUDLACEK, Ondrej (Max-Planck-Institut für Plasmaphysik, Garching, Germany); Dr SPARAPANI, Paolo (Dip. Ing. Elettrica e Elettronica, Univ. of Cagliari, Cagliari, Italy); Dr LOMAS, Peter (Culham Centre for Fusion Energy, Abingdon, United Kingdom); Dr DELOGU, Rita (Consorzio RFX, Padova, Italy); Dr CARCANGIU, Sara (Dip. Ing. Elettrica e Elettronica, Univ. of Cagliari, Cagliari, Italy); Dr GERASIMOV, Sergei (Culham Centre for Fusion Energy, Abingdon, United Kingdom); Dr BLANKEN, Thomas (Eindhoven University of Technology, Eindhoven, Netherlands); Dr BOLZONELLA, Tommaso (Consorzio RFX, Padova, Italy); Dr SHEIK, Umar (Swiss Plasma Centre – EPFL, Lausanne, Switzerland)

Presenter: Dr SOZZI, Carlo (Istituto di Fisica del Plasma - CNR, Milano, Italy)

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