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**See Annex of J. Pamela et al., "Overview of Recent JET Results and Future Perspectives", Fusion Energy 2000 (Proc. 18th Int. Conf. Sorrento, 2000), IAEA, Vienna (2001).*

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## INTRODUCTION.

The development of vertical instabilities in elongated plasma is one of the major concerns for present and future fusion plasma experiments. During Vertical Displacement Events (VDEs), currents can flow partly in the plasma outside the last closed flux surface and partly through the vacuum vessel and other parts of the magnetic boundary system. These halo currents can induce mechanical stresses and eventually lead to serious damages to the experimental device. Moreover, asymmetries can develop in the toroidal distribution of halo currents worsening their detrimental effect. In order to build safely future devices, experimental data from present ones have been collected and analysed, building single-machine or multi-machine [1] scalings. The complementary approach of implementing numerical codes able to model and simulate disrupting plasmas is also being pursued. The problem of disruptions and of their avoidance, or at least mitigation, [2] is very complex since technical construction details of the single device are very tightly mixed with general physical laws to determine the final result. Recent Alcator C-Mod data show for example that many differences in halo current amplitude and symmetry were induced by the change of the divertor structure [3]. It is then clear that to extrapolate to ITER results of present machines it is very important to understand which characteristics and trends are machine independent and which are specific to a single device. The aim of this work is to compare some recent halo-related data from two tokamaks, JET and ASDEX-U, paying particular attention to the use of homogeneous analysis tools and definitions.

## 1. EXPERIMENTAL SET-UP

In this paper we focus on magnetic diagnostics measuring directly or indirectly amplitude and distribution of halo currents. ASDEX Upgrade is equipped with a set of 90 shunts in the lower divertor region distributed in poloidal and toroidal arrays and measuring currents flowing between divertor tiles and support. They can give a precise estimation of the ratio average poloidal halo current to initial plasma current (Ih/Ip or halo fraction) and of the ratio local toroidal maximum value to average halo current (toroidal peaking factor, TPF).

Two sets of shunts were recently refurbished in the upper divertor region. One toroidal array of four shunts allows a direct comparison with JET measurements. One poloidal array of five shunts gives information on halo distribution at fixed toroidal position.

In the past two kinds of sensors were used at JET to measure halo currents, shunts and magnetic pick-up probes. A large part of JET data present in the ITER database comes from the pick-up probe measurements. JET halo current sensors were refurbished in 2001, to improve the halo current measurements capabilities [4]. The new system consists of three toroidal field pick-up coils and three rogowski coils that were installed in three toroidal locations 90° apart behind the upper inner wall protection (Fig.1).

## 2. DATA ANALYSIS

We will mainly concentrate on the data obtained by the refurbished diagnostics in both experiments. Recent analyses of the main set of diagnostics can be found in [5] and in [6] and references therein.

An example of halo currents measured in ASDEX Upgrade by the shunts of the upper divertor (toroidal array only) is shown in Fig.2.

Data represented are local measurements (currents flowing through single tiles), sampled at 5 kHz in order to follow fast phenomena. In JET since 2002, halo current data are derived mainly from the new upper toroidal field pick-up coils. They measure Bt due to poloidal halo currents. In order to derive the halo amplitude, the toroidal field variation due to external currents and the poloidal field pick-up have to be eliminated. Details on this procedure are given in [4]. An example of measurements from these coils is given in Fig.3. JET data are also sampled at 5 kHz.

## 3. DISCUSSION AND FUTURE WORK

Halo data from JET and ASDEX-U has similar spatial and temporal resolution in the case of upward VDEs. TPF and halo fraction values calculated (using homogeneous definitions) for this work are below the threshold foreseen for ITER: typical TPF*(Ih /Ip )=0.5, rare TPF*(Ih /Ip )=0.75. Regarding the spatial distribution, it has to be noted that the maximum of the toroidal asymmetry of halo current distribution does not have a fixed phase and then the statistics over many shots should contain the full TPF variation. On the other hand one should consider that with the number of toroidal measurements available (3 for JET and 4 for upper divertor ASDEX-U) only n=1 structures can be resolved, while the identification of more localised patterns of interaction remains difficult. TPF dependence on the pre-disruption plasma parameters and configuration (plasma shape, • p ,q95 ; H-mode, ITB), and on the plasma evolution during the disruption itself (qmin , dIp /dt ) is a very important issue for the compared characterisation. Dedicated experimental campaigns were undertaken at JET. First analyses confirm the dependence found in ASDEX-U of high value of TPF at low edge qmin , where qmin is defined as the minimum value of q reached during the disruption. TPF at JET is also higher for plasmas with lower • p , where the plasma current decays with slower derivative. More detailed discussion on these points is present in [2 and 6]. In ASDEX Upgrade asymmetric halo currents can rotate toroidally, the probability being higher when the current quench is slower [5]. No rotations were detected at JET up to now with the help of SXR data, as was done in ASDEX-U. It is difficult to reach any conclusion also by looking directly at JET halo current measurements since, even with the new system of 3 coils, single measurement changes in amplitude can be due to both internal dynamics or global rotation. This point will be further addressed in future analysis and experiments at JET.

The new halo coils (rogowski and pick-up) to be installed at JET during the 2004 shutdown will also improve future disruption studies at JET. They will increase toroidal and poloidal spatial resolution [7]. In Fig. 4 one poloidal array of rogowski coils (four will be installed) is shown.

## CONCLUSIONS

First results from refurbished halo diagnostics installed at ASDEX-U and JET show agreement with previous scalings. Comparison of data using the same analysis tools indicates similar TPF dependencies on qmin . Dedicated experiments in different machines are valuable to address the issue of “size scaling” of halo currents and their asymmetries.

## ACKNOWLEDGEMENTS

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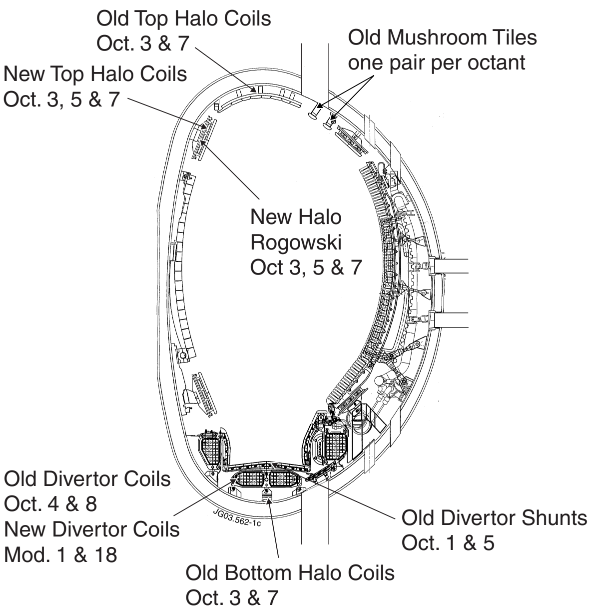


*Figure 1: JET halo diagnostics*

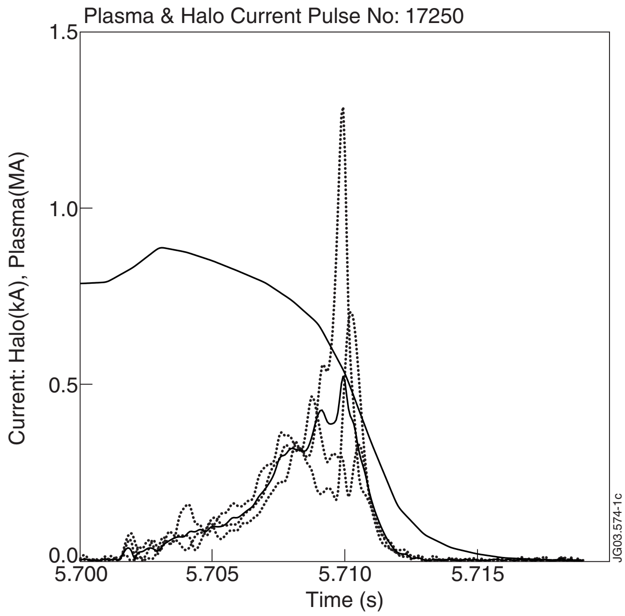


*Figure 2: Example of plasma (continuous lines) and average halo current (thick line) measurements in ASDEX Upgrade .*

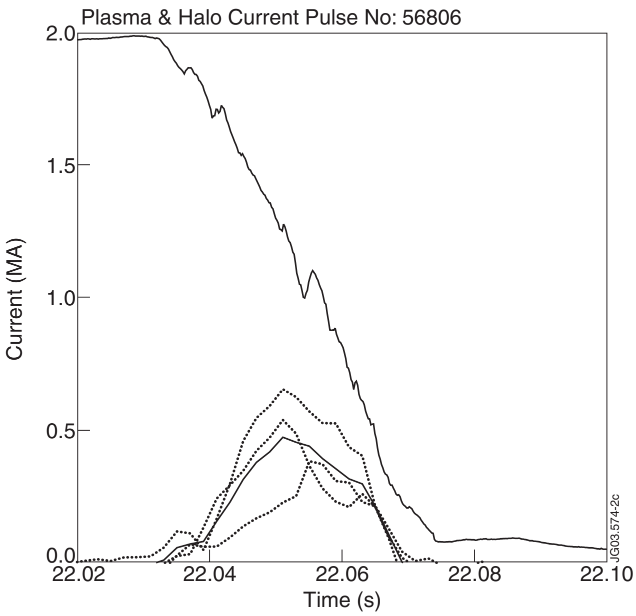


*Figure 3: Example of plasma (continuous lines) and average halo current (thick line) measurements at JET.*

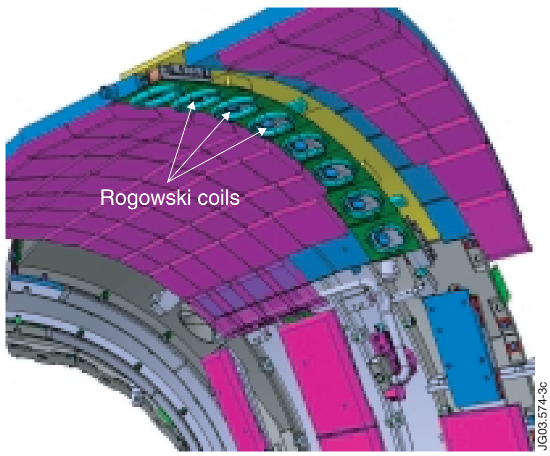


*Figure 4: Detail of the new system or rogowski coils to be installed at JET.*