Contribution ID: **1118** Type: **Regular Poster**

Magnetic configurations and scenarios for the Divertor Tokamak Test Facility

Thursday, 13 May 2021 12:10 (20 minutes)

The flexibility of the new Divertor Tokamak Test facility

DTT [1] is a new tokamak devoted to the study of power exhaust issues in the context of efforts to make nuclear fusion usable as an energy source, whose construction is starting in the ENEA Site, Frascati, Italy: an engineering model of DTT is shown in Fig. 1.

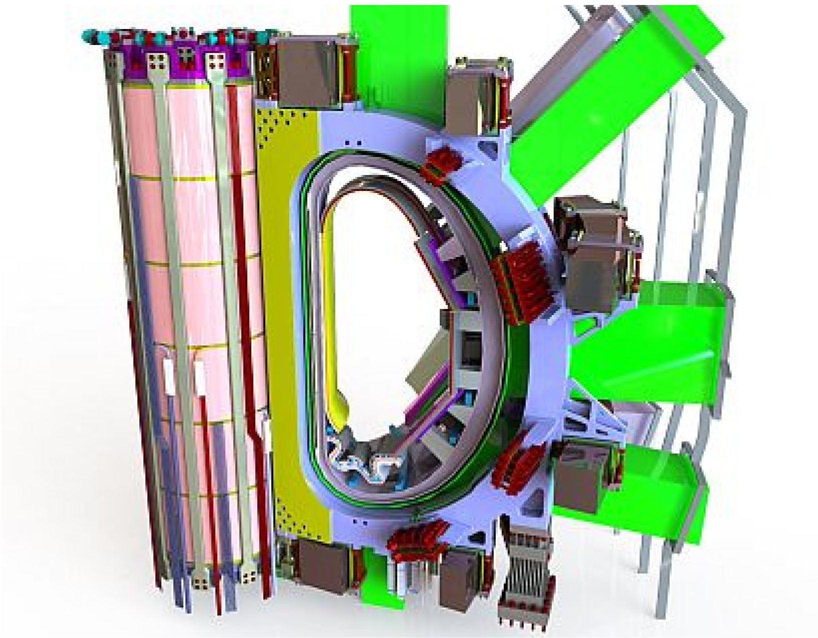

Figure 1: Engineering model of DTT

In this frame, DTT will allow the investigation of different scientific and technological solutions to the disposal of power and particle fluxes through the divertor, in conditions similar to those expected in ITER and DEMO [2]. The power flowing through the last closed magnetic surface, normalized to the machine radius, will be of the same order of ITER and DEMO, when the whole foreseen auxiliary heating power (45 W) will be installed.

To explore effectively a broad range of possible alternatives, DTT has been designed to be able to accommodate the divertor configurations proposed till now. The magnetic system of DTT is up-down symmetric and composed of:

- 18 D-shaped superconducting Toroidal Field (TF) coils, that produce a 6T toroidal field on the machine axis R0 = 2.14 m;
- 6 independent superconducting modules for the Central Solenoid (CS), able to provide a poloidal flux up to 32.4 Vs, that can sustain plasma discharges lasting about 100 s;
- 6 independent superconducting Poloidal Field (PF) coils, that allow a number of different plasma configurations with the required shape;
- 2 in-vessel Vertical Stabilization (VS) coils, designed to allow a fast control of the plasma column position in case of plasma perturbations (H-L transitions, ELMs, soft disruptions);
- 4 in-vessel divertor coils, that allow the sweeping of strike points and, in general, an affective control of the local magnetic configuration in the divertor region.

The passive stabilization of the plasma column is obtained by a number of inboard and outboard stabilizing plates and by a D-shaped, double shell, stainless steel vacuum vessel, in which flows the water, enriched of Boron when operating at full performance, that provides the neutron shield to the magnets. The resulting vertical instability growth rate is of the order of 50-100s^(-1).

Reference Single Null scenario

The Single Null (SN) reference scenario allows to obtain 5.5 MA plasma discharges up to 100 s, with 45 MW additional heating coupled to plasma. Some snapshots of the time evolution for this configuration are shown in Fig. 2.

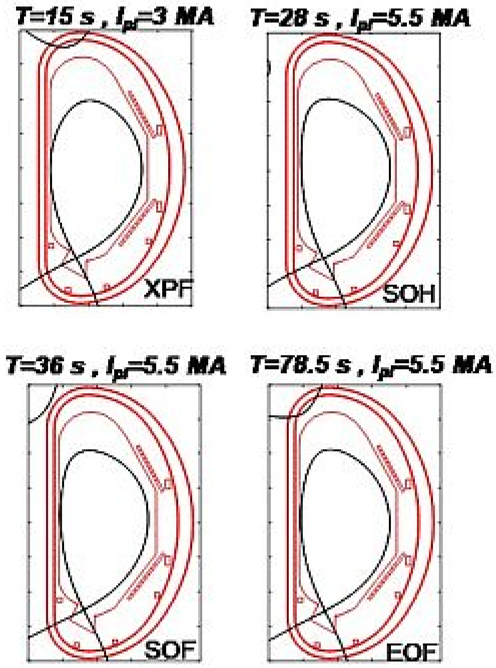

Figure 2: Time snapshots of Single Null scenario

The possibility of achieving a safe breakdown also without the assistance of ECRH was analysed and the maximum ramp-down rate evaluated. The constraints coming from the structural limits of the magnetic system of the machine were assessed.
This full performance scenario requires a strict control of the magnetic surfaces, then the reconstruction capability with respect to the set of magnetic measurements currently foreseen was assessed, testing the reconstruction of LCPS in presence of noise and during fast perturbations as unexpected H-L transitions, ELMs and minor disruptions. Moreover, a first assessment of MHD stability during the whole scenario was performed. The integrated modeling of DTT plasmas is described in [3] and has been carried out with JINTRAC consistently with the scrape-off layer simulations described in [1], pedestal from EUROped code (EPED1) and core-edge coupling taken into account on iterative basis.
The impact of VDEs and major disruptions on the coils, vessel and other conductive structures has been analysed in terms of induced currents, voltages and forces, for events with different current quench durations: the results allowed the engineering assessment of the main load assembly. Preliminary axisymmetric evaluations of the heat load on first wall structures were carried out to give requirements on the components design. Other SN scenario were developed, including day-0 and day-1 operations with reduced additional heating.

Advanced plasma configurations

A number of different magnetic configurations can be studied in DTT, thanks to its flexibility which has been a key driving factor in the design. Double Null (DN), X-divertor (XD), quasi Snow-Flake (SF), Super-X (SX) and Negative Triangularity (NT) configurations can be obtained at significant plasma currents, as shown in Fig. 3.

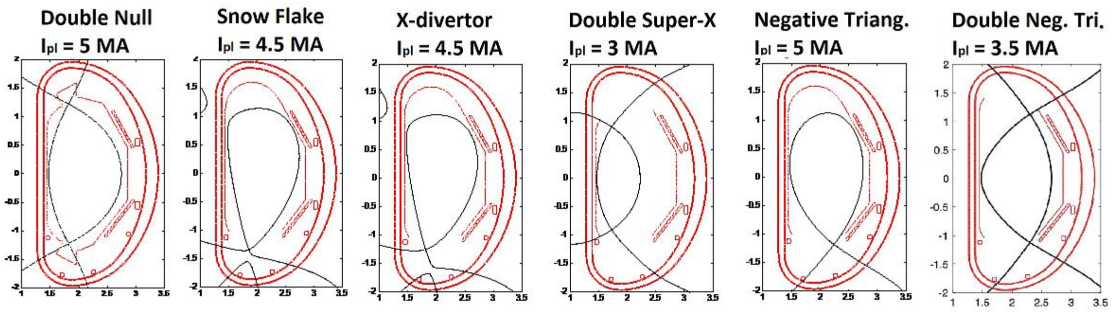

Figure 3: Advanced configurations proposed for DTT

These configurations will require the development of ad-hoc divertor(s) and, in case of SX and NT, modified first wall and stabilizing plates to solve heat load and stability issues. These configurations were developed within the framework of the EUROfusion work-packages WPDTT1-ADC and WPPMI-PEX/DTT [4].
In particular, a range of NT configurations is possible with different impacts on the tokamak structures, from the less invasive SN-NT with δupper=-0.12 to the more requiring SN-NT at 5 MA with δlower=-0.16 and DN-NT at 3.5 MA with δ=-0.38. While the first configuration can be obtained without changes in the reference design, the latter require the development of proper divertor(s) and the displacement of the first wall from the current position. As reference, the average triangularity of SN configuration is around 0.3, with 0.65 m minor radius.
The test of different divertor(s) and first wall modules is one of the main tasks for DTT, then the Remote Maintenance and the supporting and connection systems will be designed in such a way as to allow easy replacement of the components. The external and internal coils allow an effective control and optimization of the local magnetic configuration in the vicinity of the divertor target, providing the possibility of using strike point sweeping, upper and lower nulls wobbling and change of the distance between first and secondary null points as tools to widen the target regions for the heat load deposition.

Acknowledgment
This work was carried out in the frame of the DTT activity. The authors are very grateful to all the colleagues involved in the DTT project for their precious contribution.
This work was partly supported by EUROfusion Consortium, through the contributions of WPDTT1-ADC and WPPMI-PEX/DTT work-packages.

References

[1] DTT Interim Design Report (2019)
https://www.dtt-project.enea.it/downloads/DTT_IDR_2019_WEB.pdf
[2] Martin P., this conference
[3] Casiraghi I., this conference
[4] WPDTT1-ADC-E4 Annual activity Report 2019
https://idm.euro-fusion.org/?uid=2MNAYR

Affiliation

ENEA

Country or International Organization

Italy

Primary authors: RAMOGIDA, Giuseppe (ENEA); DTT CONTRIBUTORS

Presenter: RAMOGIDA, Giuseppe (ENEA)

Session Classification: P5 Posters 5

Track Classification: Magnetic Fusion Experiments