The role of the Divertor Tokamak Test facility in the Italian and European magnetic fusion programs

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The Divertor Tokamak Test (DTT) facility is a 6T superconducting toroidal device, presently under construction at ENEA Frascati Research Center, with a major radius of R = 2.19m, plasma current of I_p = 5.5 MA and total installed additional heating power of P_{add} ~ 45 MW. The first plasma is presently scheduled for Spring 2028.

With its tungsten divertor and wall, DTT has been conceived from the start to address the issue of power and particle exhaust (PPEX) in reactor relevant conditions. For this reason, its operation space has been designed to be characterized by dimensionless plasma parameters as close as possible to those of ITER and DEMO. The motivation underlying this choice stands in the necessity of addressing physics and technology issues on the same footing, viz. in an integrated fashion, for a focused and meaningful analysis of PPEX in burning fusion plasmas particularly in the view of DEMO. In fact, at full performance, DTT will reach power levels in the scrape-off layer, P_{sol}, such that P_{sol}/R approaches the corresponding values in ITER and DEMO. Meanwhile, the DTT magnetic system is very flexible and, in addition to the conventional single-null configuration, allows exploring double-null and a variety of alternative divertor concepts, including liquid-metal-based solutions. With this background, the DTT plasma scenarios are illustrated in this work, motivating the choice of the heating mix, and addressing macroscopic stability properties and expected plasma transport. The unique features of PPEX as well as plasma wall interactions in DTT in the presence of a W-divertor and wall will be emphasized, discussing the important role that the DTT divertor experiment is expected to play in the EUROfusion program.

Nominal machine and plasma parameters at full performance in DTT will be achieved in a stepwise approach, with ~20 MW installed power in 2028 to be increased up to ~45 MW in 2032. Thus, a first phase until 2032 has been envisaged based on scenarios at 3T/2MA and/or 6T/4MA, with additional heating power up to ~20 MW (~14.4 MW ECRH and ~3 MW ICRH absorbed by the plasma). Negative neutral beam power up to ~9.5 MW at ~510 keV will be installed during phase 2 that will be completed by 2036. New/advanced divertor solutions will be tested during the following phase 3, when DTT will be routinely operating at full performance with ~29 MW ECRH and ~6 MW ICRH.

The research plan for the various phases is being actively discussed within EUROfusion and International collaborations. Key element in support of the preparation of DTT operations is the theory and simulation activity based not only on the available tools but also on those being developed for addressing the peculiar aspects of burning plasmas as self-organized systems. The absorption of DTT negative neutral beam injection in these conditions will be discussed along with energetic particle first orbit and ripple induced losses. The interplay of nonlinear drift Alfvén fluctuations with plasma turbulence and their impact on thermal plasma as well as energetic particle transport processes will also be briefly mentioned.

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*With the contribution of the researchers involved in the DTT Physics group and, in general, of all the scientists belonging to the working groups of the DTT program.