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A Volumetric Neutron Source (VNS) for the nuclear qualification of invessel components: design and role in the EU roadmap

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According to the recently released Research Plan ([1] and references therein), ITER operation is currently foreseen to start in 2034, with the long-duration high neutron fluence discharges for the qualification of Test Blanket Modules (TBM) being scheduled for the latest stage of the machine operation (DT-2) –making it potentially susceptible to additional delays. While the role of ITER to investigate the physics of burning plasmas and their control and operation remains fundamental, the long wait time between today and the availability of its results offers the opportunity for another nuclear machine to be built and operated in parallel. Its role shall be complementary to ITER in producing the knowledge for the construction and operation of a Fusion Power Plant (FPP), i.e. it must be focused on the technology qualification. In this context, a Volumetric Neutron Source (VNS) is proposed. In its current configuration [2], VNS is a medium-size, large aspect ratio tokamak (⊠ = 2.67 m, ⊠ = 4.25) with a limited fusion power (⊠⊠⊠⊠ < 40 MW) but reactor-relevant peak neutron wall load on the outer midplane (NWL ≃0.5 MW/m2), where testing ports are located. Fusion is mainly obtained via beamtarget reactions, following the experience of the recent D-T campaigns in JET [3]. This approach allows the machine size to be kept small and, most importantly, an operation with low tritium consumption - since VNS must rely on external tritium supply. The aim of this device is to test in-vessel components like breeding blanket modules under 14 MeV neutron irradiation levels, and operational conditions in general (e.g. heat loads and magnetic field strength), very close to a reactor environment. The reference plasma scenario has been conceived as fully noninductive (by means of NBCD and ECCD). This aspect is relevant both for allowing the thermal equilibration of breeding blanket modules, which is an essential condition for testing, but also to achieve significative neutron fluences (i.e. tens of dpa) in few full-power years. In these conditions, VNS will allow the achievement of TRL level of 7, or even 8, for these fundamental components [4]. In this contribution, a detailed description of current VNS design and its physics basis are illustrated, and criticalities are highlighted. Plus, its potential role in the new Europan Roadmap is discussed. Strategically, parallel operation of VNS and ITER would allow the achievement of all the necessary technology, physics and operation knowledge to build and
operate an FPP, significantly reducing the need for qualification phases on the reactor itself [5].

References
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Track Classification: Overview of existing and future machines