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Electrical Design and Voltage Holding Analyses of the MITICA Beam Source Mock-up and its Intermediate Electrostatic Shield

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The high-Q operation of the ITER tokamak will require two Neutral Beam Injectors (NBIs) for plasma heating and current drive. Each beam will be generated by a 40A current of Deuterium negative ions, accelerated up to the specific energy of 1MeV and then neutralized. The power delivered to the plasma by each NBI shall reach 16 MW with duration up to 1h. The beam source will be constituted by an RF-driven negative ion source at –1 MV potential, by a Multi-Aperture, Multi-Grid (MAMuG) electrostatic accelerator (consisting of 5 stages at intermediate potentials), and a gas-box neutralizer at ground potential. All components will be installed in a vacuum vessel (also at ground potential), together with a high-capacity cryo-pumping system which controls of the background gas pressure.
In order to validate the ITER NBI design and address all the outstanding issues related to these demanding requirements, a full-scale prototype Injector called MITICA is under construction in Padova at Consorzio RFX in the Neutral Beam Test facility (NBTF). Single-gap insulation at 1 MV in vacuum and/or very low-pressure gas is indeed one of the expected issues which MITICA will have to deal with and that could not be fully addressed so far on the basis of the theoretical models and experimental results available in literature. Recent numerical analyses indicate that an intermediate additional electrostatic shield, biased at -600kV, surrounding the Beam Source might be necessary to guarantee the required voltage holding capability.
For this reasons, before the assembly and installation of the real Beam Source, dedicated voltage holding tests up to 1 MV are planned to be performed in the MITICA VV, using a mockup of the Beam Source and, if necessary, also a mockup of the intermediate electrostatic shield.
In this work the design of this experimental setup from the electrical point of view has been performed by means a new 3D numerical tool, called Voltage Holding Prediction Model (VHPM), based on the clumps theory in vacuum. In particular the electrical design of the Mock-up of the Beam Source, its shield and the mobile anode (needed to adjust the gap length) is presented as well as the expected voltage holding performances of the system

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