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First year of operation of SPIDER, prototype source of ITER neutral beam injectors

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To reach fusion conditions and to control the plasma configuration in ITER, the next step in thermonuclear fusion research, two heating and current-drive neutral beam injectors (NBIs), each supplying 17MW, by accelerating negative hydrogen or deuterium ions to 1MeV. The requirements of ITER NBIs (40A negative H or D ions for 1 hour) have never been simultaneously attained. So in the dedicated Neutral Beam Test Facility (NBTF) at Consorzio RFX (Italy) the performances of the ITER NBI (divergence <7mrad, aiming <2mrad) will be studied and optimised. The NBTF includes two experiments: MITICA, full-scale ITER NBI prototype, and SPIDER, full-scale prototype of the ITER NBI source with 100keV particle energy. SPIDER aim is to investigate source uniformity (over a 1m×2m area), negative ion current density and beam optics.
The present contribution will briefly outline the activities and the experiments carried out in the SPIDER beam source during its first year of operation with volume generation of negative ions. First a description will be given of the preparation activities in view of the start of the operations and of the improvements that were found necessary to guarantee reliable operational capabilities. In order to extend the source pressure range and to provide a thorough investigation of the properties of the early SPIDER beams, a mask was installed in the accelerator, leaving only isolated beamlets (for a total number of 80 beamlets out of 1280). The detailed investigation of the plasma properties, to assess the efficiency of RF coupling to the plasma in different configurations of the RF circuits, are presented. During the first extraction of negative particles from the source, the features of the co-extracted electrons were studied and correlated with the plasma parameters. Particularly, the magnetic filter field effectiveness in reducing the co-extracted electron current was verified; correspondingly, the decrease of the plasma emissivity was studied as well as the influence on the negative ion current. Finally the first characterisation of the SPIDER beam, in terms of beamlet divergence and deflection, is proposed and compared with numerical models while varying the source parameters. The negative ion beam is found to exhibit values of current density and optics similar to those expected in volume operation.

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