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Synergy of numerical simulations and experimental measurements to improve the interpretation of negative ion beam properties

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The ITER tokamak requires two heating Neutral Beam Injectors (NBIs), based on the neutralisation of 40A of negative hydrogen ions accelerated to 1MeV with a pulse length of one hour. As these simultaneous parameters were never experimentally achieved, in order to optimise source operation and to assess beam properties, a specific test facility ("PRIMA") was established in Padova, comprising two experiments: SPIDER (full-size negative ion source with 40A beam, 100keV particle energy) and MITICA, the prototype of ITER NBIs.
A key NBI component is the particle accelerator, where electrostatic and magnetic fields produce the beam optics, which is modified by loss of additional electrons (stripping) and generation of secondary particles. The design of SPIDER and MITICA accelerators was based on the most advanced numerical codes available for the investigation of the expected beam properties and on the most up-to-date experience of various research groups. Several diagnostic systems will characterise source and beam during the experiments.
In view of the operation, effort is presently devoted (within bilateral collaboration frameworks between Italian and Japanese agencies) to the preparation for the synergistic employment of simulations and experiments. Specifically, the characterisation of the beam properties is carried out in the NIFS-R&D multi-cusp negative ion source (NIFS-RNIS) by a sophisticated set of source and beam diagnostic systems. Simulations are mainly performed at Consorzio RFX, by a suite of numerical tools to compute or investigate various aspects of beam physics. Preliminary comparisons showed very good agreement between simulations and measured data regarding the basic features of the accelerator. Numerical codes allow also the investigation of extreme operational conditions, including phenomena not accessible to direct measurement, like the interception of grids by beam particles.
The present contribution describes the synergy between numerical codes and sophisticated diagnostic techniques. Both are applied to real-time characterisation of the beam, with the main scopes of providing interpretation of the measured results and supplying data for successive choices during the operation. These activities allow also extensive validation of numerical models and the choice of the most useful set of codes to be used in future experiments like DEMO.

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