Overview of SPIDER NBI source for ITER

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To reach fusion conditions and control plasma configuration in ITER, a suitable combination of additional heating and current drive systems is necessary. Among them, two Neutral Beam Injectors (NBI) will provide a total of 33MW hydrogen/deuterium particles electrostatically accelerated to 1MeV; efficient gas-cell neutralisation at such beam energy requires negative ions, obtained by plasma-assisted caesium-catalysed surface conversion. The ion source plasma is generated by 8 inductively-coupled drivers (typical electron density of the order of $10^{18}m^{-3}$ and electron temperature around 10-20eV at 0.3Pa filling pressure), expanding into a single 2m tall chamber after diffusing through a magnetic filter. By lowering the electron temperature and density, this creates the conditions for the existence of an ion-ion plasma in front of the apertures of the plasma electrode. The beam features depend on the parameters of this plasma.

As ITER NBI requirements have never been simultaneously attained, a Neutral Beam Test Facility (NBTF) was set up at Consorzio RFX (Italy), hosting two devices, which integrate the experience of several research groups worldwide. MITICA will represent the full-scale NBI prototype with 1MeV particle energy. SPIDER, with 100keV particle energy, started testing and optimising the full-scale ion source: extracted beam uniformity >90%, negative ion current density (for one hour) and beam optics (beam divergence <7mrad; beam aiming direction within 2mrad). A review is given of the first 3.5 years of operation of SPIDER and of the lessons learnt therein, regarding the current of negative ions at perveance match, the beam divergence and the overall plasma and beam uniformity. Particularly, the strategy to improve the SPIDER performances will be described, which is a result of detailed diagnostic capabilities combined with a numerical effort, applied to the interpretation of the experimental findings. Correspondingly, the set of diagnostic systems is planned to be improved to allow for deeper investigation capabilities of the proposed modifications.