Neutral beam ion shine-through calculations for the reduced field and current plasmas in ITER

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ITER research plan includes Pre-fusion Power operation (PFPO) phases that plan an operation with reduced fields and currents. The aim of the reduced field and current operation is to have an H-mode access in H and He plasmas. This is important since the predictions of the threshold power by extrapolating empirical scaling laws are uncertain and because only limited amount of heating power will be available.

In the second phase of the PFPO, a neutral beam ion (NBI) operation is expected. The access to H-mode favors operation in low electron density, on the other hand the NBI shine-through poses a lower limit to electron density. Fortunately, the NBI system can be operated with lower voltage (=lower injection energy). The aim of this contribution is to assess the limits of the NBI system in the PFPO in terms of the shine-through. This is done by carrying out beamlet-based NBI simulations and calculating the shine-through heat power load at the wall structures, especially to the so called shielding block that locates under the first-wall panels and will get significant heat load from gaps between the blanket modules and thus will be the first structure exceeding engineering limits in terms of heat power load.

The injection energy of the NBI system cannot be changed arbitrarily due to beam perveancy considerations. Namely, the power needs to be scaled according to $P_{\mathrm{NBI}} \propto E_{\mathrm{inj}}^{2.5}$, where E_{inj} is the injection energy and P_{NBI} the NBI power. In the simulations with the hydrogen beams into helium plasmas it was observed, however, that the shine-through power depends much stronger on the injection energy than beam perveancy condition, namely $P_{\mathrm{ST}} \propto E_{\mathrm{inj}}^{3.9}$, where P_{ST} is the shine-through power (or the power load at the critical shielding block element). This study will be utilized to guide the operational window and maximum NBI pulse duration in the ITER PFPO phase. The results will be compared against earlier studies such as [1].

References

[1] M.J. Singh *et al.*, New J. Phys. **19**, 055004 (2017)