Optimisation of the magnetic field configuration for the negative ion source of ITER neutral beam injectors

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The negative ion source of the neutral beam injectors for ITER requires that the co-extracted electron current is not larger than the negative ion current [1]. To this purpose a suitable magnetic field configuration is adopted, generated by a current flowing in the plasma grid and by two permanent magnets on either side of the source [2].
In the present design of the system however the magnetic field is not uniform across the beam. This paper focuses on strategies aimed at optimising the magnetic field distribution and improving the beam optics, based on two-dimensional and three-dimensional magnetic simulations.
For the filter field on the plasma side, ferromagnetic material can be inserted in the bias plate (the grid preceding the plasma grid). This should result in a more efficient extraction of negative ions with respect to electrons.
Analogously, between plasma and extraction grid the magnetic field can be rendered more uniform by placing thin sheets of ferromagnetic material downstream of the extraction grid. The interference with the suppression magnets is also discussed.
Finally it is proposed that the return path of the plasma grid current is designed so that it lies on the same plane as the plasma grid and the resulting stray field is minimised.
It is shown that these modifications reduce the magnetic field in the region downstream of the grounded grid, with the advantage of a smaller deflection of the beam. The effect on electron collection in the same region is discussed and solutions are proposed to manage the power associated to accelerated electrons.
The three-dimensional model is also used to improve uniformity of the filter field in the vertical direction, taking into account the effects of finite extension of the permanent magnets, and to optimize the return current path.

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[1]Hemsworth R S, Rev. Sci. Instrum. **79** (2008) 02C109
[2] DDD 5.3 ITER documentation