Dealing with post-accelerated electrons in the ITER SINGAP accelerator (P3-B-226)

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Electrons formed by stripping of the negative deuterium beam can be accelerated up to 960 keV in the 1 MeV SINGAP 40 A negative ion accelerator proposed by Europe for the ITER neutral beam injectors. SINGAP accelerates 1280 pre-accelerated 40 keV deuterium beamlets to 1 MeV in a single 350 mm wide gap [1]. At the expected gas pressure of 0.03 Pa inside the accelerator, 2.7 MW of electrons are calculated to leave the accelerator and strike various beamline components, especially the neutraliser.

The accelerators of the ITER injectors are designed to produce 4 “column” beams which pass through the 4 vertical channels of the neutraliser. Unperturbed the accelerated electrons create small, high power density, £3.3 kW/cm2, spots on the leading edges of the neutraliser channels, which is far in excess of their power handling capability. The hot spots arise from the overlapping of beamlets due to the bending induced by the far field of the magnetic filter in the ion source.

The proposed solution bends the electrons further downwards, redistributing the power over the neutraliser floor, a vertical electron dump perpendicular to the beam axis located below the neutraliser entrance, and the neutraliser entrance. The bending is to be effected by a magnetic field transverse to the beam direction at the exit of the post-acceleration grid. This field is created by vertical columns of permanent magnets either side of each column beam. After passing between the magnet columns, the electron beams reach the electron dump with a maximum power density of 2.1 kW/cm2. The peak power density on the neutraliser entrance is 1.35 kW/cm2 and on the neutraliser floor 0.82 kW/cm2. Electron backscattering would reduce all the numbers by 20%.

To further reduce the average power density seen by the beamline components it is proposed to sweep the electron beam in an oscillatory fashion. It is suggested that a failsafe, inexpensive, way is to use a power supply with a ripple of ±10% to produce the current through the plasma grid which creates part of the magnetic filter in the ion source. This creates a varying far field from the magnetic filter, and requires no extra interlocks or hardware.

The paper will give details of the electron generation and calculated power densities on the beamline components with the proposed solution.

Reference

[1] H.P.L. de Esch, R.S. Hemsworth and P. Massmann, Updated physics design ITER SINGAP accelerator, Fus. Eng. and Des. 73(2005)329.