NEGATIVE ION BEAM HALO MITIGATION AT THE 1 MV TESTBED AT IRFM.

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Large electrostatic accelerators are used to provide the negative ion beams needed for the production of Neutral Beams on large tokamaks like ITER. The beam halo is a modest fraction of beam particles that exits such an accelerator with a significantly larger divergence than the main beam. Halo particles impinge on the accelerator grids, thereby not only loading these grids, but also producing secondary particles that dump more power on the grids. Halo particles that make it out of the accelerator will load downstream beamline components, like neutraliser, residual ion dump and the duct. Elimination or reduction of the halo leads to more power to the tokamak while loading beamline components less.

In the context of the EFDA/F4E contract TW6-THHN-ASD3, beam experiments and calculations aimed at characterising and suppressing the negative deuterium ion beam halo have been performed at IRFM. All experiments have been performed on one single beamlet, allowing excellent measurement of the spatial profile. The MV test facility is particularly useful for such experiments as the wide acceptance angle of the post-acceleration grid allows direct measurement of the beam halo on a one-directional CFC target using an infrared camera looking from behind. Also the high acceleration voltage (hundreds of kV) is helpful in providing sufficient signal on the target.

Thermocouples have been integrated in the CFC beam target as a means to provide an independent verification of the infrared camera measurements.

From the experiments the following conclusions can be drawn:

1. Measurements of the beam halo have been performed. Using a plasma grid with a classic shape the following results have been measured:
    a. No halo (<2%) in volume operation (no caesium present in the ion source) at low accelerator pressure (<0.01 Pa).
    b. Halo formation takes place when the pressure in the main acceleration gap is increased.
    c. Halo formation takes place when operating the accelerator off-perveance.
    d. Around 8% halo is measured in caesiated operation at perveance match and 0.05 Pa pressure in the main acceleration gap.
2. We hypothesized that significant halo originates from negative ions being formed on the metal parts of the plasma grid (as could happen when neutral atoms from the source hit the plasma grid covered with caesium). Based on this hypothesis we tested a new design for the plasma grid, aimed at substantially reducing the halo. The test was successful and the halo at optimum perveance was reduced from 8% to 3%, at perveance match and 0.05 Pa pressure in the main acceleration gap.
3. A new phenomenon that we call "Magnetic Tail" has been identified. It arises from the deflection of beam ions in the magnetic fields of the electron suppression magnets. The Magnetic Tail presents itself as an asymmetry in the beamlet power density profile. On multiaperture systems it would look like a beam halo due to the convolution of all the individual beamlet profiles.

The paper will discuss the model of halo formation on the caesiated plasma grid, the experimental measurements using the "classic" and the "halo-free" grids and show measurements of beamlet profiles with the above mentioned "Magnetic Tail".