Langmuir probe characterization of the NIO1 ion source plasma

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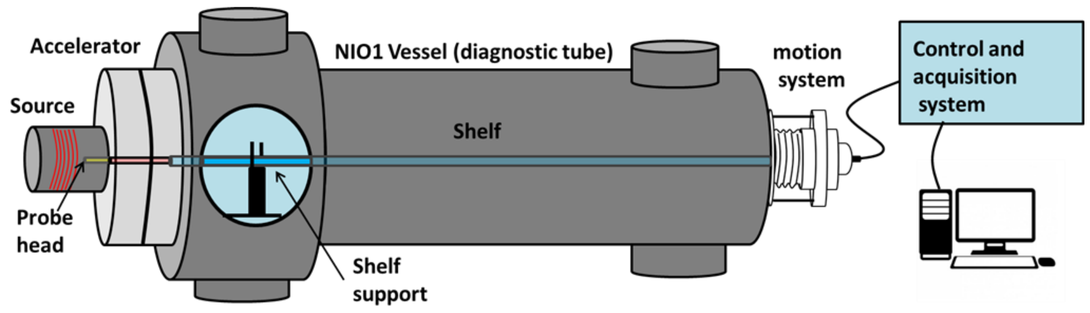
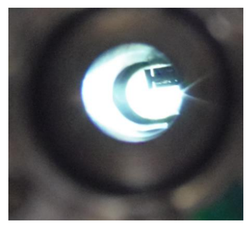
Introduction

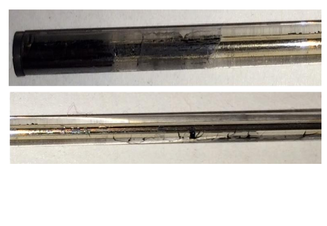
In view of the future experiments on the large ion sources used for the neutral beam injection system of ITER and DEMO reactor, a small scale negative ions source NIO1 (negative ion optimization, phase 1) is operated at Consorzio RFX since 2014.

The production and survival of negative ions strongly depends on the plasma properties in the vicinity of the apertures from which particles are extracted and a beam is formed.

In order to characterize these properties against the variable pressures, input power and magnetic field strength in the source a dedicated campaign with a movable Langmuir probe immersed in the plasma was carried out.



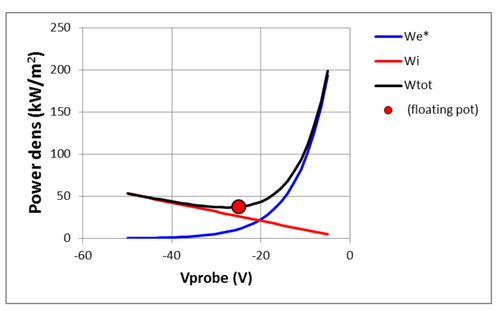




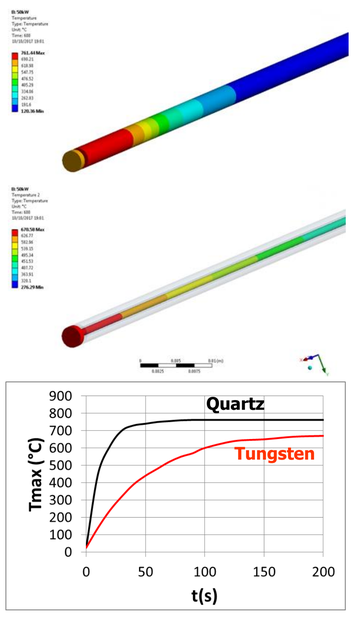
Probe Design and control system

Probe Support (Quartz) L=100 mm
Probe Tip (tungsten) R=5 mm, H=1mm, Area: ~10 mm^2
Expected plasma Parameters $n_e=3\cdot10^{17}m^{-3}$, $T_e=7eV$

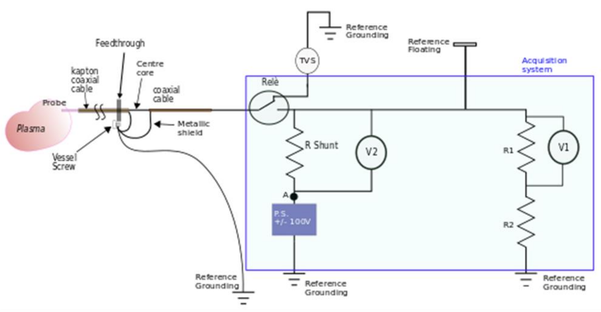
To minimize the power load in cw mode due to --> probe at potential $V=V_f$.
$V_f=Te\cdot\log(mi/(2\cdot\pi\cdot me)^{0.5}$
$j_e=0.25\cdot n_e\cdot(8T_e/\pi m_e)^{0.5}\cdot\exp(V_p/T_e)$.
$J_i=0.6\cdot q\cdot n_e\cdot(Te\cdot q/mi)^{0.5}$
$P=j_i\cdot V_f=50$ kW/m^2

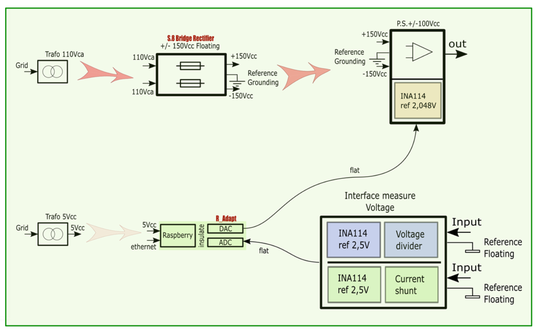


A finite element analysis of the temperature rise of tungsten and quartz under the mentioned power loads saturates in a hundred of seconds

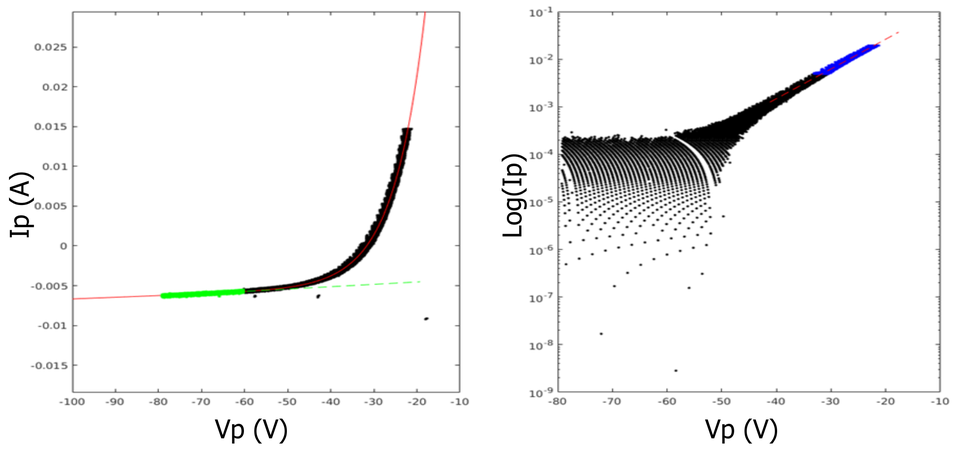


The control of the probe biasing (usually from -50 V to 5 V, depending of the RF power and the region inside the source to be probed) and the acquisition of the collected current was developed using an homemade system based on small single-board computer Raspberry PI; the details of such system are described elsewhere [8].





Data Analysis

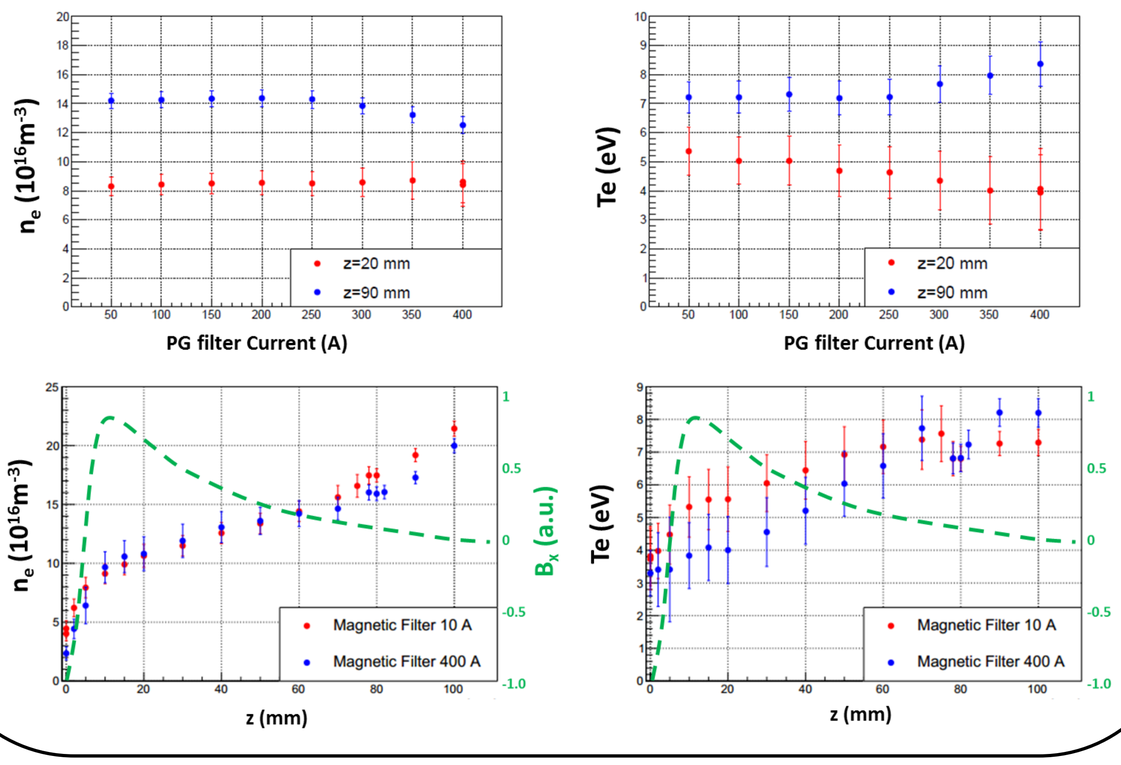


The I-V characteristic of the probe is analyzed using the following fitting formula:

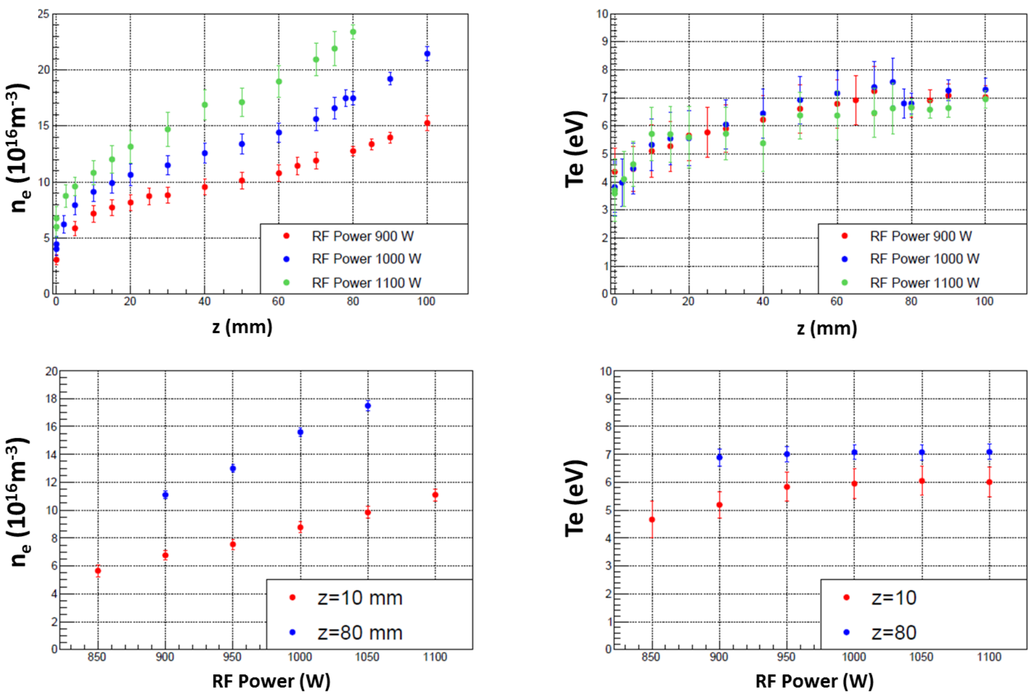
$$f = -e^{a}\frac{q}{2}\sqrt{b\frac{q}{m_i}}A[1+c(d-x)]\left[1-e^{\frac{x-d}{b}}\right]$$

Here the four parameters of the fit (a,b,c,d) are related with the plasma parameters as follows: a = log (n_e), (n_e being the electron density), b = T_e, (electron temperature), c is the parameter which express the variation of the collection area with the voltage, d = V_f is the floating potential; A is the probe area

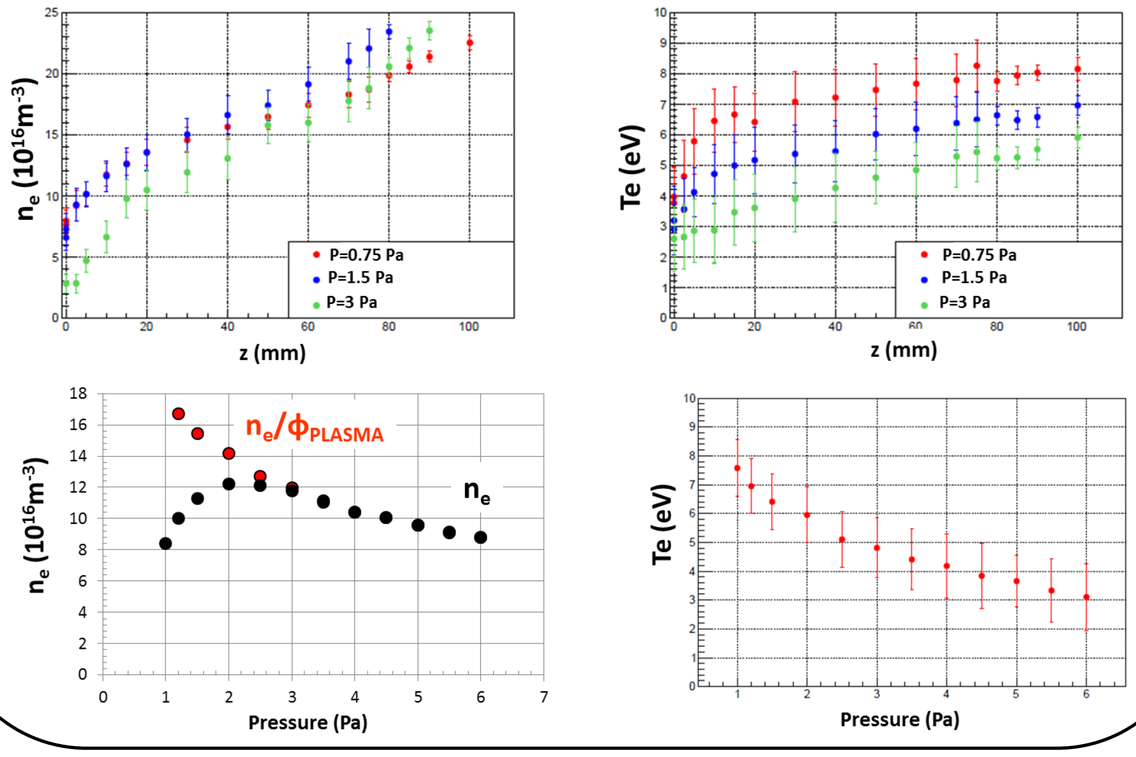
SCAN in B field



SCAN in RF Power



SCAN in Filling Pressure



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