A 3D boundary sheath analysis on Faraday probe measurements in a non-equilibrium plasma

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Presented at the 30th International Electric Propulsion Conference, Florence, Italy
September 17 – 20, 2007

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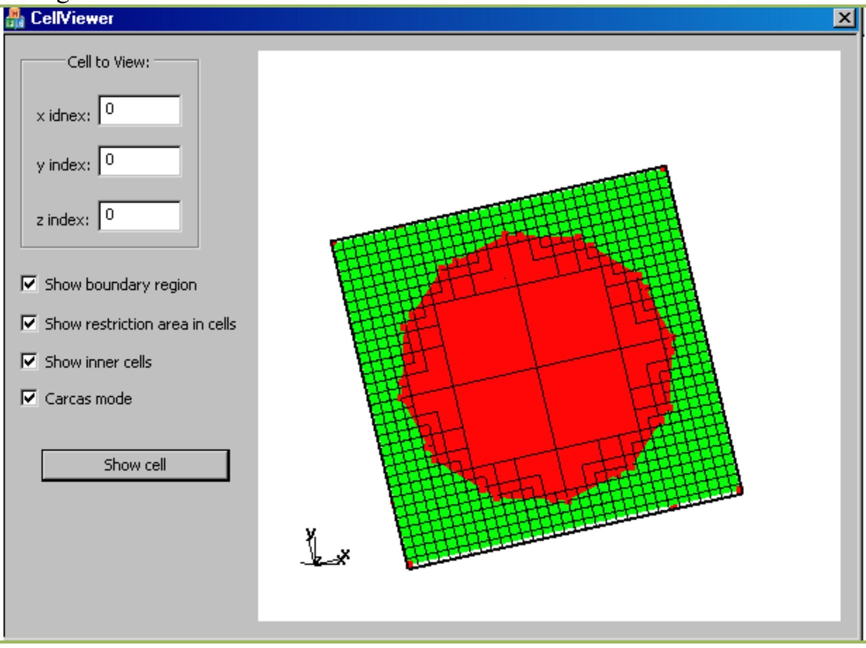
Abstract: In this work we tried to develop the codes for boundary cells in our algorithms. It has interest because potential decrease near the wall create big tensity field. So the trajectory of ion or electron changes greatly. In our trajectories analysis algorithm it is very important to know behavior of simulated particle near the wall. This work is just our simulation of the model suggested on last IEPC[1].

I. Introduction

In the paper «Numerical Simulation of Faraday Probe Measurements in a Multi-component Non-equilibrium Plasma» (85) IEPC-2005 was presented 2D axis symmetrical model of non- equilibrium plasma which can calculate parameters of plasma near the wall with the Faraday probe. We were interested in the results of this work for the 3D model creation in the boundary cells.

1. Model description:

The shown is the grid for this calculation:



Detailed cell grid

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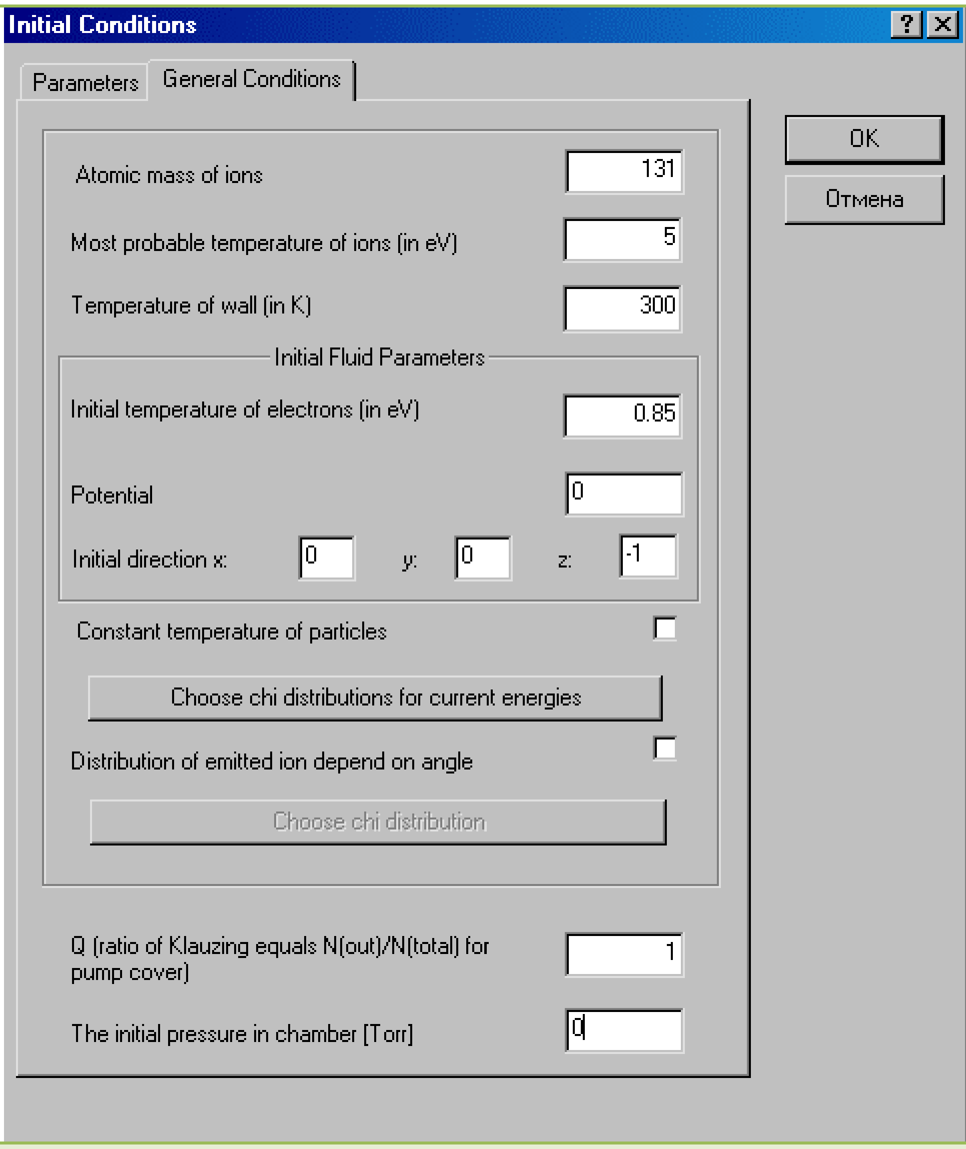


Initial Conditions

2. The equations which were used during process of calculation

For a collisionless planar sheath with cold ions, continuity and conservation of energy for the ions can be expressed in terms of the ion density, n_i, and velocity, u_i, as

$$n_i(x)u_i(x) = n_{is}u_{is} \quad (1)$$

$$\frac{1}{2}m_i u_i^2(x) + e\phi(x) = \frac{1}{2}m_i u_{is}^2 \quad (2)$$

where the subscript s refers to values at the edge of the sheath. The sheath edge ($x = 0$) is properly defined as the point where the electron and ion number densities are equal.

For a steady sheath, the electrons assume a Maxwellian distribution. The electron number density is then determined from the local potential through the Boltzmann relation.

$$n_e(x) = n_{is}\exp\left(\frac{e\phi(x)}{k_B T_e}\right) \quad (3)$$

Poisson's equation closes the set by relating the potential to the ion and electron number densities in the sheath.

$$\frac{d^2\phi(x)}{dx^2} = -\frac{e}{\varepsilon_0}\left(n_i(x) - n_e(x)\right) \quad (4)$$

The equations system

3. Initial data

Table 1. Distribution properties for a Maxwellian beam population in a simulated BHT-200 plume.

	Single Beam
n_i, 10^{14} m^{-3}	1.100
v_i, m/s	2,381
T_i, K	11,600
L_D, 10^{-4} m	7.09
v_B, m/s	855.3
M	2.78

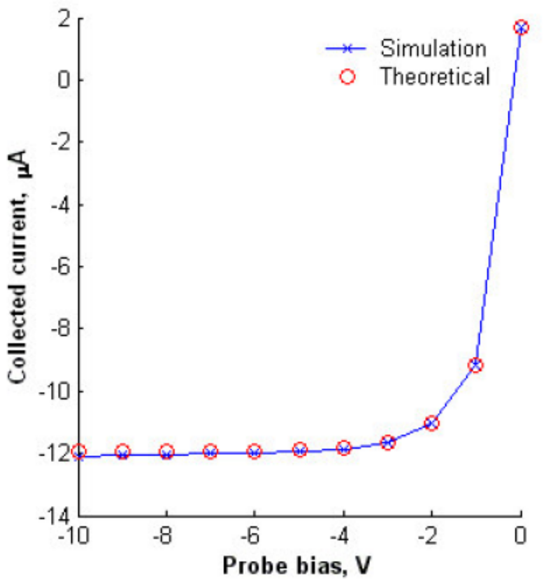


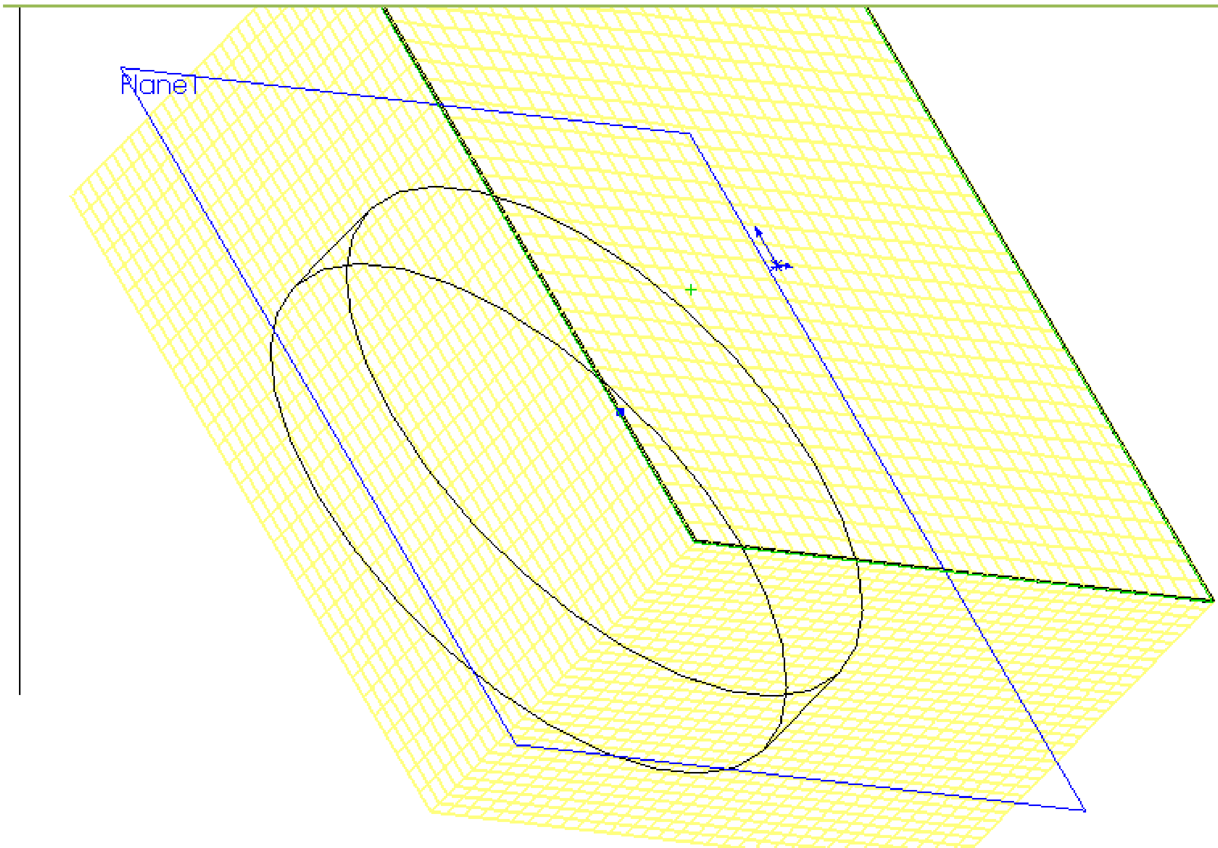
Figure 29. The simulated IV characteristic for a single beam distribution

Volt-ampere characteristic

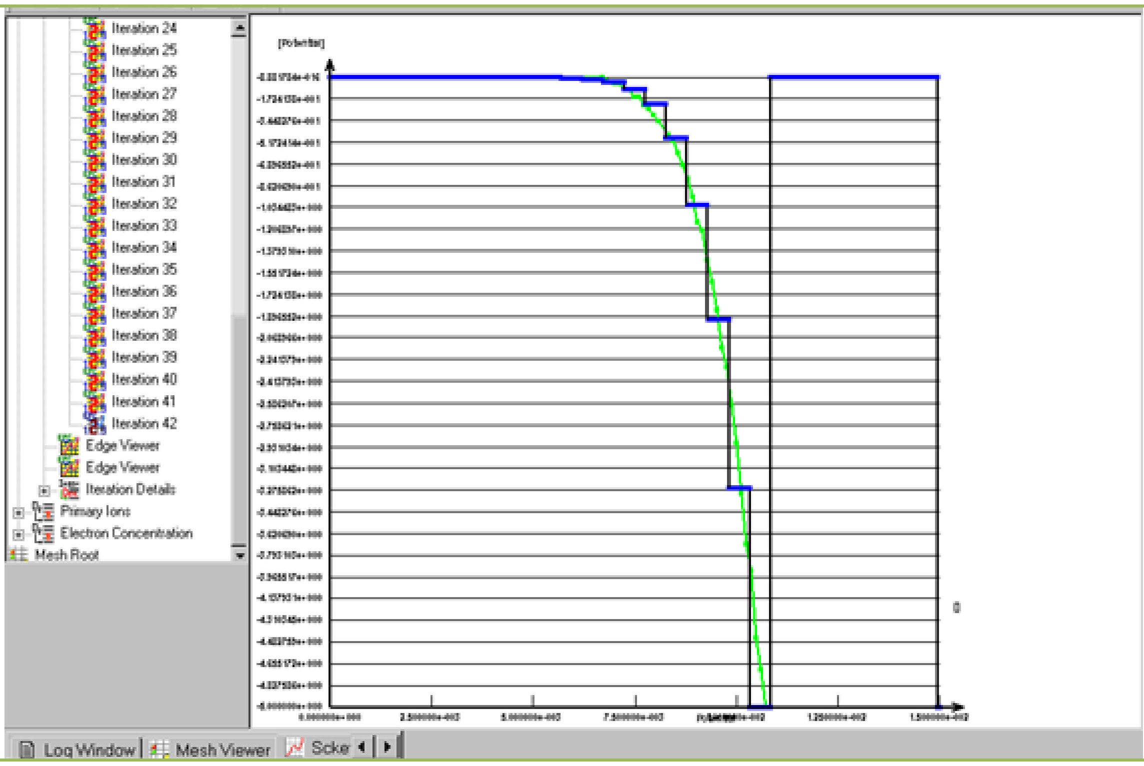
After the calculation of this curve we get the temperature of electrons Te = 0.85 eV.

4. Calculation result

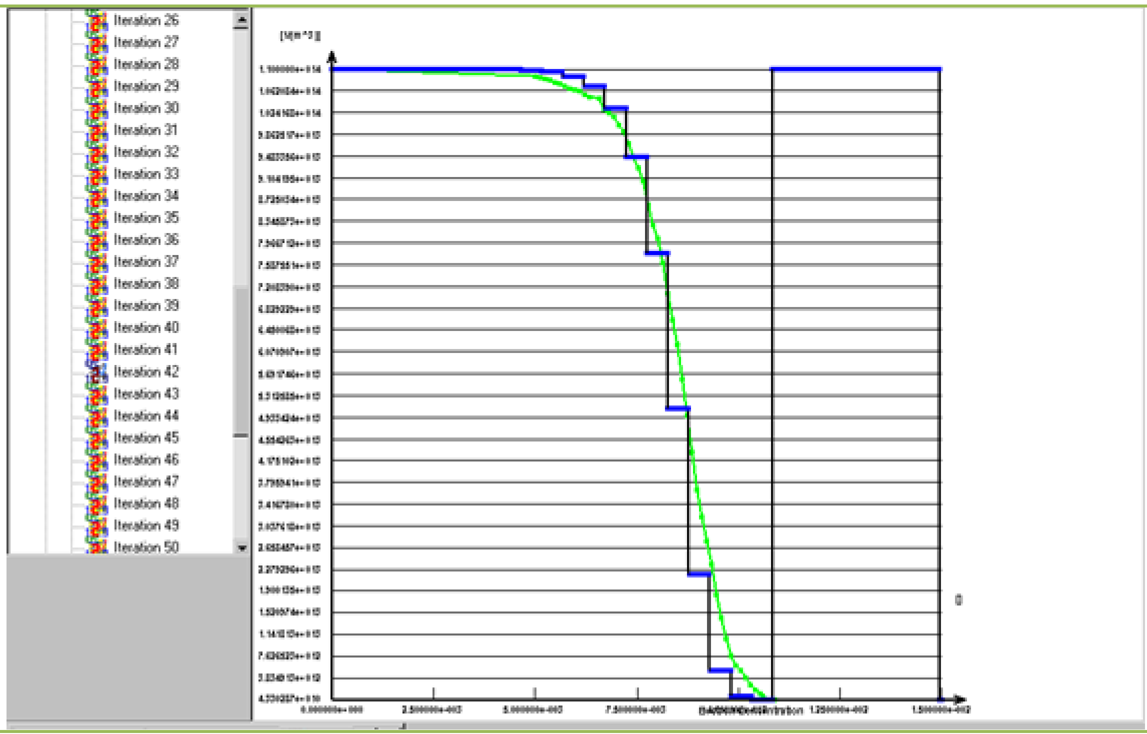
The result of calculation for the 32x32x32 grid:



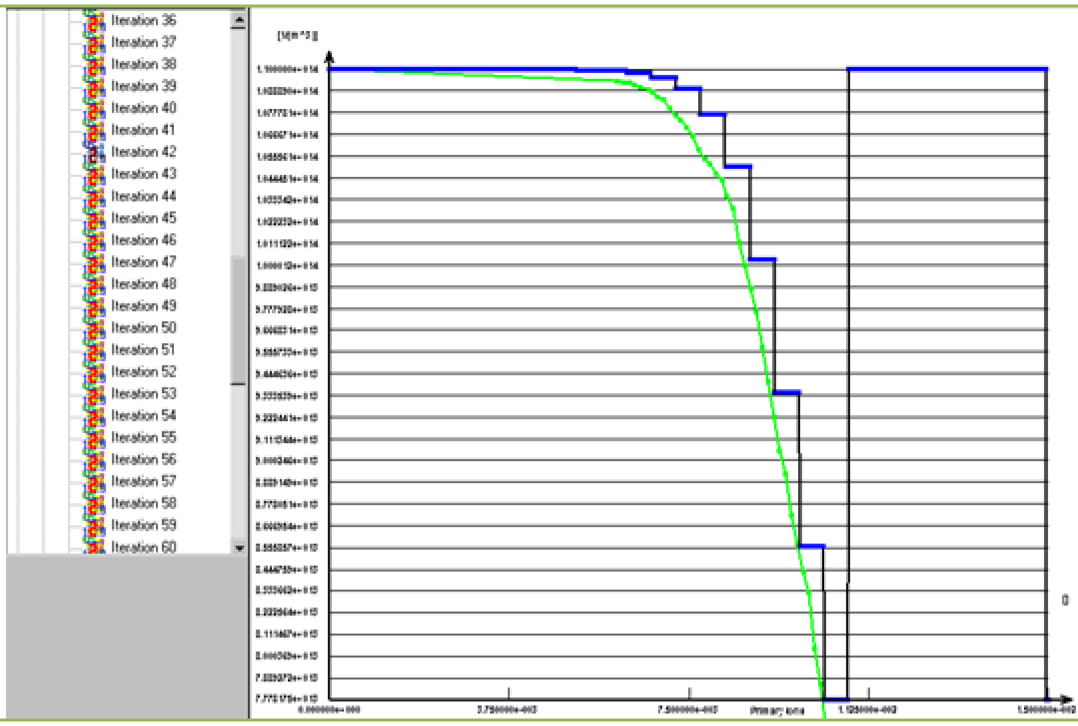
Computation domain



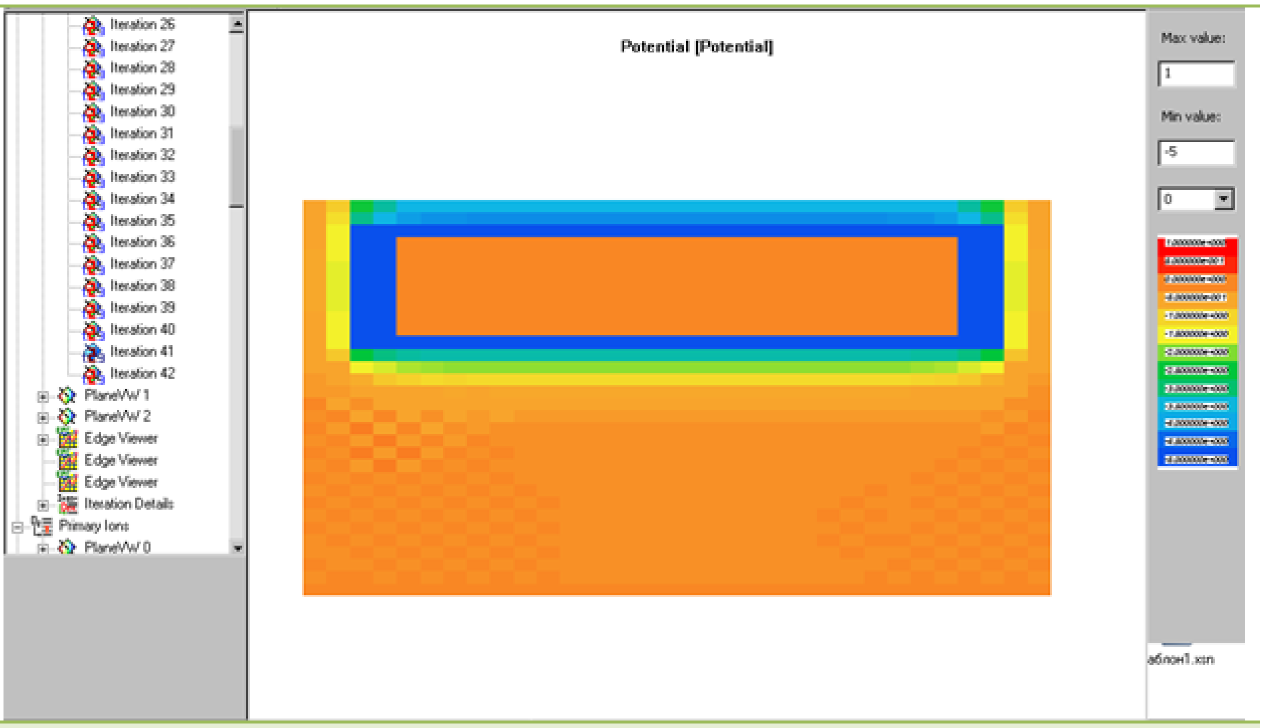
Potential distribution



Electrons concentration distribution

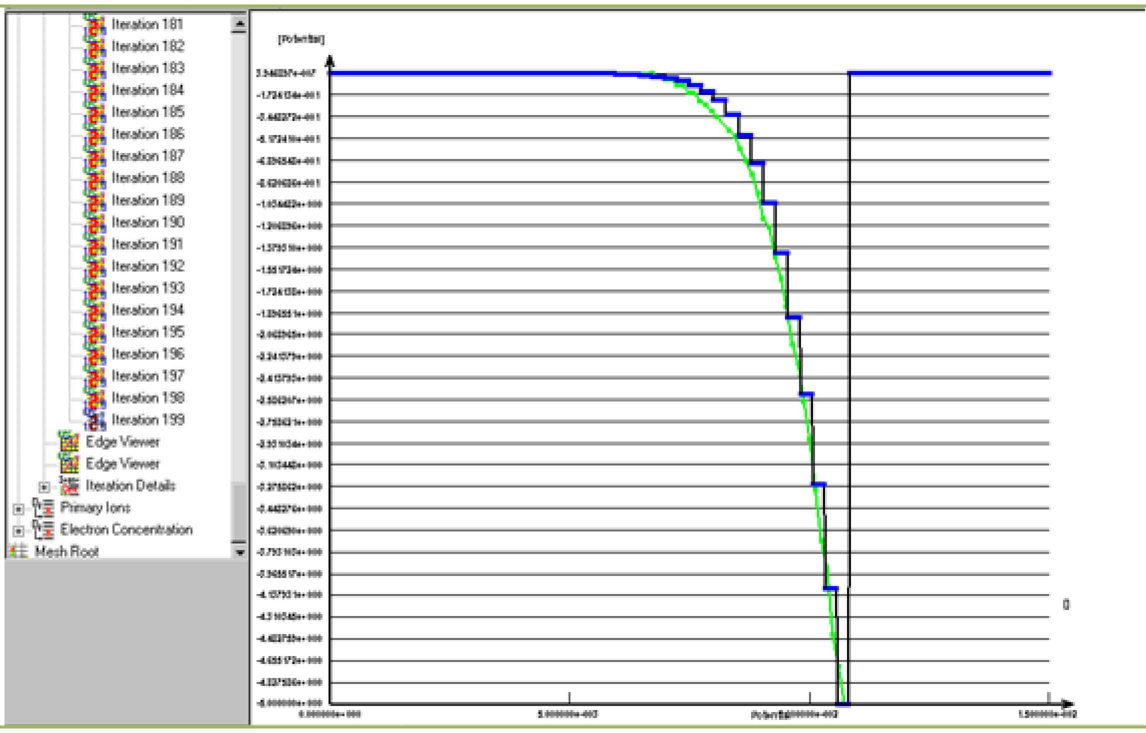


Ions distribution concentration



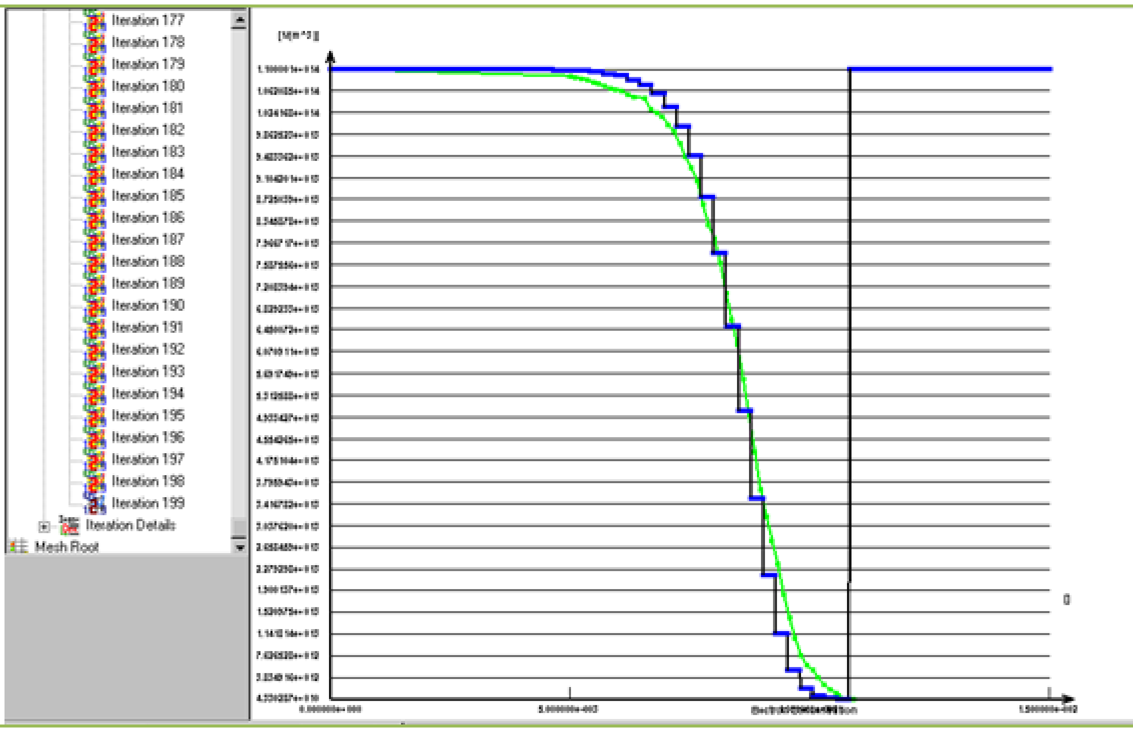
Potential distribution on the 42 iteration

The results of calculation for the 64x64x64 grid:

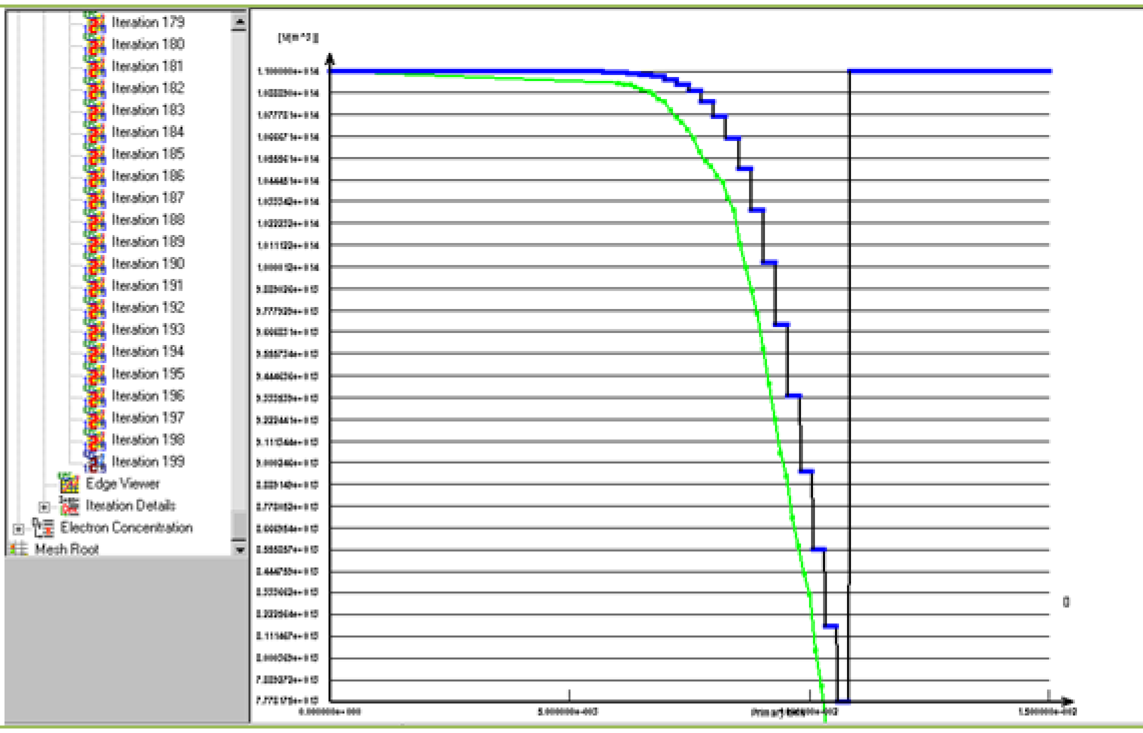


The potential distribution along axis

6

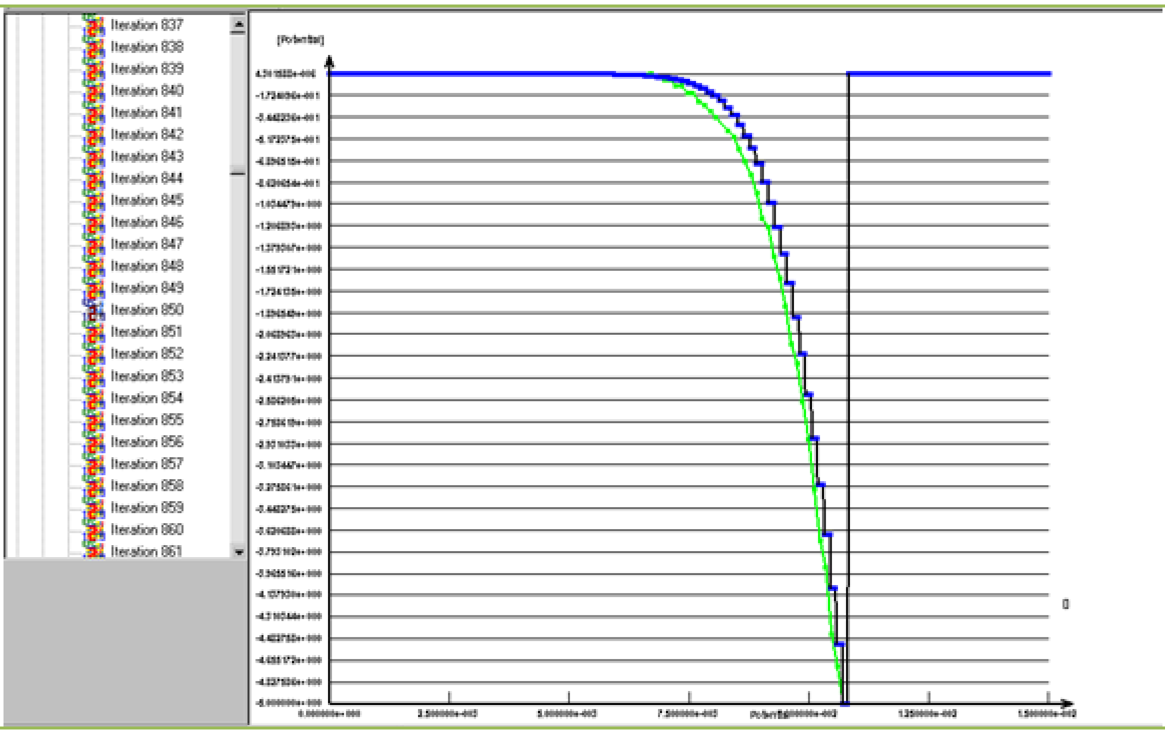


The electron concentration distribution along main axis

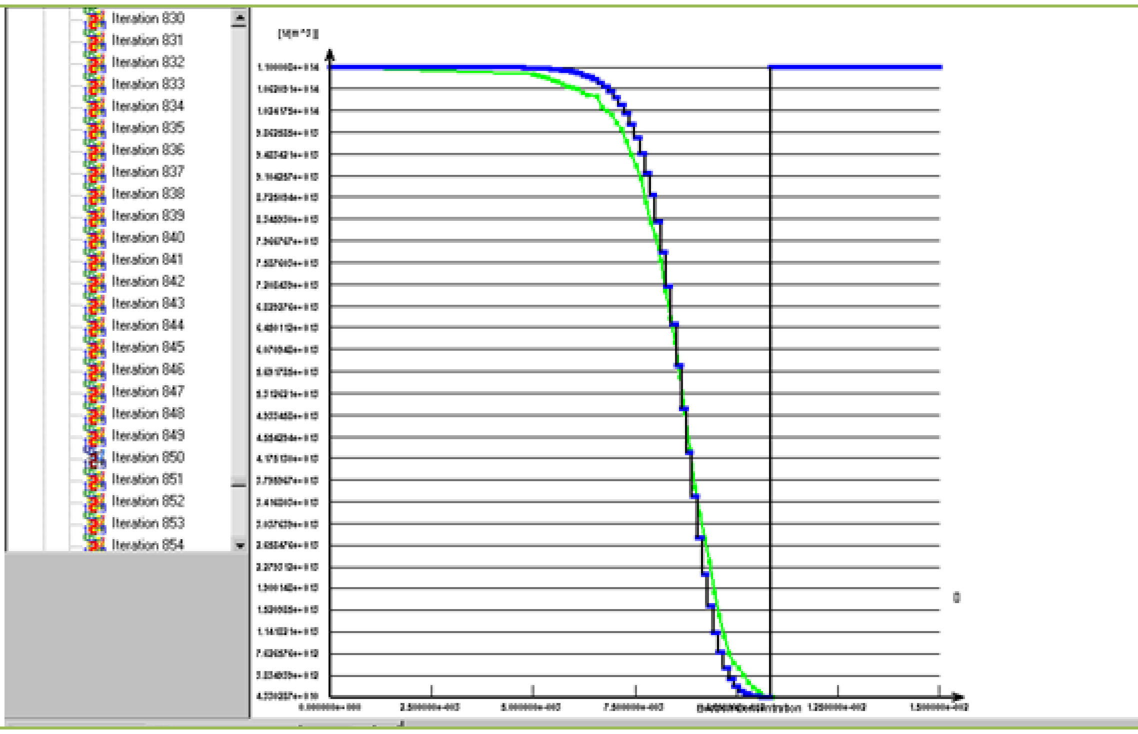


The ions distribution along main axis

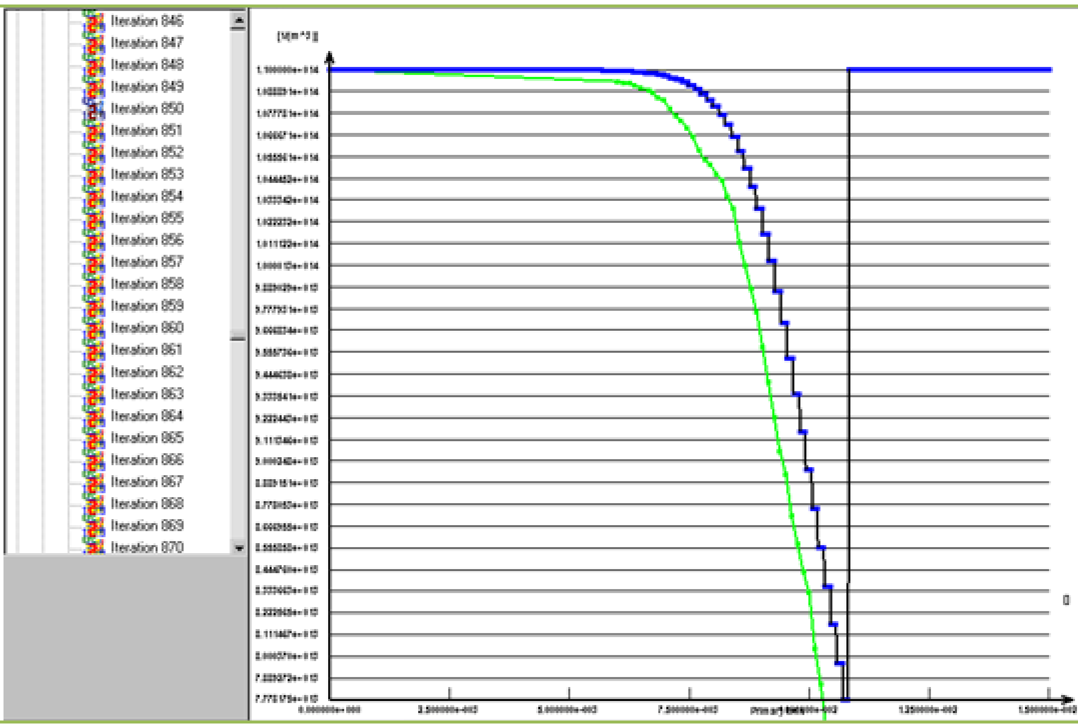
The results of calculation for the 128x128x128 grid:



The potential distribution along main axis



The electron concentration distribution



The ions distribution along main axis

References

[1] *Jeremiah J. Boerner and Iain D. Boy, «Numerical Simulation of Faraday Probe Measurements in a Multi-component Non-equilibrium Plasma», IEPC-2005*