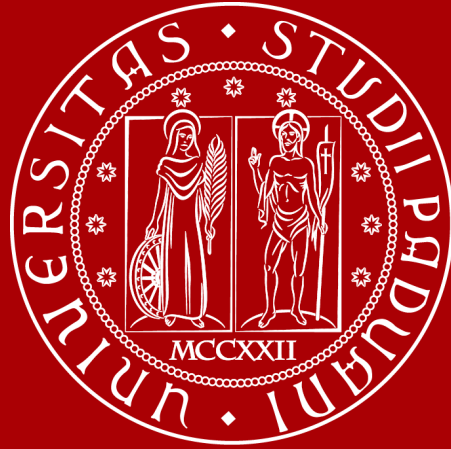




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Development of an innovative numerical model for the analysis of electric plasma thrusters

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Overview



1. Introduction

2. Methodology

3. Results

4. Future expected results

Electric propulsion: electrical power is used to ionize the propellant, which is then accelerated by means of electrostatic or electromagnetic fields.

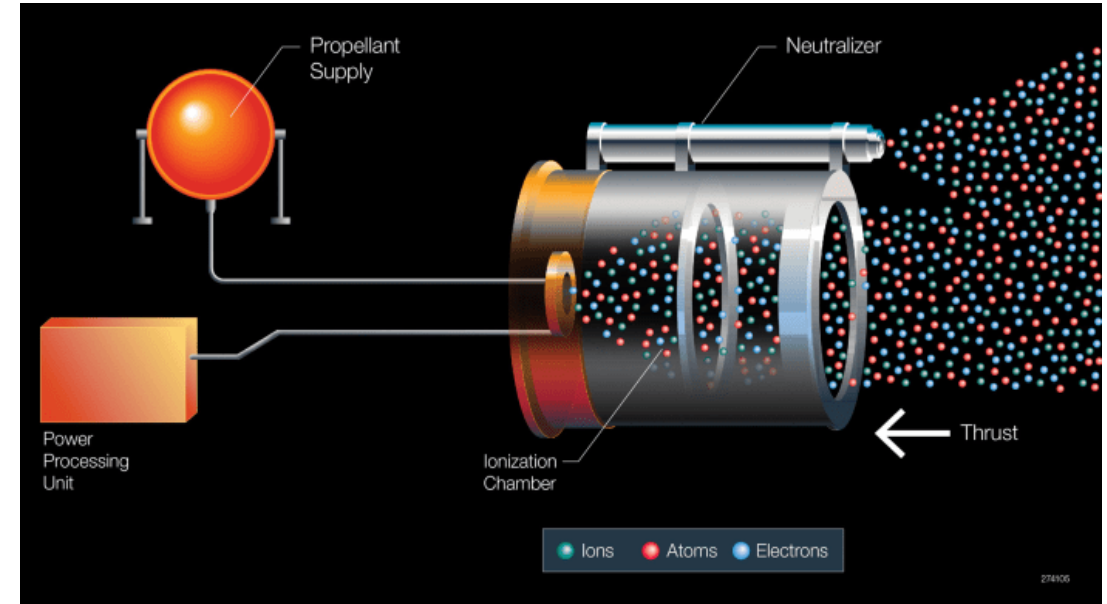
Compared to chemical thrusters:

- ✓ Higher Specific Impulse (I_{sp})
- × Less Thrust (T) produced

Power limited:

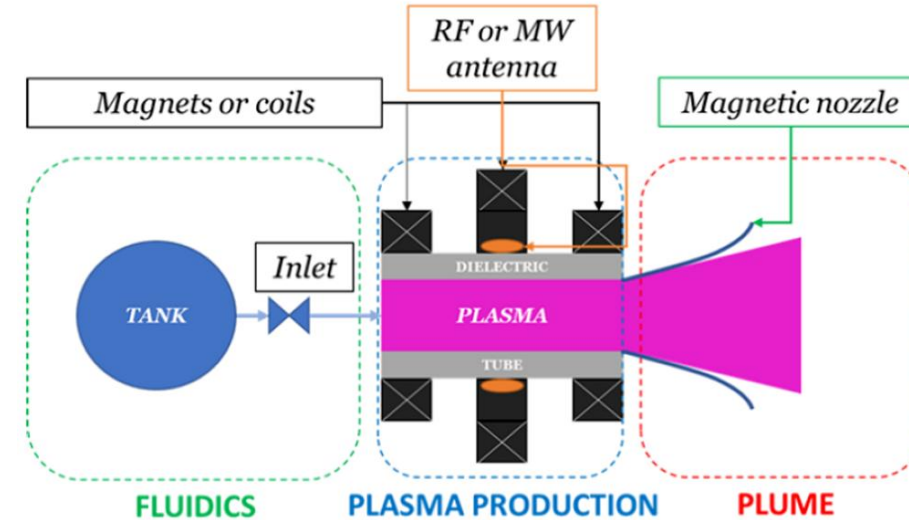
$$\eta = \frac{T^2}{2\dot{m}P_w}$$

- η = thruster efficiency in terms of power
- $\dot{m}$ = mass flow rate
- P_w = power input



Different types of electrical thrusters:

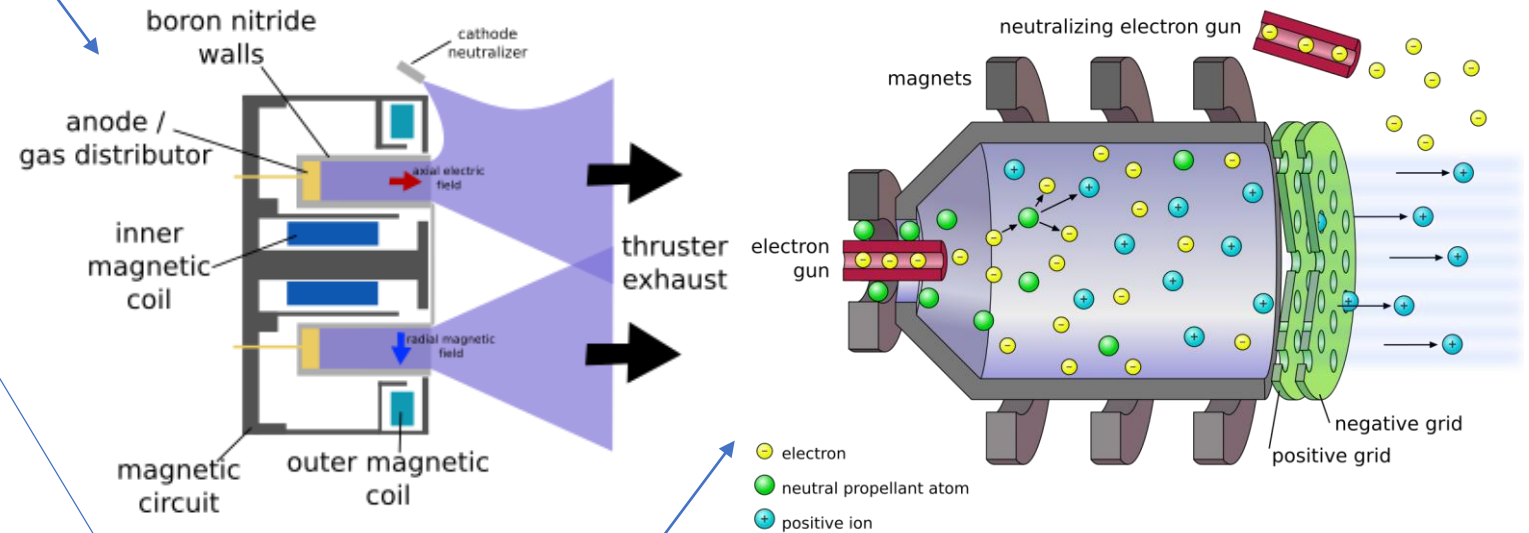
➤ **Helicon Plasma Thruster (HPT)**



➤ **Hall Effect Thruster (HET)**

➤ **Gridded Ion Thruster**

➤ ...





Vastly different plasma densities, from 10^{14} m^{-3} in the magnetic nozzle to 10^{19} m^{-3} in the plasma formation region.

➤ **Global Source Model (GSM)**

To obtain properties of the plasma discharge within the plasma formation region, which will be the boundary conditions for the Particle-In-Cell (PIC) code.

➤ **3D Particle-In-Cell code (ProPIC)**

To simulate the plume (acceleration) region and evaluate the performance of the thruster, primarily in terms of **Thrust** and **Specific Impulse**.



AI integration

- Data analysis of experimental data

Digital Twin (DT) model development through numerical and experimental tests

- Definition based on GSM & ProPIC: development of the codes, focus on the latter.
- Validation with laboratory tests.

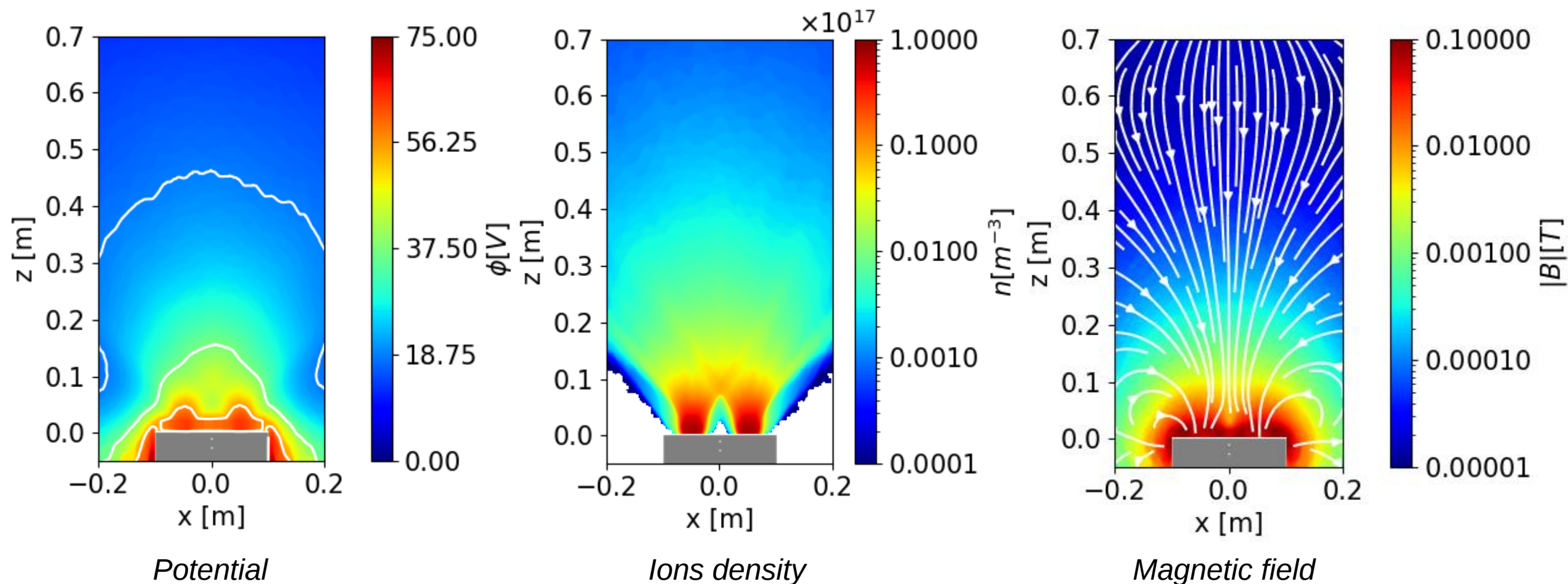


Results

Numerical codes development



Simulations of a **cluster of HPTs**:



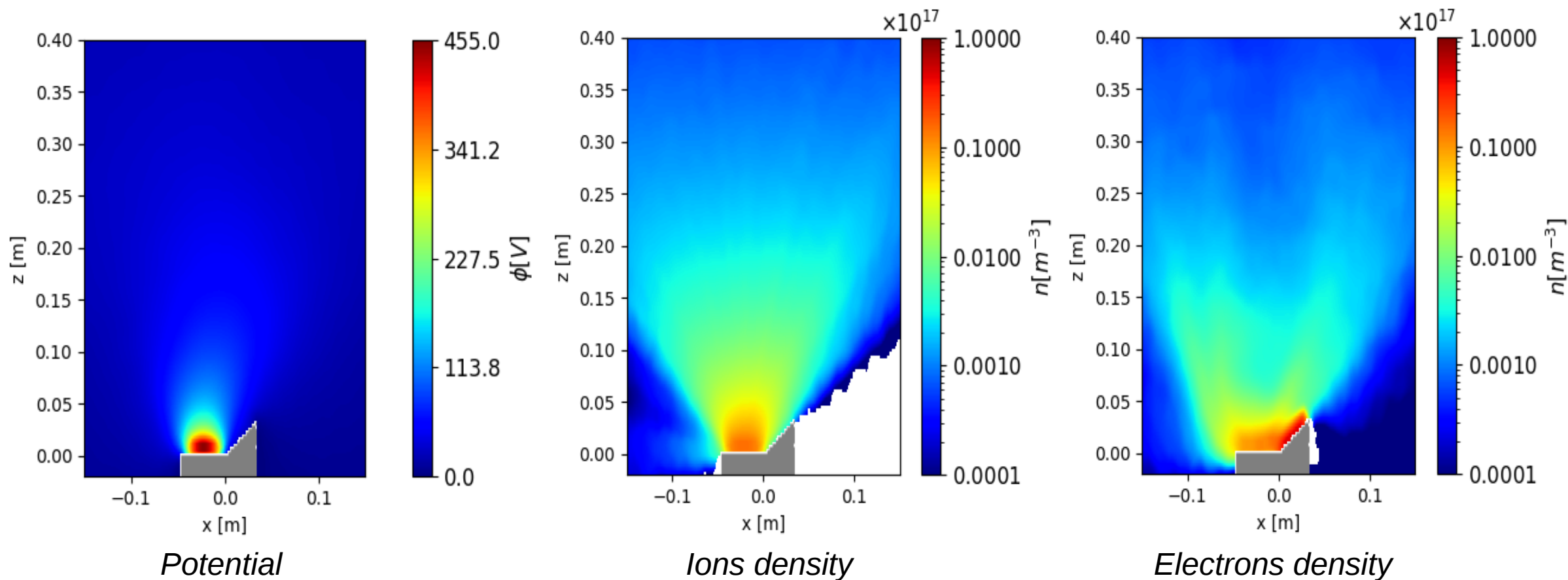


Results

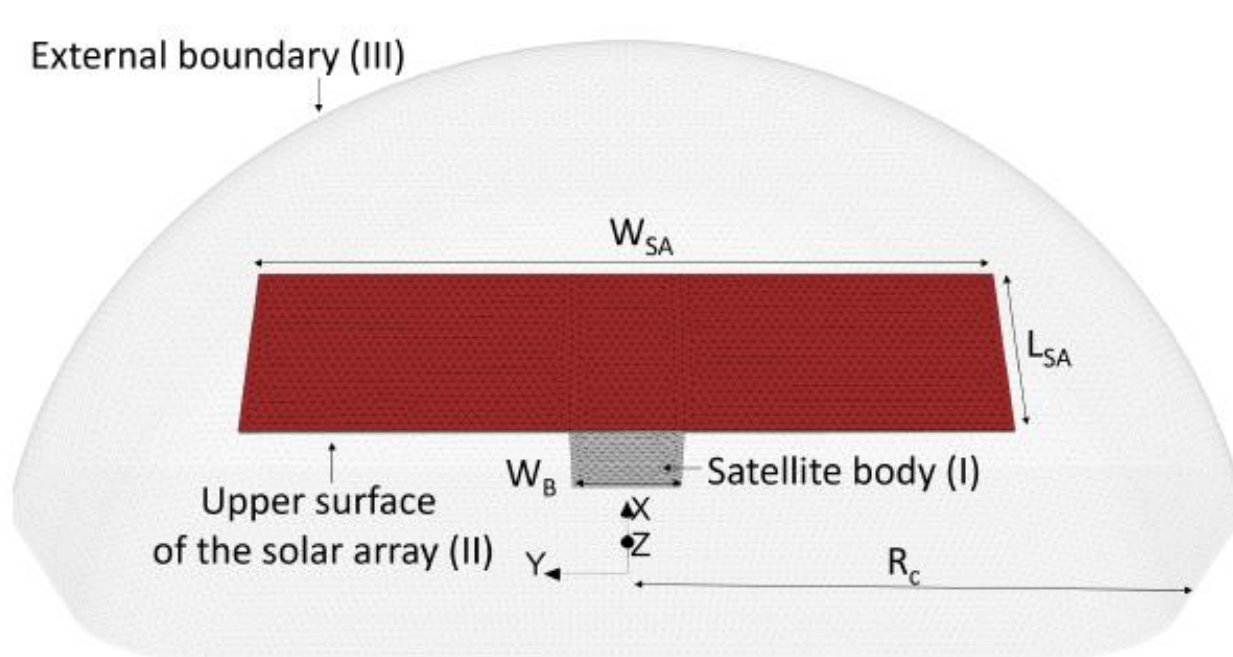
Numerical codes development



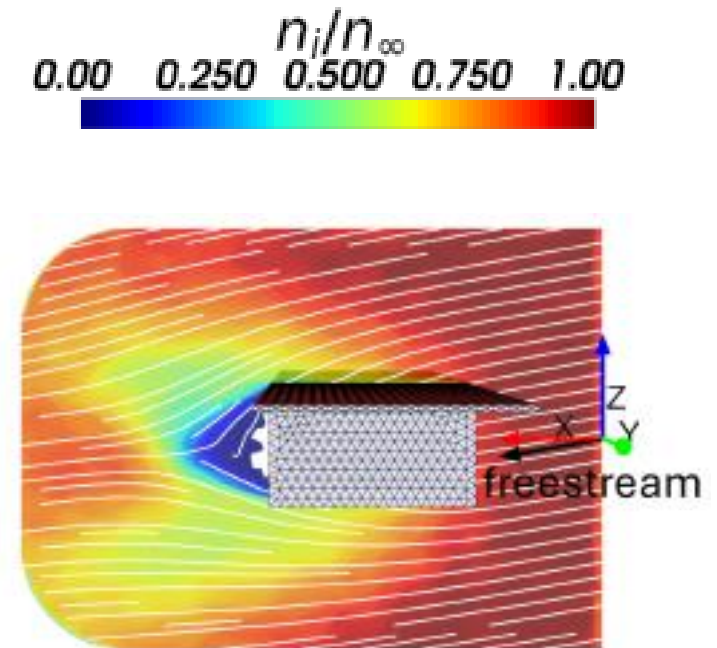
Simulations of a **cathode – anode** configuration:



Satellite's interactions with the environmental plasma:

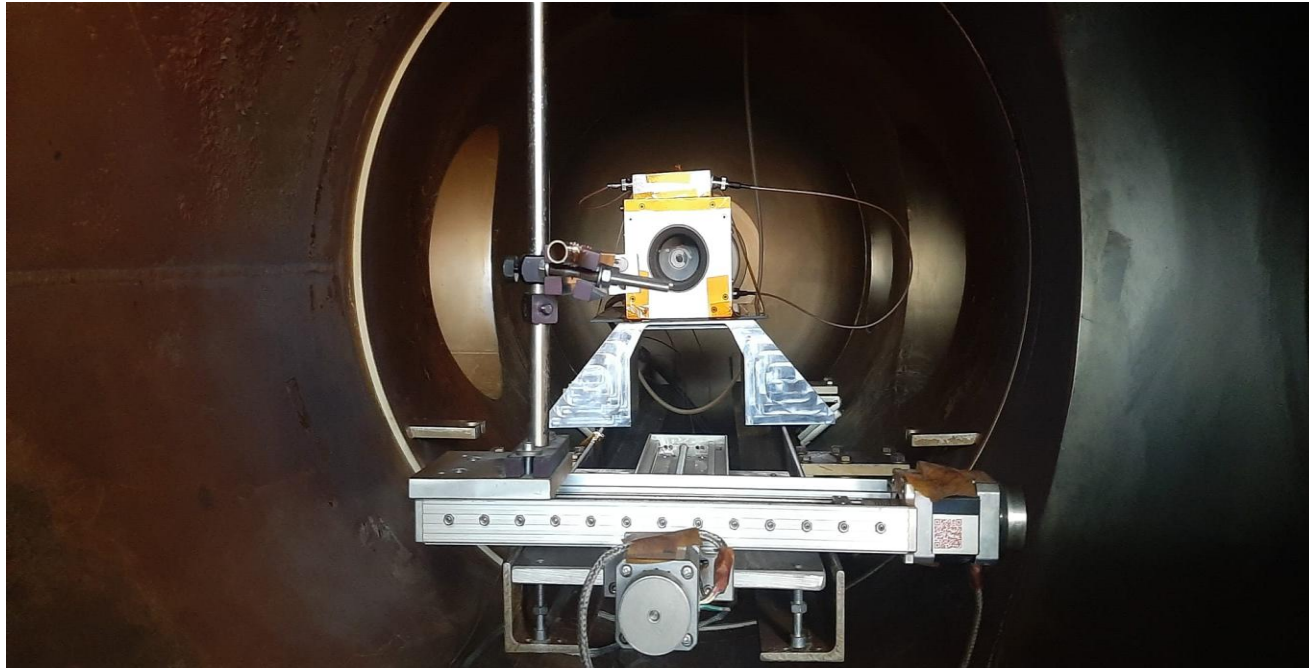


Geometry

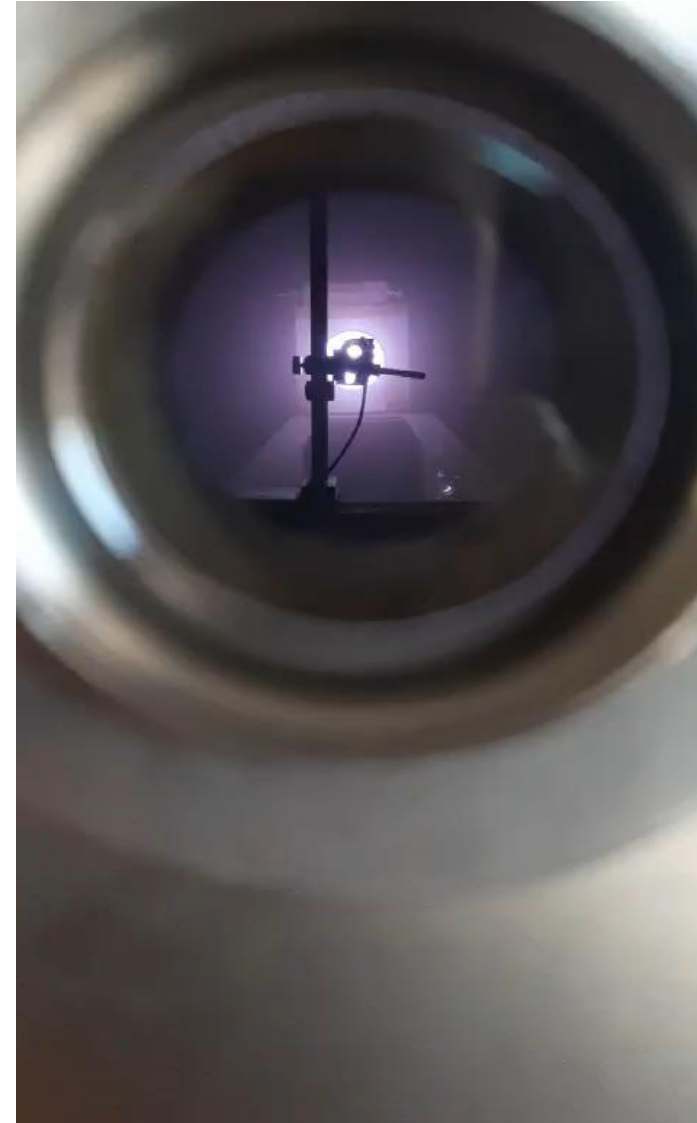


Environmental ions interaction

Experimental setup and testing:



HPT with a Faraday probe to measure the ions current



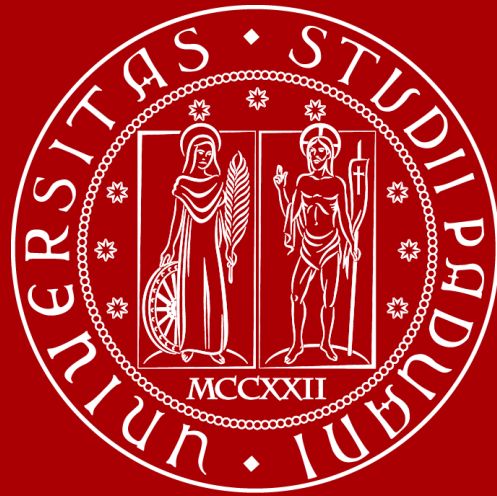


Future expected results



- 1. Finalizing the development of the numerical codes**
- 2. First prototype of a cathode to test cathode – anode configurations**
- 3. Experimental campaign to validate the numerical models upgrade**
- 4. Digital Twin first model**
- 5. AI integration to perform data analysis**

Thanks for the attention



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