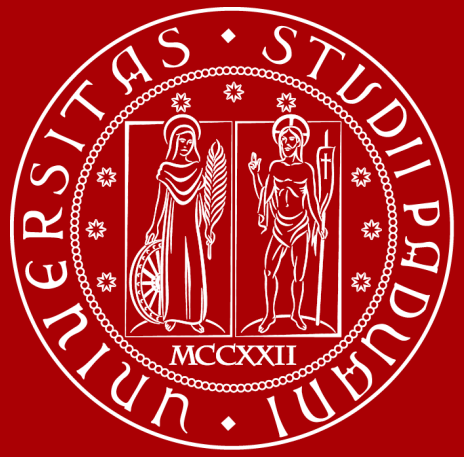


UNIVERSITÀ
DEGLI STUDI
DI PADOVA

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

Federico Cescon - 39th Cycle

Supervisor: Daniele Pavarin

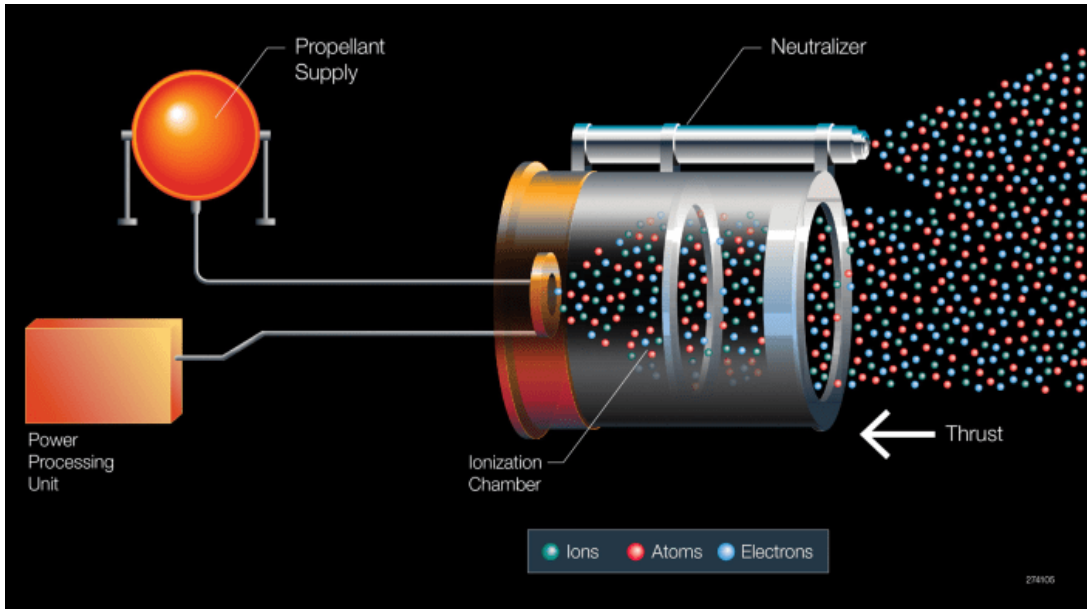
11/02/2026

Overview

1. Introduction
2. Methodology
3. Results
4. Future steps

Introduction

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:

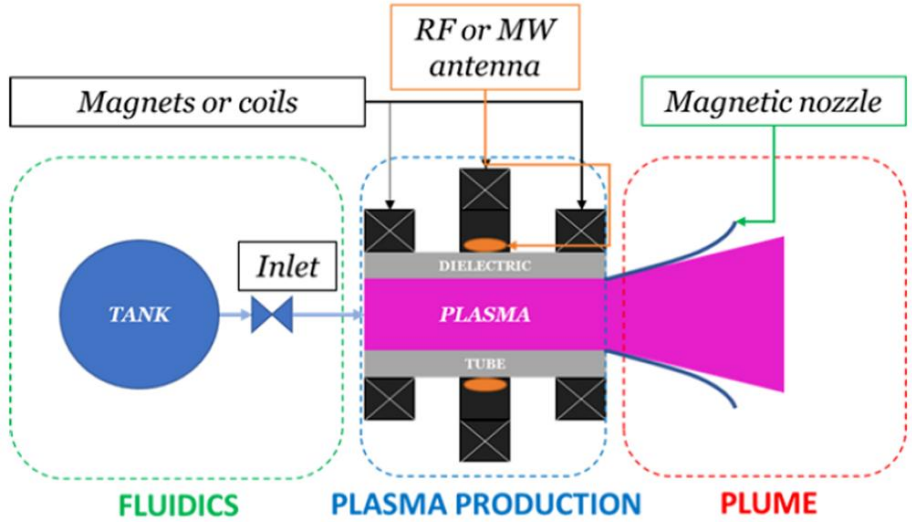
$$\eta = \frac{T^2}{2\dot{m}P_w}$$

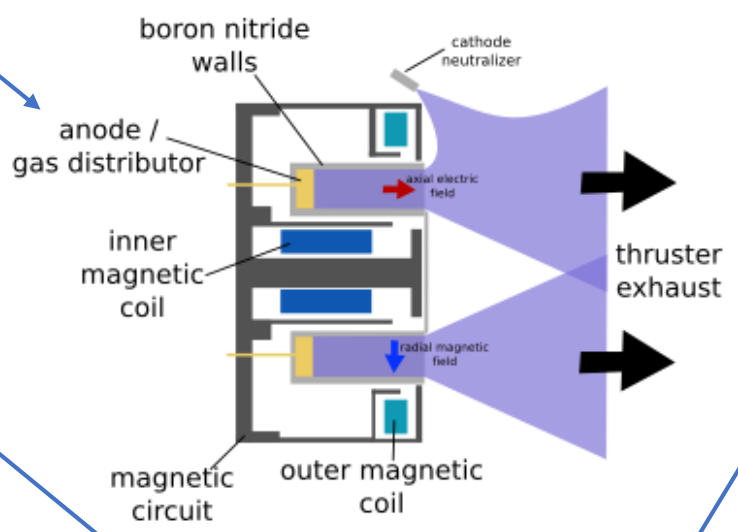
- η = thruster efficiency in terms of power
- $\dot{m}$ = mass flow rate
- P_w = power input

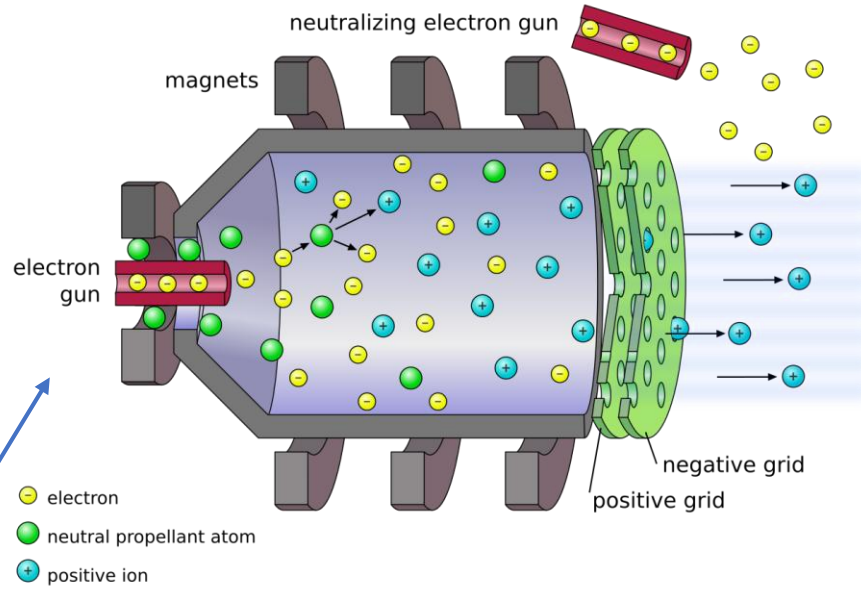
Introduction

Different types of electrical thrusters:

- **Helicon Plasma Thruster**
- **Hall Effect Thruster**
- **Gridded Ion Thruster**
- **…**







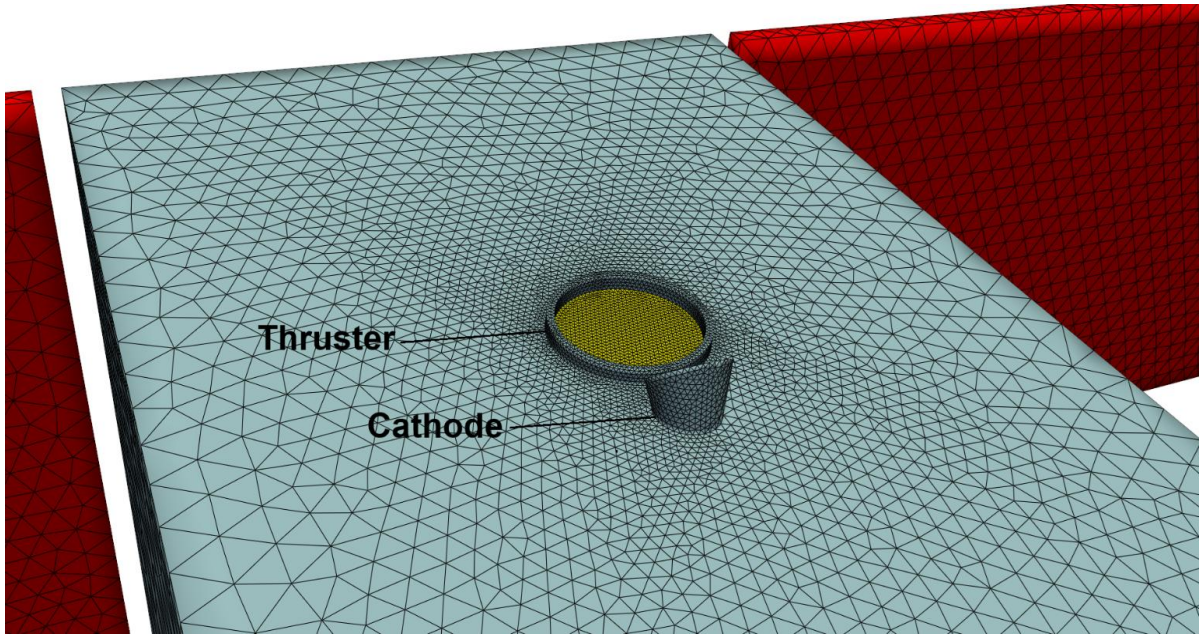
Methodology

Particle-In-Cell (PIC) code:
Digitally model the thruster to study the plume dynamics.

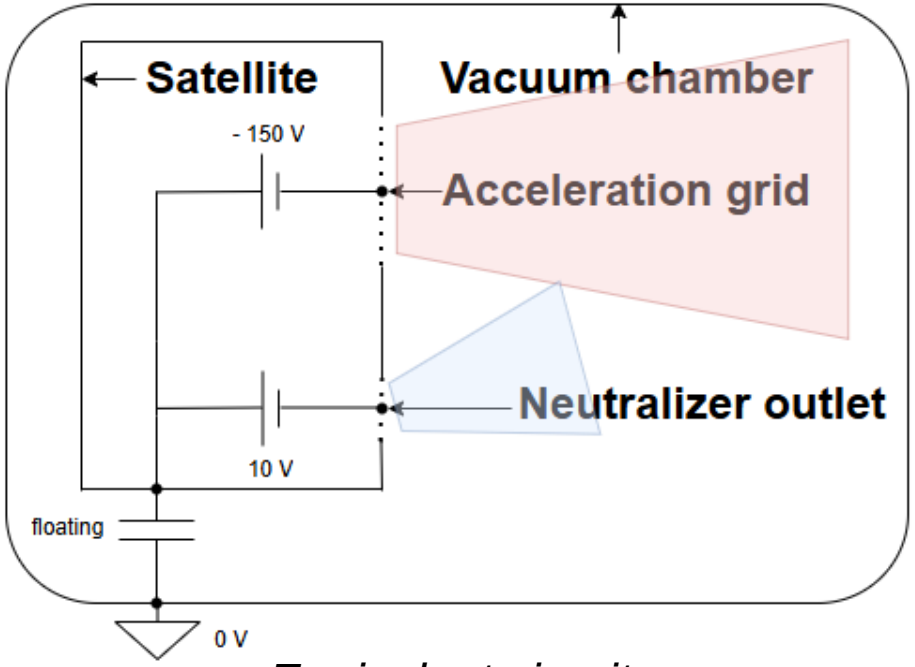
- ProPIC is an electrostatic solver specifically developed to model plasma plumes in 3D.
- PIC codes provide greater accuracy and fidelity than fluid or hybrid codes at the cost of greater computational resources required.
- 3D approach enables the study of **non-axysimmetric** thruster configurations and the **interactions** with the host spacecraft (S/C).
- Evaluation of the performance of the thruster, primarily in terms of **Thrust** and **Specific Impulse.**

Methodology

Activity focused on the **Gridded Ion Thruster (GIT):**



Geometry setup



Equivalent circuit

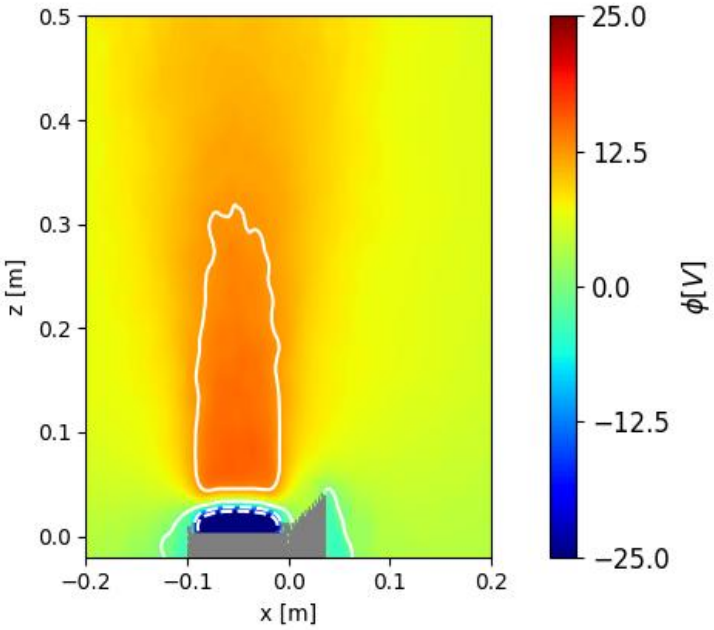
Development of the code to study:

- Neutralization process during initial transient.
- Sputtering of the S/C body and solar arrays.

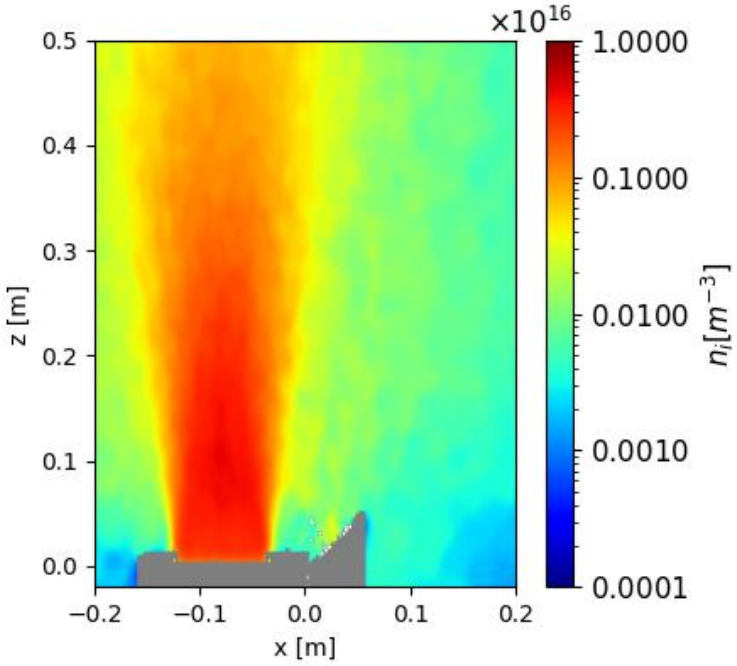
Results
Numerical code development

Neutralization process:
Collisions between particles play a key role in the neutralization process.

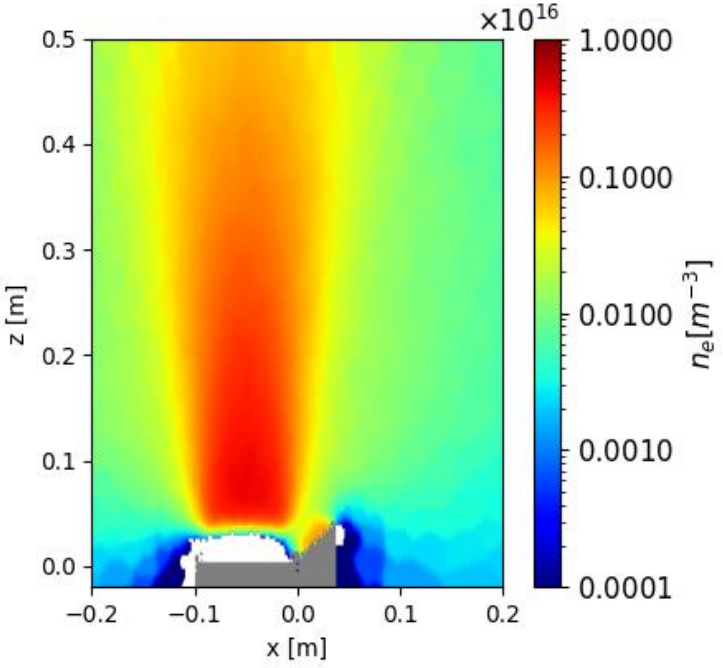
➢ Validation of the results against experimental data in the literature.



Potential



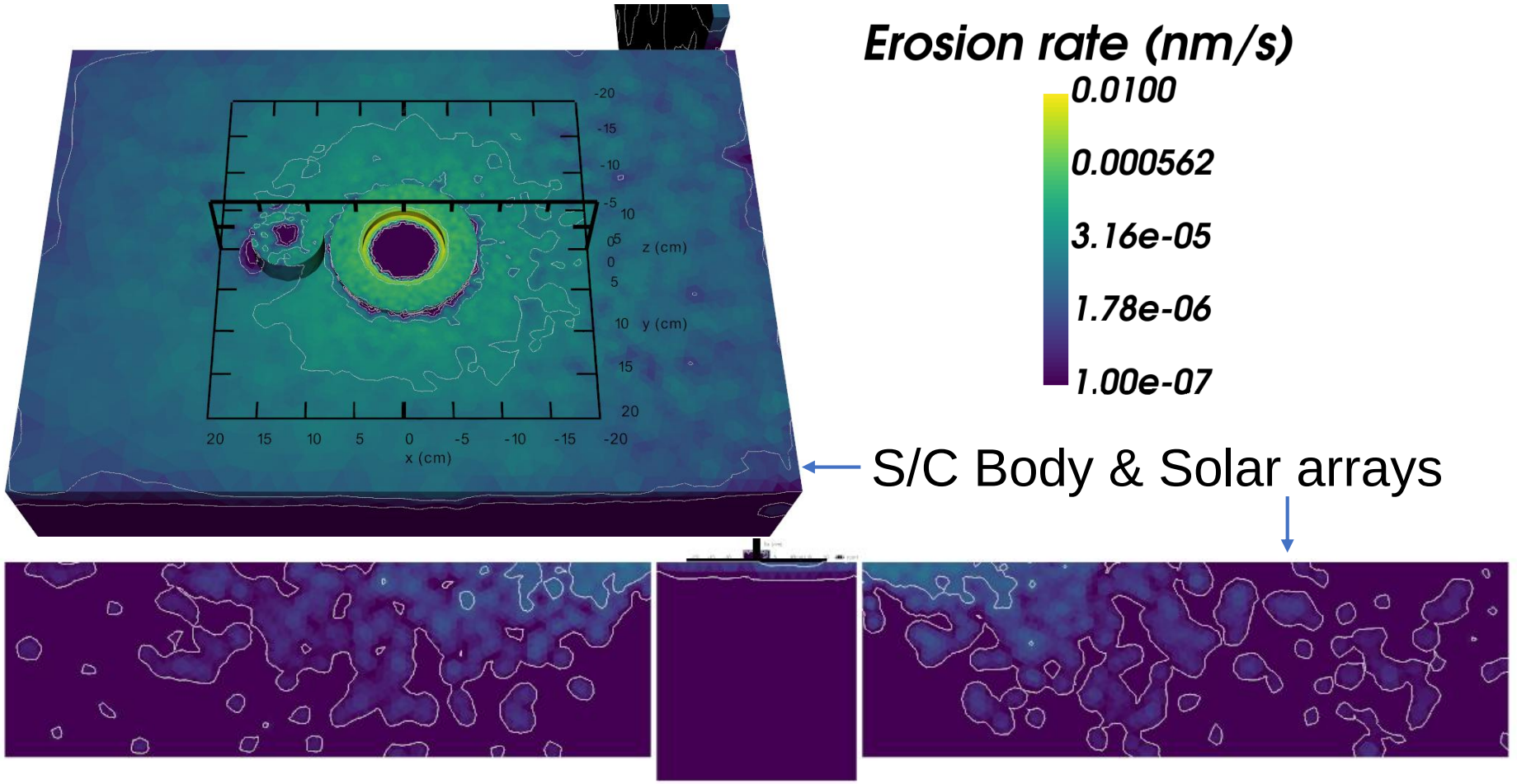
Ions density



Electrons density

Results
Numerical code development

Surface sputtering:
Erosion rate is well under typical values found in ground-testing.

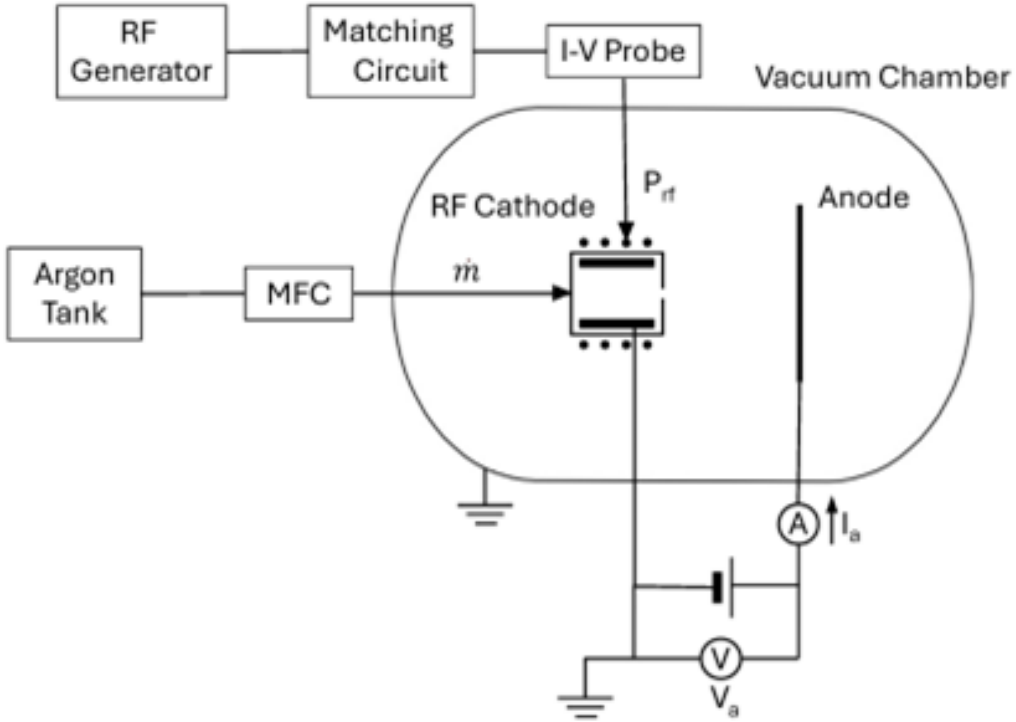


Results
Testing

Experimental tests:
In-house manufacturing of an RF cathode.

➢ Discharge current produced compatible with simulation values.

RF Cathode during testing (Ar)



Testing setup

Future steps

1. Finalizing the development of the numerical codes
2. Testing and further validation with the RF cathode prototype
3. Publications
4. Thesis writing

Thanks for the attention

UNIVERSITÀ
DEGLI STUDI
DI PADOVA

This study was carried out within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under contract n. 2024-5-E.0 - CUP n. I53D24000060005.