

01. Introduction to the PIC simulation

02. Random number generation and its application

03. Particle weighting and normalization

04. Particle pusher

05. Poisson's equation

06. One-dimensional electrostatic PIC code

07. Numerical tips and tricks in PIC simulations

08. Visualization

09. Electromagnetic field solver

10. Relativistic particle pusher

11. One-dimensional electromagnetic PIC codes

12. Advanced boundary conditions

13. Parallelization and high-performance computing

## Particle-in-Cell (PIC) kinetic simulations

### 14. Advanced PIC simulations

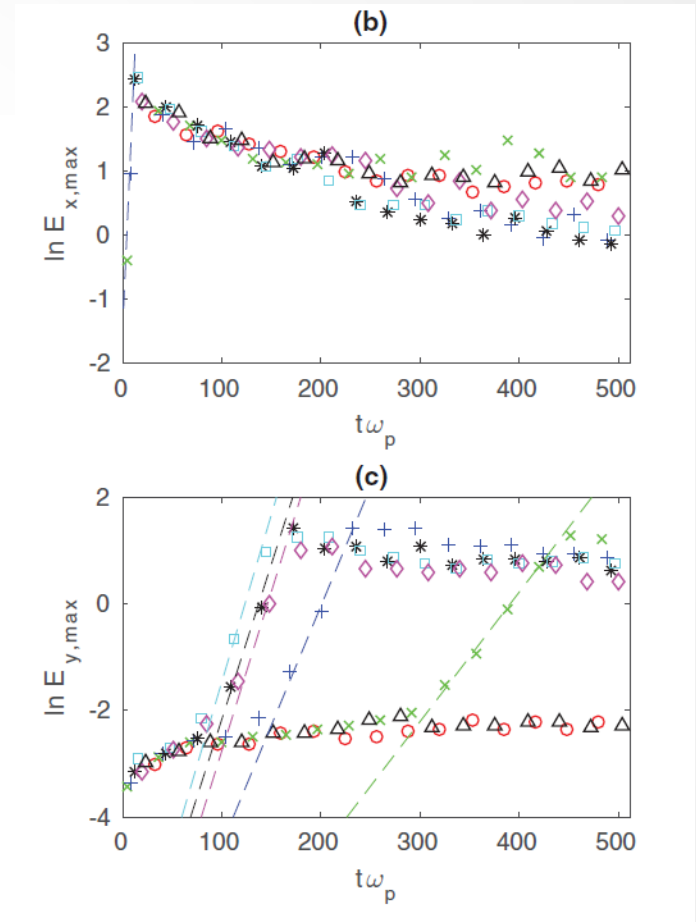
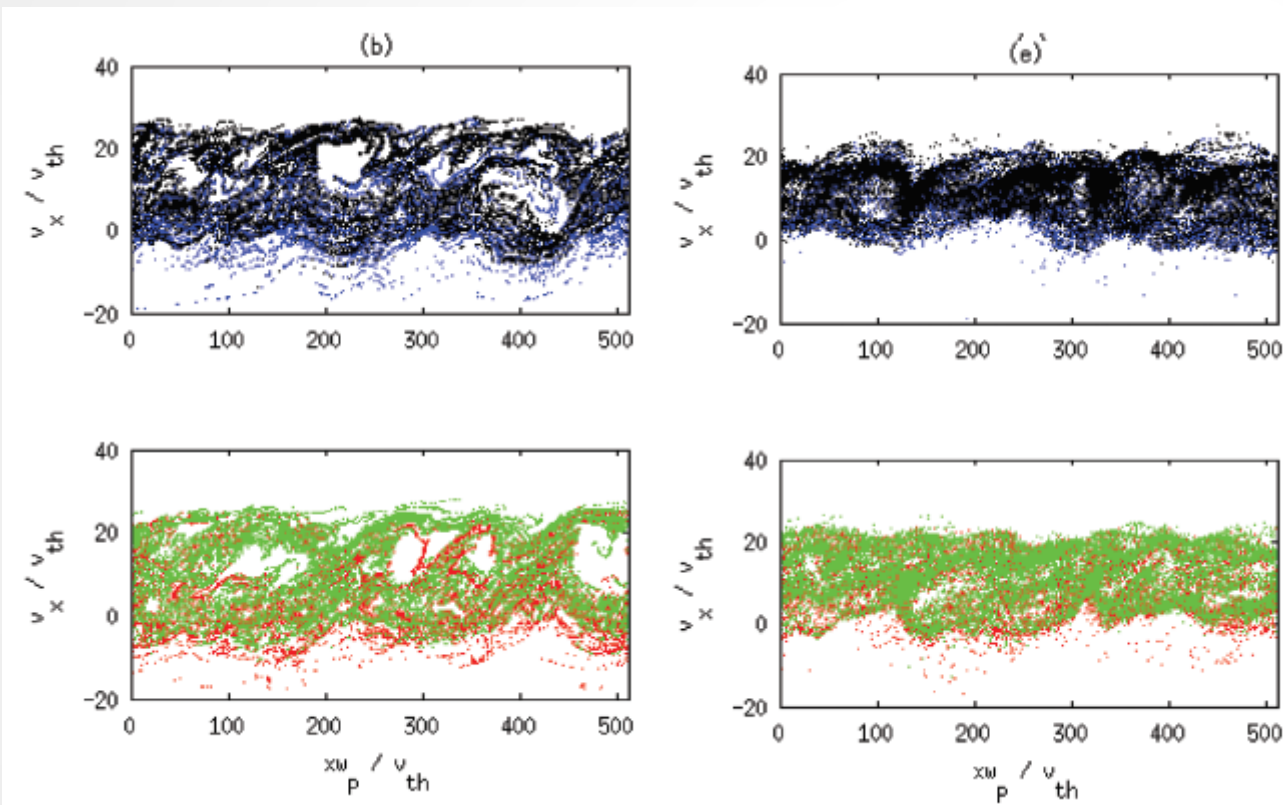
**Chun-Sung Jao (饒駿頌)**

Assistant Research Scholar,  
Institute of Space Science and Engineering,  
National Central University, Taiwan

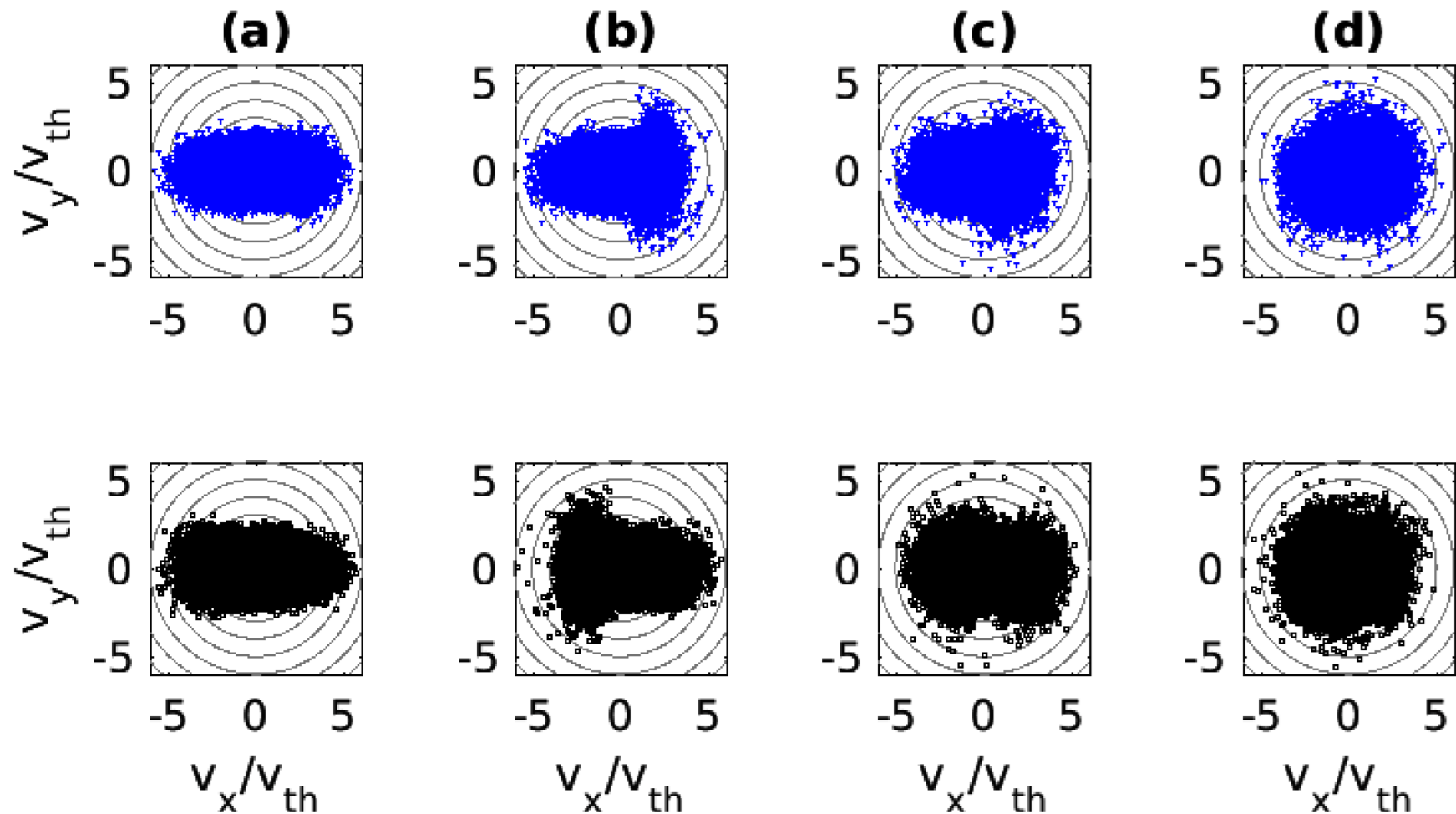
University of São Paulo, 2019.11.25-12.06

[csjao@jupiter.ss.ncu.edu.tw](mailto:csjao@jupiter.ss.ncu.edu.tw)  
[csjao899@gmail.com](mailto:csjao899@gmail.com)

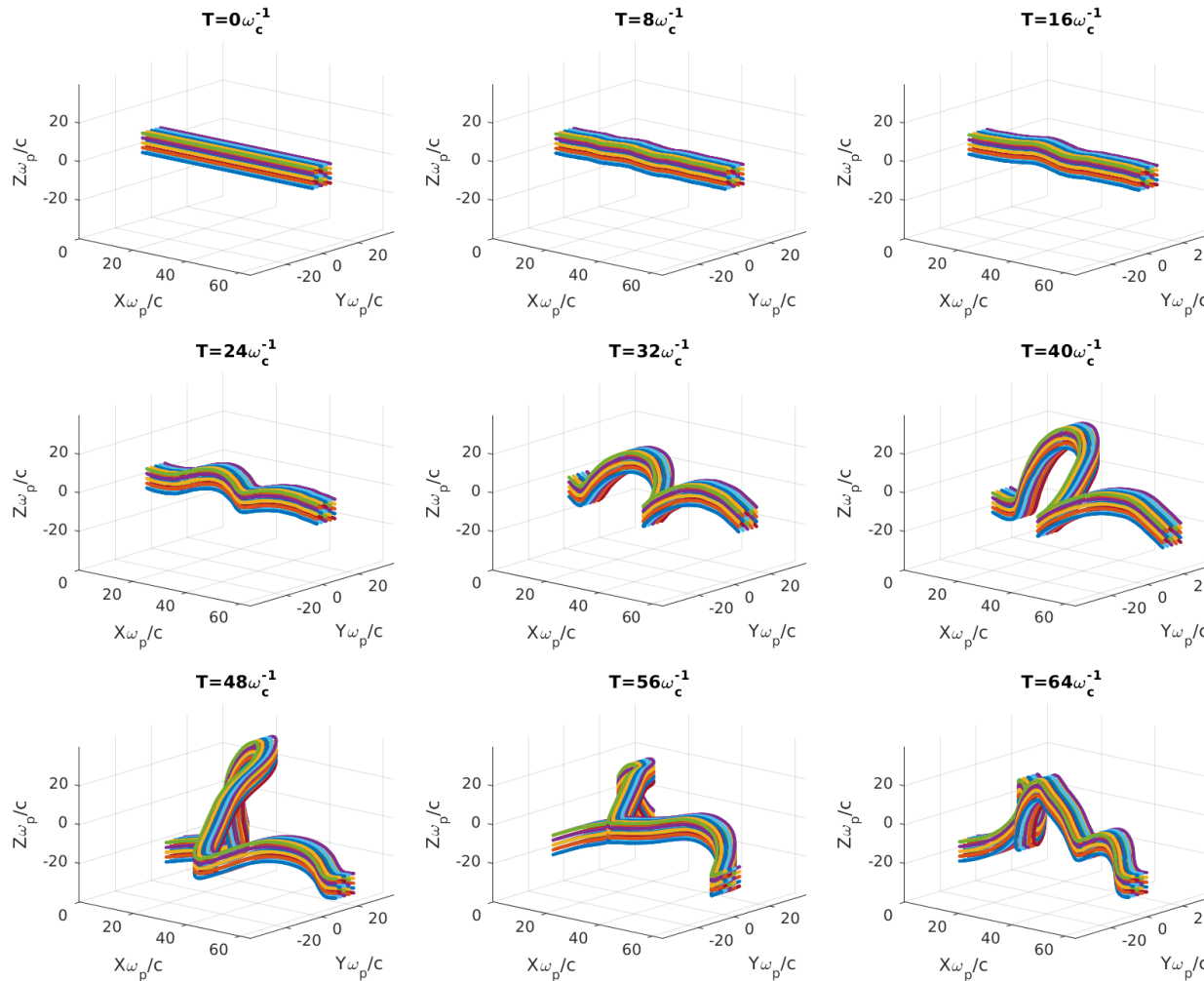
# Streaming instability in electron-positron plasmas



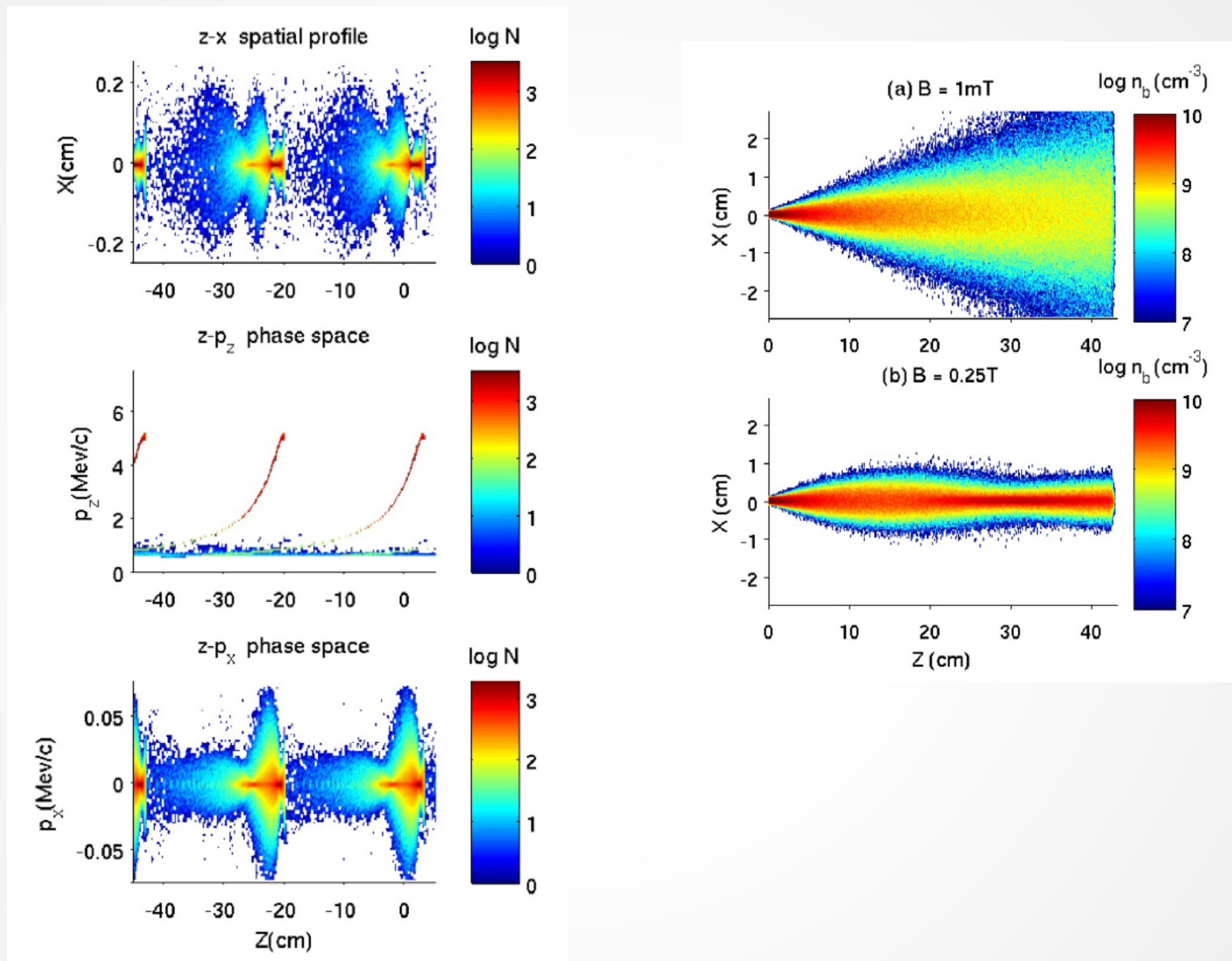
# Firehose instability in electron-positron plasmas



# Firehose instability in electron-positron plasmas

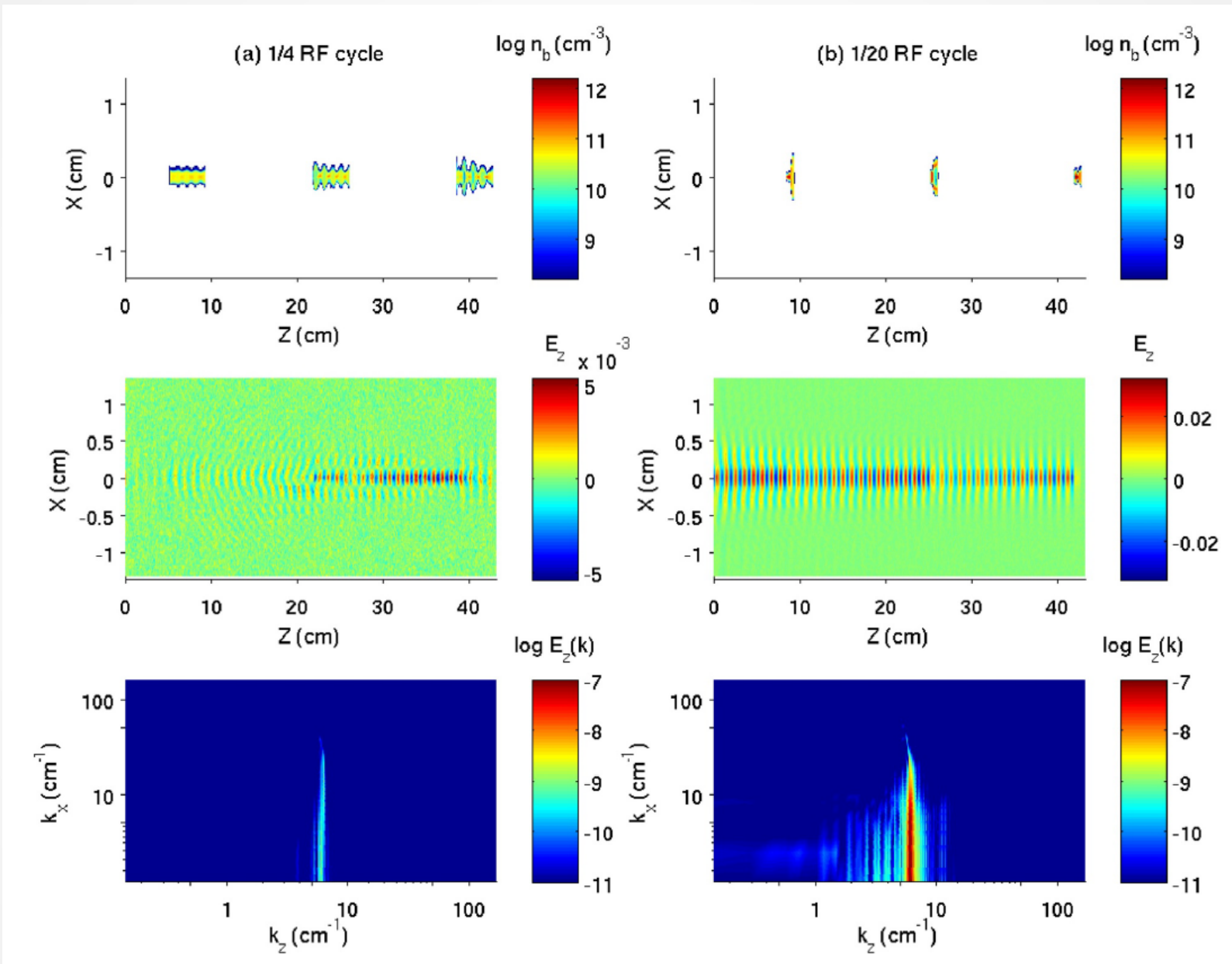


# Laboratory experiment

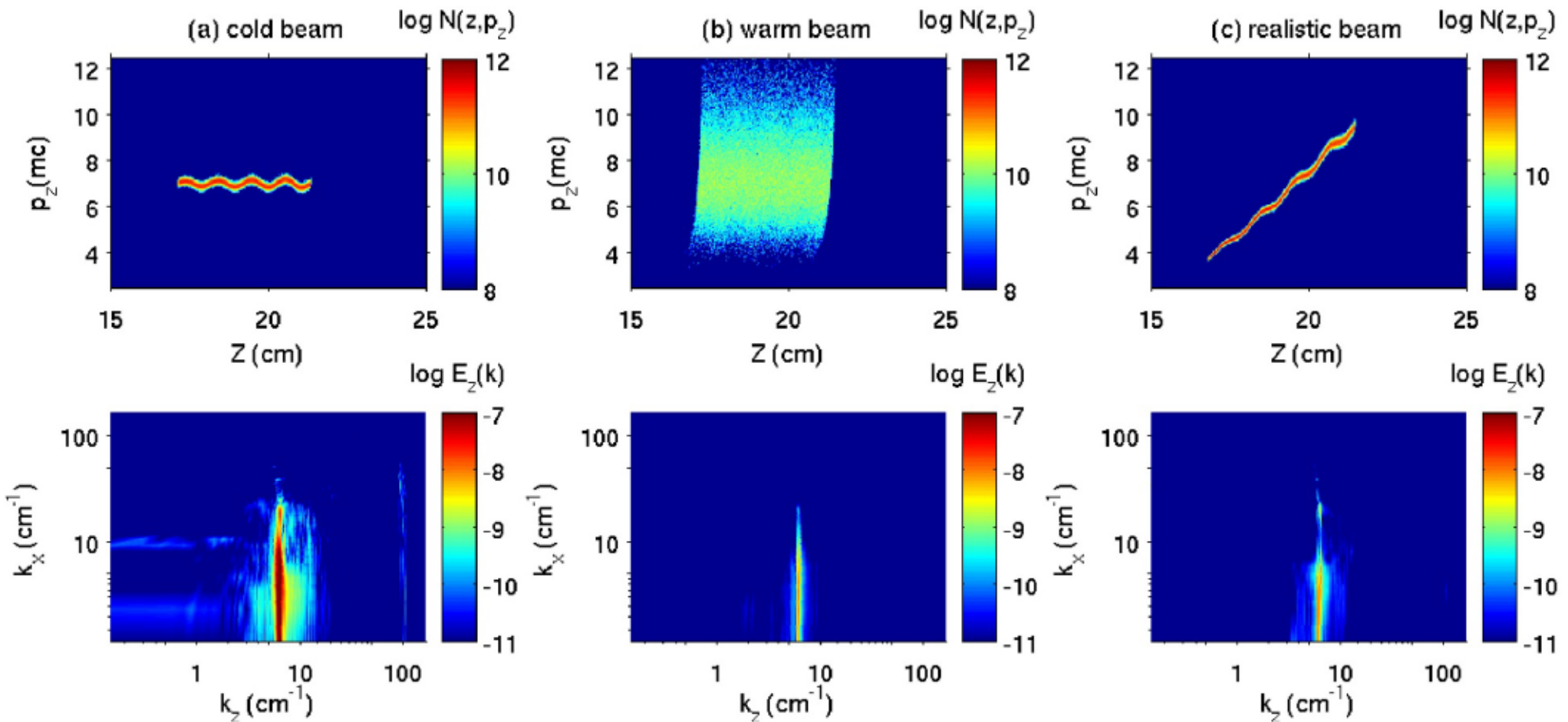




# Laboratory experiment

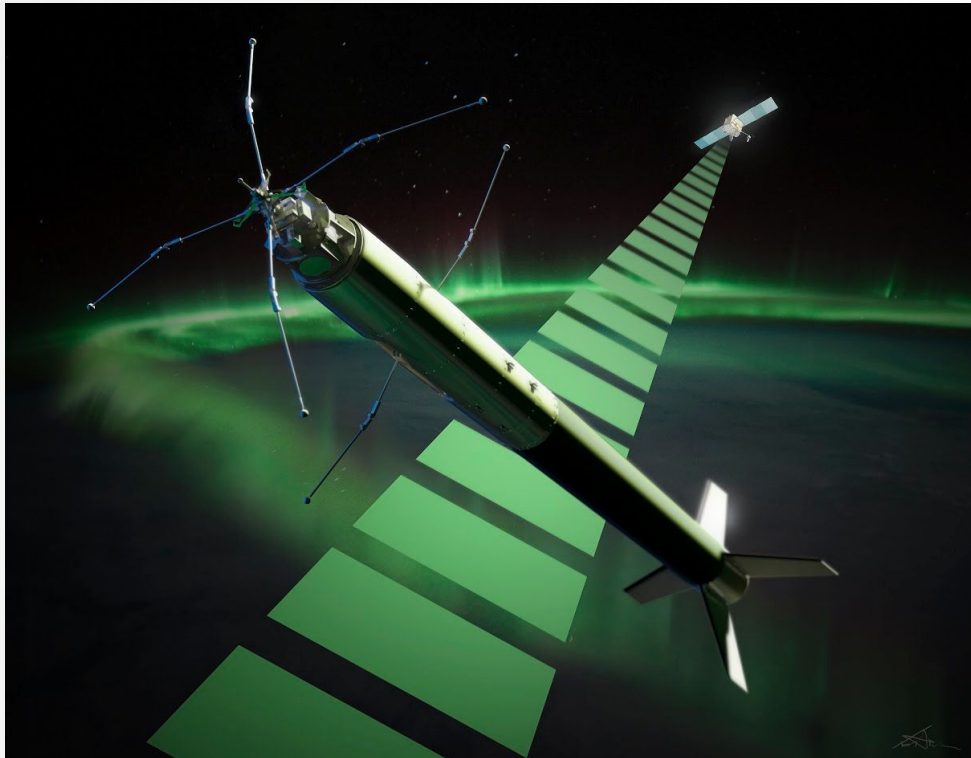


# Laboratory experiment

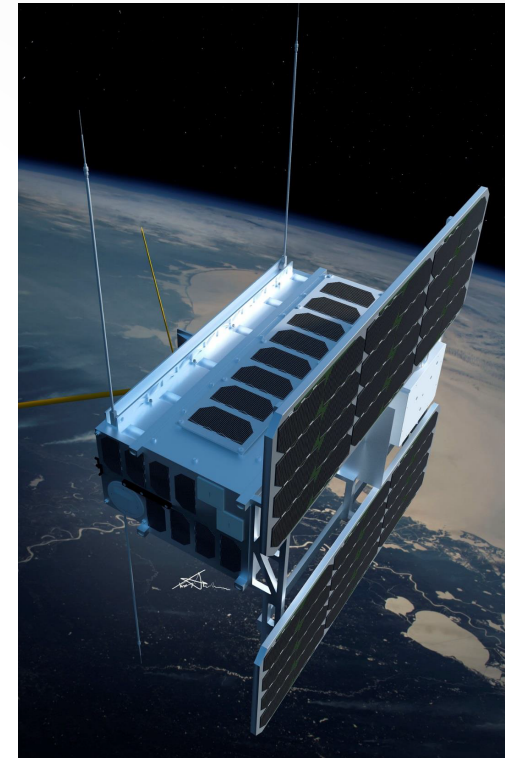


# Plasma-object interaction

[<https://www.mn.uio.no/>]



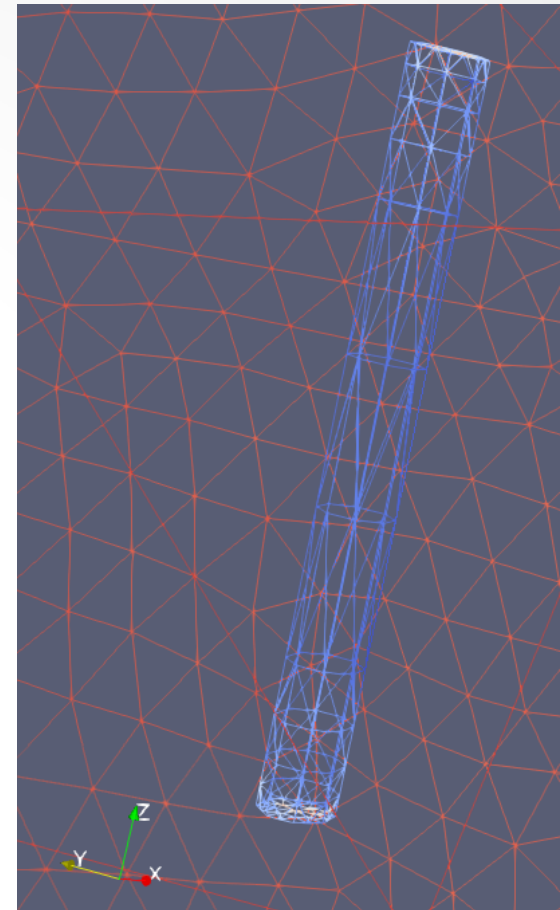
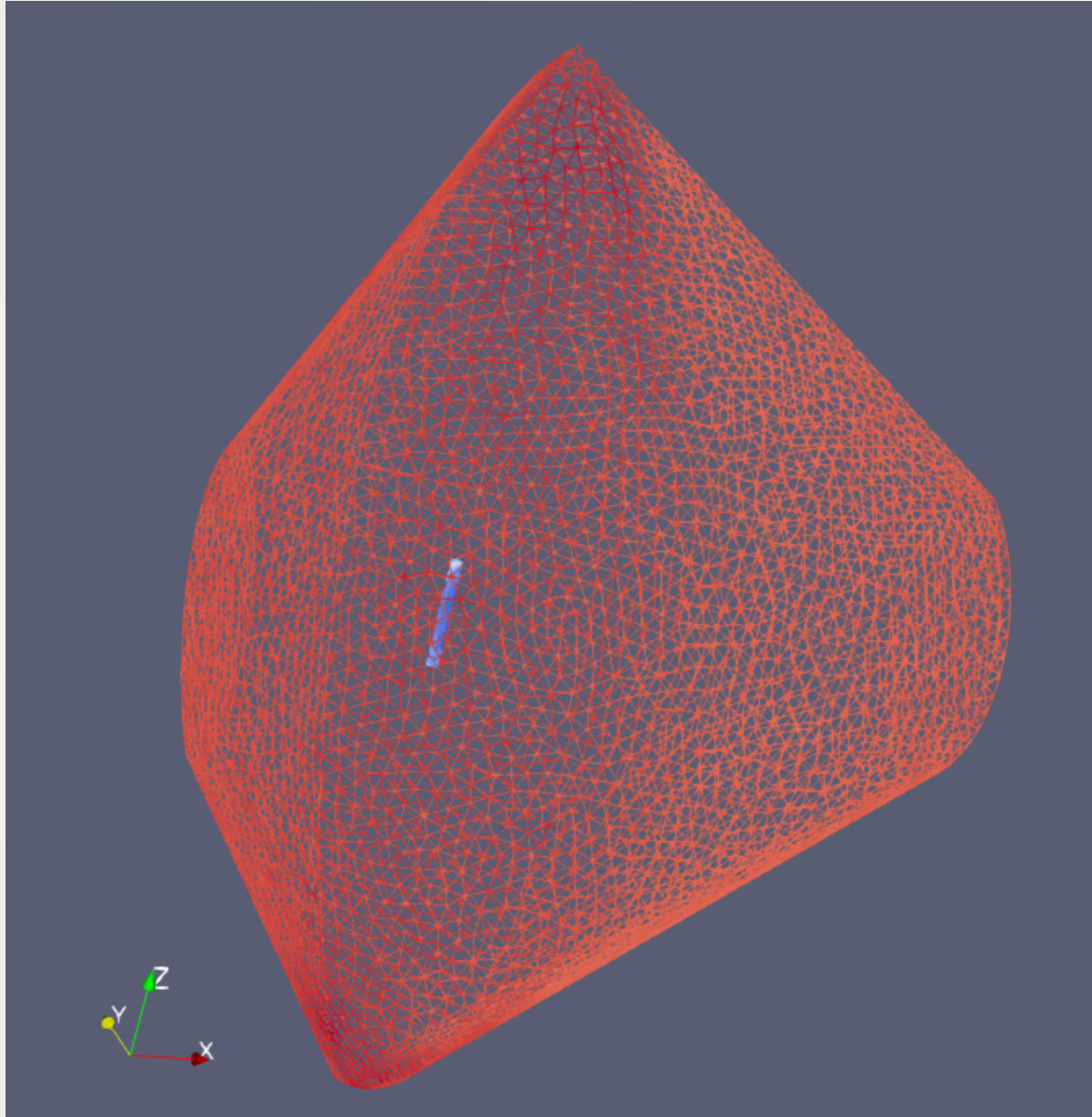
**ICI-4 sounding rocket**



**» The in-situ measurements can be influenced by local plasma disturbances, which are due to ionospheric plasma interacting with solid objects, such as spacecraft and booms.**



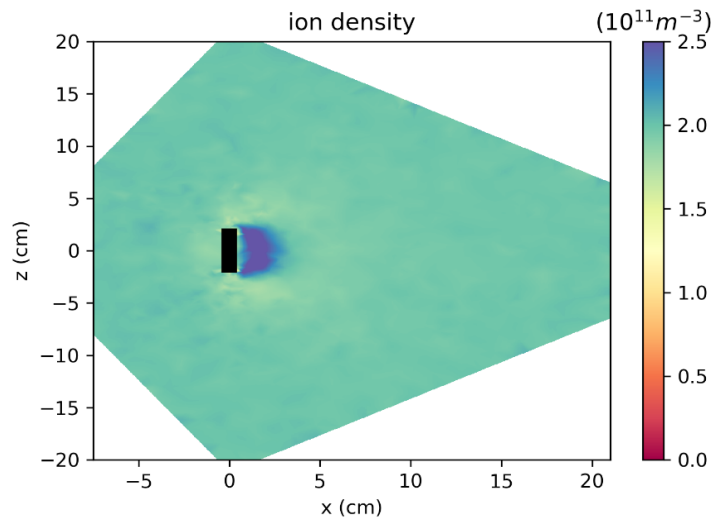
# Plasma-object interaction



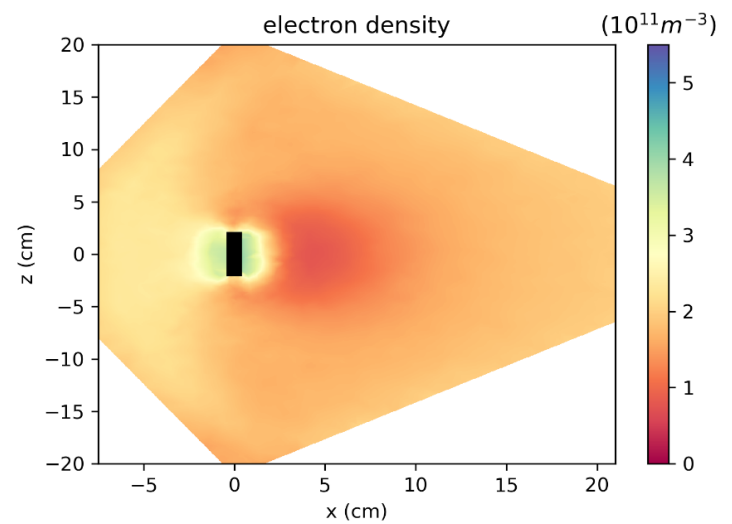
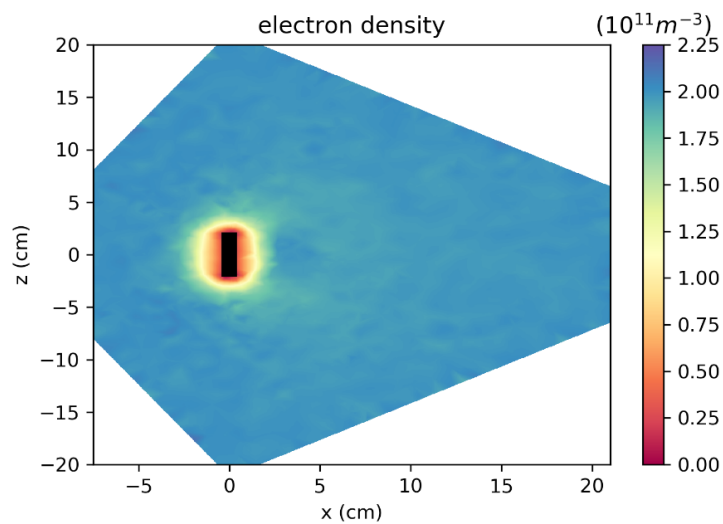
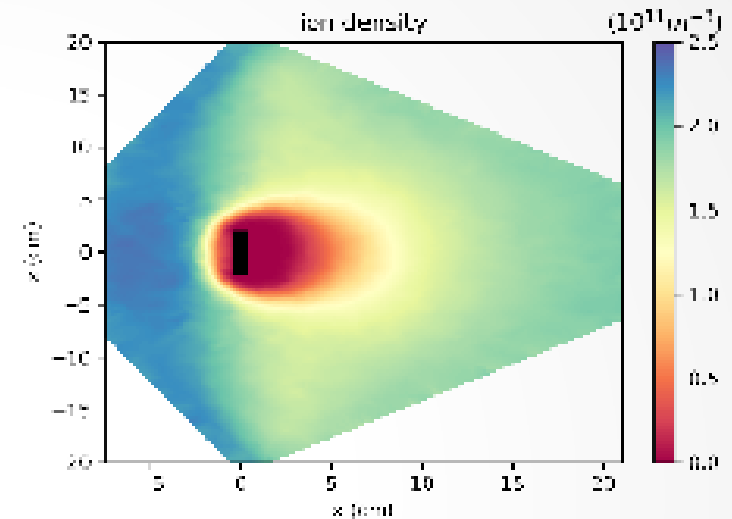
**unstructured adaptive tetrahedral mesh**

# Plasma-object interaction

No bias

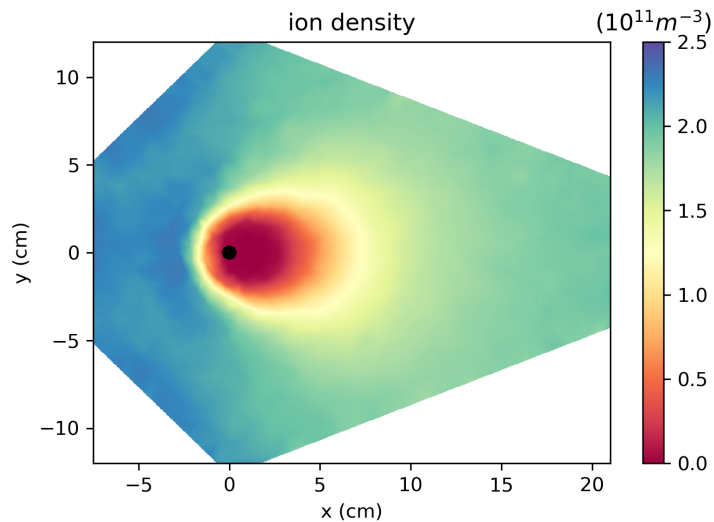


With bias (3V)

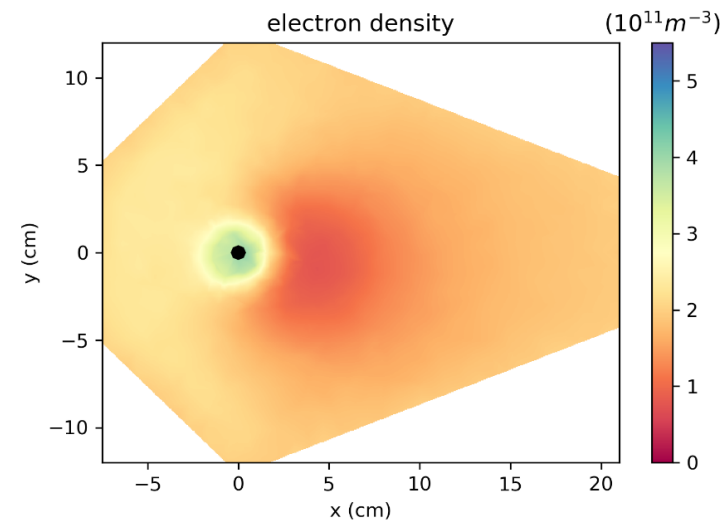
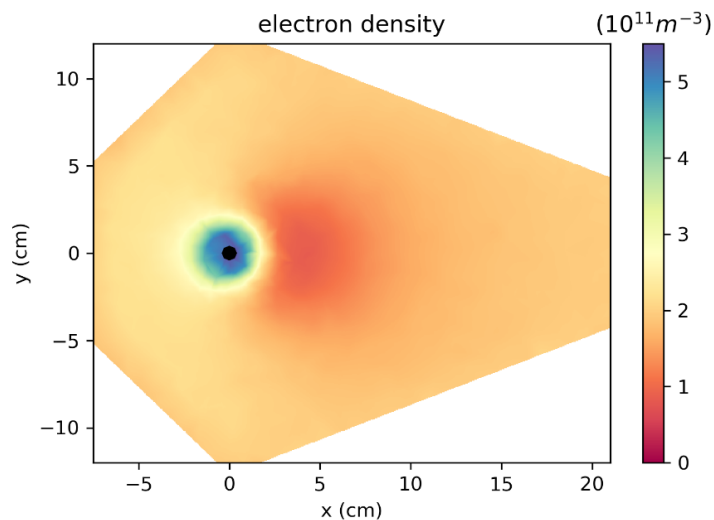
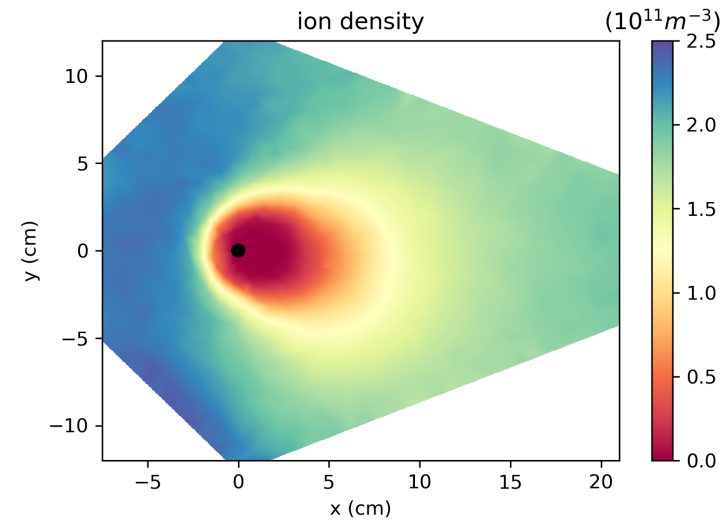


# Plasma-object interaction

## Without magnetic field



## With magnetic field



## **Advanced Methods for Space Simulations**

### **KEMPO1 Kyoto university ElectroMagnetic Particle cOde: 1d version**

<https://www.terrapub.co.jp/e-library/amss/pdf/209.pdf>

## **EPOCH**

<https://gitlab.com/arm-hpc/packages/wikis/packages/EPOCH>

## **OSIRIS**

<http://epp.tecnico.ulisboa.pt/osiris/>

## **Gmsh**

<http://gmsh.info/>

## **The 14th International School/Symposium for Space Simulations**

<https://iss14.org/>