Determination of DFMS effective field of view on ROSETTA

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Context

- DFMS : mass spectrometer with two modes : neutral and ions.
- The plasma around ROSETTA and the photoelectric effect leads to strongly negative equilibrium potential (-10V/-40V).
- The plasma sheath around ROSETTA thus disturbs the ion current measured by DFMS by deflecting ion trajectories.
- Thus, the measurement in ion mode do not represent the composition of the plasma in the coma.

Objectives

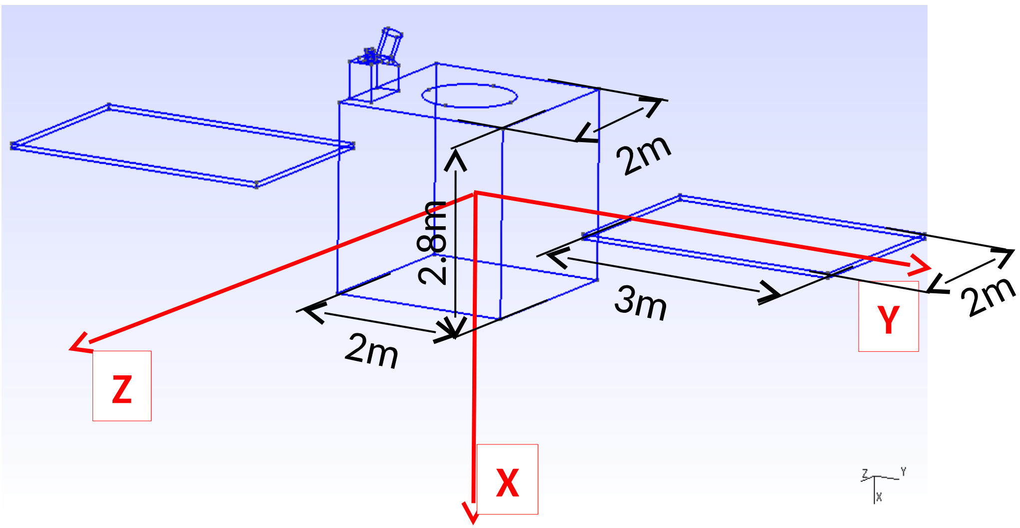
- Find out the effective field of view of DFMS in ion mode for a given plasma set of parameters
- Simulate and compute potential map around ROSETTA for a given plasma
- Compute and plots backtracked trajectory ending on DFMS to get effective FOV
- Deduce the effective composition of the plasma from the measurements

Reminder of last time work

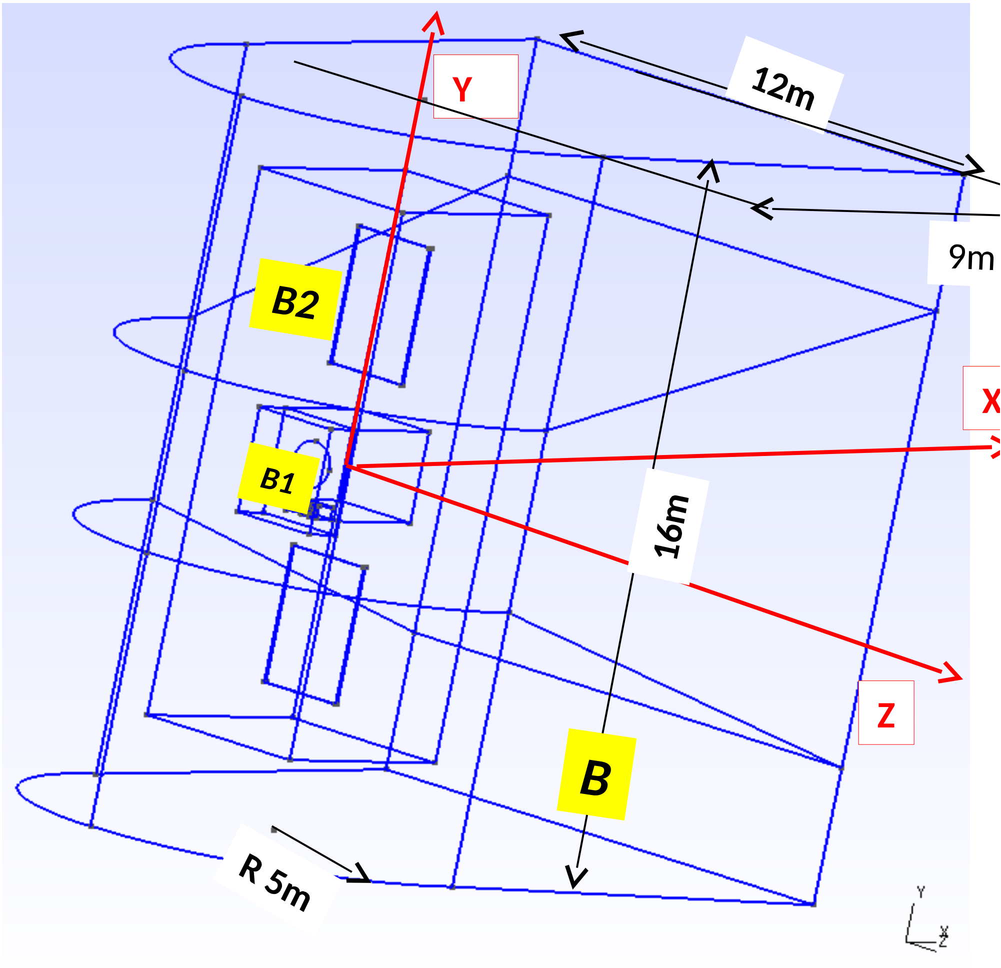
- Use of Maxwell-Boltzmann distribution to model electrons
- Effect when reducing solar panel size, on potential map and on backtracked trajectories
- Validation of the physical meaning of the results while increasing model precision
- Problem of divergence of backtracked trajectories with very close velocities on the detector

Geometrical model

NUMERICAL MODEL (1)

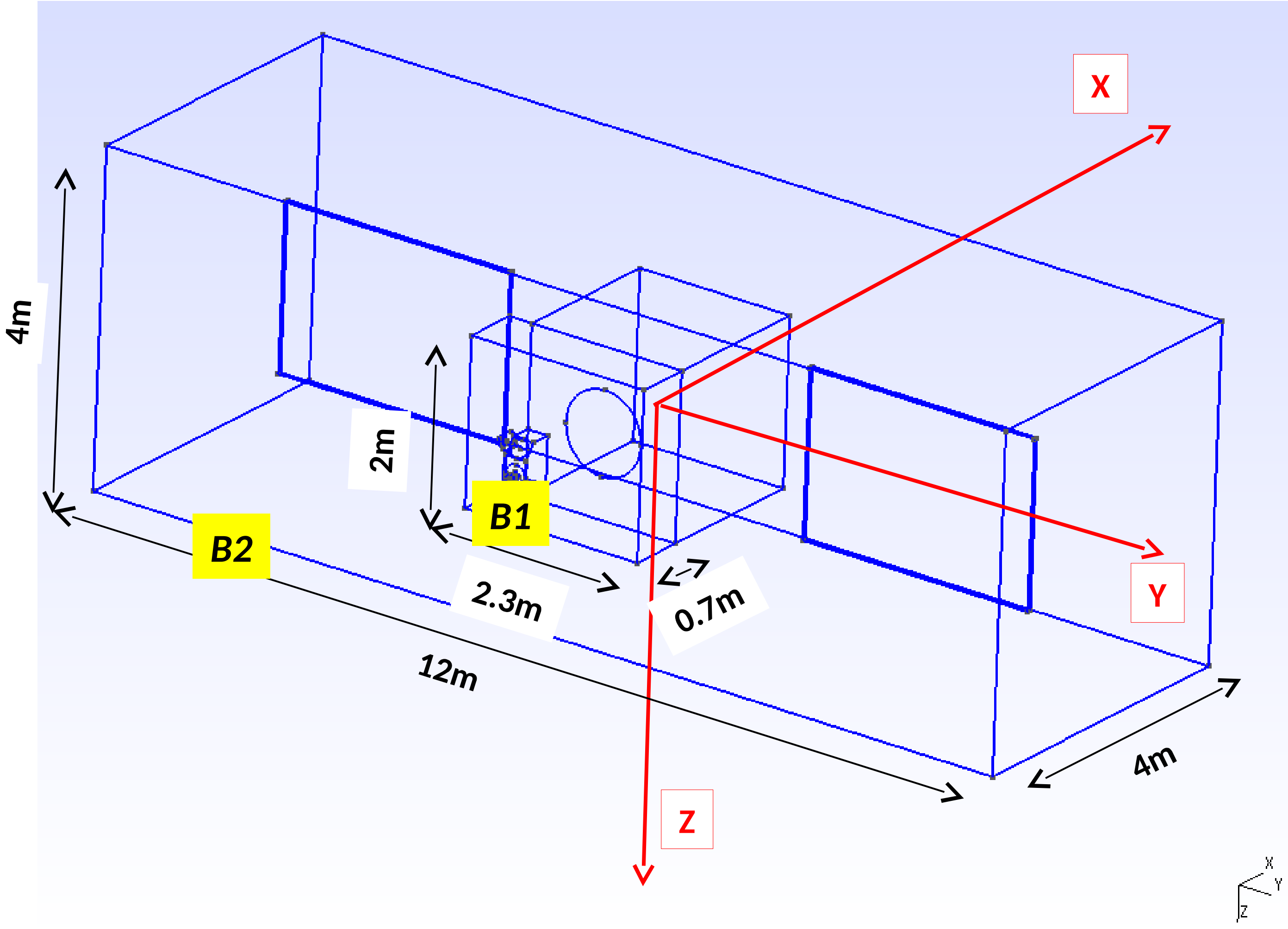


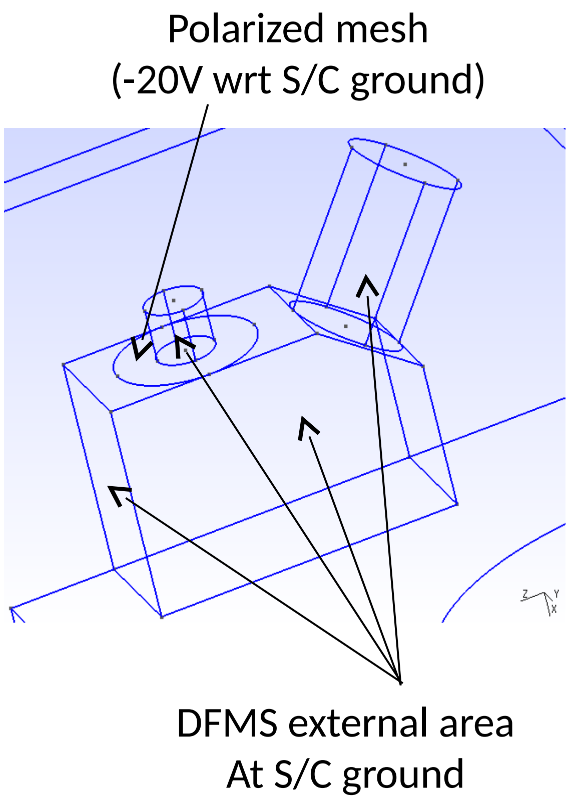
NUMERICAL MODEL (2)



Geometrical model

NUMERICAL MODEL (3)



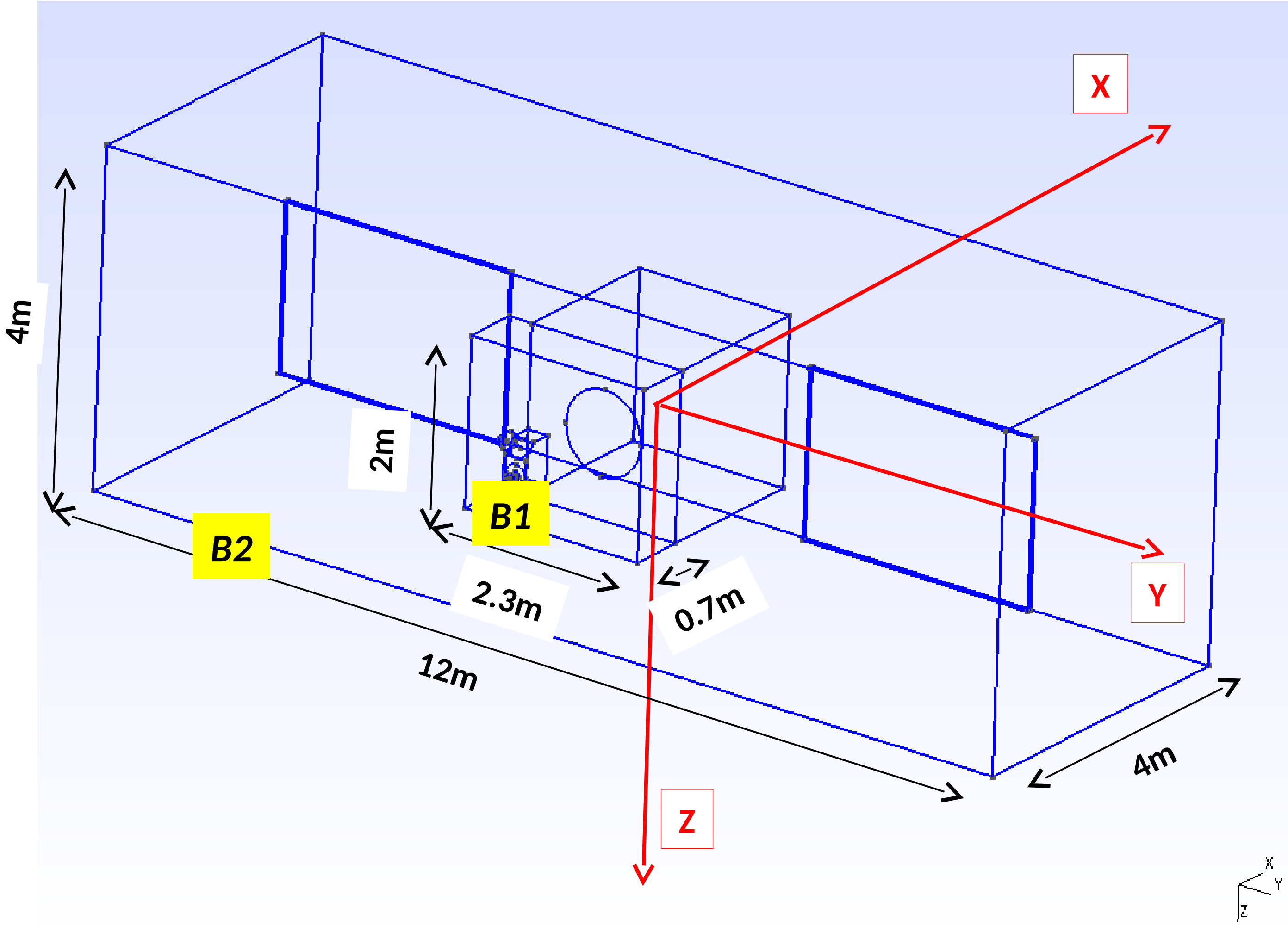


SPIS Model

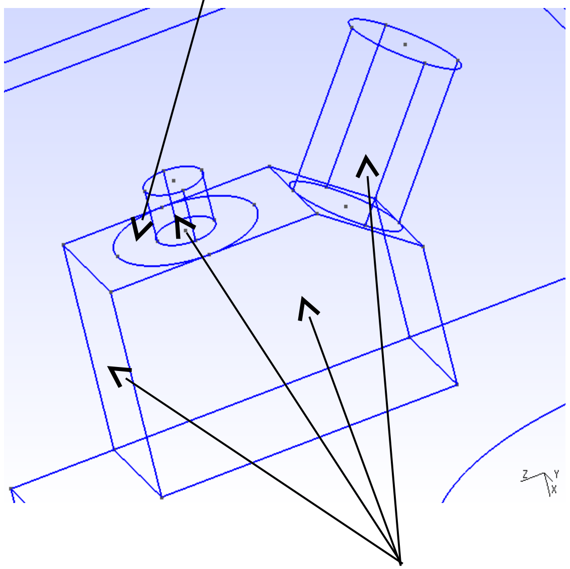
- Potential map is characterized by a tetraedric mesh with constant electric field in each tetrahedron.
- Electron population follows Maxwell-Boltzmann equation, ion and photoelectrons are tracked using Particle In Cell (PIC) model.
- Potential 0V on external boundary, and floating spacecraft potential with capacity 1 nF.

Geometrical model

NUMERICAL MODEL (3)



Polarized mesh
(-20V wrt S/C ground)



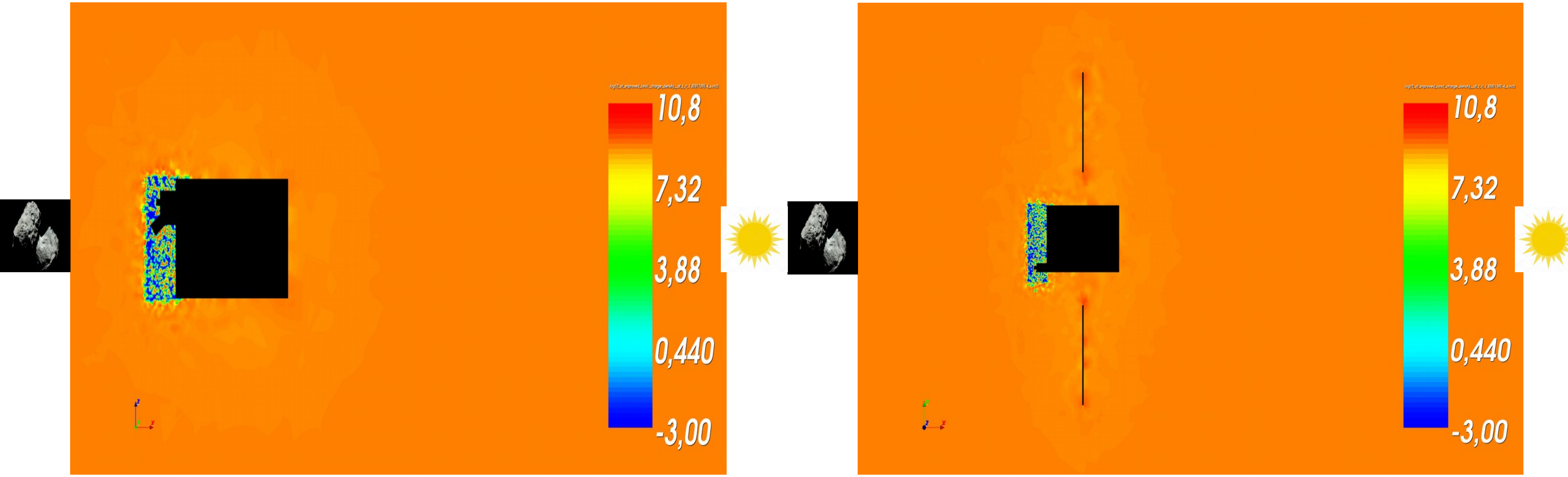
DFMS external area
At S/C ground

SPIS Model : parameters

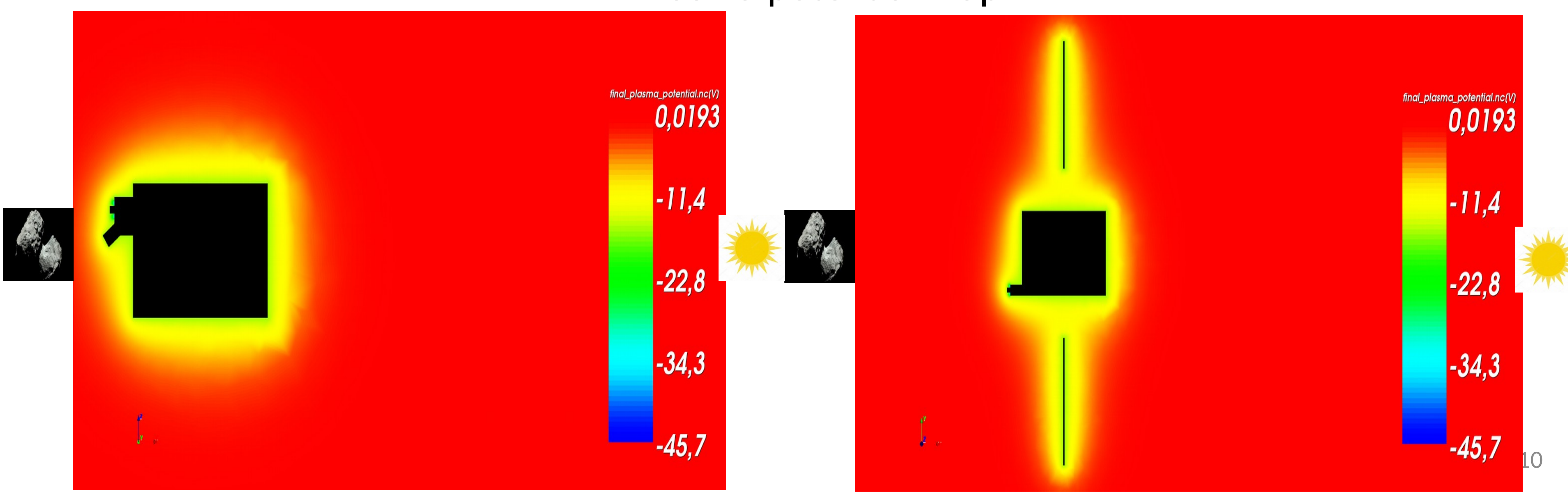
- Ions H_2O^+
- Internal resolution 0,2m, external 0,3m. Around DFMS 2cm or 5cm
- Csat 1 nF
- Aluminium surface, ITO on solar panels (face to sun)
- Ion temperature 0,008617 eV (300 K)
- Electron temperature 7eV/Photoelectron temperature 2eV
- Density 1,0E9 part/m^3
- Time step plasma/populations : 4,0E-7 s
- Time step simulation : 1,0E-6 s
- Distance to sun 1,3 AU
- Potential on ROSINA polarized ring -20V (to change to -5V)

Simulation cuts with photoelectrons

Ion log density map

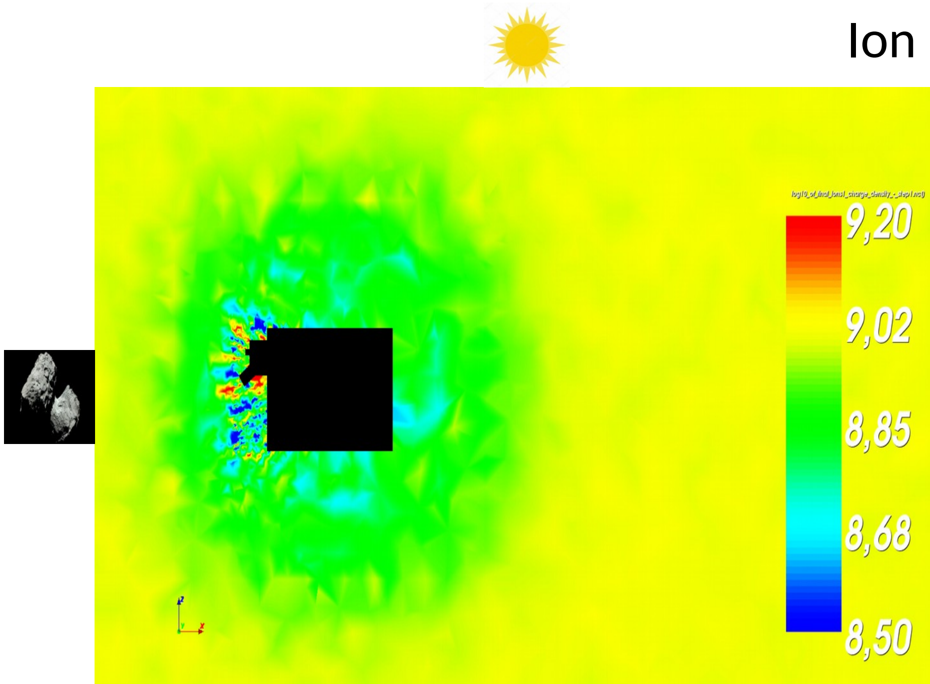


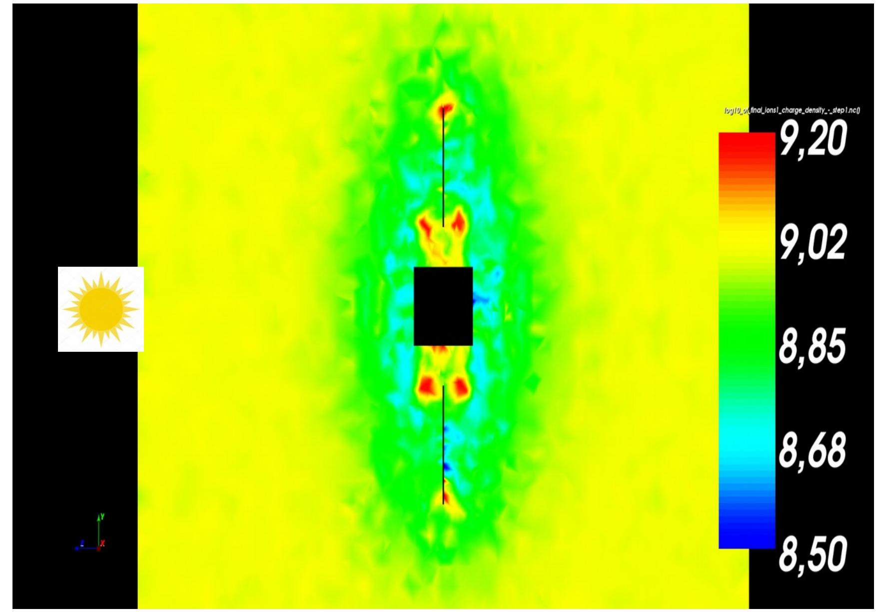
Plasma potential map



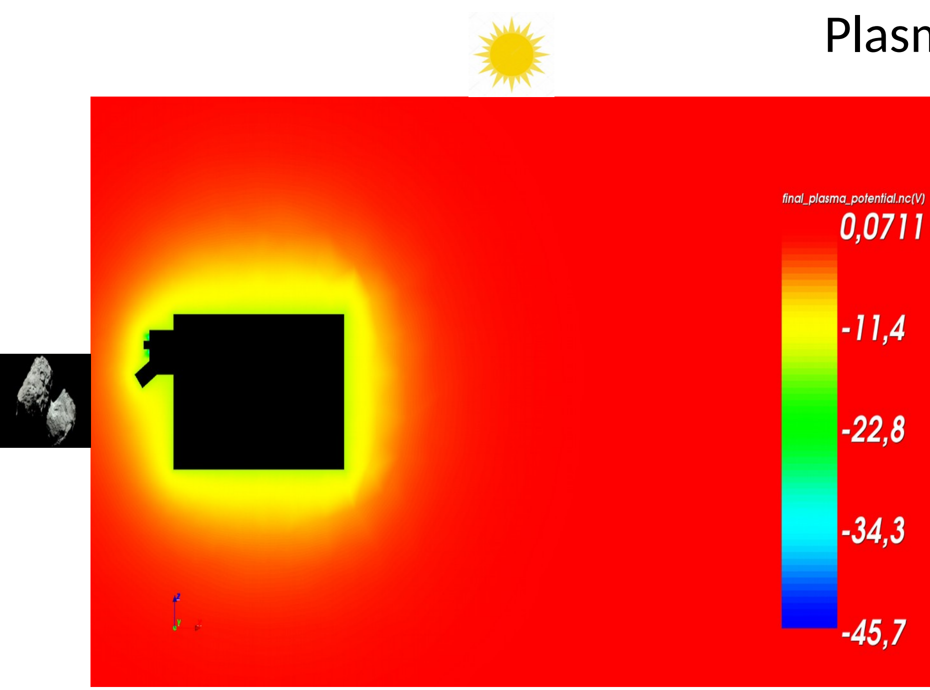
Simulation cuts with photoelectrons on panel at 90°

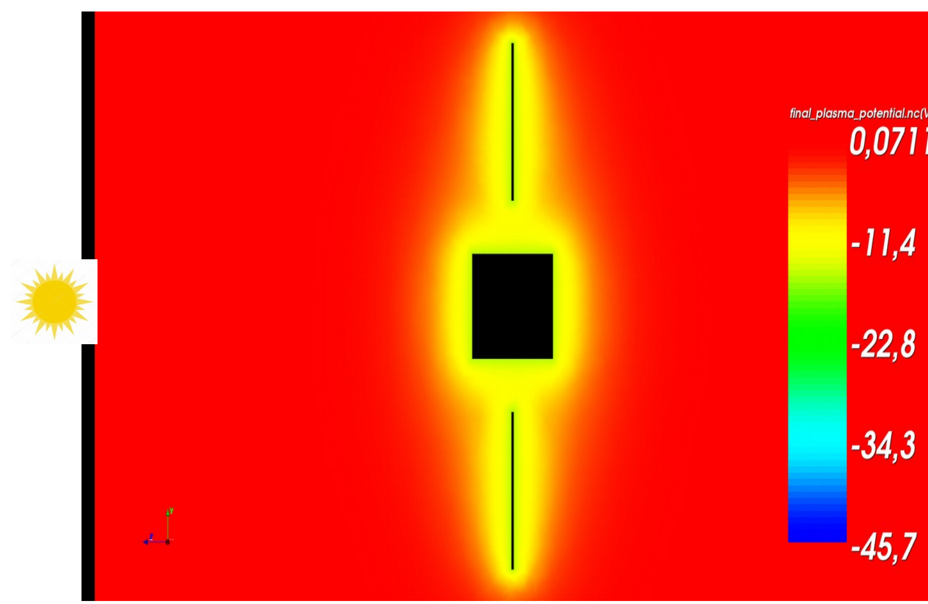
Ion log density map





Plasma potential map





Computation of ion trajectories

- Computing of 10000 trajectories uniformly distributed among 20° field of view

- Linear potential on each tetrahedron

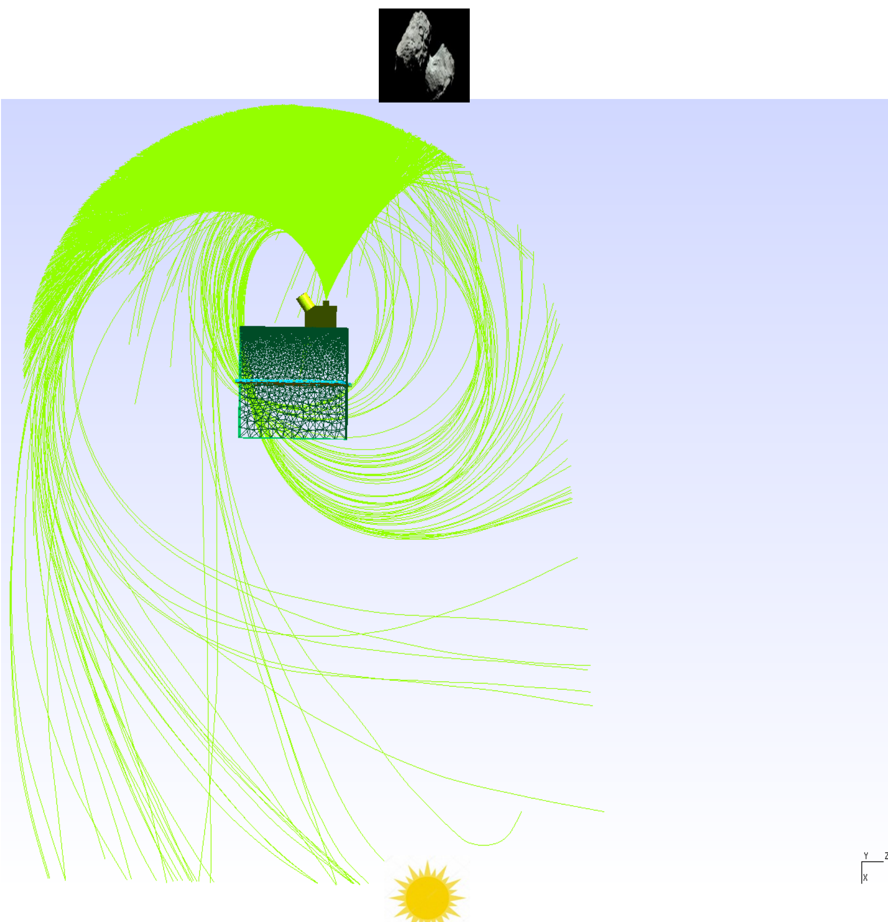
- Backtracked ion trajectories stop at contact with surface : real trajectories are the ones beginning on external surface and only those are taken into account in the following

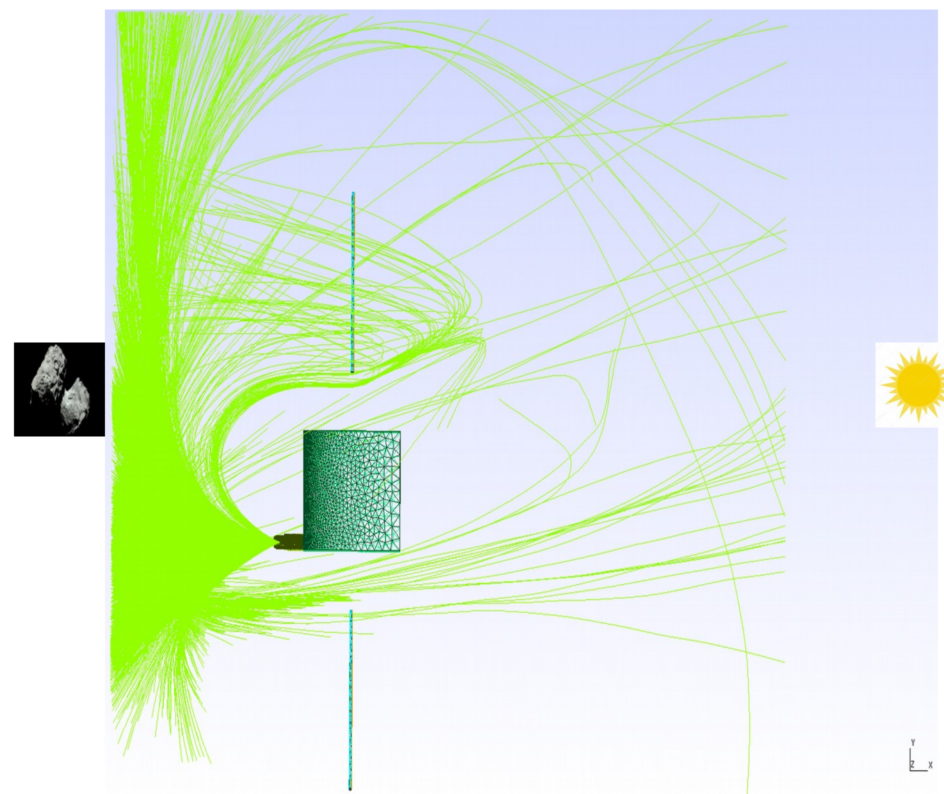
- Fixed velocity norm (energy) on the external boundary

Trajectories of H2O+ ions at 600 m/s on external surface

<u>Ion trajectories :</u>

- Trajectories at given velocity on external surface: 600m/s
- Sun in +x direction, comet in -x direction
- ROSINA resol : 2 cm

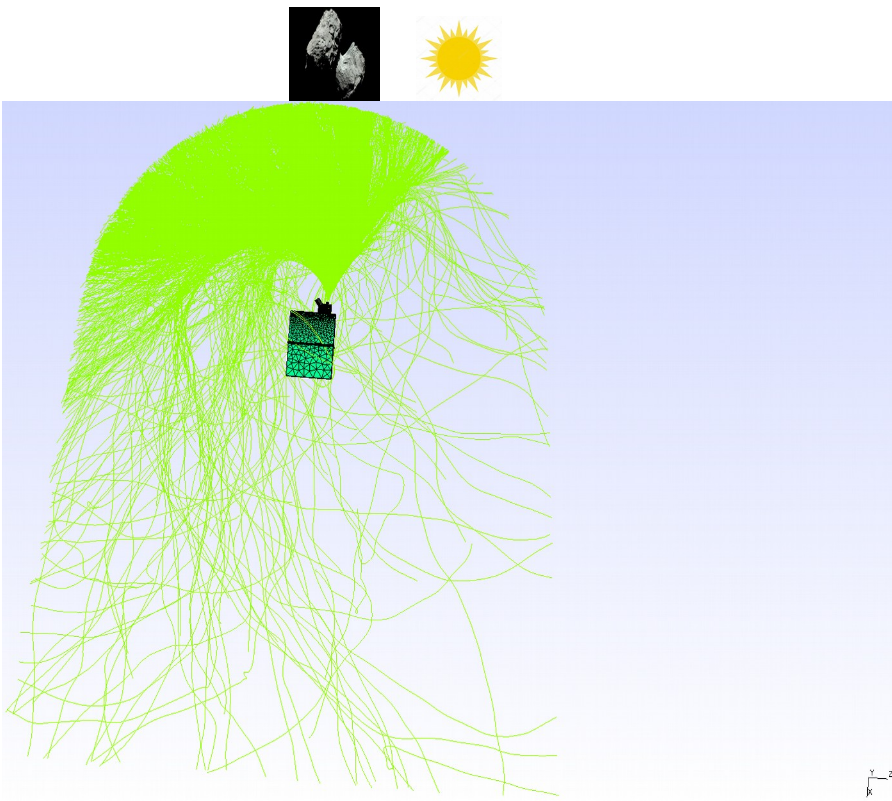


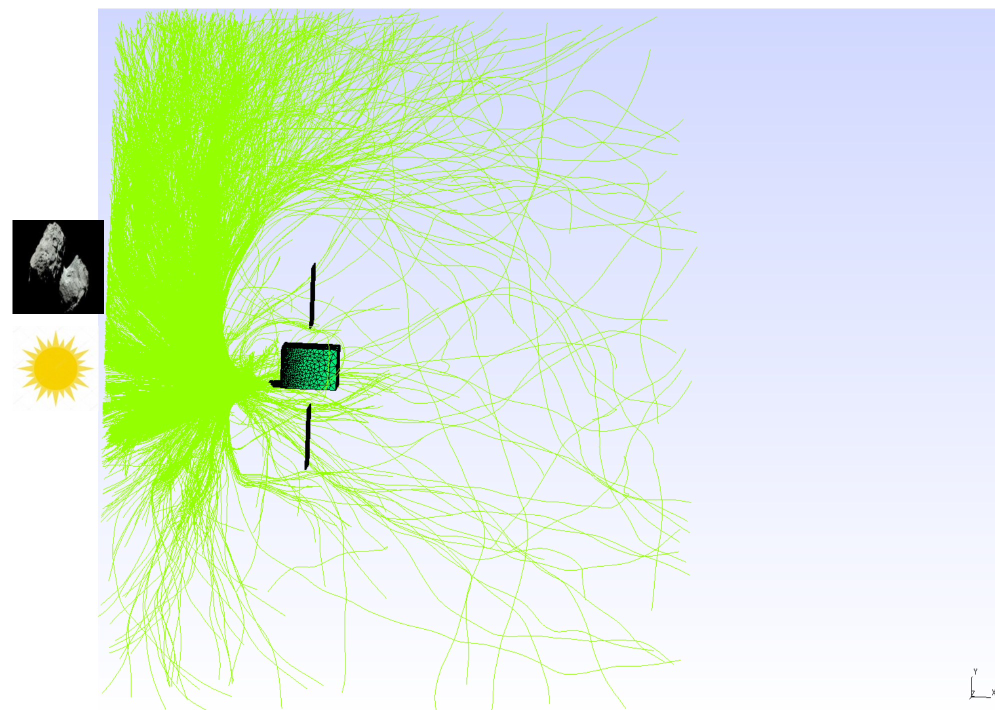


Trajectories of H2O+ ions at 600 m/s on external surface when sun and comet are on the same side

<u>Ion trajectories :</u>

- Trajectories at given velocity on external surface: 600m/s
- Sun in -x direction, comet in -x direction
- ROSINA resol : 5 cm





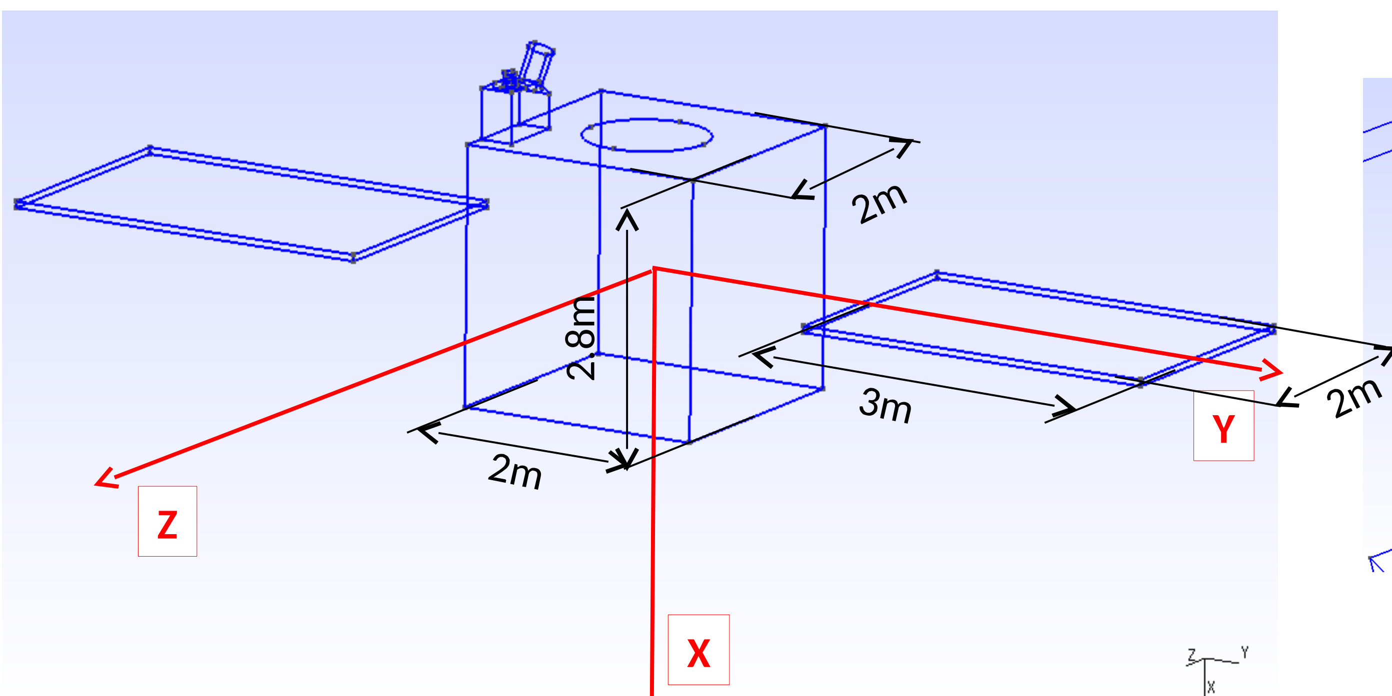
Plot effective field of view

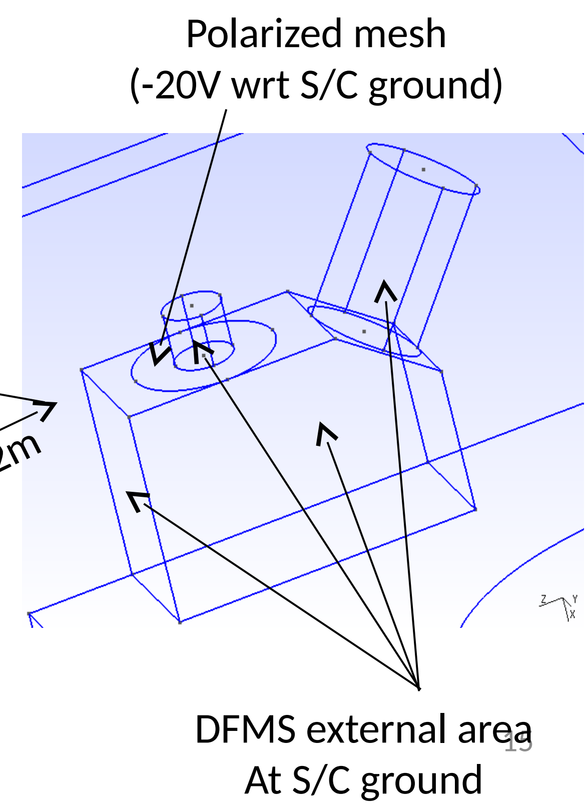
- Aim : get a first idea of the effective field of view of the ROSINA detector and find the assymetry

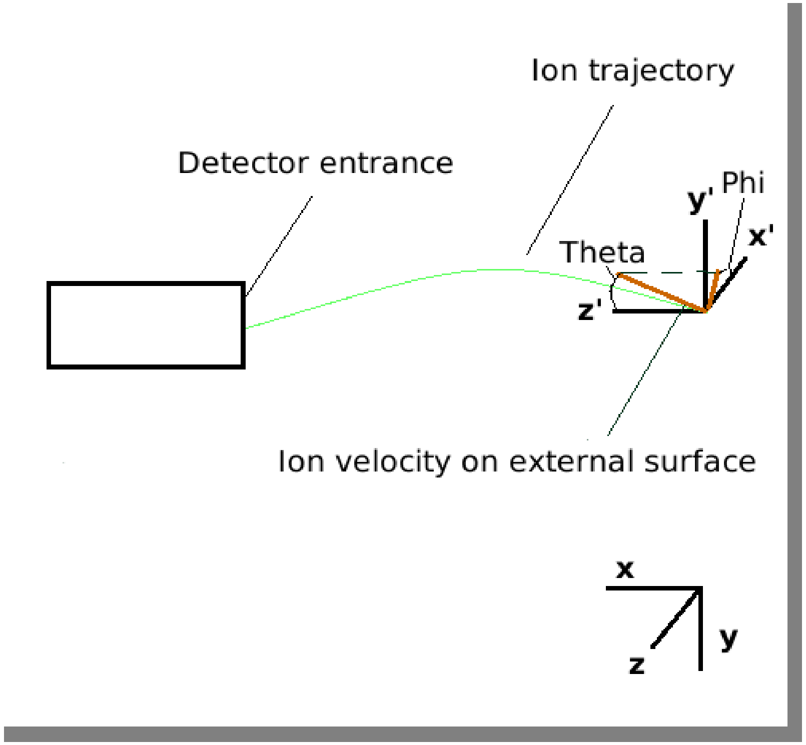
- Suspected assymetry because of the non centred position of ROSINA on the face : ions don't « see » the same sheath in all directions

- Suspected assymetry because of the presence of solar panels in y direction

- Suspected assymetry because of the near shape of ROSINA

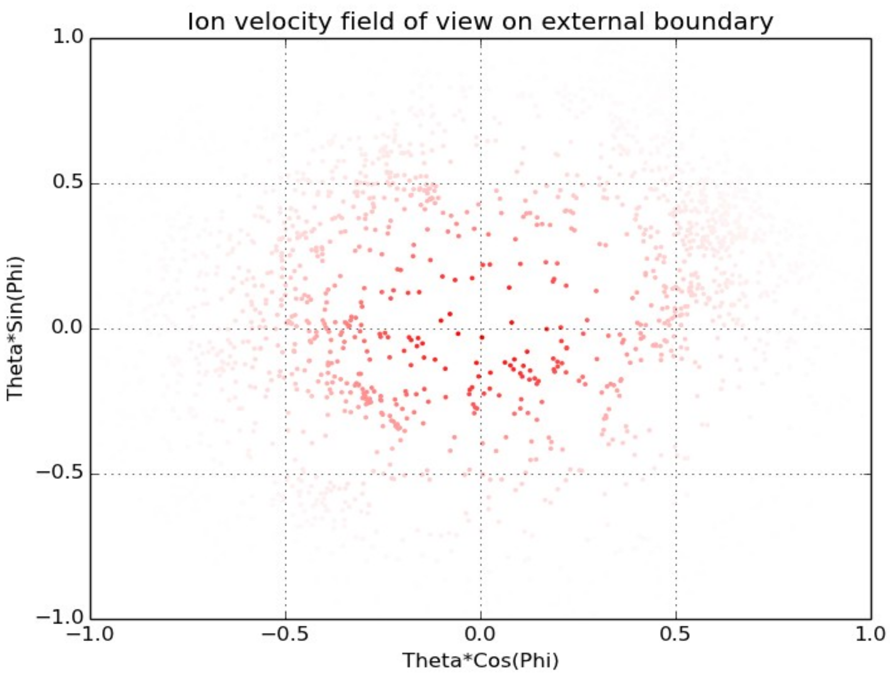


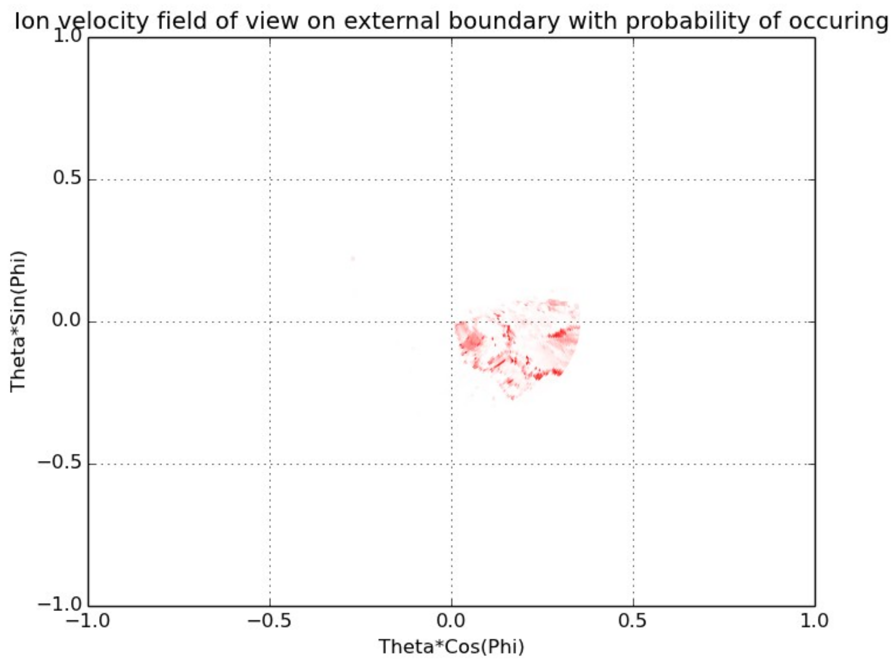




First idea of a view field shape :

- Trajectories at given velocity on external surface: 600m/s
- Sun in +z direction, comet in -x direction
- Potential not smooth : holes





Conclusions

- Simulated model of ROSETTA orbiter with reduced length of solar panels provides equilibrium potentials consistent with estimated values by LAP.
- Ions detected by DFMS have widely dispersed velocity directions in the undisturbed plasma. Accurate computation of the effective DFMS/RTOF FOV required to get actual values of the ionized coma parameters.
- Presence of photoelectrons seems to make potential smoother

Perspectives

- For a given arrival velocity, compute backtracked trajectories along the detector entrance, get the shape of corresponding start points on external volume and check the variations of corresponding input velocity directions.
- Compute effective field of view at other velocity norms and study the evolution
- Smooth potential map to avoid discontinuities : any ideas of practicable ways to do that ?