JUICE and Rosetta Spacecraft charging

& Langmuir Probe sweeps simulations using SPIS

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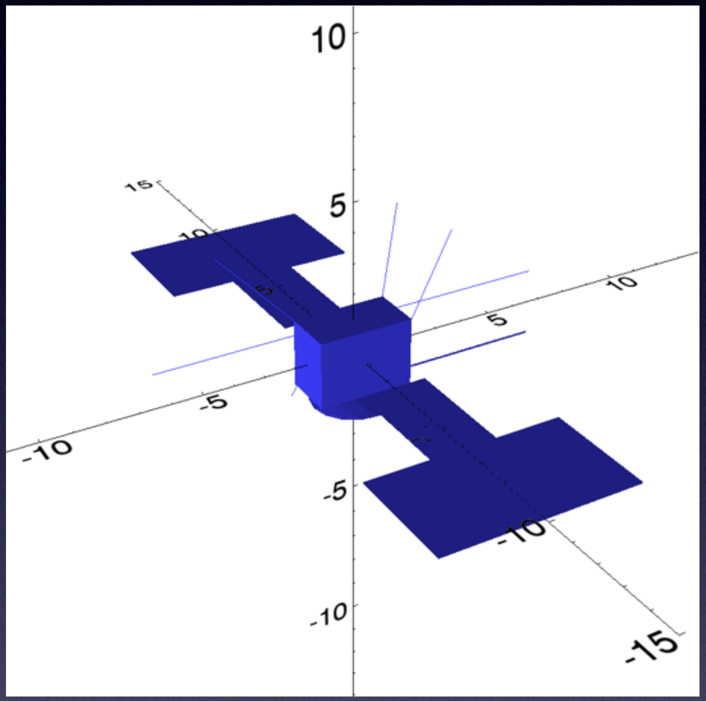
Spacecraft Charging

Non-conducting materials JUICE Simulations



- Previous simulations identified possible scenarios and risks of differential charging between a non-conducting solar array cover glass and the rest of the (conducting) spacecraft. Possibly leading to arching, ESDs, and impacting the performance of the Langmuir Probes and other instruments

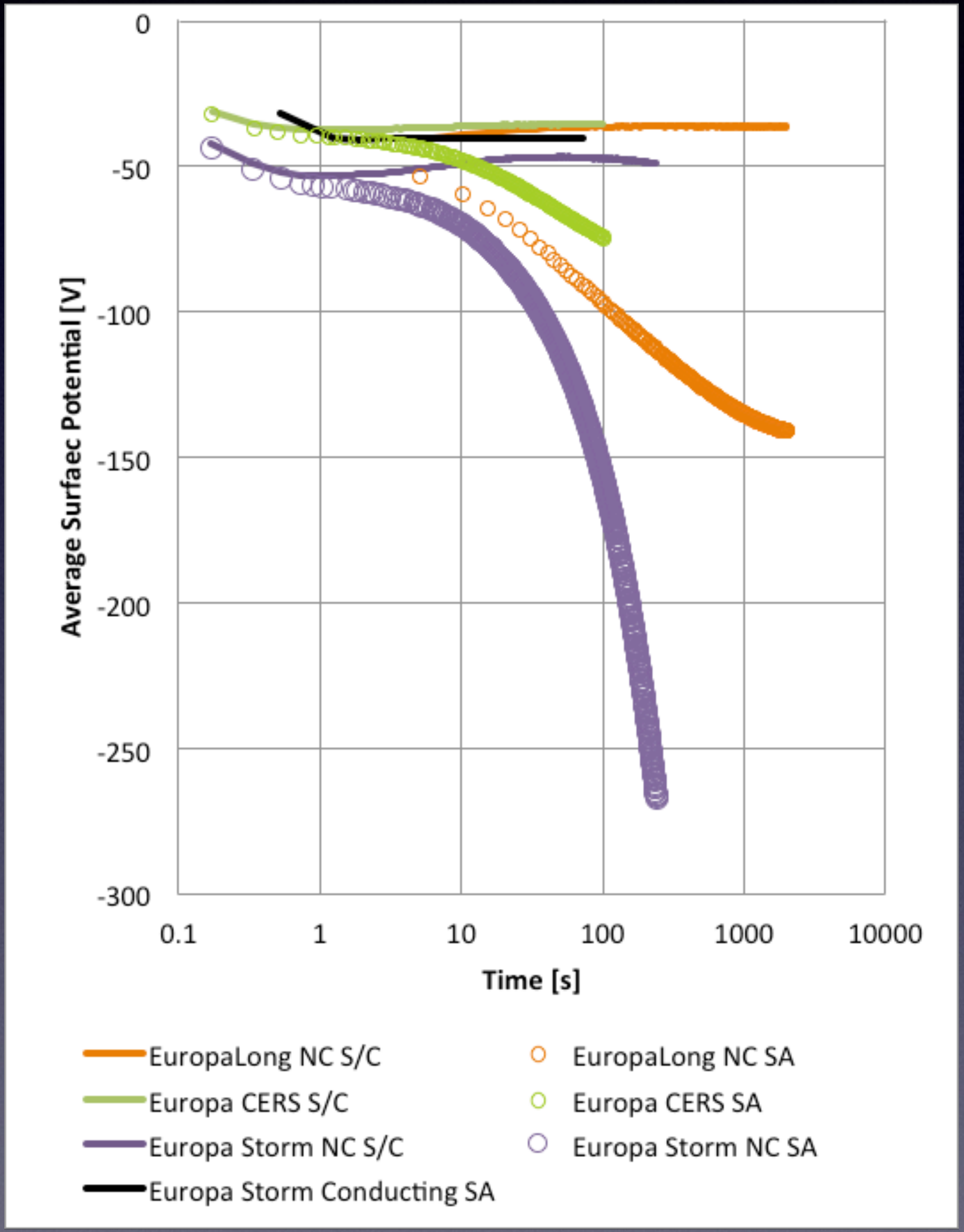
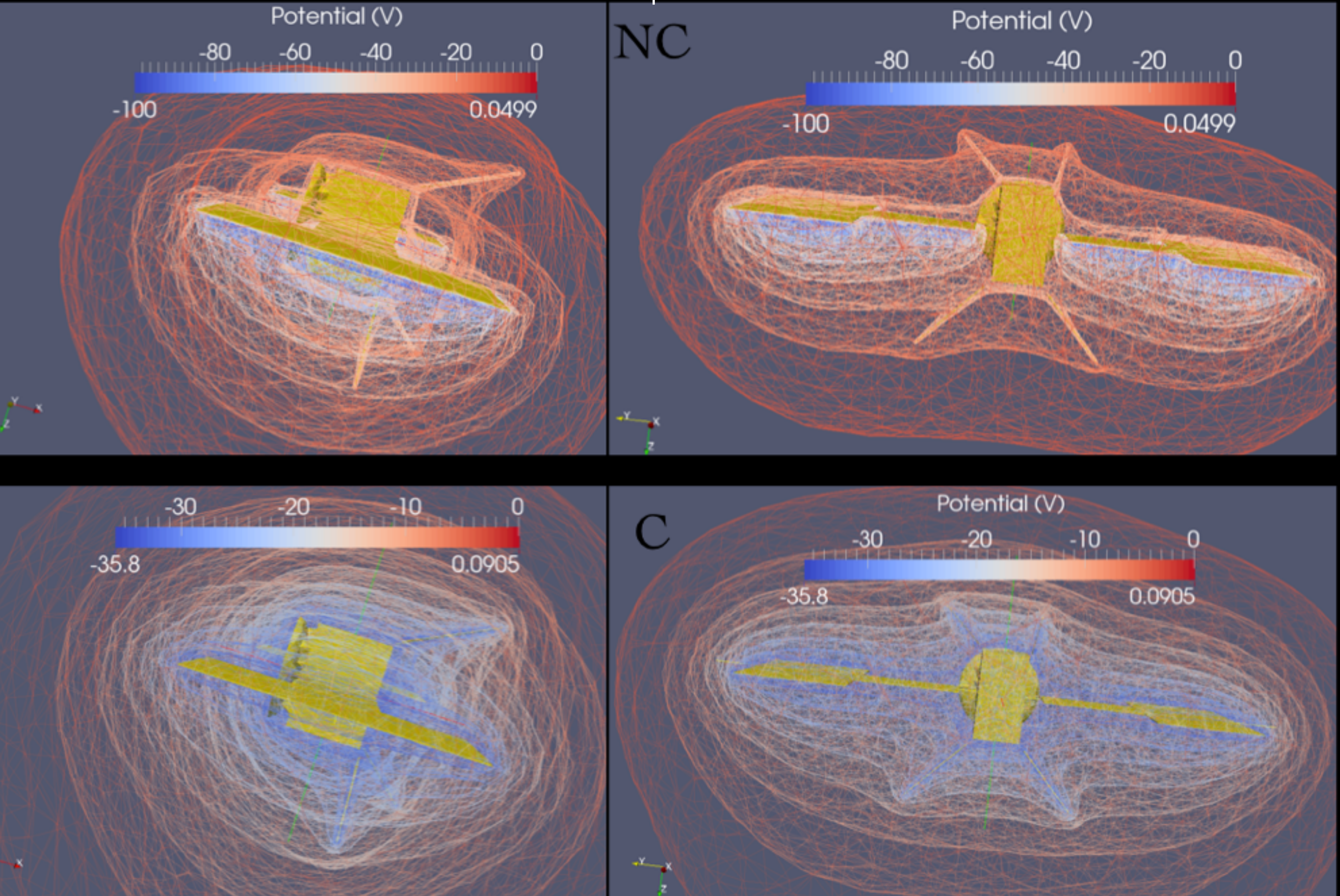


Figure 2. Model comparison of Europa "Storm" and Europa plasma potential evolution on spacecraft surfaces for over time. The conductive model reaches steady state after about two seconds, whereas the non-conductive model simulation never converges in this timespan.

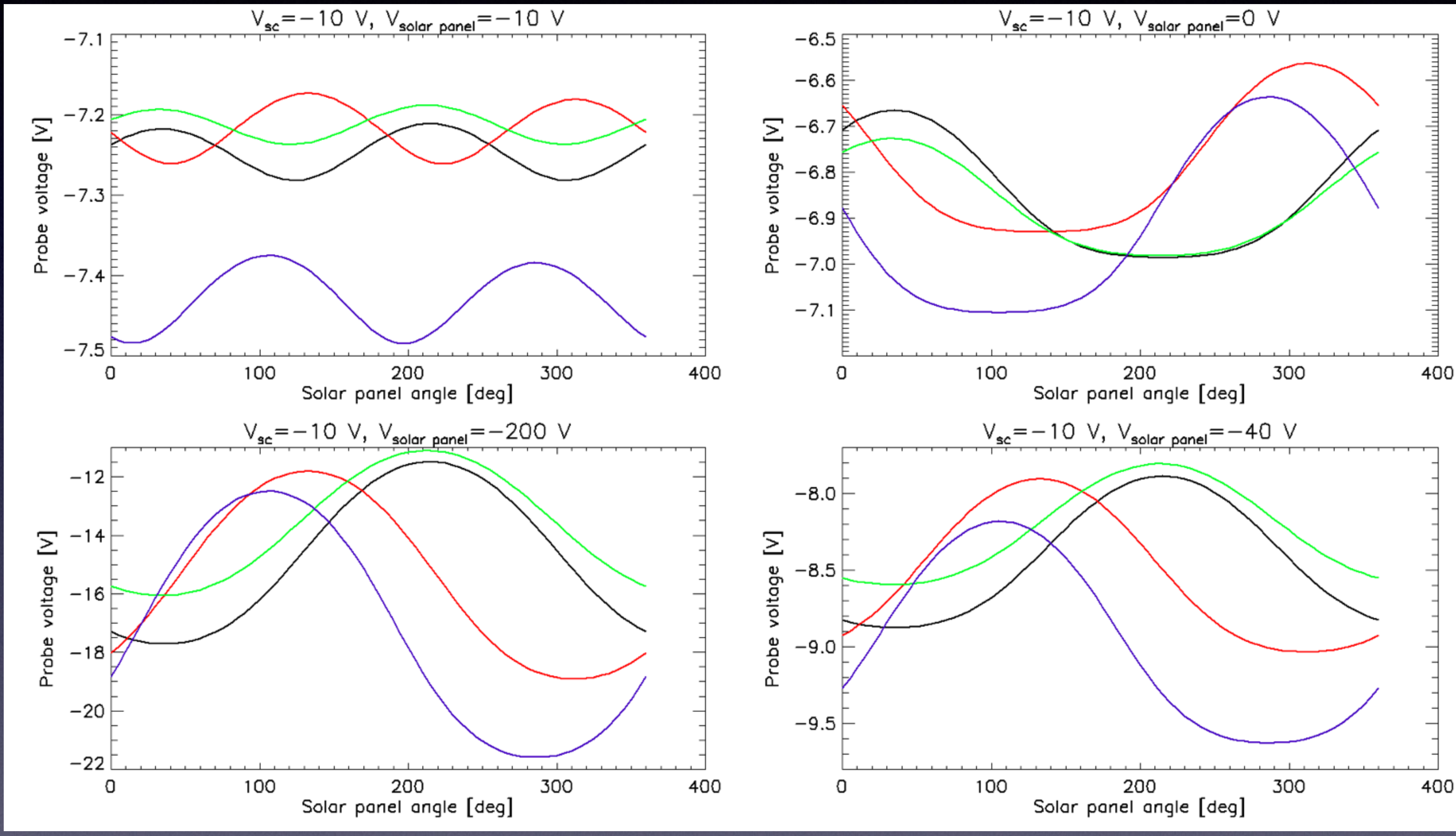
Non-conducting materials

JUICE Europa Simulations



NC Vacuum simulation

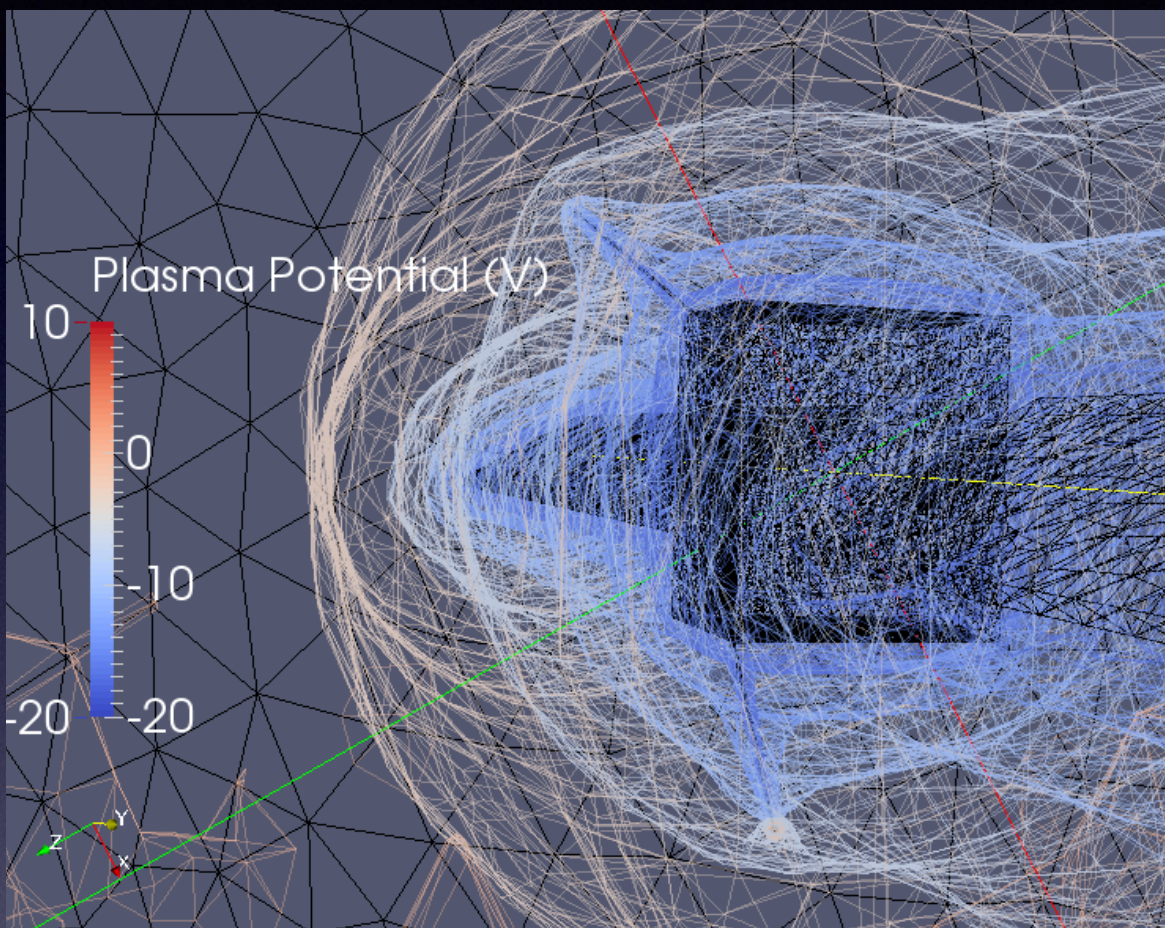
- Langmuir Probe sensitive to Vsc and potential of the plasma immediately surrounding the probe (Vfloat = aVsc, where 0≤a≤1
- a dependent on solar aspect angle (position in relation to S/C orientation)
- Non-conducting surfaces will affect any probe in any configuration.
- Since potential of Solar panel cover glass is impossible to know in situ, we will not be able to separate this potential from the Vsc using the Vfloat method.



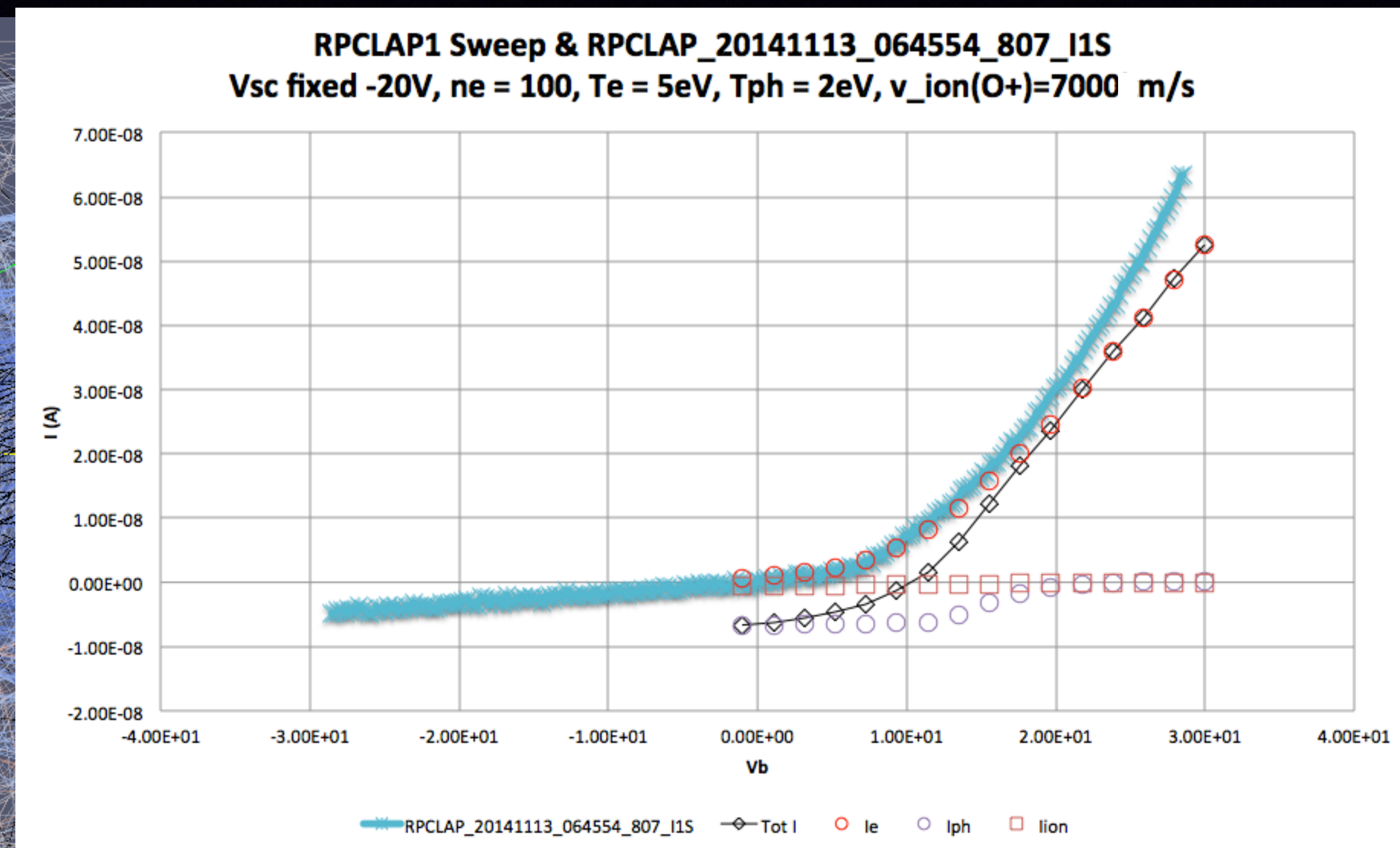
Credit: Christopher Cully , University of Calgary, cmcully@ucalgary.ca

Rosetta & Comet 67P

Static S/C Sweeps



Rosetta "Comet" simulation, fixed Vsc = -20V. Vprobe = +10V.
Comet in down(+X+Z) direction, Sun in +X direction.

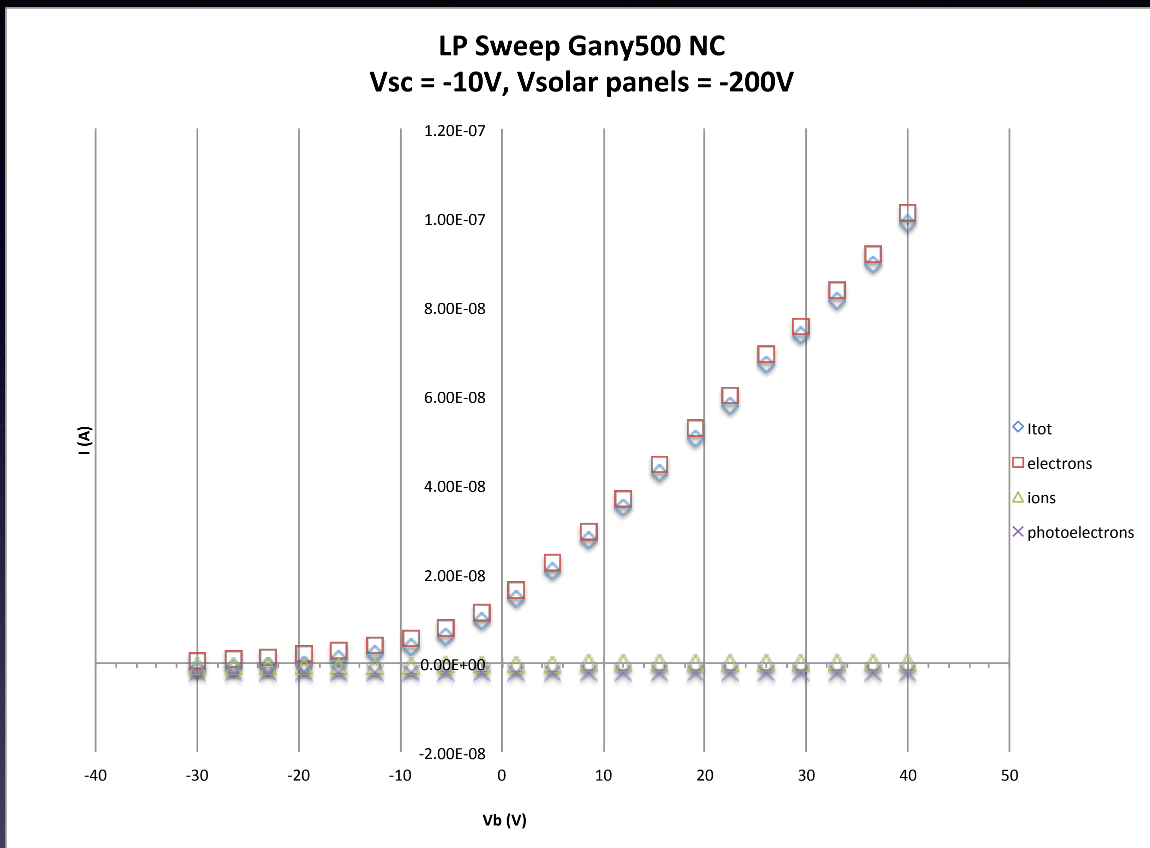


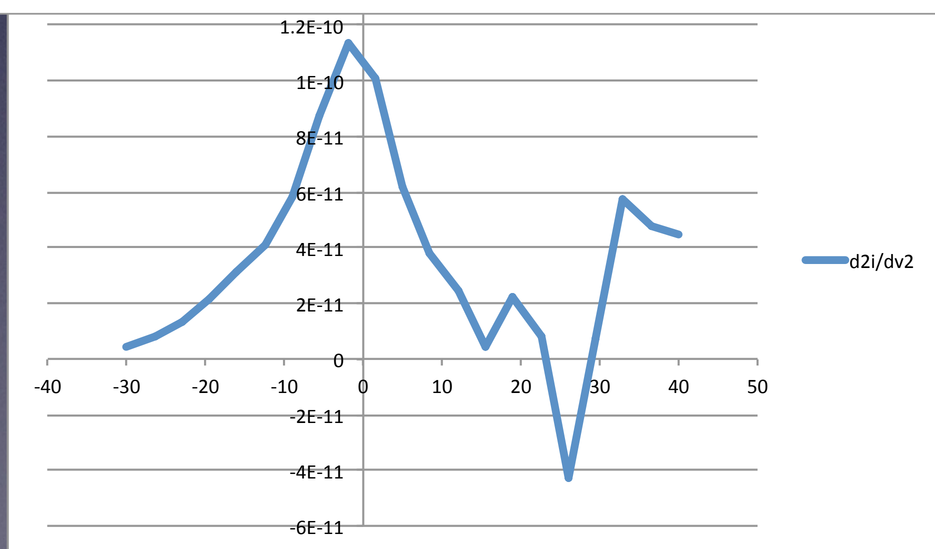
Rosetta "Comet" simulation, Simulated sweep (black) vs arbitrarily chosen real sweep in similar conditions

- Tests our understanding of the Comet plasma environment. Comet does not have maxwell-boltmann distributed electrons. Charged Nano-grain dust. Not confirmative with standard OML-theory simplifications.
- The sweep results show a much smaller electron current than input, signifying a significant (60%) proportion of the electrons being deflected by the S/C, even when the probe is attracting.

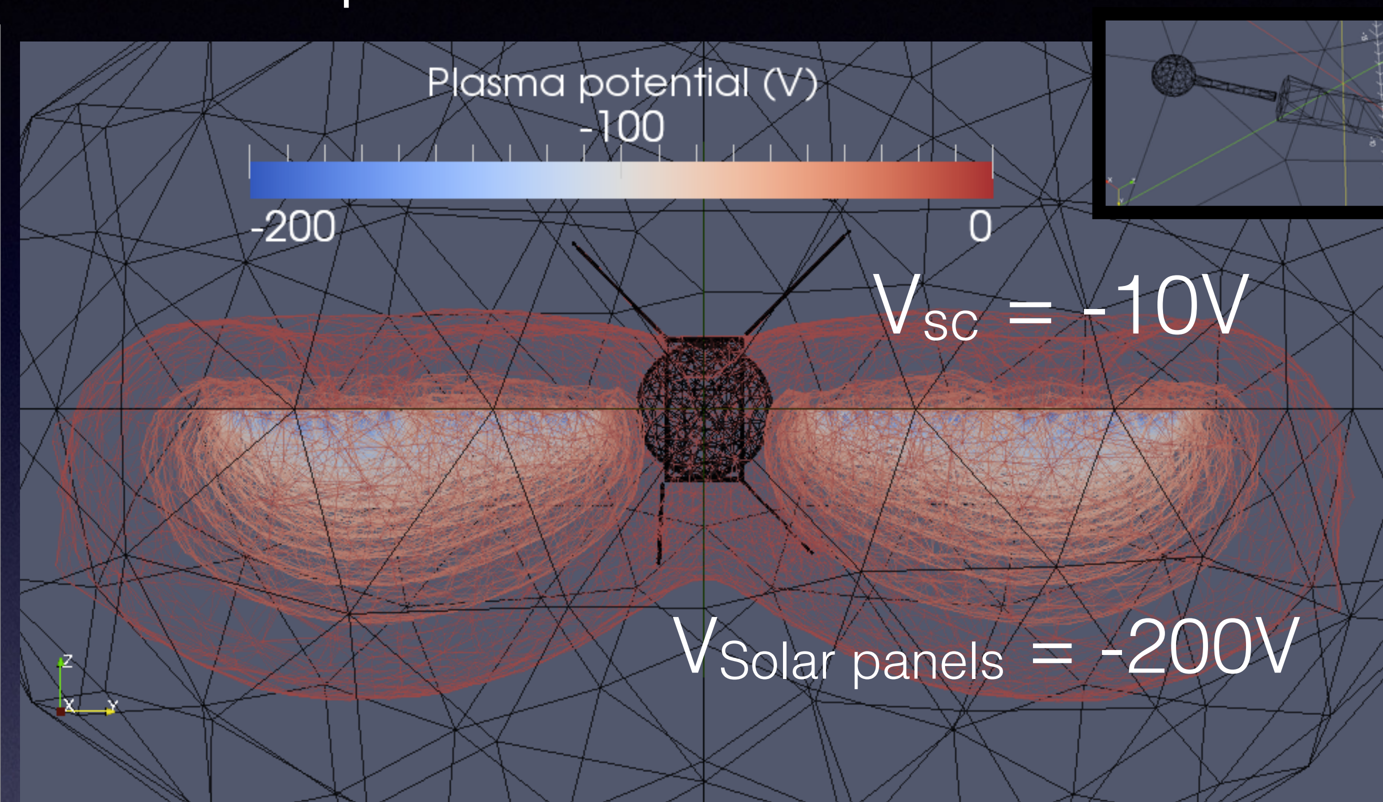
JUICE Europa

Static S/C Sweeps





JUICE Sweep(above),
and second derivative plot (below)



- Problems with photoelectrons (small, slope in wrong direction) error in simulation?
- SEE & Hot electrons missing in sweep.
- Strange kink in electron current at Vb≈ +40
- With a dense high energy Maxwellian-Boltzmann Distributed electron population, Vsc should be obtainable from sweep.

Conclusions

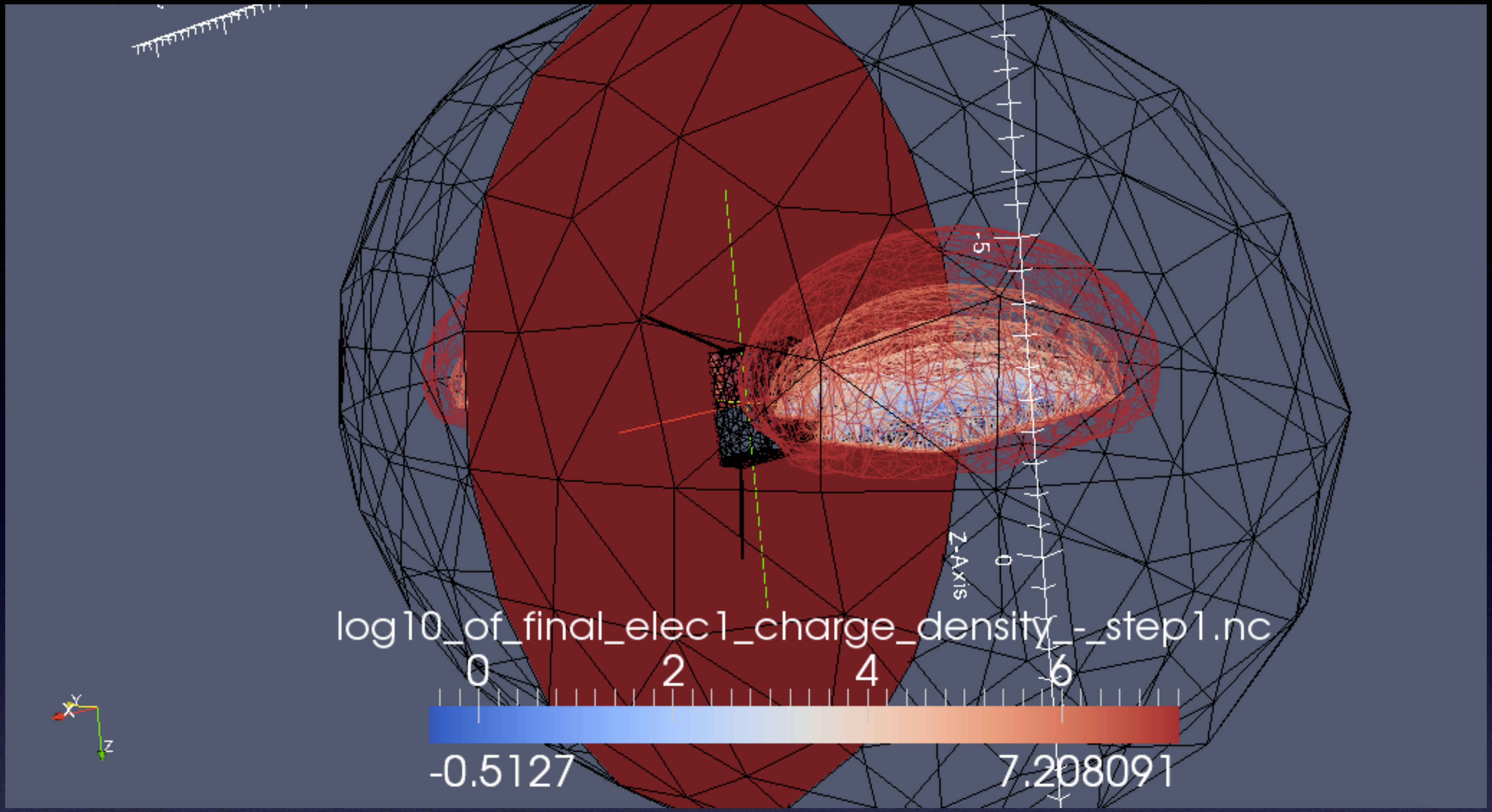
Swedish Institute of Space Physics identifies two major internal uses for SPIS:

- Static S/C potential simulations to further understanding (and aid operation) of currently on-going in-situ measurements.
- Identify feasible scenarios (& limitations and risks) of future missions.

Proven not only useful for the Langmuir probe, but also other plasma instruments e.g PEP (ESA JUICE) & MIP (ESA Rosetta)

“The end.”

Extra slides


Z-Axis
log10_of_final_elec1_charge_density_-_step1.nc
0
2
4
6
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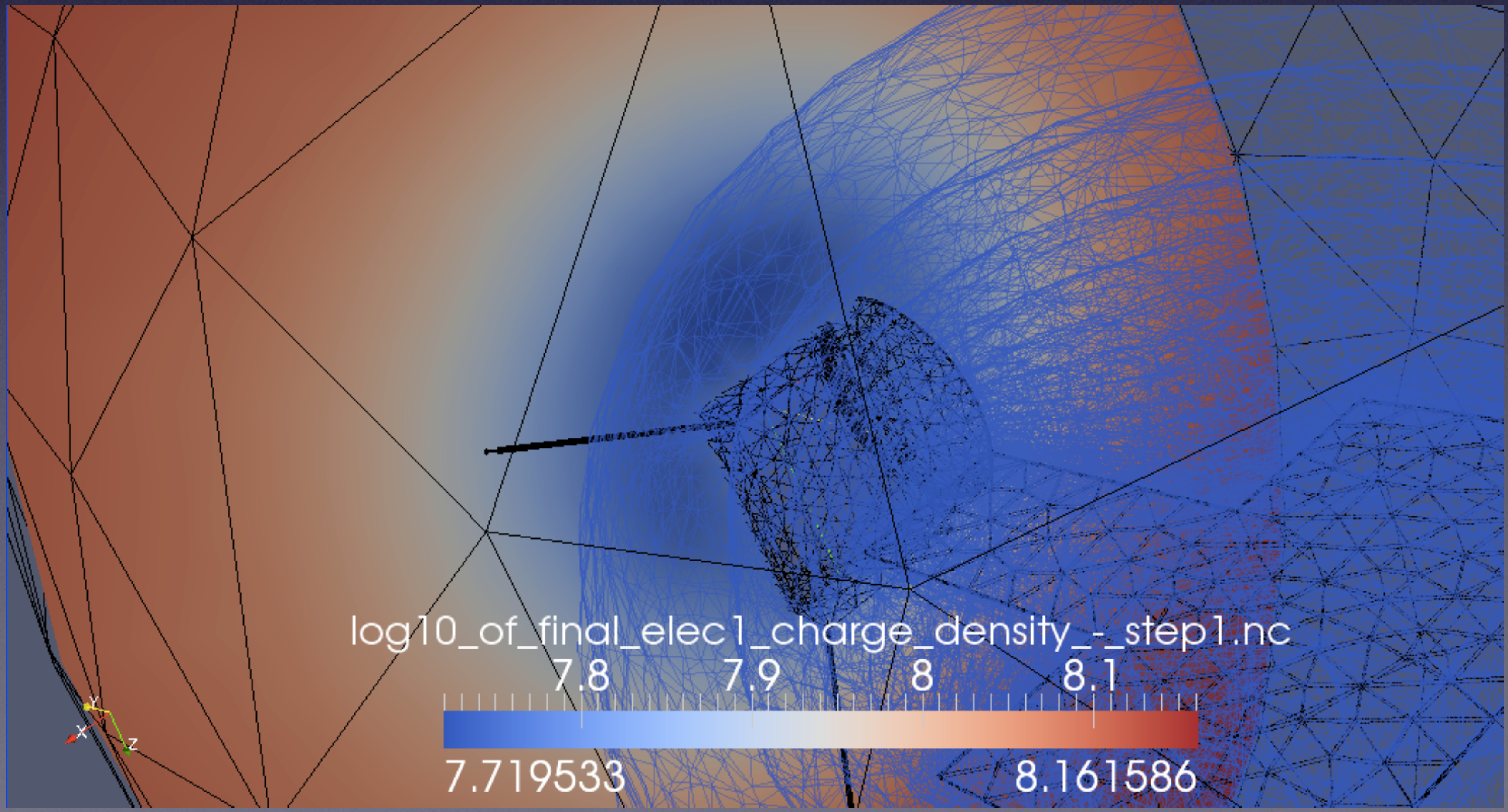
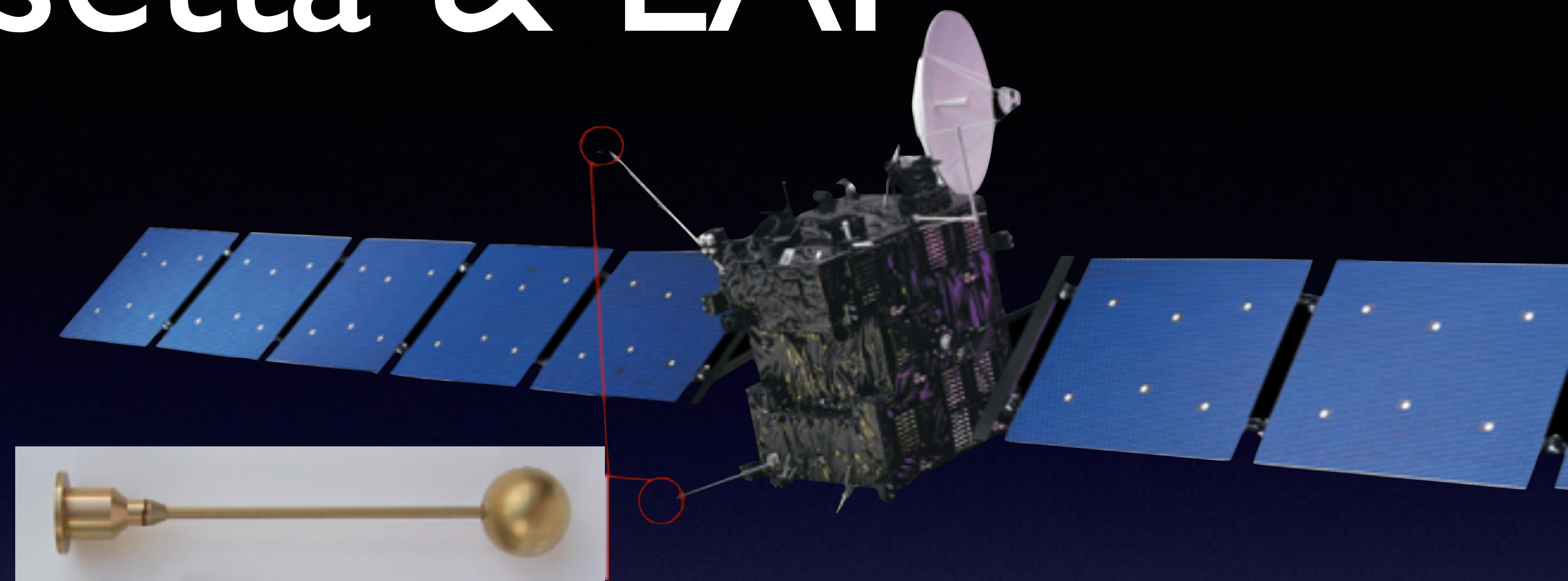
7.208091


log10_of_final_elec1_charge_density_-_step1.nc
7.8
7.9
8
8.1
7.719533
8.161586

Rosetta & LAP



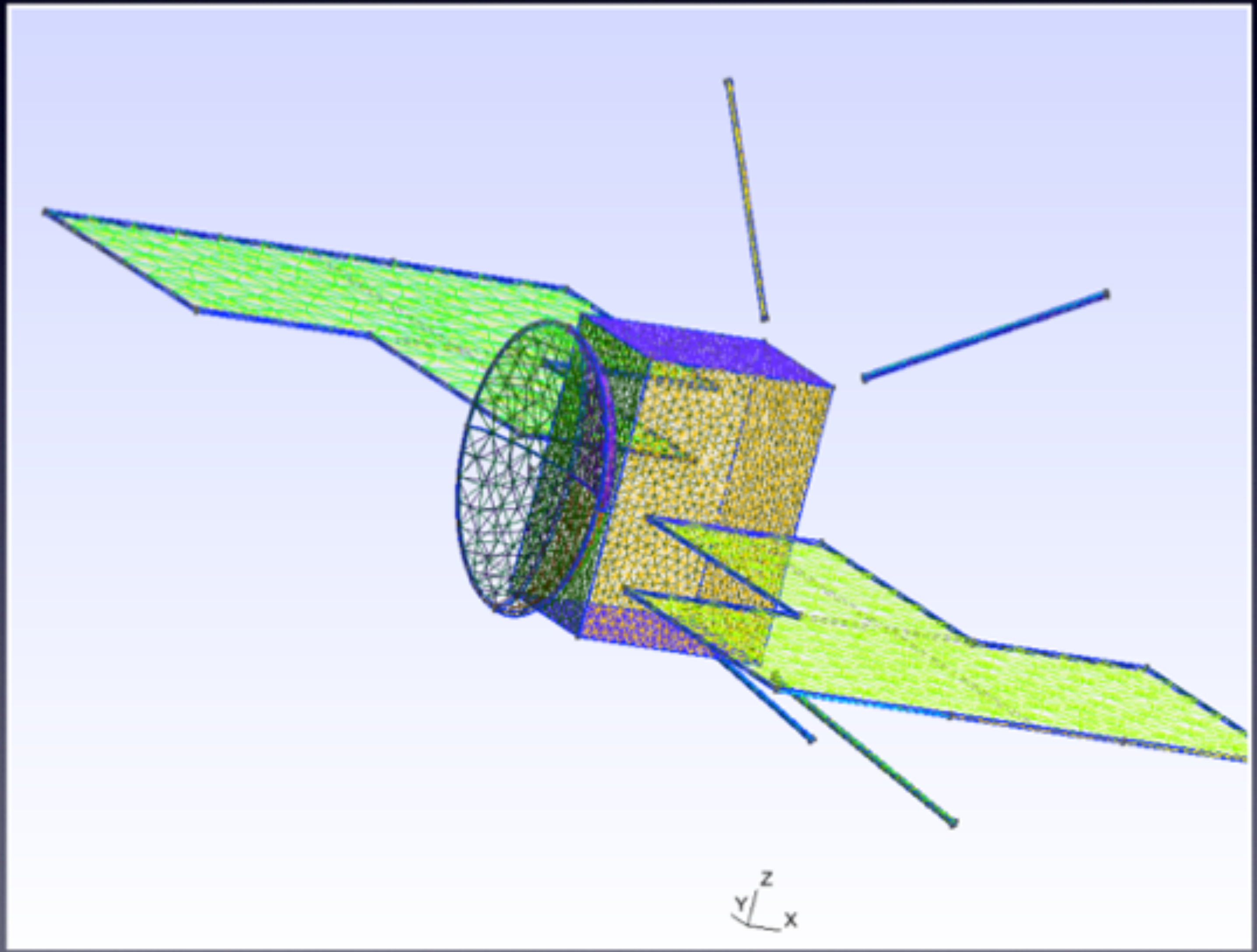
Langmuir Probe onboard Rosetta

image credit:
A. Eriksson, IRFU & ESA

- Orbiter & Lander
- Langmuir Probes
  - Measures spacecraft potential and plasma parameters, such as plasma density, electron temperature, and plasma flow speed
  - Mounted on two booms of different length

JUICE

- Simplified unclassified model:
- 2.15x1.7x3.13 m box
- 2x32 m^2 solar array
- 4 Langmuir booms and probes
- 3.2 m^2 HGA



Plasma densities

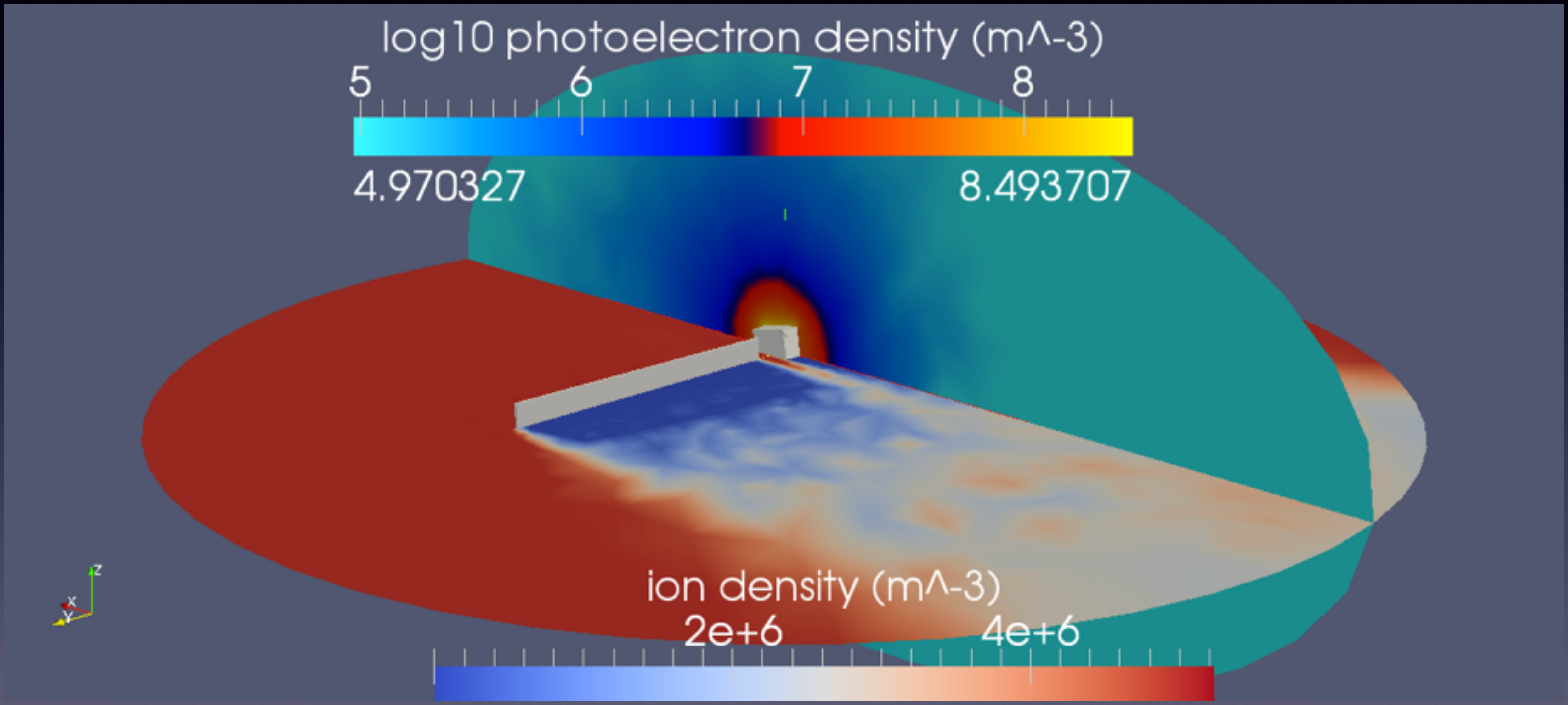
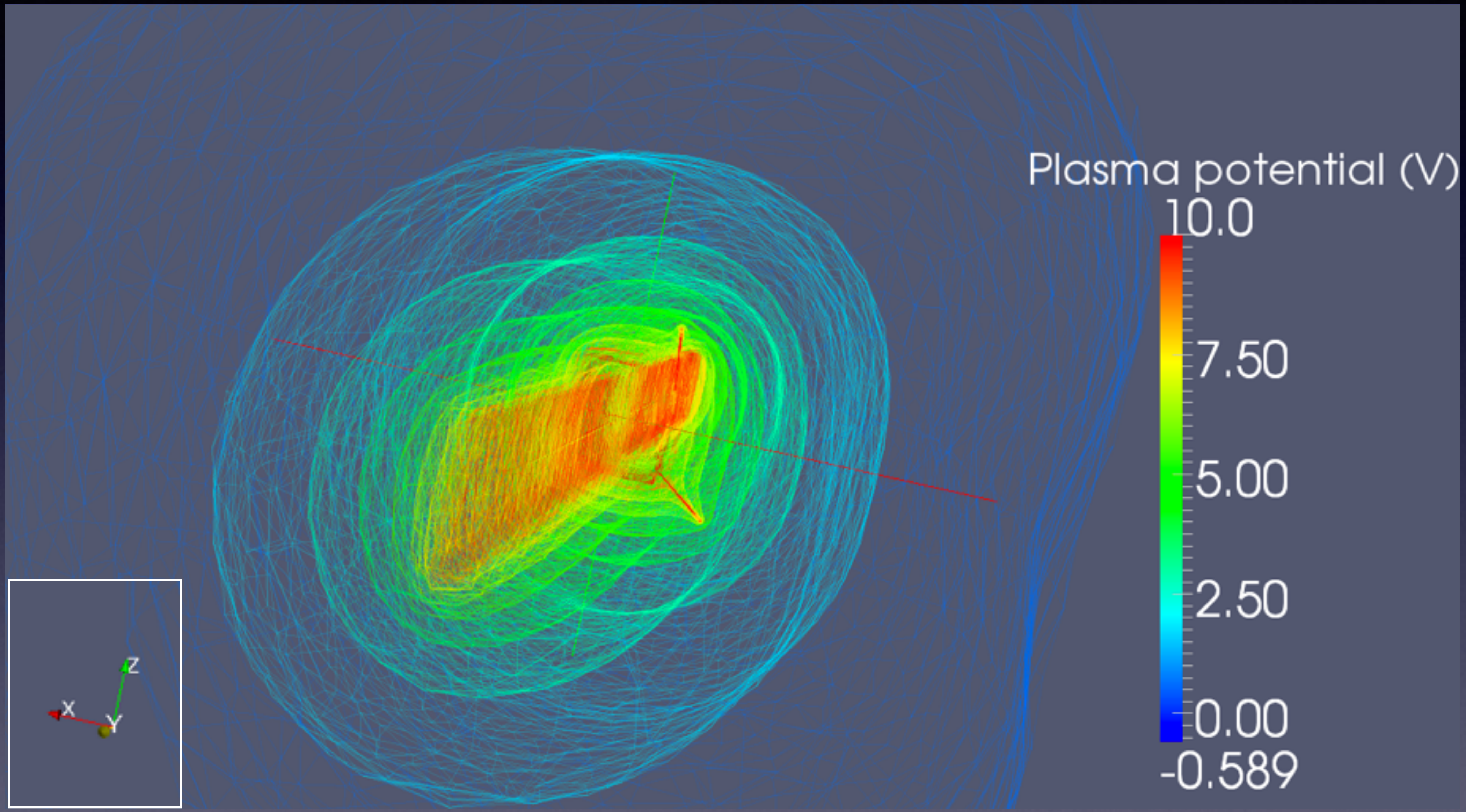


Photo electron and ion density 3D plot of Rosetta.

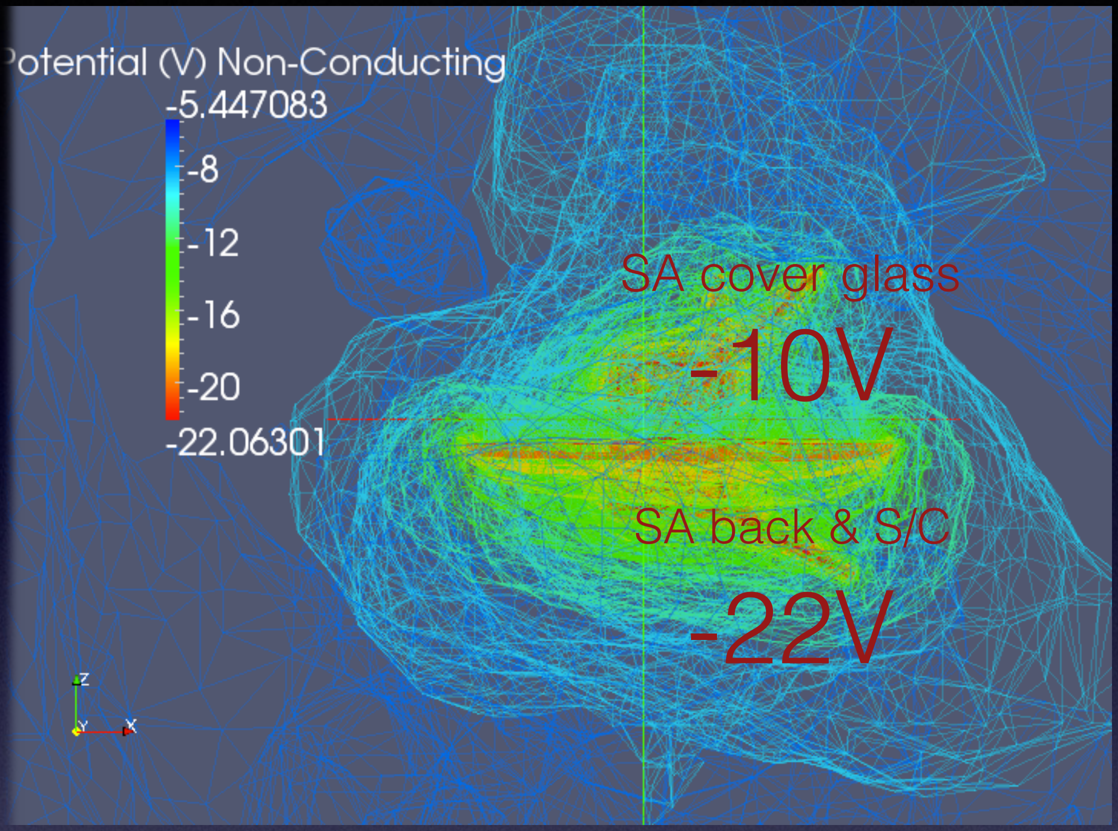
4 million particle simulation, 1 AU, T_e = 12 eV, T_{ion} = 5 eV, T_{ph} = 2 eV, n_e = n_{ion} = 5cm^3 solar wind at v_{sw} = 400 km/s. Sun in +x direction, Rosetta depicted as white

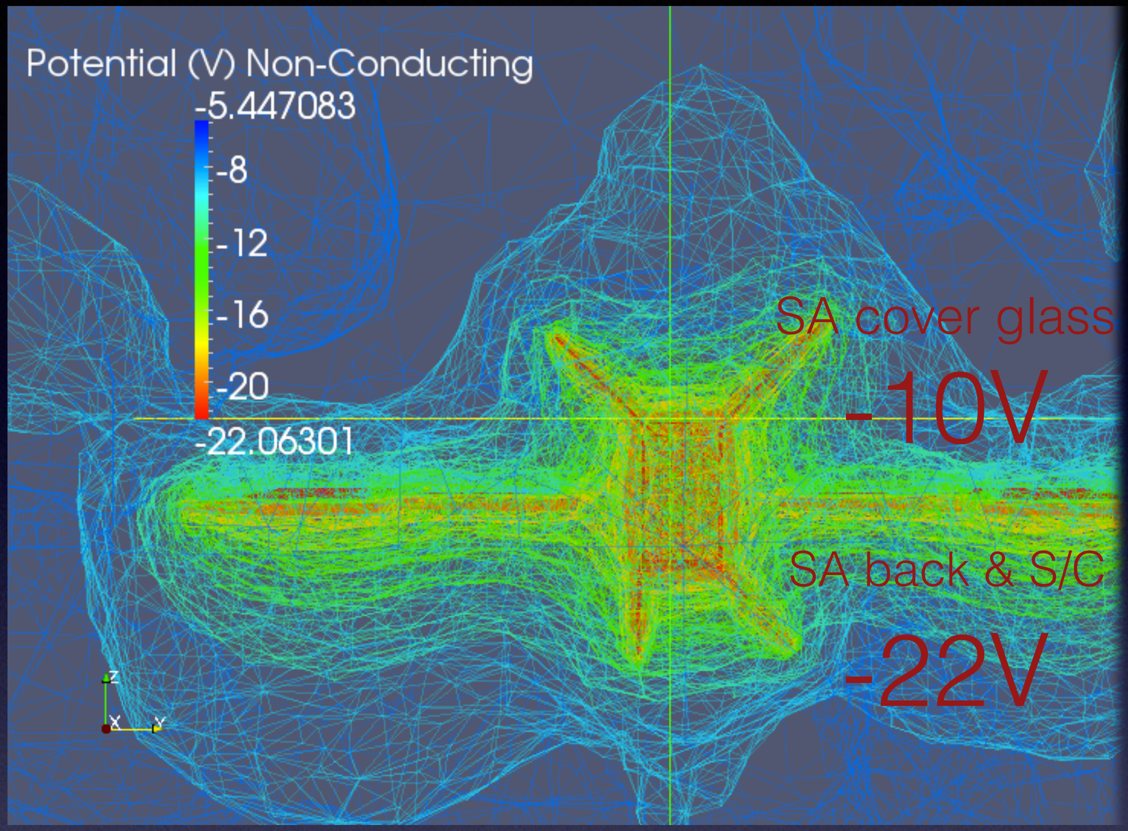
Electrostatic potential

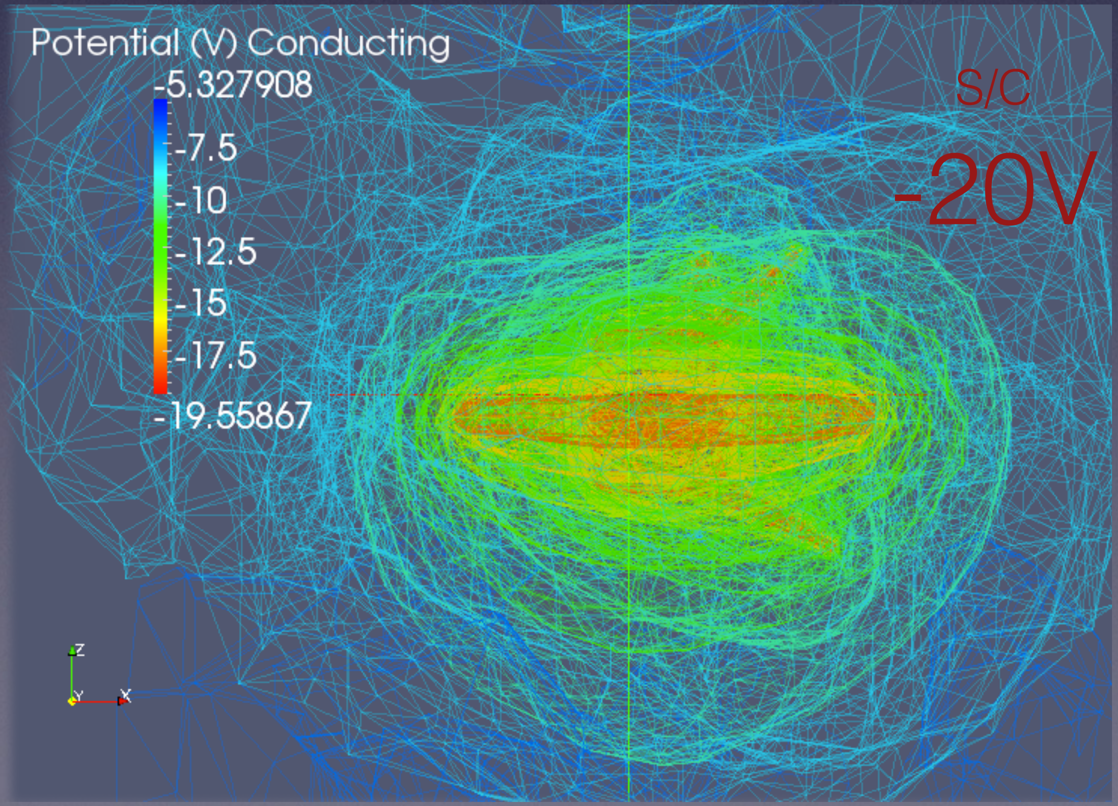


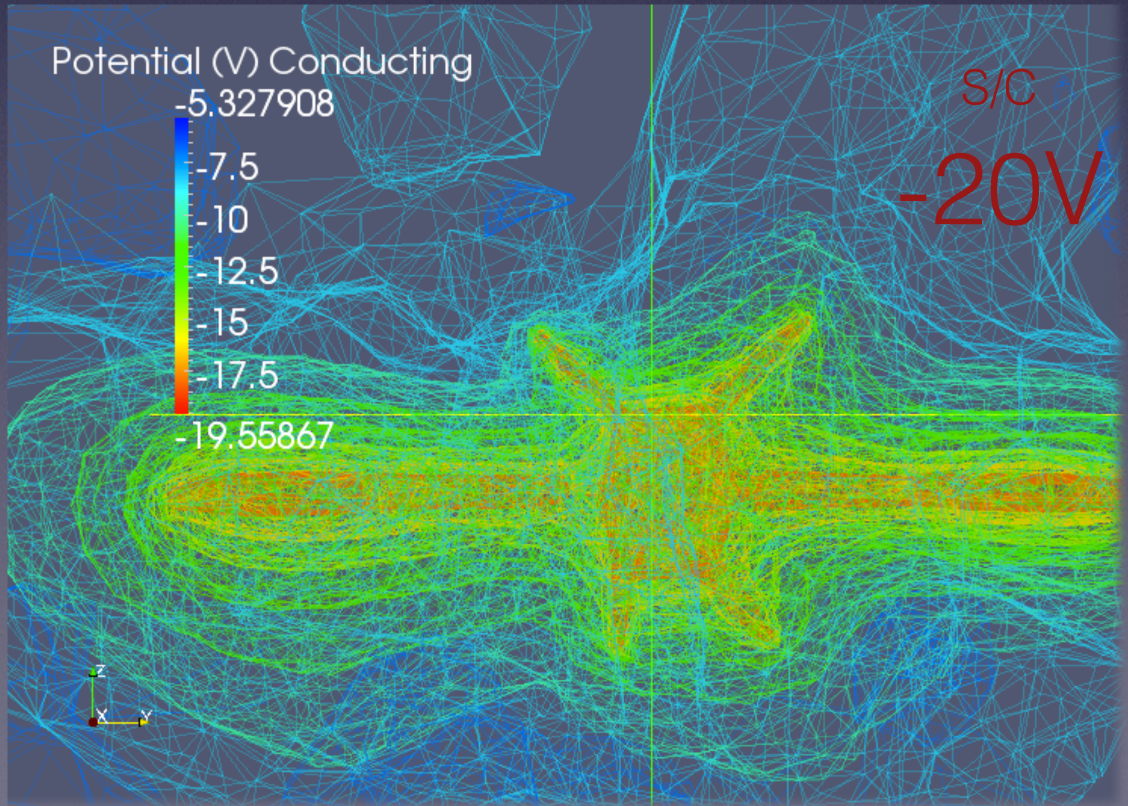
10 equipotential shells surrounding the spacecraft from 10 to 0 V. SPIS 8.3 million particle simulation for a +10 V charged spacecraft at 1 AU, in T_e=12eV, T_{ion}=5eV, T_{ph}= 2eV, n_e = 5cm^3 solar wind at v = 400 km/s.

Ganymedes 500km orbit (eclipse & SEE, neutral plasma)
$149 cm^{-3}$ cold electrons, $1 cm^{-3}$ 1 keV electrons, $150 cm^{-3}$ O^+









Export to SIMION for JUICE PEP