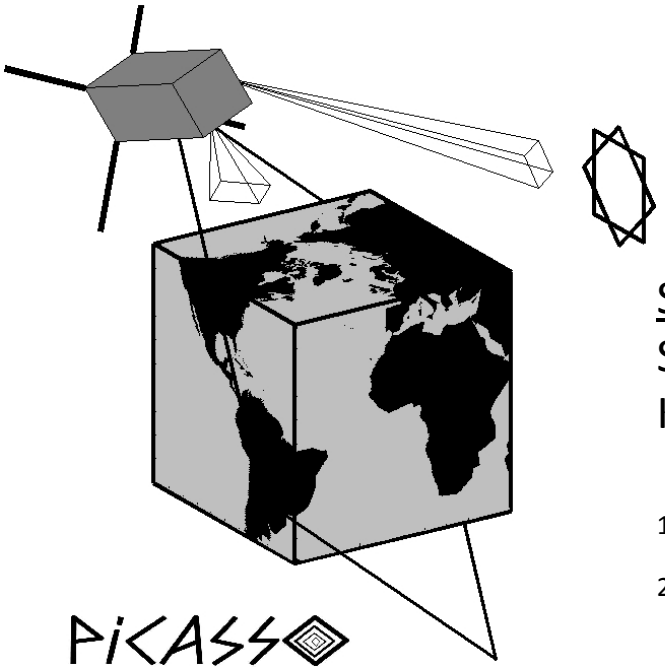
Use of a Langmuir Probe Instrument on Board a Pico-Satellite



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2. PICASSO platform
3. Expected plasma environment
4. SLP instrument
5. LP on board pico-satellite
6. Proposed solution
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PICASSO mission

- ESA in-orbit demonstrator
- Quasi polar orbit, altitude: 400 - 700 km
- expected orbital lifetime: 1-2 years
- Launch in 2017
- 2 scientific instruments:

VISION: visible and near-infrared hyper-spectral imager

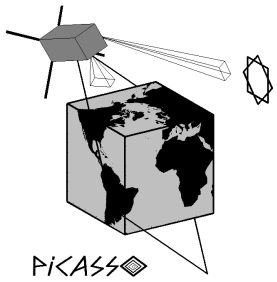
Scientific objectives:

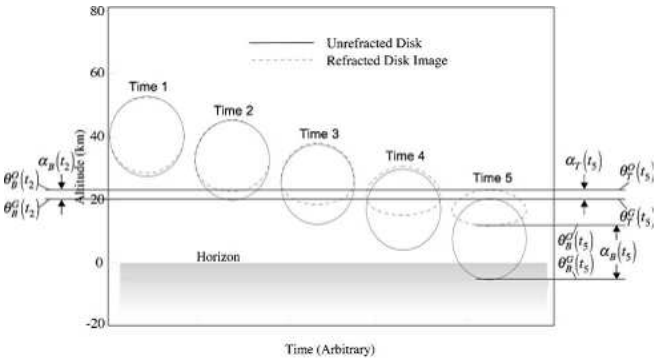
1. Polar and mid-latitude stratospheric ozone vertical profile retrieval
2. Upper atmosphere temperature profiling based on the Sun refractive flattening

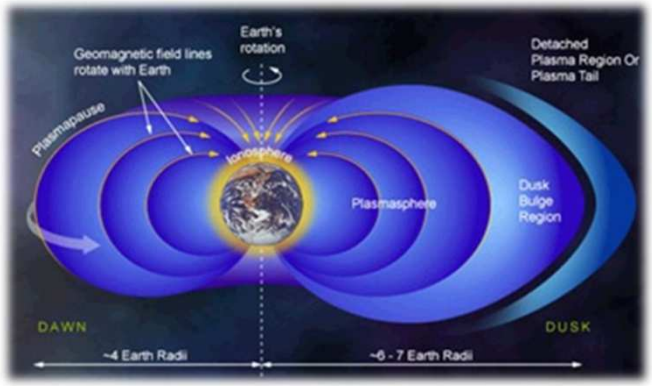
SLP: Sweeping Langmuir Probe

Scientific objectives: in-situ study of

1. Ionosphere-plasmasphere coupling
2. Subauroral ionosphere and corresponding magnetospheric features
3. Aurora structures
4. Turbulence (multi-scale behavior, spectral properties)







PICASSO platform

Triple unit (34x10x10 cm, 1U for payload), four 2U deployable solar panels

Telecom: UHF/VHF + S-Band

Attitude control: magneto-torquers & dynamical wheels

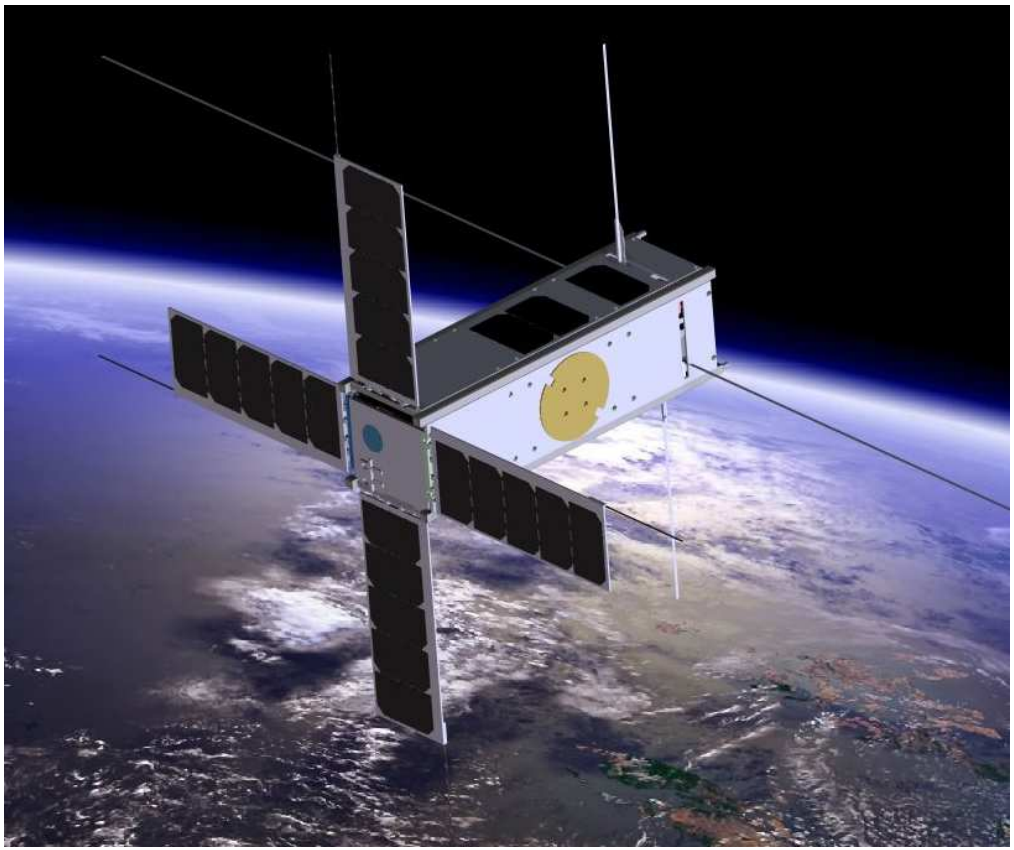
Attitude: inertial flight, one face towards the Sun

Mass: 3.9 kg, power consumption: 6.3 W

Downlink: 40 MB/day, Uplink: 400 kB/day

Pointing accuracy: ~1° (knowledge: 0.2°)

Star tracker & GPS



Expected plasma environment

	Minimum (> 95% probability)	Maximum (> 95% probability)
Plasma density (#/m^3)	10^8 (10^9)	10^{13} ($5x10^{12}$)
Electron temperature (K)	600 (700)	10 000 (5 000)
Debye length (m)	5.4e-4 (8.2e-4)	0.69 (0.15)
Electron plasma frequency (Hz)	5.7e5 (1.8e6)	1.8e8 (1.3e8)

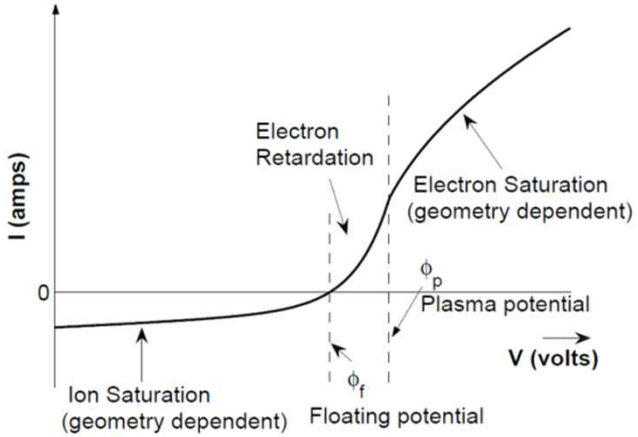
SLP instrument

Instrument overview

SLP is made of 4 thin cylindrical Langmuir probes whose electrical potentials are swept with respect to the S/C potential. From the electric current collected by each probe, the following parameters will be retrieved on ground:

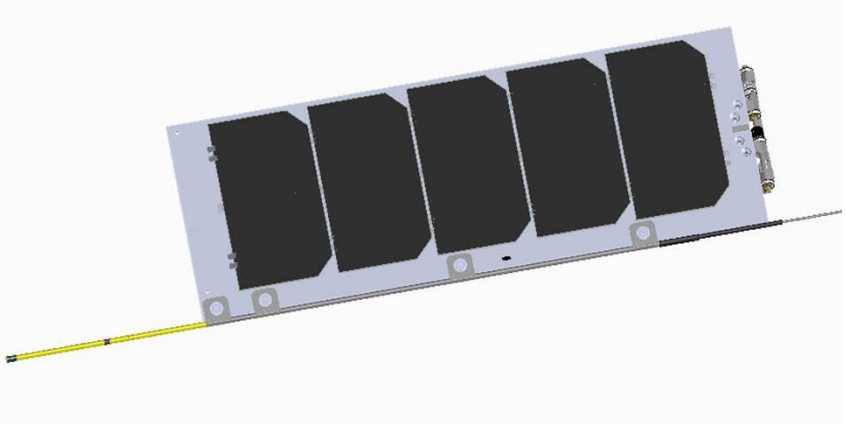
- ✓ electron density and temperature
- ✓ ion density
- ✓ Spacecraft potential

Download raw data: I-V curves contain more information than only 3 parameters !



Key numbers:

- ➢ 4 probes
- ➢ Probe diameter: 2 mm
- ➢ Probe length: 40 mm
- ➢ Boom length: 40 mm
- ➢ Sampling frequency: 10 KHz
- ➢ 50 I-V curves/s => Ne, Te, Ni, $V_{S/C}$
- ➢ Bias voltage: -5 V to 13 V wrt S/C GND



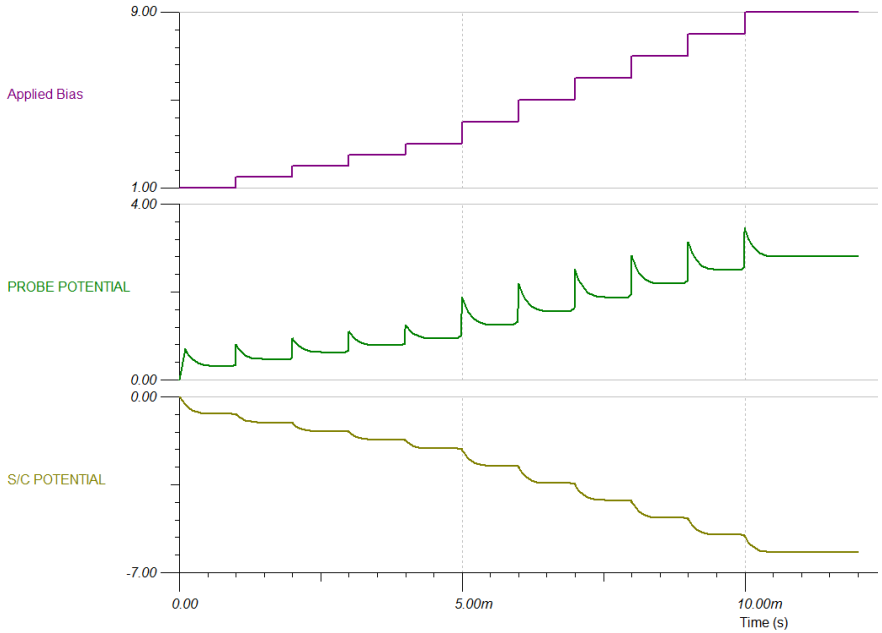
LP on board Pico-Satellite

Problem of using LP on board Pico-Satellite

Limited conducting area of the S/C with respect to the area of the probe

⇒ **Spacecraft charging** (e- saturation region)
- ⇒ Drift of the instrument's electrical ground during the measurement
- ⇒ Unusable data

Risk:
Too low S/C potential: unable to sweep appropriate potentials (e- saturation region)



Proposed solution

Proposed solution

- Increase conducting surface of the S/C (at least 200 cm² on all sides of the S/C, incl. solar panels)
- Measure the floating potential of one probe while measuring the I-V curve with another probe

  => The 2 probes that are in the same environment (light/shadow, wake)

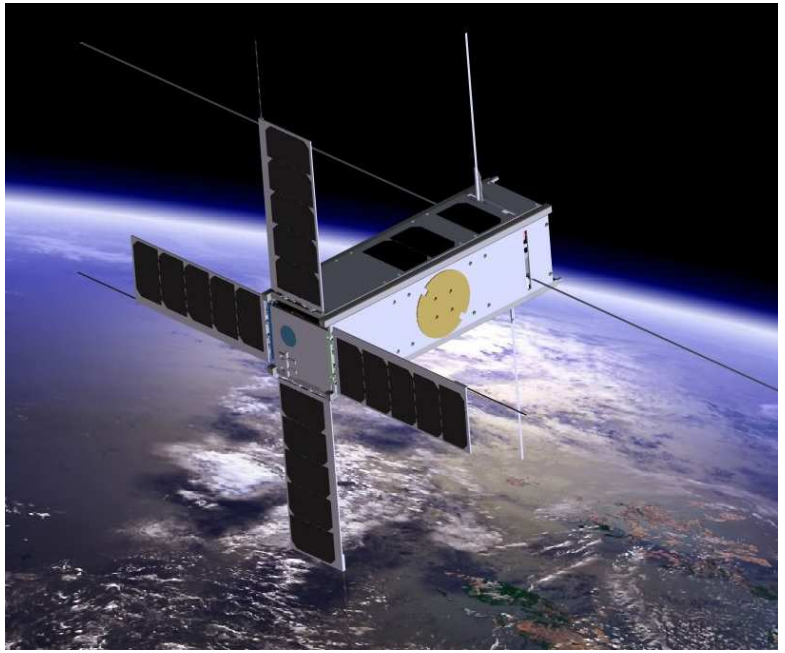
Advantages

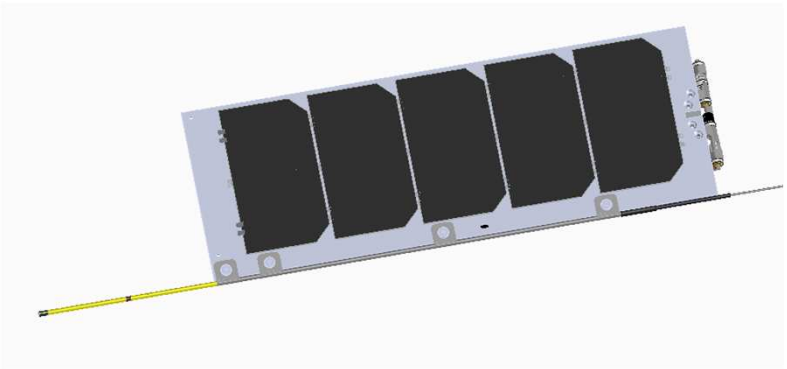
Robust: no filament

No risk of electron collection from e-gun

Disadvantage

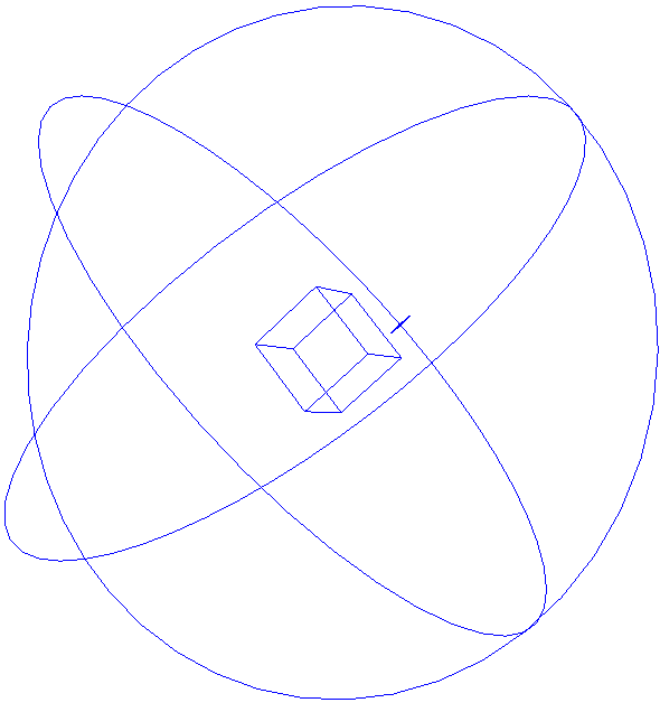
Limited range in e- saturation region in very high density plasma

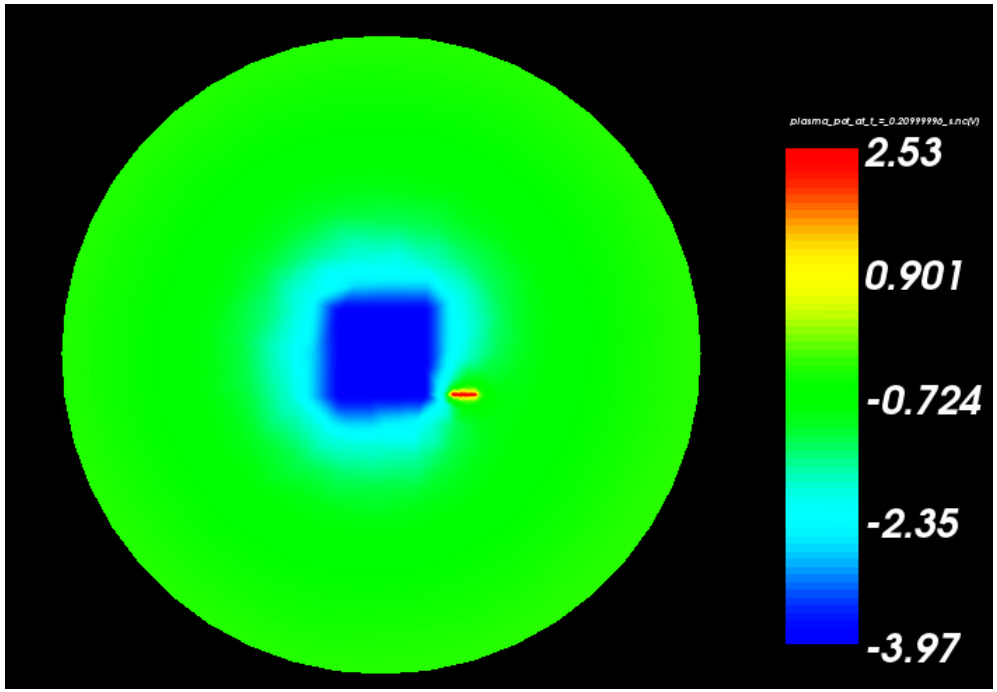




Simulations

Particle-in-cell (PIC) modelling and simulations

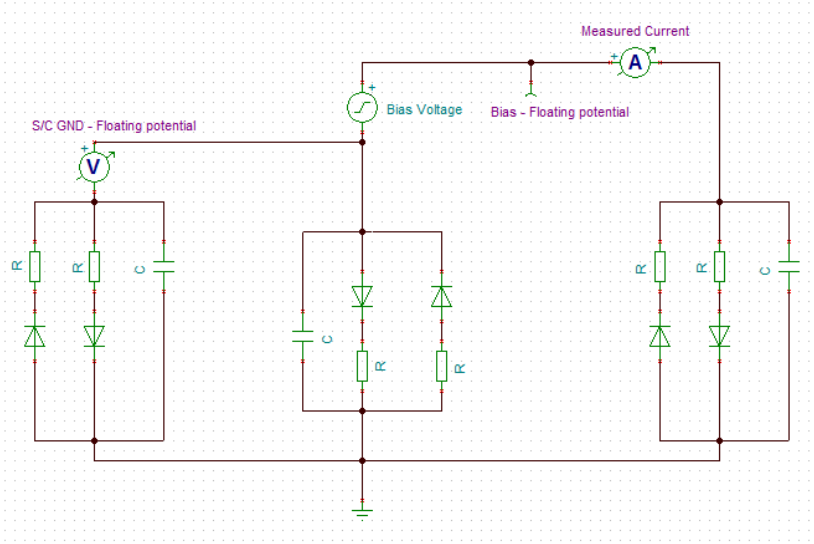


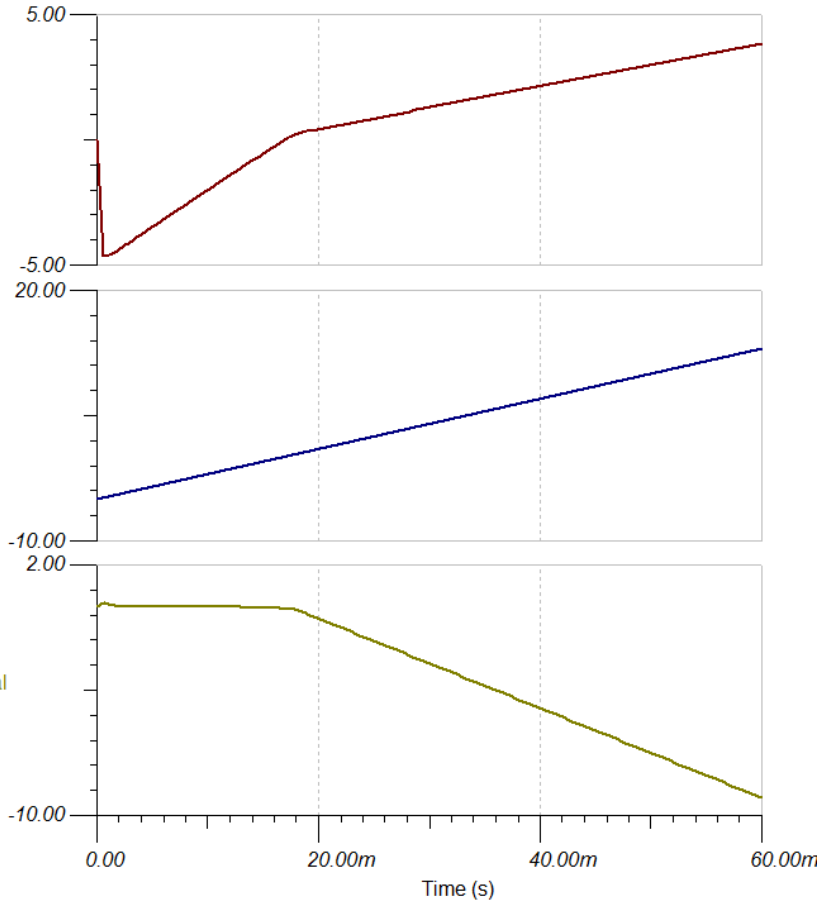


Applied Bias: 6.5 V

Simulations

Electrical circuit modelling and simulation





R and C values derived from measurements in plasma chamber

Probe potential for extreme cases

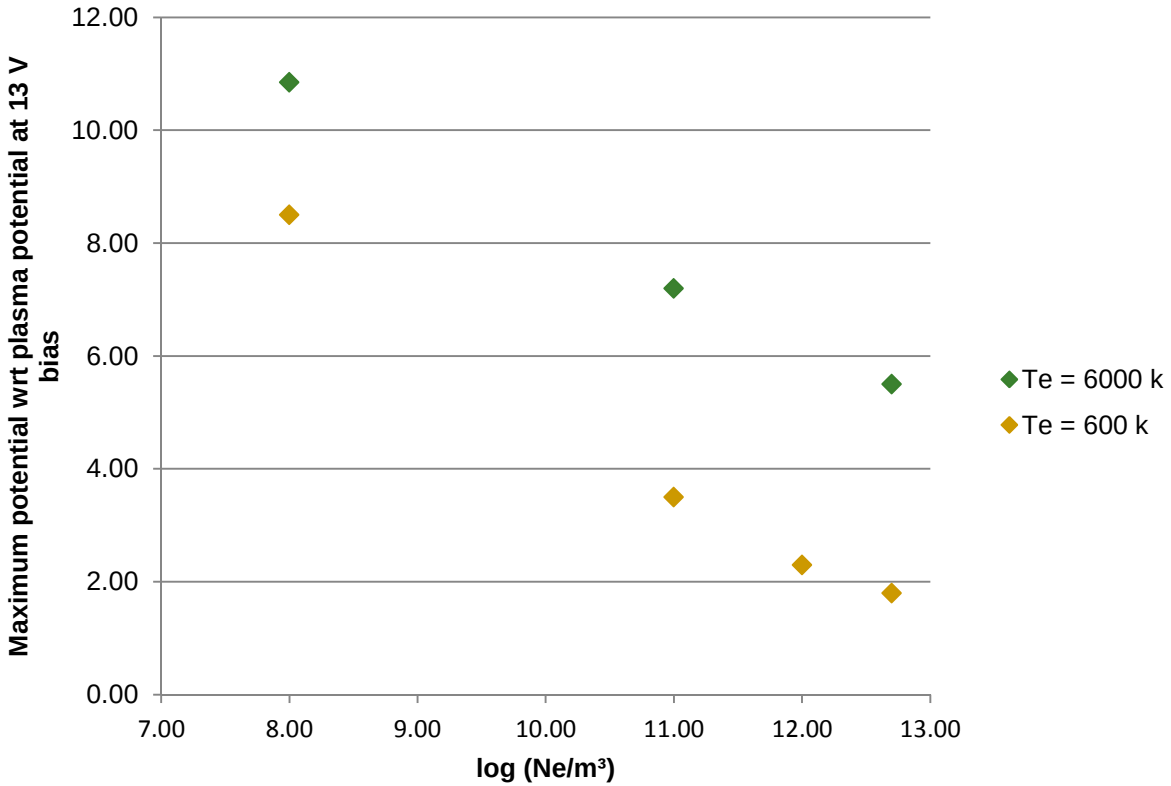
Maximum probe potential with respect to plasma potential

SPIS simulations for extreme cases

Most unfavorable case:
- High Ne
- Low Te
- Eclipse (no photoelectron)

Floating potential:
-0.16 V for Te = 600 K
-1.9 V for Te = 6000 K

=> Always possible to reach electron saturation region



Conclusions

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⇒ **Spacecraft charging** (e- saturation region)
- ⇒ Drift of the instrument's electrical ground during the measurement
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Risk:
Too low S/C potential: unable to sweep appropriate potentials (e- saturation region)

Proposed solution

- Maximize conducting surface of the S/C
- Measure the floating potential of one probe while measuring the I-V curve with another probe

Allows sweeping bias in e- saturation region even in the worst conditions of the PICASSO mission

Thank you for your attention!