Effects of the PICASSO platform on the Sweeping Langmuir Probe (SLP) instrument

S. Ranvier[1], J. De Keyser[1], J.P. Lebreton[2]

[1] *Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Belgium*
[2] *Laboratoire de Physique et Chimie de l'Environnement et de l'Espace (LPC2E), France*

sylvain.ranvier@aeronomie.be

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PICASSO mission and platform

Launched on 03.09.2020 with Vega VV16
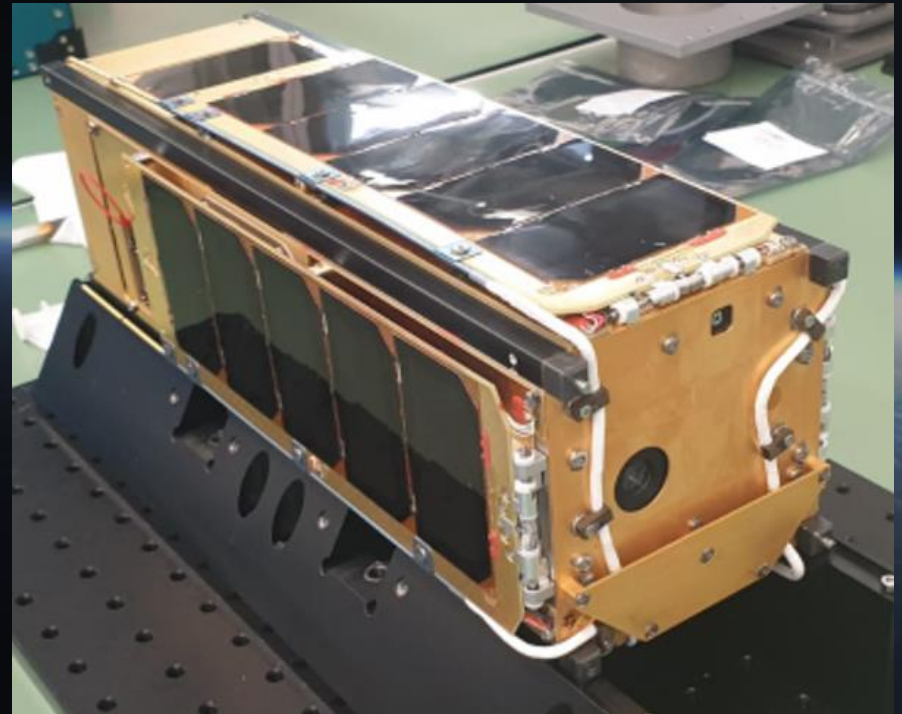
Orbit:

Apogee: 538 km

Perigee: 530 km

Inclination: 97.49 degrees

Platform:

3U CubeSat (AAC Clyde Space AB)

1U for payload

PICASSO mission and platform

- Four deployable solar panels => deployable booms for SLP
- Power generation (ave.): 8,7W , power consumption (ave.): 8.25W
- Two on-board computers (OBC and PLC)
- ADCS: theoretical pointing accuracy~ 1° (knowledge: 0.2°)
- Dimensions: 340.5 x 100 x 100 mm
- Gold coated (at least 1200 cm² conducting surface)
- Mass: 3,9 kg
- UHF/VHF: 400 kB/day uplink
- S-band: up to 100 MB/day downlink
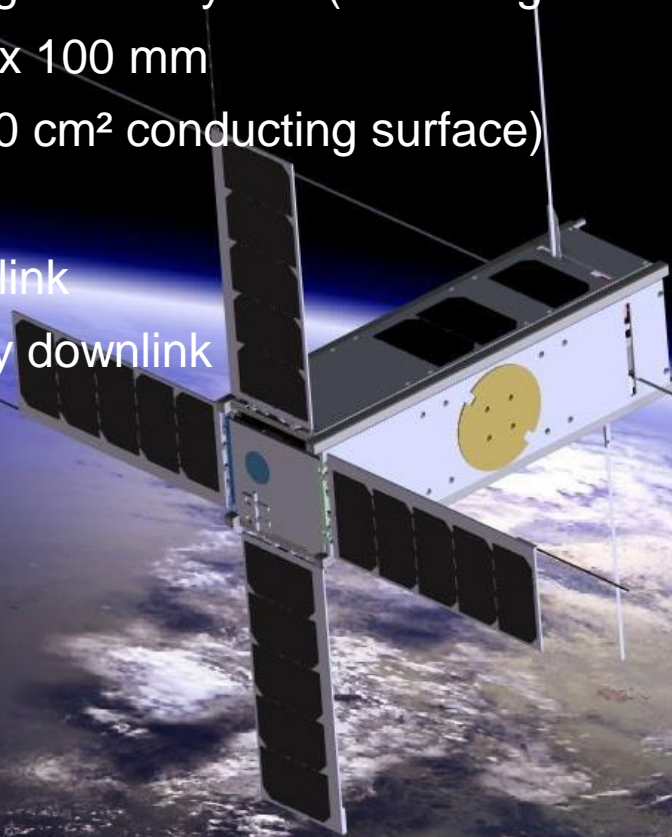
PICASSO mission and platform

Payload

SLP (Sweeping Langmuir Probe):
Four channel Langmuir probe instrument
Fully developed at BIRA-IASB

Measurements:
- Plasma density, electron temperature and spacecraft potential

VISION (Visible Spectral Imager for Occultation and Nightglow):
Visible and near-infrared hyper-spectral imager
HW: VTT, Finland; SW: BIRA-IASB

Objectives:
- Retrieve polar and mid-latitude stratospheric ozone vertical profile
- Upper atmosphere temperature profile based on the Sun refractive flattening

SLP: scientific objectives

Expected plasma parameters

	Minimum	Maximum
Plasma density (#/m³)	10^8	10^{13}
Electron temperature (K)	600	10 000
Debye length (m)	5.4e-4	0.69

- Ionosphere-plasmasphere coupling

    Study field-aligned density distribution and temperature effects
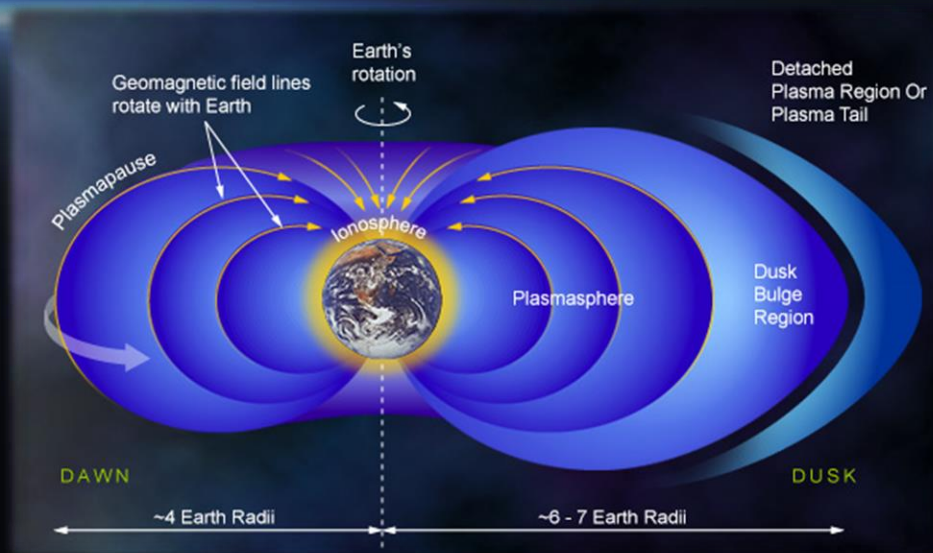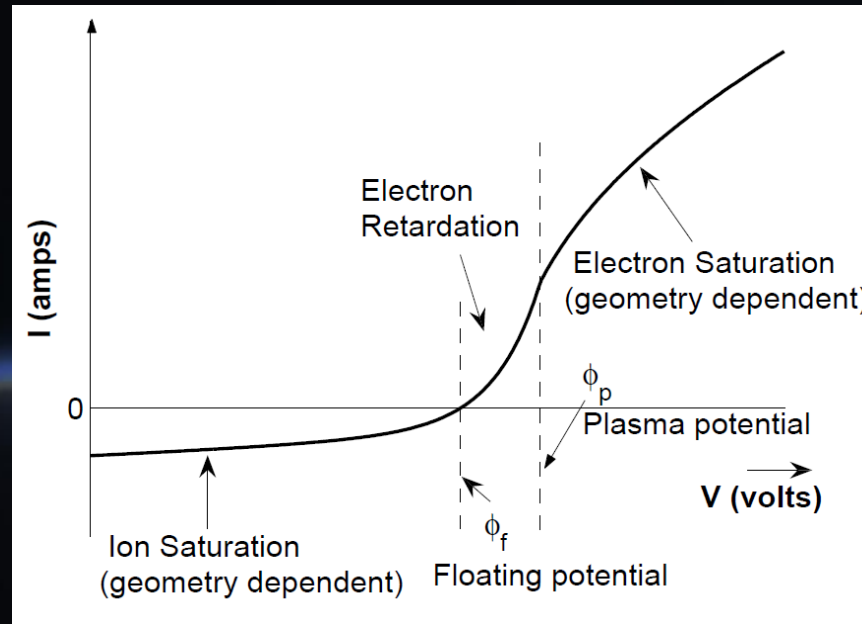
SLP: scientific objectives cont.

- Aurora structures

- Polar cap arcs

- Ionospheric dynamics

  Coordinated observations with EISCAT's heating radar

SLP: Measurement principle

Based on conventional Langmuir probe theory
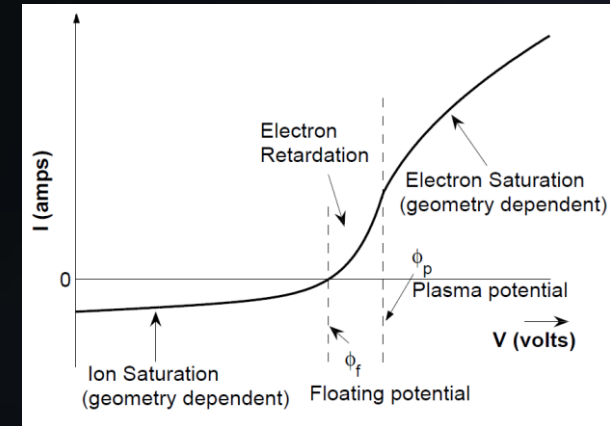

From *PhD Thesis of A. Barjatya, 2007*

3 regions

- Ion density derived from ion saturation region

- Electron T° and S/C potential retrieved from electron retardation region

- Electron density derived from electron saturation region

SLP: Measurement modes

1. Nominal mode

From *PhD Thesis of A. Barjatya, 2007*

- Limited downlink bandwidth => reduced # of steps

- 3 regions measured with different step sizes

- Ion and e- saturation regions: large voltage step size (> 1 V)

- Electron retardation region: adapted to e- T°

    e.g.with 30 steps

    Step size from ~ 10 mV to 150 mV for e- T° of 600 K and 10.000 K

- With 43 samples / sweep => up to 45 sweeps / s
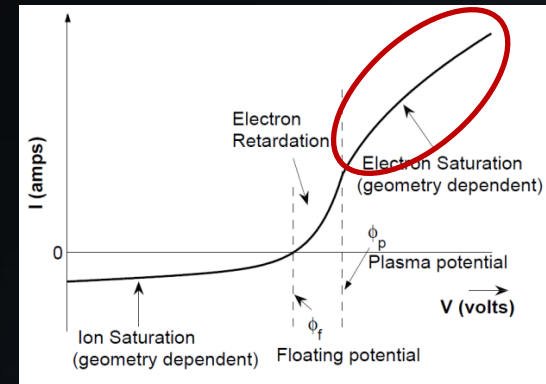
    => ~ 170 m spatial resolution for Ne, Te, Ni and S/C potential

SLP: Measurement modes

2. Fixed-bias mode (e⁻ density only)

- Based on m-NLP principle

- Constant bias in e⁻ sat. region

- Retrieve only **e⁻ density**

- Use at least 2 probes simultaneously

- Sampling freq.: 5 KHz

- Spatial resolution ~ 1,5 m

- Can be used to study turbulence

- Large data volume !!

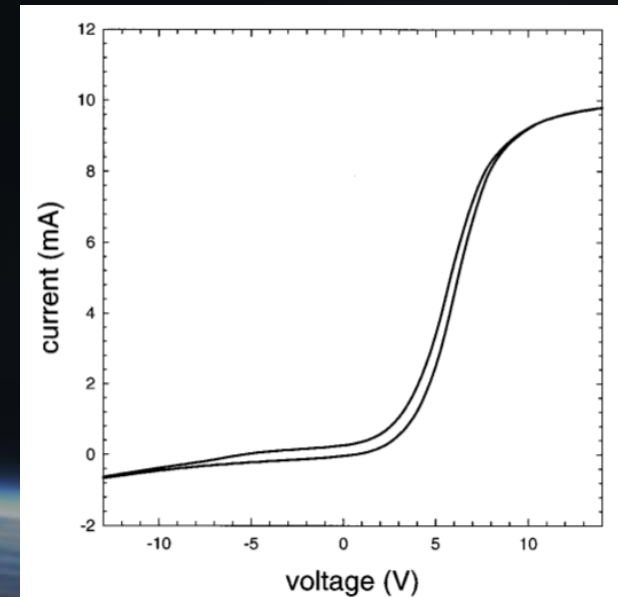
From *PhD Thesis of A. Barjatya, 2007*
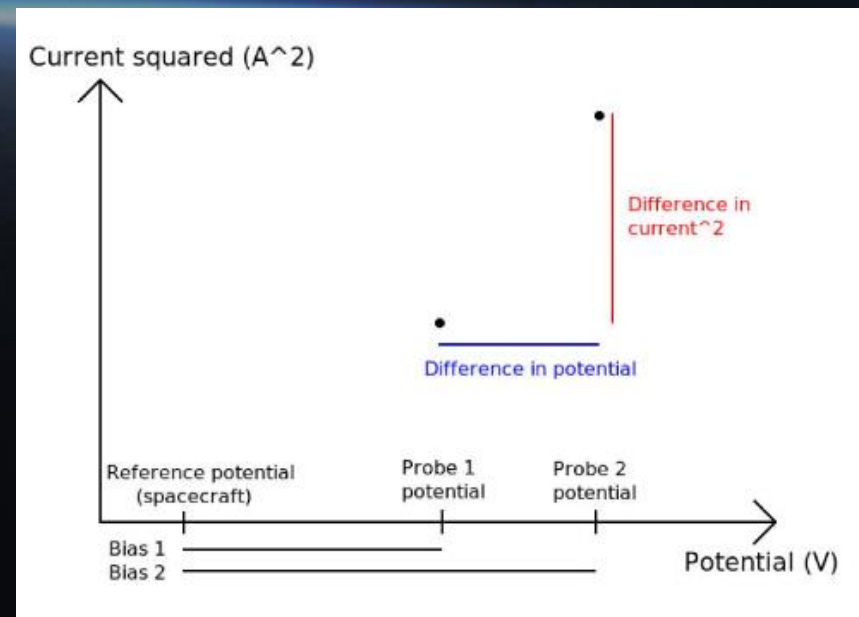
From *T.A., Bekking, University of Oslo*

SLP: Measurement modes

3. Monitoring mode

- Assess the amount of contamination of probe surface

- Sweep in both directions

- Different sweep durations

S/C charging

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

Proposed solution
Measure the floating potential of one probe while measuring the I-V curve with another probe

Advantages:

- Robust: no filament

- No risk of electron collection from e-gun

- **Gives insight about S/C charging**

HW: Probes

- 4 identical probes

- 40 mm Ti tubes of 2 mm diameter

- Attached to the extremity of the solar panels via 40 mm boom
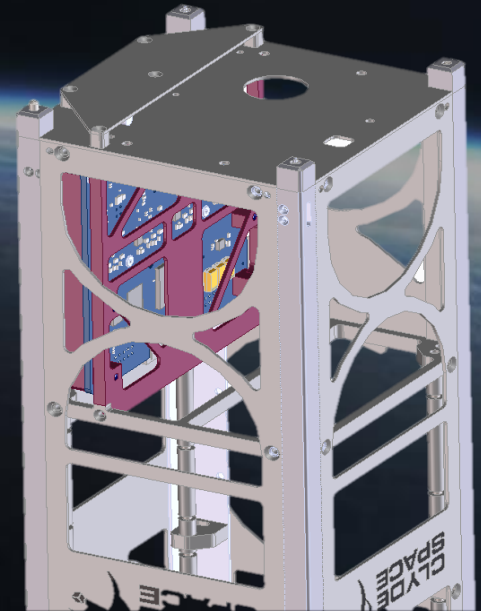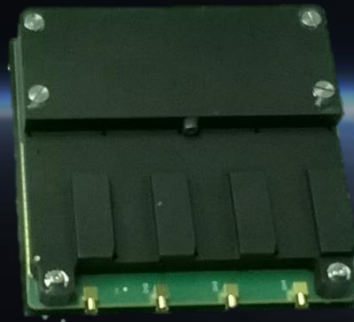
- Gold plated

- Mass of assembly: 6 g
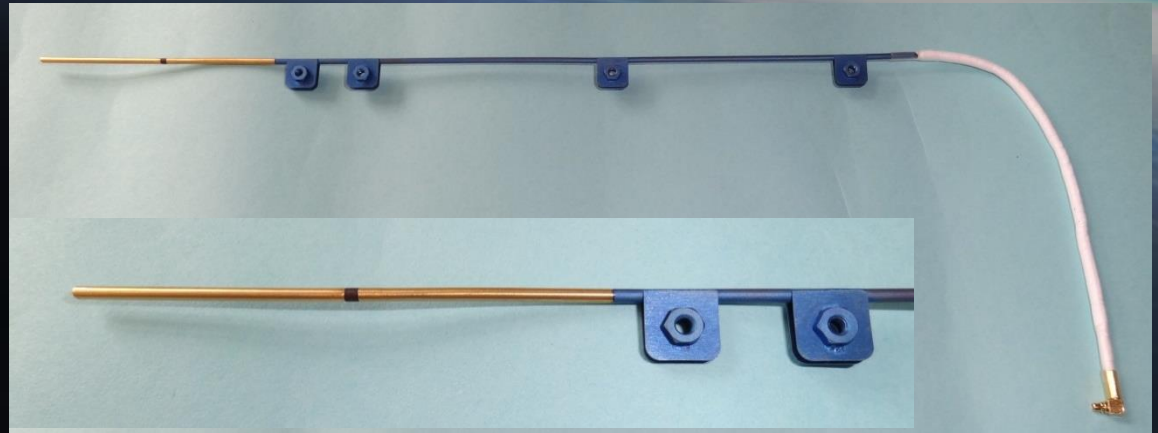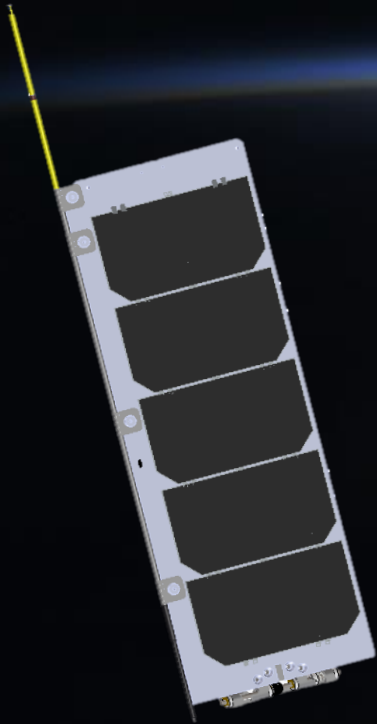
HW: Electronics box
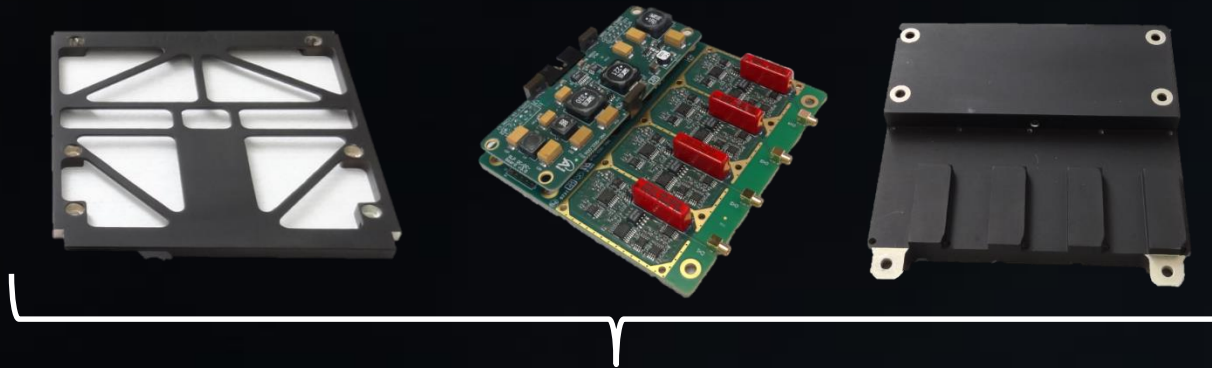
Electronics box

- 104 x 98 x 25 mm
- Power (average): 2.2 W

Mass:

SLP Electronics	87 g
Shielding cover	41 g
4 Booms/probes **Incl. interface and harness**	24 g
TOTAL SLP MASS	152 g

Current status

- PICASSO platform still in commissioning phase

    $\Rightarrow$ Very limited usage of payload, attitude knowledge only in sunlight

    $\Rightarrow$ no science data yet

- All SLP health indicators are nominal (internal voltages, temperature at different locations on the electronic boards, communication with payload computer, booting sequence, internal current source, etc.)

- One probe, which was functioning nominally during the first 3 months, seems to be disconnected (probably a soldering crack at the base of the probe)

    => Not critical: the four channels and probes are exactly identical (all can be used either as traditional LP or to measure the floating potential): full redundancy

First results: linear sweep

Example of linear sweep with equidistant steps:

- -5 V to + 5 V
- 200 samples
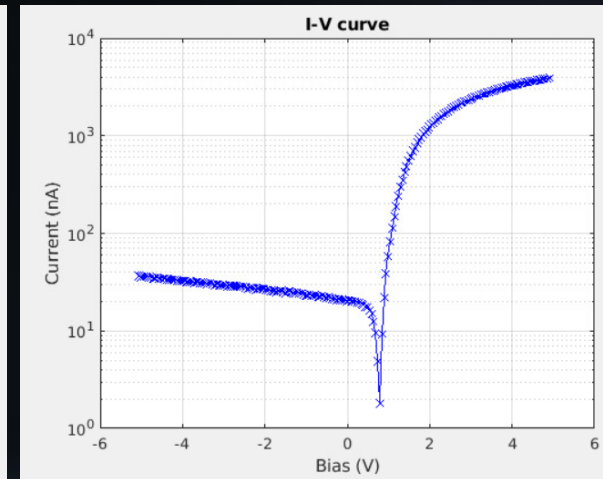- I-V sweep : probe #1
- Floating probe: probe #3

$\Rightarrow$ N= ~ 5e11 /m³
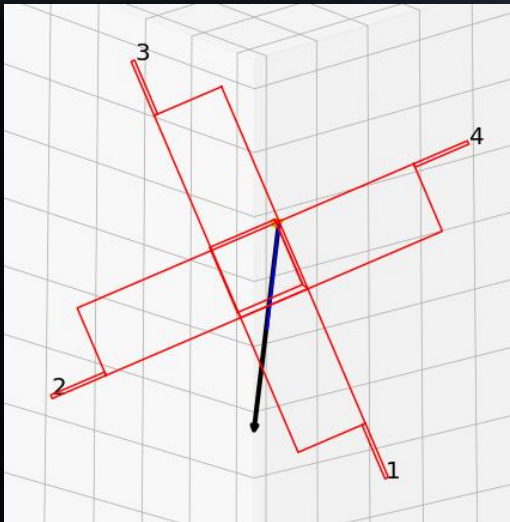
$\Rightarrow$ Te= ~ 2000 K

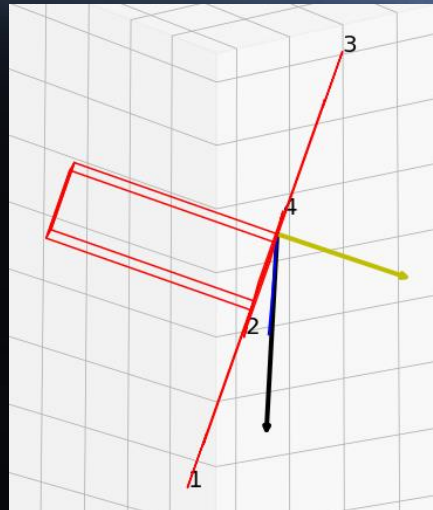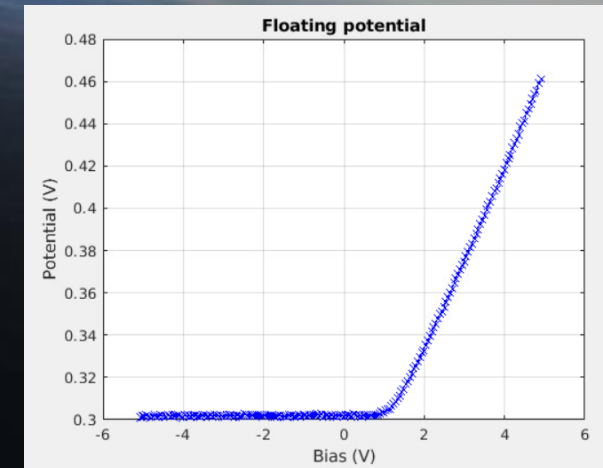$\Rightarrow$ **Clean data**
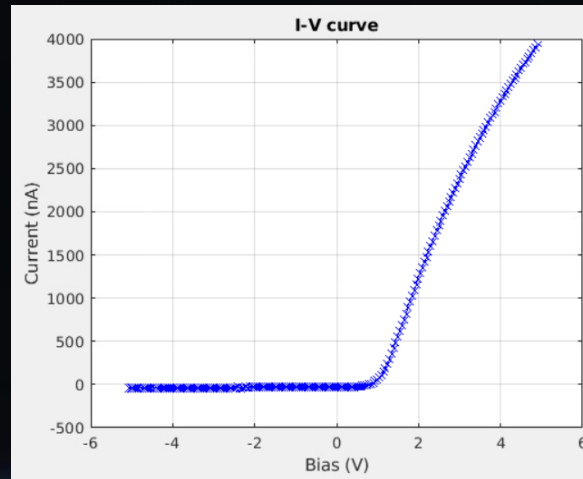
I-V curve. Linear scale

I-V curve. Semi-log scale

Attitude of PICASSO wrt velocity vector (black arrow) and Sun direction (yellow).

Attitude of PICASSO wrt velocity vector (black arrow) and Sun direction (yellow).
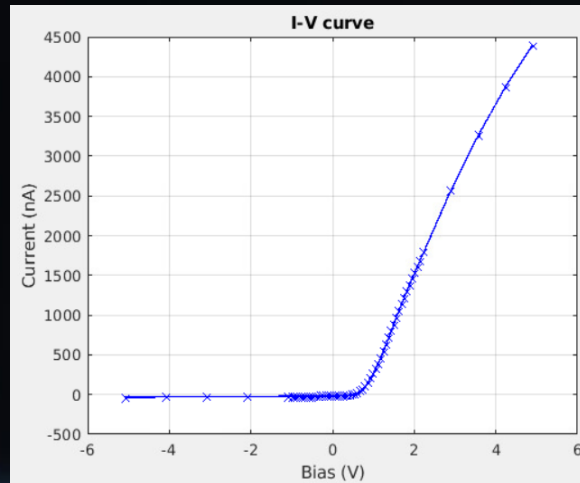

Potential measured with floating probe
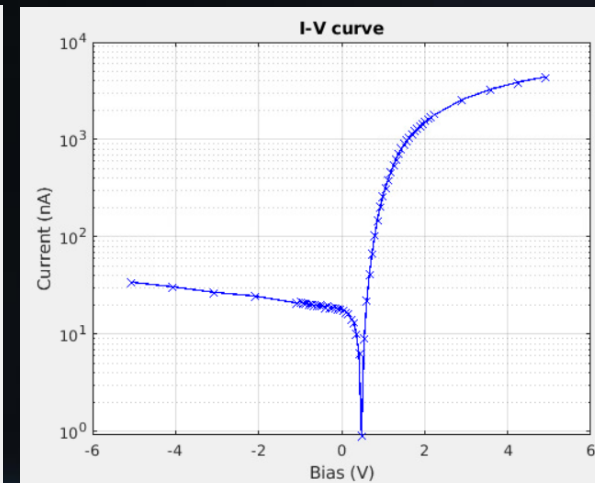
First results: adaptive sweep

Example of adaptive sweep:

- -5 V to + 5 V

- 60 samples:
  - 5 in ion saturation region
  - 50 in e- retardation region
  - 5 in e- saturation region

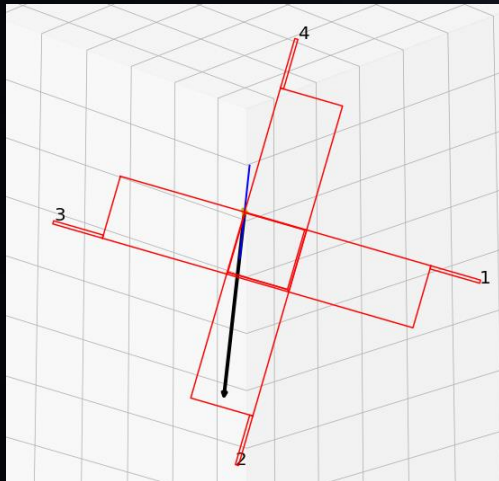- I-V sweep : probe #1

- Floating probe: probe #3

⇒ **e- retardation region well resolved**
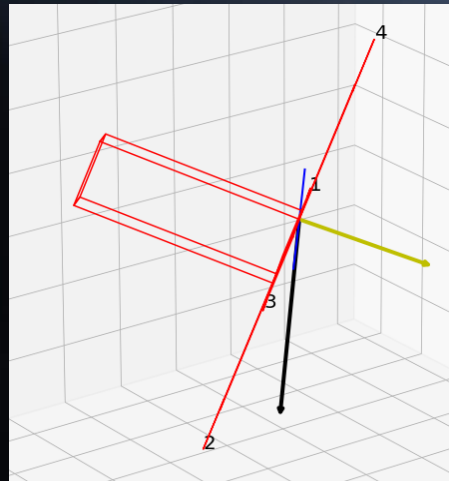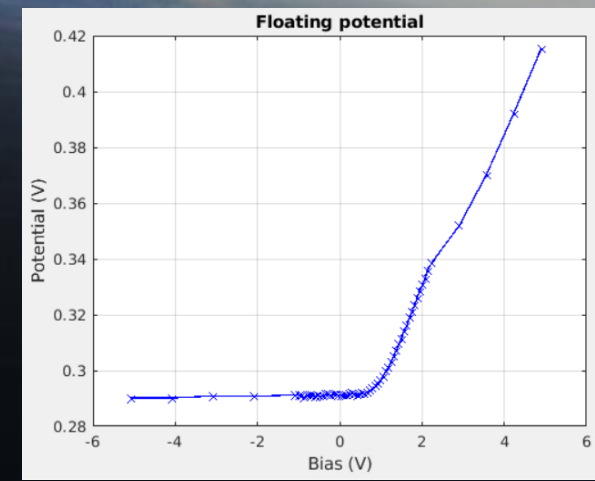

I-V curve. Linear scale.

I-V curve. Semi-log scale.

Attitude of PICASSO wrt velocity vector (black arrow) and Sun direction (yellow).

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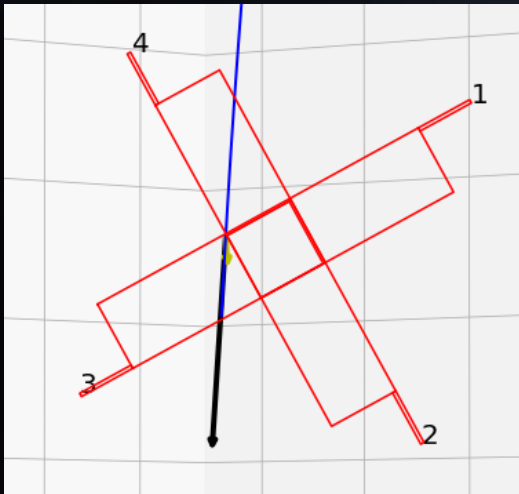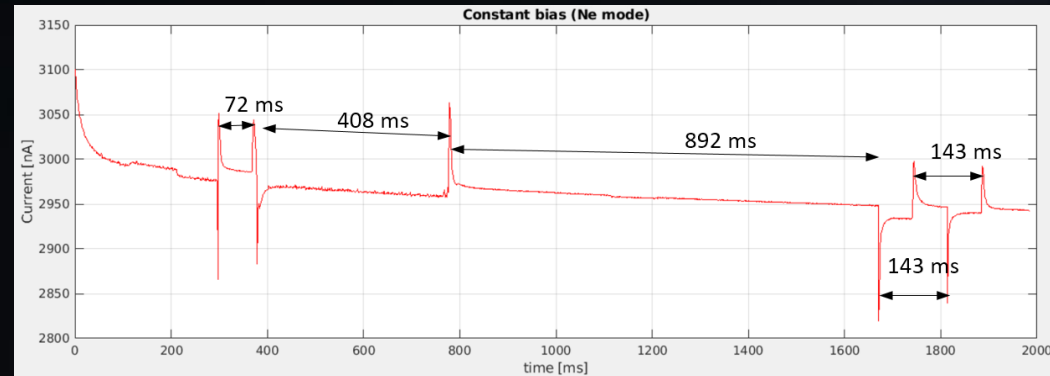

Potential measured with floating probe.

First results: fixed-bias mode

Example of fixed-bias measurement:

- Probe #1: floating probe
- Probe #2: 4 V
- Probe #3: 3 V

- 1k sample / s

- **In sunlight**

$\Rightarrow$ **Noise structures from the platform visible both on current and potential**

Current from probe #2

Attitude of PICASSO wrt
velocity vector (black arrow)
and Sun direction (yellow).

Attitude of PICASSO wrt
velocity vector (black arrow)
and Sun direction (yellow).

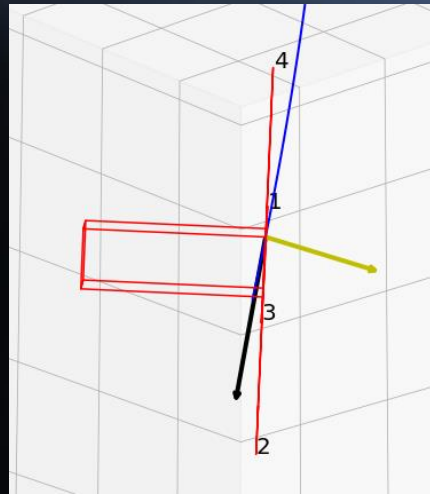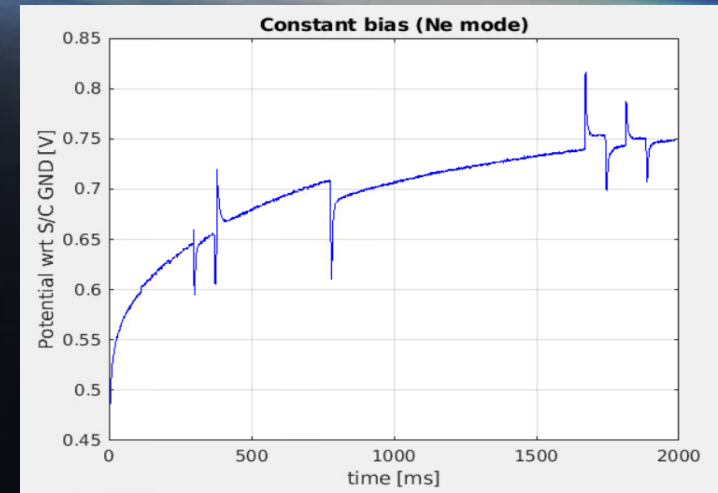Potential measured with floating probe.
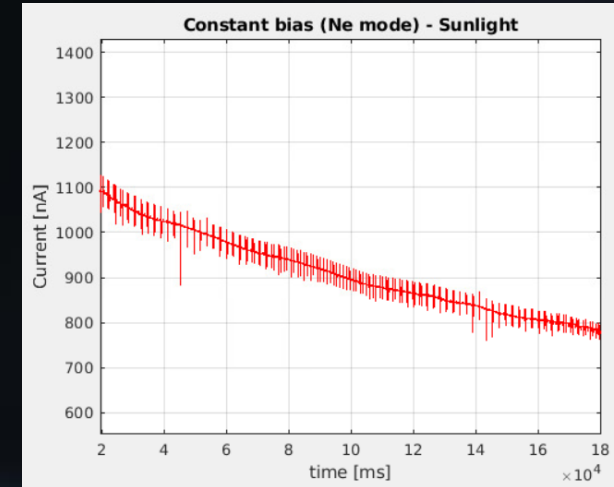
First results: fixed-bias mode

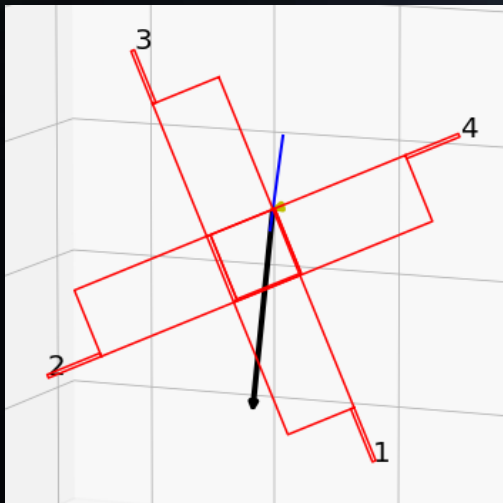Longer fixed-bias measurement **in sunlight**

N = ~ 2e11 /m³
Te= ~ 2200 K

- Probe #1: 6 V
- Probe #2: 4 V
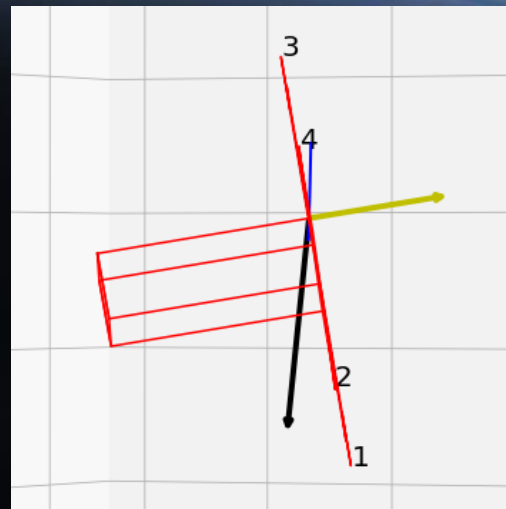- Probe #3: floating probe

- 1k sample / s

$\Rightarrow$ Noise structures from the platform visible both on current and potential
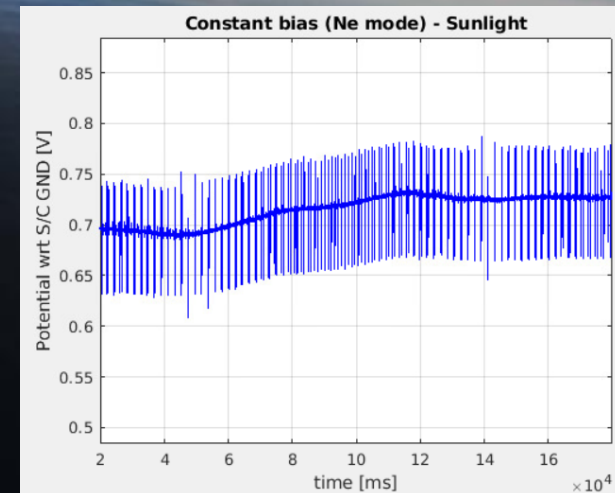

Current from probe #1

Attitude of PICASSO wrt velocity vector (black arrow) and Sun direction (yellow).

Attitude of PICASSO wrt velocity vector (black arrow) and Sun direction (yellow).

Potential measured with floating probe.

First results: fixed-bias mode

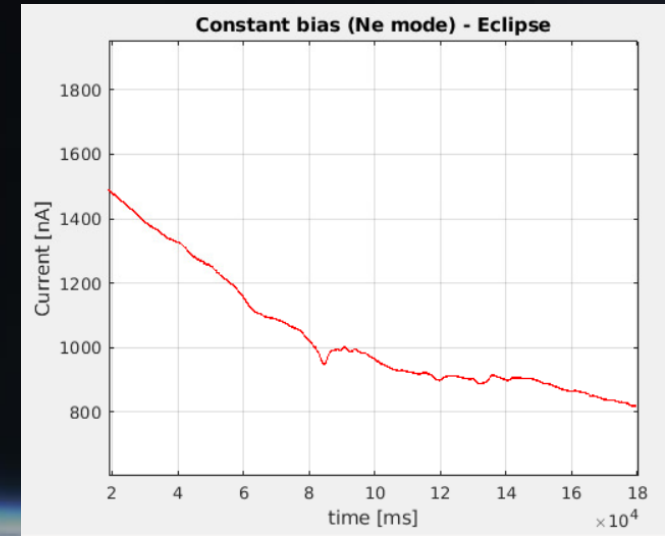Longer fixed-bias measurement **in eclipse**

N = ~ 4e11 /m³

Te= ~ 1600 K

- Probe #1: 6 V
- Probe #2: 4 V
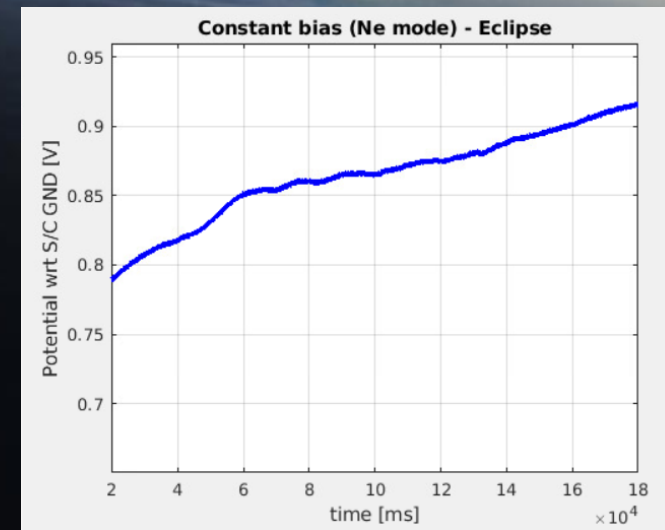- Probe #3: floating probe

- 1k sample / s

⇒ **No noise structures in eclipse**

⇒ **Noise attributed to Battery Charge Regulator (BCR)**

- Timing and duration of noise structures in sunlight compatible with BCR-originated noise

Current from probe #1

Potential measured with floating probe.

Conclusions

- PICASSO platform still in commissioning phase
    - ⇒ Limited number of measurements

- SLP health is nominal except that one probe seems to be disconnected
    - ⇒ Not critical since all four channels are identical (full redundancy)

- All SLP modes have been successfully tested

- Both linear and adaptive sweeps produce clean I-V curves

- Noise structures are visible when measuring in sunlight

    - ⇒ Preliminary tests indicate it is related to the Battery Charge Regulator (BCR) of the platform

    - ⇒ Still possible to perform I-V sweeps in sunlight, even if some curves are perturbed by the noise

    - ⇒ More of a problem for fixed-bias mode

- Assessment of probe surface contamination on going

- **Next steps:**

    - Validation of SLP data with EISCAT data (coordinated campaign)

    - When platform commissioning completed: start science mode

Thank you !

For more information: please contact sylvain.ranvier@aeronomie.be