Inputs on SPIS in relation to electron measurements on Solar Orbiter

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Oct 2018

25th SPINE Workshop

ESTEC

Baseline Mission Profile

- Launch: Feb 2020, Vehicle: NASA‘s Atlas V
- Total mission duration, incl. extended phase: >10 yrs
- Cruise phase (~3.5 years):
  - Chemical Propulsion;
  - Multiple gravity assist manoeuvres (Venus, Earth);
- Science phase:
  - Three-axis stabilised, Sun pointing;
  - Raising of orbit inclination angle;

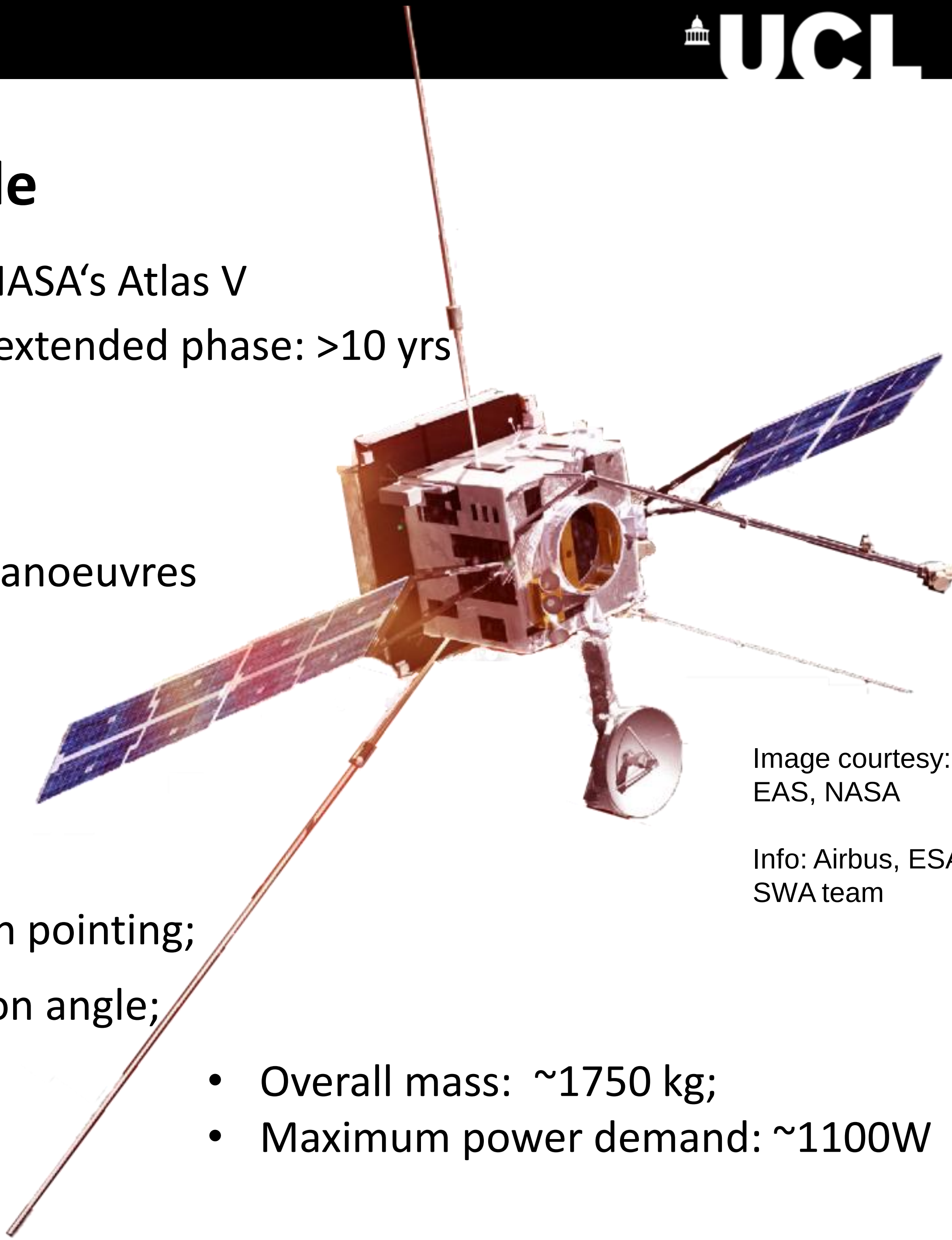

Image courtesy: EAS, NASA

Info: Airbus, ESA SWA team

- Overall mass: ~1750 kg;
- Maximum power demand: ~1100W

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Instruments and Measurements

Info: Airbus, ESA, NASA

	Investigation	Measurements
In Situ Group	Solar Wind Analyzer (SWA)	Solar wind ion and electron bulk properties, ion composition (1eV- 5 keV electrons; 0.2 - 100 keV/q ions)
	Energetic Particle Detector (EPD)	Composition, timing, and distribution functions of suprathermal and energetic particles (8 keV/n – 200 MeV/n ions; 20-700 keV electrons)
	Magnetometer (MAG)	DC vector magnetic fields (0 – 64 Hz)
	Radio & Plasma Waves (RPW)	AC electric and magnetic fields (~DC – 20 MHz)
Remote Sensing Group	Polarimetric and Helioseismic Imager (PHI)	Vector magnetic field and line-of-sight velocity in the photosphere
	EUV Imager (EUI)	Full-disk EUV and high-resolution EUV and Lyman-α imaging of the solar atmosphere
	Spectral Imaging of the Coronal Environment (SPICE)	EUV spectroscopy of the solar disk and corona
	X-ray Spectrometer Telescope (STIX)	Solar thermal and non-thermal X-ray emission (4 – 150 keV)
	Coronagraph (METIS/COR)	Visible, UV and EUV imaging of the solar corona
	Heliospheric Imager (SolOHI)	White-light imaging of the extended corona

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SWA Hardware Elements

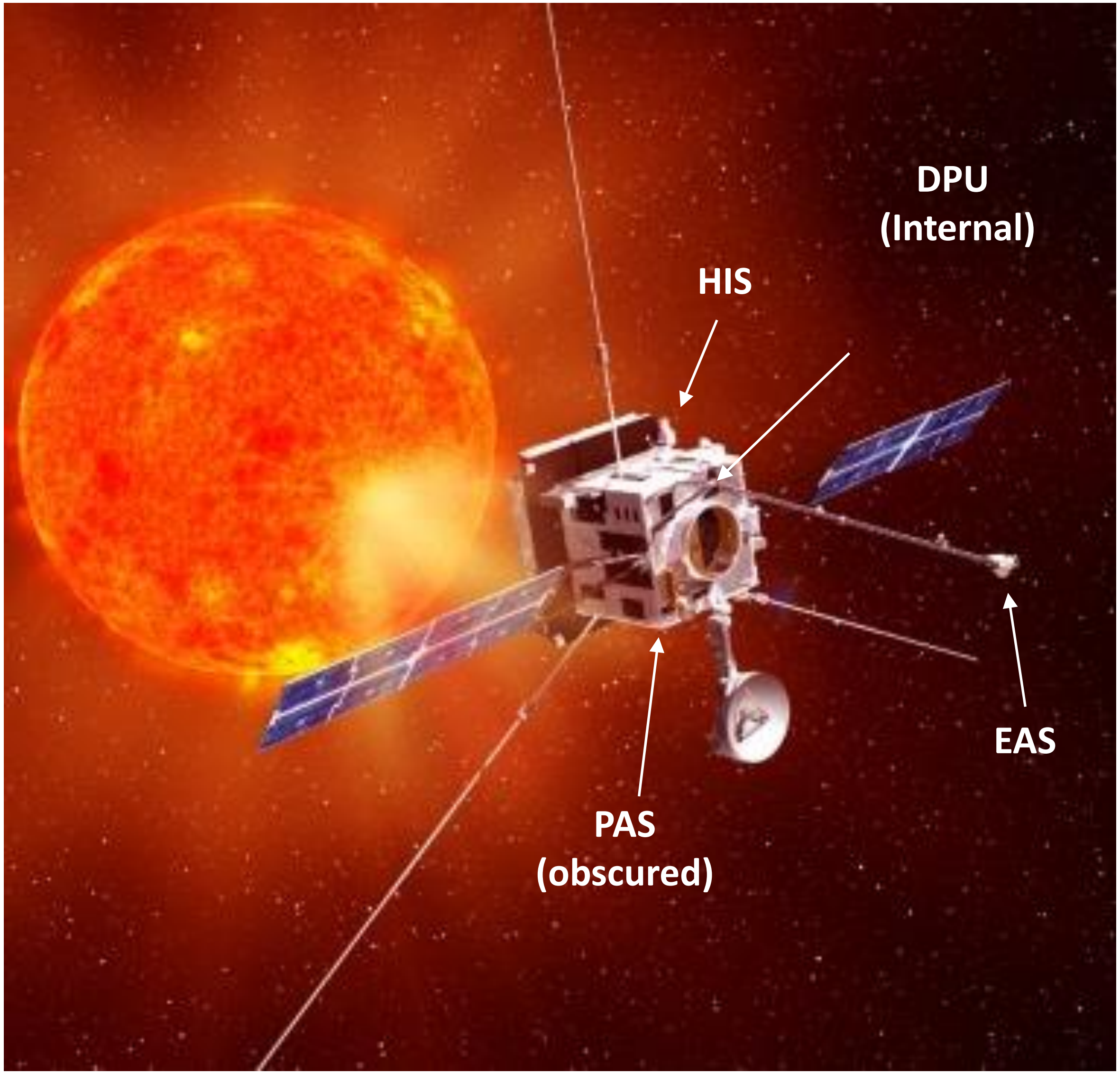

Image courtesy:
EAS, NASA

Info: Airbus, ESA
SWA team

SWA Hardware Elements

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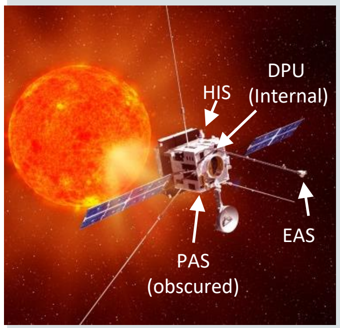
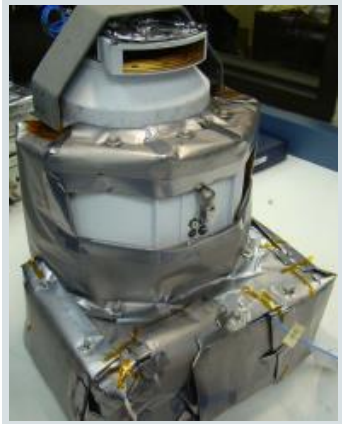
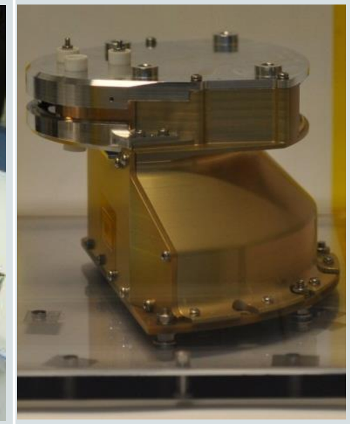
Subsystem	Electron Analyser system (EAS)	Heavy Ion sensor (HIS)	Proton and Alpha sensor (PAS)	Data Processing Unit (DPU)
				
Species	Electrons	Heavy Ions	Protons and Alpha Particles	-
Measurement	High temporal resolution determination of the core, halo and strahl **electron** velocity distributions (1 eV < E < 5 keV) and their moments	Major charge states of C, O and Fe; 3-D velocity distributions of prominent heavy solar wind ions, suprathermal ions, and pick-up ions of various origins, such as weakly-ionized species (He^+, O^+)	The velocity distribution of **protons and alpha particles** (0.2 < E < 20 keV/q) at high time resolution equivalent to the ambient proton cyclotron period.	Provide SWA suite control, commanding and data handling functions.

The SWA Electron Analyser System (EAS)

- 3D Electrons measurement , 0 - 5 keV, using electrostatic analyser
- Combined FoV is full sky (although there is blockage by the spacecraft).

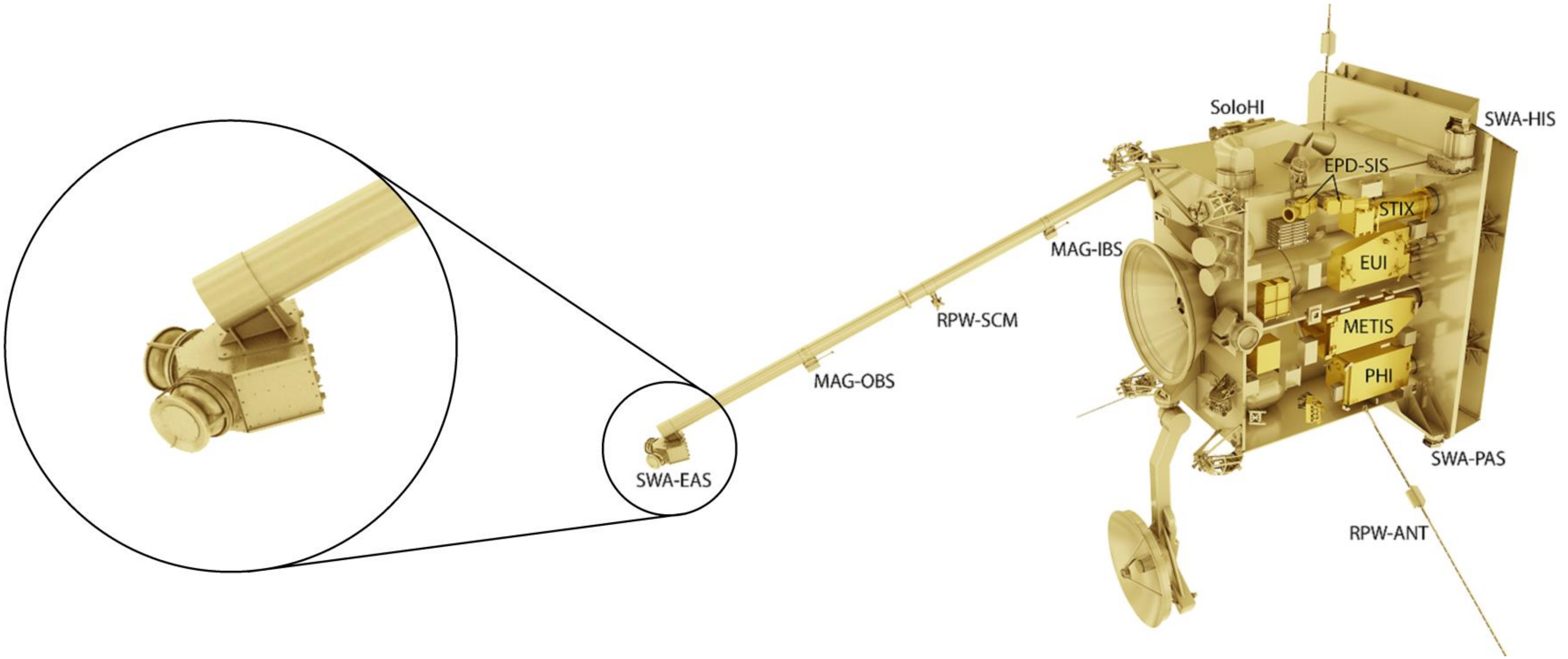


Image courtesy:
EAS

The SWA Electron Analyser System

- 3D Electrons measurement , 0 - 5 keV, using electrostatic analyser
- Combined FoV is full sky (although there is blockage by the spacecraft)
- Additional blockage due to the new baffle being added

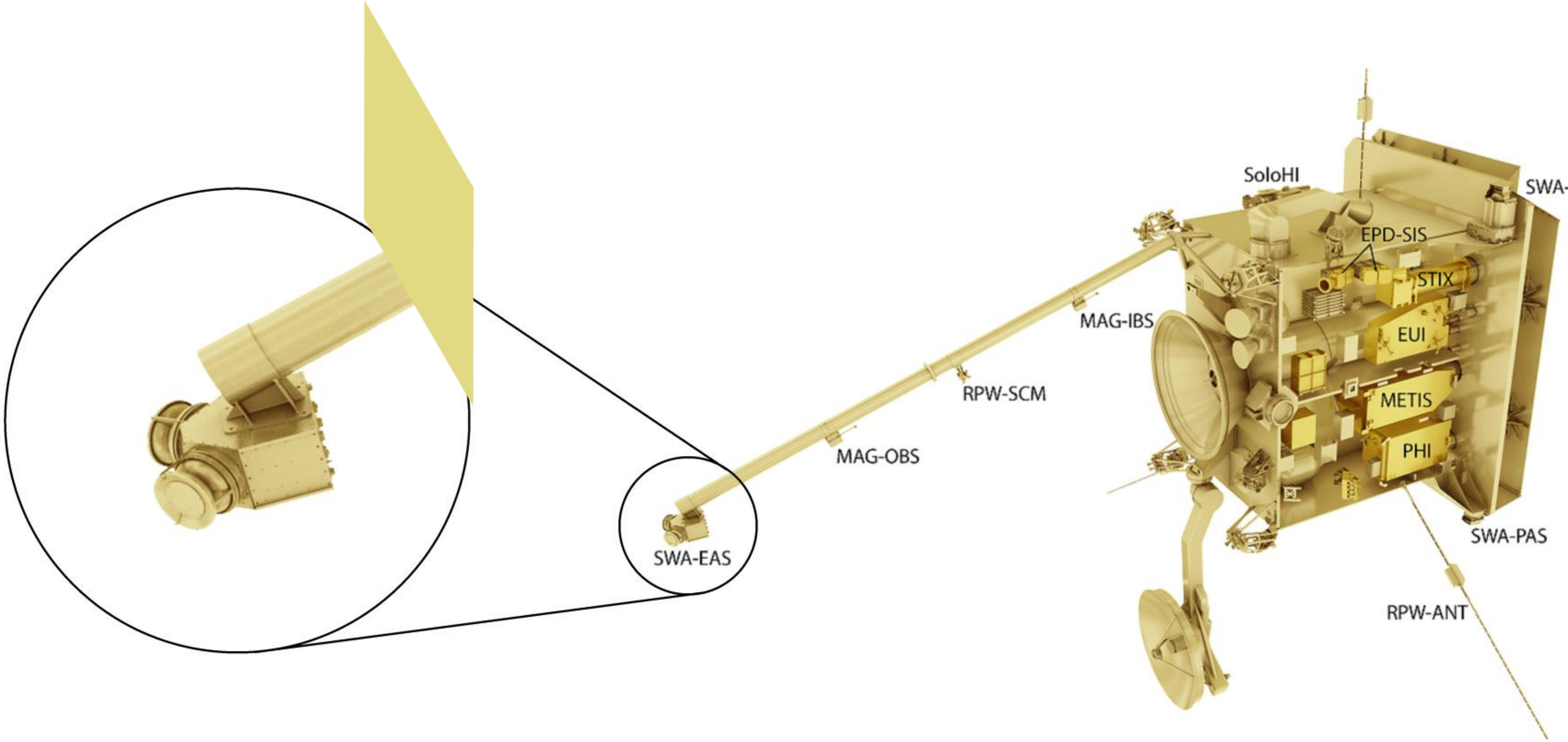
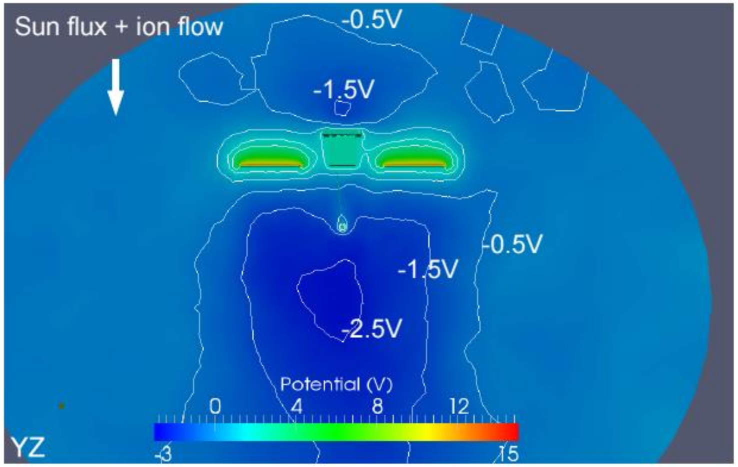


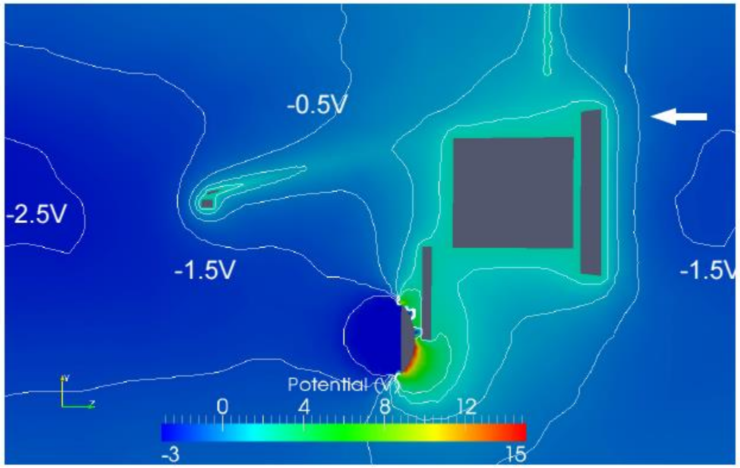
Image courtesy:
EAS

Challenges

- Spacecraft charging can potentially affect the science done by the particle instruments including SWA sensor.

- EAS original requirements :
  - no part of S/C should be charged +1 V different to the other part
  - no strong charging overall (> ~10V)
  - no strong B field, which affects the electron distributions





Spacecraft potential simulations by Stanislas Guillemant and Vincent Genot, IRAP

Example of an excellent study done by Déprez et al.:

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Electrostatic perturbations due to all non-grounded surfaces on Solar Orbiter

Grégoire Déprez, Fabrice Cipriani and Axel Junge

July 06th, 2018

Courtesy of Solar Orbiter project / ESTEC
Presented by Déprez et al., July 2018

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Recap of Non conductive / isolated surfaces and associated potentials

S/c Surface	Potential (V)
RPW antennas	6.5
PAS/HIS radiators and SoloHI PCBE	-100
Solar cells coverglass	8
Solar arrays internal gaps and edges	-100
Inner IBoom ice deposit	-5
Outer Iboom ice deposit	-3
MAGOBS Ice layer	-40
MAGIBS Ice layer	-13
EAS baffle ICE layer	-2
Yoke shadowed OSRs (80mm large)	-100
SPICE SORA OSRs + platform radiator OSRs	-5 / -20

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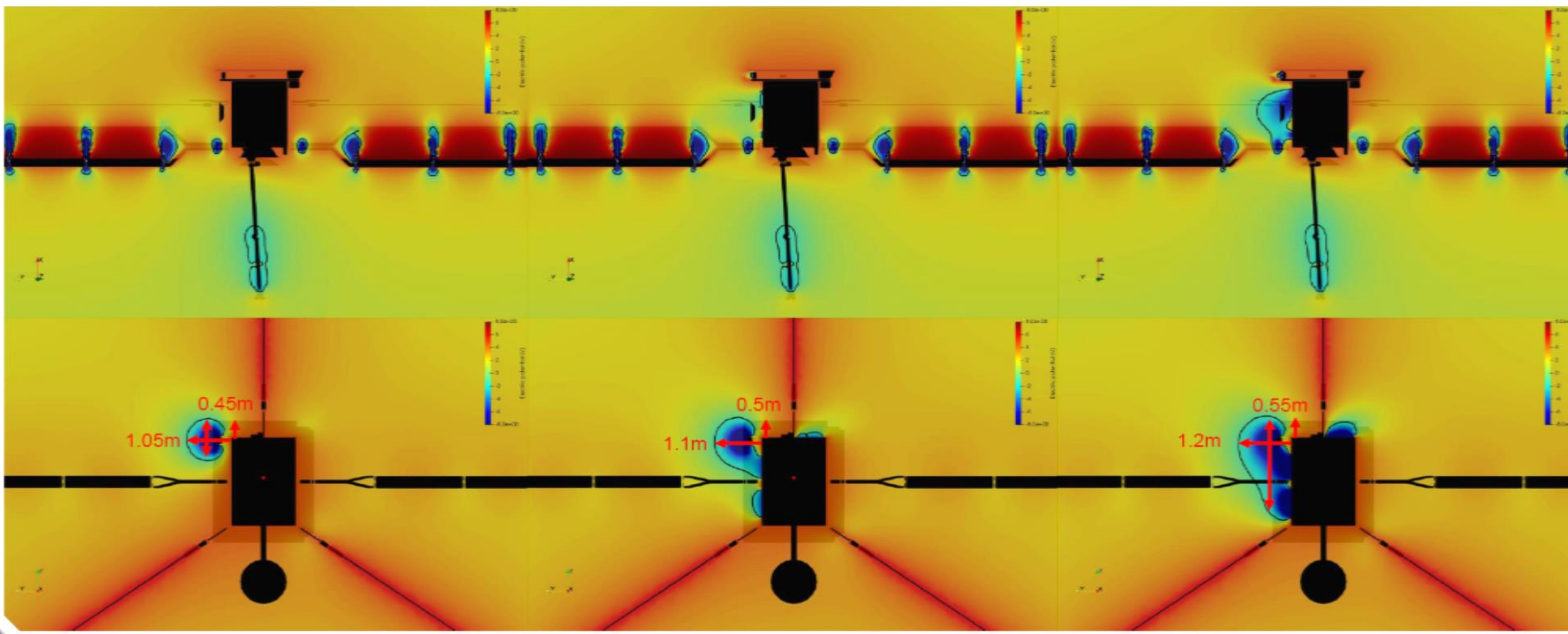
Electrostatic potential perturbation extension comparison

Case 1 (all OSRs at SC GND) | Case 2 (all OSRs at -5V) | Case 3 (all OSRs at -20V)



Open questions:

- Propellants differ in types, and as a result the ice composition varies
  - **Could SPIS include the composition of droplet and or their conductivity profile based on the temperature ?**

- Droplets can contaminate the S/C via scattered spots of ice, or as a solid layer.
  - **Could SPIS include calculations based on the effect of each?**

- The design of Solar Orbiter (including adding baffle) are all to make sure the measurements are least affected. However there will be S/C charging, and:
  - **After the launch of Solar Orbiter, SPIS will be crucial for understanding how the charging affects our electron measurement.**

End-to-end simulation:

- SPIS is a powerful tool, and indeed very valuable for the science to be done by Solar Orbiter.

- Analysis of various surfaces had been done. For the best science operations we would prefer to have the S/C model with **all the surfaces included.**

- Ideally, we would like to be able to do a simulation where:
  - The user could enter environmental conditions, e.g. distance to the sun
  - Add a source of electrons in infinity
  - Run SPIS and see how S/C charging affects the distribution of the electrons (for instance the trajectory , and velocity)

  ✓ **This way we could take the measured distribution, and extract the original distribution of the plasma .**