UCL DEPARTMENT OF SPACE AND CLIMATE PHYSICS
MULLARD SPACE SCIENCE LABORATORY

Spacecraft effects on electron measurements - combining SPIS with data from Solar Orbiter's Solar Wind Analyser

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5. Planetek, Bari, Italy

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- 1b. Solar Orbiter: Architecture

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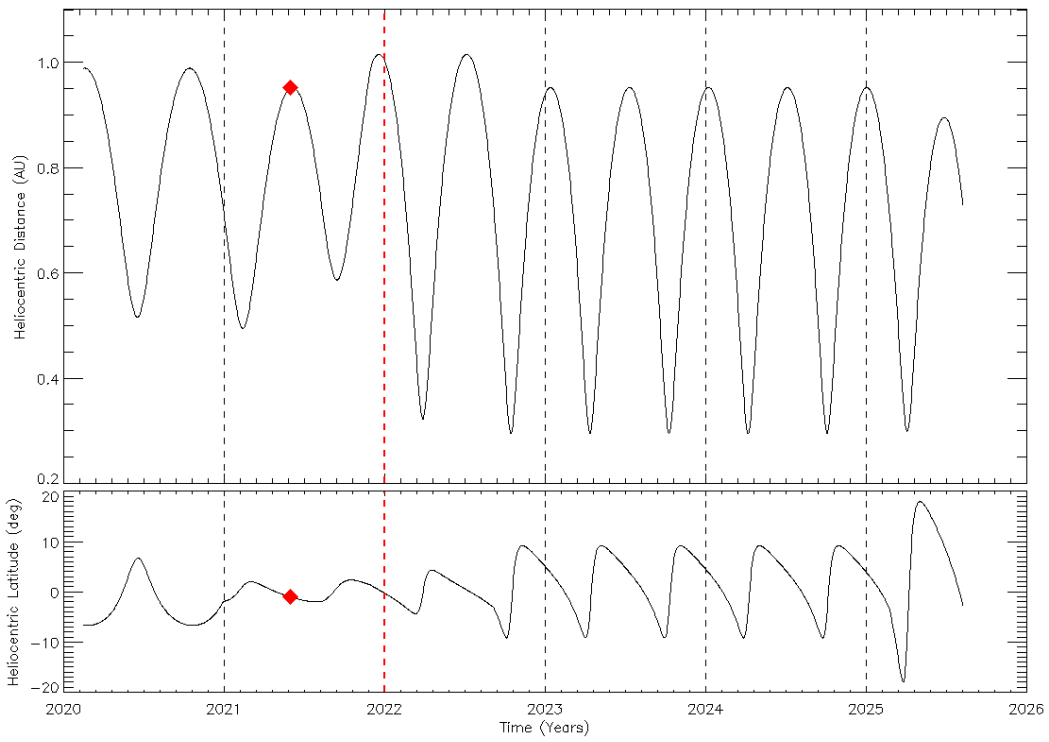
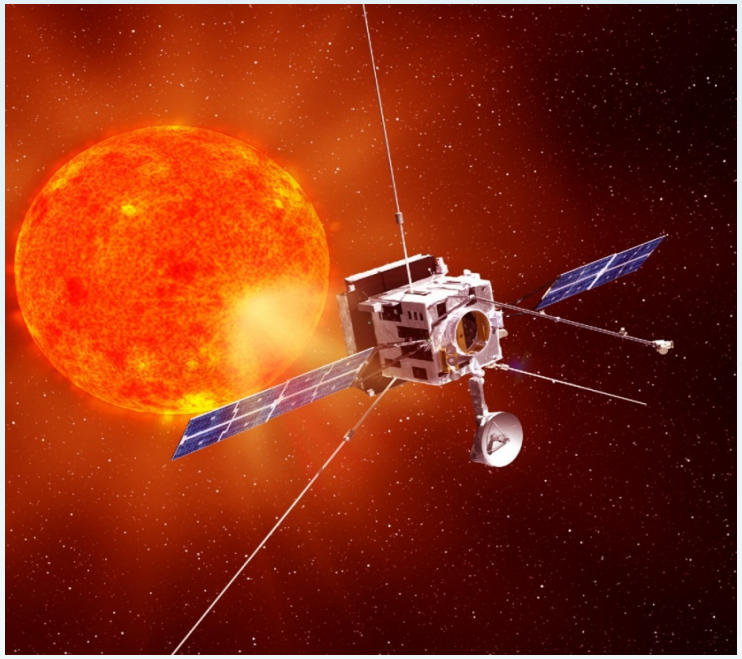
- 4b. SPIS: Some initial results

- 5. Conclusion

Solar Orbiter: Orbits

- Solar Orbiter was launched on the 10th February 2020
- It has been in orbit for 16 months
- Has recently completed its second full orbit

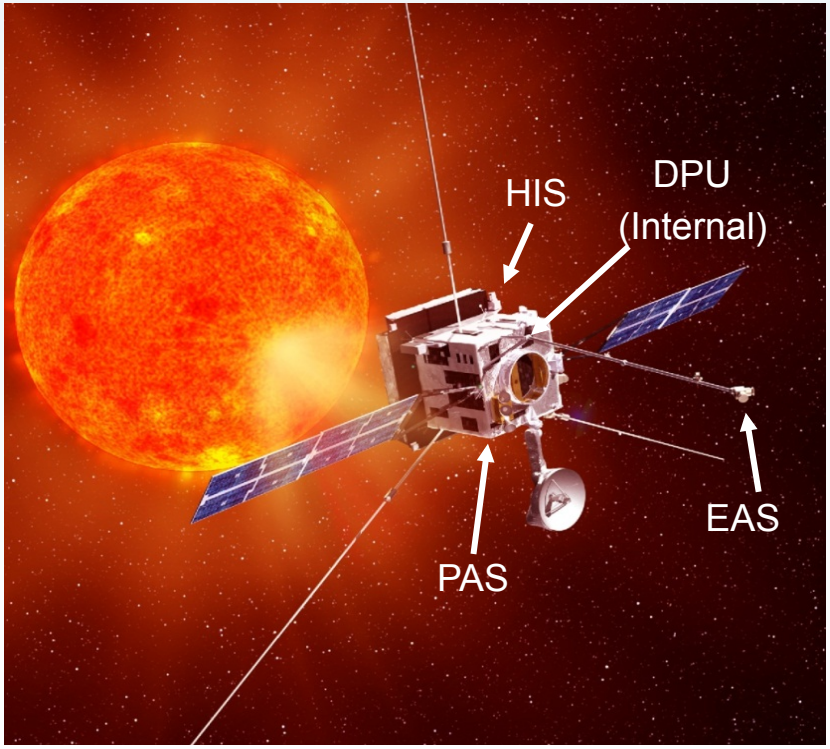


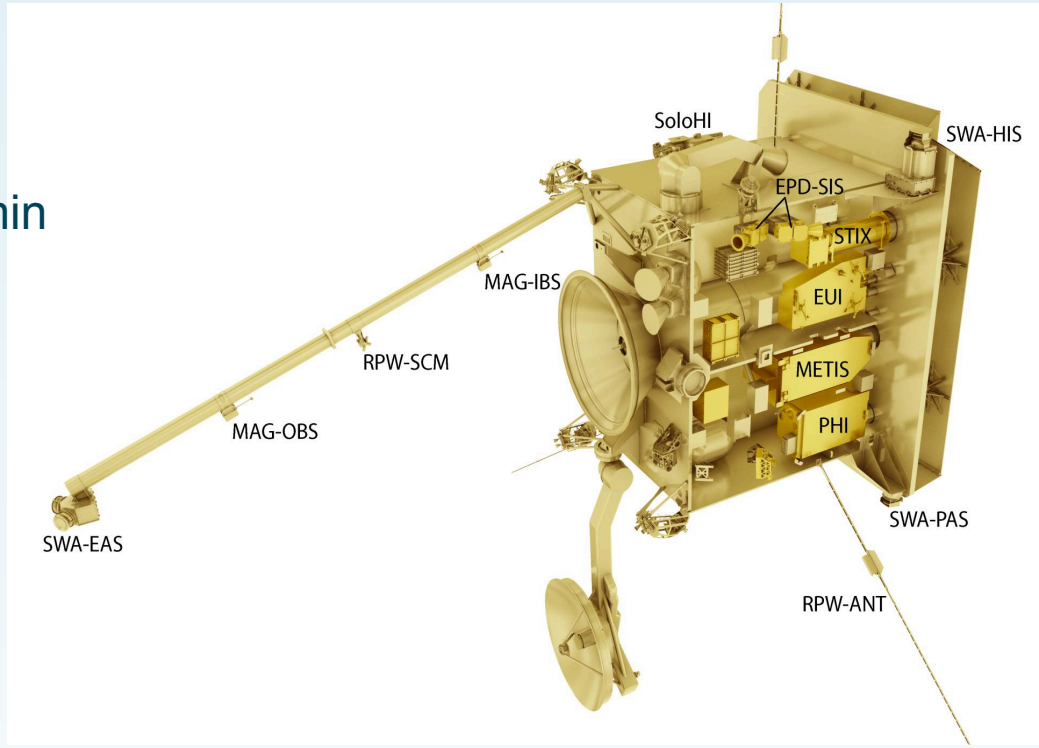


- The SC is still in its Cruise Phase
- The Science Phase begins at the start of 2022

Solar Orbiter: Payloads

- 10 instruments on board
- *Remote Sensing* instruments will operate around closest approach & min and max latitudes
- *In situ* instruments will operate continuously

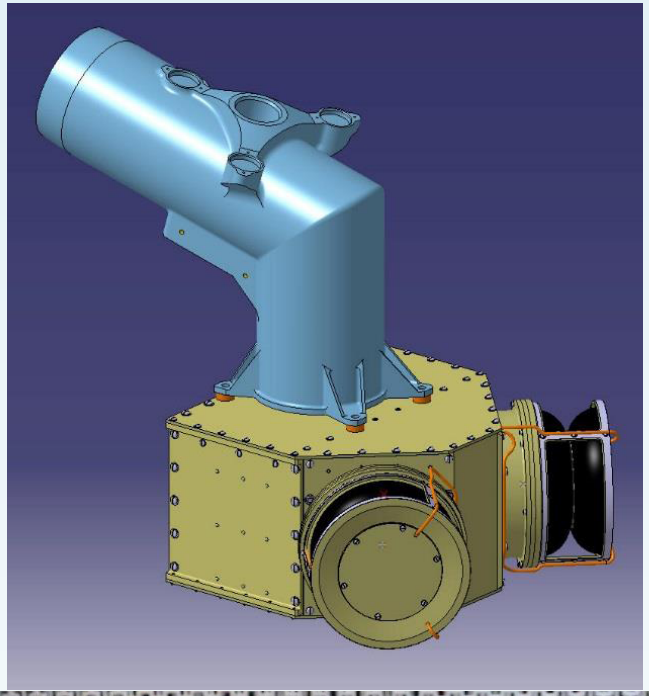


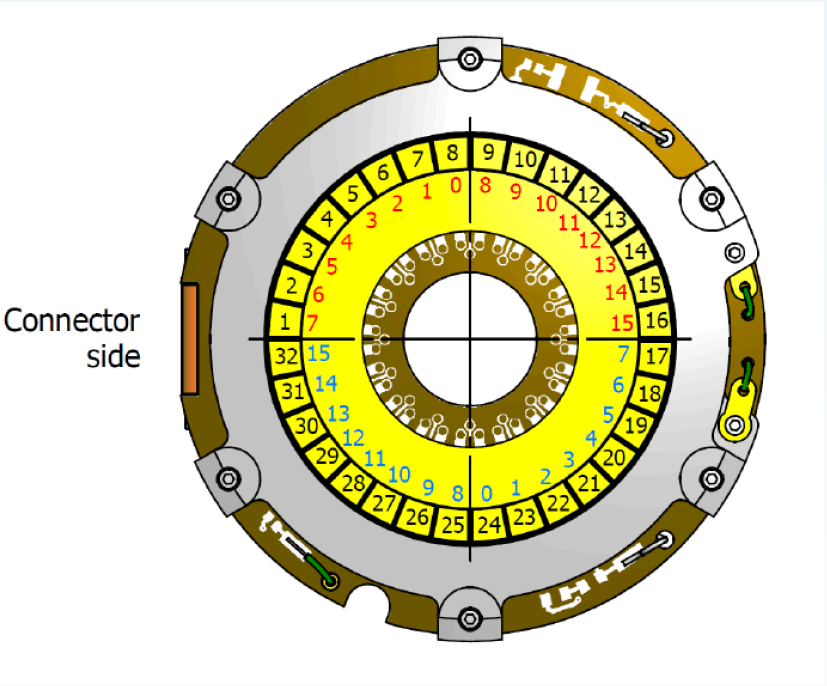


- The **Solar Wind Analyser (SWA)** is made of 3 separate sensors:
- Heavy Ion System (HIS), SwRI & UMich, USA
- Proton Alpha System (PAS), IRAP, France
- **Electron Analyser System (EAS), UCL-MSSL**
- Data Processing Unit DPU, 3 companies, Italy

Solar Orbiter: SWA-EAS

- SWA-EAS is a Top-Hat electrostatic analyser
- Electrons are measured on **32 anodes** that cover 360 degrees





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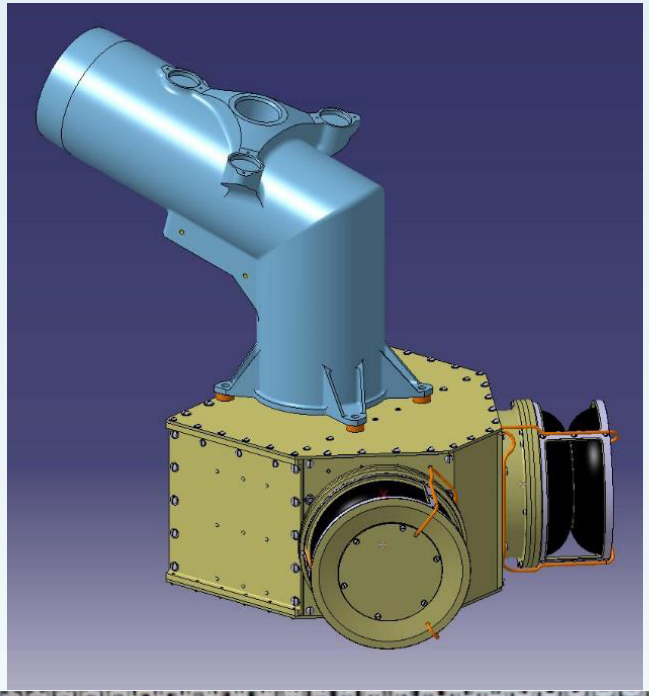

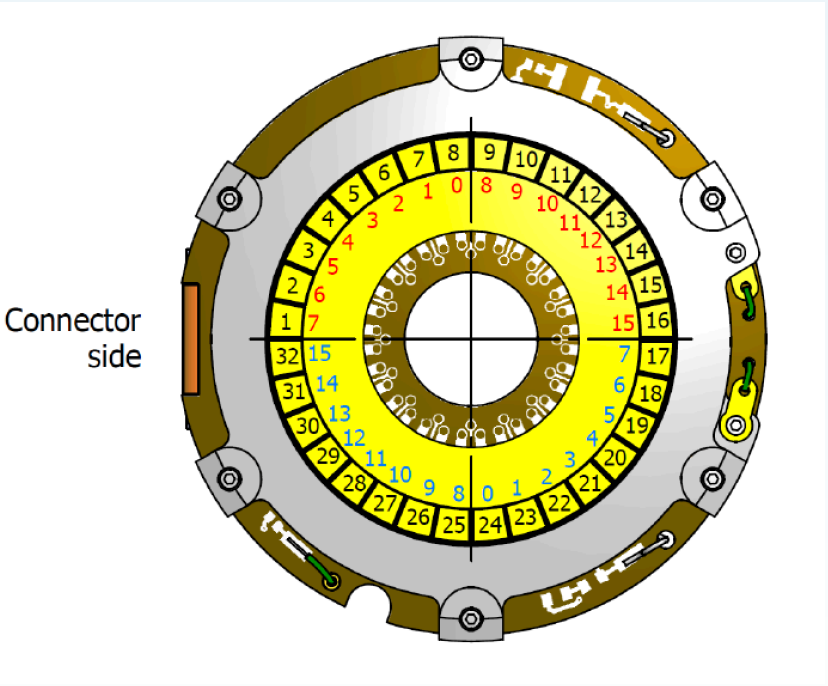

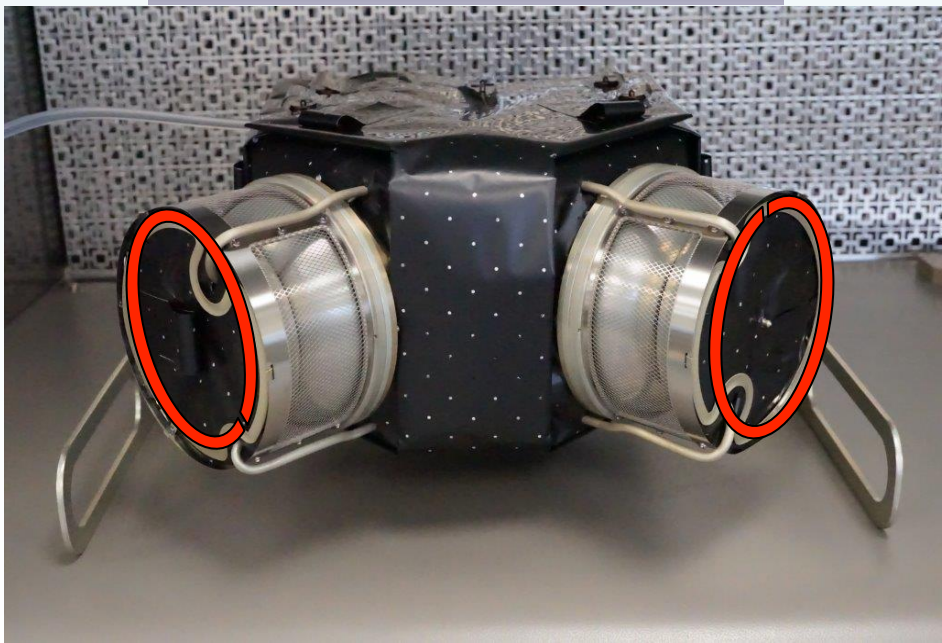

Solar Orbiter: SWA-EAS

- SWA-EAS is a Top-Hat electrostatic analyser
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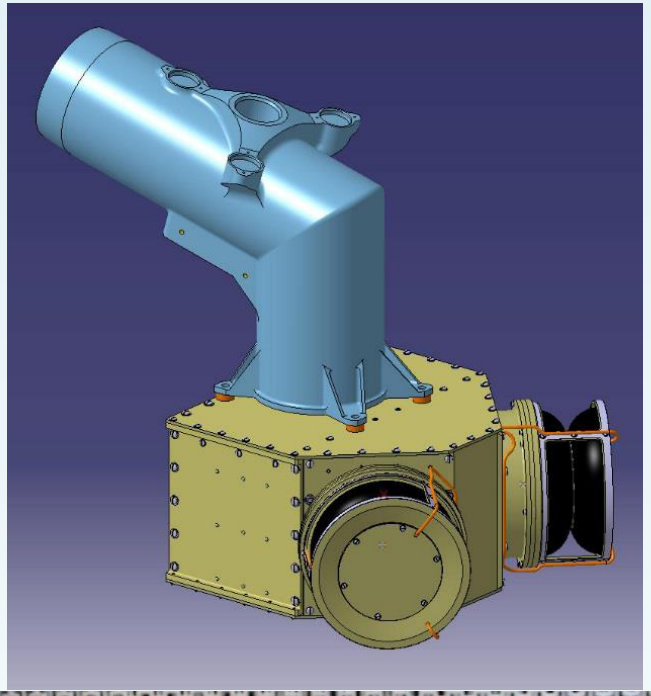
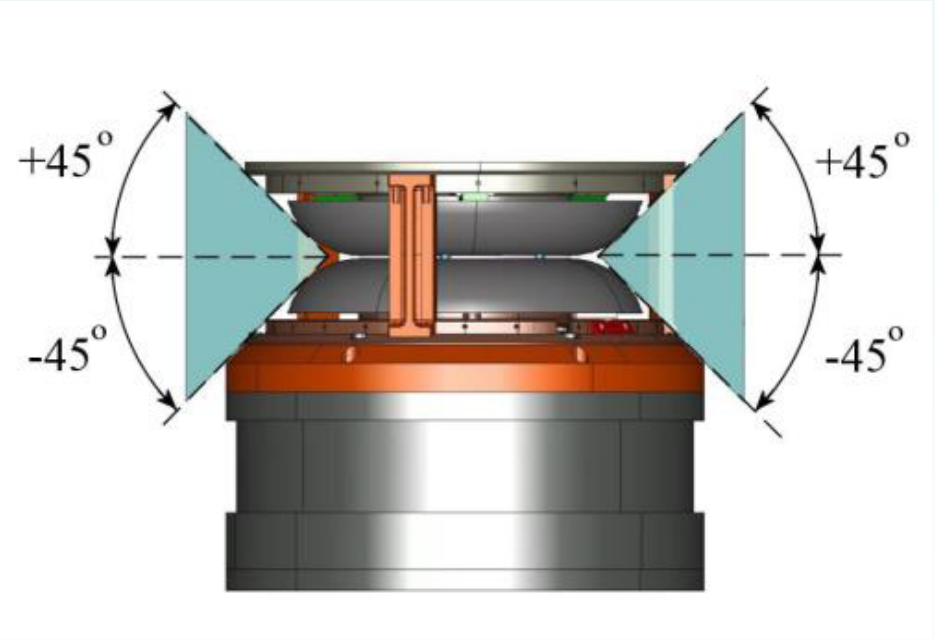
- Electrons are directed into **16 Elevations** that cover a 90 degree spread





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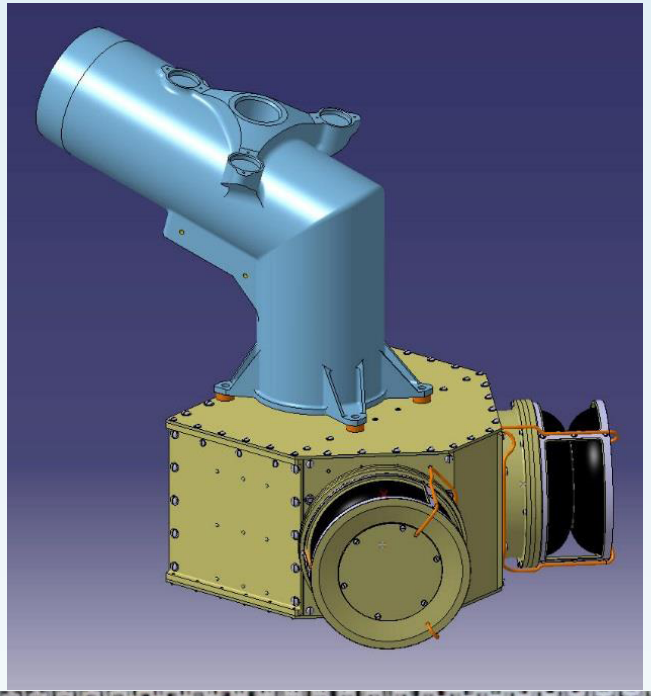

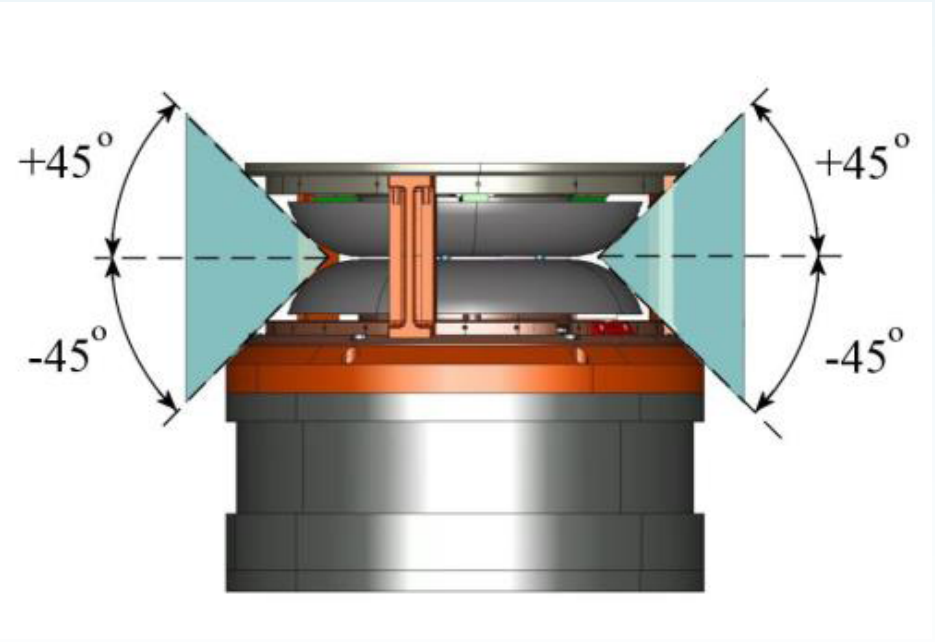

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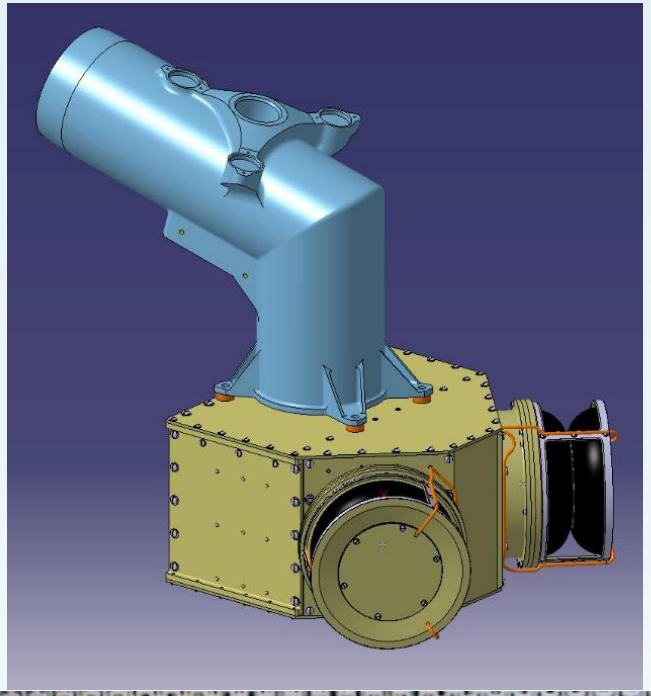
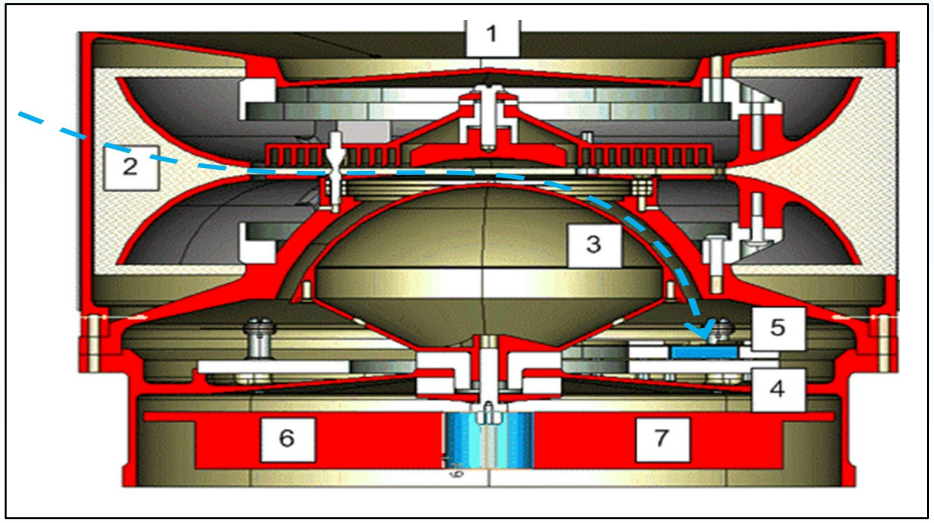
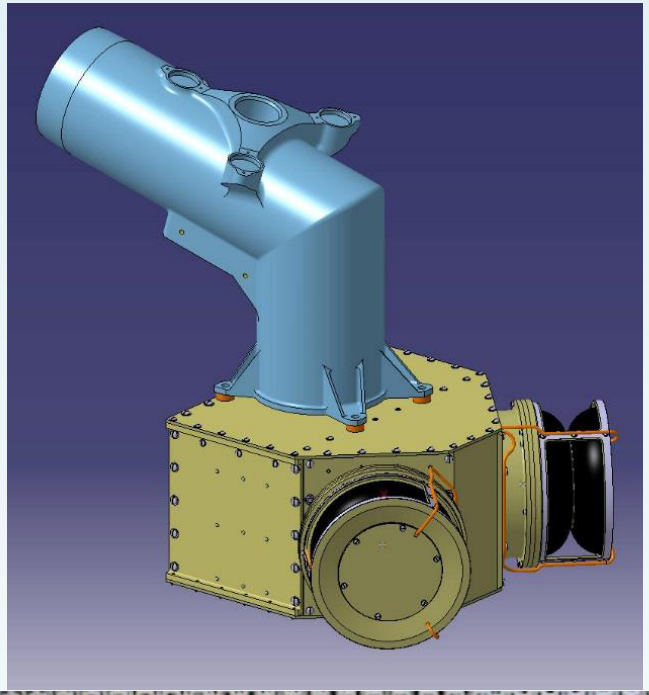
- Electrons are directed into **16 Elevations** that cover a 90 degree spread
- Electrons are measured over a spectrum of **63 energies** from 0.5eV to 10KeV

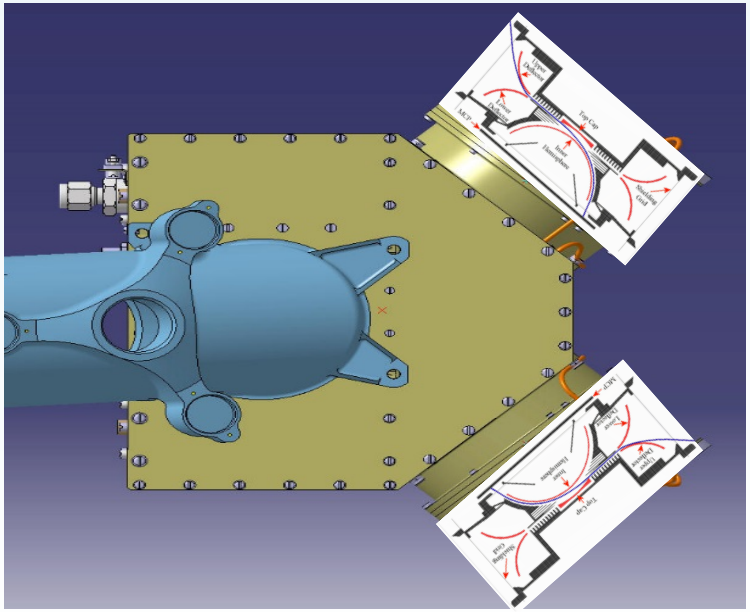




Solar Orbiter: SWA-EAS

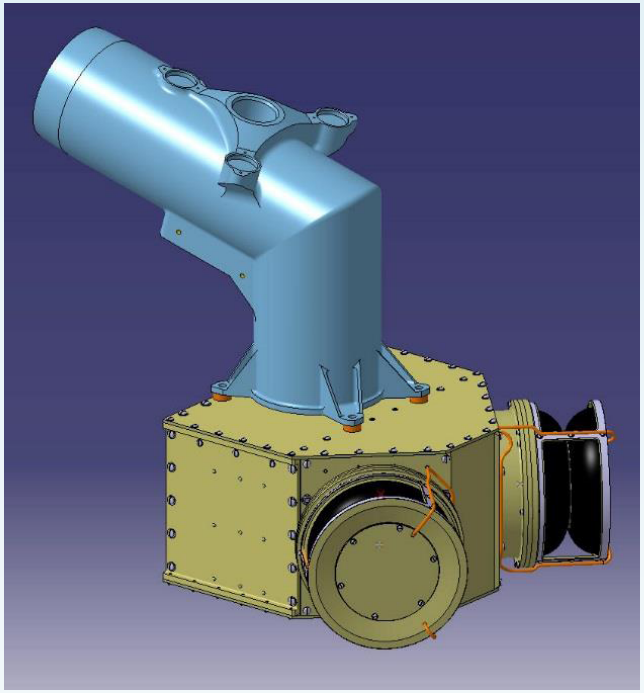
- In **1 second** each EAS covers the 63 energy levels, & the 16 deflectors & the 32 anodes
- The 2 EAS ‘Heads’ are offset from each other by **90 degrees**
- This means that in 1 second the 2 EAS heads measure electrons over the entire **4π space** around the EAS instrument

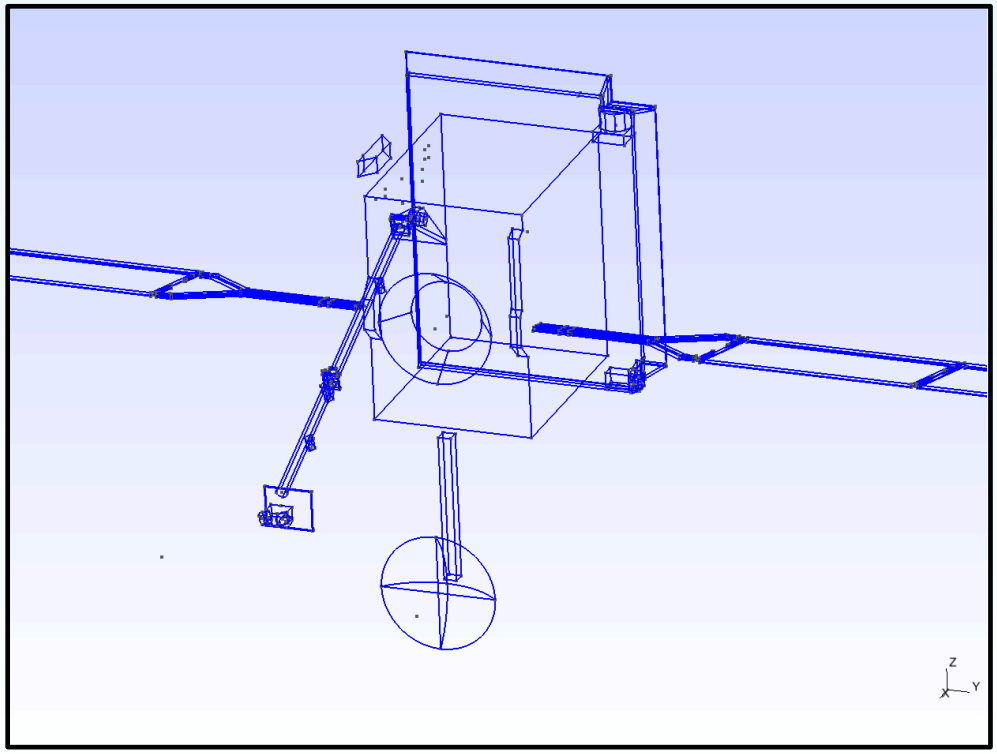




Solar Orbiter: Architecture

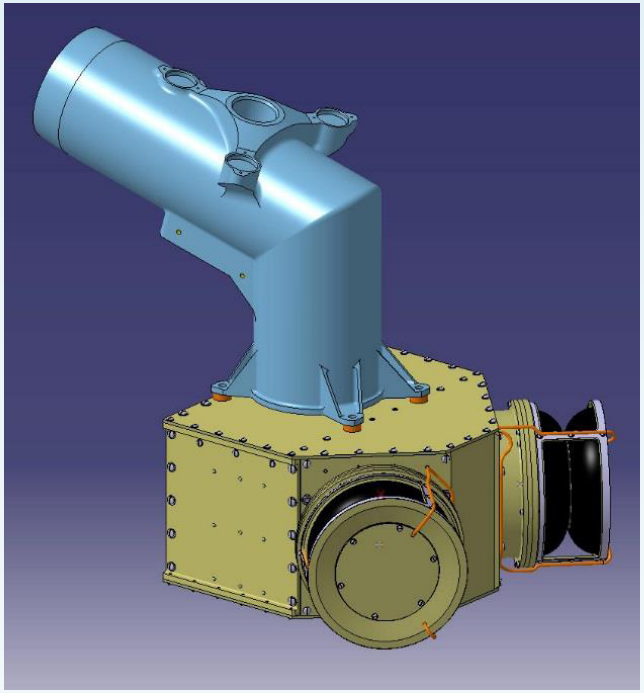
- SWA-EAS has a **4π FOV**
- The SC has many features that can interfere with EAS FoV
- Solar Arrays, SC body, Baffle plate, HGA etc

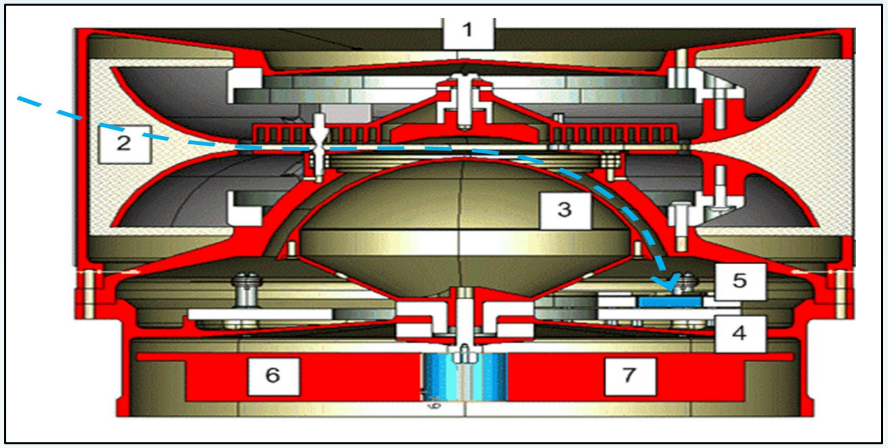


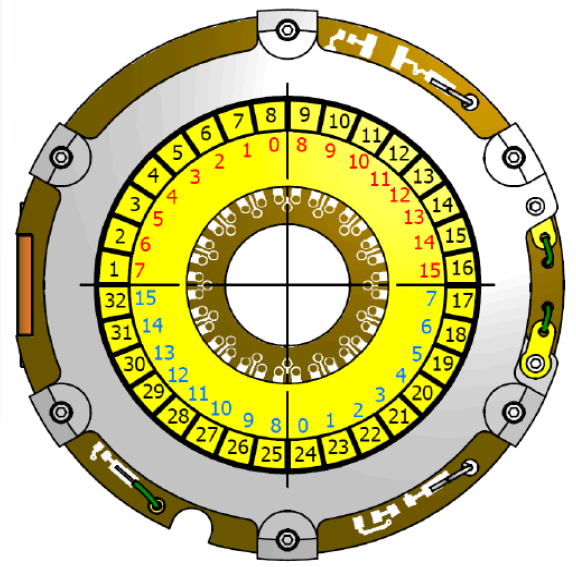


Solar Orbiter: Instrument Interference

- SWA-EAS has a **4π FOV**
- The instrument also has features that can interfere with EAS FoV

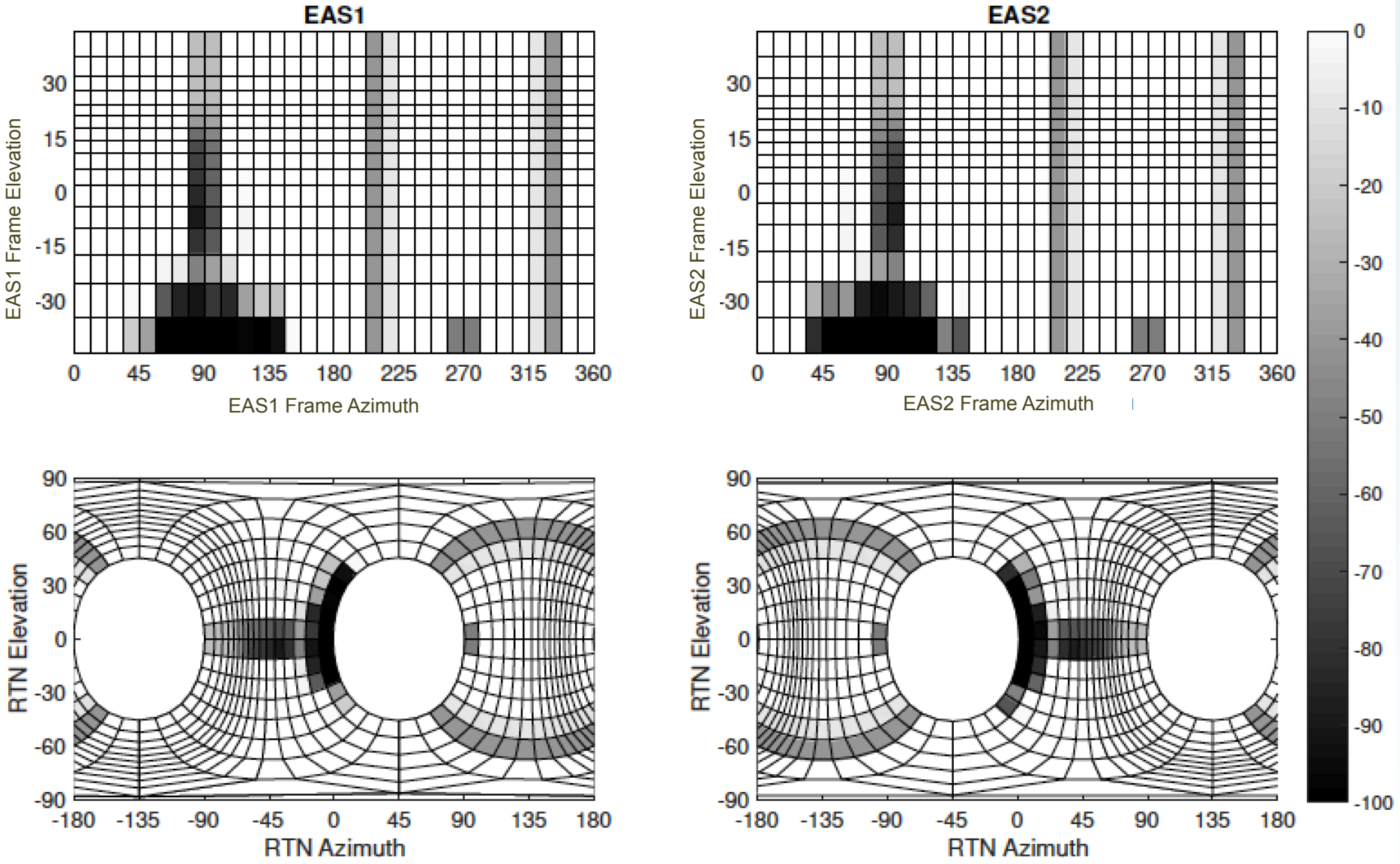






Solar Orbiter: Instrument Interference

- Percentage of pixel blockage in sensor frame & in a RTN frame



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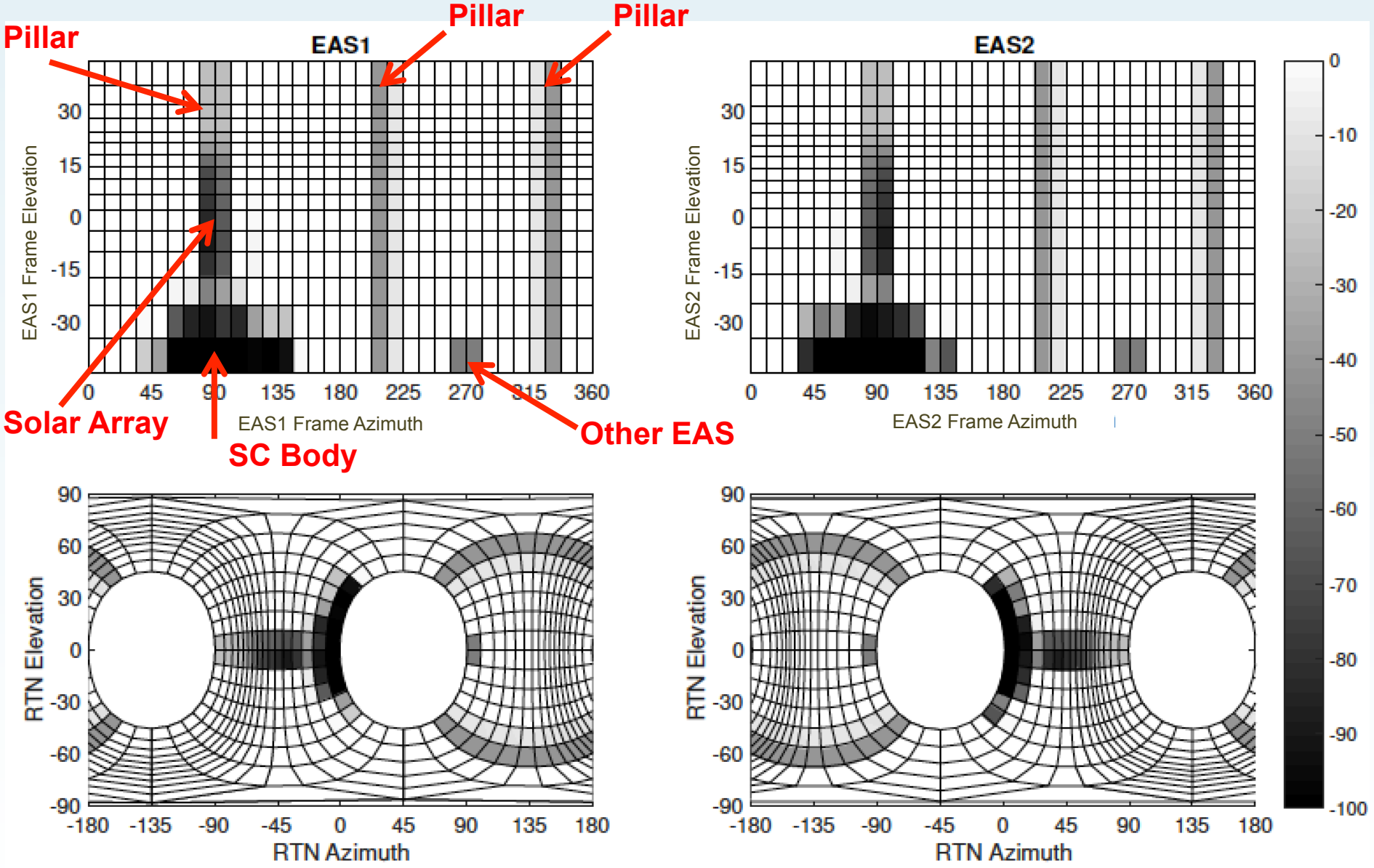
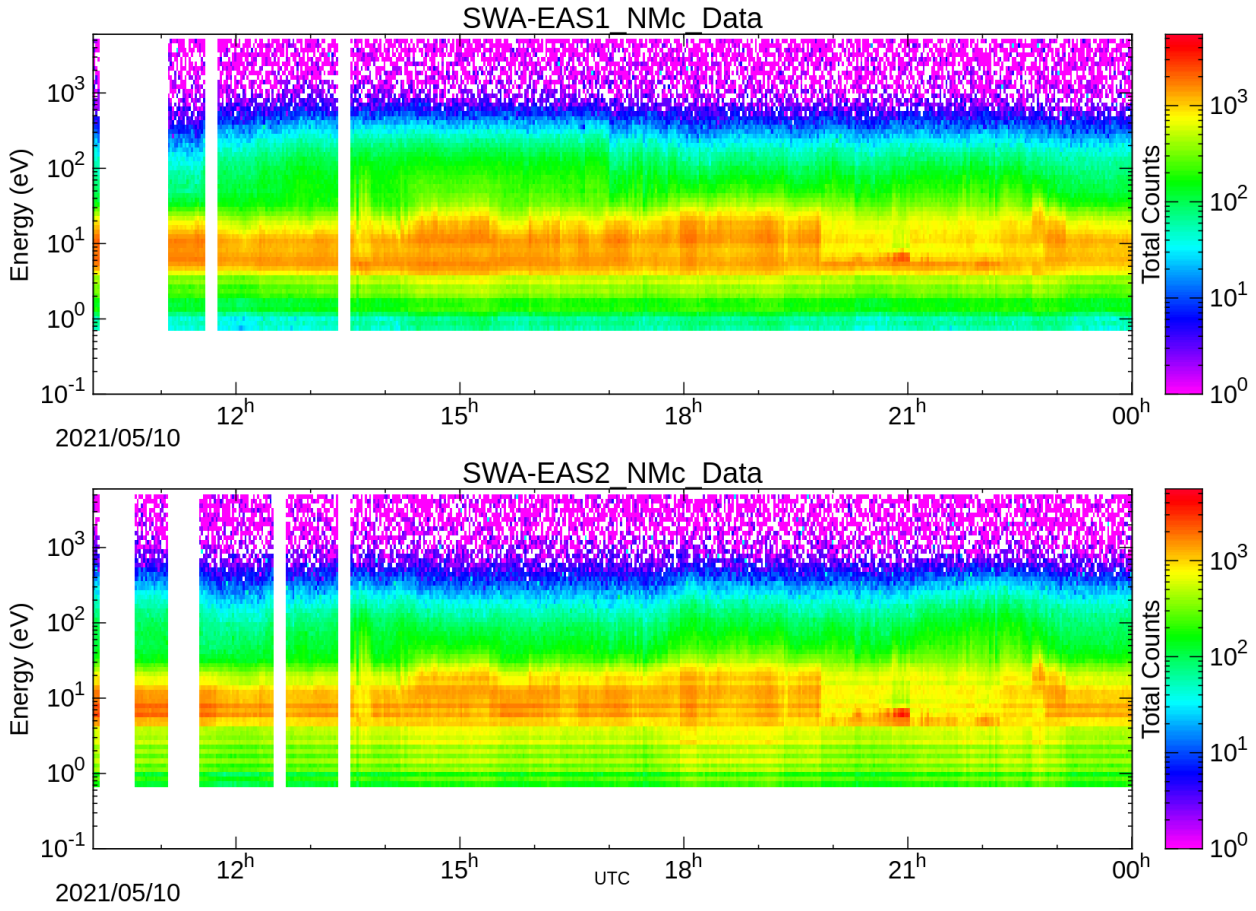


EAS Data

- The EAS data is a [time, 63, 16, 32] array per day
- It is usually displayed as a time, energy spectrogram for each 32 anodes and 16 deflector
- Or with averaging or summing over the anodes & deflectors



- Notice the distribution peaks at ~10 eV

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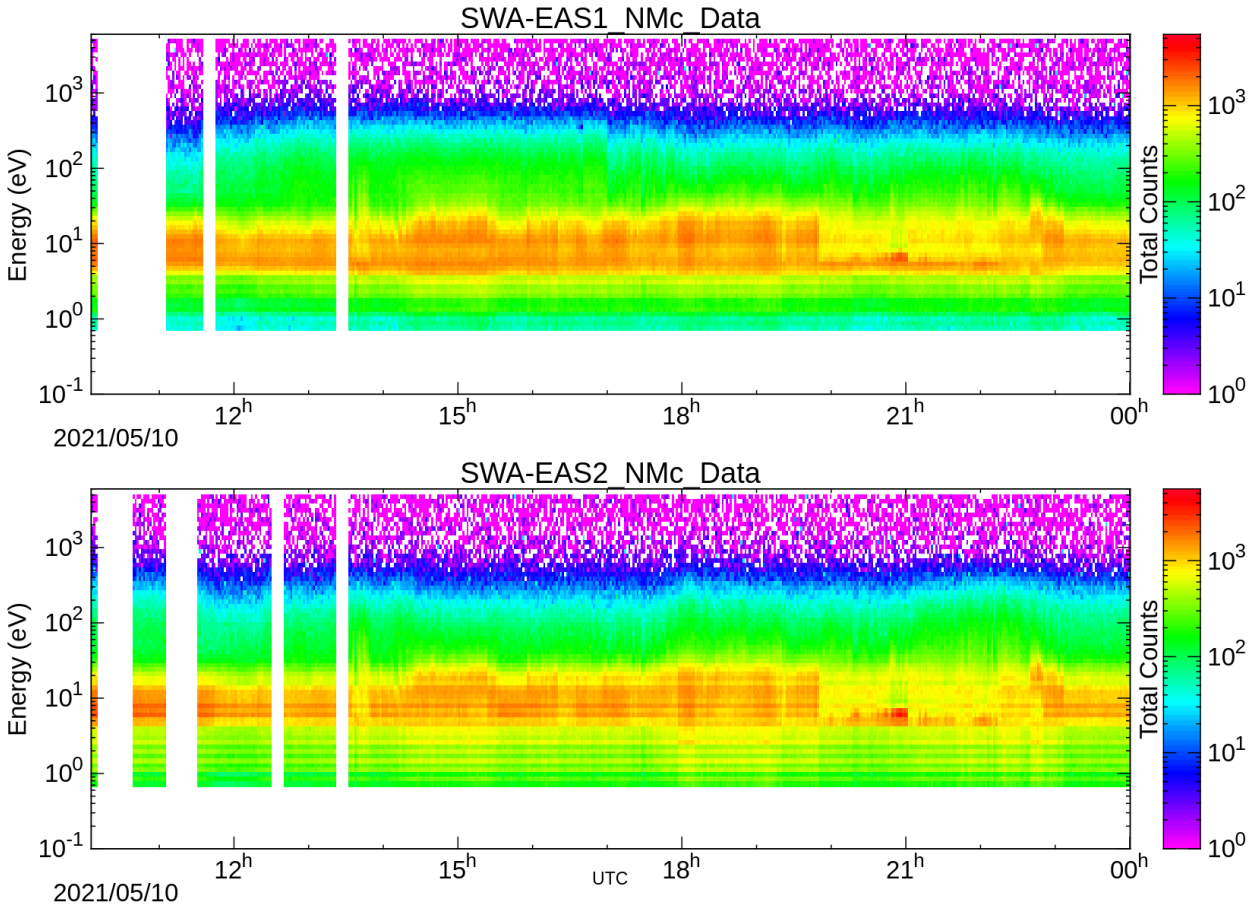
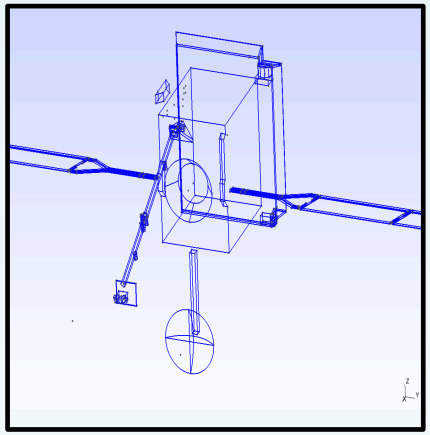
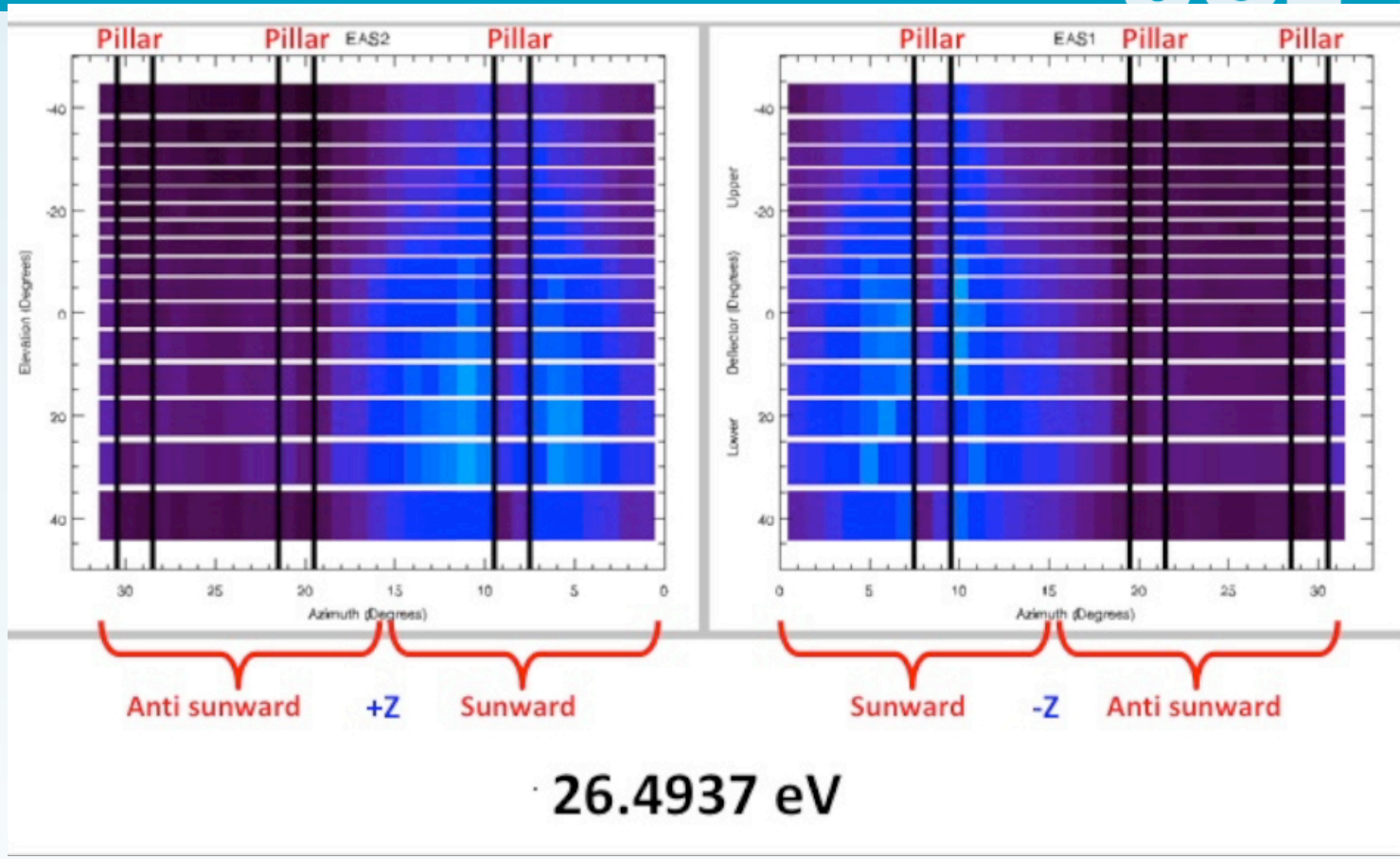
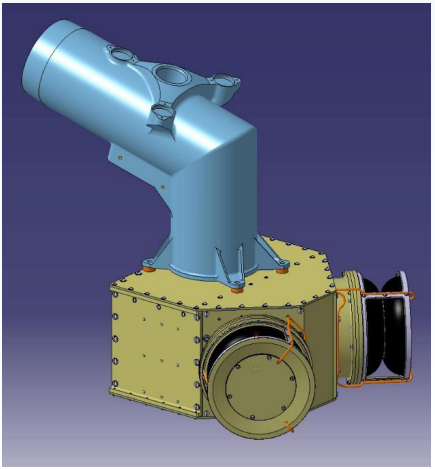


- Notice the distribution peaks at ~10 eV
- In the following plot (movie??) I have summed over the whole time array rather than the anodes and deflectors …….

EAS Data



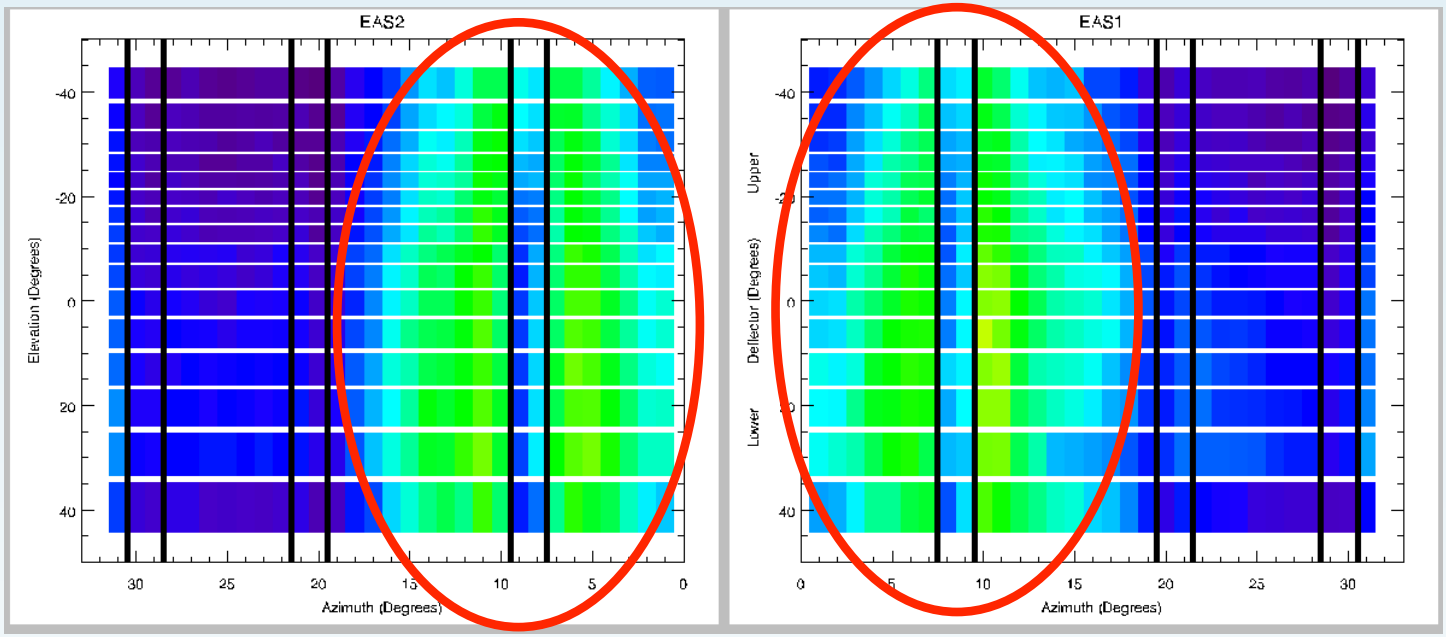




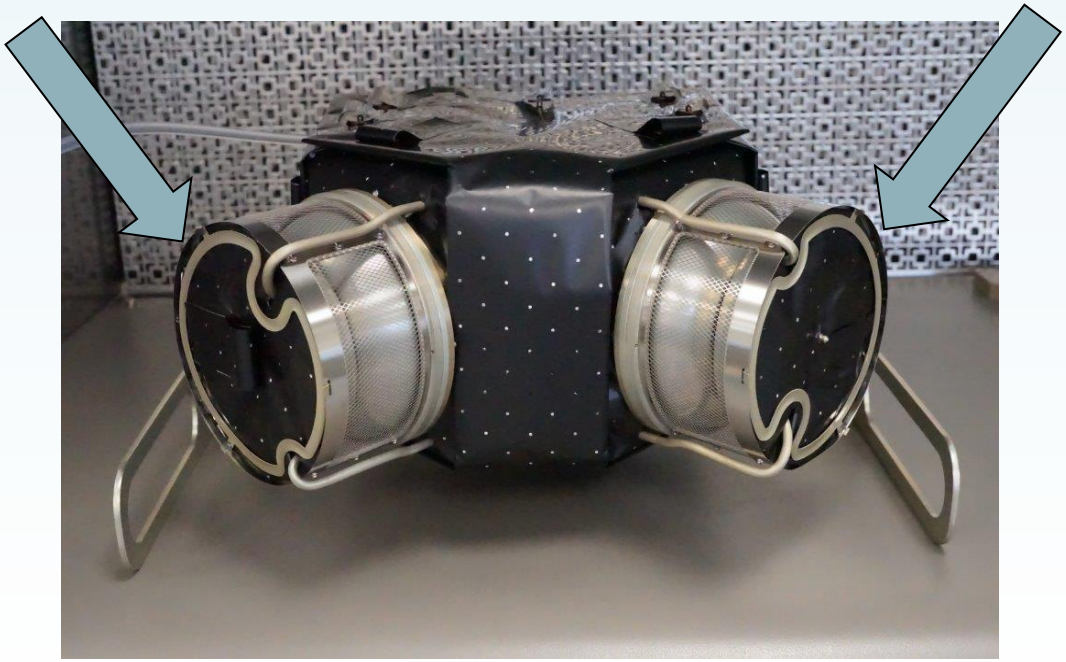
- Lots of direction & structure in the measured plasma
- Not all of it is real Solar Wind
- Lots of SC effects, enhancements, blockages
  - Pillars, Boom/Baffle etc

EAS Data

13.1970 eV

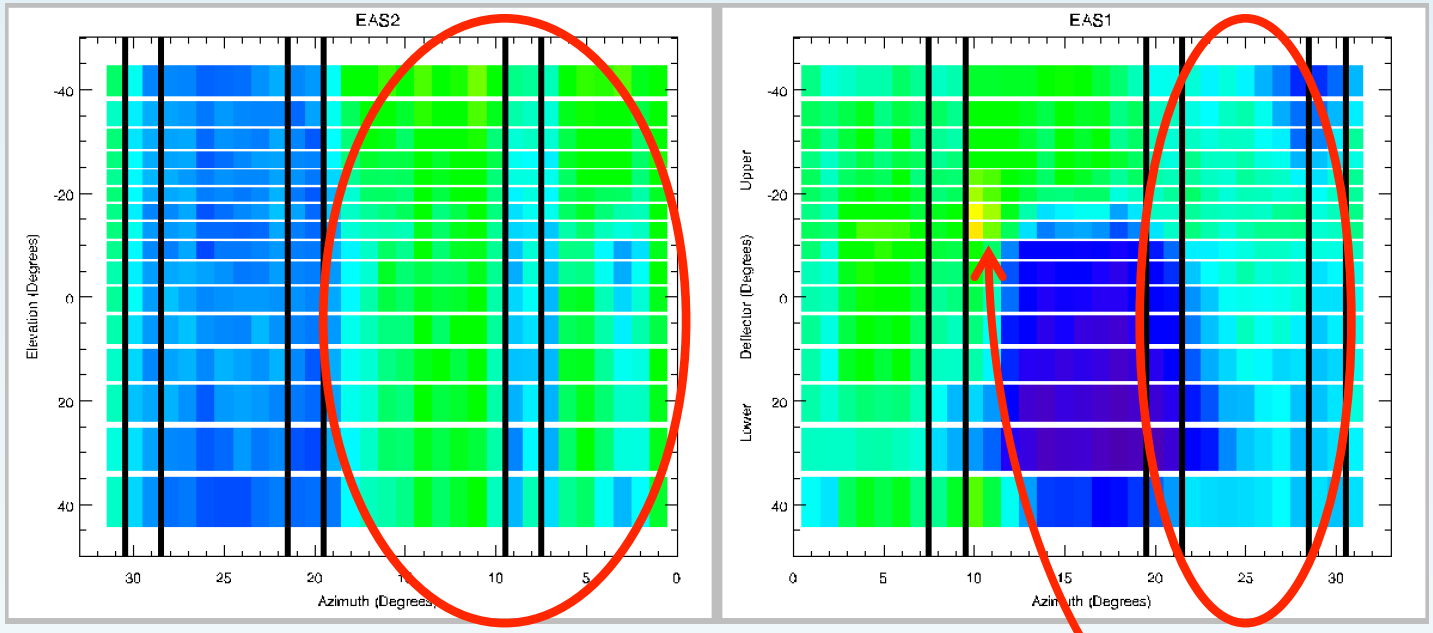


- Solar wind plasma coming around the SC body
- Being detected by both EAS heads

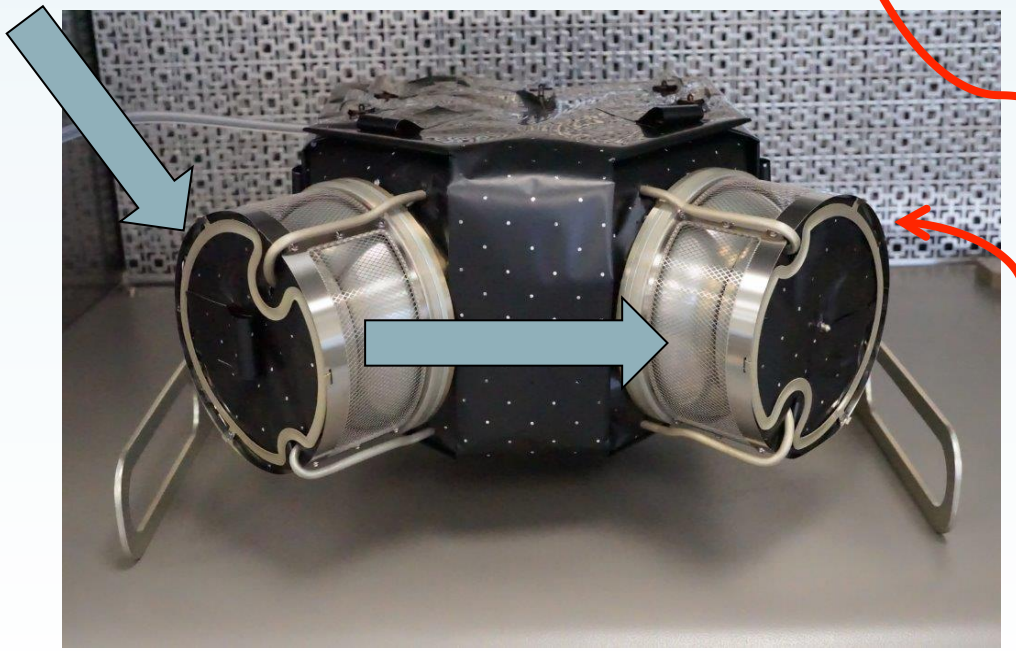


EAS Data

5.7253 eV



- Photoelectrons measured by EAS2 is continuing on into EAS1
- An enhanced measurement from the Solar array photoelectrons



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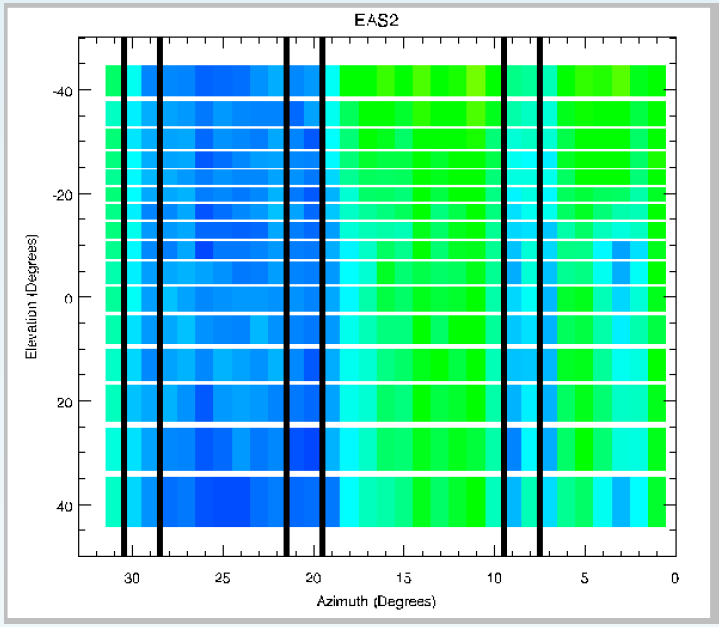
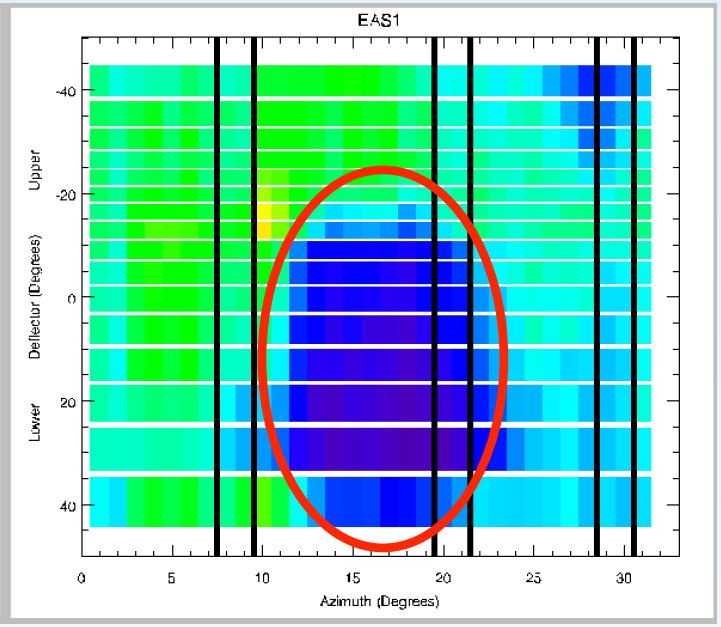
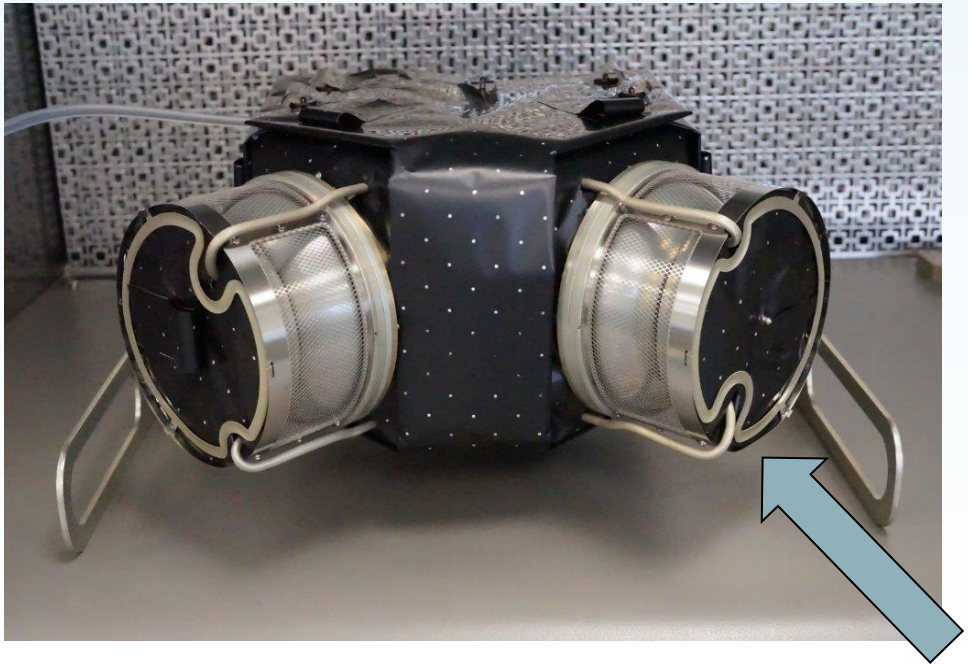


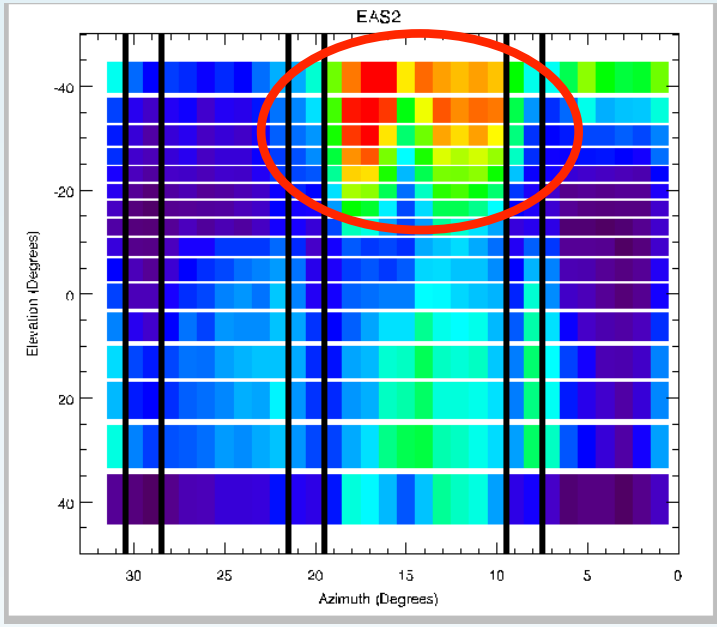


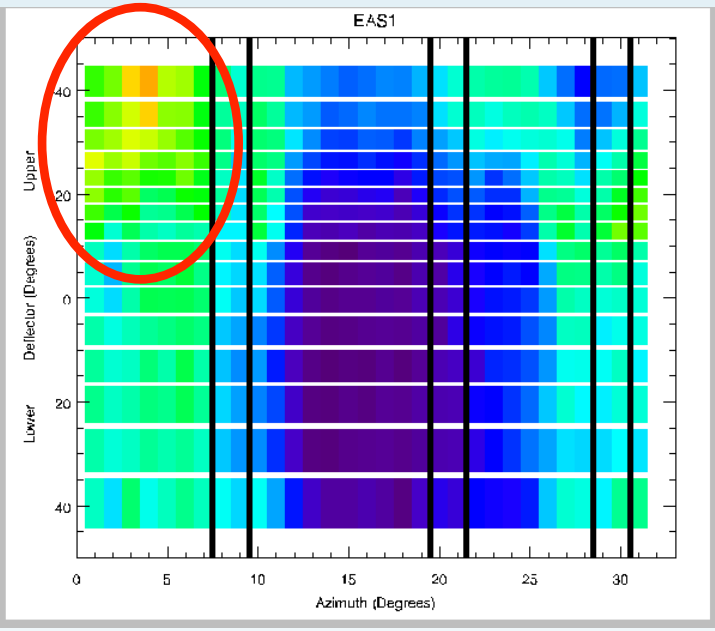
- An interesting depletion on EAS1 is always seen



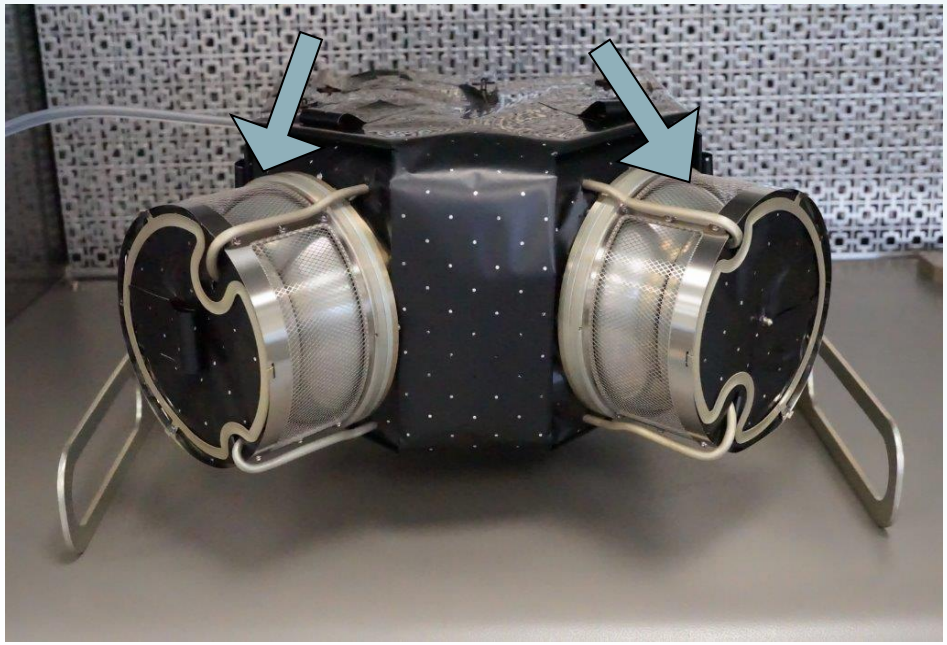
EAS Data

4.3283 eV



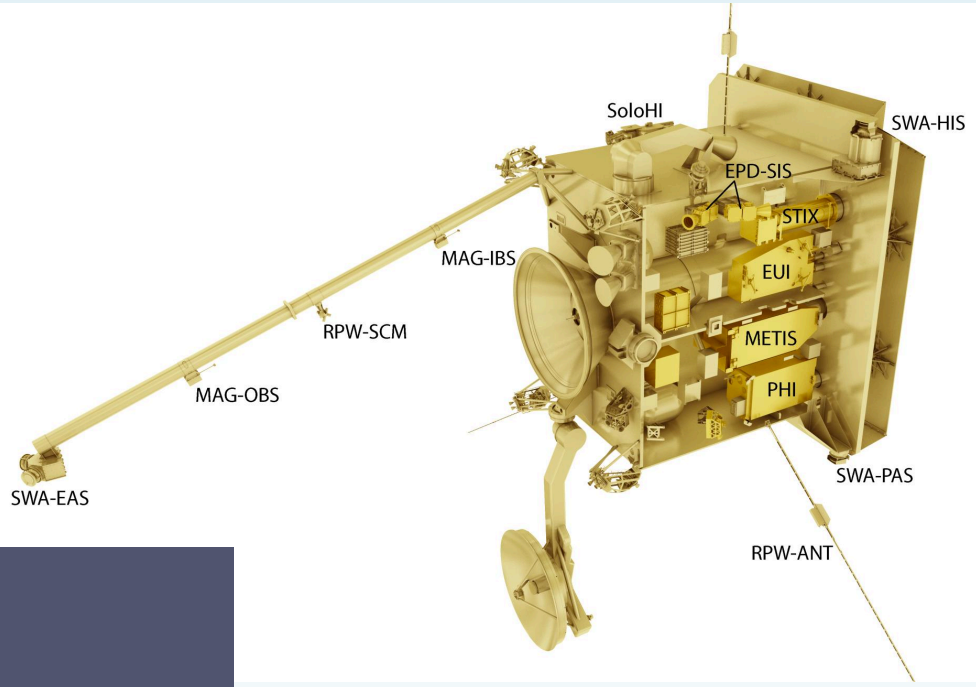


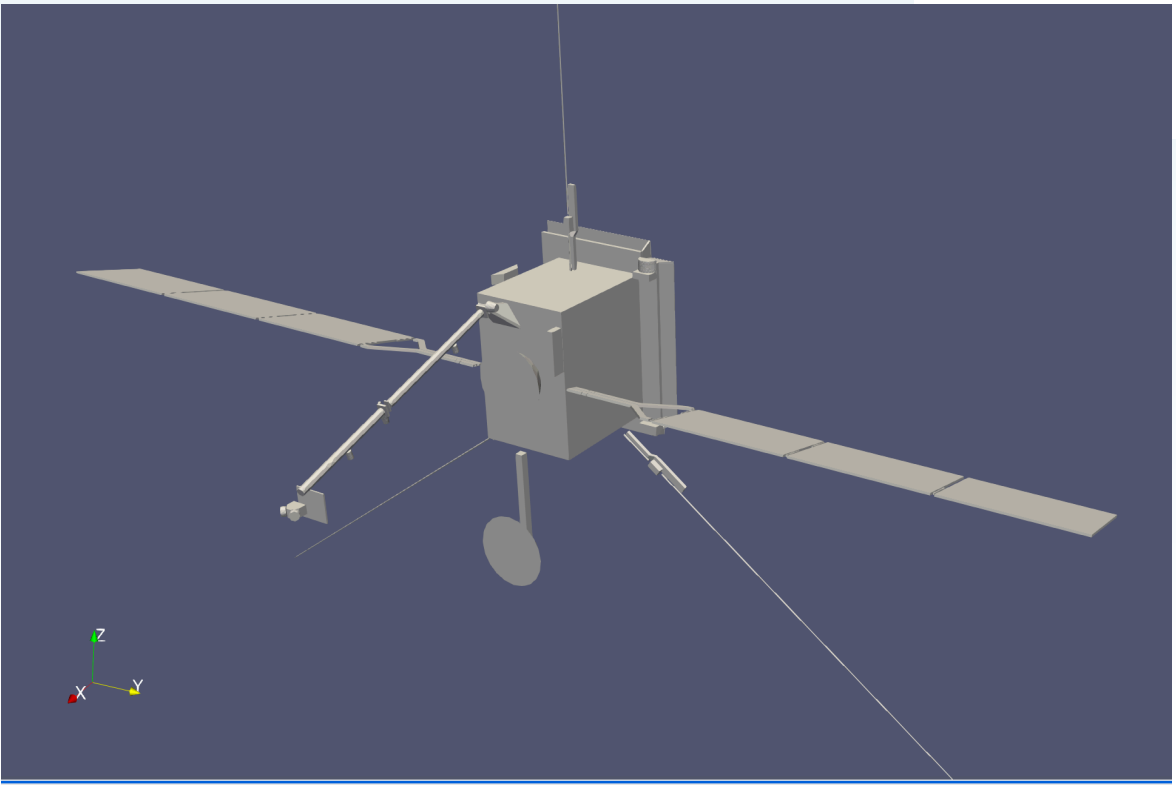
- Photoelectrons measured by EAS2 & EAS1 from the boom or baffle



Solar Orbiter: SPIS Modelling

- SO SPIS model provided by ESA
  - Solar Arrays
  - HGA
  - Boom
  - EAS, Baffle
  - RPW
  - Heat shield
  - Radiators



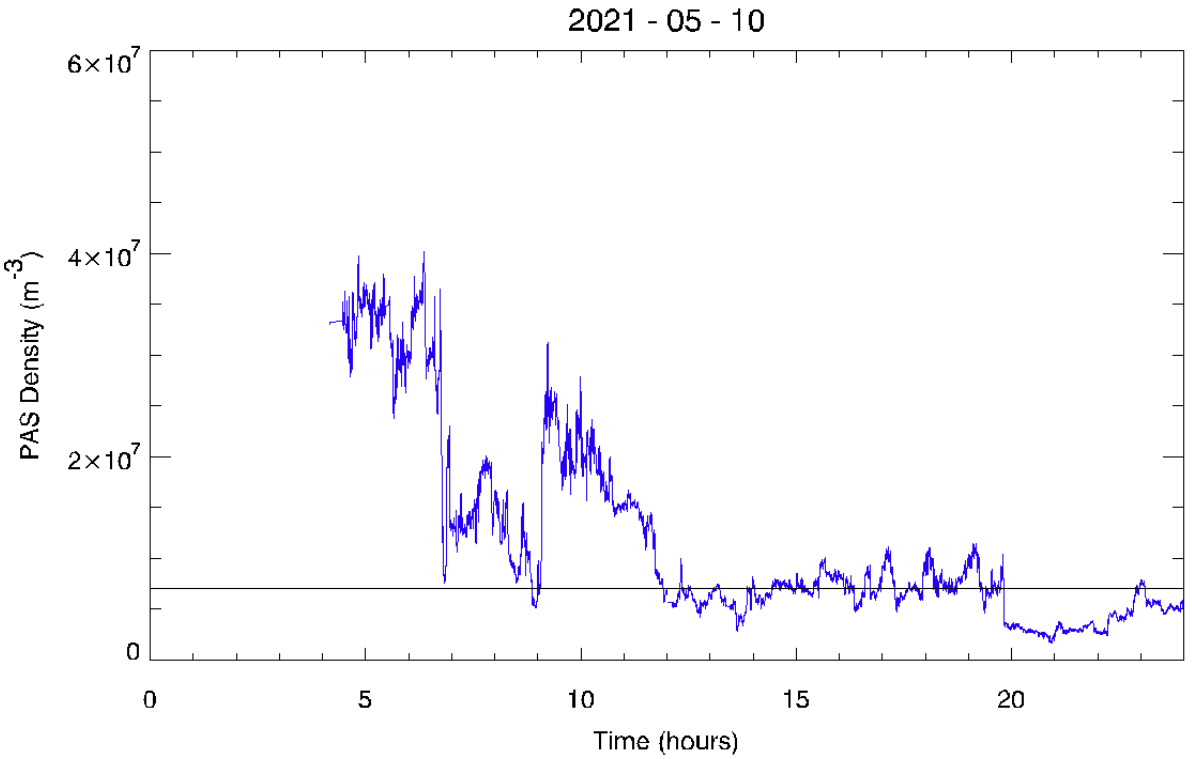


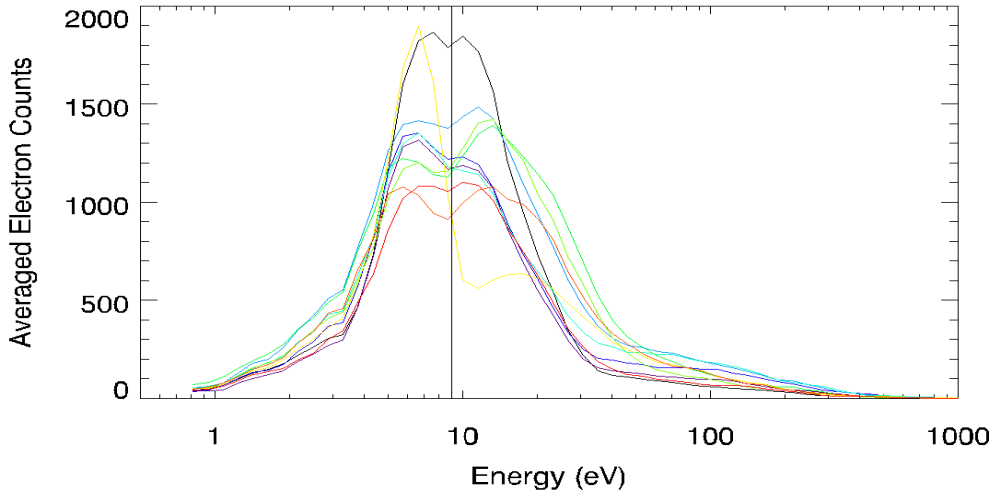
- 43 groups
- Group materials & properties, not precise

- Runs on a 64 thread, 32 core machine
- Run time is about 40 minutes

Solar Orbiter: SPIS Modelling

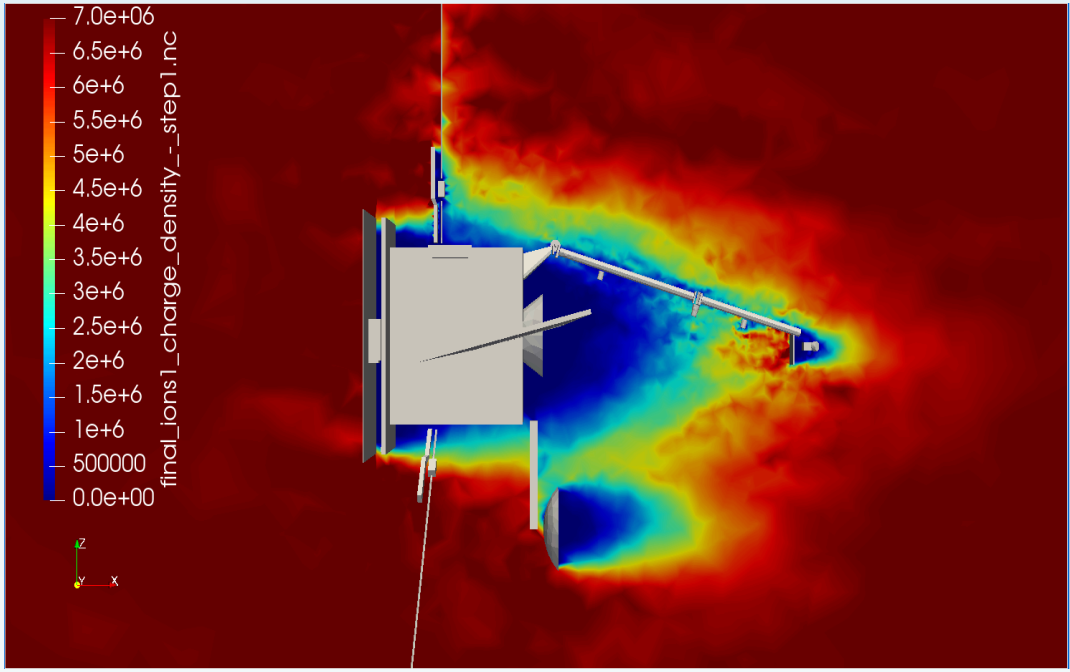
- SWA data measured on 10th May 2021
- Due to thruster firing, EAS does not operate until 10:00
- PAS ‘on-board’ ion density measures average 7e6 m^-3
- On average EAS shows a potential ~9eV

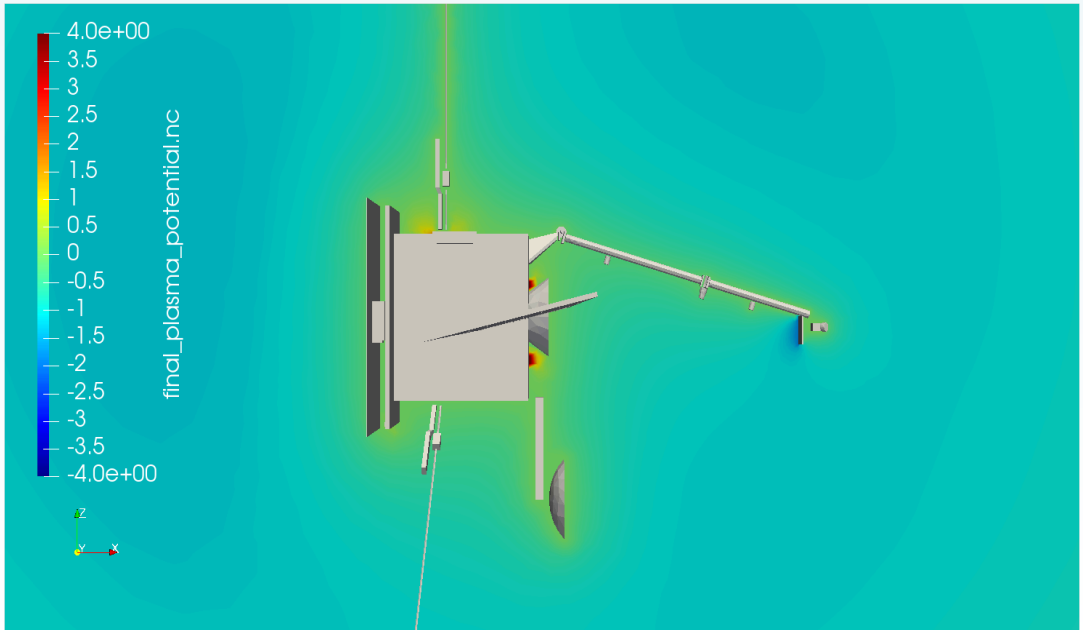




Solar Orbiter: SPIS Modelling

- To compare with data measured on the 10th May.....
- Version 6.0.0
- Ion & Electron input density = 7e6 m^-3
- Initial potential = +9 eV
- Sun distance ~ 1AU

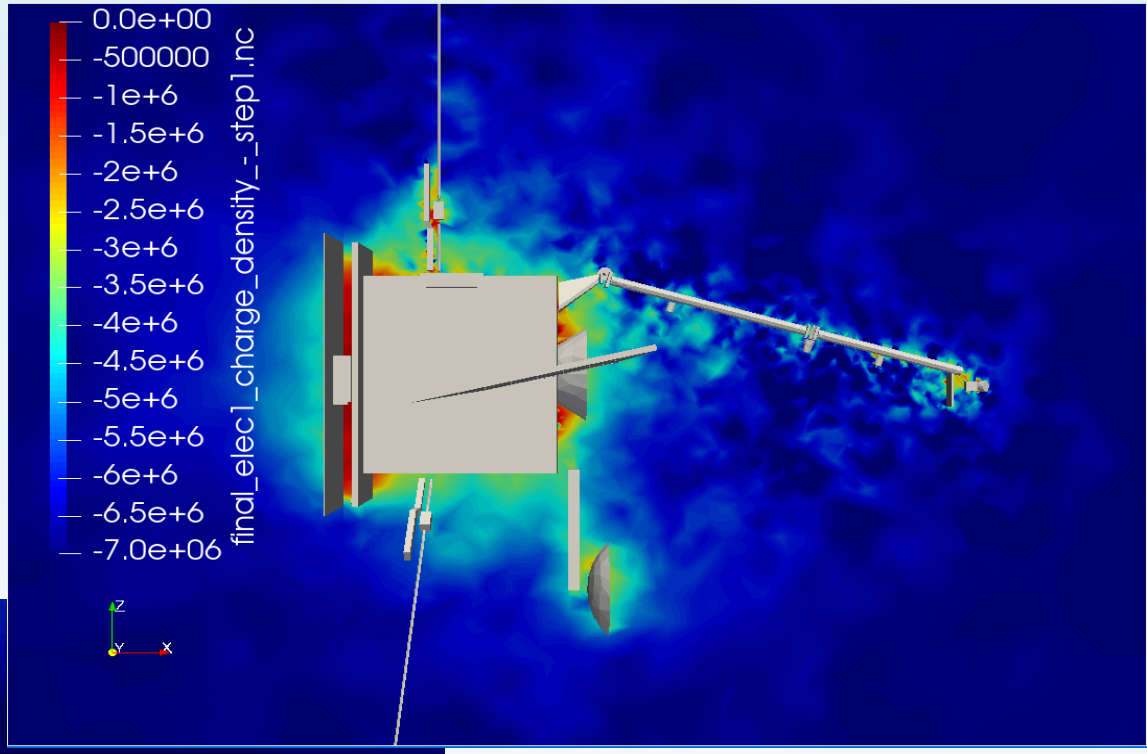


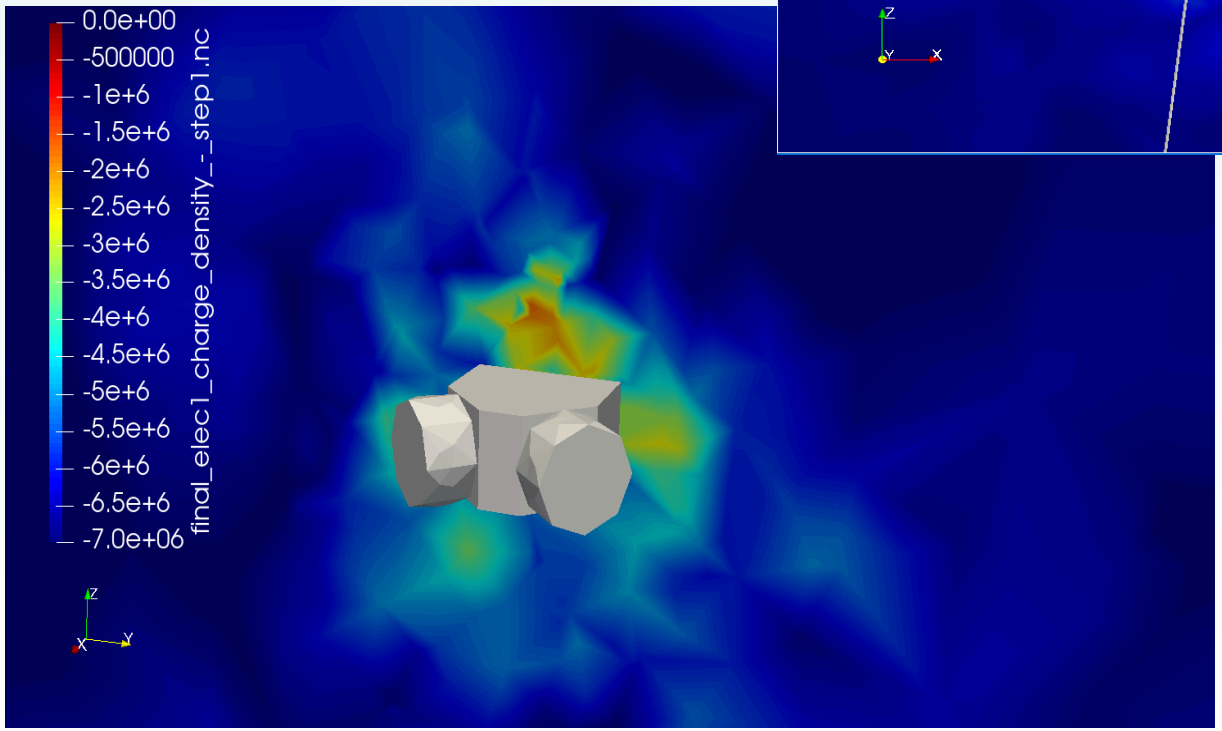


- Both ions & electron density is as expected
- Ion density shows a ‘nice’ wake as expected
- EAS is sitting in an ion void
- The resulting potential seems low compared to the observed values

Solar Orbiter: SPIS Modelling

- There appears to be some structure in electrons around EAS
- Probably due to the boom and/or the baffle





- These results will need to be compared with the measured data
- This is work in progress and the model needs more work

Conclusions

- The Solar Orbiter mission offers an exciting laboratory for Spacecraft charging
  - Thruster firing -> varying boom charging etc
  - Variable solar distance

- SWA-EAS is in prime position

- In the two orbits of the mission so far EAS has already measured ~144 days of data

- Our SPIS model is now being developed further to assist in the full analysis of the electron data set

- Next steps:
  - Better material and electrical properties
  - Deployment of ‘instruments’
  - Separate EAS1 & EAS2

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  - Thruster firing -> varying boom charging etc
  - Variable solar distance

- SWA-EAS is in prime position

- In the two orbits of the mission so far EAS has already measured ~144 days of data

- Our SPIS model is now being developed further to assist in the full analysis of the electron data set

- Next steps:
  - Better material and electrical properties
  - Deployment of ‘instruments’
  - Separate EAS1 & EAS2

- **THANK YOU FOR LISTENING** **Further details from: g.lewis@ucl.ac.uk**