In-situ sensors and instrumentation for Space Weather and the Sunjammer Solar Sail mission opportunity

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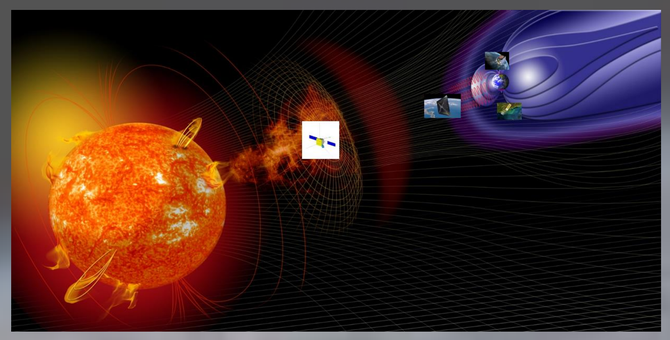


Flight missions and Space Weather

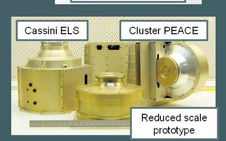
- Charged Particle Spectrometer (ChaPS), TechDemoSat
  - LEO (600km), launch Q1 2014
- Solar Wind Analyser (SWAN), Sunjammer
  - L1 and inside of L1, launch Q1 2015
- Ion and Neutral Mass Spectrometer (INMS), QB50
  - LEO (380km), launch Q2-Q3 2015
- UCLSat – 2U CubeSat for QB50, launch Q2-Q3 2015
- Solar Wind Analyser (SWA) Suite, Solar Orbiter
  - 0.28 to 0.8 AU, launch Q3 2017

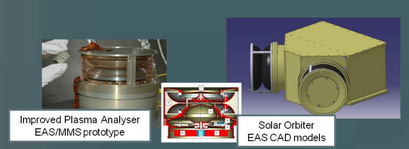
Summary

In-situ sensors play a key role in space weather missions, carrying out reliable and continuous measurements of the environment. A number of such sensors are under development at MSSL for missions currently in build as well as for future missions. In particular, the Solar Wind Analyser (SWAN), is being built for NASA's Sunjammer solar sail mission. SWAN is a miniaturised sensor combining an electrostatic analyser with an energetic particle detection system. The instrument is designed to carry out measurements of the low to medium energy solar wind plasma on a spacecraft with a large solar sail and aims to demonstrate the ability to provide real-time data for advanced space-weather warning systems. Besides continuous real-time observations for space weather purposes, the instrument will contribute towards furthering our understanding of the science of space weather. This is still a relatively young field and significant work is required to fully understand the physics of these space-based events.

Plasma instrumentation at MSSL

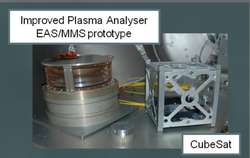
- Strong plasma instrumentation heritage
  - Magnetospheric missions: Cluster, Double Star, Polar
  - Planetary environments: Cassini, Mars and Venus Express, Mars 96 (launcher failed)
  - Cometary studies: Giotto
- Top-hat with enhanced capabilities
  - Solar Orbiter EAS
  - Baseline for EJSM, L-Depp
  - Other studies: MMS, Cross-scale
- Strong instrument development programme and state-of-the-art test and calibration facilities

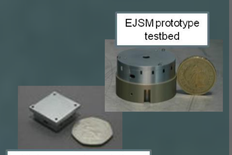


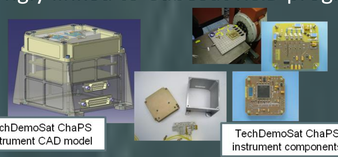


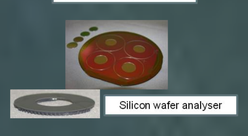
Instrument miniaturisation

- Low resource analyser development using MEMS-based (Micro-Electro-Mechanical Systems) fabrication techniques
- Generic technologies suitable for creating highly integrated "matchbox" sized analyser systems: small, low resource, more capable
- Technology demonstration on UK TechDemoSat mission
- Strongly linked to CubeSat R&D programme



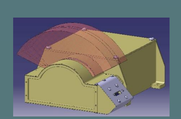






SWAN for Sunjammer

- Based on ChaPS
- Solar Wind ion measurements
- 22° x 60° Field of view. Compensate for ±30° solar sail orientation
- Energetic particle detector: Multiple Pixels, varying energy cut-offs
- Delivery Q2 2014
- Further development: Hot Plasma Monitor for GEO – combined electron-ion analysis and detection

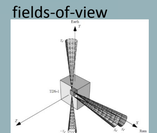


	ChaPS - Magnetosphere	SWAN-El	SWAN-En
Primary sampling region	Auroral Electrons at the poles	Solar Wind Ions	Solar Wind Ions
Particle Type	Electrons	H, He	Electrons, ions
Key View direction	N-S	Sun pointing	Sun pointing
PROPERTIES			
Energy range (eV)	10 to 4,000 eV	30 to 10,000 eV	El: > 250 keV, Ions: > 5 MeV
Energy resolution (%)	< 40	< 8	< 10
Elevation acceptance	< 1.8°	± 11°	± 11°
Azimuth acceptance	< 20°	60°	60°
Energy Sweep time	1s	30s	-
Energy Sweep steps	64x4	64	-

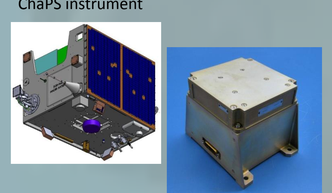
ChaPS analyser on TechDemoSat

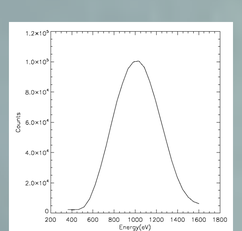
- CubeSat form factor
- Planar geometry - Bessel box variants
- 4 sensors optimised for Magnetospheric electrons x 3, RAM ions x 1
- Instrument delivered in March 2012
- Further miniaturisation activities ongoing including analyser in a silicon wafer

ChaPS sensors fields-of-view

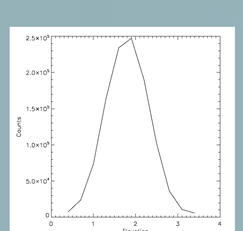


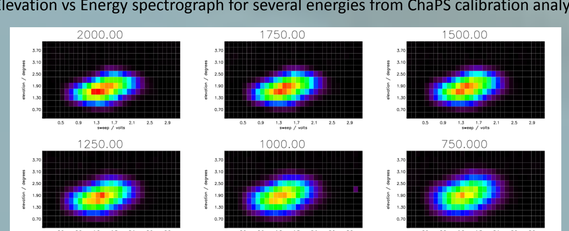
The TechDemoSat satellite and the ChaPS instrument





Elevation vs Energy spectrograph for several energies from ChaPS calibration analyser





Elevation

Energy

Acknowledgements: SWAN development funded by the UKSA