The Hot Plasma Environment Monitor (HOPE-M) for telecoms satellites

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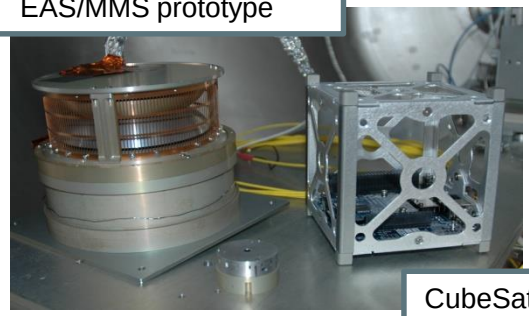
Plan

- Introduction
- Hot Plasma Environment Monitor (HOPE-M)
  - Instrument design
  - Key technology developments
- Some results from ChaPS
- Summary

Instrument Miniaturisation

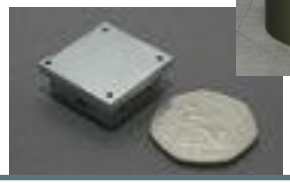
- Aggressive development programme
- Low resource analyser development using MEMS-based (Micro-Electro-Mechanical Systems) fabrication techniques
- Generic technologies suitable for creating highly integrated “matchbox” sized analyser systems: small, low resource, more capable
- Technology demonstration on UK TechDemoSat, Sunjammer and QB50 precursor missions

Improved Plasma Analyser EAS/MMS prototype

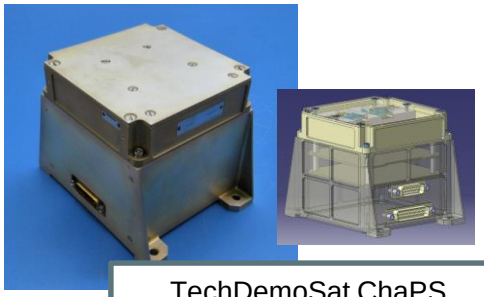


CubeSat

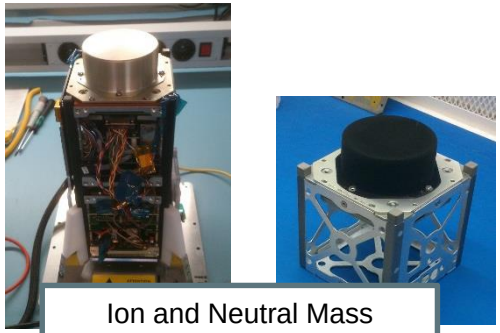
EJSM prototype testbed



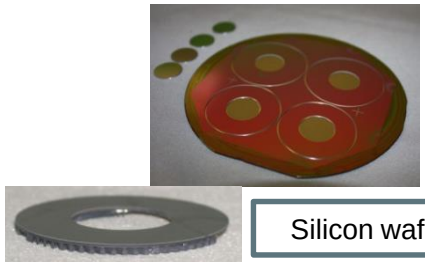
High temporal resolution proof-of-concept analyser



TechDemoSat ChaPS instrument and CAD model

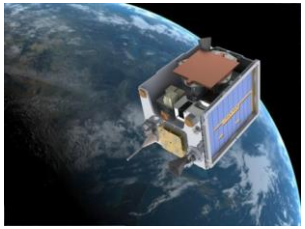


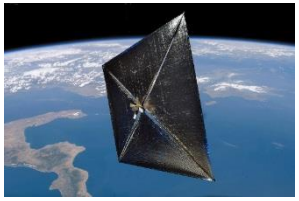
Ion and Neutral Mass Spectrometer for QB50

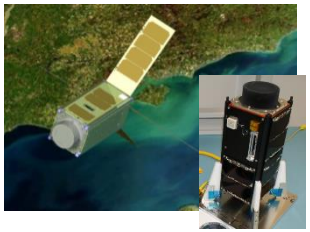


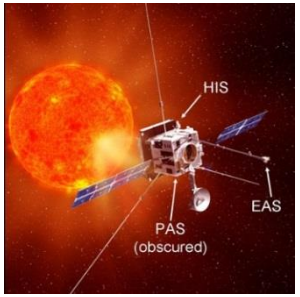
Silicon wafer analyser

Flight Missions and SSA





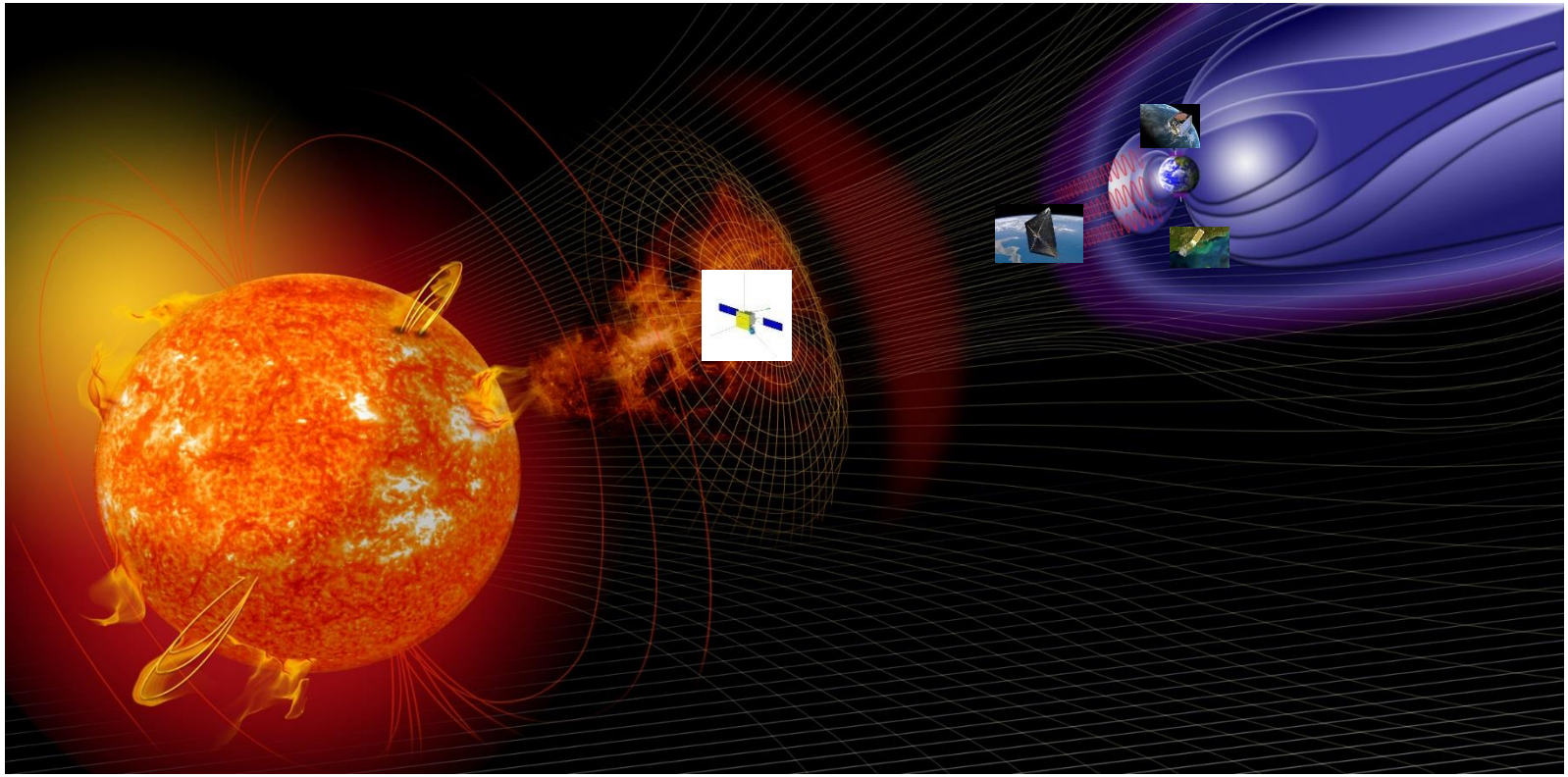




- Charged Particle Spectrometer (ChaPS), TechDemoSat – launch 19th June, 2014
- Solar Wind Analyser (SWAN), Sunjammer - launch Q1-Q2 2016
- 14 x Ion and Neutral Mass Spectrometer (INMS), QB50 - launch precursor June 2014, main 2016
- UCLSat – 2U CubeSat for QB50, launch 2016
- Solar Wind Analyser (SWA) Suite, Solar Orbiter - launch 2017

Image credits: NASA, ESA, SSTL, L'Garde

Flight Missions and SSA



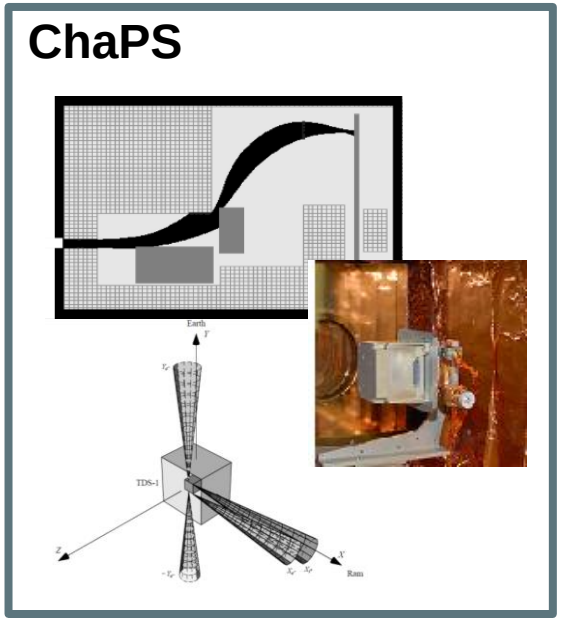
Background Image credit: NASA

Key technology developments

- Combined Electron-ion Energy Analyser
  - Flexible design, ability to tune performance
- Dual polarity high voltage power supply
- Micro-channel plate detector for simultaneous detection of electrons and ions
- Compact digital electronics
  - Complex capabilities for environment monitoring on telecoms satellites at GEO
- Silicon detector development in parallel

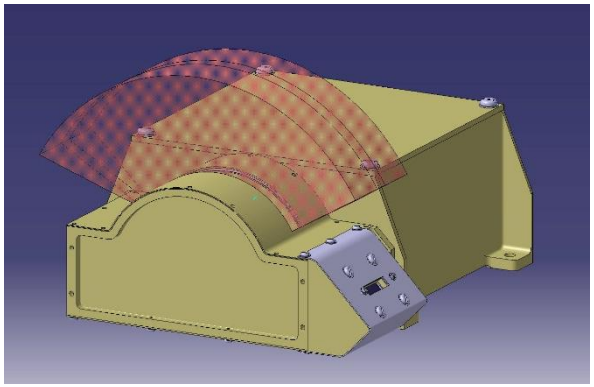
HOPE-M design overview

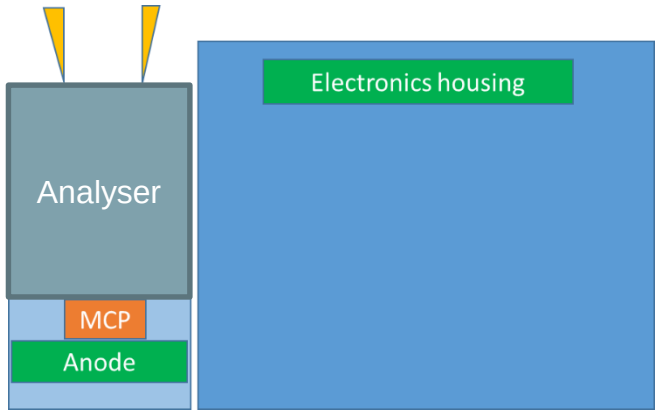
- Based on ChaPS
  - Delivered for UK TechDemoSat
  - Miniaturised electrostatic analysers
  - Combined electron-ion
  - Variants of the Bessel Box geometry
- HOPE-M design
  - Combined Electron and ion measurements
  - ± 22° x ± 60° Field of view
  - Separate detector for higher energies

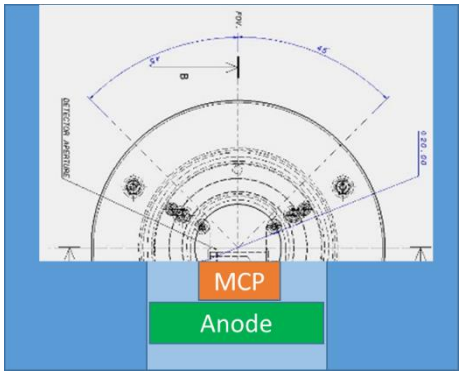


Mechanical Aspects

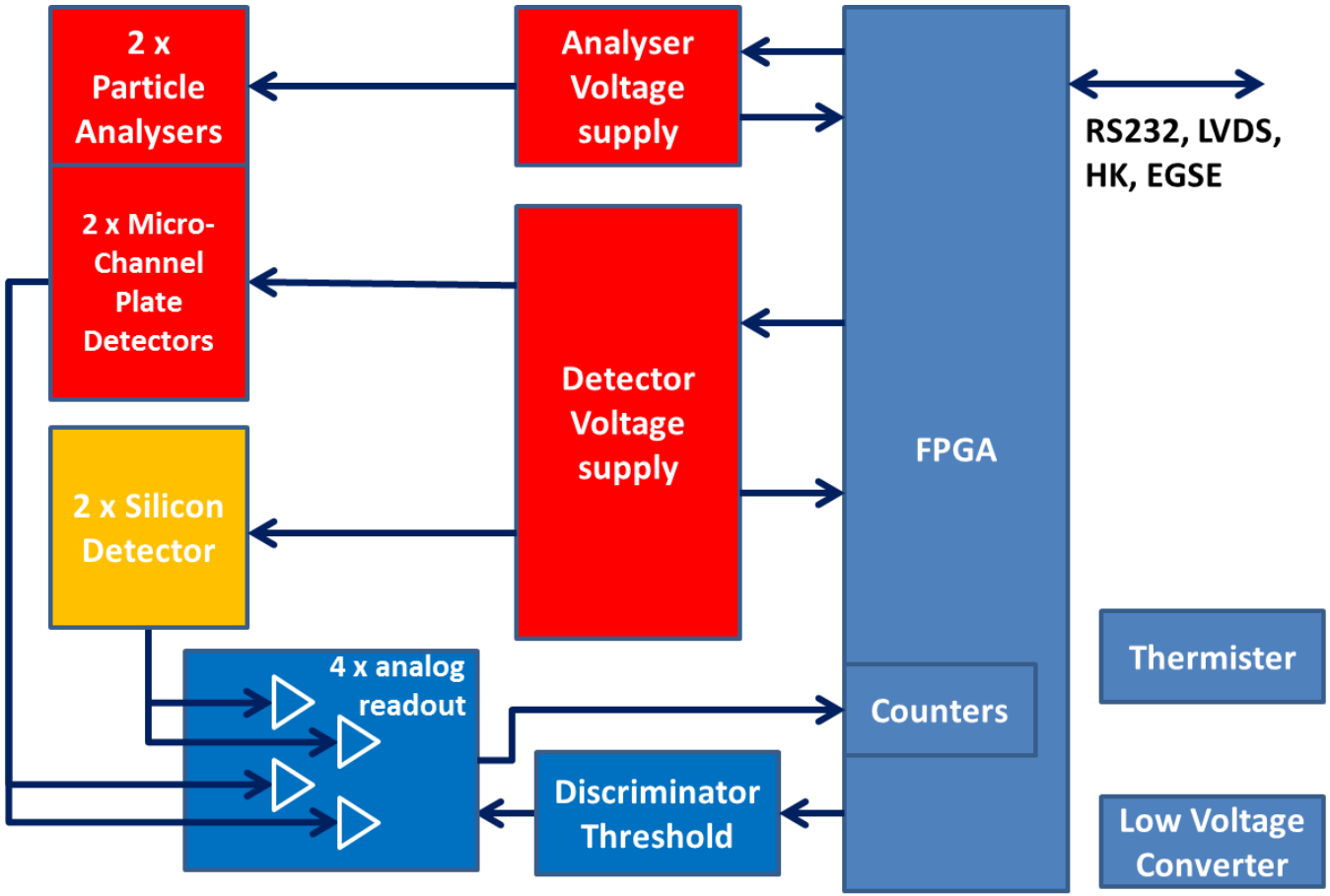
- Modular design – analyser head, electronics box
  - Taylor design for Science or monitoring,
- Two Bessel boxes
- Single MCP for breadboard
- Four readout channels



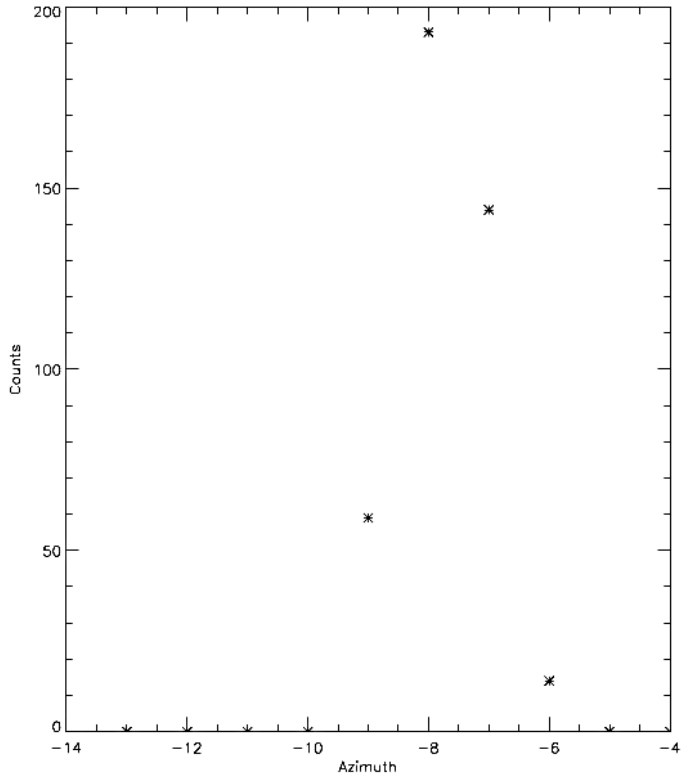


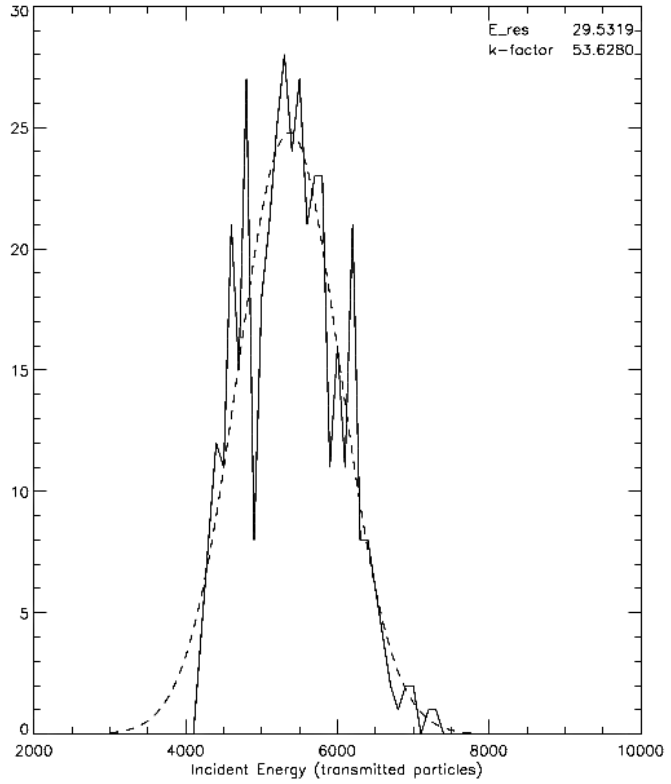


System Architecture

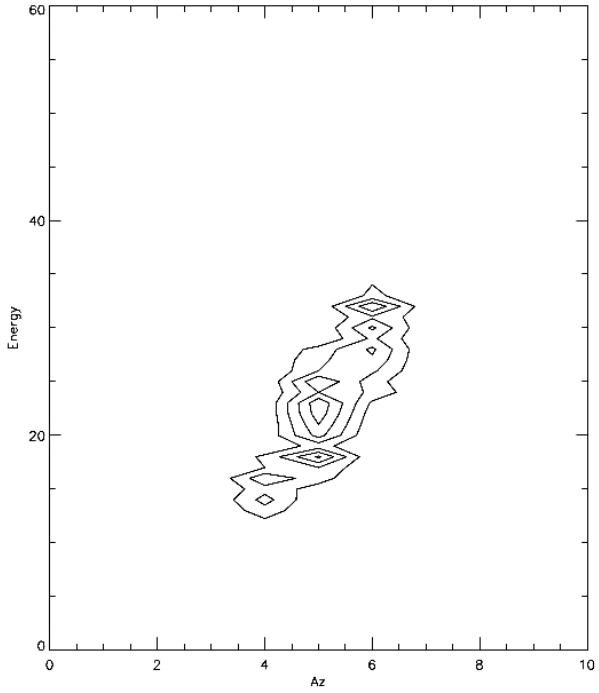


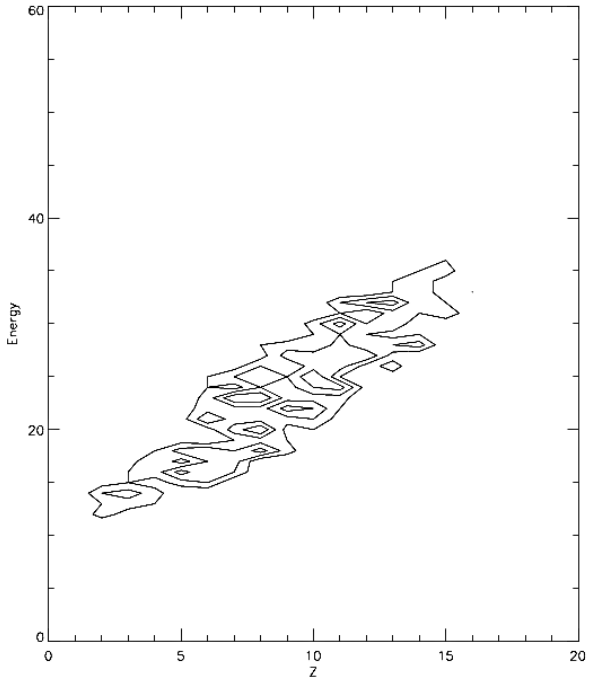
Simulation results - 1

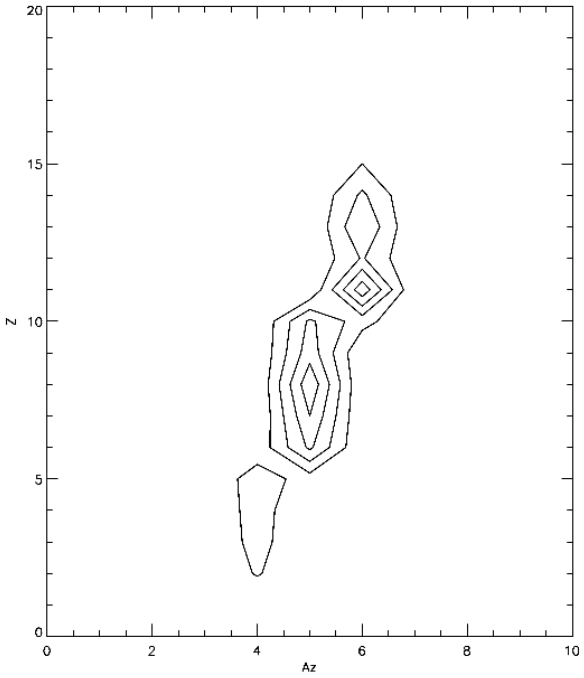




Simulation results - 2





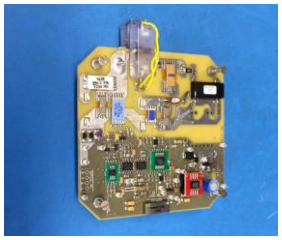


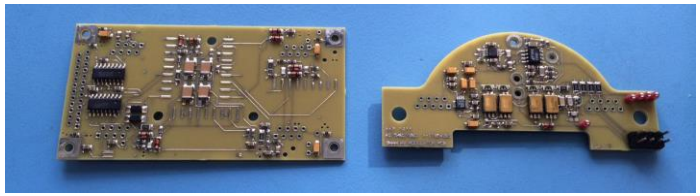
Performance parameters

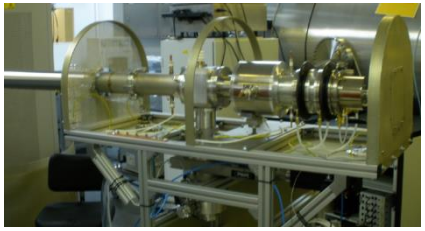
	ChaPS - Magnetosphere	HOPE-M (breadboard)
Primary sampling region	Auroral Electrons at the poles	GEO
Particle Type	Electrons	Electrons, Ions
Key View direction	N-S	Earth pointing
PROPERTIES		
Energy range (eV)	10 to 4,000 eV	30 to > 30,000 eV
Energy resolution (%)	< 40	< 30
Elevation acceptance	< 1.8°	± 11°
Azimuth acceptance	< 20°	± 60°
Energy Sweep time	1s	30s
Energy Sweep steps	64x4	64

Status and ongoing developments

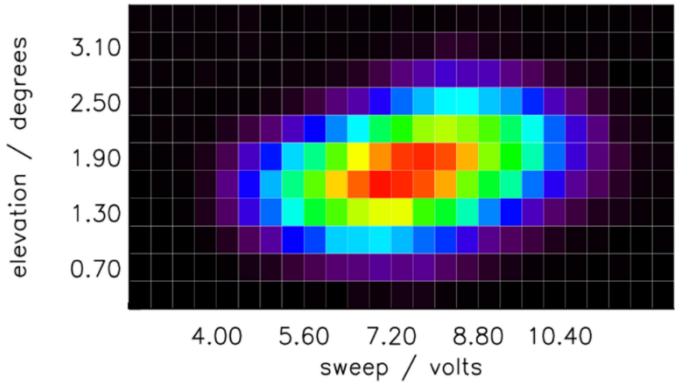
- HV and front end electronics tested on the bench
- Analyser breadboard parts fabricated, integration next week
- Test in LEPIC facility. Provides both electrons and ions in one calibration chamber

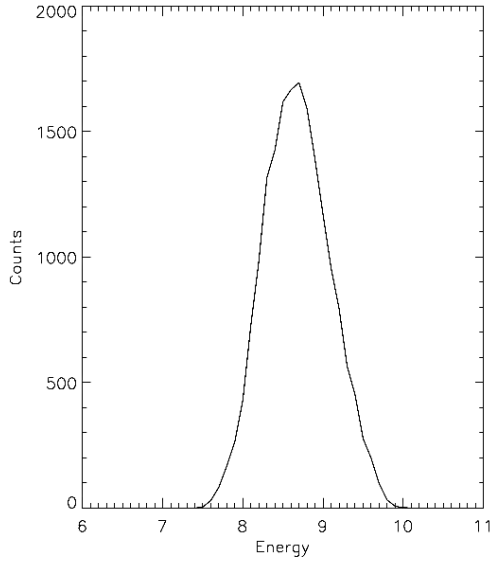


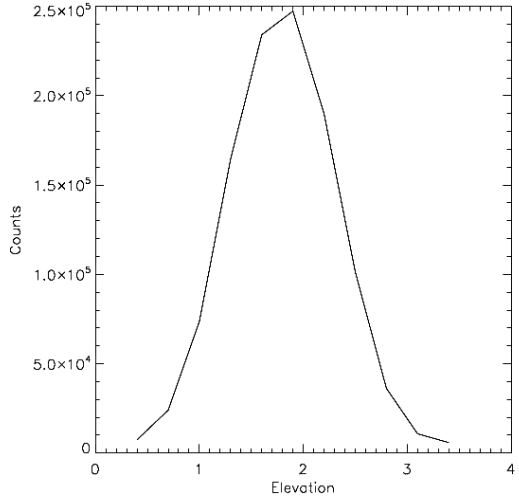


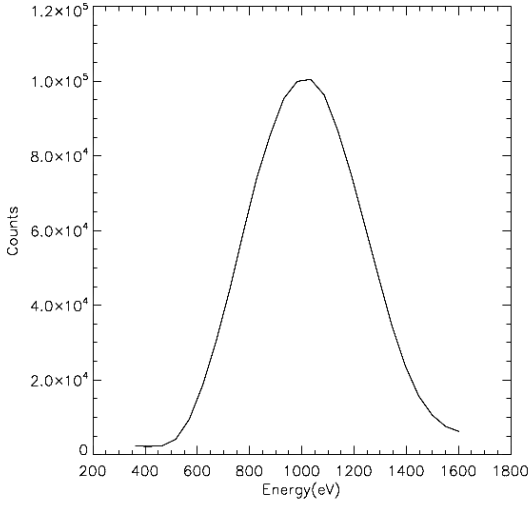


Expected results
(Data from ChaPS calibration)









Summary

- Strong Heritage
- Aggressive Miniaturisation Programme
- Developments for flight missions
  - Solar Orbiter EAS
    - Approaching CDR. Launch 2017
  - ChaPS
    - Flight Demonstration on TechDemoSat
    - Instrument delivered March 2012, launch 19th June, 2014
  - QB50
    - INMS under development
    - Prototype on precursor, launch 19th June, 2014
  - SWAN for Sunjammer
    - Launch 2016

Summary

- HOPE-M for geostationary satellites
  - Combined low resource electron-ion analyser
  - Modular design, ability to tune for science/monitoring
  - Target mass 0.5 kg
- Enabling technology for future missions
  - Generic technologies
  - Silicon wafer fabrication

Acknowledgements

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- MSSL team
  - In-situ: Gethyn Lewis, Ben Taylor, Andrew Malpuss
  - Science: Andrew Fazakerley
  - Engineering: Mark Hailey, Hubert Hu, Rahil Chaudery, Andullah Khalil, John Coker
  - Workshops: Doug Davies, Gary Davison, Ian Phillips, Simon Hemsley

ChaPS – Overview

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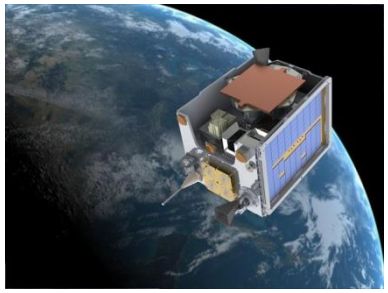
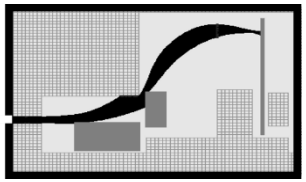
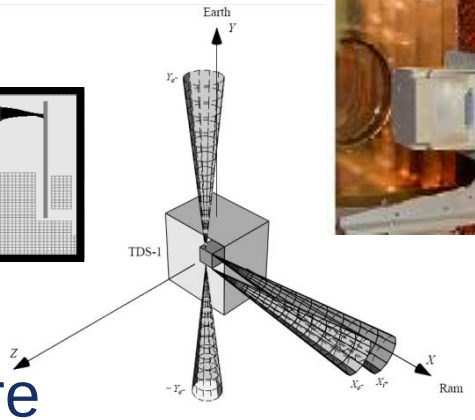
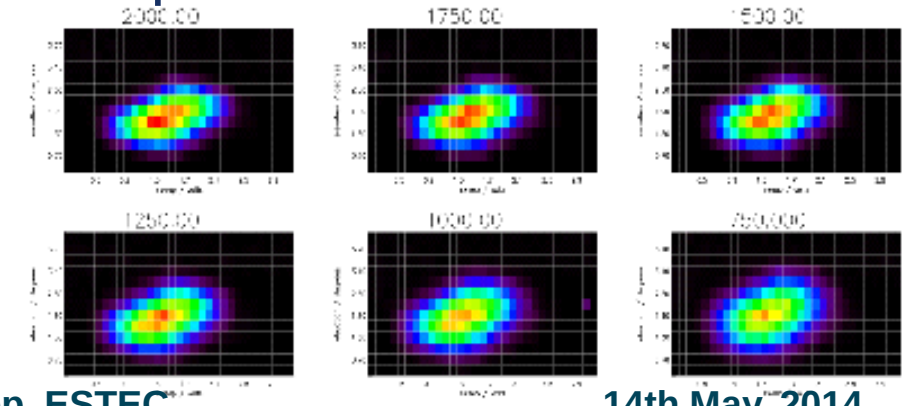


- ChaPS (Charged Particle Spectrometer)
  - Suite of miniaturised Bessel Boxes
  - Electron and ion analysis
- Three modes
  - Electrons in the auroral regions
  - Electrons and ions in the ionosphere
  - Spacecraft potential
- Delivered March 2012
- Launch Q3-2013







ChaPS – Overview

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- Demonstration
  - Combined electron-ion analysis
  - Miniaturised geometry
  - Ability to tune performance
  - Various k-factors
  - “Intelligent” FPGA
- Further development for two mission opportunities
  - Addition of neutral particle sensing for QB50
  - Auroral sensor being tuned for Solar Wind ions for Sunjammer