Miniaturised sensor development programme for studies of the space plasma and radiation environment

D. Kataria, A. Smith, R. Bedington

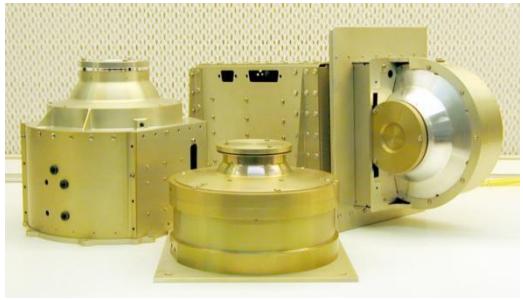
Mullard Space Science Laboratory
Dept. of Space and Climate Physics
University College London

Plan

- Introduction
- Miniaturisation programme
- Technology toolbox
- Ongoing Activities and Timeline
- Applications and Summary

Research at MSSL

- Department of Space and Climate Physics, University College London
- More than 40 years in space research and instrumentation
- Eight research groups supported by specialist engineers conduct our scientific research
- Currently 16 instruments in space
  - Earth, Mars, Venus, Saturn



Missions – Past, Present and Future

- Giotto
- Cluster II
- Cassini
- Mars Express
- Venus Express
- Solar B

- Herschel
- STEREO
- SOHO
- XMM-Newton
- Swift
- Integral

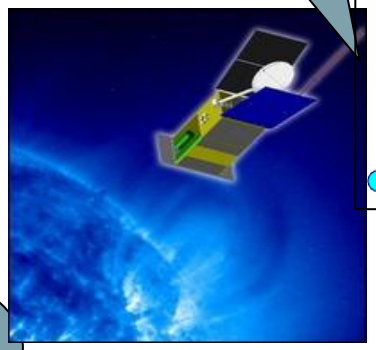
- Solar Orbiter
- Cosmic Visions
- Cubesats/NanoSats

- GAIA
- JWST - Nirspec
- Astrosat

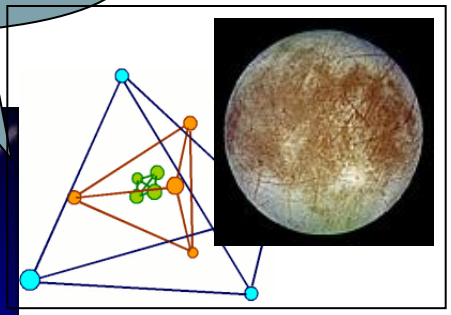
Plasma Instrumentation

R&D Activities and Capabilities

Mission Studies

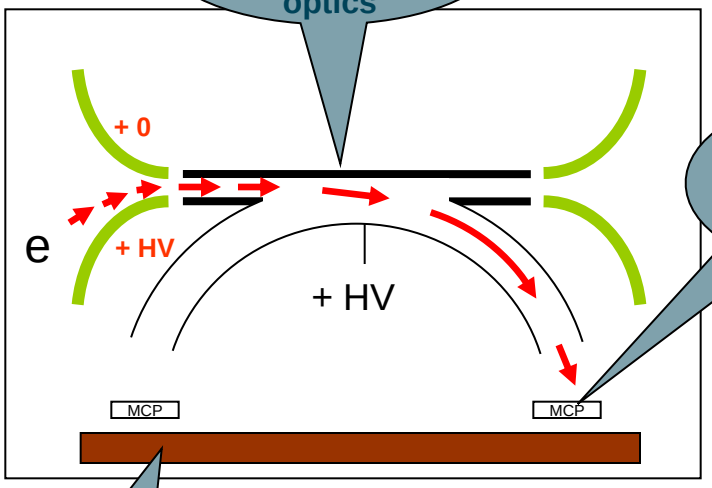


Solar Orbiter



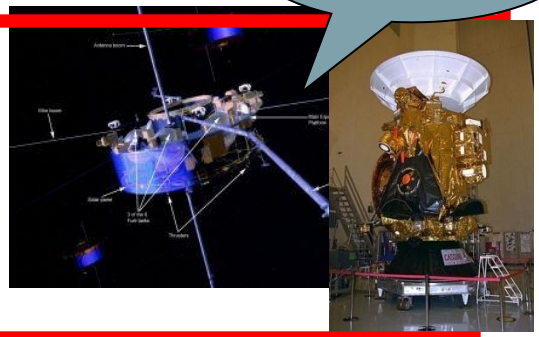
X-scale, EJSM

Charged particle optics

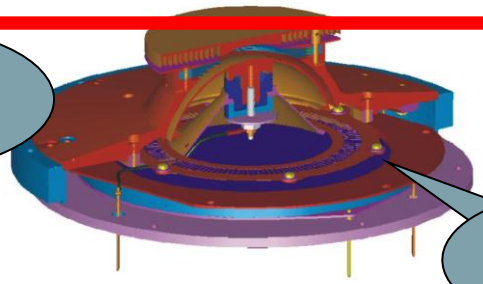


Detector research

Post Launch support

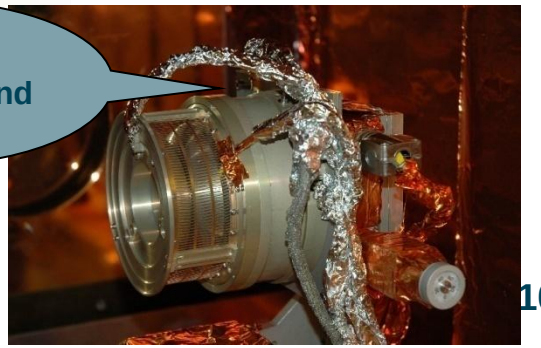


Electronic subsystems



Design and build

Test, Calibration and Facilities



Plasma Instrumentation

R&D Activities and Capabilities

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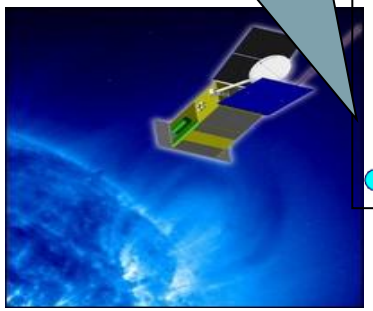
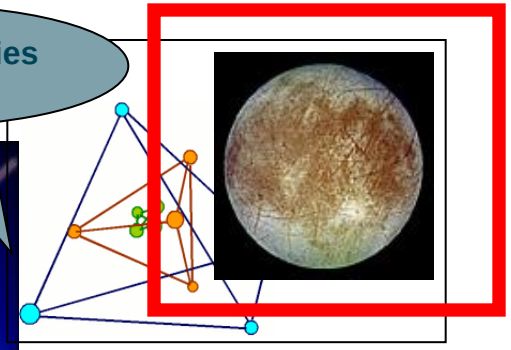


Solar Orbiter



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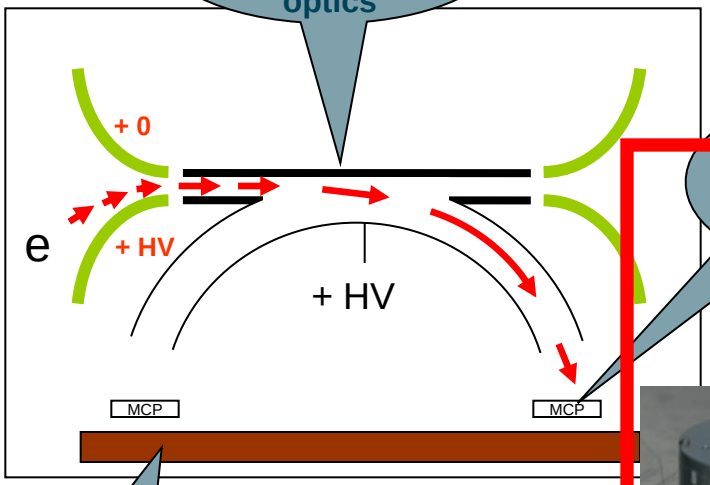

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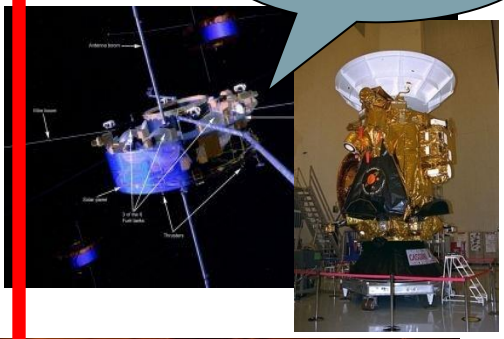

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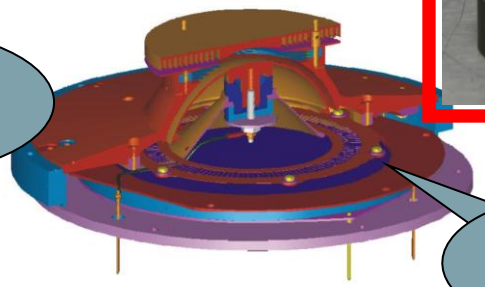

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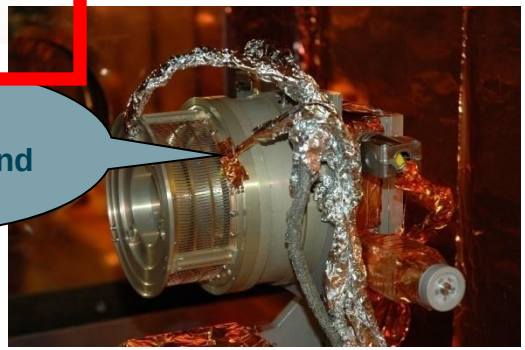


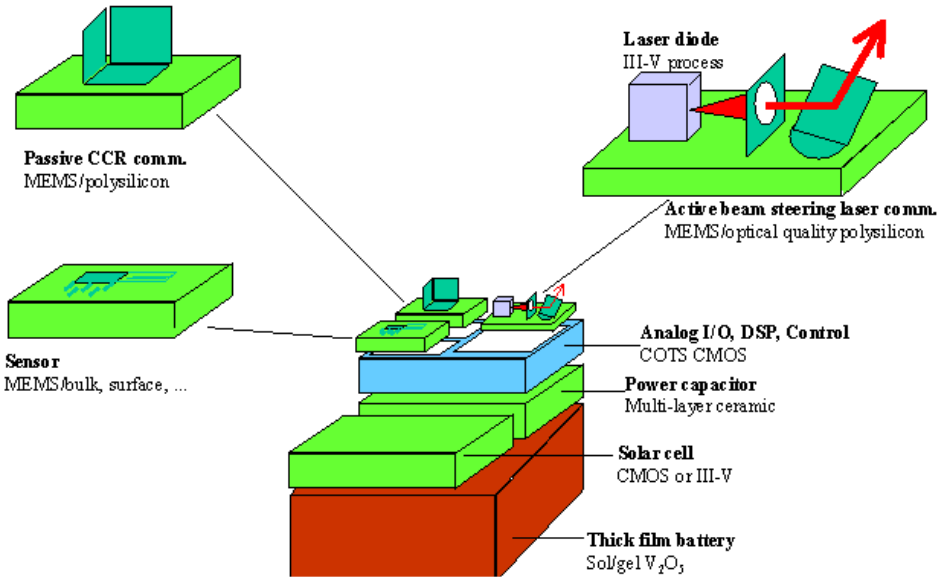
The Future is Small
MEMS-based Analyser

- Aims
  - Low resource analyser development using MEMS-based (Micro-Electro-Mechanical Systems) fabrication techniques
  - Provide generic technologies suitable for creating highly integrated “matchbox” sized analyser systems: small, low resource, more capable
- Ideal for Space Applications

Future is small
Generic Technology "Toolbox"

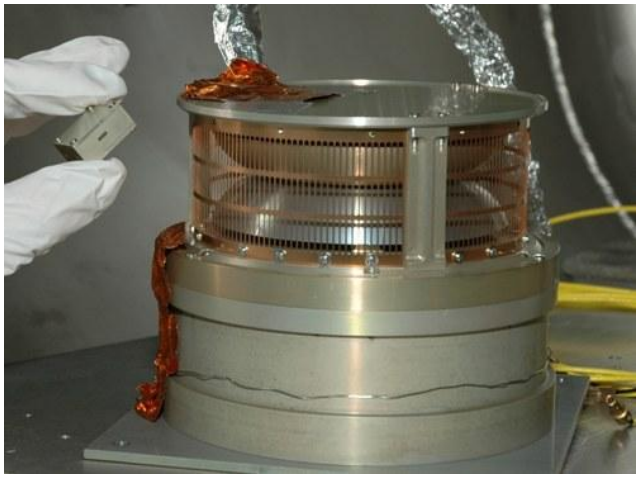
- Smart Dust

- Sensor system
- Processing Electronics
- Active/Conditioning system
- Wireless system
- Power system
- Integration and Packaging

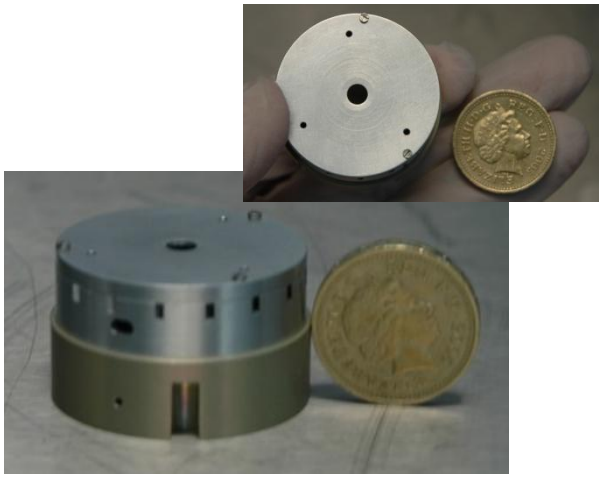


Sensor System
Techniques

- Fabrication
  - Conventional, silicon, laser
  - Liga
- Analysis
  - Electrostatic, energy only
- Detection
  - MCPs, silicon
- Readout
  - Pixellated, position sensitive



Phase 1: Proof-of-concept Analyser along with the IPA analyser



Phase 2: ChaPS: Technology Testbed Prototype

Performance and Resources

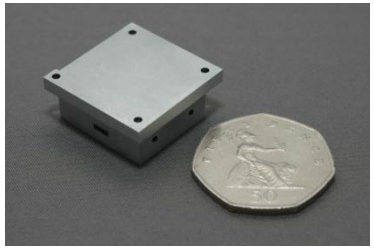
Estimated

	Cassini ELS	Cluster LEEA	IPA	ChaPS
Particles detected	Electrons	Electrons	Electrons	Electrons and Ions
K Factor	6.14	6.14	6.14	~ 8
Geometric Factor	8×10^{-4} cm^2 sr	~1.6×10^{-4} cm^2 sr	~1.2×10^{-4} cm^2 sr	~ 1×10^{-4} cm^2 sr
Energy Resolution	0.167	0.127	0.127	~0.22
Energy Acceptance	0.59eV – 26.4KeV	0.59eV – 26.4KeV	0.59eV – 26.4KeV	Few eV to 20KeV
Angular Resolution	5.24° x 20°	2.79° x 15°	2.79° x 22.5°	~ 17° x ~21°
Angular Acceptance	5.24° x 160°	2.79° x 180°	2.79° x 360°	~17° x 360°
Mass	Analyser head ~0.2 kg Total 1.4 kg	Analyser head ~0.2 kg Total 1.9 kg	Analyser head ~0.2 kg Total 0.9 kg	Analyser head ~ 0.01 kg Estimated Total < 0.3 kg
Power	2 W	2 W	1.5 W	0.4-0.5 W

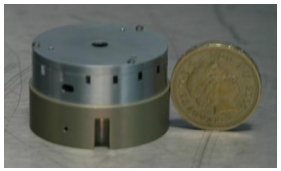
Electronics and Conditioning Element

- Electronics:
  - Power supplies: HV and LV key focus
    - Miniaturised HVs under development for Solar Orbiter/Future missions
    - Choice of analyser geometry is key
  - FPGA: Strong heritage, rapidly evolving technology
  - Readout ASIC: Number of solutions currently available or under development within Europe
  - Integrated ASIC essential for low resource final solution
- Conditioning: Ionizer for neutral particle studies
  - Key requirement for number of MSSL/UCL interests
  - Low resource technique under development. Proof-of-concept testing in progress.

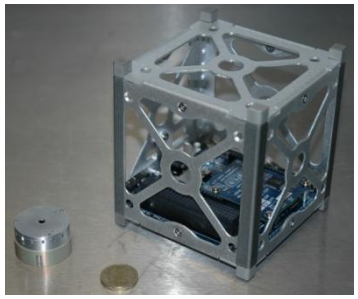
Current Timeline



- Analyser Prototype
  - Continuing tests with proof-of-concept analyser
  - Technology testbed prototype assembly and testing
    - Full instrument – analyser, detector, electronics
    - TRL 5/6 by early 2011



  - Potential launch opportunities - 2011/2012 timeframe:
    - UKube – UK CubeSat programme. Details being finalised. Competitive AO. Launch late 2011/early 2012
    - Other potential opportunities
  - Design modifications
    - Performance “tailoring” and flight compatibility



Ongoing Developments
Activities and Timeline

- Ionizer development and testing
  - TRL 4 by Dec 2010. Integration and testing 2011
- Integrated MEMS Electrostatic Analyser and Silicon detector study
  - Large dynamic range, few eV to several MeV
  - TRL 5/6 in the 2011/2012 time frame
- Next Phase
  - Wireless functionality – Post doc joining in Sept/Oct.
  - Integration and Packaging - “Instrument-on-chip” solution
  - Feasibility study for self powered solution

Potential Missions and Applications

- Space Science
  - Cosmic Vision candidates – EJSM, M3
- Space Weather applications
- Upper Atmosphere Research
  - CubeSat constellation under study
- Spacecraft Subsystems
- Education and Outreach

Summary

- Strong heritage, aggressive miniaturisation
- “Toolbox” of generic technologies being developed
- Miniaturised proof-of-concept analyser undergoing testing and prototype testbed under development
- Continuing R&D Programme
  - Neutral particles - TRL 4 by end of 2010
  - Highly Integrated Sensor Systems – 2012 time frame
- Enabling technology, range of applications
  - Space Weather Constellations, CubeSat/NanoSat, Planetary

Acknowledgements

- UK STFC Funded programme
- STFC Case funded studentship
  - Industrial partner: Astrium UK, industrial supervisor Steven Eckersley
- ESA Innovation Triangle Initiative study

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