



Space Environment Monitoring System (SEMS)

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New Facility and Capabilities

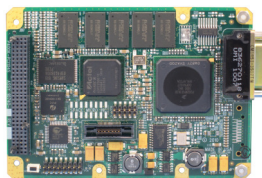
- 20,000 sq. ft
- Improved Clean Room
 - Class 10,000
- Additional Environmental Equipment
 - Thermal vacuum
 - Random vibration
 - Sine vibration
 - Shock
 - Thermal cycling
- SECRET facility
 - COMSEC handling



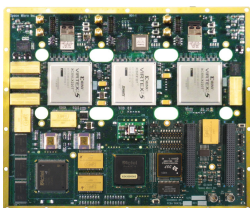


Radiation Hardened Products

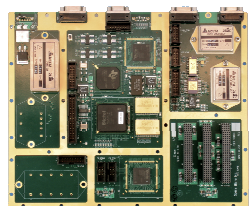
Digital Boards



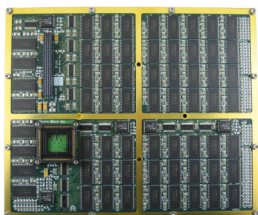
Proton400k-L™ Dual-Core Computer



Proton300k™ Reconfigurable SBC



Proton200k™ Custom DSP SBC



Solid State Buffer

Systems/Instruments



ProtonX-Box™ Avionics Suite

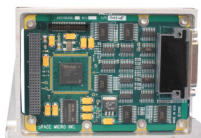
-----Examples of Configured Slices -----



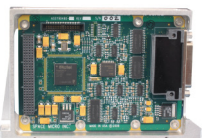
Proton200k™



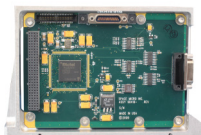
FPGA/SpaceWire



Digital I/O



Analog I/O



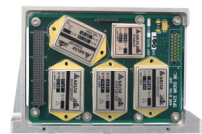
GPS (Receiver not shown)



Valve/Relay Driver



Power Switch

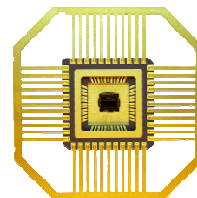


Power Supply

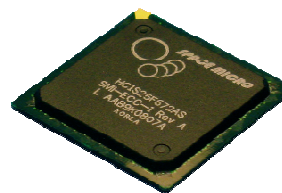
Components



8 Gb RH NAND Flash



H-Core™ Pat. "Watchdog" IC



2.5 Gbps ECC IC



Divert Attitude
Controller (DACS)

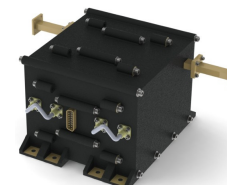
RF Microwave



uSTDN™ Transponder



uSGLS™ Transponder



Ka-Band Transmitter



uXLPA™ Linearized SSPA



Abstract & Motivation

Space Micro is developing a reconfigurable, radiation hardened space weather subsystem, called SEMS1000, which highly leverages commercial detectors and COTS microelectronics technology.

The SEMS1000 includes the following features:

1. Total ionizing dose (TID) monitor
2. Proton flux
3. Electron flux
4. Nuclear event detector(s)
5. Spacecraft charging monitor (SCM)
6. Temperature monitor
7. ESD event amplitude and waveform characterization

In this application, Space Micro's Proton 200K DSP card is the core of the SEMS1000 system and will process all detector data for reporting to the bus C&DH processor. Embedded in this system are Space Micro patented SEU mitigation techniques which enable its computers to exceed SEU performance of traditional rad hard computers. SEMS1000 is currently optimized for GEO applications, but can be tailored or customized for LEO or MEO, plus addition or deletion of other detectors.

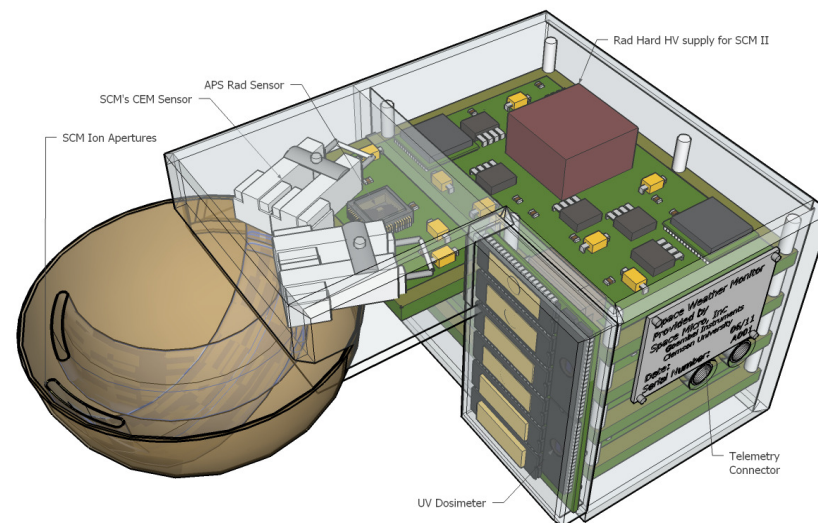
Performance specifications and size, weight, and power (SWAP) metrics will be presented, along with mechanical and thermal analysis. Radiation test data from both proton and heavy ion testing will be presented to demonstrate the SEU mitigation and resulting error rates.

This system is now available for insertion into new programs/missions such as SBSS, PTSS, AEHF, GPS follow-on, ORS, GOES, and TacSat series.



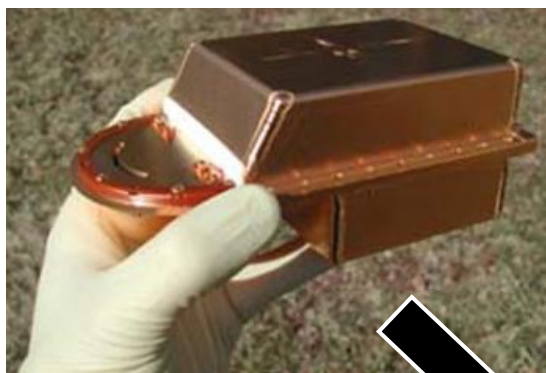
SEMS1000™ Space Weather Instrument

- Situational awareness of space environment
- Sensor suite providing data on:
 - Space Charge Monitor w/ earth reference
 - Deep Dielectric (spot measurement)
 - Passive UV-EPRM dosimeter
 - TID
 - Heavy Ions
 - Options:
 - APS stack (directionality)
 - Plasma/neutral particles mass spectrometer (density and atmospheric drag)

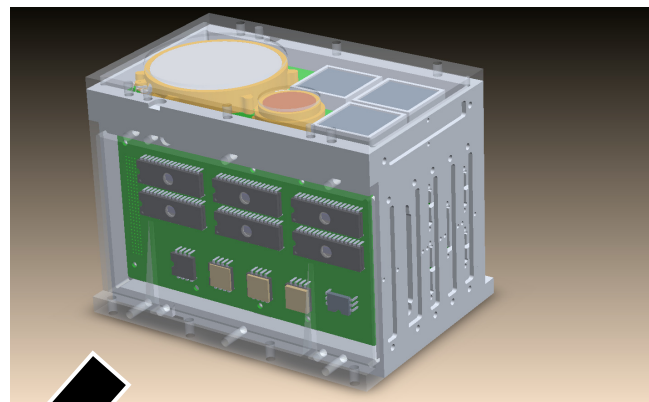




Space Environmental Monitoring System

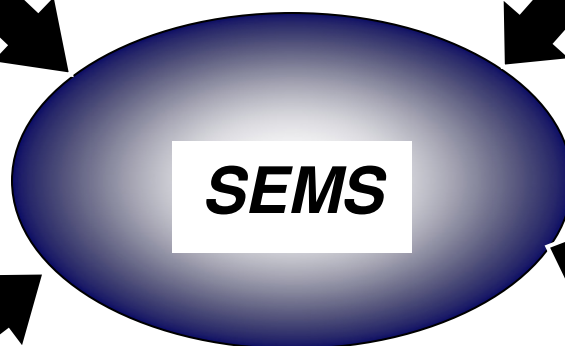
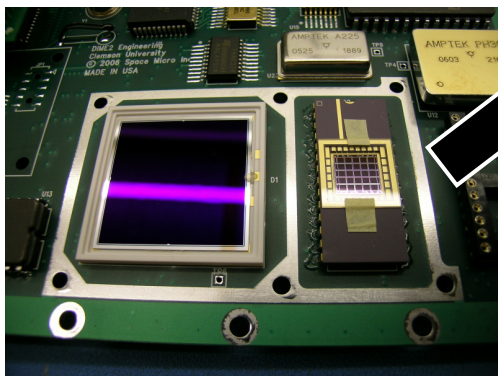


Spacecraft Charge Monitor
(Ion Spectrometer)

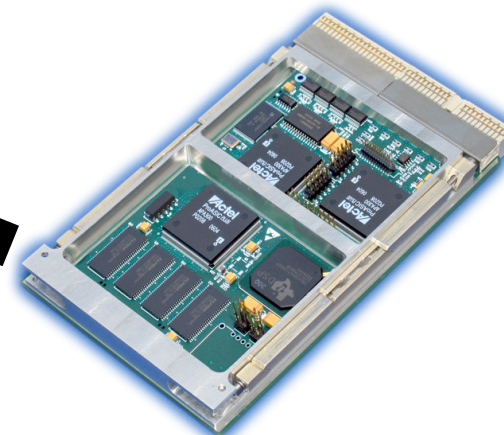


QinetiQ Merlin™ & USAFA
Sensors

Space Micro's
Radiation Sensors



- *Spacecraft Charging*
- *Radiation Sensing*
- *Ion Sensing*



Space Micro's Proton200k™
RH Computer

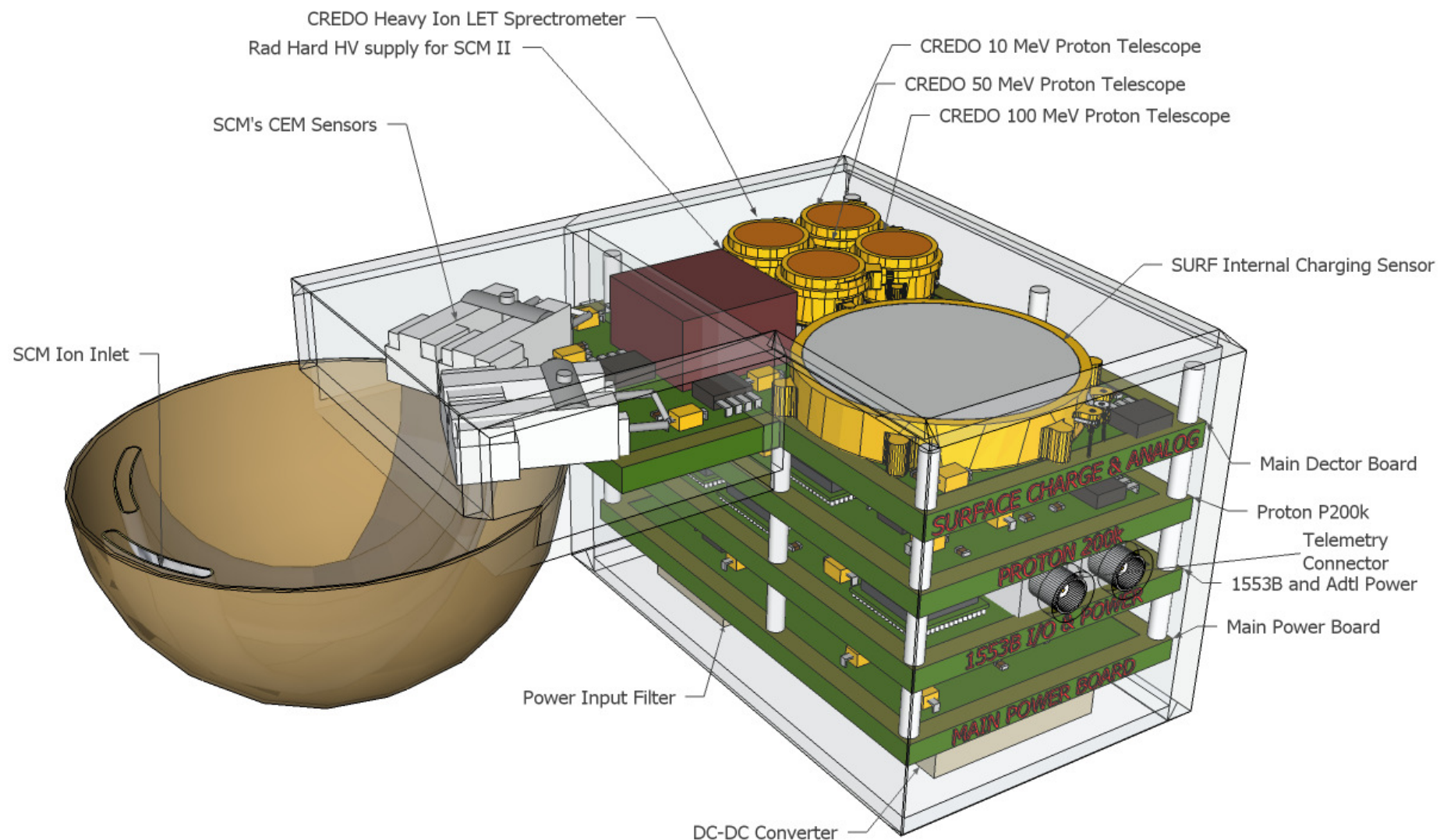


SEMS Monitors Space Weather

- Ion & Neutral Composition
- Electrons Flux
- Proton Flux
- Single Event Effects Detection
- Surface Charge Level
 - Rate of Surface Charge Change
- Deep Dielectric Charge Levels (4 materials)
- Passive Accumulated Total Dose (binned for energy levels)
- Solar Wind Exposure
- Spectrum Tracked by SCM-II Ion Spectrometer
- Rate of Dose over the Reporting Period
- Change in Rate of Dose between Periods



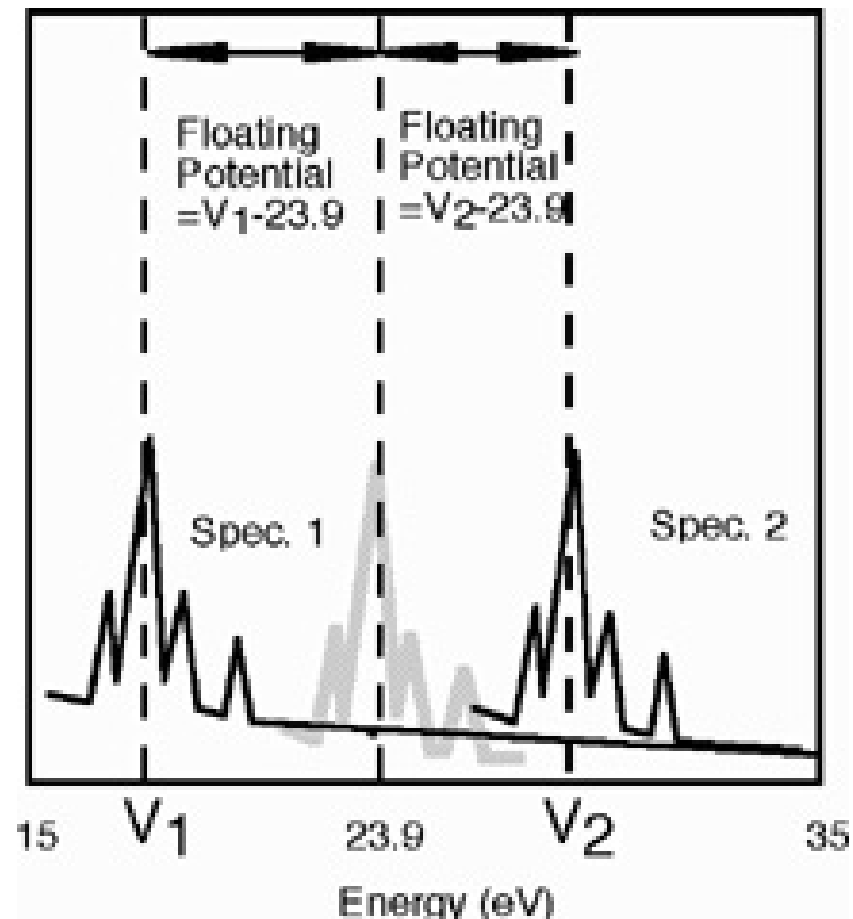
SEMS System Configuration





Spacecraft Charge Sensor

- Simple, one-to-one correlation between the change in the kinetic energy of the charged particle (in eV, 'electron volts') and the spacecraft's floating potential (in volts)
- Measure known environment
 - Electron spectra
- Spectrometer measuring electrons
- Provides voltage potential of satellite referenced to environment





Radiation Dosimeters

- Radiation Sensor Module of an array differentially shielded UVEPROM Sensor Cubes
 - Monitors Electron and Proton flux
 - Passive – Does not require power
- SEE monitor of LET sensors to compute SEE Probability
 - Monitors Protons and Heavy Ion SEE strikes
- Onboard Programmer Unit that will enable ground control of the sensor during flight
- Interrogator Unit to wake up and read the UVEPROM Sensor upon satellite command



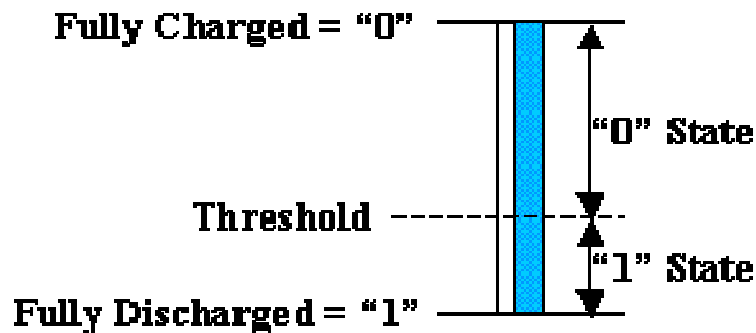
Radiation Sensor Comparison

Type	Measurement	Dynamic Range	Advantages	Disadvantages
UVEPROM	TID	1 Rad – Mrad	Digital, Large range, Unpowered while sensing, can easily be shielded for binning, Cost effective	Only beginning to be employed
Active Pixel Sensor (APS)	Dose Rate/SEE Probability	Individual particle detection	Wide range of detection capabilities	Significant support electronics and processing.
PIN Diode	TID, Dose Rate	10000 rad Sensitivity 100 rad-s	Detection of dose rate events, Fluence	Requires support hardware for dosimetry, Analog Readout introduces Errors
RadFET Thick Oxide	TID	1000 rad Sensitivity 1 rad-s	Small, reproducible results	Not sensitive, providing difficulty for binning by shielding,
RadFET Thin Oxide	TID	10 Mrad Sensitivity 10s rad	Small, reproducible results	Not sensitive, Analog Readout Errors
OSL	TID	μ rad-10,000 rad	Wide range accurate, proven	Passive, Destructive read, not adaptable to real time
Geiger	TID/Dose Rate	μ rad-500 rad/hr	Wide range, proven	Requires accumulation electronics
SRAM	SEE	1-40 MeV-cm ² /mg	Inexpensive SEE	Binary particle ranging

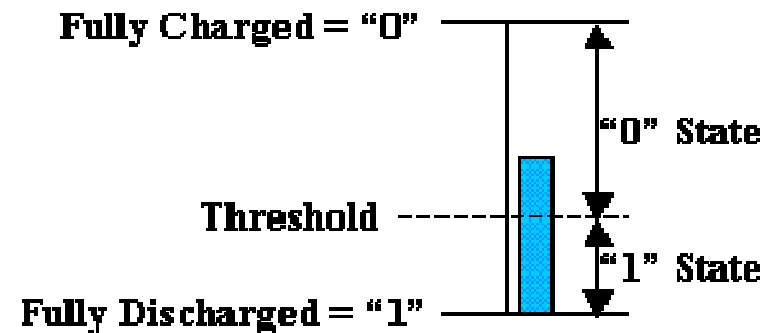


UVEPROM Charge Changed by Radiation

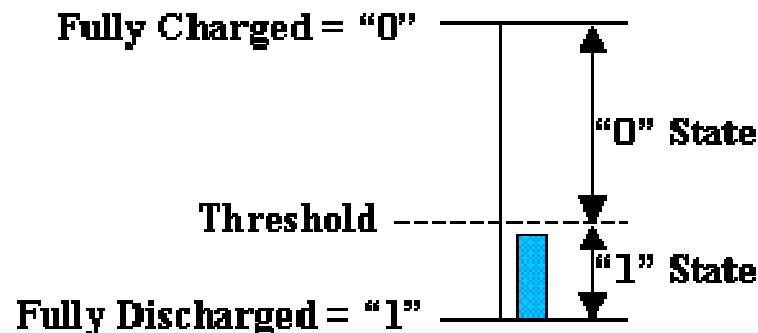
Write 0s to Cell



Radiation Reduces Charge But Still in "0" State



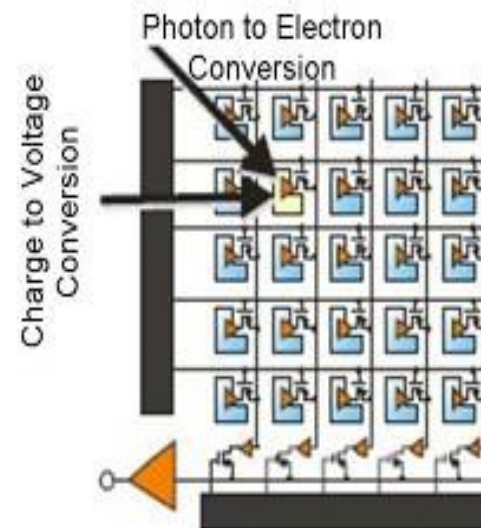
Additional Radiation Further Reduces Charge Now in "1" State





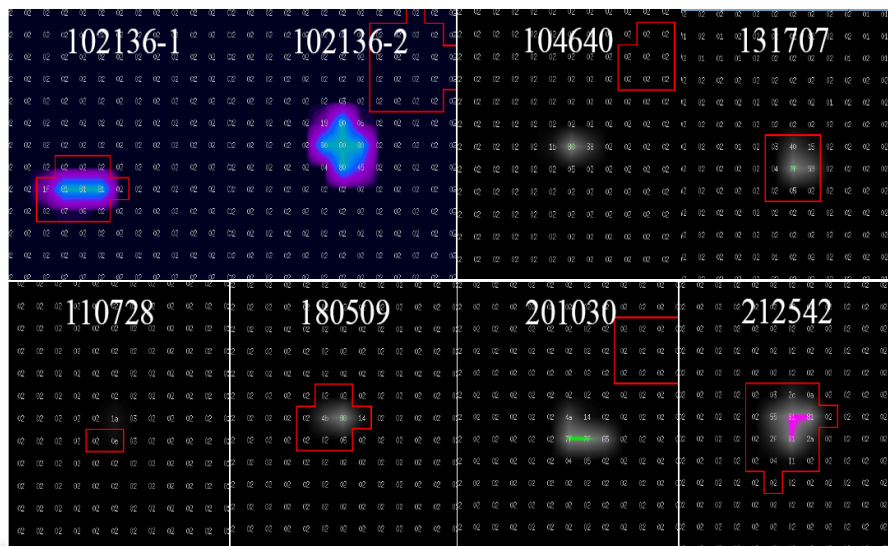
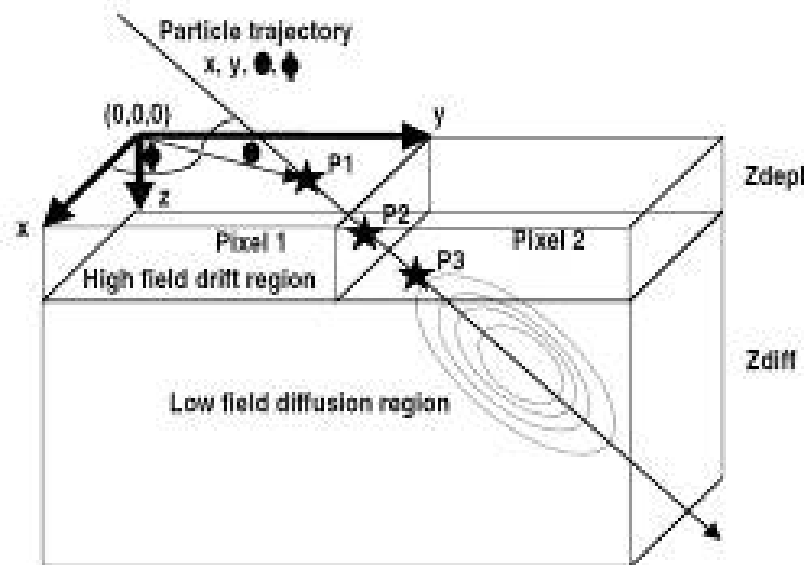
SEE Sensor Concept

- Active Pixel Sensor (APS)
- Matrix addressed photodiode arrays
 - Cadmium Zinc Telluride, or
 - silicon based arrays
- Particle trajectory through the sensor can be marked by the x and y coordinate of the sensor, the angles of incidence in the plane (Φ , Θ), the particle type and energy
- Potential for charge spread across more than one pixel from a single particle strike (see next slide)



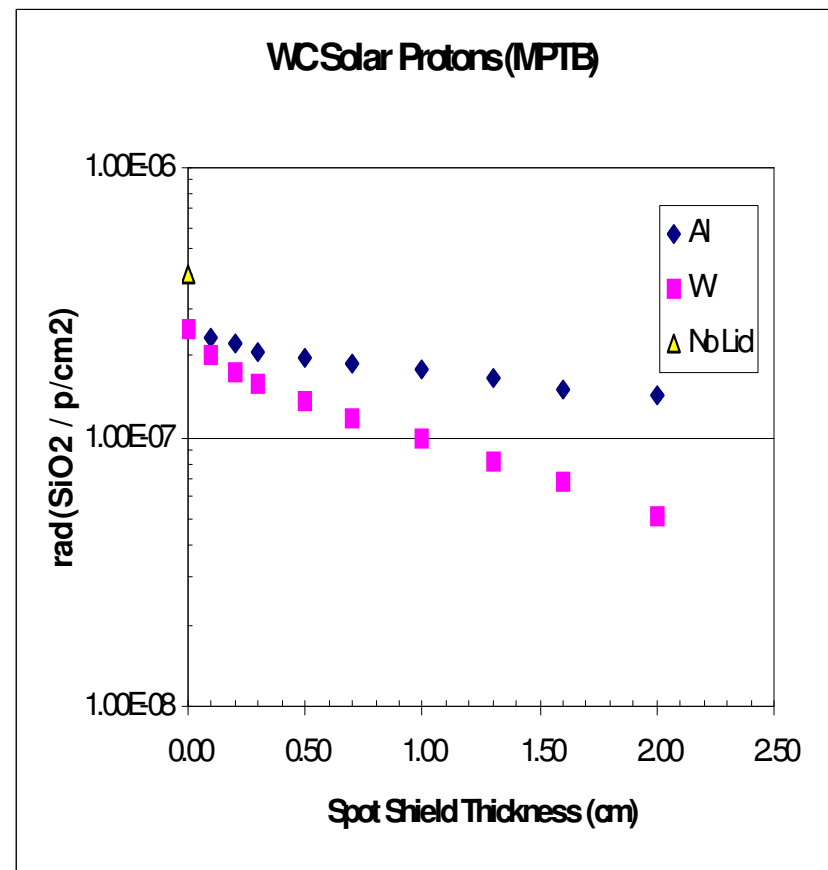
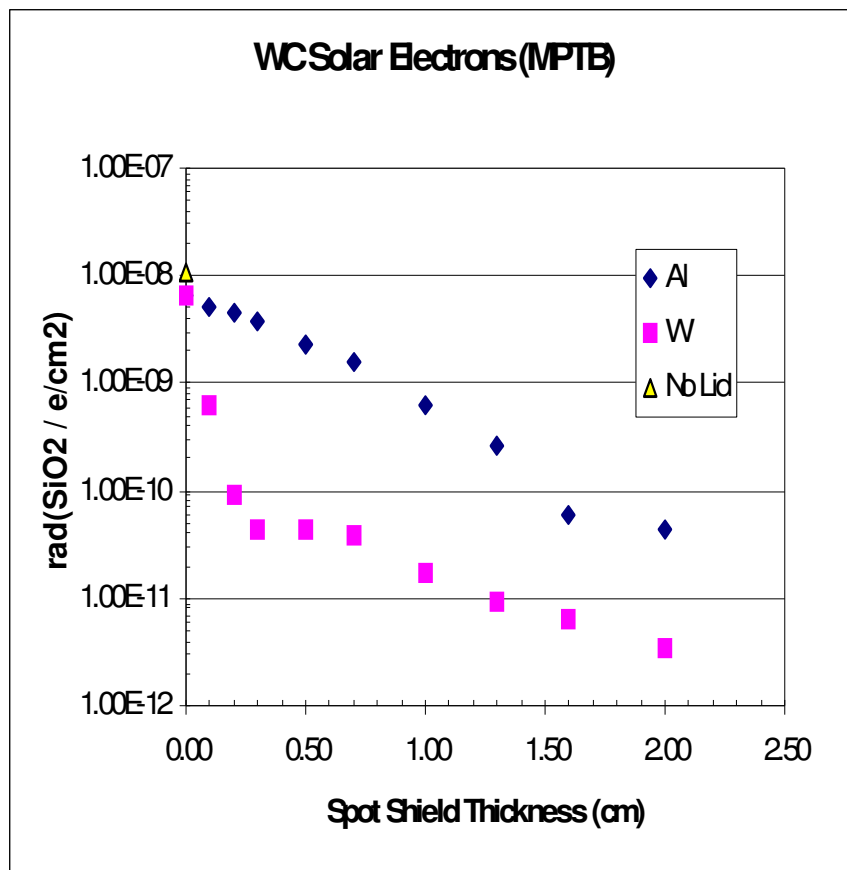


Radiation Strikes on ASP Sensor



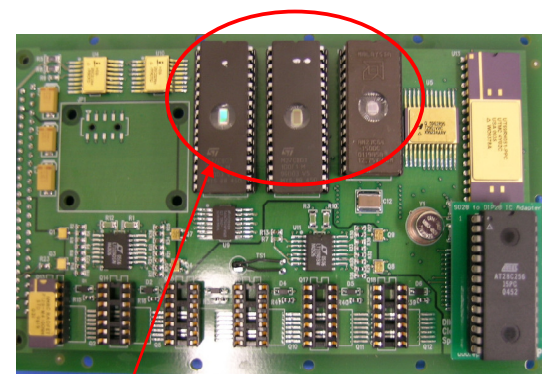
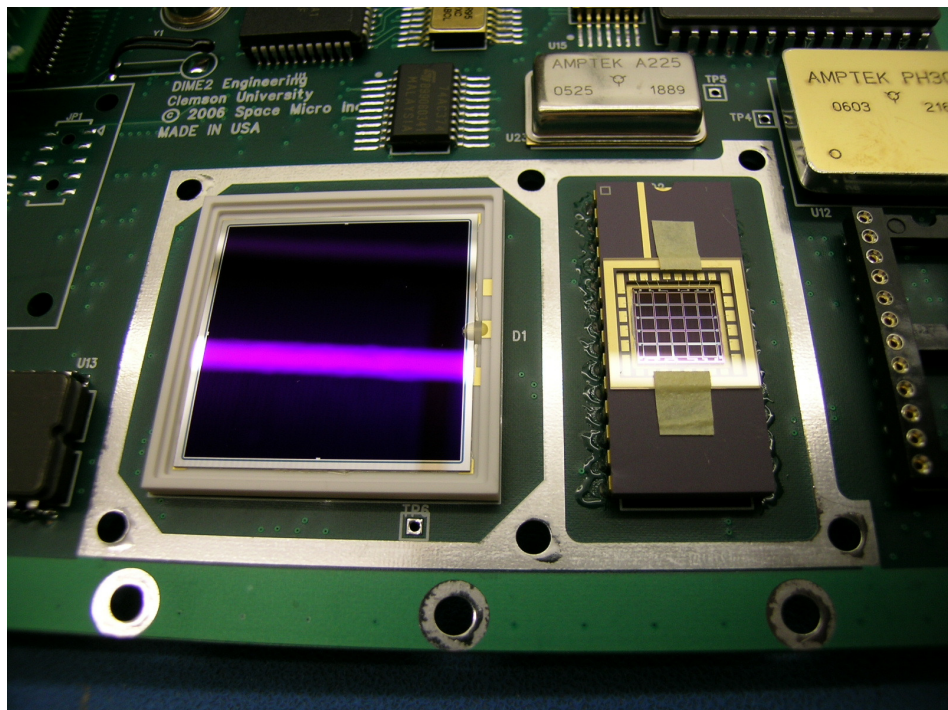


Use Shields to Further Bin Radiation





Radiation Dosimeters Built for NASA SET



UVEPROM Radiation Sensors

Flight Dosimeter Board for NASA SET

DIME



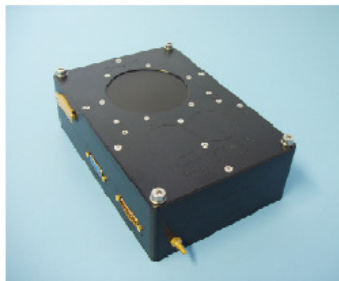
Conclusions

- **Space Weather suite has been designed**
 - Funded under AF TSAT program
 - Modular for multiple detectors/instruments
 - Flexibility of space parts quality to match budgets
 - Adapts to add new technology detectors and sensors
- **Space Micro can support**
 - Space Communications (uSTDN, uSGLS)
 - Space Weather & SSA (SEMS1000 suite)
 - Space Image Processing (IPC5000)
 - Space avionics (Proton X-box)



Another Offering from Space Micro & QinetiQ

MERLIN[®] Space Weather Monitor



Space Charge/TID/SEE
Space Weather Hazard Monitor

Space Micro Inc
(Merlin[®] Licensed from QinetiQ, UK)

Space weather storms put satellites at risk of damage and outages. Space weather is very unpredictable and hazard levels fluctuate from minute to minute as well as over longer timescales such as the 11-year solar cycle. Merlin[®] reduces risks for satellite owners, operators and insurers by providing local hazard awareness.

In the short term, clear, comprehensive local weather data gives much better information to satellite operators to make crucial decisions such as delaying non-urgent tasks and increasing staff alert levels. Faster diagnosis with more accurate data insures the best corrective measures are taken. Satellite lifetime can thus be properly estimated leading to potential life extension.

In the long term, Merlin[®] can provide satellite designers with clear evidence for planning improvements and modifications to future satellites.

Heritage

Merlin[®] distills 15 years of flight experience from QinetiQ's CREDO & SURF series of scientific instruments. Merlin[®] is in orbit since 2005 on ESA's Galileo Testbed Satellite (GIOVE-A) and has been delivered to NASA for the "Living with a Star" Program.

v2.2

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SPACE MICRO

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Closing thought



Thank you for your support!

 ***SPACE MICRO***