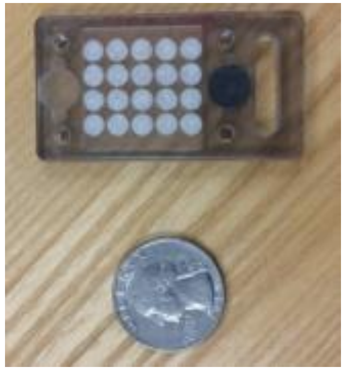
NASA Crew Personal Active Dosimeters (CPADs)

Leveraging Novel Terrestrial Personal Radiation Monitoring Capabilities for Space Exploration

TCC Radiation Technologies Event

9/21/16 Martin Leitgab

1) Novel Capabilities in Terrestrial Personal Radiation Dosimeters Yet Unused in Space



- Currently used NASA personal dosimeters (ISS): **Passive dosimeters**
    * **To be returned to ground** upon mission completion for analysis
    * **No in-flight exposure information**
    * Integral exposure information over entire mission, **no time resolution**

- Novel capabilities in terrestrial personal dosimeters:
    * **Active dosimeters**: configurable/autonomous recording of radiation exposure and internal storing of data
    * **Displays** for immediate user exposure feedback
    * **Wireless data transmission**

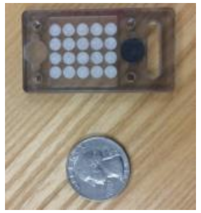
Opportunities to enhance Crew personal dosimetry with new features in terrestrial dosimeters

2) Technology Need for Exploration Mission 2 and Beyond

- **Requirements**: Need for wearable **personal active dosimetry**, capable of:

1) Measuring **time resolved** and time integrated absorbed dose
2) Operating for 30 days without being charged or requiring data download
3) Being read out by the crew via a **display on the dosimeter**

Requirement not met with existing NASA radiation hardware (passive dosimeters)



Space Radiation Analysis Group (SRAG, SD2) develops
COTS-based Crew Active Personal Dosimeters (CPADs) to meet requirements

- Derived requirements from intent of basic requirements:

a. Minimum impact to Crew mission operations

@ To minimize health risk projection uncertainties, CPADs to be worn at all times
@ CPADs need to be changed in all garment changes
@ Any additionally required Crew interaction to be avoided (e.g. data Xfer, power)

b. Accurate detection of space radiation environment (charged particles)

3) Market Survey/Technology Downselect

- **Use COTS products/base to minimize resource footprint of project**

  * Conduct **Market Survey** and **Technology Downselect**:

    @ Review COTS radiation detection technology options

    @ Identify most suitable radiation detection technology/implementation and vendor

- Apply basic selections to **identify/downselect COTS candidate dosimeters**:

Action a) Identify dosimeters with needed features (**keeps development gap small**):

@ Ready-to-purchase, packaged products (no research papers/components)

@ **Battery powered**

@ Capable of **record time-stamped dose**

@ **Readout via common interface to laptop**

@ **Small (<100 cm^3) & lightweight (<100g)**

3) Market Survey/Technology Downselect

Result a) Selected 2 Direct Ion Storage and 3 Silicon Diode COTS dosimeter candidates

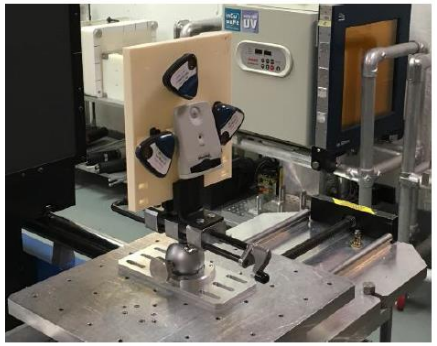
Candidate Detection Technology	Comment
Silicon diodes	Established (30 yrs), low power, small size, rugged; calibration potentially LET/energy dependent; used by IPs (ESA, JAXA)
Direct Ion Storage (DIS)	Established (20 yrs), low power, small size, rugged; used by IPs (ESA)
CsI(Ti) crystals	Too high power consumption, charged particle response probably not adequate
GM tubes	Only counter, charged particle response not adequate
Ionization chambers	Too large, too high power
MOSFET	No packaged product available; sensitivity probably not adequate; used by IPs (ESA)

Selected Company, Product	Technology
Mirion, Instadose 1	DIS
Mirion, Instadose 2	DIS
Mirion, DMC 3000	Si diode
Thermo Fisher Scientific, EPD	Si diode
Fuji Electric Co, NRF-30	Si diode

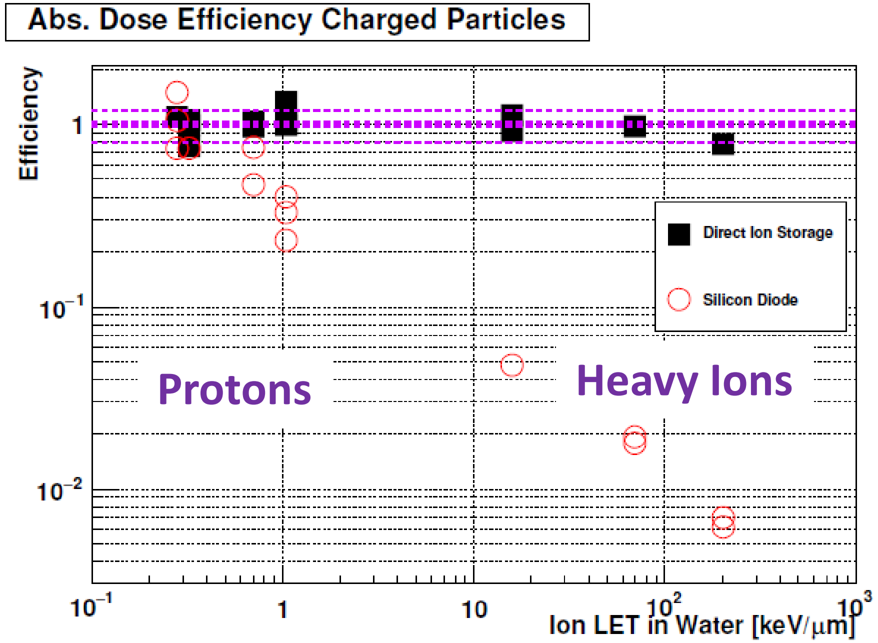
Selected Dosimeters

4) Technology Downselect

Action b) Test dosimeter candidates in space-relevant charged particle radiation fields



Radiation Testing @ TRIUMF, NSRL



Result b) Tests selected Mirion DIS as sole feasible COTS technology & implementation

- Mirion Technologies holds patents on DIS technology
  -> Selected as sole source vendor

5) CPAD Development Requirements

- MPCV Operations Needs

Requirements Category	Flowed Down Requirement	Comment
Size/form factor, weight	Within 20% of Instadose 1: < 3 x 1 x 0.6”; < 50 g	Close to existing ID-1 product
Battery	Life 30+90 days, capacity < 200mAh	Exceeded by existing ID-2 product
Data storage	>= 4500 points	Exceeded by existing ID-2 product
	‘Dynamic read’: only record dose if beyond 20 muGy resolution (at most once per minute)	New feature (exists in industry)
Data Transfer	Bluetooth wireless data transmission disable feature (for mission duration): Implement reset buttons for BLE processor	Close to existing ID-2 product
Non-shatterable display	Display cumulative absorbed dose since mission start and dose over last 10 minutes (‘rate’)	New feature (exists in industry)

- Approach: **Enhance existing COTS features** with additional **new features** to meet all CPAD requirements

MIRION TECHNOLOGIES

+

MIRION TECHNOLOGIES

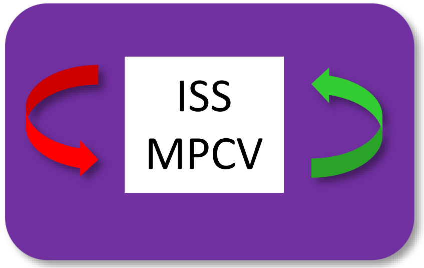
+

= CPAD

6) Leveraging Synergy between NASA ISS and MPCV Programs

- **ISS** currently uses **passive dosimeters for Crew personal radiation monitoring**
- **Benefits for ISS Program** from use of adoption of CPADs as operational personal dosimeters:
  * **Reduced ground processing cost/time**
  * Reduced up-down logistics
  * Near real-time data availability
- **Benefits for MPCV Program**: ISS agreed to fund **2017 Technology Demonstration Mission**

Test bed for exploration



Exploration technology use on ISS

- ISS Additional Operations Needs

Category	Flowed Down Requirement	Comment
Battery compartment	Tool-free accessibility	New feature (exists in industry)
Battery	Life 8 months, capacity < 200mAh	Exceeded by existing ID-2 product
Bluetooth Wireless Data Transmission	Autonomous data transfer to webserver, transmission quality assurance, database framework	Exceeded by existing ID-2 product

7) Summary and Future Activities

- **MPCV Crew Personal Active Dosimeters** will bring **novel capabilities in COTS personal radiation monitoring** to space exploration
- CPADs have **operational use option for ISS increasing efficiency and reducing cost** contingent on success of Technology Demonstration mission
- **Accelerated schedule** due to use of COTS base:
    * **August 2016 Contract start date**
    * September 2016 Deliverables due- basic board schematics and layouts
    * December 2016 Deliverables due- pre-production drawings, bill of materials
    * **February/March 2017 Delivery of CPAD hardware and software**; acceptance testing
    * **June/July 2017 ISS Technology Demonstration Mission** target (SpX-12 or similar)
    * **Fall 2017 Preparation for operational use of CPADs on ISS** if Tech Demo Mission successful
    * **2018 Flight on MPCV Exploration Mission 1**
    * **2022 Flight on MPCV Exploration Mission 2**