



# Space Radiation Analysis Group Operational Tools

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<sup>1</sup>Kerry Lee

<sup>1</sup>A. Bahadori , <sup>2</sup>J. Barzilla , <sup>2</sup>T. Bevill, <sup>1</sup>D. Fry, <sup>2</sup>R. Gaza, <sup>2</sup>A.S. Johnson, <sup>2</sup>J. Keller, <sup>2</sup>M. Langford,  
<sup>1</sup>E. Semones, <sup>2</sup>N. Stoffle, and <sup>2</sup>A. Welton

<sup>1</sup>NASA Johnson Space Center, SD2, Houston, TX 77058 U.S.A.

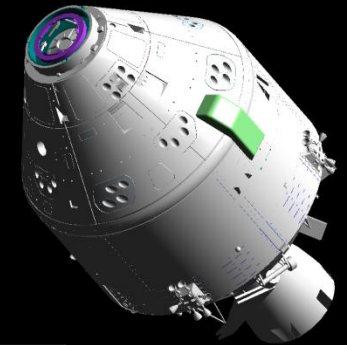
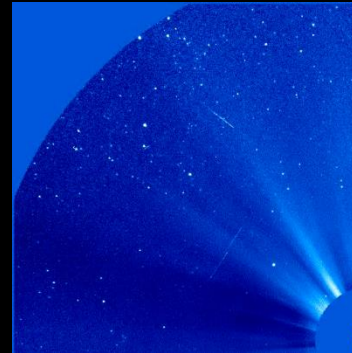
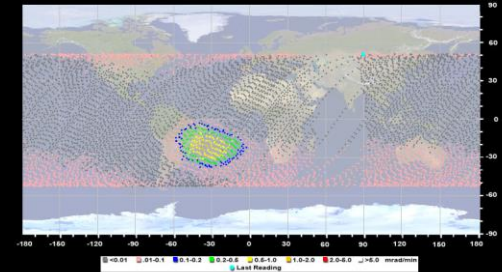
<sup>2</sup>Lockheed-Martin Space Operations, Houston, TX 77258 U.S.A.



# OVERVIEW

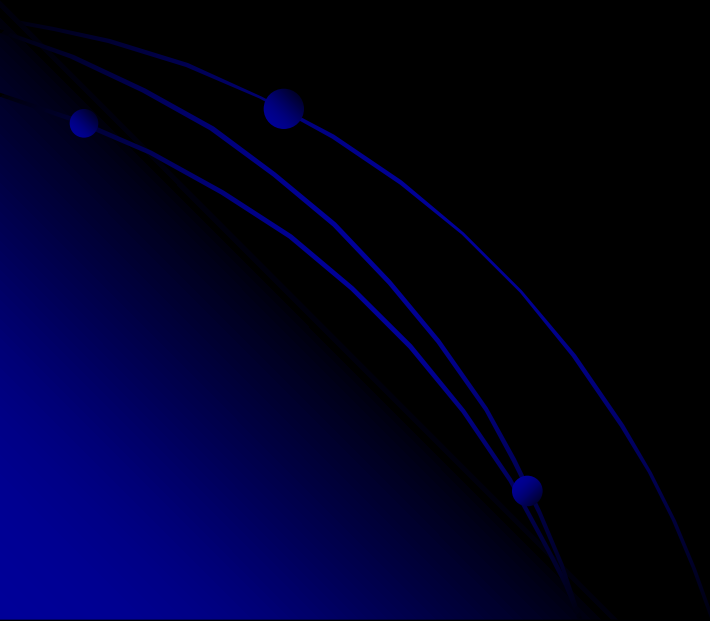
- SRAG Operations
- Data and Measurements
- Technology Development
- SRAG Future

ISS TEPC Dose Rates (Ascending): 10/10/04 00:00:00 to 10/25/04 23:59:59 (GMT)





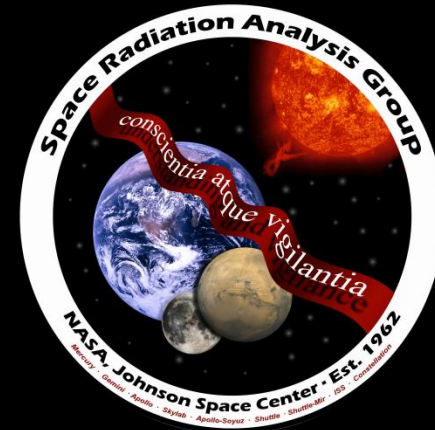
# SRAG Operations





# Operations

- SRAG, est. 1962
  - Real-time console operations
  - Crew, ambient monitoring
  - Pre-flight planning
  - Design evaluations
- Radiation Health Office
  - Interpretation
  - Record Keeping
  - Risk Estimation
  - Crew Selection



NASA Space Life Sciences (SLS) Reorganization combined SRAG and RHO. SLS changed names to Human Health and Performance (HH&P).





# Radiation Monitoring for Crew and Space Vehicle

## ➤ Console Operations Support

- 24 hours Contingency Support
- 4 hour/day Nominal Support

## ➤ Active Radiation Detectors

- Tissue Equivalent Proportional Counter (TEPC)
- Charge Particle Directional Spectrometer (CPDS)
- Intra-Vehicular TEPC( IV-TEPC)

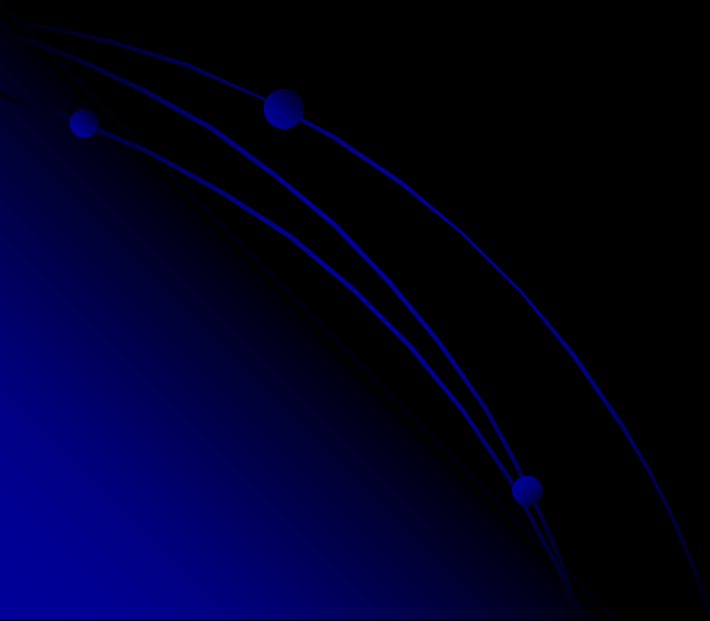
## ➤ Passive Radiation Detectors

- Crew Passive Dosimeter (CPD)
- ISS Radiation Area Monitor (RAM)





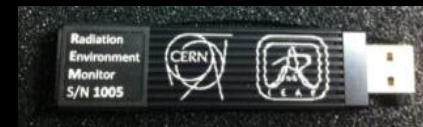
# Data and Measurements





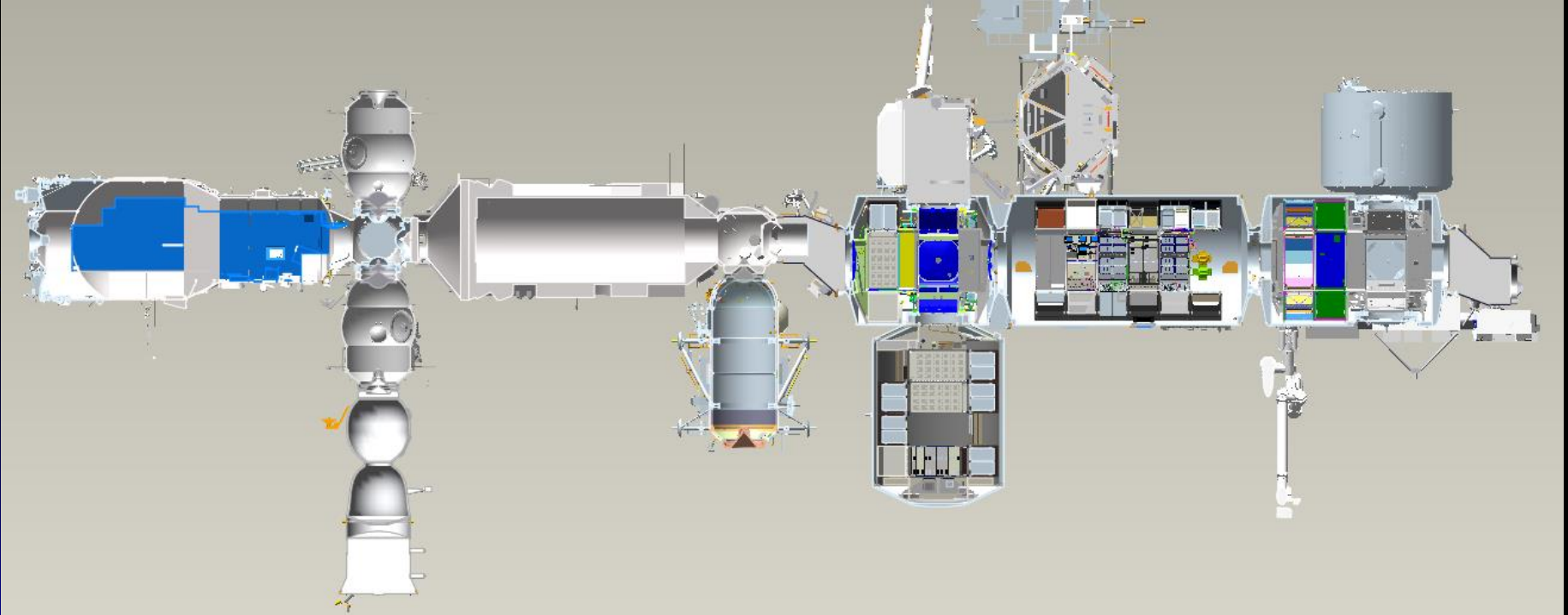
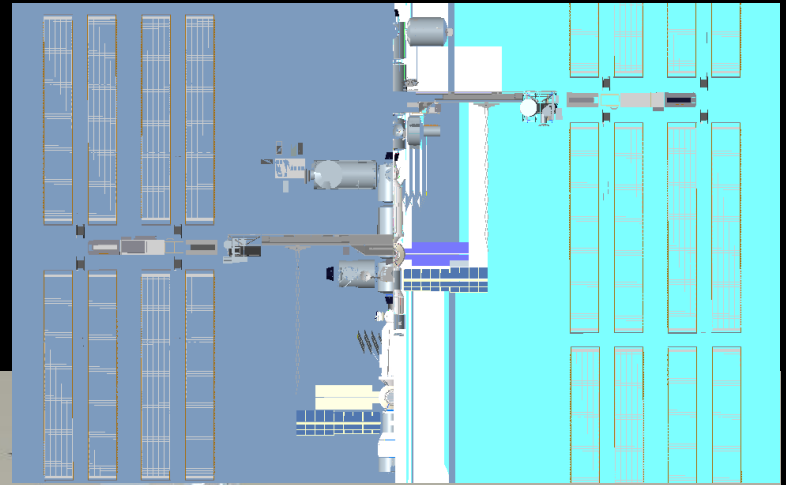
# Instrumentation

- RAM – Radiation Area Monitors
  - Passive dosimeters, 20+ locations on ISS
- REM – Radiation Environment Monitor
  - Active dosimeter with USB interface
- TEPC – Tissue Equivalent Proportional Counter
  - Located in ISS Service Module
- IV-TEPC – new TEPC detector
  - Moves about ISS every 4-6 weeks



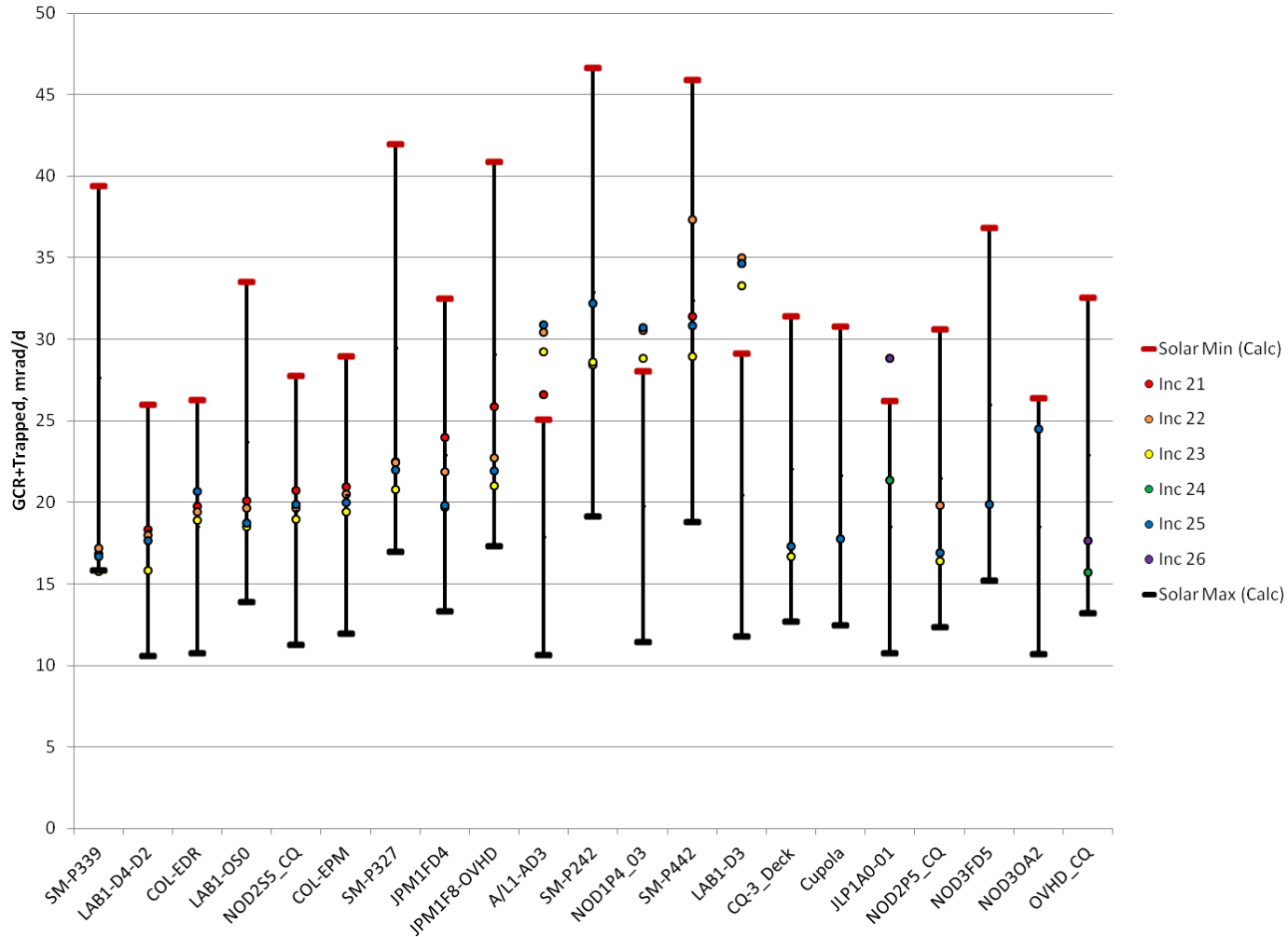


# ISS Configuration



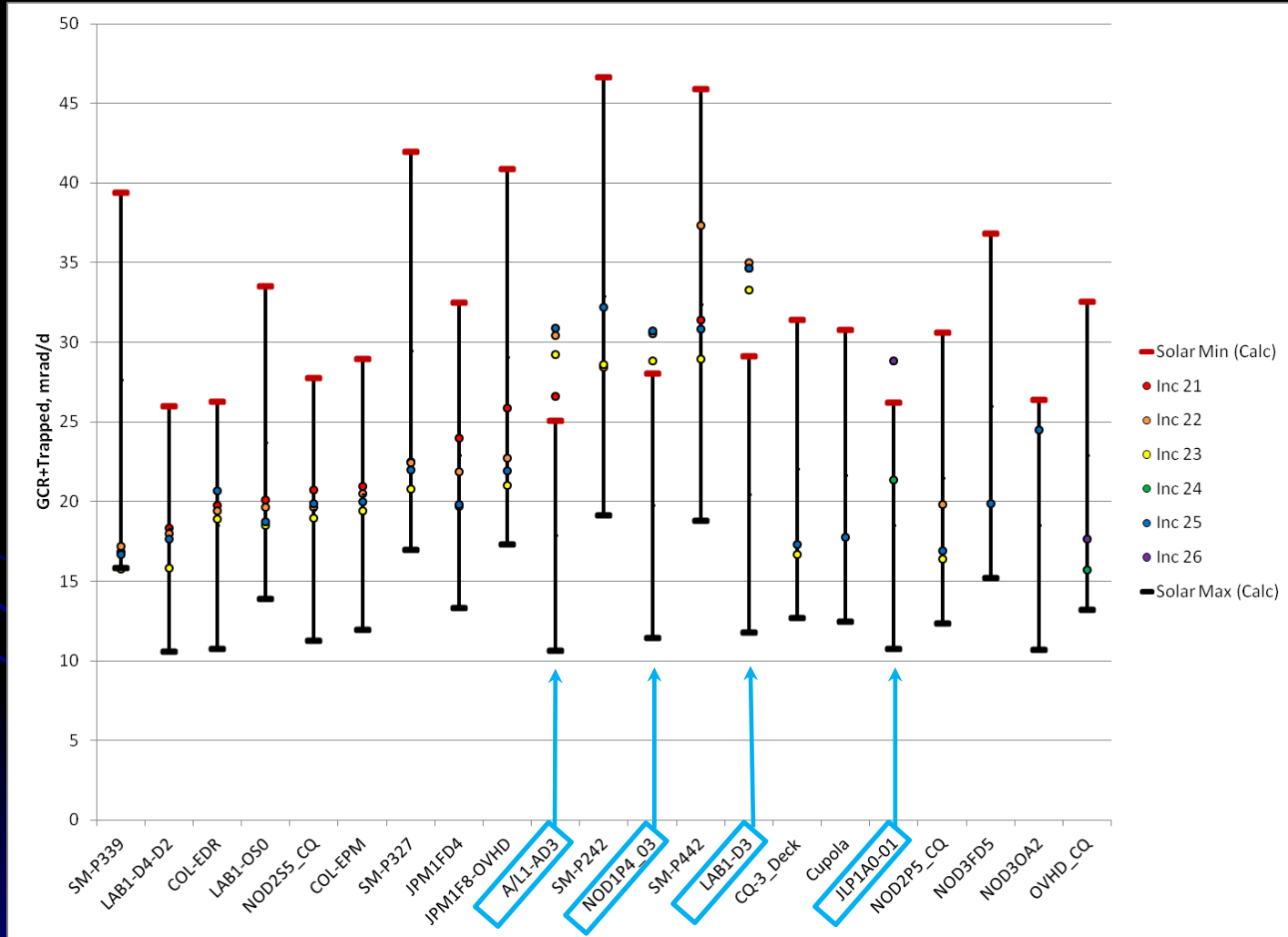


# Comparison to RAM Data





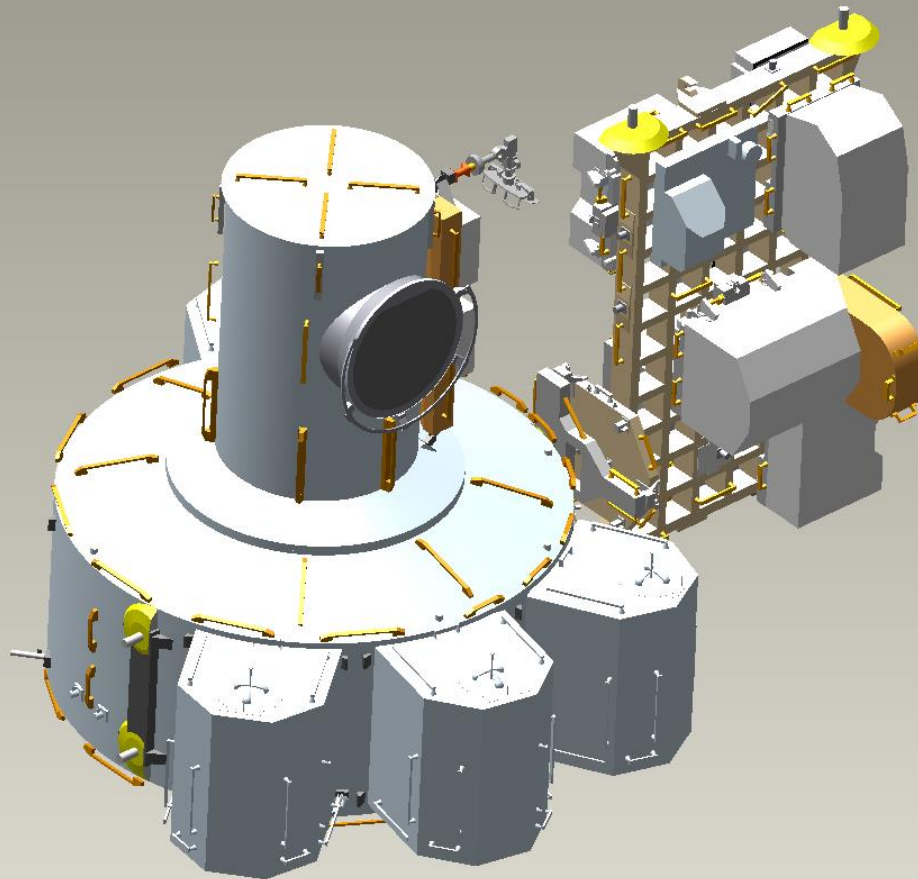
# Comparison to RAM Data







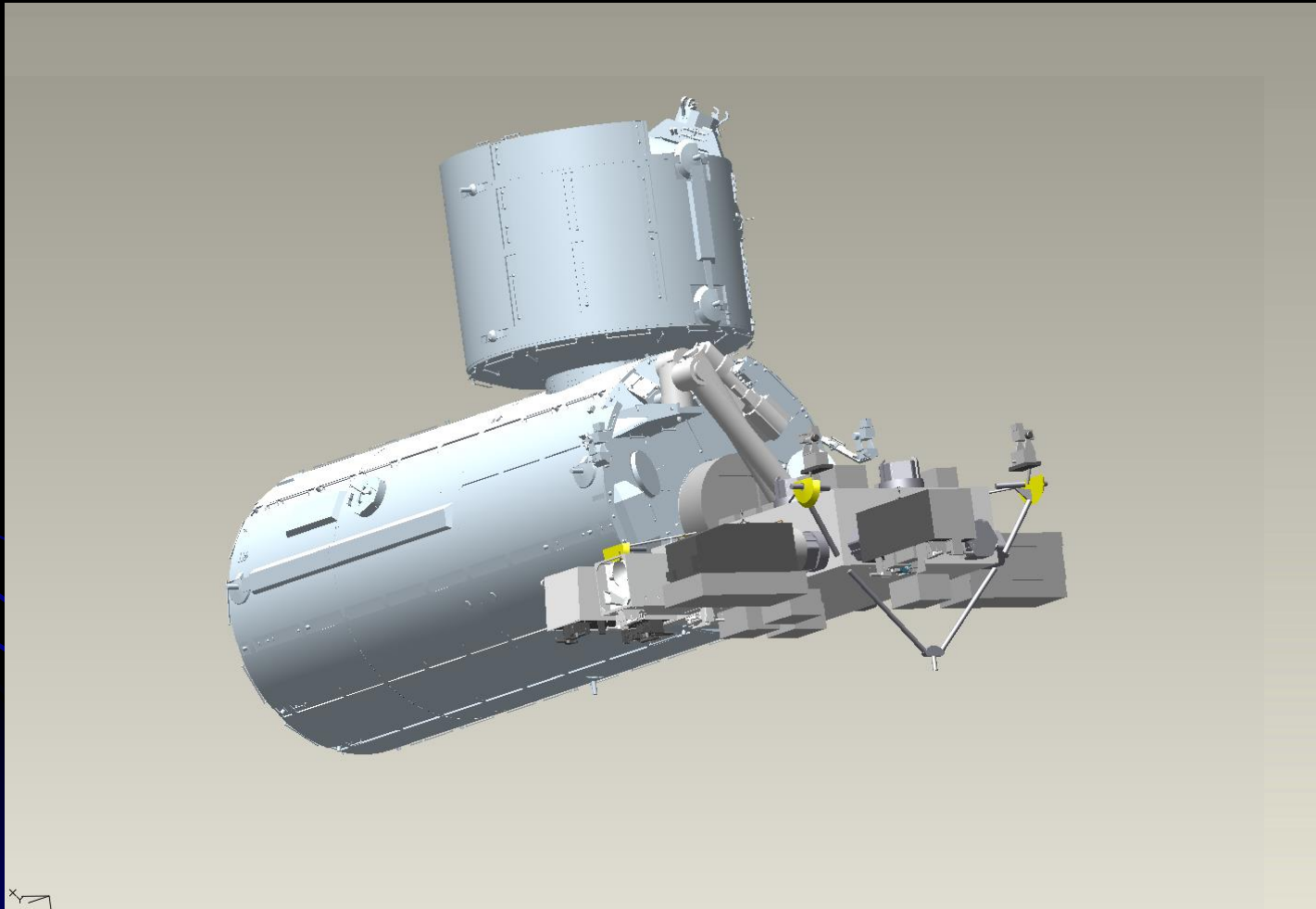
# A/L1-AD3







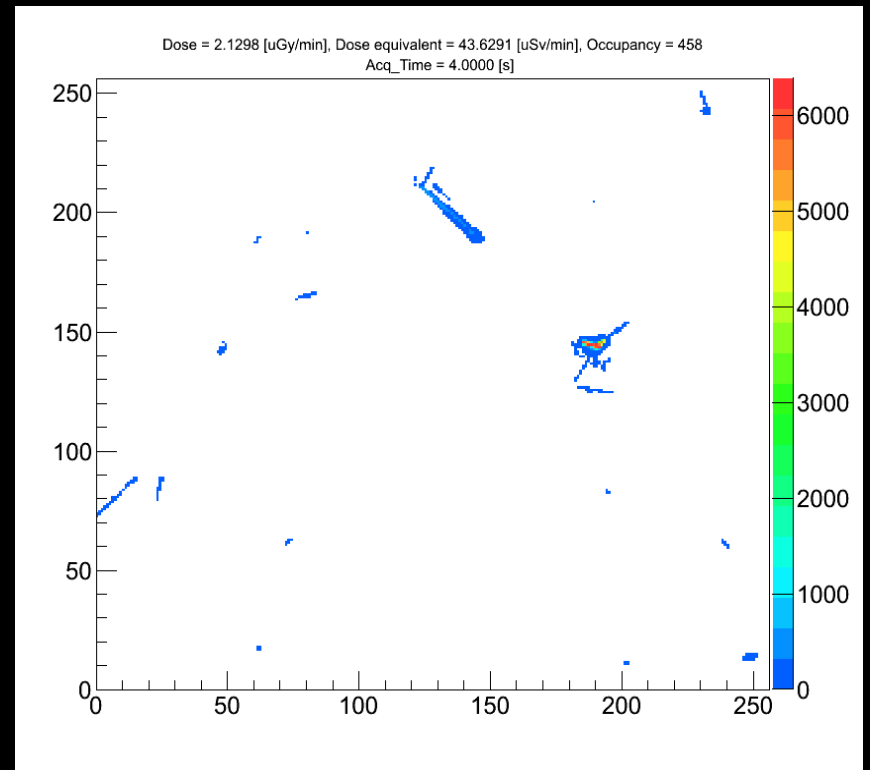
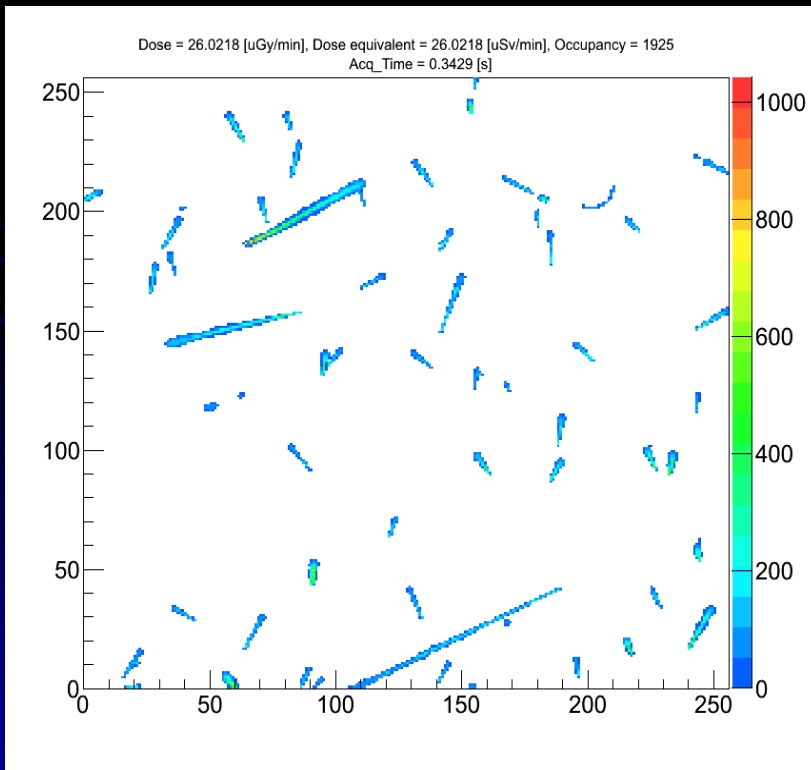
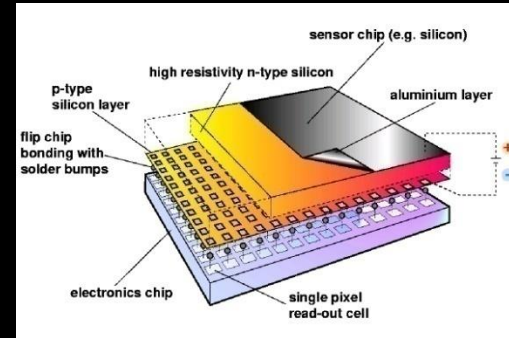
# JLP1AO-01





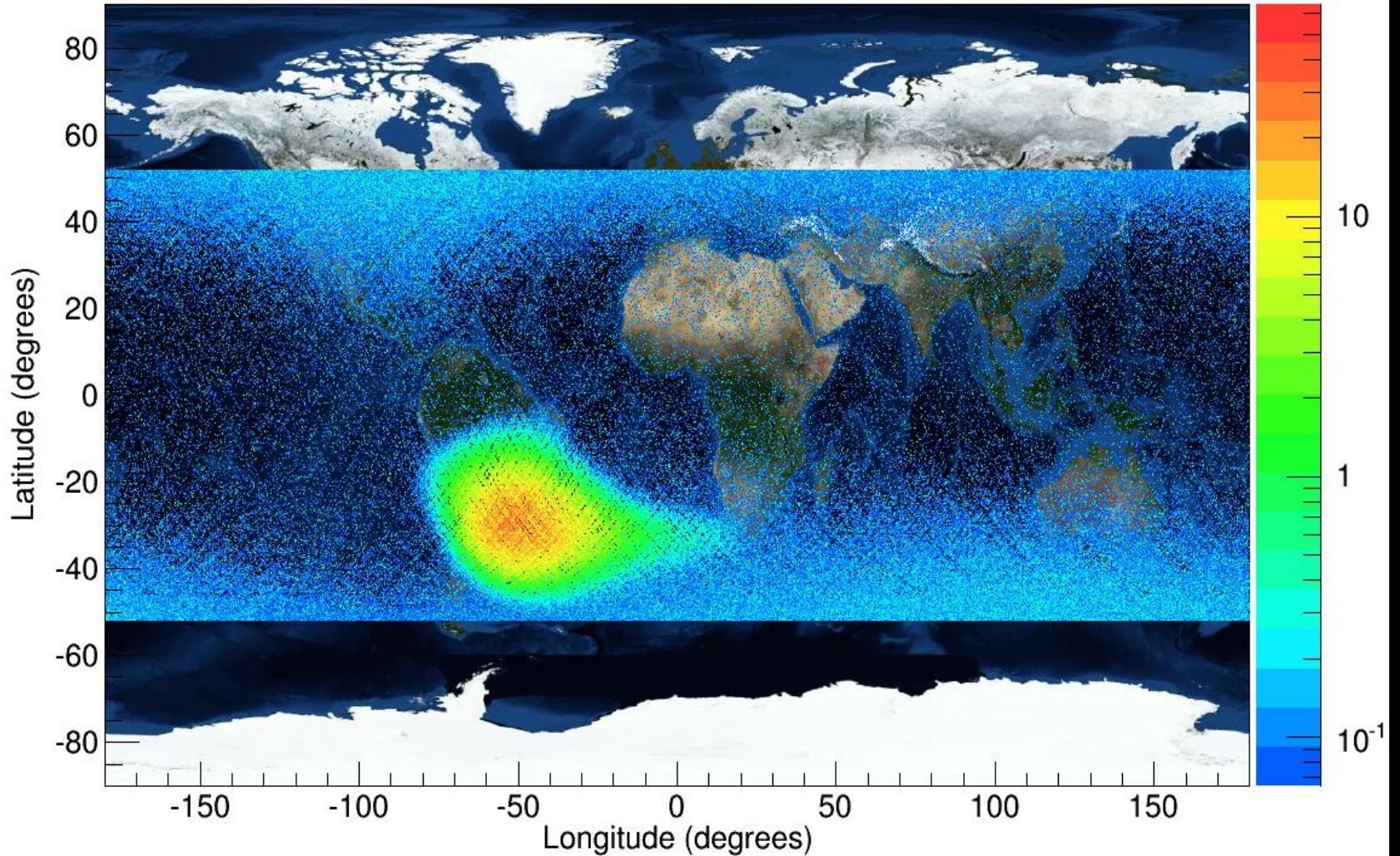
# Raw REM Data Frames

REM is based on a 256 x 256 pixel grid detector with total area of 2 cm<sup>2</sup>. Low mass and power.



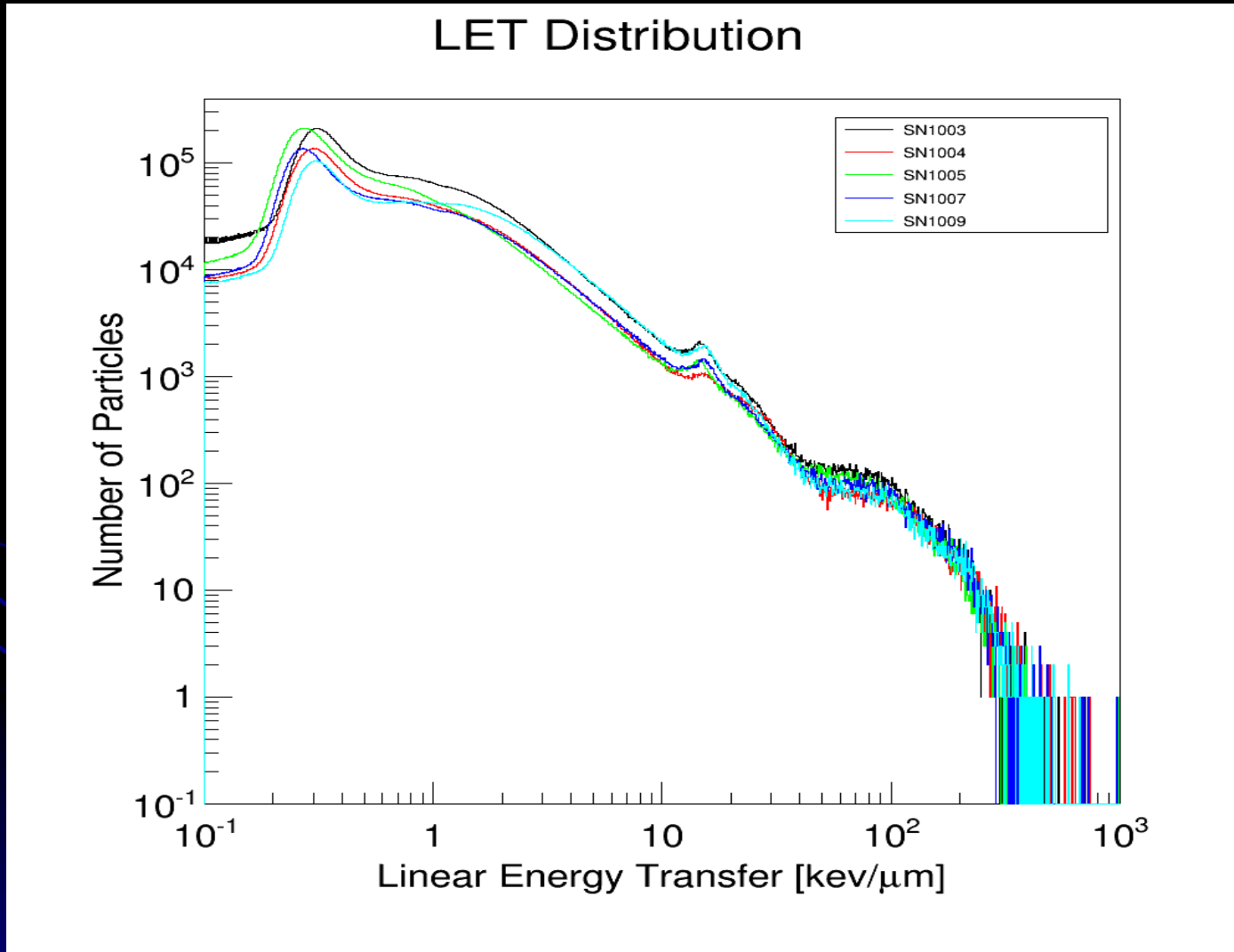


REM Orbital Dose Rate Map ( $\mu\text{Gy}/\text{min}$ )  
G03-W0094 (S/N 1009)  
GMT 2012/320 through GMT 2013/045



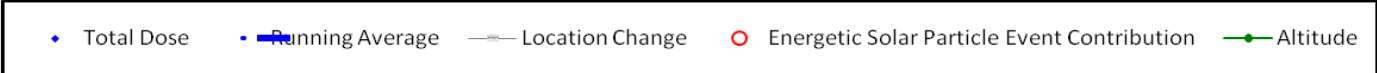
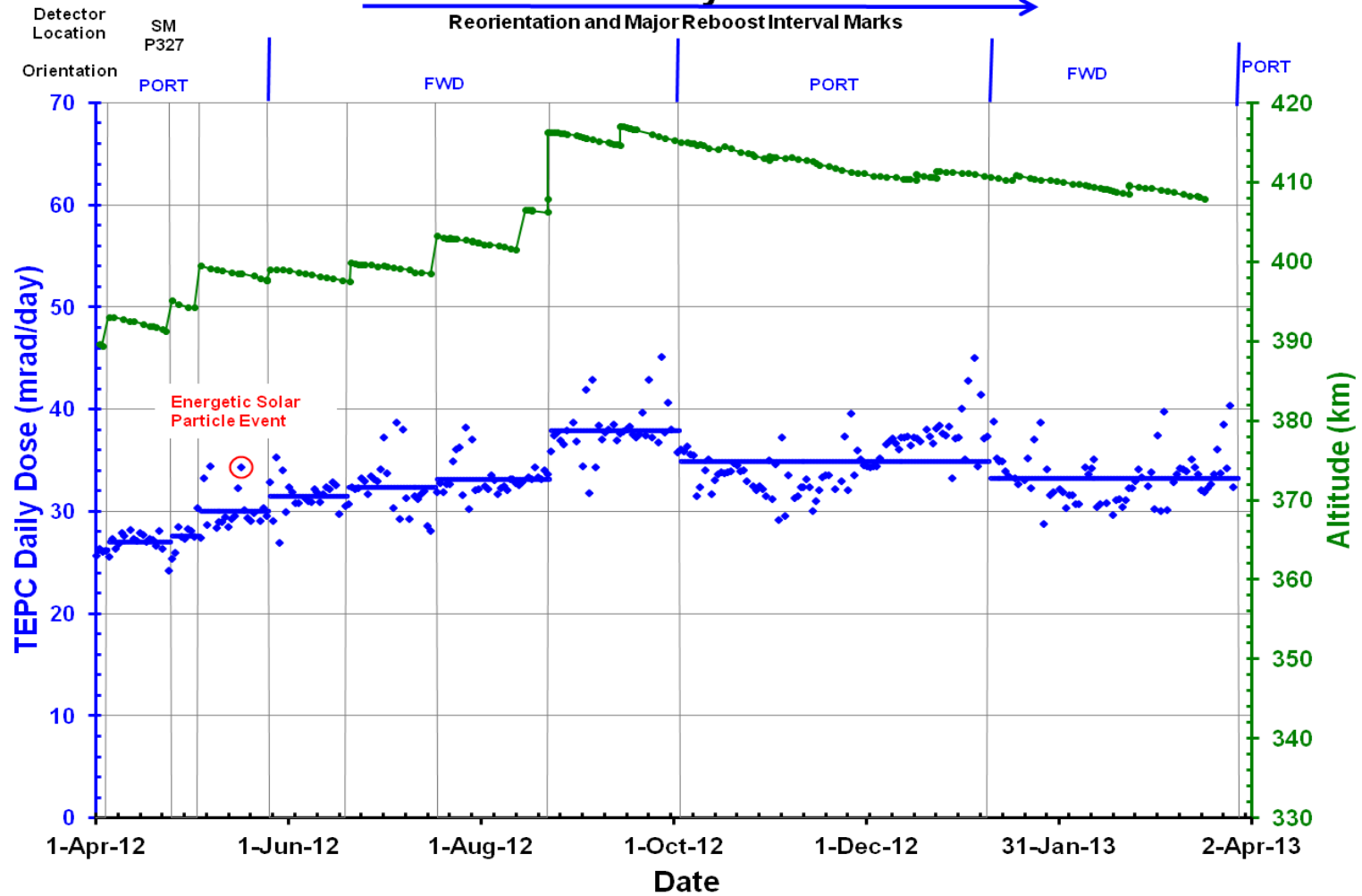


# REM Instrument LET Measurements





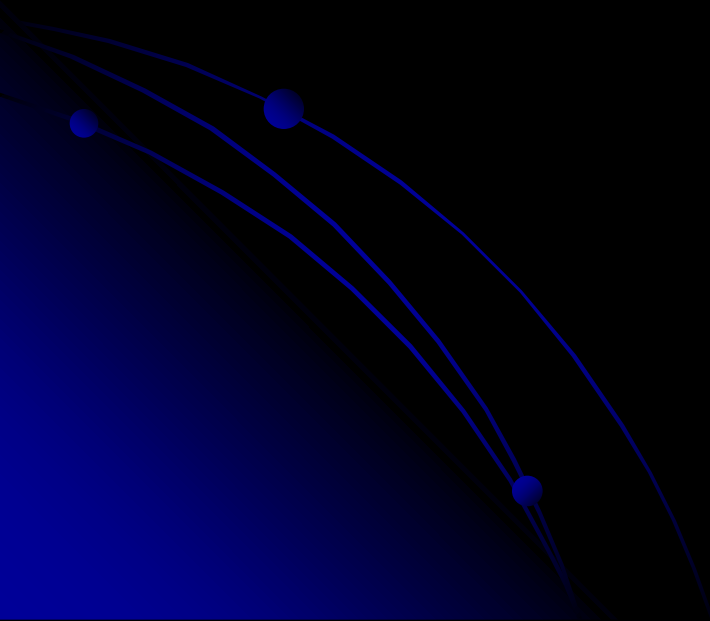
# ISS TEPC Daily Dose 1 Year Trend







# Technology Development





# Update to Advanced Radiation Protection Project

- MC-CAD: Radiation protection design through analysis of complex CAD geometries using Monte Carlo radiation transport codes.
- ISEP: The Integrated Solar Energetic Proton Event Alert Warning System. Collaboration with JSC/GSFC/MSFC/LaRC/Univ. Alabama/Univ. Tenn.
- Both tasks are underway with expected operational products completed in Sept. 2014
- ARP was a casualty of sequestration on 3/1/2013
- Partial funding regained in April for ISEP to continue through September 2013
- MC-CAD remains unfunded by OCT
- ISEP will deliver models that need further verification and MC-CAD will deliver a prototype CAD-FLUKA interface





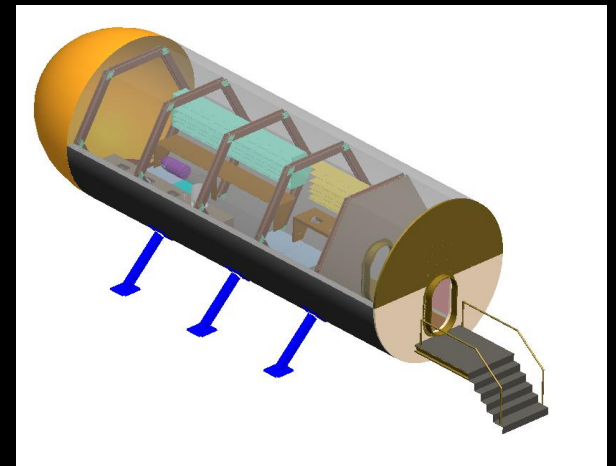
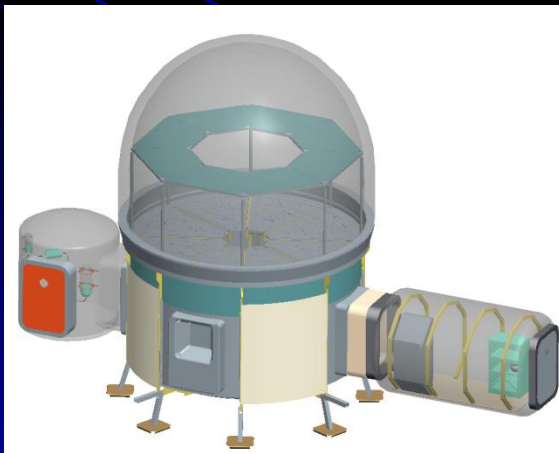
# Technology Development

- Active Shielding
  - Research to determine if it is mass and/or power prohibitive
  - Technology development on system components that will improve shielding effectiveness and decrease mass and power needs
- Measurements
  - ISS Detailed Test Objective – REMs starting summer 2012
    - Actual: Launched in August began operations in October
  - Exploration Flight Test 1 (EFT-1) (RAMs and REMs) – 2014
  - Radiation Assessment Detector (RAD) with an added fast neutron detector channel – 2015



## MC-CAD Project in Review

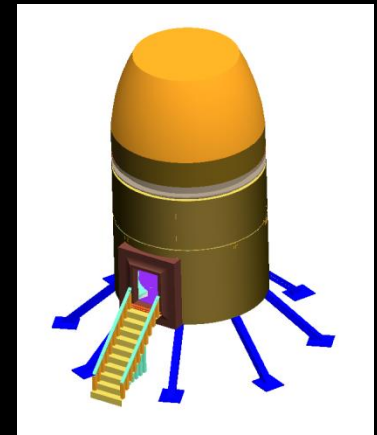
- Collaboration with the University of Wisconsin has been established to make use of their existing DAG-MC (Direct Accelerated Geometry – Monte Carlo) tool as a universal geometry and navigation interface to radiation transport packages
- Teamed with FLUKA collaboration at CERN to make use of the FLUGG (FLUKA-GEANT4 interface) to link DAG-MC with FLUKA (FLU-DAG)





## DAG-MC Overview

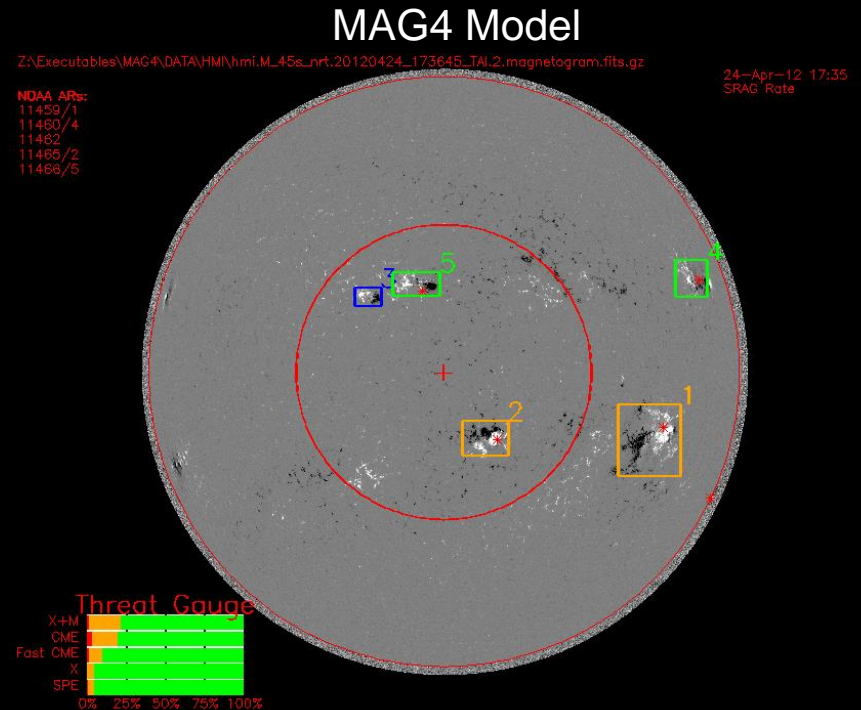
- Functioning version that currently works with MCNP. Used regularly for Fusion ITER project.
- CAD converted to MOAB (Mesh Oriented datABase)
- Fast binary search algorithms
- Material assignment, boundary conditions, source definition, tally/scoring
- Imprint and merge for touching surfaces (water tight)
- Navigation within CAD on complex geometry is only about 2.5 times slower than simplistic native quadric combinatorial geometry models





# Space Weather Forecasting

- Historical database for identification of event trending/characteristics
- Probabilistic modeling for operational mission planning
- ISEP: integration of probabilistic spectral and SEP dose modeling
- Dose projection for in-event risk mitigation
- Forecasting of event onset and impact outside of low-earth orbit.



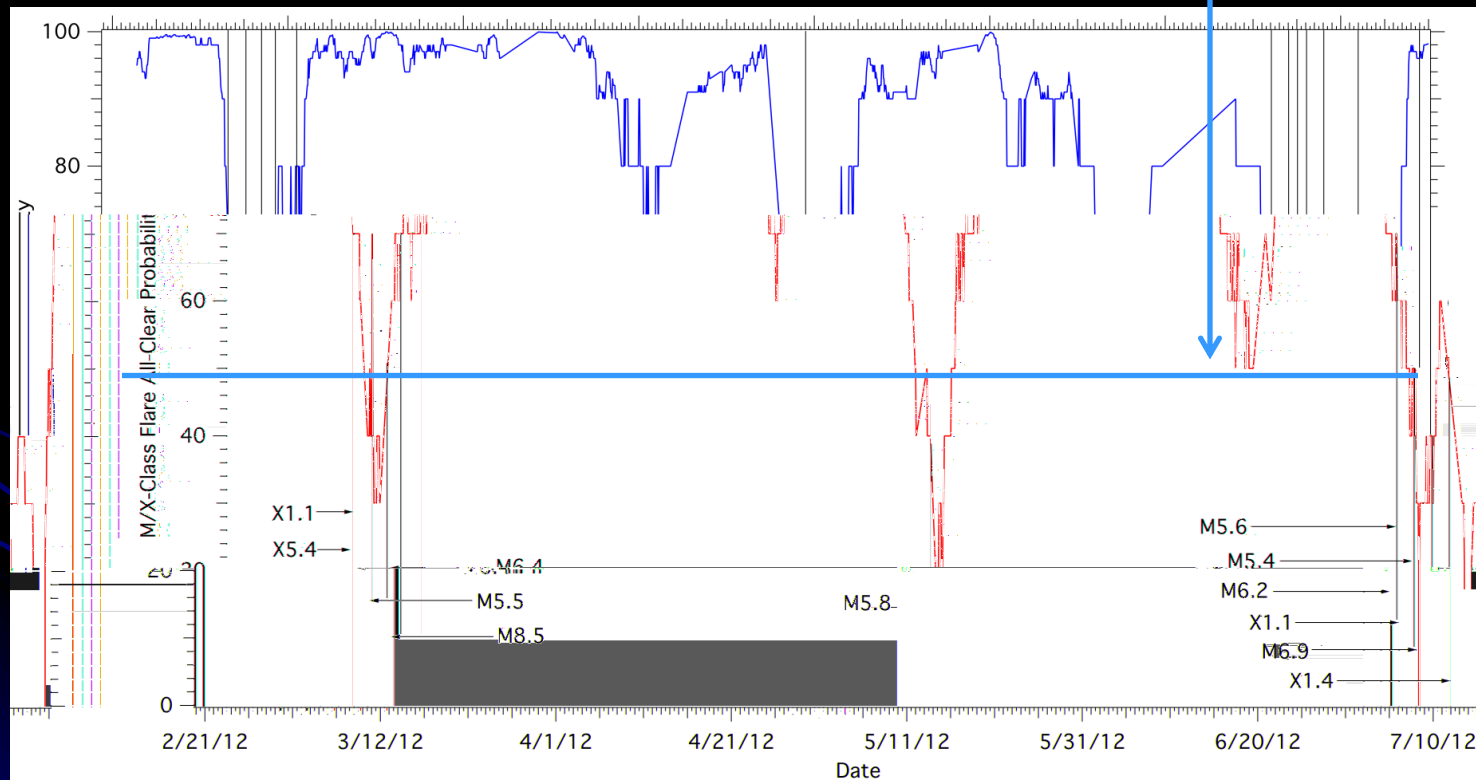
David Falconer University of Alabama

In Collaboration with CCMC and University of Alabama



# Model Validation and Testing: All-Clear (Preliminary)

- Change in 'All-Clear' probability is sufficiently distinct for operational use.
- Thresholds for 'go / no-go' call will be user dependent and user-defined.
- Operational thresholds will be investigated in FY13.



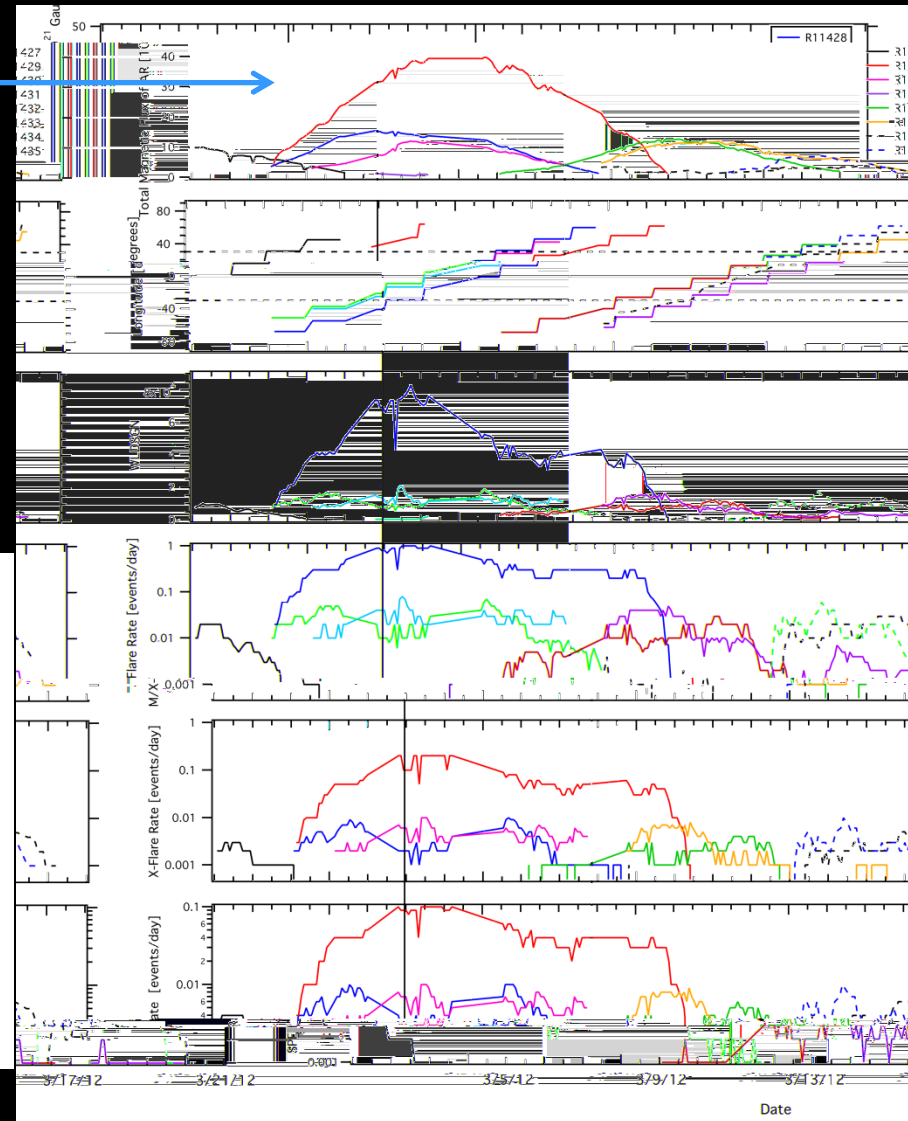
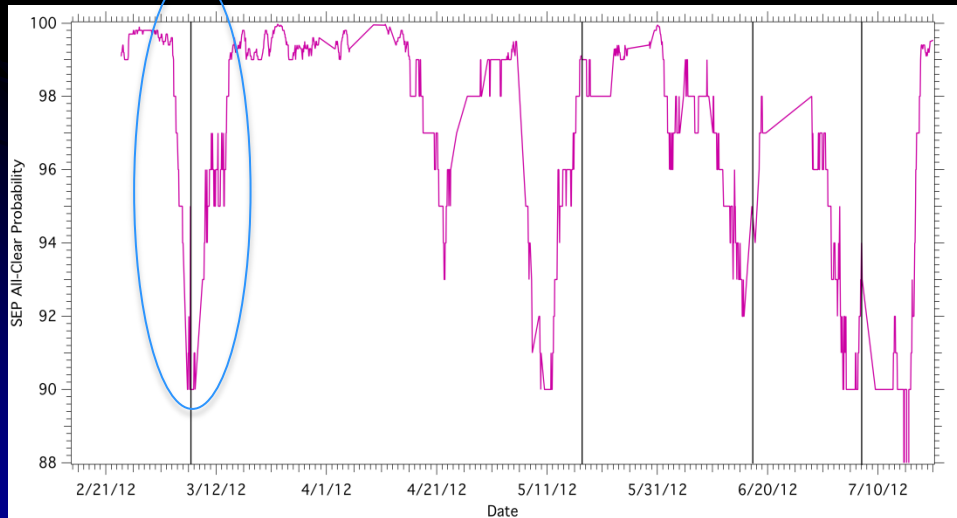
ARP / ISEP: FY12 Review

A full assessment of forecast skill being performed by University of Alabama and JSC.



# Model Validation and Testing: All-Clear

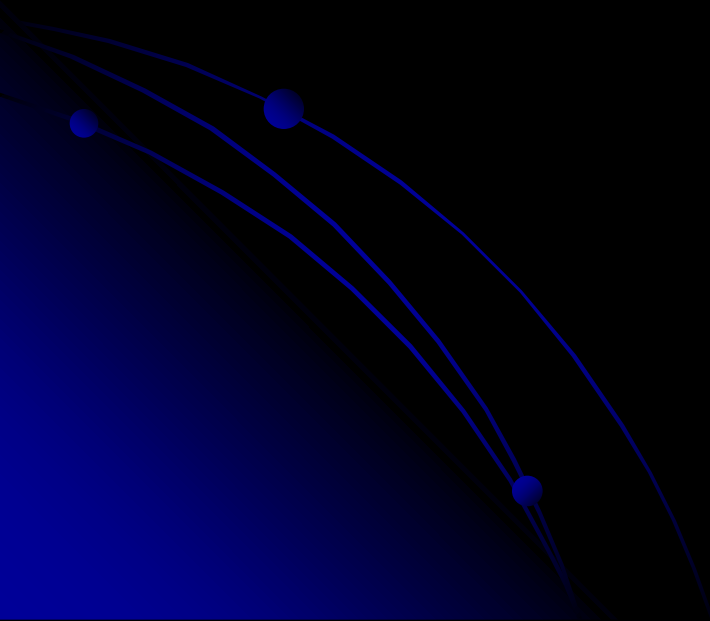
All-clear probability is cumulative over disk. However, time dependence of single-region growth correlates with region identified as producing flares and SEP.







# SRAG Future

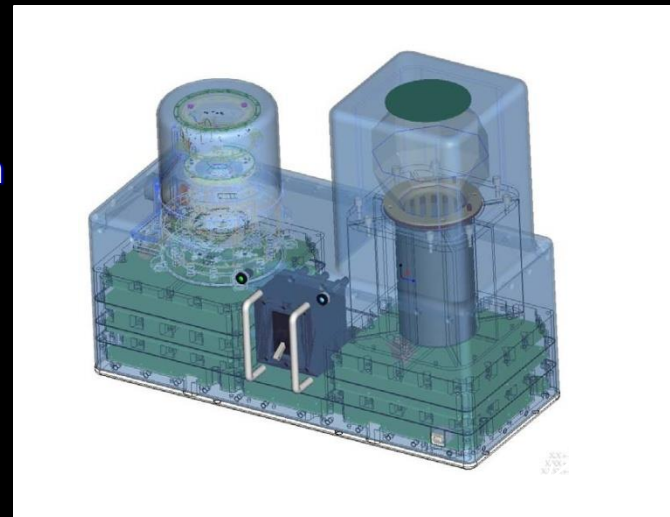






# Future SRAG Instrumentation

- ISS Radiation Assessment Detector
  - Designed to measure neutrons and charged particles from protons through Iron
  - Will provide real-time data
  - Can be relocated within the habitable volume



- MPCV Hybrid Electronic Radiation Assessor (HERA)

- Based on timepix technology and REM heritage
- Will be integrated into MPCV
- Will provide real-time data





## Operational Toolset Next 5 Years

- SRAG expects to have the capability to do quick turnaround dose and risk assessments within complex vehicle geometry starting from CAD (months to week(s))
- SRAG expects to have forecasting models that give 24 hour all-clear probabilities for operating anywhere between the Earth and Mars
- SRAG expects to have models that predict overall radiation exposure early on during an SPE allowing go-no go decisions to be made
- SRAG expects to have instrumentation that continues to meet real-time data requirements that has reduced mass and power compared with today's ops instruments