Space Radiation Analysis Group Operational Tools

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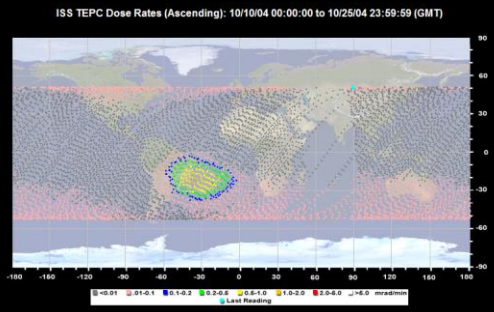
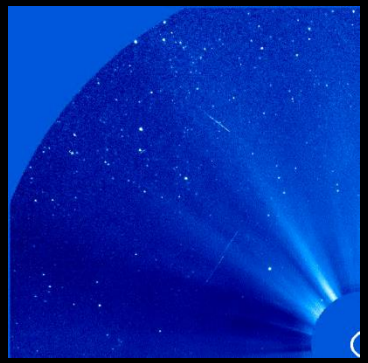
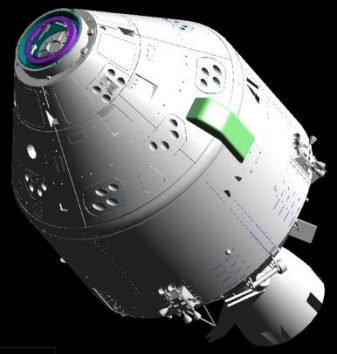
OVERVIEW

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







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

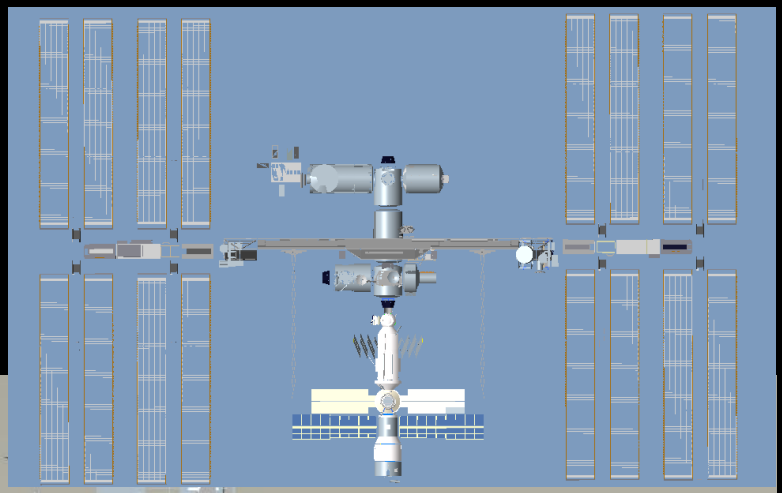
- RAM – Radiation Area Monitors
  - Passive dosimeters, 20+ locations on ISS

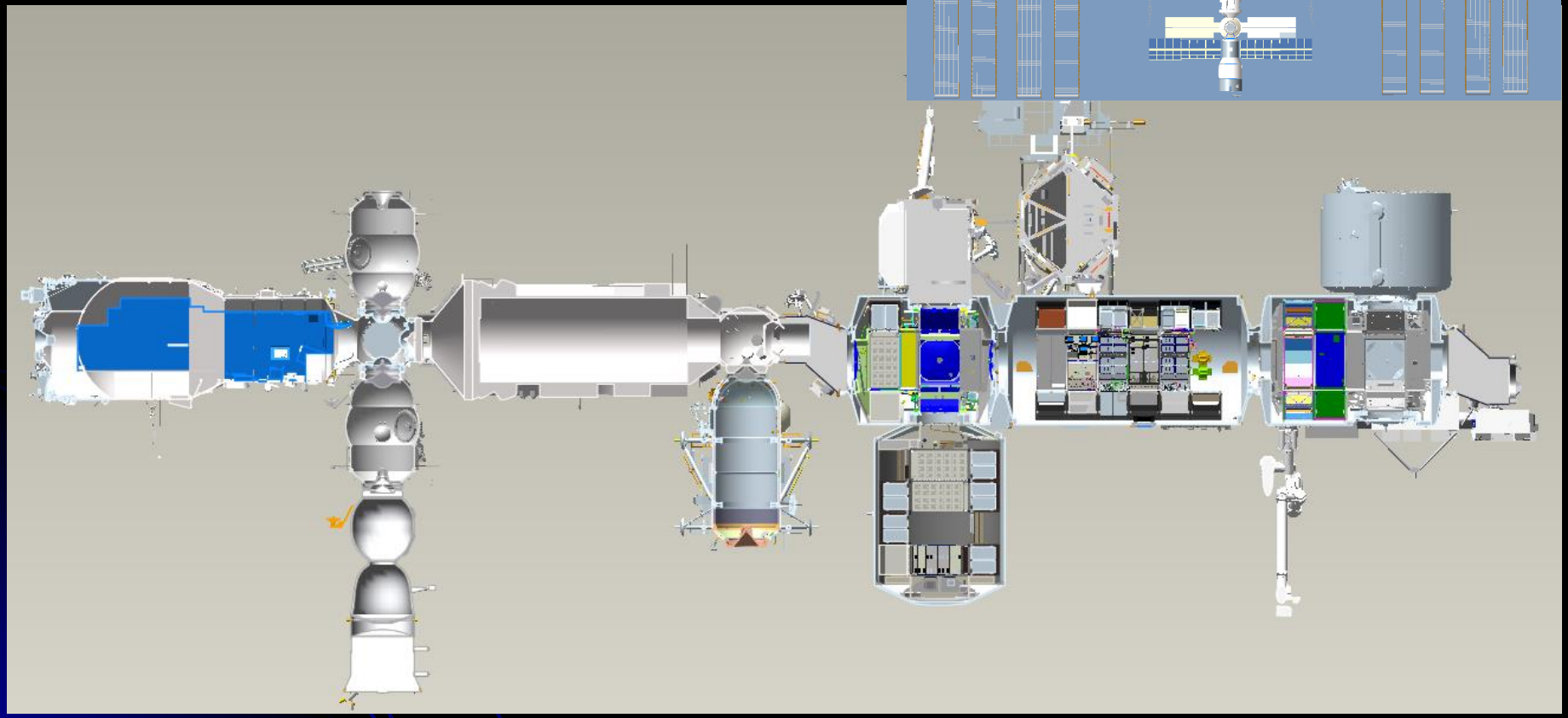
- REM – Radiation Environment Monitor
  - Active dosimeter with USB interface

- TEPC – Tissue Equivalent Proportional Counter
  - Located in ISS Service Module

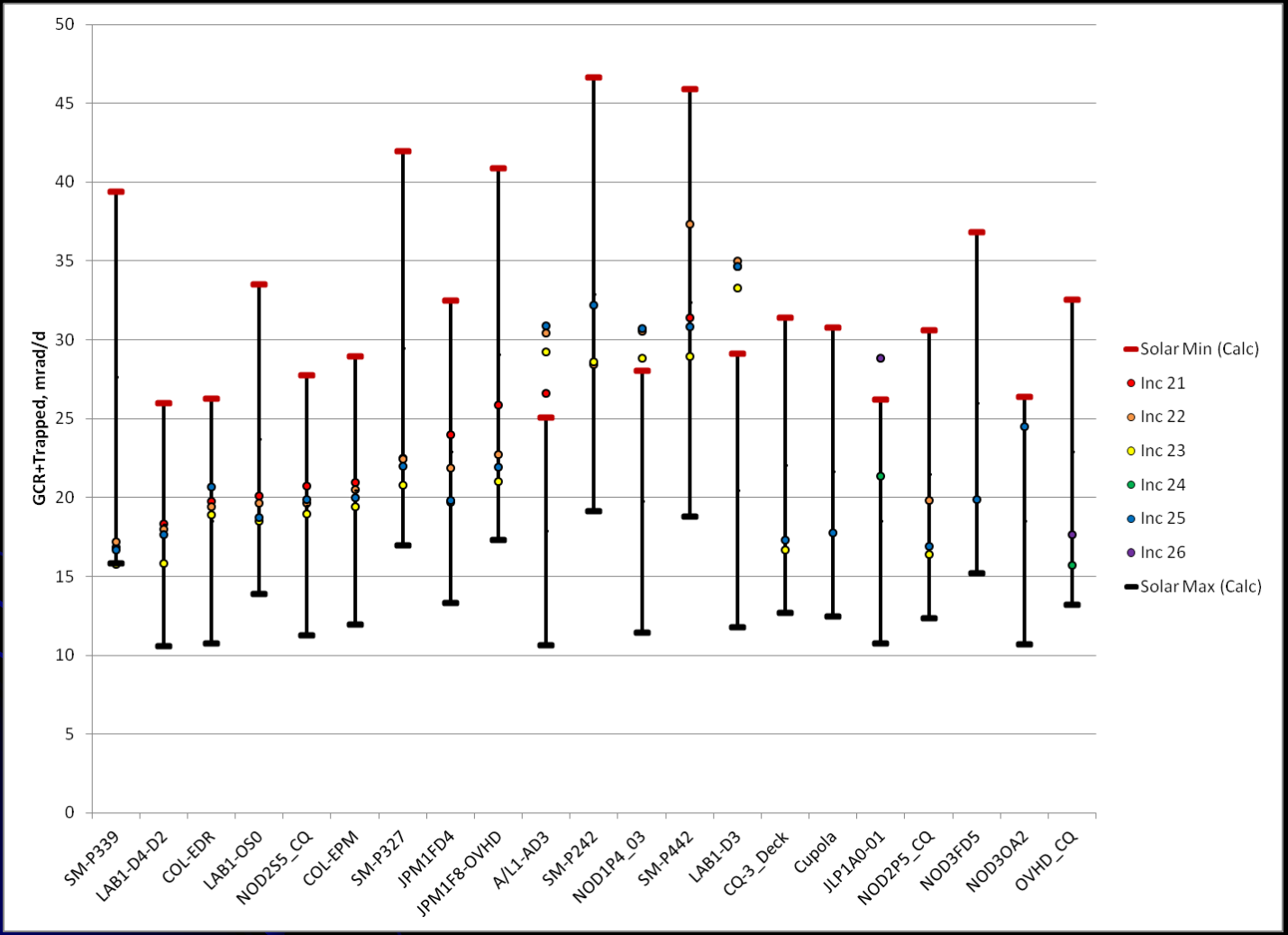
- IV-TEPC – new TEPC detector
  - Moves about ISS every 4-6 weeks

ISS Configuration

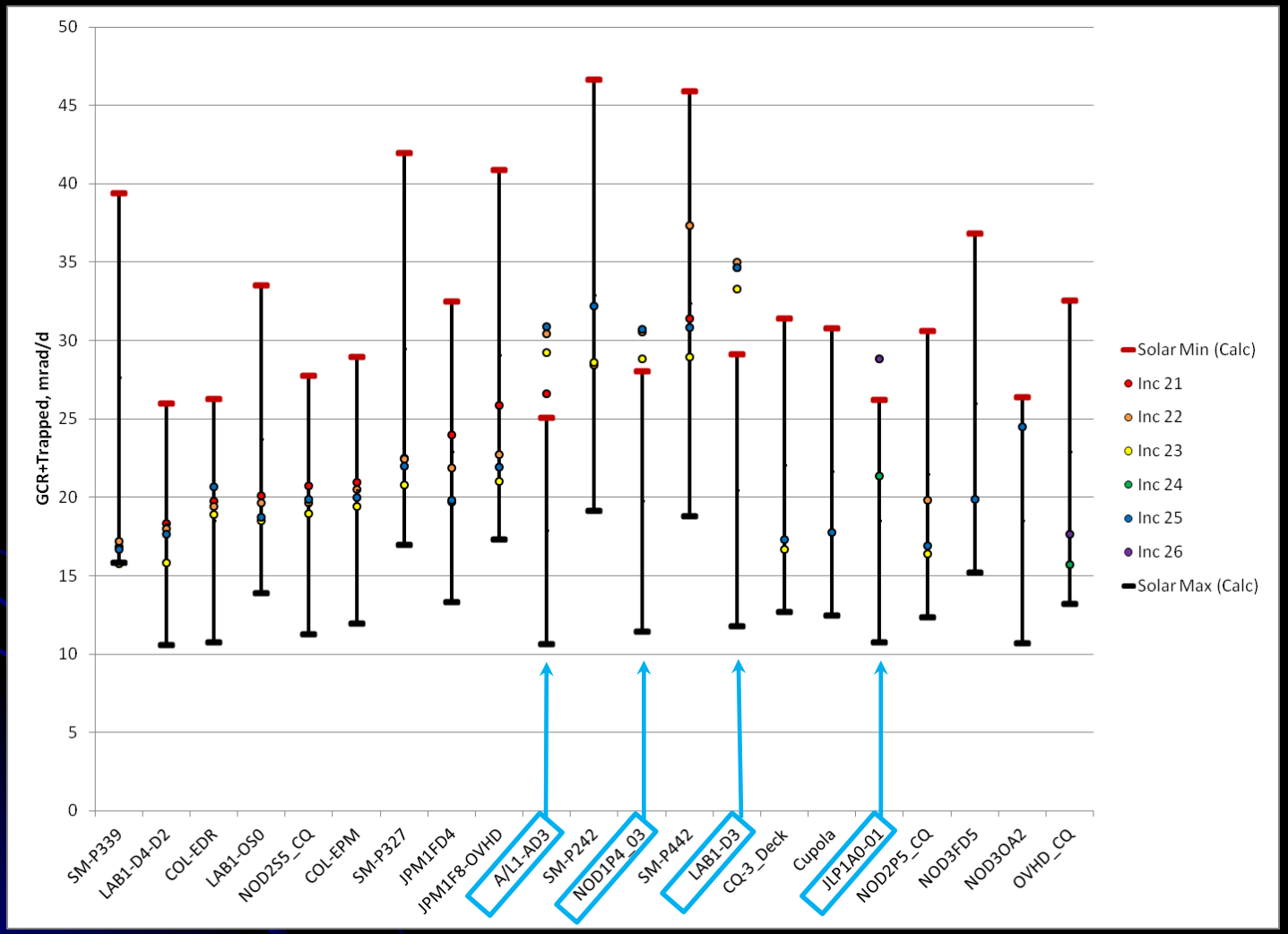




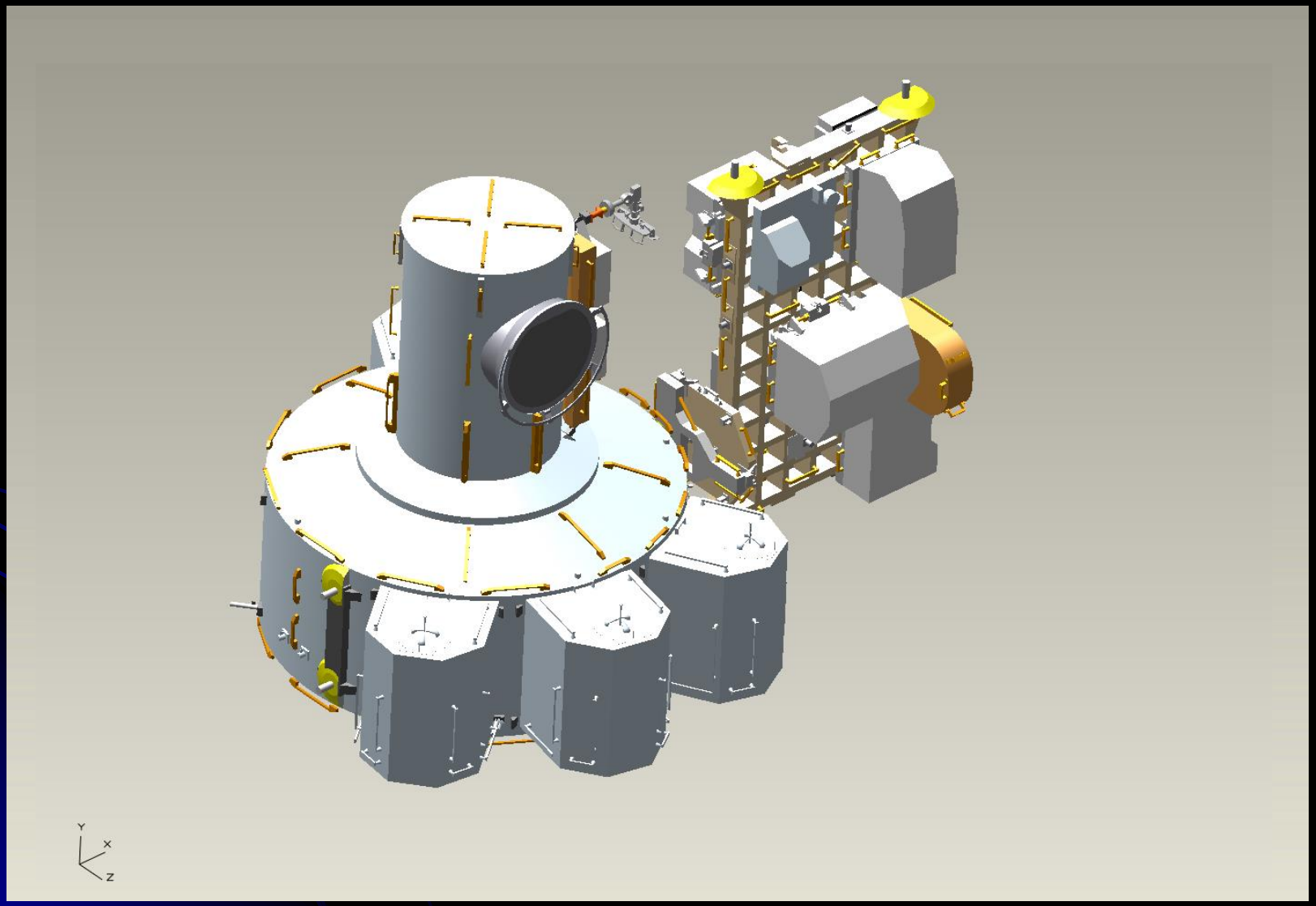
Comparison to RAM Data



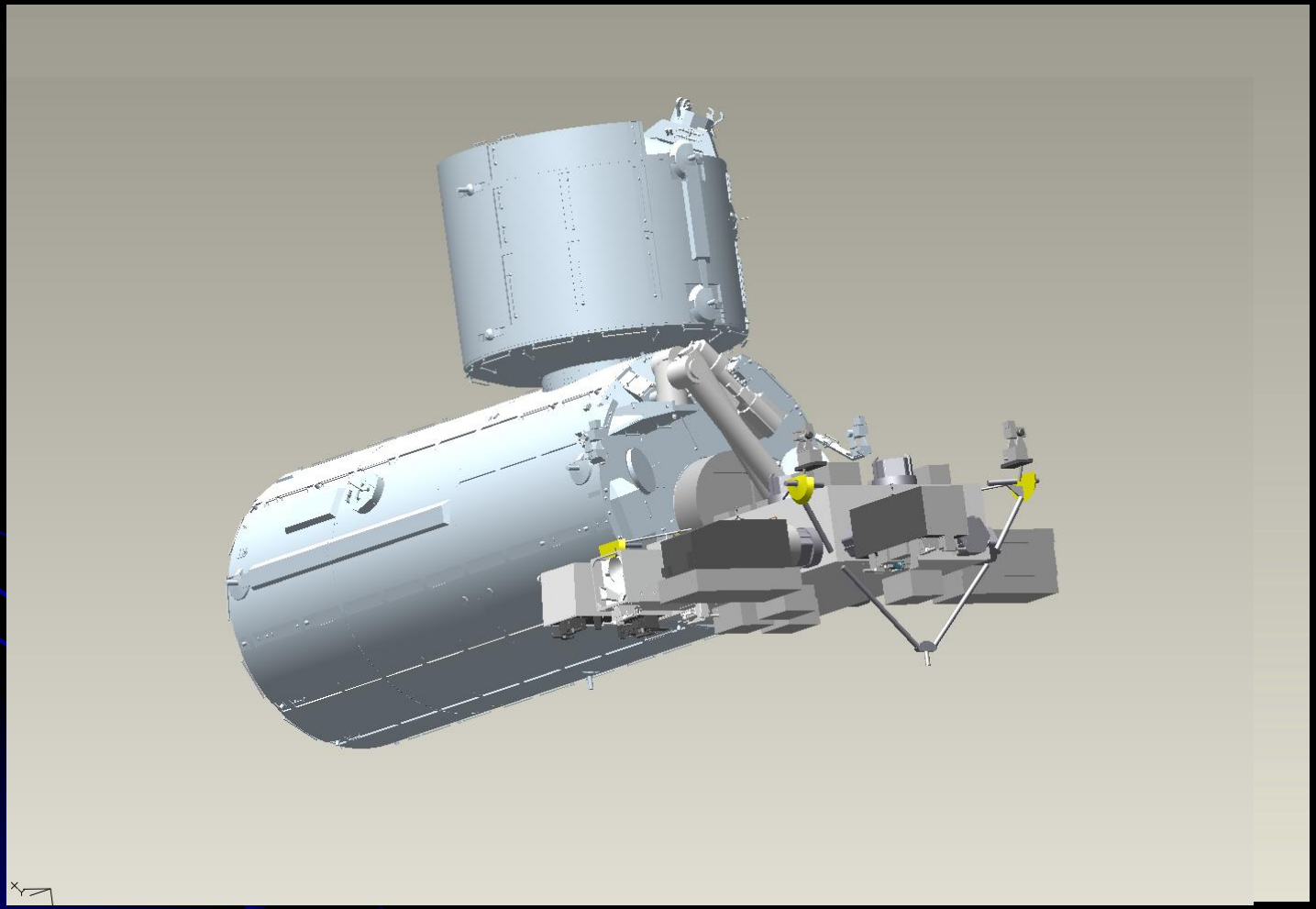
Comparison to RAM Data



A/L1-AD3

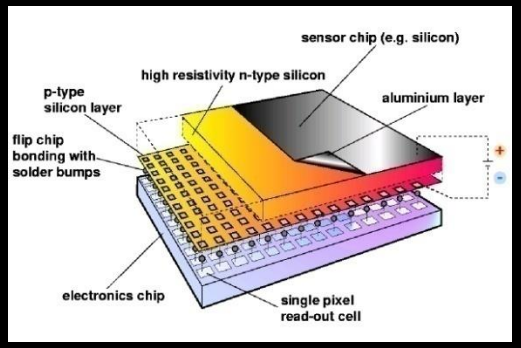


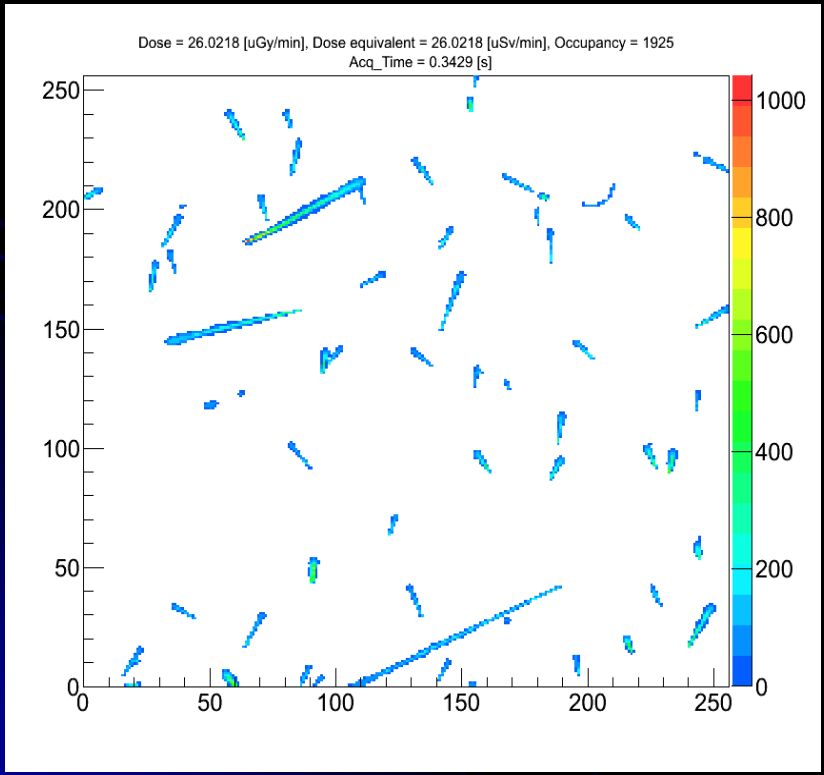
JLP1AO-01

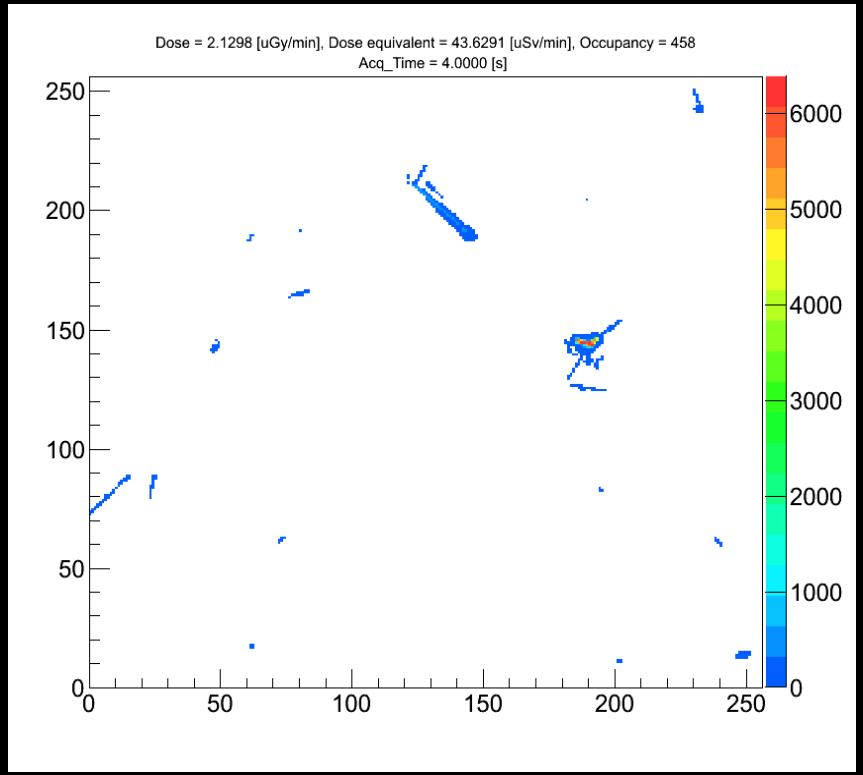


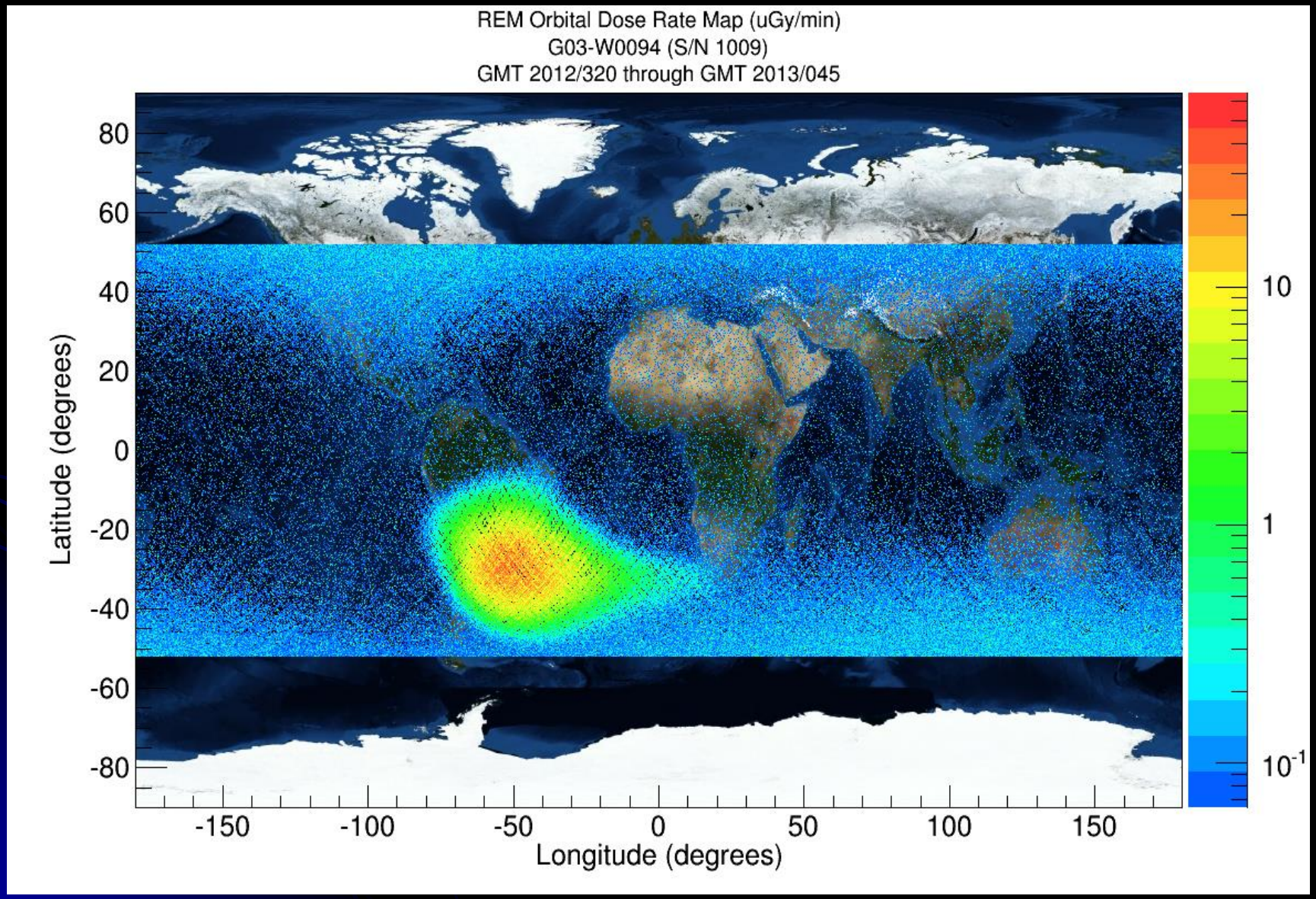
Raw REM Data Frames

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

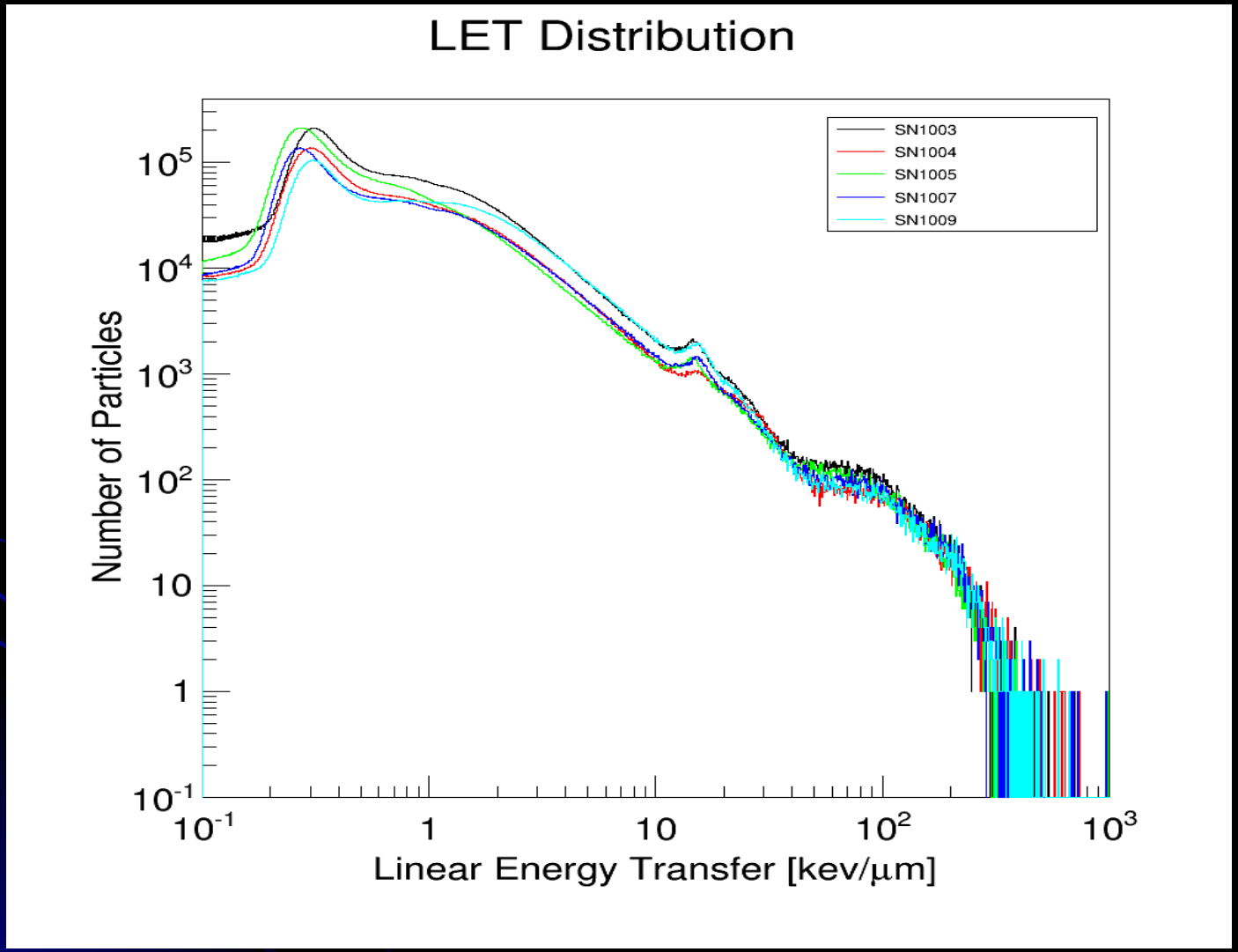


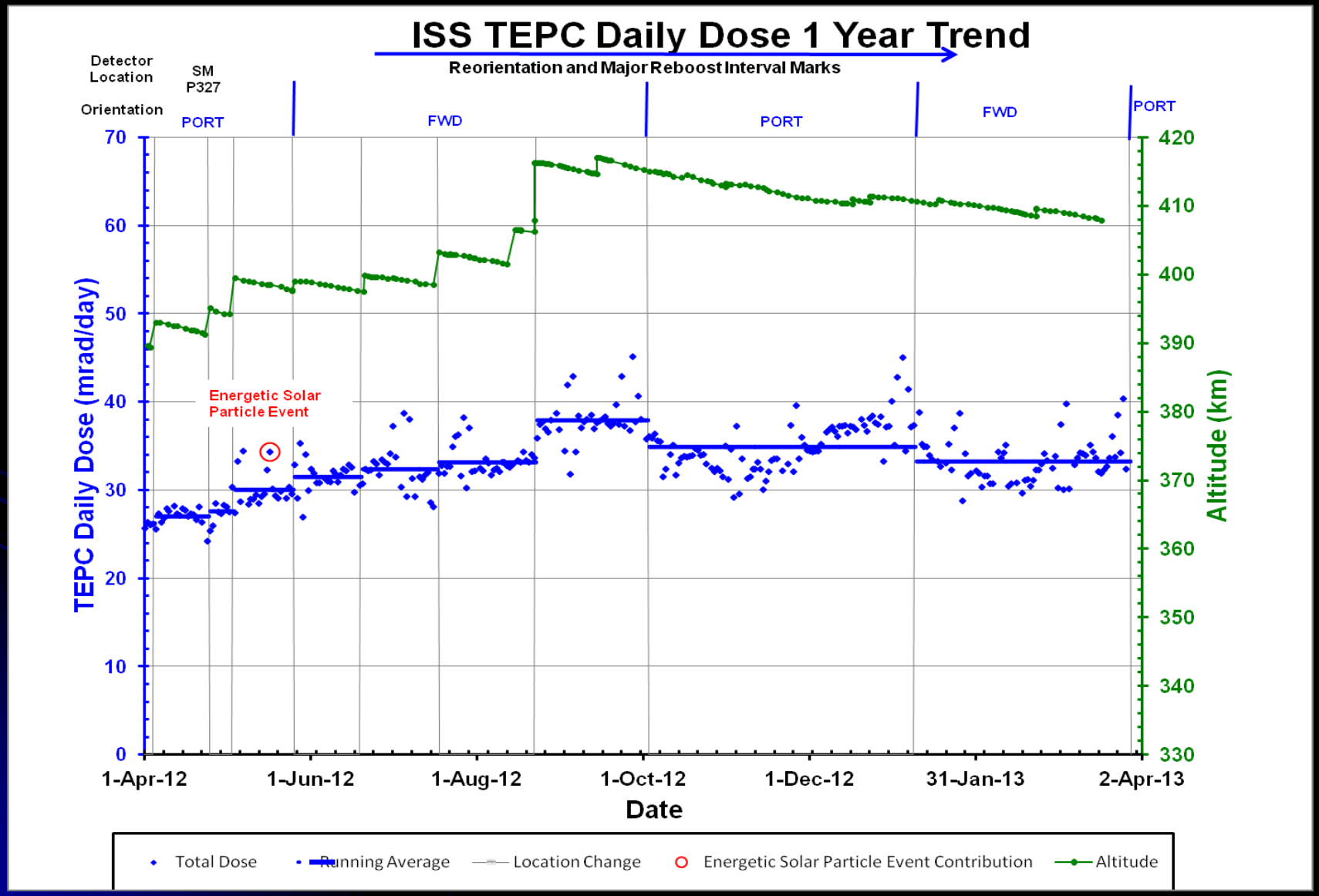





REM Orbital Dose Rate Map (uGy/min)
G03-W0094 (S/N 1009)
GMT 2012/320 through GMT 2013/045
Latitude (degrees)
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude (degrees)
10
1
10^{-1}

REM Instrument LET Measurements




ISS TEPC Daily Dose 1 Year Trend
Reorientation and Major Reboost Interval Marks
Detector Location
SM P327
Orientation
PORT
FWD
PORT
FWD
PORT
Energetic Solar Particle Event
TEPC Daily Dose (mrad/day)
Altitude (km)
0
10
20
30
40
50
60
70
330
340
350
360
370
380
390
400
410
420
1-Apr-12
1-Jun-12
1-Aug-12
1-Oct-12
1-Dec-12
31-Jan-13
2-Apr-13
Date
Total Dose
Running Average
Location Change
Energetic Solar Particle Event Contribution
Altitude

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

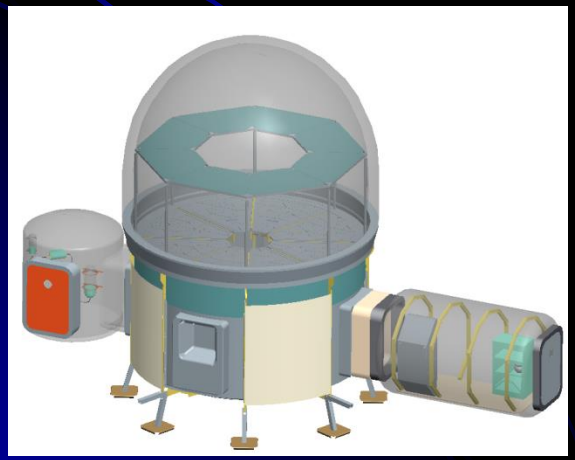
- ARP was a casualty of sequestration on 3/1/2013
- Partial funding regained in April for ISEP to continue through September 2013
- MC-CAD remains unfunded by OCT
- ISEP will deliver models that need further verification and MC-CAD will deliver a prototype CAD-FLUKA interface

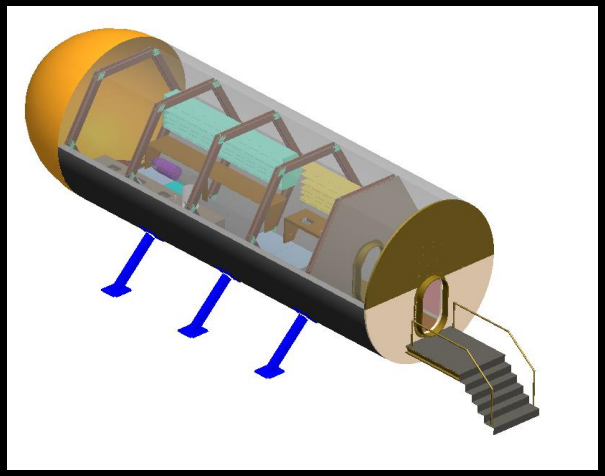
Technology Development

- 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

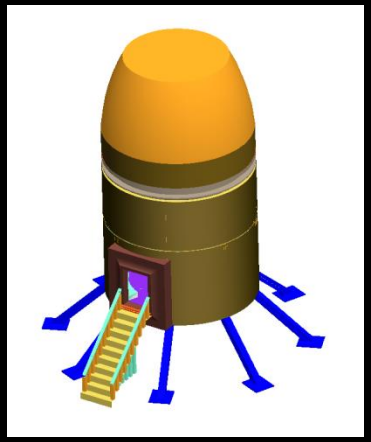
- Collaboration with the University of Wisconsin has been established to make use of their existing DAG-MC (Direct Accelerated Geometry – Monte Carlo) tool as a universal geometry and navigation interface to radiation transport packages
- Teamed with FLUKA collaboration at CERN to make use of the FLUGG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





DAG-MC Overview

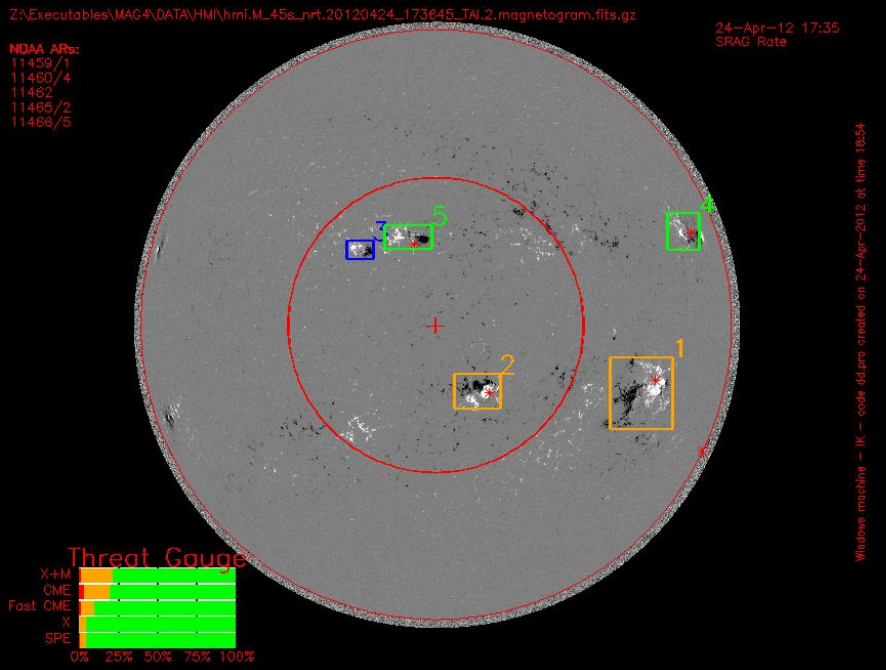
- Functioning version that currently works with MCNP. Used regularly for Fusion ITER project.
- CAD converted to MOAB (Mesh Oriented datABase)
- Fast binary search algorithms
- Material assignment, boundary conditions, source definition, tally/scoring
- Imprint and merge for touching surfaces (water 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.

MAG4 Model

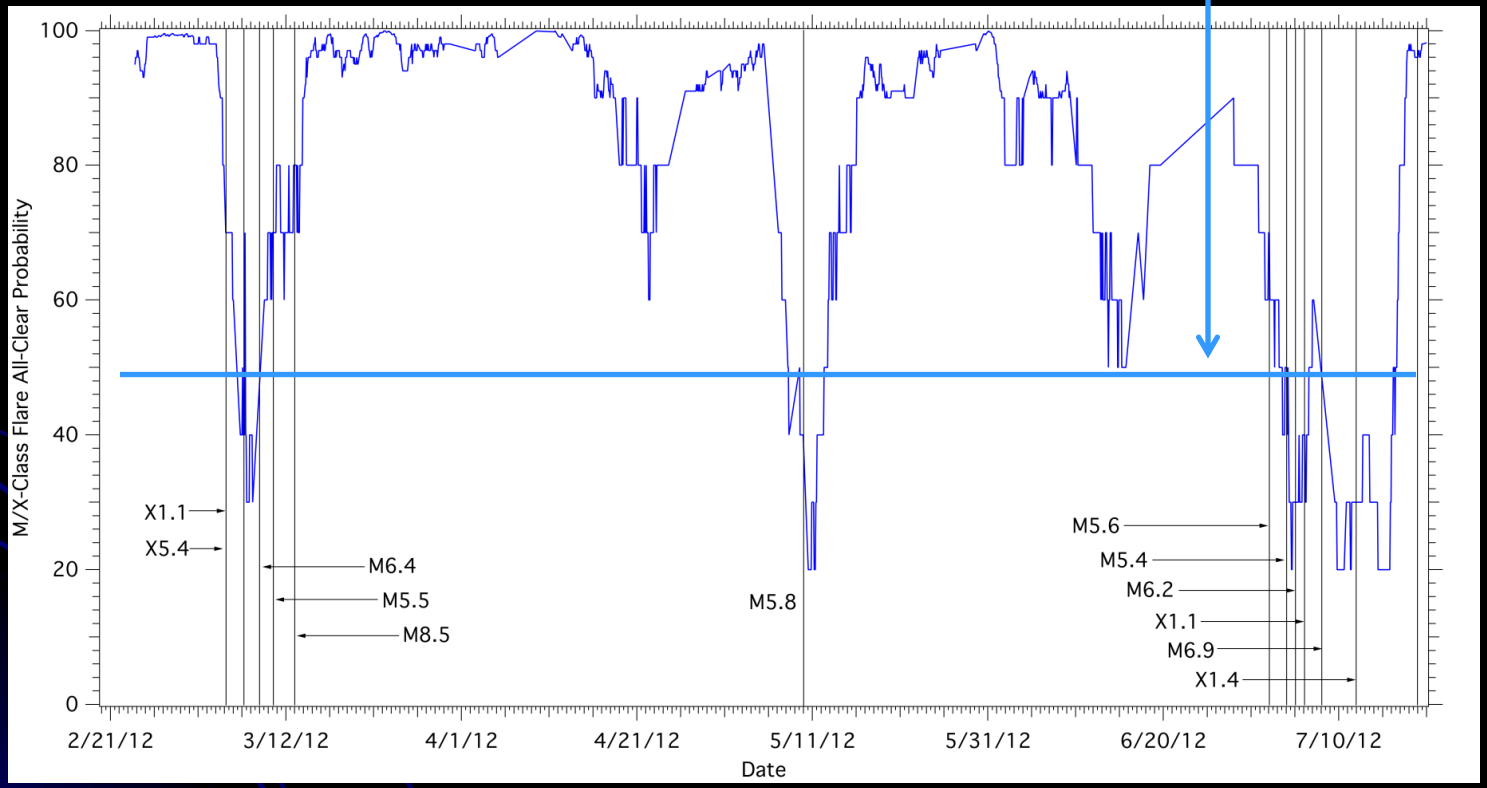


David Falconer University of Alabama

In Collaboration with CCMC and University of Alabama

Model Validation and Testing: All-Clear (Preliminary)

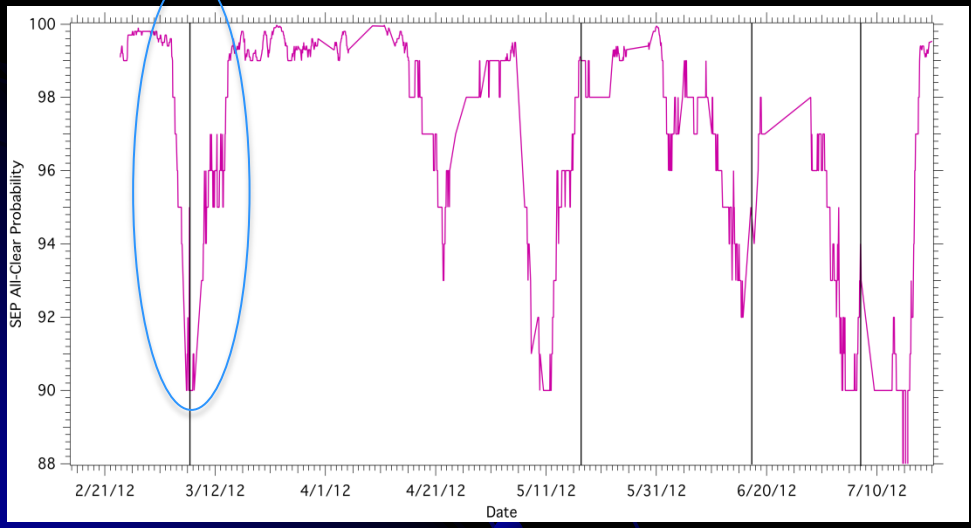
- Change in 'All-Clear' probability is sufficiently distinct for operational use.
- Thresholds for 'go / no-go' call will be user dependent and user-defined.
- Operational thresholds will be investigated in FY13.

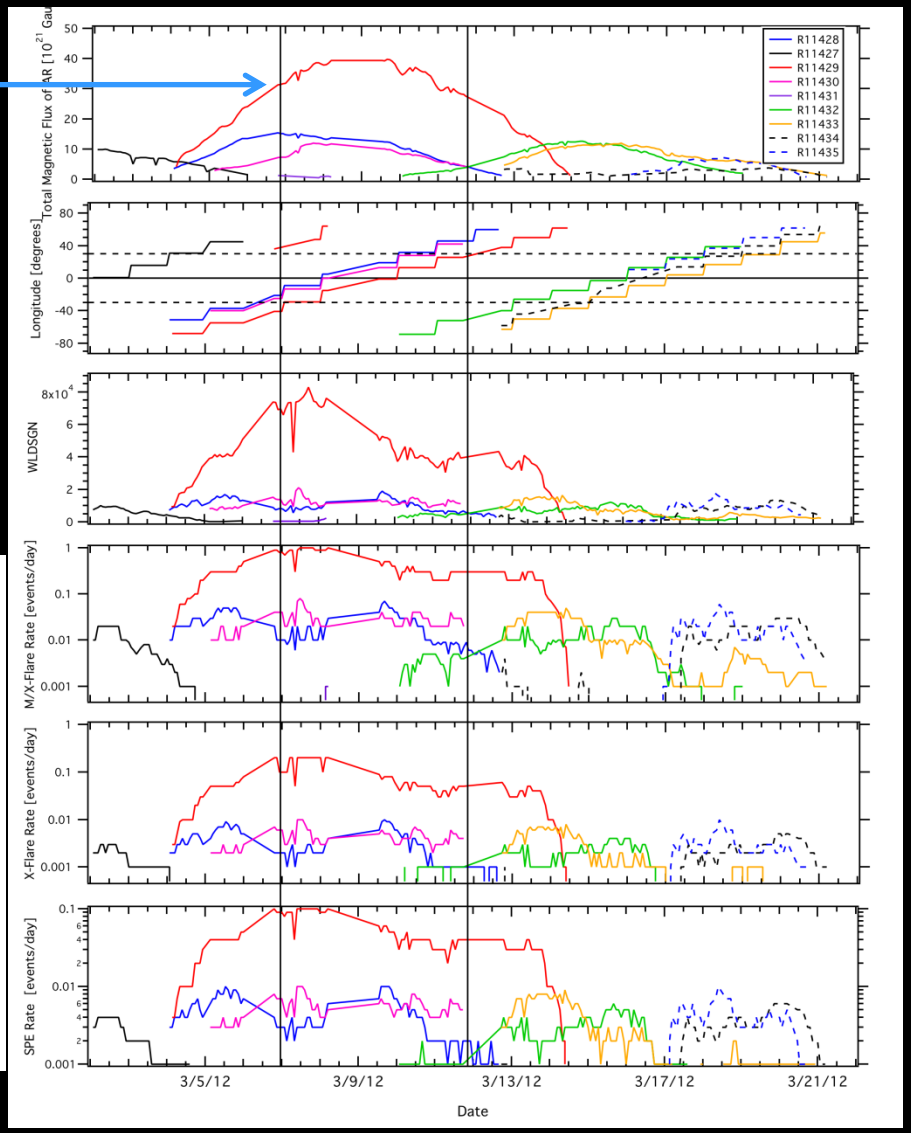


A full assessment of forecast skill being performed by University of Alabama and JSC.

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.

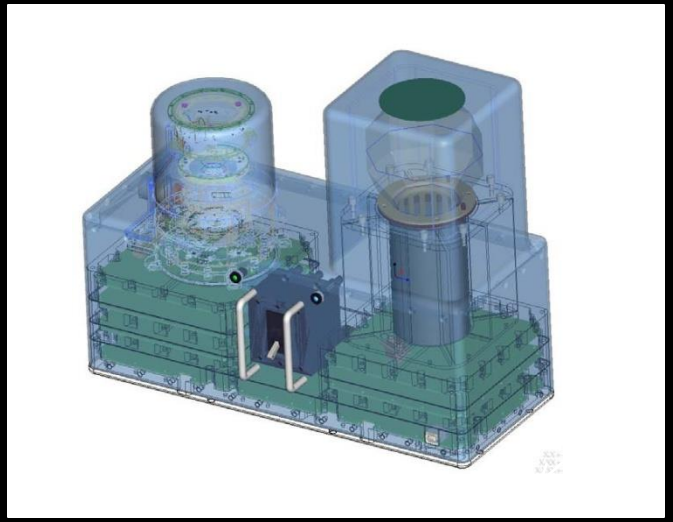




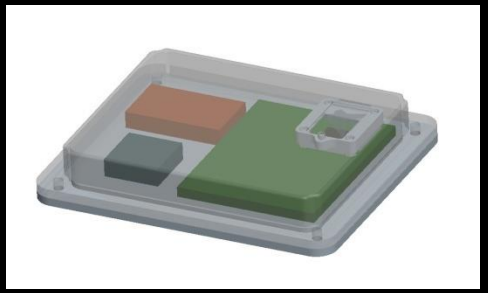
SRAG Future

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