Space Radiation Protection, Space Weather and Exploration

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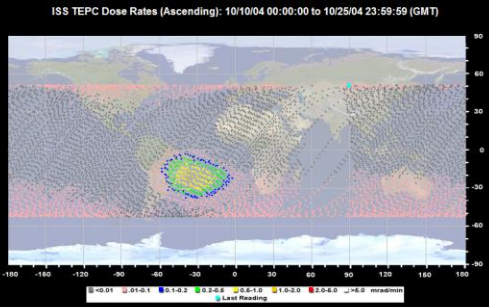
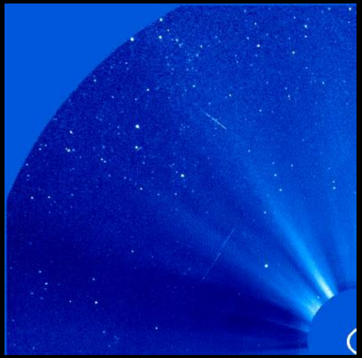
OVERVIEW



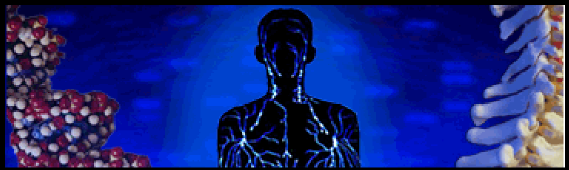
- Operations
- Measurements
- Design
- Analysis
- Space Weather
- Status



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



Space Medicine Division

Radiation Monitoring for Crew and Space Vehicle

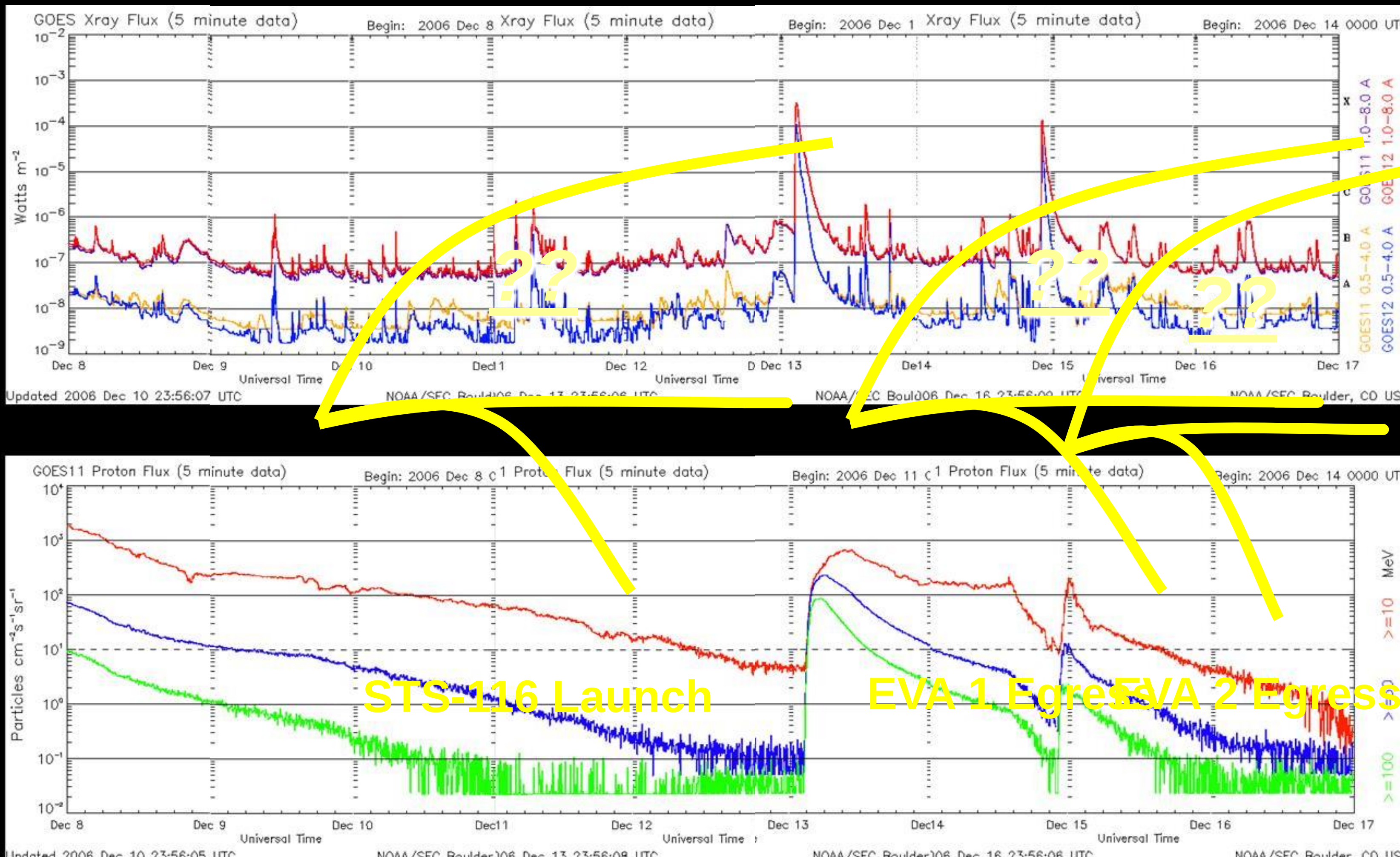
- Console Operations Support
  - 24 hours Contingency Support
  - 4 hour/day Nominal Support

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

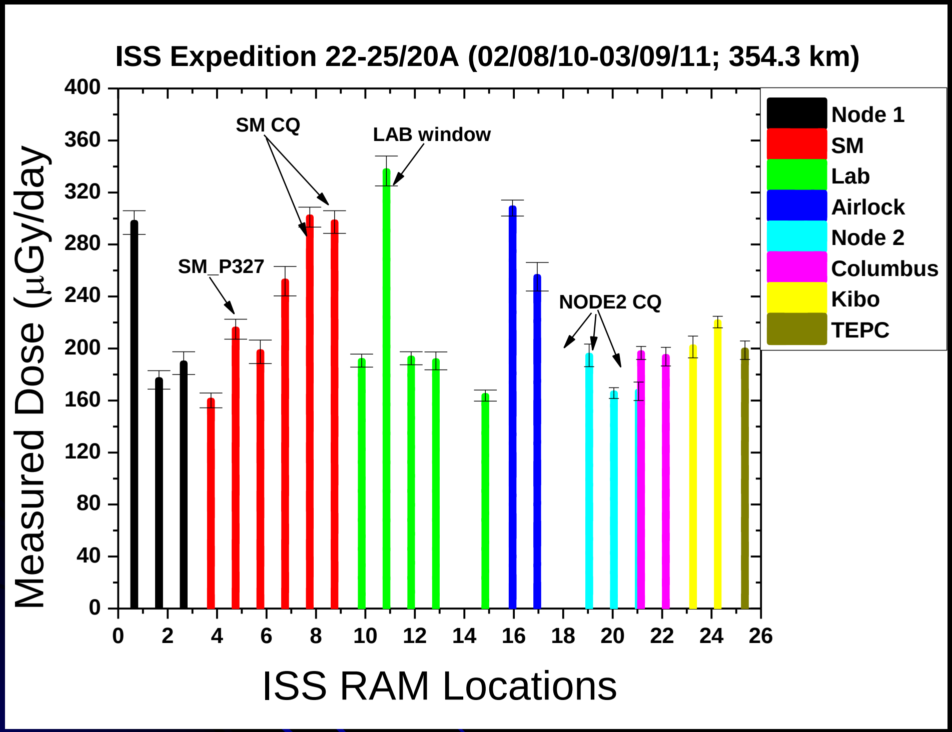
- Passive Radiation Detectors
  - Crew Passive Dosimeter (CPD)
  - ISS Radiation Area Monitor (RAM)

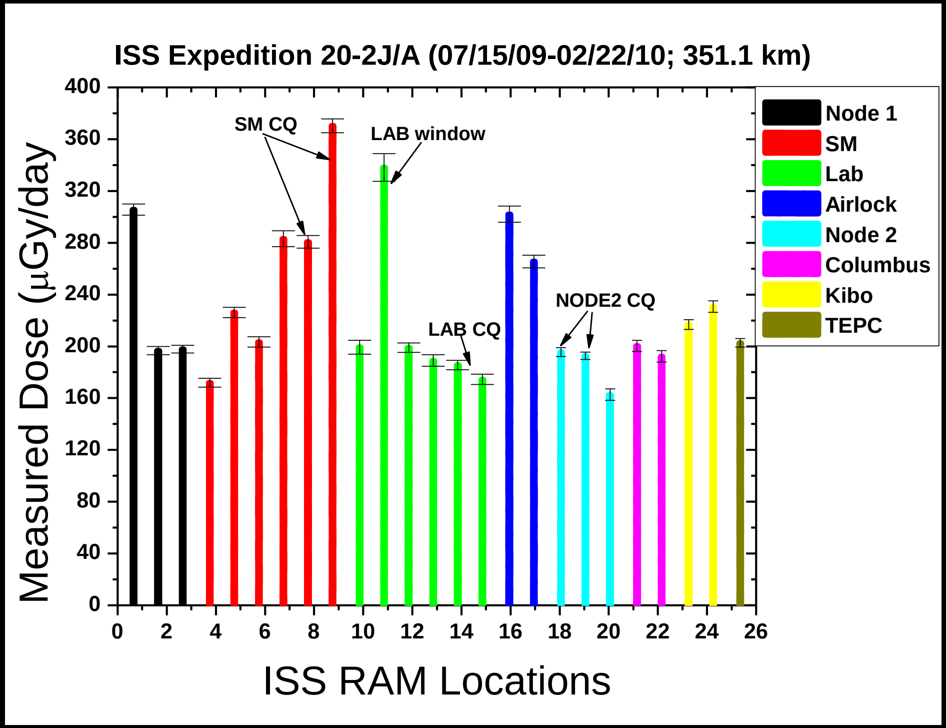
STS-116: Example Progression

Probability?



ISS Expd. 22-25/20A RAM Measured Dose Rates

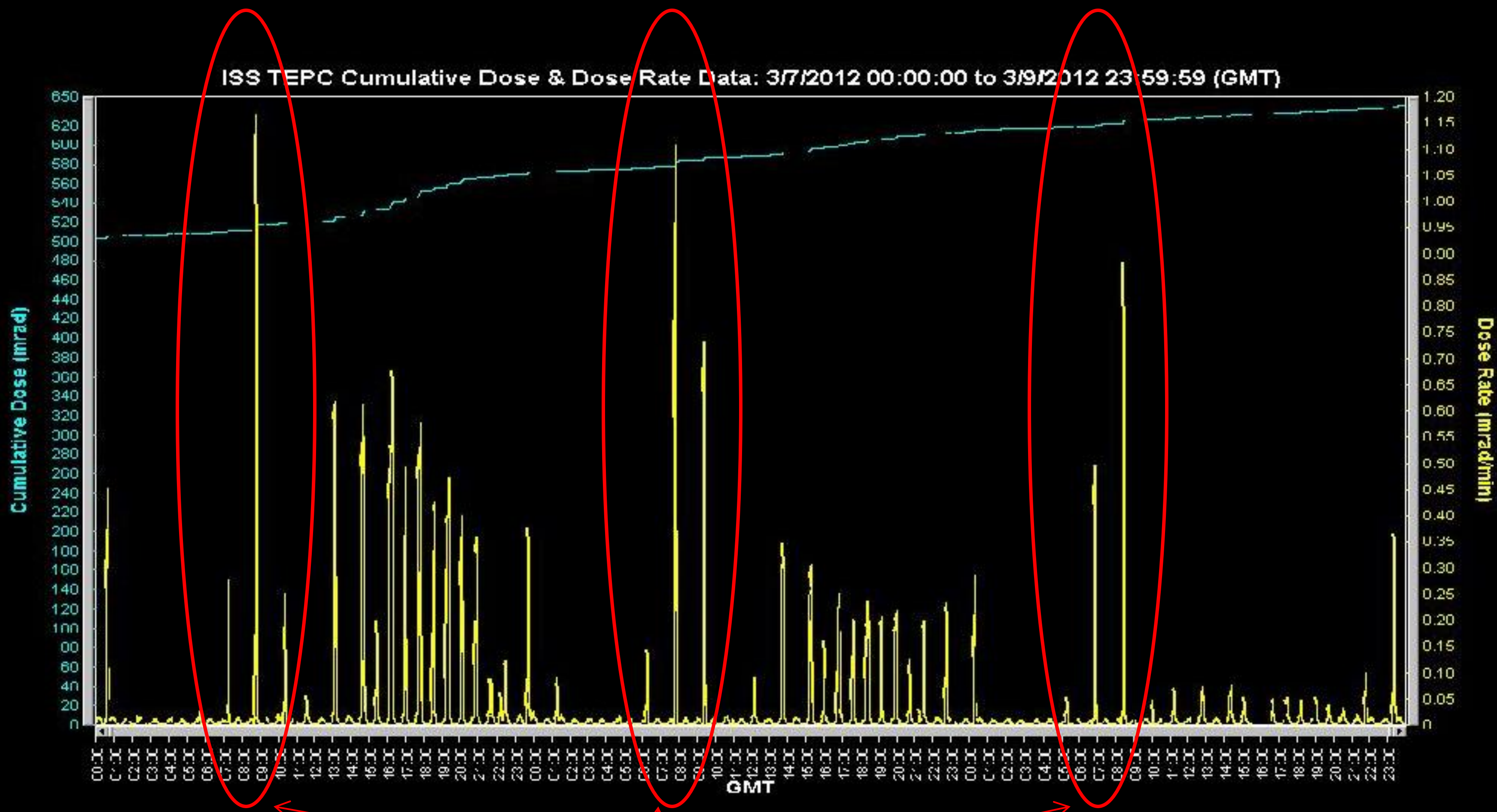




High absorbed dose rates: Lab window, SM Crew Quarters

Low absorbed dose rates: Node 2 Crew Quarters, SM-339 (behind treadmil)

ISS TEPC Measurement During 2012 March SPE



SAA Passes

Design and Analysis

Vehicle/Habitat Radiation Exposure Analysis

Environment
Particle spectrum
(SPE/GCR)

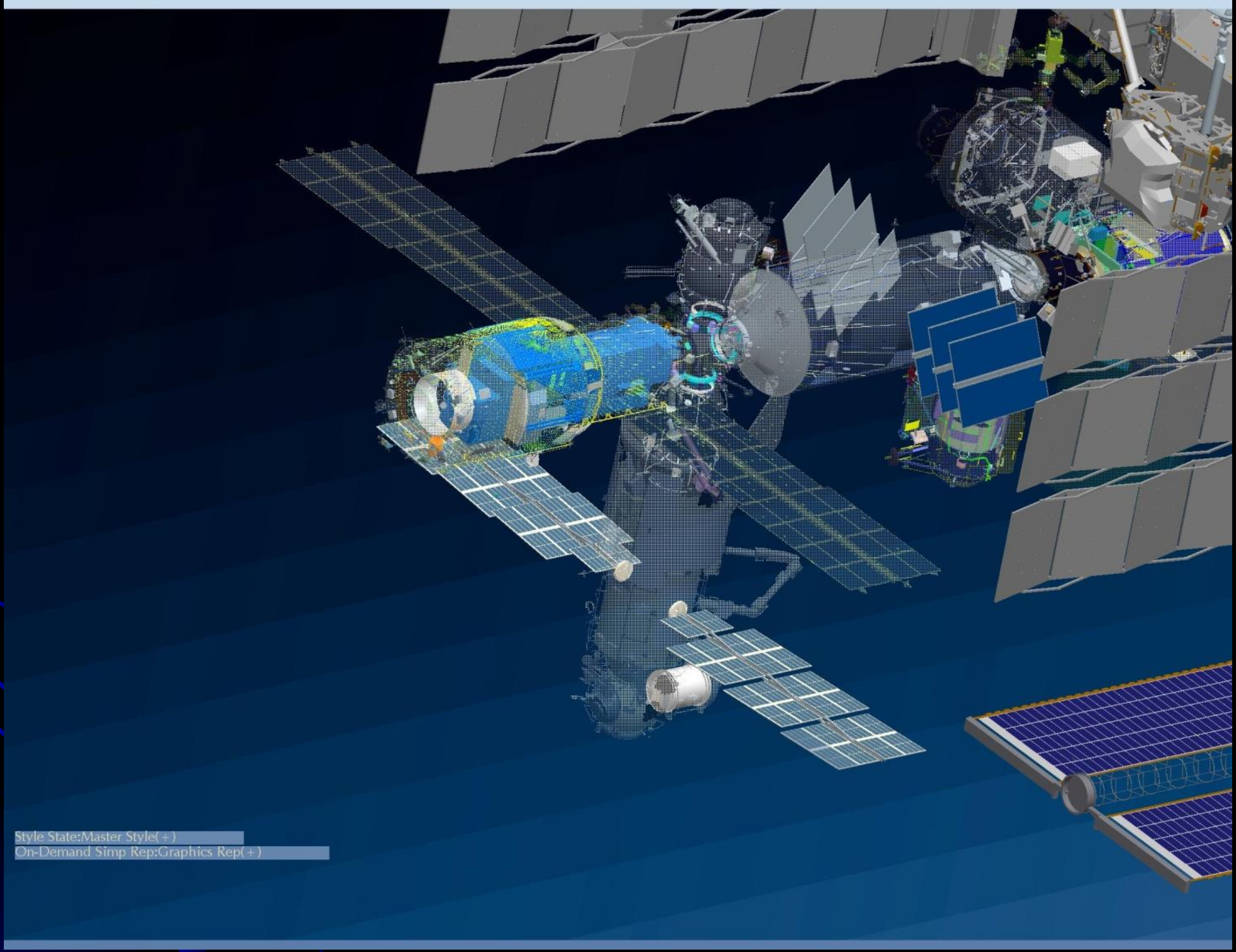
Shielding
CAD Models – As-built or
Design

Radiation Transport
Particle Transport through
Materials

Exposure Prediction

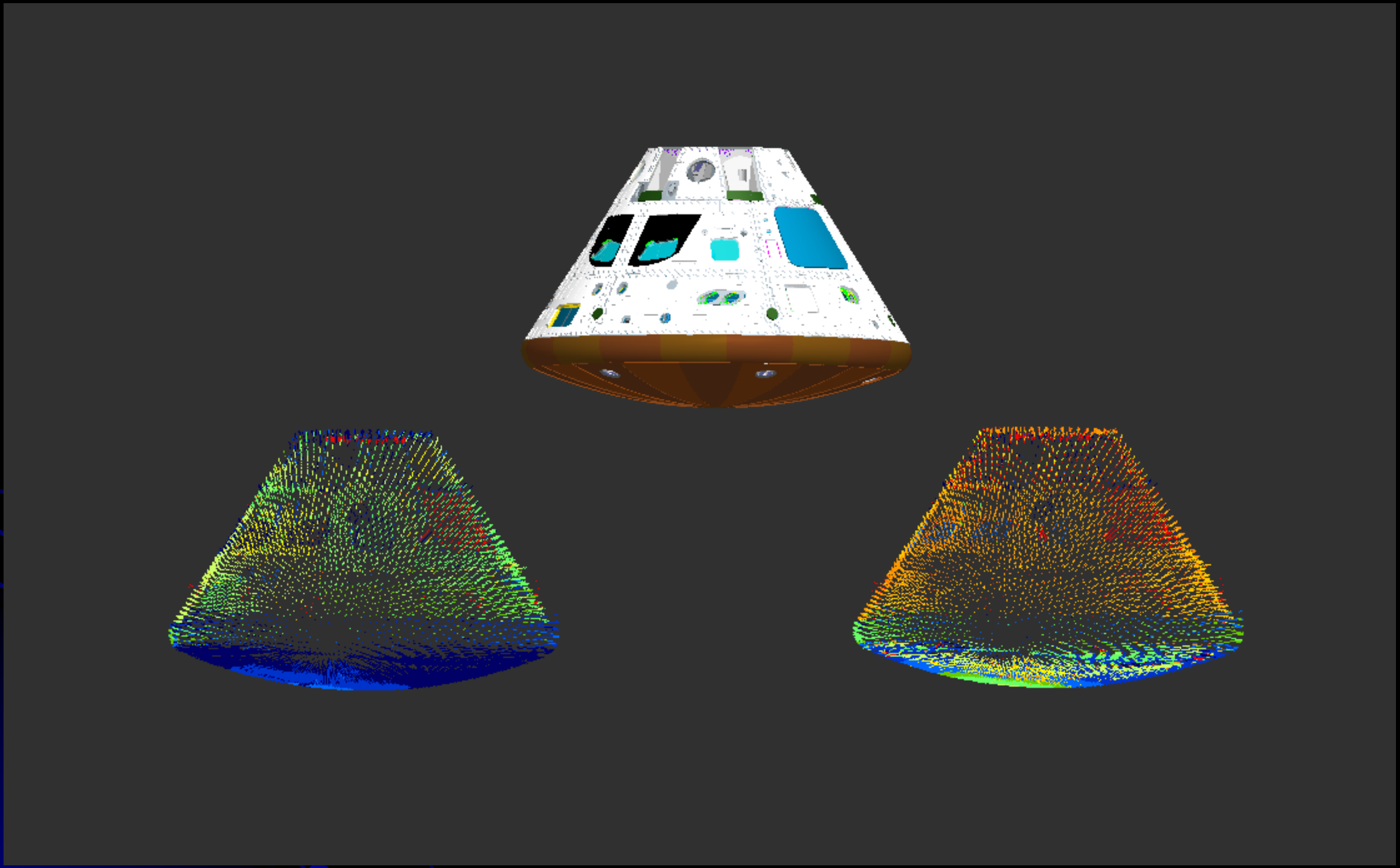
Uncertainties
Future Environment
*Biological Impacts
*Vehicle Design
Details
Transport Physics

ISS Radiation Shielding Analysis

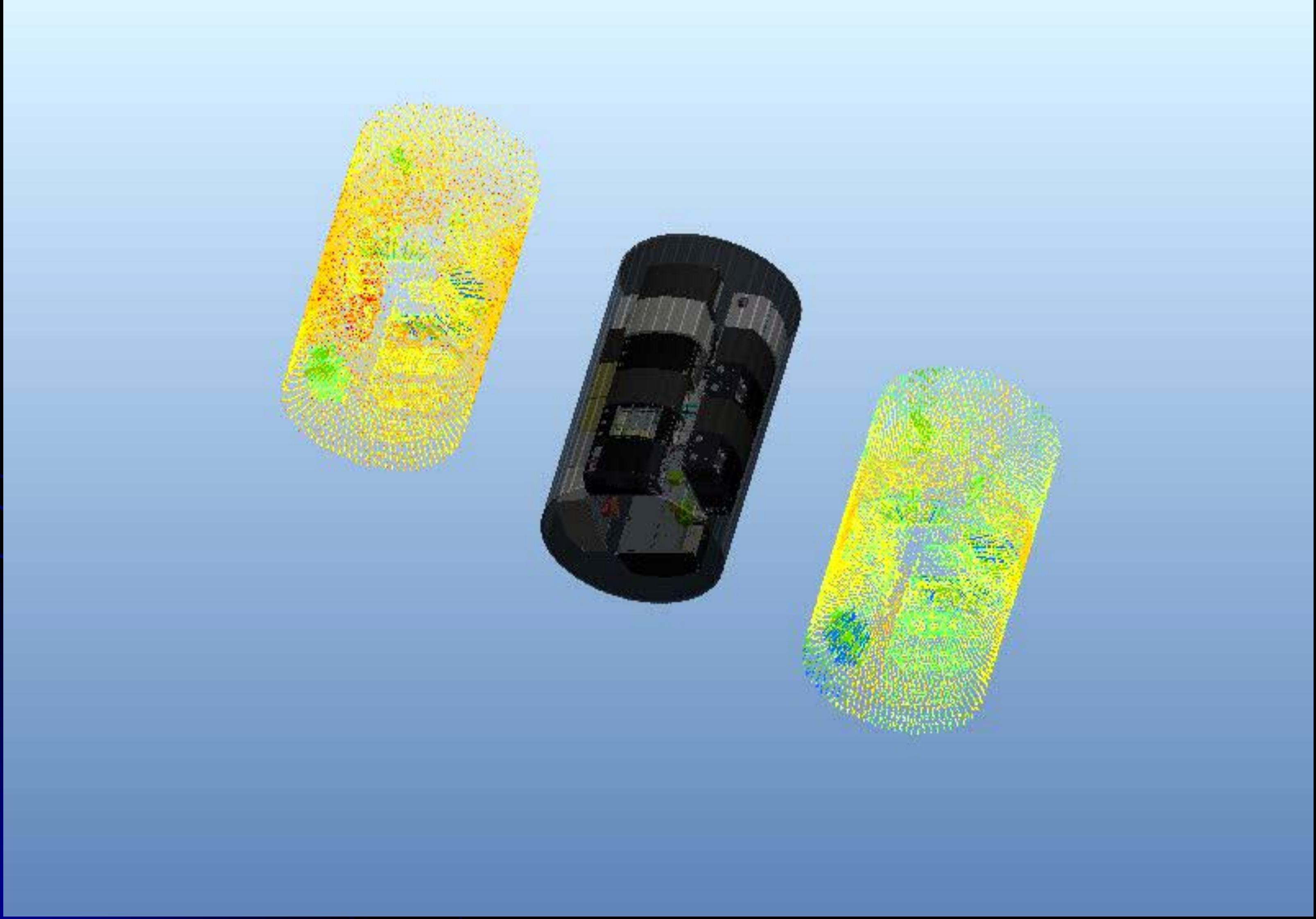


ISS Radiation Shielding Analysis

Orion Crew Exploration Vehicle Design Analysis

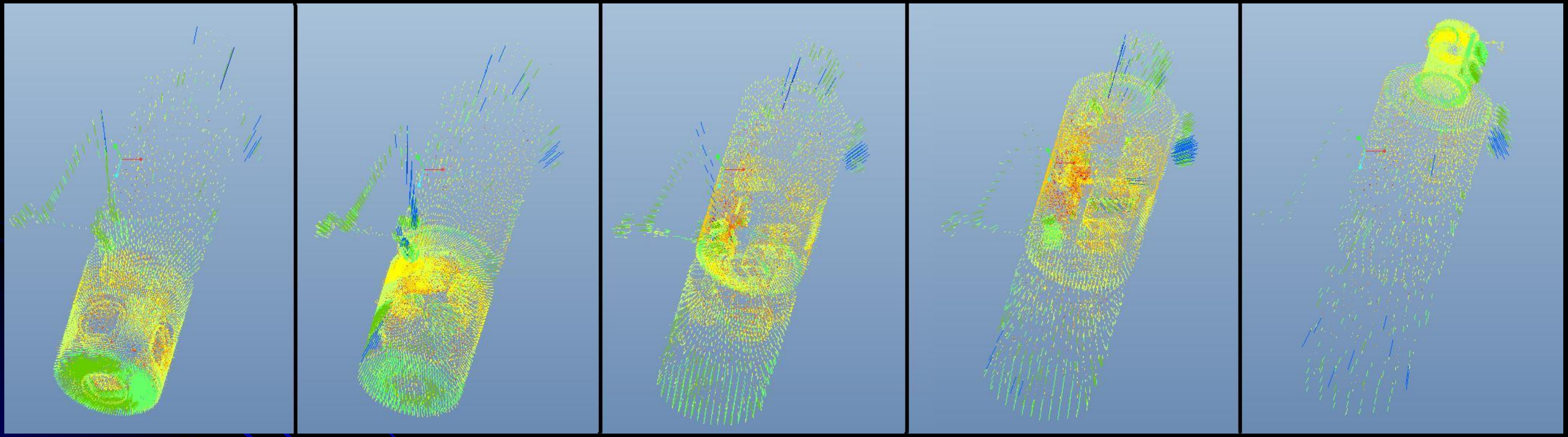


Modified ISS US Lab Design

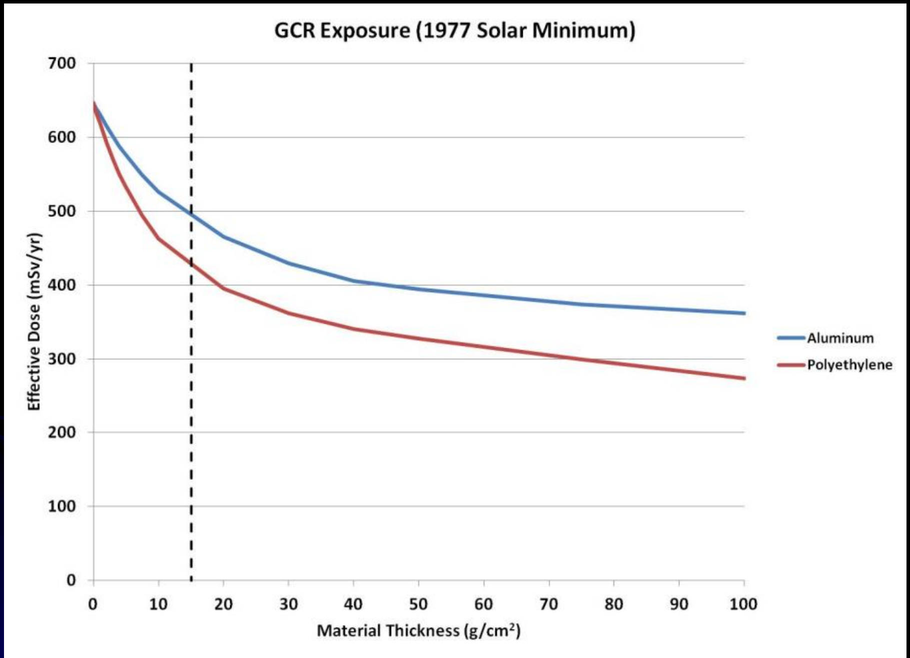


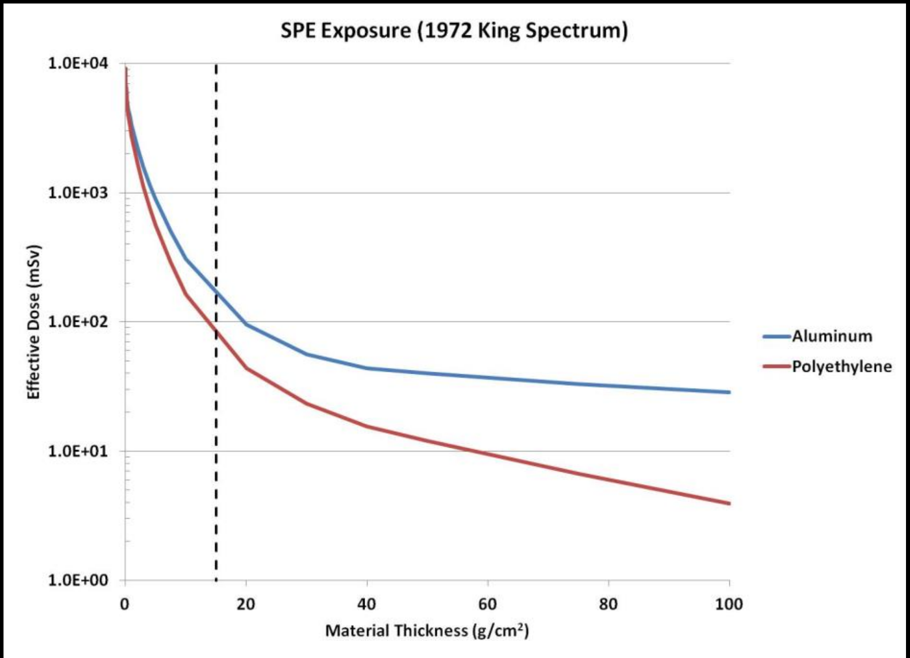
Deep Space Habitat "stack"

Deep Space Habitat Shielding Analysis



Effective Dose Depth Curves for Aluminum and Polyethylene Shields



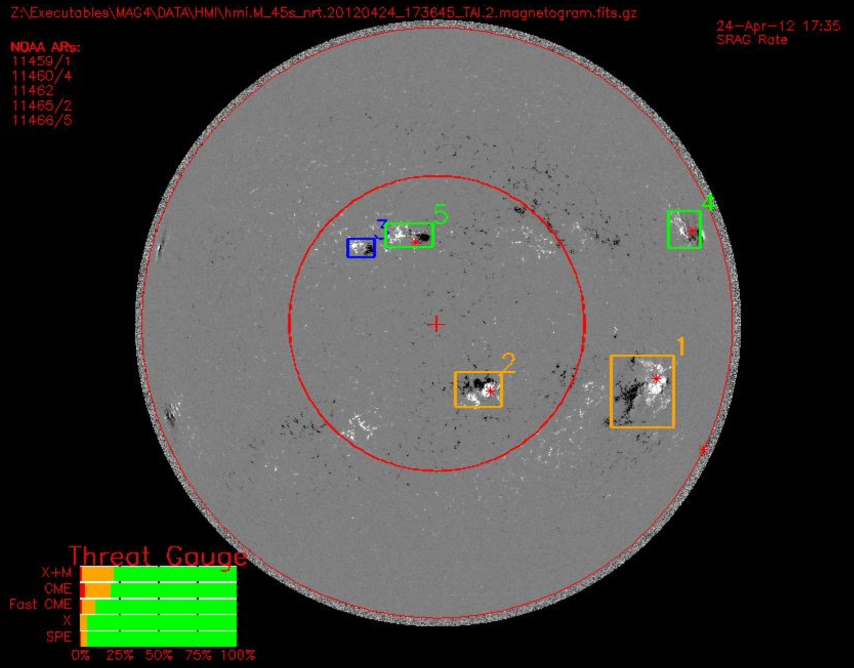


Space Weather

Space Weather Forecasting

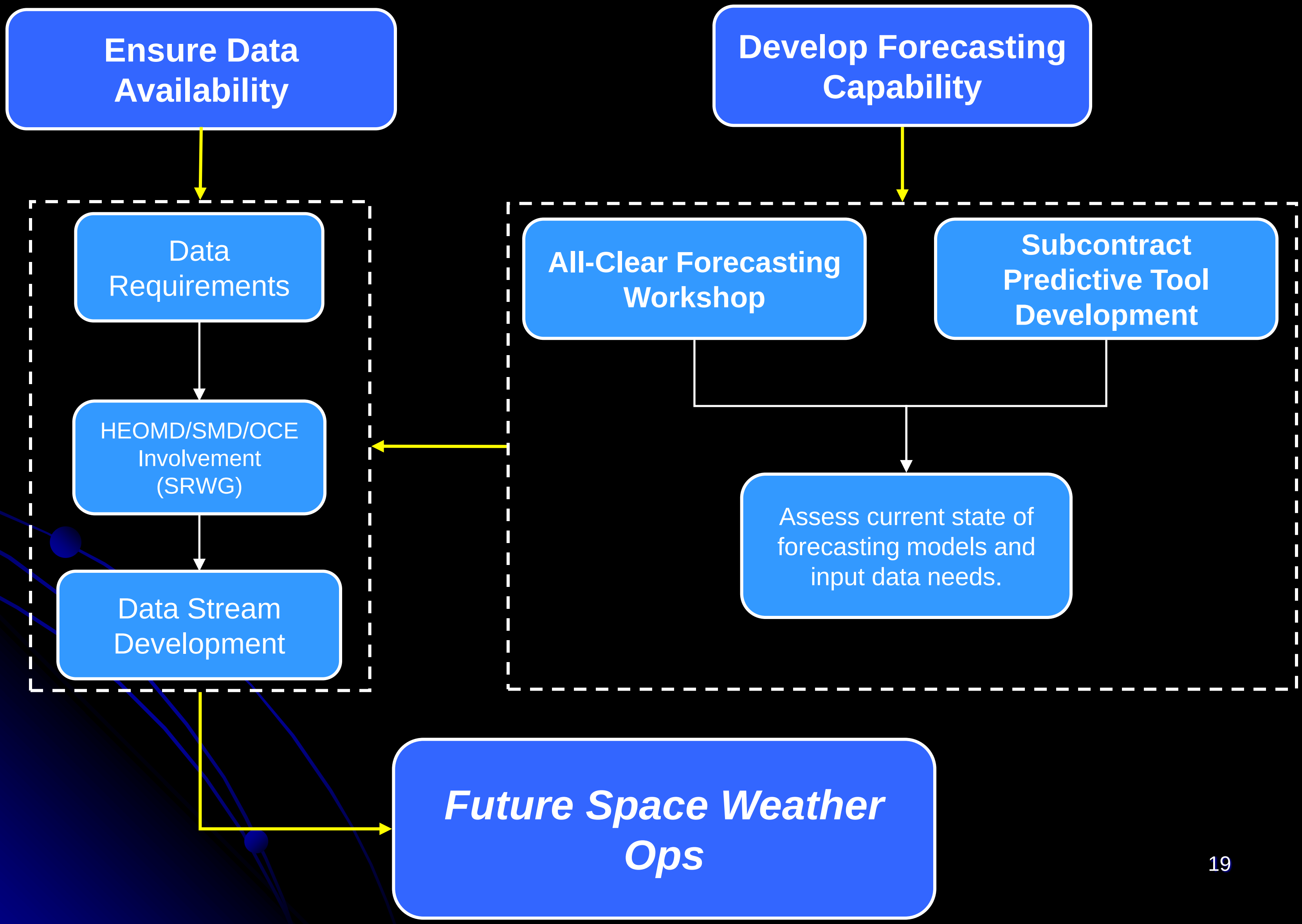
- Historical database for identification of event trending/characteristics
- Probabilistic modeling for operational mission planning
- ISEP: integration of probabilistic spectral and SEP dose modeling
- Dose projection for in-event risk mitigation
- Forecasting of event onset and impact outside of low-earth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

MAG4 Model



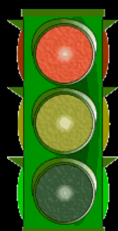
David Falconer University of Alabama

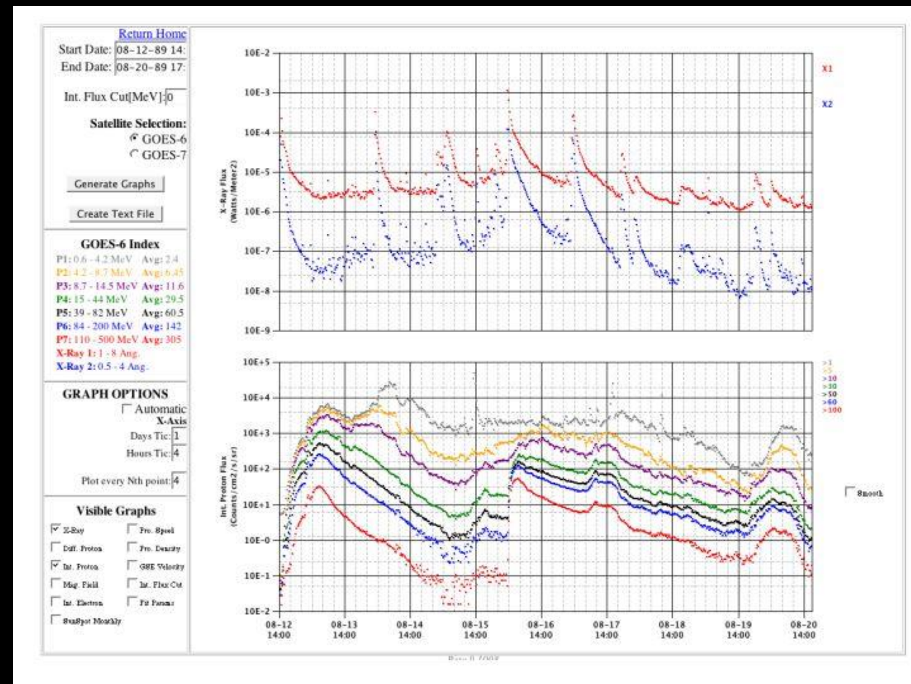
Two-Fold Consideration



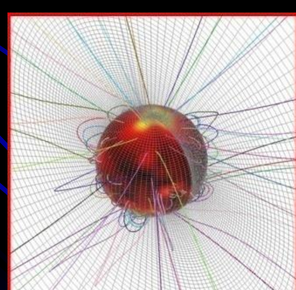
Operational Tool Development

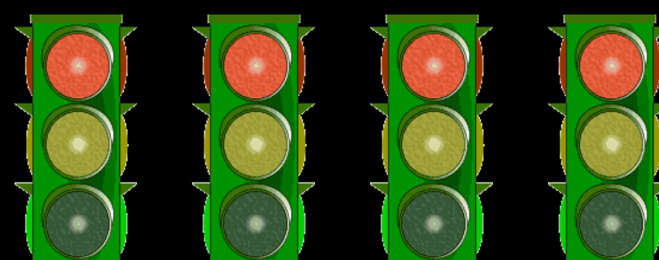
- Assess model capability:
  - historical event database
- No single-model solution





- Highly complex environment:
  - Multiple tools





Bottom Line: Forecasting tools require input data. Ties forecasting ability to asset viability – agency level problem: SMD/ESMD/SMD/OCE

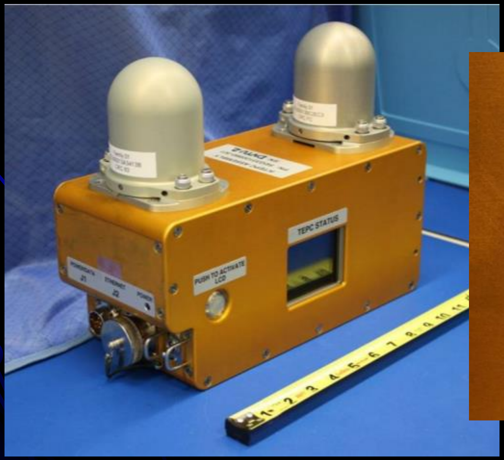
Status
Current and Future Work

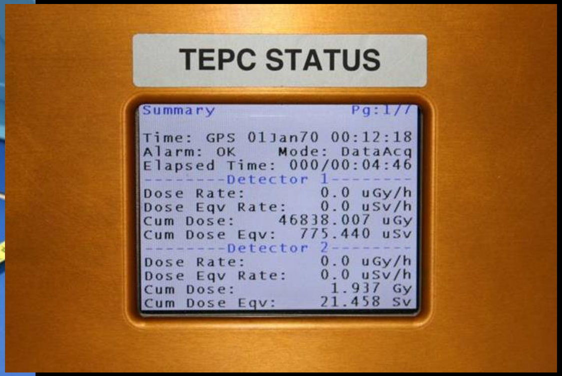
IV-TEPC

IV-TEPC is an updated version of the existing TEPC with similar capability in terms of operation and data types.

Activated on orbit on April 23, 2012. First data being analyzed now.

- Two omni-directional detectors attached to the spectrometer housing
- Provides continuous real-time data and also stores data locally
- Relocated about every 4 weeks
- Requires power and data connections
- Alarm threshold set at 5mrad/min (no local alarm - C&W system only)

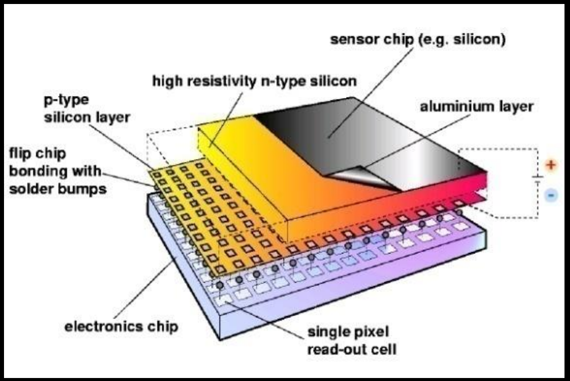




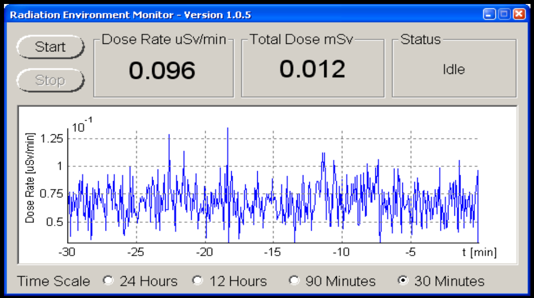
Radiation Environment Monitor (REM)

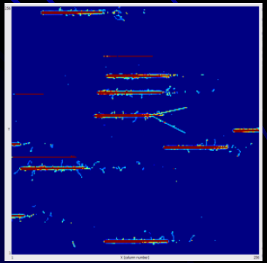
The Timepix Detector

- Developed as a High Energy Physics application of medical imaging technology
- Hybrid Pixel Detector with independent counting and readout circuitry in each pixel footprint
- 256 x 256 pixel grid with total area of 2 cm2
- Time Over Threshold mode coupled with calibration allows measurement of energy deposited per pixel



Pixel Detector Technology

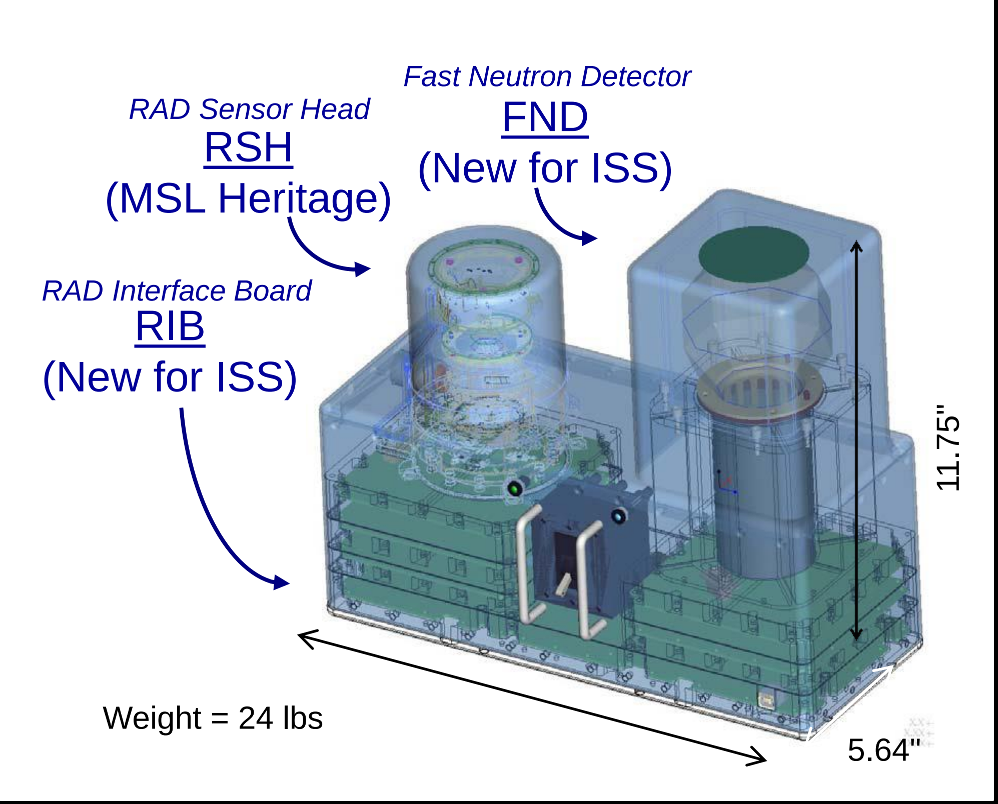




Pixel Detector Image from Medipix collaboration website: http://medipix.web.cern.ch/medipix/img/medipix2/web_flipchip.gif

ISS Radiation Assessment Detector (RAD)

- Designed to measure neutrons and charged particles from protons through Iron
- Contains CPDS-like detector stack
- Will provide real-time data
- Can be relocated within the habitable volume
- Currently in development based on the MSL-RAD instrument



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

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 this summer
  - Exploration Flight Test 1(EFT-1) (RAMs and REMs) – 2014
  - Radiation Assessment Detector (RAD) with an added fast neutron detector channel – 2015

Summary

- For long duration exploration missions (>6 months) new shielding solutions are needed to meet current NASA radiation risk limits
- Progressively reducing mass and power requirements for radiation monitoring hardware
- Collaborating to develop space weather forecasting tools for future human exploration missions
- CAD design tool development to aide in space vehicle design to minimize parasitic shielding mass through analysis during vehicle design process