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Overview of recent ISS measurements and future human spaceflight operational planning

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Overview

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- What SRAG does
- How SRAG does it
  - Modeling
  - Design
  - Operations
- Recent Solar Activity and Measurements
- Planning for the Future

What SRAG Does

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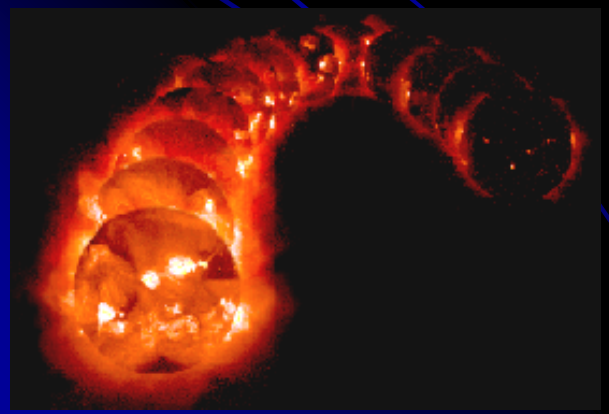
- If humans are going to work and live in space safely, then radiation protection is essential
  - Provide preflight crew exposure projections (EVA/mission)
  - Provide real-time astronaut radiation protection support
  - Monitor space weather events
  - Provide radiation monitoring to meet medical and legal requirements
  - Maintain comprehensive crew exposure modeling capability
  - Provide spacecraft design inputs through CAD model analysis
  - Develop concepts of operation to minimize exposure
  - Develop radiation monitoring hardware
  - Devolop space weather forecasting capabilities



SRAG Facilities

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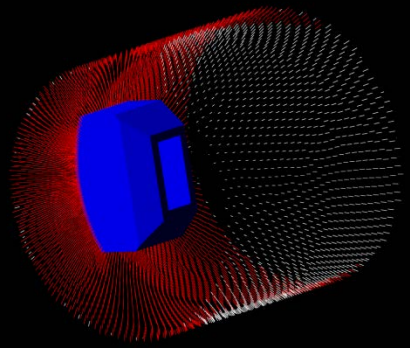
- Console in MCC
- Radiation Operational Support Area (ROSA)
  - Identical functionality to MCC for training, code testing, and model development
- Dosimetry Laboratory
- 20 Node, 480 core, Linux cluster
  - Monte Carlo Radiation Transport Calculations
- Linux Server w/ 4 NVIDIA Tesla GPU Cards and 4 ATI CrossFire GPU Cards
  - Fast raytracing of full spacecraft CAD designs
- Dedicated CAD workstation
  - CAD design analysis and verification of CAD model parameters



Requirements/Constraints

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- Crew exposure limits
- Vehicle design limits (human exposure) – SPE driven
- Measurements – mission phase / type dependant
- Limited Space Weather Forecasting Models
- Space Weather data satellite assets
- Mass – Shielding is our only real parameter that can be tweaked and that is very limited
- time, complexity, budgetary constraints, etc.

Methodology

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- What we use
  - GOES
    - X-rays
    - protons
  - ACE
    - Solar bulk parameters (velocity, density)
  - SOHO
    - LASCO, EIT
  - ISS
    - EVCPDS – outside station
    - IVCPDS/ALTEA – inside station
    - TEPC – inside station
    - Passive dosimetry

Methodology

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- How we use them:
  - Console monitoring:
    - 4 hrs/day during nominal conditions
    - Continuously during space weather conditions
  - X-ray flare
    - >M5 – alert, if EVA egress within 12 hours, return to console
  - Proton thresholds
    - >10 MeV @ 10 pfu – alert, if EVA within 12 hours, return
    - >100 MeV @ 1 pfu - return
  - Watch the event unfold – during event give recommendations to flight control team

Why Measure?

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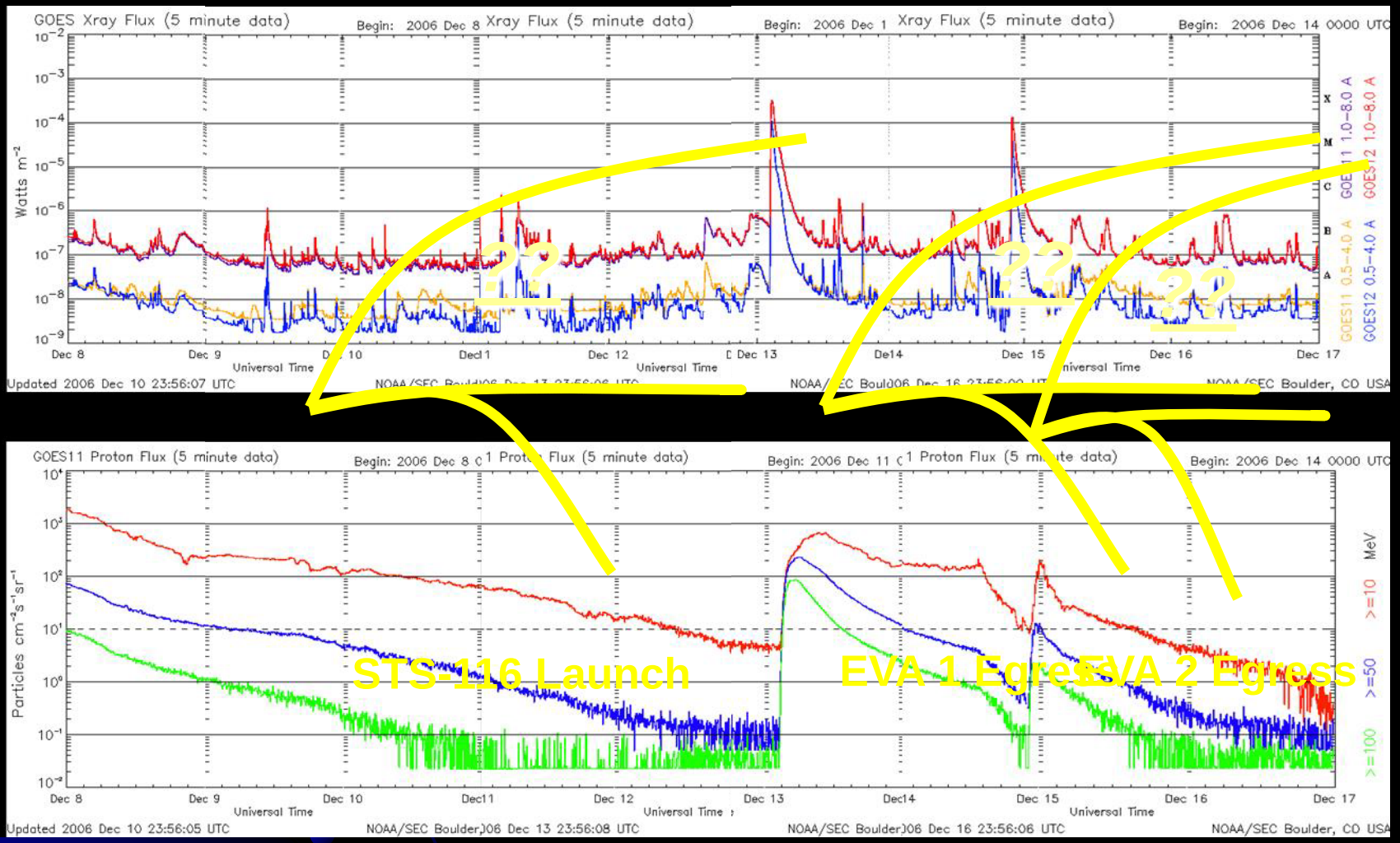
Probability of occurrence vs. Execution



Ray-Tracing Tool

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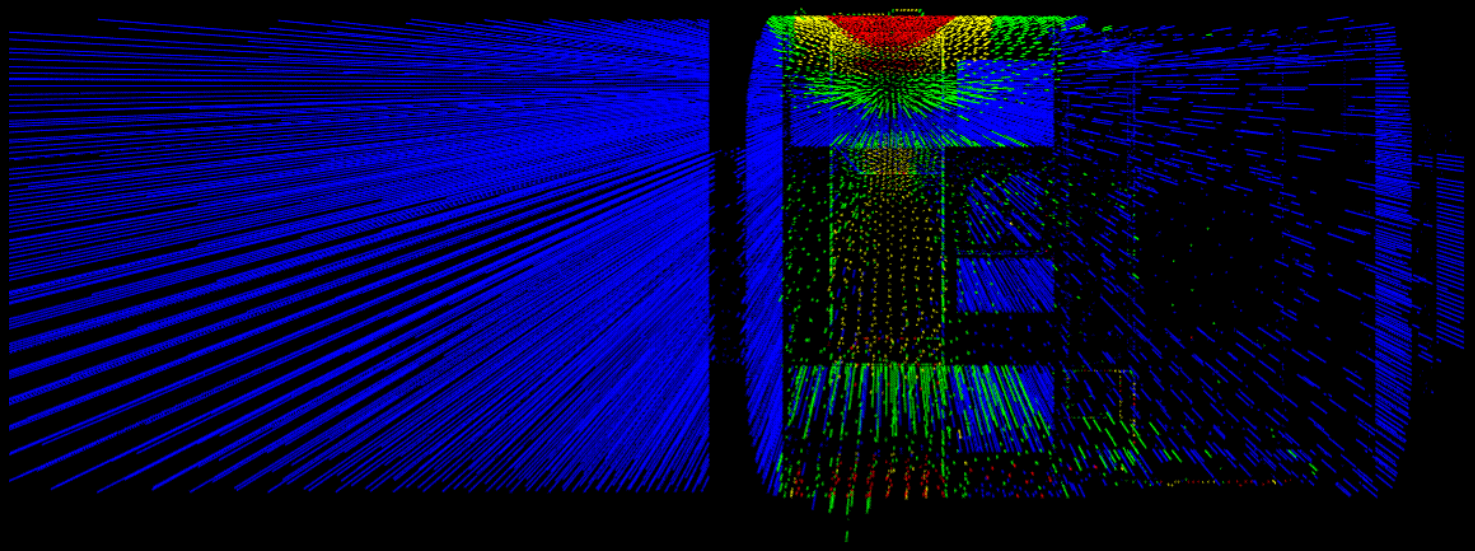

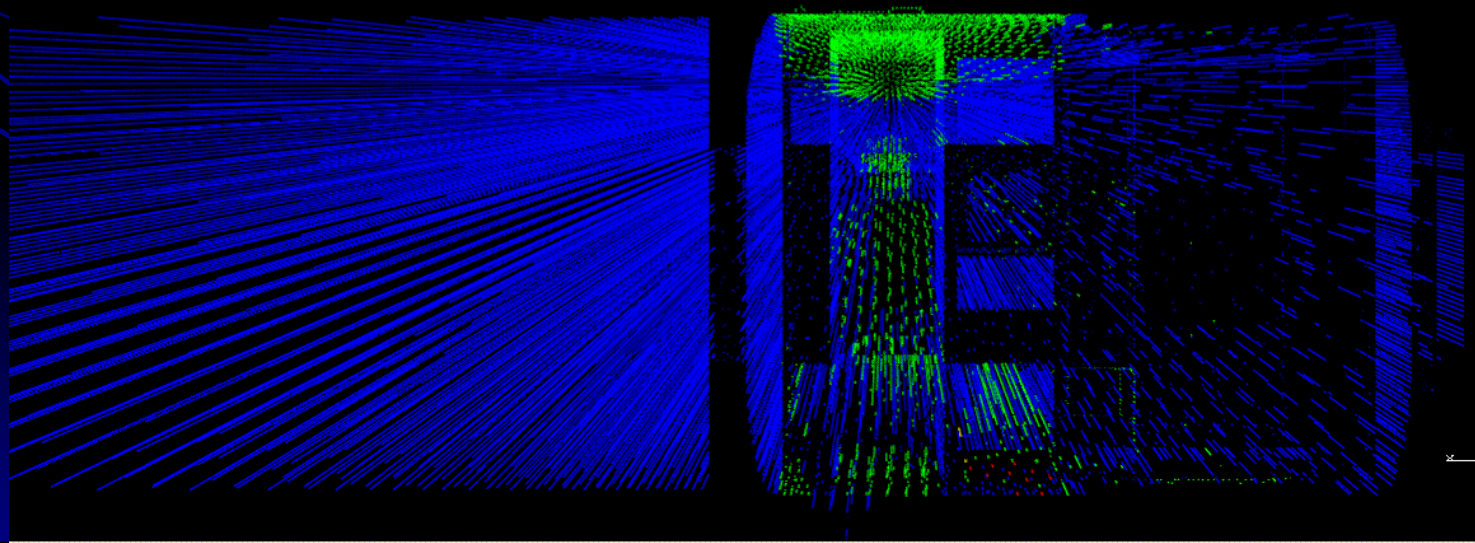

Comparison Of Shielding: 606-5 vs. 606-C

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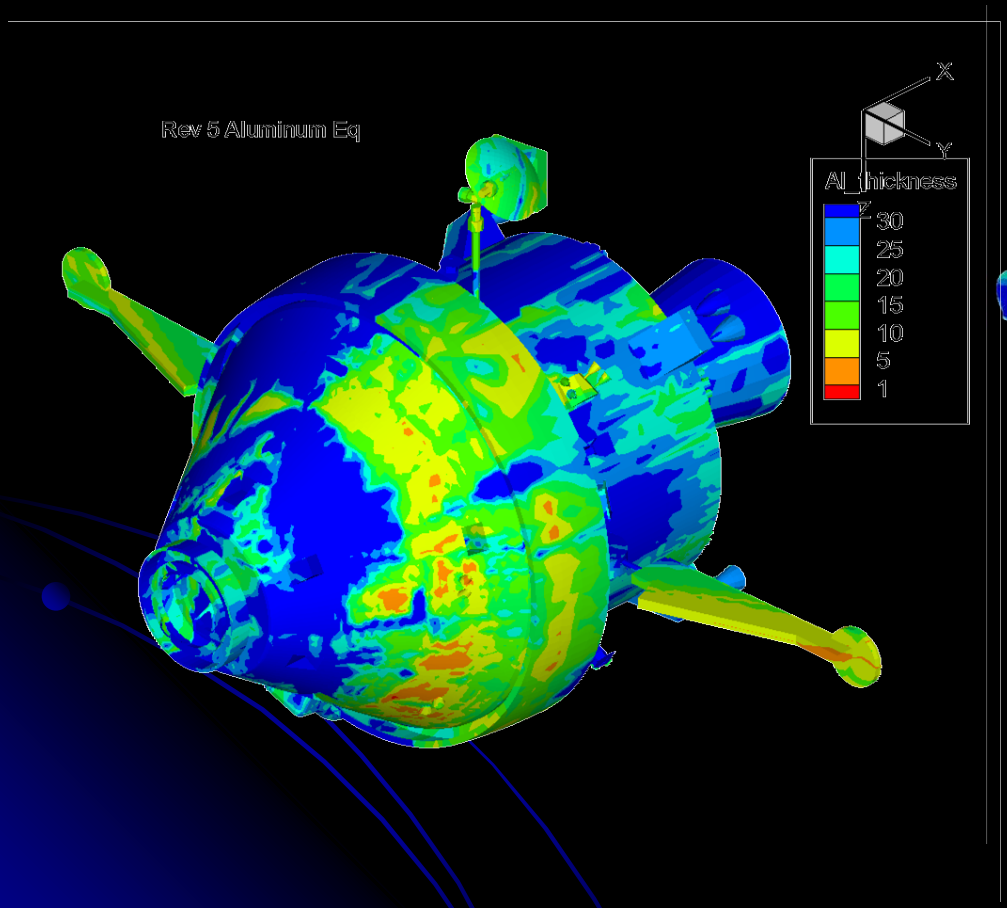

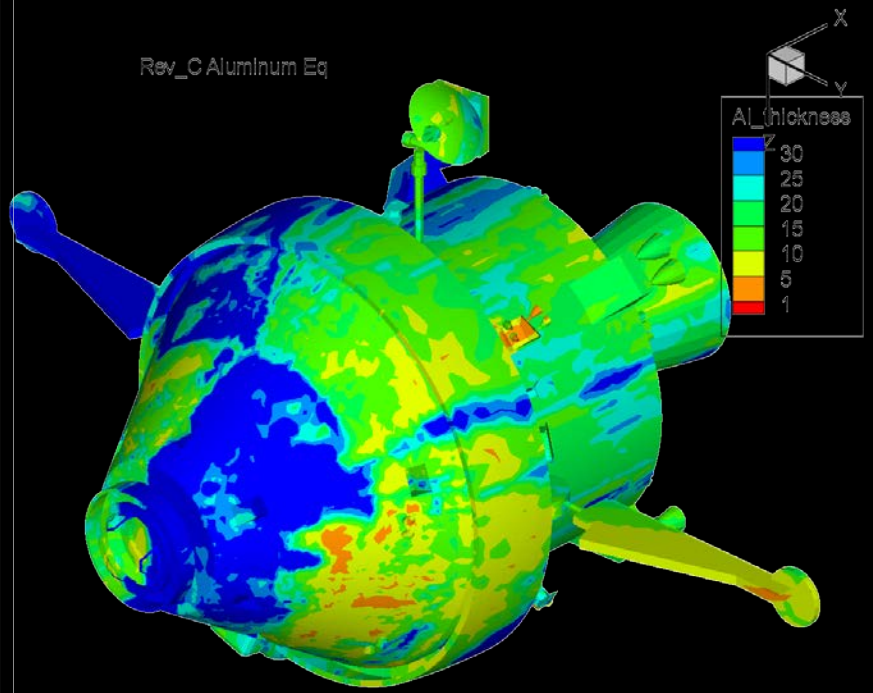

Models to Operations

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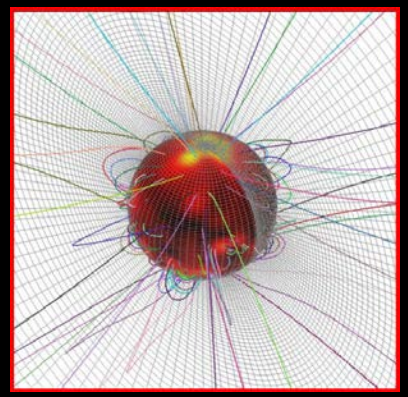

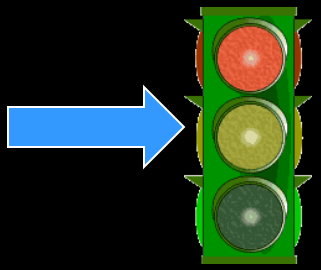

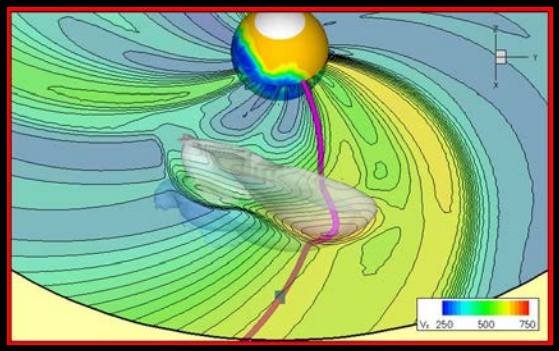

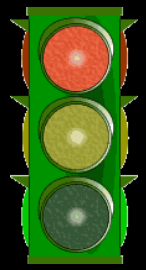

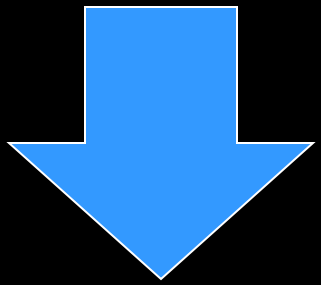

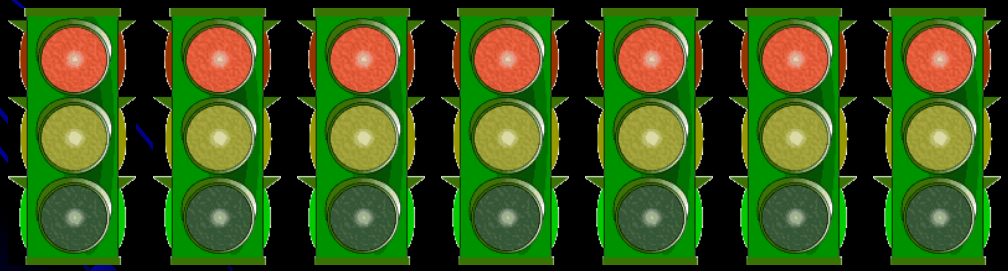

Recent Solar Activity

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- Solar Particle Events (>10 MeV flux above 10 particles/cm^2-sr-s) 10s over 10
  - 14 Aug 2010 14pfu
  - 07 Mar 2011 50pfu
  - 22 Mar 2011 15pfu

- Energetic Solar Particle Events (>100 MeV flux above 1 particle/cm^2-sr-s) 100s over 1
  - 07 Jun 2011 4.0pfu
  - 04 Aug 2011 1.8pfu
  - 09 Aug 2011 2.7pfu

TEPC Measurements

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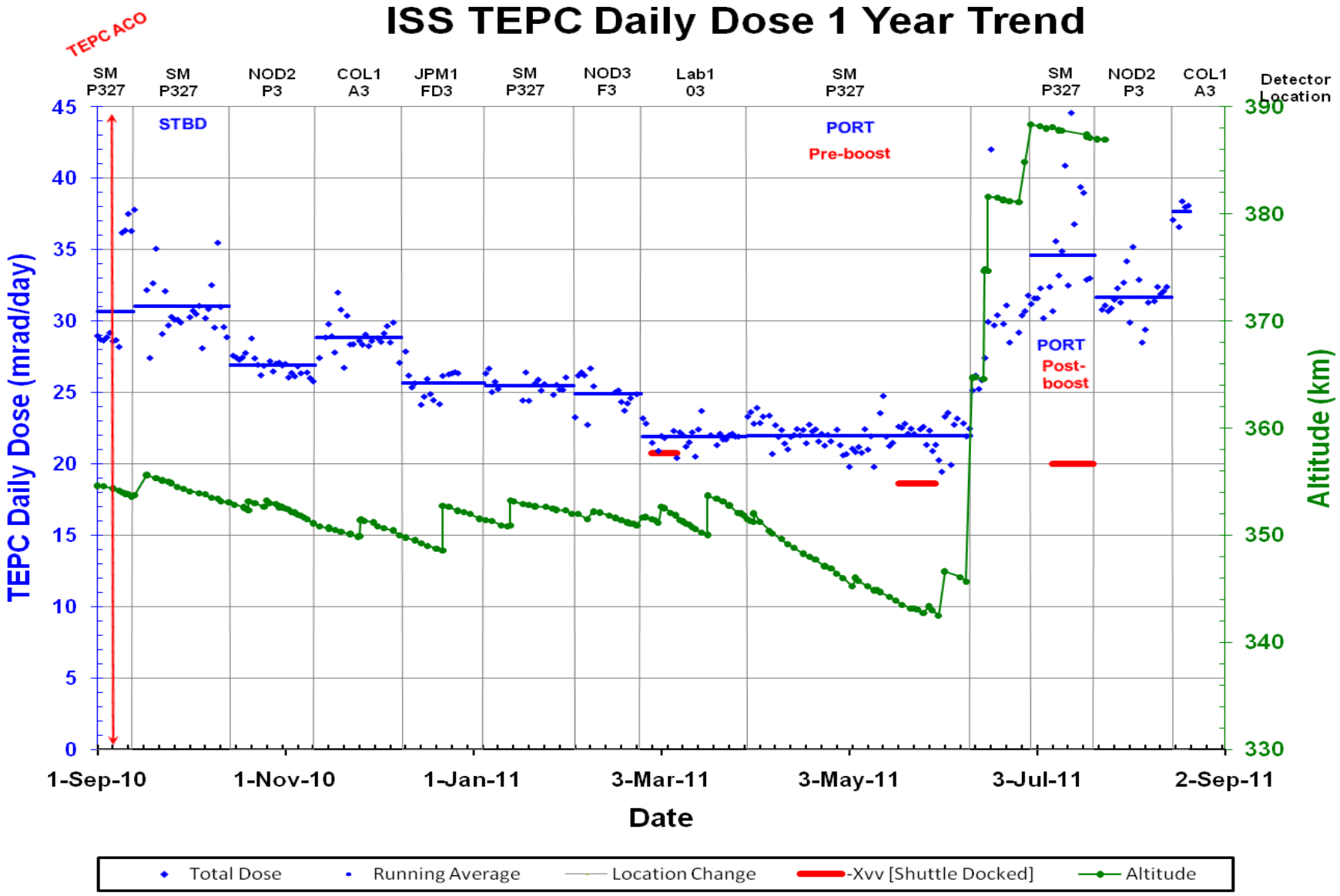

Future Exploration

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- Prepare for Long-term focus using ISS as a test bed for Exploration missions
- Technology development
  - Combine CAD and Monte Carlo transport
    - CAD to native Monte Carlo geometry conversion
    - CAD raytrace replaces Monte Carlo tracking
  - Reduce mass and power of on board radiation monitoring hardware (e.g. RAD, IV-TEPC, Medipix development)
- Advanced Monitoring and Prediction
  - Space-based assets, monitor locations
  - Predictive capability
    - Solar activity predictions
    - Quiet-time forecasts
  - Physics-based and empirical modeling
- Goal to become predictive rather than reactive

Summary

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- **Significant risk** to Exploration mission/Human System from ***Space Weather***
  - No geomagnetic protection from ***SPEs***
  - **~x10** compared to ISS
  - Surface **EVA return** times long compared to **warnings**
- **Three** mitigators
  - Vehicle/element **design**
  - Crew **selection**
  - **Operational response**

  SRAG Domain
- Efficacy requires **blurring the science/operations line**
  - Application of method to **new populations (e.g. CME vs. SPE)**
  - Attention to **viability** of input data