Space Weather and Manned Spaceflight

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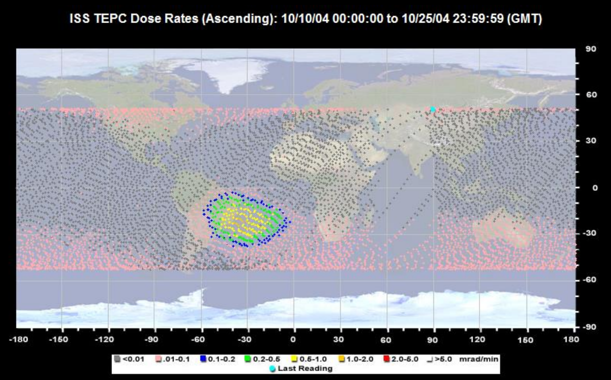
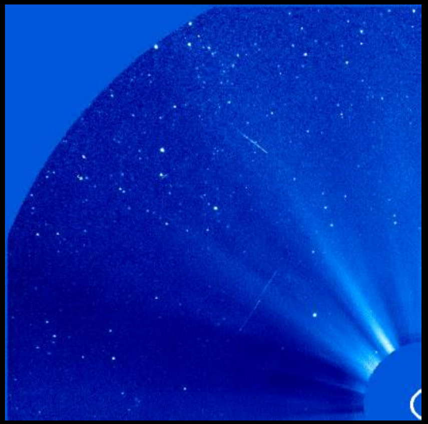
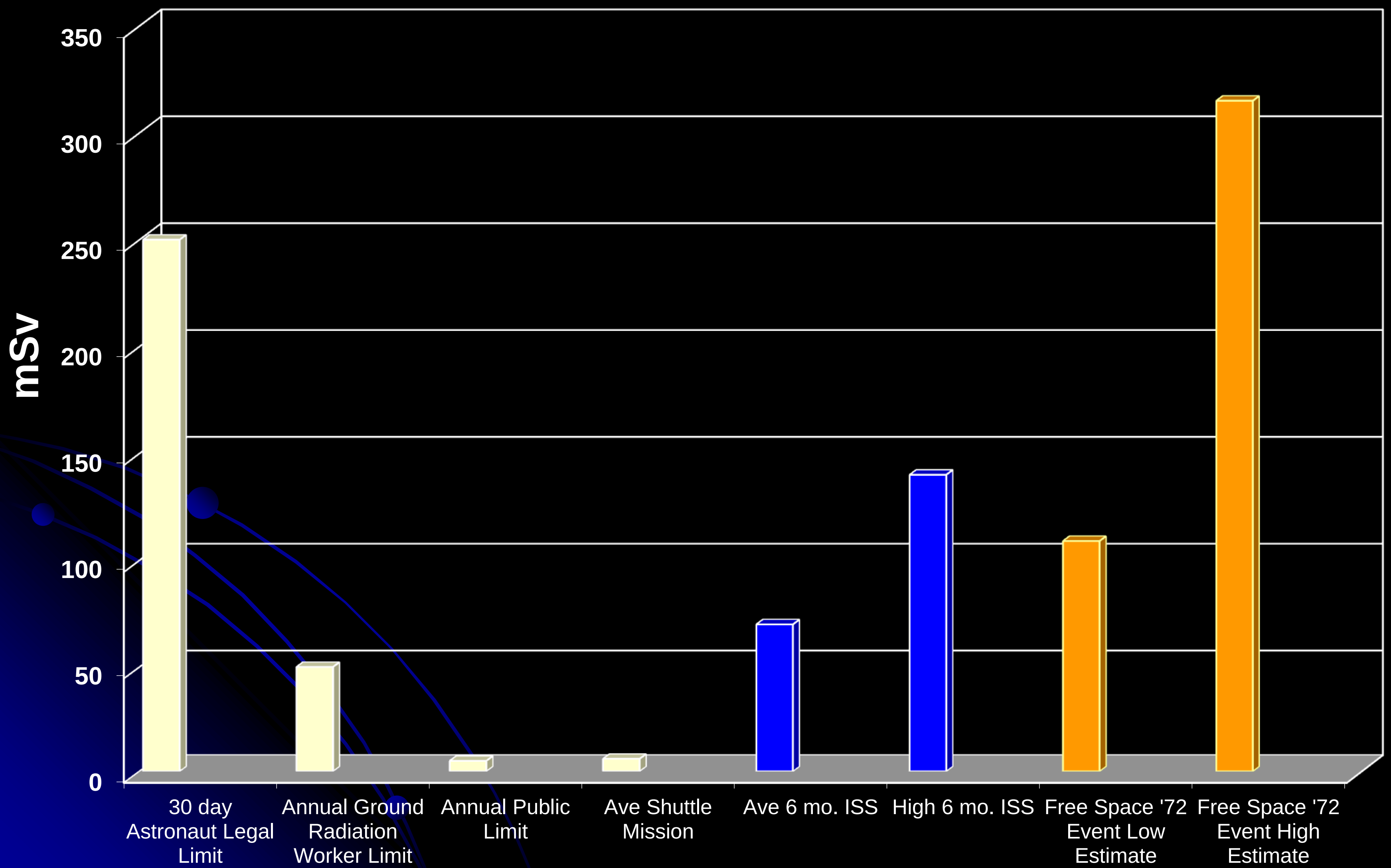
OVERVIEW



- Operational space radiation protection
  - What's a SRAG?
  - Crewed space operations
- Shift in direction
  - Crewed exploration
  - Tech. Development
  - Mars
- Primary needs & work
  - Validation and verification
  - Solar Forecasting
  - Measurements
  - Unification of NASA voice



Exposure Reference



SRAG

- Est. 1962, Continuous manned program support
  - Mercury: console, dosimetry
  - Gemini: console, dosimetry
  - Apollo: console, dosimetry
  - Apollo-Soyuz: console, dosimetry
  - Skylab: console, dosimetry, equipment design (film vault)
  - Shuttle: console, dosimetry
  - NASA-Mir: console, dosimetry
  - ISS: console, dosimetry, equipment design
  - Constellation:
    - Orion system manager
    - GFE hardware provider
    - Operations (console, dosimetry)

- Physicists, Health Physicists, Engineers, Programmers, I/T Professionals
  - (4 FTE, 20 WYE – 3 USRA)
  - Facilities
    - MPSR – SRAG Console
    - SRDL – Dosimetry lab, flight hardware controlled storage, wet lab
    - ROSA – MPSR backup/mult.vehicle support, training, server room
    - Cesium photon source – Calibration/characterization

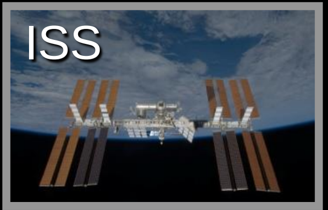
Operational Concerns

- Crew health and performance
  - Direct – exposure
  - Indirect – vehicle/suit systems
- Nominal exposures significantly greater than terrestrial rad-workers or air crews
- Risks
  - Loss of mission
  - Protracted loss of crew (REID)

- Risk management / mitigation
  - Time, Distance, Shielding
  - Planning/Re-planning
  - Manipulation of local shielding
- Primary Limitations
  - Solar forecasting
  - Environmental dynamics

Console Interfaces

Flight Director
- Notification of SEPs for hardware concerns
- Time intervals of SEP exposure risk

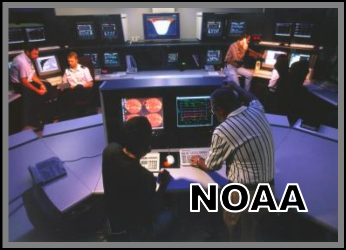


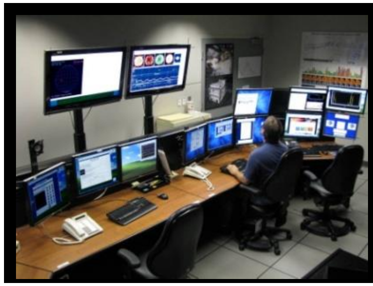
Surgeon/BME
- Maintain status of mission exposure trends
- Evaluate EVAs for Exposures (ALARA)
- During Solar Energetic Particle Events (SEPs)
  - Advise Surgeon on Magnitude of events
  - Time intervals of SEP Exposure Risk
  - Recommendations regarding Crew Shelter
- Training for SRAG Operations and Hardware

AFTAC
- Artificial Event Detection and Notification

International Partners
- Data sharing
- Alerting
- Coordinated contingency response

SWPC



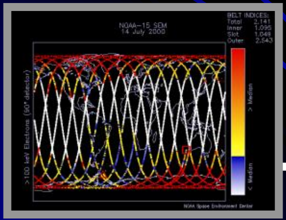


SPACE RADIATION ANALYSIS GROUP

MPSR

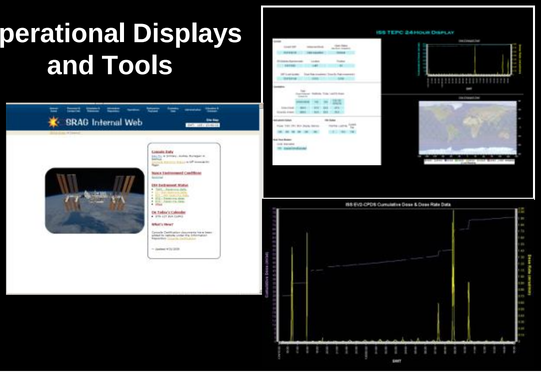
Telemetry

Crew
- ASCAN Training
- Flight Hardware Training



Alerting

Operational Displays and Tools

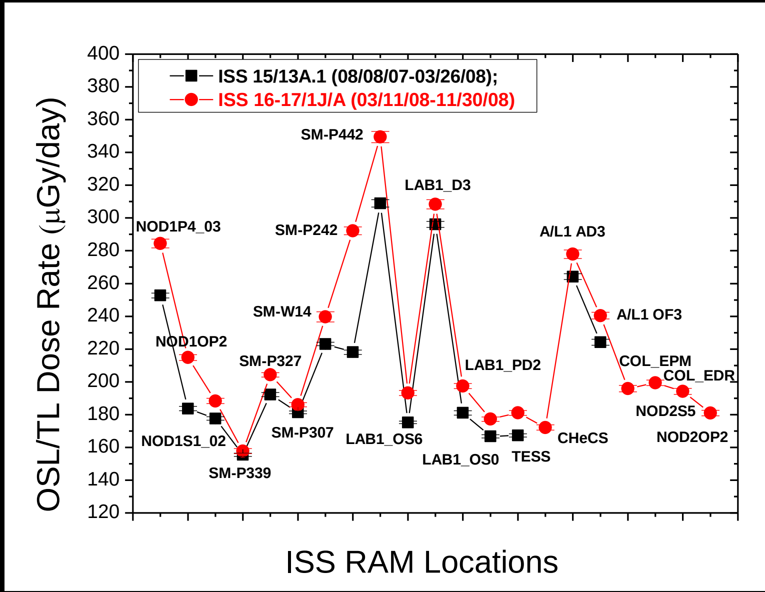


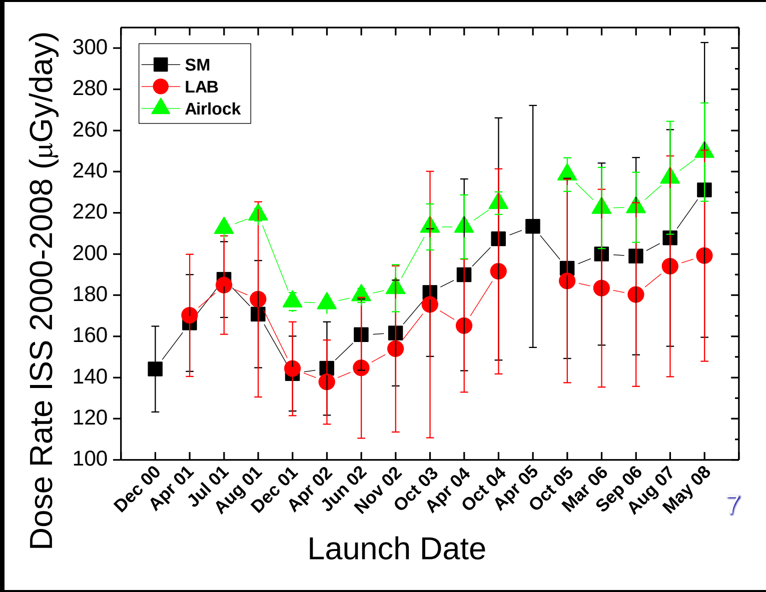
Telemetered ISS Data

MCC
ISPX Servers

SRAG Operational Radiation Measurements

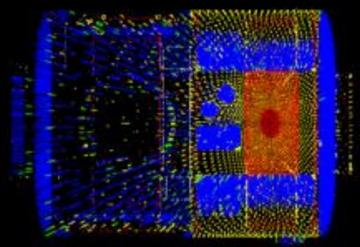
SRD Lab Workload in 2008		
Mission	**Launch Date**	**Total Number of OSL/TL/CR-39**
STS-122	02/07/2008	336
STS-123	03/11/2008	336
STS-124	05/31/2008	336
STS-126	11/14/2008	380
ISS Expd 16/1E	02/07/2008	48
ISS Expd 16-17/1JA	03/11/2008	576
ISS Expd 17/1J	05/31/2008	48
ISS Expd 18/17S	10/12/2008	83
ISS Expd 18/ULF2	11/14/2008	788
Matroshka , Space Icchiban, DOSIS, Accelerator Calibrations 200-300 detectors per year		
TOTAL	**3000+**	

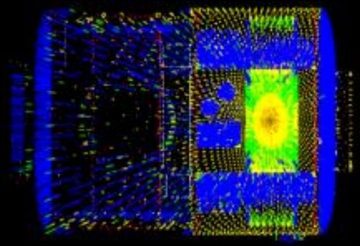




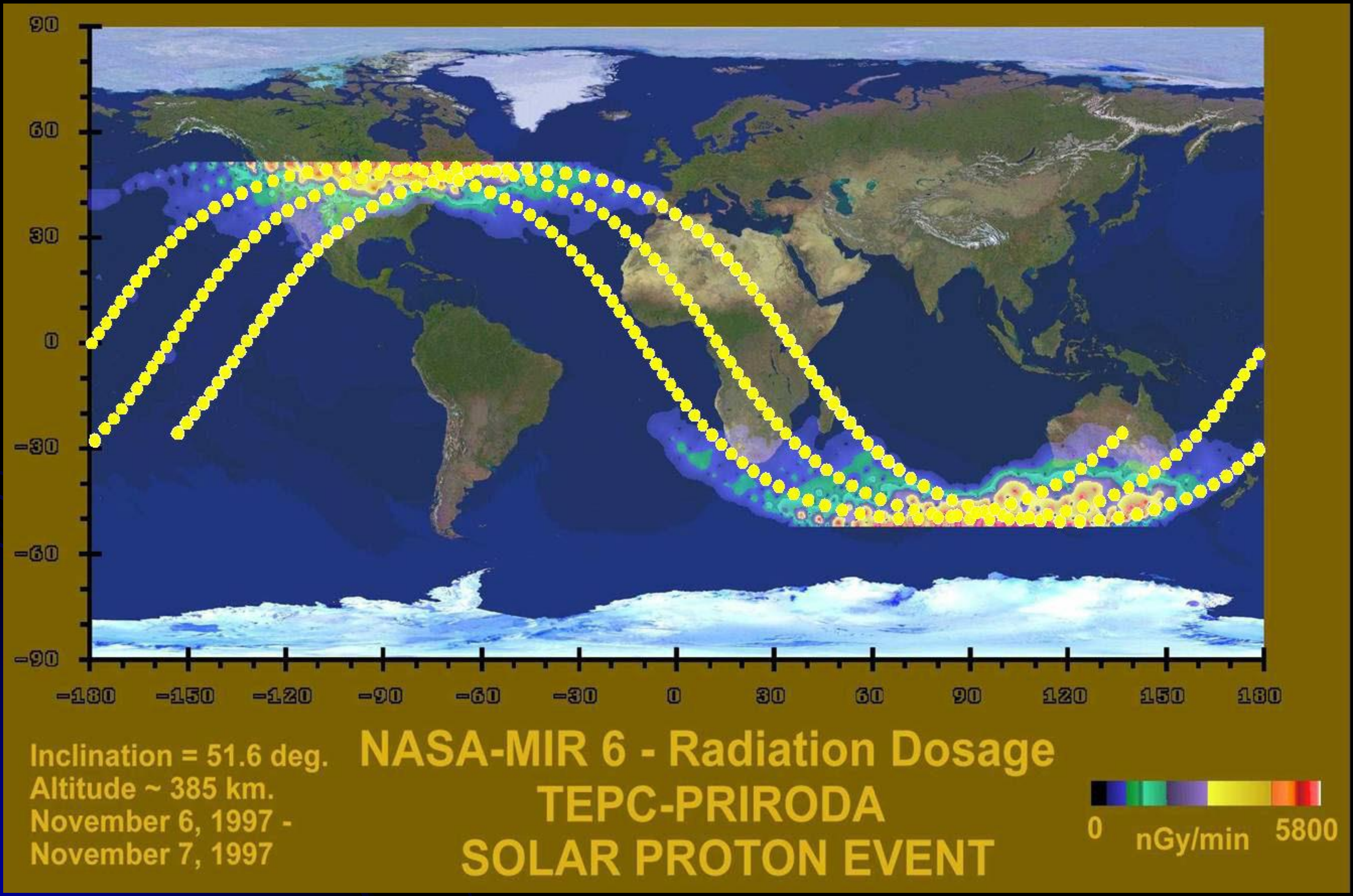
Analysis Methods

- Configuration-managed, industry-standard sector analysis modules
- Production tools derived from HRP Pro-Engineer-based products
- Rapid, precise evaluation of large structures/assemblies
- Systems engineering – performance does NOT dictate mass

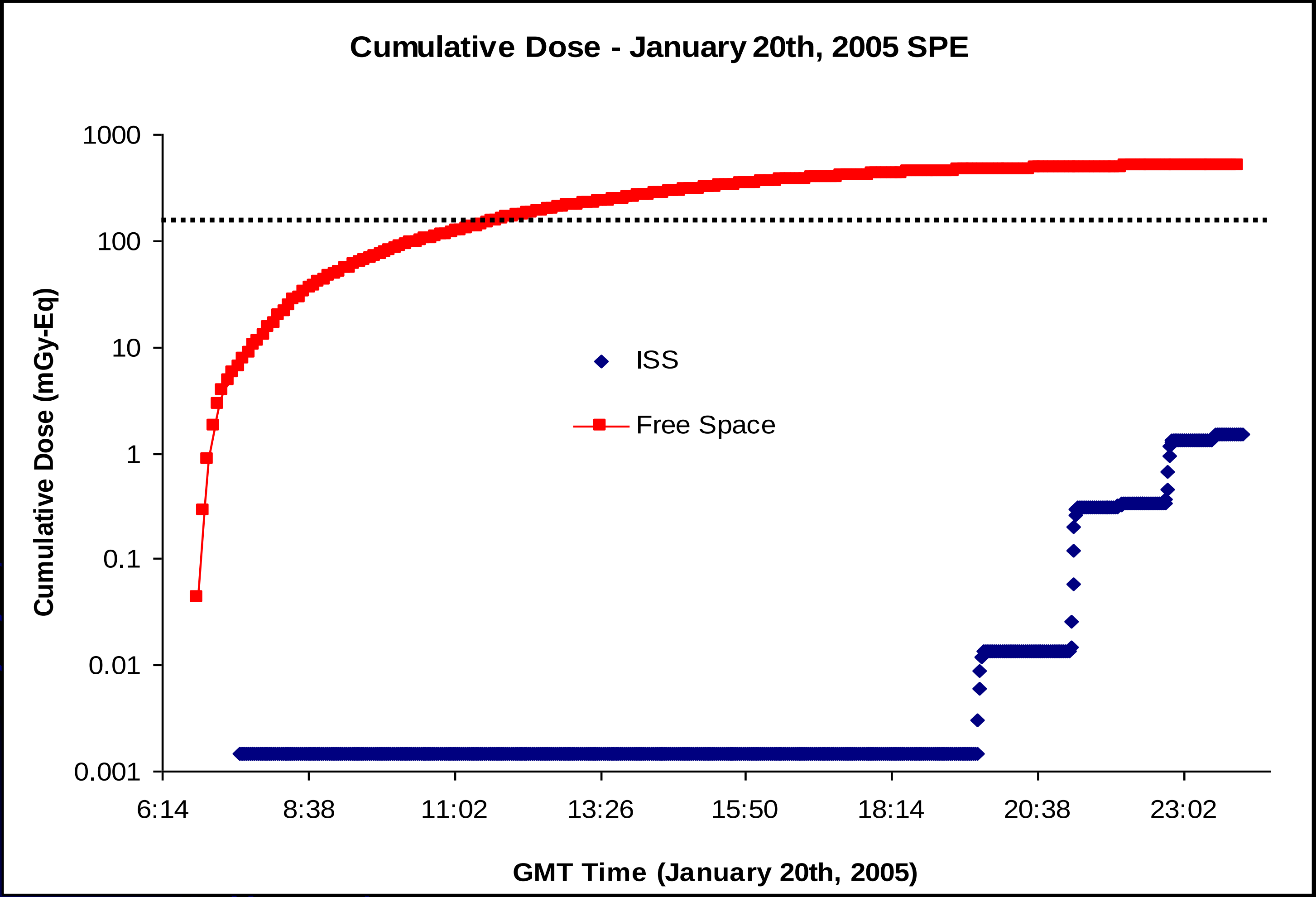




LEO Means Phasing

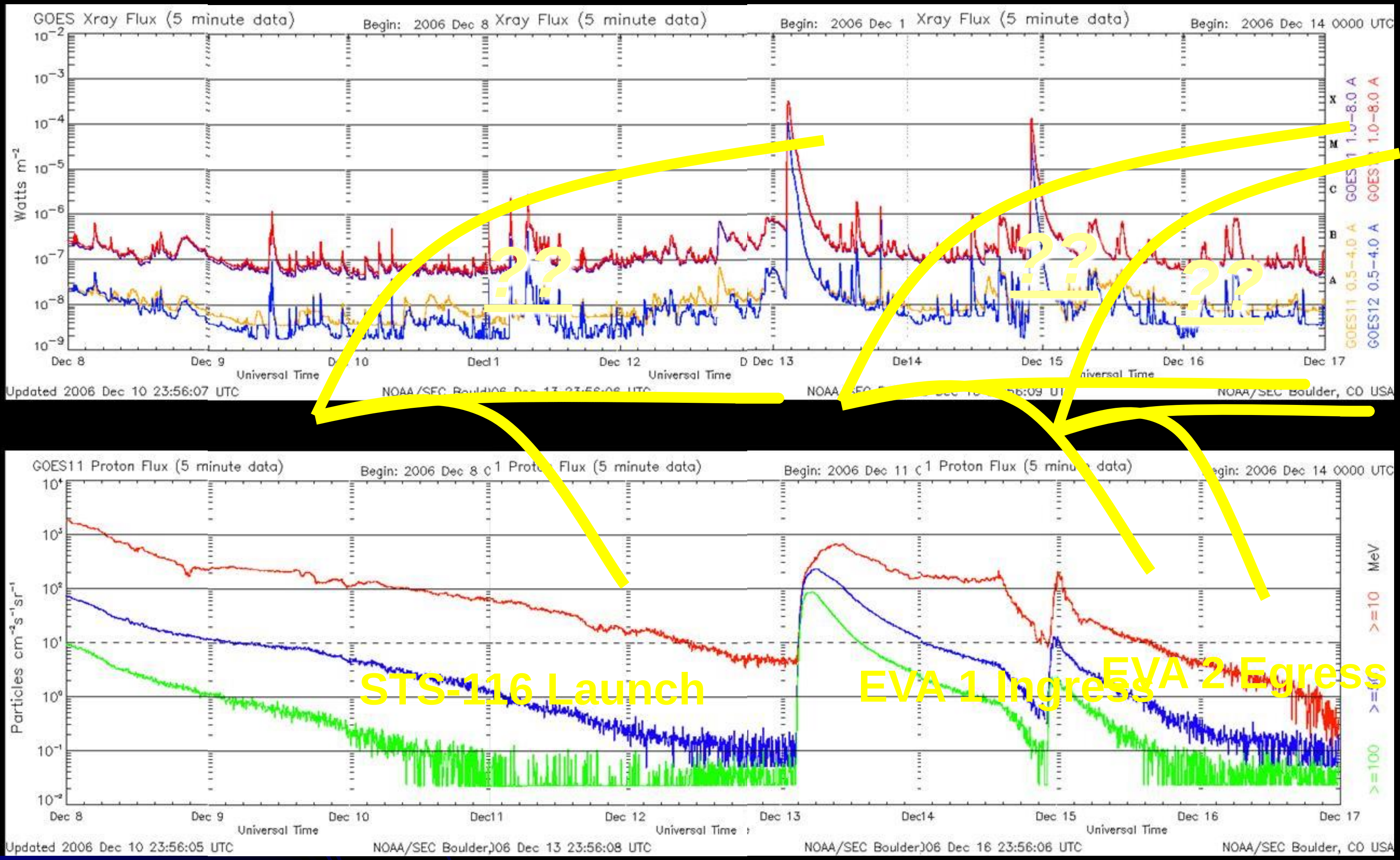


Exploration



“Holes”, Concerns

Forecasting



SRAGs "Holes", Concerns

- Team inexperience
- SEP forecasting
  - Onset
  - Peak (by energy)
  - Evolution/Temporal Profile
- SEP forecasting
  - Onset
  - Peak (by energy)
  - Evolution/Temporal Profile
- SEP forecasting
  - Onset
  - Peak (by energy)
  - Evolution/Temporal Profile

X-Ray flares: correlations

CMEs : exacerbation, potential lunar EVA impact

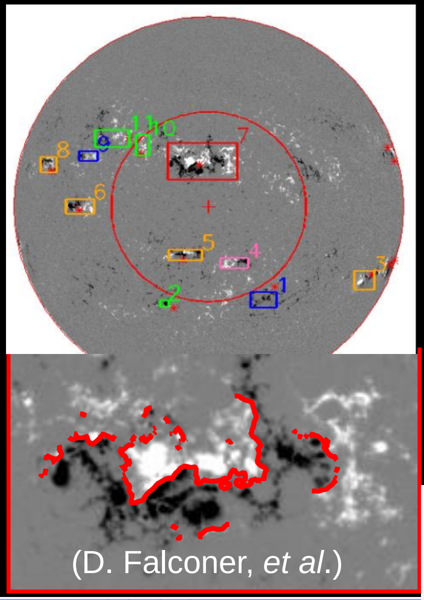
Magnetic Storms : exacerbation

Type "N" emission signatures : correlations

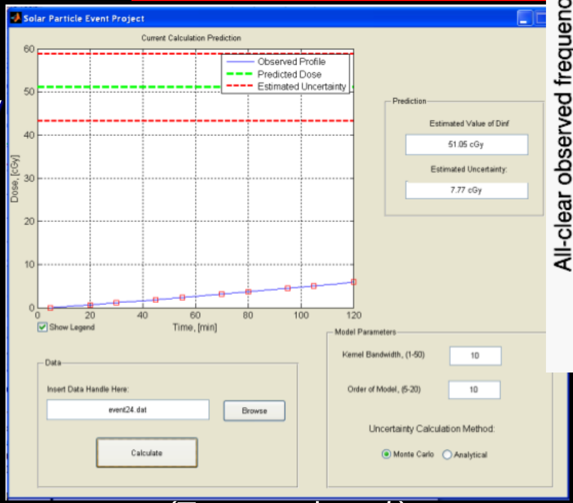
10 cm burst: correlations

Extra-Agency Collaborative Efforts

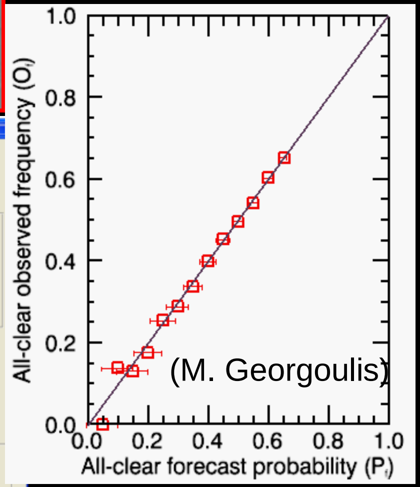
- SPE Forecasting
  - NWRA / GMU Collaboration
  - All-Clear Workshop
  - MSFC Collaboration
  - Innocentive
    - Look for multi-disciplinary approach
    - Challenge submitted and ran for 60 days.
    - 579 potential solvers looked at problem
    - Focused on active regions
- SPE Dose Projection
  - UTENN collaboration
  - Neural Network analysis
- SPE Spectral Analysis
  - NRL collaboration
  - Generation of spectral fits from 10 MeV to 1 GeV
  - Higher fidelity dose estimation
  - Transition to real-time operations



(D. Falconer, *et al.*)

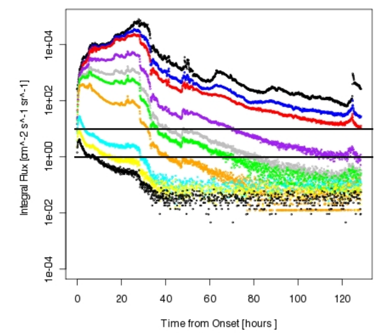


(Townsend *et al.*)



In-House Analysis

- Expand
  - Leverage information technology resources
    - Database structure for ease of data retrieval
  - Combine with robust numerical techniques
    - Time-dependent spectral fitting – spectral hardening / softening
    - Realistic vehicle geometry models
    - Realistic human models
    - Radiation transport
- Robust Historical Analysis (1967 – present)
  - Distribution of spectral character
  - Distribution of SPE dose
  - Time dependent dose for mission planning



Event Integrated Flux
$[cm^{-2}\ sr^{-1}]$

Channel	Flux
>1 MeV	3116497530.00
>5 MeV	1820664600.00
>10 MeV	1298067030.00
>10 MeV	340450353.90
>50 MeV	108314869.80
>60 MeV	58208371.92
>100 MeV	15946529.76
>330 MeV	549621.24
>420 MeV	197939.90
>510 MeV	88358.56

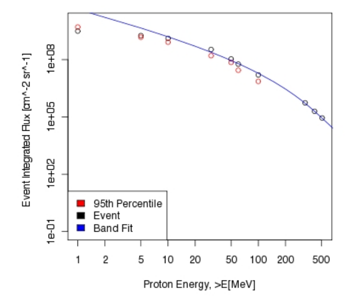
Peak Flux / Time
$[cm^{-2}\ s^{-1}\ sr^{-1}]$ / [hours]

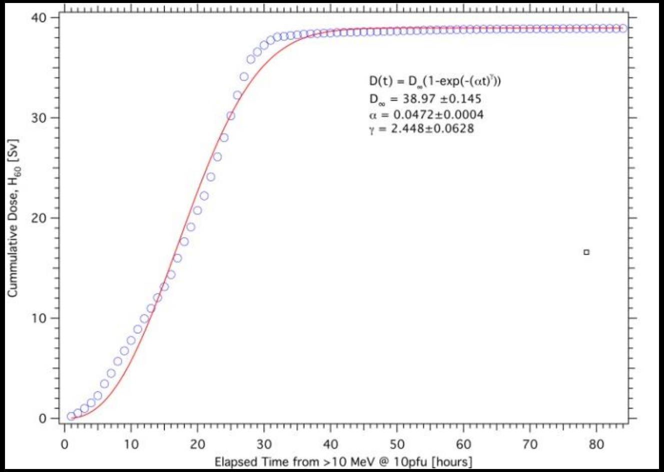
Channel	Peak Flux	Time to Peak
>1 MeV	80000	27.83
>5 MeV	35600	25.83
>10 MeV	24000	25.75
>30 MeV	5680	22.83
>50 MeV	1670	22.83
>60 MeV	1110	5.58
>100 MeV	408	5.58
>330 MeV	28.39747945207	1.00
>420 MeV	9.50004931507	1.00
>510 MeV	4.23863013699	1.00

Start Date/Time (>10 MeV @ 10pfu): 2000-07-14 10:45:00
Event Duration (>10 MeV @ 10pfu): 128.5 hours
Satellite: GOES-8
NOAA Region #:
Associated Flare Class (NOAA):

Fit Parameters	
Φ_0 $[cm^{-2}\ sr^{-1}]$	23112100
R_0 [GV]	0.204004
γ_1	2.46586
γ_2	7.12731

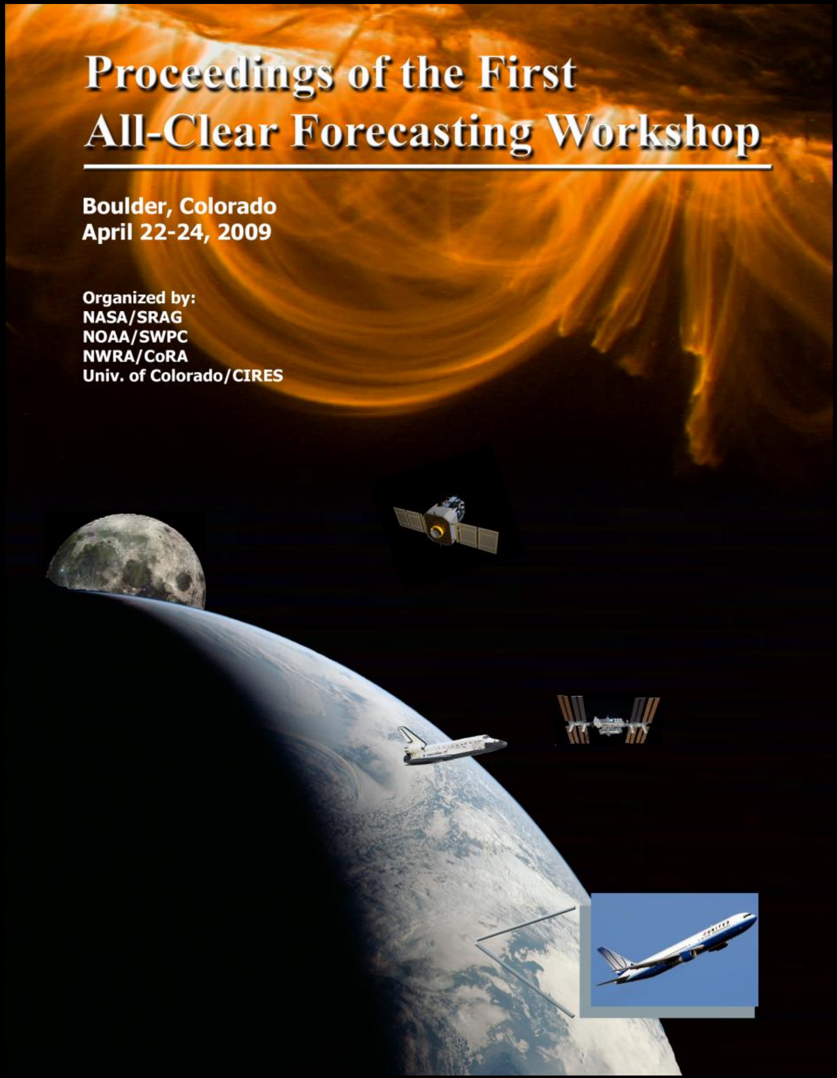
Generate HZETRN Input



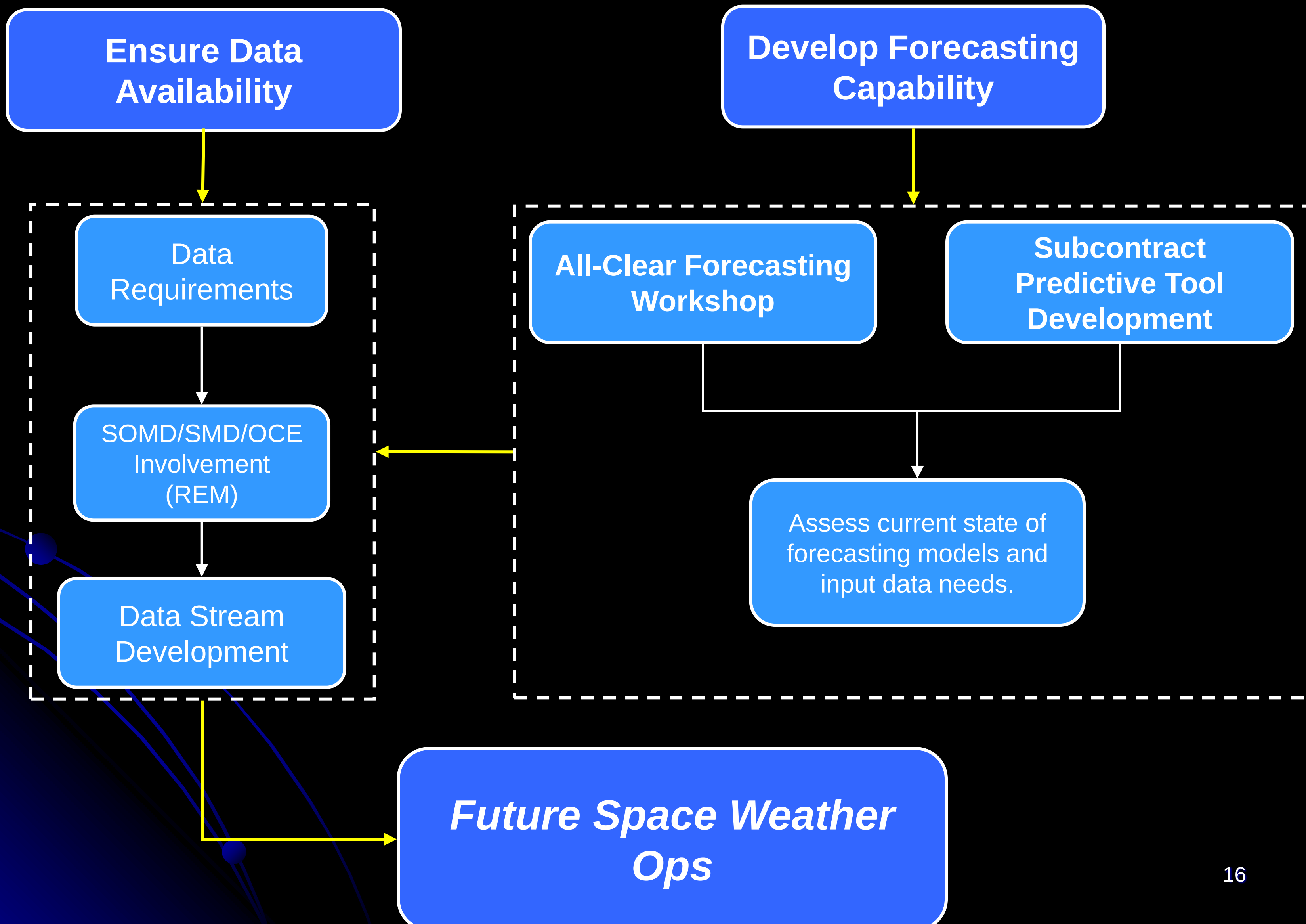


All-Clear Workshop

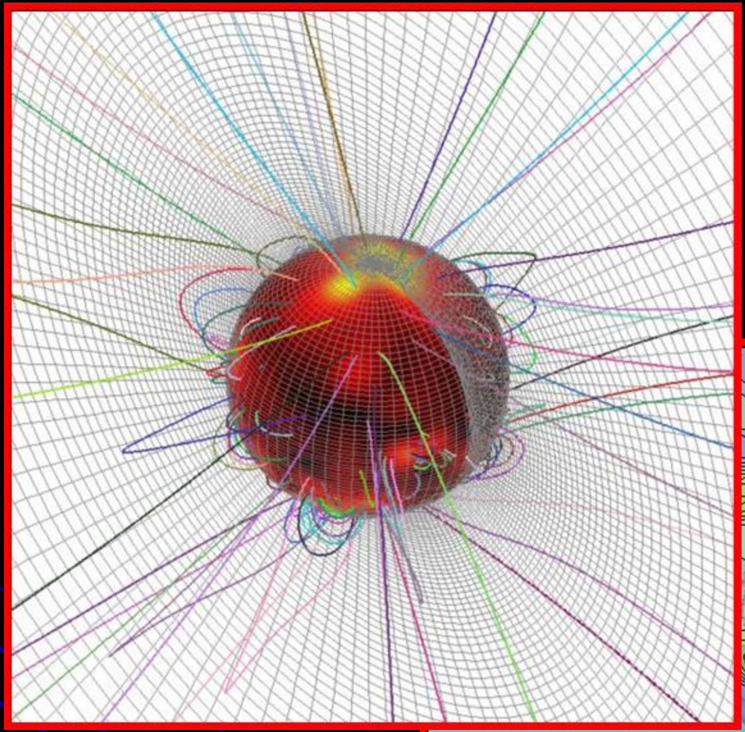
- LWS TR&T
- Collaborative effort
  - SRAG
  - SWPC
  - CoRA
  - CIRES
- Lays a foundation
  - Needs
  - Performance metrics
  - Initial developer feedback
- Shows a focus
  - Measurements (details)
  - Community approach
  - Spans power grids to space exploration

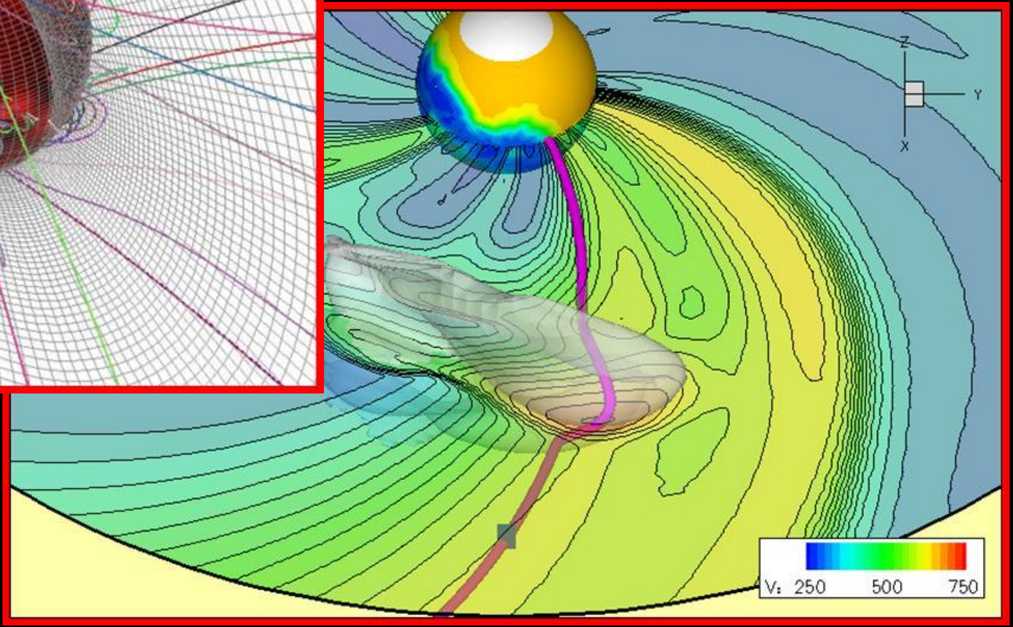


Two-Fold Consideration

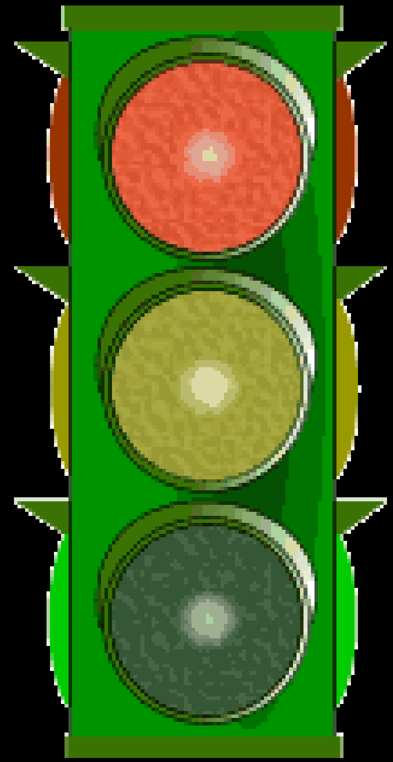


Scientific Description



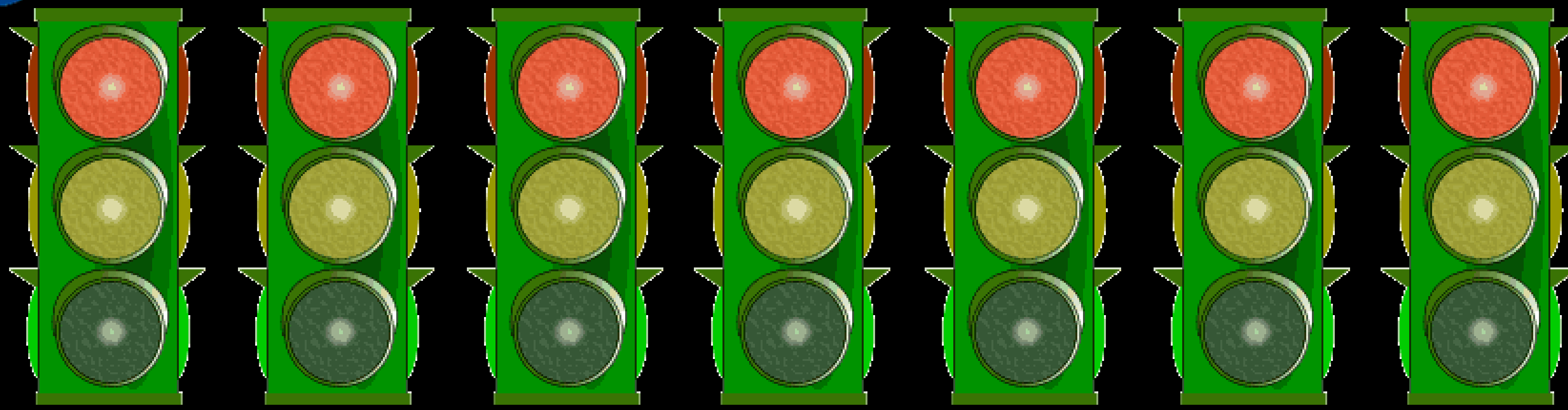


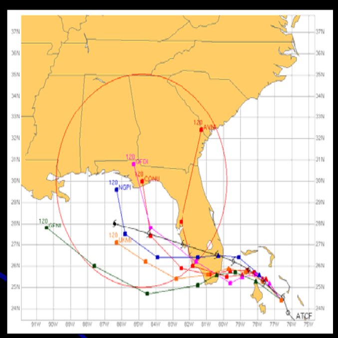
Operational Description

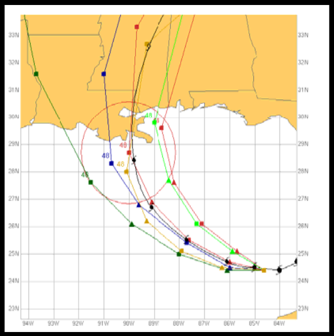


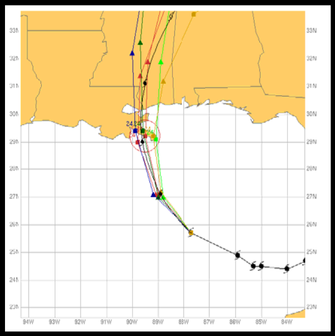
- Important differences
  - Don't need to be an expert on any particular model to interpret indicators
  - Ops description is robust in architecture, redundant in function, and is documented, validated, and verified according to customer requirements
  - No "cool" points
  - In-mission is the wrong time to learn something new

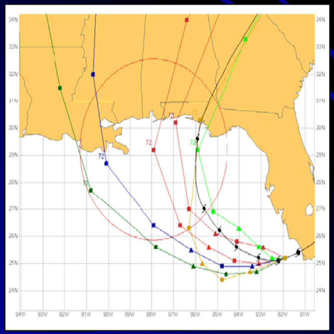
Ensembles

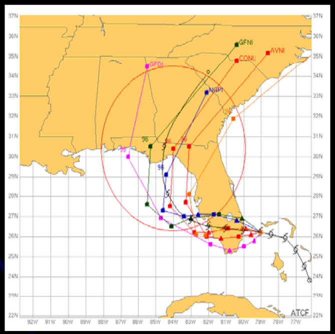


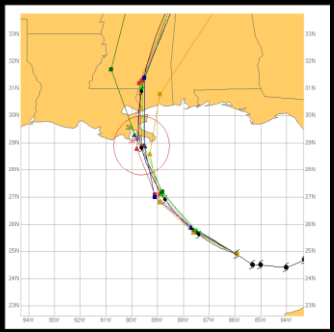






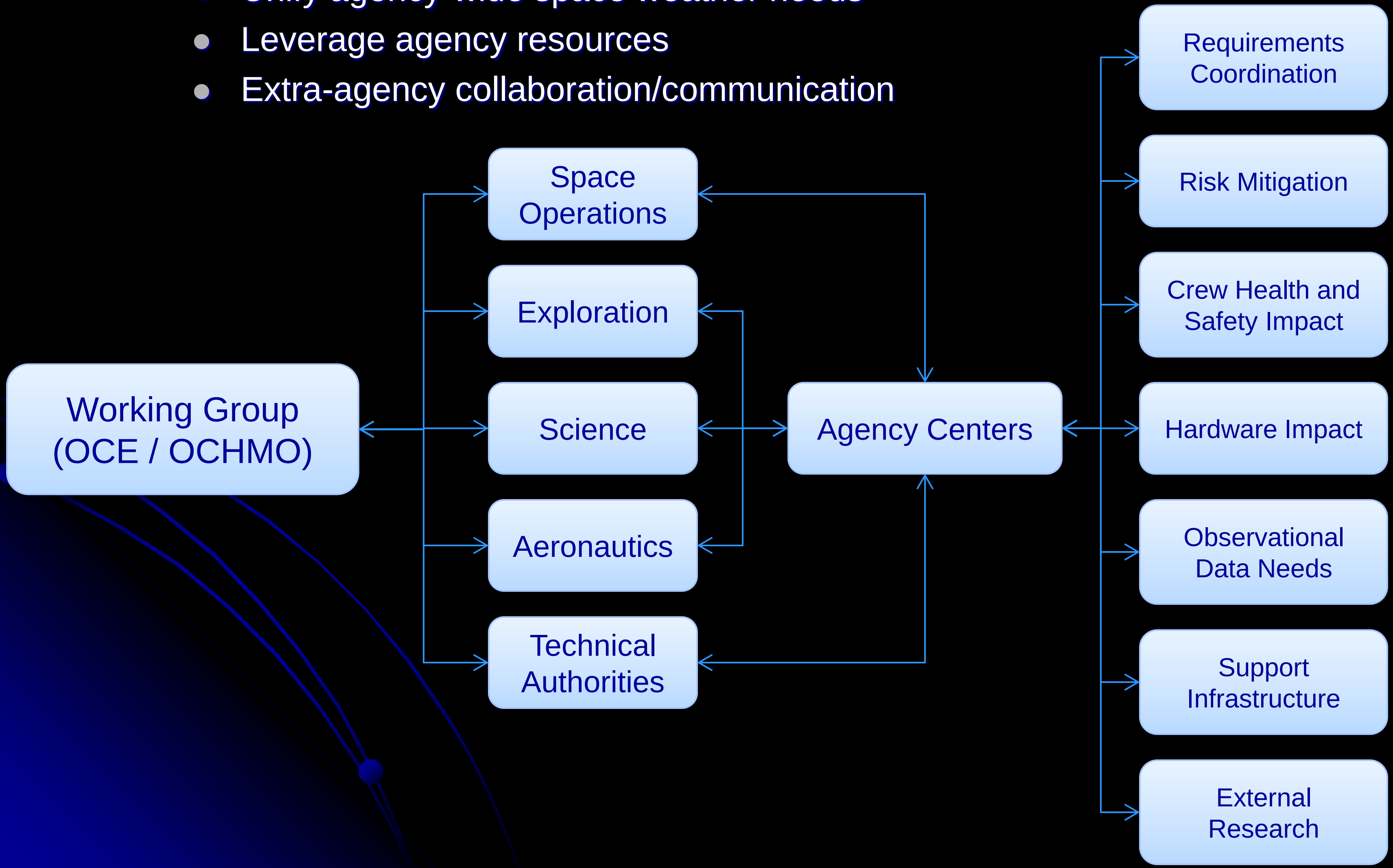






Unified Agency Effort

- Space Weather Working Group
  - Foster cross-directorate communication on space weather issues
  - Unify agency-wide space weather needs
  - Leverage agency resources
  - Extra-agency collaboration/communication



"Take Homes"

- **Scientific significance** somewhat different than **ops utility**
  - **Flares** and **CMEs** vs. **ESPEs**

- Model **validation** and **verification** is **necessary** for implementation as operational tools. **Not** achievable as an **ad-hoc** process.

- **VERY** exciting times – emergence of real forecasting ability
  - Relatively strong (but not exclusive) focus on magnetic observations of active regions

- **Models** largely dependent on **current/archive data**
  - **Model development CANNOT be de-coupled from asset viability**

- Single-focus efforts are **not** attractive. **Collaborative** efforts containing both "**developer**" and "**user**" involvement are critical to any meaningful success.

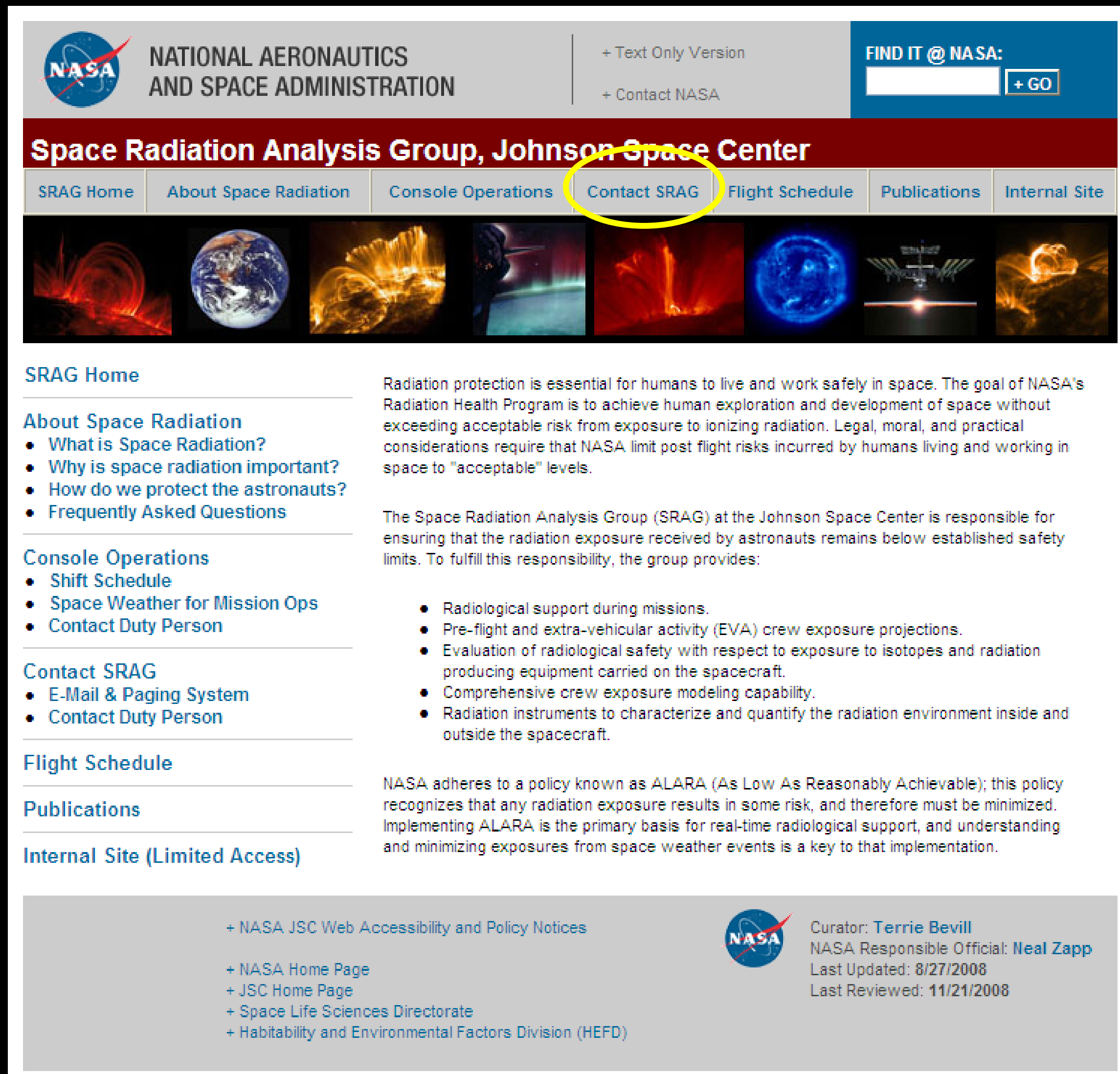
Now this is not the end. It is not even the beginning of the end.

But it is, perhaps the end of the beginning.

- Winston Churchill

Contact Information

srag.jsc.nasa.gov



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Space Radiation Analysis Group, Johnson Space Center

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SRAG Home

About Space Radiation

- What is Space Radiation?
- Why is space radiation important?
- How do we protect the astronauts?
- Frequently Asked Questions

Console Operations

- Shift Schedule
- Space Weather for Mission Ops
- Contact Duty Person

Contact SRAG

- E-Mail & Paging System
- Contact Duty Person

Flight Schedule

Publications

Internal Site (Limited Access)

Radiation protection is essential for humans to live and work safely in space. The goal of NASA's Radiation Health Program is to achieve human exploration and development of space without exceeding acceptable risk from exposure to ionizing radiation. Legal, moral, and practical considerations require that NASA limit post flight risks incurred by humans living and working in space to "acceptable" levels.

The Space Radiation Analysis Group (SRAG) at the Johnson Space Center is responsible for ensuring that the radiation exposure received by astronauts remains below established safety limits. To fulfill this responsibility, the group provides:

- Radiological support during missions.
- Pre-flight and extra-vehicular activity (EVA) crew exposure projections.
- Evaluation of radiological safety with respect to exposure to isotopes and radiation producing equipment carried on the spacecraft.
- Comprehensive crew exposure modeling capability.
- Radiation instruments to characterize and quantify the radiation environment inside and outside the spacecraft.

NASA adheres to a policy known as ALARA (As Low As Reasonably Achievable); this policy recognizes that any radiation exposure results in some risk, and therefore must be minimized. Implementing ALARA is the primary basis for real-time radiological support, and understanding and minimizing exposures from space weather events is a key to that implementation.

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+ Habitability and Environmental Factors Division (HEFD)

Curator: Terrie Bevill
NASA Responsible Official: Neal Zapp
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