ALARA Implementation And Issues

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LIMITATIONS: Shuttle

- Mission Requirements will drive inclination, attitude and altitude selection
  - Major factor in defining baseline exposure rates for given mission
- Traditional Time – Distance – Shielding practices are not always ready options
  - Time: Mission constraints usually dictate the timing of the mission.
    - Duration normally minimized, but extra time is sometimes allotted for additional work and for landing safety (Landing site weather)
    - Timing possibilities are available but limited
  - Distance: Since the source is external to the spacecraft, additional distance is not feasible

LIMITATIONS (continued): Shuttle

- Shielding: Additional shielding not flown: penalty of weight and volume. Must make use of existing structural design for shield opportunities.
  - Shuttle is very small – not very much room to go seek shelter.
  - GCR component very penetrating – shielding challenge. Sometimes a little shielding is worse than having little shielding

OPPORTUNITIES: Shuttle

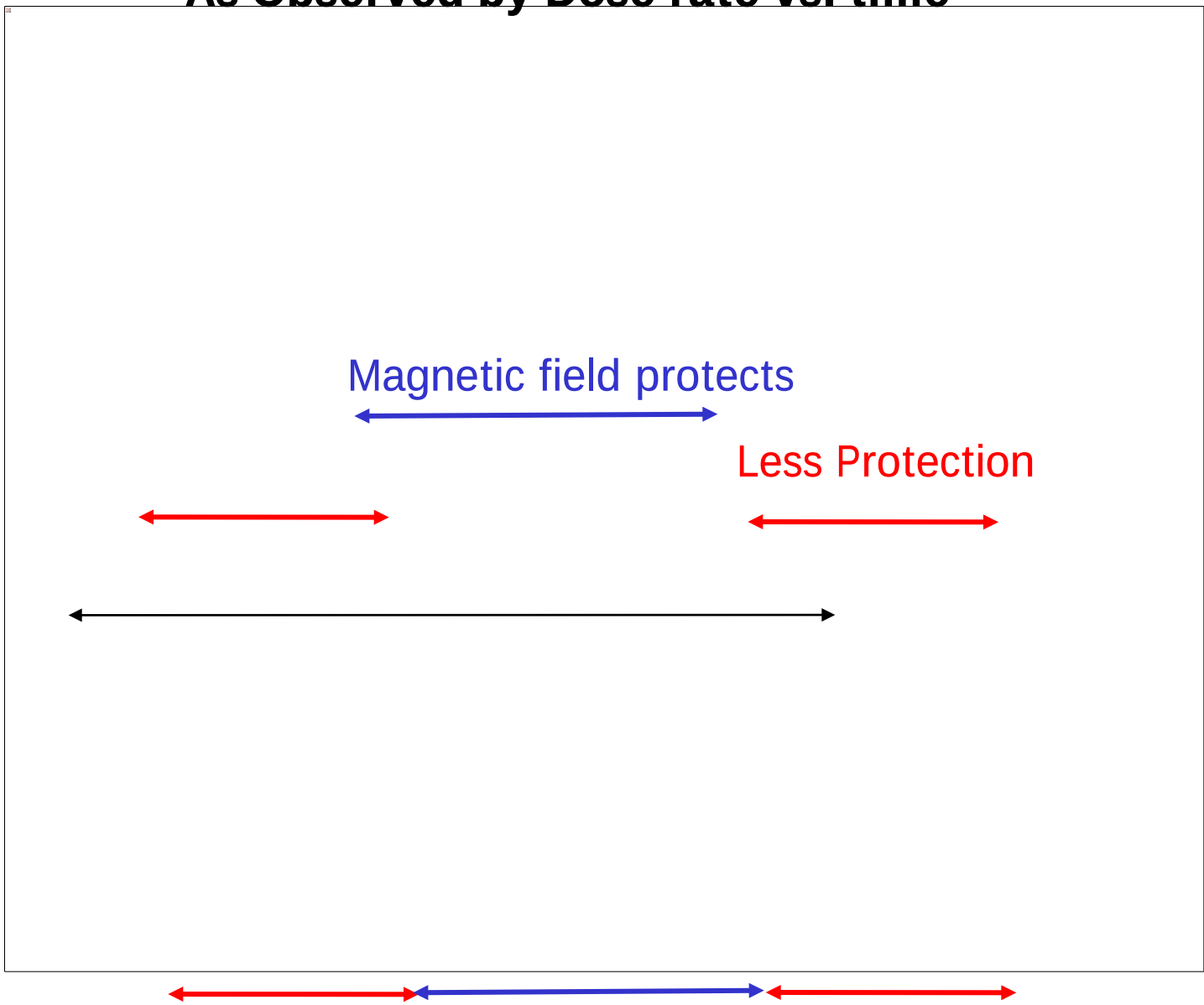
- Missions typically do not exceed 10 days (14 is max)
- Regional localization of enhanced environment allows opportunity to manage doses lower
- Timing for EVA – Seek to avoid higher dose rate areas
  - Avoid SAA (low inclination flights or high altitude)
  - Avoid high latitude electron horns (high and low inclination)
- Shield distribution, is characterized using solid models.
  - Highest shielded location - typically is the Airlock possible shelter if needed for high dose SPEs during shuttle flights. Initially, the Aft end of the Service Module is expected to be the highest shielded location on ISS.

SPE Event As observed on Mir (Nov 7, 1997)

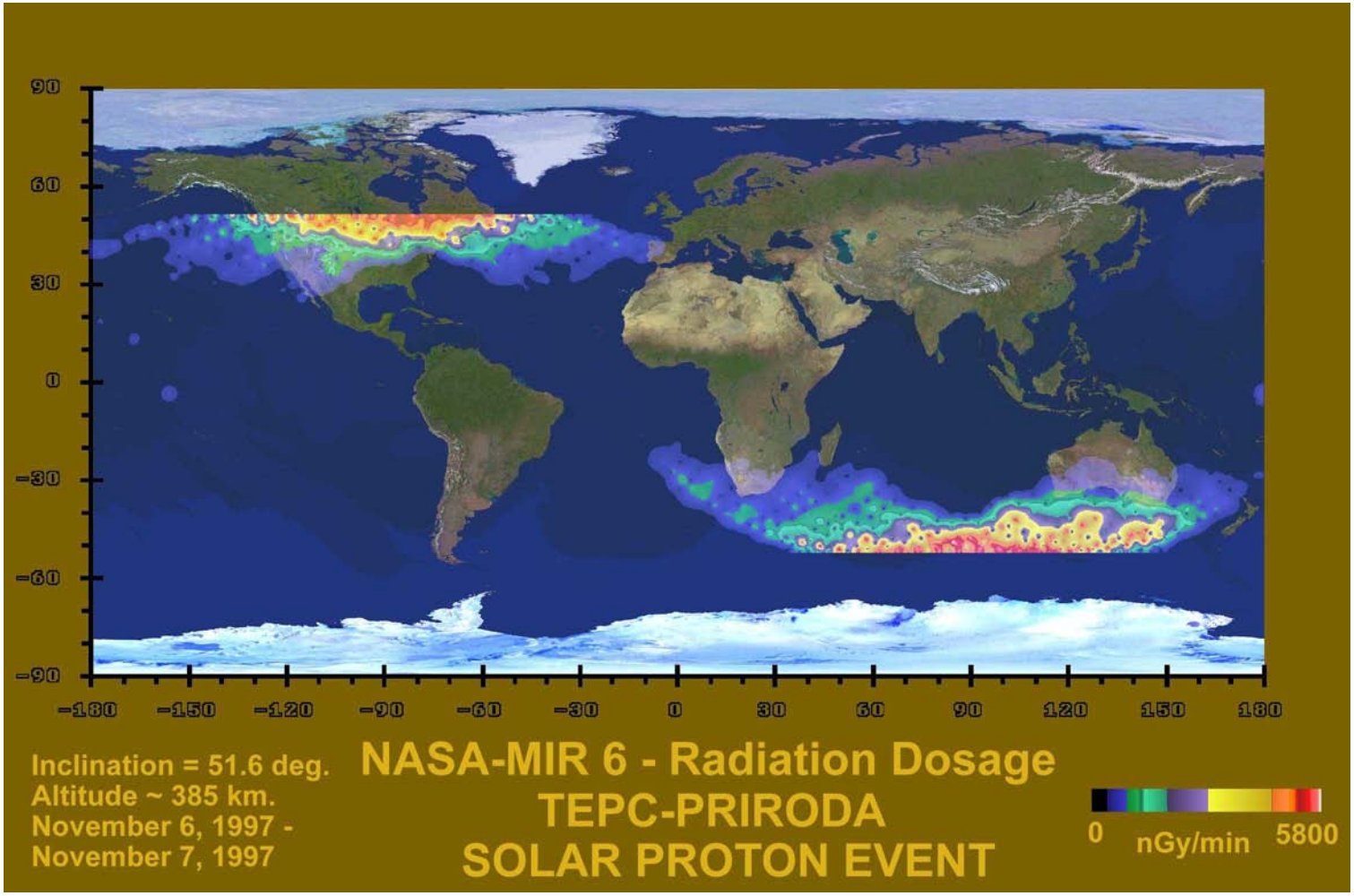
As Observed by Dose rate vs. time

This data illustrates the typical dynamics of how an SPE will influence exposure at ISS.

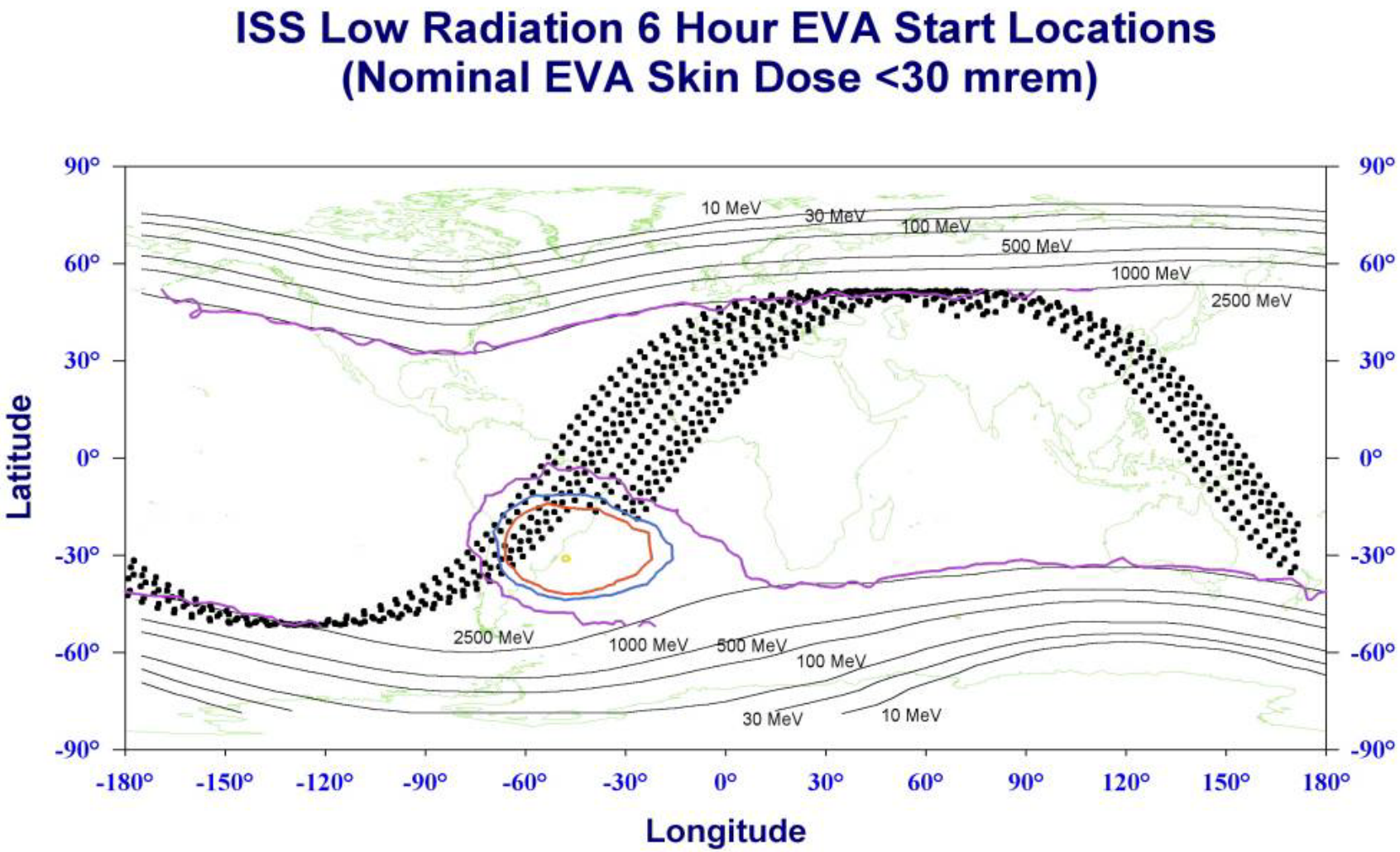
Note: SAA peaks are omitted



SPE Event Observed at Mir
Shown by Trajectory



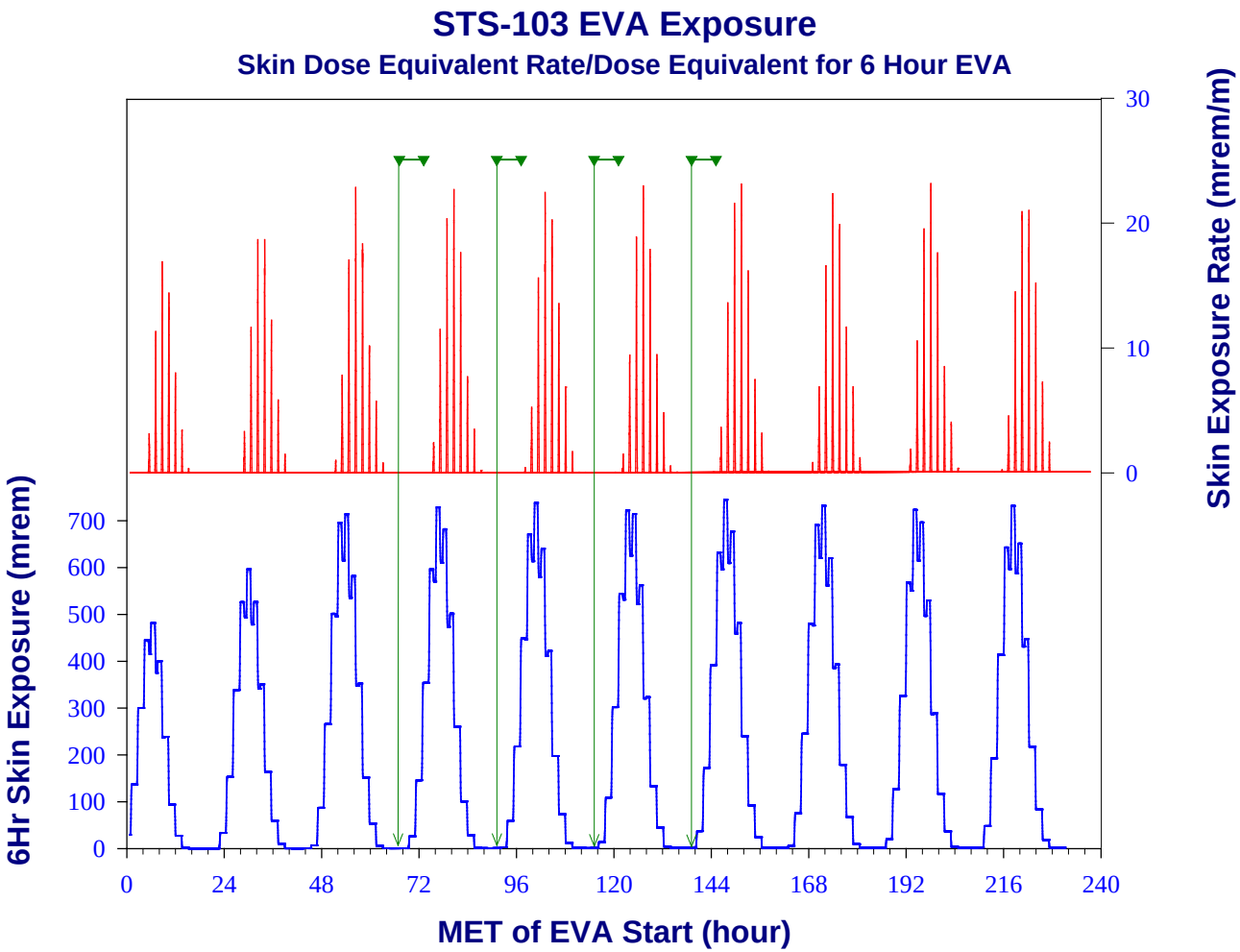
Potential EVA "Safe Zone"



OPPORTUNITIES: Preflight

- Mission exposures are estimated based on trajectory info
  - Provided to SA management during the Flight Readiness Review
  - Provided to Surgeon
    - Preliminary at L-6 months for Surgeon to review Astronaut career exposure history
    - Final update provided at FRR L-1 month
- EVA timeline is reviewed for additional exposure for EVA
  - Groundrules for schedulers establish requirement to try to avoid SAA or the electron horns.
  - SRAG provides feedback on trajectory (normally L-6 months)
  - A sensitivity analysis is performed to assess schedule slips

EVA Timing Sensitivity Analysis



Additional dose (skin) for a 6 hour EVA starting at the referenced MET

Flight Implementation

- Monitor Environment for changes
  - Flight Rules provide structure for in-flight decision-making
  - EVA timeline is reviewed for additional exposure for EVA
    - Sensitivity analysis is used to assess schedule slips.
    - As conducted EVA exposure - recalculated
  - Timing is best tool

Flight Implementation

- Respond to off-normal circumstances
  - SPEs assessed for impact to increase exposures. Local codes track (SPE-RT using GOES & trajectory inputs, etc.)
  - Look for opportunities to use timing to reduce exposure
    - Seek shelter at predetermined locations during estimated times of high exposure
    - Evaluate EVA timing
  - Electron events
    - Mostly an external hazard
    - Current tools do not characterize these types of events
    - May have to avoid EVA in electron regions

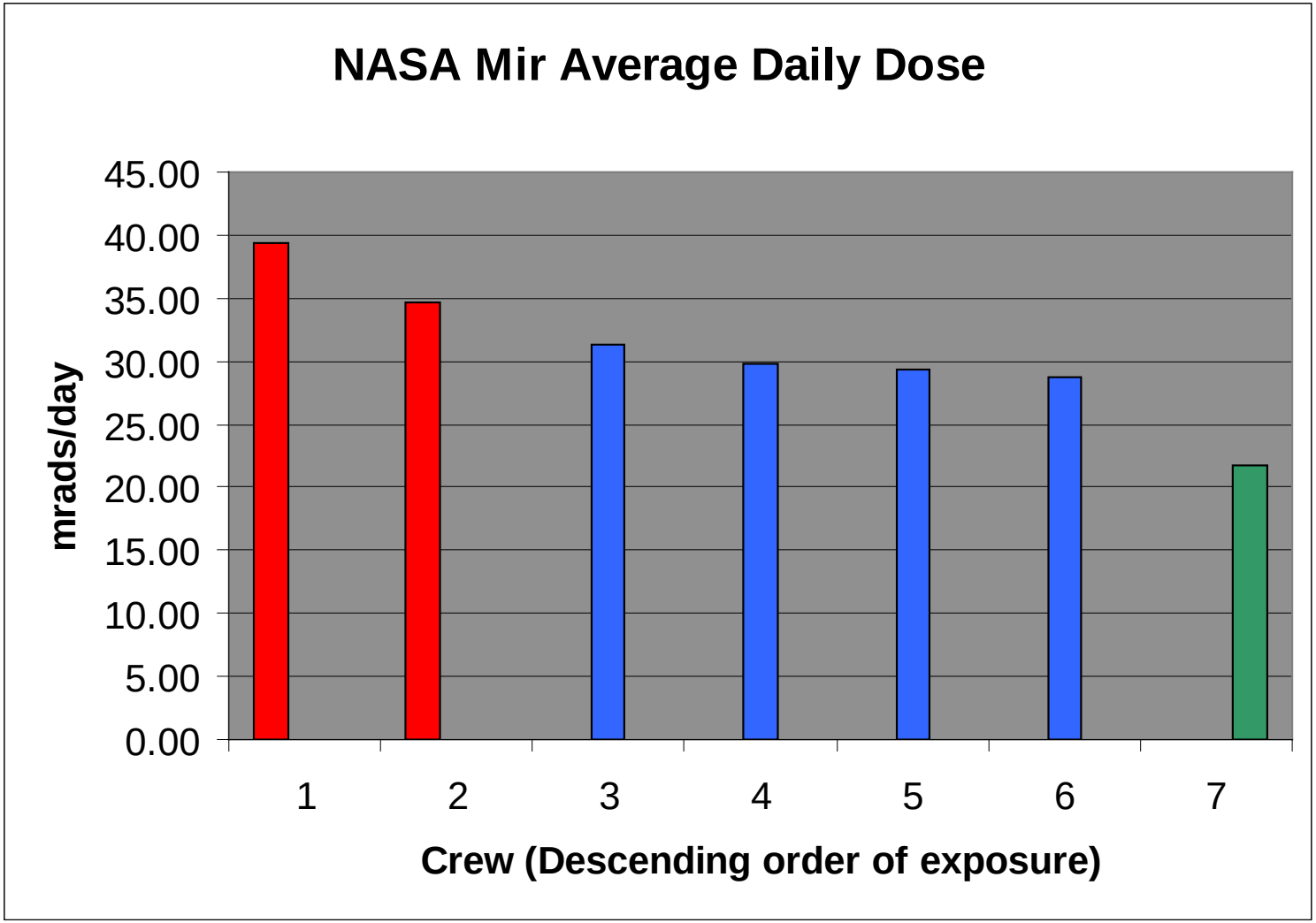
Flight Implementation

- What can we have the crew do?
  - Seek shelter during high dose rate passes
  - Adjust EVA schedule or outright cancel EVA
  - Crew sleep in alternative locations (better shielding)
  - Station crews could potentially move racks or other material for additional protection (rotate them down)
- What can we change?
  - Eventually may be able to boost shielding at crew quarters. (under evaluation)
- Mission termination a possibility, but not likely, for large events
  - Largest events observed not likely to encroach on legal limit for shuttle missions (30day limit)
  - Theoretically, annual legal limits could be approached depending on assumptions. (BFO & Q methodologies, neutron assumptions, etc.)

Challenges

- Mission Management
  - Flight Directors tend to want to interpret the limit as an available budget: (i.e. the “Operational Box” goes to 25 REM)
- Radiation Operations Group tries to maintain “the bottom of the box”
  - Make recommendations to reduce potential exposure increases based on event dynamics
- Challenge of weighing various radiation risk:
  - Vs. the risk of spaceflight
  - Vs. the cost of shuttle flight (500 M$)
  - Vs. the inherent risk of EVA as well as the cost (>100 K$/hour)
  - Time shifting of schedule does have indirect cost for replanning

Challenges (cont): Crew

- Crew has a wide range of risk perception from very sensitive to radiation issues to a “no big deal” attitude.
  - Some are very sensitive to radiation issues
  - One long duration member took active dose reduction activities
  - Some reluctance to wear dosimetry
  - “Know it all” attitudes
  - Some resentment toward a large number of radiation investigations competing against the operational hardware

NASA/Mir Average Crew Exposure Rates