U.S. ISS Radiation Monitoring: Data Processing, Archiving, & Results

UPDATE
Sep 2002—Sep 2003

Michael Golightly
NASA Johnson Space Center
Claire Dardano, J. Garza, T. Shelfer, E. Semones, F. Riman, S. Johnson, J. Flanders, and N. Zapp
Lockheed-Martin, Houston

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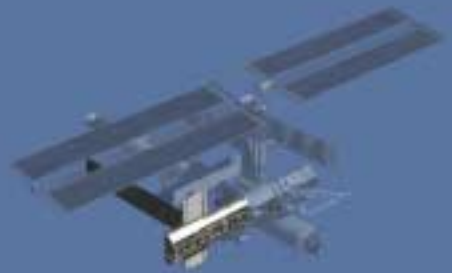
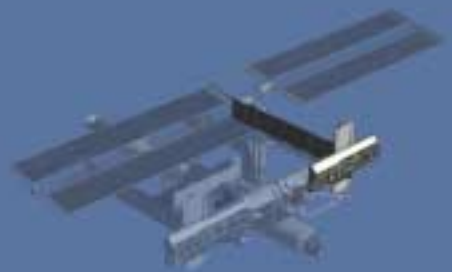
Since last we met, ISS continued to evolve . . .

Configuration at Last Meeting

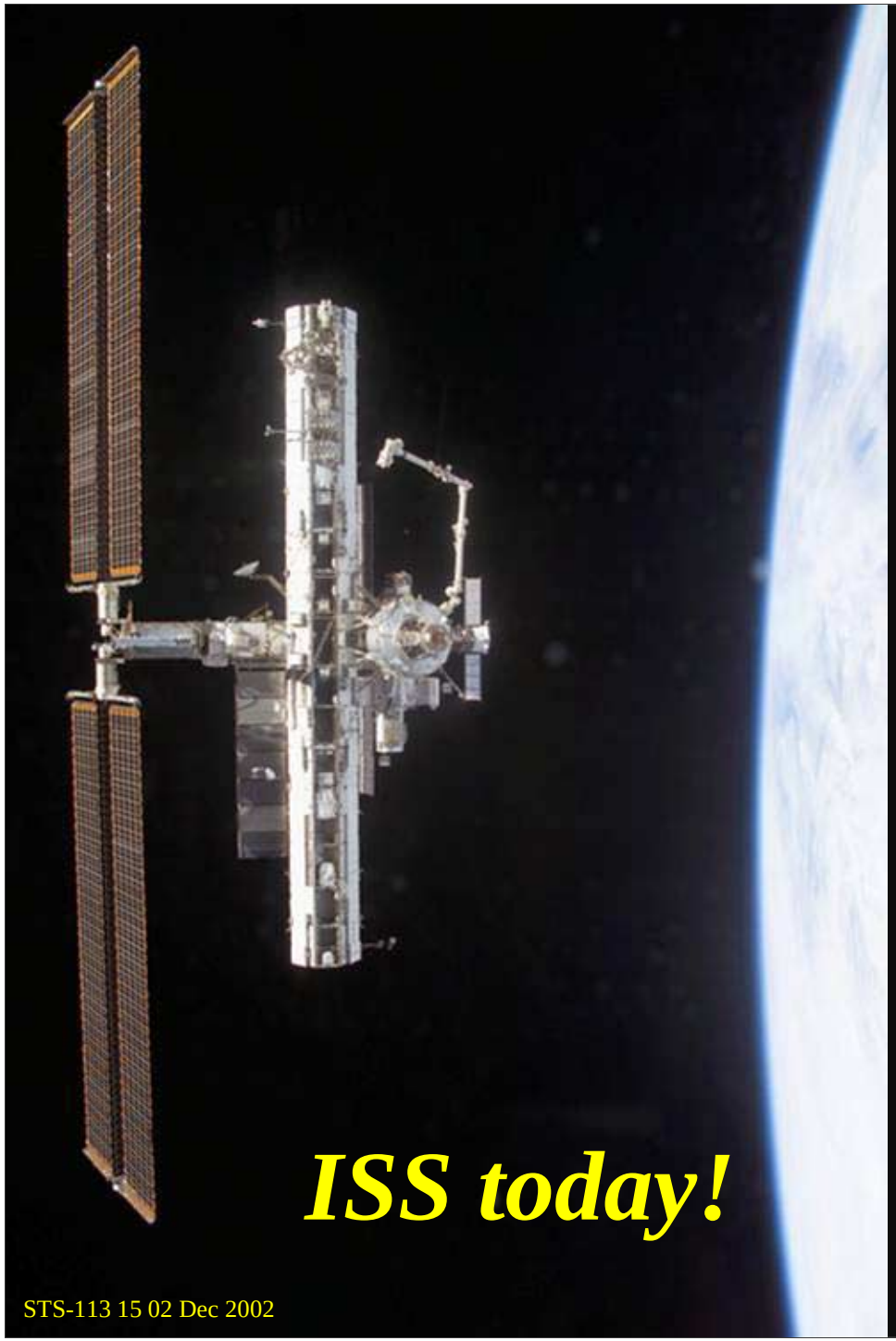
Jun 2002: STS-111, ISS crew swap, delivered RMS Mobile Base System

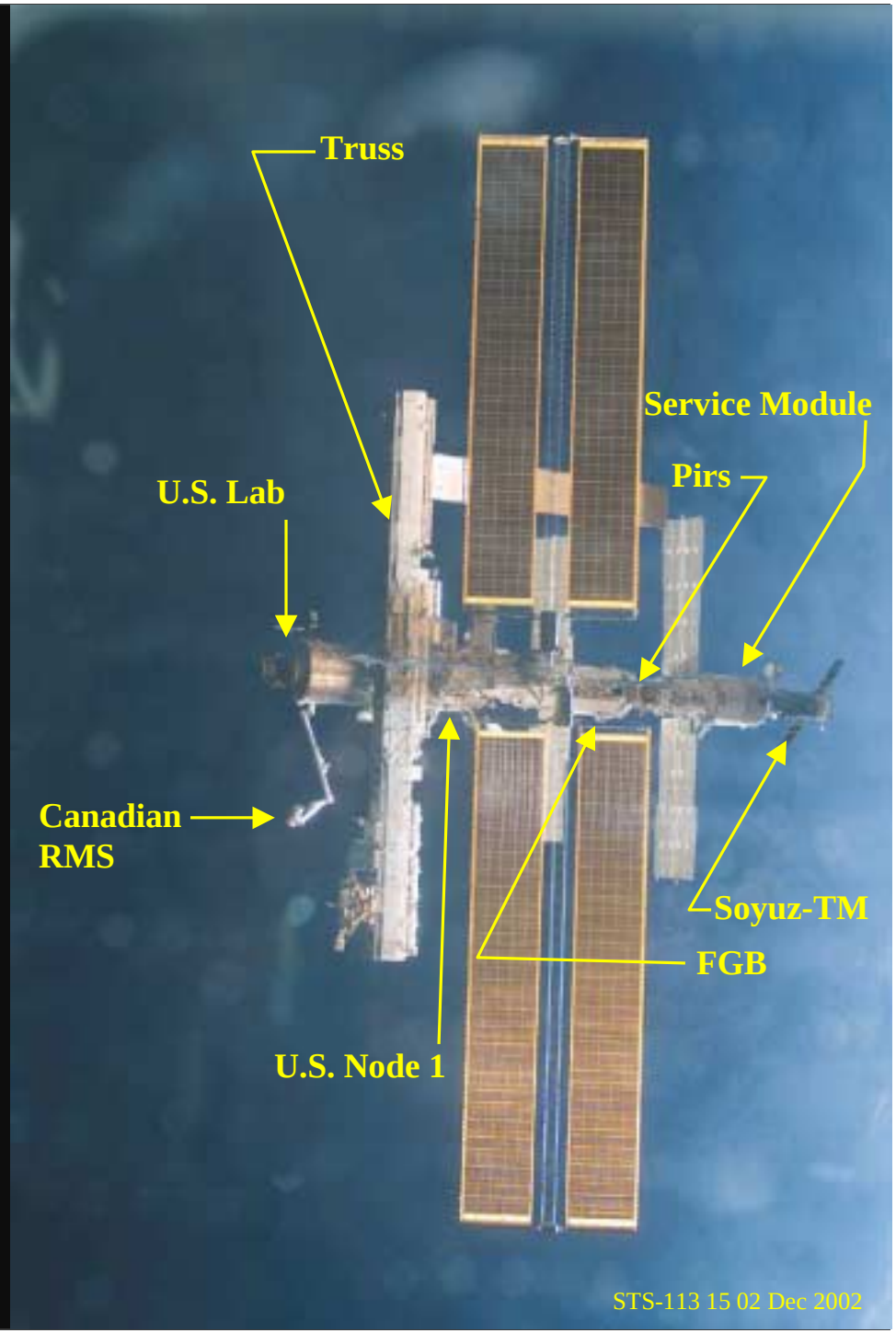


Oct 2002: STS-112, delivered 1st right Truss segment, Crew & Equipment Translation Aid Cart A



Nov 2002: STS-113, ISS crew swap, delivered 1st left Truss segment, Crew & Equipment Translation Aid Cart B


ISS today!
STS-113 15 02 Dec 2002


Truss
Service Module
Pirs
U.S. Lab
Canadian
RMS
Soyuz-TM
FGB
U.S. Node 1
STS-113 15 02 Dec 2002

ISS Program Statistics (11 Jun 2003)

(http://spaceflight.nasa.gov/station/isstodate.html)

ISS Major Elements:

Zarya:	launched Nov. 20, 1998
Unity:	attached Dec. 8, 1998
Zvezda:	attached July 25, 2000
Z1 Truss:	attached Oct. 14, 2000
Soyuz:	docked April 28, 2003
Progress 10:	docked Feb. 4, 2003
Progress 11:	docked June 11, 2003
P6 Integrated Truss:	attached Dec. 3, 2000
Destiny:	attached Feb. 10, 2001
Canadarm2:	attached April 22, 2001
Joint Airlock:	attached July 15, 2001
Pirs:	attached Sept. 16, 2001
S0 Truss:	attached April 11, 2002
S1 Truss:	attached Oct. 10, 2002
P1 Truss:	attached Nov. 26, 2002

Weight:		186,357 kg
Habitable Volume:		425 m^3
Surface Area (solar arrays):		892 m^2
Dimensions:	Width:	73 m across solar arrays
	Length:	44.5 m from Destiny Lab to Zvezda; 52 m with a Progress resupply vessel docked
	Height:	27.5 m

ISS Flights:

American:	16 Space Shuttle flights
Russian:	2 Proton flights
	6 Soyuz crew flights
	1 Soyuz assembly flight
	11 Progress resupply flights

Spacewalks:

Shuttle-based:	25 spacewalks
ISS-based:	26 spacewalks
Total time:	318 h:37 min

Crew Support:

Weight:	2,722 kg of supplies per
In flight:	3 crewmembers
Ground:	more than 100,000 personnel
Contractors:	500 facilities
States:	37
Countries	16

Meal Consumption:

Meals:	8000
Snacks:	6000
Weight:	5,443 kg

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Operational Radiation Monitoring System Progress Since WRMISS 2002

- Aug 2002: final adjustment to EV-CPDS #2 operating parameters
- Oct 2002: final software upgrade uploaded into IV-CPDS
  - ✶ Version 2.0
  - ✶ Operating nearly flawlessly since software update
- Oct 2002: backup ISS TEPC launched to ISS
- Nov 2002: backup ISS TEPC dose rate abruptly decreases by factor of two
  - ✶ Unit returned to ground for assessment
- Final adjustment to EV-CPDS #1 & #3 operating parameters
- Feb 2003: Participate in ICCHIBAN 3
  - ✶ IV-CPDS
  - ✶ ISS TEPC

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Operational Radiation Monitoring System Progress Since WRMISS 2002

- Mar 2003: begin acquisition and storage or real-time vehicle attitude data
- May 2003: Participate in ICCHIBAN 4
- 04 May 2003: break in U.S. RAM monitoring
  - ✶ RAMs returned to ground with Expedition 6 crew
  - ✶ Due to grounding of Shuttle fleet following STS-107 accident, upmass very limited
  - ✶ Insufficient mass/volume in Soyuz carrying Expedition 7 crew for new set of RAMs
  - ✶ Plan to resume RAM monitoring with Expedition 8 crew (18 Oct 2003)

Operational Radiation Monitoring System Progress Since WRMISS 2002

- 28 Jun 2003: EV-CPDS #1 stopped providing cyclic data and responding to commands
  - ✶ Believe problem is due to a corrupted database resident in the instrument
    - – Caused by errant power cycling
  - ✶ A hardware failure (ie, fuse) has not been eliminated
  - ✶ Unit is not recoverable via 1553B system
    - – Will require removal and return to the inside of ISS or installation of a wireless RS-232 system while the unit is deployed
- Jul-Sep 2003: complete flight recertification of prime ISS TEPC
- Aug 2003: finalize definition of ISS TEPC data and archival products
- Aug 2003: Complete certification of new software load for ISS TEPC
  - ✶ Changes Q(L) relationship from ICRP-26 to ICRP-60 for cyclic (real-time telemetered) data and instrument's display

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Operational Radiation Monitoring System Progress Since WRMISS 2002

- Aug 2003: begin “final” processing of original ISS TEPC data
- Jan 2004: launch prime ISS TEPC to ISS on Progress mission

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Corrections to Initial ISS TEPC Data

- Multiple errors with data collected by TEPC S/N 1003 (09 Nov 2000-28 May 2002)
  - ✶ Post-failure ground testing revealed off-set voltage incorrectly set—PHA spectra needed to be shifted 12 channels (to the right)
    - – Cause of apparent low LET under response
    - – After correction LET spectrum from Cs-137 exposure matches other TEPCs
  - ✶ (Improved) extrapolation method used to compute first 12 channels of LET data from remainder of spectrum
  - ✶ Geometric factor recomputed
  - ✶ Timing problem corrected
    - – When dose rate exceeded some threshold, instrument binned data every 4 seconds instead of every 2 seconds
      - ✓ Resulted in computed dose rates 2X higher than actually measured
      - ✓ Resulted in errors in data record time stamps and apparent large gaps in data
      - ✓ Instrument's software modified 26 Mar 2002 to eliminate problem
      - ✓ Data from 09 Nov 2000—26 Mar 2002 being reviewed and corrected by hand

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ISS As-Flown Ephemeris

- ISS as-flown ephemeris created for period 20 Nov 1998—31 Dec 2001
  - ✶ 1-minute intervals
  - ✶ Created from Two Line Element sets (TLEs) provided by the Goddard Space Flight Center and Satellite Toolkit V4.3
    - – MSGP4 propagator
    - – Switch between successive TLEs at time of closest approach (TCA)
    - – ~1450 TLEs per year or ~ 4 TLEs per day
  - ✶ Using the as-flown ephemeris, for each GMT day computed
    - – Max altitude
    - – Min altitude
    - – Geometric average altitude
    - – Trapped proton flux-weighted average altitude (AP8)
      - ✓ Approximates average altitude through the SAA
- Awaiting additional TLEs from Goddard Space Flight Center to complete remaining as-flown ephemeris

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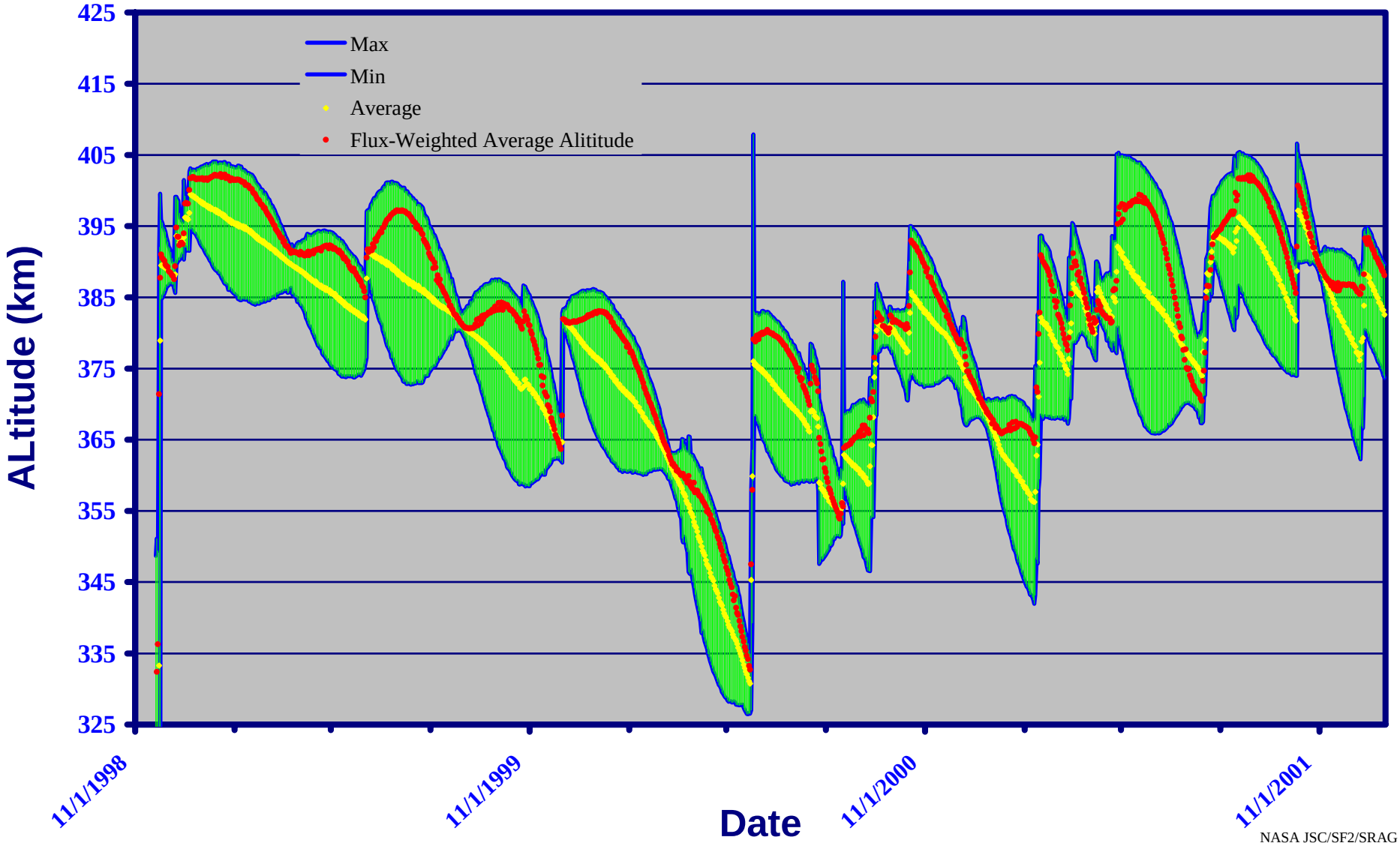
Daily ISS As-Flown Altitude



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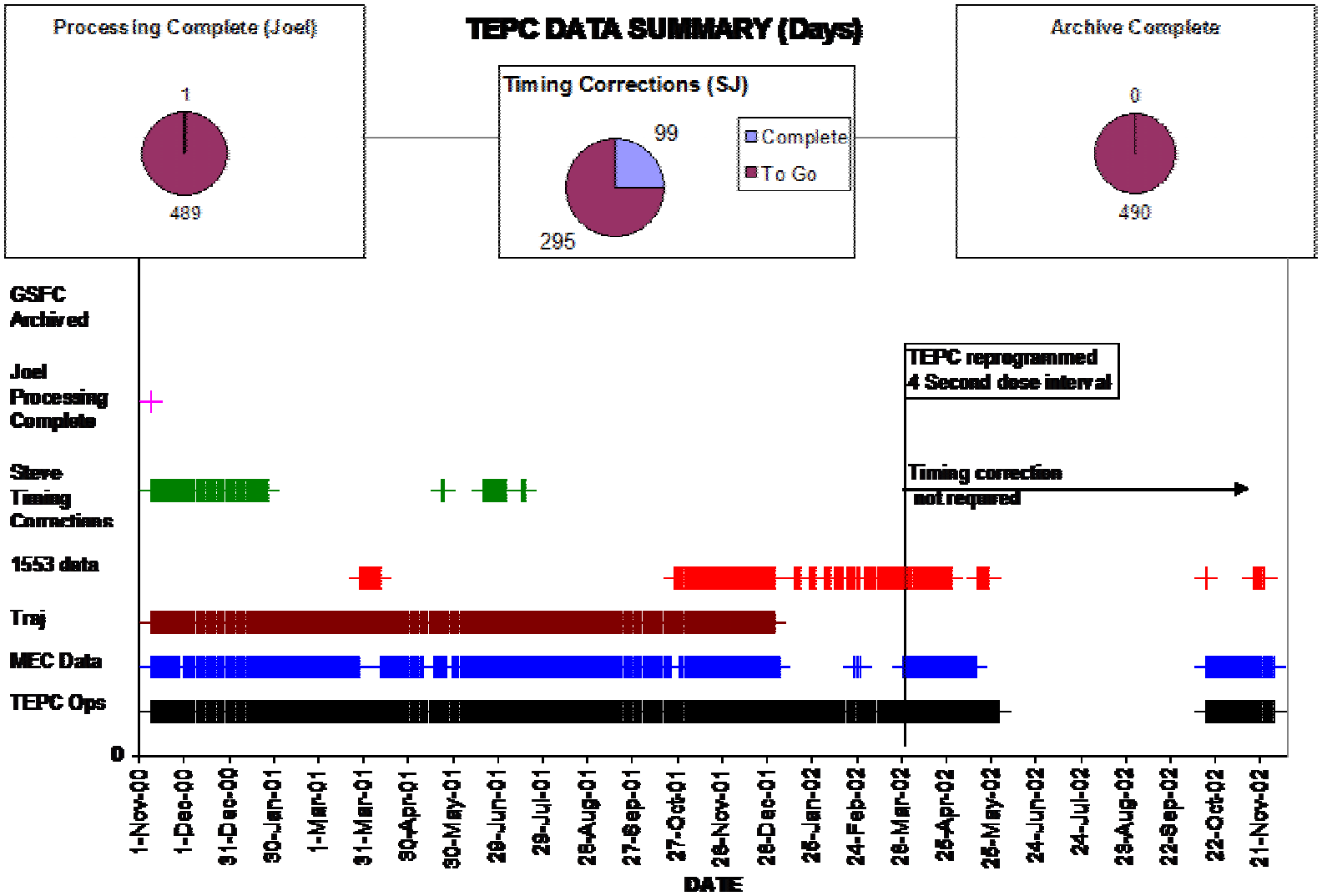
ISS TEPC Data Processing Status



28Aug03

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ISS Radiation Area Monitors (RAMs)— Monitoring Results Since WRMISS 2002

Monitoring Period	Monitoring Start Date	Monitoring End Date	Monitoring Location (Module)	RAM TLD-100 Dose Rate (μGy/d) Max	Min	Average	Max/Min
10	5-Jun-02	7-Dec-02	U.S. Node	170	126	147	1.34
10	5-Jun-02	7-Dec-02	Service Module	184	146	161	1.26
10	5-Jun-02	7-Dec-02	U.S. Lab	205	120	145	1.70
10	5-Jun-02	7-Dec-02	Airlock	182	178	180	1.03
11	24-Nov-02	4-May-03	U.S. Node	174	126	146	1.37
11	24-Nov-02	4-May-03	Service Module	192	126	162	1.52
11	24-Nov-02	4-May-03	U.S. Lab	226	130	154	1.73
11	24-Nov-02	4-May-03	Airlock	191	175	183	1.09

Module	ISS RAM Max Dose Rate/Min Dose Rate 10 (05-Jun-2002 07-Dec-2002)	11 (24-Nov-2002 04-May-2003)
U.S. Node	1.344	1.373
Service Module	1.261	1.524
U.S. Lab	1.702	1.731
Airlock	1.027	1.092
Entire Vehicle	1.702	1.790

max

min

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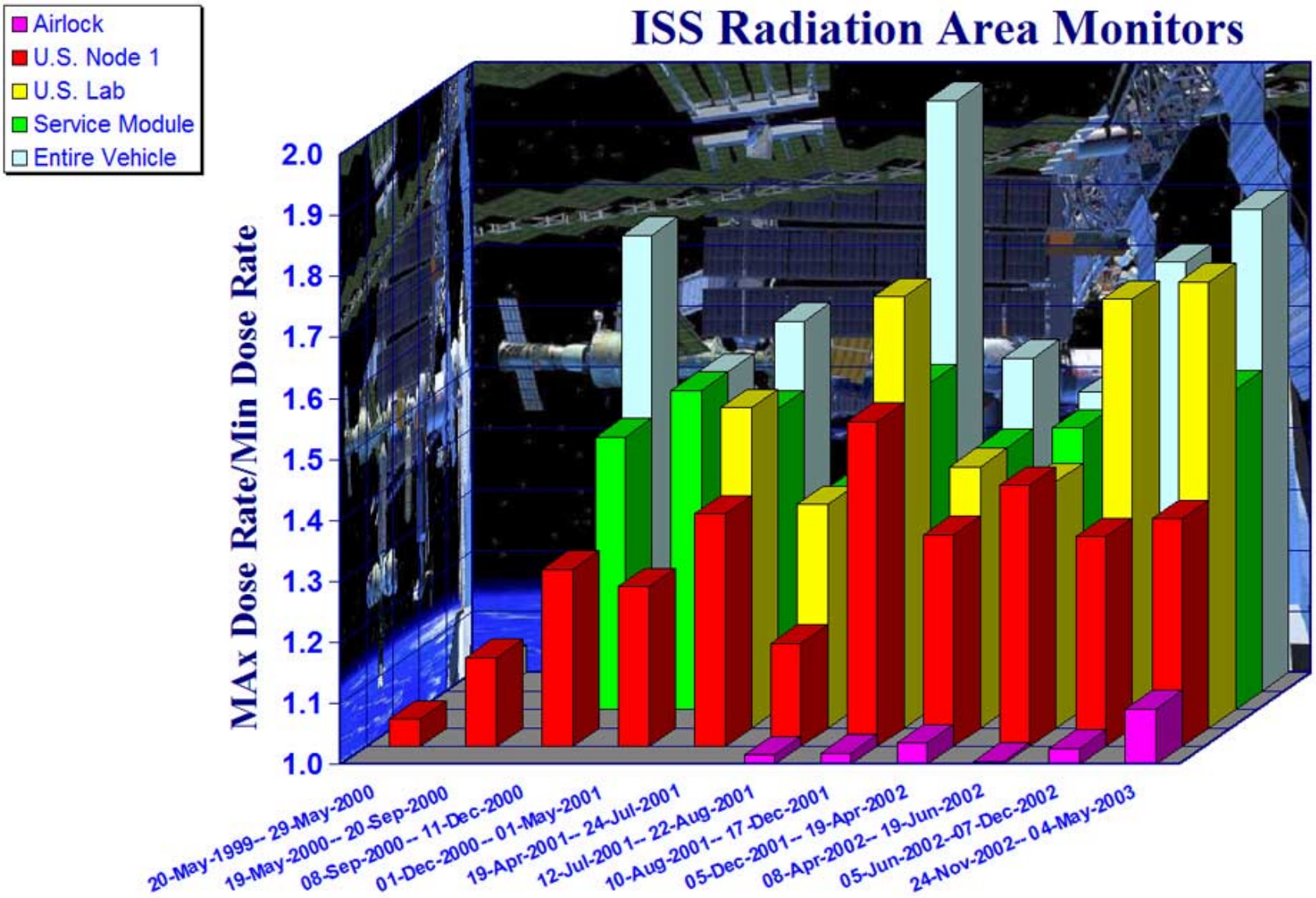
ISS Habitable Volume Dose Rate Distribution—Non-Uniform Dose Rate Distribution



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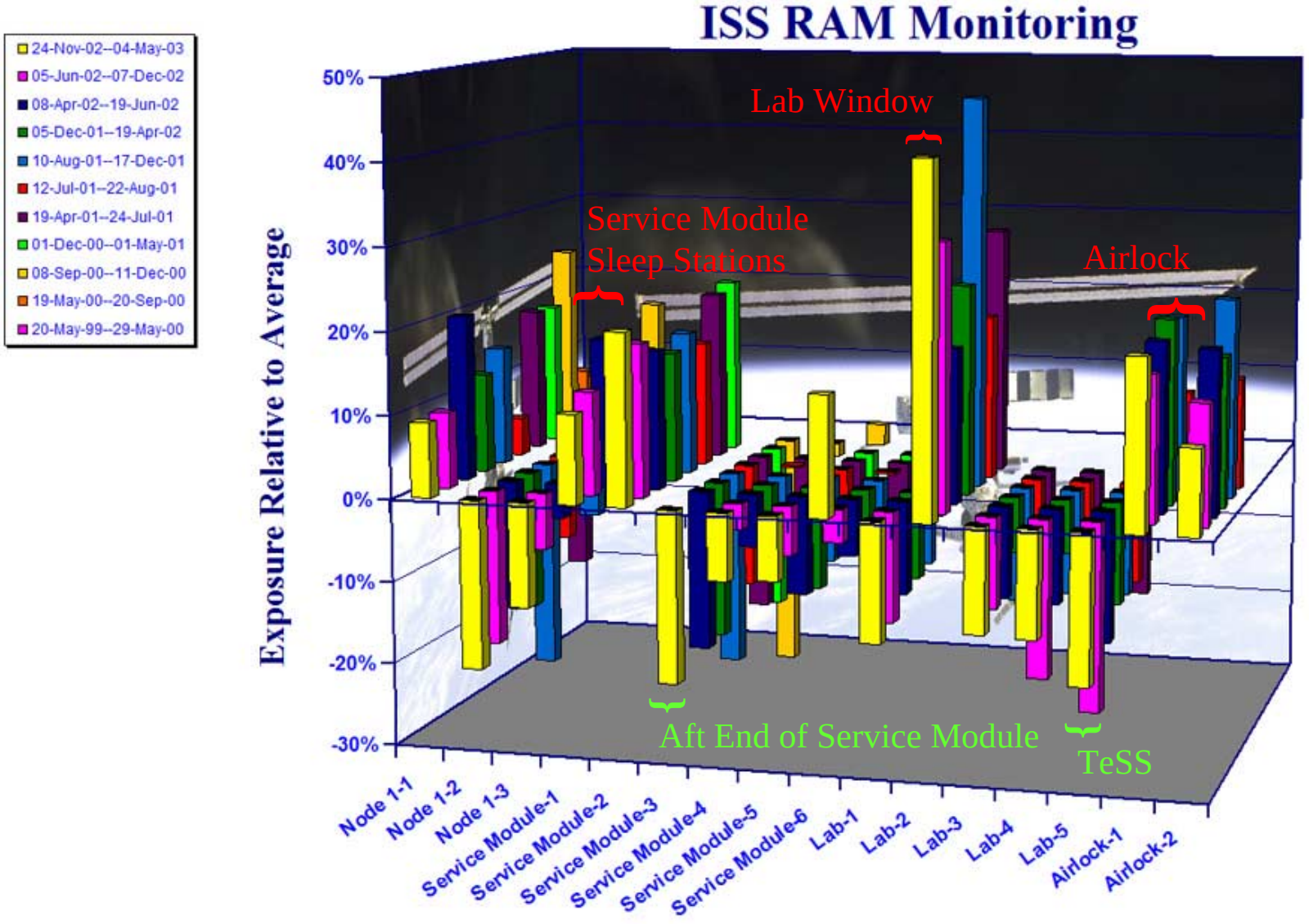
ISS Habitable Volume Dose Rate Distribution—"Hot Spots" and "Cold Spots"



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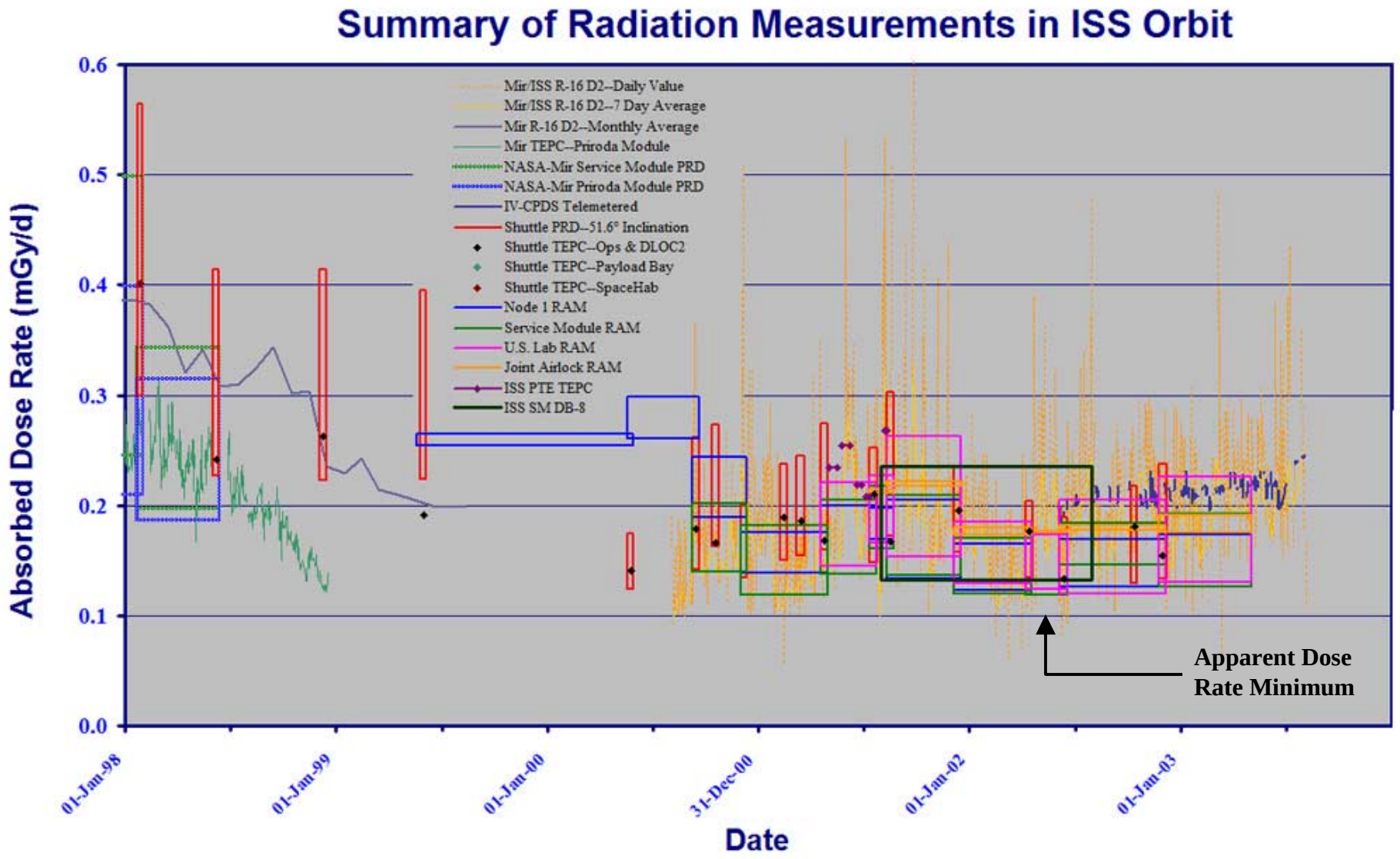
ISS Exposure Trend—Dose Rate Reaches Minimum and Begins to Increase



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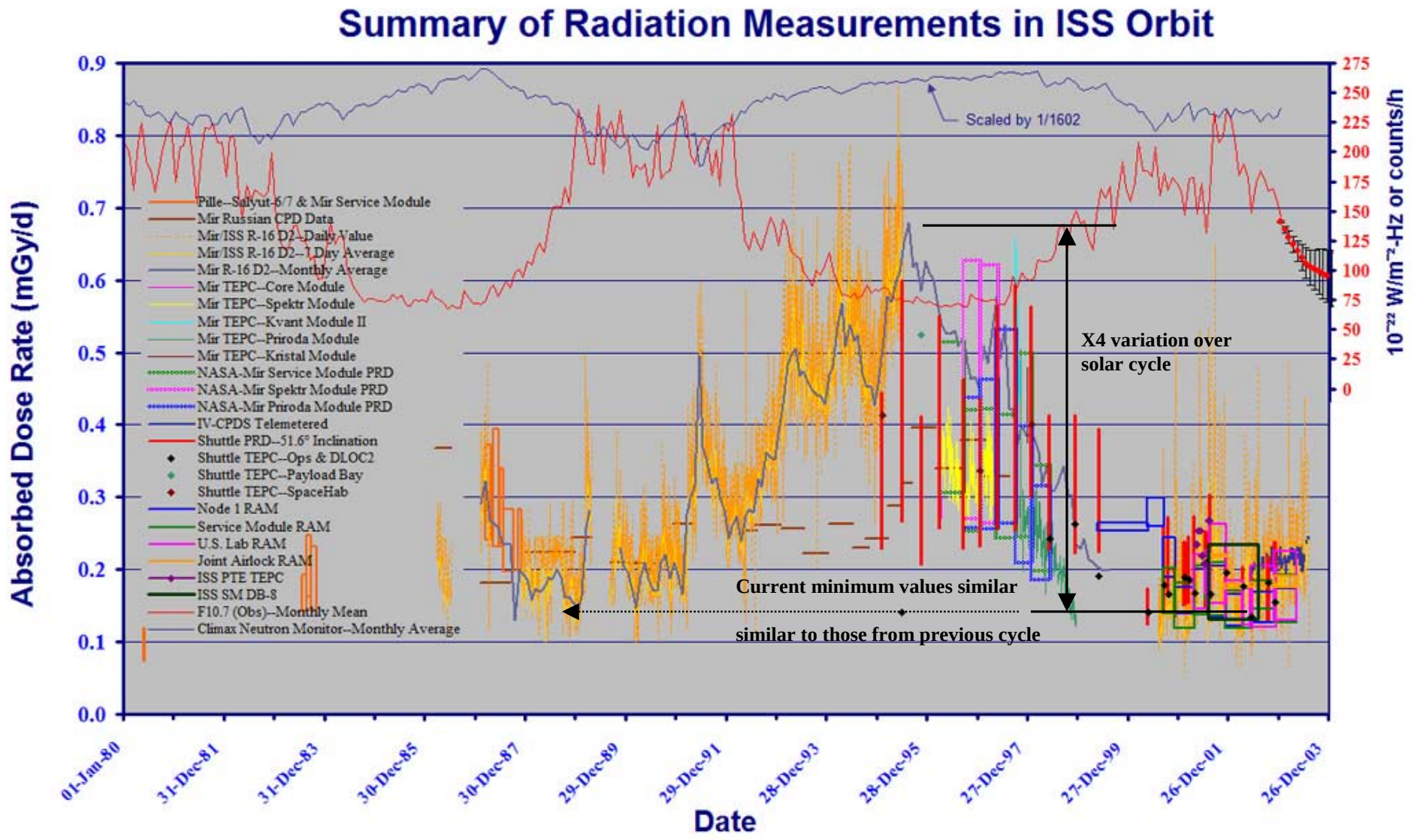
Mir and ISS Exposure Monitoring Summary—Dose Rate Modulation Over a Solar Cycle



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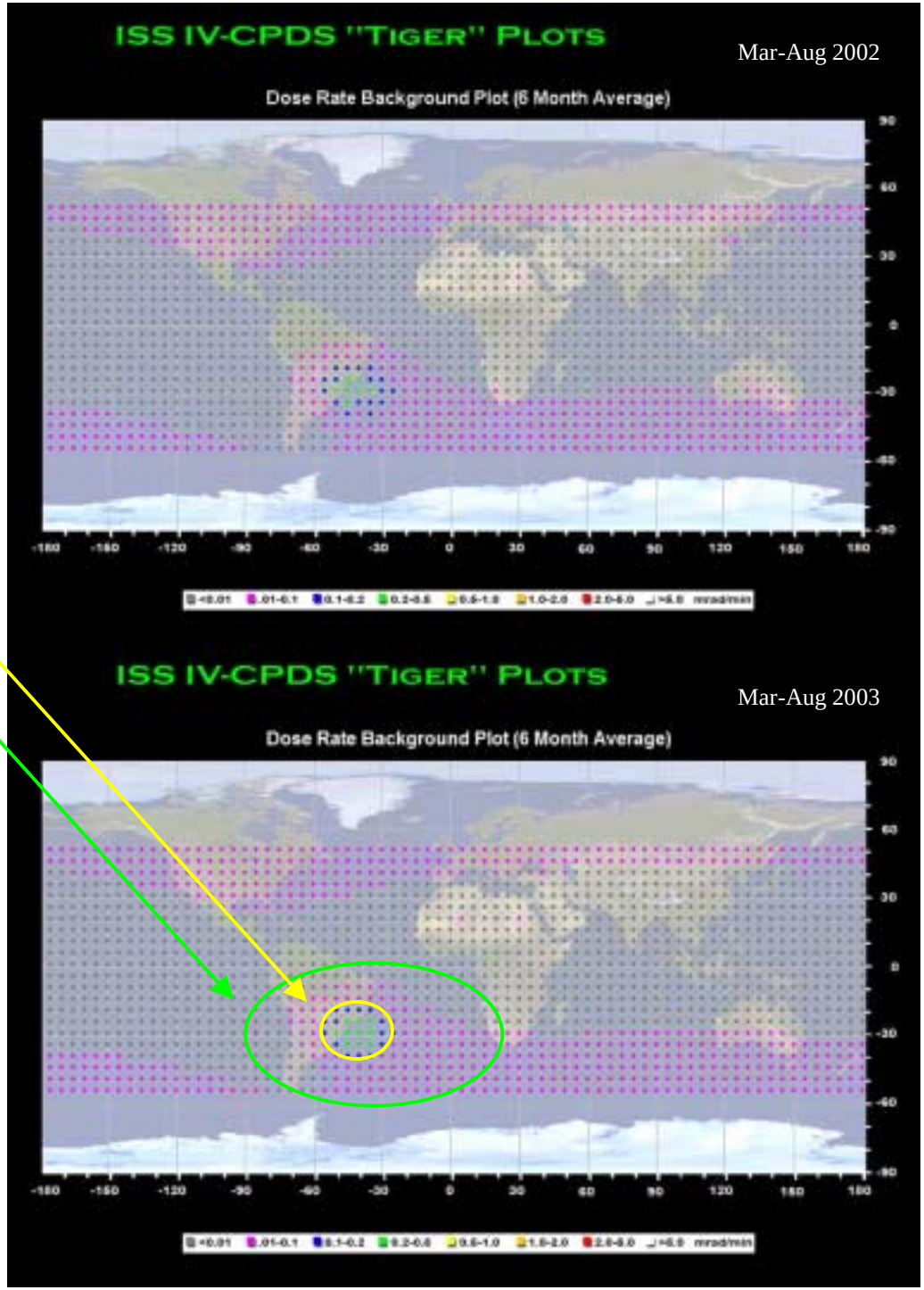
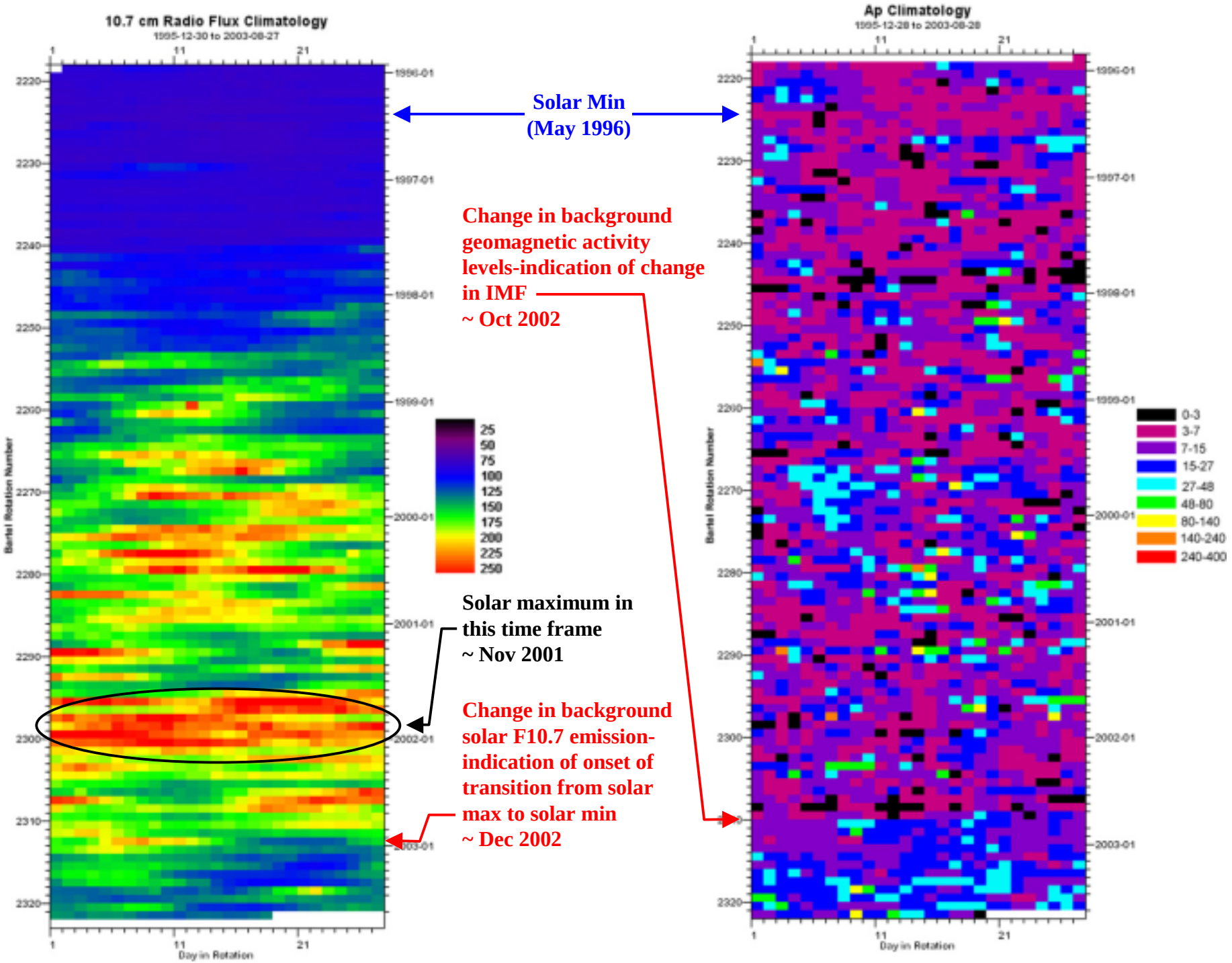
Transitioning: Solar Maximum to Solar Minimum

- Over past year there has been an increase in the spatial extent of SAA
  - ✶ Increase in overall area coverage of SAA
  - ✶ Increase in area coverage of most intense portion of SAA
- Consistent with beginning of transition of LEO trapped proton belts from solar maximum to solar minimum conditions




10.7 cm Radio Flux Climatology
1995-12-30 to 2003-08-27
Ap Climatology
1995-12-28 to 2003-08-28
Bartel Rotation Number
Day in Rotation
25
50
75
100
125
150
175
200
225
250
0-3
3-7
7-15
15-27
27-48
48-80
80-140
140-240
240-400
Solar Min
(May 1996)
Change in background geomagnetic activity levels-indication of change in IMF
~ Oct 2002
Solar maximum in this time frame
~ Nov 2001
Change in background solar F10.7 emission-indication of onset of transition from solar max to solar min
~ Dec 2002

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External Electron Measurements

- EV-CPDS seems to be measuring a significant number of electrons
  - ✶ Not high dose rates at high L-shells—outer trapped belt electrons
- Much greater flux seen in zenith direction compared to velocity and anti-velocity direction
- EV-CPDS flux measurements exhibit strong dynamics, especially in zenith direction
- No dynamics exhibited in IV-CPDS flux measurements