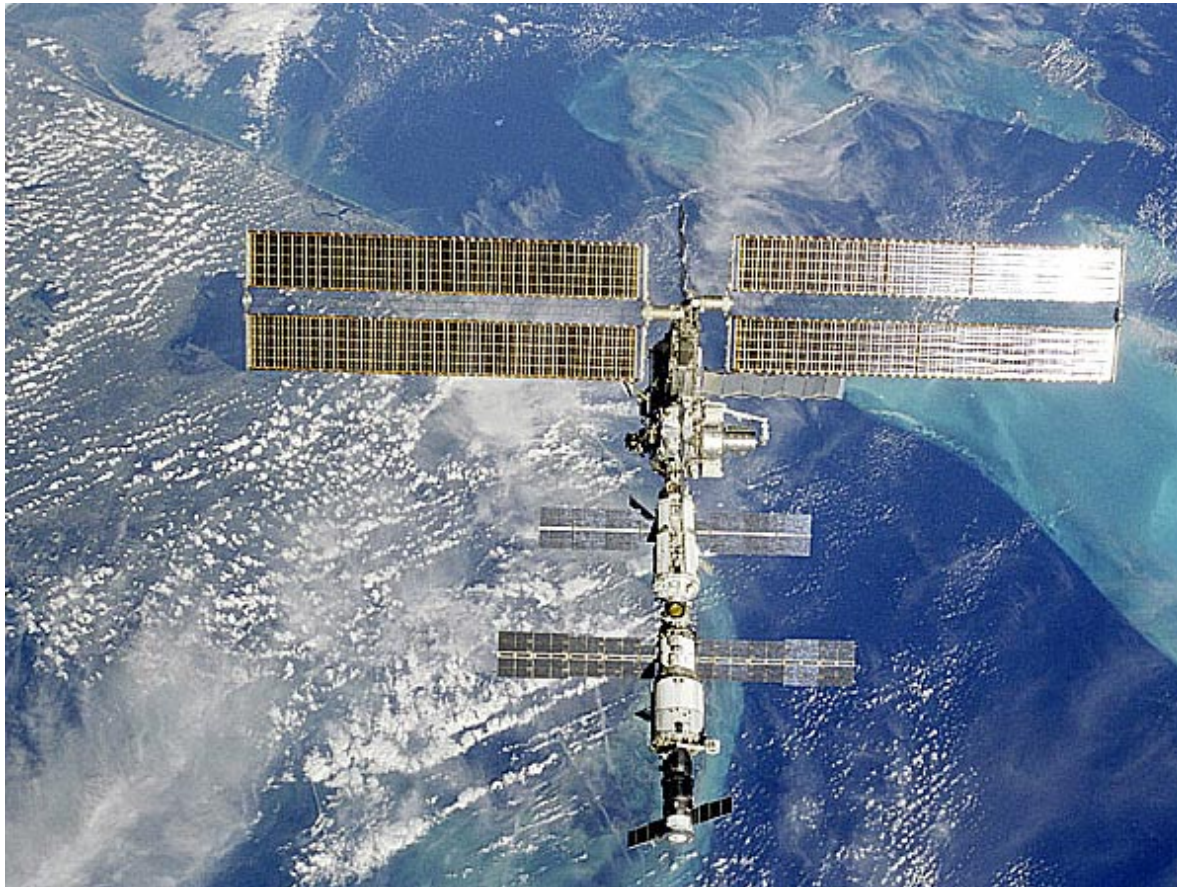


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Active Radiation Monitoring on the International Space Station



COSPAR02 - A - 02210

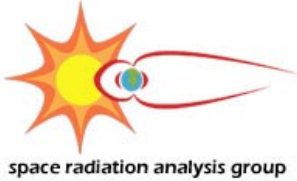
**Tad Shelfer*, Eddie Semones,
Claire Dardano, Steve Johnson,
Neal Zapp, Mark Weyland, Fadi
Riman and Joel Flanders**

Lockheed-Martin

Mike Golightly and Gwyn Smith
NASA - JSC

Space Radiation Analysis Group
NASA Johnson Space Center
Houston, TX 77058, USA

* Sustaining Engineer, tad.shelfer1@jsc.nasa.gov

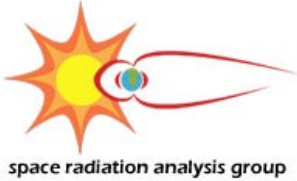


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Introduction

- ISS Expedition Information
- ISS Tissue Equivalent Proportional Counter (ISS TEPC)
 - Brief description of the instrument
 - Presentation of Expedition 1-4 data
- Intra-Vehicular Charged Particle Directional Spectrometer (IV-CPDS)
 - Brief description of the instrument
- Extra-Vehicular Charged Particle Directional Spectrometer (EV-CPDS)
 - Brief description of the instrument
- Summary and Conclusions



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International Space Station Increment Information

- Expedition 1

- Bill Shepherd, Sergei Krikalev, and Yuri Gidzenko
- Start: ISS 2R, October 31, 2000
- End: STS-102, March 21, 2001



- Expedition 2

- Yury Usachev, James Voss, and Susan Helms
- Start: ISS 5A.1, March 8, 2001
- End: STS-105, August 22, 2001



International Space Station Increment Information

- Expedition 3

- Frank Culbertson, Vladimir Dezhurov,
and Mikhail Tyurin
- Start: ISS 7A.1, August 10, 2001
- End: STS-108, December 17, 2001

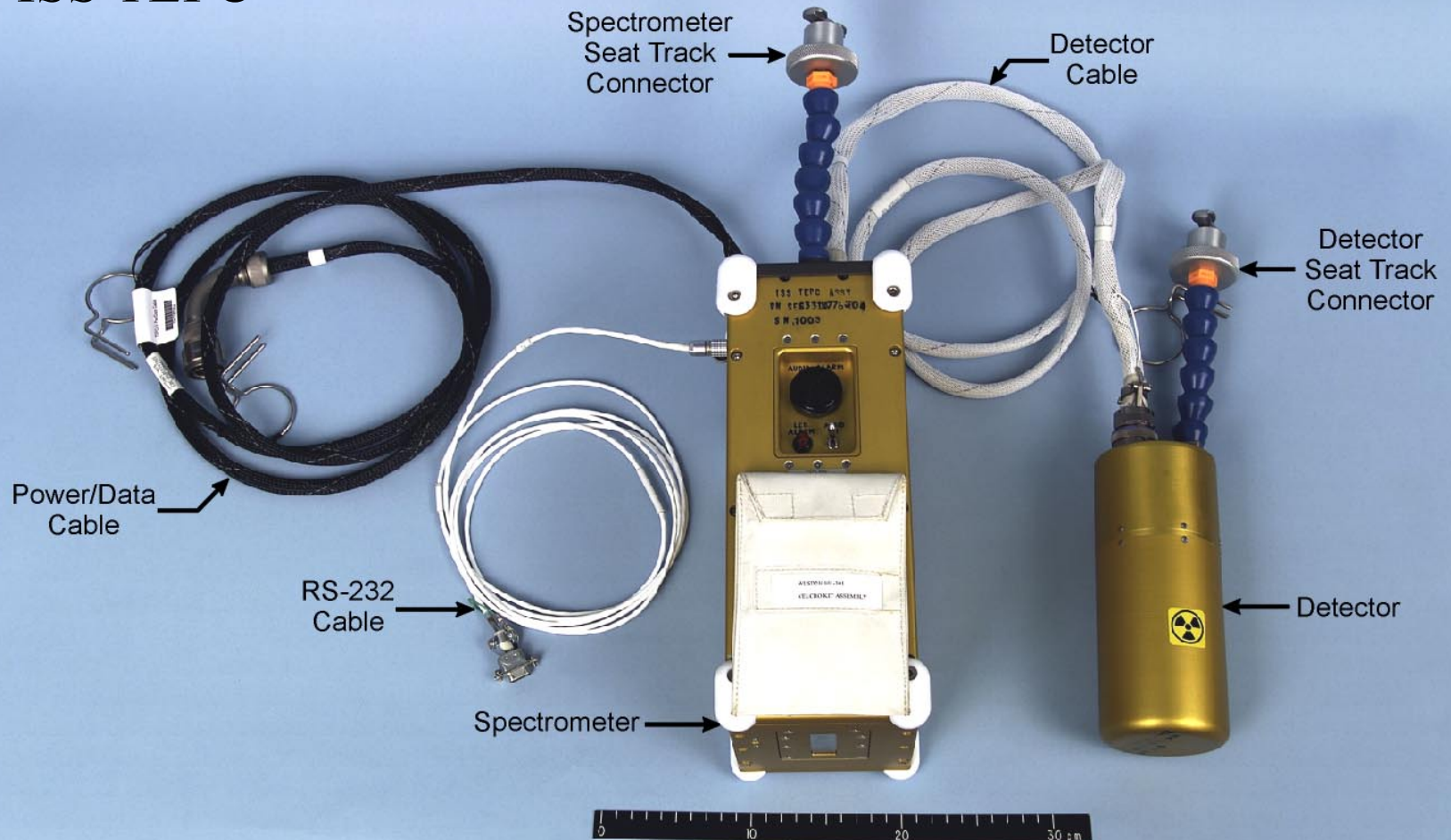


- Expedition 4

- Yury Onufrienko, Daniel Bursch, and Carl Walz
- Start: ISS UF-1, December 5, 2001
- End: STS-111, June 19, 2002



ISS TEPC





ISS TEPC Spectrometer

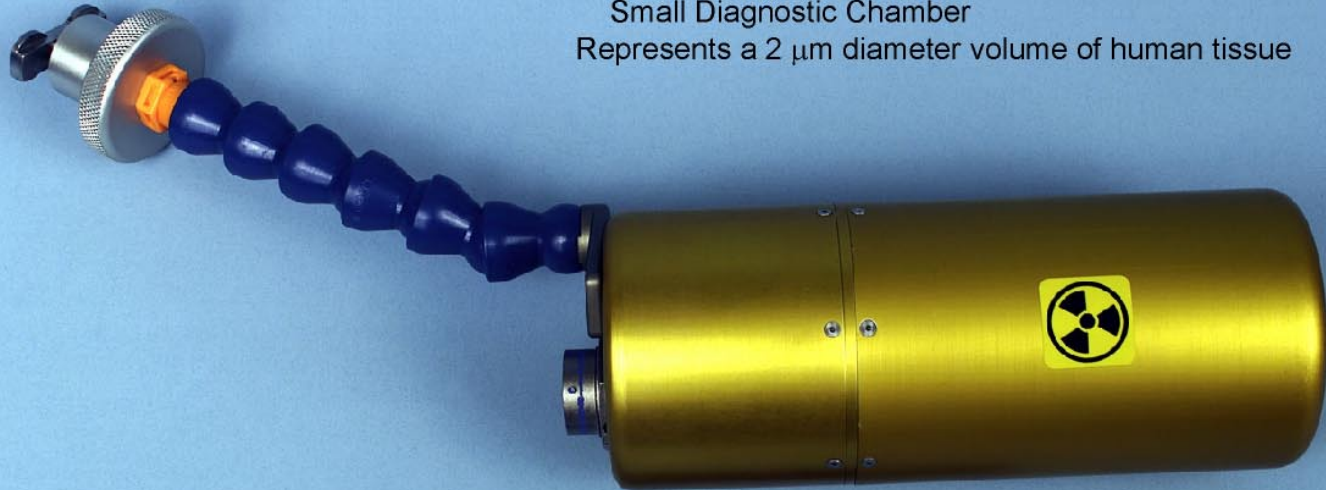
Dual Multi-Channel Analyzer Design

1024 Channels of Low-Gain Data

256 Channels of High-Gain Data

RS-232 and 1553 Communication Ports

120 V or 28 V Power Operation



Proportional Counter Detector

Fill Gas: 2 Torr Propane

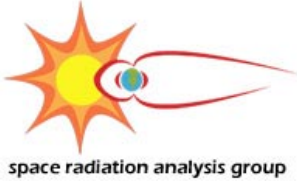
Dual Chamber Design

 Main Detector Chamber

 Small Diagnostic Chamber

Represents a 2 μm diameter volume of human tissue





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ISS TEPC Relocate History

Expedition 1

Date

Location

11/09/00	SM Panel 110
11/18/00	SM Panel 338
12/01/00	SM Panel 428
12/19/00	SM Panel 327
01/09/01	SM Panel 110
01/26/01	SM Panel 338
02/05/01	SM Starboard CQ
02/28/01	US Lab O3/O4
03/13/01	SM Panel 334
04/04/01	US Lab S1/O1

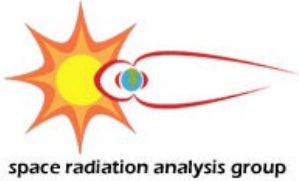
Expedition 2

Date

Location

05/10/01	US Lab S1/O1 (1)
05/18/01	US Lab S1/O1 (2)
05/25/01	US Lab S1/O1
06/01/01	US Lab S6
06/12/01	SM Panel 338
06/26/01	SM Panel 327
08/07/01	SM Port CQ

- (1) PRP Brick +Velocity
- (2) PRP Brick Zenith



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ISS TEPC Relocate History

Expedition 3

Date

Location

08/29/01

SM Starboard CQ

09/11/01

US Lab TeSS

10/09/01

US Lab Aft Closeout

10/29/01

SM Panel 325

Expedition 4

Date

Location

03/01/02

US Lab S6

03/13/02

US Lab TeSS

03/18/02

US Lab S6

04/02/02

US Lab S3

04/25/02

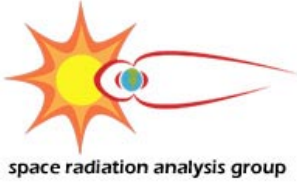
SM Panel 110

05/16/02

SM Panel 410



ISS01E6171 2001/01/31 15:32:24



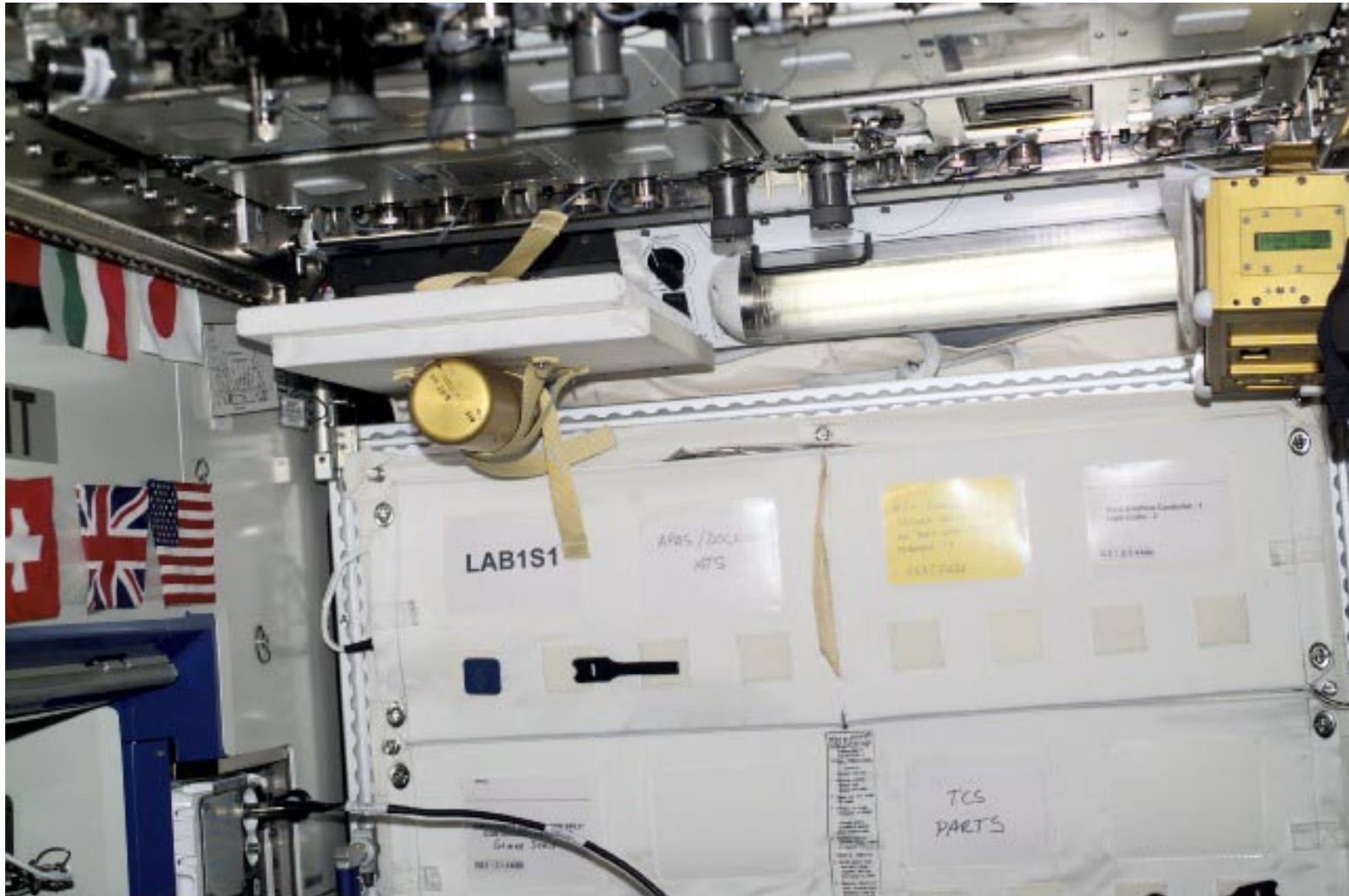
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ISS002E5963 2001/05/14 08:15:37







ISS002E8412 2001/06/26 17:47:27

ISS TEPC 24-HOUR DISPLAY

Current

Current GMT	Instrument Mode	Alarm Status <i>(Set Point: 5 mrad/min)</i>
105/00:00:00	No Signal	Nominal
Serial Number	Location	Position
1003	Service Module	Panel 336
GMT (Last Update)	Dose Rate (mrad/min)	Dose Eq. Rate (mrem/min)
105/20:38:25	0.0	0.0

Cumulative

	Total <i>(Since Instrument Turned On)</i>	Yesterday	Today	Last 24 Hours
	013/02:37:00	104	105	104-105 00:00:00
Dose (mrad)	87.9	12.4	573.9	12.4
Dose Eq. (mrem)	387.0	54	2186	54

Instrument Status

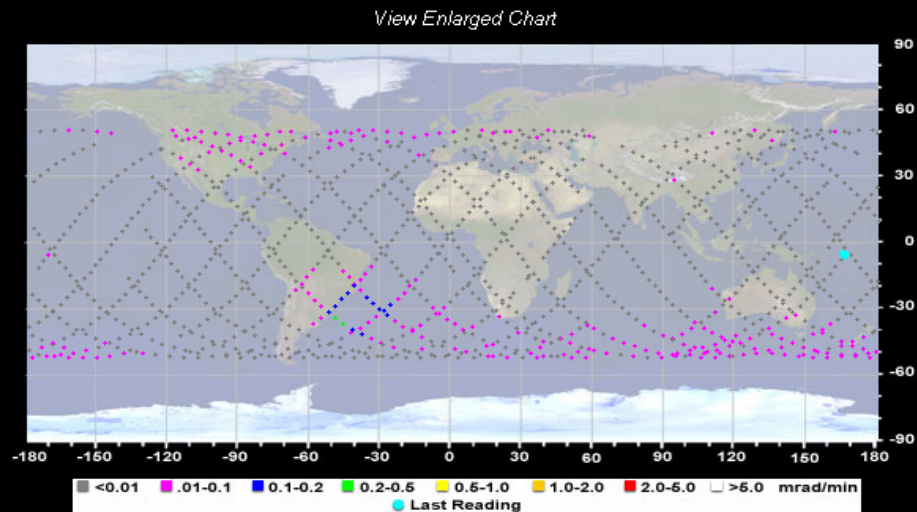
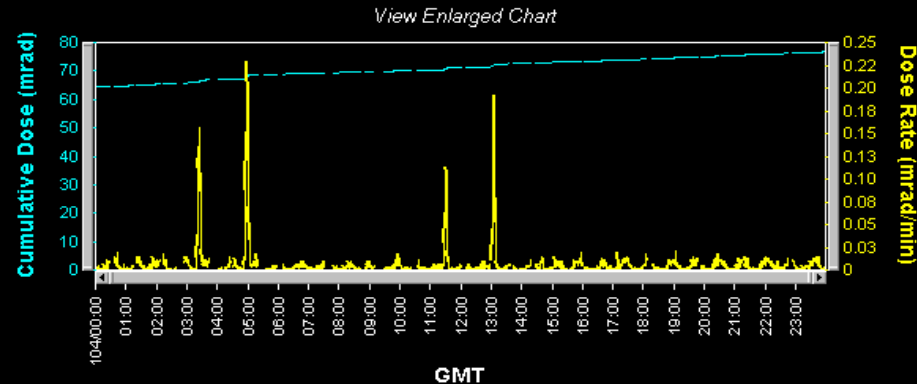
Power	1553	CPU	MCA
	Error	Error	Error

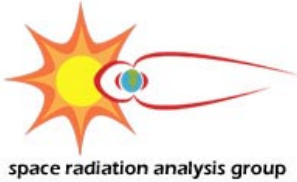
File Status

First File	Last File	Current File
0	0	0

Real Time Monitor

Code	Description
0	Nominal





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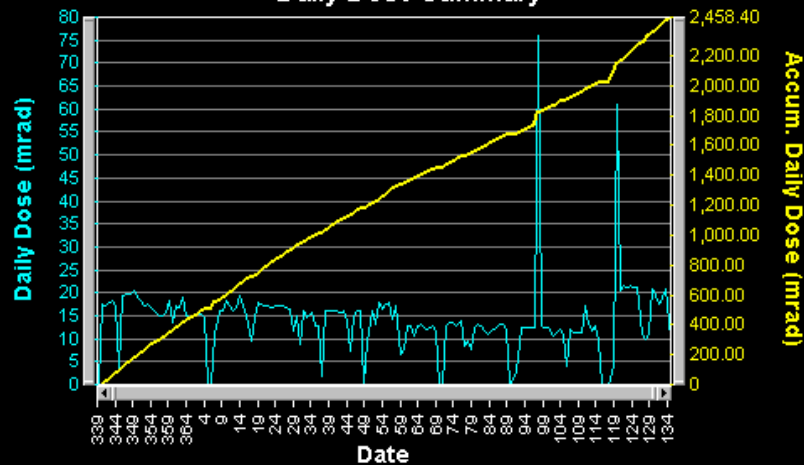
ISS TEPC DAILY DOSE DISPLAY

Start Date: GMT:

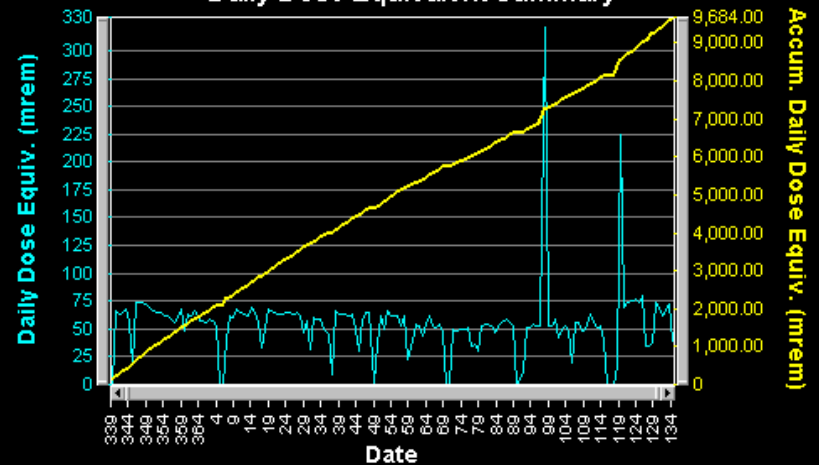
End Date: GMT:

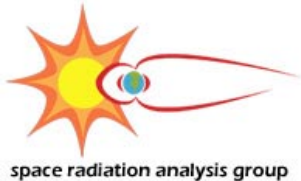
Note: ISS 4 start date & time was 12/05/2001 22:19:00.

Daily Dose Summary



Daily Dose Equivalent Summary

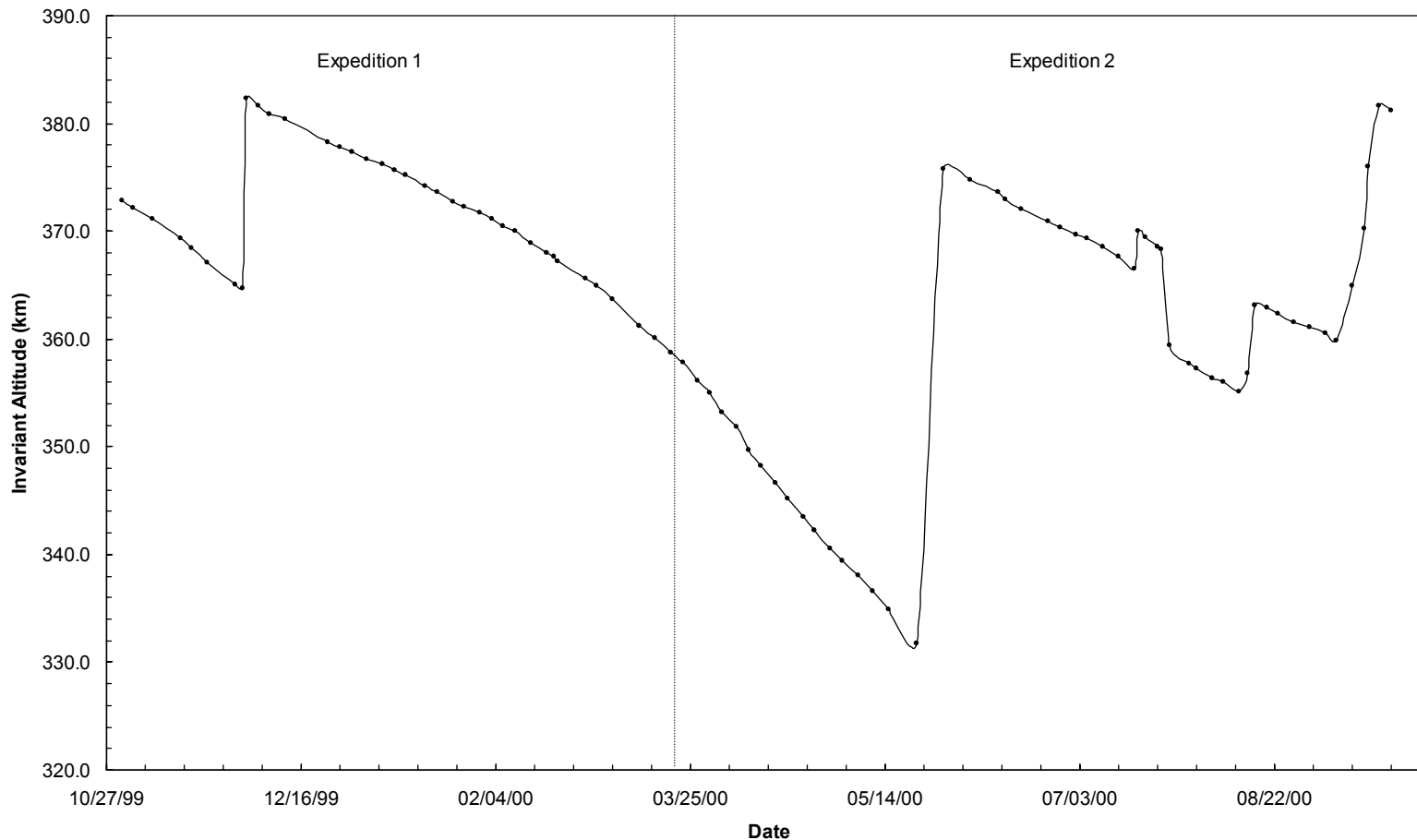




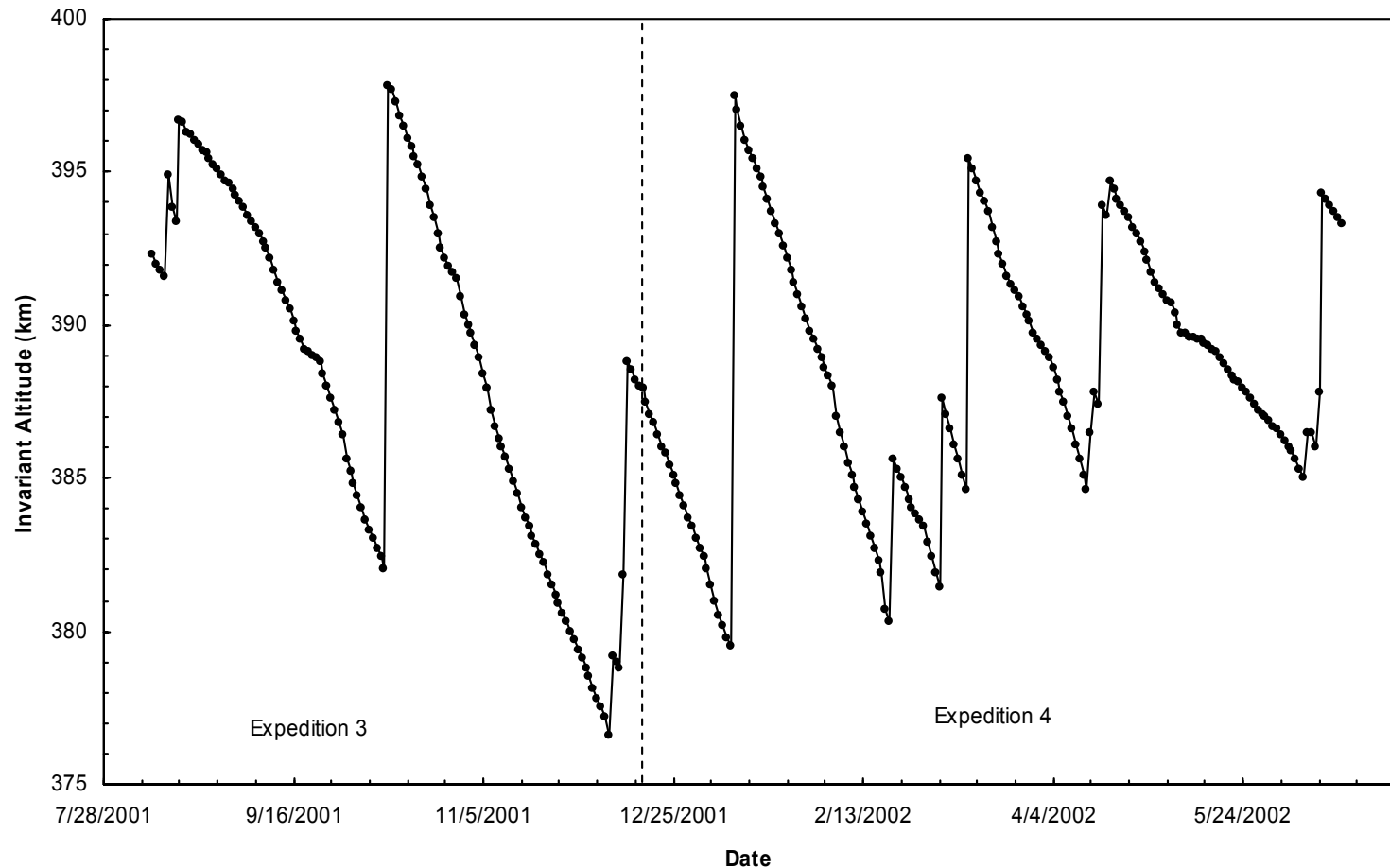
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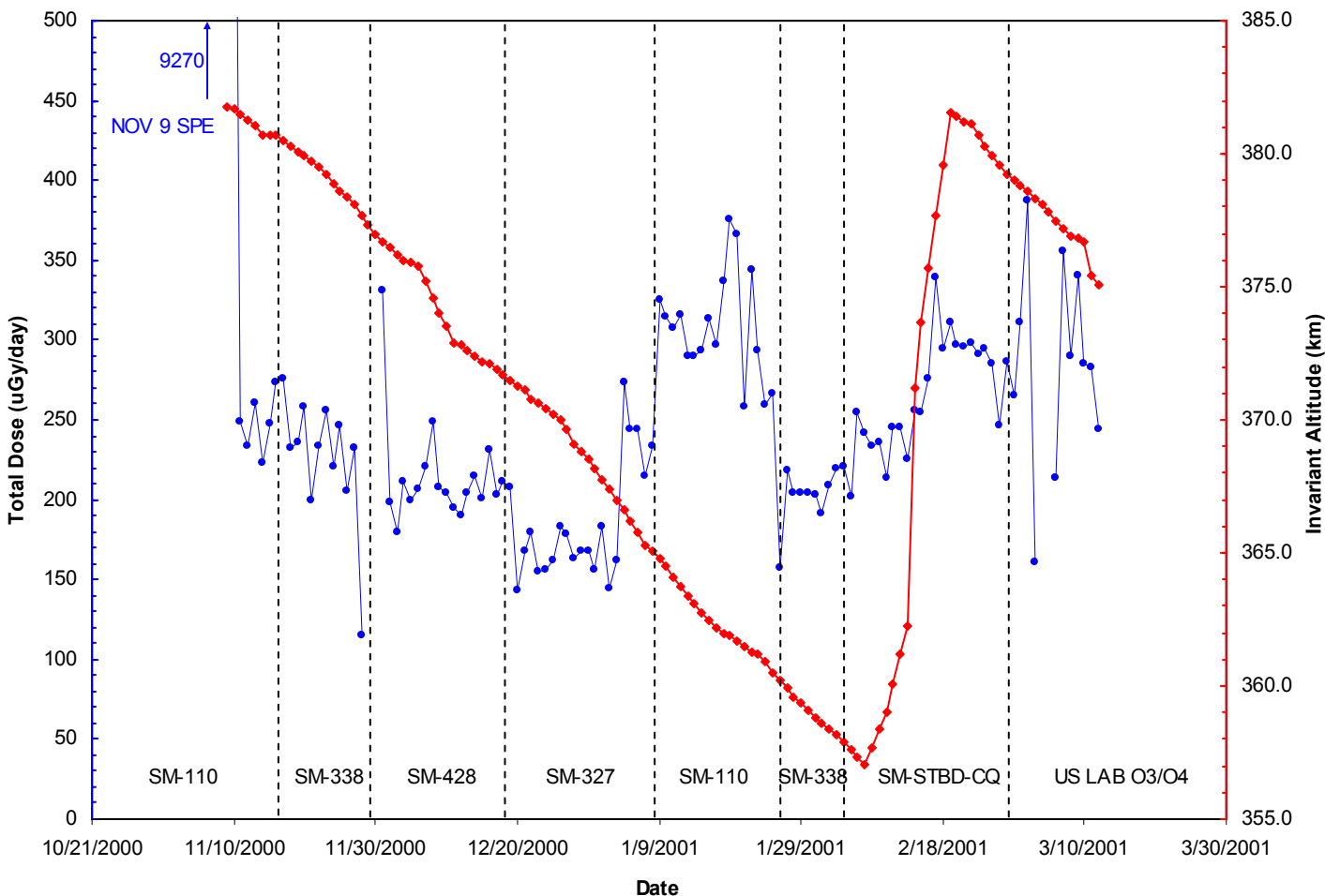
Expedition 1 & 2 As Flown Altitude Plot



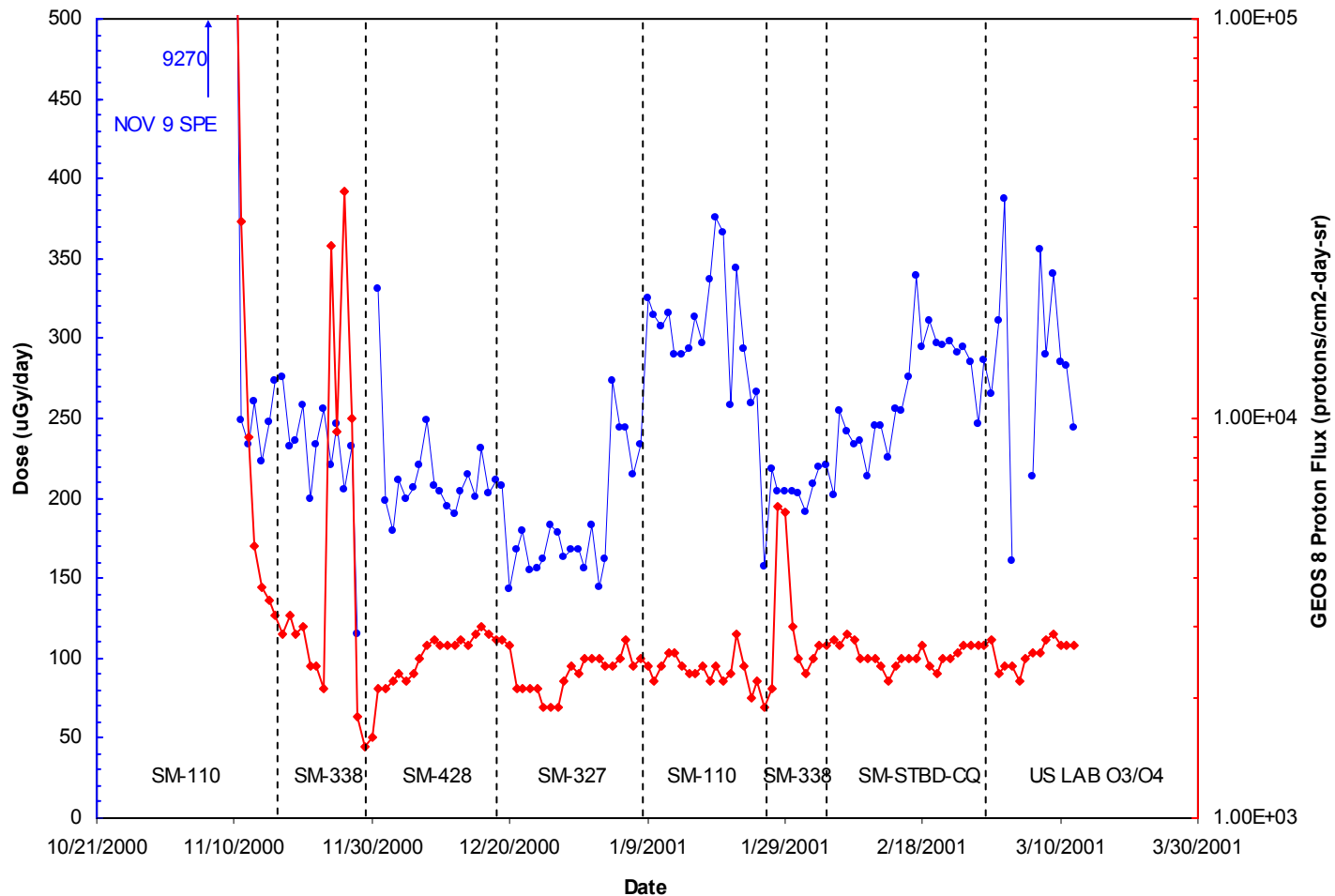
Expedition 3 & 4 As Flown Altitude



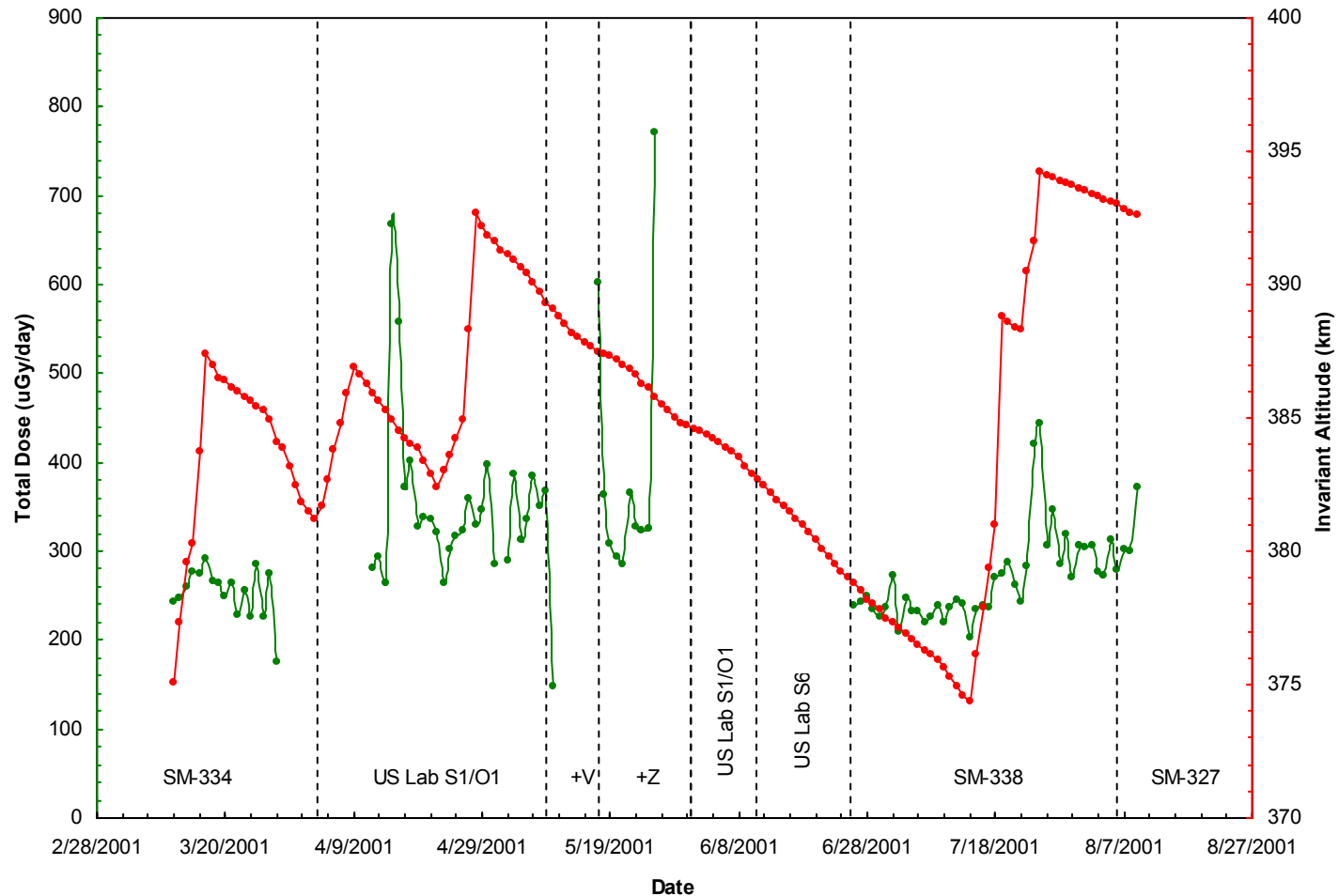
Expedition 1 Total Dose and Altitude



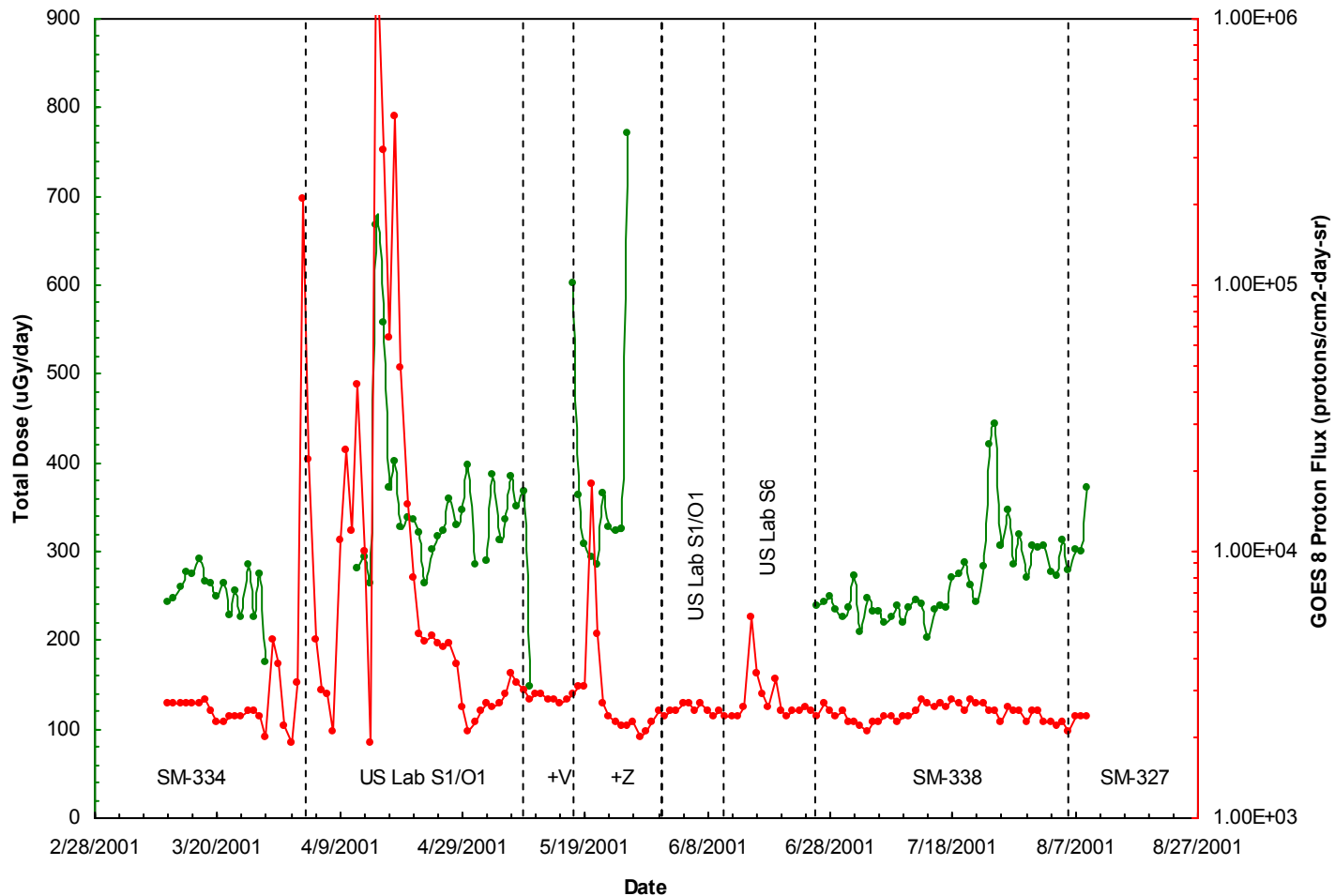
Expedition 1 Total Dose and Proton Flux



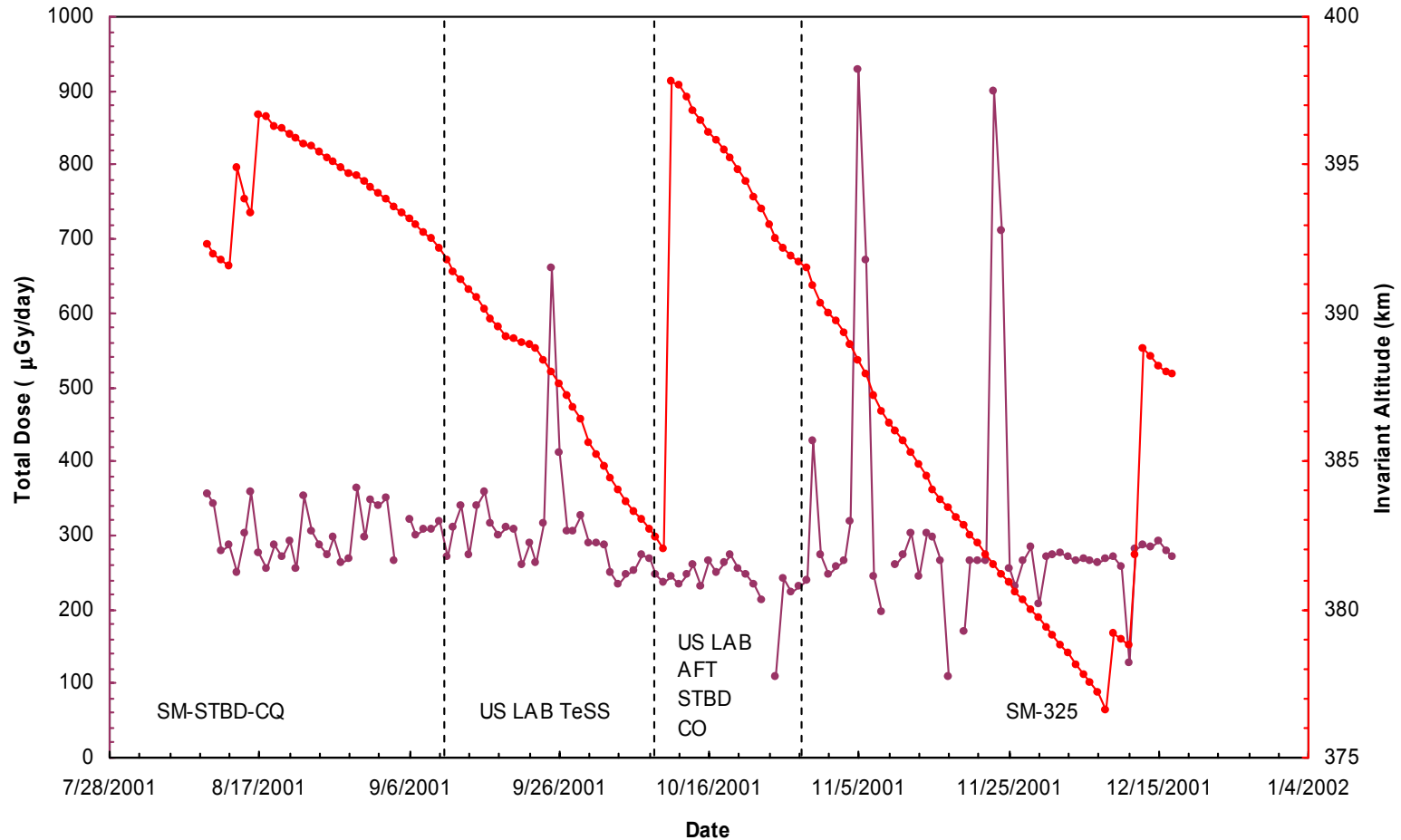
Expedition 2 Total Dose and Altitude

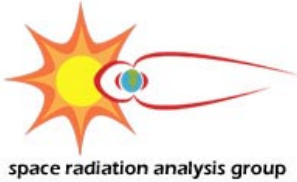


Expedition 2 Total Dose and Altitude



Expedition 3 Total Dose and Altitude

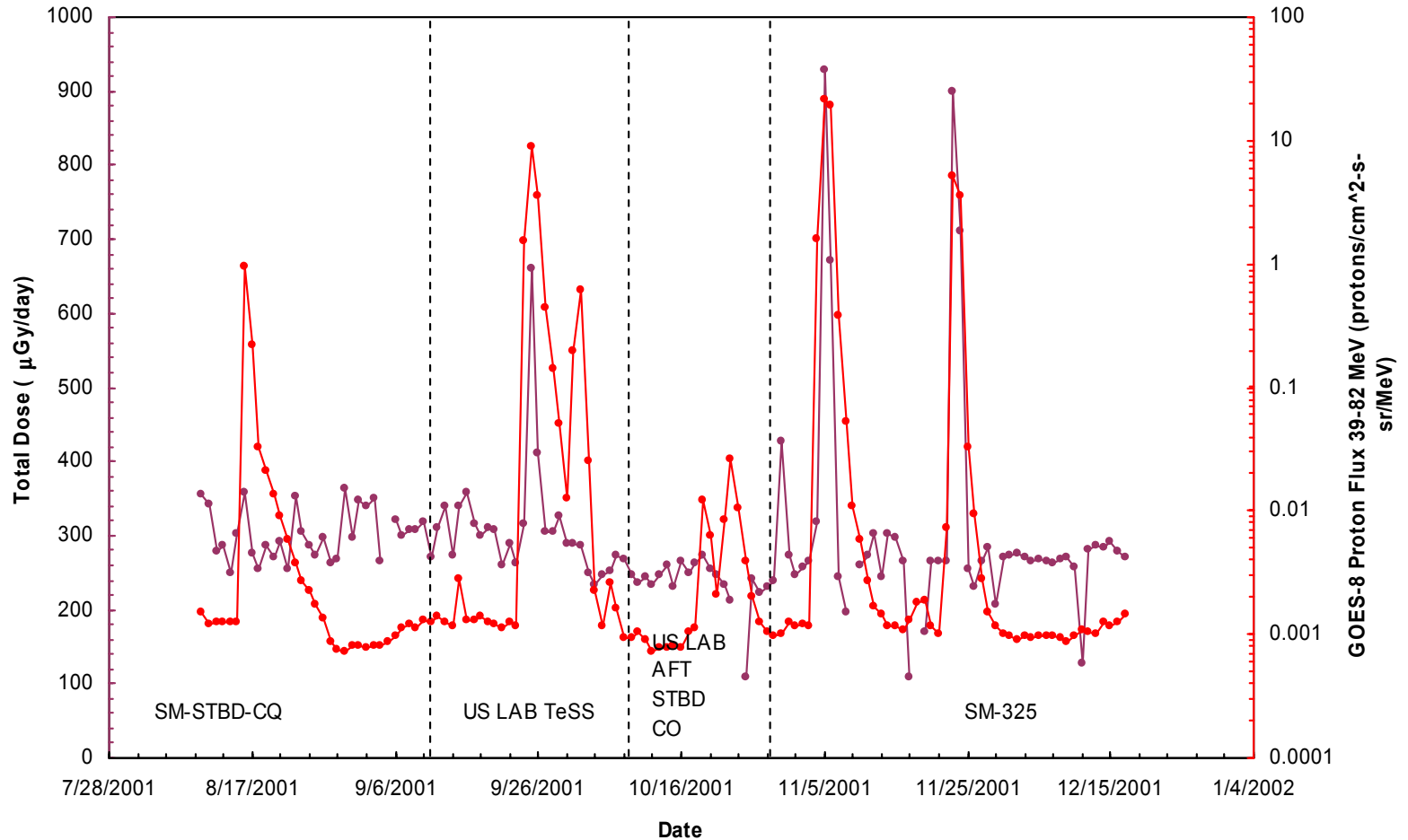




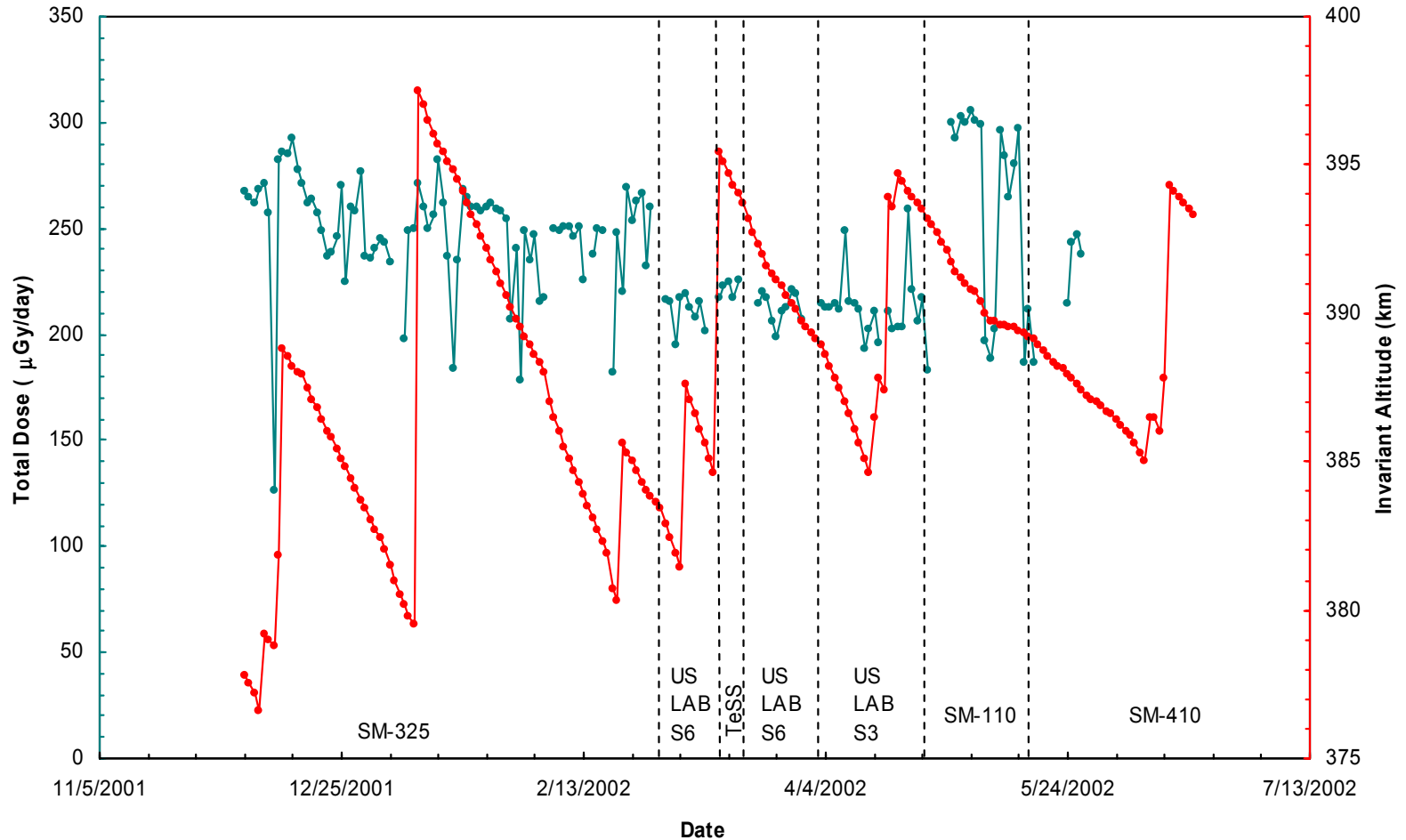
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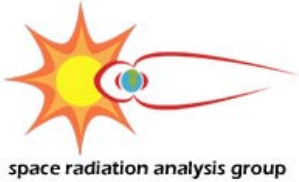


Expedition 3 Total Dose and Proton Flux



Expedition 4 Total Dose and Altitude

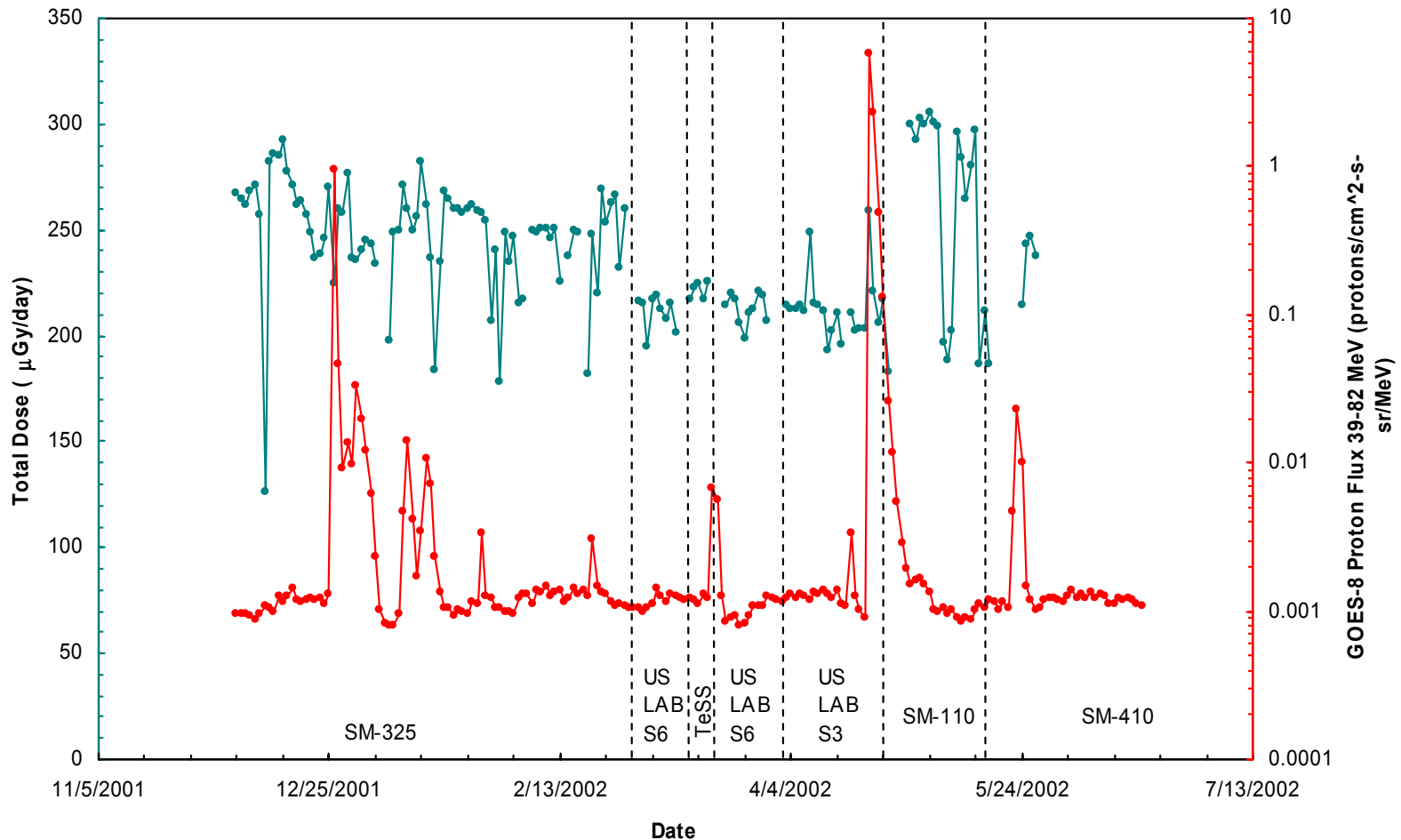


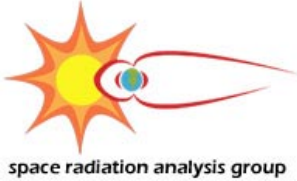


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Expedition 4 Total Dose and Proton Flux





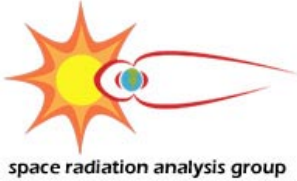
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Altitude Dependence of Measured Dose Rates

Location	Start Date	End Date	Average Altitude (km)	Total Dose Rate (uGy/day)	Total Dose Eq Rate (uSv/day)	Total Q Factor ICRP60	GRC Dose Rate (uGy/day)	GRC Dose Eq Rate (uSv/day)	GCR Q Factor ICRP60	Trapped Dose Rate (uGy/day)	Trapped Dose Eq Rate (uSv/day)	Trapped Q Factor ICRP60
SM-110	1/9/2001	1/26/2001	362	300	626	2.1	142	423	3.0	158	203	1.3
SM-110	11/11/2000	11/17/2000	381	252	578	2.3	100	353	3.5	152	226	1.5
SM-338	1/27/2001	2/24/2001	359	208	516	2.5	144	422	2.9	64	94	1.5
SM-338	11/18/2000	11/20/2000	379	221	541	2.5	101	361	3.6	121	180	1.5
SM-STBD-CQ	2/5/2001	2/13/2001	359	233	541	2.3	143	420	2.9	90	121	1.4
SM-STBD-CQ	2/14/2001	2/17/2001	375	281	598	2.1	142	418	2.9	139	180	1.3
SM-STBD-CQ	2/18/2001	2/27/2001	381	290	617	2.1	145	427	3.0	145	190	1.3
SM-327	12/19/2000	1/8/2001	369	185	493	2.7	109	379	3.5	76	115	1.5
SM-327	6/26/2001	7/18/2001	377	236	565	2.4	141	435	3.1	95	130	1.4
SM-327	7/19/2001	7/24/2001	389	295	636	2.2	140	431	3.1	154	205	1.3
SM-327	7/25/2001	8/6/2001	394	310	666	2.2	150	453	3	159	212	1.3



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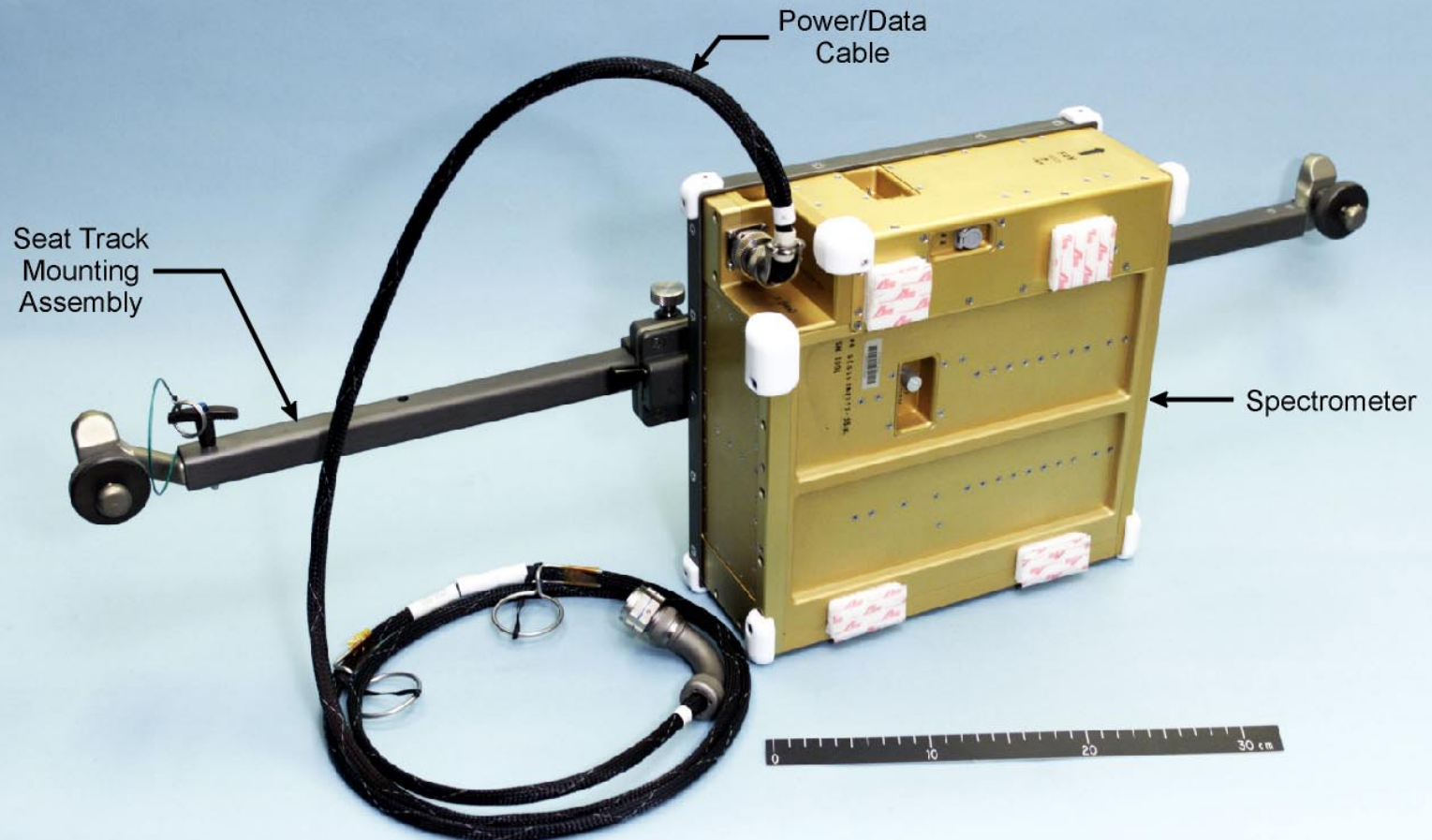
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Location Dependence of Measured Dose Rates

Location	Start Date	End Date	Average Altitude (km)	Total Dose Rate (uGy/day)	Total Dose Eq Rate (uSv/day)	Total Q Factor ICRP60	GRC Dose Rate (uGy/day)	GCR Dose Eq Rate (uSv/day)	GCR Q Factor ICRP60	Trapped Dose Rate (uGy/day)	Trapped Dose Eq Rate (uSv/day)	Trapped Q Factor ICRP60
SM-338	1/27/2001	2/24/2001	359	208	516	2.5	144	422	2.9	64	94	1.5
SM-STBD-CQ	2/5/2001	2/13/2001	359	233	541	2.3	143	420	2.9	90	121	1.4
SM-110	1/9/2001	1/26/2001	362	300	626	2.1	142	423	3.0	158	203	1.3
SM-428	12/1/2000	12/18/2000	374	214	530	2.5	96	354	3.7	119	176	1.5
SM-STBD-CQ	2/14/2001	2/17/2001	375	281	598	2.1	142	418	2.9	139	180	1.3
SM-327	6/26/2001	7/18/2001	377	236	565	2.4	141	435	3.1	95	130	1.4
US LAB O3/O4	2/28/2001	3/12/2001	377	285	613	2.2	126	414	3.3	159	199	1.3
SM-338	11/18/2000	11/20/2000	379	221	541	2.5	101	361	3.6	121	180	1.5
SM-334	3/13/2001	3/16/2001	380	264	617	2.3	149	465	3.1	115	151	1.3
SM-STBD-CQ	2/18/2001	2/27/2001	381	290	617	2.1	145	427	3.0	145	190	1.3
SM-110	11/11/2000	11/17/2000	381	252	578	2.3	100	353	3.5	152	226	1.5
SM-327	7/19/2001	7/24/2001	389	295	636	2.2	140	431	3.1	154	205	1.3
US LAB S1/O1	4/27/2001	5/9/2001	391	345	771	2.2	181	545	3.0	164	226	1.4
SM-PORT-CQ	8/7/2001	8/9/2001	393	324	684	2.1	148	455	3.1	176	229	1.3
SM-327	7/25/2001	8/6/2001	394	310	666	2.2	150	453	3.0	159	212	1.3

IV-CPDS



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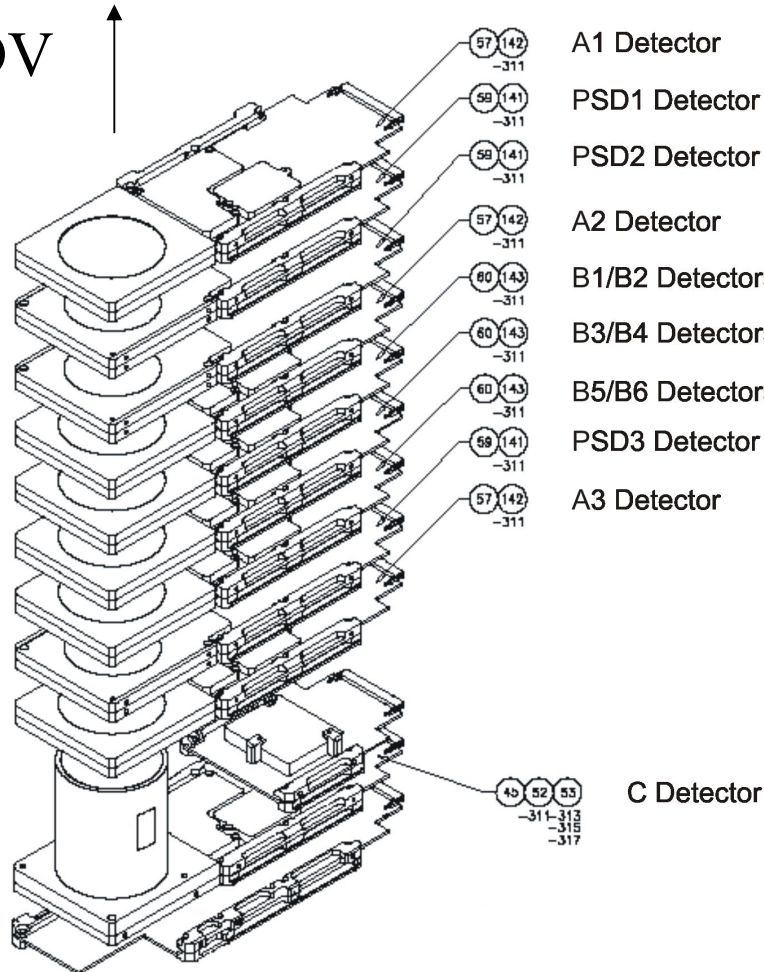


ISS002E5246 2001/05/03 19:01:32



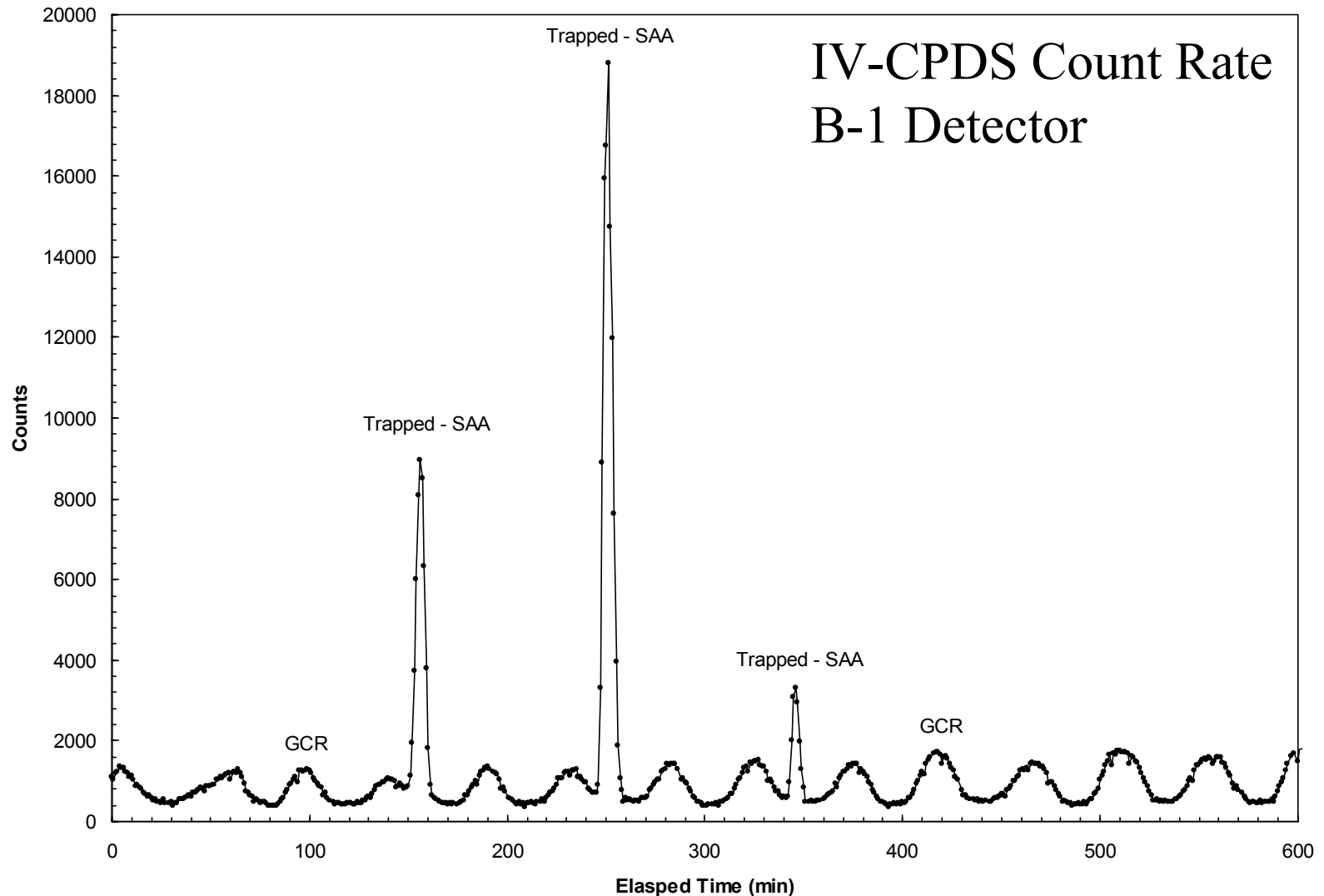
CPDS Detector Stack

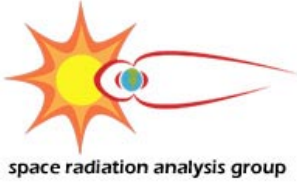
FOV ↑



Detector Types

- A - 1 mm thick Si
- B - 5 mm thick Si/Li
- C - Cerenkov
- PSD - 24 X 24 Cells

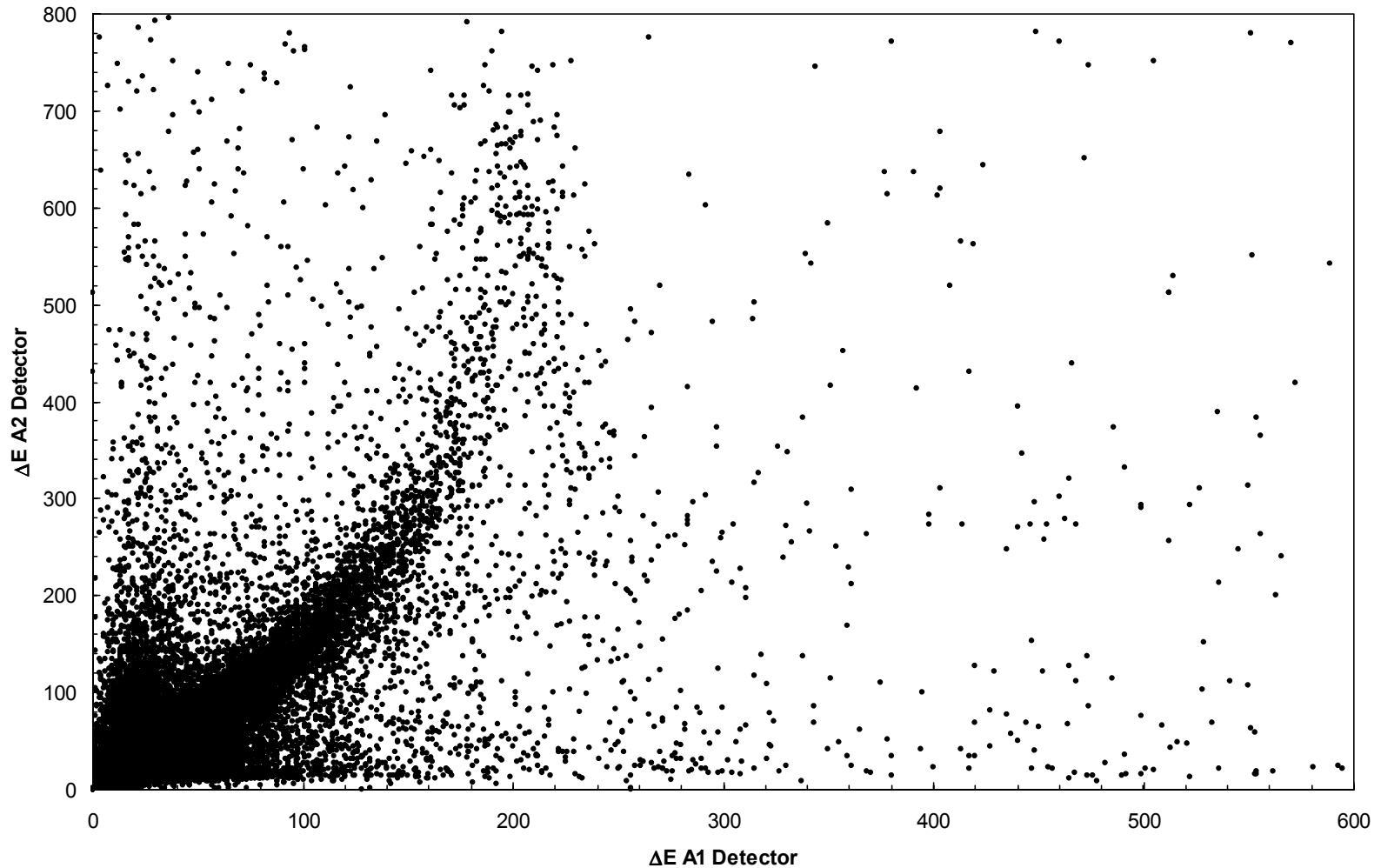




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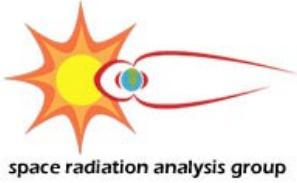
IV-CPDS ΔE A1 and ΔE A2



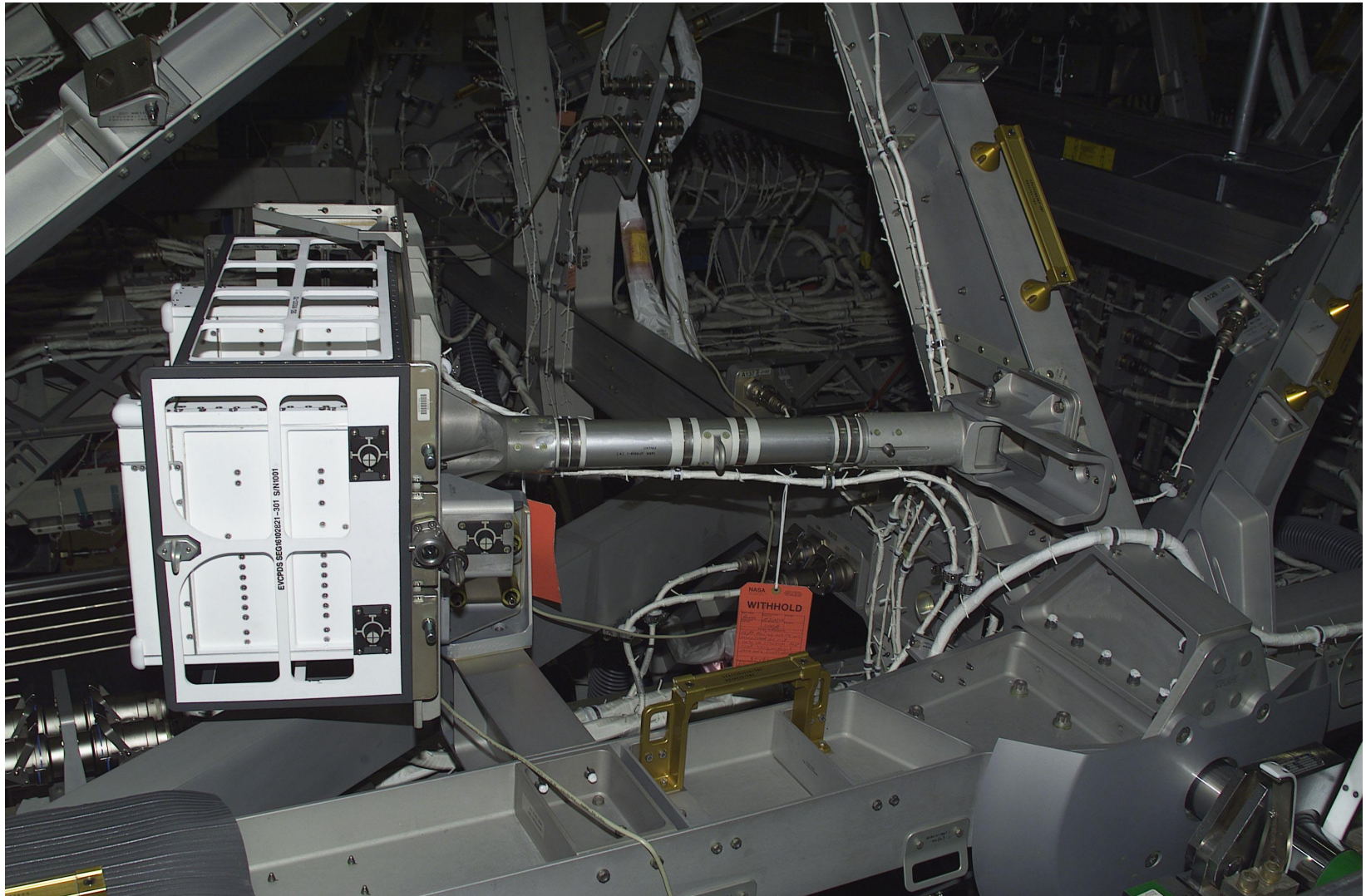


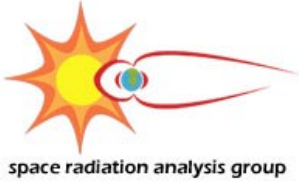
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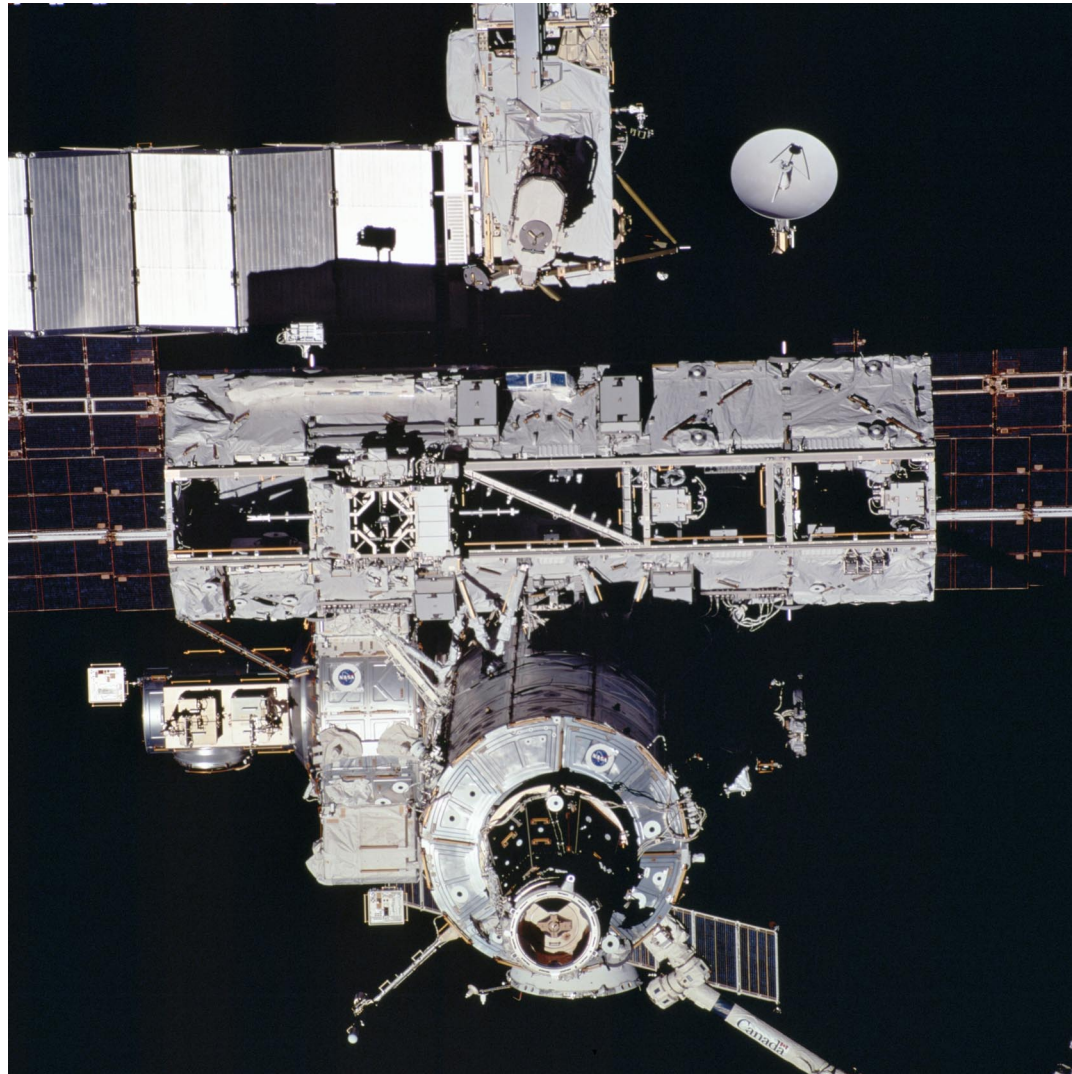


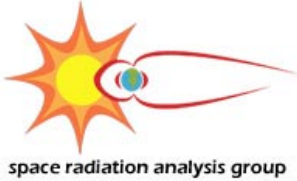
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Summary and Conclusions

- Analysis of daily average TEPC data complete for first year of operation.
- Trapped dose seems to trend with altitude as expected.
- Time to tackle minute average data files for more complete picture.
- Better method for separating Trapped and GCR dose components needed.
- Currently developing software tools to enable detailed analysis of CPDS spectral data.