



# *Space Flight Qualification on a Multi-Fiber Ribbon Cable and Array Connector Assembly*

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**Our Website: [misspiggy.gsfc.nasa.gov/photonics](http://misspiggy.gsfc.nasa.gov/photonics)**

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# Outline



- **Background/Cable Selection**
- **Fiber Configurations**
- **Qualification Plan**
- **Random Vibration Test**
- **Thermal Vacuum Test**
- **Radiation Test**
- **Conclusions**
- **Acknowledgment**





# Background/Cable Selection



- 3<sup>rd</sup> set of testing in this manner by GSFC Photonics Group
- 100/140 graded index fiber manufactured by Nufern
- multi-fiber ribbon cable by W.L. Gore
- MTP Connectors & MT Ferrules by USConec
- Non-outgassing strain relief and ferrule boots (NASA-STD-8739.5)
- Cable “*pre-conditioned*” before termination.
- Cables terminated by US Conec





# Fiber Configurations



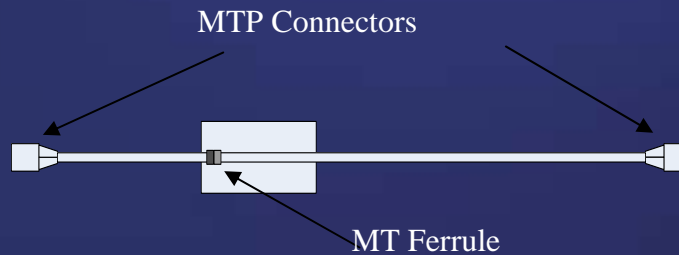
**Config A: MTP Connectors**

*Length = 6 m*



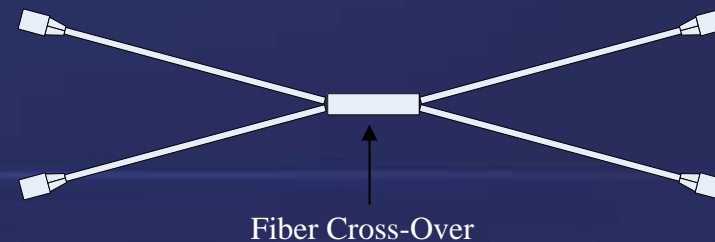
**Config B: MTP Connectors with MT Ferrule @ mid**

*Length = 6.35"*



**Config C: MTP Connectors with Cross-Over**

*Length = 0.6"*





# Qualification Plan

Insertion Loss on all channels before and after testing  
Some channels monitored insitu for insertion loss  
End face inspections before and after testing

- Vibration Induced Effects
  - Verified survival and operational ability during launch using typical launch parameters for components reliability.
  - 3 axis test, 3 minutes per axis, 12.78 grms total.
- Thermal Induced Effects in Vacuum Environment
  - In the past we did thermal cycling,
  - -25°C to +80 °C, 1°C/min ramp rate, 30 minute soak at each extreme, 60 thermal cycles total.
  - Vacuum Pressure:  $10^{-6}$  to  $10^{-8}$  Torr.
- Radiation Effects
  - Two dose rates used to provide a model for extrapolation to a lower dose rate.





# Qualification Test Matrix



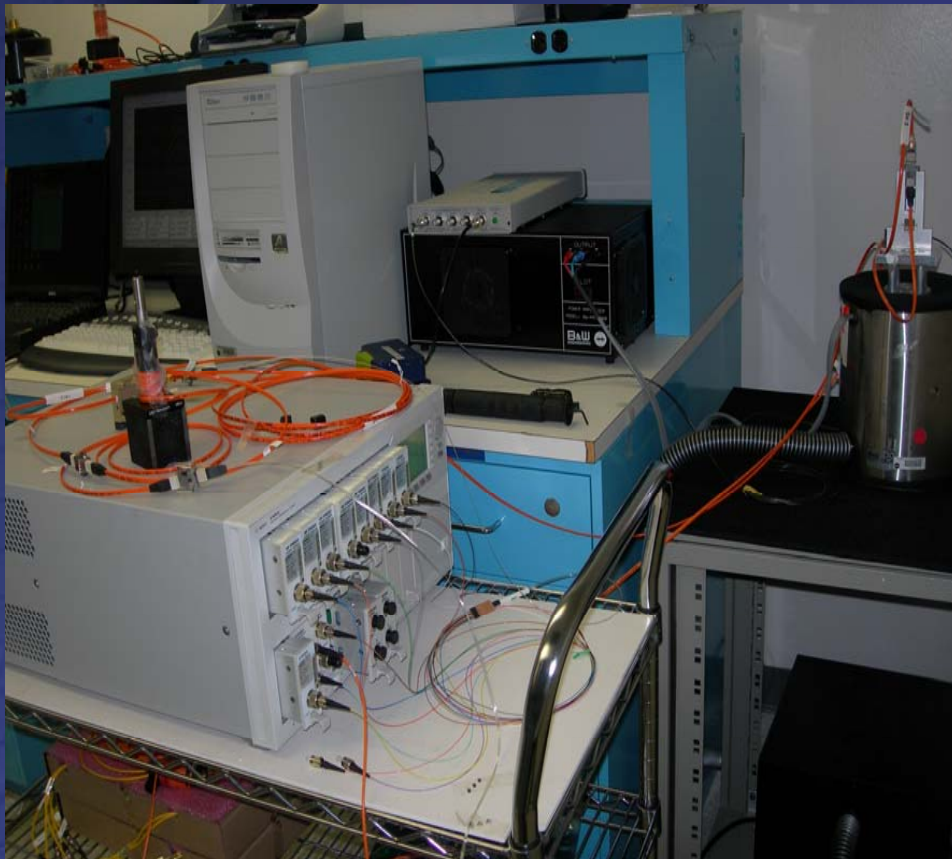
Test Type	Sample Size	Channels Monitored
Vibration	3 Config B MTP Connector (active) 2 Config B Ferrule Adapter (active) 3 Config C (active)	Config B MTP Connector: Channels 4 and 12 Config B MT Ferrule Adapter: Channels 4 and 12 Config C: Channels 2 and 11
Thermal Cycling and Vacuum	<i>Passive:</i> 2 Config B 2 Config C <i>Active:</i> 2 Config A 2 Config B 2 Config C	Config A: Channels 1 and 9 Config B: Channels 4 and 12 Config C: Channels 2 and 11
Total Ionizing Dose (Co <sup>60</sup> source)	High Dose Rate 1 Config A 1 Config C  Low Dose Rate 1 Config A 1 Config C	Config A: Channels 1 and 9  Config C: Channels 2 and 11



# Random Vibration Testing



- 3 minutes/axis, 12.78 grms total



Frequency (Hz)	Level (Protoflight)
20	0.03140 g <sup>2</sup> /Hz
70	0.48150 g <sup>2</sup> /Hz
140	0.48150 g <sup>2</sup> /Hz
150	0.25100 g <sup>2</sup> /Hz
300	0.25100 g <sup>2</sup> /Hz
400	0.10000 g <sup>2</sup> /Hz
600	0.10000 g <sup>2</sup> /Hz
2000	0.00900 g <sup>2</sup> /Hz
Overall	12.78 grms





# Vibration Induced Losses



Cable ID#	Vib-axis	Ch#12 (dB)	Ch#4 (dB)	Ch#2 (dB)	Ch#11 (dB)
Configuration B-1, MTP	X	0.03	0.03		
	Y	0.02	0.02		
	Z	0.05	0.14		
Configuration B-1, MT	X	0.17	0.43		
	Y	0.15	0.3		
	Z	0.12	0.14		
Configuration B-2, MTP	X	0.04	0.02		
	Y	0.61	0.37		
	Z	0.04	0.02		
Configuration B-2, MT	X	0.11	0.56		
	Y	0.14	0.23		
	Z	0.1	0.14		
Configuration B-3, MTP	X	0.07	0.04		
	Y	0.04	0.02		
	Z	0.05	0.03		
Configuration C-1	X			0.01	0.04
	Y			0.02	0.05
	Z			0.12	0.04
Configuration C-2	X			0.04	0.05
	Y			0.03	0.05
	Z			0.1	0.1
Configuration C-3	X			0.02	0.03
	Y			0.08	0.04
	Z			0.2	0.06

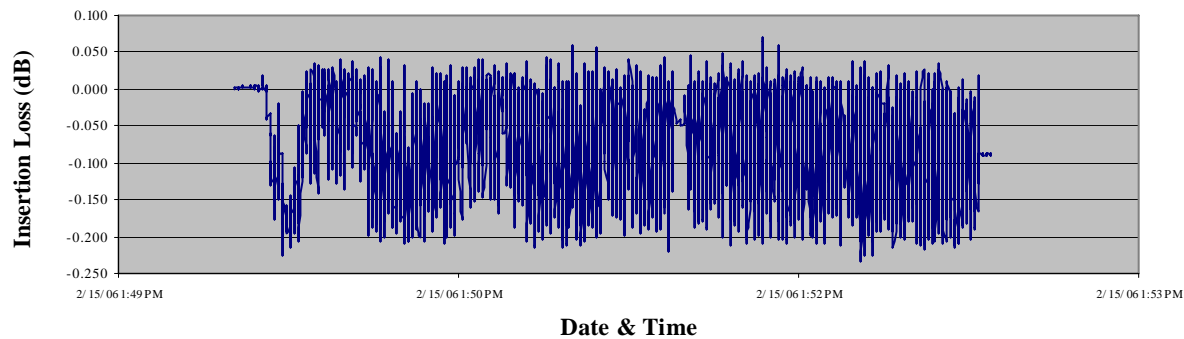




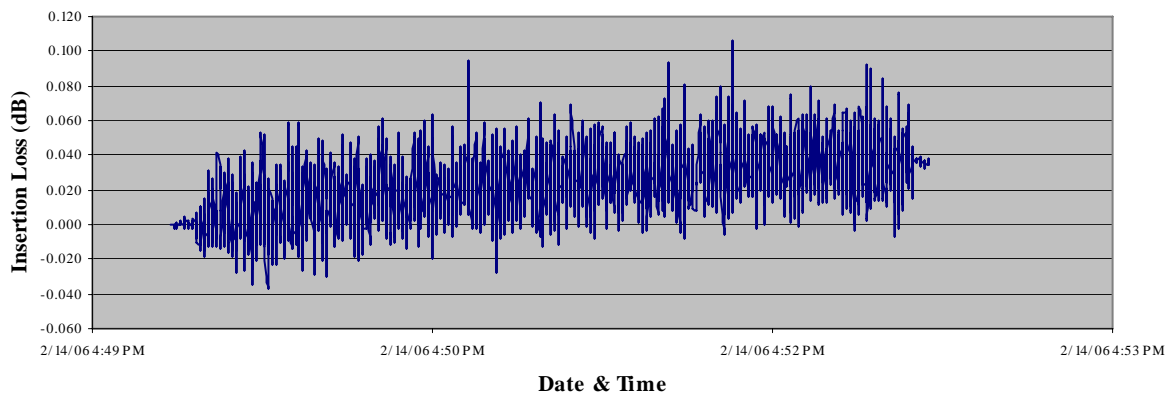
# Vibration Test Results



Insertion loss on MTferrule Ch#4 for cable C19 SN02 & C19-ISBN02 during Y-axis vibration testing



Insertion loss on MTferrule Ch#4 for cable C19 SN02 & C19-ISBN02 during Z-axis vibration testing

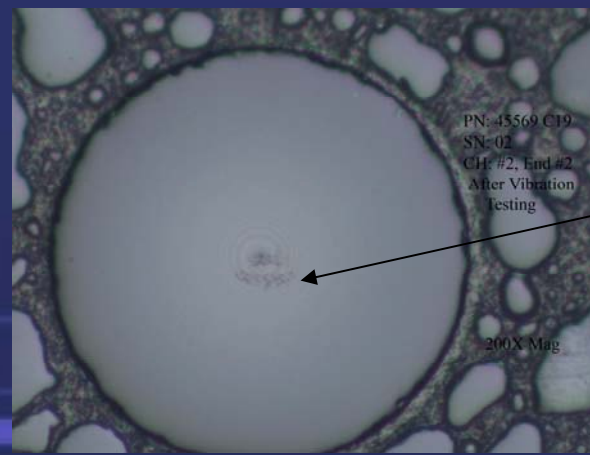
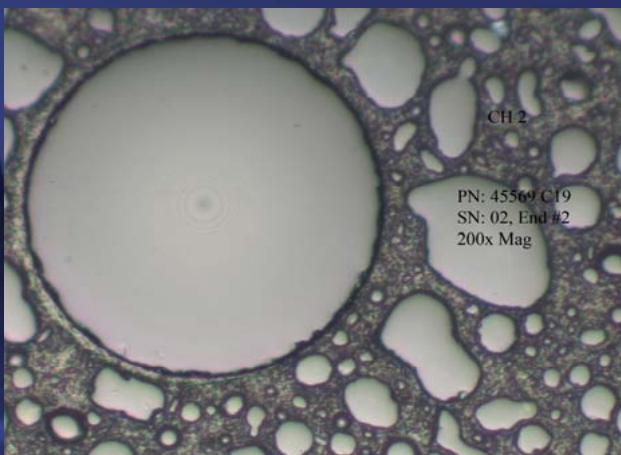




# Random Vibration Results



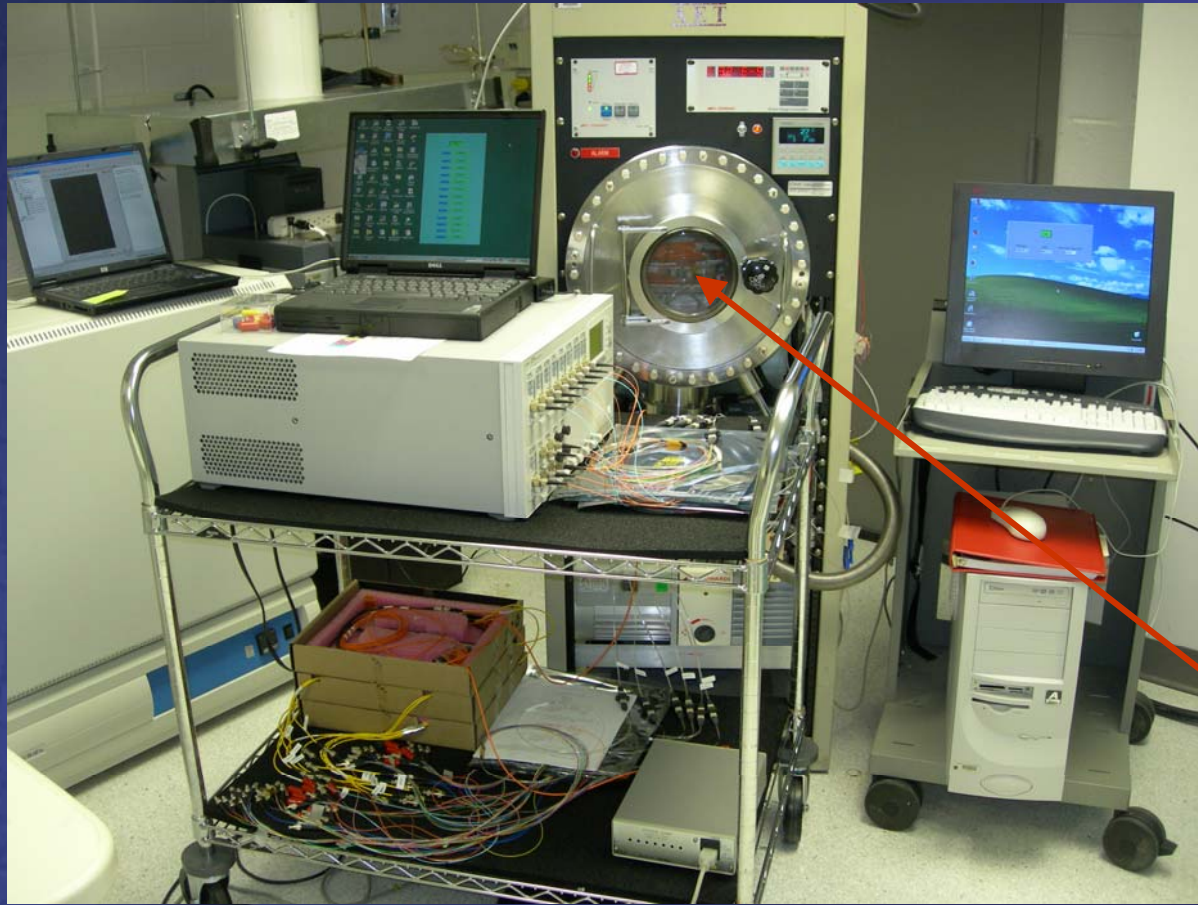
- The specification of 0.5dB maximum allowable shift
- Only two measurements slightly out of specification
- Some cables showed improved power performance. Likely due to fiber alignment between mated pairs.
- One cable configuration showed evidence of “pits” around the core of the MT ferrule. Likely to have happened during installation by contamination.



Micro  
Fracture

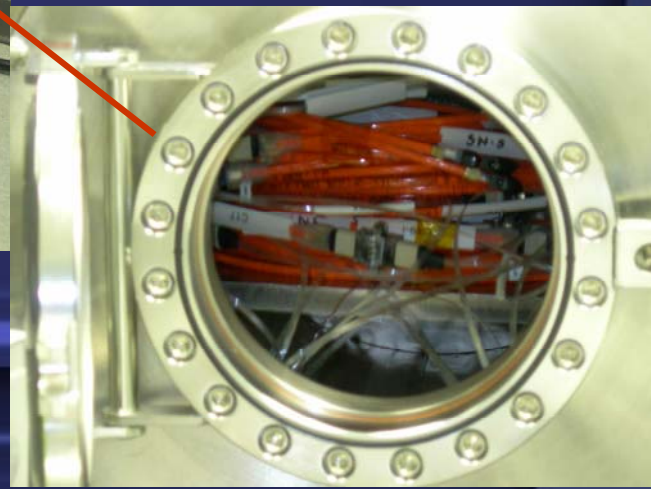


# Thermal Vacuum Testing Setup



## Actively monitored

- Cable optical transmission power
- Chamber temperature
- Chamber vacuum pressure







# Thermal Vacuum Test Results



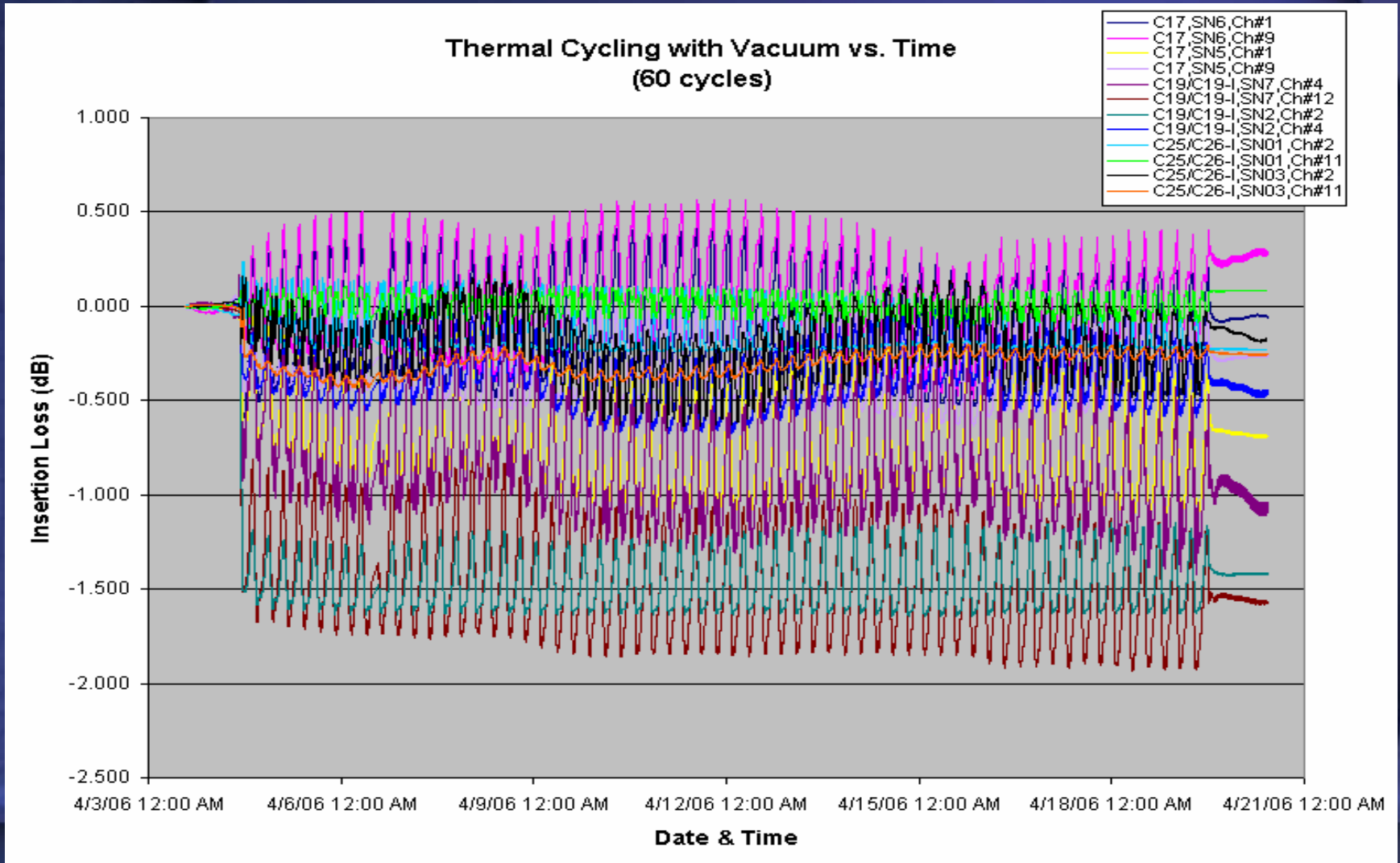
Cable ID#	Ch#	Max. insertion loss change within a cycle (dB)	Max. Insertion Loss Change over entire test duration (dB)
Configuration A-1	1	0.8	1.1
	9	0.5	0.7
Configuration A-2	1	0.7	1.0
	9	0.7	1.0
Configuration B-1	2	1.5	1.6
	4	0.4	0.7
Configuration B-2	4	1.0	1.6
	12	1.5	1.9
Configuration C-1	2	0.4	0.5
	11	0.2	0.2
Configuration C-2	2	0.5	0.8
	11	0.3	0.4

- Thermal cycling: -25°C to +80°C
- 60 cycles total
- Vacuum pressure:  $10^{-6}$  to  $10^{-8}$  torr

Insertion Loss < 2dB



# Thermal Vacuum Test Results



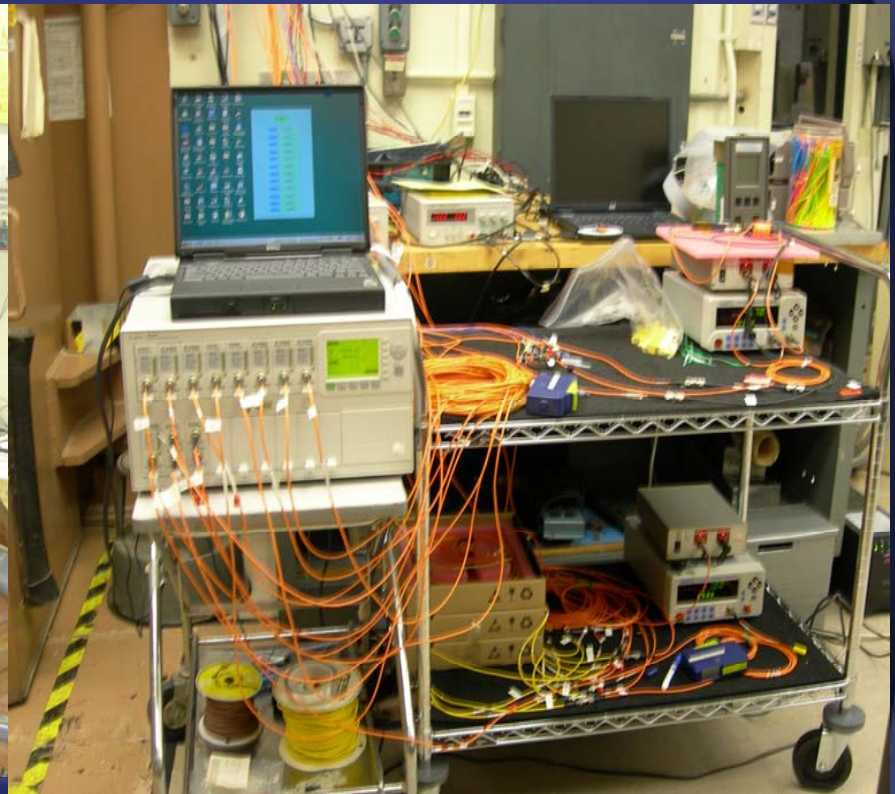
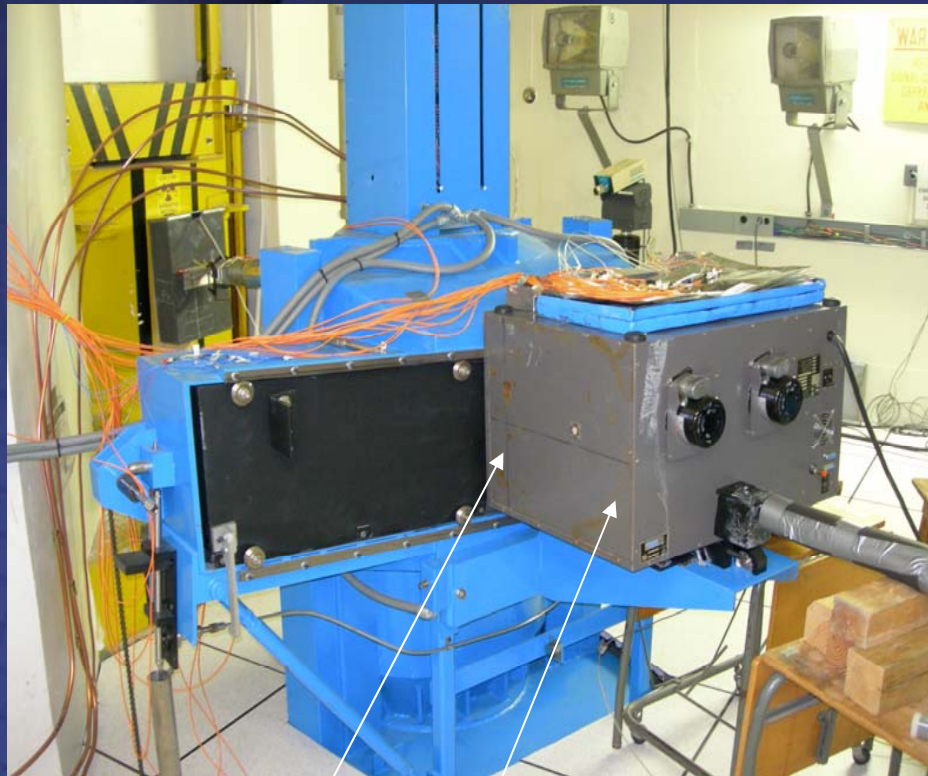




# Radiation Test Setup



NASA GSFC Cobalt 60 Sources



High dose rate  
Just behind door

Both Cables under test were inside the thermal chamber

Low dose rate  
In the back

High dose rate; 120 rads/min  
Low dose rate; 12 rads/min



# Radiation Test Parameters and Results

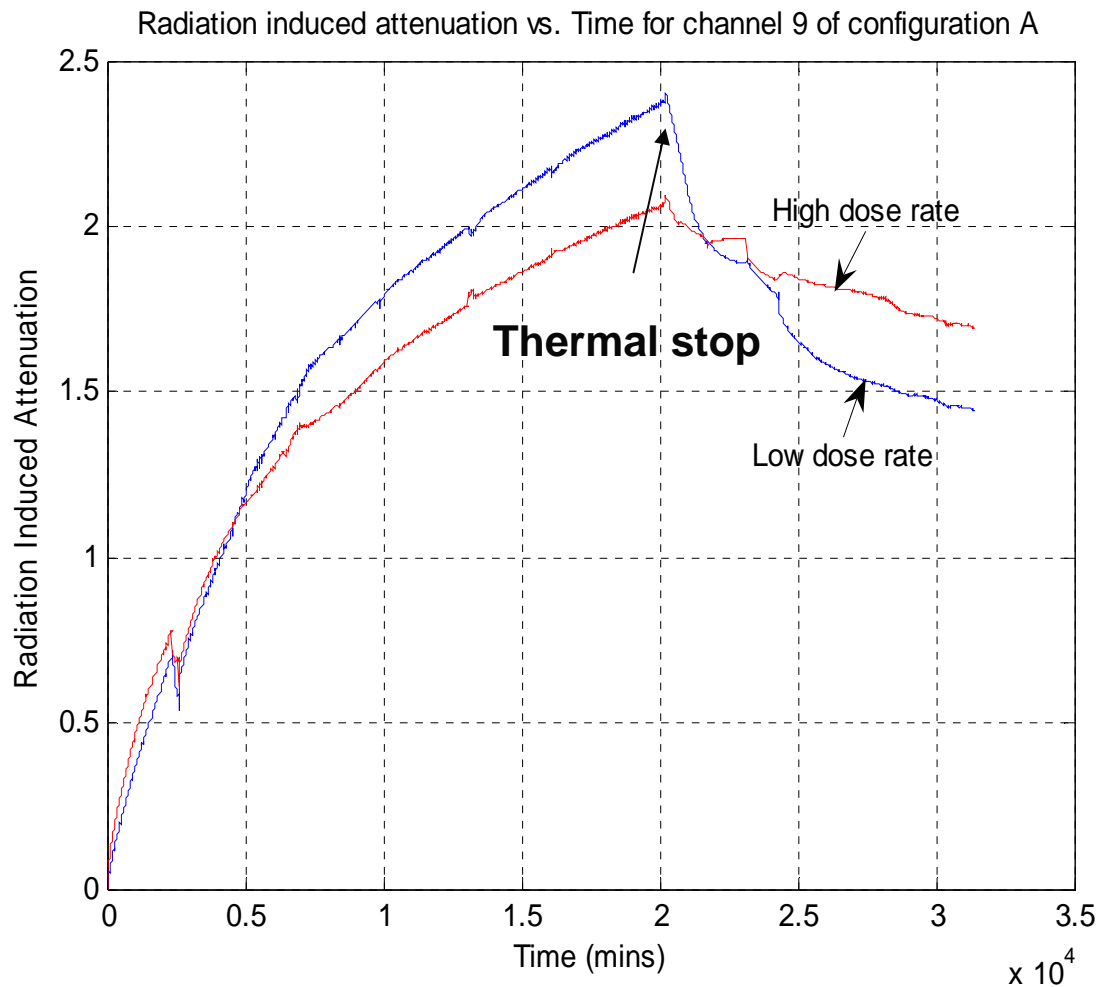


Cable ID	Ch#	Dose rate (rads/min)	Total dose (Krad)	Cable Length	Cold Temp	Attenuation at cold temp	Attenuation at room temp of 24C	Attenuation after anneal for 7 days
Config. A-2,	1	12	244	6.35m	-33C	2.3 dB/m	1.9 dB/m	1.4 dB/m
	9	12	244	6.35m	-33C	2.4 dB/m	1.9 dB/m	1.4 dB/m
Config. A-1	1	120	2440	6.35m	-21C	2.1 dB/m	1.9 dB/m	1.5 dB/m
	9	120	2440	6.35m	-21C	2.1 dB/m	2.0 dB/m	1.6 dB/m
Config. C-4	2	12	244	0.61m	-33C	22.1 dB/m	19.2 dB/m	14.9 dB/m
	11	12	244	0.61m	-33C	21.6 dB/m	18.9 dB/m	14.3 dB/m
Config. C-3	2	120	2440	0.61m	-21C	21.1 dB/m	19.2 dB/m	14.9 dB/m
	11	120	2440	0.61m	-21C	20.8 dB/m	19.0 dB/m	14.3 dB/m

**Although the intention was to test at constant temperature, that did not occur**



# Radiation Test Results

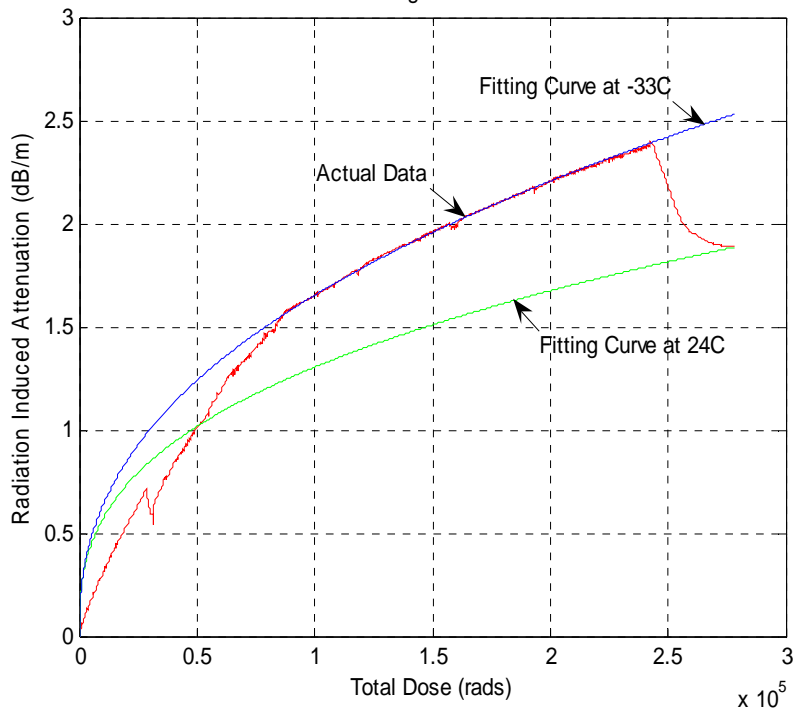




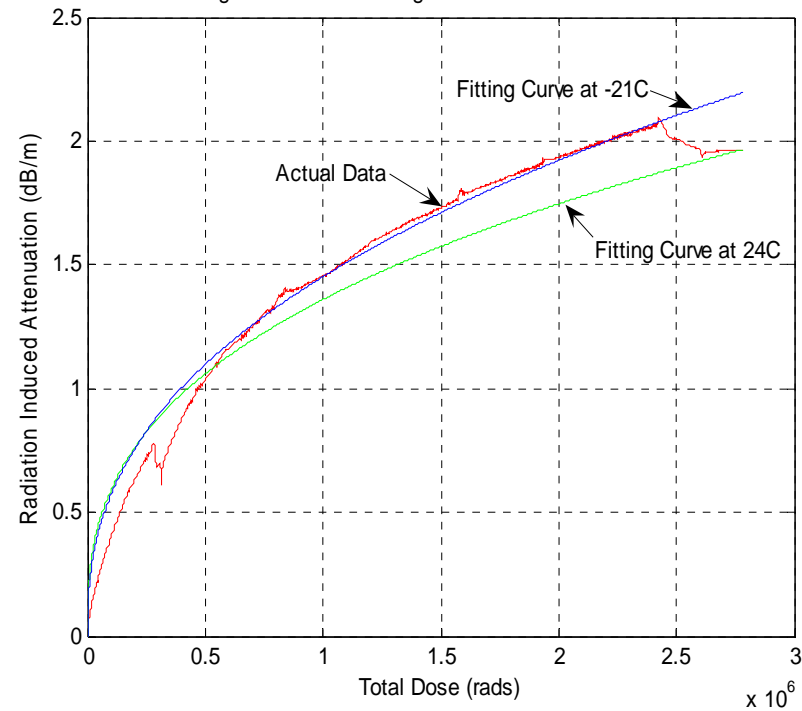
# Radiation Test Results



Low dose rate of Configuration A-2 at 12 rads/min



High dose rate of Configuration A-1 at 120 rads/min

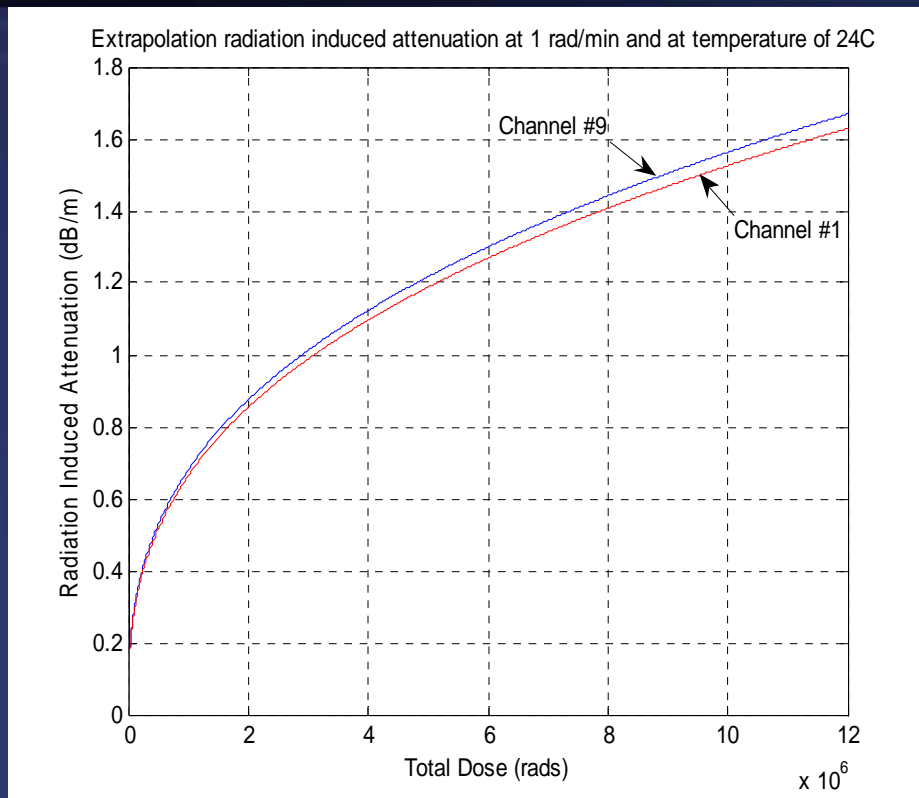


Example of results, with extrapolation curve at room temperature





# Radiation Test Model



**Extrapolation model for radiation induced losses at room temperature for any dose rate and total dose**

$$A(D) = 4.62 \times 10^{-3} TIDrate^{0.6387} TID^{0.3613}$$





# Conclusions

- Vibration Test
  - 3 axis test, 3 minutes per axis, 12.78 grms total.
  - 2 channels monitored on each cable, total 48 tests were conducted.
  - Only 2 data points were just above the spec of 0.5dB.
  - One MT mating exhibited sign of “pits” due to cleaning.
- Thermal Vacuum Test
  - -25°C to +80 °C, 60 thermal cycles total, vacuum in  $10^{-6}$  to  $10^{-8}$  Torr
  - 6 cables and total 12 channels monitored actively.
  - All channels showed less than 2 dB change in performance.
- Radiation Test
  - Two dose rates used to provide a model for extrapolation to lower dose rates.
  - Extrapolated to 1 rad/min, up to TID of 12 Mrad, ~ 1.6 dB/m at room temperature using 850 nm.



# Acknowledgements



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For more information, please see the website:

<http://misspiggy.gsfc.nasa.gov/photonics>