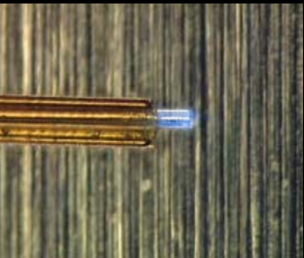


Photonic Component Qualification and Implementation Activities at NASA Goddard Space Flight Center



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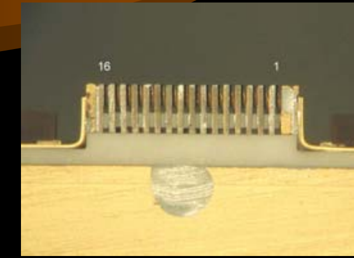
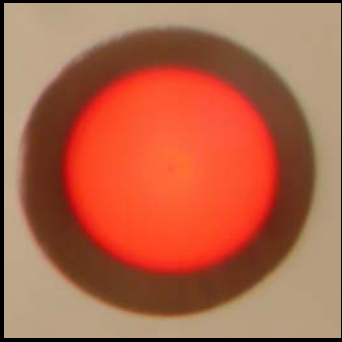
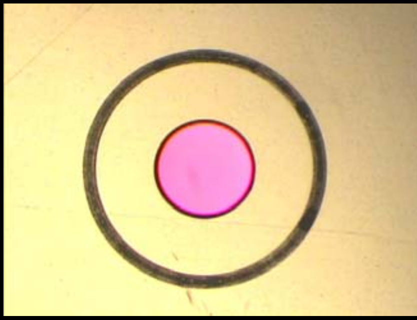


misspiggy.gsfc.nasa.gov/photonics

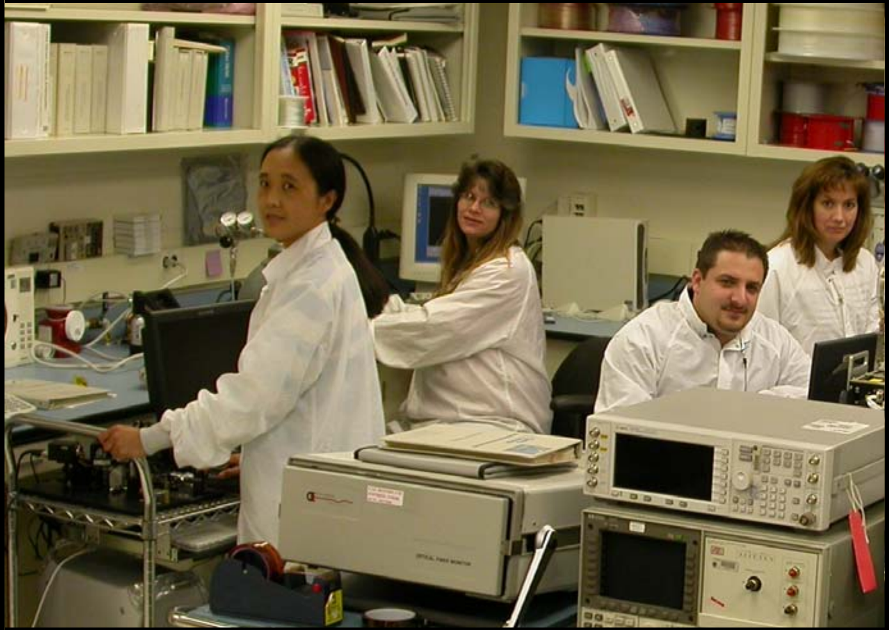


SPIE Photonics for Space Environments XI



Contributing Colleagues

The GSFC Code 562 Photonics Group & contributors



Photonics Group pictured left to right--
Dr. Xiaodan "Linda" Jin, Mary Malenab, Frank LaRocca
Patricia Friedberg, Richard Chuska, Shawn Macmurphy

Other collaborators not pictured:
Adam Matzuseski (LR Mech Lead) & Ronald Zellar (LR System Lead)

Outline

- Introduction
- NASA COTS Photonics Validation Approach
- LRO – Laser Ranging Requirements
- Laser Ranging Pre qualification Test Data
- Gimbal Life Test, Radiation Results
- ISS Cable Candidate Testing
- Conclusion

Introduction

Changes in Our GSFC Environment

Short term projects, low budgets

Instruments like GLAS, MLA, VCL, LOLA

Changes to the Mil-Spec system, NASA relied heavily.

Telecommunications products available, state-of-the-art.

Vendors and parts rapidly changing.

Most photonics now COTS.

Qualification not only impossible but far too expensive.

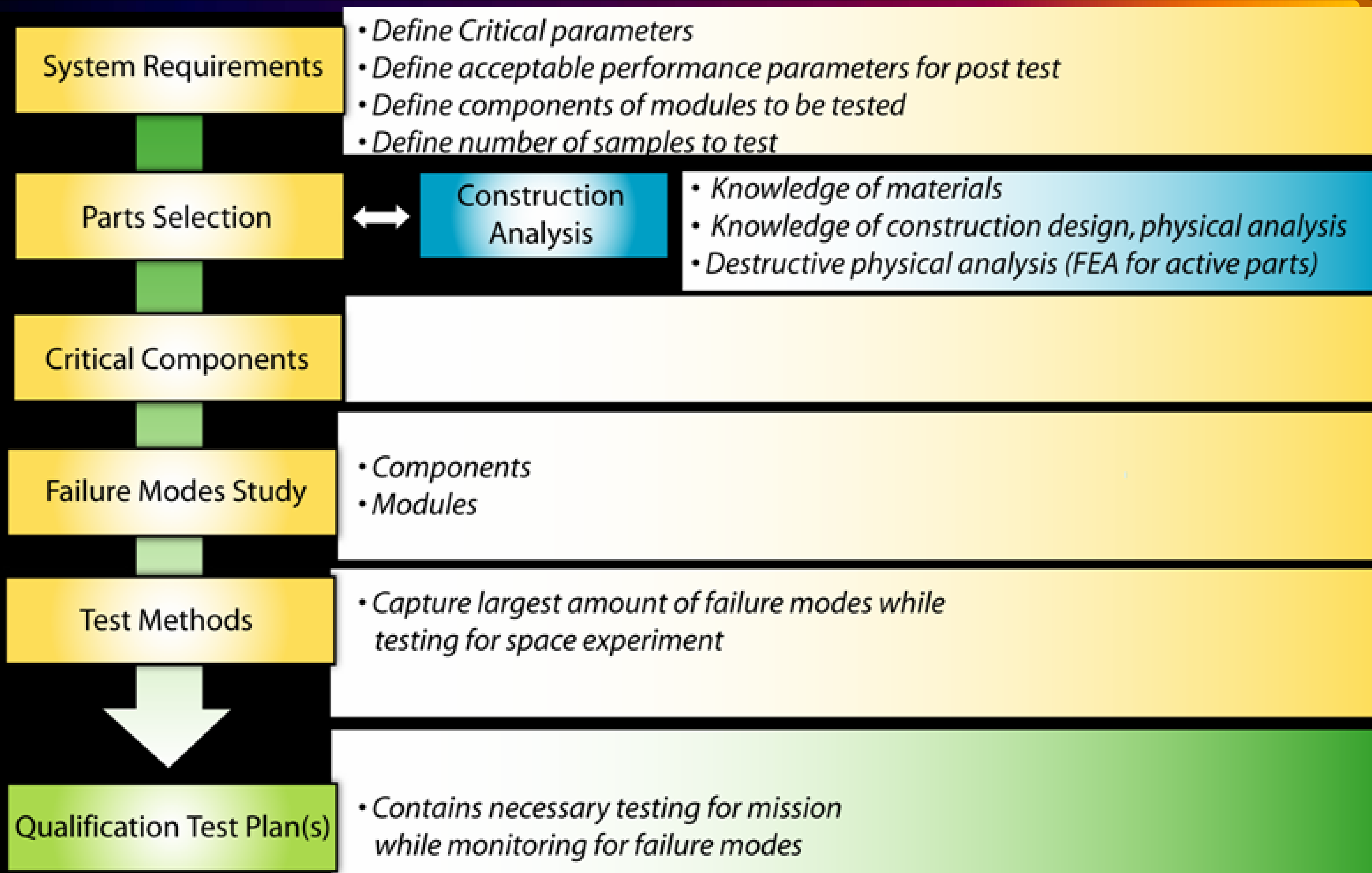
Characterization of COTS for risk mitigation.

Quality by similarity where possible.

Issues to Consider

- Schedule, shorter term
- Funds available,
- Identify sensitive or high risk components.
- System design choices for risk reduction.
- Packaging choices for risk reduction.
- Quality by similarity means no changes to part or process.
- Qualify a “lot” by protoflight method—you fly the parts from the lot qualified, not the tested parts.
- Telcordia certification less likely now.
- Pre-qualification for high risk “unknowns”

COTS Technology Assurance Approach



Flow chart courtesy of Suzzanne Falvey, Northrup Grumman, based on M Ott reference:

* *Photonic Components for Space Systems*, M. Ott, Presentation for Advanced Microelectronics and Photonics for Satellites Conference, 23 June 2004.

COTS Space Flight "Qualification"

Materials Analysis	• Outgas testing for anything unknown • Take configuration into account
Vibration Survival and "Shock Test"	• Use components levels as defined by system requirements • Define parameters to monitor during testing
Thermal Cycling / Aging Test	• Define which parameters will indicate which failure mode • Monitor those parameters during testing
Radiation Testing	• Acclerated dose rate • Extrapolation model use if possible • Worst conditions
Additional Tests	• Based on specific mission requirements
Qualification Assurance Plan	• Continued reliable performance over life of mission

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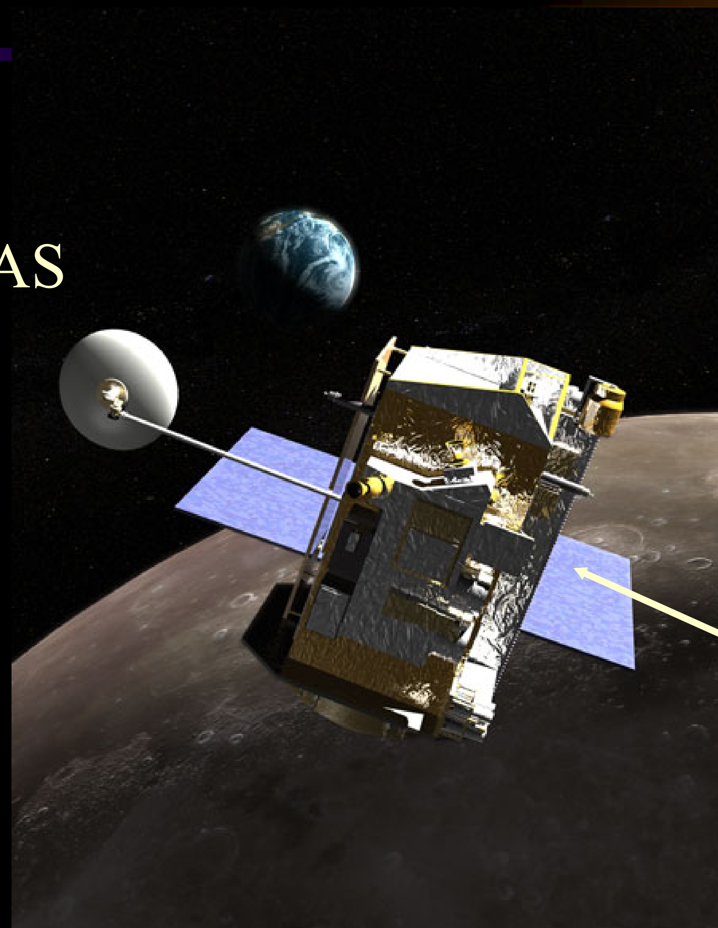
Lunar Recon Orbiter : Laser Ranging and Altimetry

HGAS

Receiver Telescope mounted on HGA and a fiber array to route signal from HGA to LOLA



Lunar Orbiter Laser Altimeter LOLA

Deployable HGA will move in x and y via gimbals

Fiber bundle will be routed through gimbals, down boom and to LOLA

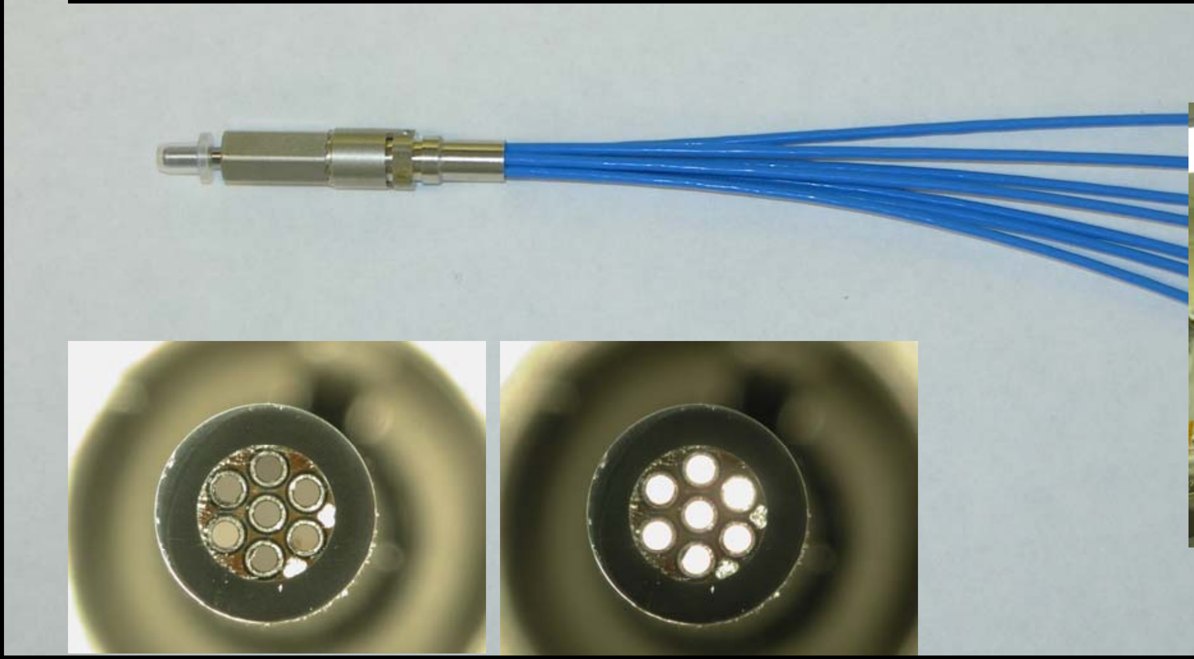
Issues: Cold temperature during gimbal movement, low loss requirements

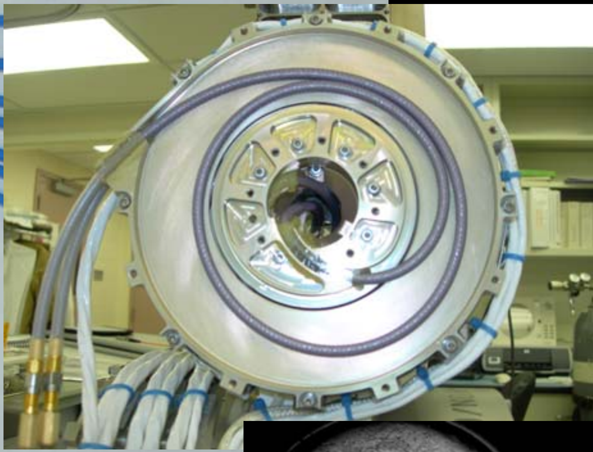
Laser Ranging Requirements

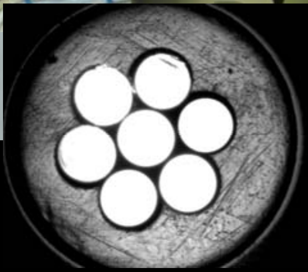
- Receiver optics system fiber bundle array
- 10 m max length of assembly
- 7 fiber bundle from receiver telescope to LOLA, single connector.
- Fiber bundle over moving gimbals in cable wraps.
- Some sections will receive nearly 1 Mrad while cold.
- Budget is 2 dB for all losses including environmental and performance.
- Data from MLA not enough for rad performance extrapolation.

GSFC Optical Fiber Arrays

AVIM connectors with custom drilling (single hole, not LR design) with 300/330 optical fiber Flexlite cable





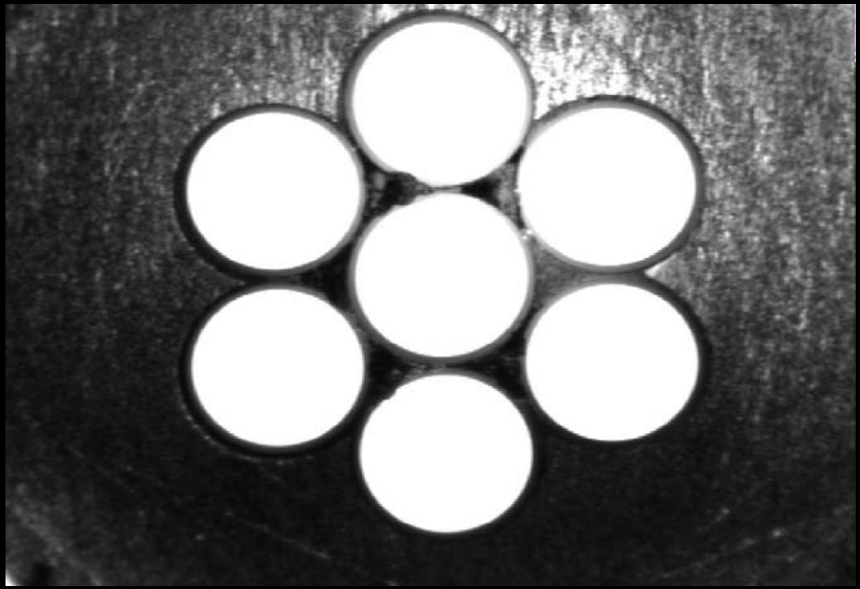


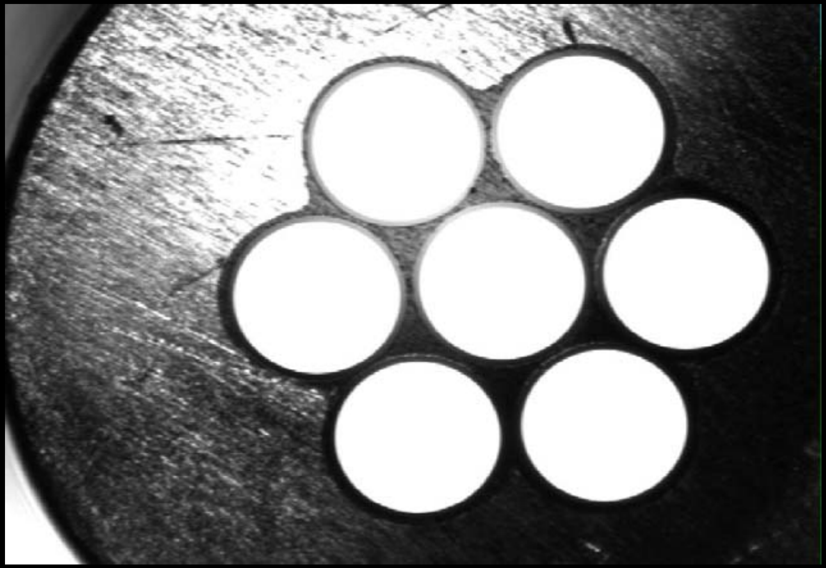
Outgas Testing to ASTM-E595

Diamond AVIMs Right Angle Boot; TML 0.01%, CVCM 0.00%

W.L. Gore Outer Jacket PFA for over metal braid; TML 0.01%, CVCM 0.00%

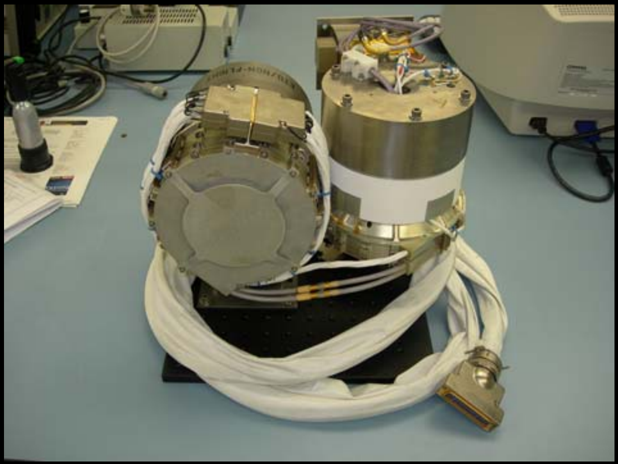
7 Fiber Array in AVIM



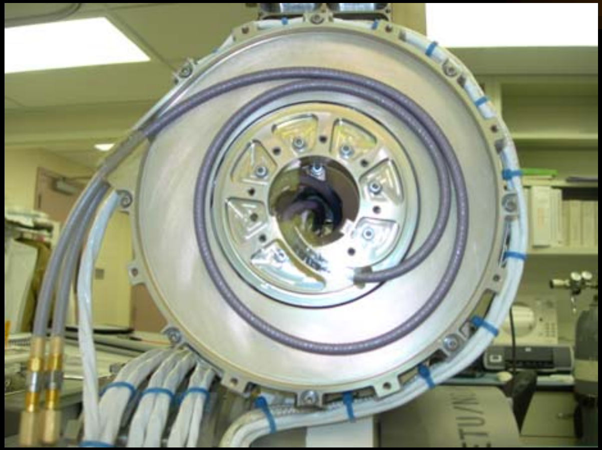


Prototype using aluminum ferrules in PM AVIM

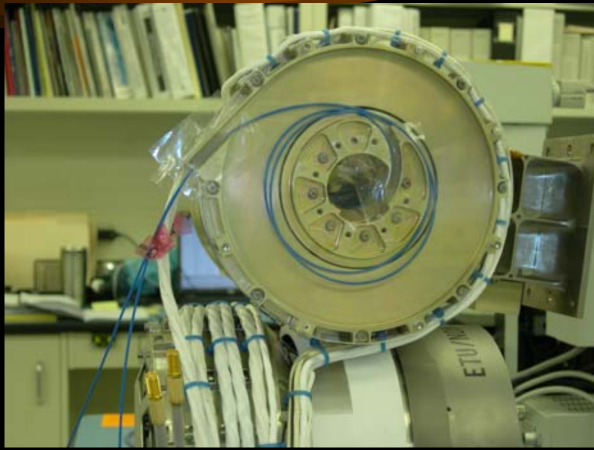
LRO Ranging Pre-Qualification Test



Gimbals



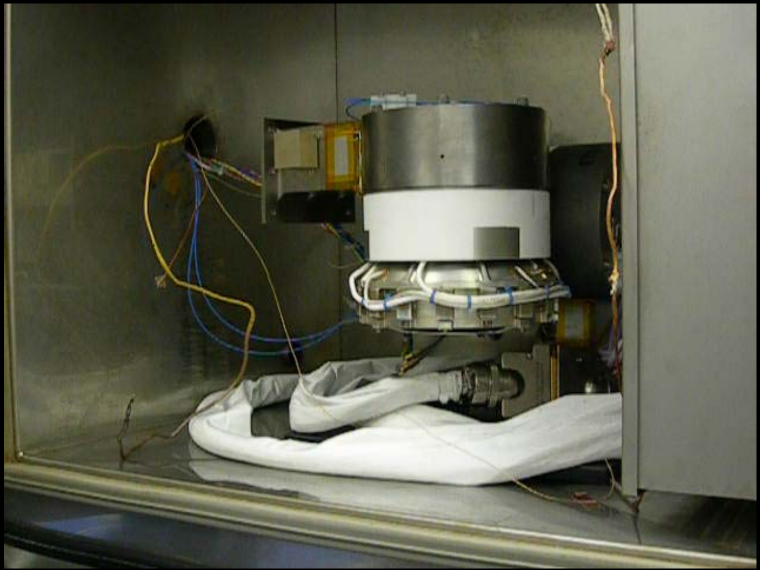
Window inside gimbal; RF cable wrap



Window inside gimbal; Flexlite MLA cable wrap inside gimbal

Fiber optic cable (4 m) gimbal test inside of thermal chamber monitored in situ @ 850 nm

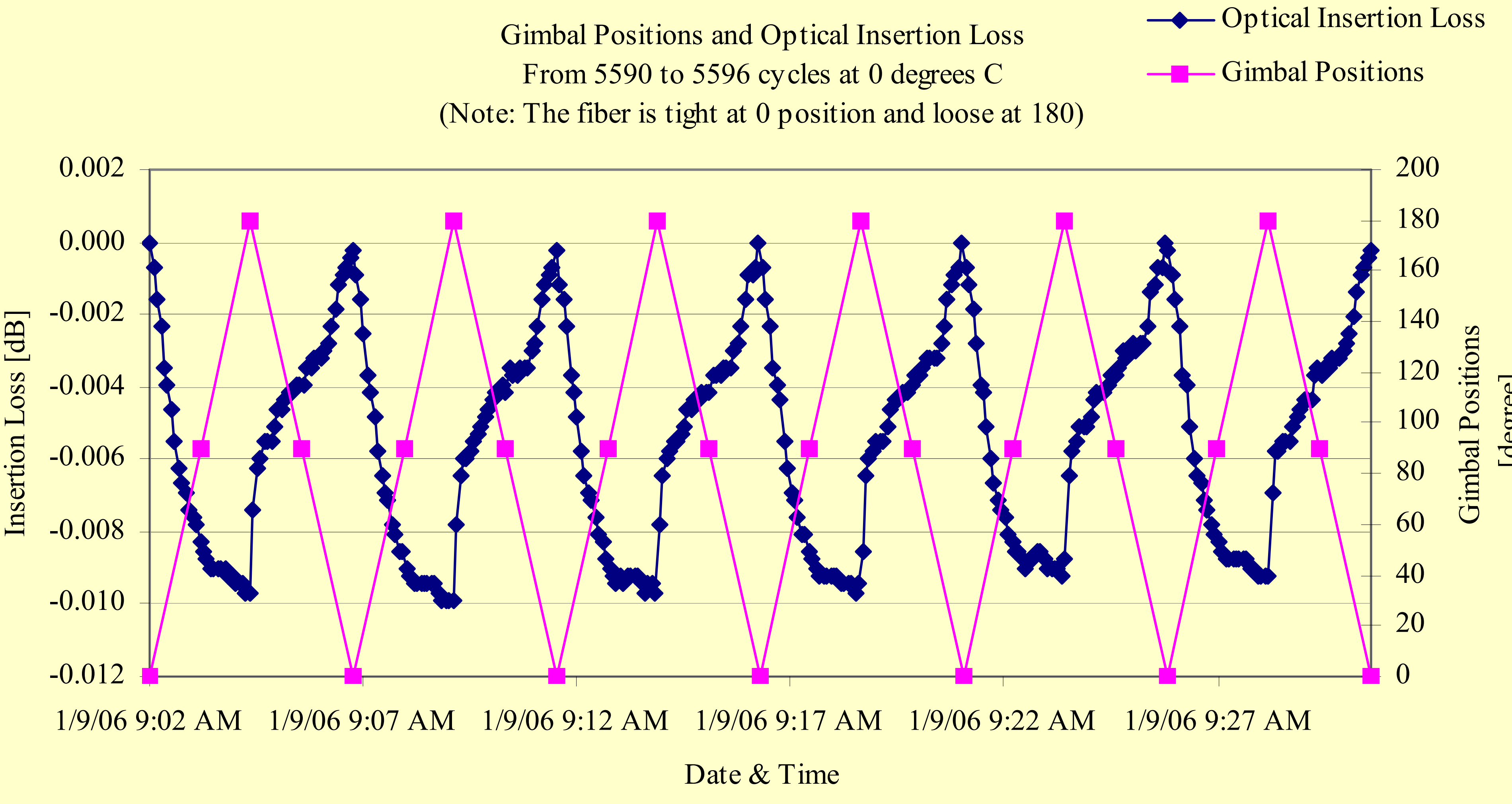
Each gimbal cycle up and back is 4 min 45 sec



Cable wrapped through twice, in constant motion to 5000 cycles per temp for 3 temps; 0°C, -10°C and -20°C

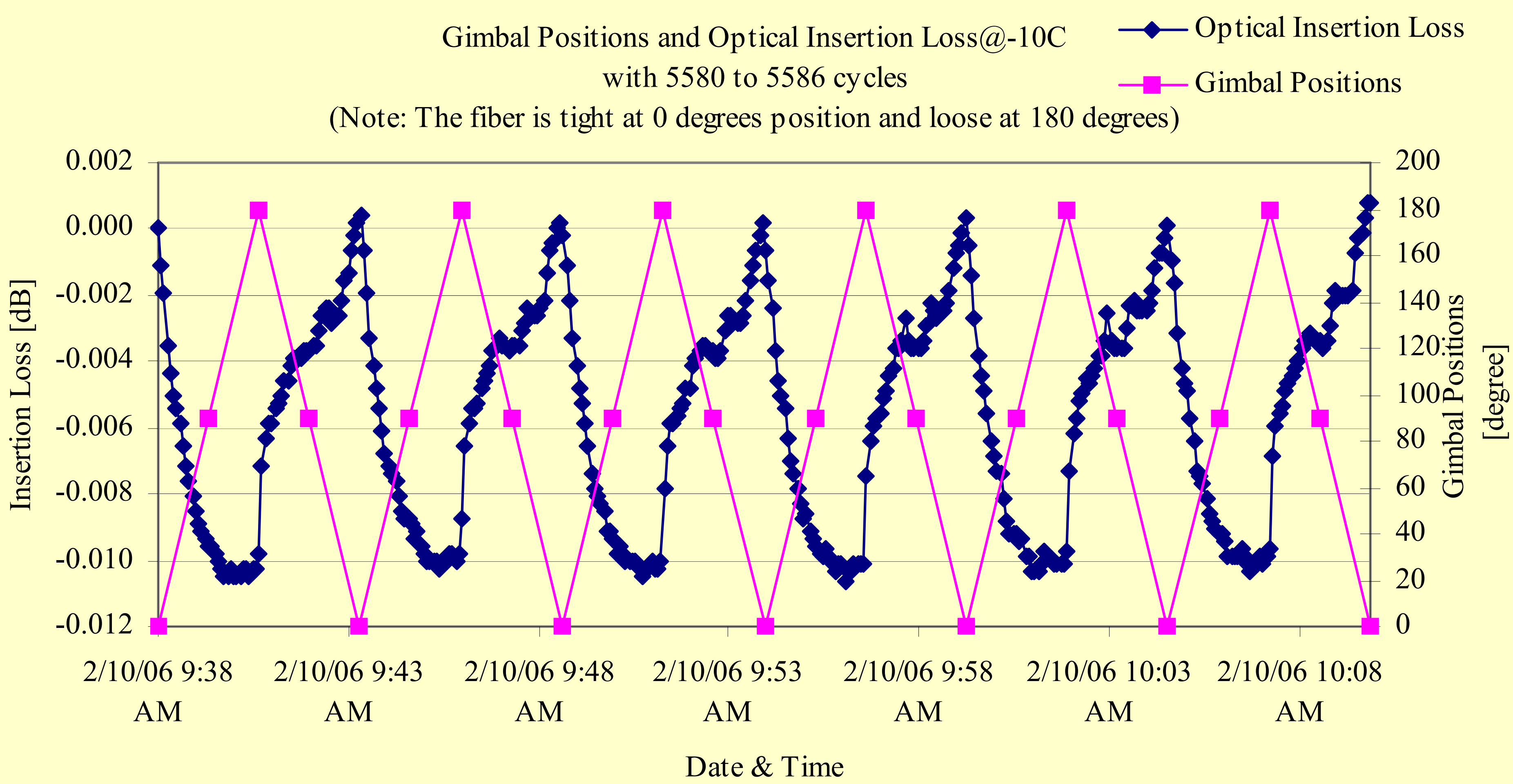
LRO Ranging and Altimetry Gimbal Test

Results of Test 1 at 0°C, Last few gimbal cycles, flex losses < 0.010 dB



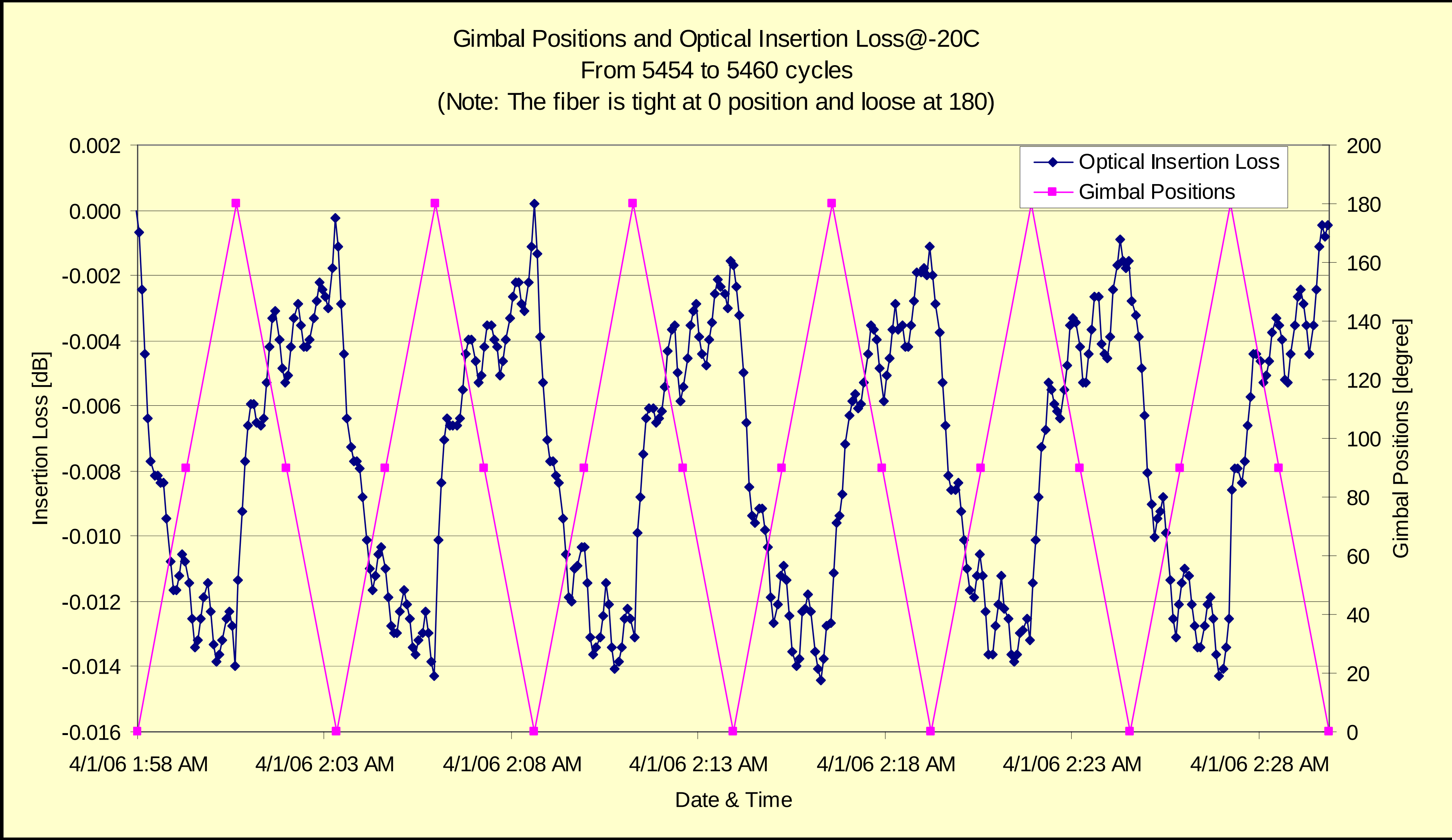
LRO Ranging and Altimetry Test

Results of Test 2 at -10°C, Last few gimbal cycles, flex losses < 0.012 dB

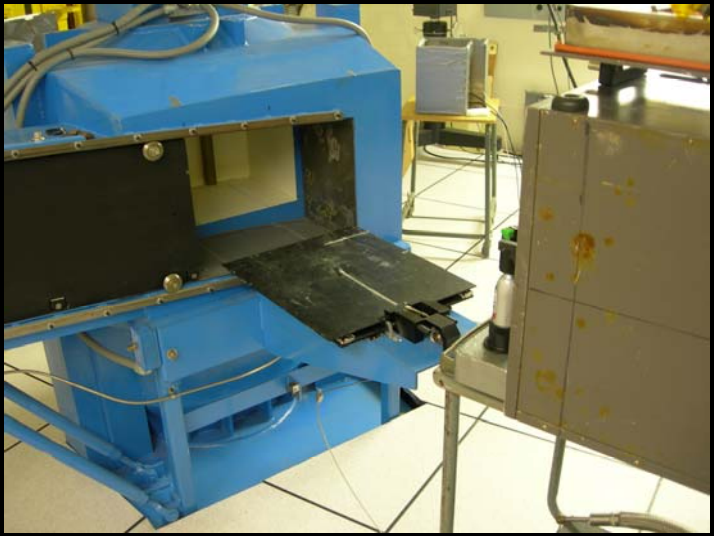


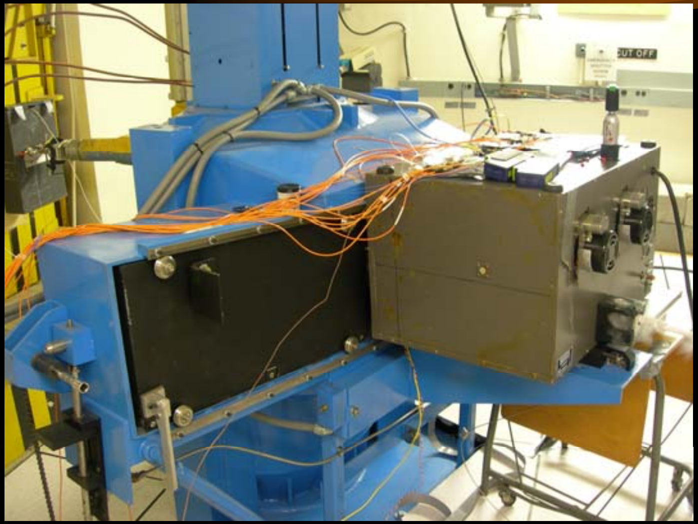
LRO Ranging and Altimetry Test

Results of Test 3 at -20°C, Last few gimbal cycles, flex losses =< 0.014 dB

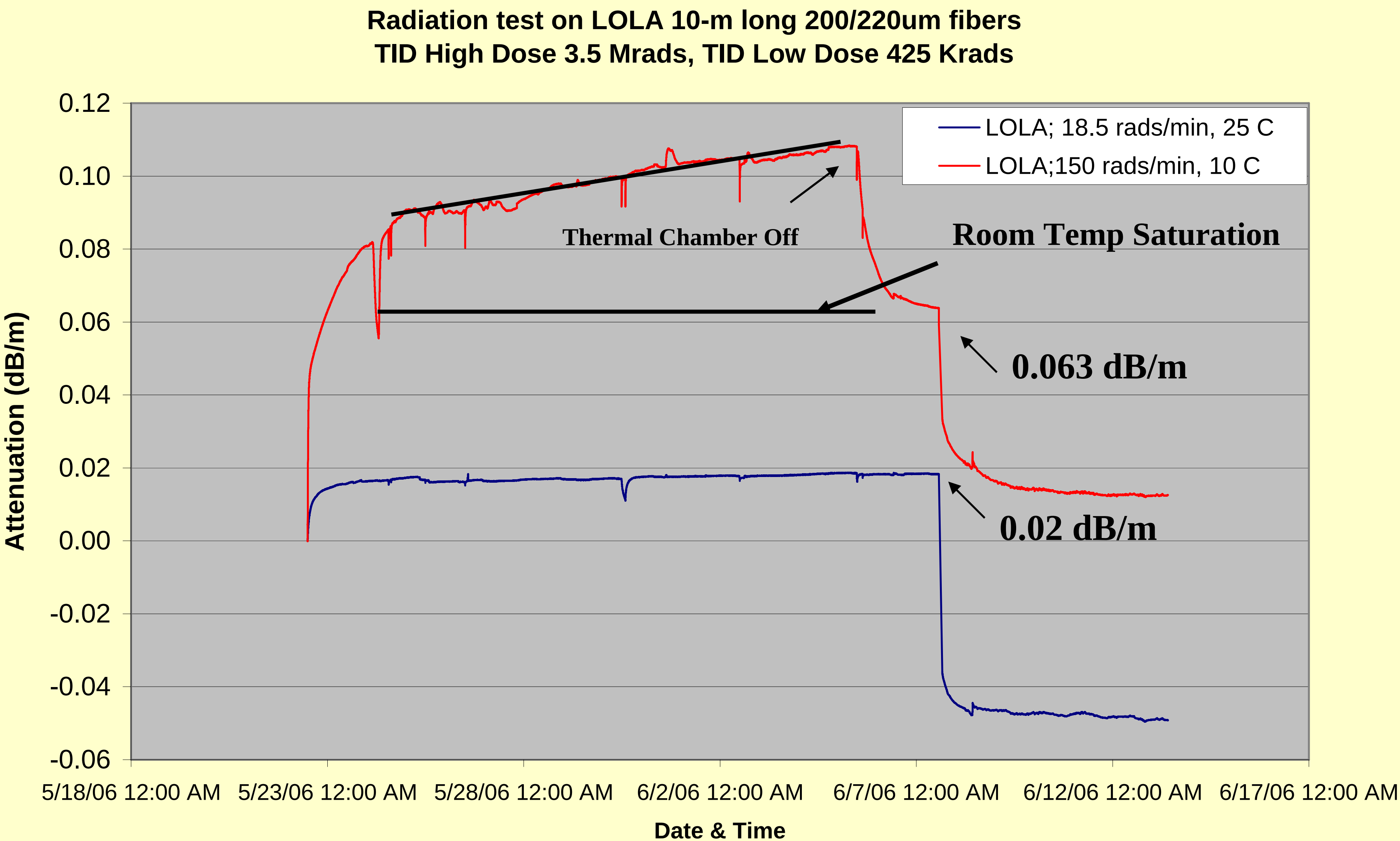


Radiation Testing LR-LOLA





Laser Ranging Radiation Prequal Test Results



Hytrel Diamond AVIMs boots- beyond 1 Mrad no changes visible.

Radiation Model & Summary

Dose rates less than 18 rads/min, 850 nm

$A(D) = 4.21 * 10^{-3} \ \Phi^{0.904} \ D^{0.096}$ dB/m, Room Temp

$A(D) = 4.21 * 10^{-3} \ \Phi^{0.672} \ D^{0.328}$ dB/m, -30°C

$A(D) = 4.21 * 10^{-3} \ \Phi^{0.500} \ D^{0.500}$ dB/m, -70°C

14 Month Mission

Laser Ranging results; exposed sections, 782 Krads, -70°C,

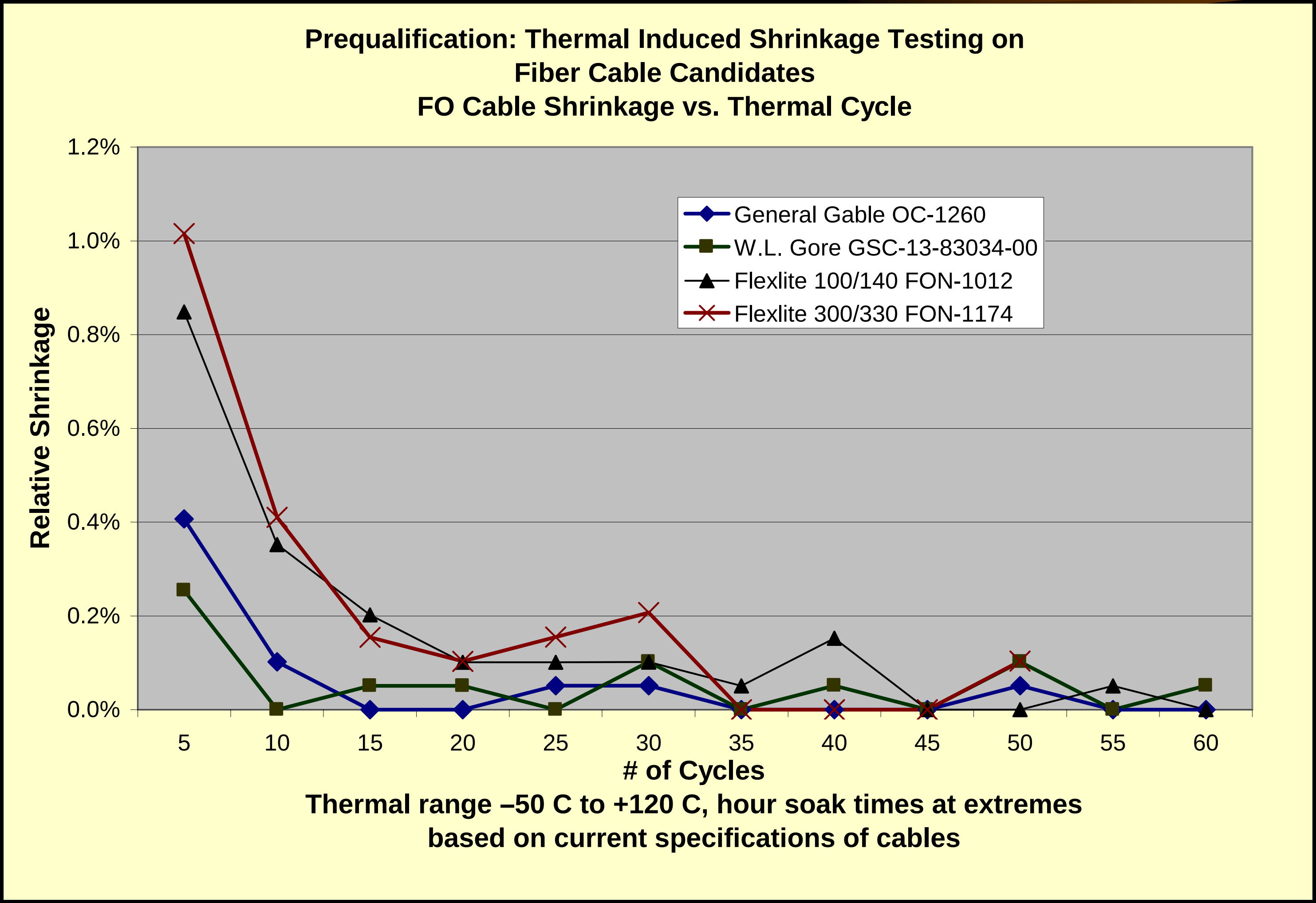
4.21 dB/m, for 0.5 m section ~ 2.1 dB.

532 nm losses will be higher

LOLA Results; shielded, 10 Krads, -30°C,

.005 rads/m, for 0.5 m losses negligible and at 1064 nm.

ISS Cable Candidates; Thermal Screening for Shrinkage



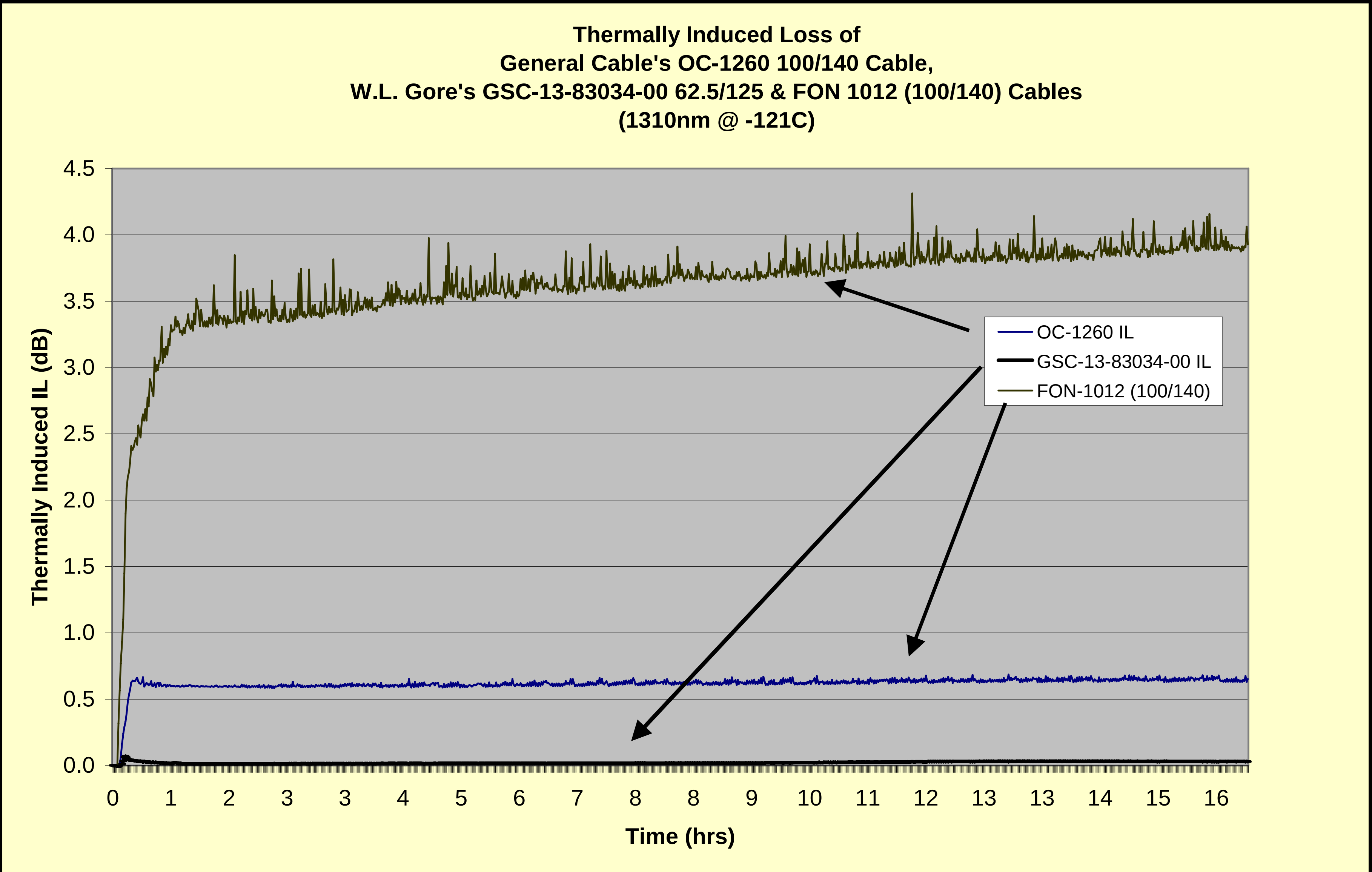
Because fluoropolymers have thermal shrinkage issues.

ISS Cable Candidates; Thermal Pre Qual, -121°C

Manufacturer	Part Number	Fiber Type	Thermal Range
W.L Gore	FON1012, FLEX-LITE™	OFS BF05202 100/140/172	-55 to +150°C
General Cable	OC-1260	Nufern (FUD-2940) 100/140/172	-65 to + 200°C
W.L Gore	GSC-13-83034-00 1.8 mm	Nufern (FUD-3142) 62.5/125/245	-55 to +125°C

The above cable candidates were tested for 16 hours at -121°C

ISS Cable Candidates; Thermal Pre Qual, -121°C



Conclusion

Upcoming testing and results for next year;

Radiation

- LRO Flight Radiation Test for 400/440 in Flexlite @ 532 nm
- ISS Candidate Testing, Test for 100/140/172, .30 NA @ 1310 nm
- 1550 nm Photline Modulator
- Fiber Amplifier Candidate Testing.

Thermal and Vibration Testing

- LRO Flight Gimbal Life testing at – 20 C
- LRO FOB/AVIM Connector
  Vibration and Thermal Cycling Requirements Validation
- LRO Fiber Optic Bundle Thermal Validation Testing
- ISS Candidate Testing for cycling and prolonged cold temperature.

Thank you for the invitation.

For more information please visit the website:

misspiggy.gsfc.nasa.gov/photonics

NASA GSFC Code 562 Photonics Group