Design and Performance of a Spectrometer for Deployment on MISSE 7

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A spectrometer for reflectance and transmission measurements of samples exposed to the space environment has been developed for deployment on the Materials on the International Space Station Experiment (MISSE) 7. The instrument incorporates a miniature commercial fiber optic coupled spectrometer with a computer control system for detector operation, sample motion and illumination. A set of three spectrometers were recently integrated on the MISSE7 platform with launch and deployment on the International Space Station scheduled for summer of this year. The instrument is one of many active experiments on the platform.

The performance of the instrument prior to launch will be discussed. Data from samples measured in the laboratory will be compared to those from the instrument prior to launch. These comparisons will illustrate the capabilities of the current design.

The space environment challenges many materials. When in operation on the MISSE 7 platform, the new spectrometer will provide real time data on the how the space environment affects the optical properties of thermal control paints and optical coatings. Data obtained from comparison of pre and post flight measurements on hundreds of samples exposed on previous MISSE platforms have been reported at these meetings. With the new spectrometer and the ability to correlate measured changes with time on orbit and the occurrence of both natural events and human activities, a better understanding of the processes responsible for degradation of materials in space will be possible.

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and

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Outline

Evolution

Design

Samples

Performance

Summary

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Factors in the Space Environment Lead to Change

- Atomic oxygen
- Contaminants
  - particulates
  - surface coatings/obscuration
  - chemical reactions
- Solar UV
- Charged particles

Spectrometers in Space?

Optical Properties Monitor (OPM)

AZ Technology and NASA MSFC

Russian MIR Space Station - 1997

8 months on exterior surface

Science Package included:

- Reflectometer
- VUV Spectrometer
- Total Integrated scatter
- Molecular contamination monitor
- Atomic oxygen monitor
- Irradiance Monitor

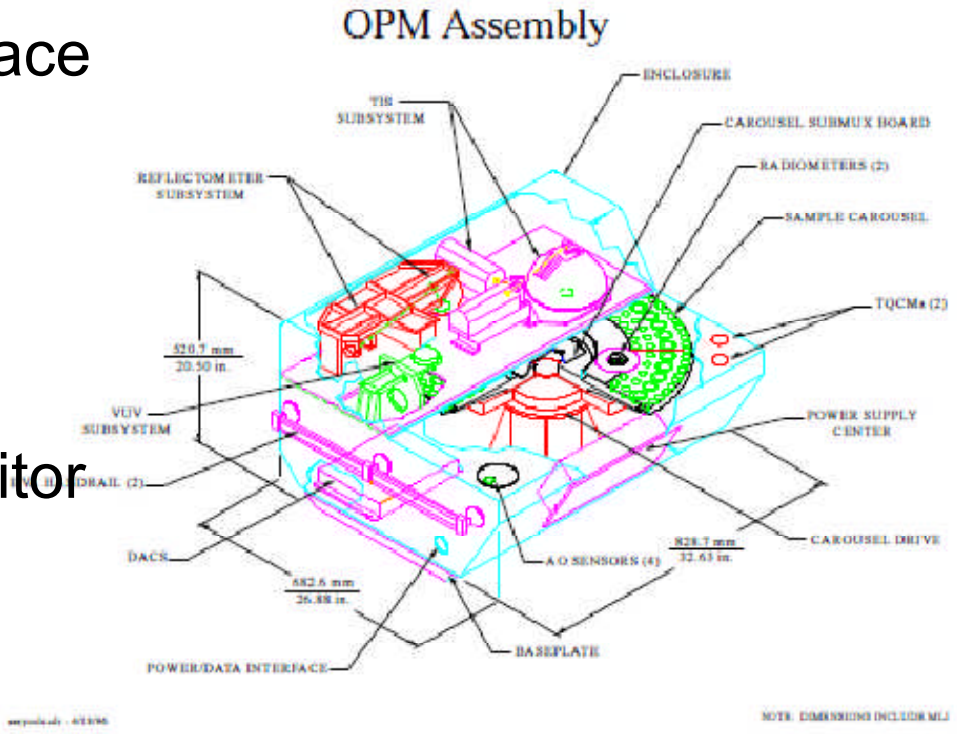
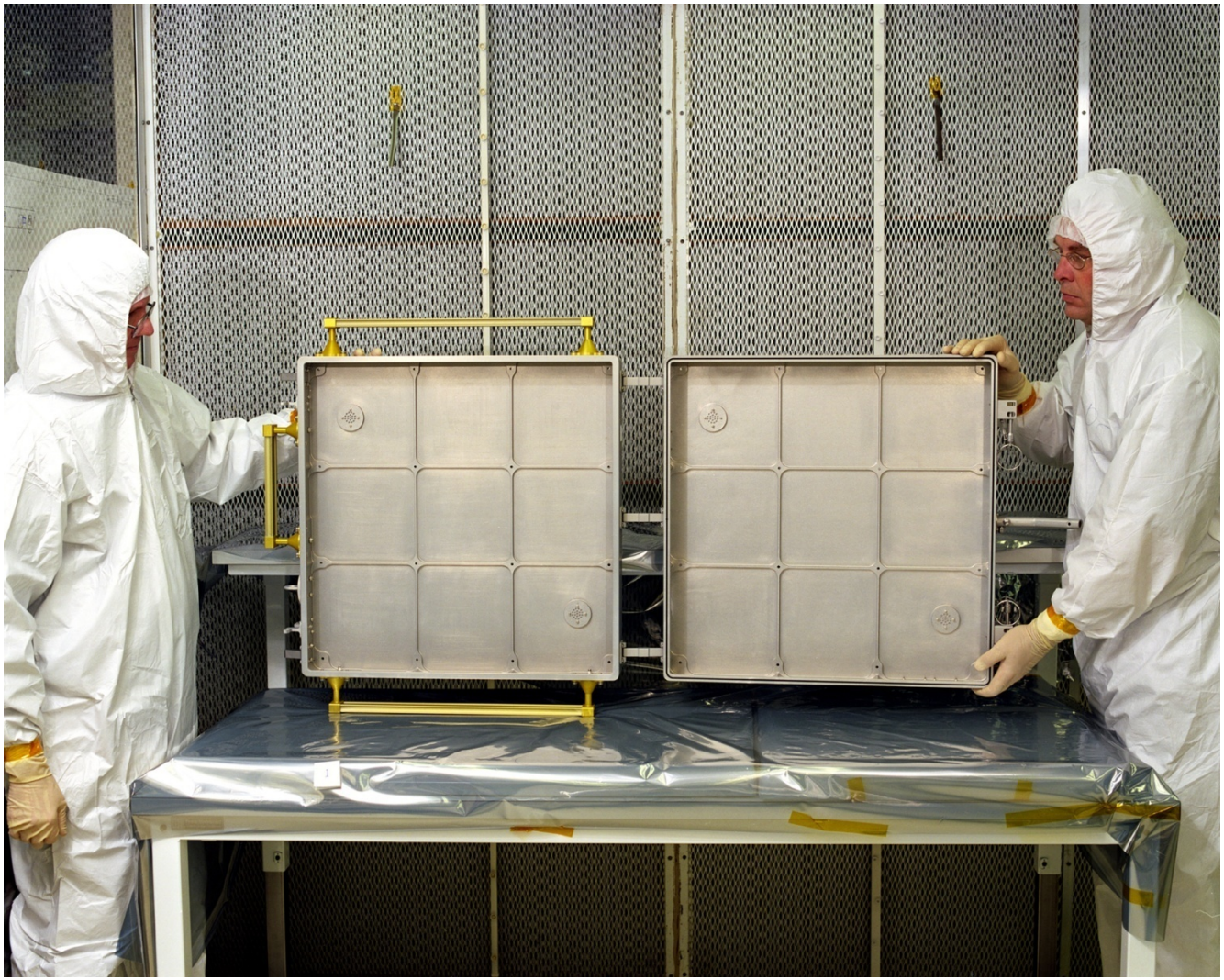


*Figure used with permission from AzTechnology

MISSE PEC

~2 ft x 2 ft Exposure area On each side



NASA IMAGE

The MISSE 7 PEC Layout

PEC baseplate is the integration platform

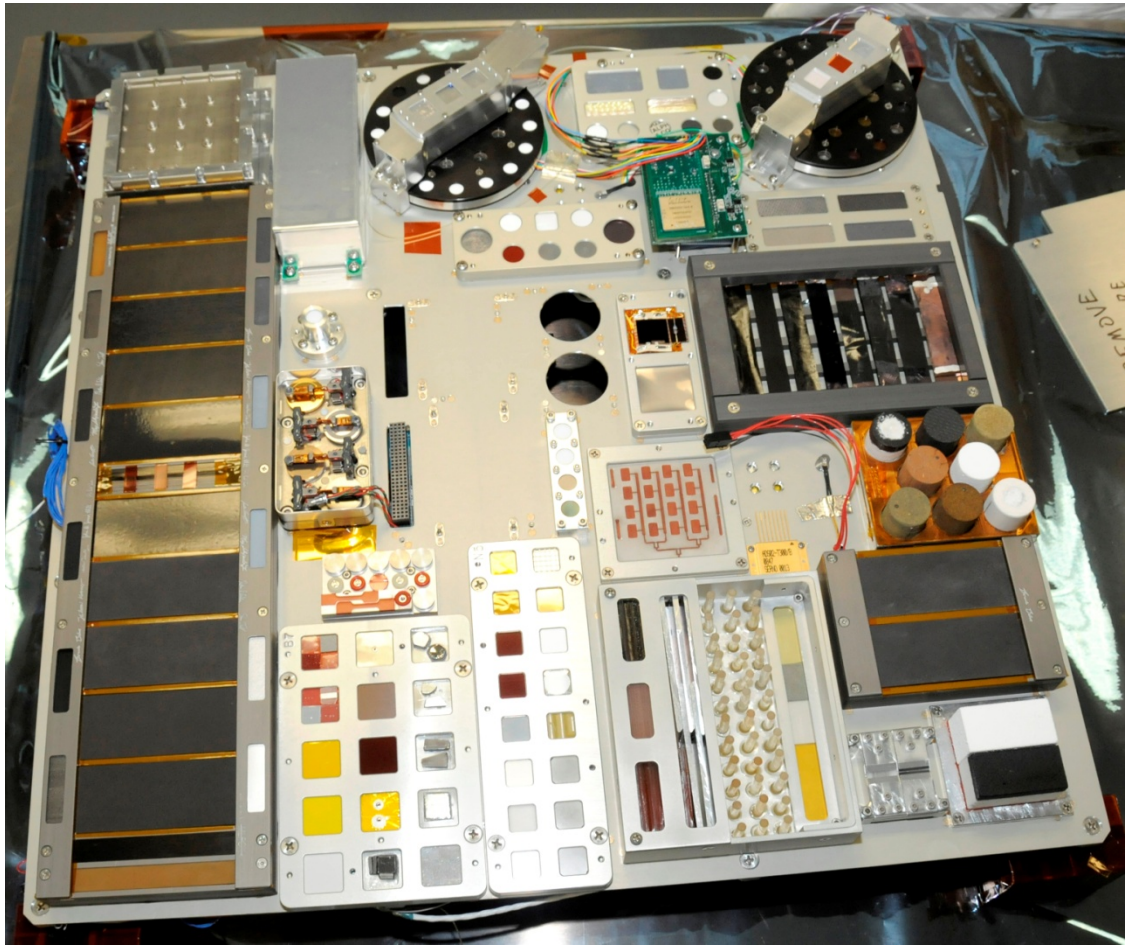
- System Integration, test in one phase
- Commercial computer boards used for control
  - Low power
  - Flash memory
- USB or RS-485 to all instrument packages
- System activated for measurement cycle each day
- Telemetry to ground through ISS link

≈ 48 experiments on the 7B platform

11 active (3 spectrometers)

Baseplate
23.75” x 23.75”

PEC Layout



Ram side, exposed surface with all except one experiment installed.

Spectrophotometer Design

- Commercial spectrometers used
  - Stellarnet BlueWave
- Fiber coupled input
- LED light engine
- Carousel to hold samples
  - motor drive for rotation
  - positioning from Hall sensors
- Reflectance and transmission configurations
- Rapid measurement sequence

Stellarnet BlueWave

Commercial spectrometers

200-1050nm range, 1.6nm resolution

2000:1 dynamic range

Design uses

- holographic grating
- 2048 CCD detector

Powered from USB

(25x75x125mm)

Single strand 400 micron core fiber input

- 2 x UV 100micron bifurcated fibers coupled together
- SMA 905 connector

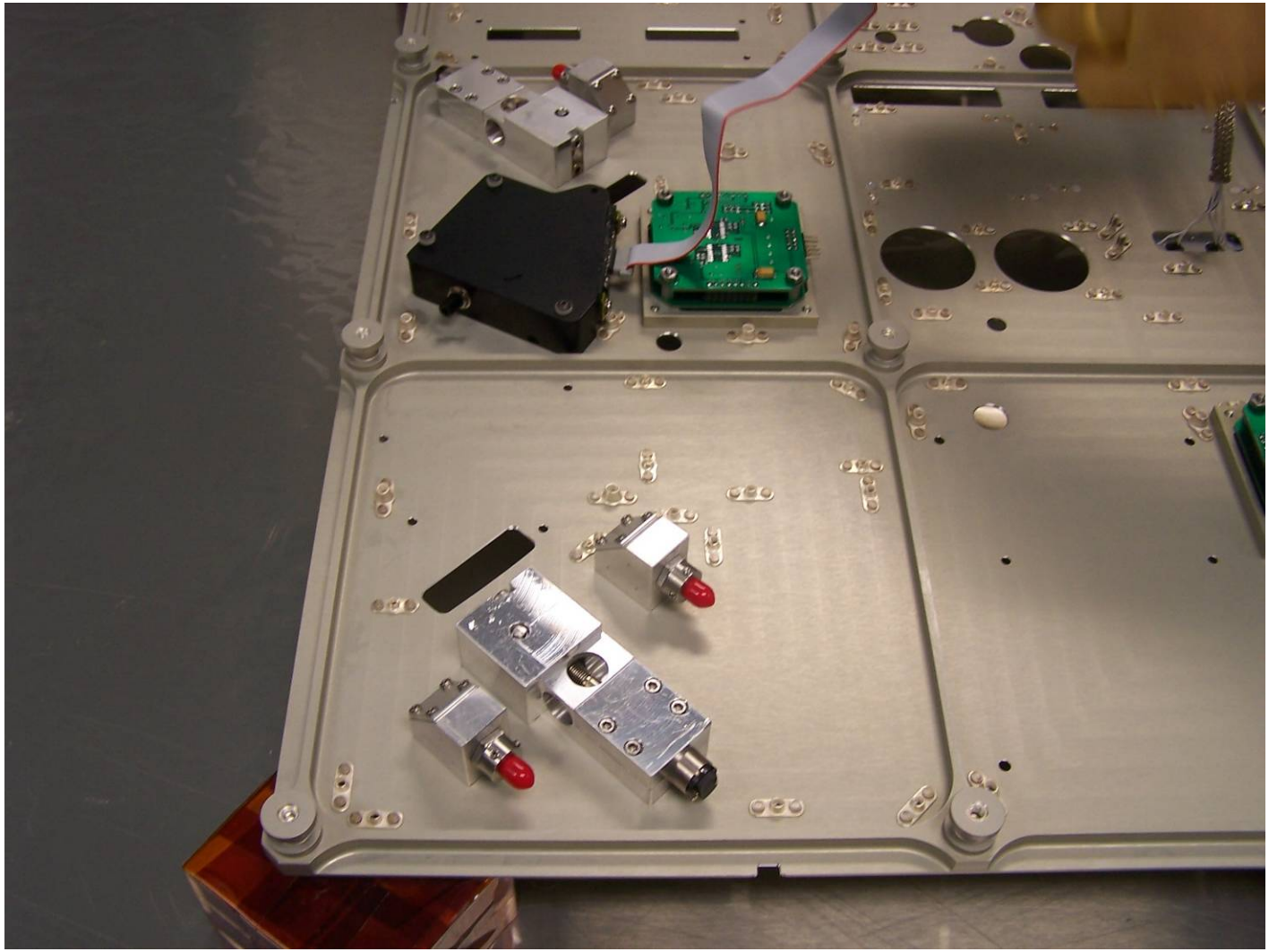
Convenient software

- detector integration time
- spectra manipulation

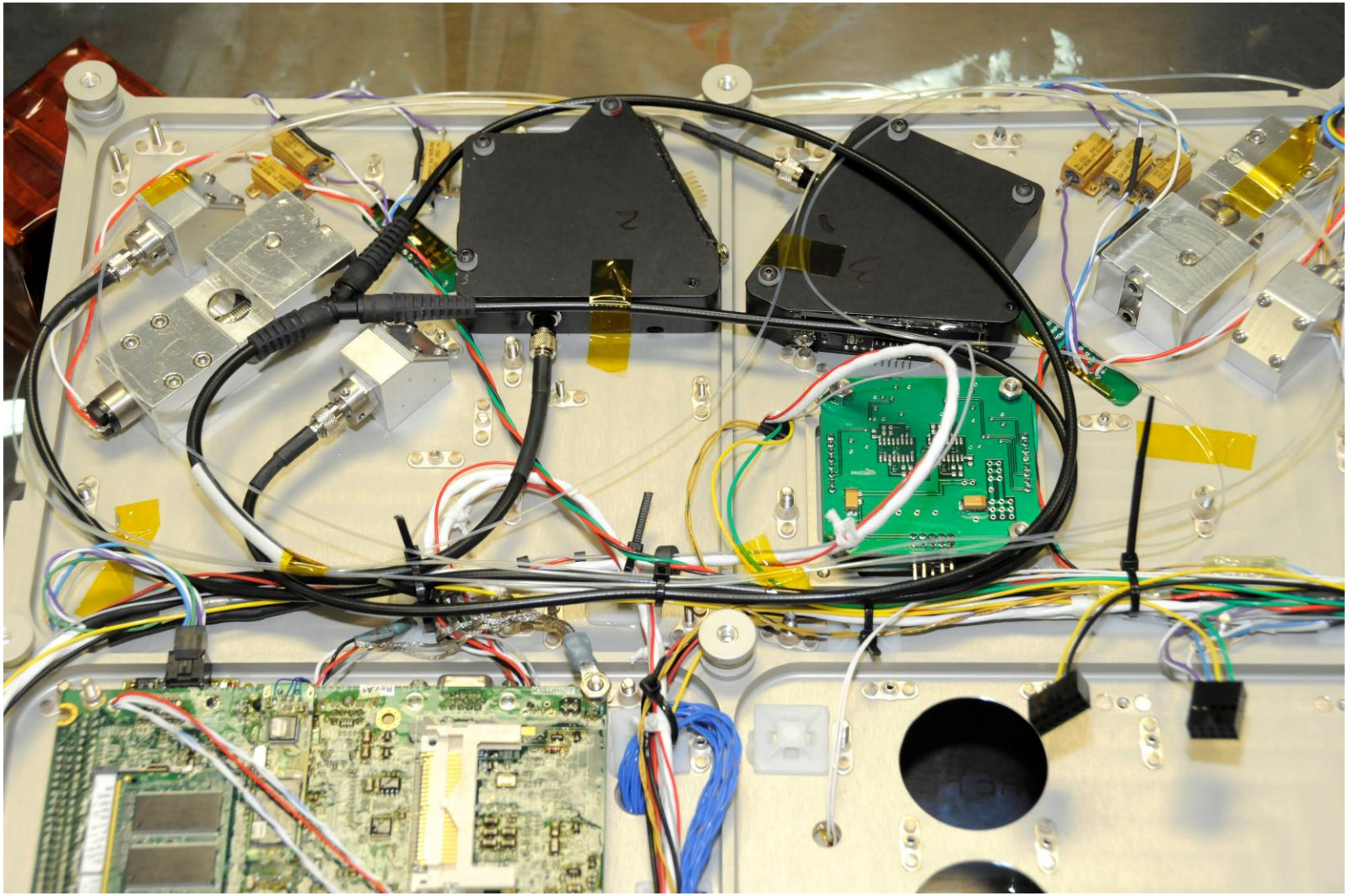
Integration is Always the Challenge

Most experiments were assembled onto both top/bottom sides of PEC baseplate
- Limited space envelope
- Experiment is separated from power/data management
- Point-to-point for all data/control lines, fibers, power

Spectrometers were assembled on both surfaces of the PEC baseplate
- Motors and the Bluewave spectrometer were located below the baseplate
- Optics were both above and below the baseplate

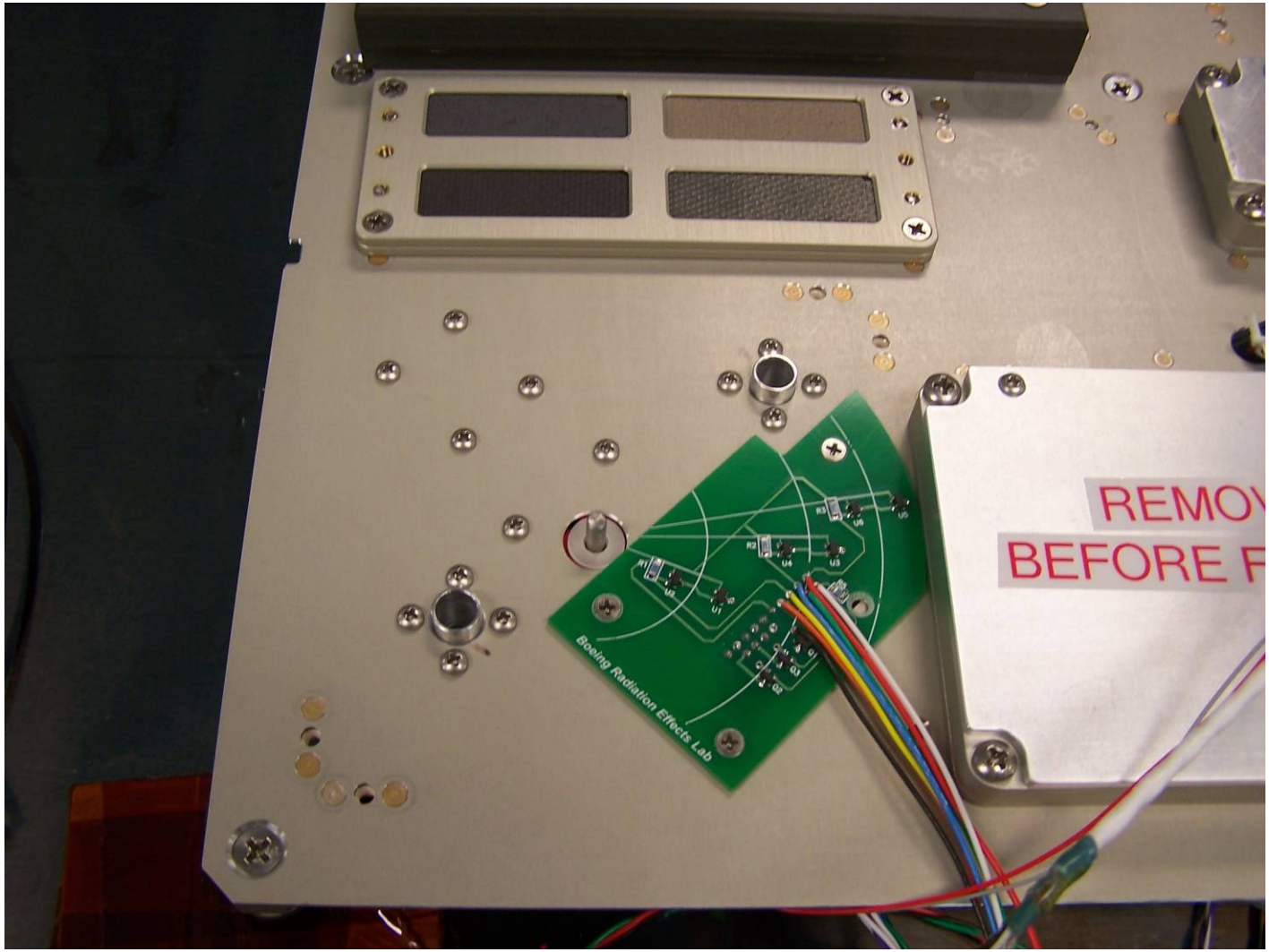


View underneath baseplate with motor, spindle, and optics installed

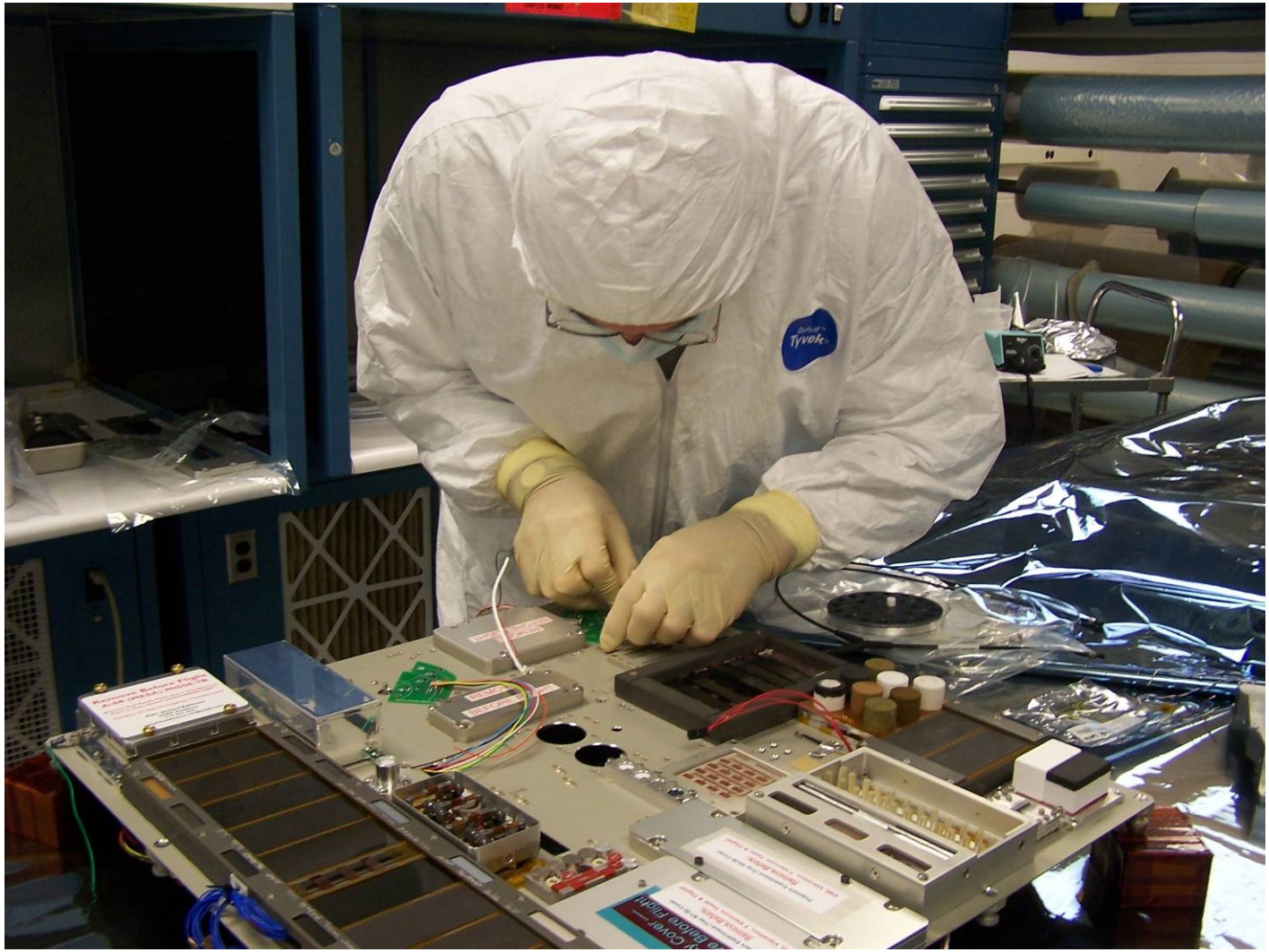


View underneath baseplate with everything installed.

Motor, spindle, and optics installed

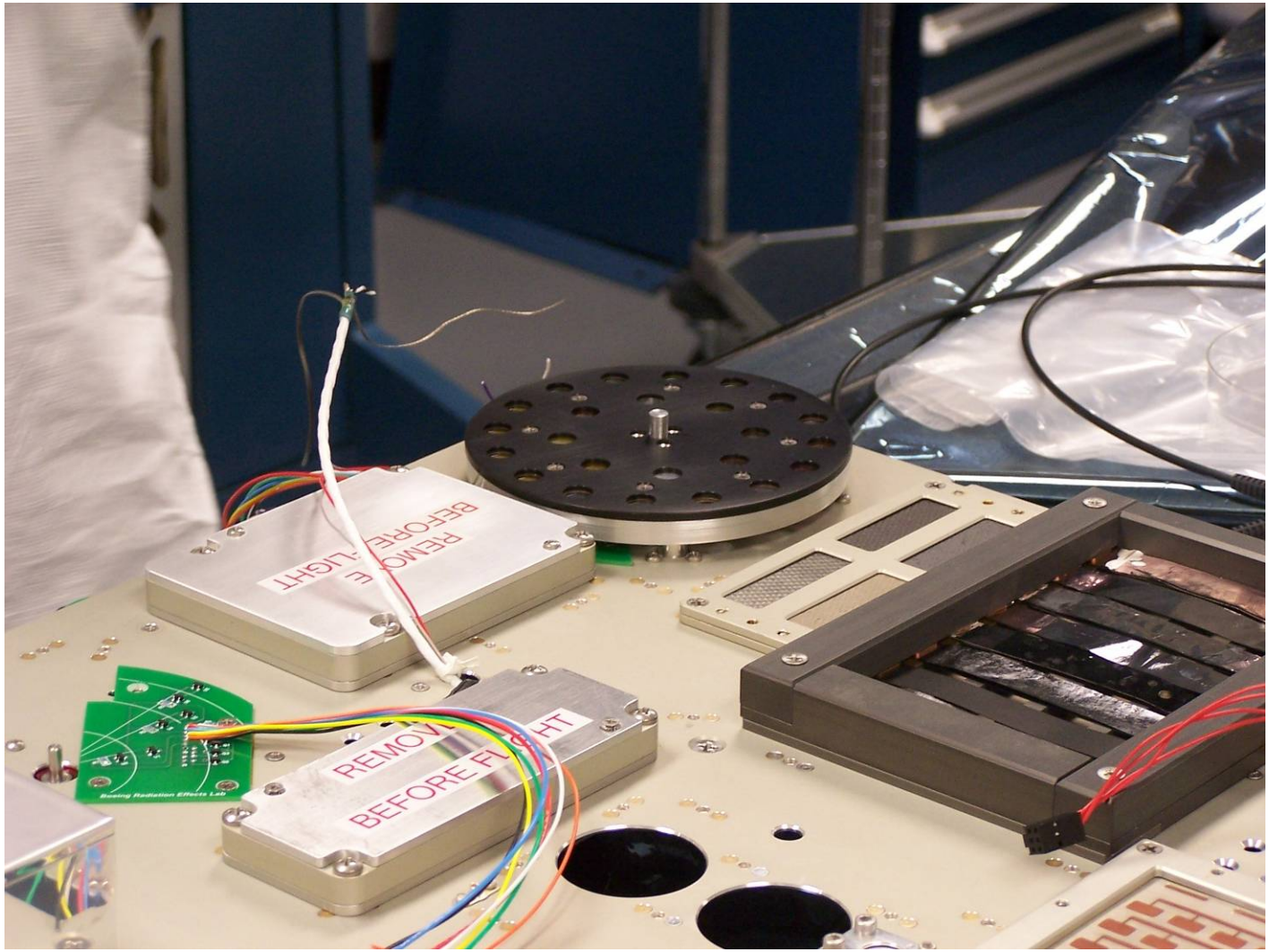


Positioner electronics installed

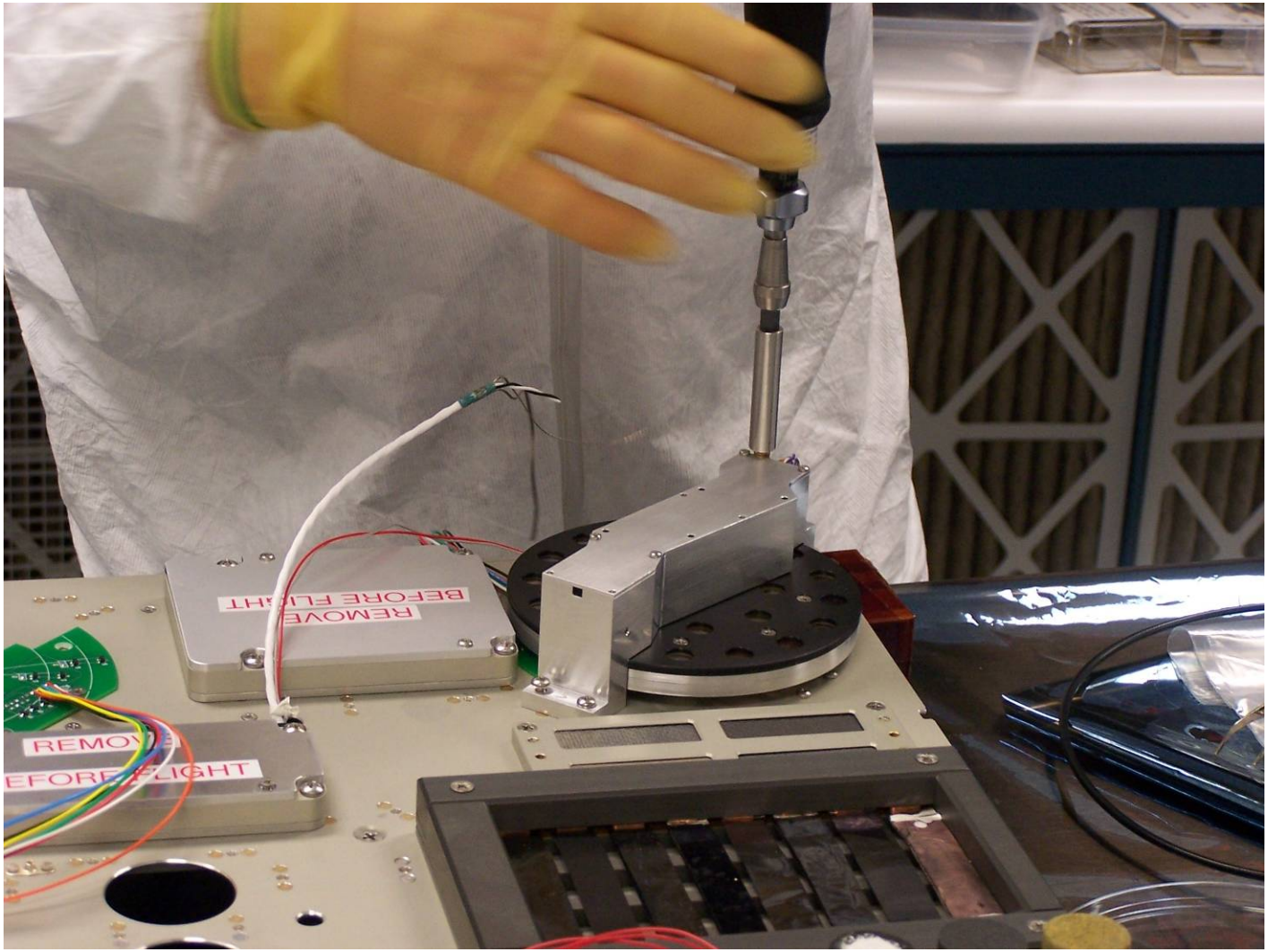


Andy Robb installing the Hall sensor boards

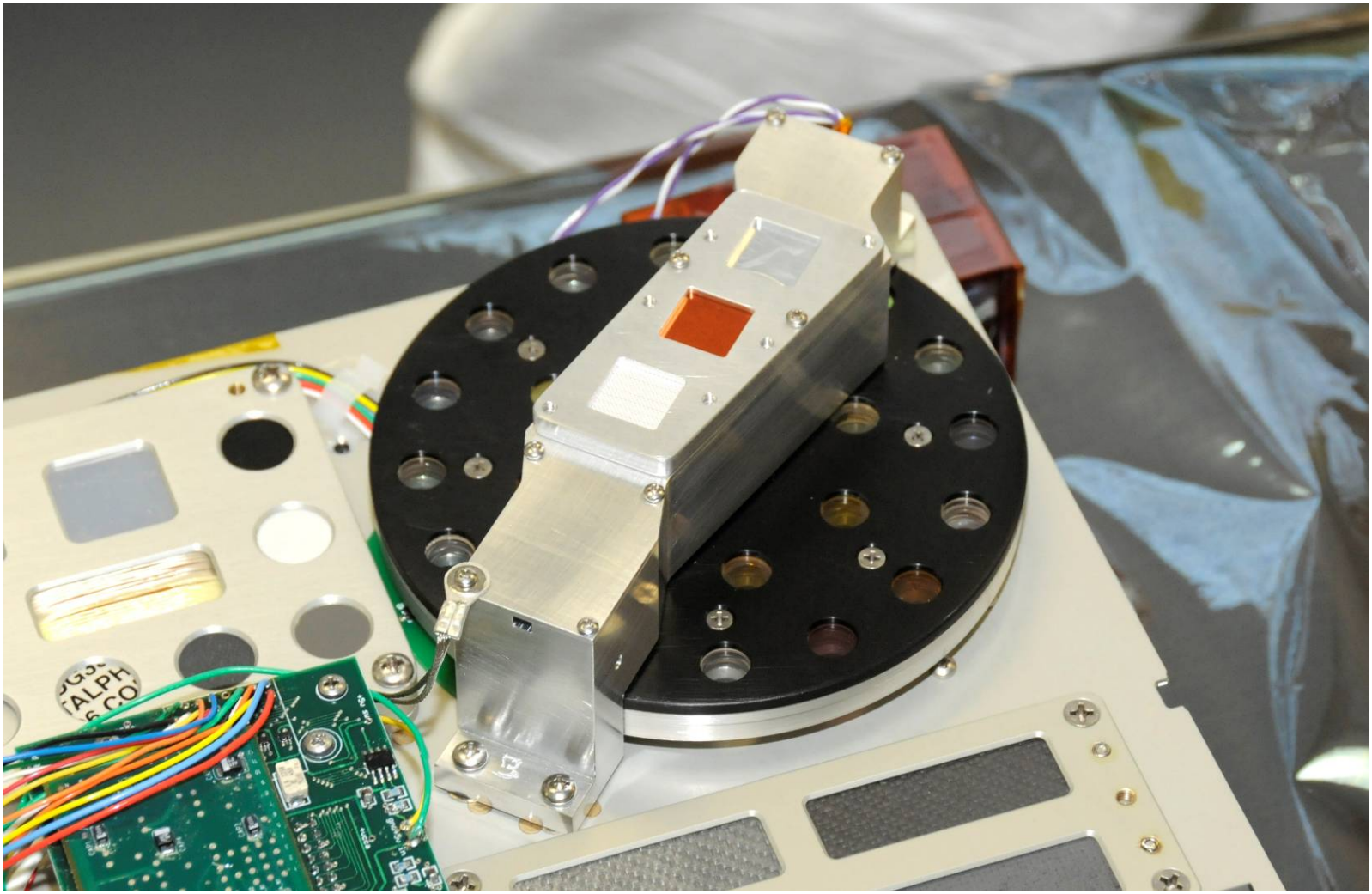
Gary and Jim install a Carousel



Carousel installed

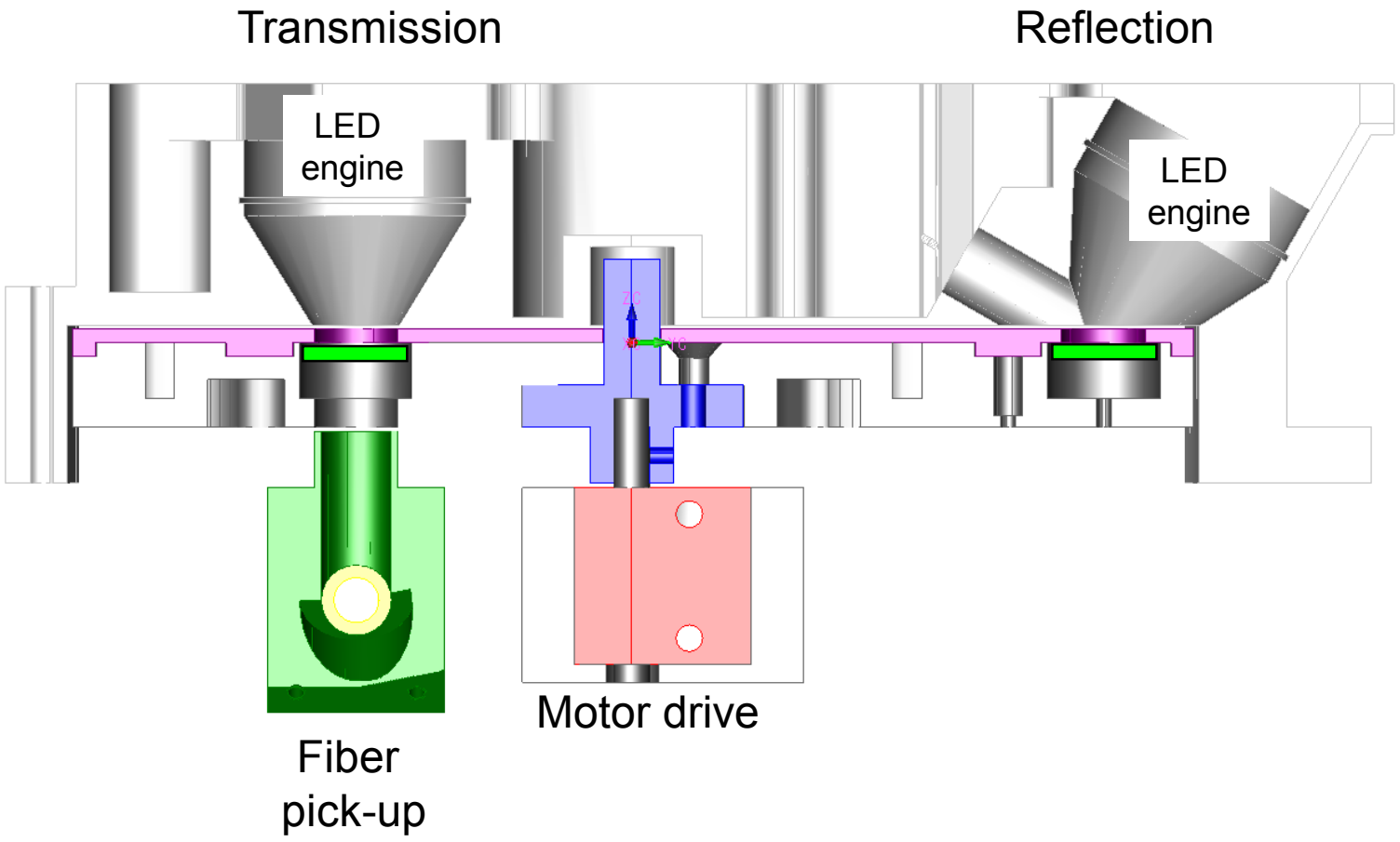


Light bar installed

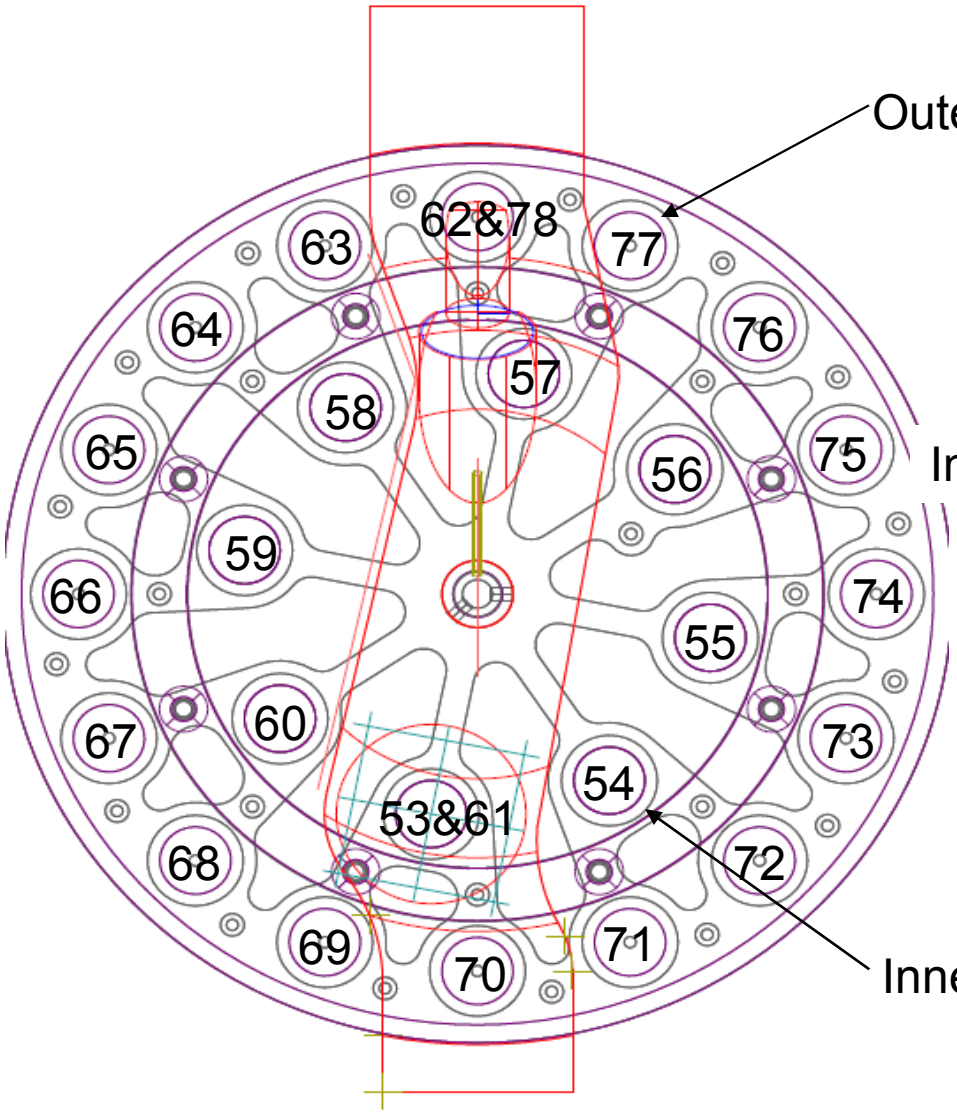


Final configuration with passive exposure samples mounted on top surface of light bar

Cross Section view of Carousel and Light Bar



Wake Spectrometer – Boeing 2

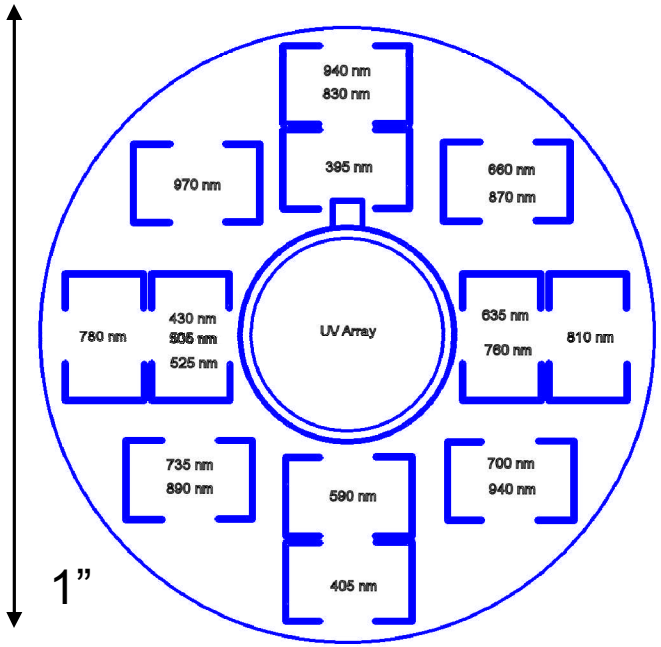


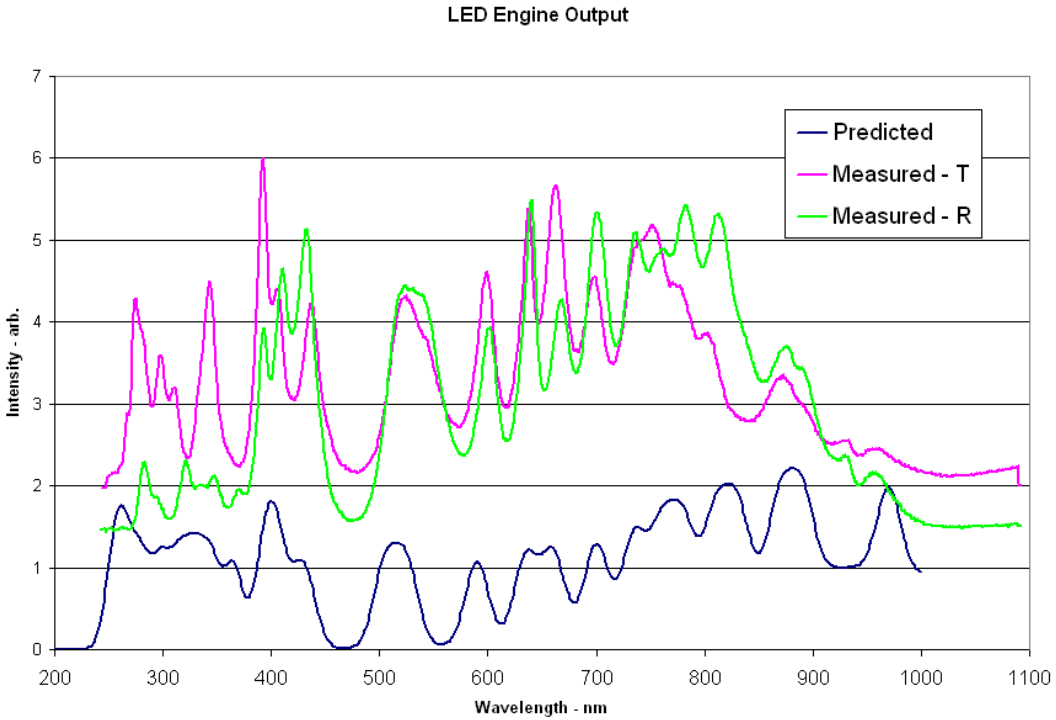
Outer row for Reflection Samples

Inner row and outer row are offset

Inner row for Transmission Samples

LED Light Engines





The Light Engine is fabricated from smd devices for discrete wavelengths
UV array is a TO-100 package with sources at 255, 265, 280, 298, 315, 330, 345, and 365 nm.

Sample Description

Sample format

0.5” diameter

0.001” to 0.125” thick

Samples types

bare fused silica

magnesium fluoride

AR coatings on fused Silica

Al_2O_3 on fused Silica, ZrO_2

SiO_2 on ZrO_2

ZnSe/ThF_4 high reflector

AZ Technology White

AZ Technology Black

…numerous other customer samples

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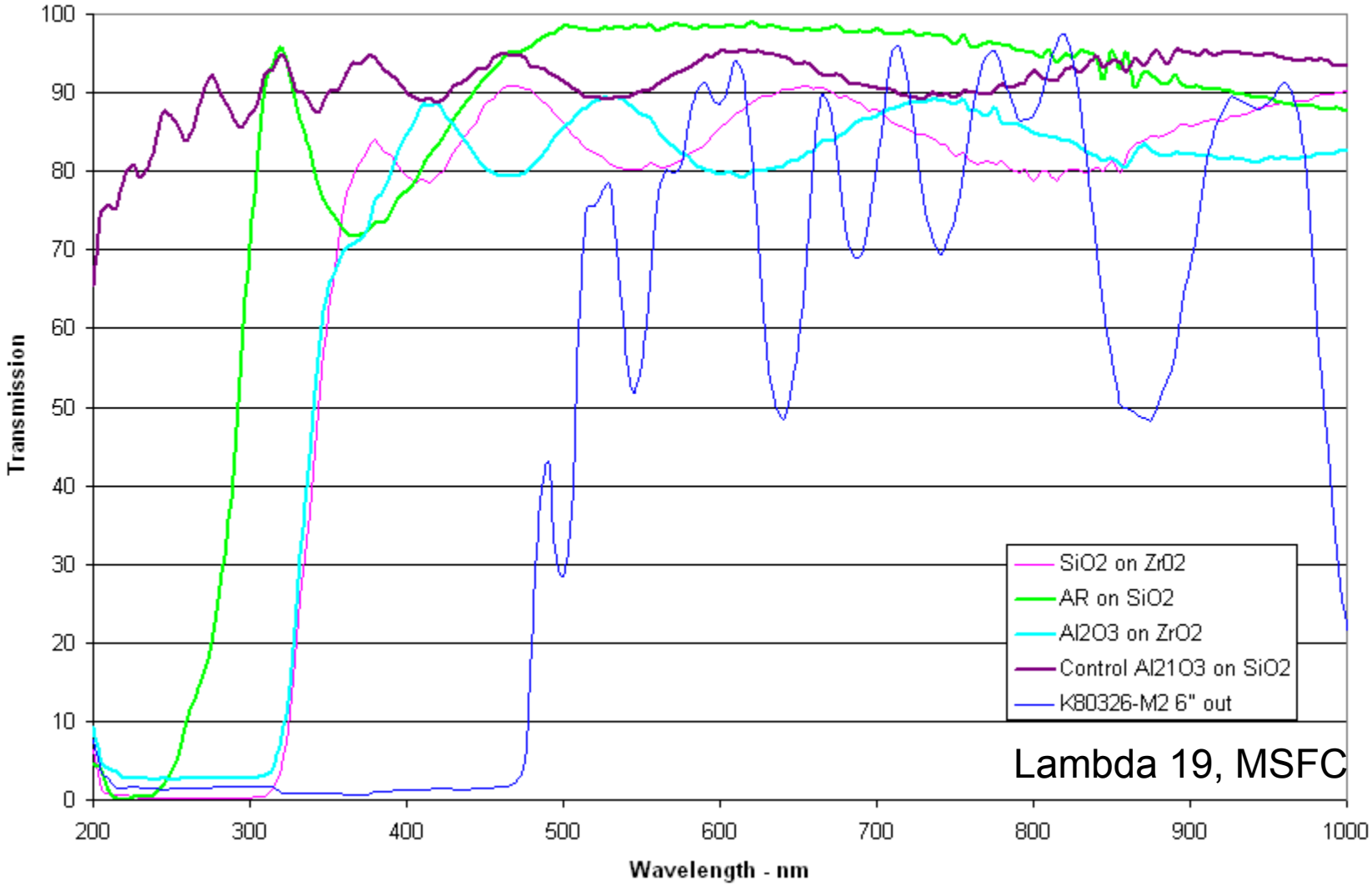
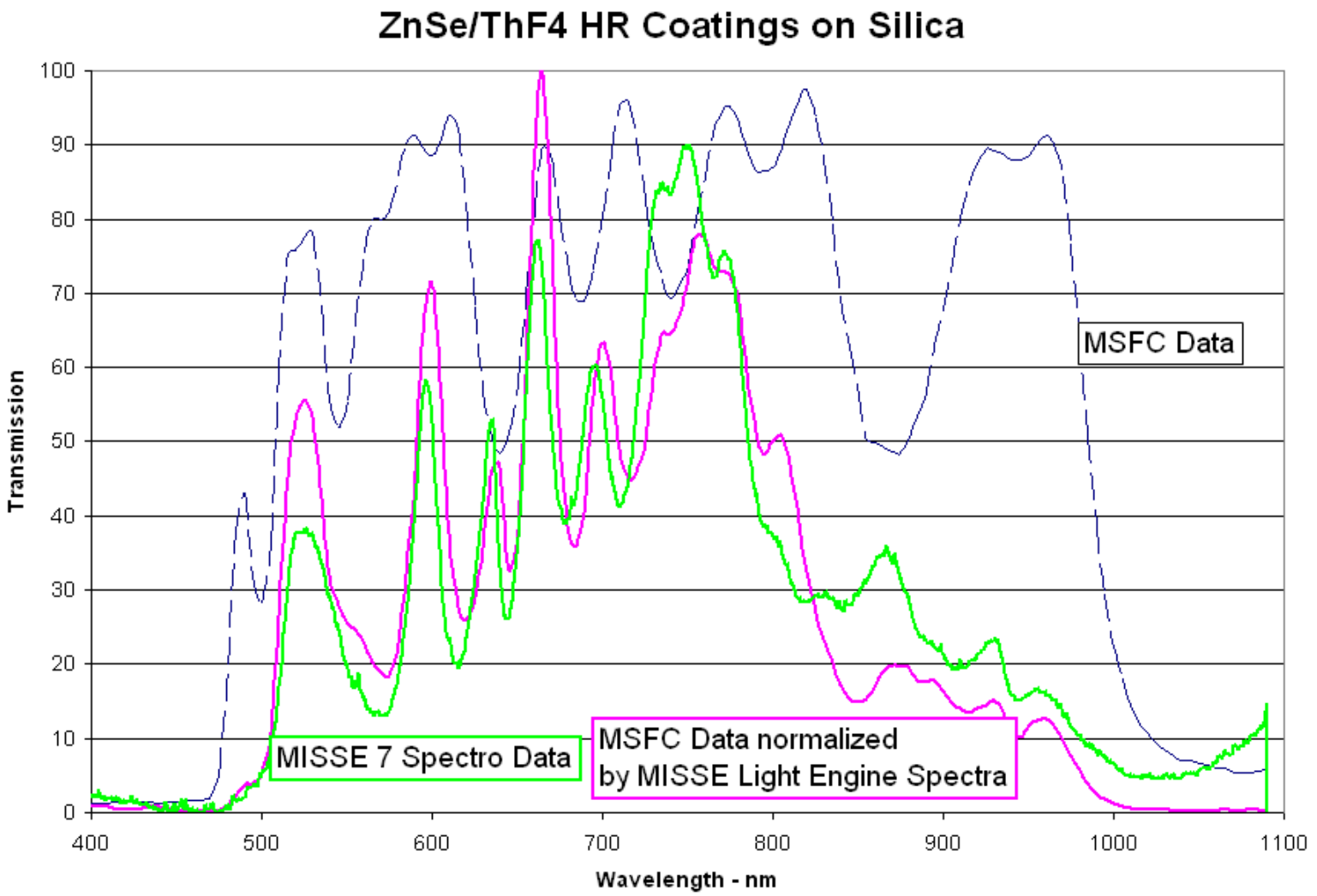
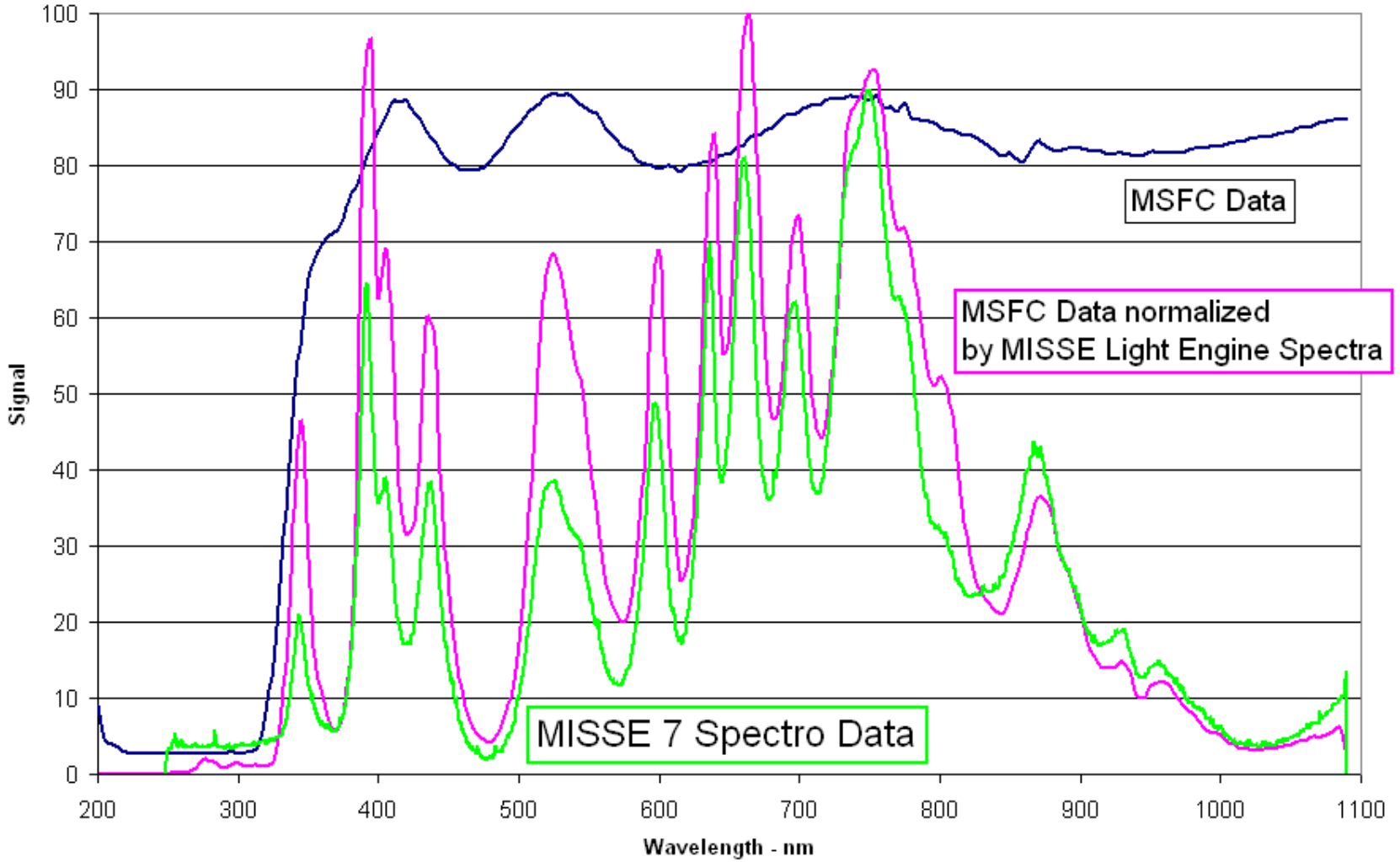
Transmission Spectra of Optical Coating Samples



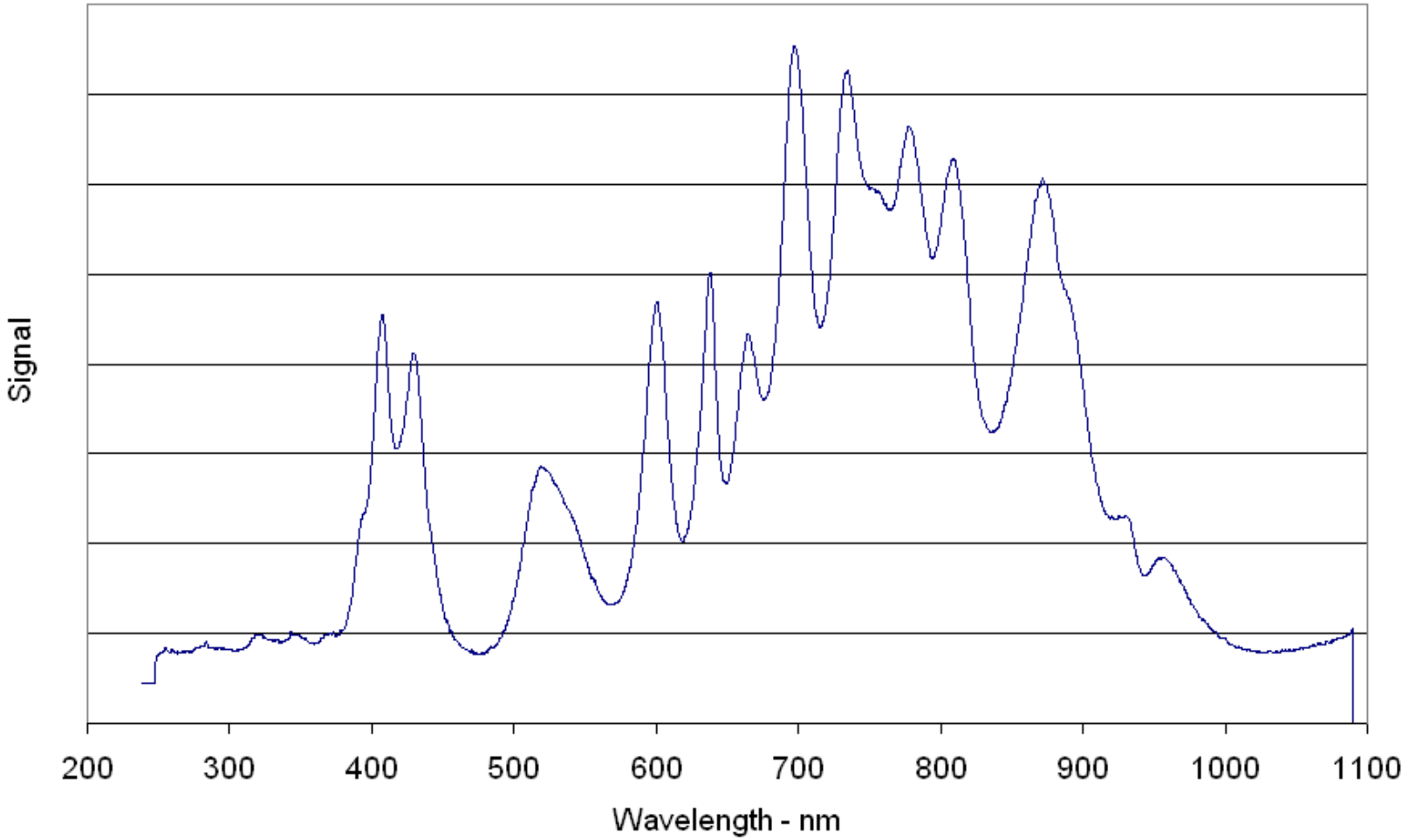
Spectra of High Reflectance Coatings



Spectra of Al2O3 on ZrO2 Samples



Reflection Spectra of AZ Technology White



Summary

- The MISSE 7 spectrometers are a significant step forward
  - Miniaturization
  - Low power consumption
  - Speed
  - Capability appears to be very good
- Data on the ground matches predictions fairly well
  - some variation in amplitudes
    - Nonuniform illumination probably responsible
    - Data is reproducible
  - Measurement of shielded control samples in sequence may provide adequate baseline
- Specific sample designs chosen which may enhance sensitivity to low level contamination

- Launch is later this year!

MISSE 7 is the right platform on which to try a new instrument design and some customized samples