
# The Infrared Spectrograph on the Spitzer Space Telescope

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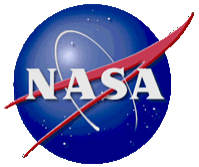
**For the Spitzer IRS Development Team**

**SCIENCE ENABLED BY NOVEL INFRARED INSTRUMENTATION**

**June 26, 2000**

**Ithaca, NY**





# Talk Agenda

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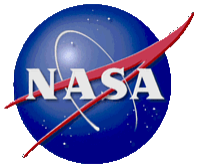
- **IRS – The Early Days**
- **Cancellation – Descope – Rebirth**
- **Development and Testing of the IRS**
- **The IRS Inflight Performance**
- **Some Jim Houck – Centric Photos**





# SIRTF and the IRS
# When "S" stood for Shuttle

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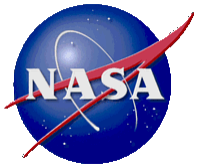
- The IRS had been a part of the SIRFT science instrument complement from the get-go
- The three SIRTF instruments, IRS, IRAC, and MIPS were selected in 1984
- At this time SIRTF was conceived as a re-flyable payload on the Space Shuttler
- When tied to the shuttle:
  - *Two weeks of observations*
  - *Pointings less than35 minutes in duration*
  - *Dodging the Earth, Moon, and Sun*
  - *Fighting with atomic oxygen glow*





# The Original IRS

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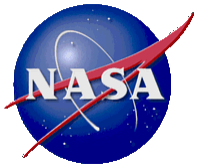
### 3.1.2 Instrument Configuration

The instrument consists of five modular infrared spectrometers located in a single 90° to 120° segment of the Multiple Instrument Chamber (MIC) and the associated electronics equipment located in the SIRTF warm electronics compartment. The spectrometers cover the entire wavelength range with high sensitivity, since the optical design and detector selection are optimized for wavelength and resolution within each spectrometer. The required number of spectrometer modules is kept to a minimum by incorporating several dispersers and several types of detectors in a single spectrometer. The instrument configuration is summarized in Table 3.2.




# The Original IRS 2

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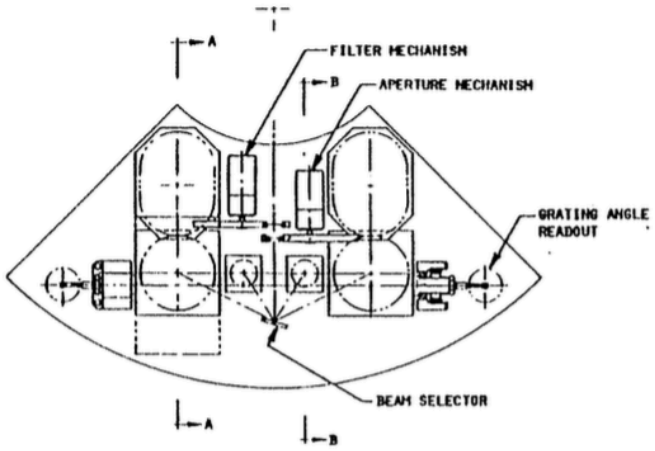
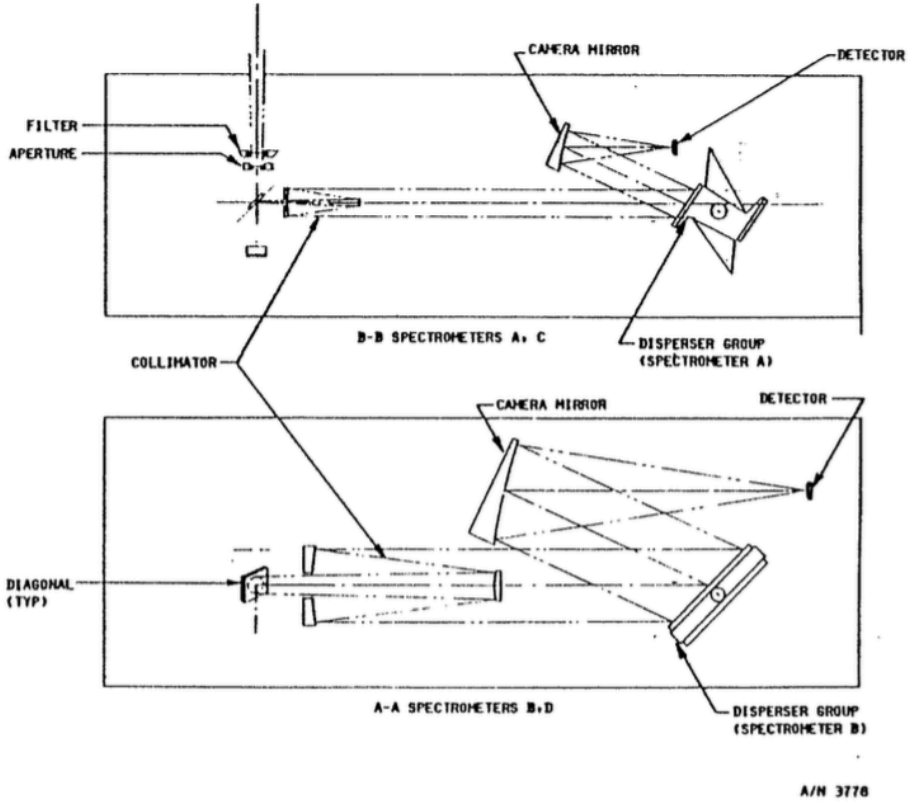
Table 3.2. Spectrometer Configuration Summary

| Spectrometer | Wavelength | Resolution | Disperser | Detector |
|---|---|---|---|---|
| A | 4-30μm | 1000, 50 | Grating/Prism | Si:Ga and Si:Sb |
| B | 28-114 | 1000 | Grating | Ge:Be and Ge:Ga |
| C | 28-114 | 50 | Grating | Ge:Be and Ge:Ga |
| D | 114-200 | 400 | Grating | Stressed Ge:Ga |
| E | 2.5-4 | 50 | Prism | TBD |

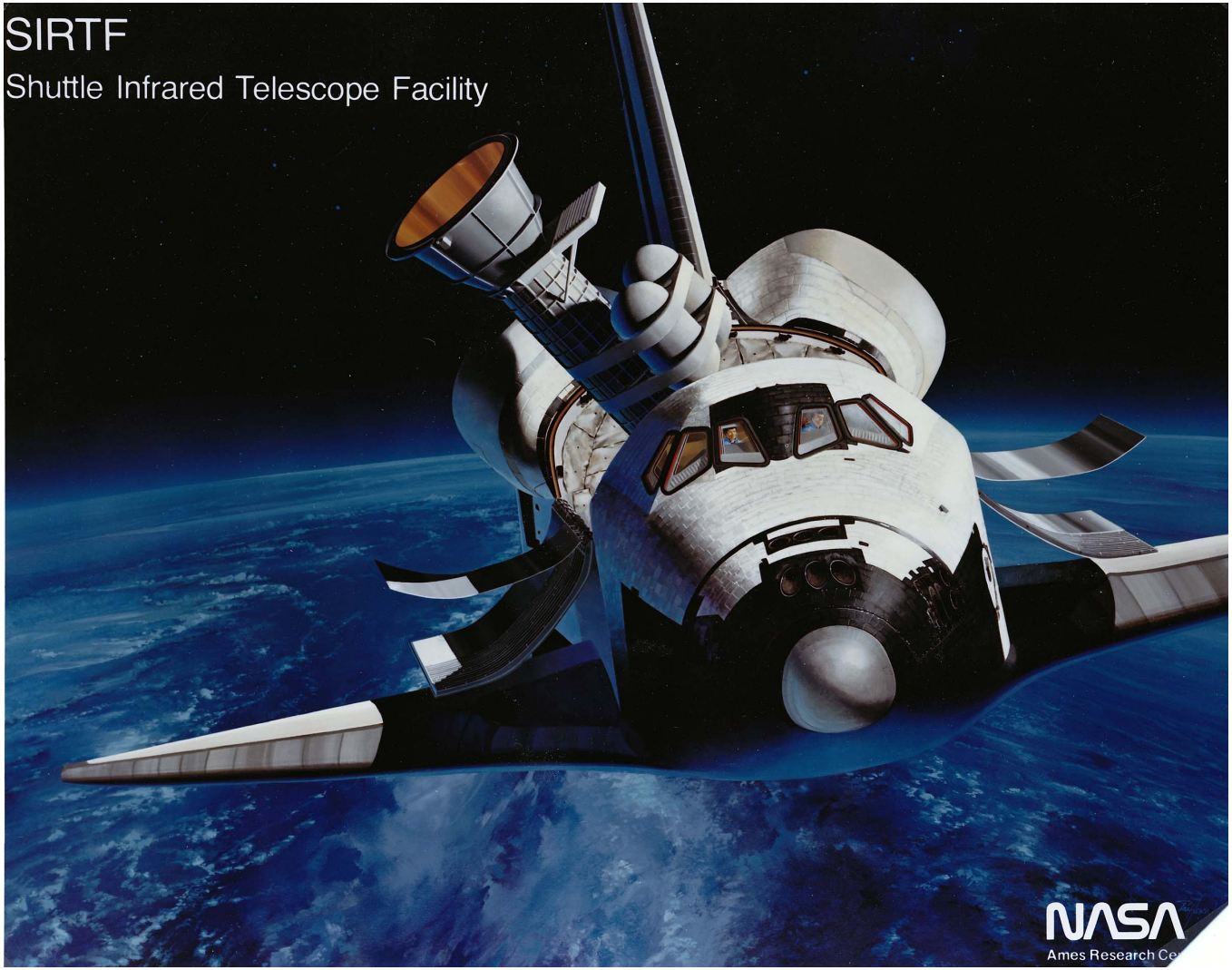
# The Original IRS 3



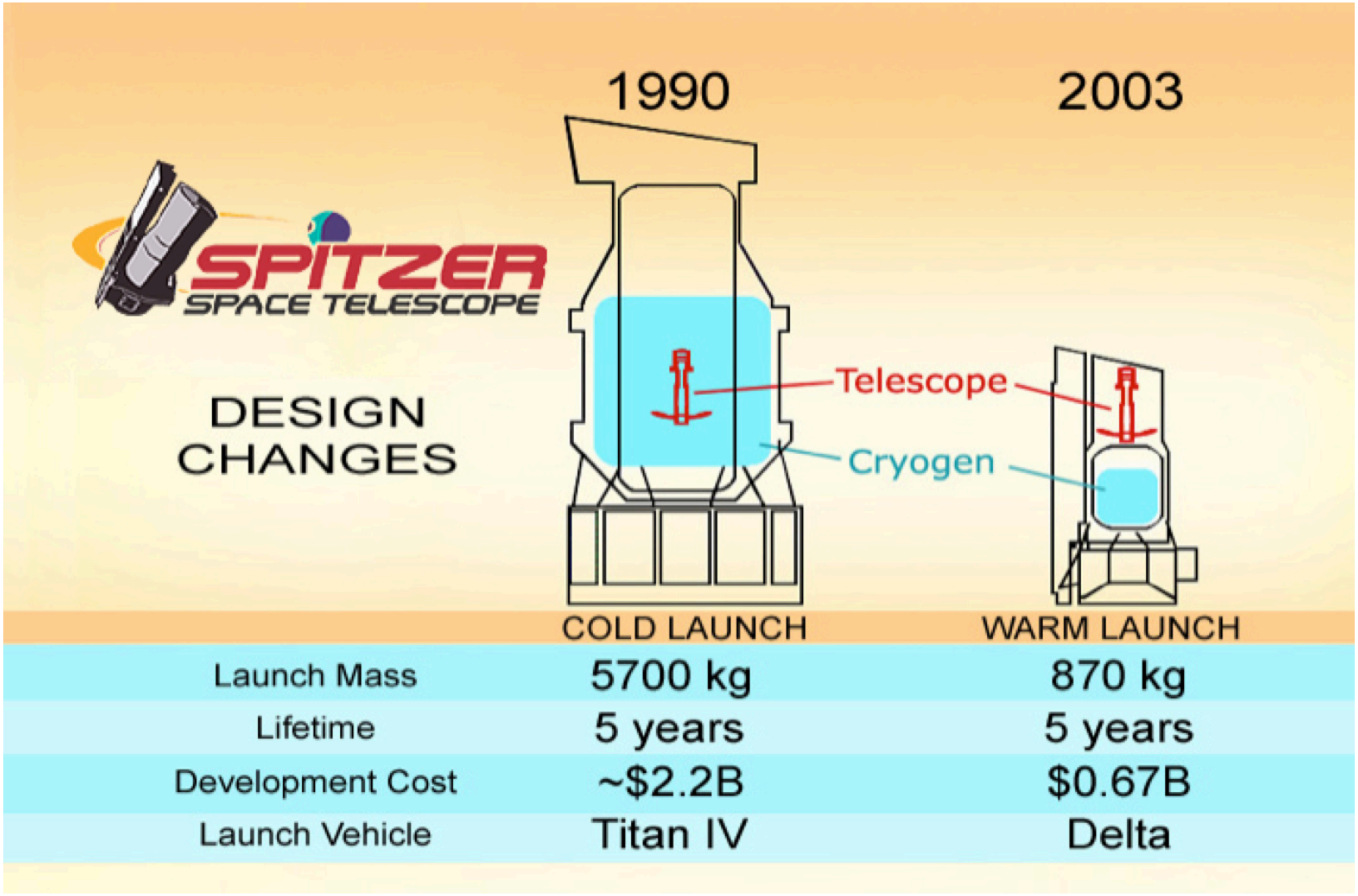




With 8 arrays and 11 mechanisms this was going to be the most complicated instrument that Ball had ever built

# The Best Thing to Come Out of the Shuttle Era



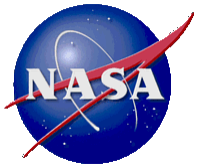
# SIRTF and the IRS Move to HEO BUT are Still Big and Expensive




| | COLD LAUNCH | WARM LAUNCH |
|---|---|---|
| Launch Mass | 5700 kg | 870 kg |
| Lifetime | 5 years | 5 years |
| Development Cost | ~$2.2B | $0.67B |
| Launch Vehicle | Titan IV | Delta |

# Disaster! SIRTF - and the IRS - is Cancelled

- Huge overruns, delays in the Hubble program couple with the mis-figured primary mirror led to drastic descopes in the Great Observatories missions.
- AXAF was cut in half
- And worst of all, SIRTF was cancelled in 1991
- The SIRTF project had moved from Ames to JPL where is underwent a new (and more realistic) cost estimate topping out at ~2.5B
- If the SIRTF program were to rise from the dead it had to figure out a way to be vastly cheaper





# The Rebirth of SIRTF and the IRS

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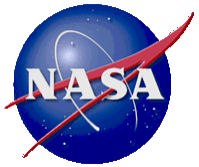
- In 1993 Jim Houck proposed that the SIRTF SWG meet in a retreat in neutral territory to figure out a new plan forward for a much cheaper mission.

- The meeting in Broomfield CO codified this new plan incorporating a number of radical changes to the observatory and the instruments:
  - *A solar drift away orbit – allowed the use of a much smaller and cheaper Delta rocket*
  - *The warm launch concept – making for a much lighter and less expensive observatory*
  - *Much simpler and cheaper instruments*
  - *Limiting requirements creep with strict adherence to only the "Big Four" science goals*

# Driving Requirements From The Big Four Science Goals

| Requirement | Science Programs | | | |
|---|---|---|---|---|
| | **Super Planets** | **Ultraluminous Galaxies** | **Early Universe** | **Planetary Debris Disks** |
| 85 cm aperture | Sensitivity at 15 μm and 30 μm | Survey sensitivity at 24, 70, 160 μm; spectroscopic sensitivity from 5 to 40 μm | Sensitivity at 8 μm | Spatial resolution at 70 and 160 μm |
| 5.5 K telescope temperature | | Sensitivity at 160 μm | | Sensitivity at 160 μm |
| 6.5 μm diffraction limit | | | Spatial resolution at 6 μm and 8 μm | |
| 0.3 arcsec pointing stability | Sensitivity, 3.5 and 4.5 μm | | Spatial resolution from 3.5 μm to 8 μm | |
| 2.5 year lifetime | Up to 160 days of observation | Up to 400 days of observation | Up to 40 days of observation | Up to 100 days of observation |




# Lowering the Cost – the IRS Axioms+

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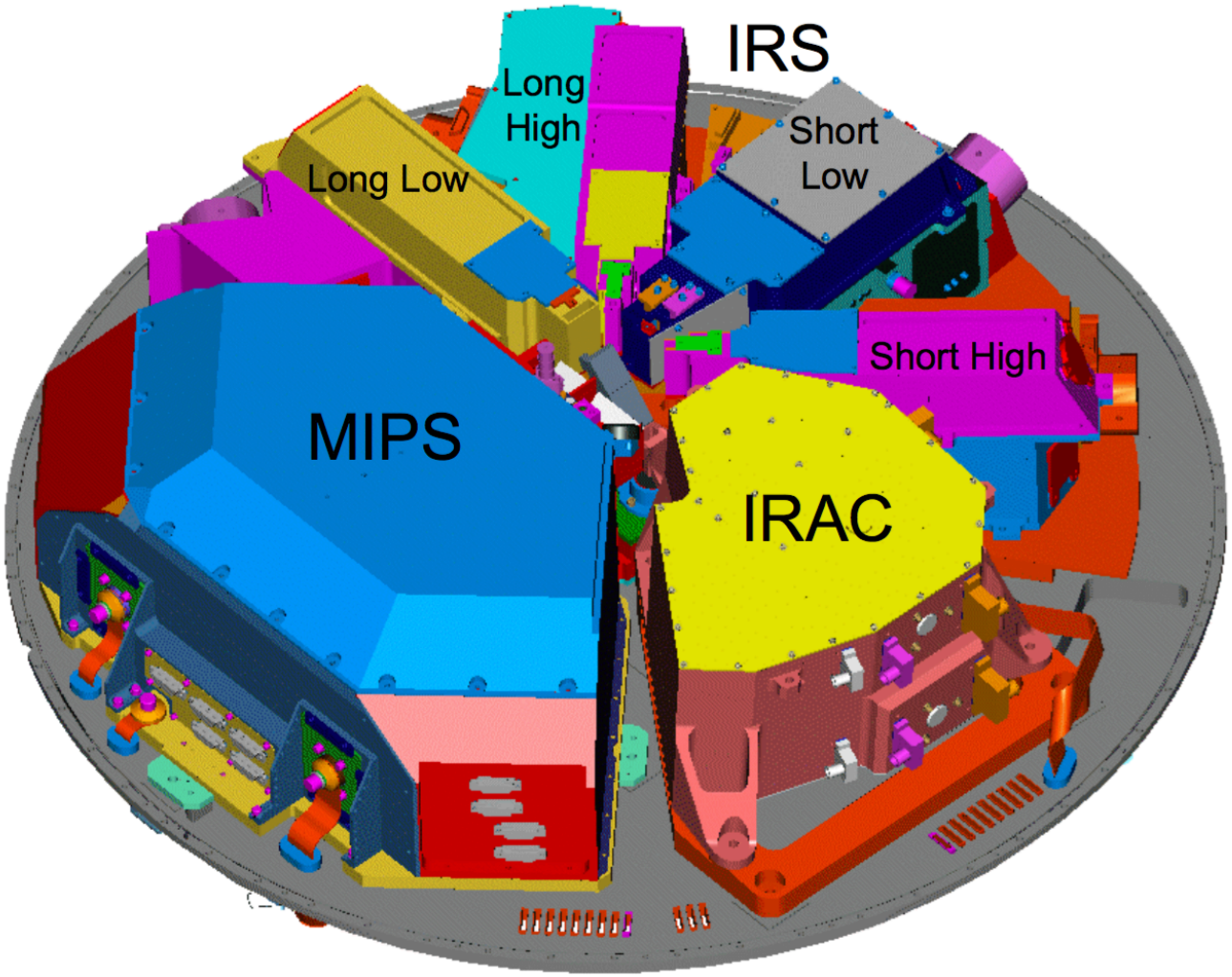
- SIRTF is a cost driven mission.
- Boeing Si:As and Si:Sb BIB arrays will be used.
- The IRS will have aluminum structure and optics.
- Only simple optics will be used.

  *Only surfaces of revolution (may be off axis)*

  *Flat gratings*
- There will be no moving parts and no adjustments. (Bolt-and-go)
- The IRS will be redundant only for credible single point failures.
- The design will strive for an observing efficiency of >80%.
- The IRS will be capable of internal health assessment.
- Shared warm electronics with the MIPS instrument

# The Resulting IRS Design – Four Discrete Modules

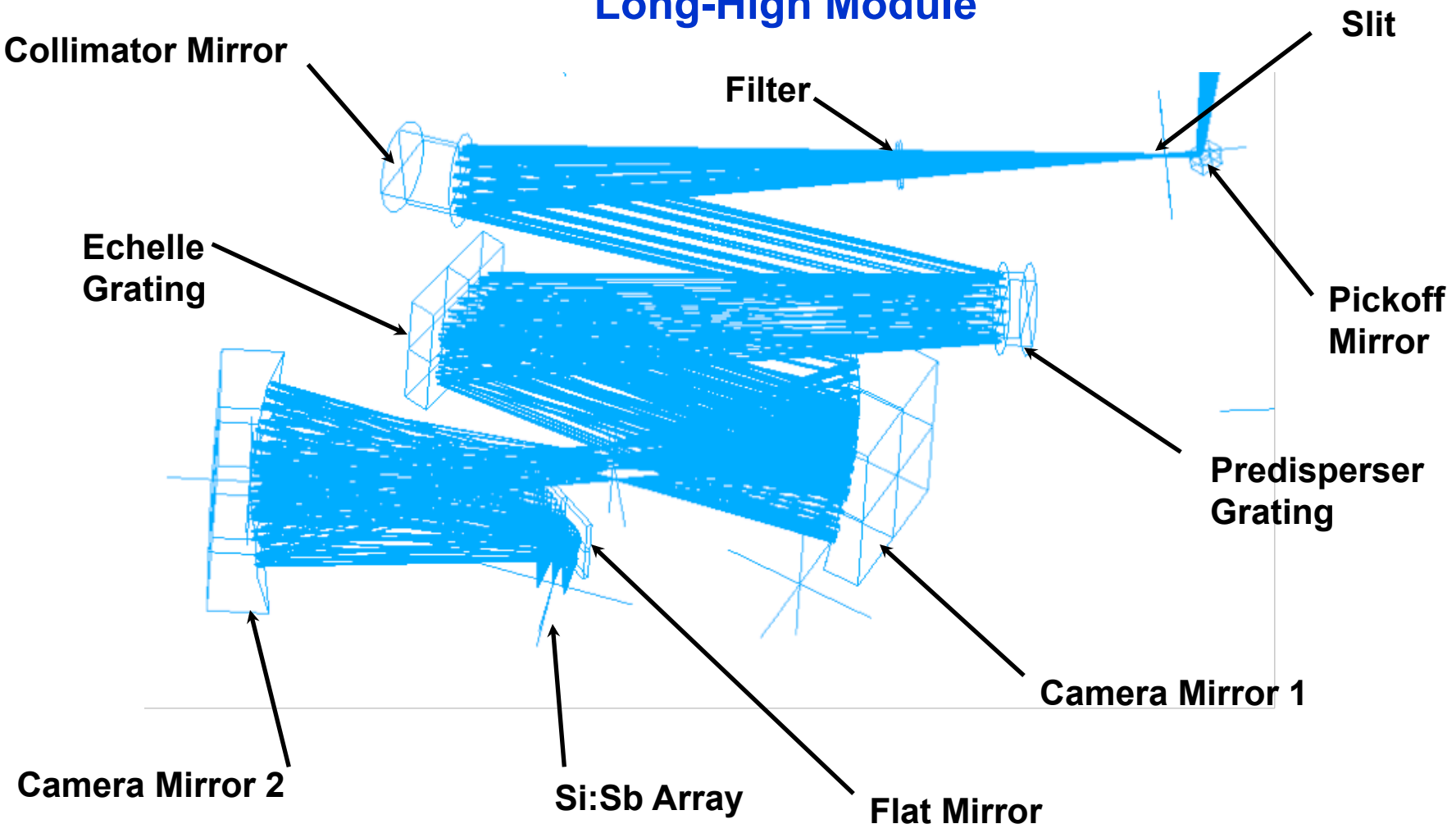


# The Four IRS Modules

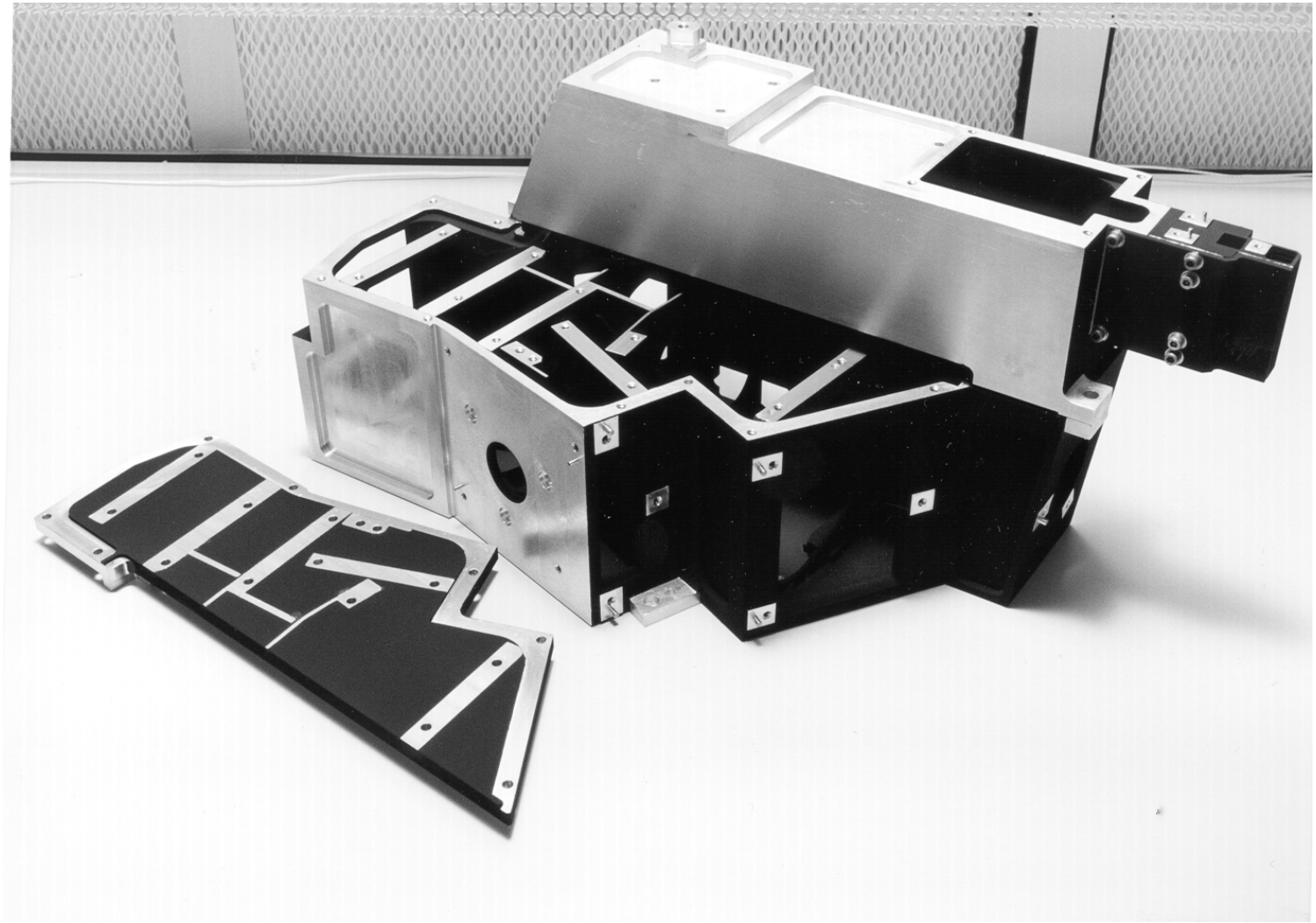
| Module | Detector Type | Wavelength Range (μm) | Spectral Resolution ($\lambda/\Delta\lambda$) |
|---|---|---|---|
| Short-Low | Si:As | 5.3–14 | 64–124 |
| Short-Low, Peak-Up | Si:As | 13.5–18.5, 18.5–26 | ~3 |
| Long-Low | Si:Sb | 14–40 | 64–124 |
| Short-High | Si:As | 10–19.5 | ~ 600 |
| Long-High | Si:Sb | 19–37 | ~ 600 |

# Code V Model & I-DEAS

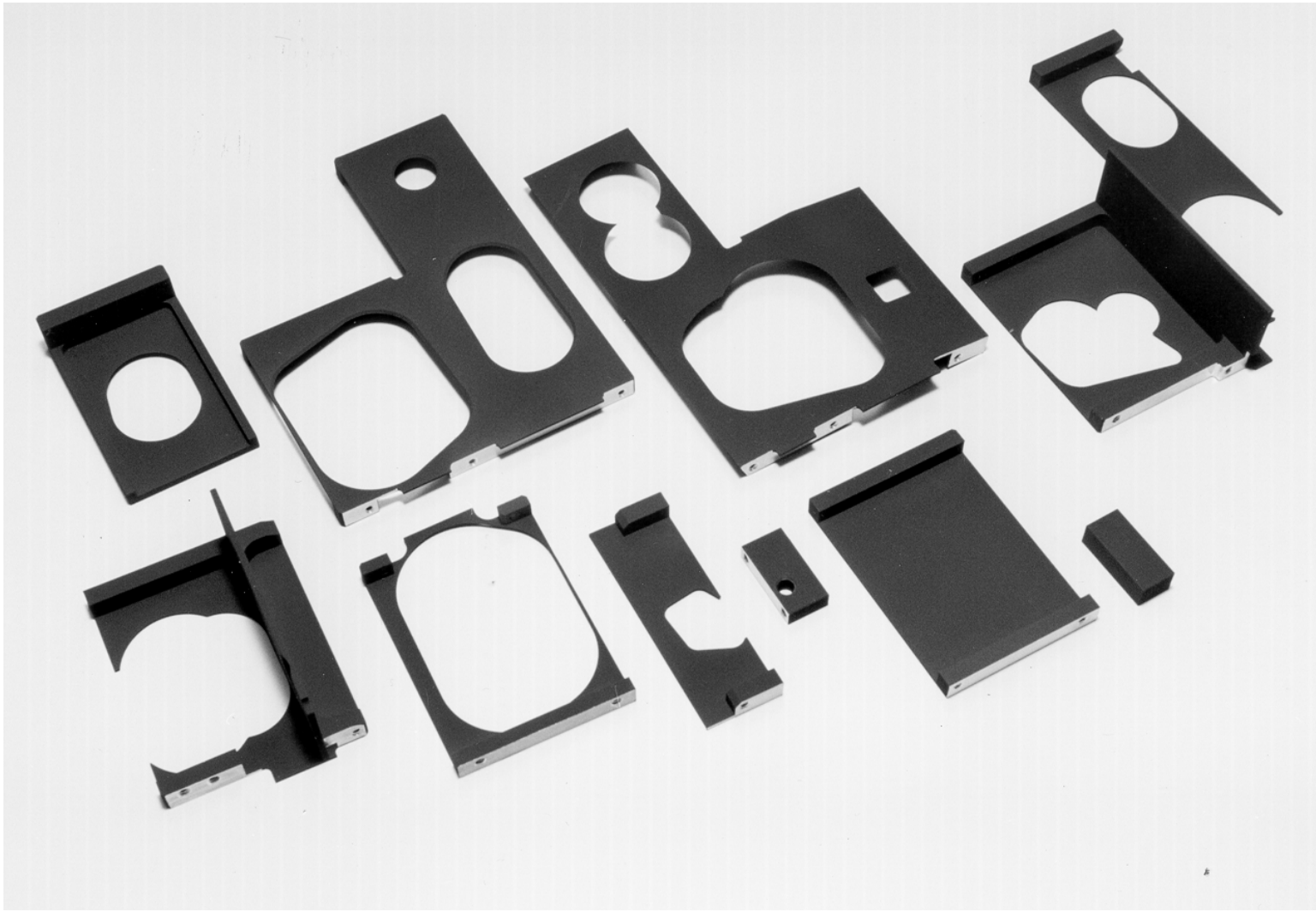
## Long-High Module



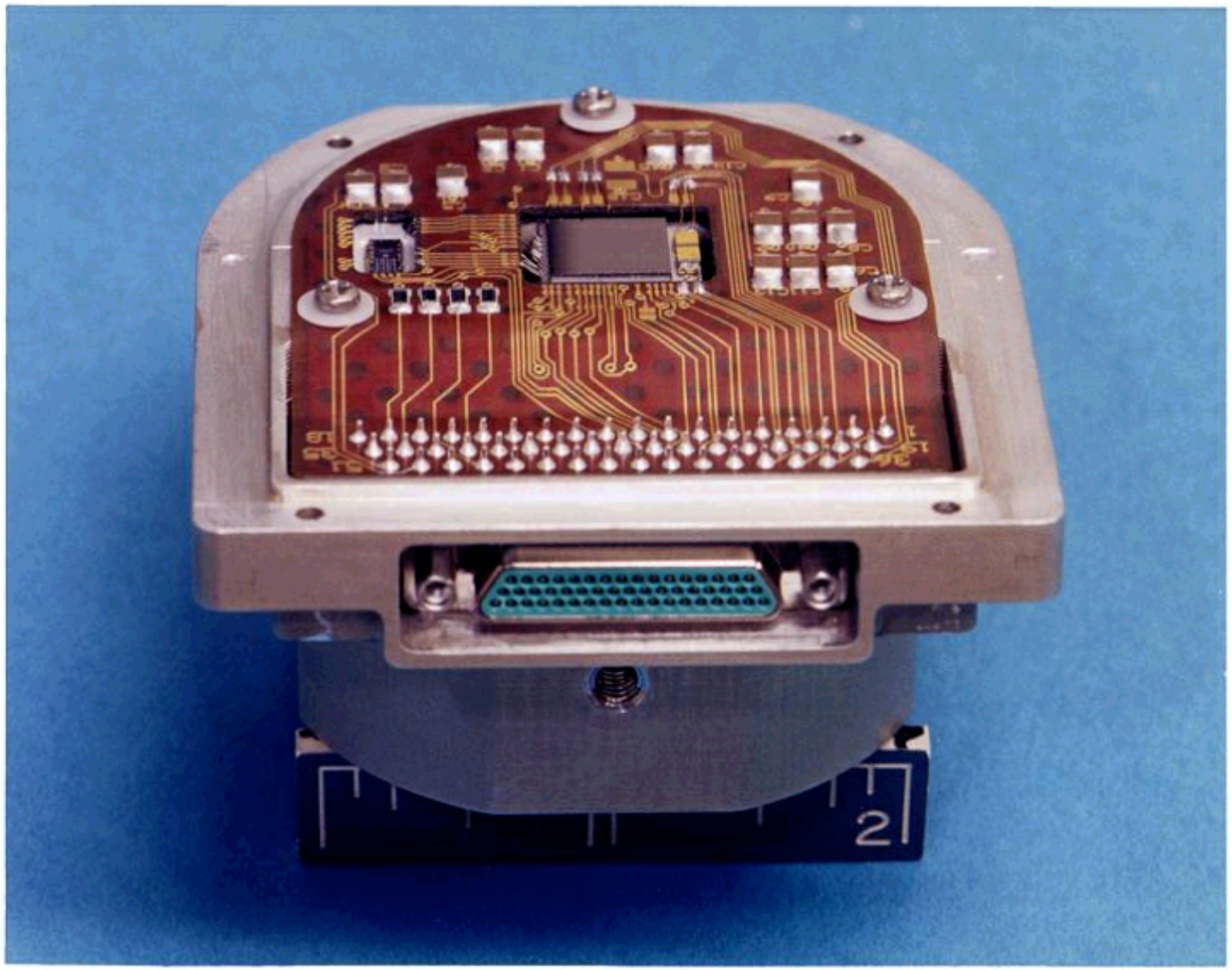
# Long Wavelength - High Resolution Housing



# L-H Baffles



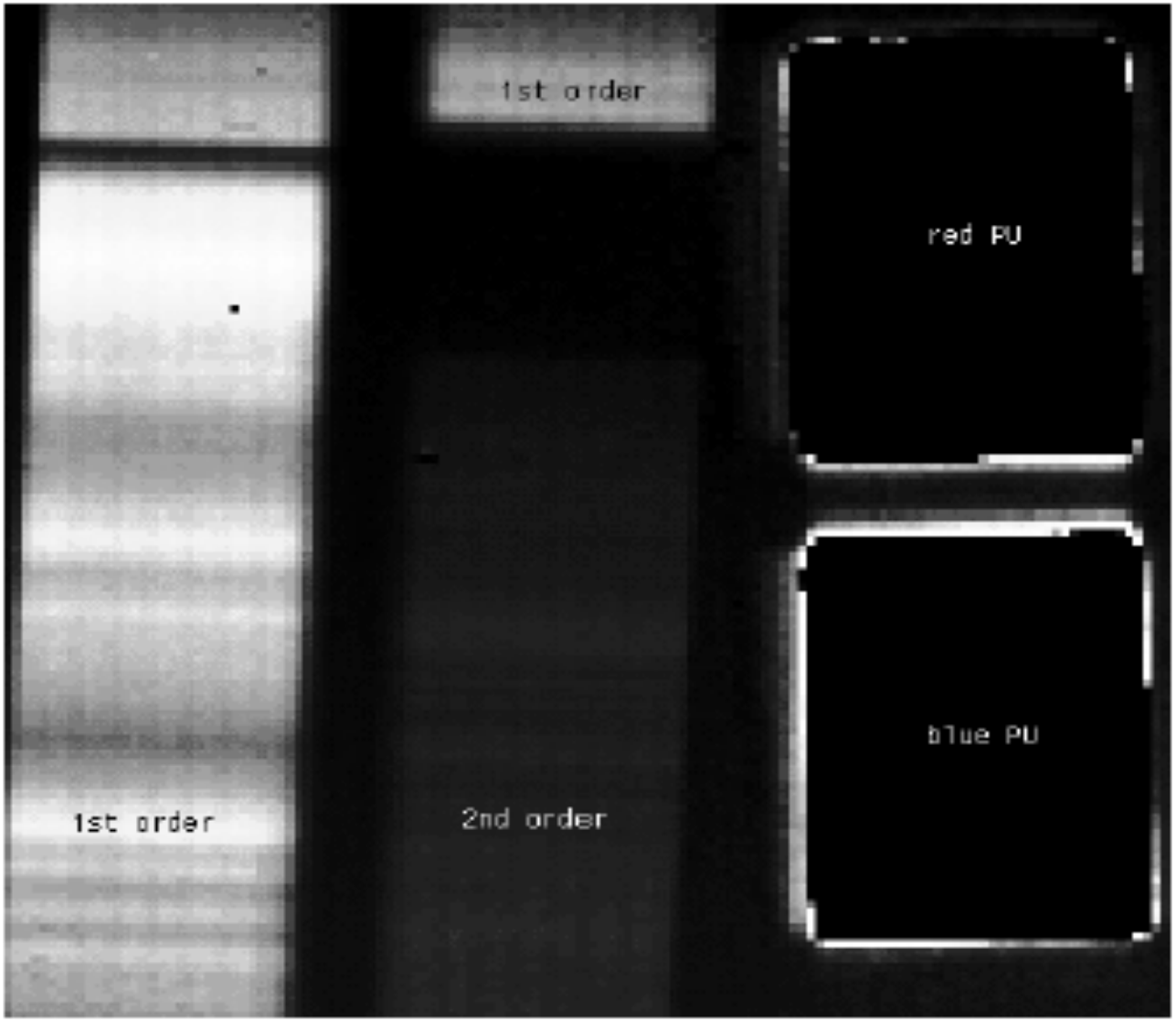
# Si:Xx Focal Plane Mount Assembly



# The Peak-Up Process

- Very few astronomical sources have accurately measured infrared positions.
- Often the optical and infrared position are not the same.
- Therefore, some infrared means is needed to accurately position a source on a slit.
- The IRS Peak-Up system provides such a capability.
- A source is first imaged several times using one of the two infrared imaging channels in the Short-Low module.
- The infrared centroid is calculated, and the spacecraft is moved to place the infrared centroid on the appropriate slit.
- The previous two steps are done autonomously in real time.

# Short-Low Exposure

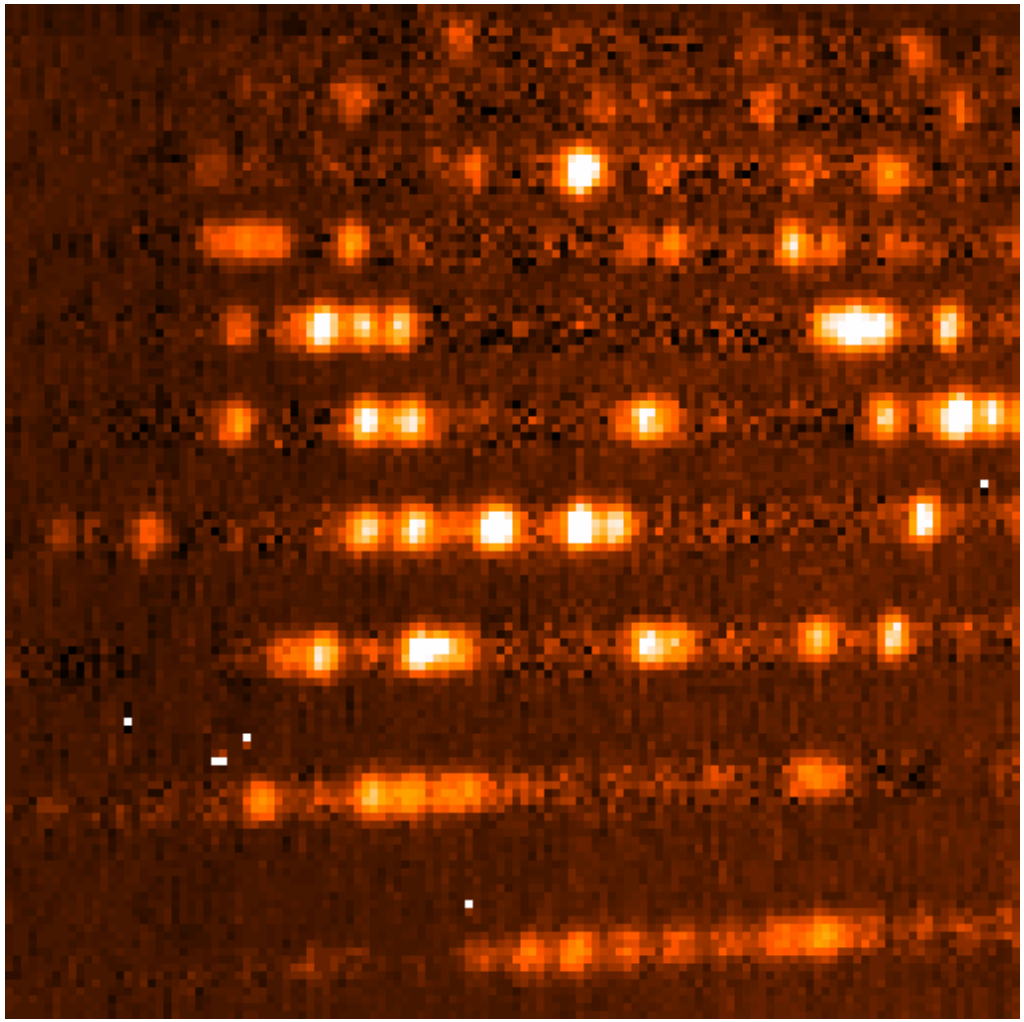



1st order is on the left
2nd order is in the middle.

The Peak-Up widows are on the right.

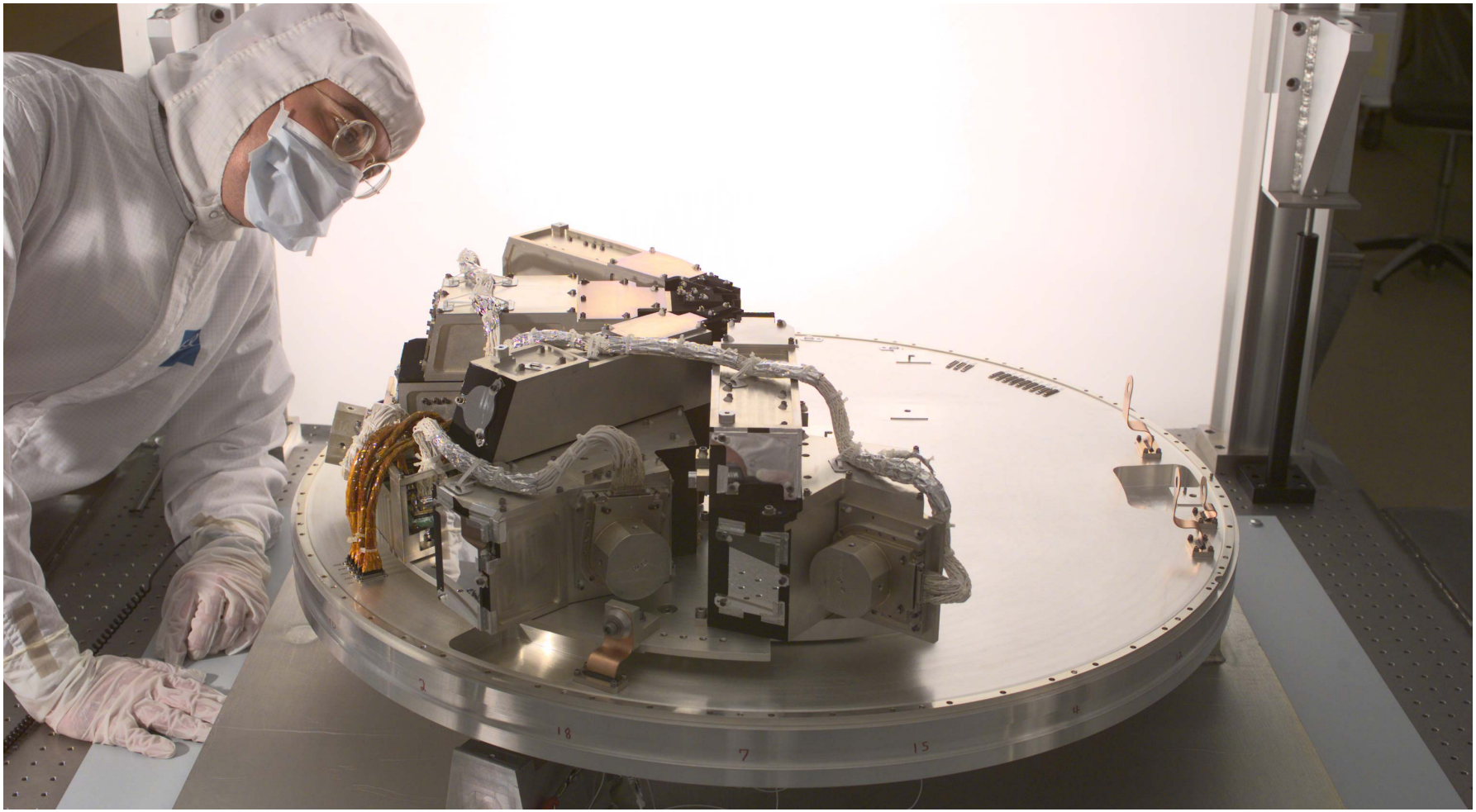
Note: the P-U images are saturated.

# 19.3 to 37 μm spectrum of $H_2O$



Water vapor as seen in 30 cm of lab air at Ball. Many lines are saturated and/or pressure broadened.

# First SI on the MIC Baseplate



# Pre-Launch Party

# August 25, 2003
# Launch!

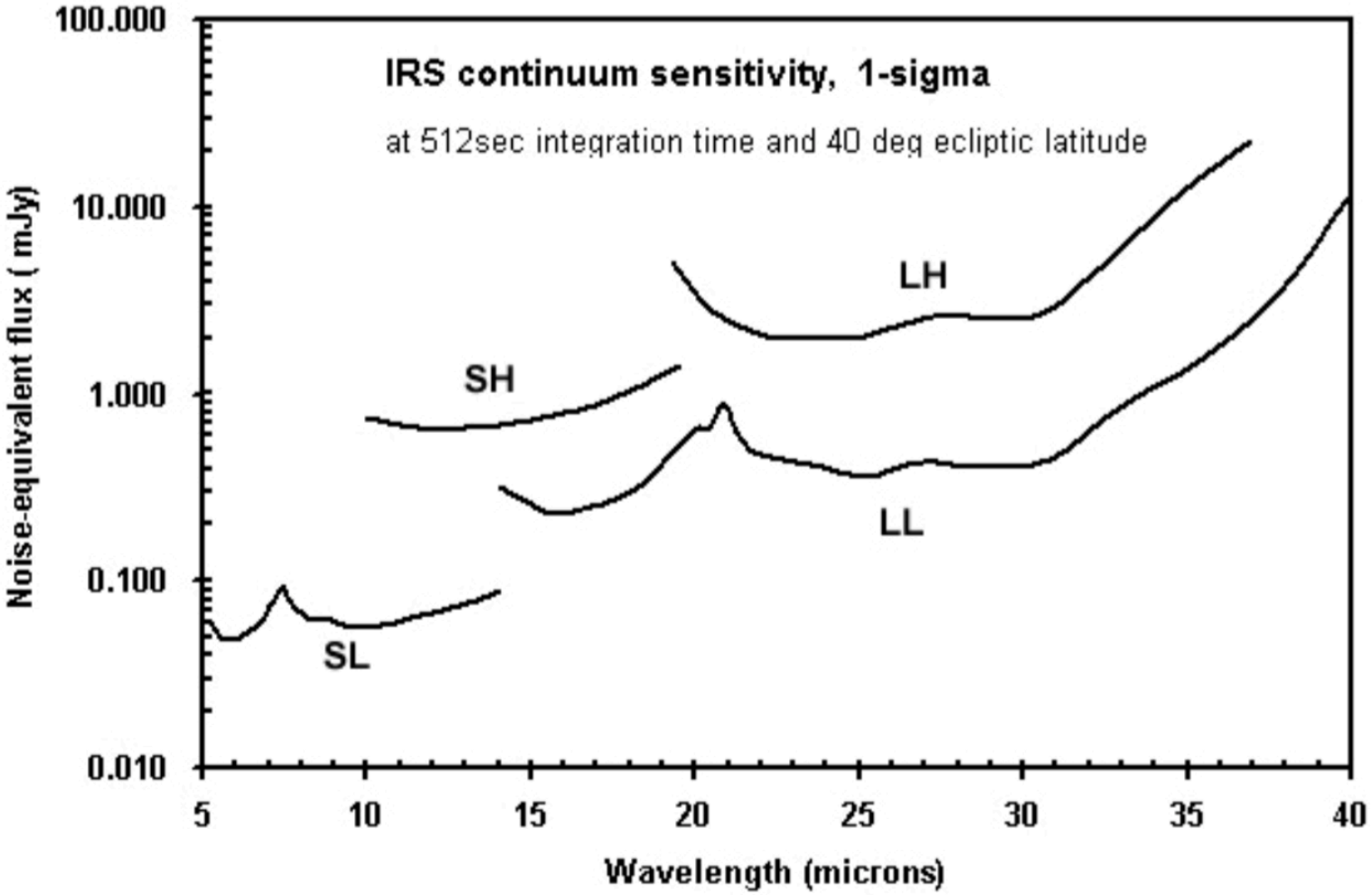
# Turning On The IRS

# Remote Participation in IOC

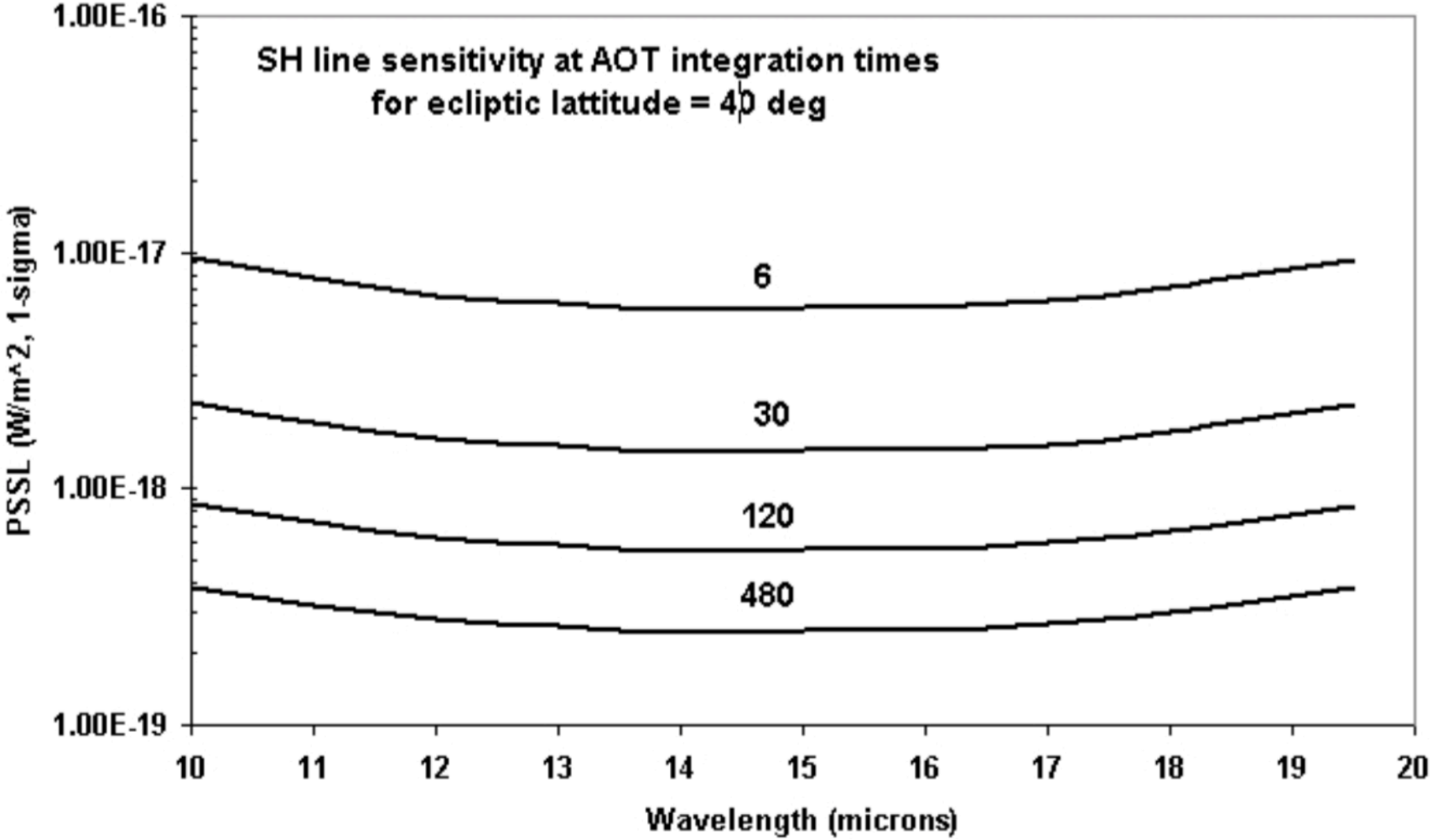
# In-Orbit Checkout

# The IRS Works! Party Time!

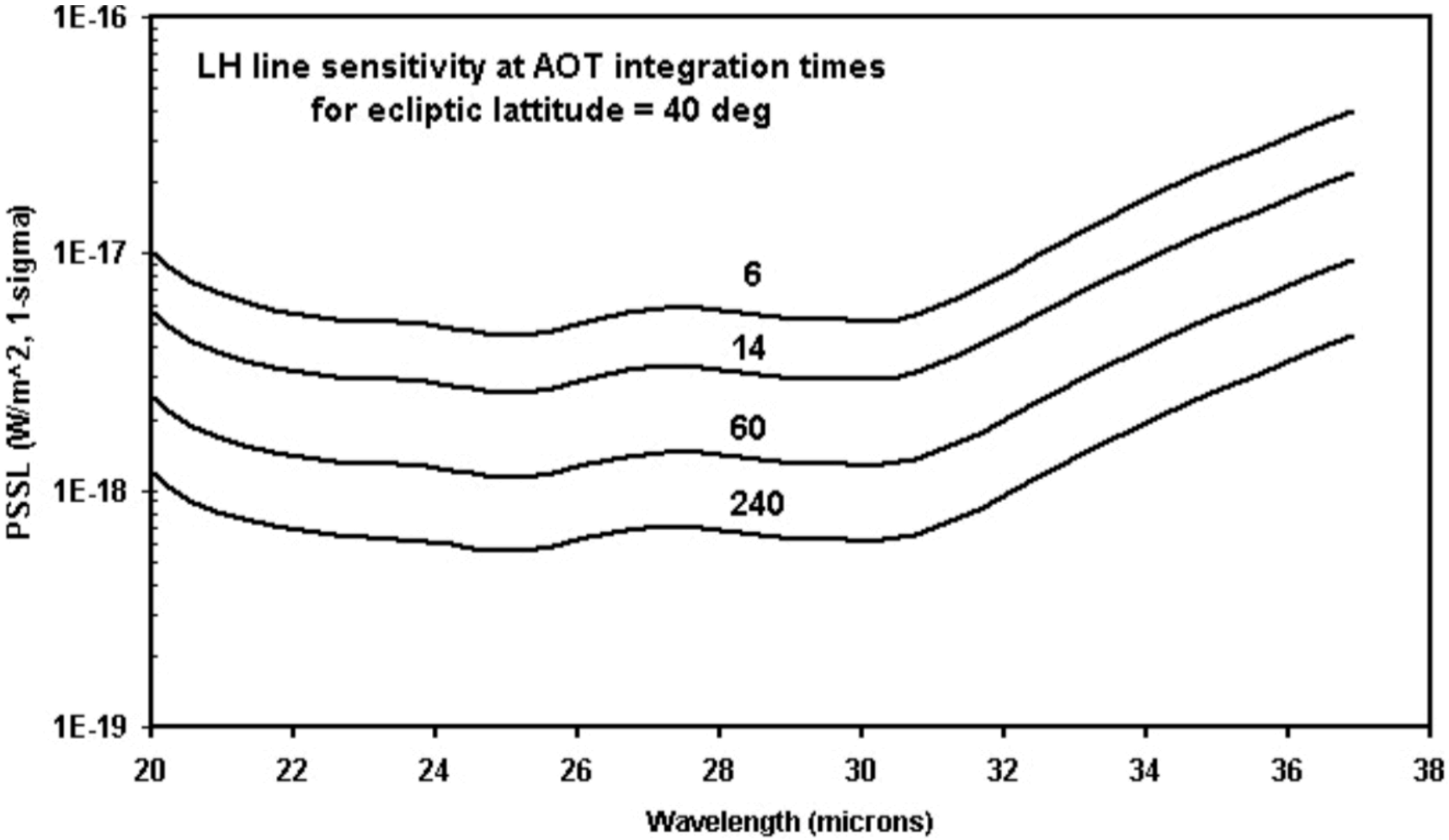
# Short-Low and Long Low Performance



# Short-High Performance



# Long-High Performance



# Conclusions

- The IRS was successfully designed on the basis of the axioms.
- Simple test hardware was used.
- The peak-up system operated as expected from detailed model simulations.

# The IRS Development Team

# A Quiet Time in IOC – Still Being Instructed