Tropospheric Emission Spectrometer

Atmospheric Science from Space using Fourier Transform Spectroscopy

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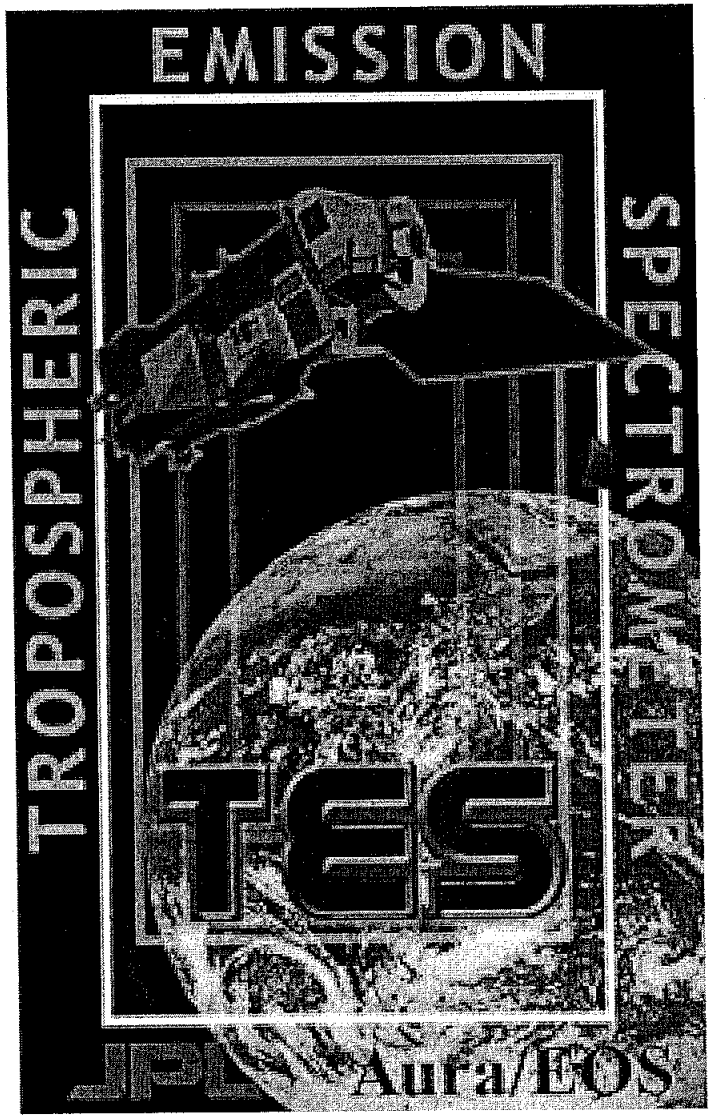


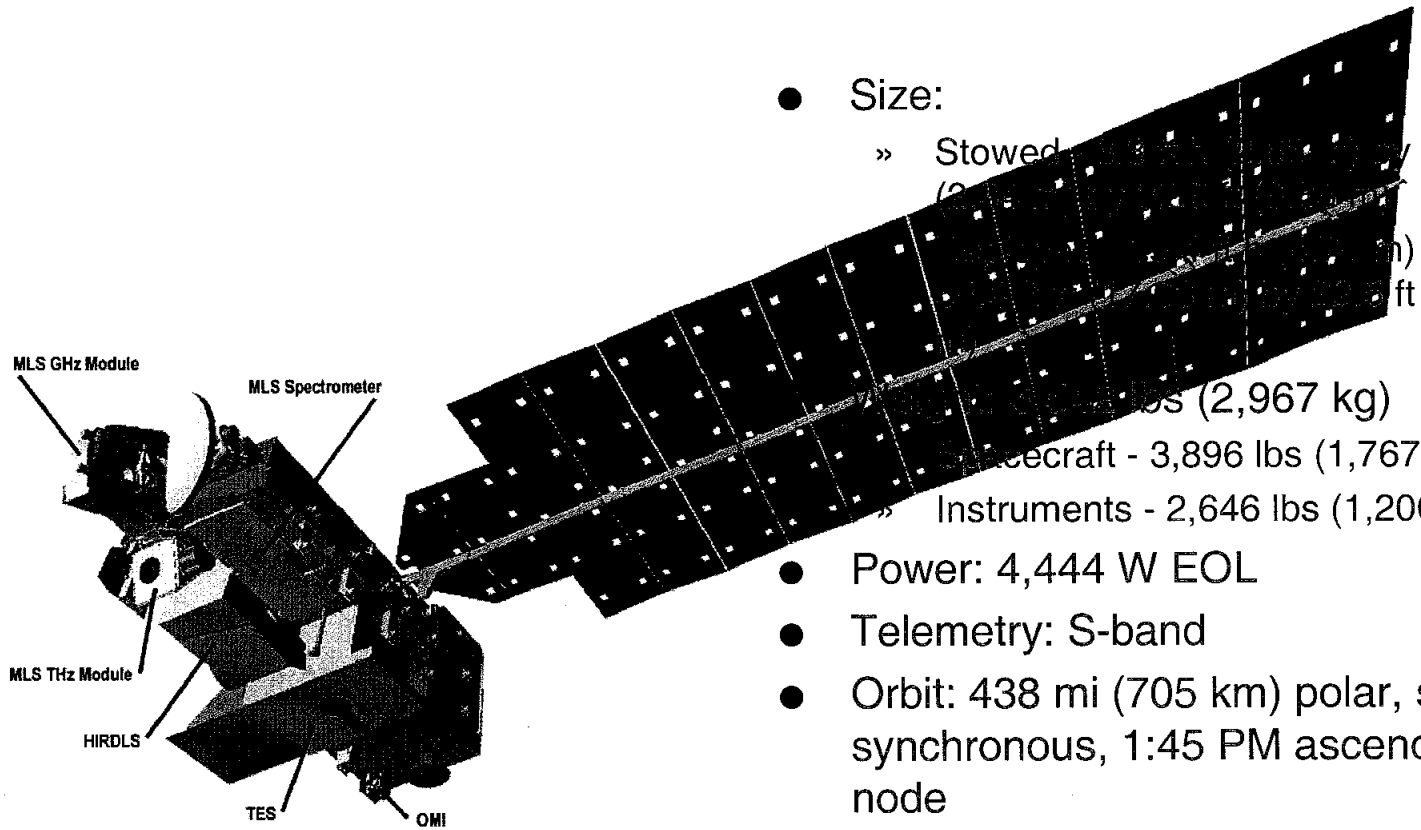
Topics

- Aura Mission
- Aura Spacecraft
- Aura Instrumentation
- TES Instrument
- TES Specifications
- TES Block Diagram
- TES Status - Interferometer
- TES Status - Coolers
- TES Status - Focal Planes
- TES Status - Electronics
- TES Status - Gimbal
- Laser
- I & T Facility
- Calibration Flow
- Calibration Hardware

Aura Mission

- The objective of the EOS Aura Mission is to study the chemistry and dynamics of the Earth's atmosphere from the ground through the mesosphere.
- The mission will provide global surveys of several atmospheric constituents which can be classified into:
  - » anthropogenic sources (CFC types),
  - » radicals (e.g., ClO, NO, OH),
  - » reservoirs (e.g., HNO, HCl)
  - » tracers (e.g., N2O, CO2, H2O).
- Temperature, geopotential heights, and aerosol fields will also be mapped.
- This mission will provide the first global measurements of several important tropospheric chemicals.

Aura Spacecraft



- Size:
  - » Stowed [illegible] 7.6 ft w
    ([illegible]
    [illegible]) by
    [illegible] ft (6.85
    [illegible] (2,967 kg)
    [illegible]ecraft - 3,896 lbs (1,767 kg)
  - » Instruments - 2,646 lbs (1,200 kg)
- Power: 4,444 W EOL
- Telemetry: S-band
- Orbit: 438 mi (705 km) polar, sun-synchronous, 1:45 PM ascending node
- Launch Vehicle: Delta 7920
- Launch: June 2003

Aura Instruments

- Microwave Limb Sounder (MLS)
  - » MLS will measure microwave radiation emitted by ozone, chlorinated compounds, and many other trace gases. MLS upper troposphere-water vapor measurements will clarify the role this key green house gas plays in global warming.
- High Resolution Dynamics Limb Sounder (HIRDLS)
  - » HIRDLS will measure atmospheric infrared radiation emitted by ozone, water vapor, CFC's, methane and nitrogen compounds. In addition HIRDLS will track the transport of ozone between the stratosphere and the troposphere.
- Ozone Measuring Instrument (OMI)
  - » OMI will measure both UV and visible radiation and will provide daily high-resolution global maps and profiles of ozone. OMI will also measure nitrogen dioxide, aerosols, other trace gases, and UV-B radiation
- Tropospheric Emission Spectrometer

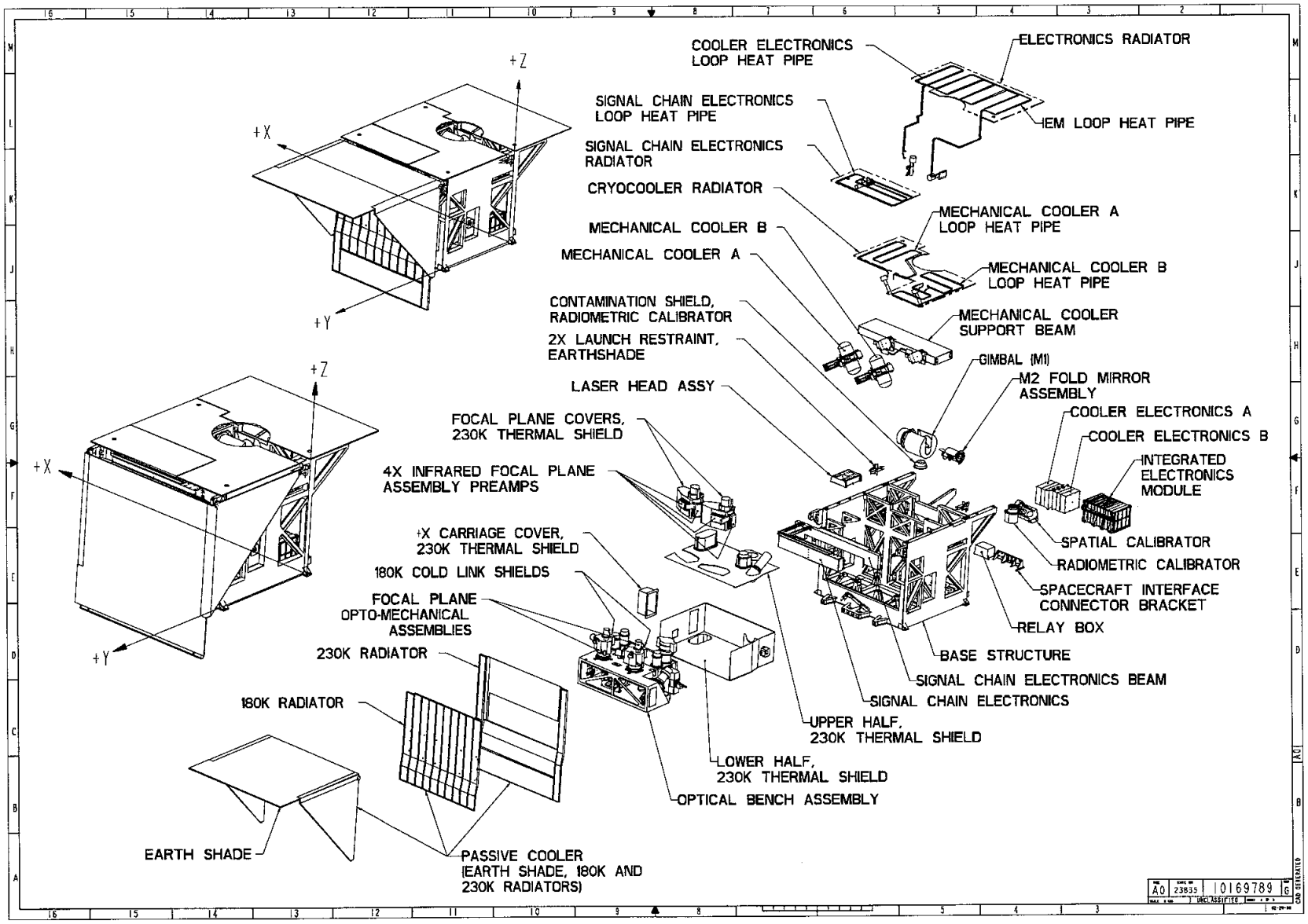
Instrument Specifications

Spectrometer Type	Connes'-type 4-port Fourier Transform Spectrometer
Max. Optical Path Difference	± 8.45 cm (nadir & calibration) ± 33.8 cm (limb); interchangeable
Scan (integration) Time	4 sec (nadir & calibration) 16 sec (limb)
Interferogram Sampling Metrology	Nd:YAG laser
Spectral Resolution (unapodized)	0.06 cm^{-1} (nadir) 0.015 cm^{-1} (limb)
Spectral Coverage	650 to 3050 cm^{-1} (3.2 to 15.4 ? m)
Detector Arrays	4 (1 x 16) arrays, optically-conjugated, all MCT PV @65K
Signal-to-Noise Ratio (spectral)	Up to 600:1 Minimum requirement is 30:1

Field of Regard	45° cone about nadir; trailing limb or cold space; internal calibration sources
Pointing Accuracy	75 ? rad pitch 750 ? rad yaw 1100 ? rad roll
Maximum Stare Time, Nadir	208 sec (40 nadir scans)
Spatial Resolution	0.5 x 5 km (nadir) 2.3 x 23 km (limb)
Radiometric Calibration	Internal, adjustable, cavity blackbody (340K) + cold space view
Radiometric Accuracy	= 1K 650 – 2500 cm^{-1} = 2K 2500 – 3050 cm^{-1}
Detector Array Co-alignment Calibration	Internal thin slit source

Instrument Allocations

Mass	385 kg
Average Power	334 W
Peak Power	361 W
Avg. Data Rate	4.5 Mbps
Peak Data Rate	6.2 Mbps
Actual Size	1.0 x 1.3 x 1.4 m (with earth shade stowed)
Lifetime	5 years on orbit


+Z
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COOLER ELECTRONICS LOOP HEAT PIPE
ELECTRONICS RADIATOR
SIGNAL CHAIN ELECTRONICS LOOP HEAT PIPE
IEM LOOP HEAT PIPE
SIGNAL CHAIN ELECTRONICS RADIATOR
CRYOCOOLER RADIATOR
MECHANICAL COOLER A LOOP HEAT PIPE
MECHANICAL COOLER B
MECHANICAL COOLER A
MECHANICAL COOLER B LOOP HEAT PIPE
CONTAMINATION SHIELD, RADIOMETRIC CALIBRATOR
MECHANICAL COOLER SUPPORT BEAM
2X LAUNCH RESTRAINT, EARTHSHADE
GIMBAL (M1)
LASER HEAD ASSY
M2 FOLD MIRROR ASSEMBLY
COOLER ELECTRONICS A
FOCAL PLANE COVERS, 230K THERMAL SHIELD
COOLER ELECTRONICS B
INTEGRATED ELECTRONICS MODULE
4X INFRARED FOCAL PLANE ASSEMBLY PREAMPS
SPATIAL CALIBRATOR
+X CARRIAGE COVER, 230K THERMAL SHIELD
RADIOMETRIC CALIBRATOR
180K COLD LINK SHIELDS
SPACECRAFT INTERFACE CONNECTOR BRACKET
FOCAL PLANE OPTO-MECHANICAL ASSEMBLIES
RELAY BOX
230K RADIATOR
BASE STRUCTURE
SIGNAL CHAIN ELECTRONICS BEAM
180K RADIATOR
SIGNAL CHAIN ELECTRONICS
UPPER HALF, 230K THERMAL SHIELD
LOWER HALF, 230K THERMAL SHIELD
OPTICAL BENCH ASSEMBLY
EARTH SHADE
PASSIVE COOLER (EARTH SHADE, 180K AND 230K RADIATORS)
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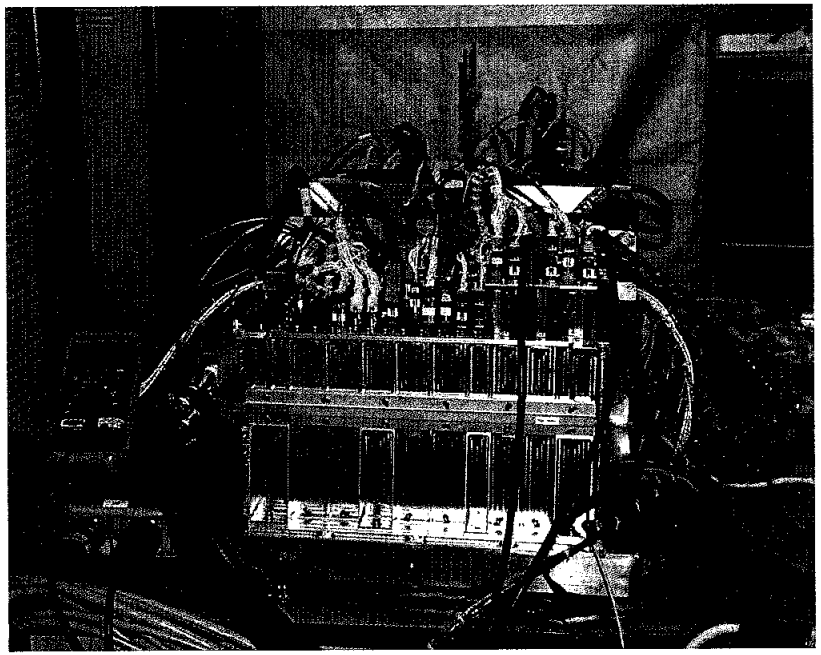
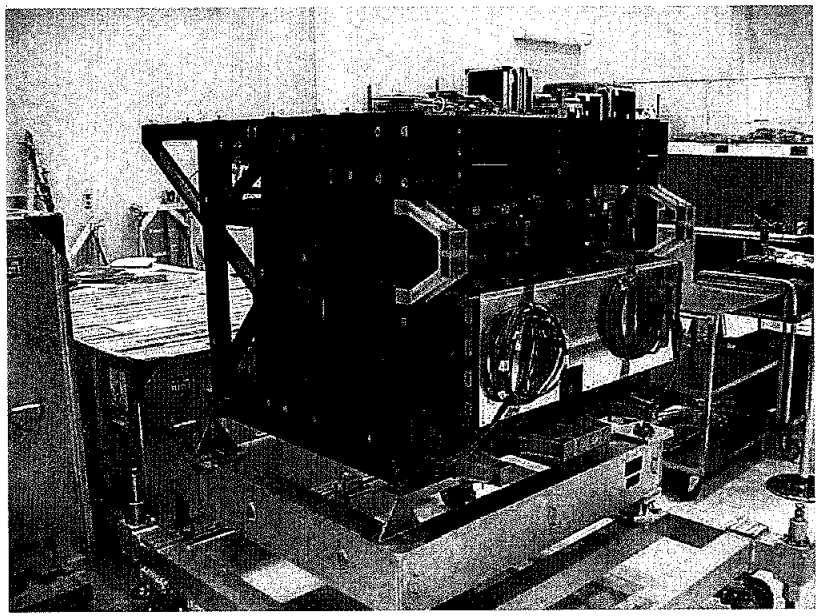
Integrated Electronics Module



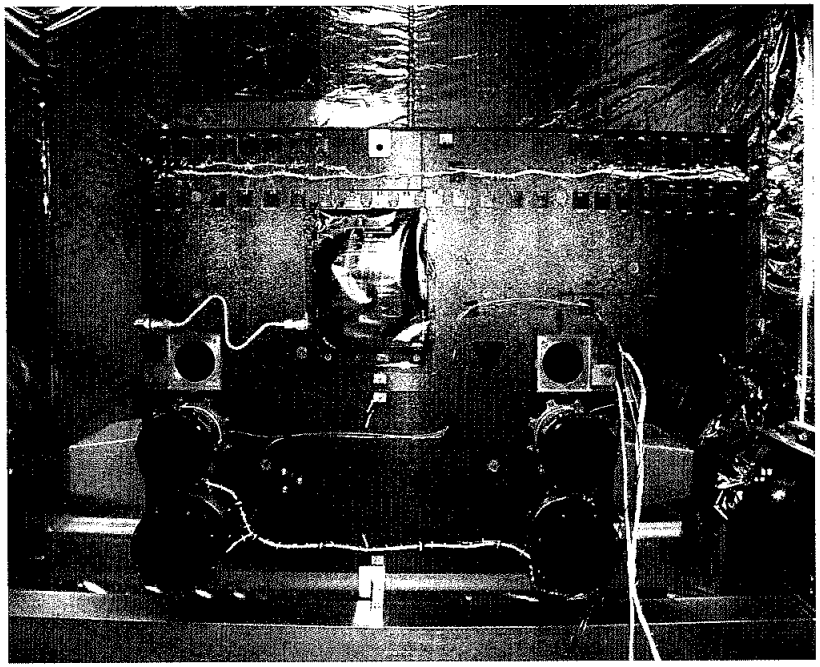
- Integrated Electronics Module holds flight computer, power supplies, and most subsystem electronics
- Standard VME interface simplifies design and test of electronics
- Minimizes cabling.

TES Structure



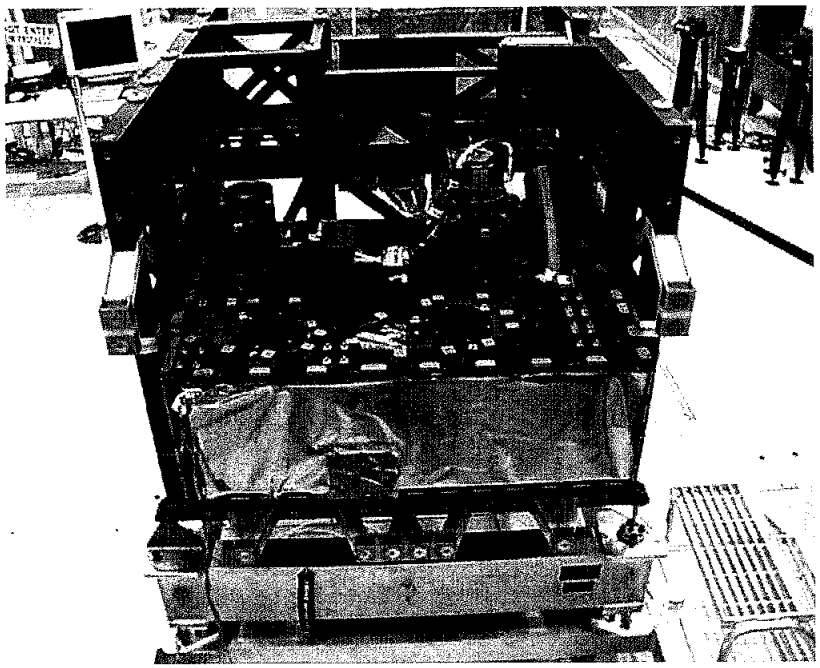
- Built by Composite Optics, San Diego
- Graphite Epoxy Structure
- Graphite Epoxy Interferometer
- Graphite Epoxy Radiators

Translator and Optical Bench



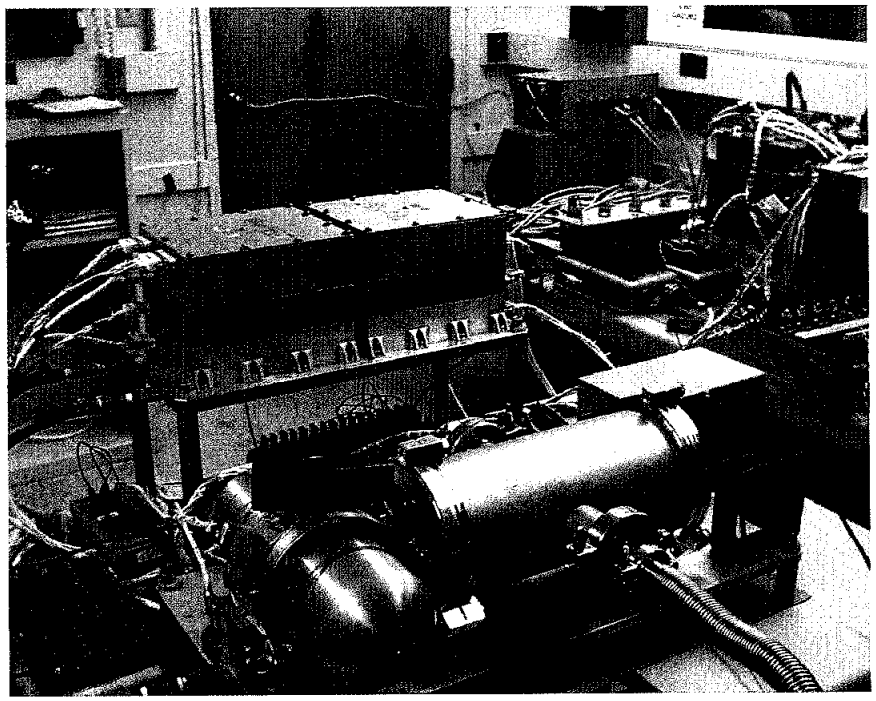
- 4 port interferometer in a composite optical bench.
- Back to back retroreflectors are moved on a set of rails by a band driven actuator.
- Optics aligned at temperature, by measurements of cold performance and ambient to cold element shifts.

Interferometer and 230 K Shield Fit Check



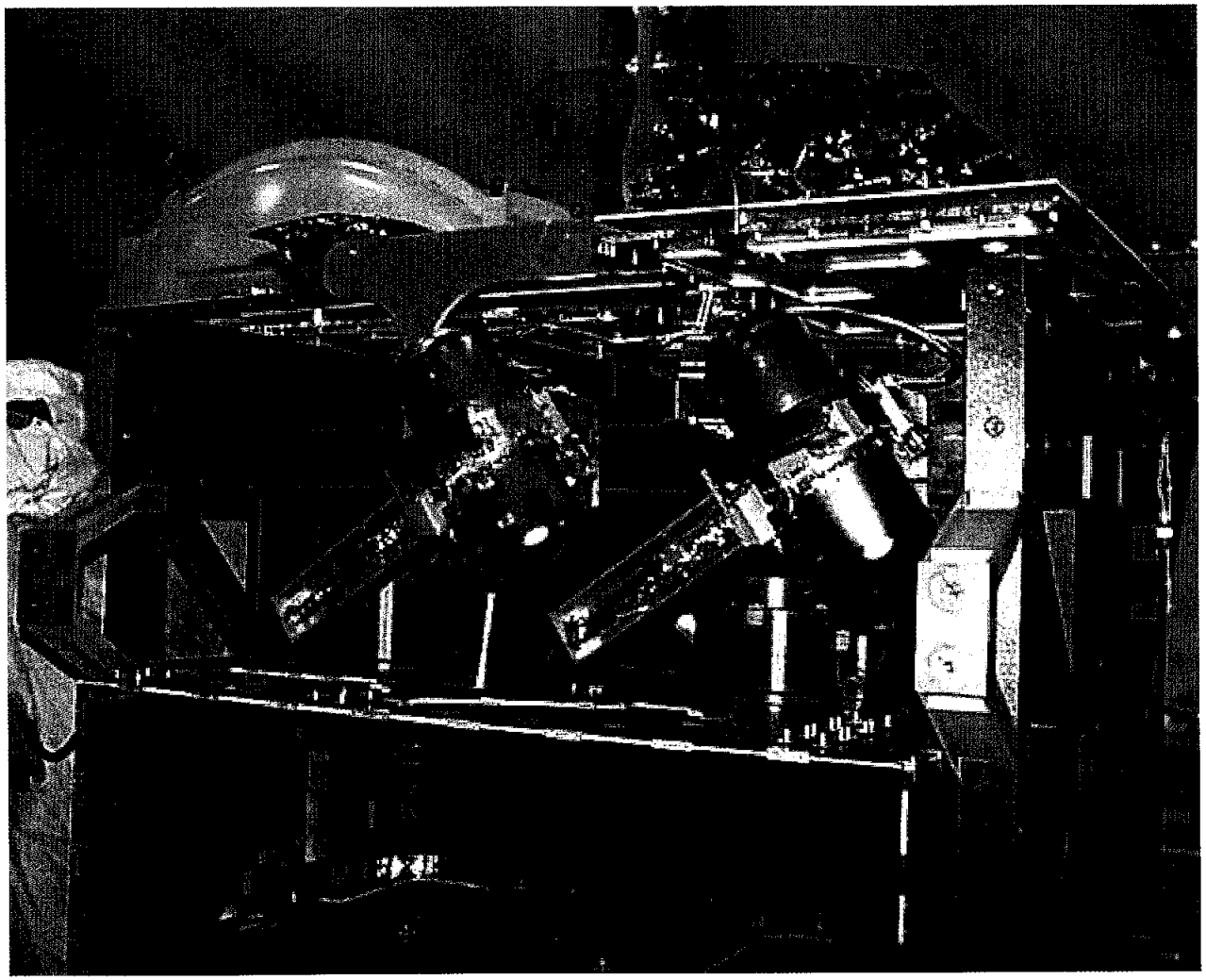
- Three zone thermal design simplifies TES integration.
- Interferometer operates at 180 K by direct coupling to space viewing radiator.
- Surrounding region cooled to 230 K by a second space viewing radiator.
- Electronics and mechanisms stay near ambient.

Cooler Subsystem

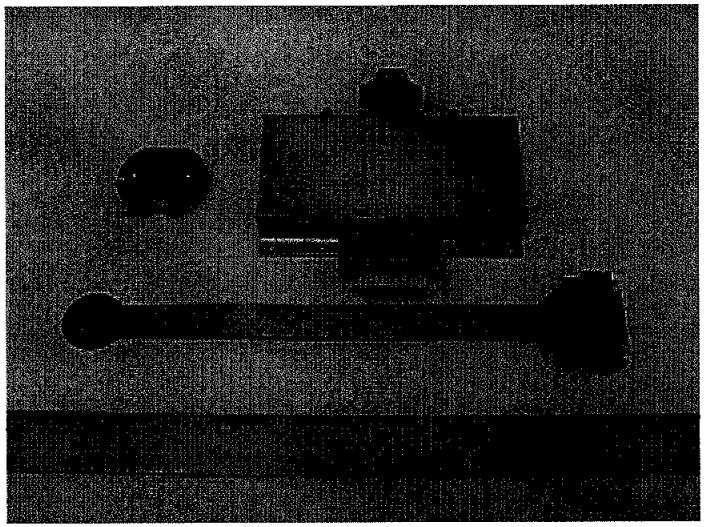


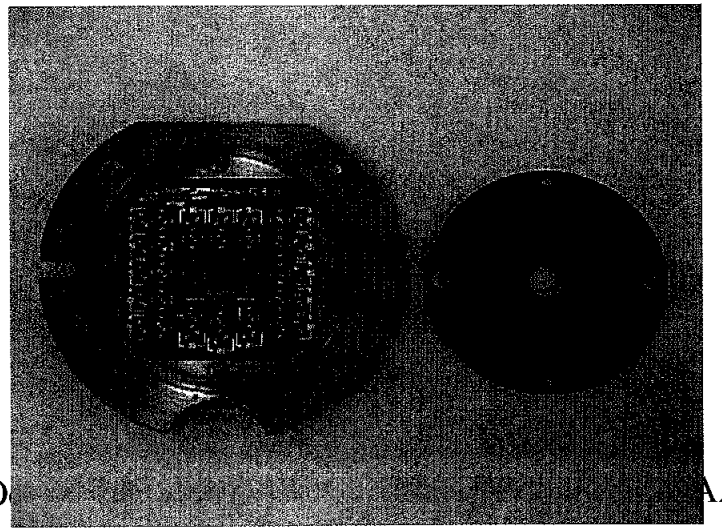
- Subsystem Contract to TRW
- Nearly identical to AIRS coolers.
- Coolers tested and delivered to integration.

Cryocooler and Radiator Test Fit



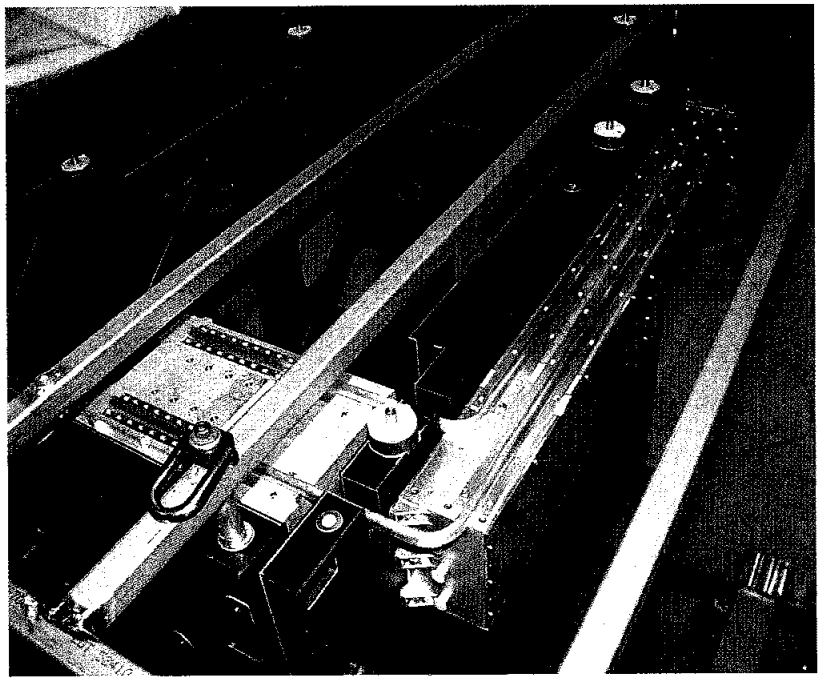
Focal Plane Arrays





- Rockwell/Boeing Subcontract
- All detectors 1 x 16 arrays of 1 x 10 aspect ration pixels.
- All pixels photovoltaic HgCdTe.
- Each array optimized for a particular spectral region.

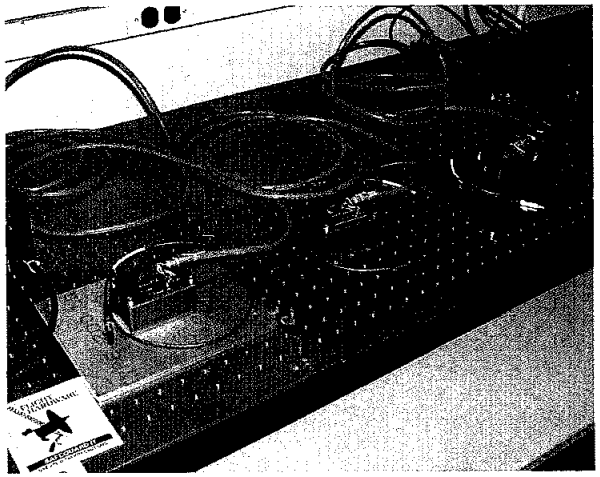
Signal Chain Assembly

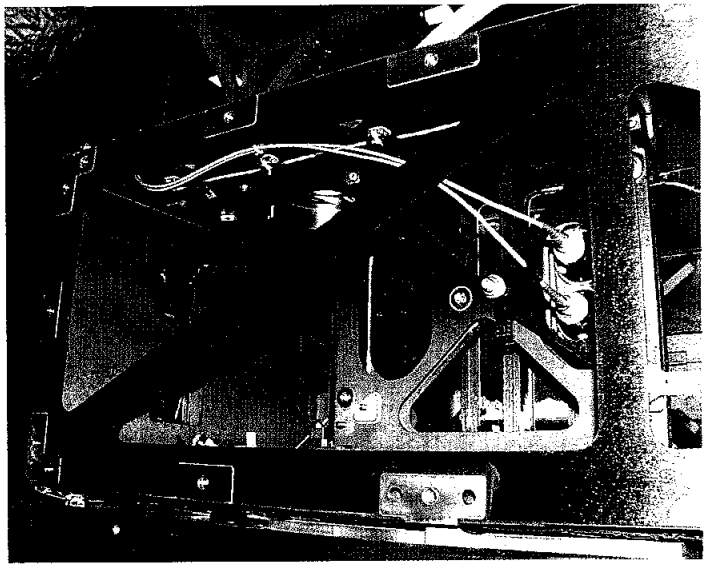


Signal Chain Chassis Fit Check

- Uses mixed signal ASICs and standard off the shelf 16 bit ADCs.
- One signal chain per pixel
- Stable Temperature maintained by heat pipes.

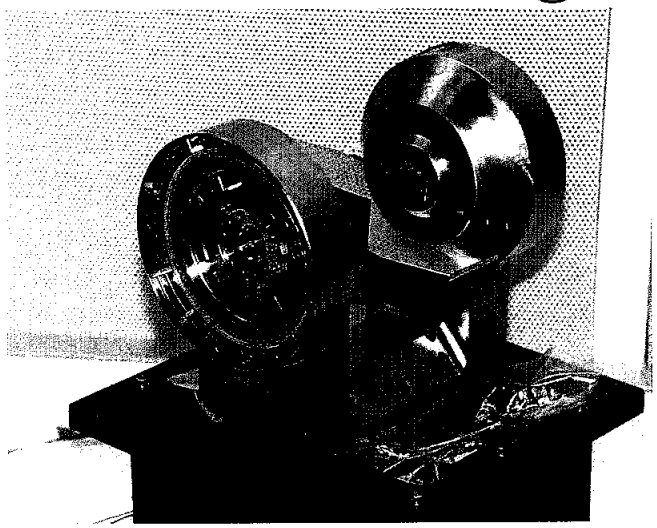
Laser Subsystem

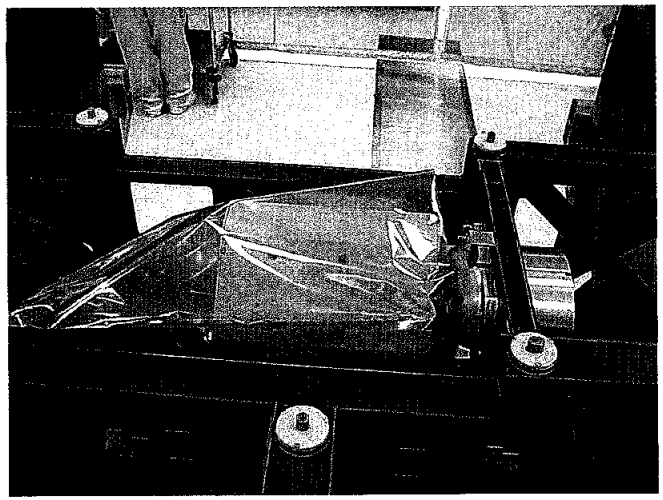




- Laser Subcontracted to Lightwave Electronics
- Laser Performance
  - » 1.06 microns
  - » Temperature controlled stability
  - » Flight version of commercial desizn
- Electronics designed and built at JPL

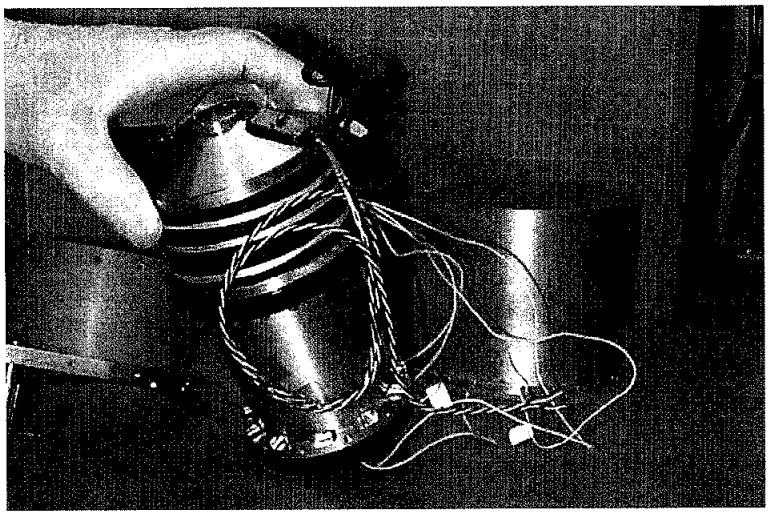
Pointing Control Subsystem

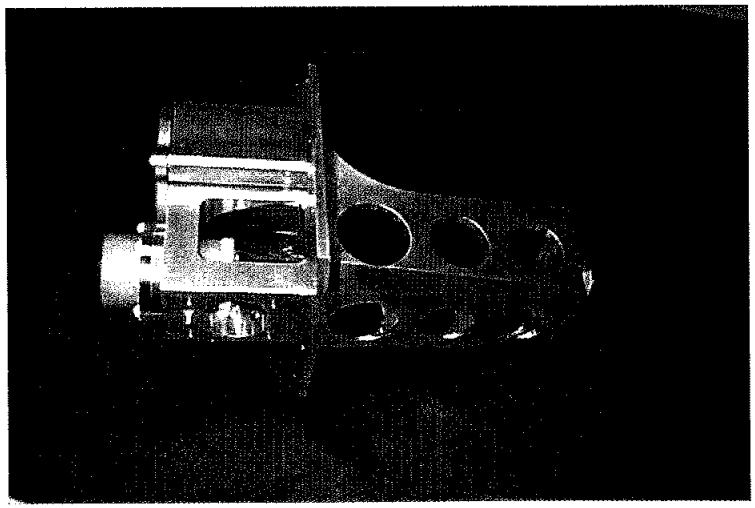




- Subcontracted to Schaeffer Magnetics/Moog
- Status
  - » Gimbal and Electronics meet performance requirements with margin.
  - » Installed in the instrument, and awaiting test.

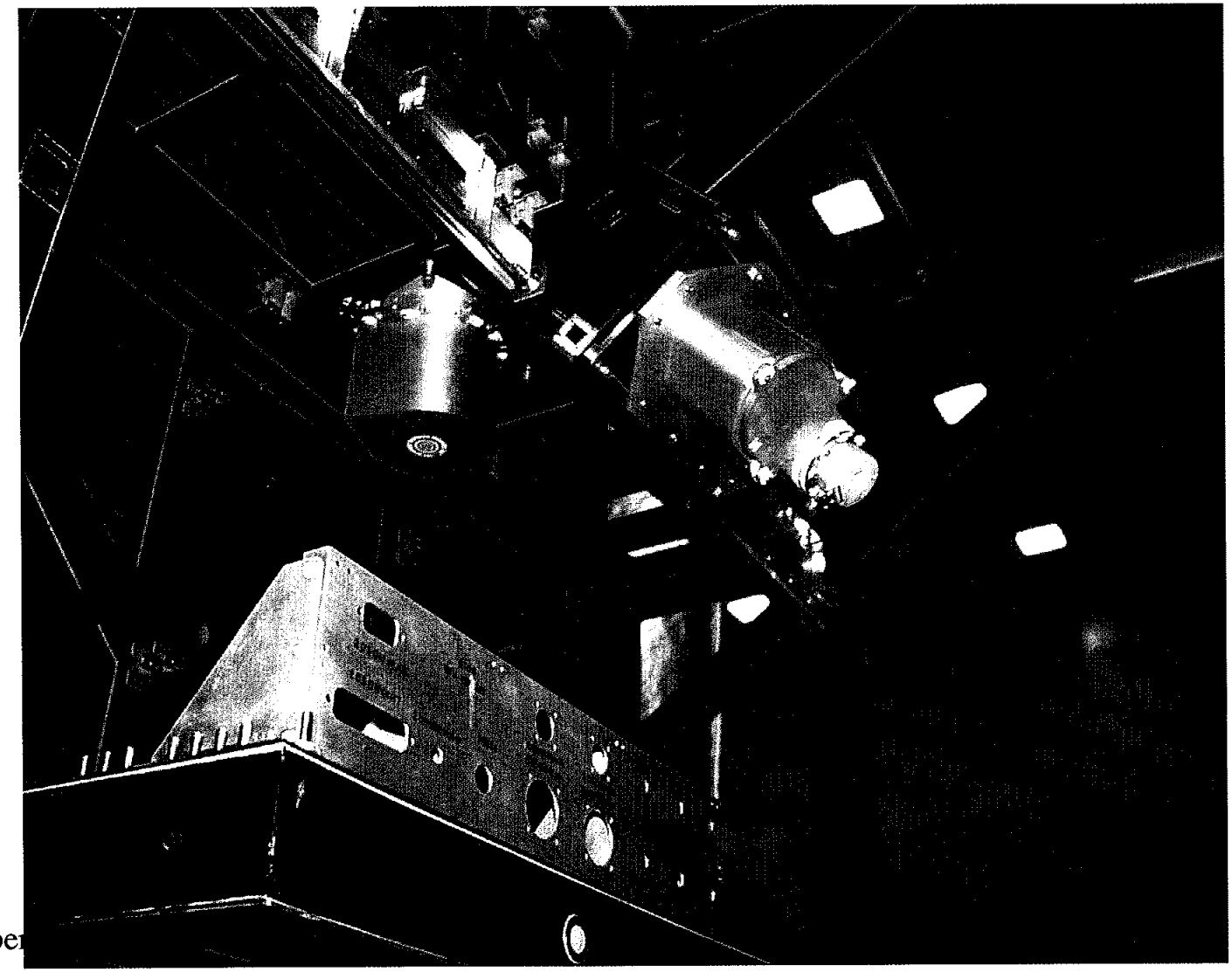
Calibration Subsystem



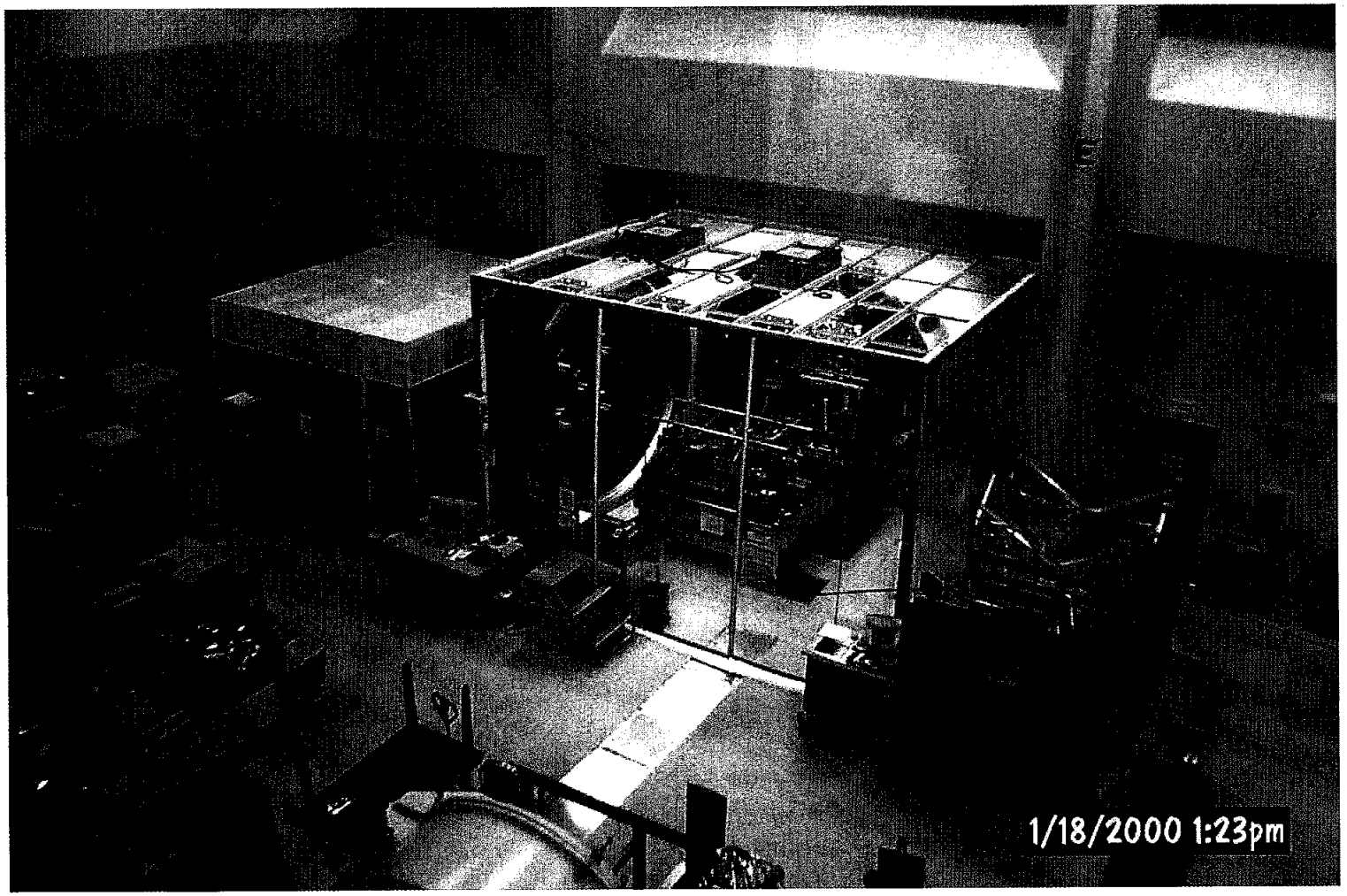


- Subcontract to Bomem
- Radiometric and alignment sources
- Status
  - » Meets all performance specifications.
  - » Installed in Instrument.

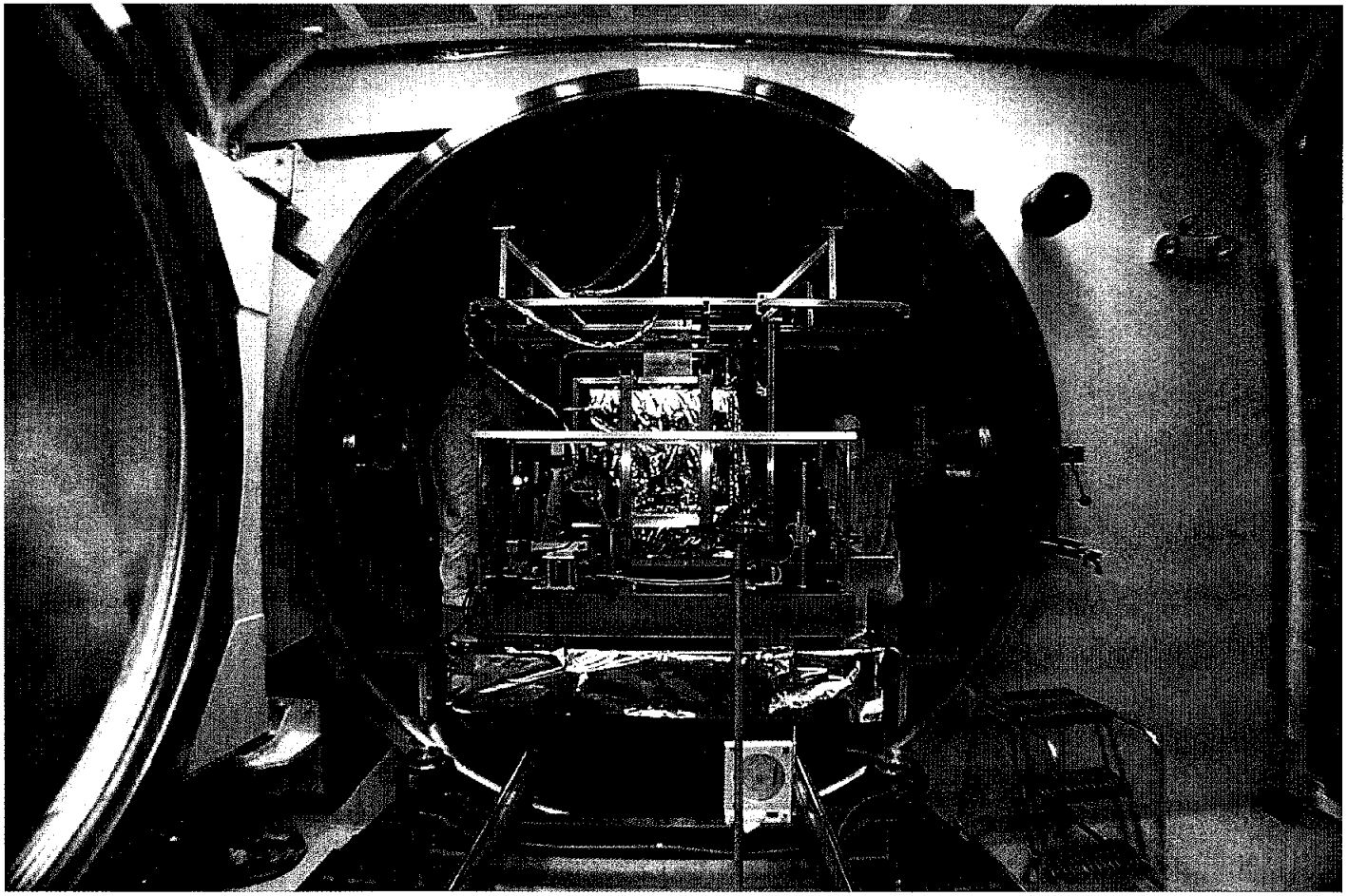
Installed Calibration Sources



I & T Facility



Installation for ThermoVac Test



Summary

- TES is a challenging instrument, using a great deal of new technology.
- The instrument is in integration and test, and proceeding into environmental test and calibration this winter and spring.
- We will deliver to the spacecraft in late summer 2002.
- Launch currently scheduled for July 2003.