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TES PROJECT OVERVIEW

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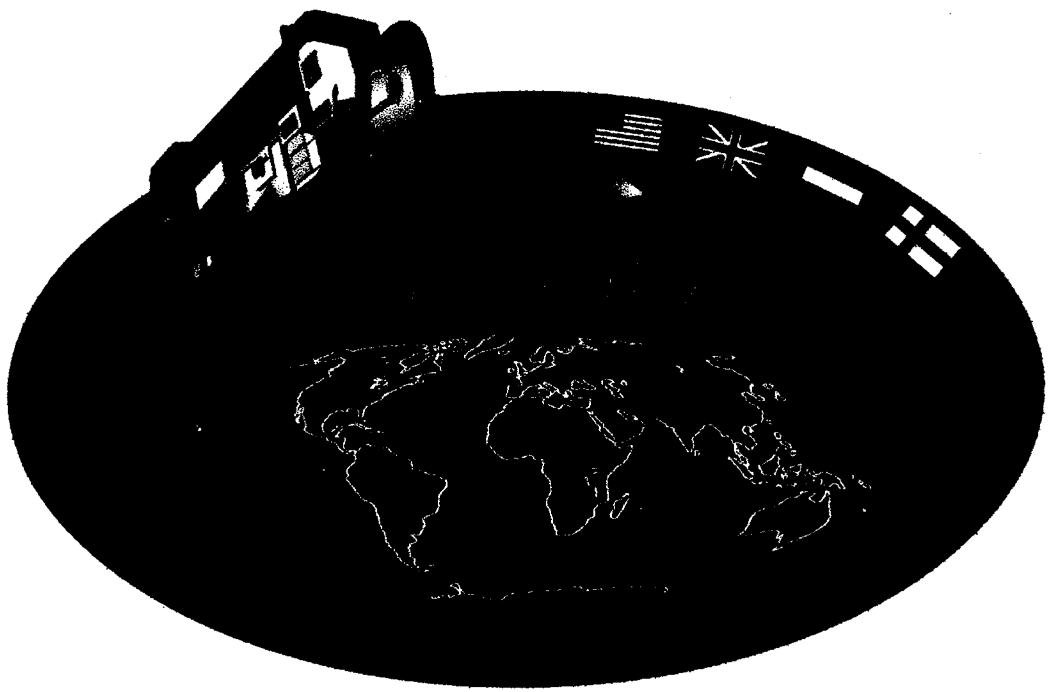
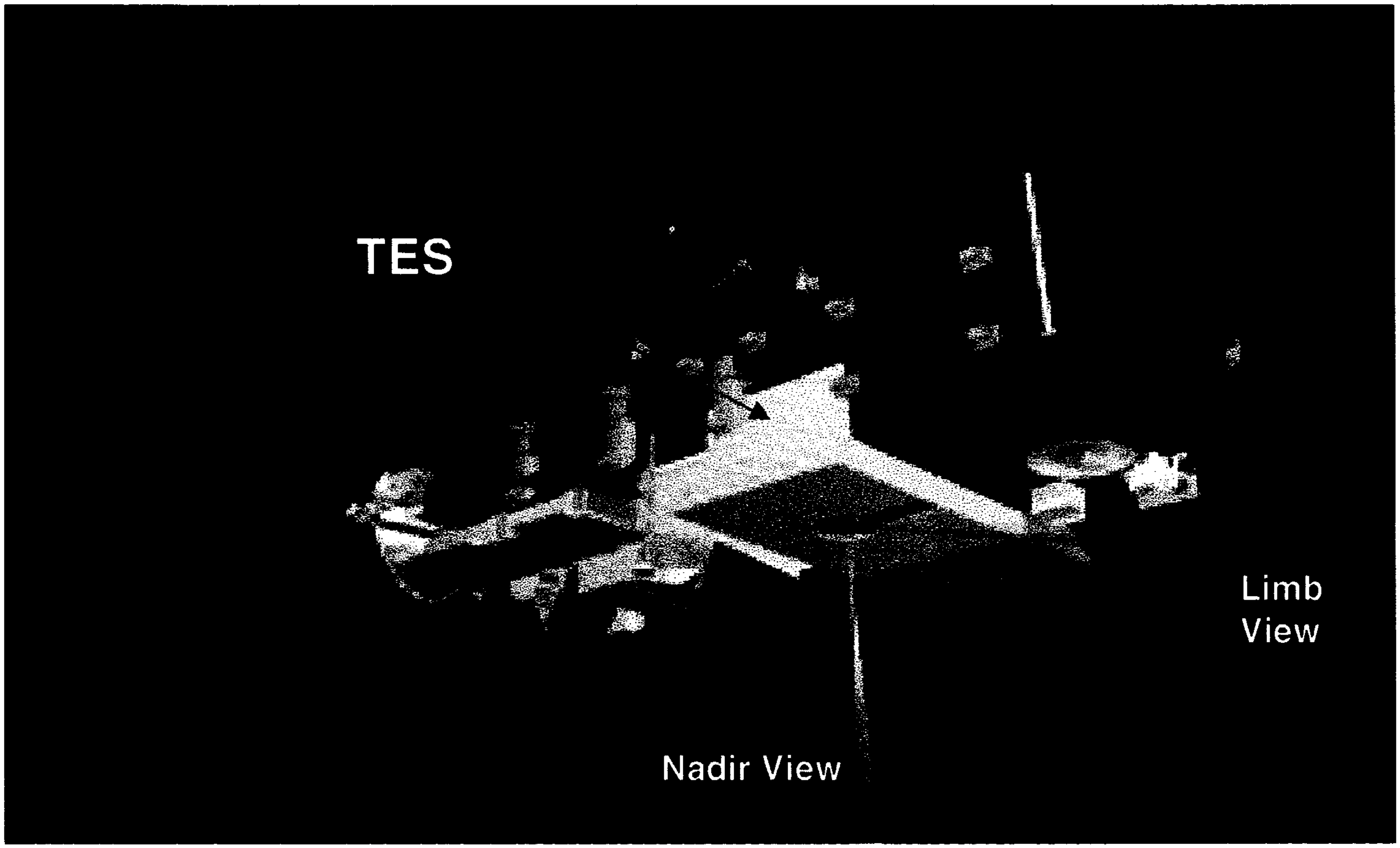


TES on the AURA Spacecraft



TOPICS

Introduction

Instrument status

Instrument Test & Calibration

Algorithm & Ground Data System status

Plans for launch and early operations

Data availability:
- for validation purposes
- for the community

INTRODUCTION

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Formal Co-Investigators

NAME	INSTITUTION	ROLE
Reinhard Beer	JPL	Principal Investigator
Shepard A. Clough	AER, Inc.	L2 Algorithms, Validation
Michael R. Gunson	JPL	Deputy PI
Daniel J. Jacob	Harvard University	Tropospheric Chem. Modeling
Jennifer A. Logan	Harvard University	Tropospheric Climatology
Frank J. Murcray	University of Denver	Correlative Measurements, Calibration
David M. Rider	JPL	Instrument Scientist, Calibration
Curtis P. Rinsland	NASA Langley RC	Spectroscopy, Validation
Clive D. Rodgers	Oxford University	L2 Algorithms, Validation
Stanley P. Sander	JPL	Tropospheric Chemistry, Validation
Fredric W. Taylor	Oxford University	Strat-Trop Exchange, Non-LTE
Helen M. Worden	JPL	Algorithm Team Leader, Calibration

ASSOCIATE INVESTIGATORS

NAME	INSTITUTION	ROLE
Kevin W. Bowman	JPL	L1B Algorithms
Linda R. Brown	JPL	Spectroscopy
Annmarie Eldering	JPL	Clouds & Aerosols
Brendan M. Fisher	JPL	Calibration
Aaron Goldman	University of Denver	Spectroscopy
Mingzhao Luo	JPL	Calibration, L3 Products
Gregory B. Osterman	JPL	Operational Support Products
Mark Shepherd	AER, Inc.	L2 Algorithms
Susan Sund Kulawik	JPL	L2 Algorithms
John R. Worden	JPL	L2 Algorithms

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TES Level 1 Requirements[1]

PRODUCT	UNITS	ACCURACY REL::ABS[2]	HORIZONTAL RES::COV[3]	VERTICAL RES::COV[4]
L1B Radiances [@ 10 μm]	$W/m^2/sr/cm^{-1}$	1%::1%	5.3 x 8.5 km: GN 53 x 169 km: GL	NA::NA
Temperature Profile	K	2K::1K	5.3 x 8.5 km: GN 53 x 169 km: GL	2-6 km::0-34 km
H_2O mixing ratio	%v	3%::3%	5.3 x 8.5 km: GN 53 x 169 km: GL	2-6 km::0-34 km
O_3 mixing ratio	ppbv	3%::3-20 ppbv	5.3 x 8.5 km: GN 53 x 169 km: GL	2-6 km::0-34 km
CO mixing ratio	ppbv	3%::10 ppbv	5.3 x 8.5 km: GN 53 x 169 km: GL	2-6 km::0-34 km
CH_4 mixing ratio	ppbv	3%::14 ppbv	5.3 x 8.5 km: GN 53 x 169 km: GL	2-6 km::0-34 km
NO_2 mixing ratio	pptv	5%::500 pptv	53 x 169 km: GL	2-6 km::10-34 km
HNO_3 mixing ratio	pptv	5%::25 pptv	53 x 169 km: GL	2-6 km::5-34 km
Surface Temperature	K	1K::1K	5.3 x 8.5 km: GN	NA::NA

[1] Temporal resolution is "every other day"
[2] Values for clear skies, northern mid-latitudes & mid-troposphere
[3] GN represents global coverage (nadir view), GL represents global coverage (limb view)
[4] NA = not applicable

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INSTRUMENT STATUS

CURRENT STATUS

TES is mounted on the AURA spacecraft at Northrup Grumman Space Technology (NGST), Redondo Beach, California.

In a 1g environment, TES can only operate as an infrared spectrometer when the spacecraft is horizontal. It also needs to be in a Thermal Vacuum Chamber. The chamber at NGST is vertical, so only limited tests can be performed. Nevertheless, except for the concern discussed below, the instrument seems to be behaving normally (the NGST environment was duplicated at JPL prior to delivery, so we know what to expect).

The HiRDLS experiment on AURA has experienced a partial cooler failure (too late to fix) that puts unexpected vibration into the spacecraft.

Tests using the TES Nd:YAG control laser fringes have shown that the HiRDLS vibration is being coupled into TES.

THIS IS A SERIOUS CONCERN THAT CANNOT BE ALLAYED UNTIL WE ARE ON ORBIT.

LAUNCH

Launch will (probably) be March – April 2004

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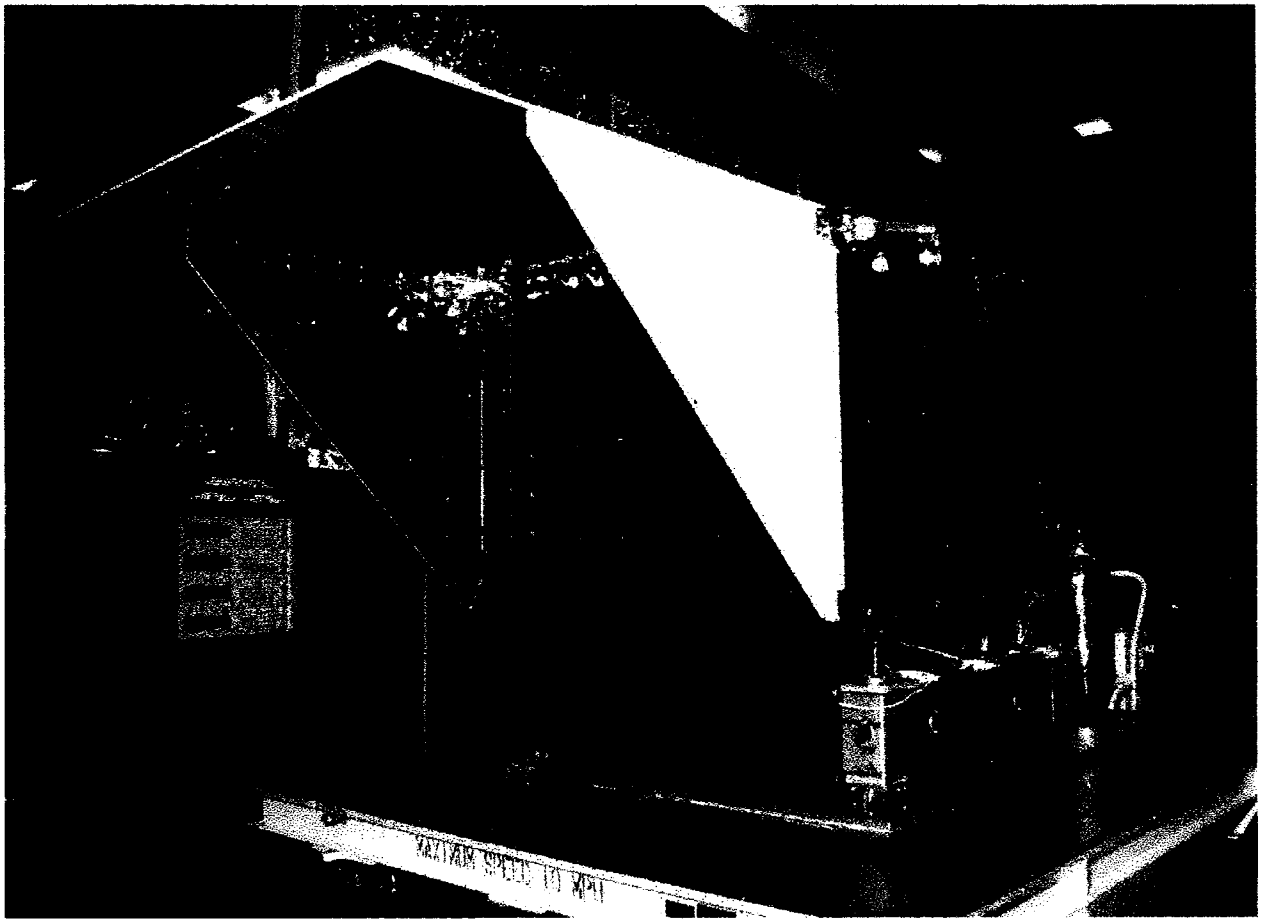
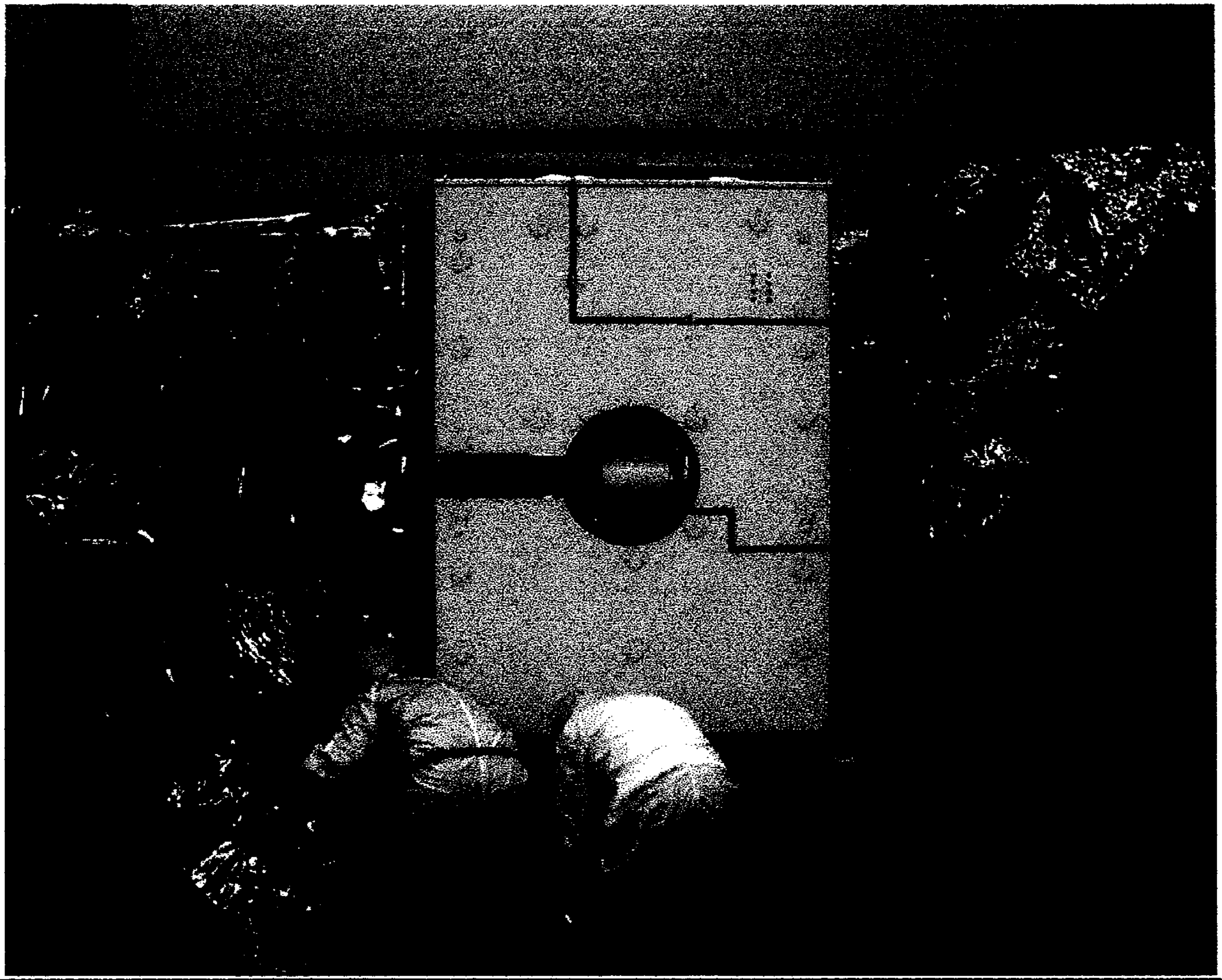
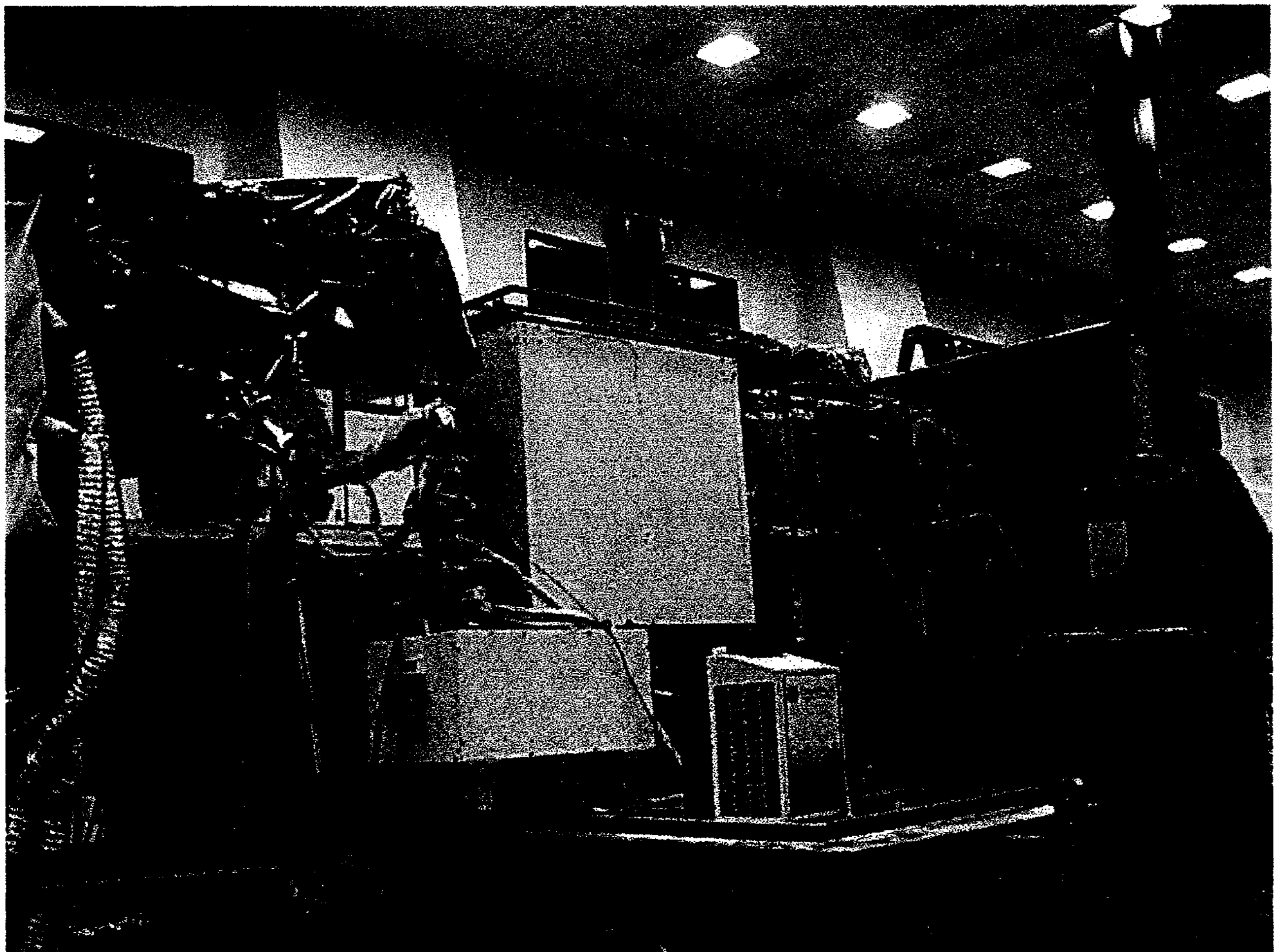
Space View Side



TES Prior to Acoustic Testing



TES on Aura



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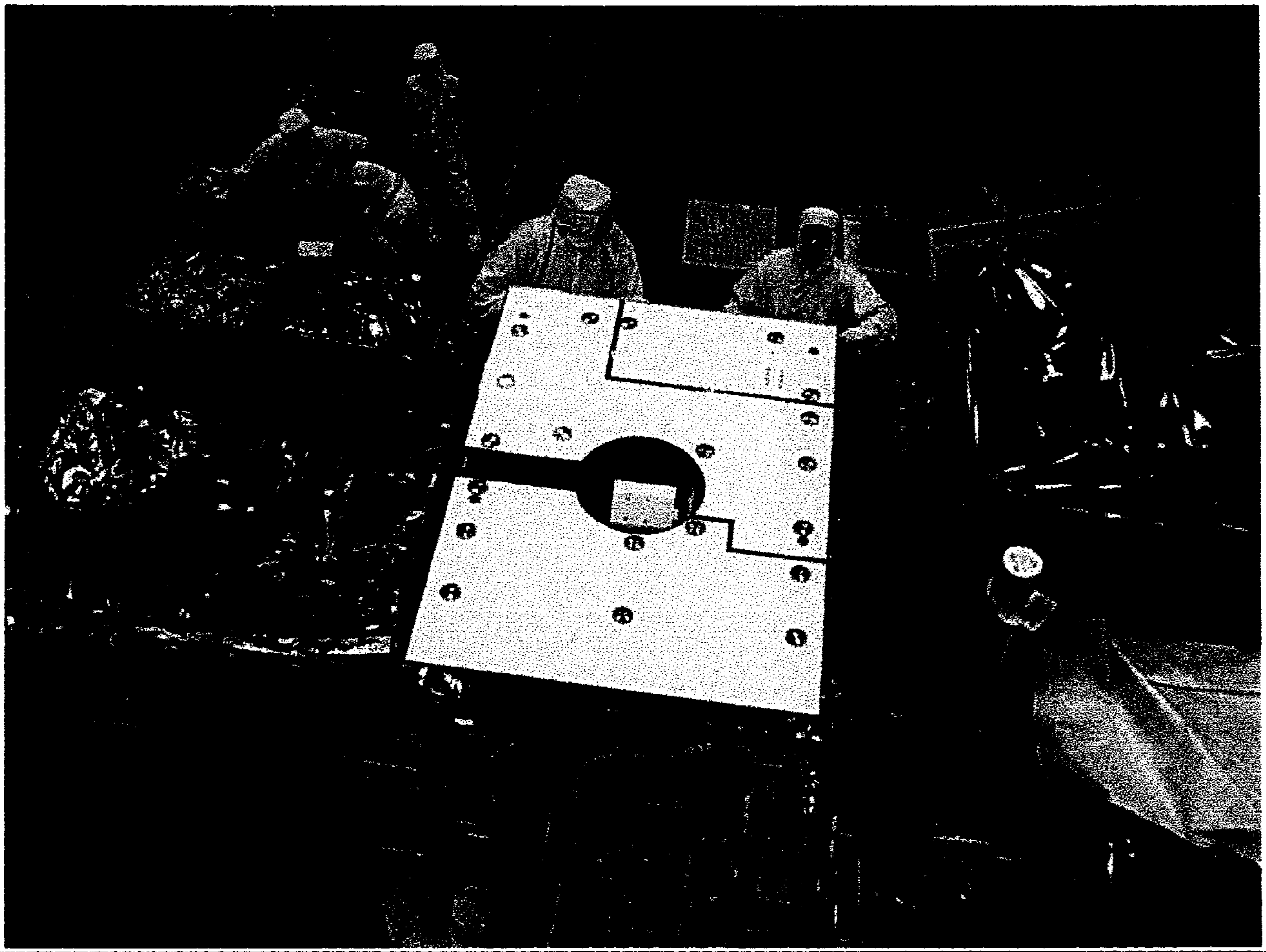
TES on Aura



INSTRUMENT TEST & CALIBRATION

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Calibration Requirements (1)

TES must provide spectra that are radiometrically calibrated (units of watts/m^2/sr/cm^{-1} *vs* cm^{-1}).

- requires a hot (340K) blackbody and a cold reference (90K BB in the lab, cold space on orbit)
- requires that signal chain *relative* gains be known
- requires that detector/signal chain system be linear (or any non-linearity known and corrected)

A primary output of this process is the Noise Equivalent Spectral Radiance (NESR) at zero input

Calibration Requirements (2)

TES must provide spectra that are frequency calibrated.

- requires a variety of gases of known properties (especially frequency) to be observed pre-launch using a gas cell and the same species in the limb on orbit
- requires that the gases (both in the lab and or orbit) be at low pressure and low concentration so that the spectral lines be unsaturated and narrow
- A CO_2 laser can provide independent verification of this calibration

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Calibration Requirements (3)

The TES Instrumental Line Shape must be known for all pixels at all frequencies.

- **requires the same gas cell measurements made for frequency calibration, followed by a deconvolution process**
- **a CO_2 laser is used to verify this process (at a few frequencies)**

Calibration Requirements (4)

The TES spatial response must be known for all pixels at all frequencies.

- requires sweeping the field-of-view with the Target Projector (TP,an illuminated slit at infinity)

- requires a numerical deconvolution of the results to remove the effect of the finite width of the TP slit

An important additional output of this calibration is the co-boresight of the 4 detector arrays (this parameter can also be measured on orbit, but not the spatial response)

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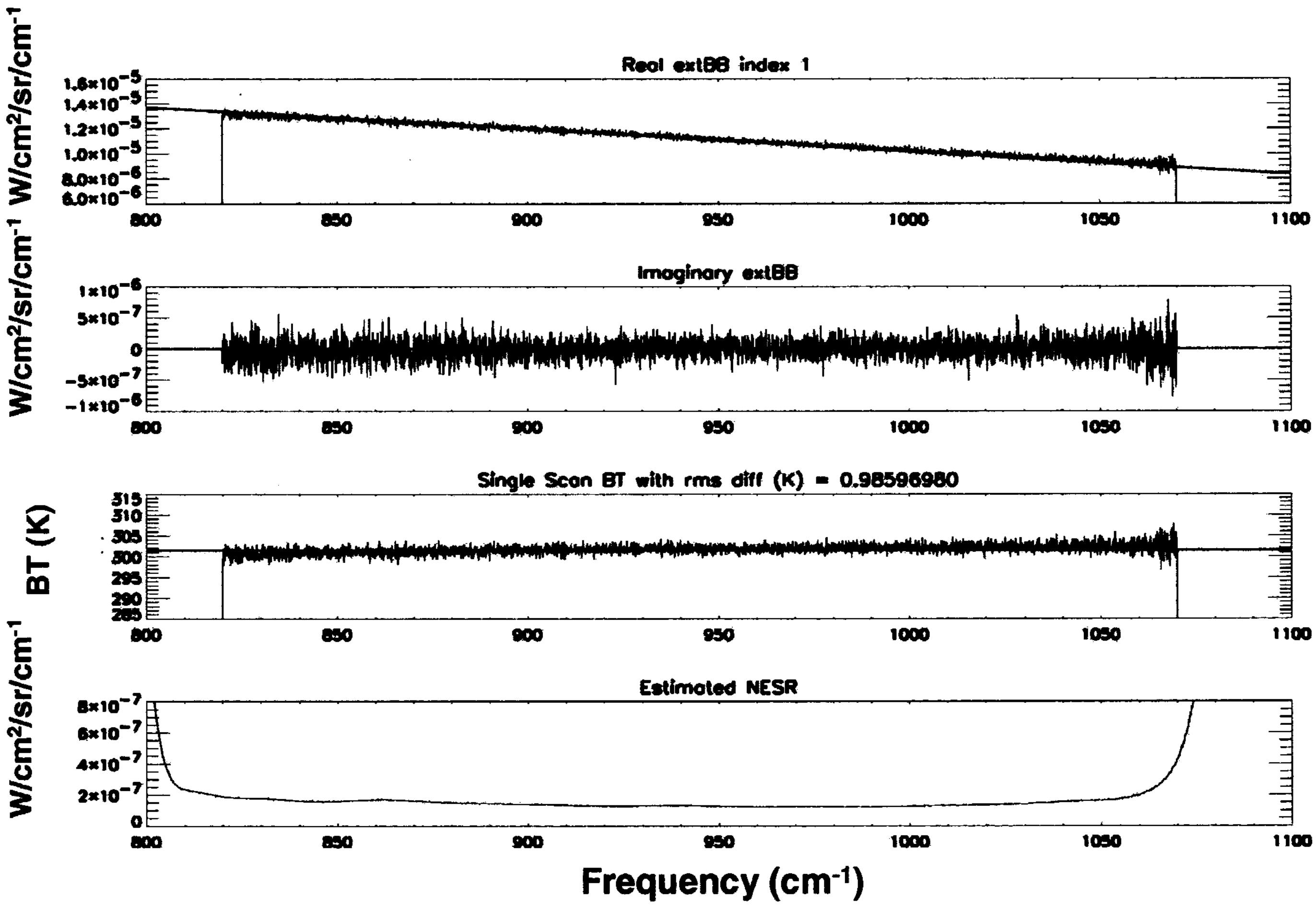
Calibration Requirements (5)

The Pointing Control System (PCS) angles for the various TES targets must be known:

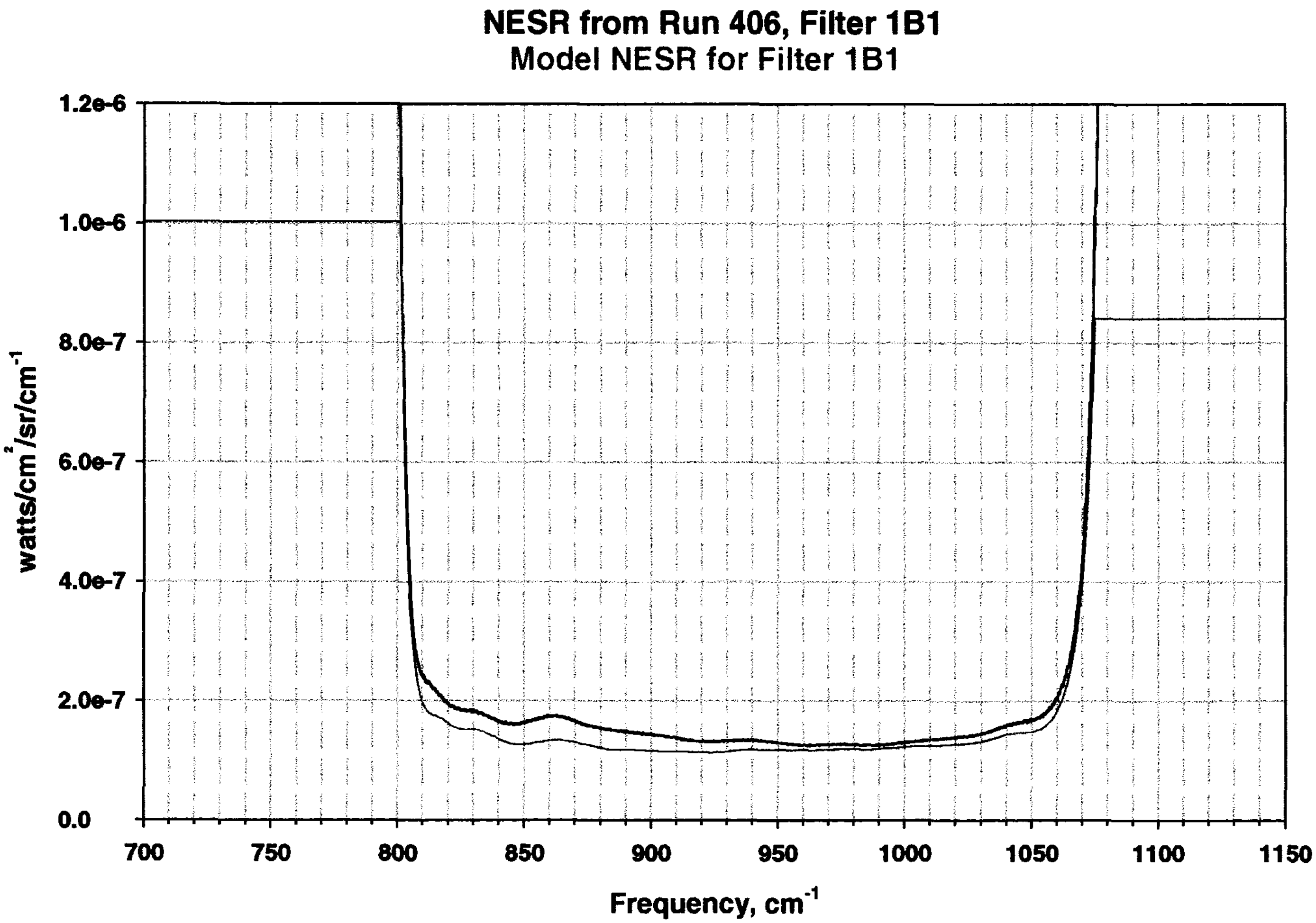
- down-looking targets by latitude and longitude within 45° of nadir (and surrogate for pre-flight calibration)
- the 16 km altitude for limb viewing
- the 300 km altitude for space viewing (and surrogate for pre-flight calibration)
- the On-Board Radiometric Calibration Source (OBRCS)
- the On-Board Spatial Calibration Source (OBSCS)
- the Target Projector, external radiometric sources and the gas cell

Most of these have required raster search patterns to establish the correct angles

Radiometric Calibration - Result



Measured & Modeled NESR's



CONTAMINATION

It was expected that the focal planes (at 65K) would experience a build-up of contamination (primarily water ice) while in the Thermal Vacuum chamber.

What was not expected was the speed at which this happens – in the region of the strongest ice band (around 800 cm^{-1}), the signal loss due to ice can be as much as 10% per day!

We also see CO_2 ice around 2340 cm^{-1} but this feature is comparatively narrow.

We believe (on the basis of other experiments [e.g., AIRS] with cold focal planes) that this rate of build-up will decrease with time once we are on orbit.

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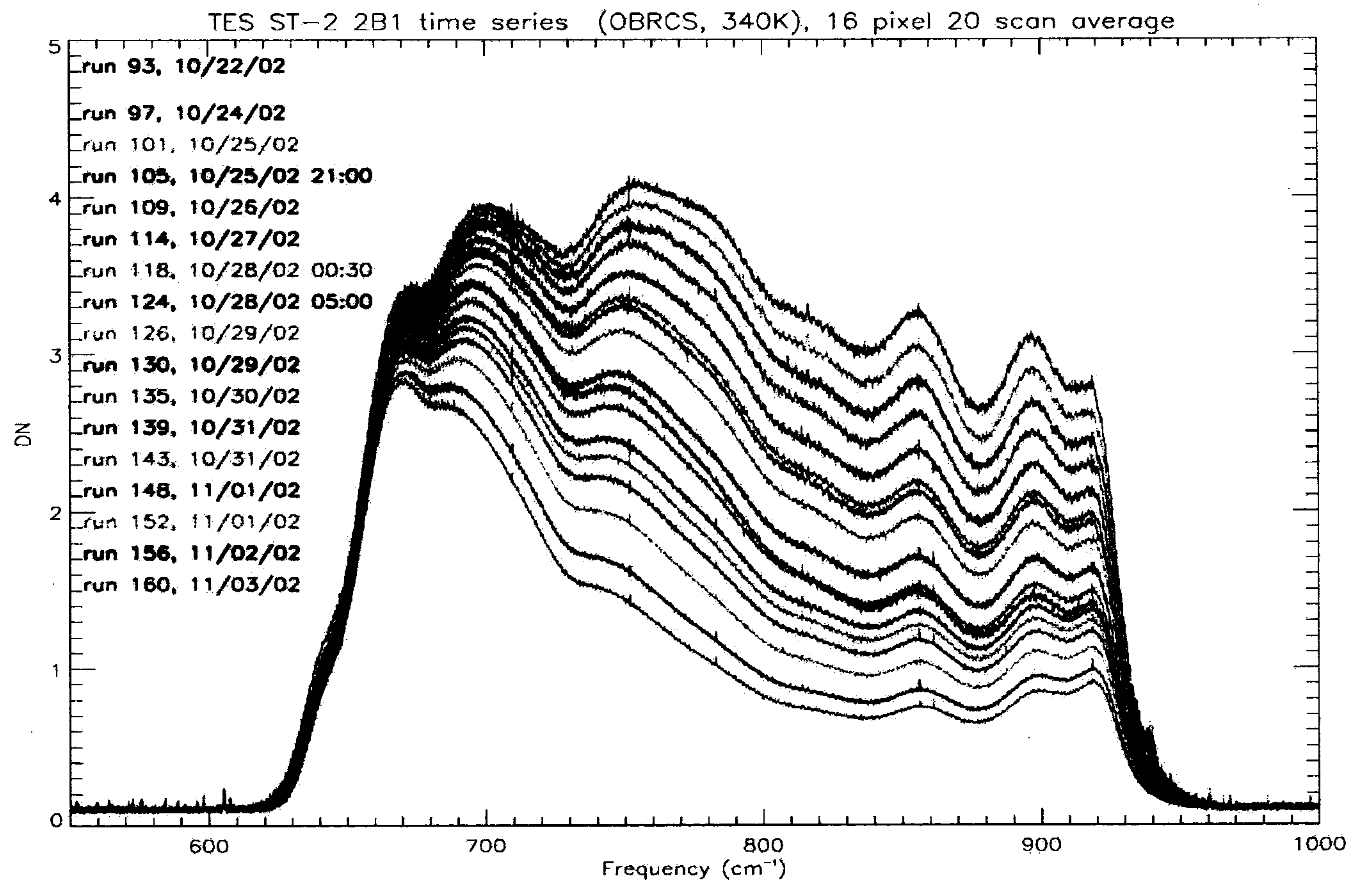
ICE BUILD-UP
(2B array over 10 days)



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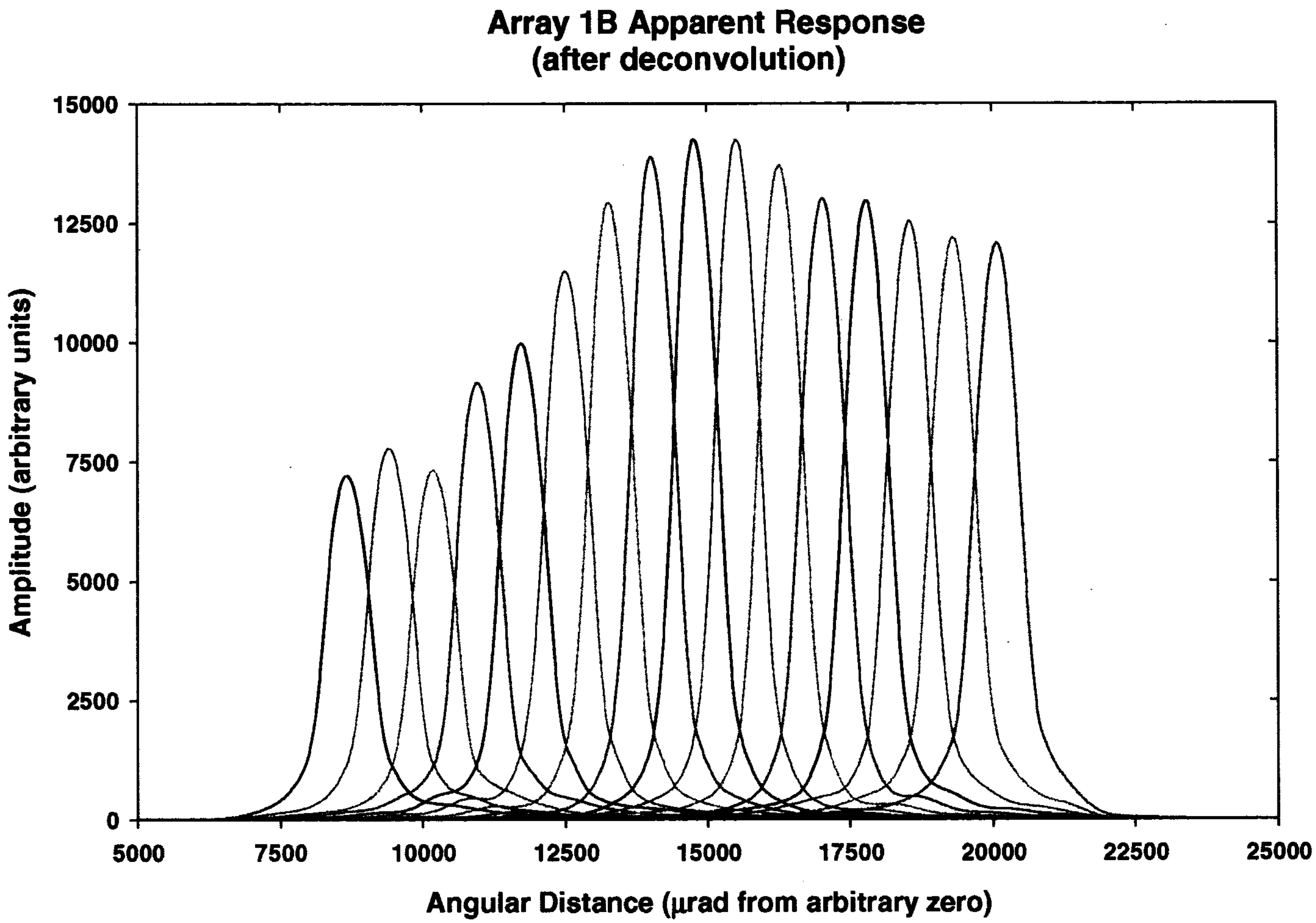
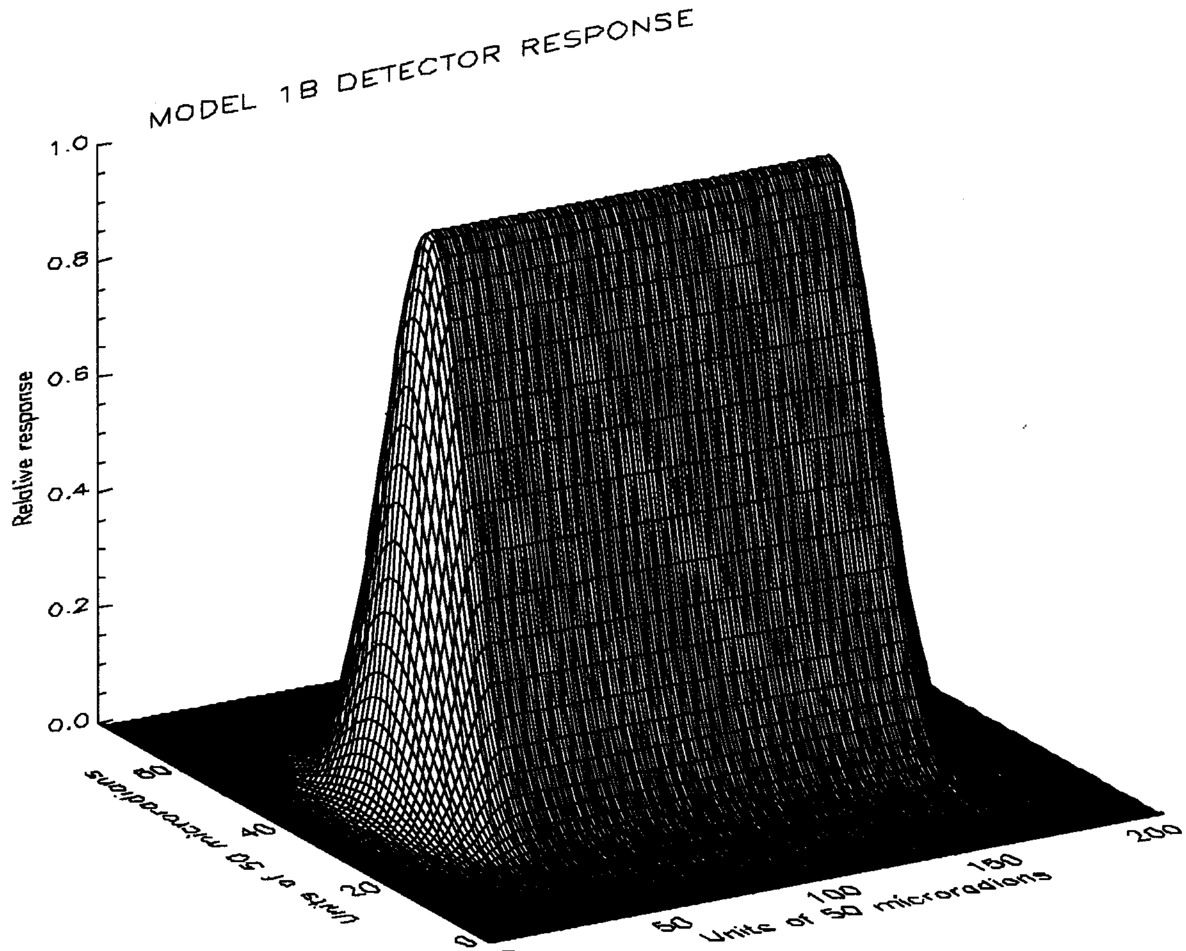
Field of View



1B Pixel Response Model



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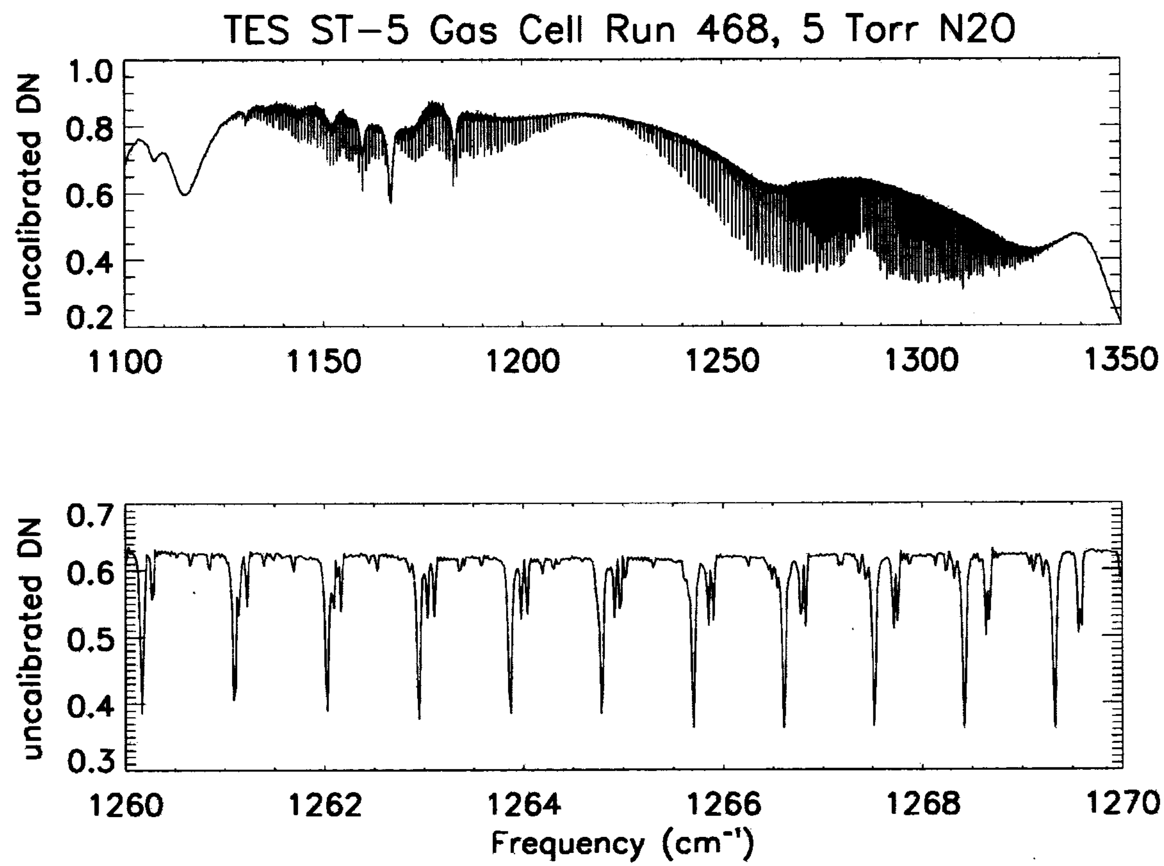
TES Gas Cell Spectra (1)



TES Gas Cell Data (2)

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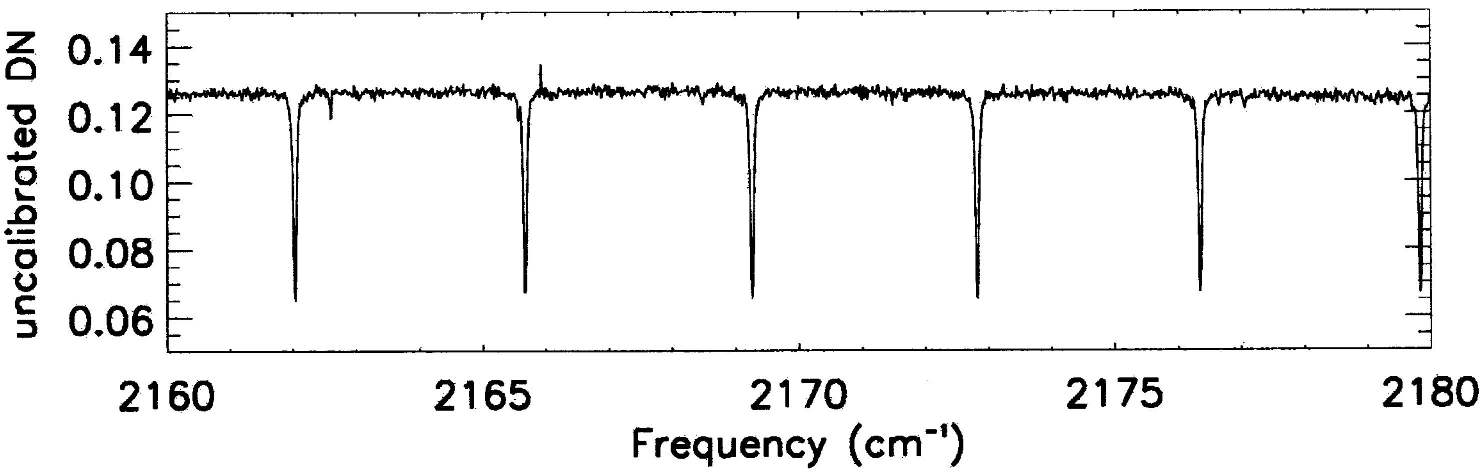
TES ST5 Gas Cell Run 473, 5 torr CO



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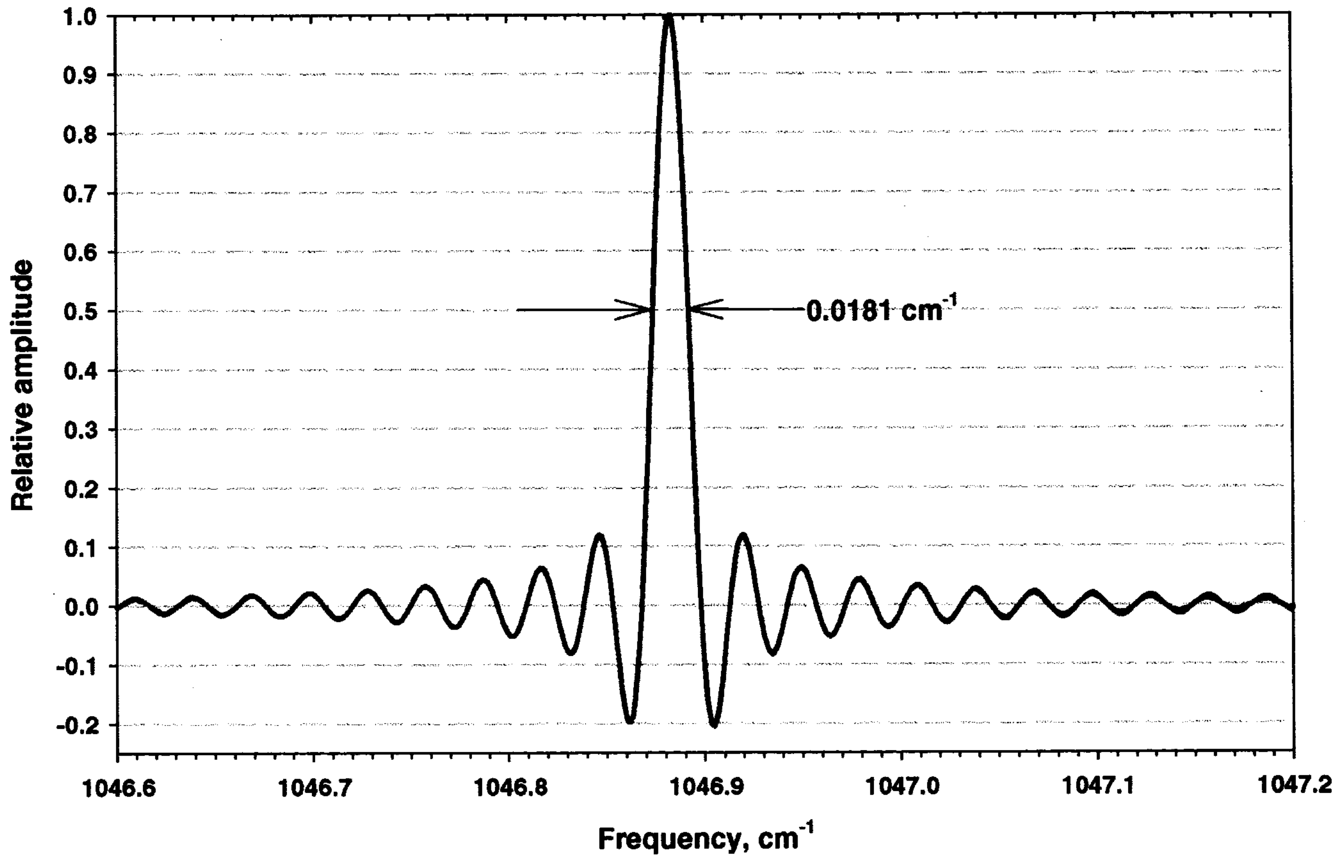
TES Instrumental Line Shape (ILS)

CO_2 Laser 00^01 - 02^00 P(20) line (nominally @ 1046.8543 cm^{-1})

Model prediction



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Relative Frequency Calibration (1B array)

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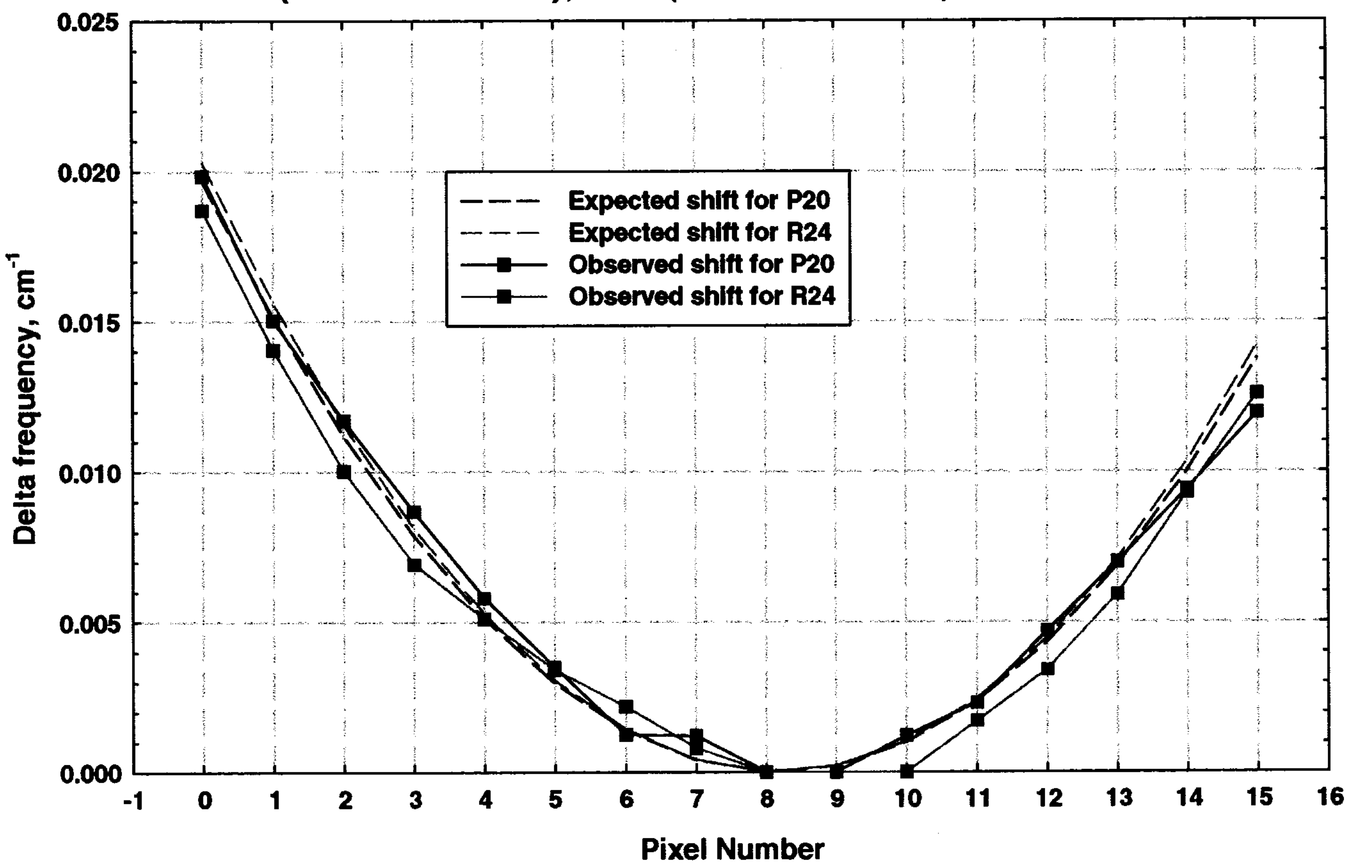
Observed & expected frequency shifts for the CO_2 laser

P20 (1046.8543 cm^{-1}); R24 (1081.0877 cm^{-1}); shift = +0.5 mrad



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ALGORITHM & GROUND DATA SYSTEM STATUS

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ALGORITHM STATUS

All Mission Critical & Mission Essential algorithms are in place and tested.

L1 algorithms were *thoroughly* tested during several months of System Tests (5 vacuum cycles of 2-3 weeks each)

L2 algorithms are being tested using back-produced spectra from MOZART model fields for one day of 16 orbits (the "One Day Test")

L1 – L2 internal & external connectivity has been demonstrated in Software Release 4 and mission operations testing

Updated Algorithm Theoretical Basis Documents (ATBD) are in progress

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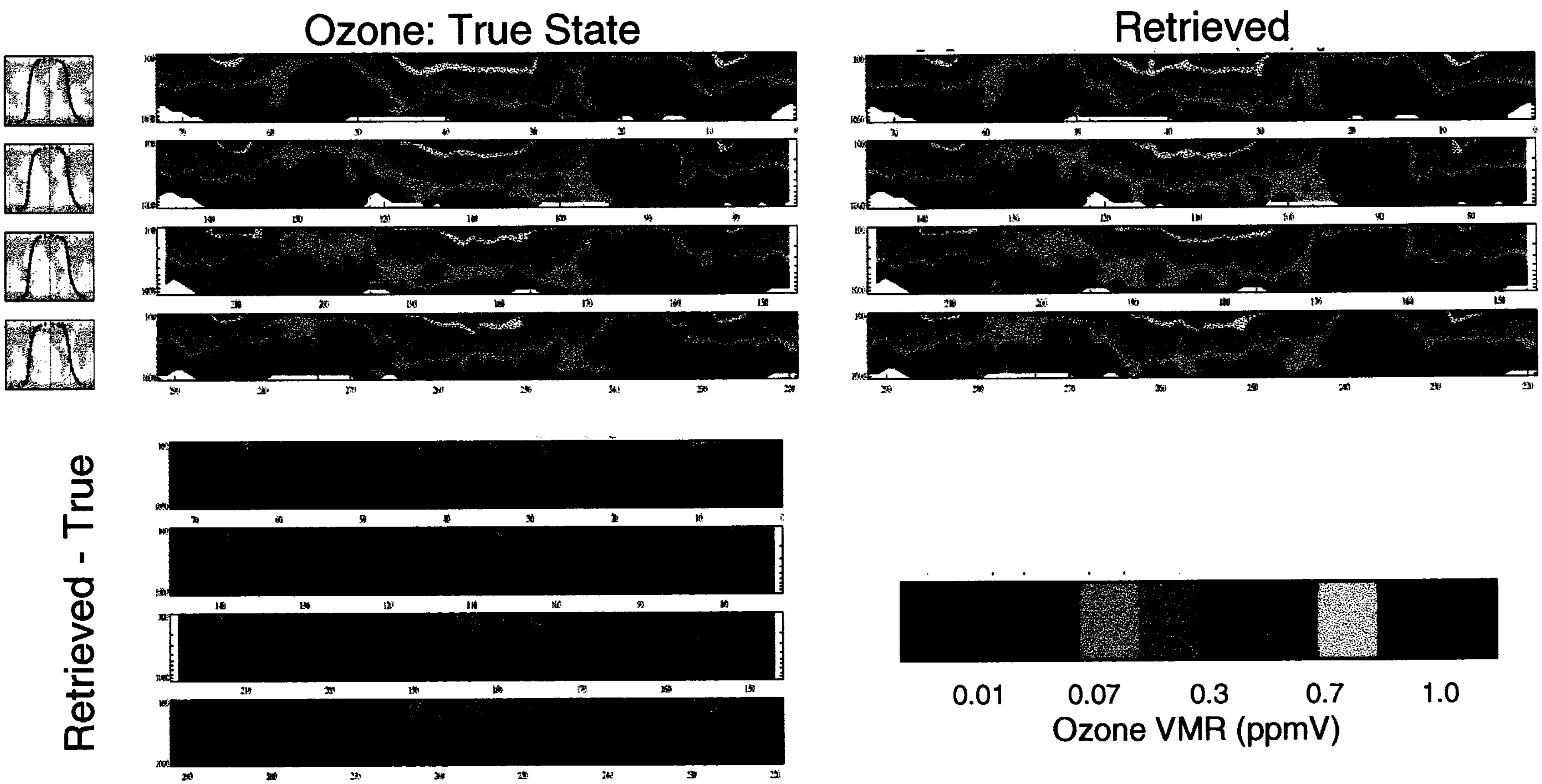
ONE DAY TEST RESULTS

(1000 – 100 hPa; 4/16 orbits shown)



SIPS / SCF / ASDC Facilities

The Science Investigator Processing System (SIPS) Production facility is hosted by Raytheon in Pasadena (152-node dual AMD Opteron cluster + RAIDs etc.).

The Science Computing Facility (SCF) for Research Products, algorithm and software development is at JPL (20-node dual AMD Opteron cluster + RAIDs etc.).

The Atmospheric Science Data Center (ASDC) is at the NASA Langley Research Center. There, all TES data will be archived.

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PLANS FOR LAUNCH & EARLY OPERATIONS

FIRST YEAR ACTIVITIES

L→ L+30	Instrument Activation (power on, unlatch, outgas, open Earth shade, cool down, signal chain on)
L+30 → L+150	Post-launch Commissioning (initial calibration to assess instrument alignment & ice accumulation, defrost as necessary, first cold space views, Global Survey checkout)
L+150→ L+240	Initial Operations (transects & staring mode to support validation, defrost as necessary, trial Global Surveys & analysis)
L+240 →	Transition to routine operations

DATA AVAILABILITY

DATA PLANS

FOR VALIDATION

- L+5 – L+8 months

FOR THE COMMUNITY

- L+12 months for nadir products
- L+18 months for limb products

SUMMARY

TES IS READY FOR LAUNCH

For more information:

http://tes.jpl.nasa.gov