The Atmospheric Chemistry Experiment (ACE): An Overview

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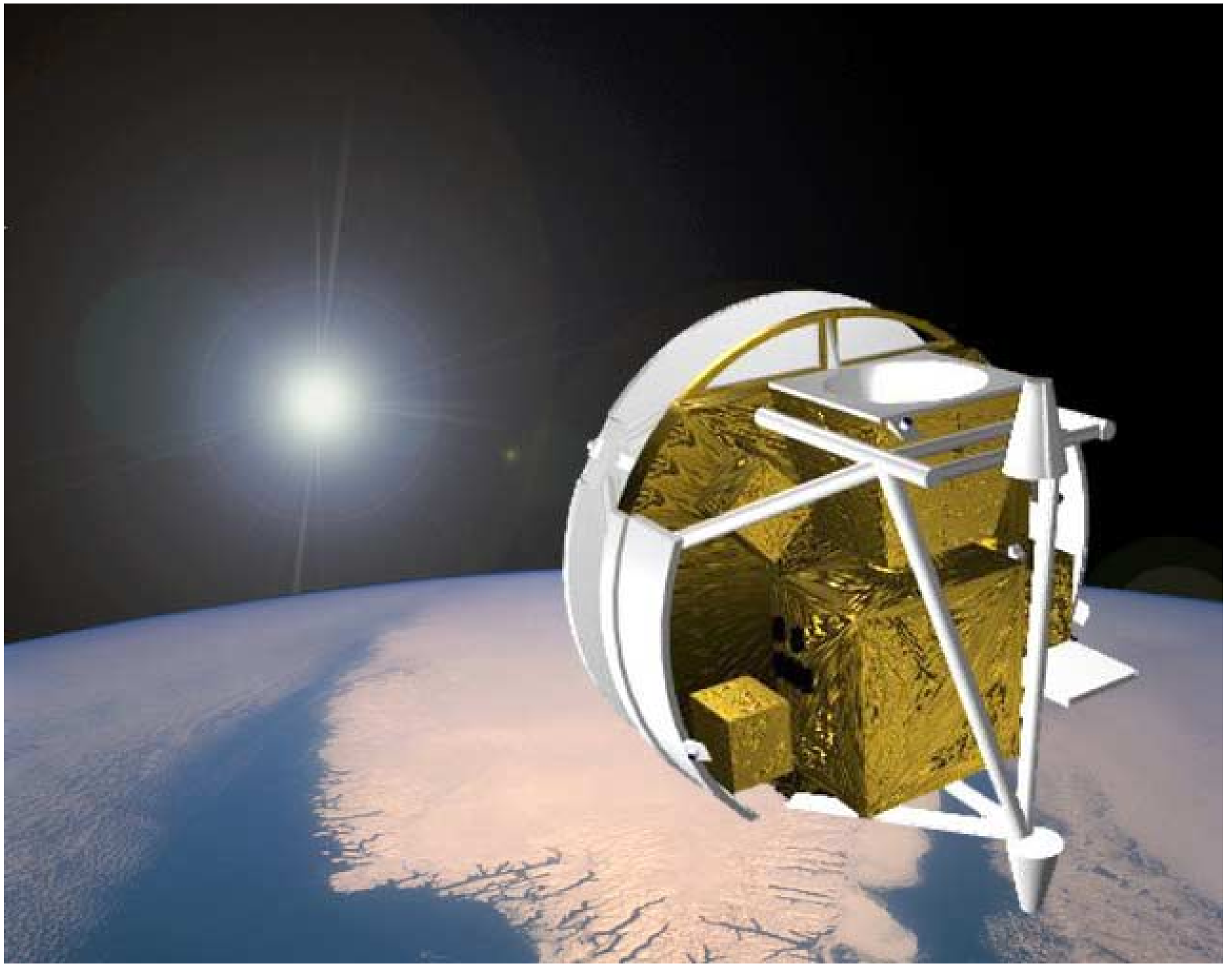
ACE Goals

To investigate the chemical and dynamical processes that control the distribution of ozone in the stratosphere and upper troposphere with a particular focus on the Arctic winter stratosphere.

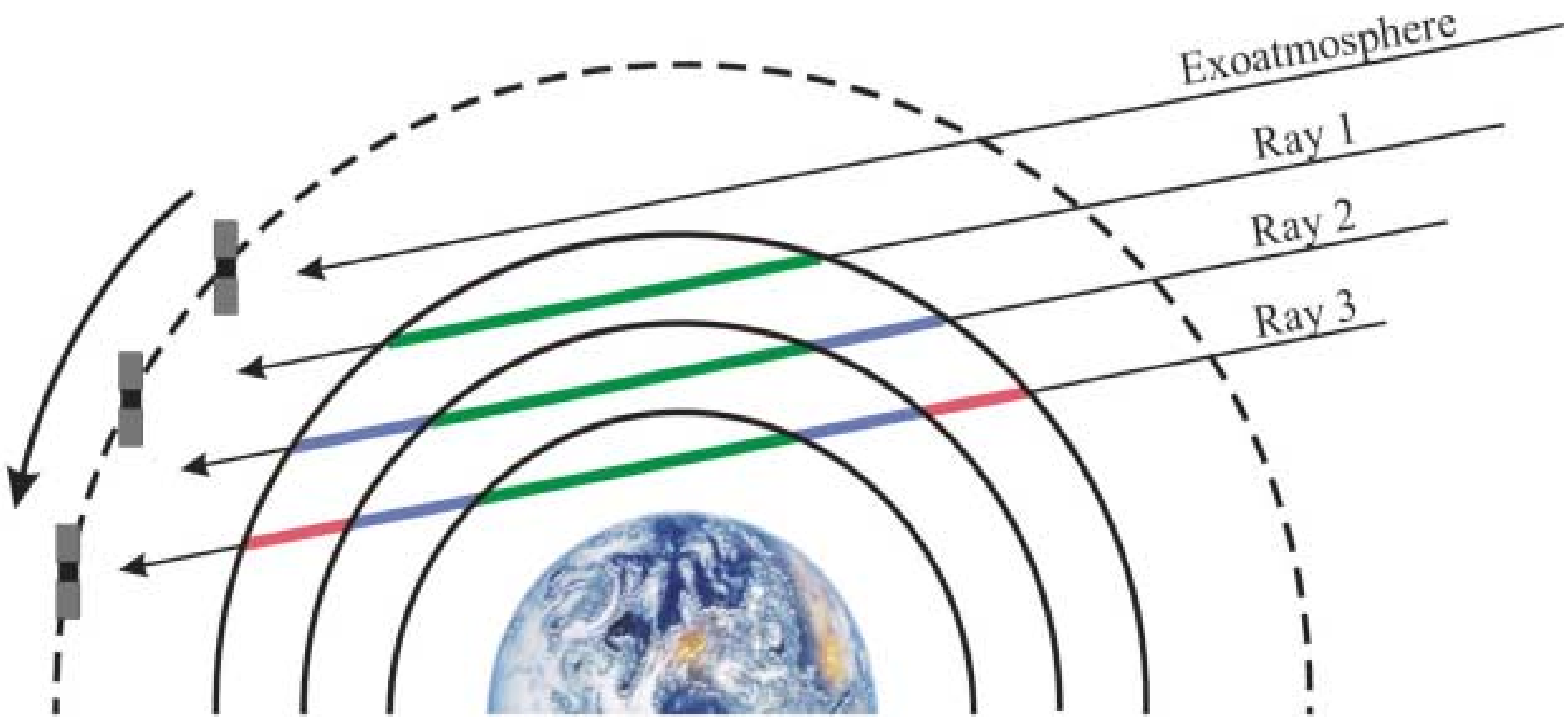
To accomplish this,

- Temperature and pressure will be measured.
- ACE will measure the concentrations of more than 30 molecules as a function of altitude.
- Aerosols will be measured and quantified.

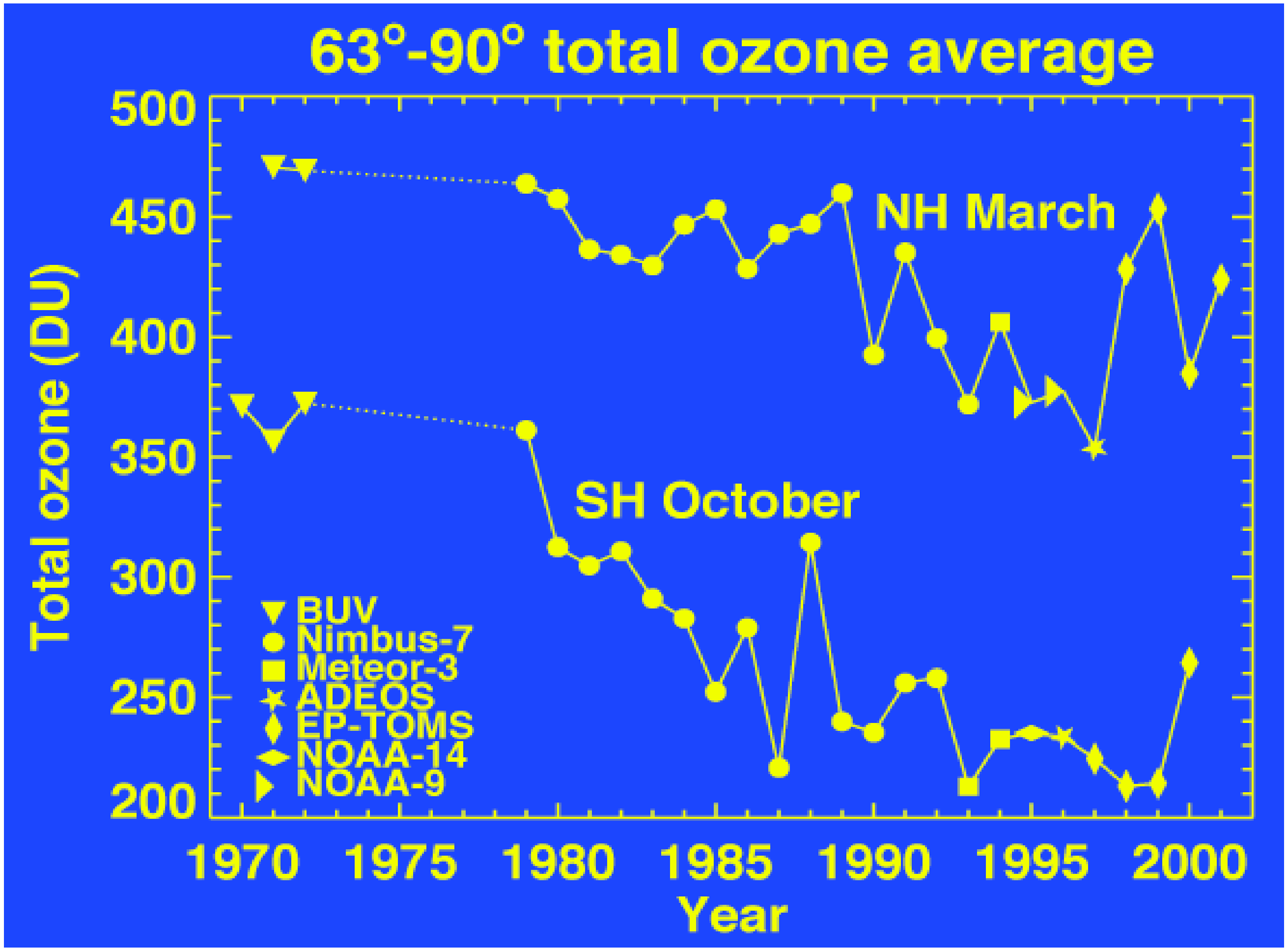
ACE Satellite



Solar Occultation



Polar Ozone

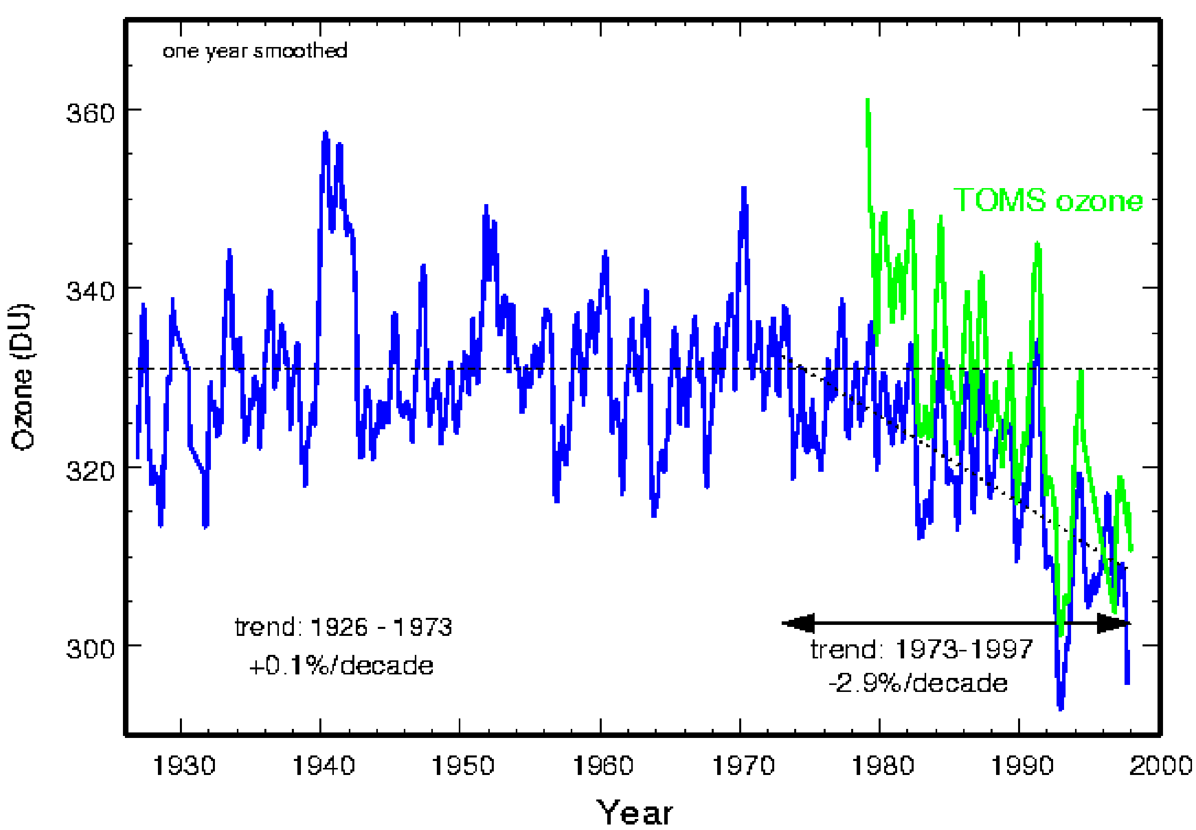

63°-90° total ozone average
NH March
SH October
Total ozone (DU)
500
450
400
350
300
250
200
1970
1975
1980
1985
1990
1995
2000
Year
BUV
Nimbus-7
Meteor-3
ADEOS
EP-TOMS
NOAA-14
NOAA-9

Polar Stratospheric Clouds

Mid-latitude Ozone Decline

McPeters May 1, 1998

Ozone at Arosa, Switzerland since 1926



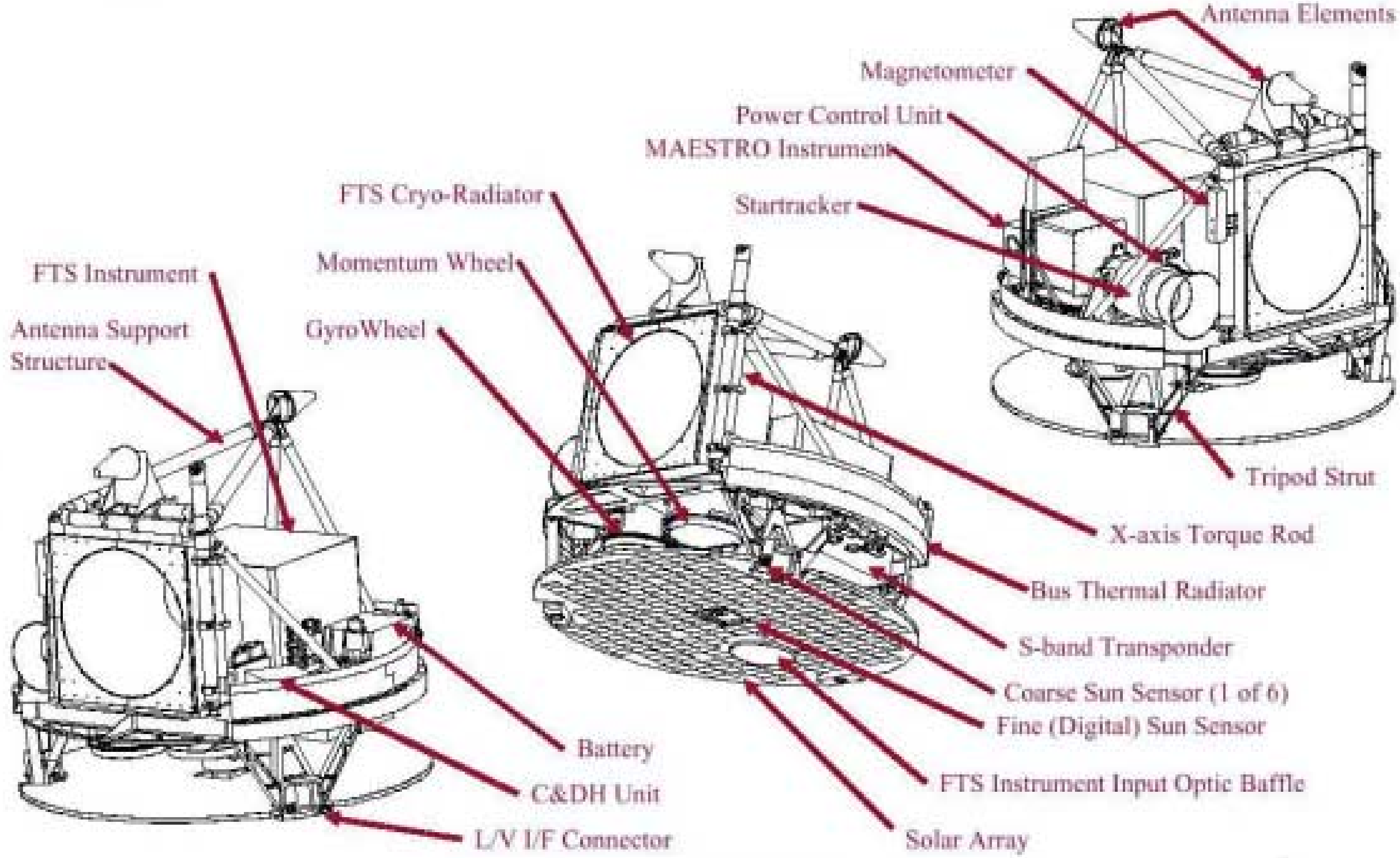
Instruments

- Infrared Fourier Transform Spectrometer operating between 2 and 13 microns with a resolution of 0.02 cm^{-1}
- 2-channel visible/near infrared Imagers, operating at 0.525 and 1.02 microns (c.f., SAGE II)
- Suntracker keeps the instruments pointed at the sun's radiometric center.
- UV / Visible spectrometer (MAESTRO) 0.285 to 1.03 microns, resolution ~1-2 nm
- Startracker

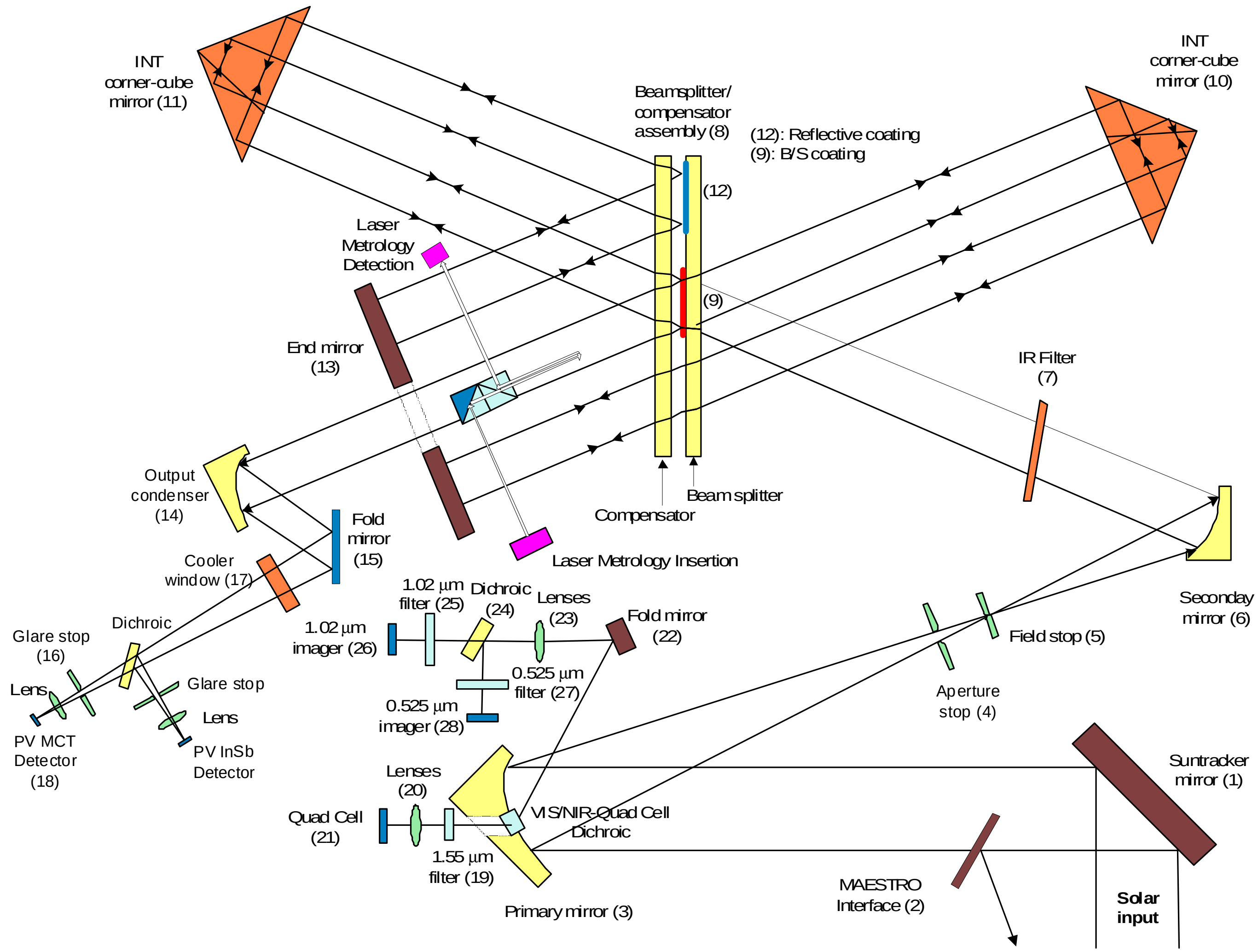
Timeline

- Feb. 2001 FTS and Imager CDR
- Mar. 2001 MAESTRO CDR
- Jun. 2001 Bus CDR
- Oct. 2002 Instrument test (Toronto)
- Sept. 2002 S/C integration & test
- Nov. 2002 Ready for launch
- Jan. 2003 Launch

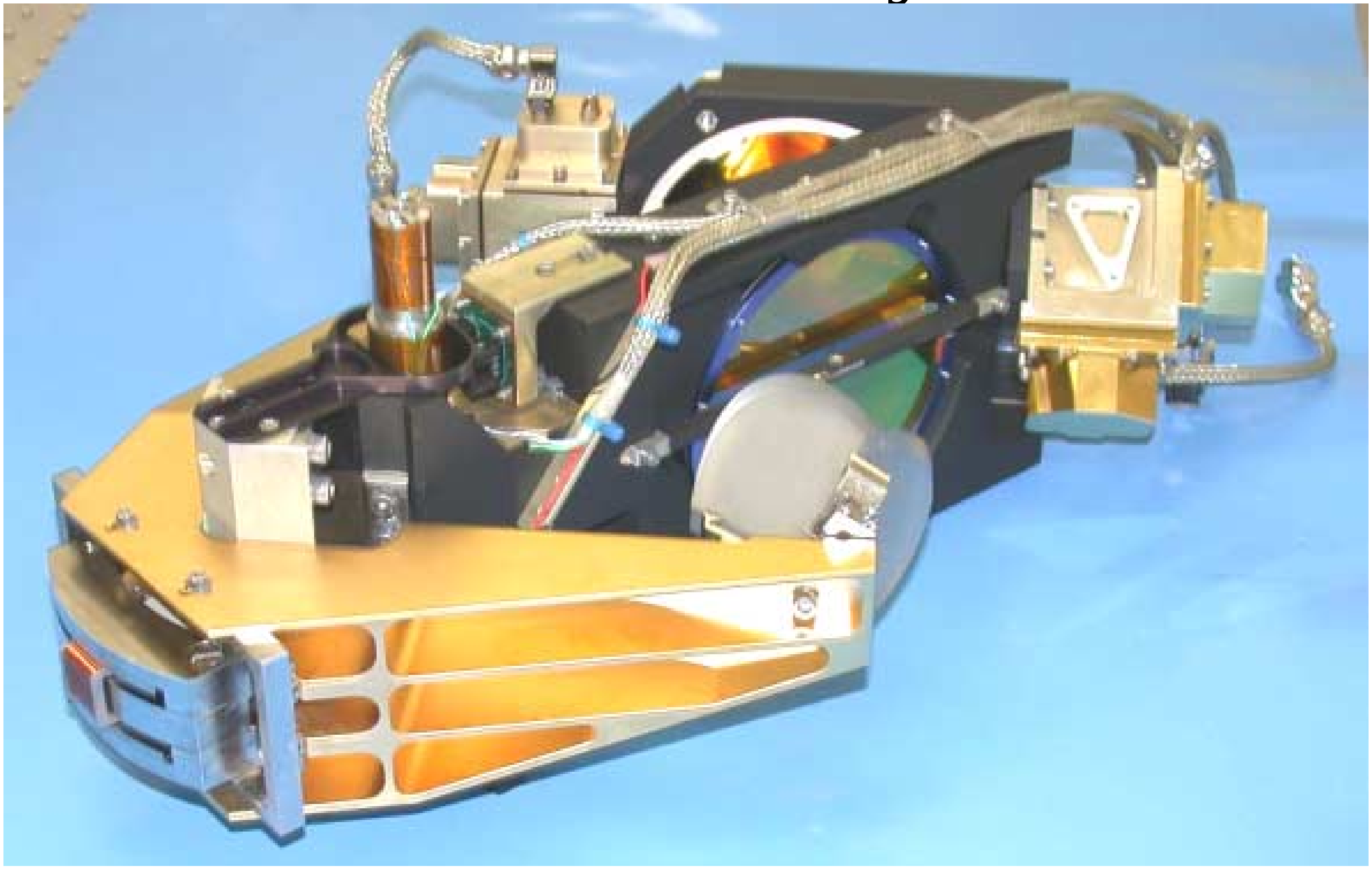
ACE Payload


Antenna Elements
Magnetometer
Power Control Unit
MAESTRO Instrument
FTS Cryo-Radiator
Startracker
FTS Instrument
Momentum Wheel
Antenna Support Structure
GyroWheel
Tripod Strut
X-axis Torque Rod
Bus Thermal Radiator
S-band Transponder
Coarse Sun Sensor (1 of 6)
Fine (Digital) Sun Sensor
Battery
C&DH Unit
FTS Instrument Input Optic Baffle
L/V I/F Connector
Solar Array

Optical Layout (Bomem)



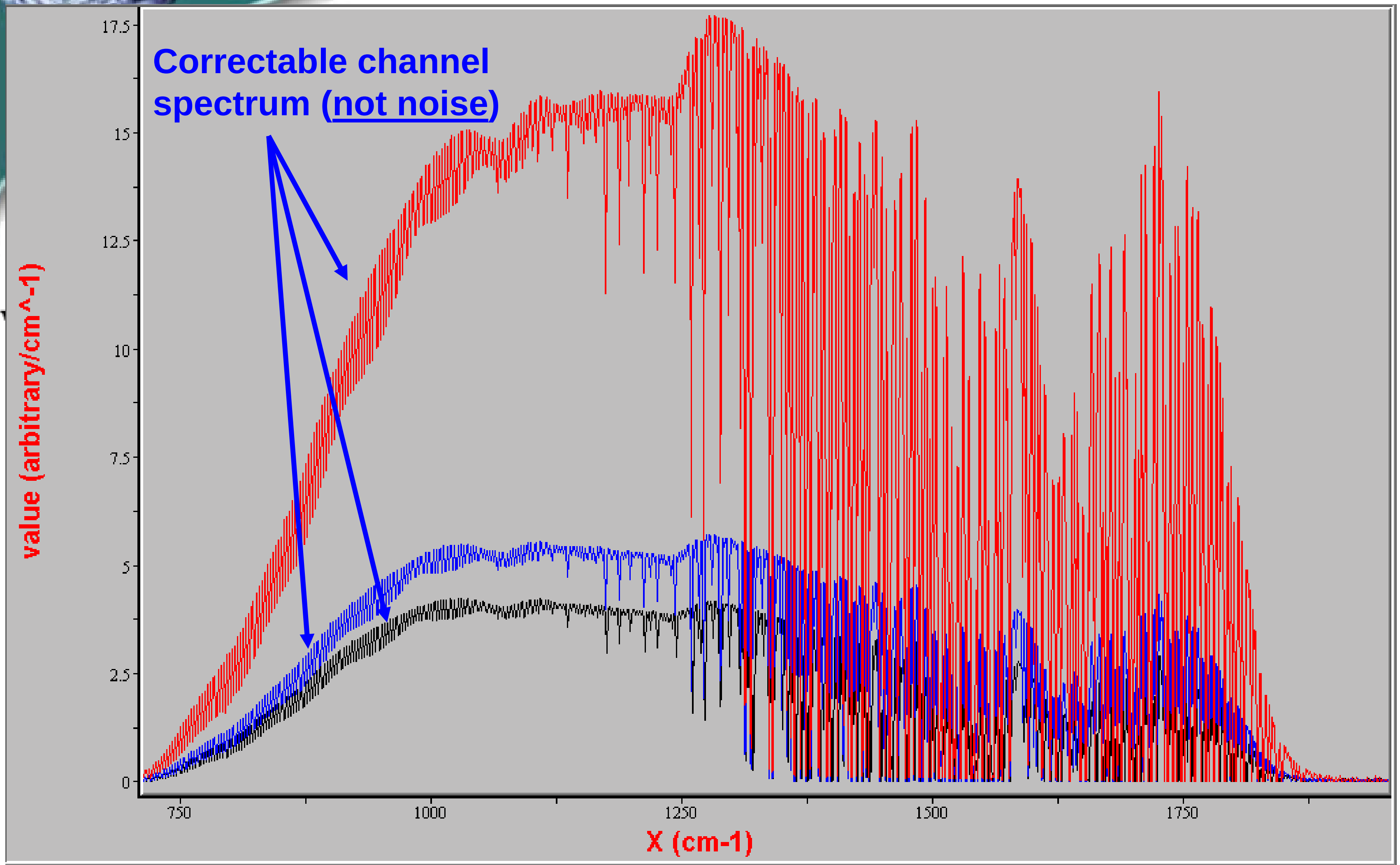
Interferometer Sub-system



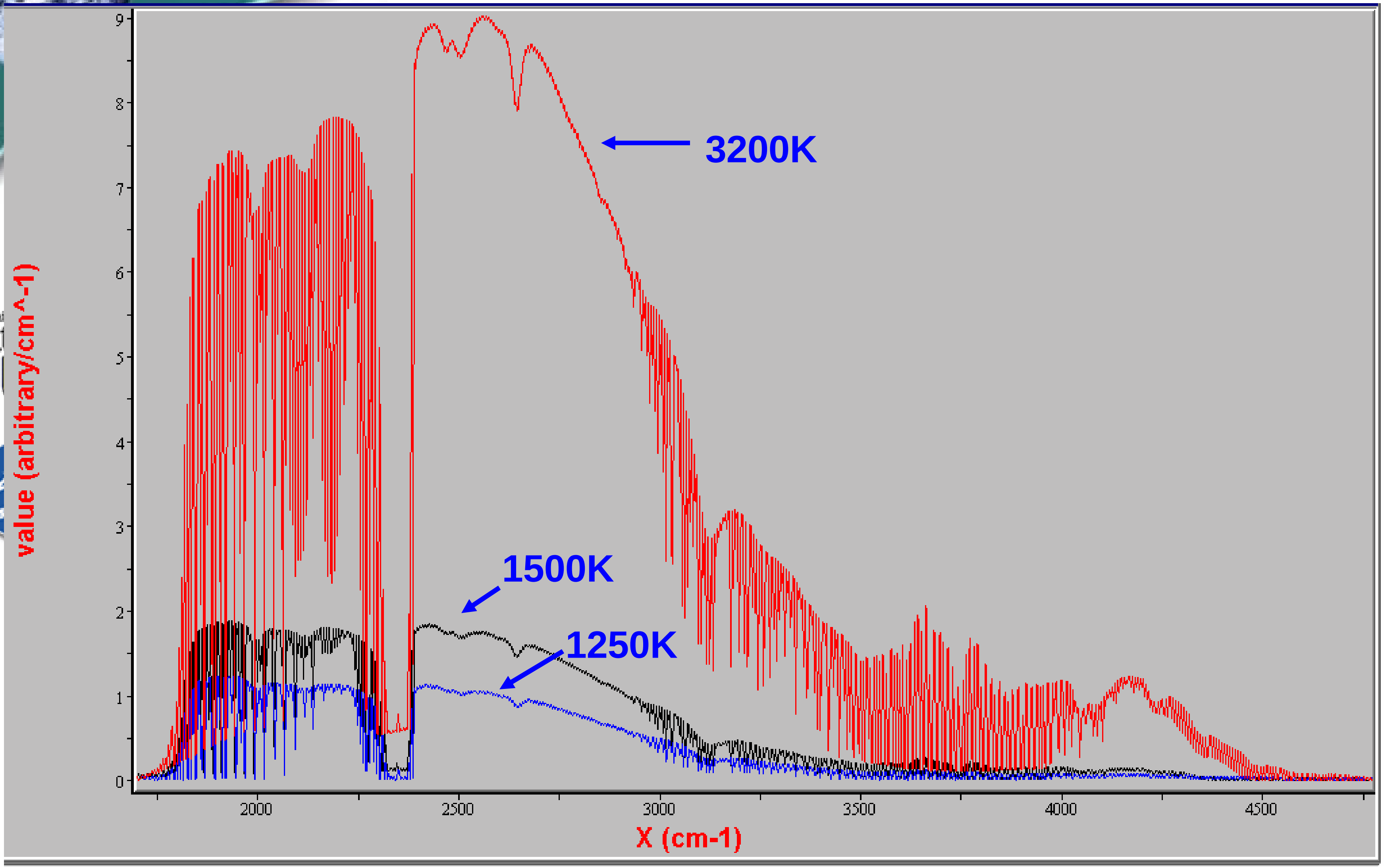
FTS Flight Model

Integration to S/C Bus

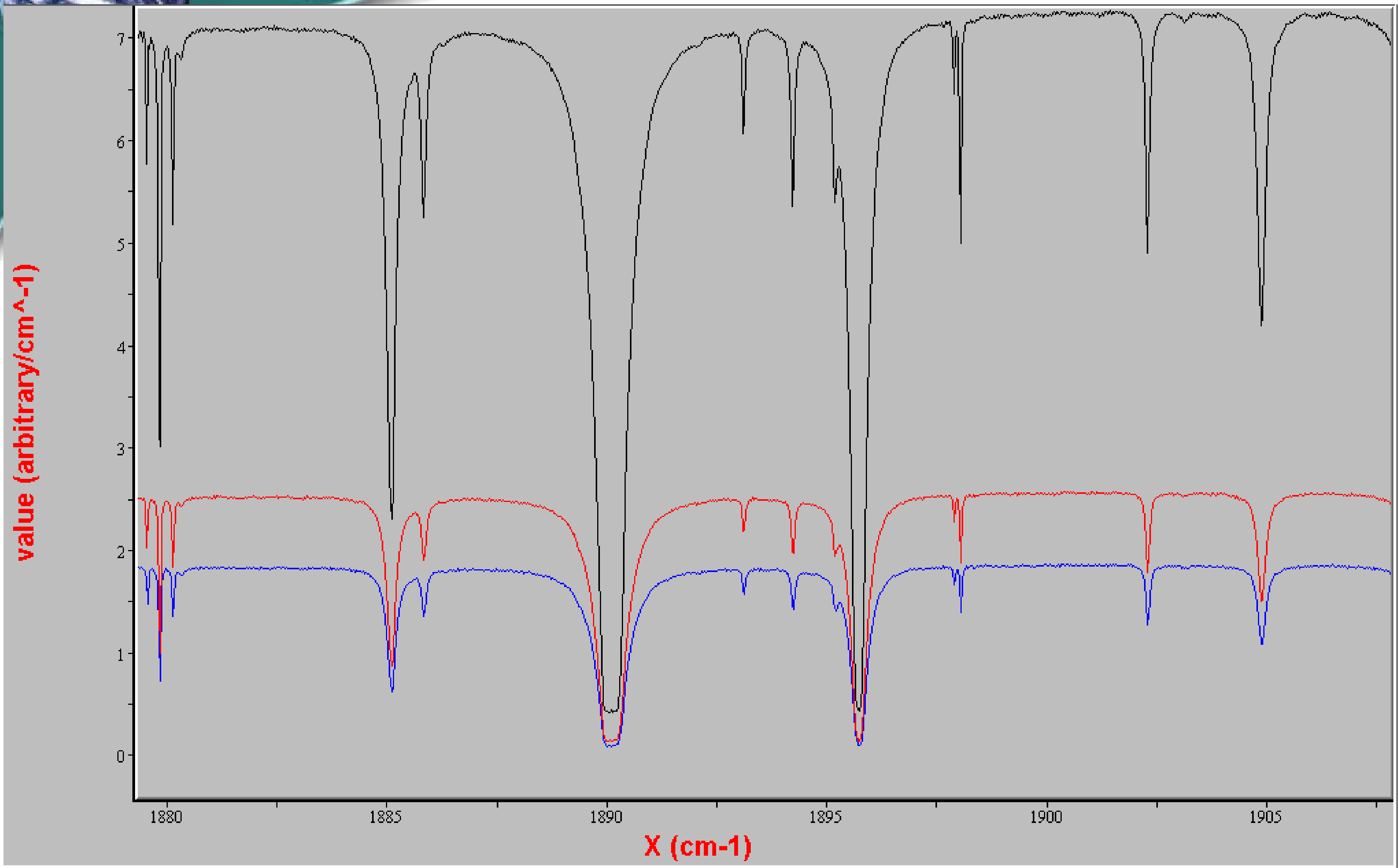
ACE-FTS: MCT Spectra



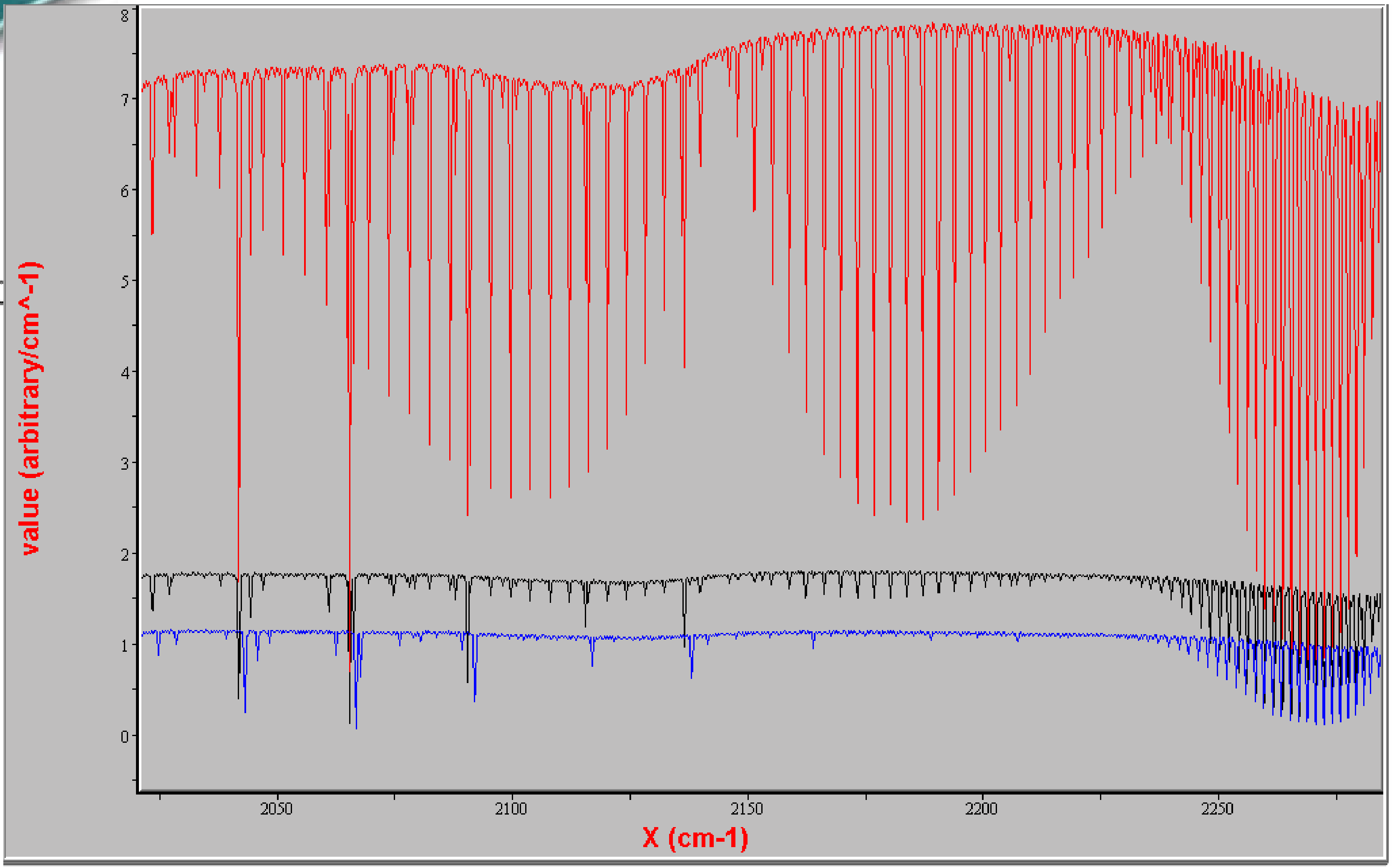
ACE-FTS Spectra: InSb channel



ACE-FTS InSb Spectra



InSb Spectra (CO lines)



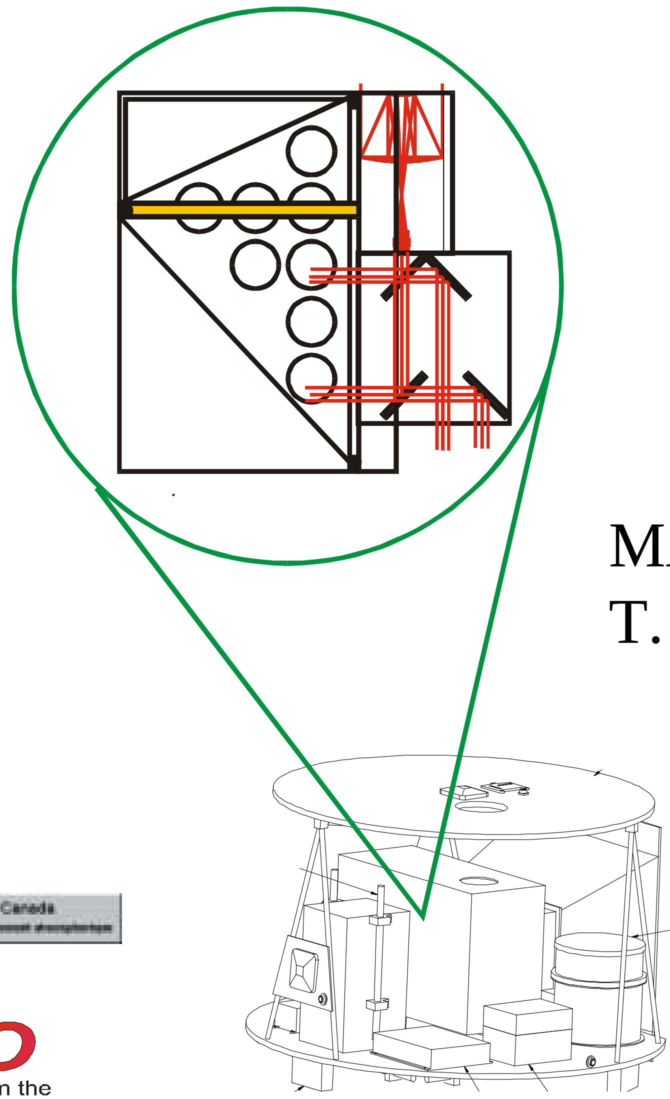
FTS Species

MINOR GASES	CO_2, CO, H_2O, O_3, N_2O, CH_4
TRACE GASES	
Nitrogen species	NH_3, NO, NO_2, N_2O_5, HNO_2, HNO_3, HO_2NO_2, HCN
Hydrogen Species	H_2CO, H_2CO_2, HDO, $H_2{}^{17}O$, $H_2{}^{18}O$
Halogens	CCl_3F (F11), CCl_2F_2 (F12), CH_3CCl_3, $CHClF_2$ (F22), CH_3Cl, CCl_4, SF_6, HF, HCl, CF_2O, $ClONO_2$, HOCl
Sulfur oxides	OCS, SO_2
Other species	C_2H_2, C_2H_4, C_2H_6, CH_3D

As well as aerosols and PSC IR spectra

ACE

Atmospheric Chemistry Experiment

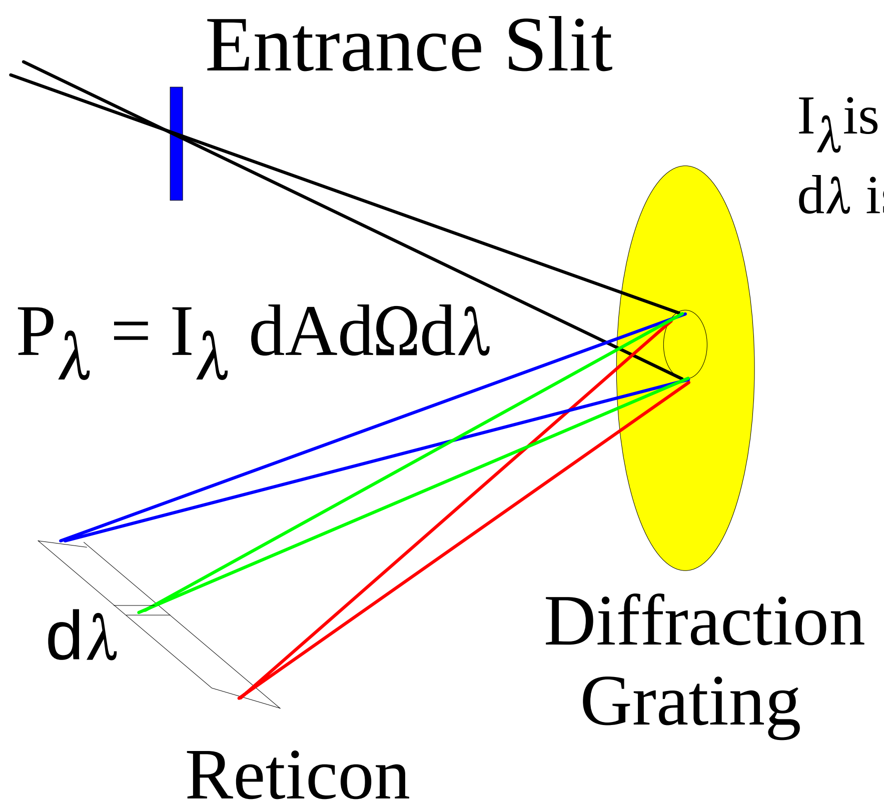


MAESTRO PI:
T. McElroy, MSC

MAESTRO

Measurement of **A**erosol **E**xtinction in the
Stratosphere and **T**roposphere **R**etrieved by **O**ccultation

MAESTRO



$$P_\lambda = I_\lambda \, dA d\Omega d\lambda$$

I_λ is solar intensity

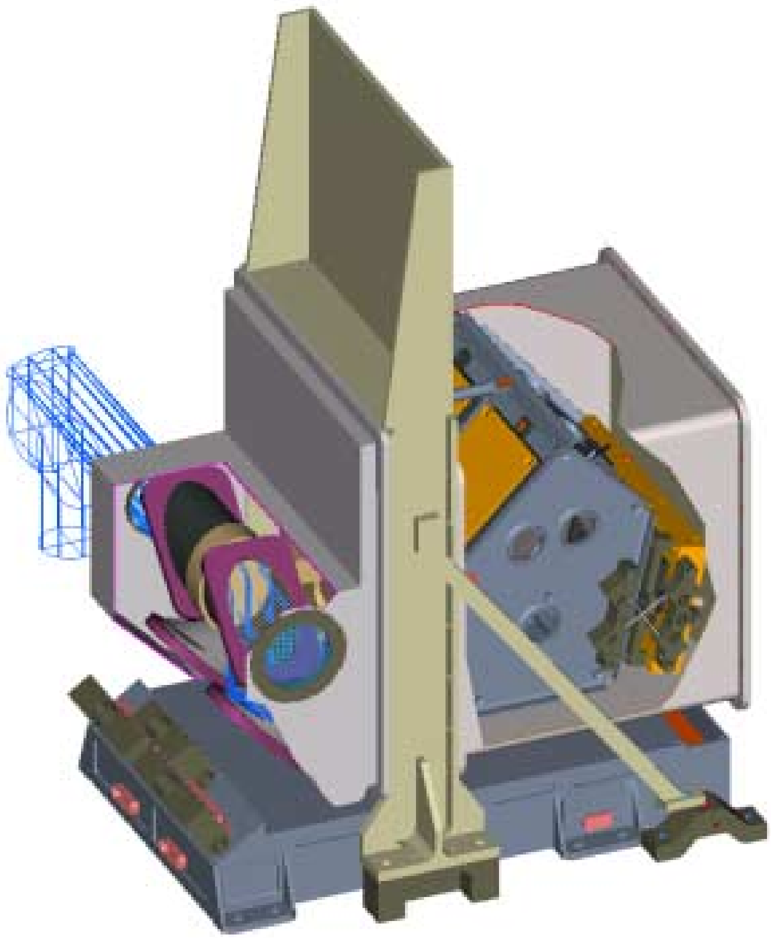
$d\lambda$ is wavelength resolution

$dA = l \bullet w$
where l = slit length
and w = slit width

$d\lambda = D \bullet w$
where D is the dispersion
and w is the slit width

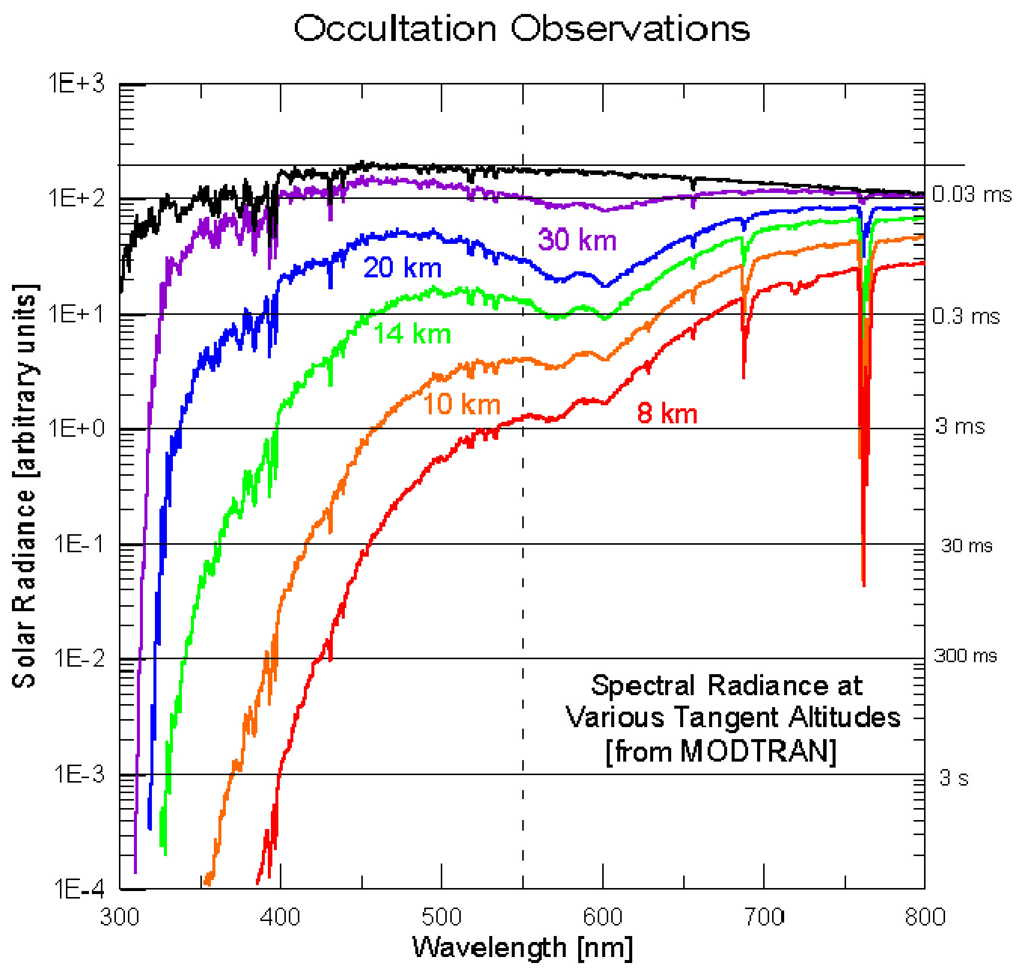
Dual concave grating spectrograph,
285-550 nm and 500-1030 nm

MAESTRO



MAESTRO (Flight Model)

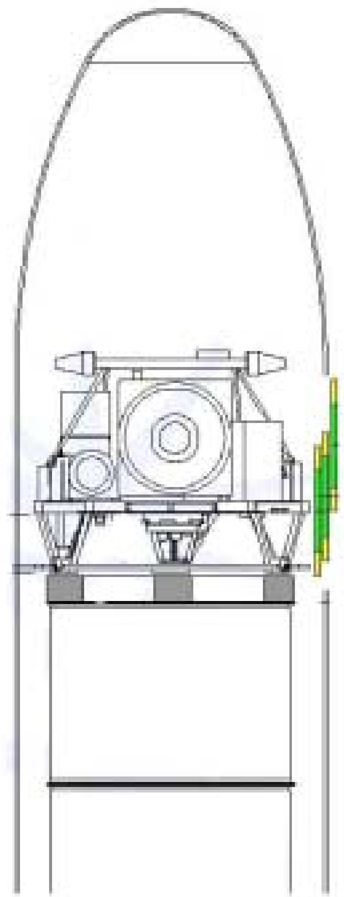
Simulated MAESTRO Data



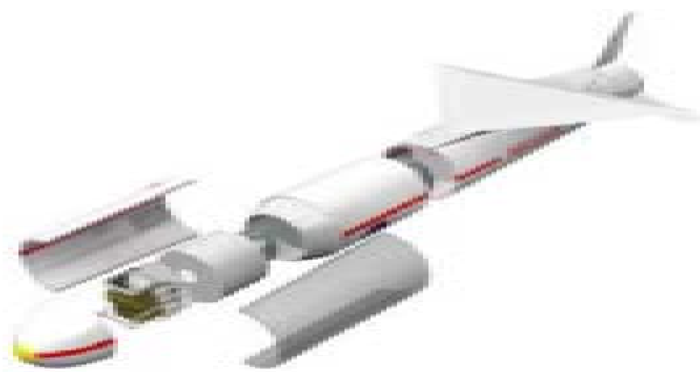
MAESTRO Species

- Primary Species: Ozone, NO_2, H_2O, Atmospheric Extinction (for Aerosols and PSCs)
- Collateral Products: O_2, $(O_2)_2$
- Secondary Species: SO_2, OClO, BrO, HCHO

Launch Vehicle



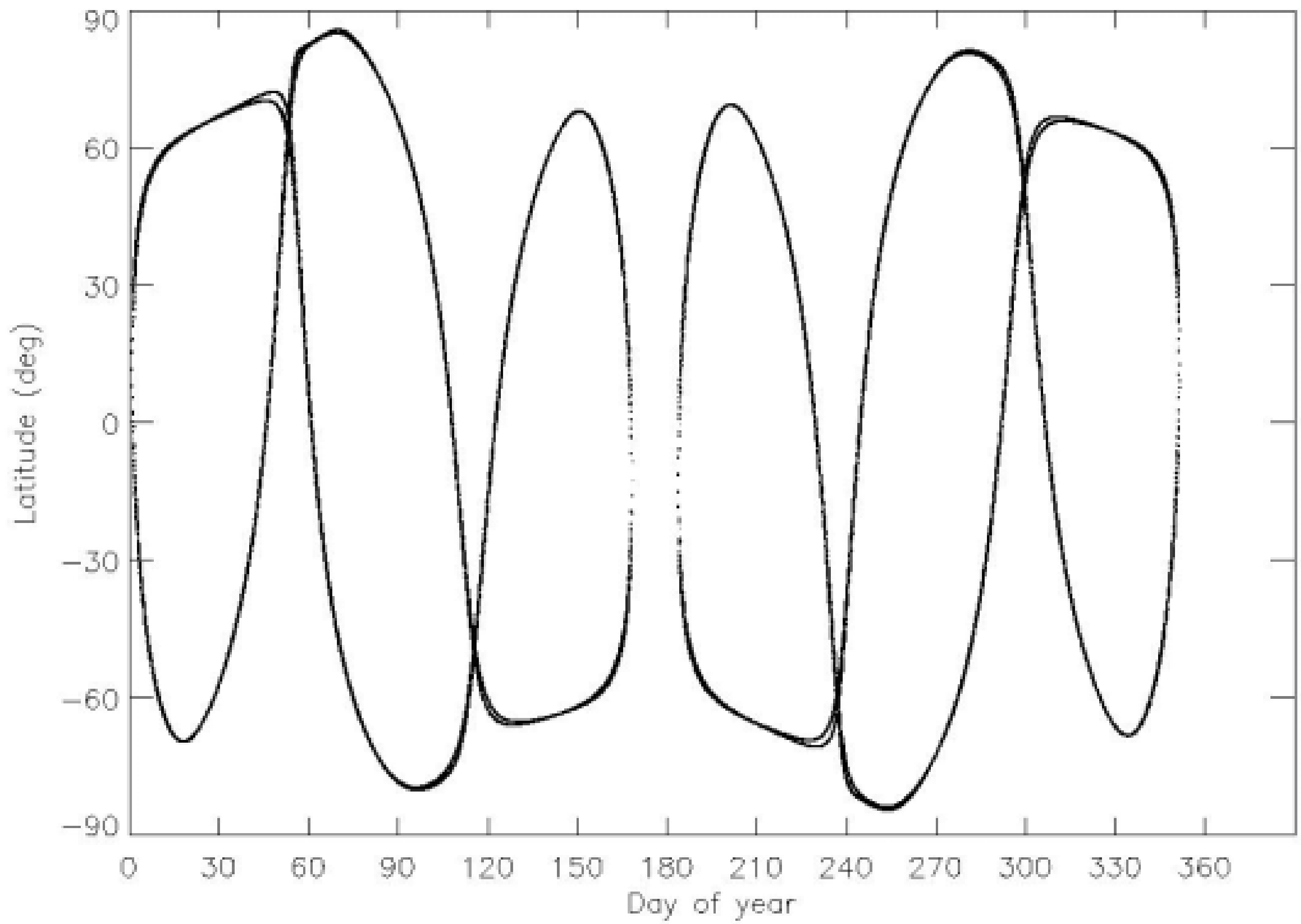
- Pegasus XL Launch; now baselined as a single spacecraft.
- ACE Mass Allocation:
  - Was 150 kg with co-passenger.
  - Now dedicated: ~270 kg.



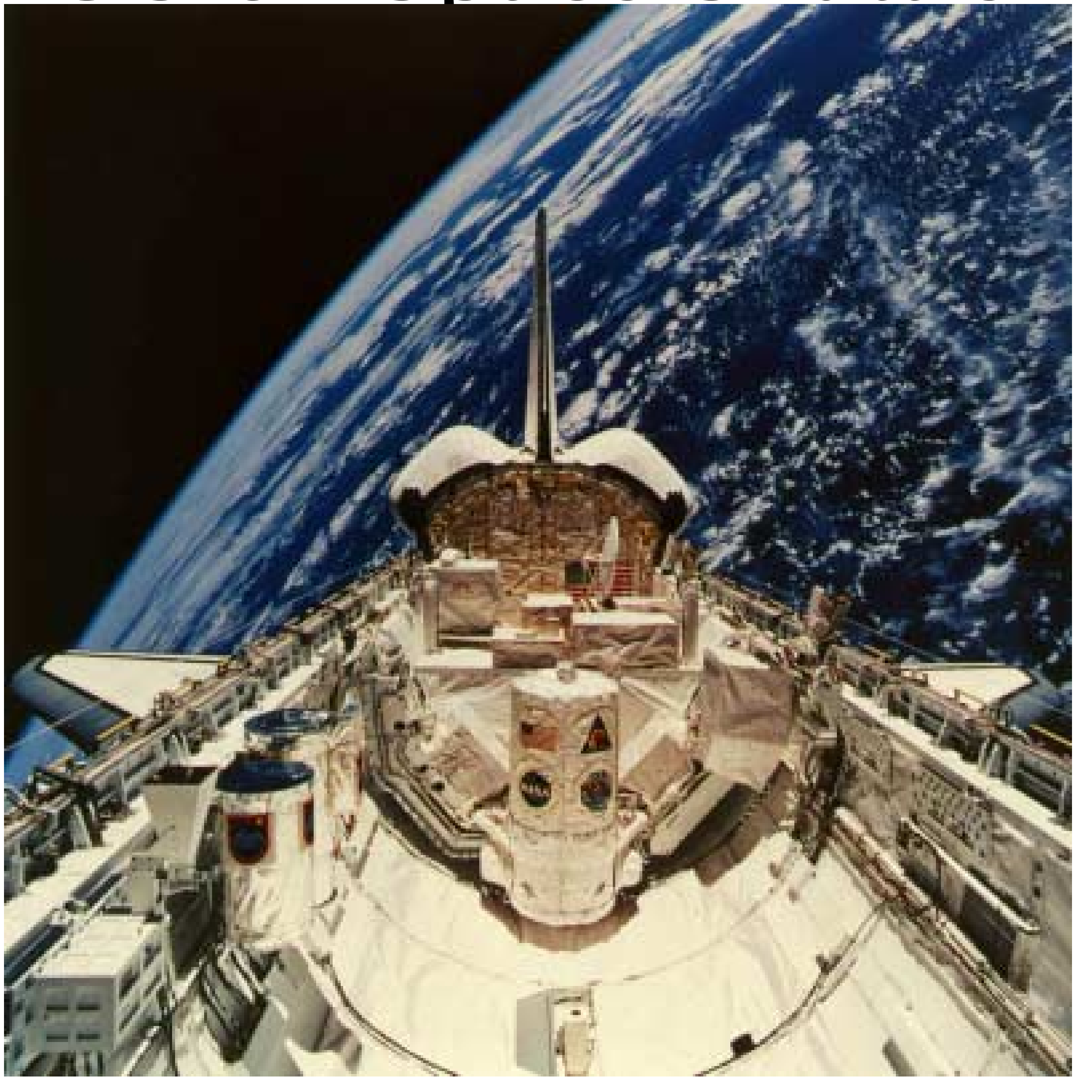
ACE Orbit

- A 650 km, 74° inclined circular orbit has been chosen as the optimum for ACE to achieve both global and high latitude coverage.
- Adjustments were made to extend the high latitude measurements during February and March.
- An Earth avoidance maneuver will be required to keep the passive cooler from seeing the Earth's surface.

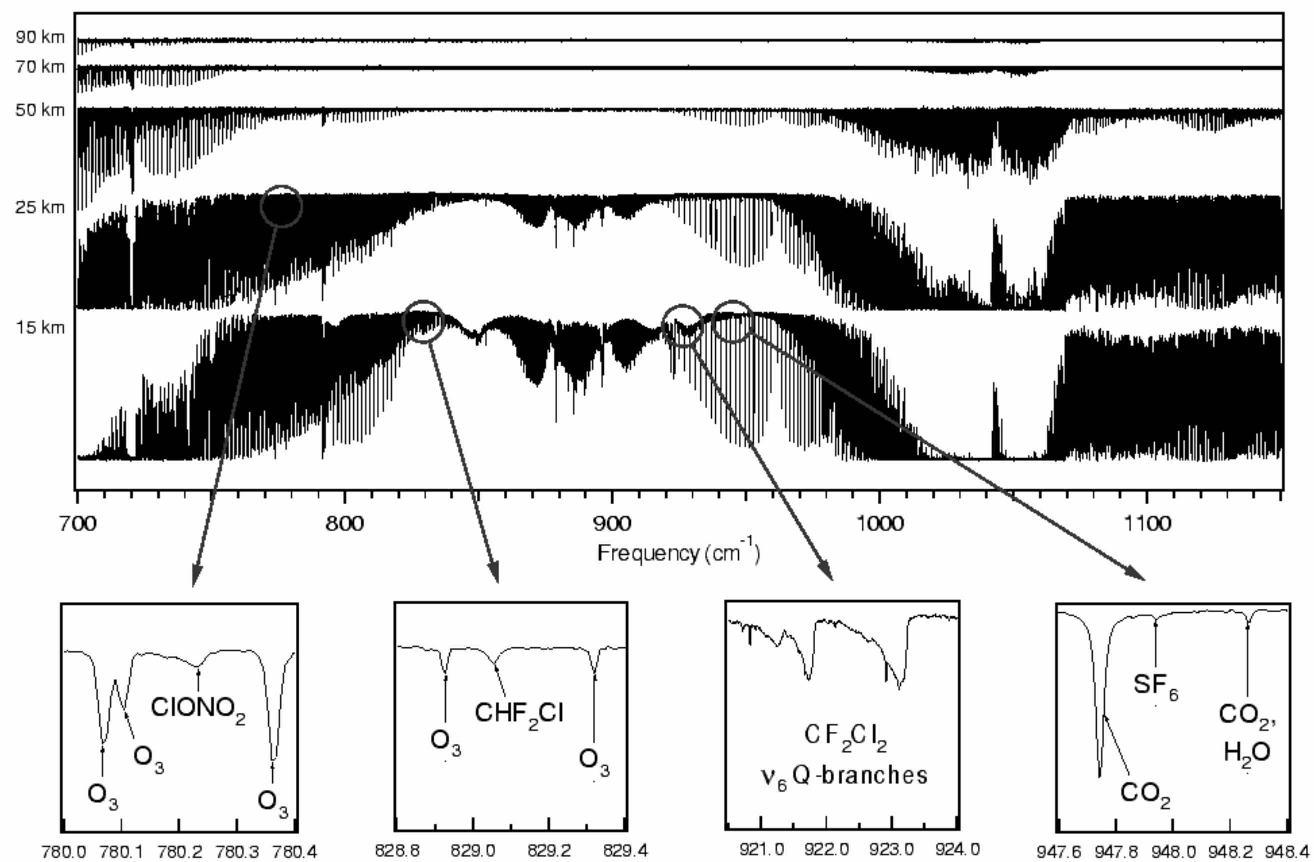
ACE Orbit (RAAN 144°)



ATMOS on Space Shuttle

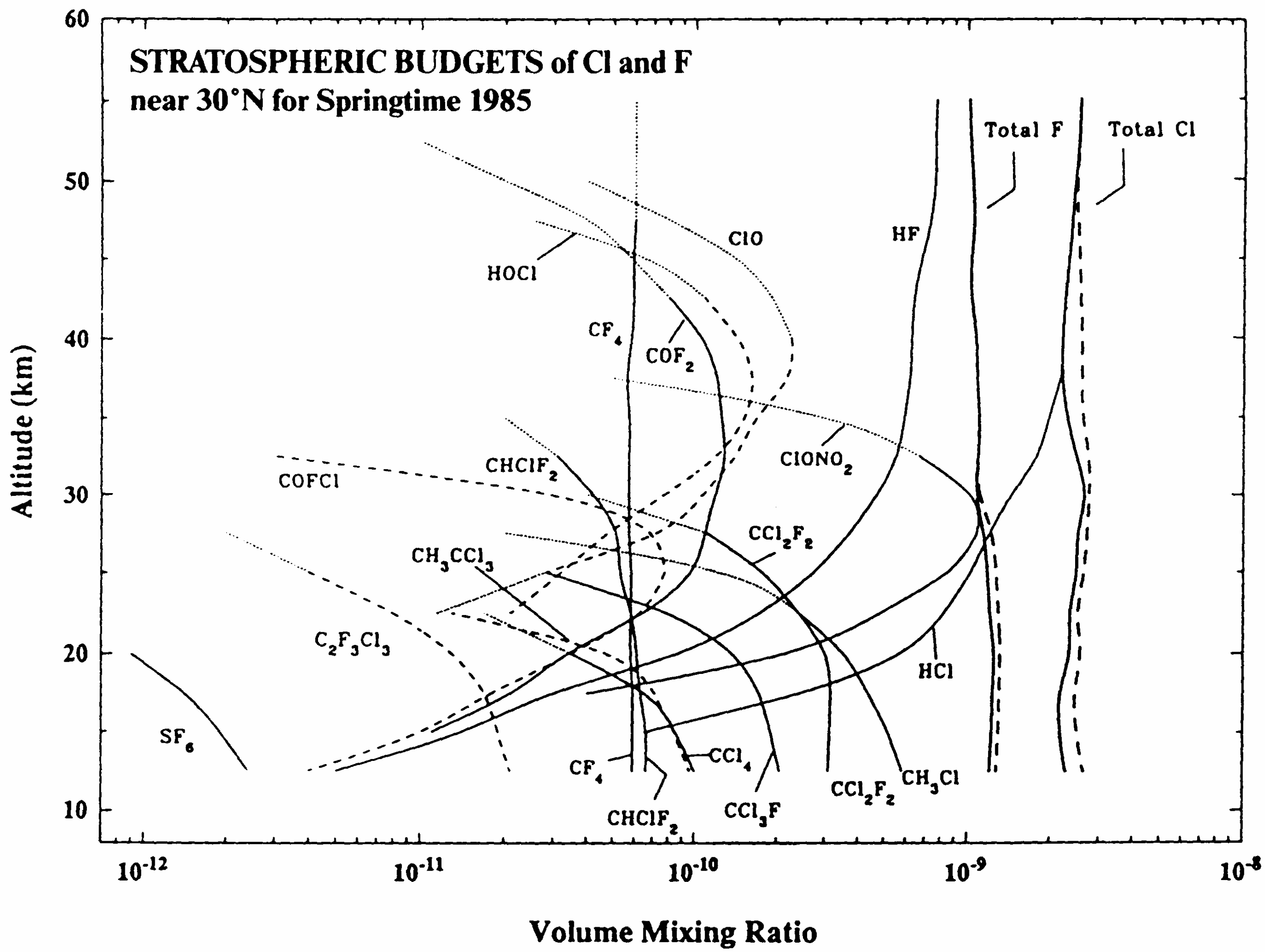


ATMOS Spectrum

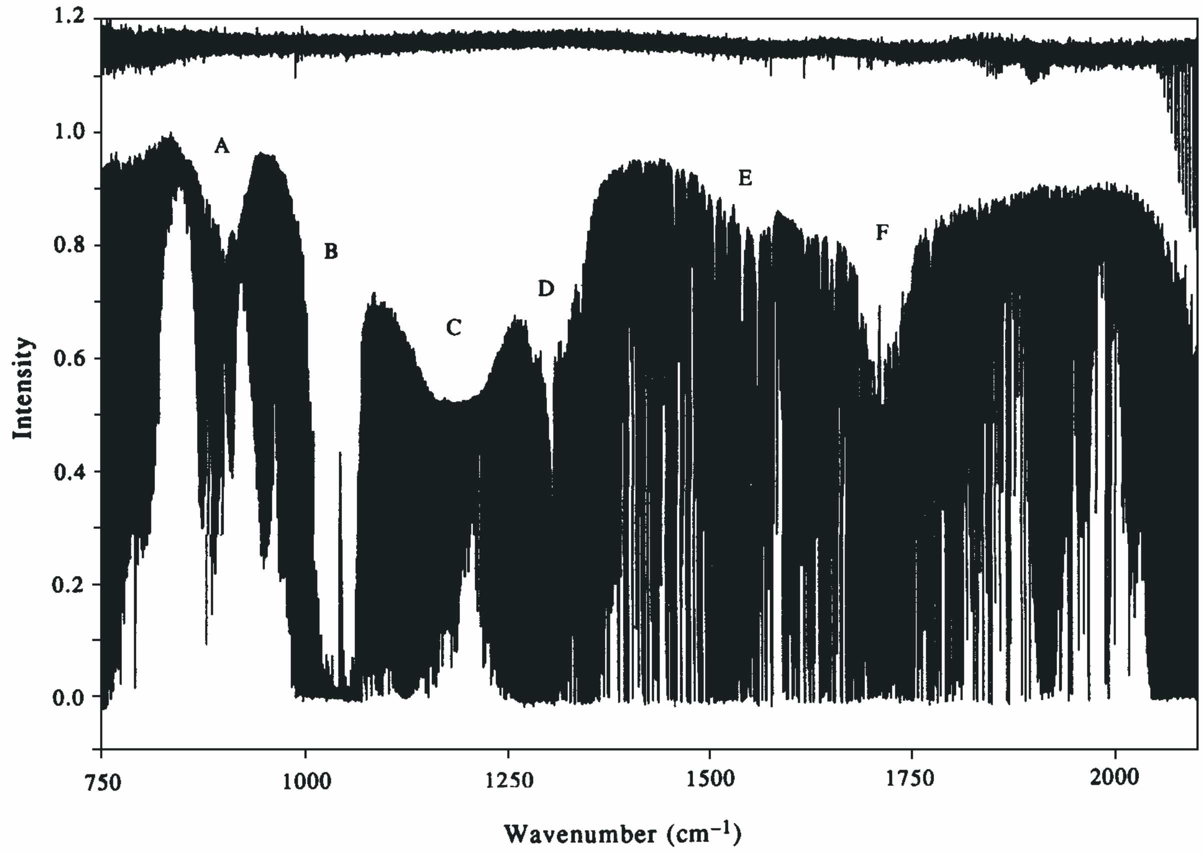


Infrared transmission at tangent altitudes between 15 and 90 km and between frequencies of 700 and 1100 cm^{-1} (recorded using the ATMOS interferometer onboard the space shuttle, Feb. 1992)

ATMOS F and Cl Budget



ATMOS (Pinatubo)



FTS Data Analysis

- Processing to occur at the University of Waterloo (along with that for MAESTRO and the Imagers)
- Fitting selected microwindows
- Global Fit approach for retrievals of P/T and of volume mixing ratios (VMRs)
- Operational processing (a new set of data every ~48 minutes)

ACE Processing System

- Sun Fire-3800 Server
  - 4-way system with 4 GB of RAM
  - 650 GB of fast storage for database
  - Multi-Terabyte tape archive
- High-availability system for mission-critical tasks

ACE Data Management

- Data is managed in relational SQL databases.
- ACE is using <u>Postgres</u>, an open-source engine.
- Databased quantities include:

Spacecraft data:	ephemeris, housekeeping;
ACE data:	measurement log, spectra;
External data:	input models, linelists, cal/val;
ACE Results:	level 2, level 3;

- This provides standardized access to data, while greatly enhancing our ability to manage it.
- Current size of database is ~40 GB, populated with ATMOS dataset.

ACE Highlights

- Ozone:
  -Vortex O_3 loss
  -Loss details (combine with modeling)
    -Chlorine and fluorine budgets
    -Gases from reactive nitrogen family
  -Aerosols and polar stratospheric clouds
  -Mid-latitudes (test case)
- Polar Vortex:
  -Descent (NO and CO)
  -Denitrification and dehydration
  -Chlorine activation (ClO)

ACE Highlights (cont.)

- Post-volcanic sulfate aerosols
- Temperature
- CFC decrease
- Tropospheric chemistry (biomass burning)
- ACE is well suited to the study of aerosols, including composition and size information from the infrared

ACE Participants:

Mission Scientist
- Peter Bernath, University of Waterloo

MAESTRO Principal Investigator
- Tom McElroy, MSC

Instrument Test
- Jim Drummond, University of Toronto

ACE Instrument Support (FTS, MAESTRO, Imagers)
- Pierre Tremblay, Université Laval
- Jim Drummond, University of Toronto
- David Turnbull, University of Western Ontario

Science Operations Center, University of Waterloo
- Chris Boone, ACE Scientist
- Mike Butler, Manager
- Debbie Loney, Admin. Assistant
- Sean McLeod, Computer Support
- Kaley Walker, Cal/Val

Additional Canadian University Participants
- Wayne F. J. Evans, Trent University
- Ian Folkins, Dalhousie University
- Ted Llewellyn, University of Saskatchewan
- Bob Lowe, University of Western Ontario
- Ian McDade, York Univeristy
- Jack McConnell, York University
- Diane Michelangeli, York University
- Jim Sloan, University of Waterloo
- Kim Strong, University of Toronto

Instrument Contractor, ABB-Bomem
- Marc-Andre Soucy, Project Manager

Bus Contractor, Bristol Aerospace
- Ian Walkty, Project Manager

MAESTRO Contractor, EMS / MSC
- Andrew Bell, EMS, Project Manager
- Tom McElroy, MSC, Project Manager

Main International Partners

Belgium:
- Reg Colin, Univ. Libre de Bruxelles

France:
- Claude Camy-Peyret, LPMA CNRS

USA:
- Curtis Rinsland, NASA Langley

Canadian Space Agency
- Glen Rumbold, ACE Manager
- Randolph Shelly, Bus
- Victor Wehrle, FTS and Science Team
- Marie Yelle-Whitwan, MAESTRO
- Dennis Ewchuk / Dan Showalter, Ground Segment

Sunset over Kitt Peak, AZ