Ares V Solar System Science Workshop

Ames Research Center

August 16-17, 2008

Brief Overview of Potential Planetary Exploration Enabled by Ares V

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NASA's Goddard Space Flight Center

Topics

- Outer Planets Flagship Concepts
  - Amy Simon-Miller, Brook Lakew, and Dennis Reuter
- Atmosphere Dynamics and Chemistry: Comparative Planetology of Complex Environments
  - Techniques
    - Remote Sensing in the Submillimeter Region
    - Heterodyne
  - Exemplars
    - UARS and Aura Microwave Limb Sounder (MLS)
    - Venus Atmosphere
  - Vesper
  - MARVEL
  - MIRO (Comet coma - Origins)

Planetary missions under formulation enabled by Ares V

- Several planetary flagship missions that are under formulation could benefit from the availability of the Ares launch vehicles.
- Typical flagship missions tend to have large wet mass and long travel time to their destinations.
- Ares launch vehicles (particularly Ares V) would benefit these missions by lifting ‘better and more complete/larger payload and reducing travel time

Planetary missions under formulation enabled by Ares V

- Outer planets flagship missions are still in pre-pre-phase A study stage
- Only holding 30% margin.
- Payload mass will most likely grow.
- Current base-lined launch vehicles are: typically Delta IVH, Titan/Centaur and Atlas III etc.
- Issues regarding the cost cap (~$2.1 B for the U.S. contribution) and power budget (limited # of RTGs due to plutonium availability and production schedule) will however need to be addressed .

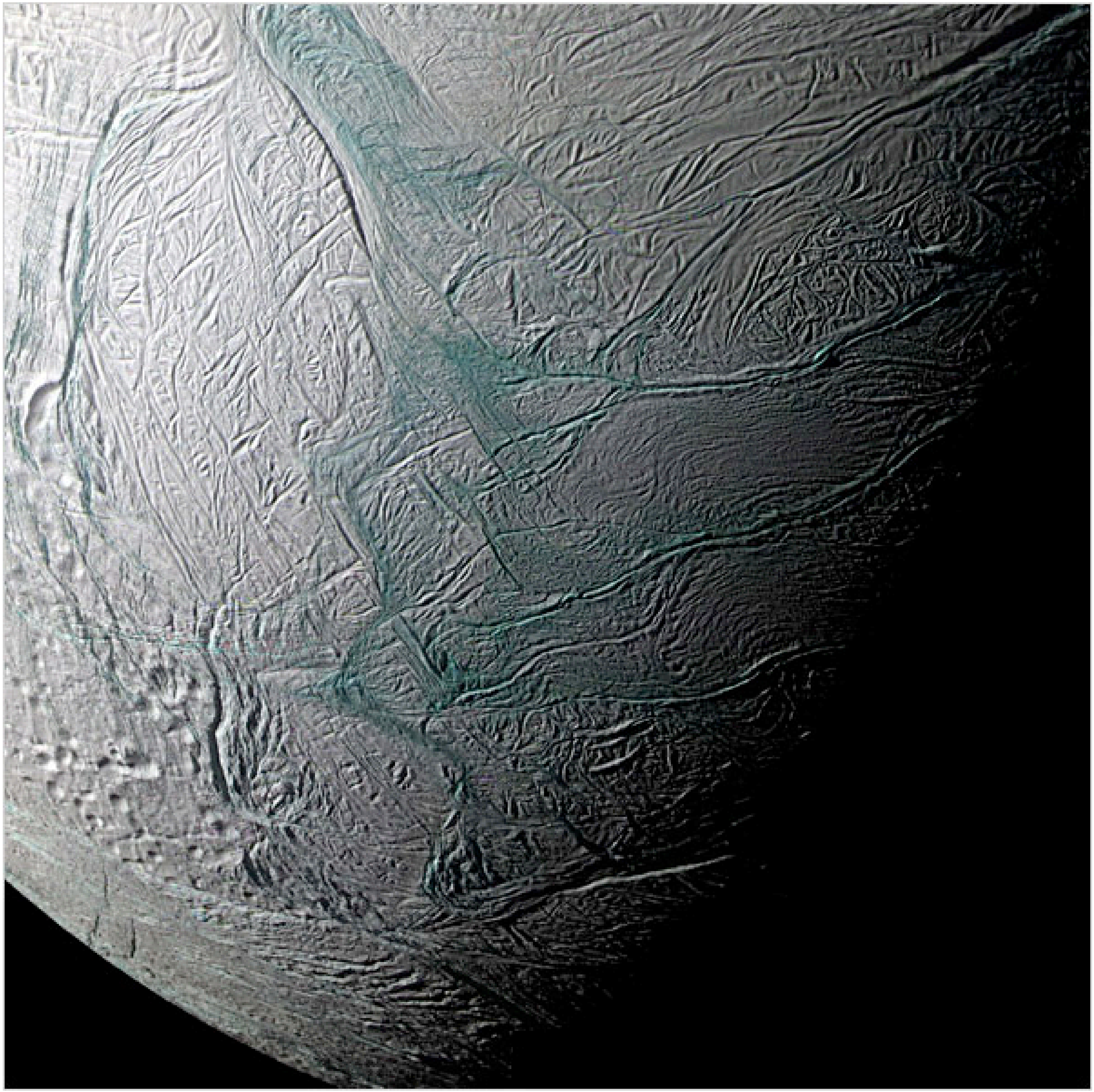
Potential Outer planets flagship missions

- Titan-Saturn System Mission
  - Possible 3 payloads
    - Orbiter (NASA)
    - Montgolfiere (Balloon, ESA)
    - Probes/Lander (ESA)
- Europa-Jupiter System Mission
  - Single payload base-lined
  - May include Io, Jupiter and Ganymede campaigns

Flagship Missions science objectives

- Titan-Saturn System Mission:
  - Titan:
    - Study the interplay of the geology, hydrology, meteorology, and aeronomy
    - Titan's organic chemistry in the atmosphere, within its lakes, on its surface, and in its putative subsurface water ocean
  - Saturn and Enceladus
    - Enceladus and Saturn's magnetosphere
    - Enceladus plume complex chemistry and geyser source
- Europa-Jupiter System Mission
    - Characterize extent of ocean and its relation to the deep interior
    - Determine global surface composition and chemistry
    - Understand the formation of surface features, including recent activity, and identify sites for future in situ exploration
    - Understand Europa in the context of the Jupiter system

Enceladus



Titan-Saturn and Europa-Jupiter missions' payload mass

Mission	Science Payload Dry Mass	Margin	Launch vehicle
Titan Orbiter+ Balloon+probe+Lander	~ 200 kg	30%?	Delta IVH
Europa-Jupiter Orbiter	~ 130 kg	30%?	Delta IVH

Other outer planets flagship missions* payload mass

Mission	Gross Wet mass	Science payload	Launch vehicle
Enceladus Orbiter w/Lander	6320 kg	303 Kg	Delta IVH
Enceladus Orbiter/ no Lander	5810 kg	85 Kg	Delta IVH
Saturn Orbiter with Lander	6200 kg	950 Kg	Delta IVH

* (not down-select in 2007)

Yet other possible future missions…

- Neptune Orbiter/ probe/ Triton lander

Science objectives:

  - Answer many questions that still surround the planet. Its main mission is to study Neptune's atmosphere and weather, its ring system, and its moons, particularly Triton.

- Uranus Orbiter / with probe

Science objectives

  - Determine the composition and vertical structure of the atmosphere, clouds, and aerosol layers.
  - Understand of the transport and deposition of energy within the atmosphere is also desired. In addition, measurements of the abundances of primary and trace constituents and several specific isotopic ratios are desired.

Mercury Sample Return

Science objectives

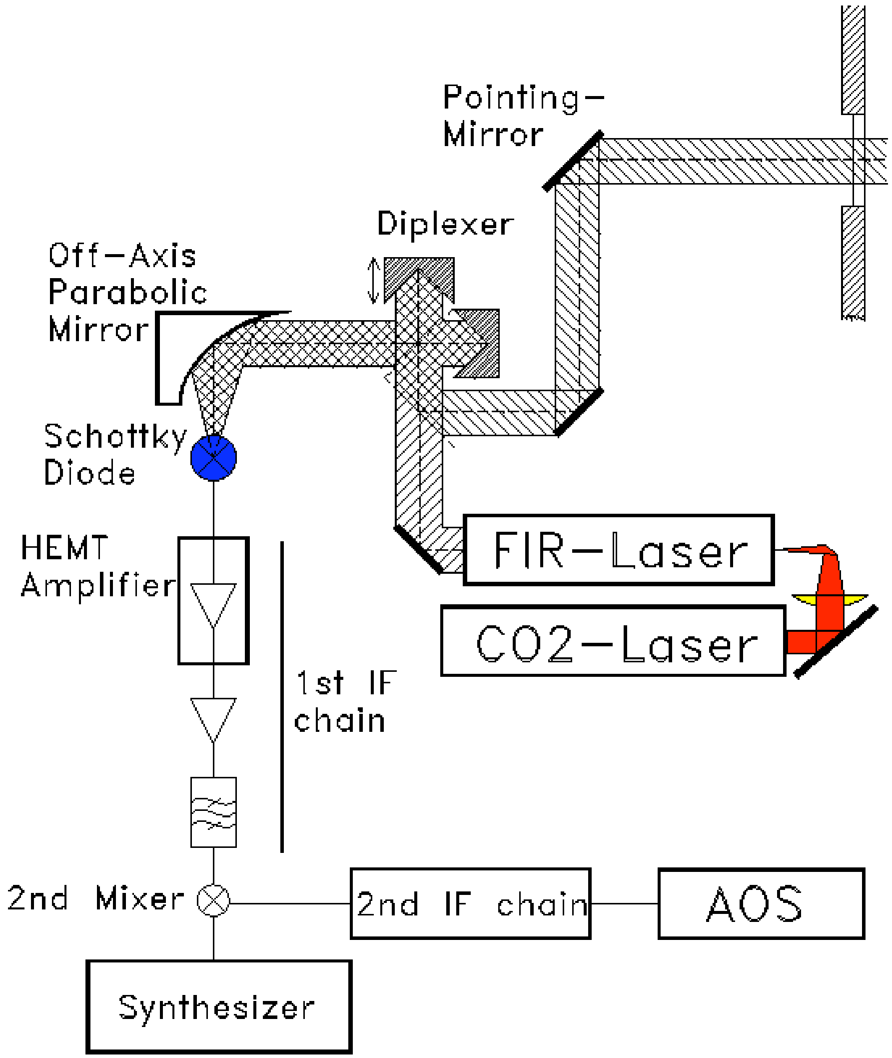
  - Provide information on the surface composition to determine whether current models for the formation of Mercury are accurate.
  - help determine the effects of weathering by the solar flux on the surface composition and structure.

And their payload mass

Mission	Estimated wet mass	Baselined launch vehicle
Neptune Orbiter/ probe/ Triton lander + Solar electric propulsion*	5700 kg	-Titan/Centaur -Shuttle C with high energy upper stage
Uranus Orbiter / with probe*	5700 kg	-Titan/Centaur -Shuttle C with high energy upper stage
Mercury Sample Return/ with Lander**	2400 kg	Atlas III B

Ref: *http://www.aiaa.org/content.cfm?pageid=406&gTable=mtgpaper&gID=65961
* A Neptune Orbiter Mission Richard A. Wallace and Thomas R. Spilker Jet Propulsion Laboratory California Institute of Technology
**ieeexplore.ieee.org/iel5/8735/27660/01235079.pdf?arnumber=1235079

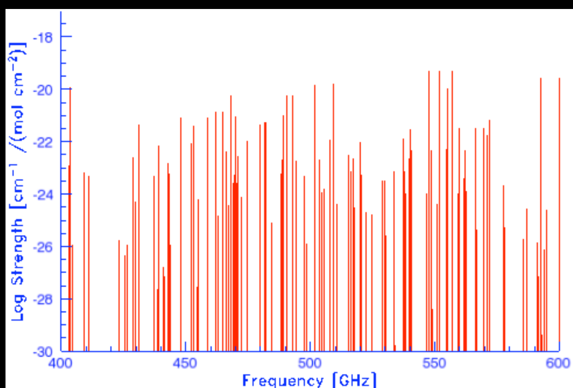
Heterodyne technique offers a powerful spectroscopic tool



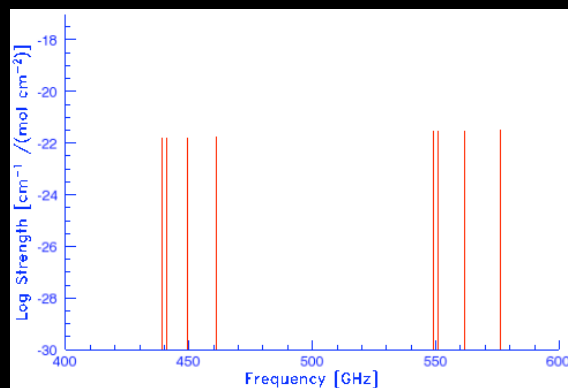
- Combines signal with high frequency local oscillator
- Difference frequency usually at RF
- High spectral resolution
  - Multi-channel spectrometer
- High spatial resolution with moderate aperture
- Extremely high sensitivity

The submillimeter spectral region has numerous molecular transitions of diagnostic interests

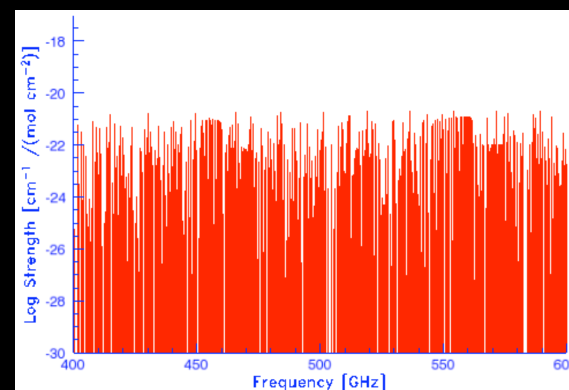
H_2O and Isotopes



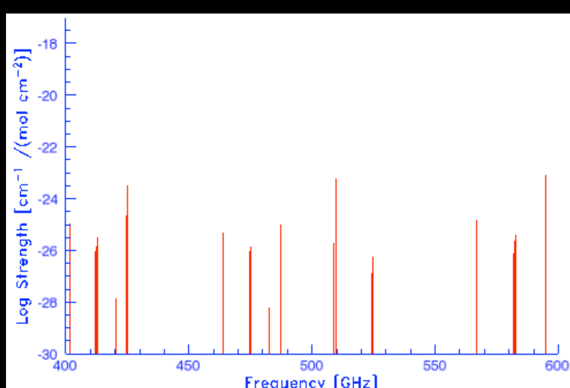
CO and Isotopes



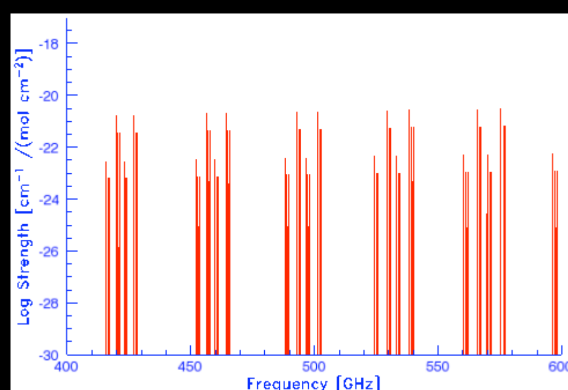
SO_2 and Isotopes



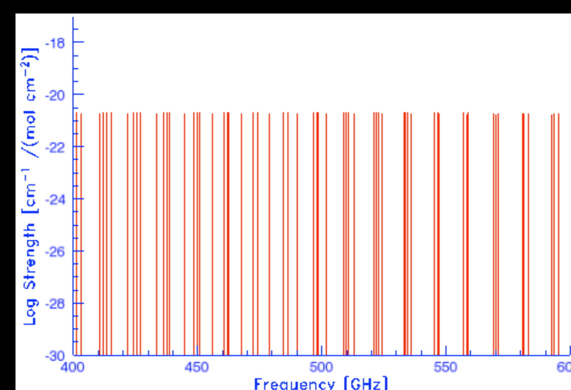
O_2 and Isotopes



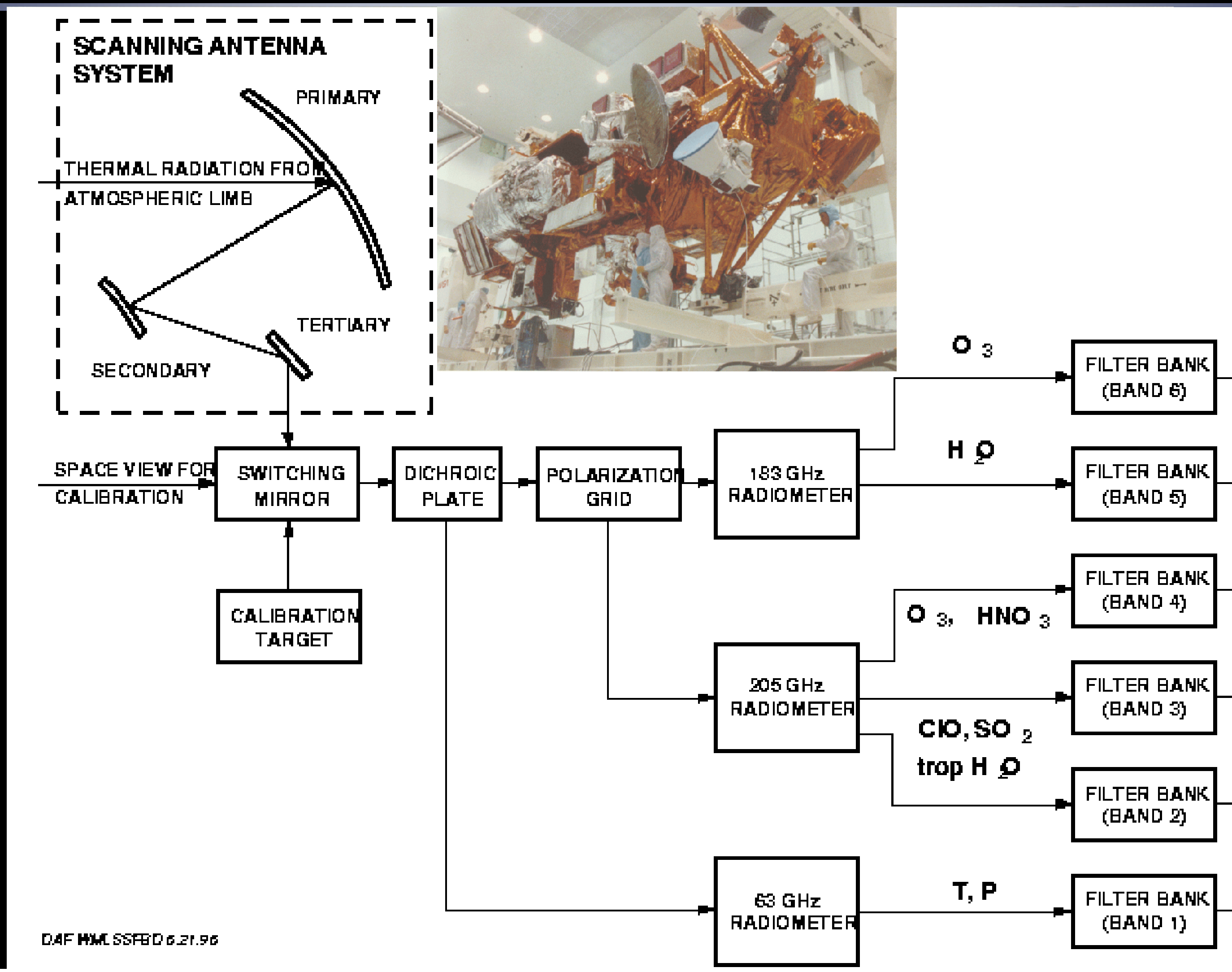
ClO and Isotopes



OCS and Isotopes



Upper Atmosphere Research Satellite (launched 1991) Microwave Limb Sounder



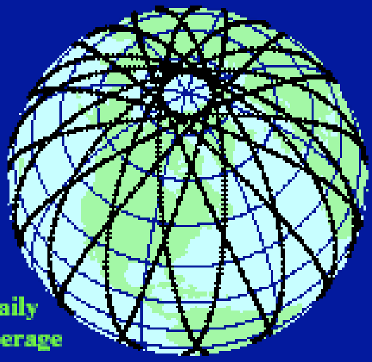
EOS Aura Mission and the Aura MLS (490 kg Mass)

Scientific Objectives

- Determining if stratospheric ozone chemistry is recovering as expected
- Improving knowledge of processes that affect climate variability
- Helping understand ozone pollution in the upper troposphere

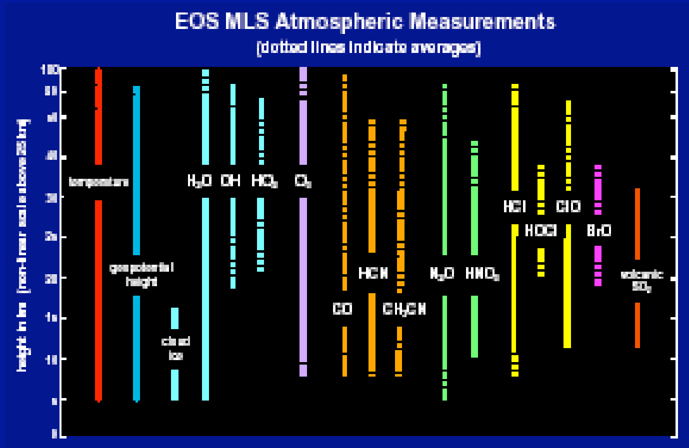
Measurements

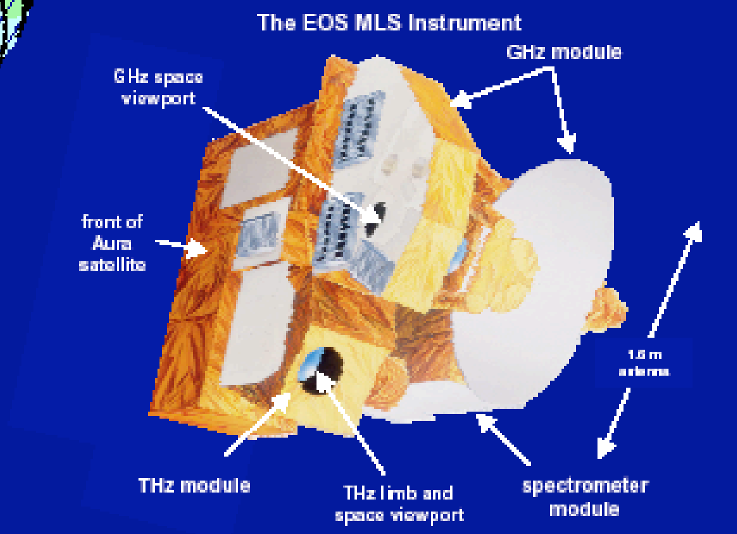
- Passive observations of thermal emission from the atmospheric limb
- Made day and night



Instrument

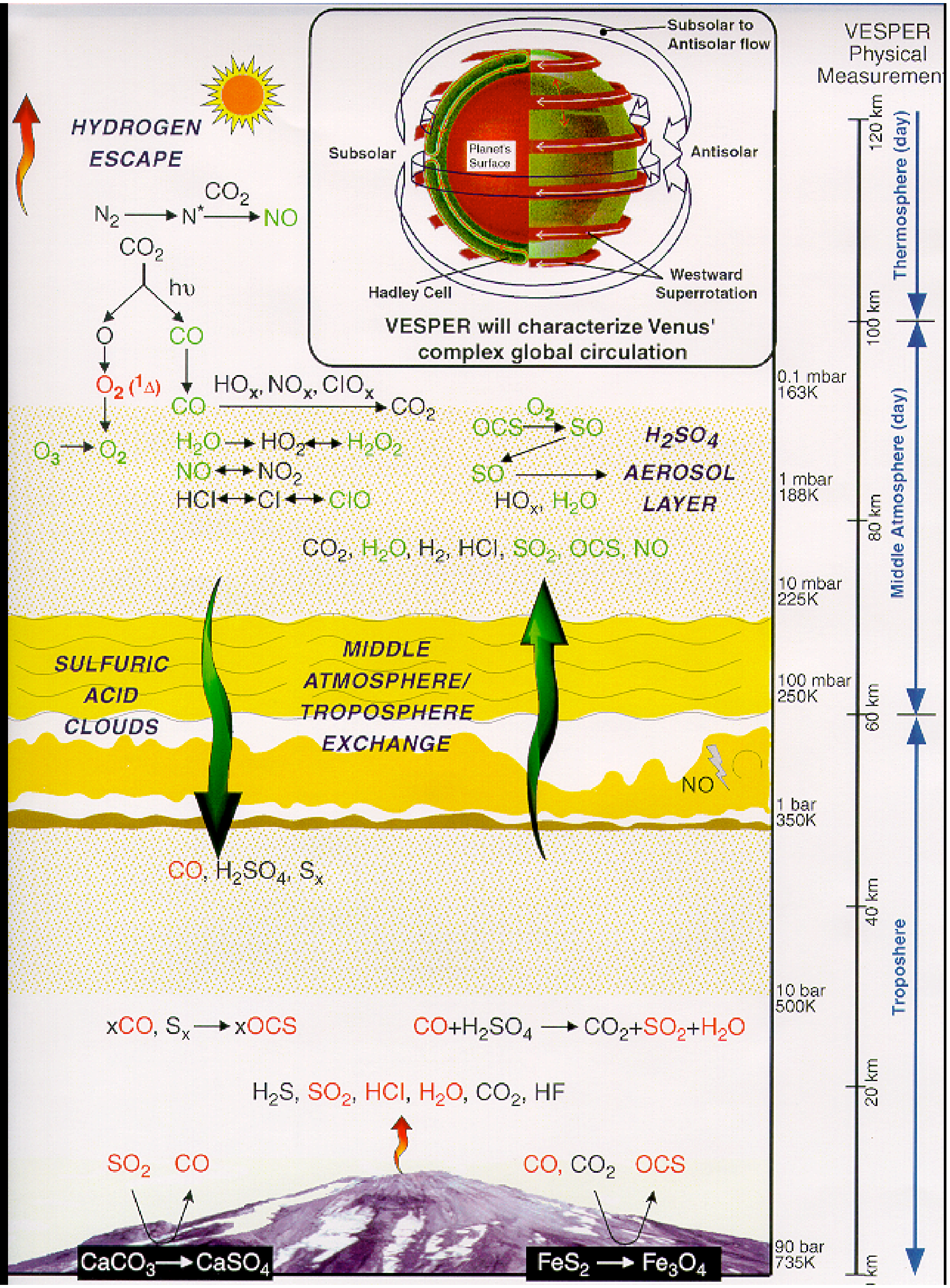
- Millimeter and submillimeter wavelength heterodyne radiometers in 5 broad bands:
  - 118 GHz, primarily for temperature and pressure
  - 190 GHz, primarily for H_2O and HNO_3
  - 240 GHz, primarily for O_3 and CO
  - 640 GHz, primarily for HCl, ClO, BrO, HO_2, N_2O
  - 2.5 THz, primarily for OH
- On NASA's EOS Aura satellite
  - to start observations in 2003 with at least 5 years operational lifetime



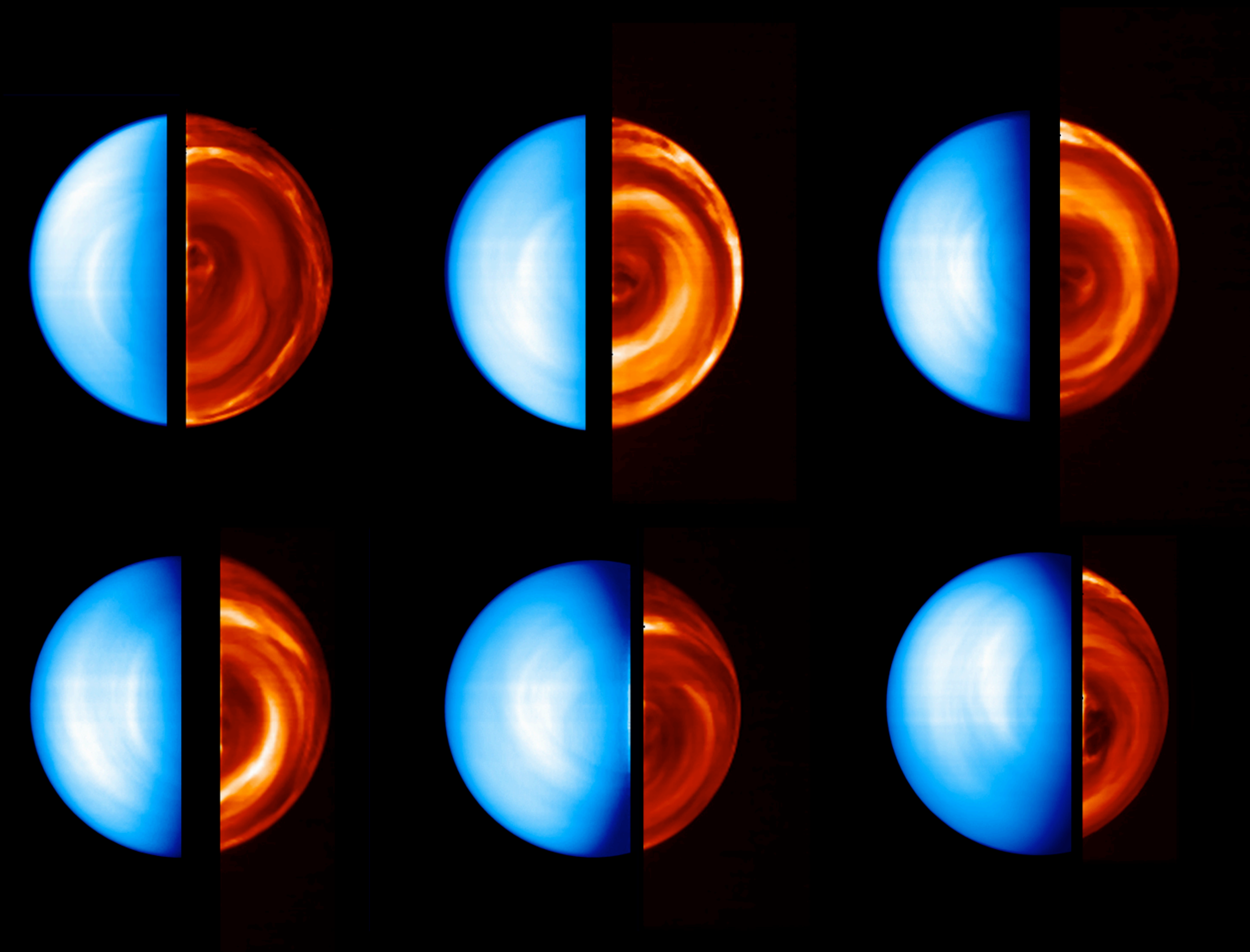


Venus Atmosphere: Global Climate Evolution

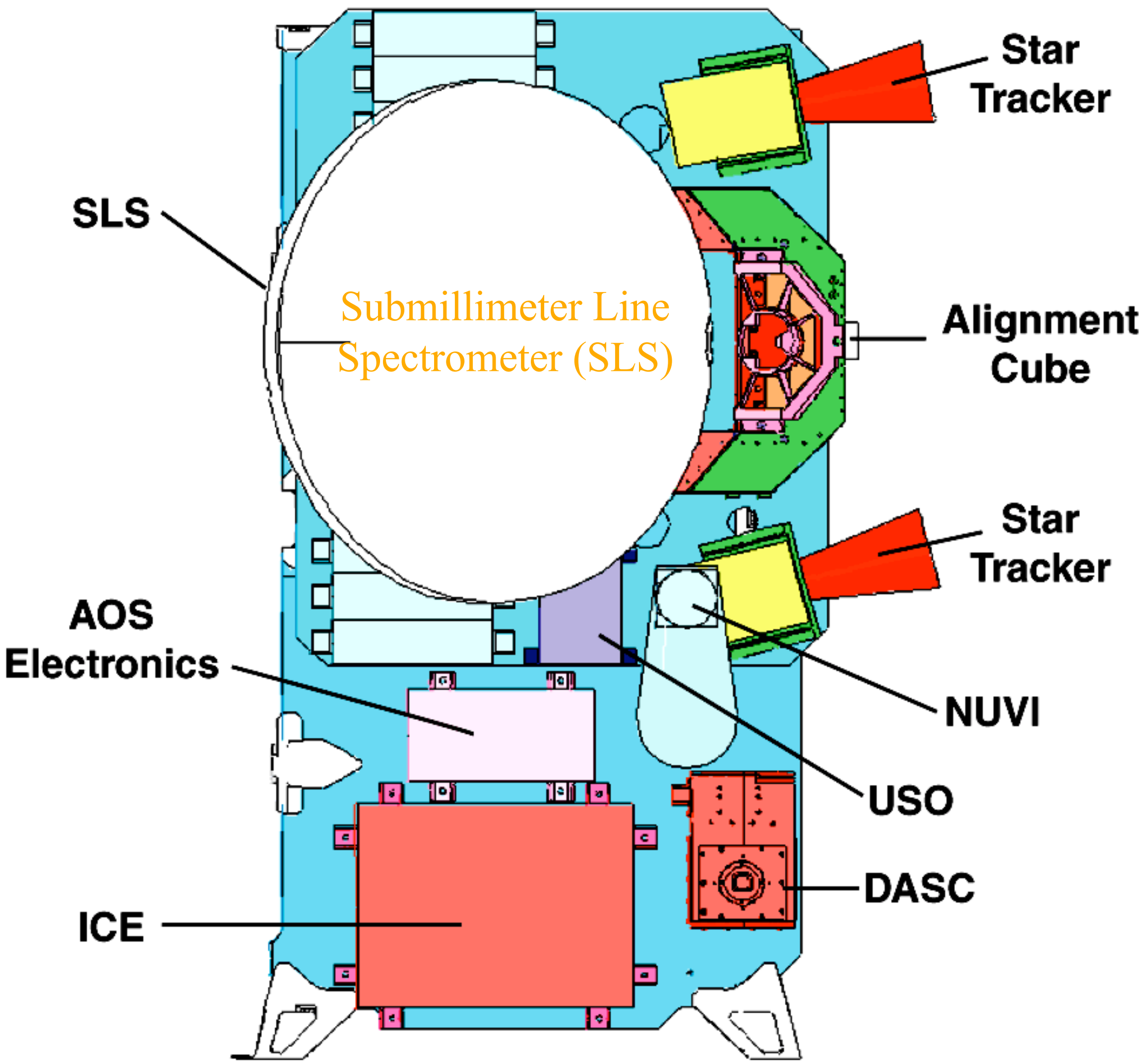
- Runaway Greenhouse
- Super-rotating cloud layer
  - Sulfuric acid clouds sustained by surface events
  - Titan also has super-rotating atmosphere
- Complex interplay and subtle of chemistry and dynamics
- Complex surface atmosphere interactions
- Potential signs of non-linear atmosphere dynamics
  - Low frequency oscillations
    - El Nino, QBO, …

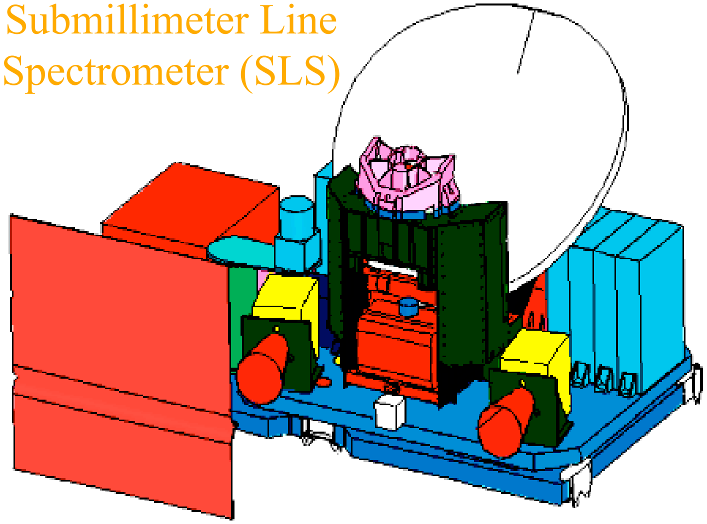


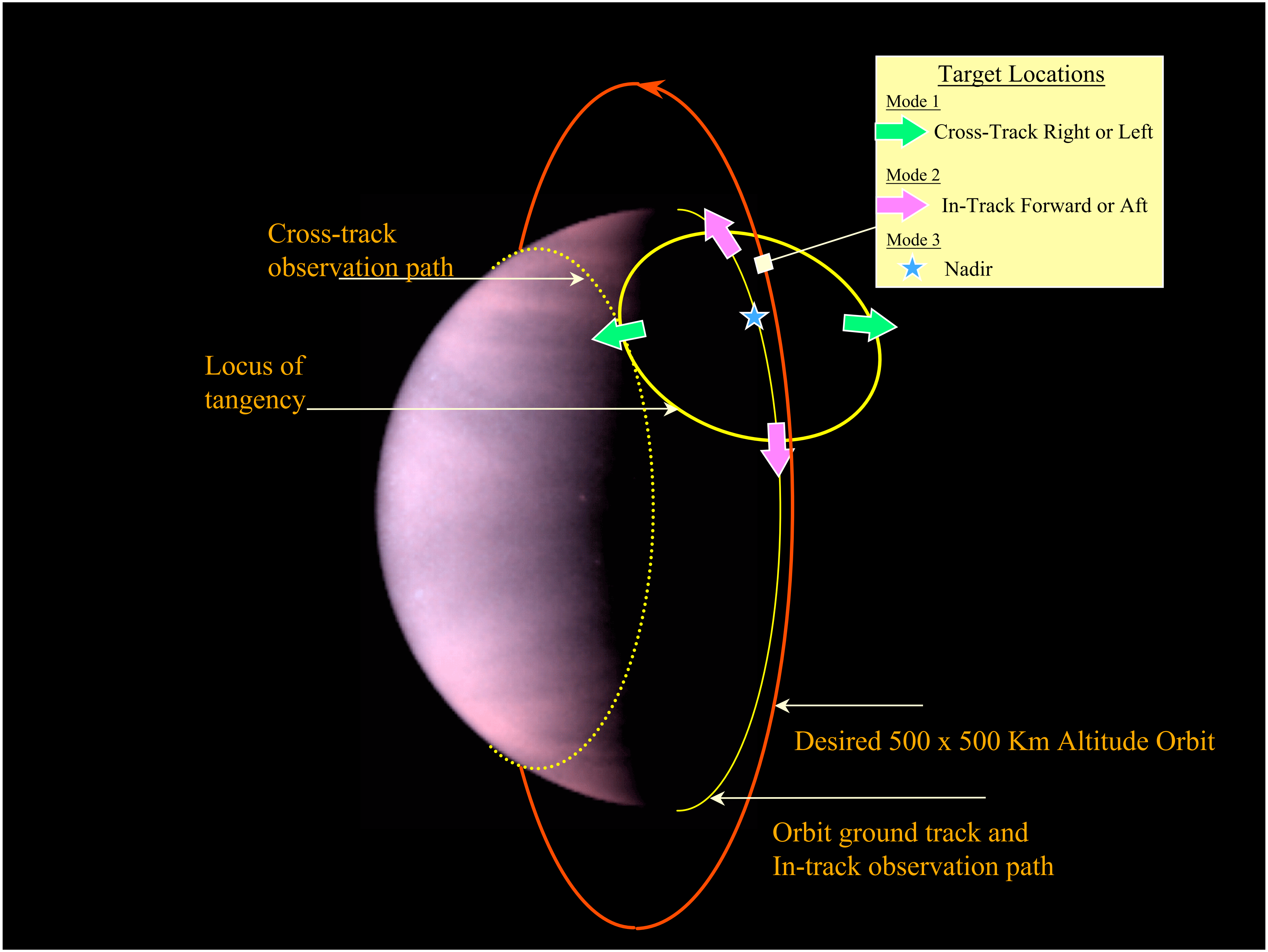
Venus South Pole Vortices



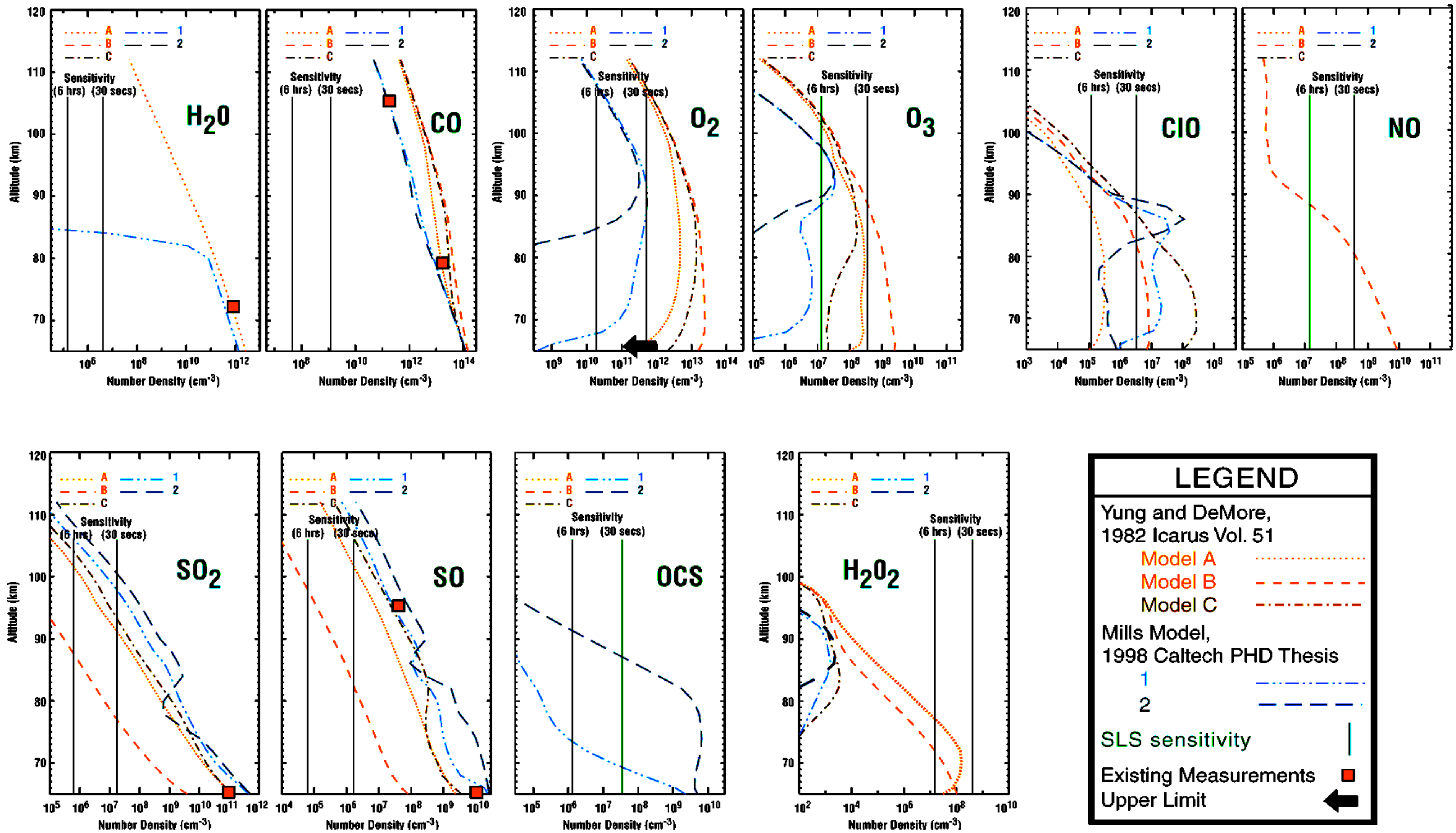
Vesper Discovery Proposal Instruments Are Optimized for their Scientific Objectives



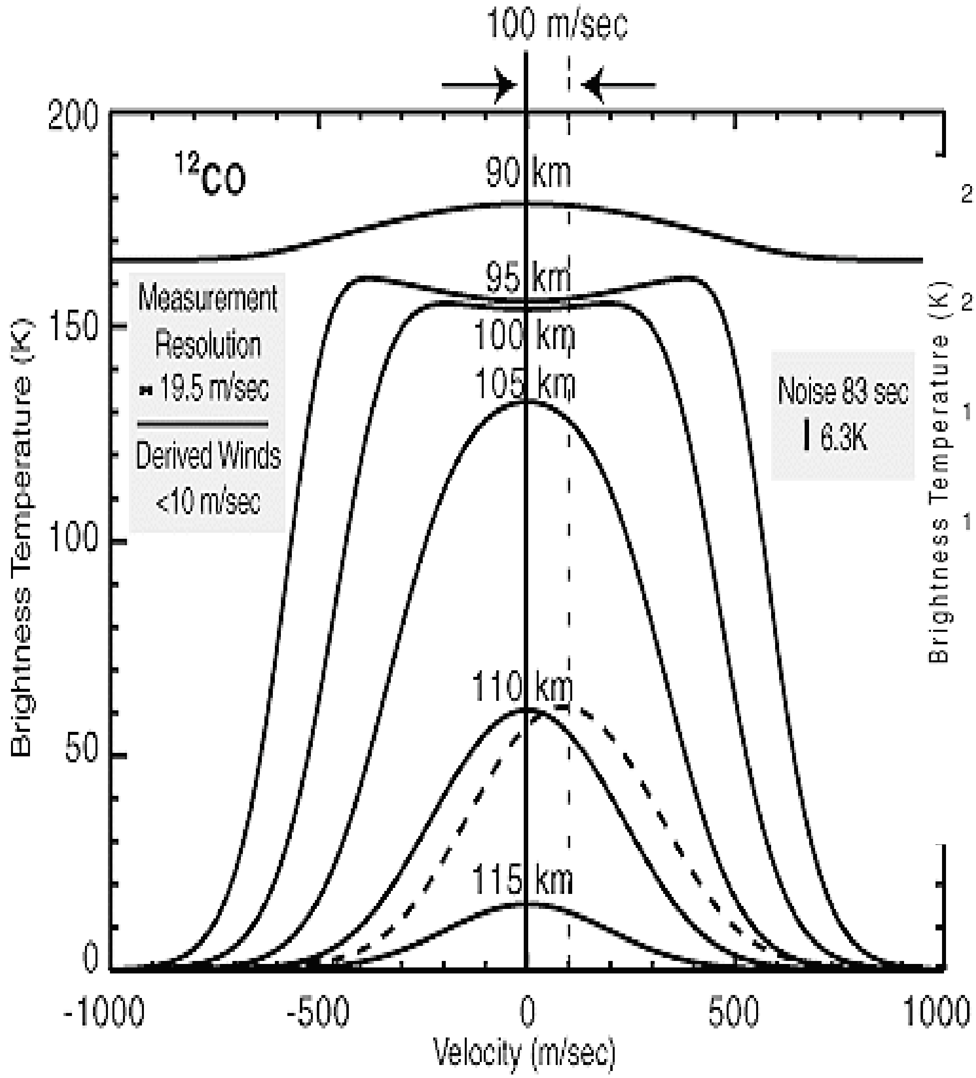


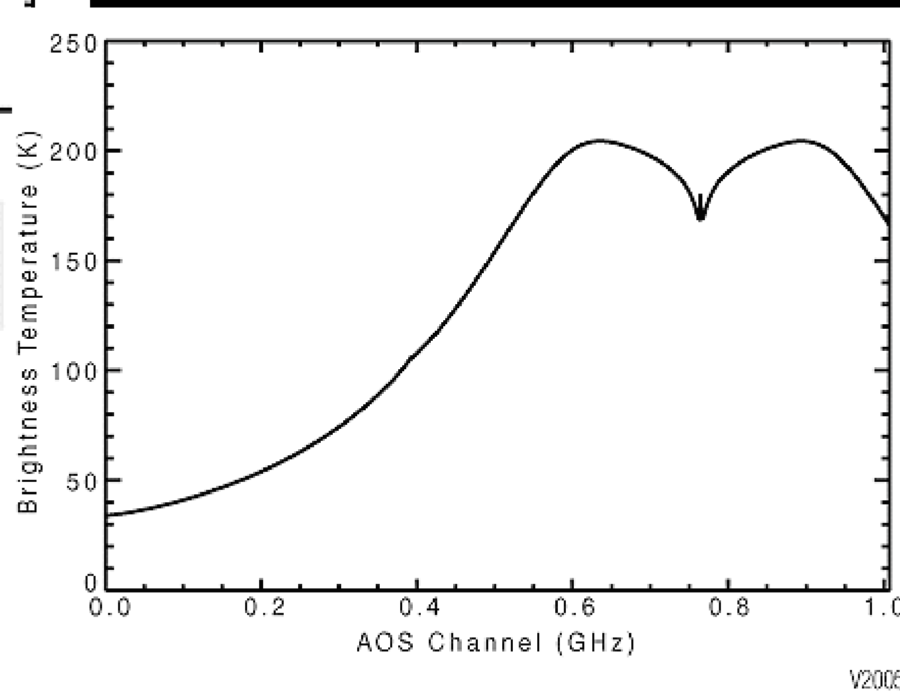

Target Locations
Mode 1
Cross-Track Right or Left
Mode 2
In-Track Forward or Aft
Mode 3
Nadir
Cross-track
observation path
Locus of
tangency
Desired 500 x 500 Km Altitude Orbit
Orbit ground track and
In-track observation path

SLS will have high sensitivity for trace atmospheric constituents



High heterodyne resolution allows velocity determination to less than 10 m/s





Scout Proposal

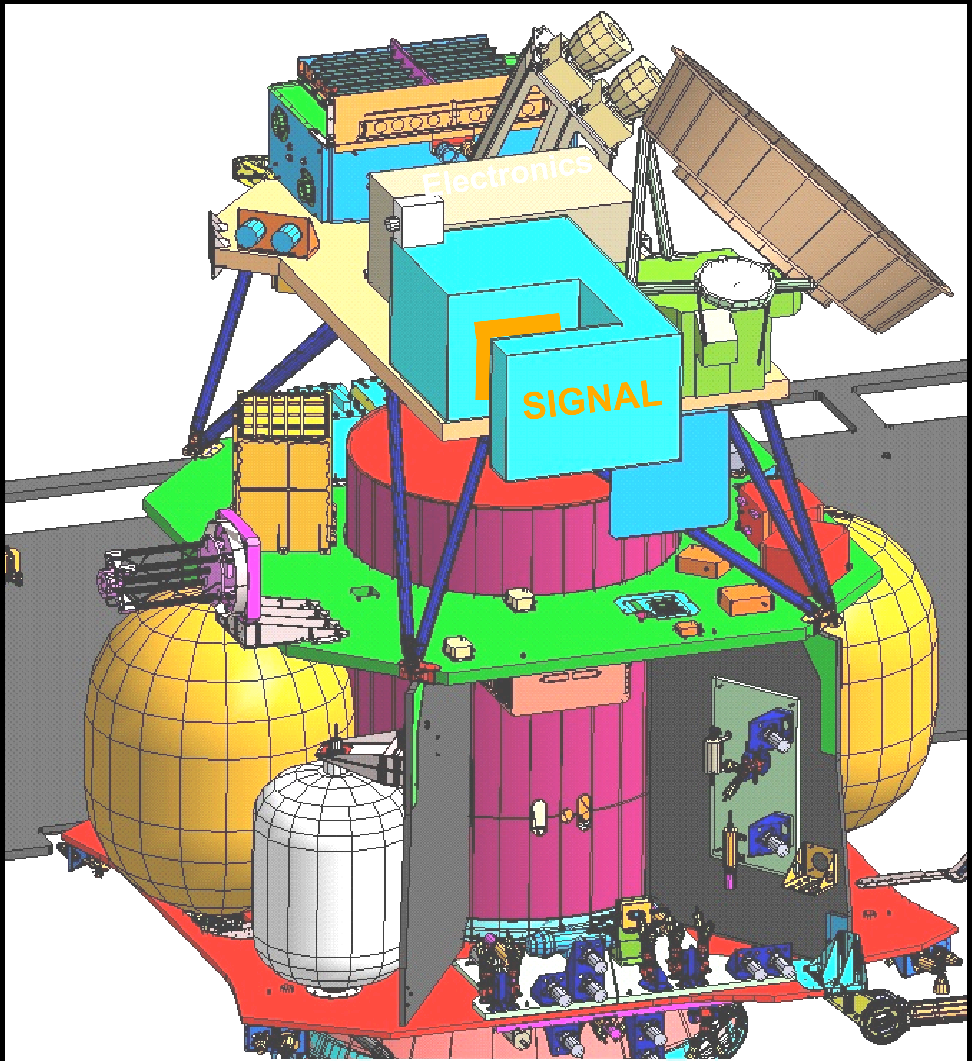
MARVEL Scout

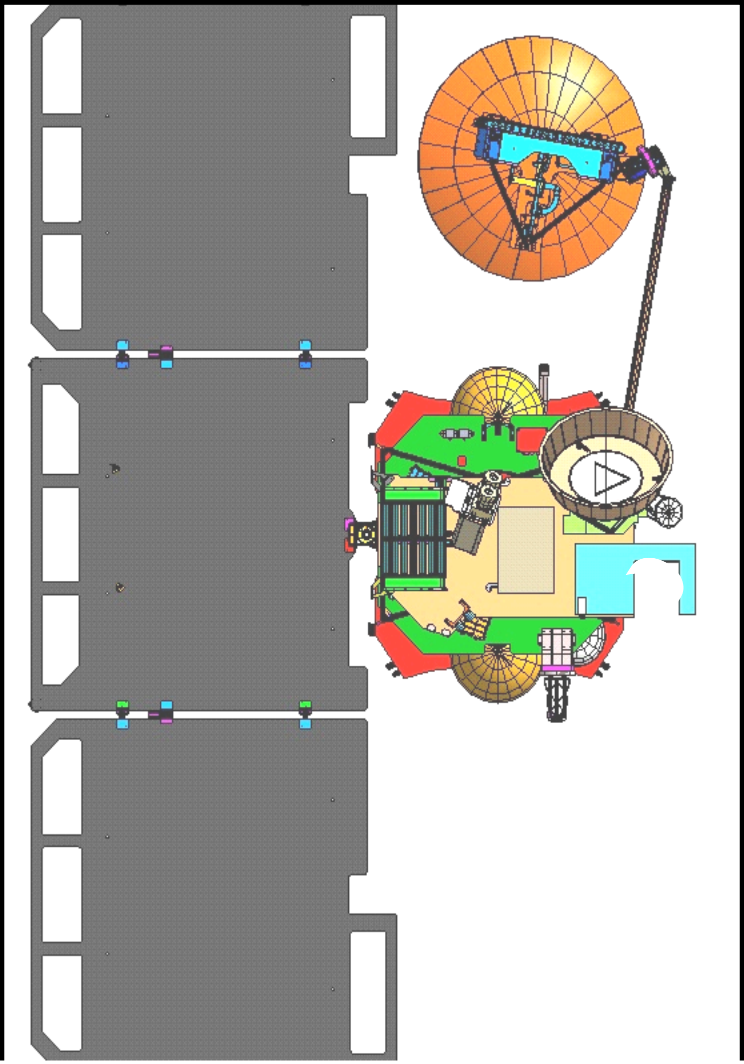
Mars Volcano Emission and Life Scout

Mark Allen, JPL/Caltech
Principal Investigator

- Search for atmospheric chemical species that are markers of extant subsurface life
- Search for atmospheric chemical species and surface thermal feature that are markers of extant volcanic activity
- Survey comprehensively the chemical composition of the atmosphere
- Analyze quantitatively atmospheric dust mineral composition
- Characterize high altitude atmospheric structure

The heterodyne instrument on MARVEL is SIGNAL

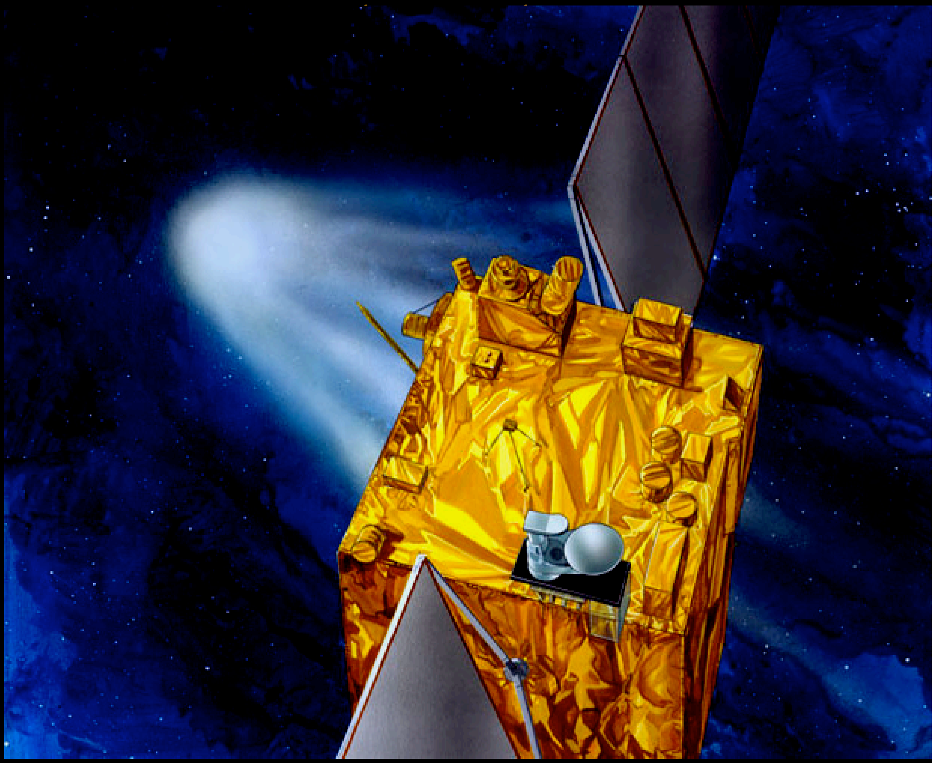




Rosetta Mission Comet rendezvous

US Contribution to Rosetta

MIRO (Microwave Instrument for the Rosetta Orbiter) is a scientific instrument on the ROSETTA Spacecraft. MIRO will measure the near surface temperatures of the asteroids, thereby allowing scientists to estimate the thermal and electrical properties of these surfaces. In addition, the spectrometer portion of MIRO will allow measurements of water, carbon monoxide, ammonia, and methanol in the gaseous coma of a comet. These measurements will allow scientists to study how the comet material sublimates (changes from its frozen state, ice, to a gas) in time and distance from the sun.



MIRO on Rosetta

MIRO - Microwave Instrument for the Rosetta Orbiter