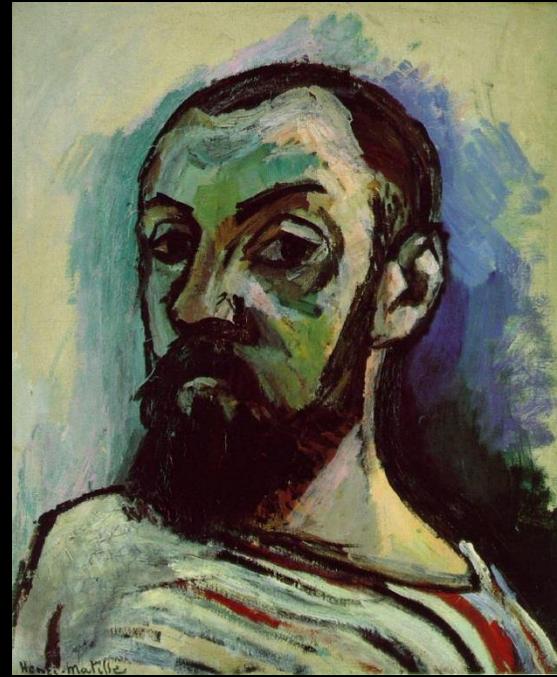
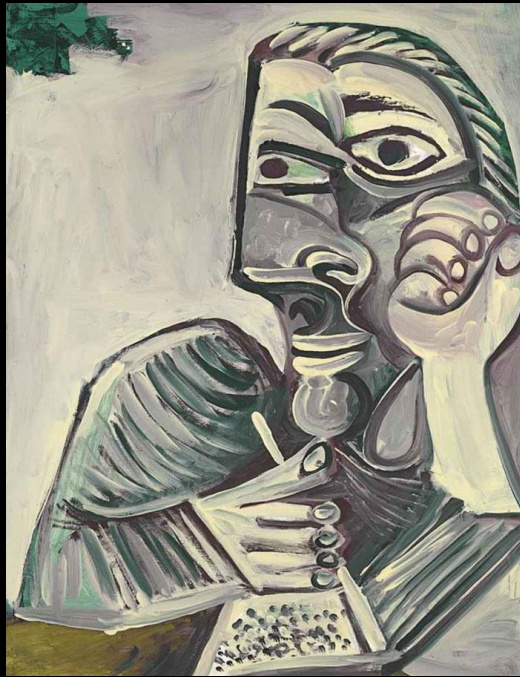




NASA Planetary Science Division's Instrument Development Programs, PICASSO and MatISSE



James R. Gaier

NASA Planetary Science Division

NASA Planetary Science

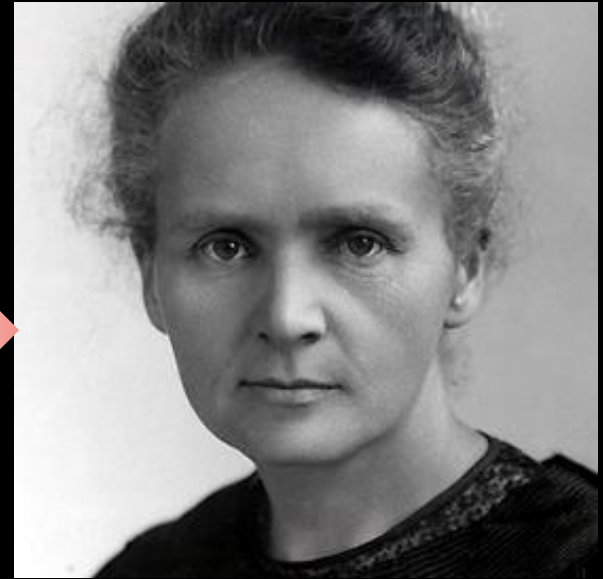
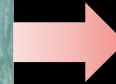
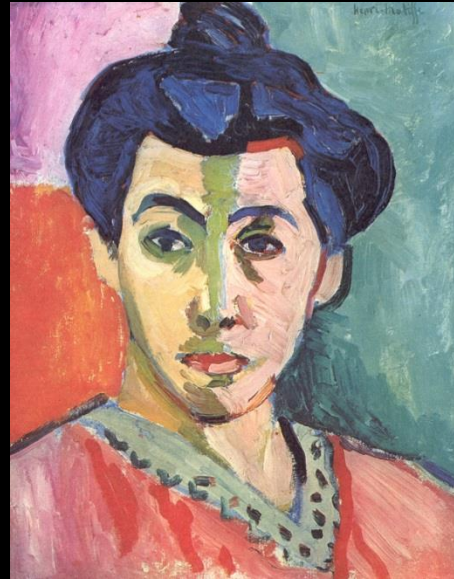
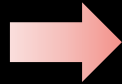


Strategic Objective: Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

It seeks to address this objective with five fundamental goals:

- Explore and observe the objects in the solar system to understand how they formed and evolve.
- Advance the understanding of how the chemical and physical processes in our solar system operate, interact, and evolve.
- Explore and find locations where life could have existed or could exist today.
- Improve our understanding of the origin and evolution of life on Earth to guide our search for life elsewhere.
- Identify and characterize objects in the solar system that pose threats to Earth or offer resources for human exploration.

Instrument Development Strategy



I have this
crazy idea

TRL 1-3

*I can make it
work*

TRL 4-6

How did we ever
do without it?

TRL 7-9



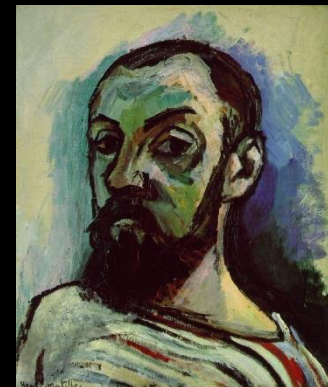
Planetary Instrument Concepts Advancing Solar System Observations (PICASSO)

- **PICASSO** supports the development of spacecraft-based instrument systems that show promise for use in future planetary missions
- **Program goal** to develop low TRL technology to feed MatISSE, etc.
 - science instrument feasibility studies
 - concept formation
 - proof of concept instruments
 - advanced component technology
- **Program objectives** to develop new technologies that significantly improve instrument measurement capabilities for planetary science missions
- **Proposals** are typically sought every year.
- **The budget** is ~\$3.5 M per year.
 - Average award ~ \$250 - \$300K/year
 - Typically ~ 12 awards



Maturation of Instruments for Solar System Exploration (MatISSE)

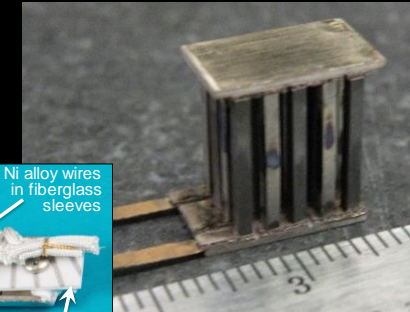
- 🪐 **MatISSE** supports the maturation of spacecraft-based instrument systems that show promise for use in future planetary missions
- 🪐 Program goal to develop instrument to point where they can be proposed to flight programs
 - Must address specific science objectives
 - Retire major technological risk
- 🪐 Program requires higher level of oversight
 - Quarterly reviews
 - Site visits
 - External reviewers
- 🪐 **Proposals** are typically sought on even numbered years
- 🪐 **The budget** is ~\$6 M per year.
 - Average award ~ \$1.0M/year
 - Typically ~ 6 awards



Instruments Being Developed for Venus

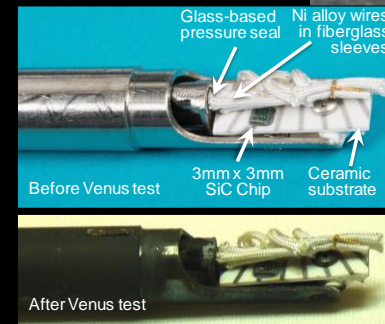
- **Planetary Heat-Flux Sensor for Venus**

- Michael Pauken - JPL



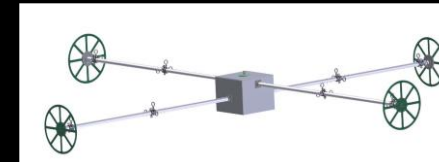
- **High Temperature Electronics**

- Gary Hunter - NASA GRC



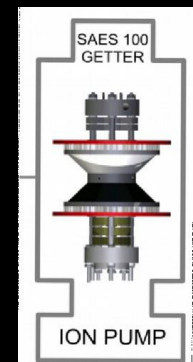
- **Airborne Electromagnetic Sounding of the Interiors of Venus, Mars, and Titan**

- Bob Grimm - SWRI



- **Piezoelectric Micro Valve for Atmospheric Descent Sampling**

- Jurij Simcic - JPL





TRL 6 Instruments Adapted

- **Development of an Instrument to Measure Turbulent Eddy Fluxes in Planetary Atmospheres (Scott Rafkin/SWRI)**
- **Europa Short Wavelength InfraRed Spectrometer - Radiation and Planetary protection Maturation ESWIRS-RPM (Bob Green/JPL)**
- **CIRIS: A near- and mid-infrared Fourier transform spectrometer for investigations of the surface composition and habitability of Europa. (Kevin Hand/JPL)**
- **SIRSE: Spectral ImageR/ Spectrometer for Europa (Dennis Reuter/GSFC)**
- **Adapting and testing micro mass spectrometers to identify biomarkers for astrobiology missions (Frisco van Ameron)**
- **Technical development of the MASPEX instrument for Europa Exploration (Jack Waite/SWRI)**
- **A Probe For Europa's Plasma Interaction (Frances Bagenal/Colorado)**
- **Development of Large Format Rad-Hard Focal Plane Arrays and Readouts for Thermal Radiometer for Europa Clipper Mission (Matt Kenyon/JPL)**
- **Planetary Instrument for Submillimeter-wave Surface and Atmospheric Reconnaissance and Research in Orbit (PISSARRO) (Goutam Chattapahyay/JPL)**



Title Ultra Compact Short Wavelength Infrared imaging Spectrometer (UC-SWIRS)

PI: Robert O. Green / Jet Propulsion Laboratory

TRL = 6

Platform: Compatible with Venus Lander, Balloon, or Orbiter

Key Capabilities:

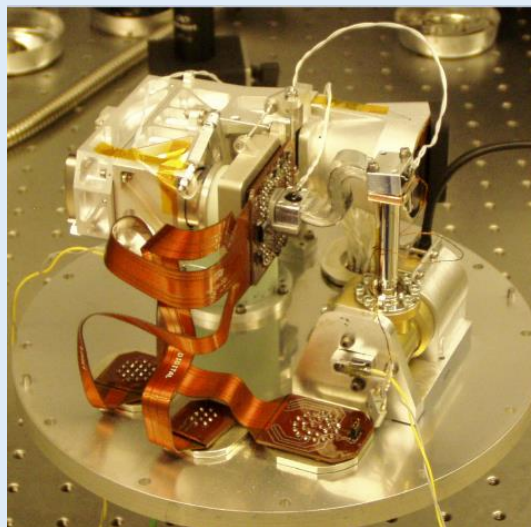
- Spectral range: 0.4 to 5 microns
 - full range or subset
- Spectral sampling: 10 nm
 - adaptable to requirements
- Radiometric range: 0 to specific saturation
- Radiometric sampling: 16 bits
- Spatial swath: ~5 to 45 degrees
 - adapted to requirements
- Spatial sampling: 0.1 to 1 milliradians
 - adapted to requirements)

Key Advantages over State of the Art:

- Collects measurements with full spectral and image content
- Multiple octaves of spectrum collected with single detector and instrument
- Nominal mass: 3kg
 - function of exact requirements
- Nominal power: 3 W
 - function of environment
- Onboard compression/analysis

Contact Information:

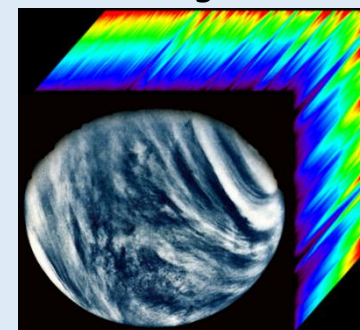
Name: Robert O. Green
Institution: Jet Propulsion Laboratory
Email: Robert.O.Green@jpl.nasa.gov



UC-SWIRS engineering model. UC-SWIRS can be configured for lander, Balloon or Orbiter science investigations.



Example UC-SWIRS Lander image cube



Example UC-SWIRS Orbiter image cube

New Science Enabled:

- Spectroscopy from the visible through short wavelength infrared with image coverage
- A broad range of material composition and process investigations
- Specific science investigations are a function of the platform and refined requirements



Venus: Trace Gas Measurements with an Eddy Flux Option

PI: Scot Rafkin/Southwest Research Institute

TRL = 6

Platform: Lander, Balloon, or Probe! Choose one, two or all three!

Key Capabilities:

- Integrated acoustic anemometer and laser spectrometer for eddy flux measurements of momentum, energy and trace gases.
- Spectrometer available as stand alone instrument for key trace gas measurements (SO_2 , OCS , H_2SO_4 , H_2O , CO , H_2S , HCL ...) with necessary accuracy and sensitivity.
- Rapid measurement: > 1 Hz
- Modular subsystem design is easily adaptable to different platforms and even other planets.

Key Advantages over State of the Art:

- Fast response to capture fine structures.
- Up to 8 unique channels; expansion possible.
- Robust against corrosion, high temp and press.
- Low Resource (< 1 W, < 1 kg).
- Onboard data processing minimizes data volume.
- Solid state laser and optics, no moving parts.
- Can be integrated with acoustic anemometer for simultaneous wind and eddy flux measurements.

Contact Information:

Name: Scot Rafkin
Institution: Southwest Research Institute (Boulder)
Email: rafkin.swri@gmail.com

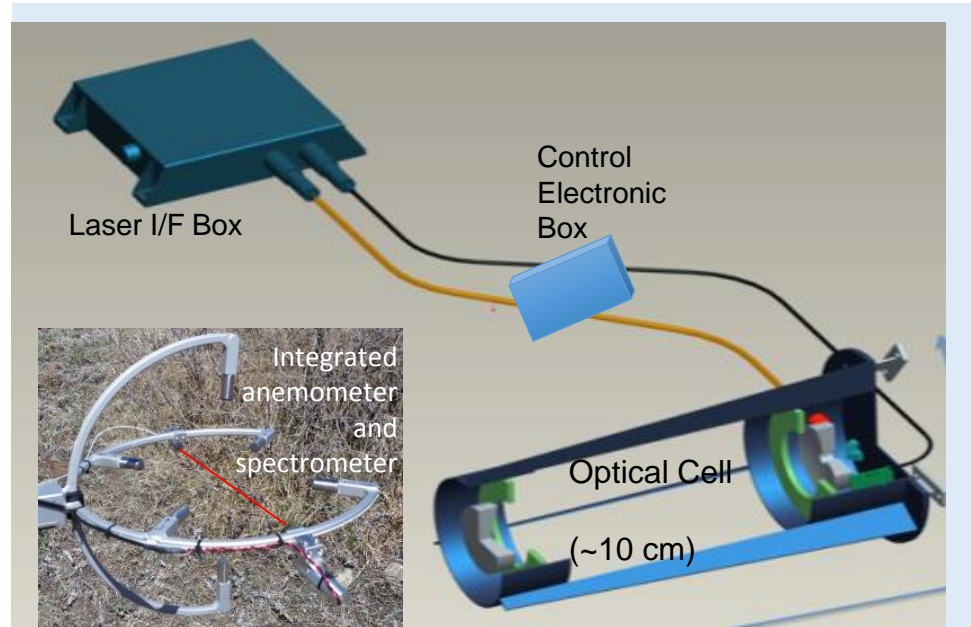


Figure Caption: Modular instrument design. Optical cell with patented mirror design is ~10 cm in length. Can be integrated on to an acoustic anemometer for eddy flux measurements. Integrated acoustic anemometer and laser spectrometer (with laser path shown by red line) undergoing field testing (inset, above).

New Science Enabled:

- Rapid measurement of multiple trace gases to capture fine structure on descent or fast variations on a balloon or at the surface.
- Simultaneous measurement of key chemical species to assist in closure of chemical cycling.
- Addition of eddy flux provides dynamical source term for momentum, heat and mass.



Submillimeter-Wave Spectrometer Instrument for Venus Exploration

PI: Goutam Chattopadhyay/Jet Propulsion Laboratory

TRL = 5

Platform: Venus Orbiter

Key Capabilities:

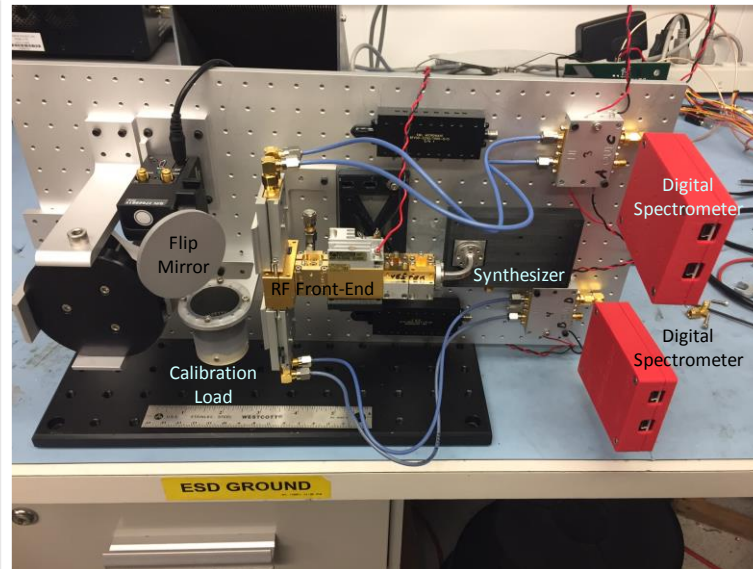
- A submillimeter-wave limb sounder providing unique data on the atmospheric physics and composition of Venus' atmosphere.
- High-resolution submillimeter-wave spectrometer instrument allows sub-ppb sensitivity for trace species, direct temperature, pressure, wind measurements.
- High-TRL instrument matured through MatISSE investments.
- Flight heritage: based on proven technologies from SWAS, Herschel, EOS Aura, and Rosetta MIRO instrument.

Key Advantages over State of the Art:

- MIRO was 19 Kg and needed 88 W DC of power. This instrument weighs less than 7 Kg and needs less than 12 W of DC power.
- Uses state-of-the-art CMOS all digital back-end spectrometers and low-power frequency synthesizer.

Contact Information:

Name: Goutam Chattopadhyay
Institution: Jet Propulsion Laboratory
Email: goutam@jpl.nasa.gov



High-TRL low-mass and power (12W) highly-integrated submillimeter-wave spectrometer for Venus exploration. The entire instrument can fit in 2U form factor.

New Science Enabled:

- Provide elemental and isotopic compositions of species in Venus' atmosphere, especially the noble gases and nitrogen-, hydrogen-, carbon-, and sulfur-bearing species.
- Provide the knowledge of how the global atmospheric circulation patterns of Venus differ from those of Earth and Mars.
- Provide information related to the key processes, reactions, and chemical cycles controlling the chemistry of the middle, upper, and lower atmosphere of Venus.
- Determine how solar energy drives atmospheric circulation, cloud formation, and chemical cycles that define the current climate on terrestrial planets.



Title: Venus Climate Sounder

PI: M. Kenyon/JPL

TRL = 5

Platform: Orbiter

Key Capabilities:

- **CRITICAL HERITAGE:** Venus Climate Sounder (VCS) builds on Mars Climate Sounder (MCS) w/ simple mods to achieve half scale height limb profiling from low, polar, circular Venus orbit
- **BETTER DESIGN:** Keeps MCS excellent radiometric stability and accuracy but uses only one telescope (smaller/simpler)
- **RELIABLE & CHEAP(ER):** No cooler or active cooling of anything

Key Advantages over State-of-the-Art:

- **PERFECT PITCH:** Use new large format thermopile array with 2x smaller pixel pitch to achieve FOV
- **COVERS ALL WAVELENGTHS:** Detectors measure from 0.3-100 um with near perfect efficiency
- **LONG STARES AT LIMB:** Negligible low-frequency (1/f) noise in detector-signal chain allow for long integration times for high signal-to-noise

Contact Information:

Matt Kenyon
JPL
mkenyon@jpl.nasa.gov



Figure: (Left) MCS has returned daily global maps of temperature, pressure, dust and ice from Mars, from the surface to 80km for more than 11 years. (Right) VCS incorporates all the design features of MCS for high accuracy radiometry, but utilizes a modern thermopile array that reduces the FOV by 2x and includes 10 spectral channels in a single telescope.

New Science Enabled: Address Decadal Science:

- (i) *How do the global atmospheric circulation patterns of Venus differ from those of Earth and Mars?*
- (iii) *What are the influences of clouds on radiative balances of planetary atmospheres, including cloud properties: microphysics, morphology, dynamics and coverage?*
 - Global structure of middle atmosphere mapped with half scale height (2-3 km) vertical resolution from the cloud tops to 110 km, both day and night.
 - Global variation of temp, pres, aerosol opacity and water vapor over day/year
 - Improved understanding of the structure and circulation of the middle atmosphere of Venus