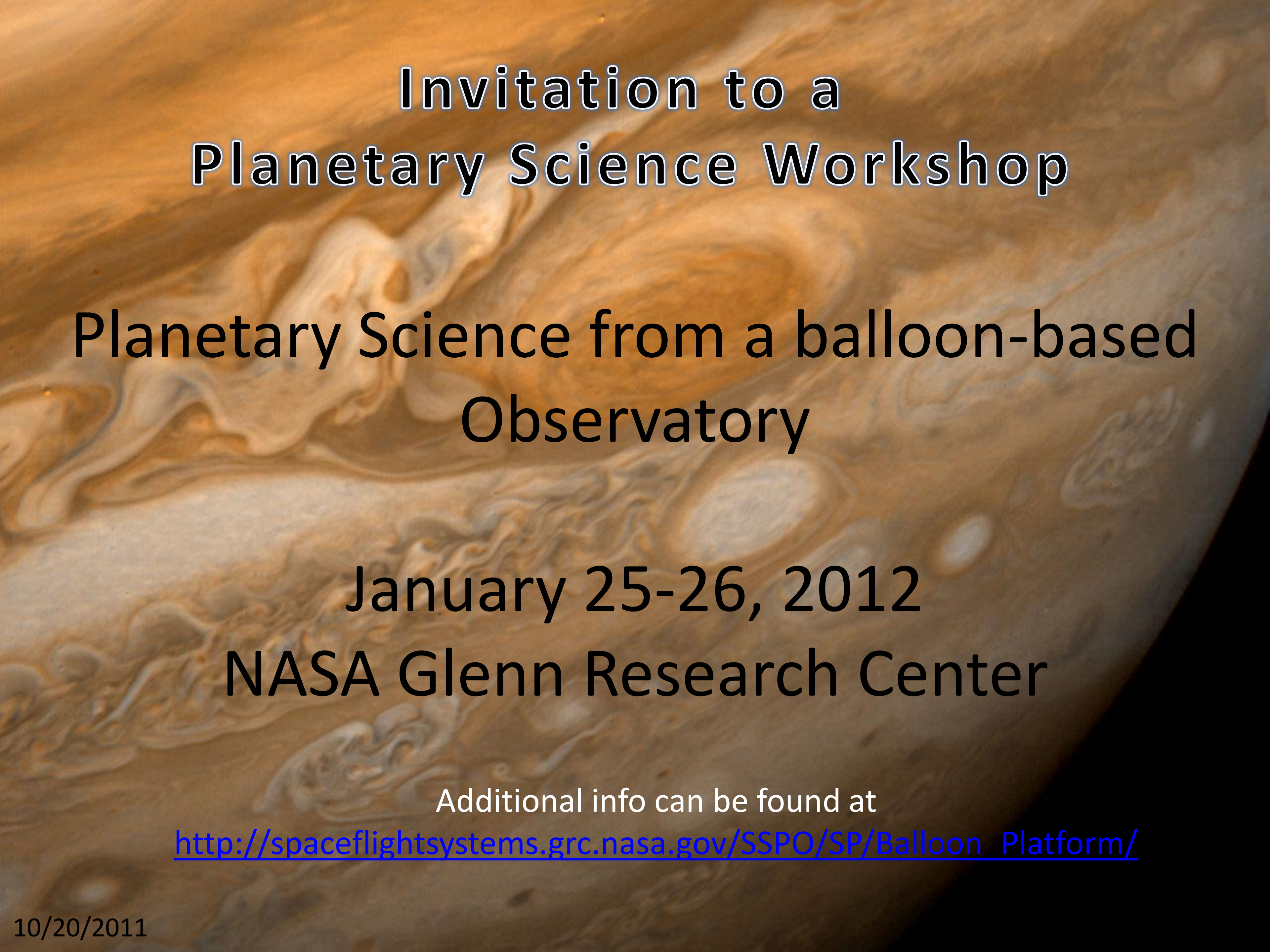


# Invitation to a
# Planetary Science Workshop

## Planetary Science from a balloon-based Observatory

## January 25-26, 2012
## NASA Glenn Research Center

Additional info can be found at
http://spaceflightsystems.grc.nasa.gov/SSPO/SP/Balloon_Platform/

10/20/2011

# Outline

- Why Should You Listen >> Recent Changes
- Purpose of Workshop
- Notional Agenda
- Expected Outcomes

Additional info can be found at
http://spaceflightsystems.grc.nasa.gov/SSPO/SP/Balloon_Platform/

# Global Factors

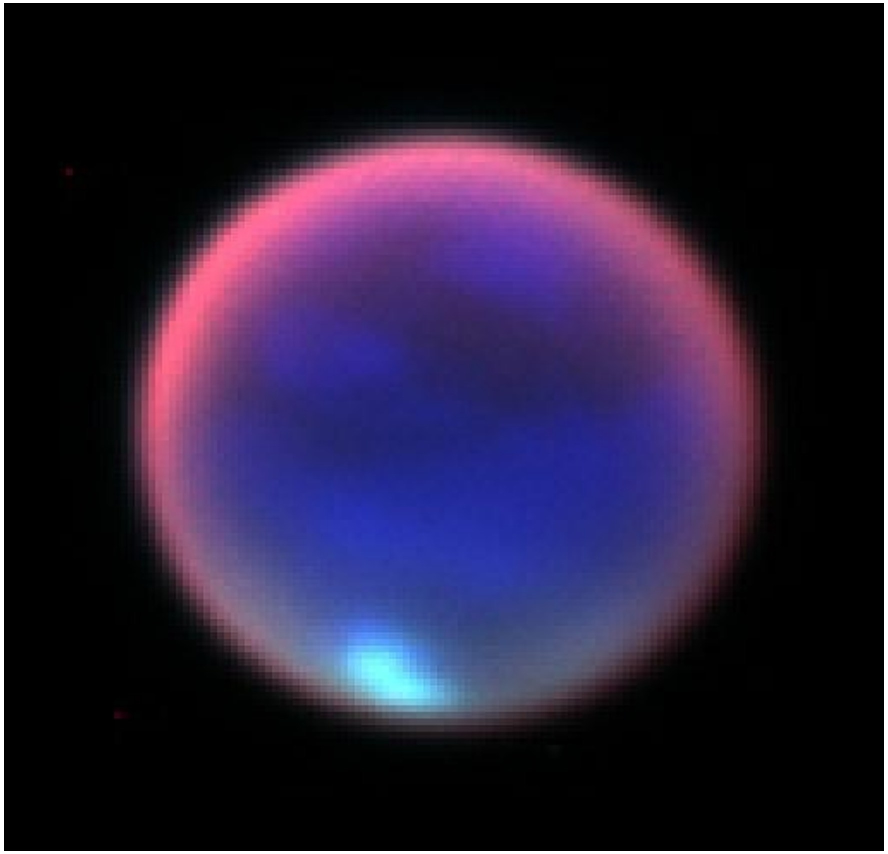
- Increasing cost pressures will require novel approaches for getting more science with less resources
- Recent technical advances
- Other SMD divisions having been utilizing platform and enhancing capabilities

# Not your Grandfather's Balloons

- Balloons today can operate at over 120,000 ft (above 99.5% of atmosphere)*
- Carry payloads in excess of 6,000lbs*
- Operate at altitude for over 50 days*
- Are relatively inexpensive to develop, launch, operate and can be done so quickly
- Recently demonstrated sub-arc second pointing for ten's of minutes

* Currently all these are not doable on the **same** mission. Near term goal is to fly 2000lbs at 120K ft for 100 days.

# New Capabilities May Enable New Science… For Less



<u>High Value / Unique Science</u>

- Atmospheric/Dynamics
- Venus Observations
- Near & mid IR spectroscopy
- Small bodies / Organics
- TNO's
- Technology Development
- Lightning / airglow
- NEO's

# Purpose of Workshop

- Level 0: Determine the level of planetary science support for a balloon based planetary observatory
- Level 1:
  - Present the Planetary Science community the SOA in balloon platform capabilities and near term plans
  - Present recent mission examples
  - Explore, discuss, and articulate the expected science benefits
  - Identify driving architecture requirements
  - Identify technical tall poles
- Follow–up activities will include refining science objectives and driving requirements, developing solution options for technical challenges, and developing cost and schedule estimates
- Prepare for potential special session at 2012 LPSC

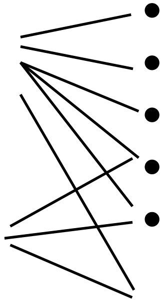
# Notional Agenda

- Overview of SOA and ongoing capabilities advancement activities for Balloon missions
- Recent mission experiences highlighting science capabilities
- Science  impacts if this facility was available today
  - Discussion of various science
  - Driving architecture/mission requirements to achieve needed science
- Identify key technical challenges, if any
- Identify follow-on activities (concept developments, focused research, studies, etc)
- Plan LPSC Special Session

# Science Impact Example: VENUS Science Applications

**Broad Science Goals:** → **Observations:**

- Understand Venus’ 3-D Circulation
- Understand Venus’ Atmospheric Chemistry



- Track UPPER clouds (day-side) at UV wavelengths.
- Track lower & middle clouds in IR windows, *including* windows longward of 2.5 μm.
- Doppler-shift experiments in visible and near 10-12 μm.
- Maps of tracer species (e.g., CO, OCS, $H_2O$, $H_2SO_4$, sulfur compounds).
- Correlate tracers with cloud coverage and possible regions of upwelling and downwelling.
- High-resolution (0.1” or better) image sequences of evolving cloud morphologies.

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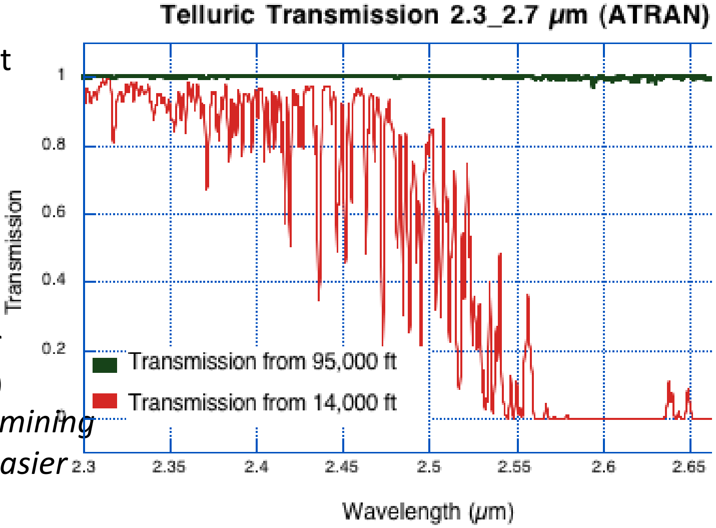
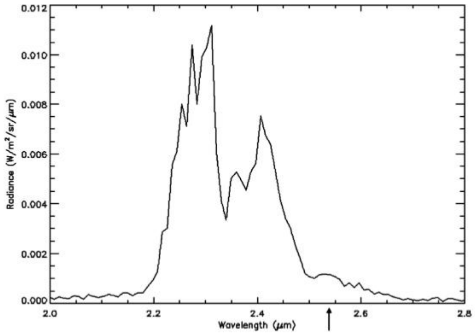
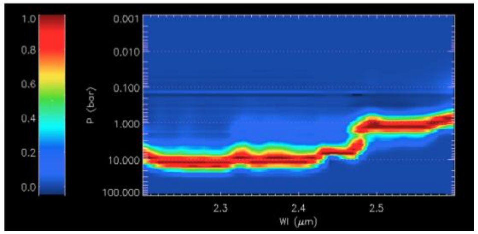
## Observational Advantages of Balloons:

- Spectroscopy in critical bands not available at 14,000 or 41,000 ft (e.g., at 2.5 - 2.6 μm or near 4.3 μm).
- Observations when Venus is near the Sun (i.e., during inferior conjunction observations of the night side).
- Diffraction-limited spatial resolution.
- Continuous observations for weeks (or months with super-pressure balloons.)



*Venus’ flux near 2.5-2.6 μm is critical to determining cloud altitudes (far right panel) and is much easier to observe from the stratosphere (near right).*





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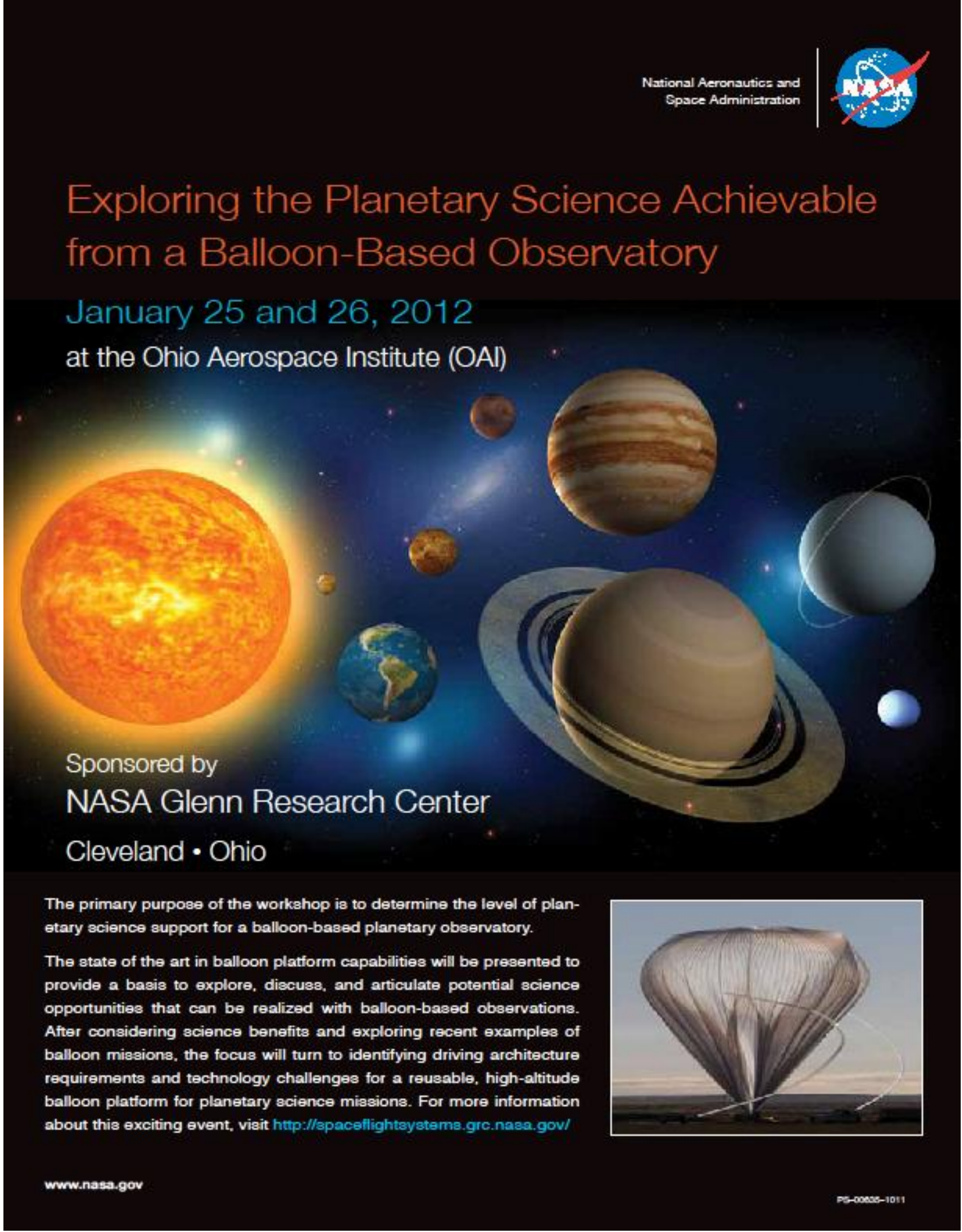
## Balloon Science Opportunities:

- Inferior conjunctions (every 19 months) provide several months of night-side viewing with disk diameters up to 60”. Imaging at 0.1” resolution would rival VIRTIS spatial resolution.
- IR spectra to characterize cloud heights, particle sizes and composition, particularly at some wavelengths that are obscured from the ground.

If you have not fully committed to attending yet sit in on an upcoming Virtual Meeting via WebEx and phone on November 16th at 11:00am eastern

Contact myself, Karl Hibbits or Eliot Young to get on invite list



National Aeronautics and
Space Administration

## Exploring the Planetary Science Achievable from a Balloon-Based Observatory

January 25 and 26, 2012
at the Ohio Aerospace Institute (OAI)

Sponsored by
NASA Glenn Research Center
Cleveland • Ohio

The primary purpose of the workshop is to determine the level of planetary science support for a balloon-based planetary observatory.

The state of the art in balloon platform capabilities will be presented to provide a basis to explore, discuss, and articulate potential science opportunities that can be realized with balloon-based observations. After considering science benefits and exploring recent examples of balloon missions, the focus will turn to identifying driving architecture requirements and technology challenges for a reusable, high-altitude balloon platform for planetary science missions. For more information about this exciting event, visit http://spaceflightsystems.grc.nasa.gov/

www.nasa.gov

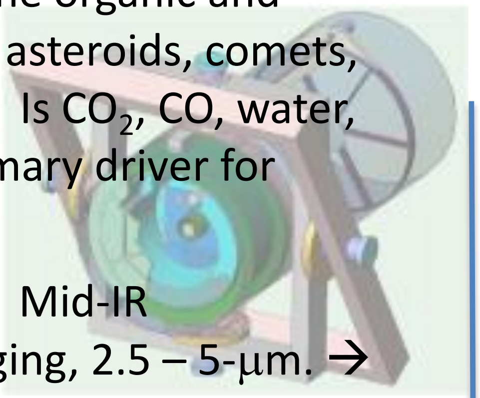
PS-00635-1011

# Backup

# Potential Advantages of a Balloon-Based Facility

- Low-cost planetary science
- Hubble-like performance at greatly reduced cost
- Clear access to wavelengths obscured by Earth’s atmosphere
- Very stable photometry
- Ability to observe targets close to sun
- Long observation periods (enables some atmospheric science)
- Low-cost enables the facility to be dedicated for planetary science – eases operations
- Large payload capacity – offers piggyback science, student projects, technology demonstrations
- Broadens flight opportunities for planetary PI’s
- Fast development cycles and science return

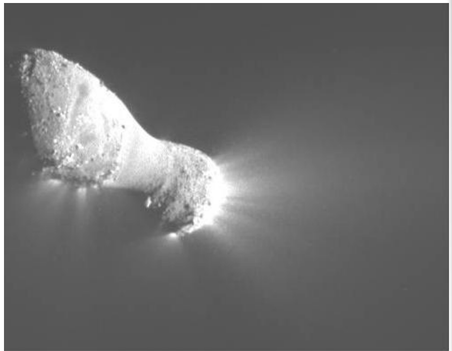
# Small Body Organic and Volatile Investigation



**Science Goal:** What is the organic and volatile compositions of asteroids, comets, and other small bodies? Is $CO_2$, CO, water, or other volatile the primary driver for comet outbursts?

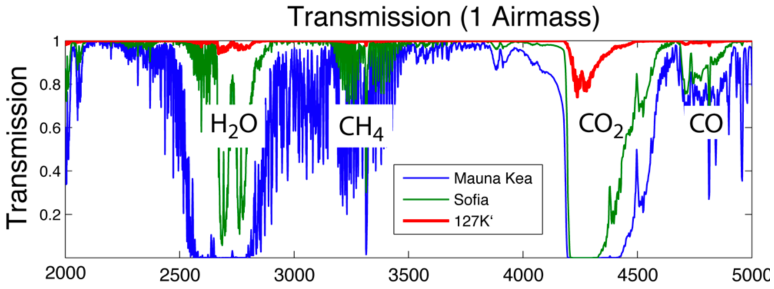
**Measurement Concept**: Mid-IR spectroscopy. Non-imaging, 2.5 – 5-μm. → measure $CH_n$, CO, CN, $CO_2$, water, hydroxyl, and trace species.

**Potential targets:** NEA, MBA, irregular satellites, Jupiter Trojans, Centaurs, KBOs.

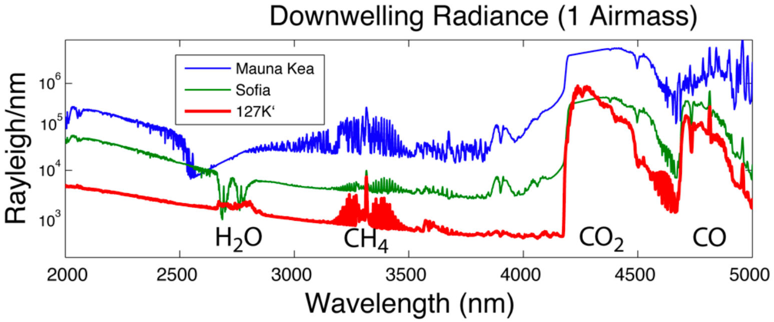


## Stratospheric Platform:

- Adequate atmospheric transmission with minimal downwelling radiance in the Mid-IR (2.5- 5 μm).
- Long duration of each observation (minutes) enables high SNR. Individual dim tgts can be observed for hours to further improve SNR. Total mission duration of weeks of weather-free, observing ensure many tgts are observed, or fewer tgts observed over large baseline.



Transmission (1 Airmass)



Downwelling Radiance (1 Airmass)

# Small Body Thermal Investigation

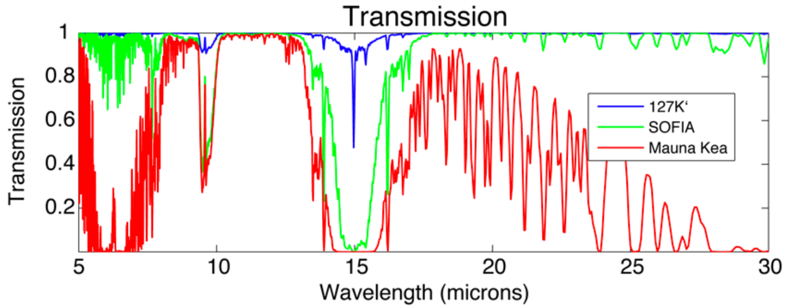
**Science Goal:** What are the non-gravitational forces on small bodes (Yarkovsky effect, YORP, etc.). What is the non-ferrous silicate composition of bodies?

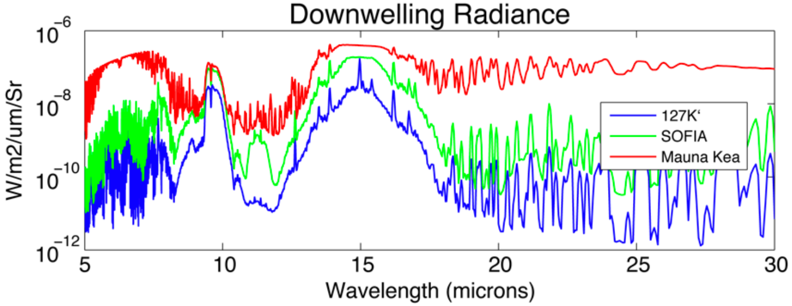
**Measurement Concept**: TIR spectroscopy. 7-14μm. → measure the Christensen and reststrahlen bands of clays and rock forming minerals.

**Potential targets:** NEA, MBA, irregular satellites, Jupiter Trojans, Centaurs, KBOs.

## Stratospheric Platform:

- Adequate atmospheric transmission with minimal downwelling radiance in the TIR (7-14 μm).
- Long duration of each observation (minutes) enables high SNR. Individual dim tgts can be observed for hours to further improve SNR. Total mission duration of weeks of weather-free, observing ensure many tgts are observed, or fewer tgts observed over large baseline.





# UV Observations of Solar System Bodies

Science Goals:

1. Understand the space weathering of airless silicate bodes.
2. Understand Planetary Aurora.
3. Understand composition of atmospheres of comets, Io, Venus, Mars, gas giants.

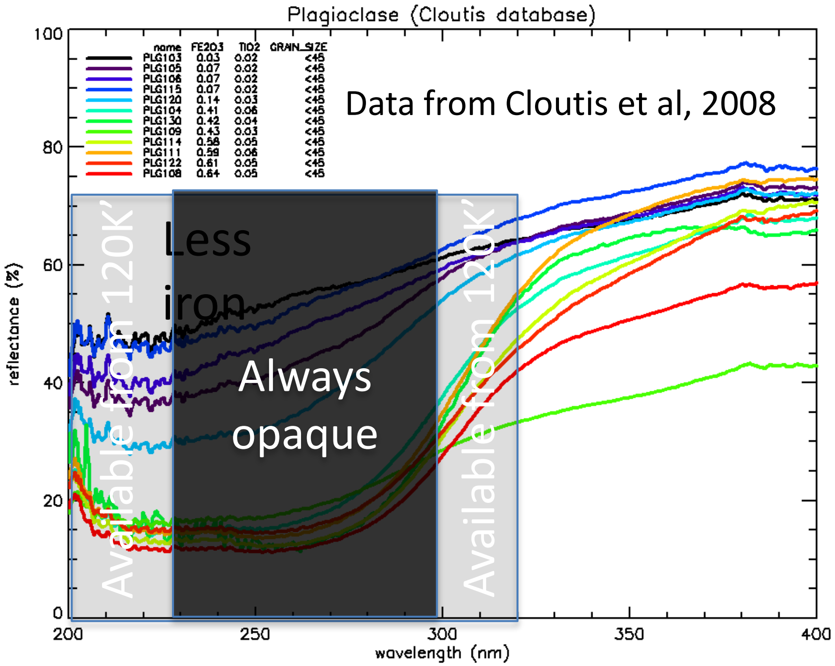
Measurements:

1. Airless Bodies: Far-UV – NUV. Low UV reflectance is due to oxygen-metal charge transfer (OMCT). Sensitive to small amounts of Fe. absorptions.

2. Aurora and atmospheres: OH emission, O at 297nm, $CO_2$ doublet and FDB bands, CO Cameron bands, NO and N emission, SO and $SO_2$, as well as $H_2$ emissions.

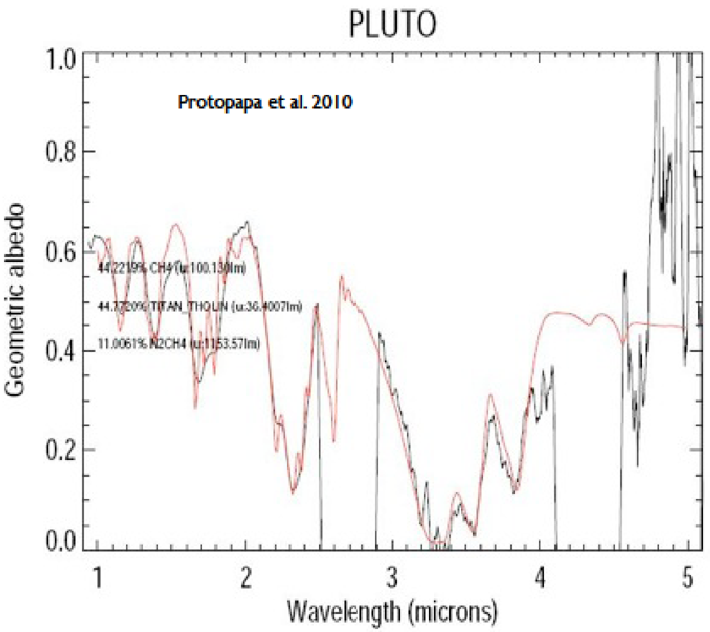
Stratospheric Platform:

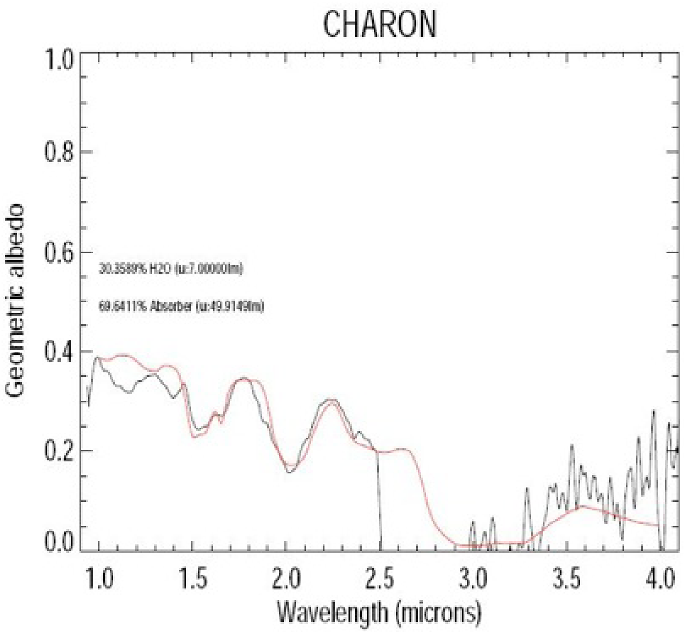
- Near UV and portion of far-UV available to characterize OMCT and other UV absorptions on airless bodies.
- Reduced Rayleigh scattering may enable daytime observations.



Data from Cloutis et al, 2008

# PLUTO, TRITON & Large TNOs: 3 - 5μm Spectra





**Broad Science Goals:**

- Inventory of compounds, including amino acid precursors (e.g., HCN, $NH_3$, Methanol)
- Understanding basic properties of remote surfaces: grain sizes, temperatures, dilution/ mixing of constituents, crystalline form.

- Much stronger lines at 3 - 5 μm than the overtones shortward of 2.5 μm.
- Better chance of detecting weak isotope lines, (e.g. $^{13}C$).
- With 3-5 μm spectra, Hapke-type modeling will provide more powerful constraints of surface properties and, in conjunction with 1 - 2.5 μm spectra, allow better modeling of frost layers.

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**Balloon Science Opportunites:**

- Much lower background than even the best terrestrial sites (Pluto's M-band spectra represents 4 consecutive nights from the 8-m VLT!).
- Better spatial resolution: enables separate spectra of countless close-spaced object pairs or spatially resolved spectra of many objects at the 0.1" level.

# The General Need for High Resolution Imaging in Visible Wavelengths

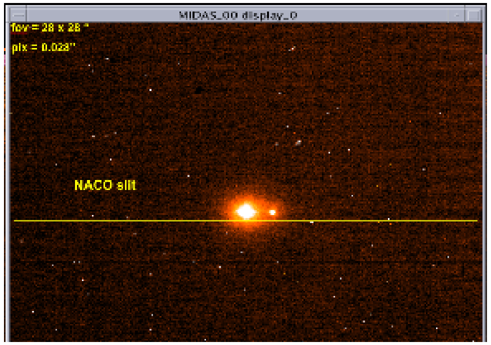

**Fig 1.** Spatially resolved spectroscopy of Pluto & Charon from the VLT/ NACO. Protopapa et al. 2010

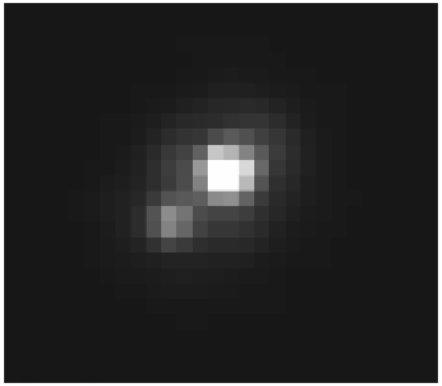

**Fig 3.** HST/HRC discovery of the binary centaur (42355) 2002 CR$_{46}$ with 300 sec of on-target integration. Noll et al. 2006.

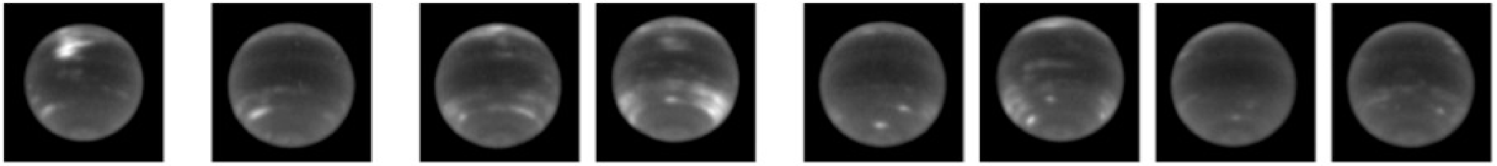

**Fig. 2** Neptune (HST) in the 0.619 μm filter of WFPC2 in 1994, 1997, 2001-2002 and 2004-2007 (left to right).

## Broad Science Goals:

- Understanding basic weather on giant planets: long-term monitoring of the giant planets at wavelengths shortward of 1.0 μm.
- Clean PSFs: finding & observing faint objects, often next to bright objects. Goals include the understanding of formation scenarios (asteroids, centaurs, TNOs, satellites and comets), ring/ satellite systems, separate spectroscopy of close binaries, and discovery of faint NEOs.
- Astrometry without the atmosphere: vastly improved occultation predictions (e.g., for TNOs).

**Balloon Science Opportunites:** A simple 1-m telescope in the stratosphere has a 0.12" diffraction limit, outperforming every telescope shortward of 1 μm except for HST.