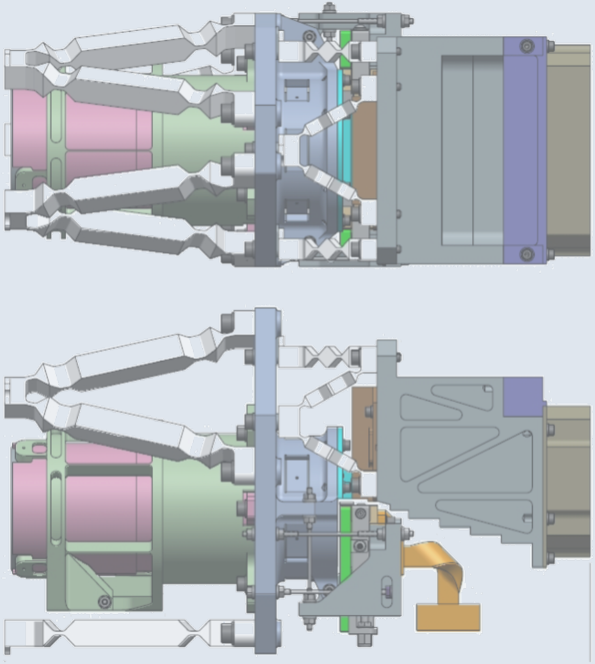

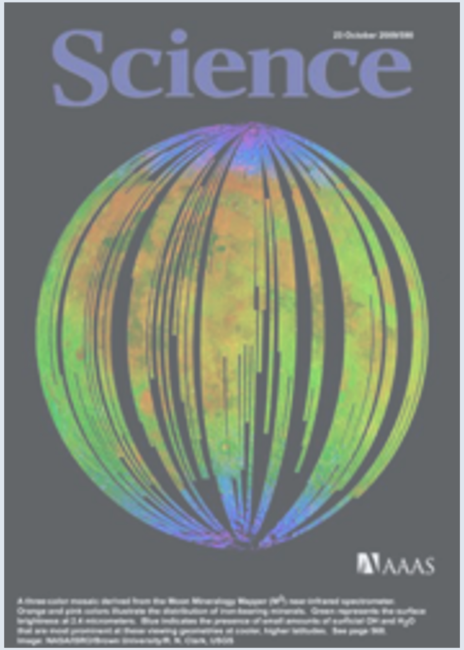

Virtual Research Presentation Conference

Next Generation Infrared Spectrometers for Solar System Exploration

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Program: Strategic Initiative

Assigned Presentation # RPC-211

Jet Propulsion Laboratory
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Tutorial Introduction

Abstract

- This project's objectives are tied to identifying and advancing key spectrometer types that use JPL-enabling technology to position JPL to respond to a broad set of future solar system instrument opportunities.
- Infrared spectrometers are required to address key Decadal science. This includes:
  - history of small bodies and their use as tracers of solar system evolution and reorganization
  - reservoirs of volatiles on Mars, the Moon, Icy Satellites, and asteroids
  - composition, including salt and organic content of ices in the outer solar system

Problem Description

- A decade of first-generation JPL space imaging spectrometers generated key discoveries (NIMS, VIMS, OMEGA, CRISM; M3)
- The next generation of more capable spectrometers developed here will improve upon these successful instruments by:
  - Expanding the spectral ranges in order to decipher a target's full compositional and thermal history,
    - *E.g.*, Mapping of minerals, volatiles, organic distributions, and thermal properties on comets, asteroids, rocky moons, icy moons, and other solar system targets, via full spectral access from ~0.35 to 13µm;
  - Miniaturization to take advantage of SmallSat, CubeSat, and landed missions that would open up many more mission opportunities.
    - *E.g.,* SIMPLEx and mass-constrained landers/rovers

Methodology - VMDIS

- The objective of this task is to advance two spectrometers using JPL enabling technology:
- **(1) VMDIS**: a micro VSWIR+MWIR Dyson Imaging Spectrometer (VMDIS) (~0.6-3.6 µm) based on the new digital readout CHROMA 18 µm pitch detector array with 512 spectral channels and 1024 spatial elements for orbital, flyby and landed/roving missions requiring full imaging spectroscopy (this delivers the performance of 1024 point spectrometers in image format) with mass <8 kg, power <40 W, and volume ≤3U, SNR ≥100 for reference science case
    - The current state-of-the-art in planetary imaging spectroscopy is the JPL Moon Mineralogy Mapper, with spectral coverage from 0.4-3.0 µm and ~8 kg, <20 W and 50x50x30 cm volume.
    - At Mars, the MRO CRISM spectrometer had a mass of 33 kg and measurement power of 44 W.
    - A prototype Dyson imaging spectrometer for Earth (0.35-1.8 µm) with ≥4 times the throughput of M^3 and CRISM has also been developed at JPL.
    - Building on this investment, and using JPL developed grating, slit and zero-order-light-trap technology, the VMDIS (~0.6-3.6 µm) instrument exceeds the performance of M^3 and CRISM with a combined order reduction in resource requirements. The extension of the spectral range to 3.6 µm is required for key lunar and solar system science related to volatiles (e.g. hydroxyl compounds, water, and ice) and organics. A new digital out detector array brings key advantages in terms of performance and efficiency.

Methodology - pHyTES

- The objective of this task is to advance two spectrometers using JPL enabling technology:
- **(2) pHyTES**: a planetary HyTES (pHyTES) imaging spectrometer for orbital, flyby and landed/roving missions (~3 to 12 μm, 512 spectral channels x 512 spatial elements, mass <10 kg, power <40 W, volume ≤12U, SNR ≥100 for reference science case
  - Currently, LWIR and MWIR space instruments with fine spatial scale are commonly of the multispectral type with a limited number of wavelengths measured (e.g. MRO-MCS, LRO DIVINER).
  - Mars Global Surveyor and New Horizons have carried MIR point spectrometers.
  - Using JPL technologies, the planetary HyTES instrument proposed here brings full imaging spectroscopy (3-12 μm) with 512 cross-track samples in with reduced resource requirement enabled by current technology

Results (VMDIS)

Accomplishments versus goals:

- Optomechanical parts were fabricated and delivered (goal achieved)
- Telescope mirrors fabricated and received (goal achieved)
- Critical aspheric CaF_2 lens approaching completion (fabrication goal partly achieved)
- Grating and slit designed and ready for fabrication (fabrication goal partly achieved)

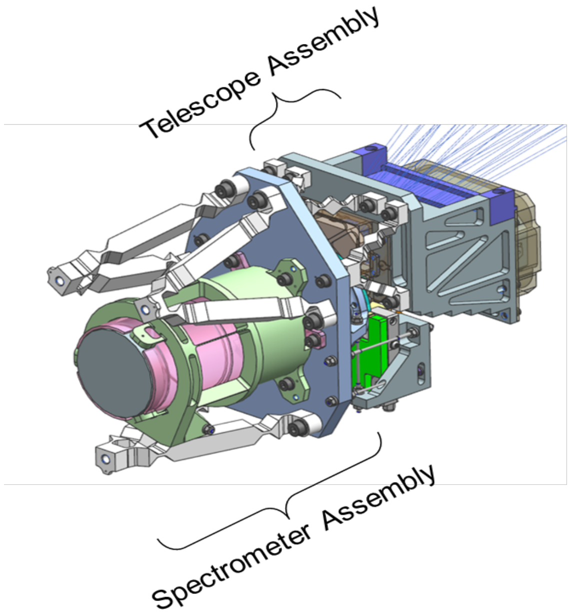
Significance:

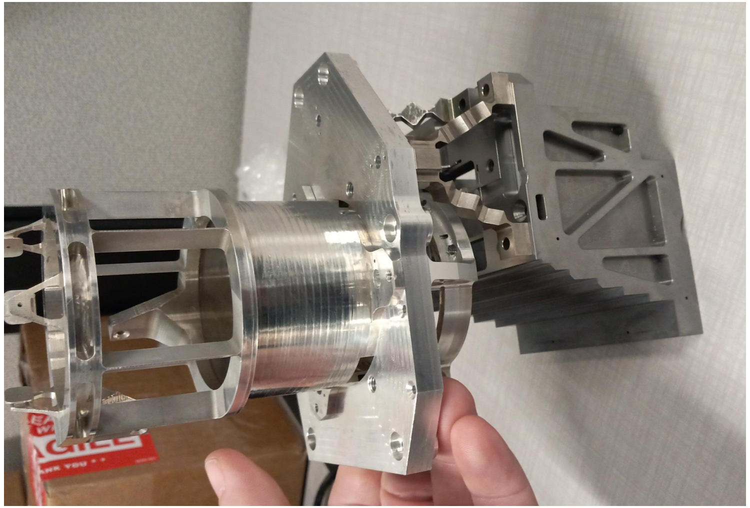
- Simplified optomechanical design and parts enable low cost, U-class spacecraft and missions
- Athermal aspheric telescope with inexpensive mirror and body materials reduces cost and delivery schedule significantly by opening up choice of providers

Next steps:

- VMDIS will complete fabrication and assembly of components in the first half of the year and then move on to testing in thermal vacuum, with the goal of demonstrating operation of the system in a relevant environment.

Results (VMDIS)





Telescope and spectrometer main parts before final finishing
(telescope body, spectrometer body, bipods, mounting plate)

Results (pHyTES)

Accomplishments versus goals

- Optical parts were fabricated and delivered (goal achieved)
- Vacuum chamber and Ricor 508N coolers operated at 60K (goal achieved)
- BIRD detector wire bonded to ceramic and delivered (goal achieved)
- Order sorting filters arrived and straylight completed (goal achieved)

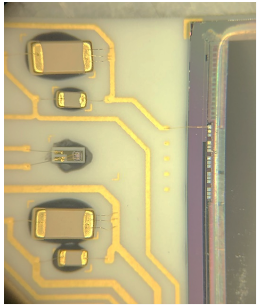
Significance

- New optical material for the Dyson ($As_{40}Se_{60}$) allows transmission of the full science passband of 2.5μm to 12μm. The material also allows the opto-mechanical parts to be all aluminum, hence greatly reducing mass.
- Miniature coolers like the Ricor 508N have flown and now have been demonstrated to operate down to 60K

Next steps

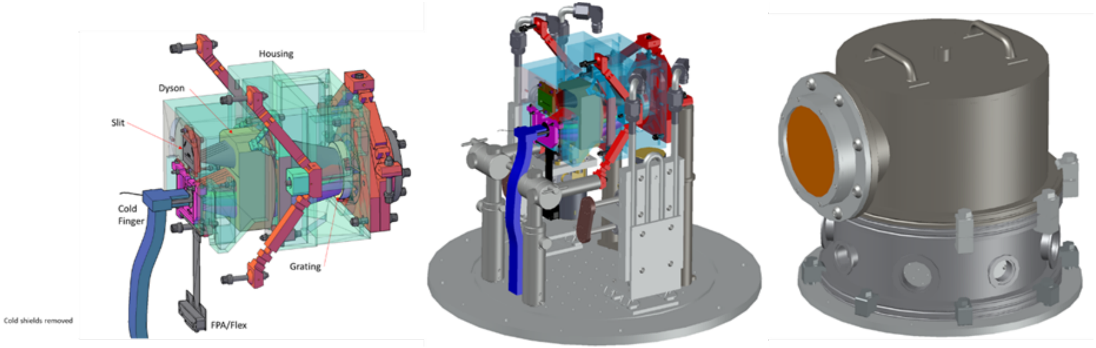
- We hope to be awarded a future proposal to advance the design to TRL 6

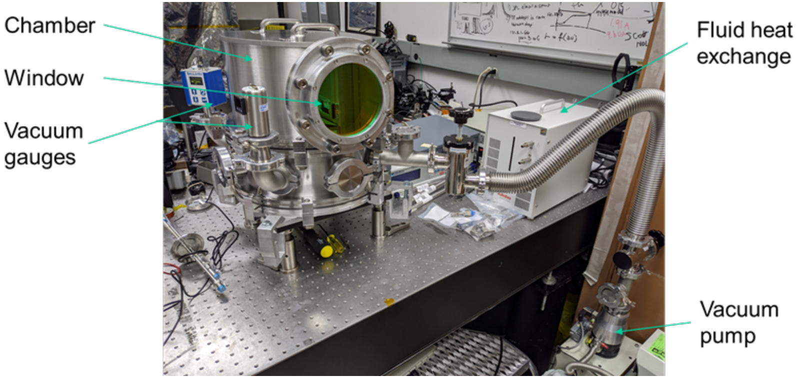
Results (pHyTES)



BIRD detector wire bonded to ceramic carrier

First Dyson block made from $As_{40}Se_{60}$ chalcogenide glass. Both a spherical and flat surface diamond turned on the back side.





Testbed used to cool down to 60K using RICOR 508N

Publications and References

Pantazis Mouroulis, Robert O. Green, Daniel W. Wilson, Christopher S. Smith, and Myrtle F. Lin "Compact imaging spectrometer for planetary missions", Proc. SPIE 11504, Imaging Spectrometry XXIV: Applications, Sensors, and Processing, 1150406 (22 August 2020); https://doi.org/10.1117/12.2568062