National Aeronautics and Space Administration

Next Generation Infrared Spectrometers for Solar System Exploration

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Program: Strategic Initiative (4x)

Project Objective:

A next generation of more capable spectrometers is needed

This Initiative responds to the essential need for infrared spectrometers to address key decadal planetary science by addressing two key challenges in Spectroscopy:

(1) 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.

- A decade of first generation space imaging spectrometer generated key discoveries (NIMS, VIMS, OMEGA, CRISM; M3)
- However, limited spectral ranges have limited their ability to decipher a target's full compositional and thermal history

(2) Miniaturization for low cost mission platforms

- current spectrometers are too large to take advantage of SmallSat, CubeSat, and mass-constrained landed missions that would open up many more mission opportunities

Spectrometer Suite

- **Midwave-infrared and Longwave-infrared Point Spectrometer (MLPS)**
- **Visible Midwave Dyson Imaging Spectrometer (VMDIS)**
- **Compact Imaging Fourier Transform Spectrometer (CIFTS)**
- **Planetary Hyperspectral Thermal Emission Spectrometer (pHyTES)**

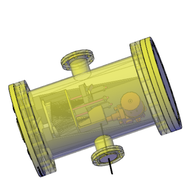
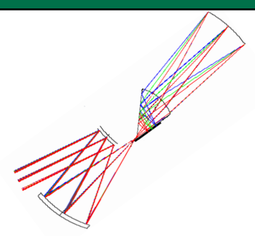
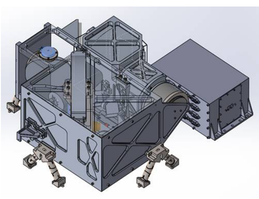
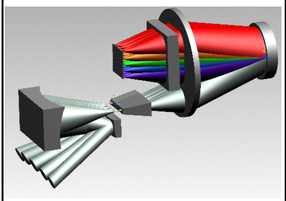
Key Decadal planetary science that we address:

- History of small bodies and their use as tracers of solar system reorganization
- Reservoirs of volatiles on Mars, the Moon, Icy Satellites, and asteroids
- Composition, incl. salt and organic content of ices in the outer solar system.

FY 19 Results:

- Very productive first year has successfully advanced the readiness of all four spectrometers.
- MLPS was a one-year effort that has been completed this FY
- VMDIS and pHyTES are three year efforts and are nearly through the design phase. Performance modeling indicates that requirements can be met with the current designs.
- CIFTS was only a one year investment, and during this time progress was made to establishing a feasible design for imaging FTIR in a small package. Results from this R&TD will be instrumental in seeking additional funding to continue this work.
- The end goal is to advance all four of these spectrometers in order to respond to upcoming mission opportunities.

Instrument Master Table: These four spectrometers are under development through this initiative

Instrument Property	MLPS	VMDIS	CIFTS	pHyTES
				
Instrument Type	**Point Spectrometer**	**Imaging Spectrometer**	**FTIR**	**Imaging Spectrometer**
Key Science	Composition measurement in small-spacecraft package Volatiles, organics, silicates, measured simultaneously, on asteroids, Moon, etc.	Composition with imaging in small-spacecraft package Volatile and mafic mineral mapping on the Moon, asteroids, Mars	Atmospheric compositions, vertical profiles, transports, interaction with surfaces, and chemical isotopes	High resolution mapping of igneous minerals and alteration products on planetary surfaces; atmospheric science
Description	Uses three unique JPL technologies (BIRD, thermopile, bifaceted grating) to combine MIR/LWIR in small package	Combines JPL technologies (grating,slit, uniform Dyson design) with external partner technologies (Teledyne digital CHROMA array) to create new SWIR spectroscopy capabilities in miniature package	An atmospheric science instrument, adding a mega pixel FPA imaging vs the traditional point mapping FTS.	Uses many unique JPL technologies (freeform concave grating, BIRD detectors, thermal suppression filters, Dyson alignment techniques, precision slit)
KEY PERFORMANCE METRICS				
Spectral Coverage	2-4, 5.5-12 um	0.6-3.6 μm	Threshold 0.35 – 11.2 um Baseline: 0.25 – 15.4 um	3 to 12 μm
Spectral Resolution	10 nm, 150 um	7 nm	Tunable in flight, up to R = 36,000 at 10 um (or 0.28 nm at 10 um)	17.6nm
SNR	SEE INDIVIDUAL INSTRUMENT SECTIONS for SNR Vs Wavelength			
Field-of-View (deg)	3.0 (BIRD), 27 (Thermopile)	32	8.5 x 6.4	50
Instantaneous Field-of-View (mrad)	3.0 (BIRD), 27 (Thermopile)	0.5	0.23	1.7
Payload Size	2U	3U	12U	<12U
Payload Mass (kg)	2	≤ 8	30	≤ 10
Payload Power (W)	<6W (function of target)	≤ 40	30	≤ 40

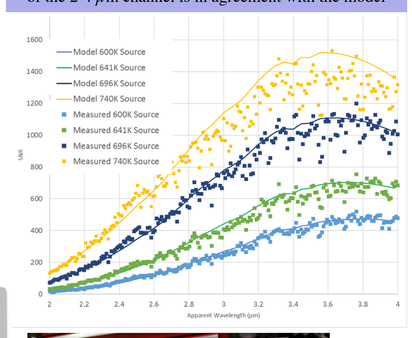
Benefits to NASA and JPL:

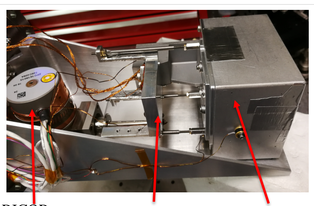
- We develop four Infrared Spectrometers to maintain JPL's competitive advantage for anticipated mission opportunities over the next 1-2 decades.
- These are state-of-the-art, low resource requirement instruments that also take advantage of JPL unique technologies (HOTBIRD, thermopile, e-beam gratings, etc.)

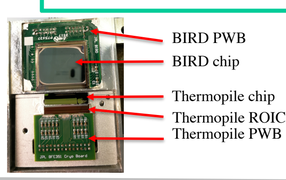
MLPS

MPLS is the first of its kind mid- and long-wave infrared spectrometer combined on a single focal plane with freeform optics enabled by a bifaceted grating

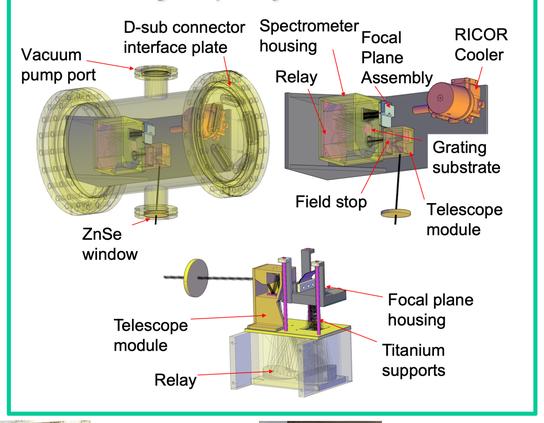
SNR measurements show that the measured performance of the 2-4 μm channel is in agreement with the model





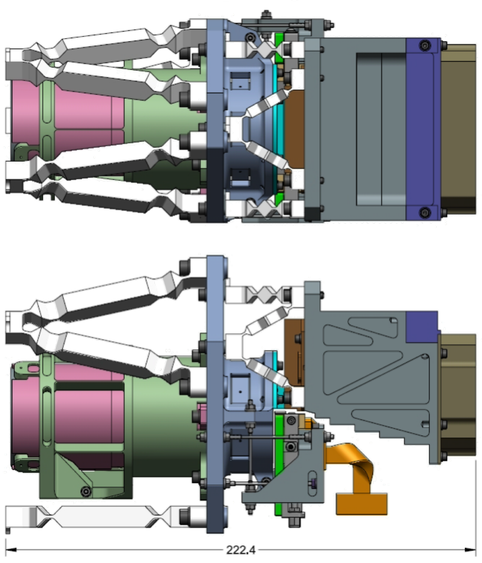


MLPS Design: Capability in a 2U Form Factor

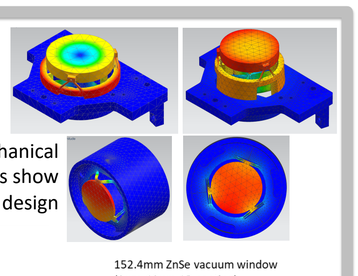


VMDIS

VMDIS Optomechanical assembly incorporating high uniformity compact spectrometer and telescope designs

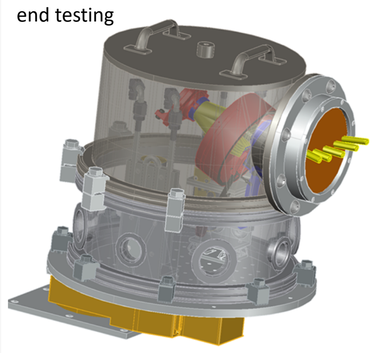


pHyTES



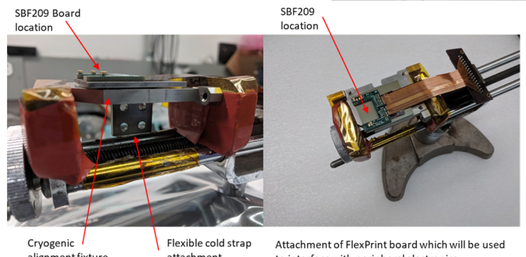
Opto-mechanical simulations show robust design

Vacuum housing to allow end-to-end testing



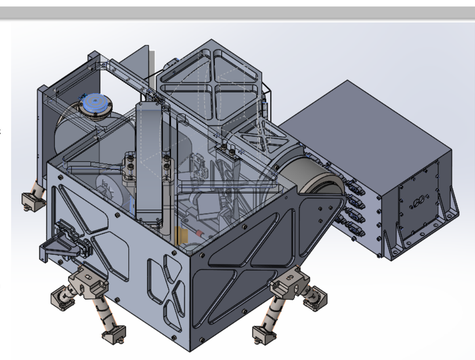
152.4mm ZnSe vacuum window (3μm-12μm AR coating)

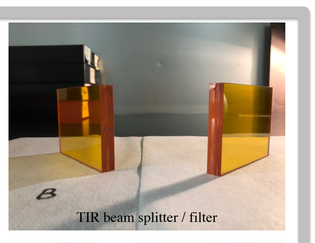
Vacuum chamber



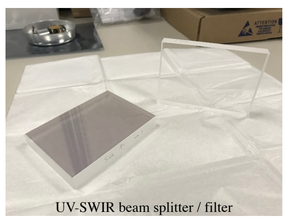
CIFTS

CIFTS modulates the input photons, and demodulates the collected time-series data into the scene spectra. Broadband camera covers UV to TIR, designed as an atmospheric sounding instrument.

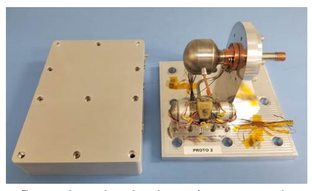




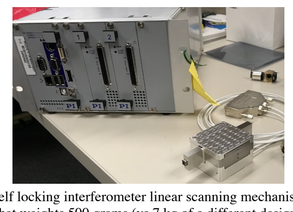
TIR beam splitter / filter



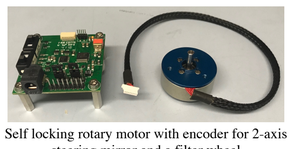
UV-SWIR beam splitter / filter



Cryocooler and cooler electronics to operate the FPA at 55K



Self locking interferometer linear scanning mechanism that weights 500 grams (vs 7 kg of a different design)



Self locking rotary motor with encoder for 2-axis steering mirror and a filter wheel

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