BIRCHES: Mars CubeSat Instrument

BIRCHES (Broadband InfraRed Compact High-Resolution Exploration Spectrometer)

P.E. Clark, IACS/CUA/NASA GSFC and Flexure Engineering

D. Reuter, R. MacDowall, D. Patel, S. Banks, NASA/GSFC

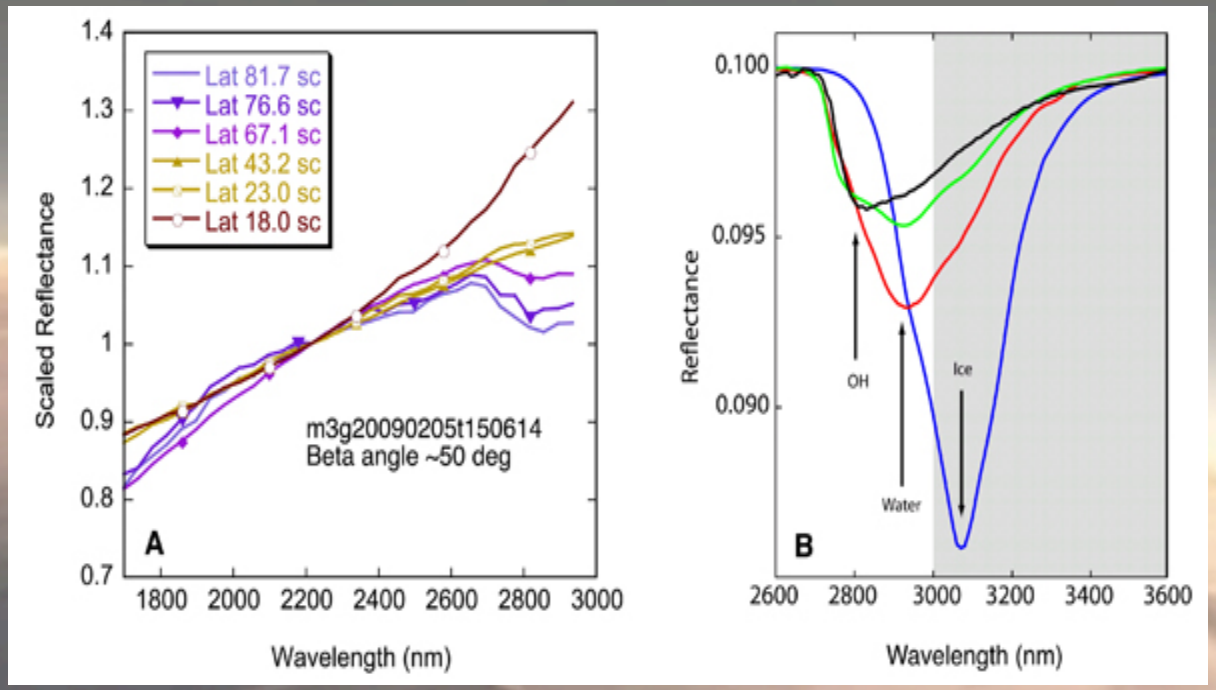
BIRCHES Mars Science Objectives

MEPAG Goal	BIRCHES Measurement	Target Requirement
Water and other Volatile Exchange on all scales	H2O, CO2 forms, components, frost, clouds	Temporal inter- and intra- Seasonal and Global Event Variations
Geology processes and evolution, Composition of Surface, Dust Distribution	Silicate Minerals, sulfides, carbonates, oxides, hydrates	Spatial and Seasonal Variations

BIRCHES Concept

- High-resolution spectrometer with compact microcryocooler, 1.5 U in volume, <2.5 kg, <5 W
- HgCdTe detector for broadband measurements from approximately 1 to 4 microns
- Sufficient spectral resolution (5 nm) to characterize and distinguish important volatiles (water, H_2S, NH_3, CO_2, CH_4, OH) and mineral (silicate, oxides, carbonates, hydrates) bands
- Flexibility in maintaining spot size (10 x 10 km +/- 10% area) regardless of variations up to 5x in altitude or in using variable spot size at given altitude as application requires
- Generic (for family of spectrometers) adaptable (for point spectrometer or imager modes) compact, low cost detector interface electronics based on GSFC work on low-cost, generic ASICs.

BIRCHES Broadband Enhancement



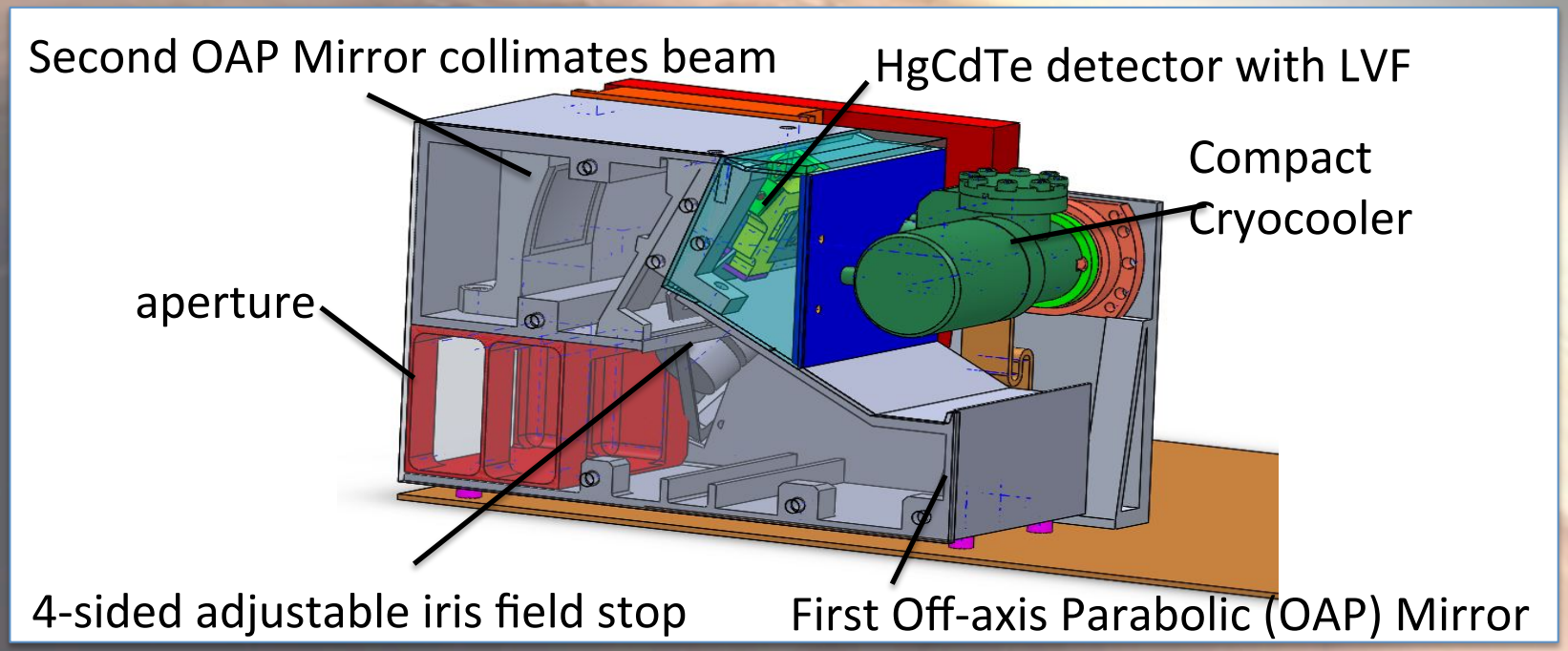
Chandrayaan M3 NIR Spectra (Pieters et al, 2009) illustrating tantalizing apparent variation in several water related features (OH, Water, Ice) approaching 3 μ, but without the resolution and range (<3 μ) to clearly distinguish them.

IR bands measurable by BIRCHES

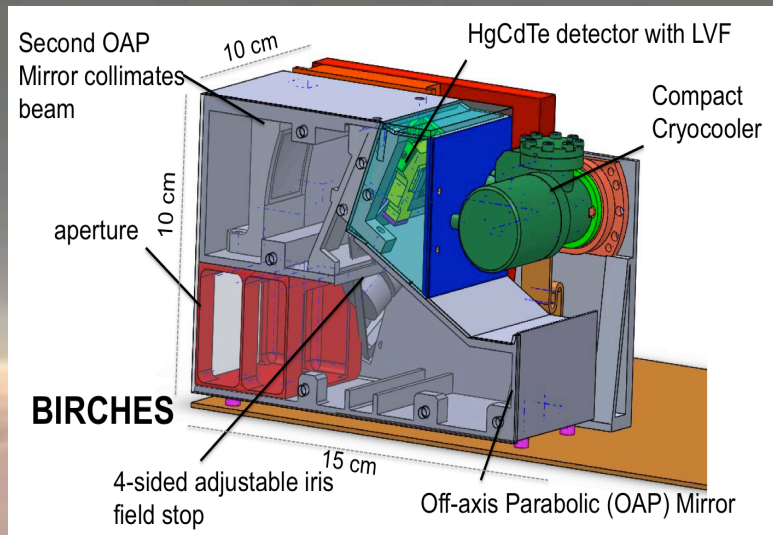
form	microns
Water	
water vapor	2.738
	2.663
liquid water	3.106
	2.903
	1.4
	1.9
	2.85
	2.9
	2.7-2.8
hydroxyl ion	
	2.81
	2.2-2.3
	3.6
bound water	2.85
	3
	2.95
	3.14
adsorbed water	2.9-3.0
ice	1.5
	2
	3.06
Other volatiles	
NH3	1.65, 2
Organics	1.2, 1.73, 2.3
H2S	3
CO2	2.7
CH4	3.3
Mineral Bands	
pyroxene	0.95-1
olivine	2, 2.9
carbonate	2.35, 2.5
sulfide	3
iron oxides	1
hydrated silicates	3-3.5

BIRCHES Prototype

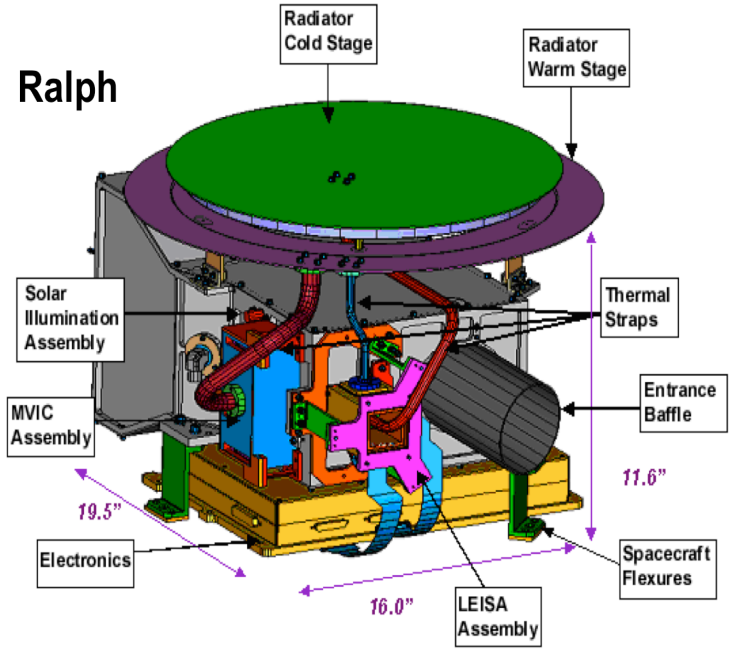
- Compact broadband IR spectrometer with HgCdTe detector with compact linear variable filter rather than diffraction grating
- Compact microcrycooler to maintain spectrometer below 140 K and within 1 K during science operations
- compact optics box designed to remain below 240 K and within 1 K during science operations even in lunar environment
- New Horizons Ralph and OSIRIS Rex OVIRS heritage design

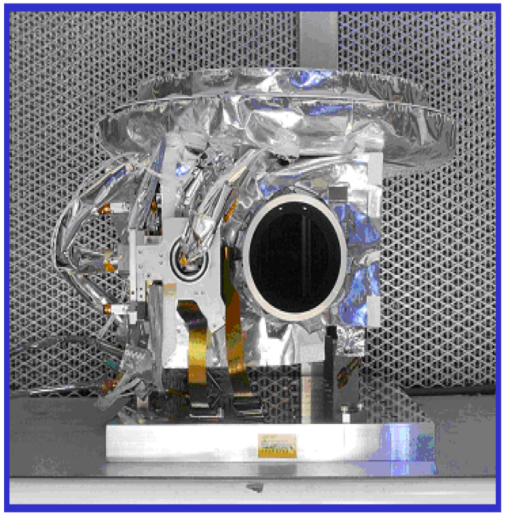


BIRCHES Heritage



Property	Ralph	BIRCHES
Mass kg	11	2
Power W	5	<5#
Size cm	49x40x29*	10x10x15
*19.5x16.0x11.6 inches equivalent		
#includes 3W cryocooler		





Miniaturized BIRCHES concept (top) derived from much larger and heavier (Comparison Table) New Horizons Ralph Instrument (bottom).

Summary

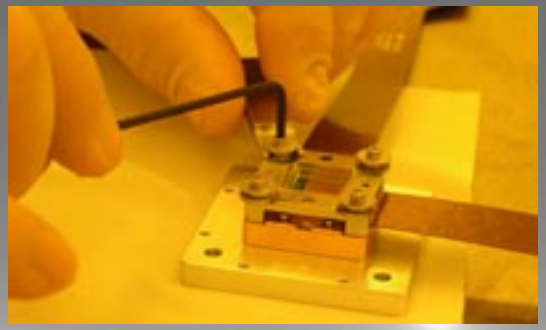
The Broadband InfraRed Compact High Resolution Exploration Spectrometer **(BIRCHES)**

- **is designed with the high spectral resolution (5 nm) and the wavelength range from 1 to 4 µm needed to fully characterize water and other volatiles.**
- **Is robustly designed for a range of planetary environments**
- will thus be able to provide details of volatile systematics (distribution as a function of time of day, latitude, and nature of regolith) for a range of targets.
- **is compact enough (1500 cm^3 or 1.5 U) to be deployed on inexpensive cubesat platforms** that could provide the basis of distributed multi-platform missions to explore the dynamics of interactions between volatiles and their environments.

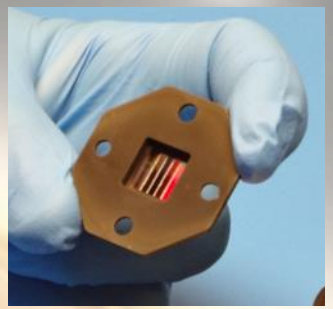
Backup

BIRCHES Components

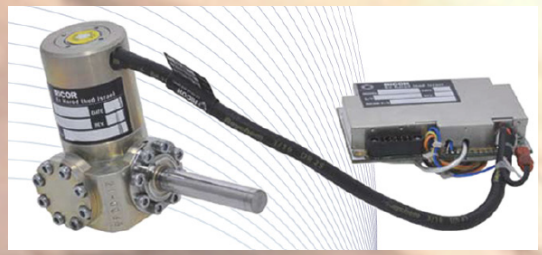
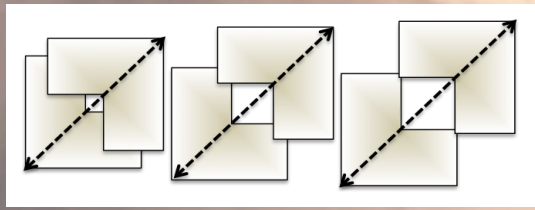
Teledyne Detector HgCdTe array



Linear Variable Filter
Similar to OSIRIS-REx OVIRS design



Off the shelf tactical cryocooler with cold finger to maintain detector at ≤140K



Adjustable Iris for flexibility in square window width in each direction by moving notch leaves simultaneously in opposite directions along a 45 degree diagonal.