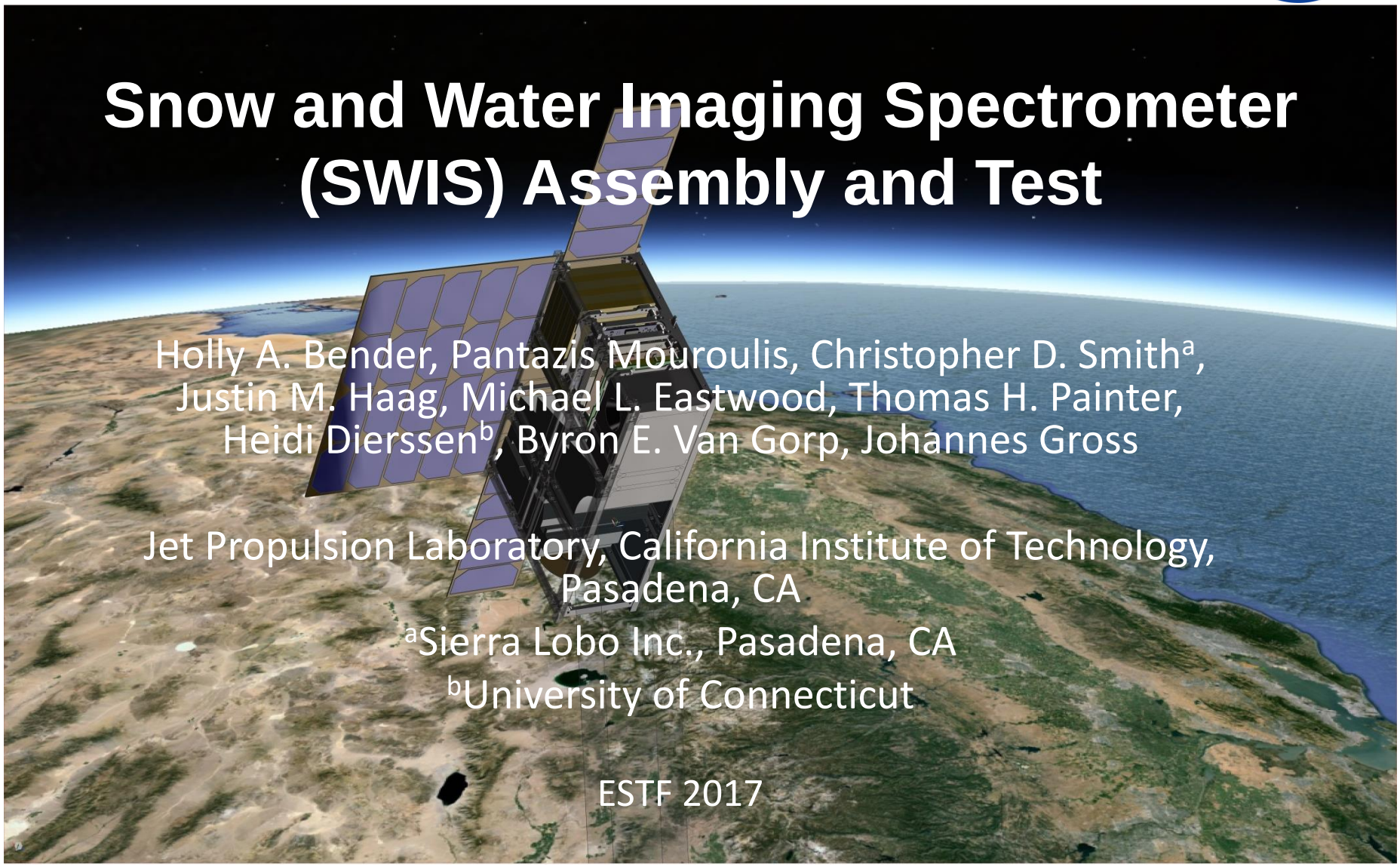

Snow and Water Imaging Spectrometer (SWIS) Assembly and Test

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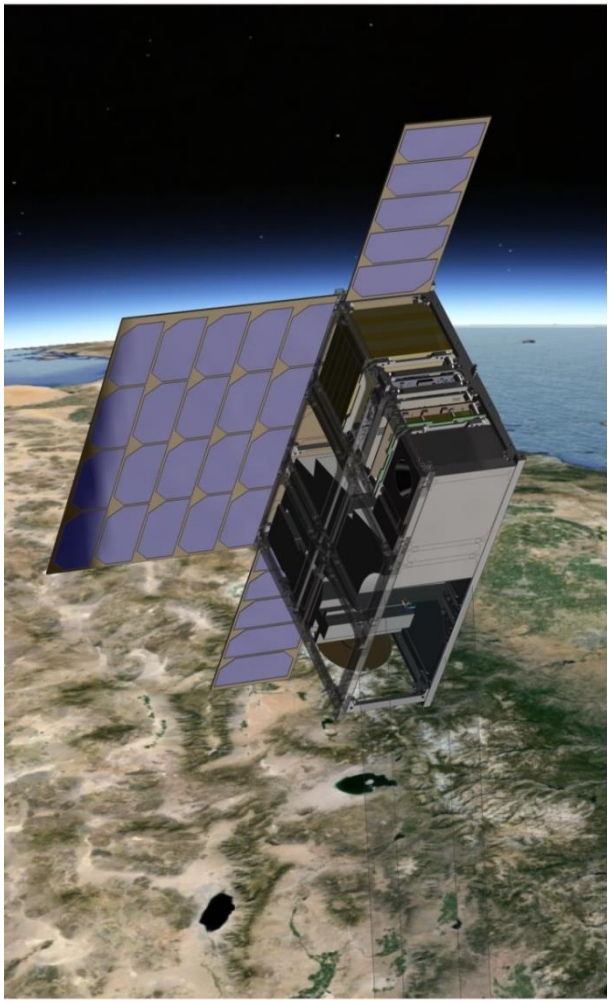
Overview

- Introduction
- Research and applications
- Instrument specifications
- Mission concepts
- CubeSat configuration
- Assembly and warm alignment
- Status and work to go

Goal: demonstrate the potential utility of CubeSats to make useful scientific contributions in imaging spectroscopy

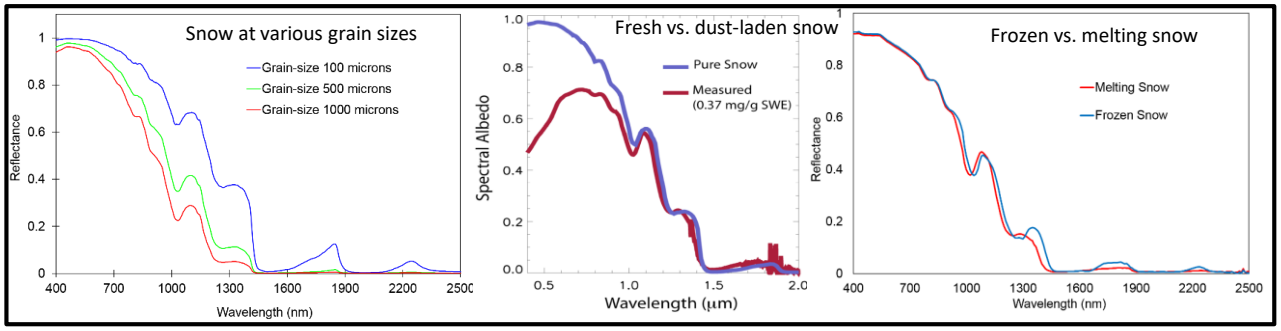


SWIS CubeSat, artist's concept

Research and applications

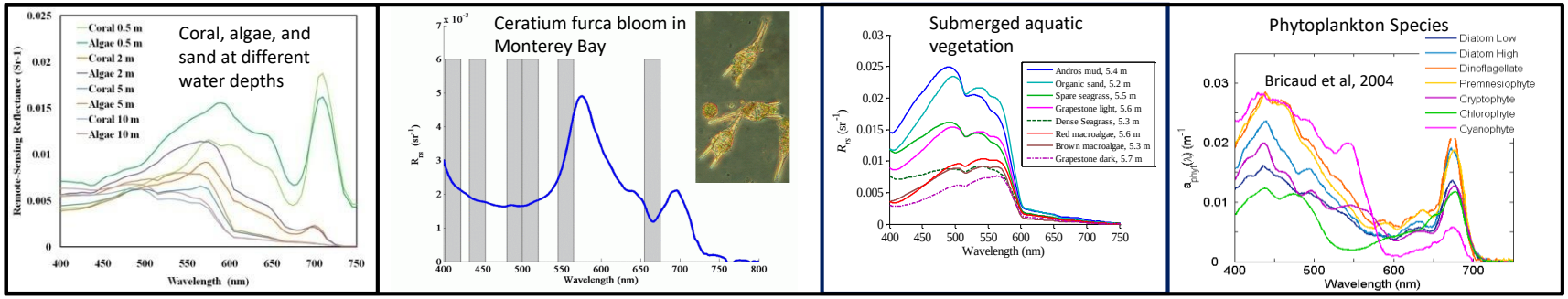
The CubeSat platform is particularly well-suited for two critical science applications with time varying properties that are distributed around the globe:

Snow cover monitoring



Snow spectral signatures contain critical features in **1000-1500 nm** range

Coastal ocean science



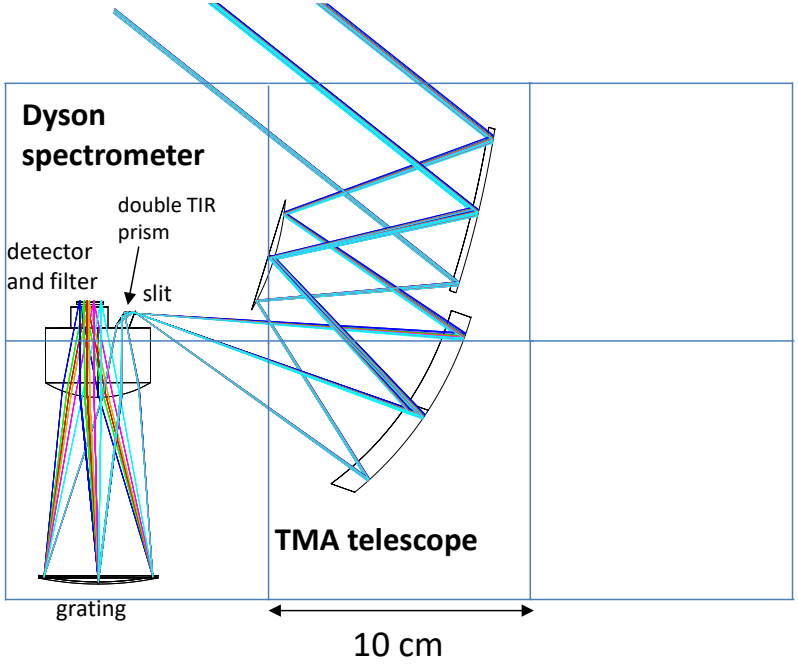
Coastal ocean spectral signatures mainly **below 900 nm**

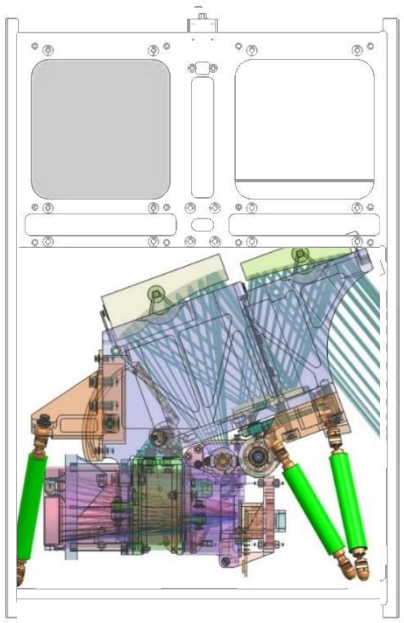
Mission requirements

- **High spectral resolution** for detecting subtle changes in the spectral signature of aquatic habitats.
- **High radiometric sensitivity / SNR** to tease out subtle spectral features from on-orbit radiance dominated by the intervening atmosphere.
- **Near IR spectral coverage** for discriminating between atmospheric and surface water signatures.
- **High spatial resolution** to limit spectral mixing and resolve signals from ecologically important features.
- **Maneuverability** for viewing off-nadir targets and higher repeat coverage of key locations.
- **Calibration** using solar radiance and lunar views.

Instrument specifications

Spectrometer and telescope inside 6U CubeSat frame (20 x 30 x 10 cm)





Optomechanical design within 6U CubeSat structure

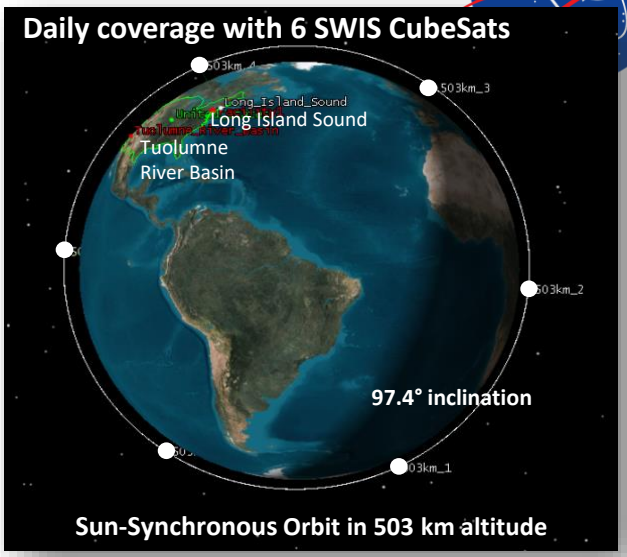
SWIS specifications	
Spectral range	350 – 1700 nm, single FPA
Spectral sampling	5.7 nm
Cross-track spatial elements	600 (+40 monitor)
Cross-track FOV	10° (±20° pointing)
Resolution	0.3 mrad
Detector pixel size	30 µm
Focal length	100 mm
F/#	1.8
Uniformity	95%

Mouroulis et al, Proc. SPIE 9222, (2014)
Bender et al, Proc. SPIE 9611, (2015)

Mission examples

Global coverage: 6 CubeSats

SWIS: Global access (6 CubeSats)	
Resolution	160m from 500km orbit
Mission lifetime	~2 years (no propulsion)
Target frequency	Global daily coverage with 6 CubeSats 10° FOV; 50° FOR with pointing
*Global coverage at low (~1 km) resolution subject to future data transmission rate improvements	

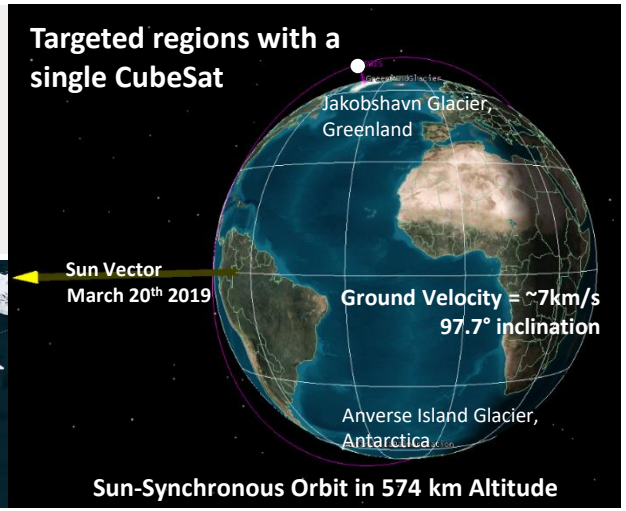


Targeted regions of interest: 1 CubeSat

Gradients from dry snow, to melting snow and ice, to melt-fed open ocean **span the most critical zones of climate change-impacted regions.**

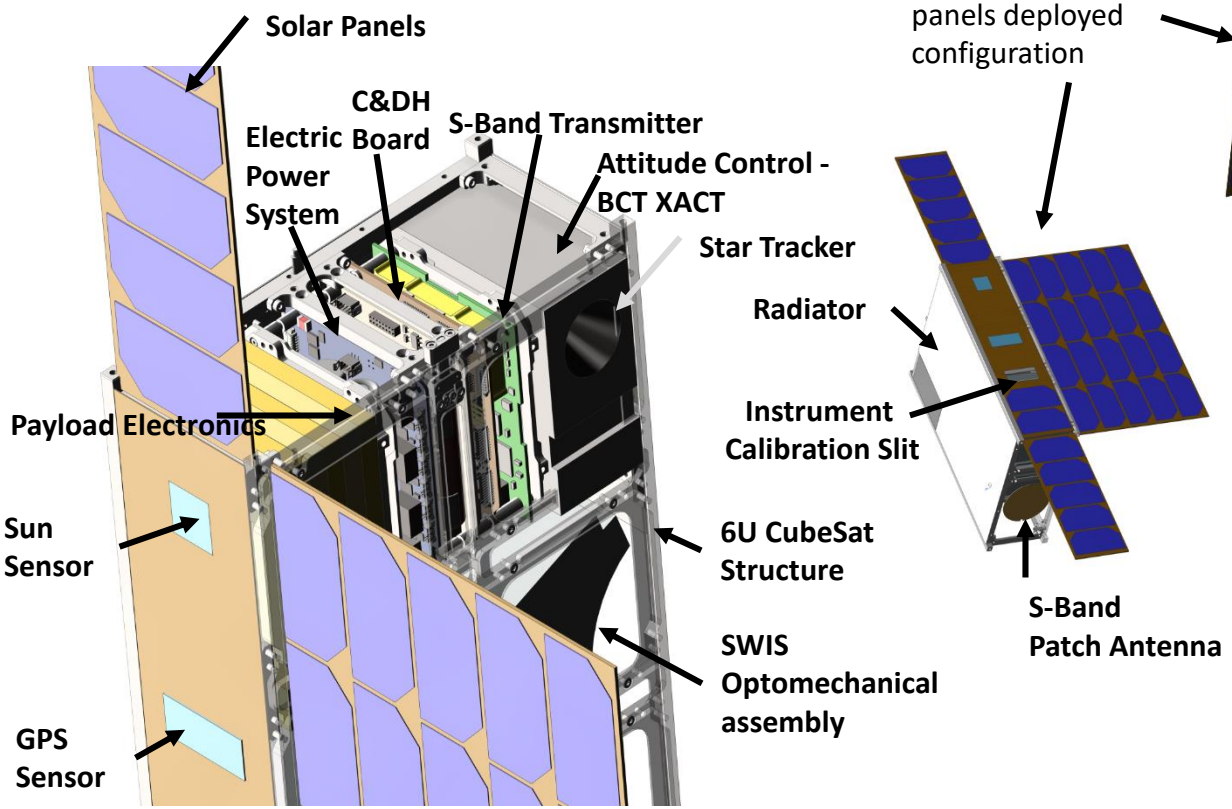
SWIS could **simultaneously map the controlling processes of melt and the response of ocean biology** to melt fluxes and nutrient loading.

Bender et al, Proc. SPIE 9881, (2016)

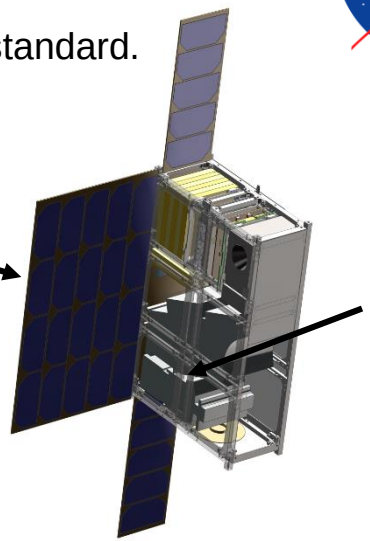


6U CubeSat configuration concept

The current SWIS design has a good feasibility within a flexible CubeSat standard.

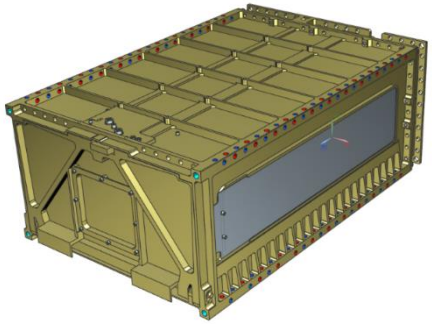


SWIS cubesat concept: panels deployed configuration



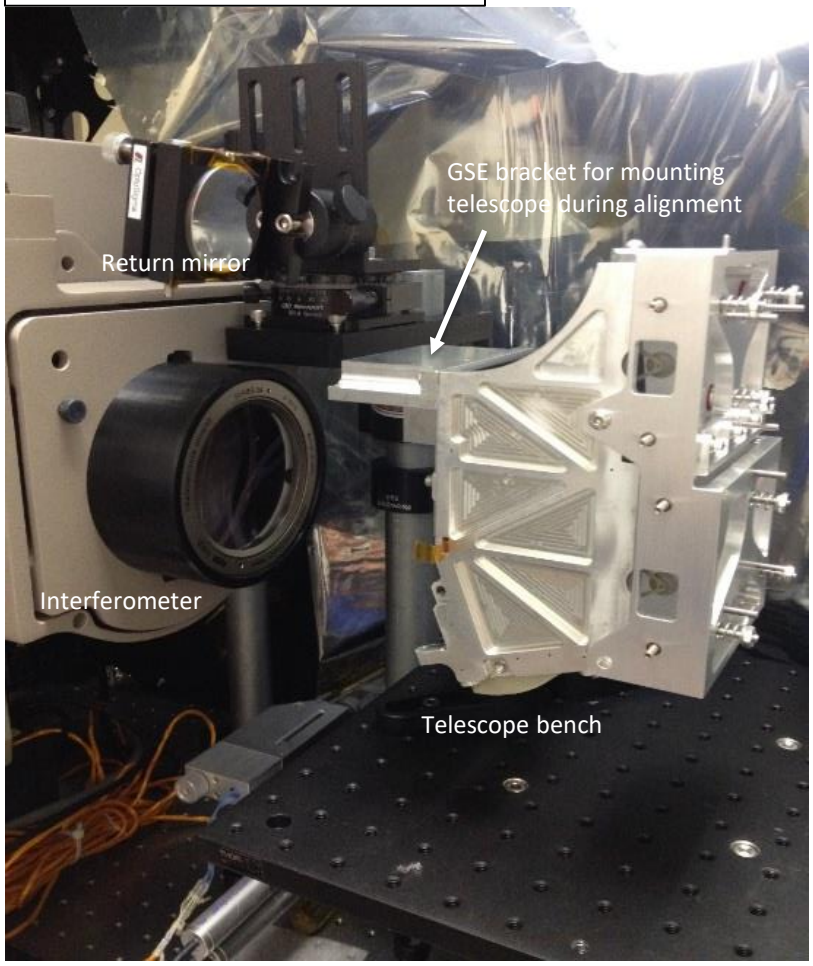
Telescope and spectrometer within 4U of 6U CubeSat

Spacecraft designed to fit within a standard 6U Canisterized Satellite Dispenser (current: Planetary Systems Corporation)

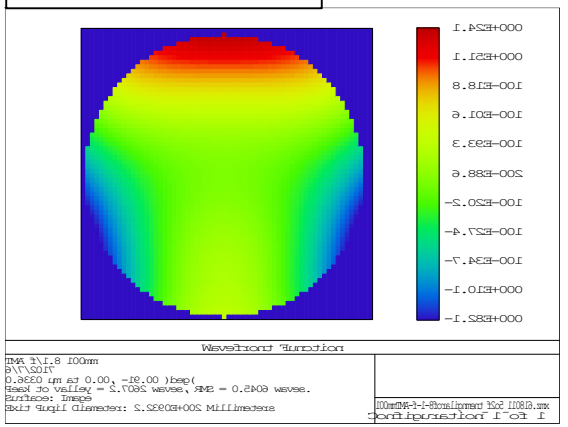


Telescope alignment

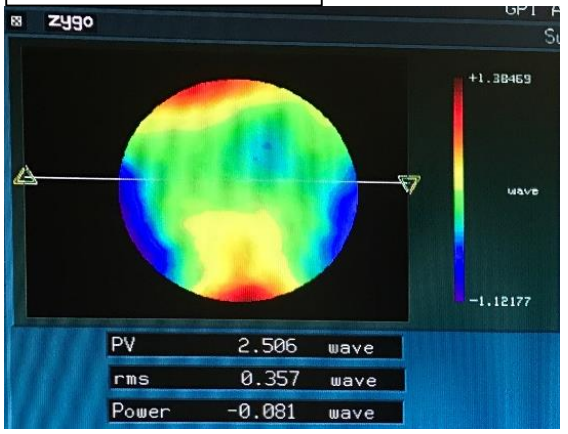
Telescope interferometric alignment



Model prediction:

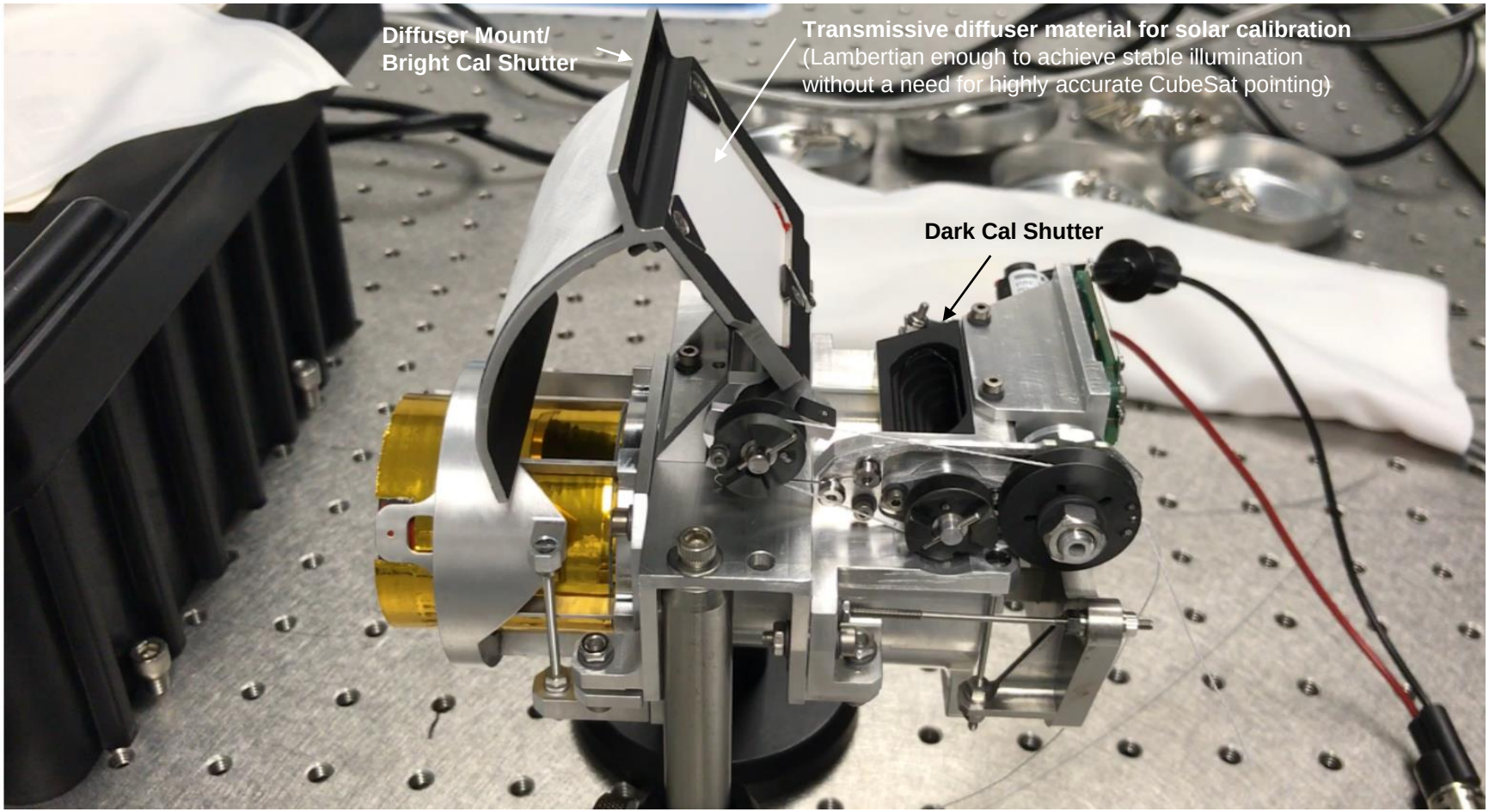


SWIS actual:



Spectrometer and calibration mechanism

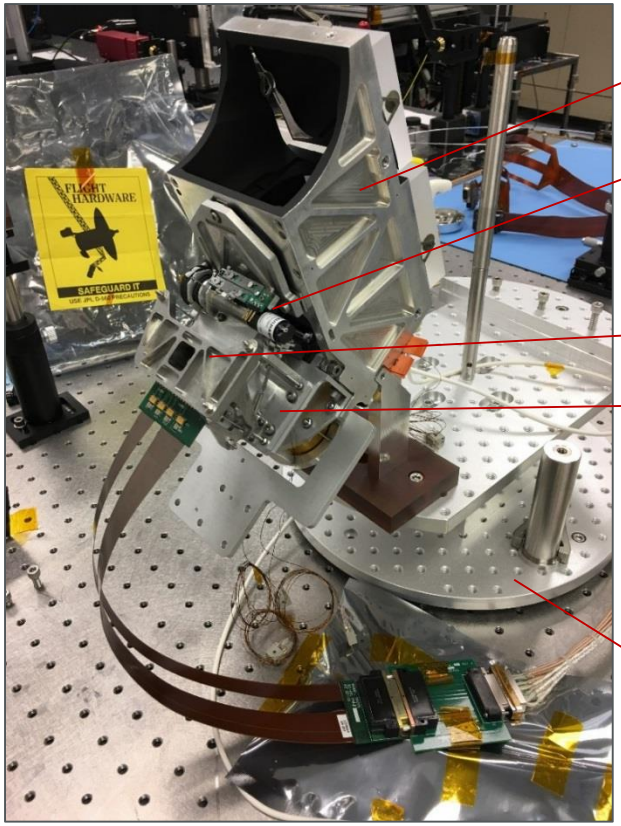
Single drive on-board calibration mechanism performs the dual function of positioning the on-board calibrator and providing a shutter for dark frames



Assembled Dyson spectrometer with calibration mechanism in science position

Full optical assembly

Completed assembly



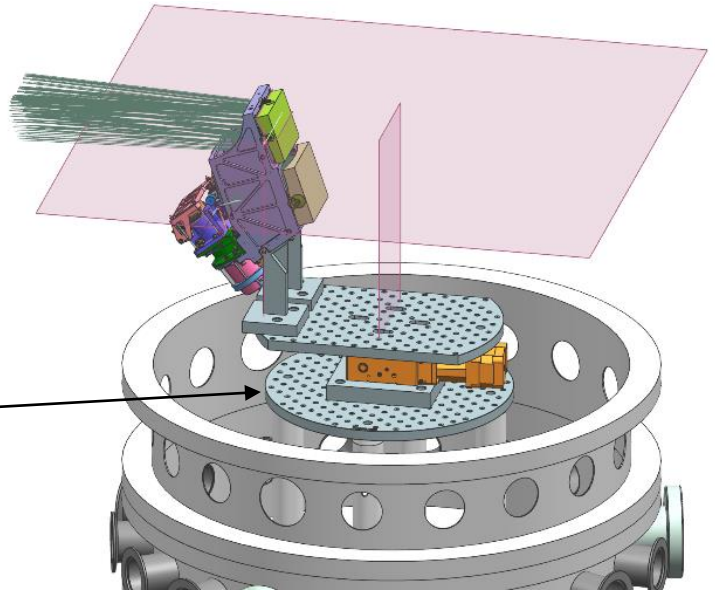
telescope

calibration mechanism

detector

spectrometer

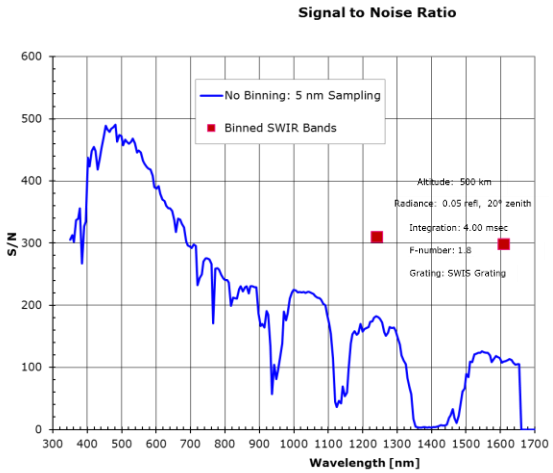
rotation stage (for thermal chamber tests)

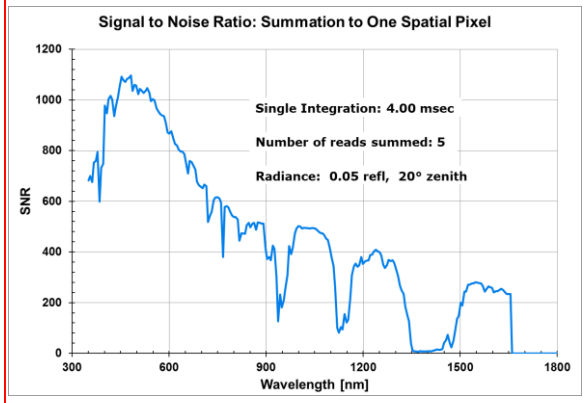


Thermal vacuum chamber mount design

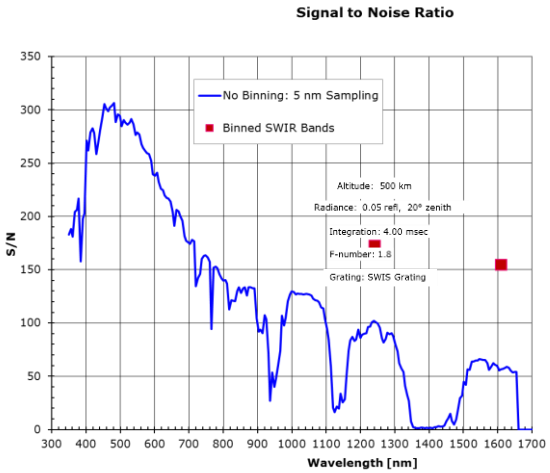
Detector QE and Projected SNR

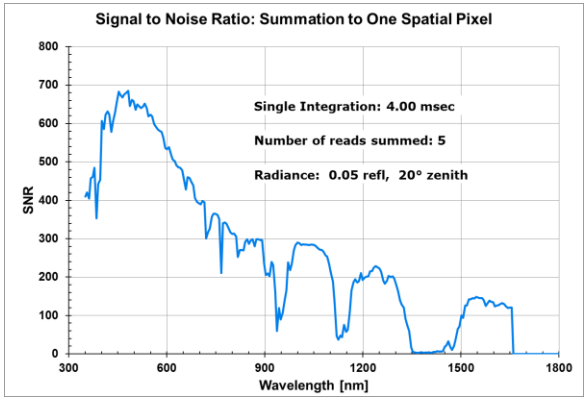
Proposed SNR:





Current projected SNR:

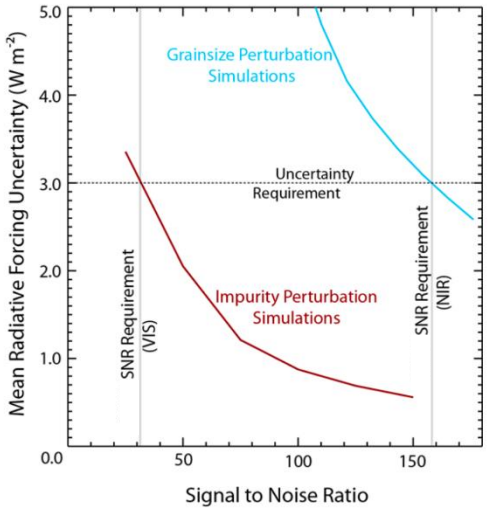




Science impact:

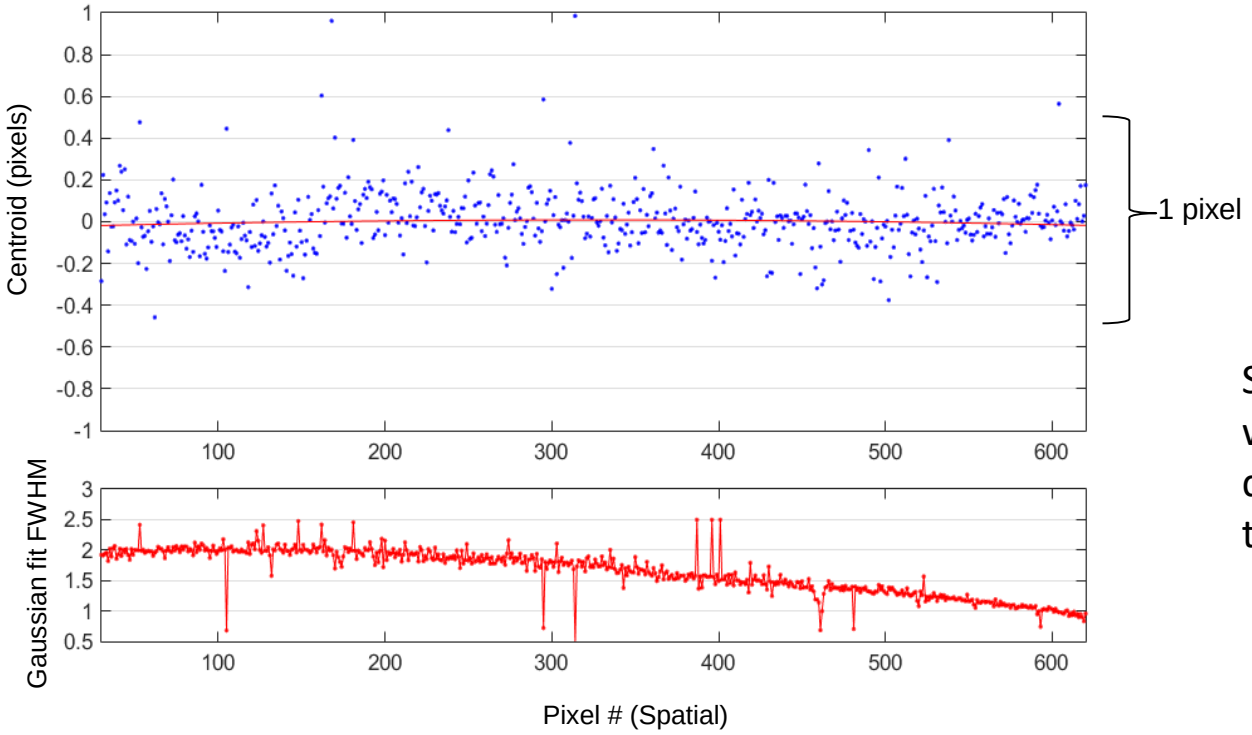
The two main controls on **snow albedo**:

- Grain size (impact in 900-1300 nm); SNR requirement > 160
- Radiative forcing by dust and black carbon (impact in 350-1000 nm); SNR requirement > 30.



Room-temperature preliminary alignment

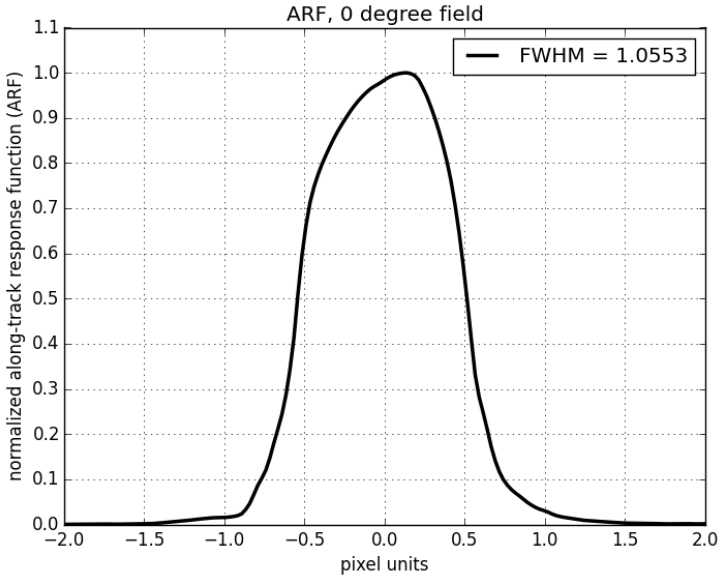
633 nm laser line



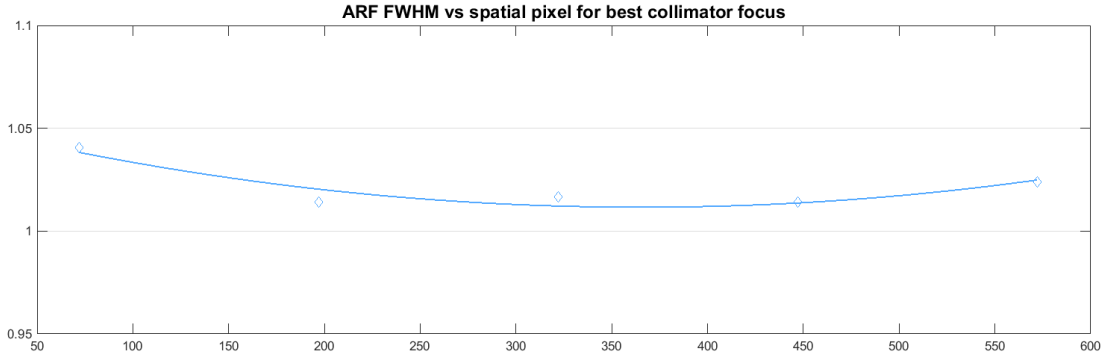
Scatter and bad pixels will improve when detector is at operating temperature <250K

Room-temperature preliminary alignment

Along-track response function (ARF)

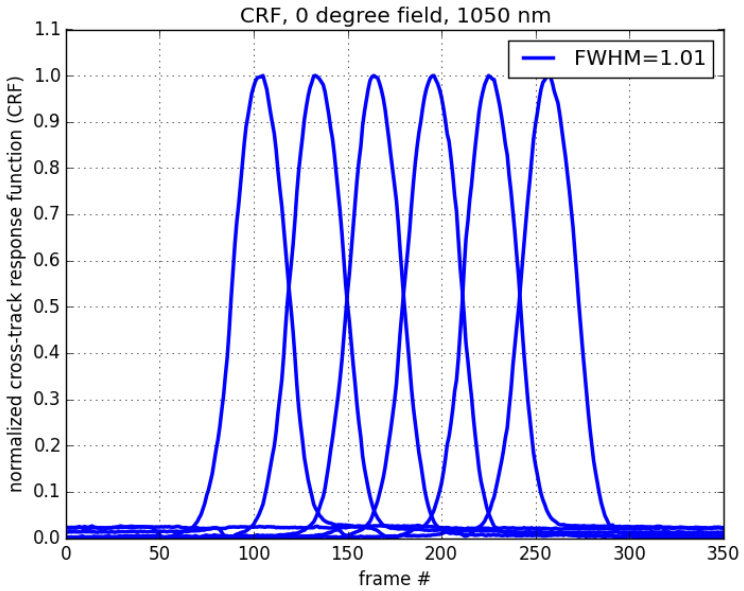


ARF FWHM vs Spatial Pixel



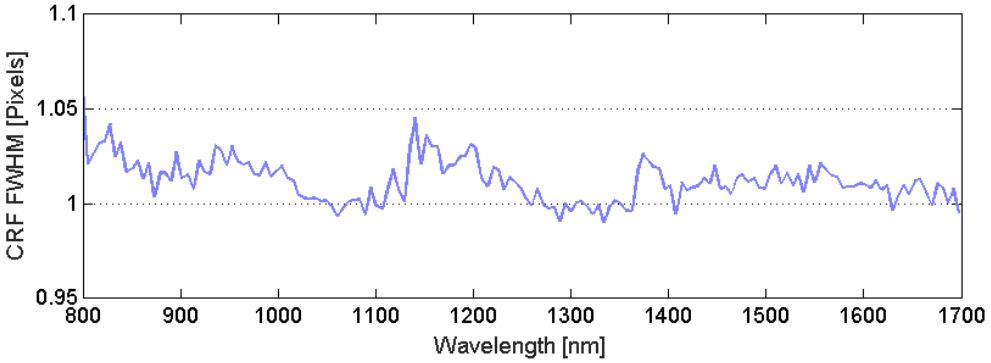
Room-temperature preliminary alignment

Cross-track response function(CRF)



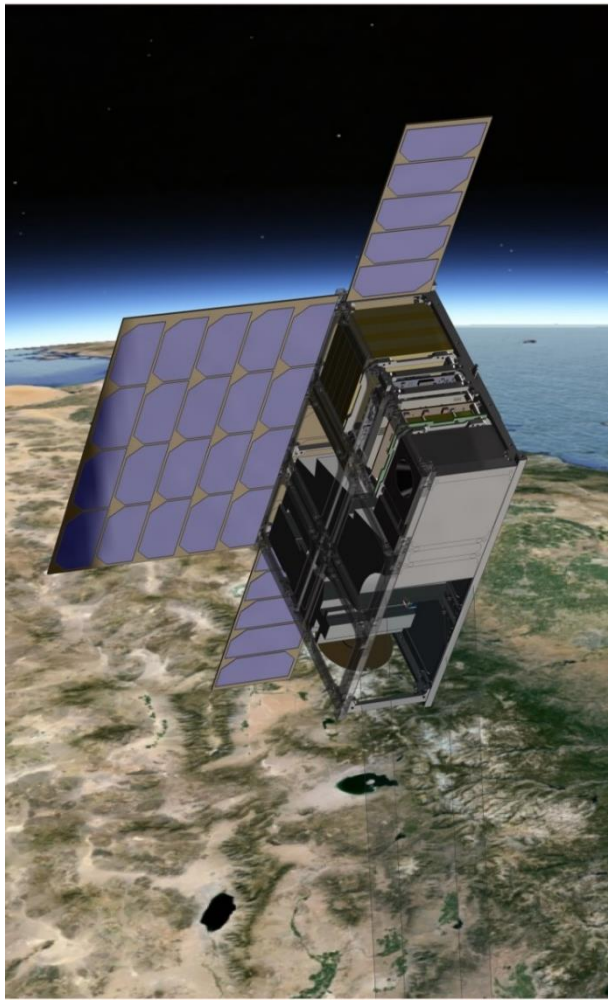
CRF Floor is artifact of high detector temperature

CRF FWHM vs wavelength



Summary

- Imaging spectrometer design suitable for CubeSat applications
- Advances the state of the art in compact sensors of this kind in terms of size and spectral coverage
- Innovative single drive performs dual mechanism function of positioning the on-board calibrator (OBC) as well as providing a shutter for dark frames
- Spacecraft configuration design favorable for accommodation in 6U CubeSat frame
- Useful missions can be designed with high spatial and temporal resolution to address targeted areas of the Earth's surface
- Optomechanical assembly complete with alignment underway
- Thermal and vibration testing of optomechanical assembly to be completed by end of FY17



SWIS CubeSat, artist's concept

Acknowledgments

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Industrial Partner: Teledyne Scientific & Imaging (Jianmei Pan, task manager)