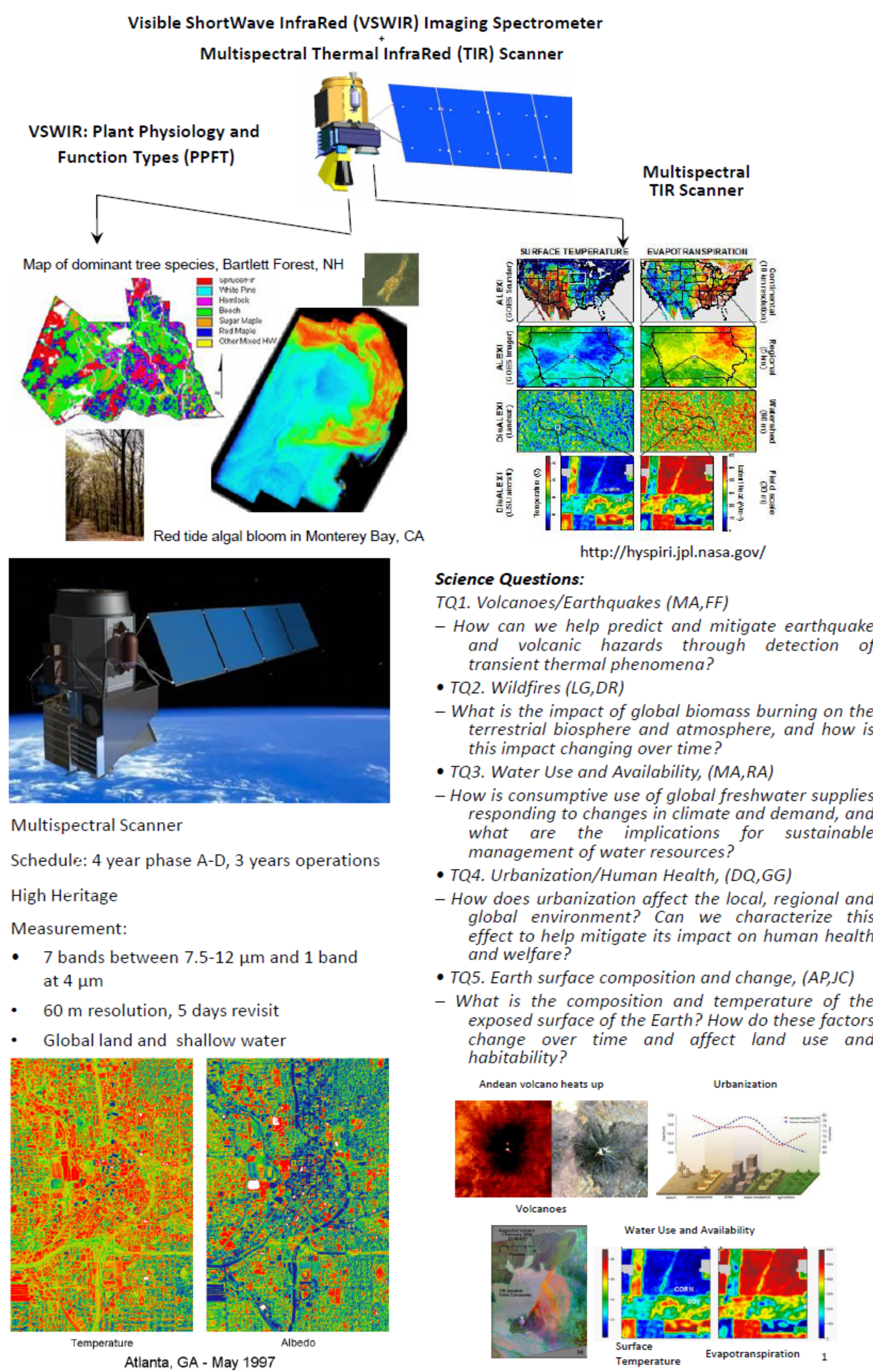


# The Hyperspectral Thermal Emission Spectrometer's (HyTES) first science deployment

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## HyspIRI Background



## HyTES Rational and Objective

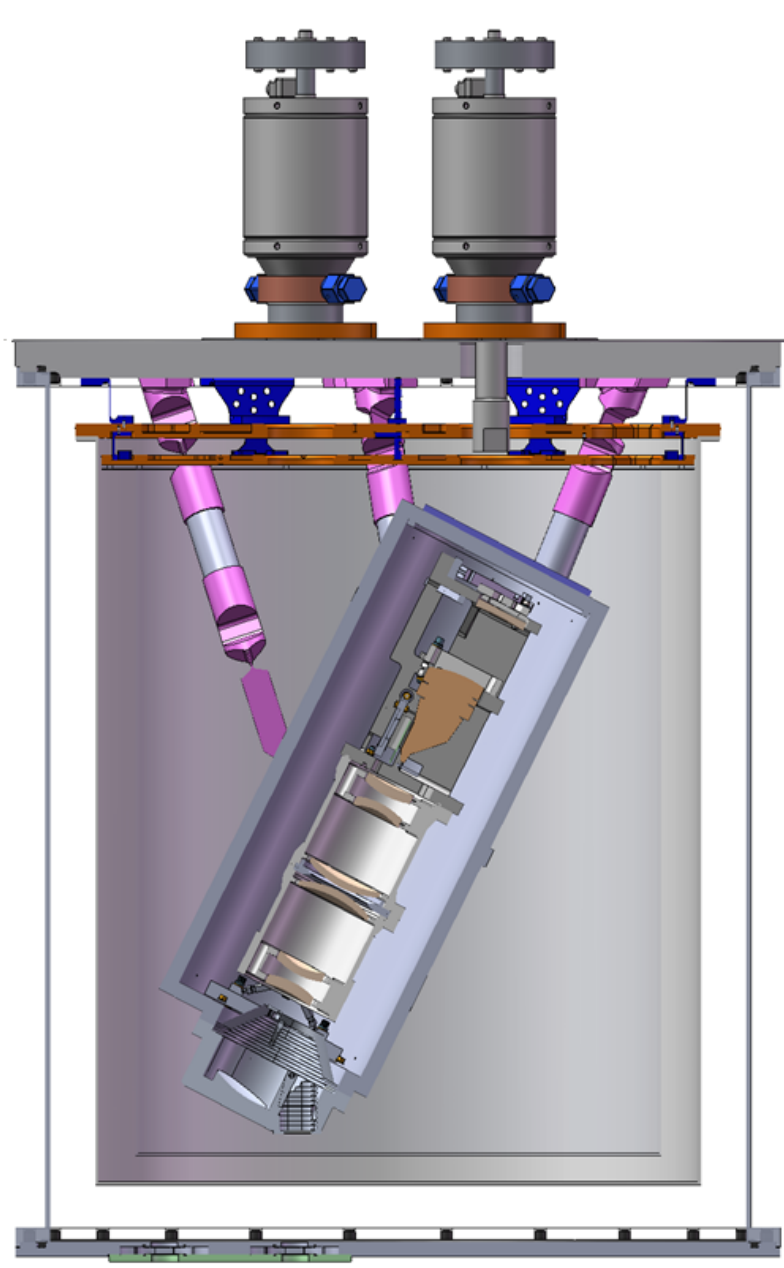
• Develop a thermal infrared imaging spectrometer with high spatial and spectral resolution which will provide precursor thermal infrared data for the NRC Recommended HyspIRI mission.

• Build and deploy an airborne Hyperspectral Thermal Emission Spectrometer (HyTES) with 512 pixels across track with pixel sizes in the range of 5 to 50 m depending on aircraft flying height and 256 spectral channels between 7.5 and 12  $\mu\text{m}$ .

• Key enabling JPL technologies:

1. Dyson spectrometer: small form factor with high throughput, self-baffling
2. Quantum well Infrared photodetector: high uniformity and yield
3. Precision slit: enables low distortion and provides additional baffling
4. Convex diffraction grating: low scatter, high efficiency

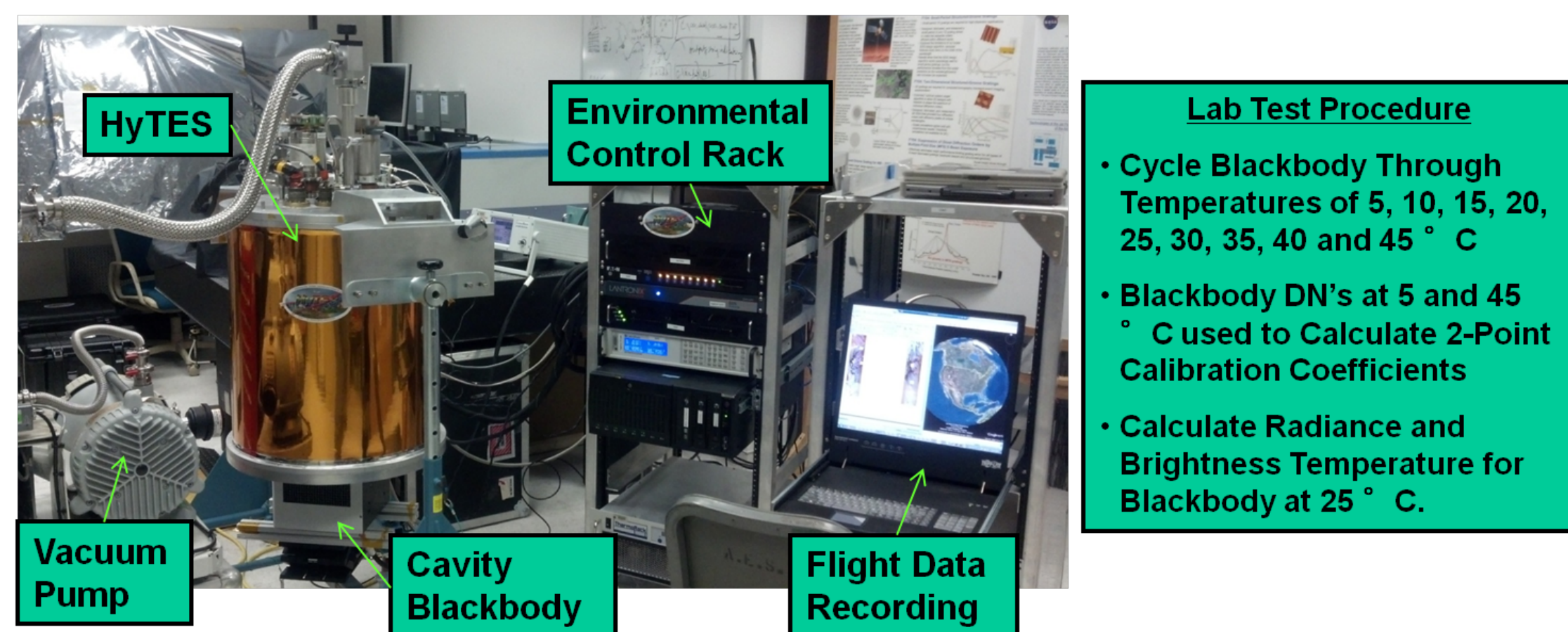
Instrument Characteristic	HyTES
Mass (Scanhead) <sup>1</sup>	12kg
Power	400W
Volume	1m x 0.5m (Cylinder)
Number of pixels x track	512
Number of bands	256
Spectral Range	7.5-12 $\mu\text{m}$
Integration time (1 scanline)	30 ms
Total Field of View	50 degrees
Calibration (preflight)	Full aperture blackbody
QWIP Array Size	1024x512
QWIP Pitch *	19.5 $\mu\text{m}$
QWIP Temperature	40K
Spectrometer Temperature	100K
Slit Width	39 $\mu\text{m}$
Pixel size at 2000 m flight altitude	3.64m
Pixel size at 20,000 m flight altitude	36.4m



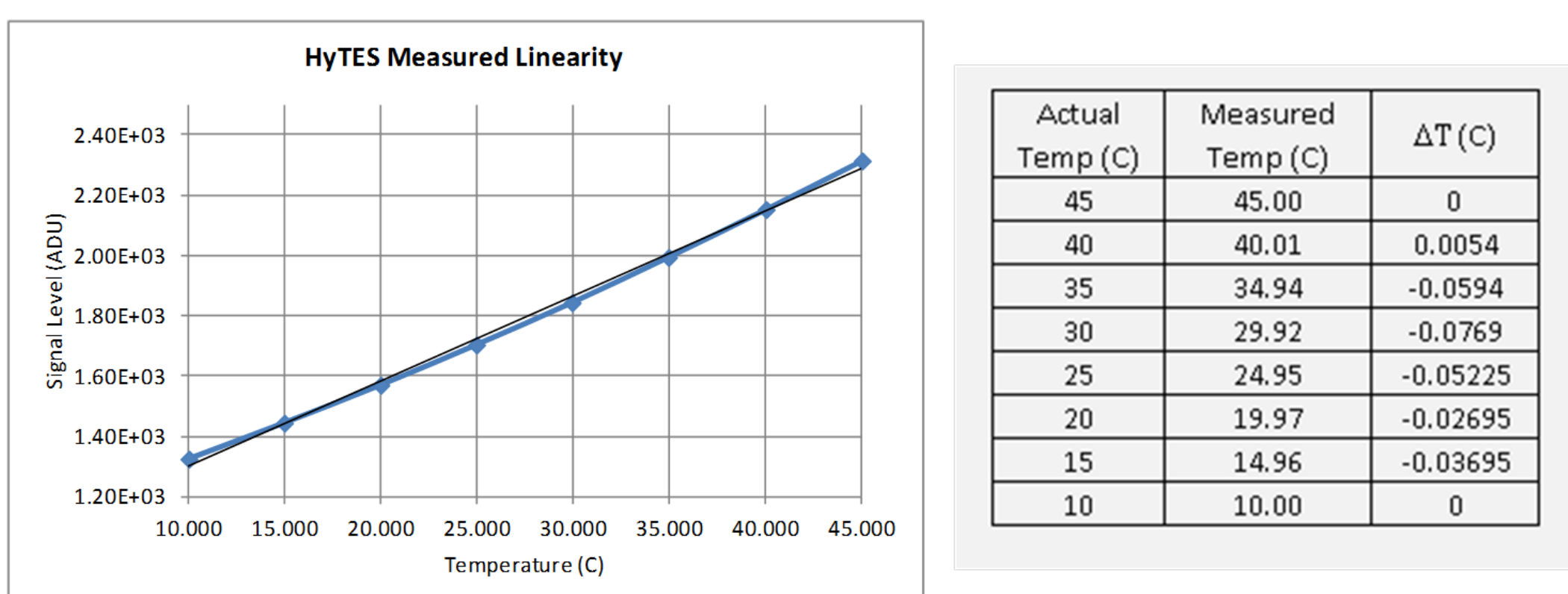
HyTES Instrument Layout



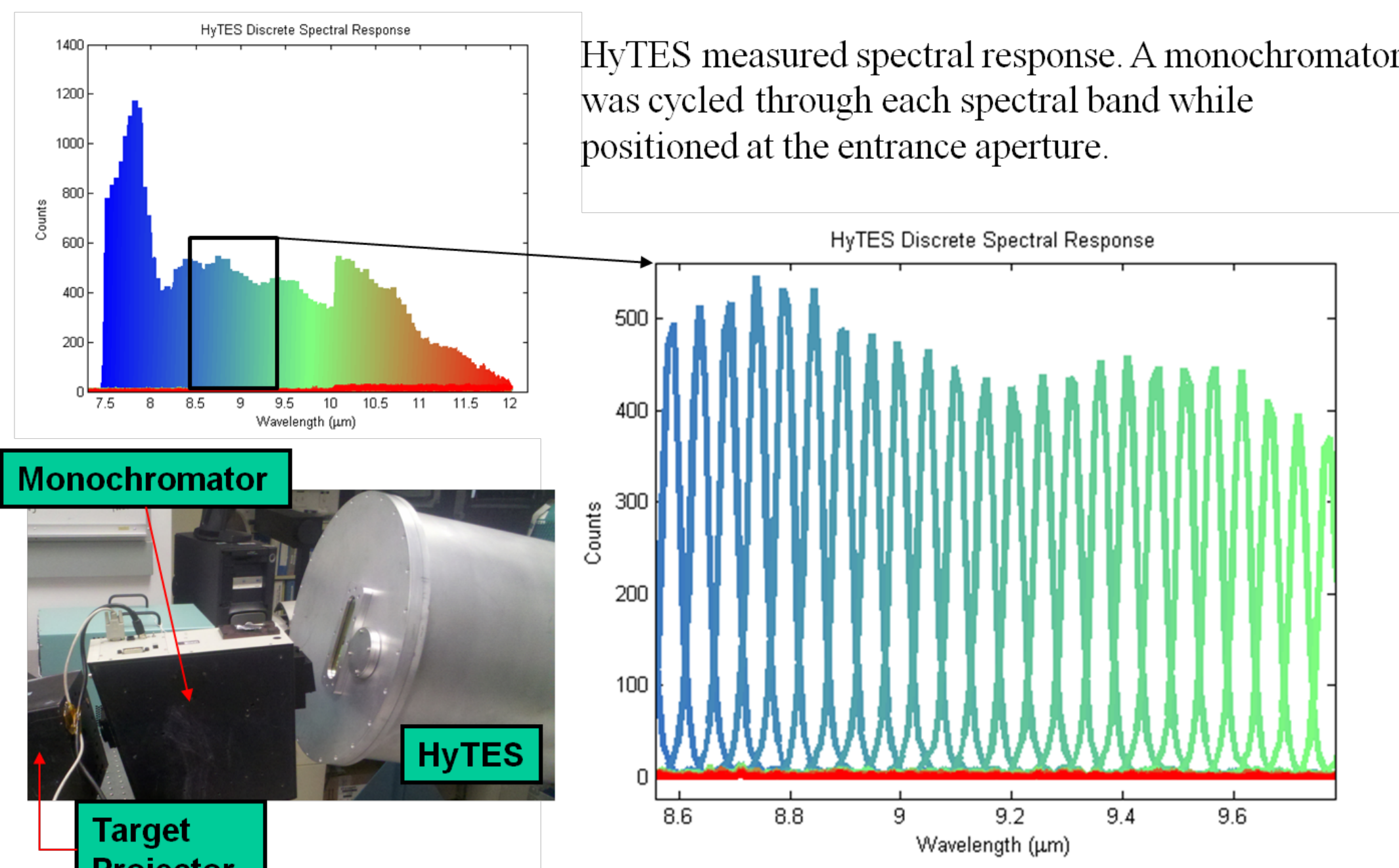
## HyTES Laboratory Testing



HyTES shown with high accuracy cavity blackbody. This is the set-up used for measuring system linearity, brightness temperature and NEDT.

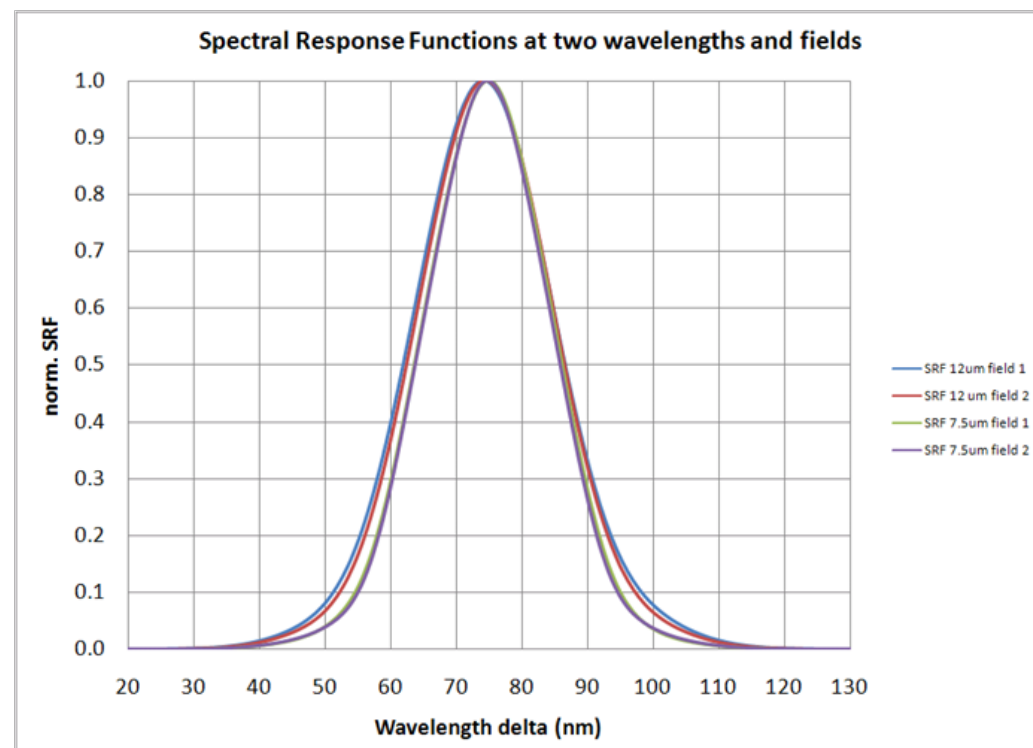


Excellent linearity measured (<+/- 0.1C)



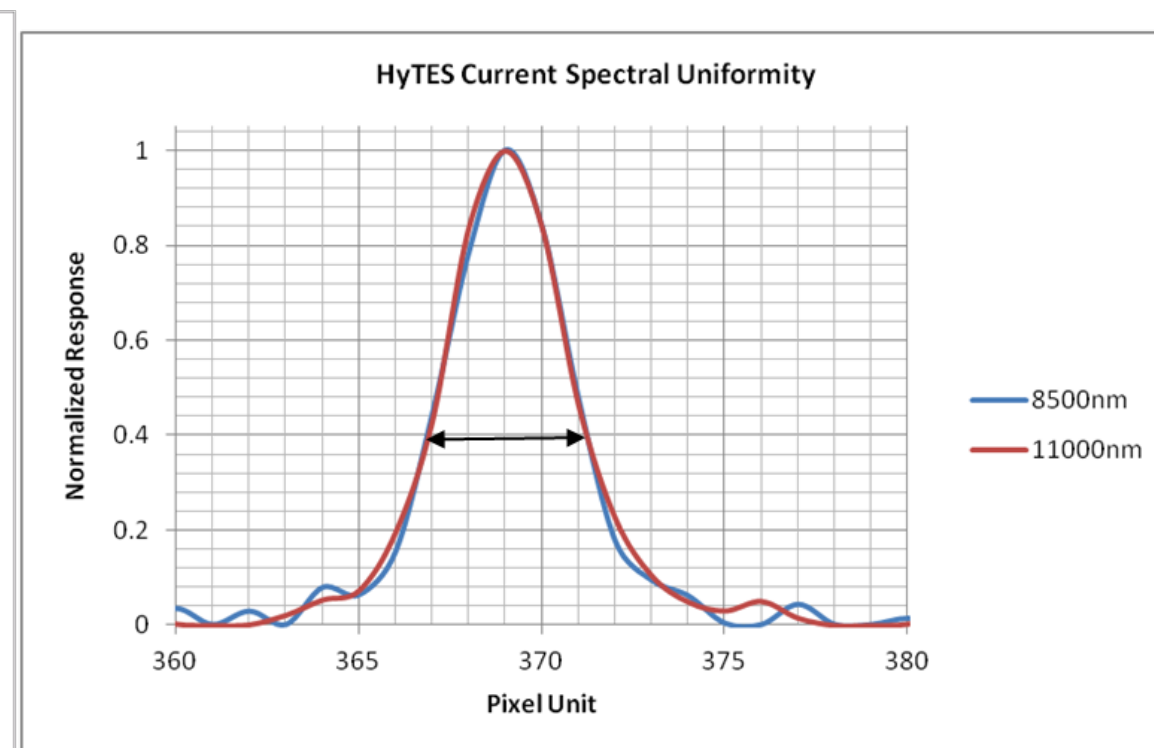
HyTES measured spectral response. A monochromator was cycled through each spectral band while positioned at the entrance aperture.

## Predicted spectral response

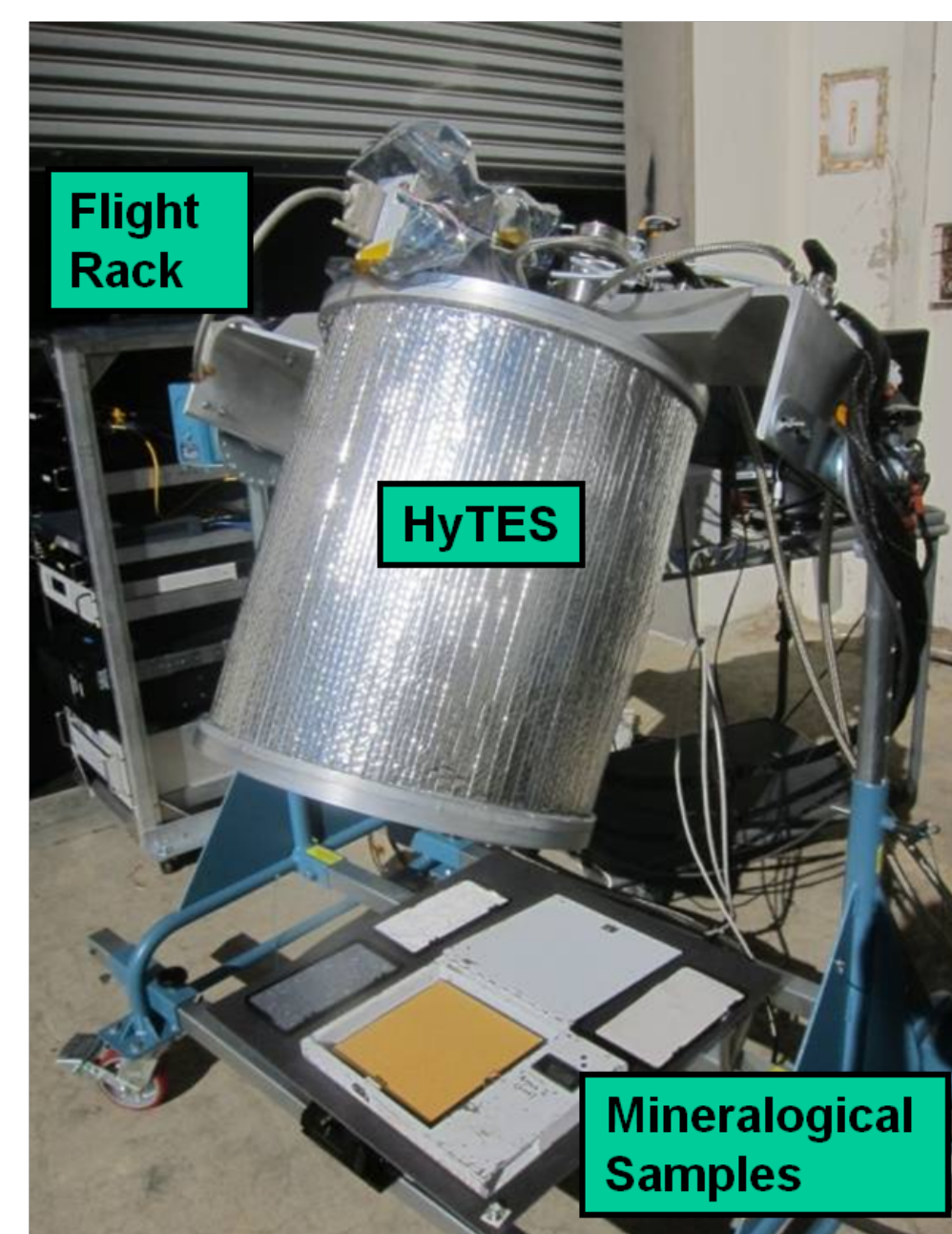


Arrow on measured response shows a FWHM of about 4 pixels (or 2 effective pixels) which is 35.2nm.

## Measured spectral response

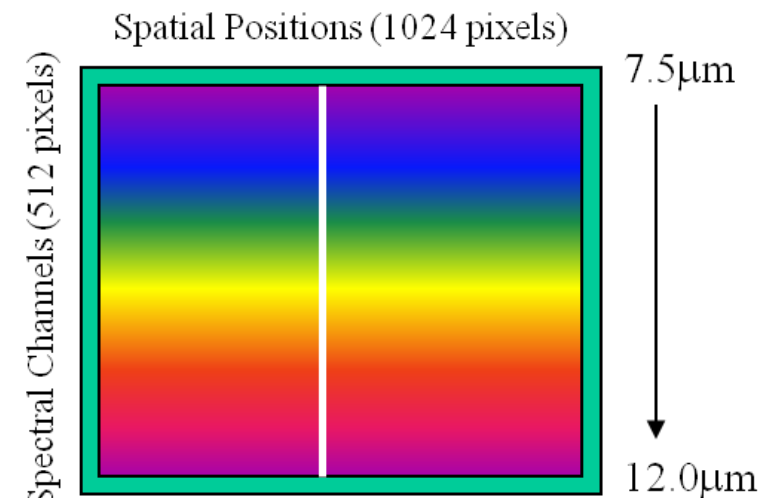
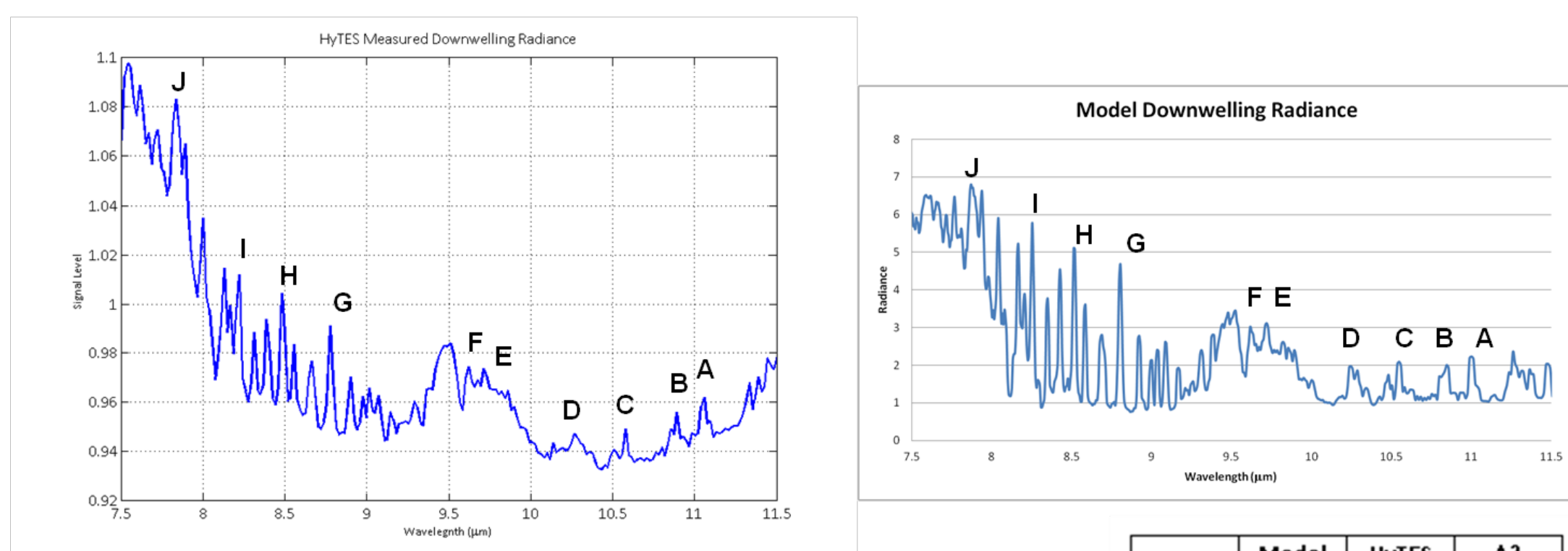


## HyTES Preflight Testing



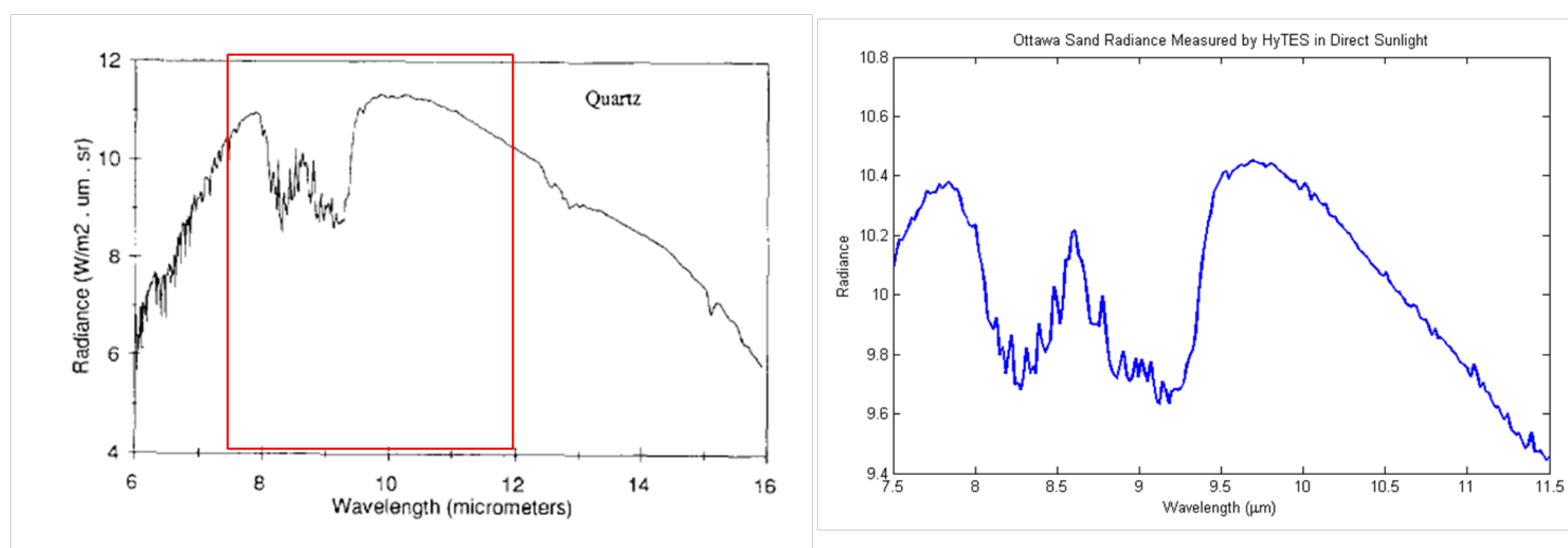
### Test Procedure in Direct Sunlight

- Obtain spectral calibration from downwelling radiance using diffuse gold.
- Observe mineralogical species: Quartz, Silicon Carbide

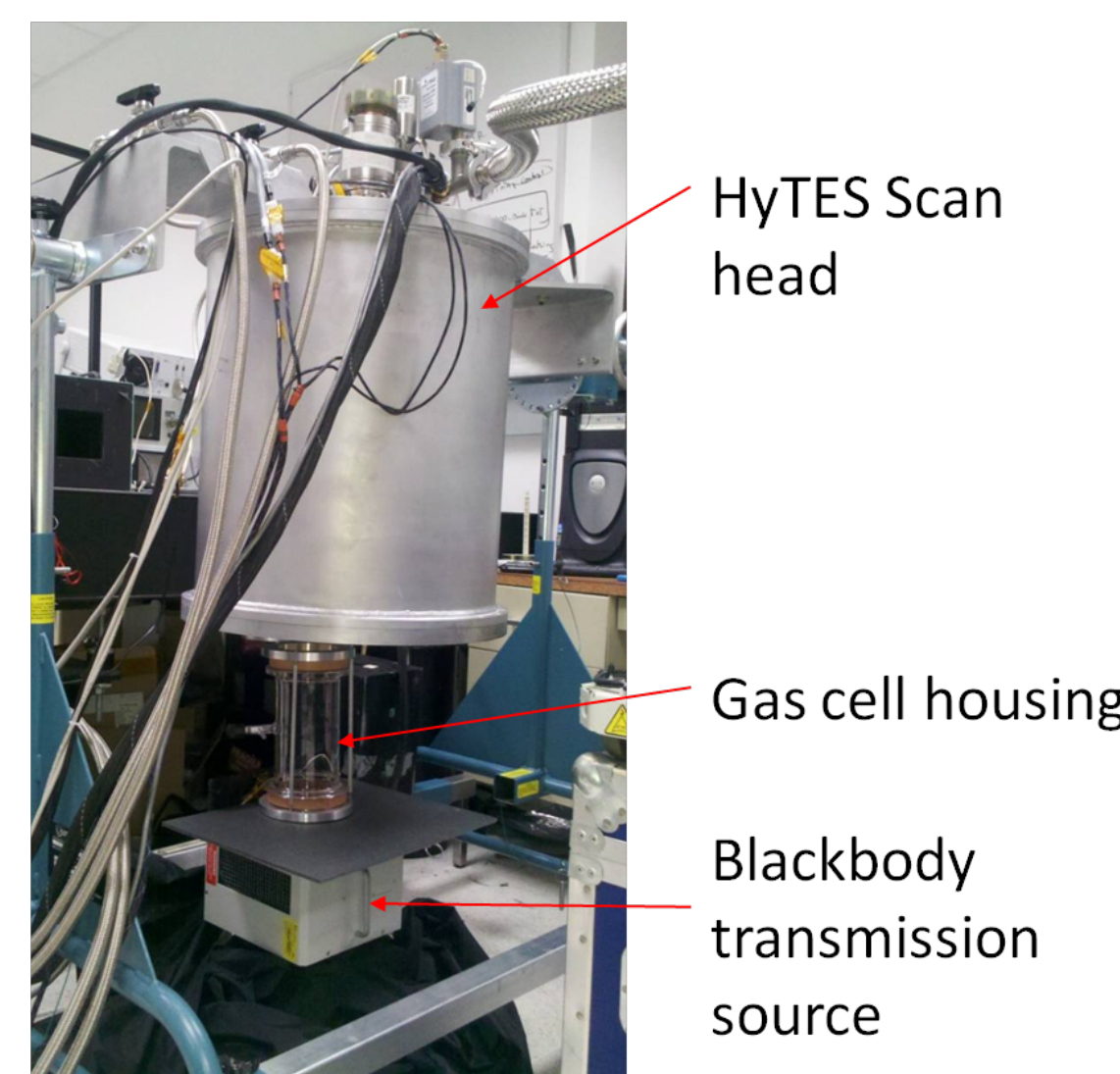


HyTES spectral calibration is very good. Wavelength determination for each feature is well within one bandwidth.

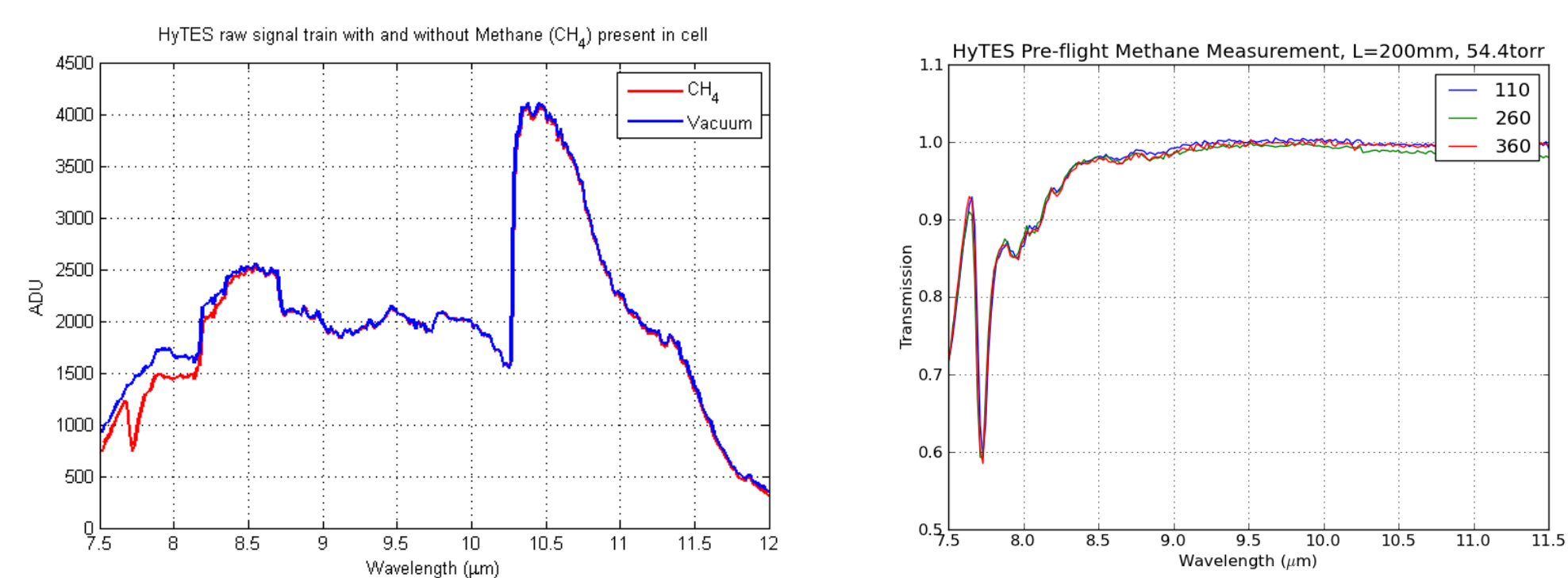
	Model	HyTES	$\Delta\lambda$
A	11.0010	11.01	-0.009
B	10.8460	10.853	-0.007
C	10.5485	10.5404	0.0081
D	10.2459	10.237	0.0089
E	9.7180	9.7246	-0.0066
F	9.6150	9.6125	0.0025
G	8.8028	8.8051	-0.0023
H	8.5106	8.5105	0.0001
I	8.2508	8.2524	-0.0016
J	7.8740	7.875	-0.001



Previously measured field radiance of Quartz (micro-FTIR)



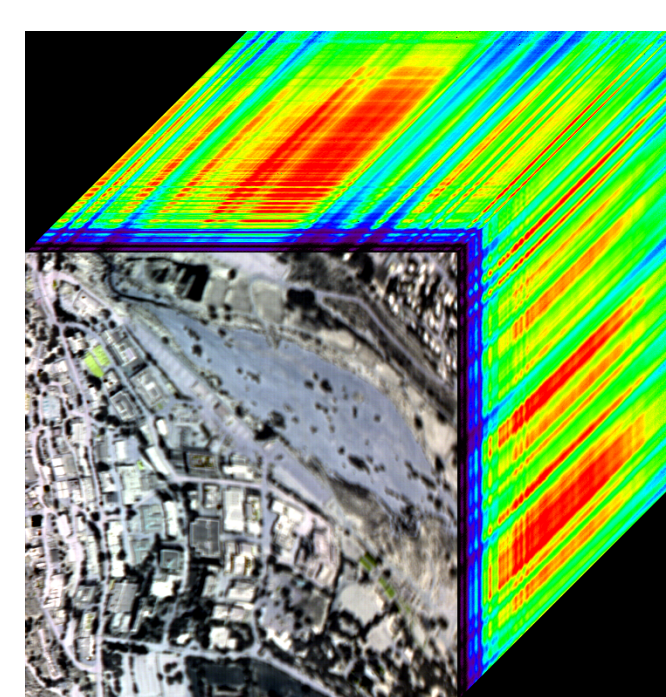
- 200mm cell length
- ZnSe transmission optics with anti-reflection coatings for maximum transmission.
- All gas species are held at 50torr pressure



CH<sub>4</sub> raw signal converted to transmission spectra. Absorption spectra agree with spectra in NIST and PNNL databases.

## HyTES Science Flights

HyTES image cube of JPL.



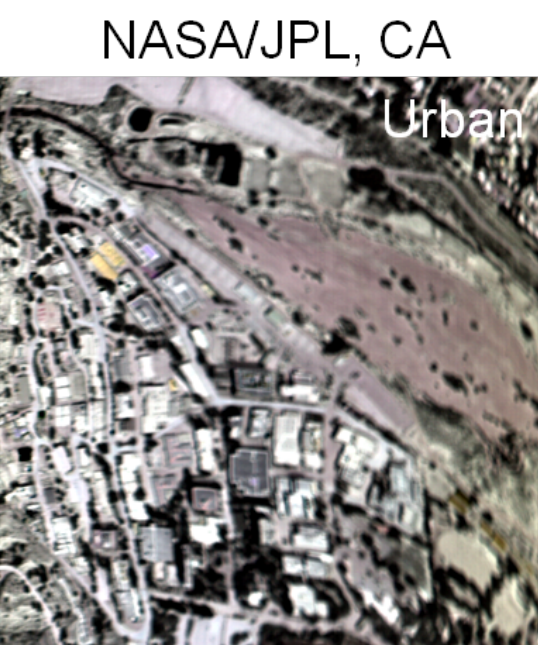
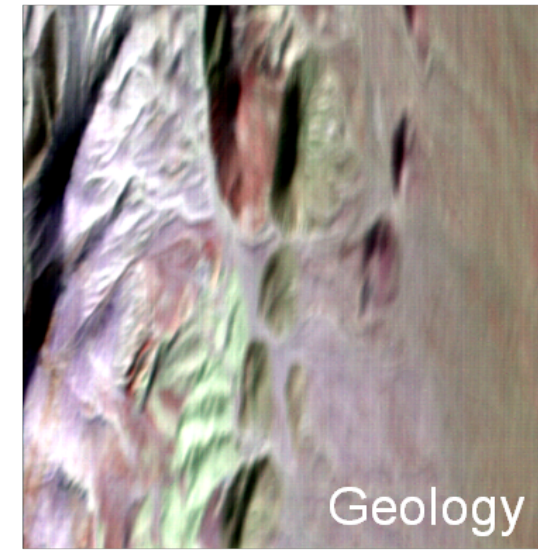
HyTES looking NADIR during flight.

### Objectives

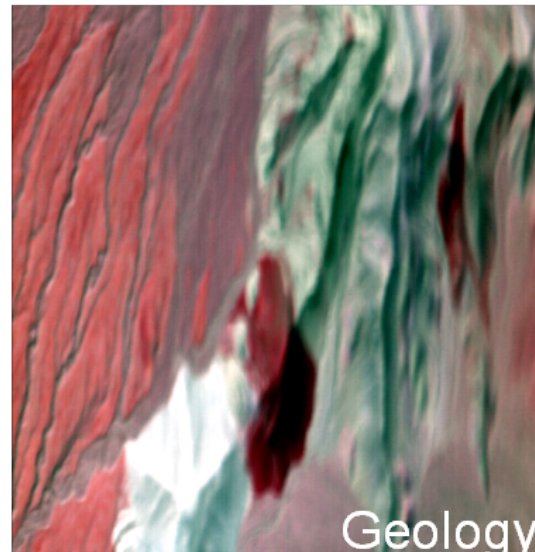
- Acquire data from a range of targets for evaluation in various disciplines: Solid Earth, Ecosystems, Atmospheric composition
- Evaluate upgrades made to instrument after previous engineering campaign
- Evaluate whether current detector has sufficient sensitivity to detect enhanced methane emissions



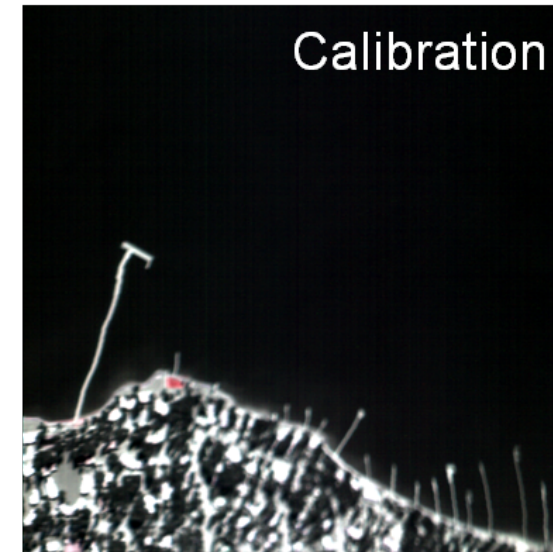
Cuprite, NV



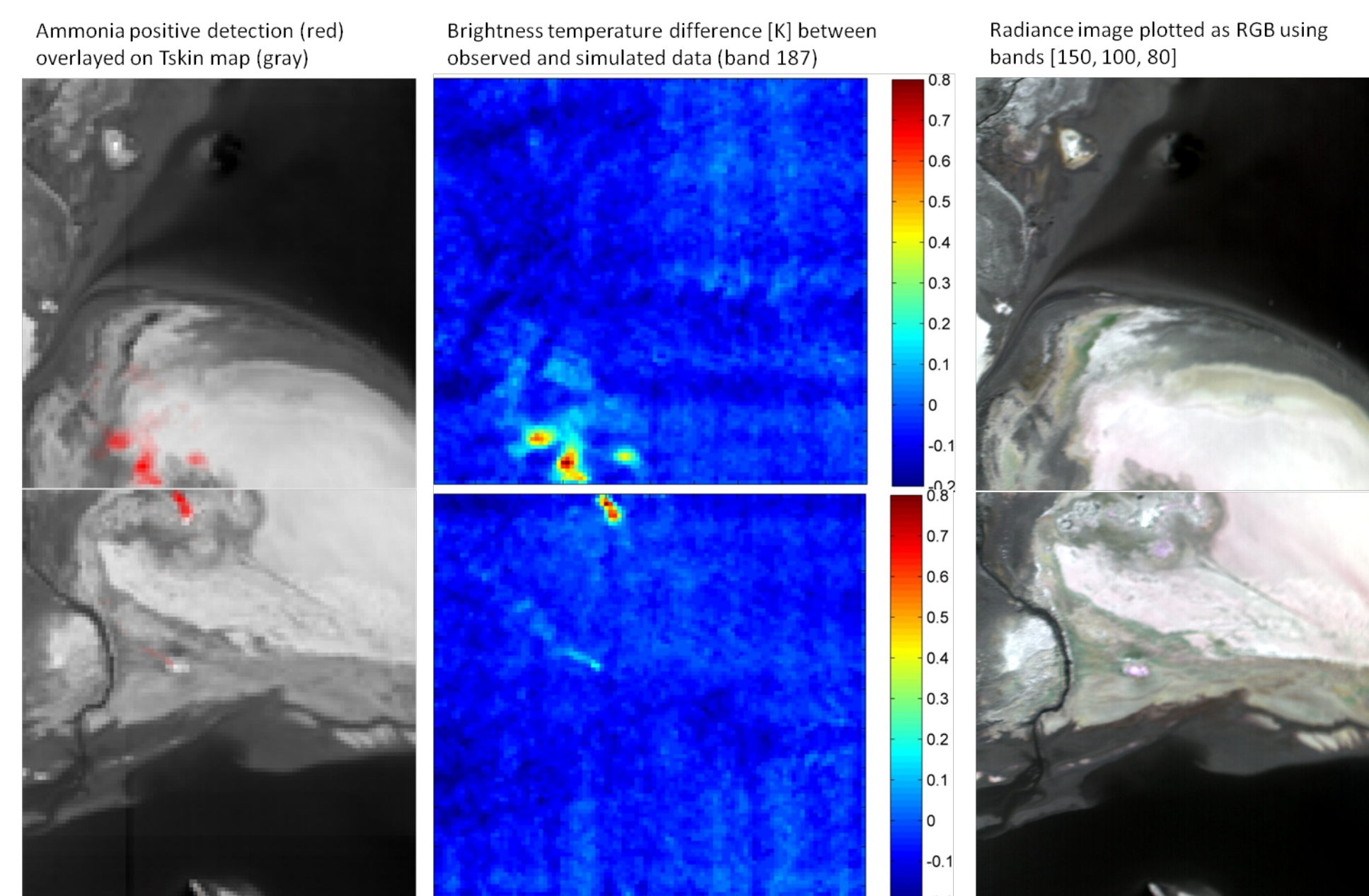
Death Valley, CA



Lake Tahoe, CA/NV



bands 150 (10.08  $\mu\text{m}$ ), 100 (9.17  $\mu\text{m}$ ), 58 (8.41  $\mu\text{m}$ ), 58 displayed as RGB each image is 485 x 512 pixels



## HyTES Summary

The HyTES study was a success. The HyTES instrument was built and then flown on a Twin Otter aircraft over various sites in the southwestern USA. Results indicate HyTES will provide precursor data suitable for the HyspIRI mission and for use in Earth Science.

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