HyTES recent campaigns and transition to high altitude platform

Thursday, June 16 - Day Three, 10:00 AM
Session A7: Surface, Soil, and Snow

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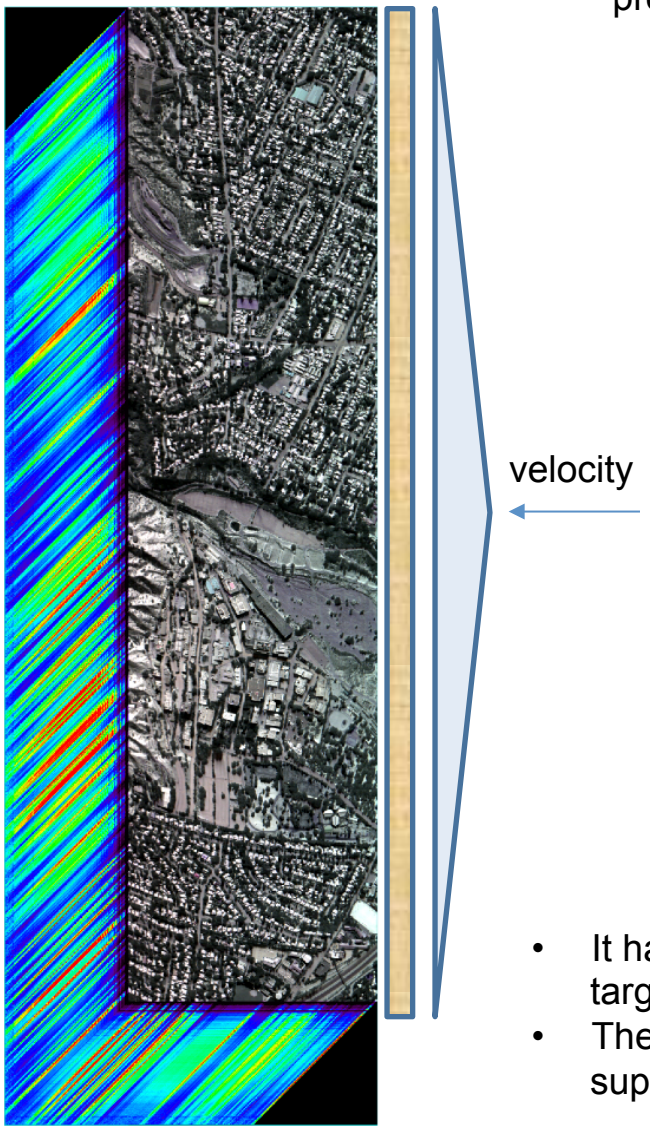
Outline

- **HyTES sensor description**
- **Recent campaigns**
- **Transitioning to higher altitude platforms**
- **Concluding remarks**

HyTES Instrument

Push broom imaging



HyTES Image cube of JPL flyover, Summer 2014.
L1A: bands 150 (10.08 µm), 100 (9.17 µm), 58 (8.41 µm), displayed at RGB

- HyTES was originally developed under an IIP to support HyspIRI by providing higher resolution *spatial and spectral* science products.

Basic Instrument Parameters

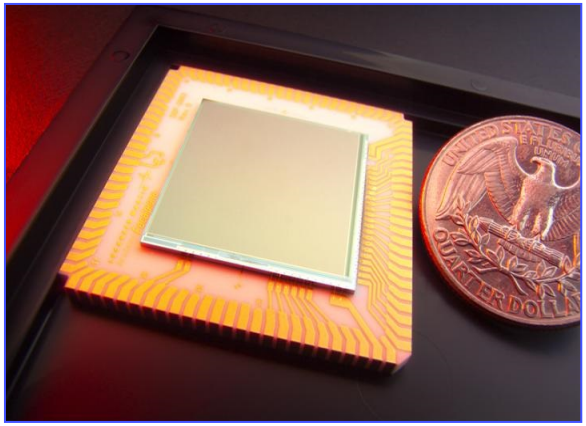
Volume (scan head)	0.6m x 0.4m + peripheral struts
Number of spatial pixels x track	512
Number of spectral channels	256
Spectral range	7.5 - 12μm
Frame Speed	35 or 22 fps
Total field of view	50deg
Calibration	Full aperture blackbody
Detector temperature	40K
Optics temperature	100K
NEΔT	200mK
IFOV	1.7066 mrad
Low Altitude pixel size/swath	2m/1Km
High Altitude pixel size/swath	20m/10Km

- It has also been used to spatially map trace gas plume signatures over targets of interest.
- The HyTES cryosat system has undergone a design modification to support operation in the ER-2 under the AITT program.

QWIP Technology

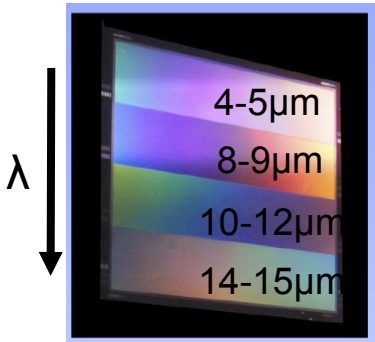
Quantum well infrared photodetector (QWIP) developed at JPL

- Detector Material - Spatially separated 2-color QWIP
- Array Size - 1024x1024 pixels
- Pixel Pitch - 19.5 microns
- Wavelength - 7.5-12 microns; three spectral bands
- Input Circuit - Direct Injection
- Integration Type - Snap Shot mode
- Integration Time - Adjustable integration time > 10 μs
- Integration Modes - Integrate-While-Read & Integrate-Then-Read
- Well Depth - 8.1×10^6 electrons

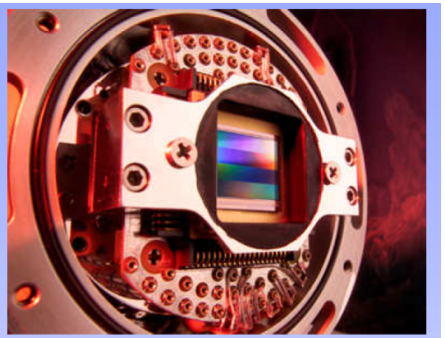


1024x1024 pixel single-band QWIP FPA

2-point corrected image of focal plane array used in HyTES.



Four-band FPA



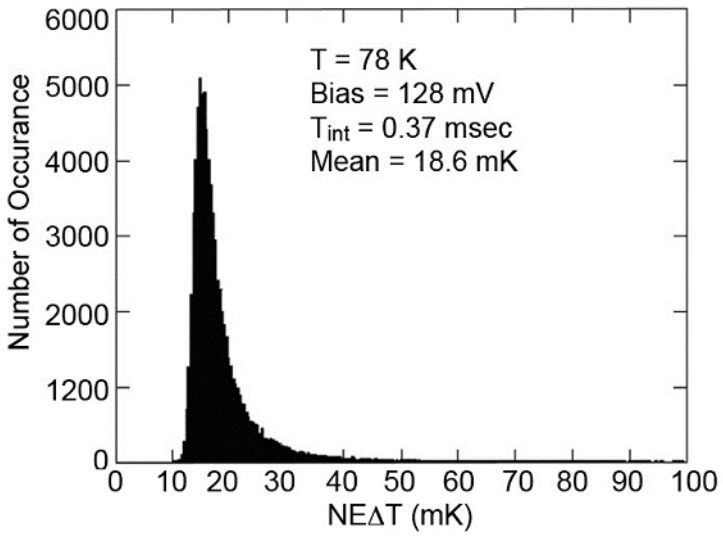
Four-band FPA in Dewar

CBIRD Technology

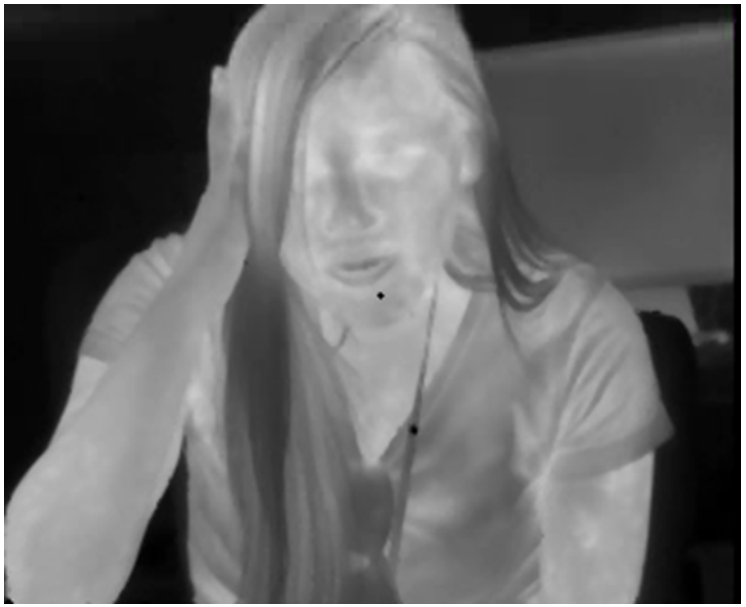
New potential detector technology for future pushbroom hyperspectral sensors:

- Antimonide superlattice based long-wavelength infrared photodetectors using a complementary barrier infrared detector (CBIRD) design offers the possibility of stabilized, uniform arrays with low dark current, higher operating temperature than QWIP and higher QE.

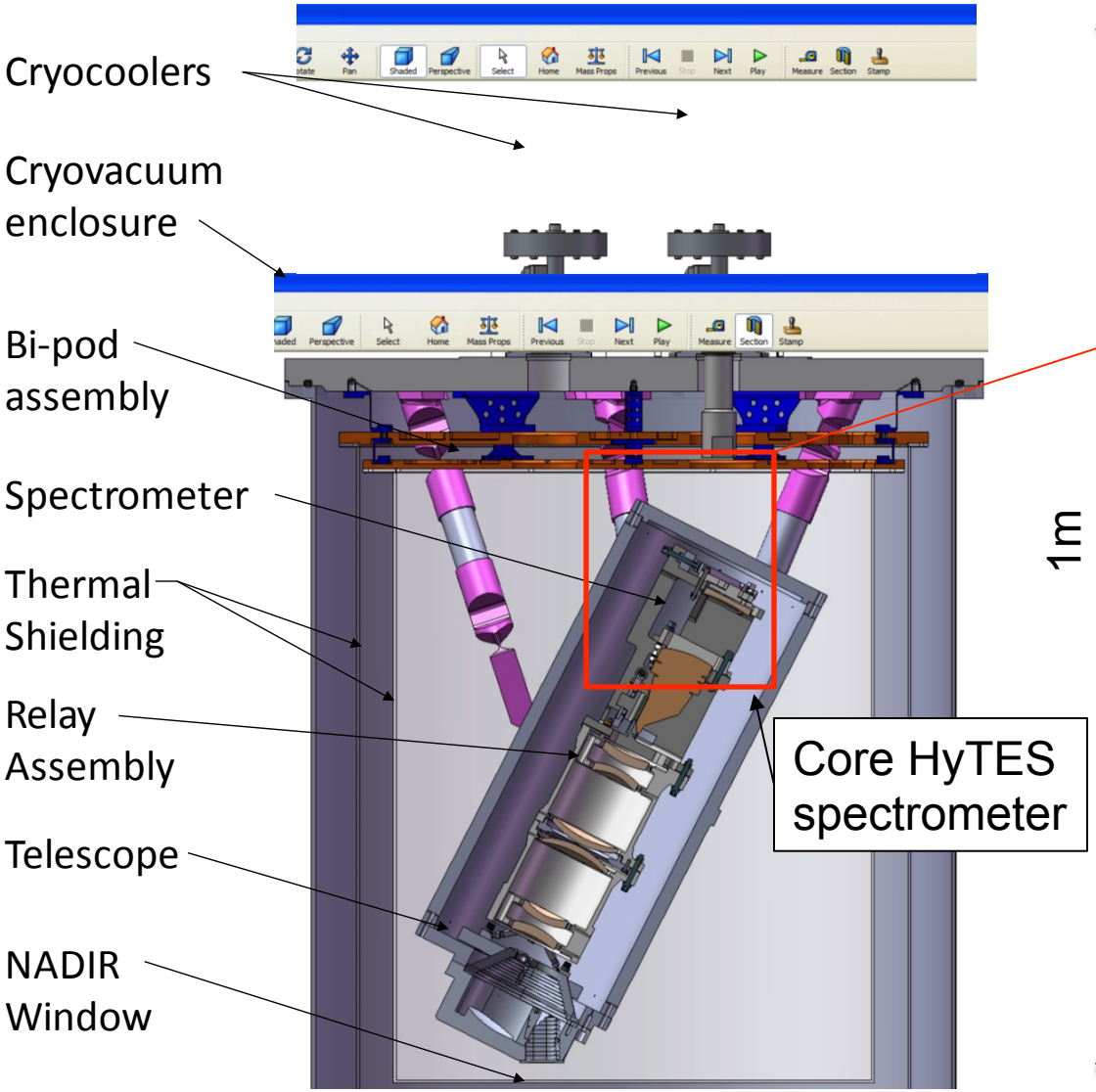
- Antimonide-based superlattice infrared absorbers can be customized to have cut-on wavelengths ranging from the short-wave infrared (SWIR) to the very long-wave infrared (VLWIR).

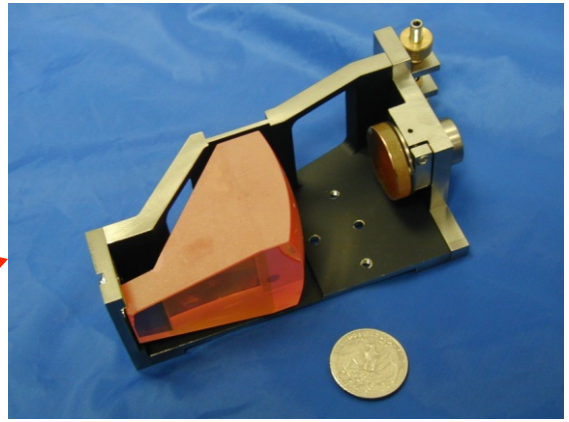


Format	– 320x256
Pixel pitch	– 30 mm
ROIC	– ISC 0903 DI
Pixels	– Fully reticulated
Pixel Size	– 26x26 mm^2
Polarity	– N on P
Cutoff wave.	– 10 µm
Oper. temp.	– 78 K
QE (8-9.2 µm)	– 54% (without A/R)
NEDT	– 18.6 mK with f/2 300K
Substrate	– Removed
Temp. Cy	– 29



HyTES Instrument

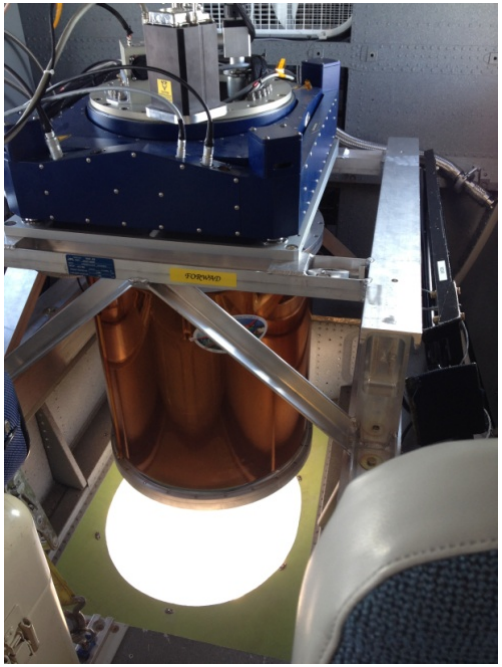




- HyTES flew its last campaign with this cryovac configuration in January 2016.
- It has been transitioned to an even smaller configuration for higher altitude deployment.
- The new smaller design still works on the twin otter.

http://airbornescience.jpl.nasa.gov/hytes/

HyTES Flights



HyTES has flown 6 campaigns since 2012.

All flights have been out of Grand Junction Colorado on a low altitude Twin Otter aircraft.

HyTES is scheduled to have its first high altitude flight on NASA's ER-2 in 2016.

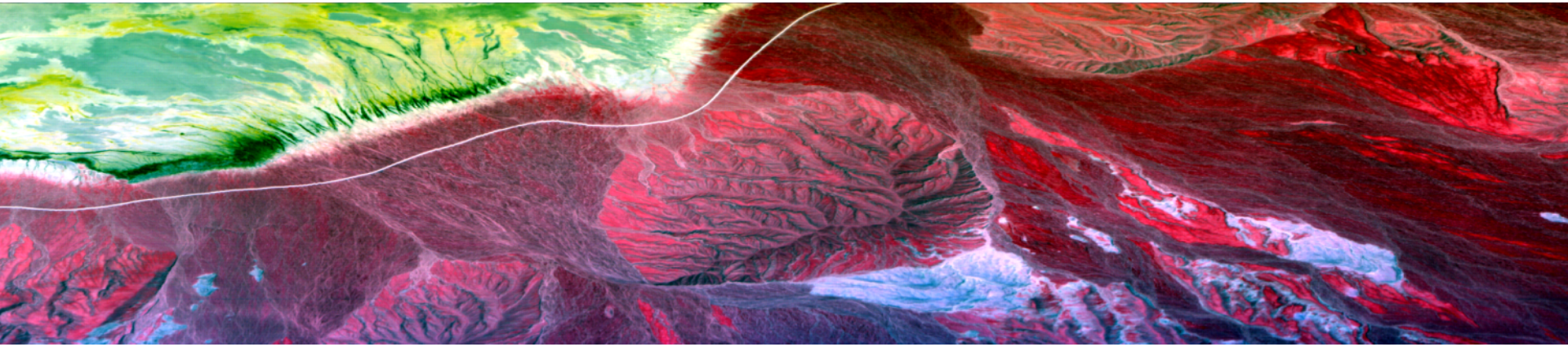
A suite of additional instruments are used to stabilize the system as well as to assist with pointing knowledge.

HyTES instrument team

HyTES Campaign Products

Death Valley, CA

Quartz alluvial fan



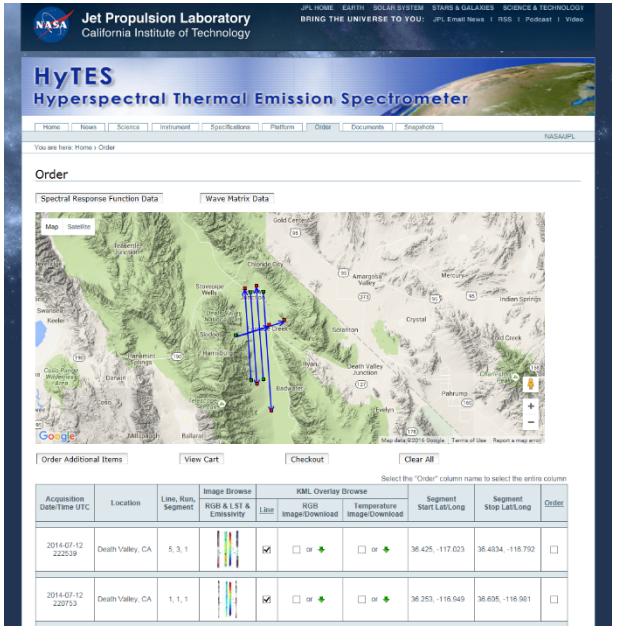
Carbonate

Basalt

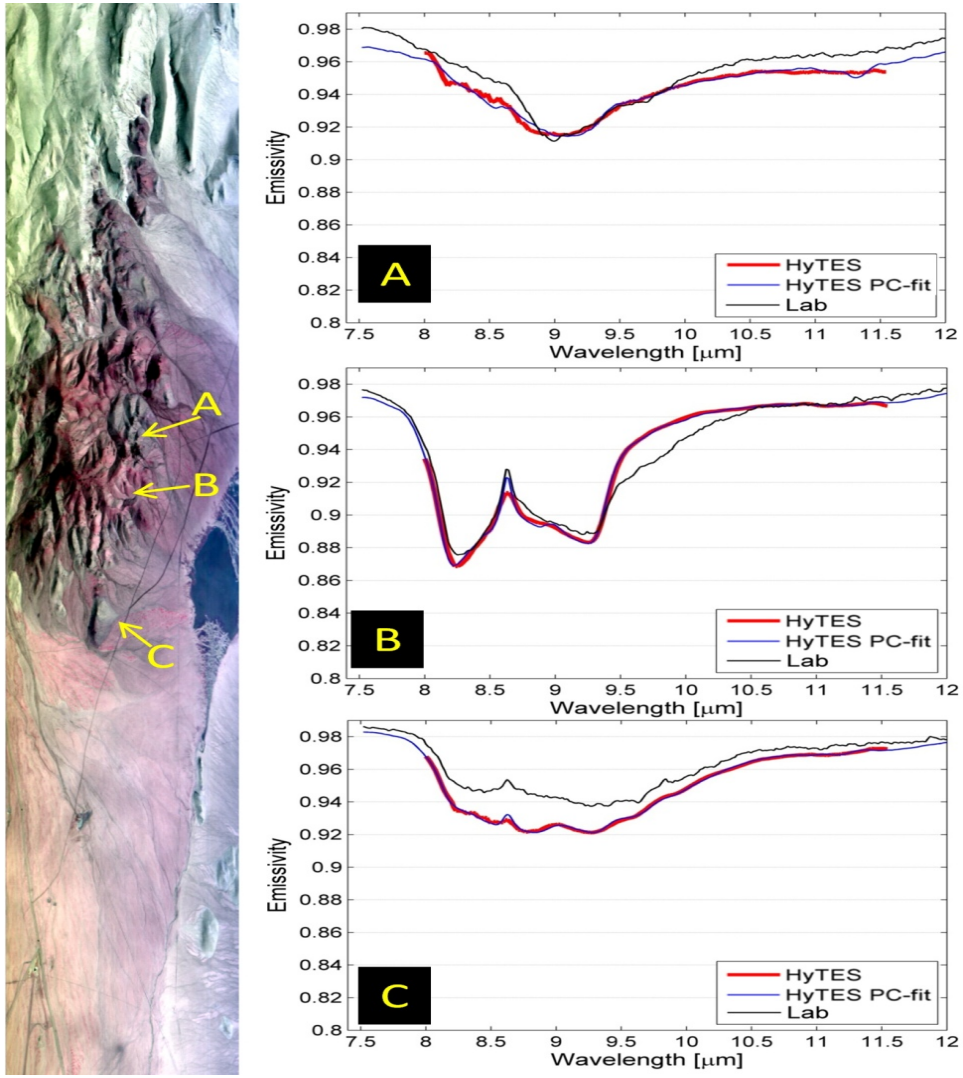
HyTES image of Death Valley
L1A: bands 150 (10.08 μm), 100 (9.17 μm), 58 (8.41 μm), displayed at RGB

- Data from all previous flights can be found at the web portal shown to the right.
- One can browse quick looks and order higher level products.
- ATBD documentation is available from L1 to L3

Web portal at *hytes.jpl.nasa.gov*

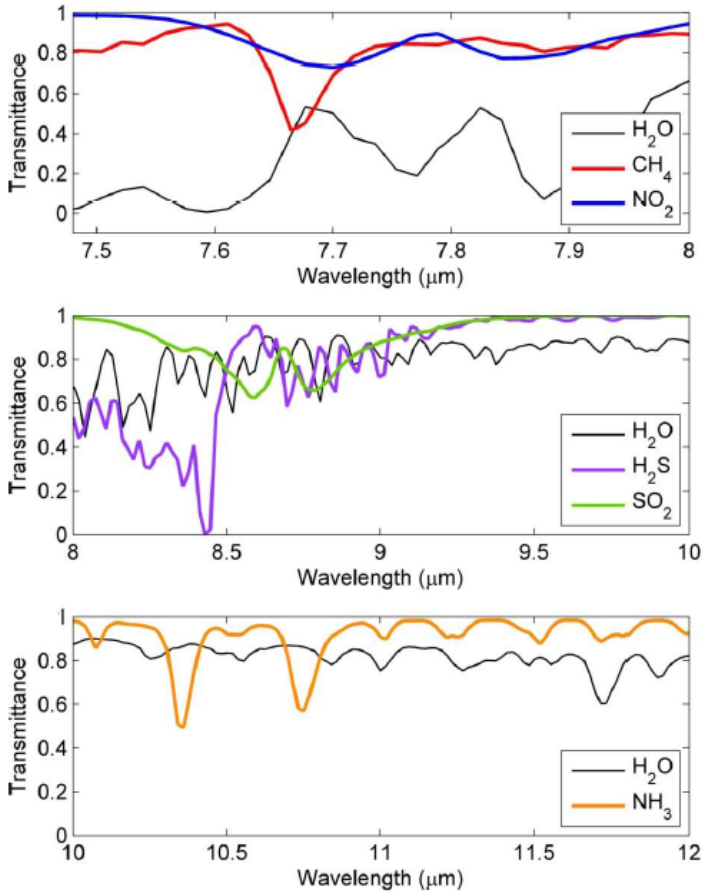


Spectral retrievals from calibration sites

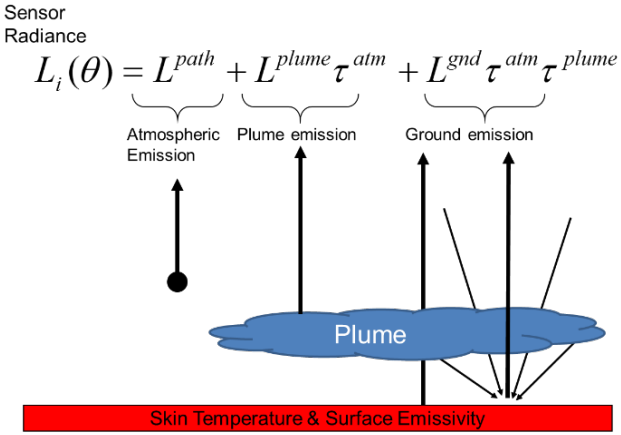


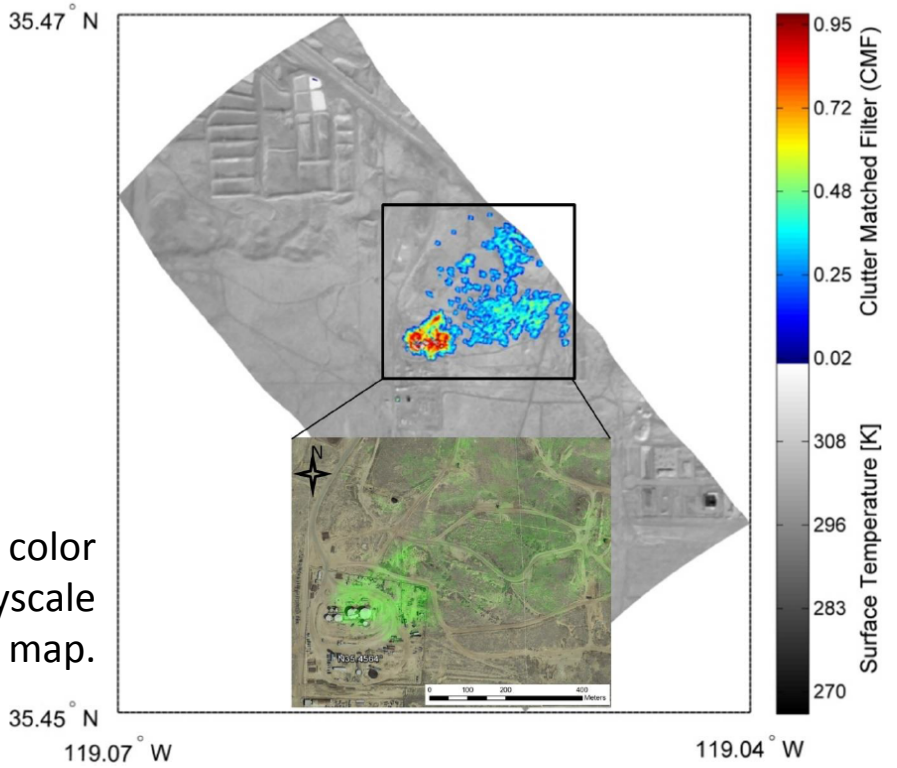
HyTES Radiance image over Cuprite, Nevada with bands 150, 100, 75 displayed as RGB and retrieved emissivity spectra over areas consisting of Alunite (A), Quartz (B), and Kaolinite (C). TES retrieved spectra for the window bands are shown in red, a Principal-Component (PC) regression fit to the TES data covering all wavelengths are shown in blue, and lab spectra of samples collected in these areas are in black.

Plume retrievals and spectra



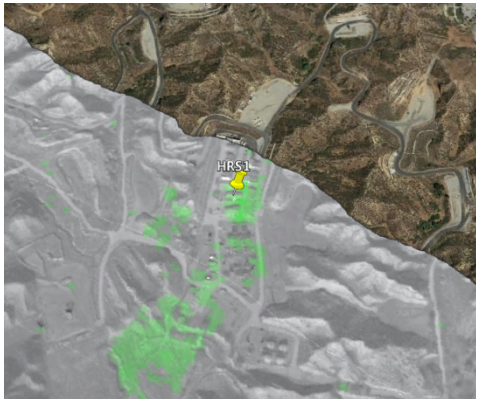
Spectral retrieval of various trace gas species



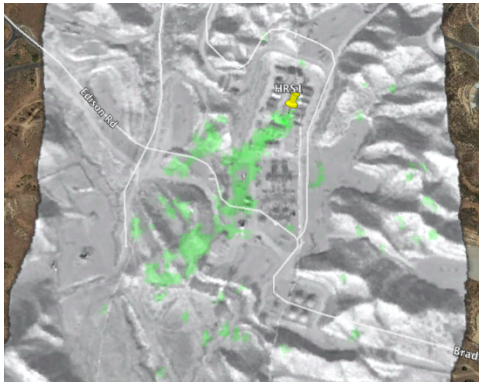


Higher-level plume visualization images showing a color Clutter Matched Filter (CMF) algorithm overlay on grayscale surface temperature image on a geospatial map.

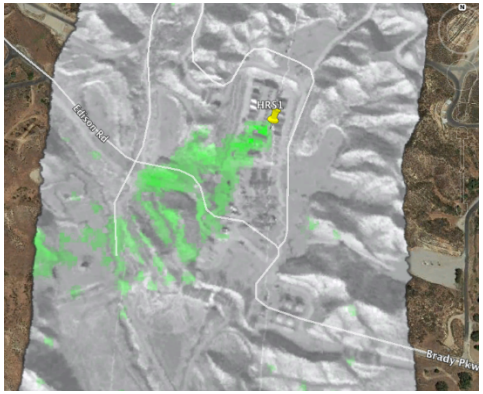
Honor Ranch Leak Discovery



Jan 21

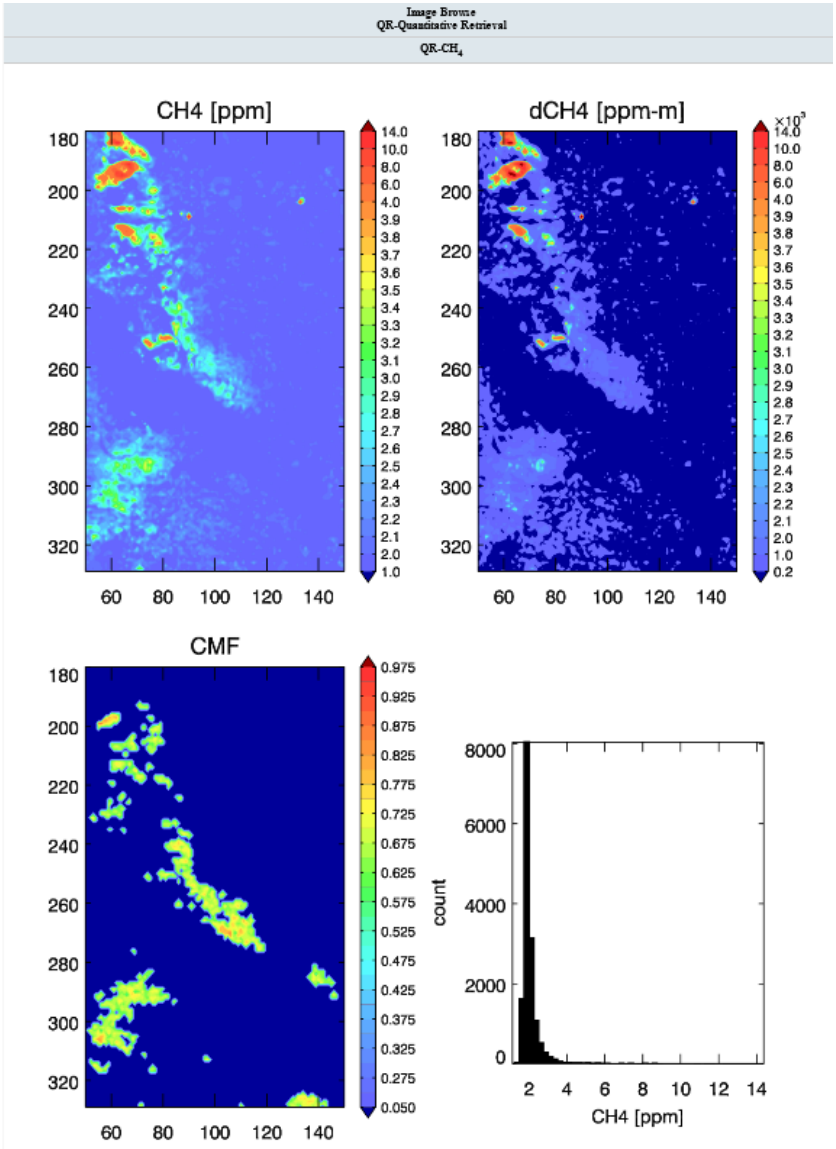


Jan 26, run 1



Jan 26, run 2

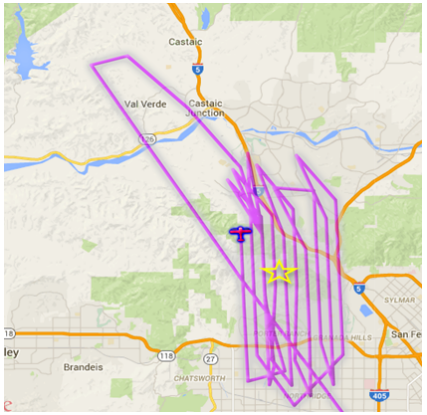
Aliso Canyon: Porter Ranch

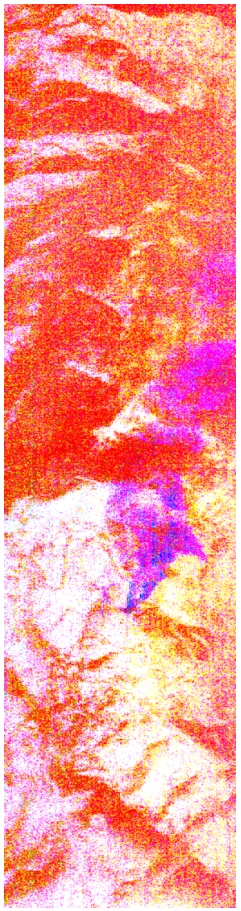


Quantitative retrievals (QR) of methane concentration

- Began Oct 23; plugged on Feb 11
- Complex, highly variable methane source
- Megacities Carbon Project: sustained monitoring of LA basin methane emissions (pre-leak, ongoing)

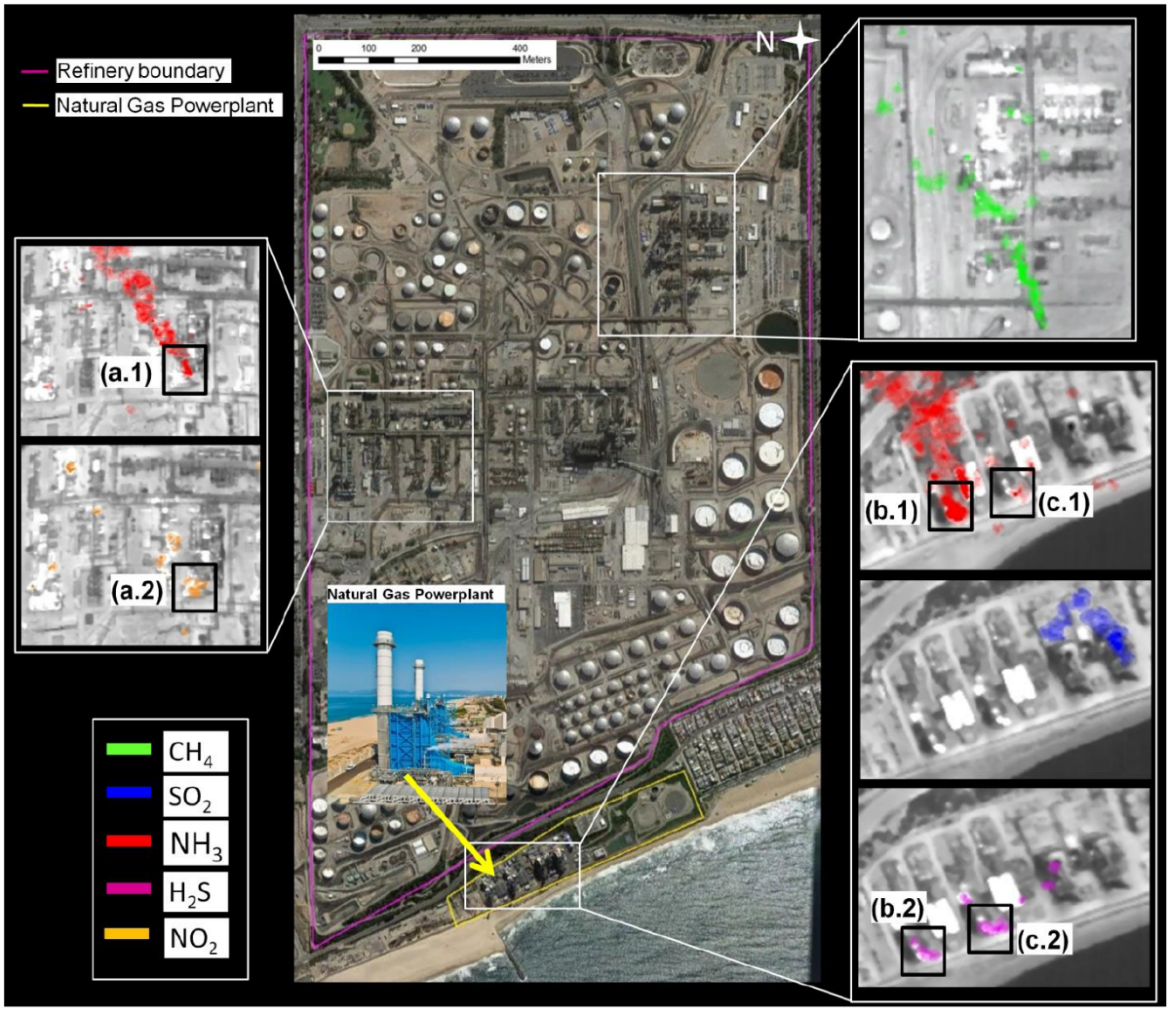
Typical flight lines





Kuai, L., Worden, J. R., Li, K., Hulley, G. C., Hopkins, F. M., Miller, C. E., Hook, S. J., Duren, R. M., and Aubrey, A. D.: Characterization of anthropogenic methane plumes with the Hyperspectral Thermal Emission Spectrometer (HyTES): a retrieval method and error analysis, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2015-402, in review, 2016.

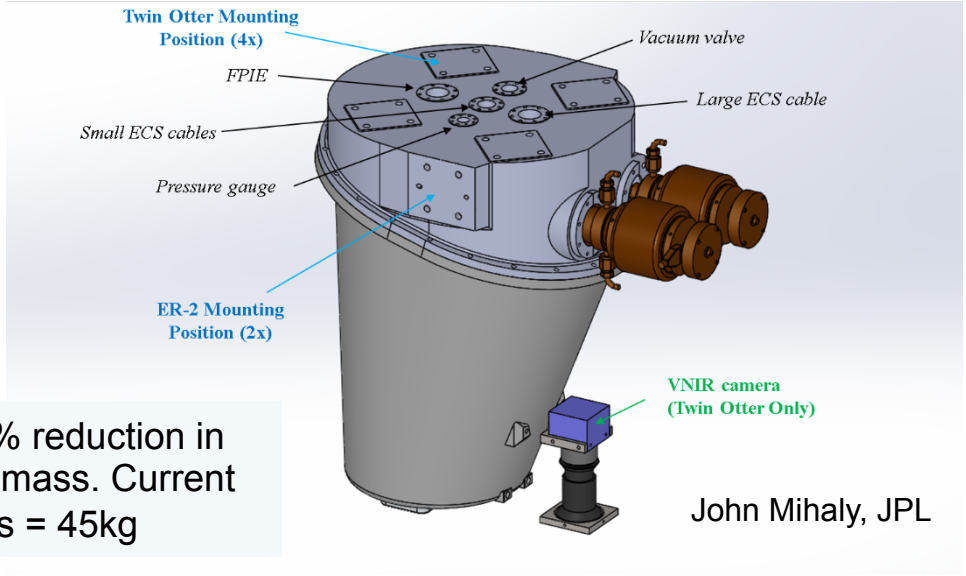
Multi-species



A HyTES Multi-species gas detection example showing a Google Earth image (center) of the area covered by a HyTES flightline over a refinery (magenta outline) and a natural gas powerplant (yellow outline) near El Segundo, CA. The insets show HyTES imagery of five detected trace gases (CH4, NO2, NH3, H2S, and SO2) highlighted in different colors and overlayed on retrieved surface temperature data in grayscale. Three examples are indicated where two different gases were detected 25 simultaneously within the same plume consisting of several contiguous pixels; NH3 and NO2 were detected over the refinery at the location **a.1**,/**a.2**, while at the natural gas powerplant, NH3 and H2S were detected at location **b.1**/**b.2**, and **c.1**/**c.2** respectively. Small plumes of SO2 (blue) can also clearly be seen being emitted from areas of the power plant (inset photograph).A distinctive CH4 plume was detected in the southeastern region of the refinery.

Hulley, Glynn C., et al. "High spatial resolution imaging of methane and other trace gases with the airborne Hyperspectral Thermal Emission Spectrometer (HyTES)." Atmospheric Measurement Techniques 9.5 (2016): 2393-2408.

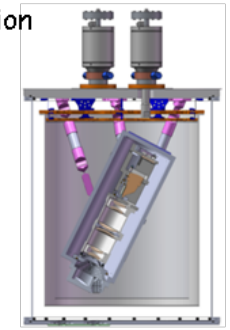
HyTES New ER-2 Platform

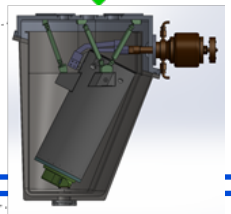


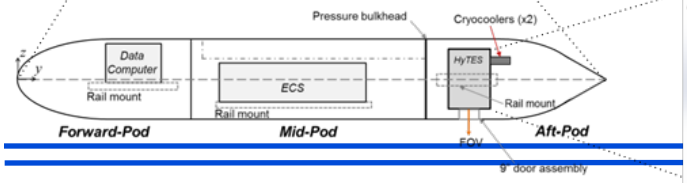
Nearly 50% reduction in scan head mass. Current mass = 45kg

John Mihaly, JPL

HyTES enclosure size reduction for accommodation in ER-2 wing pod

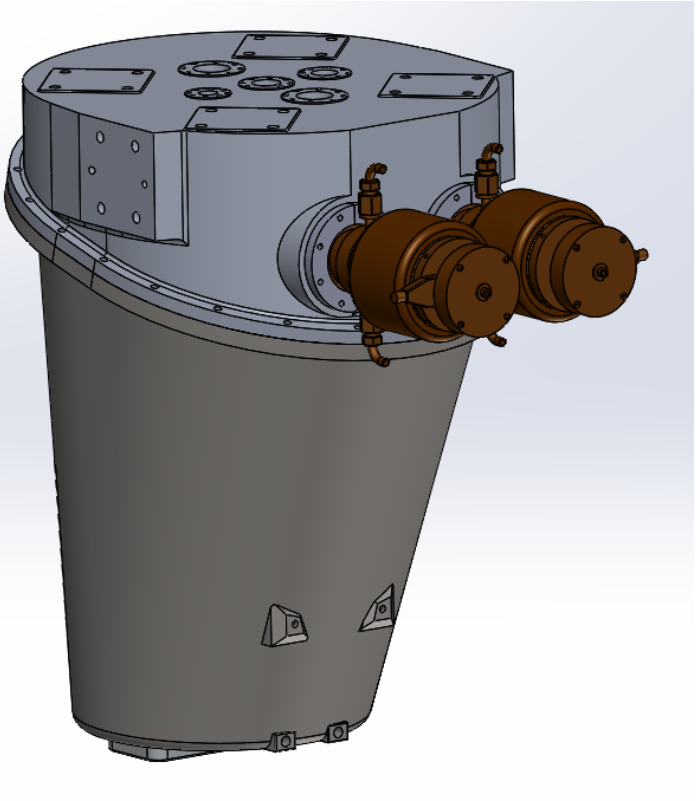


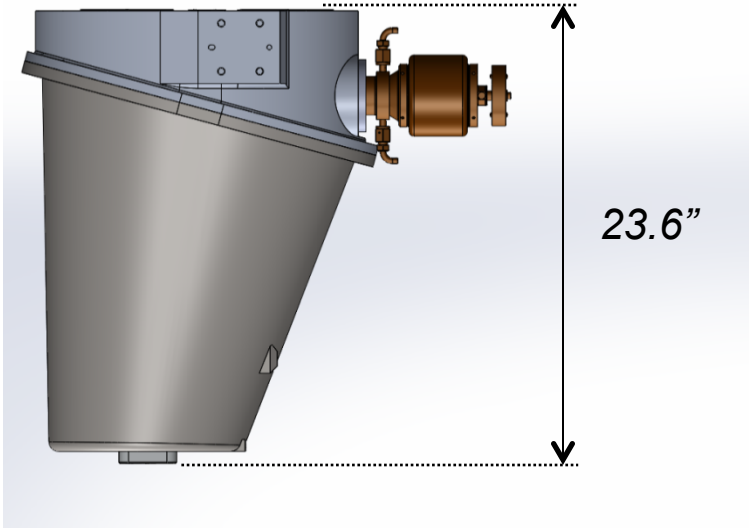


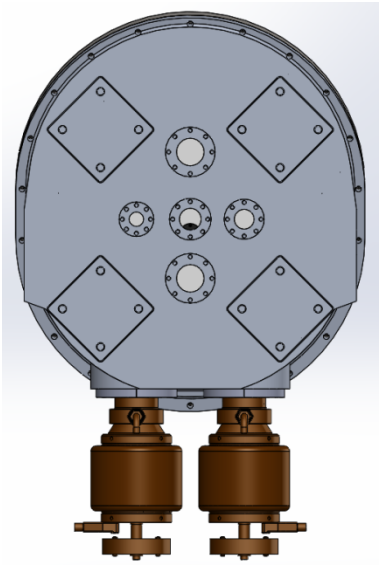


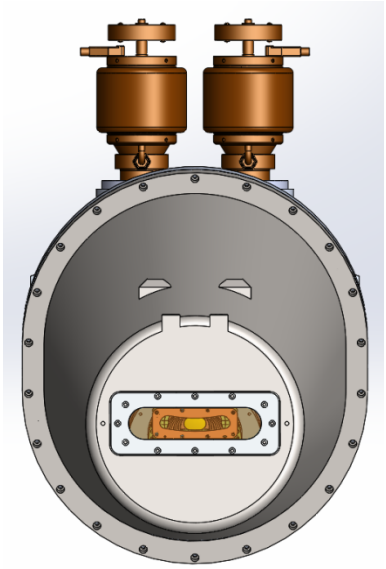
ER-2 HyTES scan head

New Sensor Enclosure Design









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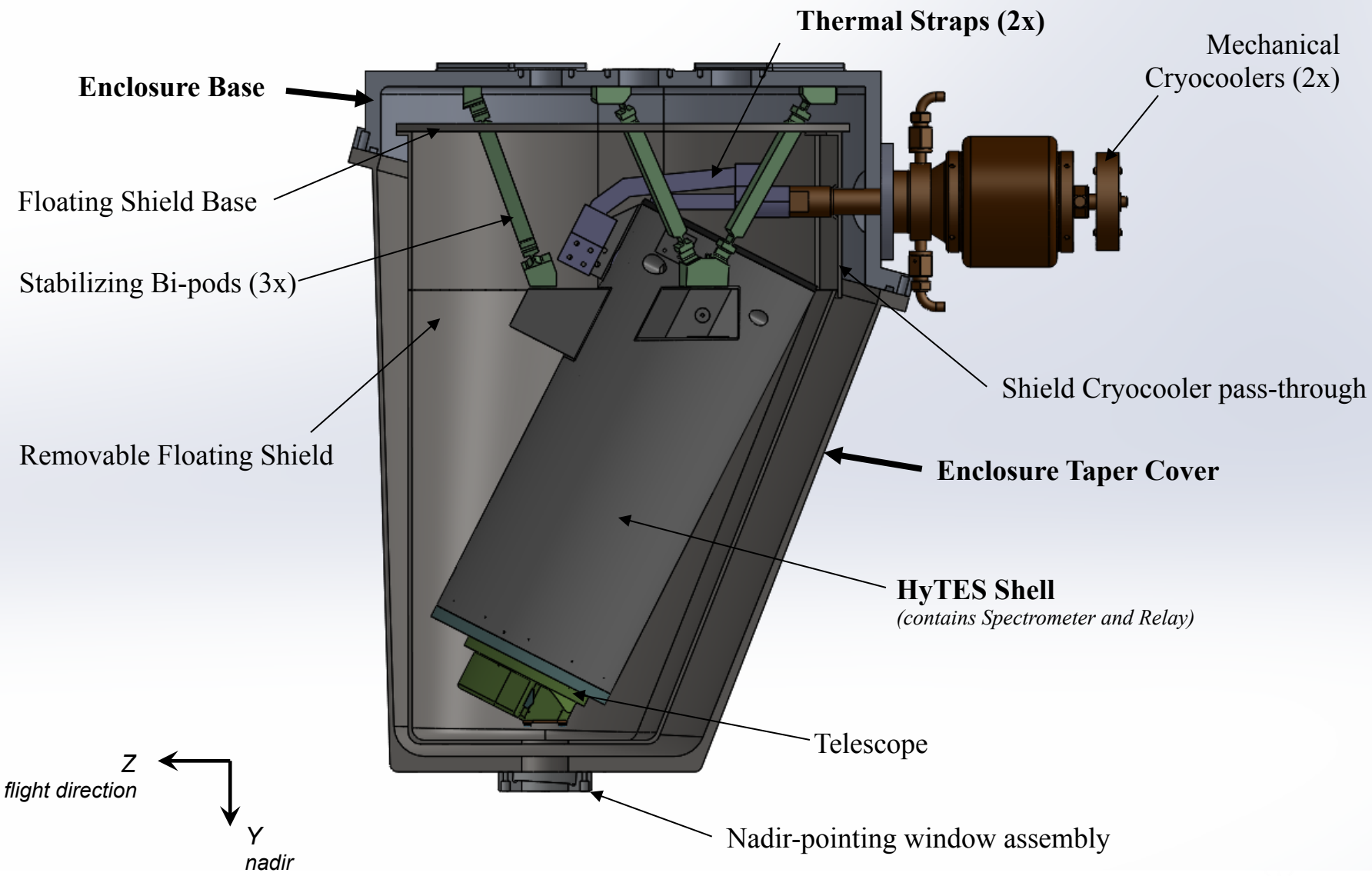
New Cryovacuum Enclosure



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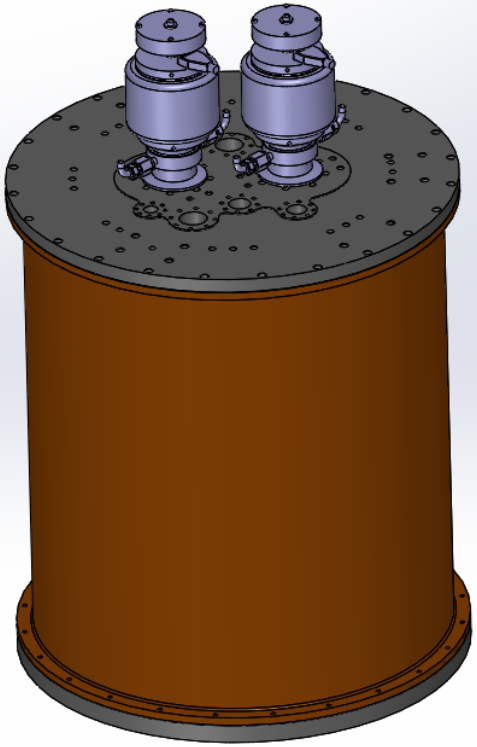
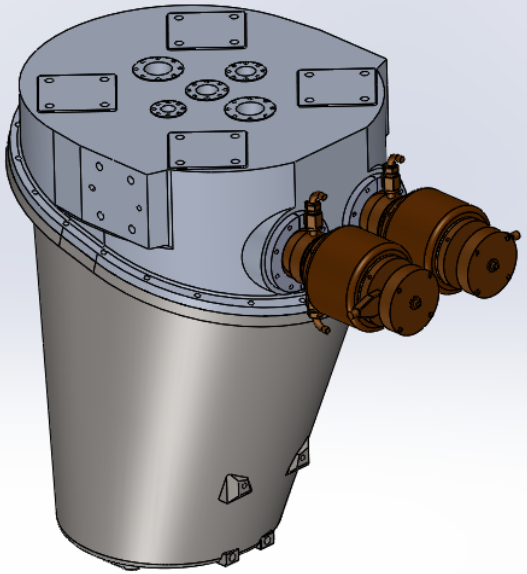
Original Enclosure vs. NEW Enclosure

Original



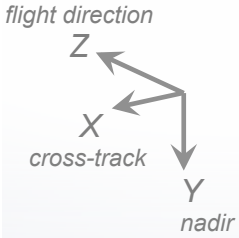
170 lbs

NEW



99 lbs

& 1 less O-ring



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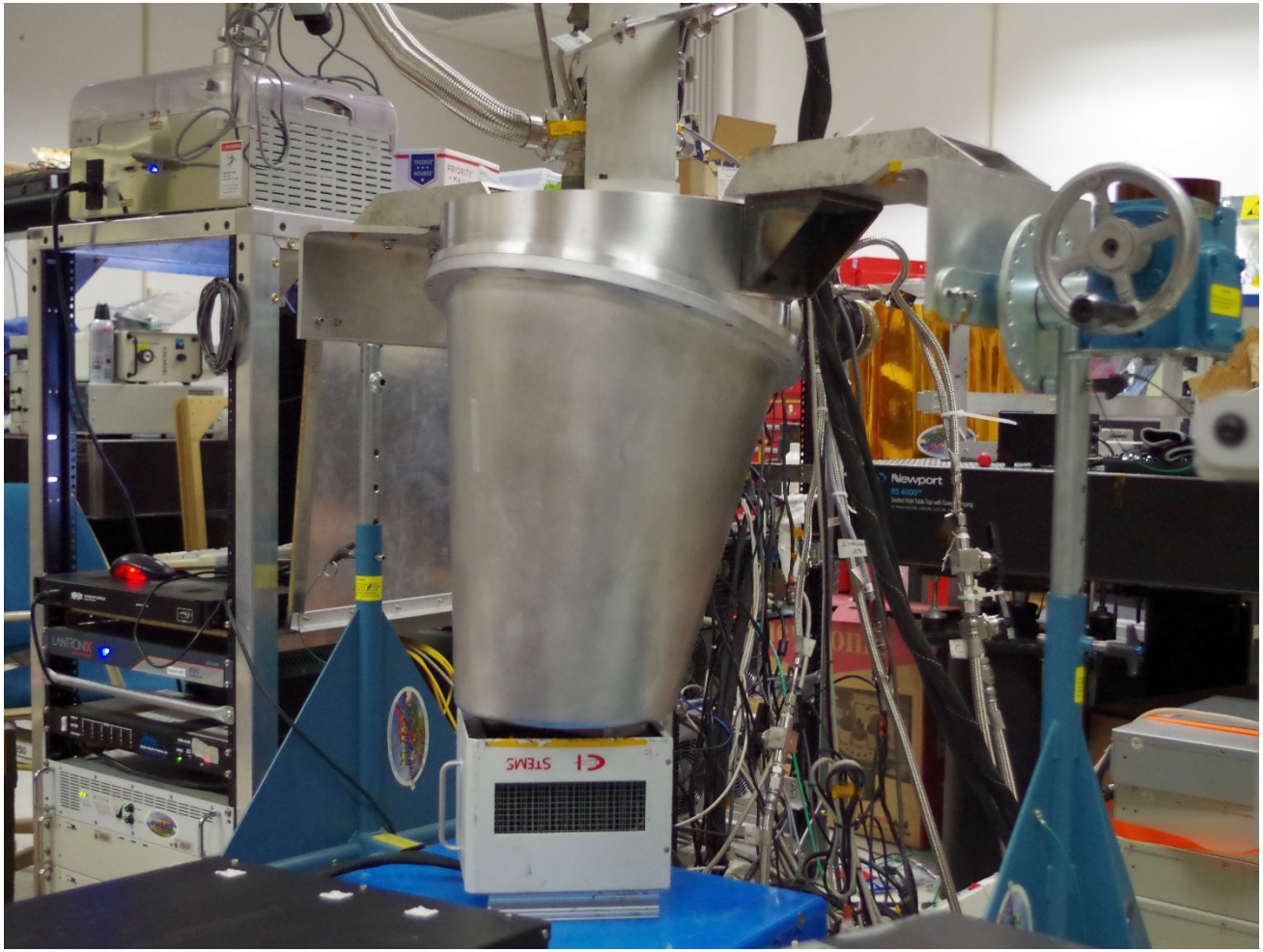
HyTES in Laboratory with Calibration Target



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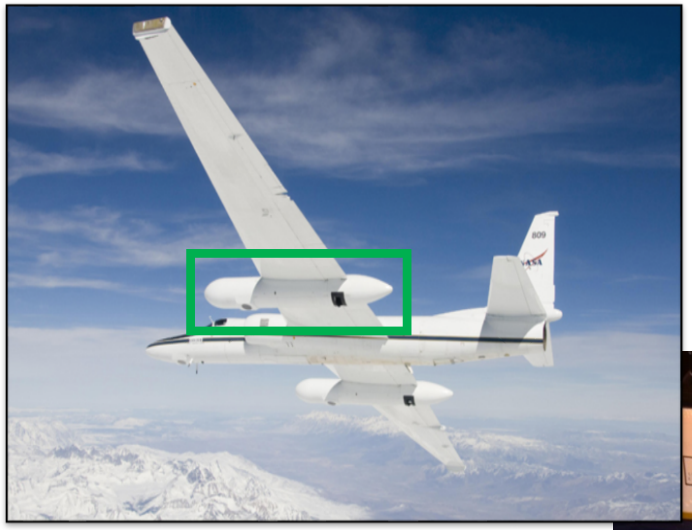
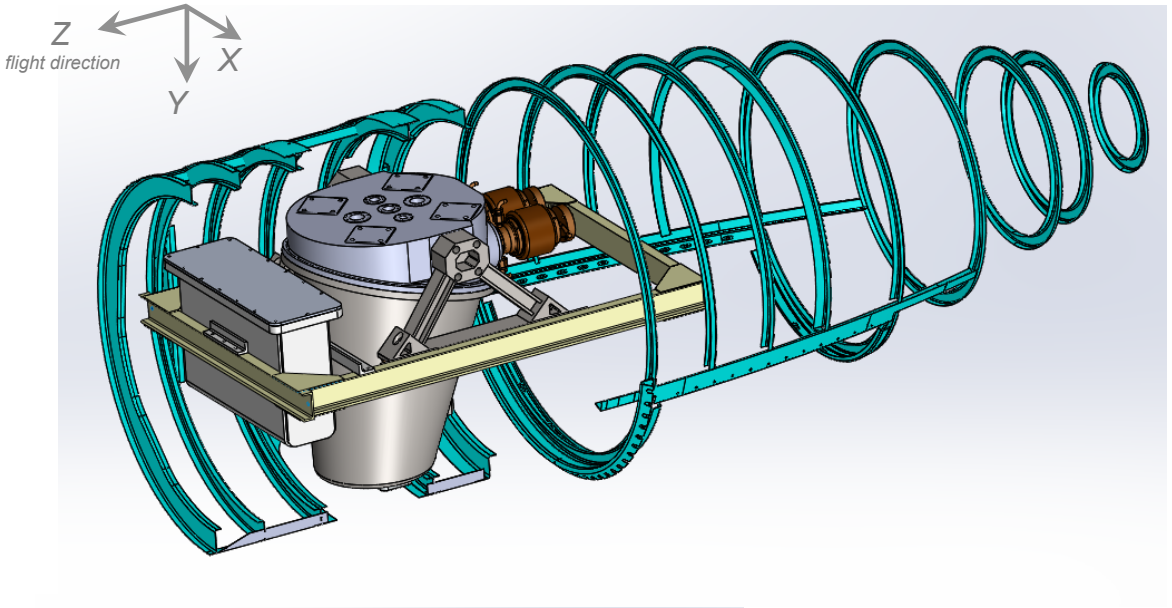
HyTES at Armstrong

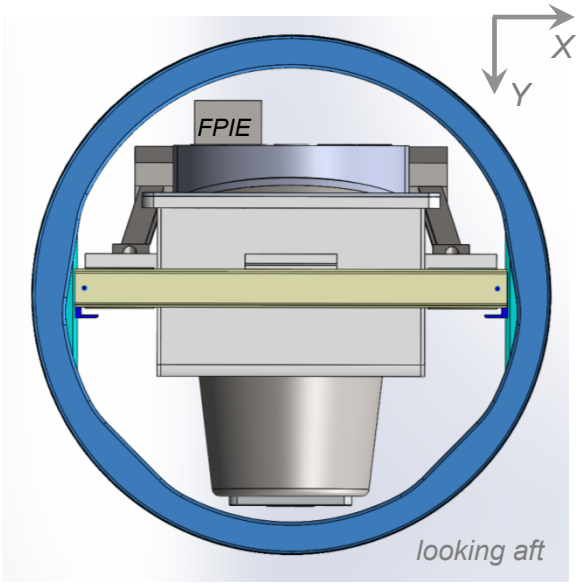


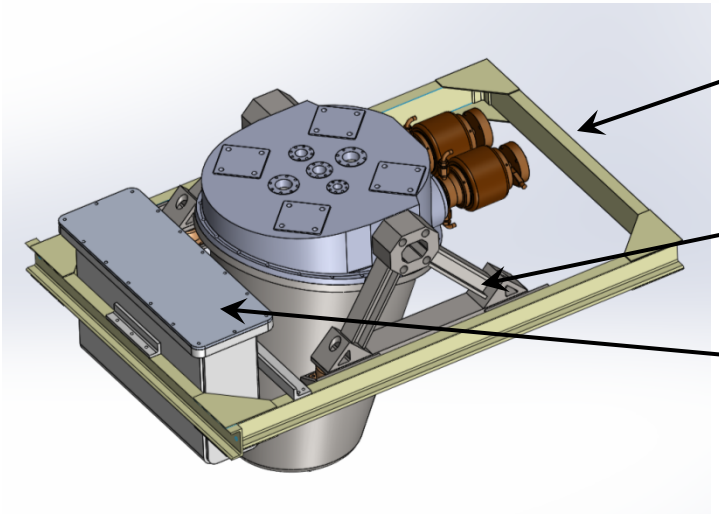
Integrate HyTES into the “Wing Pod” of the ER-2 aircraft

Team of students at CSULA helped design the peripheral mid and fore body components.

ER-2 Implementation



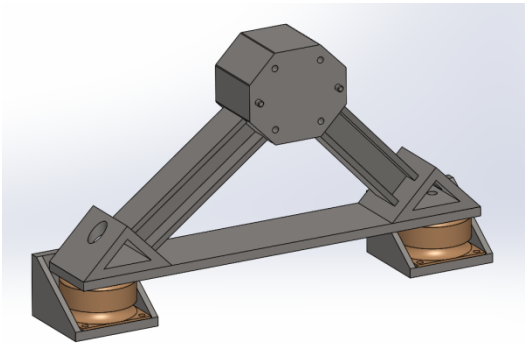




rack obtained from AFRC

New Mounts procured and delivered

PCM



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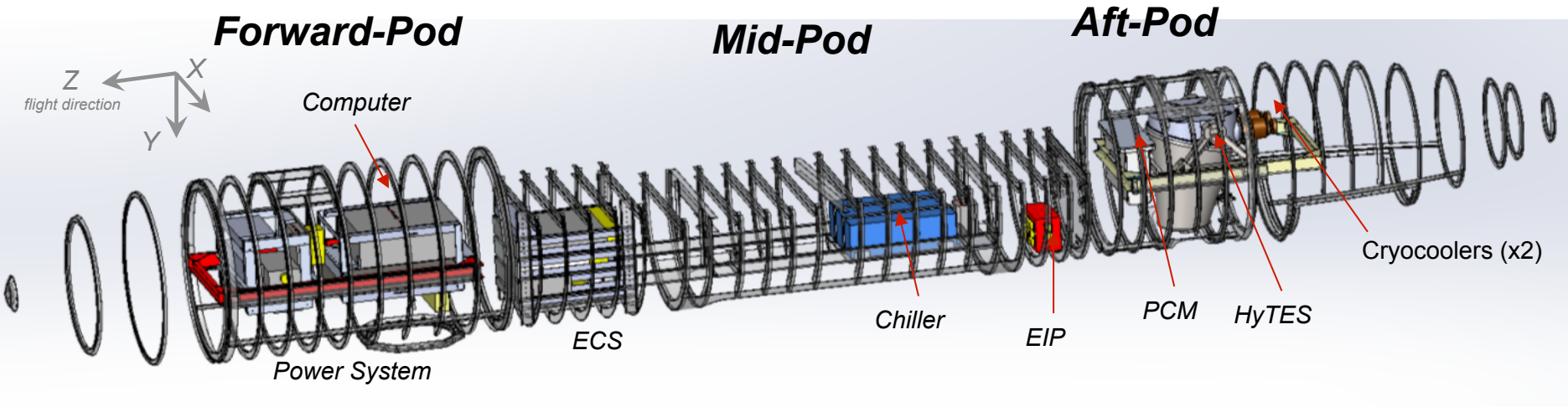
HyTES ER-2 Superpod layout



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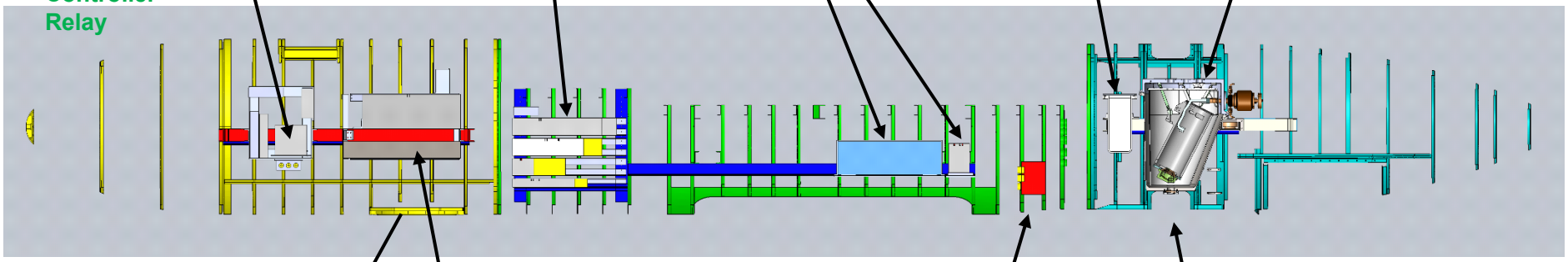
Cut-away view of Superpod



Cryocooler Controller
Temp Controller
Focal plane power
Lantronix network hub

KGS Power
Invertor
Power
Controller
Relay

C-MIGITS

Chiller

PCM

HyTES
Scanhead

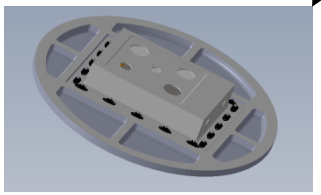
FORWARD

AFT

Data Computer
Power
distribution box

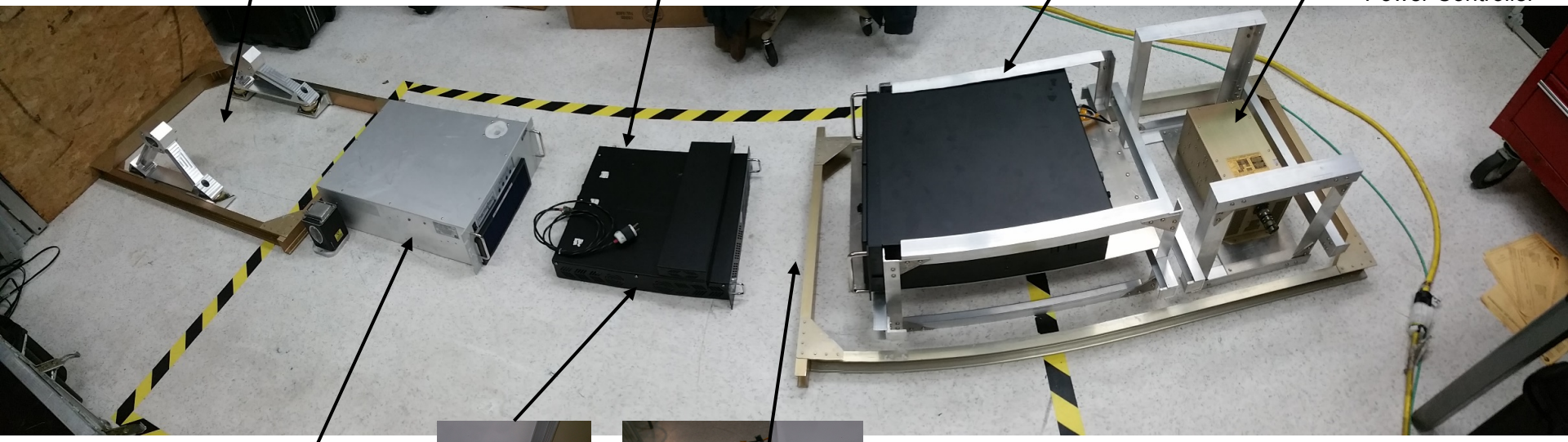
EIP
Interface
MUX
located
near focal
plane power

Clear Aperture (no window)



Auxiliary Panel

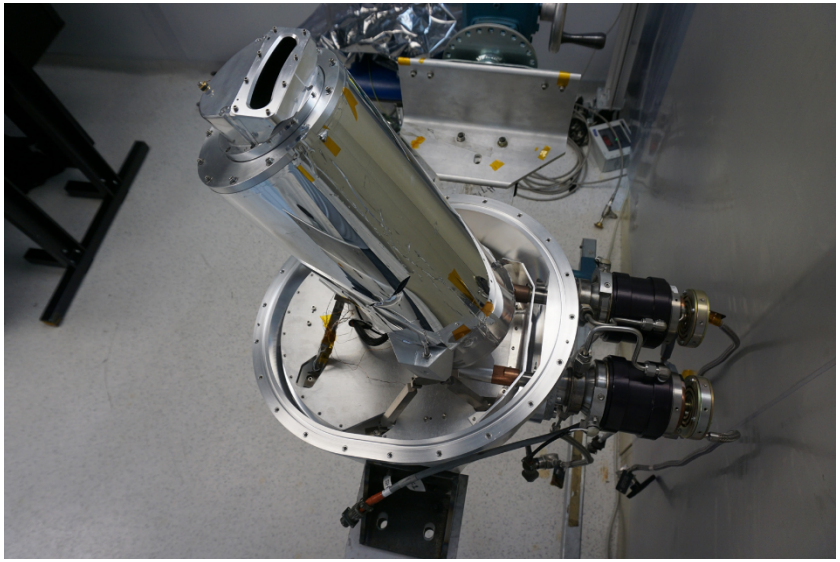
HyTES Hardware in Lab



Focal plane power

EIP interface (mounted on focal plane panel)

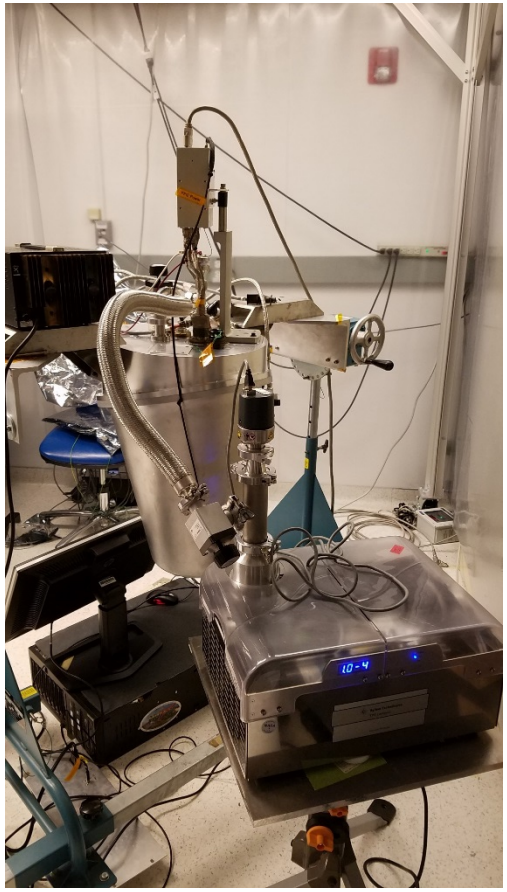
HyTES Scan Head in Lab



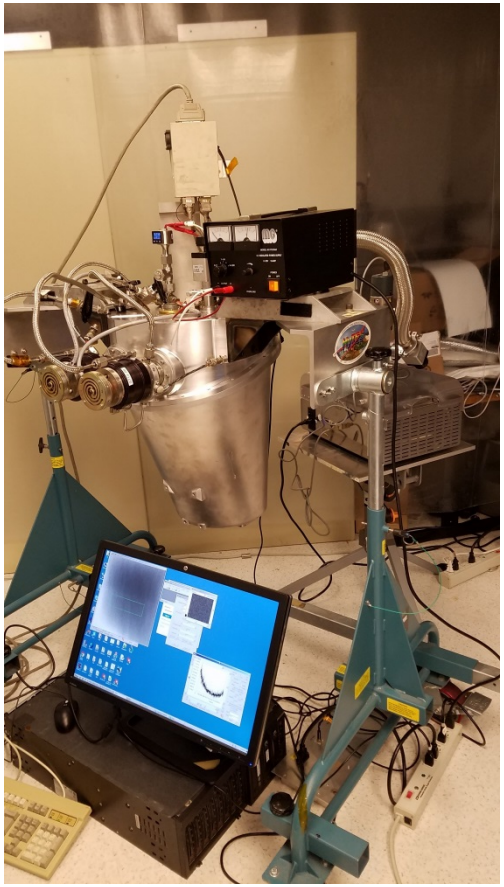
Scan head during assembly

Completion of assembly

HyTES Scan Head in Lab



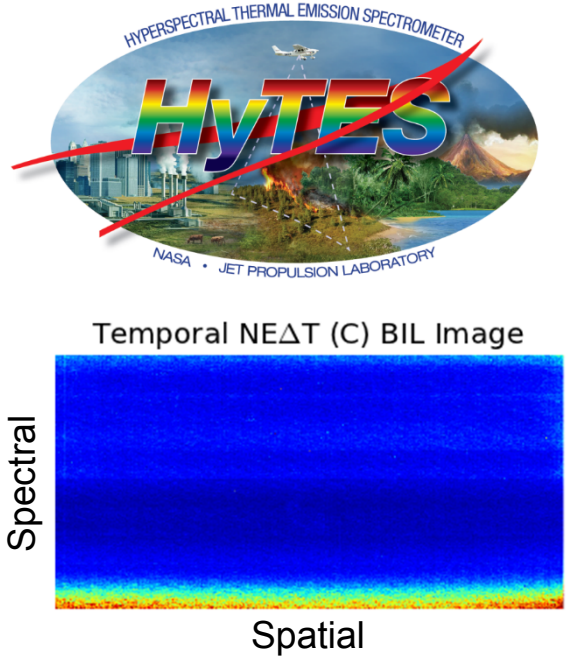
Successful pressure check the assembled system.



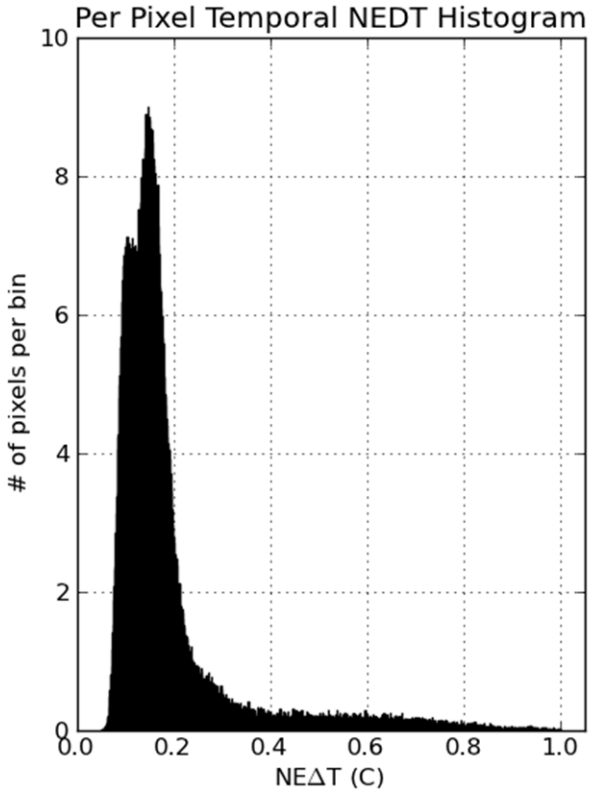
Successful FPA aliveness test after assembly and pump down verification.

HyTES Calibration Results

HyTES New ER-2 Configuration at cold equilibrium.

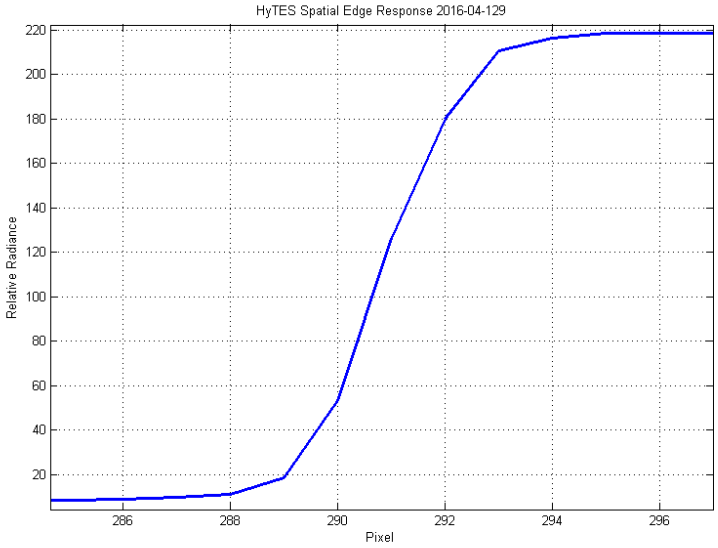


2-point calibration at
5C and 45C
25C Target

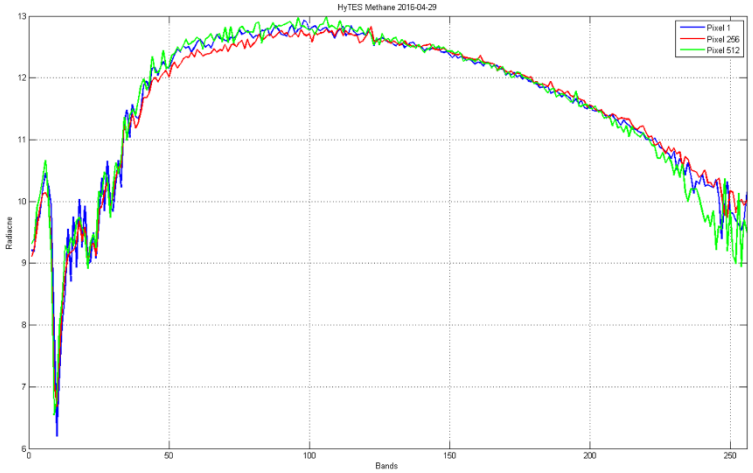


ESTO
Earth Science Technology Office

HyTES Calibration results



Accurate spatial response with input edge stimulus



Accurate spectral and cross field calibration response with input methane stimulus

Summary

- HyTES has flown many successfully science campaigns. All of the data from these are available online for download at http://hytes.jpl.nasa.gov
- The instrument successfully flew a ***rapid response*** campaign to Aliso Canyon in January 2016 to capture the SoCal Gas facility leak. Other smaller leaks were also discovered. The proper authorities were alerted via sponsor.
- HyTES transition to the ER-2 platform is progressing well technically and is expected to be completed in July 2016.
- The sensor can still operate on the twin-otter with the new vacuum assembly. A Twin otter trace gas campaign is expected to start sometime in August 2016 (pending the completion of ER2 readiness).
- We're currently scheduled to fly in the October 2016 time frame, but we will be ready earlier if the ER-2 becomes available.

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.