Testing the Expected Performance of the HyspIRI-TIR with the Prototype HyspIRI Thermal Infrared Radiometer (PHyTIR)

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2013 HyspIRI Science Workshop

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PHyTIR Project Overview

• Funded by NASA Instrument Incubator Program (IIP)
• To demonstrate a laboratory prototype of the HyspIRI TIR instrument
• Currently 2.5 years into 3-year project
• Goals are to demonstrate that:
  ➢ The detectors and readout meet all signal-to-noise and speed specifications.
  ➢ The scan mirror, together with the structural stability, meets the pointing knowledge requirements.
  ➢ The long-wavelength channels do not saturate below 480 K.
  ➢ The cold shielding allows the use of ambient temperature optics on HyspIRI without impacting instrument performance.
PHyTIR is Currently Assembled and Ready to Test

- Rotary Encoder
- Interferometric Encoder
- Vacuum Enclosure Containing Back-End Optics and 60K Focal Plane
- Scan Mirror
- Yoke
- M2
- M1
HyspIRI TIR Scan Concept

Focal Plane
8 Spectral Bands
× 256 Pixels

Scan Mirror

Direction of Spacecraft Motion

256 Pixels
15 km ±0.7°

9287 Pixels, 596 km, ±25.5°

• 60 m Pixel Footprint at Nadir
• Time-Averaged Science Data Rate 0.020 Gbps
• Assuming 14 bits, 2:1 Compression, 31% Land
• Scan Mirror Rotation Rate 14.2 RPM
• Pixel Dwell Time 32 microseconds
Key Differences from HyspIRI TIR Instrument

- Commercial cryocoolers used
- 3 representative spectral filters instead of 8
- Laboratory electronics used for control and data collection
PHyTIR Optics

- Scan Mirror
- M2
- M1 Baffle
- M1
- Vacuum Window
- Fold Mirror
- FPA
- Filters
- Lyot Stop and Baffle
- M3 Relay
- Vacuum Enclosure

Nadir Baffle

Nadir 51° Field of View

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TIR Focal Plane

- Butcher-Block Filter Assembly
- Baffles to Prevent Crosstalk Between Spectral Channels
- HyspIRI will have 8 filters, PhyTIR has 3 filters

- CMOS Read-Out Integrated Circuit (ROIC)
- 32 Analog Output Lines to Enable Necessary Pixel Read Rate

- MCT Detector Array – 256 elements cross-sweep
- 1 Bandgap to Cover Full Spectral Range
- \( \geq 4 \) Detector Columns per Spectral Channel to Allow Time Delay and Integration (TDI)

- 60 K Cold Tip of Cryocooler

- JPL/Teledyne focal planes are in hand at JPL
- Digitization in off-chip ADCs
- TDI performed after digitization
- Cold testing shows expected performance at full readout speeds
Focal Plane Readout Architecture

16 x 256 pixels in each spectral band. Only 4 x 256 pixels are read out.

Analog MUX
Analog MUX
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Analog MUX

4 µm  7.3 µm  8.3 µm  8.6 µm  9.1 µm  10.5 µm  11.3 µm  12 µm

PHyTIR Bands
PhyTIR Focal-Plane Assembly

- Focal-Plane Board
- Fold Mirror
- 60K Baffle
- Moly Plate
- Moore Mount
- 60K Baffle
NETD of PhyTIR Bands

Noise-Equivalent Temperature Difference with TDI

- 4 microns
- 8 microns
- 12 microns

Scene Temperature (K)

Noise Equivalent Temperature Difference (K)

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NETD of PhyTIR Bands – Full Temperature Range

![Diagram showing Noise-Equivalent Temperature Difference with TDI](image)

- **4 microns**
- **8 microns**
- **12 microns**

**Scene Temperature (K)**

**NETD (K)**

Date: 10/17/2013
PHyTIR Testing

- Instrument is in air. Vacuum enclosure around focal-plane is evacuated. Scan mirror rotating.

- Blackbody source will allow measurements of:
  - Response
  - Noise
  - Temperature Sensitivity
  - Linearity
  - Saturation Temperature
  - Limited testing of efficacy of optical design and cold baffle to minimize radiation from warm optics and baffling.

- Slit sources will allow measurements of:
  - Capability for coordinating scan mirror with focal-plane data collection
  - Detector Point Spread Functions
  - Precision of Scan Mirror Position Determination
  - Pointing Stability
Plans for Remaining PHyTIR Activities

• October Through December 2013
  ➢ Complete Instrument Housing
  ➢ Optimize Motor Control
  ➢ Automate Thermal System
  ➢ Basic Detector Testing
  ➢ Receive Target Projector Test Source with Blackbody and Slits

• January Through March 2014
  ➢ Blackbody Testing
  ➢ Field-of-View and Pointing Testing
  ➢ Write Final Report