National Aeronautics and Space Administration

LDCM Operational Land Imager and Thermal Infrared Sensor Performance

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SPIE
Earth Observing
Systems XVI

data continuity mission

LDCM
LANDSAT

NASA GSFC / USGS EROS

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Landsat and LDCM Spectral and Spatial Requirements

	Landsat-5/7 TM/ETM+ Bands (µm)			LDCM Band Requirements (µm)			
				30 m Coastal/Aerosol	0.433 - 0.453	Band 1	
ETM+	Band 1	30 m Blue	0.450 - 0.515	30 m Blue	0.450 - 0.515	Band 2	
ETM+	Band 2	30 m Green	0.525 - 0.605	30 m Green	0.525 - 0.600	Band 3	OLI
ETM+	Band 3	30 m Red	0.630 - 0.690	30 m Red	0.630 - 0.680	Band 4	
ETM+	Band 4	30 m Near-IR	0.775 - 0.900	30 m Near-IR	0.845 - 0.885	Band 5	
ETM+	Band 5	30 m SWIR-1	1.550 - 1.750	30 m SWIR-1	1.560 - 1.660	Band 6	
ETM+	Band 6	60/120m* LWIR	10.40 - 12.50	120 m LWIR-1	10.30 –11.30	Band 10	TIRS
				120 m LWIR-2	11.50 –12.50	Band 11	
ETM+	Band 7	30 m SWIR-2	2.090 - 2.350	30 m SWIR-2	2.100 - 2.300	Band 7	
ETM+	Band 8**	15 m Pan	0.520 - 0.900	15 m Pan	0.500 - 0.680	Band 8	OLI
				30 m Cirrus	1.360 - 1.390	Band 9	

Operational Land Imager (OLI)

- Key instrument requirements
  - Cross-track FOV 185 km
  - S/C altitude 705 km
  - Geodetic accuracy*
    - Absolute 65 m
    - Relative 25 m
  - Geometric accuracy**
    - Absolute 12 m

Band Name	CW (nm)	Bandwidth (nm)	GSD (m)	SNR
Coastal/ Aerosol	443	20	30	130
Blue	482	65	30	130
Green	562	75	30	100
Red	655	50	30	90
NIR	865	40	30	90
SWIR 1	1610	100	30	100
SWIR 2	2200	200	30	100
PAN	590	180	15	80
Cirrus	1375	30	30	50

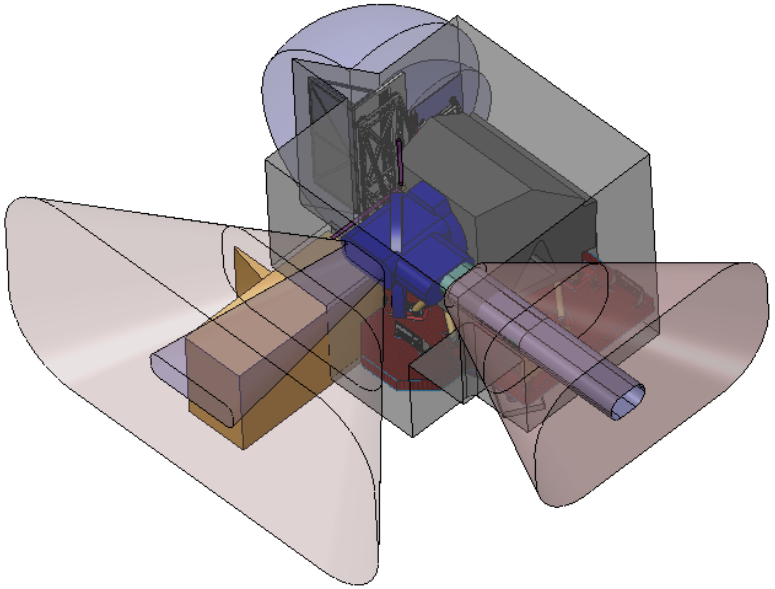
Visible/NIR SWIR

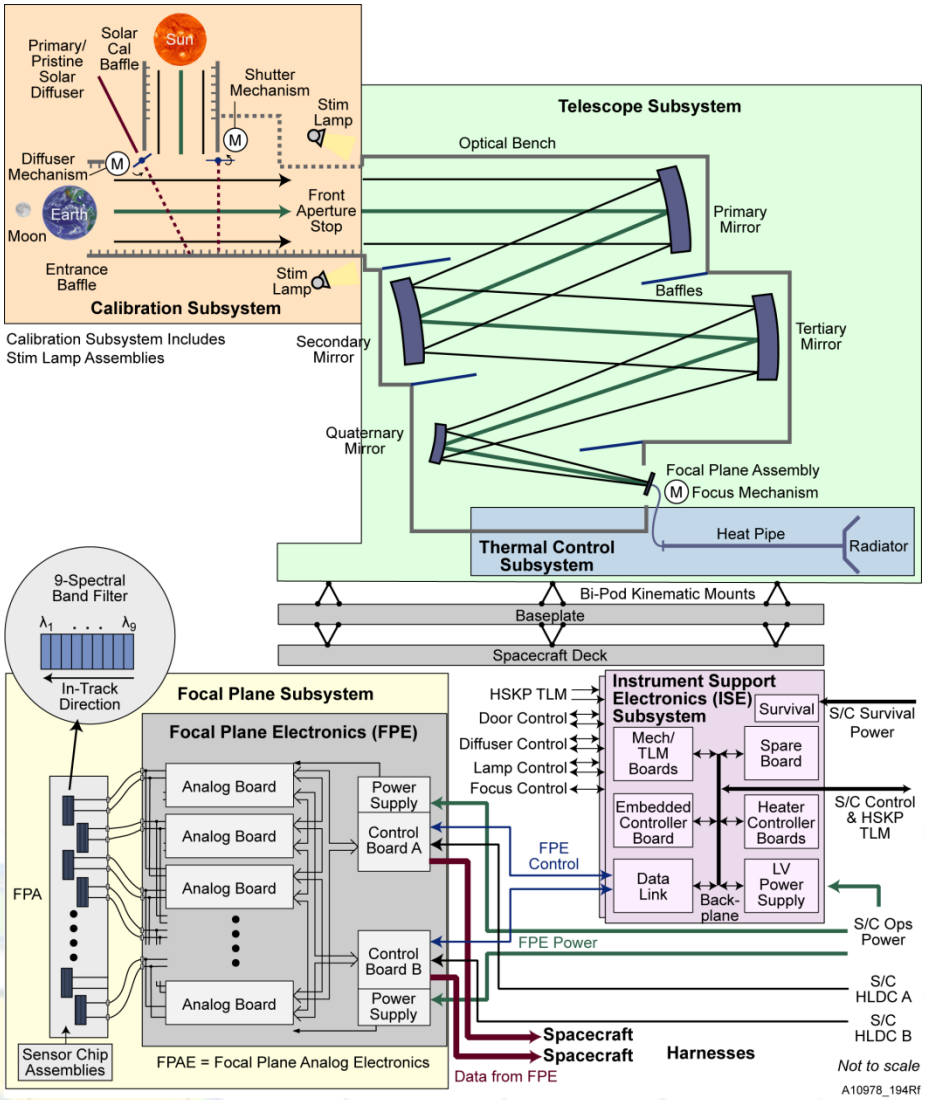
*No terrain compensation
**w/ terrain compensation

Instrument Complete

Operational Land Imager (OLI)

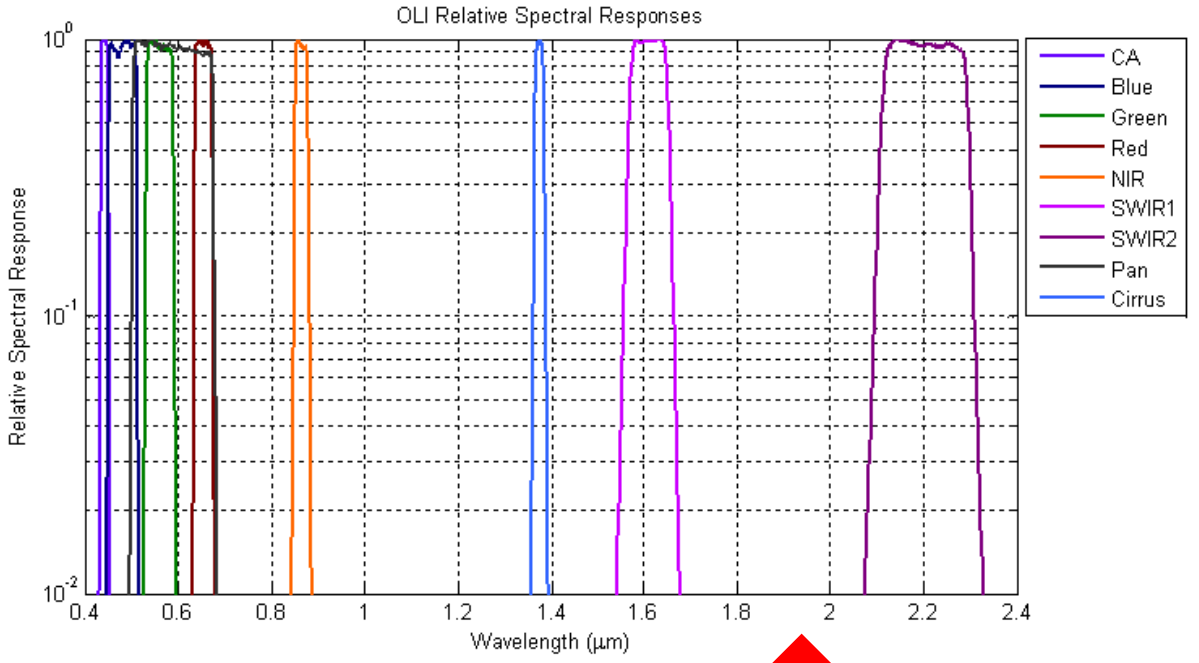
- Pushbroom VIS/SWIR sensor
- Four-mirror telescope with front aperture stop
- FPA consisting of 14 sensor chip assemblies, passively cooled
- On-board calibration with both lamps and full aperture diffusers

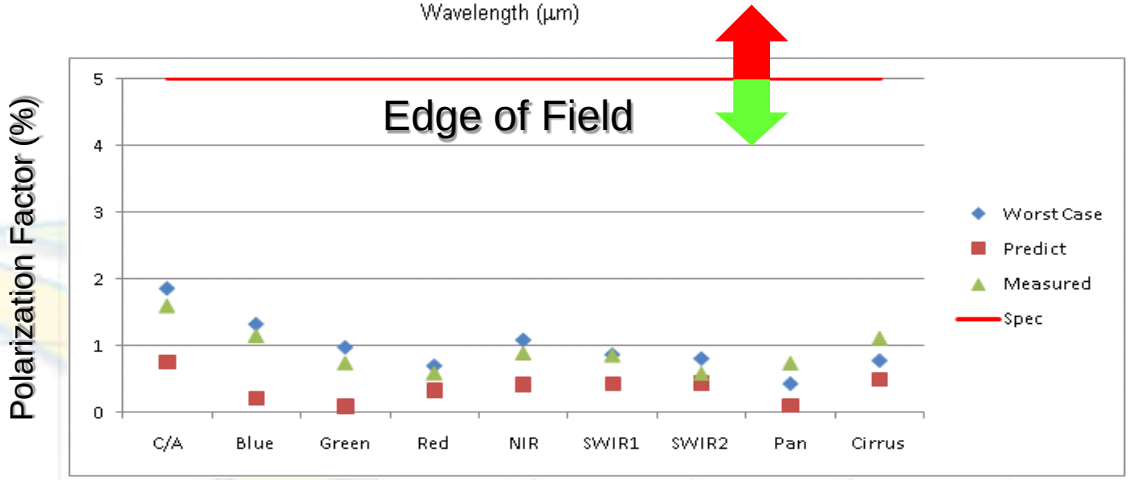




OLI Spectral and Polarization Performance

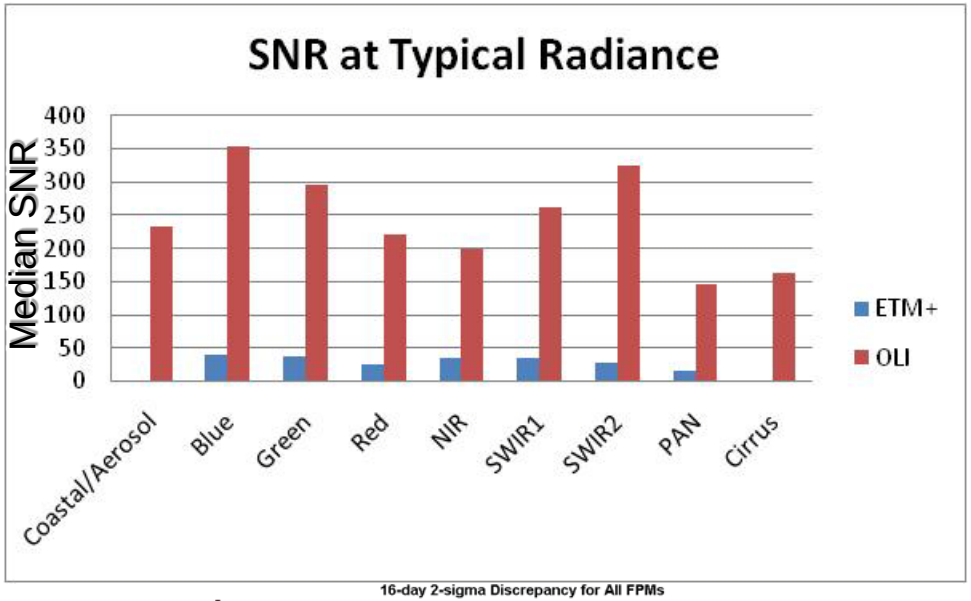
- Spectral Performance
  - Measured at instrument level for sampling of detectors from each focal plane module
    - Meets all requirements
  - Out-of-Band Response measured at focal plane module level for all detectors
    - typically below 10^{-4}
- Polarization Sensitivity
  - Measured at instrument level
  - Below 2%

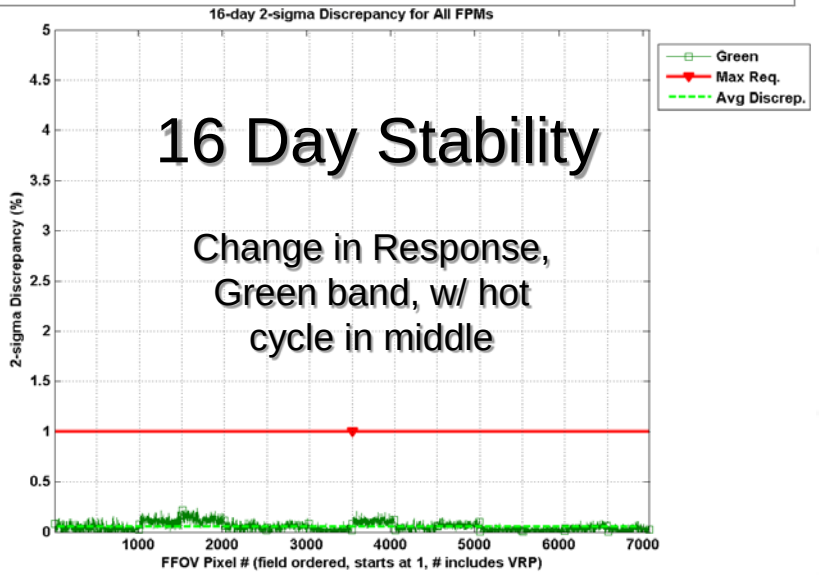




OLI Radiometric Performance

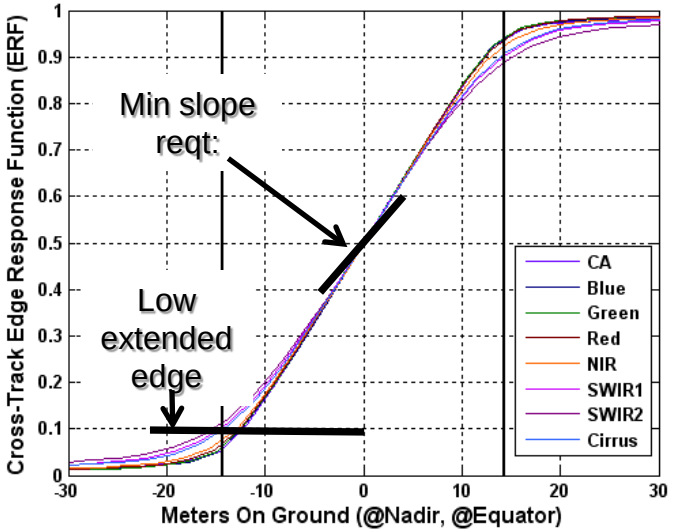
- SNR
  - SNR significantly exceeds requirements and heritage
- Calibration
  - Absolute uncertainty ~4%
    - Extensive round robin for validation
    - Transfer-to-Orbit uncertainties included
  - Stability over 60 seconds (2 standard scenes)
    - <0.02% 2σ
  - Stability over 16 days (time between Solar Diffuser Cals)
    - <0.54% 2σ for all but Cirrus Band which is <1.19%
- Uniformity
  - Typically better than 0.5%
    - A few detectors and FPM boundaries may exceed this

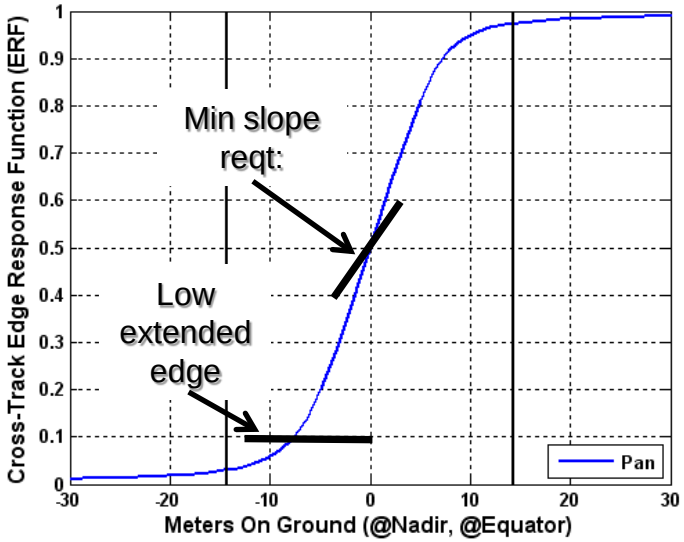




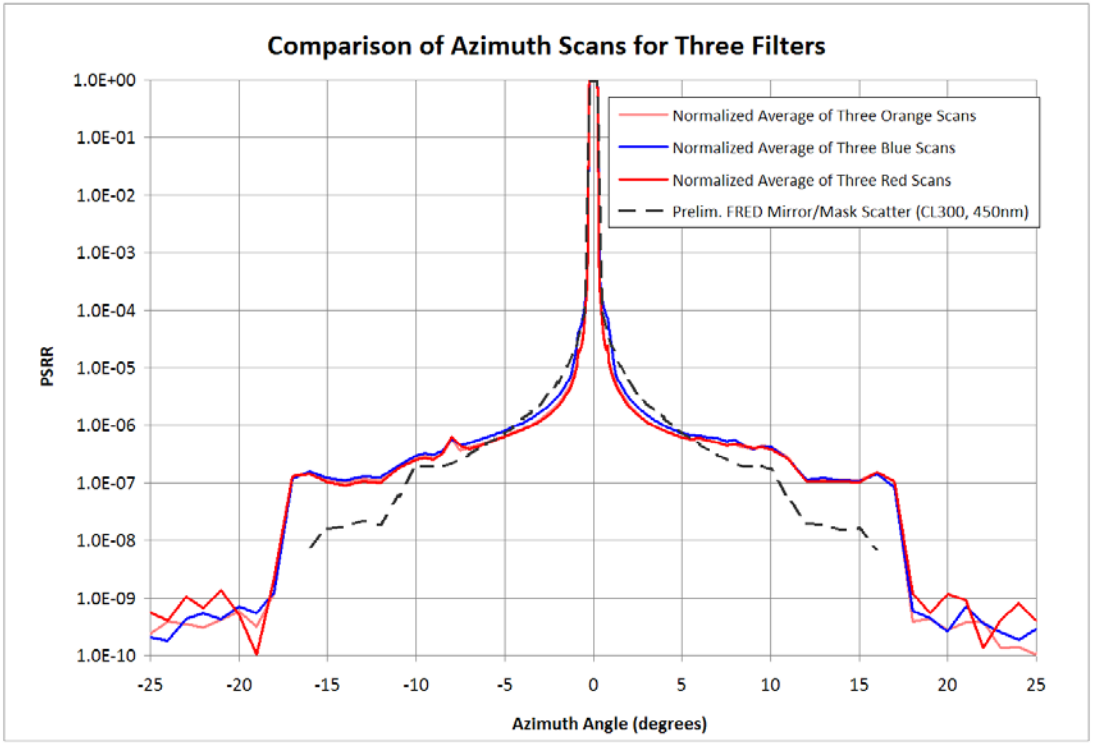
OLI Spatial Performance

- Spatial Performance
  - Want sharp edges for change detection
  - Measured spatial response has:
    - Steep slope (exceeding reqts)
    - Low extended edge (good half edge extent)
    - No ripple/overshoot
- Geolocation
  - Want good pointing knowledge, again for change detection
  - Performance depends on both instrument and spacecraft; final measurements made during initial on-orbit checkout
  - Pre-launch instrument measurements mapped line of sight of all detectors to reference pixel/boresight to ~1/10th of a pixel
  - On target to have absolute geometric accuracy of <1/2 pixel





OLI Stray Light

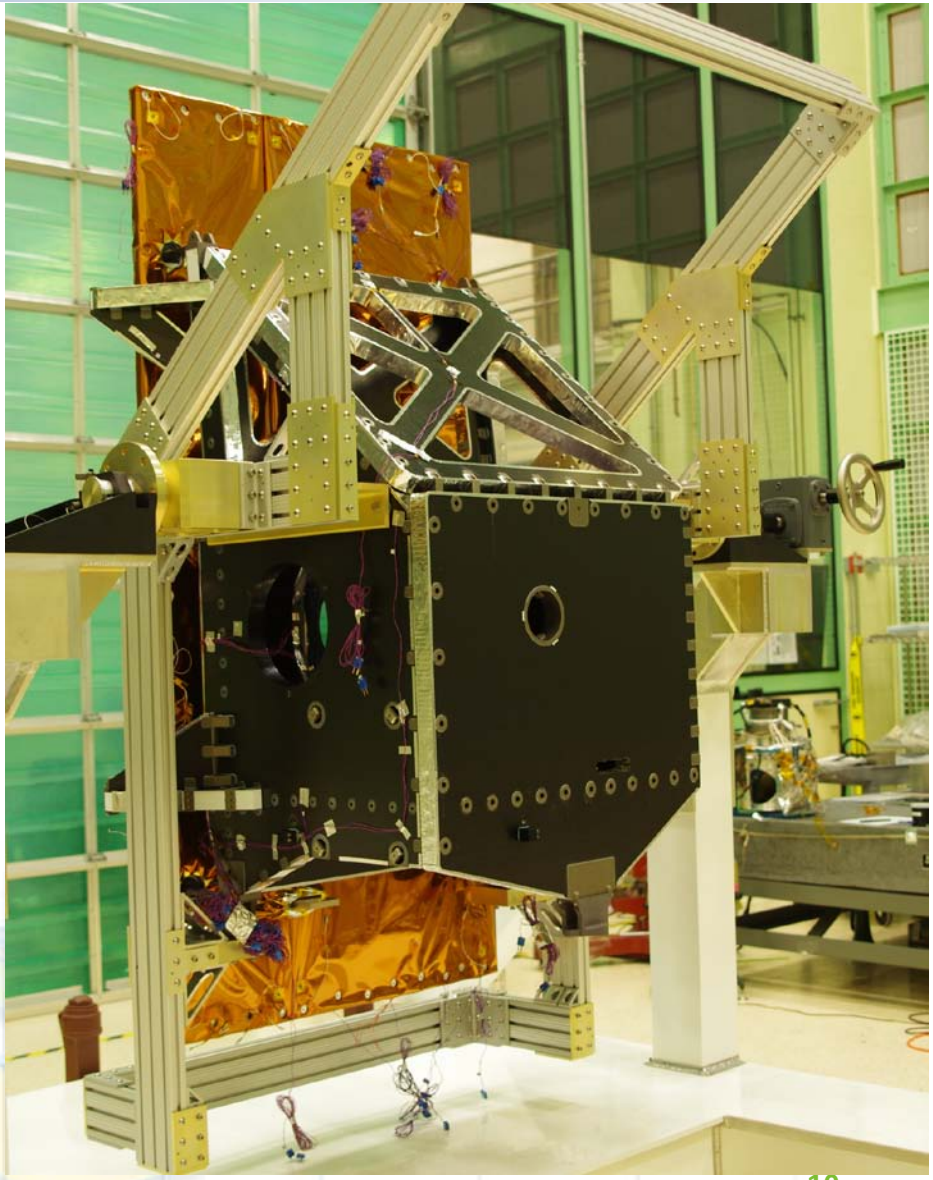


- Meets requirements
- Consistent with modeled performance

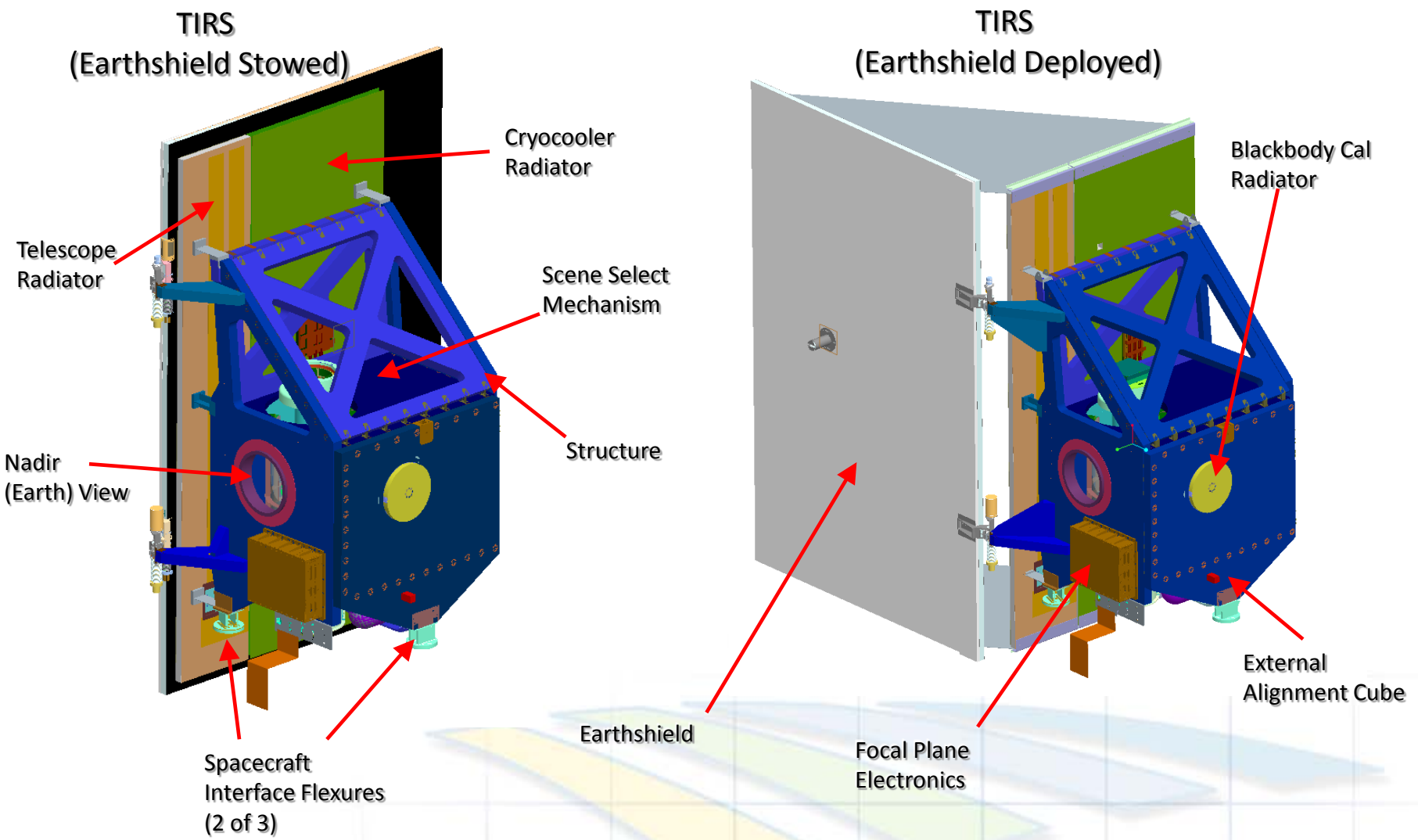
Stray Light Ninjas

Thermal Infrared Sensor (TIRS)

- Quantum well infrared photodetector (QWIP) focal plane array (built at GSFC), at 43K
- 2-Channel IR spectral imager
  - 10.8 μm and 12 μm
  - Split window atmospheric correction
- Two full aperture calibration sources
  - Onboard blackbody
  - Space view
  - Calibration every 34 minutes
- Scene select mirror selects between calibration sources, nadir
- 185 km ground swath (15° FOV)
- 100 meter resolution
- TIRS delivery December 2011
- 3.25 year life, Class C instrument
- TVAC testing (full instrument) started

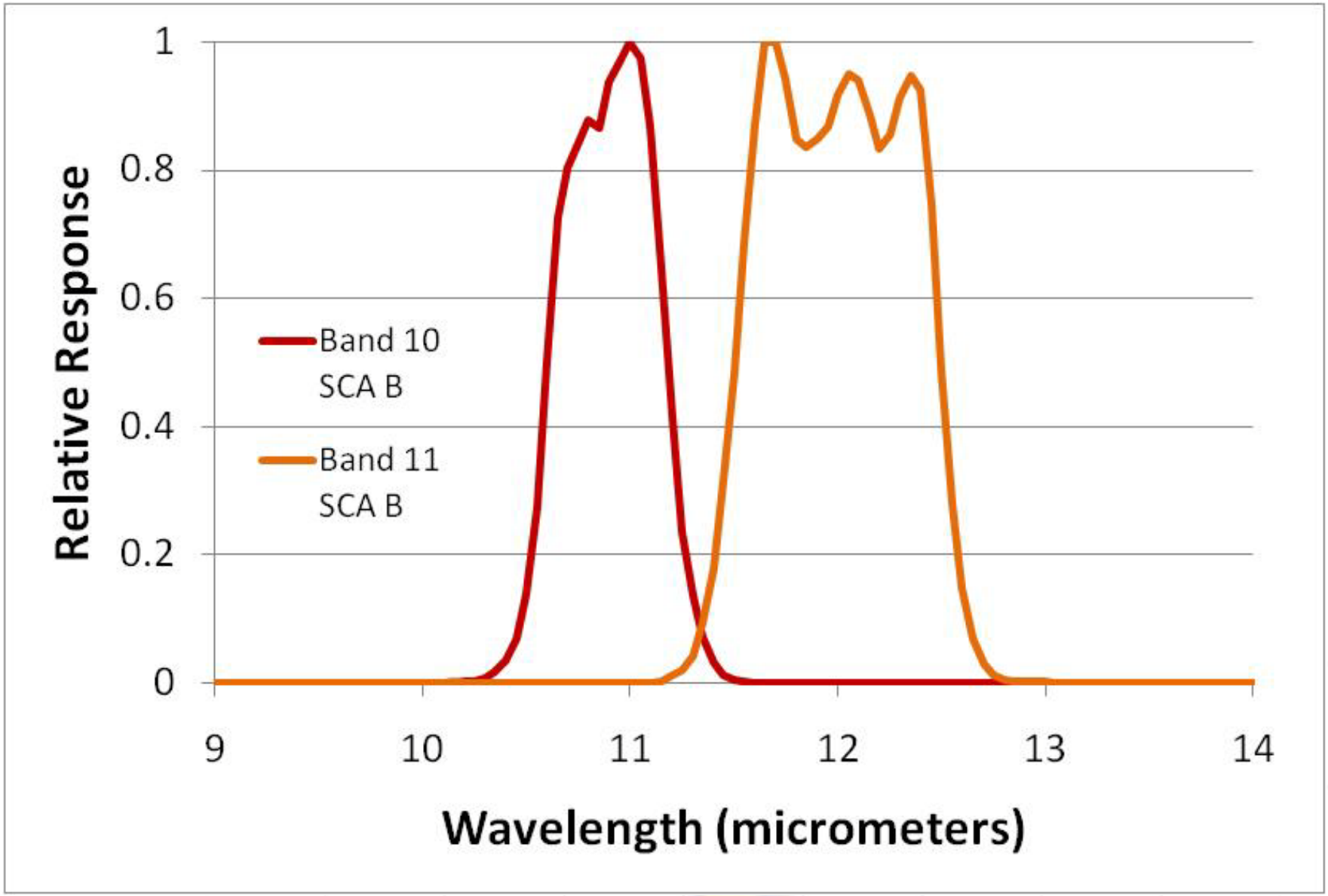


TIRS Overview



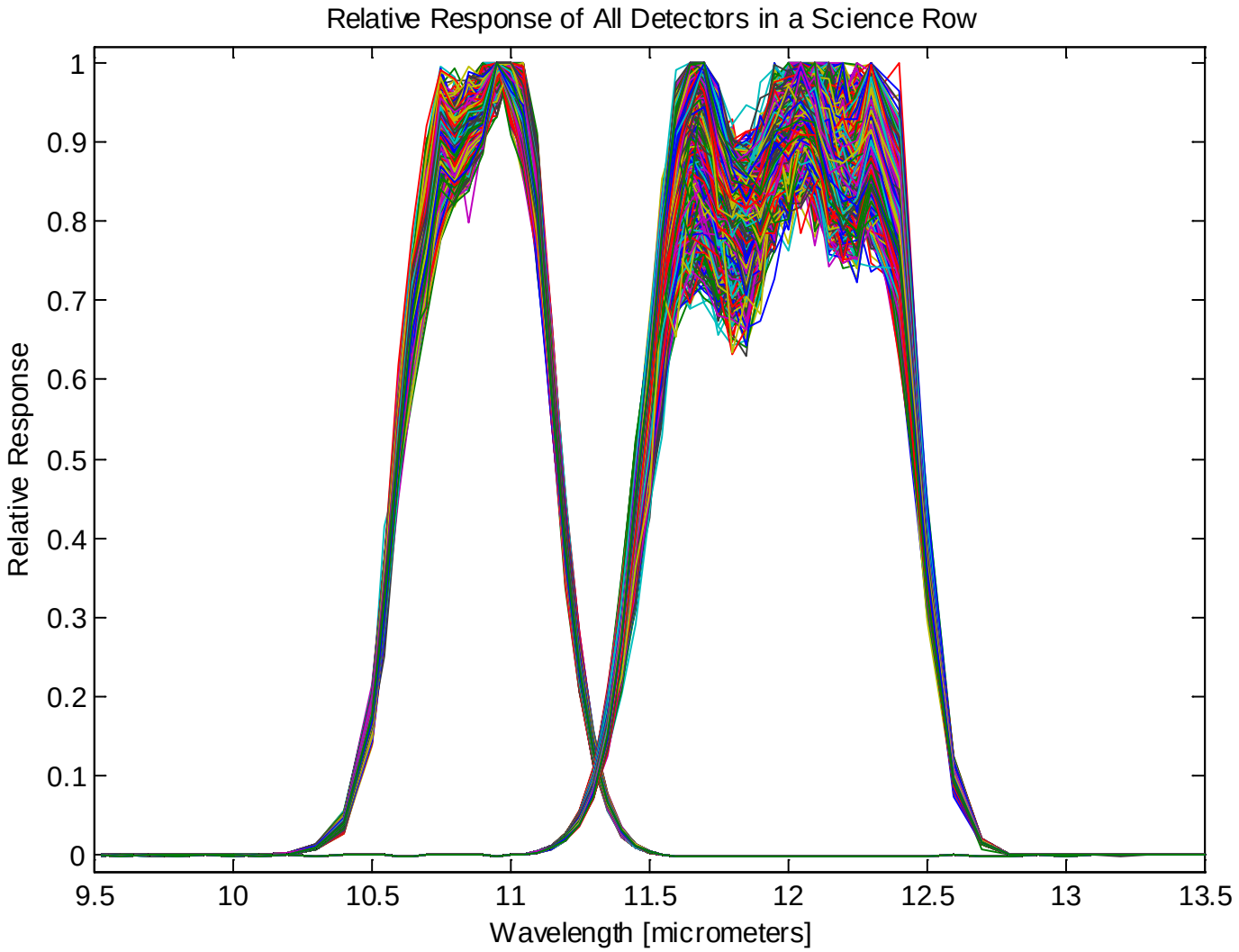
TIRS Relative Spectral Response

Average: based on component level measurements



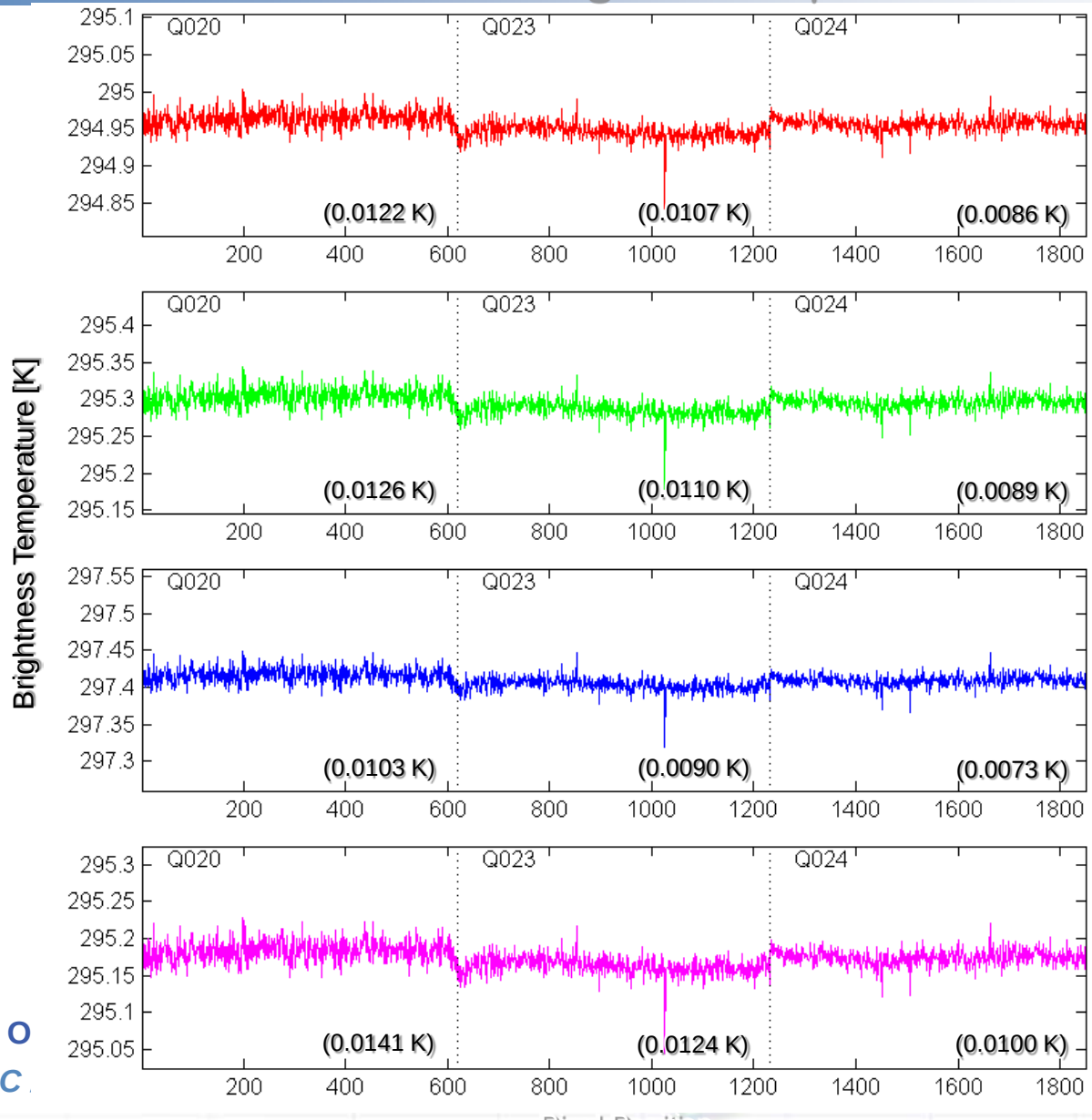
TIRS Relative Spectral Responses

All Detectors – based on component measurements



Spectral Uniformity Impact

300K Surface Target : 10.8 μm band



Tropical

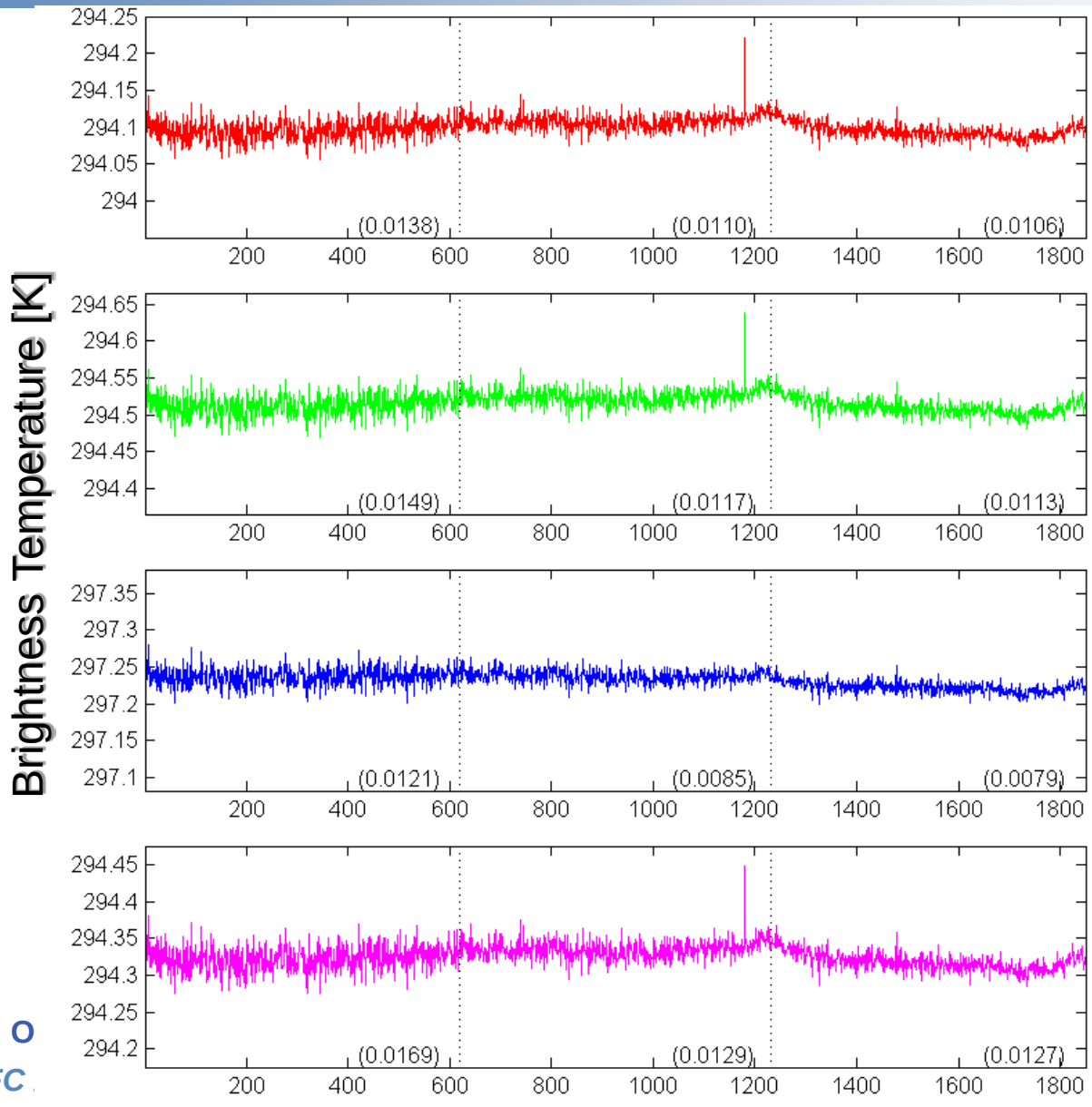
Mid-Latitude Summer

Mid-Latitude Winter

Sub-Arctic Summer

Spectral Uniformity Impact

300K Surface Target : 12.0 μm band



Tropical

Mid-Latitude Summer

Mid-Latitude Winter

Sub-Arctic Summer

TIRS Calibration Images

Dark Band

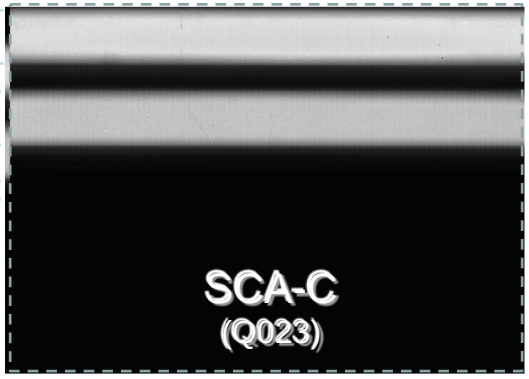
10.8 um Band

12 um Band

~ 36 un-vignetted rows

~ 36 un-vignetted rows

~ 18 dark rows



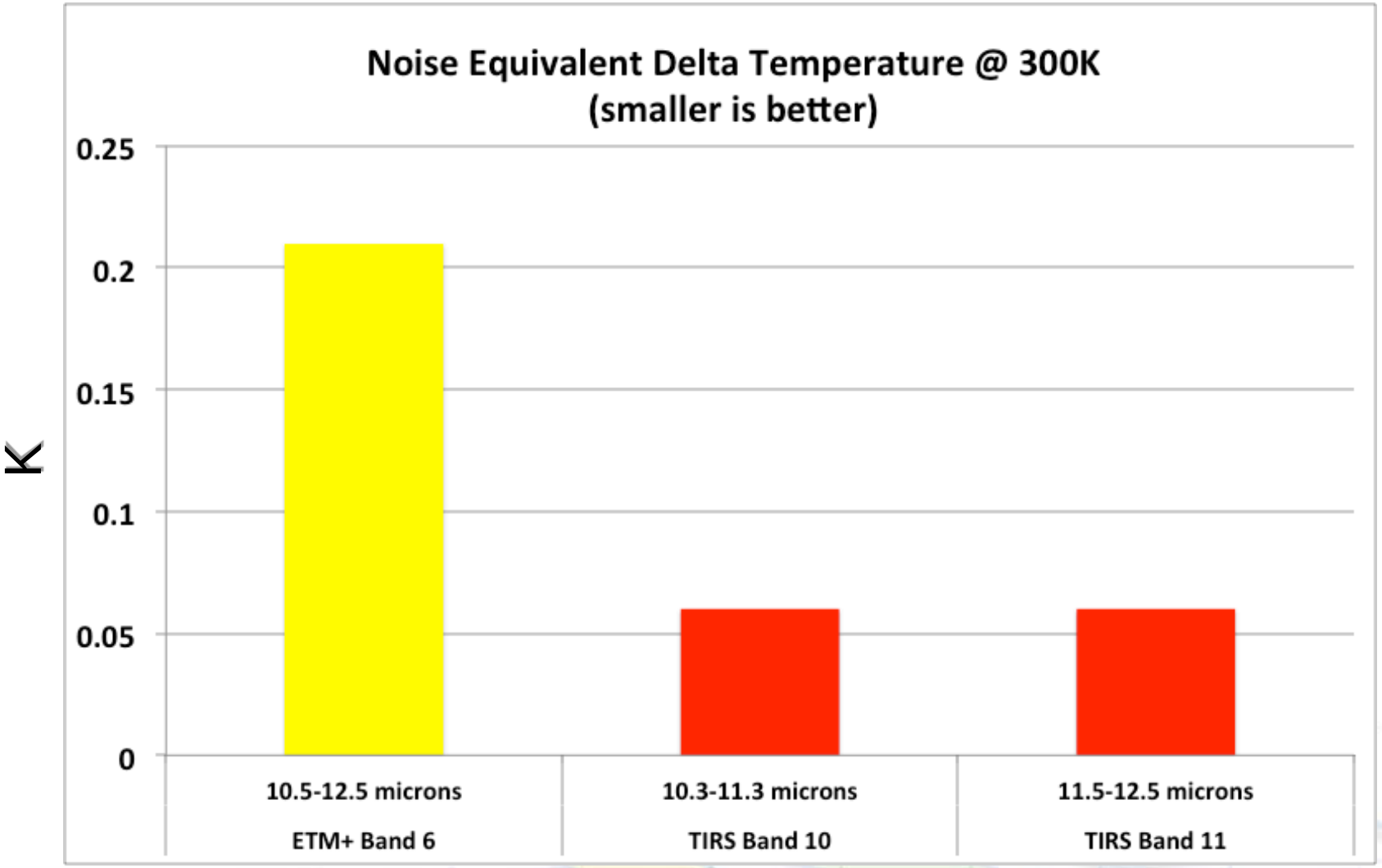
12 um Band

10.8 um Band

Dark Band

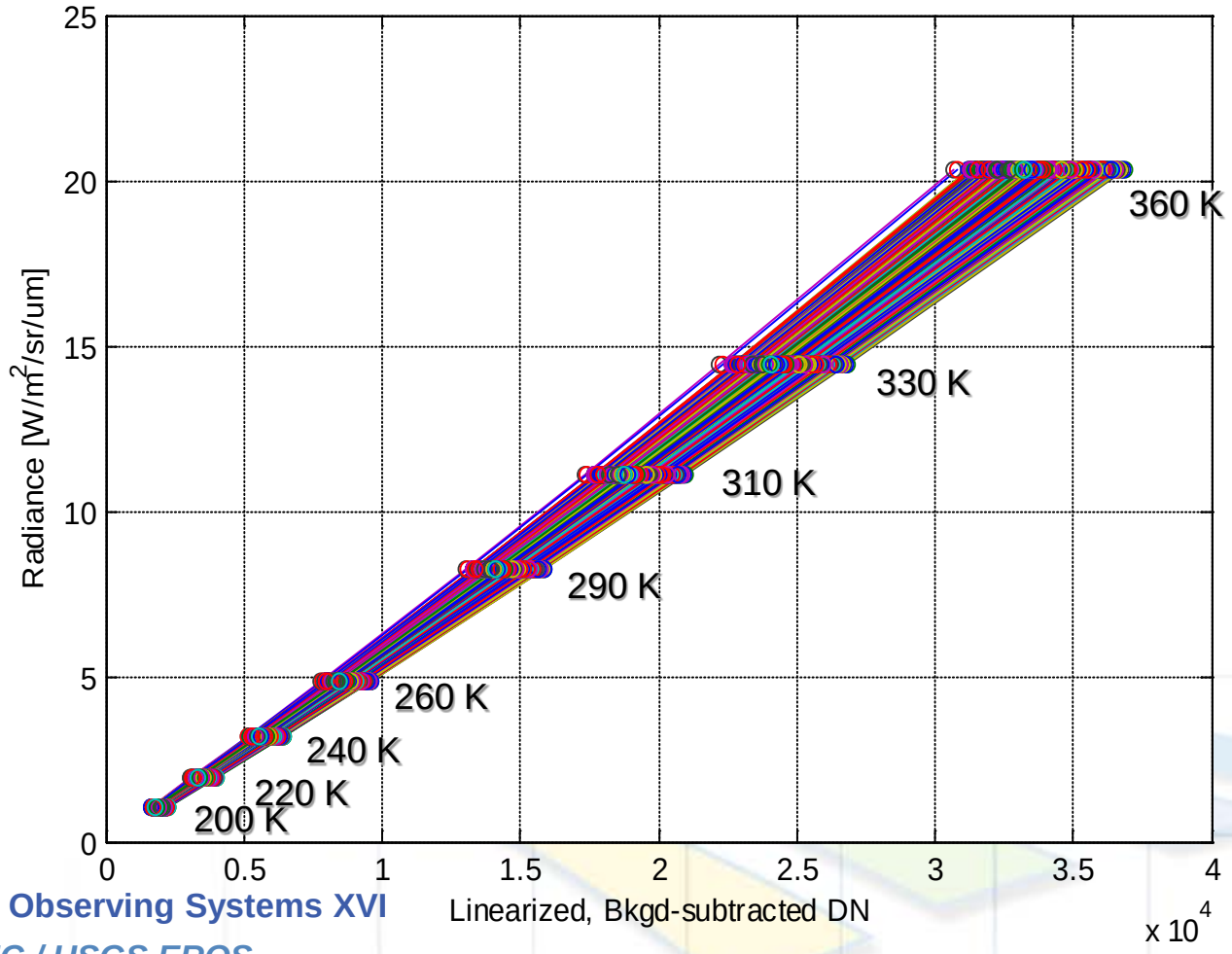
- SNR ~1,500 for 360 K source and ~1,000 for 300 K
- >3X more than required
- Consistent with shot-noise limited

TIRS Preliminary Radiometric Performance



Radiometric Responsivity Variation with 12.0 μm Band

Radiance vs. Linearized, Bkgd-subtracted DN for IRSM temperatures of:
[200 K, 220 K, 240 K, 260 K, 290 K, 310 K, 330 K, 360 K]



Summary

- OLI
  - Instrument complete – currently investigating heater controller anomaly
  - SNR performance substantially exceeds requirements
  - Absolute calibration meets requirements
  - Relative (detector to detector) calibration meets requirements with possible exception of a few FPM boundaries and a few detectors
  - Spatial response meets requirements
- TIRS
  - Instrument now in primary thermal vacuum performance testing
  - SNR performance expected to substantially exceed requirements
  - Absolute calibration expected to exceed requirements
  - Relative (detector-to-detector) calibration expected to meet requirements