The Portable Remote Imaging Spectrometer (PRISM) Coastal Ocean Sensor

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The PRISM Team

Instrument team

Pantazis (Zakos) Mouroulis: *PI, optics*
Byron Van Gorp: *System engineer & mechanics*
Robert O. Green: *Calibration, radiative transfer*
Daniel Wilson: *Diffraction grating*

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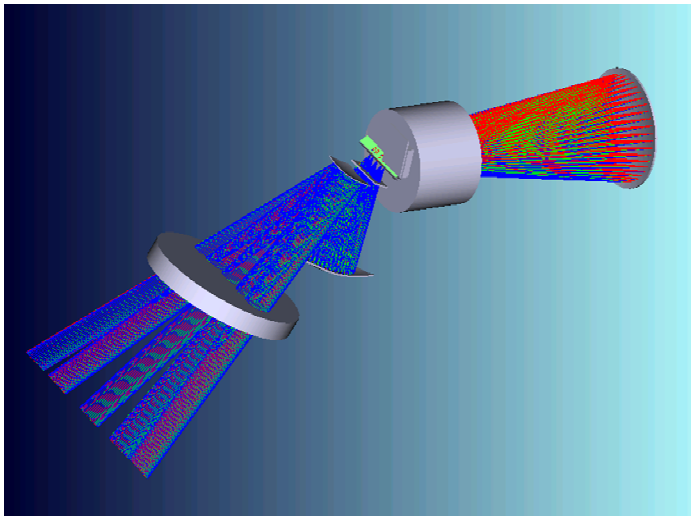
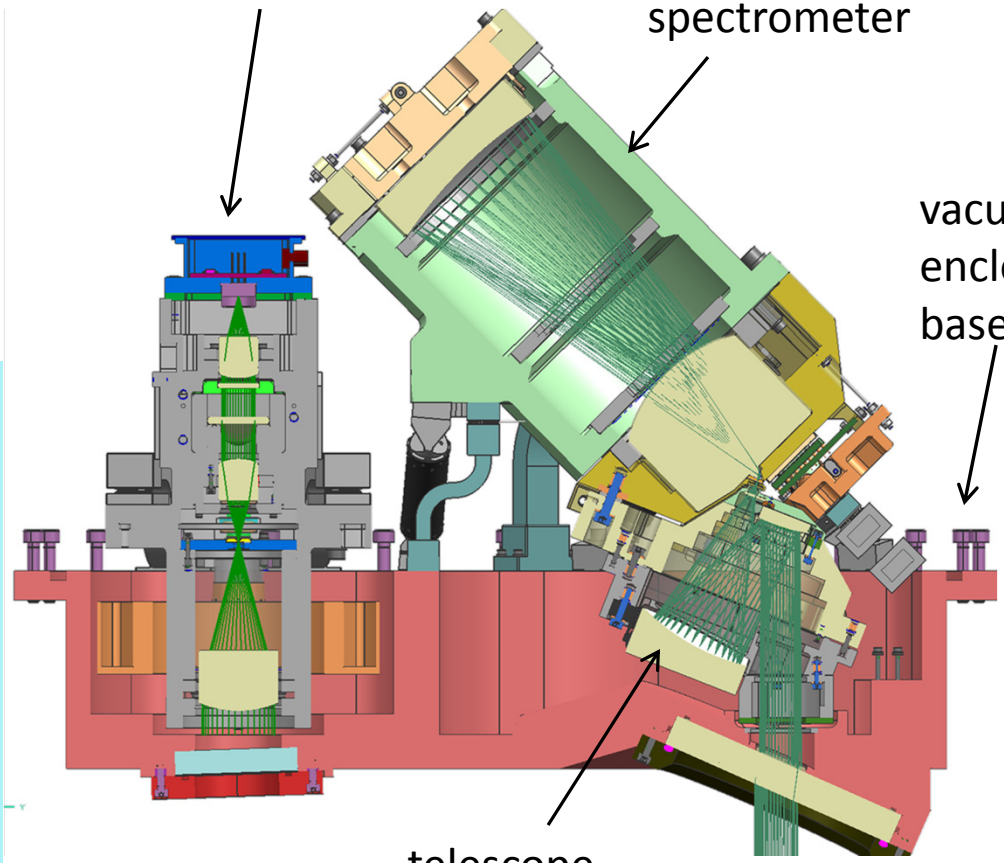
Science team

Heidi Dierssen (UConn): *Science lead*
Bo-Cai Gao (NRL): *Atmospheric correction algorithm*
Joe Boardman (AIG): *Orthorectification, geolocation*

PRISM schematic





Spectrometer parameters

Spectral	Range	350-1050 nm
	Sampling	2.85 nm
	Resolution (FWHM)	3.5 nm
	Calibration uncertainty	< 0.1nm
Spatial	Field of view	31.7°
	Instantaneous FOV sampling	0.882 mrad
	IFOV resolution (FWHM)	0.97 mrad
	Cross-track spatial pixels	608
	Ground resolution	0.35 – 20 m
Radiometric	Range	0 to max. beach R
	Sampling	14 bit
	Stability	>99%
	Calibration uncertainty	<2%
	SNR	2000 @450 nm*
	Polarization variation:	< 1%
Uniformity	Spectral cross-track uniformity	>95%
	Spectral IFOV mixing uniformity	>93%

* At AVIRIS equivalent integration time and spectral sampling

Values in red are measured

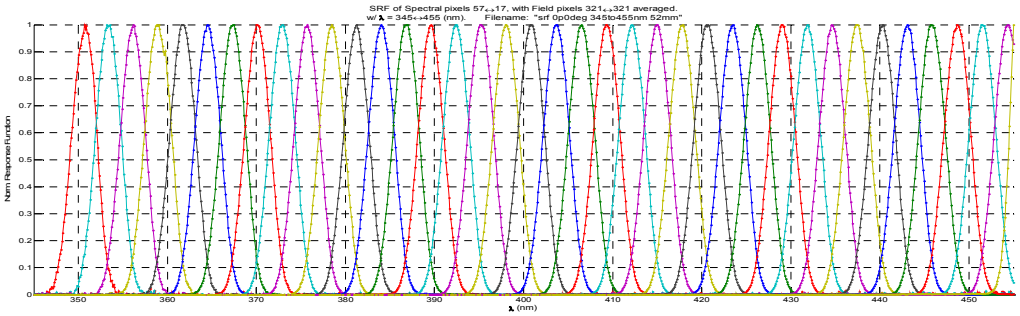
SWIR channel parameters

Parameter	Channel 1	Channel 2
Channel center (nm)	1240	1610
Bandwidth (nm)	20	60
FOV (mrad, FWHM)	2.4	2.4
Boresight knowledge (mrad, relative to spectr.)	0.05	0.05
Radiometric stability	99%	99%
SNR @ 1.2μW/cm^2 sr	325	390

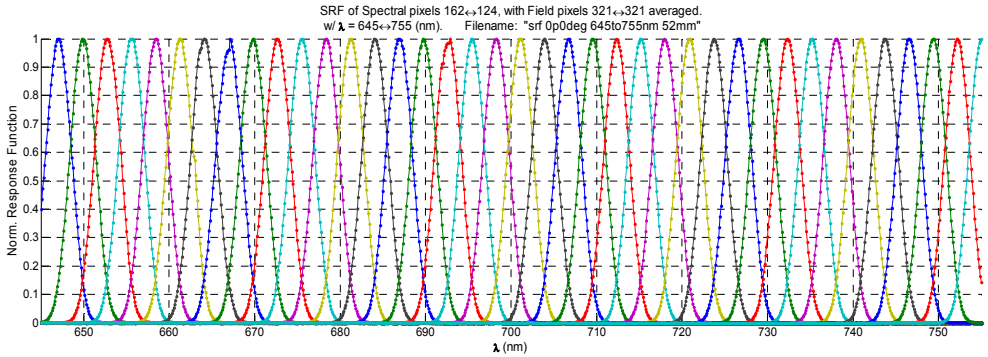
PRISM integrates new technologies and design techniques to achieve performance

Performance metric	System parameter	Enabling technology
SNR	Throughput (F/No=1.8)	Dyson spectrometer and two-mirror telescope design
Dynamic range	Readout rate (176 Hz)	Teledyne HyViSI detector and JPL readout electronics
Polarization insensitivity	Angles of incidence, grating response	Optical design, grating groove design, coatings
Uniformity	Optical prescription	Dyson design, concave grating, lithographic slit
Stray light suppression	Optical surfaces, slit, grating	Coating and filter design, black Si slit, low scatter grating
Calibration stability	Operating temperature (~22° C), vibration response	Optomechanical design, detector mount, athermalization

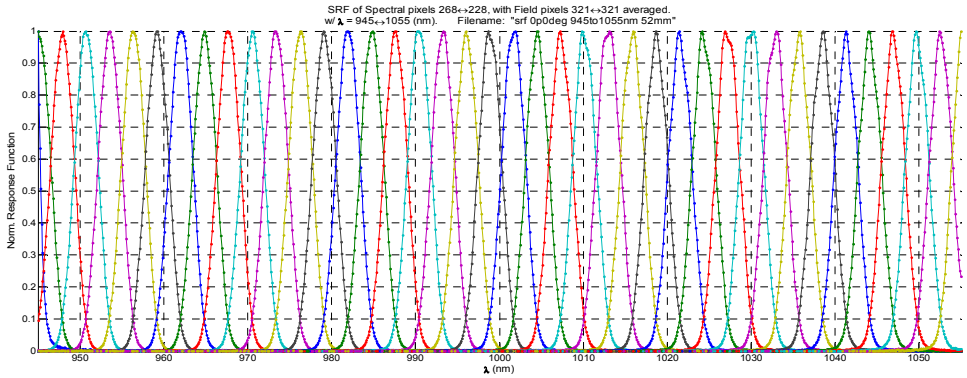
PRISM spectral characteristics: spectral response functions



350-450 nm

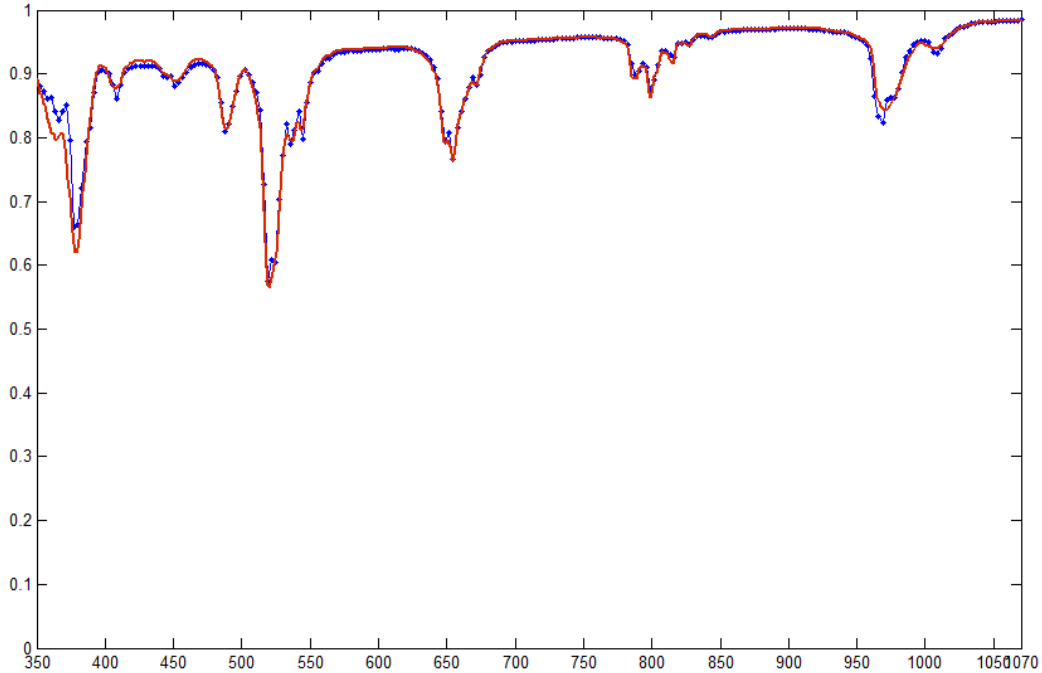


650-750 nm



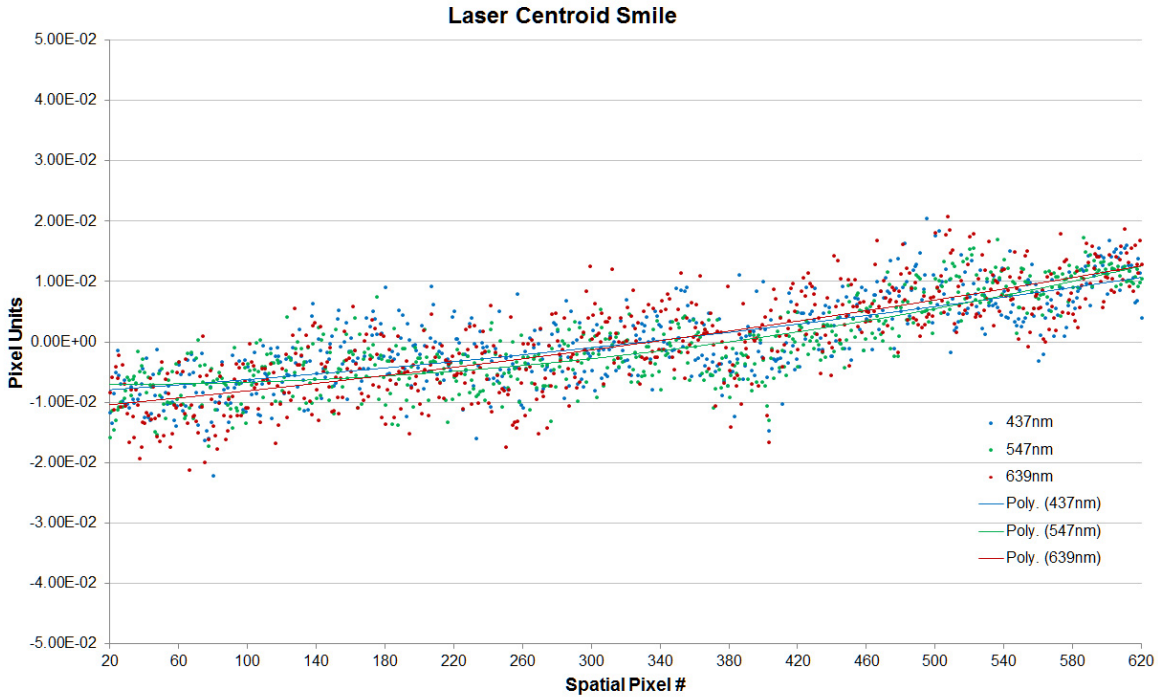
950-1050 nm

Test spectrum extraction



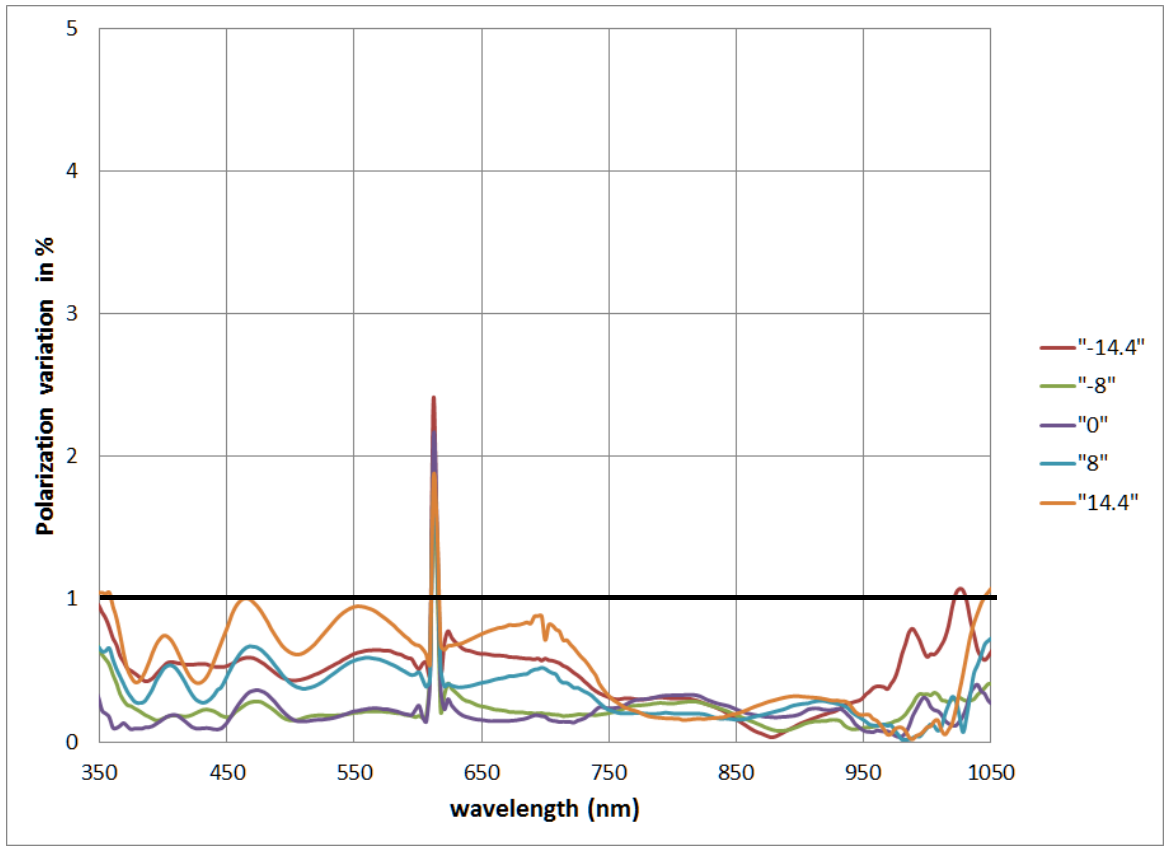
Spectrum of Er-doped spectralon panel received through PRISM (blue curve) and through reference ASD spectrometer (red curve).

Spectral uniformity



Scatter plot of spectral channel centroids as a function of spatial location for three isolated wavelengths (Hg lamp 437 nm and 547 nm, and laser at 639 nm).

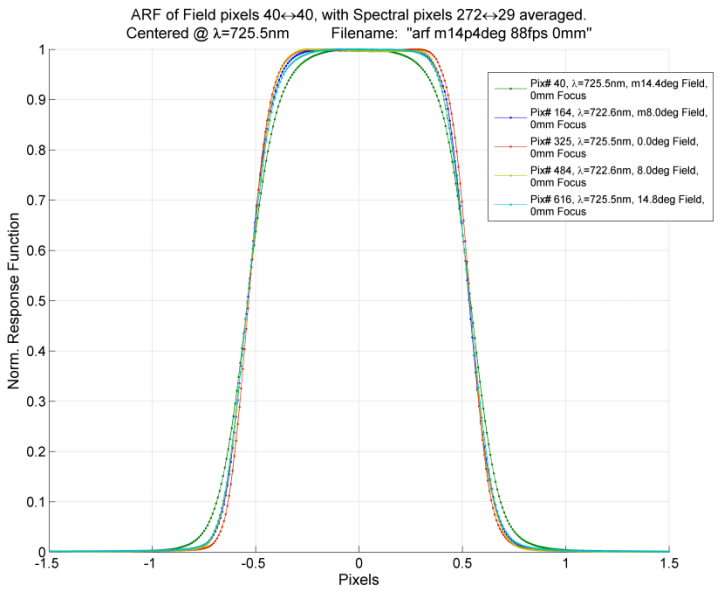
Polarization characteristics



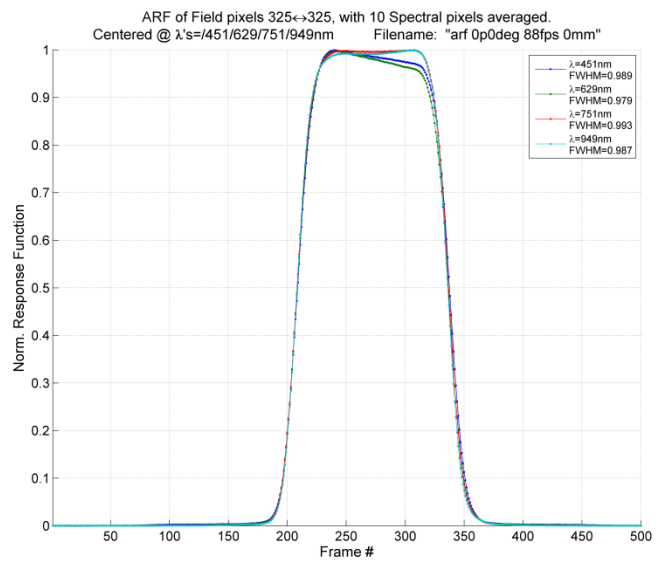
Polarization variation throughout the spectral range for five positions spanning the field of view.

Variation = $(I_{max} - I_{min})/(I_{max} + I_{min})*100$

Spatial characteristics: Along-track response



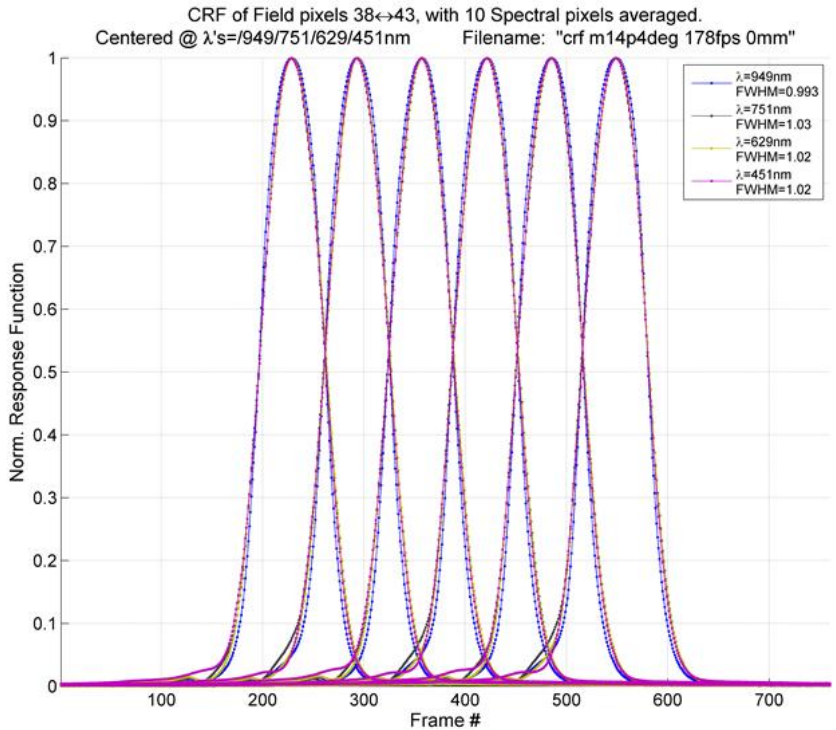
Along-track spatial response functions (without flight motion blur) for all field positions.



Example along-track spatial response functions (without flight motion blur) for four wavelengths spanning the PRISM spectral range at a single field position.

FWHM =~1.1 pixel

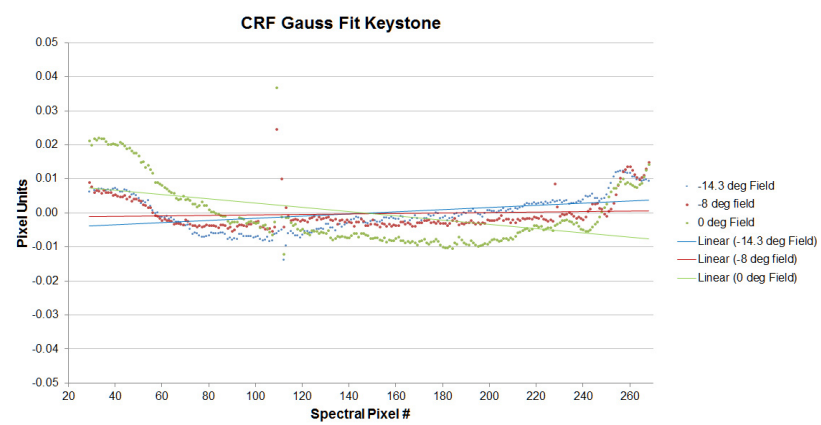
Spatial characteristics: Cross-track response



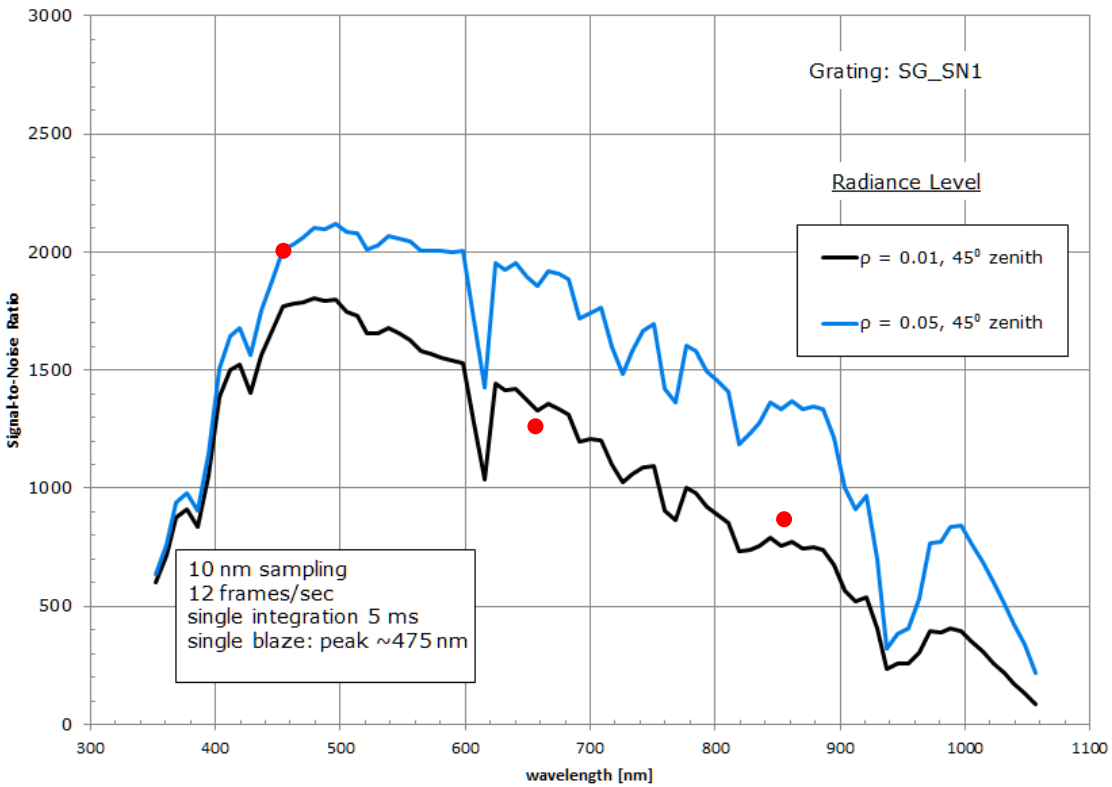
Example cross-track spatial response functions for four wavelengths spanning the PRISM spectral range at a single field position.

FWHM resolution =~1.05 pixel

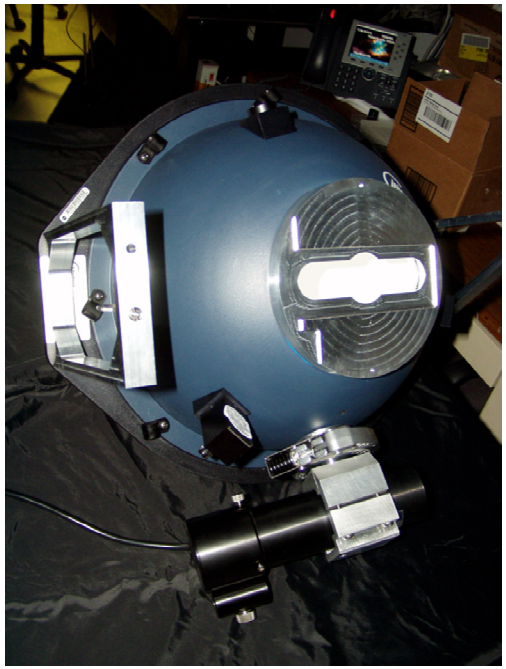
Spatial/spectral IFOV mixing



Predicted flight SNR based on lab calibration

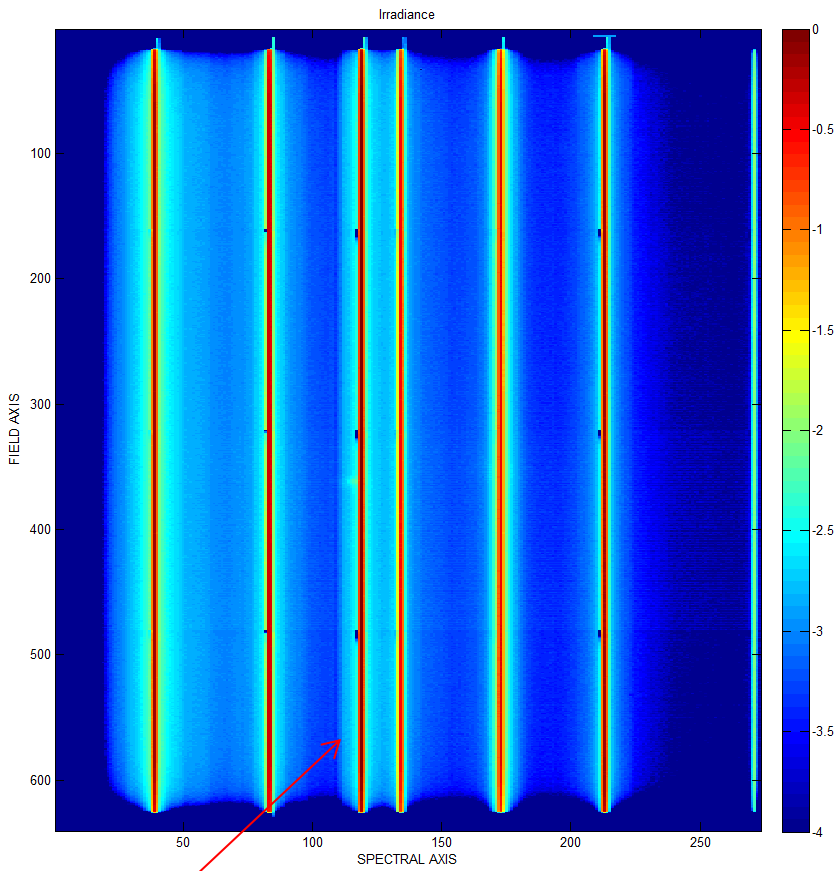


Predicted in-flight PRISM SNR incorporating measured data from known radiance of NIST-traceable lamp illuminated spectralon panel.



Integrating sphere for spectral and radiometric field calibration

Stray light assessment



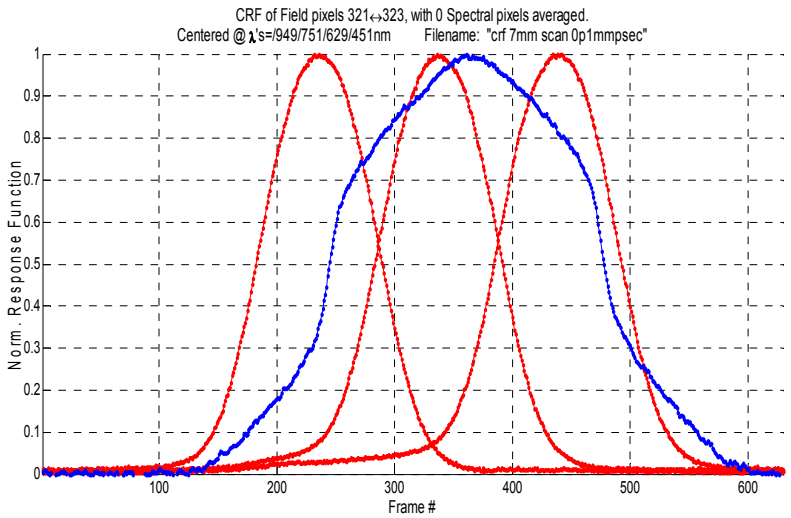
Order-sorting filter seam location

Image of several laser lines covering the entire field of view.

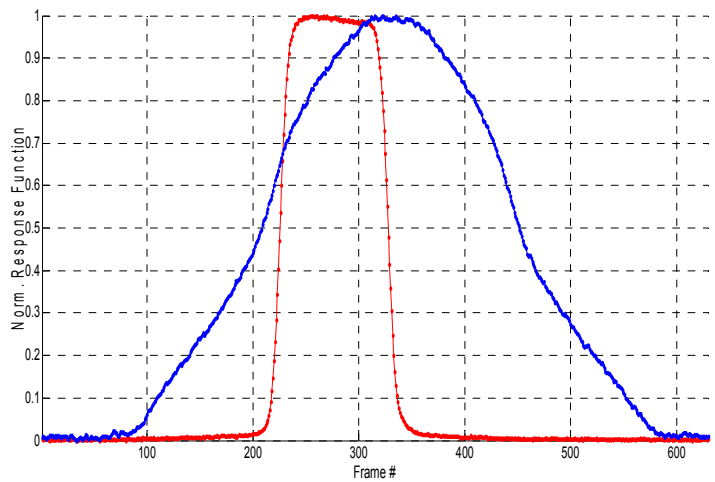
(image taken at room temperature, small residual imperfections disappear at operating temperature)

SWIR geometry and spatial characteristics

Boresight alignment of SWIR radiometer (blue) and spectrometer (red)

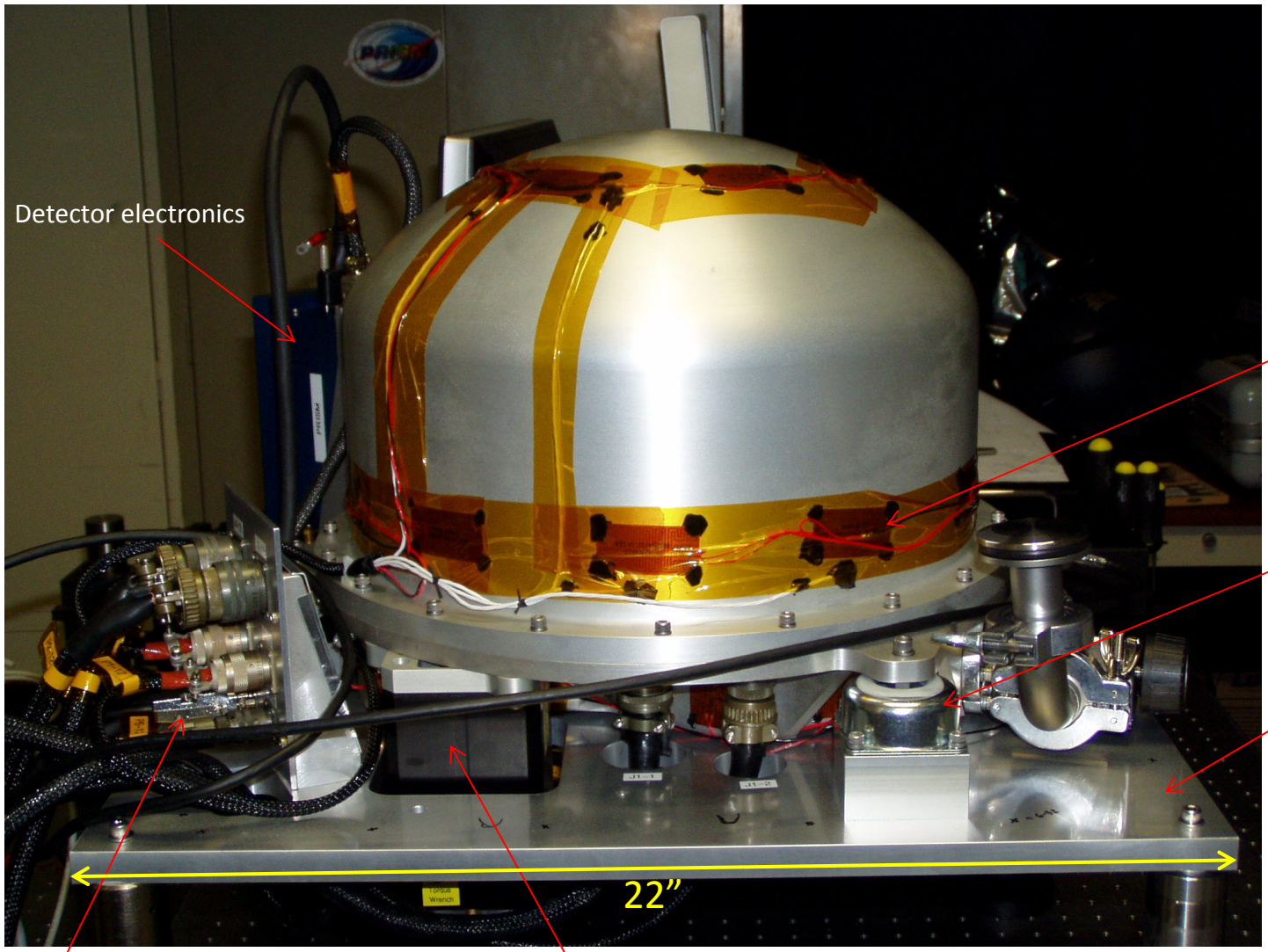


Cross-track, spectrometer channels 321-323

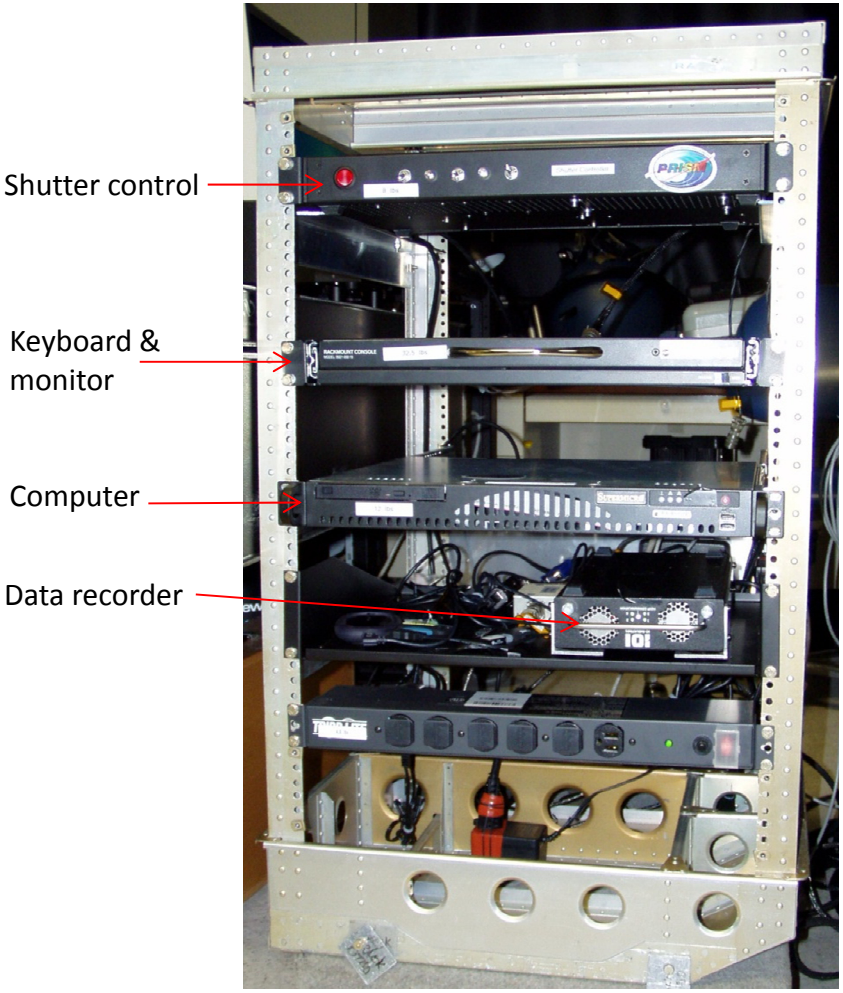


Along-track, without motion blur

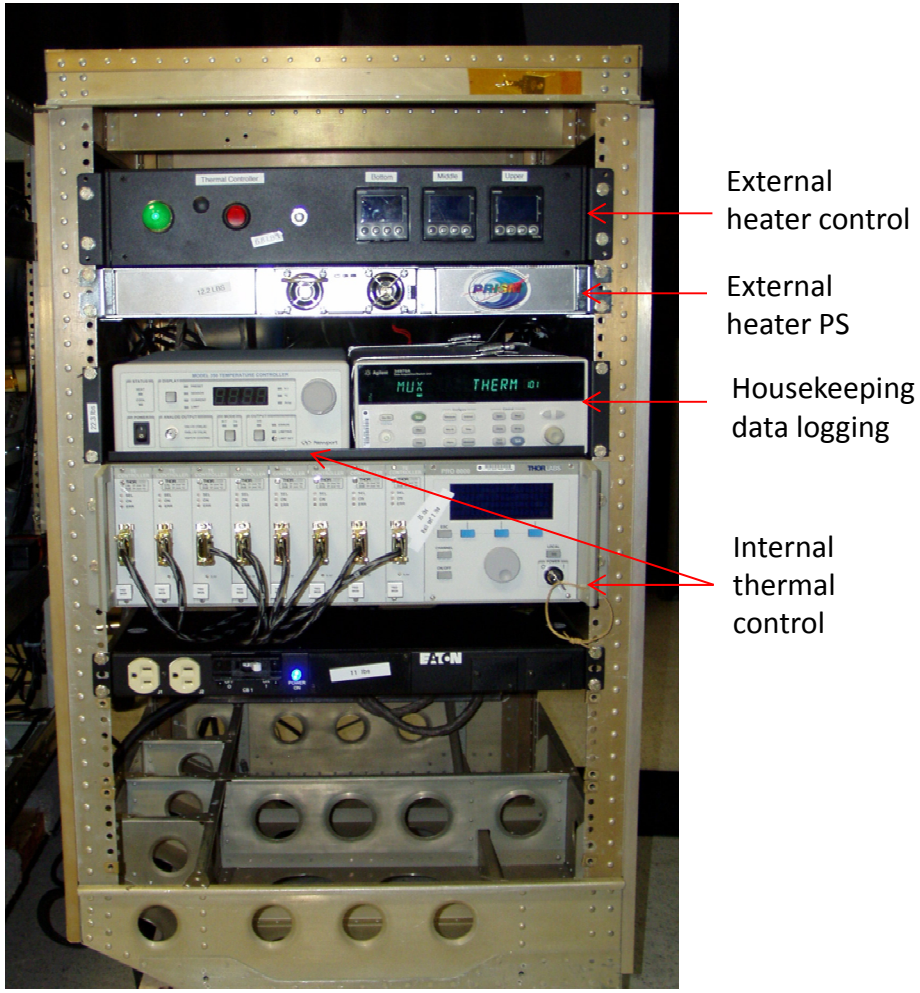
SENSOR HEAD AND AIRCRAFT MOUNTING PLATE



ELECTRONICS



Operator rack



Control rack

TEST FLIGHT SCHEDULE

Calibration/engineering flight May 2012:

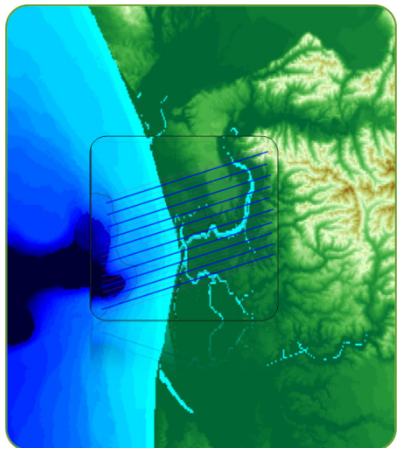
- Ivanpah Playa (spatial properties, radiometry high-R targets)
- Lake Tahoe (low R water target)

From left to right, Ivanpah Playa calibration site marked with tarps, dark tile targets, portable solar radiometers.

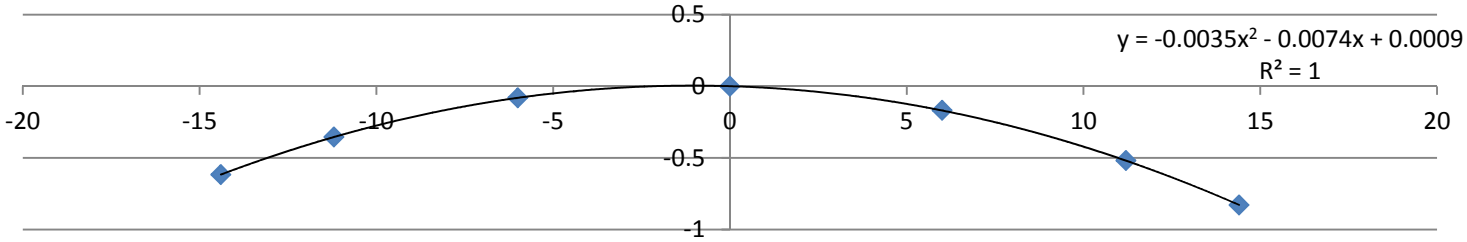
Lake Tahoe buoy

First test/science flight July 2012:

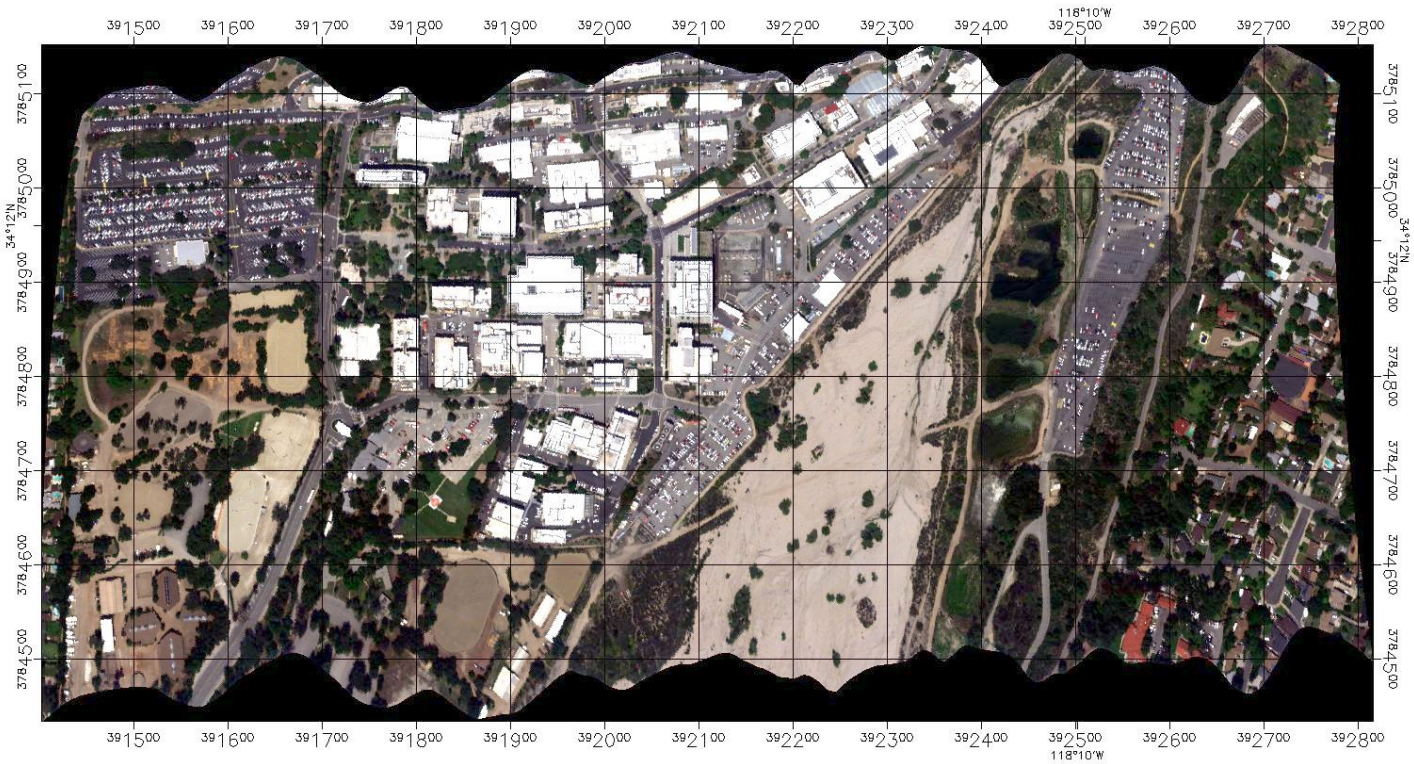
- Monterey Bay/Elkhorn Slough: seagrass coastal habitat



Slit curvature projected on ground (corrected in post-processing)



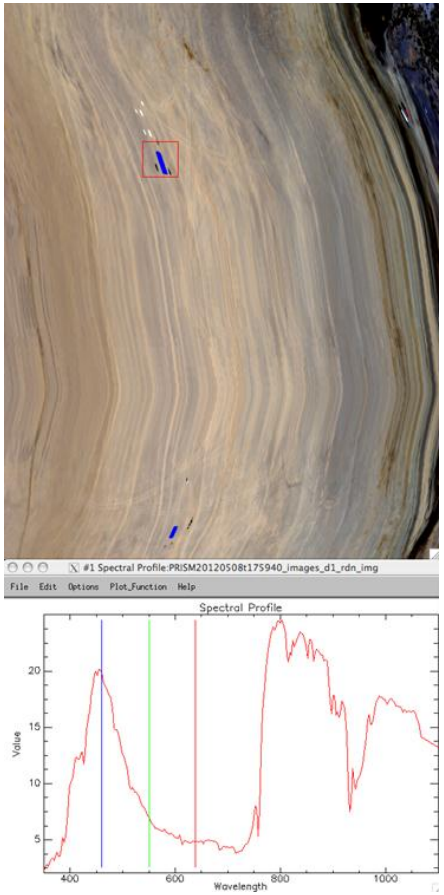
Agrees well with theoretical prediction of 0.82°



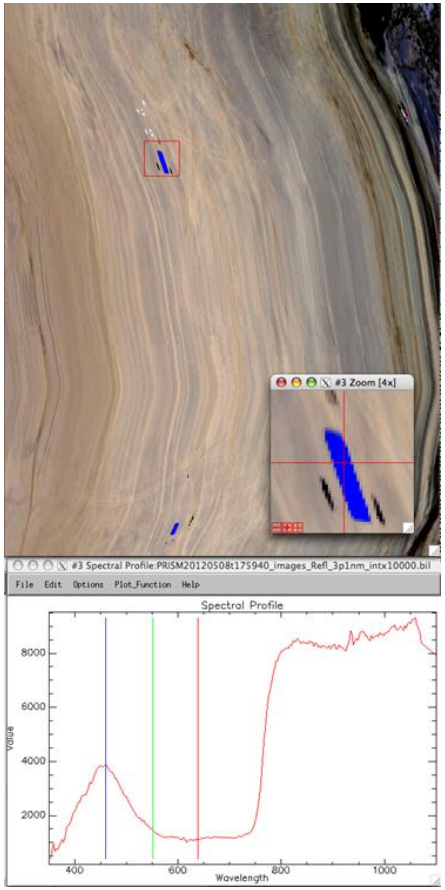
First rectified PRISM image of JPL/Arroyo Seco area

Preliminary atmospheric removal algorithm and radiometric calibration show good results

(Bo-Cai Gao, R. Green)



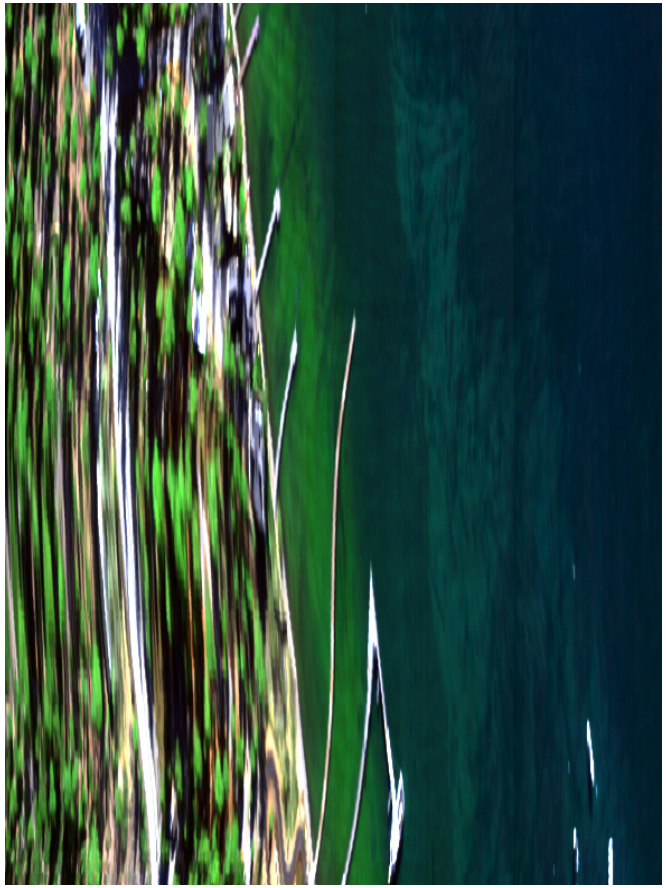
Apparent radiance



Reflectance after radiometric correction and atmospheric removal

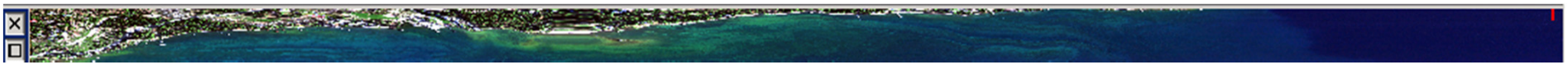
PRISM non-rectified image from Ivanpah with blue tarp spectrum

Retrieved spectrum is remarkably smooth at a single integration and without any applied spectral smoothing. Features above 900 nm are temporarily attributed to database inaccuracies in water vapor line parameters. Improved atmospheric correction algorithm will attempt better mitigation of these effects.

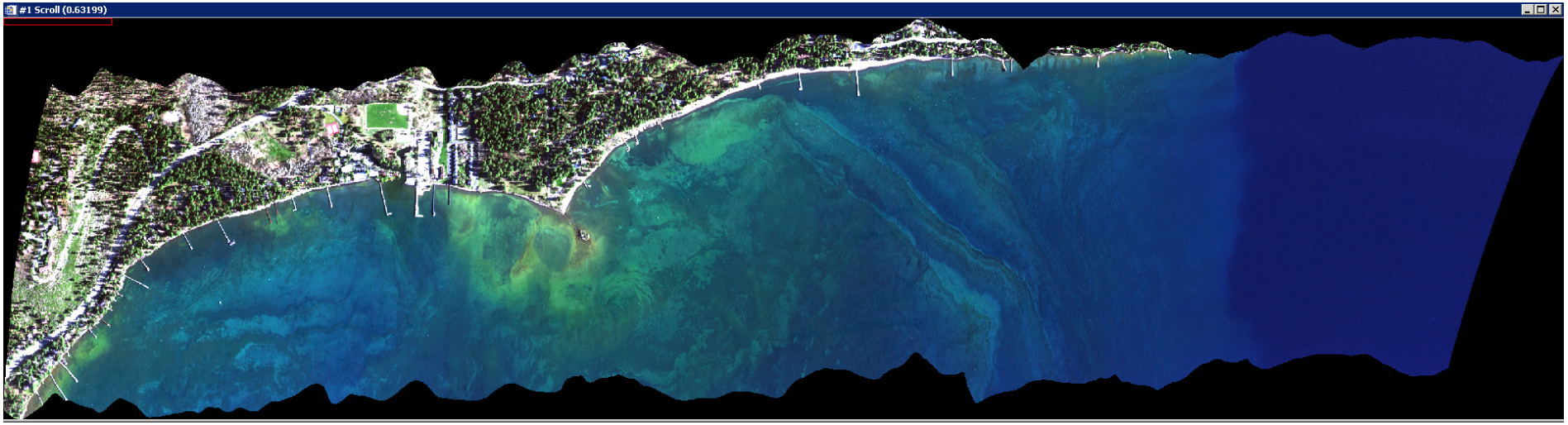


PRISM raw image from Lake Tahoe shows apparent elongation due to along-track oversampling.

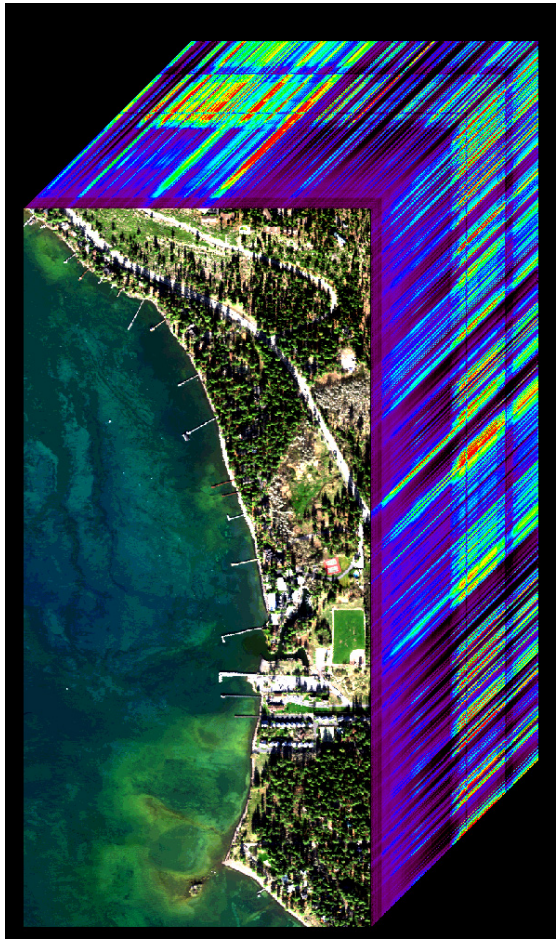
PRISM Tahoe Radiance before and after orthorectification

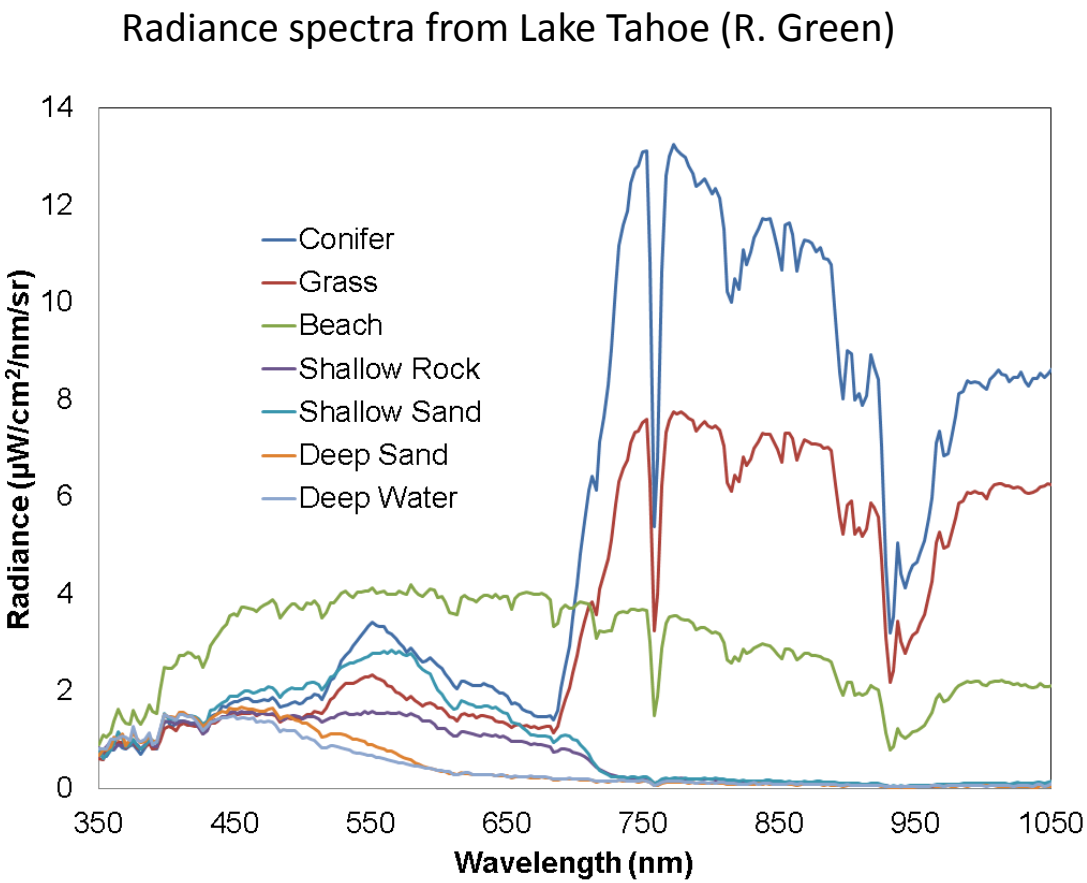


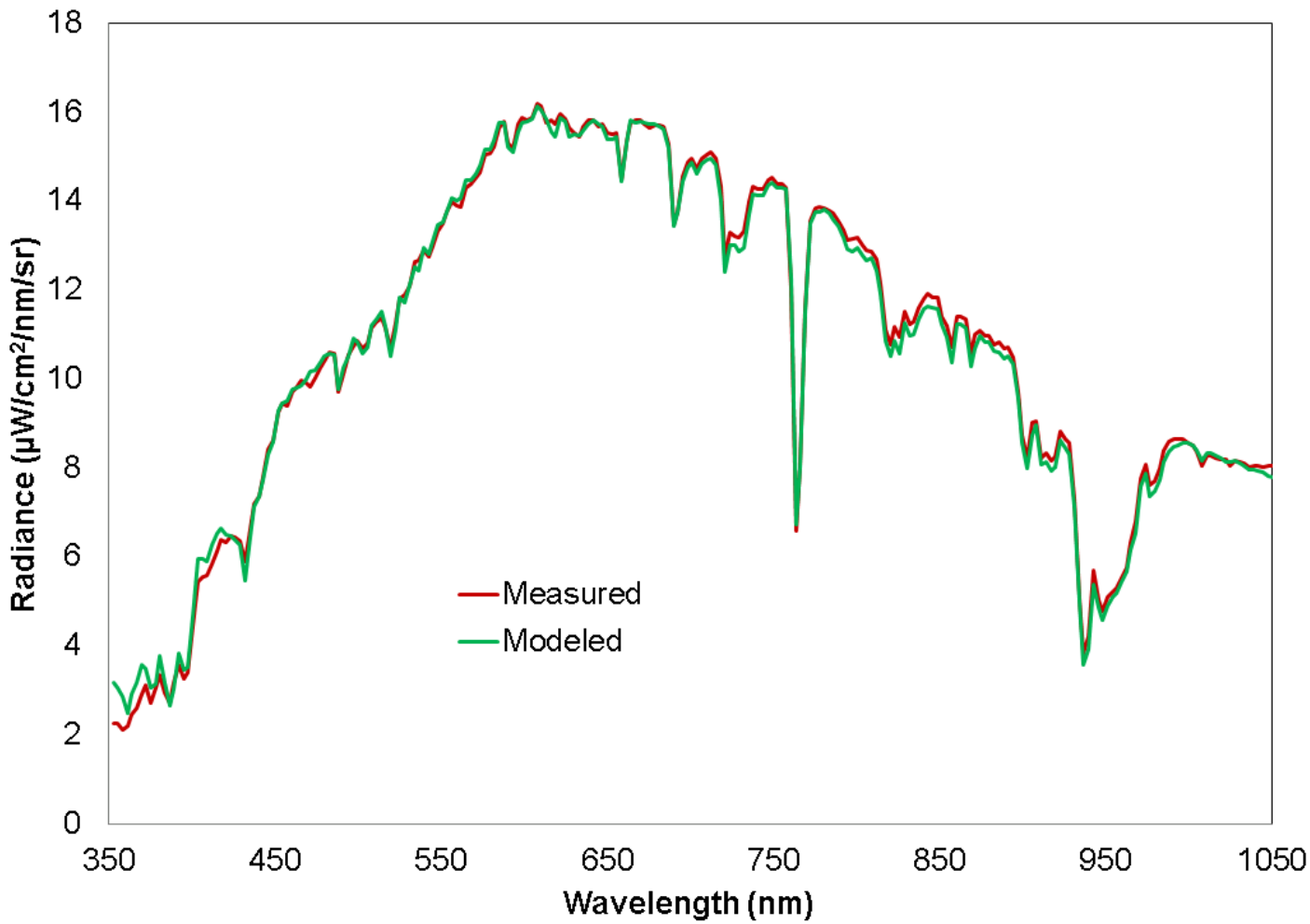
PRISM along track oversampling increases SNR



RGB image of Dollar Point (650, 550, 450 nm). Every spectrum is tagged with latitude, longitude, and elevation.





Data processing and algorithm refinement continuing.

Calibration/validation PRISM to MODTRAN from Ivanpah data
(against measured ground reflectance and atmospheric parameters)