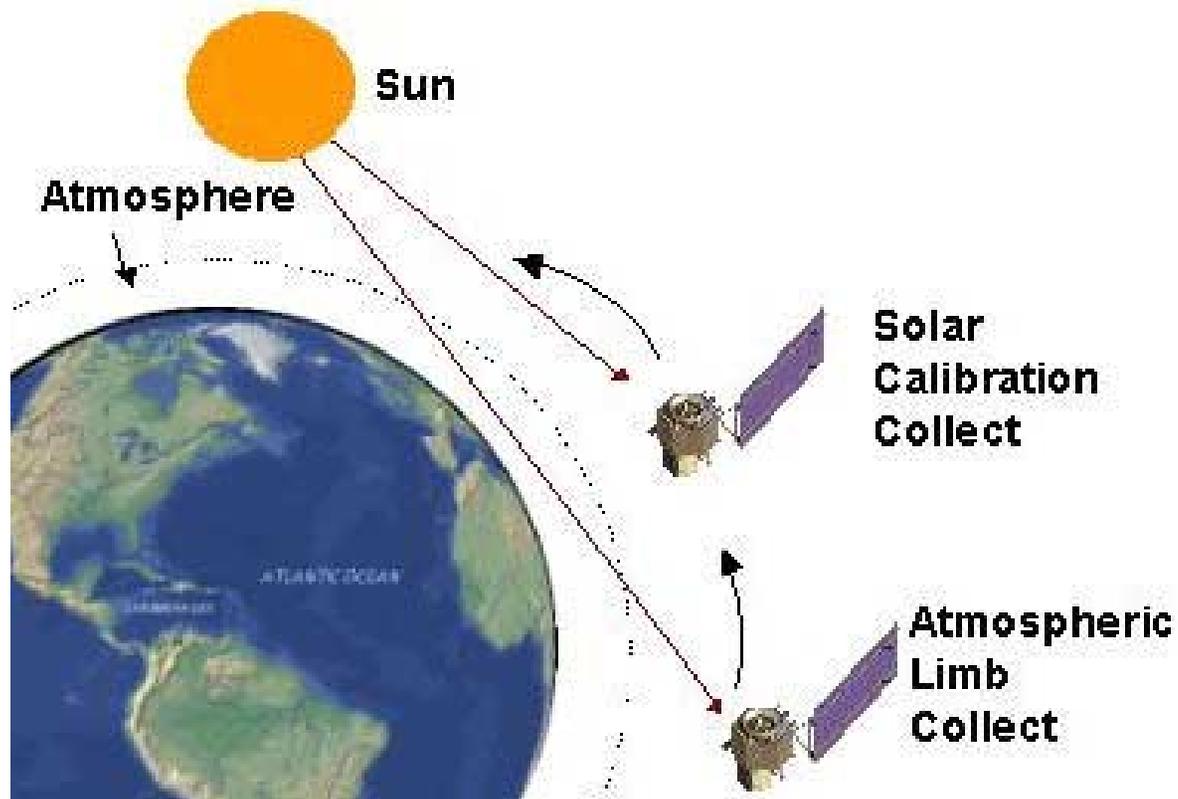




# On-Orbit Spectral Calibration

## Verification of the Hyperion Instrument

Pamela Barry, John Shepanski, Carol Segal, TRW, Redondo Beach



July 10<sup>th</sup> 2001  
IGARSS 2001



# Introduction

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*Hyperion Instrument*

*Spectral Calibration*

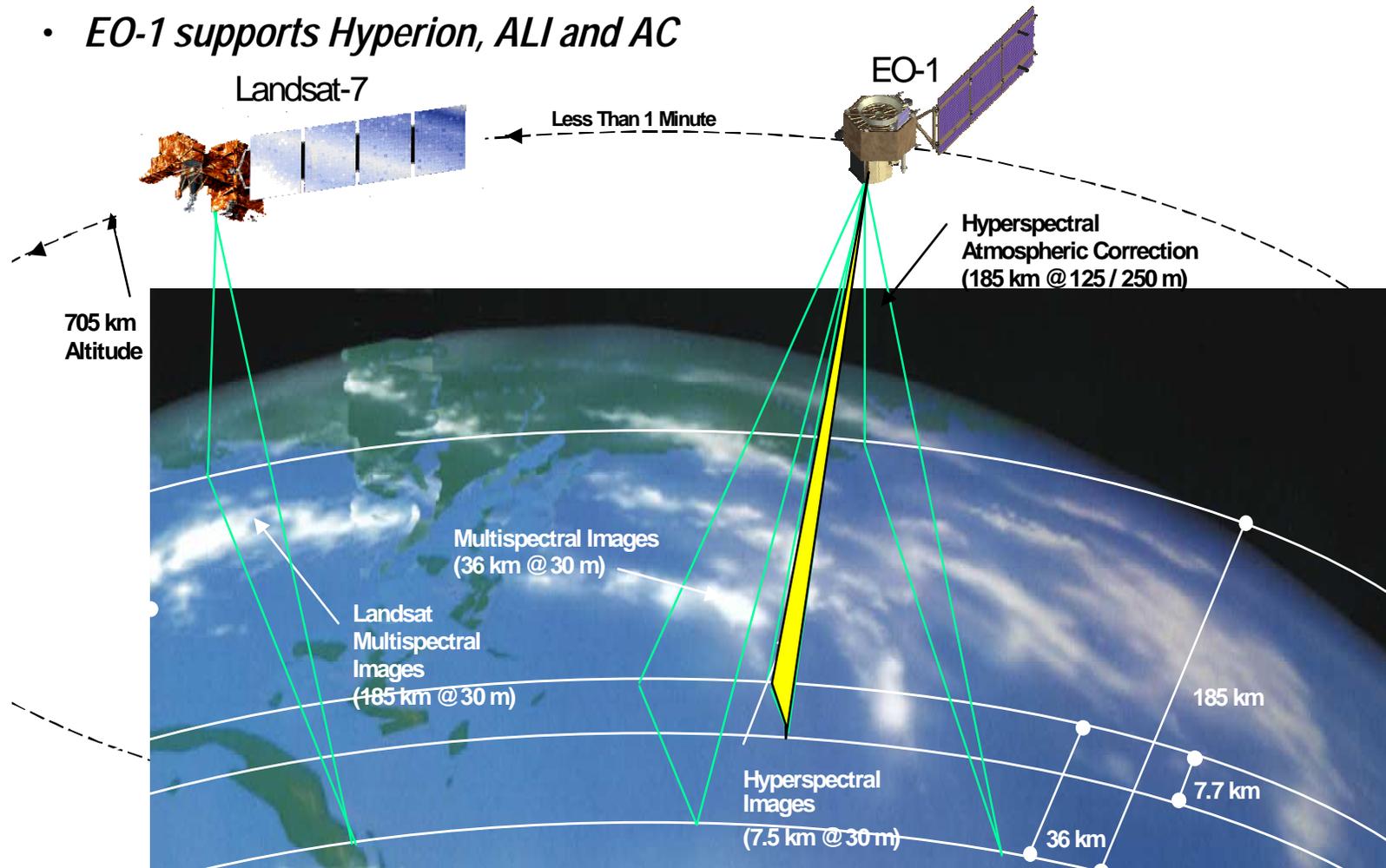
*On-Orbit Verification Technique*

*Comparison*

# Hyperion Instrument – EO-1 Launch and Orbit

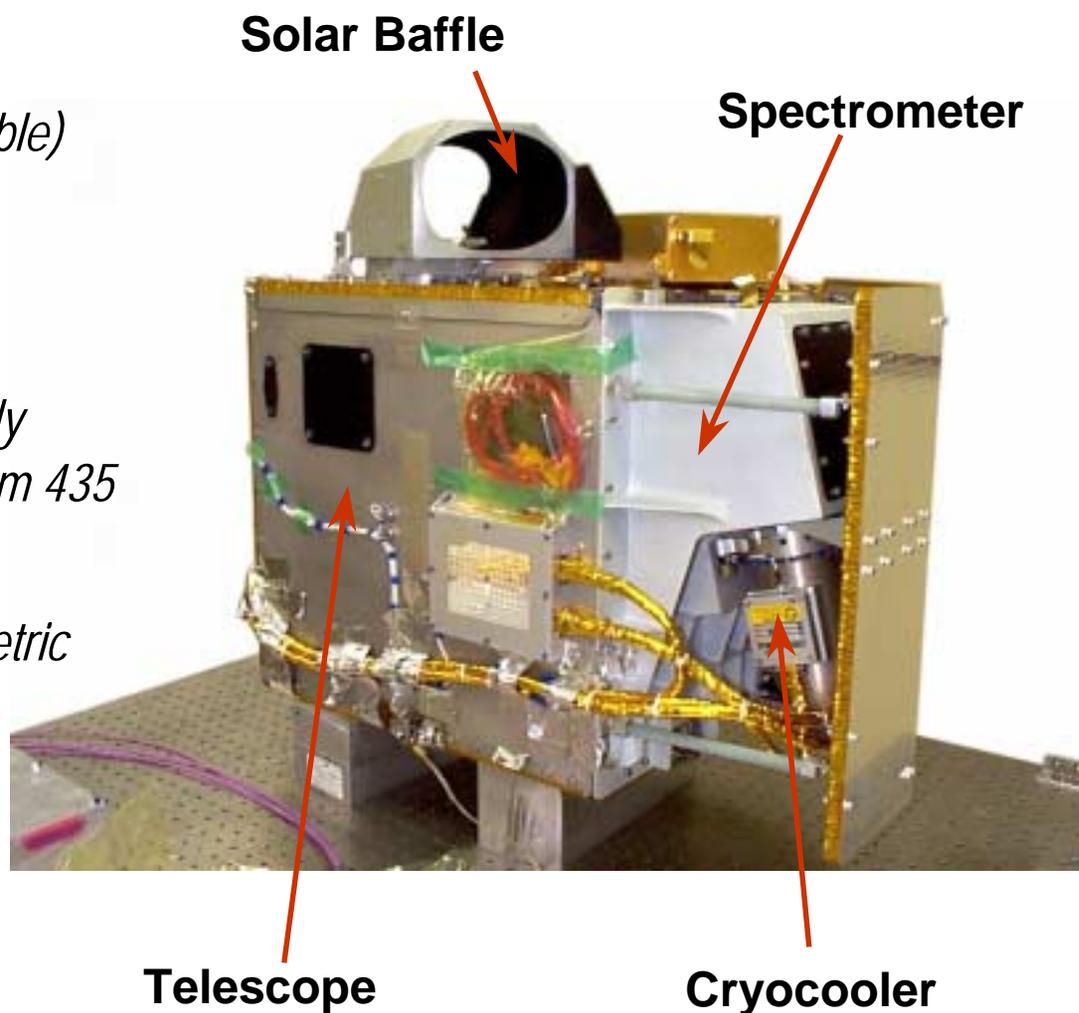


- *EO-1 Spacecraft launched November 21, 2000 from Vandenberg Air Force Base*
- *EO-1 orbit is one minute behind Landsat-7*
- *EO-1 supports Hyperion, ALI and AC*



# Hyperion Image Overview

- *7.7 km swath width*
- *160 km swath length (time variable)*
- *30 meter spatial resolution*
- *10 nm spectral resolution*
- *200 radiometrically and spectrally calibrated continuous bands from 435 nm to 2400 nm*
- *Better than 6% absolute radiometric accuracy*



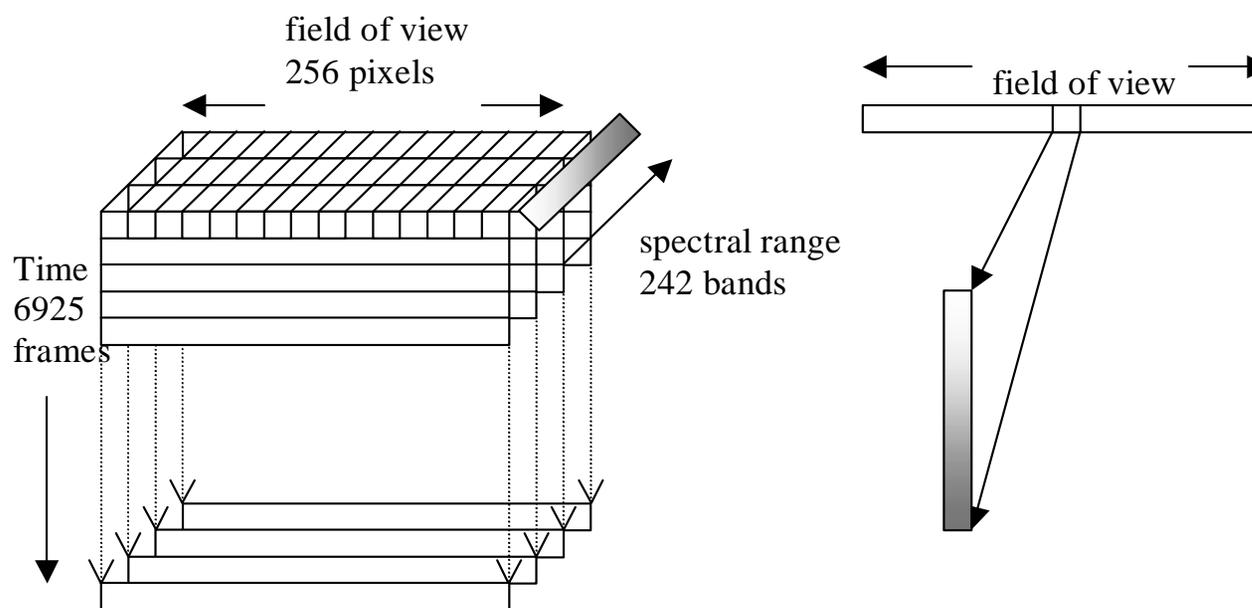


# Hyperion Data Cube

*Pushbroom configuration, entire swath width collected each frame sampled every 4.5 ms, or 223.4 frames/second.*

*Common fore-optics, dichroic filter reflects 400 nm to 1000 nm to the VNIR and transmits 900 nm to 2500 nm to the SWIR.*

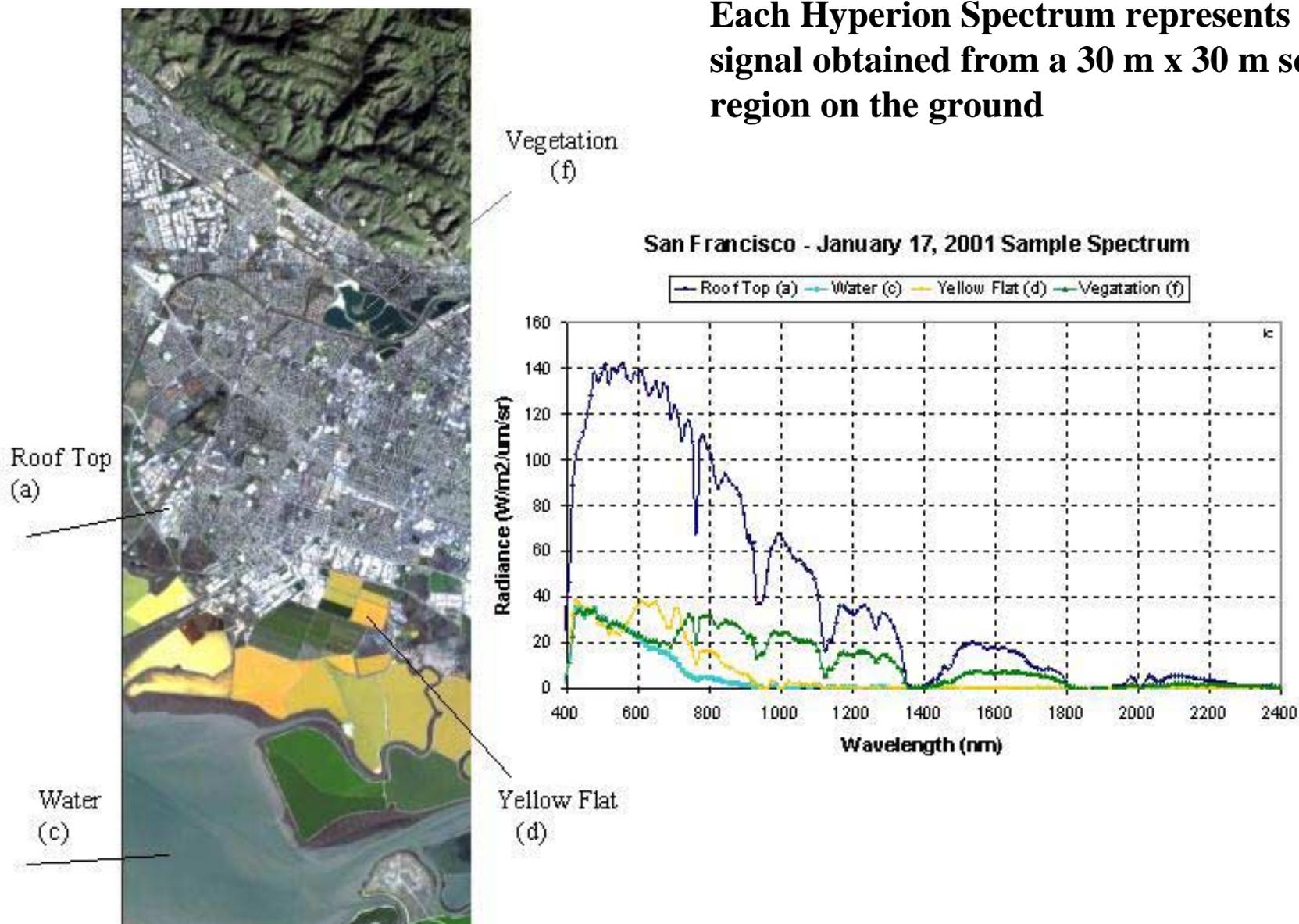
*Gratings disperse light onto two focal planes*



- *Produces a three dimensional data cube 256x6925x242 in 30 seconds!*

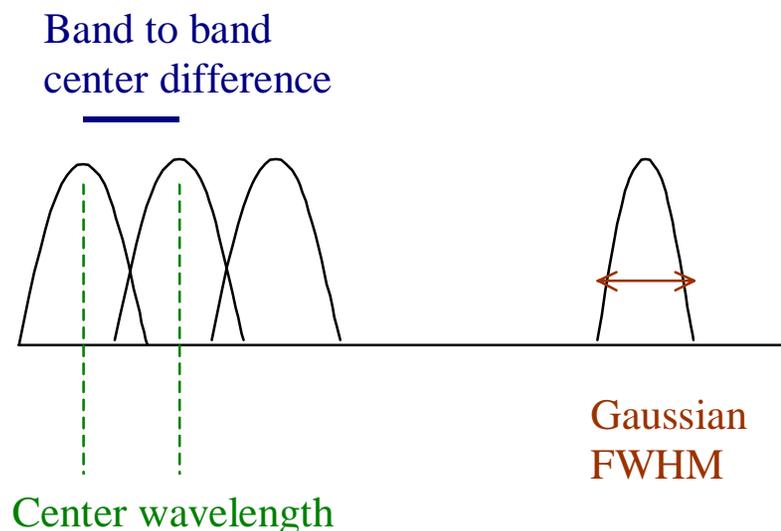
# Samples of of Hyperion Spectra

Each Hyperion Spectrum represents the signal obtained from a 30 m x 30 m square region on the ground



# Spectral Calibration

*Defined by a center wavelength and assumed Gaussian full width half max*



*Measured center wavelength and bandwidth at discrete locations on the focal plane, 20 VNIR locations, 25 SWIR locations.*

*Used to define a value for EVERY VNIR and SWIR pixel, 256 field-of-view locations and 242 spectral bands.*

*Contained in two ascii files SpectralL0\_revA.1, BandwidthL0\_revA.1 (\_revA.1 because of file format change)*



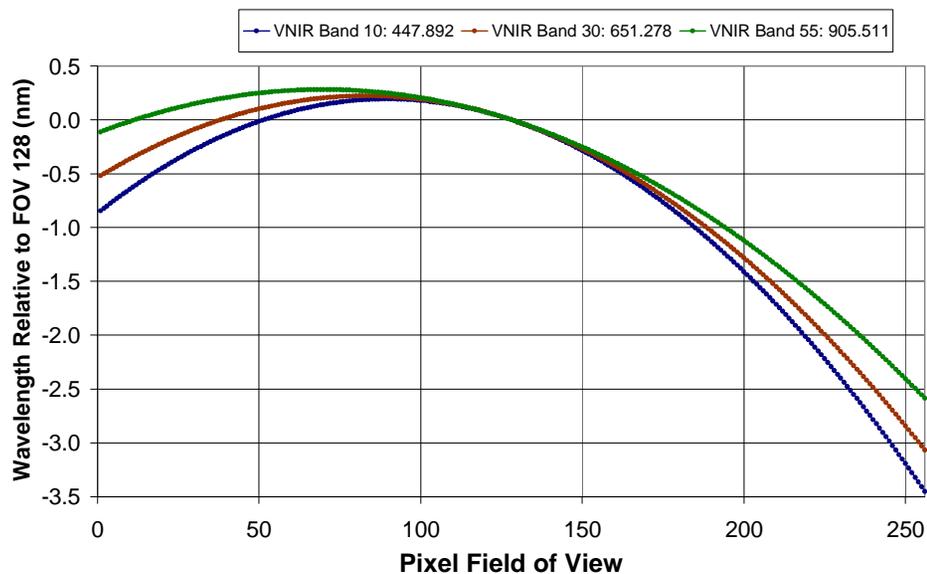
# Characteristics of Spectral Calibration

*Center wavelength and Bandwidth described by the assumed Gaussian*

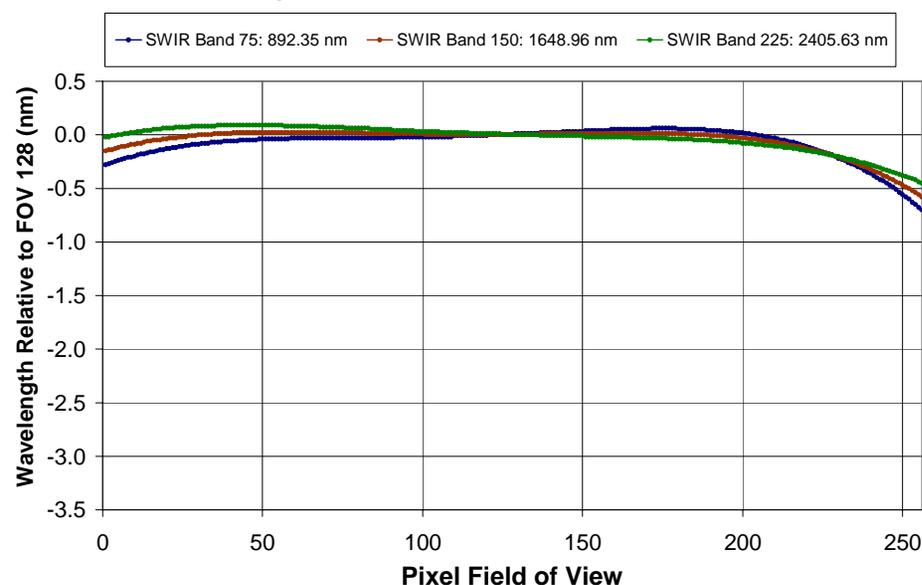
*Dispersion which is nm spacing of spectral channels, Hyperion dispersion (~10nm/pixel) closely matches the bandwidth (10 nm)*

*Cross-track spectral error which is the maximum variation of the center wavelength across the field-of-view for a single spectral channel, 2.6-3.6 for VNIR and .40-.97 for SWIR. Example below.*

**VNIR Spectral Variation Across the Field of View**



**SWIR Spectral Variation Across the Field of View**





# On-Orbit Spectral Calibration Verification

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## *Goal*

*verify center wavelength for VNIR and SWIR*

*verify cross-track spectral error*

*verify dispersion*

## *Performed atmospheric Limb collect*

*collect of reference spectrum (atmosphere and diffuse reflectance)*

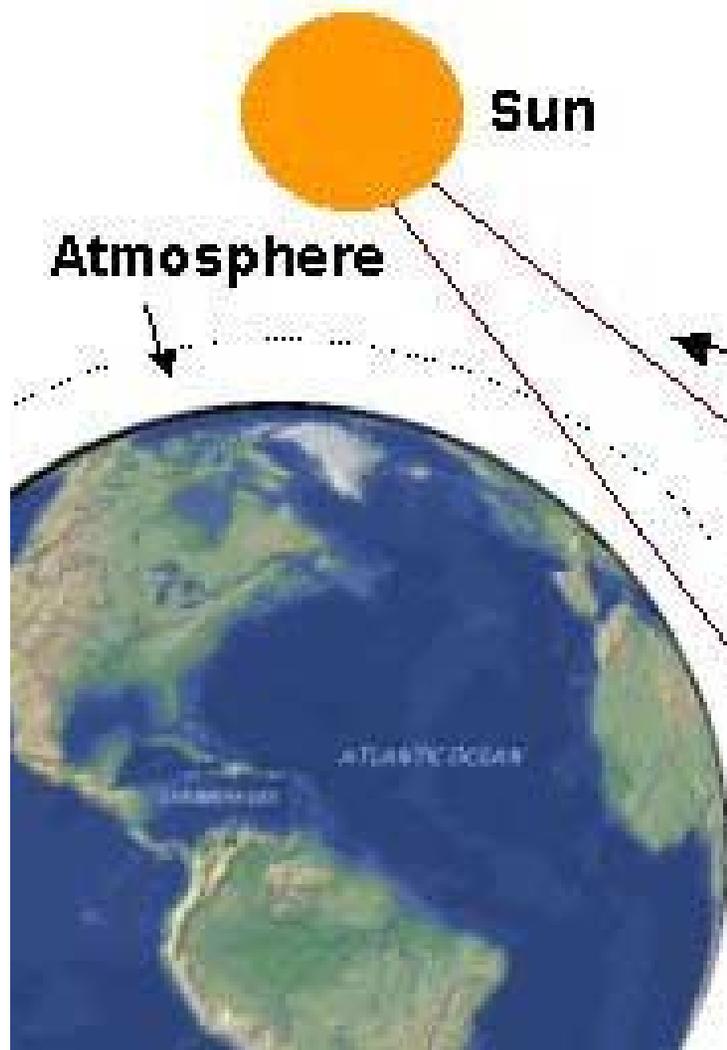
*collect uniform across the field-of-view*

*spectral features spanned SWIR, in VNIR*

## *Following to present:*

*description of collect, and data analysis technique and verification of SWIR spectral calibration*

# Hyperion Spectral Calibration



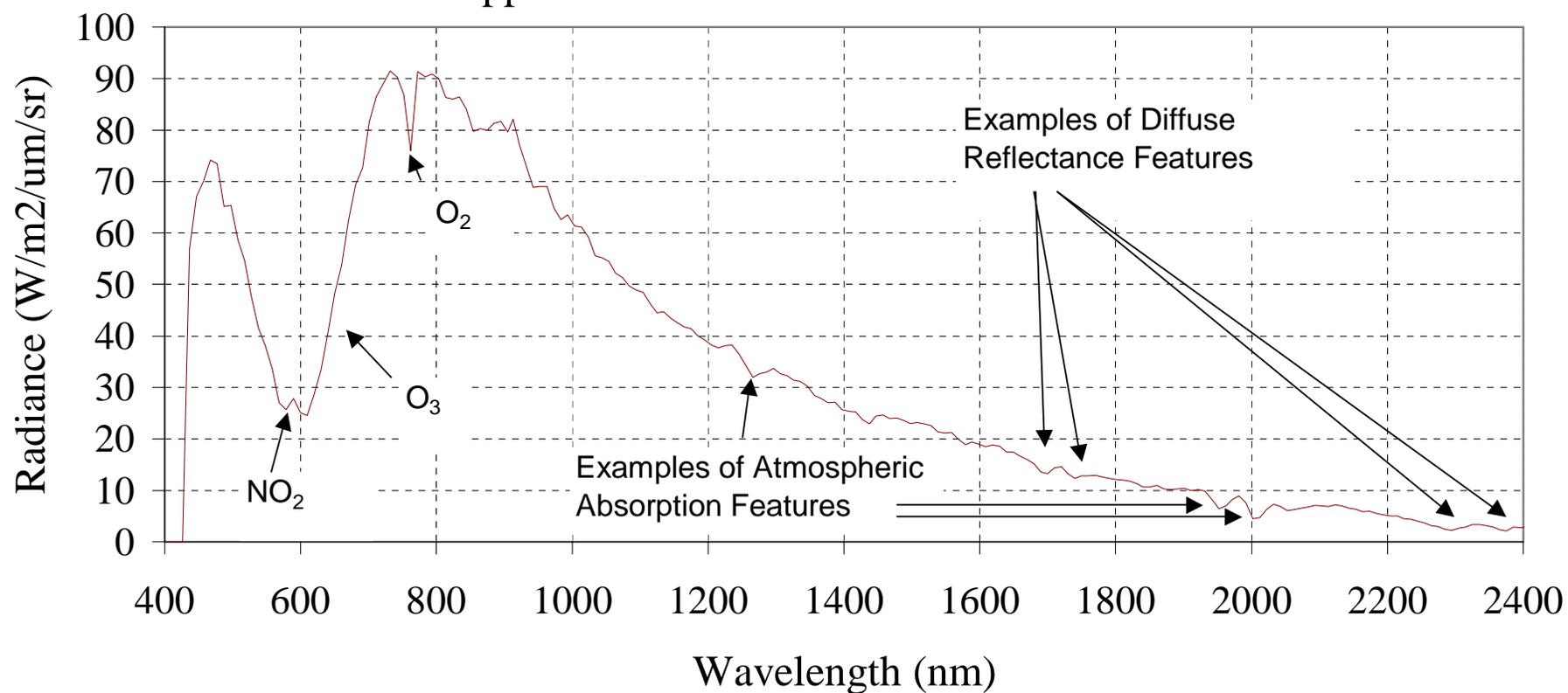
Early solar cal, sun is rising through earth's limb during collect

View sun, off cover, through atmosphere

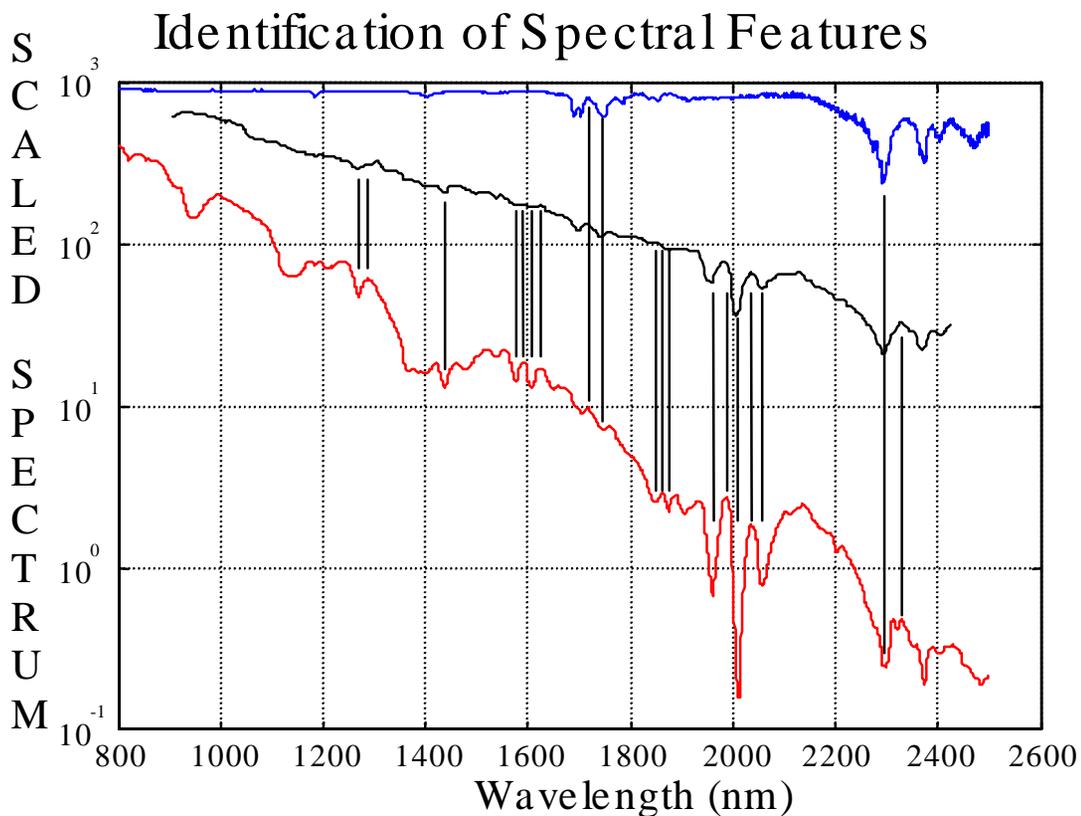
**Solar  
Calibration  
Collect**

**Atmospheric  
Limb  
Collect**

## Atmospheric Limb Sample Spectra for the VNIR and SWIR Approximate Identification of Features



# Spectral Calibration –SWIR



*Hyperion Spectra of Atmospheric Limb Collect – red*  
*Atmospheric Reference Profile from Modtran 3 – black*  
*Cary 5 & FTS measured Diffuse Cover Reflectance – blue*

## Process:

- 1.) **Create Pseudo-Hyperion Spectra from reference:**  
*Modtran-3 for atmosphere, and Cary 5 & FTS measurements for diffuse reflectance of the cover*
- 2.) **Correlate Spectral Features:** *band number units of Hyperion max/min correlated with reference wavelength of max/min*
- 3.) **Calculate Band to Wavelength map:** *apply low order polynomial to fit the data over the entire SWIR regime*



# Spectral Comparison

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*Technique used to verify center wavelength for SWIR focal plane, verification wavelength dependent, ranges from +/- 1 nm to +/-2.5 nm.*

*Accuracy of the technique dependent on reference spectrum and analysis method*

- accuracy of the diffuse reflectance reference spectrum < 1 nm*
- accuracy of the atmospheric absorption reference spectrum, +/-2.5 nm*
- accuracy of analysis method +/- 1 nm*

*Results used to verify no change in SWIR dispersion:*

*10.09 nm/pixel pre-flight*

*10.09 nm/pixel on-orbit*

*Results used for verify no change in SWIR cross-track spectral error:*

*< 1nm pre-flight*

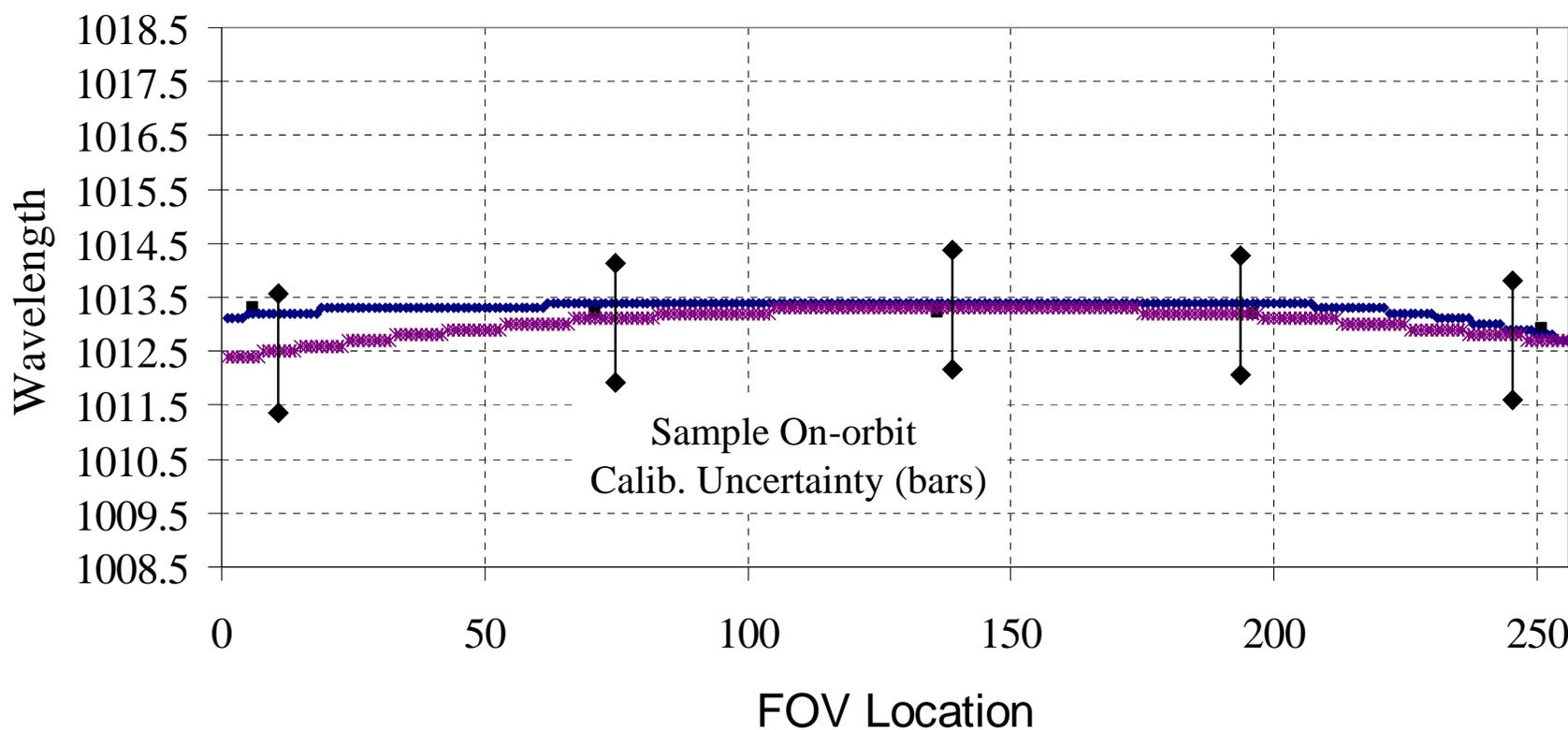
*< 1 nm on-orbit*



# Calibration Comparison: SWIR

SWIR Comparison of Spectral Calibration: Spectral Band 87

- Pre-Flight Points
- ◆ Pre-Flight Calibration
- \* On-Orbit Calibration

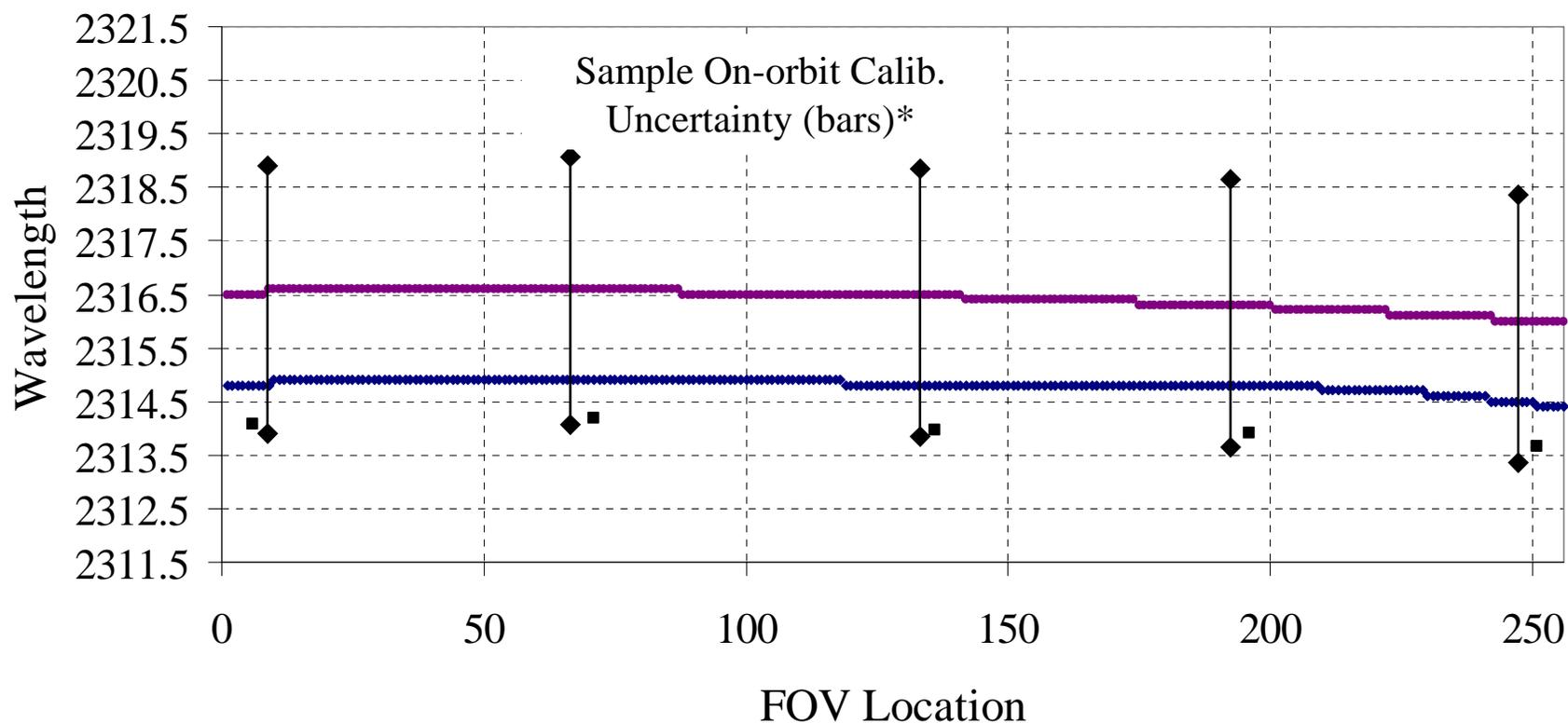




# Calibration Comparison: SWIR

## SWIR Comparison of Spectral Calibration: Spectral Band 216

- Pre-Flight Points
- ◆ Pre-Flight Calibration
- On-Orbit Calibration



\* Larger uncertainty (atmospheric model parameters)



# Conclusions

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***Developed on-orbit technique based on atmospheric limb collect***

*strength was the absorption features of the diffuse reflectance of white paint*

*current largest source of errors associated with: reference atmospheric profile related to knowledge of cut through the atmosphere*

***On-orbit verification of SWIR center wavelength, cross-track spectral error***

*measurement, dispersion measurement all agree with pre-flight measurements and requirements*

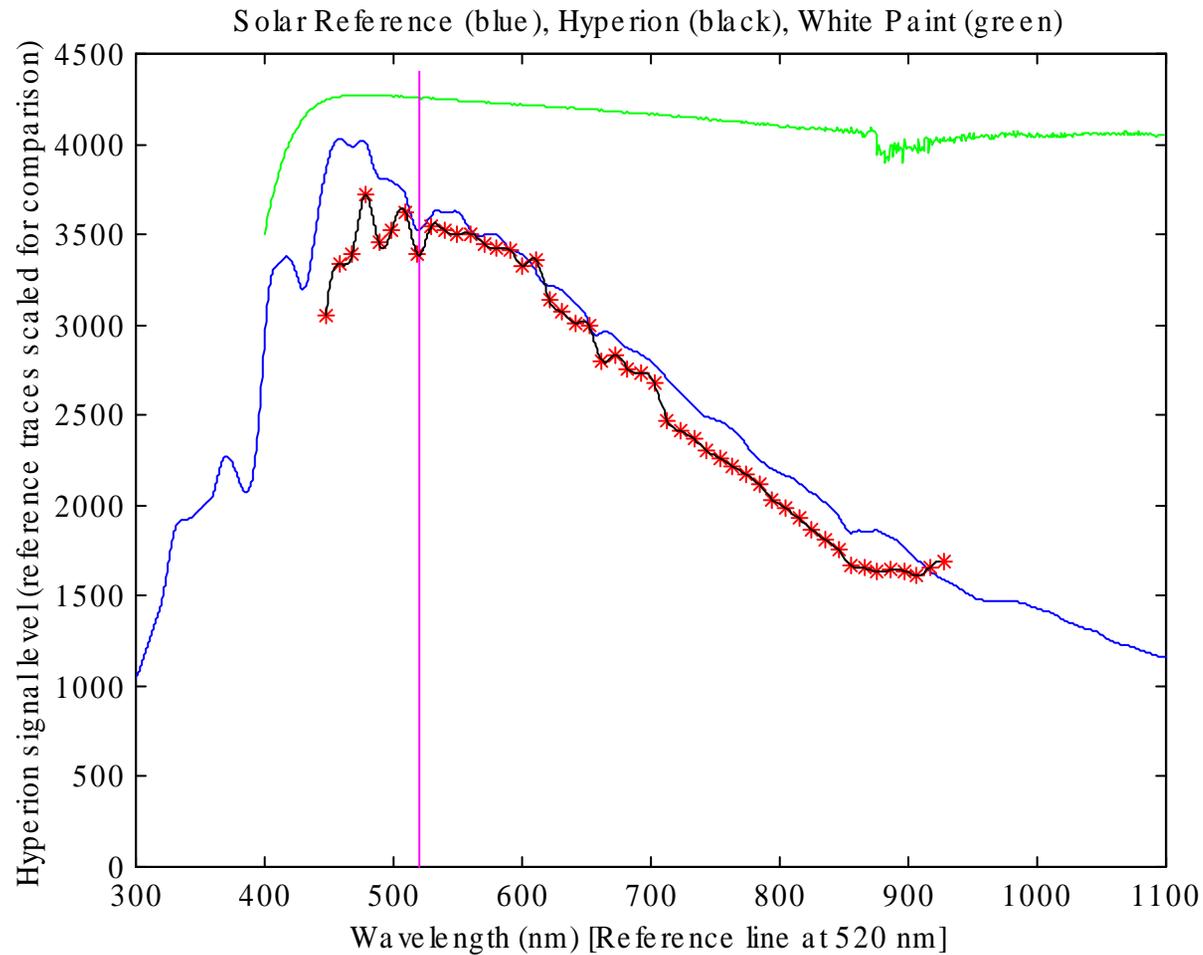
***VNIR spectral calibration verification performed using combination of Oxygen line (762.5 nm) from atmospheric line and Fraunhofer line (520 nm) visible in solar calibration collect.***



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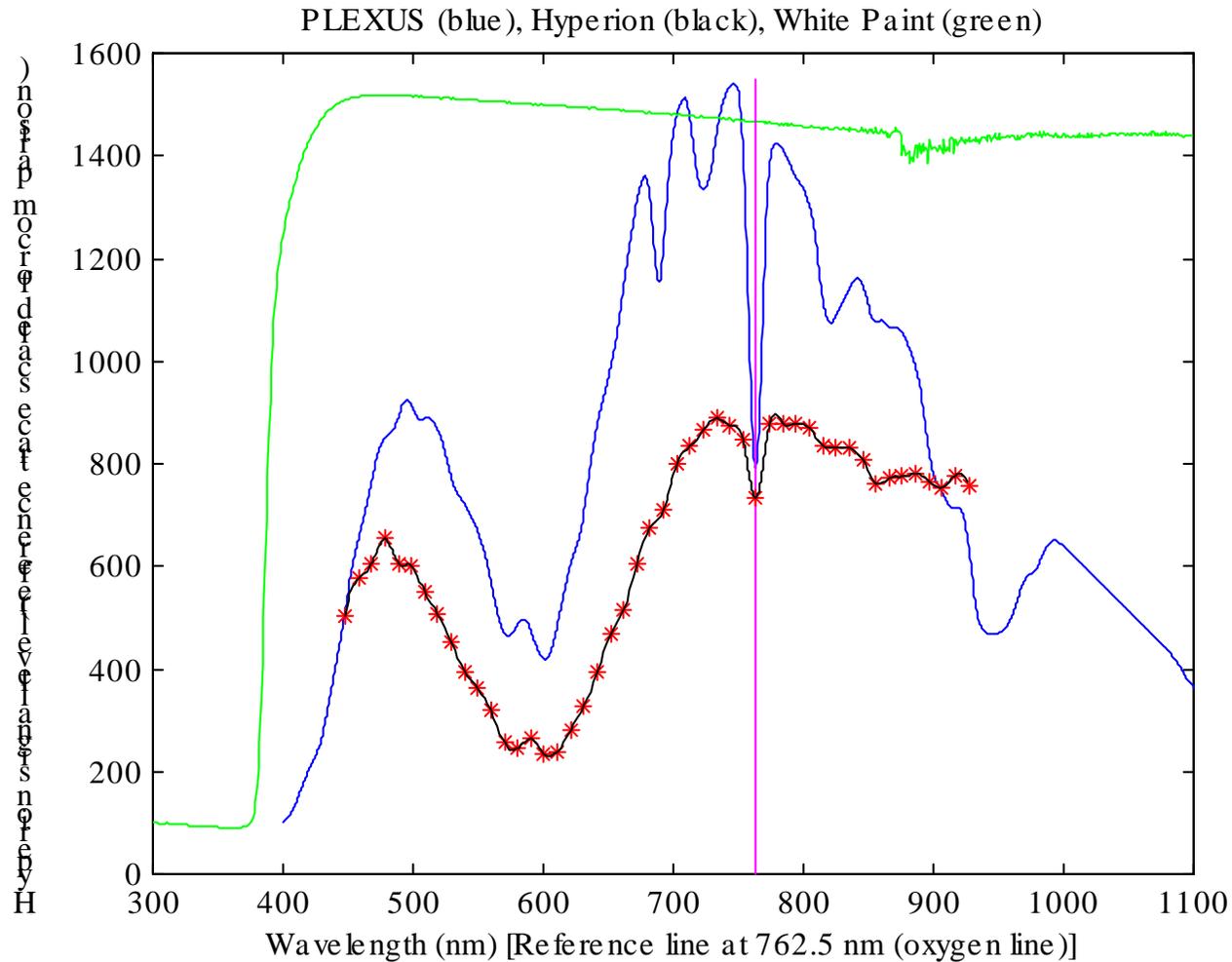
## *BACK-Up Slides*

# VNIR Spectral Calibration: Solar



Hyperion Data (black, red), Solar Reference (blue, scaled),  
White Paint Transmission (green, scaled)

# Atmospheric Limb: VNIR

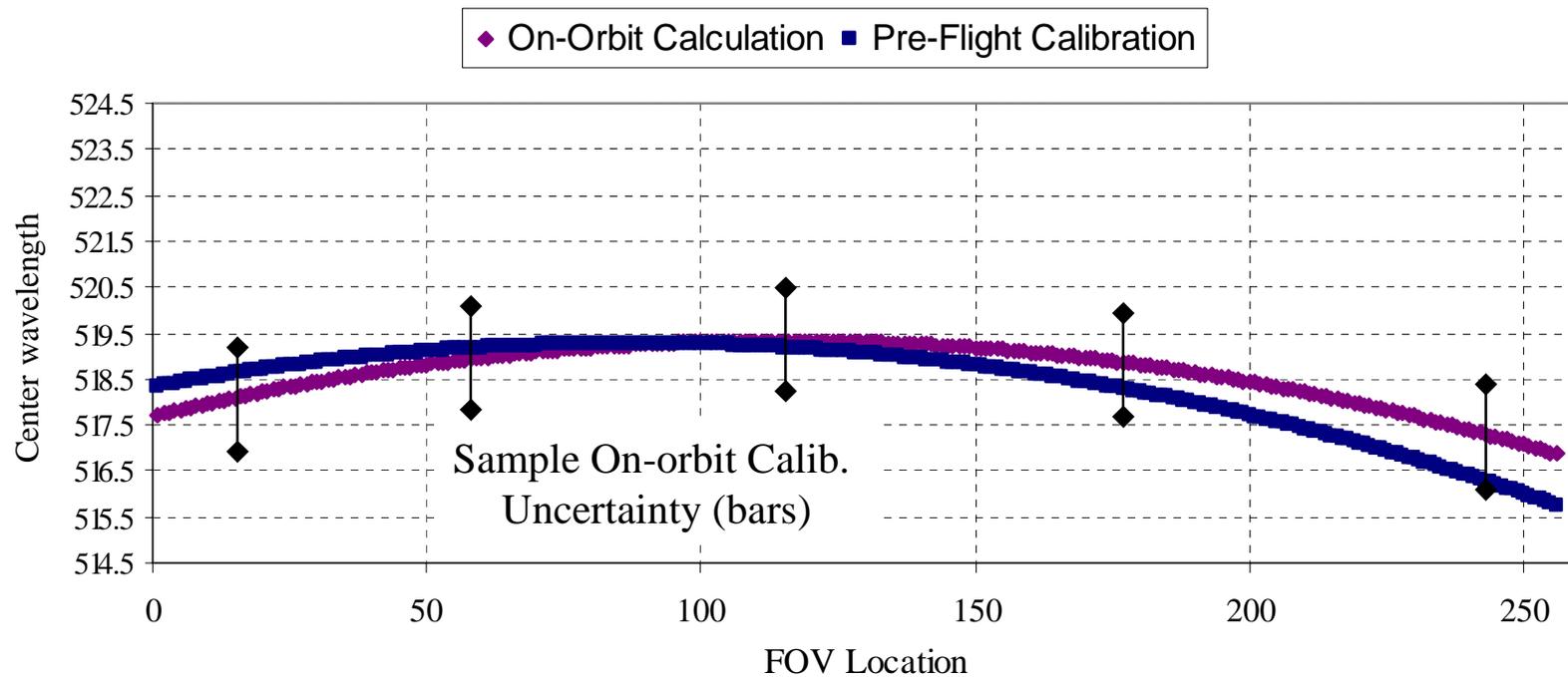


Hyperion Data (black, red), PLEXUS Calculation (blue, scaled),  
White Paint Transmission (green, scaled)

# Calibration Comparison: VNIR



VNIR Comparison at Spectral Channel 17





# Calibration Comparison: VNIR

VNIR Comparison at Spectral Channel 41

