

# **CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) on MRO**

## **Calibration Upgrade, version 2 to 3**

Dave Humm

*Applied Physics Laboratory, Laurel, MD 20723*

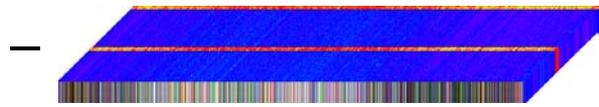
18 March 2012

# Calibration Overview

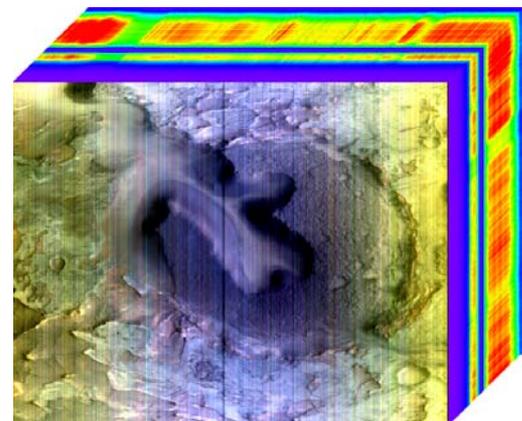
- All scene images are calibrated to radiance using internal calibrations to remove time-variable instrumental effects
- The first correction is to subtract shutter-closed dark measurements from the scene and from a sphere measurement taken close in time



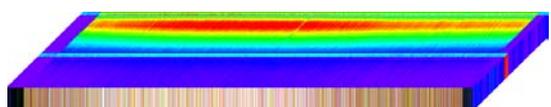
Raw scene image, units DN



Companion dark image, units DN



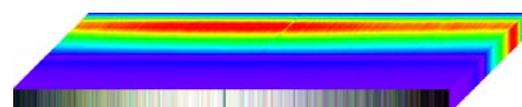
Corrected scene image, units DN



Raw sphere image, units DN

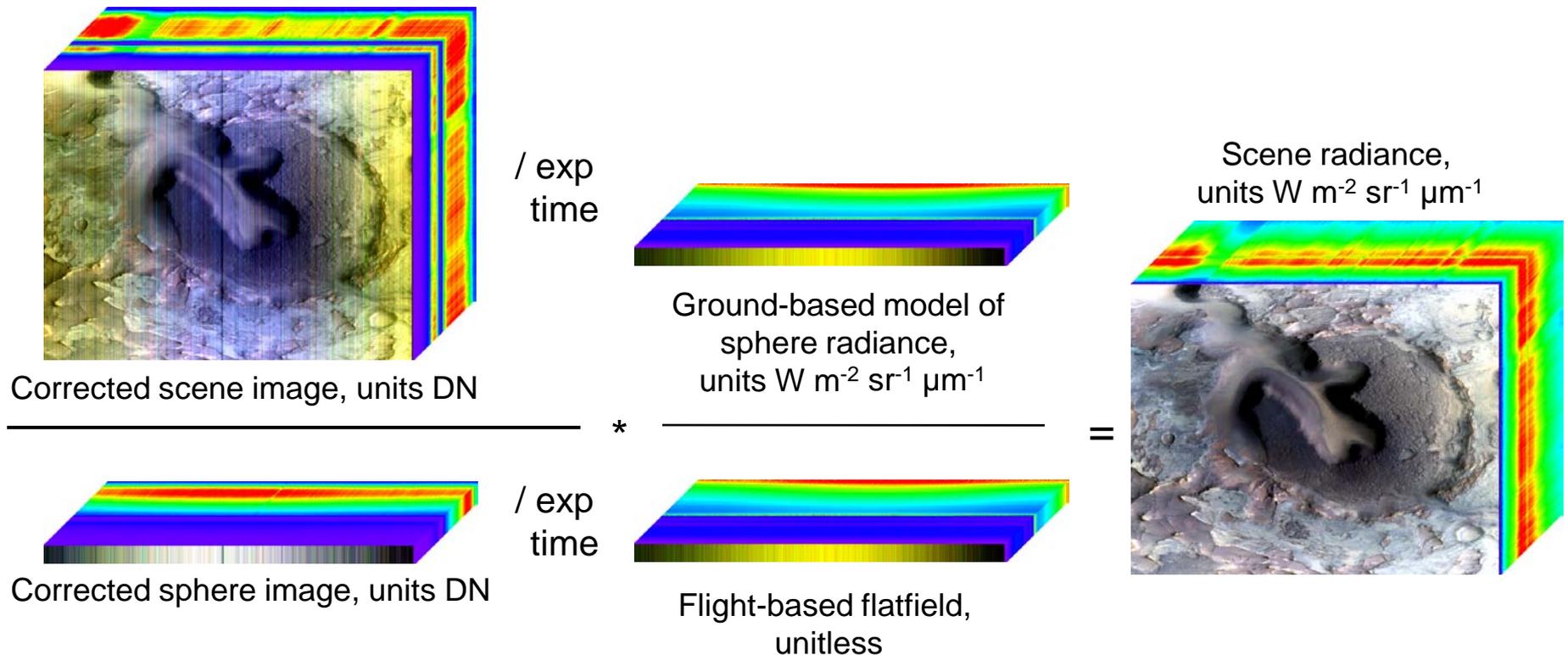


Companion dark image, units DN

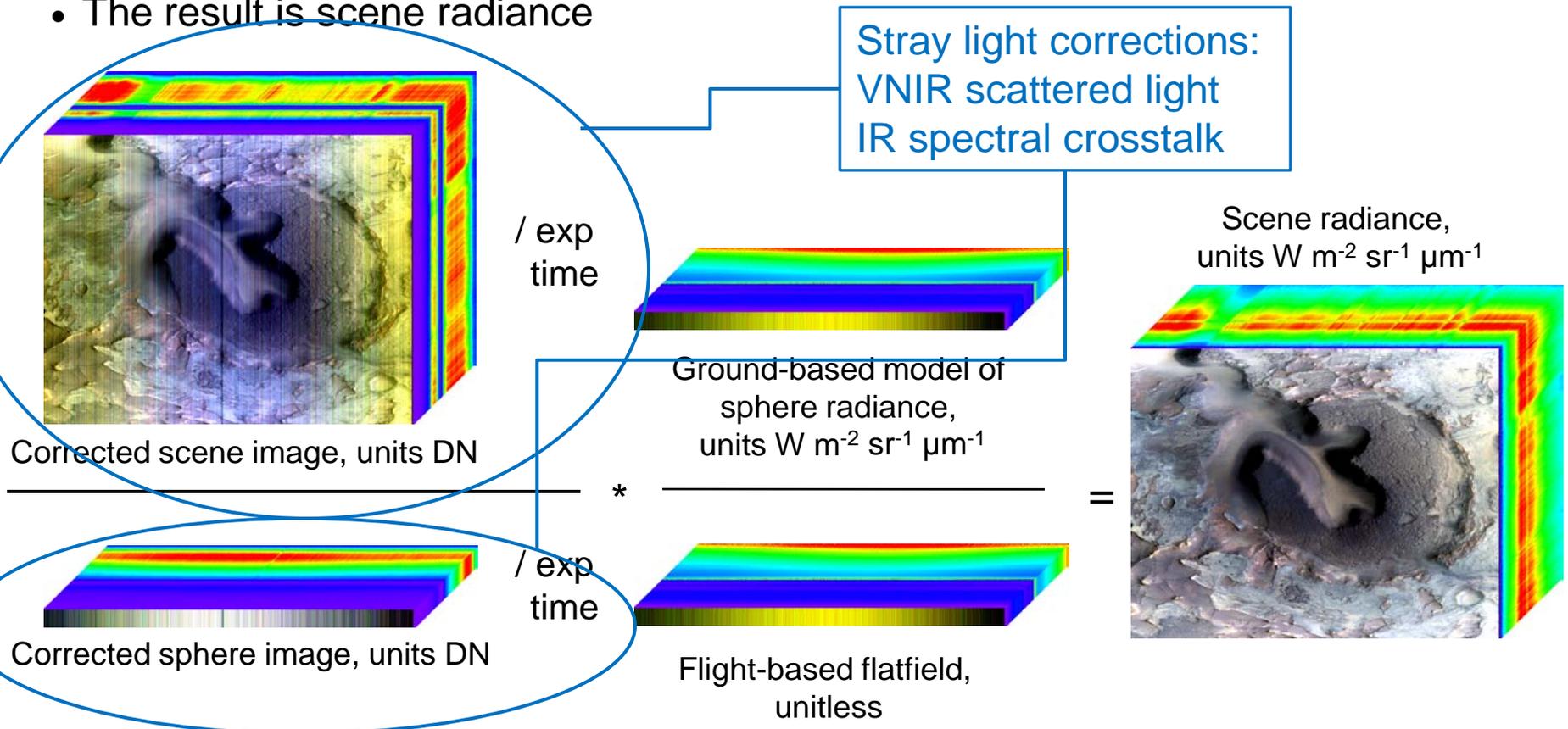


Corrected sphere image, units DN

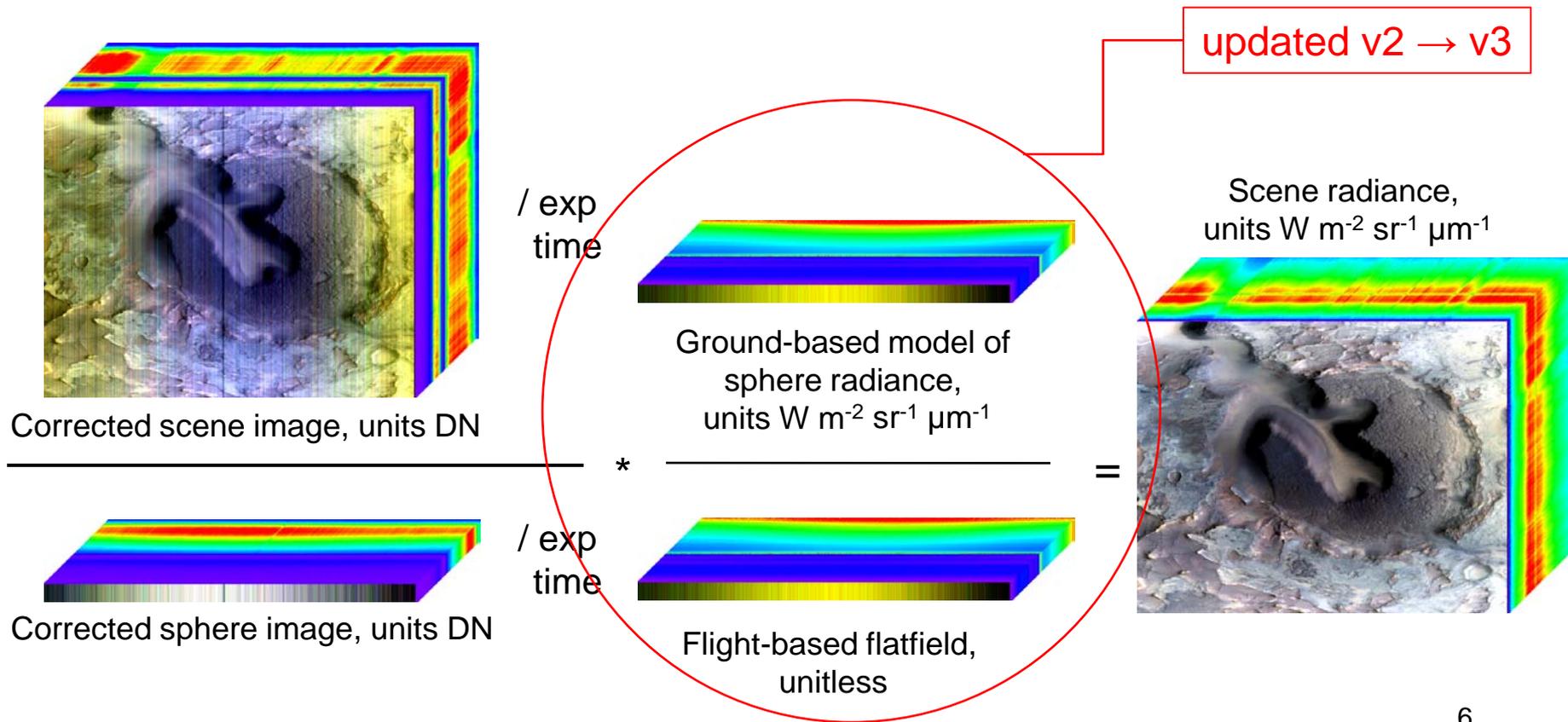
- The corrected scene and sphere images are both divided by exposure time to yield values linearly related to radiance
- The scene is ratioed to the sphere, multiplied by a ground-based model of the sphere's radiance, and divided by a flight-based flatfield
- The result is scene radiance



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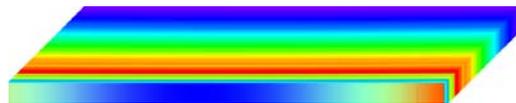


- To convert radiance to I/F, the solar flux at 1 AU is convolved with the bandpasses for each CRISM pixel
- The radiance is divided by the solar flux scaled to Mars' solar distance
- The result is I/F

Scene radiance,  
units  $W\ m^{-2}\ sr^{-1}\ \mu m^{-1}$



$$* (\text{solar distance in AU})^2 * \pi$$



Solar flux at 1 AU,  
units  $W\ m^{-2}\ \mu m^{-1}$



Scene I/F, unitless

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Scene radiance,  
units  $W m^{-2} sr^{-1} \mu m^{-1}$

RA TRDR

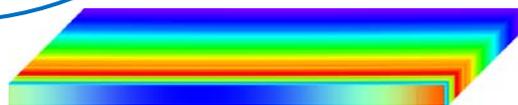


\* (solar distance in AU)<sup>2</sup> \*  $\pi$

IF TRDR  
Additional noise  
filtering in v3

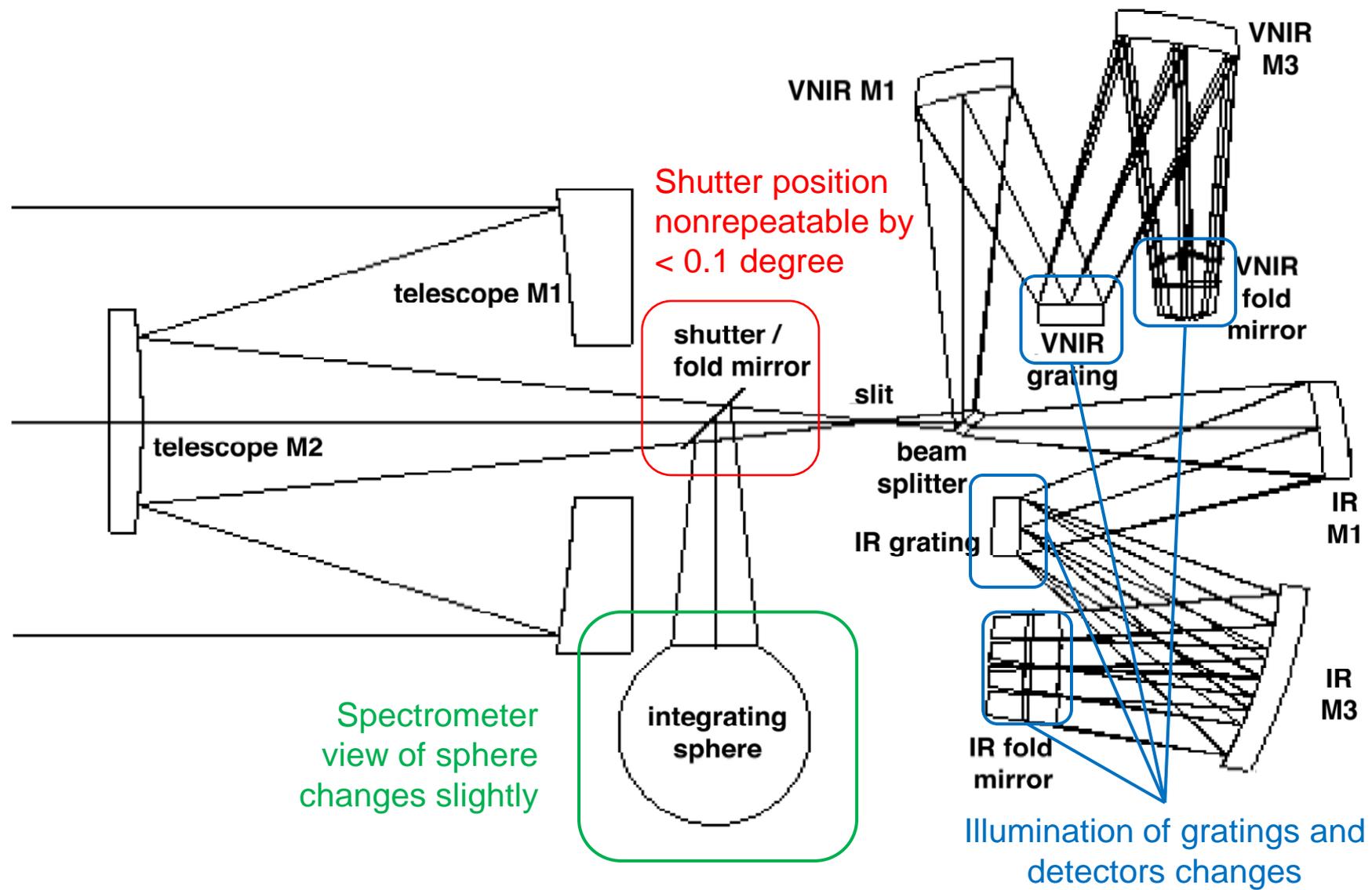


Scene I/F, unitless

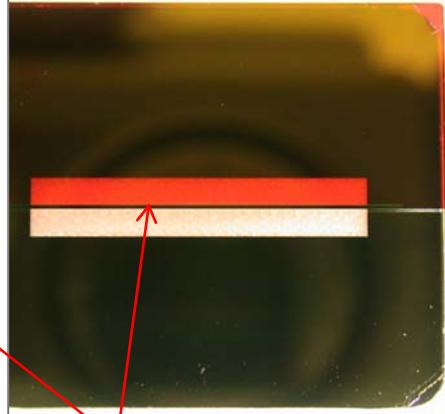
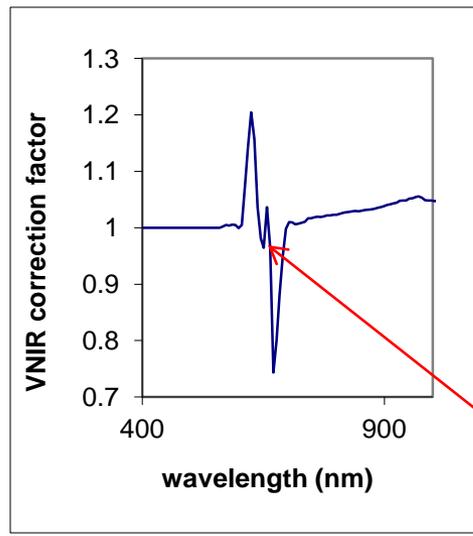
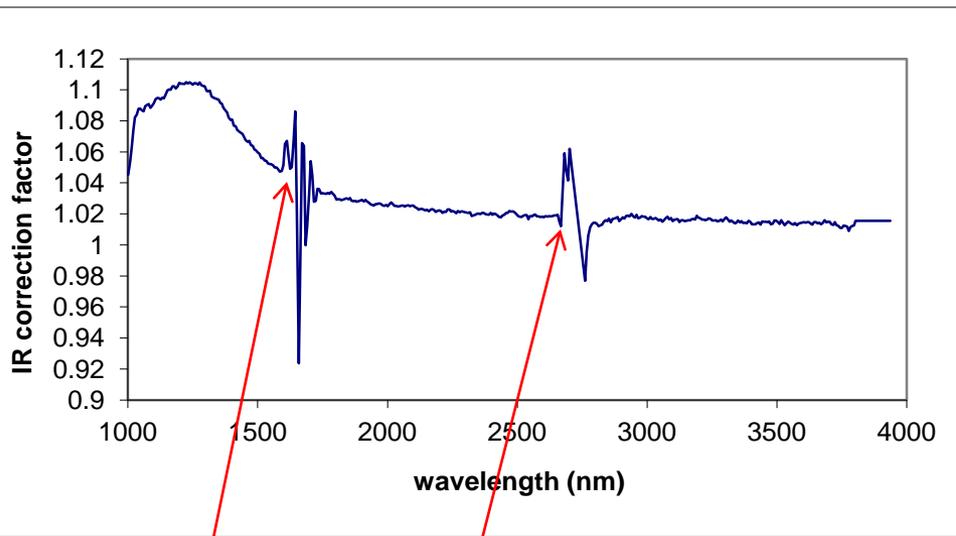


Solar flux at 1 AU,  
units  $W m^{-2} \mu m^{-1}$

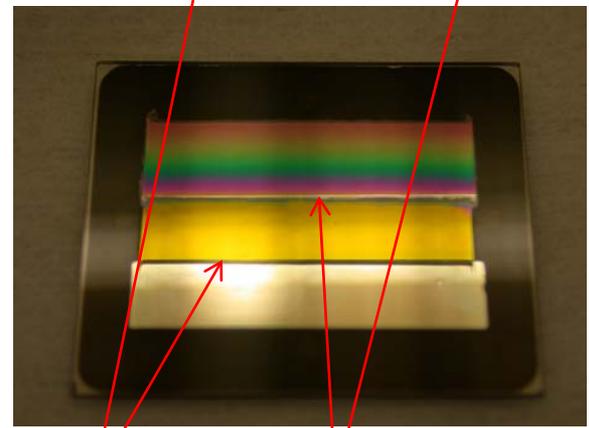
# Correction for shutter mirror nonrepeatability



# Spectrum of v2 calibration nonrepeatability (1 of 2)

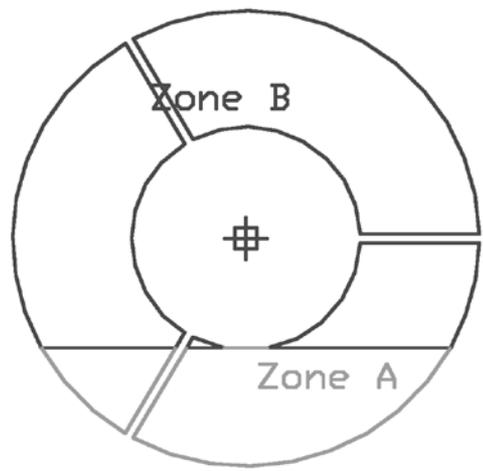


Zone boundary

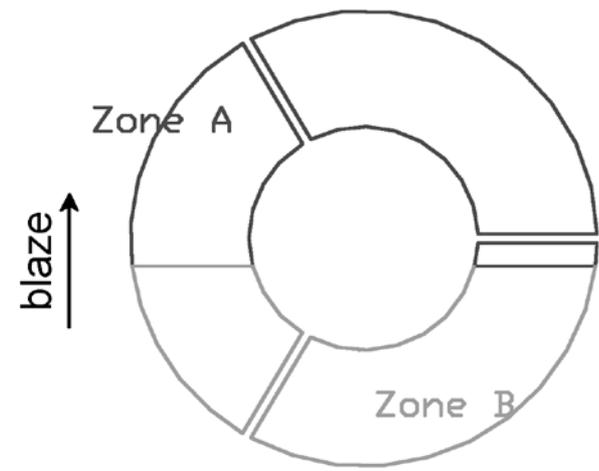


Order sorting filter zone boundaries

IR Zoning (73/27)



VNIR Zoning (55/45)



Diffraction grating zones

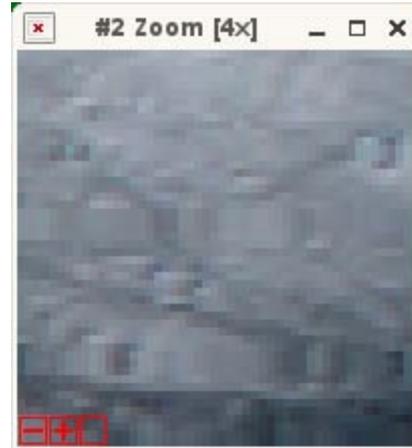
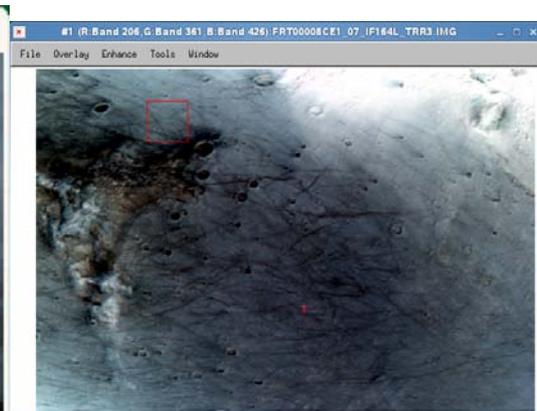
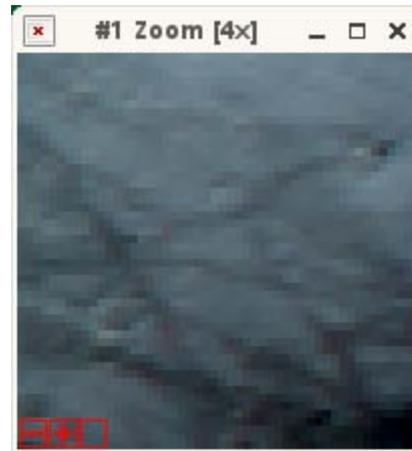
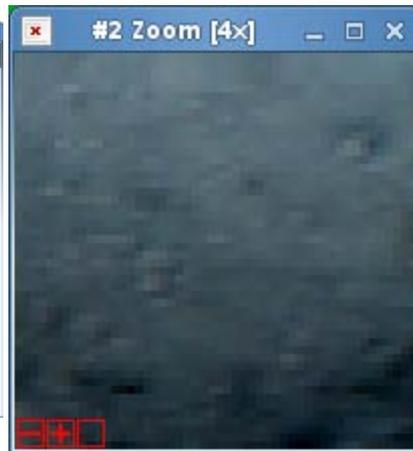
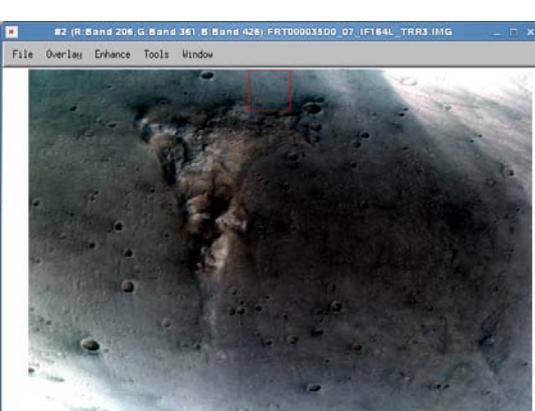
# Spectrum of v2 calibration nonrepeatability (2 of 2)

- The spectrum of the onboard calibration source is affected by tiny changes in the shutter mirror angle for different onboard calibrations.
- The diffraction gratings have zones with different spectral efficiency profiles, and a change in the pattern of illumination changes the relative contribution of the zones, changing the spectrometer efficiency.
- A small change in the angle of the shutter mirror will also change the angle of light arriving at the detector, slightly changing the shadows of the zone boundaries of the order sorting filters.
- The plots show correction factors derived from analysis of many flight calibration images with the sphere temperature and detector temperature fixed.
- The smooth function derives from filling the grating zones, and the sharp spikes from the shadows of the order sorting filter zone boundaries.
- In the v3 calibration for both VNIR and IR, the deviation of this correction factor from 1 is scaled according to the size of the VNIR order sorting filter artifact, and the correction factor is applied to the radiance model for the onboard source.
- CRISM bad bands occur at the 650 nm VNIR order sorting filter boundary, the VNIR/IR boundary at 1000 nm, and the 2700 nm IR filter boundary. Although the data are noisier at the other IR filter boundary at 1650 nm, the calibration is surprisingly effective, and these bands are not considered bad bands.

- Repeated images were taken of Gusev Crater.
- A 51x51 pixel square was identified in each unmapped image, with the intent of repeating the same position.
- Spectra were compared using the median of each square.
- The scenes could have different lighting conditions, dust coverage, etc.

2006\_346/FRT35D0\_TRR3

2007\_351/FRT8CE1\_TRR3

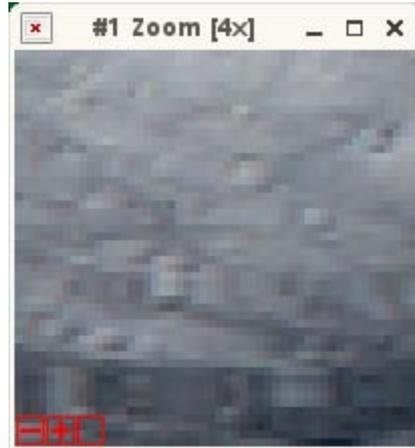
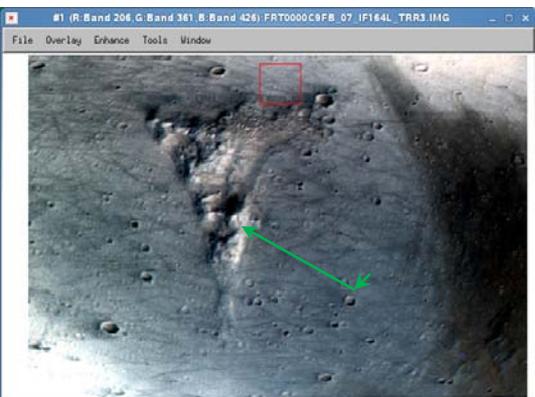
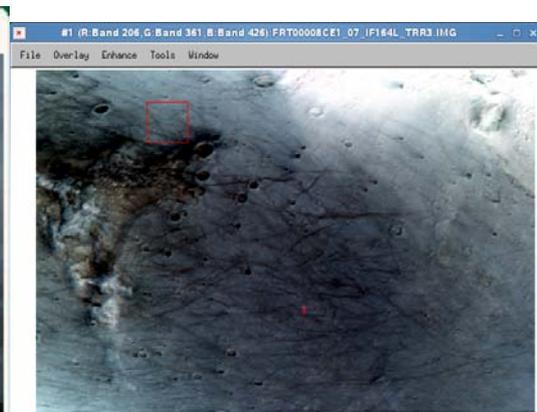
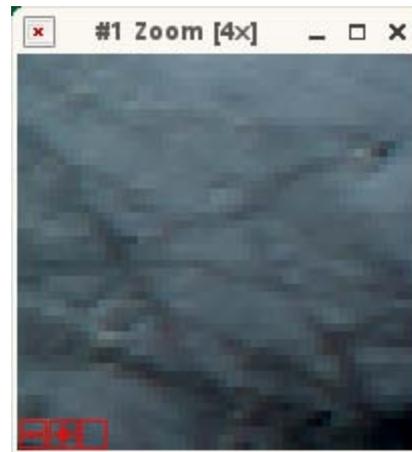
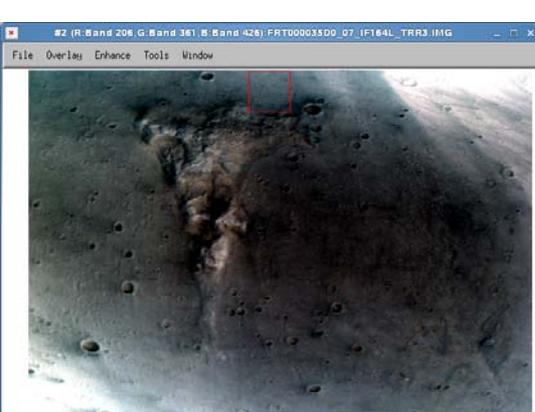


2008\_265/FRTC9FB\_TRR3

2008\_281/FRTCDA5\_TRR3

2006\_346/FRT35D0\_TRR3

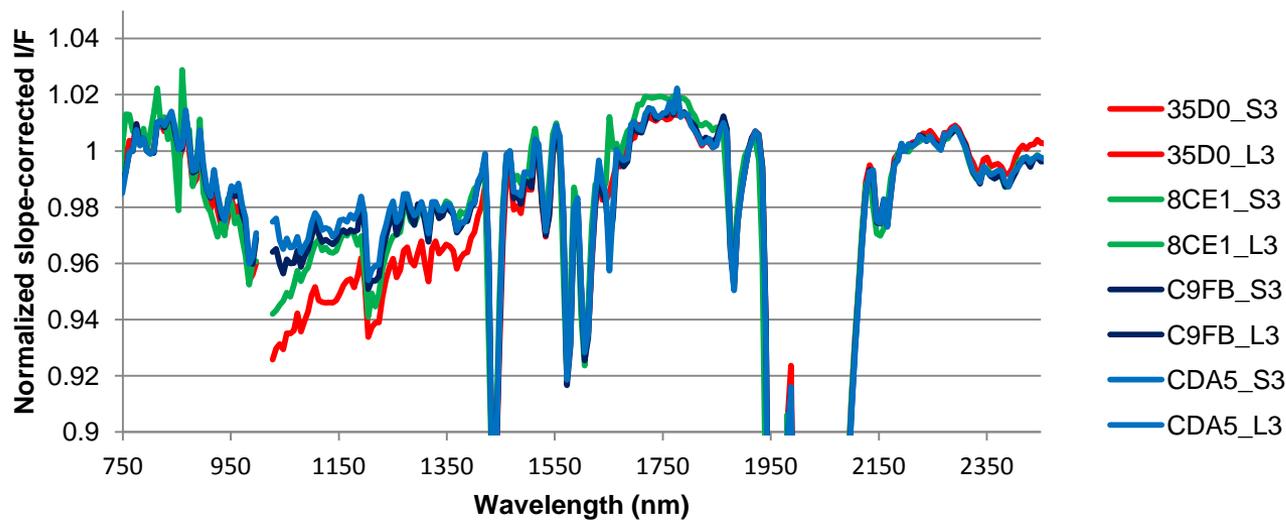
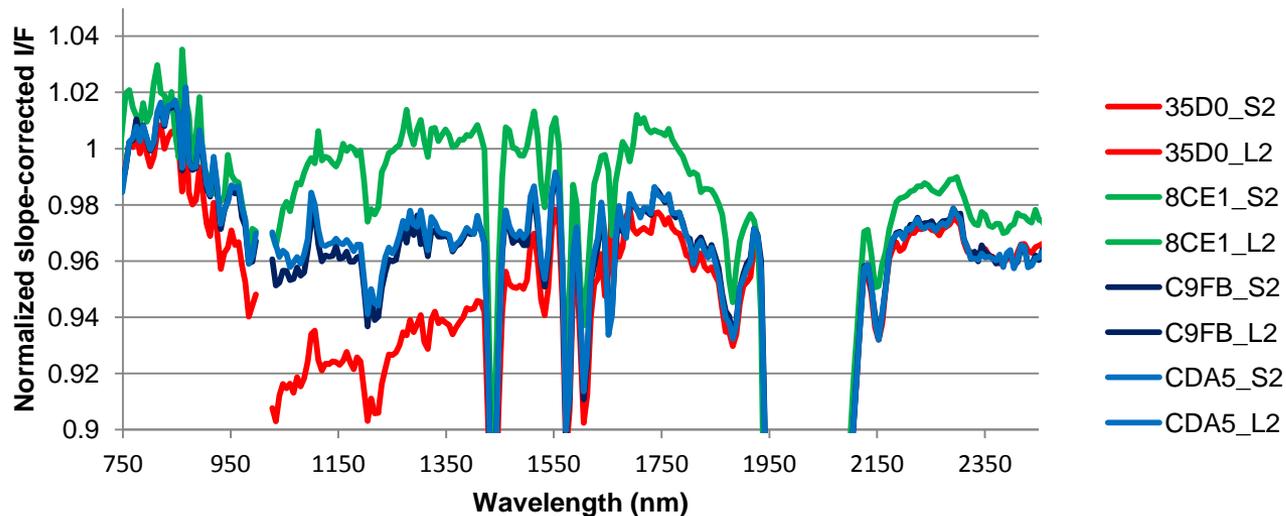
2007\_351/FRT8CE1\_TRR3



spirit

2008\_265/FRTC9FB\_TRR3

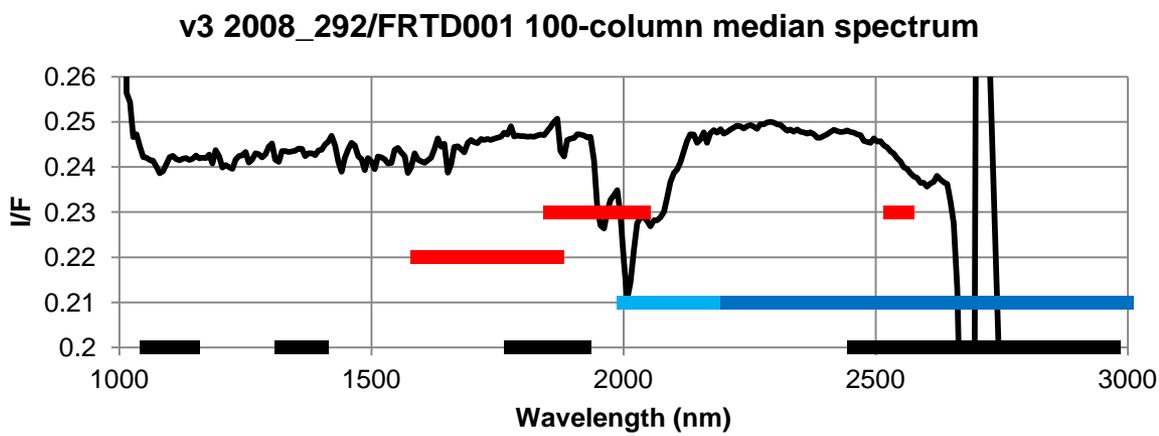
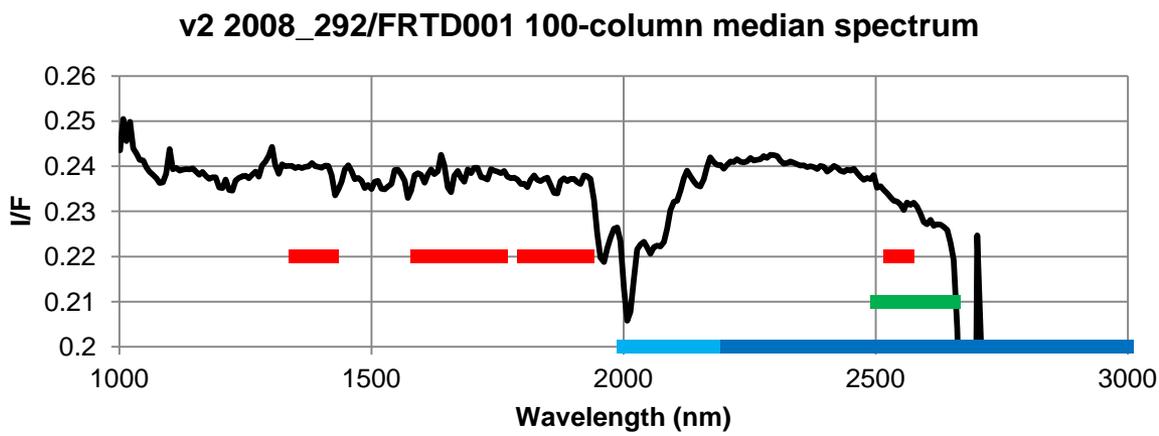
2008\_281/FRTCDA5\_TRR3



- The I/F for each scene is scaled by a linear function which scales the v3 spectrum to 1 at 794 nm and 2198 nm. This accounts for variation in photometric angles and dust for the different scenes.
- The v3 repeatability is better but not perfect.
- Likewise, v3 VNIR/IR matching is better but not perfect. From this plot, it appears the 35D0 IR is undercorrected, but since the plot is scaled to make the spectra agree at 794 nm, the mismatch could just as well be from the VNIR side.
- Note changes from v2 to v3 at 1100 nm and 1750-1900 nm.
- Note v3 I/F is typically a bit higher than v2 above 1600 nm.
- Note the spectra still appear “noisy” at the 1% and less level, even with 51x51 median applied. See, for example, the VNIR spectra <1000 nm. This is typically not random noise but rather residual calibration artifacts, and one must be careful interpreting narrow features <1% in depth.

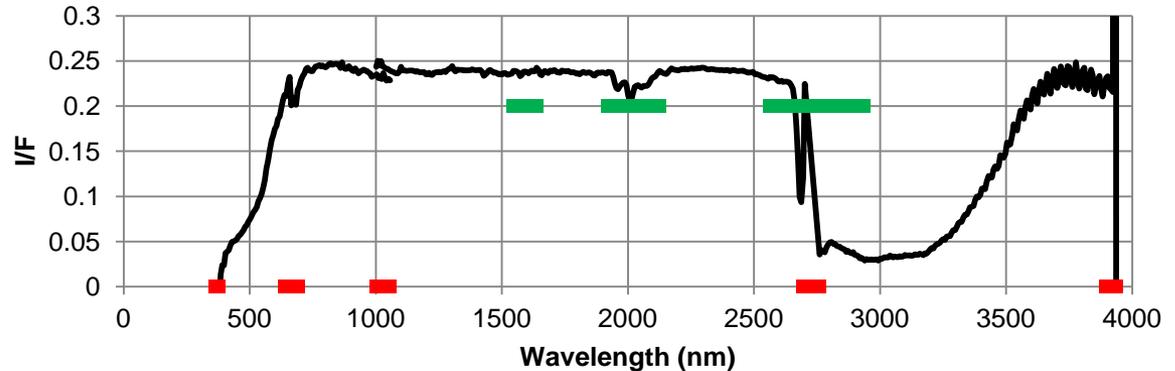
# Empirical corrections

- CRISM I/F for a scene from the Olympus Mons summit, 100-column median
- Laboratory water vapor correction
- Deimos-based approx -4% I/F adjustment > 2 microns
- Deimos-based empirical correction
- Empirical correction based on Olympus Mons summit images; 46A1 for v2 and 7901 for v3

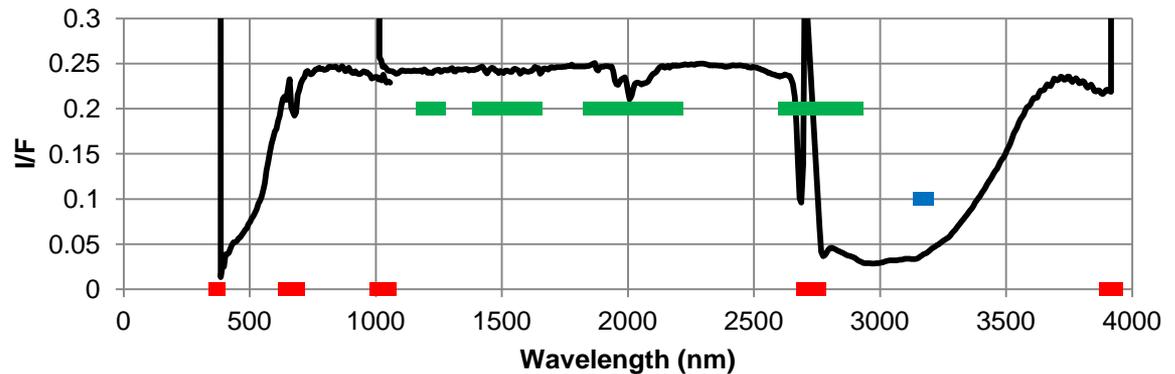


- CRISM I/F for a scene from the Olympus Mons summit, 100-column median
- Flight-based flat field set equal to zero
- Modified stray light subtraction
- Bad bands

v2 2008\_292/FRTD001 100-column median spectrum



v3 2008\_292/FRTD001 100-column median spectrum



- Flight-derived flat field
  - Flat field is derived from special nadir-looking (gimbal fixed) observations designated FFC
  - Flat field is median of lines in multiple images
  - Some wavelengths are excluded to avoid interaction of instrument smile with deep, narrow atmospheric spectral features
- Version 2 calibration
  - Flat field derived from a small number of FFC images selected for crosstrack uniformity, 2 full-resolution hyperspectral images and 3 10x binned multispectral images
  - Fewer wavelengths excluded from flat field
- Version 3 calibration
  - Flat field derived from the median of all lines of a large number of FFC images with no selection, 169 full-resolution hyperspectral images and 56 10x binned multispectral images
  - Larger range of wavelengths excluded near 2 microns, and wavelengths near 1440 nm CO<sub>2</sub> feature excluded