CALIBRATION OF NEON'S AIRBORNE IMAGING SPECTROMETERS

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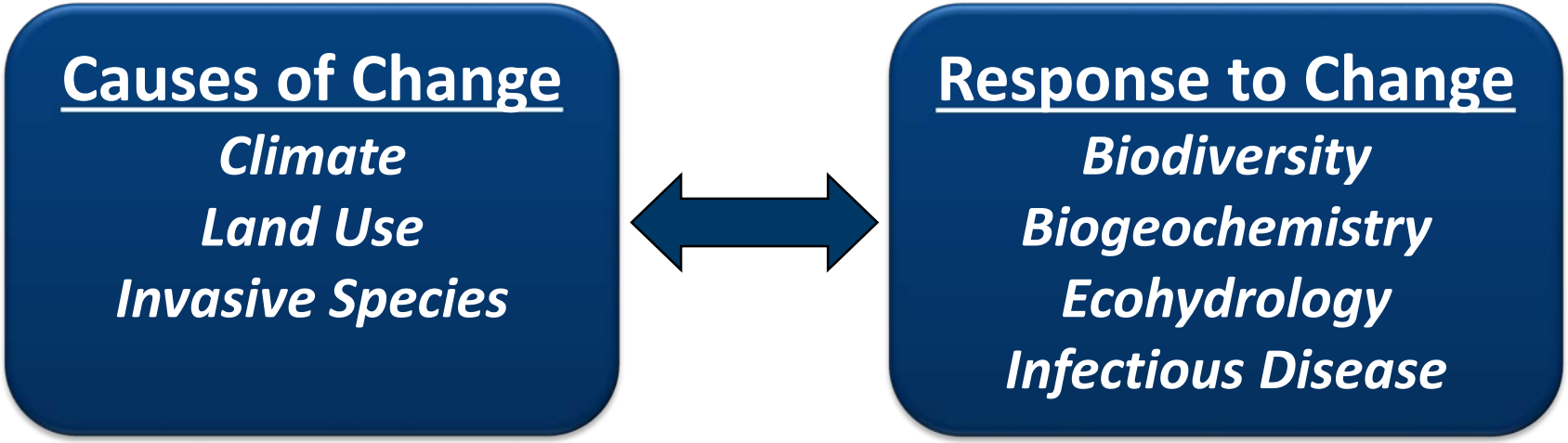
Funded by the National Science Foundation to…

… to *enable understanding* and *forecasting* of the *impacts* of *climate change, land use change* and *invasive species* on *continental-scale ecology*

…by providing infrastructure to support research, education and environmental management in these areas

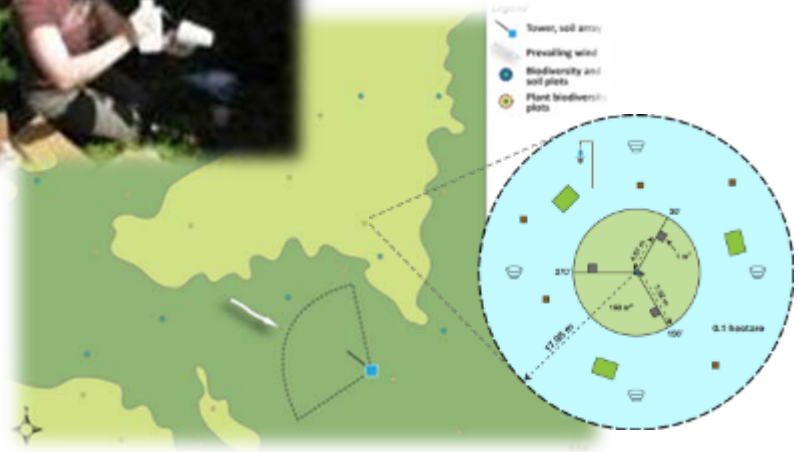


NEON Observation Systems

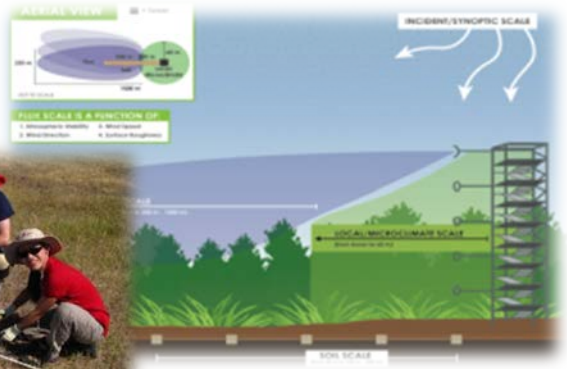
AOS/AIS

AOP

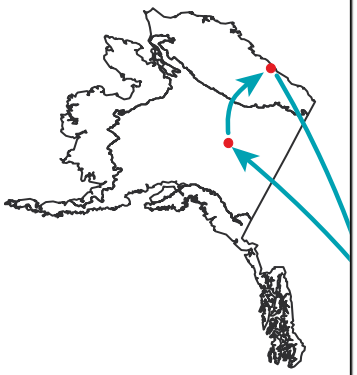
TOS

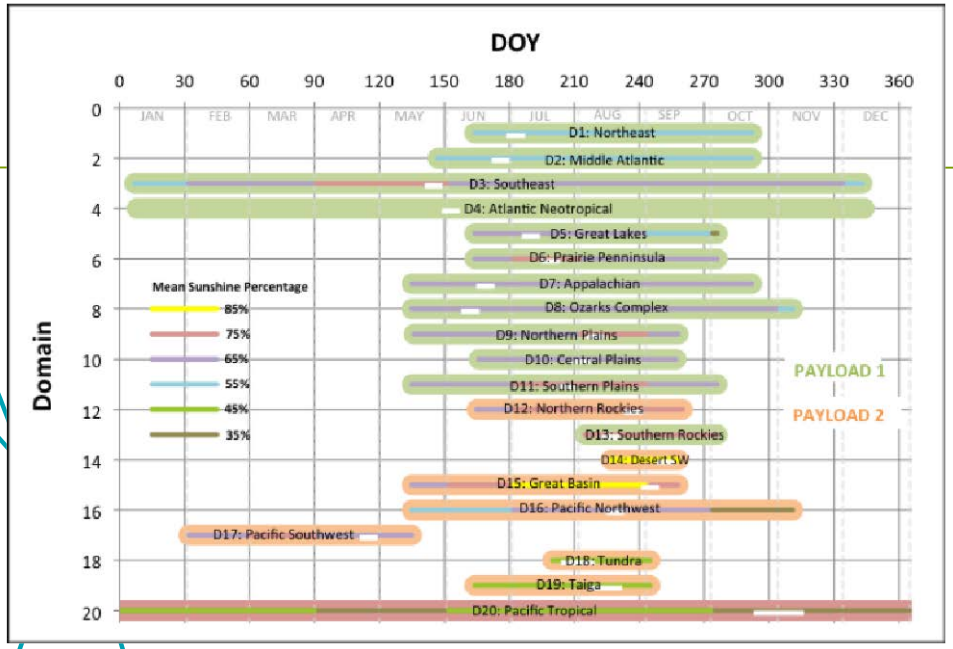


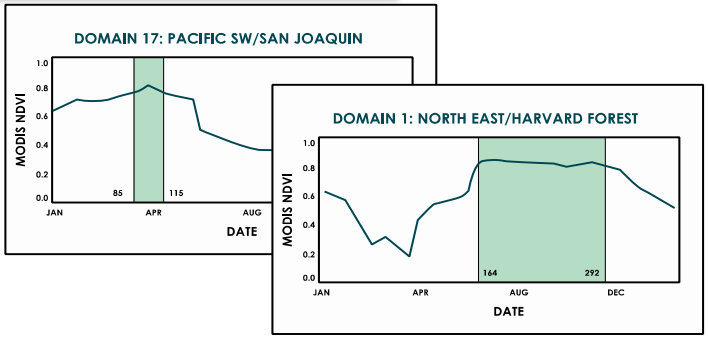
TIS



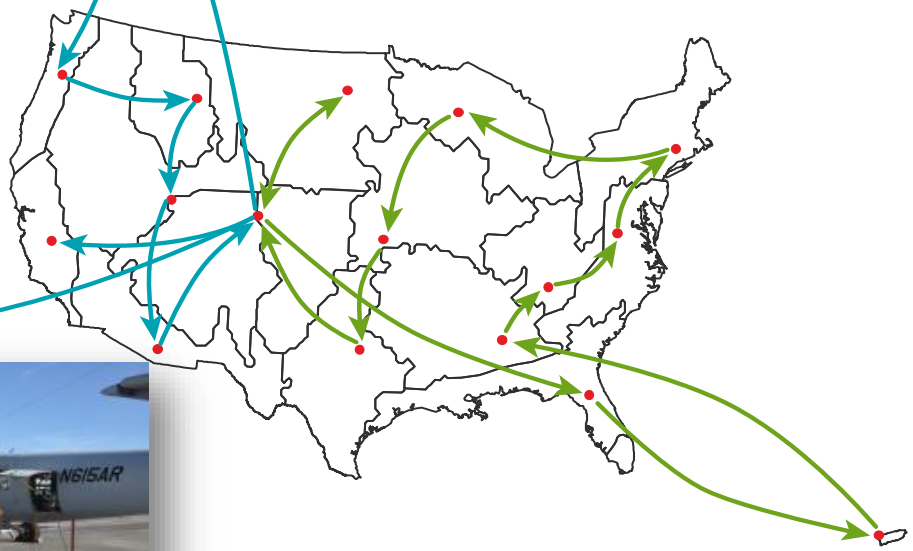
AOP Flight Concept



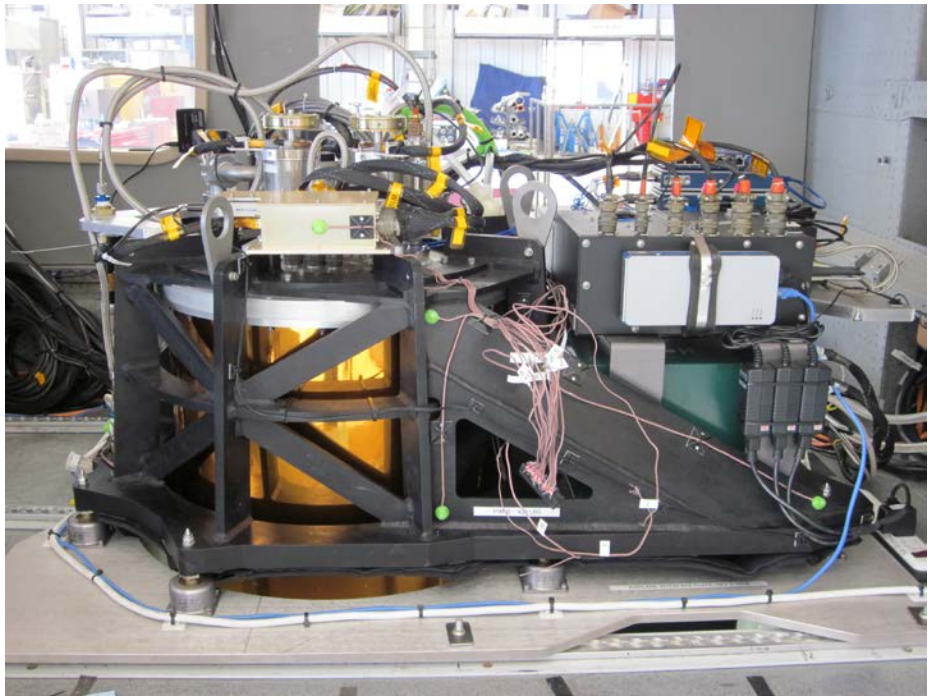


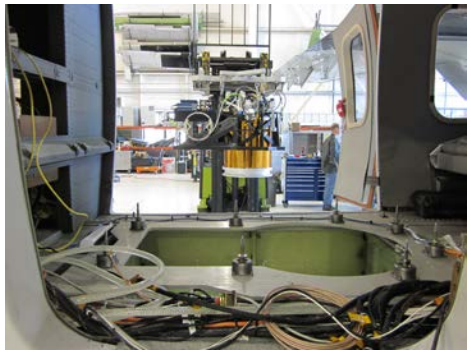


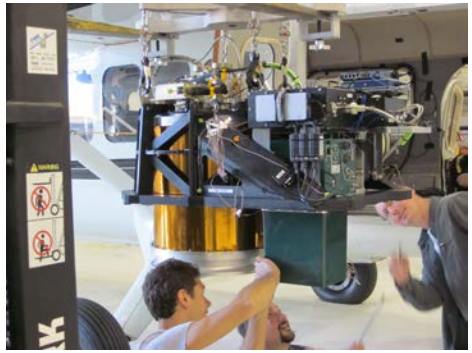
NDVI data determines the annual flight window for each domain.

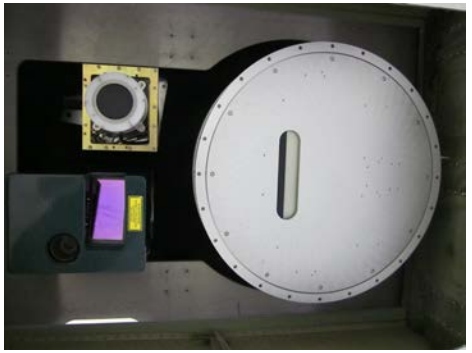


NEON Airborne Payload

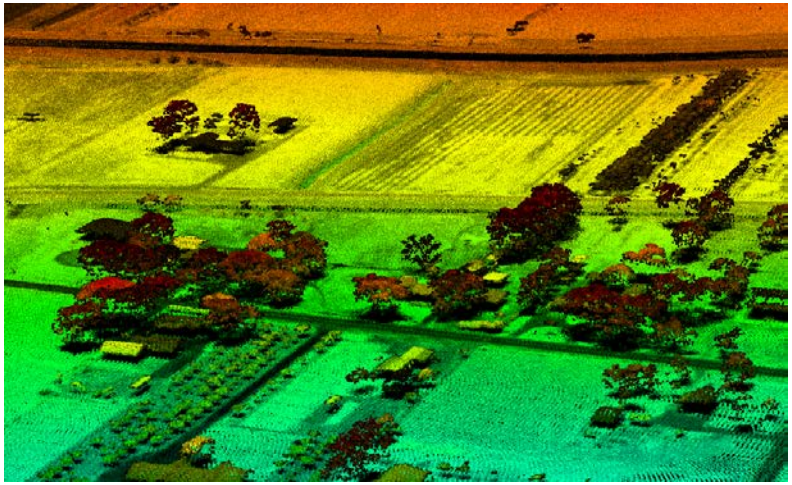








AOP Data



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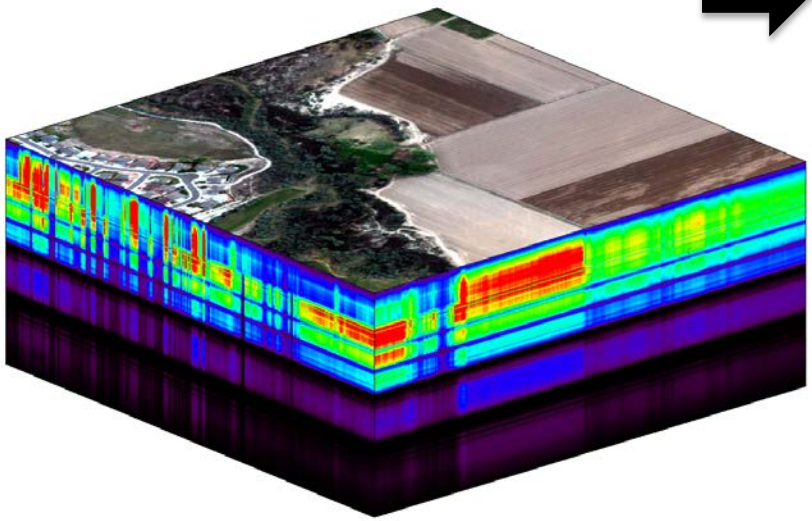
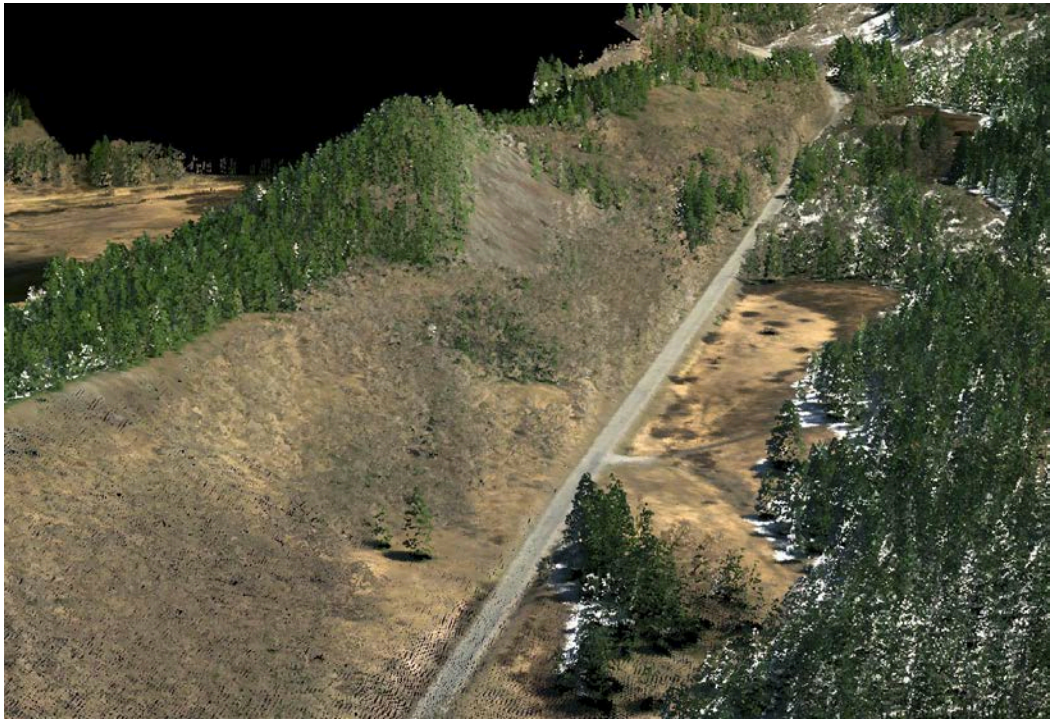
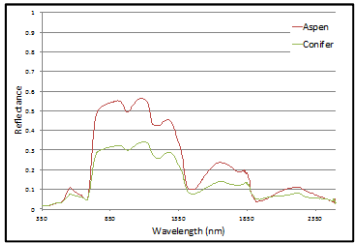
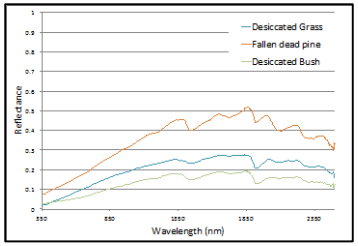
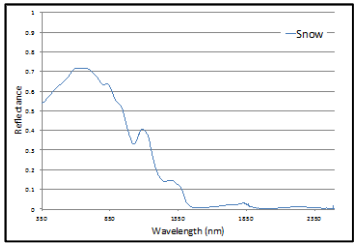




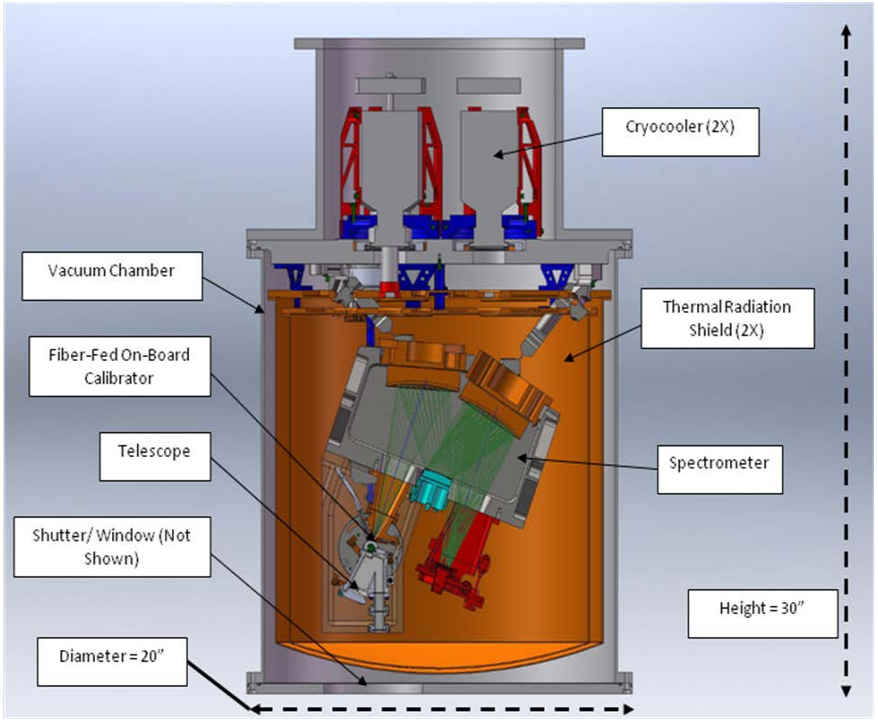


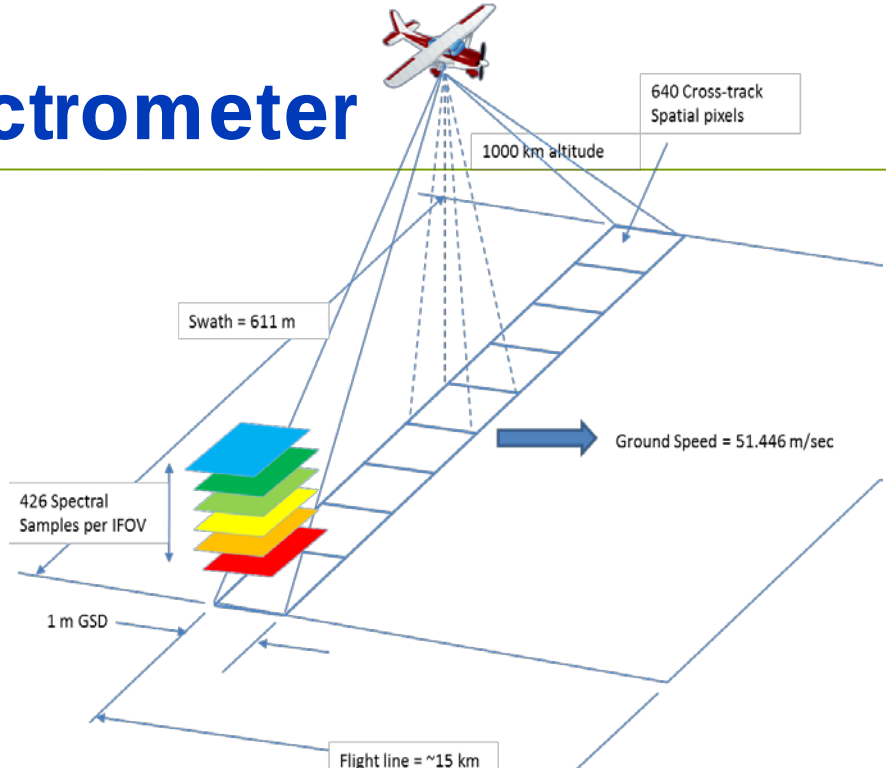


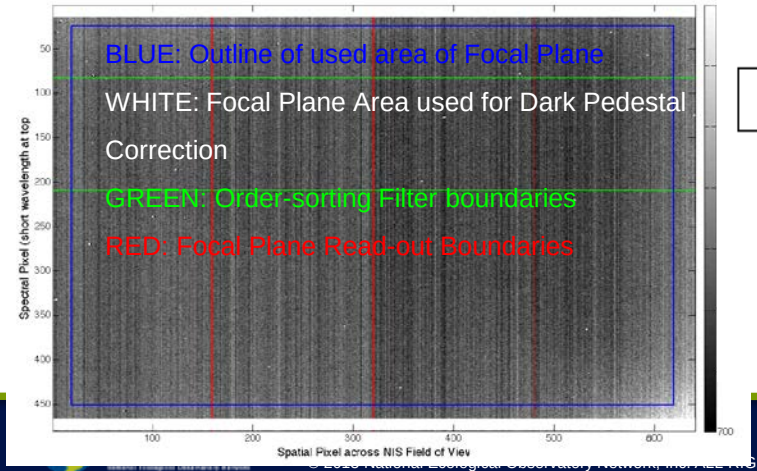


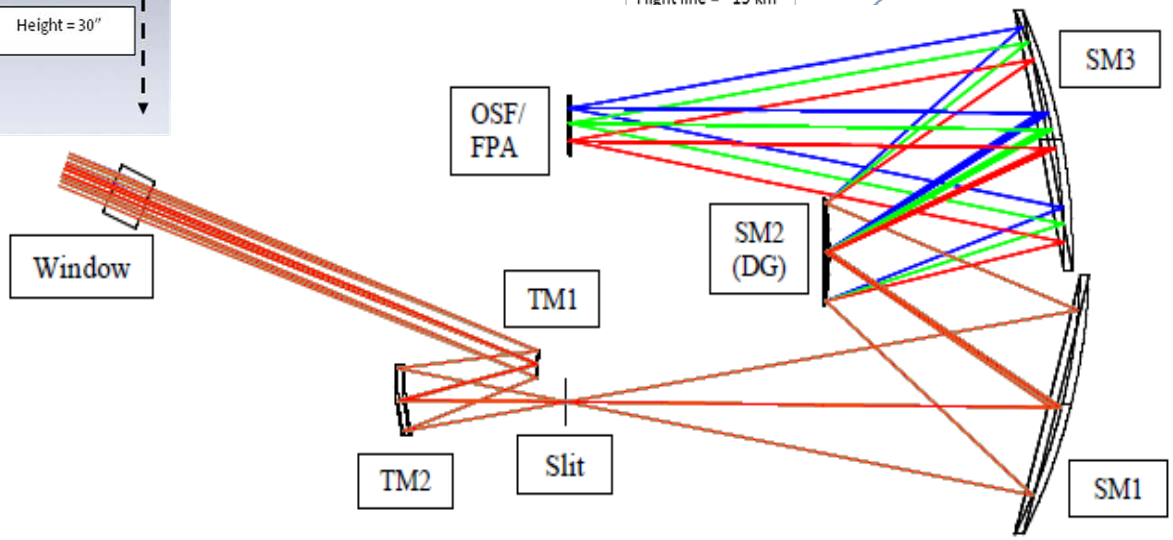
Aspen & Pine Dead Grass Snow

The NEON Imaging Spectrometer

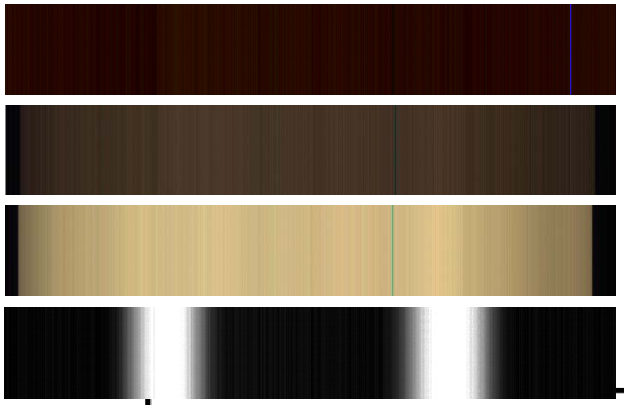








NIS Raw Flight Line Sequence

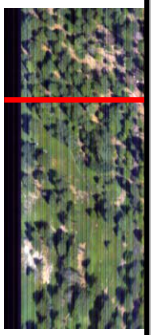


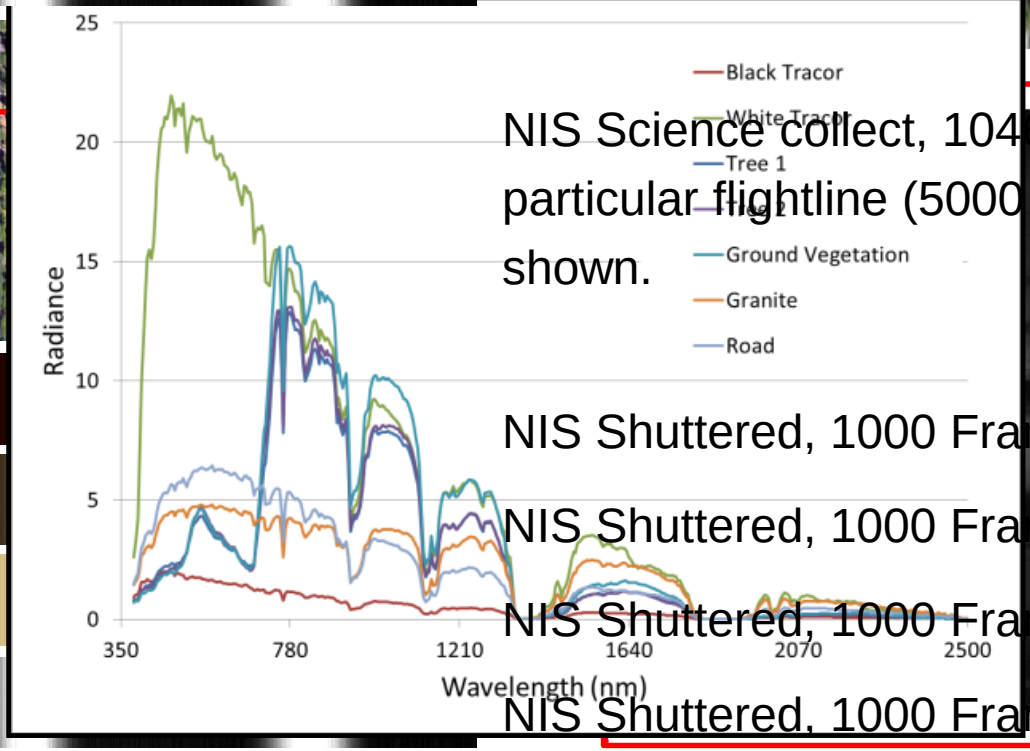
NIS Shuttered, 1000 Frames of Dark Offset

NIS Shuttered, 1000 Frames of Dim OBC

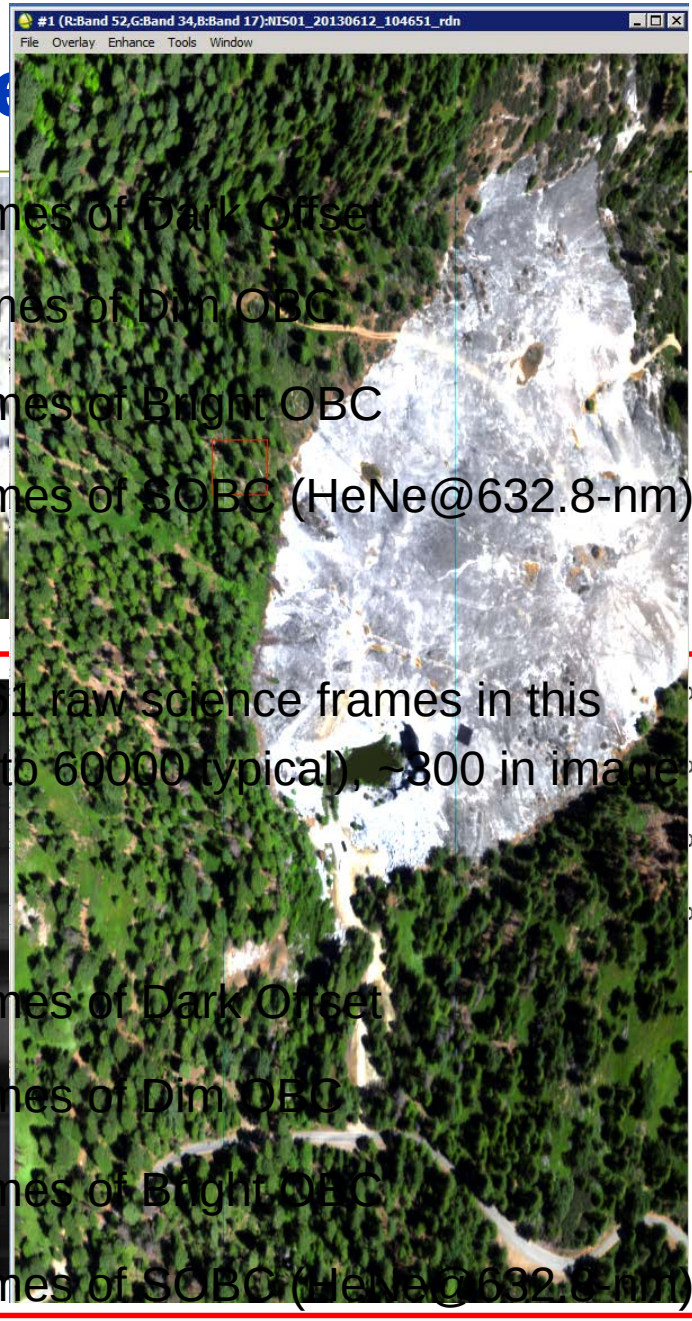
NIS Shuttered, 1000 Frames of Bright OBC

NIS Shuttered, 1000 Frames of SOBC (HeNe@632.8-nm)





NIS Science collect, 10461 raw science frames in this particular flightline (5000 to 60000 typical), ~300 in image shown.



NIS Shuttered, 1000 Frames of Dark Offset

NIS Shuttered, 1000 Frames of Dim OBC

NIS Shuttered, 1000 Frames of Bright OBC

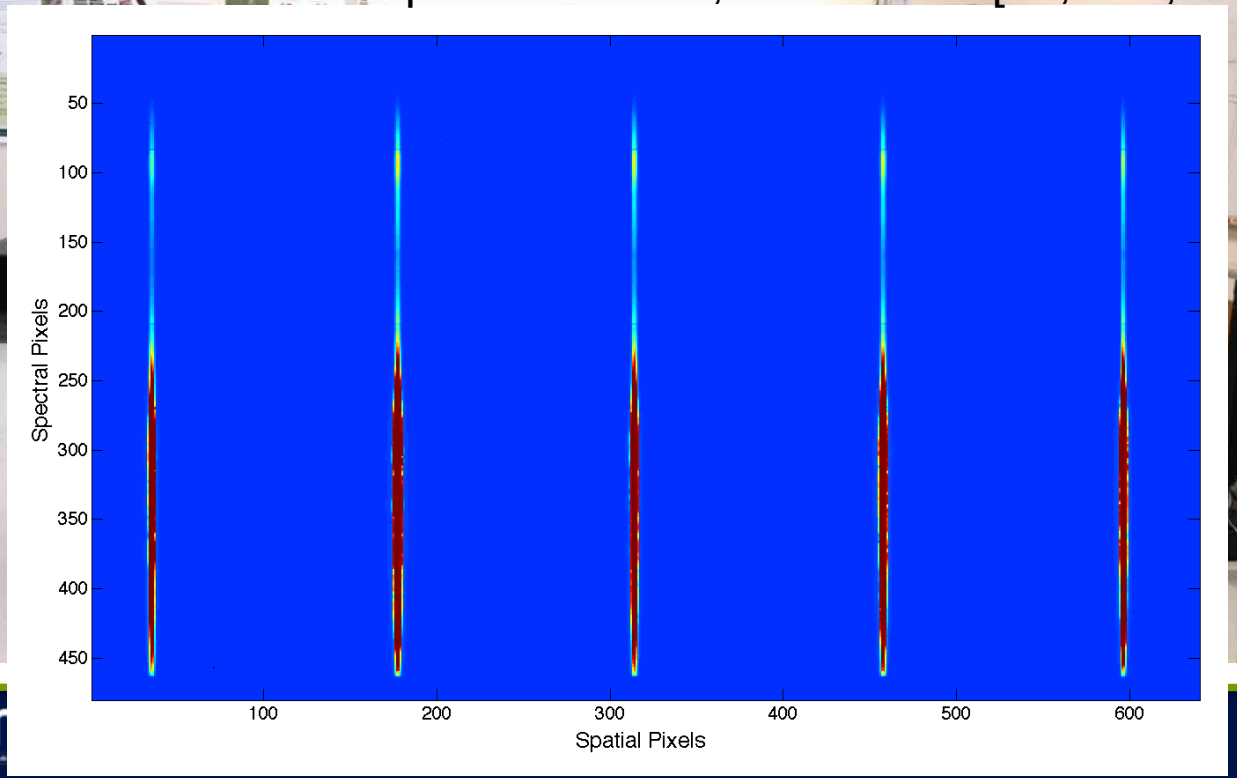
NIS Shuttered, 1000 Frames of SOBC (HeNe@632.8-nm)

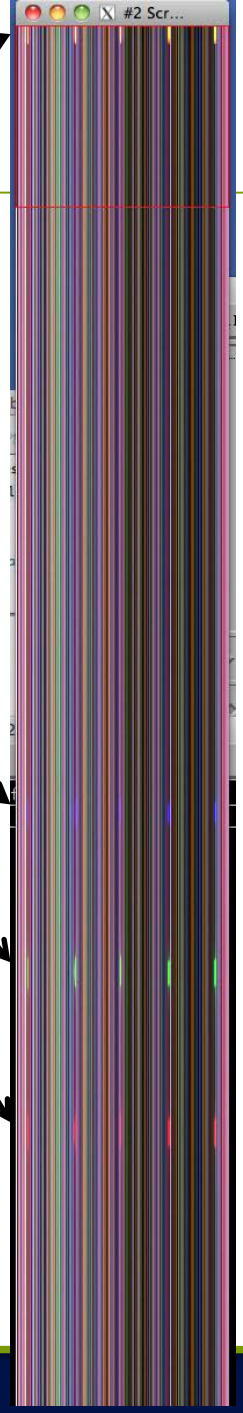
Spectral/Spatial Calibration

Raw NIS-1 image collected on BIP/SCIP

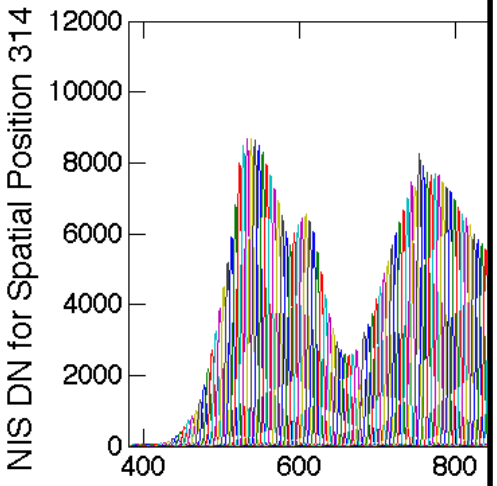
- BIP/SCIP illuminates 5 spatial pixel locations
- Zero-order light collected at start
- RGB show up sequentially in image (partial scan shown)

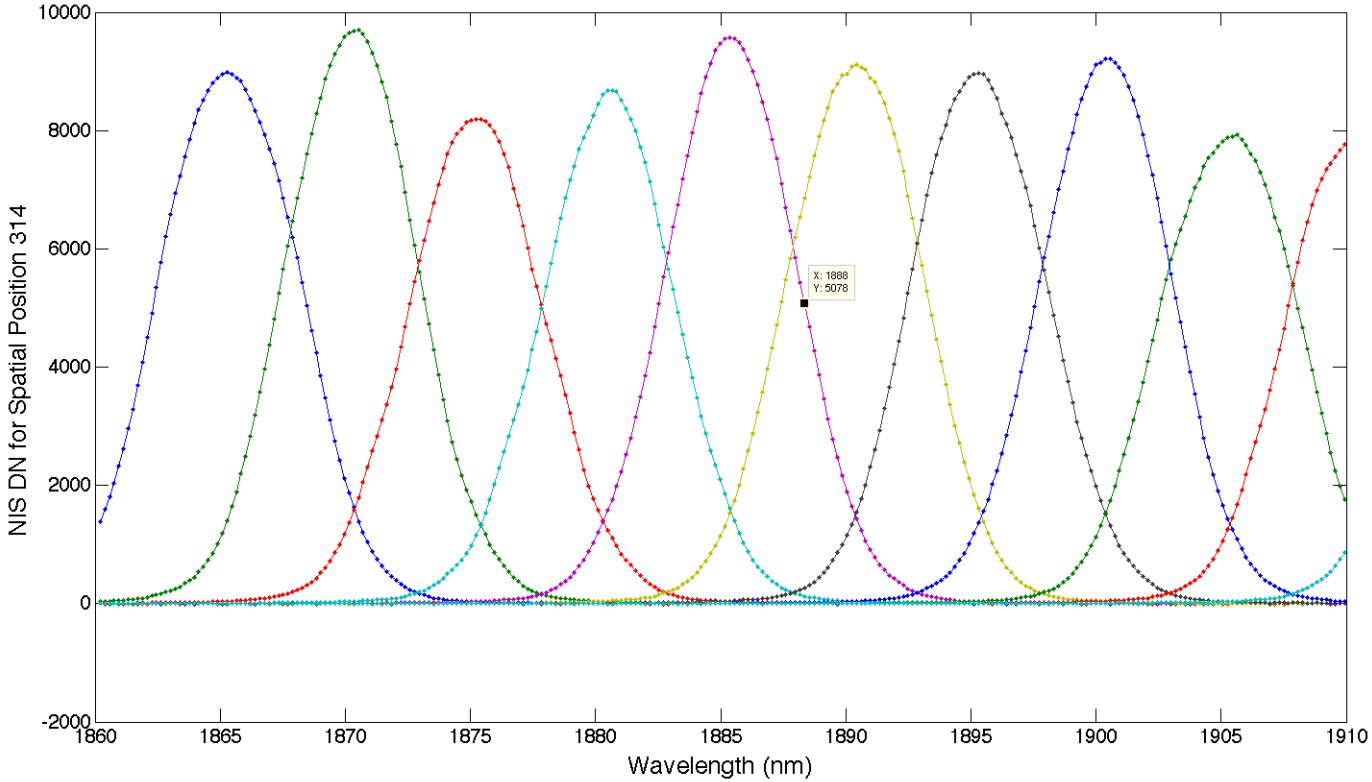
SCIP Illumination in 5 spatial columns, in this case [35, 177, 314, 457, 596]

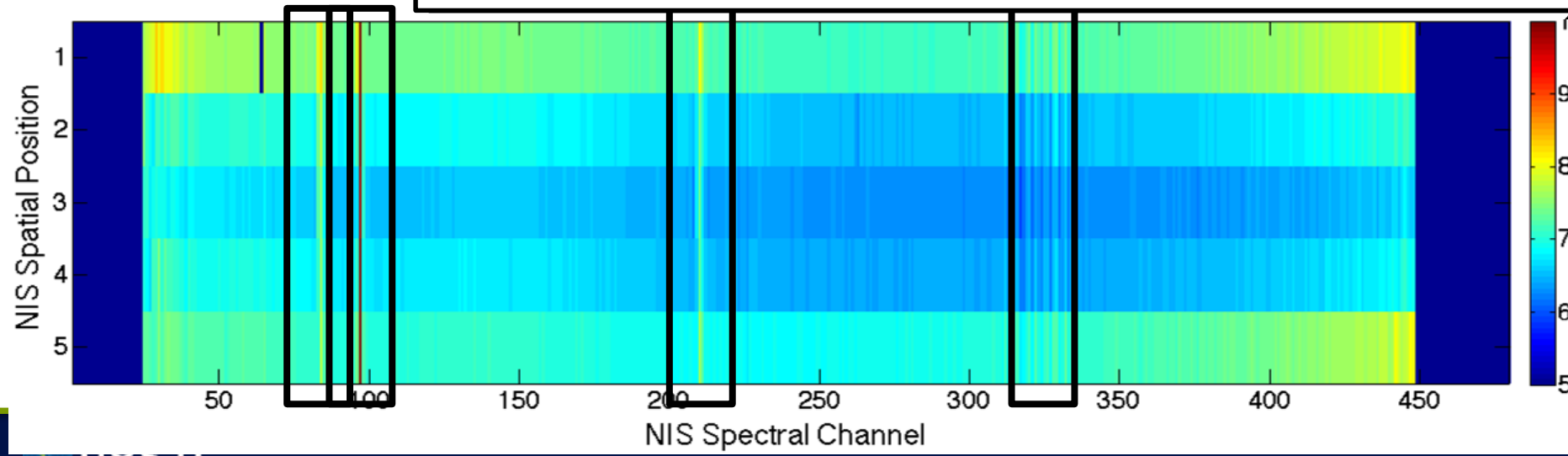




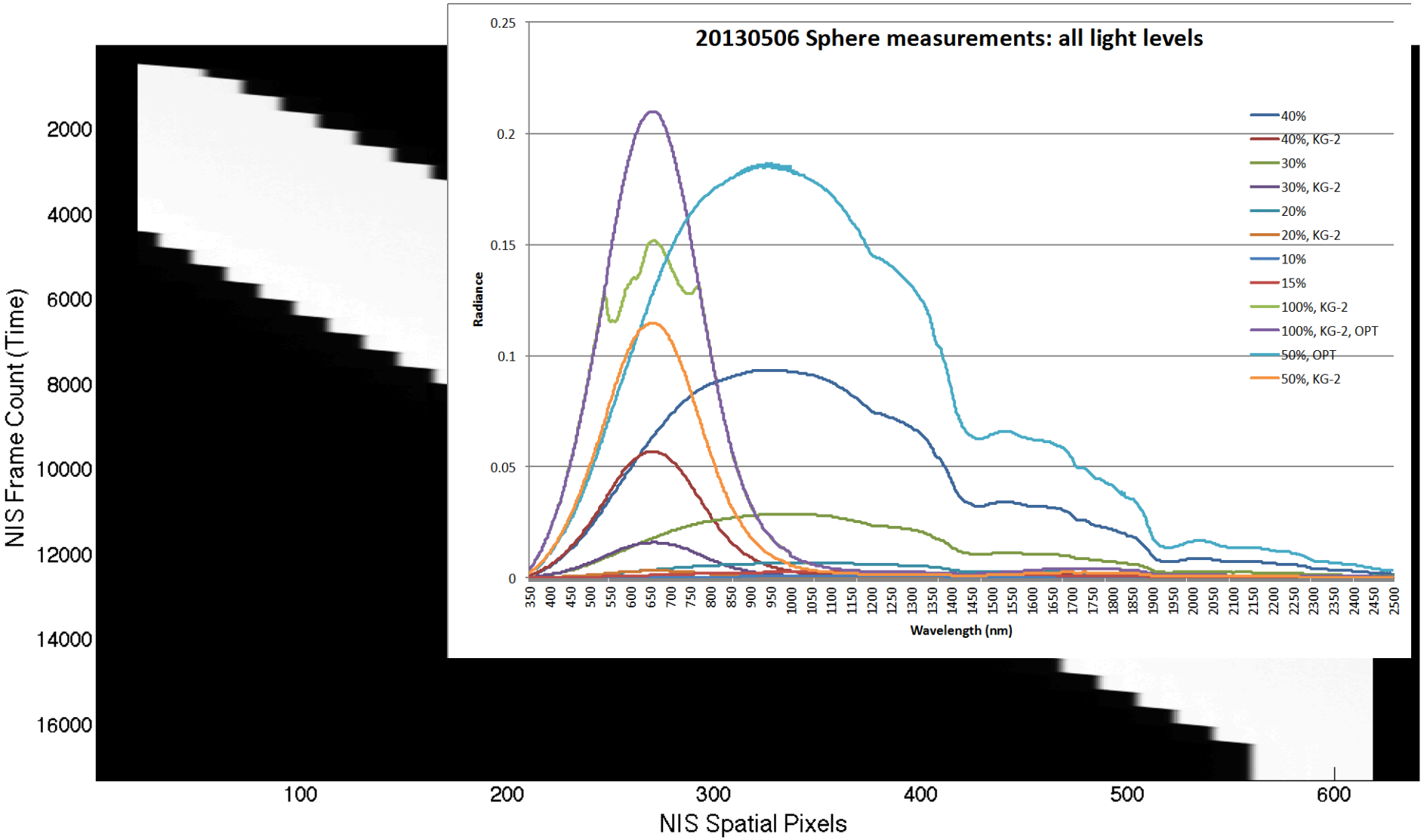
Spectral C



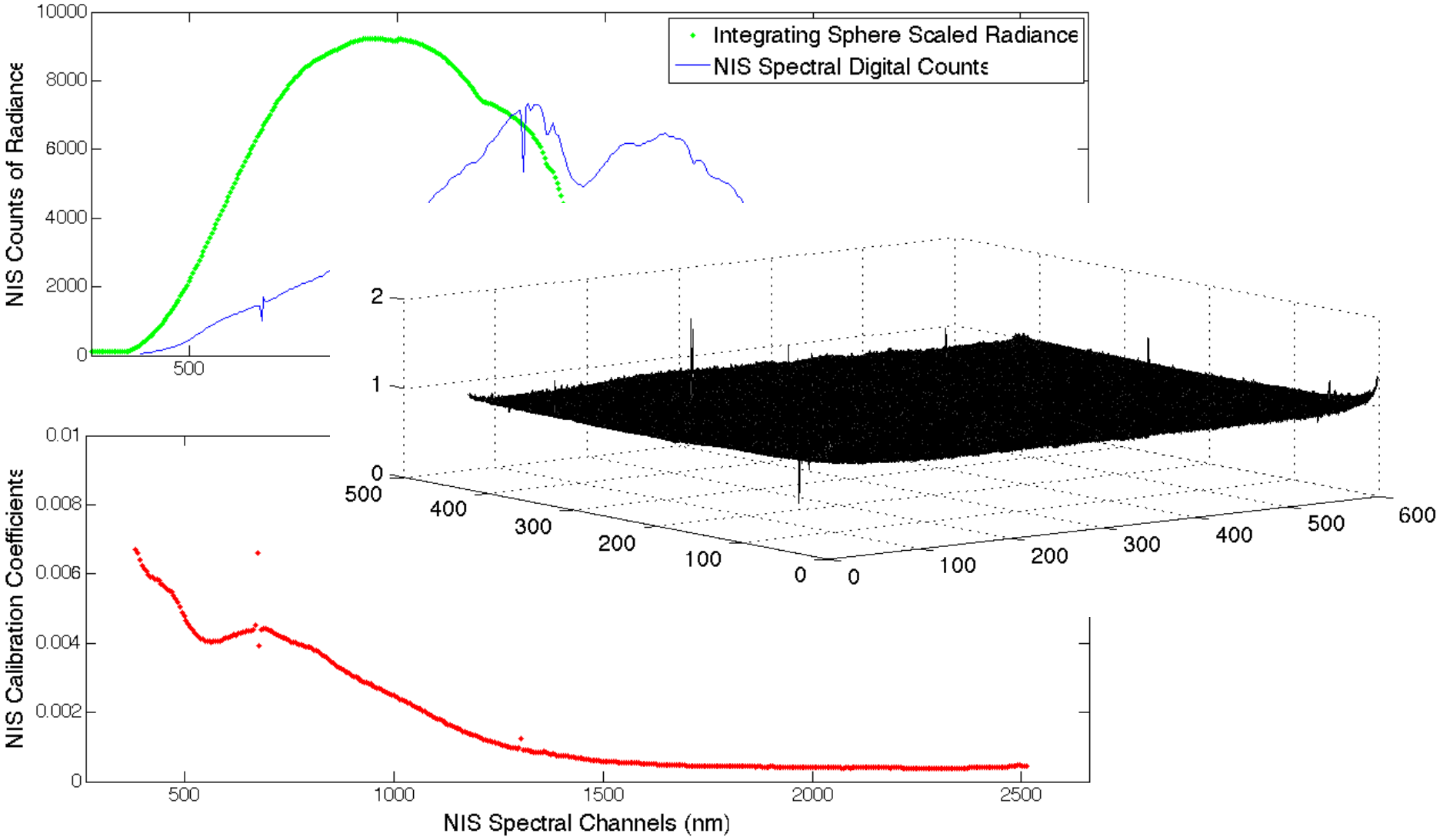




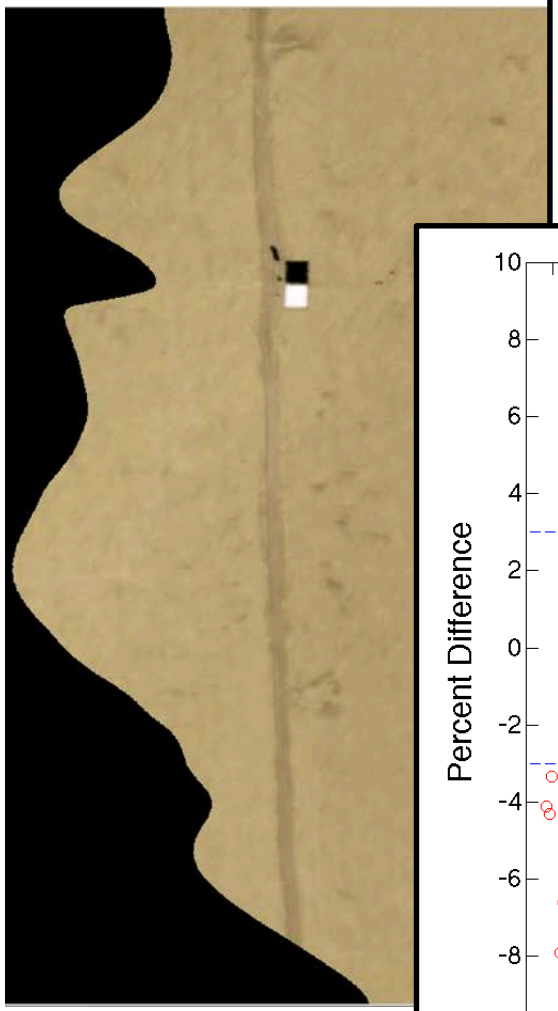
Radiometric Calibration

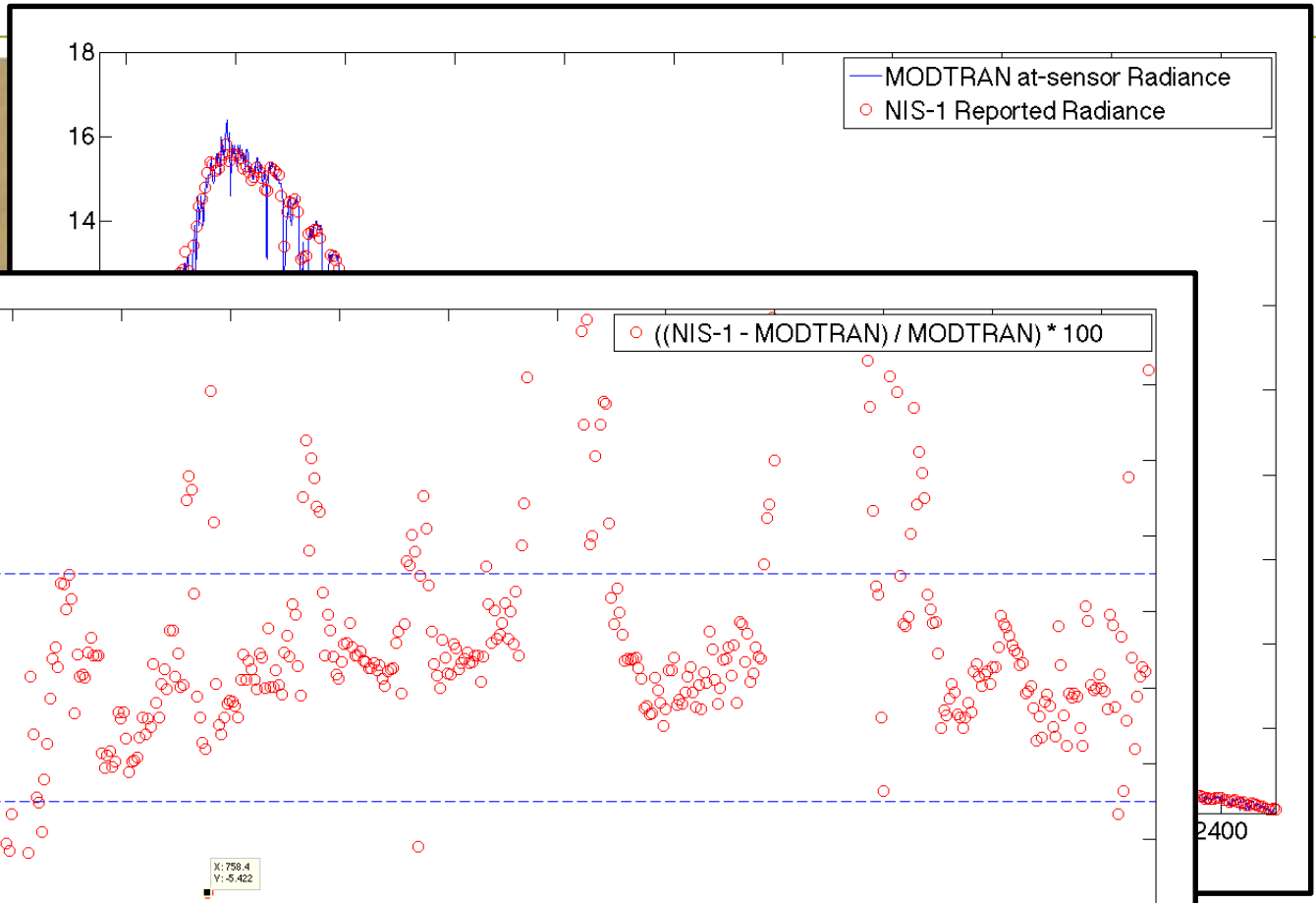


Radiometric Calibration

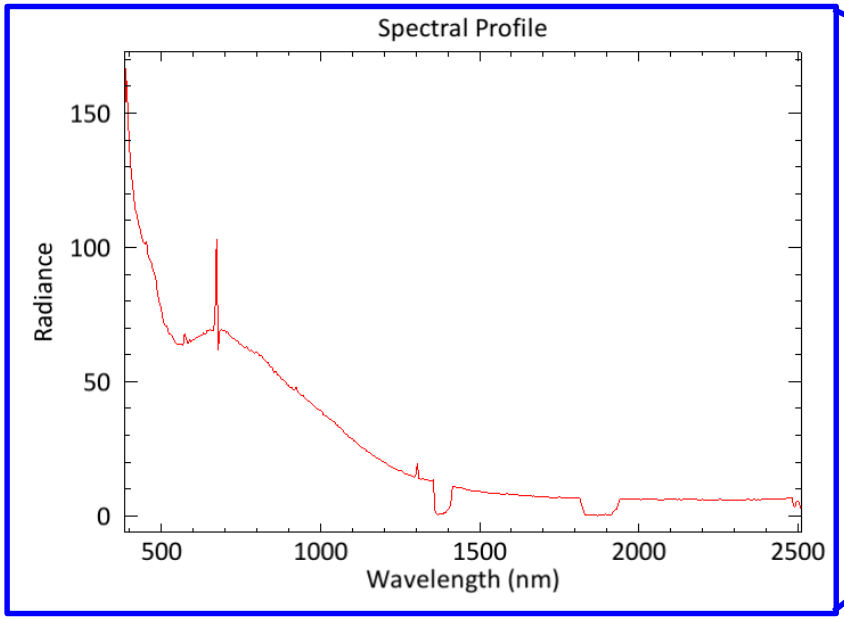


Vicarious Calibration at Railroad Valley

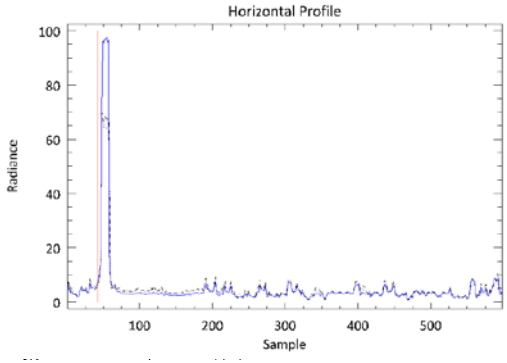


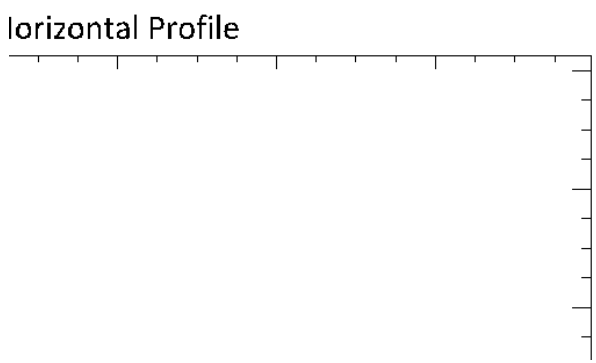


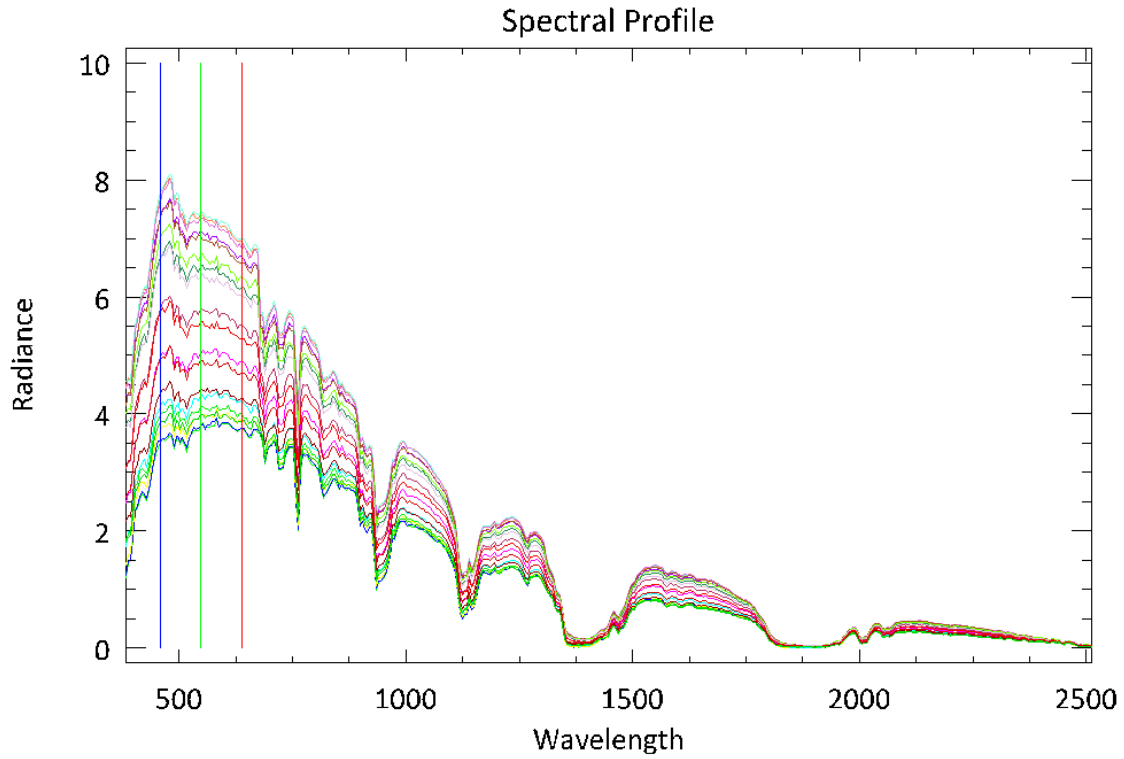
NIS Stray Light in Imagery

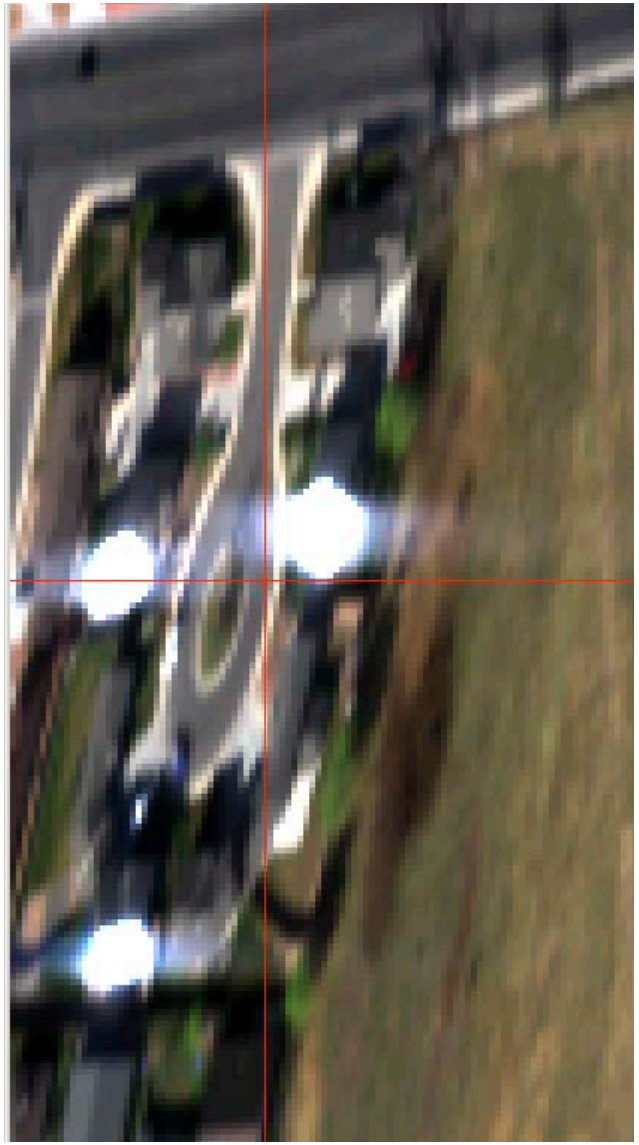


NIS Stray Light in Imagery



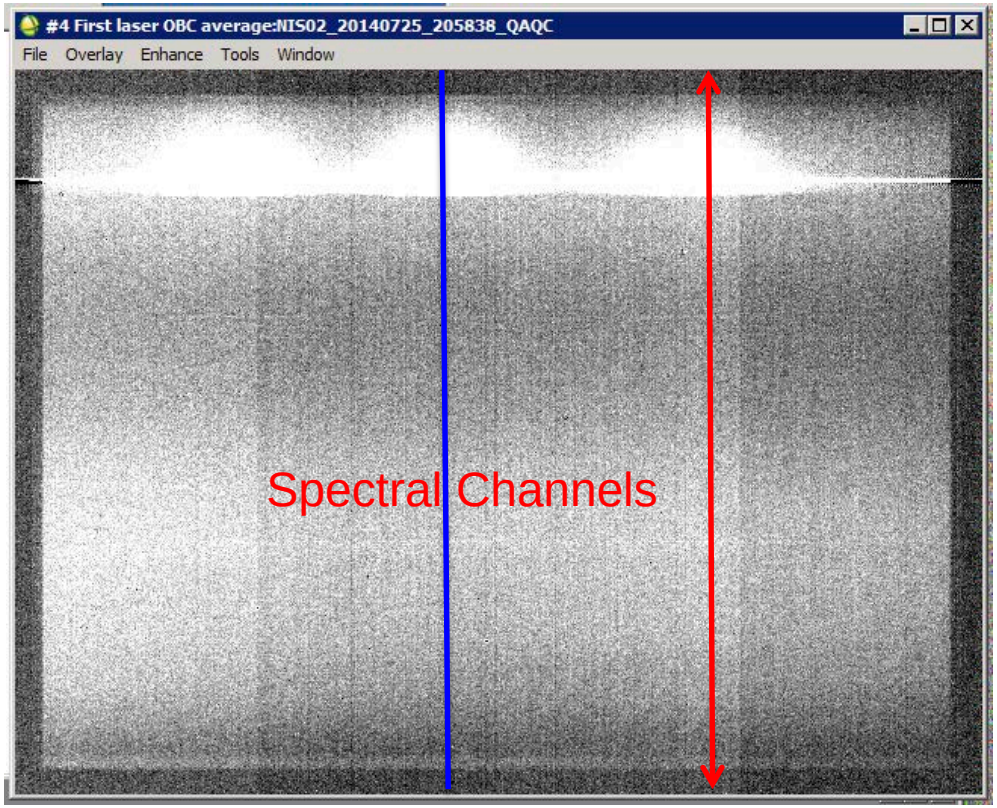


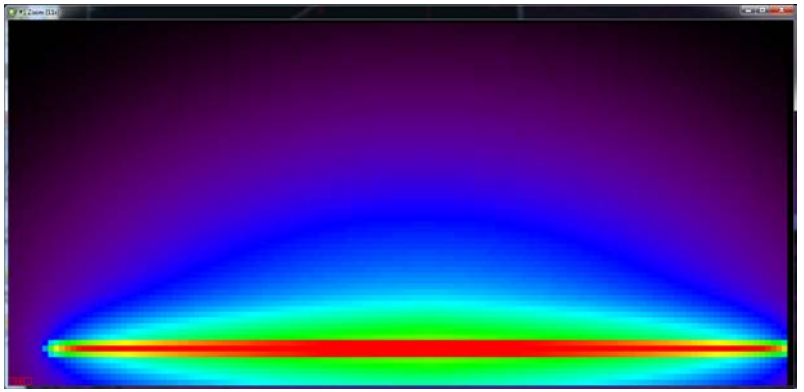


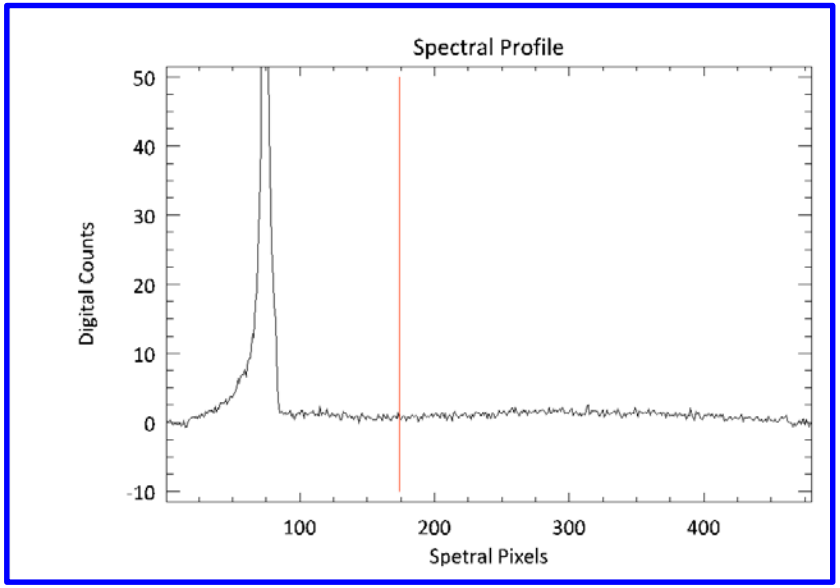


NIS Stray Light in On-Board Calibration Data

HeNe Laser injected at three spatial locations

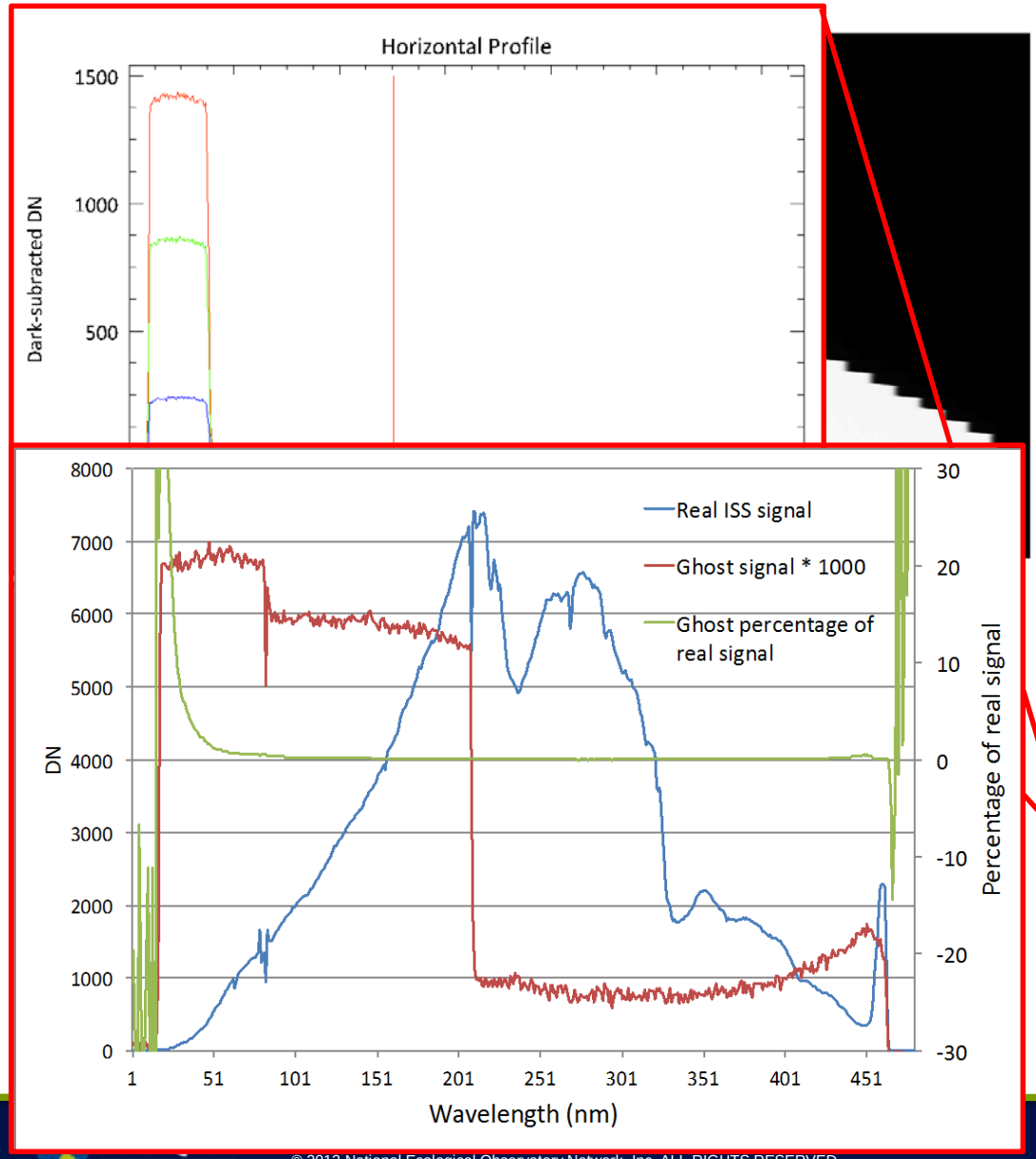


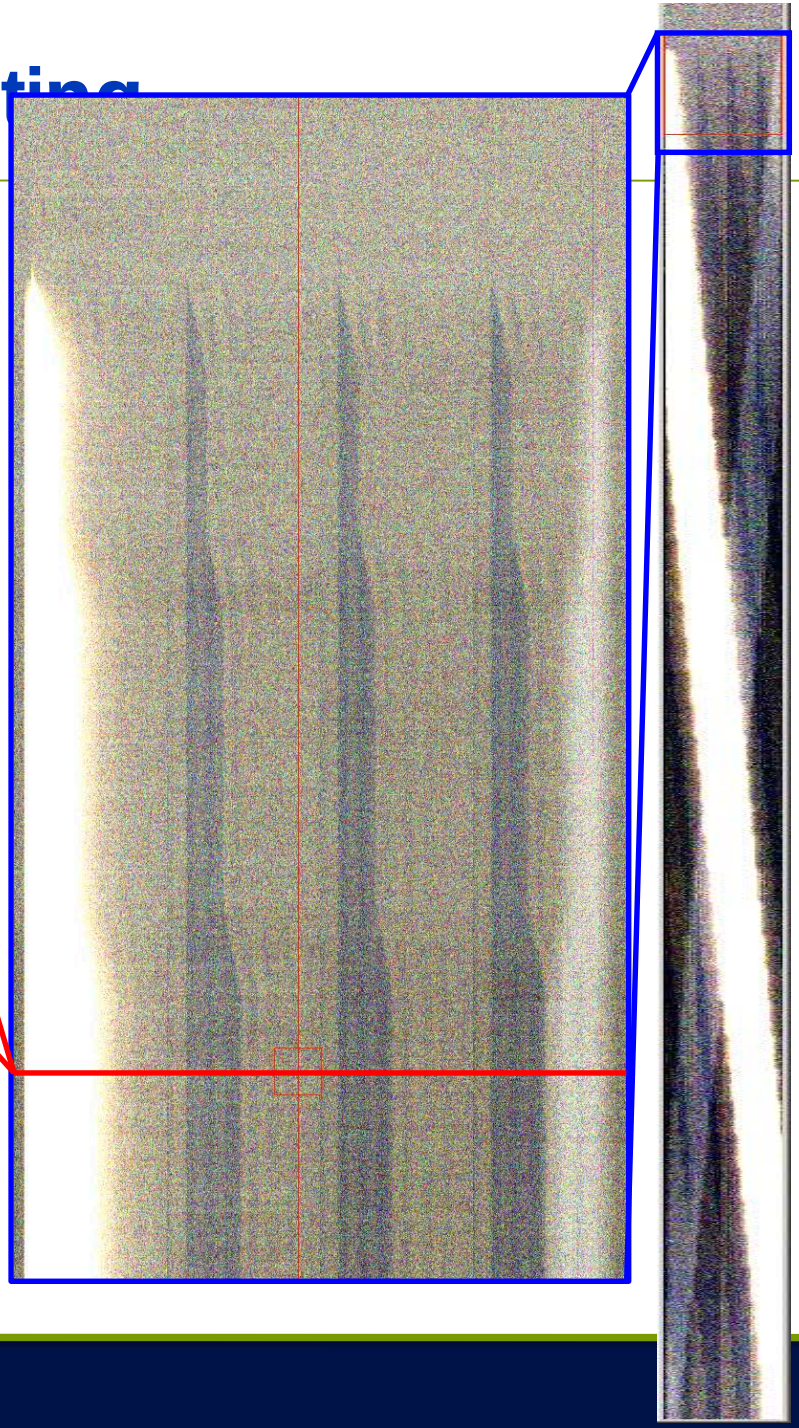




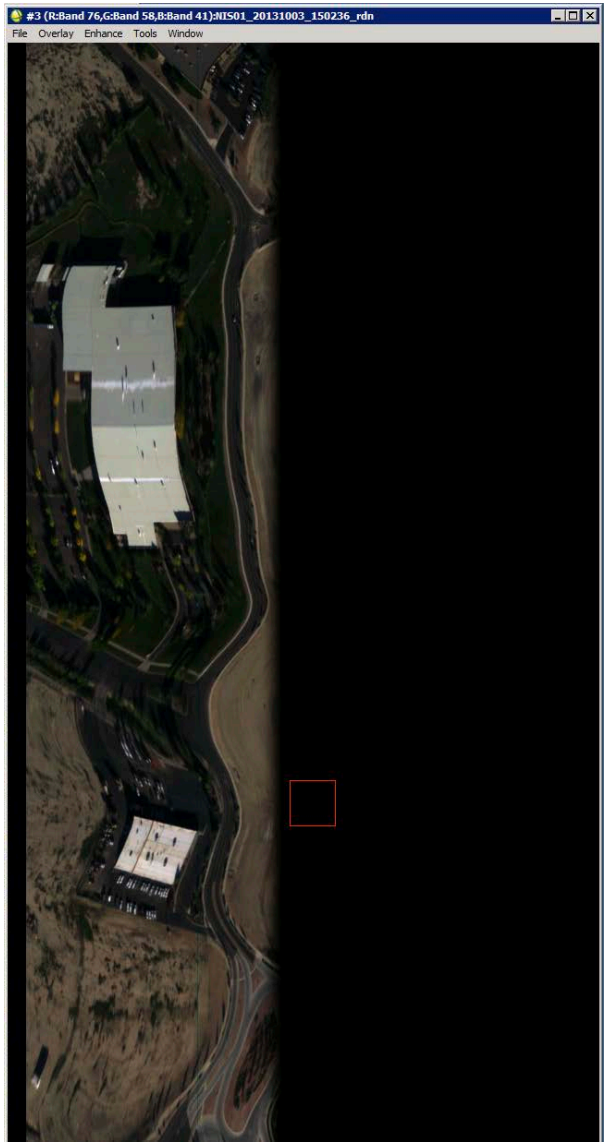
Conclusion: We do not have a well-behaved PSF spatially and spectrally.

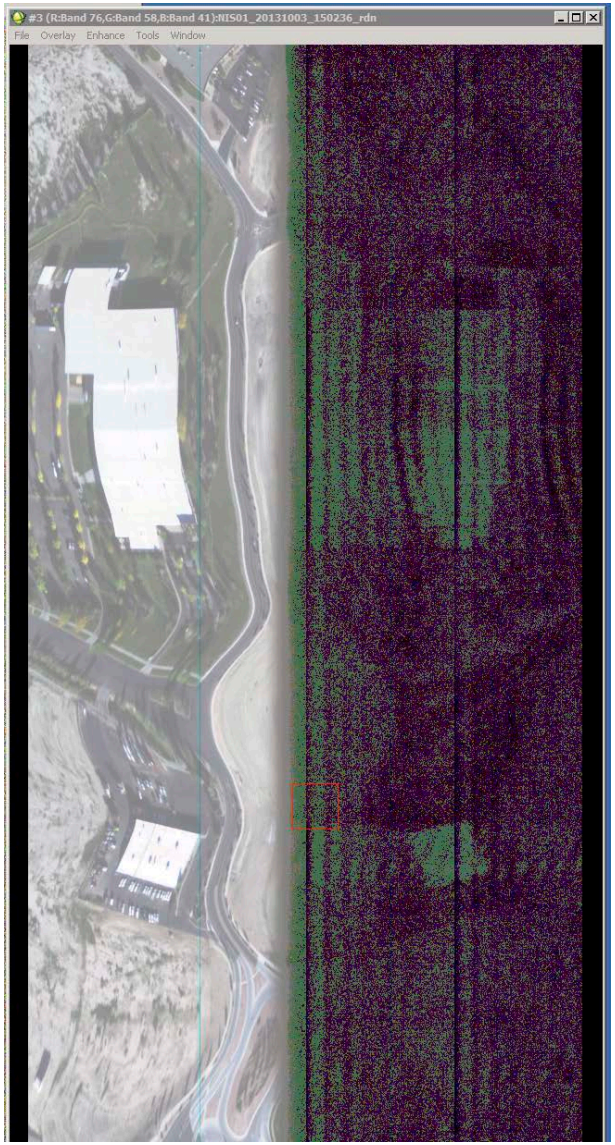
NIS Calibration Data Ghosting



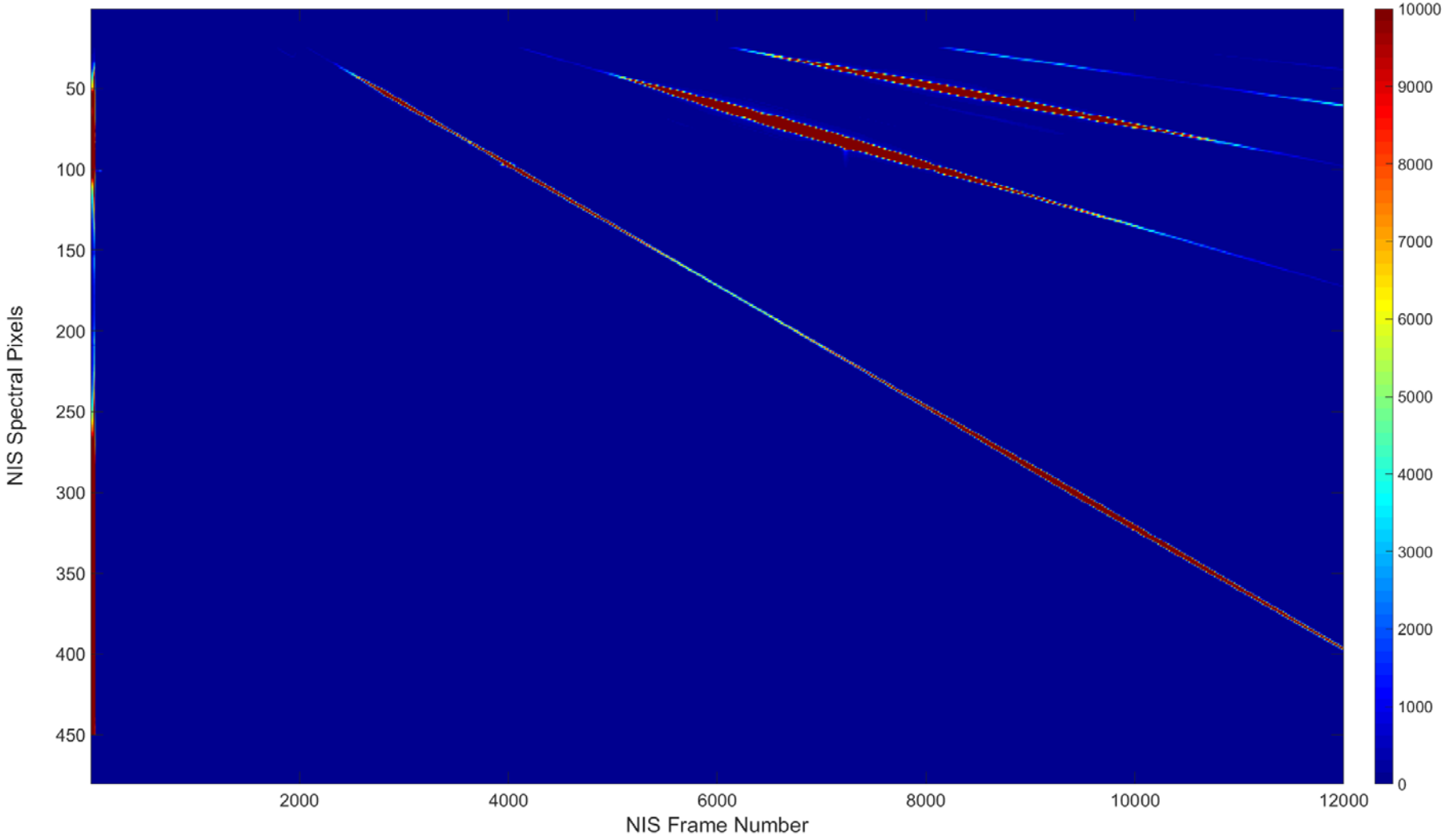


Ghosting in NIS Imagery

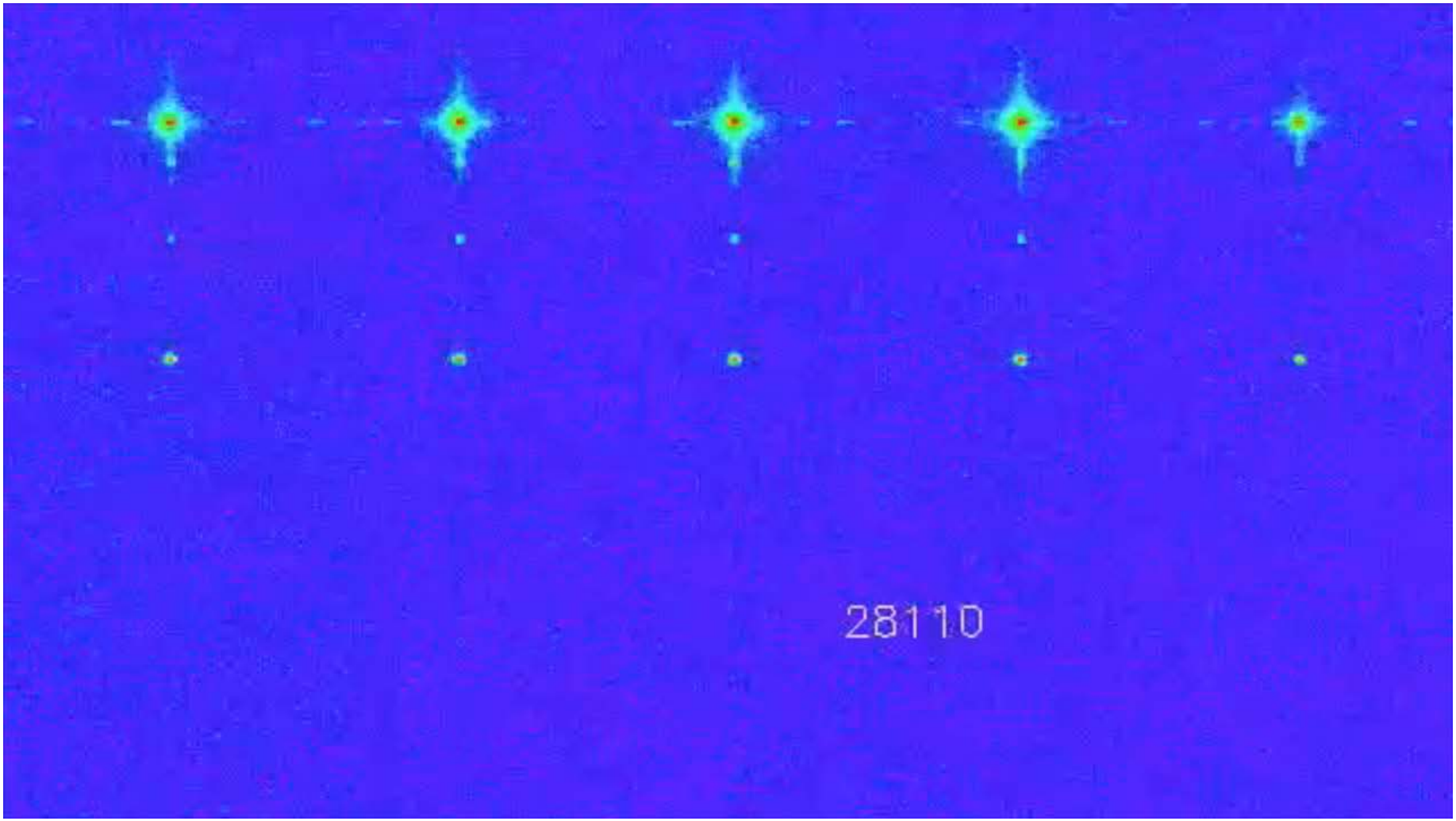




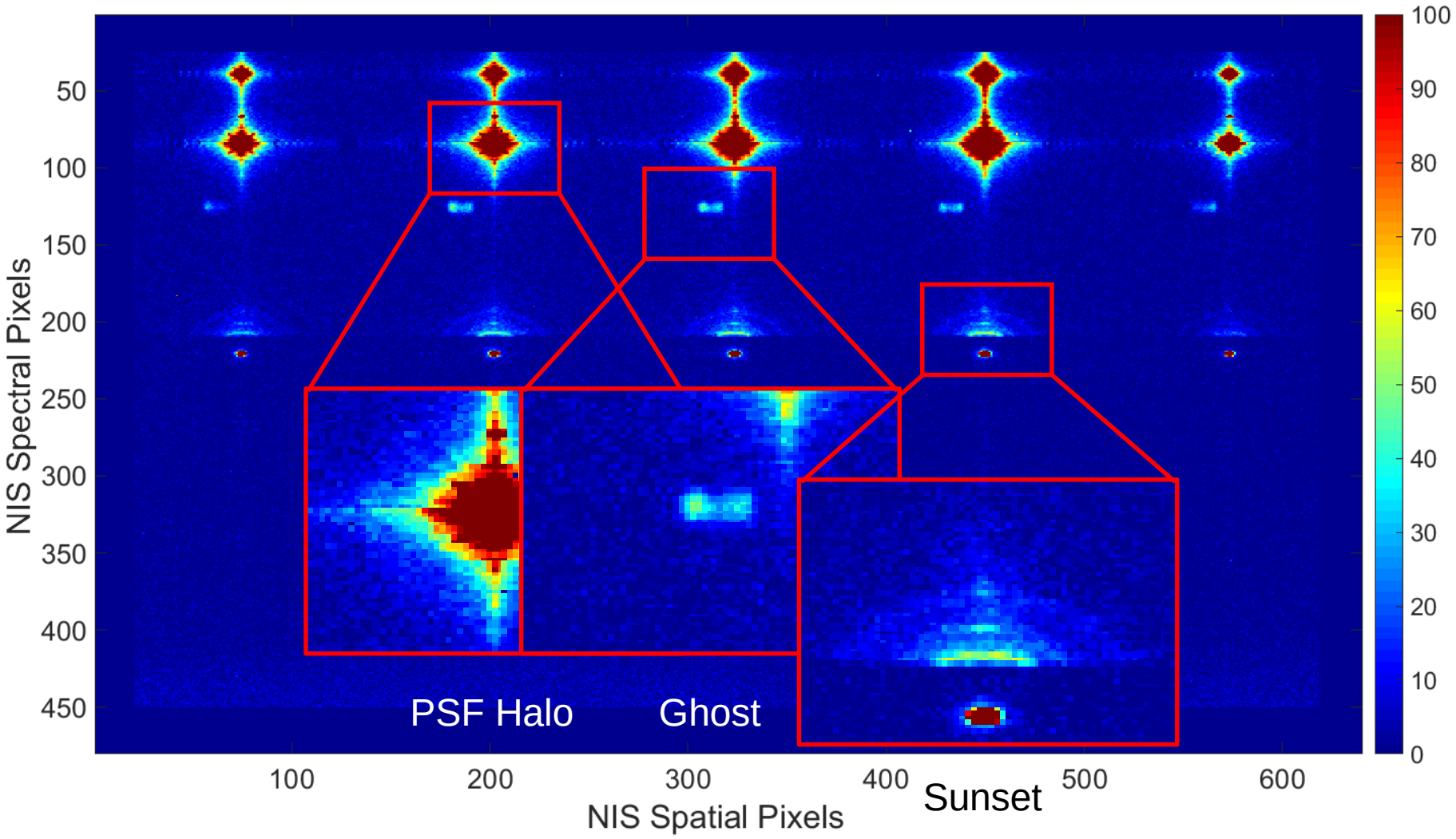
NIS Monochromator Scan



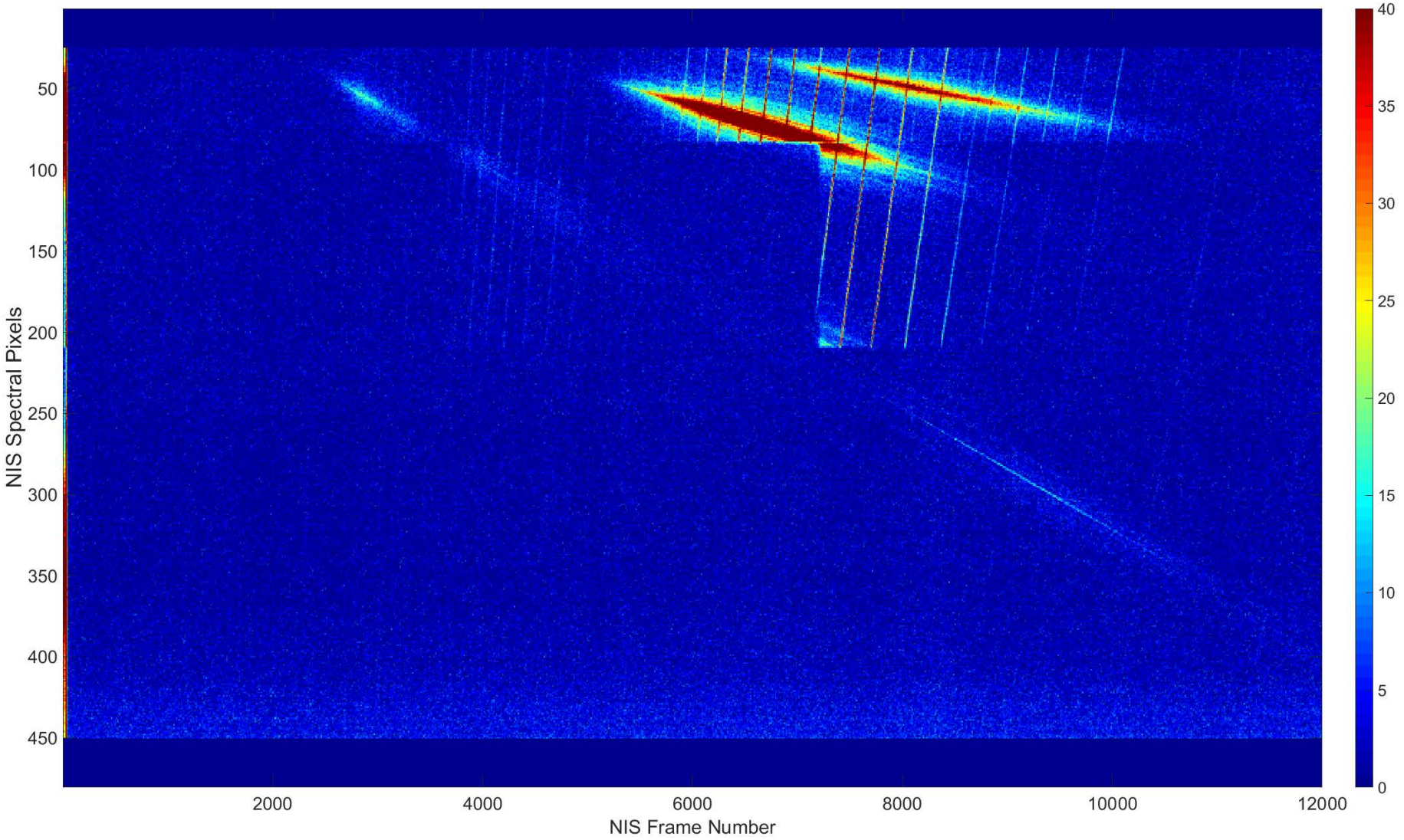
NIS Monochromator Collect (subset)



Sample NIS Frame from NEON Lab

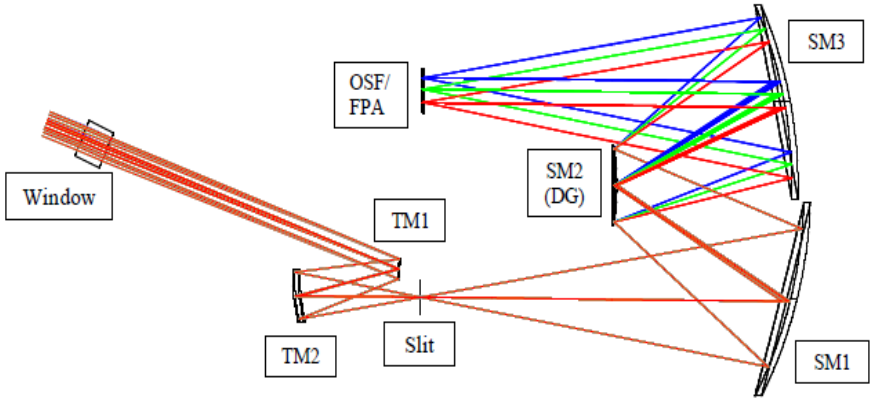


Ghosting in Monochromator Scan



Ghosting Mechanism

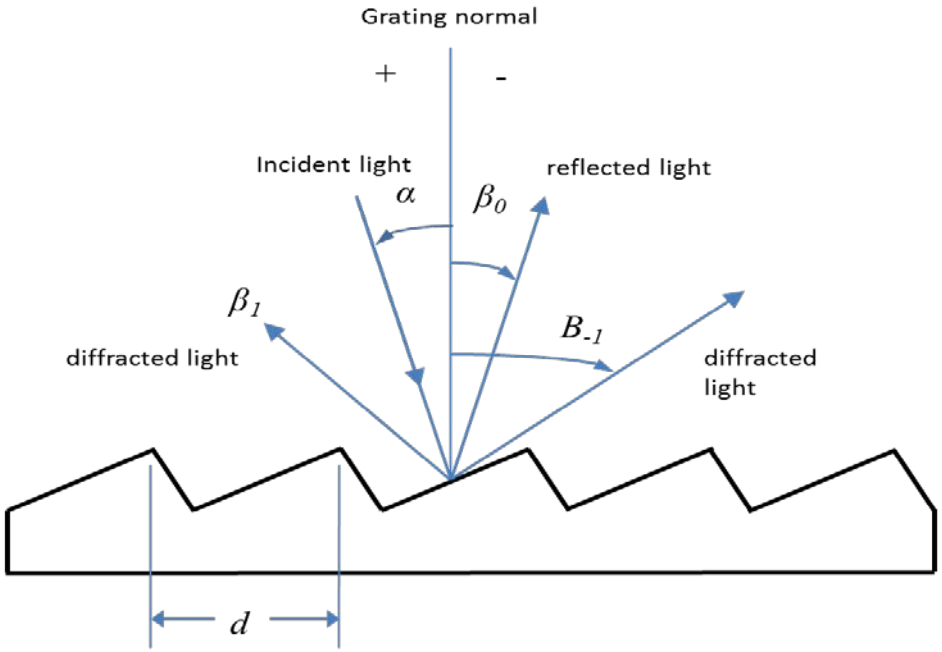
NIS Offner Spectrometer



Red path: First order from slit to detector

Blue path: FPA or OSF reflection via M3, grating, and M3 again, through high negative grating order.

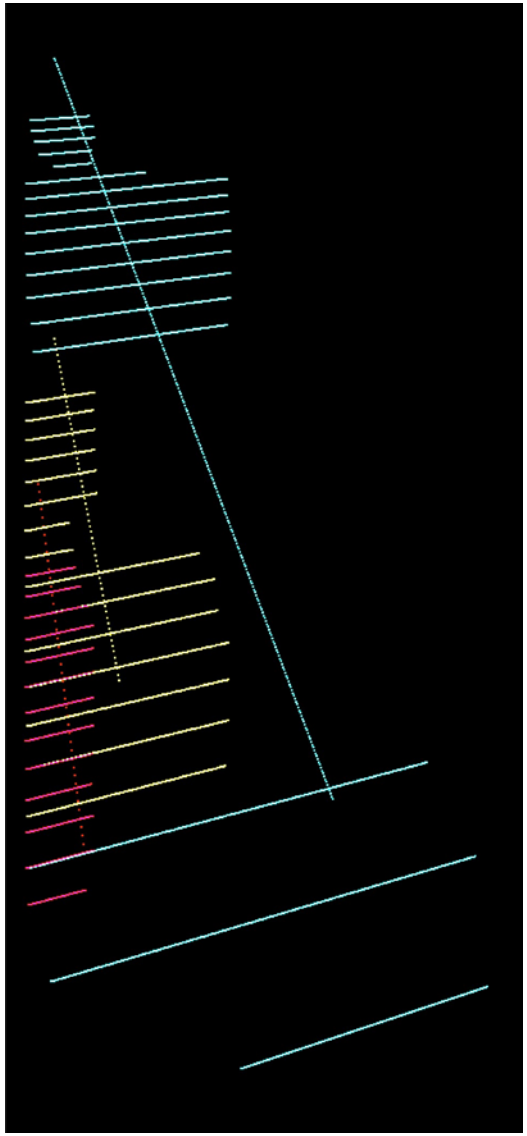
NIS Grating with Reverse Angle of Incidence (reflection from FPA)



$$m\lambda = d\,(\sin\alpha + \sin\beta)$$

Where: m is the diffraction order (using $m = 1$)
d is the groove spacing (mm)
α is the incident angle to grating normal
β_m are the angles of diffracted light for order(s) m

Derivation of Ghost Mapping



Three orders from NEON Monochromator

- 1st order (turquoise) and associated ghost lines
- 2nd order (yellow) and associated ghost lines
- 3rd order (red) and associated ghost lines

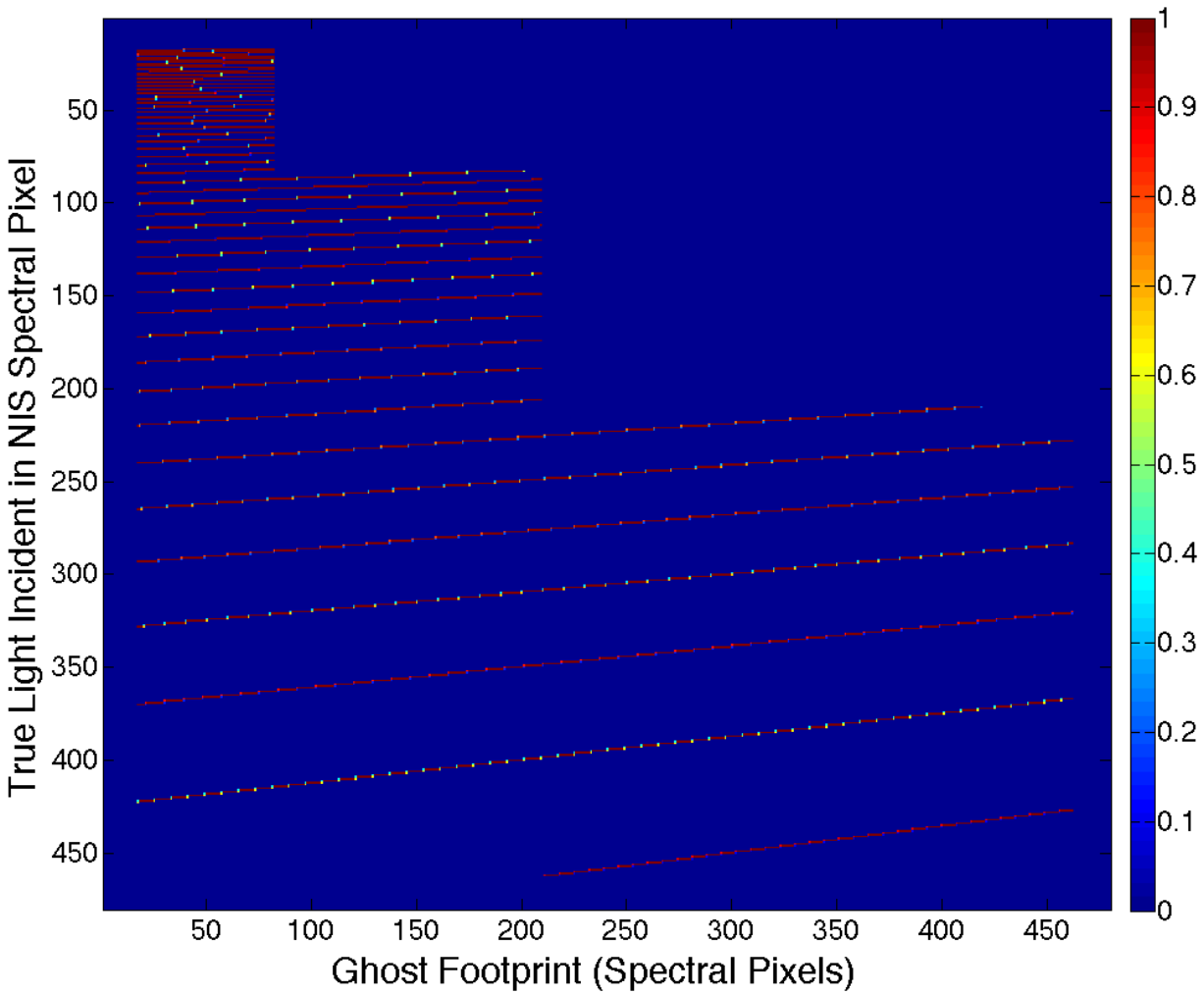
This drives a solution with 6 parameters

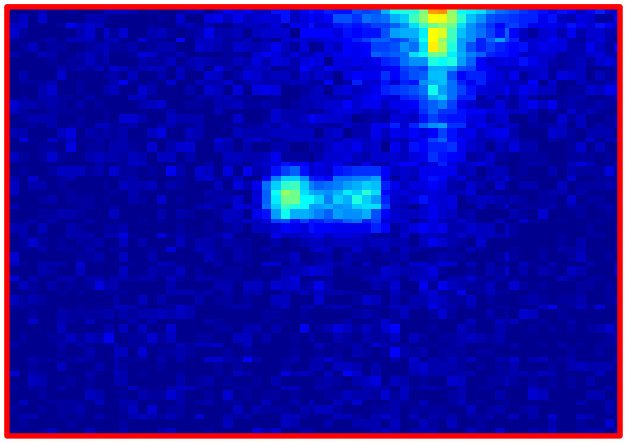
1. True light FPA row number
2. Ghost order(s) caused
3. Ghost starting row location
4. Ghost ending row location
5. OSF-rejected Ghost starting row location
6. OSF-rejected Ghost ending row location

This can be condensed to a matrix describing where the ghost light goes for light incident on a particular row.

NIS GOLLUM

Ghost Order Lambda Look Up Matrix (GOLLUM)

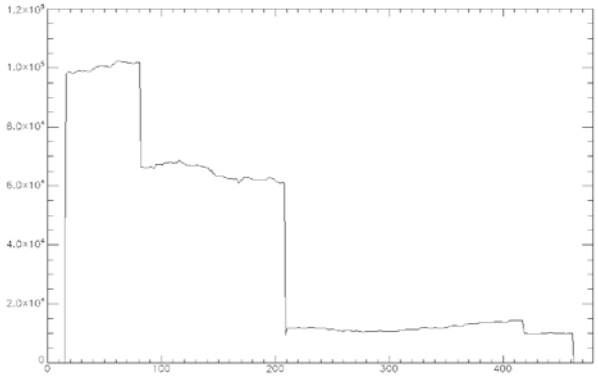




Working on improving characterization for mapping location and shape of the Ghost

- Line sources
- Translate sub-pixel slit
- Edge filters

NIS Ghost Busting



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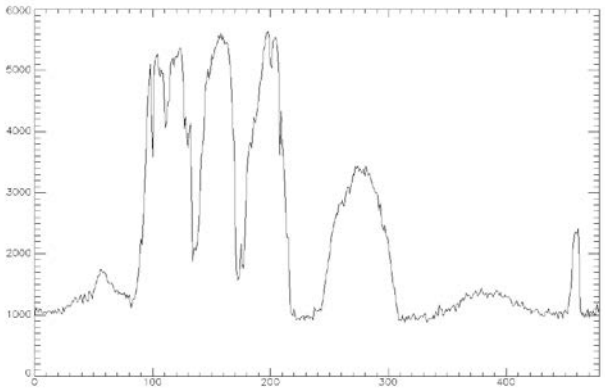

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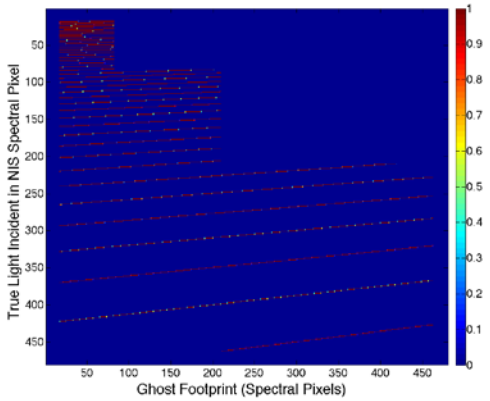
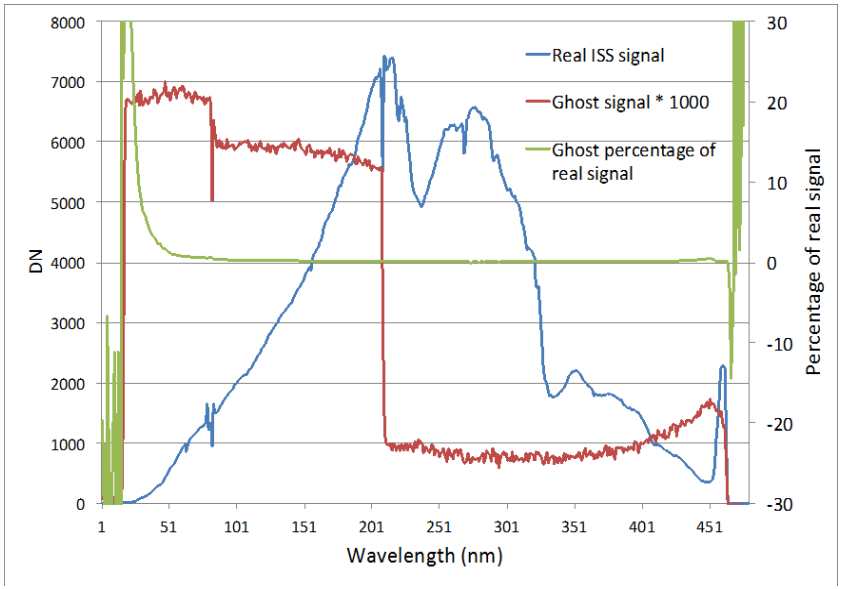
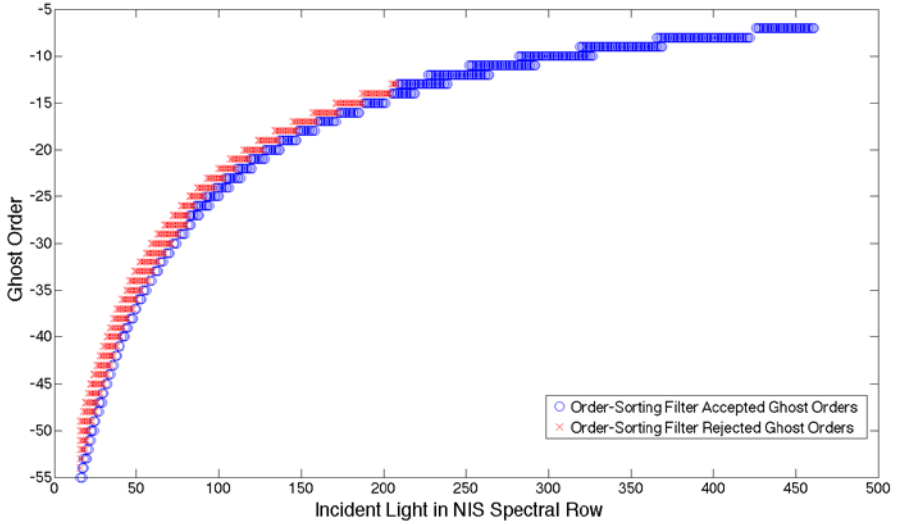
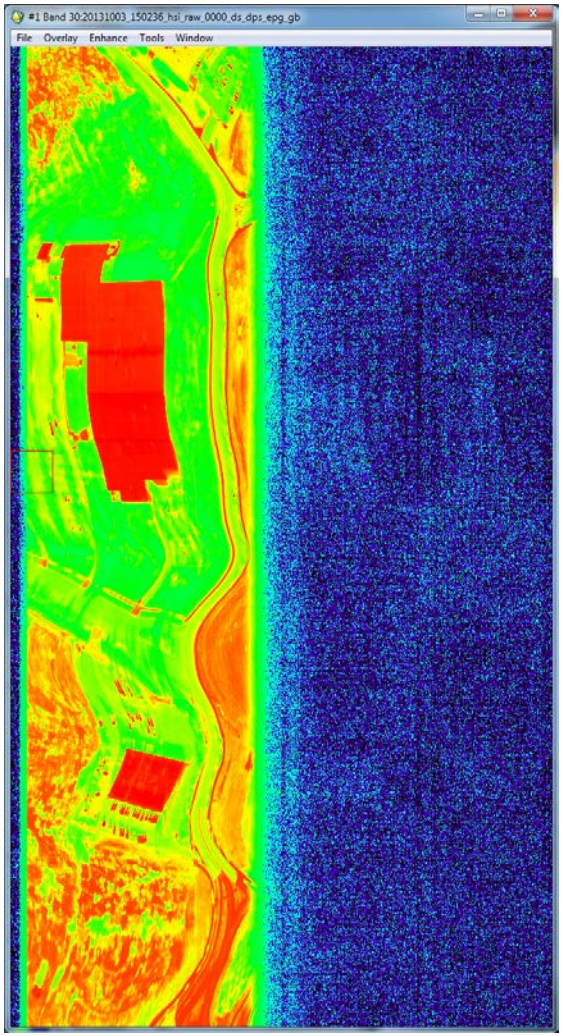




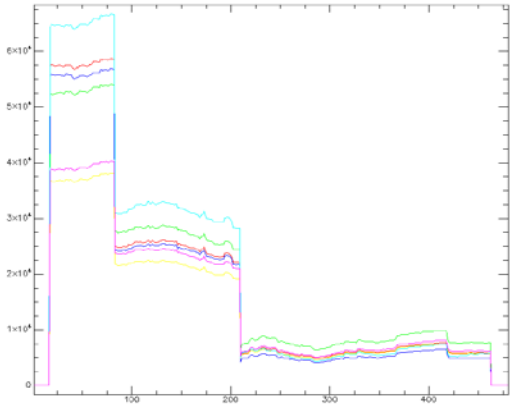


NIS Ghost Busting

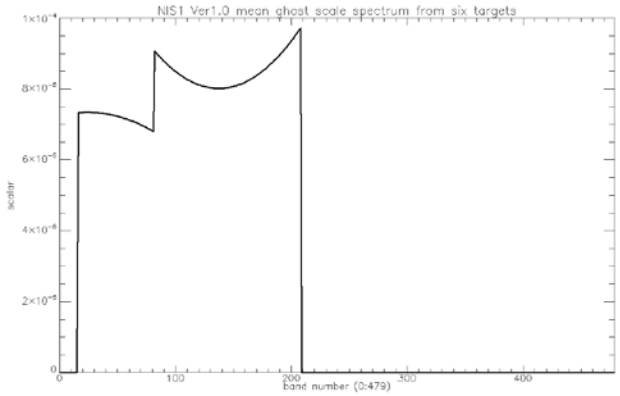
DFS-DPS-EPG-Ghost



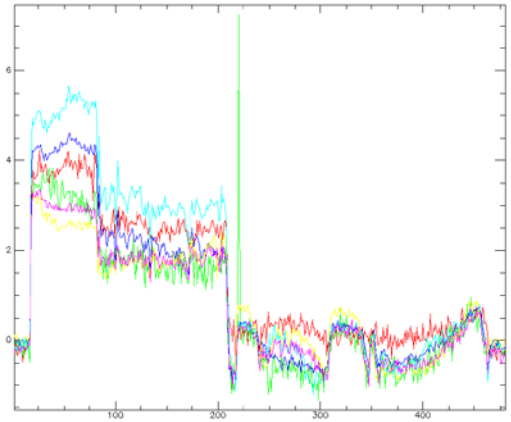
Calculated Ghost Spectra
(un-scaled from GOLLUM)



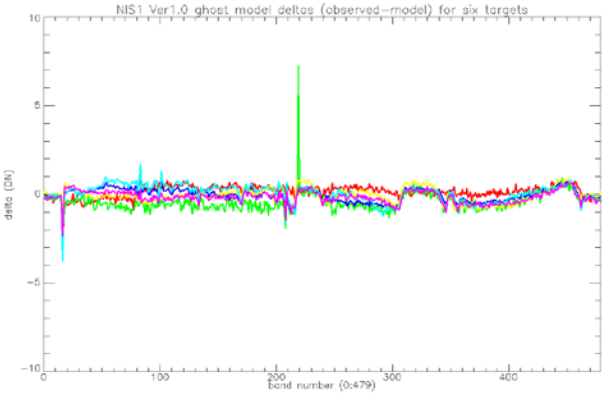
Preliminary Ghost Scale



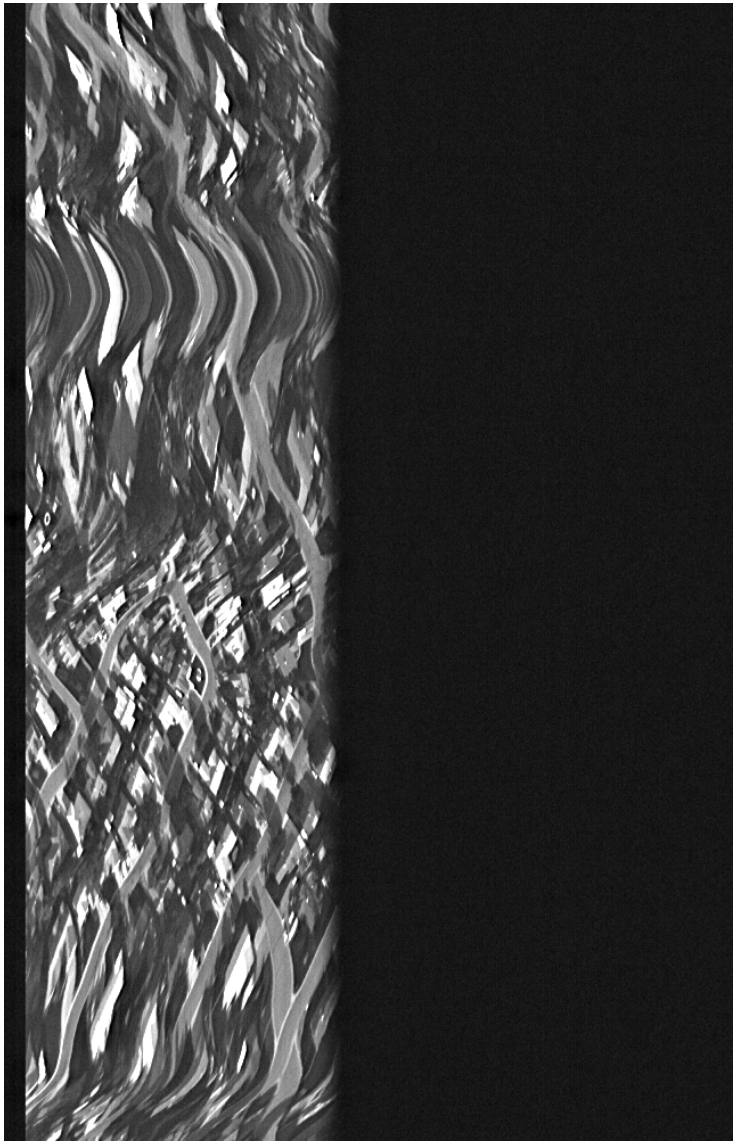
Observed Ghost Spectra

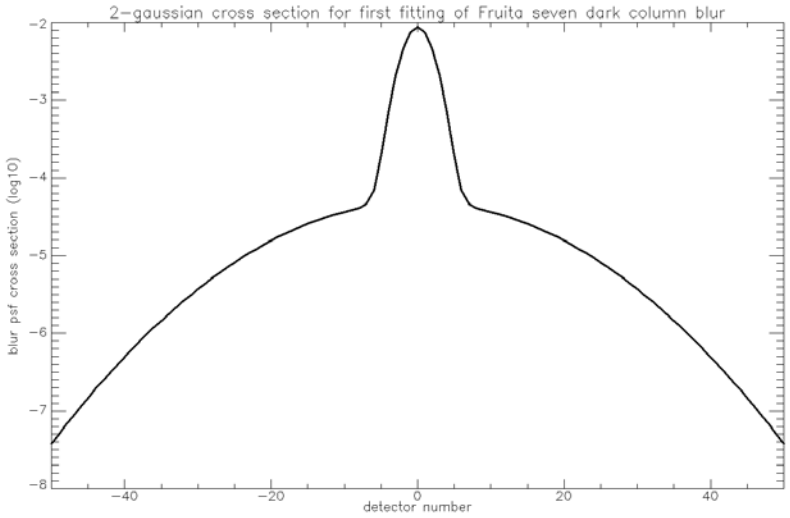


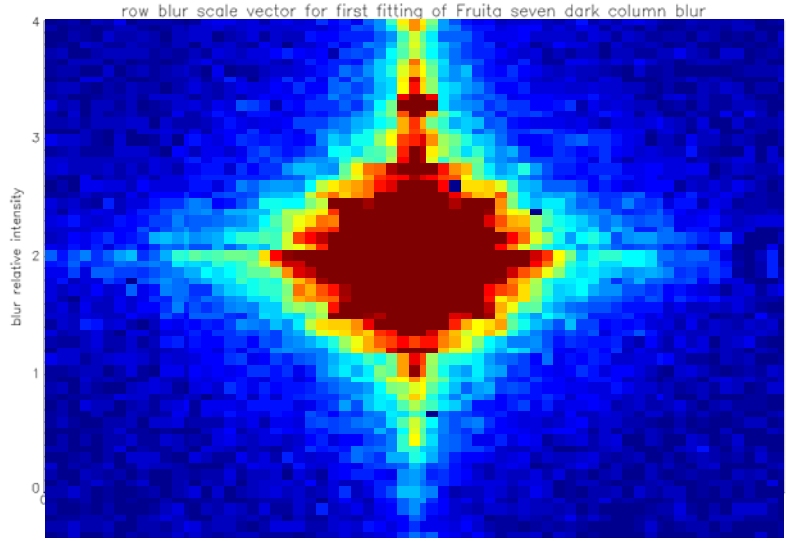
Residuals



GOLLUM Application and early PSF work







Conclusions

- Gain and offset are intimately linked
- Without corrections, true offset never obtained
- Lead to errors in the calibration (Lab or Vicarious)
- Next steps
  - Continue characterization of true PSF
  - Determine if application of correction improves data
  - Transient Ripple
  - Second-order Sunsets on Blue side of OSF junction