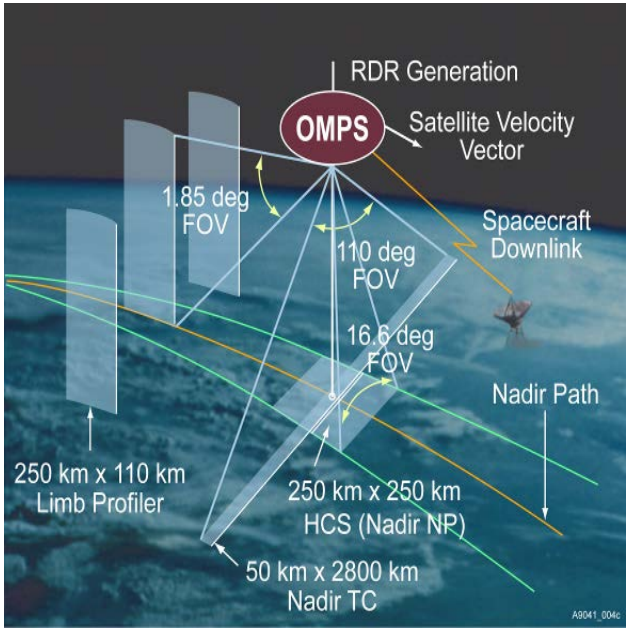
SNPP Limb sensor performance update and Level 1 status

NASA OMPS Limb instrument & L1 team

G.Chen, DeLand, Haken, Janz, Jaross, Kahn, Kelly, Kowalewski, Kowitt, Linda, Moy, Taha, Warner

Additional Material:

N. Gorkavyi, D. Soo



Wavelength: 290 –1000 nm

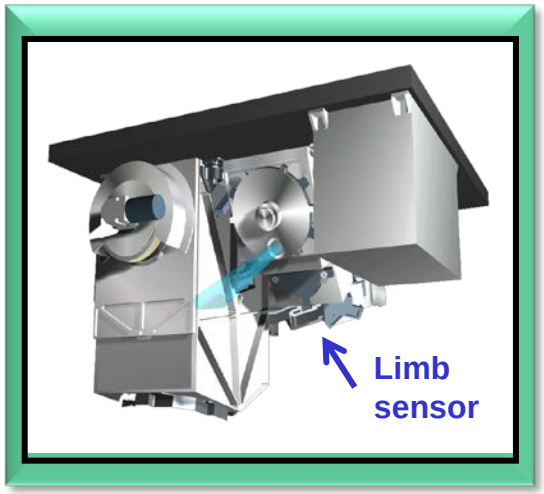
Bandwidth: 1 – 30 nm

Vertical range: 105 km (0-60 km permanently)

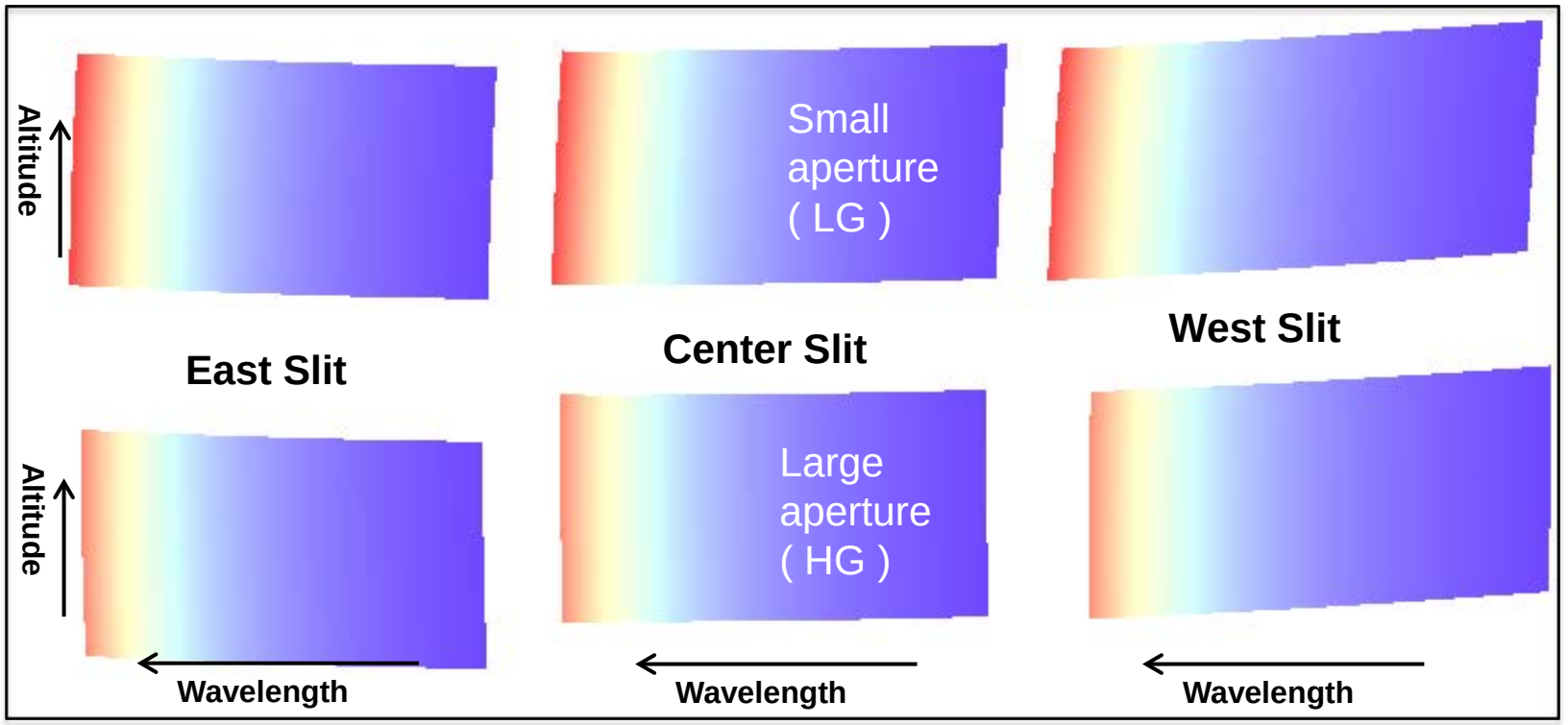
3 vertical slits; view aft

Primary error sources

- ***Pointing***
- ***Stray light***

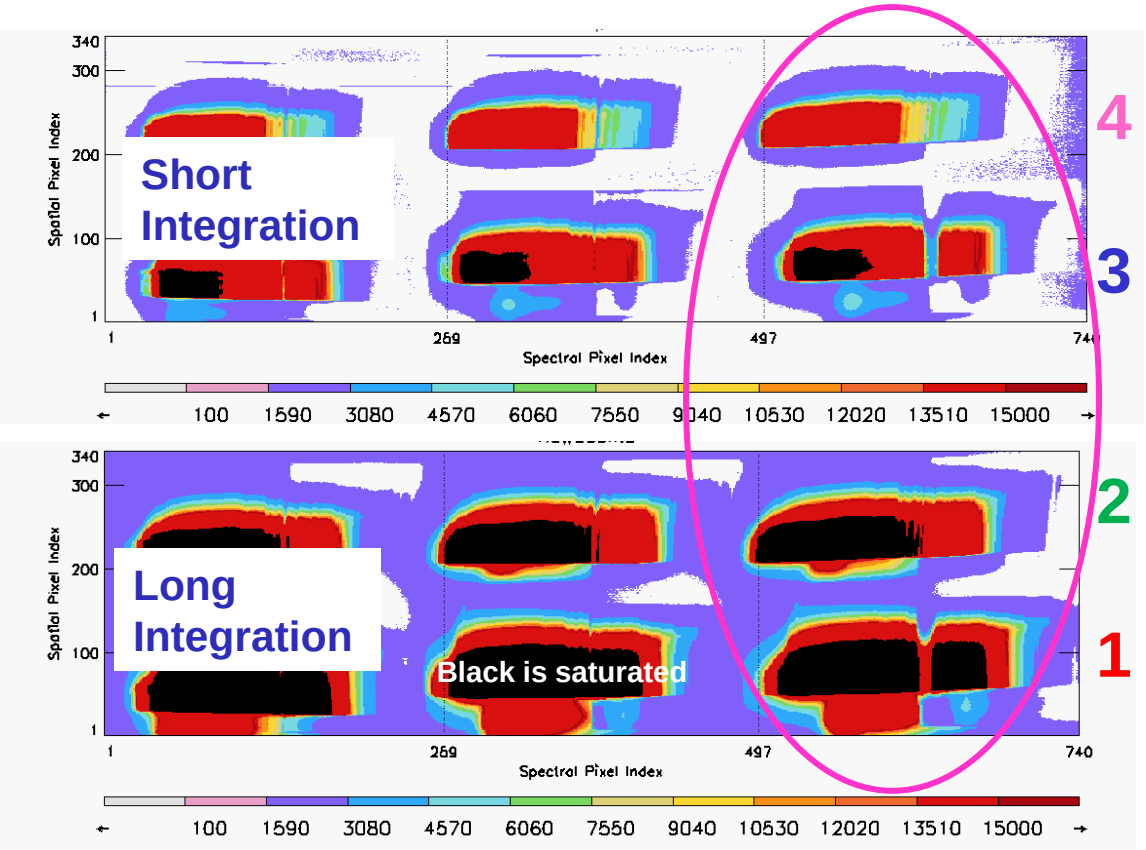


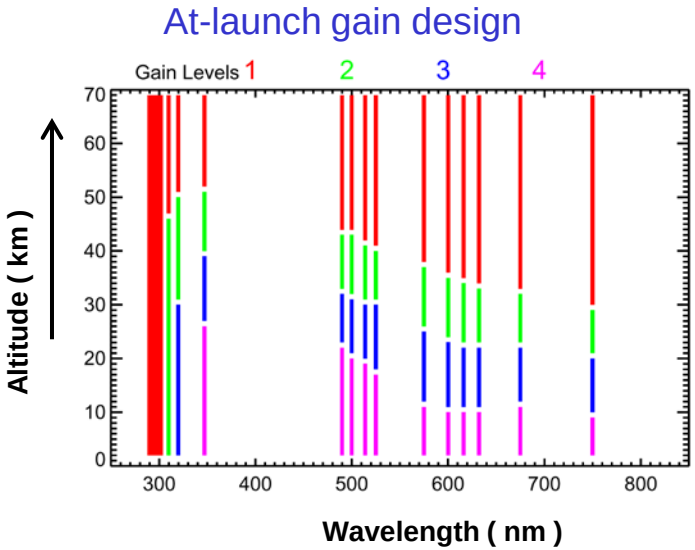
6 images collected on detector



Of the 250,000 photosensitive pixels, fewer than 70,000 are sent to the ground (mostly within the 6 aperture regions)

Original Gain stitching has been modified as of v2 release





Gain 1 **HiGain Long**
Gain 2 **LoGain Short**
Gain 3 **HiGain Long**
Gain 4 **LoGain Short**

Combining LoGain and HiGain created radiance discontinuities

Current operations (since Dec., 2013):
HiGain (280 - 500 nm) LoGain (450 - 1020 nm)
Gain 1 & Gain 3 Gain 2 & Gain 4

Stepped IT timing sequence

Current Timing:

Short – 0.04 s x 15
Long – 1.25 s x 10

} *interleaved*

time of median photons close to half of report interval

Flight hardware has the ability to discard saturated ITs on per-pixel basis

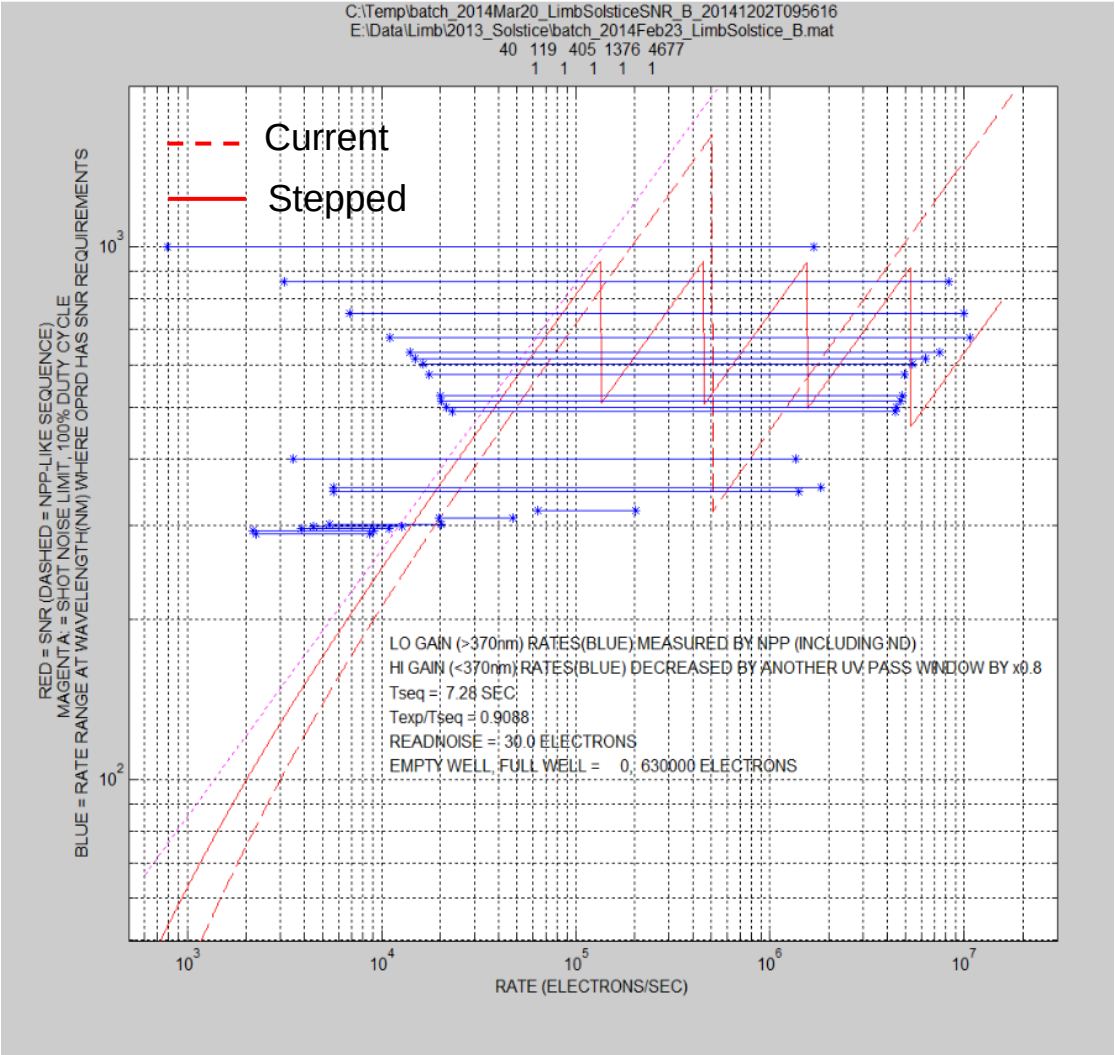
Proposed Timing:

12.7 s
1.13 s
0.04 s
0.34 s
0.10 s
3.78 s

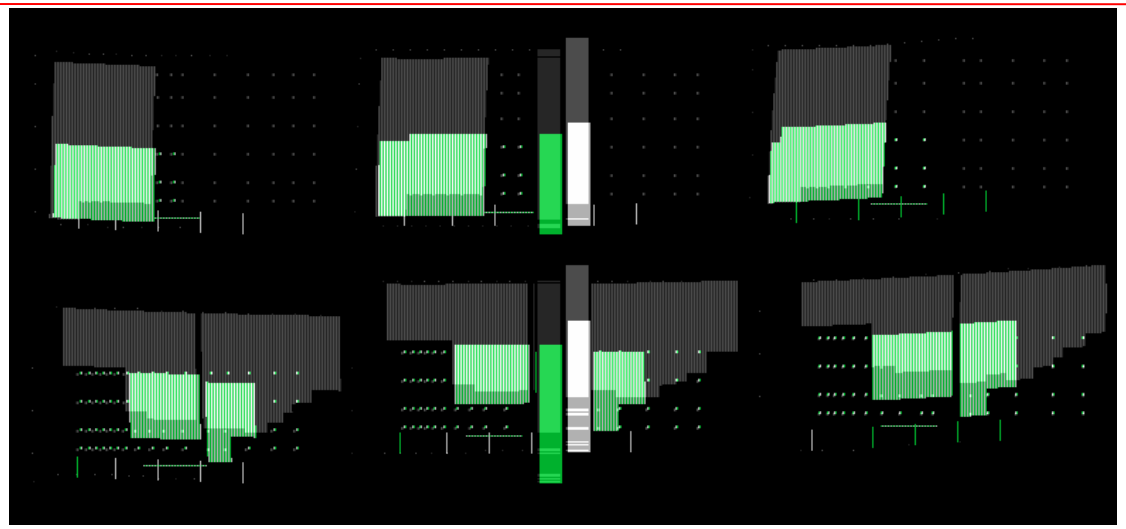
} *sequential*

time of median photons varies with altitude and wavelength

SNR vs. Signal Rate



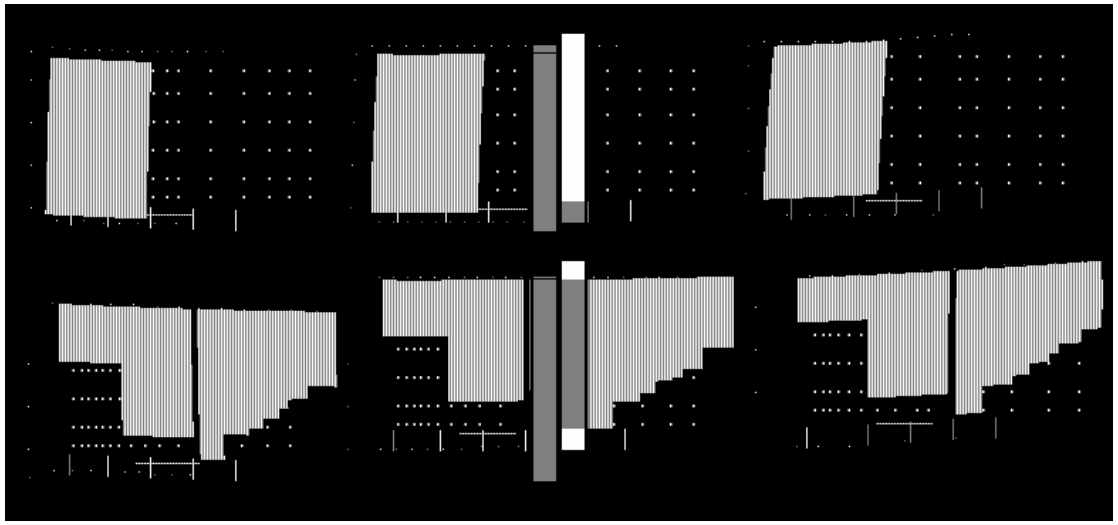
New timing reduces sampled pixels



Current v0.8 Sample Tables

- Long: 62,000 pixels
- Short: 26,500 pixels

Total: 88,500 pixels



Stepped IT Sample Table

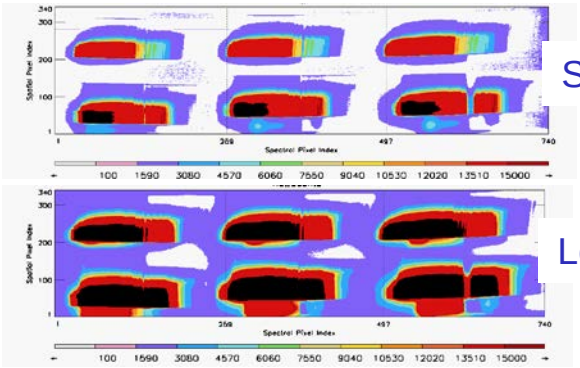
- Merged Long + Short
- 68,400 pixels
- Could eliminate high alt. VIS / NIR
- Could eliminate 2 UV slits

Implementation is still TBD

Level 1 Products

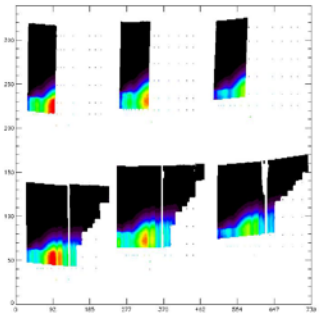
Level 1A

Counts-short [pixel x time]
Counts-long [pixel x time]



Level 1B

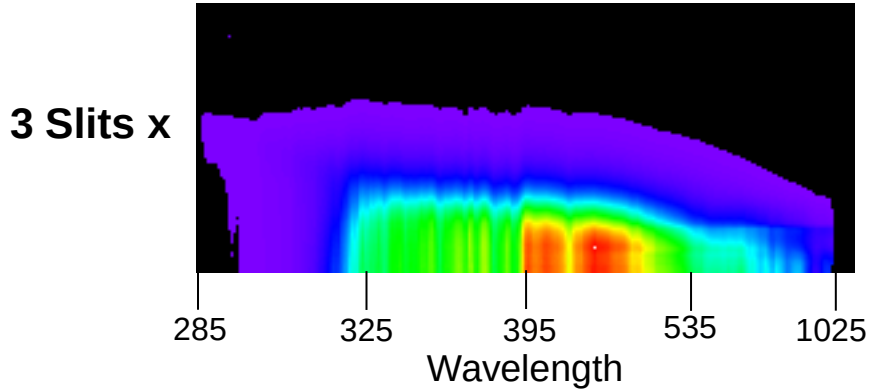
Radiance [pixel x time]
Irradiance [pixel x time]
Wavelength [pixel x time]
Geolocation [pixel x time]



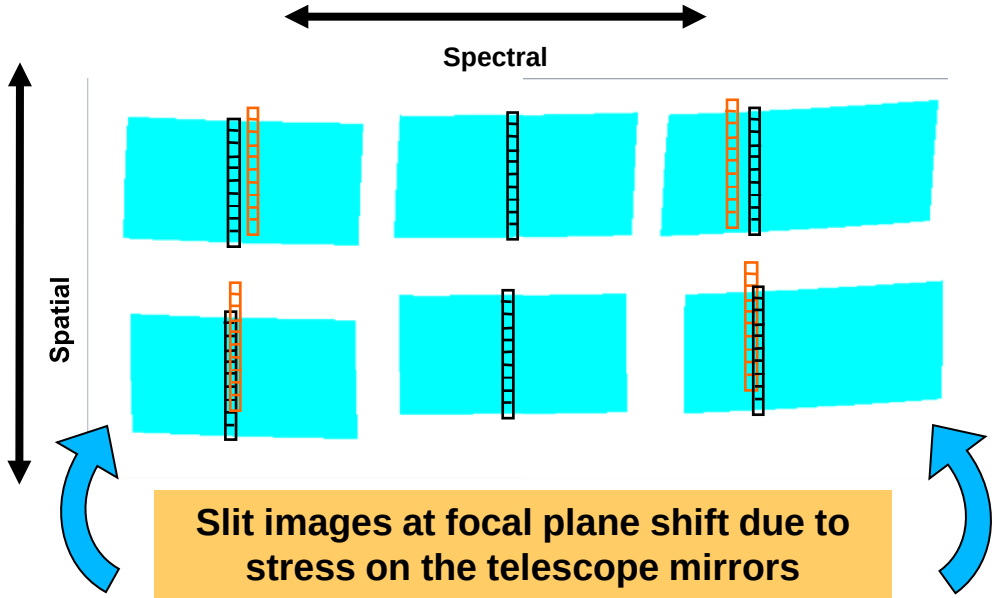
Level 1G [release product]

TOA Reflectance [TH x WVL x time x slit]
Recon. Radiance [TH x WVL x time x slit]
View conditions [time x slit]

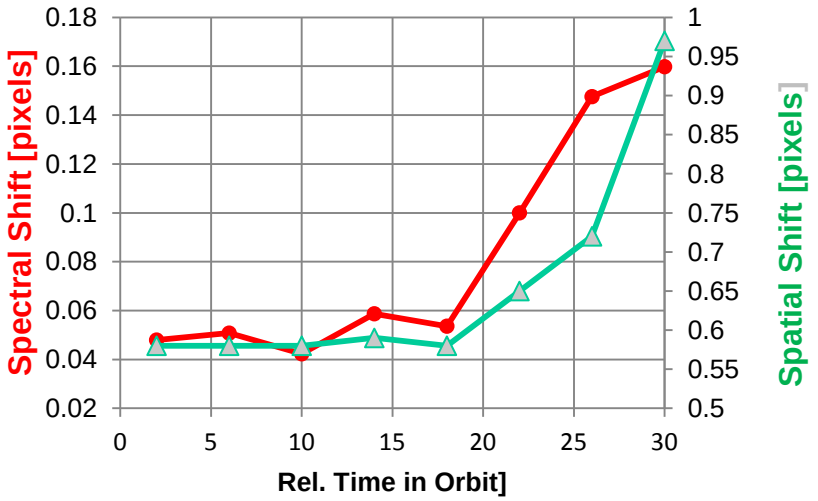
Associated **L1_ANC** contains colocated temperature, pressure, ozone



Variation in telescope temperature causes CCD images to shift

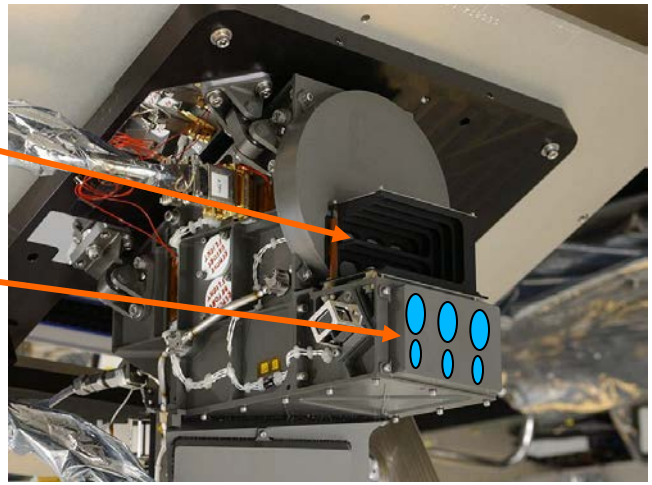


Slit images at focal plane shift due to stress on the telescope mirrors



Thermally expanding entrance baffle

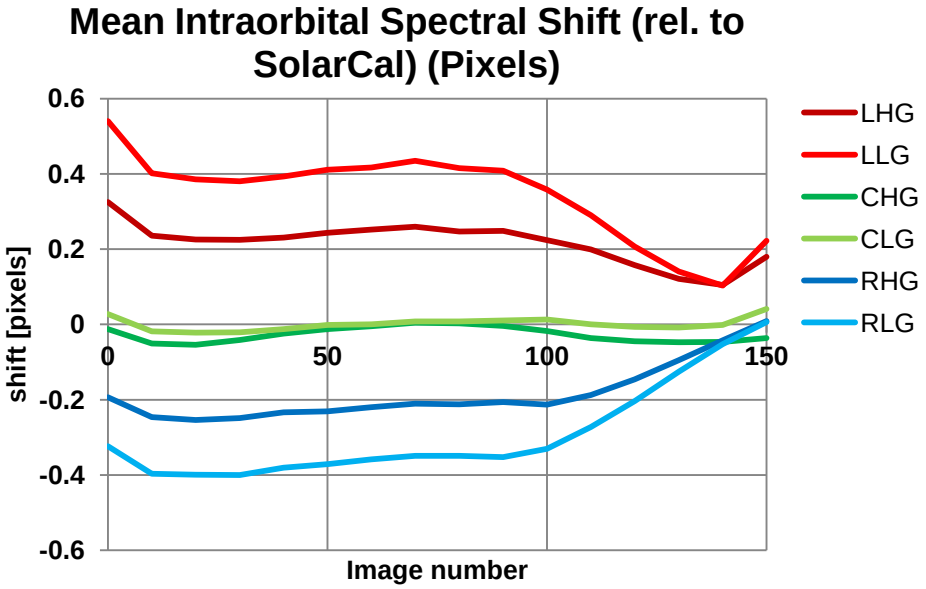
Telescope mirrors

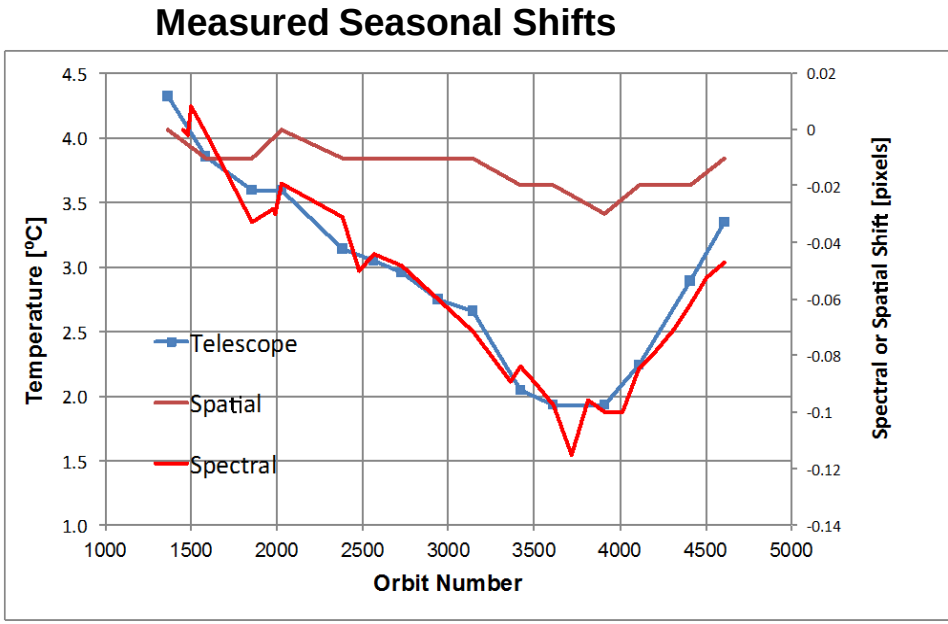


Courtesy of BATC

Shifts occur when sunlight illuminates the entrance baffle

Spectral shifts have been characterized





Orbital dependence is highly repeatable

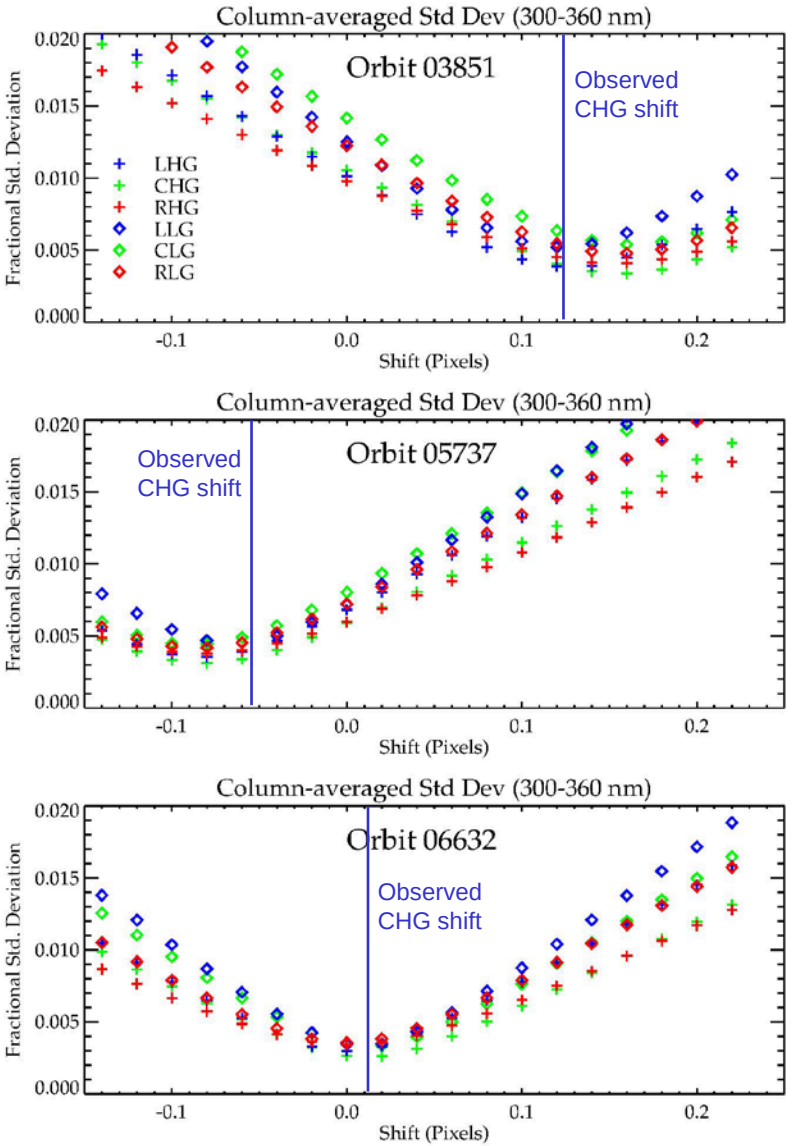
Corrections in Level 1B product

	Intra-orbital	Seasonal
Spectral Shift	Parameterized v. time in orbit	Parameterized v. orbit number
Spatial Shift	Parameterized v. time in orbit	Parameterized v. solar beta angle *

L1B solar irradiance synthesized from Day 1 measurement

Irradiance Scale factors derived from Hi-res reference spectrum – tabulated vs. spectral shift

Comparisons between a measured UV solar spectrum and the Day 1 spectrum are best when it is adjusted to the new wavelength scale

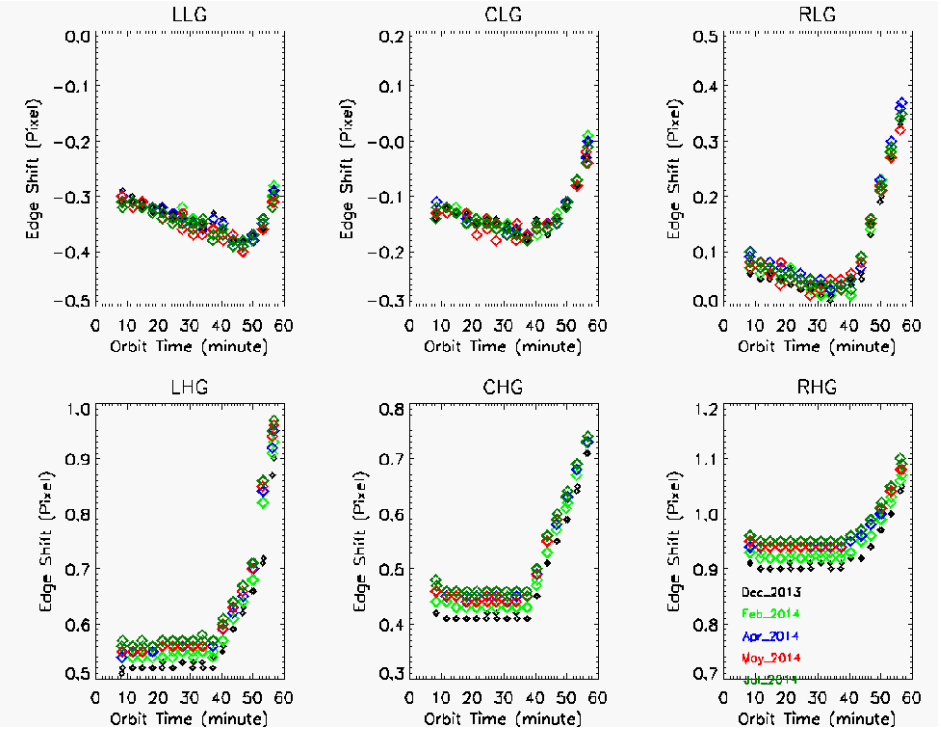


Additional pointing shifts beyond internal ones

We understand pointing changes caused by internal mirror shifts (using slit edge images).

Slit Edge offsets (km)

	L	C	R
Low Gain	-0.30	-0.10	0.10
High Gain	0.55	0.45	0.95



Additional pointing errors have been detected

350 nm Scene-based offsets (km)

	L	C	R
Low Gain	1.40	1.60	1.70
High Gain	1.20	1.40	1.50

Limb points higher than SC Diary indicates

Comparison to VIIRS

OMPS Residual vertical offsets (arcsec)

	East	Center	West
LoGain	78	90	96
HiGain	72	84	90

→ Mean (pitch) = 85 arcsec

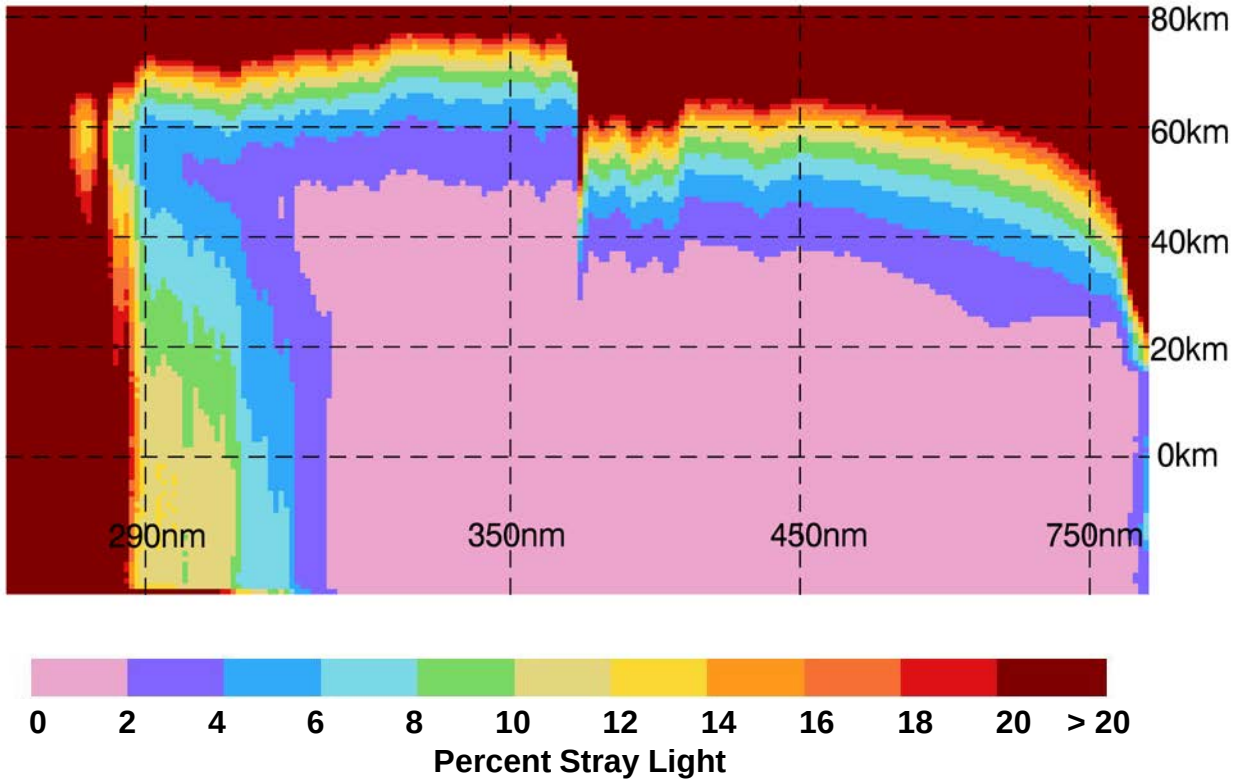
Difference (roll)
= 124 arcsec

From VIIRS SDR/GEO LUT Update 002
Feb. 2, 2012

SNPP-VIIRS Angle adjustments (transformation is yaw, roll, pitch order)

Angle	Current (arcsec)	Proposed (arcsec)	Delta (P – C) (arcsec)
Yaw	33.2	95.4	62.2
Roll	41.2	-227.3	-268.5
Pitch	-59.3	153.2	212.5

Stray light correction ≅ stray light model



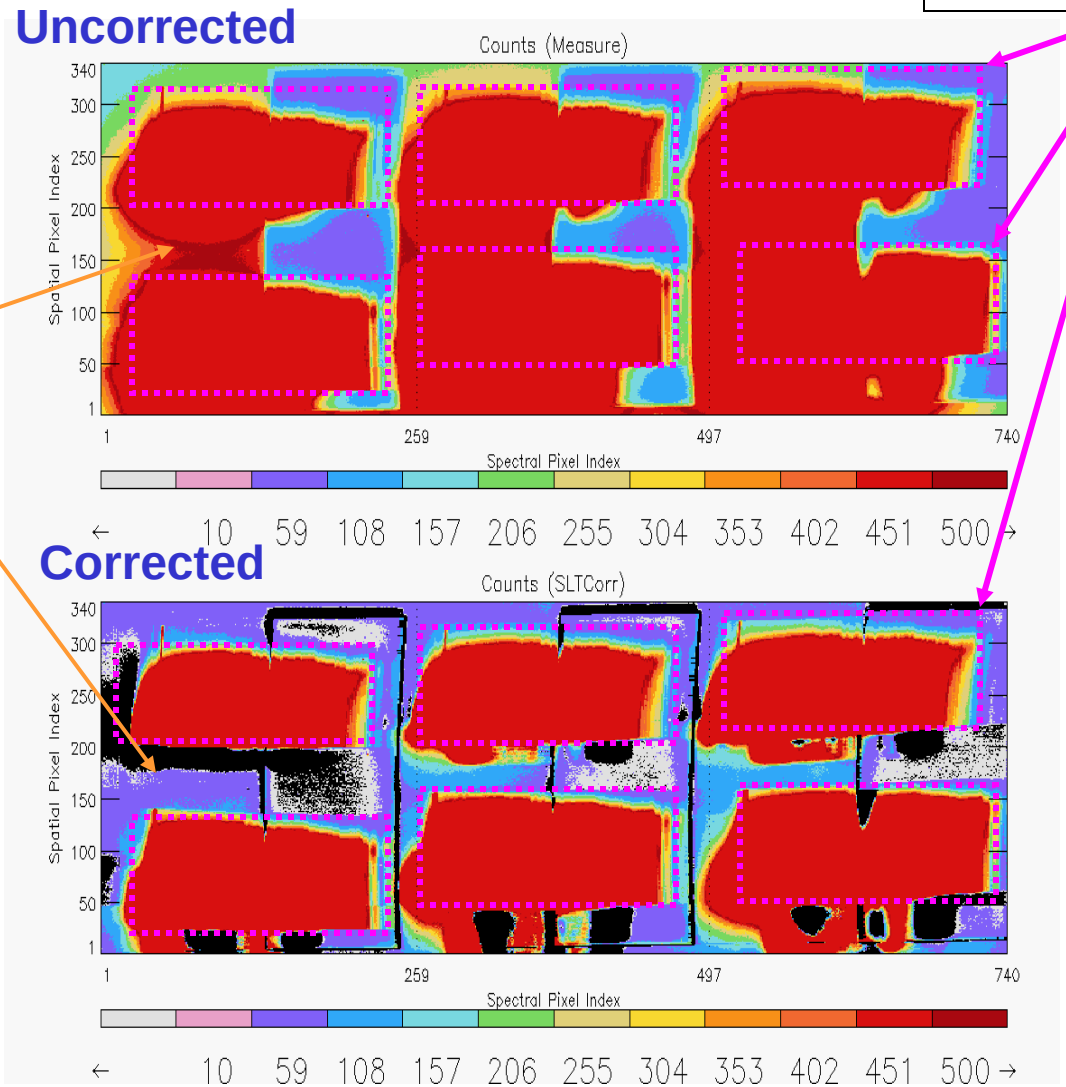
- Low signal levels
- Physically close to other apertures
- Increased reflection within detector
- Etalon effect makes scattered light difficult to characterize

Stray light verifications

Optical Region

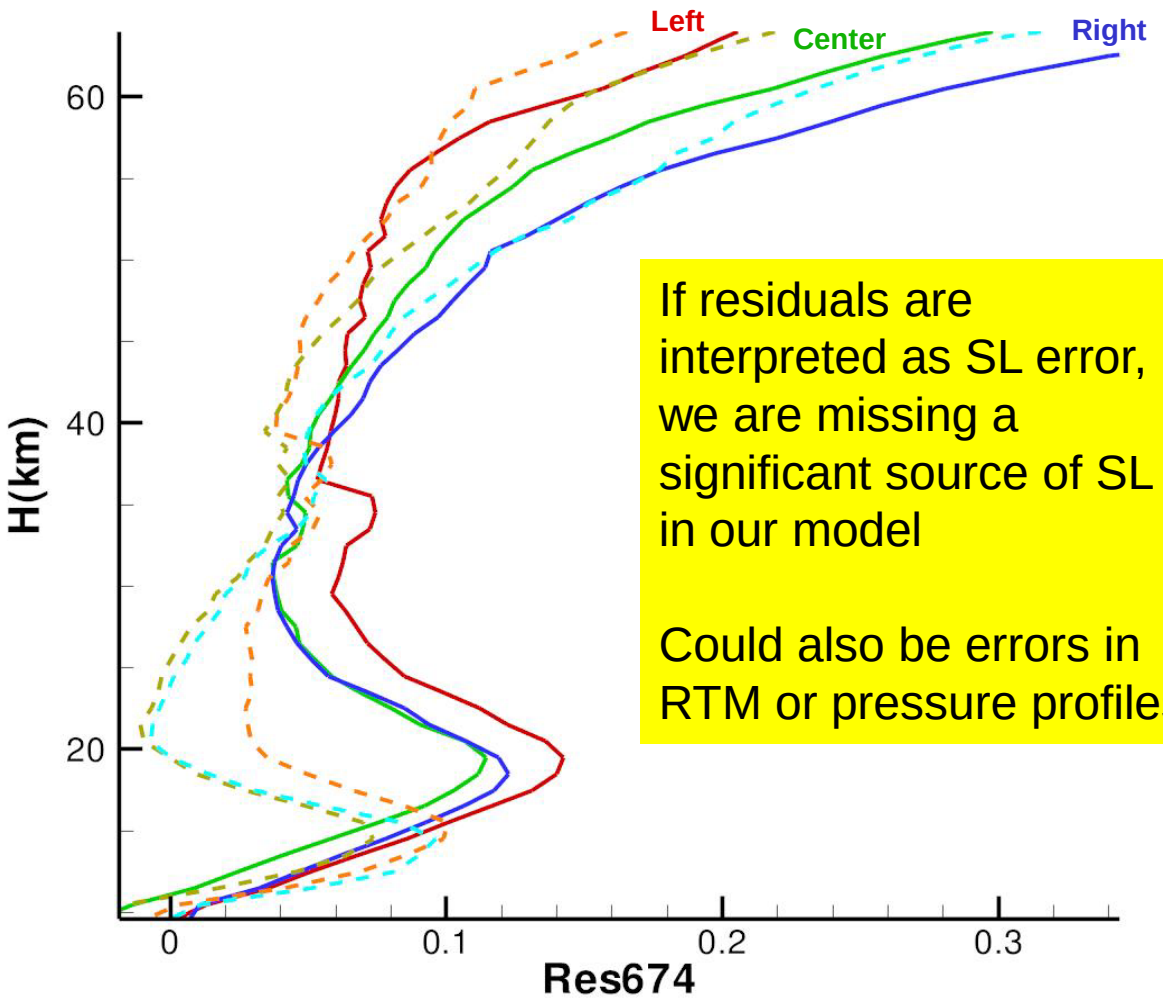
Stray light correction evaluated using non-optical regions on detector

Stray light errors remain in high-altitude VIS / NIR



Residuals have stray light signature

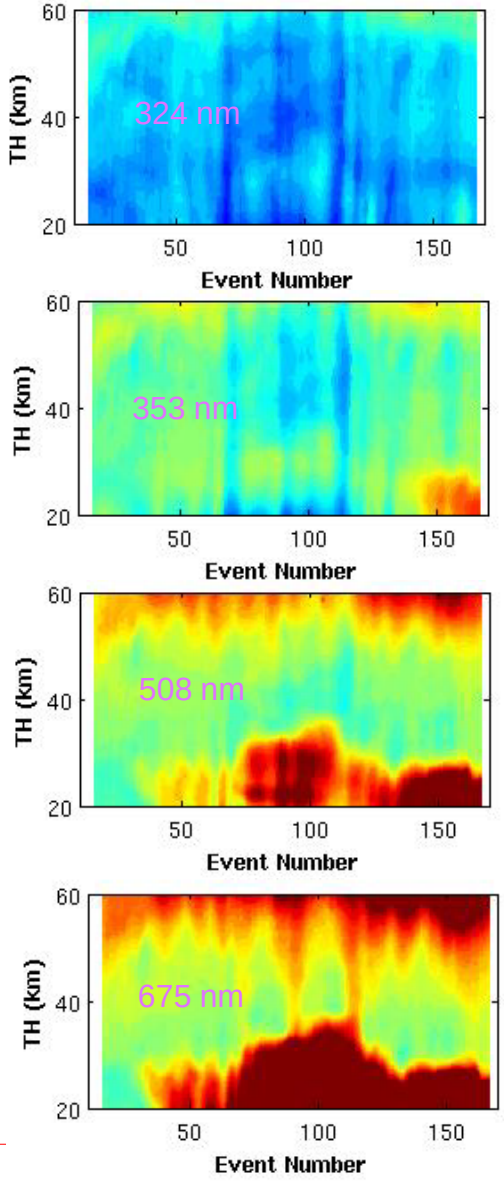
Residual 674 nm for **Frame 20**,
Daily average for **March 25** and **October 13 (dashed)**, 2013



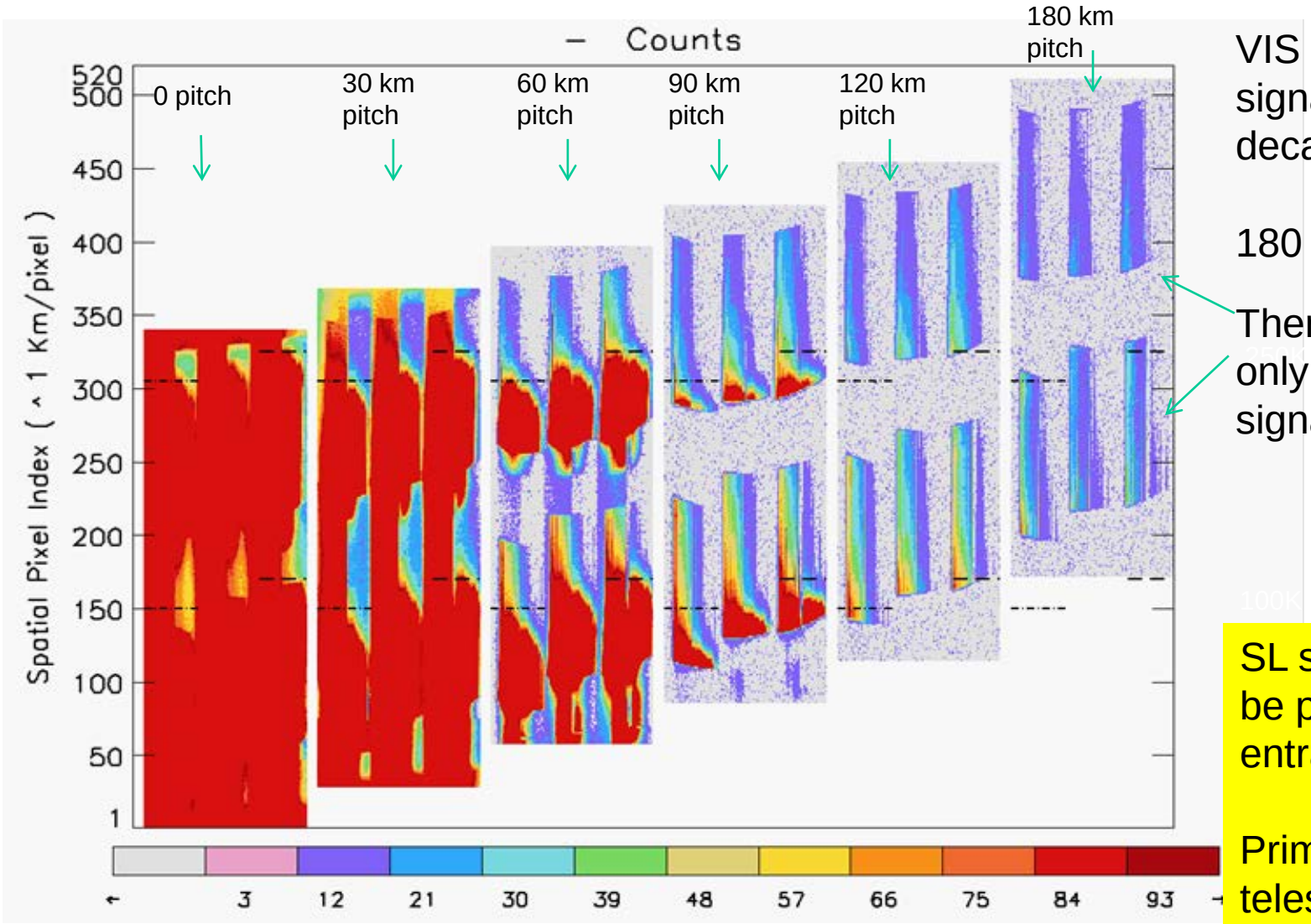
If residuals are interpreted as SL error, we are missing a significant source of SL in our model

Could also be errors in RTM or pressure profiles

Orb 15054, Center Slit



Pitch-up suggests additional stray light source



VIS backscatter signal drops one decade per 20 km

180 km ➔ 10^{-9}

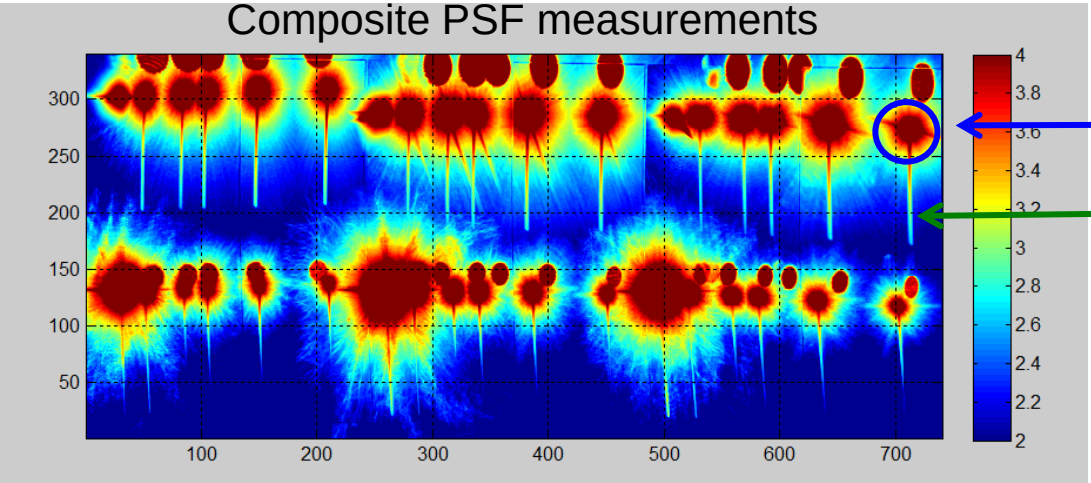
There should be only background signal

SL source must be prior to entrance slit

➔

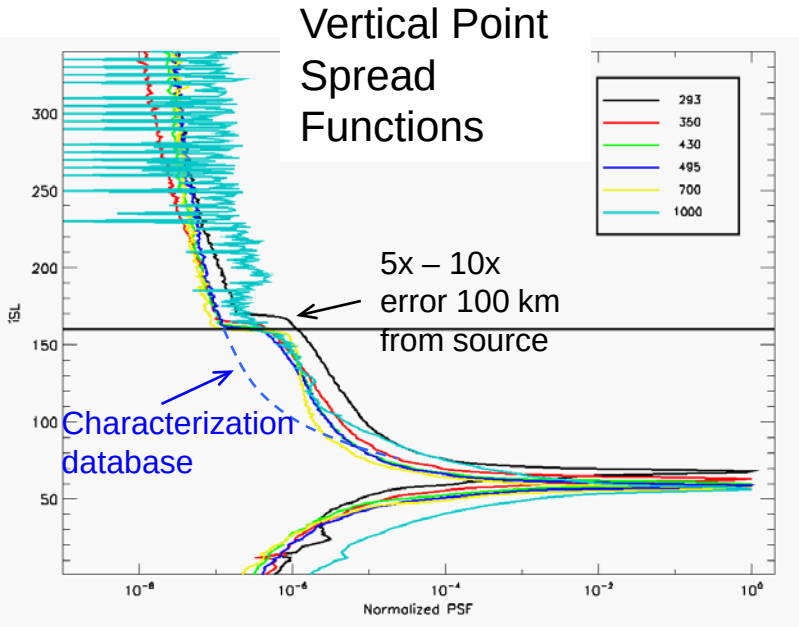
Primary telescope mirror

Current SL correction ignores telescope scatter



Spectrometer scatter

Primary mirror (telescope) scatter

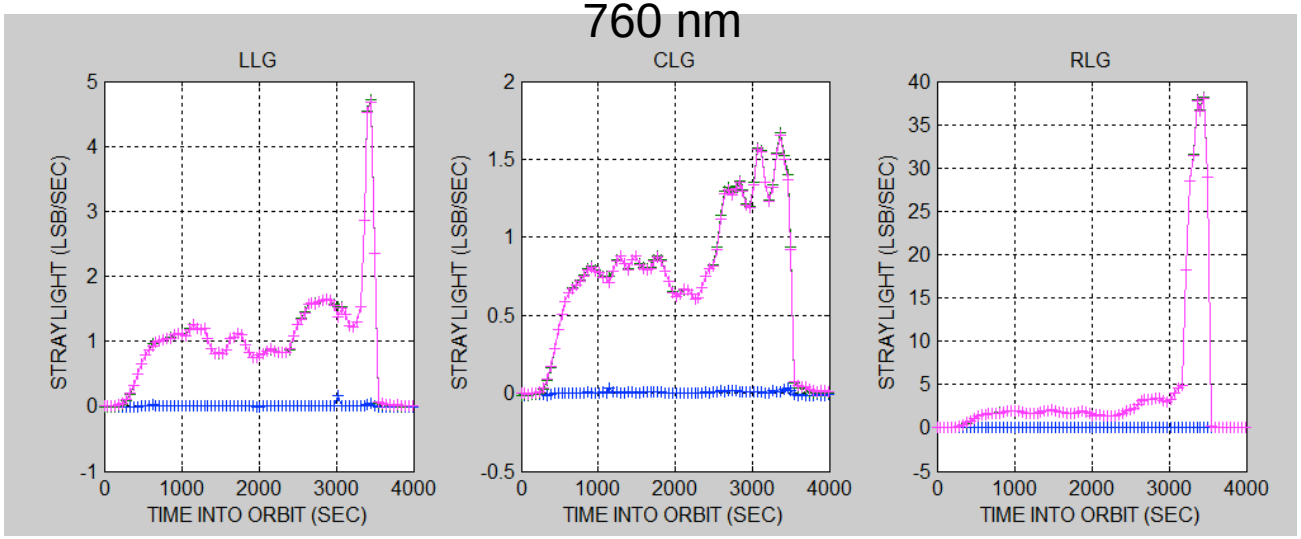


Greatest difference is for source pixels far from target (e.g. Earth surface)

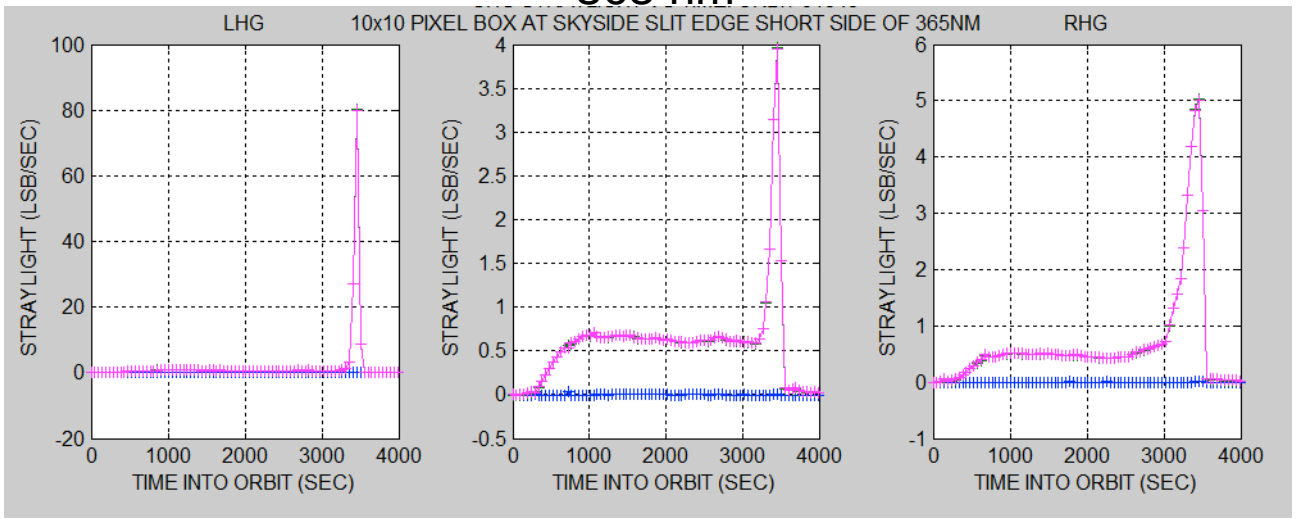
Largest Earth limb vertical contrast is in the NIR, so largest error occurs there

Pitch-up confirms sun intrusion at end of orbit

760 nm



365 nm



Occurs earliest in Right slit (closest to sun)

As low as SZA=78˚

Expect it to be worst in early July, but have not investigated

Summary of L1G changes for next release

	Version 2	Next Release	Long Term
Radiometric	Calibrated radiances on uniform grid	Sun-normalized radiances on uniform grid	L-T trend corrections
Wavelength registration	Varies intra-orbitally & seasonally	same	L-T trend corrections using solar cal.
Altitude registration	Static offset corrected via early RSAS analysis; intra-orbital variation	Zero all 3 slits using updated RSAS (100-300m); remove small seasonal cycle using slit edge	Intra-orbital & L-T drifts; still measuring the moon
Stray Light	Jacobian based on delivered PSFs	Simple empirical scaling of correction	Correction for telescope SL and >1µm leakage; sun leakage corr.
Transients	No flagging	Smear transient flagging	Pixel transient rejection

Extra slides

Stray Light improvements

