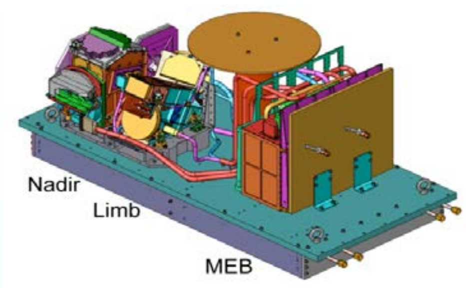
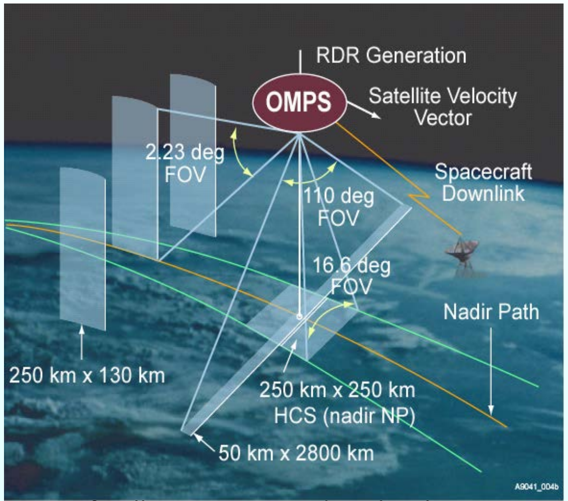
Center for Satellite Applications and Research



S-NPP Ozone Mapper Profiler Suite Nadir Sensor Performance

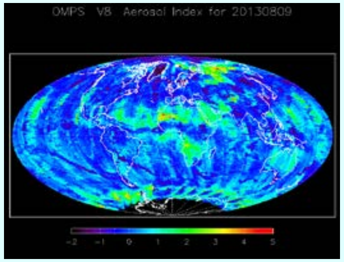
**C. Pan[1], X. Wu[2] and L. Flynn[2]*

** 1 ESSIC, University of Maryland, College Park, MD 20740; 2 NOAA NESDIS/STAR, College Park, MD 20740*

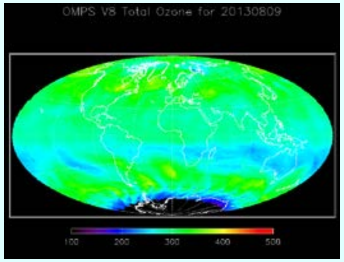


Curtsey of Ball Aerospace and Technologies Corp.

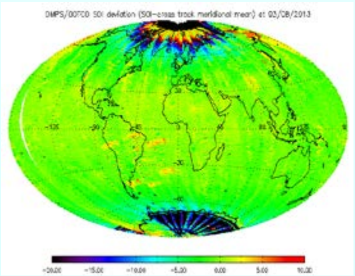
SUOMI NPP SDR Science and Validated Product Maturity Review
December 18-20, 2013
5830 University Research Court, College Park, MD 20740



Aerosol Index



Ozone map

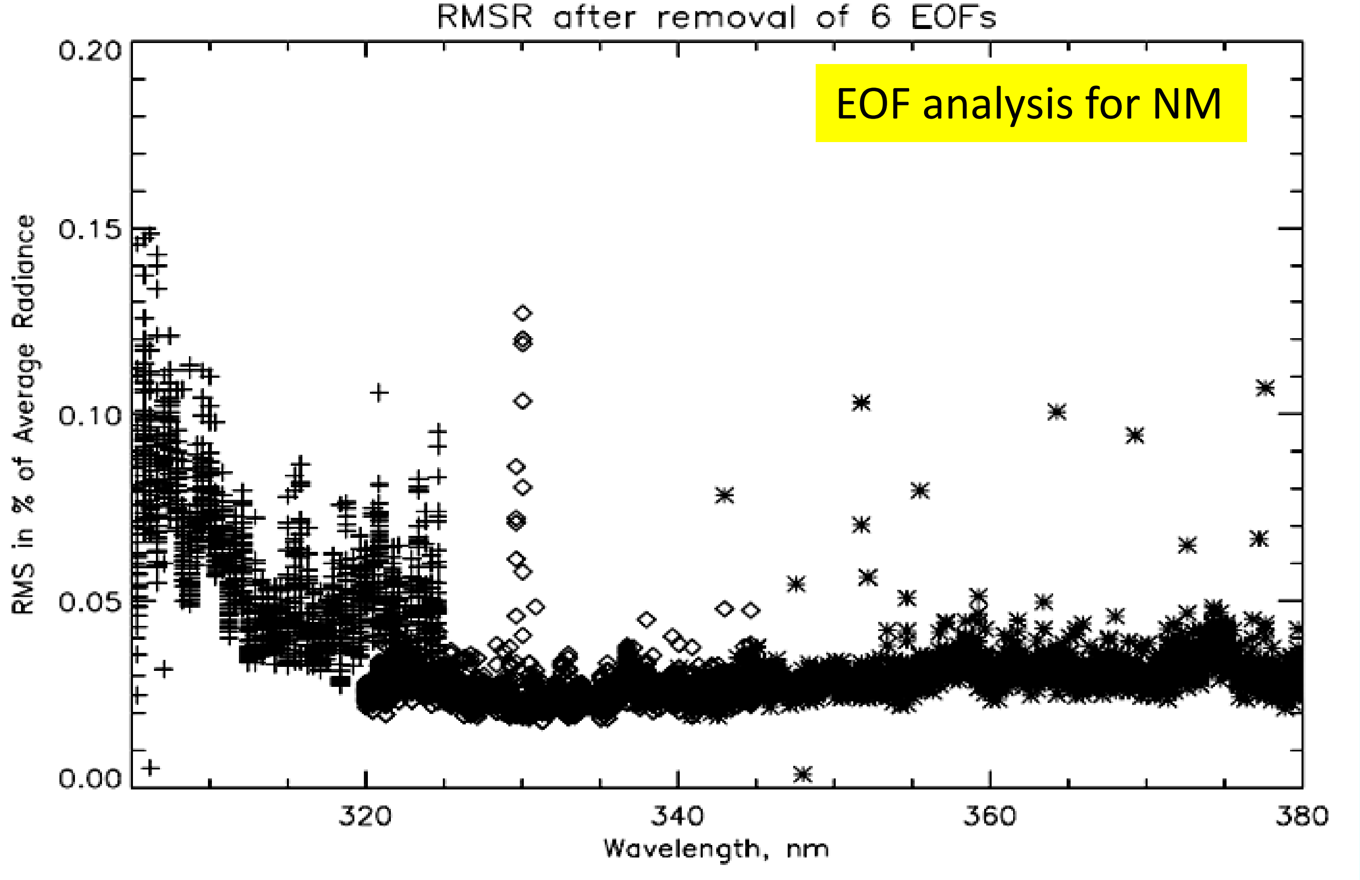


So2 index

Topics

- Sensor noise
- Dark current
  - Distribution
  - Dark generate rates
  - Readout noise
- Linearity
  - LED output drift
  - Nonlinearity
  - Calibrated residual
- Wavelength registration
  - Dichroic shift
  - Orbital variation and intro-orbital variation
  - Cross-position variation
- Absolute solar irradiance
- Normalized Earth view irradiance
- Stray light

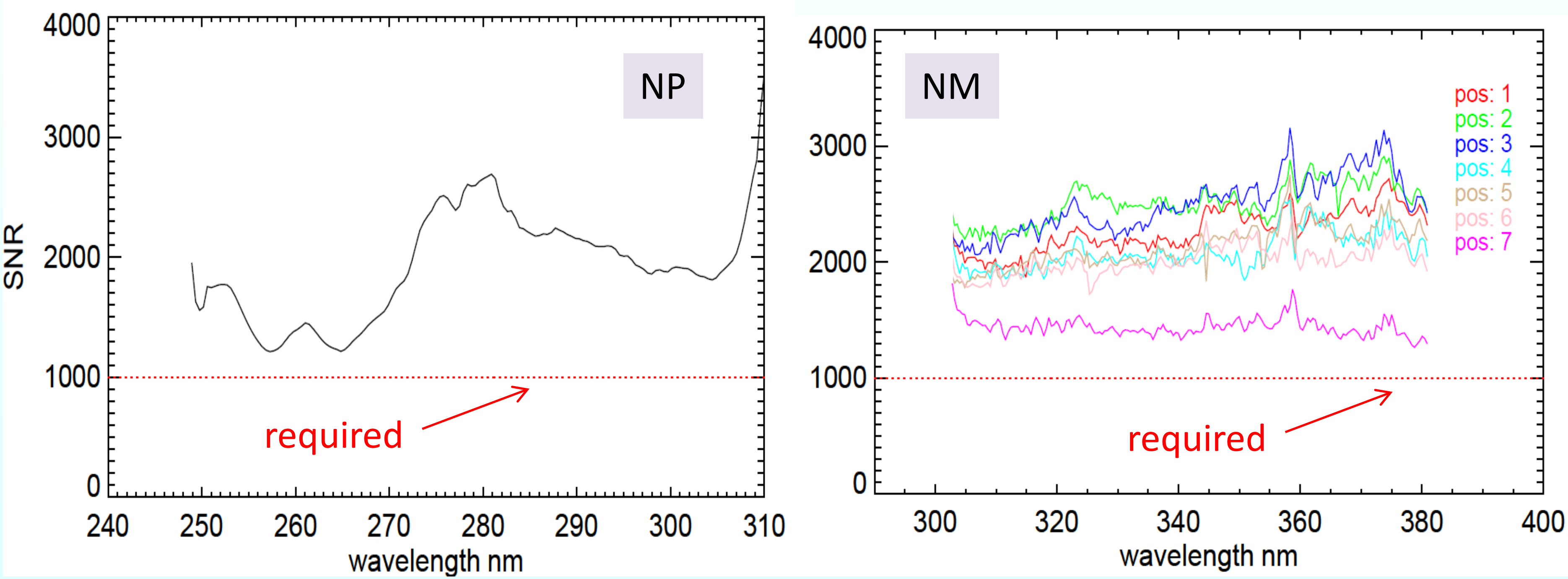
Earth view noise < 0.1 % RMSR



Noise in the SAA causes noticeable uncertainty for NP @ wavelength < 290 nm

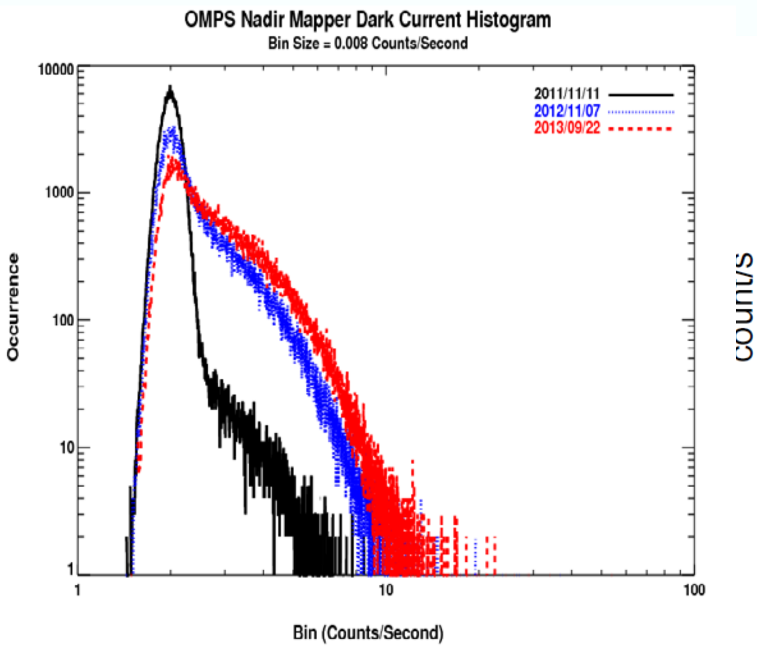
Solar view SNR > 1000

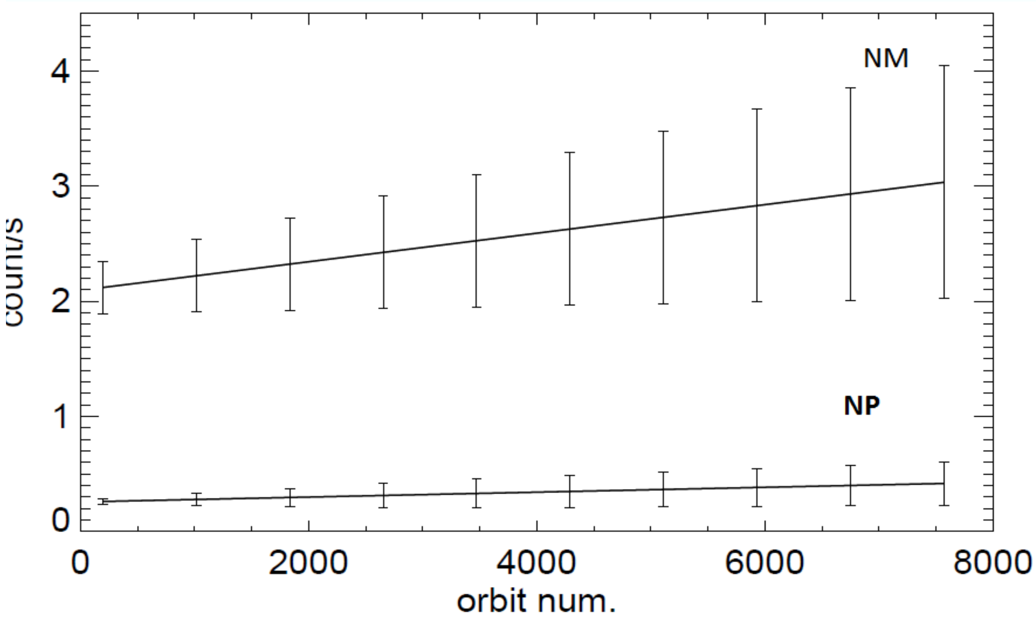
Working Diffuser



Reference diffuser has a similar pattern and also meets the requirement.

Increasing dark currents, as expected

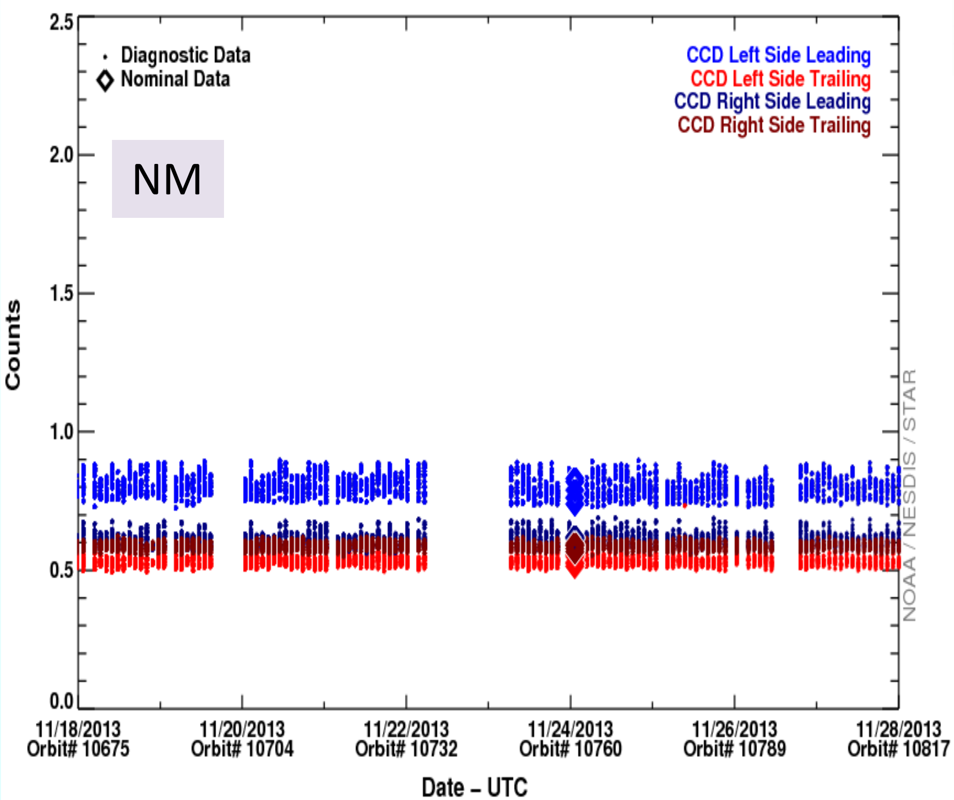


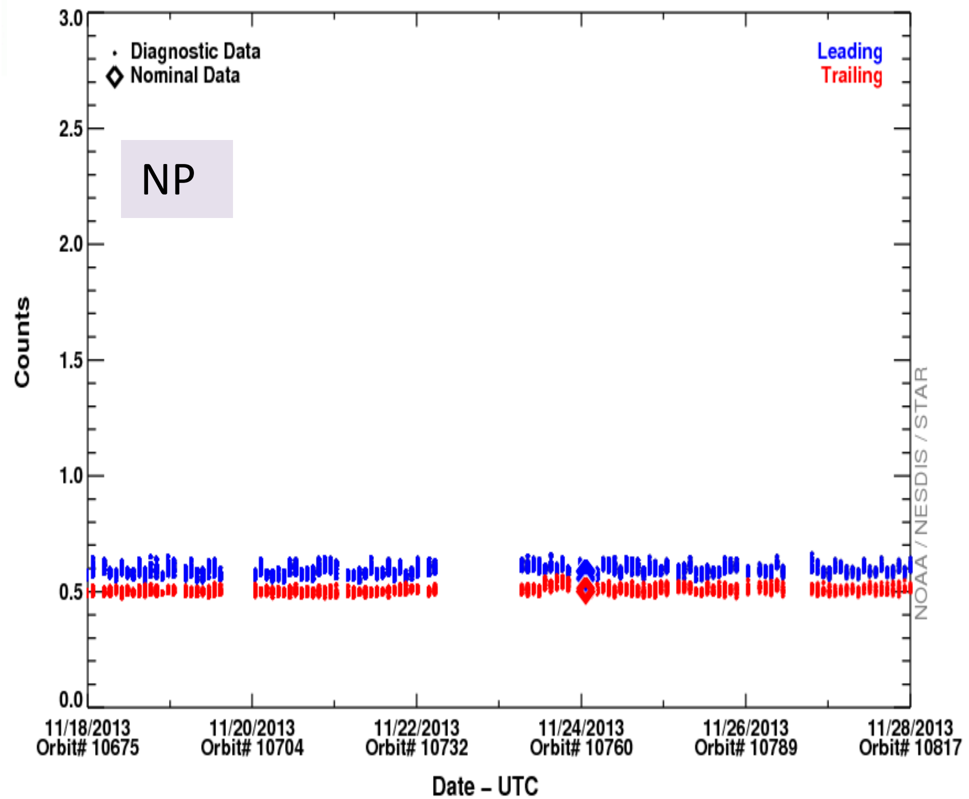


- Weekly increase in mean is about 0.6% for the NM and 0.8% for the NP, resulting in uncertainties in ozone data ~ 0.03% for NM and 0.1-0.5 % for NP.
- The change in dark has negligible impact on the dynamic range of the sensor response for at least 7-10 years.

STAR Center for Satellite Applications and Research

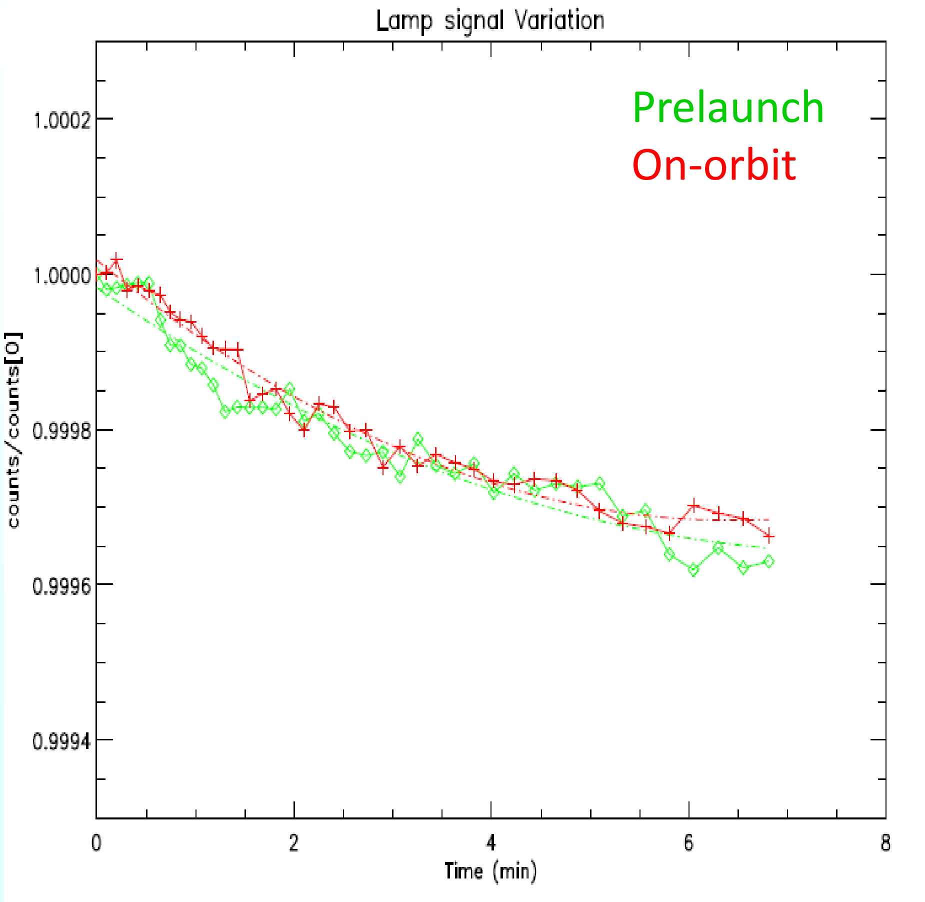
Dark readout noise keeps ~25 e- (primary e-side)

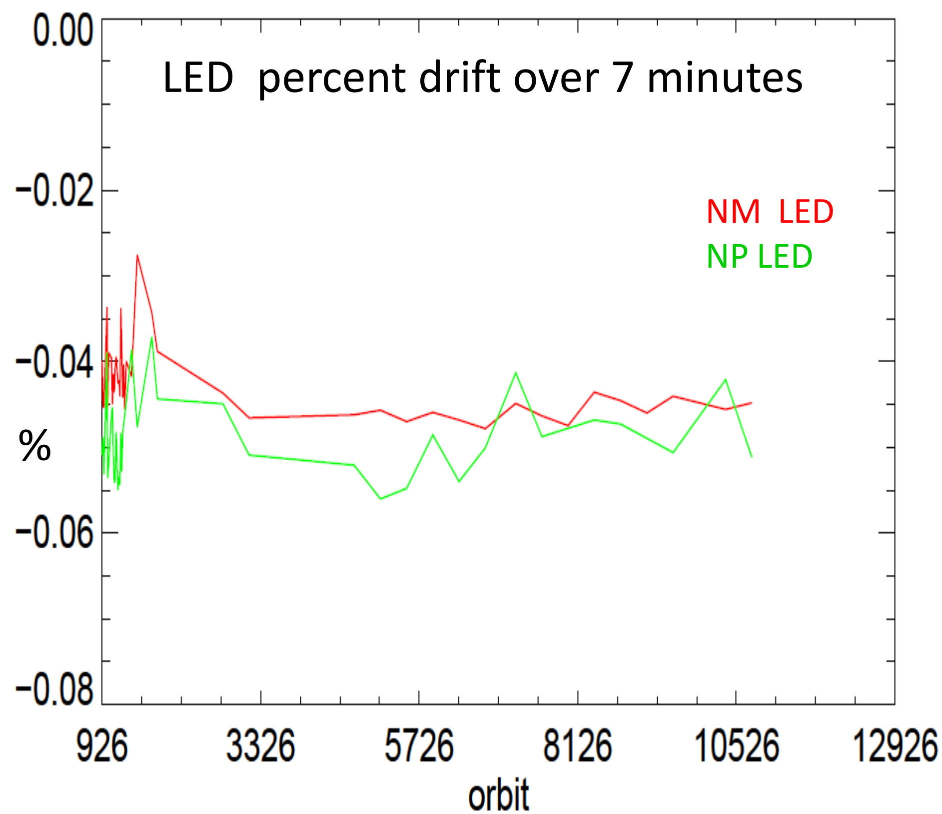




Noise < prelaunch prediction of 60 e-

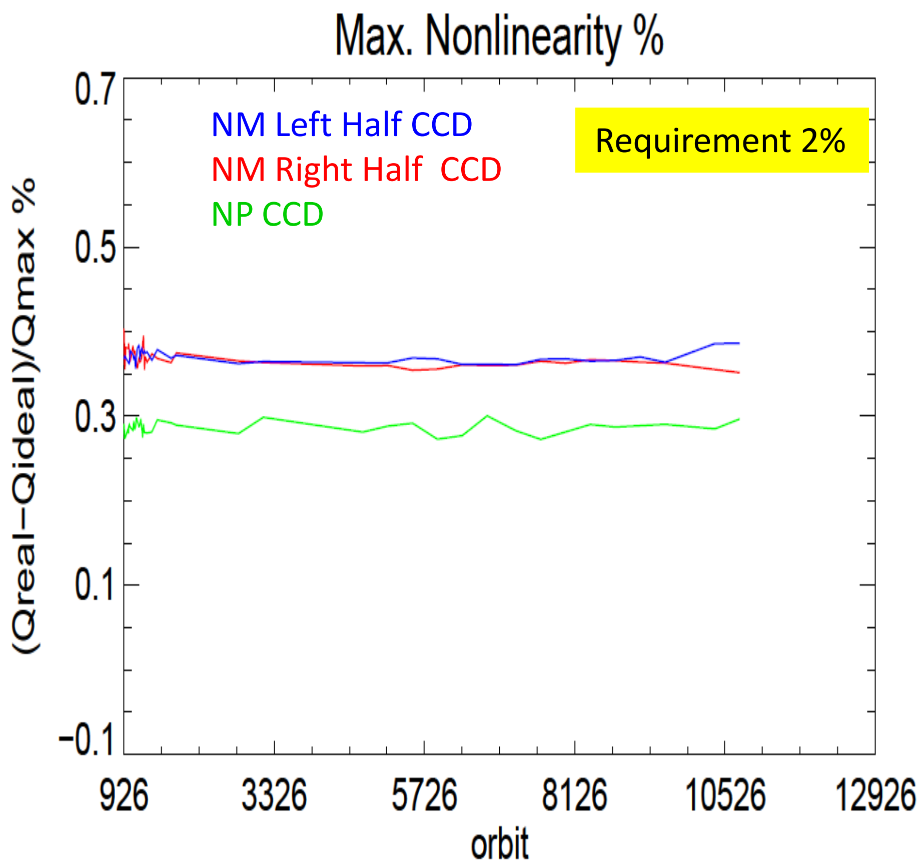
LED output variation < 0.06% over 7 min.



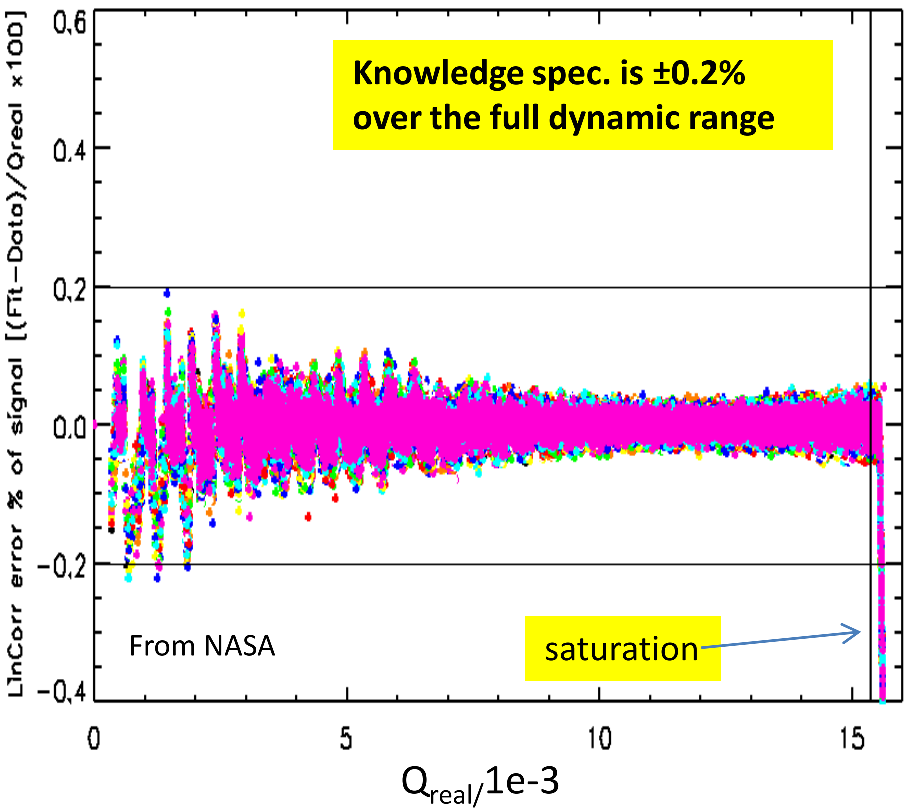


Specification: 1% per min.

Nonlinearity < 0.45 of full well

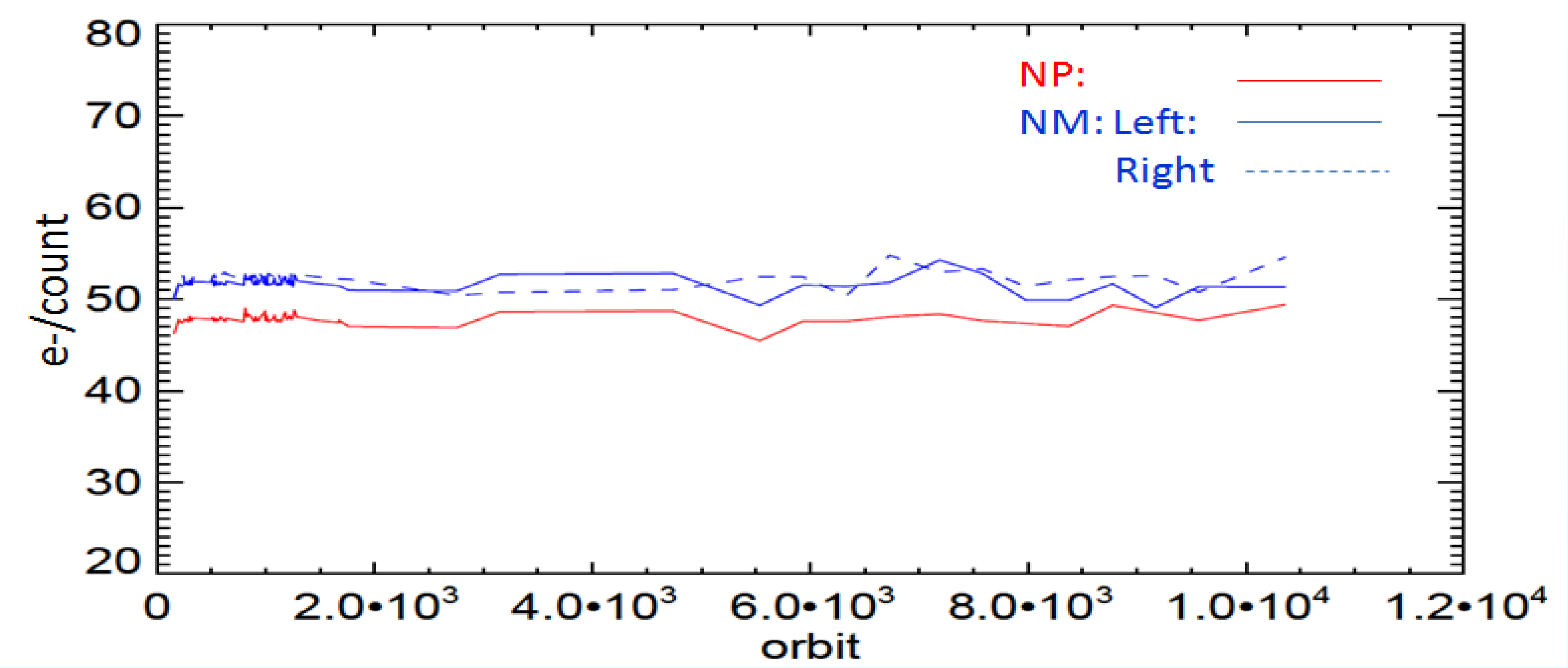


NP Linearity Measurement regression residuals
Orbits 230 - 1166



CCD gain is stable

The number of electrons corresponding to one analog count of the analog to digital converter (ADC)

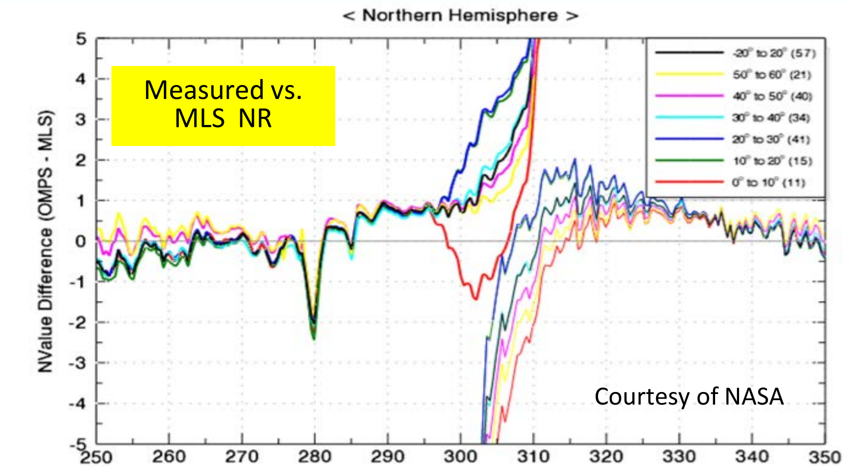


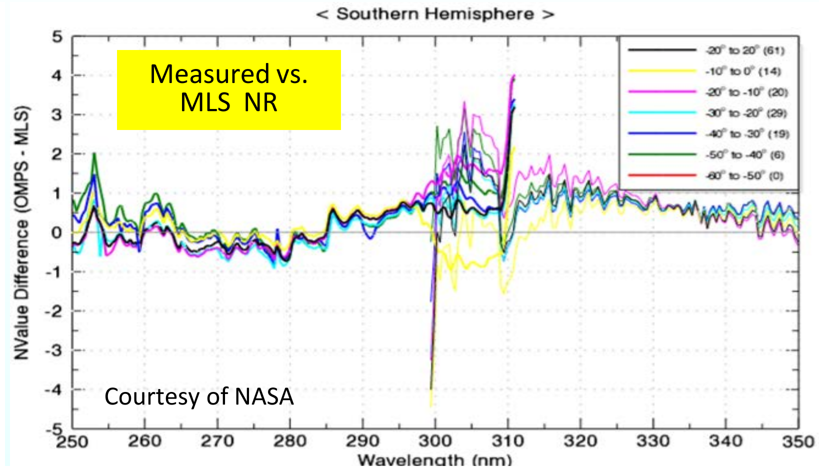
Small offset relative to the TVAC test results

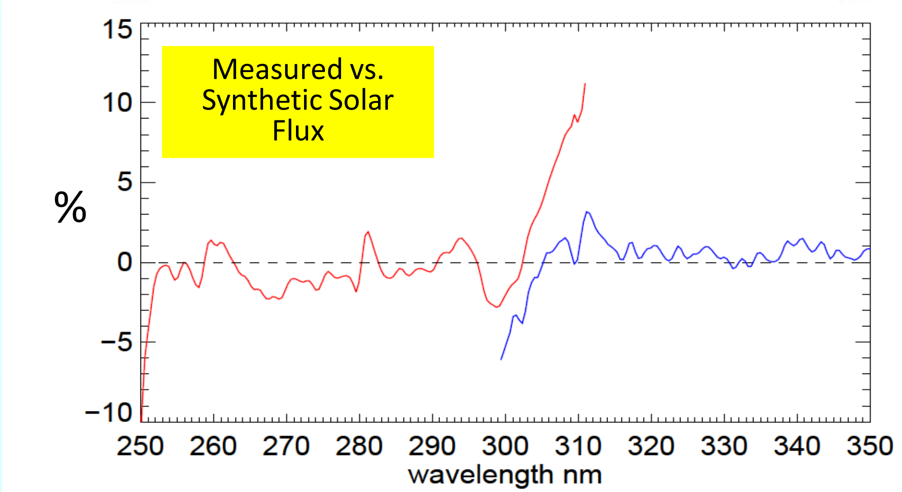
Dichroic shifted > 0.1 nm from ground to orbit

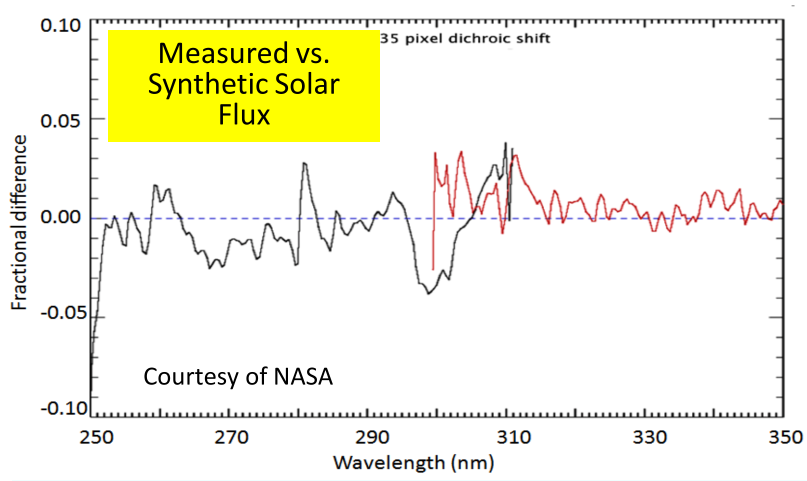
Without shift

After add a 0.15 nm shift

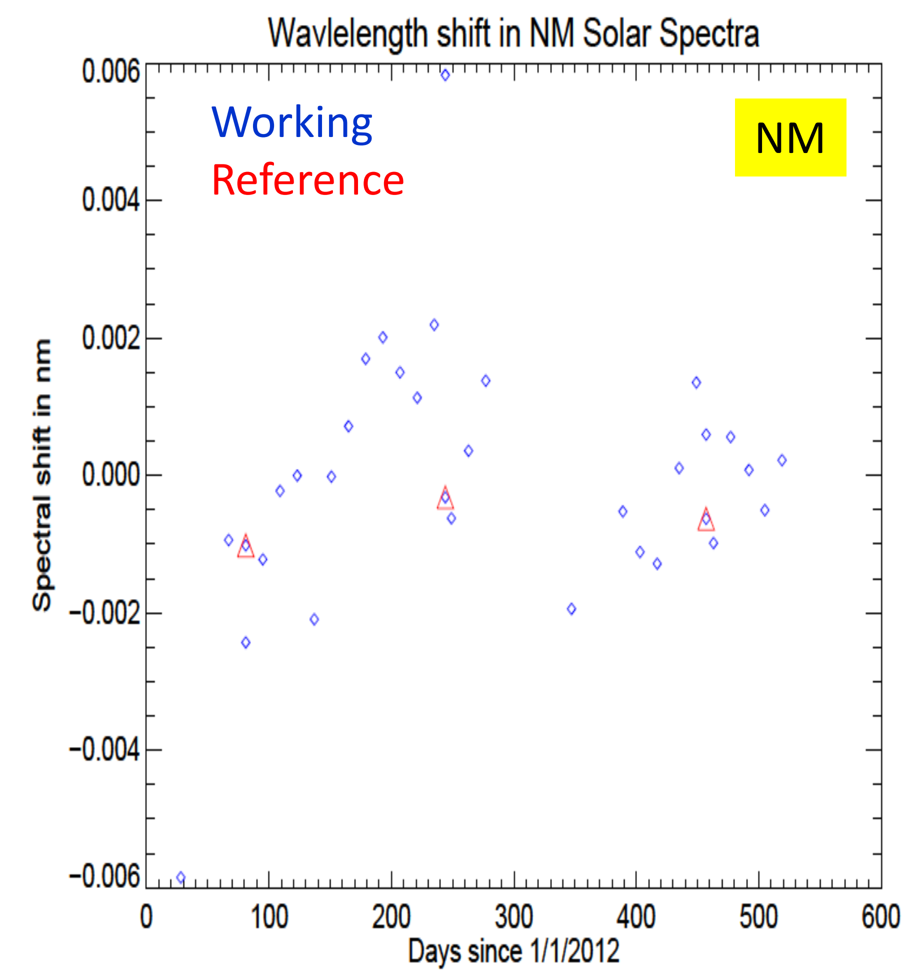


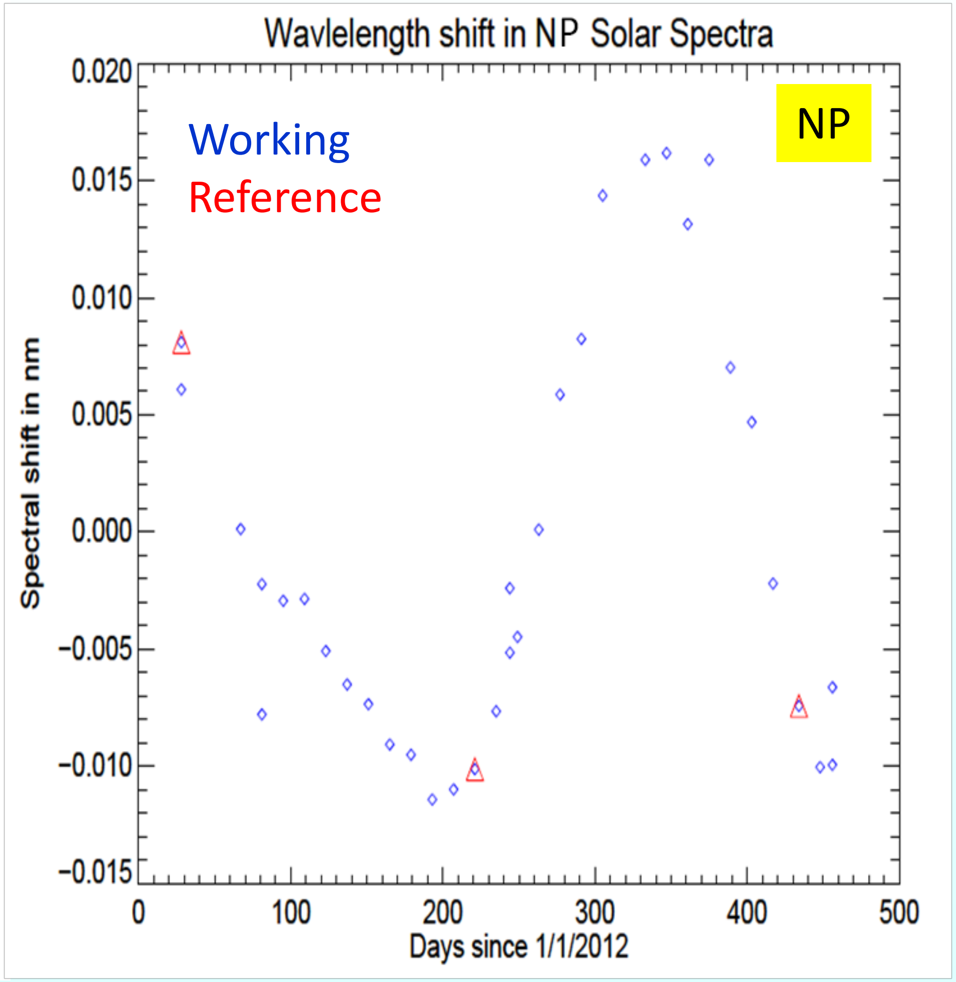






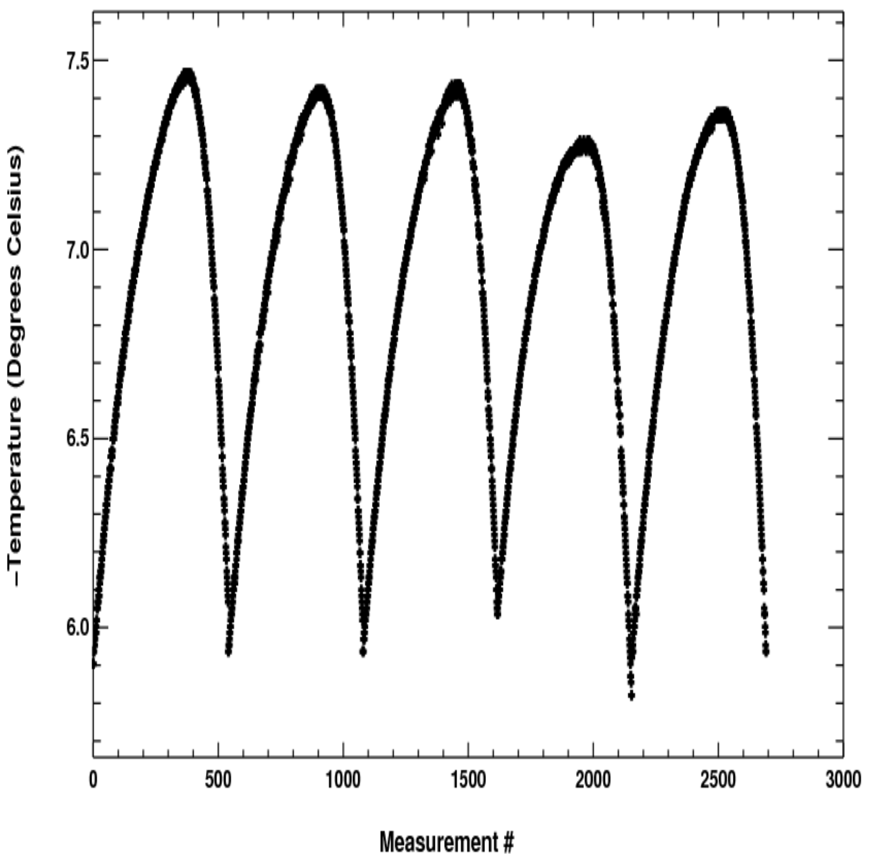
Orbital wavelength variation < 0.02nm



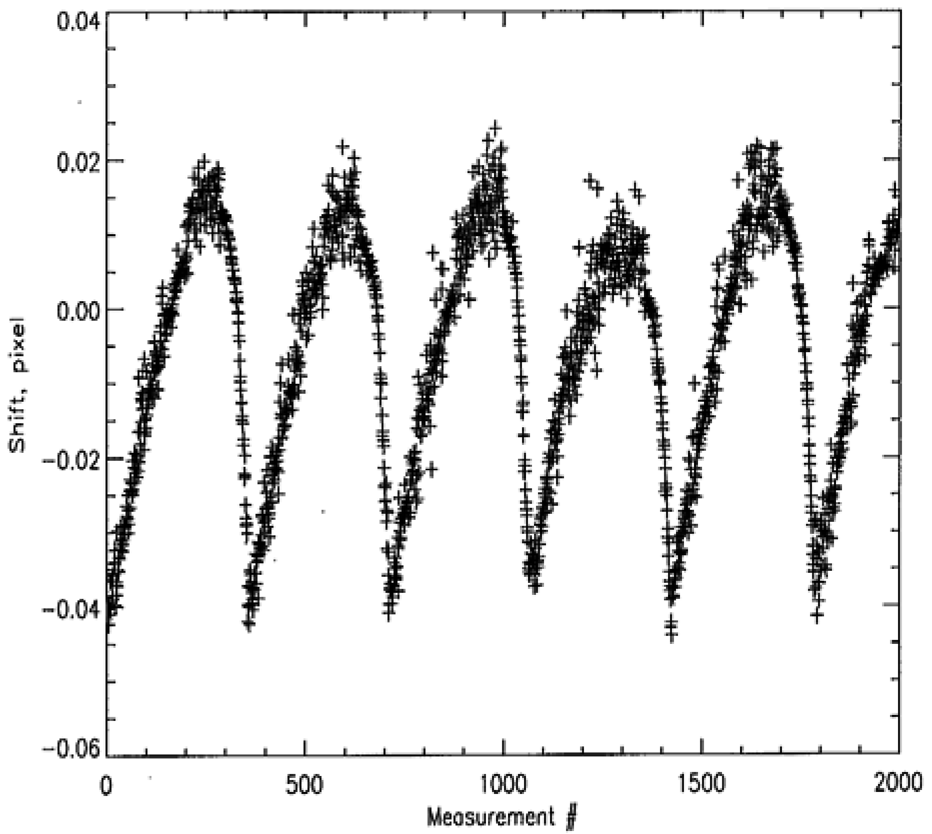


Intro-orbit wavelength changes < 0.025 nm

NM housing temperature (°C)



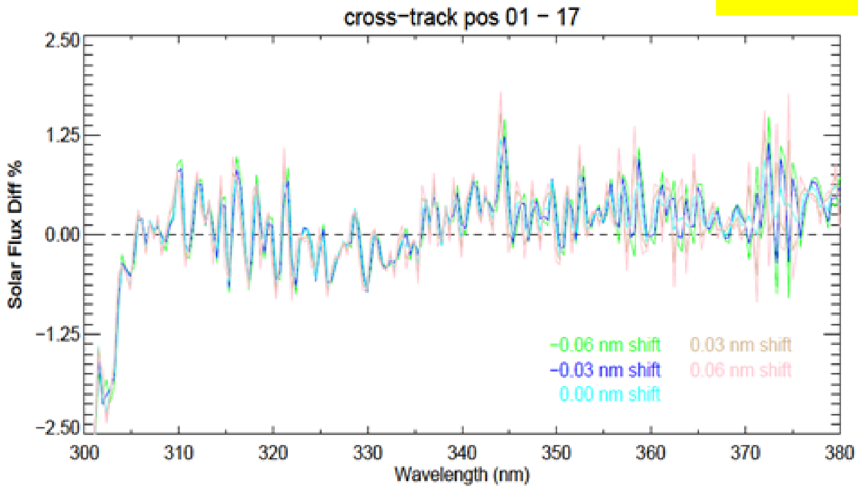
Intro-orbital wavelength shift in pixel

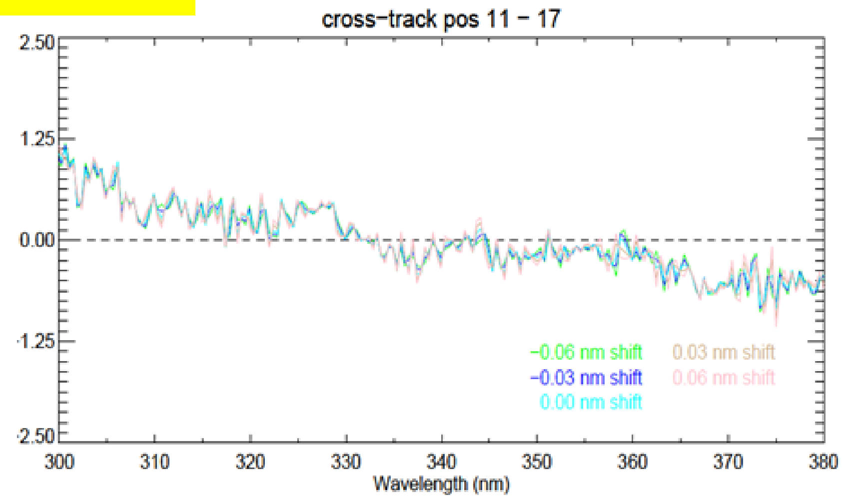


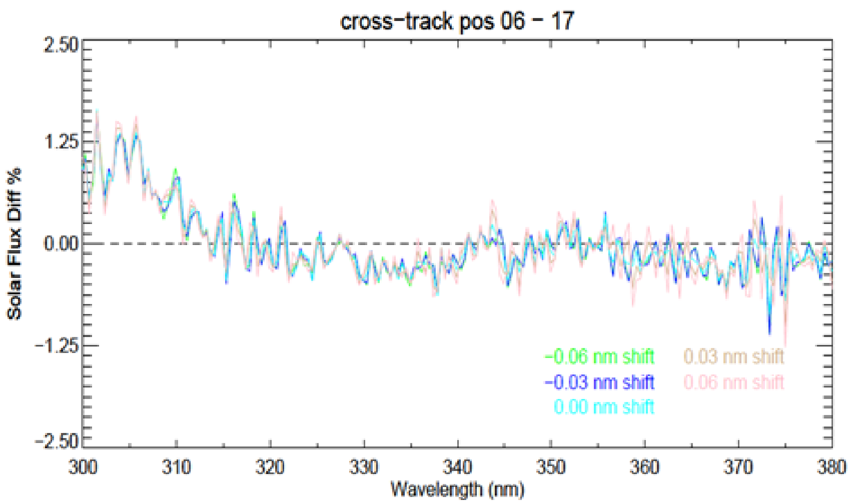
This variation is compensated in the EDR algorithm

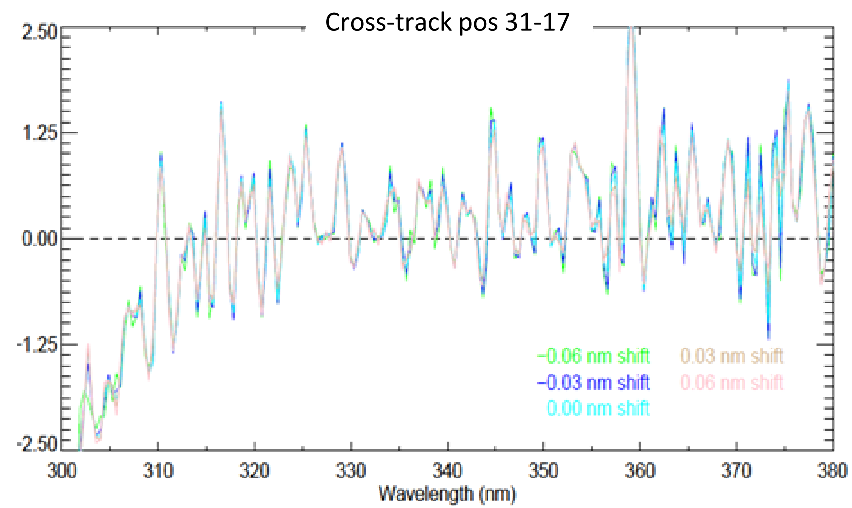
Cross-track position difference indicates wavelength variation

NM Solar data

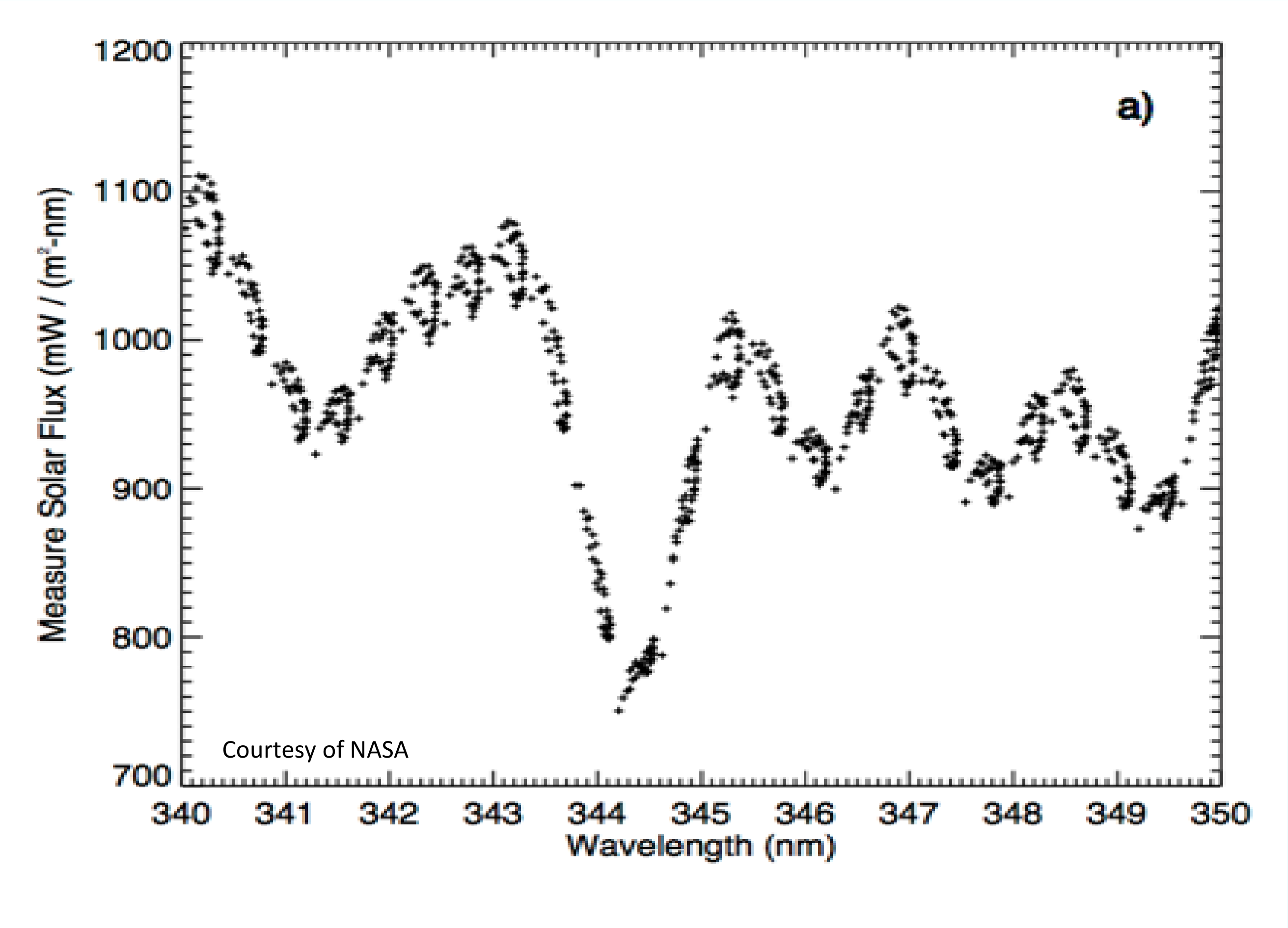




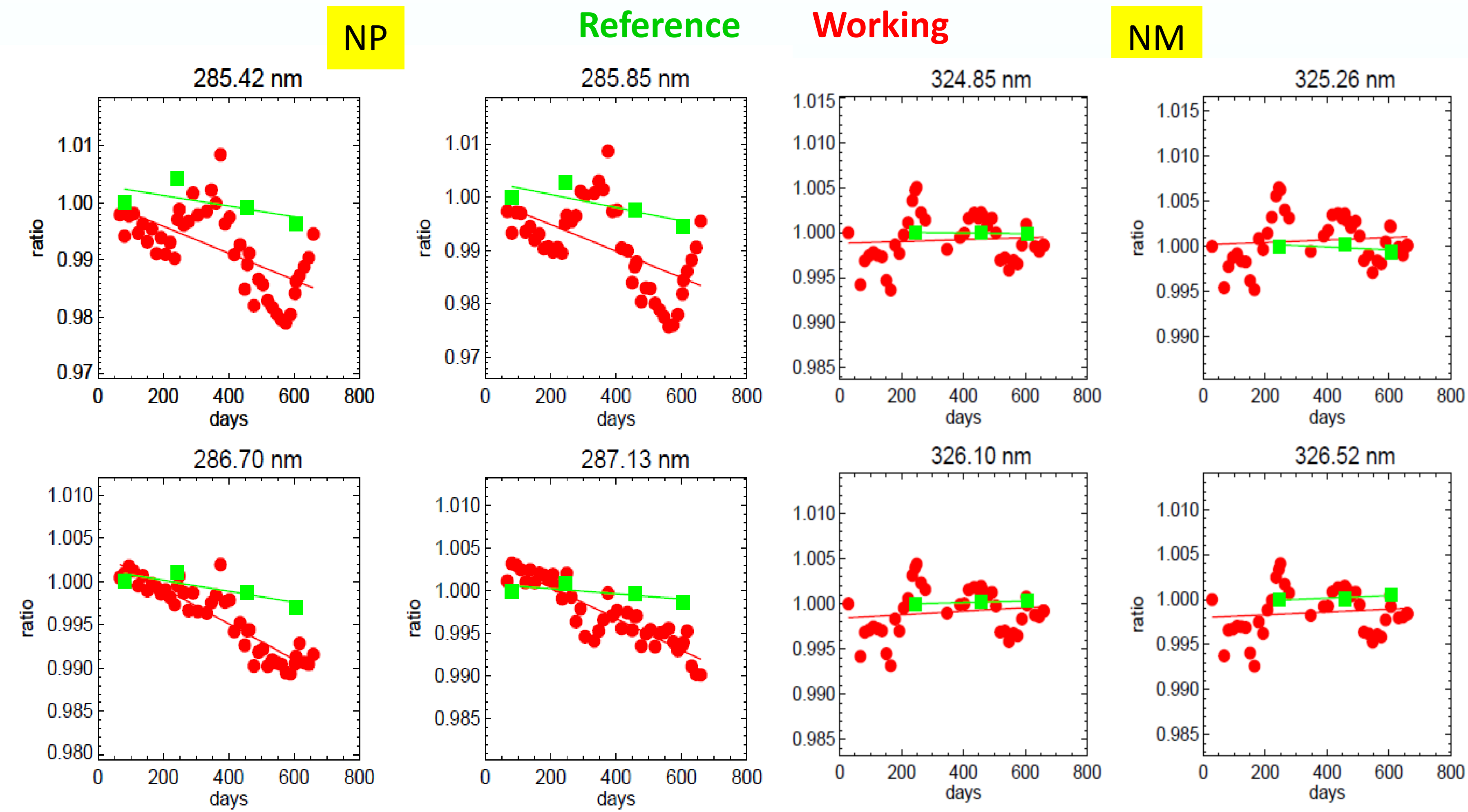




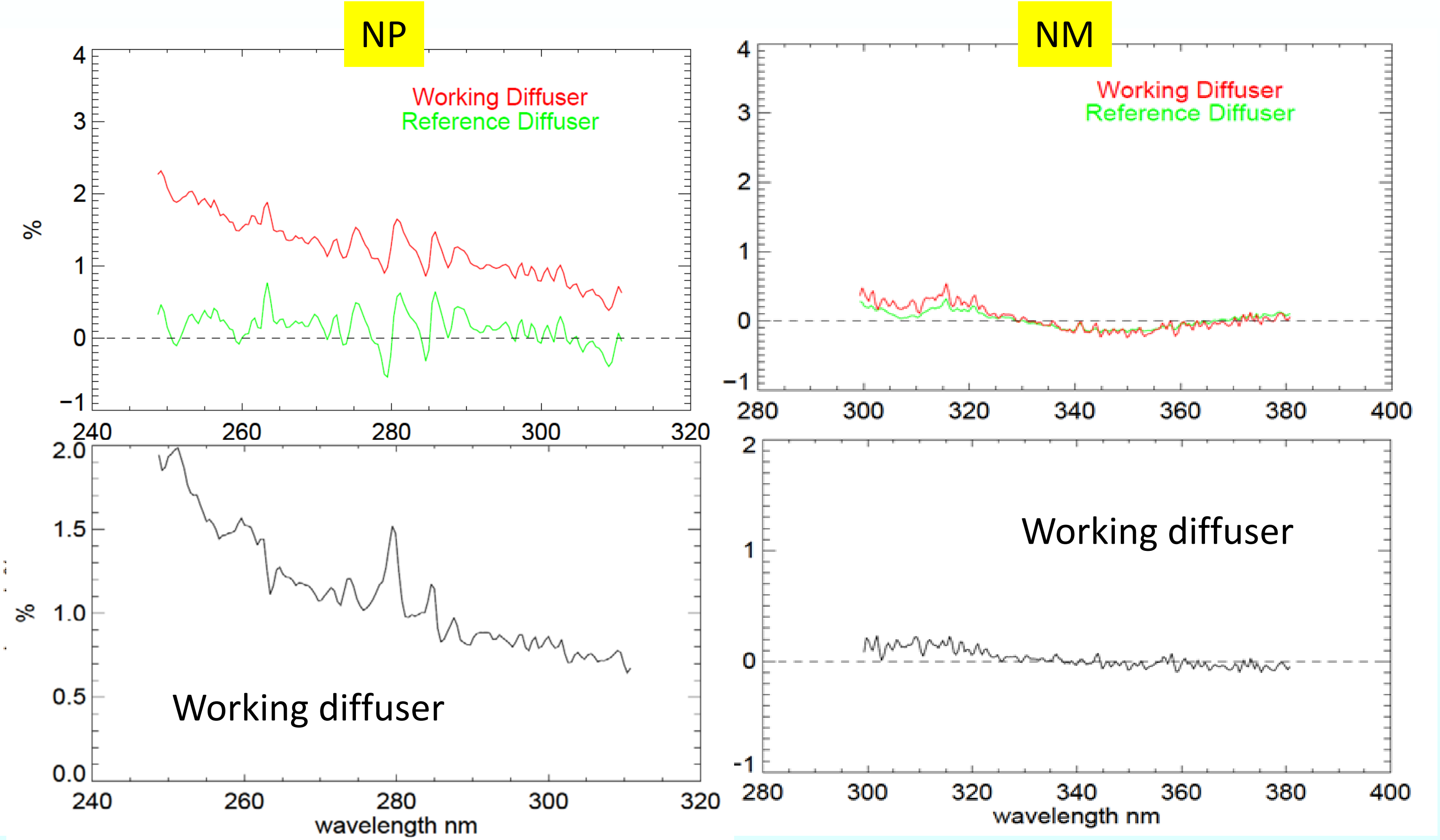
Absolute solar irradiance uncertainty < 7%



Trending of sensors' optic throughput



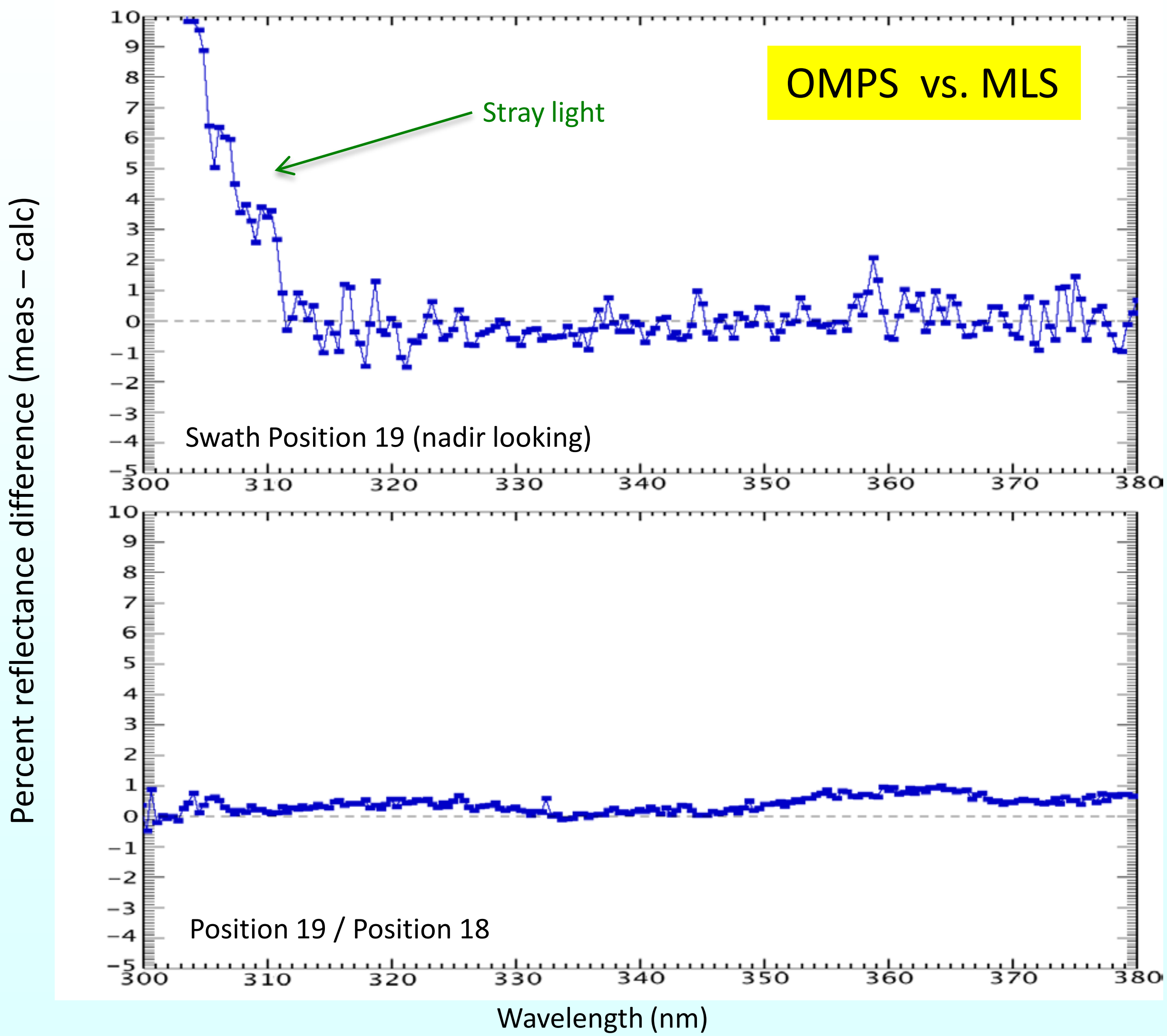
Sensor optic degradation < 0.5%



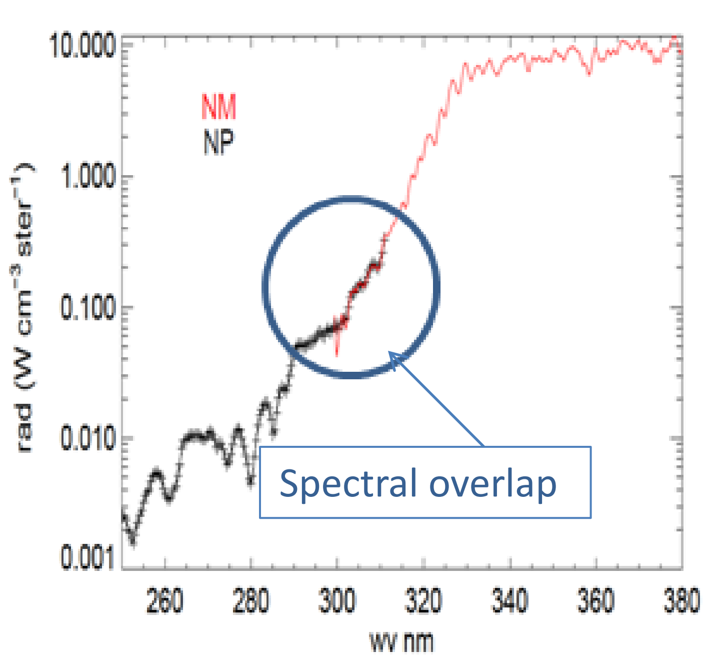
Small degradation indicates a high level of sensor stability

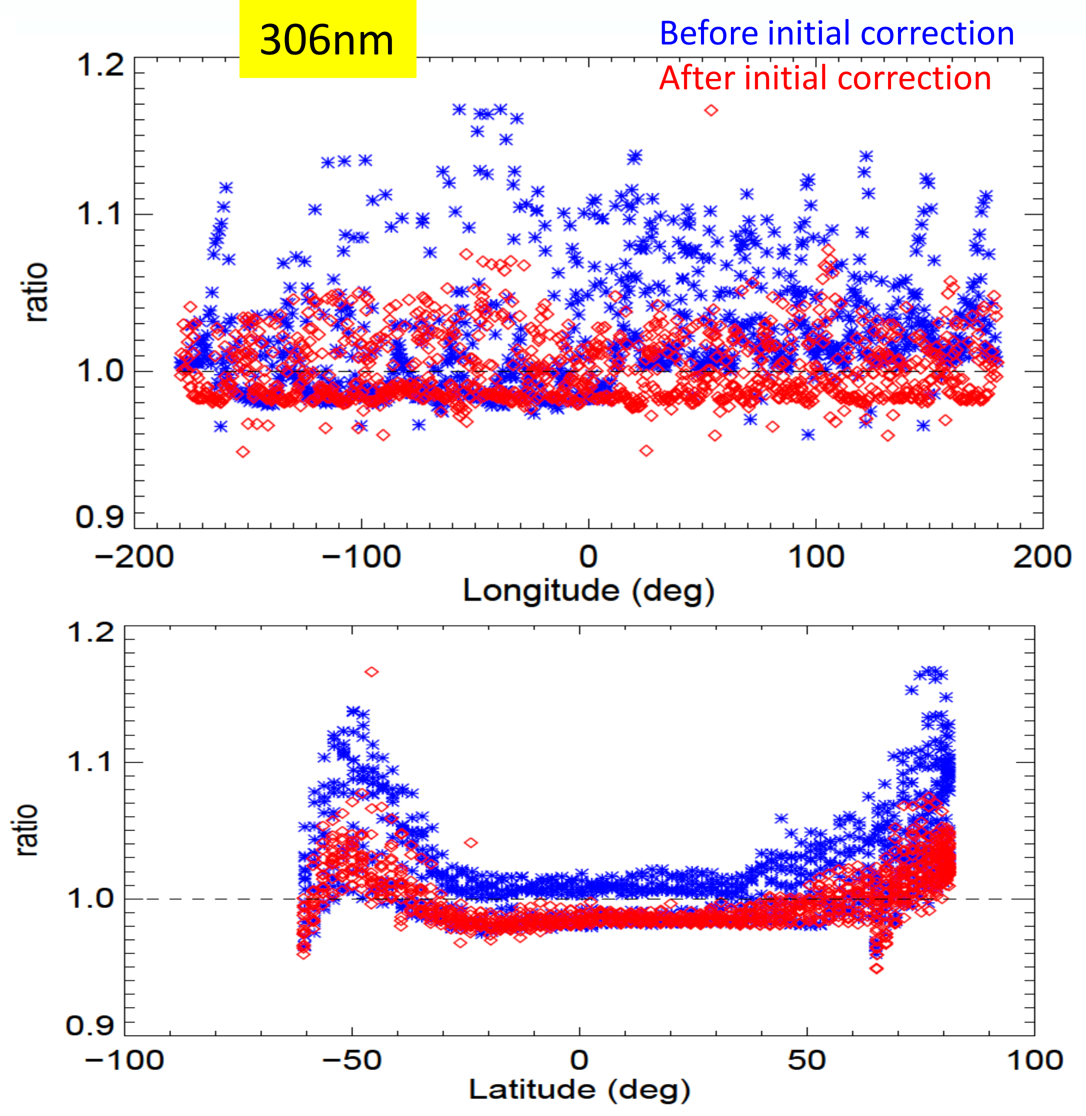
Normalized radiance uncertainty < ± 1%

Indicating the absolute radiance uncertainty < 8%



Stray light correction improves EV radiance





Stray light < average 2%

Summary

Parameters	Specification/Prediction Value	On-Orbit Performance
Non-linearity	< 2% full well	< 0.46%
Non-linearity Accuracy	< 0.2%	±0.2%
On-orbit Wavelength Calibration	< 0.01 nm	~ 0.02 nm
Stray Light NM Out-of-Band + Out-of-Field Response	For NM ≤ 2	average < 2%
Intra-Orbit Wavelength Stability	Allocation (flow down from EDR error budget) = 0.02 nm	~ 0.025 nm
SNR	1000	> 1000
Inter-Orbital Thermal Wavelength Shift	Allocation (flow down from EDR error budget) = 0.02 nm	~0.025 nm
CCD Read Noise	60 –e RMS	< 25 –e RMS
Detector Gain	43 (for NP) 46 (for NM)	47 (for NP) 51 (for NM)
Absolute Irradiance Calibration Accuracy	< 7%	< 7% in 300-310 nm: up to ~10 % for both NM and NP
Absolute Radiance Calibration Accuracy	< 8%	< 8%
Normalized radiance Calibration Accuracy	< 2%	< 1%

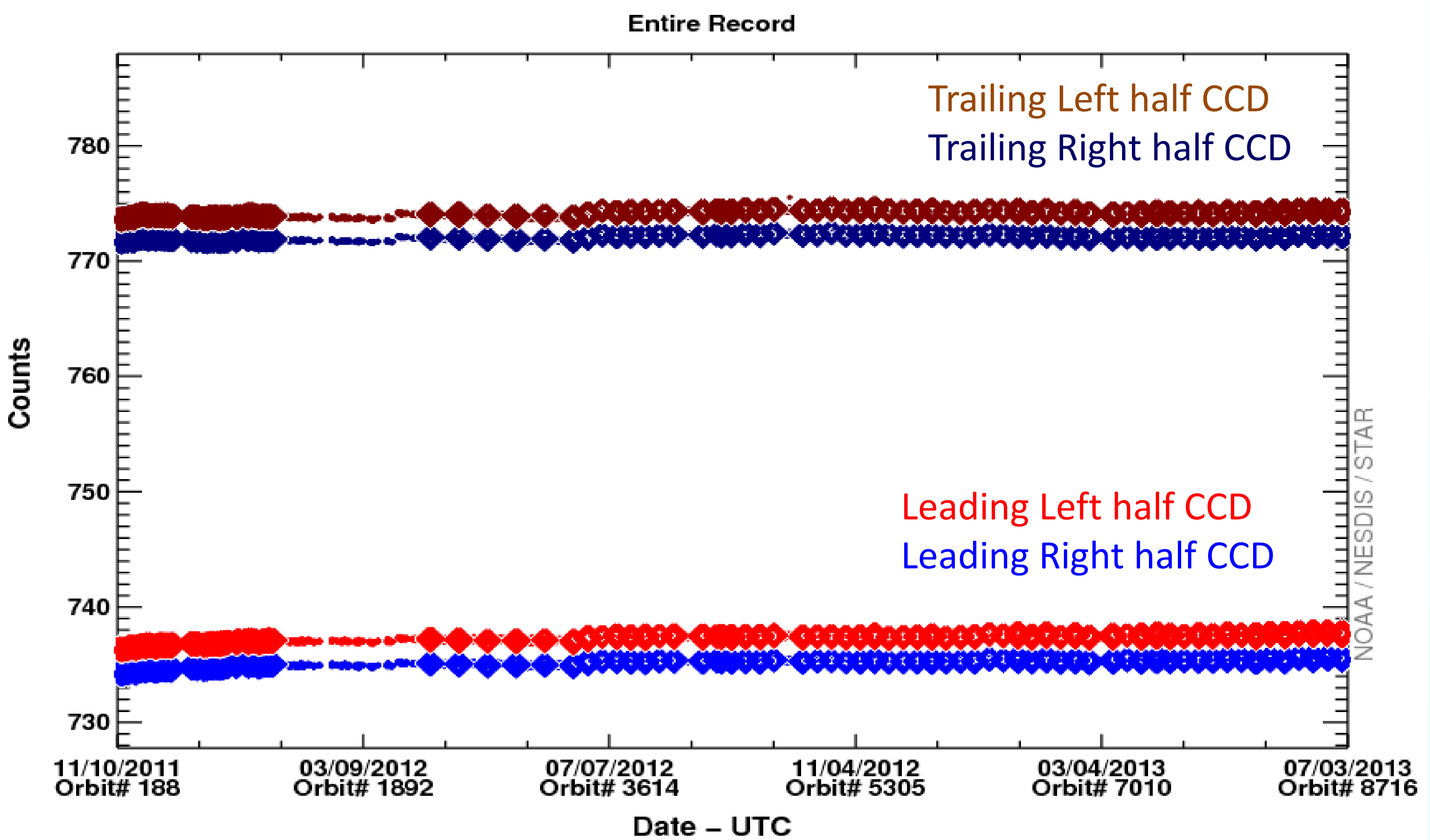
Path forward

- Investigate thermal impact on dichroic from ground to orbit
- Determine temperature shift along orbit
  - wavelength shift vs. temperature difference of sensor telescope
  - apply thermal correction if necessary
- Refine stray-light correction when necessary

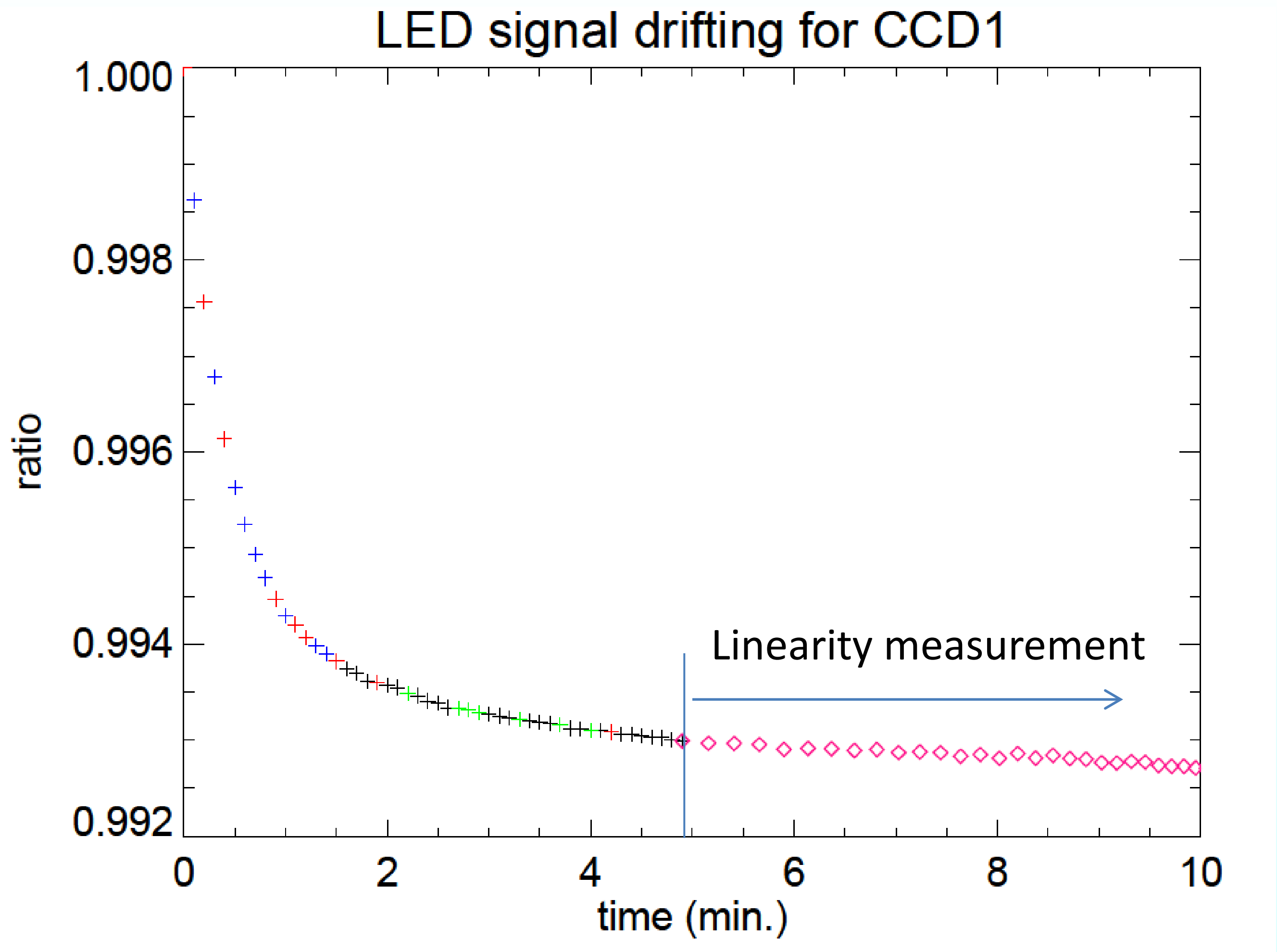
OMPS SDR calibration tables

Table Description	Table Type	Delivery Status
NM & NP Day 1 Solar	LUT	Once (will be repeat)
NM & NP Wavelength	GND-PI	Once (will be repeat)
NM & NP CF Earth	GND-PI	Monthly (ceased)
NM & NP Dark Tables	GND-PI	Weekly
Diagnostic Flight Sample Tables	SCT	When necessary
Earth-view Flight Sample Tables	SCT	Once
Earth-view Ground Sample Tables	GND-PI	Once
Calibration Flight Sample Tables	SCT	Once
NM & NP Radiometric Coefficients	LUT	TBD
NM Stray Light Coefficients	LUT	Once
NP Stray Light Coefficients	LUT	Not planned
NM & NP Linearity (Flight & Ground)	SCT/GND-PI	Not planned
NM & NP Flat Field	SCT	Not planned

Electronic bias changes is negligible



LED warm up reduces output drifting

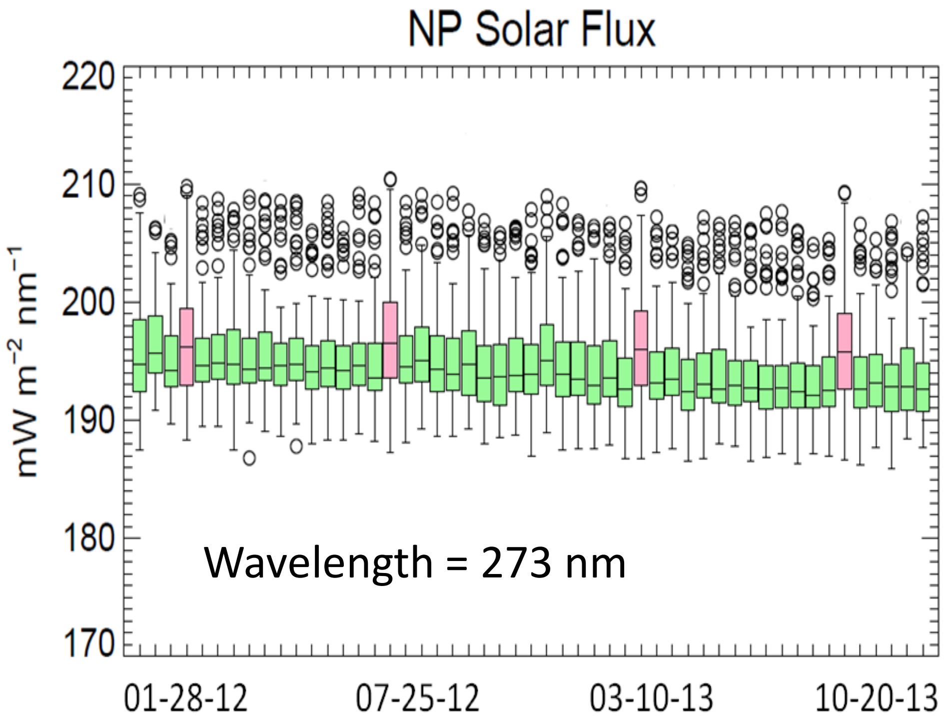


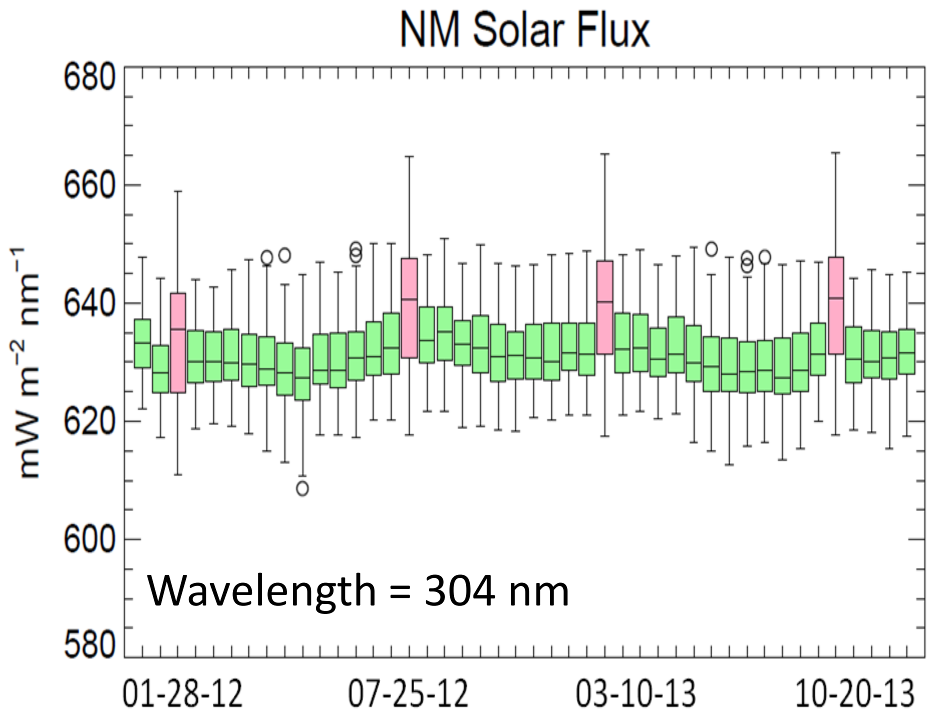
CCD Temp.
(°C)

-29.9624
-30.0100
-30.0338
-30.0576

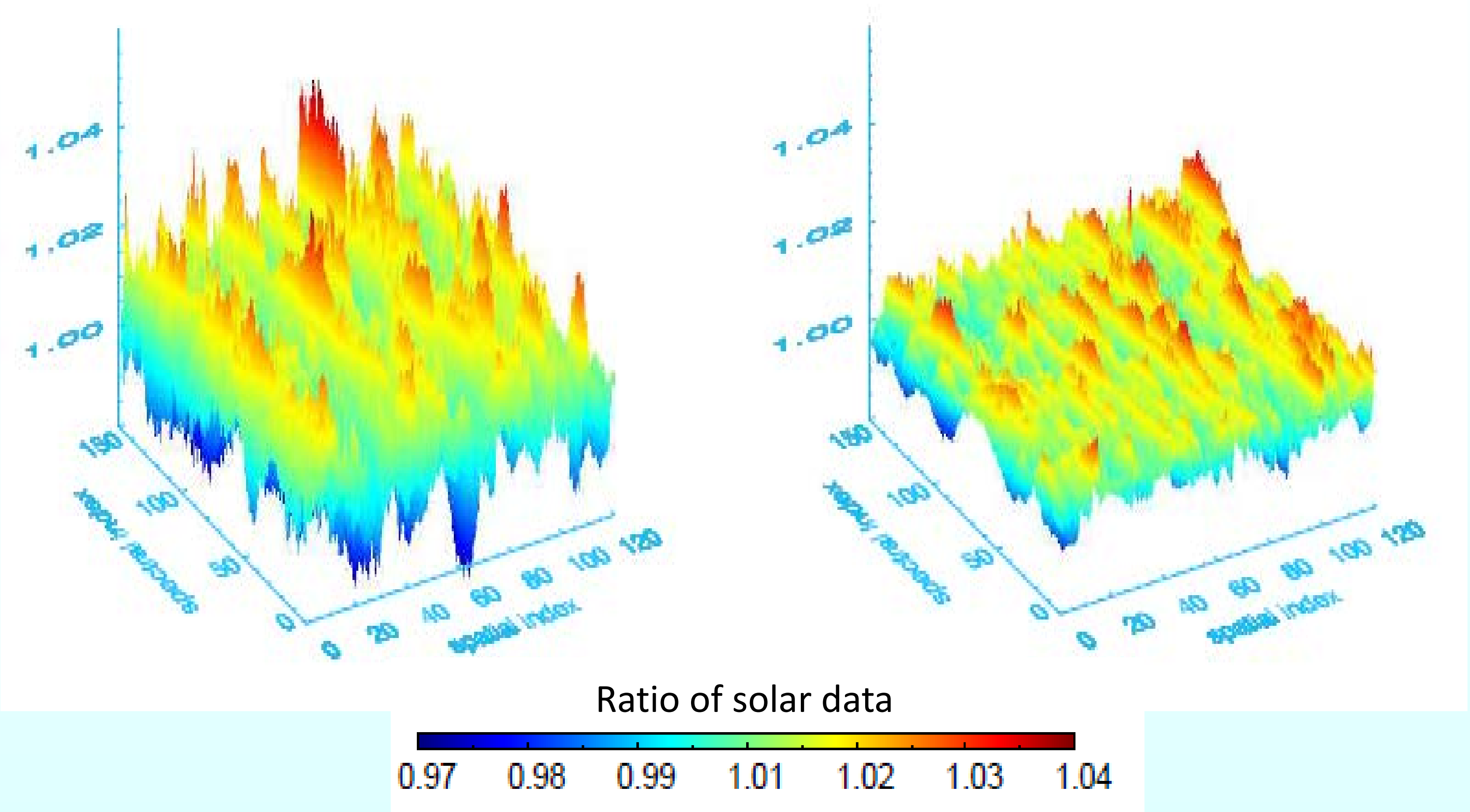
Solar flux trending shows a small change for both sensors

Working
Reference



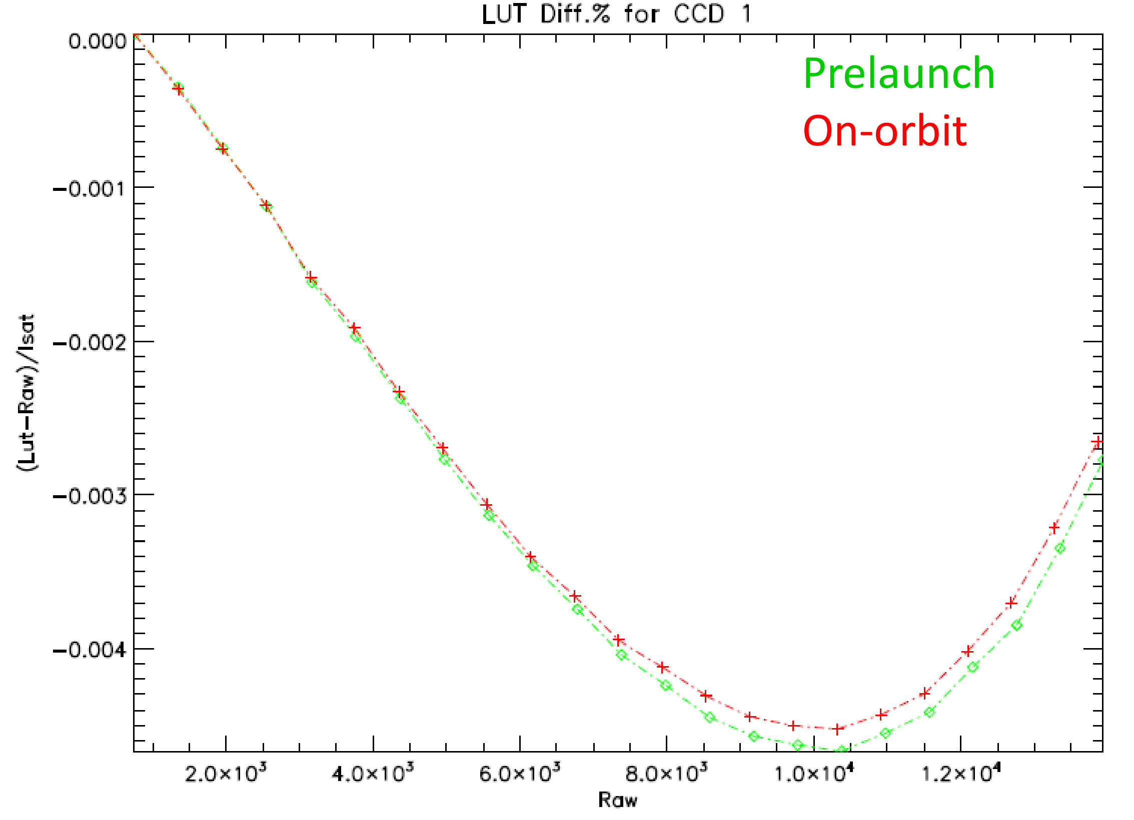


Solar measurement reduces view angle dependence



Data is being used to study diffuser feature

Non-linearity meets requirement

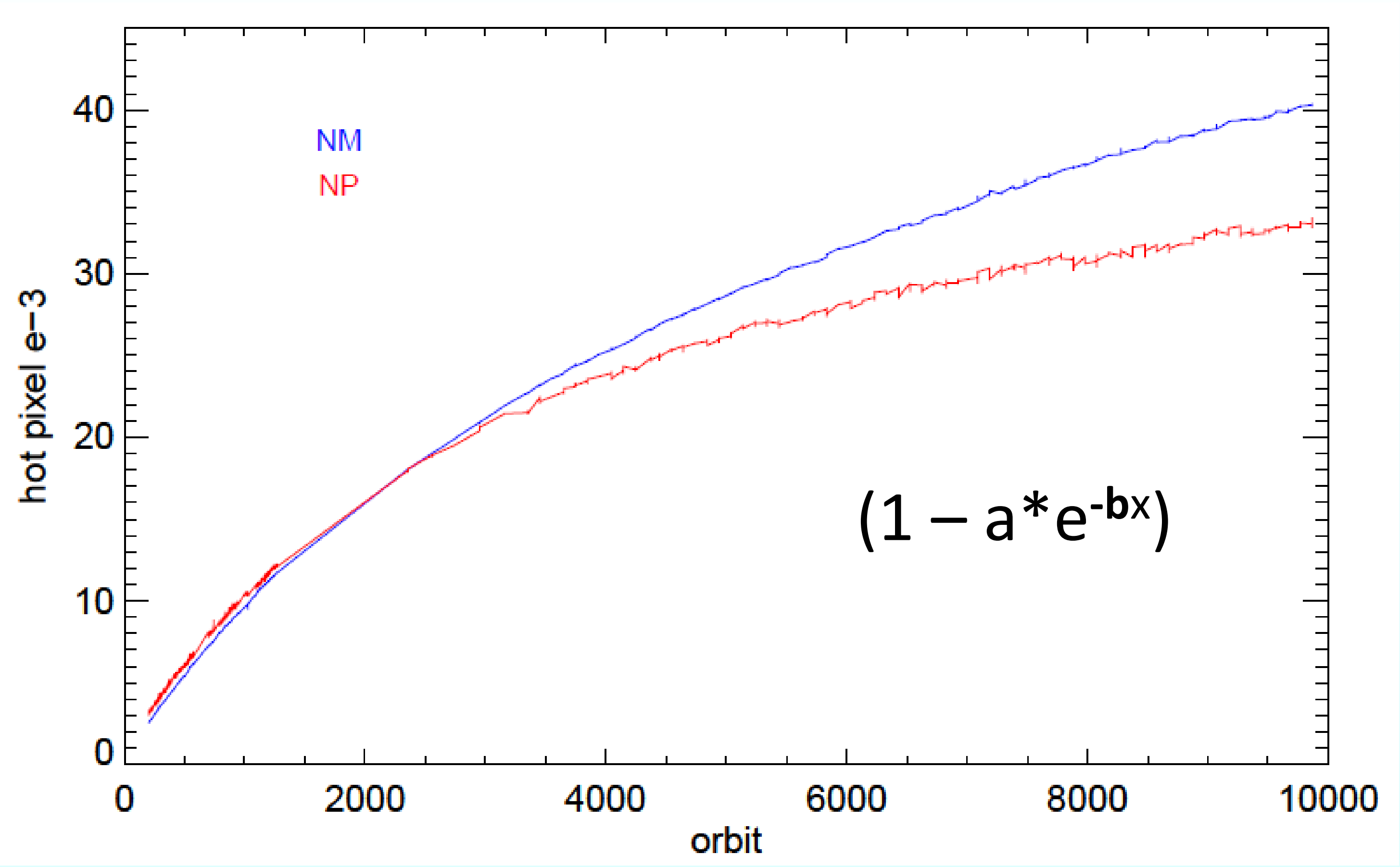


$$\eta = {(Q_m - Q_i)}\Big/{Q_{\max}}$$

where Q_m is the measured response to a LED measurement input, Q_i is the ideal response to the Q_m, and Q_{max} is the full well response.

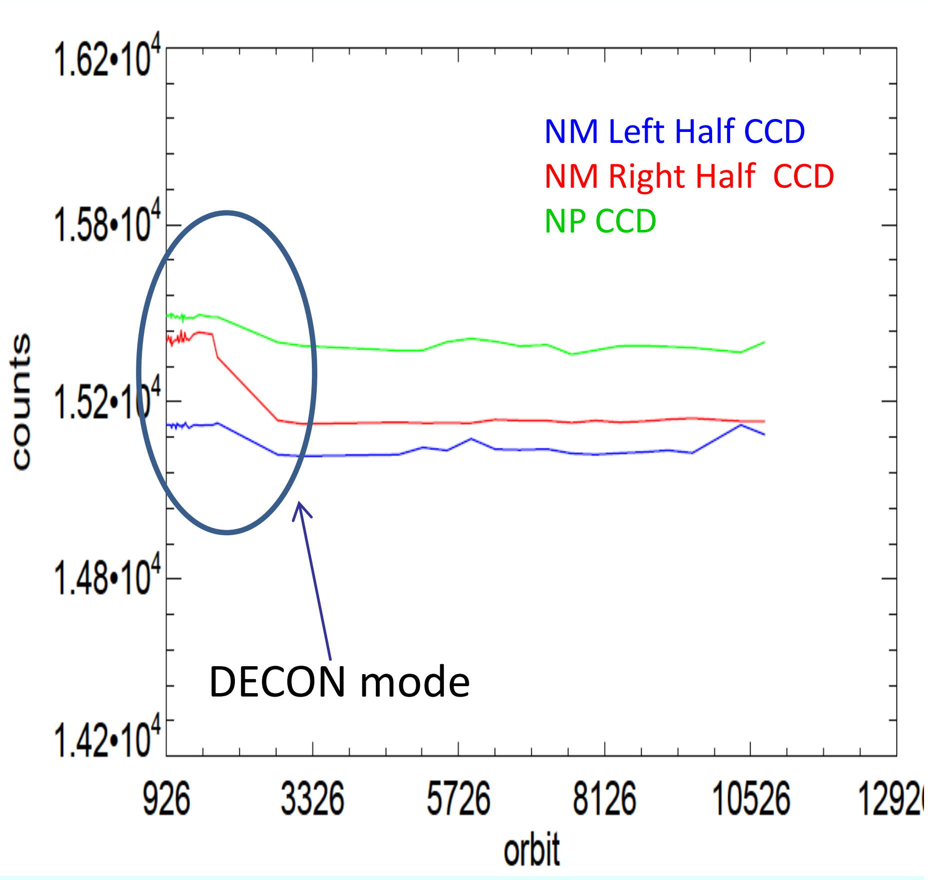
The nonlinearity is about 0.39 for the NM and is 0.32 for the NP; the linear fitting RMS is 0.07% for the NM and is 0.02% for the NP.

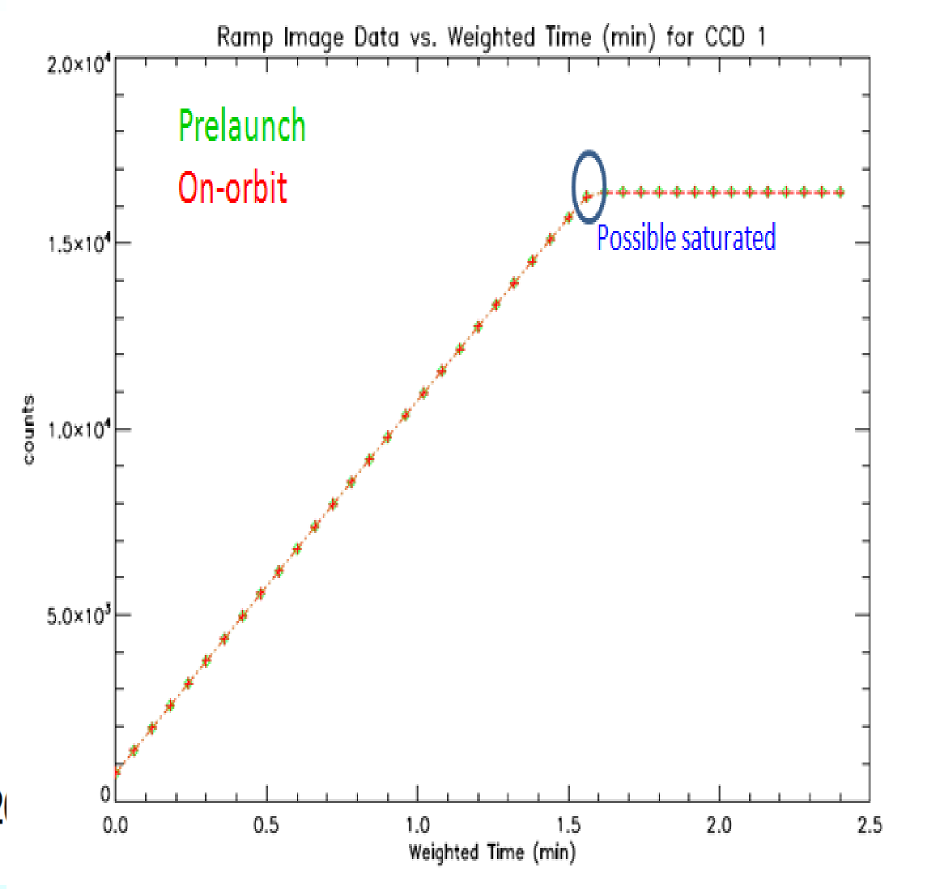
Hot pixels causes dark change



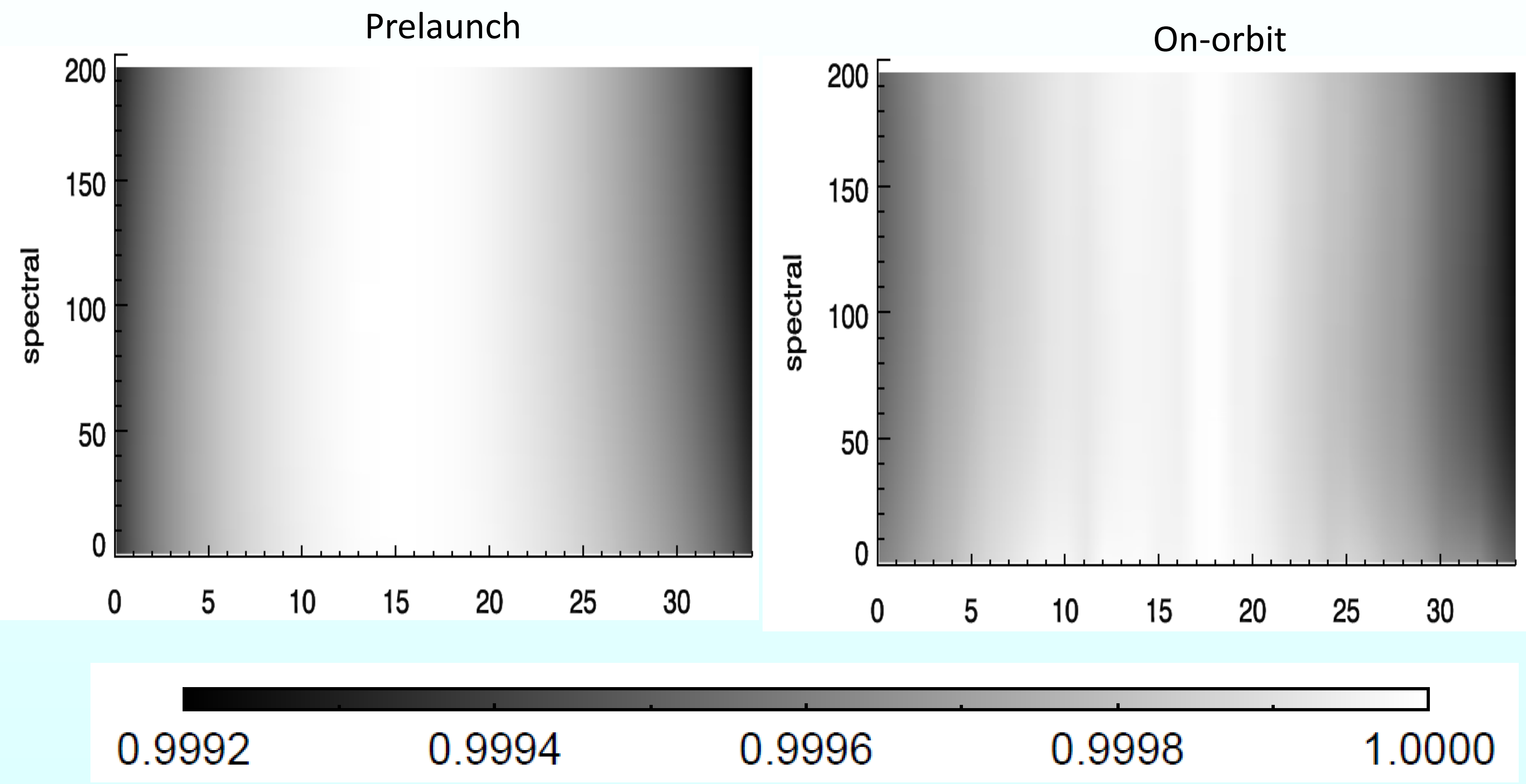
After ~7 year, 99% pixels will become hot.

Detector dynamic range is being monitored

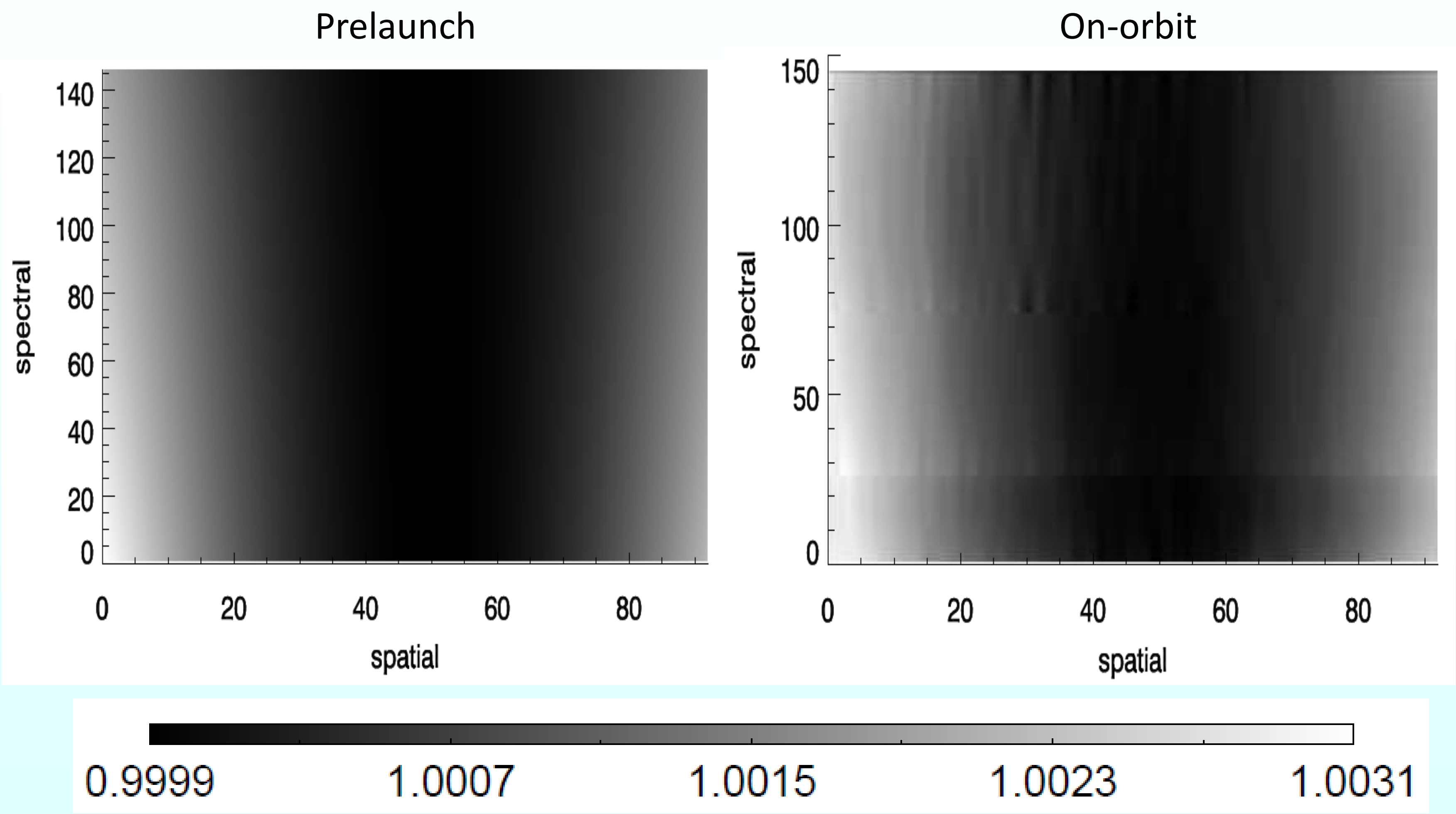




NM “spectral smile” <0.2 nm

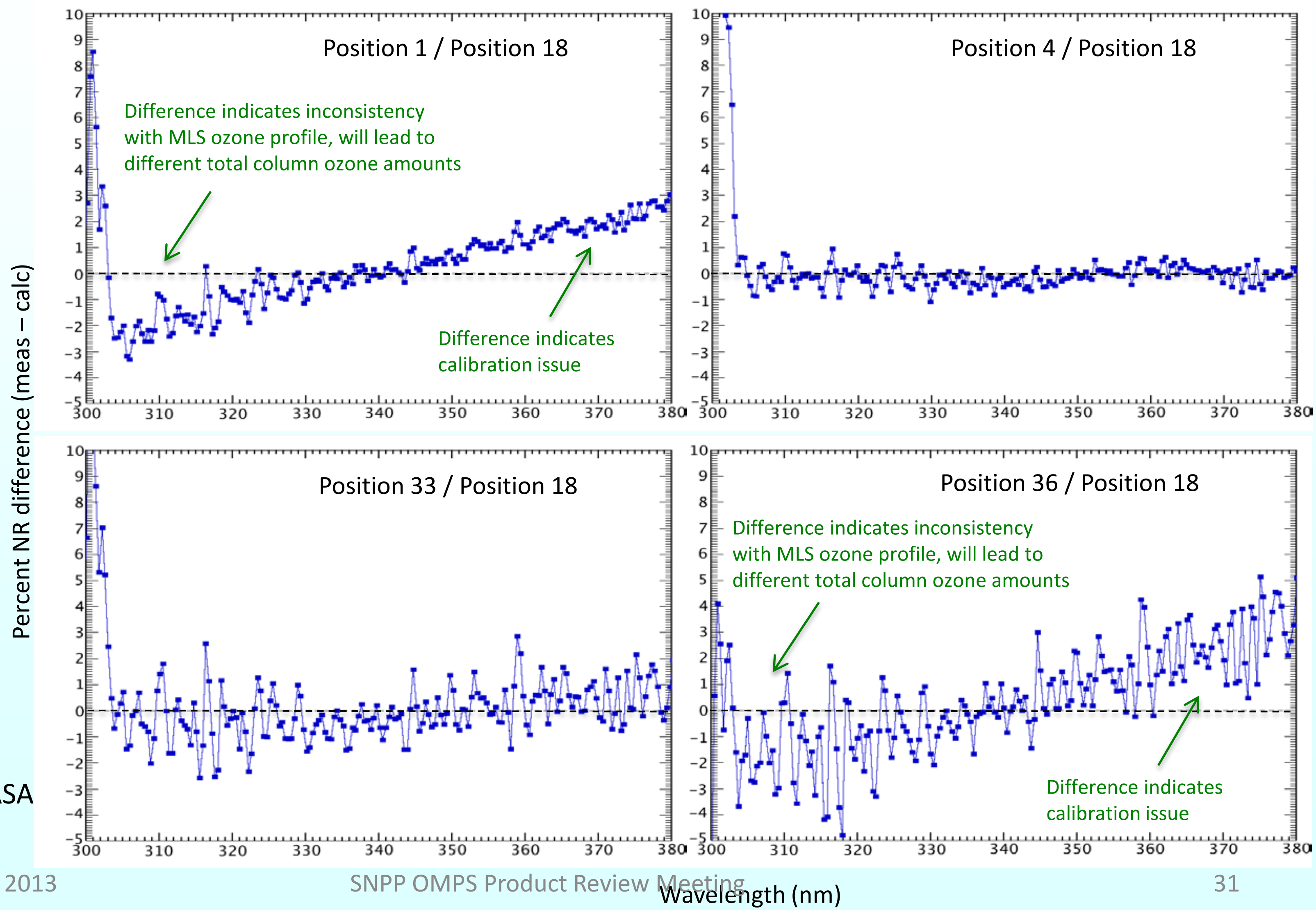


NP “spectral smile” < 0.7 nm



Cross-track position pattern from Earth data

Problems at the far off-nadir positions lead to swath dependent ozone effects



Courtesy of NASA

System Linearity

- System non-linearity
- LED data noise
- LED output drifts
- Dynamic range of detector response
- Calibrated accuracy
- LED lamp warm up behavior
- LED illumination uniformity
- CCD gain

EVLED_Closed – 1 orbit
Every 4th week

NP Lamp Warm up	50 images
NP Linearity	83 images
NP FF Lamp	1 image
NM Lamp Warmup	50 images
NM Linearity	83 images
NM FF Lamp	1 image

Dark Current

- Dark distribution
- Dark generate rates
- Electronic bias
- Hot pixels
- Dark Signal Non-uniformity (DSNU)
- Readout noise

DC – 1 orbit weekly

NM / NP Closed Darks	21 images
NM / NP Storage Darks	9 images