A New Method for Suomi-NPP VIIRS Day Night Band (DNB) On-Orbit Radiometric Calibration

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VIIRS Day Night Band (DNB)

Suomi-NPP VIIRS is a new generation of Earth Observing Satellites (EOS), launched on 10-28-2011

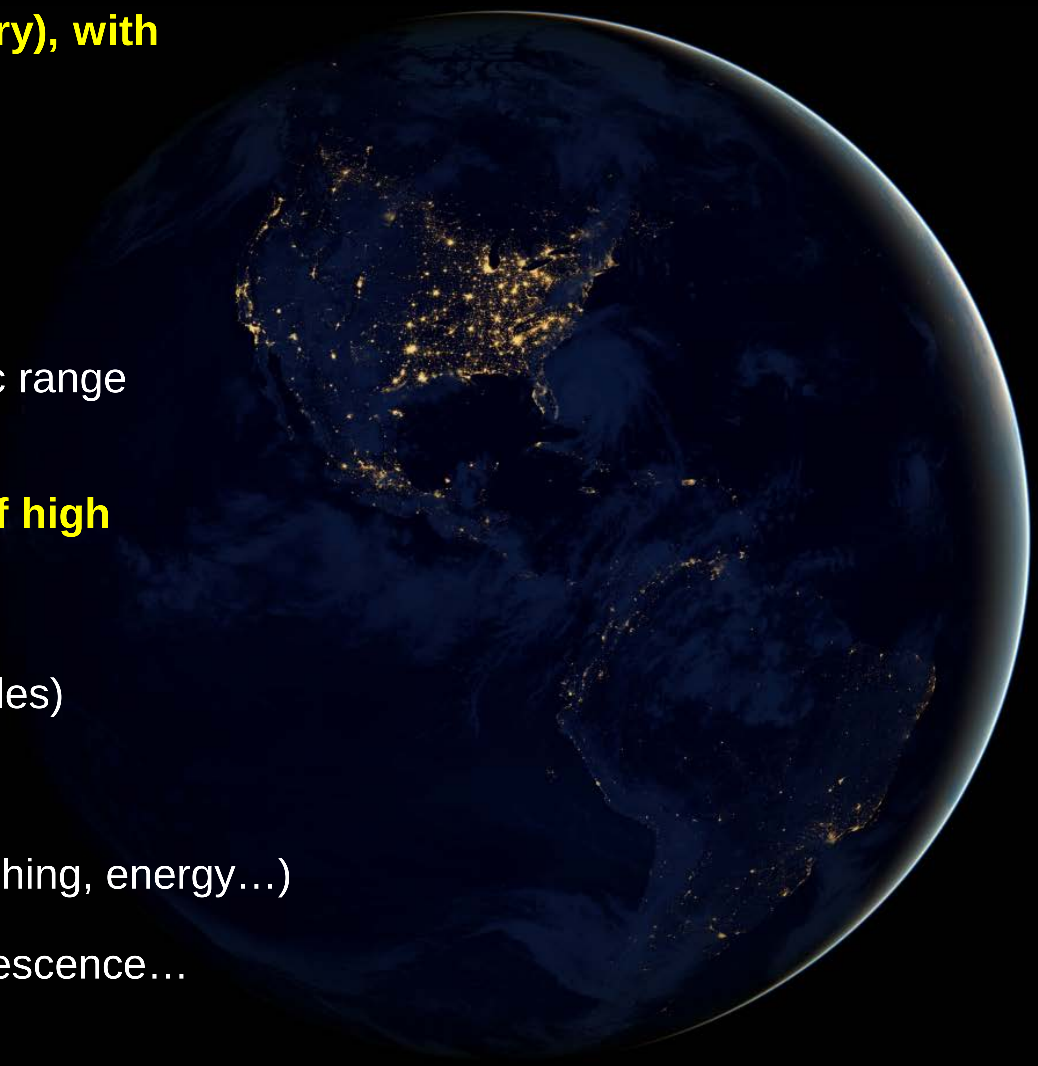
The DNB is a panchromatic solar reflective band capable of radiometric measurements at night

Design heritage from DMSP OLS (imagery), with enhancements on:

- On-board calibration processing
- Much higher spatial/radiometric resolution
- Better Signal to Noise (SNR) and dynamic range

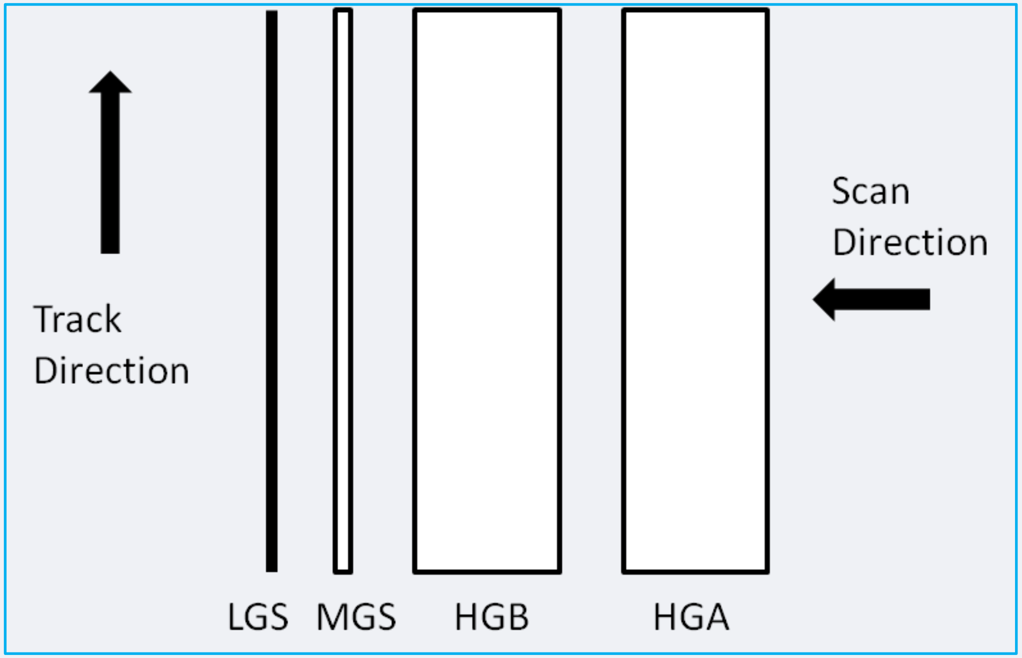
DNB is providing science quality data of high interest to various applications:

- Diurnal observations capability (winter/poles)
- Clouds: Optical depth over urban areas
- Anthropogenic lights: human activities (fishing, energy…)
- Natural lights: wild fires, aurora, bioluminescence…



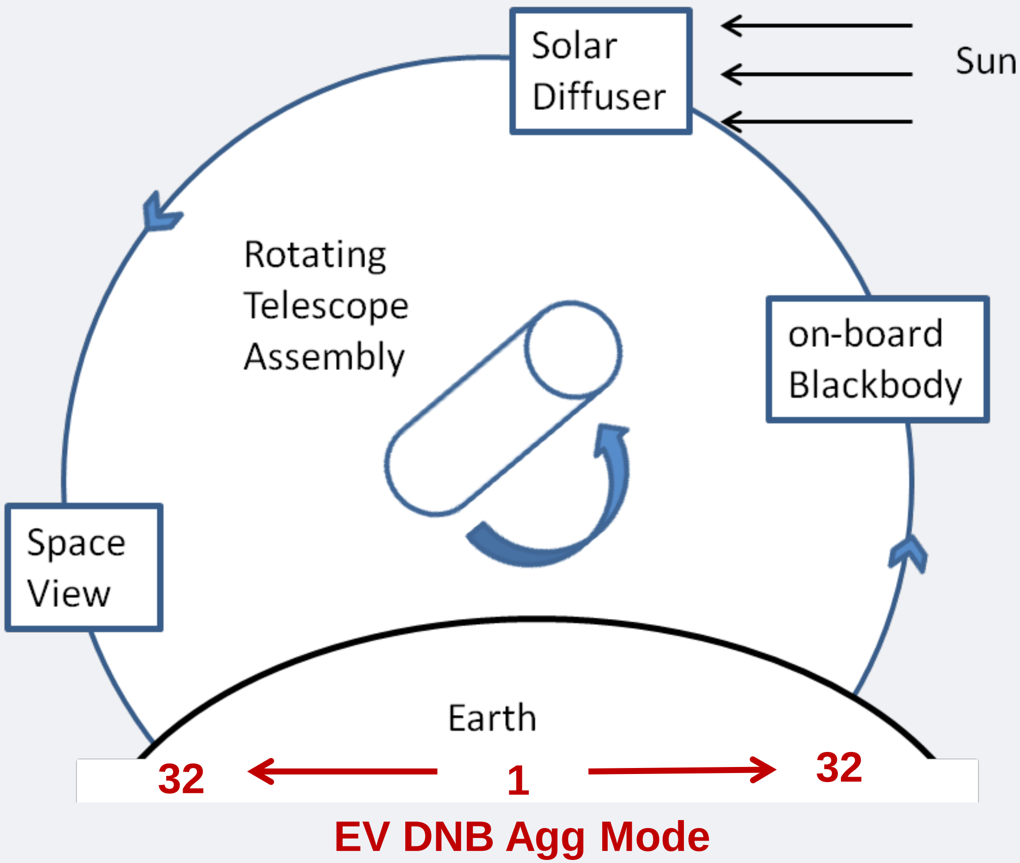
DNB Technical Configuration

- Temperature controlled CCD
- Dynamic Range: 10^{-6} to 10^{2} W m^{-2} sr^{-1}
- Three gain stages LGS, MGS, HGS (HGA/HGB redundant arrays)
- 500 – 900 nm bandpass
- 672 sub-pixel detectors in track
- 250, 3 and 1 sub-pixel detectors in scan direction for HGS, MGS and LGS
- HGS/MGS: TDI
- LGS: ND filter
- HGA and HGB are two identical HGS



- Earth View (EV) observations (±56)
- Near constant spatial resolution ~750 m
- 16 detectors, 32 aggregation modes, varying detector sub-pixel dimension to achieve the constant spatial resolution
- Each detector/agg mode calibrated individually

DNB Calibration



Cal View: All DNB gain stages in one agg mode

72 scan cycle: agg mode 1 to 36, 2 HAM sides

Current approach:

LGS gain: SD

Perform VROP, use EV data to derive offset and gain ratios for all gain stage and agg mode once a month

- Discontinuous
- Lost of science data

New approach:

LGS gain: SD

Compute offset and gain ratios from calibration view data collected from different part of the orbit

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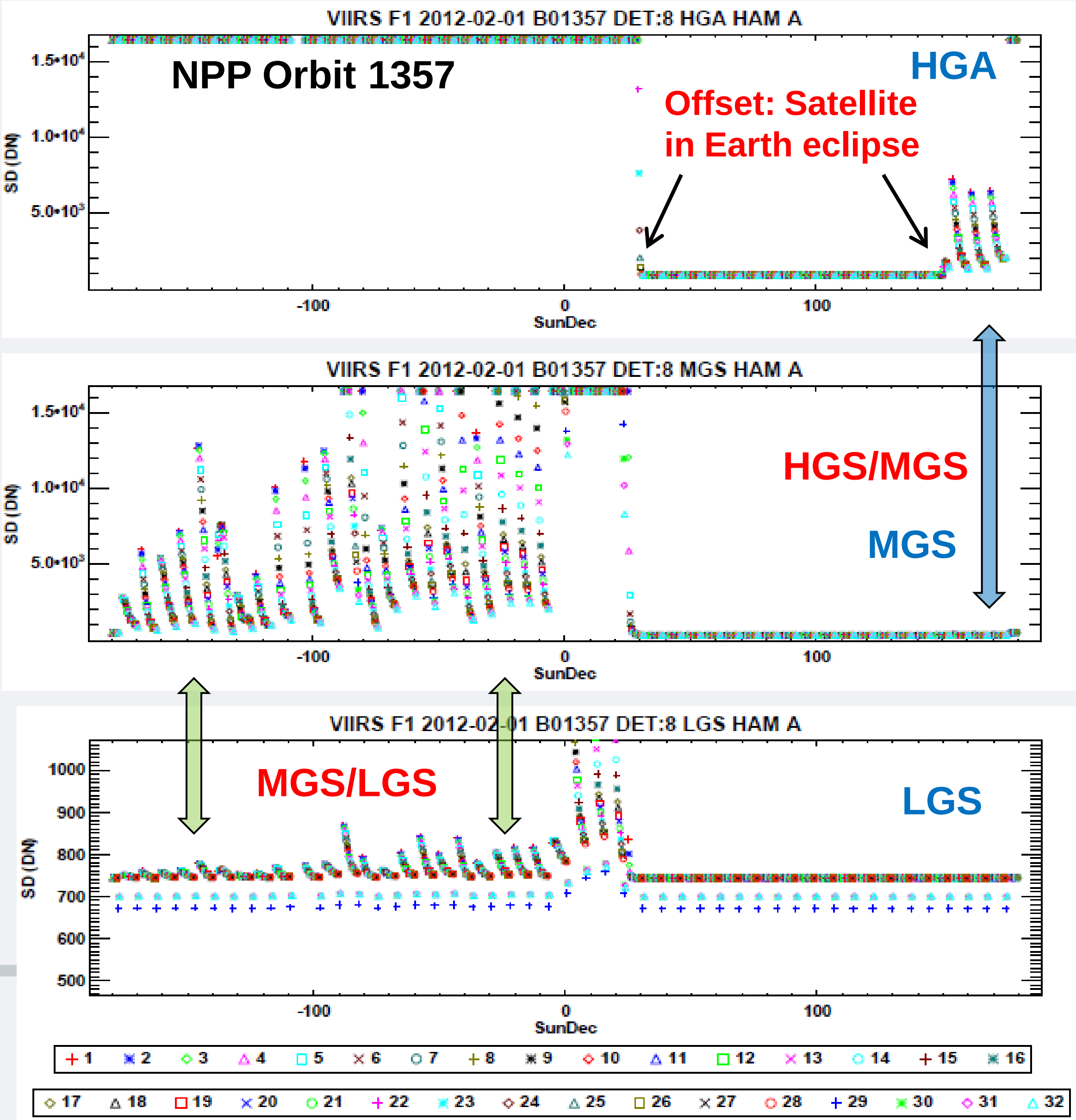
DNB Calibration View Data



Observed signals in Solar Diffuser (SD) within an orbit

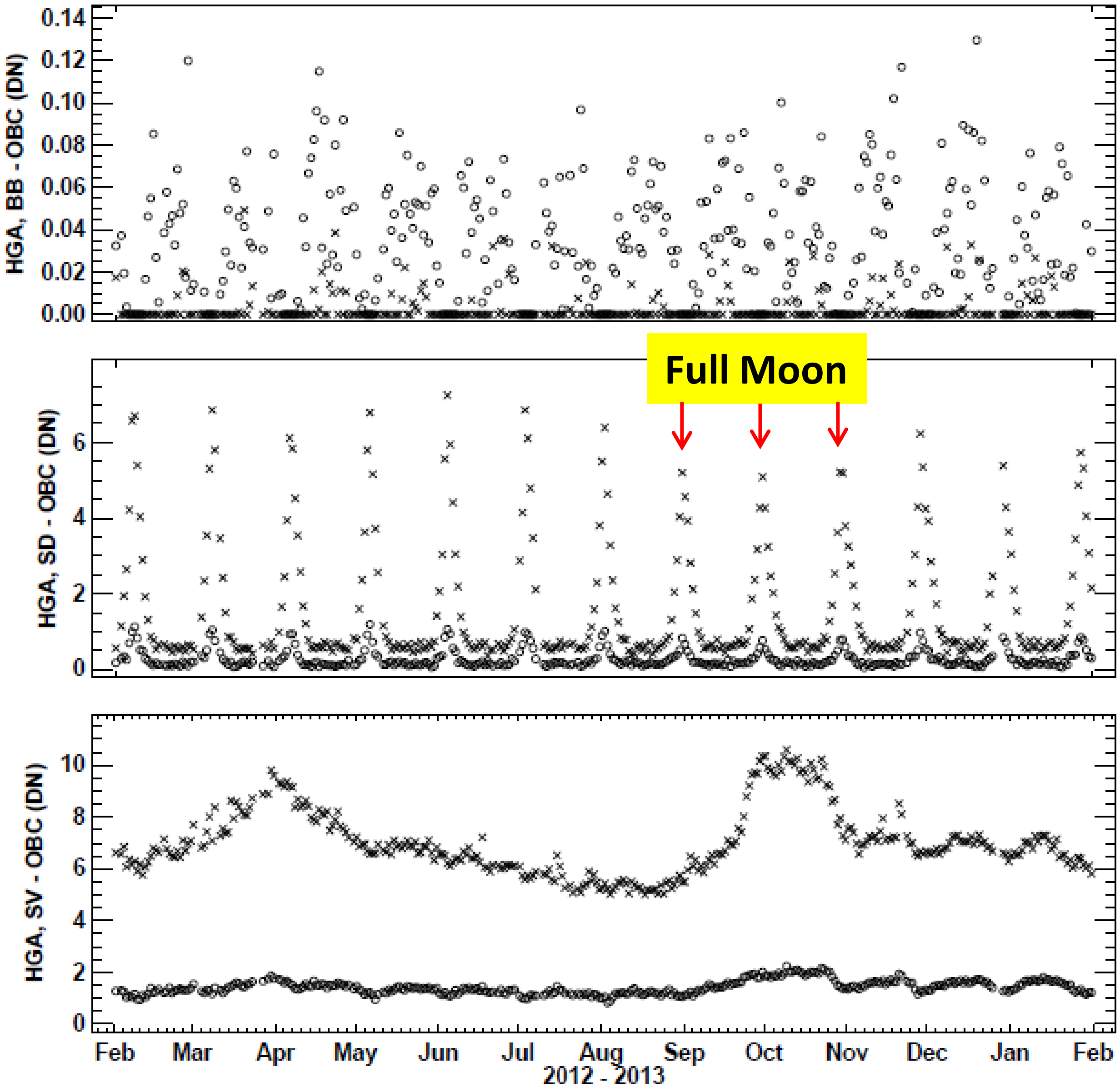
- Agg mode gain/offset variations/cycle

Offset: VIIRS in dark side of the Earth

Gain ratio: use signal within dynamic range of cross-stage calibration

Raw DN, detector 8/ HAM side A

Calibration View Dark Signals



Daily dark signal comparison:

Feb, 2012 – Jan, 2013

- OBC ~ BB < SD < SV

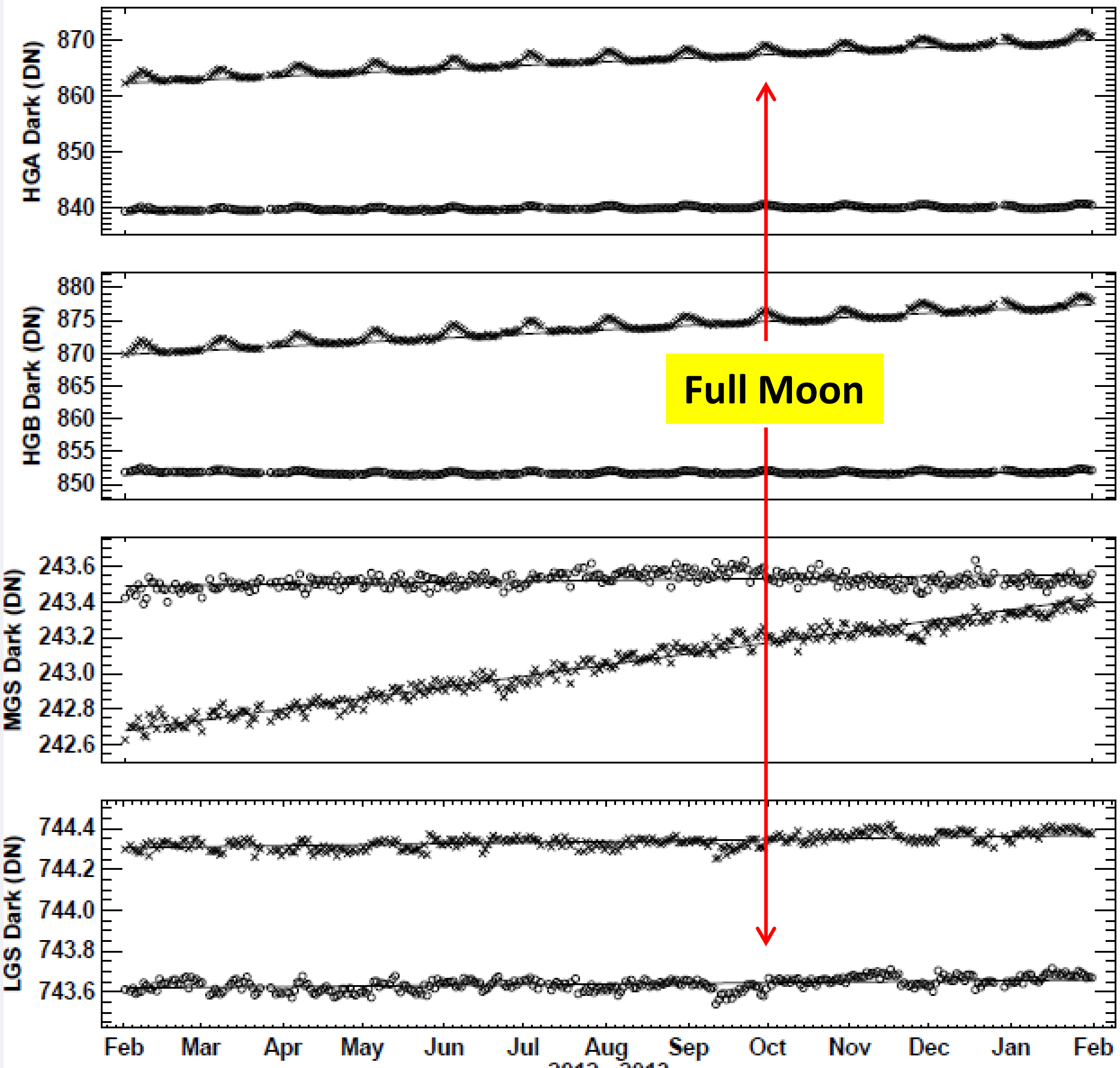
- Select dark scans: solar declination 40 – 140 degrees
- Dark signal: mean of lower 50% of dark scans (~ 8)
- Per gain stage, agg mode, HAM, cal view.
- OBC dark signal = min(all cal views)

Detector 8, HAM side A

X: mode 1

O: mode 22

Calibration View Dark Signals Trend



Daily OBC dark signal:

Feb, 2012 – Jan, 2013

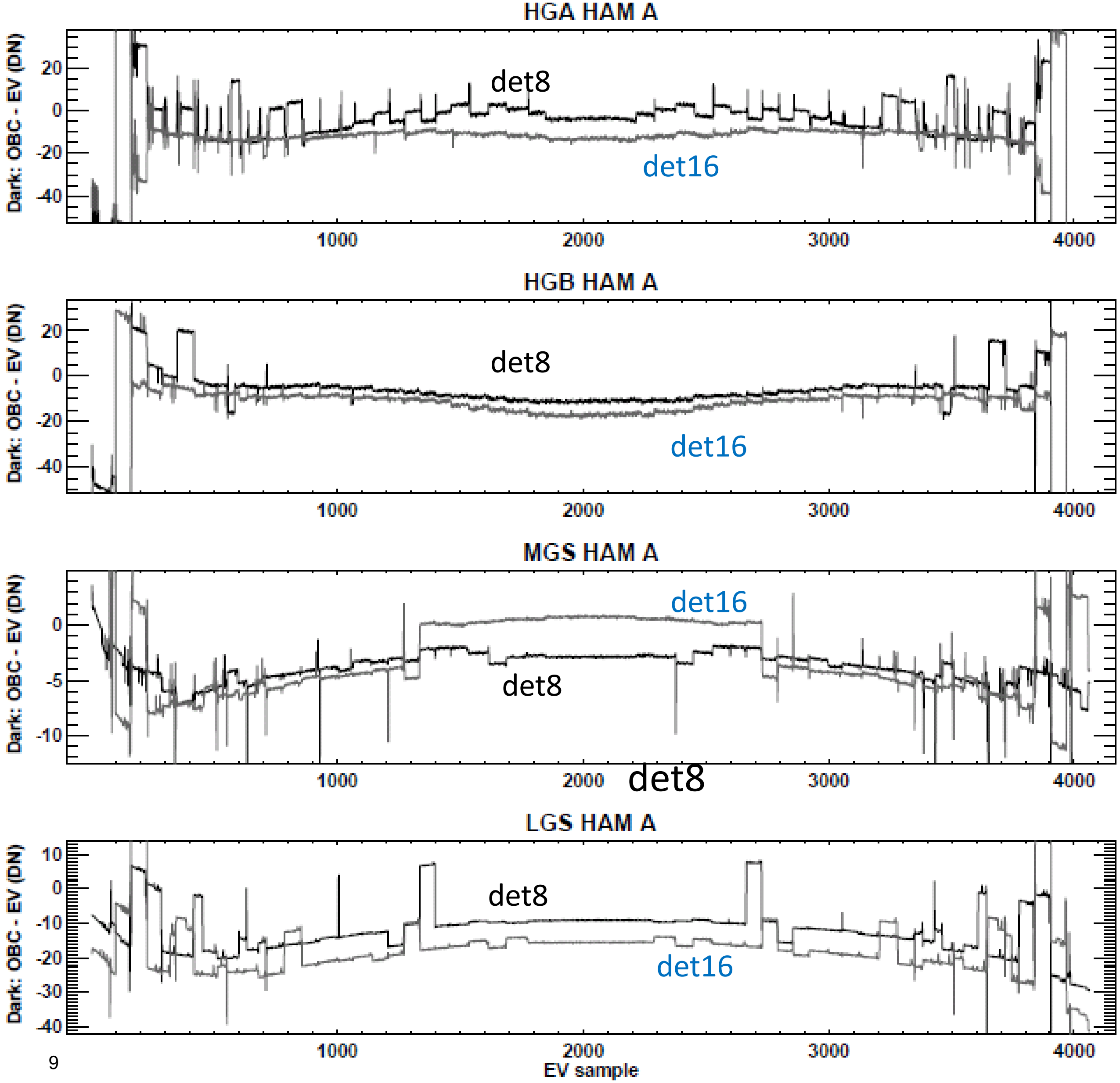
- Very stable dark signal
- Moonshine in HGA and HGB
- Reduce moon straylight: Fit dark signal trend using data collected near new moon (< ¼ moon)
- HGS: <1DN/mon
- MGS/LGS: little to none
- Lower agg modes have higher temporal drift

Detector 8, HAM side A

X: mode 1

O: mode 22

Cal Dark Signal to EV Dark Offset



Cal: mode based

EV: sample based

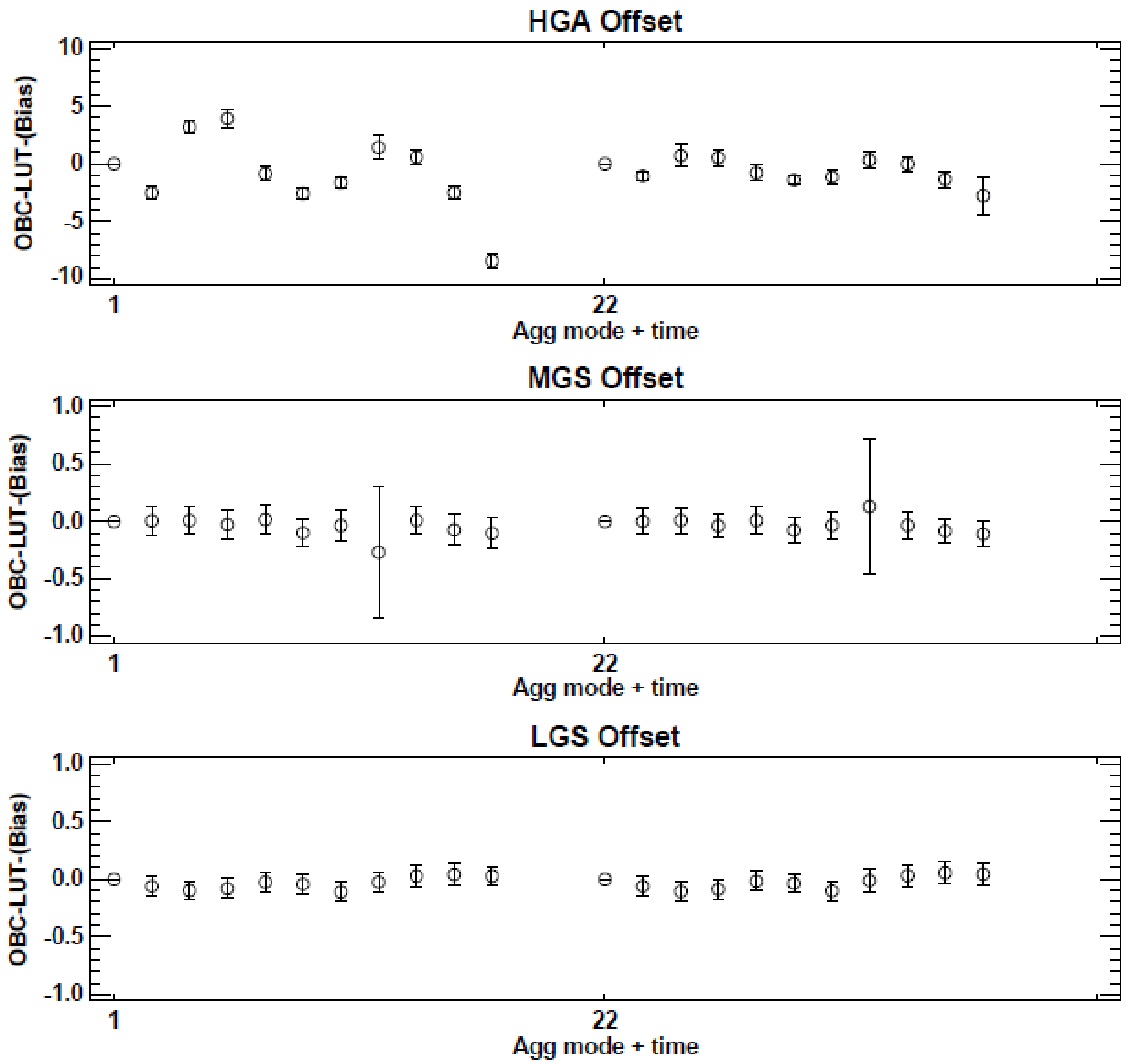
- Difference in internal offsets

EV dark offset (VROP) - Cal view dark signal

Patterns are gain, detector dependent.

Patterns are used to transfer Cal view dark signal into EV dark offset

Cal vs. EV Dark Offset



Comparison of monthly VROP EV dark offset and Cal dark offset

- Normalized to Feb, 2012
- mode average and sample range

HGA fluctuations

- nighttime airglow

MGS, LGS: near constant

Agg mode 1 and 22

Detector 8, HAM side A

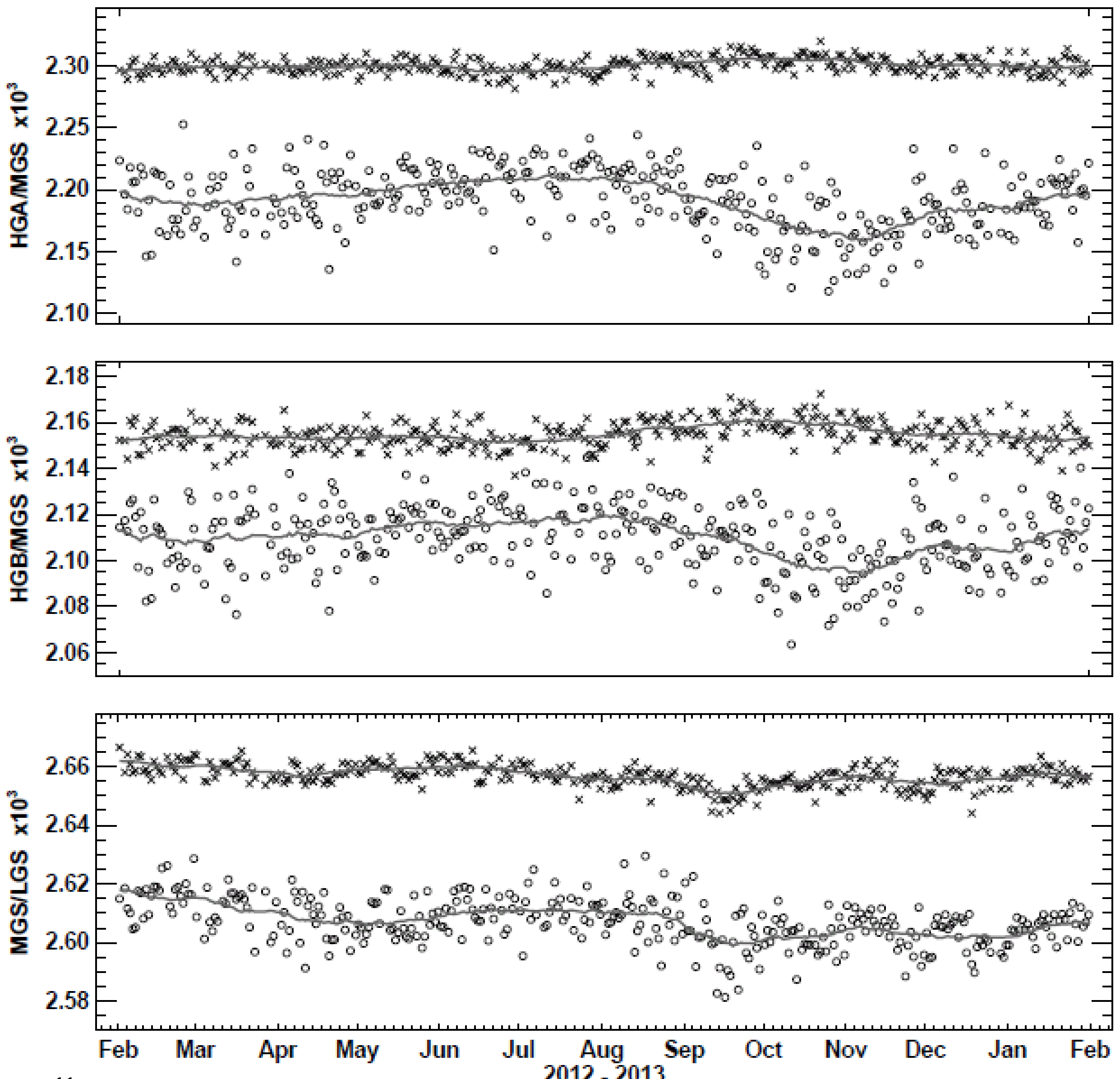
O: mean

Error bar: sample range

OBC: Cal offset

LUT: VROP offset

Calibration View Gain Ratio



- Daily gain ratios:

Feb, 2012 – Jan, 2013.

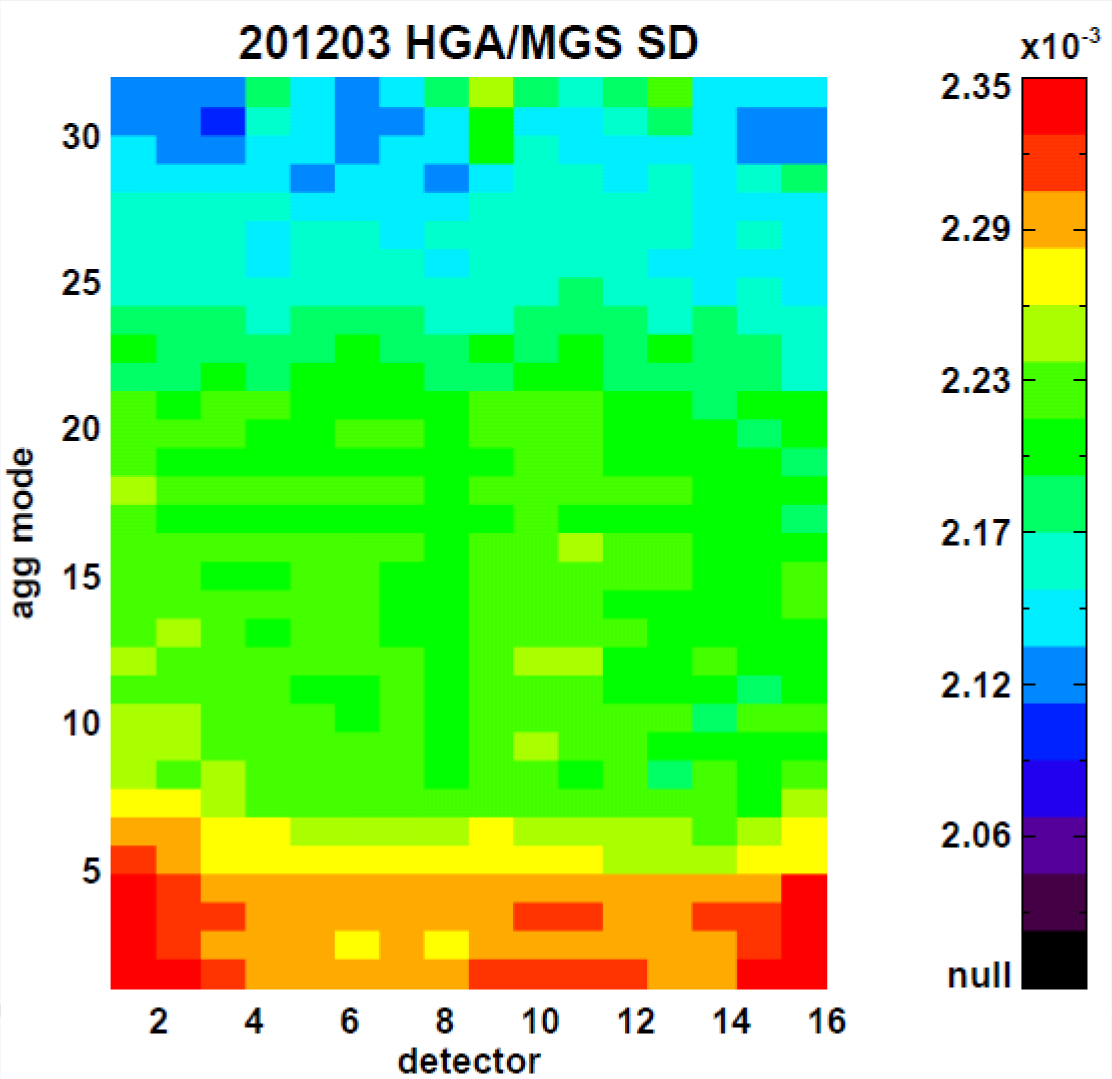
- Compute background (from Cal dark signal) adjusted dn
- Compute gain ratio using dn pairs that are within dynamic ranges of adjacent gain stages
- Higher: 4000 – 14000 dn
- Lower: >10 dn
- Compute running average to reduce noise

Detector 8, HAM side A

X: mode 1

O: mode 22

Calibration View Gain Ratio



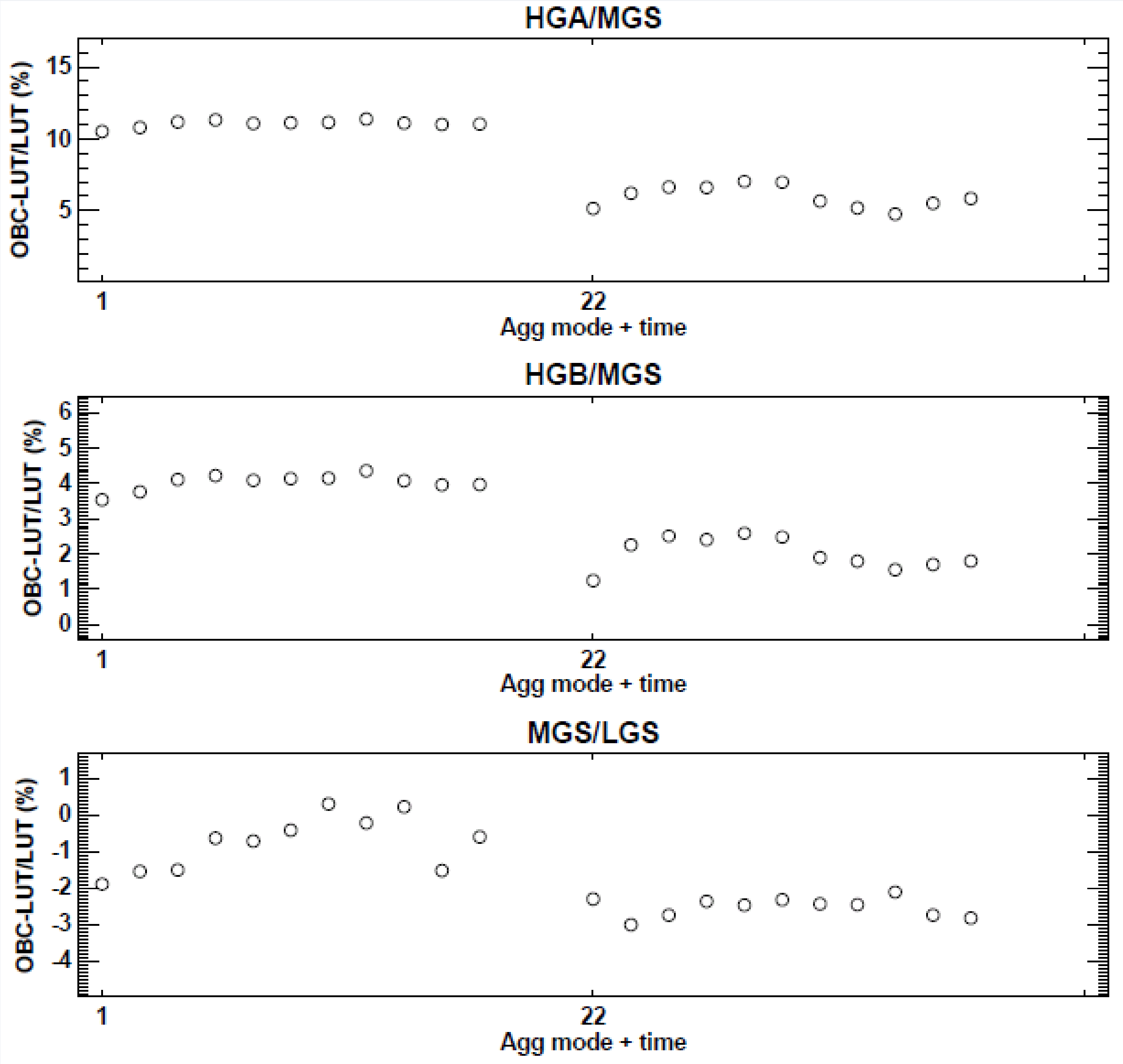
Monthly average DNB gain ratios derived from SD data for March, 2012

HGA/MGS gain ratios

- some detector variation (across mode)
- higher variations in higher agg modes

Calibration view signal levels adequate to determine gain ratios for all DNB cross-stages and agg modes

Cal vs. EV Gain Ratio



Agg mode 1 and 22

Comparison of monthly VROP gain ratios with Cal gain ratios

- HGA/MGS, HGB/MGS gain ratios different, up to 5%
- HGS/MGS higher in Cal view
- MGS/LGS drift in VROP
- EV terminator straylight/near field response

Detector 8, HAM side A

OBC: Cal gain ratio

LUT: VROP gain ratio

Conclusion and Discussion

The new DNB on-orbit calibration method is based on the on-board calibration data:

- Continuous calibration and without special Ops (VROP) – No data loss
- Method was verified, and will be in operation in the next major SDR update

Dark Offset determination:

- Determined by nighttime calibration view data, around new moon
- Provide darker and more stable HGS offset than VROP - No nighttime airglow
- Use the best known EV dark offset for optimal Cal-EV offset mapping
  - HGS (Pitch maneuver), MGS/LGS (VROP)

Gain Ratio determination:

- Determined by calibration view data from daytime and terminators
- Smoothed daily values to provide gain change over time
- More accurate: much lower straylight in calibrators

Thank You