Analysis of GLM Static Calibration Data

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Background: GLM

http://www.goes-r.gov
Credit: Lockheed Martin

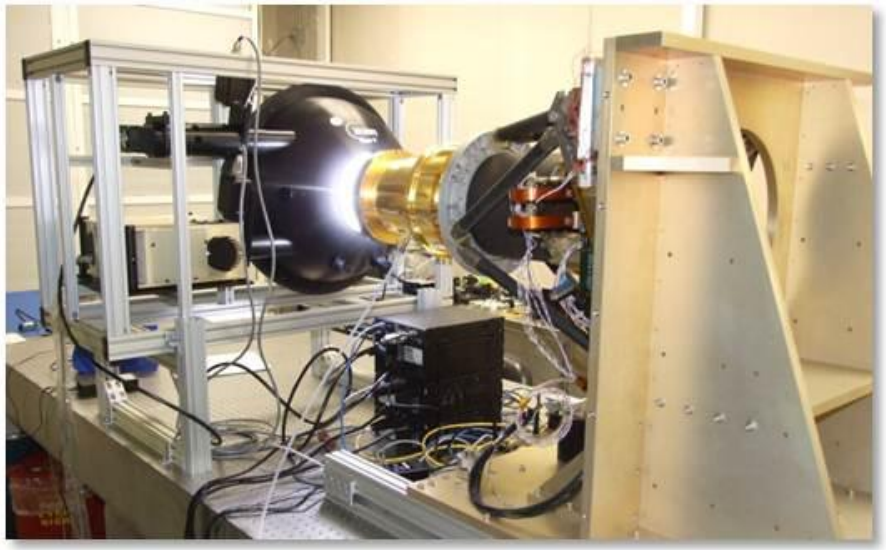
- **Lightning detection instrument built by Lockheed Martin for GOES-R**
  - **CCD-based detection**
  - **Advanced electronics for on-board processing of events**
  - **Ground processing algorithms for lightning detection**

Instrument Parameter	Specification	References
ADC Resolution	14-bit System	
CCD Format	1372 rows x 1300 columns Variable-pitch array	Bredthauer, SPIE, v. 8453, 2012
Frame Rate	500 Hz	
Detection Wavelength	777.4 nm	Center of OI triplet

Calibration Overview and Additional Analysis

- **GLM Static Calibration Methodology**
  - **Large sphere and Laser**
- **Results of GLM testing**
  - **Large sphere and laser**
  - **Lessons learned from supplementary measurements**
- **Additional analysis of GLM vendor data**
- **Further Gain studies**
- **Updated plans for FM2**

GLM Vendor Instrument Calibration Methodology and Setup



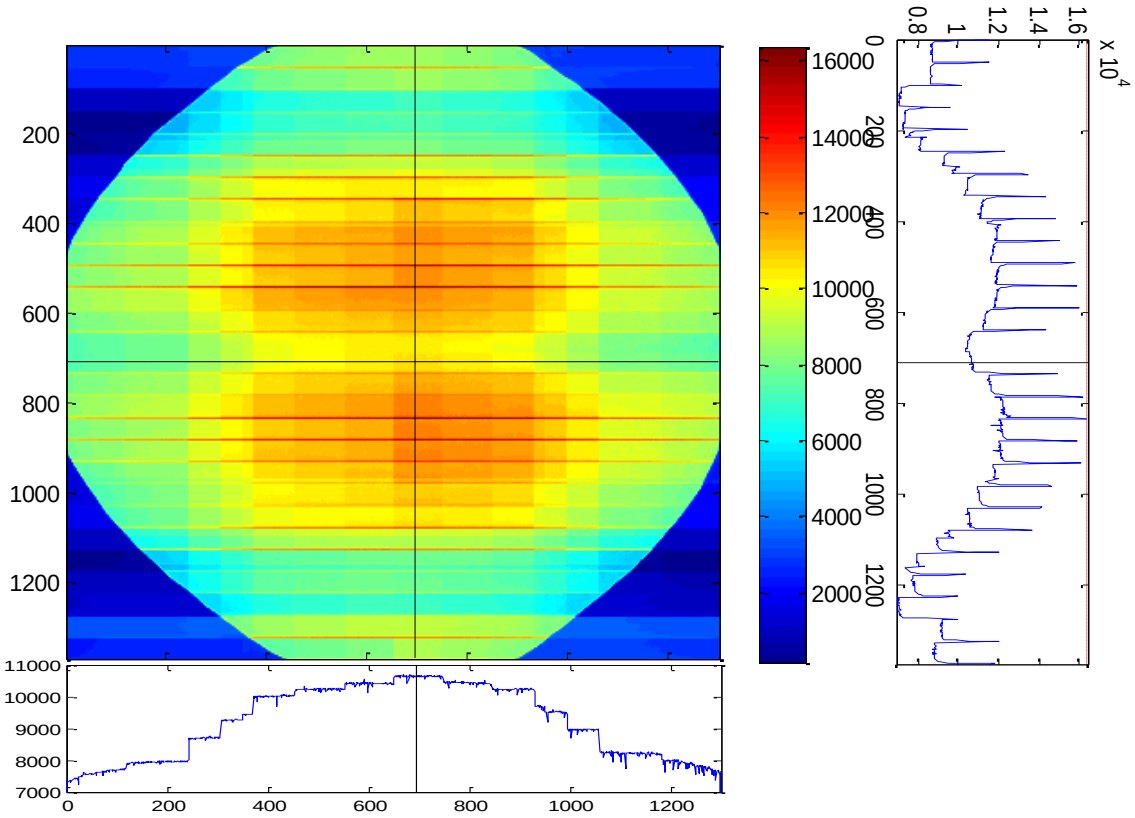
GLM Sensor Unit during calibration testing

http://www.goes-r.gov
Credit: Lockheed Martin

- **Employ large integrating sphere positioned to fill input optics**
  - **Short sphere to optics separation distance**
- **Measure average background images for range of radiances**
- **Calculate slope of count output versus reported radiance input**
  - **Sphere monitoring photodiode reports input radiance to GLM**
- **Replace Sphere by laser light delivery systems for gain test to refine sphere results**
  - **Operate GLM as a power meter**
- **Measure instrument counts versus input laser power in laser footprint**

Results of Large Integrating Sphere Illumination

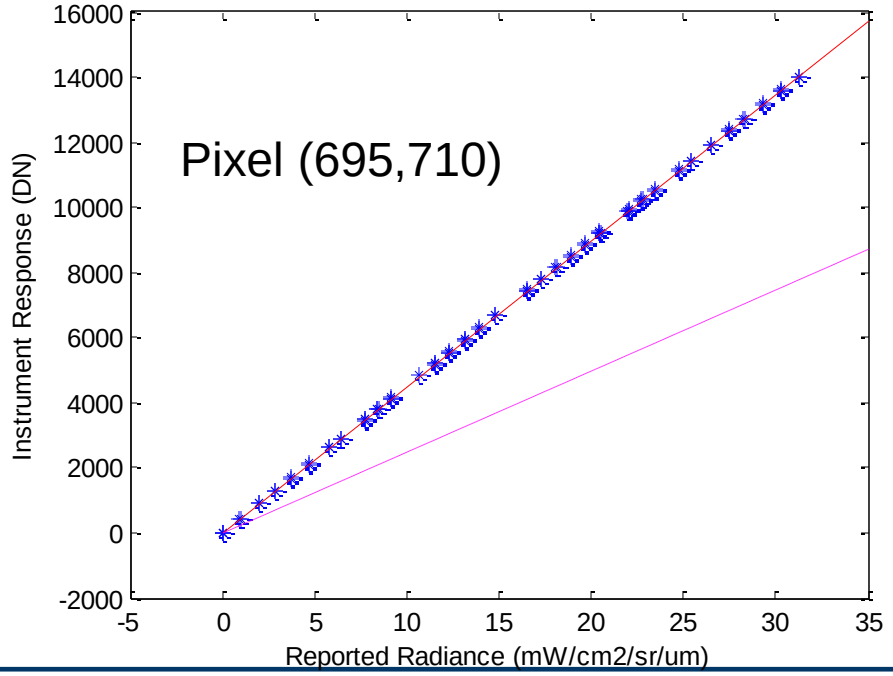
- **Largest pixels have greatest signal levels**
  - **Largest solid angle**
- **Bright horizontal lines observed**
  - **Vertical profile shows overshoot at 2nd pixel of each column in subarray**
  - **Signal amplitudes near ADC limit of 16383 for several rows**

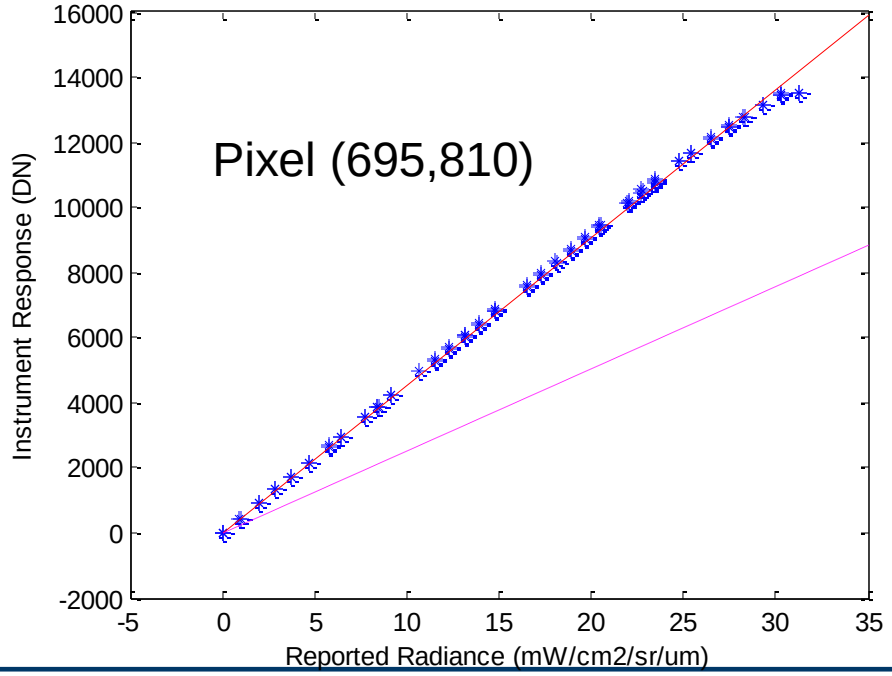


Setting near 20.5 mW/cm2/sr/µm

Analyzed Results: Instrument Response as a function of Reported Input Radiance

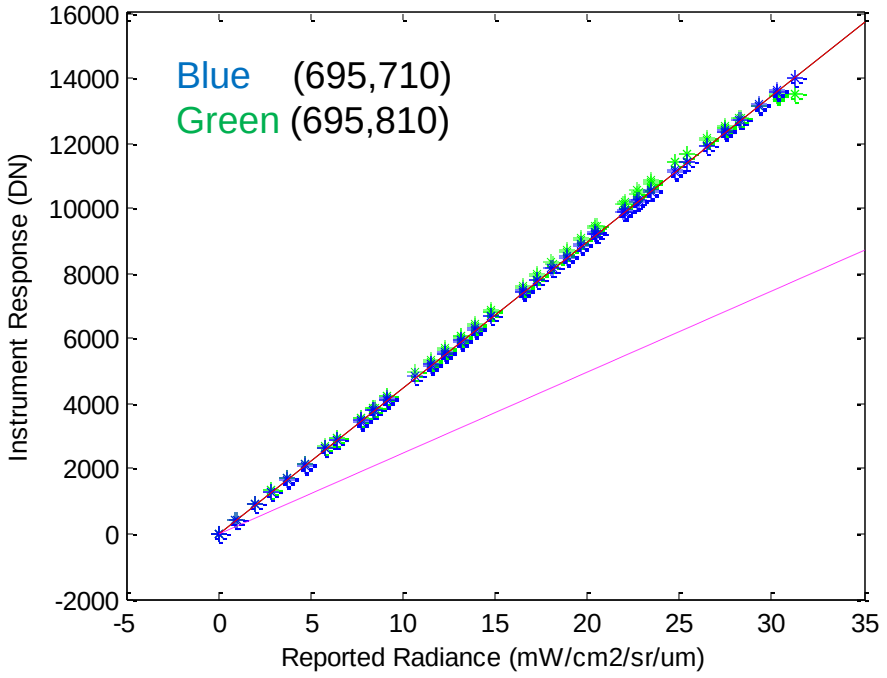
- **Response (in digital numbers) versus illumination level for two pixels**
  - **Left: Linear fit having no major deviations in response**
  - **Right: Linear fit having slight deviations at high illumination**
- **Calibration coefficient near 450 DN/(mW/cm^2/sr/μm) for both pixels**
  - **Coefficients approximately 80% larger than expected**
  - **Dashed line shows expected instrument response**

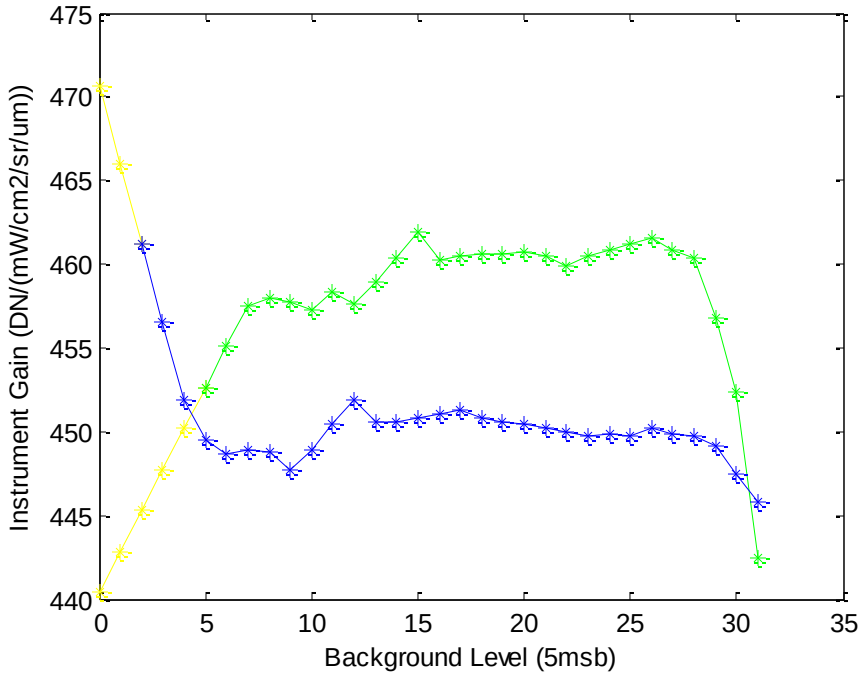




Investigated Data: Instrument Response as a function of Input Radiance

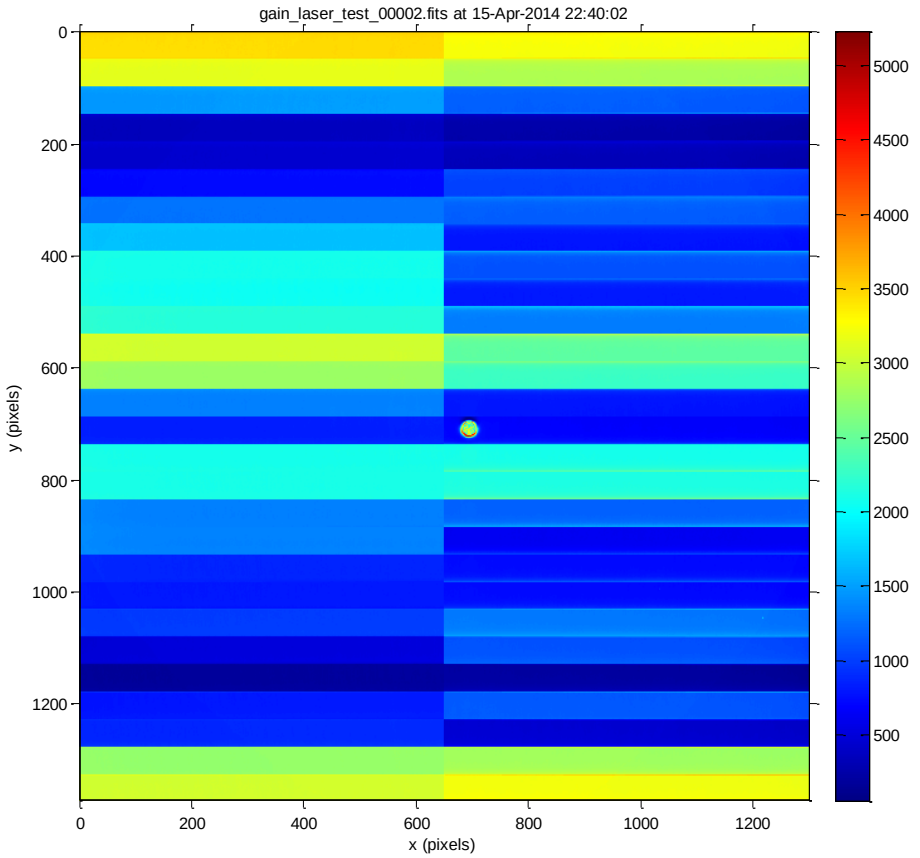
- **Left: Plotted response (in digital numbers) versus illumination level for two pixels**
- **Right: Plotted piecewise gain vs average background level**
  - **Yellow points represent extrapolated values below the DC offset**
  - **Blue and green curves show the same pixels with the green curve has less headroom due to higher DC offset**





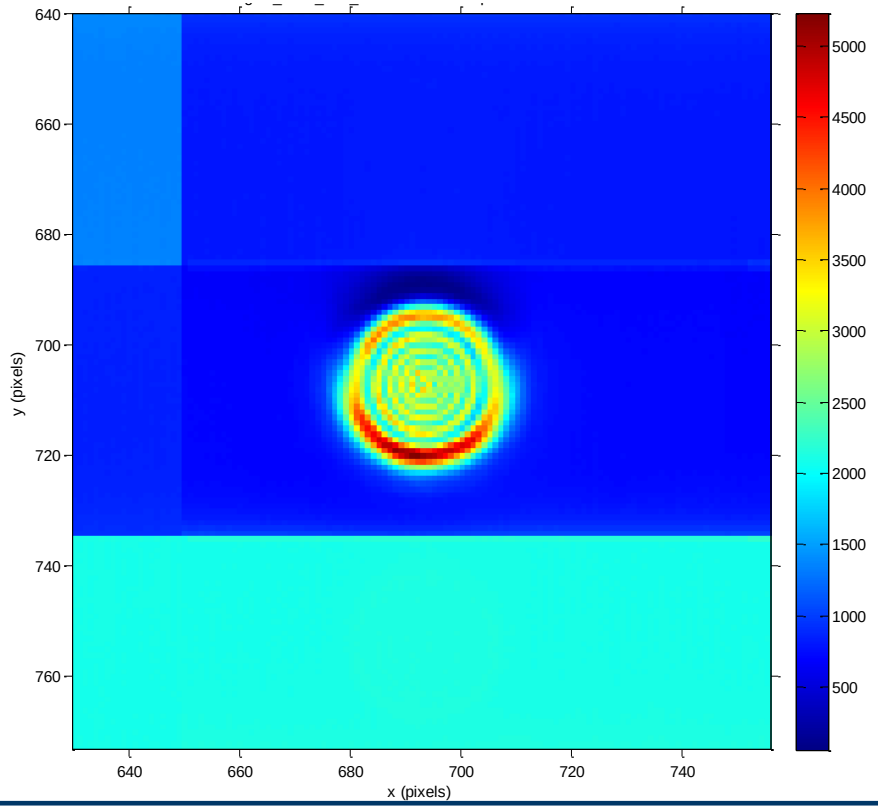
Added Laser Gain Measurement: Verify Instrument Transfer Value (e-/DN)

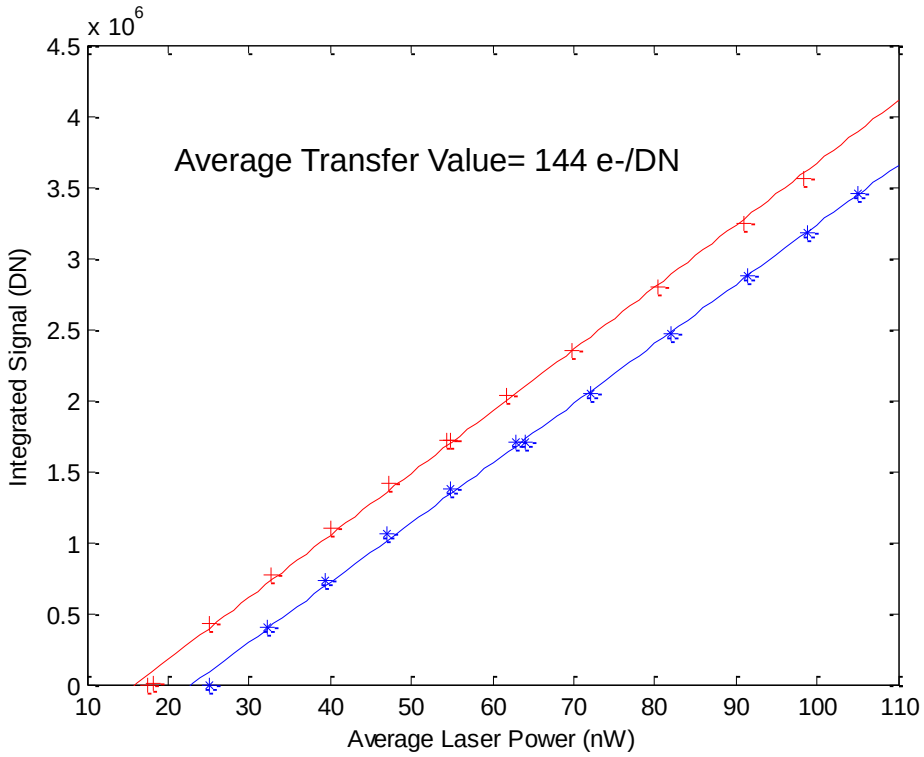
- **Simple analysis based on using GLM as a power meter**
- **Wavelength tuned to maximize transmission through spectral filters**
- **Only illuminates small number of pixels**
- **Must transfer gain to all pixels in CCD**



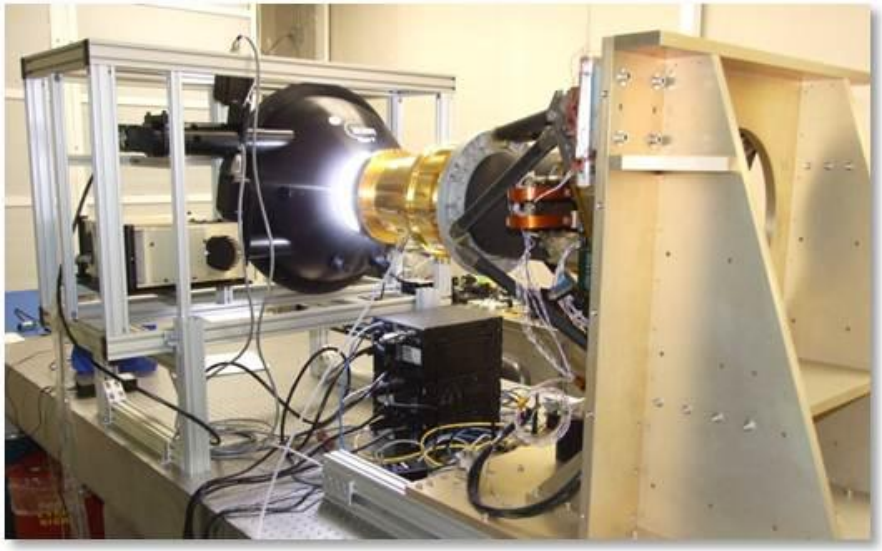
Laser Gain Measurements and Results

- **Summed the response due to the laser light for each light power level**
- **Fitted data using linear equation ($y = a_1x + a_0$)**
- **Average transfer value for two measurement runs = 144 e-/DN**
  - **Sphere gain 1.8x of laser gain value**





Lessons Learned from Supplementary Measurements

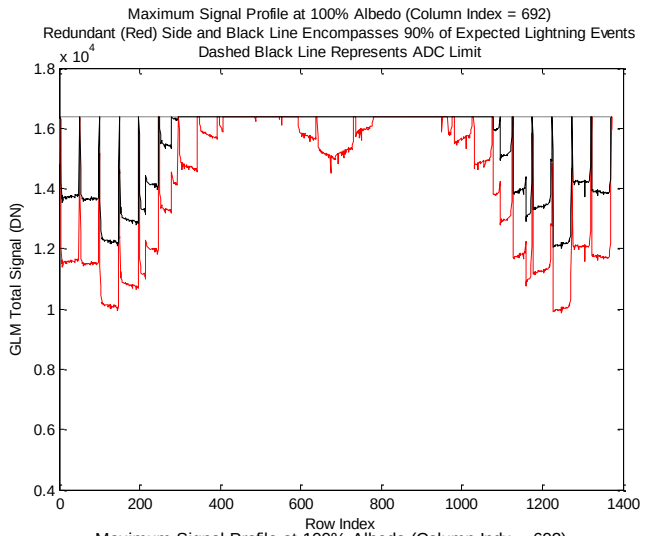


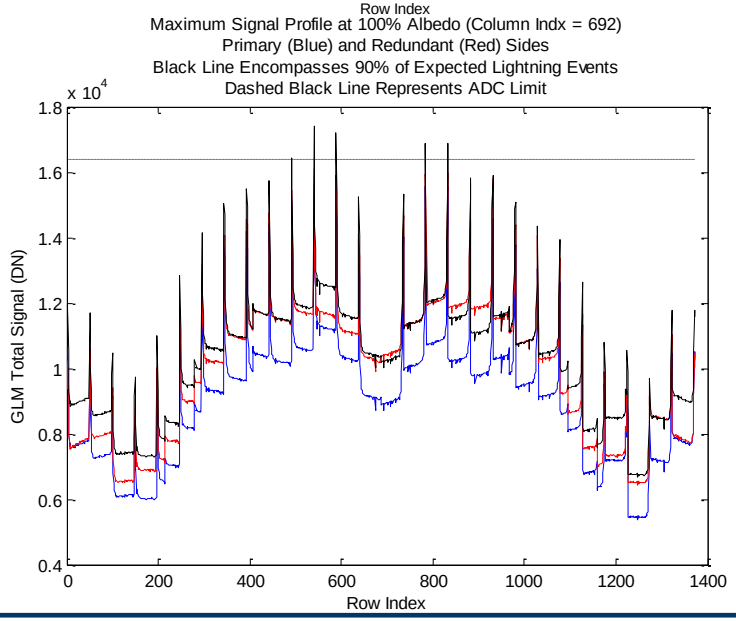
http://www.goes-r.gov
Credit: Lockheed Martin

- **Sphere sensor displayed correct values**
- **Differences between spectral filter on integrating sphere monitoring photodiode and instrument filters**
  - **Additional optical analysis was performed to verify**
- **Retro-reflections accounted for by monitoring photodiode**
- **Acceptance of out-of-band light by instrument**
- **GLM vendor reporting 80% correction due to test setup**

Best (left) and Worst (right) Extremes for Simulated Gain Cases and Impacts

- **Correction by laser gain measurement increases input radiance by 1.8x**
- **Plots on right show unmodified dynamic range calculations with unmodified radiance values**
  - **GLM would saturate in brightest conditions**
  - **Some pixels would be blind under these conditions**
- **Corrected radiances (below) show GLM would not saturate with the radiance of a Lambertian source**





Summary

- **Updated static calibration methodology was executed by GLM vendor, accounting for details of test set up**
  - **Short separation distance between sphere and instrument**
    - **Allowed light to retro-reflect from instrument back into sphere**
    - **Allowed light at high angles of incidence to enter instrument**
  - **Gain discrepancy resolved by lab testing and analysis**
  - **Flight model 1 is well calibrated**

- **Static calibration plan was updated for FM2-4 from lessons learned**
  - **Increase separation distance between sphere and instrument**
  - **Perform laser gain measurements on each subarray of CCD**