Landsat 8 Radiometry Overview

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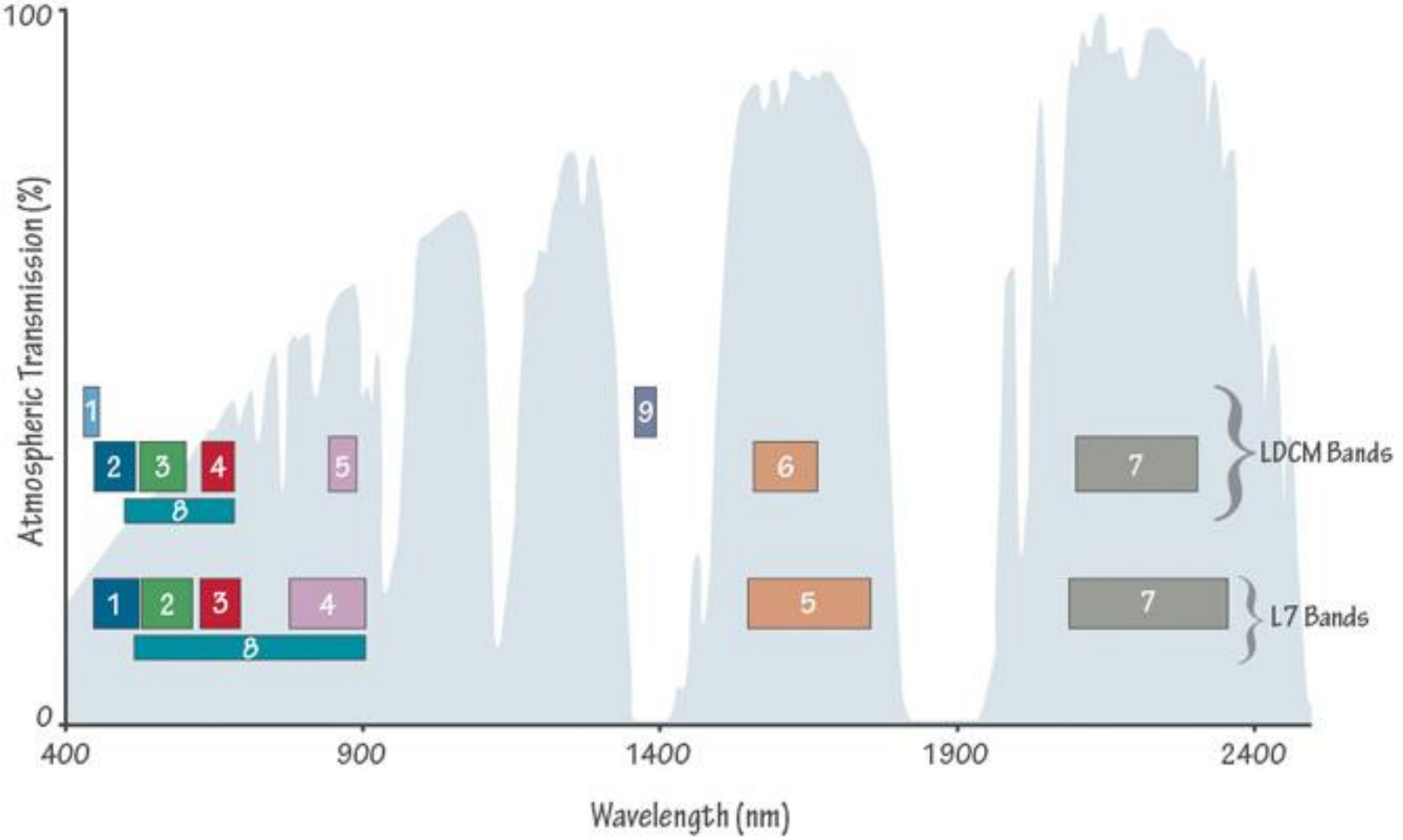
Slides from various sources, i.e., don't formally reference this presentation

Overview

- **Landsat-7 vs Landsat-8 Radiometric Requirements/Performance Comparison**
  - Bands (shortened)
  - SNR/Radiometric Resolution (shortened)
  - Saturation Radiances
  - Absolute Calibration
- **Instrument Architecture**
  - On-board Calibration Devices/function
  - Pushbroom vs. whiskbroom: Radiometric Implications
    - Processing Differences
    - Banding and Striping Differences
- **Data Product Considerations**
  - Scaling
- **Summary**

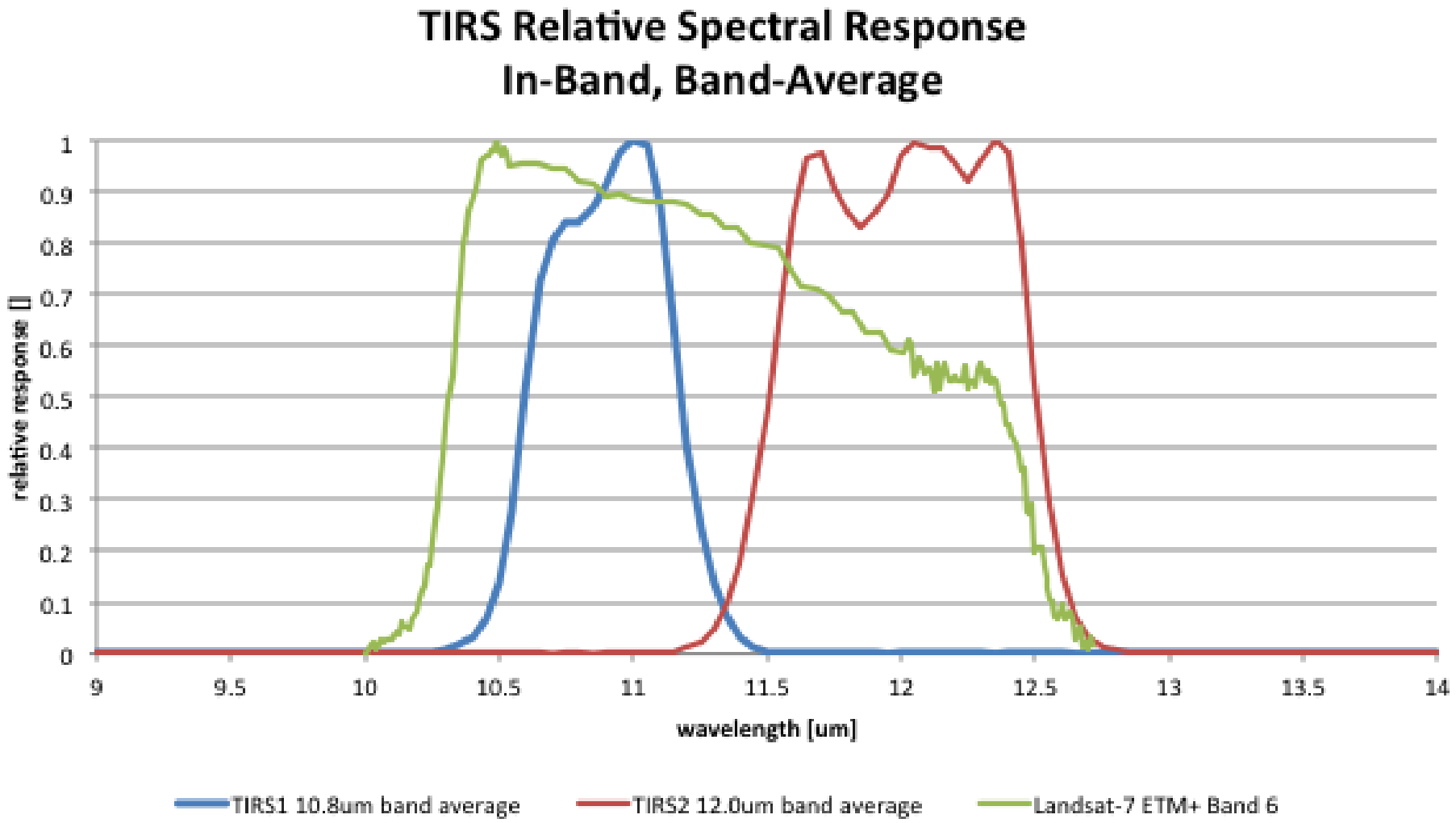
Reflective Spectral Bands



From Laura Rocchio

LDCM Emissive Bands

LDCM

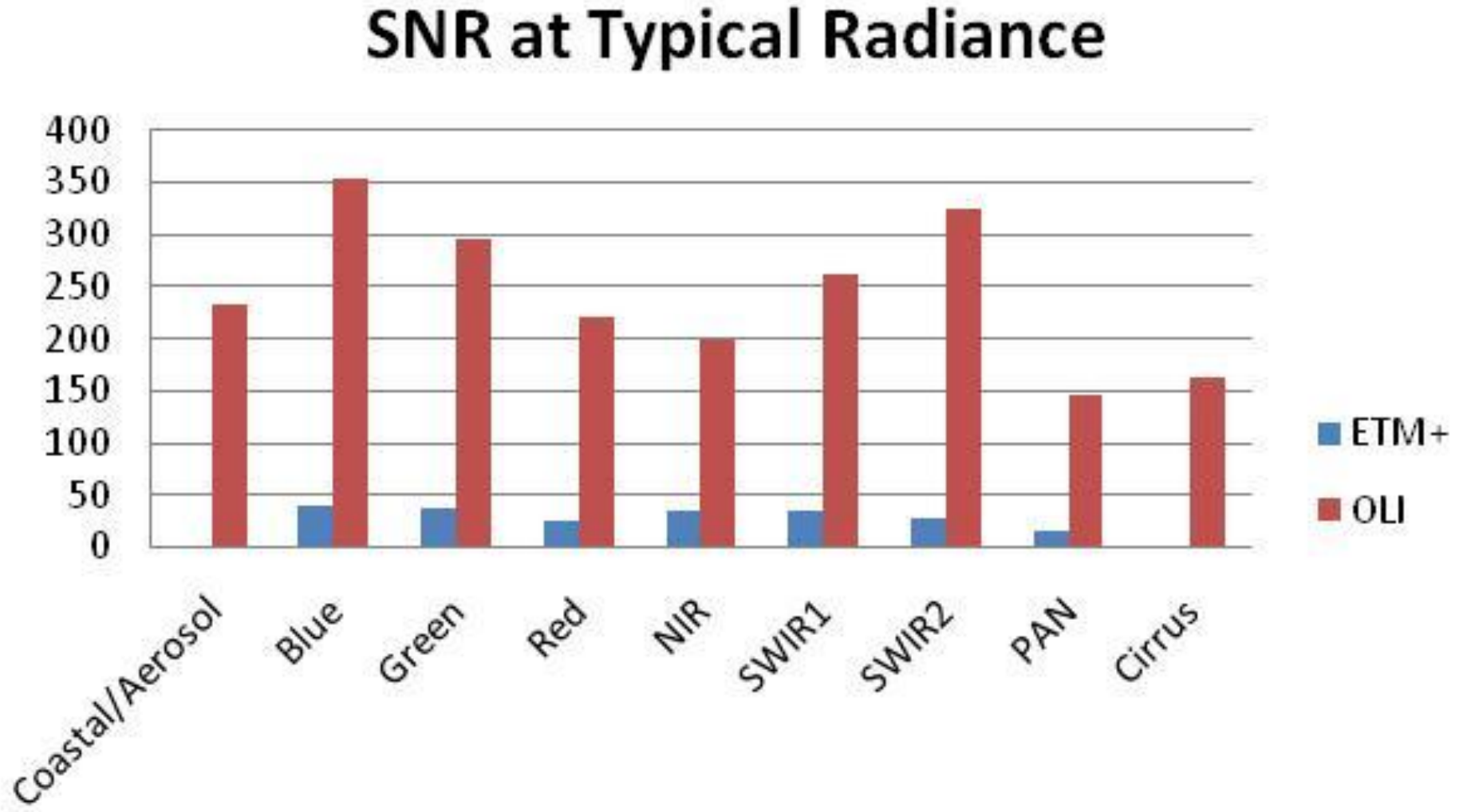


http://ldcm.gsfc.nasa.gov/spacecraft_instruments/tirs_band_average.html

Radiometric Precision

- **Detector-by-Detector Radiometric Precision**
  - Analog system noise
    - Optical Throughput
    - Integration Time
    - Detector Sensitivity
    - Detector/Electronics Noise
  - Data quantization
    - OLI/TIRS 12 bits transmitted; TM/ETM+ 8 bits
      - 4096 levels vs 256 levels for TM/ETM+ (16 x)
    - Background/Offset levels
      - ~275 for OLI; 1000-1500 for TIRS; 3 for TM; 10-15 for ETM+
  - Radiance Scaling Range/Saturation Radiances
    - Range/quantization levels = radiometric step size ➔quantization noise
    - OLI ~ 2x ETM+ Saturation Radiance (uses 1 bit)
    - TIRS ~365 K saturation versus ETM+ ~345 K (uses < 1 bit)
  - Total noise/precision (function of signal level)
    - NEΔL/NEΔT (1 sigma noise expressed in radiance/temperature)
    - SNR

OLI SNR performance versus ETM+



From Ed Knight slides

TIRS Noise Performance

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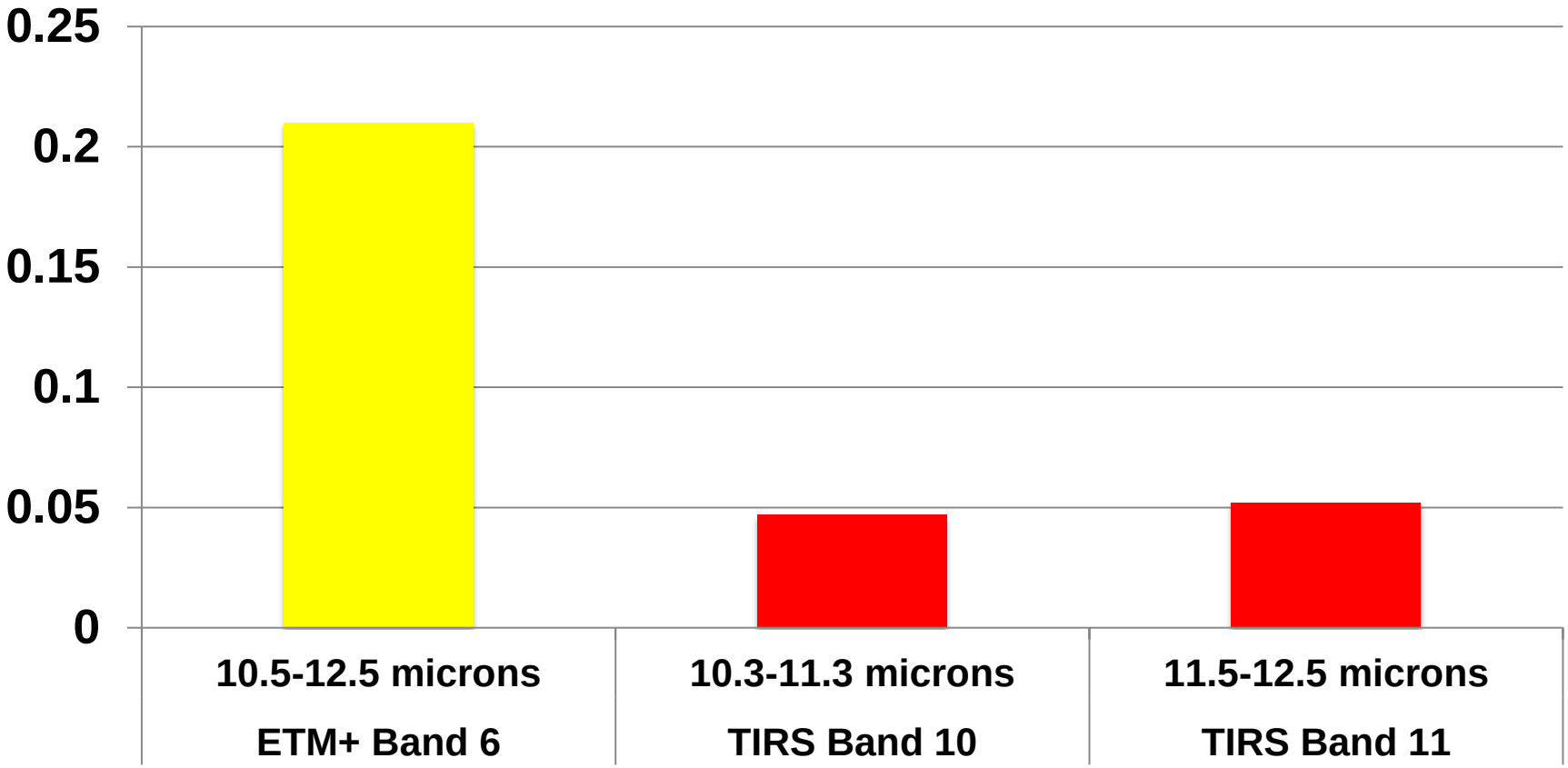
Noise Equivalent Delta Temperature @ 300K (smaller is better)



LDCM Saturation Radiances

- **Reflective**
  - OLI at or above 100% reflectance at minimum solar zenith angle observed
  - ETM+ at 35-51% (high gain); 52-77% (low gain)
  - Saturated pixels should be rare, except for specular reflections
- **Emissive**
  - ETM+ ~345K; TIRS ~365K
  - Saturated pixels should be rarer

Absolute Radiometric Calibration

- **OLI**
  - Requirements
    - TOA Radiance (5% 1 sigma)—same at ETM+
    - TOA Reflectance (3% 1 sigma)
  - Predicted Performance
    - TOA Radiance (3.5% 1 sigma)—similar to ETM+
    - TOA Reflectance (2.5% 1 sigma)
    - Calibrations independent (at launch)
      - Separate scaling coefficients provided in metadata
  - Plan in place to cross calibrate during LDCM commissioning
- **TIRS**
  - Requirements
    - TOA Radiance
      - 2% 260K -330K; 4% 240-260K; 330K-360K – ETM+ was 5%
  - Predicted Performance
    - TOA Radiance
      - ~1% 260K-330K; ETM+ similar

Instrument Architecture: On-board Calibration

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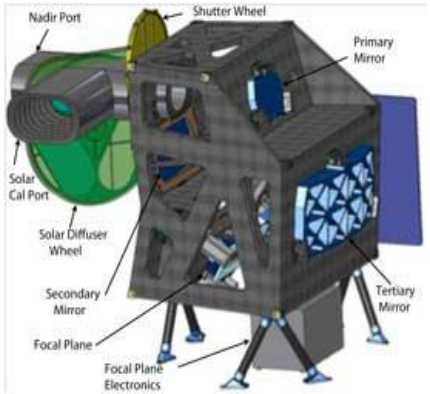
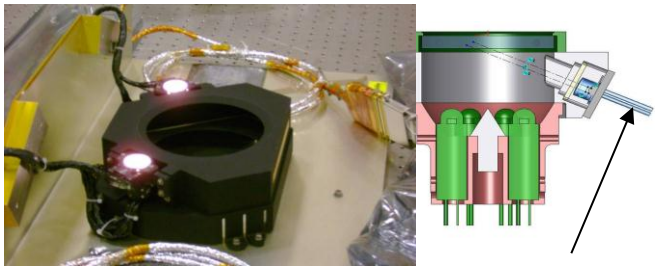
- **OLI**
  - Shutter
    - Exercised before and after each acquisition interval (~2 orbit) to provide pre-dark and post dark versus every scan line for ETM+
  - Two solar diffusers
    - Spectralon vs Paint for ETM+
      - Extensive attention to contamination control in manufacturing/I&T
      - Better illumination geometry (~45°) vs ~70° for ETM+ diffuser
      - Achieved by pointing diffuser port at sun (maneuver)
    - NIST traceable reflectance calibration (out into SWIR region)
      - New capability at NIST utilized
      - Flight parts directly characterized (did not rely on witness samples)
    - Different usage frequencies to track degradation
      - Working ~ weekly; Pristine ~semi-annually
    - Illuminated/Calibrated in-Situ with Heliostat
      - First part of transfer to orbit experiment
  - Lamps
    - Through Full System versus at Focal plane for ETM+
    - Constant Current control
    - Built in radiance monitor (visible wavelengths)
    - Three pairs of lamps with different frequencies of usage to track degradation
    - Collects generally once/day for working lamps (vs every scan line for ETM+





Instrument Architecture: On-board Calibration

- **TIRS**
  - Scene Select Mechanism (SSM)
    - Used to point to Earth, Black Body or Deep Space to provide cal data before and after every interval (~2/orbit) versus every scan line for ETM+
  - On-Board Black Body Calibration Source
    - Full aperture full system versus internal for ETM+
      - Temperature settable from ~260K to ~330K, versus T1, T2, T3
      - Similar to MODIS OBC
      - Ops Con is to set at ~300K, but cycle through temperature range regularly
    - NIST traceable radiance calibration (via SDL)
  - Deep Space Port

Implications of Push-Broom Design

- **Processing**
  - No line-by-line shutter, background, black-body, lamp data
  - Calibration generally only available before and after science data intervals, i.e., every ~ 40 minutes
    - Blind detectors, video reference pixels can provide some data on drift between calibrations (not currently planned to be used for processing)
  - OLI: Shutter data before and after each interval
    - Will be used to provide bias levels via BPF; interval specific BPF to be used for data processing
  - TIRS: Deep space and OBC data before and after each interval
    - Deep Space data provides background levels; stored in BPF

Check with Ron on this slide

OLI Radiometric Processing Flow (simplified)

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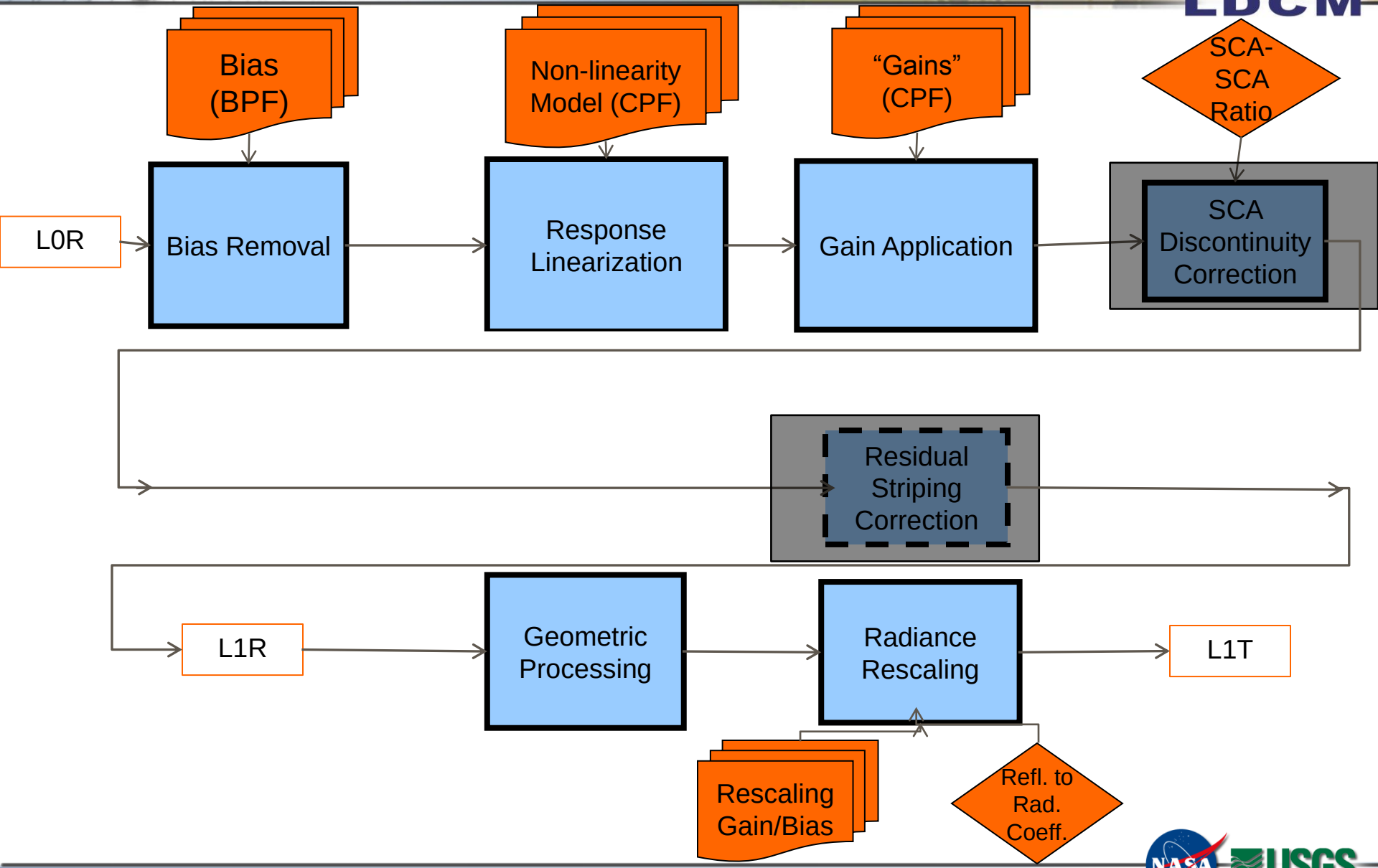
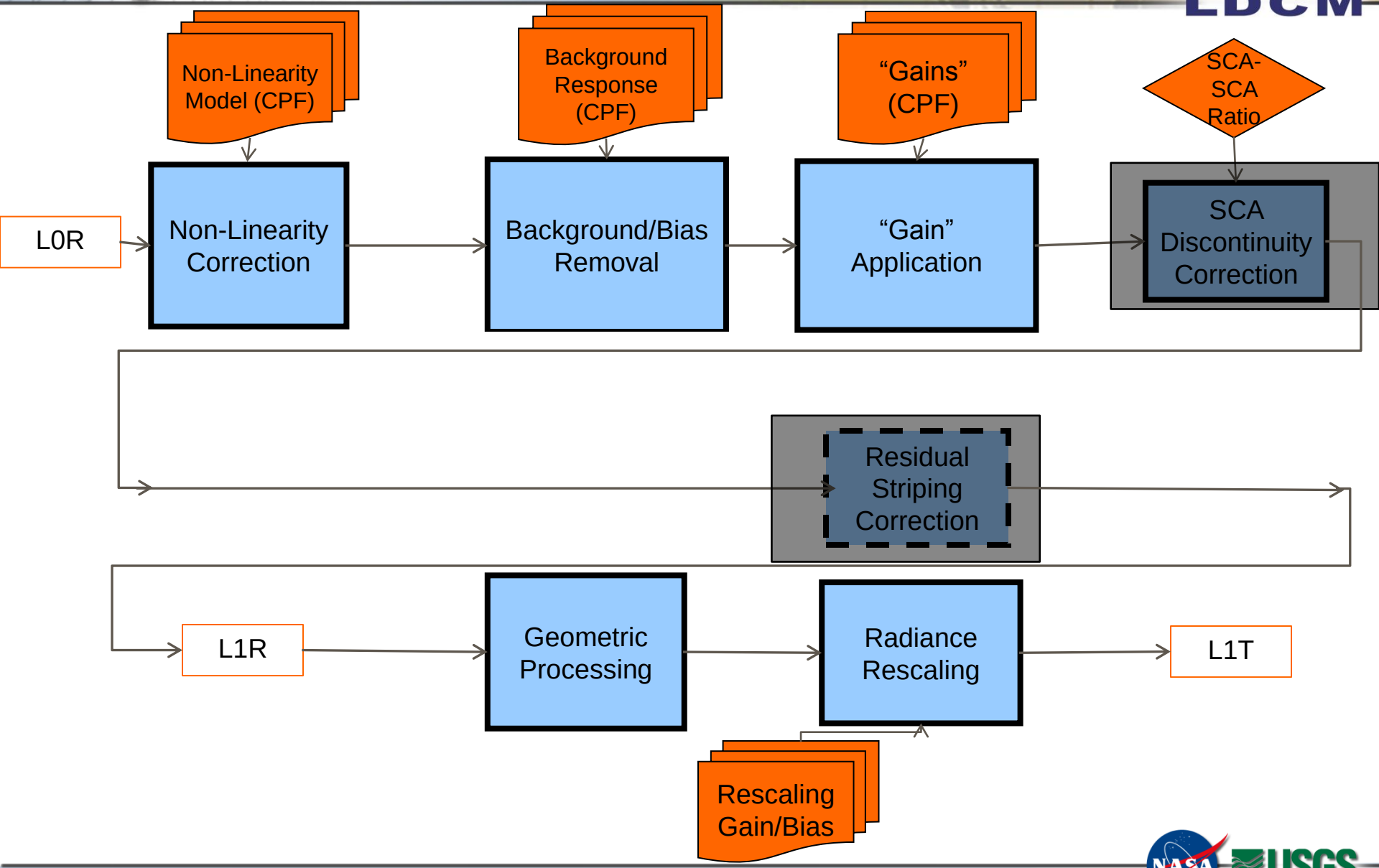


Modified K. Vanderwerff slide

TIRS Radiometric Processing Flow (simplified)

LDCM

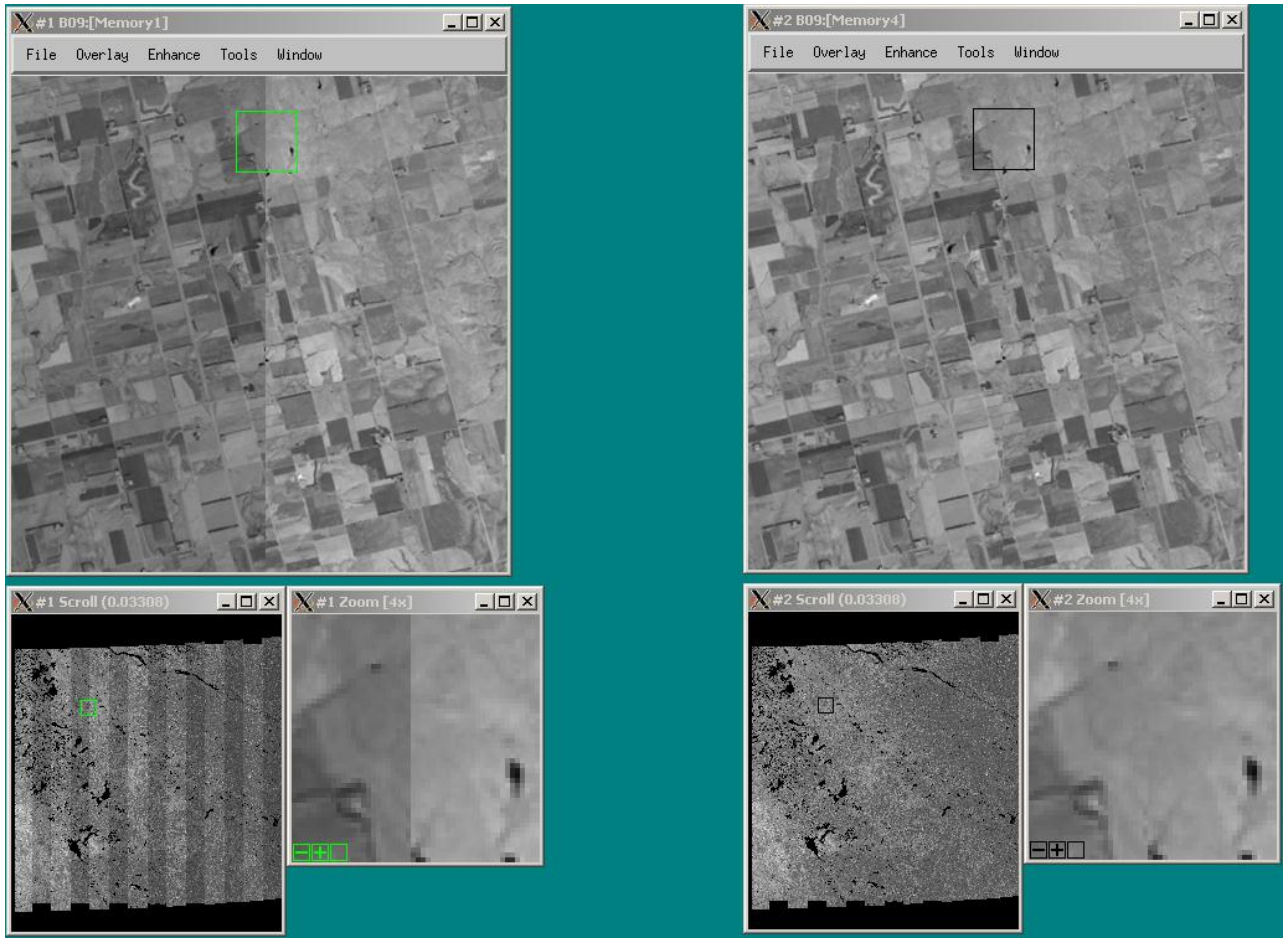


Modified K. Vanderwerff slide

Implications of Push-broom Design

- **Thousands of Detectors**
  - Each views unique area on the ground
  - Assumptions of scene content based destriping techniques easily violated
- **Multiple Focal Plane Modules/Sensor Chip Assemblies**
  - 14 for OLI; 3 for TIRS
  - Each with unique detectors, filter pieces, electronics
    - Generally matched very well
  - Within and between spectral, linearity differences
    - Will produce between-module discontinuities/banding
    - Even if matched as well as whisk broom instruments, artifacts will be visible due to higher SNR
- **Instrument, Operations, Image Assessment System have multiple techniques with dealing with banding and striping (OBC's, side slithers, bulk scene statistics, cosmetic corrections)**

SCA Discontinuity Simulation



Before

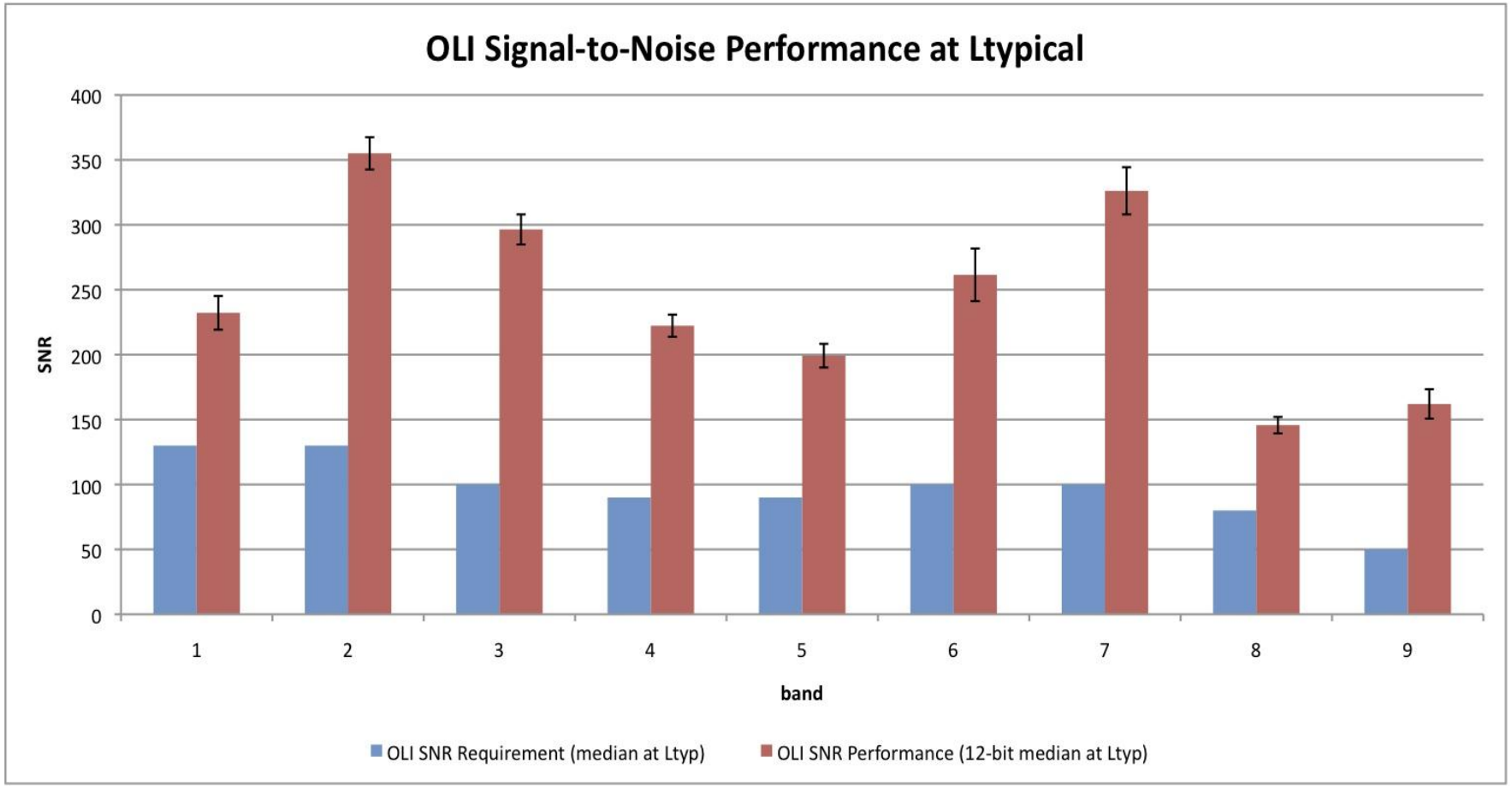
After

Radiometric Data Scaling

- **OLI Data – scaled TOA "reflectance" or radiance**
  - Two sets of coefficients in metadata
  - Independent traceability to NIST reflectance and radiance
- **TIRS Data – scaled TOA radiance**

- **Backup Slides**

Pre-Launch OLI Signal-to-Noise Performance



Pre-Launch OLI Signal-to-Noise Performance