GSFC RS Technology Demonstration Instrument

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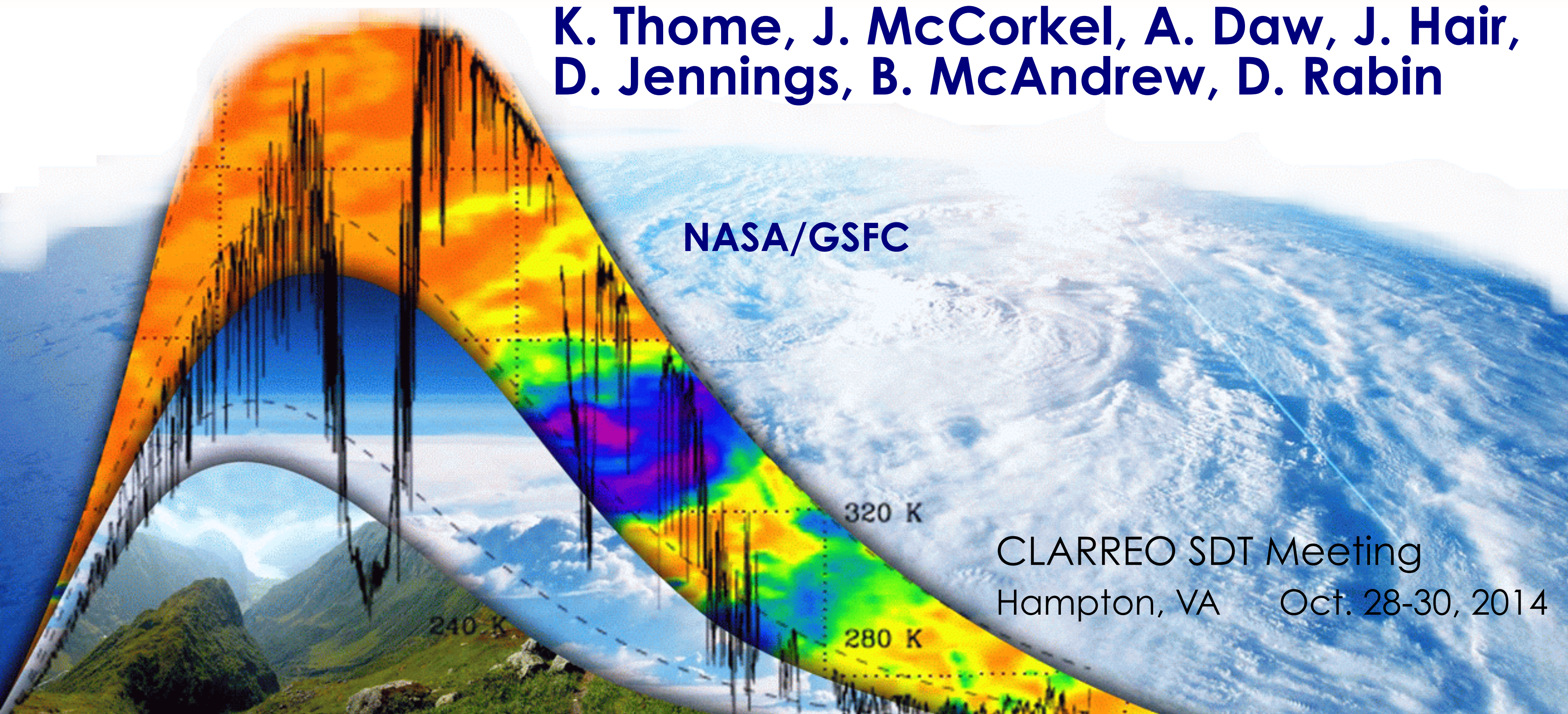
NASA/GSFC

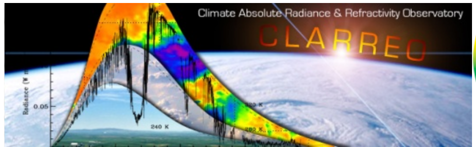


CLARREO SDT Meeting
Hampton, VA Oct. 28-30, 2014

CLARREO RS GSFC Overview

Past nine months have seen work on both new starts as well as on-going activities

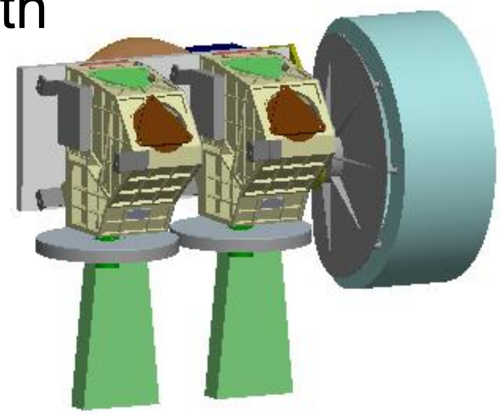
- Continued efforts with the Calibration Demonstration System
  - Refining NIST methods in the GSFC calibration facility
  - Additional solar and lunar views
  - Updated calibration hardware to improve repeatability
- Developed
  - Mission architecture study
  - Plans for Technology Demonstration System
  - Budgets for Risk Reduction Unit



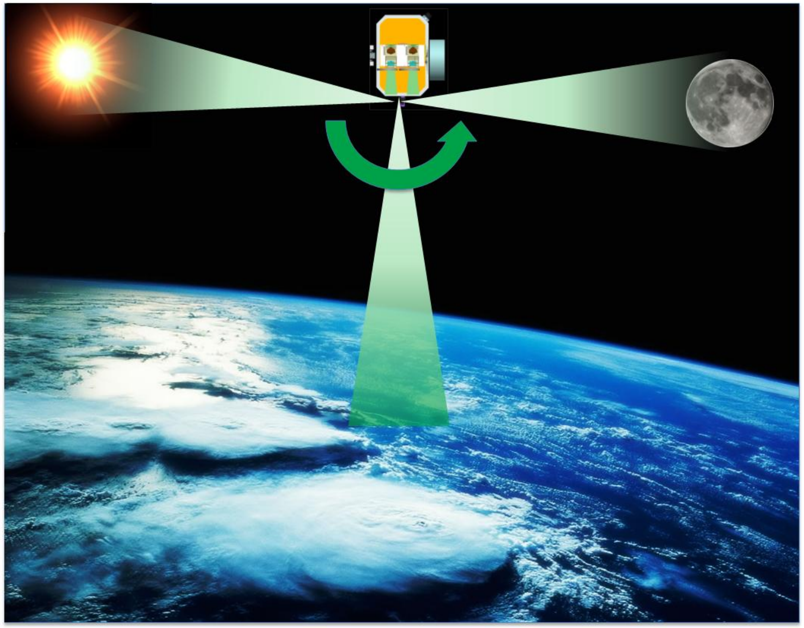
RS Instrument

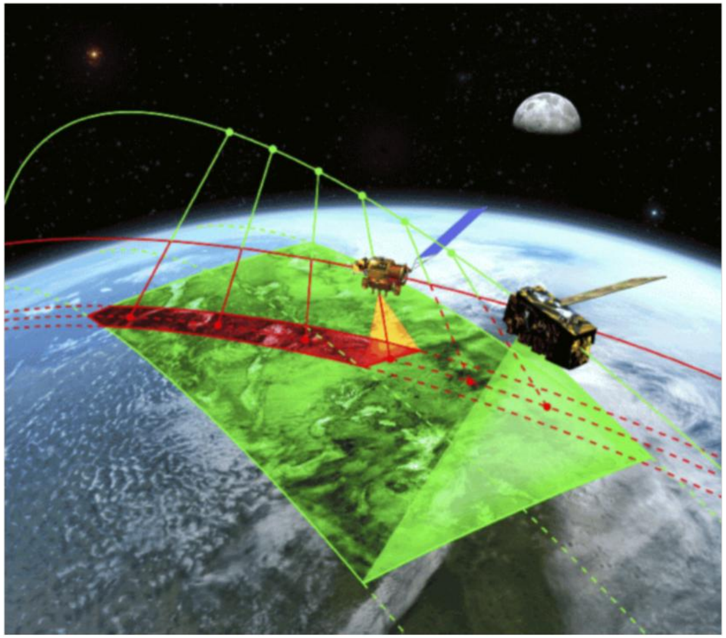
Offner system covering 320 to 2300 nm with 500-m GIFOV and 100-km swath width

Reflectance traceable to SI standards at an absolute uncertainty <0.3%



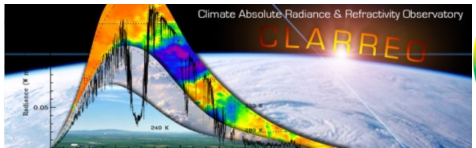
Benchmark reflectance from ratio of earth view to measurements of irradiance while viewing the sun





Lunar data provide calibration verification

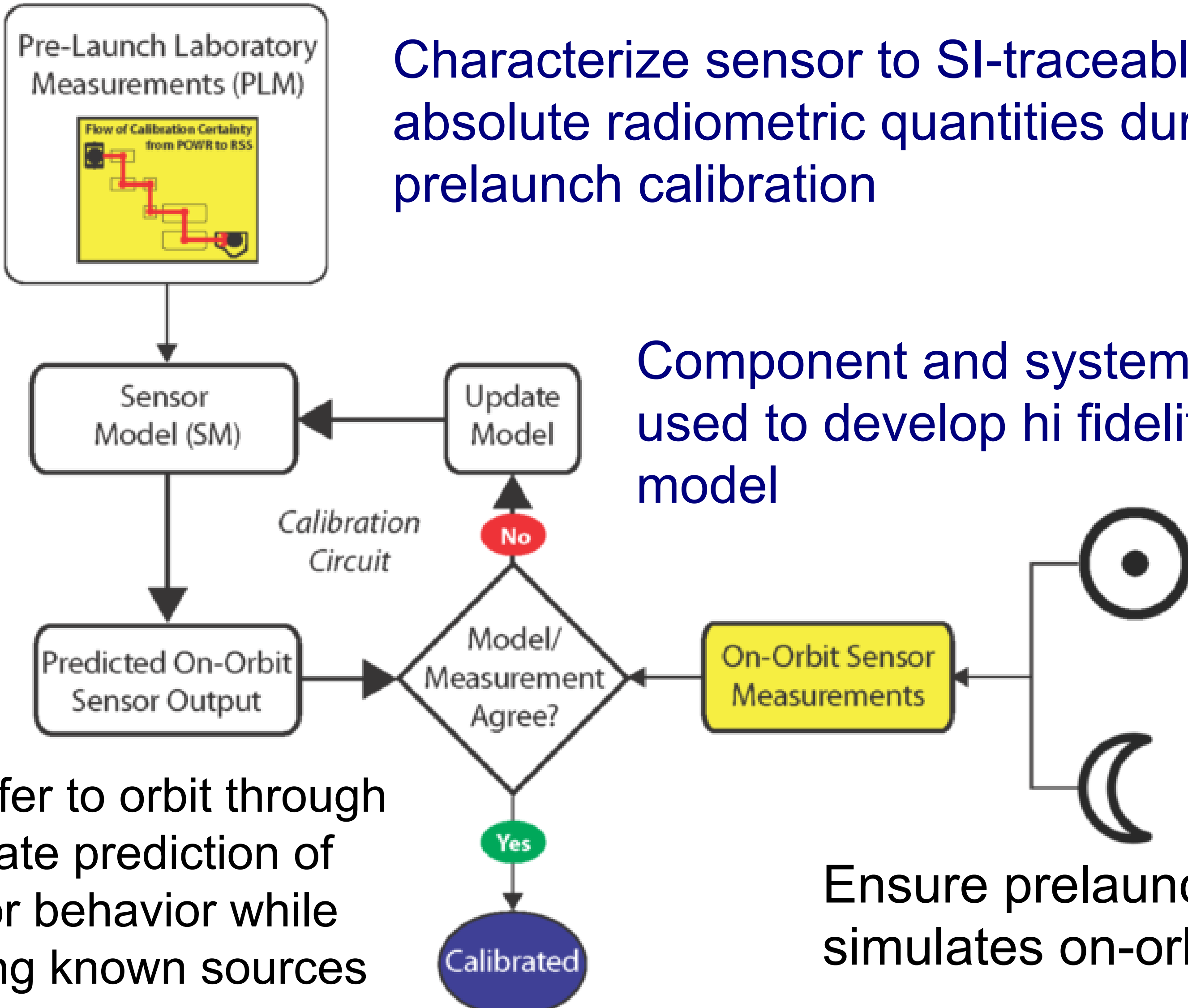
Inetrcalibration plays a key role in developing climate record



Need to Demonstrate Calibration approach

Characterize sensor to SI-traceable, absolute radiometric quantities during prelaunch calibration

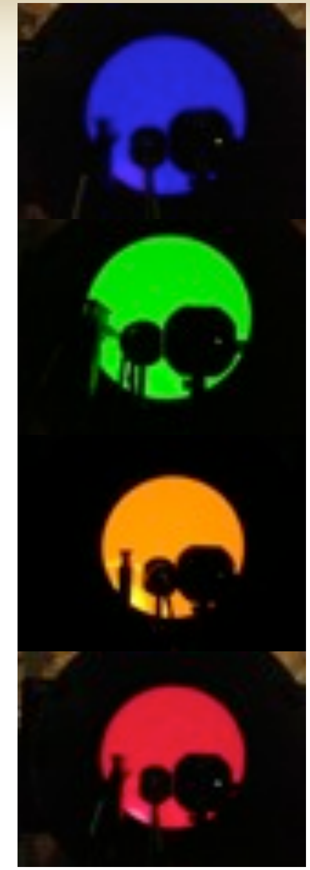
Component and system level data used to develop hi fidelity sensor model



Transfer to orbit through accurate prediction of sensor behavior while viewing known sources

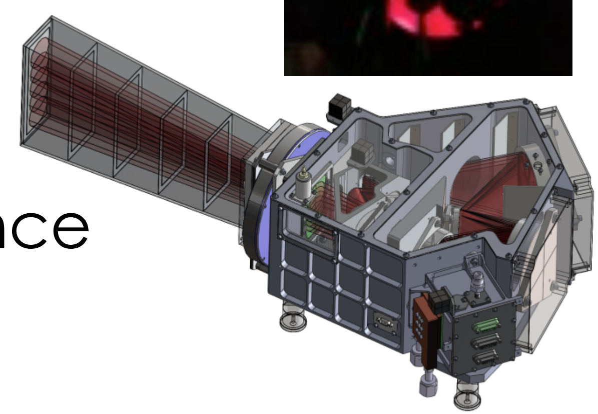
Ensure prelaunch calibration simulates on-orbit sources

Calibration Demonstration System (CDS)



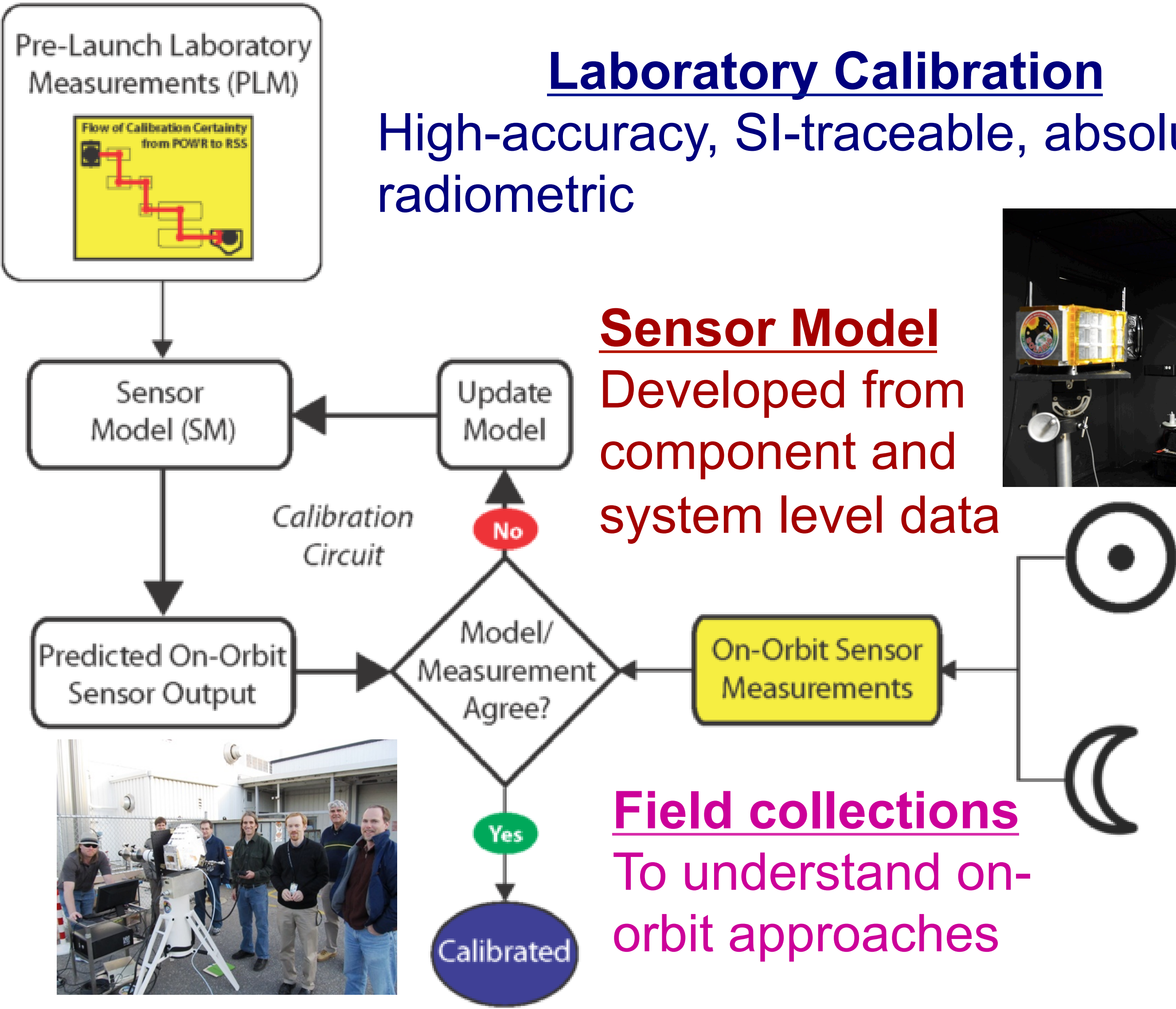
Reducing risk of achieving on-orbit SI-traceability achieved through CDS

- Reflected solar version is SOLARIS (SOlar, Lunar for Absolute Reflectance Imaging Spectroradiometer)
- Transfer-to-orbit error budget showing SI-traceability
- Technology demonstration for optics, depolarizers, & prelaunch calibration methods
- Field collections to evaluate reflectance retrieval, lunar views, and cross-comparisons with other systems



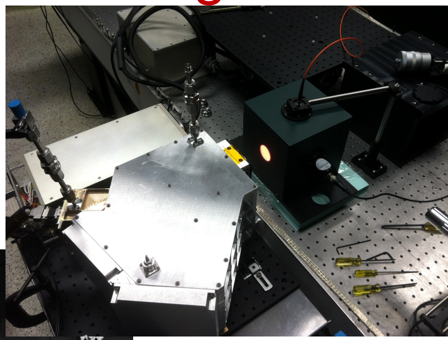
SOLARIS CDS testing overview

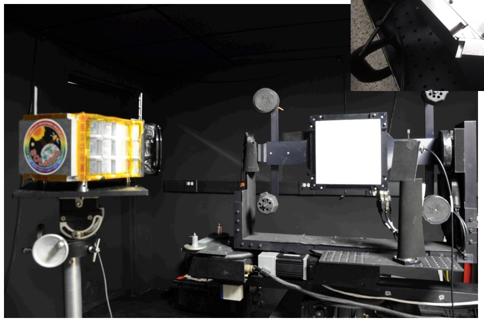
Follow calibration plan for CLARREO with emphasis on radiometric and spectral calibrations, sensor stray light, and optical modeling



Laboratory Calibration

High-accuracy, SI-traceable, absolute radiometric



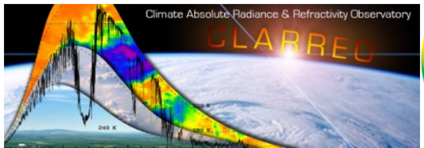


Sensor Model

Developed from component and system level data

Field collections

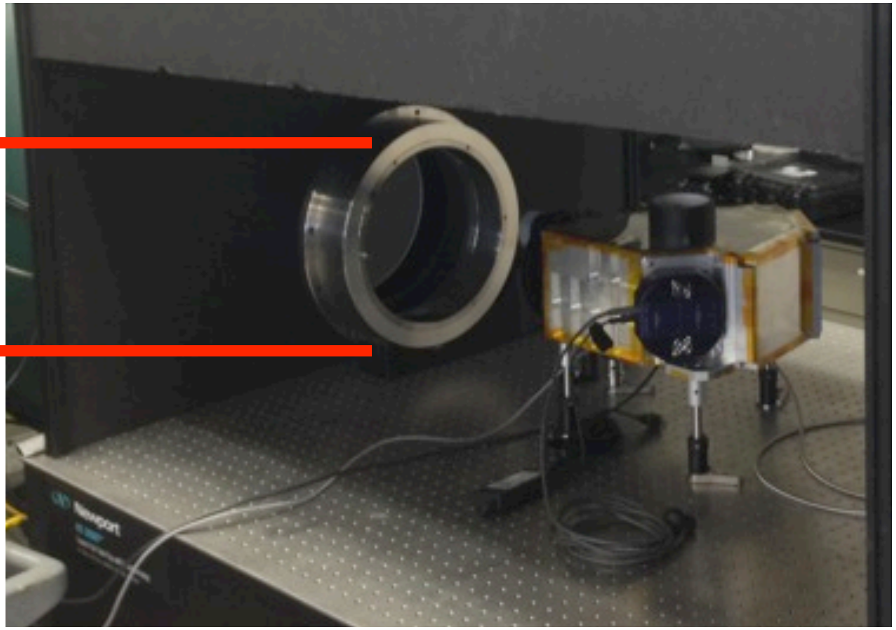
To understand on-orbit approaches

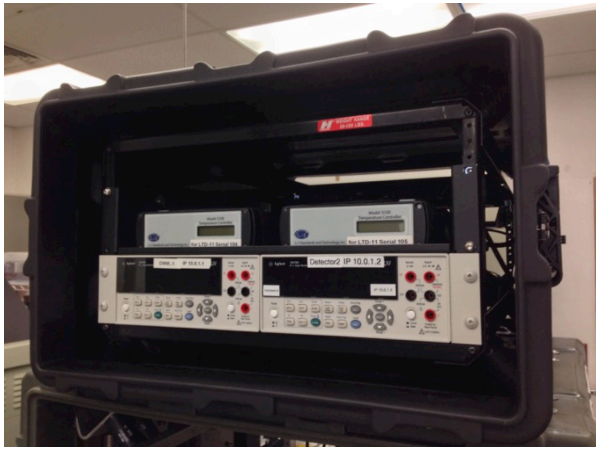


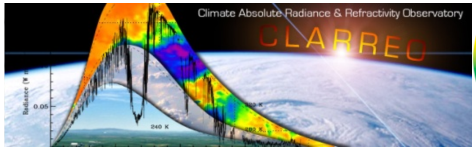
Laboratory cal depends on detector-based methods

Laser-based, monochromatic, SI-traceable source with <0.09% (k=2) uncertainty

- Highly-accurate, unfiltered detector calibrates narrow-band source output
- Leveraging CLARREO knowledge to apply this method to other projects including JPSS VIIRS





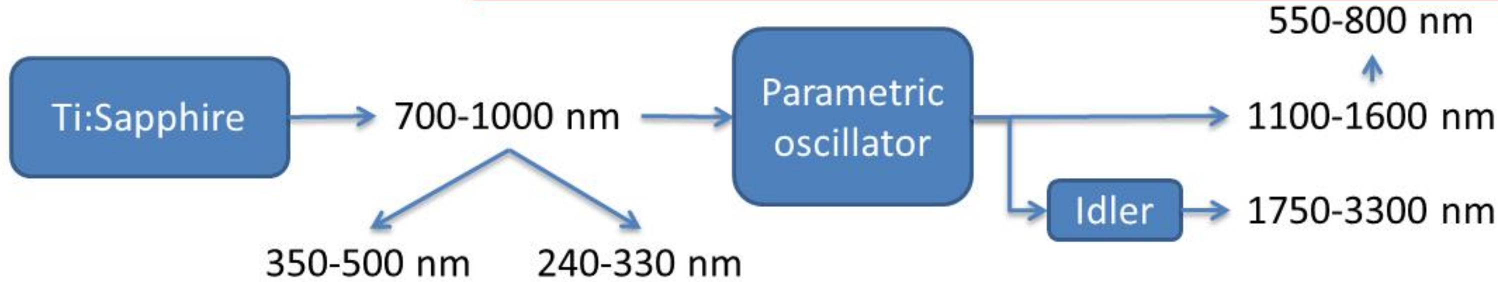


NIST, SOLARIS, and CLARREO

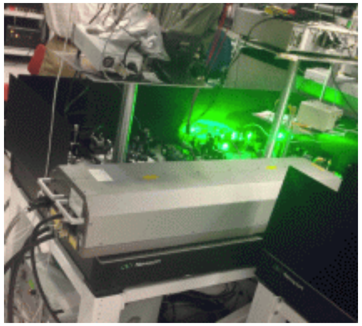
NIST plays a key role in advising and reviewing SOLARIS and, eventually, CLARREO

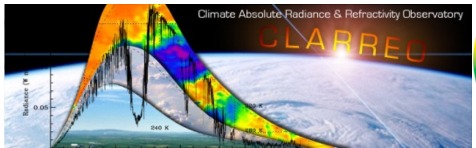
Fancy light bulb: SIRCUS

Spectral irradiance and radiance responsivity calibrations using uniform sources (SIRCUS)

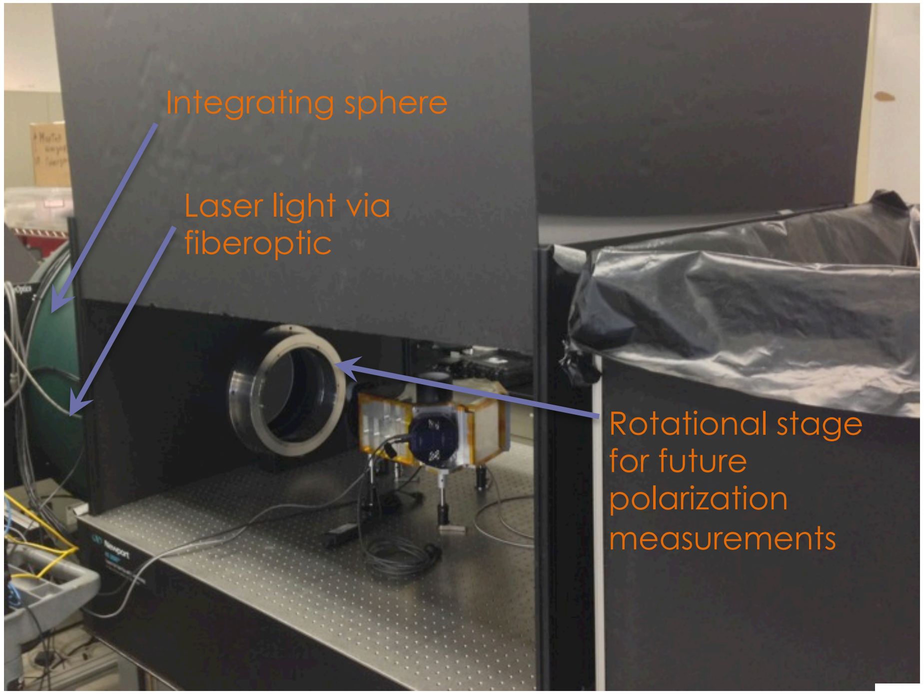


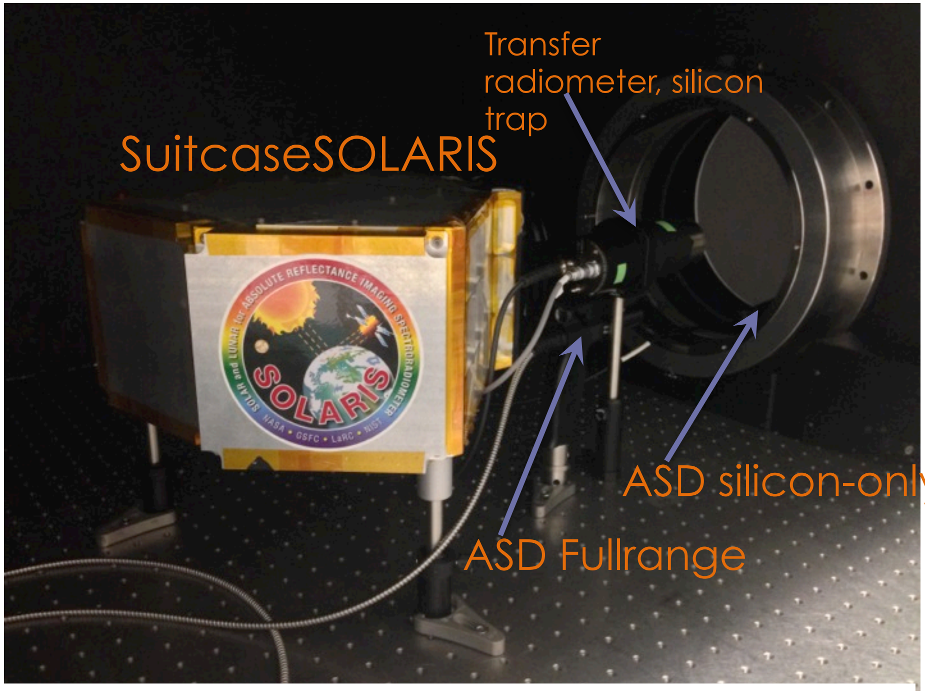
- Collaboratively helping develop 'operational' version of SIRCUS
  - Extension to wavelengths > 1 micrometer
  - Laboratory calibration protocols and equipment
- Calibration of transfer radiometers needed for detector-based accuracy
- **New laser source to improve automation**

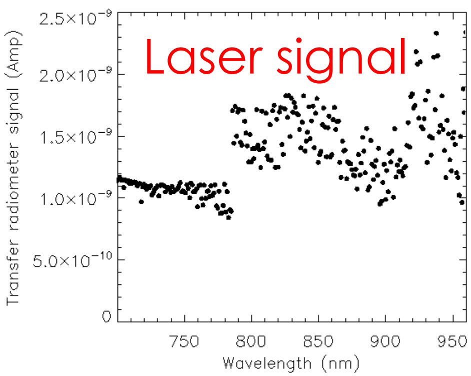


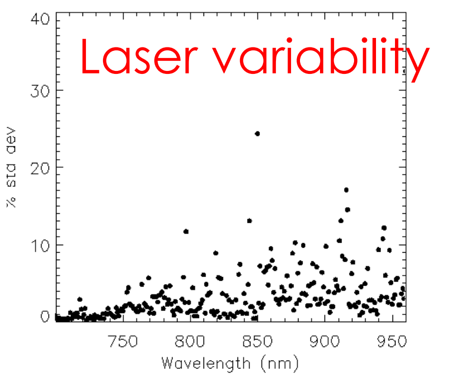


Laboratory source stability needs further refinement





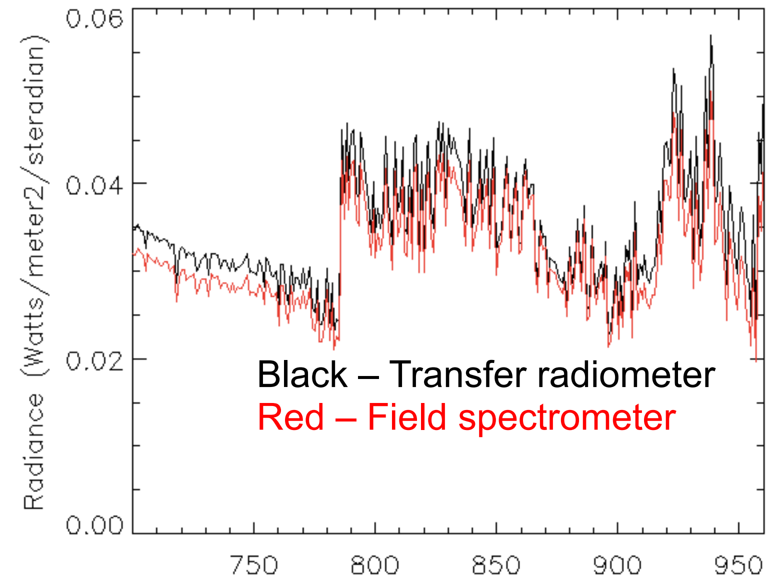


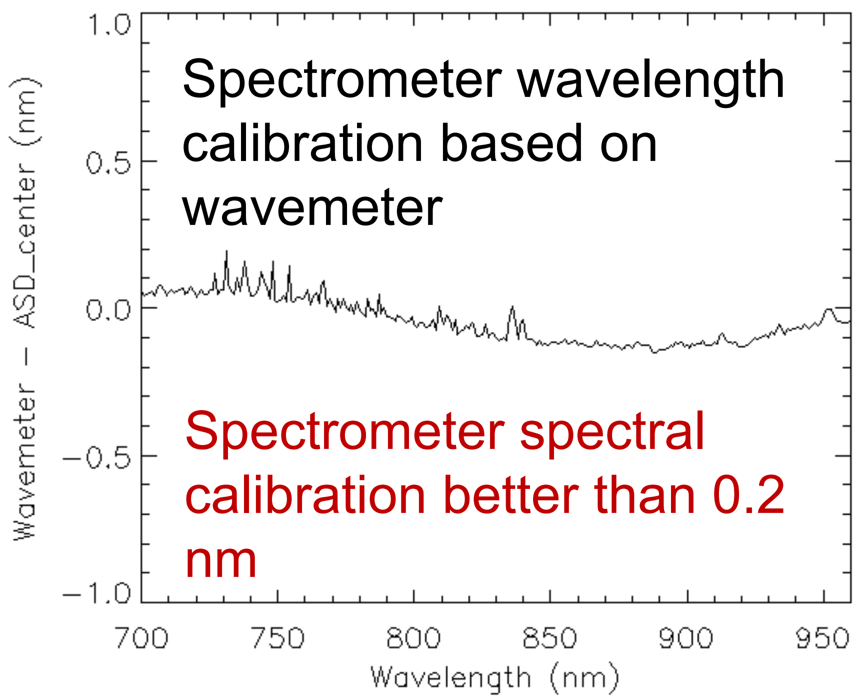


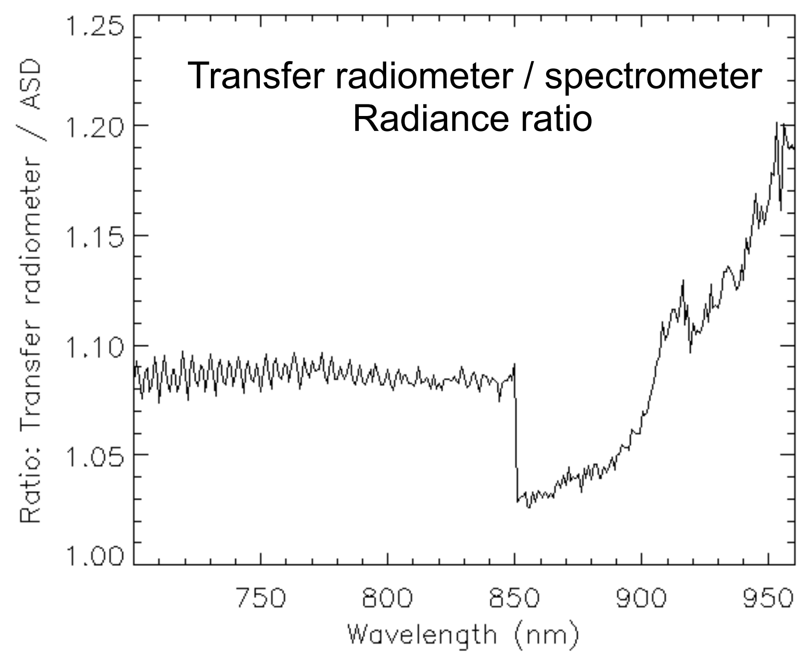
- Techniques to limit background stray light are being developed
- Work still needed to reduce variability of the source

Evaluation against non-imaging field spectrometer

- Well-know field spectrometer with 3%claimed uncertainty
- Integrate field instrument radiance across radiance output while viewing laser source

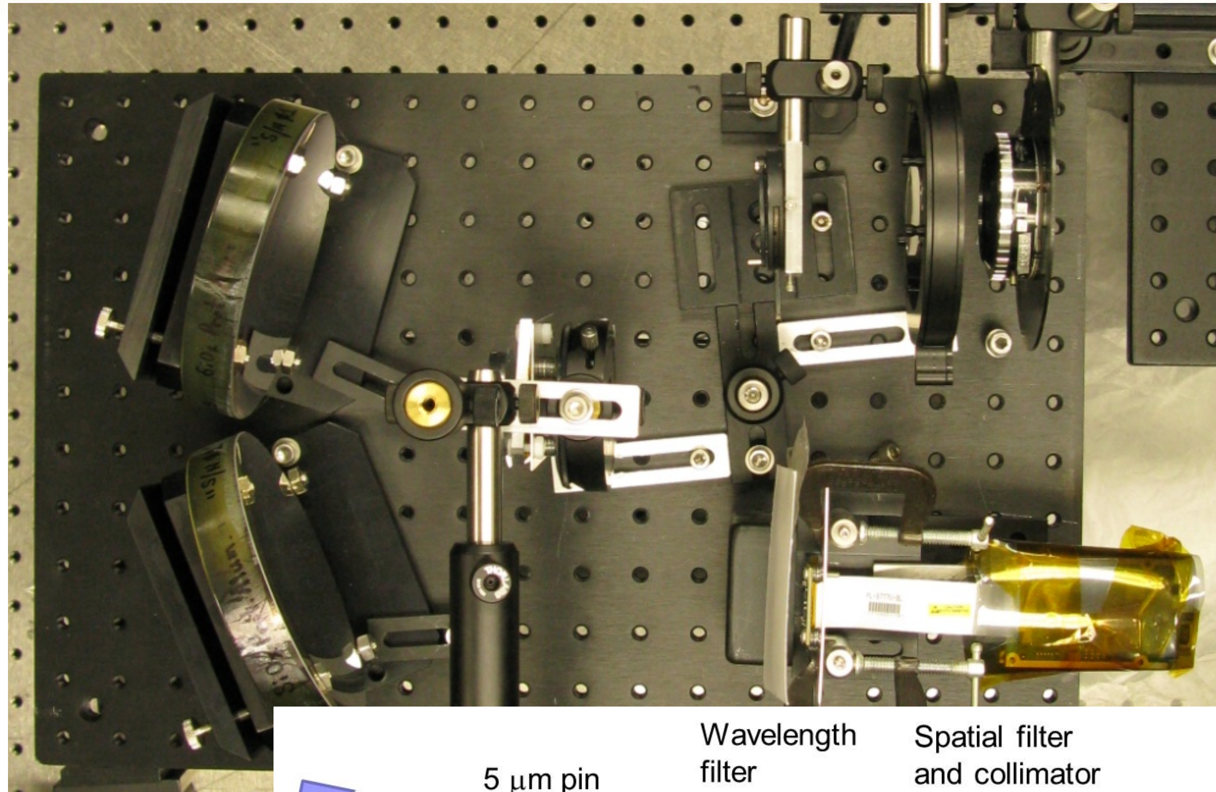


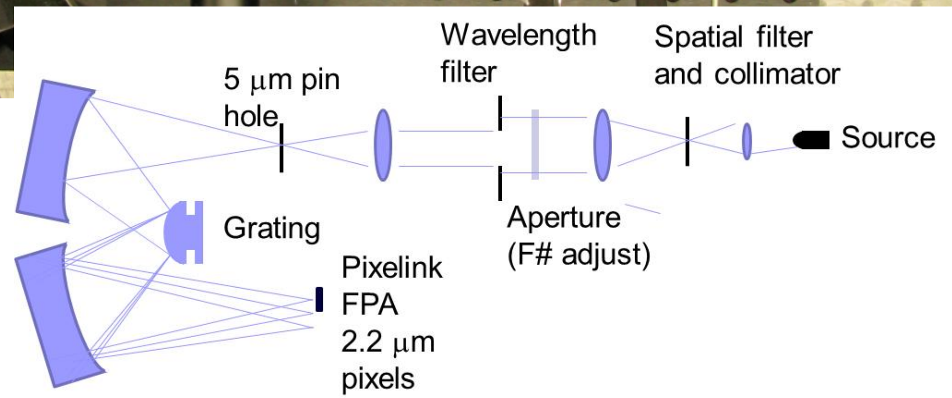


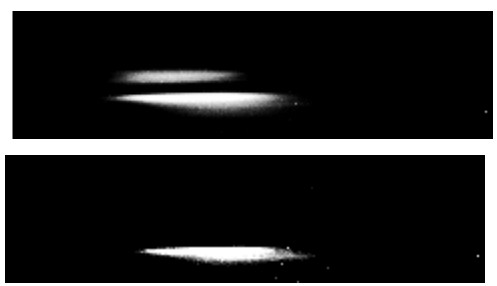


Sensor model data from component tests

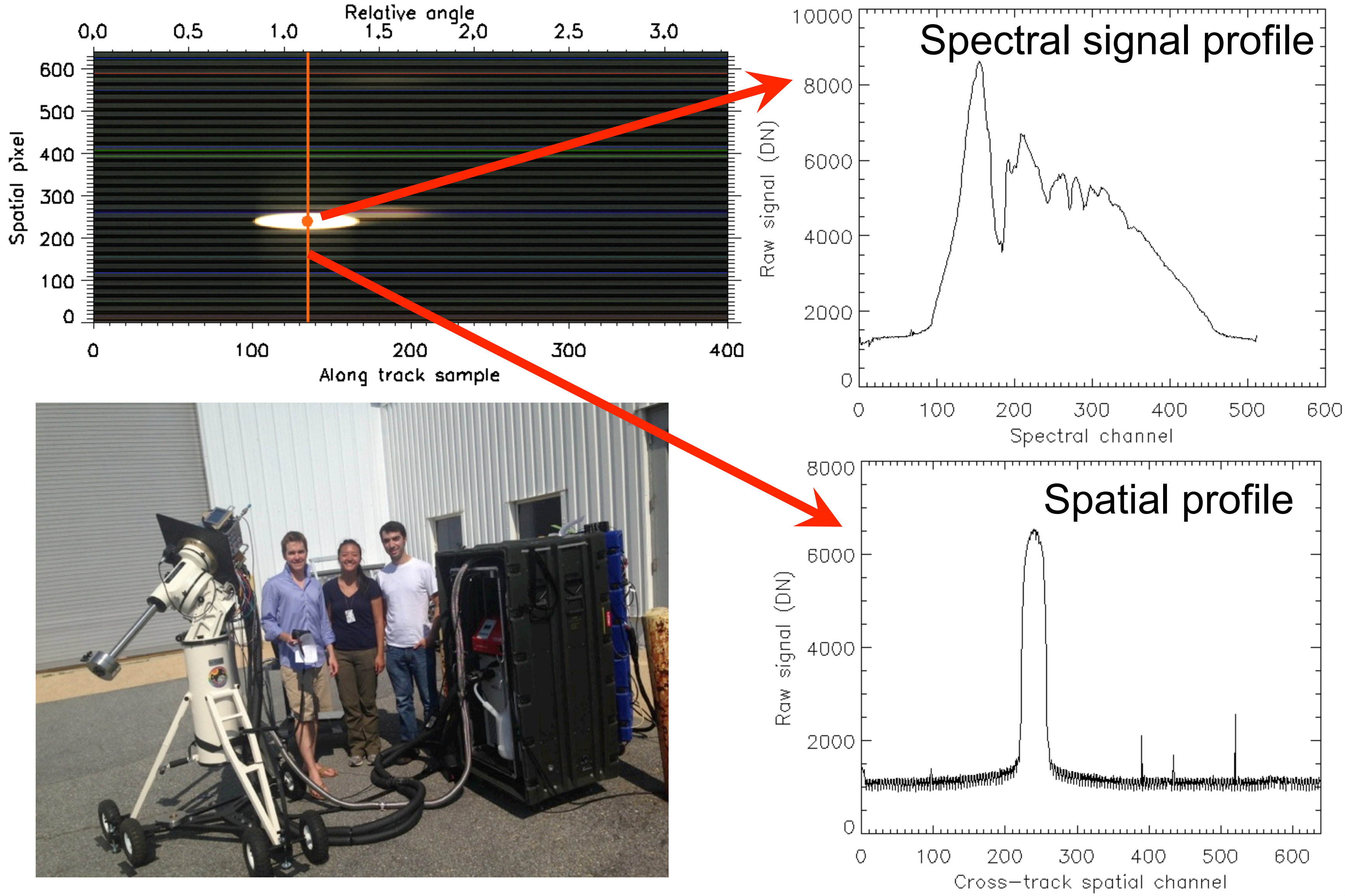
- Example shown here is the experimental set up used to characterize the grating system
- Indicated a stray light feature due to a manufacturing artifact
- Baffling was included to mitigate the effect





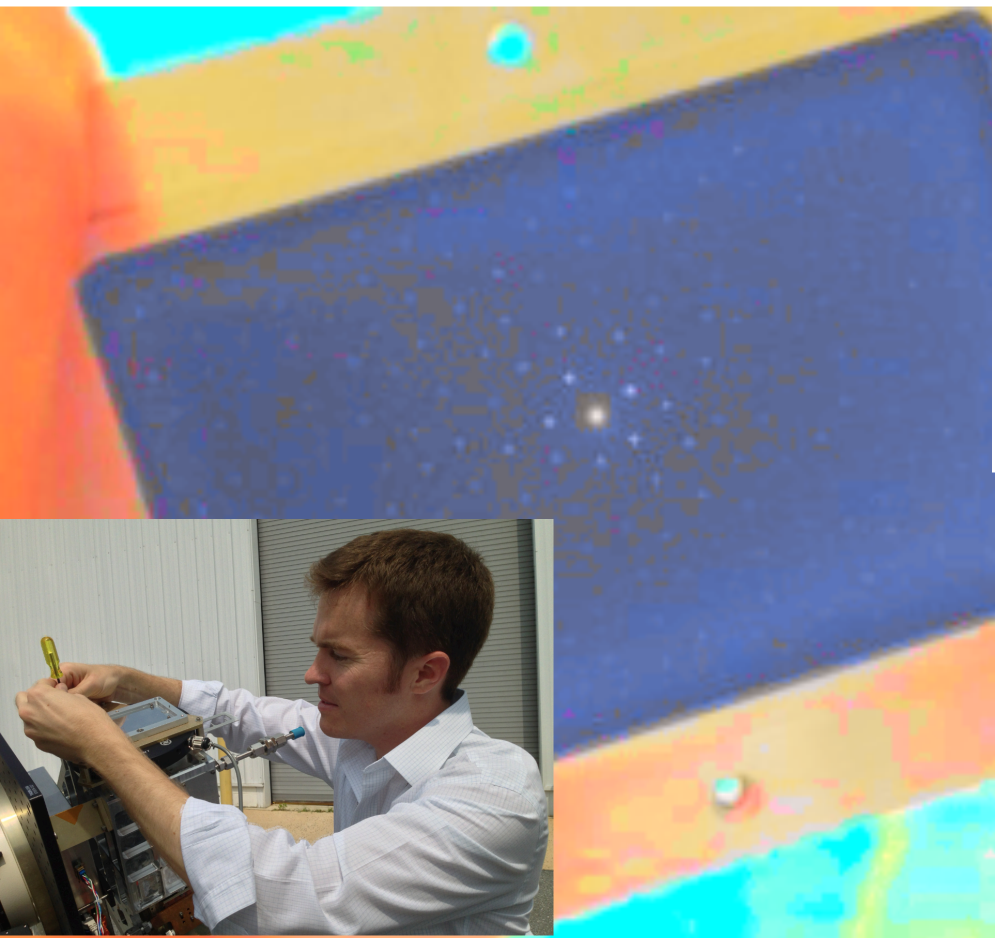


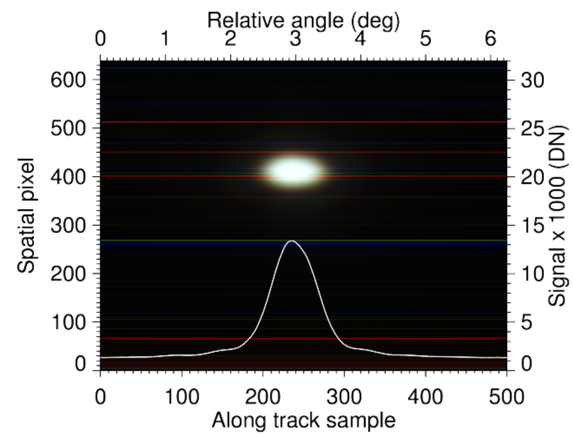
Field collections evaluate solar approach



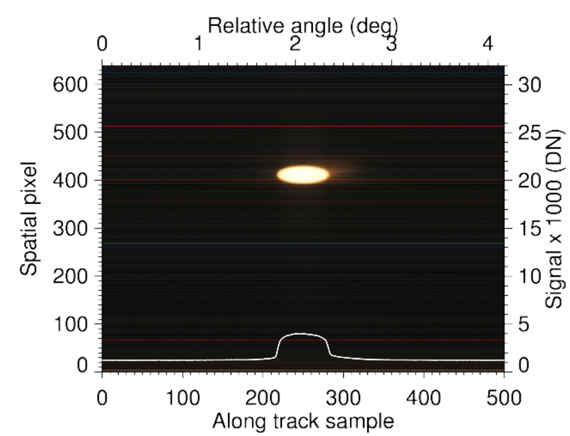
Evaluating multiple solar attenuator methods

- Perforated plate being studies as method for more uniform flat field source
- Neutral density filter used for absolute irradiance calibration
- Scanning is needed to evaluate all detectors





Perforated plate

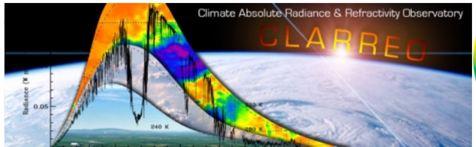


ND4 neutral density filter

FY15 Plan

Complete extension of calibration scales to 1.6 micrometers and near-IR transfer radiometer calibration at NIST

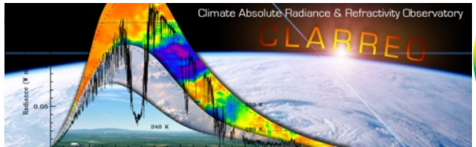
- Recurring peer reviews of the CLARREO calibration approach at NIST
- Collaborate with NIST on J1 VIIRS calibration at El Segundo-protocol developments
- Implement operational versions of SIRCUS
- Implementation of recently-purchased improved laser source
- Calibrations of SOLARIS and multiple airborne systems including closure on Landsat field campaign data
- Further measurements of solar and lunar irradiance



FY16 Plan

RS Collaboration with NIST to extend calibration scale to 2.3 micrometers

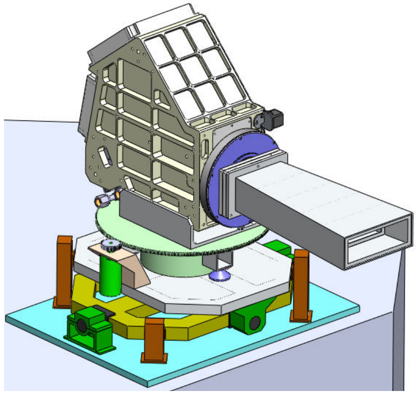
- Implementation of NIST-calibrated reflectance standard to evaluate uncertainties
- RS Instrument model development will continue
- Further measurements of solar and lunar irradiance in addition to field deployments
- Repeatability of lunar retrievals
- Absolute measurement of solar irradiance



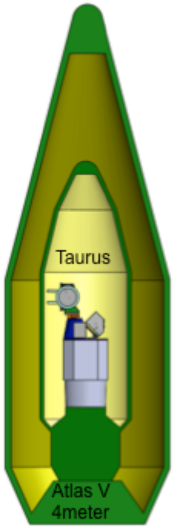
Mission architecture studies

Evaluated low-cost option using one-box approach for RS

- Risk is stray light, spectral dependence of optical elements, and detector design
- Significantly lower mass and size compared to MCR design
  - Instrument mass reduces from 77 kg to 35 kg CBE
  - Power reductions not expected to change significantly due to data rates and pointing requirements essentially identical as MCR design



One-box approach to CLARREO RS with nominal Atlas and Taurus fairings for size reference



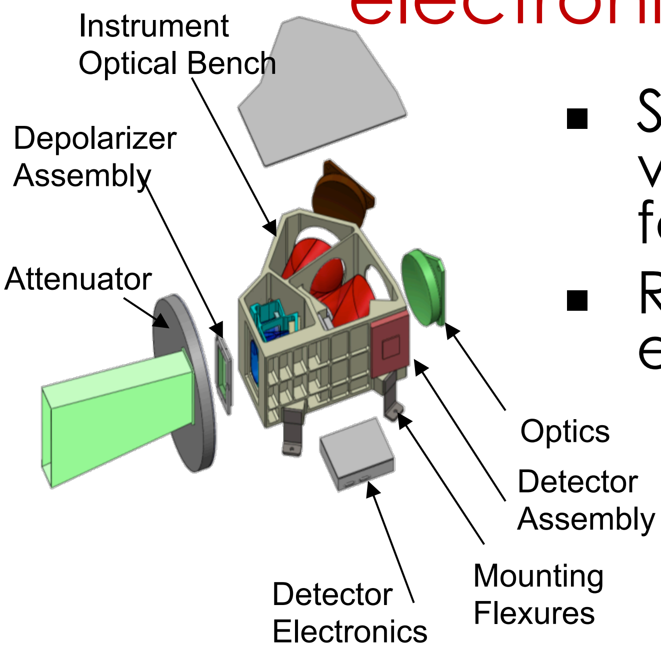
Risk Reduction Unit

Reduce cost/schedule risks of a future CLARREO-like mission

- Mission architecture studies showed benefits and gaps in CDS effort
- A well developed RRU should shorten mission development time period by ~3 years
- Reduce schedule risk of future flight instruments
  - RRU matches flight design in form, fit, and function
  - Essentially a non-flight quality EDU without EDU price
  - Matures flight technology and systems integration
- Undergo environmental testing to prove validity of design

RS RRU

Fully integrated, EDU quality sensor with flight electronics and thermal system



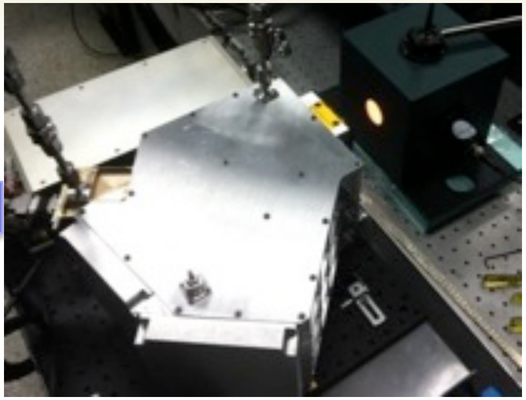
Exploded view of RS RRU

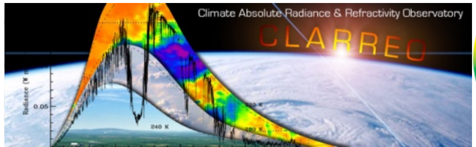
- Sensor would be ready for thermal vacuum testing including flight quality focal plane electronics
- Reduce risk from acquisition and evaluation of long lead components
  - Investigate alternate sources for this hardware
  - MCT detector for full spectral coverage
  - Optical elements including grating for full spectral coverage and depolarizers
- Complete acquisition of test hardware started with CDS

Technology demonstration

Advance key measurements on the way to deploy on ISS

- Take the lessons learned from SOLARIS and apply to a low-cost approach
- Similar to approach as LASP with their IIP and balloon deployment
  - Advantage of independent labs working the same metrology to prove advances in accuracy
  - Differences in design such as attenuator methods





Tech demo and RRU

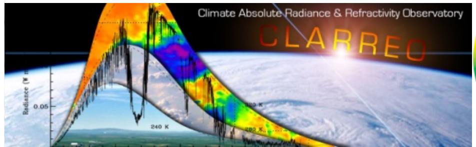
Goal of Tech Demo is to prove CLARREO-like measurements in space

- RRU lowers risk of a full CLARREO sensor development emphasizing sensor technology
- RS Tech Demo emphasizes proving CLARREO-like measurement approaches on orbit
  - Earth view to direct-solar ratio
  - Transfer-to-orbit calibration – “NIST in space”
  - Instrument model based on ground calibration methodologies
  - Detector and optical system stability
  - Intercalibration with existing sensors to demonstrate the approach for future Decadal Survey missions

Tech demo challenges

Class-D instrument similar in development as Cloud Aerosol Transport System lidar

- Short sensor development timeline
  - Mitigate long-lead items by funding procurements early
  - Rely on COTS procurements and in-house spares when possible
- Simplified thermal system relying on ISS cooling loop, mechanical coolers, and radiator
- Pointing system sufficient to demonstrate intercalibration
- Low cost sufficient to motivate NASA HQ to fund



Summary

Plans for FY 2015 and beyond concentrate on taking SOLARIS to below the 1% plateau

- **Key goal is to produce a peer-reviewed SI-traceability for CLARREO-like measurements**
- Achieving the <1% uncertainty in FY 2015 is at risk
  - Parallel development efforts are limited by lack of personnel
  - Greater susceptibility to hardware failures because of lower procurement funds
  - Improvements to laboratory calibration facilities will be limited or delayed
  - **RRU funding would mitigate this risk significantly**
- Develop and test sensor model
- **Tech demo** would show error budget for reflectance retrieval