Remote Sensing Support at NIST

Carol Johnson and Steve Brown

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NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

NIST CENTENNIAL 1901-2001

Remote Sensing Support at NIST

- Establish traceability to national radiometric standards maintained at NIST
  - develop specialized artifacts; calibrate them; and disseminate them
  - measurement intercomparisons
- Verification of radiance scales from commercial standards laboratories

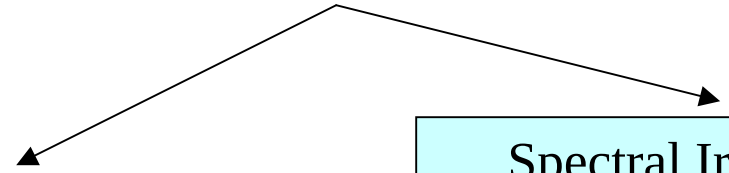
Principles of Radiometric Scales

- Electrical substitution (Detector-based Radiometry)
  - **Optical power** is substituted for **electrical power**
- Blackbody radiation (Source-based Radiometry)
  - Planck radiation law; links **radiance** to **temperature** scales
- Validity tests
  - Comparison of source-based to detector-based to yield a fundamental constant
  - International intercomparisons

Measurement Chain
Detectors & Radiometers

High Accuracy Cryogenic Radiometer (HACR)

Transfer Detectors (Si "trap" detectors)



Spectral Comparator Facilities (UV/Vis-NIR/IR)

Customer Detectors

Source: Thermal Sources filtered using Monochromators

Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources (SIRCUS)

NEW

Customer Radiometers

Source: Tunable Lasers

Measurement Chain — Radiometric Sources

Spectral Radiance

Gold-Point Blackbody

Radiance Strip Lamp 1 (1337 K)
Radiance Strip Lamp 2 (1530 K)
Variable Temperature
Blackbody (1611 K to 2655 K)

Customer:
—Radiance Strip Lamps
—Integrating Sphere Sources

Detector: Prism-grating spectroradiometer

Spectral Irradiance

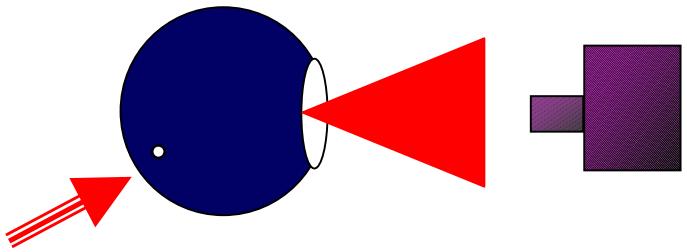
High Temperature Blackbody and Filter Radiometers NEW

Working Standard Lamps (FELs)

Customer FEL Lamps

Detector: Double-grating spectroradiometer

Radiometer Spectral Responsivities

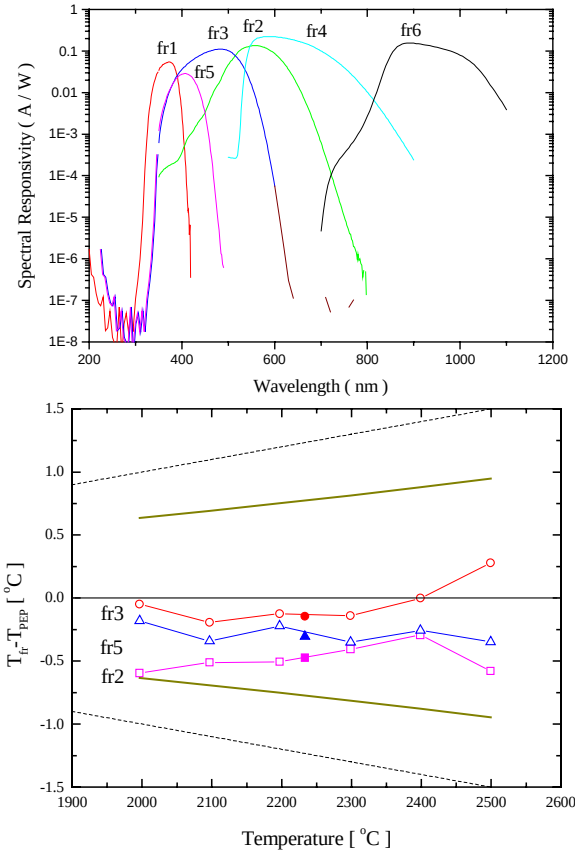


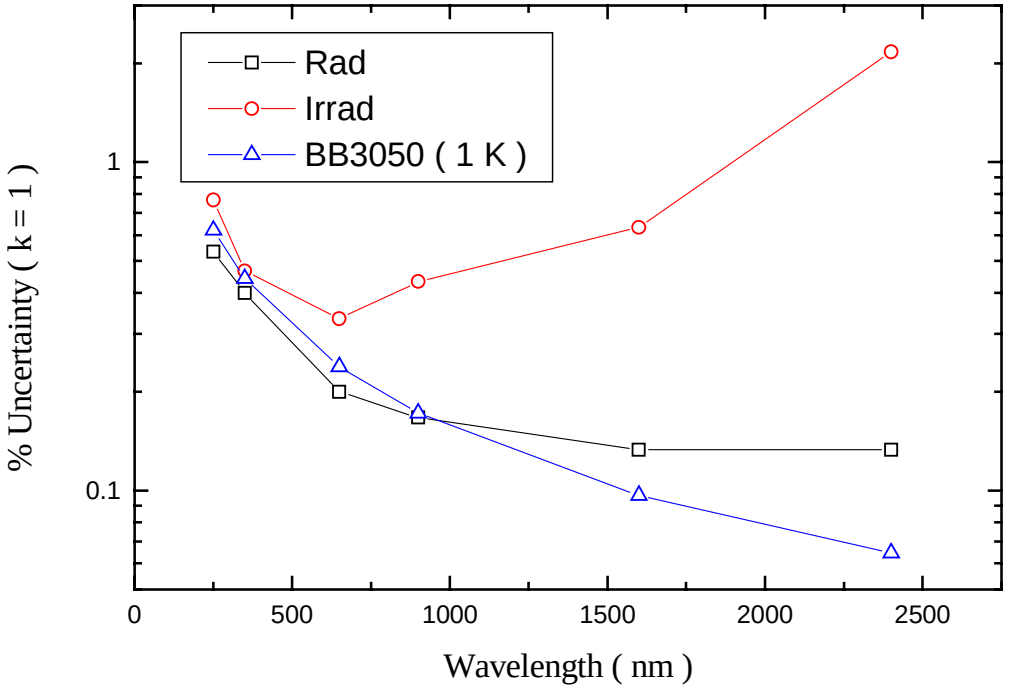
Tunable laser

Transfer std
Detector

- System Level Calibration, *L* or *E*
  - entrance pupil filled
  - source equivalence
- High Flux Levels
  - impacts uncertainties
  - accuracy of wings
- Tunable Lasers
  - UV to IR coverage
  - accurate wavelength
  - narrow bandwidth
- Uncertainties
  - reduced by x 2 to 4

Detector-based Spectral Irradiance





Use a high temperature black body (3000 K) to directly calibrate FEL lamps (50 cm away from 1 cm^2 aperture)

Products

- SeaWiFS
  - SeaWiFS Transfer Radiometer (SXR)
  - SeaWiFS Quality Monitor (SQM)
  - SeaWiFS Intercalibration Round-Robin Experiments (SIRREXs)
  - Prelaunch Calibration of SeaWiFS at Orbital
  - Measurement Comparison for OCTS

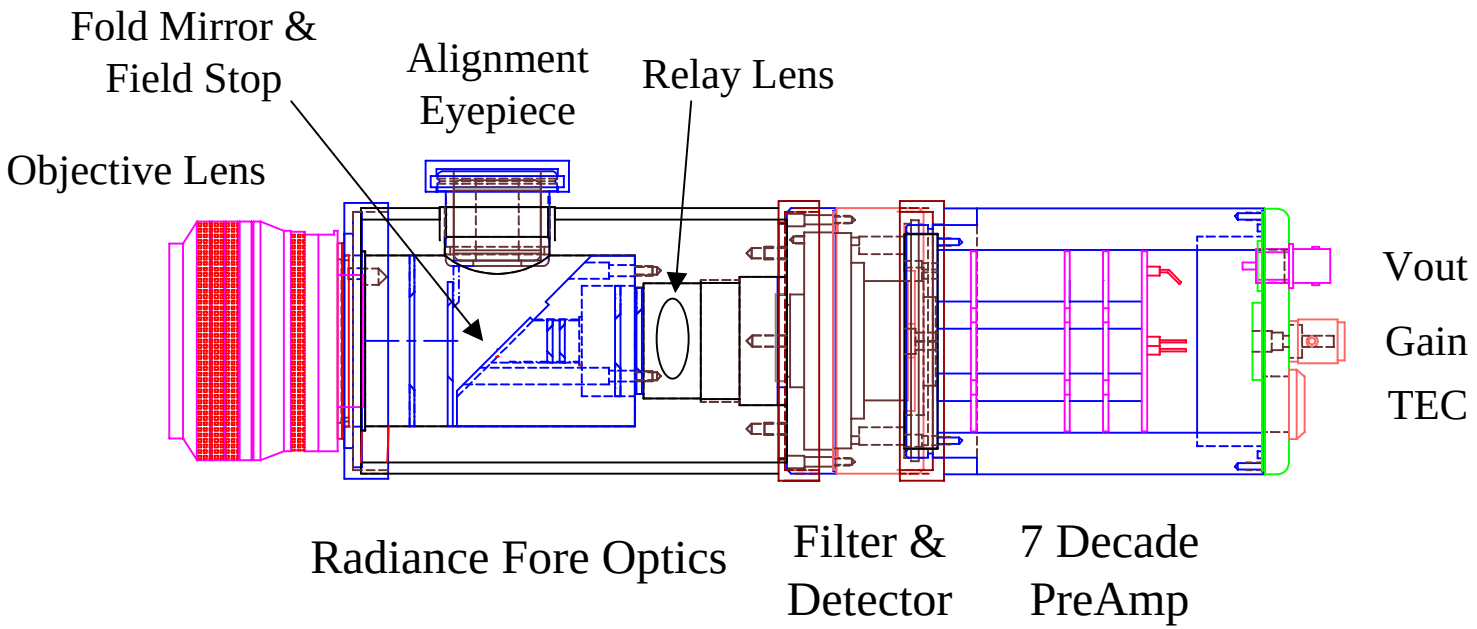
- MOBY/NOAA
  - Dual Purpose (radiance and irradiance) Filter Radiometers
  - Comparisons at Snug Harbor
  - Marine Optical System (MOS) Spectrograph Characterization

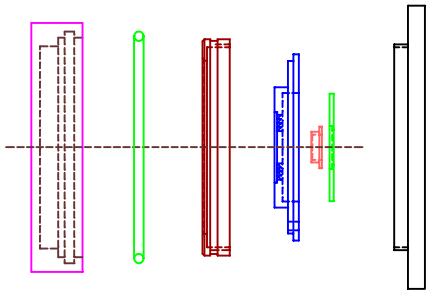
Products, Cont.

- EOS
  - Visible Transfer Radiometer (VXR)
  - Shortwave Infrared Monochromator (SWIXR)
  - Thermal Infrared Filter Radiometer (TXR)
  - EOS/NIST Portable Radiance Source—NPR
  - Measurement Comparison Activities

- SIMBIOS
  - SXR-2 (copy of SXR by SIMBIOS Project)
  - Characterization on SIRCUS of SXR and SXR-2

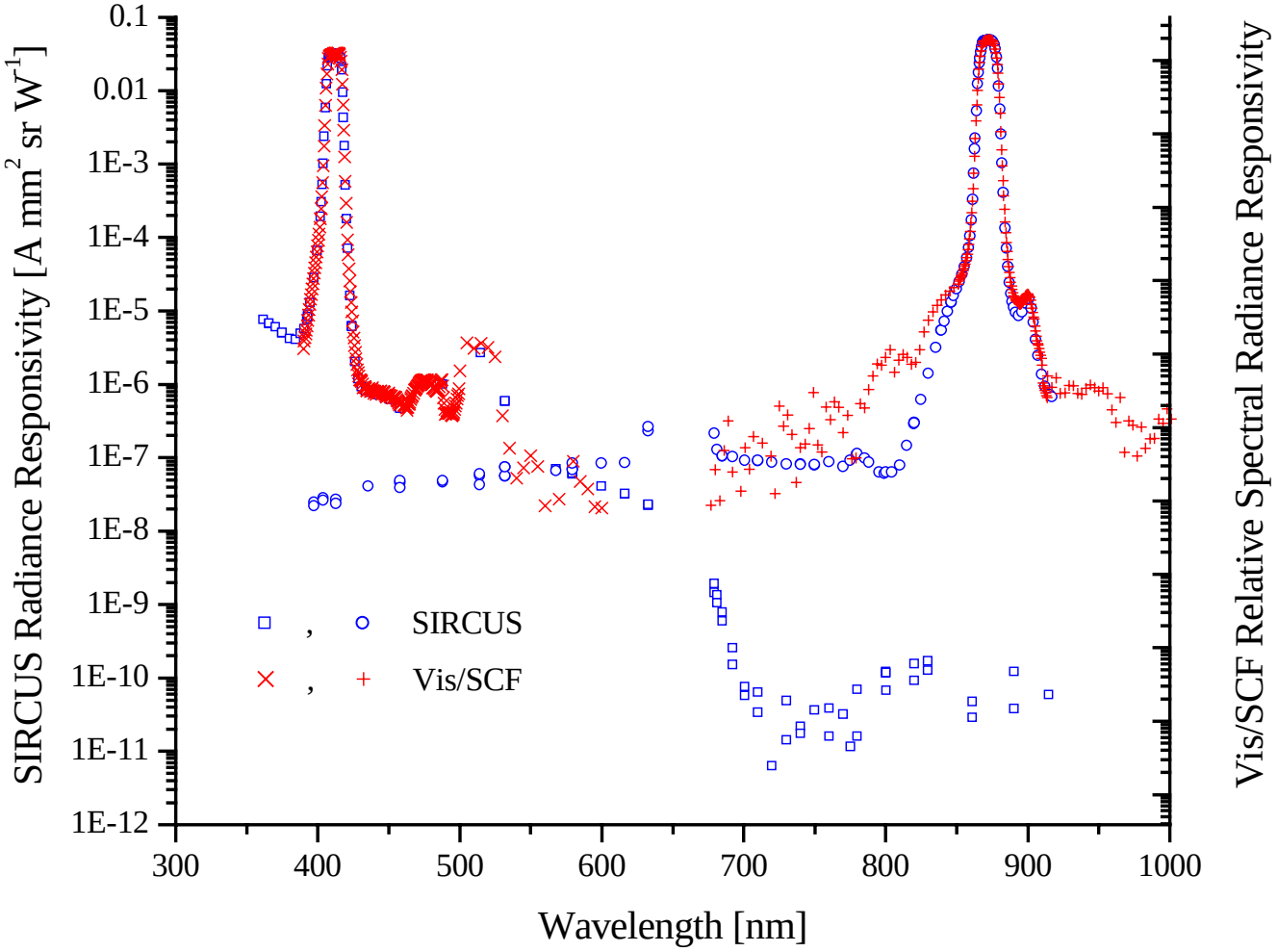
Standard Lamp Monitor (SLMs)



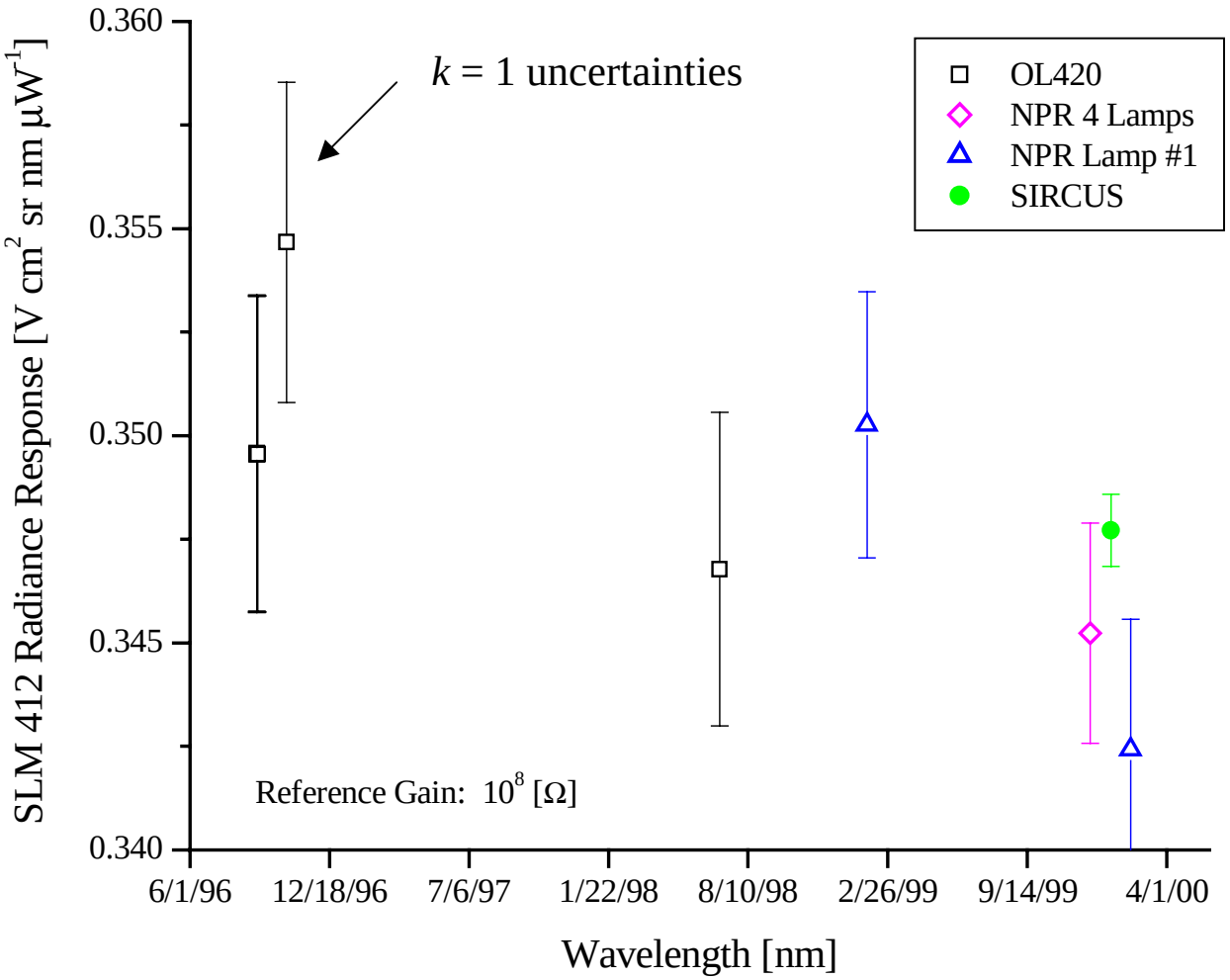


Irradiance Fore Optics
(Exploded View)

Spectral Response—Radiance Mode

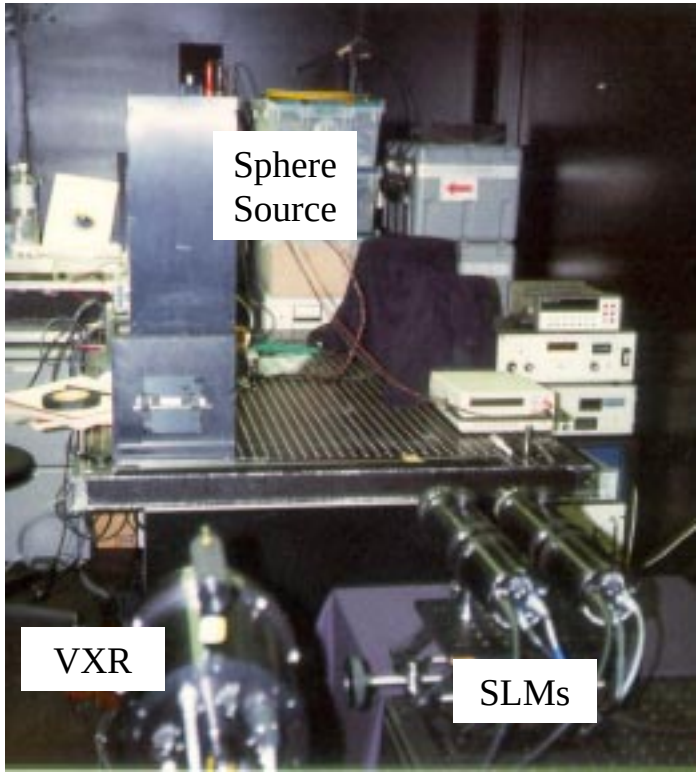


History of SLM 412, Radiance Mode



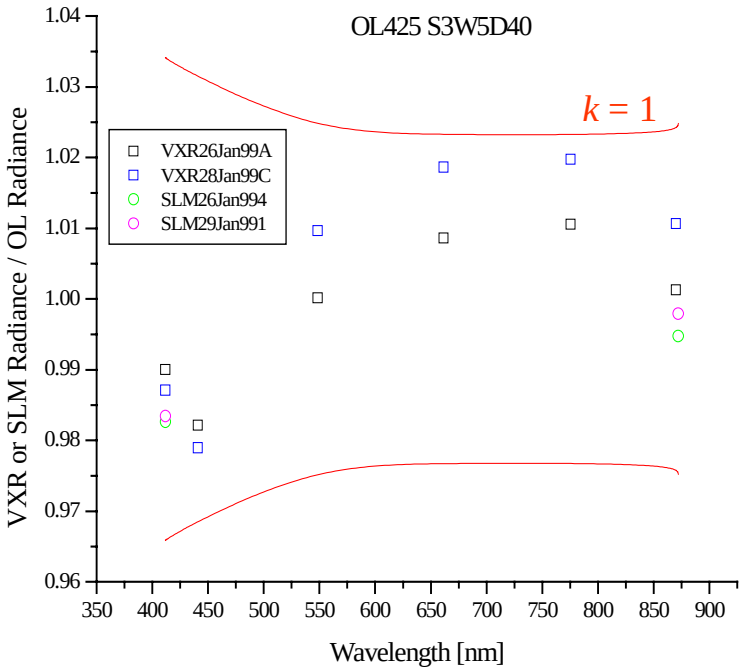
Comparisons at Snug Harbor

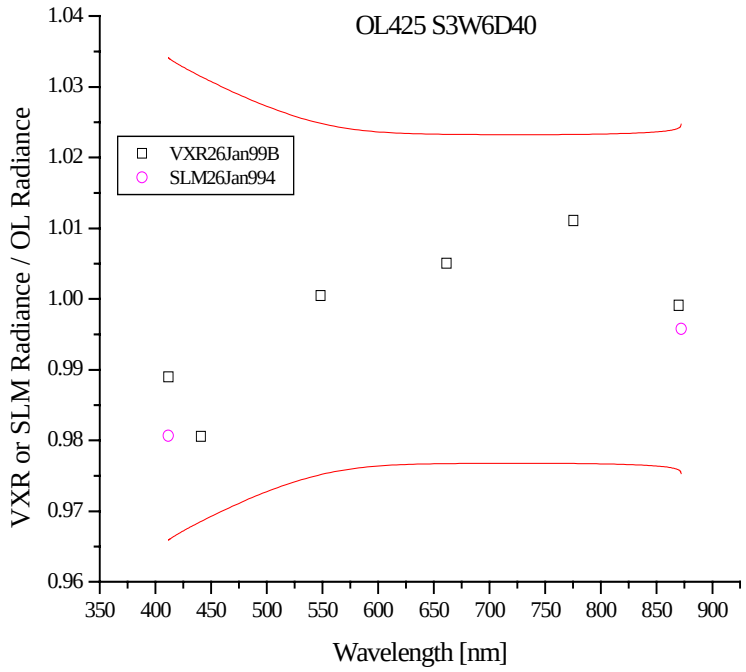
Calibration Hut, Honolulu



- September 1996
  - NIST & SXR
  - SLMs, MOBY, MOS, OL420
- January 1999
  - NIST & VXR, NPR
  - SLMs, MOBY, MOS, MD5, Diver's Lamps, OL420, OL425
- February 2000
  - NIST & VXR, NPR
  - SLMs, MOBY, MOS, OL425

OL425 in 1999

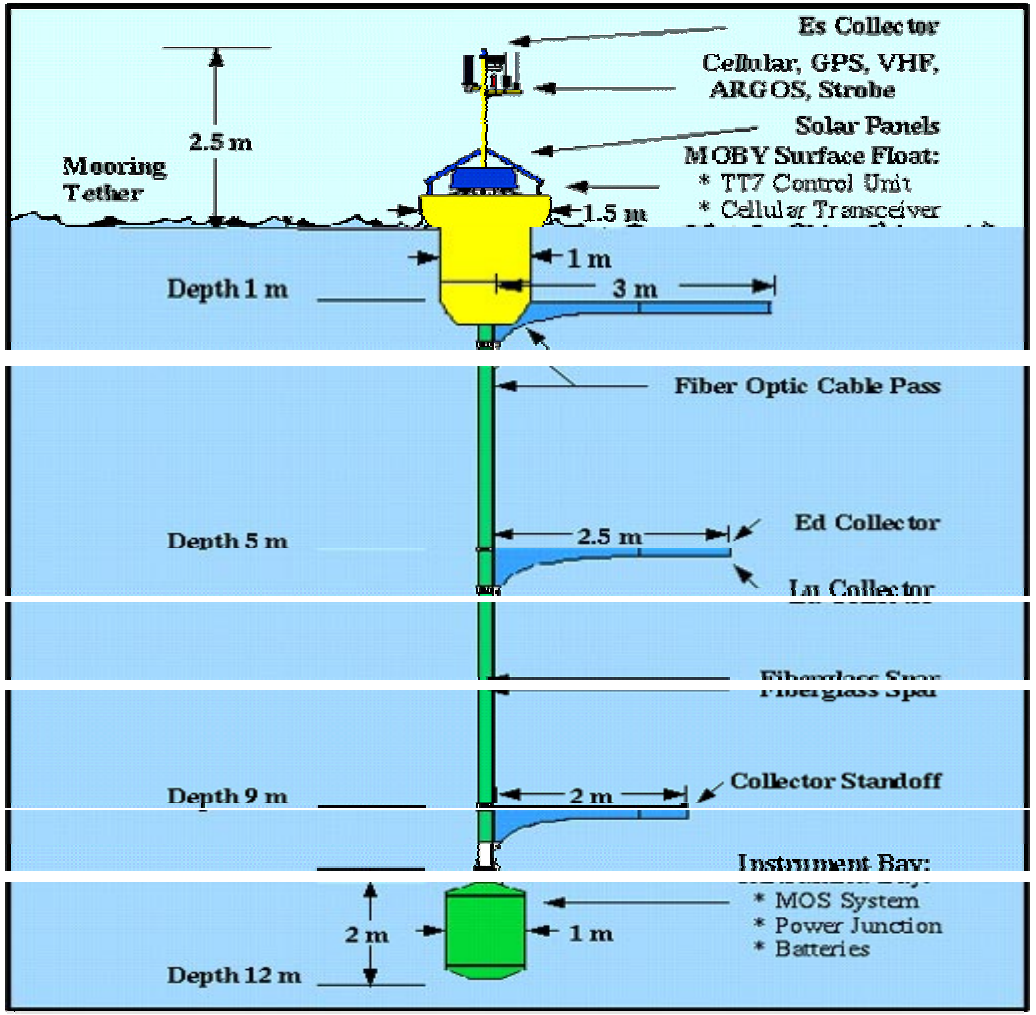




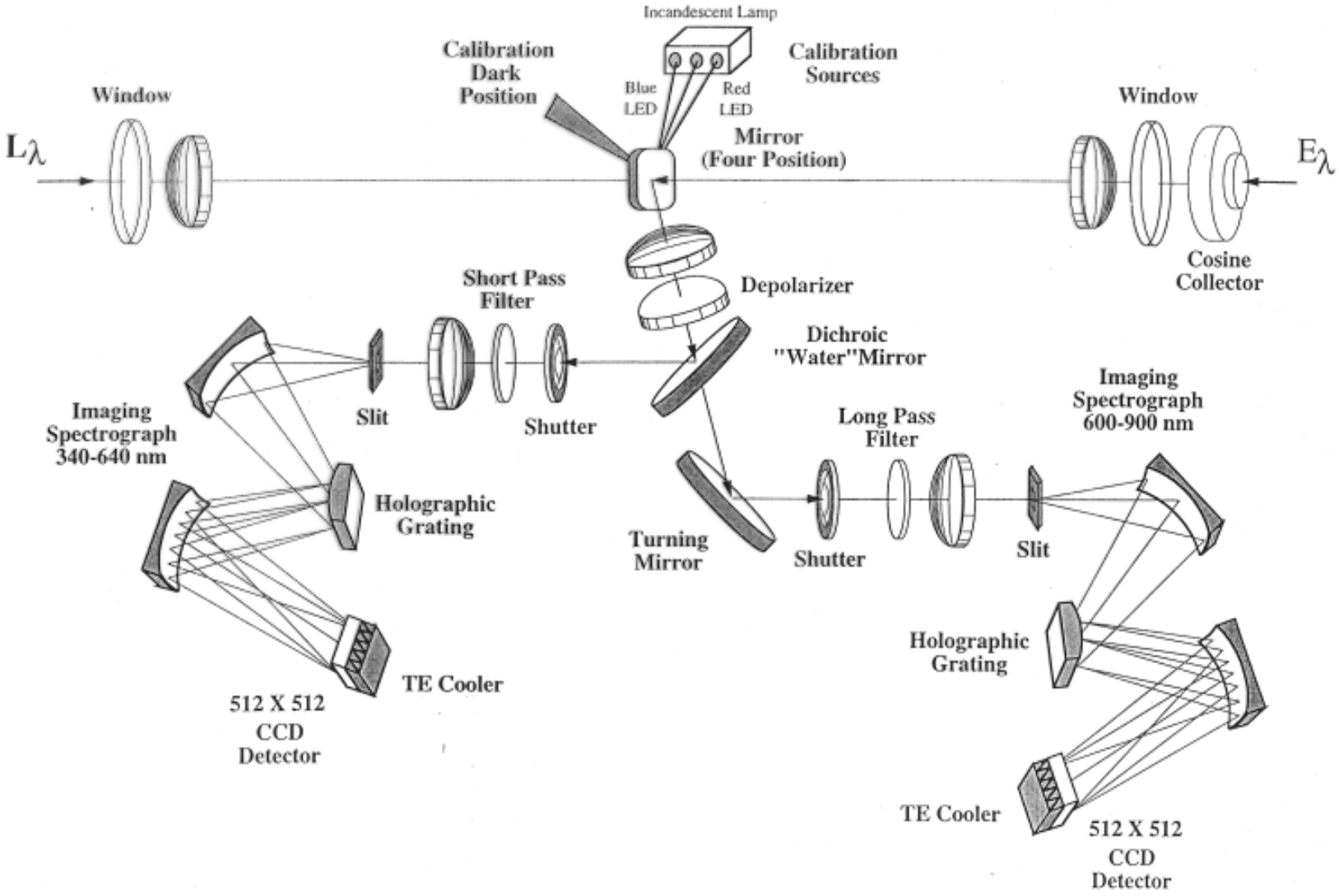
Calibrated at S3W5D100; scaled using OL425 Photometer

Calibrated at S3W6D100; scaled using OL425 Photometer

Marine Optical Buoy (MOBY)

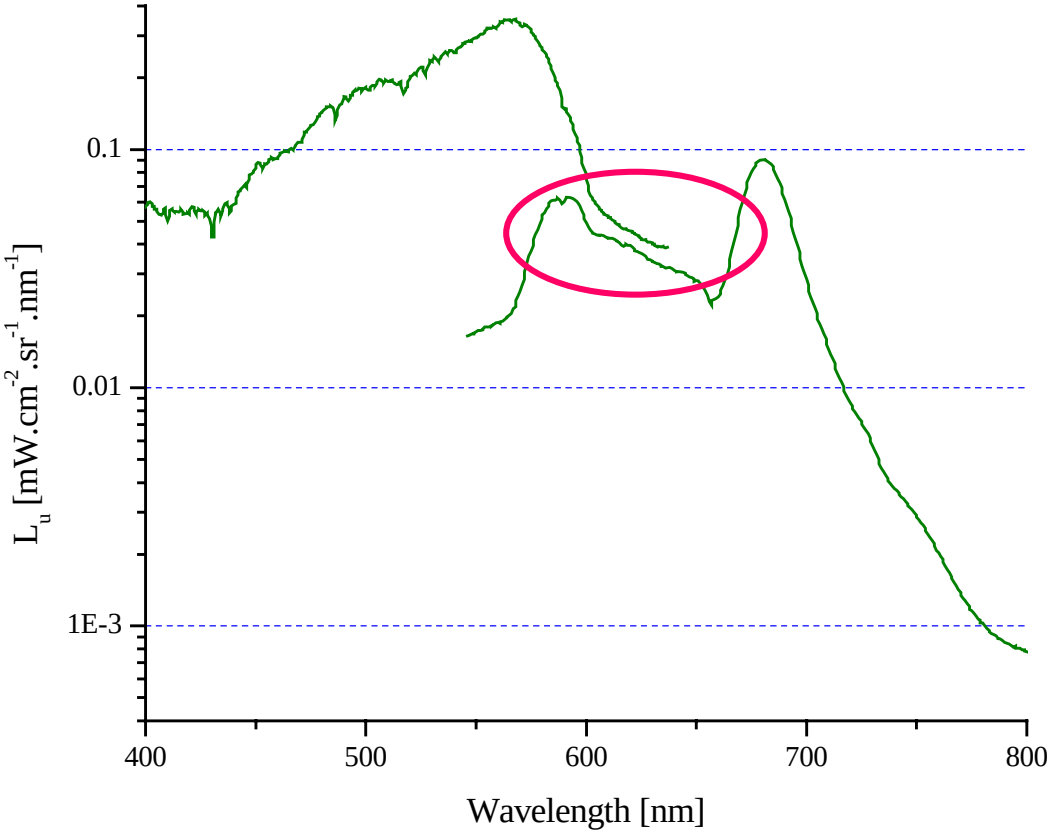


Marine Optical System (MOS)

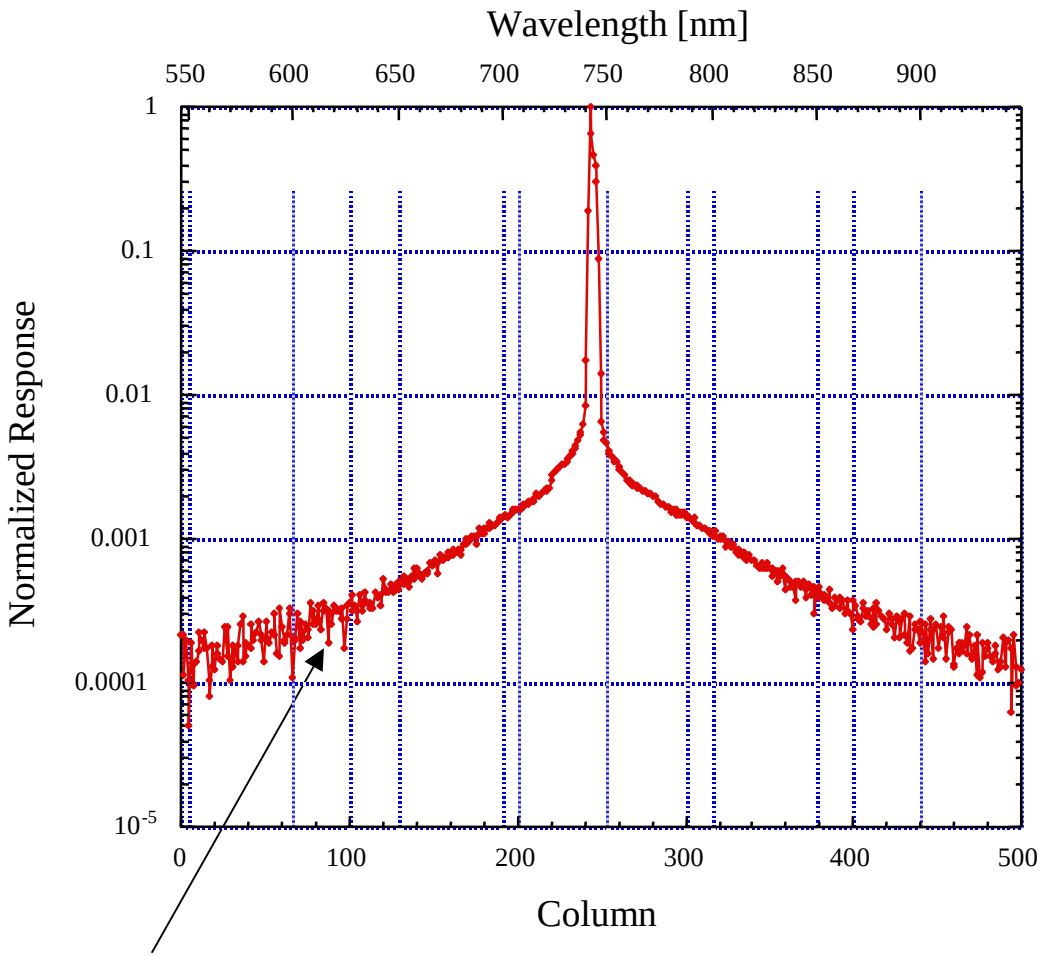


Upwelling Radiance Measurements with MOBY

Measurements with the red and the blue spectrographs disagree in the spectral overlap region

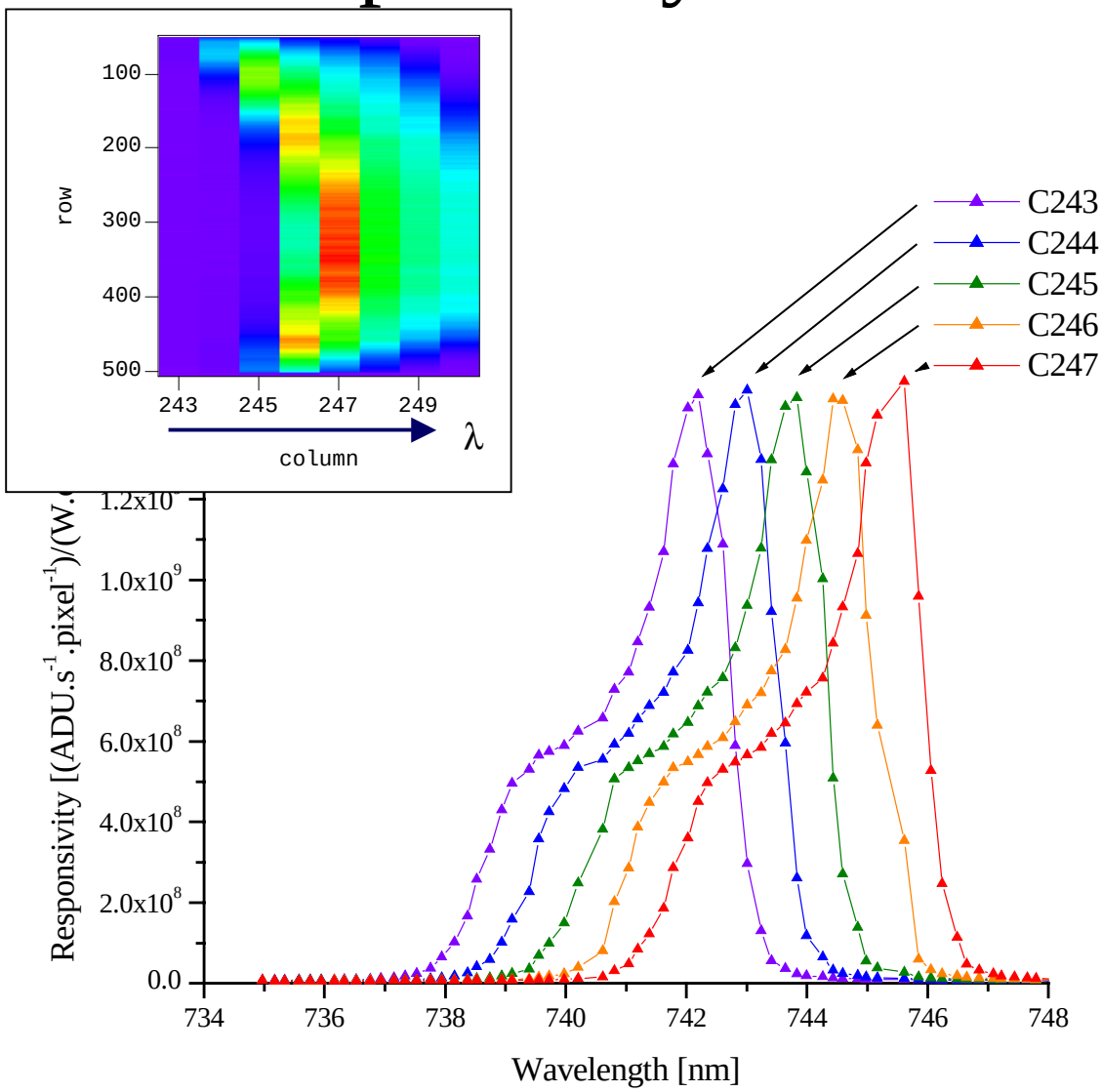


System Response to Monochromatic Excitation



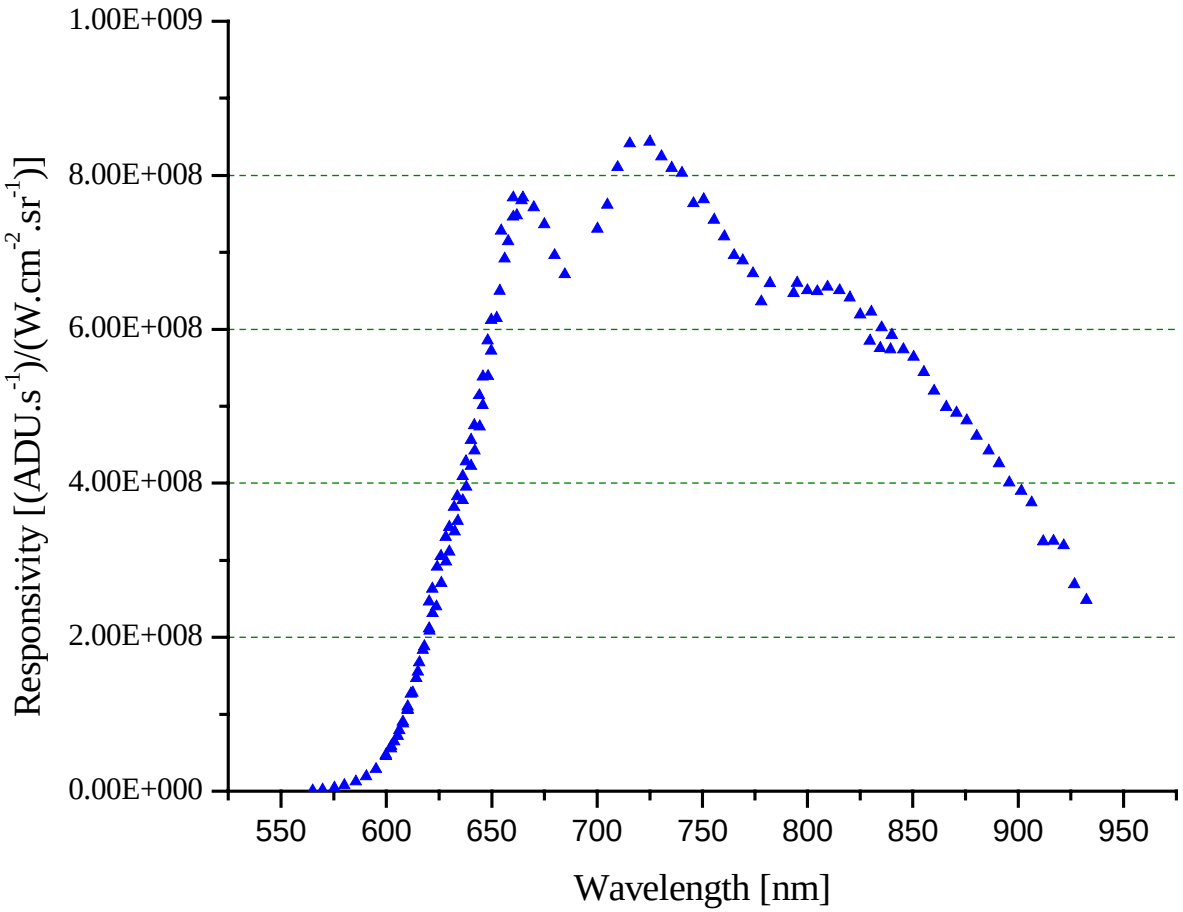
Finite response at pixel 100 (~625 nm)

Responsivity at 0.2 nm steps

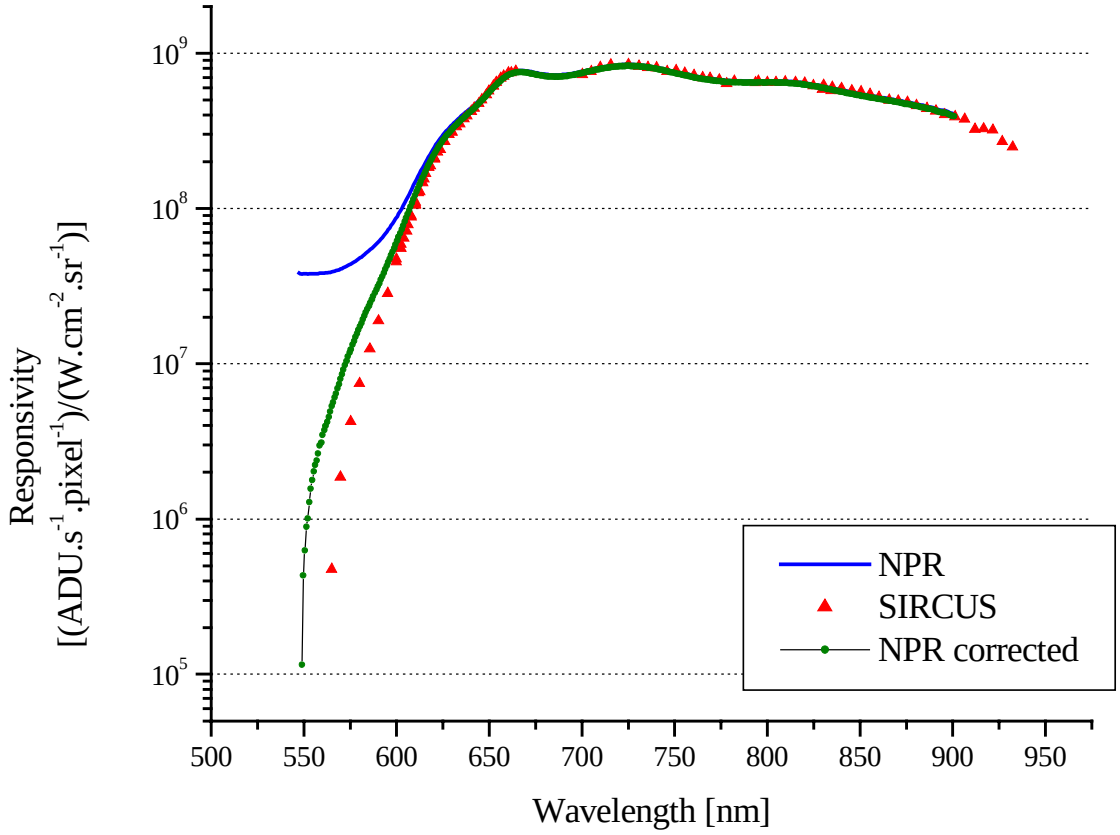


$$\sigma(\lambda - \lambda_0)$$

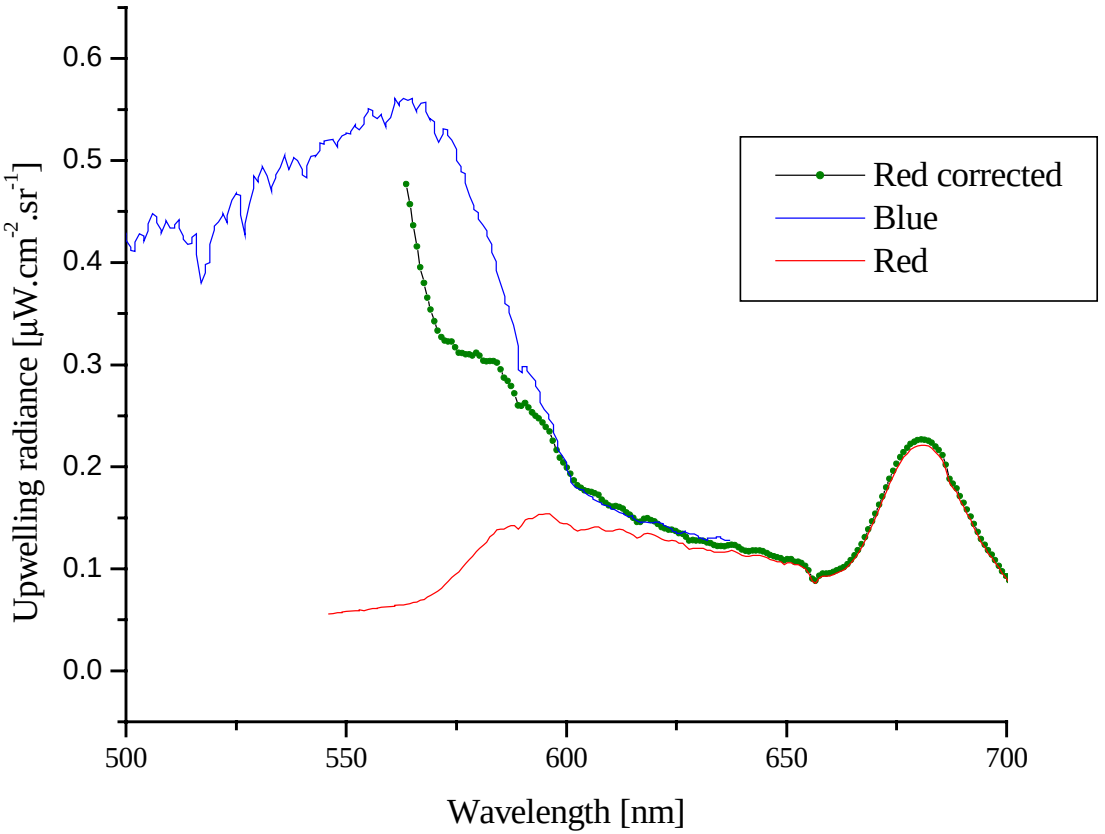
Absolute Spectral Responsivity : $R(\lambda_0)$



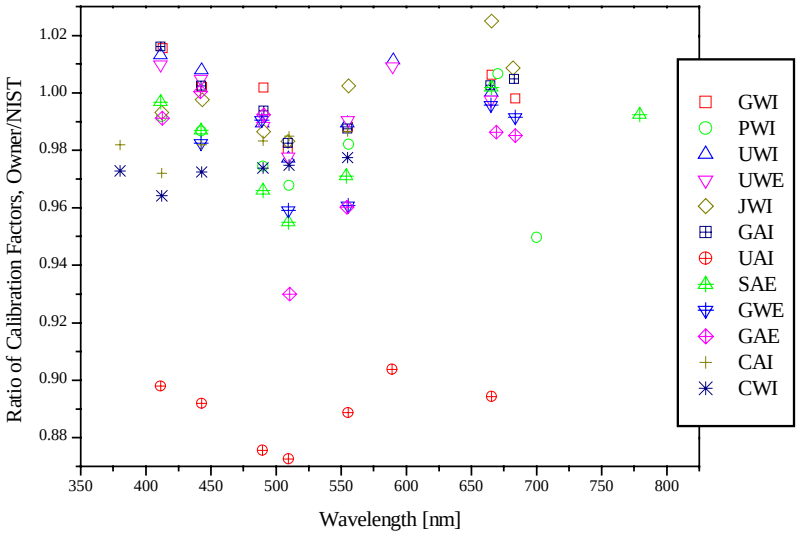
Broadband vs. Narrowband Calibration



Effect on Upwelled Radiance Measurements



SIRREX-5 Results

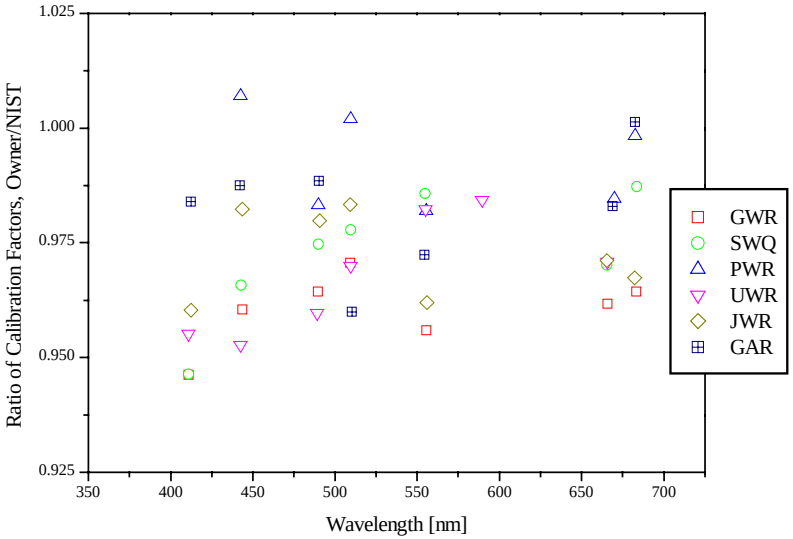


Irradiance

Participant's ocean color radiometers

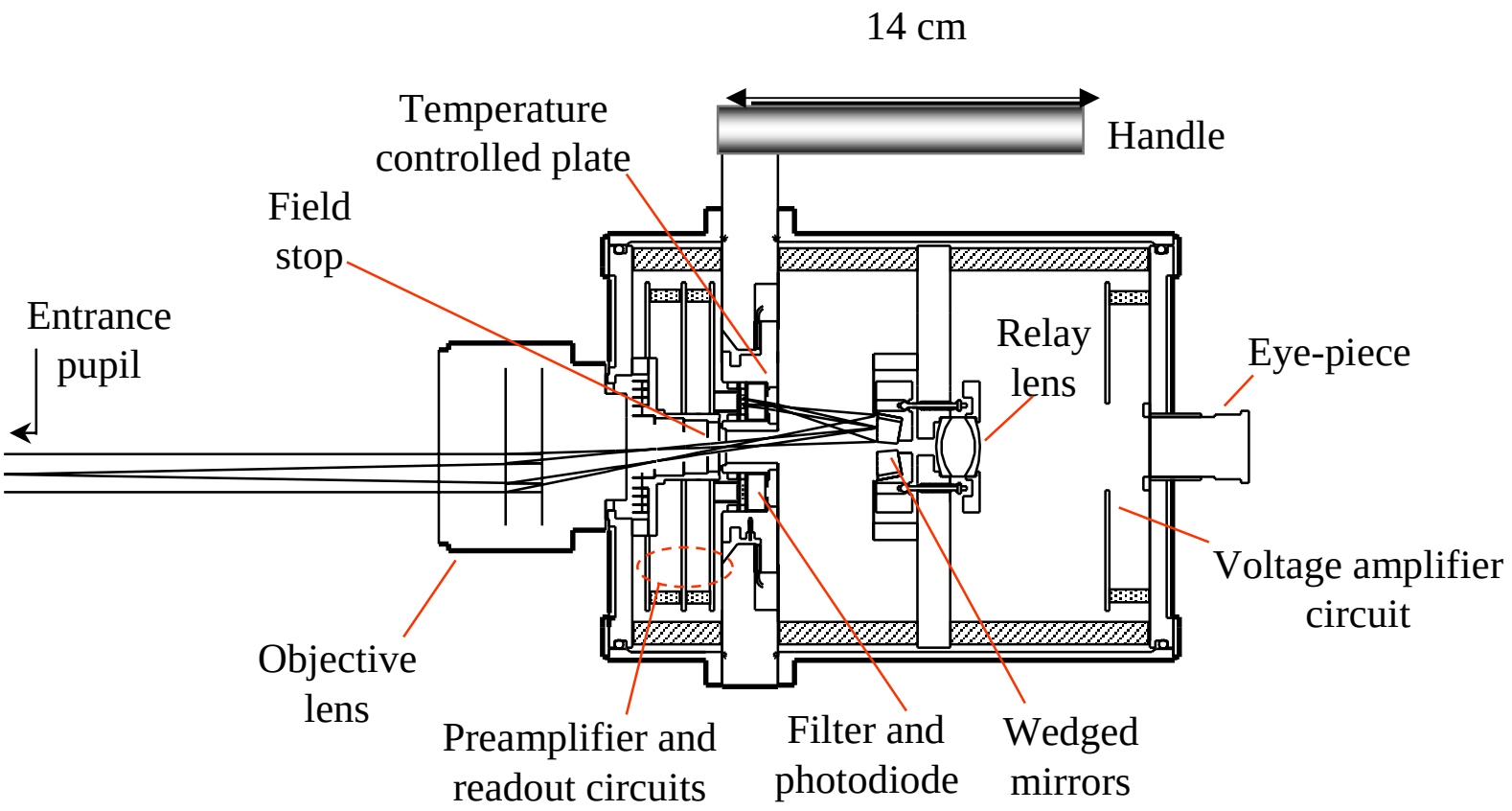
Comparison of Calibration Factors

Owner to NIST

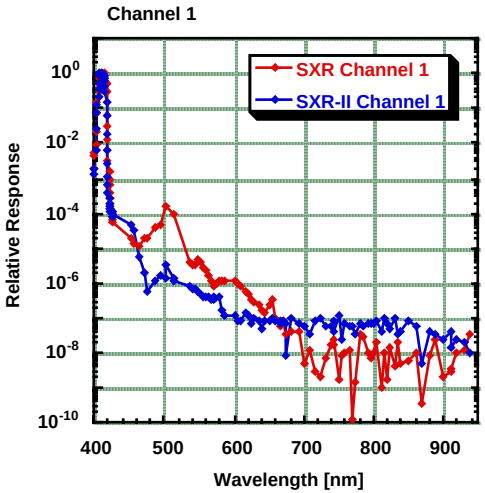


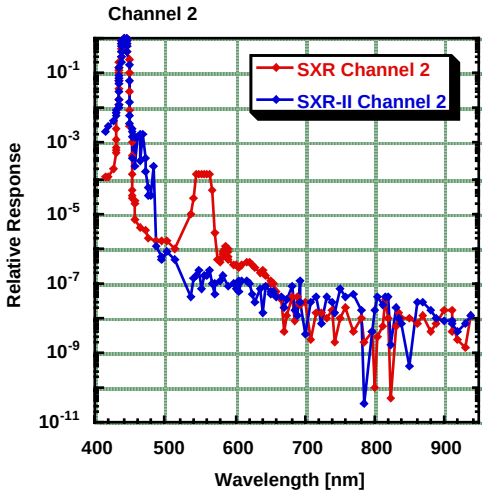
Radiance

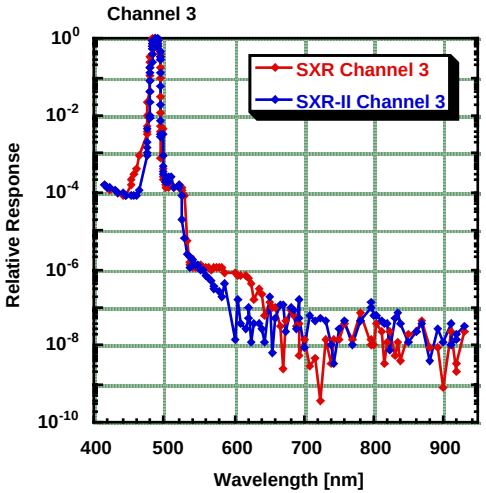
Visible Transfer Radiometer (VXR)

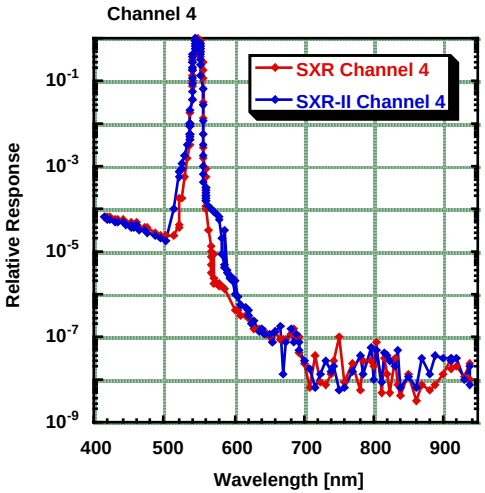


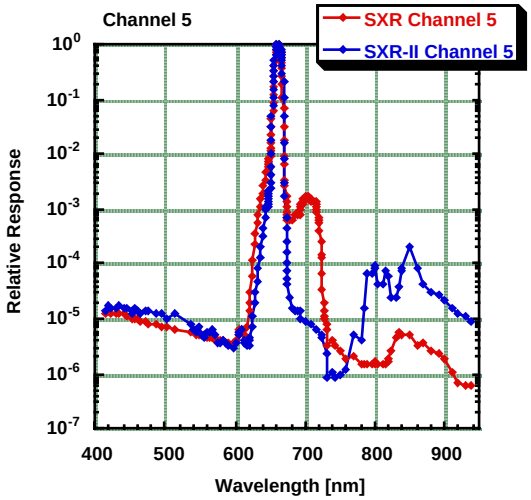
Recent SXR & SXR-2 on SIRCUS

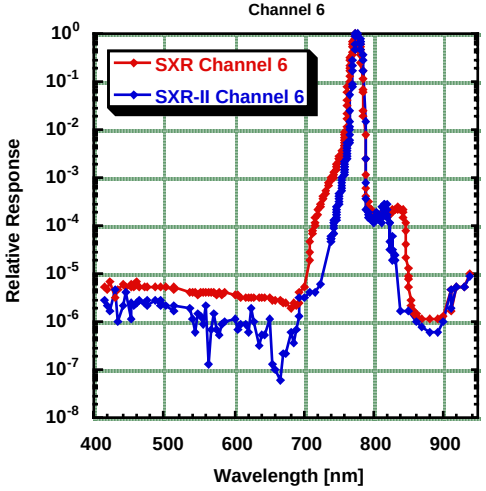












Summary

- Traceability to NIST using specialized artifacts
  - e.g. SLM
- Verification of radiance scales from commercial standards laboratories
  - Snug Harbor
- Problem-solving
  - First calibration and characterization of CCD-based spectrograph using narrowband source (SIRCUS)
- Establish ‘real-world’ uncertainties
  - e.g. Sirrex 5