Some NIST Capabilities Related to CLARREO

Joseph Rice, Sergey Mekhontsev, Leonard Hanssen, Eric Shirley, Jinan Zeng, Steve Brown, Keith Lykke, Allan Smith, Carol Johnson, Robert Saunders, Toni Litorja, Joel Fowler, Stephen Maxwell, David Allen, Howard Yoon, Jeanne Houston, and Jerry Fraser

Optical Technology Division
National Institute of Standards and Technology
Gaithersburg, MD 20899 USA

Note. References are made to certain commercially-available products in this presentation to adequately specify the experimental procedures involved. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that these products are the best for the purpose specified.

Outline: Some NIST Capabilities Related to CLARREO

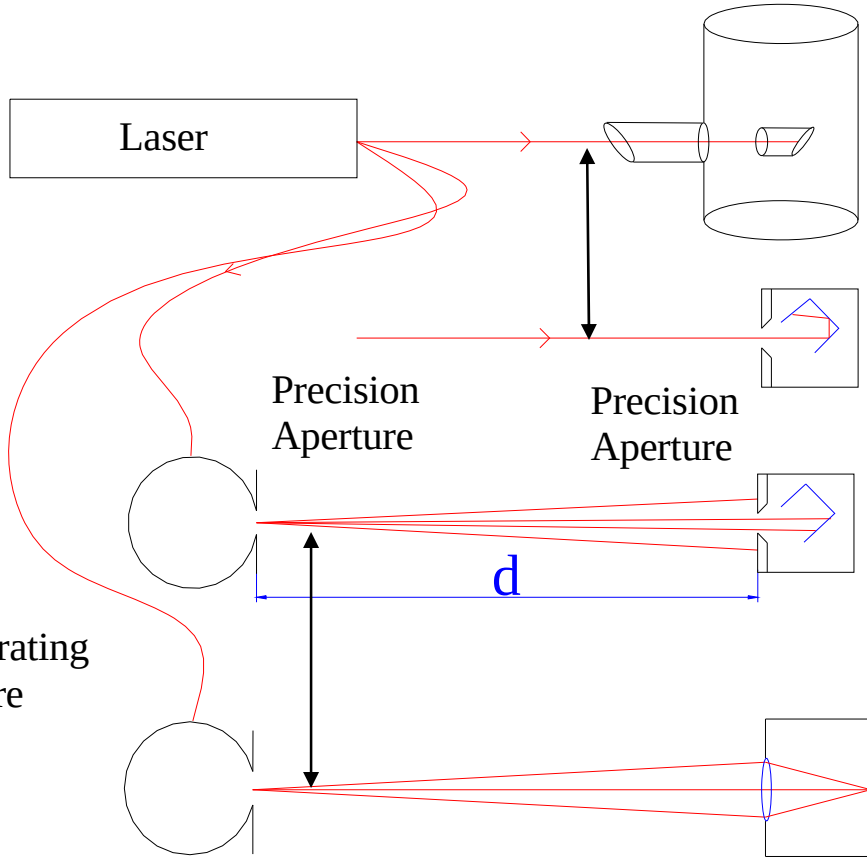
Solar-Reflected (Joe Rice, first half)

- Spectral Irradiance and Radiance Responsivity with Uniform Sources (SIRCUS)
- Hyperspectral Image Projector (HIP)
- Absolute Spectrally-Tunable Detector-Based Source

IR (Sergey Mekhontsev, 2nd half)

- Diffuse and specular reflectance, transmittance, and emittance using Fourier Transform Spectrometers
- Total-Integrated-Scatter and IR BRDF using IR lasers
- Standard and Transfer Blackbodies
- Operation in a vacuum chamber: CBS3

Establishment of the Spectral Radiance Responsivity Scale at SIRCUS



At each laser wavelength:

1. Measure Power Responsivity And Convert to Irradiance Responsivity Using Trap Aperture Area

2. Measure Sphere Irradiance And convert to Sphere Radiance Using d and Sphere Aperture Area

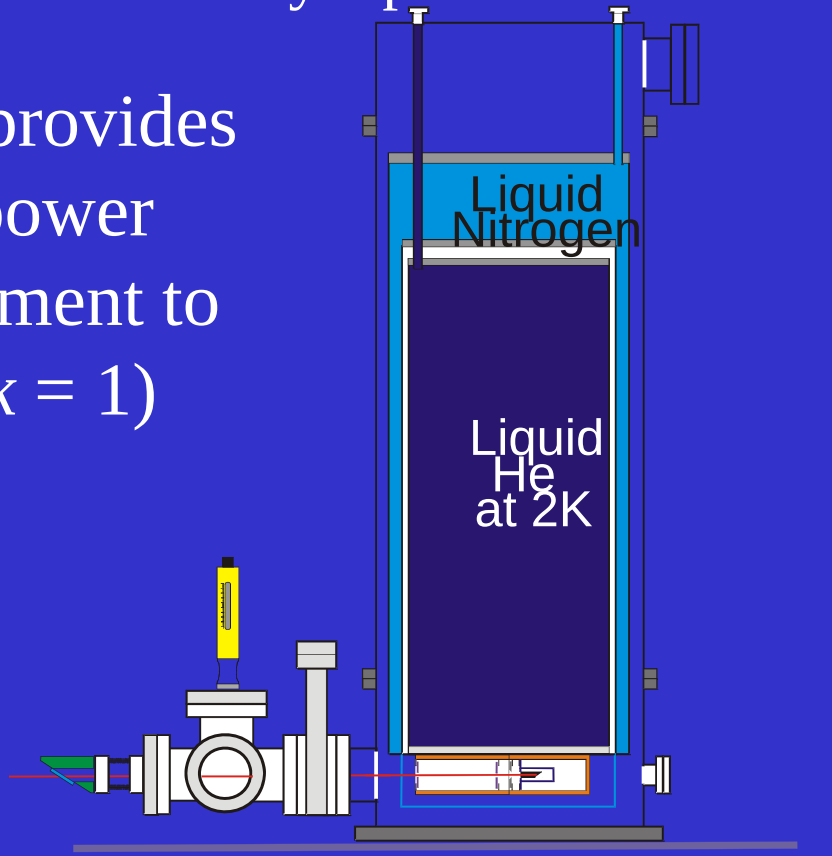
3. Measure Radiance Responsivity of Radiation Thermometer

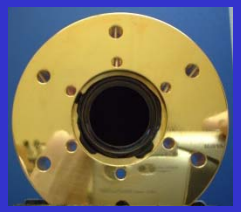
$$L(\lambda,T)=\frac{c_{1L}}{n^2\lambda^5\left(\exp\left(\frac{hc}{n\lambda kT}\right)-1\right)}$$

For realization and dissemination of temperature scales above Ag freezing point: RadiationThermometer assigns temperature T to blackbody based on radiance L.

NIST Optical Measurements are Traceable to the Electrical Watt through the Primary Optical Watt Radiometer (POWR)

- POWR provides optical power measurement to 0.01% (k = 1)

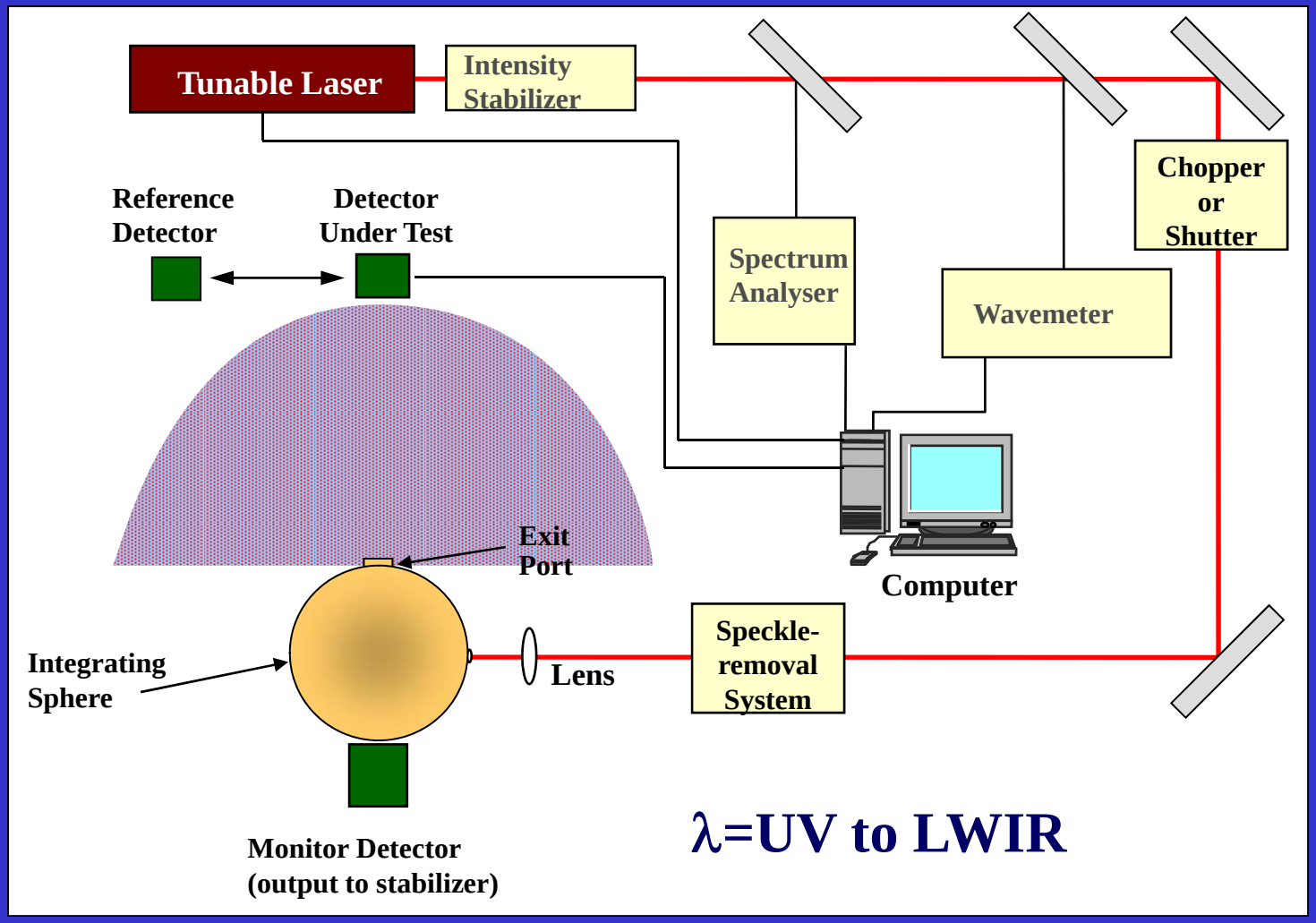




Allan Smith, Jeanne Houston, Joe Rice

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

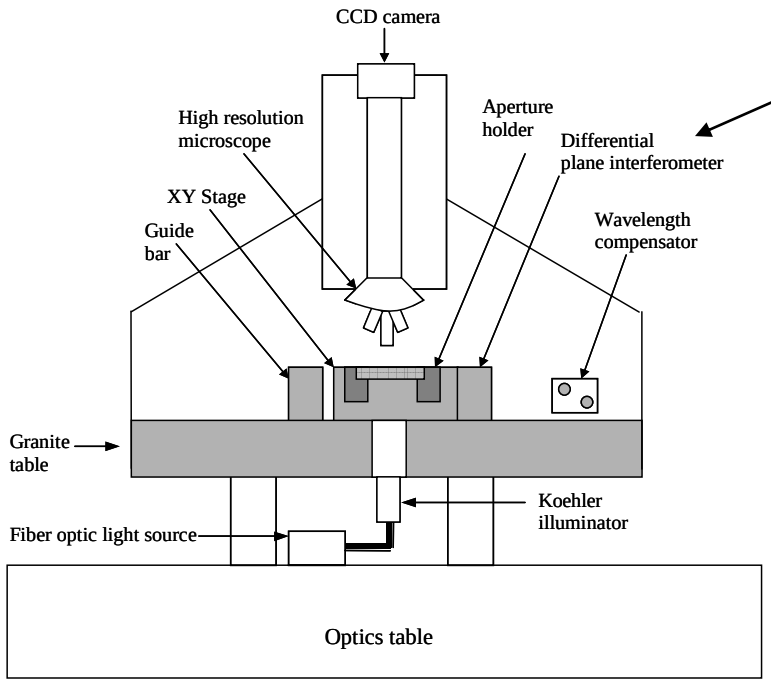
- A version of this will be implemented at NASA Goddard for use with testing the Solar Reflected CLARREO Calibration Development System



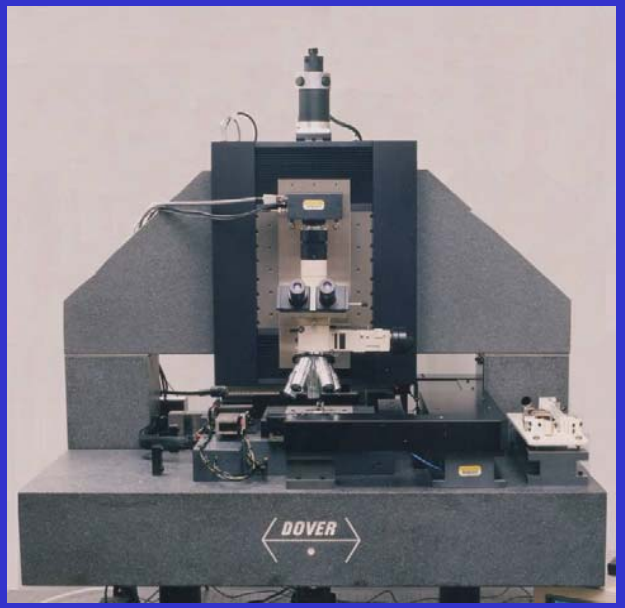
Keith Lykke
Steve Brown
George Eppeldauer

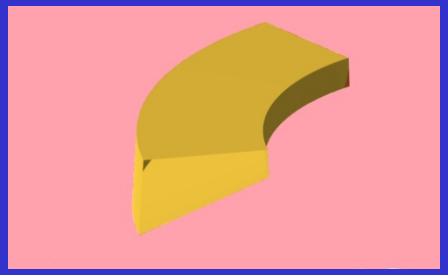
Aperture Area Measurements are Performed at NIST by the Absolute Aperture Area Measurement Machine

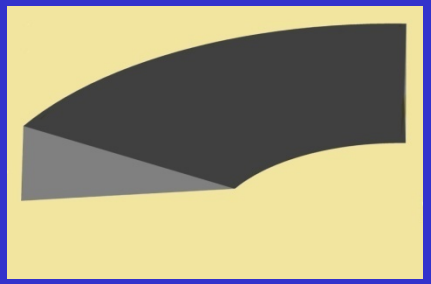
Aperture area measured to better than 0.01%



Length metrology through interferometer traceable to HeNe laser wavelength







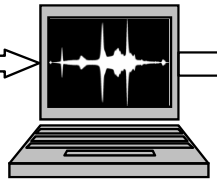
Toni Litorja
Joel Fowler

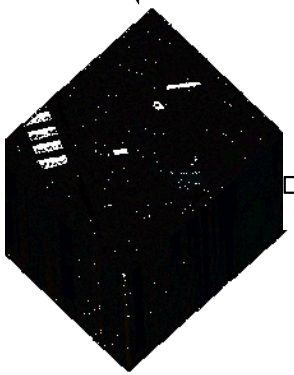
Hyperspectral Image Projector (HIP) Concept

Supercontinuum Light Source

Input Hyperspectral Image Cube

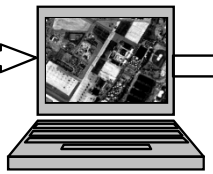
Component Spectra





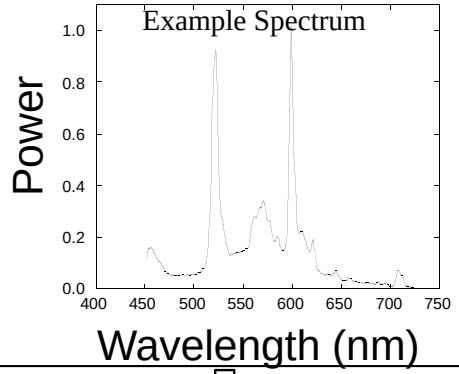
Principle-components-type algorithm reduces image cube to Component Spectra and Abundance Images

Abundance Images



Spectral Engine

- Uses light from supercontinuum source
- Produces programmable spectra that match component spectra
- Directs these to Spatial Engine



Spatial Engine

- Projects images with component spectra into sensor
- Reference instrument characterizes output

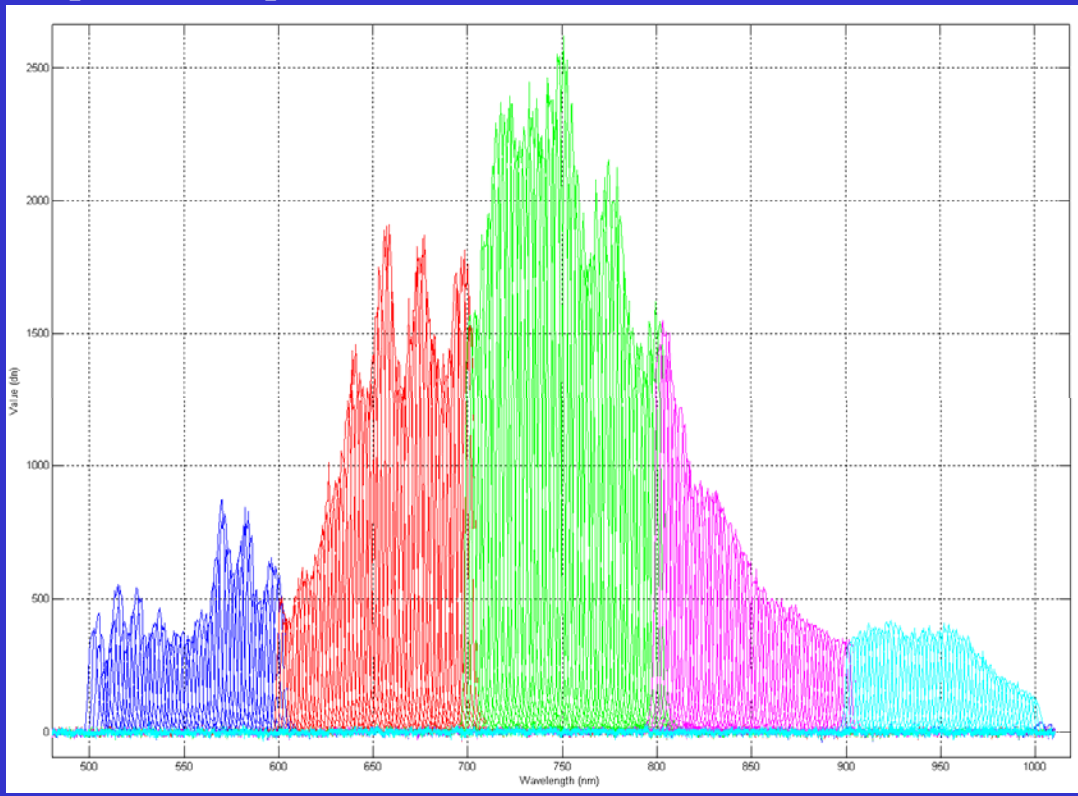
Sensor Under Test

Reference Instrument

LASP IIP Hyperspectral Imager (HSI) Tests at the HIP

- "Sun" scans with solar spectrum
- "MTF" patterns test optical performance and stray light
- Simulated ground track motions of real scene
- Digital attenuation studies validate linearity and attenuations
- Spectral response calibration provides spectral and radiometric calibration

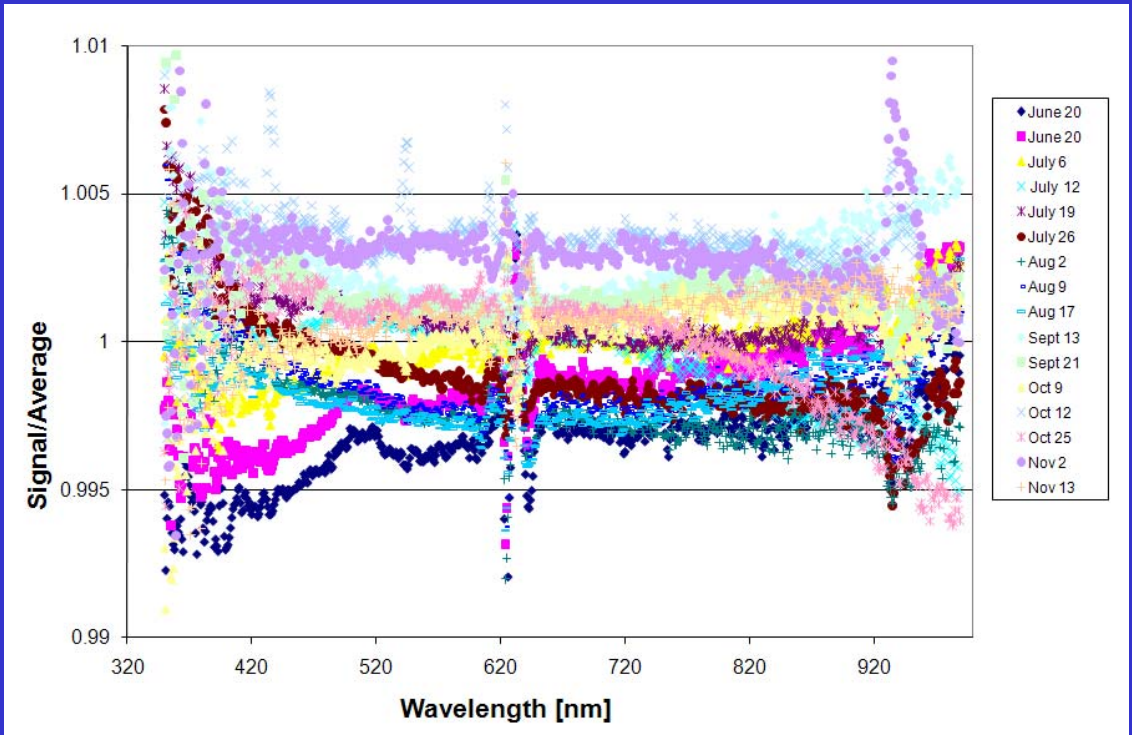
HIP Projected, LASP HSI Measured



Wavelength (nm)

Existing Spectral Radiance Scales Are Based on Lamps

- Laboratory solar-reflected band spectroradiometers have not demonstrated the capability that they can maintain a scale at the 0.1% level (yet). Only about 1% (1sigma) at best.
- Typical results from spectroradiometer measuring lamp-illuminated sphere:



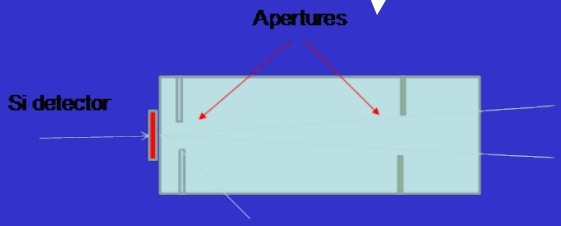
Graphic courtesy of NIST's Remote Sensing Laboratory

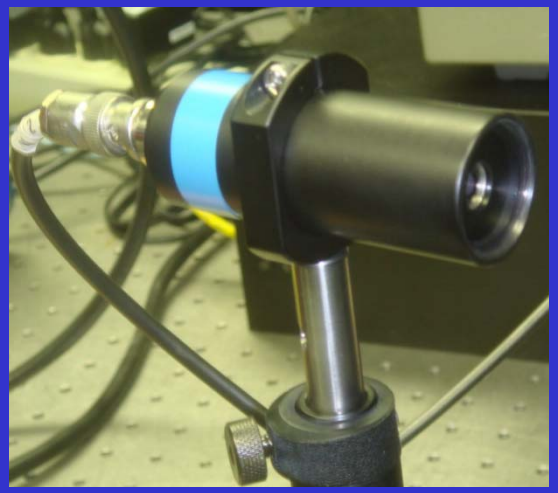
- However, unfiltered radiance detectors **have demonstrated** the potential to hold a radiometric scale at the 0.1% level and better.

Absolute Spectrally-Tunable Detector-Based Source

- Absolute detector measures radiance of single-line spectra
- These data are then used to set the spectral radiance scale use to calibrate spectroradiometer

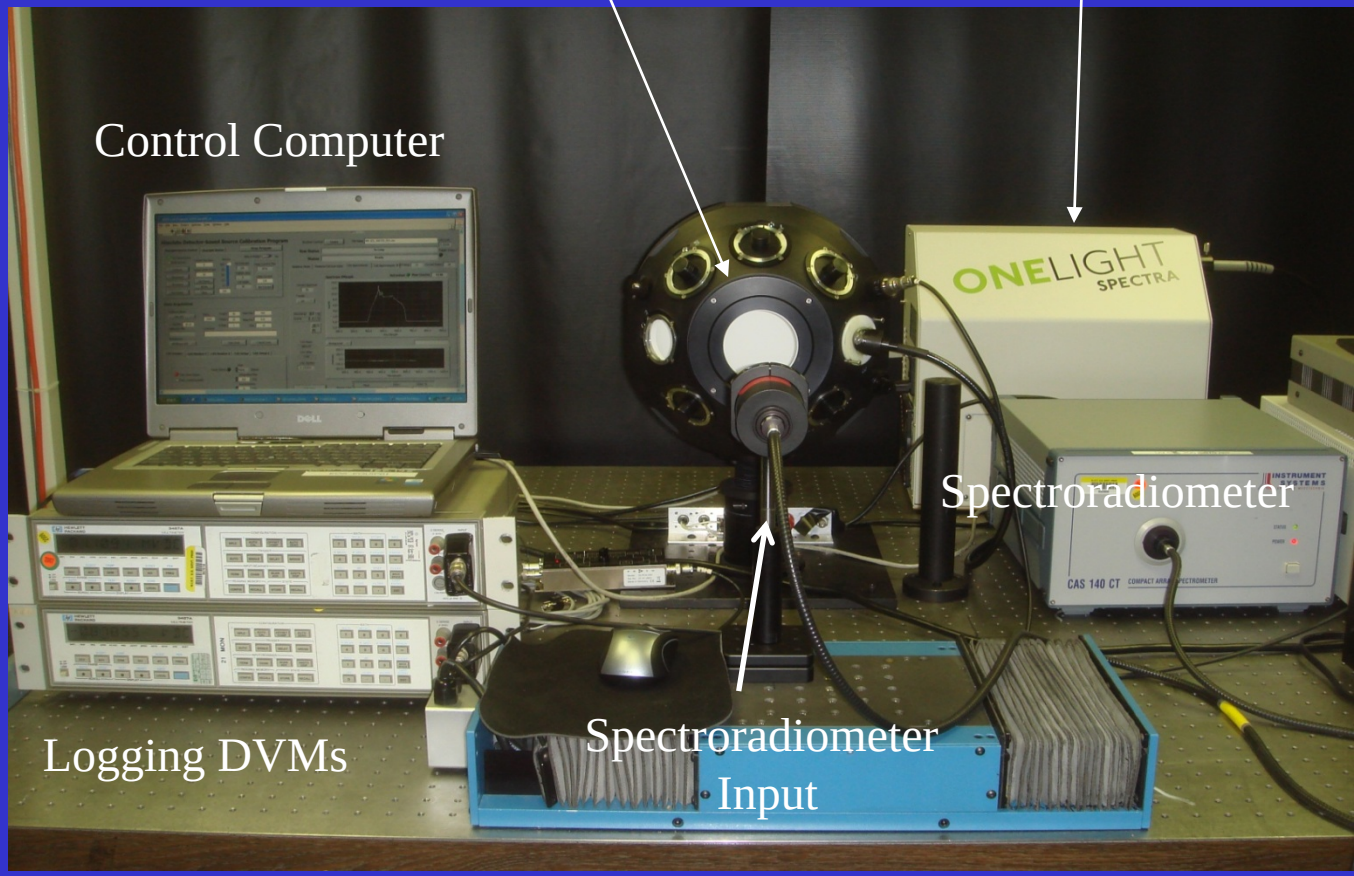
Absolute Radiance Detector





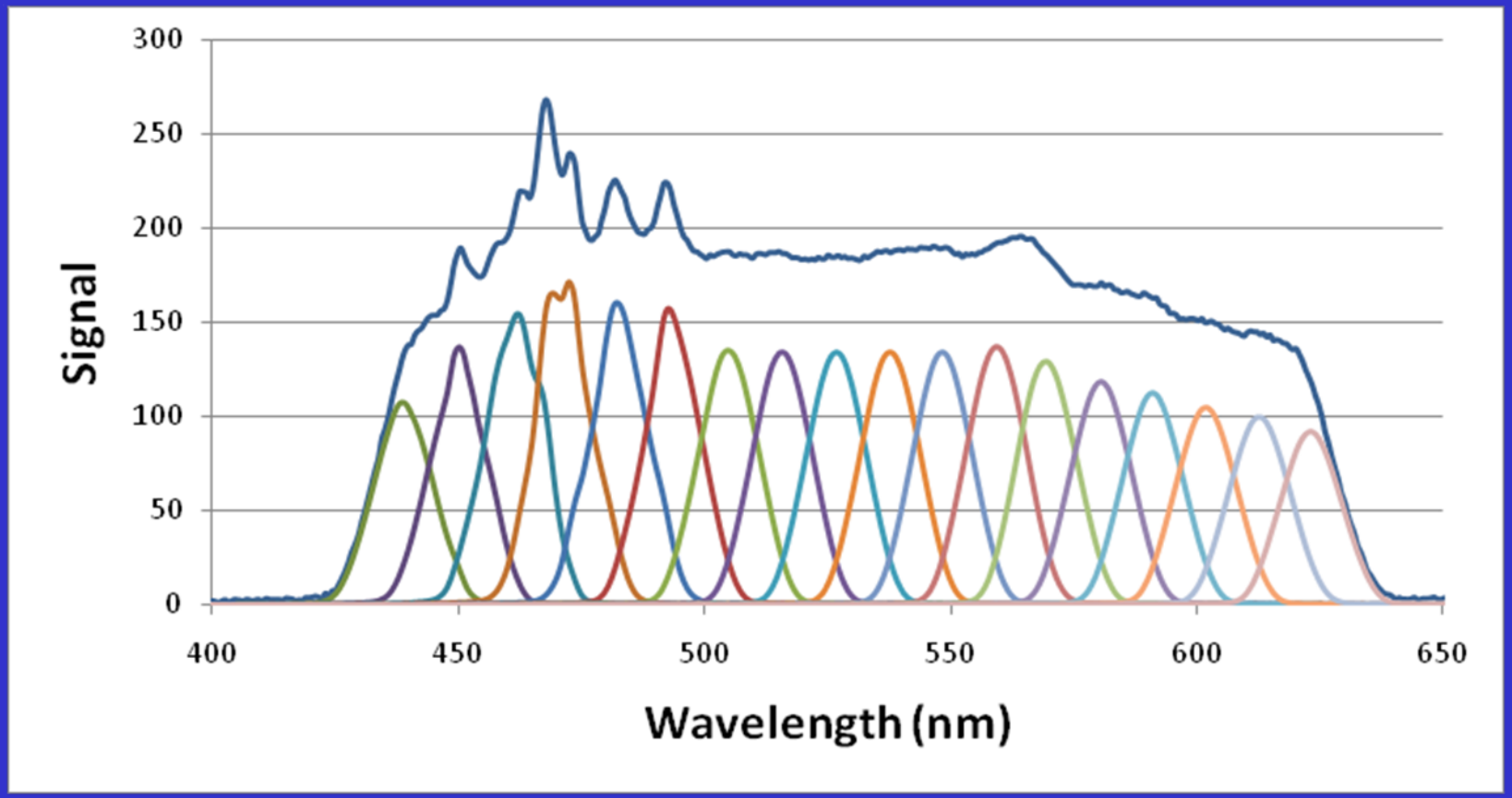
Integrating Sphere

Spectrally-Tunable Source
- currently Vis, lamp-based
- could be from the HIP in future



For more details, see Brown et al., *Proc. SPIE* **7807**, 78070A (2010)

Broadband vs Narrowband Operation



For more details, see Brown et al., *Proc. SPIE* **7807**, 78070A (2010)

Questions?