Hyperspectral Imager Calibration in the Blue: Issues and Experiments

Daniel R Korwan, Rong-Rong Li, Jeffrey H Bowles, W. David Miller, Mary Kappus

Naval Research Laboratory, Washington, DC

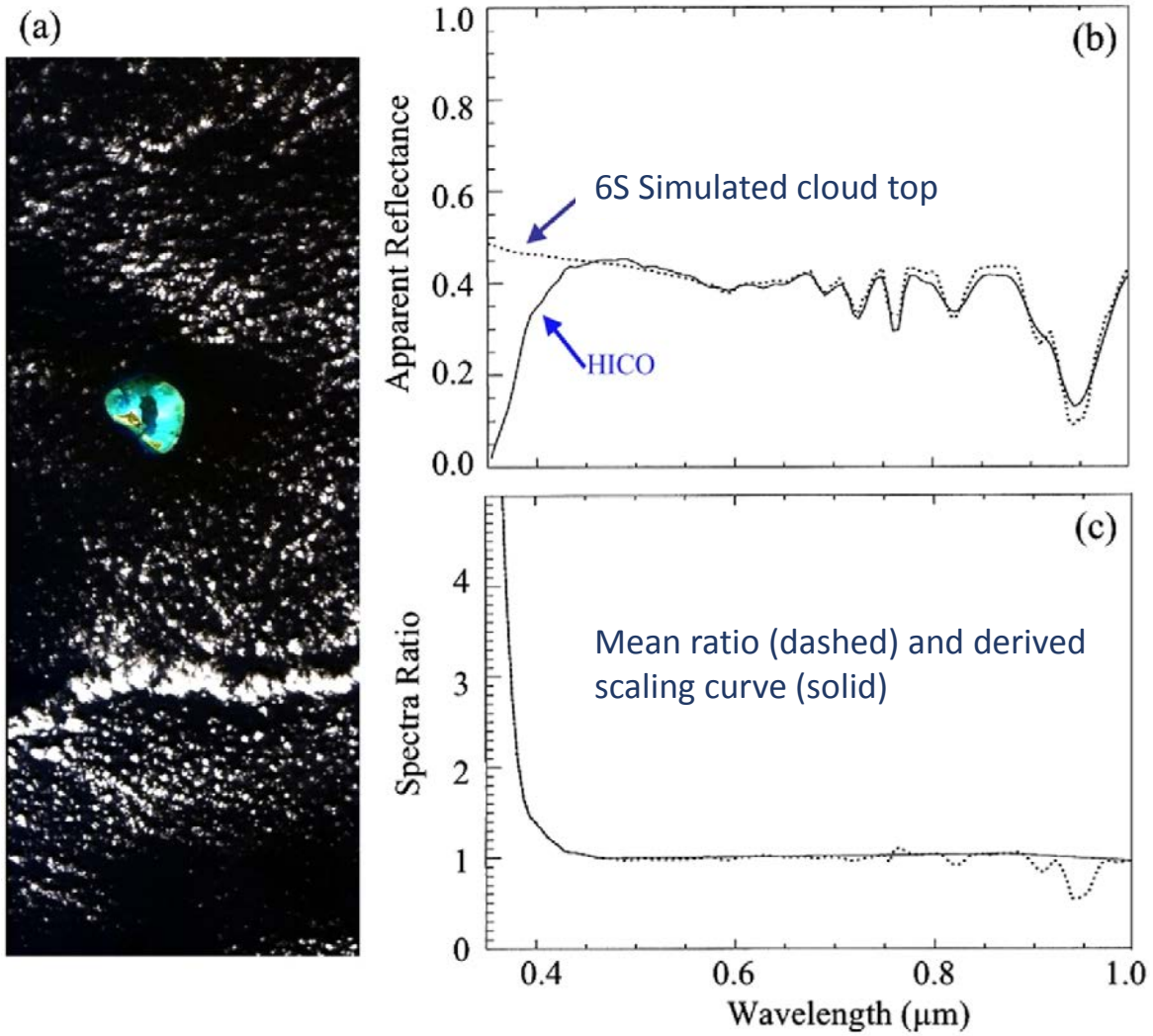
Outline

- What is the blue problem?
- Possible culprits
  - Stray light
  - Polarization
  - Atmospheric correction
- Testing culprits
  - HICO calibrations with two spheres
  - Outdoor testing
  - Sphere testing with asd

What's wrong in the blue?

- Many hyperspectral imagers for in-water applications often have lower than expected radiances at blue wavelengths (below 450-500nm)
  - These can be quite large and even lead to a negative remote sensing reflectance after atmospheric correction
- Examples of Sensors with a blue problem
  - PHILLS
  - CASI
  - HICO
  - microSHINE
  - AISA (Minwei Zhang, et. al. Application of AISA measurements for water quality and benthic habitat mapping in optically shallow waters: challenges in radiometric calibration and atmospheric correction, International Ocean Color Science 2015)
  - Aviris (Gao, Atmospheric correction over water, Hyspiri 2014)
  - Others not published

Blue problem example- HICO



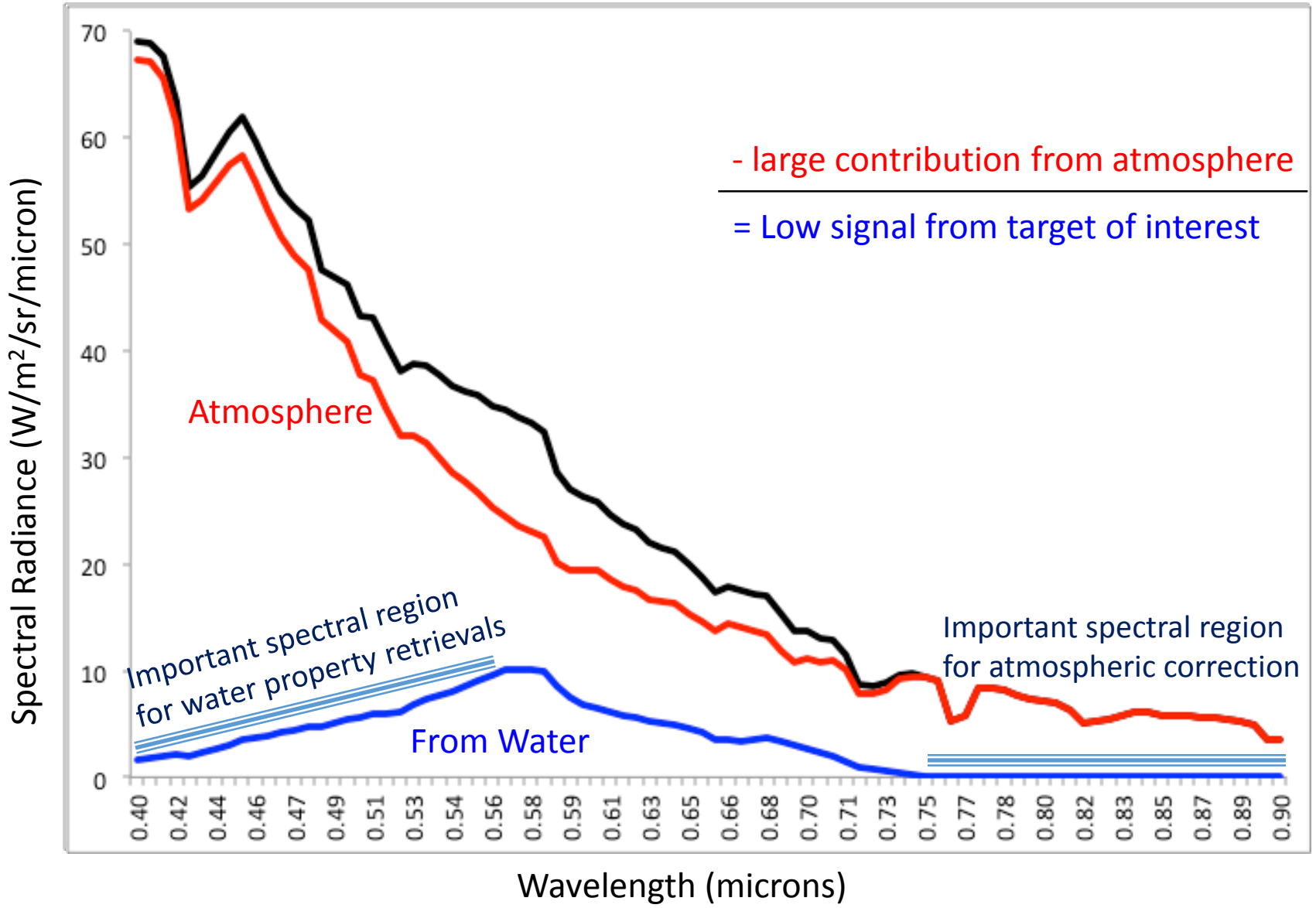
Bo-Cai Gao, Rong-Rong Li, Robert L. Lucke, Curtiss O. Davis, Richard M. Bevilacqua, Daniel R. Korwan, Marcos J. Montes, Jeffrey H. Bowles, Michael R. Corson, "Vicarious calibrations of HICO data acquired from the International Space Station," Appl. Opt. **51,** 2559-2567 (2012);

Possible culprits

- Atmospheric correction
  - Especially over water, small aerosol signal used to remove large atmospheric signal to get at low water leaving radiance
- Polarization
  - Most sensors exhibit some polarization sensitivity due to reflective optics, especially blazed gratings
  - Most environmental signals exhibit at least some degree of polarization
  - Calibration assumes no polarization sensitivity in instrument
- Stray light
  - Out of band stray light could contaminate the in band signal
  - During calibration this could affect the gains, but this won't be a problem unless a differently shaped spectrum is measured
  - Unfortunately typical calibration spheres are weak in the blue and strong in the red, which is opposite from most environmental signals

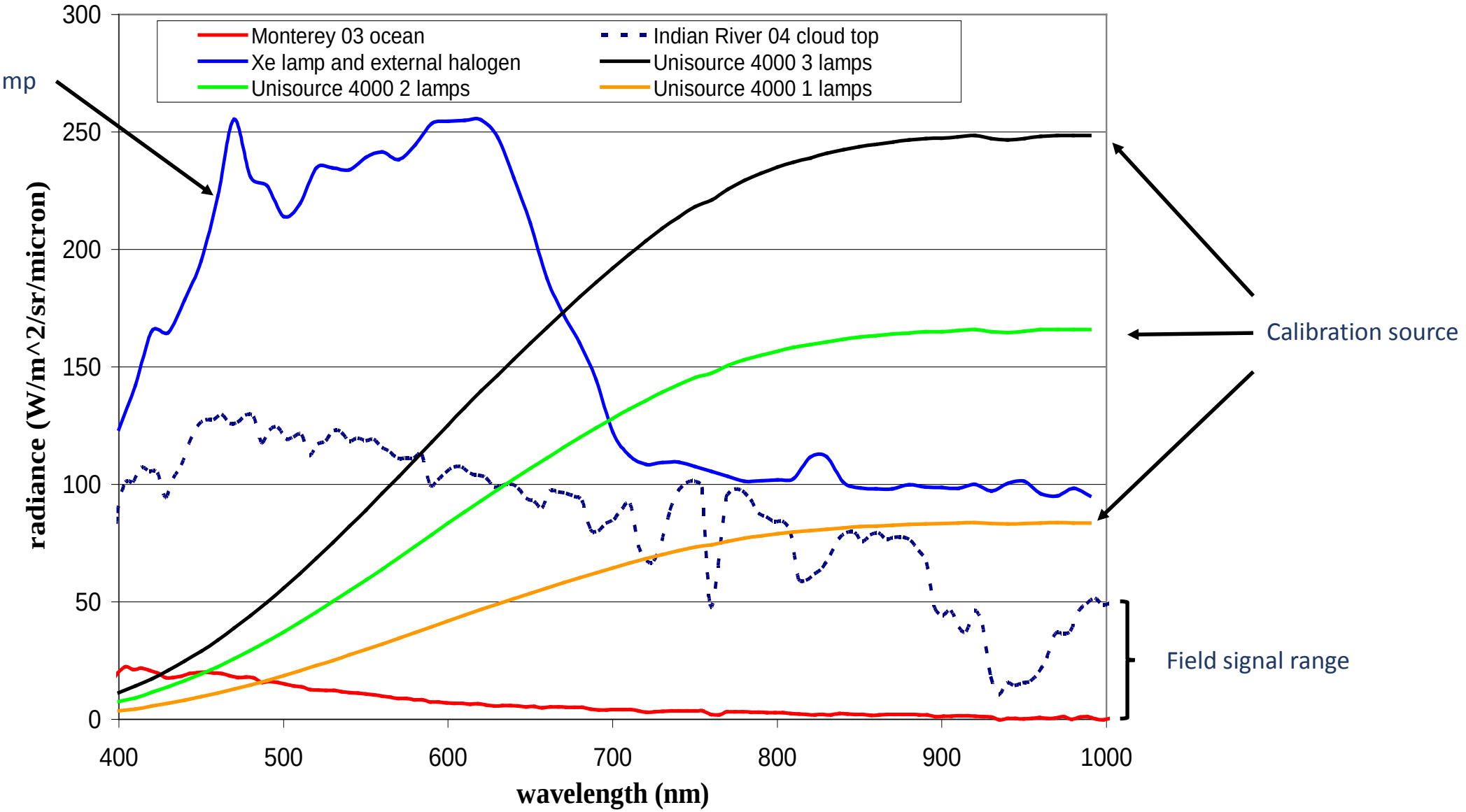
Atmospheric Correction

Radiance from Water, Atmosphere and Total at Sensor

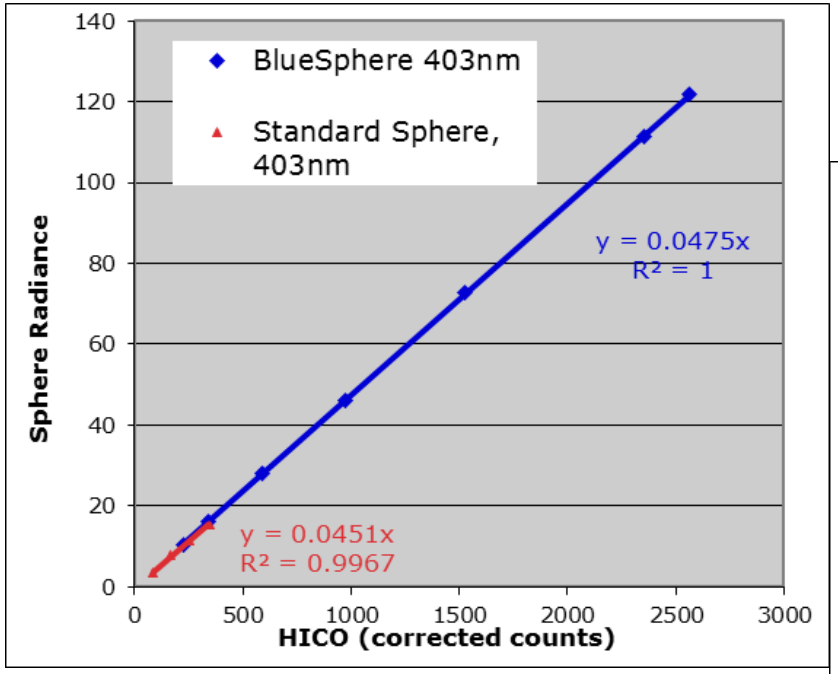


Stray Light- Typical field vs. sphere signals

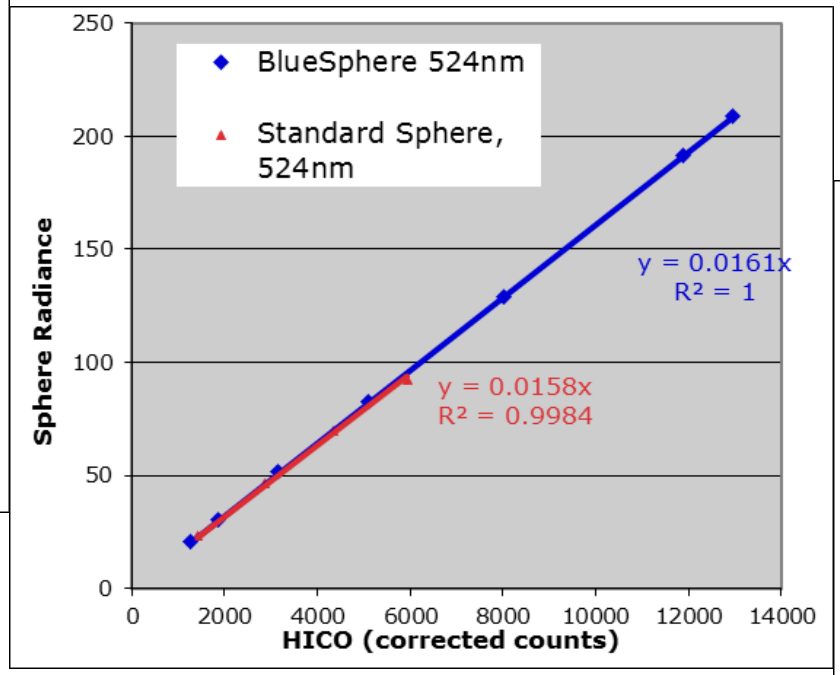
Calibration source enhanced with Xe lamp

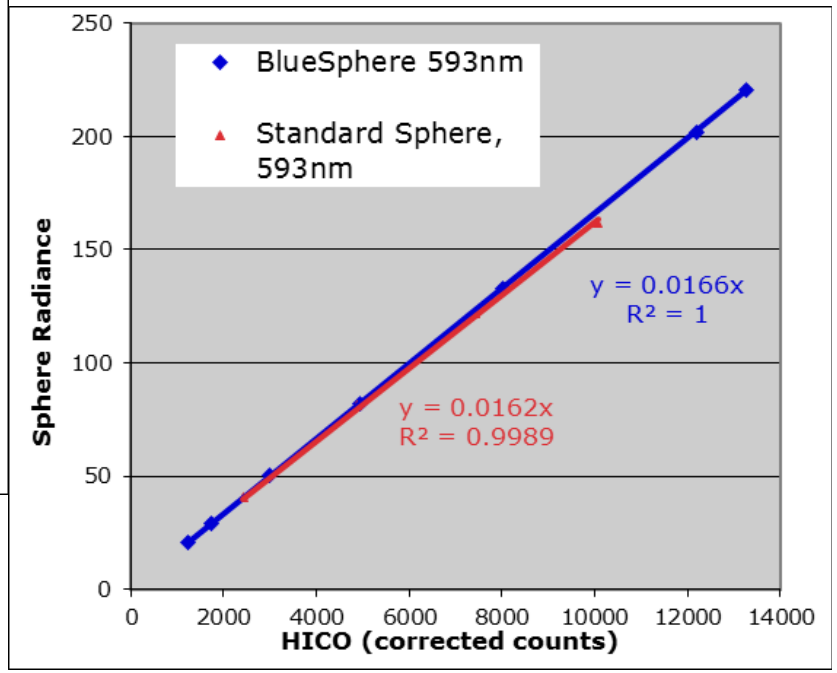


HICO gains blue enhanced vs. halogen spheres- completely different sphere spectra derive same gains



HICO calibrated with blue enhanced source and ND filters (blue line), and halogen source at different lamp levels (red line)



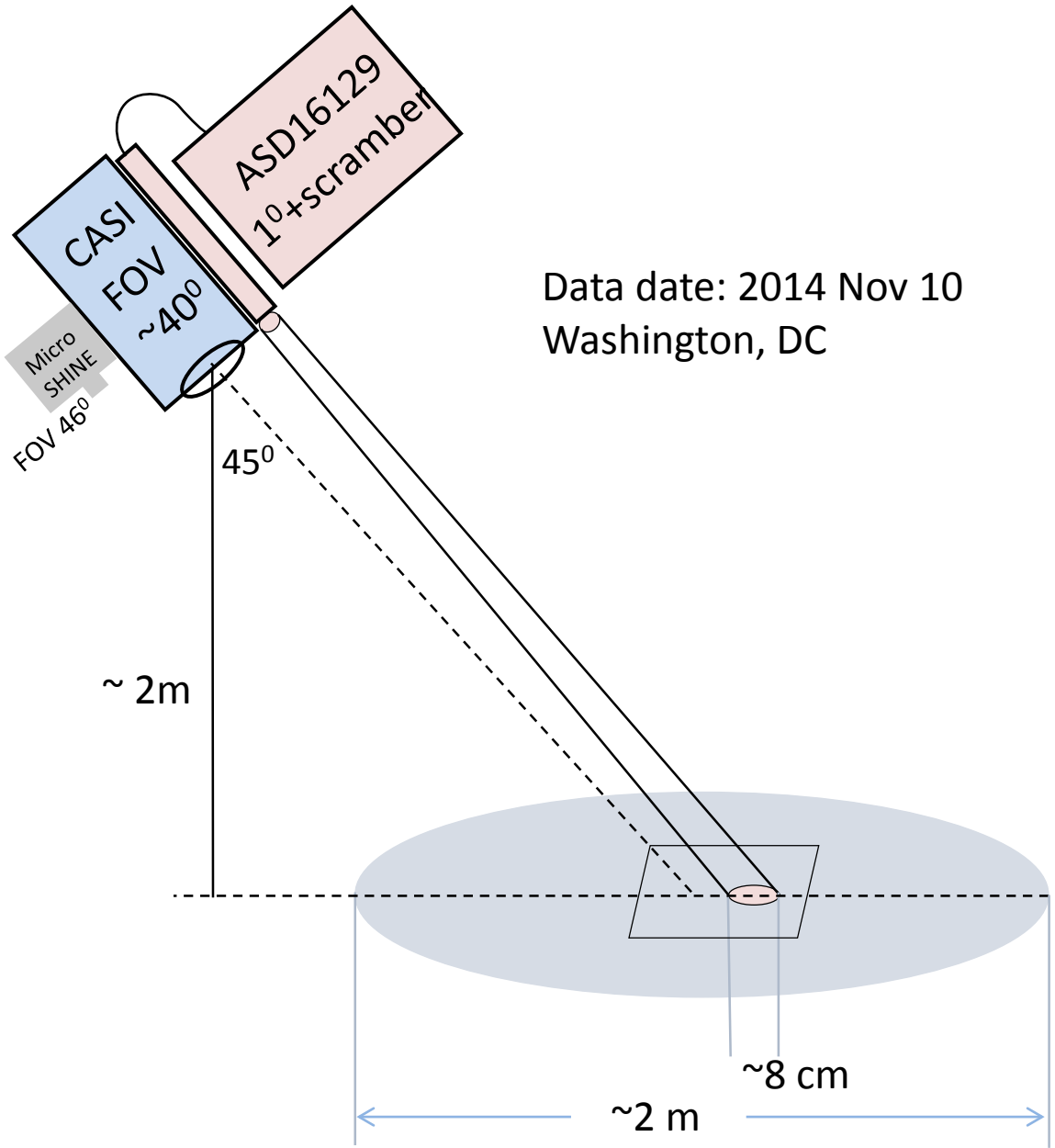


If there is a stray light issue, gains (slopes) should be different, but they are the same

Outdoor test- measure all sensors at the ground simultaneously

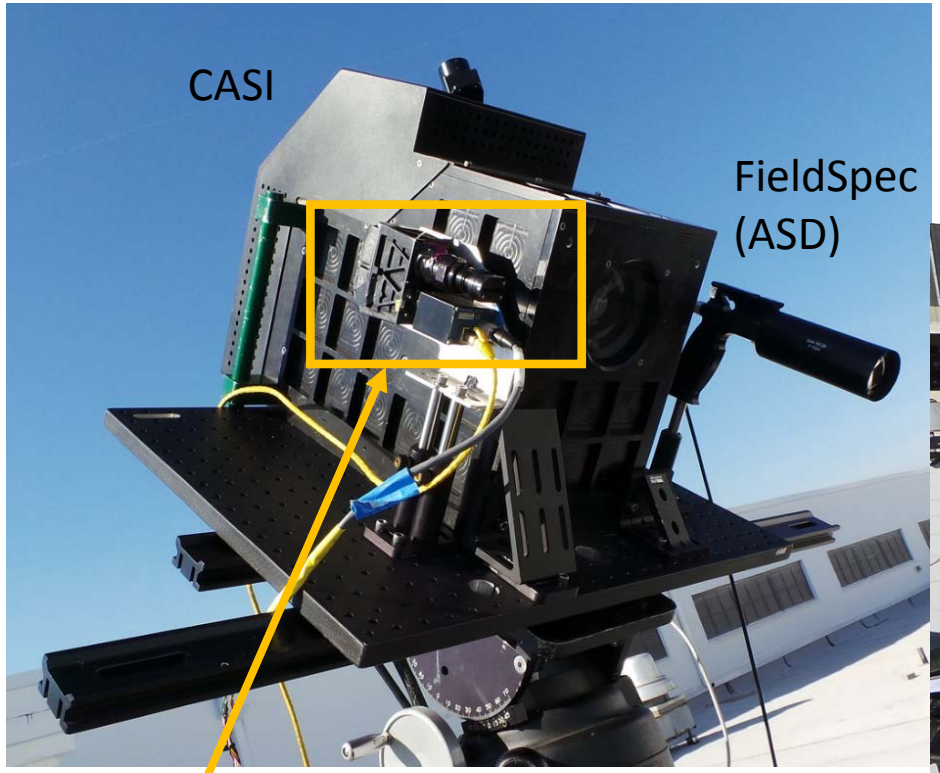
- Low to ground- removes atmosphere
- Simultaneous comparison to independently calibrated instrument- Field Spec ASD
- No polarization- spectralon plaque and sun far off specular direction

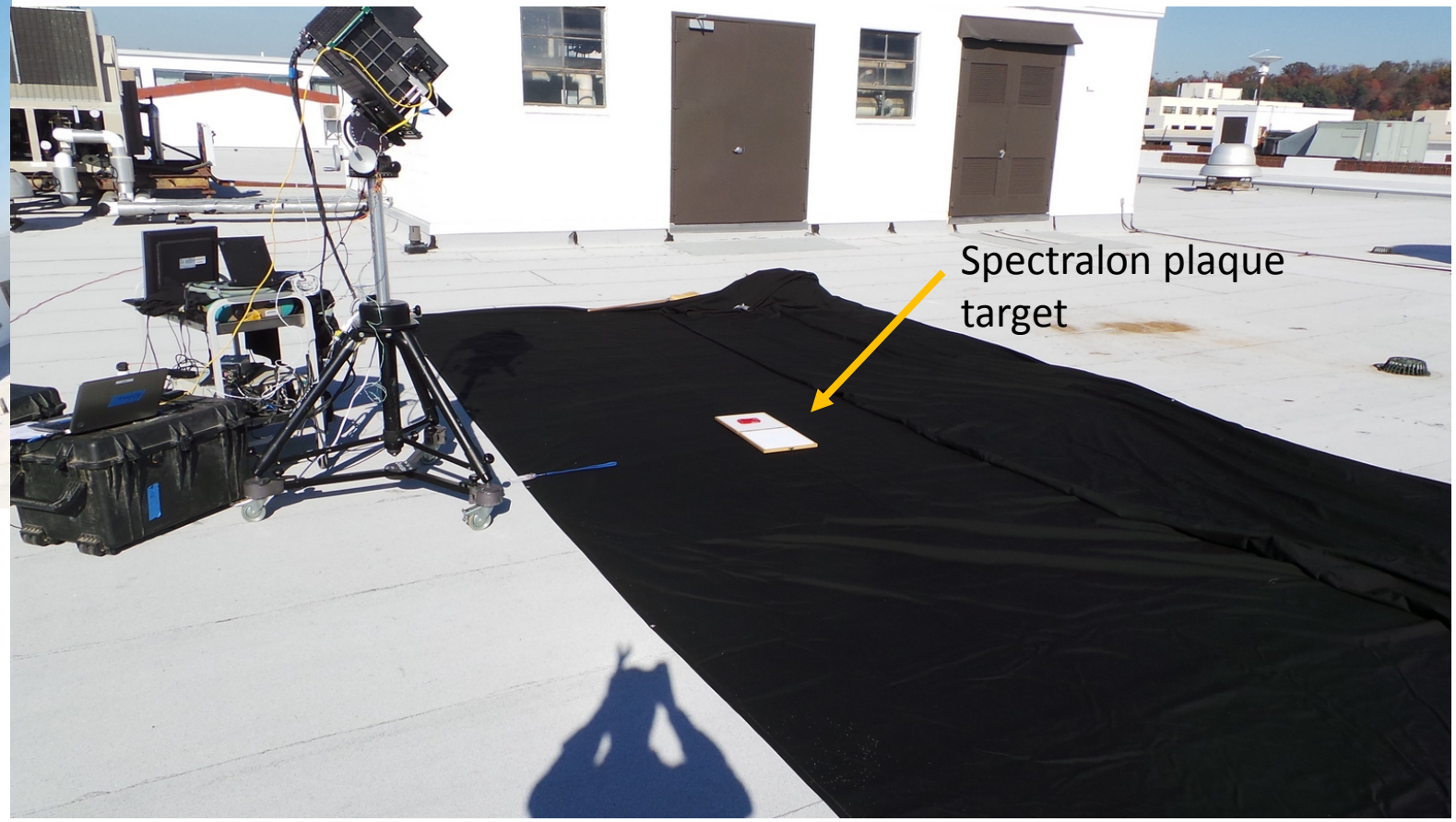
Rooftop Test Setup



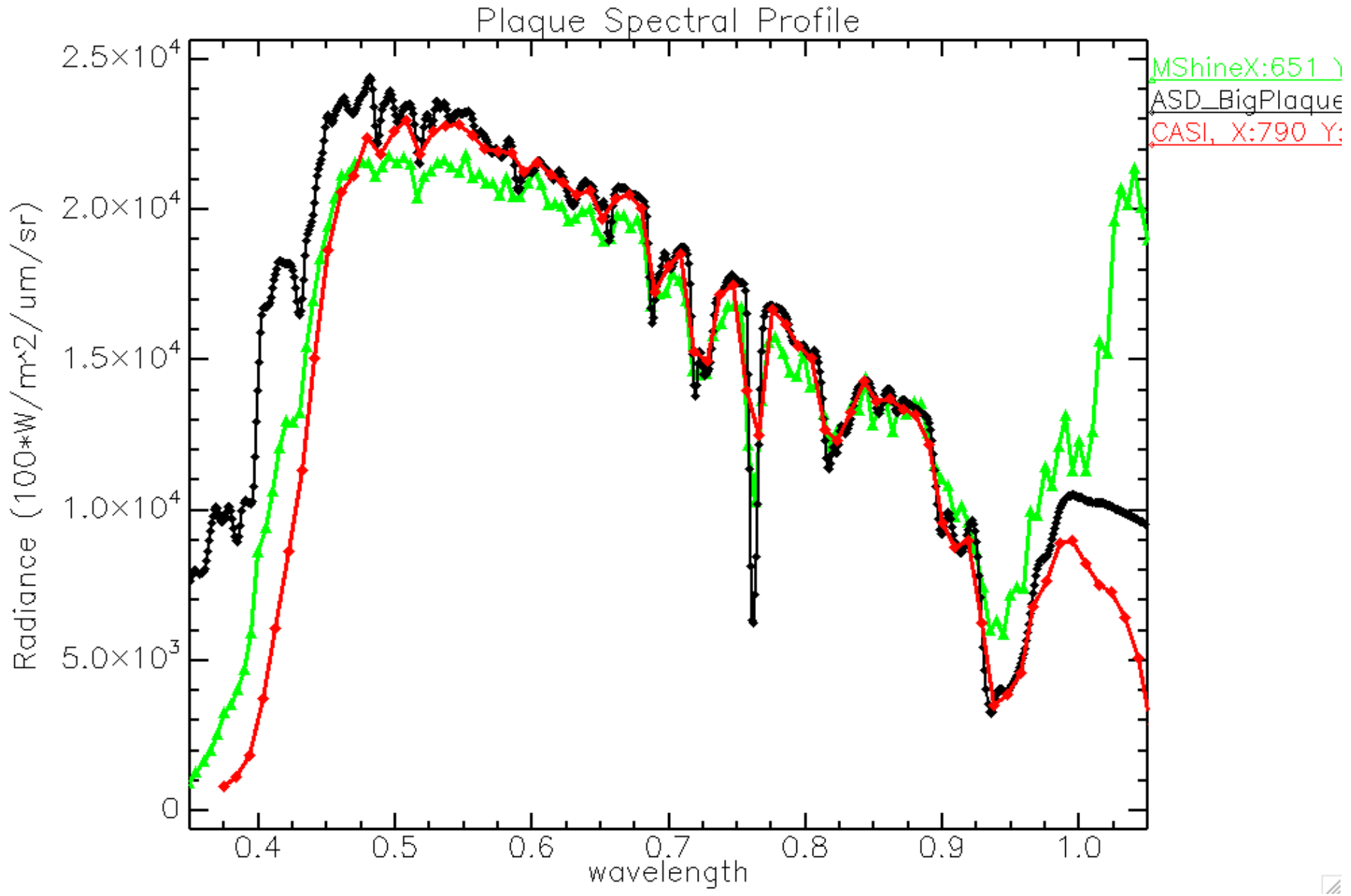
Data date: 2014 Nov 10
Washington, DC

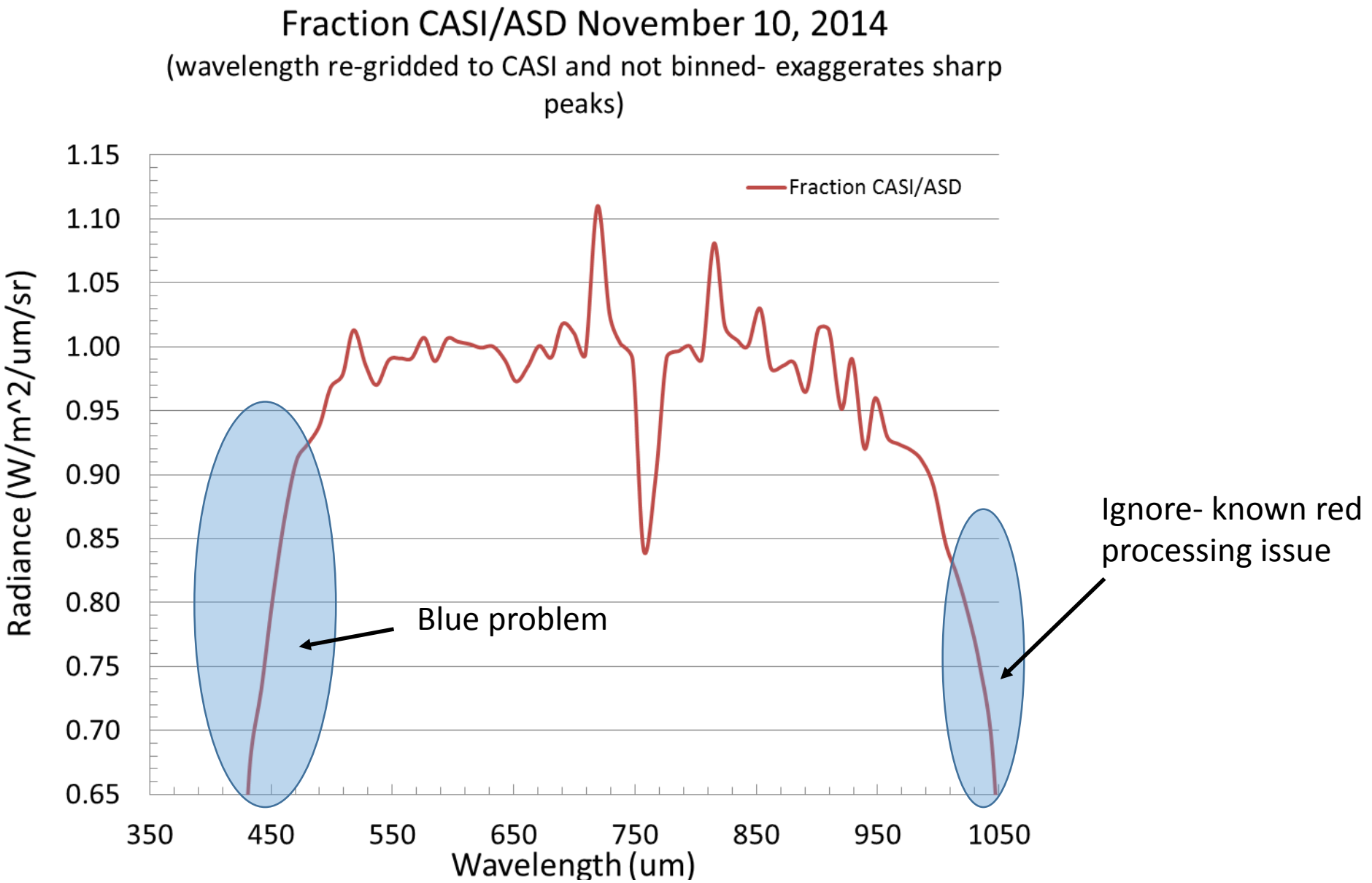
Rooftop Test Setup continued…





ASD (black) VS CASI(red) and MicroShine (green)



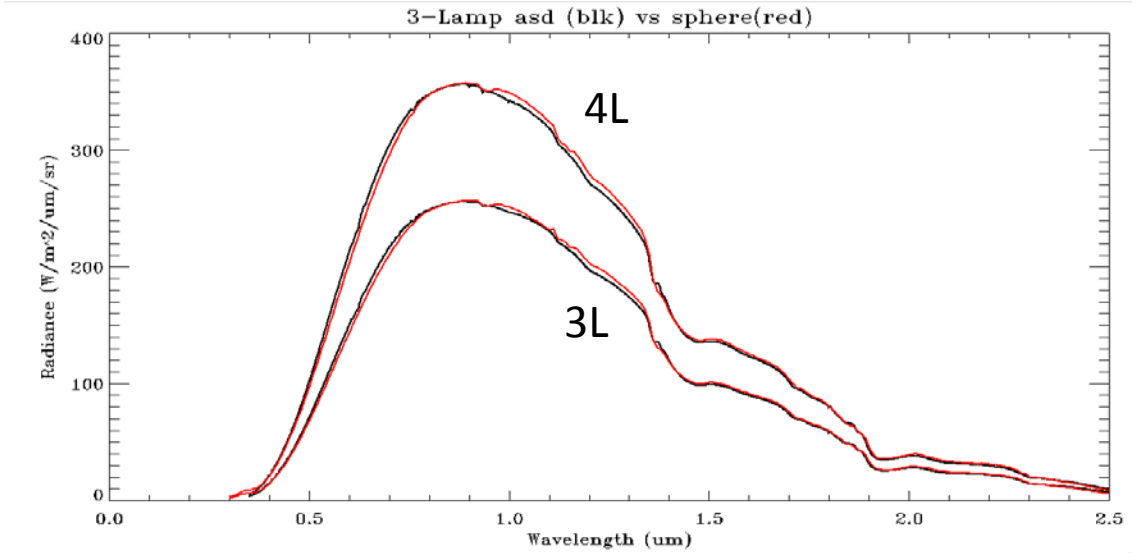

Fraction CASI/ASD November 10, 2014
(wavelength re-gridded to CASI and not binned- exaggerates sharp peaks)
Fraction CASI/ASD
Radiance (W/m^2/um/sr)
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
350
450
550
650
750
850
950
1050
Wavelength (um)
Blue problem
Ignore- known red processing issue

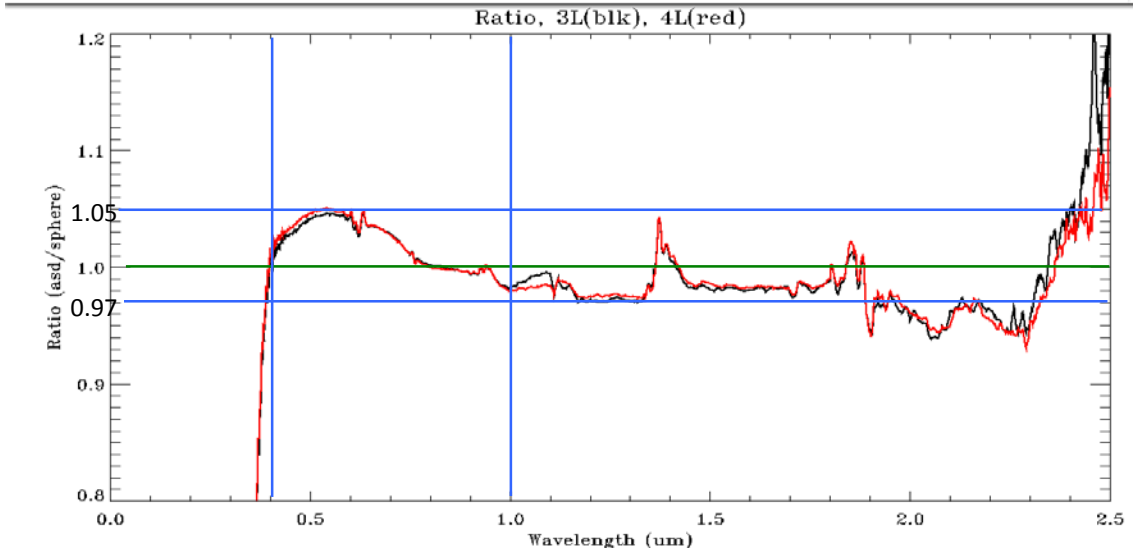
ASD gives correct radiance of integrating sphere

ASD vs Sphere

Sphere (red) 2014 July-independent calibration

ASD (blk) 2015 Jan





Conclusions

- Still don’t understand blue issue
- Not polarization effect
- Doesn’t *appear* to be stray light from HICO calibrations
- Not atmospheric effect

- What is it??????????????