

# **4STAR: Spectrometer(s) for Sky-Scanning, Sun-Tracking Atmospheric Research**

**Collaboration involving:  
NASA Ames, Battelle PND, NASA GSFC**

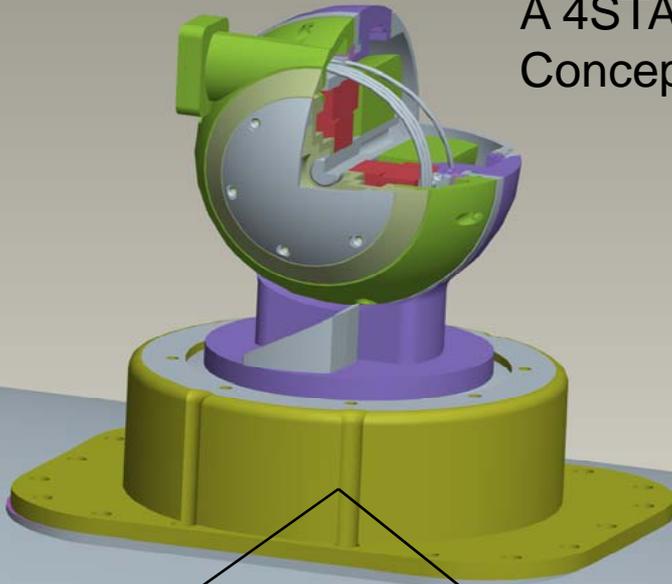
**Phil Russell, Jens Redeman, Steve Dunagan, Roy  
Johnson, Stephanie Ramirez: NASA Ames**

**Beat Schmid, Connor Flynn: Battelle PND**

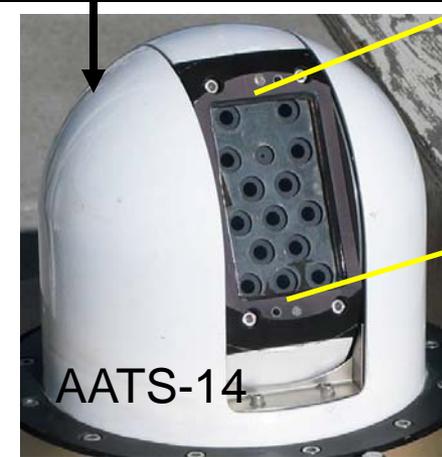
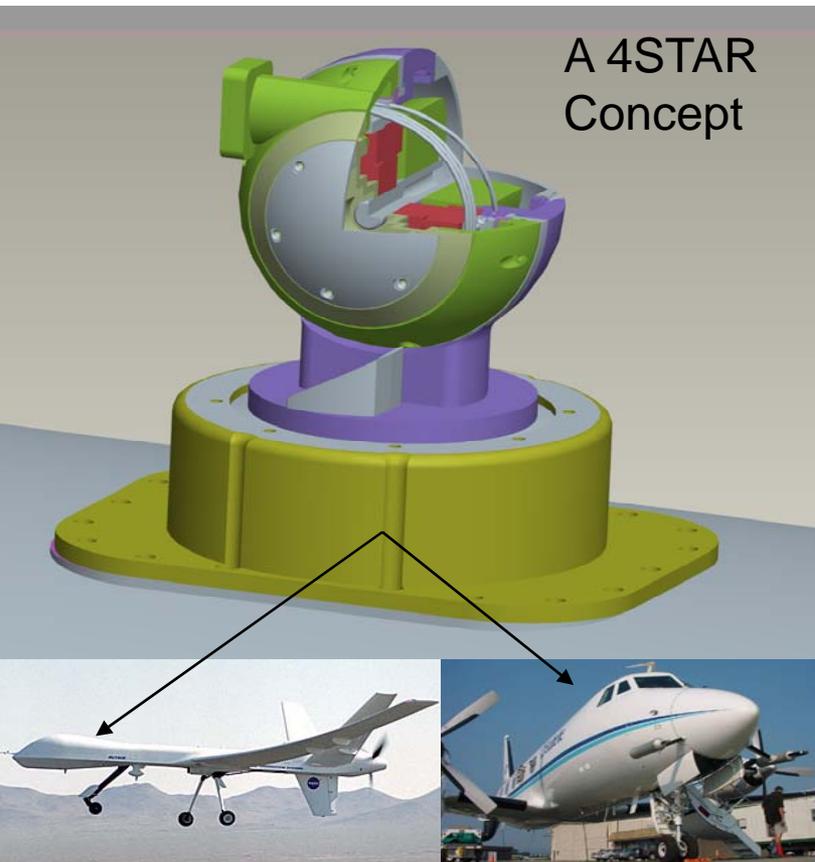
**Brent Holben, et Aeronet**

# 4STAR: Spectrometer(s) for Sky-Scanning, Sun-Tracking Atmospheric Research

A 4STAR  
Concept



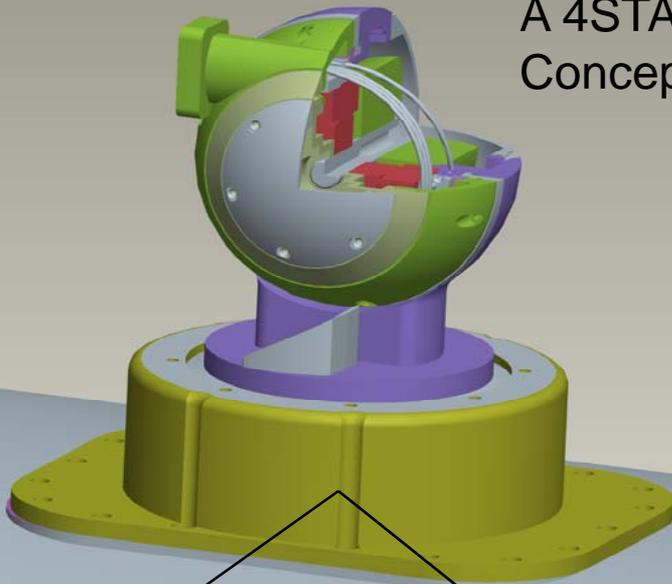
# 4STAR: Spectrometer(s) for Sky-Scanning, Sun-Tracking Atmospheric Research



- AOD( $14\lambda$ )
  - Aerosol size distributions
- H<sub>2</sub>O
- O<sub>3</sub> (special conditions)
- Vertical profiles, horizontal transects, ...

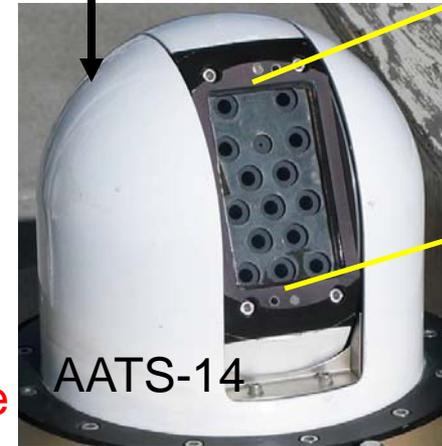
# 4STAR: Spectrometer(s) for Sky-Scanning, Sun-Tracking Atmospheric Research

A 4STAR  
Concept



## AERONET-Like

- Size distributions to larger sizes
- $n_{re}(\lambda)$ ,  $n_{im}(\lambda)$
- Shape
- Hence aerosol type



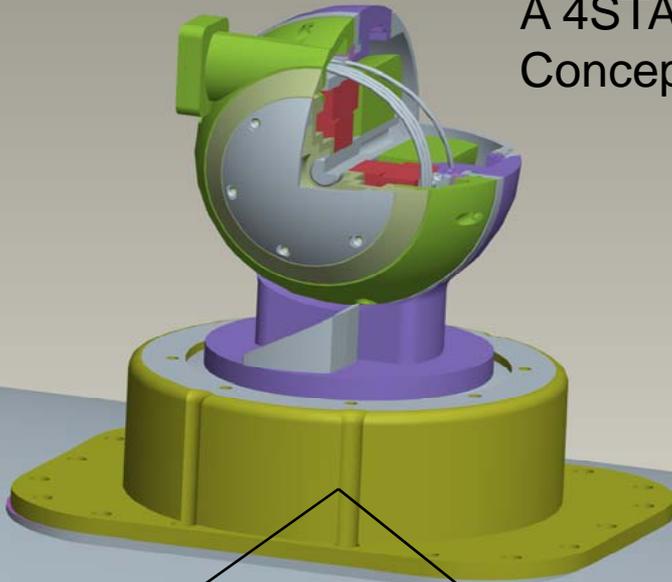
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# 4STAR:

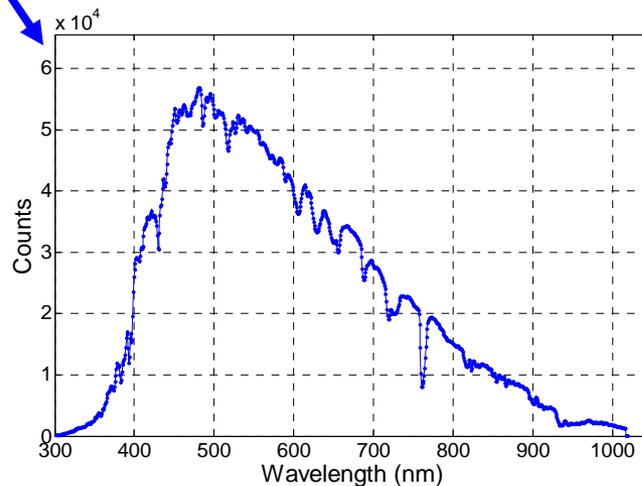
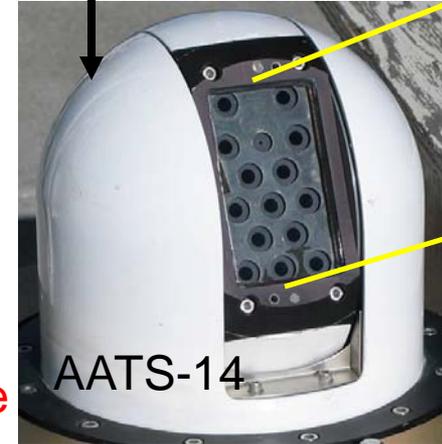
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A 4STAR  
Concept



### AERONET-Like

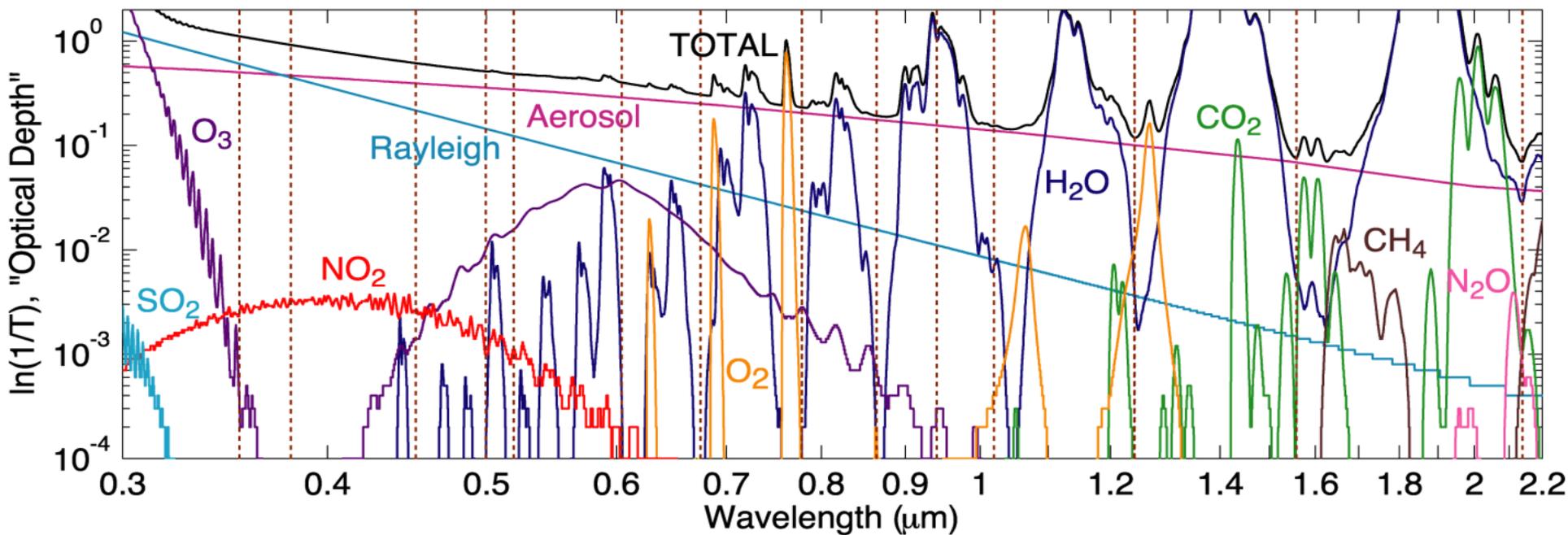
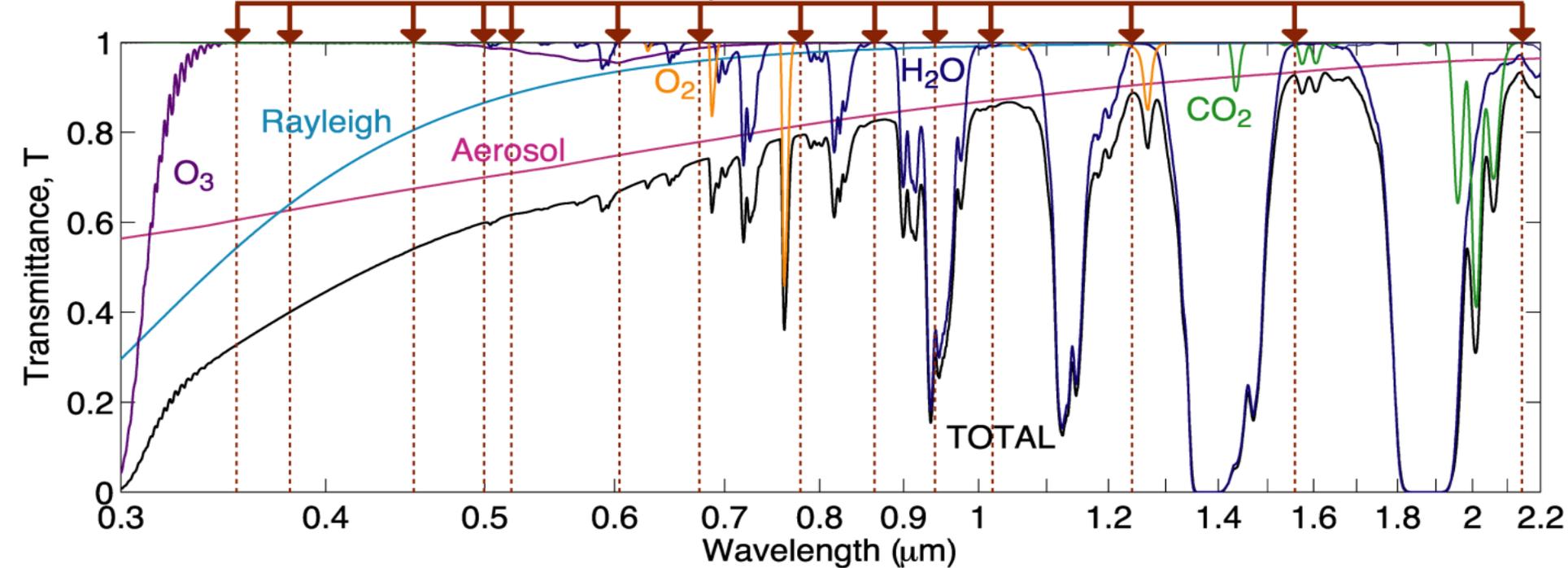
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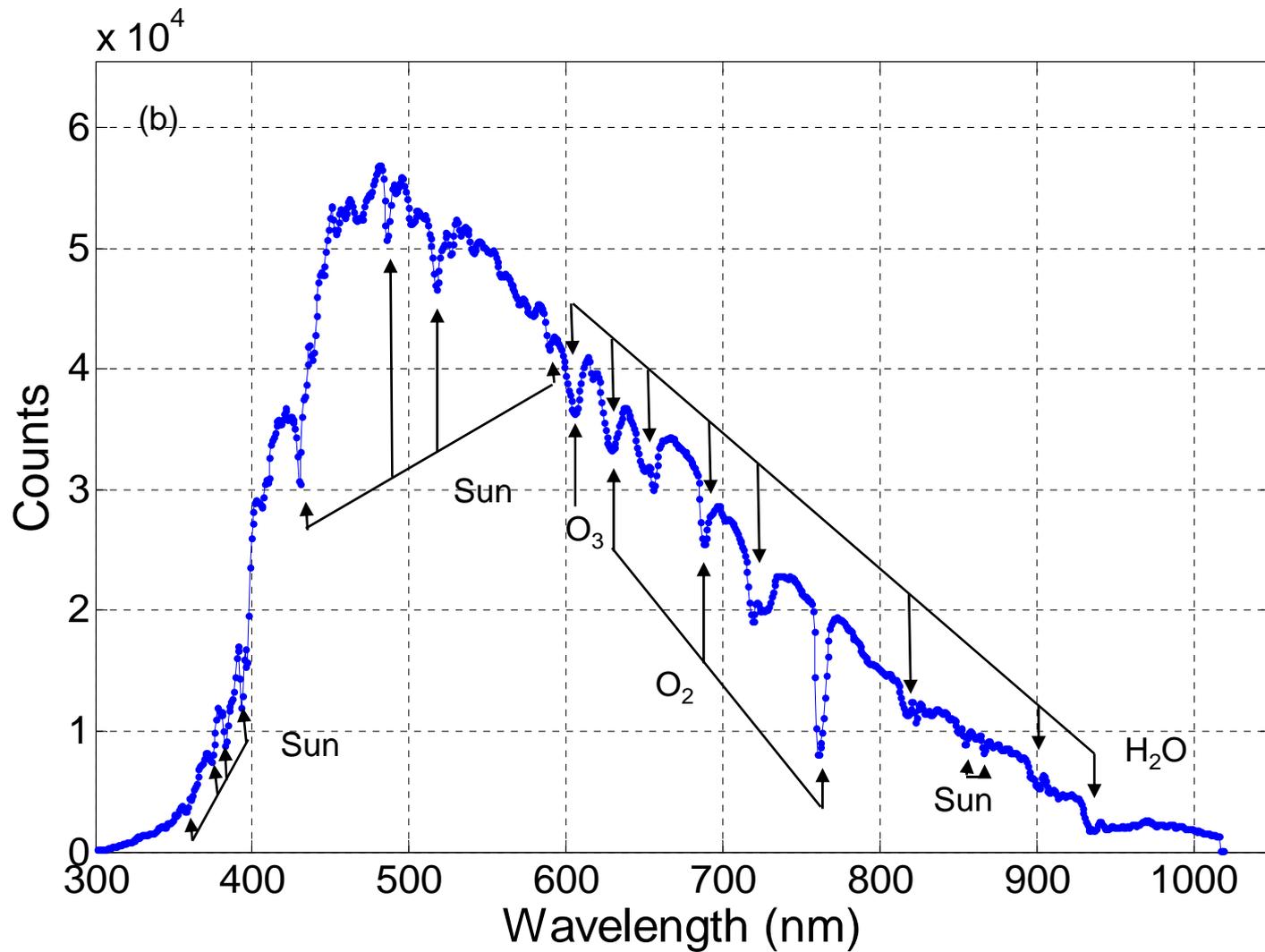


- Improve  $H_2O$ ,  $O_3$
- Add  $NO_2$ ,  $SO_2$ , ...
- Improve aerosols



Ames 14-channel sunphotometer, AATS-14





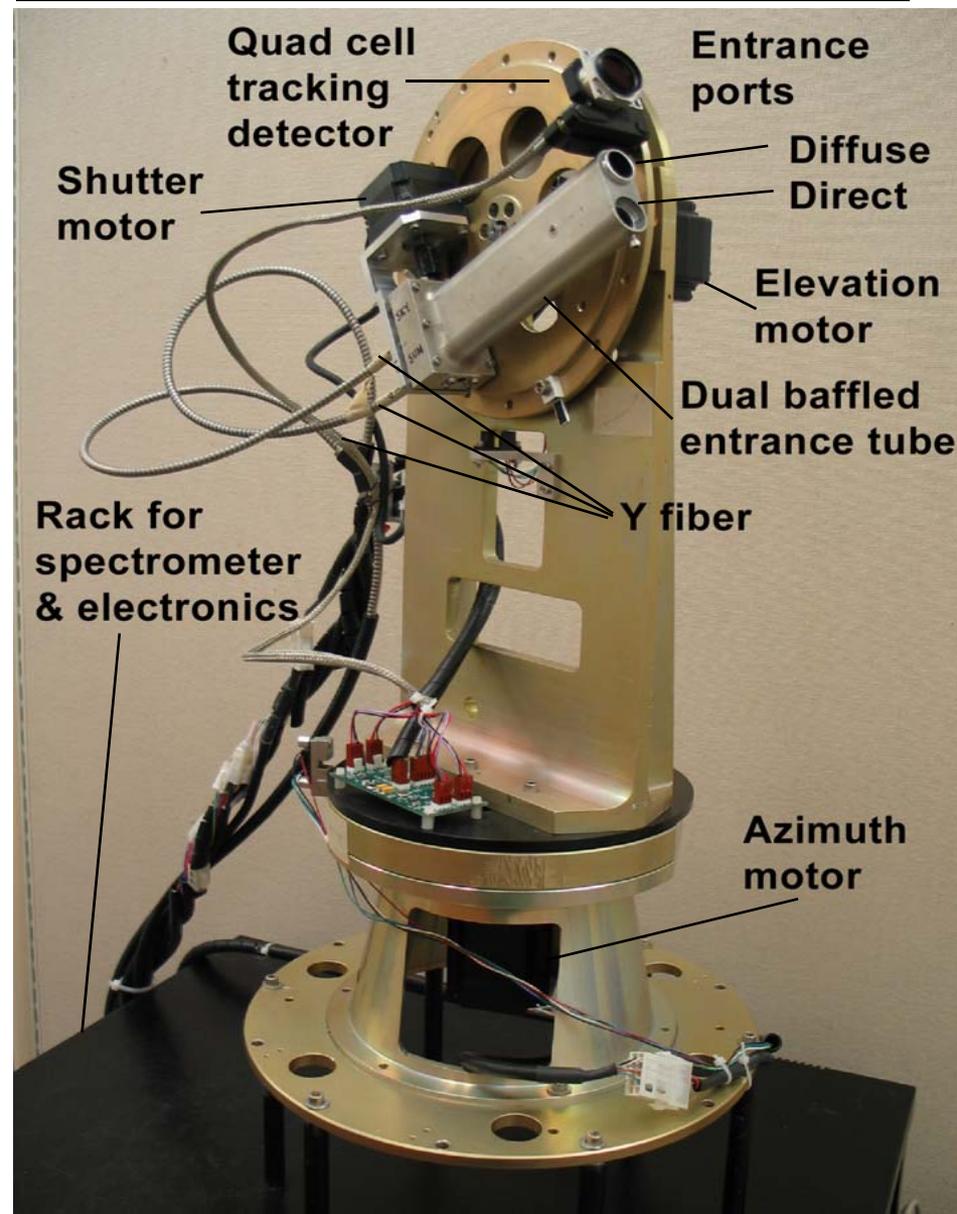
*Data from 4STAR-Ground. (b) Output counts for direct-sun spectrum. Arrows denote major contributors to features.*

# Is it feasible to do all this?

## Technological Hurdles

1. Maintaining calibration to 1% stability over a period of months.
2. Demonstrating stray light rejection to permit measuring skylight within a few degrees of the sun.
3. Devising a fiber optic coupling that maintains 1% calibration stability with as many as possible of the following desirable characteristics:
  - detachable during assembly before calibration
  - detachable between calibration and scientific measurements
  - rotatable during measurements

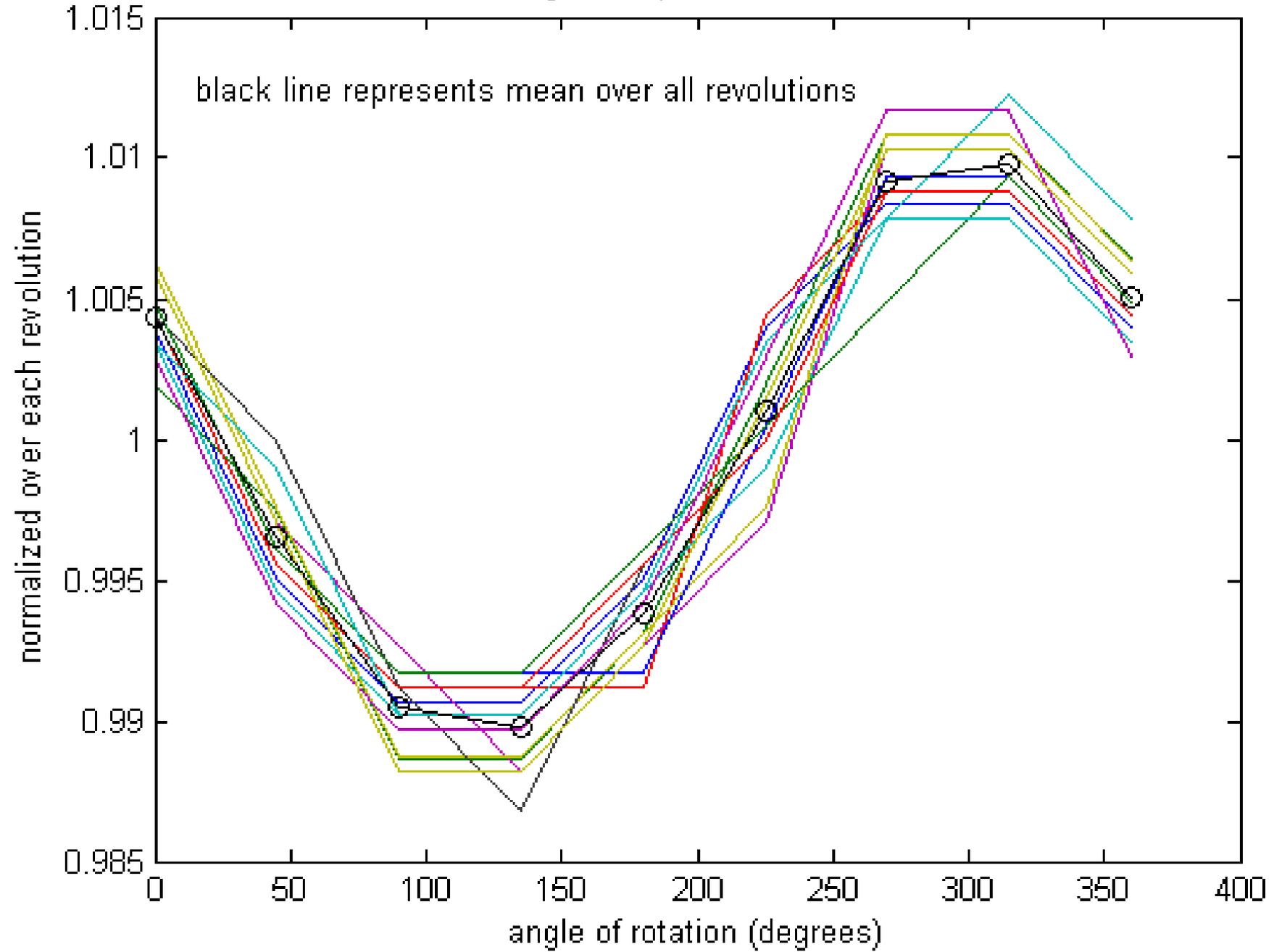
## Ground Prototype (4STAR-Ground)



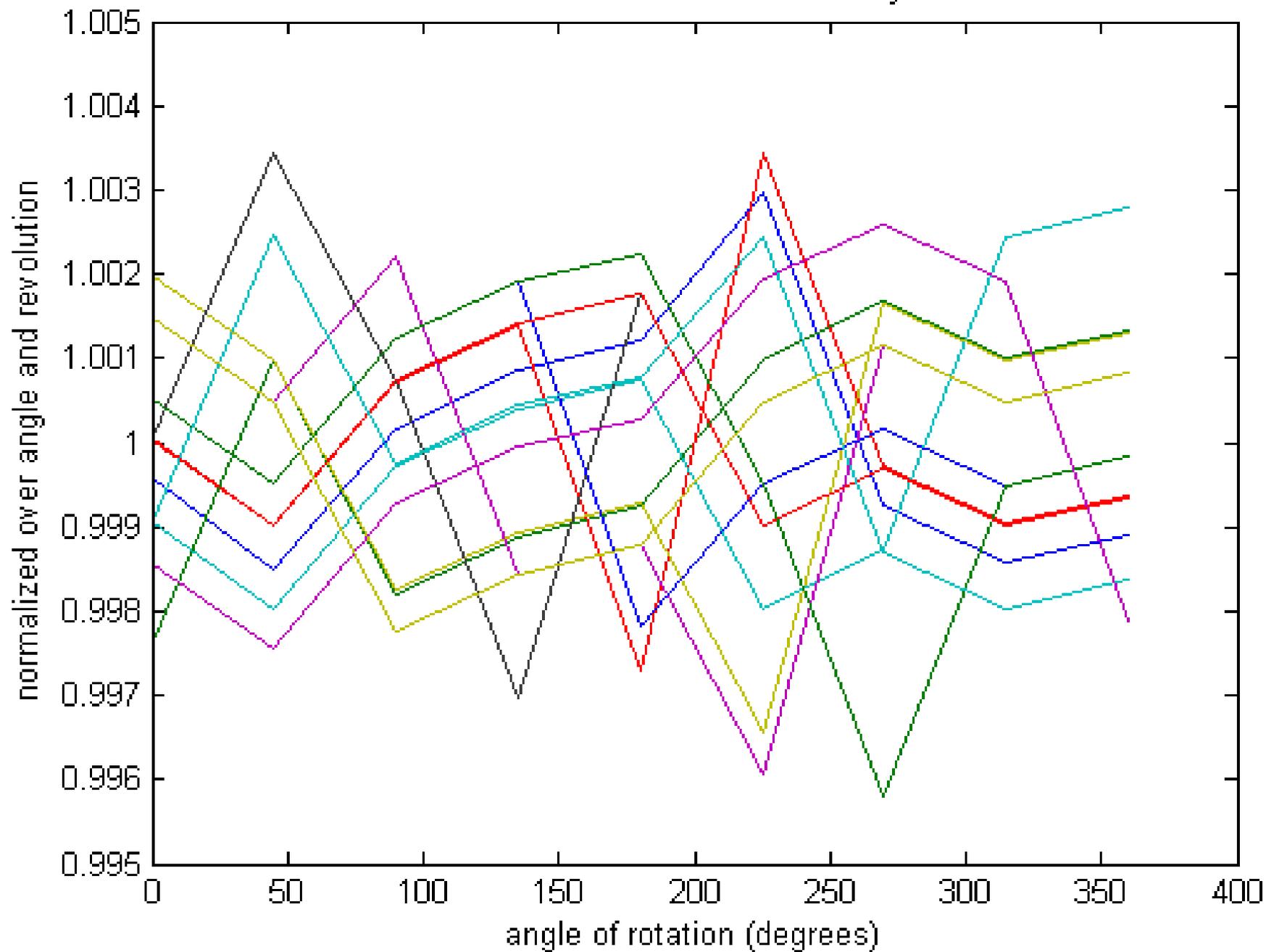
# Fiber Optic Rotating Joint

- Observation: There are design and deployment considerations that would benefit from using a detachable fiber optic coupler, but it must be sufficiently stable to preserve system calibration to a fraction of a percent.

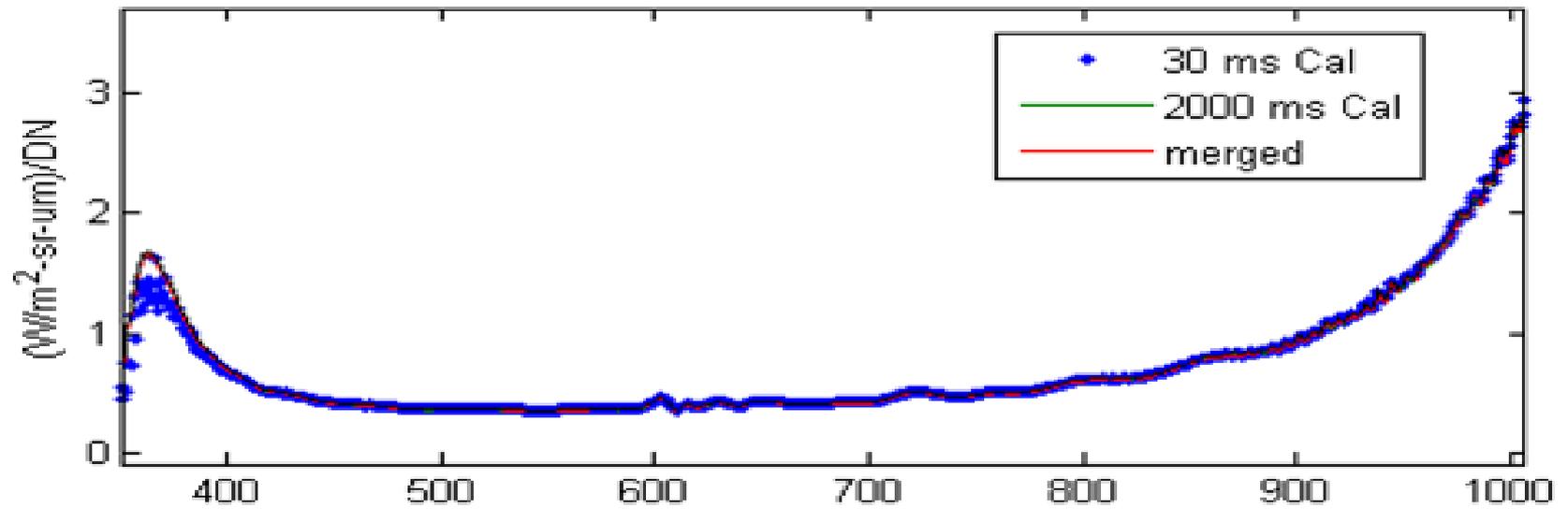
Sinusoidal signal response due to fiber rotation



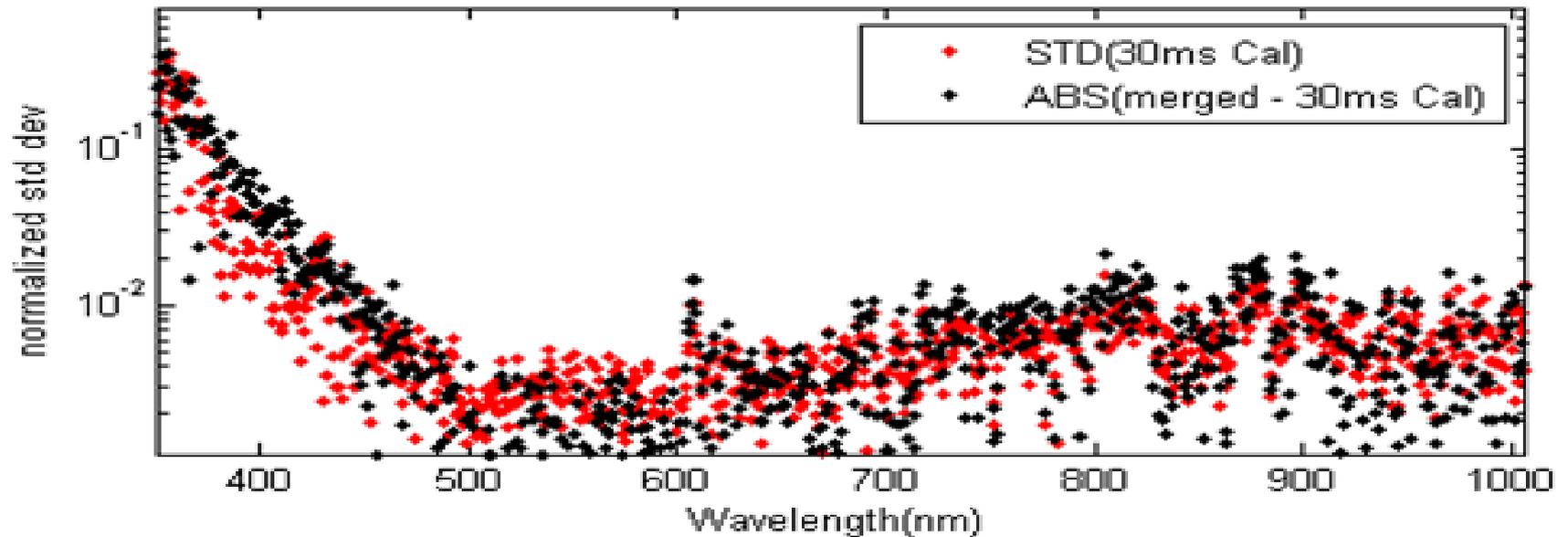
Fractional variation after normalized by sinusoid



Calibration of 4STAR from 30" Sphere



Normalized Std Dev of Calibration

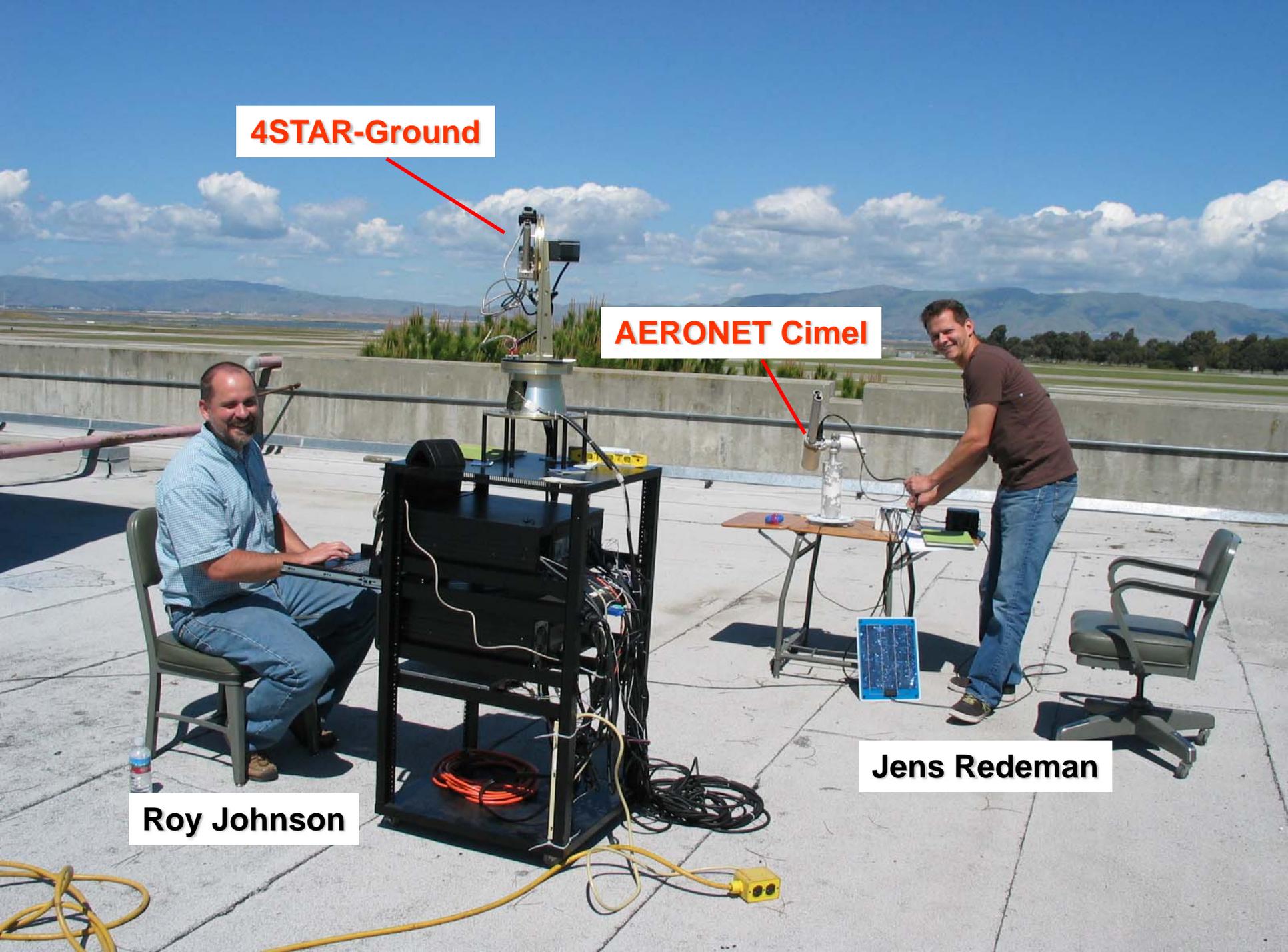


**4STAR-Ground**

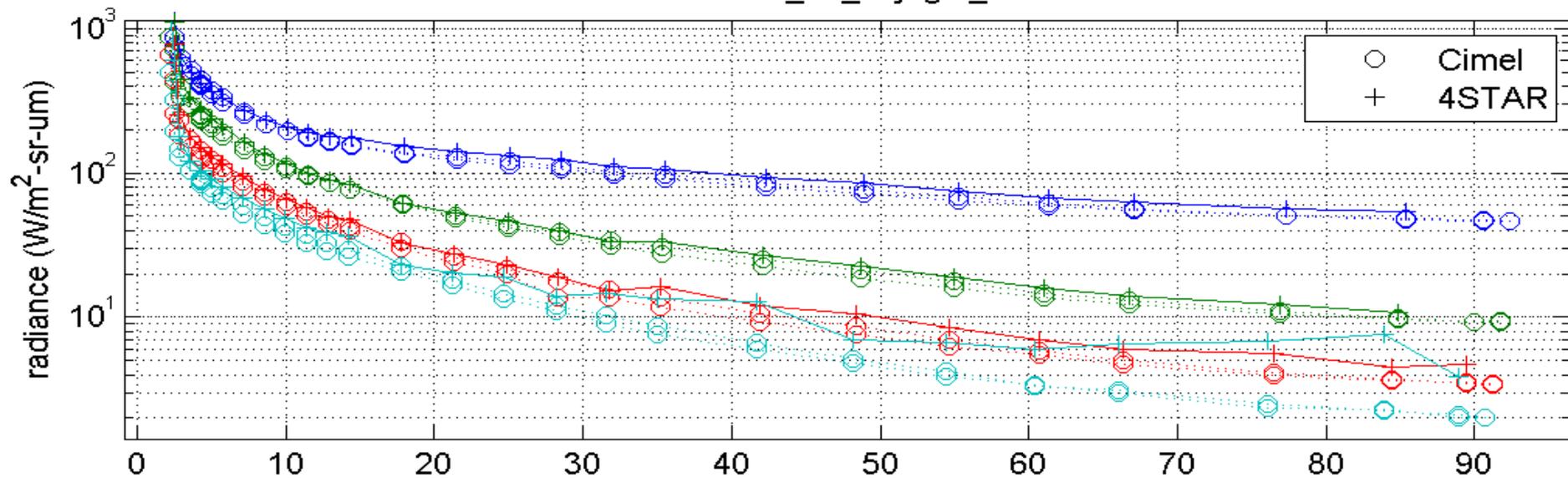
**AERONET Cimel**

**Roy Johnson**

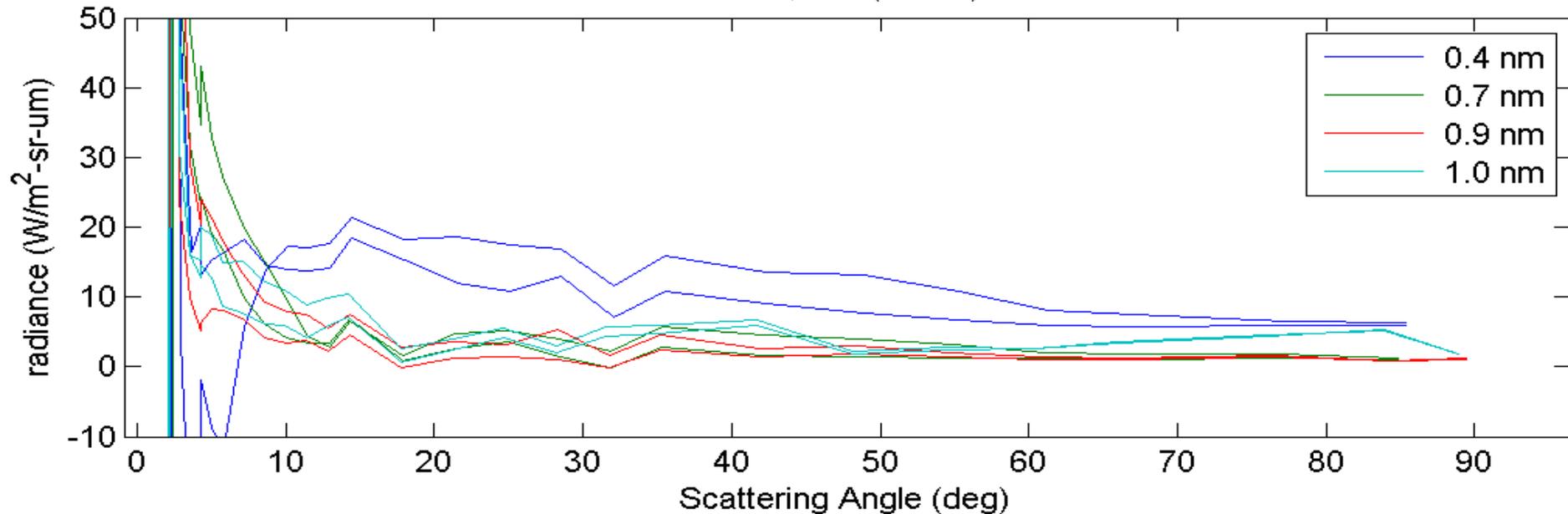
**Jens Redeman**



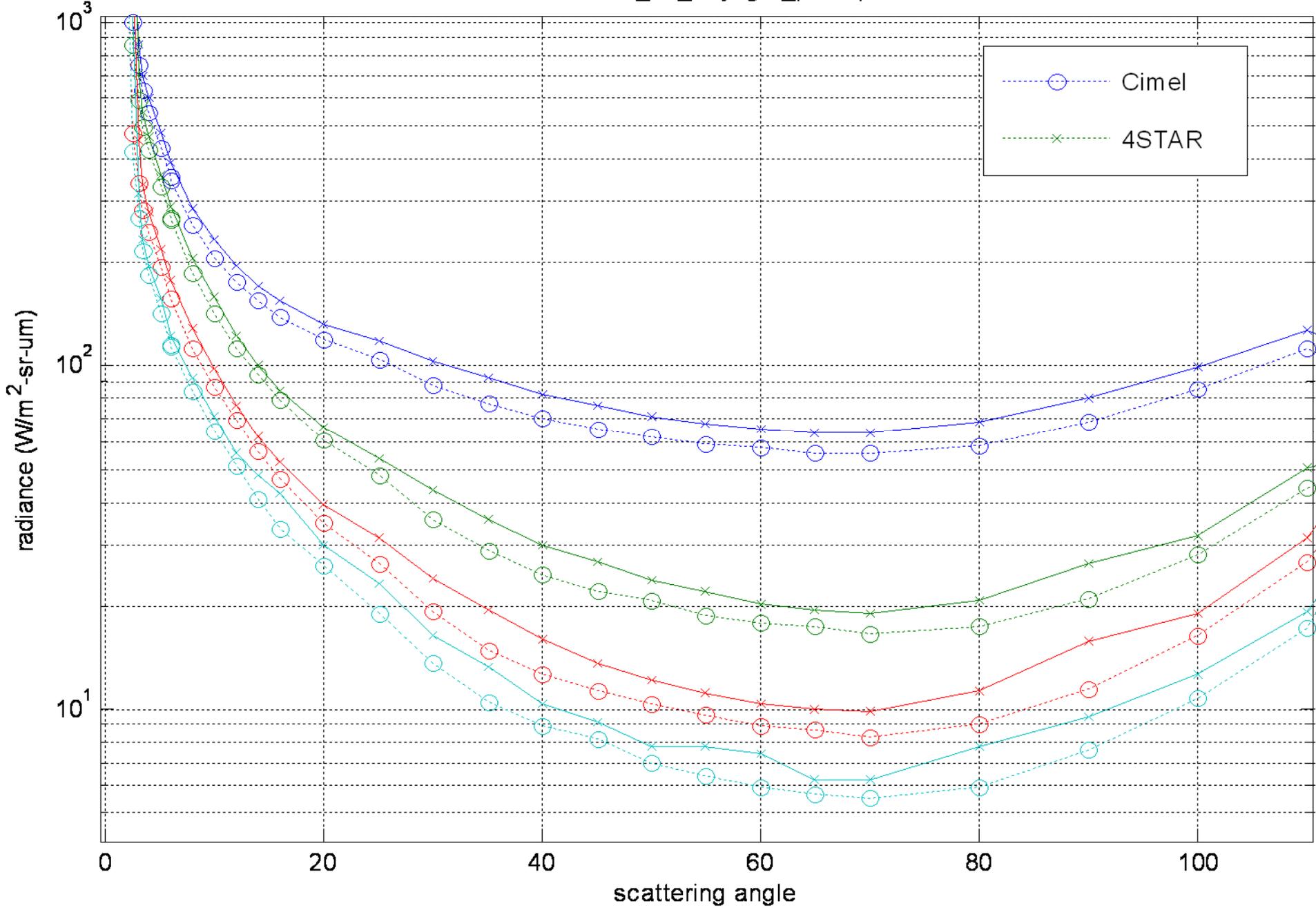
Almucantar comparison for SZA=44.8859  
data file: 20070418\_12\_skylight\_almucantar.txt



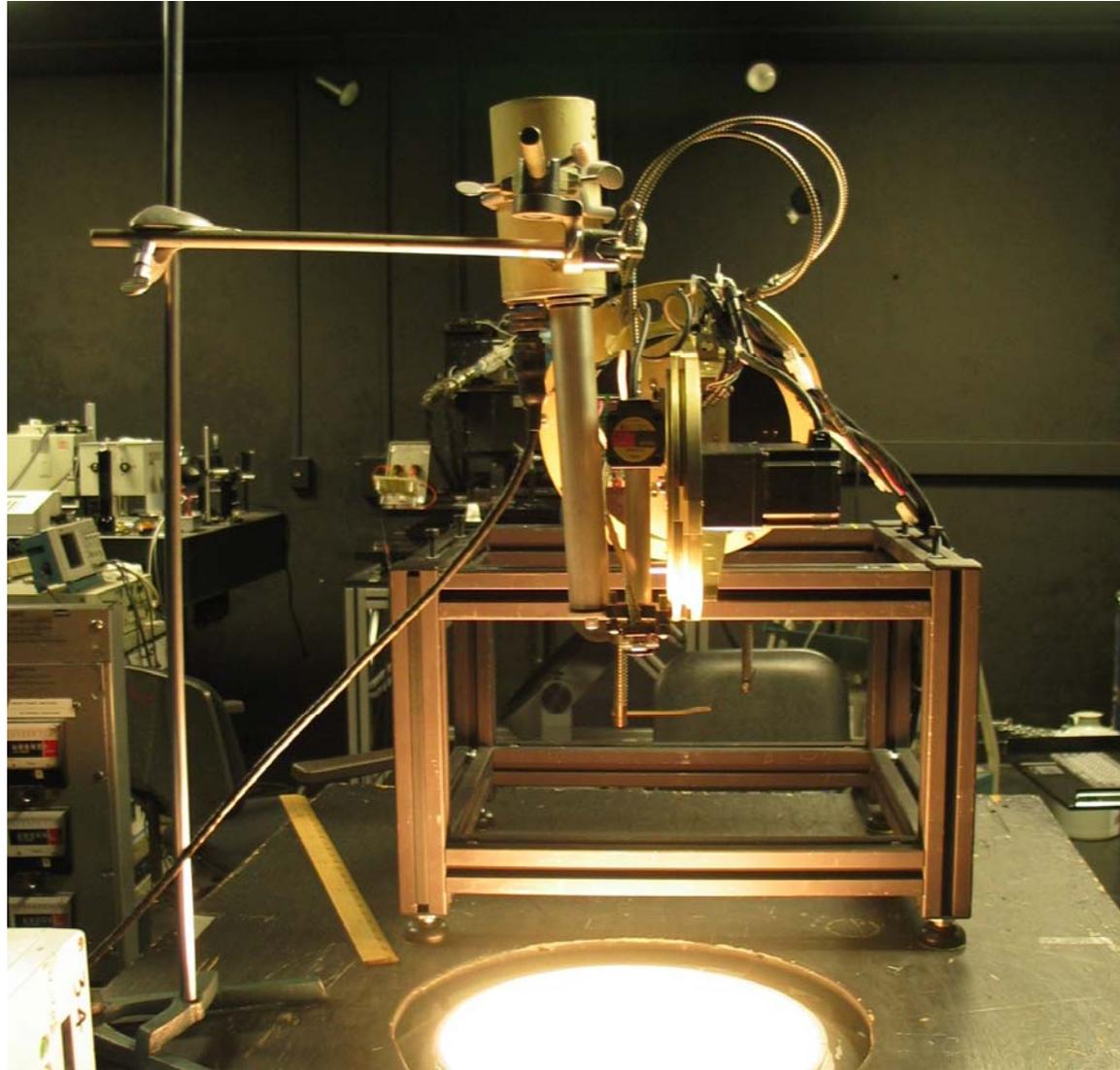
4STAR - Cimel, max(delta t) = 3.9 min



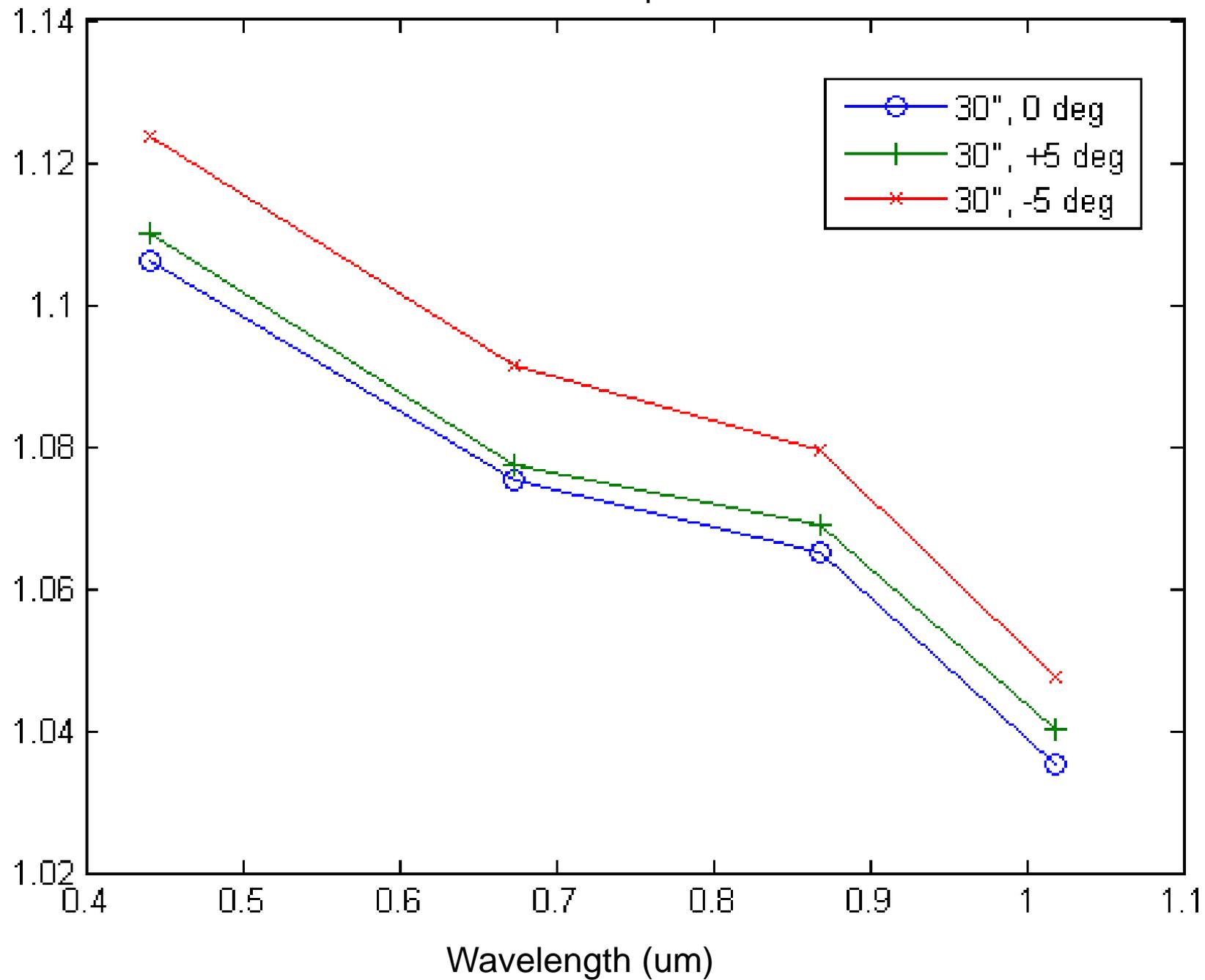
Principal plane comparison for SZA=30.7  
data file: 20070427\_15\_skylight\_principal.fixed.txt



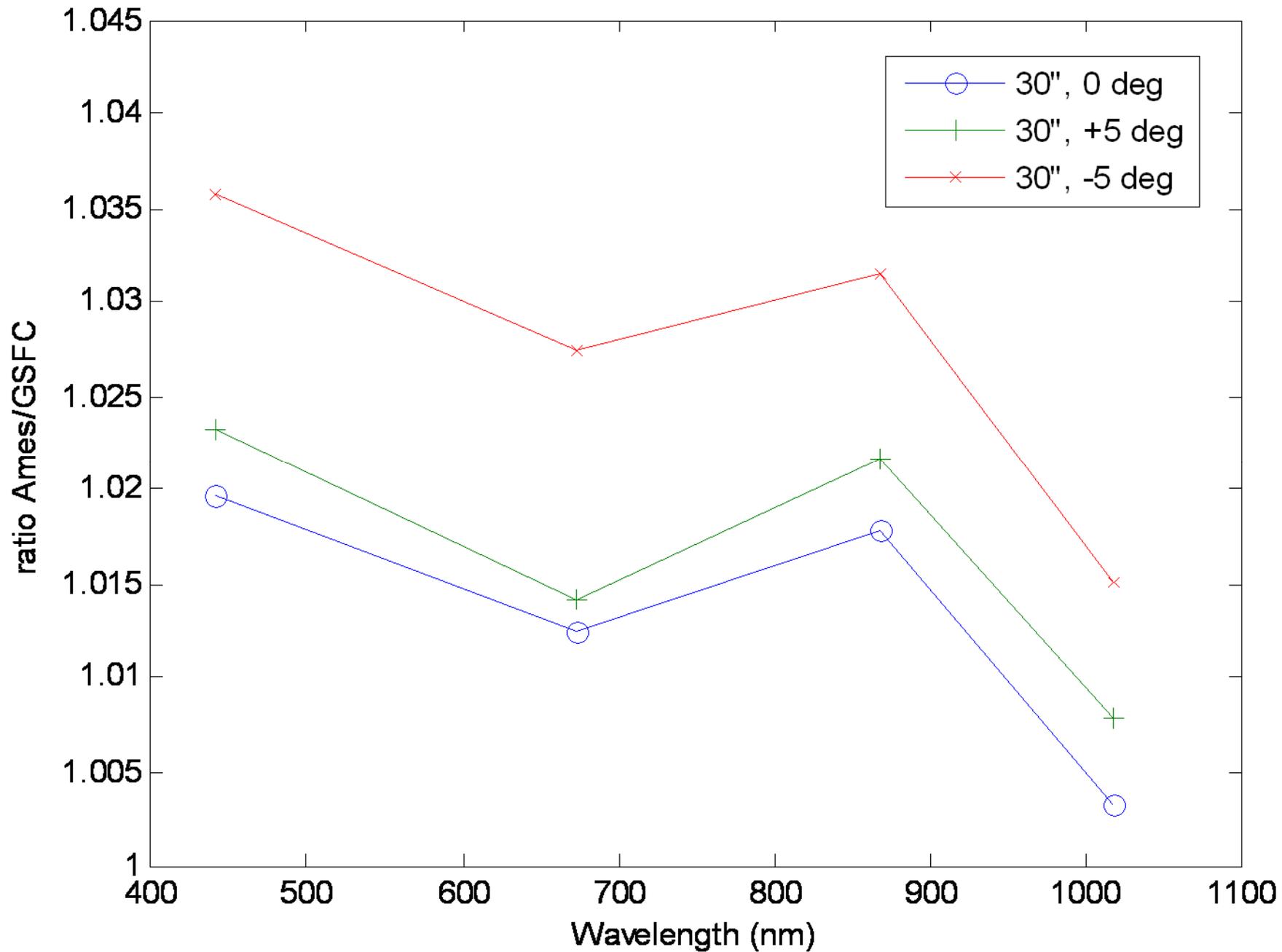
# 4STAR-G and Cimel over NASA Ames 30" sphere



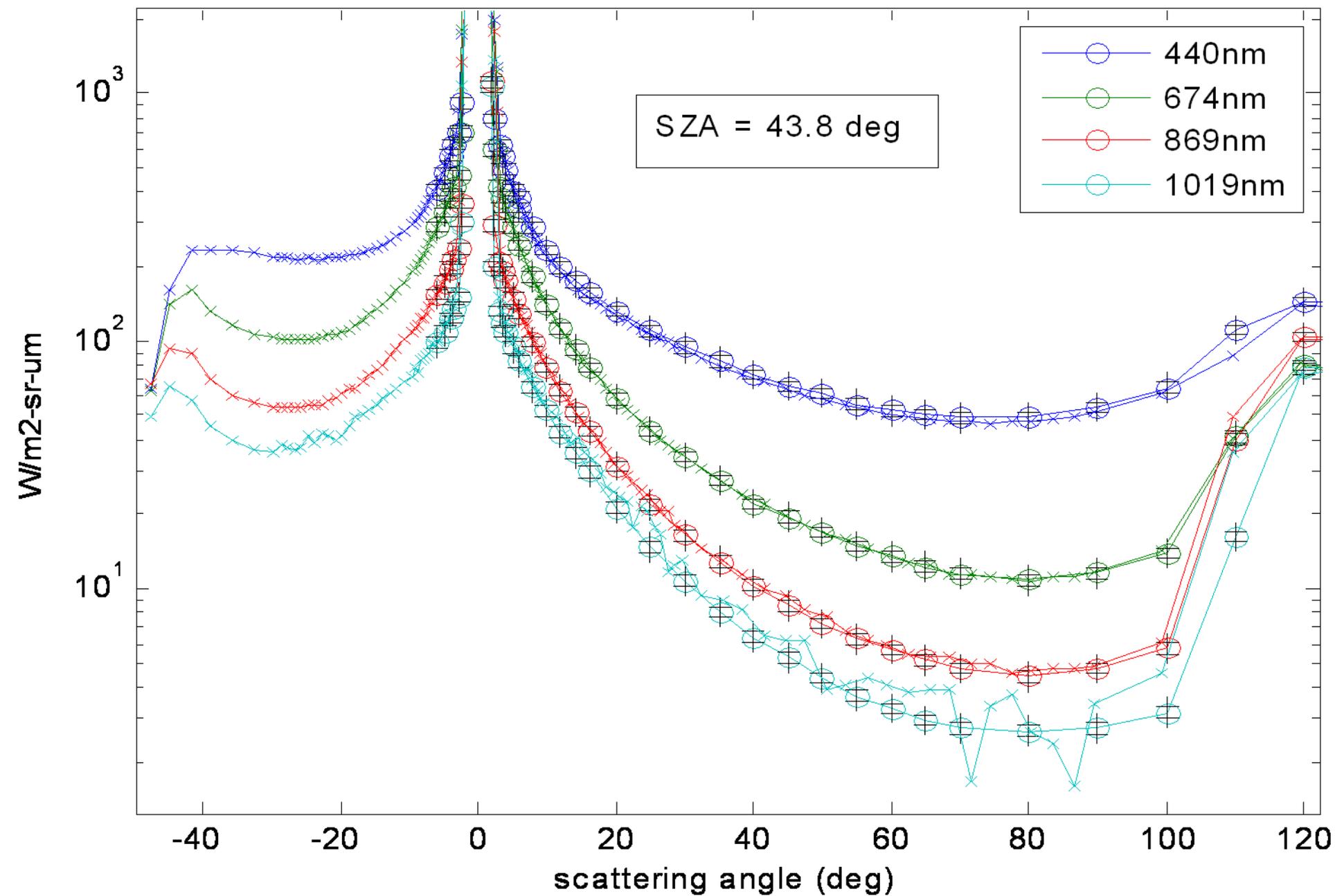
NASA Ames 30" sphere vs Aeronet



NASA Ames 30" sphere vs Aeronet



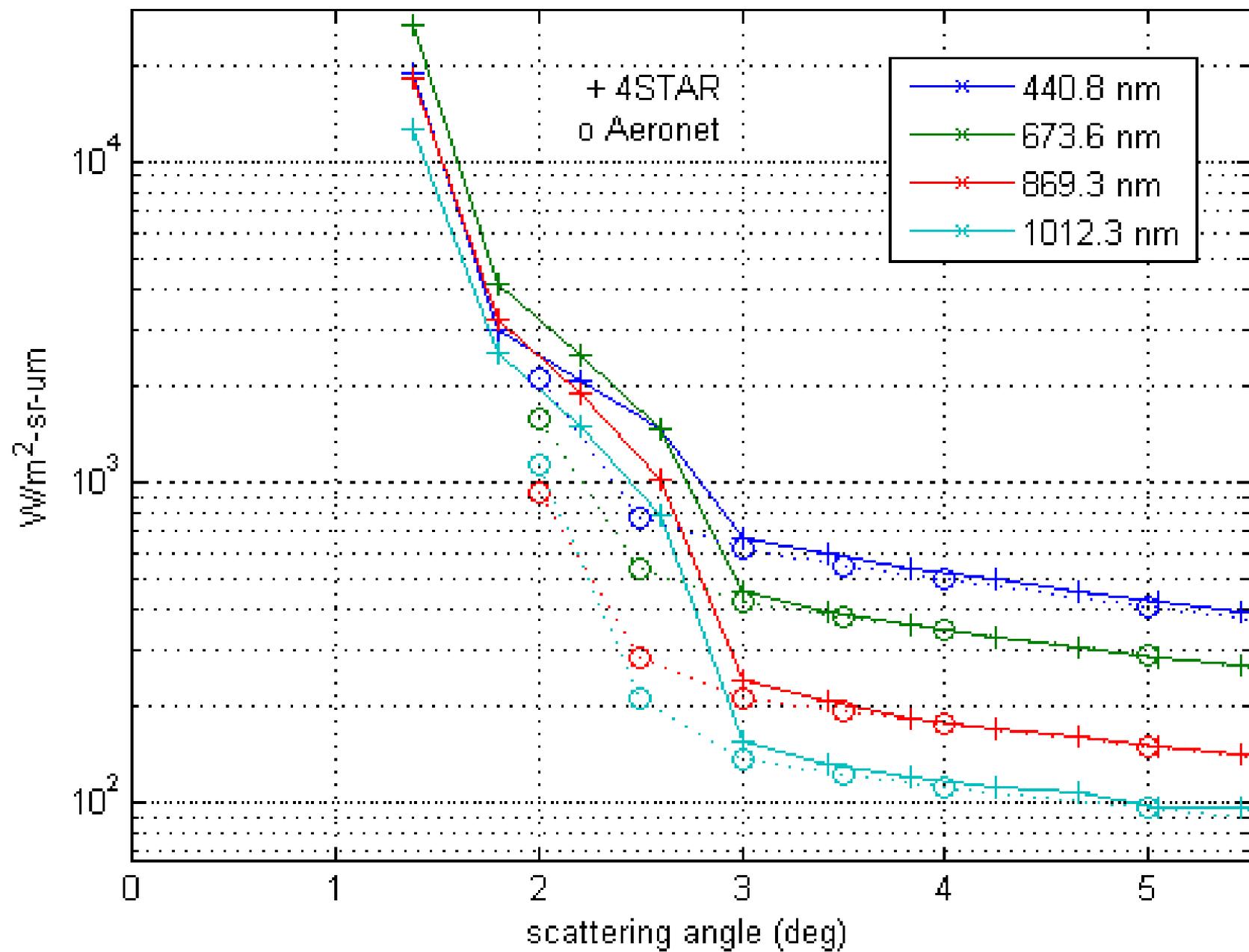
# 2007-04-30 PP, apples to apples calibration



# So far so good!

- Fiber coupler results show potential, more testing needed.
- Radiance cals and sky scans show excellent agreement with Cimel, providing 4STAR calibrated radiances to Aeronet team for retrievals
- More light needed in LW sky channel, new front-end with focusing optics in design stage
- Concerned with possible stray light nearby sun,  $< 3$  deg scattering angle. How important?

Principal plane comparison  
data file: 20070430\_11\_skylight\_principal.fixed.txt



Out of band artifact identified