



National Renewable Energy Laboratory

**Memo**

To: Daryl Myers and Thomas Stoffel  
 From: Afshín M. Andreas  
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Subject: Calibration of SRRL BMS and AOCS Quantum Sensors

Instruments: Licor LI-190 s/n Q8435 (BMS Global Horiz.), s/n Q20555 (BMS Upwelling), s/n Q8709 (AOCS Global Horiz.), and s/n Q8433 (AOCS Global Tilt).

NREL PV Radiometric Measurements Task monitored the millivolt and count output of four (4) SRRL LI-190 Quantum Sensors while measuring the spectral distribution of natural sunlight in global horizontal incidence mode on 14 April 2008 from 300 nm to 1100 nm at 2nm intervals using a LICOR LI-1800 Spectroradiometer. The millivolt output from the BMS sensors were recorded by the BMS CR23X data logger and the count output from the AOCS sensors were recorded by the AOCS tattletale data logger.

The LI-1800 S/N PRS-158 spectrometer was calibrated against NREL's National Institute of Standards and Technology (NIST) Standard of spectral irradiance F571 on 7 April 2008.

The LI-1800 has a command ("PP") to automatically integrate the data between 400 and 700nm and display the result in the Quantum (PAR) units of  $\mu\text{mol/s/m}^2/\text{nm}$ . All data were used to compute the calibration factors shown in Table 1.

Table 1. April 14, 2008 NREL Quantum LI-190 Calibration Summary

Time (MST)	LI-1800 PP $\mu\text{mol/s/m}^2$	Q8435 mV (avg.)	$\mu\text{mol/s/m}^2/\text{mV}$ CF	Q20555 mV (avg.)	$\mu\text{mol/s/m}^2/\text{mV}$ CF
12:39	1777	-6.8139	-260.7888	5.7981	306.4789
12:40	1777	-6.8370	-259.9078	5.7951	306.6397
12:42	1776	-6.8721	-258.4358	5.7929	306.5798
12:43	1775	-6.8567	-258.8703	5.7893	306.6002
12:45	1773	-6.7956	-260.9060	5.7832	306.5768
12:46	1771	-6.7789	-261.2529	5.7817	306.3115
		<b>Avg.</b>	<b>-260.0</b>	<b>Avg.</b>	<b>306.5</b>
		<b>Sigma</b>	<b>1.1610</b>	<b>Sigma</b>	<b>0.1200</b>

Time (MST)	LI-1800 PP $\mu\text{mol/s/m}^2$	Q8709 counts	$\mu\text{mol/s/m}^2/\text{count}$ CF	Q8433 counts	$\mu\text{mol/s/m}^2/\text{count}$ CF
12:39	1777	751	2.3662	519	3.4239
12:40	1777	751	2.3662	518	3.4305
12:42	1776	750	2.3680	518	3.4286
12:43	1775	750	2.3667	517	3.4333
12:45	1773	749	2.3672	517	3.4294
12:46	1771	747	2.3708	517	3.4255
		<b>Avg.</b>	<b>2.367</b>	<b>Avg.</b>	<b>3.429</b>
		<b>Sigma</b>	<b>0.0018</b>	<b>Sigma</b>	<b>0.0034</b>
	<b>AOCS CF requires:</b>	<b>Photons/s/m<sup>2</sup>/count</b>	<b>1.426E+18</b>		<b>2.065E+18</b>

Note: 1 micromole = 6.022e17 photons.

## UNCERTAINTY

The estimated uncertainty in the LI-1800 spectral irradiance calibration is  $\pm 4.0\%$  from 400 nm to 700 nm. The accuracy of the CR23X data logger was about 0.8%. Estimated uncertainty in the derived calibration factor is  $\pm 4.8\%$  (limit of error). Spectral data is plotted below.

**Figure 1.** Measured Spectral Distributions indicated by LI-1800 Spectroradiometer 14 April 2008

