# Calibration Report: Pyrheliometers

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Calibration date: 2016-06-20.
Next calibration due: 2018-06-20.
Reference standard: AHF-31041.

The calibration coefficients and their associated uncertainties (U95%) have been determined for one pyrheliometer. The unit of the calibration coefficient (S) is $\mu V/(W/m^2)$. The reference standard was Eppley Laboratories Inc., absolute cavity radiometer AHF31041, with its associated data acquisition system. Cavity AHF31041 participated in the 2015 International Pyrheliometer Comparison (IPC XII) at the Physikalisch-Meteorologisches Observatorium, in Davos Switzerland. It is therefore traceable to the World Radiation Reference. Cavity AHF31041's calibration is verified annually at the National Pyrheliometer Comparison held at the National Renewable Energy Laboratory in Golden Colorado, most recently in September of 2016.

The sensitivity factor and its associated uncertainty (95%) are as follows:

| Manufacturer | Serial Number | logger $\mu V/(W/m^2)$ | S U95 |
|---|---|---|---|
| Kipp and Zonen | CH1-010254 | 10.69 | $\pm 0.46\%$ |

Application
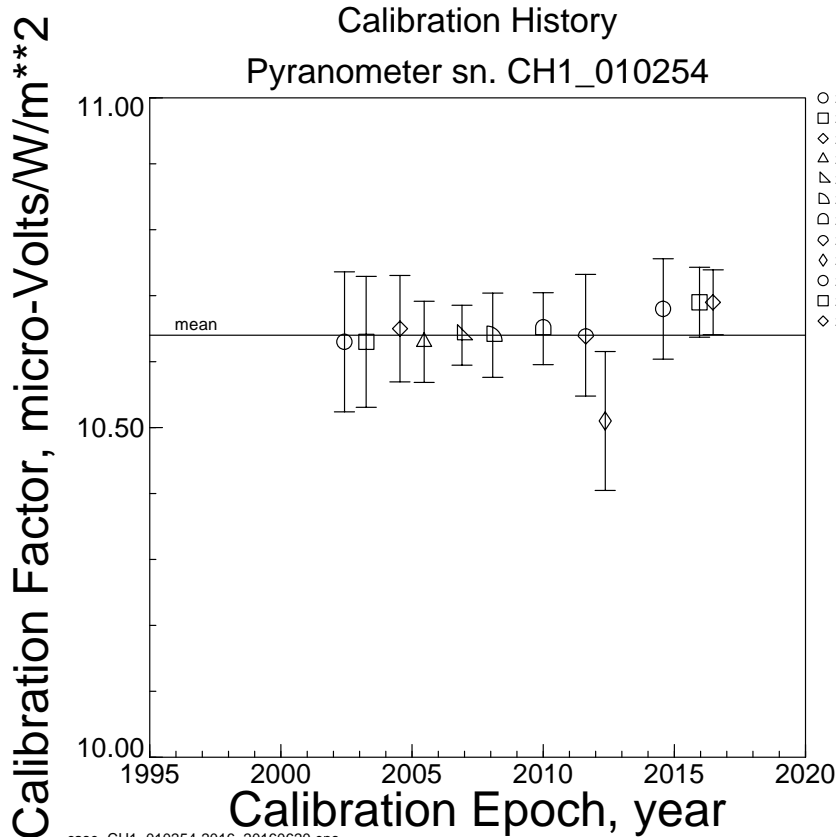
$$I = (mV\ output)/S \pm sqrt(2)*U95\%$$

Where: I = the irradiance measured by the pyrheliometer
(mV output) = microvolt output of the pyrheliometer
S = calibration coefficient of the pyrheliometer
U95% = the 95 % confidence level of a field measurement.

Some supporting plots, a list of past calibration values, and a brief description of the calibration process is presented below.
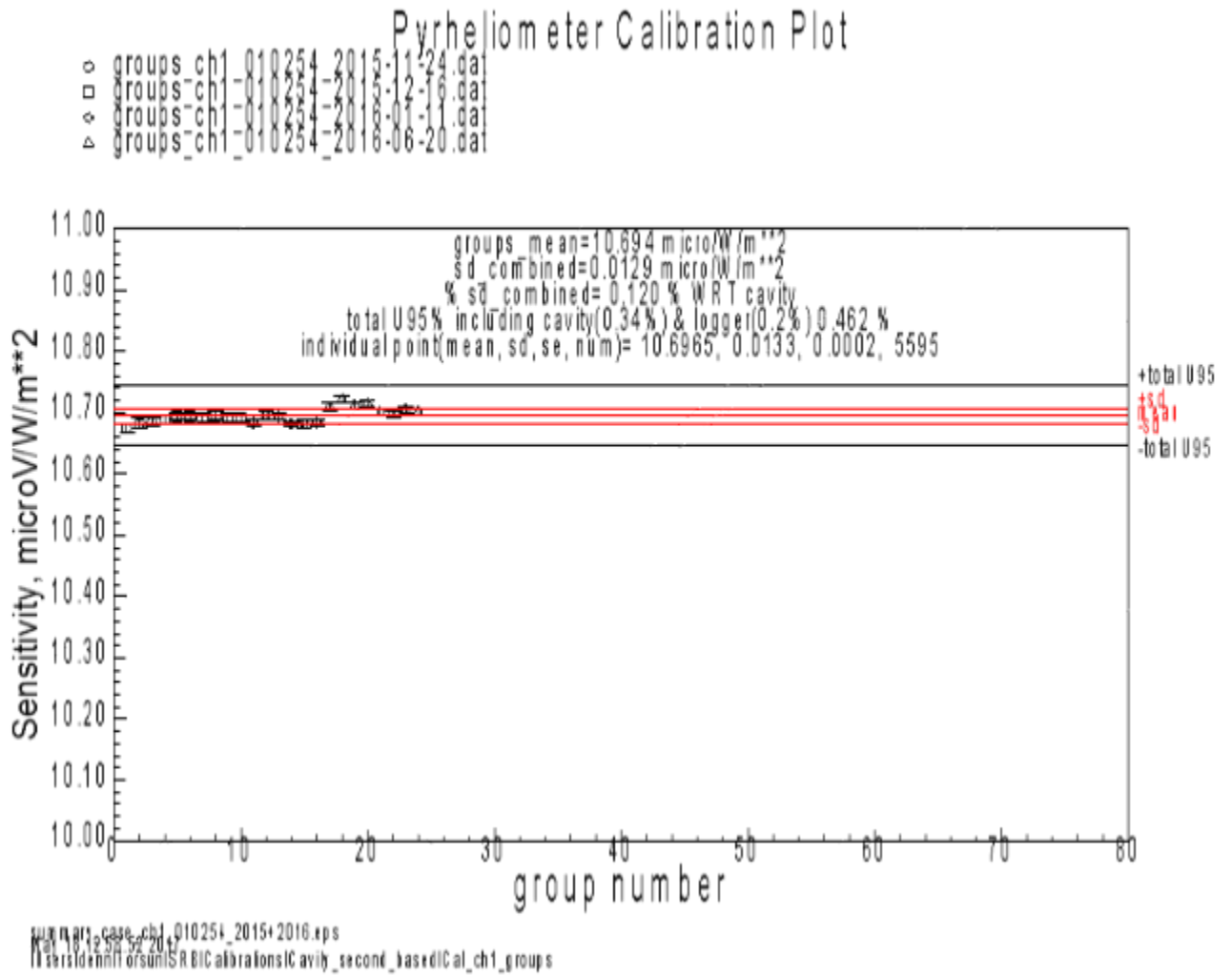
Calibration coefficients for several days. Each symbol represents a cavity run which is approximately 25 minutes. These data are combined to get a final calibration coefficient for the entire, multi-day, calibration session.

# Calibration History
## Pyranometer sn. CH1_010254



| | | |
|---|---|---|
| ○ 2002 6 1: | cal=10.630 mv/W/m**2, U95= 1.00 %, | Origional Cal. |
| □ 2003 4 3: | cal=10.630 mv/W/m**2, U95= 0.93 %, | minute data |
| ◇ 2004 7 15: | cal=10.650 mv/W/m**2, U95= 0.76 %, | 1 HZ data |
| △ 2005 6 15: | cal=10.630 mv/W/m**2, U95= 0.58 %, | 1 HZ grouped data |
| ◁ 2006 11 25: | cal=10.640 mv/W/m**2, U95= 0.43 %, | 1 HZ grouped data |
| ◠ 2008 2 1: | cal=10.640 mv/W/m**2, U95= 0.60 %, | lost documentation |
| ◠ 2010 1 1: | cal=10.650 mv/W/m**2, U95= 0.51 %, | comparison to AHF-31041 |
| ◇ 2011 8 15: | cal=10.640 mv/W/m**2, U95= 0.87 %, | comparison to AHF-31041, 1H |
| ◇ 2012 5 11: | cal=10.510 mv/W/m**2, U95= 1.00 %, | comparison to AHF-31041, 1H |
| ○ 2014 7 26: | cal=10.680 mv/W/m**2, U95= 0.71 %, | comparison to AHF-31041, 1H |
| □ 2015 12 16: | cal=10.690 mv/W/m**2, U95= 0.50 %, | comparison to AHF-31041, sta |
| ◇ 2016 6 20: | cal=10.690 mv/W/m**2, U95= 0.46 %, | comparison to AHF-31041, sta |

case_CH1_010254-2016_20160620.eps
May 18 14.40.27 2017
/Users/denn/Forsun/SRB/Calibrations/History_PSP-NIP-Cavity

Calibration history for pyrheliometer CH1-010254. The solid horizontal line represents the mean value. The symbols and their error bars represent the mean and U95 of each calibration event. The column on the right presents numerical values for each calibration event and a brief description of the calibration method used.

# CALIBRATION  HISTORIES

Pyrheliometer: Kipp and Zonen CH1-010254.

| date | day of year | S ($\mu$V/(W/m$^2$)) | U95 (%) | |
|------|-------------|----------------------|---------|---|
| 2016 June 20 | 172 | 10.69 | 0.46 | 1Hz,  ref. AHF-31041 |
| 2015 Dec. 16 | 349 | 10.69 | 0.50 | 1Hz,  ref. AHF-31041 |
| 2014 July 26 | 207 | 10.68 | 0.714 | 1Hz,  ref. AHF-31041 |
| 2012 May 11 | 118 | 10.51 | 1.43 | 1HZ, ref. AHF-31041 |
| 2011 Sep 01 | 244 | 10.64 | 0.87 | 1HZ, ref. AHF-31041 |
| 2010 Jan 01 | 001 | 10.65 | 0.51 | comparison to AHF-31041 |
| 2008 Feb 01 | 032 | 10.64 | 0.60 | lost document |
| 2006 Nov 25 | 329 | 10.64 | 0.58 | (1 HZ grouped data) |
| 2006 May 10 | 130 | | | Setup error, no useable data. |
| 2006 Jan  27 | 357 | | | Setup error, no useable data. |
| 2005 Jun  15 | 166 | 10.63 | 0.58 | (1 HZ grouped data) |
| 2004 Jul  15 | 197 | 10.65 | 0.76 | (1 HZ data) |
| 2003 Apr  03 | 093 | 10.63 | 0.93 | (minute data) |
| 2002 Jun  01 | 182 | 10.6 | | |

# A Very Brief Description of the Calibration Process.

1) Deploy the Cavity Radiometer, select the 4 second data collection parameter file. Start the cavity calibration process.
2) Modify the field radiometer program, set the parameter that causes one second data collection.
3) Prepare the tracker hardware to operate in manual shade/unshade mode. Either in manual mode or with the automatic pneumatic cylinder.
4) Start the cavity in sun-run mode, do this on a minute that is a multiple of 5 into the hour. Note a cavity calibration and sun-run takes almost 30 minutes.
5) Raise or lower the tracker shading balls every 5 minutes, on multiples of 5 minutes into the hour.
6) Continue this process as long as sky conditions permit while cavity irradiance is greater than 700 Watts/meter**2.
7) On both the cavity computer and the field radiometer computer, open a web browser and email the data files to the data processing computer,  Files could also be copied to an external memory stick.
8) Remove data that is flagged as "unstable" in the cavity data file.
9) Run a splitter program on the field radiometer file to generate a separate file for the shaded and unshaded periods for each instrument.
10) Run a plotting program on each data file so the data can be reviewed for: cloud events; bad shading; errors in the splitting routine; etc.  Remove bad data.
11) Run a calibration program to determine the calibration coefficient for each instrument.
12) Combine several days of calibration data to get a final calibration coefficient.
13) Produce a calibration document, such as this one, for each instrument.  To be considered valid a calibration must be both traceable to recognized standards, in this case the World Radiation Reference (WRR) in Davos Switzerland, and documented.