# VSF instrument calibration results
# for Emmanuel Boss - University of Maine

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The following sensors were calibrated November 18, 2014 using NIST traceable 0.1 µm beads, Thermo Scientific catalog number 3100A and lot number 43585: **BB9-132, BB3-349, BBRT-142, FLBBRTD-3697 & FLBBRTD-3698.** Water temperature of the calibration was 15 °C.

## Background information

AC9 data:
Our first procedure for checking the quality of a bead calibration takes the experimental ac9 values recorded during the calibration and uses these data as a model input to determine what the ac9 values should be based on the theoretical spectral scattering shape for the specific NIST beads using Mie theory. This routine fits a modeled spectral shape for the beads to the experimental ac9 data. The difference between the experimental and modeled ac9 data is then calculated. In theory, the difference between these two parameters should be within the accuracy of the ac9 (+/- 0.003 $m^{-1}$). Any significant difference (> 0.005 $m^{-1}$) indicates possible contamination of the tank water or other issues during calibration. The calibration passed this test.

Scaling factor slope calculations:
Scaling factors are determined using the linear slope calculated by Type II regression of ac9 data against the raw digital counts of the sensor over all bead additions. The clean water background values are removed from both the ac9 and ECO sensor data before regression. A good calibration should have an $r^2$ value of at least 0.999 and a percent standard error of the slope of less than 1%. All calibrations met this criteria.

Results:

## BB9-132

| λ | 11/18/2014 scaling factor | 11/18/2014 dark counts |
|---|---|---|
| 407 | 1.140E-04 | 41.9 |
| 439 | 2.303E-05 | 53.0 |
| 485 | 2.157E-05 | 50.8 |
| 507 | 1.692E-05 | 55.3 |
| 527 | 1.937E-05 | 54.2 |
| 594 | 1.069E-05 | 56.8 |
| 651 | 9.968E-06 | 52.1 |
| 715 | 8.565E-06 | 52.3 |
| 878 | 6.519E-06 | 51.5 |

Note: we previously calibrated this instrument on 3/7/2013 and found the following percent increase in the new scaling factors compared to these previous values:

| λ | 3/7/2013 scaling factor | % increase |
|---|---|---|
| 407 | 4.533E-05 | 86.2 |
| 439 | 1.999E-05 | 14.1 |
| 485 | 1.946E-05 | 10.3 |
| 507 | 1.615E-05 | 4.6 |
| 527 | 1.682E-05 | 14.1 |
| 594 | 1.047E-05 | 2.2 |
| 651 | 9.738E-06 | 2.3 |
| 715 | 8.375E-06 | 2.2 |
| 878 | 6.404E-06 | 1.8 |

While 5 of the 9 channels show good stability, the channels on the blue head (and the 527 nm channel) have significant drift. In particular, the 407 nm channel may be nearing the end of its useful life. Dark counts were similar between the two calibrations (~ 1-2 counts), with the highest difference again being in the 407 nm channel (~ 4 counts).

## BBRT-142

| | 11/18/2014 | 11/18/2014 |
|---|---|---|
| **λ** | **scaling factor** | **dark counts** |
| 660 | 7.199E-06 | 64.2 |

We previously calibrated this instrument on 3/7/2013 and found that this recent calibration was only 3.8% higher than the previous calibration. This is within the expected drift rate. Dark counts were unchanged between calibration (within 1 count).

## FLBBRTD-3697

| | 11/18/2014 | 11/18/2014 |
|---|---|---|
| **λ** | **scaling factor** | **dark counts** |
| 700 | 1.503E-06 | 47.6 |

This sensor was just calibrated by the factory on 9/23/2014. We found a scaling factor that was ~8% lower than that of the factory. This is not unusual given the difference in calibration methods used by the factory.

## FLBBRTD-3698

| | 11/18/2014 | 11/18/2014 |
|---|---|---|
| **λ** | **scaling factor** | **dark counts** |
| 700 | 1.525E-06 | 48.6 |

This sensor was also just calibrated by the factory on 9/23/2014. Similar to the other FLBBRTD, we found a scaling factor that was ~9% lower than that of the factory.

**BB3-349**

| | **11/18/2014** | **11/18/2014** |
|---|---|---|
| **λ** | **scaling factor** | **dark counts** |
| 470 | 6.003E-06 | 50.5 |
| 532 | 3.827E-06 | 42.0 |
| 660 | 2.088E-06 | 46.7 |

These calibration results were somewhat troubling. We last calibrated this sensor on 12/12/2013 and found the following:

| | **12/12/2013** | **12/12/2013** |
|---|---|---|
| **λ** | **scaling factor** | **dark counts** |
| 470 | 7.7709E-06 | 54.5 |
| 532 | 4.3372E-06 | 49.6 |
| 660 | 3.5646E-06 | 41.6 |

The new scaling factors are all significantly lower (470 = 26% lower, 532 = 13% lower, and 660 = 52% lower). This is very unusual, as under normal drift conditions, scaling factors increase over time. The dark counts are also significantly different from the last calibration. This could suggest that the electronics of this sensor might not be stable and are varying under different environmental/power setups. This bears close scrutiny. I would suggest that the next time we conduct a calibration (within 1-2 months) that this sensor is sent back to us to see if we get a similar calibration. If not, this sensor may need factory service.