Calibration results with 0.1 μm NIST beads for Emmanuel Boss's BB9-132.

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3/7/2013

The BB9 sensor was calibrated during March of 2013 using NIST traceable 0.1 μm beads, ThermoScientific catalog number 3100A and lot number 40549.

<u>AC9 data</u>:
We have a new procedure for checking the quality of a bead calibration that takes the experimental ac9 values recorded during a bead calibration and uses the 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. Essentially 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). Any significant difference (> 0.005 or so) indicates possible contamination of the tank water or other issues during calibration. The table below shows the residual/difference between the modeled and experimental ac9 wavelength values for each bead addition during the BB9-132 bead calibration on 3/7/2013:

bead addition	**412**	**440**	**488**	**510**	**531**	**556**	**648**	**676**	**715**
1	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.003	0.002	0.000	0.000	0.000	0.000	0.000	-0.001	0.000
3	0.003	0.001	0.000	0.000	0.000	0.000	0.000	-0.001	0.000
4	0.004	0.001	0.000	0.000	0.000	0.000	0.000	-0.001	0.000
5	0.004	-0.001	0.000	0.000	0.000	0.001	-0.001	-0.002	0.000
6	0.005	-0.001	0.000	0.000	0.000	0.001	-0.001	-0.002	0.000

Overall, this was a great calibration. The small increase in uncertainty in the low blue 412 nm wavelength is most likely a function of the high magnitude of scattering from the beads in the blue (~ 1 m^{-1} in the final bead addition) combined with some small spectral uncertainty in the actual centroid wavelength of the ac9 412 nm filter.

BB9 centroid wavelengths:

BB9-132 has nine channels of backscattering. The build sheets for this BB9 were used to estimate the actual centroid wavelengths (nm) for this sensor by convolving the reported optical characteristics of the LEDs and band-pass filter sets used in the build. The actual centroid wavelengths: 407, 439, 485, 507, 527, 594, 651, 715 and 878.

For the most part, the actual centroid wavelengths of this sensor are close to the standard wavelengths (i.e. 412, 440, 488, 510, 532, 595, 650, 715, 880) normally given for the sensor, however, they are almost always slightly different, and the actual centroid wavelengths should be (and are) used when calculating scaling factors. While these differences are small, they can decrease the accuracy of the scaling factors if the standard wavelengths are used in calculations, especially when the difference between the actual and standard wavelength is > 5 nm.

BB9 dark counts:

The dark counts were determined for BB9-132 during the calibration run. The table below is for BB9-132:

λ	**dark counts**
407	45.7
439	54.6
485	53.6
507	54.4
527	53.6
594	54.3
651	51.3
715	53.6
878	51.0

Dark counts appear reasonable and within specification.

Scaling factor slope calculations:

Scaling factors are determined using the linear slope calculated by 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 (% SE) of the slope of ~ 1% or better. The tables below are the results for BB9-132 on 3/7/2013:

	407	**439**	**485**	**507**	**527**	**594**	**651**	**715**	**878**
slope	1233.4	2975.1	3253.1	4009.4	3918.3	6584.3	7264.1	8630.4	11673.7
r^2	0.999848	0.999979	0.999956	0.999954	0.999994	0.999997	0.999973	0.999985	0.999922
SE	7.60	6.74	10.84	13.57	4.96	7.10	18.95	0.77	1.03
% SE	0.62	0.23	0.33	0.34	0.13	0.11	0.26	0.01	0.01

It is evident from these data that this was a very good calibration. The uncertainties in the slopes were all well under 1%. If we now convolve the slope data with the theoretical β/b values for the beads at each wavelength, we get the following scaling factors for BB9-132's calibration:

λ	**scaling factor**
407	4.533E-05
439	1.999E-05
485	1.946E-05
507	1.615E-05
527	1.682E-05
594	1.047E-05
651	9.738E-06
715	8.375E-06
878	6.404E-06