Rapport BIPM-98/12

Bilateral Comparison of 1.018 V Standards between the JV and the BIPM, October 1997

by D. Avrons*, P.O. Hetland**, D. Reymann* and T.J. Witt*

*Bureau International des Poids et Mesures, F-92312 Sèvres Cedex
** Justervesenet, Fetveien 99, 2007 Kjeller, Norway

A comparison of the voltage reference standards of the BIPM and the JV was carried out from August to November 1997. Two 732B Zener diode-based travelling standards, BIPM6 and BIPM7, were shipped as freight via courier service. The BIPM measurements of the travelling standards were carried out by comparing the 1.018 V outputs with a reference standard cell whose value is known with respect to the BIPM Josephson voltage standard with a combined standard uncertainty of 10 nV. The JV carried out direct measurements of the travelling standards with its Josephson array voltage standard. Results of all measurements were corrected for the dependence of the output voltage on ambient temperature and pressure.

Figure 1 shows the results of the 1.018 V measurements of BIPM6 in both laboratories. The measurements were analyzed using a linear least-squares fit to the voltages as a function of time. The straight lines on the graph show the predicted values. The dashed lines represent the standard uncertainties of the predicted points. The results are referenced to the mean date of the JV measurements, 9 October 1997. In this way, the values and uncertainties of the JV measurements are essentially the same whether we use a least-squares fit or a simple average. The BIPM value and uncertainty for the reference date are calculated from the least-squares fit. Figure 2 shows the results for BIPM7.

Table 1 lists the results of the comparison and the component uncertainty contributions. The uncertainty components arising from the uncertainies in the BIPM measurements of the temperature and pressure coefficients would lead to a type B uncertainty if only one travelling standard were used. In the case of more than one, we do not expect significant correlation among the corrections for different standards and in our uncertainty table they are treated as type A uncertainties. In combining the component uncertainties we apply the usual propagation of uncertainties analysis for

the uncertainty of the mean value of the result. Thus, since the final result is calculated from the mean of the results from each travelling standard, its type A variance is the sum of the type A variances of the travelling standards divided by the square of the number of travelling standards. The total variance is the sum of 1) the type A variance, 2) the type B variances and 3) the variance deduced from the transfer uncertainty.

The final results of the comparison are presented as the difference between the value assigned to a 1.018 V standard by the JV, U_{JV}, and that assigned by the BIPM, U_{BIPM}, on the reference date. The result is

$$U_{JV} - U_{BIPM} = -0.043\ \mu V; \qquad u_c = 0.023\ \mu V \text{ on } 1997/10/09,$$

where u_c is the combined type A and type B standard uncertainty from both laboratories. This is a very satisfactory result. The combined uncertainty is unusually small because of the small value of the transfer uncertainty, which is taken to be the standard deviation of the comparison results obtained with the two travelling standards. Because only two travelling standards were used, the uncertainty of the transfer uncertainty is rather large. Our experience leads us to expect typical values of the order of 0.050 μV for the transfer uncertainty.

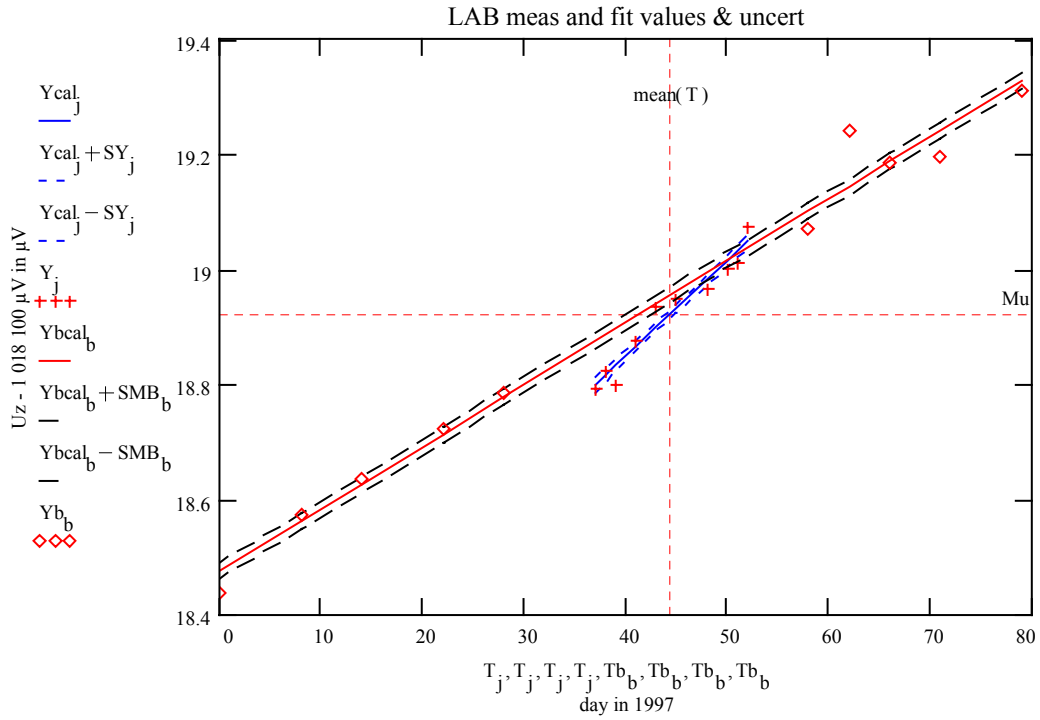

Figure 1. Values measured by JV (j) and BIPM (b) for BIPM6. The solid lines result from least-squares fits and the dashed lines are the corresponding uncertainties of the fitted values. The origin is 26 August 1997.

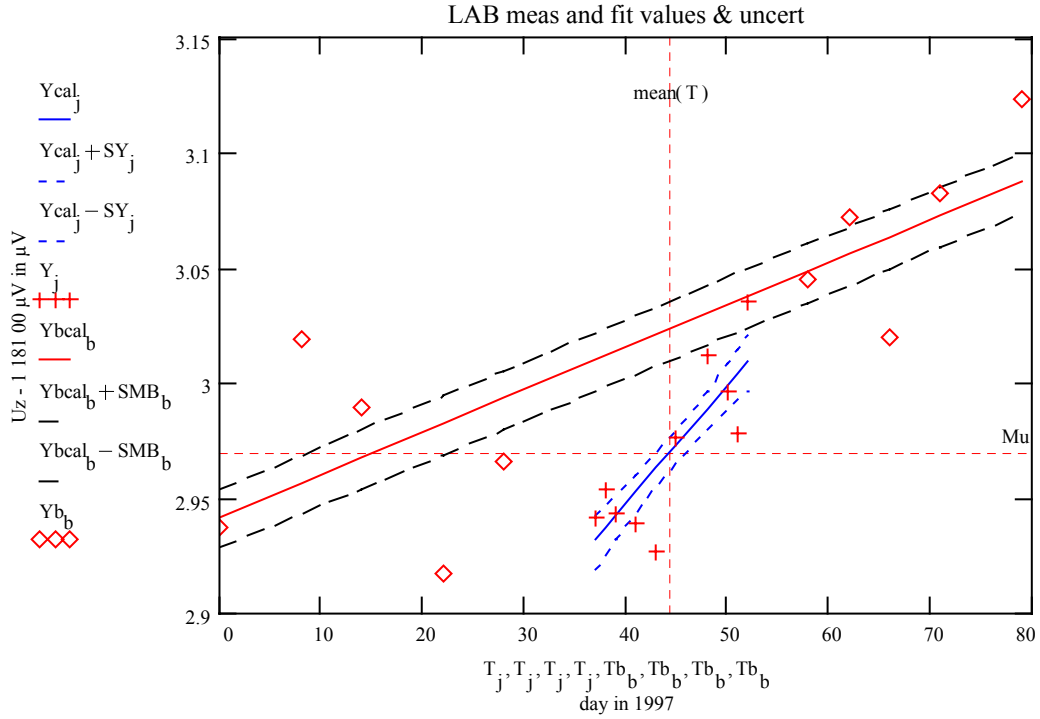

Figure 2. Values measured by JV (j) and BIPM (b) for BIPM7. The solid lines result from least-squares fits and the dashed lines are the corresponding uncertainties of the fitted values. The origin is 26 August 1997.

Table 1. Results of the JV/BIPM bilateral comparison of 1.018 V standards using Zener travelling standards. Mean Date 9 October 1997.

3 Dec, 1997 Corrected JV type B uncer to .0041μV

BIPM value

units are μV

		BIPM6@1.018 V	BIPM7@1.018 V
1	JV value, U_{JV}	1018118.922	1018102.970
2	JV unc (A)	0.007	0.007
3	JV unc (B)	0.004	0.004
4	JV unc (total)	0.008	0.008
5	BIPM value, U_{BI}	1018118.955	1018103.024
6	BIPM unc (A)	0.014	0.013
7	BIPM unc (B)	0.010	0.010
8	BIPM unc (tot)	0.017	0.016
9	pc & tc unc	0.001	0.018
10	tot rss for this Zener	0.016	0.023
11	U_{JV} -U_{BIPM}	-0.033	-0.054
12	mean U_{JV} -U_{BIPM}	-0.043	
13	unc of transfer	0.015	
14	Total unc of comparison	0.023	
15	mean date yy/mm/dd	97/10/9	97/10/9

References to Table 1.

1, 2, 3 and 4 are the JV value, type A, type B and combined uncertainties.

5, 6, 7 and 8 are the BIPM value, type A, type B and combined uncertainties.

9 is the rss total uncertainty associated with the corrections for temperature and pressure; we assume that the uncertainties in the pressure and thermistor measurements are negligible and that the total uncertainty is dominated by that of the coefficients. For a single travelling standard this would be a type B uncertainty but with more than one, there is negligible correlation among them and the uncertainty becomes type A.

10 is the total type A uncertainty for the Zener in this column and is the rss of 2, 6 and 9.

11 is the comparison result from the Zener in each column.

12 is the mean difference for all n(=2) Zeners.

13 is the uncertainty due to transport and is given by the standard deviation of the results from all travelling standards.

14 is the total combined standard uncertainty of the comparison. From usual rules of uncertainty propagation (se e.g., *Guide to Expression of Uncertainty in Measurement*, equation E-3), the variances corresponding to the standard deviations 10 are summed for the n Zeners and divided by n^2. These are then added to the variances corresponding to 3, 7 and 13. The total uncertainty is the square root of this sum.