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Bilateral Comparison of 10 V Standards between the PSB and the BIPM, April 1998

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A comparison of the voltage reference standards of the BIPM and the PSB was carried out from 18 March to 3 June 1998. Two PSB Fluke 732B Zener diode-based travelling standards, s/n 5565004 and 6265012, were carried by air as hand baggage. The BIPM measurements of the 1.018 V outputs of the travelling standards were carried out by comparison 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 BIPM measurements of the 10 V outputs of the travelling standards were carried out by dividing the 10 V output down to 1.018 V using a custom-built resistive divider and comparing this with a reference standard cell whose value is known with respect to the BIPM Josephson voltage standard. The combined standard uncertainty of the link from 10 V to the Josephson standard is 0.01 μV and has been verified by measurements using the BIPM 10 V Josephson array voltage standard. The PSB carried out direct measurements of the travelling standards with its Josephson array voltage standard before and after carrying the Zener standards to the BIPM. Results of all measurements were corrected for the dependence of the output voltages on ambient temperature and pressure using coefficients determined in separate measurements at the BIPM. The coefficients are given in BIPM Calibration Certificates Nos. 7 and 8, 1998.

Figure 1 shows the results of the 10 V measurements of standard no. 5565004 (referred to as 004) in both laboratories. The measurements were analyzed using a linear least-squares fit to the voltages as a function of time. The straight dashed lines on the graph show the predicted values. The results are referenced to the mean date of the BIPM measurements, 27 April 1998. In this way, the values and uncertainties of the BIPM measurements are essentially the same whether we use a least-squares fit or a simple average. The PSB value and uncertainty for the reference date are also calculated from a linear least-squares fit. Figure 2 shows the results for travelling standard no. 6265012 (referred to as 012) at 10 V. Figure 3 shows the results for 004 at 1.018 V. Figure 4 shows the results for 012 at 1.018 V. Figures 3 and 4 indicate that unexpected rapid changes occurred in the 1.018 V outputs of both standards upon return to the PSB. This may be associated with humidity. The simple model that assumes a linear drift in the Zeners as a function of time is clearly not appropriate in this case. Because of the unusual behavior of the 1.018 V outputs of the travelling standards, these results are not included in the bilateral comparison.

Table 1 lists the results of the comparison and the component uncertainty contributions. The components arising from the uncertainties 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 uncertainties we apply the usual method of combining variances to calculate the uncertainty of the mean value of the result. Thus, 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 10 V standard by the PSB, U_{PSB}, and that assigned by the BIPM, U_{BIPM}, on the reference date. The result is

at 10 V: $U_{PSB} - U_{BIPM} = 0.16\ \mu V$; $u_c = 0.11\ \mu V$ on 1998/04/27,

where u_c is the combined type A and type B standard uncertainty from both laboratories. This difference corresponds to 1.6 parts in 10^8 of the 10 V output. These are very good results in view of the limitations of the travelling standards.

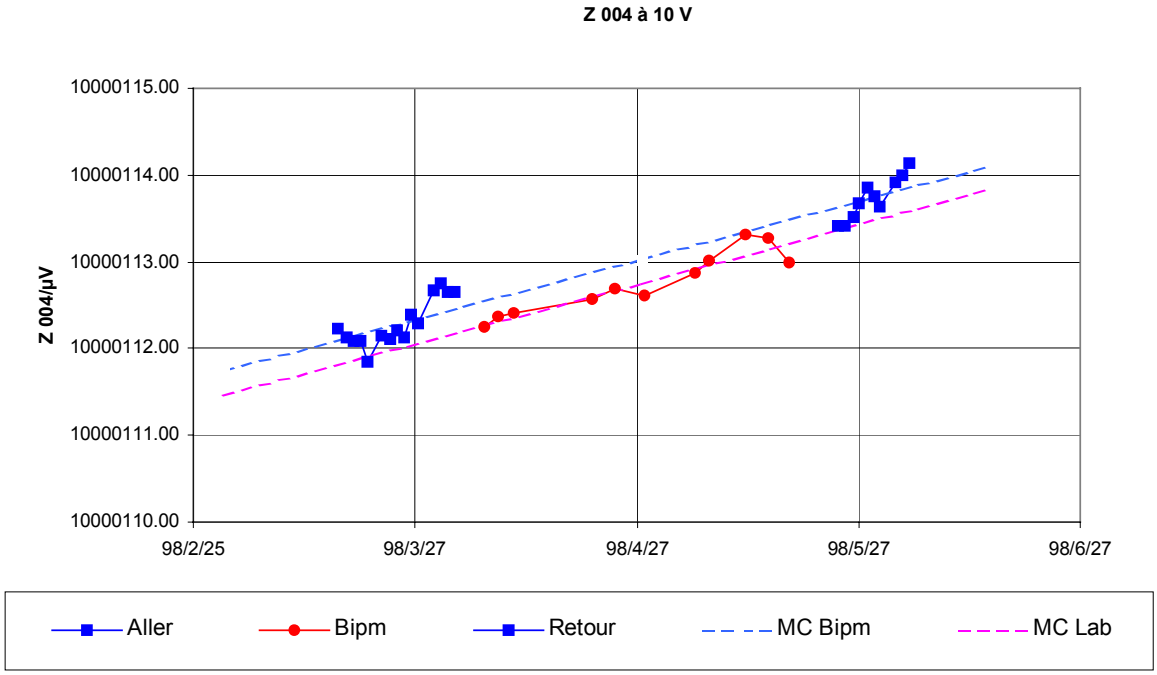

Figure 1. Values assigned to the 10 V output of Zener 5565004 by the PSB (Lab) and the BIPM. Dashed lines are the result of linear least-squares fits (MC).

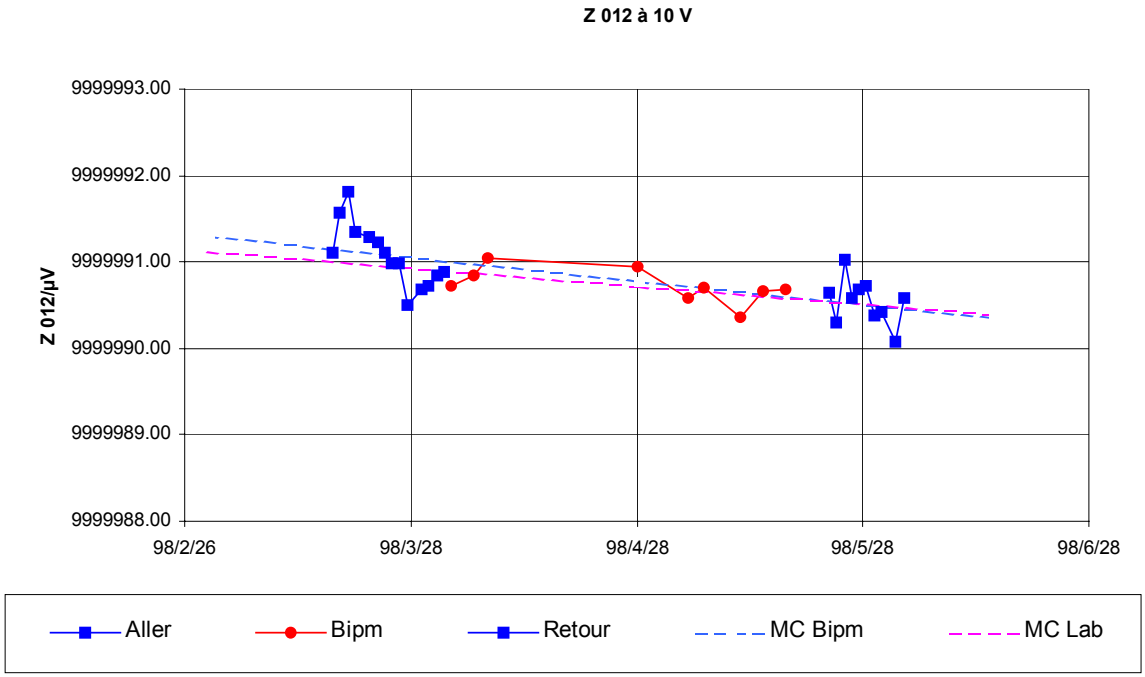

Figure 2. Values assigned to the 10 V output of Zener 6265012 by the PSB (Lab) and the BIPM. Dashed lines are the result of linear least-squares fits (MC).

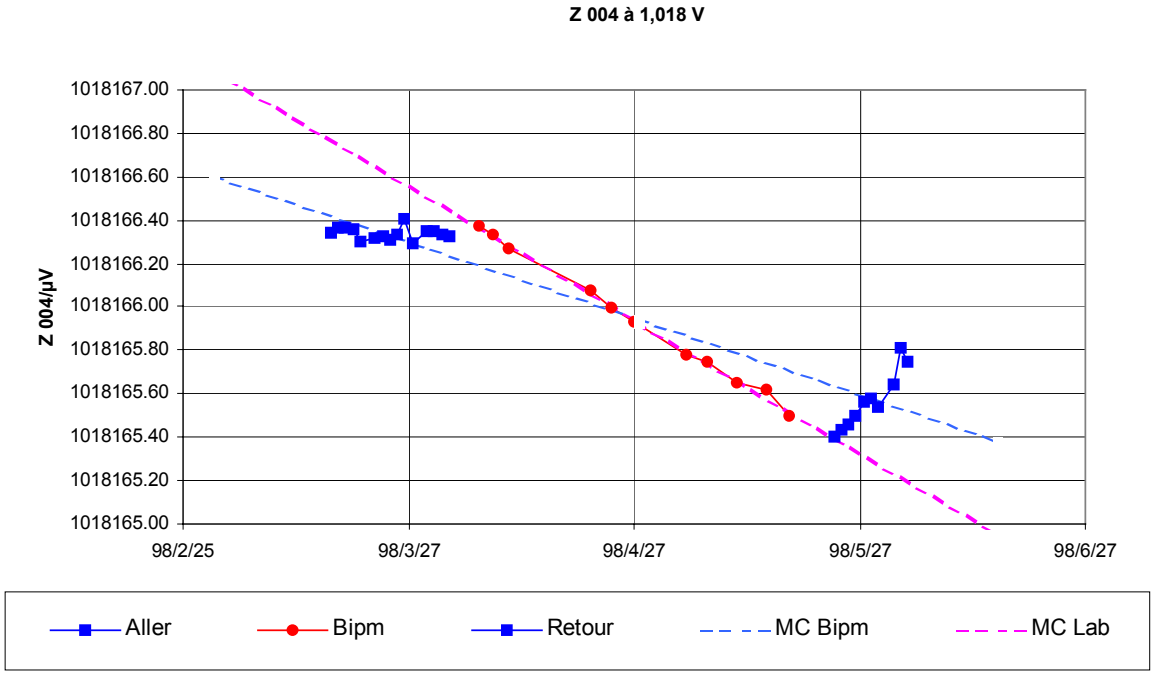

Figure 3. Values assigned to the 1.018 V output of Zener 5565004 by the PSB (Lab) and the BIPM. Dashed lines are the result of linear least-squares fits (MC).

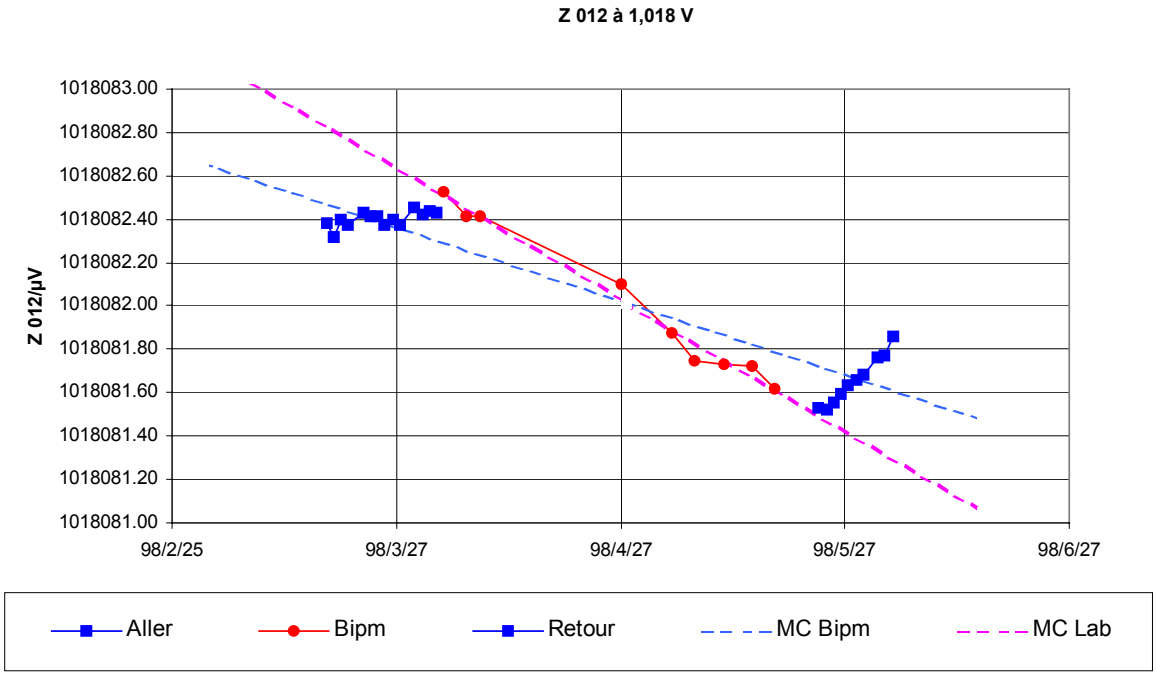

Figure 4. Values assigned to the 1.018 V output of Zener 6265012 by the PSB (Lab) and the BIPM. Dashed lines are the result of linear least-squares fits (MC).

Table 1. Results of the PSB/BIPM bilateral comparison of 10V standards using Zener travelling standards. Mean Date: 27 April 1998.

units are μV

		Z.004 at 10 V	Z.012 at 10 V
1	PSB value, drift model	10000113.03	9999990.79
2	PSB unc (A), drift model	0.04	0.06
3	PSB unc (B)	0.03	0.03
4	BIPM value, drift model	10000112.76	9999990.73
5	BIPM unc (A), drift model	0.04	0.06
6	BIPM unc (B)	0.01	0.01
7	$U_{PSB} - U_{BIPM}$	0.27	0.06
8	Unc (A) of $U_{PSB} - U_{BIPM}$	0.06	0.08
9	mean $U_{PSB} - U_{BIPM}$	0.16	
10	unc of transfer	0.11	
11	Total unc of comparison	0.11	
12	mean date yy/mm/dd	98/04/27	

References to Table 1.

1. Results from a linear least-squares fit to the PSB data.
2. The type A standard uncertainty following from the least-squares fit to the PSB data.
3. The type B uncertainty estimated by the PSB.

4-6. Same as 1-3. But for the BIPM results.

7. The comparison result following from each travelling standard.
8. The combined type A uncertainty in 7; the root-sum-square of the contributions from both laboratories.
9. The mean of the results on line 7.
10. The standard deviation of the mean of the results from the two travelling standards.
11. The root-sum-square combination of items in lines 3,6,8 and 10.
12. The mean date of the comparison, the mean date of the BIPM measurements.