Noise Characteristics of Phoenix TIMS *X*act Faraday Detectors with 1 x 10^{11} ohm resistors

TECHNICAL

Technical Brief T10512

Introduction

High precision isotope ratios require an optimal signal to noise ratio. Here we assess the electronic noise of the new ***X***act Faraday detectors on Phoenix TIMS using a range of different integration times and compare the results to the theoretical noise calculated from the Johnson law.

Experimental

Phoenix has nine Faraday collectors each directly connected to its own resistor/amplifier circuit board. The boards slot into in a Peltier cooled (16°C) and evacuated housing situated immediately above the Faraday collector block.

Baselines were measured on nine ***X***act Faraday collectors fitted on a Phoenix TIMS using a number of different integration times over an hour (see Table 1). The average and standard deviation of the nine data sets provides a representative value for the noise characteristics at that integration time, together with the variance. These results are presented in Table 1 and in Figures 1 and 2. The data are presented in microvolts where 10 microvolts is equivalent to 1 x 10^{-16} amps.

Johnson Noise

The theoretical thermodynamic limit of noise in a resistor is defined by the Johnson Law ...

$$\bar{v_n^2} = 4k_BTR$$

Where k_B is Bolzmann constant = 1.38 x 10^{-23} Joules per Kelvin. T is the temperature on the resistor in Kelvin (in this case 289K), R is the resistance of the resistor in ohms (1 x 10^{11}). For different integration times (t) this can be simplified to:

$$\text{Noise} = \sqrt{(4 \times k_BTR(1/t))}$$

Figures 1 and 2 show the theoretical noise shown in pink for different integration times. It can be seen that the noise levels of the new ***X***act Faradays are at the predicted level irrespective of the integration time.

Conclusions

Noise levels of the new ***X***act Faraday/Resistor/Amplifier detectors are close to the thermodynamic theoretical limit calculated from the Johnson equation.

Integration time (secs)	Mean (microvolts)	1SD (microvolts)
1	39.5	2.9
1	38.9	2.6
2	26.6	1.9
3	21.1	1.3
4	18.0	1.2
5	16.3	1.2
6	14.2	0.7
8	13.0	1.1
10	11.6	0.8
12	10.9	0.7
15	9.6	0.7
20	8.5	1.4
60	5.3	0.5
300	2.8	0.5

Table 1. *Noise level of Phoenix* ***X***act *Faraday collectors*

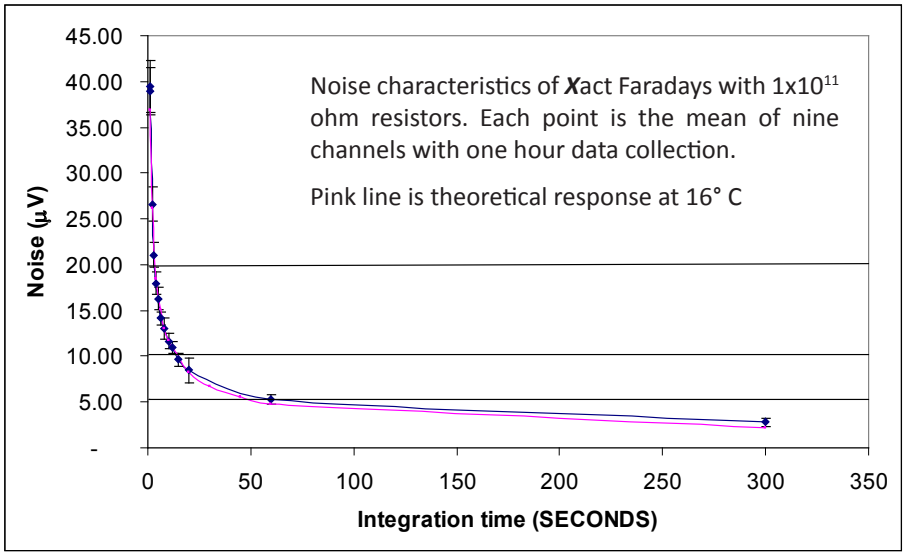

Figure 1. *Faraday noise with different integration times*

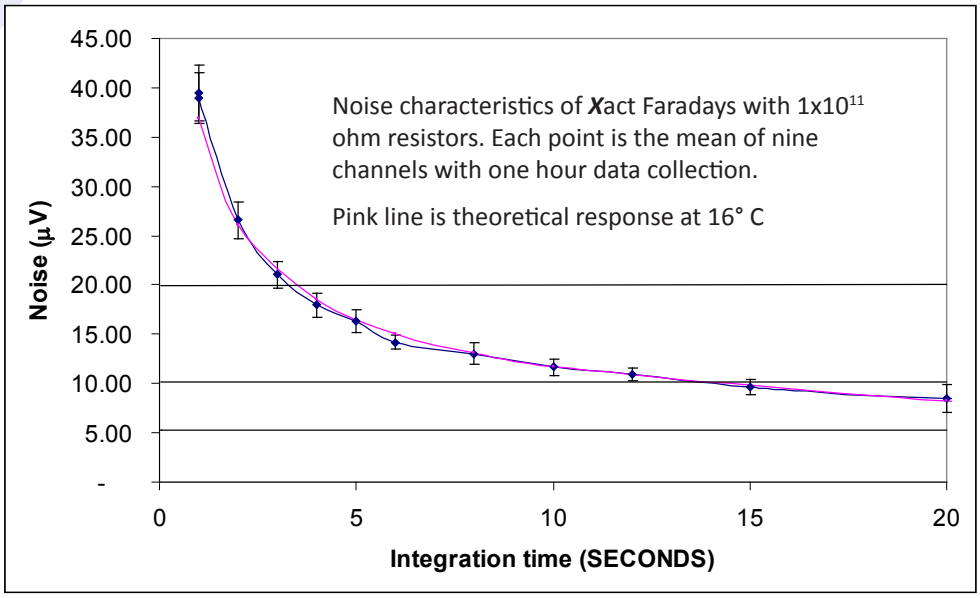

Figure 2. *Noise levels in the range 1 to 20 second integration, closely follow the theoretical Johnson noise curve*