Isotope Ratio Analysis of NBS U010 Uranium Standard Using External NBS U500 Mass Fractionation Correction

NUCLEAR

Application Brief N11010

Zenon Palacz, IsotopX Ltd, Middlewich, Cheshire, UK.

Introduction

The NBS Uranium Standard U010 has been analysed in the STATIC Faraday multi-collection mode. This standard has a large range in isotope abundance and the accuracy and precision of an analysis are a good test of the linearity and noise levels of the Faraday cups.

Because Uranium does not have a stable isotope ratio, any mass fractionation correction must use an external mass calibration. This is achieved by analysing a different standard of known isotopic composition under exactly the same analytical conditions. An ideal standard would have similar isotopic abundances to the unknown sample, but in order to challenge the Phoenix TIMS we have chosen to use NBS U500 which has a $^{235}U/^{238}U$ of 0.99969, two orders of magnitude larger than that of U010.

BEAD	234U/238U	stdErr%	235U/238U	stdErr%	236U/238U	stdErr%
1	**0.010463**	0.013	**1.0022**	0.009	**0.001527**	0.03
2	**0.010455**	0.014	**1.0017**	0.009	**0.001526**	0.03
3	**0.010473**	0.008	**1.0031**	0.007	**0.001529**	0.03
4	**0.010462**	0.013	**1.0024**	0.008	**0.001525**	0.03
5	**0.010453**	0.015	**1.0017**	0.012	**0.001527**	0.03
6	**0.010469**	0.010	**1.0027**	0.008	**0.001529**	0.02
7	**0.010462**	0.011	**1.0024**	0.006	**0.001526**	0.04
8	**0.010463**	0.013	**1.0023**	0.008	**0.001526**	0.02
MEAN	**0.010463**		**1.0023**		**0.001527**	
1SD	**0.000007**		**0.0005**		**0.000001**	
1RSD	**0.063%**		**0.045%**		**0.095%**	

Table 1. Eight replicate measurements of NBS U500 to determine the instrumental mass bias

Experimental

Eight separate samples of two micrograms of U500 were analysed on triple Rhenium filaments. The results are shown in Table 1. The analyses were made with an ion beam of 3 volts for the ^{238}U, and four blocks of 20, 10 second integrations.

The mean $^{235}U/^{238}U$ is 1.0023, which provides a mass bias of 0.088% per mass unit.

A further set of measurements of the U010 standard were made. 2 micrograms of Uranium was analysed at a ^{238}U intensity of 6 volts, such that the total ion intensity was similar to the NBS U500 measurements. ^{235}U ion signals were 60mV, and the minor ^{234}U and ^{236}U less than 0.4mV. The results are shown in Table 2 and Figures 1 to 3 overleaf.

Bead	234/238 raw	stdErr%	235/238raw	stdErr%	236/238 raw	stdErr%
1	**0.0000566**	0.38	**0.010159**	0.007	**0.0000693**	0.33
2	**0.0000553**	0.38	**0.010163**	0.006	**0.0000703**	0.33
3	**0.0000546**	0.35	**0.010168**	0.010	**0.0000708**	0.28
4	**0.0000546**	0.36	**0.010169**	0.007	**0.0000697**	0.26
5	**0.0000555**	0.28	**0.010170**	0.008	**0.0000695**	0.23
6	**0.0000560**	0.32	**0.010158**	0.008	**0.0000704**	0.31
7	**0.0000544**	0.34	**0.010163**	0.009	**0.0000705**	0.26
8	**0.0000546**	0.36	**0.010168**	0.007	**0.0000701**	0.28
9	**0.0000556**	0.29	**0.010164**	0.009	**0.0000701**	0.27
10	**0.0000561**	0.40	**0.010170**	0.007	**0.0000699**	0.25
11	**0.0000546**	0.36	**0.010170**	0.008	**0.0000706**	0.26
MEAN	**0.0000553**		**0.010166**		**0.0000701**	
1SD	**0.0000007**		**0.000004**		**0.0000005**	
1RSD	**1.4%**		**0.04%**		**0.7%**	

Extrenal Fractionation corrected

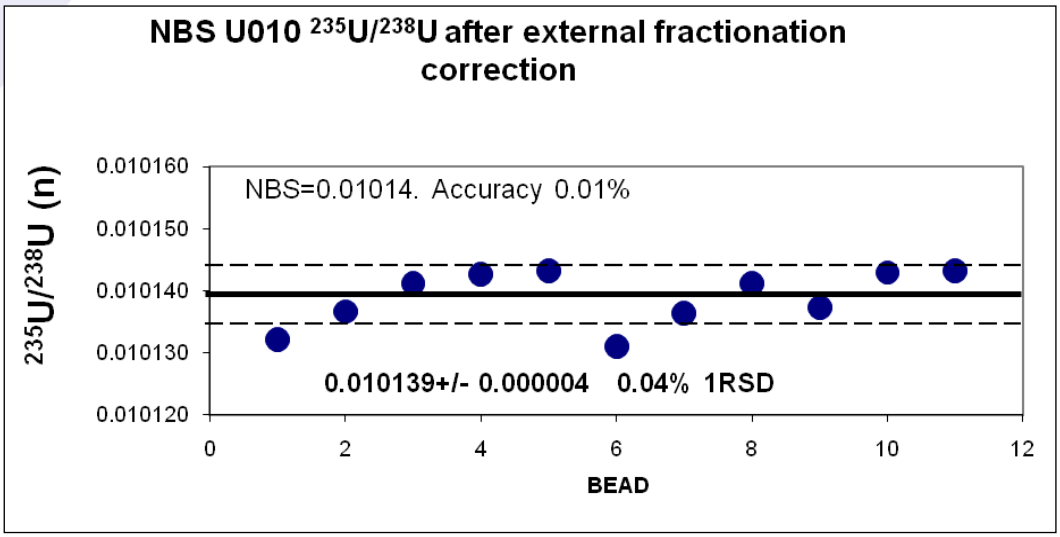
Bead	234/238 corr	stdErr%	235/238 corr	stdErr%	236/238 corr	stdErr%
1	**0.0000564**	0.38	**0.0101320**	0.007	**0.0000692**	0.33
2	**0.0000551**	0.38	**0.0101365**	0.006	**0.0000702**	0.33
3	**0.0000544**	0.35	**0.0101411**	0.010	**0.0000707**	0.28
4	**0.0000544**	0.36	**0.0101425**	0.007	**0.0000696**	0.26
5	**0.0000553**	0.28	**0.0101431**	0.008	**0.0000694**	0.23
6	**0.0000558**	0.32	**0.0101309**	0.008	**0.0000703**	0.31
7	**0.0000543**	0.34	**0.0101362**	0.009	**0.0000704**	0.26
8	**0.0000544**	0.36	**0.0101411**	0.007	**0.0000700**	0.28
9	**0.0000554**	0.29	**0.0101372**	0.009	**0.0000700**	0.27
10	**0.0000559**	0.40	**0.0101428**	0.007	**0.0000698**	0.25
11	**0.0000545**	0.36	**0.0101431**	0.008	**0.0000705**	0.26
MEAN	**0.0000551**		**0.010139**		**0.0000700**	
1SD	**0.0000007**		**0.000004**		**0.0000005**	
1RSD	**1.4%**		**0.04%**		**0.7%**	
NBS			**0.01014**			
ACCURACY			**0.01%**			

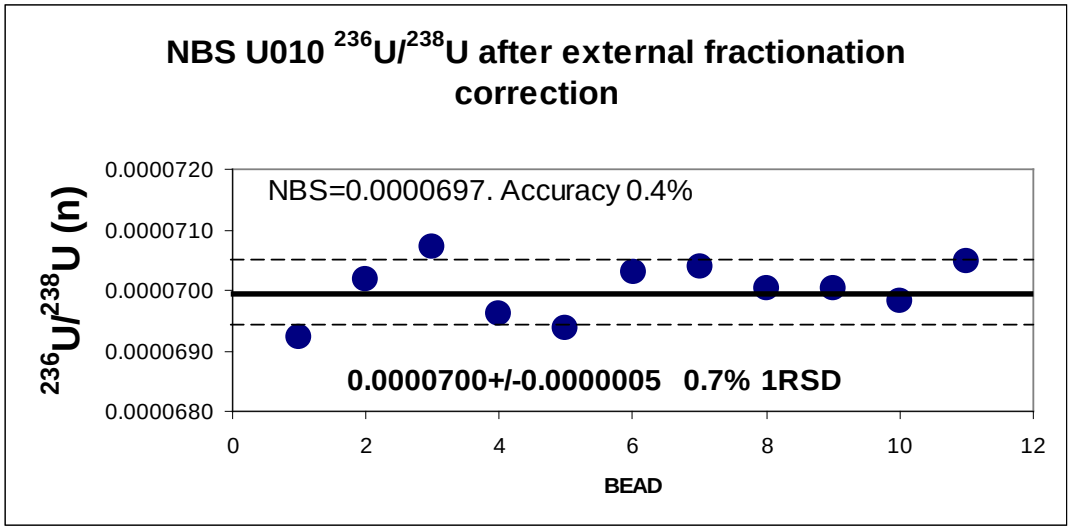
Table 2. Replicate measurements of NBS U010 standard

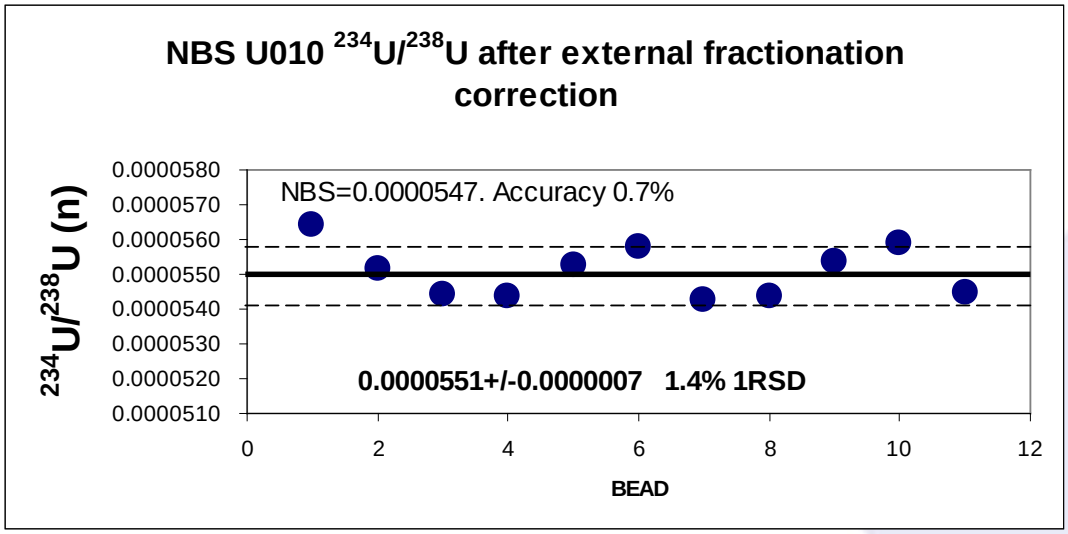
Results

The reproducibility of the $^{235}U/^{238}U$ is 0.04%. The minor isotopes ^{236}U and ^{238}U have measurement precisions of better than 0.5% and can be reproduced to 1.4% for the $^{234}U/^{238}U$ and 0.7% for the $^{236}U/^{238}U$.

Following fractionation correction using the mass bias determined from U500, the $^{235}U/^{238}U$ ratio is 0.010139 which is within 0.01% of the certified value. This confirms that using the Phoenix TIMS, accurate fractionation correction can be applied even when the chosen isotopic standard has a composition that is 2 orders of magnitude different from that of the sample.







Summary - Reproducibility of <0.05%1RSD can be achieved with NBS U010, and an accuracy of 0.01% using an external fractionation correction with NBS U500