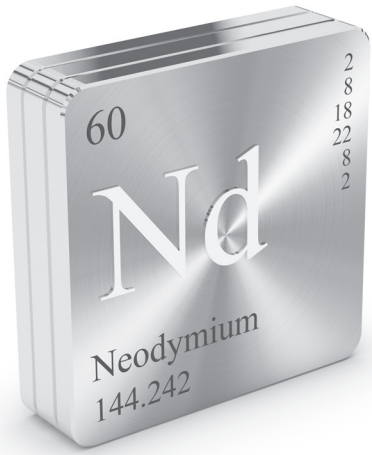
TIMS: Long Term Reproducibility of Nd Isotopic Data Acquired on TRITON *Plus*

Anne Trinquier, Thermo Fisher Scientific, Bremen, Germany

Key Words
Neodymium, TRITON ***Plus*** TIMS, Static Mode, Virtual Amplifier, $10^{11}\Omega$ Amplifier

Introduction

Neodymium is a rare earth metal with seven naturally occurring isotopes: ^{142}Nd (27.2%), ^{143}Nd (12.2%), ^{144}Nd (23.8%), ^{145}Nd (8.3%), ^{146}Nd (17.2%), ^{148}Nd (5.7%) and ^{150}Nd (5.6%). The ability to resolve Nd isotopic anomalies at the ppm level in materials with a wide range of Nd concentrations is essential for investigating fundamental relations in geochronology, geochemistry, cosmochemistry and environmental sciences. Neodymium isotope Thermal Ionization Mass Spectrometry (TIMS) has proven successful in running Nd both as Nd^+ on multiple filament assemblies[1,2] (300–500 ng) and NdO^+ on single filament assemblies[3,4] (1–10 ng). With the advent of second-generation TIMS instruments in the late 1990's, the reproducibility of Nd isotopic analyses improved by an order of magnitude, down to 2 ppm/amu (ref. 1), thus improving time resolution of geochronology by a factor of 3. Subsequent publications show a gross inter-laboratory consensus on a typical external reproducibility on the order of 2–5 ppm/amu on 500 ng Nd^+ loads. The present study on a Thermo Scientific™ TRITON *Plus*™ TIMS assesses the precision and reproducibility over 1 year of Nd isotope analyses in metal form (Nd^+) on double filament assemblies on one Nd standard (Merck #170335) for sample loads ranging from 500 ng to 100 ng, using 10^{11} Ω amplifiers, automated mode and analytical runs of about 1 hour.



The Virtual Amplifier

In static acquisition mode, the uncertainty on amplifier gain calibration propagates into the uncertainty of the isotopic ratio analysis. However, if, during analysis, all cups are sequentially connected to all amplifiers, all ion beams are in turn measured with the same set of amplifiers, and the stochastic calibration biases of the amplifiers can be averaged out. The virtual amplifier thus reduces the propagation of the uncertainty of the gain calibration procedure. The switching of amplifier-cup associations is performed as an inter-block action in a few ms. To ensure association of all Faraday cups with all amplifiers, the number of data blocks should be a multiple of the number of active amplifiers.[5]

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Analytical Protocol

Neodymium Static Analysis with Virtual Amplifier	
Isotopic Standard	MERCK Neodymium ICP standard 170335 $^{143}Nd/^{144}Nd = 0.512399 \pm 3$ (2SD)*
Filament Assembly	Zone refined rhenium double filaments
Outgasing	40 minutes at 3.2 A; 10 minutes at 4.5 A
Loading	Nd in 6M HCl
Additives	1 µL 0.3M H_3PO_4 Dull red glow for 5 s
Amount and Signal	500 ng , 2–9 V ^{142}Nd
Acquisition Mode	Static, virtual amplifier: 3 cycles of rotation (480 ratios) or 2 cycles of rotation (320 ratios), sequence
Baseline	105 s before each block
Temperature (°C)	1650 °C on the ionization filament
Normalized to	$^{146}Nd/^{144}Nd = 0.7219$, exponential correction
Internal Precision (2RSE)	6 ppm on $^{143}Nd/^{144}Nd$ (5 V ^{142}Nd, 480 ratios, ca. 1.5 h acquisition); 5 ppm on $^{143}Nd/^{144}Nd$ (10 V ^{142}Nd, 320 ratios, ca. 1 h acquisition)
Long-Term External Reproducibility (2RSD)	2 to 6 ppm/amu on 100 and 500 ng loads (n=73, 1 year)

* TRITON *Plus*, Thermo Fisher Scientific, Bremen, Application Laboratory (100–500 ng loads; n=73).

Table 1. Cup configuration.

Line No.	Mass Set	L3	L2	L1	RPQ/ IC1 C	H1	H2	H3	H4	Integration Time(s)	Number of Integrations	Idle Time(s)	Control Cup Peakcenter	Control Cup Focus
1	Main	^{142}Nd	^{143}Nd	^{144}Nd	^{145}Nd	^{146}Nd	^{147}Sm	^{148}Nd	^{150}Nd	8.389	1	5.000	^{145}Nd	^{142}Nd

External Reproducibility

Nd isotope ratios corrected for instrumental mass bias are plotted in Figure 1. Nd^+ analyses of 500 ng and 100 ng loads on double Re filament assemblies in static mode with rotation of the amplifier-cup association ("virtual amplifier") yield indistinguishable isotopic ratios. The 1-yr 2RSD reproducibility on 100 ng and 500 ng loads is 2 to 6 ppm/amu (n=73, 3.6-10 V $^{142}Nd^+$). Notably, analyses with 10 V $^{142}Nd^+$ ion beams can be limited to 1 hr and analyses with 100 ng to 1 h 30.

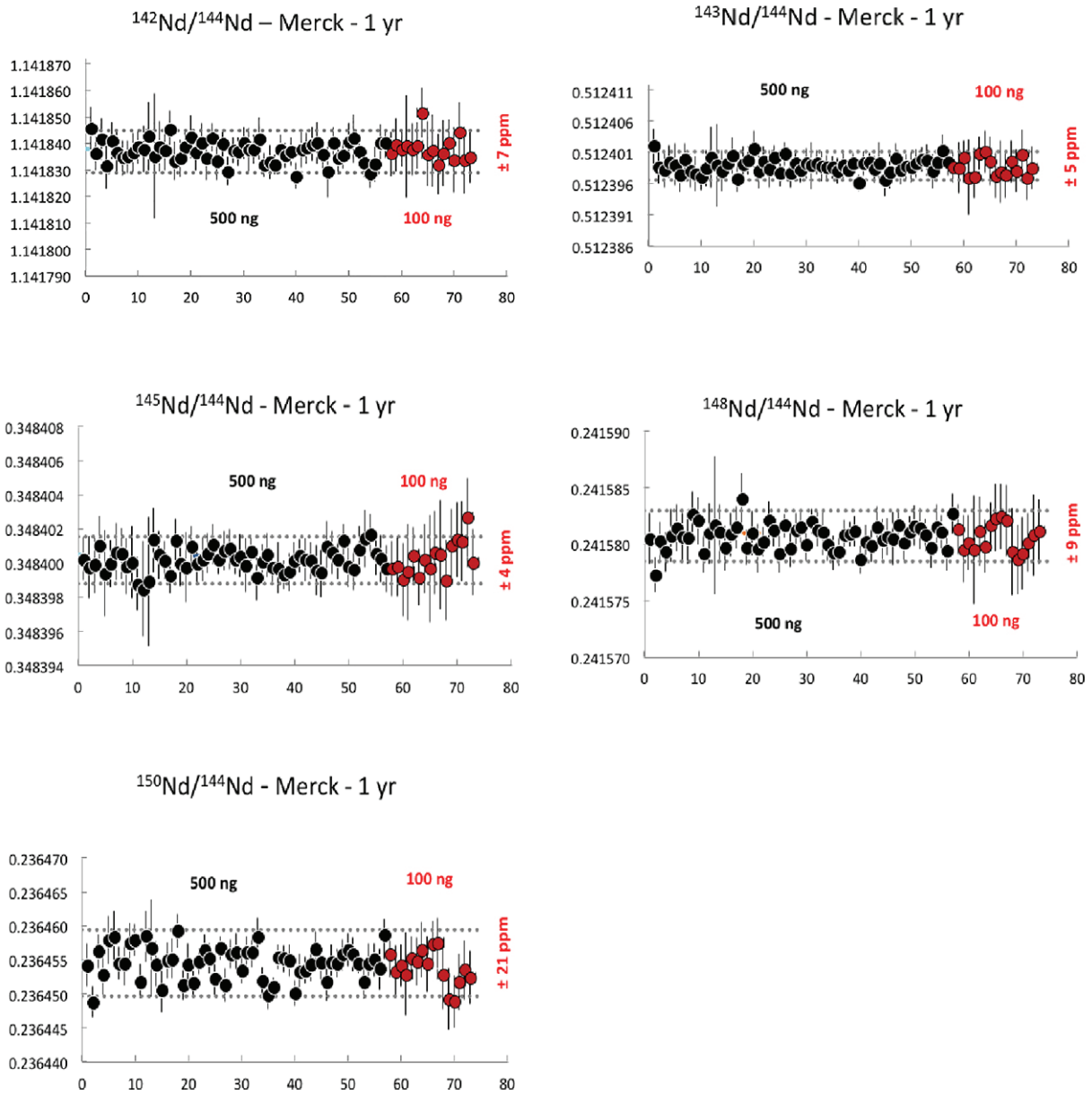

Figure 1. $^{i}Nd/^{144}Nd$ 2SD 1 year long-term external reproducibility of Nd metal analyses using the virtual amplifier. One year 2RSD reproducibility on 500 ng loads: 2 to 5 ppm/amu (n=57, no outlier, 2-10 V $^{142}Nd^+$, 3 and 2 cycles of amplifier-cup rotation). 2 cycles of amplifier rotation at ^{142}Nd = 9 V (1 h analysis) compared to 3 cycles at ^{142}Nd = 5 V (1 h 30 min analysis). 2RSD reproducibility on 100 ng loads = 2 to 6 ppm/amu (n=16, no outlier, 3.6 V $^{142}Nd^+$, 3 cycles of amplifier-cup rotation). Error bars are 2se.

Conclusion

Twice faster Nd isotopic analyses compared to literature can be achieved in static mode with virtual amplifier. One hour-long analyses yield a 2SD 1 year external reproducibility of 2 to 5 ppm/amu, similar to external reproducibility obtained in literature. This validates the stability of the current amplifier system and the Faraday cup multiple collection system and supports routine analysis to high precision.

References

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