Bridging the gap between ion counting and Faraday cup measurements – Examples from Sr, Nd, U/Pb, and U isotopes using 10^{13} Ω amplifier technology

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Accurate and precise measurement of isotope ratios from small ion beams is prerequisite for applications in isotope geochemistry and nuclear safeguards. Conventional ion counter peak jumping methods are compromised by limited dynamic range, signal stability, deadtime corrections, and low duty cycles. Faraday cups utilizing 10^{13} Ω current amplifiers have 10 times lower noise levels compared to 10^{11} Ω amplifiers but were not integrated into the electronic gain calibration network so far and had to be calibrated by indirect measurements. Here, we present gain calibration procedures fully integrated into the calibration network. Measurement data using gain calibrated 10^{13} Ω amplifiers prove the accuracy of the new gain calibration procedure implemented in a Thermo Scientific™ TRITON *Plus*™ TIMS.

The 24h baseline stability is determined to be better than 0.2 µV (normalized to 10^{11} Ω), resulting in a quantification limit (10xSD) of 2 µV (125 cps). The dynamic range of 10^{13} Ω amplifiers exceeds 30 Mcps and is superior to ion counting systems by at least a factor of 10. The 24h gain stability is less than 30 ppm (RSD) for the 10^{13} Ω amplifiers.

The isotope systems of Sr, Nd, U, and U/Pb were used to demonstrate the precision and accuracy of the 10^{13} Ω amplifiers at count rates usually applied to ion counters. The $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ results indicate accurate results with external precisions between 1‰ and 30 ppm (1 RSD) that are achieved for lowest abundant isotope beam intensities between 12 kcps and 1.5 Mcps, respectively. Static measurements of Pb and U isotopes on the ET100 standard yield a U/Pb age precision and accuracy of <0.1‰ (2 SD)[1].

Ultimately, low noise static multicollector Faraday measurements facilitates enhanced precision and shortened analysis time on small sample loading sizes and are key to high precision and accurate data by eliminating systematic non-linearities due to detector biases and deadtime effects.

Reference:

[1]Wotzlaw et al., JAAS, 2017, doi: 10.1039/c6ja00278a