APPLICATION NOTE

Measurement of osmium isotopes using Isotopx ATONA® Faradays

AN24_03 / Zenon Palacz

How small an ion beam can ATONA® ultra-low noise Faraday collectors measure and still get useful data?

Faraday collectors and ion counting collectors are both excellent analytical tools. The former are typically used for larger ion beam sizes, the latter for smaller ion beam sizes. They have their own positive and negative features. Intercalibration between the two types can be problematic and can lead to data inaccuracies. In this study we look at how the ATONA® Faraday amplifier system can be used for very small ion beam sizes, identifying how small an ion beam can be effectively measured using a Faraday collector.

Faraday multicollection positives

- *100% duty cycle, all isotopes measured all the time*
- *Immune to ion beam instability*
- *Useful for transient signals*
- *Simple data collection, no deadtime correction*
- *Virtually indestructible*

Faraday multicollection negatives

- *Higher noise than ion counter*

Ion counter positives

- *No noise*

Ion counter negatives

- *Limited range (<5e6 cps)*
- *Non-linearity on some systems*
- *Deadtime correction*
- *Peak jumping required; inefficient duty cycle*

To compare Faradays and ion counters, we analysed osmium using a Phoenix TIMS with an array of ATONA® Faraday amplifiers

We have analysed the osmium standard DrOss, with an isotopic composition of $^{187}Os/^{188}Os = 0.16092$. An integration time of 30 seconds was used. Exponential mass fractionation was performed using $^{192}Os/^{188}Os = 3.083$. All isotopes were corrected using the Nier oxygen ratios. Oxygen ratios were measured but not applied. Source vacuum was 2e-8 mbar before oxygen added and maintained at ~2e-7 mbar during analysis.

187 Intensity		2RSE[%]	
CPS	Amp	Faraday	IC
100	1.6E-17	12.67	0.96
500	8E-17	2.54	0.43
1000	1.6E-16	1.28	0.30
5000	8E-16	0.27	0.14
10000	1.6E-15	0.14	0.10

Table 1: expected precision as a function of count rate, Faraday vs ion counting

Expected data precision

Table 1 shows the expected precision of a static ATONA® Faraday measurement using 100, 30 second integrations and compares it to the precision expected for 100 ion counting measurements with a 5 second integration on the ^{187}Os isotope. At 30 seconds the ATONA® noise is ~ 1e-17 amps. The collector configuration is shown in table 2.

For the largest count rate there is very little difference between the detectors. For larger count rates of ^{187}Os the major isotopes are too large to be measured with an ion counting detector. With traditional (non-ATONA®) Faraday systems, this would require using a mixture of detector types, necessitating a precision-limiting Faraday – ion counter cross calibration.

Collector	L5	L4	L3	L2	Ax	H1	H2	H3	H4
mass	232	233	234	235	236	237	238	240	242
ion	$^{184}OsO_3$	$^{185}ReO_3$	$^{186}OsO_3$	$^{187}OsO_3$	$^{188}OsO_3$	$^{189}OsO3$	$^{190}OsO_3$	$^{192}OsO_3$	$^{192}Os^{16}O^{16}O^{18}O$

Table 2: Faraday collector configuration

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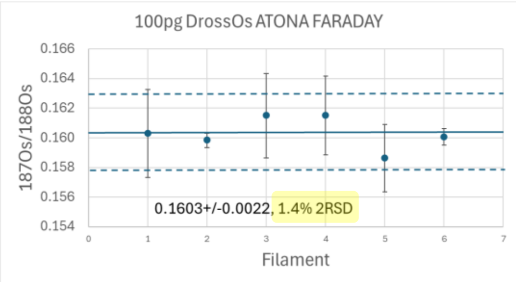
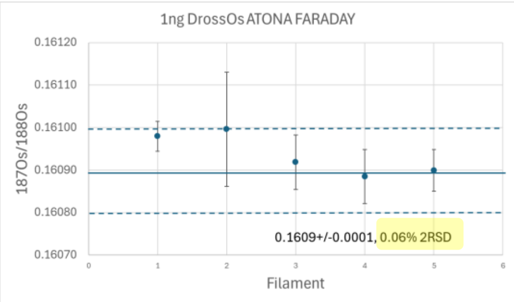
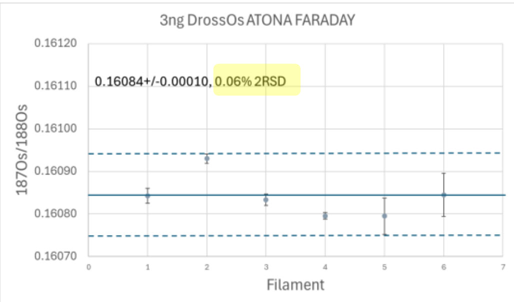
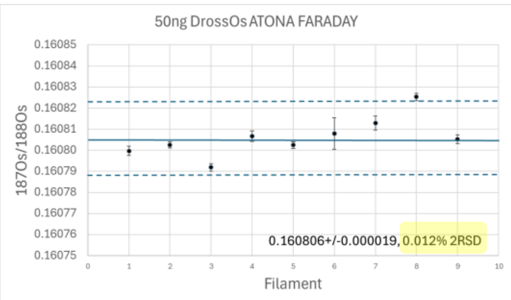
Osmium data, by sample size

The data below shows the precisions achieved for osmium samples ranging in size from 100 pg to 50 ng.

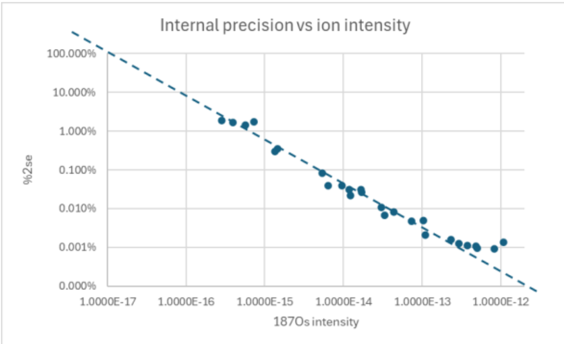








Data from 50 ng to 100 pg have been obtained. The data are all consistent but slightly lower than the certified value. In the 50 ng data there is no correlation between measured oxygen ratio (an error in oxygen correction), or rhenium. It should be noted that small and large ion signals can be measured using the same detector which would not be possible with an ion counting collector. There is no need for cross calibration or deadtime correction.



Of some note is the variability in the internal precision (see above). This is entirely due to differences in ion beam size resulting from different load quality. However, there is an extremely good relationship between ion intensity and precision. i.e. the number of ions collected controls the precision. 1% 2RSE data can be obtained on 2e-16 amps (~1,000cps) ion signals, which would correspond to much lower sample sizes with better sample loading.

What are the findings?

How small an ion beam can ATONA® ultra-low noise Faraday collectors measure and still get useful data?

Answer: ~2e-16 amps signal (1,000 cps) gives 1% 2SE data with an integration time of 30 seconds at ~2e-17 amps noise. This is as expected from counting statistics.

When do you need ion counting?

Answer: Ion counting would be needed to improve precision by about a factor of 4 at the 1,000 cps level and for sample sizes of <100 pg.

Summary

ATONA® is an ultra-low noise Faraday collector system that can take useful measurements down at the 1,000 cps level.

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