

High precision iron isotope ratio measurements

Authors: G. Craig, M. Pfeifer, C. Bouman, N. Lloyd, J. Schwieters; Thermo Fisher Scientific, Bremen, Germany

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Introduction

The Thermo Scientific™ Neoma™ MC-ICP-MS is the latest high performance MC-ICP-MS, with market-leading sensitivity, isotope ratio precision and accuracy. It enables high throughput for routine isotope ratio applications.

High precision Fe isotope ratio analysis has always been a key MC-ICP-MS application, and benefits greatly from the power of the Neoma MC-ICP-MS. The enhanced variable detector array at the heart of the Neoma MC-ICP-MS is capable of automated alignment of the 11 Faraday cup detectors on all required masses.

Method

100 ppb Fe solutions were introduced into the Neoma MC-ICP-MS with a 100 µL/min self-aspirating nebulizer connected to an ESI™ Apex Omega™ Q desolvating nebulizer system. The Neoma MC-ICP-MS was run in medium resolving power mode. The cup configuration with



amplifier assignment are reported in Table 1. Each 5-minute measurement consisted of 75 cycles of 4 s integration time. 5 measurements of a Merck™ Fe elemental standard were bracketed against the Fe isotopic standard IRMM® 014. Both Fe solutions were blank corrected against the stock 3% HNO₃.

Results

For an aspiration rate of 100 µL/min the total Fe sensitivity was calculated at 2.1 Gcps/ppm, or 336 V/ppm (10¹¹ Ω scale). This is a factor 3 better than the specified value for the instrument, demonstrating the true capabilities of the system.

Table 1. Fe cup configuration and amplifier assignment

Cup	L5	L4	L3	L2	L1	C	H1	H2	H3	H4	H5
Amplifier	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω	10 ¹¹ Ω
Isotope	⁵² Cr	⁵³ Cr	⁵⁴ Fe	⁵⁶ Fe	⁵⁷ Fe	⁵⁸ Fe	⁶⁰ Ni	⁶¹ Ni	⁶² Ni	⁶³ Cu	⁶⁵ Cu

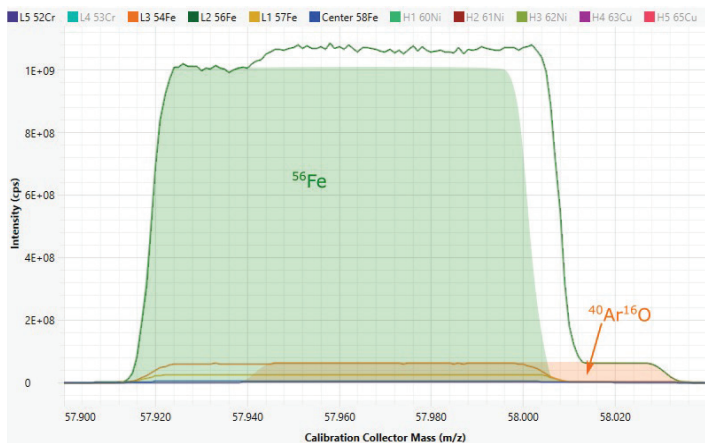


Figure 1. ^{56}Fe (green) is resolvable from the $^{40}\text{Ar}^{16}\text{O}$ interference (orange) using the medium resolving power of the Neoma MC-ICP-MS. Note that all peaks are aligned to the calibrated mass, in this case ^{57}Fe .

The resolving power was calculated as approximately 7,600 for all measurement cups. The resolving power was more than sufficient to measure ^{56}Fe free of $^{40}\text{Ar}^{16}\text{O}$ (Figure 1). No additional N_2 was used.

The 1 SD external reproducibility of the 5 replicate measurements was 9, 37 and 103 ppm for the $\delta^{56/54}\text{Fe}$, $\delta^{57/54}\text{Fe}$ and $\delta^{58/54}\text{Fe}$ respectively (Table 2, Figure 2). This is equivalent to the internal precision of an individual measurement, demonstrating the stability of the Neoma MC-ICP-MS. Reported precision on previous generation MC-ICP-MS for a 200 ppb Fe solution (i.e. double concentration) is 40 and 45 ppm for the $\delta^{56/54}\text{Fe}$ and $\delta^{57/54}\text{Fe}$ respectively¹.

Table 2. $\delta^{56/54}\text{Fe}$, $\delta^{57/54}\text{Fe}$ and $\delta^{58/54}\text{Fe}$ isotope ratios for 5 replicate measurements of 100 ppb Merck Fe solution.

	$\delta^{56}\text{Fe}$ (‰)	SE	$\delta^{57}\text{Fe}$ (‰)	SE	$\delta^{58}\text{Fe}$ (‰)	SE
1	-0.001	0.022	0.517	0.039	-0.416	0.087
2	0.009	0.027	0.504	0.047	-0.197	0.086
3	0.006	0.026	0.437	0.045	-0.243	0.071
4	-0.013	0.028	0.436	0.048	-0.395	0.078
5	0.000	0.025	0.461	0.044	-0.404	0.071
	$\delta^{56}\text{Fe}$ (‰)	SE	$\delta^{57}\text{Fe}$ (‰)	SE	$\delta^{58}\text{Fe}$ (‰)	SE
Mean	0.000	0.026	0.471	0.045	-0.331	0.079
SD	0.009		0.037		0.103	

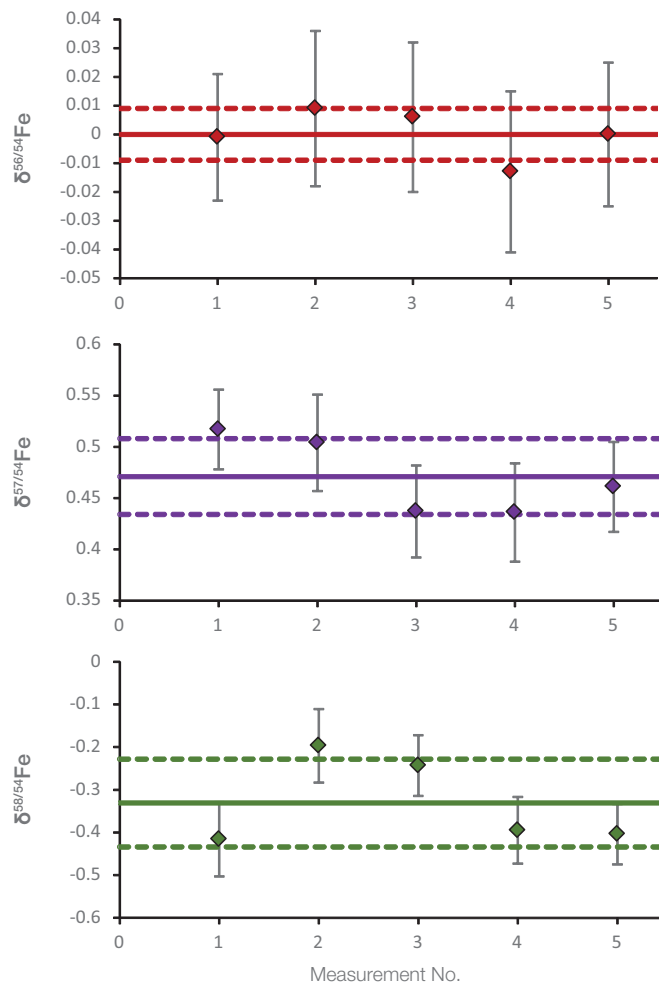


Figure 2. $\delta^{56/54}\text{Fe}$ and $\delta^{57/54}\text{Fe}$ of 100 ppb Merck Fe solution. Error bars given are 1SE. Horizontal lines show average and 1 SD of 5 replicate analyses.

Conclusion

The Neoma MC-ICP-MS demonstrates Fe sensitivity in dry plasma that is a factor of 3 better than specification.

The high sensitivity enables sample size to be reduced by a factor 2 without compromise to precision.

Table 3. Mean sensitivity (in Mcps) and isotope ratio results for each 5-minute measurement

	⁵² Cr	⁵³ Cr	⁵⁴ Fe	⁵⁶ Fe	⁵⁷ Fe	⁵⁸ Fe	⁶⁰ Ni	⁶¹ Ni	⁶² Ni	⁶³ Cu	⁶⁵ Cu	⁵⁶ Fe/ ⁵⁴ Fe	SE	⁵⁷ Fe/ ⁵⁴ Fe	SE	⁵⁸ Fe/ ⁵⁴ Fe	SE
IRMM-014	0.06	0.02	118	1930	45.4	6.24	0.03	0.01	0.01	0.09	0.03	15.70510	0.00038	0.38348	0.00002	0.04860	0.00003
Merck	0.13	0.03	101	1651	38.8	5.33	0.02	0.01	0.01	0.46	0.15	15.70522	0.00035	0.38365	0.00002	0.04859	0.00004
IRMM-014	0.07	0.02	121	1977	46.5	6.39	0.03	0.01	0.01	0.09	0.03	15.70537	0.00030	0.38343	0.00001	0.04861	0.00003
Merck	0.13	0.03	103	1674	39.4	5.41	0.02	0.01	0.01	0.46	0.15	15.70549	0.00042	0.38363	0.00002	0.04861	0.00004
IRMM-014	0.06	0.02	120	1960	46.1	6.34	0.03	0.01	0.01	0.09	0.03	15.70534	0.00044	0.38344	0.00002	0.04862	0.00004
Merck	0.13	0.03	104	1690	39.7	5.46	0.02	0.01	0.01	0.46	0.15	15.70554	0.00041	0.38362	0.00002	0.04861	0.00003
IRMM-014	0.06	0.02	120	1960	46.1	6.33	0.02	0.01	0.01	0.09	0.03	15.70554	0.00038	0.38346	0.00002	0.04863	0.00003
Merck	0.13	0.03	101	1652	38.9	5.34	0.02	0.01	0.01	0.46	0.15	15.70519	0.00044	0.38362	0.00002	0.04859	0.00003
IRMM-014	0.06	0.02	121	1978	46.5	6.39	0.03	0.01	0.01	0.09	0.03	15.70525	0.00042	0.38344	0.00002	0.04860	0.00003
Merck	0.13	0.03	102	1662	39.1	5.37	0.02	0.01	0.01	0.46	0.15	15.70525	0.00039	0.38362	0.00002	0.04859	0.00003
IRMM-014	0.06	0.02	118	1927	45.3	6.23	0.03	0.01	0.01	0.09	0.03	15.70524	0.00037	0.38344	0.00001	0.04861	0.00003

References

1. Weyer & Schwieters, 2003, Int. journal of Mass Spectrometry, 226, 355-368.

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