

WEBINAR

Custom Analysis by Radial/Axial ICP-OES:

How to Reduce Interferences for 69 Elements

THURSDAY, JULY 1 | 9:00–10:00AM EST

SPEAKERS:



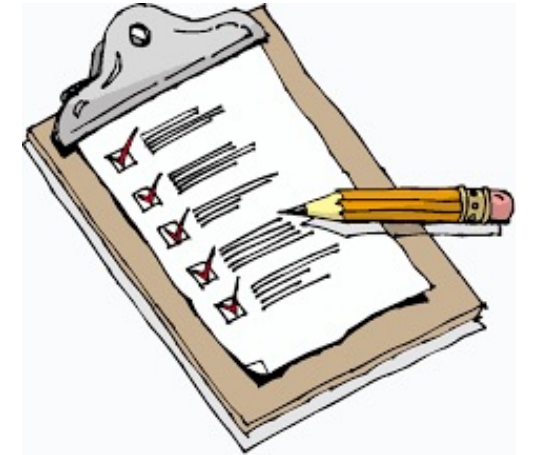
Thomas Kozikowski
Manager
Quality Control



Michael Booth
Director
Quality Control

Key Topics

- Background Info
- Identify Wanted Improvements
- Creating the Calibration Standards
- Managing Spectral Interferences
- Validating the Method
- Benefits



Audience Participation

- Today we are going to poll the audience throughout the presentation to better understand our collective challenges in the lab.
- Most of these questions will be multiple choice, and we will get to see the results after each question.
- Don't fall asleep!



Question 1

What type of ICP-OES instrument do you use in your laboratory?



- A. Axial (End-On Plasma)
- B. Radial (Side-On Plasma)
- C. Axial AND Radial (Dual-View Capability)
- D. Axial OR Radial (Must Choose before Plasma On)



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What's the Purpose of this Method?

- Inorganic Ventures manufactures over 10,000 custom blends per year. Daily production can range from 30-60 custom blends per day.
- A testing method had to be created that could handle the high sample throughput and also be capable of guaranteeing the quality of widely different samples.



Regular Blend Examples

ppm	IV-STOCK-3 (2% v/v HNO ₃)	Prep 1 (1000X)
1000	Ca, Mg, K, Na	1.0µg/g Ca, Mg, K, Na

ppm	IV-ICPMS-71A (3% v/v HNO ₃)	Prep 1 (10X)
10	Ag, Al, As, B, Ba, Be, Ca, Cd, Ce, Co, Cr ³ , Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ho, K, La, Lu, Mg, Mn, Na, Nd, Ni, P, Pb, Pr, Rb, S, Se, Sm, Sr, Th, Tl, Tm, U, V, Yb, Zn	1.0µg/g Ag, Al, As, B, Ba, Be, Ca, Cd, Ce, Co, Cr ³ , Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ho, K, La, Lu, Mg, Mn, Na, Nd, Ni, P, Pb, Pr, Rb, S, Se, Sm, Sr, Th, Tl, Tm, U, V, Yb, Zn



Complicated Blend Example

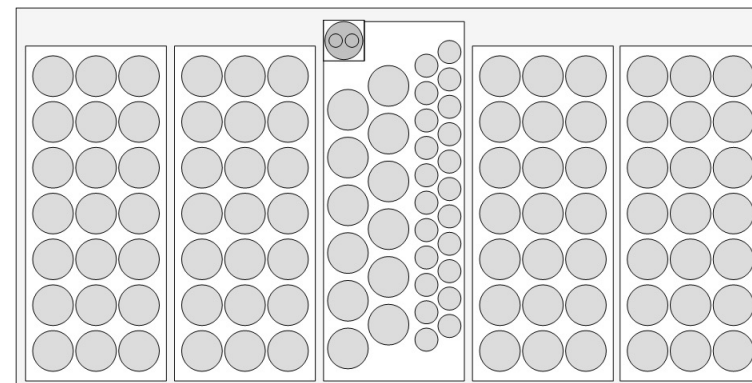
ppm	WW-LFS-1 (5% v/v HNO ₃)	Prep 1 (1000X)	Prep 2 (100X)
1000	K	1.0µg/g K	n/a
600	P	0.6µg/g P	n/a
300	Fe, Na	0.3µg/g Fe, Na	n/a
200	Al, Ce, Mg, Se, Tl	0.2µg/g Al, Ce, Mg, Se, Tl	n/a
100	Ca, Pb	0.1µg/g Ca, Pb	1.0µg/g Ca, Pb
80	As	Too low for reliable results; these will need another prep.	0.8µg/g As
70	Hg		0.7µg/g Hg
50	Ni		0.5µg/g Ni
40	Cr		0.4µg/g Cr
30	B, Cu, V		0.3µg/g B, Cu, V
20	Ba, Be, Cd, Co, Li, Mn Sr, Zn		0.2µg/g Ba, Be, Cd, Co, Li, Mn, Sr, Zn
7.5	Ag		0.075µg/g Ag (Below Curve, but ok)



Production Workflow

	30 Blends	45 Blends	60 Blends
Average Preps Required	1.5/blend	1.5/blend	1.5/blend
Prep Time at Bench	2.25hrs	3.4hrs	4.5hrs
Tube Positions Required	45	68	90*
Instrument time	N/A: Run starts at end of workday with auto shutdown		

*Autosampler can only hold 84 tubes.



Old Custom Blend Method

- 3 Calibration Standards in 10% HCl (making Ag Photosensitive)
 - Blank (0 μ g/g) STD, Low (0.1 μ g/g) STD, High (1.0 μ g/g) STD
 - Includes 500 μ g/g of Cs ionization buffer for Li, Na, and K
 - Ionization Buffer needed to be added to all samples also
- 67 Elements as part of the method
 - Axial mode only
- With all elements present in the STD, some lines have major interferences making it difficult to utilize ideal lines



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Most Wanted Method Improvements

1. Decrease the number of preps required per sample

Reminder - 1.5 preps/sample with old method

How?

A. Expand the Calibration Curve Range

- Increase the number of calibration solutions and increase the concentration of the “High” standard
- Take advantage of Radial view to avoid the signal going overrange at higher concentrations

2. Add Rb and Os to the method

How?

- #### A. Identify the correct calibration solution that will allow for the addition of Rb and Os and remain stable



Most Wanted Method Improvements

3. Decrease the amount of time required for each sample prep

Reminder - 1.5 preps/sample with old method

How?

A. Remove Cs Ionization Buffer

- Eliminates the step of spiking Cs buffer to each prep

B. Change default prep volume from 20-50mL to 10mL

- Requires an expanded calibration curve to ensure large enough sample aliquots

4. Decrease the amount of corrosion on the instrument

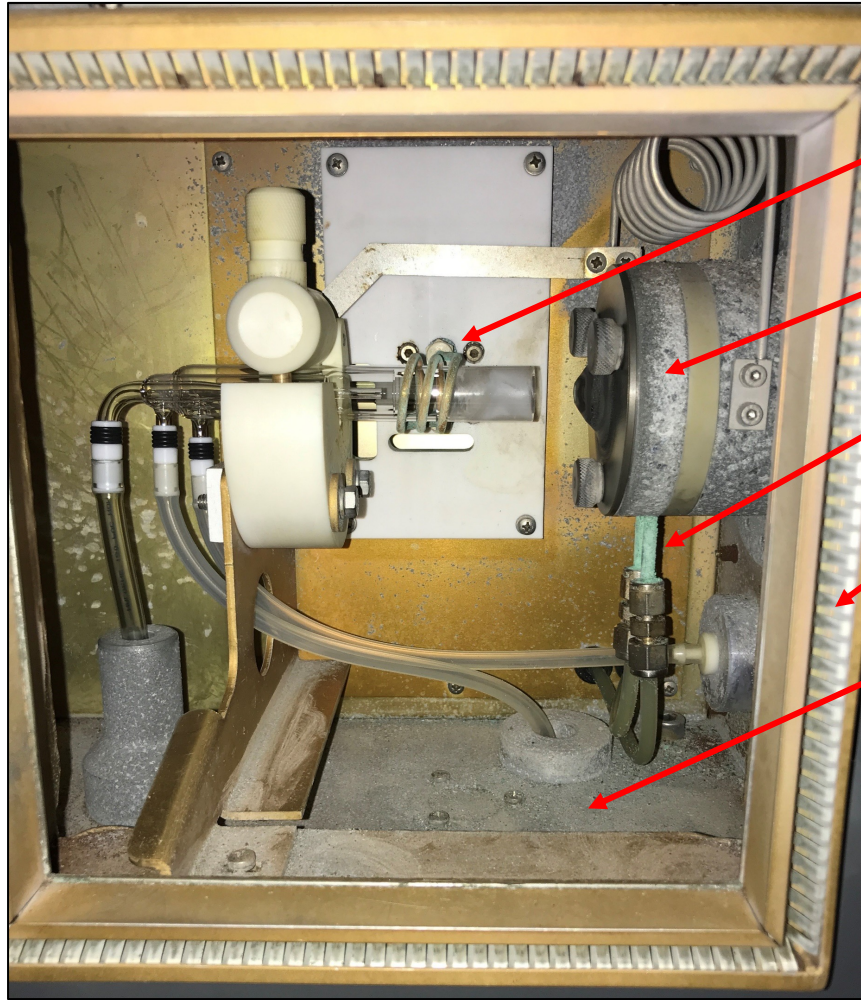
Reminder – Matrix for old method was 10% HCl

How?

A. Eliminate or lower the amount of HCl introduced to the instrument



Corrosion Caused by HCl Over Time



- Load Coil
- Optical Plasma Interface (OPI)
- Water Lines
- RF Shielding
- Walls of the Torch Box



Question 2

What would be at the top of your most wanted list?

WANTED

- A** - Decrease the number of preps required per sample
- B** - Add Rb and Os to the method
- C** - Decrease the amount of time required for each sample prep
- D** - Decrease the amount of corrosion on the instrument

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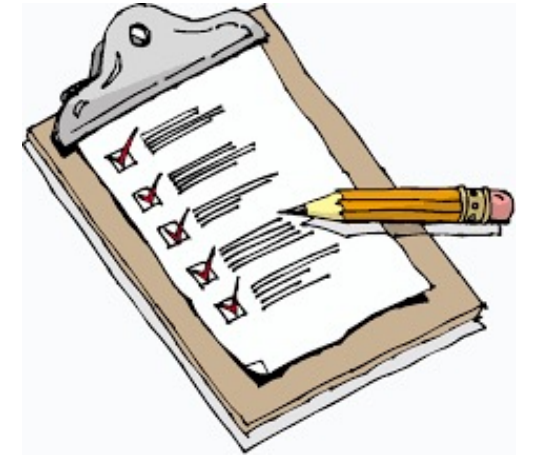
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Why split the calibration standards?

- Chemical compatibility
 - Certain elements don't behave well with other elements
 - Usually due to chemical form (Ba + S forms insoluble BaSO_4)
- Matrix compatibility
 - Certain elements precipitate in the presence of HCl or HF
 - Certain elements require HCl or HF for stability
- Spectral interferences
 - Can happen with any element regardless of matrix



H		<div>All elements at 1ppm are ok 10% HCl / 0.2% HF</div>																He
Li	Be												B	C	N	O	F	Ne
Na	Mg												Al	Si	P	S	Cl	Ar
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr		Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	**	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

*	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
**	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No



H		All elements at 50ppm, not ok 10% HCl / 0.2% HF																He
Li	Be												B	C	N	O	F	Ne
Na	Mg												Al	Si	P	S	Cl	Ar
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr		Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	**	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

*	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
**	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No



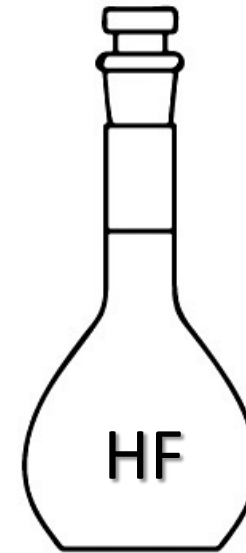
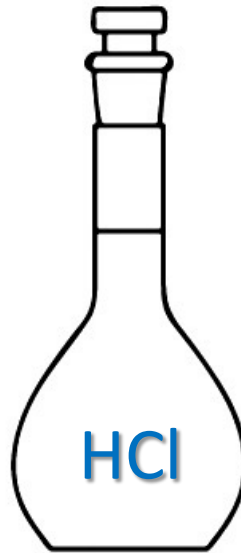
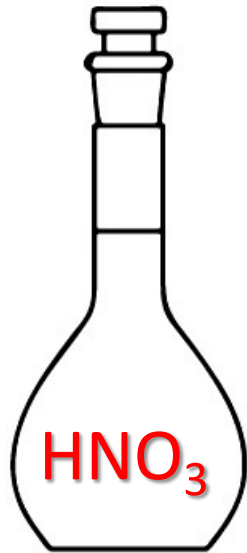
Observations with increasing to 50ppm

- All of the Rare Earth Elements (REEs) + Th precipitate
 - Reason: HF
- W and Sn precipitate
 - Reason: Fluoride ligands stolen by B, P, Al, & others
- Ag and Pb Precipitate
 - Reason: HCl
- Pt precipitates
 - Reason: Formation of an insoluble Cs_2PtCl_6 complex



Initial desired breakdown of standards

- Solution 1: Elements that are okay in only HNO_3
- Solution 2: Elements that require HCl for some reason
- Solution 3: Elements that require HF for some reason



Solution Matrix - HF

H	Not Checked by ICP																HF Elements					He						
Li	Be	HF "thieves"																Avoid HF					B	C	N	O	F	Ne
Na	Mg																	Al	Si	P	S	Cl	Ar					
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr											
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe											
Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn										
Fr	Ra	**	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og										

*	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
**	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No



Solution Matrix - HCl

H	Not Checked by ICP																HCl Elements					He						
Li	Be	Can work w/o HF																Avoid HCl					B	C	N	O	F	Ne
Na	Mg																	Al	Si	P	S	Cl	Ar					
K	Ca		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr										
Rb	Sr		Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe										
Cs	Ba	*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn										
Fr	Ra	**	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og										

*	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
**	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No

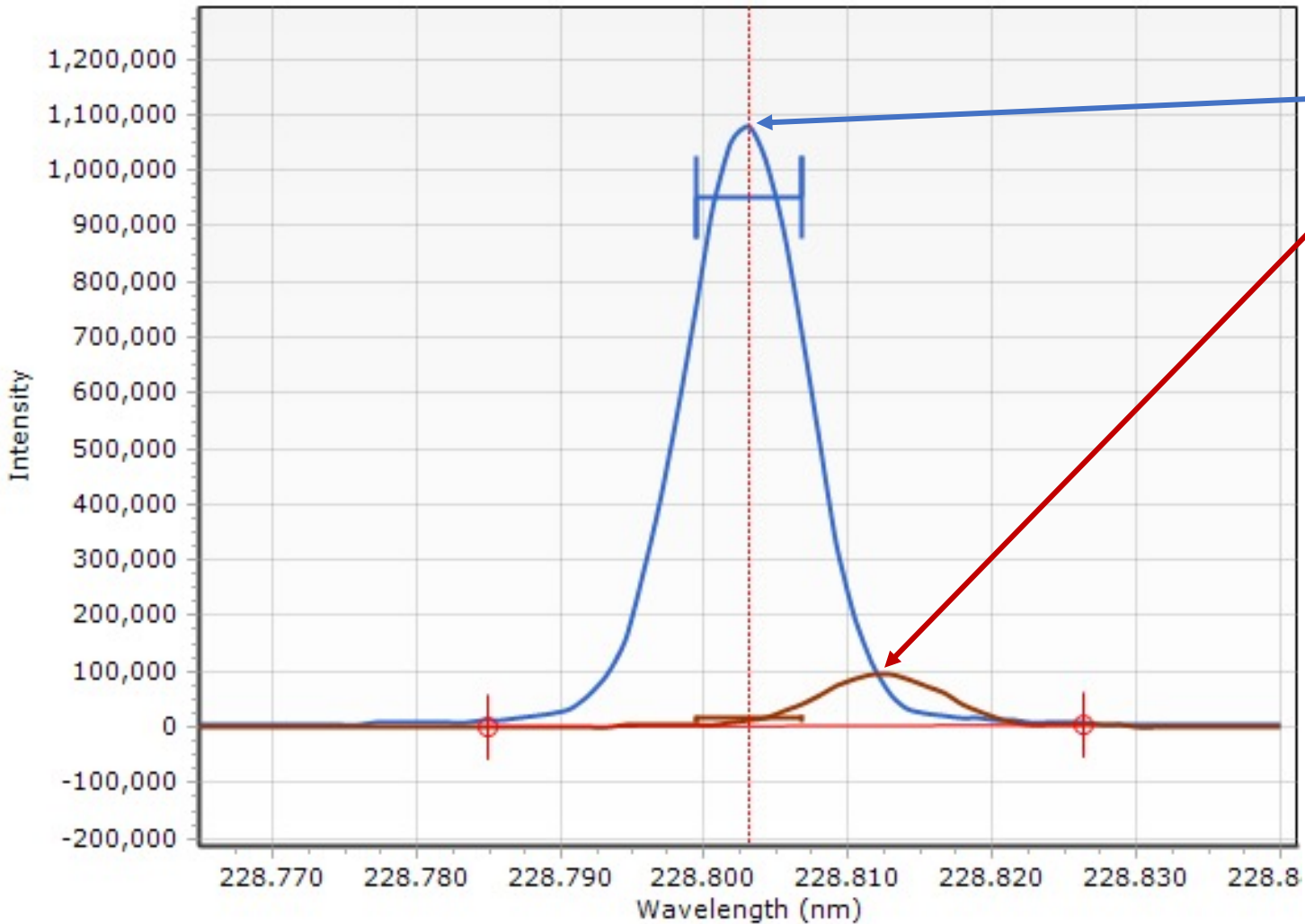


Spectral Interference Examples

- Cd 228.802 / As 228.812
 - Shoulder Interference
- Pd 340.458 / Zr / Th
 - Example where the background point can skew results
- Ir 212.681 / Y
 - Almost complete spectral overlay
 - Would not be able to use Y as an internal STD for Ir



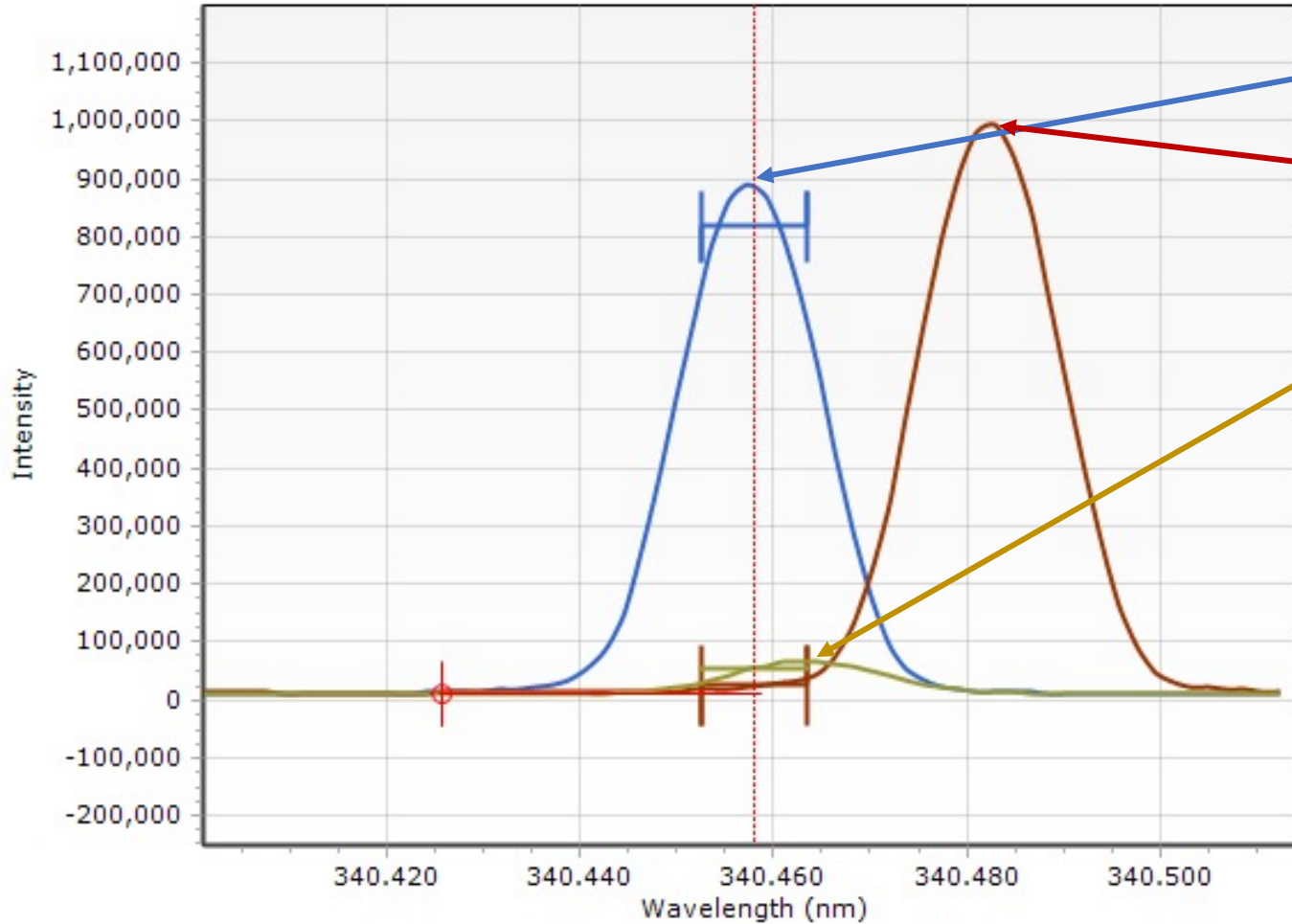
Cd 228.802 / As 228.812



- Cd 228.802 at 40ppm
- As 228.812 at 80ppm
- It's very easy to calibrate for Cadmium and then misinterpret a value for Arsenic
- Peak centering is critical for distinguishing between these two elements

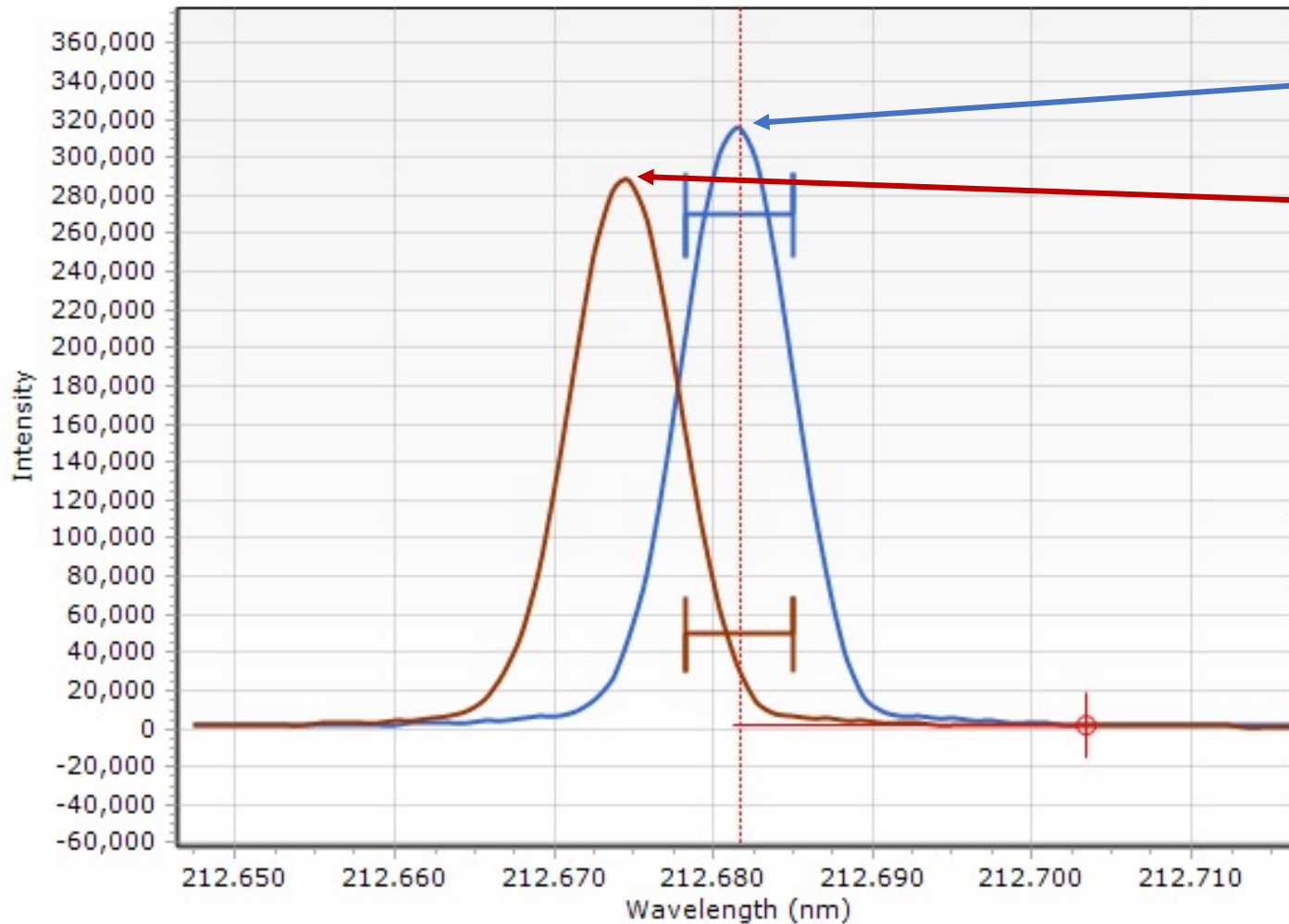


Pd 340.458 / Zr / Th



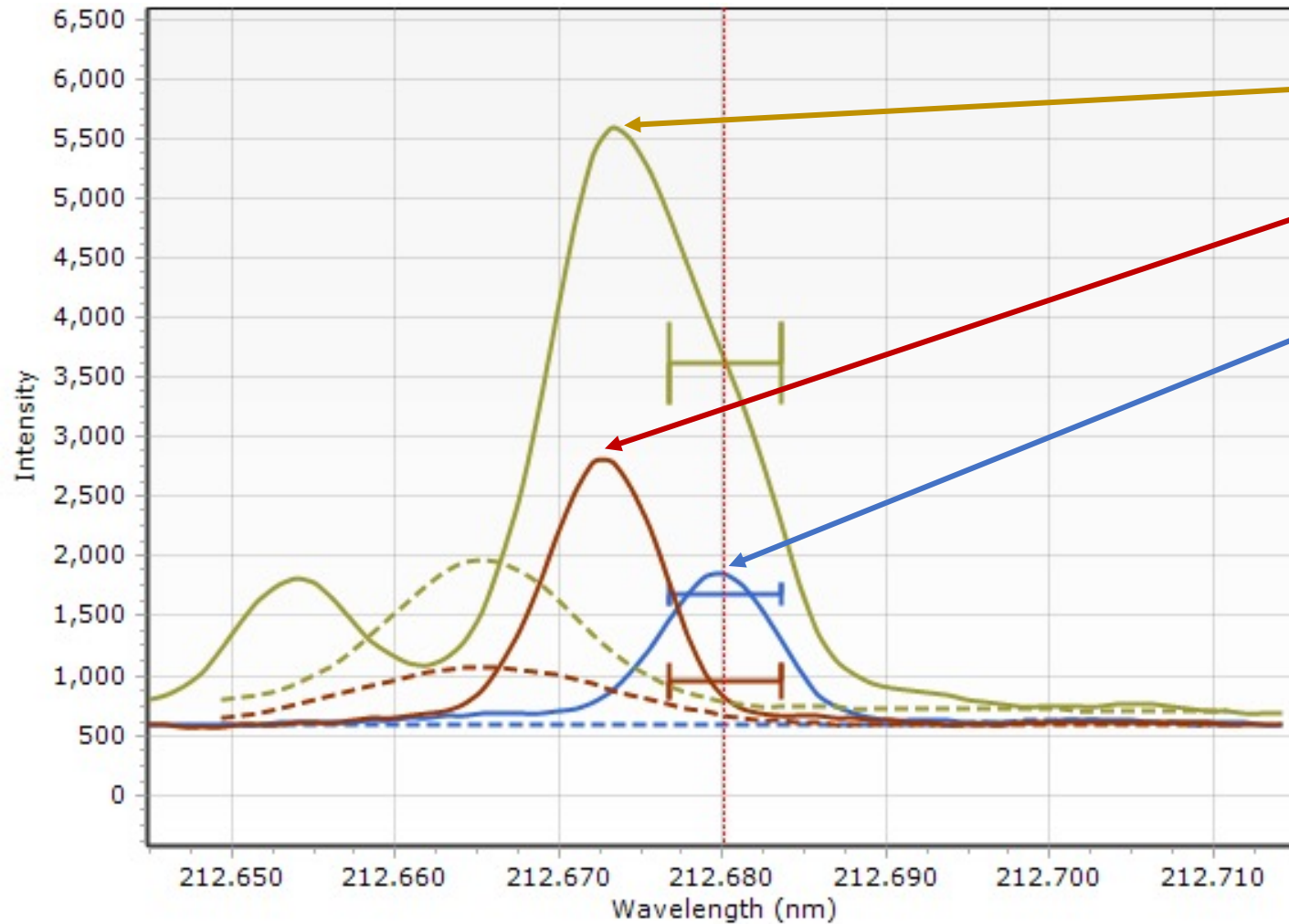
- Pd 340.458 at 40ppm
- Zr at 80ppm
- Th at 80ppm
- High levels of Thorium could be misinterpreted as low levels of Palladium
- A right sided background point can be skewed by equal levels of Zirconium

Ir 212.681 / Y



- Ir 212.681 at 80ppm
- Y at 40ppm
- These 2 lines almost overlay completely.
- If combined at equal levels in the same standard, there will always be a low bias in single element results.

Ir 212.681 / Y



- Ir and Y both at 1 ppm
- Y at 0.5 ppm
- Ir 212.681 at 0.5 ppm
- The Ir + Y at 1 ppm looks like a misshapen peak.
- At first glance this looks like 1 peak when it is in fact 2.



Left Element has an issue with a top element.																								Old	Current Issues
		Ag	Cd	Ce	Cr	Cu	Er	Eu	Gd	La	Mo	Nb	Ni	Pd	Re	Sc	Sm	Ta	Th	Ti	Tm	W	Issues?		
#		1	1	3	1	1	1	1	3	1	3	2	1	2	3	3	1	2	3	2	3	2			
As	2	0																					1	0	
Au	3											0						0					2	0	
Ce	3																0						1	0	
Er	1																			0			1	0	
Gd	3																		1				1	1	
Hf	2						0				0												2	0	
In	1											0											1	0	
Ir	3					0																	1	0	
Nd	1		0																				1	0	
Pb	1																					0	1	0	
Pd	2			0									0				0		0		0		5	0	
Pr	3		1														0						2	1	
Pt	3											0											1	0	
Rh	1																				0		1	0	
Ru	3			0																			1	0	
Sb	3										0												1	0	
Se	2			0																			1	0	
Sm	1								0					0					0		0		4	0	
Sn	2			0											0								2	0	
Th	3									0													1	0	
Ti	2				0											0							2	0	
Tl	3				0																		1	0	
U	1															0		0	0				3	0	
W	2	0																					1	0	
Zr	2					0																	1	0	
																							39	2	

- Further optimization of elements got the number of major interferences from 39 to only 2
- Great care was taken to ensure that elements were placed in compatible matrices



Other changes / limitations

- Some wavelengths go overrange at 50ppm in Axial
 - With Radial they do not
 - Ca 393, Ba 455, Li 670, etc.
- Cs is no longer used as an ionization buffer
 - This limits linearity for K, Na, and Li, but Radial mitigates
 - Reduces the number of reagents required for analysis
 - Less chance of contamination (from pipetting)



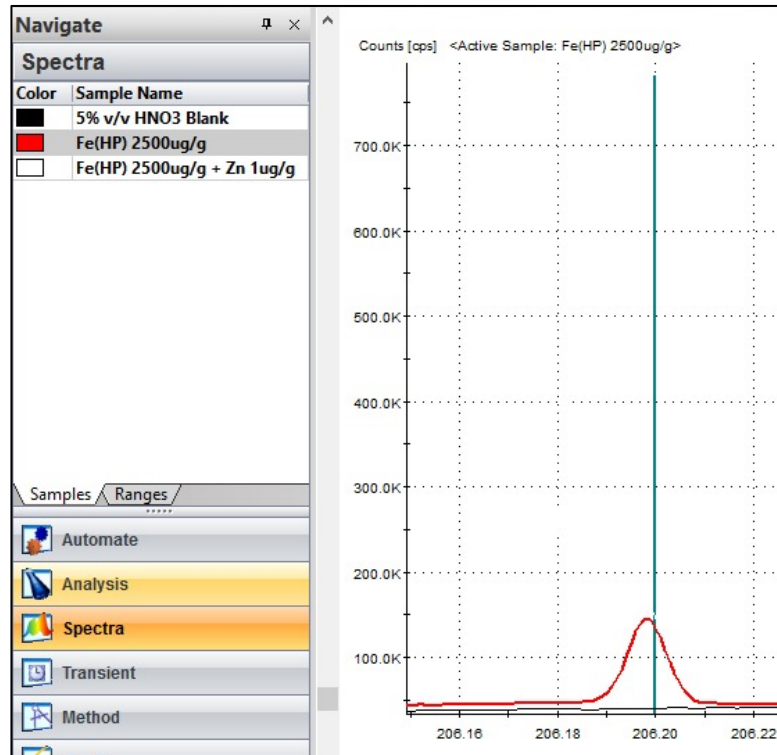
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What is a Spectral Interference

A spectral interference occurs when multiple elements share the same or very close emission wavelengths.



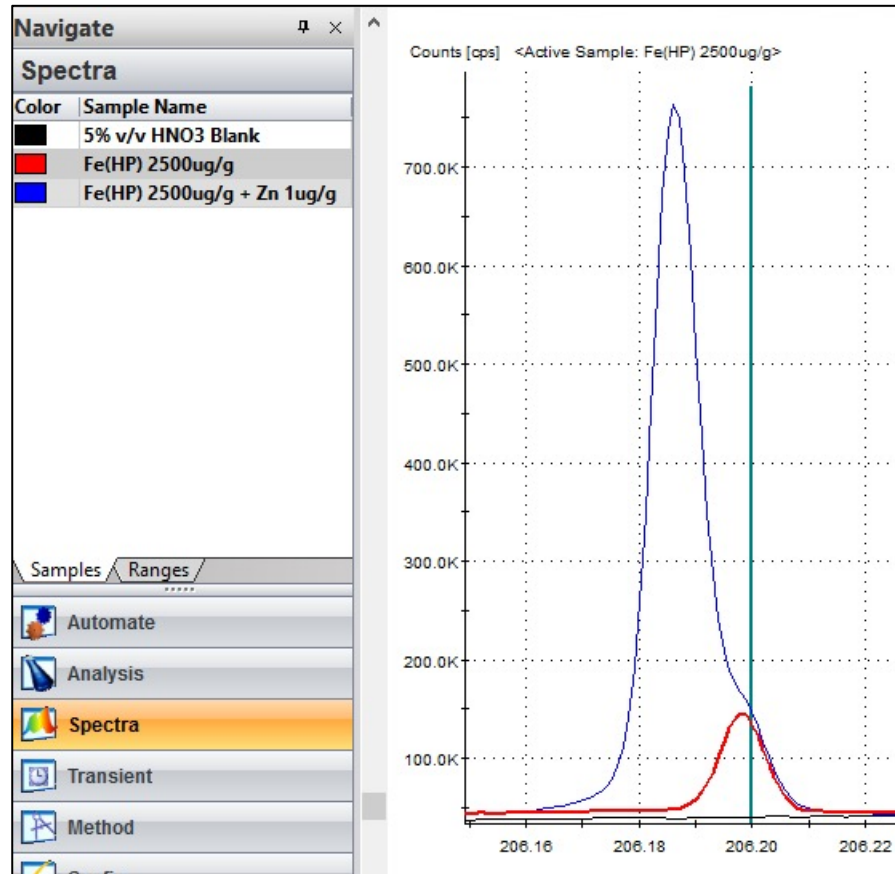
Is this Zn, or is it Fe?

Sample: High Purity Fe at 2,500 $\mu\text{g/g}$

Software Emission Line: Zn 206.200nm

Does this sample contain a Zn impurity or is it a spectral interference from Fe?

What is a Spectral Interference



Is this Zn, or is it Fe?

Sample:

High Purity Fe at 2,500 $\mu\text{g/g}$ (Red)

High Purity Fe at 2,500 $\mu\text{g/g}$ + Zn at 1 $\mu\text{g/g}$ (Blue)

Software Emission Line: Zn 206.200nm

We can see that the red peak is actually Fe!

This example could have been less of a question with proper peak centering and wavelength calibration.

What is a Spectral Interference

The intensity of light being emitted on shared wavelengths can be different based on element.

So how can you manage these interferences?

1. Instrument Software is usually a good source, but it may not account for individual instrument performance.
2. Running **Single Element Standards** is the gold standard to help determine what spectral interferences will cause problems for your method.



Question 3

Do you run any ICP-OES methods that need to account for spectral interferences?

- A. Yes
- B. No
- C. Not Sure



Building an Interference Table

Running **High Purity Single Element Standards** for your method will allow you to construct an Interference Table that you can use to help interpret your data.

Exa

Single Element Standard (80 µg/g)	Ga 417.204 nm Radial	Gd 335.863 nm Axial	Mn 259.372 nm Axial	Pd 360.955 nm Axial	Pr 422.532 nm Axial	W 220.449 nm Axial
Al	-	-	-	-	-	0.9 µg/g
Ce	4.5 µg/g	-	-	4.2 µg/g	-	-
Fe	-	-	0.1 µg/g	-	-	-
Sm	-	-	-	121 µg/g	30.1 µg/g	-
Th	-	9.4 µg/g	-	20.4 µg/g	-	-



Building an Interference Table

Our Previous Example showed an interference table for 5 single element standards with data from 6 monitored wavelengths.



Our new method uses an interference table for 75 single element standards with data from 396 monitored wavelengths.

Note: To successfully utilize this method you must keep your wavelength calibration up to date and use a validated method to keep your peaks centered.



Interference Tables – Does it Work?

LIMS Analyte	Analyte Conc	Inst Element	Conc (ppm)	Not Accounting for Interferences			# of lines	Accounting for Interferences		
				P/F?	best % diff	% passed lines		P/F?	best % diff	% passed lines
Ruthenium	1	Ru	1.000	Pass	0.18	67	6	Pass	0.18	83
Samarium	1	Sm	1.000	Pass	3.29	50	6	Pass	0.44	67
Scandium	1	Sc	1.000	Pass	0.10	100	6	Pass	0.10	100
Selenium	1	Se	1.000	Pass	2.24	50	4	Pass	0.67	100
Silicon	1	Si	1.000	Fail	13.64	0	8	Pass	6.39	13
Silver	1	Ag	1.000	Pass	0.21	100	4	Pass	0.18	100
Sodium	1	Na	1.000	Pass	0.77	50	4	Pass	0.77	50
Strontium	1	Sr	1.000	Pass	0.00	100	8	Pass	0.00	100
Sulfur	10	S	10.000	Pass	6.74	50	6	Pass	6.71	50
Tantalum	1	Ta	1.000	Pass	0.15	100	6	Pass	0.47	100
Tellurium	1	Te	1.000	Pass	2.58	83	6	Pass	5.47	33
Terbium	1	Tb	1.000	Pass	0.05	100	4	Pass	2.10	100



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Validation Concerns

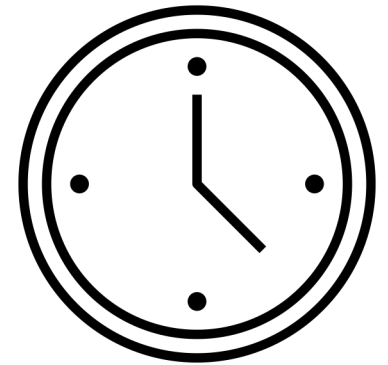
1. Stability of Calibration Standards
2. Calibration Verification
3. Matrix Matching Concerns
4. Instrument Setup



Stability of Calibration Standards

The highest concentration versions of MEB4-A, MEB4-B, and MEB4-C have been entered into IV's Stability Testing Program.

- We have collected 18 months of stability data and will continue to collect data for 5 years even though we do not expect to identify instability in these blends.



A dedicated technician runs our stability program and schedules retesting of lots based on date of manufacture and/or results of previous stability tests.

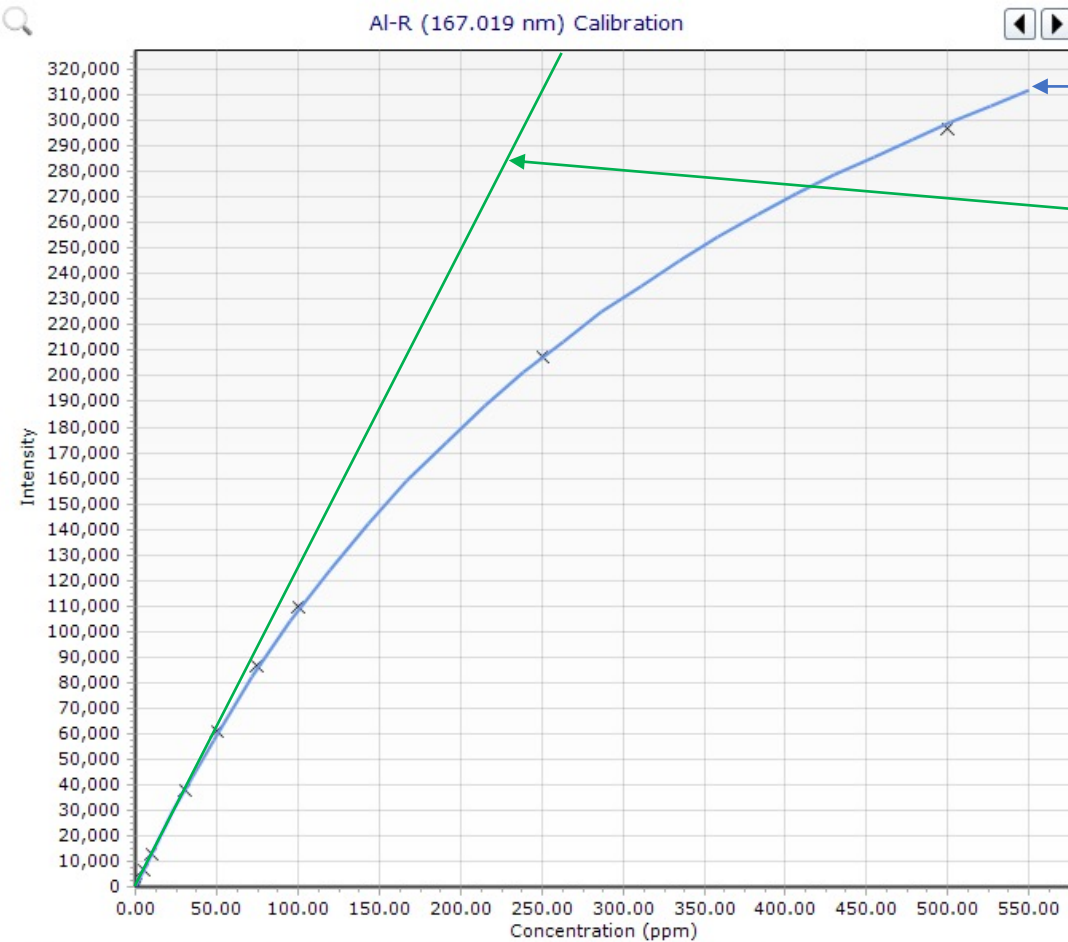


Calibration Verification

- On the Agilent 5110 VDV, Axial view not always linear
- Parabolic Rational Function (Rational Method)
 - Agilent White Paper (Originally published in August 1977)
 - This scheme works for Echelle systems; not necessarily so on other types of optical systems
- Rational Method gave a much better calibration equation for all elements, so it was chosen for final validation verification



Calibration Verification



Intensity = (1352.24830900 * Concentration) / (1 + 0.00252521 * Concentration)
Correlation coefficient: 0.99995

- Rational Method
- Linear Regression
- Linear calibration would not calibrate past 50ppm
- Across all elements/wavelengths, rational fits were better models
- Axial benefitted most, radial wavelengths were mostly linear

Peak Centering and Backgrounds

- Peak positions are locked down in a template
- Peak drift is corrected by “peak track lines” built into the Agilent Software (Carbon 192.027 & 5 Argon Lines)
- If the background is not “fitted”, it is set once and never changed (positions preserved in the template file)
- Changing any of these parameters will invalidate the interference table and would require revalidation



DLs and LOQs

- Detection Limits (DLs)
 - Depend on the element & wavelength
 - 3 x StDev of the blanks
- Limits of Quantification (LOQs)
 - A better limit for reliable measurements
 - 10 x StDev of the blanks
- These limits help us determine what dilution factor to use in samples with varying concentration levels



	IdealMin	Ideal	IdealMax	MaxTest		IdealMin	Ideal	IdealMax	MaxTest		IdealMin	Ideal	IdealMax	MaxTest
Ag	0.05	5	50	80	Ho	0.05	5	50	80	Ru	0.05	5	50	80
Al	0.05	5	50	80	In	0.20	5	50	80	S	0.5	5	50	80
As	0.20	5	50	80	Ir	0.20	5	50	80	Sb	0.5	5	50	80
Au	0.05	5	50	80	K	0.50	5	50	80	Sc	0.01	5	50	80
B	0.05	5	50	80	La	0.05	5	50	80	Se	0.2	5	50	80
Ba	0.01	5	50	80	Li	0.50	3	50	80	Si	0.2	5	50	80
Be	0.05	5	50	80	Lu	0.05	5	50	80	Sm	0.1	5	50	80
Bi	0.20	5	50	80	Mg	0.05	5	50	80	Sn	0.5	5	50	80
Ca	0.01	5	30	80	Mn	0.05	5	50	80	Sr	0.05	5	40	80
Cd	0.01	5	50	80	Mo	0.05	5	50	80	Ta	0.05	5	50	80
Ce	0.10	5	50	80	Na	0.20	5	50	80	Tb	0.05	5	50	80
Co	0.05	5	50	80	Nb	0.05	5	50	80	Te	0.5	5	50	80
Cr	0.05	5	50	80	Nd	0.1	5	50	80	Th	0.5	5	50	80
Cu	0.05	5	50	80	Ni	0.05	5	50	80	Ti	0.05	5	50	80
Dy	0.05	5	50	80	Os	0.5	5	50	80	Tl	0.5	5	50	80
Er	0.05	5	50	80	P	0.5	5	50	80	Tm	0.1	5	50	80
Eu	0.05	5	50	80	Pb	0.2	5	50	80	U	0.5	5	50	80
Fe	0.05	5	50	80	Pd	0.2	5	50	80	V	0.05	5	50	80
Ga	0.20	5	50	80	Pr	0.1	5	50	80	W	0.2	5	50	80
Gd	0.20	5	50	80	Pt	0.2	5	50	80	Y	0.02	5	50	80
Ge	0.20	5	50	80	Rb	0.5	50	50	80	Yb	0.02	5	50	80
Hf	0.05	5	50	80	Re	0.1	5	50	80	Zn	0.05	5	50	80
Hg	0.10	5	50	80	Rh	0.2	5	50	80	Zr	0.05	5	50	80
Ag Might need 10% HCl & 1ppm max					Li & Rb Ideal Value is not 5ppm									
Must dilute Au, Hg, Os in ≥ 5% HCl					LOQ is same as LOW STD (0.5ppm)									
Typically diluted in 5% HCl					Most elements diluted in 5% HNO3									

- IV's Sample Prep Logic
- Prep elements to match the Mid STD
- In blends with differing concentration levels:
 - Prep high elements to match IdealMax
 - If low levels don't fall within IdealMin:
 - 2nd prep
- IdealMin is basically LOQ
- Max Test is highest validated level allowed

Question 4

Does your method have specified minimum and maximum level prepping requirements to fall within your validated calibration range?

- A. Yes
- B. No
- C. Not Sure



Matrix Matching Concerns

- Switching samples from HNO_3 to HCl does not seem to have a significant effect on signal intensity
- Prepping samples in 10% HCl instead of 5% HCl does not cause major changes in signal intensity
 - It does enhance stability of low-level Ag (1ppm or less)
- Radial mode less affected by changes in matrix
- High Total Dissolved Solids (TDS) causes the most signal quenching – Radial View helps



Instrument Setup

Sample Introduction System

We utilize a HF resistant system to help mitigate Si and B contamination.

- PTFE Cyclonic Spray Chamber
- PEEK Concentric Nebulizer
- Demountable Torch
- Alumina Injector
- Ceramic Outer Tube

This method was designed for the Agilent 5110 VDV utilizing Axial and Radial modes.

Rinse Regimen

Global Rinses

- Start of Run – HNO_3 and HCl
- End of Run – HNO_3 , HCl , 2.5% RBS-25, DI H_2O

Method Rinse

- Usually 1% HNO_3 , (swap for 1% HCl if running Os)

Dummy Samples

- Technicians will insert blanks as “dummy samples” after sample solutions that have a high total dissolved solids



Key Topics

- Background Info
- Identify Wanted Improvements
- Creating the Calibration Standards
- Managing Spectral Interferences
- Validating the Method
- **Benefits**



Benefits of the New Method

Method Robustness

- The expanded calibration curve and method validation allows for some samples to be run without prepping

Time Savings

- Reduced the preps/sample
 - We have reduced the preps/sample from 1.5 to 1.1 (**~26% Reduction**)
- Reduced the time/prep
 - Our QC Staff have reported a time savings of approximately **30%**.

Reduction of “2nd” checks

Our QC Staff refers to blends that have one or multiple elements fail the initial check as “2nd” checks.



Are there any downsides?

- **Yes, but they are limited**

- Since the different calibration solutions have different matrices our technicians must switch diluent based on blend.

- **But you don't have to take my word for it...**

- Most concentrated versions for Calibration Curve Standards MEB4-A, MEB4-B, & MEB4-C

- **IV-57589, IV-59761, & IV-57591**

- If you are looking for Os

- **CGOS1**



Technical Support – Available to Everyone

Online Resources at inorganicventures.com

1 H X	2 He X																	19 K X	20 Ca X	21 Sc X	22 Ti X	23 V X	24 Cr X	25 Mn X	26 Fe X	27 Co X	28 Ni X	29 Cu X	30 Zn X	31 Ga X	32 Ge X	33 As X	34 Se X	35 Br X	36 Kr X
3 Li X	4 Be X																	13 Al X	14 Si X	15 P X	16 S X	17 Cl X	18 Ar X												
11 Na X	12 Mg X																	5 B X	6 C X	7 N X	8 O X	9 F X	10 Ne X												
19 K X	20 Ca X	21 Sc X	22 Ti X	23 V X	24 Cr X	25 Mn X	26 Fe X	27 Co X	28 Ni X	29 Cu X	30 Zn X	31 Ga X	32 Ge X	33 As X	34 Se X	35 Br X	36 Kr X																		
37 Rb X	38 Sr X	39 Y X	40 Zr X	41 Nb X	42 Mo X	43 Tc X	44 Ru X	45 Rh X	46 Pd X	47 Ag X	48 Cd X	49 In X	50 Sn X	51 Sb X	52 Te X	53 I X	54 Xe X																		
55 Cs X	56 Ba X																	81 Tl X	82 Pb X	83 Bi X	84 Po X	85 At X	86 Rn X												
87 Fr X	88 Ra X	104 Rf X	105 Db X	106 Sg X	107 Bh X	108 Hs X	109 Mt X	110 Ds X	111 Rg X	112 Cn X	113 Nh X	114 Fl X	115 Mc X	116 Lv X	117 Ts X	118 Og X																			
																		57 La X	58 Ce X	59 Pr X	60 Nd X	61 Pm X	62 Sm X	63 Eu X	64 Gd X	65 Tb X	66 Dy X	67 Ho X	68 Er X	69 Tm X	70 Yb X	71 Lu X			
																		89 Ac X	90 Th X	91 Pa X	92 U X	93 Np X	94 Pu X	95 Am X	96 Cm X	97 Bk X	98 Cf X	99 Es X	100 Fm X	101 Md X	102 No X	103 Lr X			

Customers can visit our website's Tech Center, which includes:

- Interactive Periodic Table
- Sample Preparation Guide
- Trace Analysis Guide
- ICP Operations Guide
- Expert Advice
- And much, much more.



Thank You!

Please feel free to ask questions!

