Streamlining Method Development for Metals Analysis Using Agilent 5900 ICPOES and IntelliQuant 2.0

National Environmental Monitoring Conference2021Metals Analysis and Remediation Session10 August, 2021

Greg Gilleland Application Scientist, Optical Spectroscopy Agilent Technologies





### Agilent Smart Tools reduce your remeasurement





### All labs remeasure some of their ICP-OES samples. Do you know how much remeasurement is costing you?

A recent online poll showed the average amount of remeasurement is 15%.

For a small to medium lab\* this will consume almost 2 additional weeks per year

\* 250 samples per week, 2.5 minutes ICP-OES analysis time per sample







### What issues lead to sample remeasurement?

# Sample Related

- Spectral Interference
- Analytical Line Saturated
- Improper prep

# **Operation Related**

- Nebulizer blockage
- Peri pump tubing disconnected
- Internal Standard failure
- Analyte carry-over



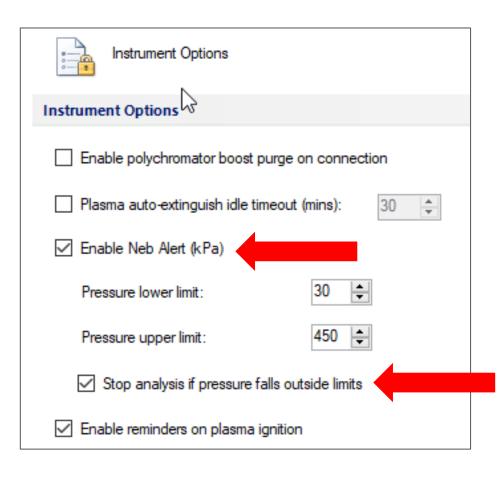


## 5800/5900 ICP-OES with Smart Tools to reclaim your wasted time

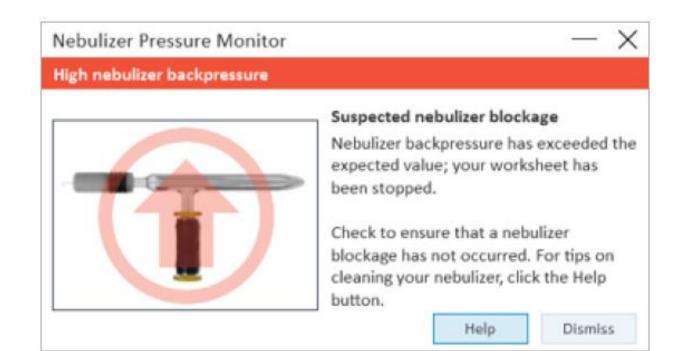
Use Smart Tools to gain insights into your **instrument operation** to reduce remeasurement

- NebAlert
- Outlier Conditional Formatting (OCF)
- Early Maintenance Feedback (EMF)
- Automated air filter blockage alert
- Automated instrument performance tests
- Intelligent rinse
- Plasma ignition optimization
- Internal standard monitor

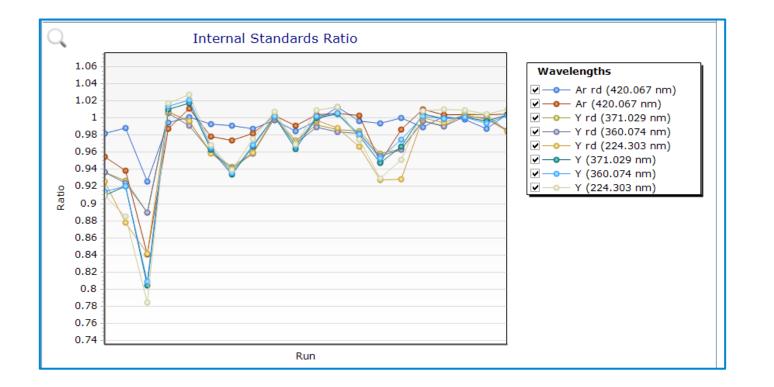
Smart Tools Operational Insights



### NebAlert







### Internal Standard monitor



### Outlier Conditional Formatting (OCF)

	Rack:Tube	Solution Label	Outlier Summary 8.615 nm	Co 230.786 nm 2 ppm	Cr 67.716 nm ppm	Cu 327.395 nm ppm	Fe 273.358 nm ppm	K 766.491 nm ppm	La 408.671 nm 6 ppm	Li 670.783 nm ppm	М( 279.80 ррі	🗖 Ra	ck:Tube	Solution Label	Outlier Summary 8.615 nm	Co 230.786 nm ppm	Cr 267.716 nm ppm	Cu 327.395 nm ppm	Fe 273.358 nm ppm	K 766.491 nm ppm	La 408.671 nm ppm	Li 670.783 nm ppm	М( 279.80 ррі
	2:2	ORESA 45e 2	1.3645	1.1683	19.5747	14.8628	3340.6496	57.8595	0.0167	0.1325	7	2:2	C	ORESA 45e 2									
	2:3	SRM 2781 1	0.2291	0.1247	3.7995	11.3385	520.5713	93.9258	0.3927	0.1407	107	2:3	S	SRM 2781 1									
	2:4	SRM 2781 2	0.2323	0.1270	3.8096	11.8384	531.5788	97.1176	0.3894	0.1445	109	2:4	S	SRM 2781 2									
	2:5	SRM 2782 1	A 1.5177	1.4996	2.3091	53.5224	5852.2210 o	71.4071	1.2246	0.1355	55	2:5	S	SRM 2782 1	A				5852.2210 o				
	2:6	SRM 2782 2	1.4482	1.4303	2.1963	51.4172	5474.6380	67.6546	1.1696	0.1378	52	2:6	S	SRM 2782 2									
	2:1	ORESA 45e 1	1.4282	1.2215	20.2531	15.9087	3385.5674	61.0864	0.0047				C	ORESA 45e 1									
	2:2	ORESA 45e 2	1.4042	1.1999	20.0833	15.1864	3409.9162	59.4210	0.0166		- 1		0	ORESA 45e 2									
	2:3	SRM 2781 1	0.2293	0.1244	3.8020	11.4742	534.8713	96.1179	0.3911	0.1418	110	2:3	\$	SRM 2781 1									
	2:4	SRM 2781 2	0.2405	0.1306	3.9745	12.0563	550.3115	100.0555	0.4072	0.1418	112	2:4	S	SRM 2781 2									
	2:5	SRM 2782 1	A 1.5041	1.4722	2.2825	53.6837	5822.7552 o	71.1665	1.2091	0.1284	55	2:5	S	SRM 2782 1	A				5822.7552 o				
	2:6	SRM 2782 2	1.4680	1.4463	2.2234	51.6004	5436.4548	66.9066	1.1841	0.1276	51	2:6	S	SRM 2782 2									
		ORESA 45e 1	1.4573	1.2448	20.6513	16.0510	3447.9631	62.1334	0.0053	0.1377	4	2:1	C	ORESA 45e 1									
	2:2	ORESA 45e 2	1.4048	1.2037	20.1358	15.2630	3419.2366	59.4457	0.0166	0.1269	7	2:2	C	ORESA 45e 2									
	2:3	SRM 2781 1	0.2334	0.1267	3.8933	11.6111	551.2126	98.6493	0.3990	0.1374	113 🗸	2:3	S	SRM 2781 1									~
<											2	·	1 .li. 🏲										,
												V Display											
												Flag	Flag Ru	ıle		Pass Valu	e Enable						
												A	Result	Concentration (	Overrange	N/A	~						
												В			% RSD > Pass Value	10.00	-		nly apply when r	esult > 10.0	🔹 * MDL		
												C		Concentration	< MDL ecovery variation > Pass Value	N/A							
												E		uation Test Fail	-	N/A							
																1.	1	I					

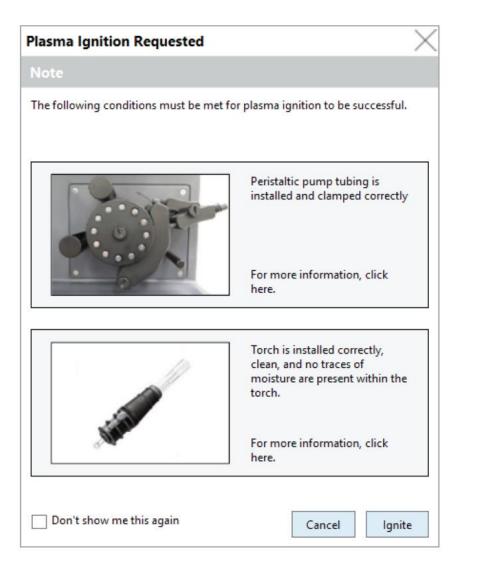


### Outlier Conditional Formatting (OCF)

1 🛛 🗉					
🖌 Display f	lagged only				
Flag	Flag Rule	Pass Value	Enable		
A	Result Concentration Overrange	N/A	✓		
в	Result Concentration % RSD > Pass Value	10.00 🛟		Only apply when result > 10.0 🔹 * MDL	
С	Result Concentration < MDL	N/A			
D	Internal standard % recovery variation > Pass Value	15.00 🜩			
E	QC Equation Test Fail	N/A			

Instrument						Early Mainte Feedback	
Connect • 💿 Plasma •	🔹 🔯 Pump 👻					I EEUDAUN	
Status	User Maintenance Counters				🗌 Receive	Popup Alerts Restore/Set Default Cou	inters
Configuration							
Calibration	Define new counter	Inspect pre-optics window	0 1	Replace peri-pump tubing	2	Clean spray chamber	1
Tests		Plasma on hours: 32/40	Reset	Plasma on hours: 32/40	Reset	Solutions measured: 727/1000	Reset
Dashboard	Clean nebulizer	Inspect torch	? 1	Perform wavelength cal.	? Ū	Clean AVS	0 Ū
Maintenance							
Ignition	Solutions measured: 138/500 Reset	Solutions measured: 138/500	Reset	Days elapsed: 4/30	Reset	AVS switches: 183/10000	Reset
😋 Plasma							
Optics							
O Pump O Camera	Instrument Counters						
Ø Water Cooling	Power on hours 2075						
<ul> <li>Plasma Torch Door</li> <li>Torch Loader</li> </ul>	Plasma on hours 331						
Preoptics	AVS switches 183						
Gas Module	Solutions measured 5132						

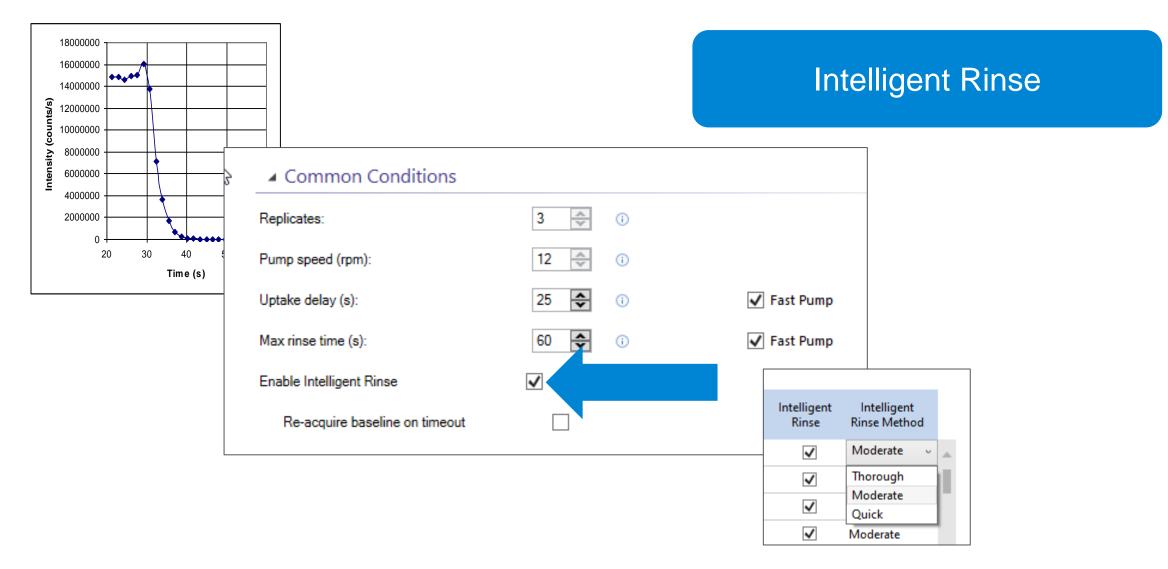




### Optimized plasma ignition

- Prevents difficult ignition
- Prevents torch melts
- Prevents torch 'fountains'







### What issues lead to sample remeasurement?

# Sample Related

- Spectral Interference
- Analytical Line Saturated
- Improper prep

# **Operation Related**

- Nebulizer blockage
- Peri pump tubing disconnected
- Internal Standard failure
- Analyte carry-over





### Smart tools that reduce your remeasurement

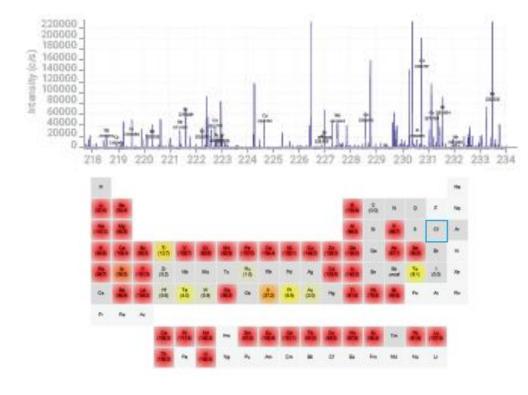
Use Smart Tools to gain insights into your samples

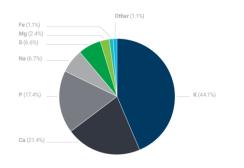
- IntelliQuant 2.0
  - Full spectrum scan
  - Identify sample preparation and chemical compatibility mistakes
  - Automated spectral interference identification
  - Understand sample composition
- IntelliQuant Screening
- Internal Standard Monitor
- Argon Emission Monitor

Smart Tools

# Sample Insights







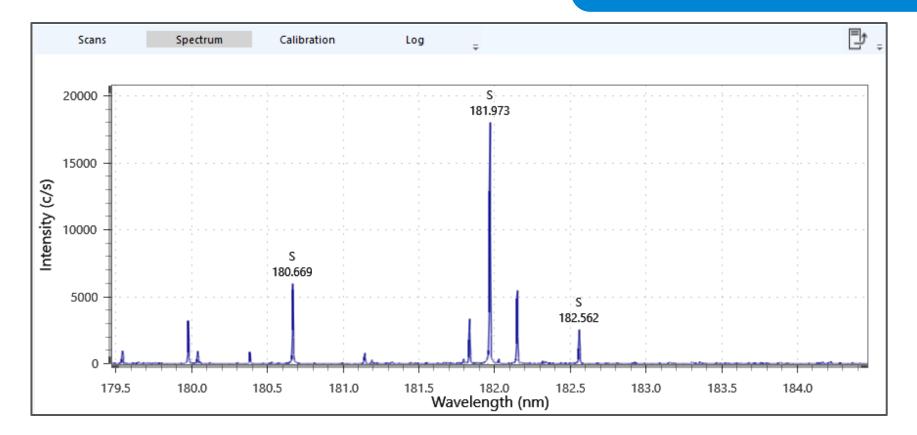
Full spectrum scan shows everything that is in the sample

Periodic table heat map with semi-quant values to quickly identify sample preparation mistakes.

Smart view to identify composition of a sample

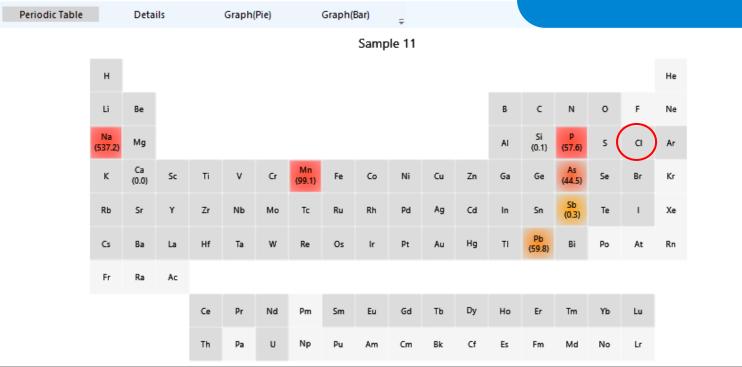


# Full spectrum scan shows everything that is in the sample



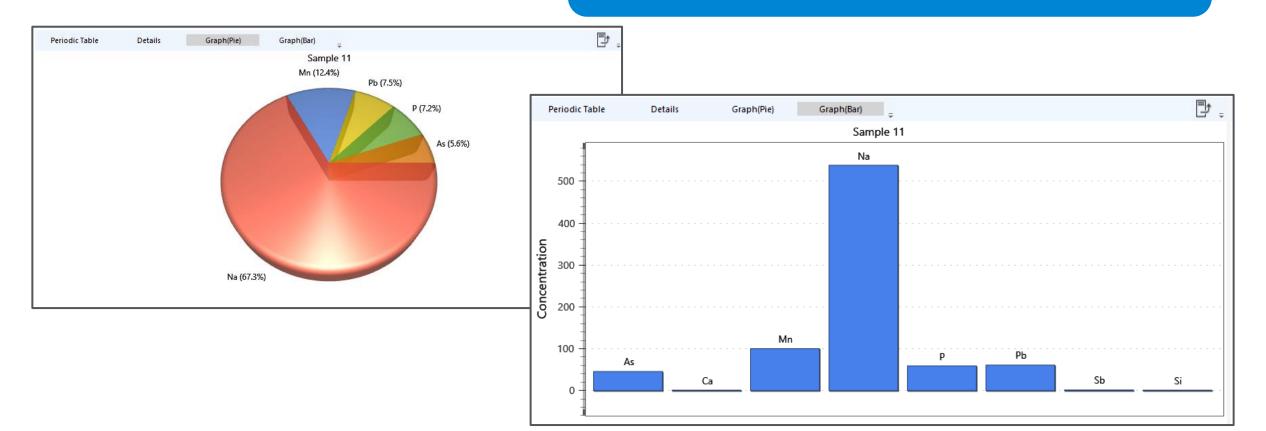


Periodic table heat map with semi-quant values to quickly identify potential spectral interferences and sample preparation mistakes.





# Smart view to identify composition of a sample





Period	lic Table	C	etails	Graph(Pie)	Graph(Bar	) 📮		i 🗄 🗗
Element	Used	Flags	Wavelength	Rating	Concentration	Intensity	Background	
Cr	~		267.716	****	0.01	713.5	1797.4	^
Eu	~		397.197	****	19.34	4432902.5	41958.3	
Gd	~		238.204	****	0.01	940.7	1012.0	
Ho	~		336.224	****	19.02	687983.0	13457.1	
La	~		339.895	*****	20.57	699214.0	19081.5	_
Mg	~		398.852	*****	18.96	1821827.8	23847.6	
Ni	~		279.553	***	-0.01	1221.1	1225.6	

Periodic Table		Details	Graph(	Pie)	Graph(Bai	÷ (		≡	=
Element Used	Flags	Wavelength	Rating		Concentration	Intensity	Background		
~		238.204	****		0.01	940.7	1012.0		
		259.940	*		0.00	87.3	839.0		
Gd									
		342.246	*****		23.72	1461570.6	19501.4		
		335.048	*	?	21.07	1103125.7	19640.2		
~		Analyte: Gd	(335.048)		19.02	687983.0	13457.1		
		Confidenc	e: verv w	eak	20.57	583463.7	12449.7		
		Interferenc			25.12	981837.7	17631.1		
		Confidence			11.07	57904.7	1690.8		
		Confidenc	e: very st	long	15.03	67062.7	2354.1		
Но									
		345.600	*	?	13.44	429784.4	7680.3		
~		339.895	*****		20.57	699214.0	19081.5		
		341.644	*****		20.80	626566.0	28783.0		
		348.484	****		21.42	535862.0	12040.4		

List of recommended wavelengths based on standard IntelliQuant analysis or IntelliQuant screening

Star rating system for analyte wavelengths along with question marks next to concentration outliers or those with spectral interferences



Background-corrected scans at multiple wavelengths to confirm presence or absence

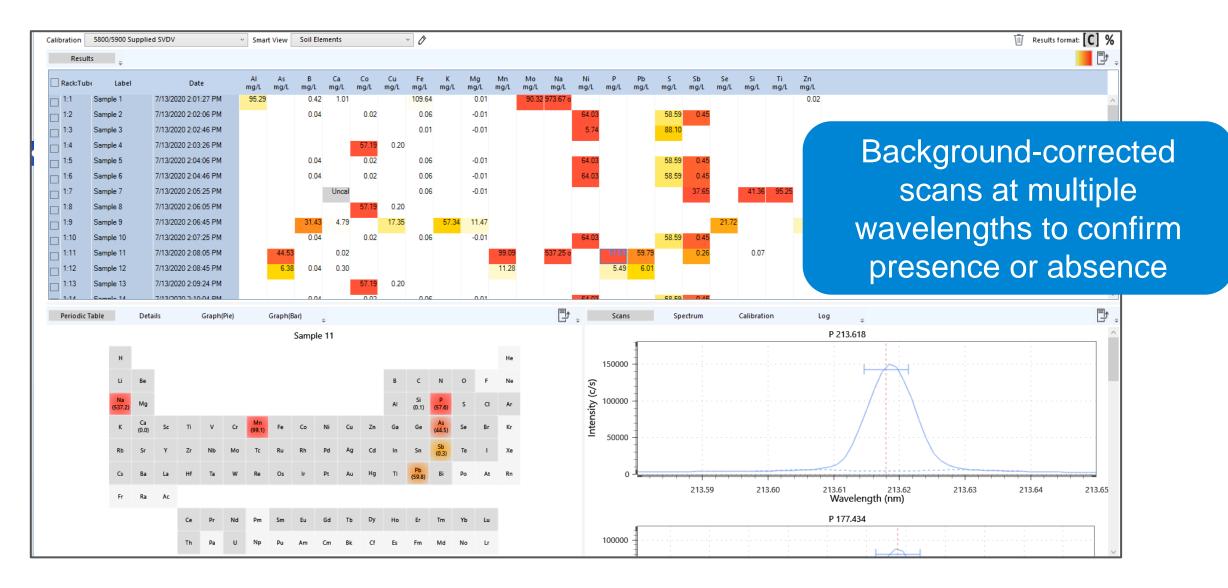


Period	dic Table		Details	Graph(Pie)	Graph(Bar	) ÷		ii 🗗 📮
Element	Used	Flags	Wavelength	Rating	Concentration	Intensity	Backgroun	d
Cr	~		267.716	****	0.01	713.5	1797.4	^
Eu Fe	~		397.197	****	19.34	4432902.5	41958.3	List of recommended wavelengths based on standard
Gd	~		238.204	****	0.01	940.7	1012.0	IntelliQuant analysis or
	~		336.224	****	19.02	687983.0	13457.1	IntelliQuant screening
Ho	~		339.895	****	20.57	699214.0	19081.5	
Mg	~		398.852	****	18.96	1821827.8	23847.6	
Ni	~		279.553	***	-0.01	1221.1	1225.6	$\sim$



Period	dic Table		Details	Graph(	Pie)	Graph(Bar	r) ÷		
Element	Used	Flags	Wavelength	Rating		Concentration	Intensity	Background	
	~		238.204	****		0.01	940.7	1012.0	^
Gd			259.940	*		0.00	87.3	839.0	Star rating system for analyte
			342.246	*****		23.72	1461570.6	19501.4	wavelengths along with
			335.048	*	?	21.07	1103125.7	19640.2	<b>3 3</b>
	~		Analyte: Gd	(335.048)		19.02	687983.0	13457.1	question marks next to
			Confidence	e: verv w	eak	20.57	583463.7	12449.7	concentration outliers or those
			Interference	-		25.12	981837.7	17631.1	with spectral interferences
			Confidence	e: verv st	rona	11.07	57904.7	1690.8	
				,		15.03	67062.7	2354.1	
Но									
			345.600	*	?	13.44	429784.4	7680.3	
	~		339.895	****		20.57	699214.0	19081.5	
			341.644	****		20.80	626566.0	28783.0	
			348.484	****		21.42	535862.0	12040.4	~







Calibration	5800/5900 Supp	lied SVDV	~ Sma	rt View	Soil Elements	~ 0
Resu	ults 📮				AI Open IntelliQuant smart view	vs edito
Rack:Tu	ibe Label	Date	AI mg/L	As mg/L	All elements excluding gases Common Elements	Fe ng/L
1:1	Sample 1	7/13/2020 2:01:27 PM	95.29		EPA 200.7 Food Majors	09.6
1:2	Sample 2	7/13/2020 2:02:06 PM			Major Cations	0.0
□ □ 1:3	Sample 3	7/13/2020 2:02:46 PM			N + CI	0.0
□ 1:4	Sample 4	7/13/2020 2:03:26 PM			PGMs Precious and Base Metals	
1:5	Sample 5	7/13/2020 2:04:06 PM			Rare Earth Elements	0.0
1:6	Sample 6	7/13/2020 2:04:46 PM			Soil Elements Toxics	0.0
L 1:7	Sample 7	7/13/2020 2:05:25 PM			USP232/233	0.0
□ <sup>1:8</sup>	Sample 8	7/13/2020 2:06:05 PM			Custom 57.19 0.20	

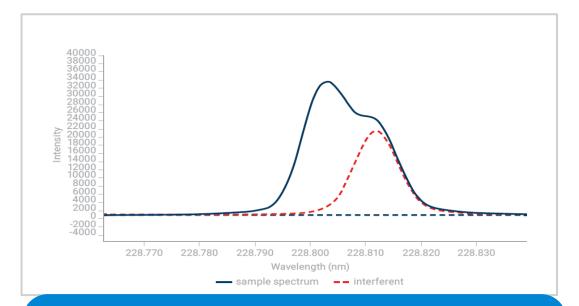
Background-corrected scans at multiple wavelengths to confirm presence or absence

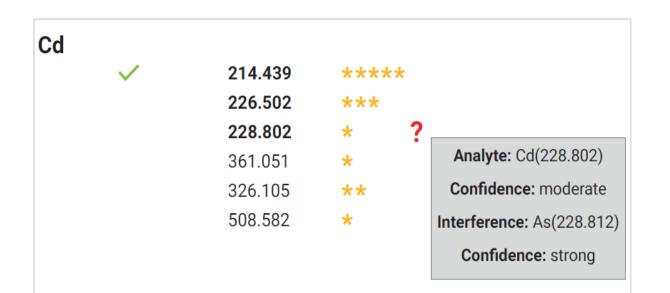
- Customizable element lists
- Customizable calibrations



### How does IntelliQuant 2.0 reduce your remeasurements?

Get greater **sample insight** by <u>automatically</u> detecting spectral overlap.





Cd 228.802nm has unusual peak shape. User is unsure about this result. (User will not see red interferent spectrum, this was added in to help understand existence of overlap) IntelliQuant automatically identifies Cd 228 had a spectral overlap and ranked it low with one star. IntelliQuant identified that Cd 214.439nm was the best wavelength to report a result with five stars. Data analytics is used to rank the wavelengths.

### \*Based on a user inserted %RSD threshold in OCF smart tool



### How does IntelliQuant 2.0 reduce your remeasurements?

Have semi quant result in ~20s\*

Know what is in the sample to avoid interference

Know what concentration to make the calibration standards

for expert in und foresun	nples3 standard r																								-	∰ X3
<u>File</u> •																									6	🕜 <u>H</u> elp -
▪ 🕍 Close	Plasma IF sample for scre	_ · ·	Stop I	CP Applet		<b>2</b> ument	Autosamp		Report	l Int	elliQuant librations															
and left sampless X	Calibration		in Al quant and	v Smart	10000	VII alamani	te avelueli		~ ~	~															Results format	[c] %
Configuration				* Smart	view 7	an elemen	its excludi	ing gases	Ť	0															III Results format	
-	Result	lts ÷																								Ŀ
Conditions	Rack:Tub	be Labe	21	Dat	•	B ppm	Ca ppm	Cd ppm	Co ppm	Cu ppm		K ppm	Mg ppm		Na Ni pm ppm	P ppm			Zn ppm							
Sequence	1:1	Fertilizer sample	. 1	8/08/2019 2:0	5:21 PM		2 325.5 0				.5 111.1		270.0 o			.6	2.3E+00		75.4							
	🗆 <sup>1:1</sup>	Fertilizer sample	• 1	N08/2019 2:0	3:12 PM	10.0	0 126.9 0	0	0.2	2 70	.3 107.5	0.6	270.7 o	230.5 o	0	.6	2.3E+00		74.1							
Autosampler	1:1	Fertilizer sample	. 1	8/08/2019 2:1	1:03 PM	9.9	9 202.4 0	•	0.2	2 70	.9 106.0	0.6	271.9 o	233.4 o	0.	.6	2.3E+00		75.4							
IntelliQuant Analysis	1:1	Fertilizer sample		8/08/2019 2:1		10.1	1 136.7 c	0	0.2	2 78	.4 111.1	0.7	549.7 o	252.6 o	0.	.6	2.4E+00		79.5							
intend don't i maij 55	□ <sup>1:2</sup>	Ready-to-use inf					0 18.4				0.2				10.0	908.7 c		0.0	0.1							
	1:2	Ready-to-use inf				-0.1	1 15.3				0.2				11.2	9.5										
	1:2 1:2	Ready-to-use inf Ready-to-use inf					14.6				0.2				11.8	813.5 c		0.0								
																										8.
	Periodic T	Table D	Details	Graph(Pi	)	Graph(E	Bar)	÷								t	Scans	-	Spectrum	Calibration	La	÷				
		Table C	Details	Graph(Pi		Graph(E Ready-to			mula							t	Scans		Spectrum	Calibration		ng <sub>∓</sub> Fe 238.204				- -
		Table E	Details	Graph(Pi					mula					Не		t <sub>e</sub>	Scans		Spectrum	Calibration		÷				
				Graph(Pi					mula	8	, c	N	0 F		Ē	·	15000		Spectrum	Calibration		÷	<u></u>			<b>ٿ</b> ```
		H Li B Na M	le Ag	Graph(Pi					mula	B (0.0)	) C Si	N P	0 F	Ne		(c/s)	15000		Spectrum	Calibration		÷				<b></b>
		H LL 8 Na (10.0)	le Ag 1.0)		1	Ready-to	o-use in		76		si	p (908.7) (1		Ne		(c/s)	15000		Spectrum	Calibration		÷				· · · ·
		H LL 8 (10.0) 3 K (20.4) (11	te Ag 1,0) Sa 8,4) Sc	i V	l	Ready-to	o-use in	fant for	76	Al  ) Ga	si	p (908.7) (1	<mark>S</mark> CI 2.4) CI	Ne Ar Kr	Ē	(c/s)	15000		Spectrum	Calibration		÷				· · · ·
		H Li 8 (10.0) (3 (20.4) (11 Rb 5 (0	le Ag 1.0) Sc Sc 1.0) Y	i V r Nb	1	Ready-to Fe (0.2) Ru	o-use in Co	Ni C Pd A	u Zn (0.1) g Cd	Al  } Ga I In	Si Ge Sn	p (908.7) (1 As Sb	S CI Se Br Te I	Ne Ar Kr Xe		(c/s)	15000		Spectrum	Calibration		÷				· · · ·
		H Li 8 No 9 K C204) C3 C3 C3 E	le Ag 1.0) Sc Sc 1.0) Y	i V	1	Ready-to	o-use in Co	Ni C	u Zn (0.1) g Cd	Al  } Ga I In	Si Ge Sn	p (908.7) (1 As Sb	<mark>S</mark> CI 2.4) CI	Ne Ar Kr Xe		(c/s)	15000		Spectrum 238.17	Calibration		Fe 238.204	238.21	238.22	238.23	····
		H Li 8 No 9 K C204) C3 C3 C3 E	le Ag 3a Sc Sc Sc Sc Sc Sc Sc Sc Sc Sc	i V r Nb f Ta	1	Ready-to b Fe b (02) Ru Os	Co Rh Ir	Ni C Pd A	u Zn (0.1) g Cd u Hg	Al I) Ga I In I TI	Si Ge Sn Pb	р (1008.7) (1 Аз ! Sb <sup>?</sup> Bi f	S CI Se Br Te I	Ne Ar Kr Xe Rn		(c/s)	15000					Fe 238.204	238.21	238.22	238.23	
		H Li 8 No 9 K C204) C3 C3 C3 E	le Ag Ag Ag Ag Ag Ag Ag Ag Ag Ag	i V r Nb f Ta s Pr	Cr (Mn (0.0 Mo Tc W Re	Ready-to b Fe b (02) Ru Os	Co Rh Ir Eu	Ni C Pd A Pt A	u Zn (0.1) g Cd u Hg b Dy	Ai i) Ga i In TI Ho	Si Ge Sn Pb	p (1 (906.7) (1 As 5 Sb 7 Bi 8	S CI Se Br Te I No At	Ne Ar Kr Xe Rn		(c/s)	15000					Fe 238.204	238.21	238.22	238.23	

### \*20s achieved using automation



## **Real World Examples:**

- EPA OTS report estimated that ICP has a 99.9% false positive rate for TI and 25-50% for As
- Similar observations have been made regarding Cd data in soils containing significant amounts of As
- This can lead to expensive and unnecessary remediation and possible exposure to legal action

Journal of Environmental Quality Seil Heavy Metal in the Environment A Comparison of Reliability of Soil Cadmium Determination by Standard Spectrometric Methods M. B. McBrid 2011 World of Coal Ash (WOCA) Conference - May 9-12, 2011 in Denver, CO, USA http://www.flyash.info/ First publish All rights res means, elec Evaluation of Inductively Coupled Plasma (ICP) retrieval sys False Positives for Arsenic and Trace Metals Read the fu Analysis in Coal Ash and Coal Ash Media Richard J. Abst REMEDIATION HE JOURNAL OF ENVIRONMENTAL ANUP COSTS, TECHNOLOGIES, & TECHNIQUES <sup>1</sup>Haley & Aldr Inducti Edited By: John A. Simor Laboratories. Online ISSN: 1520-6831 method © Wiley Periodicals, Inc. measu **KEYWORDS** the sev dynamic reac Research Article inductiv Arsenic and thallium data in environmental samples: Fact or ABSTRACT digests fiction? at low ( The phenome the line Susan D. Chapnick, Leonard C. Pitts, Nancy C. Rothman samples via li measu been docume First published: 16 September 2010 | https://doi.org/10.1002/rem.20260 | Citations: 3 below fact that a rela of several stro

#### Abstract

Protection Ag data reported

this phenome

A U.S. Environmental Protection Agency Office of Technical Standards Alert estimated that environmental data reported using inductively coupled plasma spectrometry (ICP-AES) has a

LATEST ISSUE >

Summer 2020

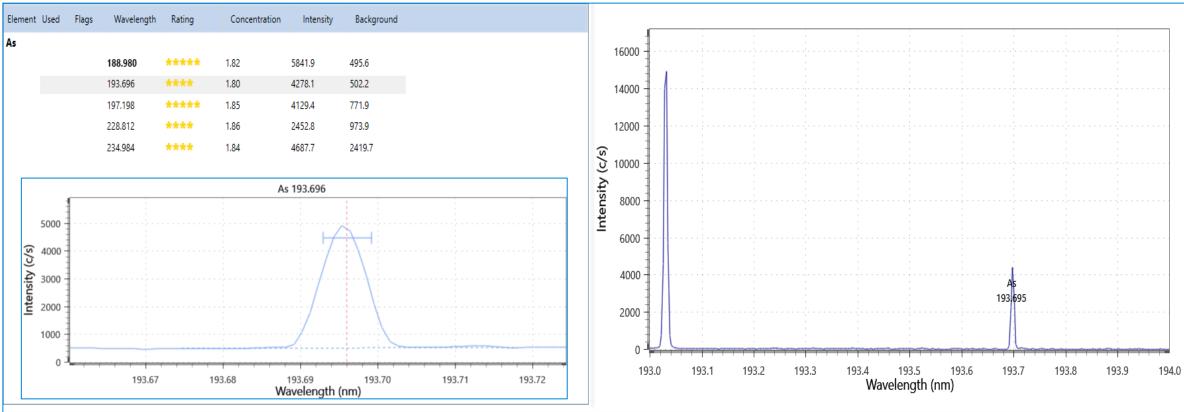
Volume 30, Issue 3

#### DE 44414.8191666667

## **Real World Examples**

### Al interference on As in earth sample

### US EPA method 6010 recommends the As193.696 nm emission line



2 mg/L As in 0ppm AI (minimal background signal). Carbon emission line at 193.028 nm)

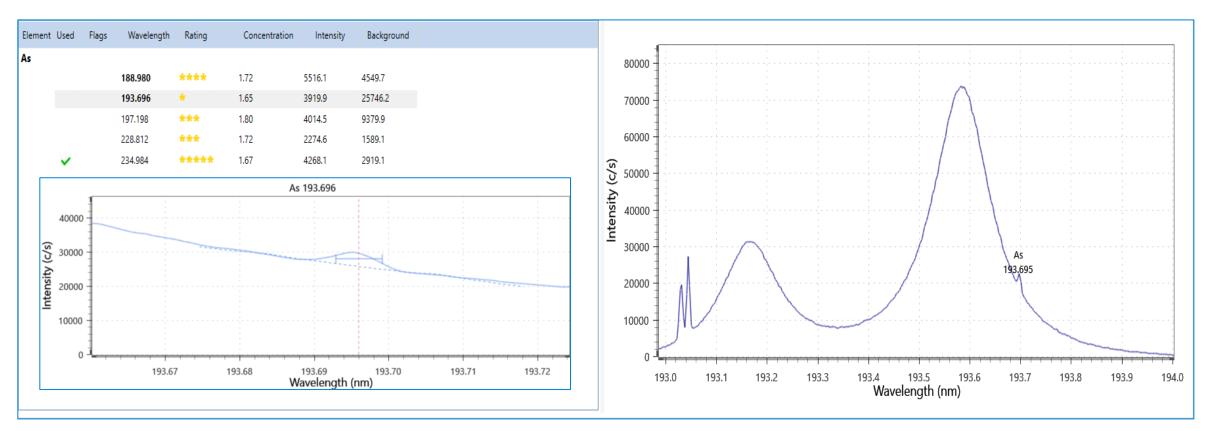
INSET – As wavelength scan at 193.696 nm



### **Real World Examples**

### Al interference on As in earth sample

### US EPA method 6010 recommends the As193.696 nm emission line



2 mg/L As in 5,000ppm AI (broad aluminum auto-ionizing doublet is clearly visible)

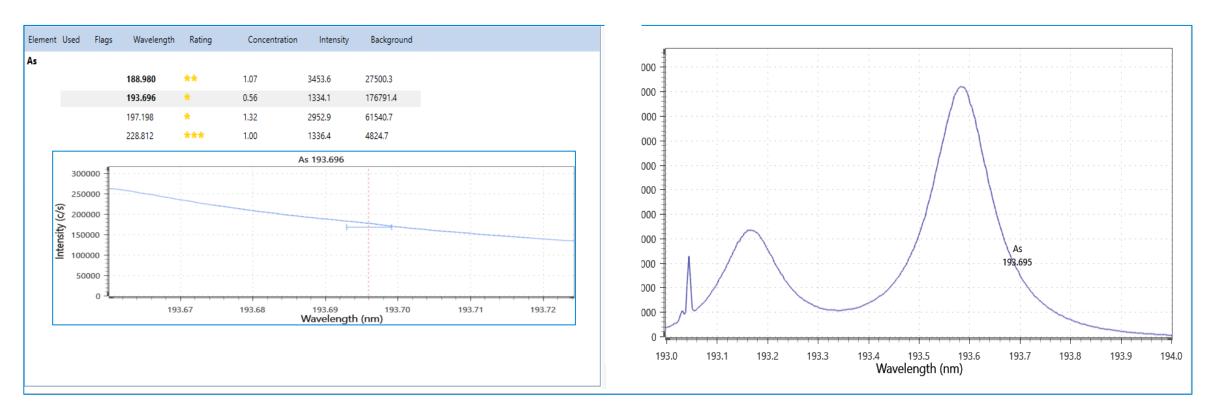
INSET – As wavelength scan at 193.696 nm



## **Real World Examples**

### Al interference on As in earth sample

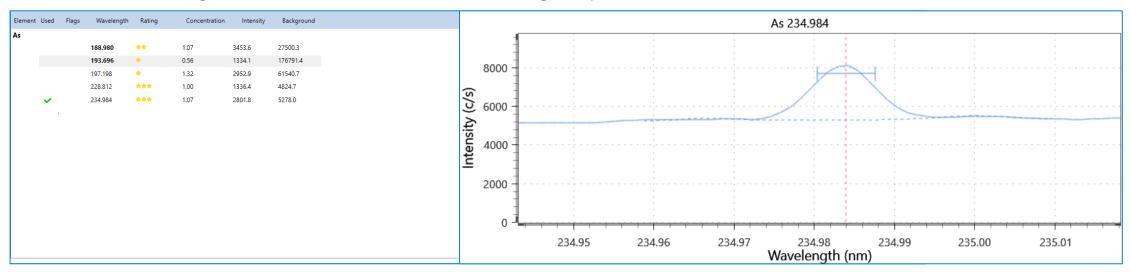
US EPA method 6010 recommends the As193.696 nm emission line



2 mg/L As in 50,000ppm Al INSET – As wavelength scan at 193.696 nm



# The Solution: IntelliQuant for High Aluminium on As



### How do I recognize when AI is affecting my results?

2 mg/L As in 50,000ppm Al

IntelliQuant analyzes a suite of As lines for SRBR and recommends As 234.984nml line in the presence of high Al.

IntelliQuant informs the operator that the result from the As 193 line is of poor quality for this particular sample and recommends a suitable alternative wavelength with a lower MDL.

# Thank you for your attention! Questions?





