Avio ICP-OES product line

Helmut Ernstberger

13.6.2019, Budapest Seminar

PerkinElmer long history in ICP-OES

- 1979 – PerkinElmer Introduces the ICP 5000
- 1984 – PerkinElmer Plasma II Introduced
- 1987 – PerkinElmer introduces the Plasma40
- 1993 – PerkinElmer introduces Optima 3000
- 1995 – Optima 3000DV Introduced
- 2001 – Optima 4300 and Optima 2000
- 2005 – Optima 5300 and Optima 2100
- 2007 –Optima 7300 and Optima 7000
- 2011 –Optima 8x00 Family
- 2016 –Avio 200 2017 –Avio 500

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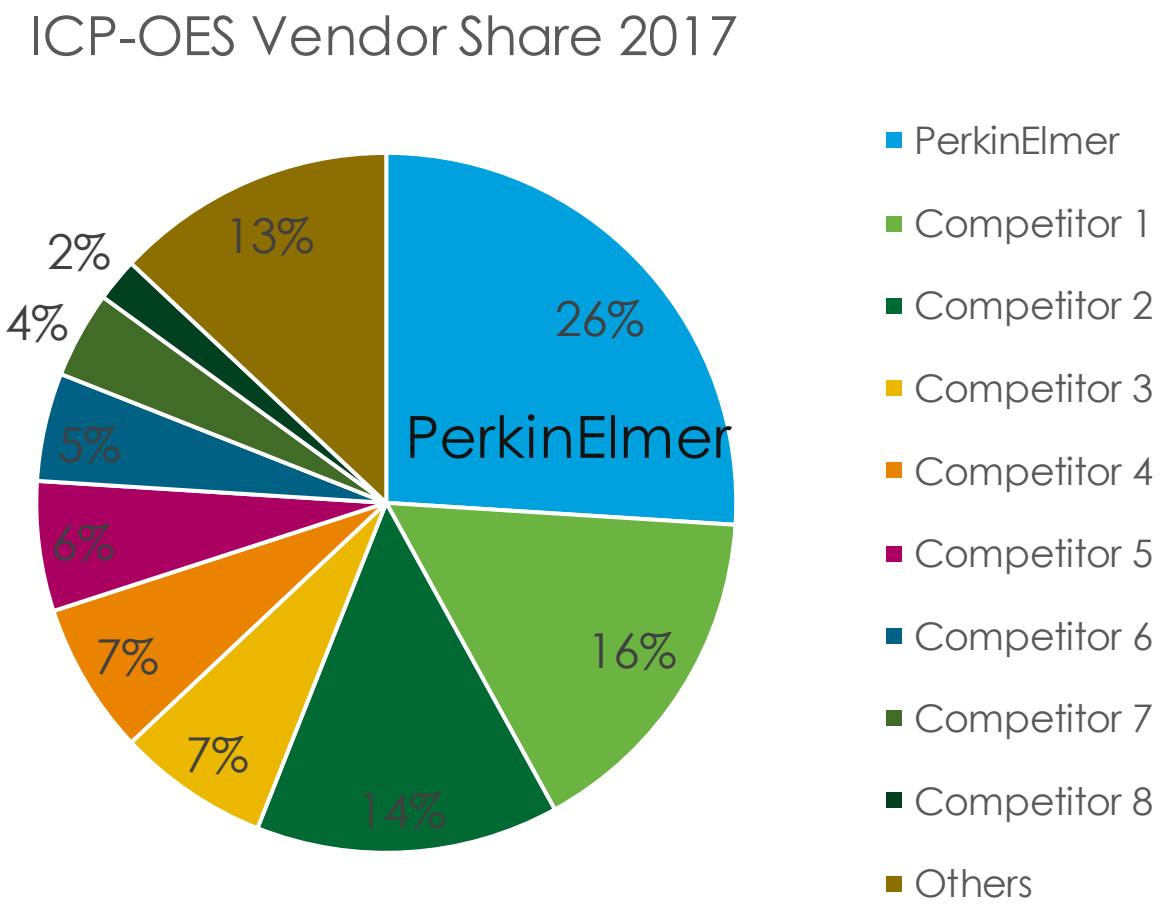
PerkinElmer Continues to Lead the Market for ICP-OES



Source: SDI Global Assessment Report 2018

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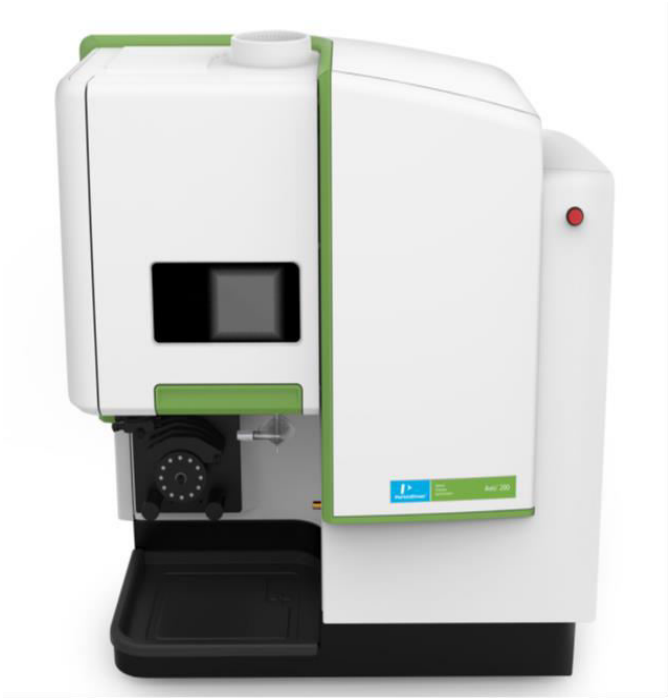
New AVIO series

- Avio 200, launched July 2016



Scanning array ICP-OES

- Avio 500, launched July 2017

Simultaneous ICP-OES

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What do Avio 200 and 500 have in common?

- Flat Plate technology for low argon consumption
- 40 MHz RF generator for robustness and stability
- PlasmaShear
- Vertical torch
- Easty to use torch mount
- Dual View
- Viewing height selectable element by element
- PlasmaCam
- Interference correction capabilities IEC, MSF
- Syngistix Software
- RoHS compliant
- 4-channel, 12-roller peristaltic pump
- Compact size

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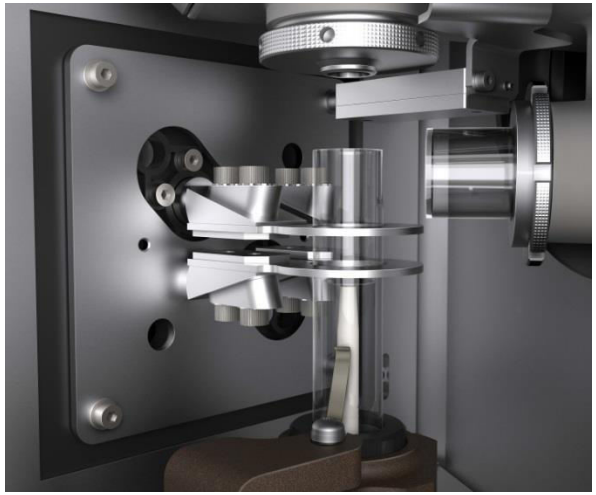
Argon saving: Flat Plate Technology



Patented Flat Induction Plates operate at 40 – 60% of the Argon flow of helical designs

- Avio and Optima platforms are the only ICP-OES systems capable of running a stable plasma at 8 L/min plasma gas
- Same robust plasma conditions for all samples
- Full power range allows the analysis of all sample types
- No helical load coil needed: eliminates maintenance, consumables cost, downtime and leakage risk

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Load coil vs Flat plate – Performance evaluation

- Side by side comparison
  - Optima 8300 vs Optima 4300 DV
  - Difference: RF generator / Flat Plate
  - Same sample introduction system: GemCone / Cyclonic

- Matrix Robustness according to Mermet's criteria for Mg
  - Mg II (280.270 nm) / Mg I (285.213 nm) > 8 for robust plasma
  - Vary Neb flow and plasma power

Plasma parameters	Load Coil	Flat Plate
Plasma Power [W]	varied	varied
Plasma gas flow [L/min]	15	8
Aux. gas flow [L/min]	0.2	0.2
Neb. gas flow [L/min]	varied	varied

- High Matrix Samples
  - Digested coal fly ash: NIST 1633c
  - Mg in digest = 10 mg/L

Load coil vs Flat plate - Plasma robustness

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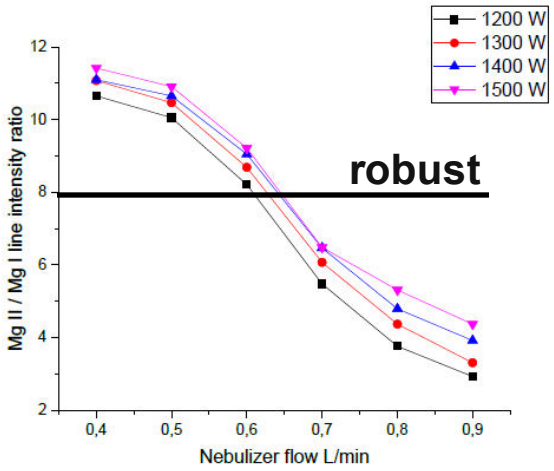
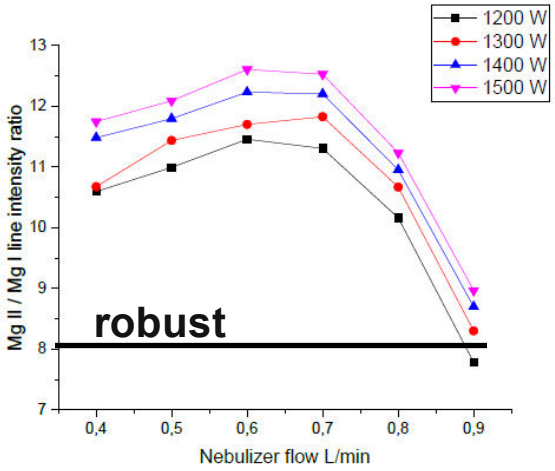
Radial measurement

a) load coil



b) flat plate



Determined Mg II / Mg I line intensity ratios (radial) in SRM1633c using a) load coil and b) flat plate plasma with GemCone nebulizer and syclonic spray chamber

Better efficiency of energy transfer for Flat Plate

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Load coil vs Flat plate - Sensitivity

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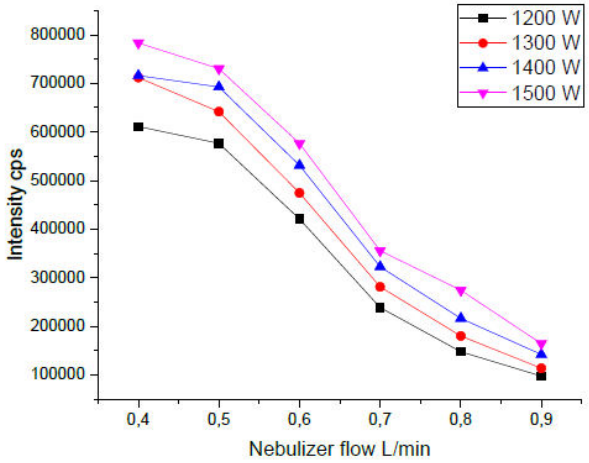
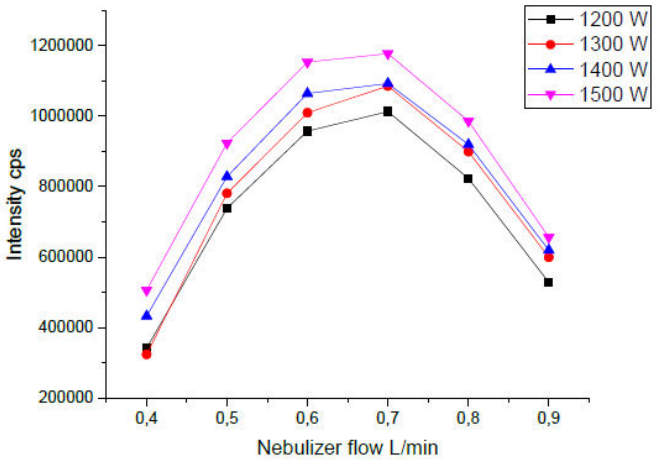
a) load coil



b) flat plate



Determined intensities (radial) of the Mg II 280.270 nm in SRM1633c using a) load coil and b) flat plate plasma

Higher sensitivity for Flat Plate

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Load coil vs Flat plate – Method detection limits

- MDLs determined according to EPA 200.7
- Axial view
- Matrix: Aqua regia, 1:5 diluted

Element	Wavelength [nm]	Flat Plate MDL [µg/L]	Improvement factor over load coil
As	188.979	8.2	1.5
Co	228.616	1.6	19
Cr	267.716	1.5	23
Cu	324.752	2.7	10
Mn	257.610	2.7	7
Ni	231.604	0.6	23
Pb	220.353	2.1	9
Zn	213.857	0.5	44

Flat Plate detection limits on average 17 times lower

Source: University of Jyväskylä, with permission

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Saving Argon: PlasmaShear

PlasmaShear exclusive to PerkinElmer

- Improved performance
- Efficient removal of the tail plume without the need of argon
- Eliminates self-absorption
- Extended linear range
- Matrix independent
- Increase accuracy
- Reduces maintenance time

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Vertical Torch Configuration

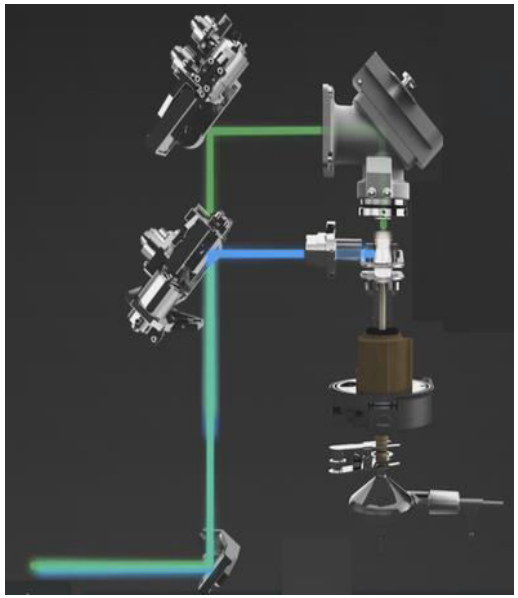
New Vertical Torch Configuration

- Easy-to-use torch mount with fewer parts
  - No tools required
  - One-handed removal
  - Quick-change components
- Easy and cost-effective maintenance
  - Removable injector independent of torch
- Lockable depth position for repeatable torch insertion
- Adjustable, even while the ICP is running, to ensure optimum results
- Solid design
- Accommodates a vast array of sample introduction accessories that make running sample analysis simple, regardless of sample matrix

Dual View: the Best of Both Worlds – No Compromise

Designers of the first Dual View ICP-OES (Optima 3000 in 1995)

- Provides analysis of both low-level and high-level elements in one method
  - Sub-ppb to % level concentration range for all elements across UV and Vis
- Fully-selectable radial viewing height and axial sampling depth
- Delivers flexibility for different sensitivities; i.e. Na and K
- Allows regulatory methods to be run at prescribed wavelength
- Removes EIE interferences
- 1500W in both axial and radial modes



Lower Cost and Time Savings

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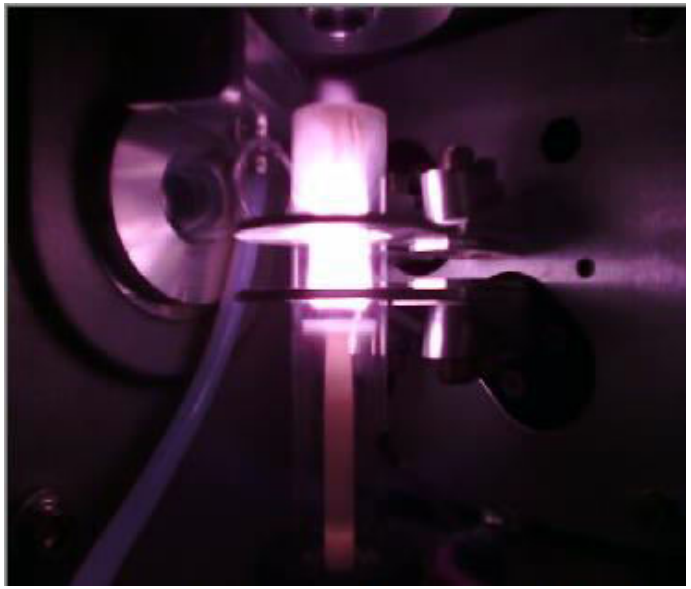
PlasmaCam Viewing Camera



- Real-time plasma viewing
- Verify sample introduction components during analysis
- Simplifies method development
- Perform remote diagnostics
- Ensures maximum up time

Industry's first integrated color camera for continuous plasma viewing during analysis

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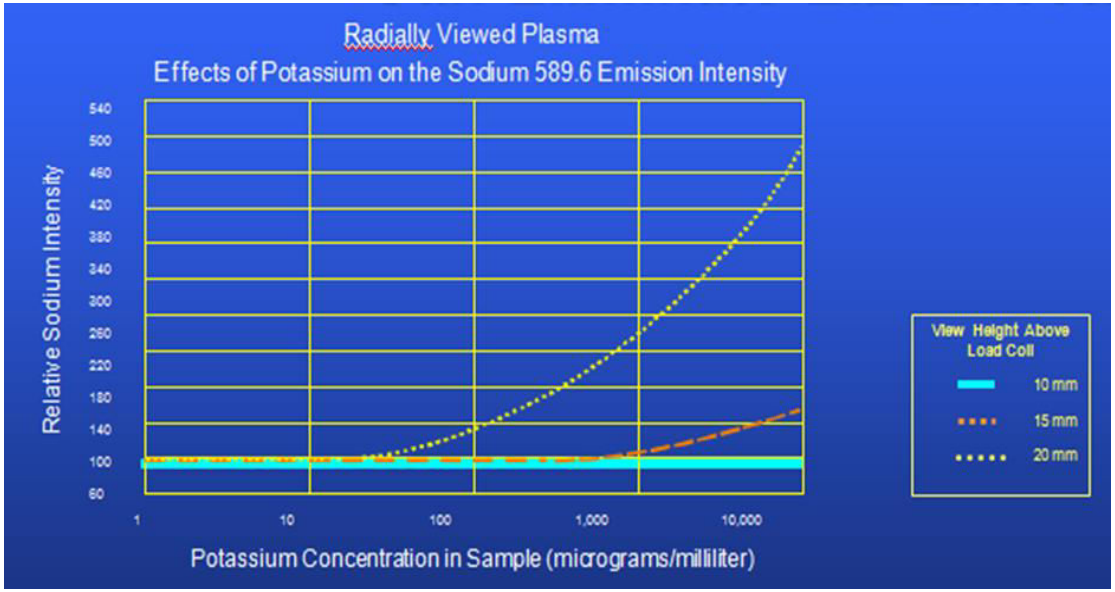
Adjustable viewing height can eliminate EIE Effects



	F'n	Element	Plasma (L/min)	Aux (L/min	Neb (L/min)	Power (watts)	View Dist	Plasi Vie
10	A	K 766.490 rad I+Srl	15	0.2	0.70	1400	15.0	Radial
11	A	K 766.490 rad I+Y	15	0.2	0.70	1400	10.0	Radial
12	A	Mg 279.077 rad II+Y	15	0.2	0.70	1400	15.0	Radial
13	A	Mg 285.213 rad I+In	15	0.2	0.70	1400	15.0	Radial
14	A	Mn 260.568 ax II+Y	15	0.2	0.70	1400	15.0	Axial
15	A	Mn 257.610 ax II+Y	15	0.2	0.70	1400	15.0	Axial
16	A	Na 588.995 rad I+Srl	15	0.2	0.70	1400	10.0	Radial
17	A	Na 589.592 rad I+Srl	15	0.2	0.70	1400	15.0	Radial
18	A	P 213.617 rad I+In	15	0.2	0.70	1400	15.0	Radial
19	A	P 213.617 ax I+In	15	0.2	0.70	1400	15.0	Axial

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Avio 500 ICP-OES Features

- Simultaneous instrument
- High performance optical system
- Universal Data Acquisition
- Argon Quick Change
- SmartRinse

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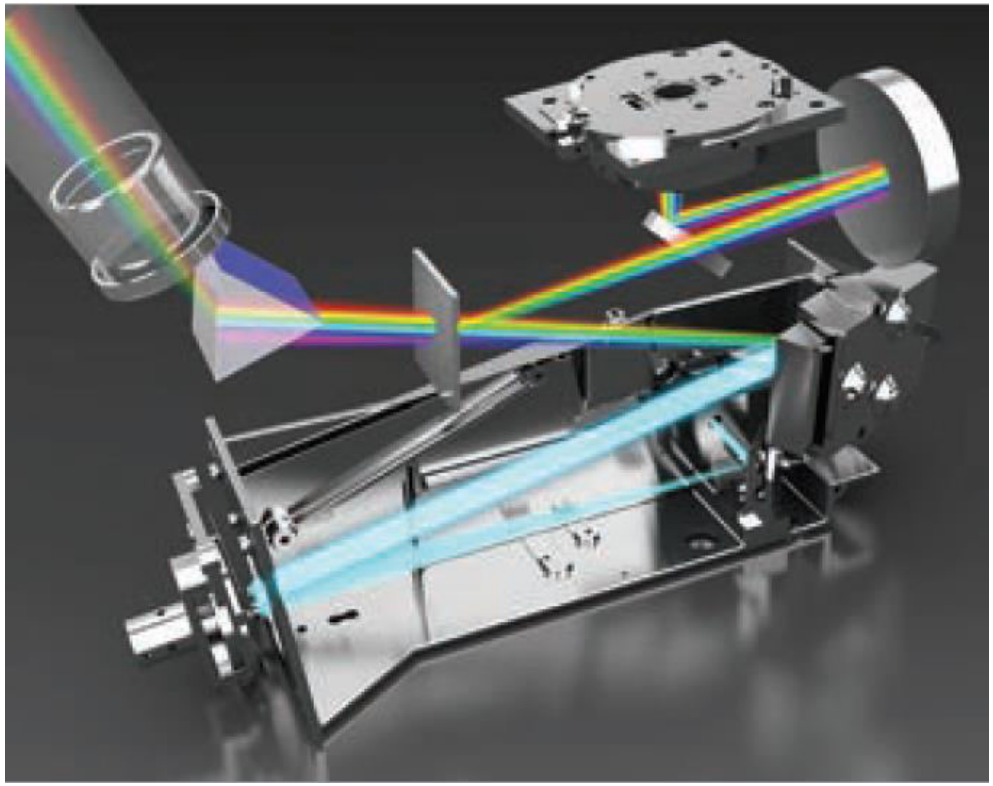
Analysis Speed: Optics & Detector

- Unique optical system & detector allow simultaneous reading of both the visible and UV regions of the spectrum
- Requires thermally stable optical bench



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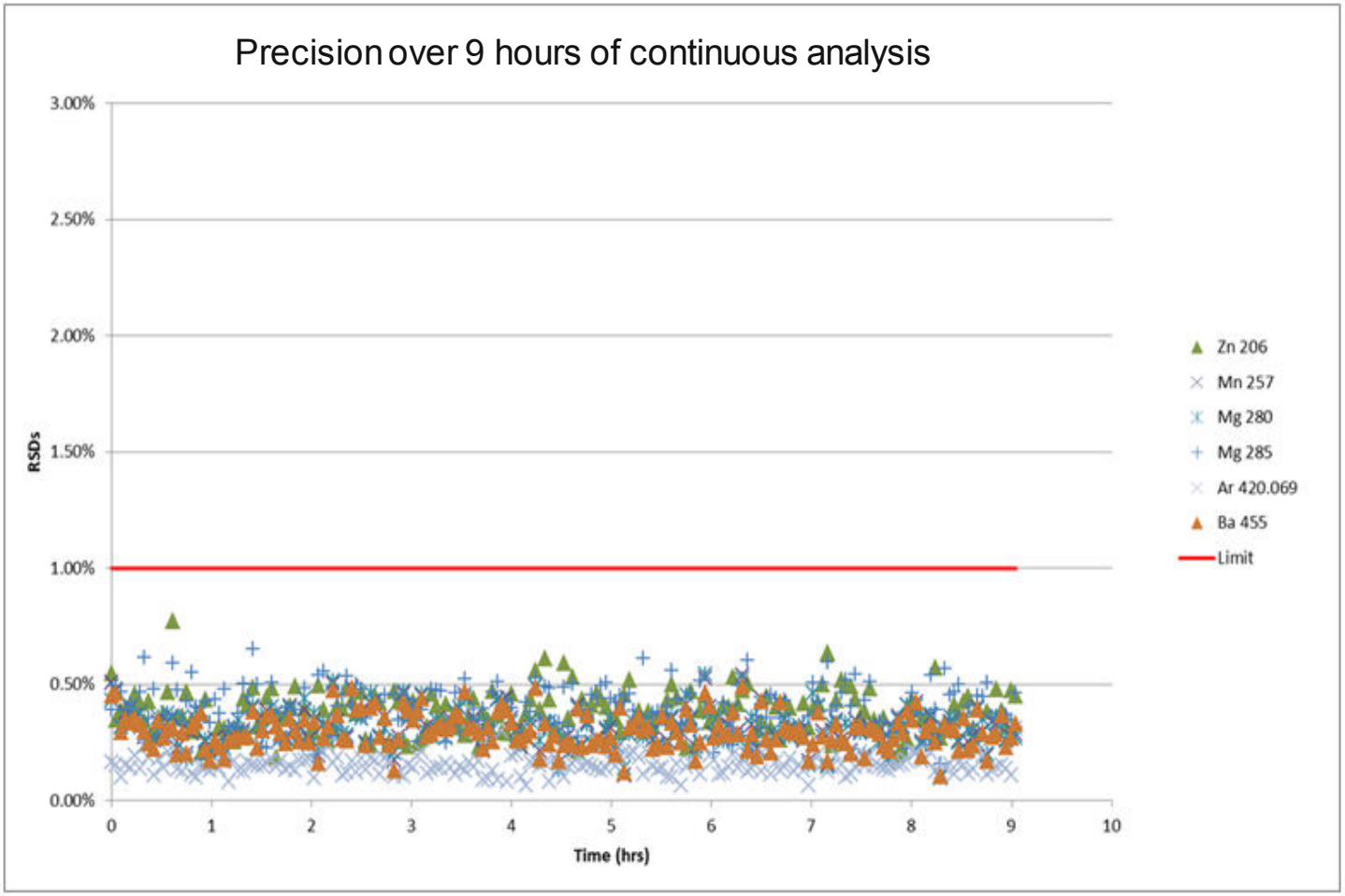
Avio 500 Performance: Unsurpassed stability



Meinhard Type K1 and standard baffled cyclonic spray chamber

9-hour stability run results in <1% RSD

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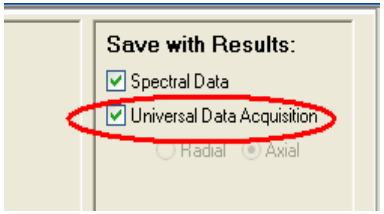
Universal Data Acquisition - UDA

- UDA gathers data for all 6300+ wavelengths available on ***both*** detectors for each sample
- Simple click to turn on
- Uses approx 80kB
- No time penalty
- Live concentration results on screen for every element



Benefits

- No need to re-analyse samples for additional elements/ to confirm results
- Saves analyses time (and money) during method development, all of this can be done offline (not using gas, sample.)

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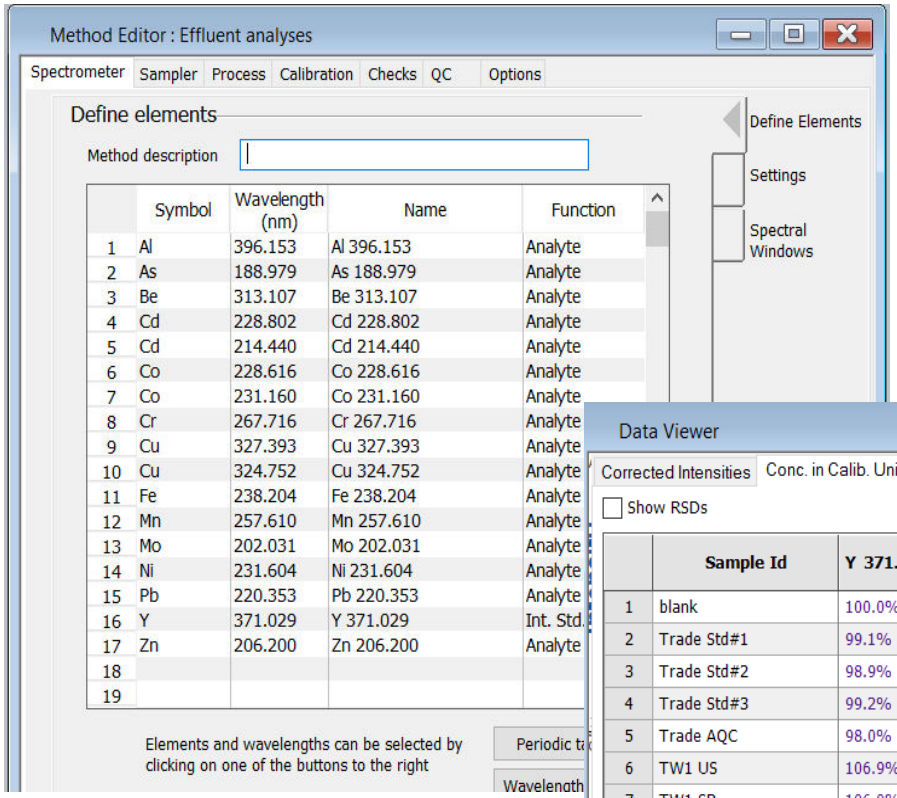
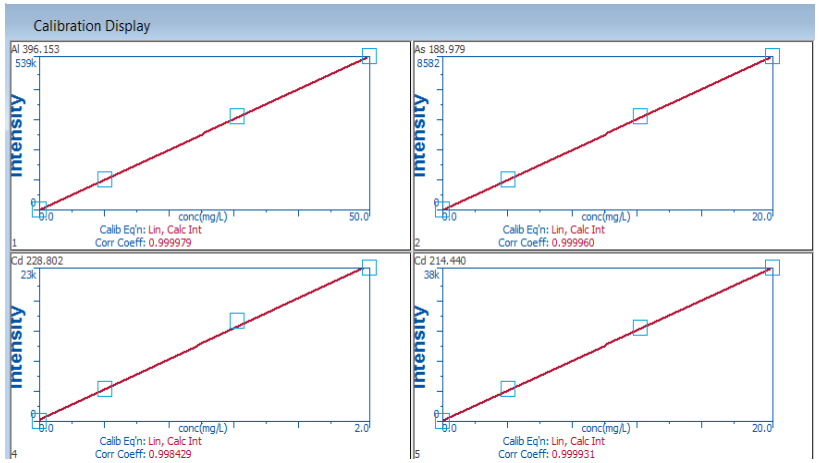
UDA for Quantitative Analysis Scenario…



	Symbol	Wavelength (nm)	Name	Function
1	Al	396.153	Al 396.153	Analyte
2	As	188.979	As 188.979	Analyte
3	Be	313.107	Be 313.107	Analyte
4	Cd	228.802	Cd 228.802	Analyte
5	Cd	214.440	Cd 214.440	Analyte
6	Co	228.616	Co 228.616	Analyte
7	Co	231.160	Co 231.160	Analyte
8	Cr	267.716	Cr 267.716	Analyte
9	Cu	327.393	Cu 327.393	Analyte
10	Cu	324.752	Cu 324.752	Analyte
11	Fe	238.204	Fe 238.204	Analyte
12	Mn	257.610	Mn 257.610	Analyte
13	Mo	202.031	Mo 202.031	Analyte
14	Ni	231.604	Ni 231.604	Analyte
15	Pb	220.353	Pb 220.353	Analyte
16	Y	371.029	Y 371.029	Int. Std.
17	Zn	206.200	Zn 206.200	Analyte
18				
19				



Data Viewer

Corrected Intensities | Conc. in Calib. Units | Conc. in Sample Units | Internal Standards | QC

Show RSDs

	Sample Id	Y 371.0...	Al 396.1... (mg/L)	As 188.... (mg/L)	Be 313.... (mg/L)	Cd 228.... (mg/L)	Cd 214.... (mg/L)	Co 228.... (mg/L)	Co 231.... (mg/L)	Cr 267.... (mg/L)	Cu 327.... (mg/L)	Cu (m
1	blank	100.0%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0(
2	Trade Std#1	99.1%	10.000	4.000	0.400	0.400	4.000	4.000	4.000	4.000	4.000	4.0(
3	Trade Std#2	98.9%	30.000	12.000	1.200	1.200	12.000	12.000	12.000	12.000	12.000	12.(
4	Trade Std#3	99.2%	50.000	20.000	2.000	2.000	20.000	20.000	20.000	20.000	20.000	20.(
5	Trade AQC	98.0%	25.319	10.084	1.046	1.067	10.252	10.107	10.141	10.350	10.099	10.4
6	TW1 US	106.9%	16.313	-0.320	-0.002	-0.009	0.001	0.060	0.043	0.017	0.320	0.1(
7	TW1 SP	106.0%	28.386	4.328	0.442	0.407	4.224	4.100	4.134	4.183	4.345	4.2(

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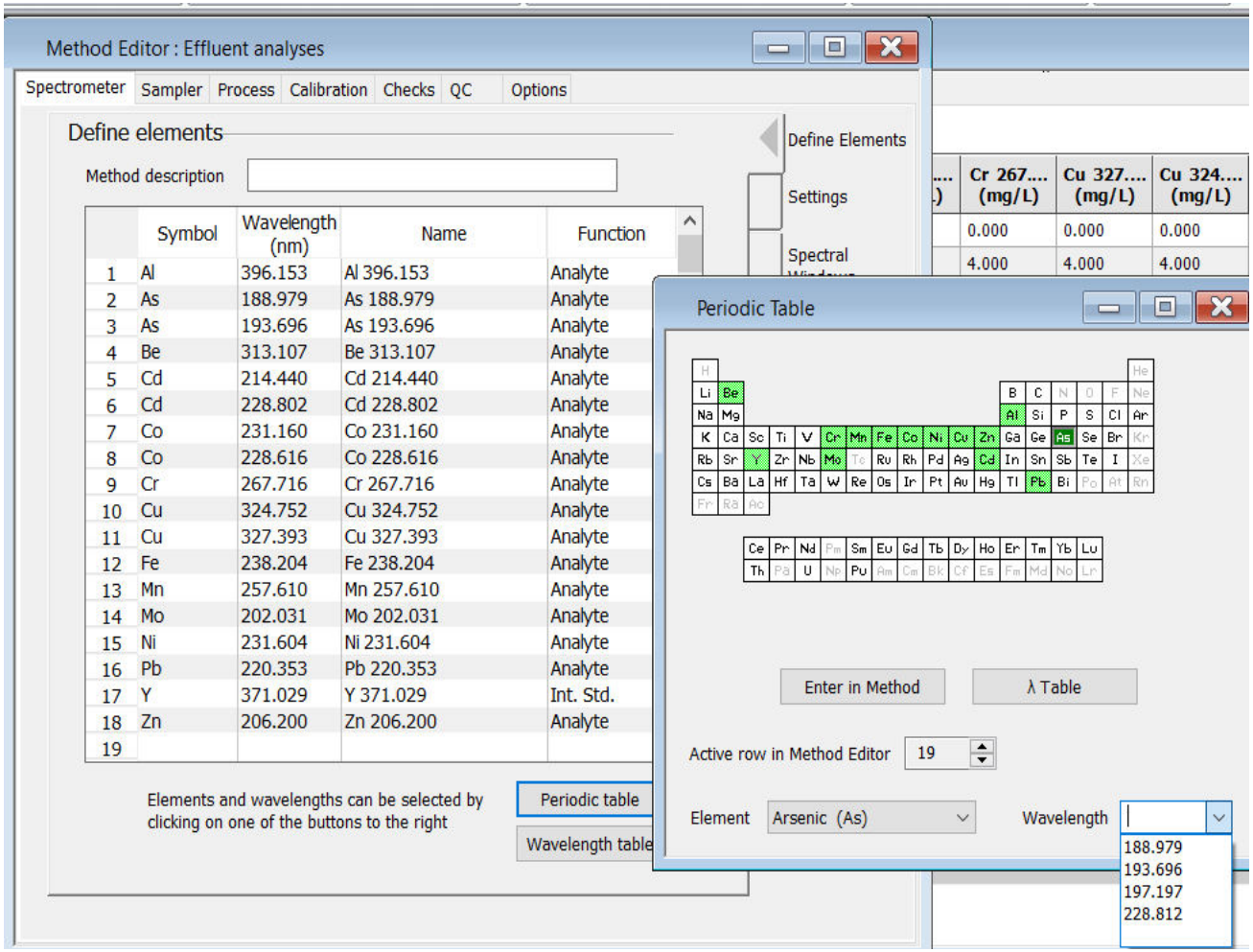
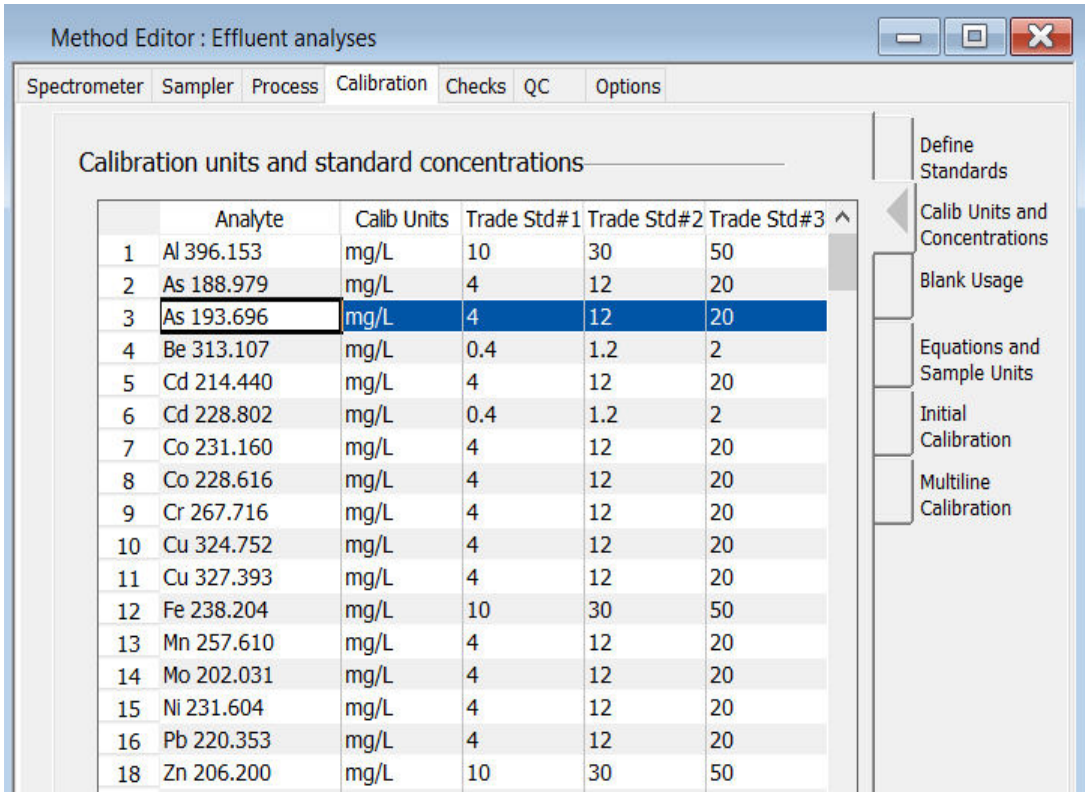

Method Editor : Effluent analyses
Spectrometer
Sampler
Process
Calibration
Checks
QC
Options
Define elements
Method description
Define Elements
Settings
Spectral
Symbol
Wavelength (nm)
Name
Function
1 Al 396.153 Al 396.153 Analyte
2 As 188.979 As 188.979 Analyte
3 As 193.696 As 193.696 Analyte
4 Be 313.107 Be 313.107 Analyte
5 Cd 214.440 Cd 214.440 Analyte
6 Cd 228.802 Cd 228.802 Analyte
7 Co 231.160 Co 231.160 Analyte
8 Co 228.616 Co 228.616 Analyte
9 Cr 267.716 Cr 267.716 Analyte
10 Cu 324.752 Cu 324.752 Analyte
11 Cu 327.393 Cu 327.393 Analyte
12 Fe 238.204 Fe 238.204 Analyte
13 Mn 257.610 Mn 257.610 Analyte
14 Mo 202.031 Mo 202.031 Analyte
15 Ni 231.604 Ni 231.604 Analyte
16 Pb 220.353 Pb 220.353 Analyte
17 Y 371.029 Y 371.029 Int. Std.
18 Zn 206.200 Zn 206.200 Analyte
19
Elements and wavelengths can be selected by clicking on one of the buttons to the right
Periodic table
Wavelength table
Periodic Table
Enter in Method
λ Table
Active row in Method Editor
19
Element
Arsenic (As)
Wavelength
188.979
193.696
197.197
228.812
Cr 267.... (mg/L)
Cu 327.... (mg/L)
Cu 324.... (mg/L)
0.000
0.000
0.000
4.000
4.000
4.000

Enter calibration concentrations and reprocess data



	Analyte	Calib Units	Trade Std#1	Trade Std#2	Trade Std#3
1	Al 396.153	mg/L	10	30	50
2	As 188.979	mg/L	4	12	20
3	As 193.696	mg/L	4	12	20
4	Be 313.107	mg/L	0.4	1.2	2
5	Cd 214.440	mg/L	4	12	20
6	Cd 228.802	mg/L	0.4	1.2	2
7	Co 231.160	mg/L	4	12	20
8	Co 228.616	mg/L	4	12	20
9	Cr 267.716	mg/L	4	12	20
10	Cu 324.752	mg/L	4	12	20
11	Cu 327.393	mg/L	4	12	20
12	Fe 238.204	mg/L	10	30	50
13	Mn 257.610	mg/L	4	12	20
14	Mo 202.031	mg/L	4	12	20
15	Ni 231.604	mg/L	4	12	20
16	Pb 220.353	mg/L	4	12	20
18	Zn 206.200	mg/L	10	30	50

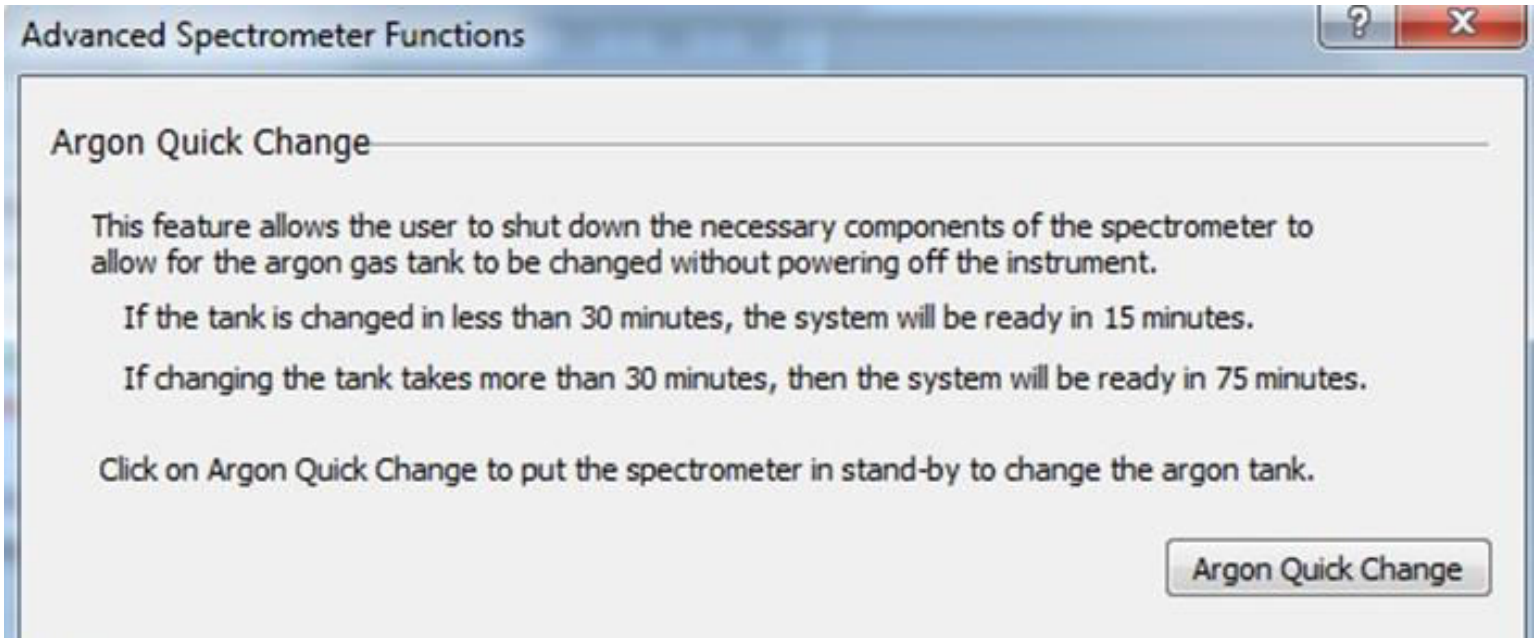
Quantitation with UDA standard sets

- UDA Standard set
  - Covers a wide element range (69 elements)
  - Include UDA standards in run
- ALL wavelengths info is collected with UDA
- Retrospective quant analysis
  - Calibrate any UDA element not part in your original standards mix
  - Assign internal standard
  - Reprocess with UDA solution as standard
  - Quantitative analysis result – however only 1 concentration level

Answer questions about your samples which are asked in hindsight!

Argon Quick-Change

- A mode in the software that allows Ar tanks to be changed without powering off the Avio 500
- Instrument goes into Stand-by Mode
- The user has 30 minutes to change the Ar tank
- After the tank is changed, start up time is 15 minutes
  - Time required to purge the detector



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Analysis Speed

- Sample: 1 ppm mixed element standard
- Number of wavelengths: 20
  - **Elements:** Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Se, Sr, V, Zn
    - Some elements with low sensitivity (i.e. As, Se, Pb, etc.)
    - Some elements with high sensitivity (i.e. Mg, Na, Sr, etc.)
- Default Read Time Range: 1 - 5 seconds
  - Software automatically selects best integration time within the range based on a pre-shot
  - Time selected per wavelength
  - Integration Time based on signal intensity
- Views: axial & radial

- **Analysis Time: 30 seconds**

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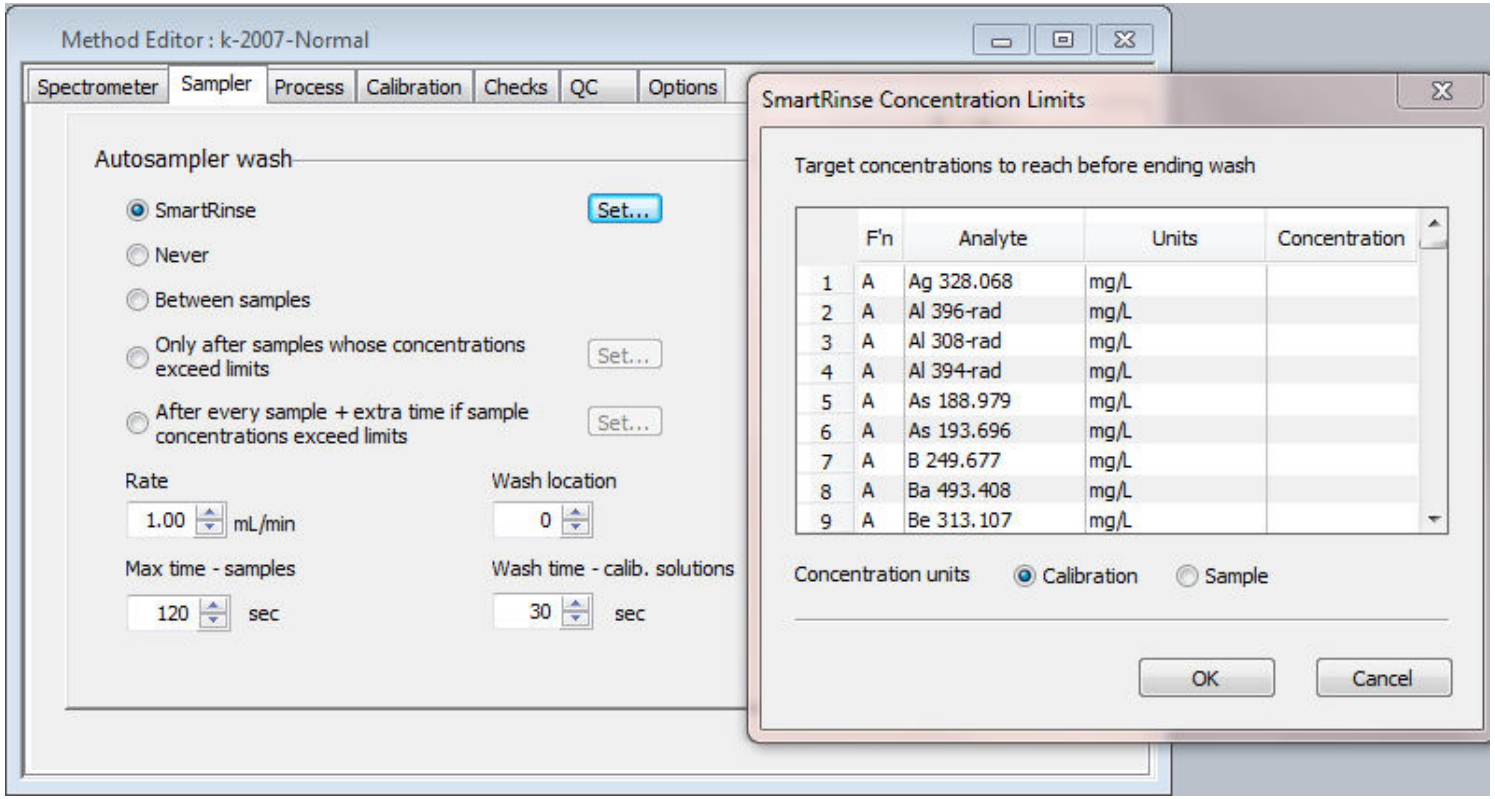
Analysis Speed: Sample Washout

- Sample washout can be the longest time going from sample-to-sample
- A variety of sample introduction components are available to minimize washout
  - ESI FAST
  - Cetac ASXpress
  - Glass Expansion Niagara
- A variety of rinse options are available in Syngistix

Sample Washout: SmartRinse

- User-defined concentrations for each element in the method
- When the concentrations are below the user-defined thresholds, rinsing is complete



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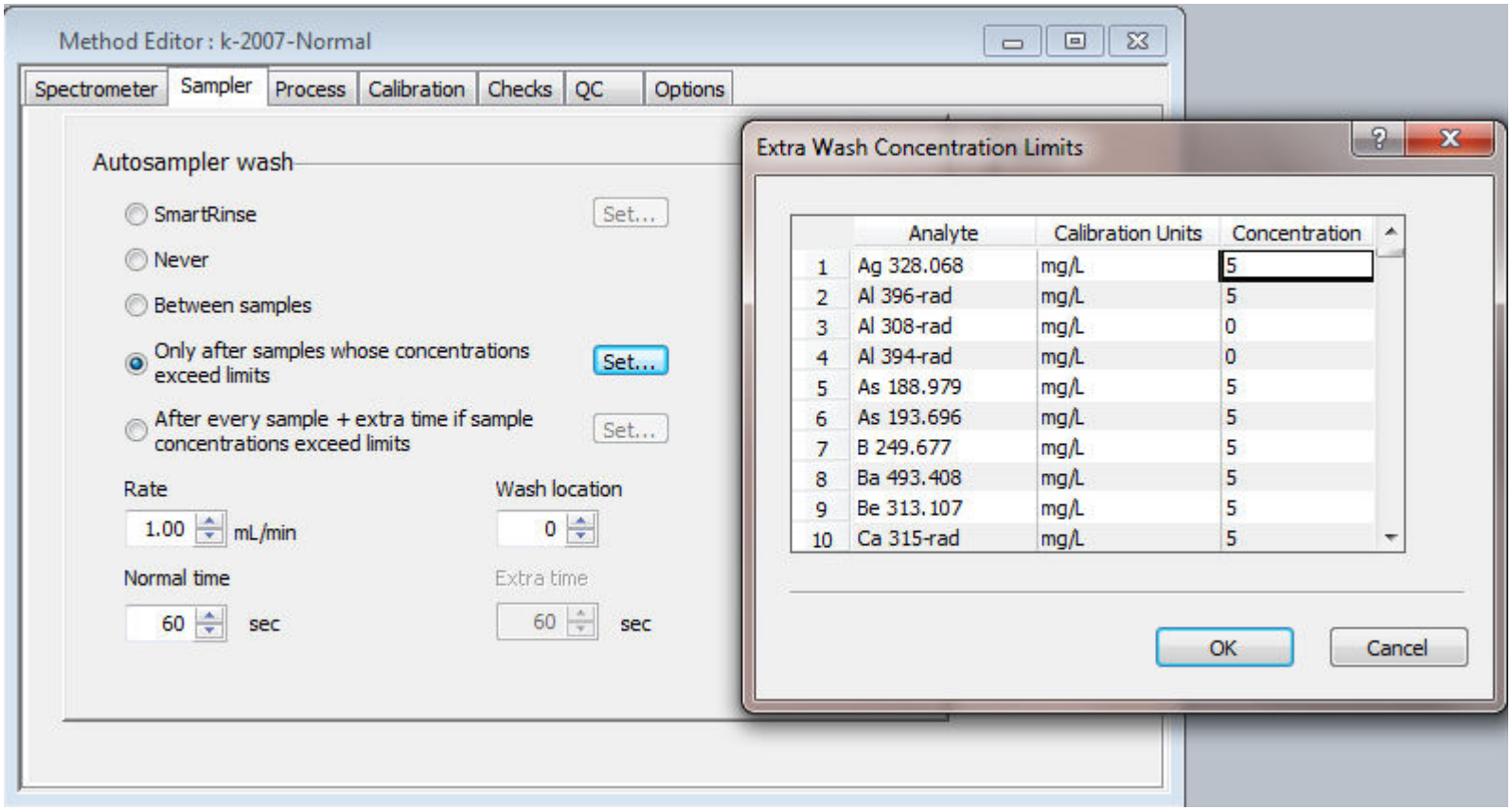
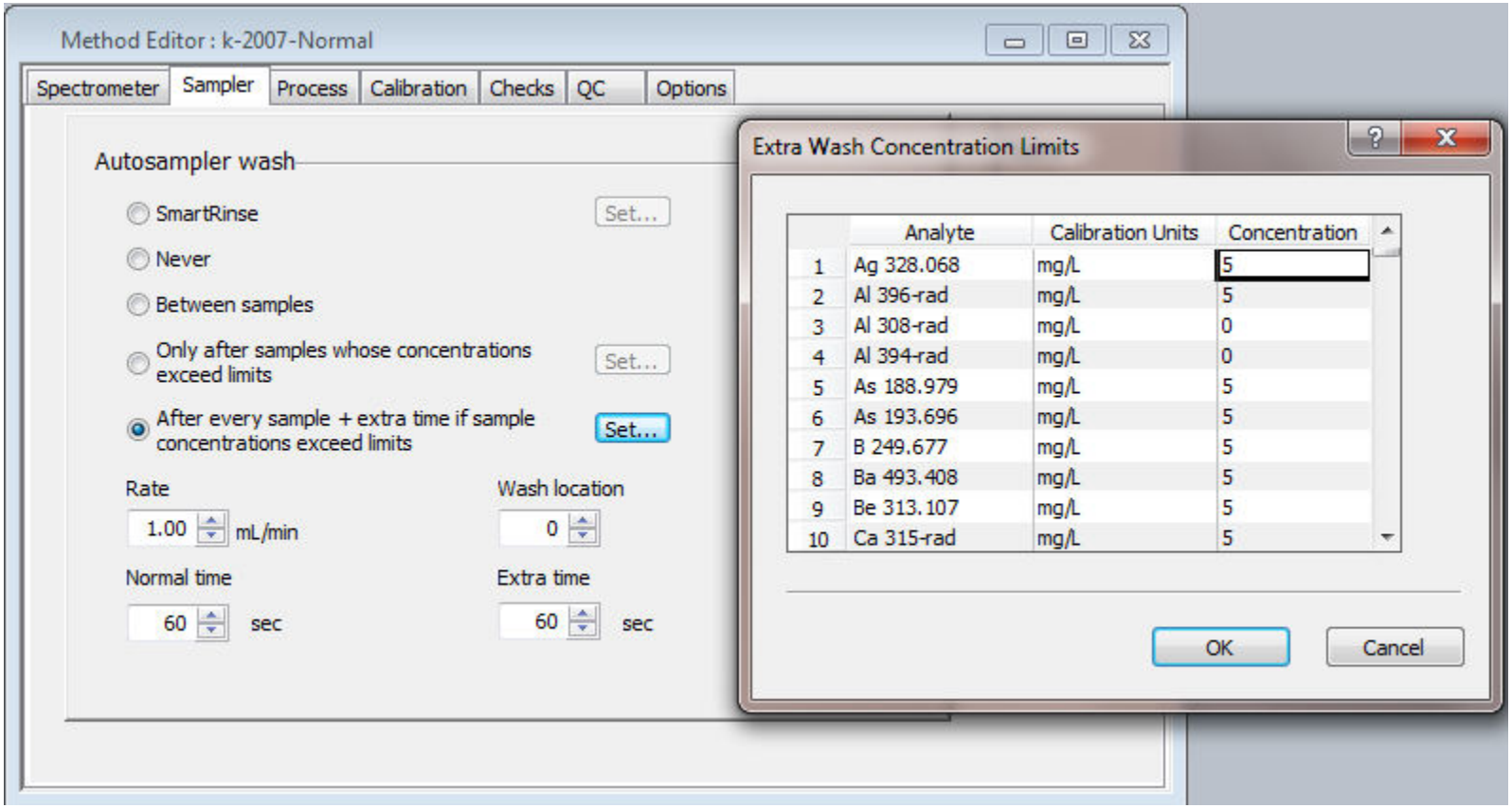
Sample Washout: Upper Limits-1

- User-defined upper-limit concentrations for each element to determine if washing is required



Sample Washout: Upper Limits-2

- User-defined upper-limit concentrations for each element to determine if extra washing is required



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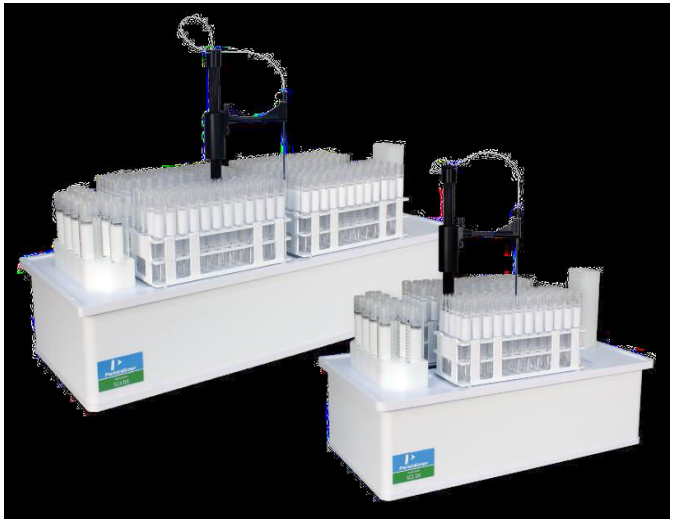
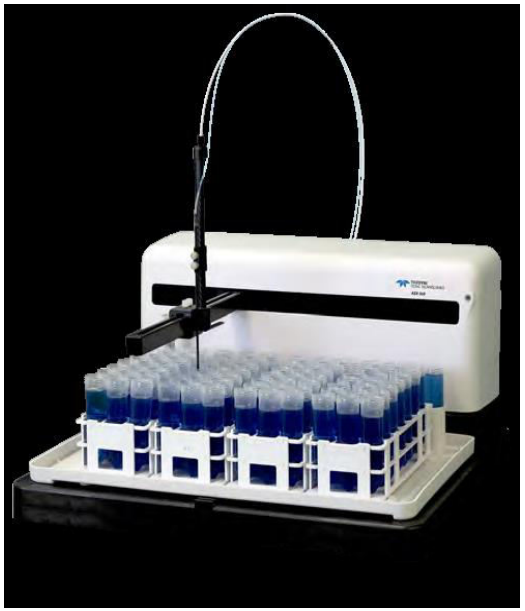
Full Range of Intelligent Autosamplers and Diluters





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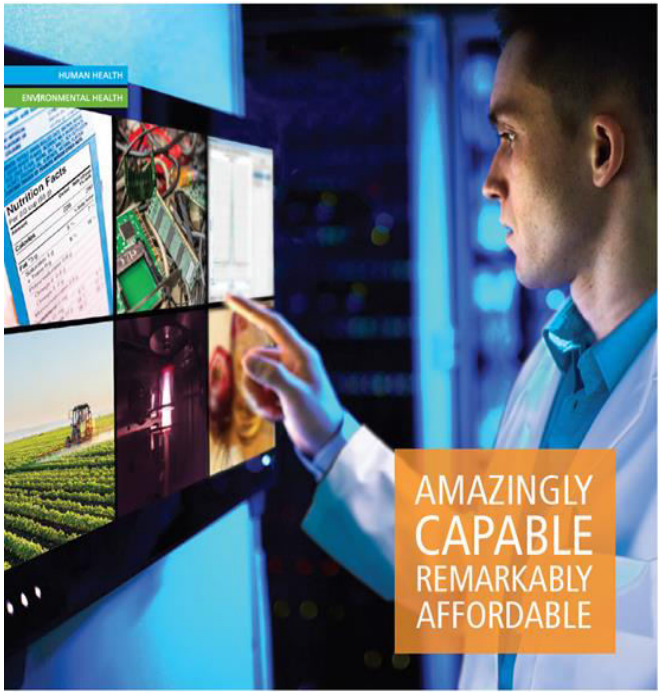
prep3

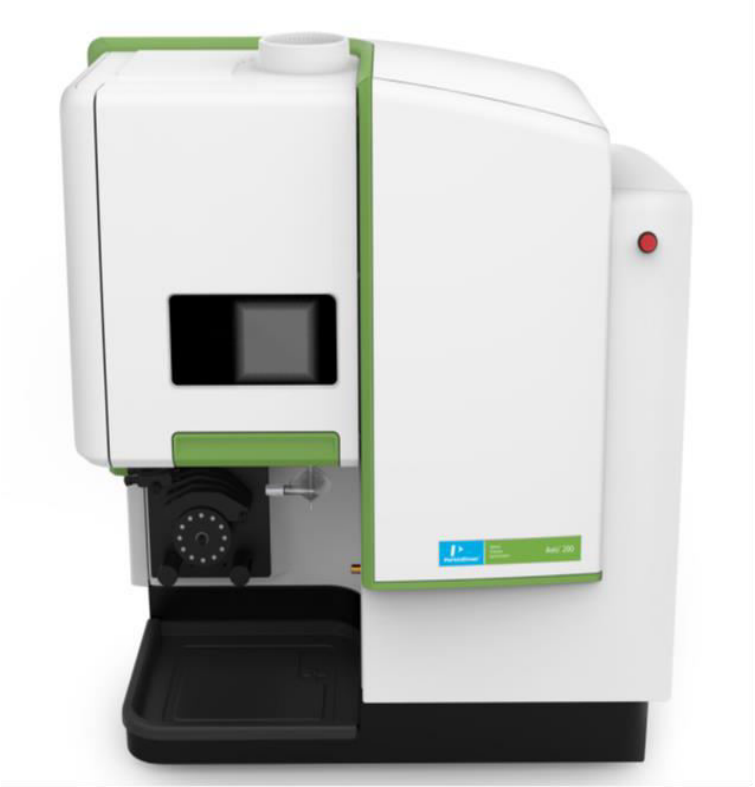
- Automatic calibration from stock standard solution(s)
- Automatic sample dilution
- Automatic over-range dilution
- Automatic internal standard out-of-range dilution
- Analyze samples from undiluted to up to 25x diluted
- Fully supported by PerkinElmer Syngistix software

https://www.youtube.com/watch?v=yvWIy-fDyuA

P1 = Sample, P2 = Diluent, P3 = Internal Standard

P1+ P2 = Constant, P1/(P1+P2) = Dilution Factor





AVIO 200 ICP-OES

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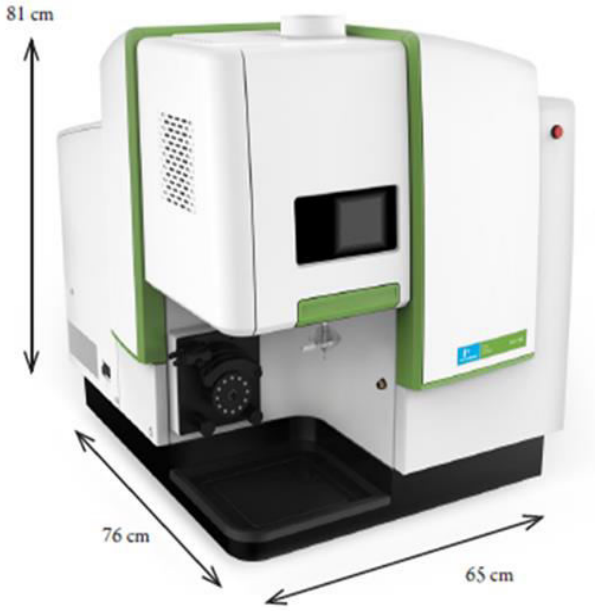
Avio 200…

- Scanning Array Spectrometer
- Does not require to be thermostated
- Designed to turn off when not in use
- OFF is OFF
- Optical system with very high light throughput allows short read times
- Fastest start up from cold (10 min)
- DWS for best stability
- Smallest ICP on the market at 65x76x81cm



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Fastest Start up

- 10 minutes from cold
  - No gas
  - No electricity
- How? DWS – Dynamic Wavelength Stabilisation
  - Use of the Neon reference source corrects for any peak shift due to temperature and purge (or lack of)

Benefits

- Excellent stability despite changing laboratory environment
- Best precision and accuracy

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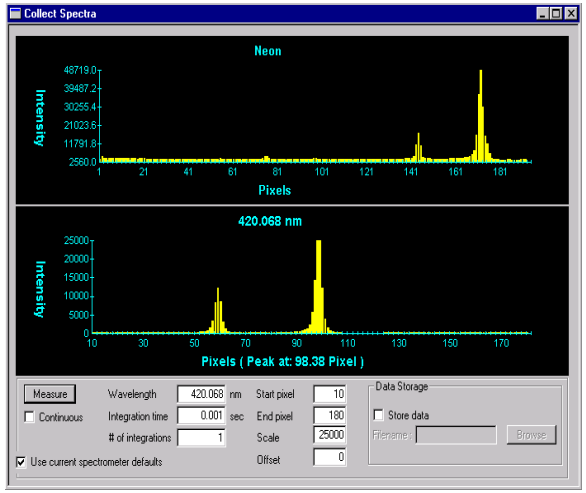
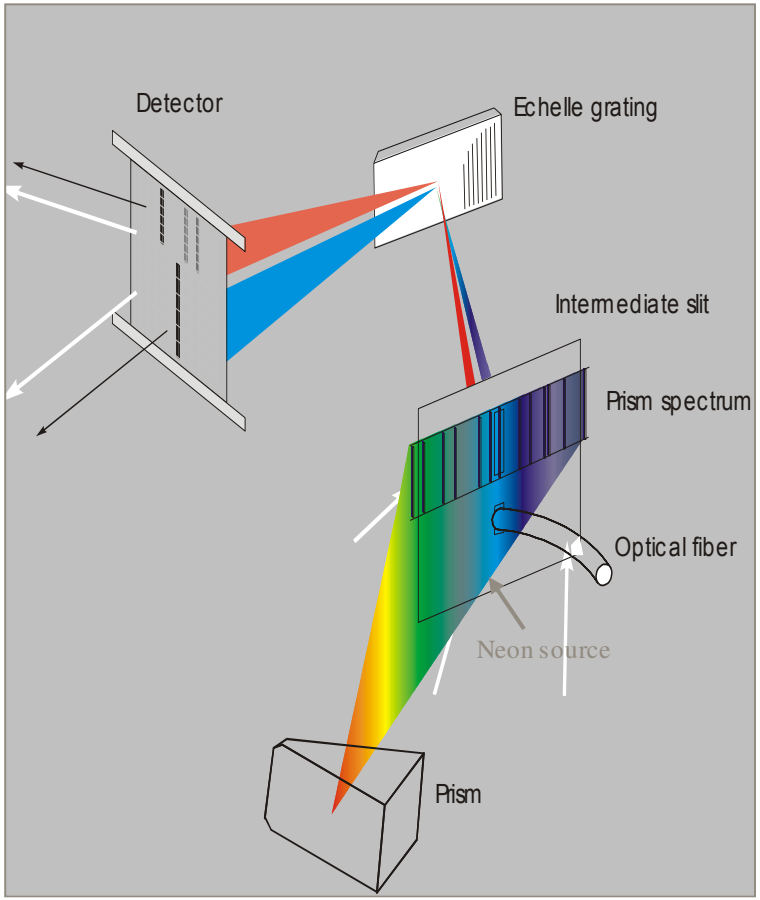
Dynamic Wavelength Stabilisation (DWS)

- All wavelengths are automatically referenced to Neon to eliminate wavelength drift
- done in real time for every replicate of every measurement
- Temperature fluctuations allowed





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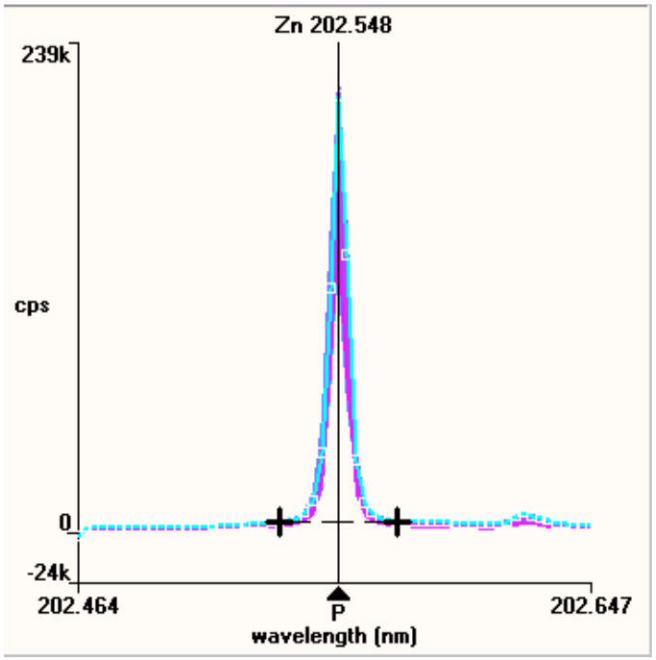
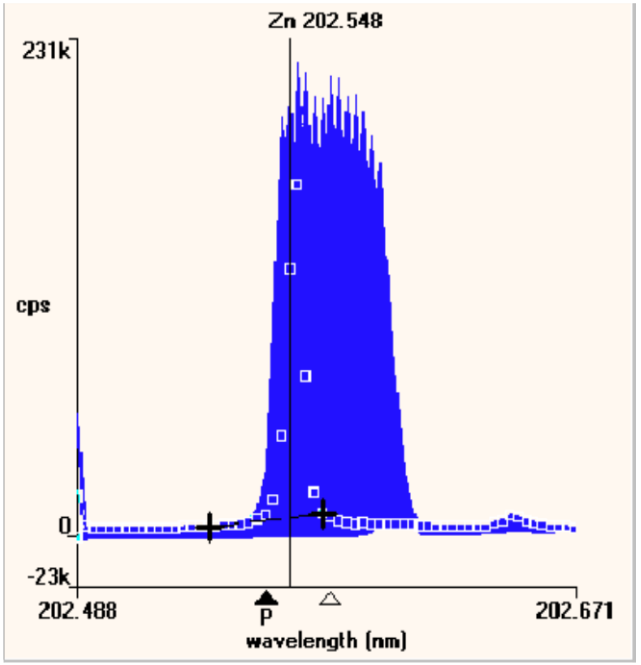
With and Without DWS



With: 20 hour run over a temperature range of 10-35 °C



Without: 20 hour run over a temperature range of 10-35 °C

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Avio 200 Speed – 6 wavelengths, radial

Sample to sample times with autosampler without FAST valve

	Read time 0.5-2s	Read time 0.2-0.2s
Flush and read delay (typical)	40-50 s	40-50 s
Analytical time	72 s	48
Washout (typical)	20 s	20 s
Sample to sample time	**137**	**113**

Sample to sample times with autosampler with FAST valve

	Read time 0.5-2s	Read time 0.2-0.2s
Flush and read delay (typical)	10-15 s	10-15 s
Analytical time	72 s	48
Washout (typical)	10-15 s	10-15 s
Sample to sample time	**97**	**73**

Analytical time is average for solutions with range 0 – 100 ppm analyte

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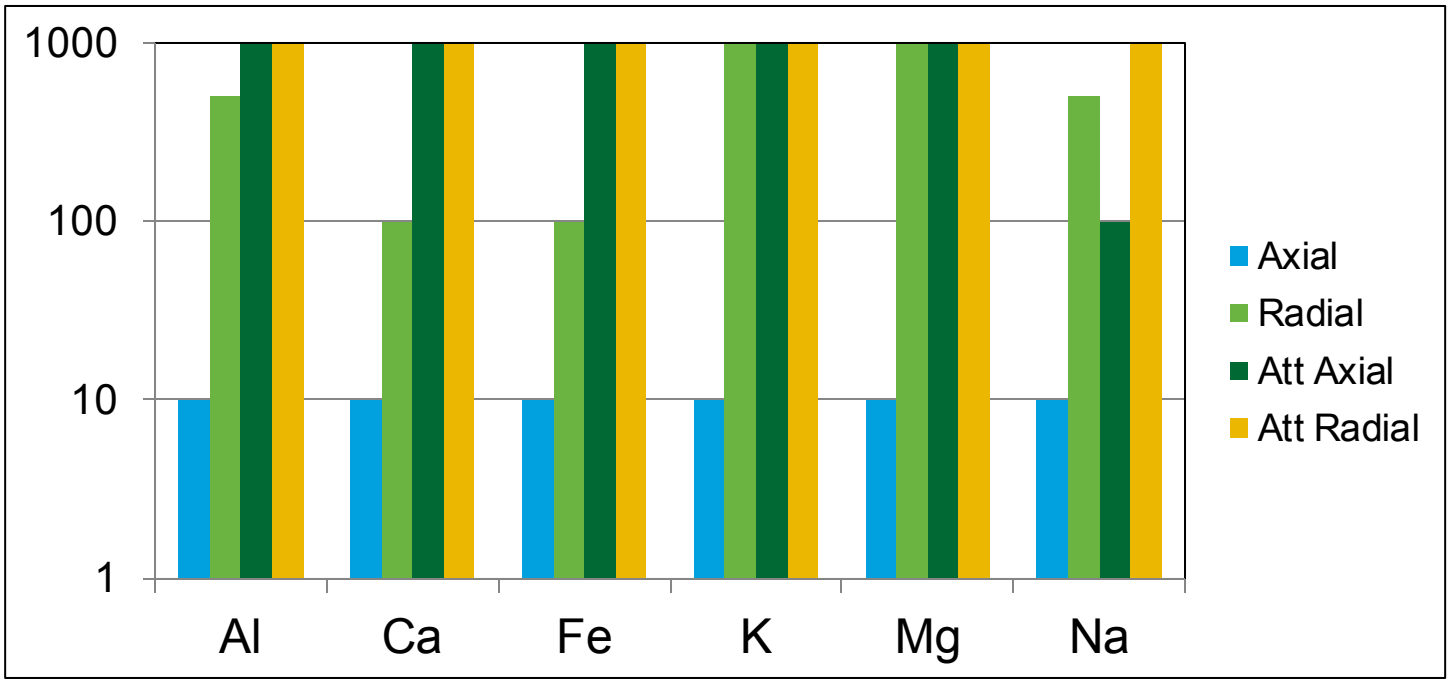
Attenuation mode

- Ability to extend the dynamic range is valuable for the analysis of high concentration samples.
- Attenuation Mode provides a simple way to dramatically extend the dynamic range (ca. 50x)
- Eliminate the need for additional sample prep or repeat analyses.
- Avoids the efforts involved with validating alternate wavelengths.
- Freely selectable, element by element.
- Allows measurement of both high & low concentration elements in the same method, using a mix of attenuated and unattenuated modes.

Attenuation mode

- Comparison of detector saturation limits for Attenuated and Normal modes Axially and Radially



Attenuation Mode allows concentrations greater than 1000 mg/L to be measured without dilution

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The Avio Series

- **When to choose an Avio 500?**
  - Simultaneous instrument
  - High sample throughput regardless of number of wavelengths
  - Instrument used continuously or in planned intervals - Continuously ON
  - Backup quantitation with UDA

- **When to choose an Avio 200?**
  - Scanning array instrument
  - High sample throughput for < 10 wavelengths
  - medium sample throughput for > 10 wavelengths
  - Instrument used intermittently or ad hoc – OFF is OFF, short startup
  - versatility

Thank you for your attention!

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