



How to Decide Which is the Right Technique for your Application?

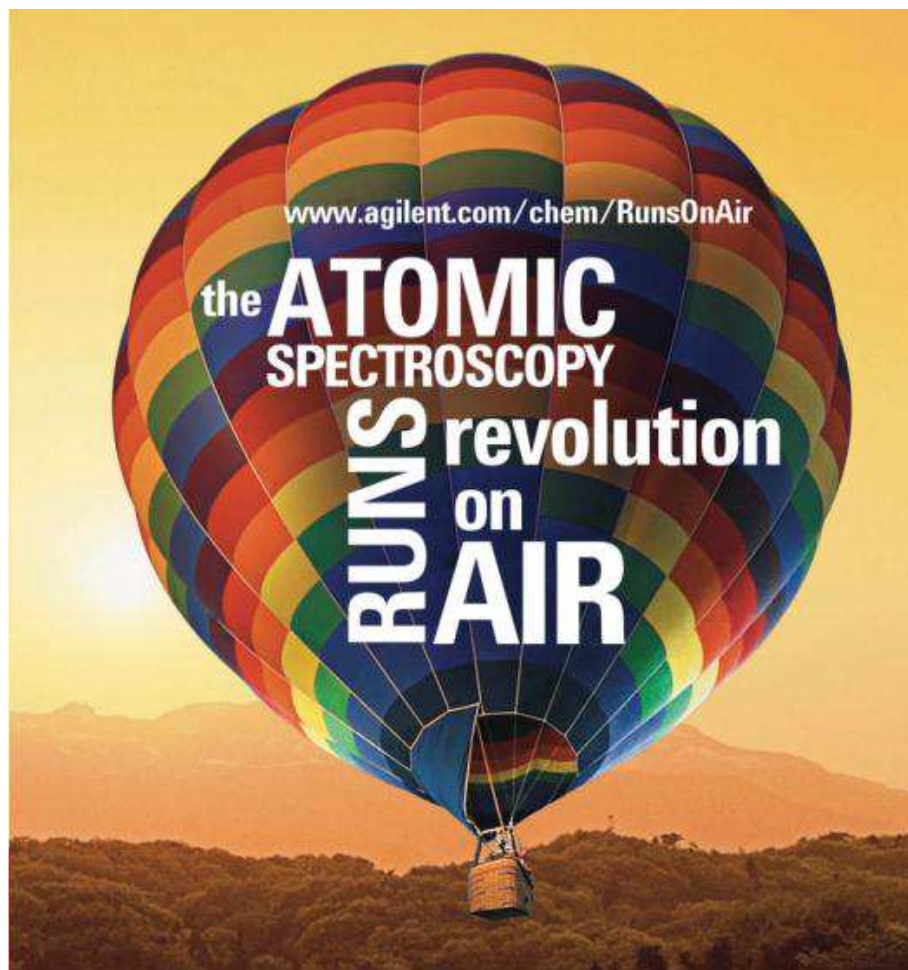
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Product Specialist,
Atomic Spectroscopy**

Agilent Technologies

22.03.2012



2011 – The Atomic Spectroscopy Revolution



With the 2011 launching of the Atomic Spectroscopy Revolution, Agilent now offers the most comprehensive and innovative range of inorganic (atomic) spectroscopy instruments for liquid sample analysis:

- Flame Atomic Absorption (AA);
- Graphite Furnace AA;
- Vapor Generation AA;
- Microwave Plasma-Atomic Emission (MP-AES);
- ICP-Optical Emission; as well as
- The 7700 Series ICP-MS

Agilent's New Atomic Spectroscopy Portfolio



ICP-OES

ICP-MS



4100 MP-AES



Flame AAS

Graphite Furnace AAS



AAS instruments can be flame only, furnace only, or combined (switchable)

Important Decision Making Criteria

Sample type

Analytical performance required

- Detection limits
- Precision

Required throughput

- Number of samples
- Number of analytes

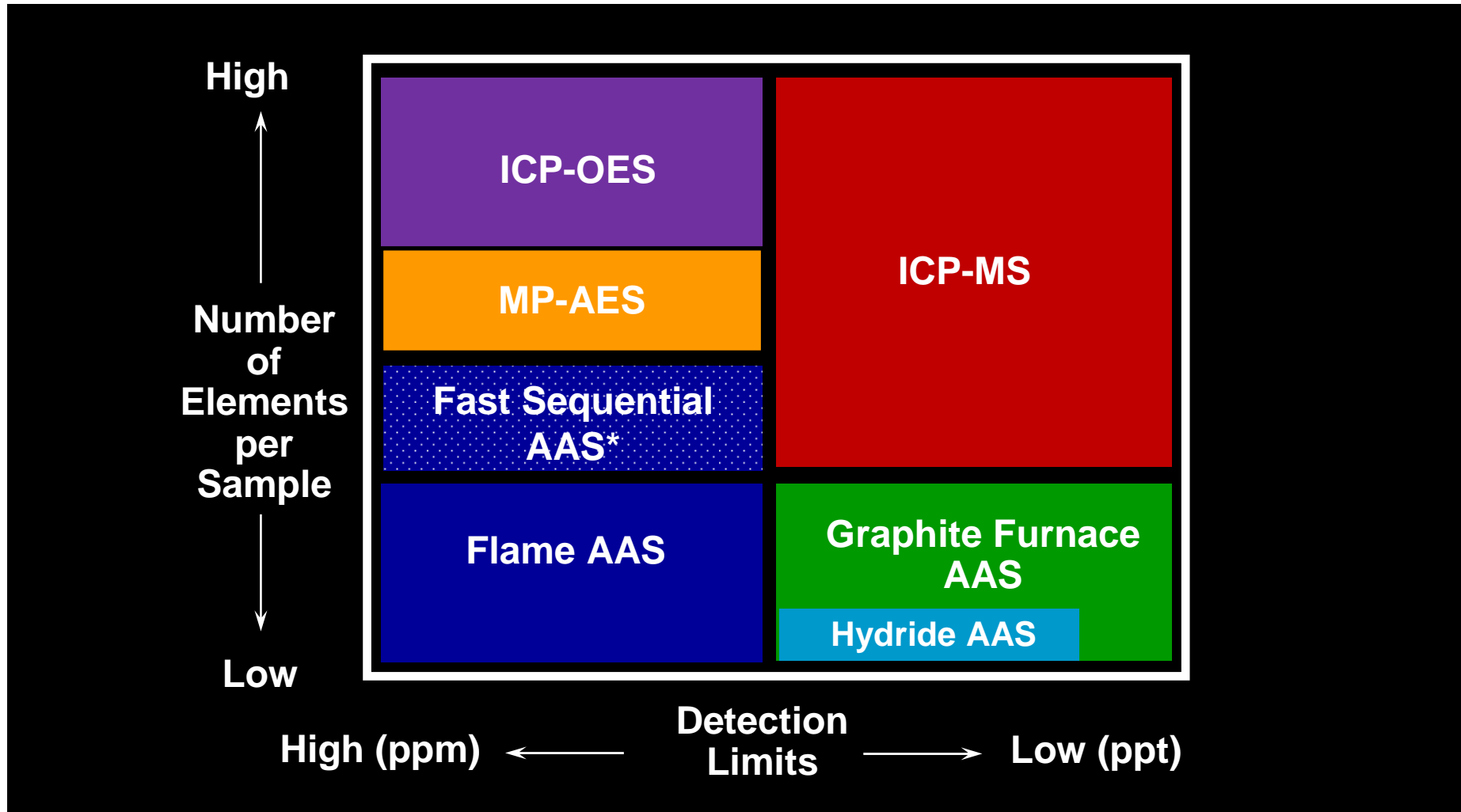
Operator skill

Capital investment

Operating cost

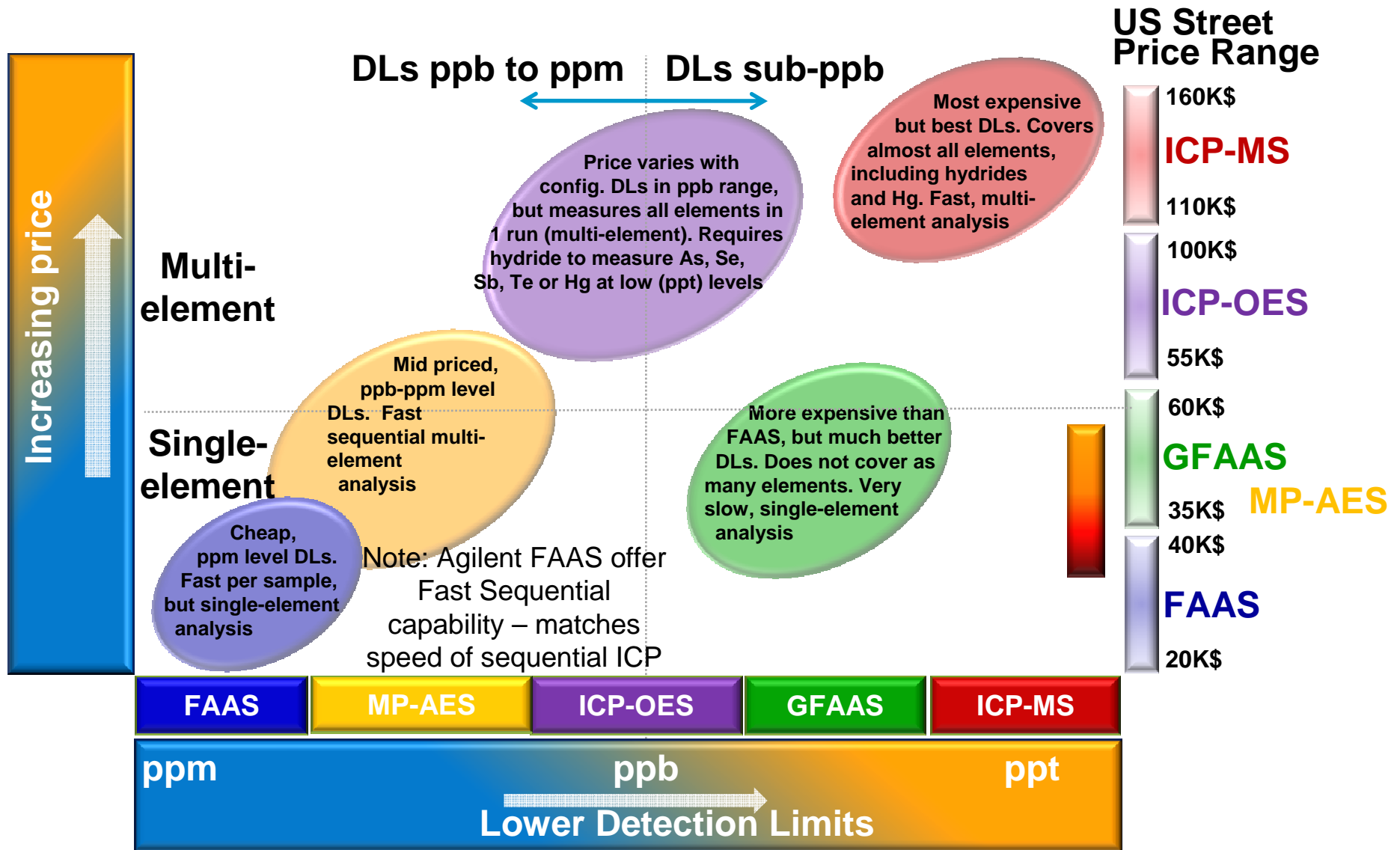


Number of Analytes vs Detection Limits



* Note: Fast Sequential AAS doubles throughput & is exclusive to Agilent Flame AA (as is MP-AES)

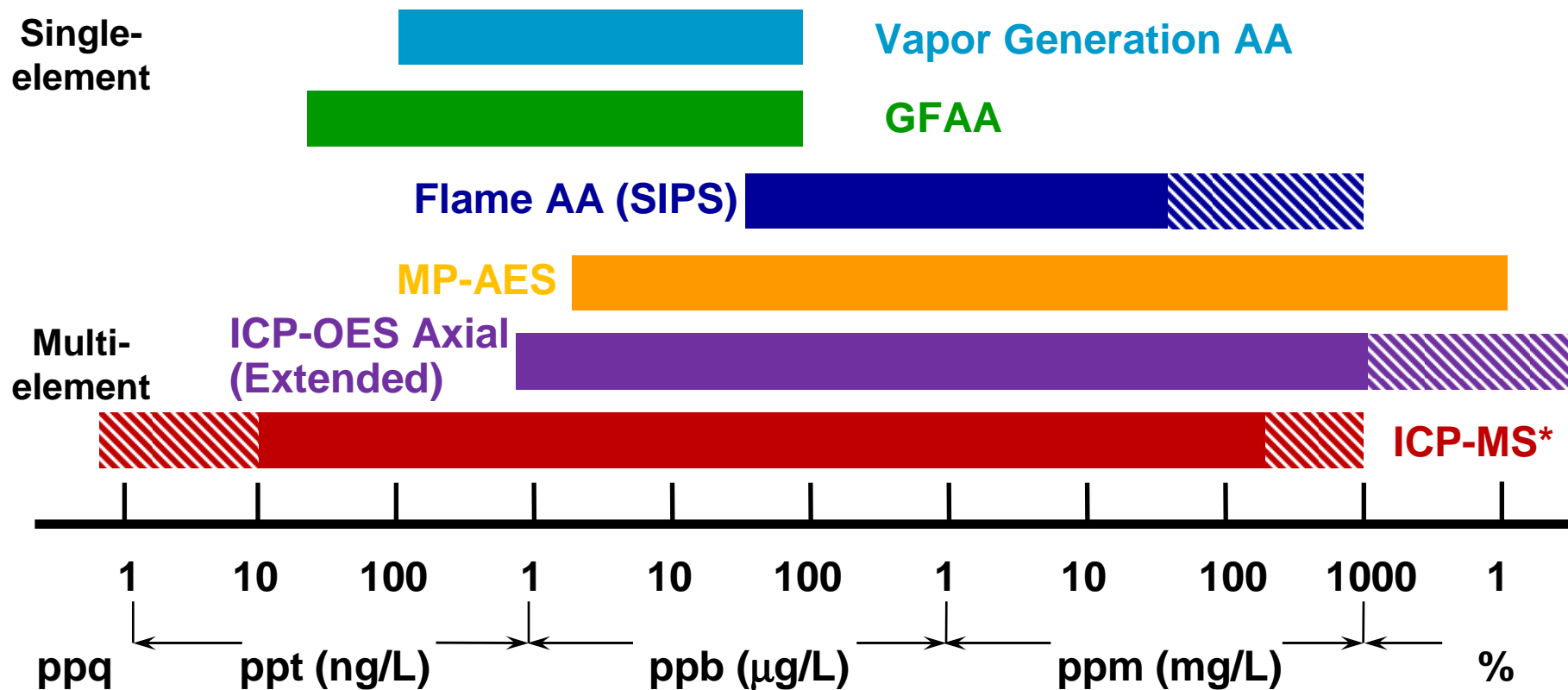
Agilent Inorganic Product Portfolio Positioning



Example - Dynamic or Working Range Comparison

The true working range combines the detector dynamic range, the matrix tolerance and method limitations such as calibration linearity and washout

Note – this is the measurement range, not the matrix level that can be tolerated



* Note: 9 orders detector dynamic range can be extended with HMI (standard on the 7700x). For many elements, accurate analysis at <10ppt requires a cleanroom

Overview of Atomic Absorption (AA) Spectroscopy



Characteristics of Atomic Absorption

Determine **concentrations of metals** in solution

67 elements

From **ppb to %** levels

Precision typically **better than 1 % RSD**

Sample preparation is simple

Instrument is easy to tune

Instrument is **easy to operate**

Technique is very **specific**



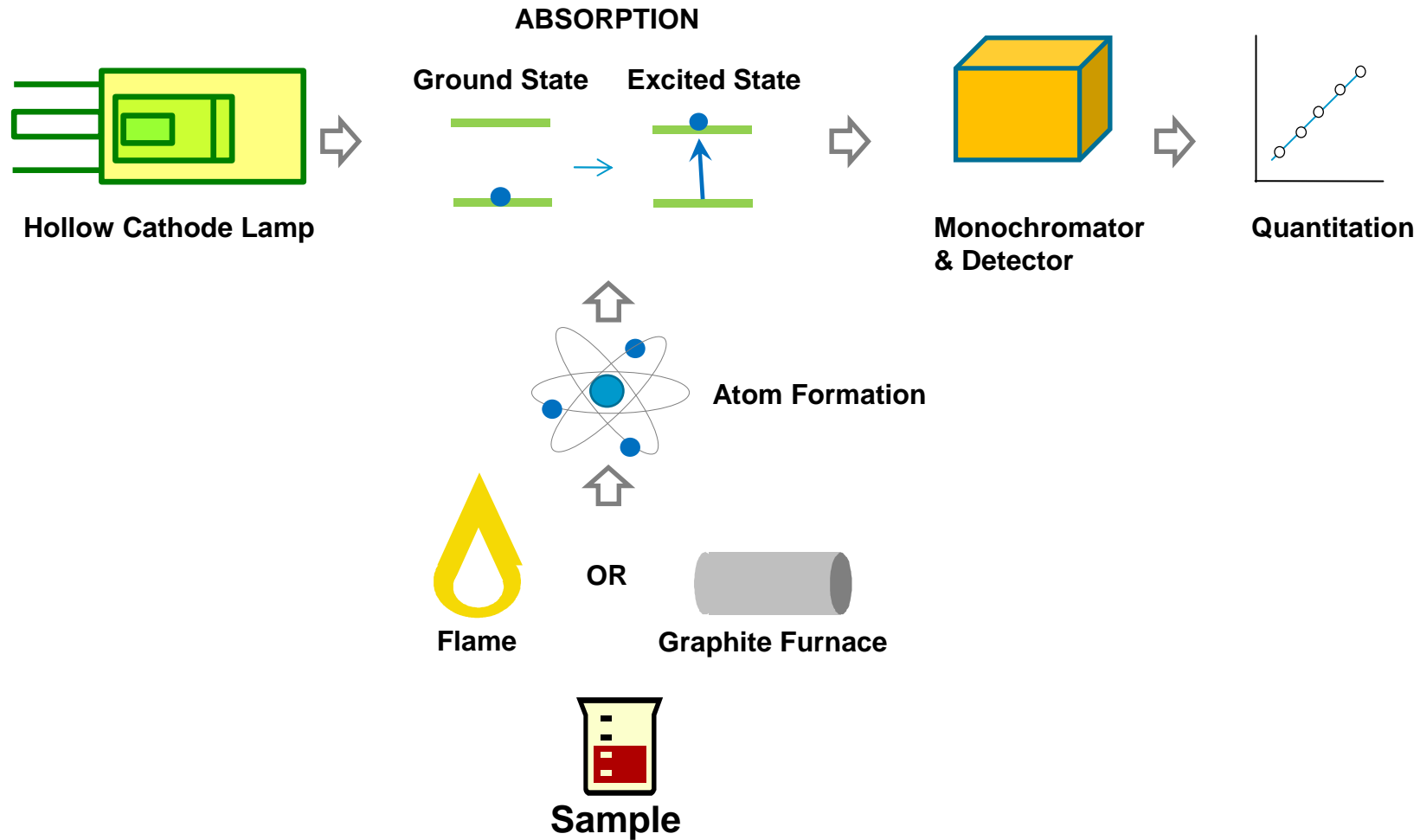
Elements Measurable by AA

H																	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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Flame Only
 Flame & Furnace



Atomic Absorption Overview



Agilent Atomic Absorption Product Range

Entry level - SpectrAA-55B

- Stand alone system
- Keyboard control with LCD
- Optional PC control (req. for accy support)



Mid range – AA240 series

- External PC control
- Greater automation
- “Fast Sequential” capability (4 lamps)



Top end – AA280

- External PC control
- Premium positioning
- Highest performance
- Greatest automation
- “Fast Sequential” capability (8 lamps)



Compatibility with Other Agilent Accessories

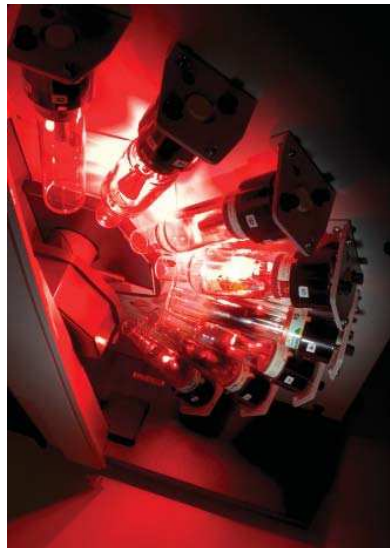
**SPS3 for
automated
sample
presentation**



**SIPS-10/20
for on-line
dilution with
flame AA**



**UltrAA
high intensity
lamps**



**VGA-77
for hydride
determinations**



Agilent Flame AA Systems – Benefit # 1

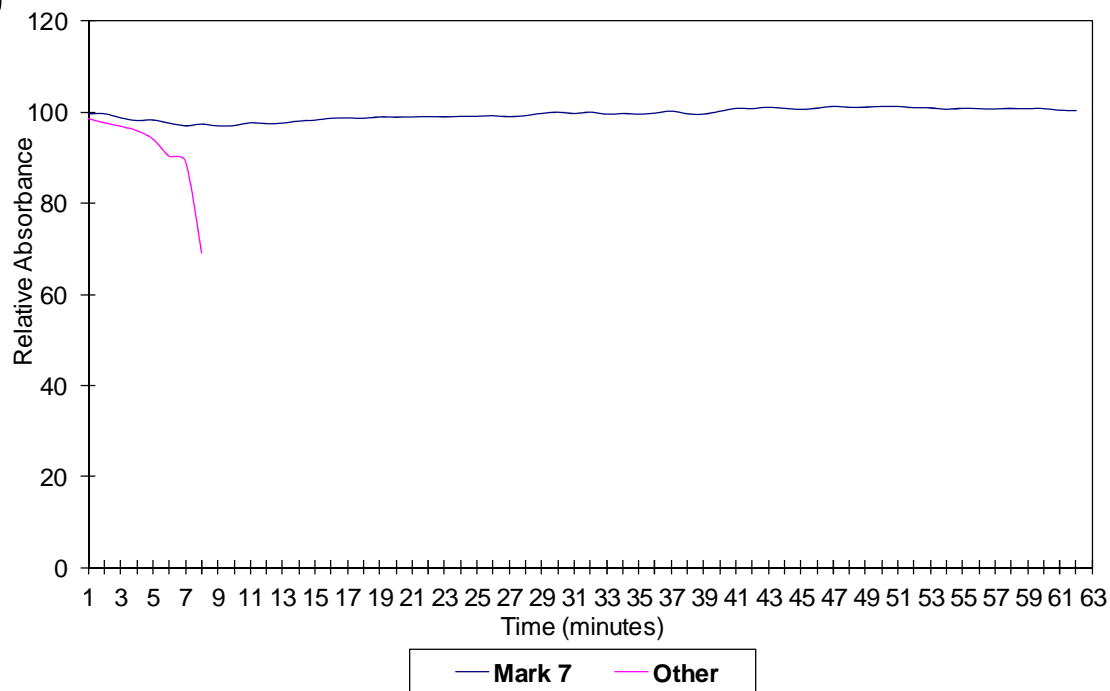
Flexibility, Ease of Use & Superior Flame Performance

Tunable performance means...

- Highest flame sensitivity: > 0.9 Abs. for 5 mg/L Cu
- Best precision: < 0.5 % RSD using 10 x 5 s readings
- Extended operation with difficult samples
- No loose gas hoses and no tools required for gas connection
- Fast change-over to furnace operation (manual - < 30 s)



5 mg/L Cu in 7.5% NaCl

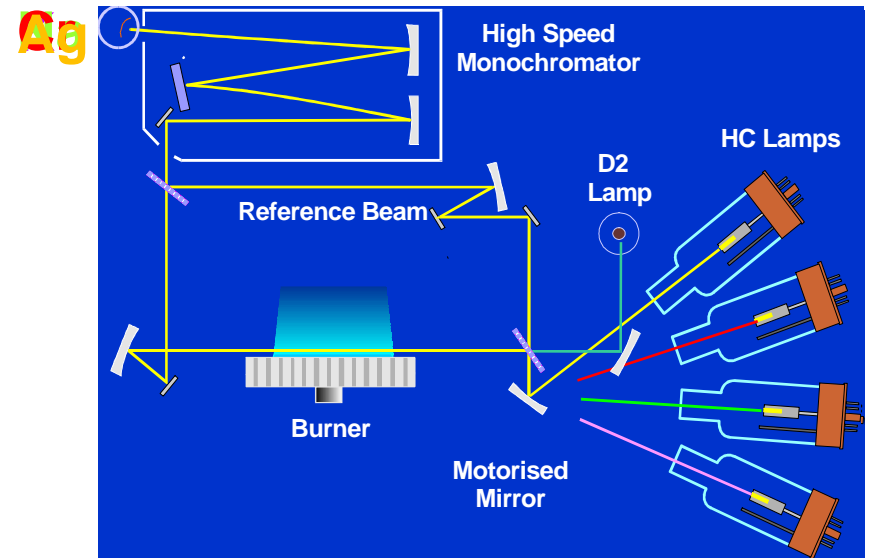


Agilent Flame AA Systems – Benefit # 2

Fastest Flame AA Analysis – Double the Productivity

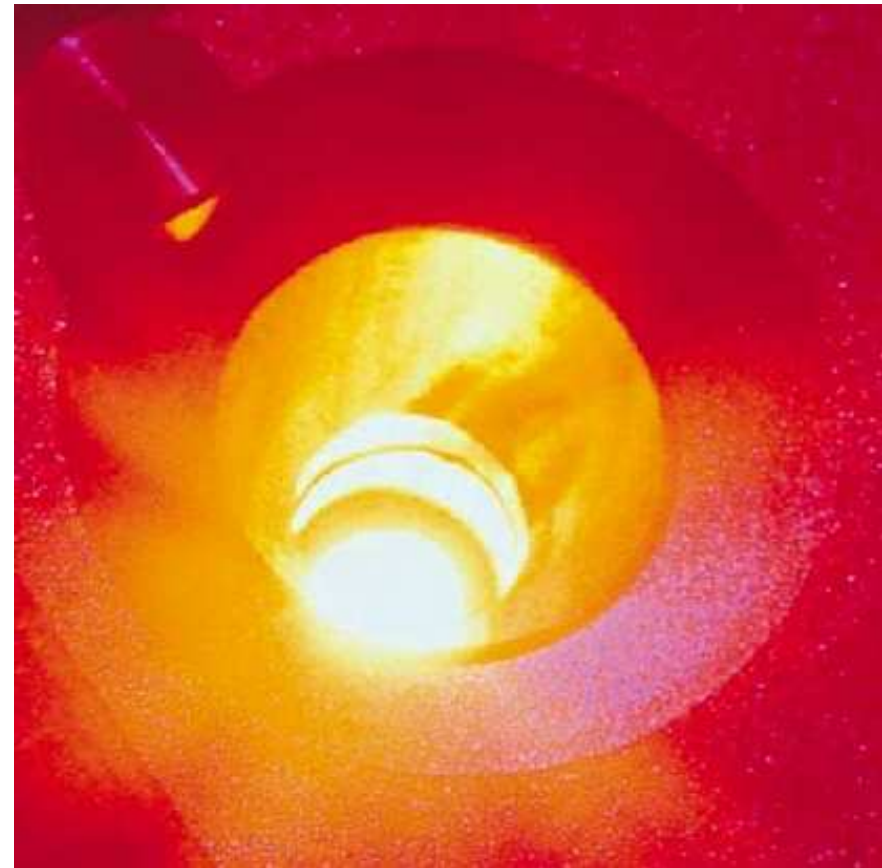
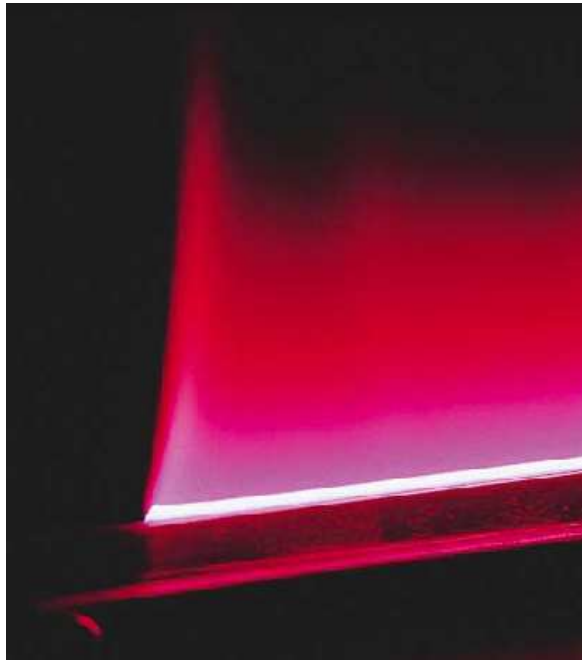
FS models provide Fast Sequential AA which means...

- All elements measured in a single reading
- Double the productivity of any other conventional AA
- Conserves sample volume
- Saves labor and reduces running costs
- Allows Internal Standard correction for improved precision and accuracy

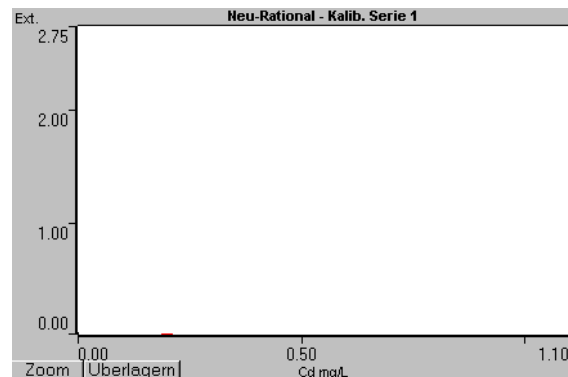
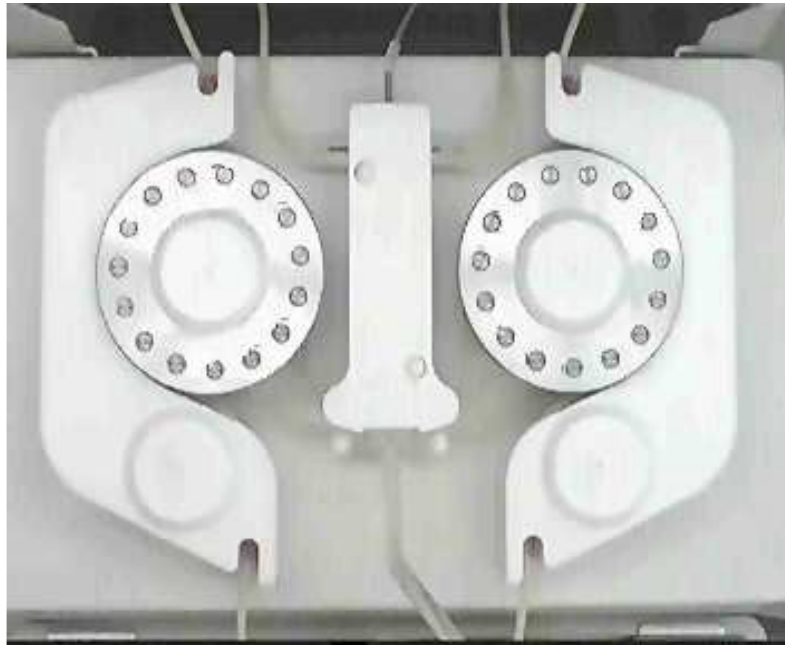


Tube	Sample Labels	K	766.5 mg/L	Na	589.0 mg/L	Cr	357.9 mg/L	Ag	328.1 mg/L	Cu	324.8 mg/L	Mg	285.2 mg/L	Fe	248.3 mg/L	Co	240.7 mg/L	Cd	228.8 mg/L	Zn	213.9 mg/L	Ca	422.7 mg/L
1:1	Sample 001	0.4206	0.0978	4.332	0.214	0.273	0.2488	1.374	2.481	0.659	0.6110												
1:2	Sample 002	0.1941	0.0590	0.231	1.175	3.191	0.2293	2.251	3.415	0.873	0.4067												
1:3	Sample 003	0.4251	0.0246	1.56	0.231	3.673	0.0540	3.965	0.338	OVER	0.1907												
1:4	Sample 004	0.7545	0.0350	0.03	1.442	0.000	0.3930	1.824	0.334	0.000	0.1632												
1:5	Sample 005	0.4429	0.3950	4.606	1.380	2.993	0.1837	3.285	0.355	0.085	0.0813												
1:6	Sample 006	0.6047	0.1407	3.12	1.197	2.229	0.3500	1.080	2.436	0.621	0.0642												
1:7	Sample 007	0.3449	0.0709	OVER	1.386	3.029	0.2990	0.000	3.819	0.708	-13770.4												
1:8	Sample 008	OVER	0.1969	1.723	0.733	4.211	0.3185																
1:9	Sample 009																						
1:10	Sample 010																						
1:11	Sample 011																						
1:12	Sample 012																						
1:13	Sample 013																						
1:14	Sample 014																						
1:15	Sample 015																						
1:16	Sample 016																						
1:17	Sample 017																						
1:18	Sample 018																						
1:19	Sample 019																						
1:20	Sample 020																						

Simultaneous flame & furnace operation



SIPS Intelligent Dilution System



On-line addition of Cs buffer during 5 point autocalibration with SIPS-20

Preparation of a complete calibration from a single standard (max. 10 standards)

On-line addition of reagents (e.g. ionization suppressant, Lanthanum)

Fast on-line dilution of over range samples

Automatic pre-dilution of samples

Extends operating range (factor 100)

On-line preparation of Standard additions calibration from a single standard (up to 10 additions)

Automatic addition of Internal Standard

GTA120 Graphite Tube Atomizer

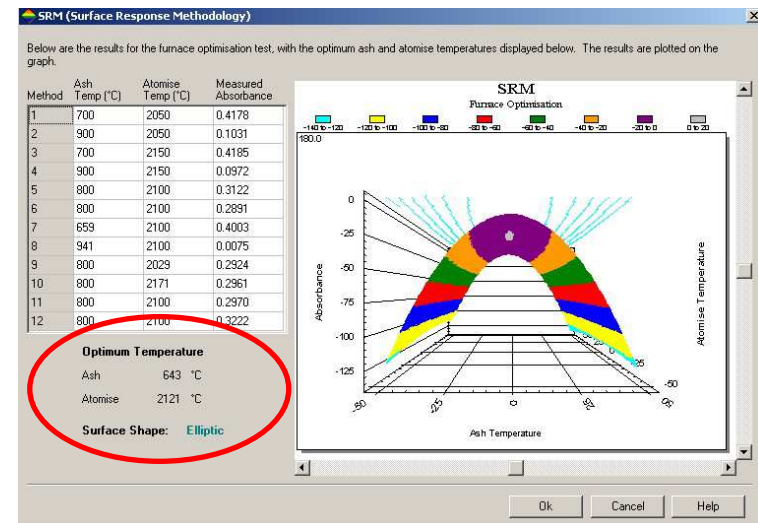
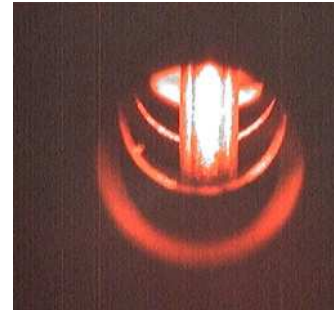


The GTA-120
graphite
furnace system
is suitable for
use with the
current range of
Agilent PC
controlled
instruments

Agilent Furnace AA Systems – Benefit # 3

Ease of Use

- PSD120 autosampler eliminates tedious standard preparation
 - Calibrate the AA using just 1 standard
 - Automatically dilute over range samples
 - Pre, Post or Co-inject modifiers
 - Hot Injection for reduced drying time
- Furnace viewing camera provides real time images of sample injection/drying for easy optimization
- Automated method optimization provides optimum ashing/atomization temperatures in < 30 mins (using SRM)



Vapor Generation Solutions

Agilent's VGA-77 provides:

- Convenience of flame AA operation
- Better sensitivity than FIAS
- Exceptional precision of 1-2 % RSD at ppb levels
- High throughput – up to 70 samples/hr
- Modular operation - change modules to eliminate contamination



Vapor Performance Comparison ($\mu\text{g/L}$)

<u>Element</u>	<u>Characteristic Concentration</u>	<u>Detection Limit</u>
As	0.2	0.1
Se	0.3	0.15
Hg (normal cell)	0.3	0.10
Hg (flow thru cell)	0.2	0.05
Sb	0.2	0.06
Bi	0.2	0.07
Te	0.15	0.15
Sn	0.3	0.2



Overview of Microwave Plasma (MP) Spectroscopy



Agilent 4100 Microwave Plasma-Atomic Emission Spectrometer (MP-AES)

New technique for elemental determination using atomic emission

- Microwave excited plasma source
- Nitrogen based plasma - runs on air (using a N₂ generator)

Improved performance compared with flame AA:

- Higher sample throughput with fast sequential measurement
 - More than 2x faster than conventional flame AA
- Superior detection limits and improved dynamic range

Easy to use:

- New generation software featuring automated optimization and software applets that load a preset method
- One piece torch with easy torch removal and replacement – no alignment

Reduced operating costs:

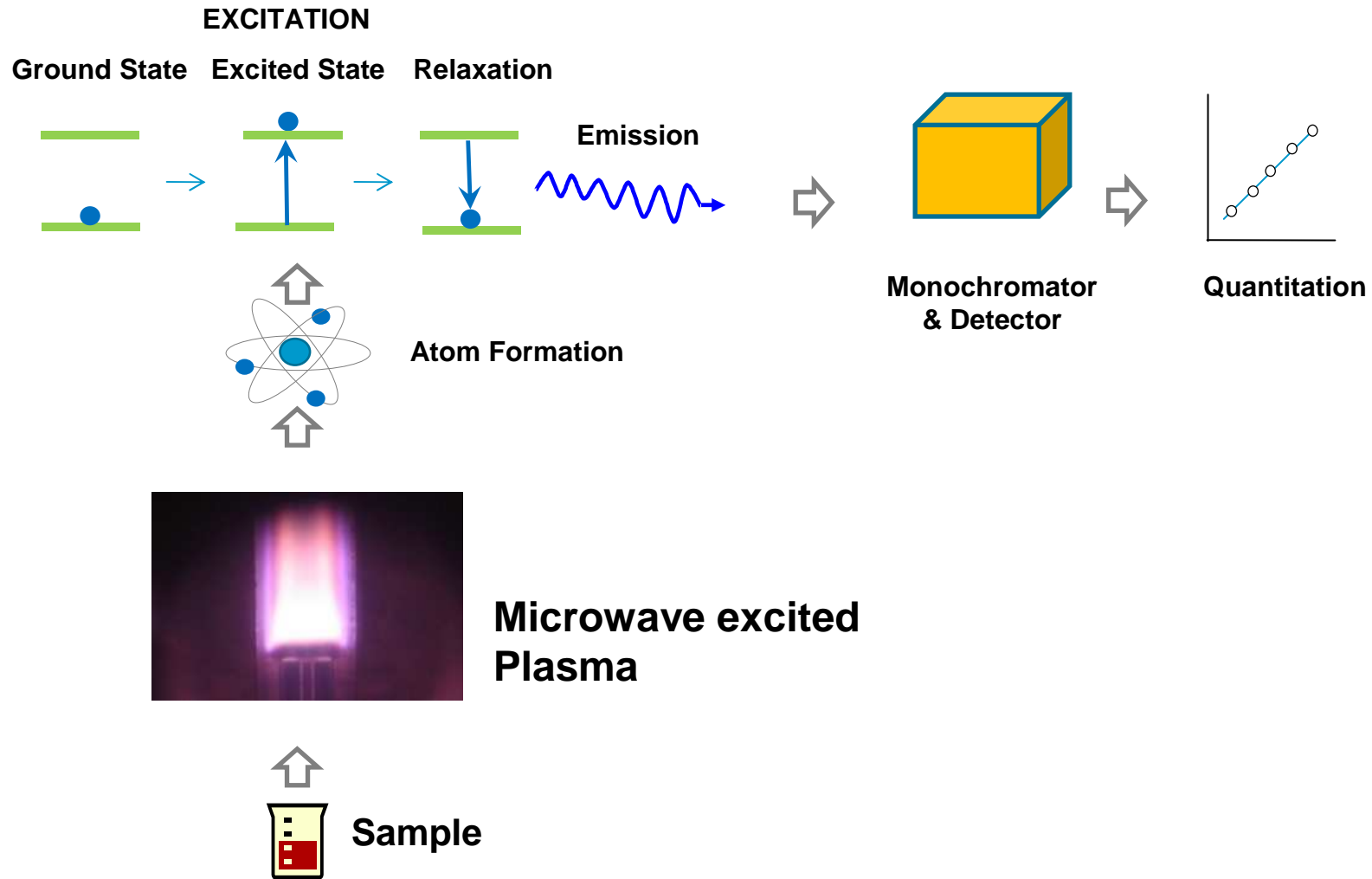
- Runs on air – eliminates need for Acetylene, Argon, etc.
- Eliminates need for source/hollow cathode lamps
- Simple installation – no chiller, 10 A supply

Improved Safety:

- Eliminates need for flammable gases and cylinder handling
- Safe, reliable unattended multi-element overnight operation



Microwave Plasma Emission Overview

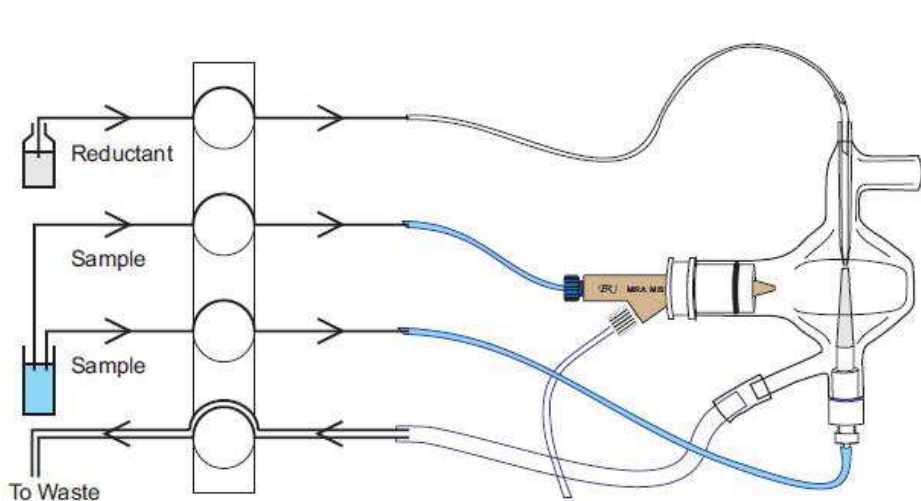


Accessory Options for the 4100 MP-AES

- Automate and simplify analysis with the SPS3 autosampler (required for unattended overnight operation)
- For organic applications, use the EGCM to bleed air into the plasma minimizing C build-up and reducing background
 - also requires the OneNeb inert nebulizer (incl. with the Organics kit)
- To enable low ppb level detection of As, Se or Hg, use the Multimode Sample Introduction System (MSIS)
 - also requires the 5 channel peristaltic pump option



Improving Detection Limits for As, Se, Hg with MSIS



Analyte	Conventional Nebulization ug/L	MSIS in Simultaneous Mode ug/L
As	90	1.0
Se	126	2.0
Hg	14	0.5

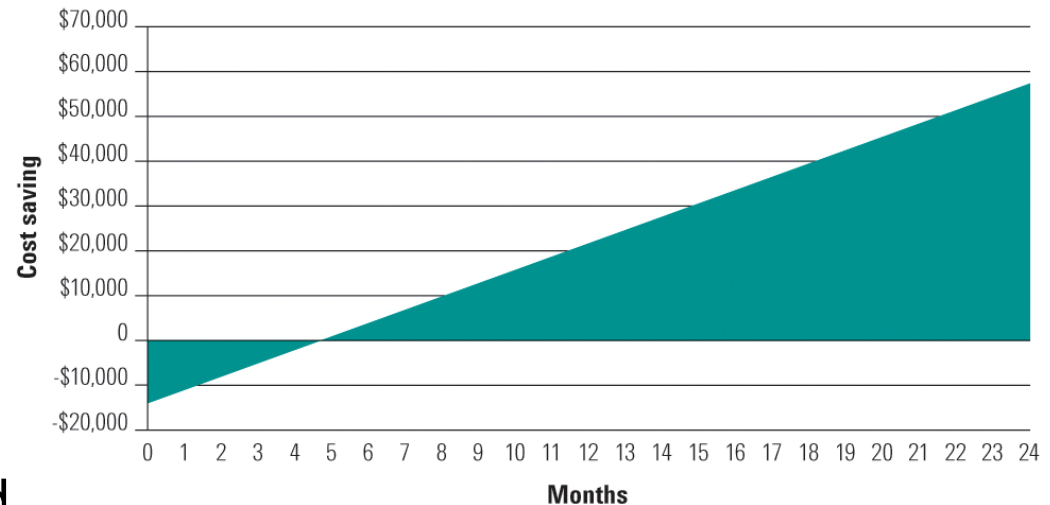
Agilent 4100 MP-AES

Lowest running costs

Runs on Air (using a nitrogen generator), which means...

- Eliminates need for flammable and expensive gases e.g. acetylene
- Improved safety – no need for flammable gases in the lab. and no manual cylinder handling
- Provides safe, unattended multi-element overnight operation
- Greater flexibility – no need for source lamps, so you can add extra elements at any time

MP-AES cost savings versus flame AA

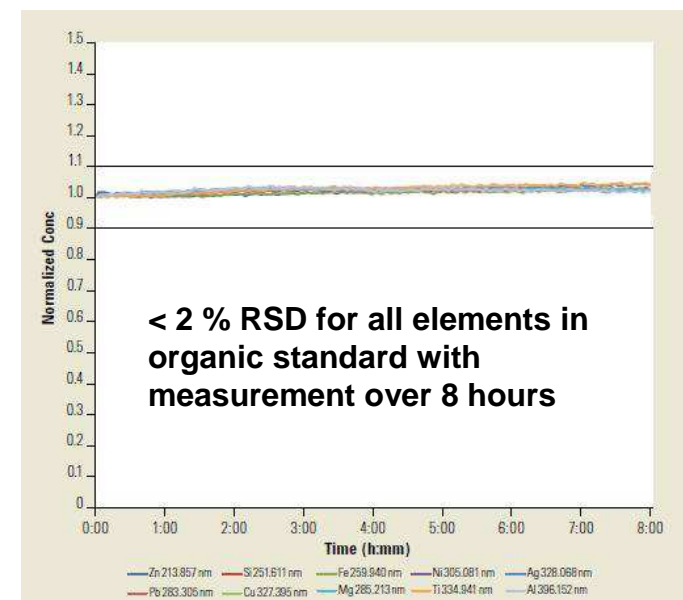
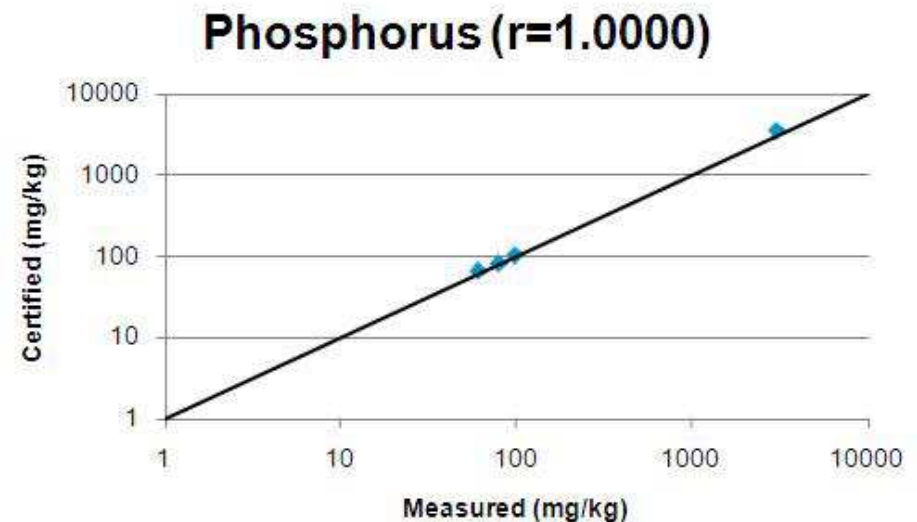


Agilent 4100 MP-AES

Superior performance to Flame AA

MP-AES provides Fast Sequential multi-element determinations which means...

- All elements measured in a single reading
- More than double the productivity of conventional flame AA systems
- Superior detection limits
- Improved dynamic range
- Better sensitivity - especially for refractory elements - and more elemental coverage e.g. S



Agilent 4100 MP-AES

Ease of Use

Simplifies operation for all users – both novice and more experienced users

- Software applets that automatically load a pre-set method - ideal for novice users
- One piece torch with simple torch loading – and no alignment
- 1 step automated method optimization

Torch installation in three easy steps



Three steps to analysis

1 Click the icon. The applet automatically loads the pre-set method

Agriculture Beverages Chemicals Energy
Food Fuels Industrial Metals

2 Enter sample labels, sample type, and weight/volume correction factors

Sample Label	Sample Type	Weight (mg)	Volume (mL)
1	Blank	0.000	0.000
2	Standard 1	0.000	0.000
3	Standard 2	0.000	0.000
4	Standard 3	0.000	0.000
5	Standard 4	0.000	0.000
6	Standard 5	0.000	0.000
7	Blank 100% Au	0.000	0.000
8	Blank 100% Au	0.000	0.000
9	100ppm	0.000	0.000
10	100ppm	0.000	0.000
11	100ppm	0.000	0.000
12	100ppm	0.000	0.000
13	100ppm	0.000	0.000
14	100ppm	0.000	0.000
15	100ppm	0.000	0.000
16	100ppm	0.000	0.000
17	100ppm	0.000	0.000
18	100ppm	0.000	0.000
19	100ppm	0.000	0.000
20	100ppm	0.000	0.000
21	100ppm	0.000	0.000
22	100ppm	0.000	0.000

Au
267.595 nm
7.074 ppm
%RSD: 0.39
7.0 ppm (15)

3 Load samples and run the analysis

Plasma Pump Run Stop MP Expert Instrument

Overview of ICP-OES Spectroscopy



Three New ICP-OES Models!

Agilent 710/715-ES

- Entry level system with CCD detector
- Affordable price, uncompromised performance
- A fully featured ICP-OES for laboratories with moderate or small sample loads

Agilent 720/725-ES

- High sample throughput
- Ultimate in performance
- Flexibility to upgrade in the future for higher productivity and performance

Agilent 730/735-ES

- Highest sample throughput
- Ultimate in performance
- The World's best ICP-OES!



0 = Axial View

5 = Radial View



Agilent 720/730-ES Series ICP-OES

40 MHz free-running RF Generator proven in more than 4000 systems

State-of-the-art, custom-designed CCD detector with unmatched performance

Switching Valve System improves washout for greater productivity and lower cost per analysis



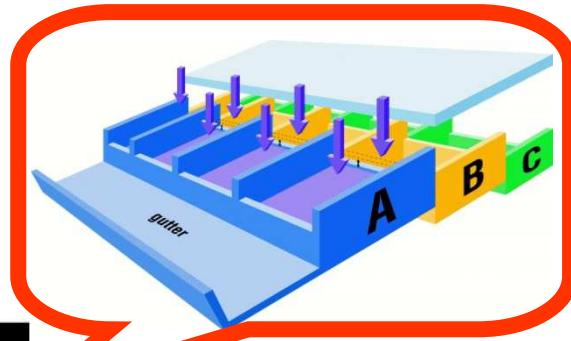
Only system to provide true simultaneous measurement from ppb to % levels

Customized sample introduction system for every application

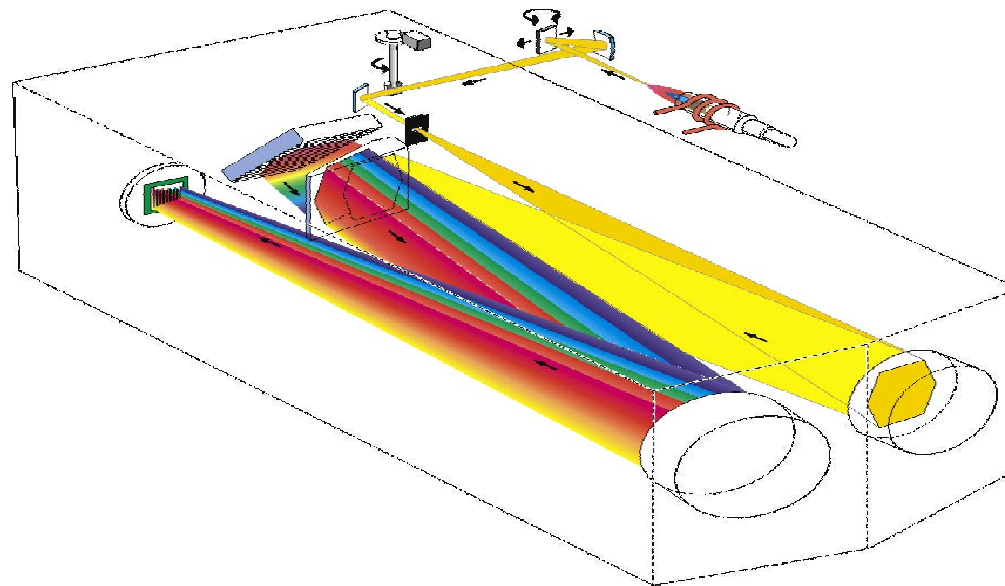
ICPEXpert II software provides even greater ease-of-use and security



Agilent 720/730-ES Series ICP-OES – Optical Bench



One of the most important and unique features of this image-mapped detector is its individual pixel anti-blooming control

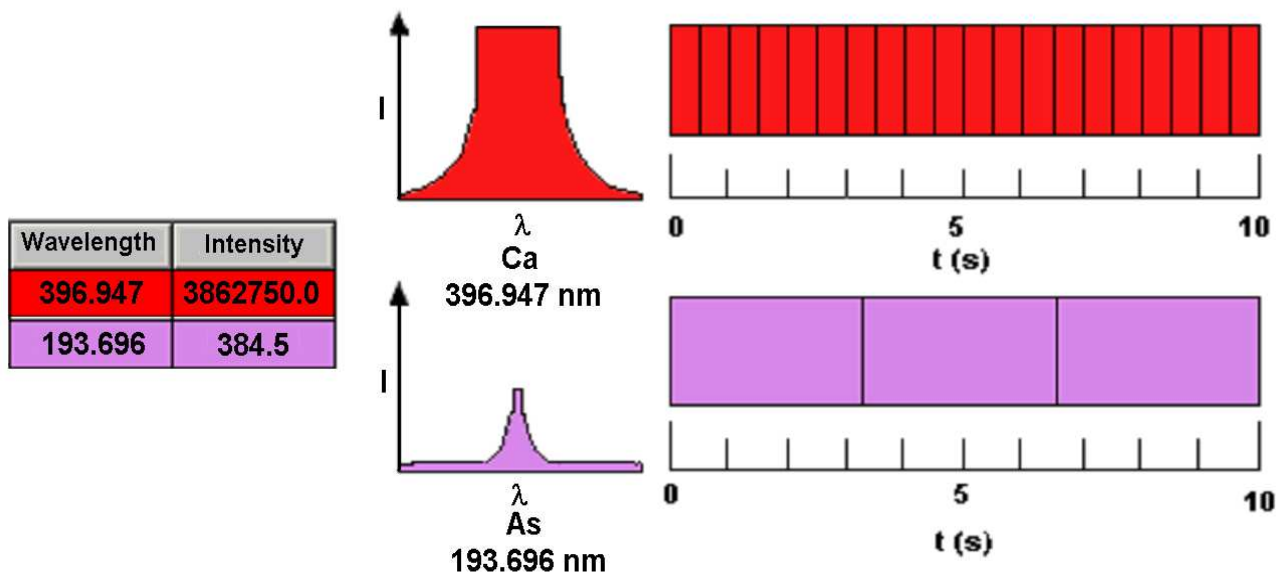


Agilent 720/730-ES Series ICP-OES – Most Innovative Detector

- Full wavelength coverage
 - Wavelength coverage 167 – 785 nm
 - Use alternate wavelengths to **extended dynamic range** and confirm results
- Individually addressed arrays
 - Adaptive Integration
- True simultaneous measurement
- Duplex readout circuitry **halves readout time**
- Peltier cooled to -35°C
 - **Ensures low noise and best detection limits**



Adaptive Integration™



Achieve outstanding results automatically with Adaptive Integration™.

Based on signal to noise ratios, multiple short readings are averaged for high signals and a smaller number of longer readings are averaged for low signals.

Agilent 710/715-ES ICP-OES

40 MHz free-running RF Generator proven in more than 4000 systems

High performance megapixel CCD detector provides excellent detection limits and wide linear dynamic range

Complete wavelength coverage from 177 to 785nm



Measure ppb to % levels from a single view with **MultiCal**

Start analyzing samples 10 minutes following plasma ignition

ICPEXpert II software provides even greater ease-of-use and security



Agilent 710/715-ES ICP-OES

Low cost entry level simultaneous ICP-OES

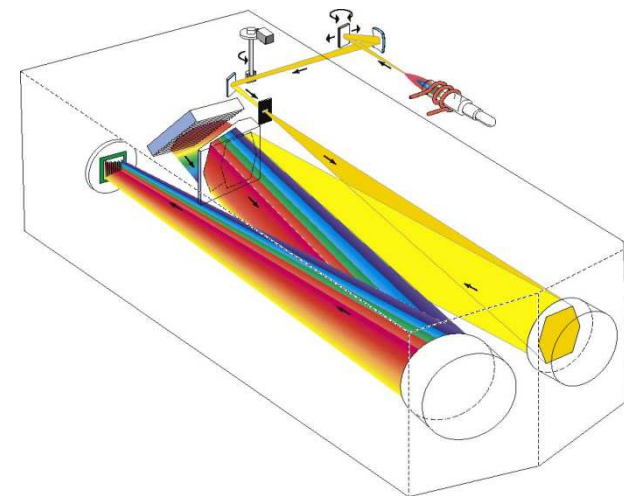
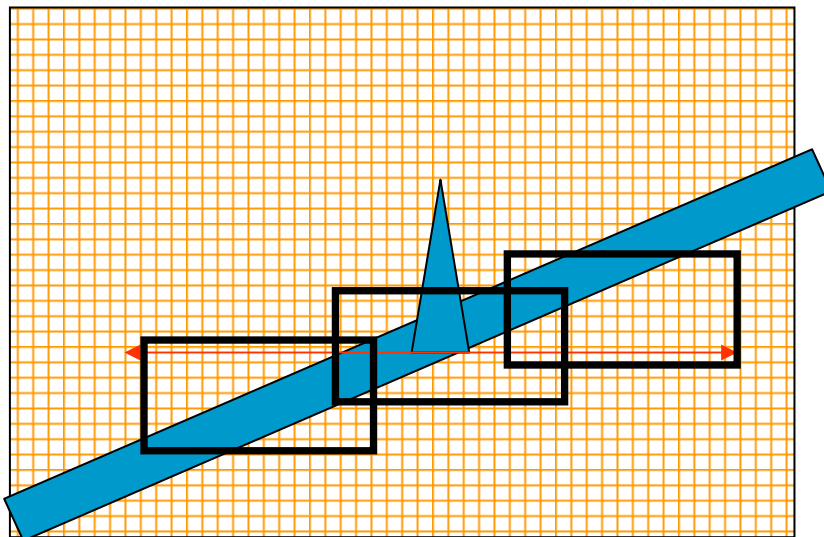
- Equipped with 3 channel pump as standard
 - On-line addition of internal standard and ionization buffer
- **Optimized sample introduction system**
 - 715-ES optimized for difficult samples
 - robust, inert sample introduction
 - 710-ES optimized for maximum sensitivity and lowest DL's
- Supports a range of accessories for added performance
 - AGM-1 Oxygen accessory for stable analysis of volatile organics
 - Mounted VGA provides sub-ppb measurement of Hg, As, Se, Sb
 - SPS3 Sample Preparation System



Agilent 710/715-ES ICP-OES - Echelle Optics

Similar optics to 720/730-ES Series

An echelle order falls across a number of detector rows

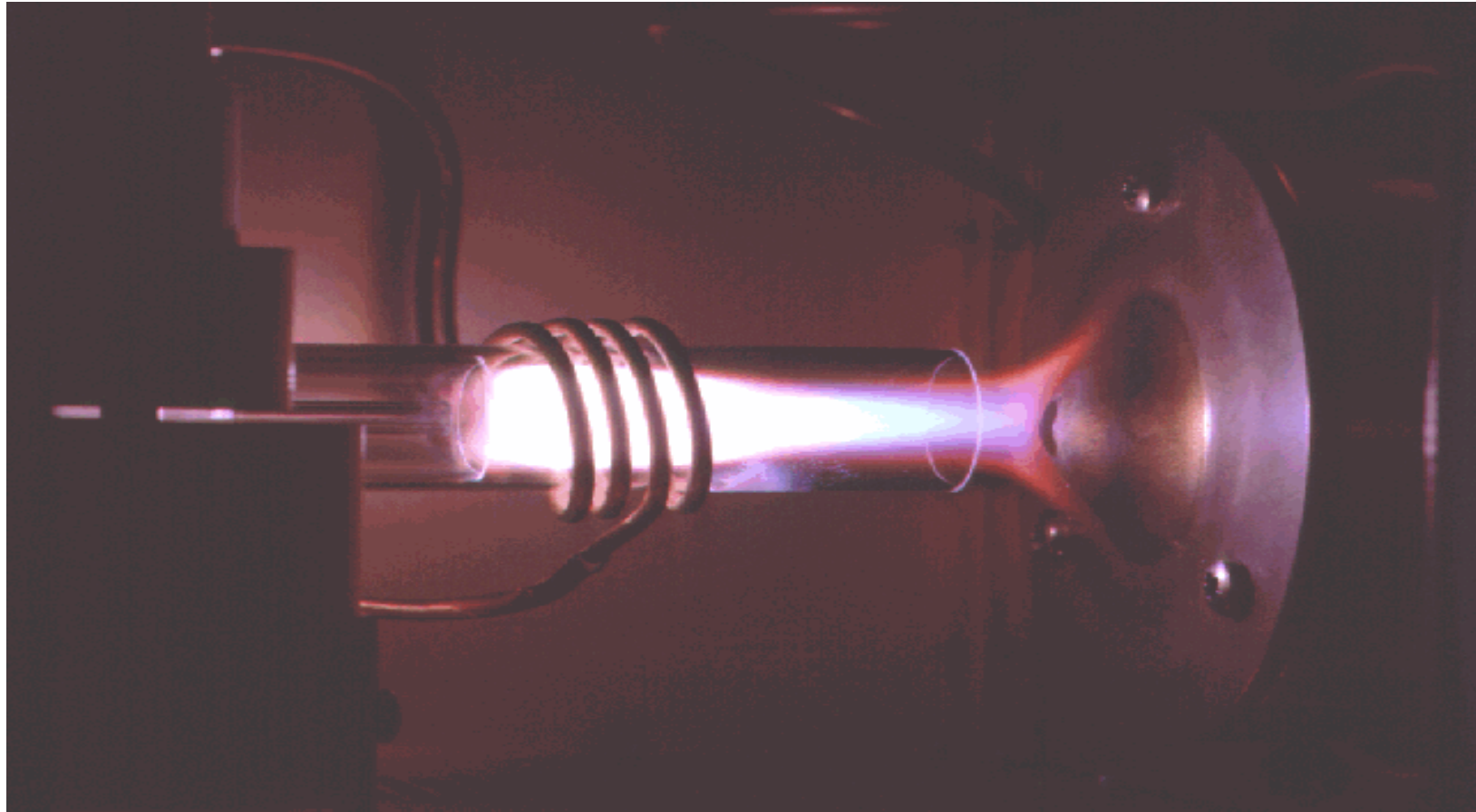


ICP-OES Configuration

- Two configurations are available:
 - Axial
 - Plasma viewed end-on
 - Lower detection limits
 - Cooled cone interface makes dual-view optics obsolete
 - Radial
 - Plasma viewed side-on
 - Recommended for complex matrices
 - High Total Dissolved Solids (>20%)
 - Organic matrices. Eg..Oils

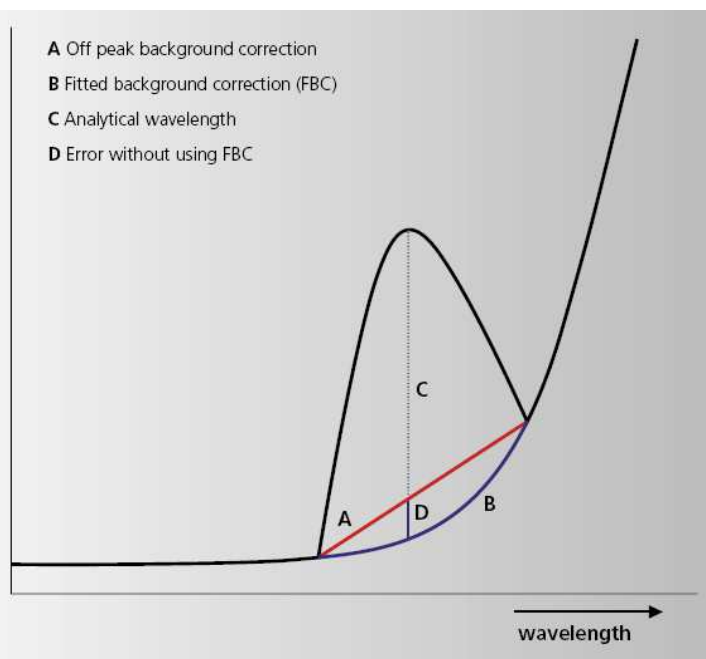


Cooled Cone Interface (CCI)



Agilent 700-ES Series ICP-OES - Background Correction Methods

Traditional off-peak - User can view actual signals to select background points



Fitted background correction calculates the true background signal, improving accuracy.

Agilent's unique Fitted background correction

- Peak shaped functions applied to the analyte peak
- Polynomial Interpolation of background signal

Advantages

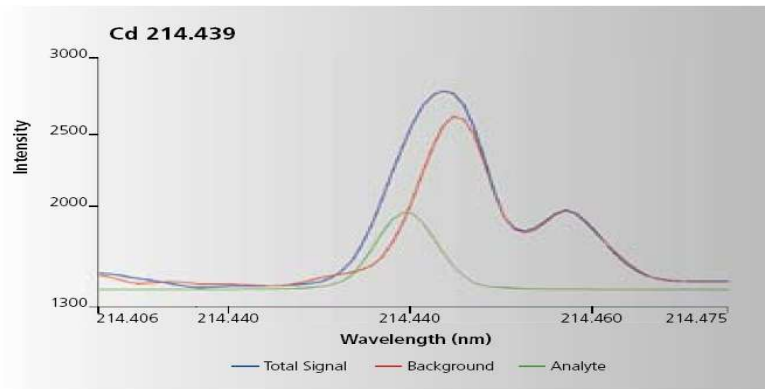
- Improved accuracy
- Requires no extra user input
- Truly simultaneous correction

Agilent 700-ES Series ICP-OES - Background Correction Methods

Agilent's patented FACT background correction

Fast Automated Curve-fitting Technique (FACT) for accurate removal of spectral interferences

- Peak modelling approach - Uses spectral data from analyte and interference standards to de-convolve the analyte peak from nearby interference peaks



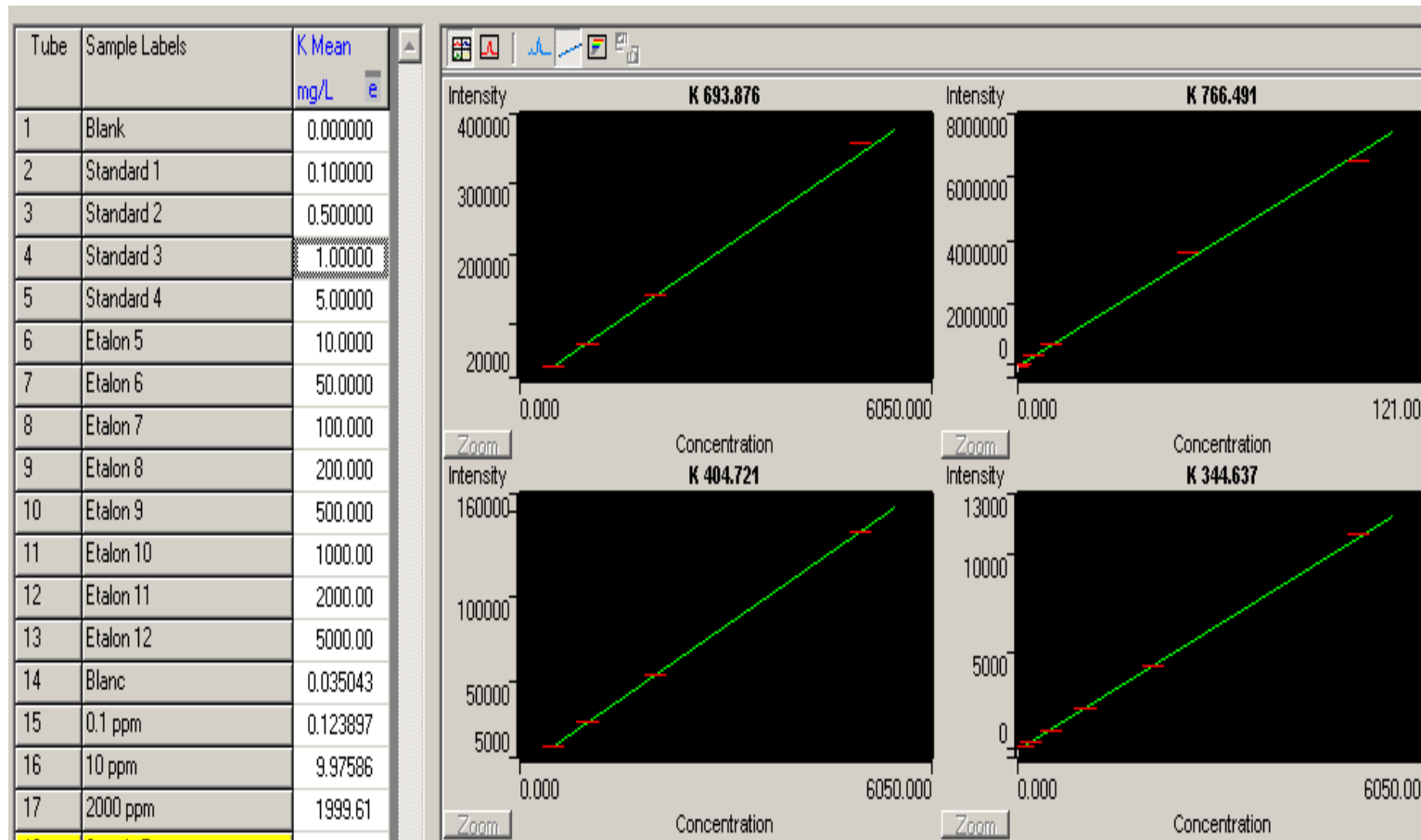
FACT removes iron interference providing accurate determination of trace level cadmium in soils.

Advantages

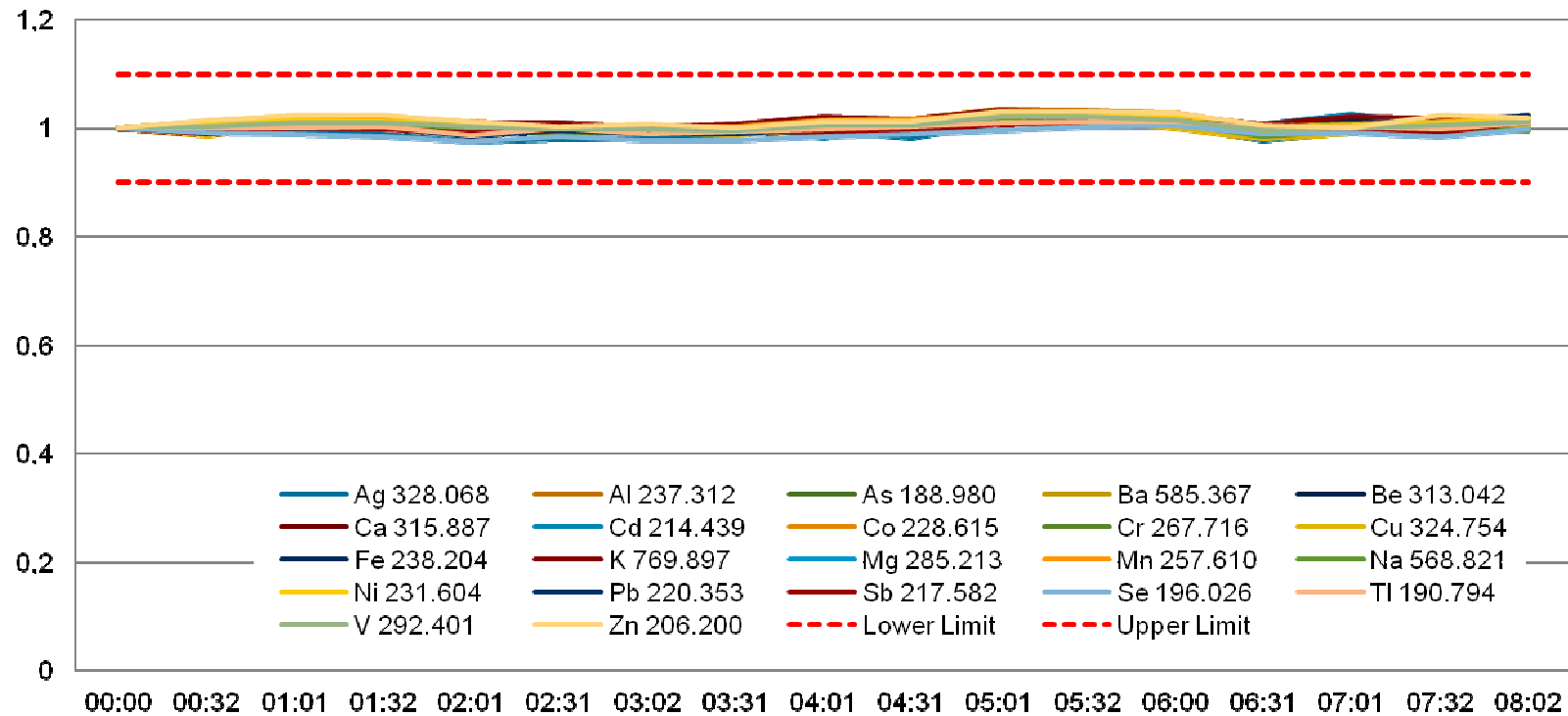
- Resolves extremely complex spectral interferences
- Gives access to extra wavelengths for improved validation
- Allows resolution of interferences as close as 3 pm

Continuous Wavelength Coverage

K measured over the concentration range from 100 ppb – 5000 ppm, using combination of sensitive and less-sensitive lines



Robust, Stable Plasma System



Agilent 720 stability < 0.98% RSD Max.

Overview of ICP-MS Spectroscopy



Agilent 8800 ICP-QQQ

- World's first **Triple Quadrupole ICP-MS (ICP-QQQ)**
- New modes of operation and performance not possible with quadrupole ICP-MS
- Joins the Agilent 7700, the highest performing quadrupole ICP-MS system
- Unique capabilities, based on proven technology

New Agilent
8800 ICP-
QQQ

Agilent
7700
Single-
quad (ICP-
QMS)



7700 Series – New Product Highlights

New ORS³ Collision/Reaction Cell

- u Longer, narrower rods, higher cell pressure and frequency – MUCH better performance in He mode

New RF Generator

- u Fast, frequency-matching 27MHz generator, for better tolerance to changing matrix (incl. organics)

Increased Matrix Tolerance

- u High Matrix Introduction (HMI) standard on 7700x model

Much smaller cabinet

- u >30% smaller footprint than any other ICP-MS

Simple software; reliable Auto-Tuning

- u MassHunter software – intuitive and easy to learn. Pre-set plasma conditions and fast lens auto-tuning

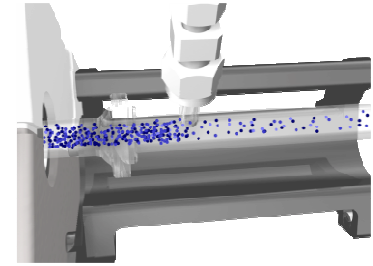


7700x – The Three Key Performance Benefits



1. Matrix Tolerance – Sample Intro/Plasma/HMI *(unique to Agilent)*
2. Interference Removal – He Mode *(unique to Agilent)*
3. Dynamic Range – 9 Orders at the Detector *(unique to Agilent)*

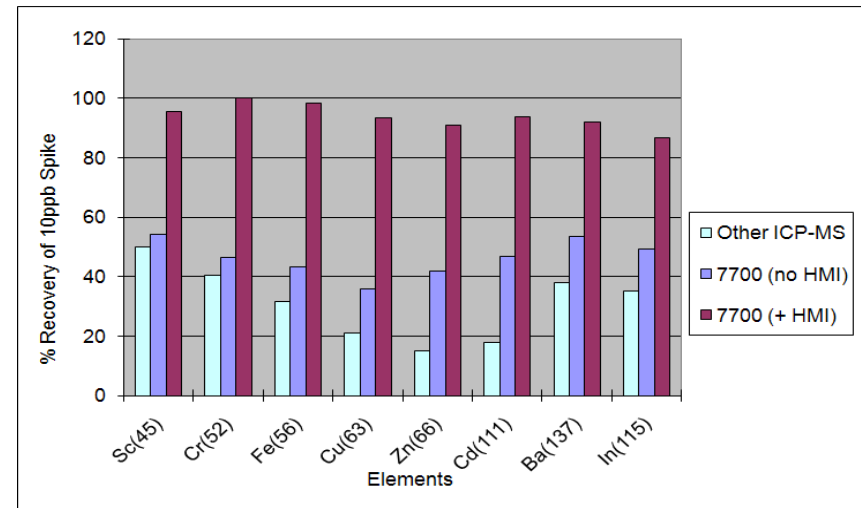
7700 Series ICP-MS



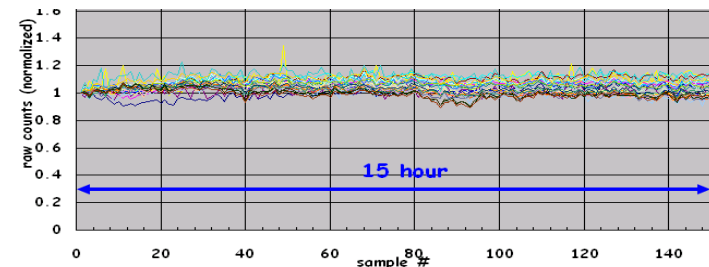
7700 has better matrix tolerance

- Handles tough sample matrices better than any other ICP-MS
 - Highest plasma temperature (lowest CeO/Ce) as standard
 - AND HMI (high matrix introduction). HMI is still unique to Agilent – and is standard on the 7700x
- Gives lower levels of interference and better long-term stability
 - Interferences are broken-down in the plasma; less material deposits on the interface cones

Relative signal (suppression) in undiluted seawater



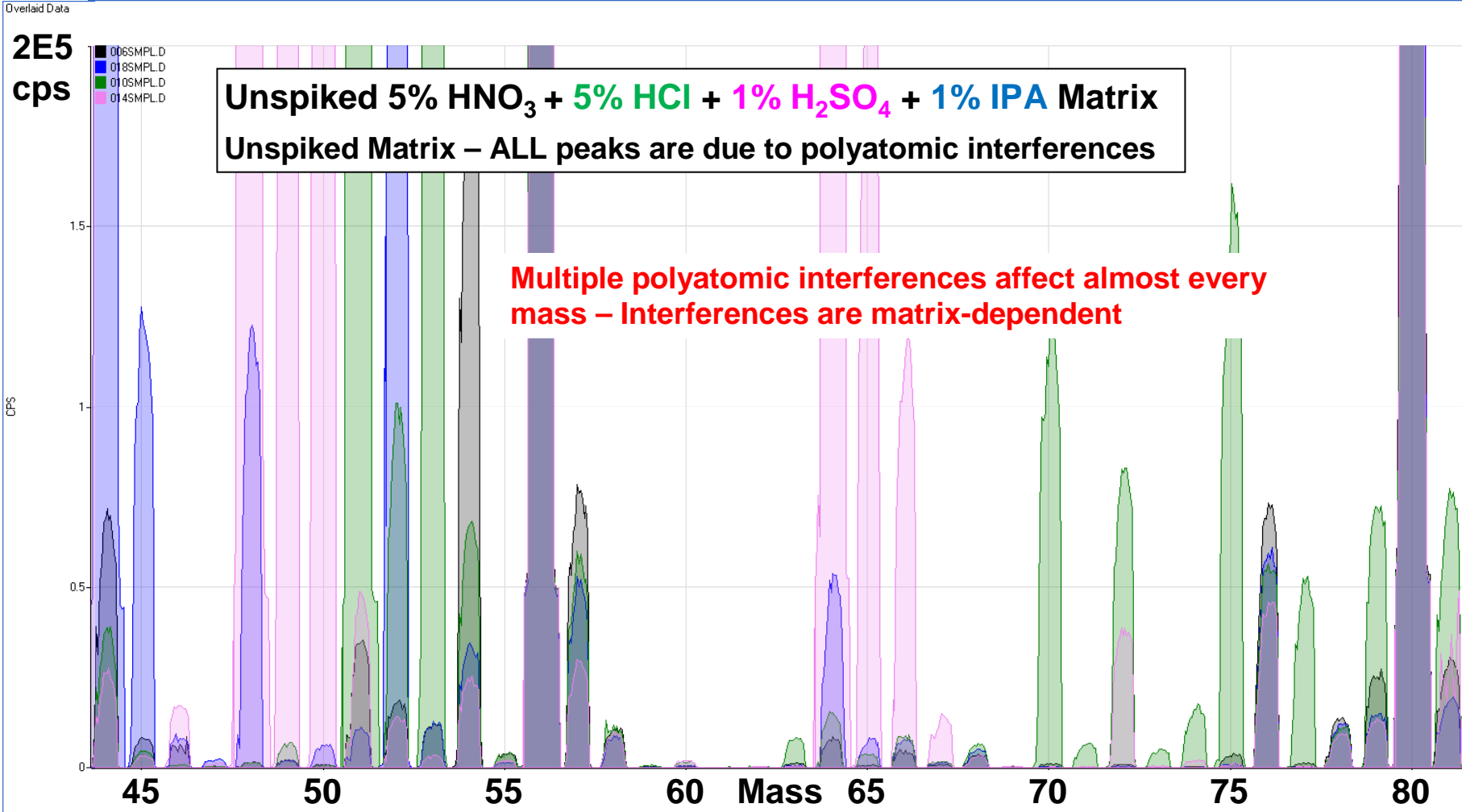
Long-term stability in undiluted seawater



HMI gives lower suppression and better long-term stability

Blank Acid Matrices and IPA in No Gas Mode

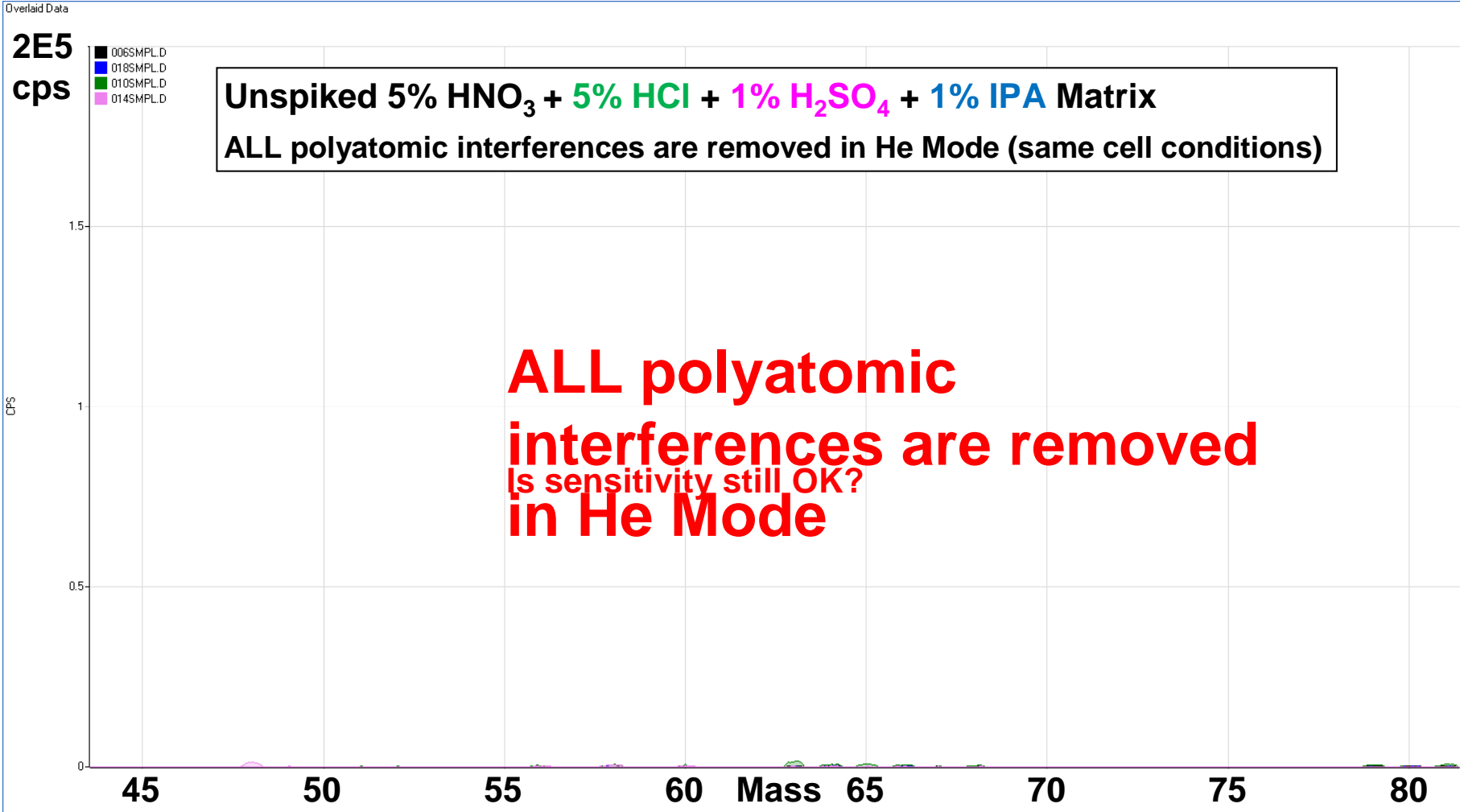
Color of spectrum indicates which matrix gave each interfering peak



No Gas Mode

Blank Acid Matrices and IPA in He Mode

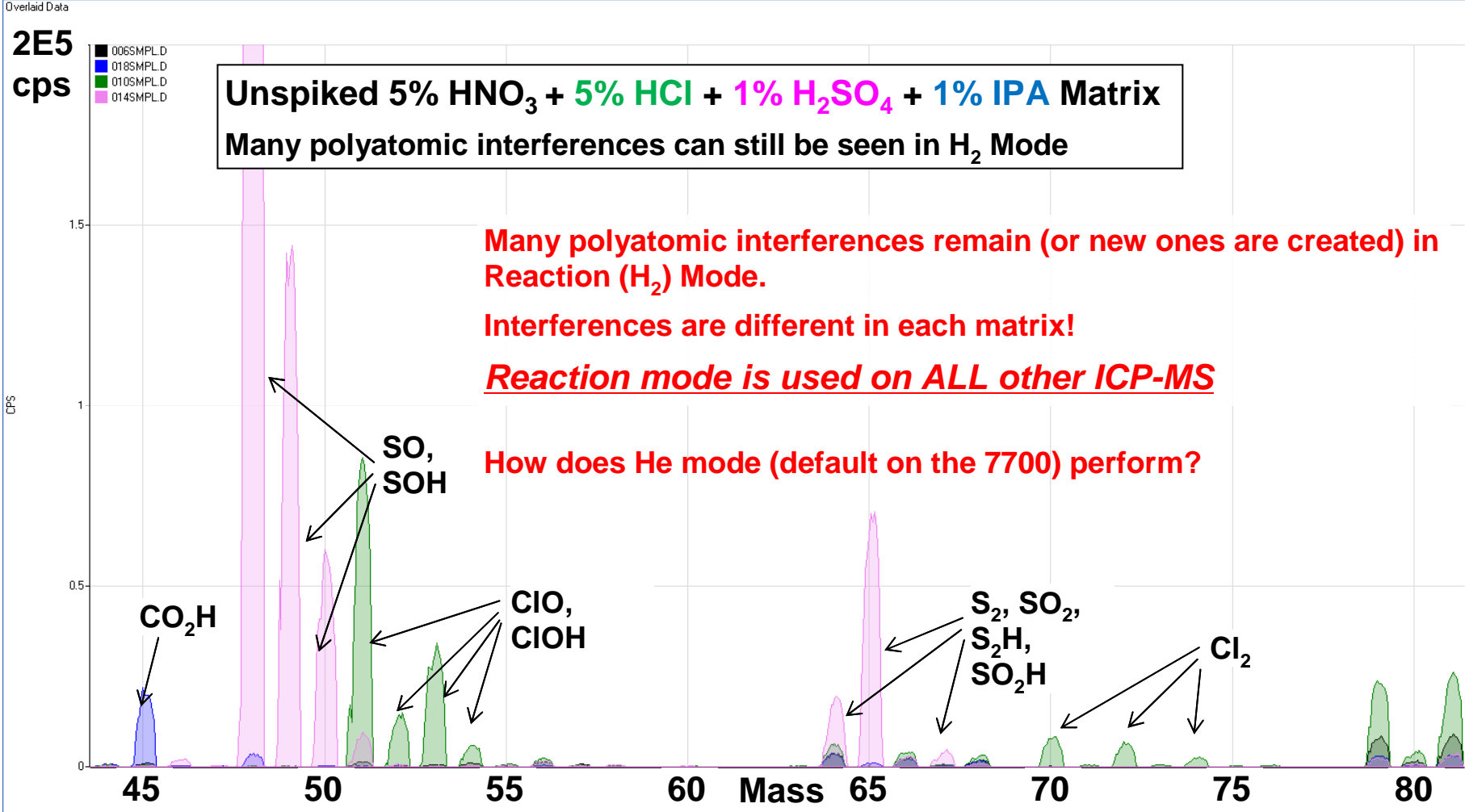
Color of spectrum indicates which matrix gave each interfering peak



He Mode

Blank Acid Matrices and IPA in H₂ (Reaction) Mode

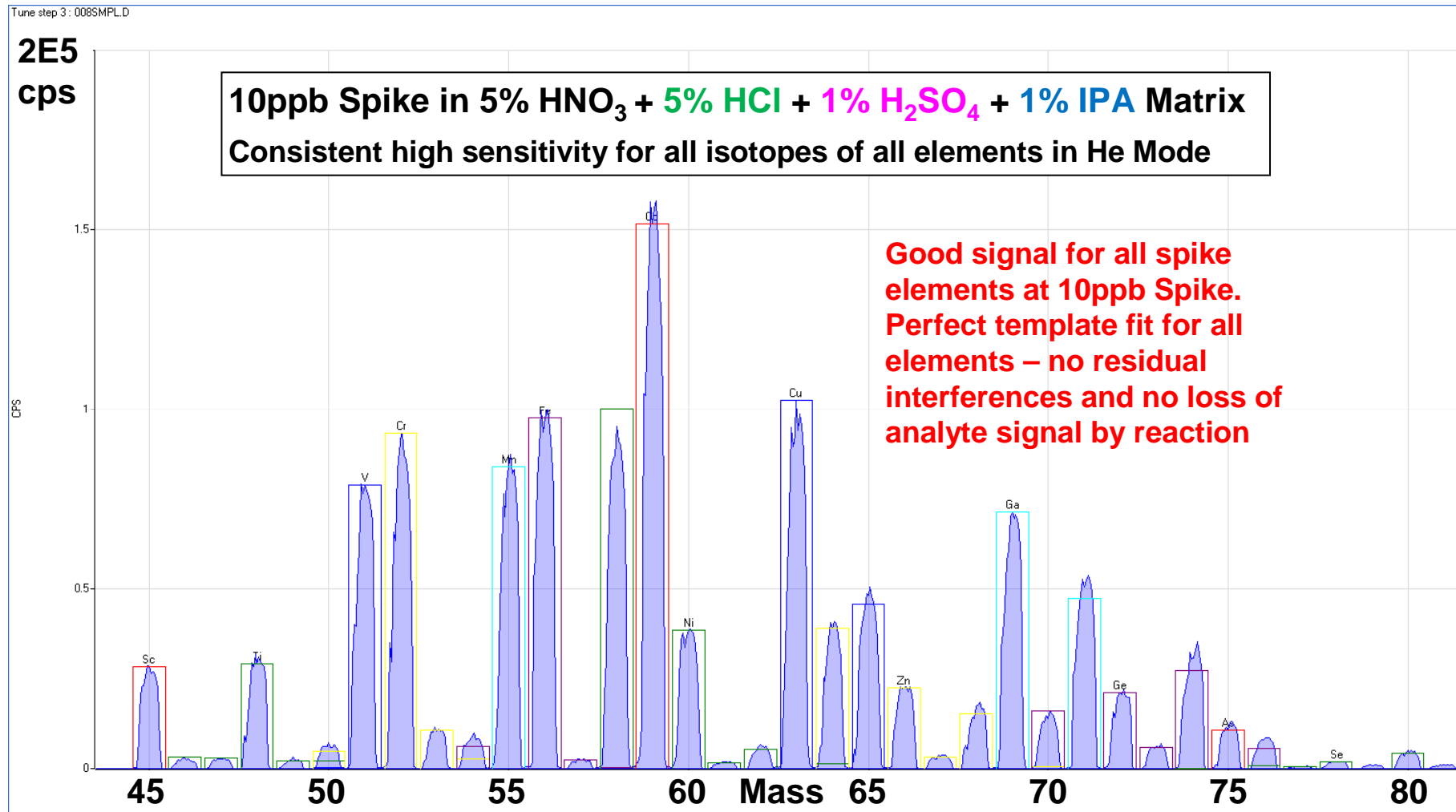
Color of spectrum indicates which matrix gave each interfering peak



H₂ Mode

Matrix Mix with Spike (10ppb) in He Mode

Consistent sensitivity and perfect template match for all elements



He Mode

7700x – Largest Analytical Range of any ICP-MS

Calibration ranges

Hg (10 – 200ppt) – NoGas Mode

As (10 – 200 ppt) – He Mode

Se (10 – 200 ppt) – He Mode

Na (0.05 – 1000 ppm) – He Mode

Overall calibration range 10ppt (Hg, As, Se) to 1000 ppm (Na) in a single method

- *without* attenuating ion transmission to increase working range

Na

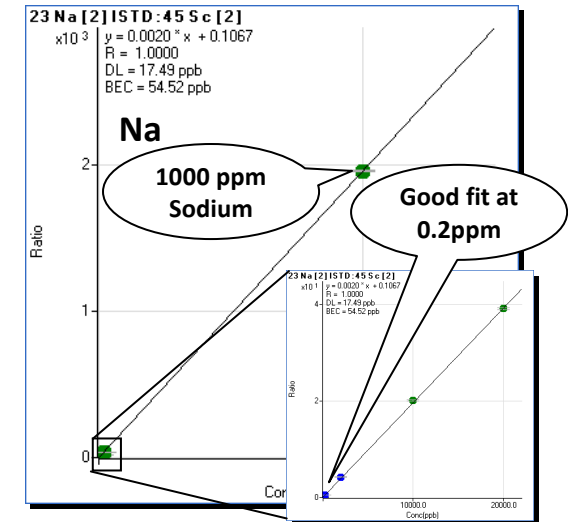
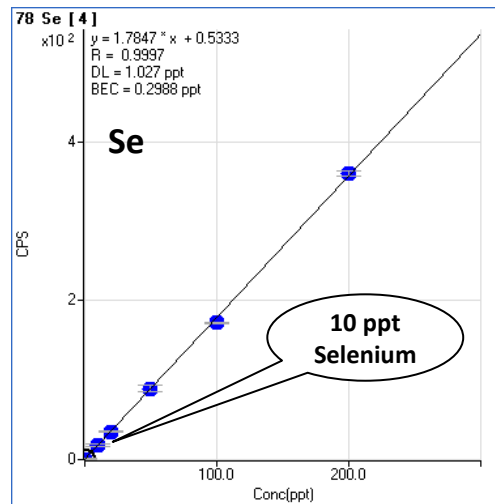
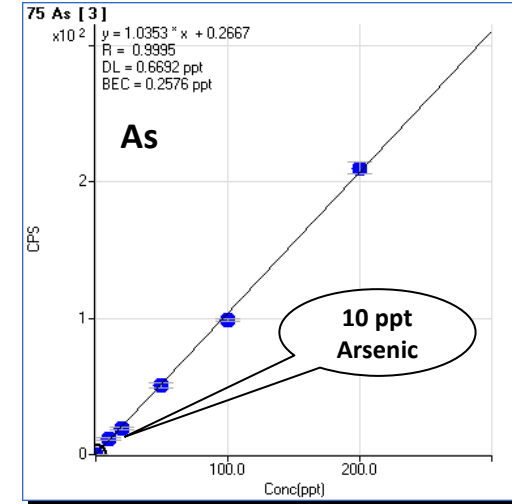
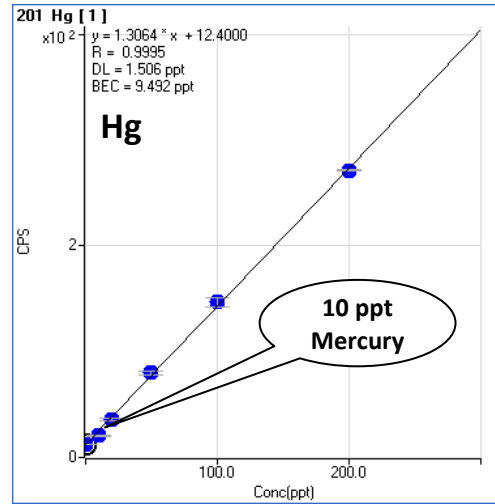
Typically, ICP-MS cannot measure above 200ppm Na without changing quad resolution or ion lens settings

Hg

Hg LOD on 7700x is about 2ppt – 7700x can QUANTITATE at 10ppt!

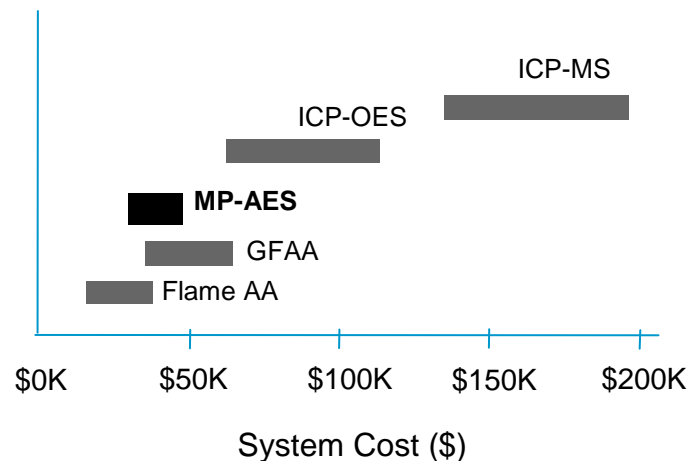
7700x can do both of the above in the same run!

These 4 plots were obtained under the same analytical conditions on the 7700x – only the gas mode (NoGas for Hg) changed



Technique Selection Criteria

- ✓ **Detection limits**
- ✓ **Sample throughput**
- ✓ **Number of elements measured per sample**
- ✓ **Matrix Interferences**
- ✓ **Ease of use**
- ✓ **Cost of Ownership**



	Flame AA	GFAA	MP-AES
Detection limits			
%	○		●
ppm	○		●
High ppb	○	○	●
Low ppb		○	●
ppt		○	
Number of Samples			
Few	○	○	●
Several	○		●
Many			
Number of Elements per Sample			
Single	○	○	●
Few	○		●
Many			●
Sample Matrix			
< 3%	●	●	●
3 – 10%	●	●	●
> 10%		●	

Technique Selection Criteria

Criteria	Flame AA	GFAA	MP-AES	ICP-OES	ICP-MS
Measurement Range					
high > 10%				X	
1 - 10 %	X		X	X	
ppm	X		X	X	X
high ppb	X	X	X	X	X
low ppb		X	X	X	X
ppt		X			X
Number of samples					
Few	X	X	X		
Several	X		X	X	X
Many				X	X
No Elements per Sample					
Single	X	X	X	X	X
Few (2-5)	X		X	X	X
Intermediate (5-10)			X	X	X
Many				X	X
Sample Matrix					
< 3%	X	X	X	X	X
3-10 %	X	X	X	X	
> 10%		X		X	



Technique Selection Criteria

Note: 1) with SIPS

Criteria	Flame AA	GFAA	MP-AES	ICP-OES	ICP-MS
Linearity					
up to 3 orders	X	X	X	X	X
5 orders	X 1)		X	X	X
6 orders				X	X
> 7 orders					X
Ease of Use					
Simple	X		X		
Moderate				X	X
Complex		X			X
Capital Investment					
Low	X				
Low-Med	X	X	X		
Med-High				X	
High					X
Running Cost					
Low	X		X		
Med	X	X		X	X
High				X	X

Questions?



Agilent MP-AES



Agilent AAS



Agilent ICP-OES



Agilent ICP-MS

The Market Leaders in Atomic Spectroscopy