Pushing the Boundaries of Single Quad ICP-MS

NEMC August 2019

Mark Kelinske
Product Specialist
ICP-MS, ICP-MS/MS

Agilent
Trusted Answers

Agilent's History in ICP-MS
30 Years of ICP-MS Innovation

Enabling high sensitivity metal analysis

PMS series

First computer-controlled ICP-MS

1987

Enabling routine robust ICP-MS analysis

4500

First benchtop ICP-MS
Cool plasma

1994

Enabling control of common interferences

7500

9 orders detector
ORS cell

2000

Enabling ease of use and productivity

7700

HMI
ISIS-DS
MassHunter SW

2009

Enabling controlled reaction chemistry

8800 ICP-QQQ

World's first ICP-QQQ

2012

A new era in ICP-MS performance

7900

UHMI
ODS detector
ISIS 3

2014

Enabling simplified ICP-MS workflows

7800

Solution ready
Method automation

2015

Flexible, high performance MS/MS

8900 ICP-QQQ

Second generation ICP-QQQ

2016

#1 selling ICP-MS !

Most Compact Instruments on the Market

Agilent 7800

Agilent 7900

Agilent 8900

What's More Important for Environmental Analysis?

- Matrix Tolerance ?
- Sensitivity ?
- Interference Removal ?
- Linear Dynamic Range ?
- Ease of Use ?

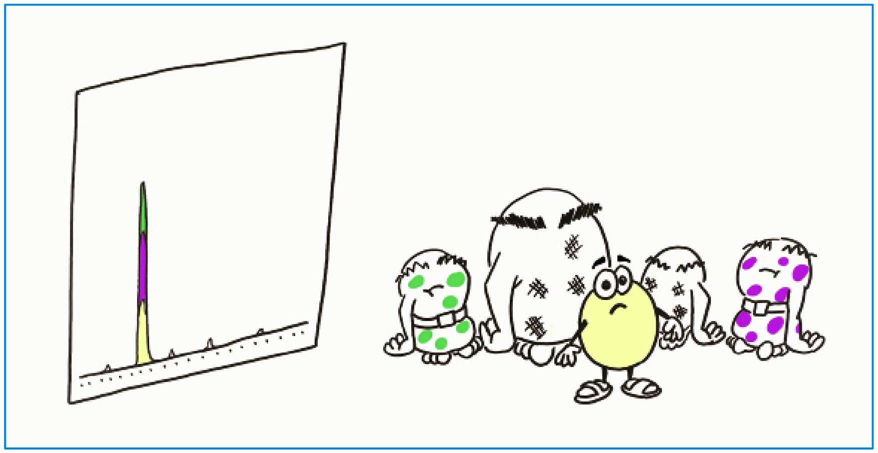
What's More Important for Environmental Analysis?

- Matrix Tolerance
- Sensitivity
- Interference Removal
- Linear Dynamic Range
- Ease of Use

Let's focus on interference removal for our discussion.

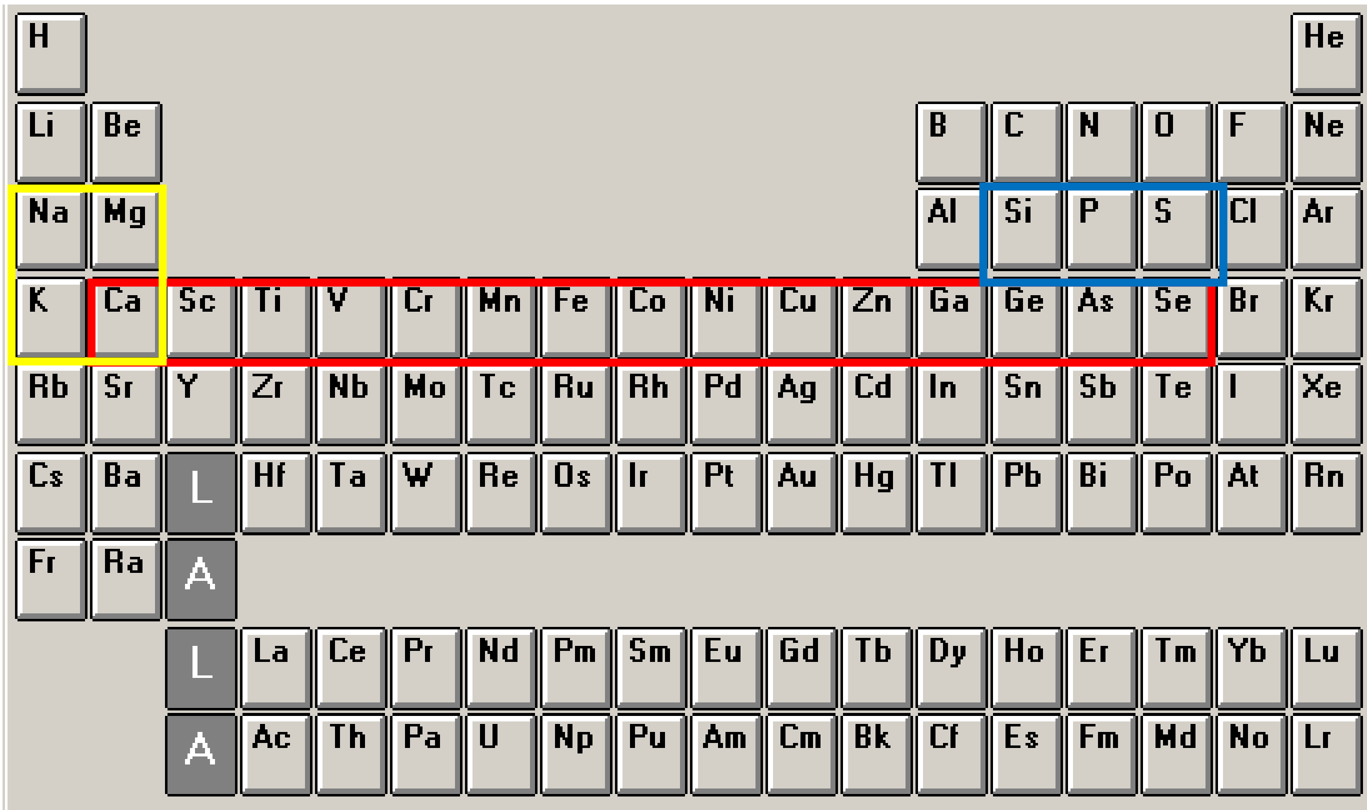
What About Interferences?

- Three main types of interferences
  - Spectroscopic
  - Physical
  - Memory

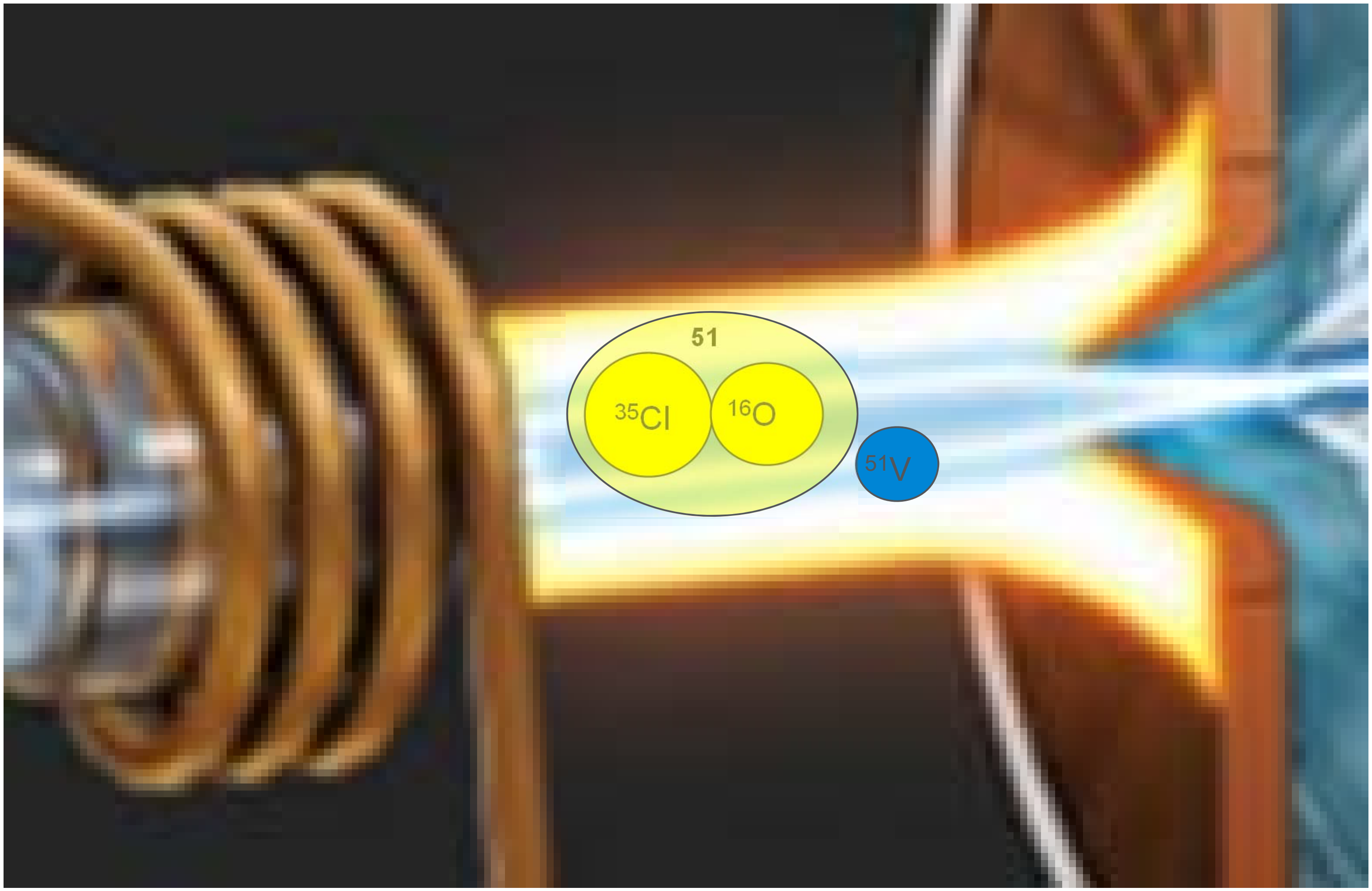


- How to control them?
  - Cell technologies
  - HMI / UHMI
  - Discrete sampling techniques

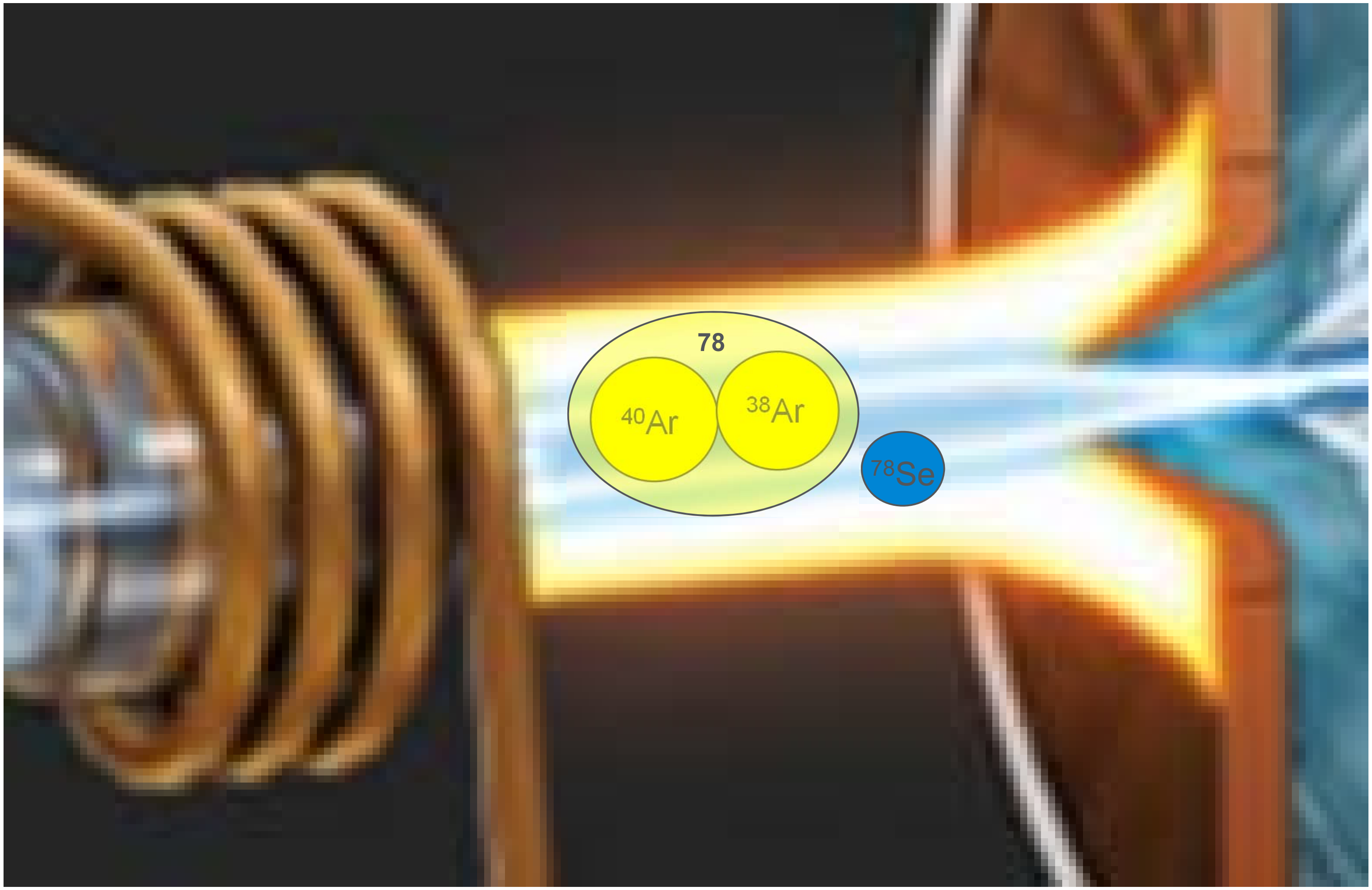
Troublesome Region of the Periodic Table



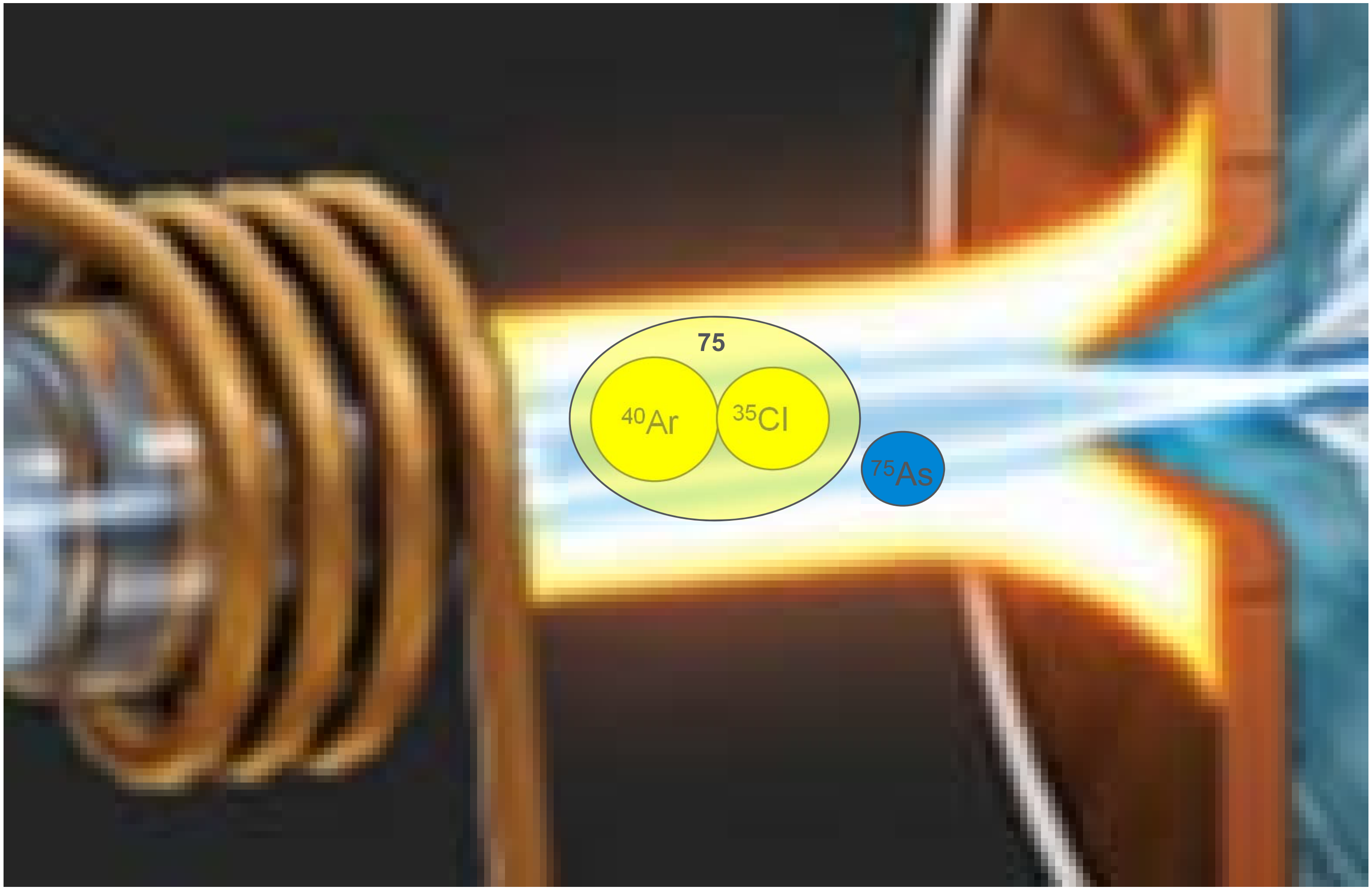
Polyatomic Interference Formation - Matrix



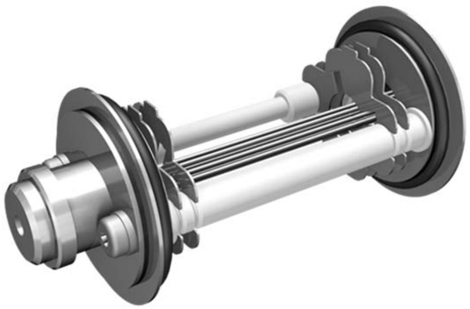
Polyatomic Interference Formation - Argon



Polyatomic Interference Formation - Both



Processes of Interference Removal in Collision/Reaction Cell



Collisional Dissociation

- Limited in ICP-MS, as collision energy must be higher than bond dissociation energy

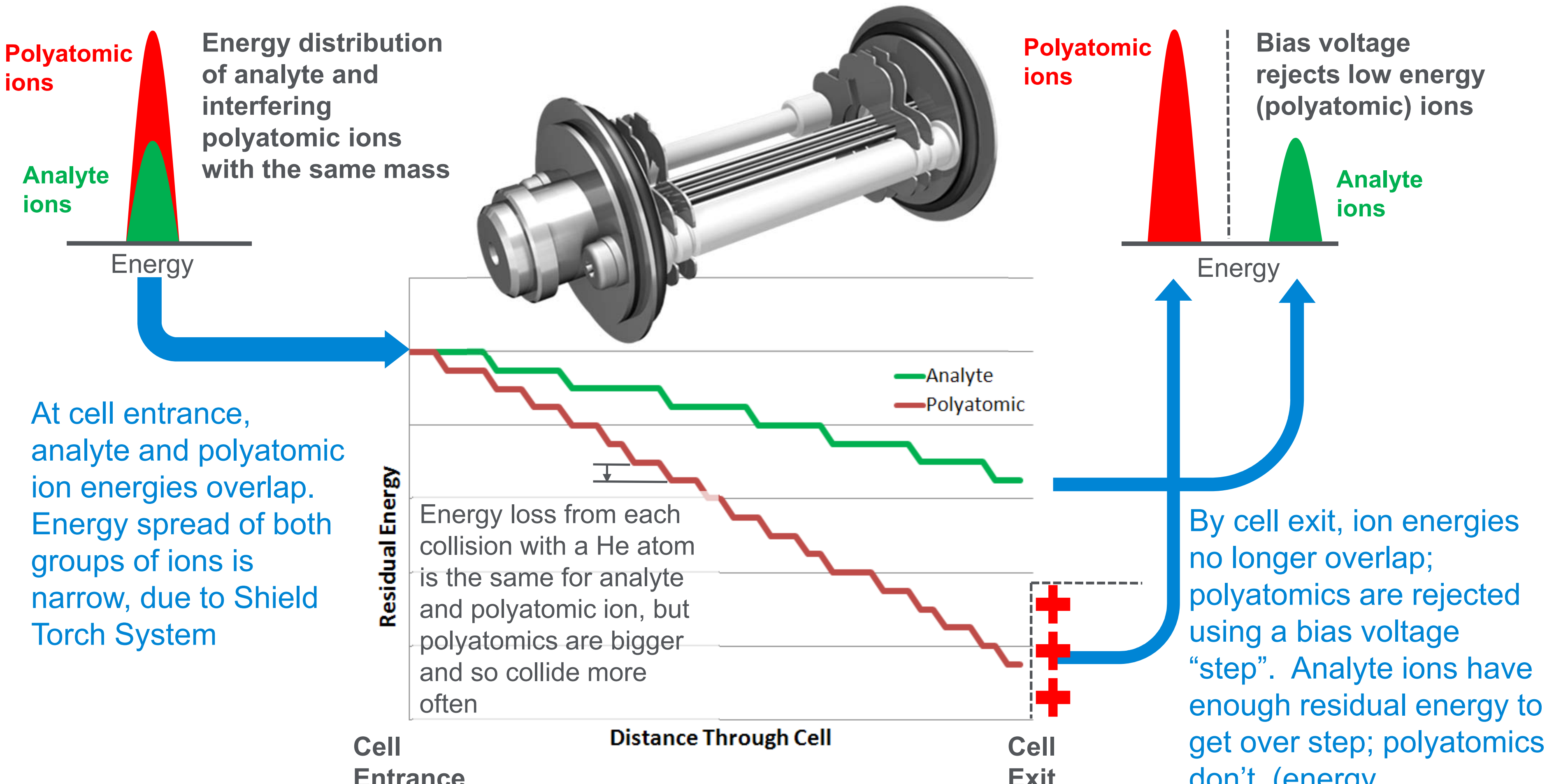
Reaction

- Can be very efficient – up to 9 orders reduction – but can also be non-selective. Highly reactive gases may react with analytes, matrix components and residual cell contamination, giving analyte loss and the formation of complex cluster ions

Energy Discrimination

- Useful in complex, variable and unknown matrices, as interference removal occurs, regardless of the level, source and chemistry of the interfering species. Can use inert cell gas, so no reaction with analytes and no formation of new cluster ions

Principle of Cell Gas Mode and KED for removing polyatomic interferences*



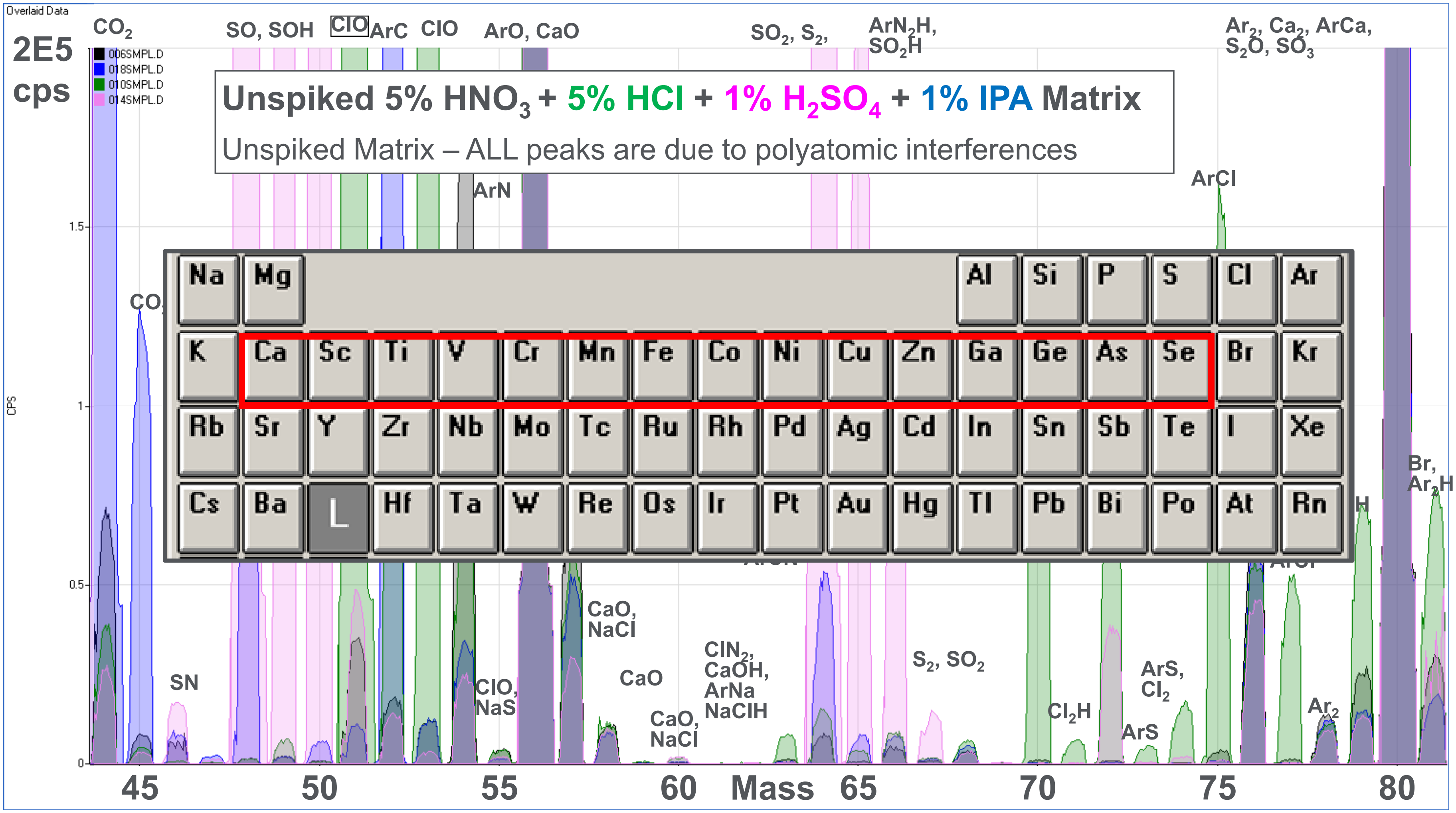
At cell entrance, analyte and polyatomic ion energies overlap. Energy spread of both groups of ions is narrow, due to Shield Torch System

By cell exit, ion energies no longer overlap; polyatomics are rejected using a bias voltage “step”. Analyte ions have enough residual energy to get over step; polyatomics don’t (energy discrimination)

*KED = Kinetic Energy Discrimination

Polyatomic Interferences in No Gas Mode

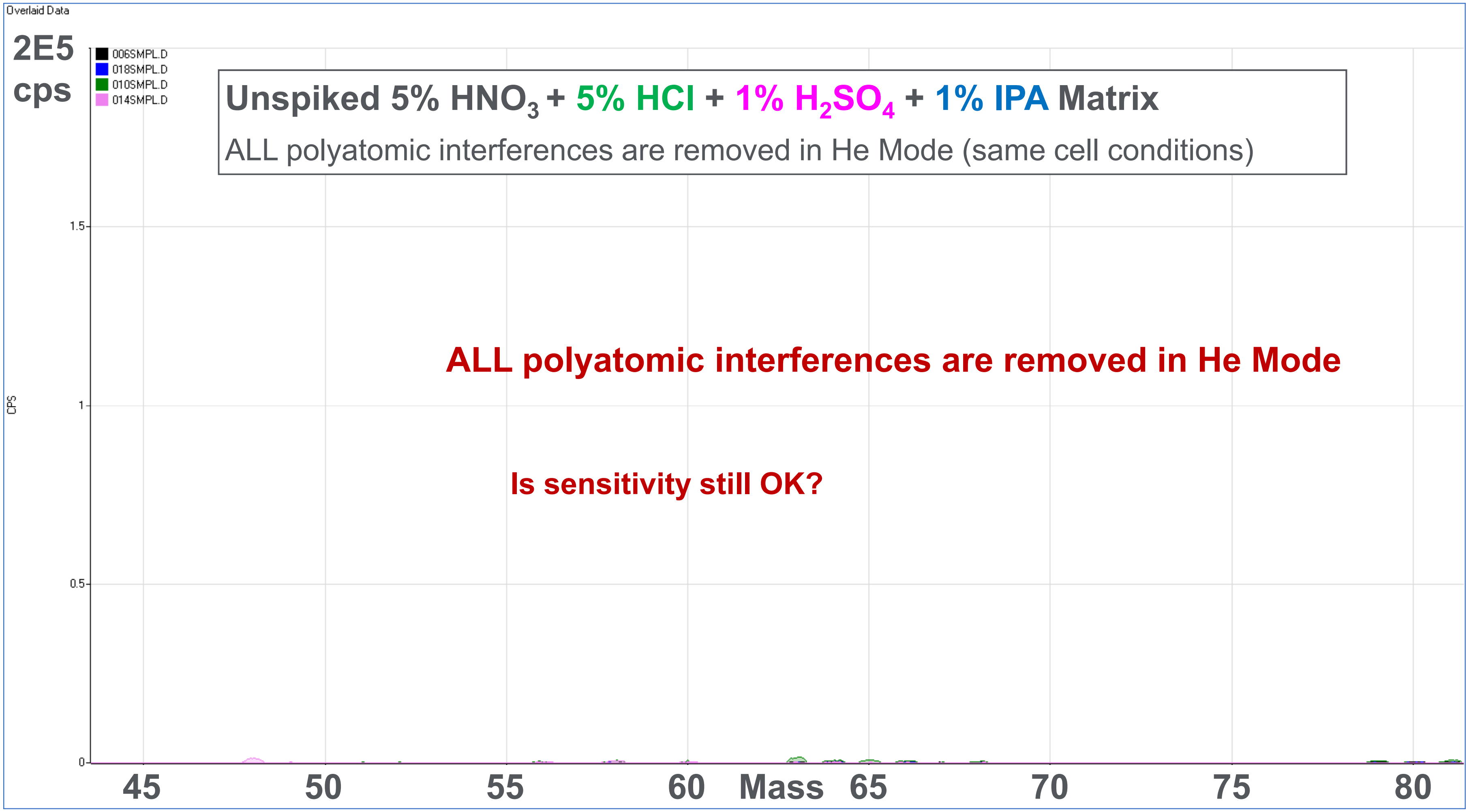
Color of spectrum indicates which matrix gave each interfering peak



No Gas Mode

Polyatomic Interferences in He Mode

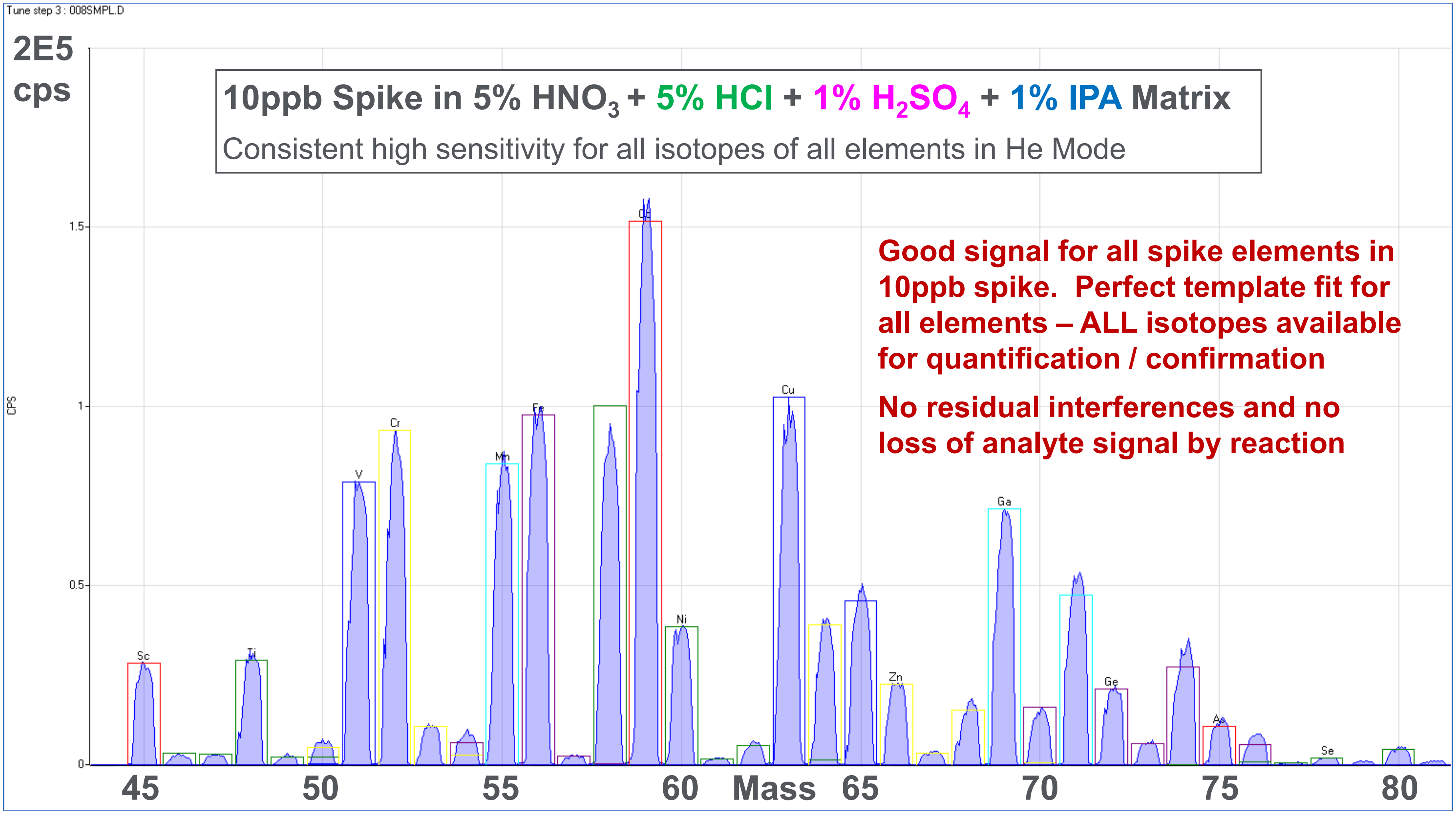
Color of spectrum indicates which matrix gave each interfering peak



He Mode

Matrix Mix with Spike (10ppb) in He Mode

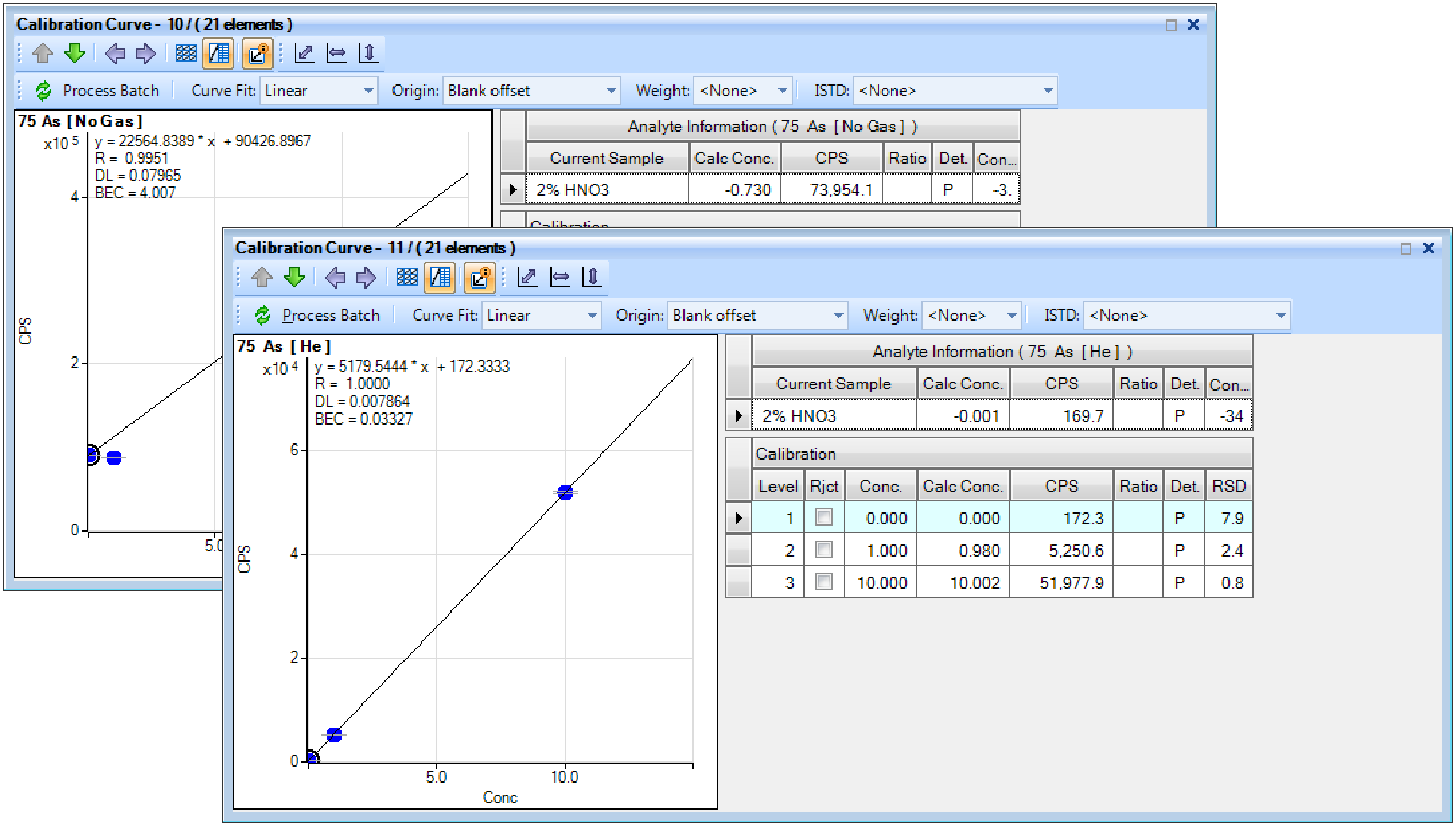
Consistent sensitivity and perfect template match for all elements



He Mode

Cal 0, 1, 10 ppb Arsenic in 1%HNO3/0.5% HCl

(ArCl interference on m/z 75)



What About Non-Traditional Analytes?

Silicon – $^{28}Si^+$

$^{12}C^{16}O^+$, $^{14}N^{14}N^+$

Phosphorus – $^{31}P^+$

$^{14}N^{16}O^{1}H^+$, $^{15}N^{15}N^{1}H^+$, $^{15}N^{16}O^+$, $^{14}N^{17}O^+$, $^{13}C^{18}O^+$, $^{12}C^{18}O^{1}H^+$, $^{30}Si^{1}H^+$

Sulfur – $^{32}S^+$

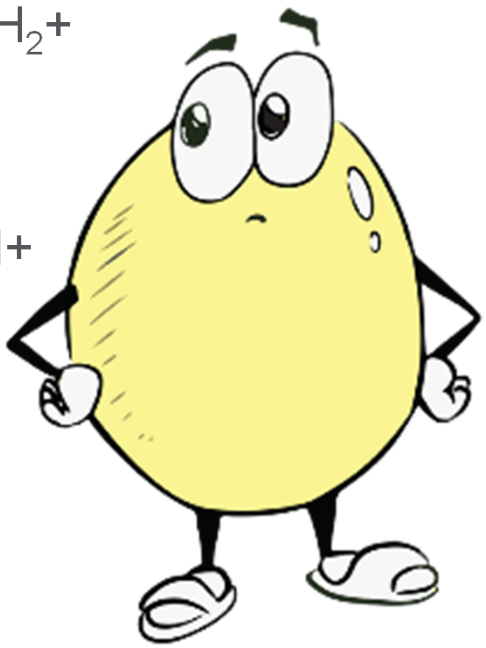
$^{16}O_2^+$, $^{14}N^{18}O^+$, $^{15}N^{17}O^+$, $^{14}N^{17}O^{1}H^+$, $^{15}N^{16}O^{1}H^+$, $^{14}N^{16}O^{1}H_2^+$

Sulfur – $^{33}S^+$

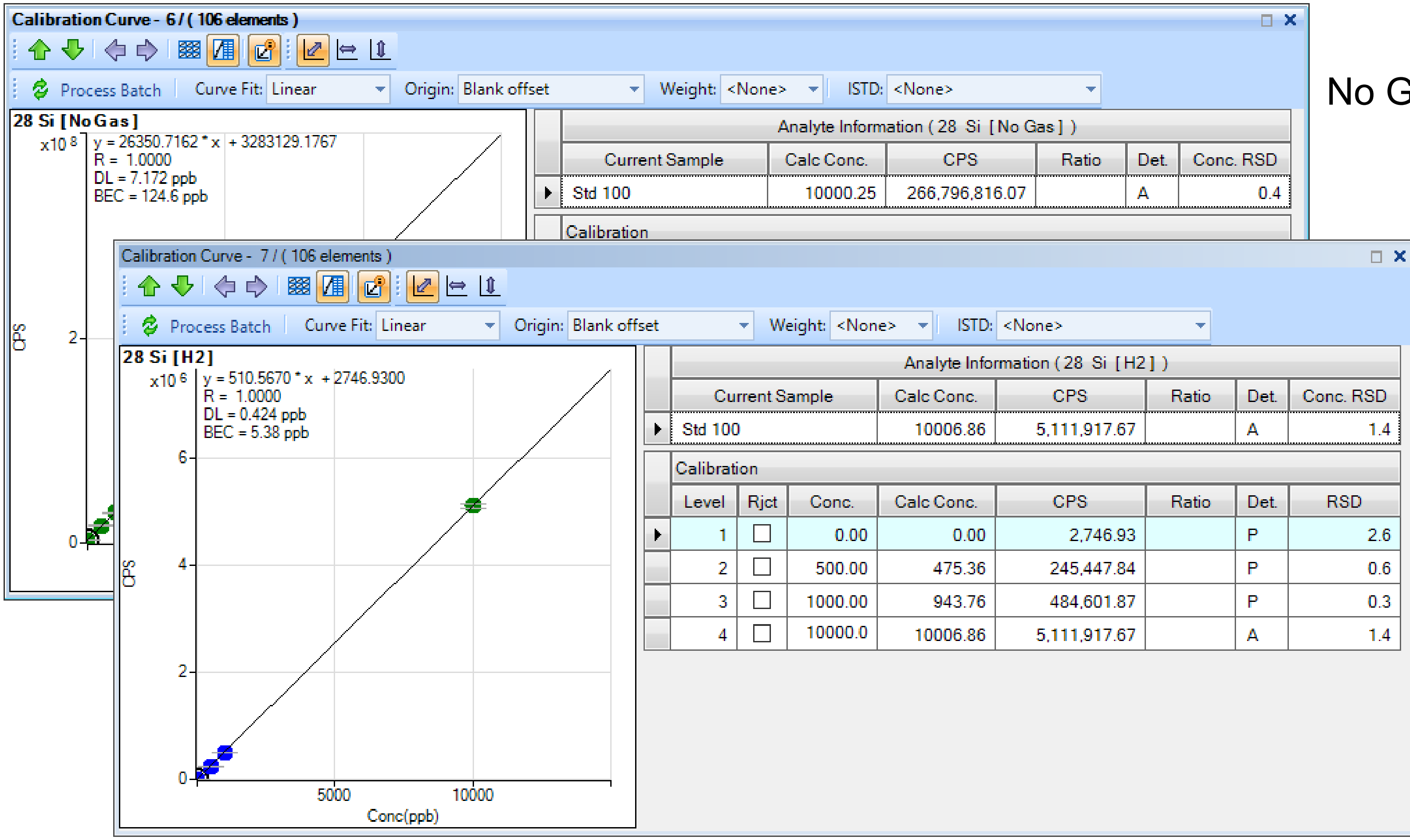
$^{15}N^{18}O^+$, $^{14}N^{18}O^{1}H^+$, $^{15}N^{17}O^{1}H^+$, $^{16}O^{17}O^+$, $^{16}O_2{}^{1}H^+$, $^{32}S^{1}H^+$

Sulfur – $^{34}S^+$

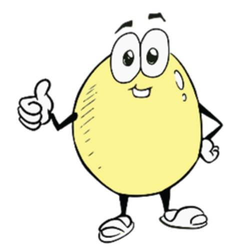
$^{15}N^{18}O^{1}H^+$, $^{16}O^{18}O^+$, $^{17}O_2^+$, $^{16}O^{17}O^{1}H^+$, $^{33}S^{1}H^+$



Example – Cal 0, 500, 1k, 10k ppb Silicon



No Gas S/N = 4.1

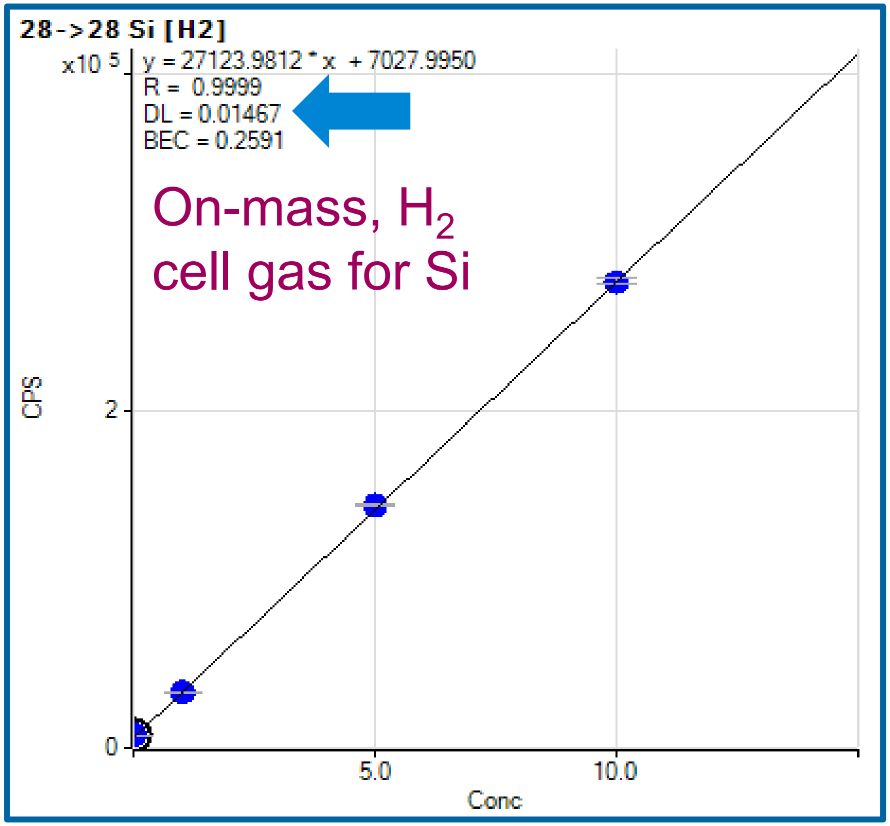


H_2 S/N = 88.4

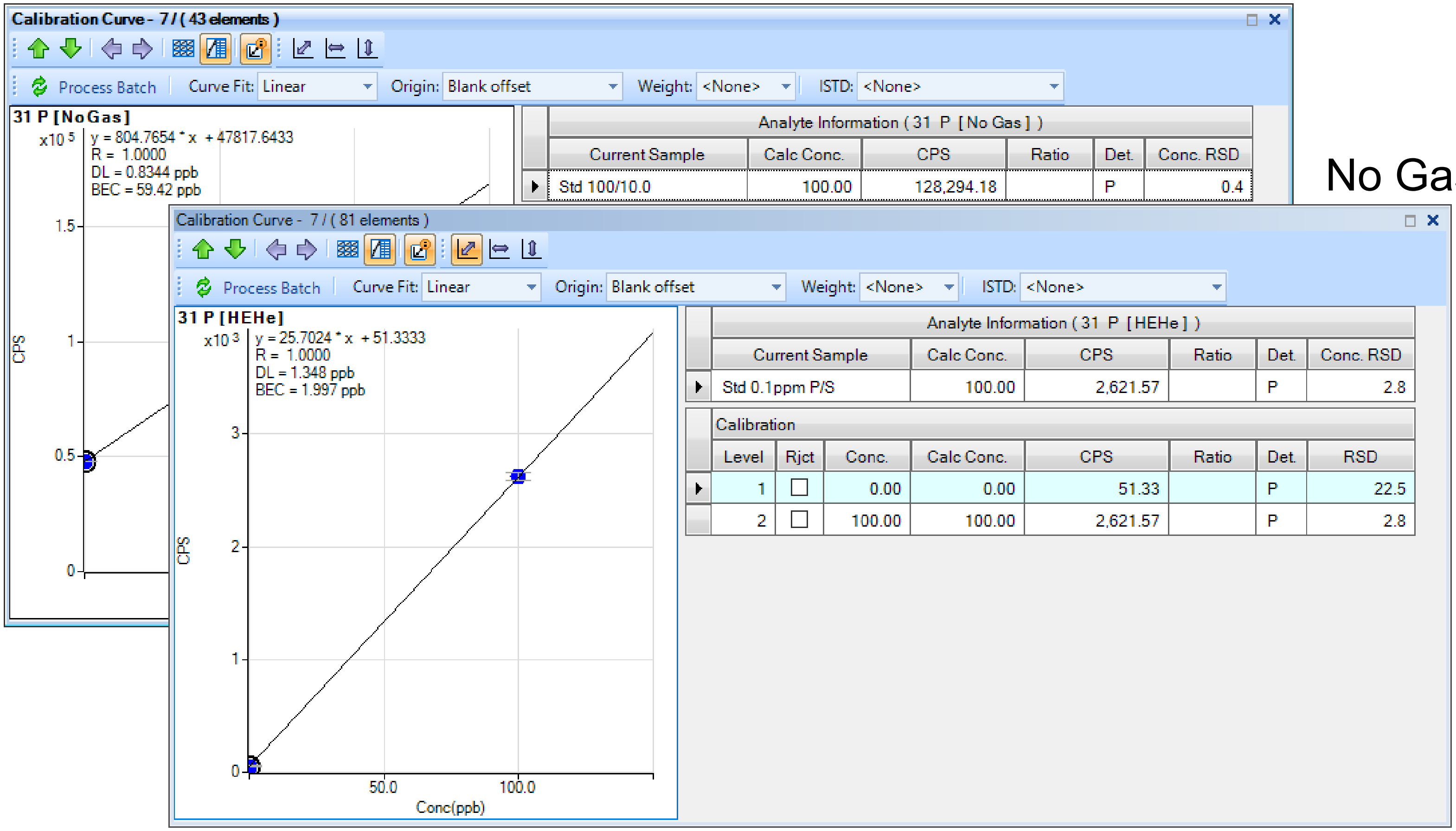
~21x improvement

Example – Cal 0,1, 5, 10 ppb Silicon ICP-MS/MS

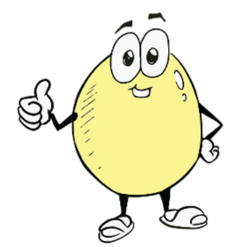
5991-6852EN



Example – Cal 0, 100 ppb Phosphorus



No Gas S/N = 1.68

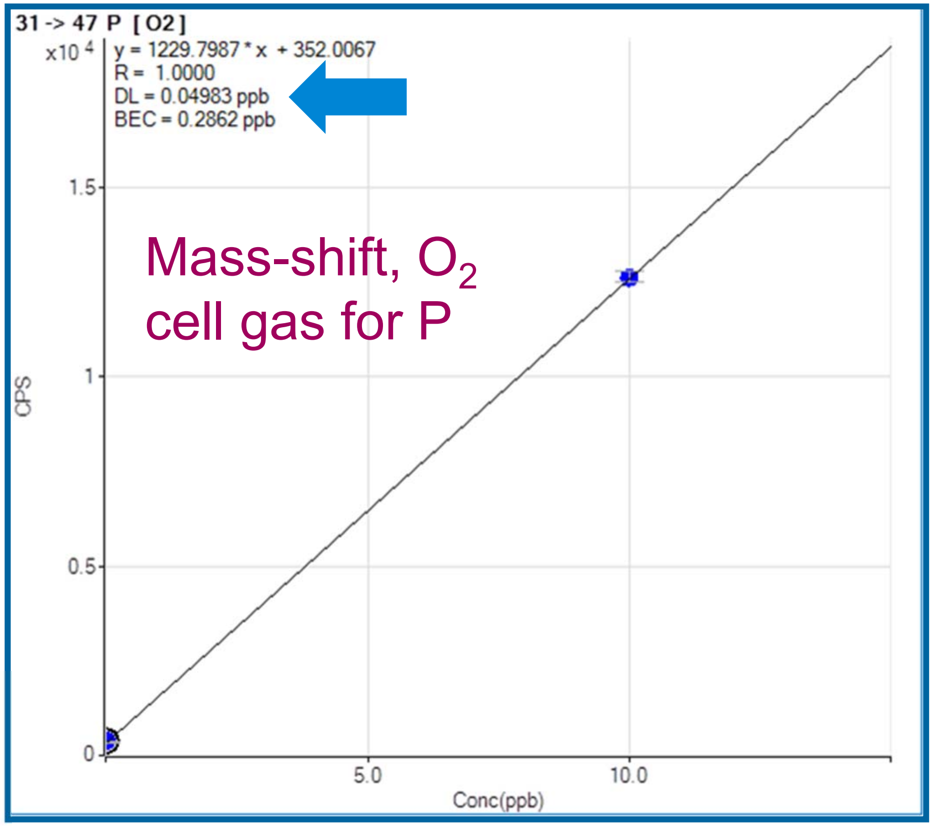


HEHe S/N = 50.1

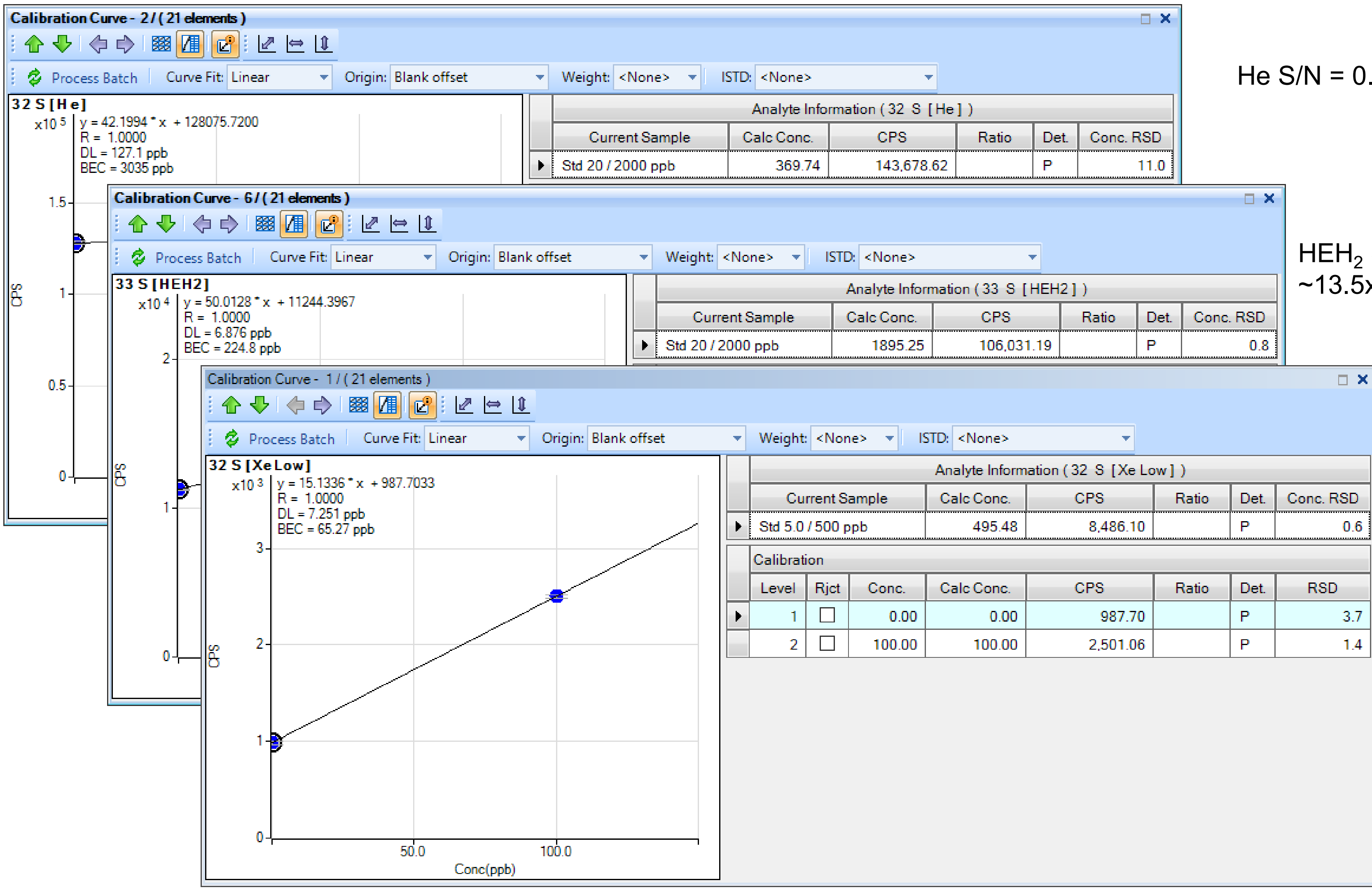
~30x improvement

Example – Cal 0,10 ppb Phosphorus ICP-MS/MS

5991-6852EN

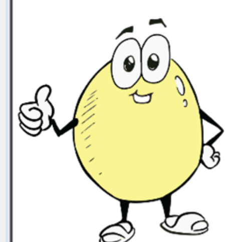


Example – Cal 0, 100 ppb Sulfur



He S/N = 0.03

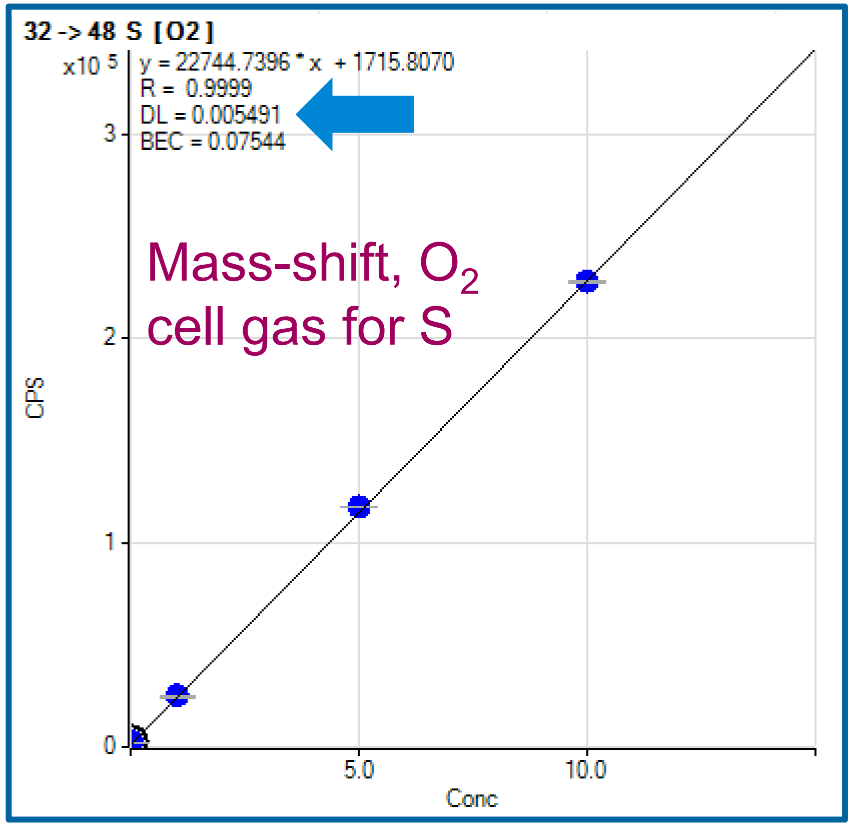
HEH_2 S/N
~13.5x improvement



Xenon S/N
~50x improvement

Example – Cal 0, 1, 5, 10 ppb Sulfur ICP-MS/MS

5991-6852EN

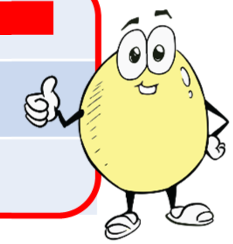


A Common Interference with a New Twist?

Cadmium – $^{111}Cd^{+}$

$^{95}Mo^{16}O^{+}$

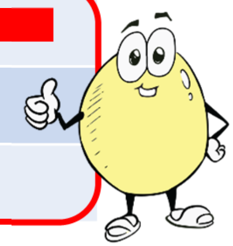
	111 Cd [No Gas] Conc. PPB	111 Cd [Helium] Conc. PPB	111 Cd [Helium + Hydrogen] Conc. PPB
Blank	0.00	0.00	0.00
10 ppm Mo	7.48	1.37	0.02
10 ppm Mo + 5 ppb Cd	12.3	6.43	5.14
Percent Recovery	96%	101%	102%



Cadmium – $^{114}Cd^{+}$

$^{98}Mo^{16}O^{+}$

	114 Cd [No Gas] Conc. PPB	114 Cd [Helium] Conc. PPB	114 Cd [Helium + Hydrogen] Conc. PPB
Blank	0.00	0.00	0.00
10 ppm Mo	5.23	1.00	0.01
10 ppm Mo + 5 ppb Cd	10.2	6.08	5.22
Percent Recovery	99%	102%	104%



Questions?

Mark Kelinske

Mark.Kelinske@agilent.com