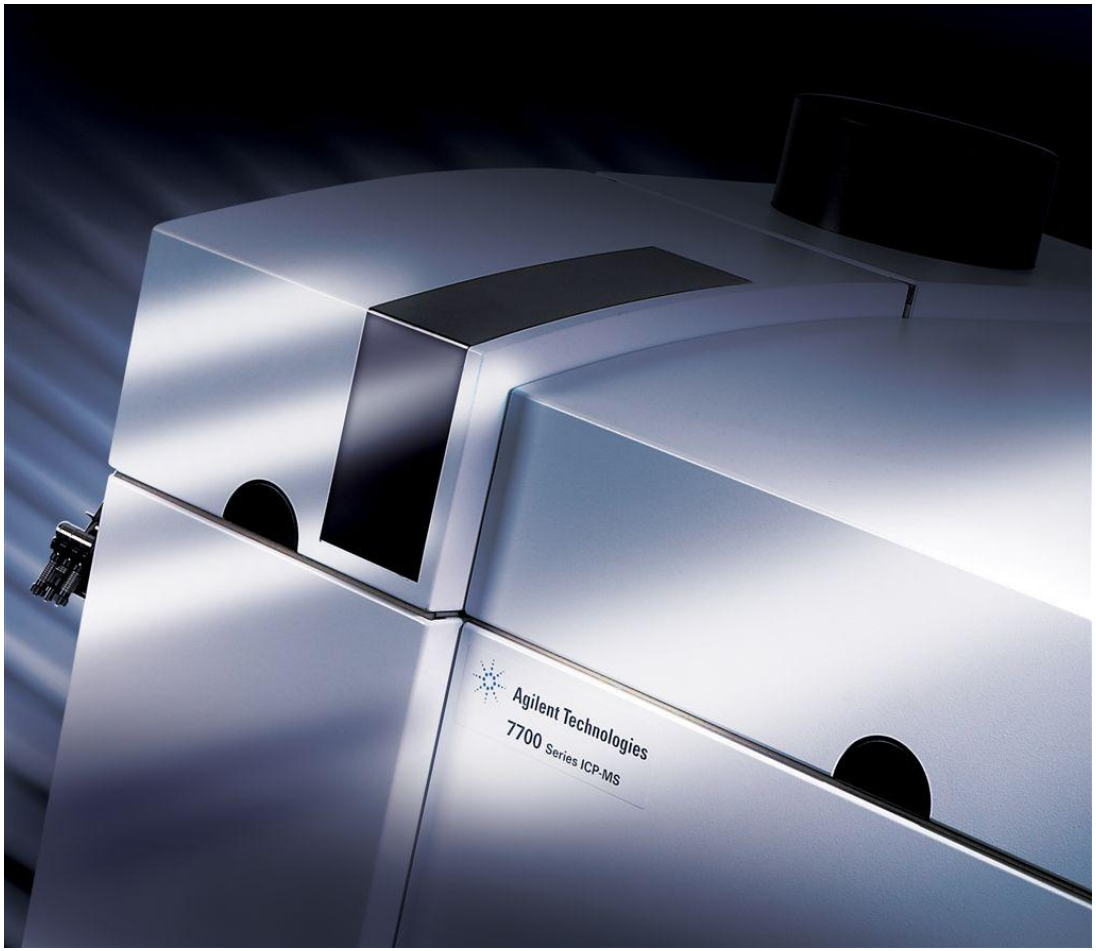


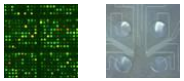
The New Agilent 7700 Series ICP-MS

the best ICP-MS just got better!

Presenter: Uwe Noetzel and Jerome Darrouzes
ICP-MS Product Specialist

Life Sciences and Chemical Analysis

Global Footprint

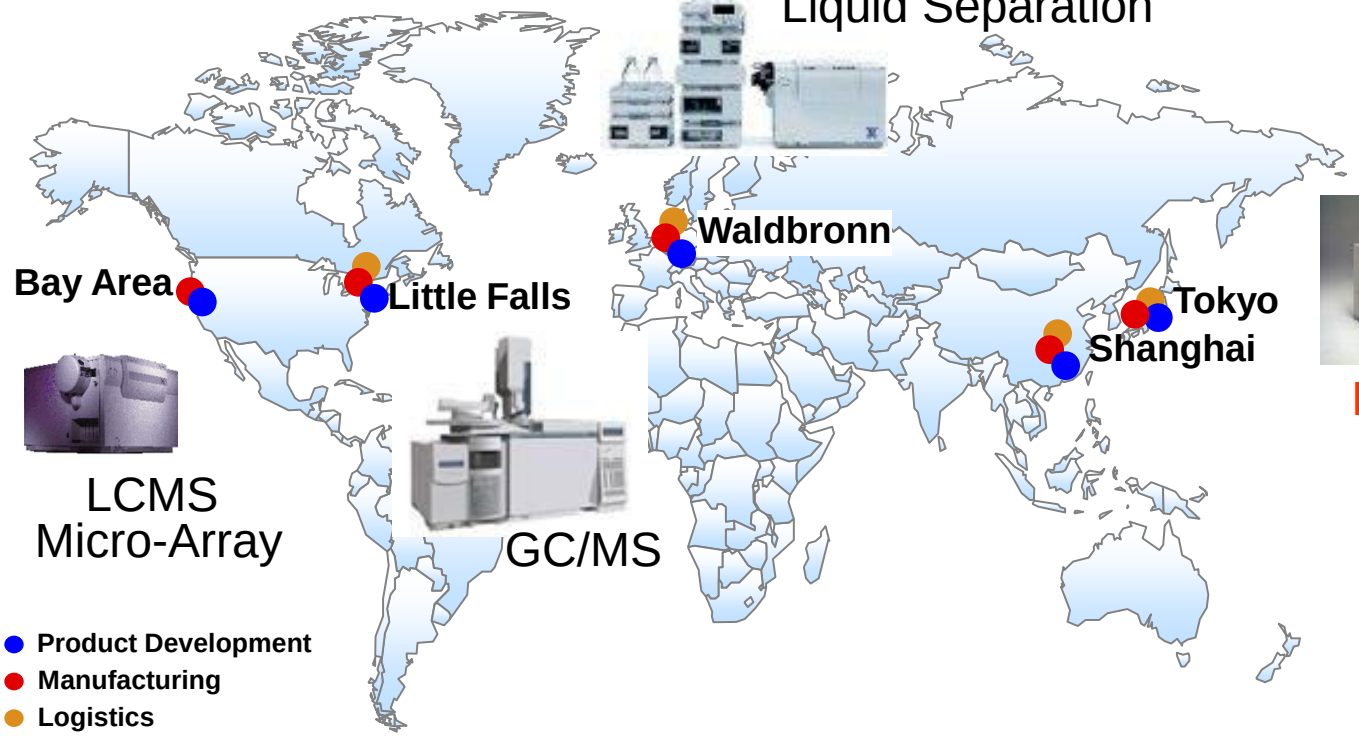


LCMS
Micro-Array

GC/MS

Liquid Separation

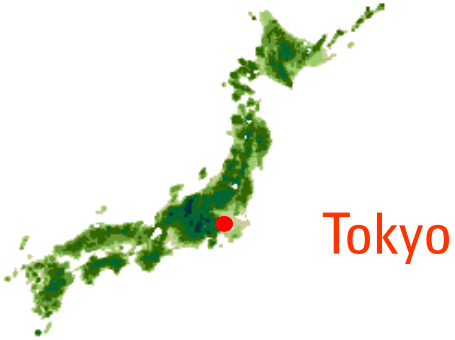
ICP-MS



- Five Product Development Centers (R&D/MKTG)
- Three Manufacturing Centers, Four Logistics Centers
- Sales and Customer Service in 100+ Countries

Tokyo Analytical Division (TAD)

- 300 Employees
- Focus on Innovation and highest possible build quality
- Accredited ISO 9001, ISO 14001 manufacturing facility
- Worldwide R&D and Production of Agilent ICP-MS
- Products for worldwide shipment
  - Agilent ICP-MS mainframe
  - Agilent ICP-MS Software
  - Agilent ICP-MS peripherals



Agilent's History of Innovation in ICP-MS – 1987 to 2009

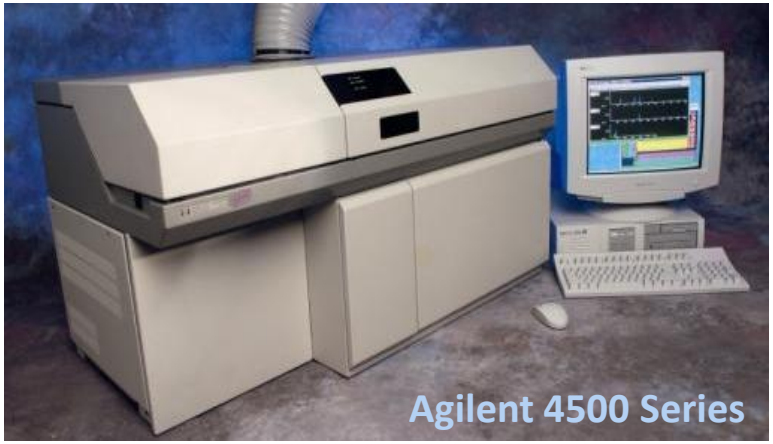
1987 – PMS 100 introduced – First computer-controlled ICP-MS
1988 – PMS 200 introduced – Second generation ICP-MS with off-axis Qpole lens
1989 – 1st ETV accessory for semicon analysis by ICP-MS
1990 – PMS 2000 introduced – Omega off-axis lens. Lowest random background ICP-MS
1992 – ShieldTorch interface developed - Ar interferences virtually eliminated in cool plasma, enabling ppt analysis of K, Ca, Fe by ICP-MS
1994 – 4500 Series introduced - World's first benchtop system. Hyperbolic profile quad, motorized torch XYZ, cool plasma
1998 – First real time ICP-MS chromatographic software – PlasmaChrom. T-mode reaction interface introduced
1999 – 4500 Series 100, 200 & 300 introduced: 1st applications-specific ICP-MS.
2000 – Agilent 7500 Series introduced - 7500a, 7500i and 7500s - the next generation in ICP-MS instrumentation. 9 orders detector range
2001 – Agilent 7500c launched – 1st generation ORS for high matrix samples.
2002 – New digital generators and LAN control introduced. First commercial GC-ICP-MS interface.
2003 – Agilent 7500cs launched – 2nd generation ORS for high purity semicon samples.
2004 – Agilent 7500ce launched – 2nd generation ORS for high matrix samples.
2005 – Low flow cell gas MFC's for Xe NH_3, O_2, etc added to 7500ce/cs.
2006 – Agilent acquires 100% of Agilent/Yokogawa joint venture
2007 – Agilent 7500cx introduced: He only mode ICP-MS
2008 – High Matrix Interface developed – enables 2% TDS samples to be run by ICP-MS
2009 – Agilent 7700 Series introduced – replaces 7500 Series. MassHunter Software introduced - common platform with other Agilent MS. ISIS-DS Discrete sampling system, for ultra high throughput analysis

ShieldTorch System

Octopole Reaction System

Agilent 7700 Series

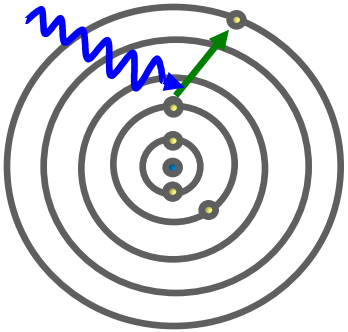
Agilent ICP-MS Instrument Development

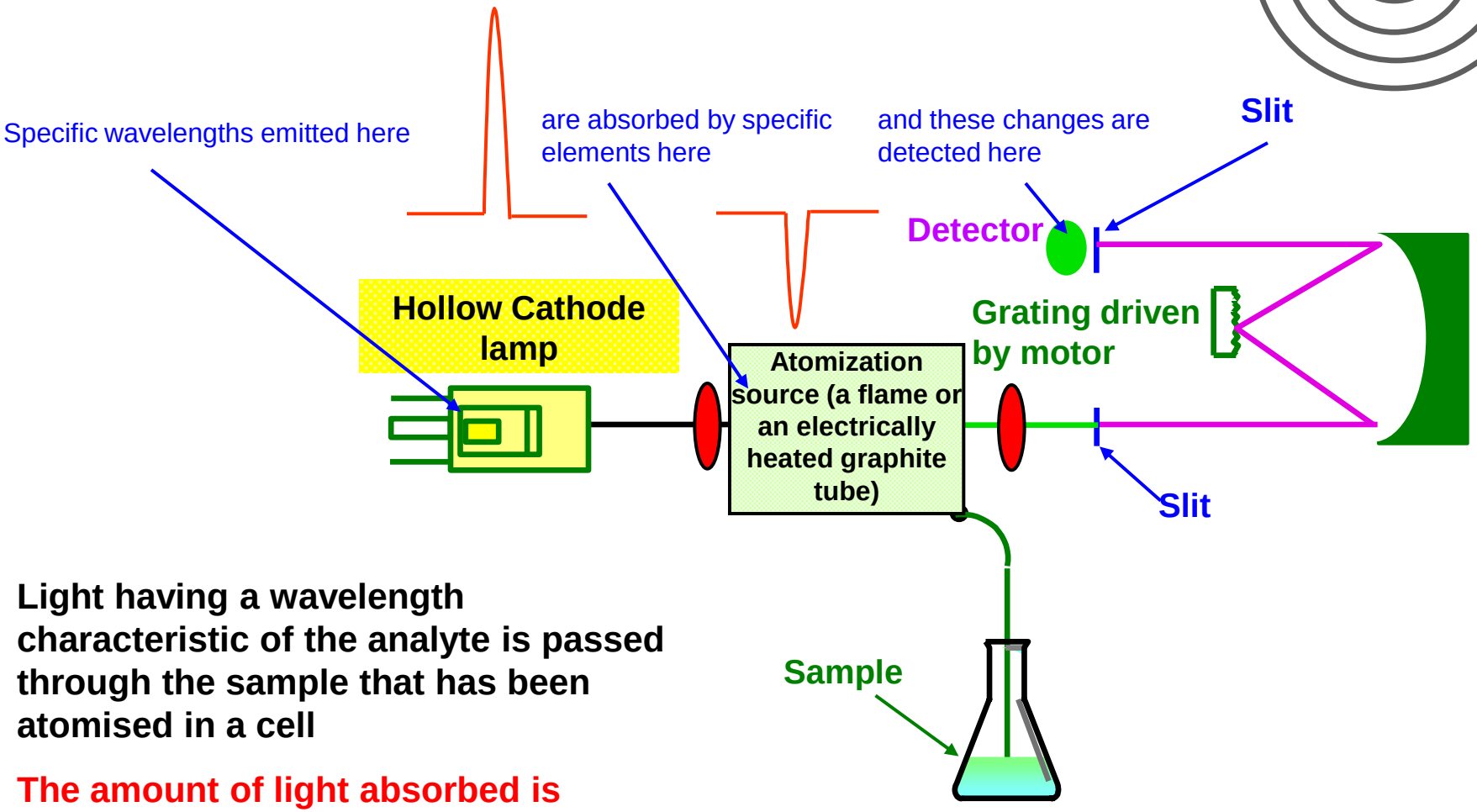


Agilent 7700 Series

The new face of ICP-MS

Atomic Absorption Spectroscopy

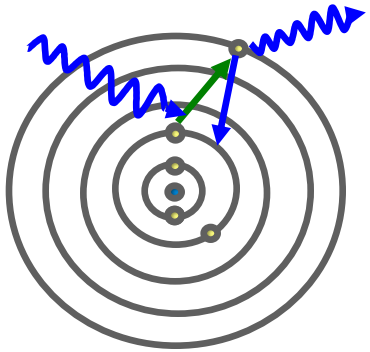




Light having a wavelength characteristic of the analyte is passed through the sample that has been atomised in a cell

The amount of light absorbed is proportional to concentration.

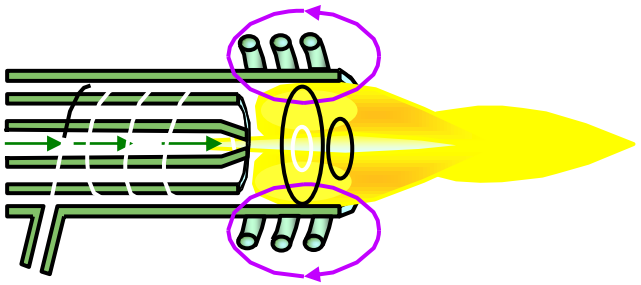
Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)

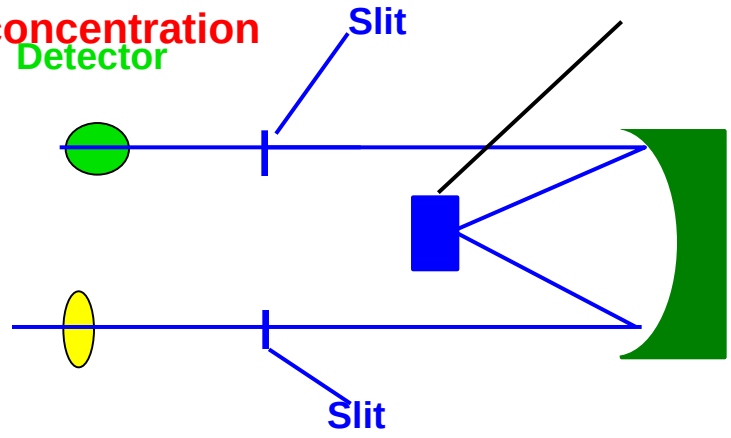


Energy from the plasma promotes an electron to a higher energy level (excitation). Electron falls back and emits light at a characteristic wavelength

Grating driven by motor allows users to scan through the wavelengths

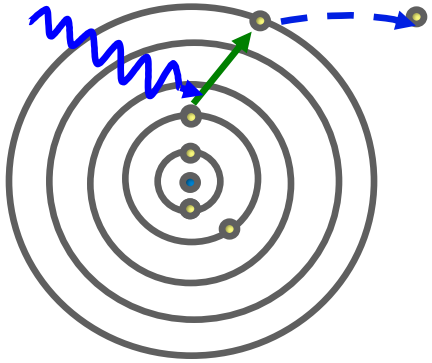
Light emission is proportional to concentration





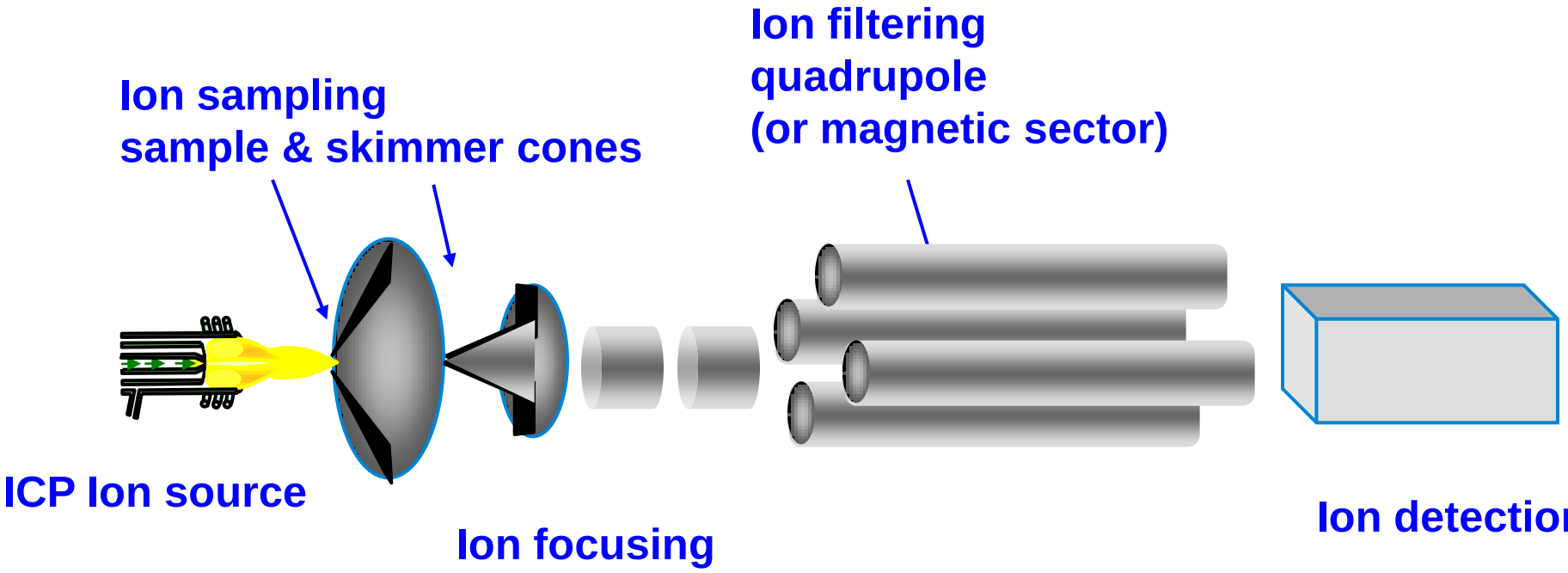
Monochromator system (Sequential type)

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)



Energy from the plasma ejects electron from shell (ionization). The result is a positively charged analyte ion.

Ions are separated by the mass spectrometer and measured. Ions measured are directly proportional to analyte concentration.



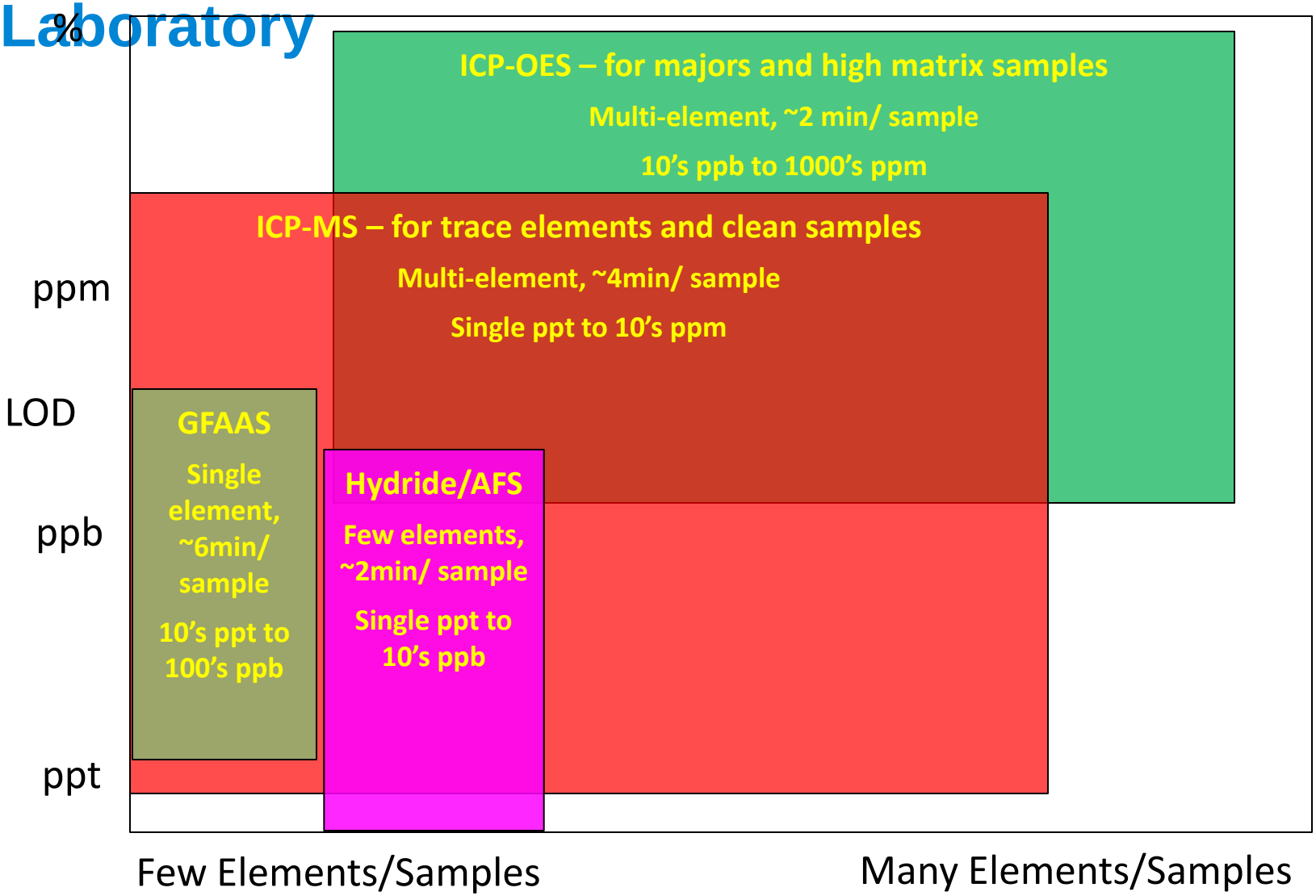
What is ICP-MS?

- **I**nductively **C**oupled **P**lasma **M**ass **S**pectrometry
- **Elemental analysis with:**
  - Wide elemental coverage
  - Very low detection limits
  - Fast analysis times (all elements at once)
  - Wide analytical working range (up to 9 orders)
    - Simple spectra
  - High matrix tolerance
  - Isotopic information

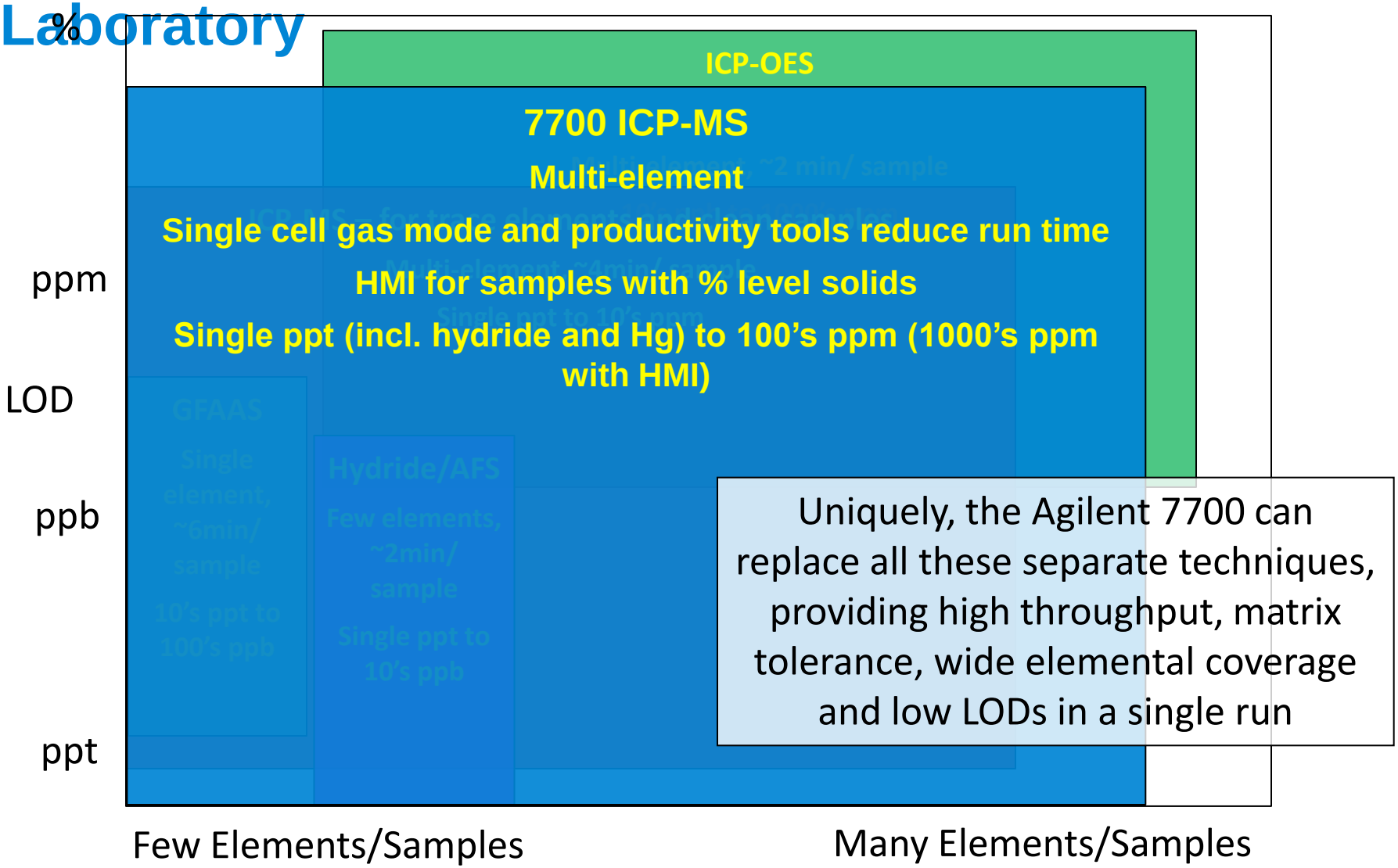
- ⇨ Viable alternative to ICP-OES or GFAAS*

*OES = Optical Emission Spectrometry, GFAAS = Graphite Furnace Atomic Absorption Spectrometry

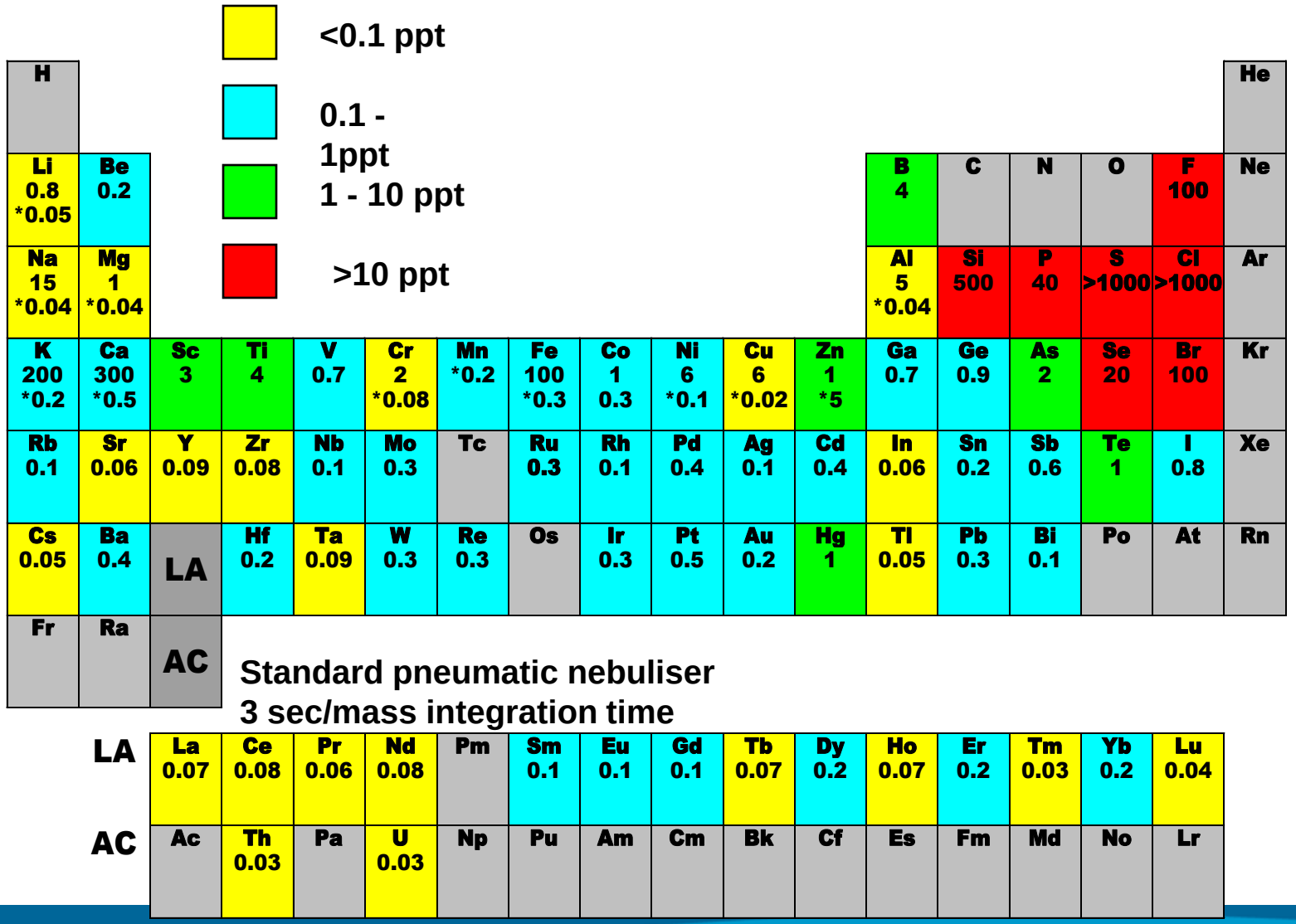
Inorganic Analysis Techniques in a Typical Laboratory



Inorganic Analysis Techniques in a Typical Laboratory

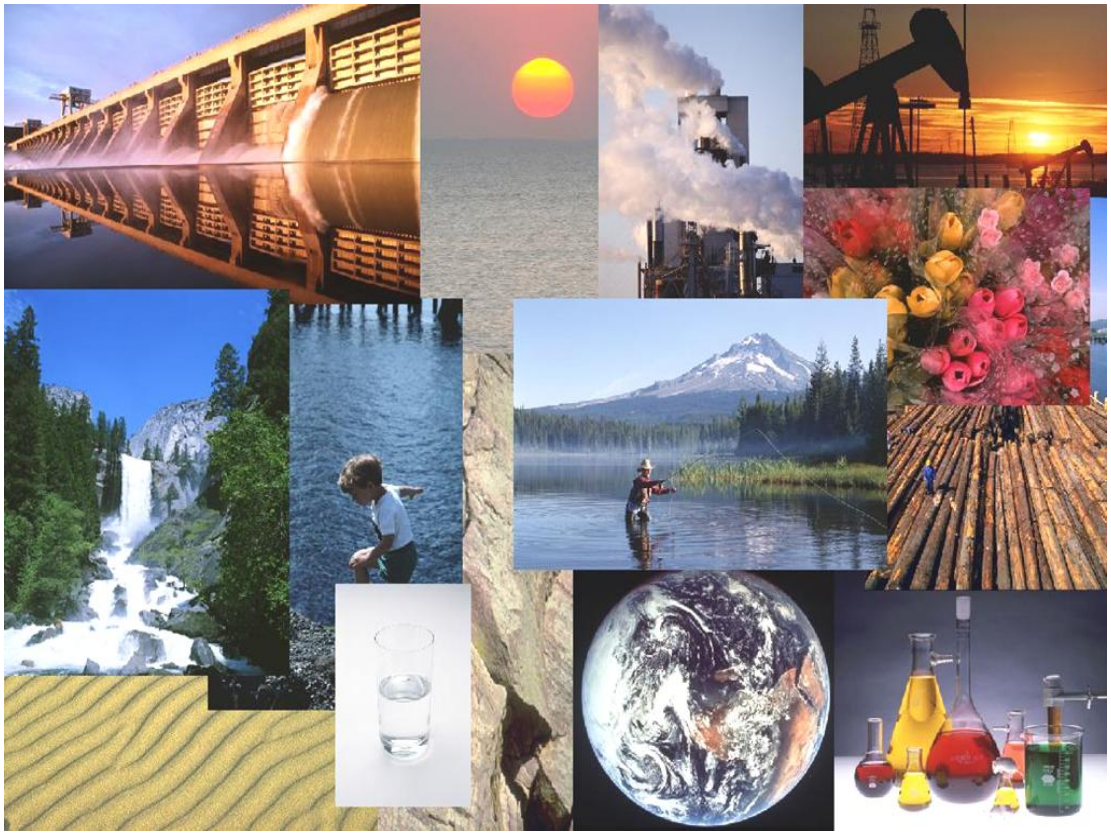


Agilent ICP-MS - 3 Sigma Detection Limits



Inductively Coupled Plasma Mass Spectrometry

- ICP-MS is a fast, multi-element, high sensitivity trace metals analysis technique
- Key applications are:
  - Environmental
  - Foods
  - Semiconductor
  - Clinical
  - Chemical/Petrochemical
  - Pharmaceutical
  - Consumer Goods
  - Forensic
  - Geological
  - Nuclear
  - Academic/Research



- ICP-MS market continues to grow as technology improves and GFAA and ICP-OES instruments are replaced with ICP-MS

7700 Series – New Product Highlights

New ORS^3 Collision/Reaction Cell

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

New RF Generator

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

Increased Matrix Tolerance

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

Much smaller cabinet

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

Simple software; reliable Auto-Tuning

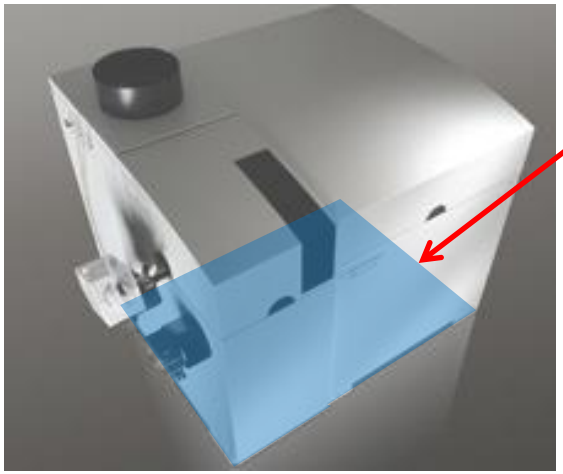
- MassHunter software – intuitive and easy to learn. Pre-set plasma conditions and fast lens auto-tuning

7700 - Smaller Cabinet; Longer Ion Path!!

The 7700 has >30% smaller footprint than any other ICP-MS, but access for maintenance has been improved (all service from front)

Despite much smaller external cabinet size, the ion path of the 7700 is actually 30mm longer than the 7500

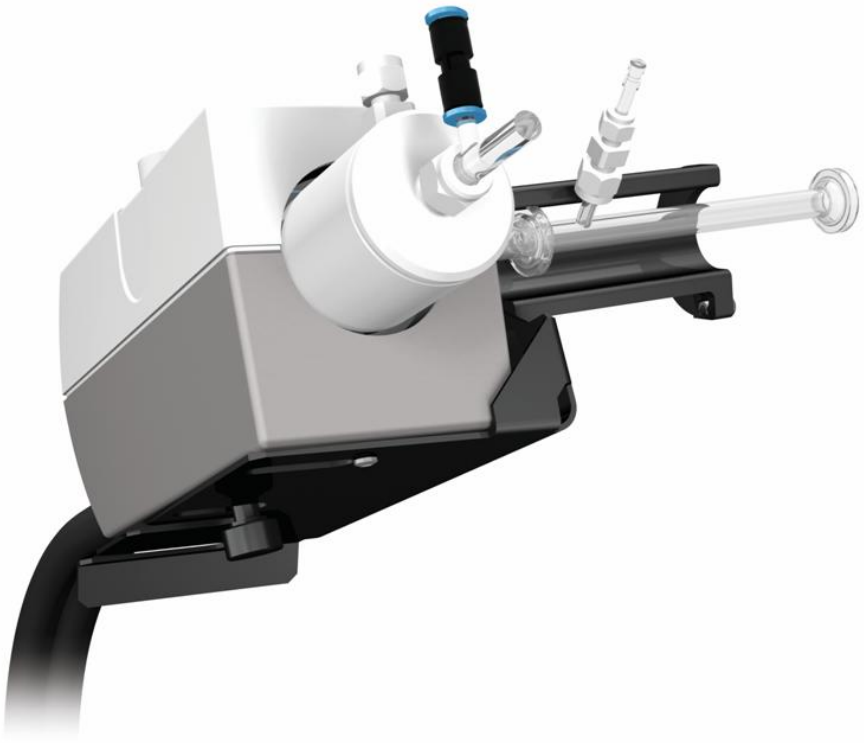
Extra length due to redesigned cell (longer octopole rods) and lens



30% smaller footprint

30mm longer ion path

7700 Series Sample Introduction

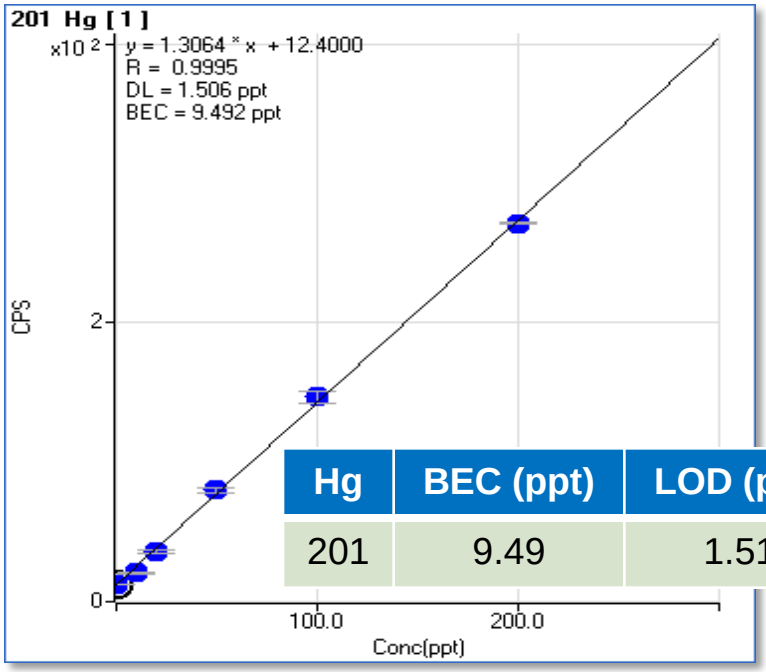


- Low-flow (typically 0.15mL/min)
- Temperature stabilized (Peltier cooled spray chamber)
- Wide Torch Injector ID (2.5mm)
- No O-rings in spray chamber end-cap – reduced risk of contamination
- Auto-alignment of torch after maintenance
- Fast frequency-matching RF generator
- Simple setup, using “pre-set” plasma conditions and auto-tuning

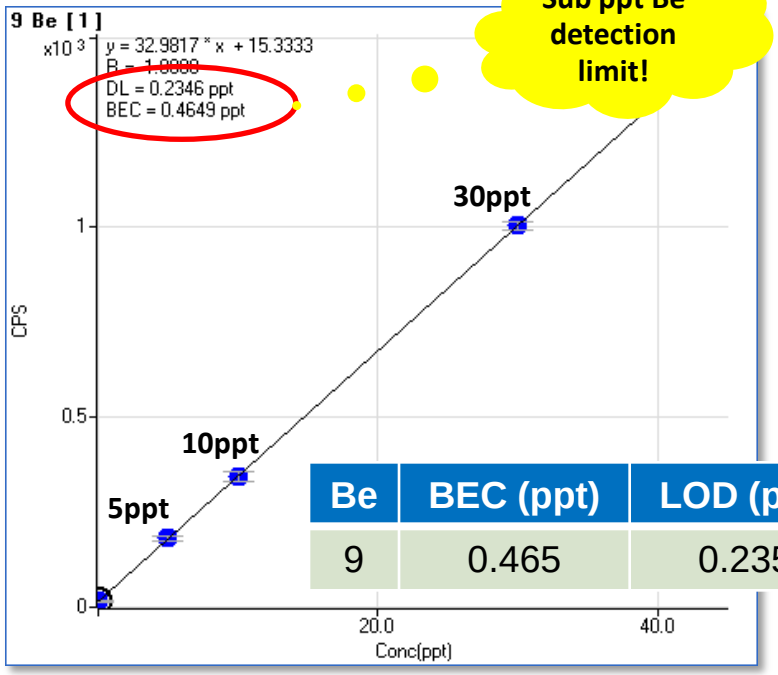
Provides most robust plasma of any ICP-MS under standard conditions

Other Benefits of High Plasma Temp.

- Reducing CeO^+/Ce^+ ratio from 3.0% to 1.0% (3x reduction) removes ~70% of many matrix-based interferences ($ArCl^+$, ClO^+, CaO^+, etc)
- Hotter plasma is less affected by a variable matrix (more robust)
- Better matrix decomposition reduces interface and lens contamination and therefore reduces maintenance
- Hotter plasma improves the ionization of poorly ionized elements, so MUCH lower LODs possible for Be (right), B, As, Se, Cd, Hg (below), etc

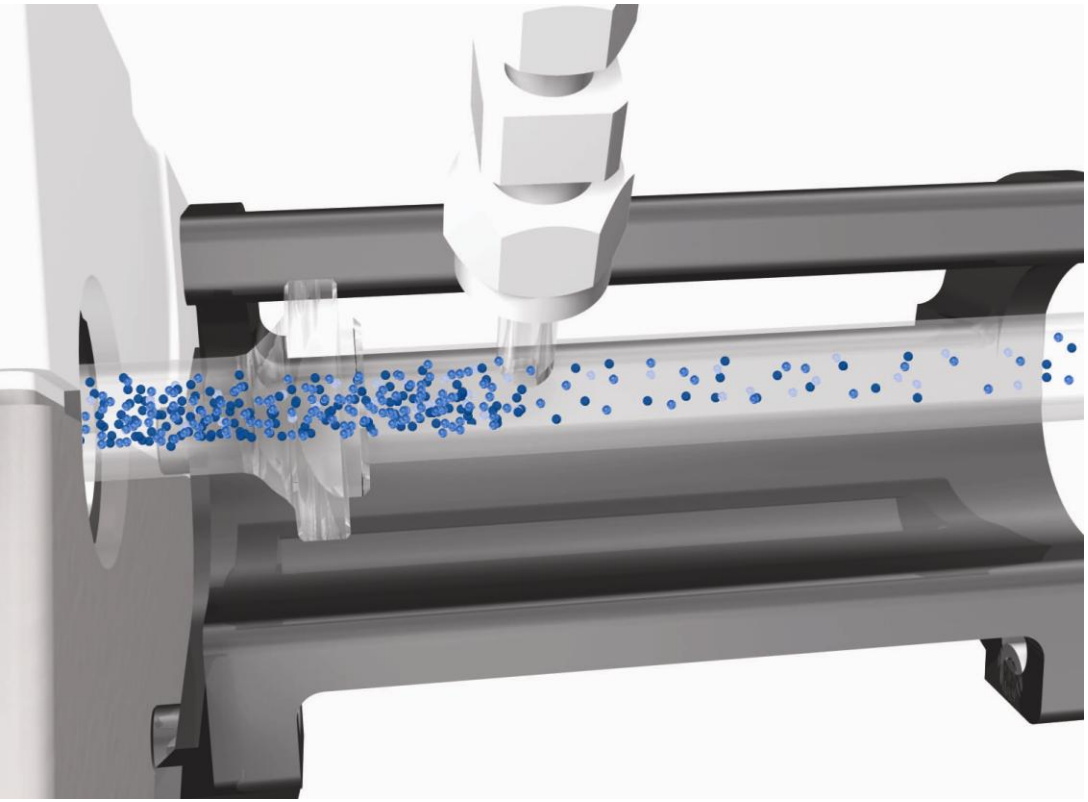


Hg	BEC (ppt)	LOD (ppt)
201	9.49	1.51



Be	BEC (ppt)	LOD (ppt)
9	0.465	0.235

High Matrix Introduction (HMI) – How it Works

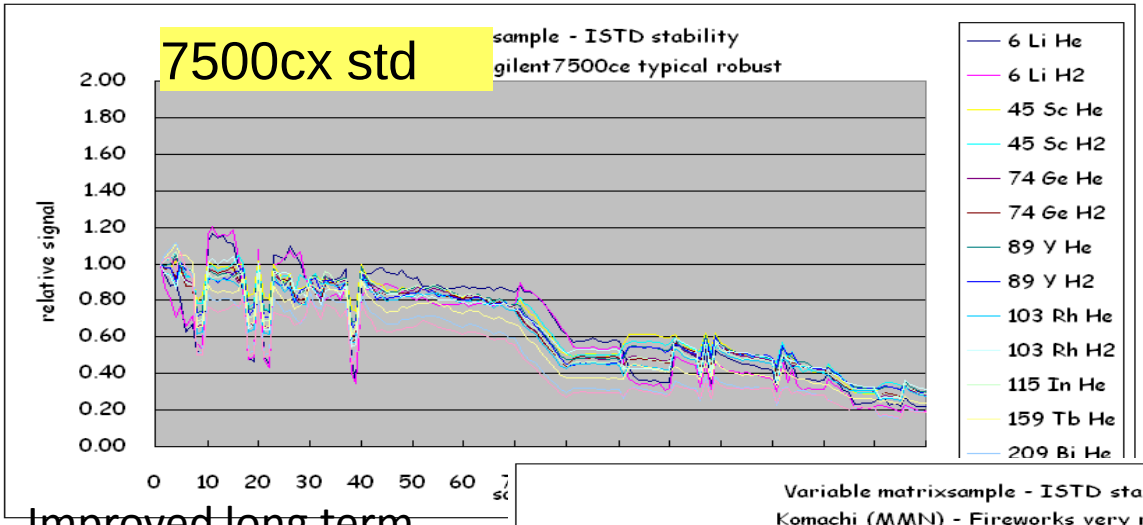


HMI is a sample dilution technique but, uniquely, it dilutes the sample in the gas state, using aerosol dilution.

This removes the main problems of liquid sample dilution:

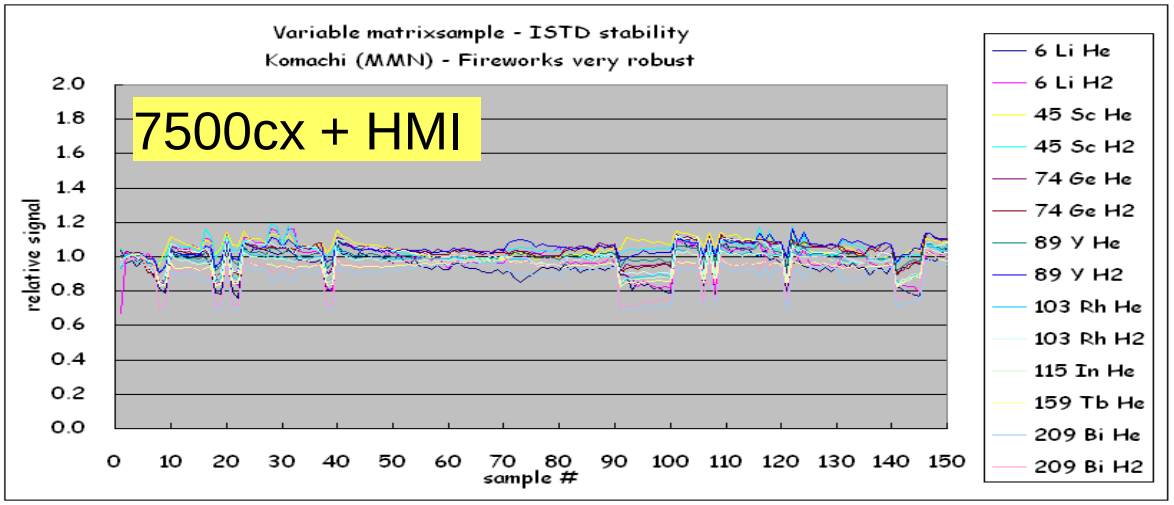
- Time
- Reagents
- Errors
- Contamination

Variable matrix sample – Ground water emulating sample (Vittel, Contrex, 1/5 seawater, ICS and mixed s

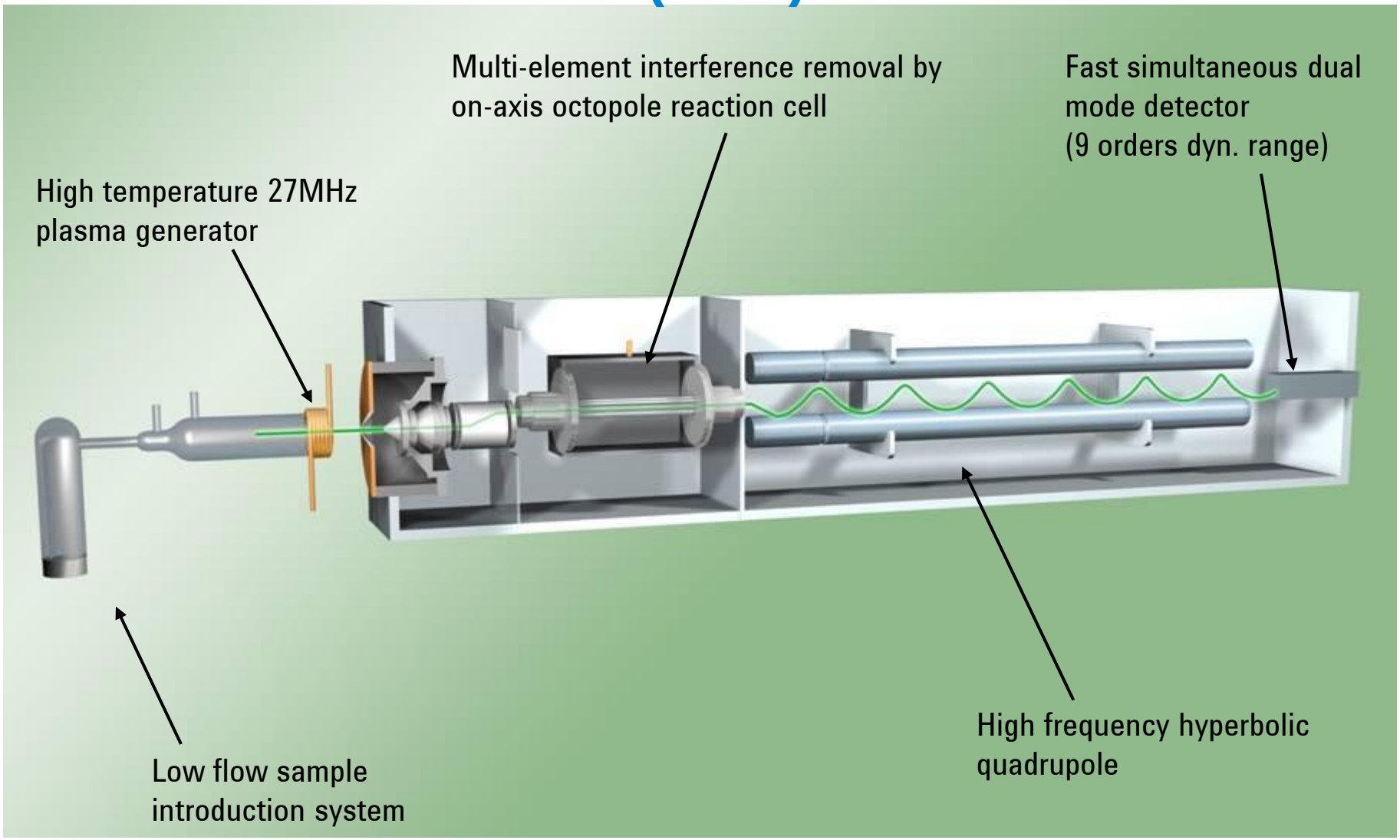


- 7500cx robust tuning
- Severe matrix suppression with some high matrix samples, and relatively high drift

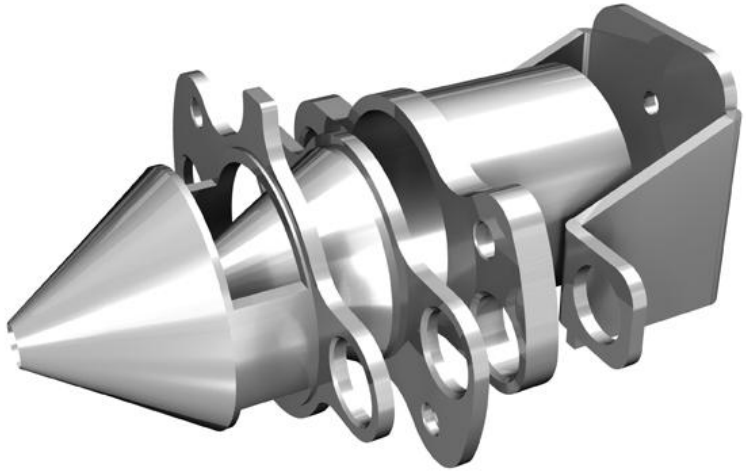
- Improved long term stability with 7500cx and HMI
- Reduced matrix suppression with high-matrix enviro samples



Agilent 7700x ICP-MS System with Collision Reaction Cell (CRC)



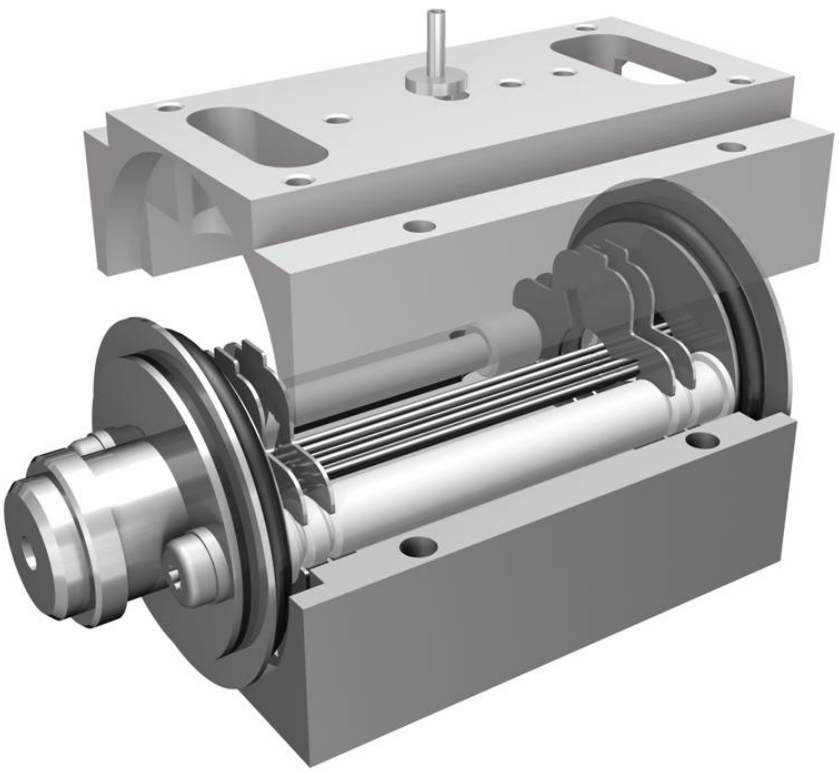
7700 Series Ion Lens



- Ion Lens focuses ions into the cell, and rejects photons and neutrals
- 7700 uses a combined Extraction/Off-axis Lens – located outside high-vacuum region, so easy to access for maintenance
- Provides ideal combination of high transmission across the mass range, low random background, and protection from matrix contamination in the high vacuum region
- No need to set up variable voltages to increase ion transmission at specific masses – all masses are transmitted all the time!

7700 Series has the highest ion transmission across the mass range of any ICP-MS, in standard, matrix tolerant conditions

All New Octopole Reaction System (ORS^3)



The 7700 uses a completely new collision/ reaction cell, with:

- **18% longer rods**
- **15% smaller ID**

and operates at

- **16% higher pressure**
- **20% higher frequency**

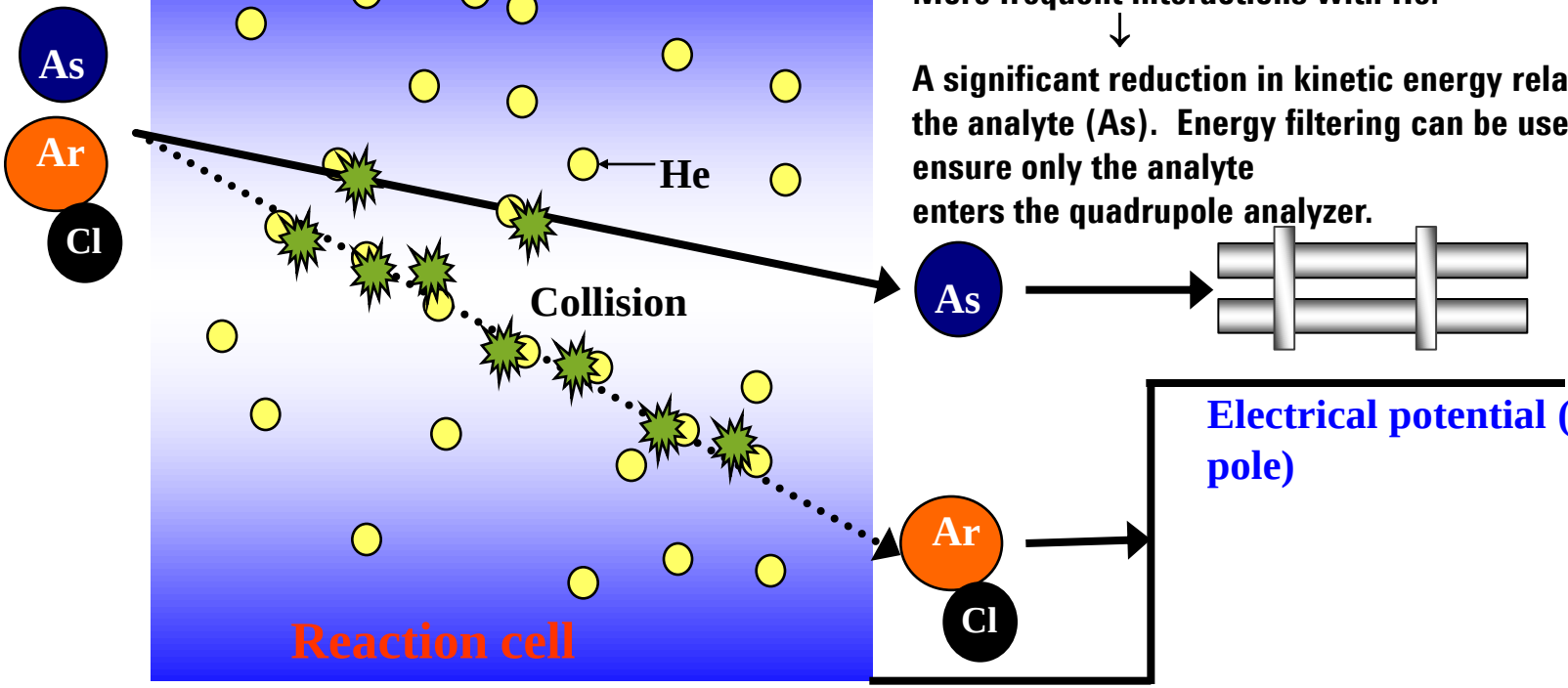
ORS^3 also operates with a much larger energy discrimination step.

Result is **much more effective removal of interferences** in He mode with KED

Major improvement compared to 7500 Series, which already offered by far the best He mode performance of any ICP-MS

Helium interactions in an Octopole Reaction Cell

Collision: Energy discrimination



Molecular interference(ArCl) has larger cross section than the analyte (As).

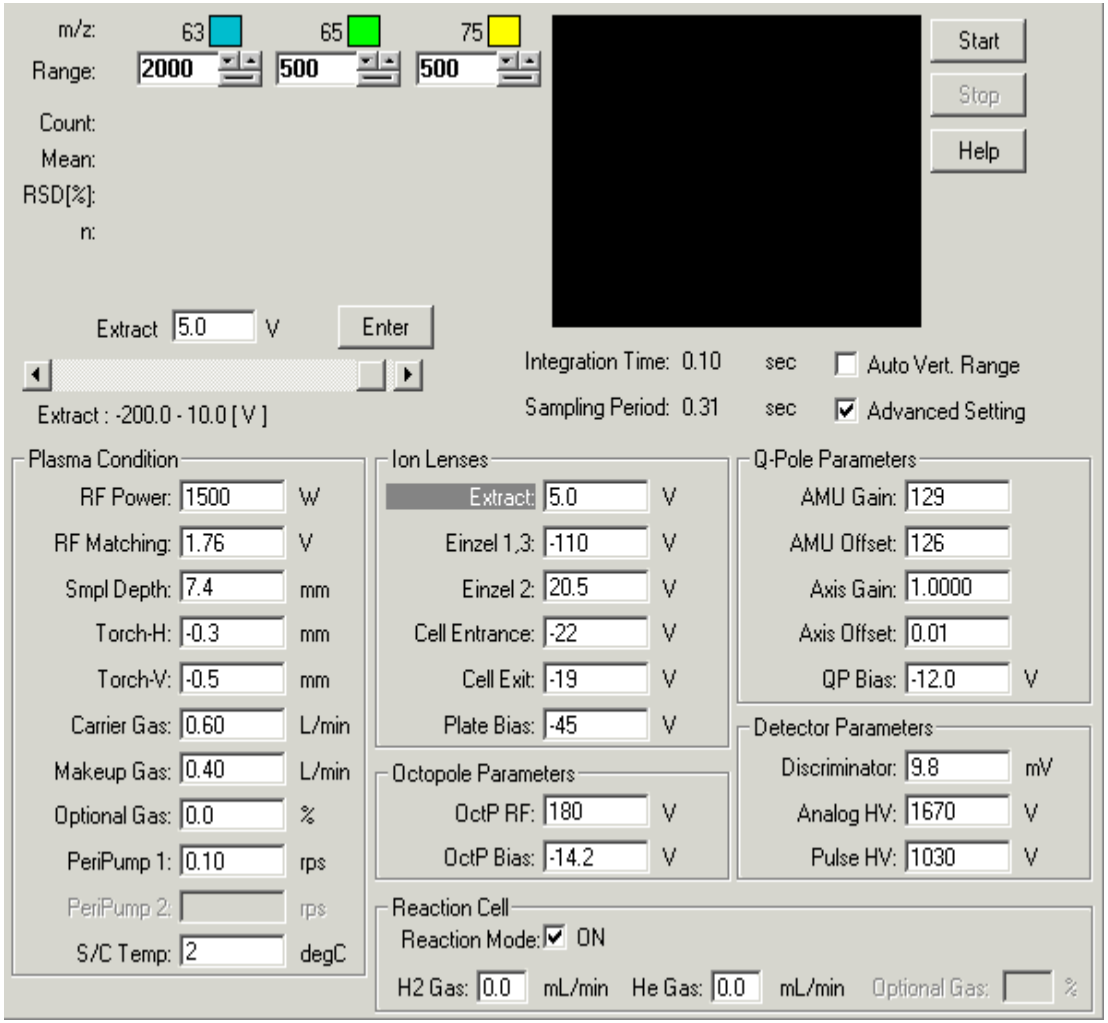
↓

More frequent interactions with He.

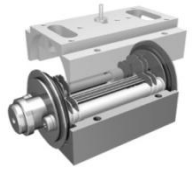
↓

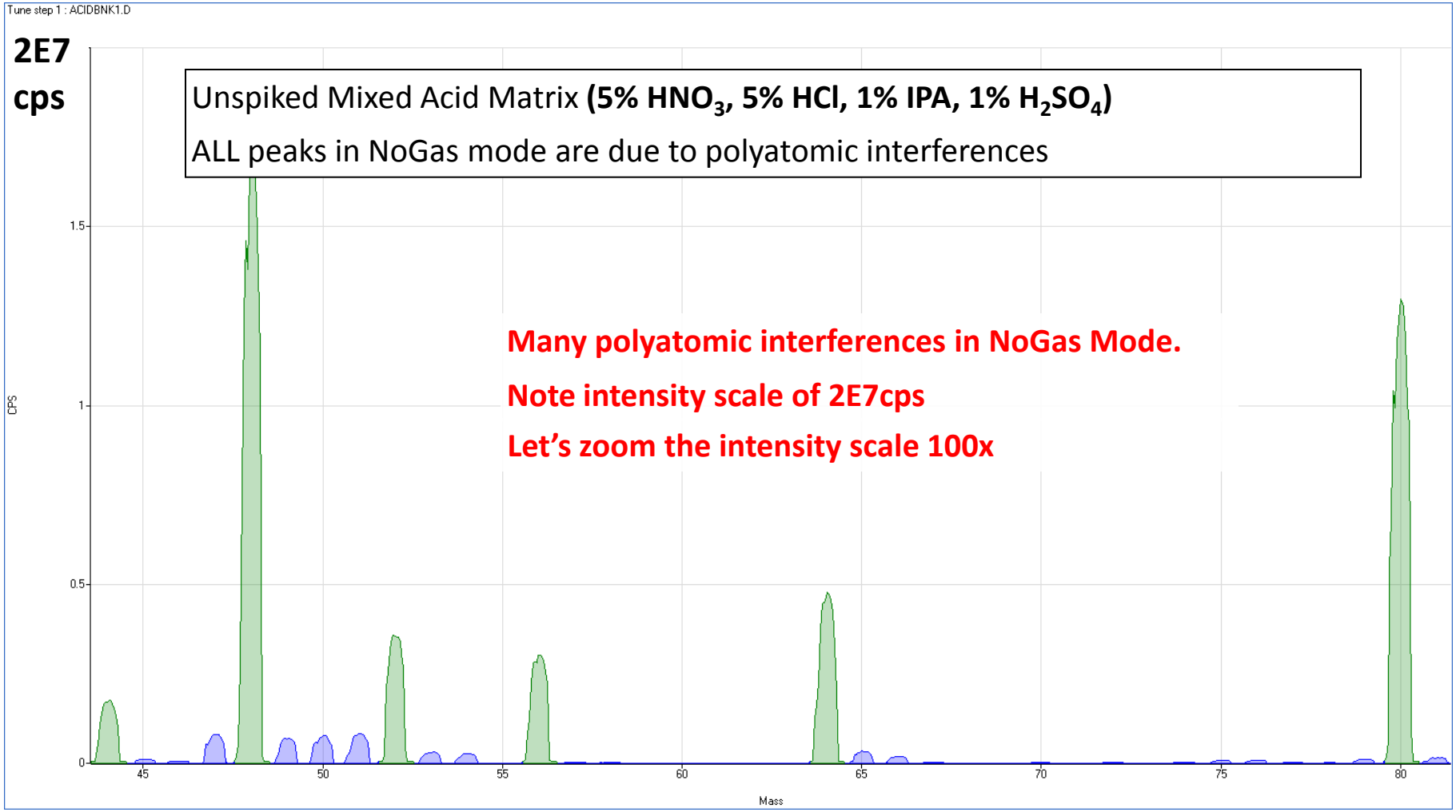
A significant reduction in kinetic energy relative to the analyte (As). Energy filtering can be used to ensure only the analyte enters the quadrupole analyzer.

Helium as a collision gas



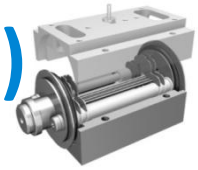
Mixed Acid Matrix in NoGas Mode

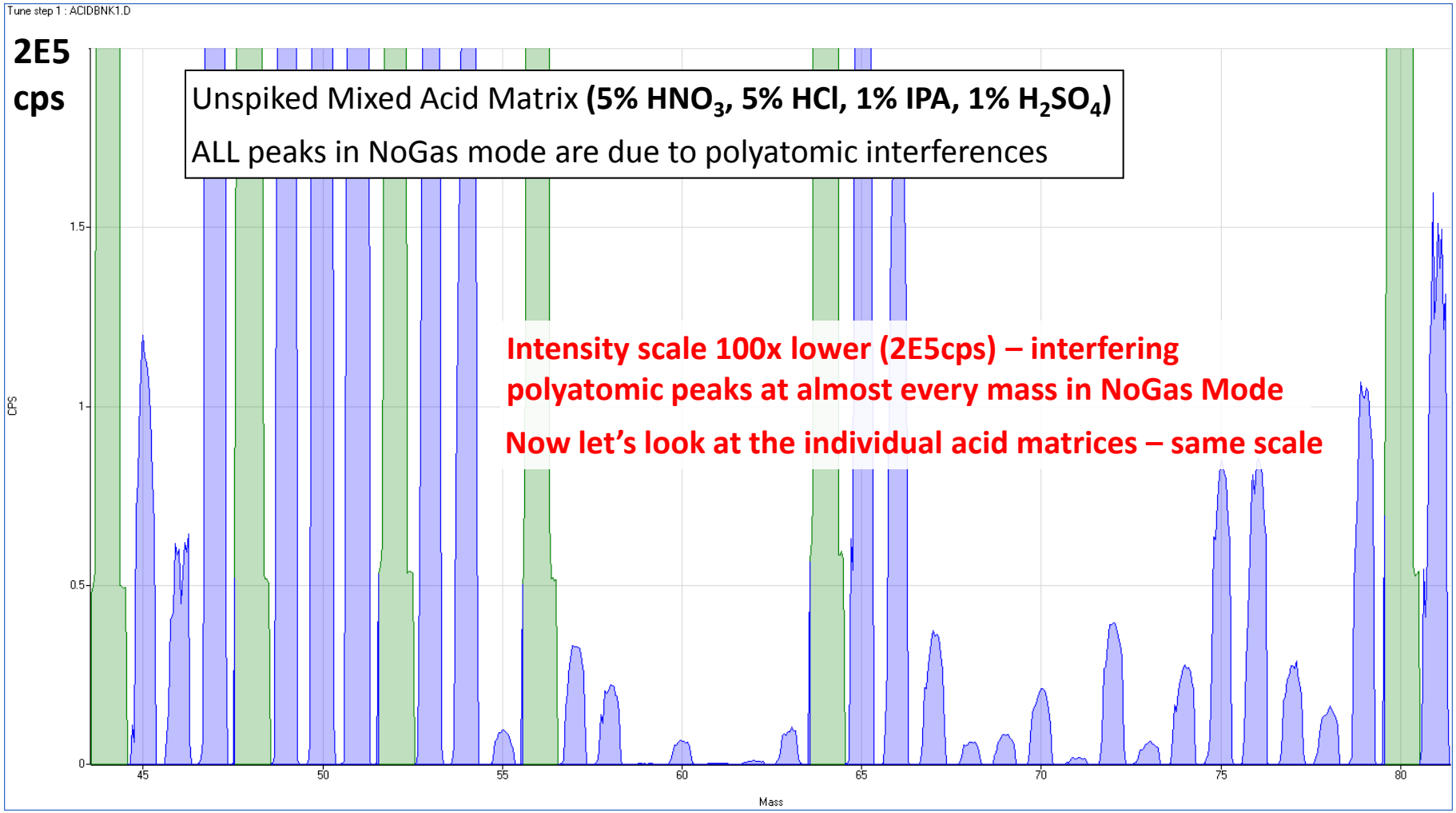




NoGas Mode

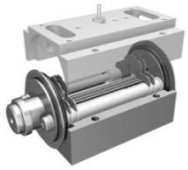
Mixed Acid Matrix in NoGas Mode (100x Zoom)

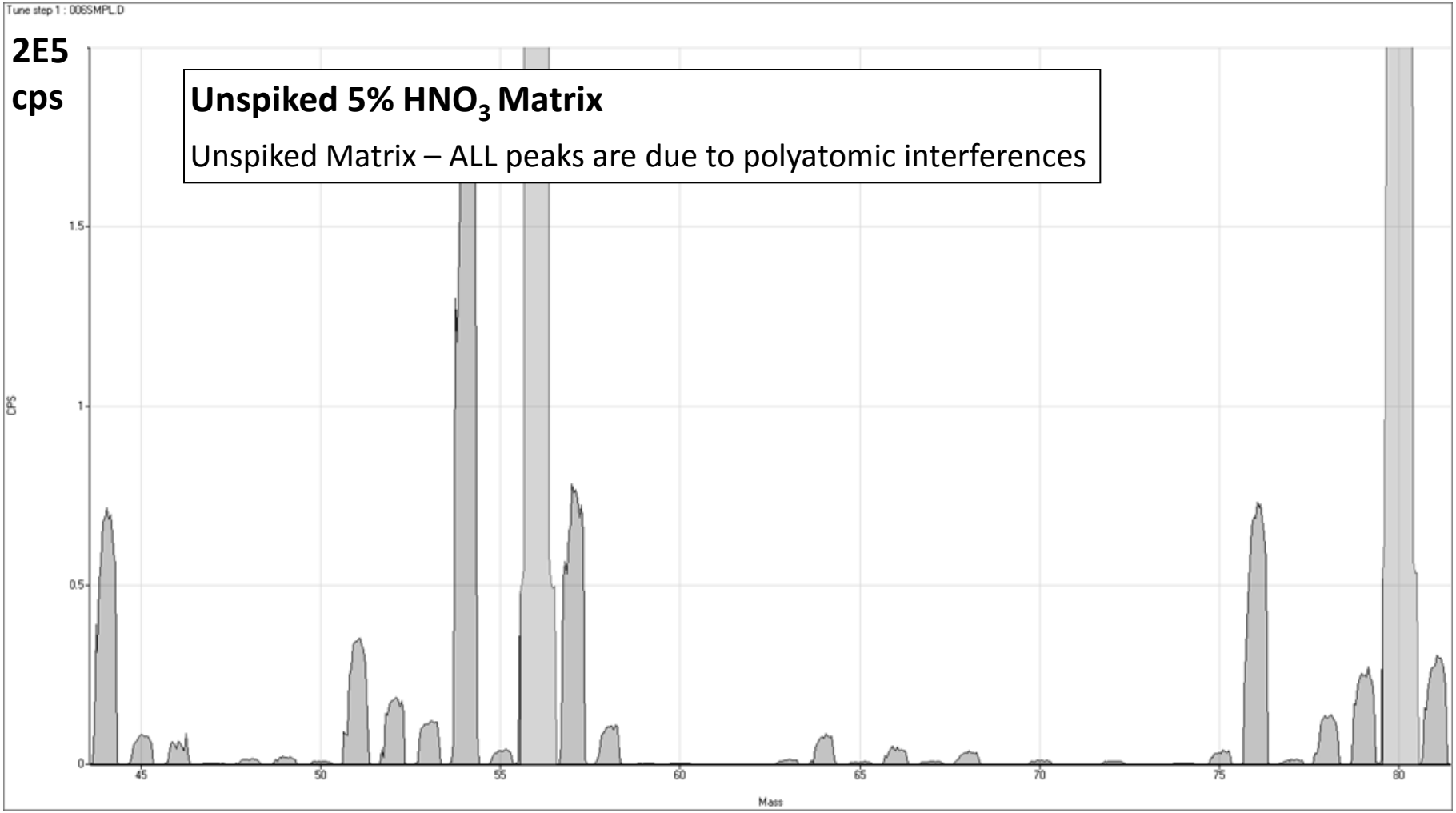




NoGas Mode

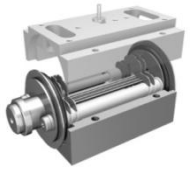
Acid Matrix in NoGas Mode (HNO_3)

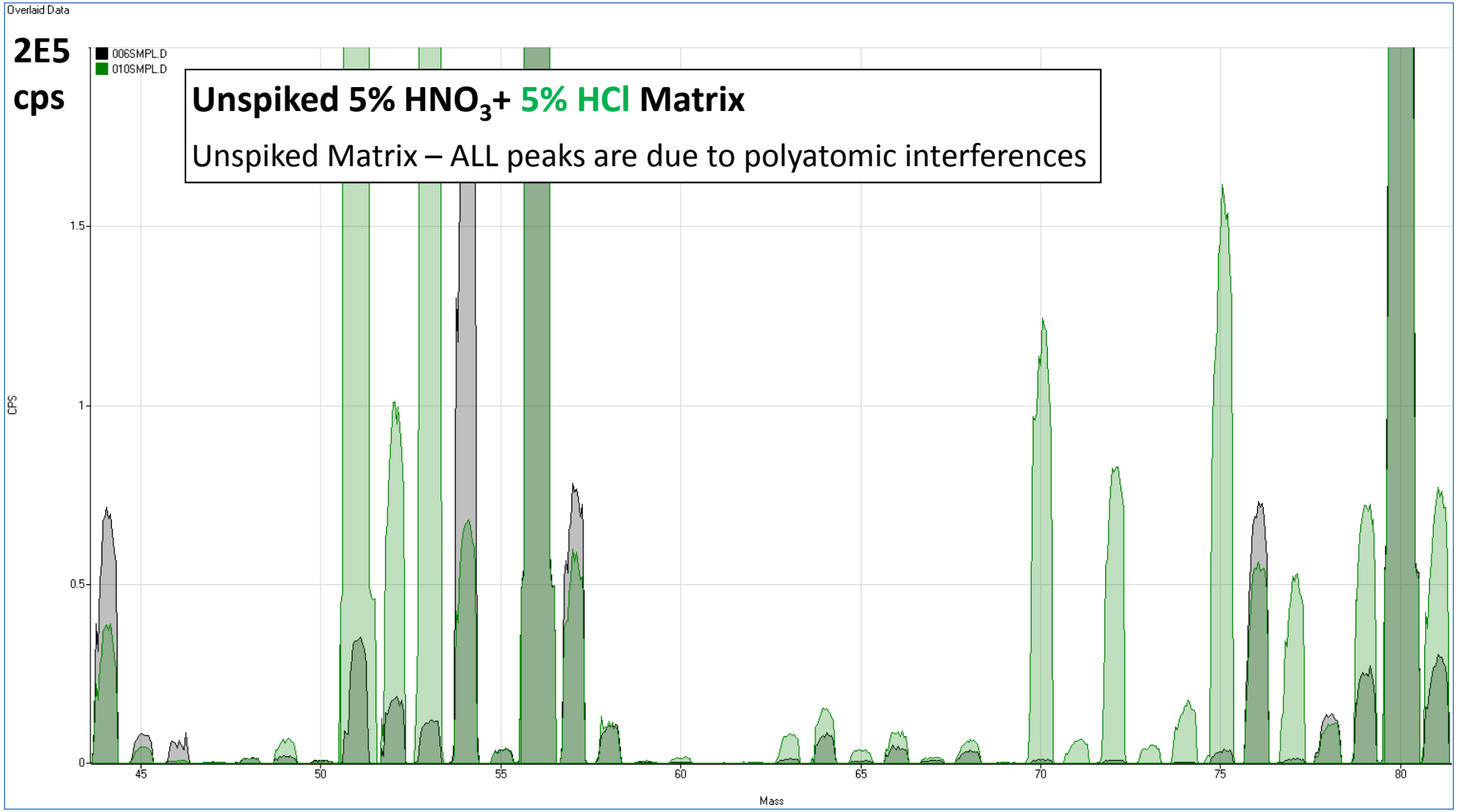




NoGas Mode

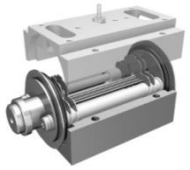
Acid Matrices in NoGas Mode (HNO_3 + HCl)

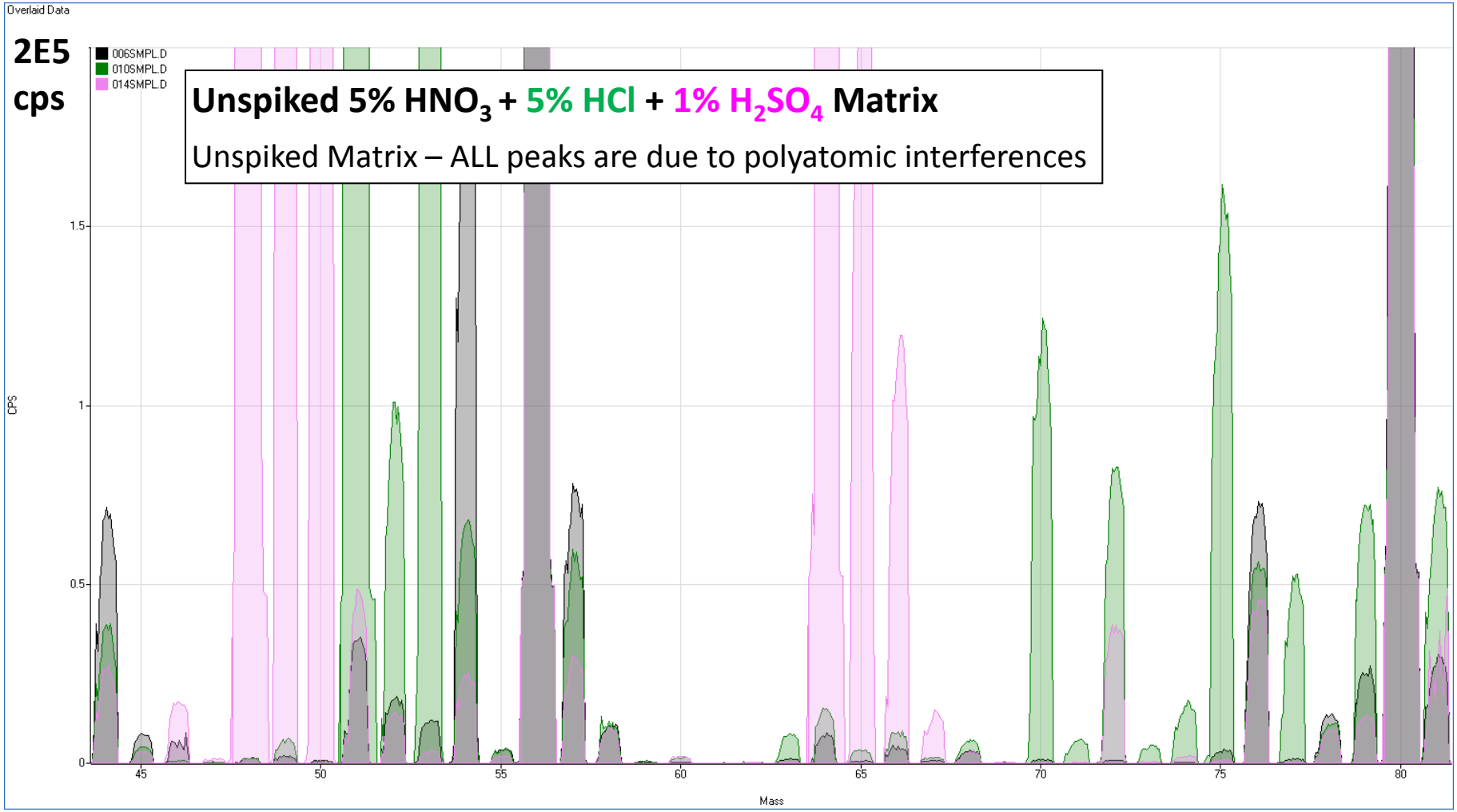




NoGas Mode

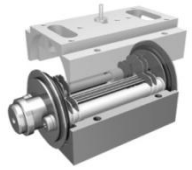
Acid Matrices in NoGas Mode (HNO_3 + HCl + H_2SO_4)

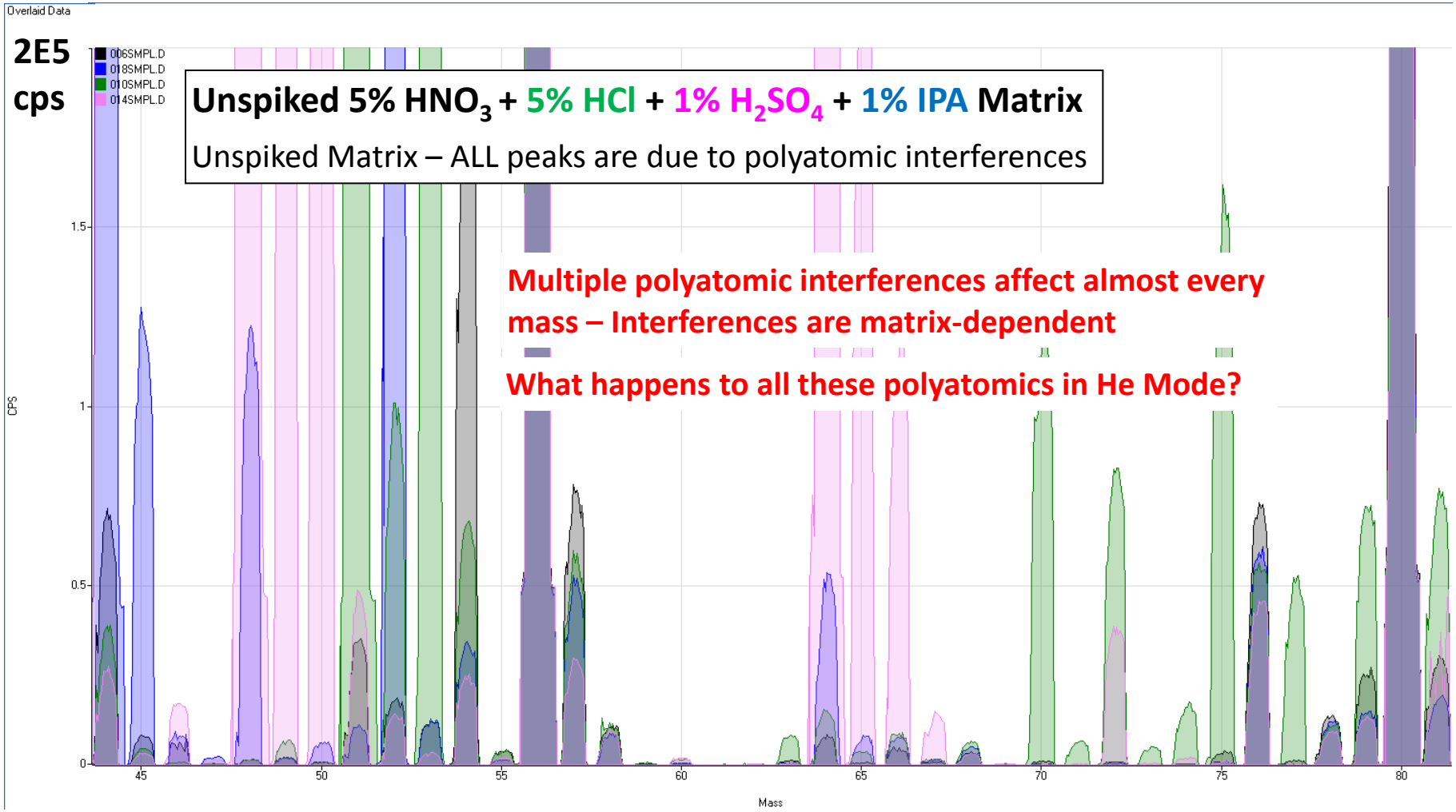




NoGas Mode

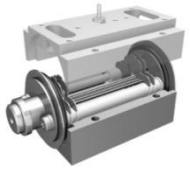
Acid Matrices and IPA in NoGas Mode (HNO_3 + HCl + H_2SO_4 + IPA)

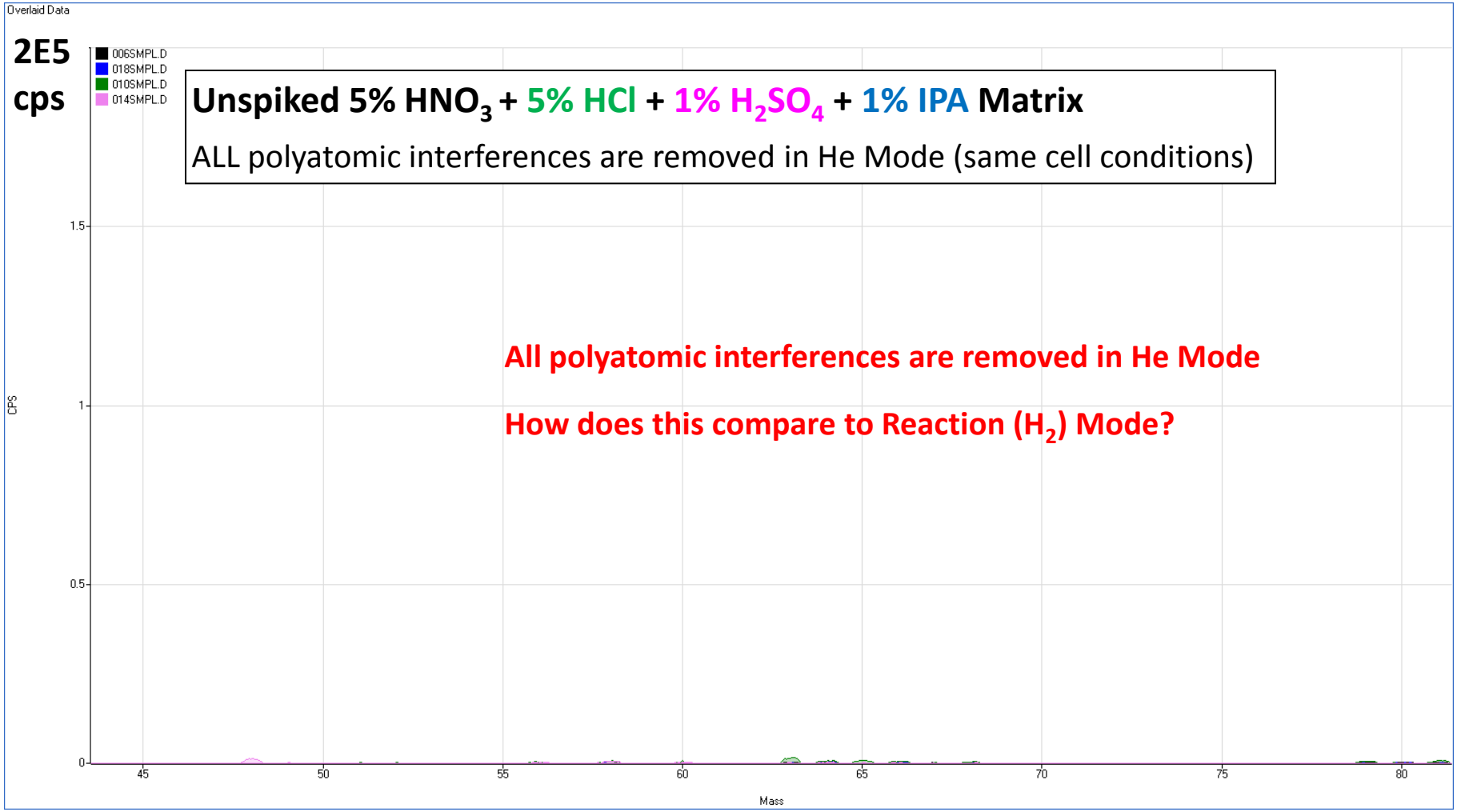




NoGas Mode

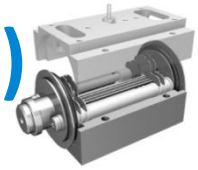
Single Acid Matrices and IPA in He Mode (HNO_3 + HCl + H_2SO_4 + IPA) – same scale as NoGas

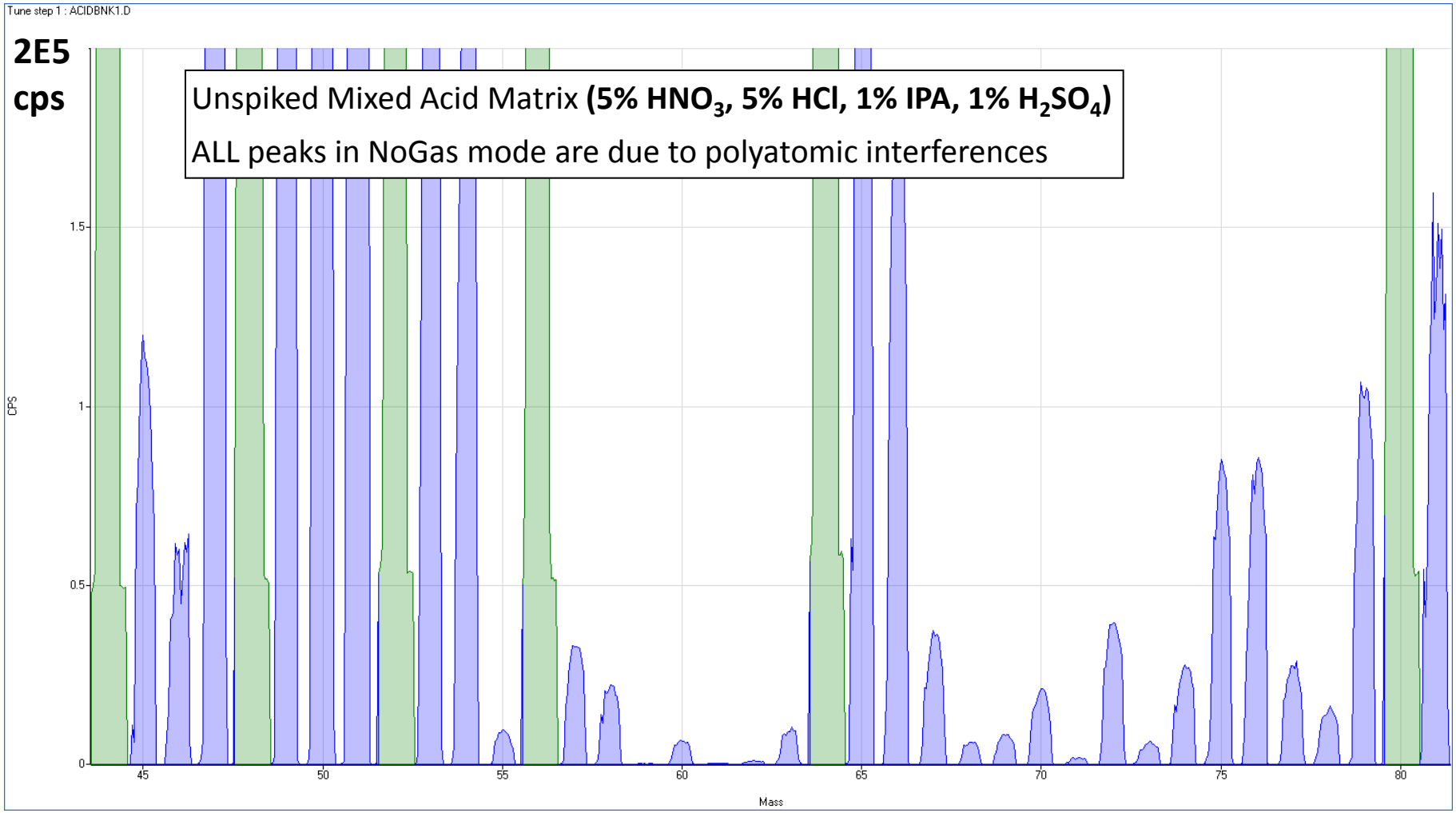




He Mode

Mixed Acid Matrix in NoGas Mode (100x Zoom)

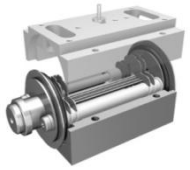


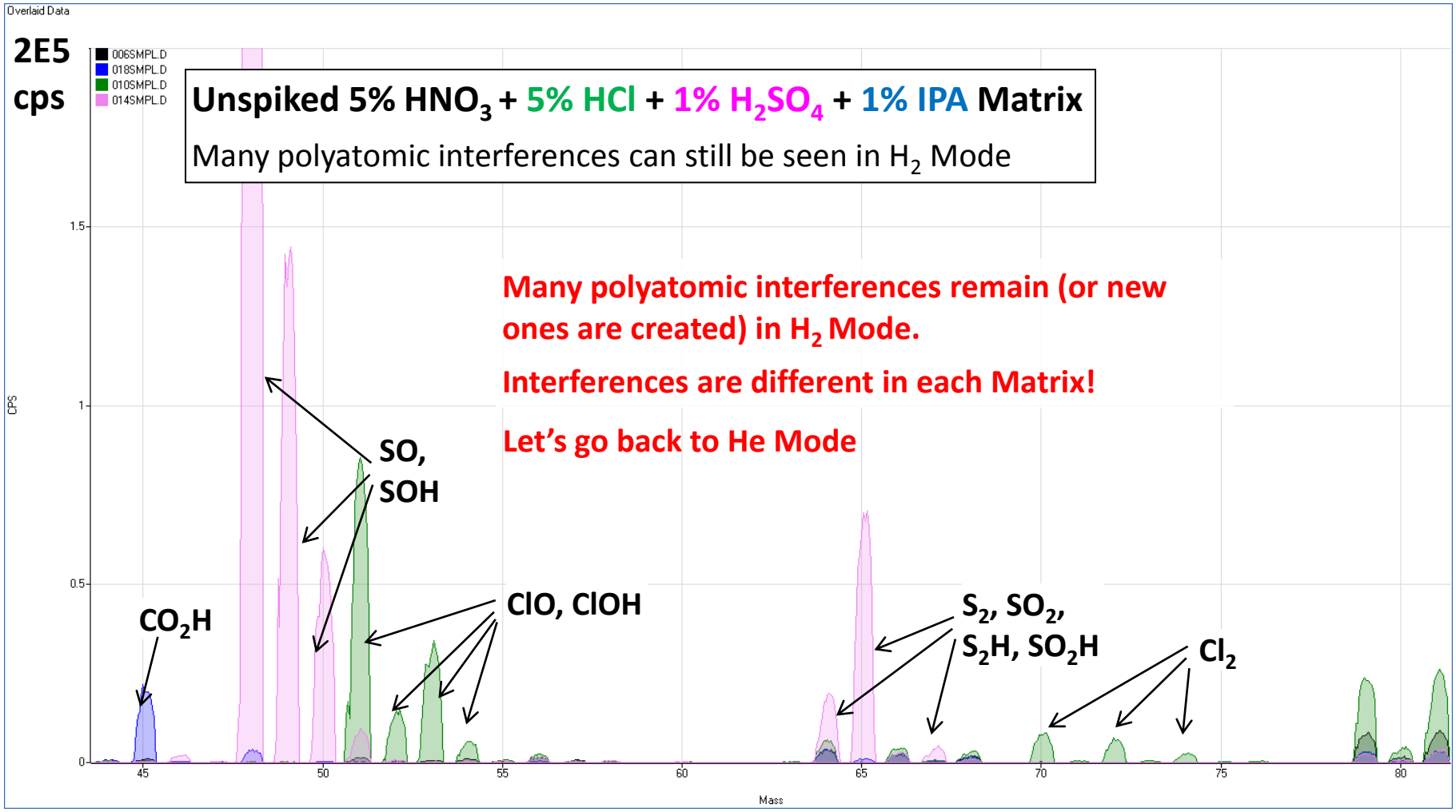


NoGas Mode

Agilent Technologies

Single Acid Matrices and IPA in H_2 Mode (HNO_3 + HCl + H_2SO_4 + IPA) – same scale as NoGas



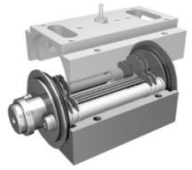


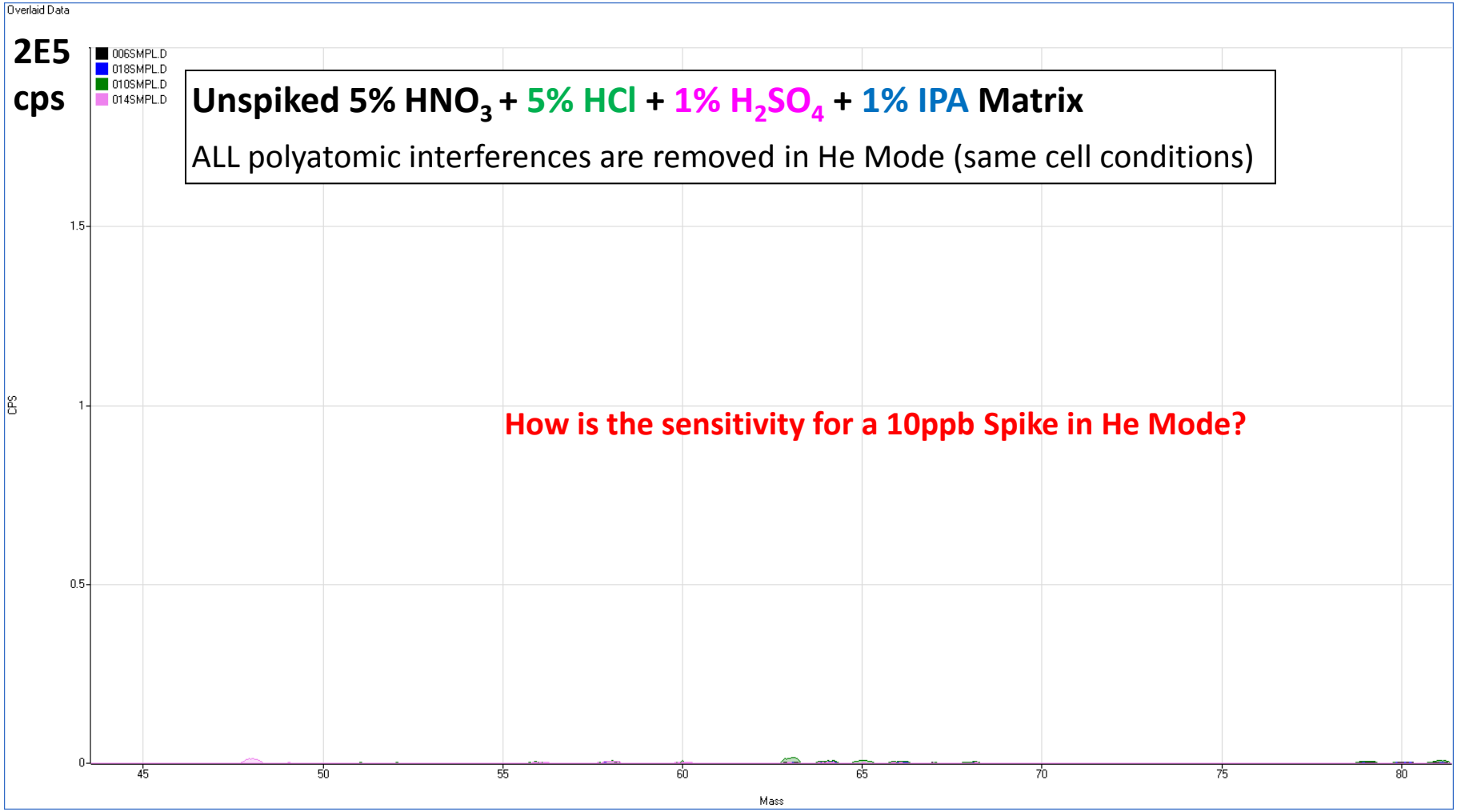
H_2 Mode

Agilent Technologies

Mixed Acid Matrix in He Mode (100x zoom)

Same Scale as NoGas Mode

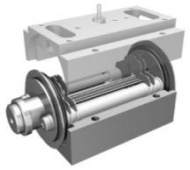


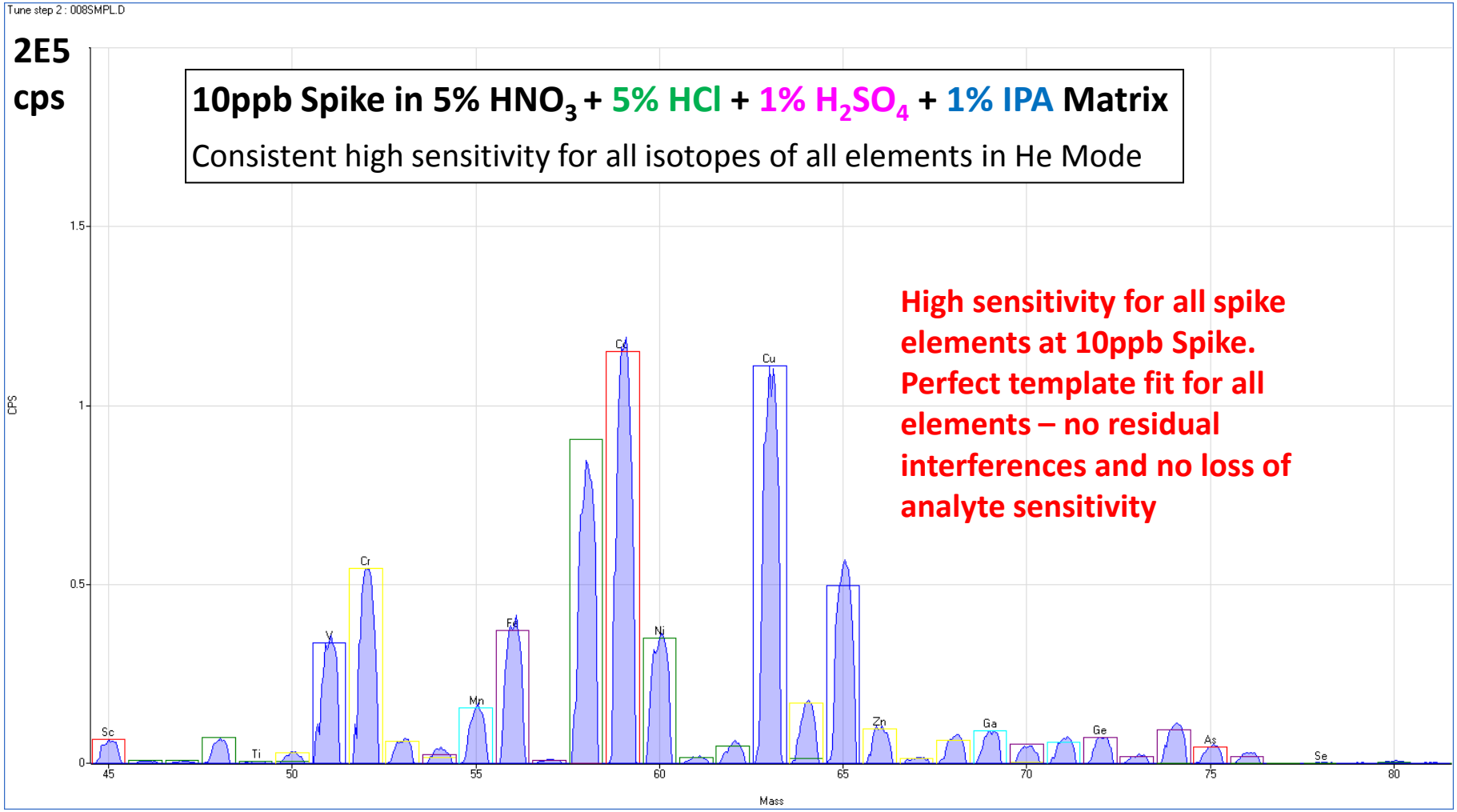


He Mode

Mixed Acid Matrix in He Mode

Consistent sensitivity and perfect template match





He Mode