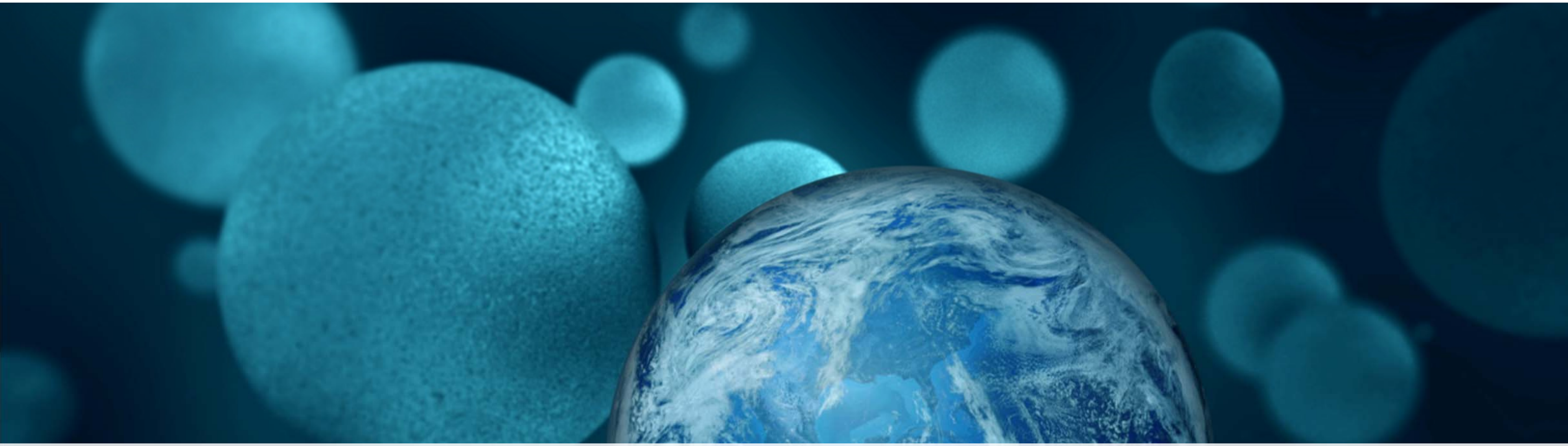

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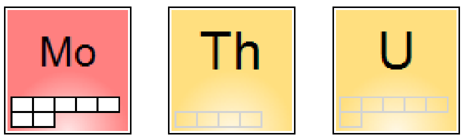
Overcoming the Challenges of Trace Elemental Analysis in Environmental Samples Using ICP-MS

Daniel Kutscher, Fergus Keenan
Thermo Fisher Scientific

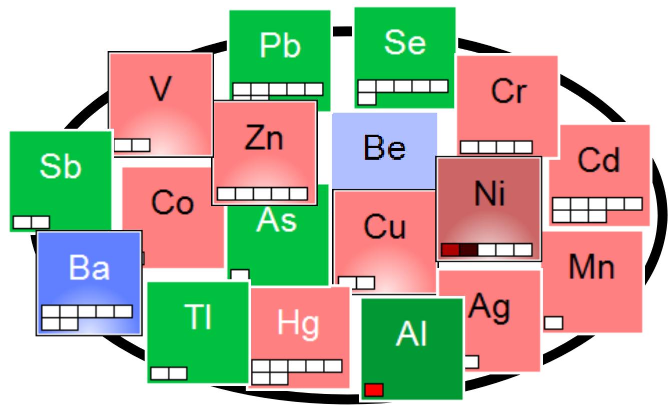
The world leader in serving science

Method Comparison for EPA Method 200.8 and SW846 Method 6020B

EPA 200.8

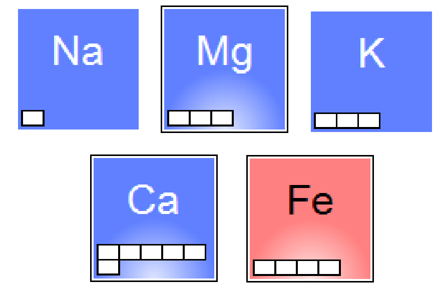


21 elements



18 common elements

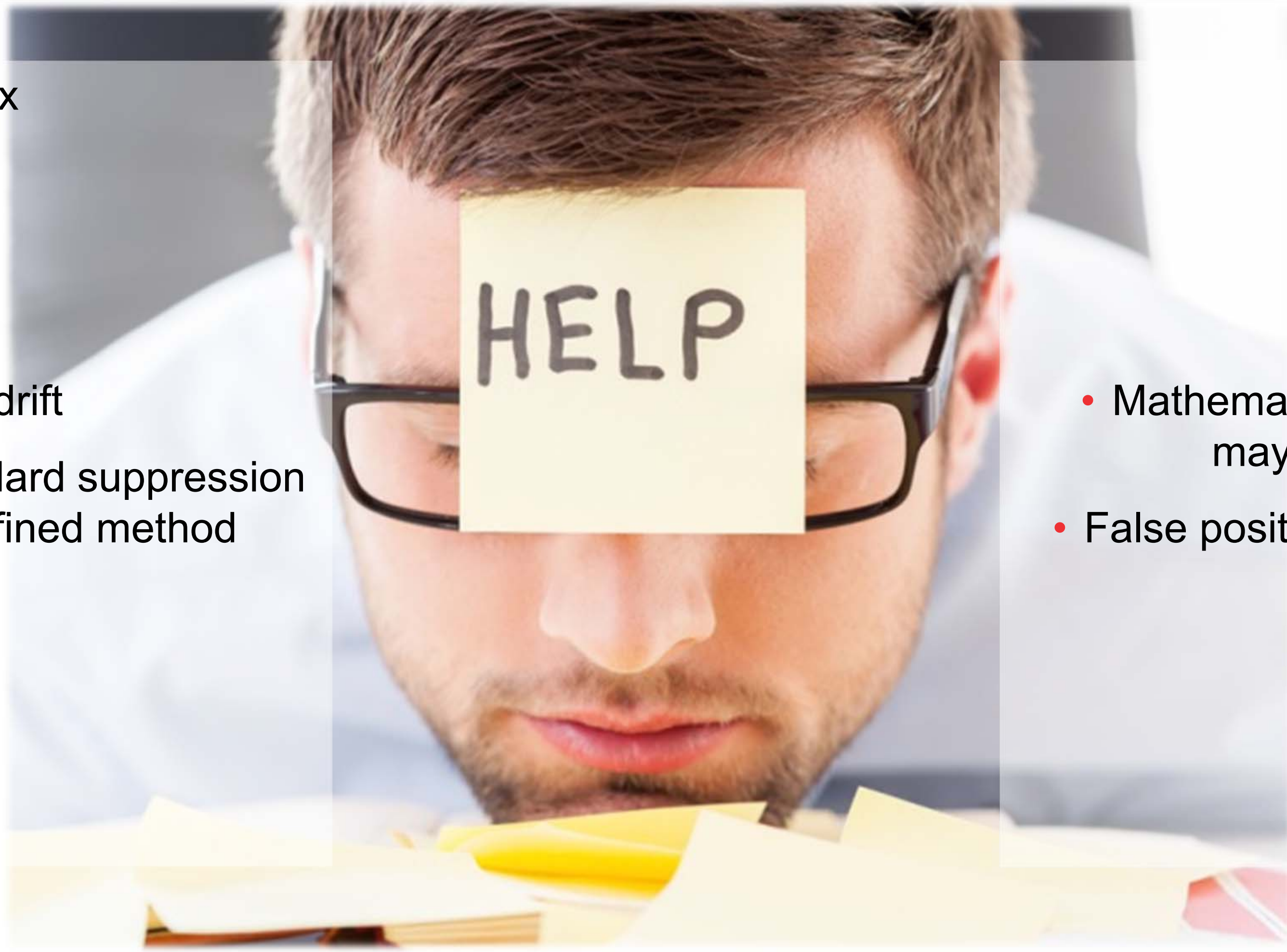
EPA 6020B



23 elements

	Method 200.8 v. 5.4 (1994)	**Method 6020B (2014)**
Applications	Drinking and wastewater	Solid waste and soils and sediments
Method type	Method for regulatory compliance; QC acceptance criteria for lab accreditation	For guidance purpose, performance-based method
Approved Elements	21	23
Collision cell usage	Approved for wastewater, not for drinking water	Approved

Challenges



- Sample Matrix
- Instrumental drift
- Internal standard suppression higher than defined method limits
- Interferences
- Mathematical corrections may amplify errors
- False positive results if not resolved

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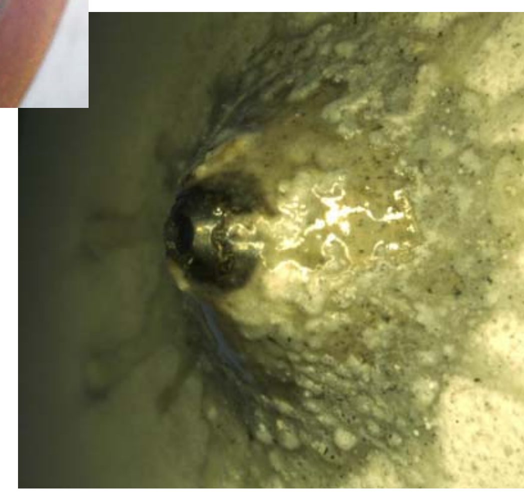
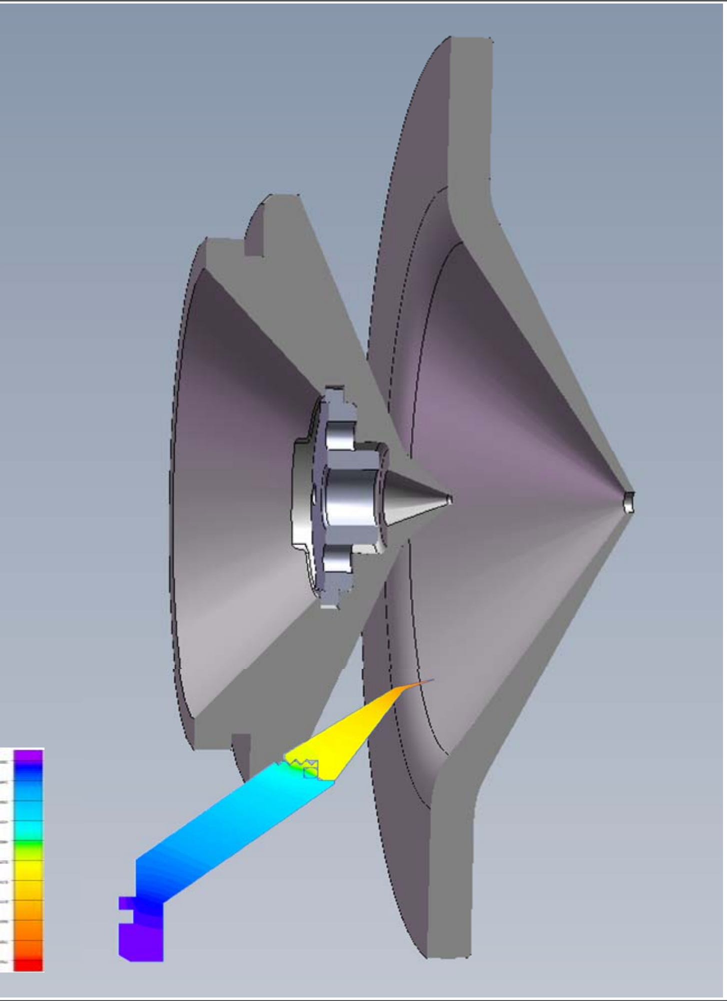
Dissolved Solids in Sample Matrix

- **Dissolved solids deposit onto interface cones**
  - Continued deposition can upset stability of instrument
  - Some sample matrix components deposit more than others
- **Too many ions in ion beam can cause spread of ion beam focusing**
  - Degrades recovery of internal standards
- **Solution – dilute the sample**
  - Dilute the sample to reduce the total matrix present
  - Use an internal standard to correct for changes in ionization, transport, etc.



Customized Interfaces for Maximum Matrix Tolerance

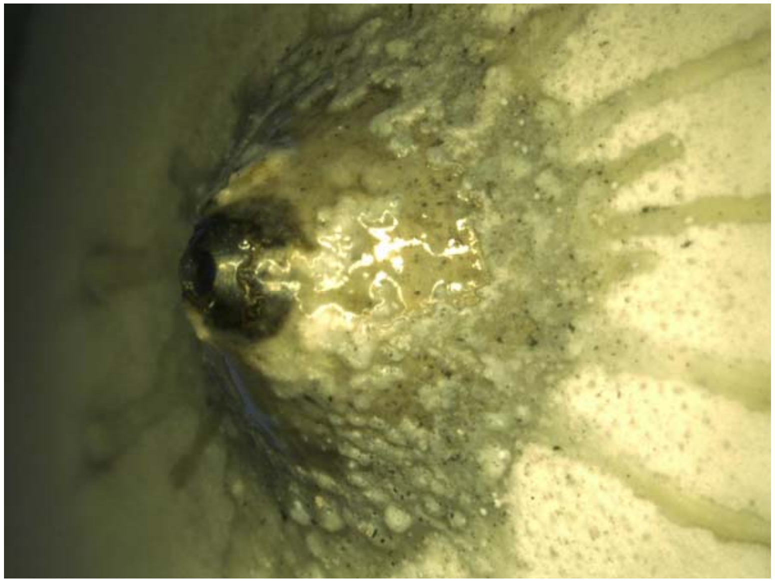


- Development research to model various skimmer cone base and tip temperatures
- Studies indicated:
  - Hotter skimmer cone tip leads to reduced deposition
  - Improved signal stability
  - Reduced cleaning/maintenance frequency

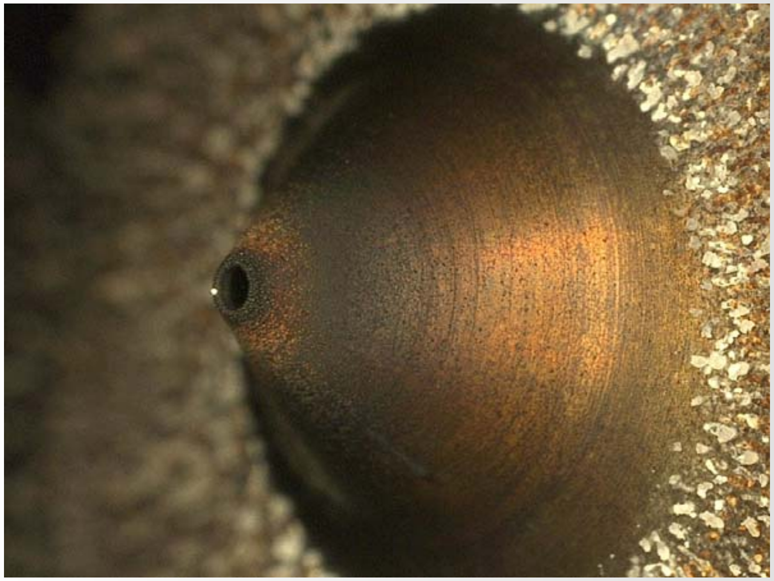
		
Robust 4.5 mm	High Matrix 3.5 mm	High Sensitivity 2.8 mm

Improved Matrix Tolerance

- Analysis of seawater samples diluted 1:10
  - 10 hours of continuous analysis
  - Data collected using standard and iCAP RQ skimmer cones for comparison



- Standard Skimmer Cone



- iCAP RQ Skimmer Cone

Handling Matrix – Customized Interfaces for Maximum Flexibility

DRIVEN BY QTEGRA ISDS

Unique interface designed for maximum coverage of sensitivity and dynamic range:

			
High Sensitivity 2.8 mm	High Matrix 3.5 mm	Robust 4.5 mm	Argon Gas Dilution

STDS	**STD**	**STDR**	**STD AGD**
KEDS	KED	KEDR	KED AGD
CCTS	CCT	CCTR	CCT AGD

Easily implemented through dedicated grouping and autotunes in the software

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He KED Performance – Precision and Sensitivity in High Matrix Samples

- Continuous high throughput analysis of brine samples
- Sample matrices contained 25% NaCl
- Sub-ppb DLs for 22 analytes and 5 internal standards
- Precision of all measurements ≤ 5%

Isotope	Detecton Limit (µg/L)	Measurement Precision (%RSD)
^{9}Be	0.56	5.3
^{52}Cr	0.61	2.2
^{55}Mn	0.38	3.1
^{56}Fe	0.42	2.5
^{59}Co	0.12	2.0
^{65}Cu	0.82	2.1
^{75}As	0.25	1.9
^{77}Se	0.55	5.3
^{88}Sr	0.09	2.2
^{111}Cd	0.05	2.4
^{137}Ba	0.14	2.6
^{202}Pb	0.14	4.2
^{208}Pb	0.04	1.8

Matrix Handling – Auto-dilution

- Supported by Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software

- Automated ***prescriptive*** dilution for preparation of:
  - Samples
  - Standards
- Automated ***intelligent*** dilution:
  - Internal standard range auto-dilution
  - Over calibration range auto-dilution

ESI
prep*FAST*

TELEDYNE CETAC SDX_{HPLD}

- Close coupling of the discrete sampling valves to ICP for minimized uptake and washout – increases throughput and reduces contamination

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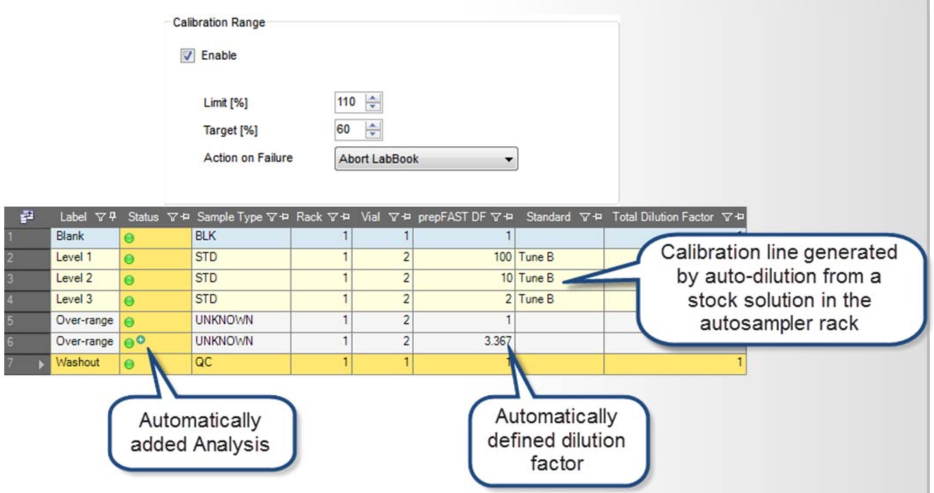
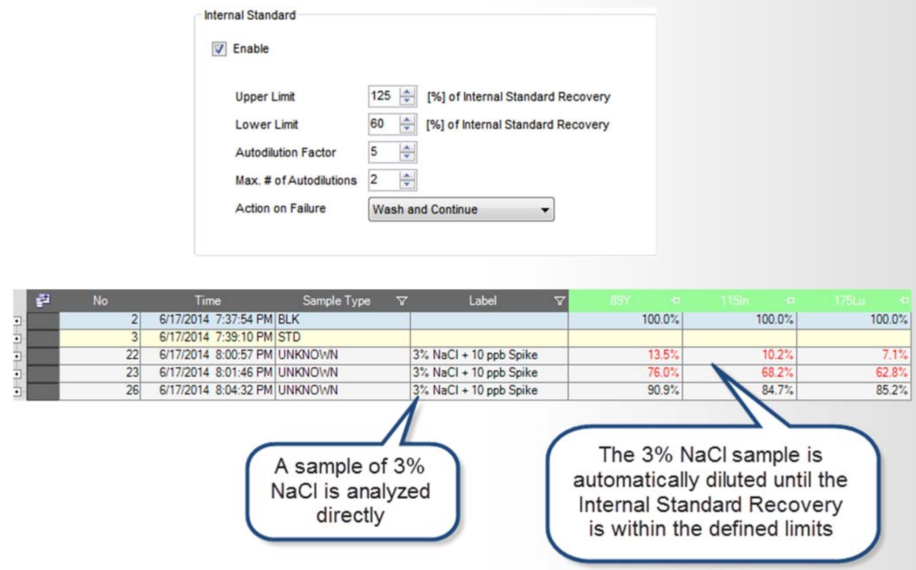
Matrix Handling - Intelligent Auto-dilution

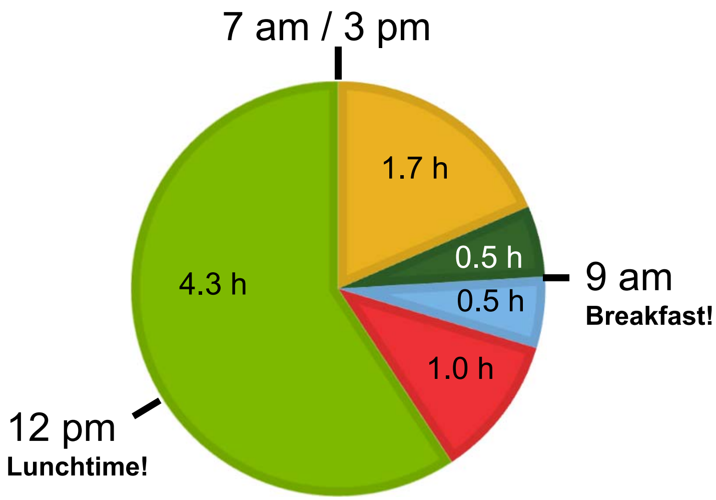
- Calibration Over-Range
  - User defines:
    - The maximum calibration limit as a percentage of the top calibration standard, e.g. 110%
    - The target concentration of the analyte after auto-dilution



- Internal Standard Recovery
  - User defines:
    - The range of acceptable Internal Standard Recovery, e.g. 60 - 125%
    - The auto-dilution factor step and # of possible dilutions



A Typical Day in the Busy Lab without Auto-dilution

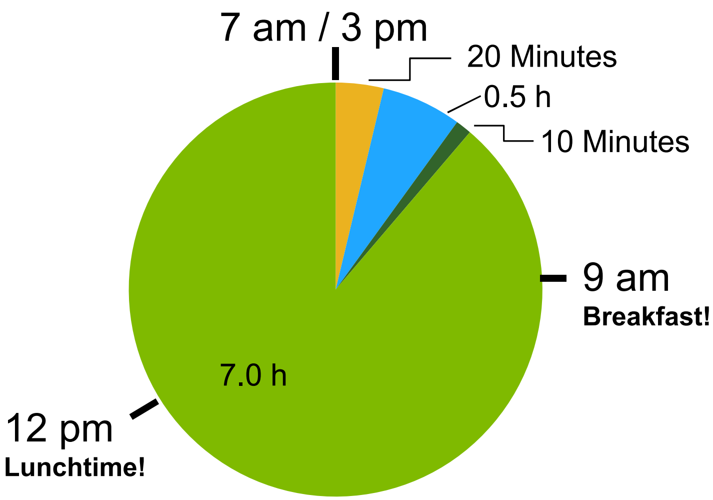


Action	Time	#	Total
Dilution	20s / sample	300	1.7 h
Preparation of Calibration/QC solutions	30 Minutes		0.5 h
Performance Verification	30 Minutes		0.5 h
Re-run failed samples	2 minutes	10%	1.0 h
Remaining Time			4.3 h

Improvement Opportunities:

- Operator time wasted for simple tasks
- Risk of contamination
- Manual interaction may be error prone

A Typical Day in the Busy Lab with Auto-dilution



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Re-run failed samples	2 minutes	10%	1.0 h
Remaining Time			4.3 h

Improvement Opportunities:

- Operator time wasted for simple tasks
- Risk of contamination
- Manual interaction may be error prone

Gain: 3 h Operator time per day!

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EPA Method 6020 B using SQ-ICP-MS

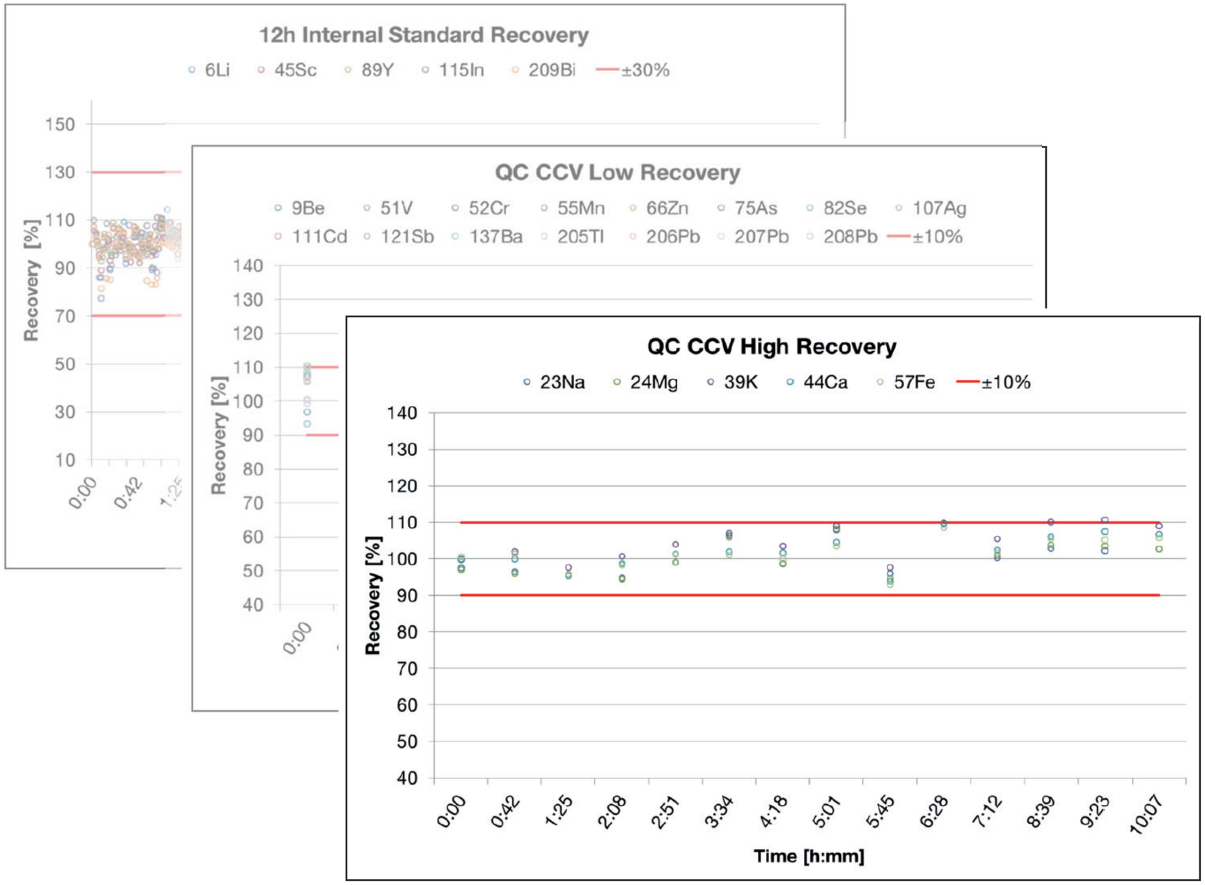
Parameter	Value
Forward Power	1550 W
Nebulizer	Burgener MiraMist®
Interface	Ni cones, Robust (4.5mm) insert
QCell Settings	KED using 100% He at 4.5 $mL \cdot min^{-1}$, 3V KED voltage
Scan settings	0.01-0.3s

- Calibration

Standard #	Concentration [µg·L-1]	Elements
1	2	Ag, Al,As, Ba, Be, Ca, Cd, CO, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, Zn
2	100	
3	1,000	
4	5,000	
5	100,000	Ca, Fe, K, Mg, Na
6	40,000, 50	Al, Hg

- Sample – similar to NIST SRM 2781 Domestic Sludge
- QC Protocol as per EPA method 6020
  - CCV low and high, DUP, SER, LCS

Results – EPA Method 6020 B



- ✓ Internal Standard Recovery well within regulatory limits
- ✓ Consistent QC recovery
- ✓ Excellent long term stability over 12 h

ThermoFisher SCIENTIFIC

Results – EPA Method 6020 B

	Sim. Sample conc.	Measured Sim. Sample	Recovery	Spiked conc.	Measured Spike	Recovery	IDL	MDL
	µg·L^{-1}	µg·L^{-1}	%	µg·L^{-1}	µg·L^{-1}	%	µg·L^{-1}	µg·L^{-1}
^{9}Be	N/A	N/A		50	45	**90**	**0.13**	**0.18**
^{24}Mg	20000	20619	**103**	50			**0.77**	**1.3**
^{27}Al	50000	51604	**103**	50			**0.44**	**1.5**
^{39}K	15000	16018	**107**	50			**3.5**	**5.4**
^{44}Ca	120000	125986	**105**	50			**8.3**	**7.4**
^{51}V	250	295	**118**	50	59	**119**	**0.02**	**0.02**
^{52}Cr	500	463	**93**	50	41	**81**	**0.03**	**0.04**
^{55}Mn	2000	2003	**100**	50	46	**92**	**0.05**	**0.07**
^{57}Fe	85000	86863	**102**	50			**0.36**	**1.6**
^{59}Co	N/A	N/A		50	59	**118**	**0.003**	**0.01**
^{60}Ni	250	280	**112**	50	50	**99**	**0.001**	**0.04**
^{63}Cu	2000	2003	**100**	50	47	**93**	**0.07**	**0.12**
^{66}Zn	4000	3727	**93**	50	55	**109**	**0.12**	**0.23**
^{75}As	25	29	**116**	50	58	**117**	**0.01**	**0.04**
^{82}Se	50	44	**88**	50	45	**90**	**0.01**	**0.45**
^{107}Ag	300	257	**86**	50	43	**87**	**0.02**	**0.3**
^{111}Cd	50	50	**100**	50	52	**104**	**0.005**	**0.02**
^{121}Sb	N/A	N/A		50	52	**105**	**0.001**	**0.07**
^{137}Ba	2000	1824	**91**	50	60	**119**	**0.03**	**0.06**
^{202}Hg	10	10	**99**				**0.002**	**0.01**
^{205}Tl	N/A	N/A		50	53	**105**	**0.002**	**0.04**
^{208}Pb	600	629	**105**	50	55	**109**	**0.002**	**0.02**

Handling Interferences – What Options are Available?

- Some typical interferences in ICP-MS:

But those aren't sufficient!

- Alternative Sample Introduction Techniques
  - E.g. aerosol desolvation to minimize the population of the precursor (parent) ions in the ICP ion source

  NOT A UNIVERSAL SOLUTION

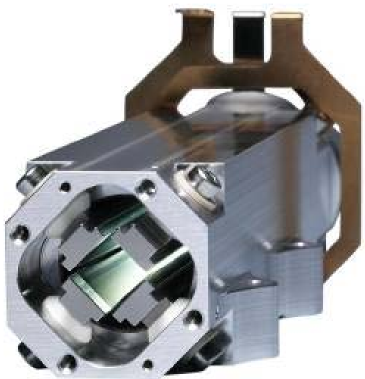
- Cold Plasma:
  - Reduce plasma power to reduce amount of Ar ionization

  NOT A UNIVERSAL SOLUTION

- Mathematical Correction Equations:
  - Measure the isotope of interest, an un-interfered isotope, a polyatomic isotope and mathematically de-convolute to return an interference free value

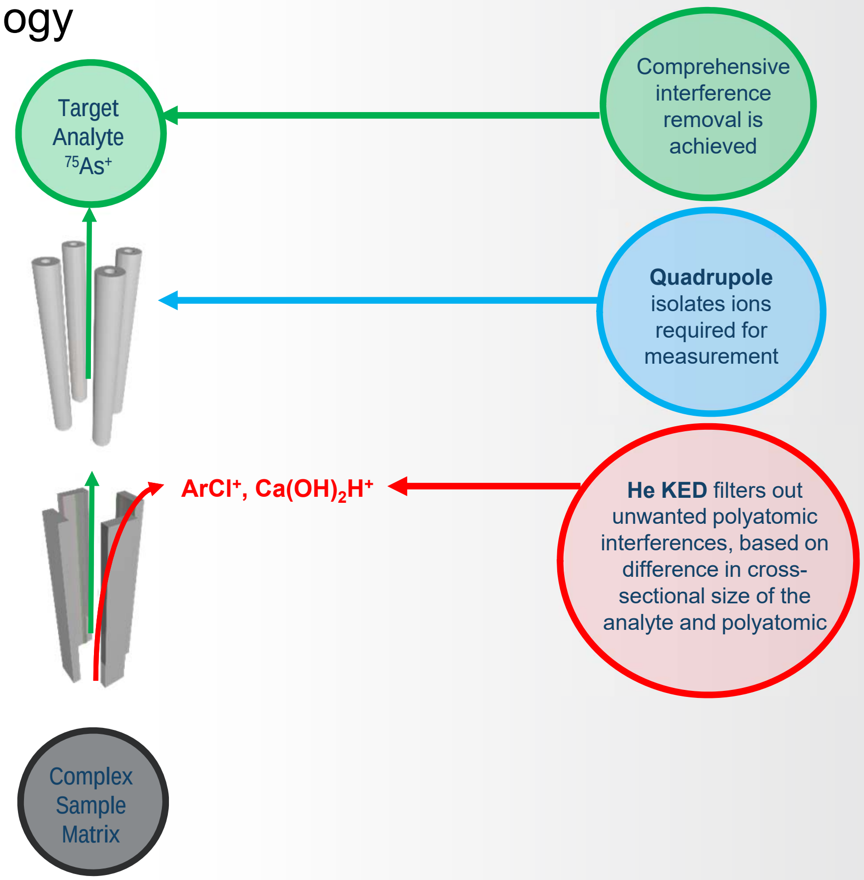
  AMPLIFIES ERRORS, DOESN'T ACCOUNT FOR UNKNOWN INTERFERENCES

- Thermo Scientific™ iCAP™ QCell Technology
- He Kinetic Energy Discrimination (KED)



Quadrupole set to filter out exact mass of target analyte

QCell in collision mode with with pure He uses energy discrimination



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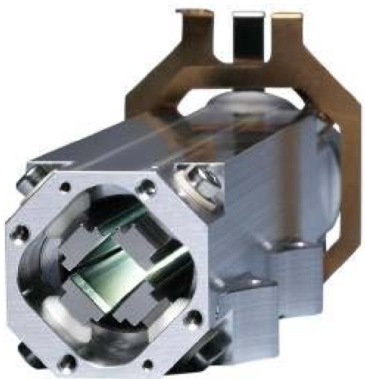
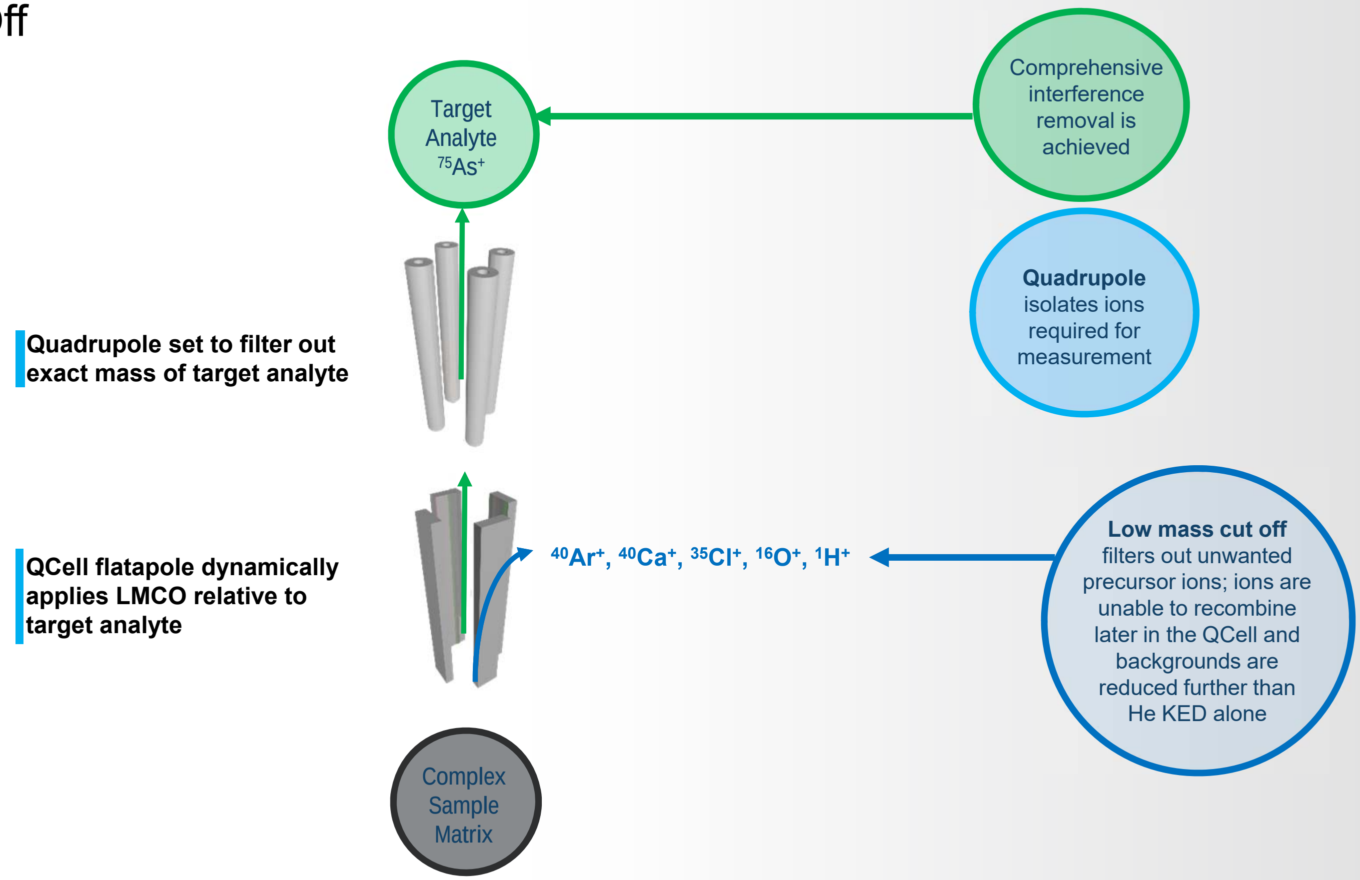
Handling Interferences with Collision Reaction Cell Technology

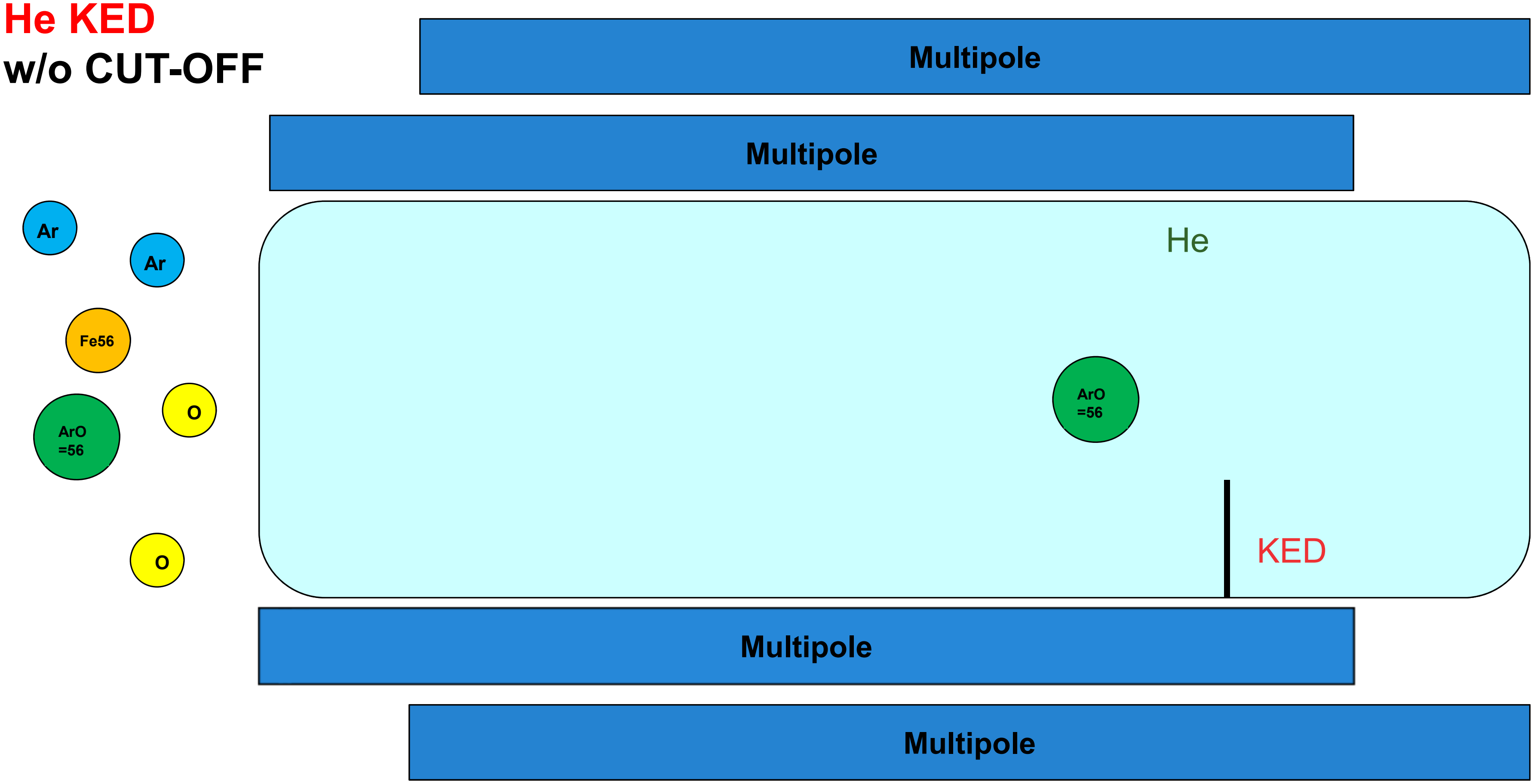
- …and Low Mass Cut Off





Interference Removal Collision Cell: Example ^{56}Fe

He KED
w/o CUT-OFF



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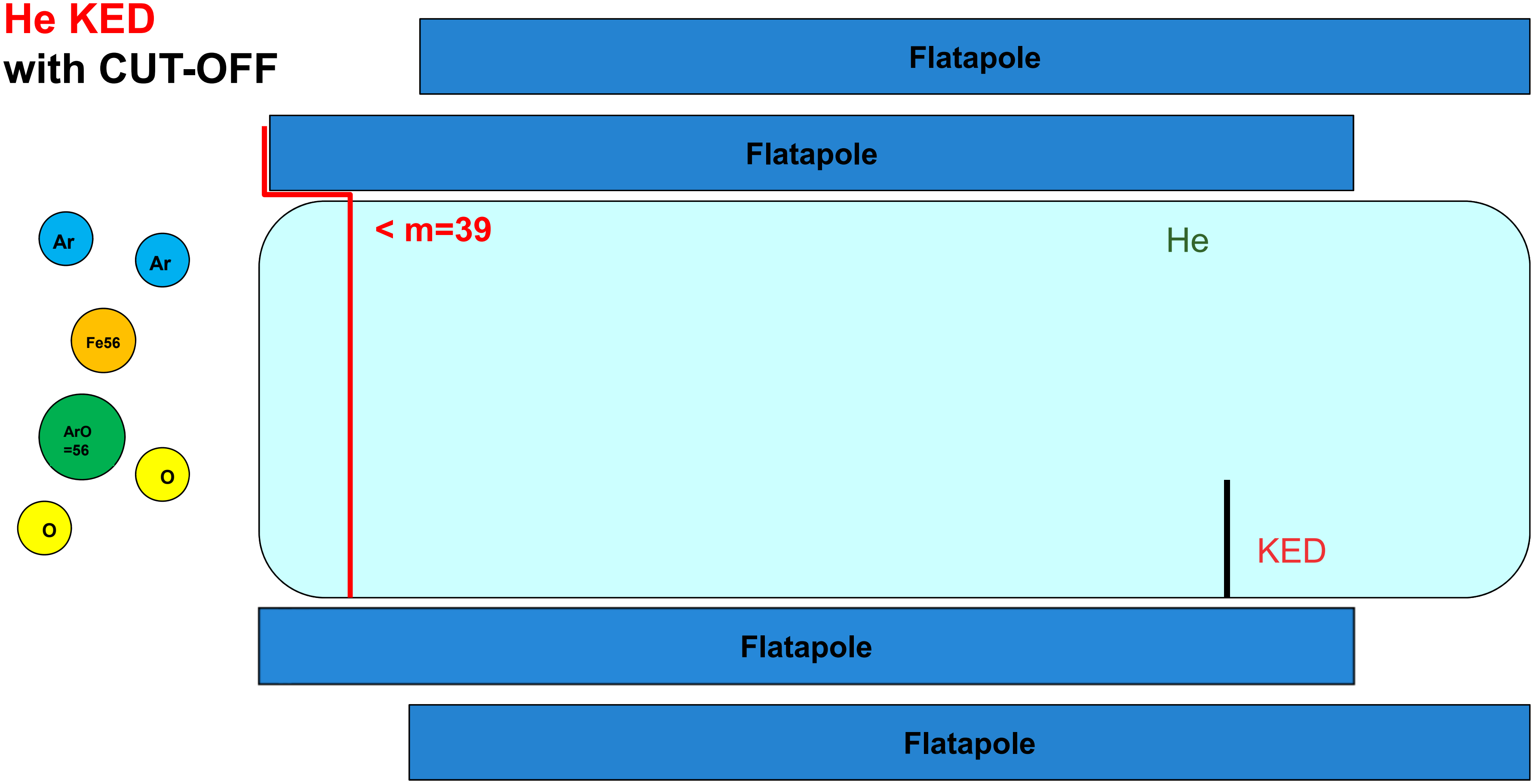
Interference Removal Collision Cell: Example ^{56}Fe

He KED
with CUT-OFF



Handling Interferences – Low Mass Cut Off

- Low Mass Cut Off (LMCO)
  - Prevents the lower mass ions that contribute to interferences from traveling through the QCell...

Mass	Interferences	Precursors
^{51}V	$^{35}Cl^{16}O$, $^{37}Cl^{14}N$, $^{34}S^{16}OH$	H, N, O, S, Cl
^{56}Fe	$^{40}Ar^{16}O$, $^{40}Ca^{16}O$	O, Ar, Ca
^{63}Cu	$^{40}Ar^{23}Na$, $^{12}C^{16}O^{35}Cl$, $^{31}P^{32}S$	C, N, O, Na, P, S, Cl, Ar
^{75}As	$^{40}Ar^{35}Cl$, $^{40}Ca^{35}Cl$, $^{40}Ar^{34}SH$, $^{37}Cl^{2}H$	H, S, Cl, Ca, Ar

Mass	LMCO	Interferences	Precursors
^{51}V	**35**	$^{35}Cl^{16}O$, $^{37}Cl^{14}N$, $^{34}S^{16}OH$	H, N, O, S, Cl
^{56}Fe	**39**	$^{40}Ar^{16}O$, $^{40}Ca^{16}O$	O, Ar, Ca
^{63}Cu	**45**	$^{40}Ar^{23}Na$, $^{12}C^{16}O^{35}Cl$, $^{31}P^{32}S$	C, N, O, Na, P, S, Cl, Ar
^{75}As	**47**	$^{40}Ar^{35}Cl$, $^{40}Ca^{35}Cl$, $^{40}Ar^{34}SH$, $^{37}Cl^{2}H$	H, S, Cl, Ca, Ar

Handling Interferences – Low Mass Cut Off

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^{63}Cu	$^{40}Ar^{23}Na$, $^{12}C^{16}O^{35}Cl$, $^{31}P^{32}S$	C, N, O, Na, P, S, Cl, Ar
^{75}As	$^{40}Ar^{35}Cl$, $^{40}Ca^{35}Cl$, $^{40}Ar^{34}SH$, $^{37}Cl^{2}H$	H, S, Cl, Ca, Ar

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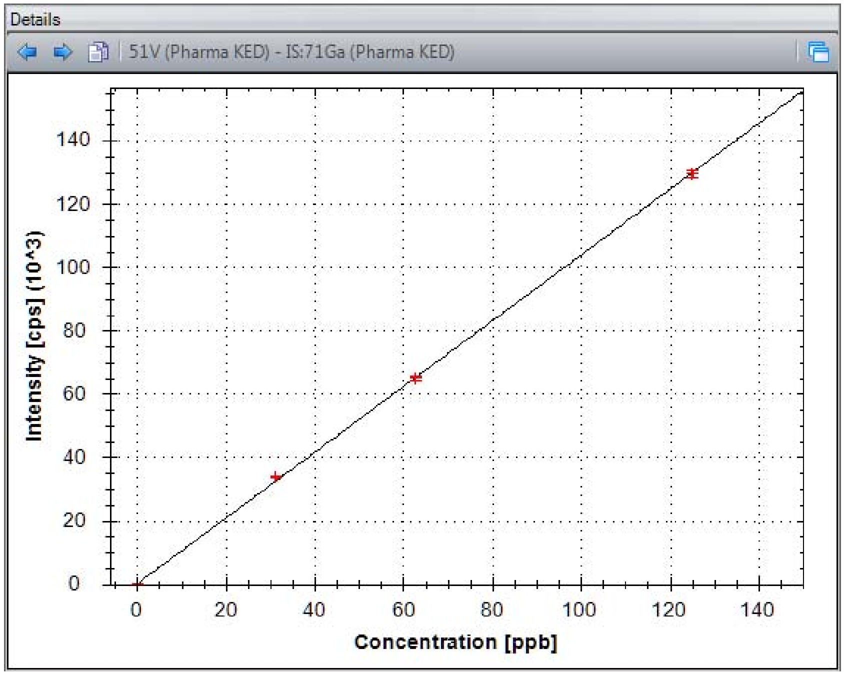
^{75}As	**47**	$^{40}Ar^{35}Cl$, $^{40}Ca^{35}Cl$, $^{40}Ar^{34}SH$, $^{37}Cl^{2}H$	H, S, Cl, Ca, Ar

- …and reduces BECs even further than He KED alone

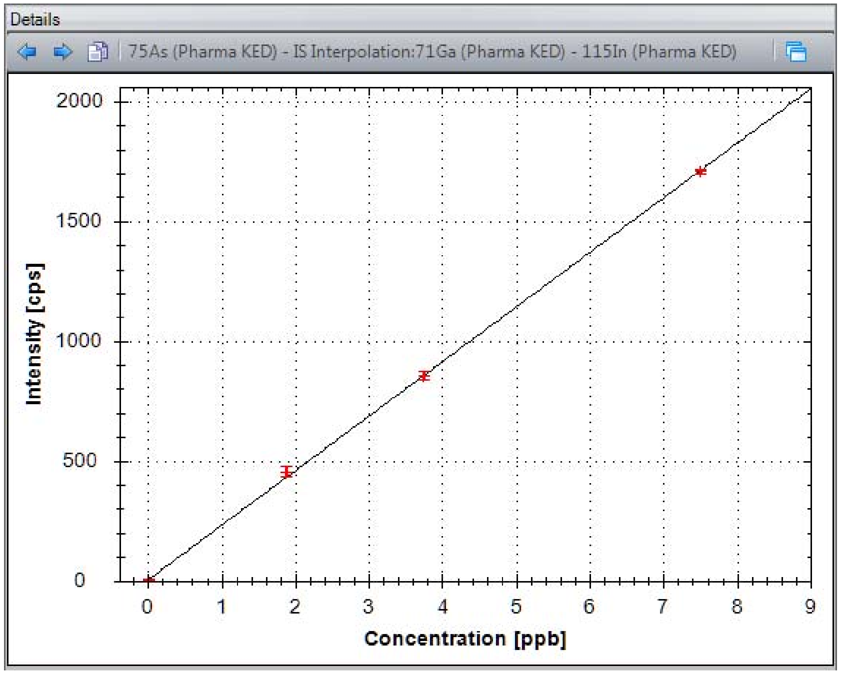
He KED Performance – Detection Limits in the Presence of Interferences

^{51}V KED



LOD = 7 ppt **BEC = 12 ppt**

^{75}As KED



LOD = 5 ppt **BEC = 17 ppt**

Sample Matrix: 2.5% HNO_3 + 1.5% HCl

EPA Method 6020 B using SQ-ICP-MS

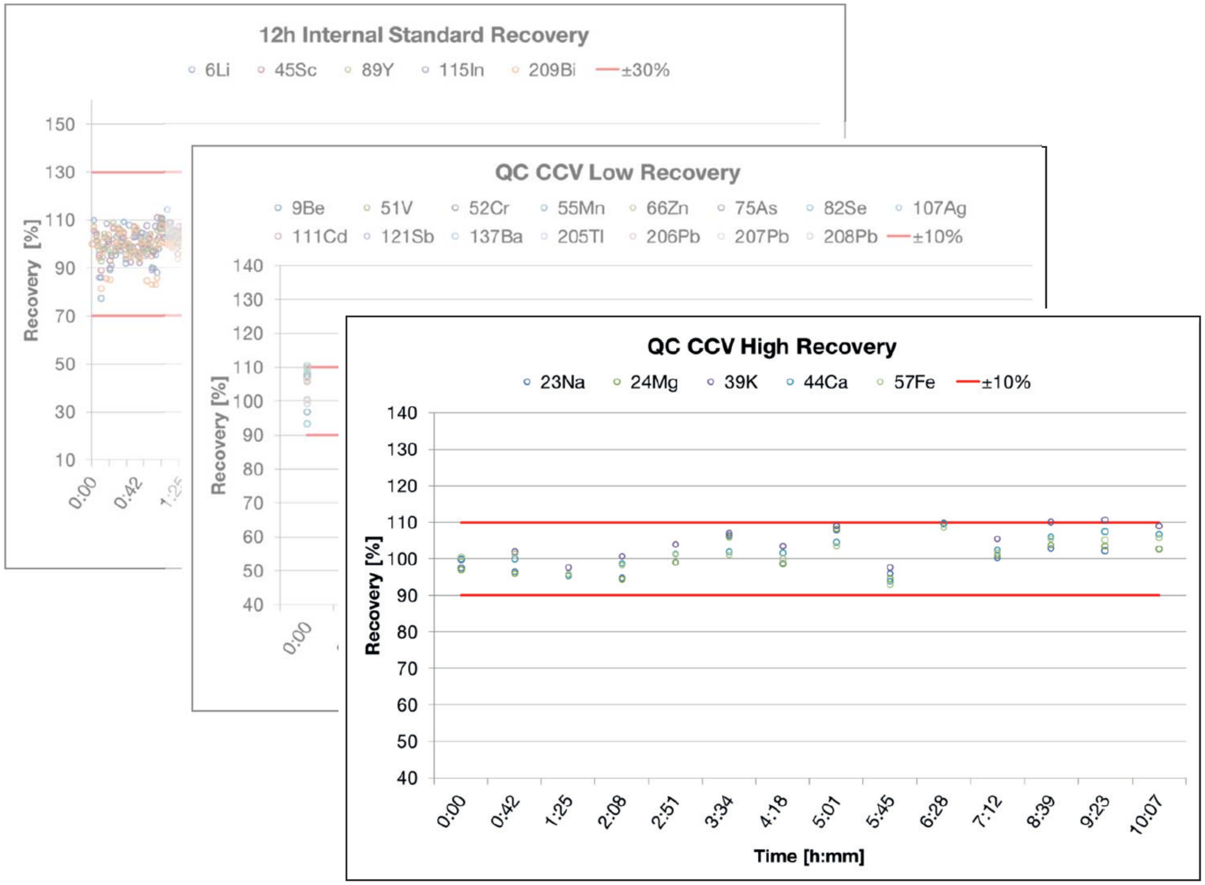
Parameter	Value
Forward Power	1550 W
Nebulizer	Burgener MiraMist®
Interface	Ni cones, Robust (4.5mm) insert
QCell Settings	KED using 100% He at 4.5 mL·min^{-1}, 3V KED voltage
Scan settings	0.01-0.3s

- Calibration

Standard #	Concentration [µg·L-1]	Elements
1	2	Ag, Al,As, Ba, Be, Ca, Cd, CO, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, Zn
2	100	
3	1,000	
4	5,000	
5	100,000	Ca, Fe, K, Mg, Na
6	40,000, 50	Al, Hg

- Sample – similar to NIST SRM 2781 Domestic Sludge
- QC Protocol as per EPA method 6020
  - CCV low and high, DUP, SER, LCS

Results – EPA Method 6020 B



- ✓ Internal Standard Recovery well within regulatory limits
- ✓ Consistent QC recovery
- ✓ Excellent long term stability over 12 h

Results – EPA Method 6020 B

	Sim. Sample conc.	Measured Sim. Sample	Recovery	Spiked conc.	Measured Spike	Recovery	IDL	MDL
	µg·L^{-1}	µg·L^{-1}	%	µg·L^{-1}	µg·L^{-1}	%	µg·L^{-1}	µg·L^{-1}
^{9}Be	N/A	N/A		50	45	**90**	**0.13**	**0.18**
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^{27}Al	50000	51604	**103**	50			**0.44**	**1.5**
^{39}K	15000	16018	**107**	50			**3.5**	**5.4**
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^{52}Cr	500	463	**93**	50	41	**81**	**0.03**	**0.04**
^{55}Mn	2000	2003	**100**	50	46	**92**	**0.05**	**0.07**
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^{59}Co	N/A	N/A		50	59	**118**	**0.003**	**0.01**
^{60}Ni	250	280	**112**	50	50	**99**	**0.001**	**0.04**
^{63}Cu	2000	2003	**100**	50	47	**93**	**0.07**	**0.12**
^{66}Zn	4000	3727	**93**	50	55	**109**	**0.12**	**0.23**
^{75}As	25	29	**116**	50	58	**117**	**0.01**	**0.04**
^{82}Se	50	44	**88**	50	45	**90**	**0.01**	**0.45**
^{107}Ag	300	257	**86**	50	43	**87**	**0.02**	**0.3**
^{111}Cd	50	50	**100**	50	52	**104**	**0.005**	**0.02**
^{121}Sb	N/A	N/A		50	52	**105**	**0.001**	**0.07**
^{137}Ba	2000	1824	**91**	50	60	**119**	**0.03**	**0.06**
^{202}Hg	10	10	**99**				**0.002**	**0.01**
^{205}Tl	N/A	N/A		50	53	**105**	**0.002**	**0.04**
^{208}Pb	600	629	**105**	50	55	**109**	**0.002**	**0.02**

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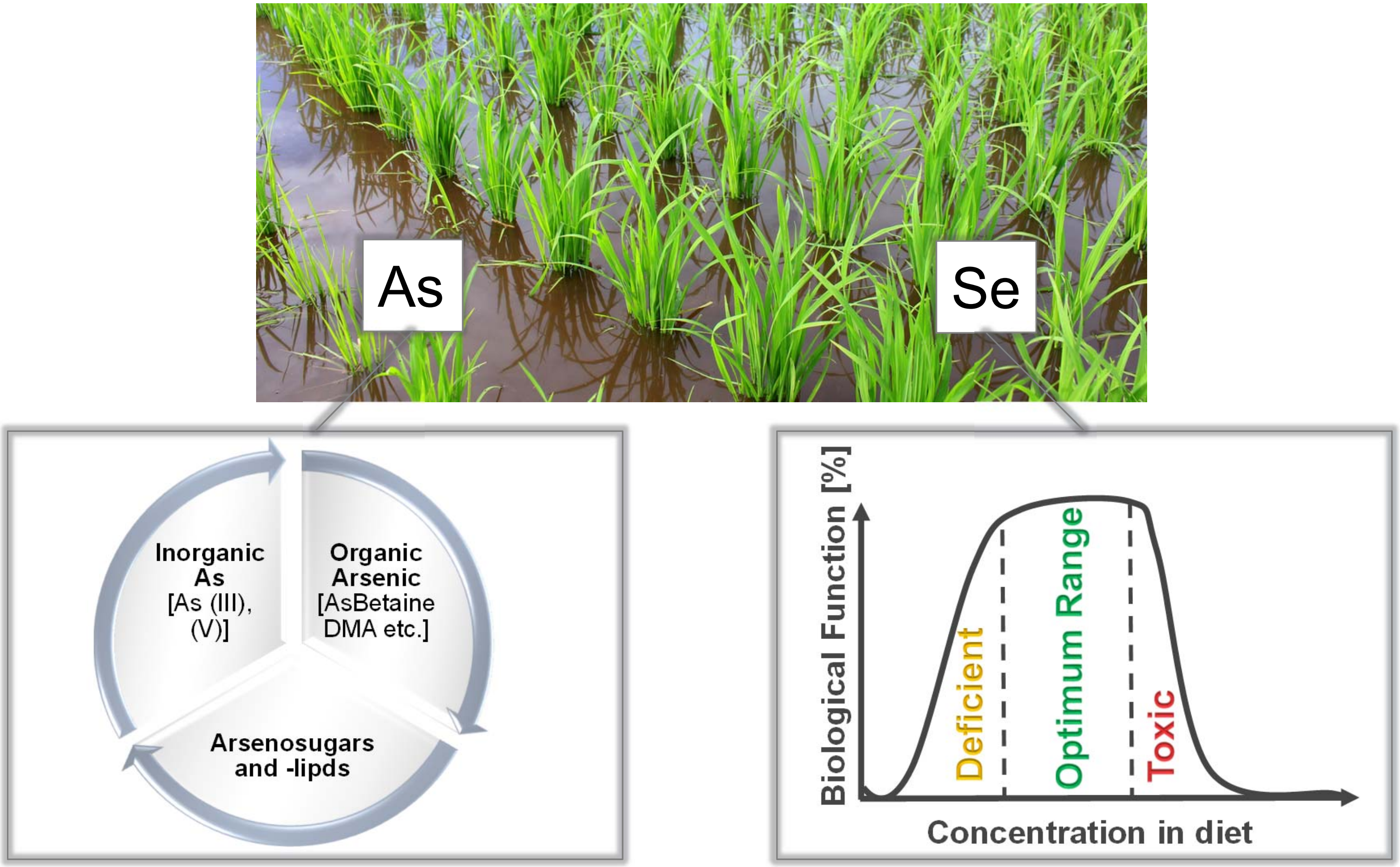
Determination of Arsenic and Selenium in Food Samples



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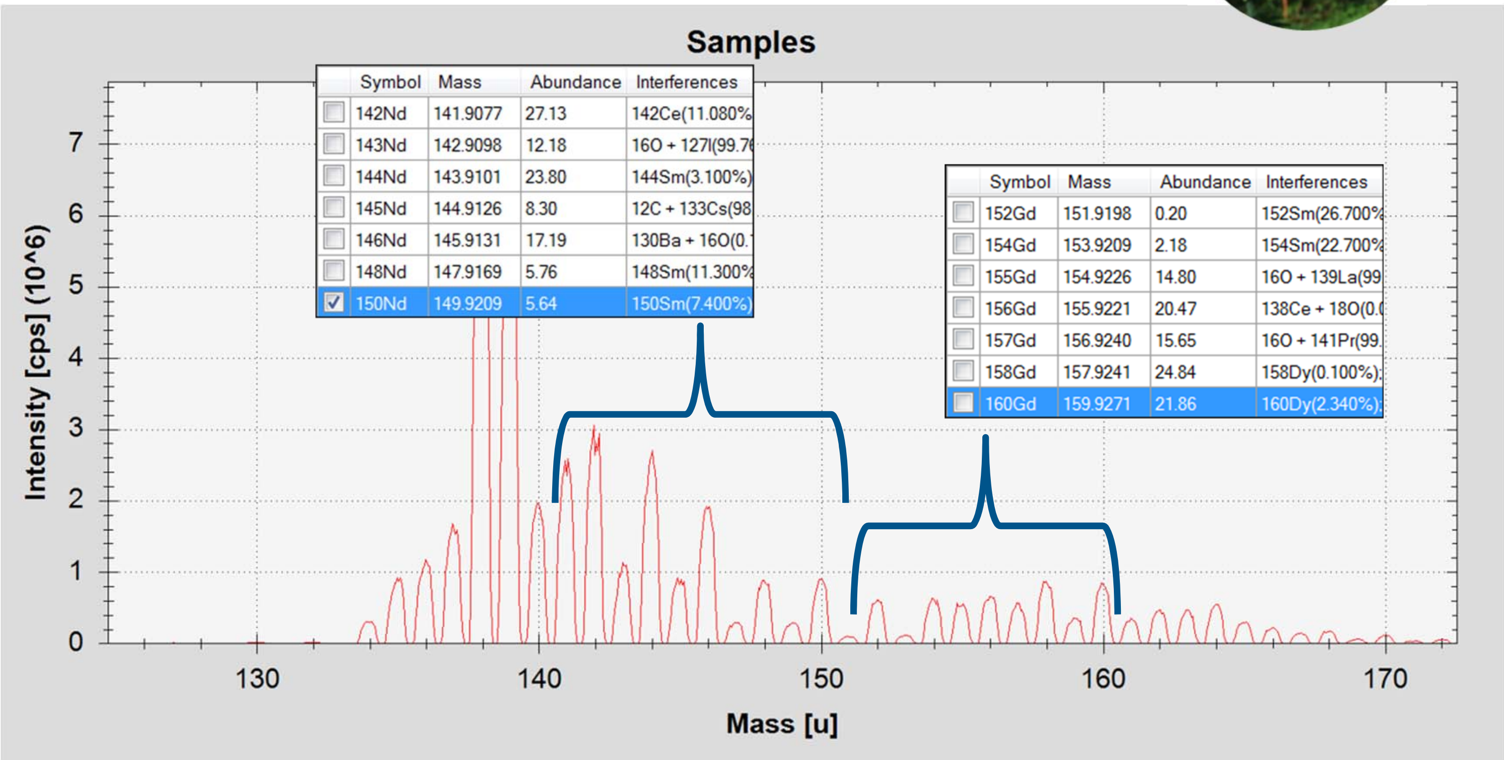
Example: REE Mass Range for Apple Leaves



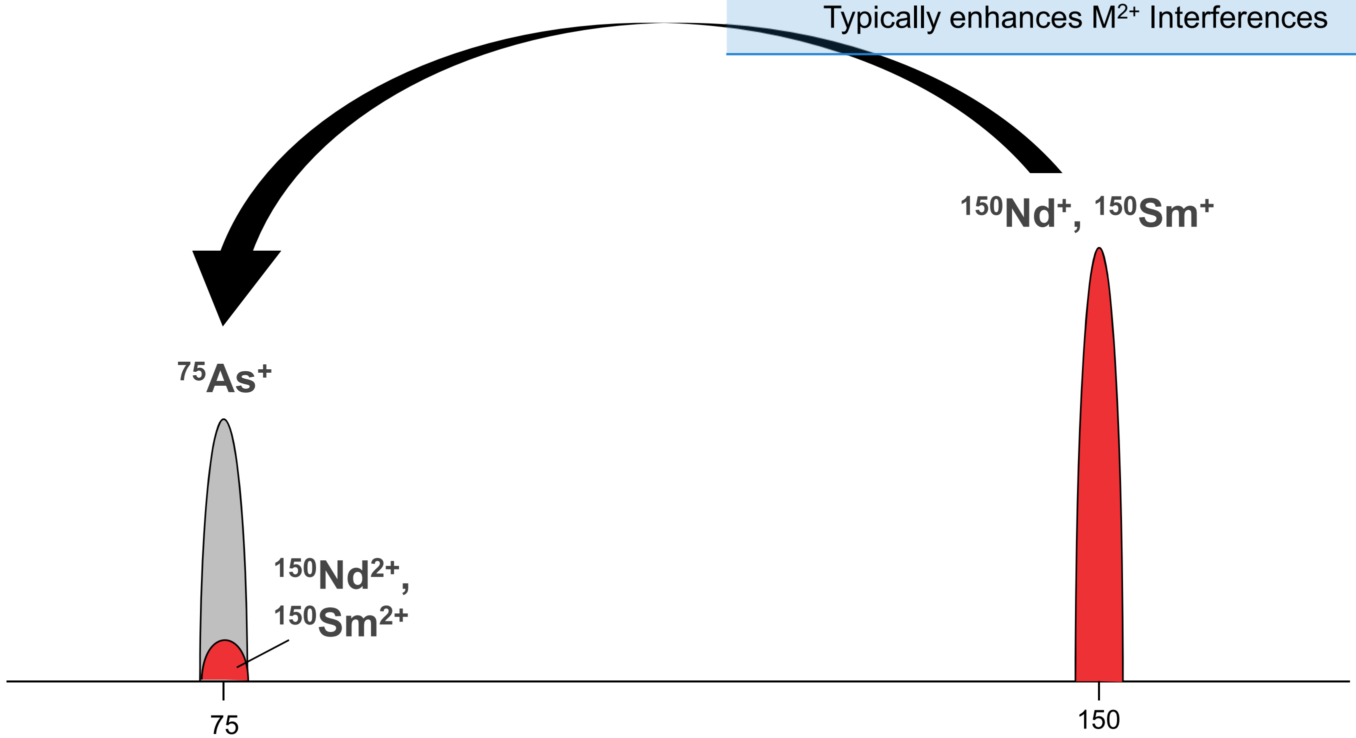
	Symbol	Mass	Abundance	Interferences
☐	142Nd	141.9077	27.13	142Ce(11.080%
☐	143Nd	142.9098	12.18	16O + 127I(99.7
☐	144Nd	143.9101	23.80	144Sm(3.100%)
☐	145Nd	144.9126	8.30	12C + 133Cs(98
☐	146Nd	145.9131	17.19	130Ba + 16O(0.
☐	148Nd	147.9169	5.76	148Sm(11.300%
☑	150Nd	149.9209	5.64	150Sm(7.400%)

	Symbol	Mass	Abundance	Interferences
☐	152Gd	151.9198	0.20	152Sm(26.700%
☐	154Gd	153.9209	2.18	154Sm(22.700%
☐	155Gd	154.9226	14.80	16O + 139La(99
☐	156Gd	155.9221	20.47	138Ce + 18O(0.
☐	157Gd	156.9240	15.65	16O + 141Pr(99.
☐	158Gd	157.9241	24.84	158Dy(0.100%);
☐	160Gd	159.9271	21.86	160Dy(2.340%);

Thermo Fisher SCIENTIFIC

Accurate Analysis of Arsenic and Selenium in REE Matrix

Single Quad ICP-MS: KED
Typically enhances M^{2+} Interferences



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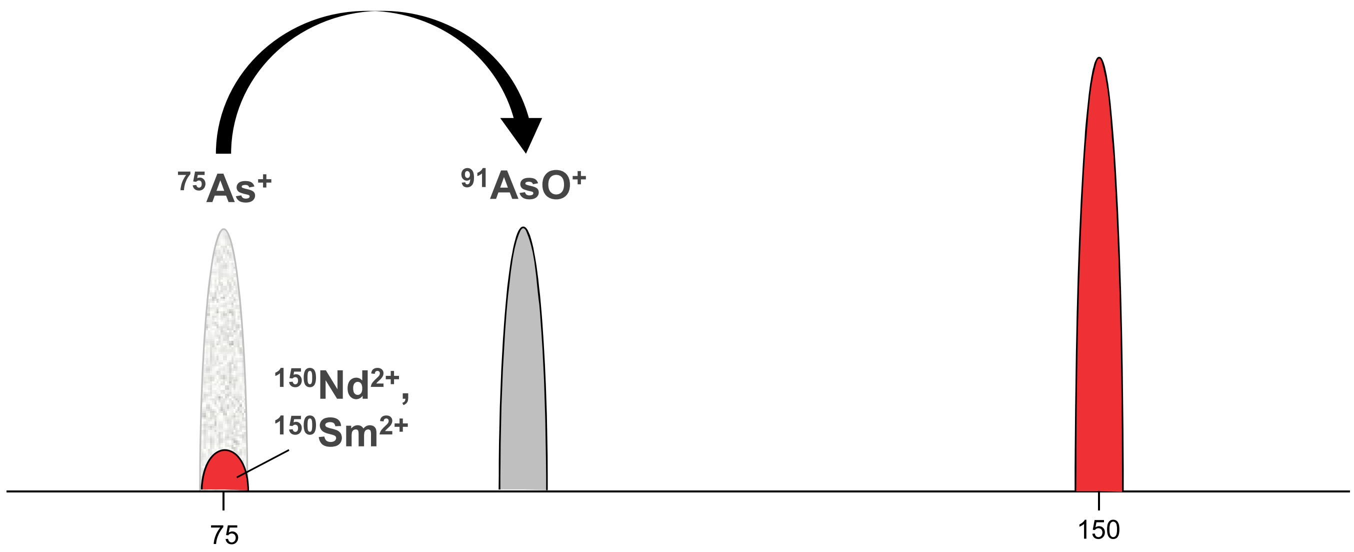
Accurate Analysis of Arsenic and Selenium in REE Matrix

Single Quad ICP-MS: KED
Typically enhances M^{2+} Interferences
Solution: Mass shift As and Se using O_2



Accurate Analysis of Arsenic and Selenium in REE Matrix

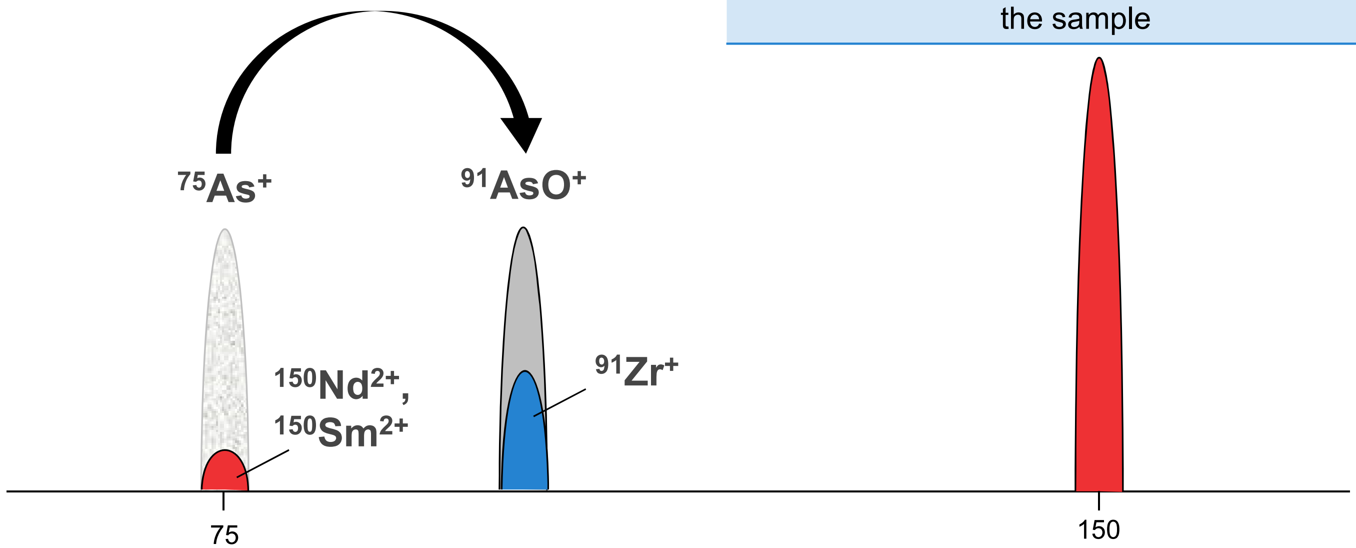
Single Quad ICP-MS: CCT O_2

Typically enhances M^{2+} Interferences

Solution:

Mass shift As and Se using O_2

Other interferences: $^{91}Zr^{+}$, $^{94,96}Mo^{+}$, if present in the sample



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Same Hardware Platform – Familiar Look and Feel

Innovative collision cell

Reaction Finder Software

Simplified power connections

Built-in safety for handling reactive gases

iCAP RQ ICP-MS

Intuitive user-friendly software

4 mass flow controllers: He, O_2, H_2, NH_3

Quick connect and push-fit sample intro components

Bench-level easy-access interface

iCAP TQ ICP-MS

Compact footprint

Additional quadrupole for superior interference removal

Robust RF generator

Analysis with SQ and TQ in a single sample run

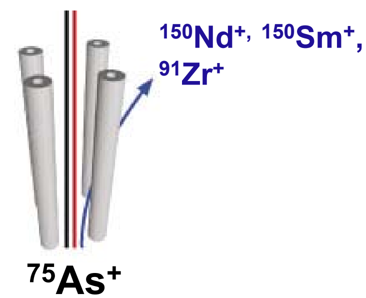
If you know how to use our single quadrupole, you already know how to use our triple quadrupole!

Accurate Analysis of Arsenic and Selenium in REE Matrix

- Solution is Triple Quadrupole ICP-MS:
  - Control ions entering Q2 using **Q1**

Type of Interference	^{75}As	SQ Mode	^{78}Se	SQ Mode
Polyatomic	$^{40}Ar^{35}Cl$	KED	$^{40}Ar^{38}Ar$	KED, H_2
	$^{40}Ca^{35}Cl$			
Isobaric	$^{150}Nd^{2+}$	O_2	$^{156}Gd^{2+}$	O_2
	$^{150}Sm^{2+}$		$^{156}Dy^{2+}$	

Q1 set to analyte mass



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Accurate Analysis of Arsenic and Selenium in REE Matrix

- Solution is Triple Quadrupole ICP-MS:
  - Control ions entering Q2 using **Q1**
  - Use O_2 to efficiently convert As and Se to AsO and SeO in **Q2**
  - REE^{++} species don't react

Type of Interference	^{75}As	SQ Mode	^{78}Se	SQ Mode
Polyatomic	$^{40}Ar^{35}Cl$	KED	$^{40}Ar^{38}Ar$	KED, H_2
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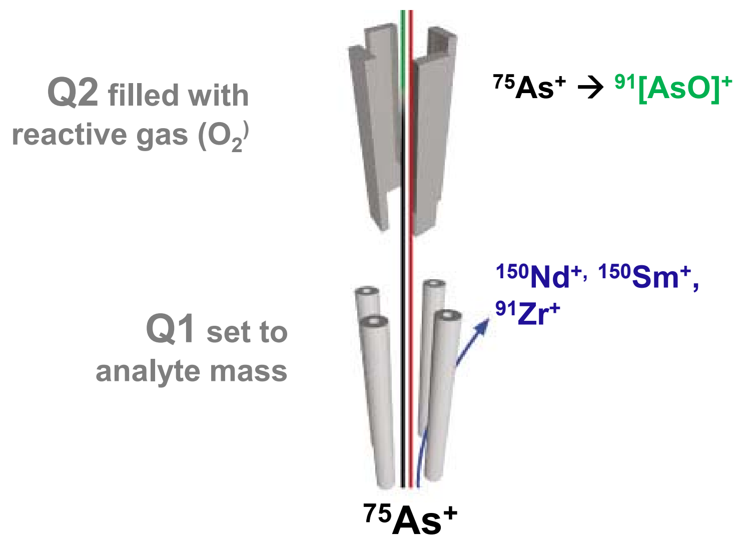

Accurate Analysis of Arsenic and Selenium in REE Matrix

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  - Selectively detect AsO and SeO free from REE^{++} interference, using **Q3**

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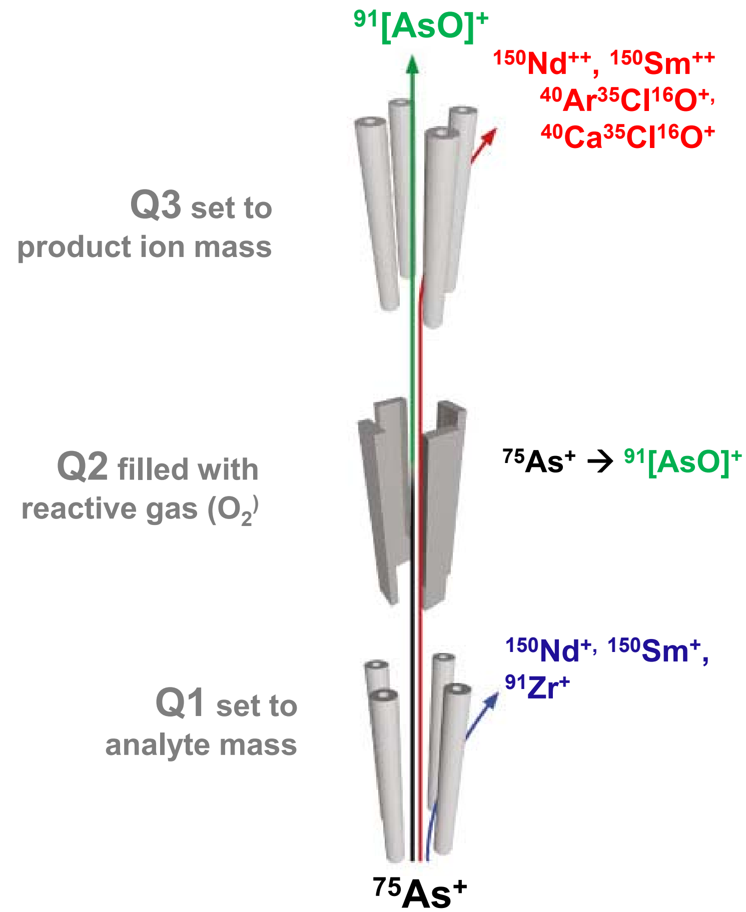

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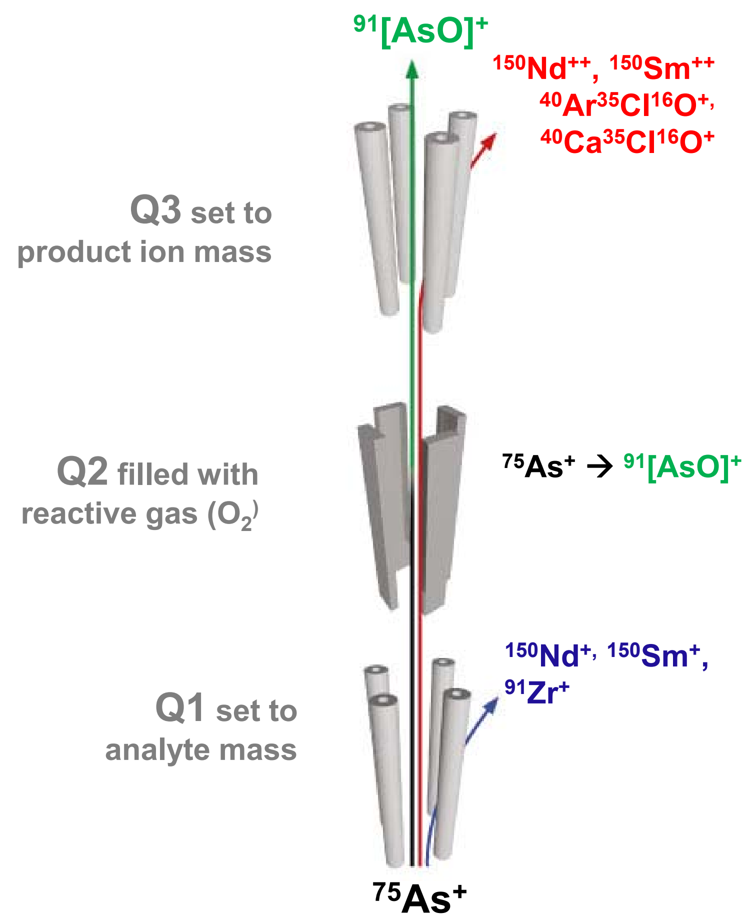
Accurate Analysis of Arsenic and Selenium in REE Matrix

- Solution is Triple Quadrupole ICP-MS:
  - Control ions entering Q2 using **Q1**
  - Use O_2 to efficiently convert As and Se to AsO and SeO in **Q2**
  - REE^{++} species don't react
  - Selectively detect AsO and SeO free from REE^{++} interference, using **Q3**

Type of Interference	^{75}As	TQ Mode	^{78}Se	TQ Mode
Polyatomic	$^{40}Ar^{35}Cl$	O_2	$^{40}Ar^{38}Ar$	O_2
	$^{40}Ca^{35}Cl$			
Isobaric	$^{150}Nd^{2+}$		$^{156}Gd^{2+}$	
	$^{150}Sm^{2+}$		$^{156}Dy^{2+}$	



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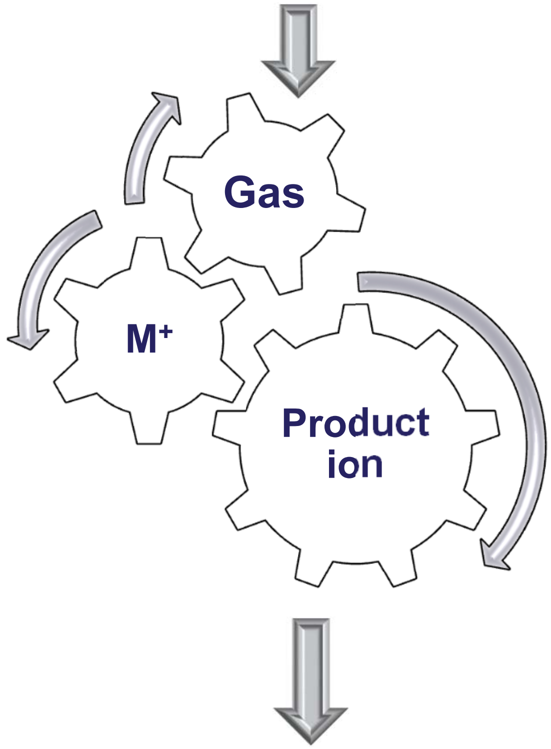
Kick Interference to the Curb



Reaction Finder – eliminate the complexity of triple quadrupole ICP-MS analysis

Eliminate the Complexity of Triple Quadrupole ICP-MS

- Reaction Finder for Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ Software

Step 1: Select your element/s or isotope/s

Step 2: You’re done!

- **Reaction Finder proposes the most appropriate gas/scan settings**
- **Settings for both single quad mode and triple quad mode are suggested, for reference**

Identifier	Q3 Analyte	SQ / TQ	CR Gas	Dwell time (s)	Channels	Spacing (u)	
78Se | 78Se.16O	78Se.16O (93.912	TQ	O_2	0.1	1	0.1	Normal
80Se | 80Se.16O	80Se.16O	TQ	O_2	0.1	1	0.1	Normal

Redefining triple quadrupole technology with unique ease of use

Simplest Method Development Using Reaction Finder

Without Reaction Finder

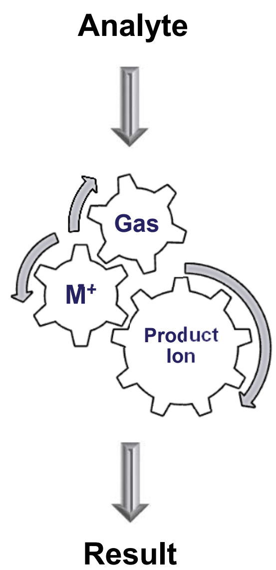
Select
- Select the Analytes to be measured

Select
- Select the internal standard element

Decide
- Are the suggested settings ok? If not, update them

Analyze
- Enter sample names and positions or import from LIMS and start the LabBook

★ Operator skills required



With Reaction Finder

Select
- Select the Analytes to be measured

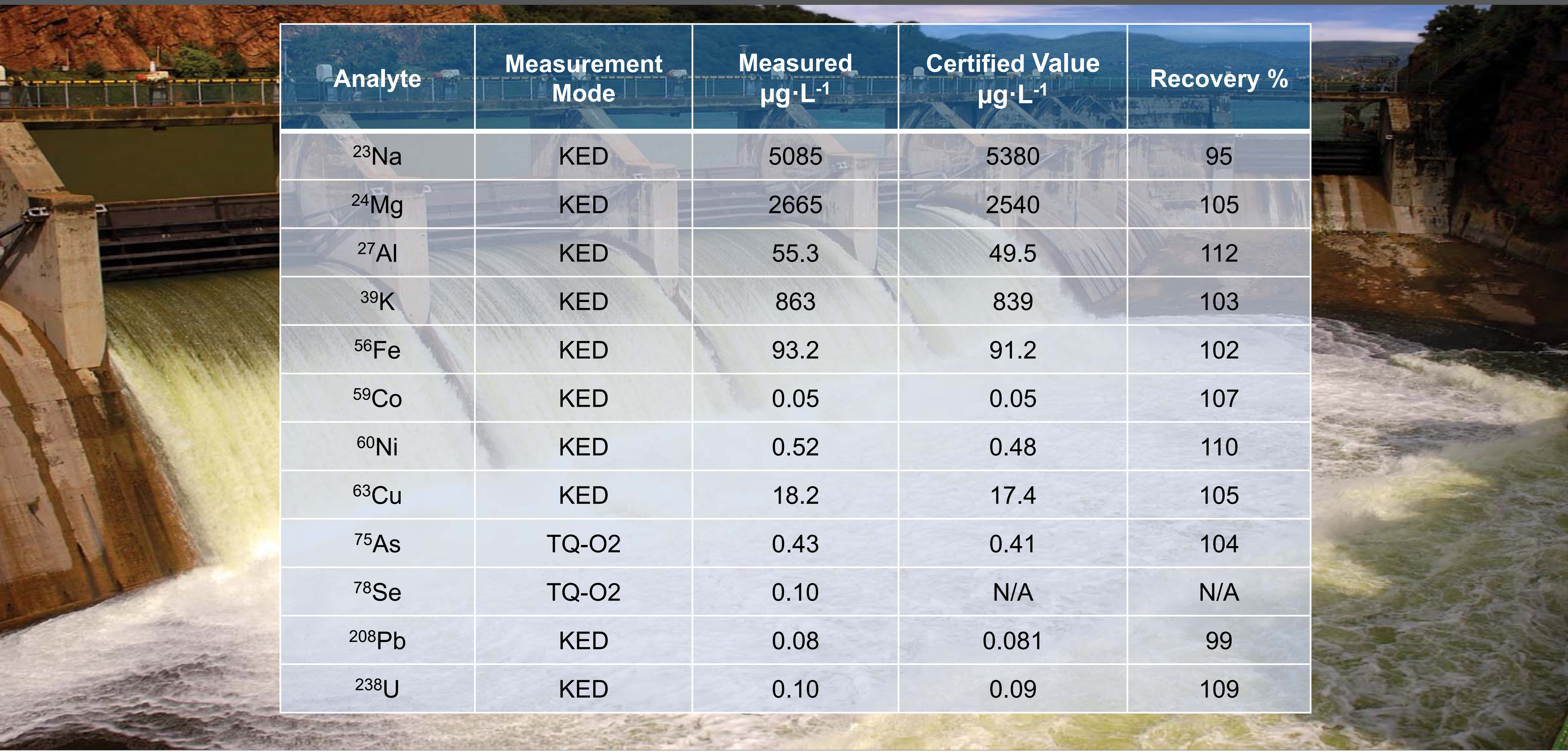
Select
- Select the internal standard element

Decide
- Are the suggested settings ok? If not, update them

Analyze
- Enter sample names and positions or import from LIMS and start the LabBook

Less than 20 Minutes until a method is set up and the samples are ready to run!

Multi-element results: River water reference material (NRC SLRS-5)



Analyte	Measurement Mode	Measured μg·L^{-1}	Certified Value μg·L^{-1}	Recovery %
^{23}Na	KED	5085	5380	95
^{24}Mg	KED	2665	2540	105
^{27}Al	KED	55.3	49.5	112
^{39}K	KED	863	839	103
^{56}Fe	KED	93.2	91.2	102
^{59}Co	KED	0.05	0.05	107
^{60}Ni	KED	0.52	0.48	110
^{63}Cu	KED	18.2	17.4	105
^{75}As	TQ-O2	0.43	0.41	104
^{78}Se	TQ-O2	0.10	N/A	N/A
^{208}Pb	KED	0.08	0.081	99
^{238}U	KED	0.10	0.09	109

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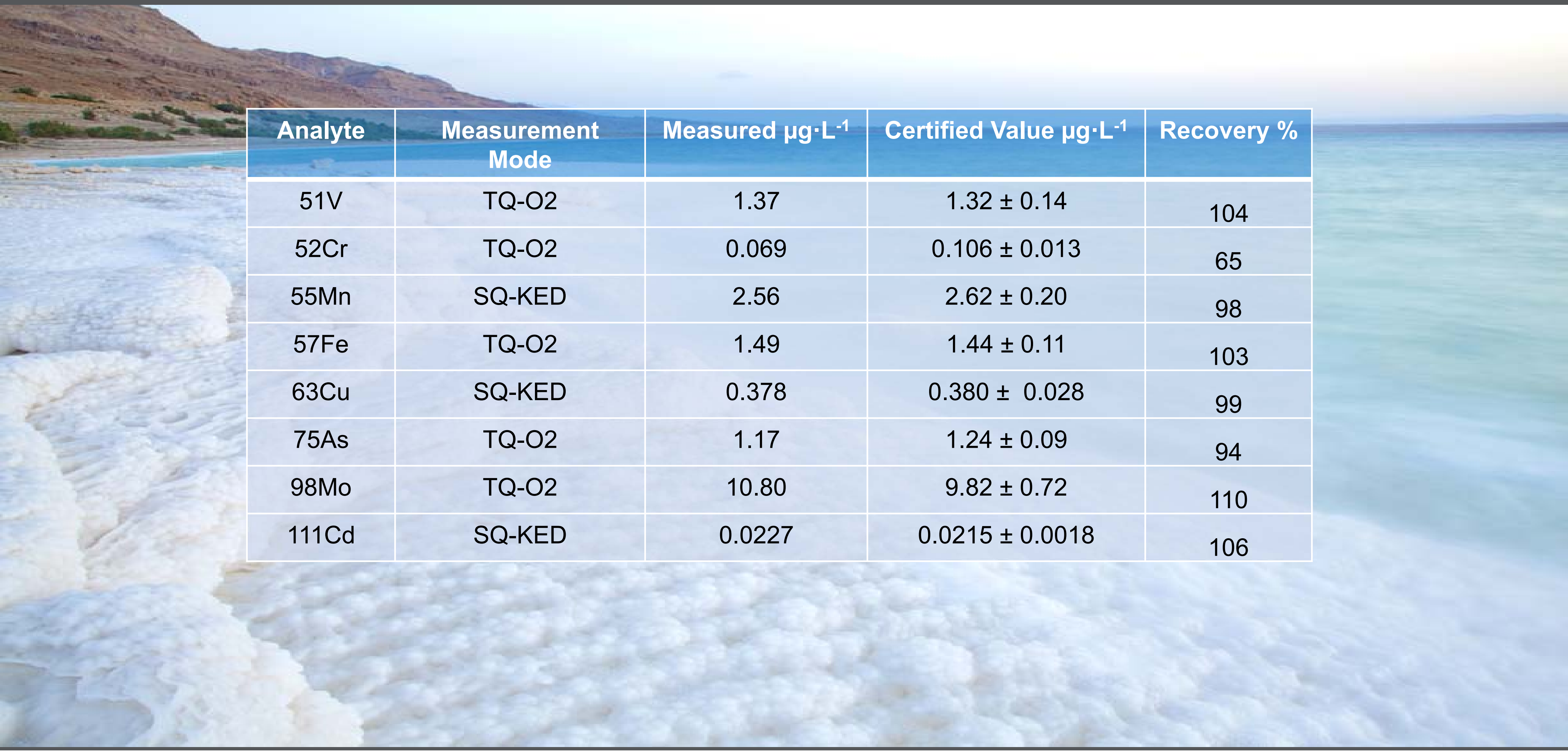
Multi-element results: River water reference material (CRM 1643F)

Analyte	Measurement Mode	Measured µg·L^{-1}	Certified Value µg·L^{-1}	Recovery %
51V	TQ-O2	36.03	36.07 ± 0.28	100
52Cr	TQ-O2	18.06	18.50 ± 0.10	98
55Mn	SQ-KED	39.50	37.14 ± 0.60	106
57Fe	SQ-KED	106.11	93.44 ± 0.78	114
58Ni	SQ-KED	55.97	59.8 ± 1.4	94
59Co	TQ-O2	24.22	25.30 ± 0.17	96
63Cu	SQ-KED	21.32	21.66 ± 0.71	98
66Zn	TQ-O2	87.78	74.4 ± 1.7	118
75As	TQ-O2	57.10	57.42 ± 0.38	99
80Se	TQ-O2	11.97	11.70 ± 0.081	102
98Mo	TQ-O2	123.8	115.3 ± 1.7	107
107Ag	SQ-KED	0.94	0.97 ± 0.0055	97
111Cd	SQ-KED	5.91	5.89 ± 0.13	100
121Sb	SQ-KED	54.59	55.45 ± 0.40	98
125Te	SQ-KED	0.95	0.977 ± 0.0084	97
205Tl	SQ-KED	6.38	6.892 ± 0.035	93
208Pb	SQ-KED	18.19	18.488 ± 0.084	98

Multi-element results: Sea Water reference material (NRC CASS-5)



Analyte	Measurement Mode	Measured µg·L^{-1}	Certified Value µg·L^{-1}	Recovery %
51V	TQ-O2	1.37	1.32 ± 0.14	104
52Cr	TQ-O2	0.069	0.106 ± 0.013	65
55Mn	SQ-KED	2.56	2.62 ± 0.20	98
57Fe	TQ-O2	1.49	1.44 ± 0.11	103
63Cu	SQ-KED	0.378	0.380 ± 0.028	99
75As	TQ-O2	1.17	1.24 ± 0.09	94
98Mo	TQ-O2	10.80	9.82 ± 0.72	110
111Cd	SQ-KED	0.0227	0.0215 ± 0.0018	106

Summary and Conclusion

- Productivity is key for most laboratories
  - Matrix tolerance allows to analyze more samples without internal standards going out of limits
  - Producitvity tools may even free up more time from the operators

- Sometimes there is more than meets the eye!
  - Advanced interfererence removal combined with modern sample introduction systems allow high throughput analysis
  - Modern software makes the technology accessible for all laboratories
  - Right first time results straight away accesible in almost any matrix