Sůl nad zlato a chemické prvky kolem nás aneb Stopová anorganická analýza pomocí AAS, ICP a ICP-MS

Pavel Janderka

pragolab

Nové trendy v instrumentální analýze

Nebezpečný svět !?

Nejíst!

Nepít!

Nedýchat!

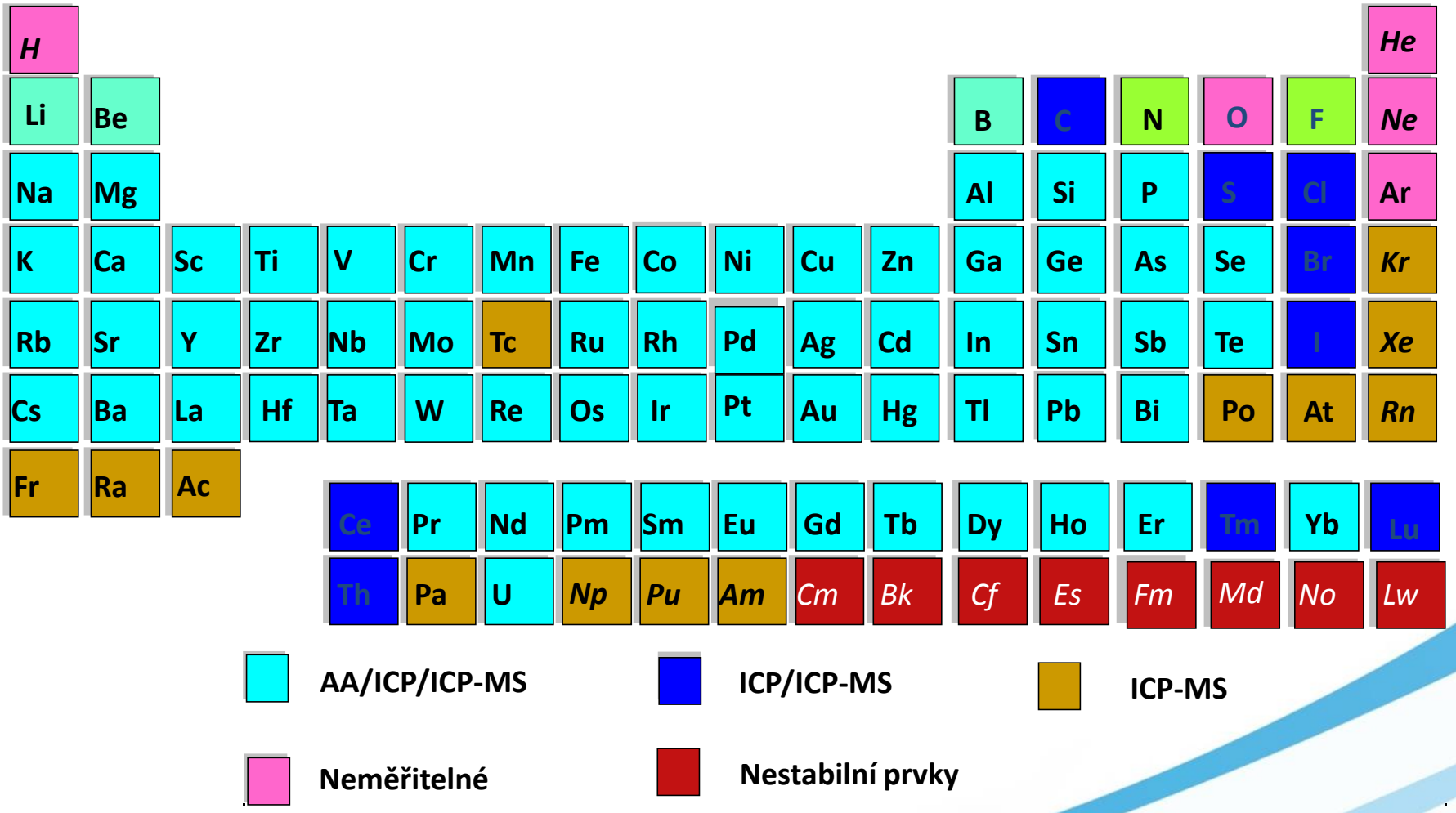
Sůl nad zlato trochu jinak!

Potraviny a nápoje
Suroviny pro výrobu potravin a nápojů
Výrobní procesy
Životní prostředí
Zdravotnictví
Odpady z domácností
Odpady z těžby a průmyslové výroby
Doprava
…
Kontaminanty ve všech fázích: g, l, s

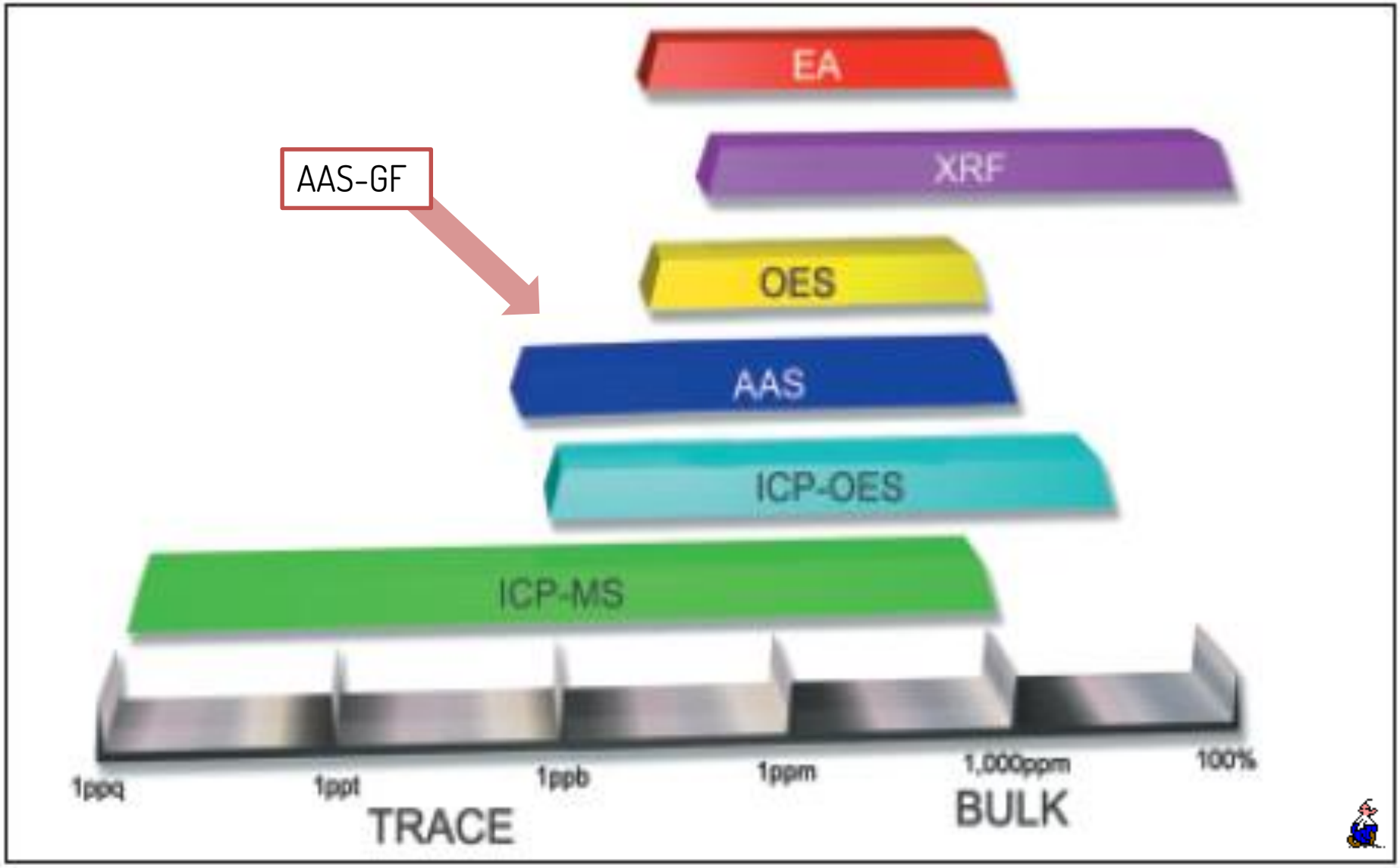
Známe i z historie – např. otrava olovem, arzenem, …


Důchod se ti snižuje
a sůl zabavuje

Periodická tabulka = společný jazyk chemiků



Typické detekční limity



Analýza prvků v kapalných vzorcích...

Technika	Objevena	Charakteristiky	Thermo Scientific
AAS	~1955	**Jednoprvková** analýza, **ppb-ppm** hladiny s plamenem nebo pecí, pro As, Se a Hg vhodné s generátorem hydridů	iCE 3000 Series
ICP-OES	~1972	Rychlá **mnohoprvková** analýza, **ppb - % hladiny**	iCAP 7000 Series
ICP-QMS	~1981	Rychlá **mnohoprvková** analýza, **ppt-ppm** hladiny	iCAP-Q Series
ICP-HRMS	~1987	Rychlá **mnohoprvková** analýza, **ppq-ppm** hladiny, bez interferencí	ELEMENT 2, XR, GD (Glow Discharge)

Porovnání analytického rozsahu

Jak tedy zvolit ten správný nástroj?

Thermo Scientific poskytuje kompletní portfolio zařízení!

Jednoelementové analýzy nebo nízký počet vzorků

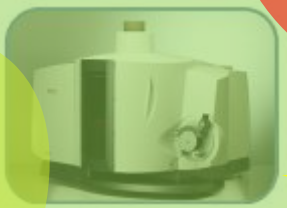
Multi-elementové analýzy

Výkon

iCE 3500 AA

iCE 3300 AA

iCAP 7000 Series ICP



iCAP-Q

ELEMENT 2 ICP-SFMS

Investice

Kdo, Co a Proč

	Primární	Sekundární	Důvod 1	Důvod 2
ŽP - vody	ICP-MS	ICP/AA GF	DL	Rychlost
Farmacie	AA FI/GF	ICP-MS	Náklady	Málo vzorků
Použité oleje	ICP-OES	AA Flame	Rozsah prvků	Robustnost
Metalurgie	ICP-OES	AA FI/GF	Rozsah prvků	Náklady
Klinické lab.	AA FI/GF	ICP-MS	Povaha vzorků	Náklady
Geologie	ICP-MS	AA Flame	Povaha vzorků	Citlivost
Analýza potravin	AA FI/GF ICP-MS	ICP-OES	Náklady	Množství vzorků
Forensní	LA-ICP-MS	AA GF	Množství vzorku	Citlivost

Příklady použití AAS

Iron and Magnesium Determination in Meat using Flame Atomic Absorption Spectroscopy

Dr Anastasia Gadzhieva, AA Applications Chemist, Thermo Fisher Scientific, Cambridge, UK

Iron, Copper and Zinc Determination in Wine using Flame Atomic Absorption Spectroscopy

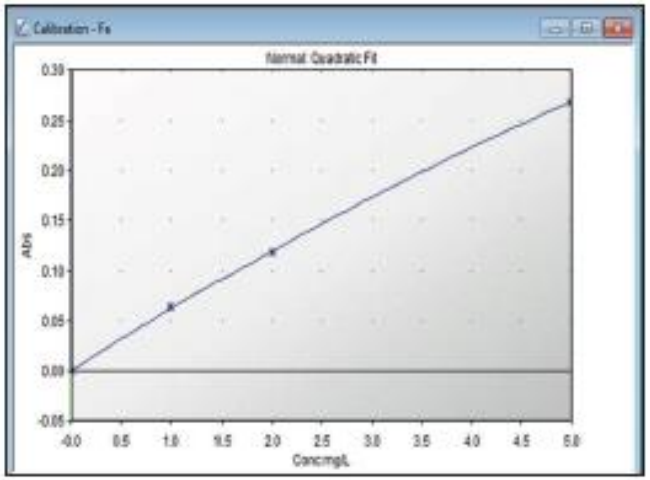


Figure 2: An example of a calibration curve for iron.

The results indicate that these meat samples do not exceed the recommended daily intake (RDI) of 15 mg/kg for iron and 350 mg/kg for magnesium.

In vino veritas, in aqua sanitas.

Ve víně je pravda, ve vodě je zdraví.

Table 1. Instrument settings for the iCE 3300 AAS.

Parameter	Iron	Copper	Zinc
Wavelength	248.3 nm	324.8 nm	213.9 nm
Band pass	0.2 nm	0.5 nm	0.2 nm
Background Correction	D2	D2	D2
Lamp Current	75%	75%	75%
Signal	Continuous	Continuous	Continuous
Flame type	Air-Acetylene	Air-Acetylene	Air-Acetylene
Fuel flow rate	0.9 L/min	1.1 L/min	1.2 L/min
Measurement Time	4s	4s	4s
Replicates	3	3	3

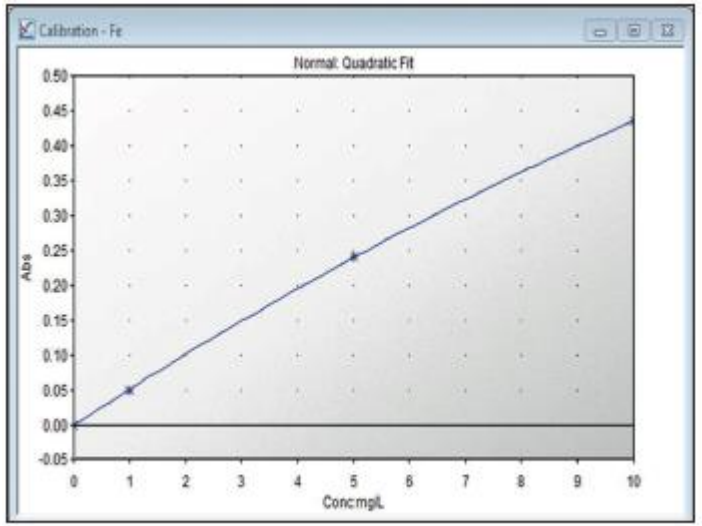


Figure 2: Calibration curve for Iron.

*All data was calculated from 3 replicate readings for each solution, the results are calculated with a view of 1:4 dilution.

Sample ID	Iron (mg/L)	Copper (mg/L)	Zinc (mg/L)
White wine*	1.165	0.027	0.988
Rosé wine*	1.835	0.028	0.514
Red wine*	2.437	0.037	0.575

Cadmium Determination in Crab Meat using Graphite Furnace Atomic Absorption Spectroscopy

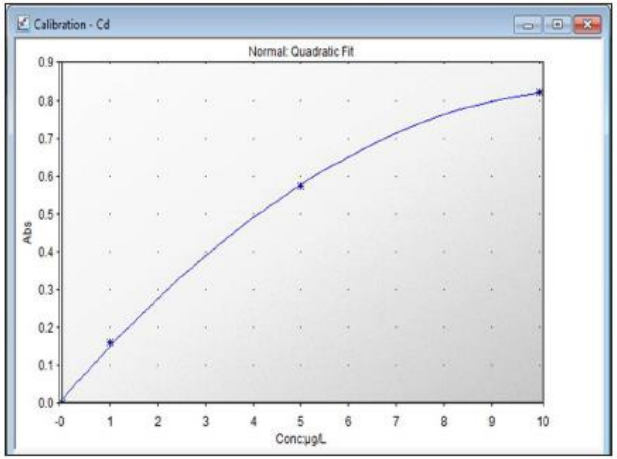


Figure 3: The calibration curve for cadmium.

Table 3. Results show the measured concentration of cadmium as well as expected and measured concentrations with percentage spike recovery for three separate crab samples (*all data was calculated from 3 replicate readings for each solution using transient peak height measurements).

Sample	Measured concentration sample (mg/kg)	Expected concentration spike (mg/kg)	Measured concentration spike (mg/kg)	Spike recovery (%)
Tinned crab*	0.0005	0.5005	0.4663	93.2
Dressed crab*	0.9641	1.46	1.4594	100.0
Crab pâté*	0.6143	1.06	1.0919	103.0

Další příklady

Food Safety Series – Accurate analysis of low levels of mercury in fish by vapor generation AA

The Analysis of Cadmium in Chocolate by Graphite Furnace Atomic Absorption Spectrometry

The Determination of Selenium in Shampoo by Flame Atomic Absorption Spectrometry

Application Notes 43019

Determination of Trace Elements in Rice Products by Flame and Graphite Furnace Atomic Absorption Spectrometry

Rebecca Price, Thermo Fisher Scientific, Cambridge, UK.

Key Words
Atomic Absorption, Esse
Rice,Toxic Elements.

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Application Notes 43060

The Analysis of Trace Elements in Honey by Flame and Graphite Furnace Atomic Absorption Spectrometry

Rebecca Price, Thermo Fisher Scientific, Cambridge, UK.

Key Words
Atomic Absorption, Flame, Deuterium, Graphite Furnace, Honey, Zeeman

Key Benefits
- The robust flame sample introduction system allows dissolved honey samples to be run without blockage or contamination.
- The advanced furnace autosampler speeds up analysis by automatically preparing the working standards from a single master standard.
- The permanently aligned true dual atomizer enables rapid switching between flame and furnace methods.
- Deuterium and Zeeman background correction offer a flexible solution for the analysis of challenging matrices such as honey.

Summary
The Thermo Scientific iCE 3500 Atomic Absorption Spectrometer is the ideal solution for the analysis of major, minor and toxic elements in honey. The permanently aligned true dual atomizer allows robust and reliable analysis of major elements by flame, followed by accurate and precise determination of minor and toxic elements by graphite furnace.

Introduction
Honey is a sweet and viscous substance produced from the nectar and secretions of plants and flowers. The nectar is transported to a beehive by honey bees, where worker bees then add enzymes to create honey. Most honey is created from a variety of plants and flowers, though in some areas, where a particular plant or flower is in abundance, monofloral honey can be produced, and this is particularly valuable. Honey is typically advertised to the consumer by floral source or geographical location, however many honey products are blended from a variety of sources. This has resulted in a global market with hundreds of types of honey, each with unique taste, color and crystallization properties. In the EU, honey must adhere to strict composition criteria, including sugar, moisture and hydroxymethylfurfural (HMF) content.[1]

Application Note 43159

Analysis of Zinc in Toothpaste using the Thermo Scientific iCE 3000 series AAS

Bhagyesh Surekar, Dr. G. W. Joshi, Dr. B.A. Patra and Rakesh Jha, Thermo Fisher Scientific, Mumbai, India

Key Words
AA, Flame, Teeth, Toothpaste, Zinc

Introduction
Typically our day starts with a mixture of chemicals, toothpaste, a paste or gel dentifrice used with a toothbrush as an accessory to clean and maintain the aesthetics and health of teeth. Toothpaste is used to promote oral hygiene: it serves as an abrasive that aids in removing the dental plaque and food from the teeth, assists in suppressing halitosis (bad breath), and delivers active ingredients such as fluoride or xylitol which help to prevent tooth and gum disease (gingivitis).[1]

Although toothpaste was used as long ago as 500 BC in ancient Egypt, China and India, it was not until the19th century that toothpastes came into general use. Ancient tooth powders used abrasive ingredients such as crushed bone, burned and crushed egg, snail or oyster shells, which were used to clean debris from teeth. First 'modern' toothpastes in the 1800s were homemade, with chalk, soap and salt as common ingredients and were sold in jars either as a powder or paste. A dentist in the US first introduced tooth paste in a tube, in 1892. The most important breakthrough in the history of toothpaste was the addition of fluoride in toothpaste in 1914. The use of fluoride in toothpastes became widespread much later in the 1950's.

Modern toothpaste is a complex formulation that has many more added ingredients since it was first introduced. Extensive work has been carried out to introduce an ingredient which can provide effective protection against various dental conditions.

Triclosan is reported as one of the commonly used important antimicrobial agents used in toothpaste that fight the bacteria which contribute to dental plaque. However, Triclosan induces damage and lesions to the cell wall of bacteria resulting in bacteriolysis (death of the cell) and hence its use is restricted or banned in many countries. [2]

As an alternative to Triclosan many leading manufacturers prefer to use bacteriostatic agents such as zinc (zinc chloride or zinc citrate) which stop the growth of dental plaque bacteria by inhibiting their metabolism. The combination of bacteriostatic and bactericidal agents as toothpaste ingredients is the most effective one way to fight dental plaque and gum disease.

This application note presents a simple, rugged flame atomic absorption spectrometry method for the analysis of zinc in toothpaste. Random samples of known international & local brands in the market were used for this work.

Thermo SCIENTIFIC

Method Guide: 40184

Atomic Absorption Full Method Sn in Canned Fruit Juice

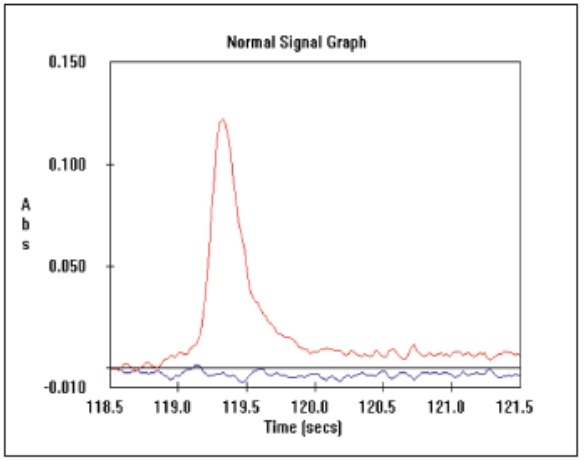


Figure 3: Correction with QuadLine background correction

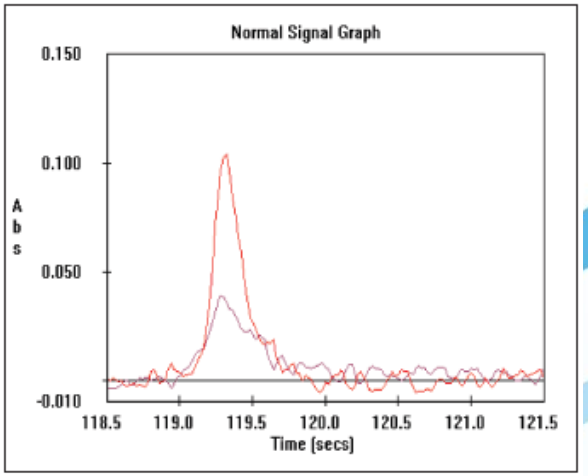


Figure 4: Correction with Zeeman background correction

The Analysis of Clinical Samples by Atomic Absorption Spectrometry

Krev a sérum

moč

3) Analytes:

The metallic elements measured in clinical analyses fall into three groups according to their role in human metabolism, and they are usually classed as essential, toxic or therapeutic.

Essential elements

- Essential major elements:
  Ca, Mg, Na, K
- Essential minor elements:
  Zn, Cu, Fe
- Essential trace elements:
  Cr, Mn, Mo, Co, V, Se, Ni

Shrnutí

Malý počet vzorků, single-element analýzy	AA
Vysoký počet vzorků na multi-element analýzy	ICP ICP-MS
Nízké detekční limity	ICP-MS ICP
'Špinavé' vzorky	ICP AA
Rozklady se střední koncentrací a vysokým pozadím	ICP ICP-MS
'Čisté' vzorky, nízké koncentrace	ICP-MS
Velmi nízké koncentrace, komplikované matrice	ICP-SFMS (nebo CRC)

Jak tedy zvolit ten správný nástroj?

TECHNICKÉ PARAMETRY

Technické vlastnosti – AAS
Některá klíčová slova při diskusích

„Mýty a nepravdy“

- AAS: zdroj světla – standardní lampy – kontinuální zdroj světla, „superlampy“, „boosted“ lampy, „dusíková plazma“,
- GF-AAS: longitudální nebo trasverzální uspořádání,
- Korekce pozadí: D_2 – Zeemanova kor., - Pulzní,
- „Sekvenční“ vs. „Standardní “ víceprvkové měření, u Fl-AAS.
- Nároky na údržbu – provozní nákladovost.

Některá klíčová slova při diskusích

- Technické vlastnosti – ICP-OES

- Optické rozlišení, spektrální rozsah „Alkal. kovy->nekovy“,
- Dostupnost „spektrálních oblastí“, pohled na plazmu
- Uspořádání vnášecího systému a plazmové hlavice – rozebiratelnost ...,
- RF generátor (frekvence, konstrukce, účinnost, stabilita, nastavení ...,
- Typ a konstrukce detektoru, možnost „Full Frame“,
- Celková stabilita plazmového a optického systému.
- Nároky na údržbu - nákladovost.

Některá klíčová slova při diskusích

- Technické vlastnosti – ICP-MS-Q (TOF)

- Citlivost (cps/ppb) a jak je to s pozadím „S/N“, (<1cps)
- Konstrukce iontové optiky (kóny – odstranění nežádoucích částic – kolizní-reakční optika a prvkové interference,
- Analyzátor (Kvadrupól, frekvence) – detektor (analogový i digitální) – rozsah linearity – rychlost skenování.
- Tzv. triple-Q vs. Single-Q,
- RF generátor (frekvence), konstrukce, účinnost, stabilita, nastavení ...,
- Nároky na údržbu – nákladovost, pracnost, periodicita.

Výběr nástroje od NÁS je na VÁS...

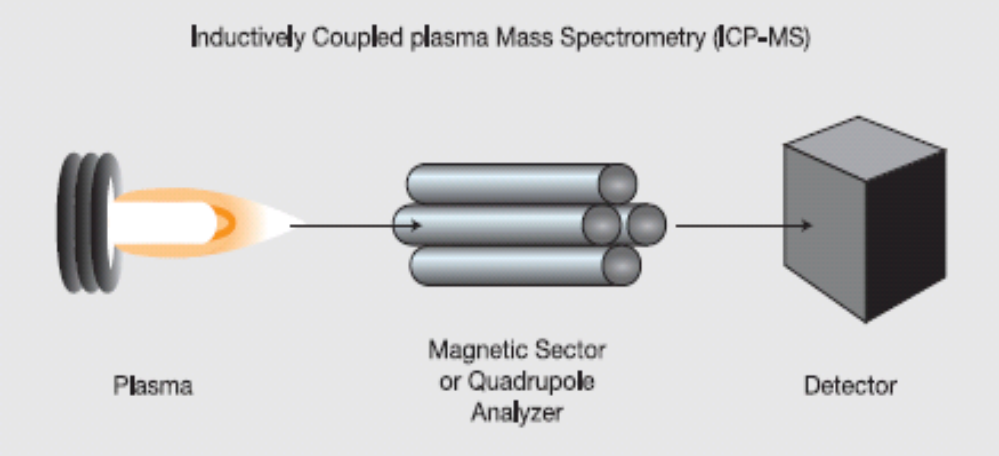
ICP-OES (iCAP **7000**)

low cost
ICP-OES analysis

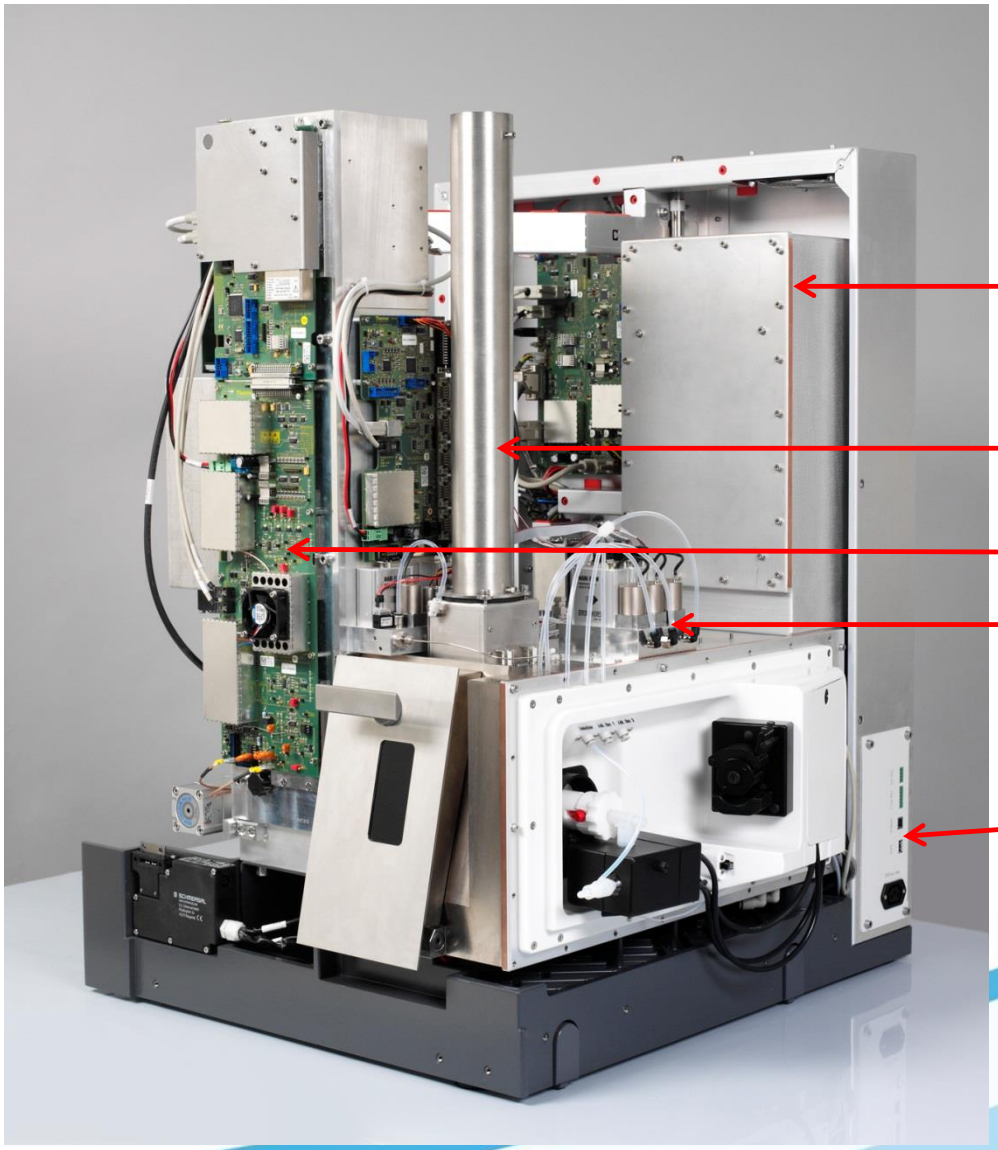
NEW

ICP-MS

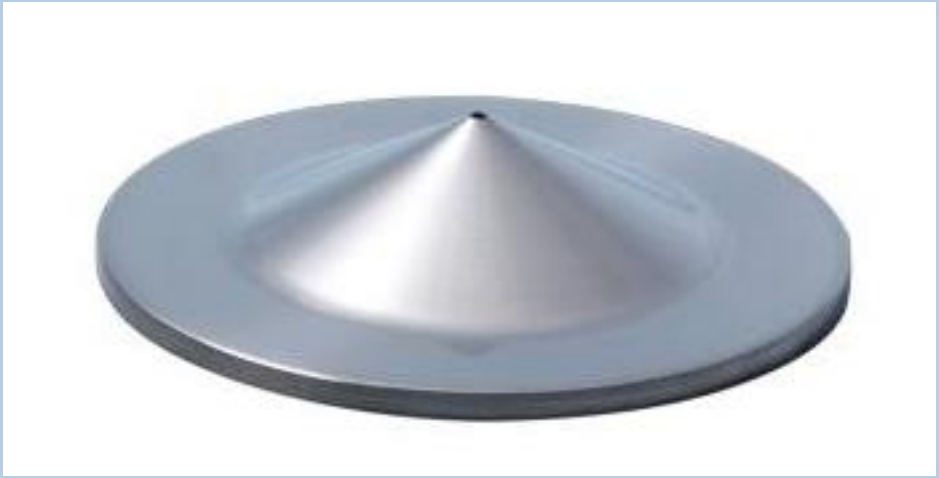
ICP-QMS spektrometr iCAP Q – Novinka 2012
2013 oceněno cenou za inovativnost



iCAP Q bez „kapoty“

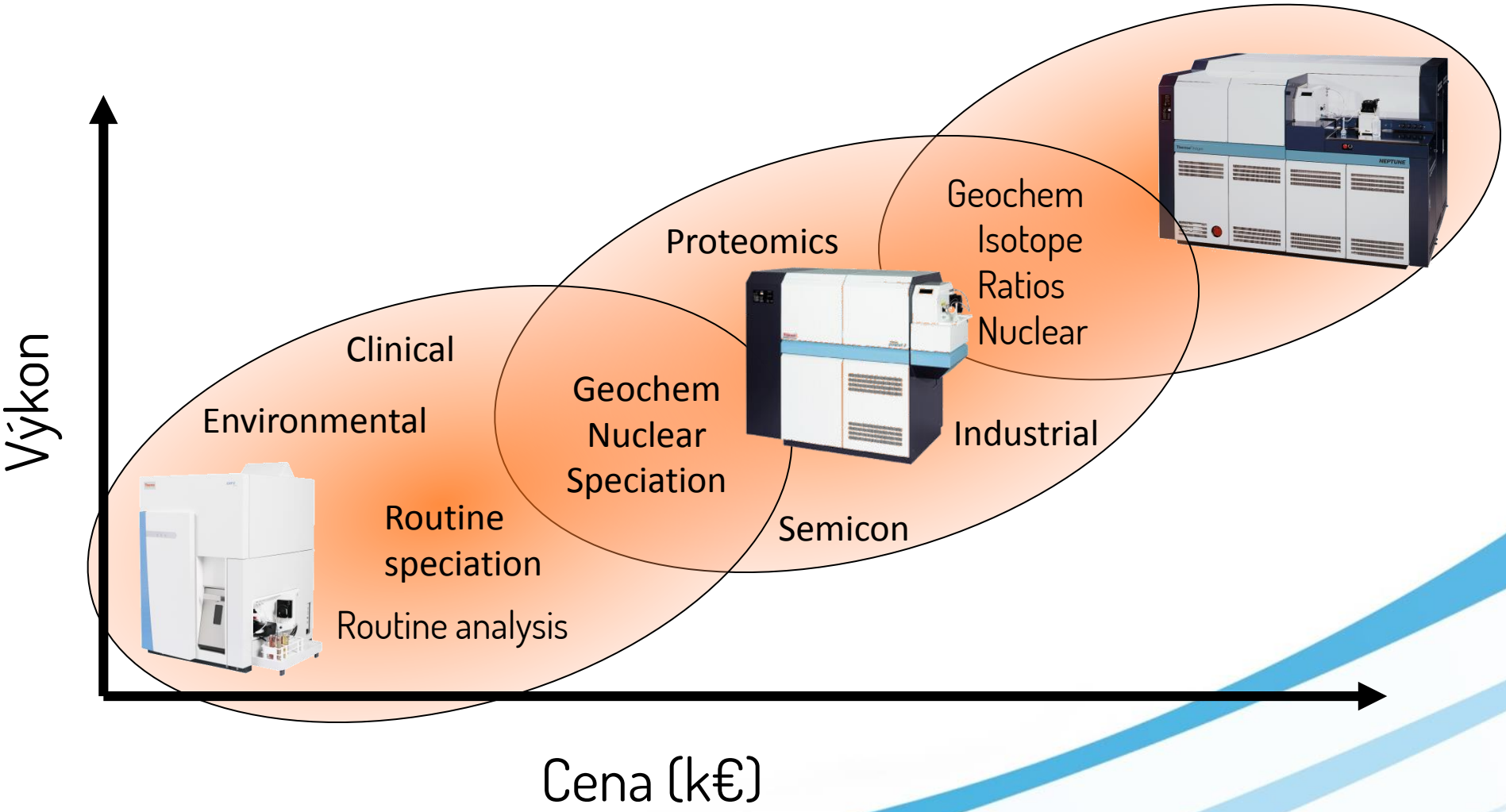


Co je nového na novém ICP-MS?



Pouze „sample cone“ je použit z XSeries2
Vše „ostatní“ je NOVÉ

Produktová linie ICP-MS od Thermo Scientific



Koncepce iCAP Q

- Robustní, dokonalý analytický výkon v kategorii Q-MS,
- Nízké provozní náklady,
- Minimální instalační nároky
- Minimální provozní údržba
- Maximální jednoduchost těch údržbových úkonů, které jsou doporučené ,
- Intuitivní, ale výkonná SW platforma **Qtegra**
- Flexibilita - pro rutinní analytický provoz 24/7 i pro výzkum a pokročilé metody (Laserová ablace, speciace LC/GC/IC) s plnou integrací všech zařízení v prostředí **SW Qtegra**

iCAP Q ICP-MS: Simplified installation

Nízko údržbové provedení

Přístroj lze nainstalovat zcela ke zdi, není nutný žádný zadní servisní přístup

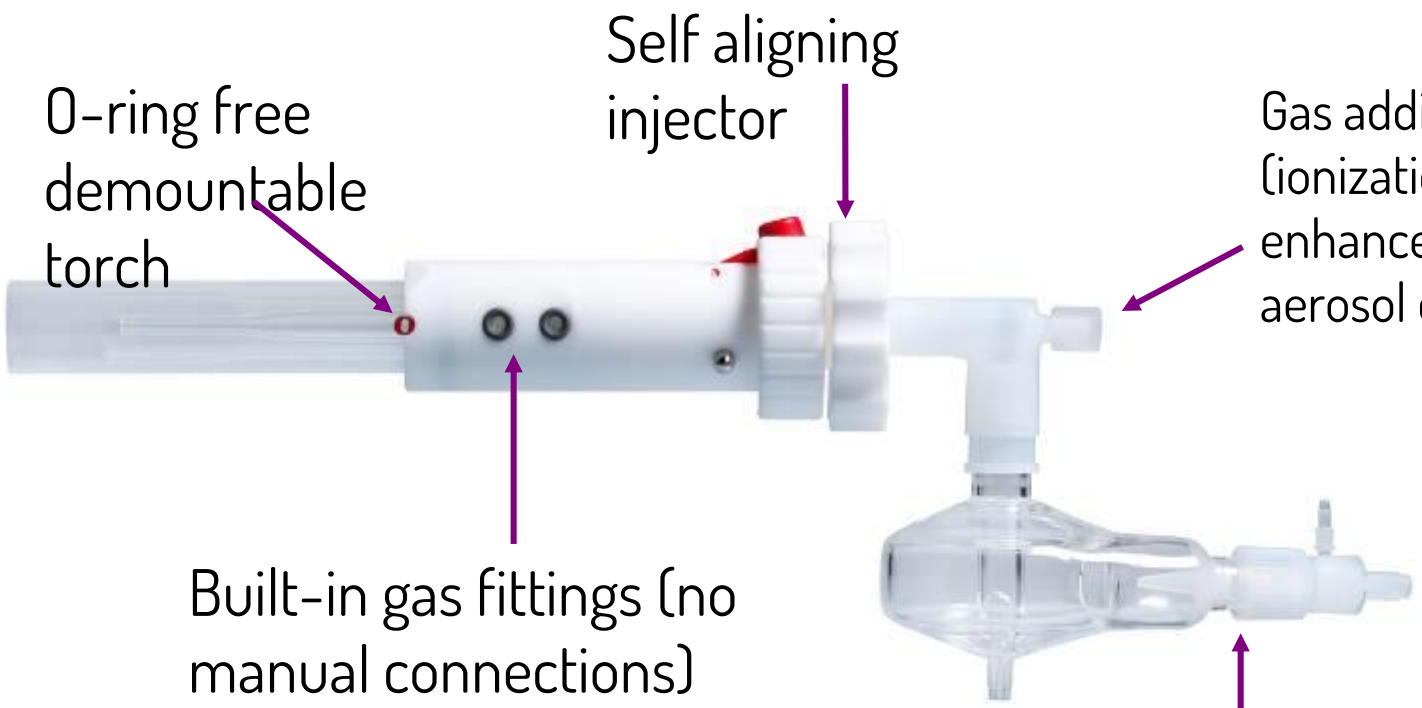
Veškerý servis jen zepředu a z boku

Všechna servisní připojení jsou na boku přístroje

Systém zavádění vzorku iCAP Q

- Čtyřkanálová peristaltická pumpa s miniválečky s nízkým pulzováním vzorku
- Peltierovsky chlazená zmlžovací komora, t_{min} -10^{0}C
- Cyclonická zmlžovací komora umístěná těsně k plazmové hlavici
- Snadný přístup k MFC

Intuitive Quick-Connect Sample Introduction Components



Jednoduše demontovatelná plazmová hlavice

Samonastavovací, volitelný injektor

Křemenný „Torch“

Držák

Snadná záměna

Snadné sestavení

Automatizované připojení plynů

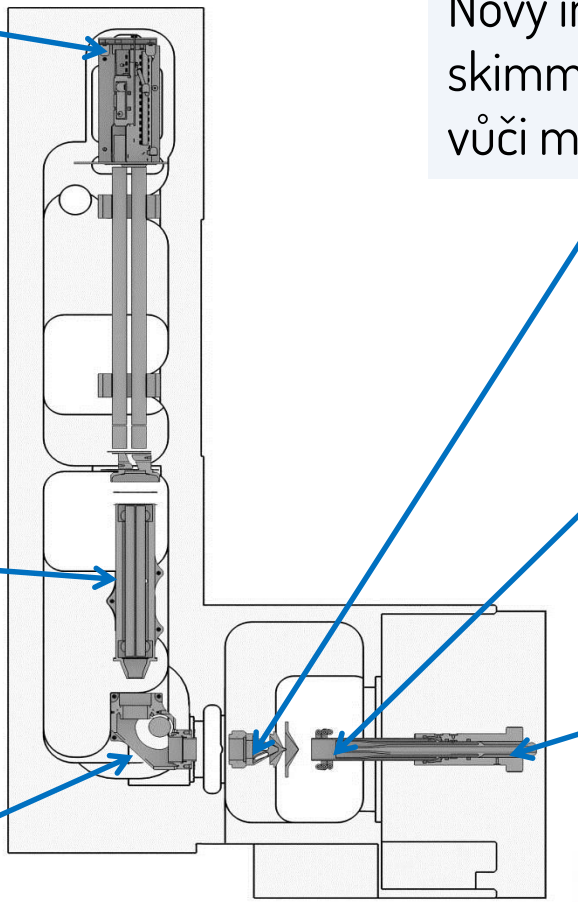
iCAP Q – Overview + Nový SW Qtegra

Nový A+D detektor

Nová elektronika a SW

Nová kolizně-reakční cela (QCell) vylepšený přenos iontů a rychlejší přepínání měřicích módů

RAPID Lens – 90° deflekce neutrálních částic a molekul plynu



Nový interface vč. nového skimmer kónu – zvýšená odolnost vůči matrici a snadná údržba

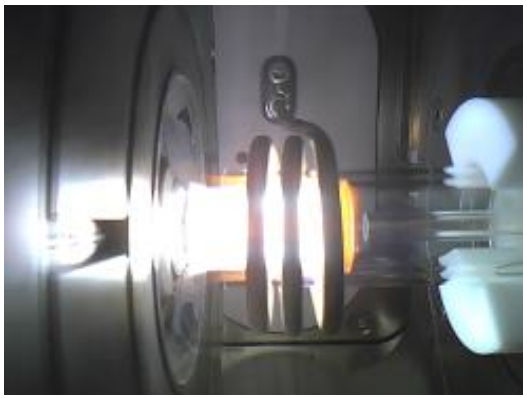
iCAP RF generátor nevyžaduje stínění plazmy

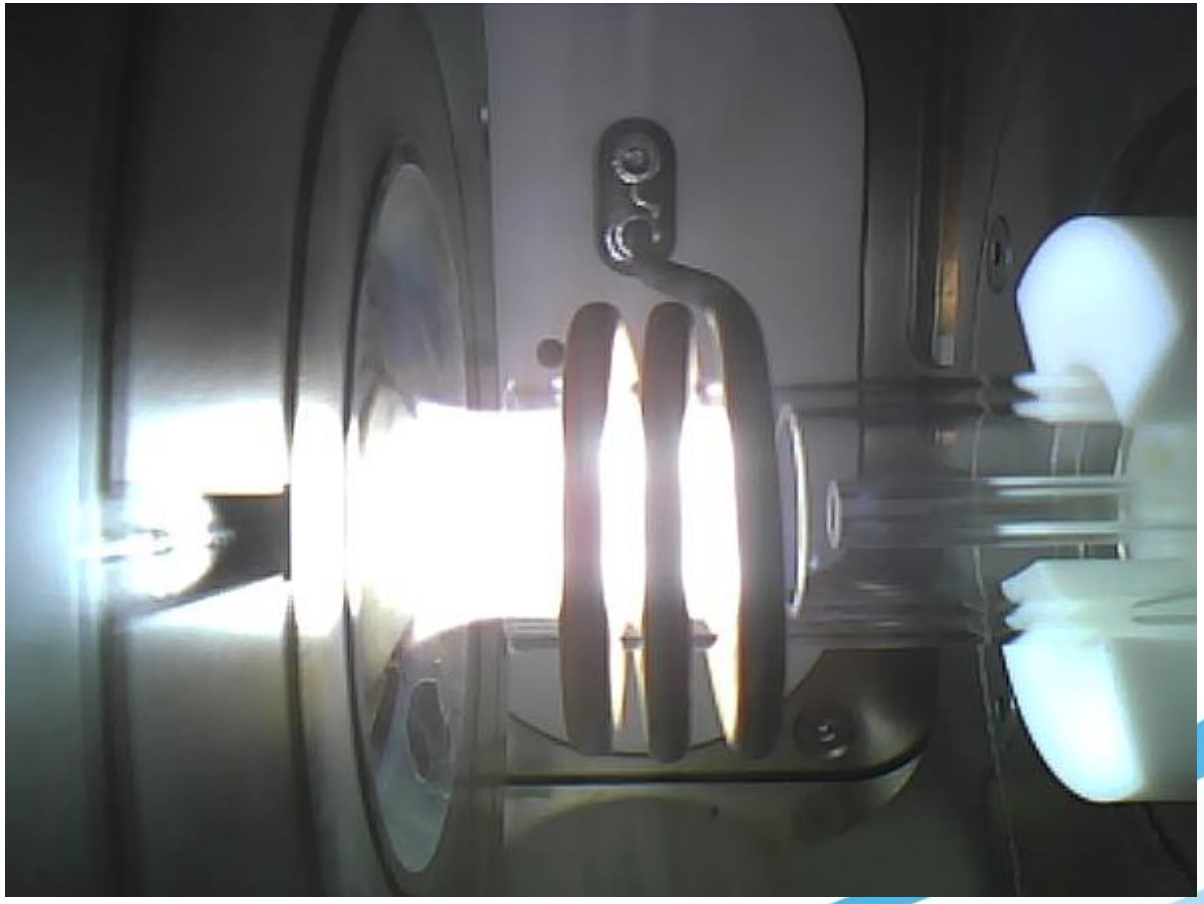
Nové provedení plazmové hlavice – snadná manipulace

Plasma TV: „Live“ pohled a sledování plazmy integrovanou video kamerou

Užitečné pro Optimalizaci plazmy, (např. O_2 pro organická rozpouštědla)

Možnost rychlé „diagnózy“ např. u vzorků s vysokým podílem rozpuštěných složek)





iCAP Q - Modely

Product		iCAP Qa	iCAP Qc	iCAP Qs
				
Sensitivity [kcps/ppb] STD Mode	^{7}Li ^{115}In ^{238}U	40 150 200	50 220 300	80 400 500
Sensitivity [kcps/ppb] KED Mode	^{59}Co	-	30	50
Oxides [%]	CeO/Ce	< 2	< 2	< 2
Doubly Charged [%]	Ba^{++}/Ba^{+}	< 3	< 3	< 3
Background m/z 4.5 [cps]	STD KED	< 1 -	< 1 < 0.5	< 1 < 0.5

iCAP Q - Modely

Product	iCAP Qa	iCAP Qc	iCAP Qs
			
Short Term Stability (10 min) [%]	< 2	< 2	< 2
Long Term Stability (2 h) [%]	< 3	< 3	<3
Detection Limits [ppt] ^{9}Be ^{115}In ^{209}Bi	< 0.5 < 0.1 < 0.1	< 0.5 < 0.1 < 0.1	< 0.5 < 0.1 < 0.1
Isotope Ratio Precision [%RSD] ^{107}Ag/^{109}Ag	< 0.1	< 0.1	< 0.1

Dramatically Different Ion Focusing:

RAPID Lens

Right

Angle

Positive

Ion

Deflection

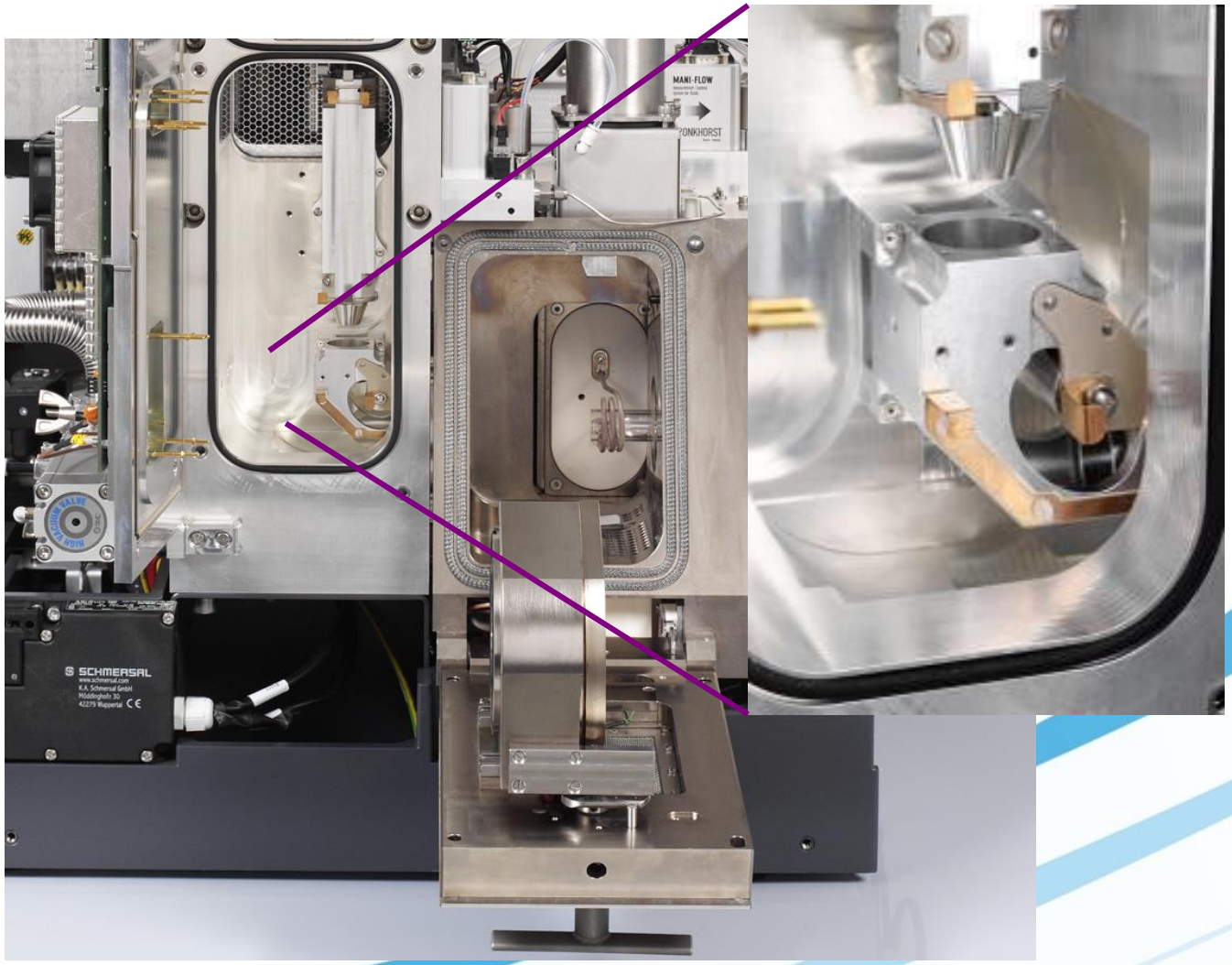
90° totální iontová fokusace s deflexí ve 3D

a

Eliminace neutrálních částic

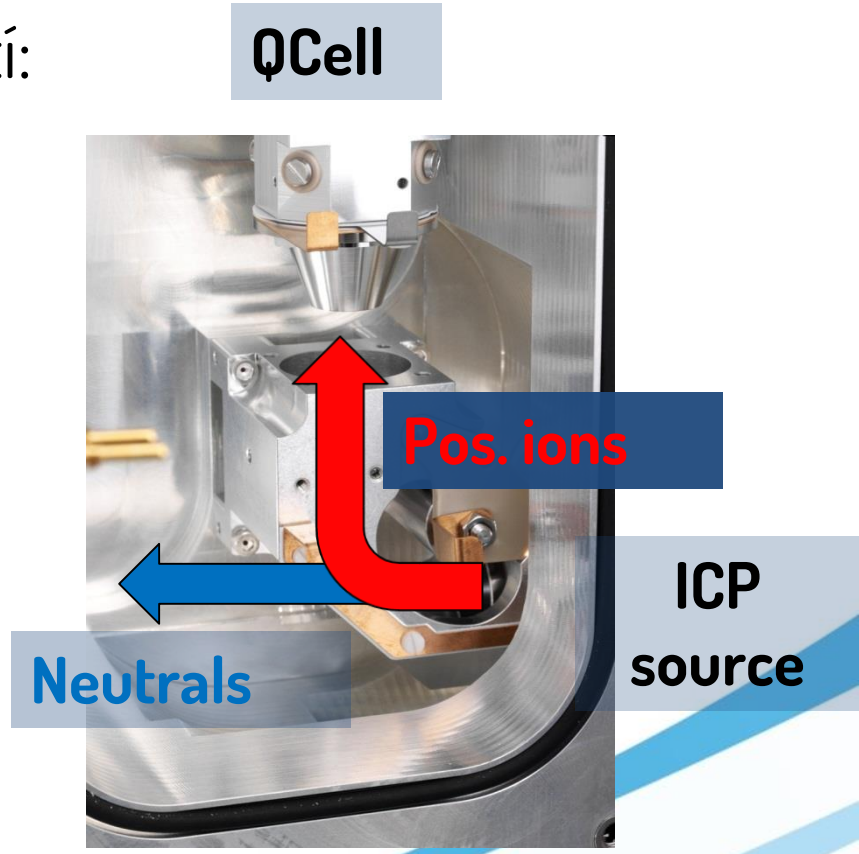
pro

dosažení nejvyššího poměru S/N ve třídě Q-ICP-MS



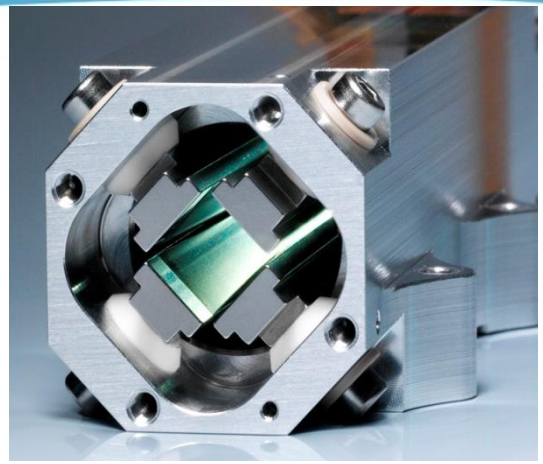
RAPID Lens – Simplicity and ion optics done right

- "Jednoduché" provedení ze 3 částí:
  - Vstupní a výstupní čočky
  - Deflekční čočky mezi nimi
- Jednoduché ovládání pomocí vložení napětí
- Optimální deflexe iontů a fokusovací vlastnosti

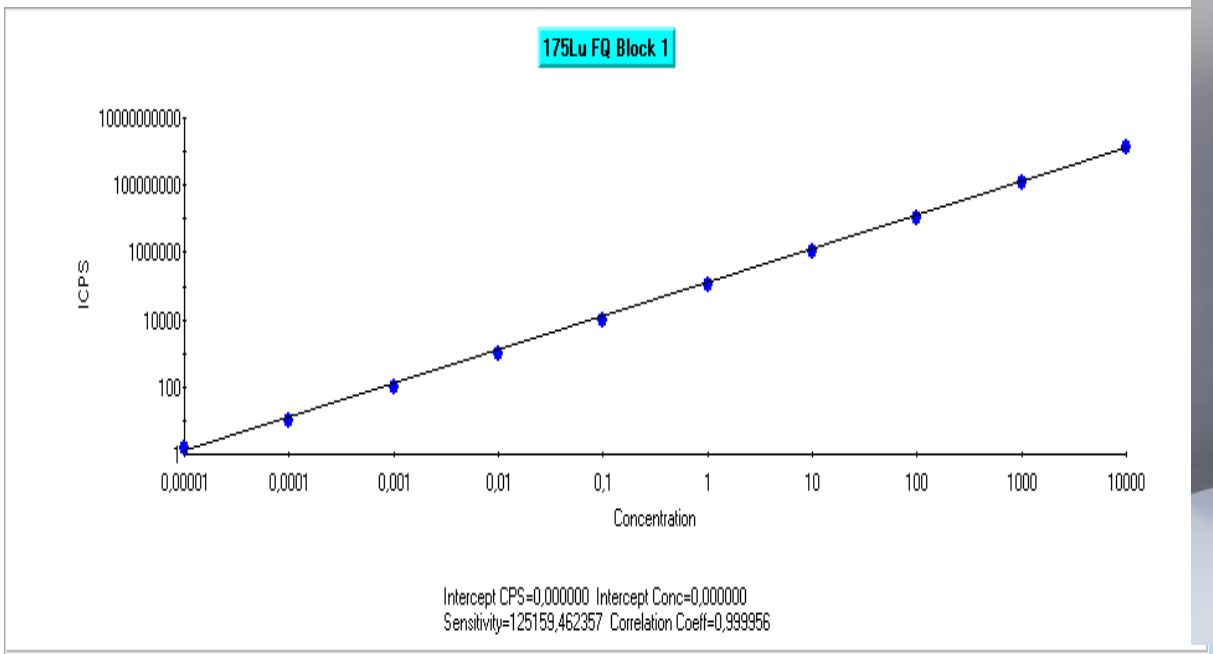


ICP-Q-MS

- **Kvadrupólová separace iontů (m/z=4-290 amu)**
- **Eliminace interferencí pomocí kolizní/reakční cely (CRC)**
- **Rozsah linearity více než 9 řádů**
- **Background < 1 (0.5 cps)**
- **Vysoký poměr Signál/Šum (S/N)**
- **Nejrychlejší skenování hm. škály (90 000 amu/s)**
- **Minimální údržba**



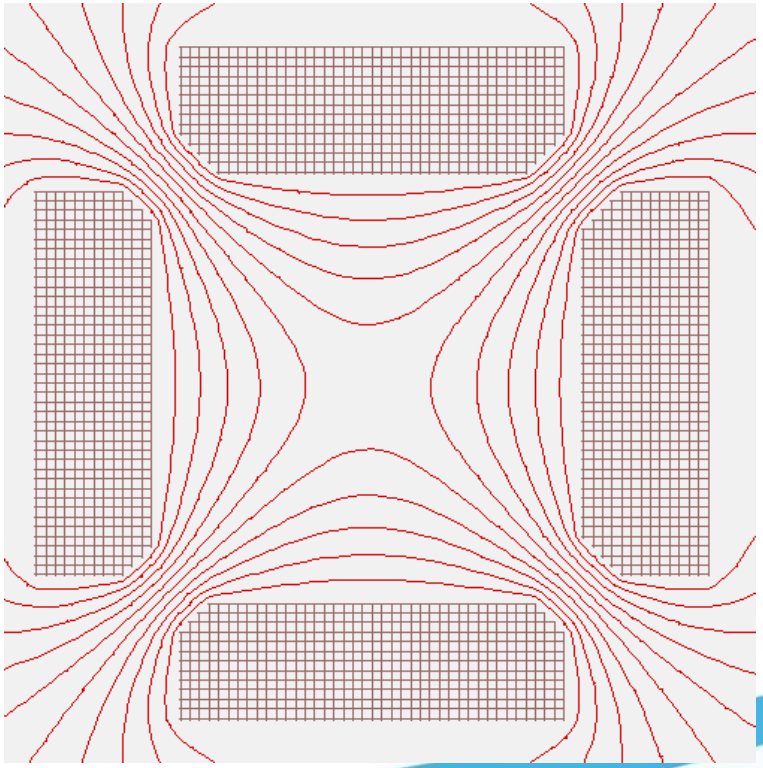
„FLATAPÓL“



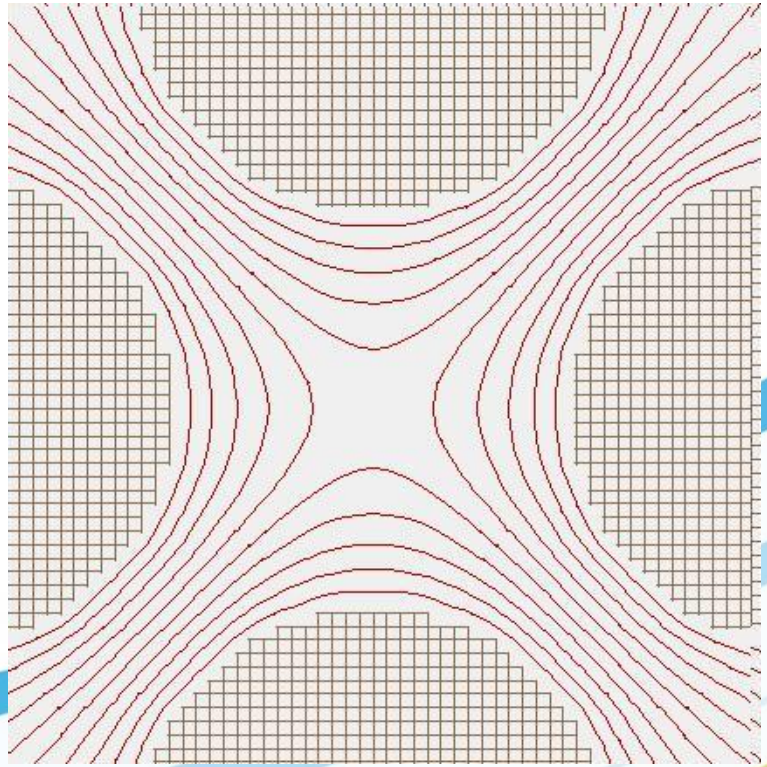
Flatapól = přibližně kvadrupól

- Pole Flatapólu je přibližně ekvivalentní poli kvadrupólu s prvky vyšších multipólů.
  - **Vysoká transmise**
  - **Potlačení (Cut-off) nízkých hmot**

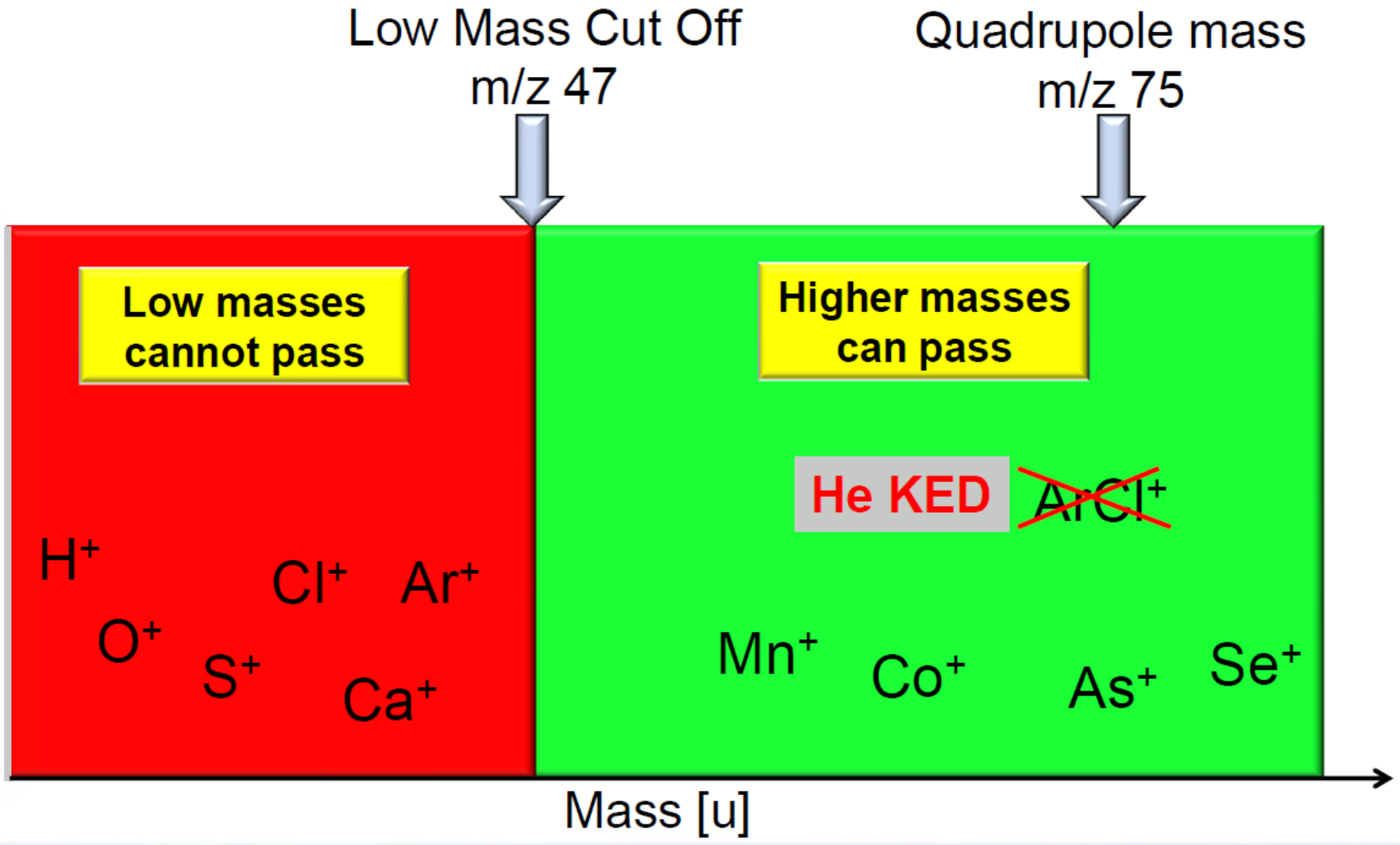
Flatapole



Quadrupole



Funkce potlačení nízkých hmot



Effect of Low Mass Cut-Off on in-cell Interference

ANALYTE	CUT-OFF MASS	POTENTIAL INTERFERENT	PRECURSORS
^{45}Sc	29	$^{13}C^{16}O_2$, $^{12}C^{16}O_2H$, ^{44}CaH, $^{32}S^{12}CH$, $^{32}S^{13}C$, $^{33}S^{12}C$	H, C, O,S, Ca
^{47}Ti	32	$^{31}P^{16}O$, ^{46}CaH, $^{35}Cl^{12}C$, $^{32}S^{14}NH$, $^{33}S^{14}N$	H, C, N, O, P, S, Cl, Ca
^{49}Ti	33	$^{31}P^{18}O$, ^{48}CaH, $^{35}Cl^{14}N$, $^{37}Cl^{12}C$, $^{32}S^{16}OH$, $^{33}S^{16}O$	H, C, N, O, P, S, Cl, Ca
^{50}Ti	34	$^{34}S^{16}O$, $^{32}S^{18}O$, $^{35}Cl^{14}NH$, $^{37}Cl^{12}CH$	H, C, N, O, S, Cl
^{51}V	35	$^{35}Cl^{16}O$, $^{37}Cl^{14}N$, $^{34}S^{16}OH$	H, O, N, S, Cl
^{52}Cr	36	$^{36}Ar^{16}O$, $^{40}Ar^{12}C$, $^{35}Cl^{16}OH$, $^{37}Cl^{14}NH$, $^{34}S^{18}O$	H, C, O, N, S, Cl, Ar
^{55}Mn	39	$^{37}Cl^{18}O$, $^{23}Na^{32}S$, $^{23}Na^{31}PH$	H, O, Na, P, S, Cl, Ar
^{56}Fe	39	$^{40}Ar^{16}O$, $^{40}Ca^{16}O$	O, Ar, Ca
^{57}Fe	40	$^{40}Ar^{16}OH$, $^{40}Ca^{16}OH$	H, O, Ar, Ca
^{58}Ni	41	$^{40}Ar^{18}O$, $^{40}Ca^{18}O$, $^{23}Na^{35}Cl$	O, Na, Cl, Ar, Ca
^{59}Co	42	$^{40}Ar^{18}OH$, $^{43}Ca^{16}O$, $^{23}Na^{35}ClH$	H, O, Na, Cl, Ar, Ca
^{60}Ni	43	$^{44}Ca^{16}O$, $^{23}Na^{37}Cl$	O, Na, Cl, Ca
^{61}Ni	44	$^{44}Ca^{16}OH$, $^{38}Ar^{23}Na$, $^{23}Na^{37}ClH$	H, O, Na, Cl, Ca
^{63}Cu	45	$^{40}Ar^{23}Na$, $^{12}C^{16}O^{35}Cl$, $^{12}C^{14}N^{37}Cl$, $^{31}P^{32}S$, $^{31}P^{16}O_2$	C, N, O, Na, P, S, Cl
^{64}Zn	46	$^{32}S^{16}O2$, $^{32}S_2$, $^{36}Ar^{12}C^{16}O$, $^{38}Ar^{12}C^{14}N$, $^{48}Ca^{16}O$	C, N, O, S, Ar, Ca
^{65}Cu	47	$^{32}S^{16}O2H$, $^{32}S_2H$, $^{14}N^{16}O^{35}Cl$, $^{48}Ca^{16}OH$	H, N, O, S, Cl, Ca
^{66}Zn	47	$^{34}S^{16}O$, $^{32}S^{34}S$, ^{33}S, ^{48}C, ^{18}O	O, C, S
^{69}Ga	47	$^{32}S^{18}O_2H$, $^{34}S_2H$, $^{37}Cl^{16}O_2$	H, O, S, Cl
^{70}Zn	47	$^{34}S^{18}O_2$, $^{35}Cl_2$	O, S, Cl
^{75}As	47	$^{40}Ar^{34}SH$, $^{40}Ar^{35}Cl$, $^{40}Ca\ ^{35}Cl$, $^{37}Cl_2H$	H, S, Cl, Ca, Ae
77Se	47	$^{40}Ar\ ^{37}Cl$, $^{40}Ca\ ^{37}Cl$	Cl, Ca, Ar
78Se	47	$^{40}Ar^{38}Ar$	Ar
80Se	47	$^{40}Ar_2$, $^{40}Ca_2$, $^{40}Ar^{40}Ca$, $^{32}S_2{}^{16}O$, $^{32}S^{16}O_3$	O, S, Ar, Ca

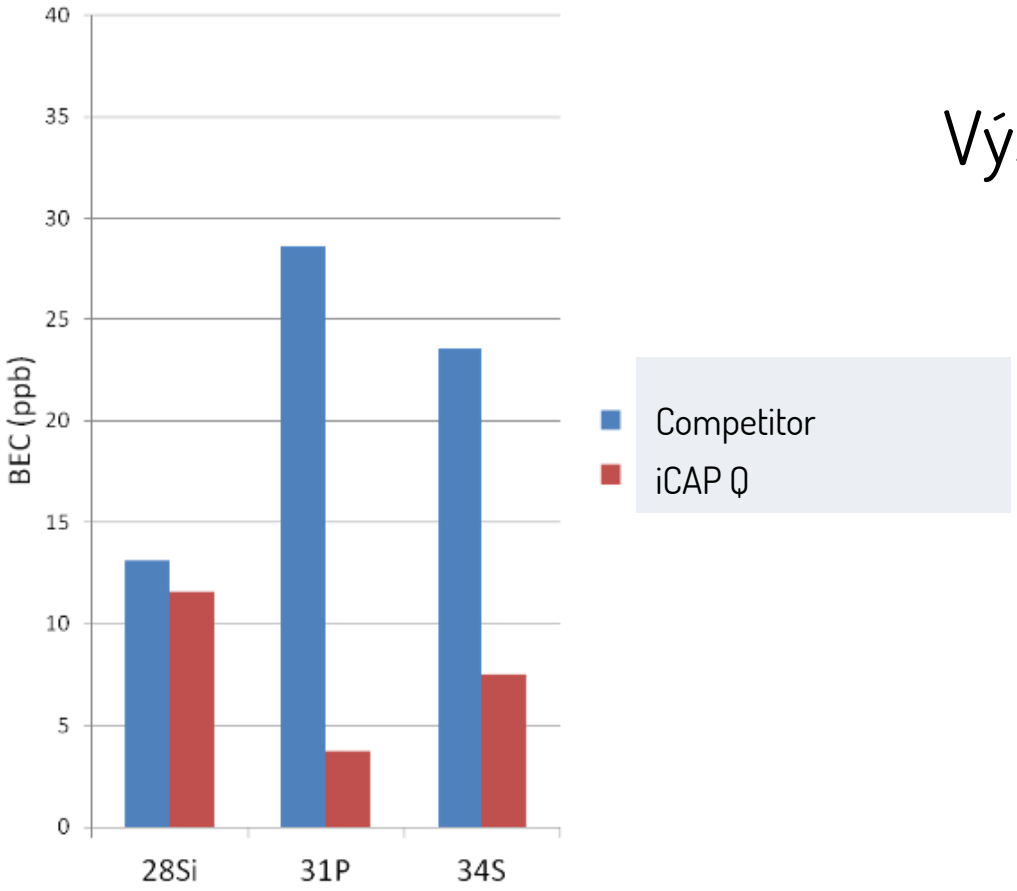
Effect of Low Mass Cut-Off on in-cell Interference Formation

ANALYTE	CUT-OFF-MASS	POTENTIAL INTERFERENT	PRECURSORS
^{45}Sc	29	$^{13}C^{16}O_2$, $^{12}C^{16}O_2H$, ^{44}CaH, $^{32}S^{12}CH$, $^{32}S^{13}C$, $^{33}S^{12}C$	H, C, O, S, Ca
^{47}Ti	32	$^{31}P^{16}O$, ^{46}CaH, $^{35}Cl^{12}C$, $^{32}S^{14}NH$, $^{33}S^{14}N$	H, C, N, O, P, S, Cl, Ca
^{49}Ti	33	$^{31}P^{18}O$, ^{48}CaH, $^{35}Cl^{14}N$, $^{37}Cl^{12}C$, $^{32}S^{16}OH$, $^{33}S^{16}O$	H, C, N, O, P, S, Cl, Ca
^{50}Ti	34	$^{34}S^{16}O$, $^{32}S^{18}O$, $^{35}Cl^{14}NH$, $^{37}Cl^{12}CH$	H, C, N, O, S, Cl
^{51}V	35	$^{35}Cl^{16}O$, $^{37}Cl^{14}N$, $^{34}S^{16}OH$	H, O, N, S, Cl
^{52}Cr	36	$^{36}Ar^{16}O$, $^{40}Ar^{12}C$, $^{35}Cl^{16}OH$, $^{37}Cl^{14}NH$, $^{34}S^{18}O$	H, C, O, N, S, Cl, Ar
^{55}Mn	39	$^{37}Cl^{18}O$, $^{23}Na^{32}S$, $^{23}Na^{31}PH$	H, O, Na, P, S, Cl, Ar
^{56}Fe	39	$^{40}Ar^{16}O$, $^{40}Ca^{16}O$	O, Ar, Ca
^{57}Fe	40	$^{40}Ar^{16}OH$, $^{40}Ca^{16}OH$	H, O, Ar, Ca
^{58}Ni	41	$^{40}Ar^{18}O$, $^{40}Ca^{18}O$, $^{23}Na^{35}Cl$	O, Na, Cl, Ar, Ca
^{59}Co	42	$^{40}Ar^{18}OH$, $^{43}Ca^{16}O$, $^{23}Na^{35}ClH$	H, O, Na, Cl, Ar, Ca
^{60}Ni	43	$^{44}Ca^{16}O$, $^{23}Na^{37}Cl$	O, Na, Cl, Ca
^{61}Ni	44	$^{44}Ca^{16}OH$, $^{38}Ar^{23}Na$, $^{23}Na^{37}ClH$	H, O, Na, Cl, Ca
^{63}Cu	45	$^{40}Ar^{23}Na$, $^{12}C^{16}O^{35}Cl$, $^{12}C^{14}N^{37}Cl$, $^{31}P^{32}S$, $^{31}P^{16}O_2$	C, N, O, Na, P, S, Cl
^{64}Zn	46	$^{32}S^{16}O2$, $^{32}S_2$, $^{36}Ar^{12}C^{16}O$, $^{38}Ar^{12}C^{14}N$, $^{48}Ca^{16}O$	C, N, O, S, Ar, Ca
^{65}Cu	47	$^{32}S^{16}O2H$, $^{32}S_2H$, $^{14}N^{16}O^{35}Cl$, $^{48}Ca^{16}OH$	H, N, O, S, Cl, Ca
^{66}Zn	47	$^{34}S^{16}O$, $^{32}S^{34}S$, ^{33}S, ^{48}C, ^{18}O	O, C, S
^{67}Zn	47	$^{32}S^{34}SH$, $^{33}S2H$, $^{48}Ca^{18}OH$, $^{14}N^{16}O^{37}Cl$, $^{35}Cl^{16}O_2$	H, N, O, S, Cl, Ca
^{68}Zn	47	$^{32}S^{18}O_2$, $^{34}S_2$	O, S
^{69}Ga	47	$^{32}S^{18}O_2H$, $^{34}S_2H$, $^{37}Cl^{16}O_2$	H, O, S, Cl
^{70}Zn	47	$^{34}S^{18}O_2$, $^{35}Cl_2$	O, S, Cl
^{75}As	47	$^{40}Ar^{34}SH$, $^{40}Ar^{35}Cl$, $^{40}Ca\ ^{35}Cl$, $^{37}Cl_2H$	H, S, Cl, Ca, Ar
77Se	47	$^{40}Ar\ ^{37}Cl$, $^{40}Ca\ ^{37}Cl$	Cl, Ca, Ar
78Se	47	$^{40}Ar^{38}Ar$	Ar
80Se	47	$^{40}Ar_2$, $^{40}Ca_2$, $^{40}Ar^{40}Ca$, $^{32}S_2{}^{16}O$, $^{32}S^{16}O_3$	O, S, Ar, Ca

Praktické výhody potlačení nízkých *m/z* s QCell

- Potlačení nízkých hmot eliminuje potenciální interference species vstupujících do kolizní cely.
- Tím je významně redukován vliv možných interferencí vlivem tvorby nových interferentů.
- Diskriminace kinetickou energií je tak mnohem efektivnější.
- Reaktivní „chemie“ fungují rovněž mnohem efektivněji.

QCell „Výkon“ – „Interference-free“ analýza P, Si, S



Výsledky:

- Si: He KED
- P: He KED
- S: $^{32}S^{16}O$ at m/z 48
- BEC nižší než konkurence

BEC = Background Equivalent Concentration

Výběr ICP-MS „dle parametrů“

Vysoká citlivost

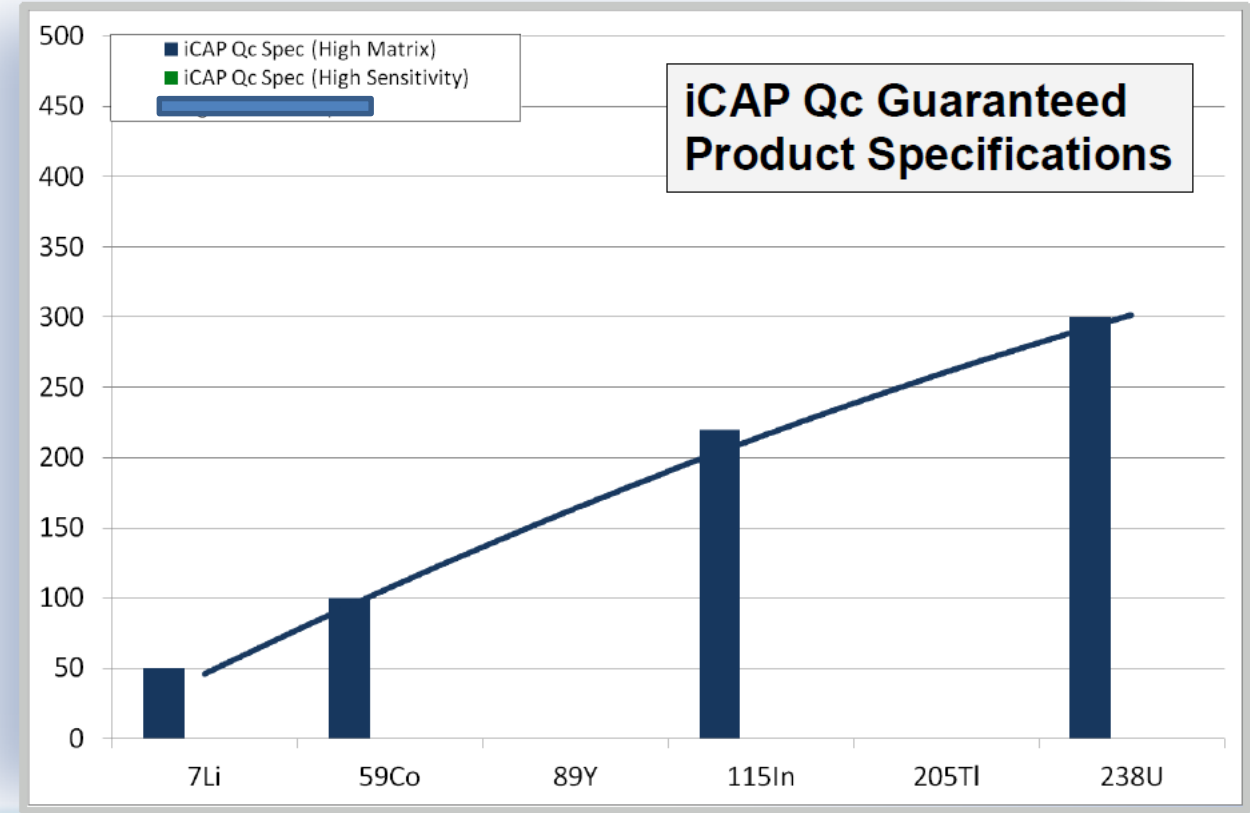
Vysoká tolerance vůči matrici

- UNIQUE Cone Inserts
  - Allows variation of central channel length
  - Interchangeable on iCAP Qc to vary instrument properties

Insert	Channel length	Properties
High Matrix	3.5 mm	High matrix tolerance
High Sensitivity	2.8 mm	High sensitivity

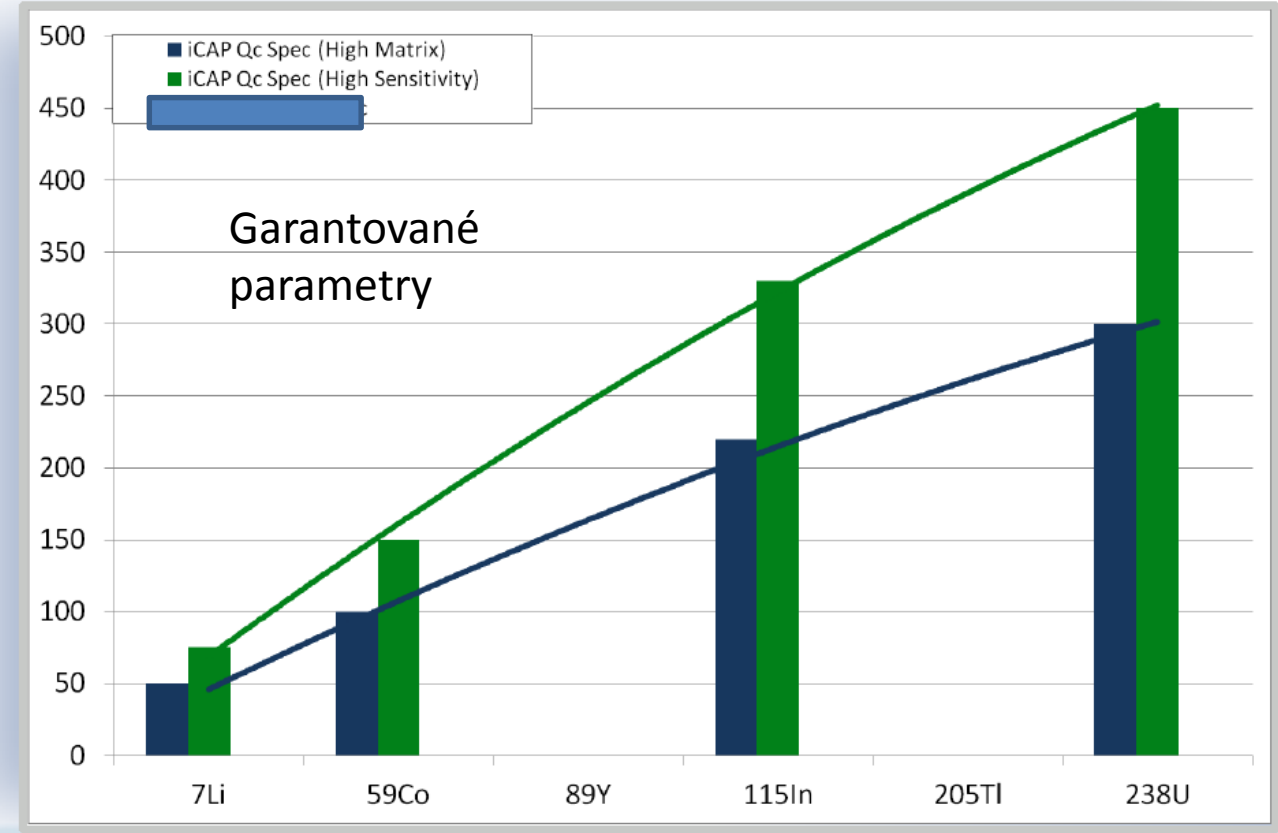
Porovnání produktových specifikací – **technické parametry**

Lets look at the sensitivity specification and mass response for the iCAP Qc with High Matrix insert:

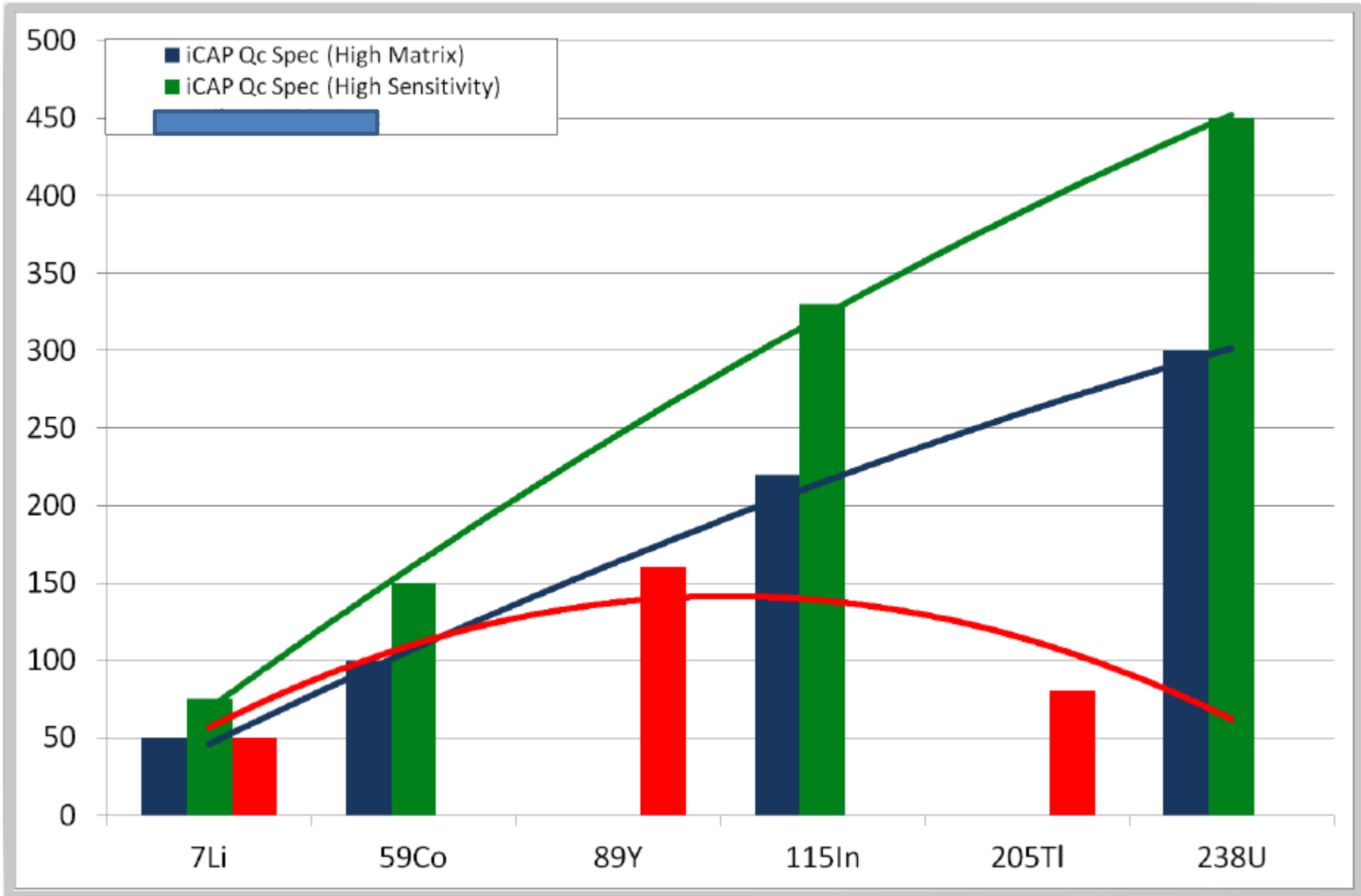


Sensitivity Performance High Sensitivity	=	**1.5 x**	**Sensitivity Performance High Matrix**

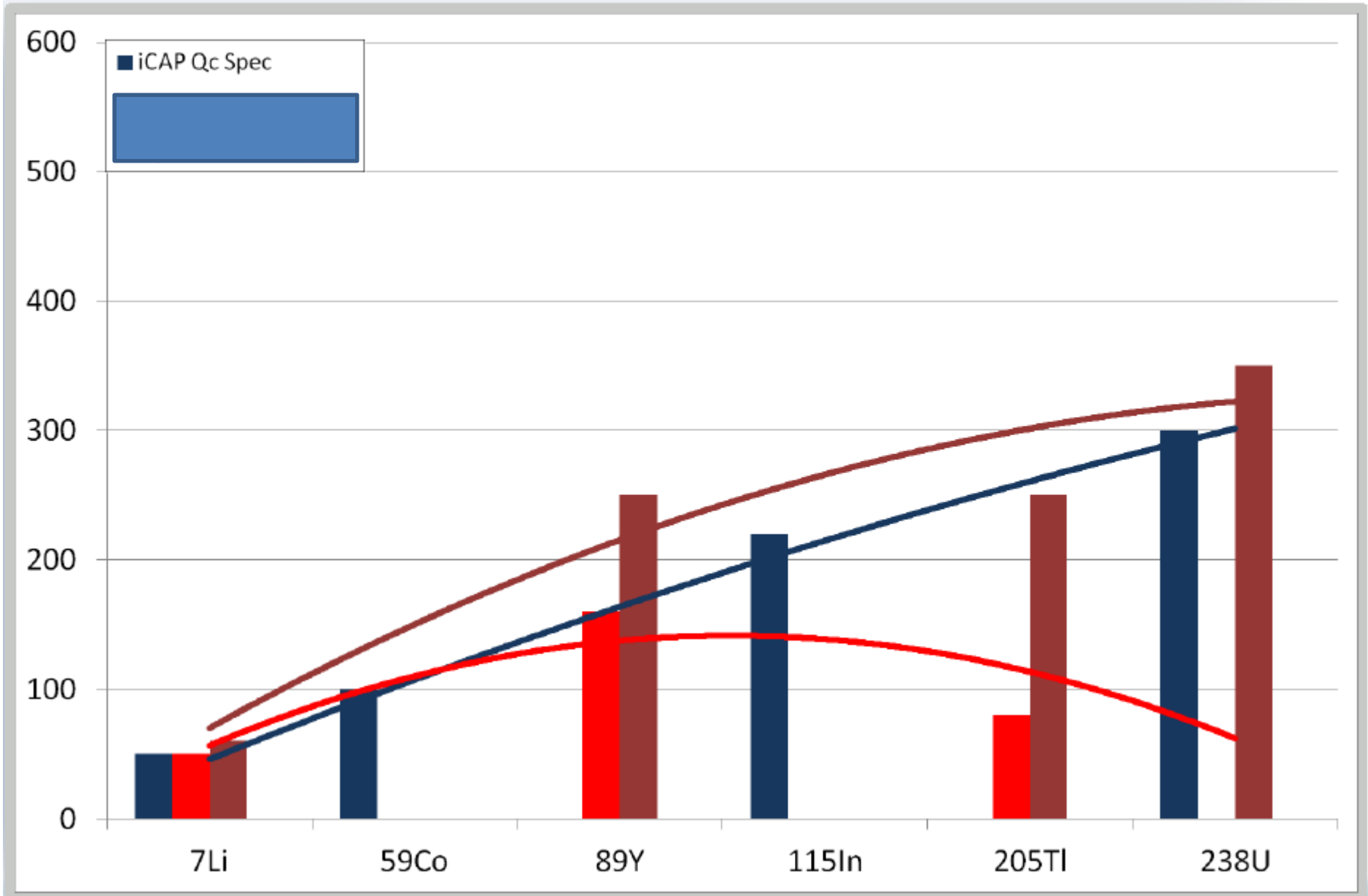
- Now add the sensitivity performance and mass response for the iCAP Qc with High Sensitivity insert:



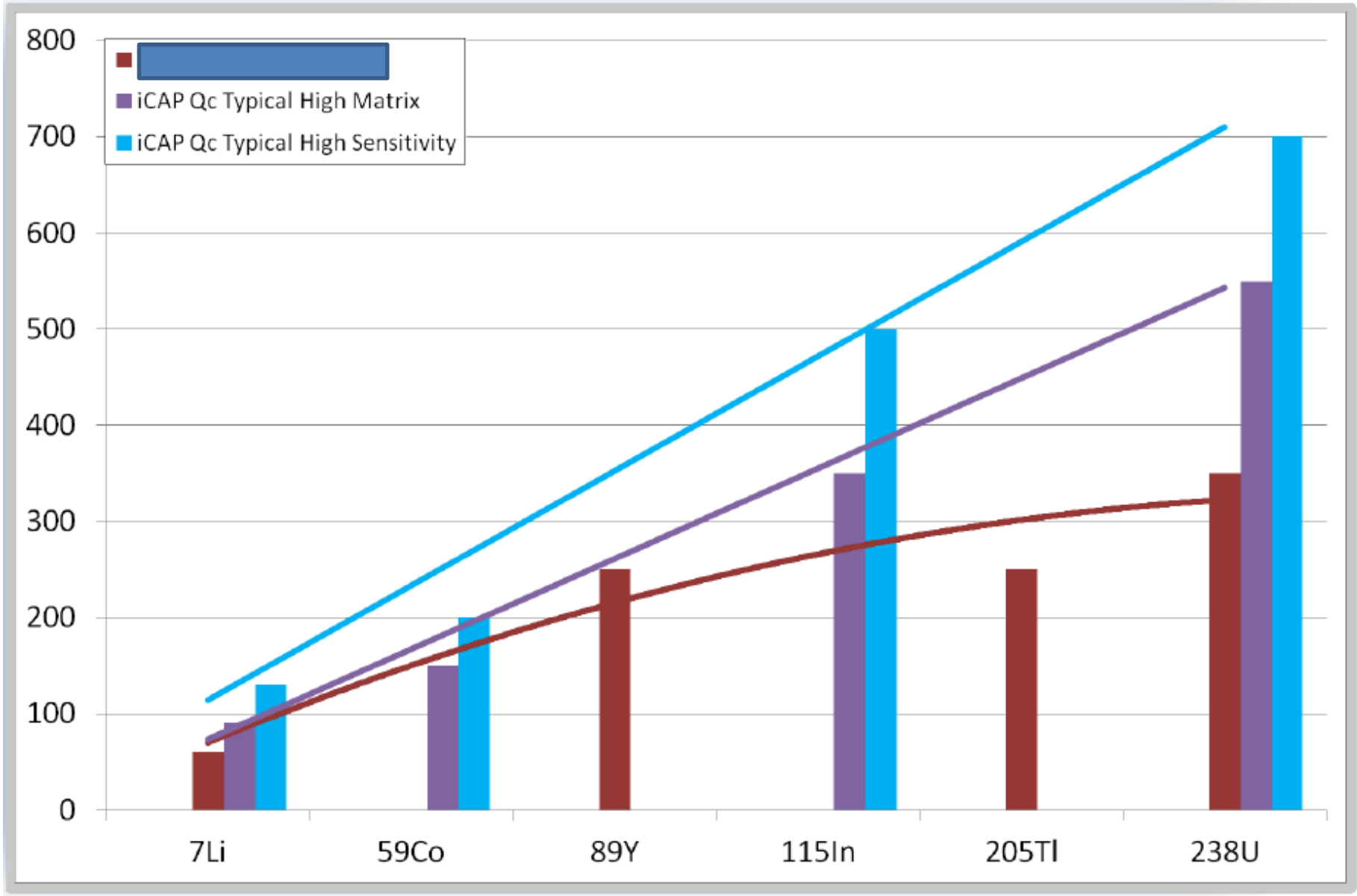
Porovnání Garantovaných parametrů



Tzv. „Typické parametry“ konkurence

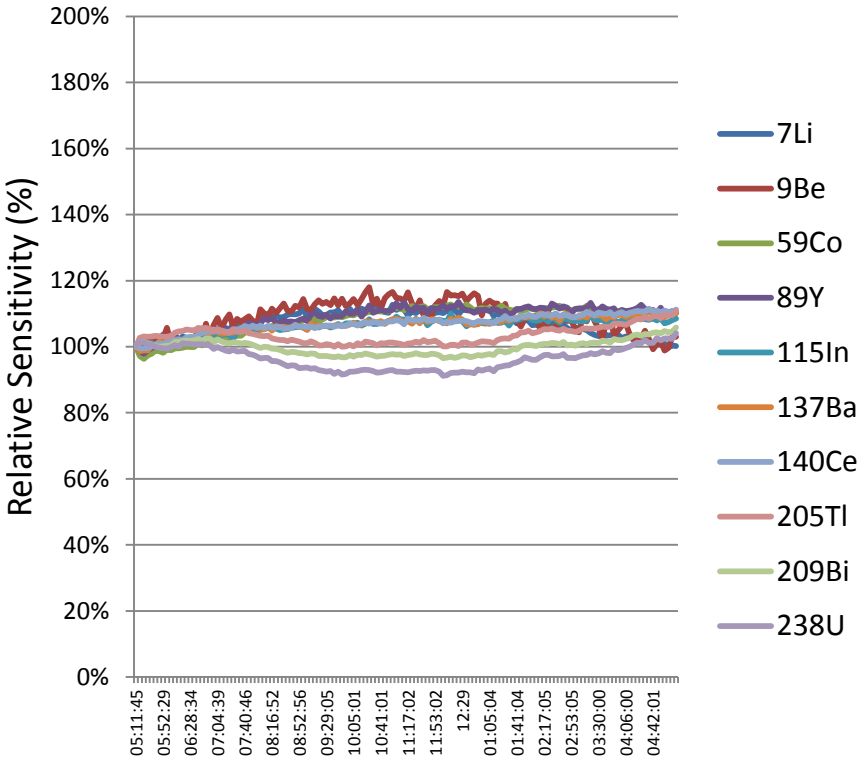


The iCAP Qc typical performance with the High Sensitivity interface



iCAP Q Interface Cone Access

Demonstrace odolnosti vůči vzorkové matrici

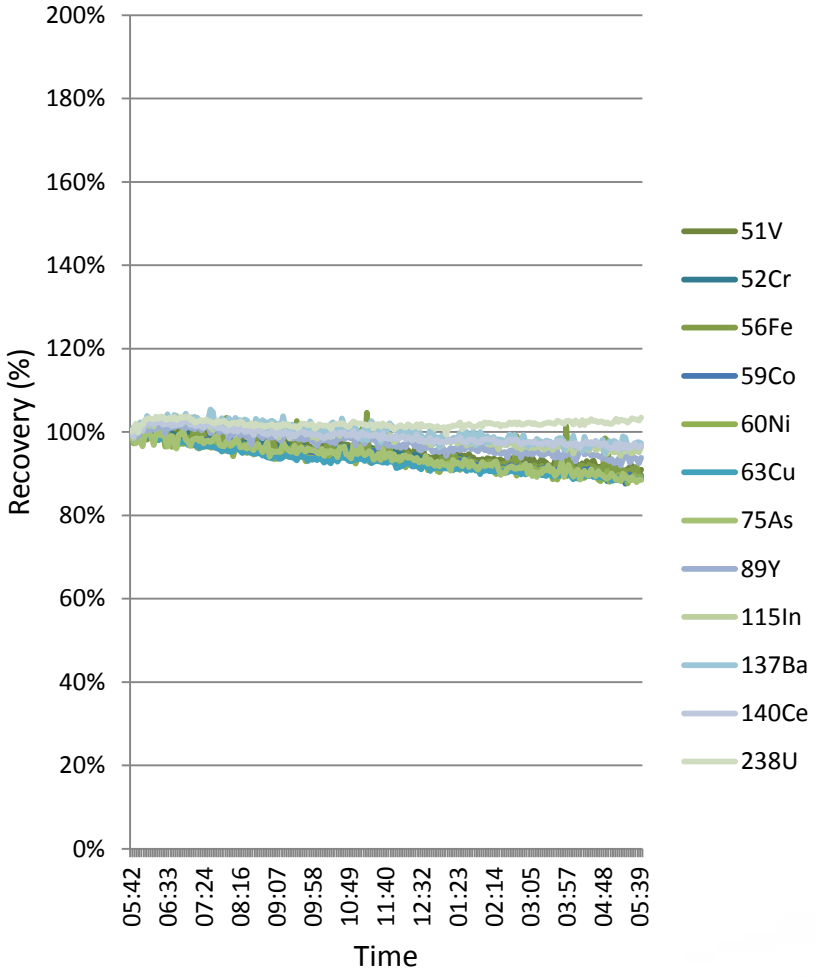


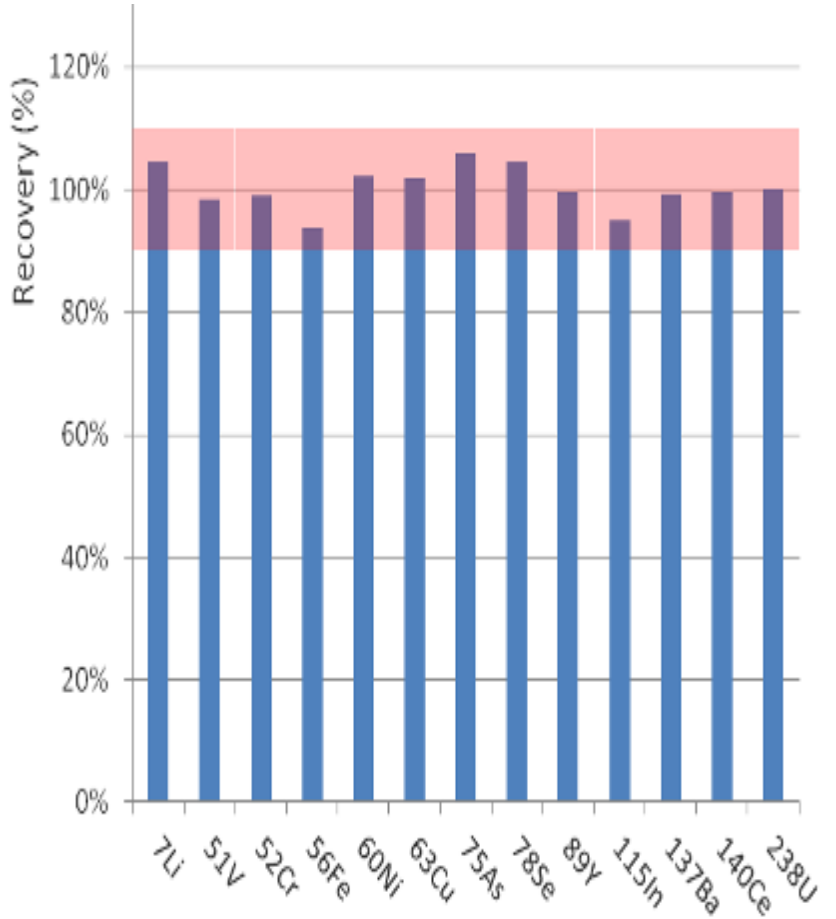
- Podmínky testu:
  - Kontinuální aspirace 10xzředěné „obohacené“ mořské vody (~0.35 % rozpuštěných pevných látek)
- Výsledky:
  - Přesahující obecné požadavky
  - Bez ztráty citlivosti
  - Celkovýl drift <10%
  - Vzorkové kóny zůstávají funkční a průchodné

Kvantifikace organického solventu: 100% ACN

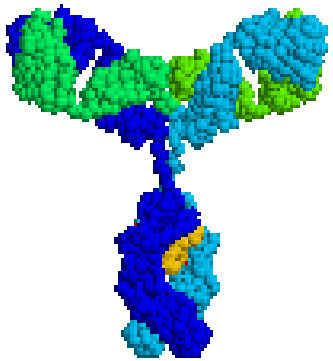
Stabilita za 12 hodin
všechny elementy <5% RSD

„Spike Recovery“ (1ppb) v 100% ACN) 90-110% získání





Děkuji za pozornost

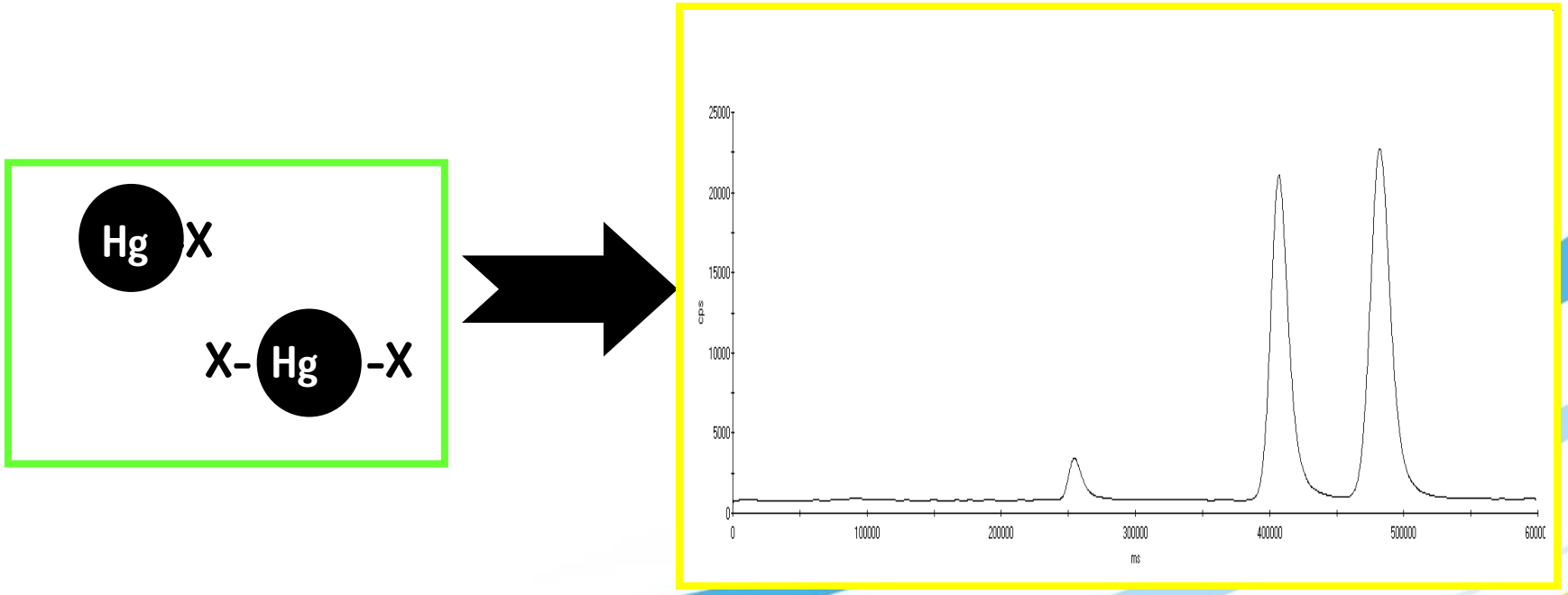


JANDERKA@PRAGOLAB.CZ

SW **Qtegra**: „Nová multi-instrumentální **platforma** uživatelského rozhraní“

Speciační analýza

- **Definice** – ‘Analytická aktivita směřující k identifikaci a kvantifikaci jedné nebo více individuálních chemických „species“ ve vzorku’ **IUPAC**
- **To znamená** – spíše než celkový obsah, je cílem snažení kvantifikace jednotlivých chemických forem
- **Příklad** – „formy-stavy“ sloučenin rtuti separované pomocí vysoceúčinné separační techniky a detekované pomocí ICP-MS



Proč potřebujeme speciaci...?

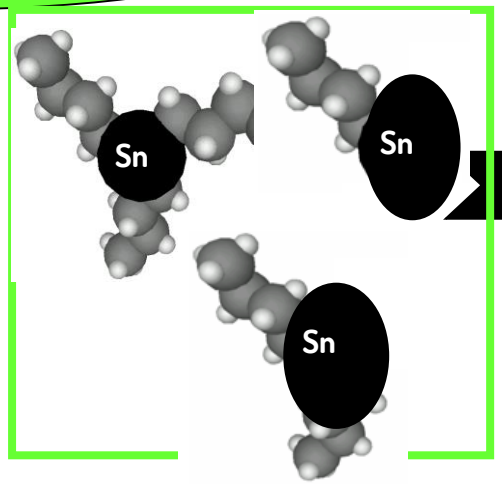
Biodostupnost

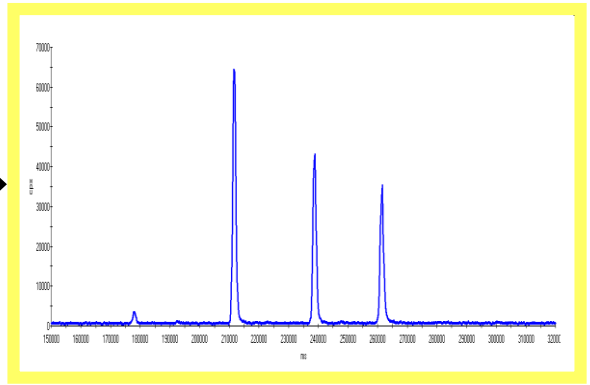
Vysoká citlivost

Environmentální osudy

Vysoká selektivita

Mobilita





Toxicita

Multi-Element/Isotope

Kontrola procesů a výroby

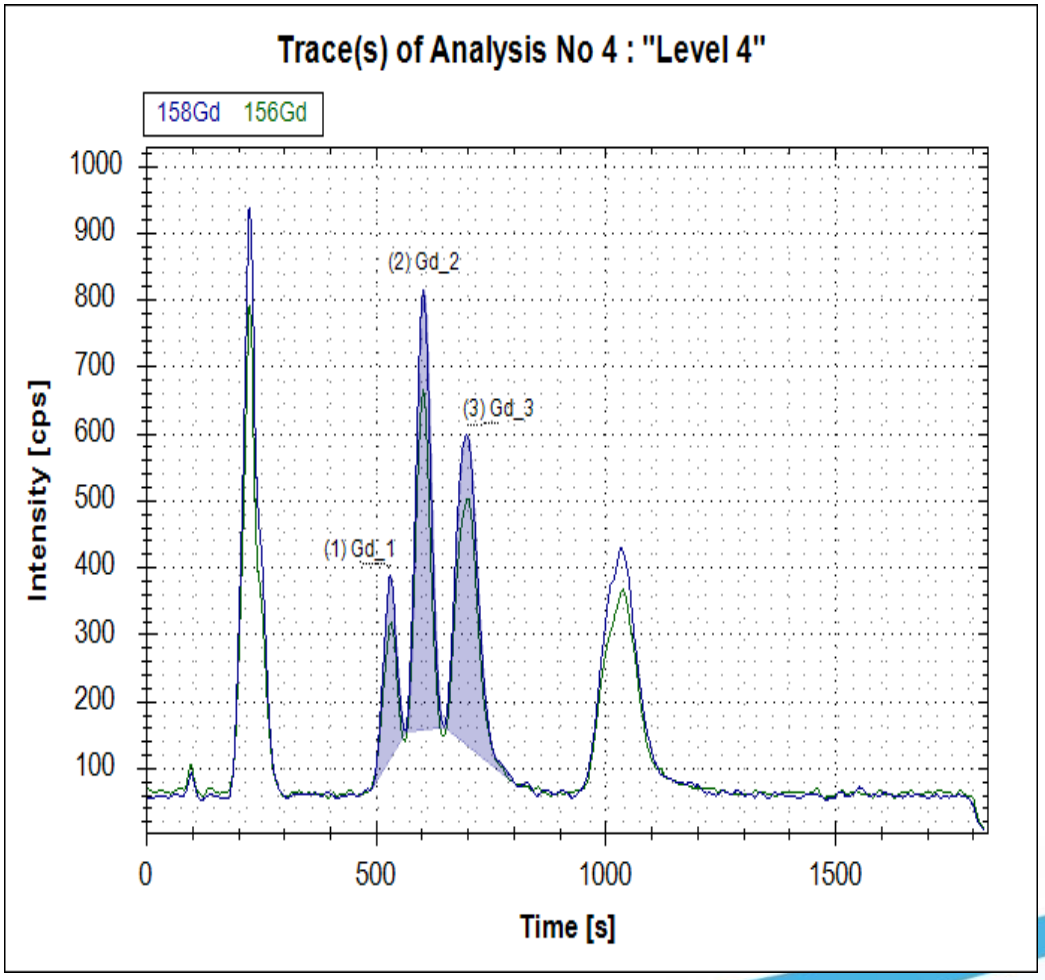
Těkavé prvkové sloučeniny

TFS – Flexibilní speciační produktové balíky

- GC
- HPLC
- IC (Ion Chromatography)

Zcela inertní IC / LC navržené na speciaci kovů

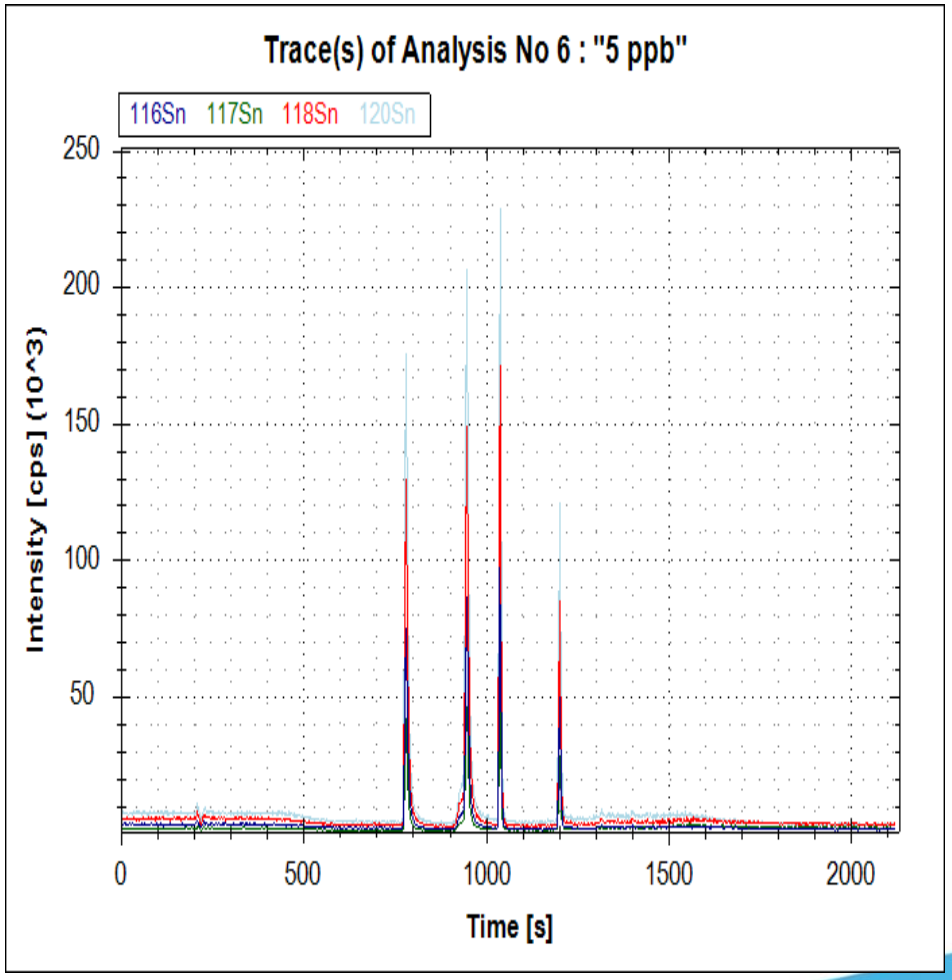
LC spojení (Accela)



- Plasma stable in reverse – phase LC applications with ACN gradients as mobile phase with O_2 additional plasma gas
- Software:
  - Qtegra plug-in in place for LC control and triggering

LC spojení (Dionex)

Alkylcíny



- Dionex ICS-5000+ analytical quaternary pump
  - Reverse phase LC: 10% acetic acid with 10-90% ACN gradient mobile phase @ 200 µl.min^{-1}

Měřící módy pro speciace

- **STD mód**

Pro nejvyšší citlivost neinterferujících analytů, např. Hg, Pb

- **KED mód**

Odstranění interferencí pomocí QCell s použitím He a Diskriminací kinetickou energií, analyty např. Cr, V, As

- **CCT mód**

QCell naplněná buď He nebo jiným plynem, např. směs He/H_2, O_2 atd.) v reakčním módu pro zvýšení citlivosti (Pb, Hg, Sn atd.) nebo pro odstranění interferencí v plynné fázi reakcemi – As, Se, S

Několik příkladů reálných speciačních analýz

Aplikační listy iCAP Q + IC Dionex

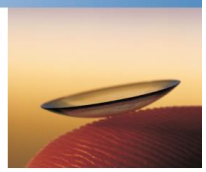
Total and speciation analysis of Mercury in contact lens solutions by ICP-MS

Daniel Kutscher, Julian Wills, Lothar Rottmann, Thermo Fisher Scientific, Germany

Application Note 43011

Key Words
iCAP Q, ICP-MS, ICS-5000, ion chromatography, Thiomersal, Hg, speciation

Goal
To develop a fully quantitative method for the determination of both total Hg and Hg species in contact lens solutions.



Introduction
While there is continual awareness regarding exposure to mercury (Hg) sources in general and $MeHg^+$ in particular due to its presence in food samples such as fish, less interest is paid to the potential risk from ethylmercury ($EtHg^+$ or EtHgX). One of the main reasons for this is the faster degradation and consequently excretion of $EtHg^+$ in the human body that results in considerably lower chronic toxicity. There remain however potential sources where acute intake of $EtHg^+$ can occur, for example as a consequence of exposure to thiomersal. Thiomersal is used as a bactericide in multi-dose (typical concentration 0.001 to 0.01%)[1] and in other health related products such as eye drops or contact lens solutions. The compound hydrolyzes in aqueous solution to form $EtHg^+$ and thiosalicylate which is an effective bactericide. Although no direct correlation between thiomersal usage and potential health risks has been established[2], the use of thiomersal has been reduced in both Germany and the USA. Its use is still permitted in multi dose vaccines and contact lens solutions at concentrations of up to 100 and 70 mg/kg respectively.

Sample and Calibration Solution Preparation
Three different commercially available contact lens solutions were prepared for total Hg and Hg speciation analysis. For total mercury analysis, the contact lens solutions were analyzed after a 2000-fold dilution in 2% HNO_3 / 0.5% HCl. However, as no detectable signal for mercury was found, a lower dilution factor (20-fold) was employed. For Hg speciation analysis, calibration standards were prepared in a matrix solution containing 0.5% NaCl and 0.01% EDTA to mimic the matrix of the contact lens solutions and to promote the formation of the same mercury complexes as in the sample matrix (such as $[HgCl_4]^{2-}$). The standards and the contact lens solutions were then diluted 2000-fold with ultra high purity water prior to injection.

For total Hg determination, gold was added to the samples and the rinse solution to minimize memory effects from the sample introduction system.

IC-ICP-MS speciation analysis of As in Organic Brown Rice Syrup (OBRS) using the Thermo Scientific iCAP Q ICP-MS

Daniel Kutscher, Julian Wills and Lothar Rottmann, Thermo Fisher Scientific, Germany and Detlef Jansen, Thermo Fisher Scientific, Switzerland

Key Words
iCAP Q, ICP-MS, ICS-5000, ion chromatography, As, speciation, food

Goal
The analysis of organic brown rice samples (OBRS) for their total arsenic content by ICP-MS and their species concentrations by IC-ICP-MS.

Introduction
Media reports and scientific publications on the determination of arsenic (As) in foodstuffs have sparked renewed interest from consumer groups and politicians leading to responses from national regulatory bodies. Following the publication[1] of a report on high As levels in organic brown rise syrup (OBRS, an ingredient in a variety of organic foods) the United State Food and Drug Administration (FDA) stated that it was carrying out a study on As in rice and rice products that is due to report later in 2012[2].

Based on previous work[3], OBRS samples were analyzed for their total arsenic content by ICP-MS and then subsequently by IC-ICP-MS to determine the concentration of six arsenic species: the two toxic inorganic species (As(III) and As(V)), and four organic species that are considered to be harmless.

Instrument configuration
All measurements – both total As and As speciation – were carried out using the Thermo Scientific iCAP Q ICP-MS. All As analyses were performed in He KED (Kinetic Energy Discrimination) mode efficiently reduce polyatomic interference of (monoisotopic) arsenic at m/z 7 separations were carried o Dionex ICS-5000 io with the iCAP sensitiv

Sample Preparation
Three different OBRS samples were sourced an for analysis. For the total As analysis, the closed wave digestion method described by Jackson et used. Preparation of the OBRS samples for As s analysis was achieved by taking 1.5 g of OBRS, mL of 0.28 M HNO_3 and refluxing for 90 minu

Total Arsenic Results
A calibration curve for the He KED analysis of shown in Figure 1.

IC-ICP-MS speciation analysis of As in apple juice using the Thermo Scientific iCAP Q ICP-MS

Daniel Kutscher, Shona McSheehy, Julian Wills, Thermo Fisher Scientific, Germany, Detlef Jansen, Thermo Fisher Scientific, Switzerland

Application Note 43009

Key Words
iCAP Q, Apple juice, As speciation, Ion chromatography, ICS-5000

Goal
Apple juice samples are analyzed by IC-ICP-MS to determine the concentration of six arsenic species: two inorganic and toxic species (As (III) and As (V)) and four organic species (arsenobetaine (AsB), arsenocholine (AsC), monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA).

Introduction
Interest in the determination of arsenic (As) species in fruit juices has been triggered by media reports in the US claiming that some apple juices may contain high amounts of arsenic[1]. Since fruit juices are frequently consumed, especially by young children, the reported values have led to serious concerns about the safety of such products. However, in the experiments conducted, only the total arsenic concentration was assessed, but no detailed investigation of the chemical form of the element was carried out. This is an important distinction since the inorganic forms of arsenic (As (III) and As (V)) are highly toxic, while the organic forms (e. g. arsenobetaine) are not considered to be toxic. Typical levels of total arsenic found in apple juice are lower than the US EPA drinking maximum contaminant level (MCL) of 10 ng/g so apple juice is generally considered safe and is currently not regulated[2]. However, as a consequence, the FDA is currently reviewing data, and may eventually tighten its current guidelines.

Instrument c
Chromatograph Thermo Scientifi system. Due to i this system is pe studies. A Therm column (2 mm I this study, as it i anionic species[3] separation of the Thermo Scientifi sensitive and sel proprietary 90° provides both hi backgrounds wh use of a He pres Discrimination) interferences in i KED mode also lowest backgrou applications at l analysis of (mon possibility to us therefore the fle reduction QCell minimize polyat would otherwise

General anal
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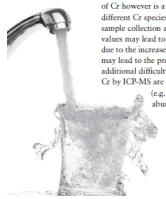


Speciation analysis of Cr (III) and Cr (VI) in drinking waters using anion exchange chromatography coupled to the Thermo Scientific iCAP Q ICP-MS

Daniel Kutscher, Shona McSheehy, Julian Wills, Thermo Fisher Scientific, Germany, Detlef Jansen, Thermo Fisher Scientific, Switzerland

Application Note 43098

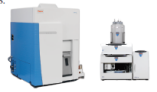
Key Words
iCAP Q, Cr speciation, Ion chromatography, Drinking water, ICS-5000

Goal
To develop a sensitive, robust and high throughput method for the trace level analysis of Cr (III) and Cr (VI) species in natural waters using IC-ICP-MS.

Introduction
Due to it widespread use in industrial applications such as chromium plating, dye manufacturing and preservation of wood and leather materials, chromium concentrations in environmental samples are monitored on a routine basis. Both the United States EPA and the European Union have specified maximum admissible chromium concentrations in their respective drinking water directives. As with many other trace elements, chromium (Cr) is typically found in more than one chemical form, each of which with different chemical properties and behavior, such as bioavailability and toxicity. For chromium, Cr (III) is essential to human beings and involved in different processes in the body while Cr (VI) is highly toxic. Total Cr content therefore in, for example, a drinking water sample does not provide sufficient information to evaluate potential hazards to populations exposed to it. In order to provide this critical information a supporting speciation analysis is required to determine the amounts of the different Cr species in the sample. The speciation analysis of Cr however is a challenging task, since the stability of different Cr species is easily affected by conditions during sample collection and treatment[1]. For example, low pH values may lead to the degradation of Cr (VI) to Cr (III) due to the increased redox potential, while high pH values may lead to the precipitation of Cr (III) as $Cr(OH)_3$[2]. An additional difficulty in the accurate speciation analysis of Cr by ICP-MS are the numerous spectral interferences (e.g. $^{35}Cl^{16}O^1H^+$ or $^{40}Ar^{12}C^+$) on the most abundant chromium isotope, ^{52}Cr.

Sample and calibration solution preparation
Daily working standards were prepared by diluting the appropriate quantity of commercially available stock solutions [1000 µg/mL] of each chromium standard in a 0.1 mol/L ammonium nitrate solution adjusted to a pH of 4. Drinking water was collected in a PFA bottle previously rinsed with high purity nitric acid. The water was analyzed directly without dilution or pH adjustment in order to keep the species unchanged before analysis.

Instrument configuration
Chromatographic separations were carried out using the Thermo Scientific Dionex ICS-5000 ion chromatography system. Due to its completely metal-free solvent pathway, this system is non-contaminating and is therefore perfectly suited for elemental speciation studies at the trace levels required by this application. For the separation of the two Cr species, a Thermo Scientific Dionex AG-7 anion exchange column (2 x 50mm) was used throughout this study. Although this column is designed to be used as a guard column, its highly effective separation medium contains capacities for the separation of both cationic and anionic species[3] and it is therefore able to completely separate both Cr species in less than three minutes. A Thermo Scientific iCAP Qc ICP-MS was used as a high performing elemental detector of the Cr species eluted from the ICS-5000. Due to the use of flatapole technology in the Thermo Scientific QCell collision cell, the iCAP Q series of ICP-MS instruments offer the selectivity to suppress spectral interferences while maintaining the high sensitivity for trace metal detection in coupled applications such as IC-ICP-MS.



Coupling of an Inert Ion Chromatographic System with ICP-Q-MS for Robust and Accurate Elemental Speciation

Daniel Kutscher, Lothar Rottmann, Julian Wills, Shona McSheehy Ducos, and Detlef Jansen
Thermo Fisher Scientific, Bremen, Germany; Thermo Fisher Scientific, Olten, Switzerland

Executive Summary
IC is a commonly used analytical approach for determination of arsenic and chromium species. IC coupled to inductively coupled plasma mass spectrometry (ICP-MS) is ideally suited for challenging applications such as arsenic speciation in food samples and Cr speciation in drinking water. The Thermo Scientific™ Dionex™ ICS-5000 IC and Thermo Scientific™ iCAP™ Q ICP-MS enables accurate, robust, sensitive, and cost effective routine analysis of trace metal species in a range of matrices.

Key Words
IC, ICP-MS, ICS-5000, iCAP Q, Speciation

Overview
Purpose: In this study, the coupling of the Dionex ICS-5000 ion chromatography system to the iCAP Q is assessed for the speciation analysis of As (inorganic and organic species in apple juice and Cr (Cr^{3+} and CrO_4^{2-}) in potable water.

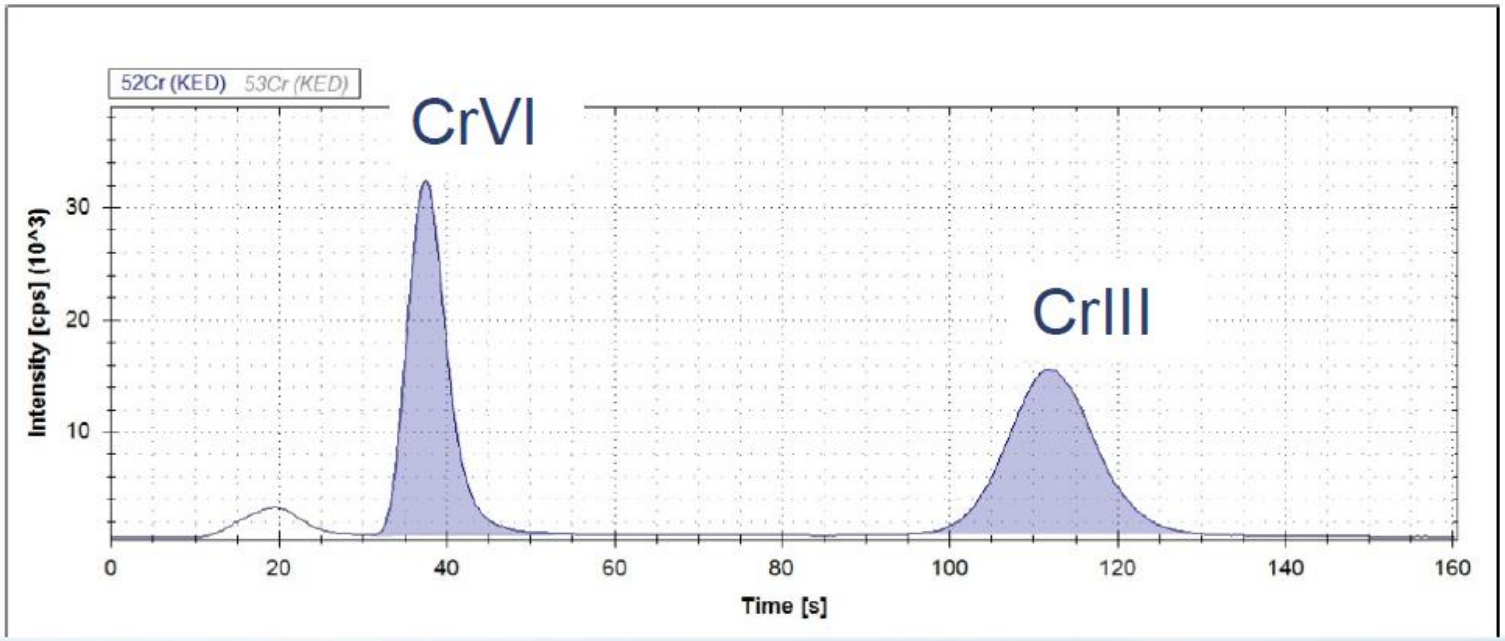
Methods: Anion exchange chromatography methods coupled to the iCAP Q was used. The Thermo Scientific™ Dionex™ IonPac™ AS7 (for As) and AG7 (for Cr) columns and common capacities for the separation of cationic and anionic species[3] and are therefore ideally suited for such applications.

Results: Baseline resolution between the Dionex ICS-5000 and the CAP Q was achieved and was shown to provide a highly sensitive speciation technique for the detection of trace elements.

Introduction
Interest in the speciation analysis of As in fruit juices has recently been triggered by media reports in the U.S. claiming that some of apple juices may contain high amounts of As[1]. However, in the experiments conducted, only the total amount of As is not sufficient to judge potential hazards, as toxicity depends on the chemical form of the element. Inorganic As species (e.g. arsenite (As (III) and arsenate (As (V)) are highly toxic, as opposed to the non-toxic organic As species (e.g. arsenobetaine). When it comes to Cr, toxicity is also species dependent; while Cr (III) is considered essential, Cr (VI) is highly toxic. Therefore, both species need to be routinely monitored.

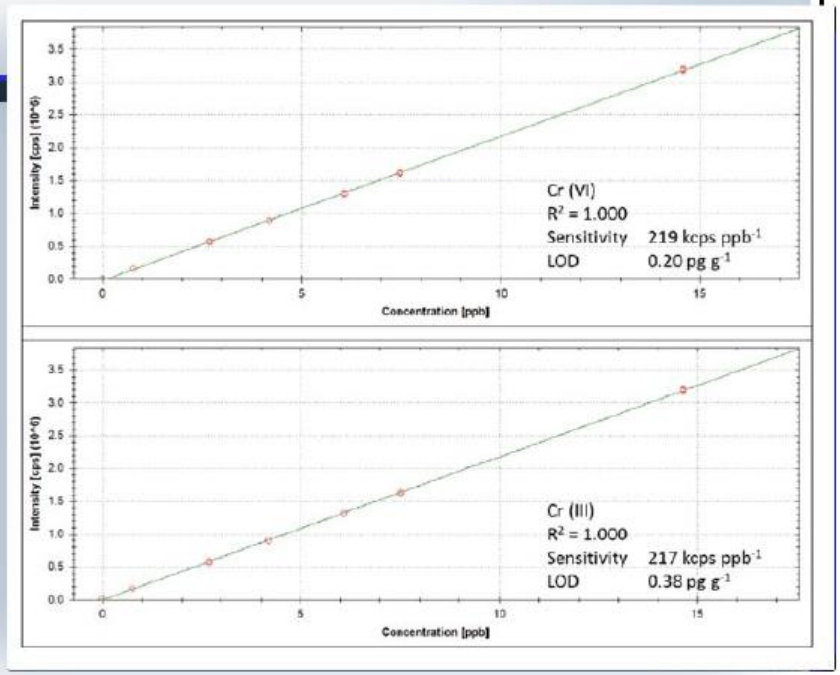
IC-ICP-MS for the Speciation of Cr (III) and Cr (VI)

Column	Dionex AG-7 (2x50mm)
Mobile Phase	0.35 mol L^{-1} HNO_3
Flow rate	0.4 mL min^{-1}
Injection volume	20 µL

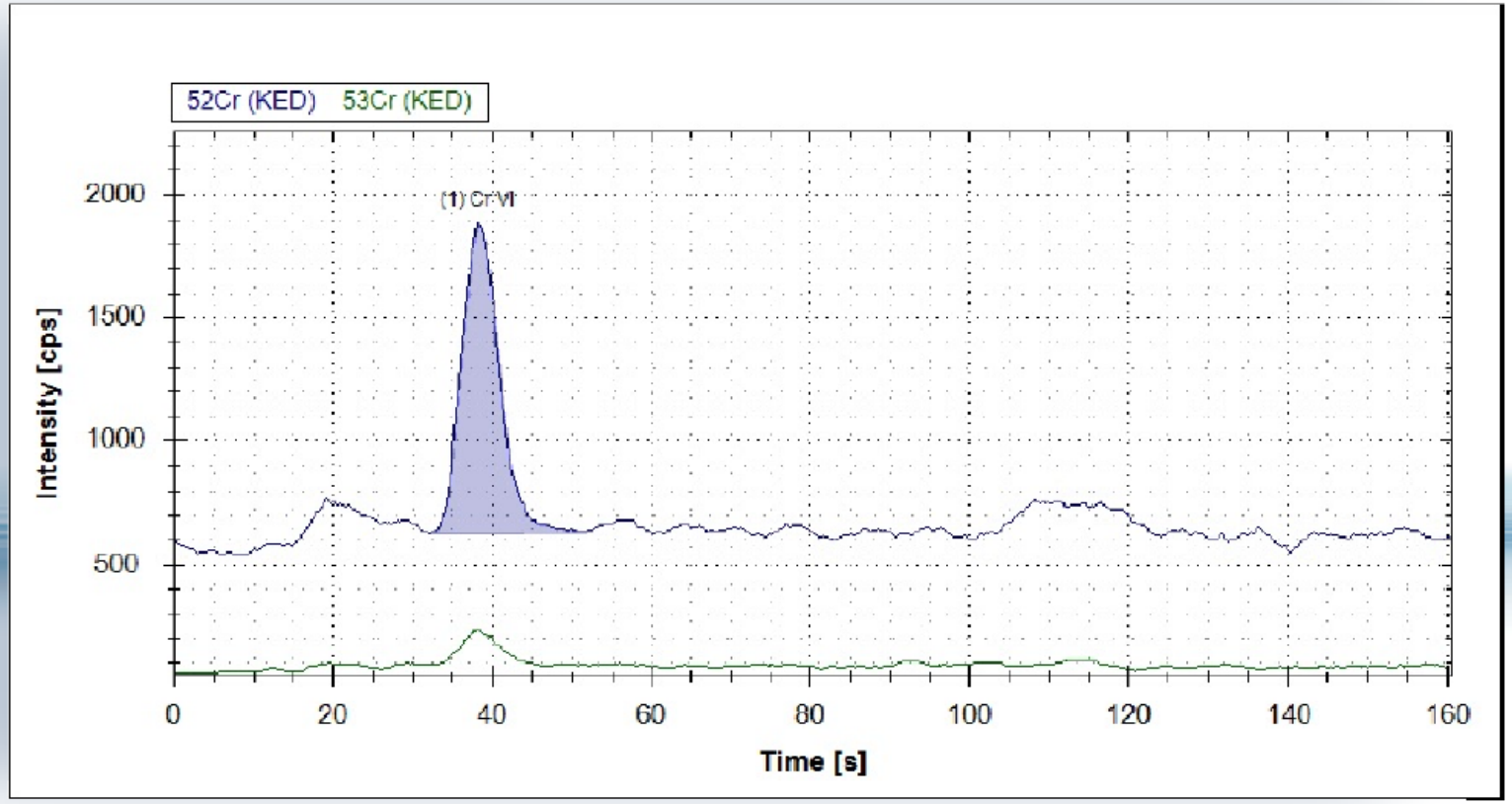


IC-ICP-MS for the Speciation of Cr (III) and Cr (VI)

- Both chromium isotopes, $^{52, 53}Cr$, can be monitored
- CrIII and CrVI are completely baseline separated
- Limits of detection:
  - **0.20 ng L^{-1} [Cr (VI)]**
  - 0.38 ng L^{-1} [Cr (III)]
- Isocratic chromatography performed in less than 3 minutes



Speciation of Cr in Drinking Water



Analysis of locally sourced tap water (Bremen):
Only Cr (VI) was detected, Concentration 42.5 ng L^{-1}
Injection without further sample treatment

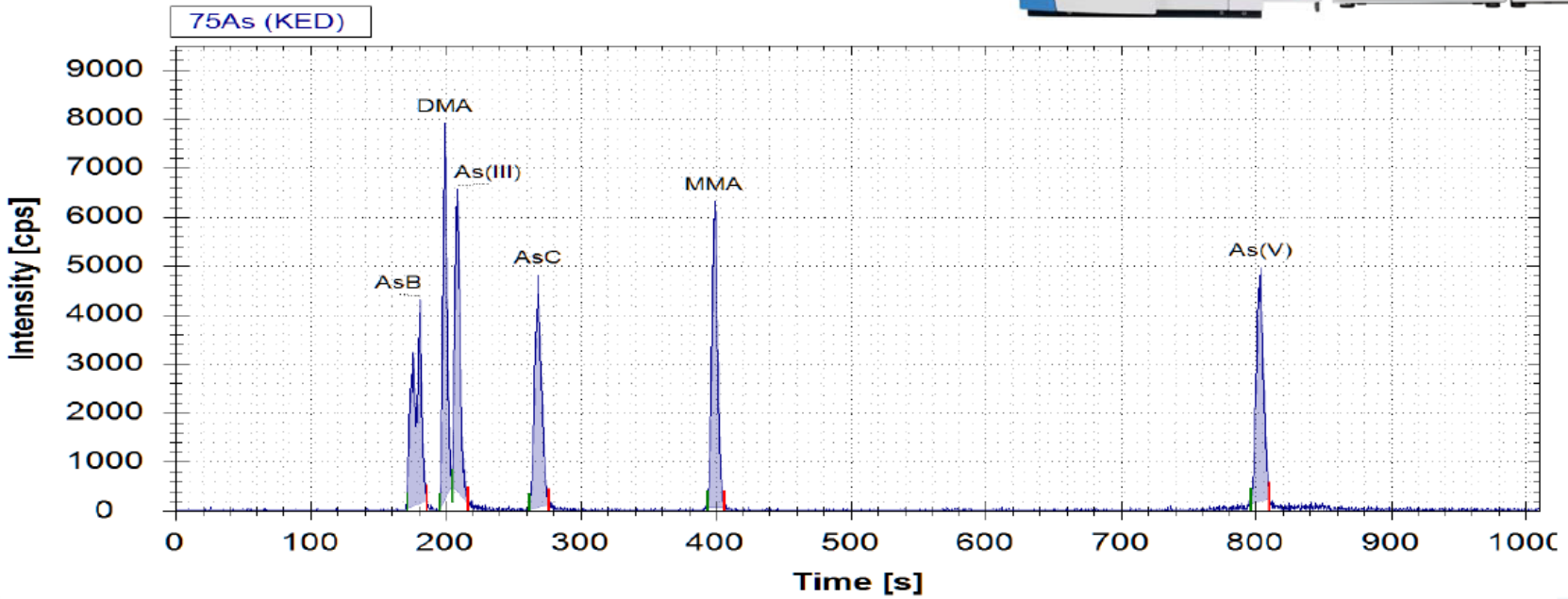
Chromium Speciation Analysis of Drinking Water

- A sensitive and fast method based on ion chromatography for the speciation of Cr has been developed
  - No need for the addition of EDTA or other charge pairing agents necessary, no additional sample preparation, no additional spectral interferences in the mass spectra
  - The IC eluent, dilute HNO_3, is relatively cheap, easily sourced and allows detection of Cr species in the single digit ppt range
  - Reduced column dimensions allow reduction of the mobile phase flow rate to 0.4 mL min^{-1}

LC Coupling (Dionex) – As Species in Apple Juice

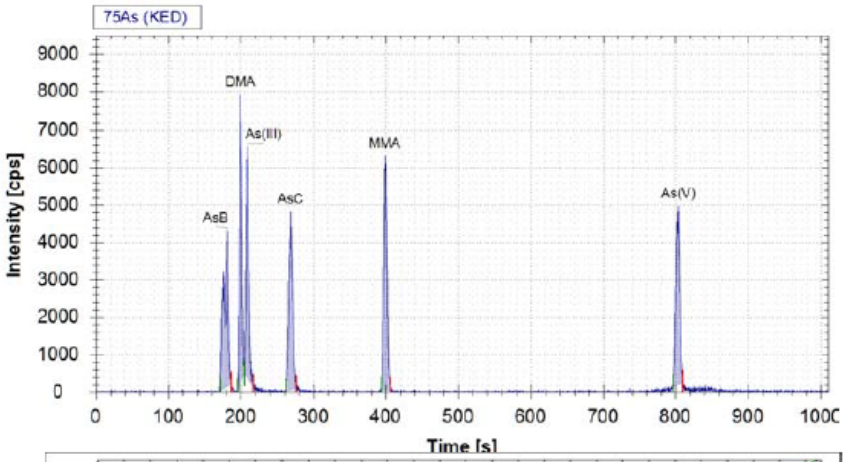
IC-ICP-MS for As Speciation

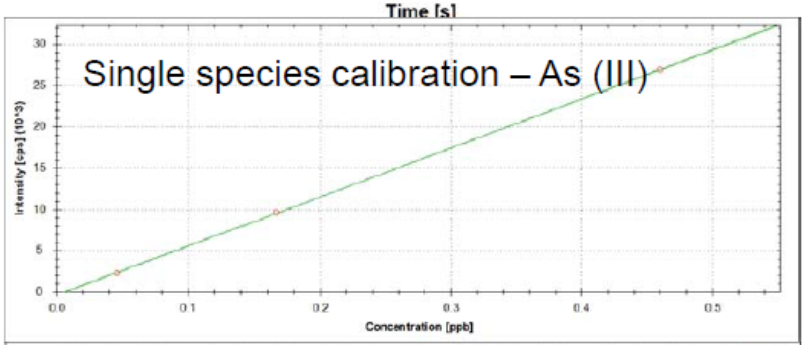
Column	Dionex AS-7 (2x250mm)
Mobile Phase	Gradient elution: 20 to 200 mM ammonium carbonate
Flow rate	0.3 mL min^{-1}
Injection volume	20 µL

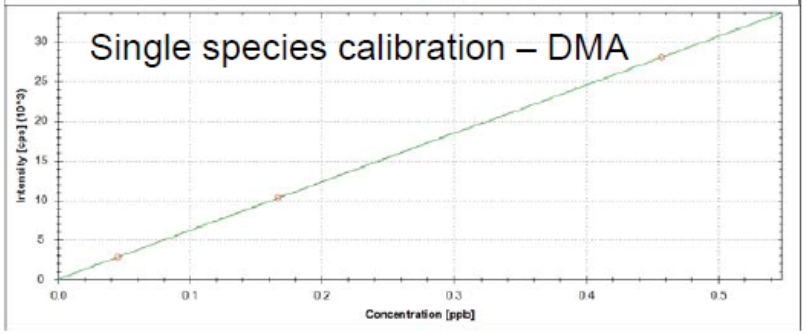


IC-ICP-MS for As Speciation

- 6 species detected
- ~7000 cps / ppb
- ~15 minute analysis
- Narrow peak shape improves S/N ratio (10 to 20s)
- Reproducibility < 4%
- Reduced solvent consumption without comprising separation efficiency

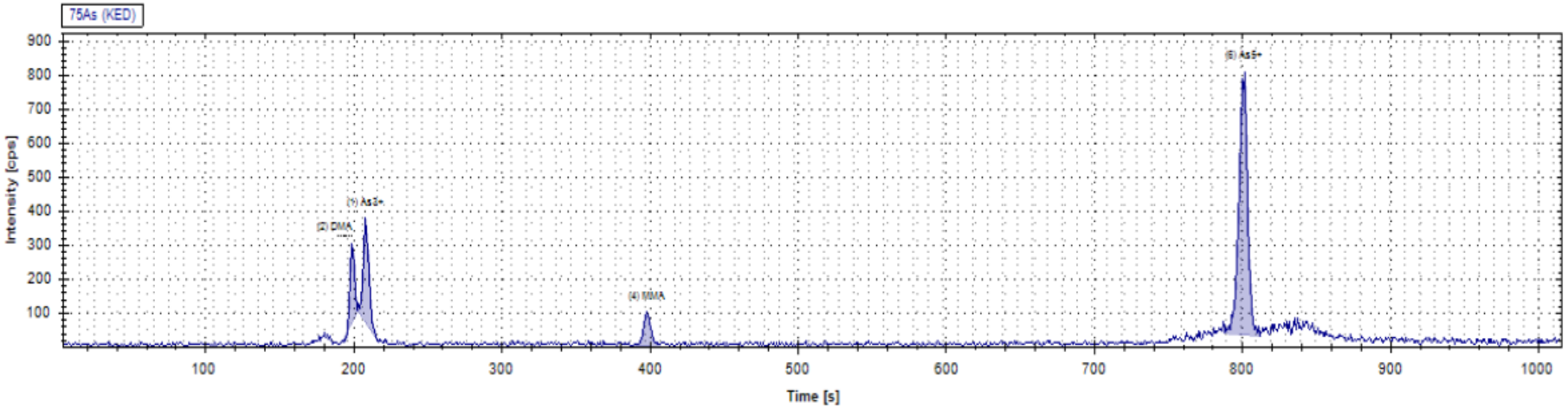






Arsenic Speciation Analysis of Apple Juice

- Low concentration of the individual species after dilution



	DMA [ng g^{-1}]	As (III) [ng g^{-1}]	MMA [ng g^{-1}]	As(V) [ng g^{-1}]	Sum [ng g^{-1}]	Total As [ng g^{-1}]
Juice 3	-	0.5 ± 0.01	-	0.8 ± 0.01	1.3	1.7 ± 0.05
Juice 4	0.4 ± 0.05	0.3 ± 0.01	0.1 ± 0.05	0.7 ± 0.01	1.5	1.8 ± 0.05

- Method detection limits (MDL): 0.001 ng g^{-1} As(V) to 0.011 ng g^{-1} (MMA)

- Not detected

ICP-OES (iCAP **7000**)

low cost
ICP-OES analysis

NEW

The Concept going forward

iCAP 6500

Fastest/Best Productivity, and flexibility through S/W plug-ins

iCAP 6300

Faster/More Productive for Routine QA/QC and easier to use

iCAP 6200

Entry level ICP – easier to use

Qtegra - New Common Software Platform - Easier to use and more plug-ins for advanced flexibility

Thermo Scientific™ iCAP™ 7000 Series ICP-OES

- Nejúspornější ICP-OES na trhu, při zachování nejvyšší kvality dat
  - **iCAP 7200 ICP-OES** – základní úroveň, cenově efektivní investičně i provozně, vhodný do laboratoří s nižším počtem vzorků.
  - **iCAP 7400 ICP-OES** – Vhodný pro rutinní laboratoře, univerzální analytické aplikace, střední počet vzorků.
  - **iCAP 7600 ICP-OES** – Nejvyšší produktivita, maximální průchod vzorků, flexibilní podpora příslušenství jak např. LA..

iCAP 7200 (Dual)

iCAP 7000 Series – tři modely

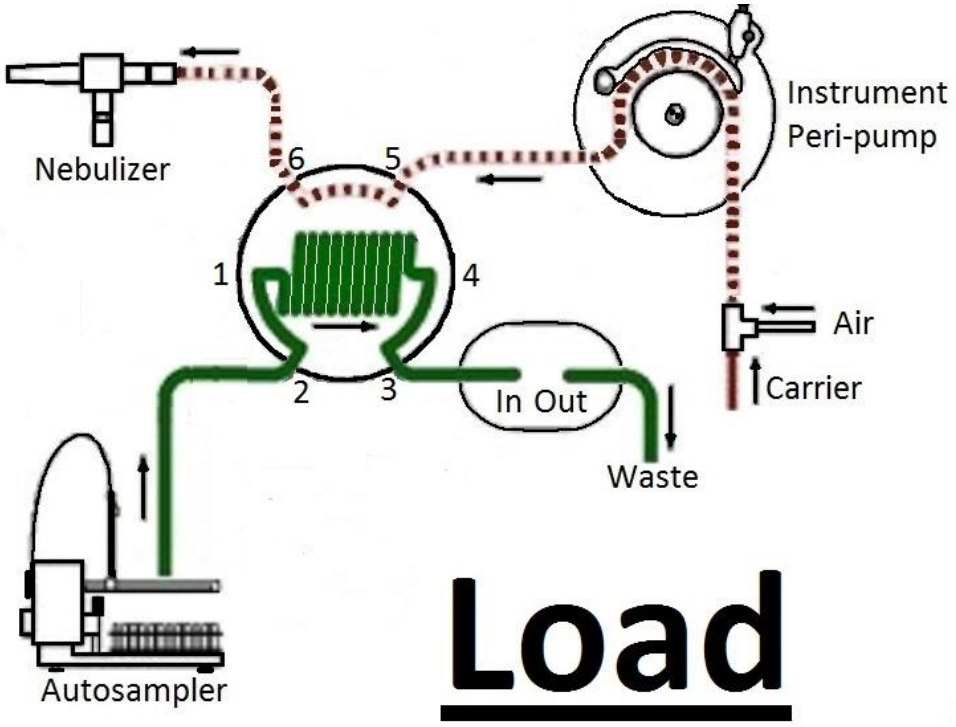
- iCAP 7400

Radial nebo Dual

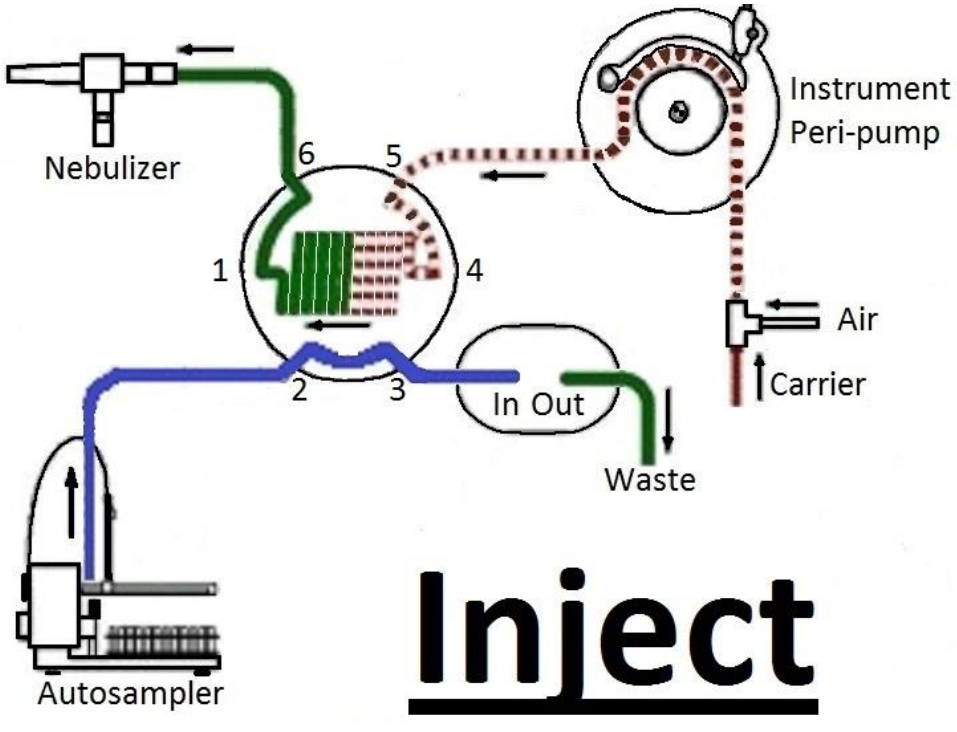
- iCAP 7600

Radial nebo Dual

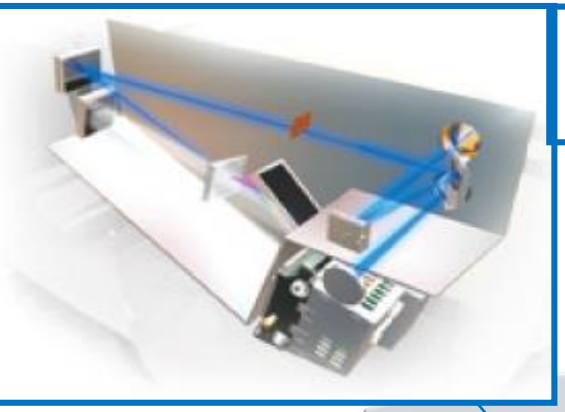
Sprint valve system – How does it work?



Sprint valve system – How does it work?



The iCAP 7000 Series ICP-OES Core Technologies

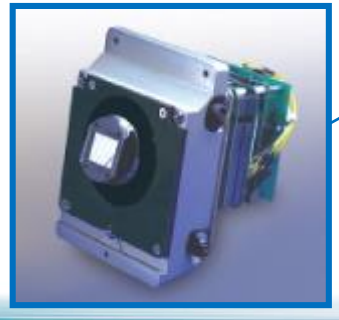


Optical design

EMT torch & Duo viewing

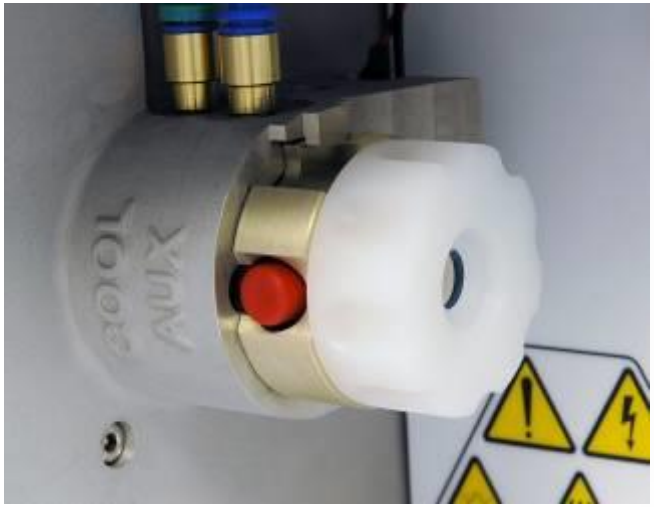
Clip-in sample intro systems

CID detector



Drain sensor

EMT Torch for Ease of Use for Routine Maintenance



TORCH ORIENTATION LOCK

- Auto alignment of the torch in the torch box
- Automatically establishes robust plasma gas connections

SCREW-THREADED CENTRE TUBE HOLDER

- Simple routine maintenance operations with the plasma on!

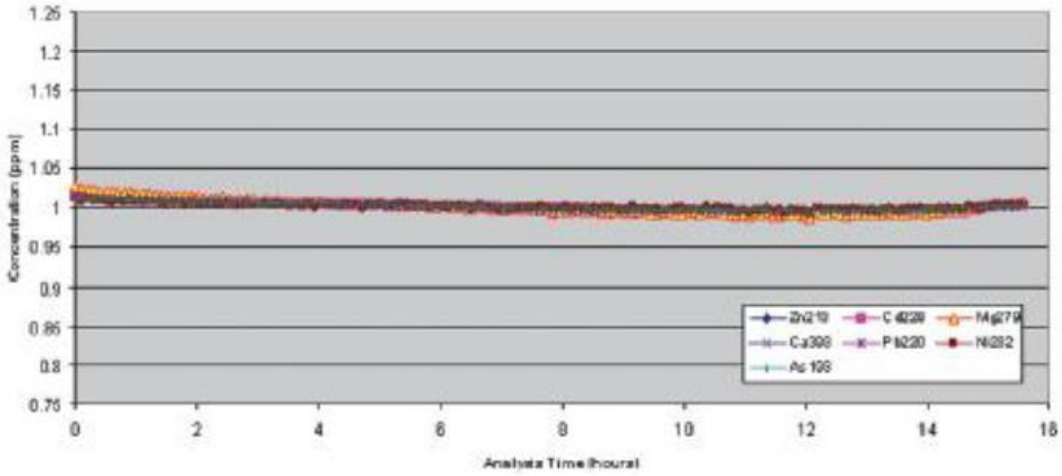
Still the best torch design and common ICP-OES/ICP-MS

Ceramic *D-Torch* Accessories – Key Features

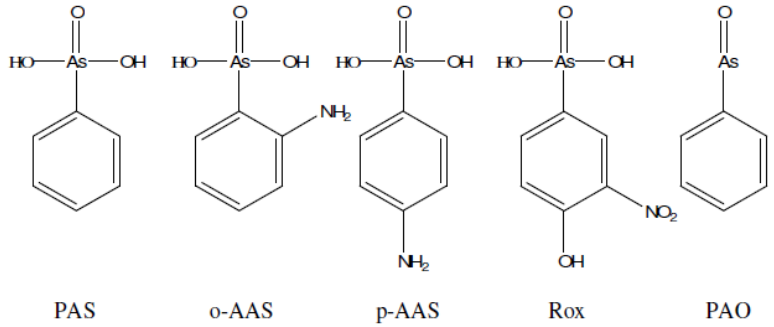
- Fully demountable design for cost effective replacement of parts
- Identical geometry to EMT (parallel tube design for optimized gas flows and sample channel stability)
- Interchangeable with EMT design in any iCAP 7000 Series ICP
- Silicon nitride (Sialon) ceramic outer tube – highly durable material
- Alumina intermediate (auxiliary) tube – excellent chemical and temperature resistance
- Compatible with EMT centre tubes to enable maximum application flexibility

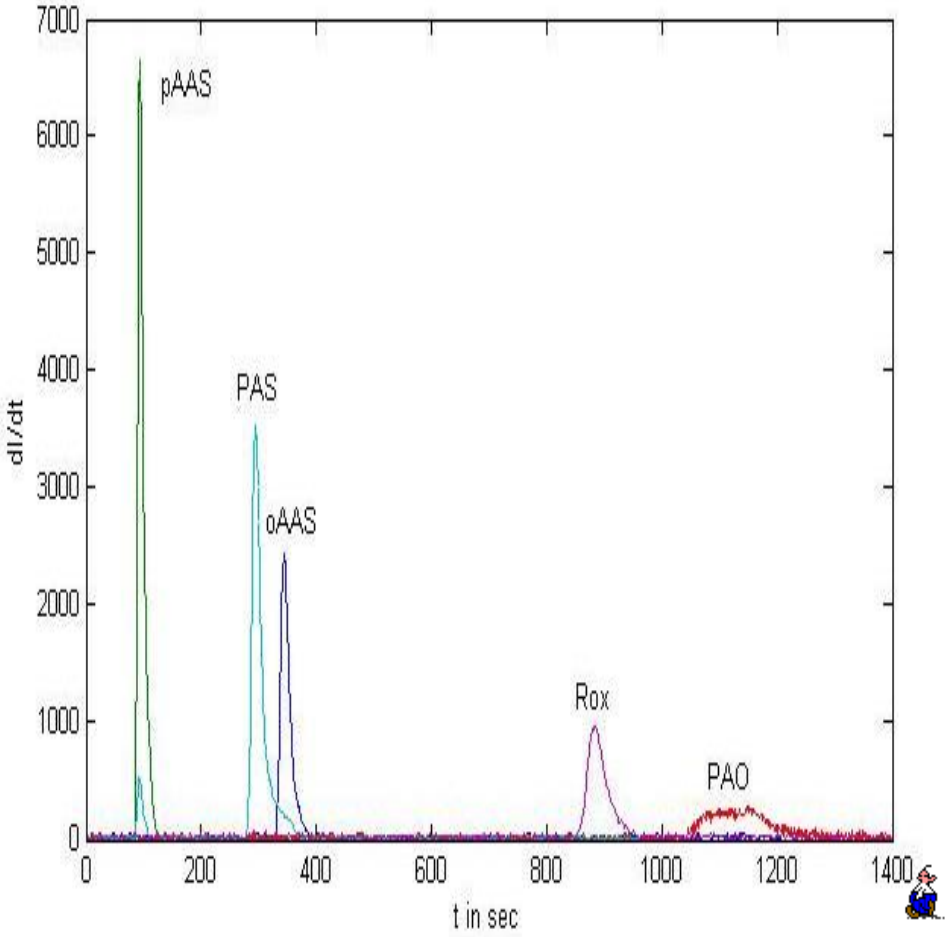
Dlouhodobá stabilita iCAP 7400

- Offers flexibility with the ability to have greater control of gas flows for method development of complex samples
  - Ideal for high salt samples
  - Ideal for organic samples
- Offers the benefits of MFC in terms of better long term stability
  - Ideal for long analytical runs

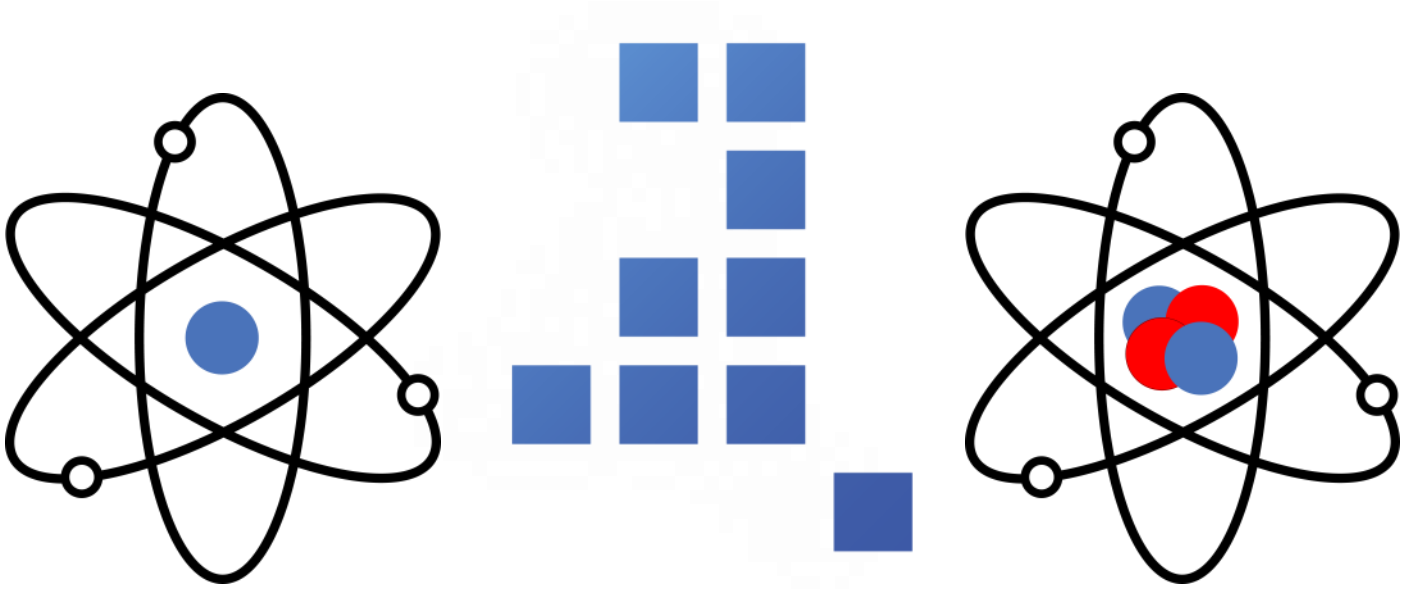


Heike Brandt, **HPLC- ICP-AES-Kopplungen**



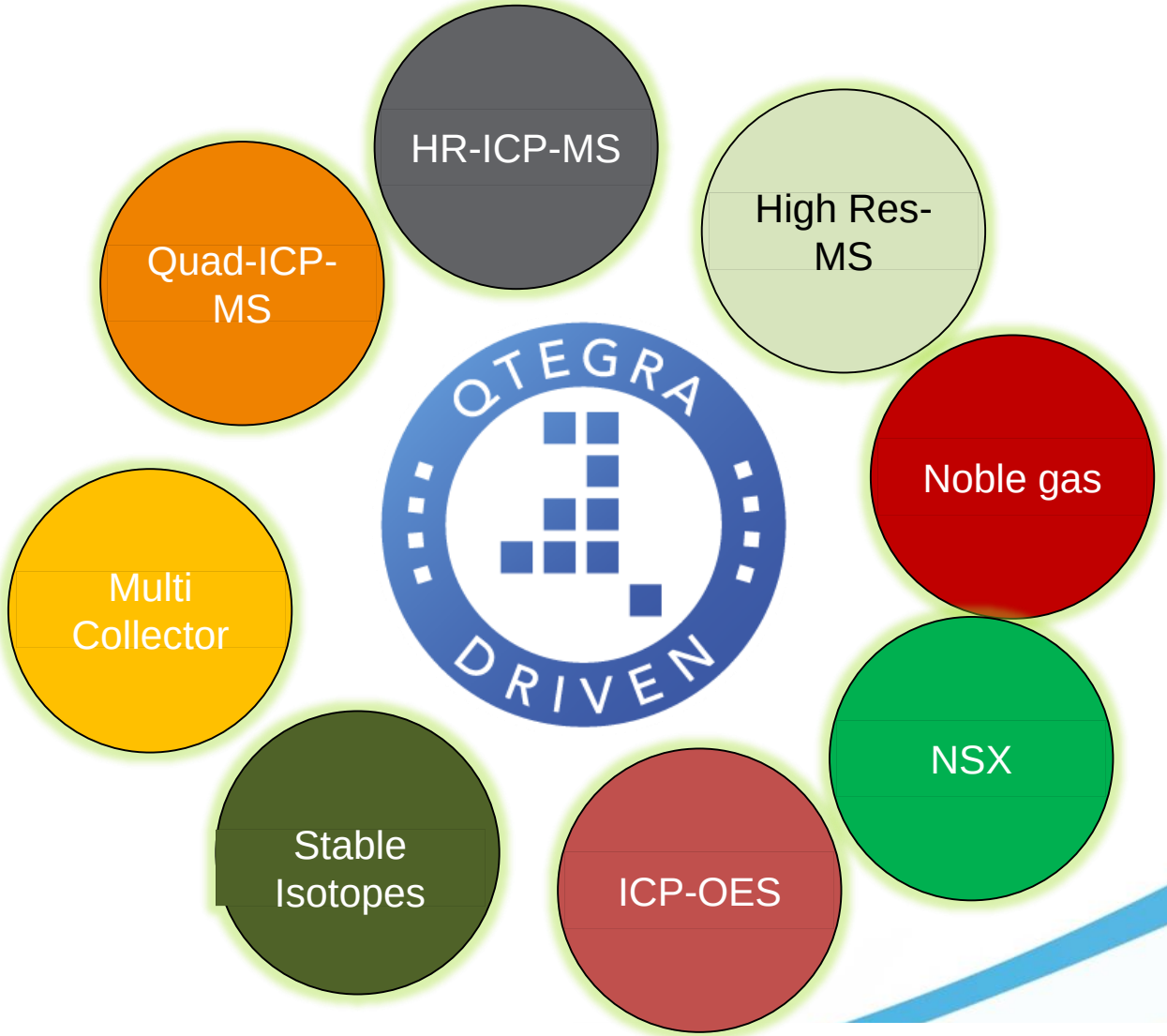


„Qtegra ISDS – a software platform“



Elementy a Isotopy

8 individuálních SW balíků …



…jsou různé…

…ale v zásadě dělají totéž.

Qtegra v 1.5 Plug-Ins


Accela LC Autosampler


Accela LC Pump


iCAP Q


Cetac ASX-100


Cetac ASX-112FR


Cetac ASX-260


Cetac ASX-520


Chromeleon


ESI SC-14DX


ESI SC-2DX


ESI SC-4DX


ESI SC-4S


PMI Analyte Laser Syst...


Cetac Laser


NWR Laser

Závěr

- Speciace je v současnosti rutinní metodologie poskytující dodatečné informace – nad rámec normální prvkové stopové analýzy
- Spojení ICP-MS s HPLC, IC nebo GC je významně zjednodušené a snadno použitelné
- Thermo Scientific je jediným výrobcem a poskytovatelem kompletního chromatografického řešení pokrývajícího většinu všech speciačních oblastí:

  Kapalinová chromatografie
  Iontová chromatografie
  Plynová chromatografie

Ve spojení s:

Kvadrupólovým ICP-MS

Sektorovým HR-ICP-MS

Multikolektorovým HR-ICP-MS

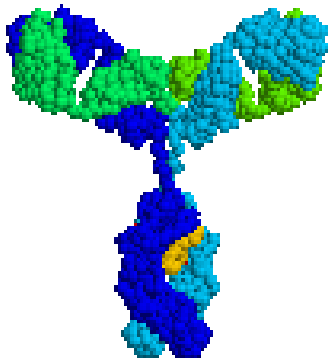
Produktová linie TFS neponechává „mnoho“ volného prostoru pro detektory typu TOF, QqQ apod.

Plasma Robustness Test

Thermo Scientific iCAP family

Thermo Scientific iCAP Q ICP-MS a Thermo Scientific iCAP 6000/7000 Series ICP-OES

Děkuji za pozornost



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