New Agilent 7900 ICP-MS Product Information

Redefining ICP-MS. *Again*!

26 Years of Agilent ICP-MS Innovation

Pioneering ICP-MS technology

PMS 100

First computer-controlled ICP-MS

Enabling routine robust ICP-MS analysis

4500 Series

World's first benchtop system.
Hyperbolic profile quad, motorized torch XYZ, cool plasma

#1 selling ICP-MS

Setting new levels to ICP-MS Performance

7500 Series

9 orders detector range
Octopole Reaction System

#1 selling ICP-MS

Bringing ease of use and reliability in ICP-MS

7700 Series

HMI, ISIS-DS, 3rd Generation ORS MassHunter SW

#1 selling ICP-MS

A new era in ICP-MS analysis

8800 ICP-QQQ

World's first ICP-QQQ for unparalleled interference removal and sensitivity

A New Dimension in ICP-MS Capabilities

7900 ICP-MS

With 10x higher matrix tolerance, 10x wider dynamic range and 10x better single to noise the new Agilent 7900 rewrites the rules on ICP-MS

1987   **1994**   **2000**   **2009**   **2012**   **2014**

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Unique Performance of the 7700

Better matrix tolerance than any other ICP-MS

- Higher plasma temperature (lower CeO/Ce ratio) under standard conditions than any other system

Best performance with Helium cell gas – eliminates need for reaction gases in all common applications

- 7700 ORS[3] improvements - removes all polyatomics in He mode, giving accurate results in complex or variable sample types – impossible on ICP-MS systems that use reactive cell gases or mixtures
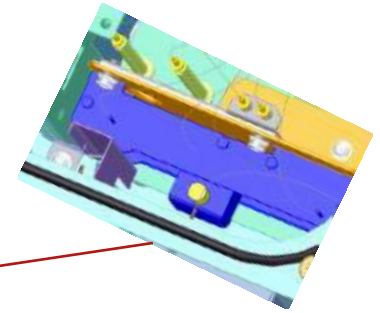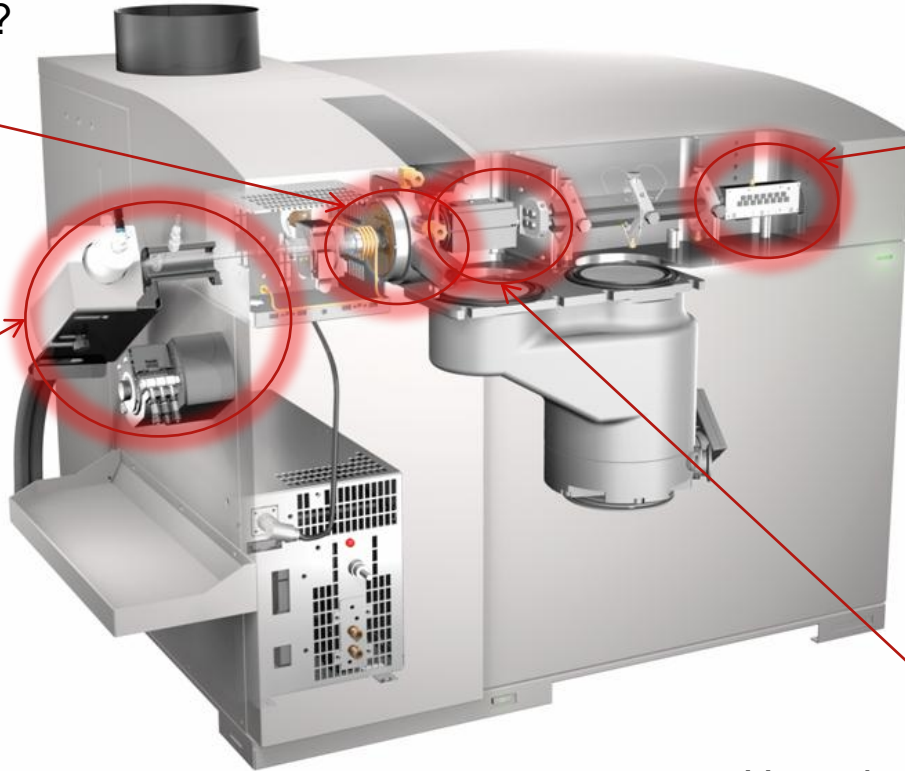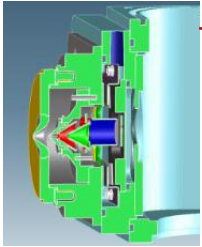
Wider dynamic range than any other quadrupole ICP-MS

- Full **9 orders** dynamic range at the detector – linear to 500ppm without changing conditions or hardware
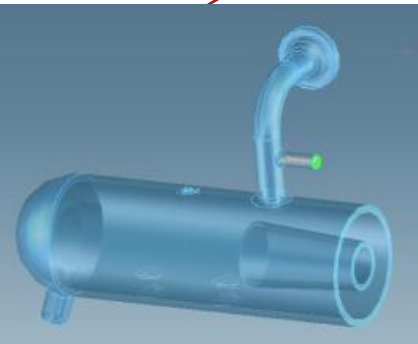
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How to Improve on the Best ICP-MS?

How about a NEW Interface, Ion Lens & Vacuum system for up to 15x **Signal to Noise** improvement?

How about NEW **detector** technology for unprecedented <u>11 orders measurement range and Fast TRA Acquisition at 0.1msec dwell time.?</u>

How about a NEW **Ultra HMI** for analysis of up to 25% NaCl brine solutions without dilutions?

How about a NEW **ORS[4]** for ultra fast gas switching <u>in less than 3 seconds?</u>

Presenting Agilent's Game-Changing 7900 ICP-MS

We took the world's best-selling, highest performing quadrupole ICP-MS, and made it 10x better!

Agilent 7900 ICP-MS Key Performance Highlights
Rewriting the rules on ICP-MS

10x better signal to noise (S/N) – even lower detection limits
- 2x higher sensitivity, 3-5x lower background

10x higher matrix tolerance – handles even tougher samples
- HMI is still unique to Agilent. On the new ICP-MS, the optional **Ultra HMI (UHMI)** extends capability to matrix levels of up to 25%

10x wider dynamic range – increases upper measurement limit
- 7700's 9 orders was best in class and new ICP-MS extends this by at least a further order of magnitude (up to 11 orders detector linear dynamic range), allowing % levels to be quantified - a first for ICP-MS

30x faster detector –faster transient signal measurement (TRA)
- **0.1ms** integration time means improved single nanoparticle analysis

Improved productivity
- New ultra fast **ORS[4]** with less than 3 seconds switching time between modes
- New **ISIS 3** for fast unattended start-up, autotune and sample delivery

Higher sensitivity & lower background than 7700x
Comparison to 7700x actual performance

~2x higher sensitivity at mid- and high-mass (~same at low-mass)

Plasma mode		Sensitivity (7900/7700x)		
		7Li	89Y	205Tl
No Gas	Normal (spec. tune)	x1.2	x1.9	x1.9
	Low Matrix	x1.0	x1.6	x1.6
	General Purpose	x1.0	x1.5	x1.8
	HMI-high	x1.3	x1.6	x1.8

3x to 5x lower background

Model	Sensitivity [kcps/ppb]			Off Mass Bkgnd [cps]			S/N [x1E3]		
	7Li	89Y	205Tl	7amu	89amu	205amu	7Li	89Y	205Tl
7700x	100	320	320	0.7	1.5	5.4	140	210	60
7900	**120**	**620**	**600**	**0.2**	**0.2**	**1.2**	**600**	**3100**	**500**
7900/7700x	1.2	1.9	1.9	0.28	0.13	0.22	4	15	8

Average ~10x better signal to noise (S/N)

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Agilent 7900 Performance Specifications

Numbers in red are better spec. than 7700.

		7700	7900
		Spec	**Spec**
Sensitivity (Mcps/ppm)	7Li	50	55
	89Y	160	320
	205Tl	80	250
Background (cps)	No gas (9amu)	<2	<1
CeO/Ce		<1.5%	<1.5%
CeO/Ce (HMI-25)		-	<0.5%
Ce++/Ce		<3%	<3%
DL (ppt) (No gas)	Be	0.5	0.2
	In	0.1	0.05
	Bi	0.1	0.08
DL (ppt) He mode	As	20	20
	Se	40	40
Short-term stability (20 min)		<3%	<2%
Long-term stability (2 hrs)		<4%	<3%

Agilent 7900 Capable of <u>Very</u> High Sensitivity
Tuned like competitor's ICP-MS – CeO/Ce <2.5%

238 U [No Gas 2]

$y = 1382.6818 * x + 0.6667$
R = 1.0000
DL = 0.001253 ppt
BEC = 0.0004822 ppt

x10^5

CPS

Conc(ppt)
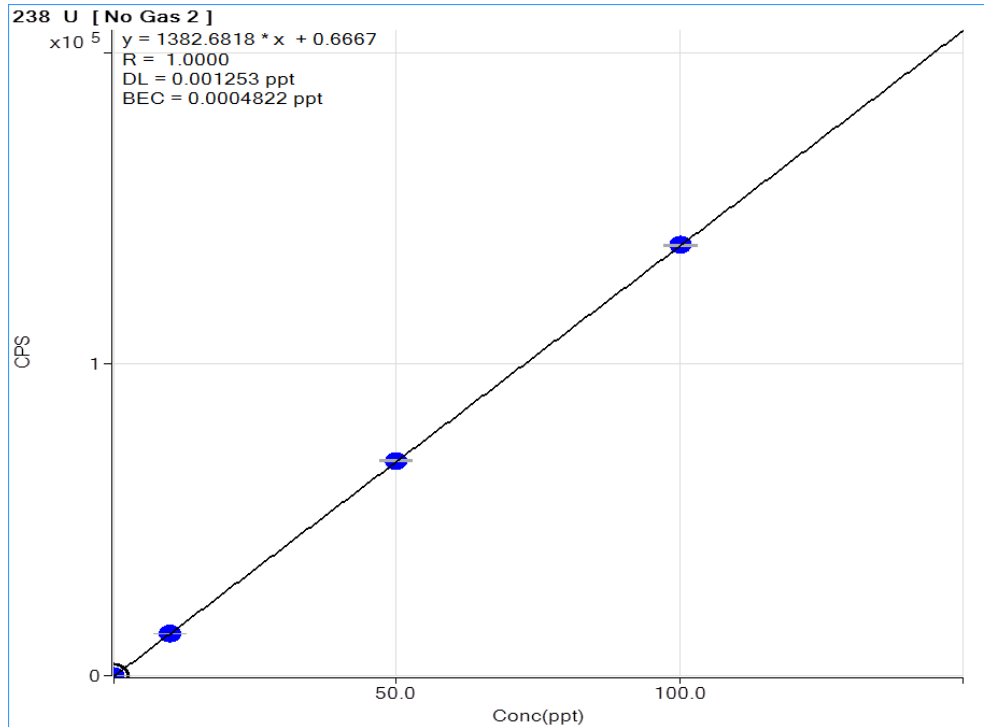
Uranium calibration in No Gas mode:

Ultra-high sensitivity
1.38 GHz/ppm

Ultra-low background:
MDL: 1.3ppq; BEC: 0.48ppq;

Calibration					
Level	Conc.	Calc Conc.	CPS	Det.	RSD
1	0	0	1	P	86.6
2	10	9.89	13676	P	0.6
3	50	49.984	69112	P	0.9
4	100	100.019	138295	P	0.4

NEW 7900 Ultra High Matrix Introduction (UHMI)

- Increased dilution range to **x100** – even higher matrix capability
- **Less matrix loading** to interface, so better long-term stability
- Maintain **high carrier gas flow** through spray chamber, so faster gas replacement and washout

	7700 HMI	New UHMI
HMI-4 (HMI-L)	0.6 L/min	0.8 L/min
HMI-8 (HMI-M)	0.35	0.68
HMI-25 (HMI-H)	0.23	**0.5**
HMI-50	N.A.	0.4
HMI-100	N.A.	0.33

UHMI Dilution Port

Plasma

Plasma Mode   ○ Low Matrix   ○ General Purpose   ● HMI   4 < ——▯—— > 100

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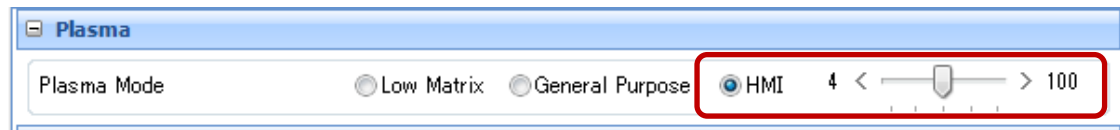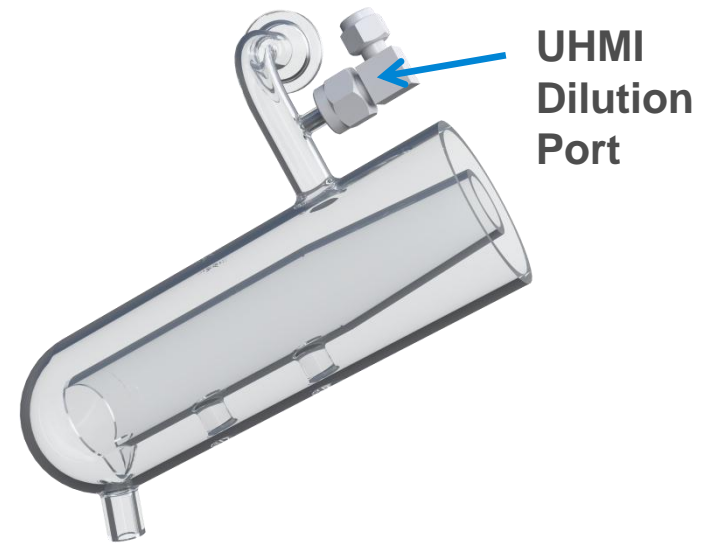
Matrix Tolerance Vastly Superior to Any Other ICP-MS

- Analysis of Brine (25% NaCl) with UHMI (HMI-50) & new Humidifier

4 hrs Quant Recovery (25% NaCl matrix + 100µg/L spike)
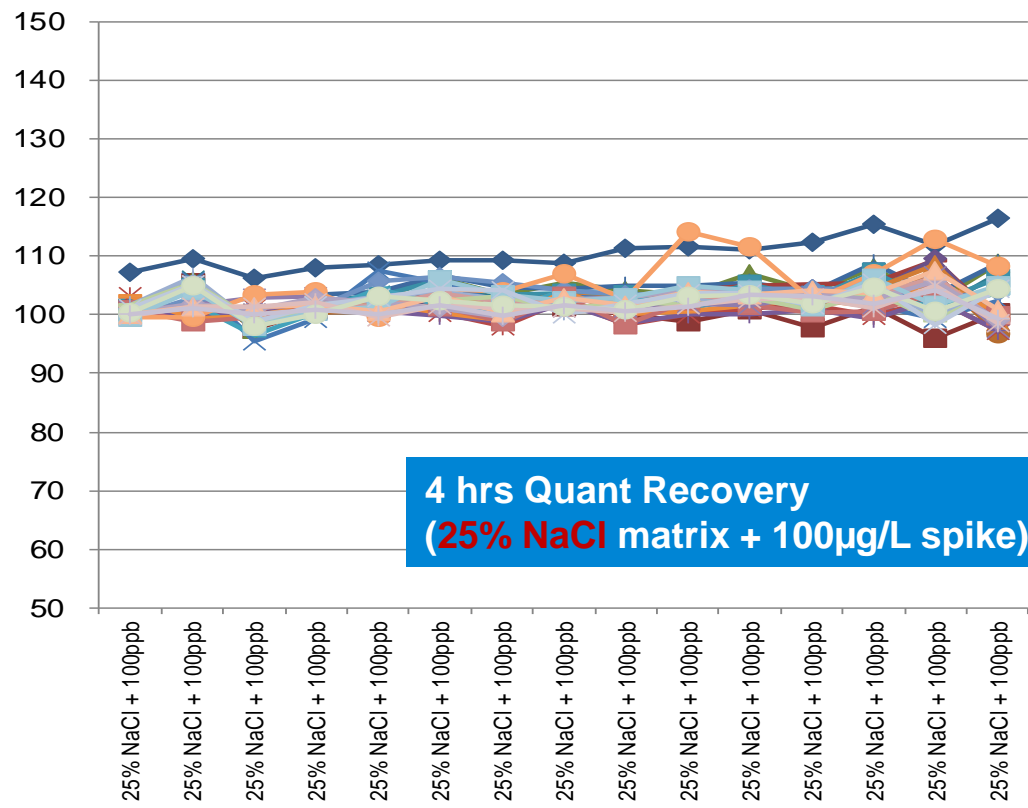
Chart legend:
- 9 Be [no]
- 27 Al [no]
- 51 V [no]
- 51 V [He]
- 52 Cr [no]
- 52 Cr [He]
- 55 Mn [no]
- 55 Mn [He]
- 56 Fe [He]
- 59 Co [no]
- 59 Co [He]
- 60 Ni [no]
- 60 Ni [He]
- 63 Cu [He]
- 66 Zn [no]
- 66 Zn [He]
- 68 Zn [no]
- 68 Zn [He]
- 75 As [He]
- 78 Se [He]
- 107 Ag [no]
- 107 Ag [He]
- 111 Cd [no]
- 111 Cd [He]
- 205 Tl [no]
- 205 Tl [He]
- 208 Pb [no]
- 208 Pb [He]
- 238 U [no]
- 238 U [He]

X-axis labels: 25% NaCl + 100ppb (repeated)

	OES DL (µg/L)	7900 DL (µg/L)
Ag	0.7	0.07
Al	0.5	0.6
Be	0.07	0.03
Cd	0.4	0.16
Co	1	0.04
Cr	1	0.05
Fe	1.7	0.33
Mn	0.2	0.12
Ni	2.5	0.12
Pb	6	0.73
Se	10	1.2
Tl	9	0.22
V	1	0.09
Zn	0.5	0.39

- Better DL than OES

- No maintenance required for cones and lenses after 8 hours continuous introduction.

Agilent Ar gas humidifier

- Hollow fiber membrane tubing

- 2 channels in one body
  - For Carrier gas and Dilution gas

- No delay on gas flow change by much lower volume
  - Easier to tune (incl. Auto tune)

Agilent Technologies
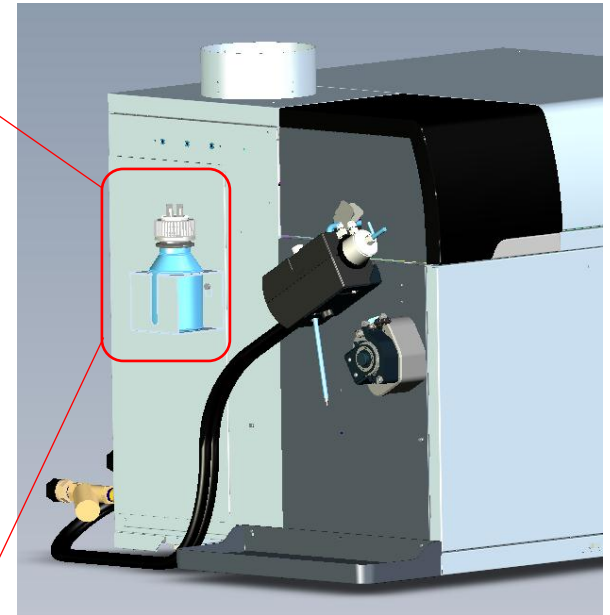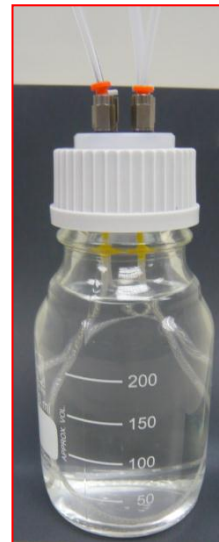
NEW 7900 Orthogonal Detector System
Improved signal to noise and dynamic range

Higher sensitivity

- High sensitivity EM (increase secondary electron generation by higher voltage at the 1st dynode)
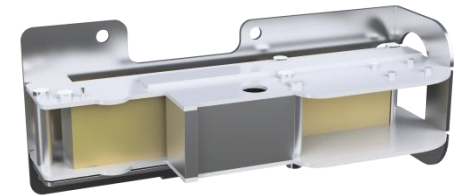
Lower background

- Off-axis from Q-pole to Detector

Improved S/N

- Reduced noise on pulse signal
- New advanced discriminator system – separate noise by pulse width and pulse height

Extended upper limit of detector range

- Analog range increased from 3 Gcps →10 Gcps

- Up to 11 orders dynamic range - 0.1 cps to 10 Gcps

Time Domain Discriminator

Pulse Height Discriminator Threshold

Amp Output

Electric noise

Ion pulse

Counted as signal

7700

Pulse Height Discriminator Output

Not Counted as signal

7900

Time Domain Discriminator Output
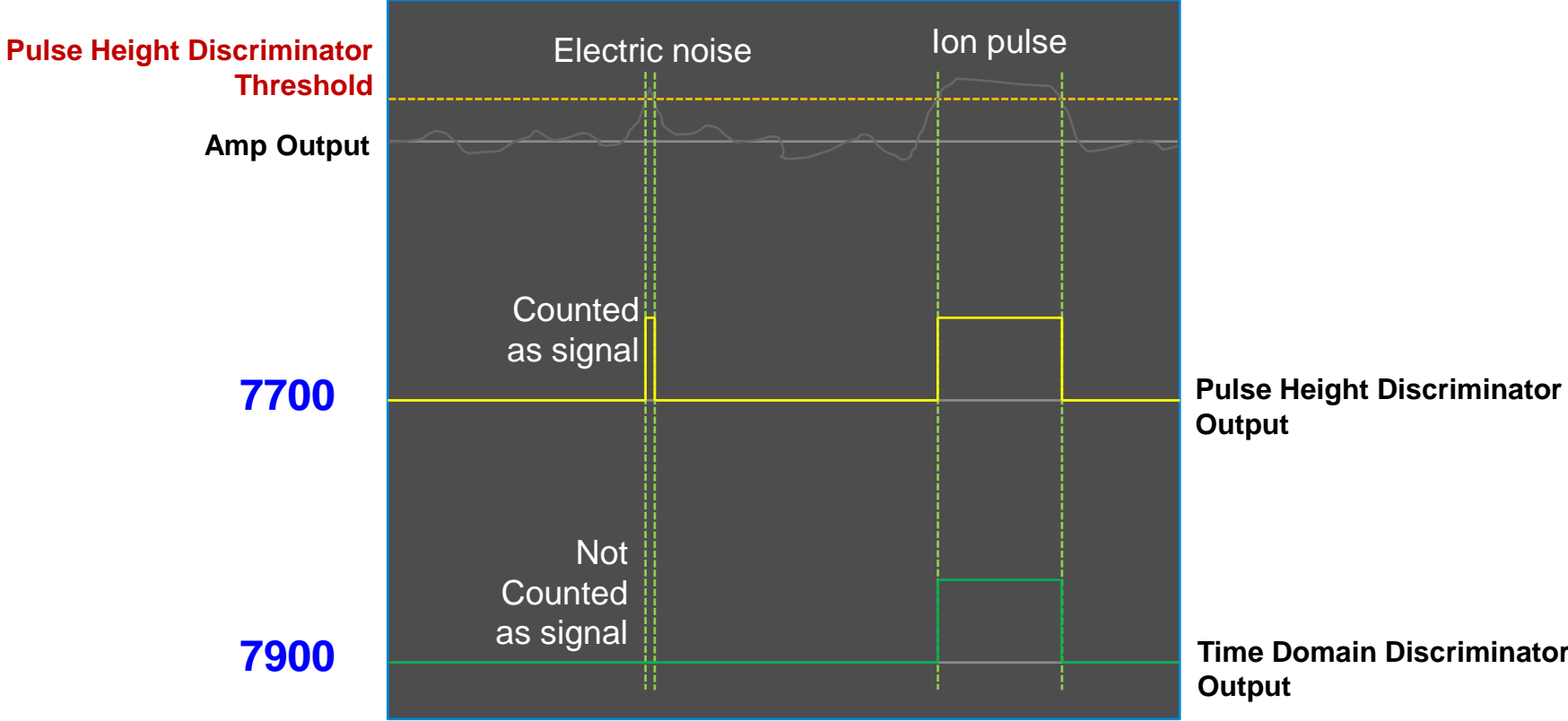
Far Wider Measurement Range Than Any Other ICP-MS
11 orders - low and high level calibrations in a single run

Cd (1ppt - 1ppb) and **Na (100ppb - 10,000ppm (1%))** in the same run

Both calibrations are linear.

Total **concentration range** covered from Cd blank (BEC of <0.1ppt) to Na top standard (1%) is 11 orders

Concentration range (11 orders) and upper measurement limit (>**1%**) are at least 10x better than any other ICP-MS

Faster TRA mode for Transient Signal Analysis
Required for Single Nanoparticle analysis

Minimum dwell time is shortened from **3 msec.** on the 7700 Series to **0.1 msec** to allow faster sampling of transient signals.
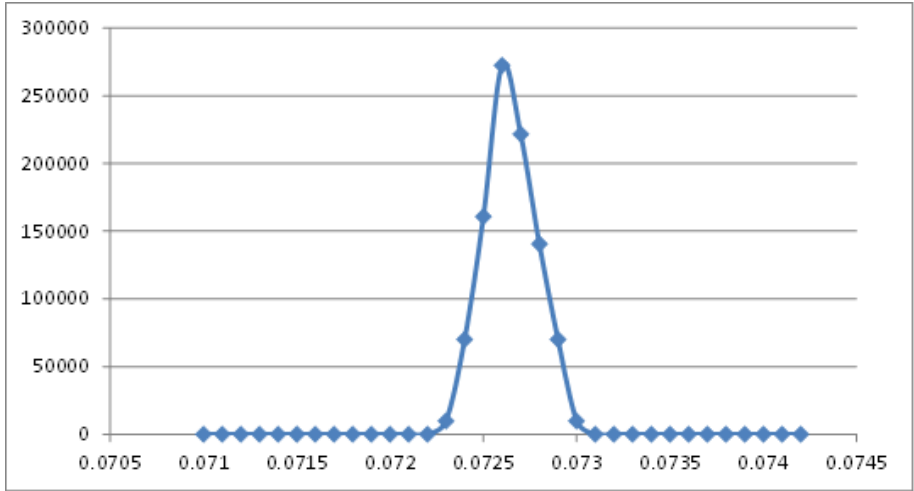
30 nm Au NP

Faster TRA mode for Transient Signal Analysis

Minimum dwell time is shortened from **3 msec.** on the 7700 Series to **0.1 msec** to allow faster sampling of transient signals.

This enables the measurement of the single NP peak signal arriving on the detector.

0.1 msec

30 nm Au Nanoparticle
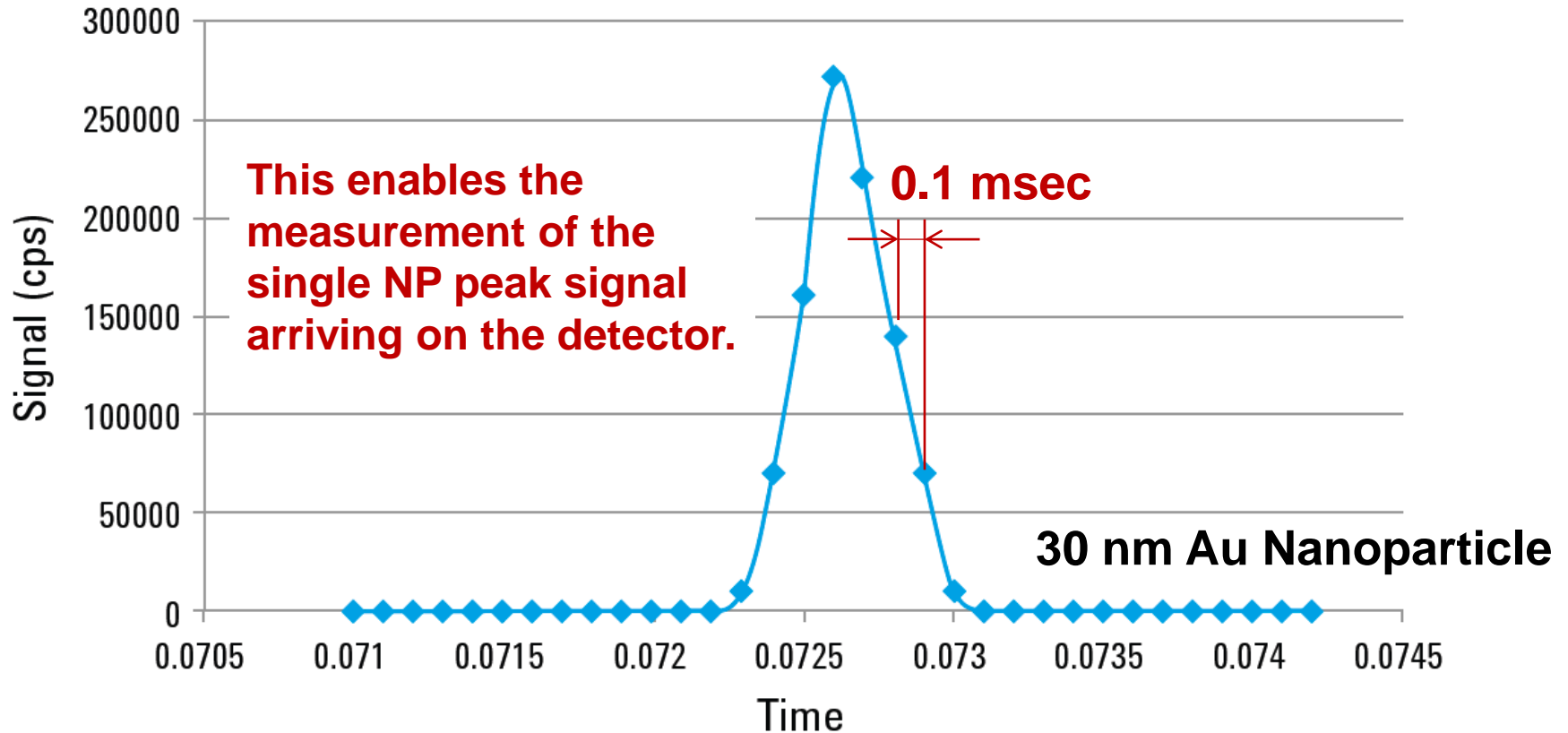
Time Resolved Analysis signal for single 30nm Au nanoparticle (dwell time 0.1ms)
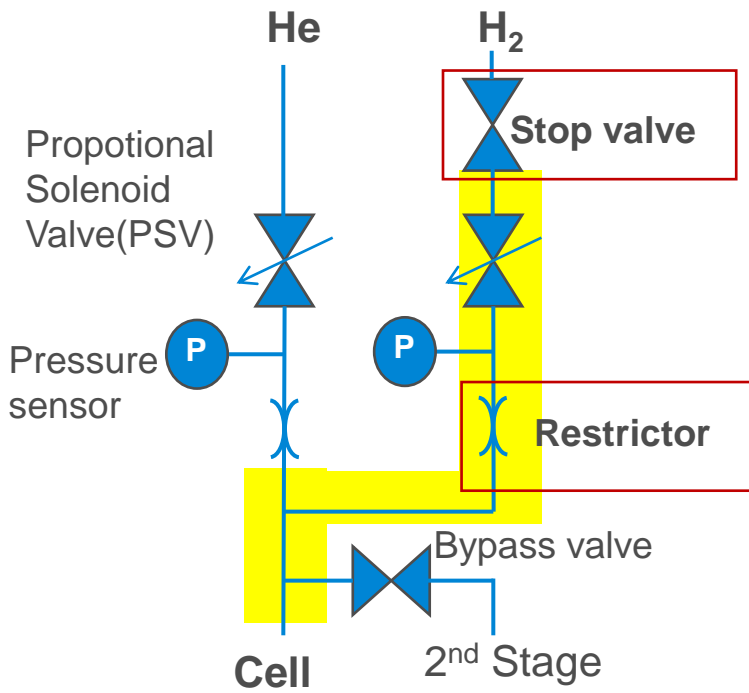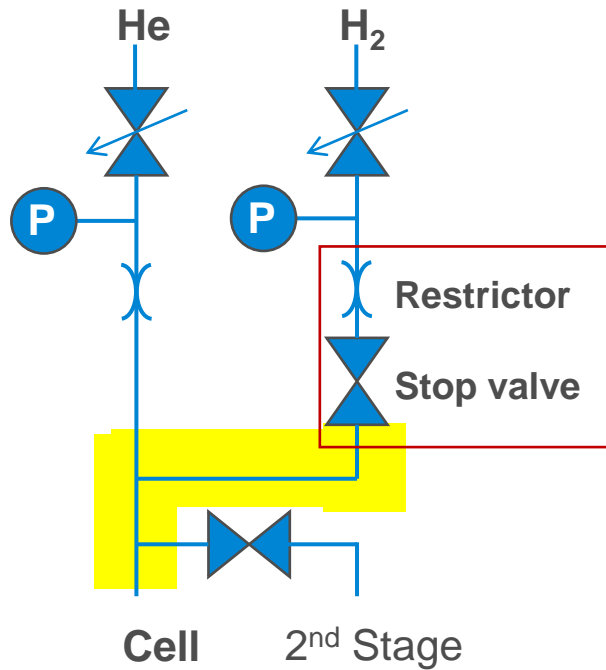
ORS[4] - Rapid ORS (Fast cell gas switching)

7700

He   H₂

Stop valve

Propotional
Solenoid
Valve(PSV)

Restrictor

Pressure
sensor   P   P

Bypass valve

Cell   2ⁿᵈ Stage

7900

He   H₂

P   P

Restrictor

Stop valve

Cell   2ⁿᵈ Stage

7700

Tune mode	No gas	He	HEHe	H2
Stabilization time	0 sec	10 sec	10 sec	15sec

7900

Tune mode	No gas	H2	He	HEHe
Stabilization time	0 sec	5 sec	5 sec	5sec

Fast Cell Gas Switching – ORS[4]

7700 H$_2$: 6.0 → 0 mL/min
10 sec.

New ICP-MS H$_2$: 6.0 → 0 mL/min
2 sec.
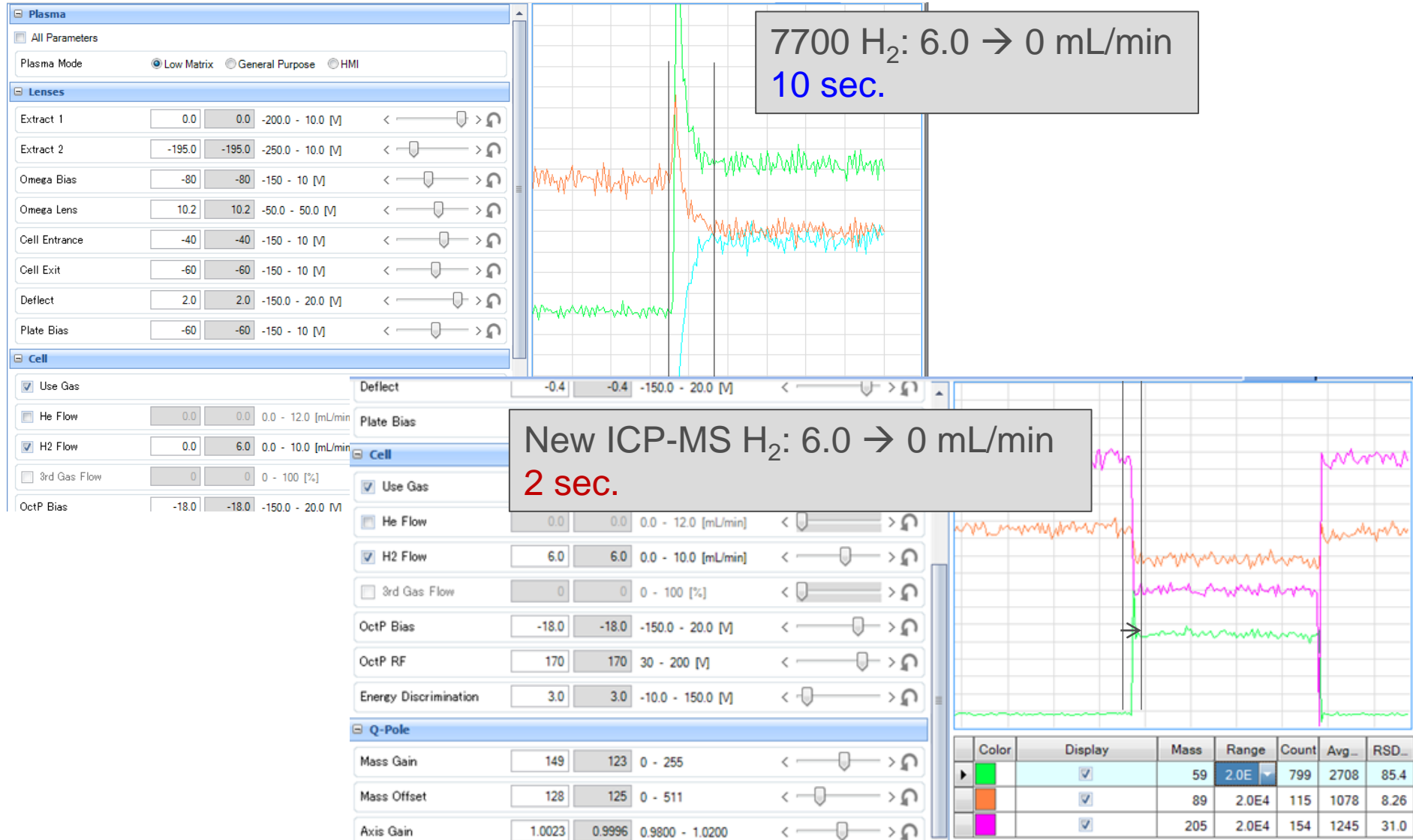
New Integrated Sample Introduction System (ISIS 3)

7 port valve (incl. online ISTD port)

Piston pump
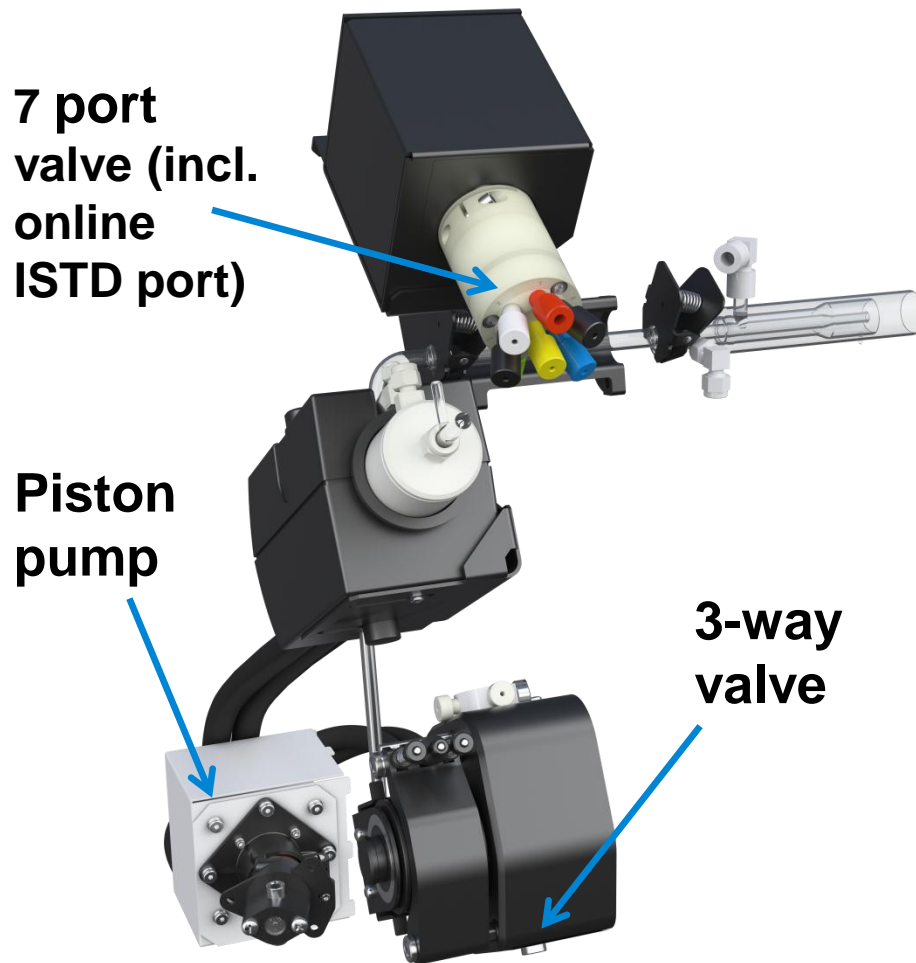
3-way valve

New features in ISIS 3

- **Close-coupled valve** – very short tube length so minimal stabilization/rinse delay

- Easier tubing setup by **color coding**

- **Piston pump** for faster sample uptake
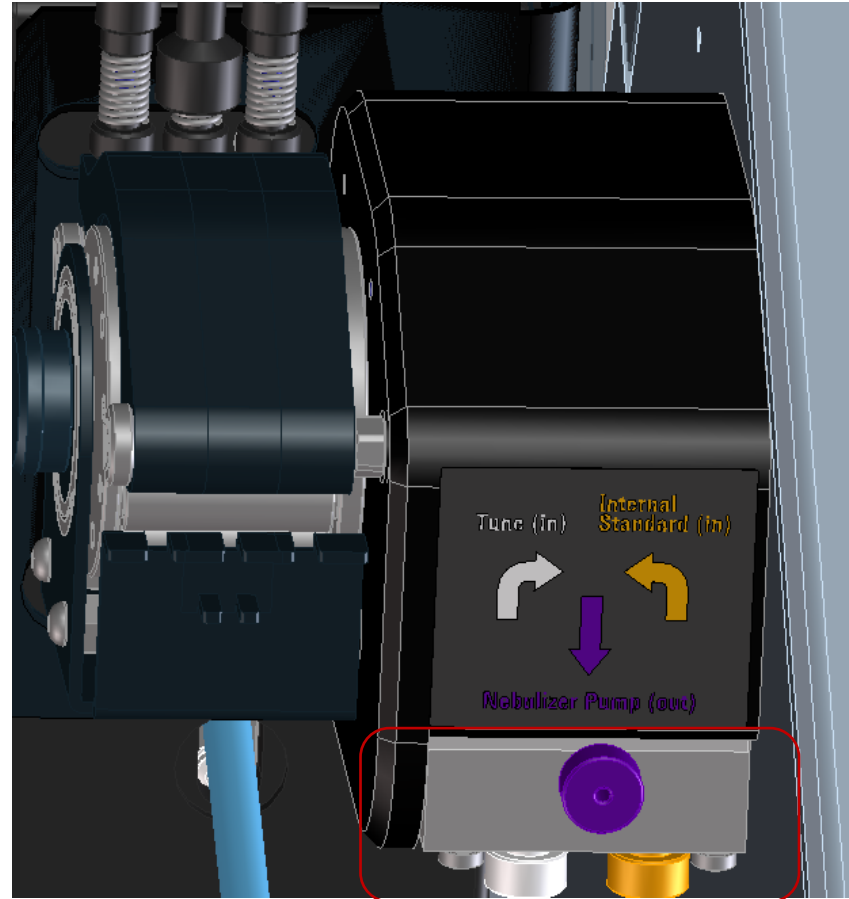
- **3-way valve** to switch between on-line ISTD or tune solution

  - ISIS is now compatible with Startup auto-optimization functions and full autotune

Tune/ISTD valve for ISIS 3

- Support Start up, Autotune in batch

- Switch Tuning solution and ISTD solution automatically
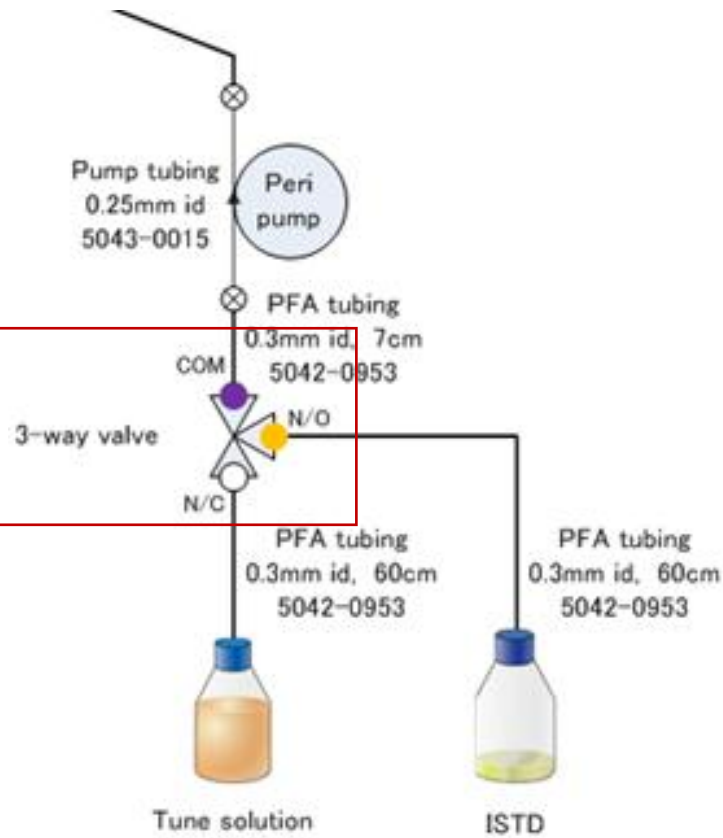
Improved Maintenance and Usability
Designed to make maintenance simpler and faster

U-series connection for MicroMist

Tighter connection S/C and Endcap

Peristaltic Pump redesigned:

- Easier to connect tubing, no drip onto Peri-pump roller

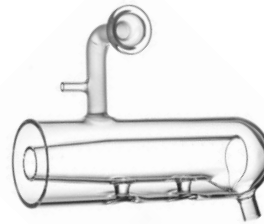Torch box cover now uses clip (not thumb screw)
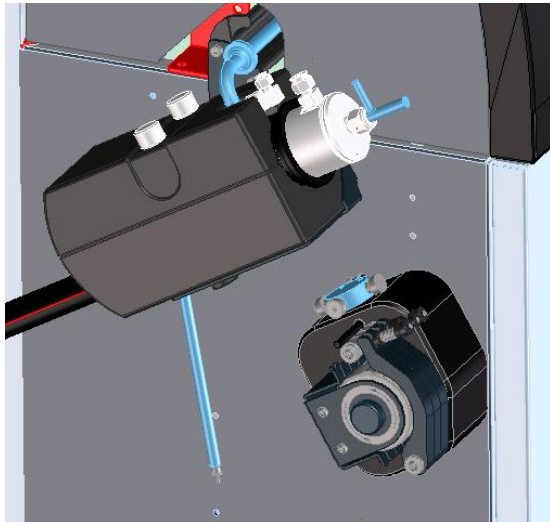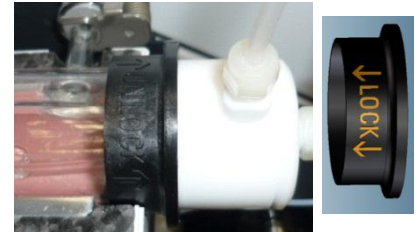
Analysis of Major and Trace elements in Brine

Sample

- Saturated salt water solution (~23% NaCl)
  - Typically analyzed by other than ICP-MS such as ICP-OES

Experiment

- Agilent 7900 ICP-MS with UHMI
- Ar gas humidifier
- HMI-25

Instrument Parameters

Mode	No gas	H$_2$	He	High Energy He
Stabilization, sec	0	5	5	5
RF Power, W			1600	Quick stabilization
Sampling Depth, mm		Preset Plasma	10	
Carrier gas, L/min		**HMI-25**	0.45	
Dilution gas, L/min			0.36	Ion lens **Auto tuned**
Ext 2, V	-235	-225	-220	-195
Omega Bias, V	-110	-120	-120	-100
Omega Lens, V	10.6	9.8	9.6	8.6
Deflect, V	10.8	0.6	1.0	-70
ORS gas, mL/min	-	6	5	10

Recovery test

Very good recoveries are obtained over a wide concentration range from 20ppb to 250ppm.
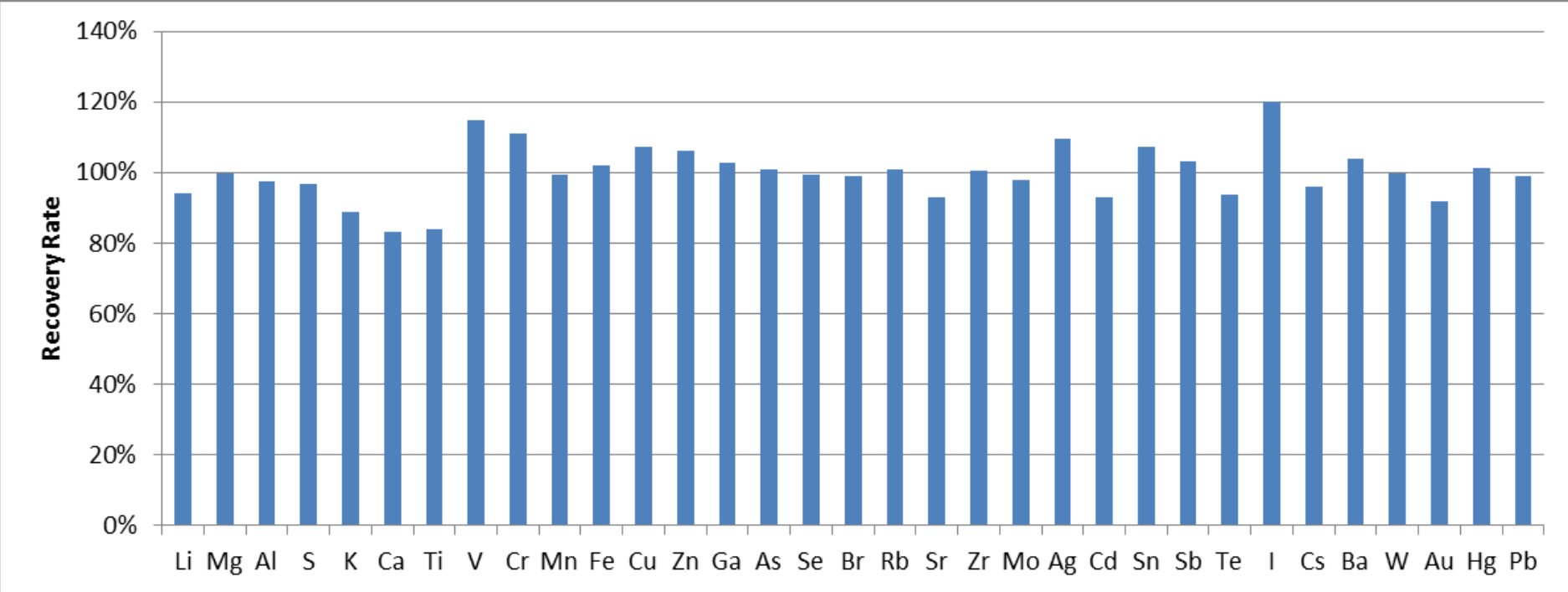
Spiked conc.:

K	250	ppm
S	62.5	ppm
Br	50	ppm
Ca	40	ppm

Sr	0.4	ppm
Al, Ti	0.2	ppm
Others	20	ppb

Long term stability (5 hours)

ISTD correction works very well,
and shows good signal stability <u>over 5 hours</u> even such a high TDS sample.
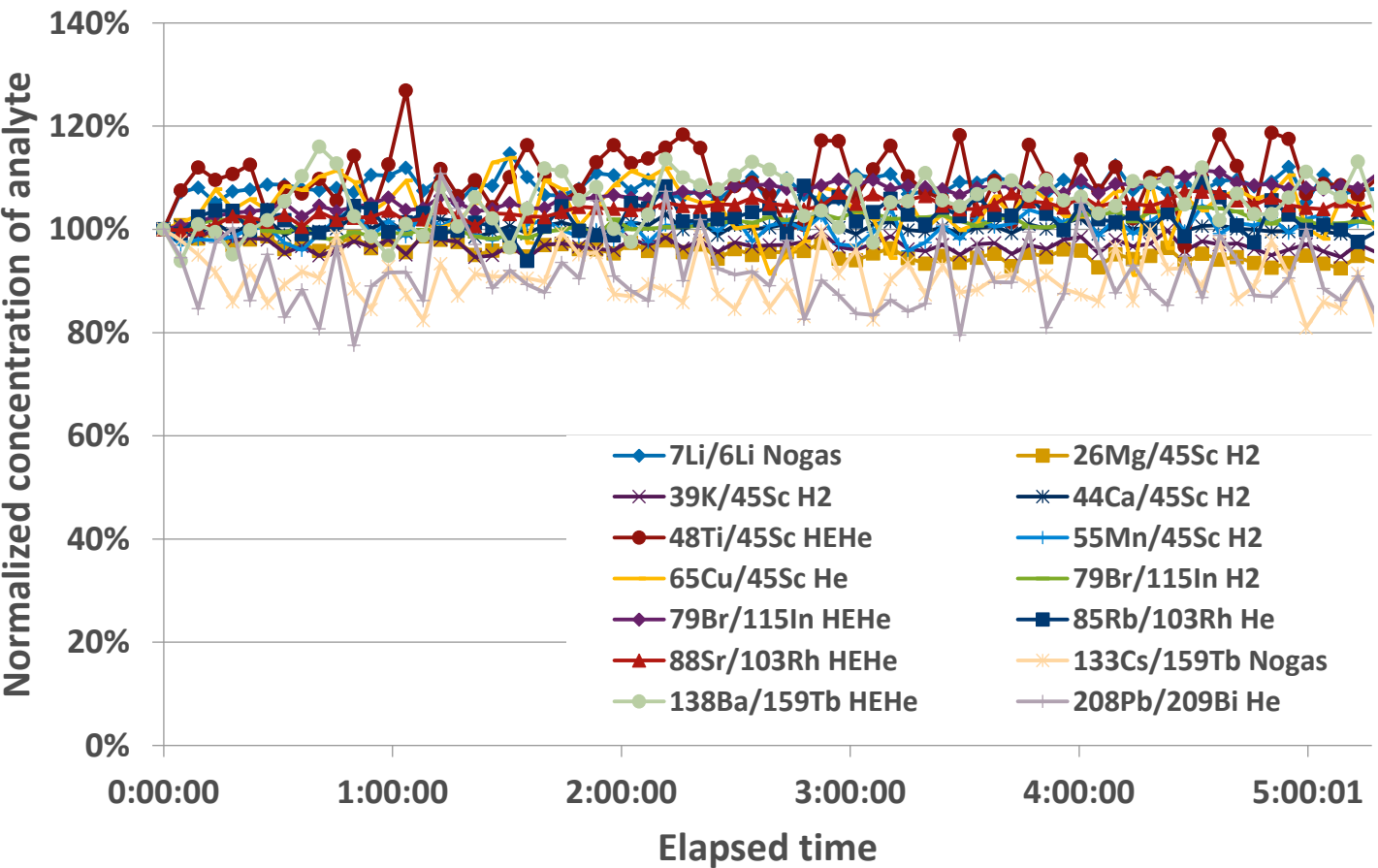
No need to clean lenses after running brine

Analysis of various type of table salts

Covers wide measurement range from <0.01 ppb to >1,000 ppm in Brine.
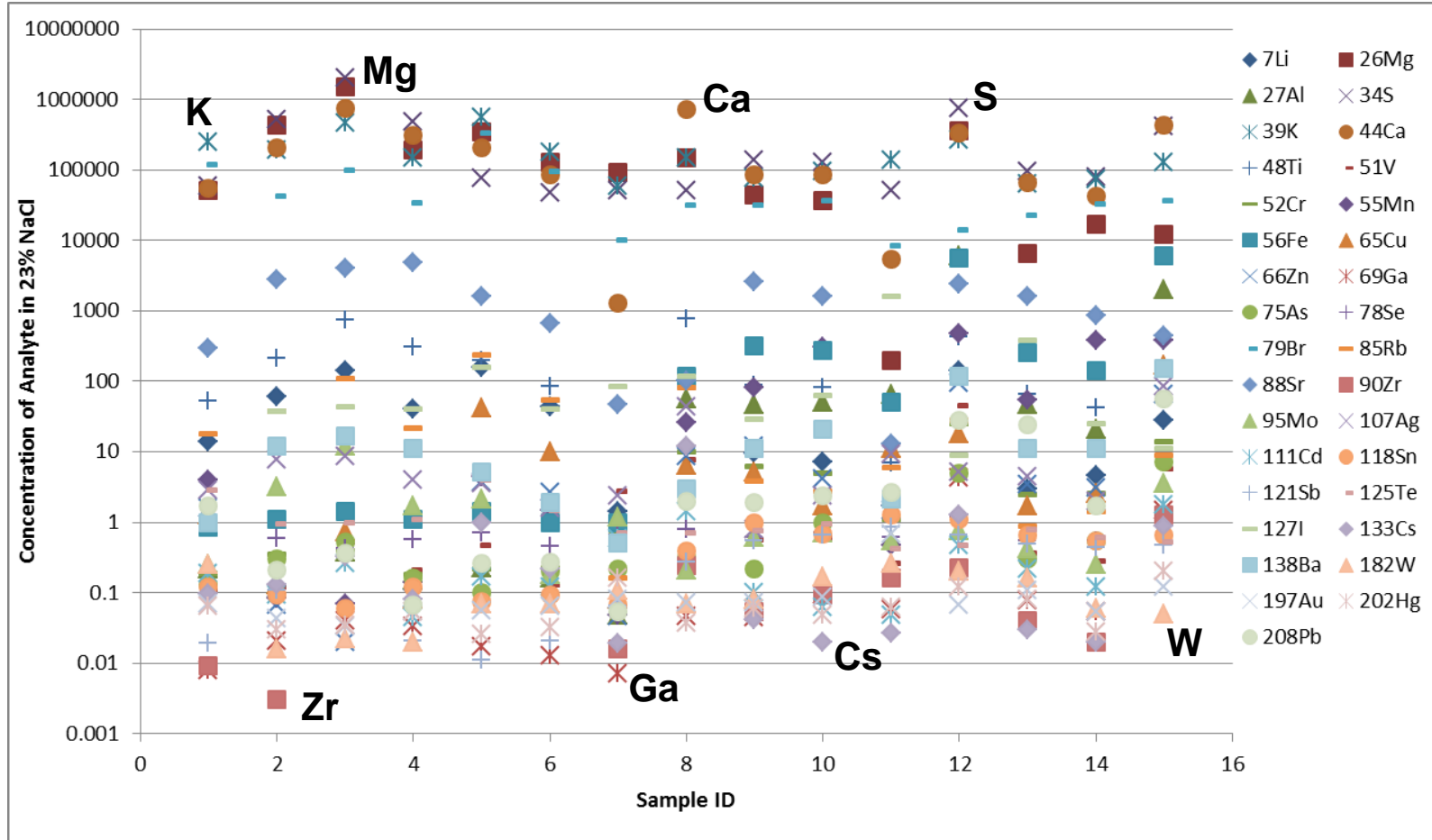
Salt samples #1-15:
Sea or Rock salt from Japan, Mexico, Germany, S.Africa, USA, Pakistan, Mongol

Determination of Trace Elements in Steel

Sample

- 17 Steel CRM form Japan Iron and Steel Federation (JISF)

Sample prep.

- Dissolving CRM with HCl/HNO3

- Final concentration of Fe in solution: **0.5%** (JISF method)

Instrument

- Agilent 7900 ICP-MS with UHMI

- HMI-25

Analytical Conditions

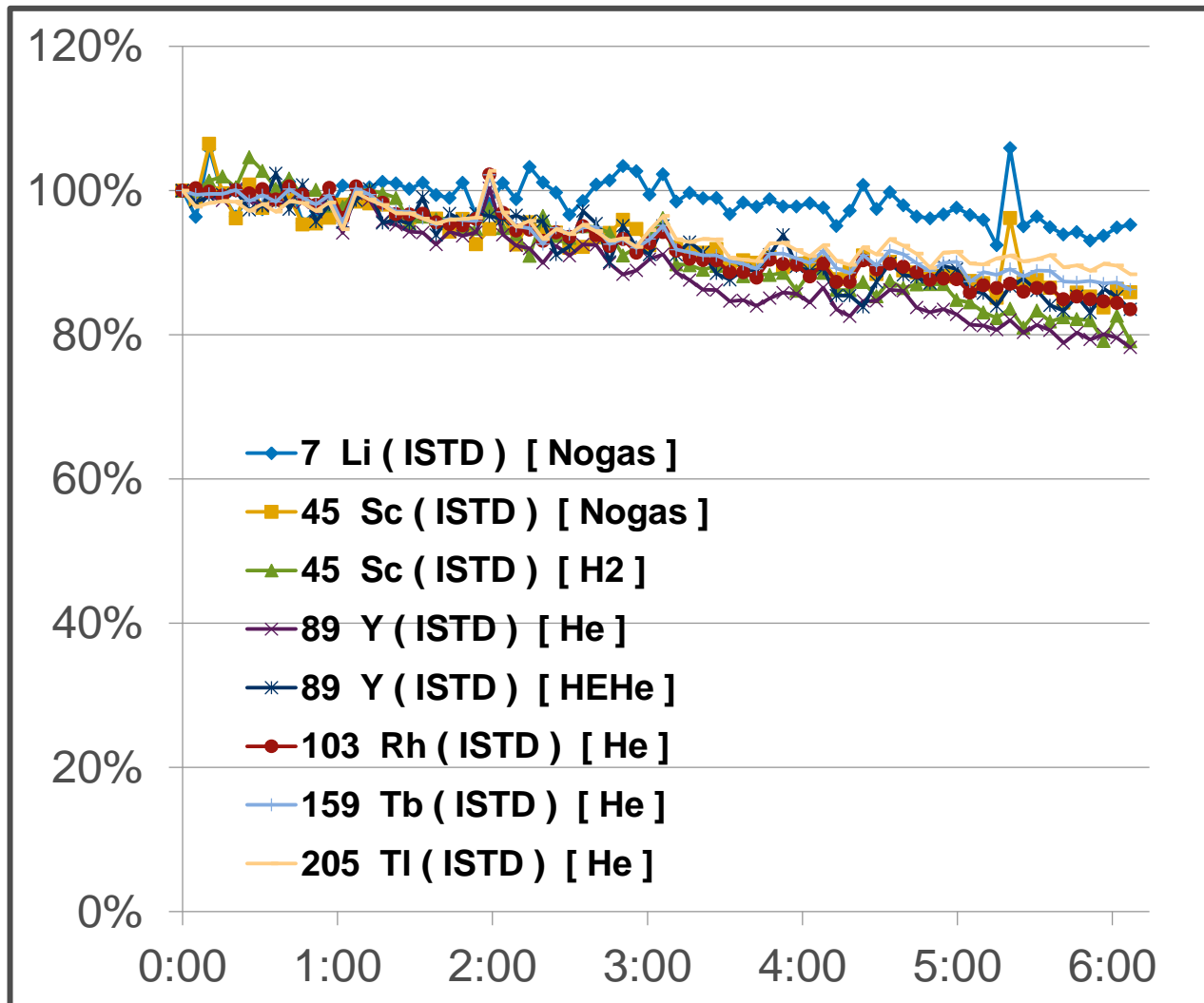|	No gas	H_2	He	HEHe
RF Power	1600 W			
Sampling Depth	10 mm			
Carrier Gas	0.45 L/min			
Dilution Gas	0.54 L/min			
Ext 1	-5	-5.3	-2.5	-7
Ext 2	-180	-195	-200	-200
Omega B	-105	-120	-115	-115
Omega L	9.6	10.9	10.7	7.2
Cell Ent	-36	-34	-26	-150
Cell Exit	-60	-70	-70	-150
Deflect	11.8	-1.4	-1.6	-75
Plate B	-45	-60	-60	-150
ORS Gas		5 mL/min	4 mL/min	10 mL/min
Oct P Bias	-8	-20	-20	-100

Preset Plasma
HMI-25

Ion lens
Auto tuned

Cell parameters
Preset

Agilent Technologies

ISTD Signal Stability (0.5% Steel, HMI-25)

Legend:
- 7 Li (ISTD) [Nogas]
- 45 Sc (ISTD) [Nogas]
- 45 Sc (ISTD) [H2]
- 89 Y (ISTD) [He]
- 89 Y (ISTD) [HEHe]
- 103 Rh (ISTD) [He]
- 159 Tb (ISTD) [He]
- 205 Tl (ISTD) [He]

Signal drift is **less than 20%** for most of ISTD elements even after **6 hours** even running **0.5% dissolved solution**!

Relationship between Counts (corrected by ISTD) and Certified Value

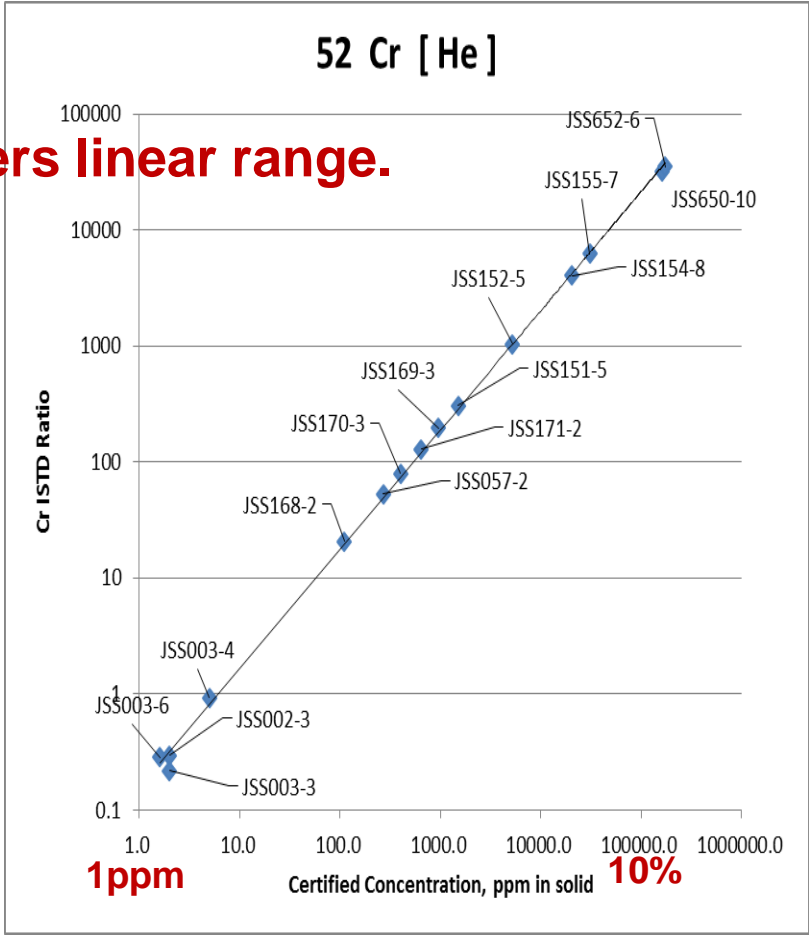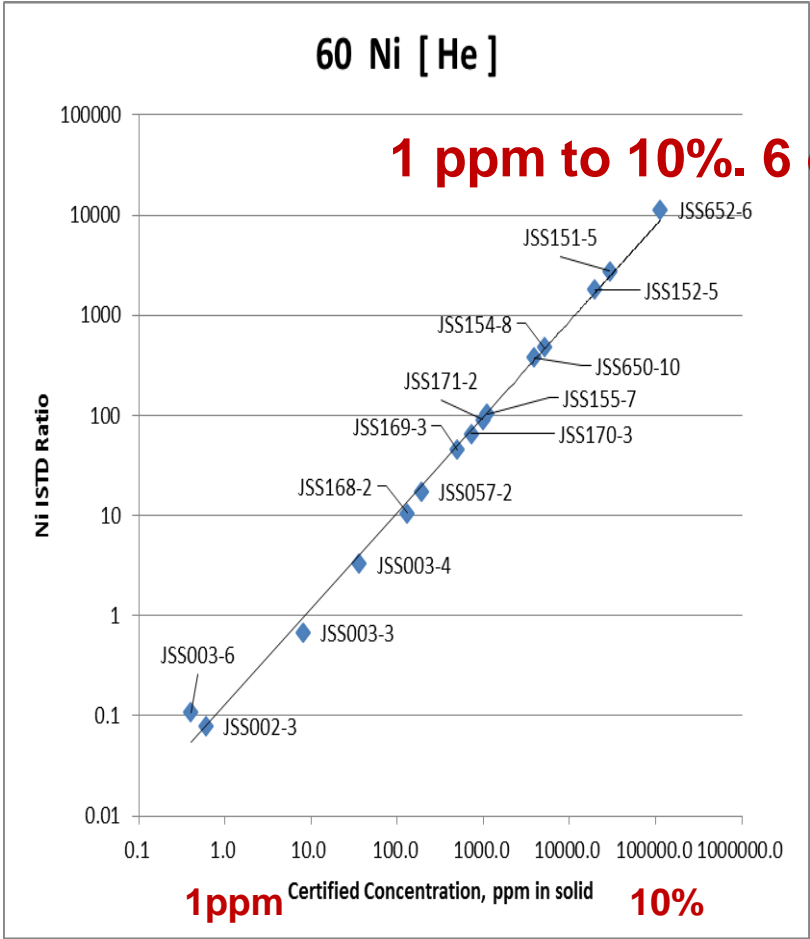# Relationship between Counts (corrected by ISTD) and Certified Value

60 Ni [He]

1 ppm to 10%. 6 orders linear range.
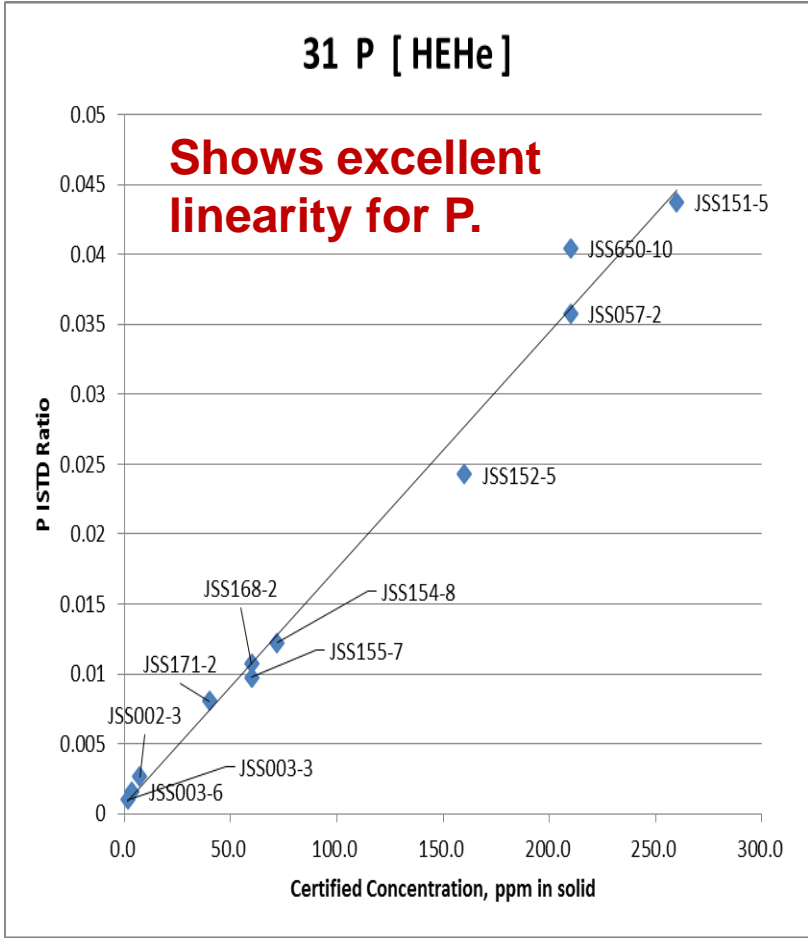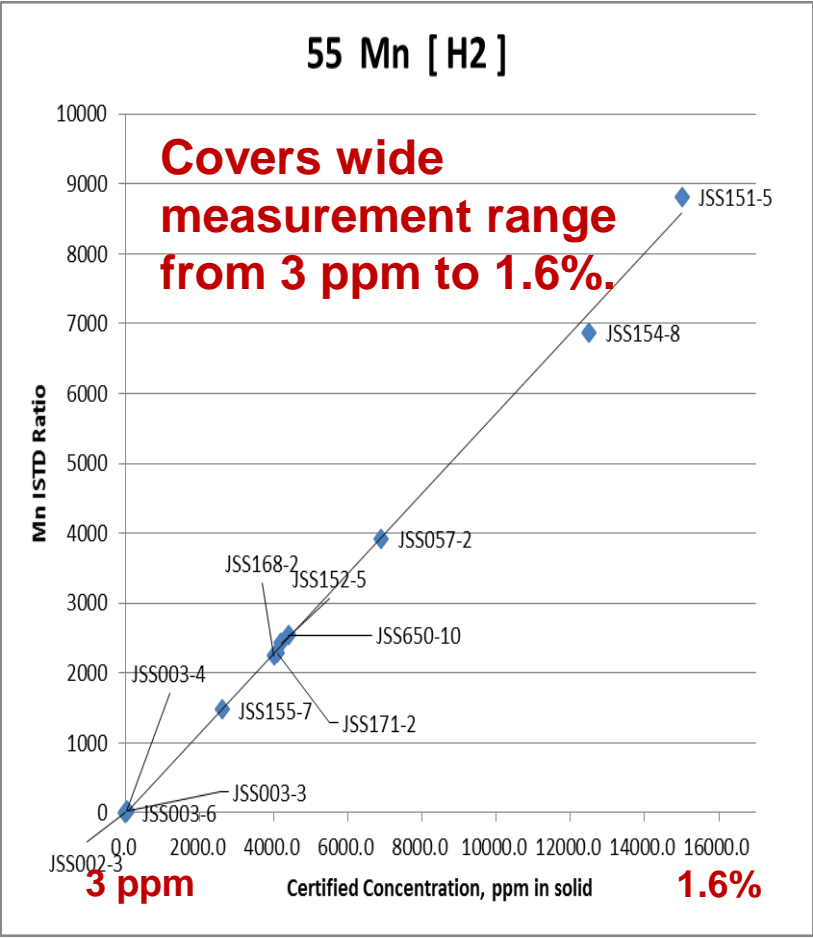
52 Cr [He]

High matrix samples (Soil) analysis with ISIS 3
 - Maximizing productivity

ISIS 3 Program on MassHunter 4.1

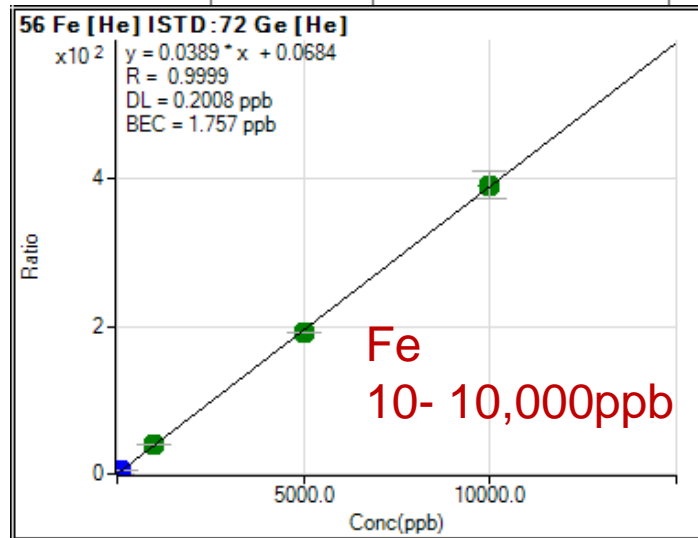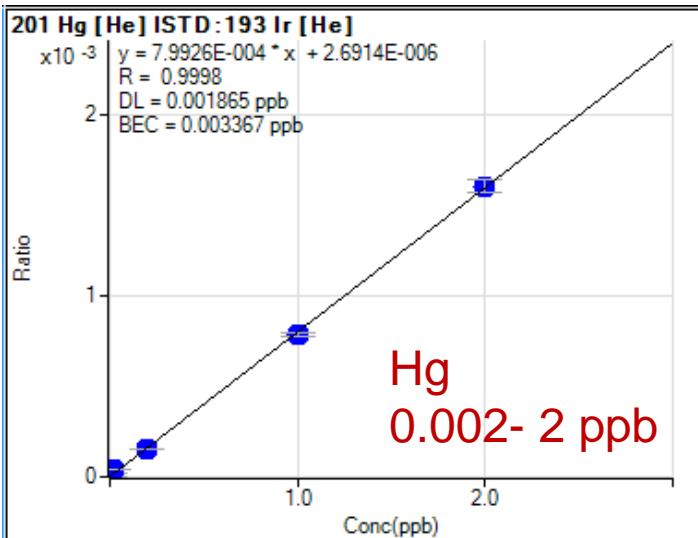**ISIS 3 pump program** enables to set optimized ISIS pump program to reduce carry over **during rinse steps**.

- Slow down the pump speed to fill the rinse solution in the rinse port.
- Wash the outside and inside of autosampler probe.

Cycle time

83 sec. / sample

- Water, Soil, Sediment CRM
- 26 elements (ppb - ppm)
- **>20% faster** than 7700 ISIS (App. Note 5990-5437EN)

078SMPL.d	2013-11-11 00:23:51	Sample	50x Soil B
079SMPL.d	2013-11-11 00:25:12	Sample	1640a
080SMPL.d	2013-11-11 00:26:35	Sample	10x 1640a
081SMPL.d	2013-11-11 00:27:57	Sample	10x SW
082SMPL.d	2013-11-11 00:29:21	Sample	10x SW MS
083SMPL.d	2013-11-11 00:30:46	Sample	10x SW MSD
084_QC1.d	2013-11-11 00:32:10	QC1	LLCCV
085_QC2.d	2013-11-11 00:33:32	QC2	CCV
086_QC3.d	2013-11-11 00:34:55	QC3	CCB
087SMPL.d	2013-11-11 00:36:18	Sample	10x RS-A
088SMPL.d	2013-11-11 00:37:38	Sample	50x RS-A
089SMPL.d	2013-11-11 00:38:59	Sample	10x RS-B
090SMPL.d	2013-11-11 00:40:20	Sample	50x RS-B
091SMPL.d	2013-11-11 00:41:43	Sample	10x ES
092SMPL.d	2013-11-11 00:43:04	Sample	50x ES
		mple	10x Soil-A
		mple	50x Soil A
		mple	10x Soil B
		mple	50x Soil B

201 Hg [He] ISTD : 193 Ir [He]

$y = 7.9926E\text{-}004 * x + 2.6914E\text{-}006$
$R = 0.9998$
$DL = 0.001865$ ppb
$BEC = 0.003367$ ppb

Ratio vs Conc(ppb), x10^{-3}

Hg
0.002- 2 ppb

56 Fe [He] ISTD : 72 Ge [He]

$y = 0.0389 * x + 0.0684$
$R = 0.9999$
$DL = 0.2008$ ppb
$BEC = 1.757$ ppb

Ratio vs Conc(ppb), x10^2

Fe
10- 10,000ppb

Method Detection Limit

		MDL (ppb)
9	B	0.07
23	Na	6.1
24	Mg	1.3
27	Al	1.3
39	K	7.8
44	Ca	12
51	V	0.03
52	Cr	0.04
55	Mn	0.04
56	Fe	0.74
59	Co	0.02
60	Ni	0.05
63	Cu	0.02

		MDL (ppb)
66	Zn	0.06
75	As	0.02
78	Se	0.25
98	Mo	0.02
107	Ag	0.01
111	Cd	0.04
121	Sb	0.02
137	Ba	0.05
201	Hg	0.01
205	Tl	0.01
208	Pb	0.03
232	Th	0.02
238	U	0.01

Quant Results
10x Diluted Sediment and Soil CRMs (ng/g)

	RS-A		RS-B		ES		Soil-A		Soil-B	
	measured	certified	measured	certified	measured	certified	measured	certified	measured	certified
Be	0.006		0.013		1.94	2.00	0.011		0.010	
Na	5297	5000	5012	5000	19770	20000	7246	7000	10090	10000
Mg	6897	7000	11960	12000	10030	10000	6960	7000	8189	8000
Al	25940	25000	59500	60000	68820	70000	50480	50000	68010	70000
K	15001	15000	20030	20000	14750	15000	19510	20000	20230	21000
Ca	29950	30000	29340	30000	7927	8000	34320	35000	11960	12500
V	27.5	25.0	105.4	100	103.6	100	10.0	10.0	80.2	80.0
Cr	30810	30000	1521	1500	81.4	80.0	0.192		39.9	40.0
Mn	876	800	612	600	407	400	10.4	10.0	9665	10000
Fe	127800	120000	40280	40000	35730	35000	19550	20000	34610	35000
Co	12.1	10.0	15.7	15.0	10.7	10.0	0.317		10.5	10.0
Ni	52.8	50	51.1	50	30.4	30	29.4	30	20.7	20
Cu	102.6	100	100.0	100	20.1	20.0	28.7	30.0	300	300
Zn	1531	1500	497	500	151	150	96.8	100	6798	7000
As	59.4	60	19.5	20	9.90	10.0	19.8	20	597	600
Se	2.41	2.0	1.13	1.0	4.89	5.0	0.925	1.0	0.089	
Cd	11.1	10	3.37	3.0	0.099		0.347		19.4	20.0
Sb	71.6	50	4.38	4.0	0.548		3.12	3.0	39.4	40.0
Ba	54.9	50	421	400	1.30		493	500	693	700
Tl	1.01	1.0	1.18	1.0	0.014		0.022		0.179	
Pb	714	700	202	200	29.8	30	39.8	40	5793	6000
Th	1.94	2.0	10.2	10.0	10.2	10.0	10.1	10.0	10.2	10.0
U	0.94	1.0	3.01	3.0	0.001		0.979	1.0	25.4	25

CCV Stability
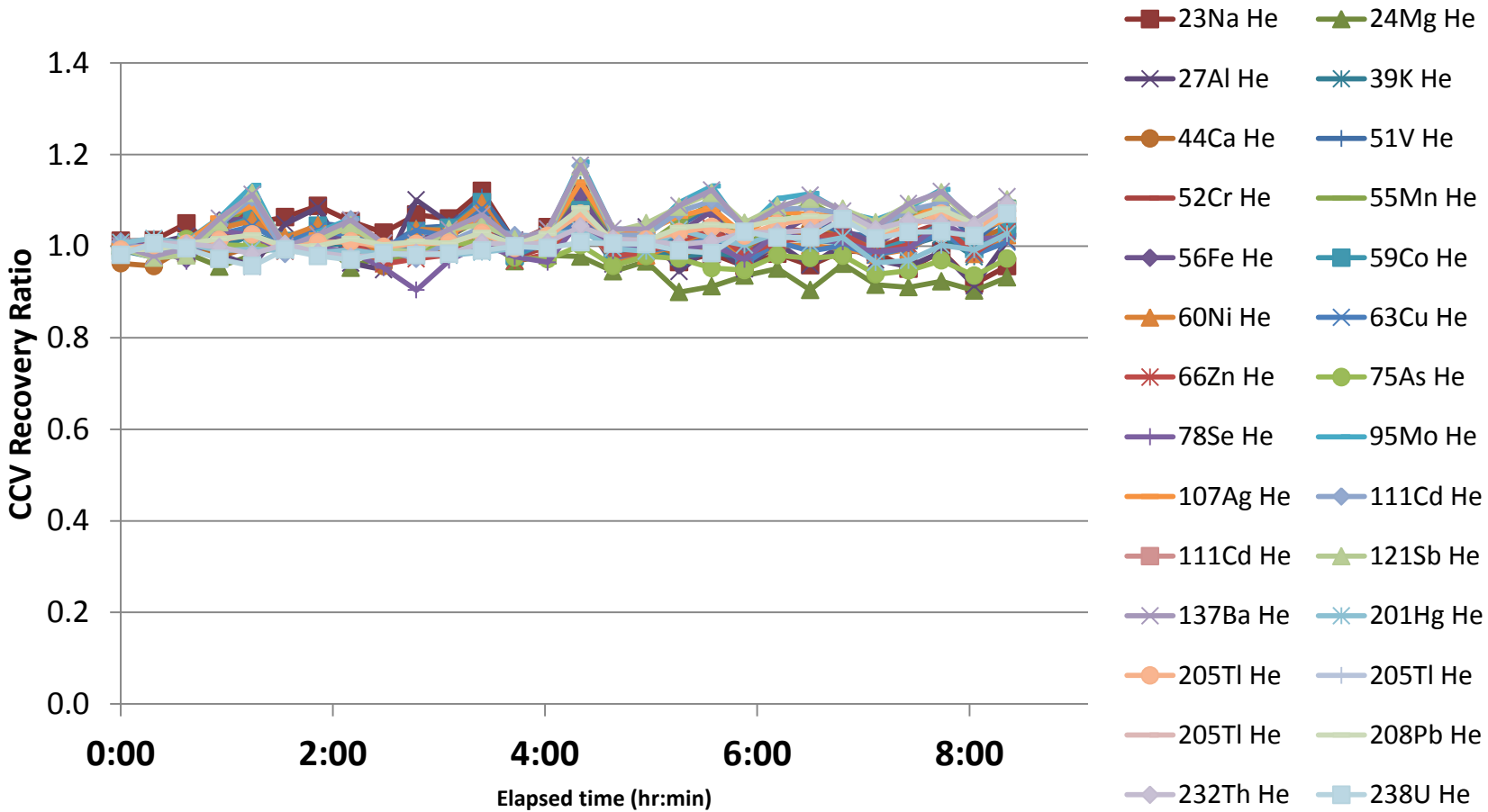
Na,Mg,K,Ca,Fe: 5 μg/g
Other elements: 50 ng/g

Interface

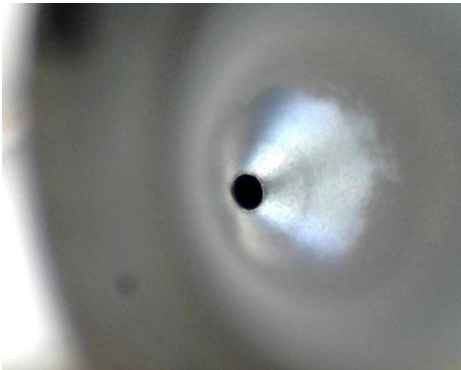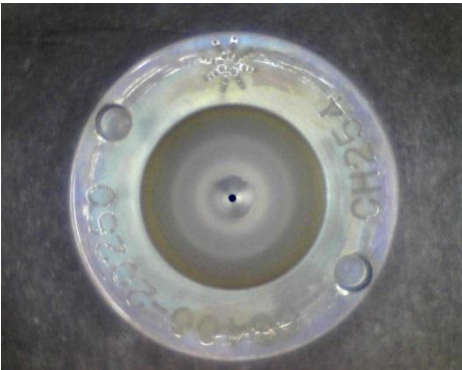|	**Sampler**	**Skimmer**	**Tip of Skimmer**

Before conditioning and sequence

After conditioning and sequence

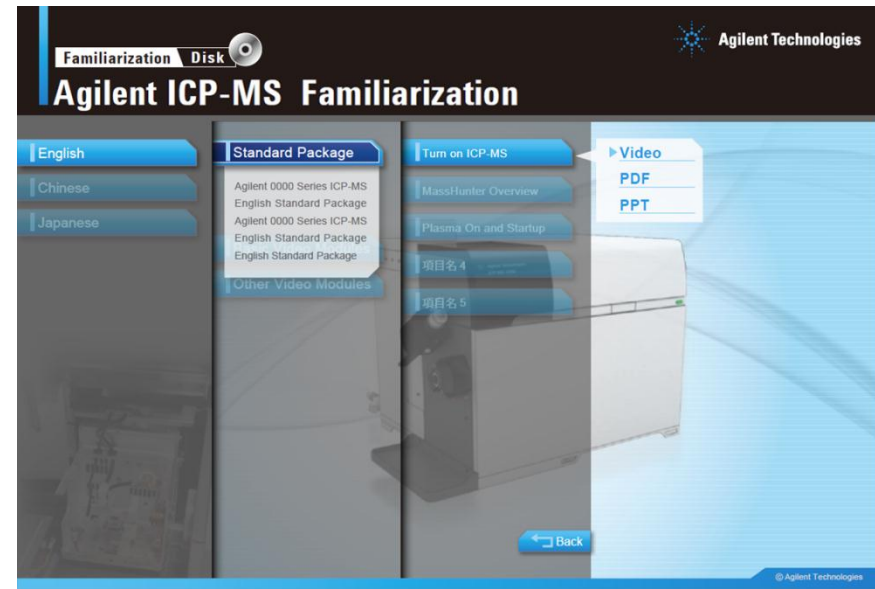# Improving Installation & Familiarization

Installation

- Intuitive Installation Checkout
- Site Prep tool for Software Installation

Familiarization

- Familiarization Tutorials
  - Familiarization Guide
  - **Familiarization Video (over 20 video clips for operation)**
  - Familiarization Slide Set

Plus:

**Remote Advisor** Now available for ICP-MS!

Summary – New Agilent 7900 ICP-MS
Better customer experience

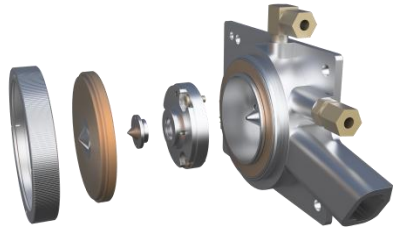## Better Analytical performance experience

- Ultra high matrix tolerance (UHMI)

- Superior sensitivity and lower background noise (ODS)

- Wider dynamic range (ODS)

- New Productivity Option (ISIS 3)

- Ultra fast scan speed for Single Nanoparticle analysis

Better Support experience

- Familiarization Tutorials/Videos

- Remote Advisor support
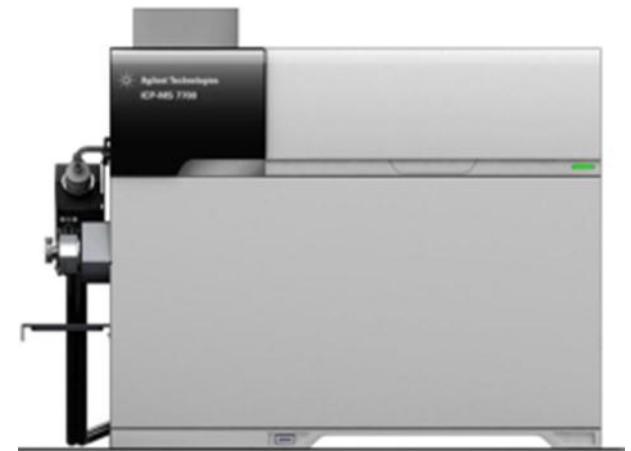
New Agilent 7900 ICP-MS

New Plasma interface & Vacuum design
Enables higher **Sensitivity**

New Orthogonal Detector system
- Higher **Sensitivity**
- Lower **Back ground**
- Extended Upper limit

New UHMI
Enables analysis of 25% brine

ORS^4
3 sec. cell gas switching

New MassHunter 4.1
- Improved User Experience
- Method automation
- SPSD common reporting engine

New Processor card New Firmware
0.1msec dwell time for fast transient and single nanoparticle analysis

New Styling
Consistent across SPSD products

New Productivity option (ISIS 3)
Faster and Fully automated from Start-up

PLUS
- ✓ New Humidifier
- ✓ Improved Usability
- ✓ 2 Days Installation
- ✓ Operating Video tool
- ✓ Remote Advisor
- ✓ Less Maintenance