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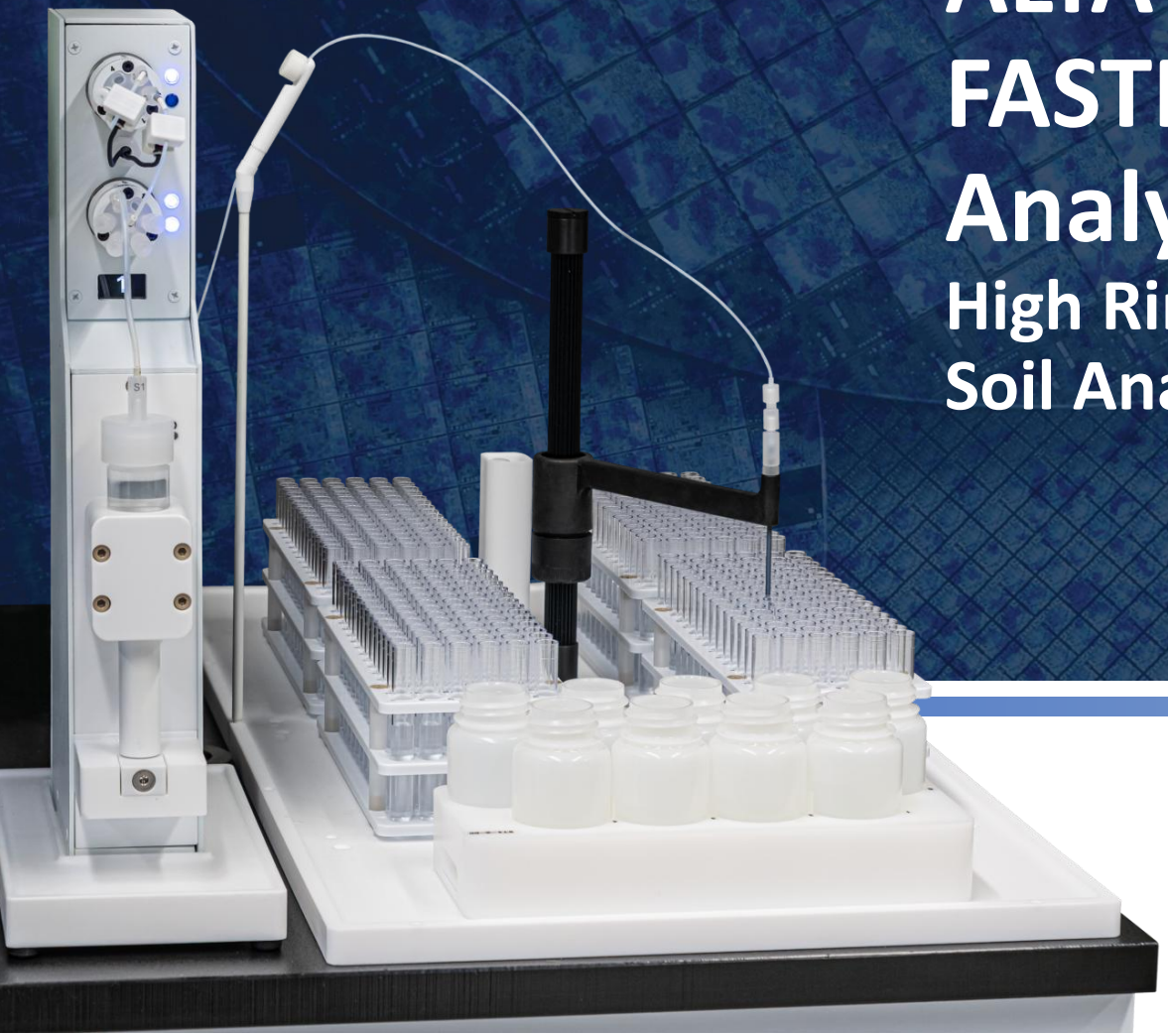
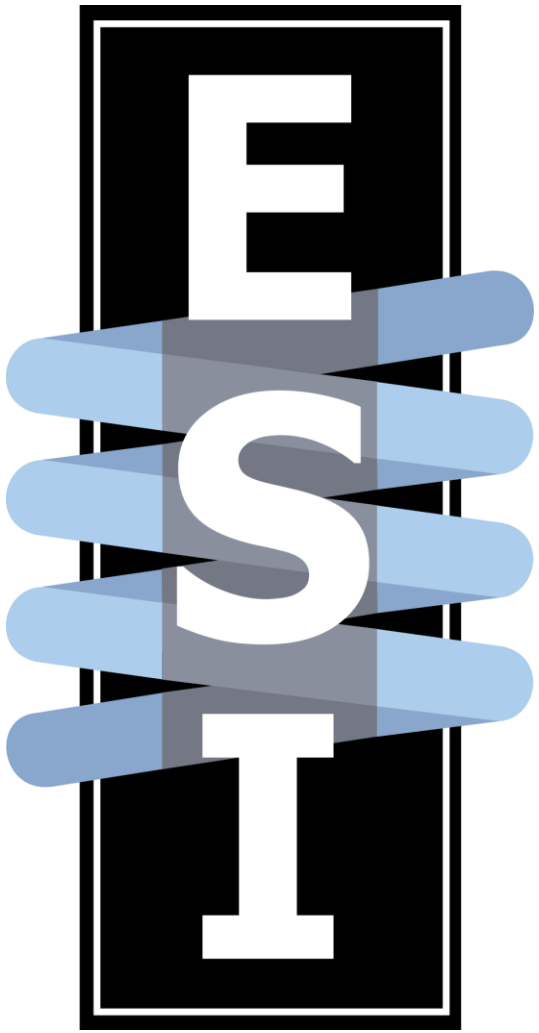
ICP | ICPMS | AA



ALTA Winter Meeting - FASTFluidic Automation for Soil Analysis:

High Rinse Out/High-throughput Agricultural Soil Analysis

Today's Topics



- **Company Introduction**
- **High-throughput Soil Analyses with High Rinseout**

  FASTFluidic FilterProbe Soil
- **Laser Ablation-ICP/ICPMS**

  SolidSample ICPMS
- **Automated Liquid Handling Systems**

  DilutionStation, FiltrationStation, TRAXStation

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Company Introduction

ESI Company Introduction

Our Mission

Empower laboratories to ***push the boundaries of possibility*** through innovative and reliable automation solutions

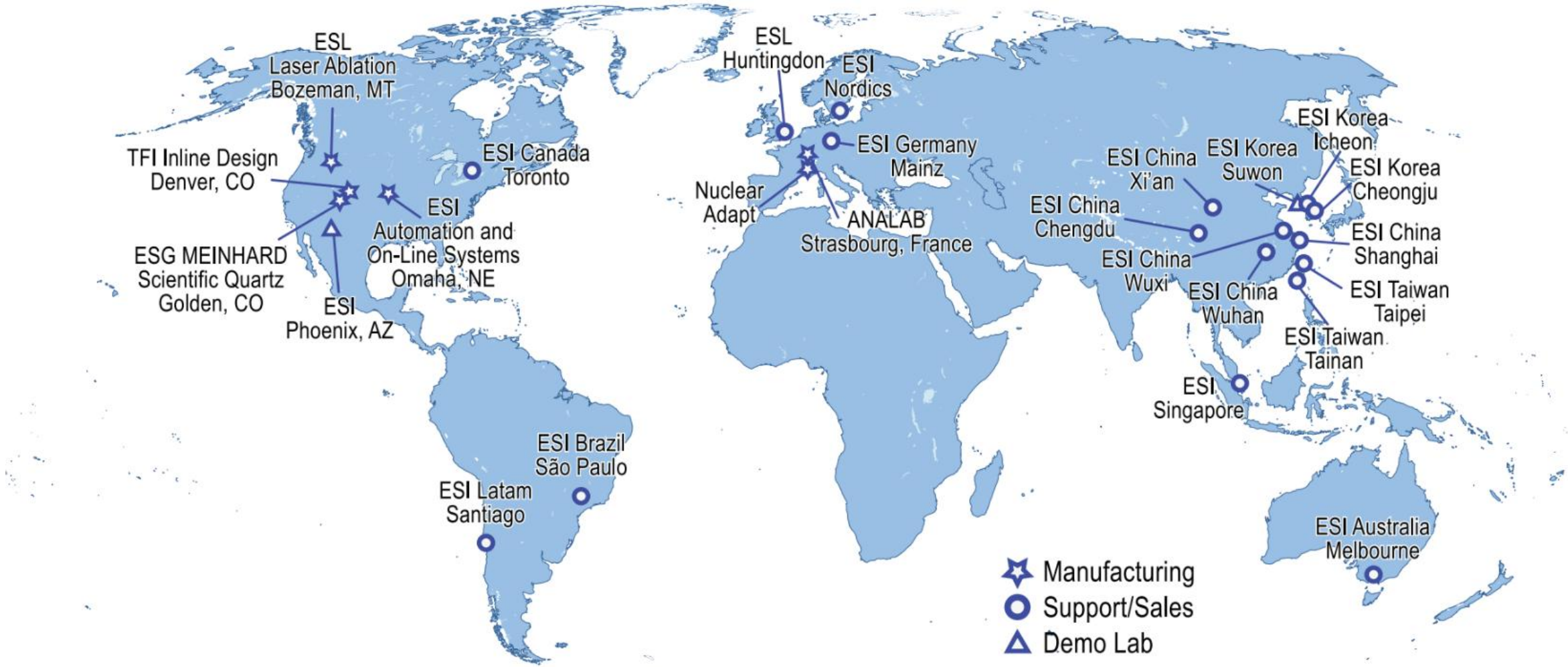
Trusted manufacturer of Automation for **Over 25 years**

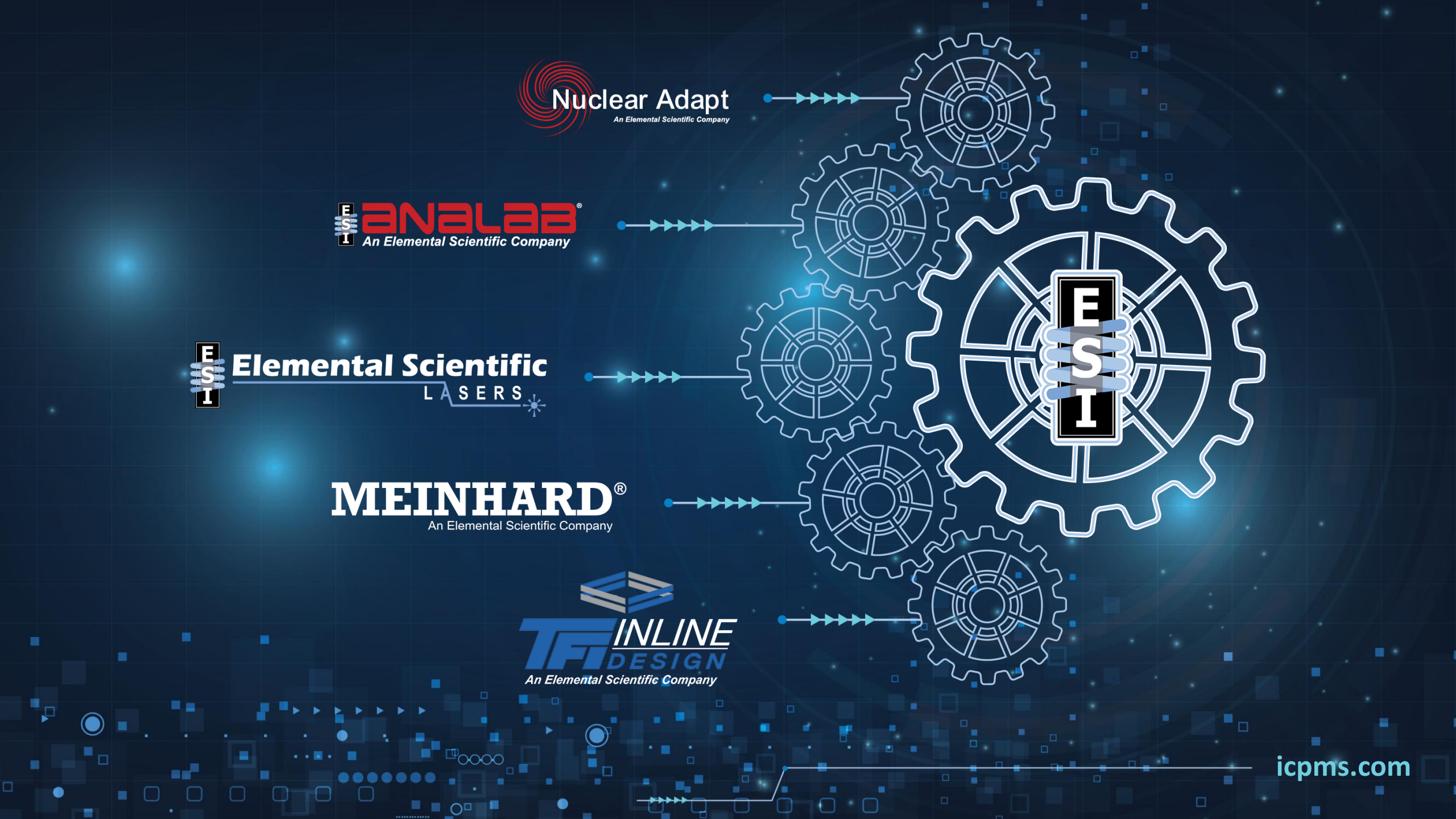
Worldwide Automation Leader for Variety of Markets and Industries

- Environmental
- Clinical & Life Sciences
- Semiconductor
- And much more!

Elemental Scientific HQ Omaha, USA

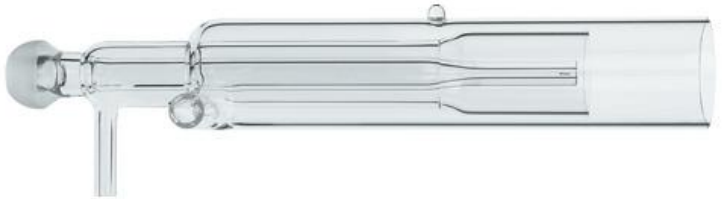
Elemental Scientific: Supporting Customers Worldwide




Nuclear Adapt
An Elemental Scientific Company
ESI ANALAB
An Elemental Scientific Company
ESI Elemental Scientific LASERS
MEINHARD®
An Elemental Scientific Company
TFI INLINE DESIGN
An Elemental Scientific Company
ESI
icpms.com

MEINHARD

- Scientific glassblowing and elemental analysis accessories for ICP and ICPMS
  - Concentric nebulizers for ICPMS
  - Quartz spray chambers
  - Quartz ICP/ICPMS torches and Injectors
  - ICPMS interface cones



MEINHARD®
An Elemental Scientific Company

ANALAB

- Evaporate Samples
  - Analyte concentration
  - Matrix elimination
- Mineralize Samples
  - Sample digestion
- Condition and Clean Vessels
  - Clean vials and bottles
  - Clean pipette tips
- Purify Reagents
  - Reagent grade acid to ultrapure acid

ANALAB® An Elemental Scientific Company

ESI

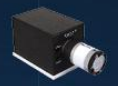
1999 — ESI
PFA microflow nebulizers & sample intro

2002 — apex
10x improvement in sensitivity

2003 — Scout
Online remote sampling technology

2005 — Autosampler
Ultraclean, intelligent autosampler

2006 — *FAST*
High throughput doubles productivity



2008 — sea*FAST*
Inline chemistry

2009 — MP²
Accurate flow from low mL/min to 10mL/min

2012 — prep*FAST*
Inline, automated dilution system

2013 — scoutDX
Remote real time trace metals monitoring

2014 — prep*FAST* S
Automated introduction of pure semiconductor chemicals

2015 — SAMPLETRAX
Automated sample identification and tracking system

2017 — prep*FAST* IC
Automated Speciation and Total Metals Analysis

2017 — ESL
Newly acquired Laser Ablation Division

2019 — RadianVPD ICPMS
Online monitor for silicon wafer analysis

2020 — Fluoronetics
Autosamplers with fluoropolymer magnetic drives

2020 — scoutNANO
Automated online nanoparticle and total metals in semiconductor chemicals

2020 — prepFAST CARBON
Semiconductor Organic Contaminants

2020 — scoutCARBON
Online organic contaminant monitoring in semiconductor chemicals

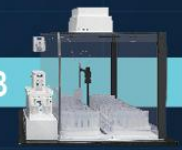
2021 — Analab
Sample Digestion and Vessel Cleaning

2022 — DilutionStation
Automated Liquid Handling

2022 — scoutPPQ
Online PPQ Metals

2023 — FiltrationStation
Automatic Sample Filtration & Dilution

2024 — prep*FAST* 3
Autodilution & Autocalibration System



2024 — Nuclear Adapt
Nuclearization of ICP & ICPMS

2024 — Radian CARBON
Organic contaminants on wafer

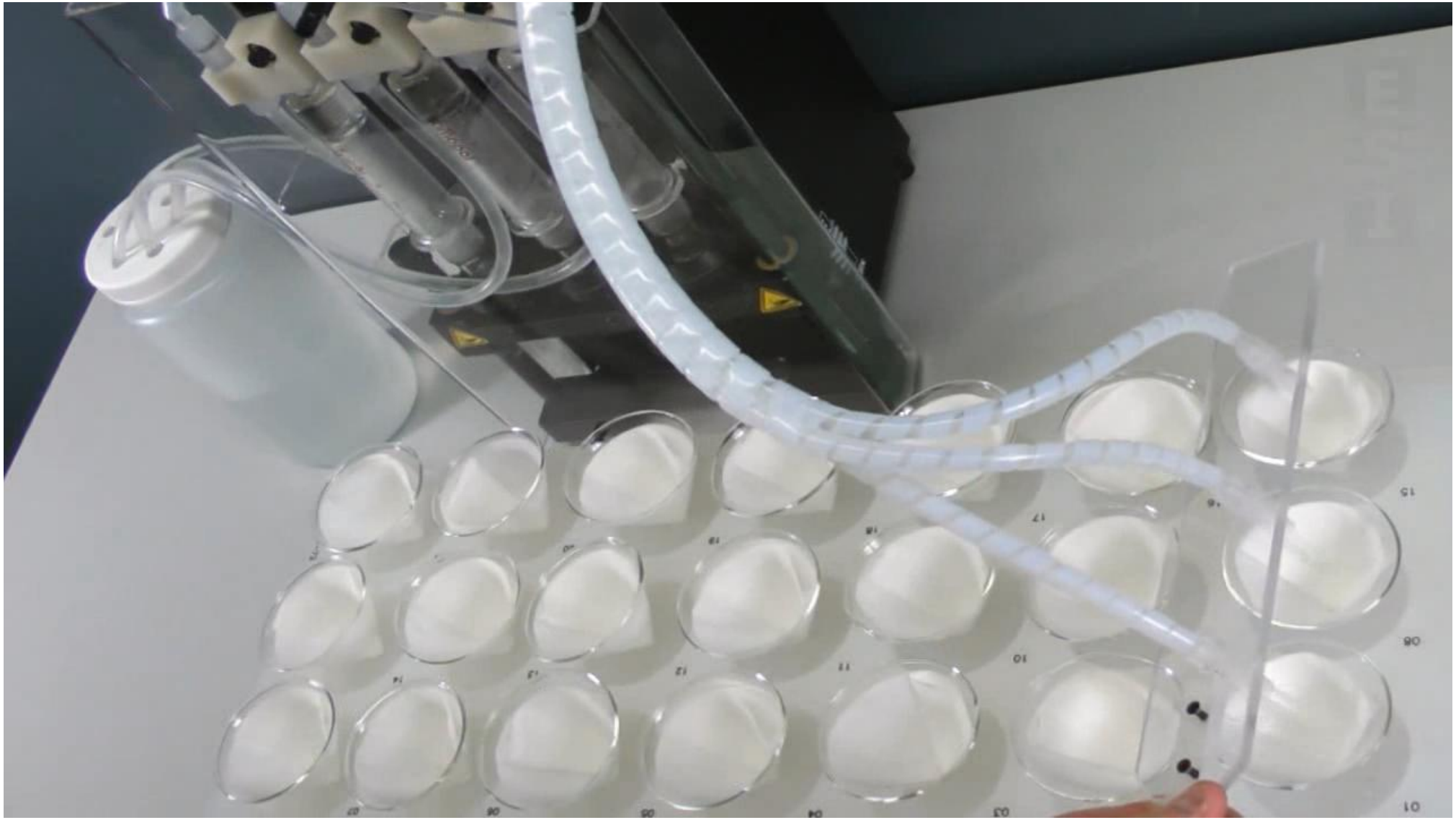
2025 — TRAXStation
Automated Liquid Handling & Tracking

2025 — GTX Autosamplers
Uncapping and Tracking Autosampler

2026 — SGTX
Semiconductor Tracking and Uncapping

2026 — SolidSample ICPMS
Multielement Solid Sample Analysis

Aliiix Dispensing Pump for Soil Extractions



Exceptional Customer Service

From Quote to Long-Term Satisfaction

Before you Buy:

We help configure the ideal system, fit to purpose for your lab's specific needs

After Purchase:

We build and tailor software methods based on your protocols

At Installation:

Your team gets hands-on training to start confidently on day one

Continued Support:

We're always available for service, updates, questions, or workflow changes

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Introducing FASTFluidics for Agricultural Soil Analysis

FAST Systems: 20+ Years of Innovation in Valve Injection

2006

FAST

High-throughput Valve Injection

2019

SampleSense FAST

Automatically sense & inject samples

2021

SampleSense FAST UHT

Ultra-high Throughput

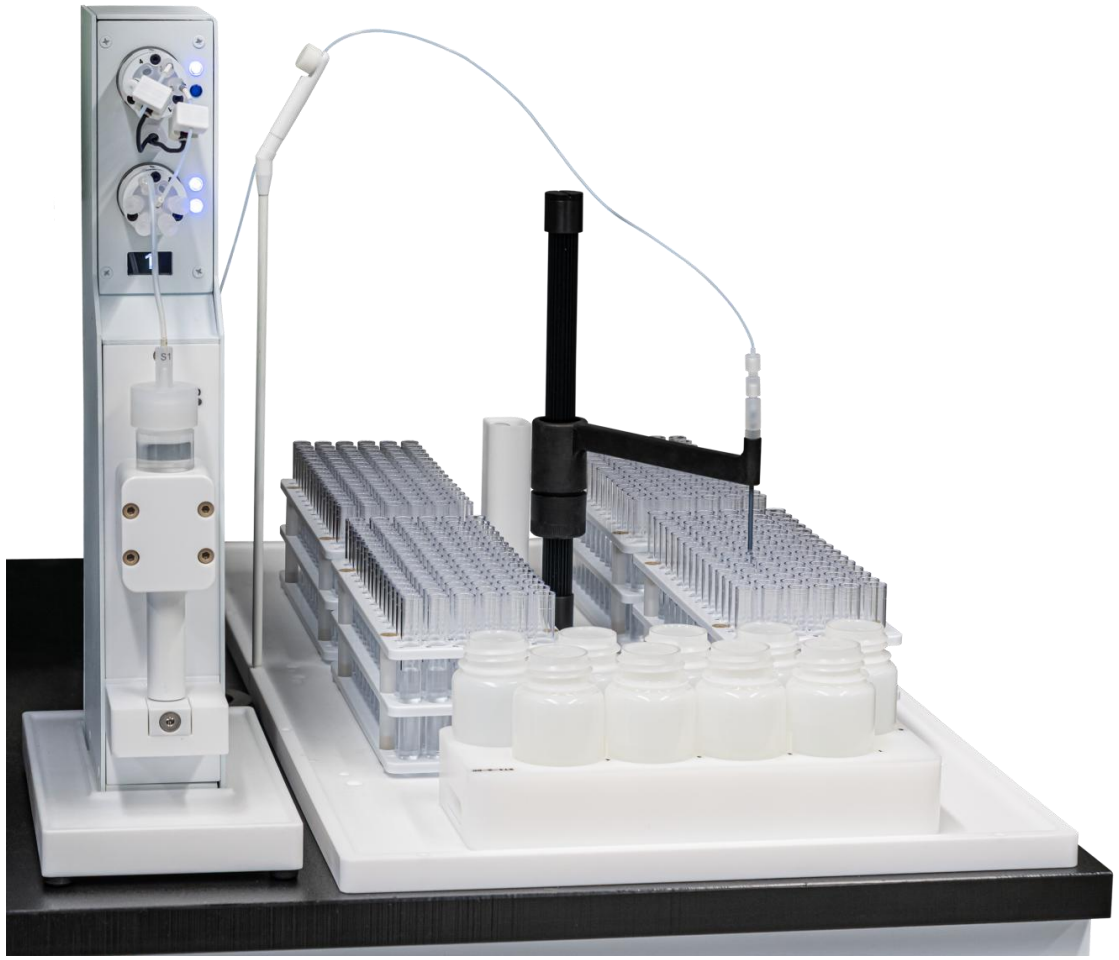
2026

FASTFluidic FilterProbe

FASTFluidic FilterProbe Soil

4th Generation ICP Valve Injection with Backflush Rinsing

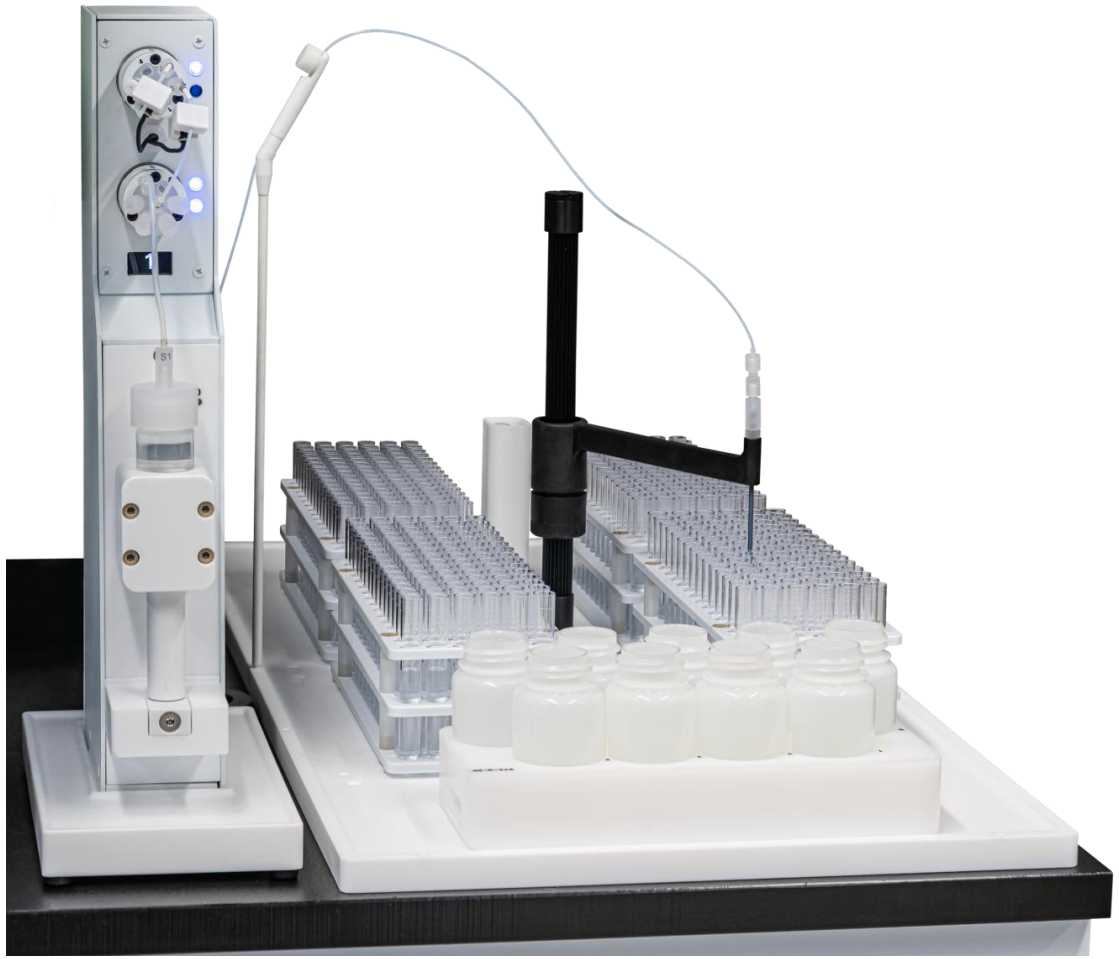
- Prevents valve & nebulizer clogs caused by fibers in sample
- Improves rinse out factor between samples (>500X)
- High-throughput (<10 sec per sample) with 3 sec integration time
- Limit wasted autosampler movement with mobile RidingRinse
- Very low valve maintenance



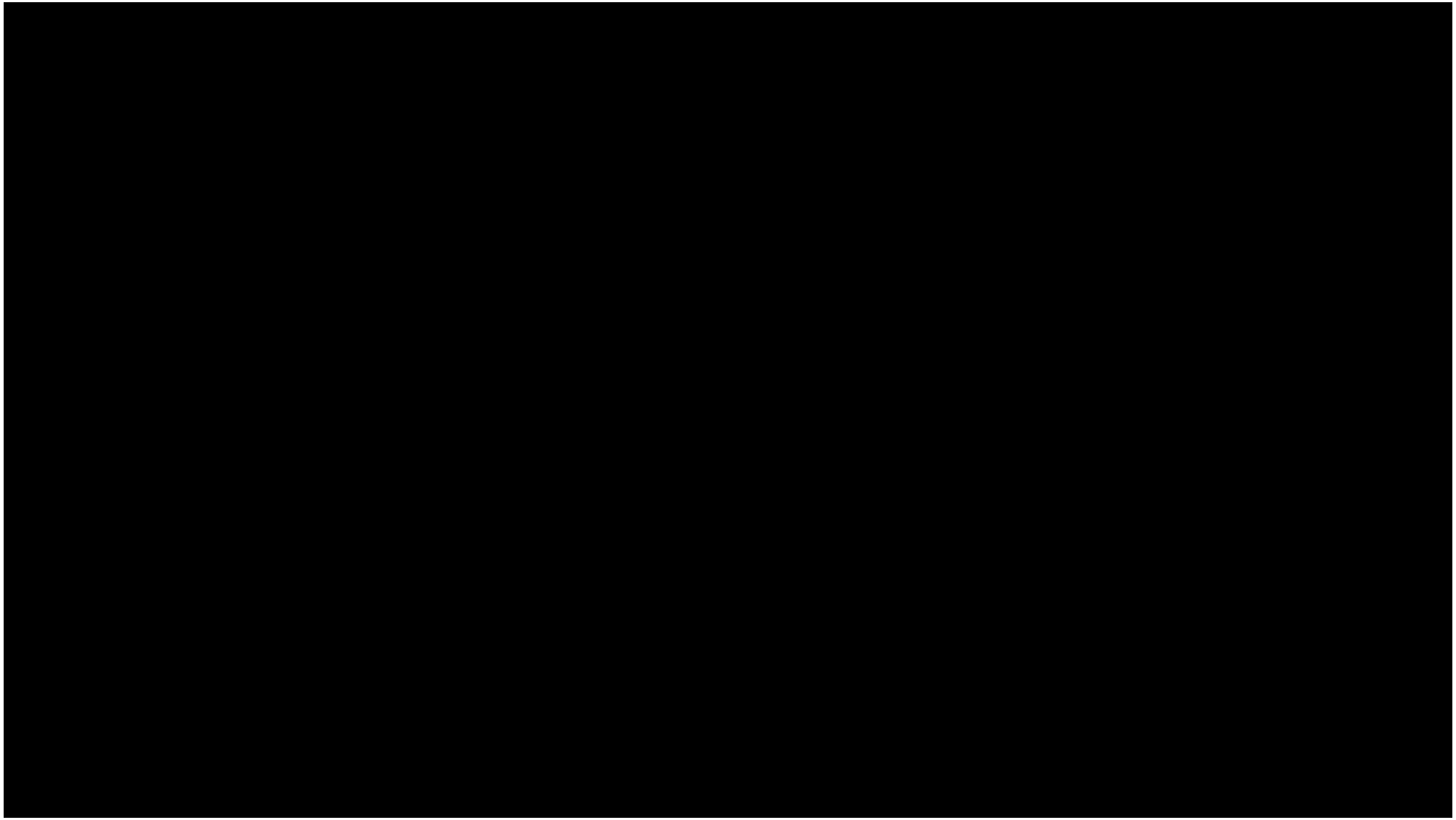
FASTFluidic FilterProbe Soil Components

4th Generation ICP Valve Injection with Backflush Rinsing

- DXW Autocorrecting Autosampler
- FilterProbe with Syringe-driven Backflush
- RidingRinse Mobile Rinse Station
- Magnetic SnapValves
- SampleSense 3
- High-pressure Quartz Syringe

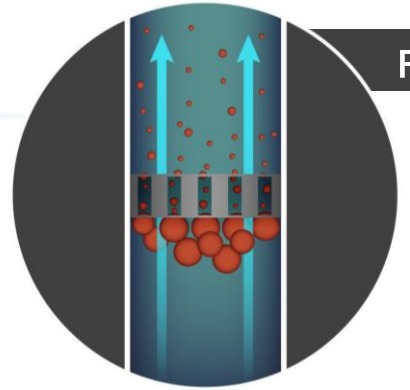


Ultra High-throughput Soil Analysis: 8 seconds per sample



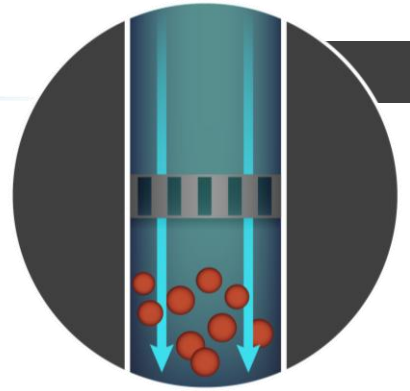
Anti-clogging FilterProbe with Syringe Backflushing

- Innovative anti-clogging inline inert CTFE filter
- Automatic syringe-driven backflushing
- Prevents valve and nebulizer clogging for all sample types
- FilterProbe benefits:
  - Reduce maintenance
  - Increase system longevity
  - Minimize rinse liquid consumption



Filtering Sample

CTFE filter prevents particulates from entering sample line, eliminating clogging



Backflushing

While sample is analyzed, FilterProbe is rapidly backflushed at RidingRinse

RidingRinse: Mobile Rinse Station

- Improves sample-to-sample time by several seconds per sample
- Moves with the autosampler carriage, providing immediate access to the rinse station
- Minimizes unnecessary autosampler movements
- Simple rotary motion enables in-place rinsing and backflushing

Multiposition Magnetic SnapValves

- Innovative magnetic coupling technology
- Remove & Reinstall in seconds, no tools required
- Easy to clean – no alignment or adjustments needed
- Display screen notifies users which position is connected for multiposition valve

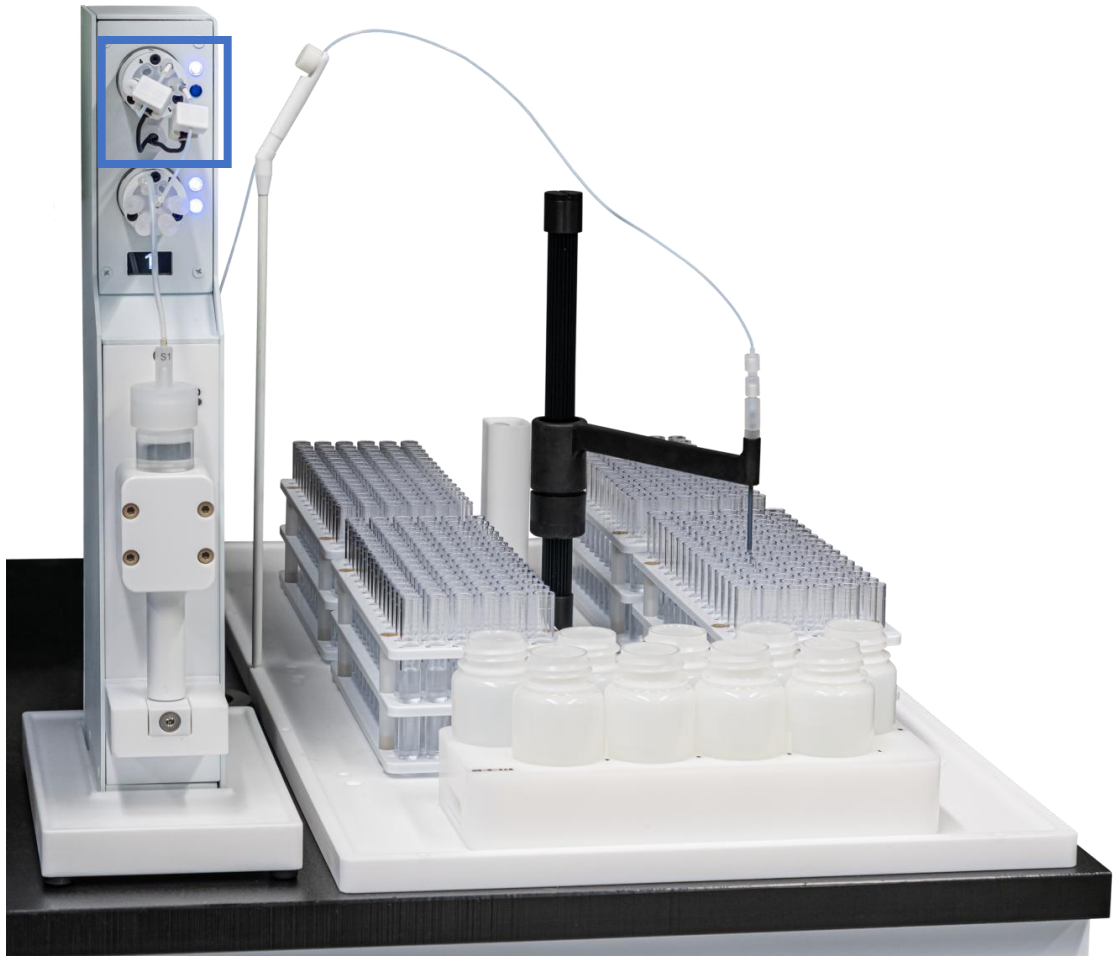
SampleSense 3 Sensor Technology—No Adjustments

Senses Samples & Communicates Status
Intelligence Center Located at the Valve Module

Time Saving & Method Simplification
Eliminates development time

Innovative Sample Loading
Accounts for oil viscosity & adjusts timing

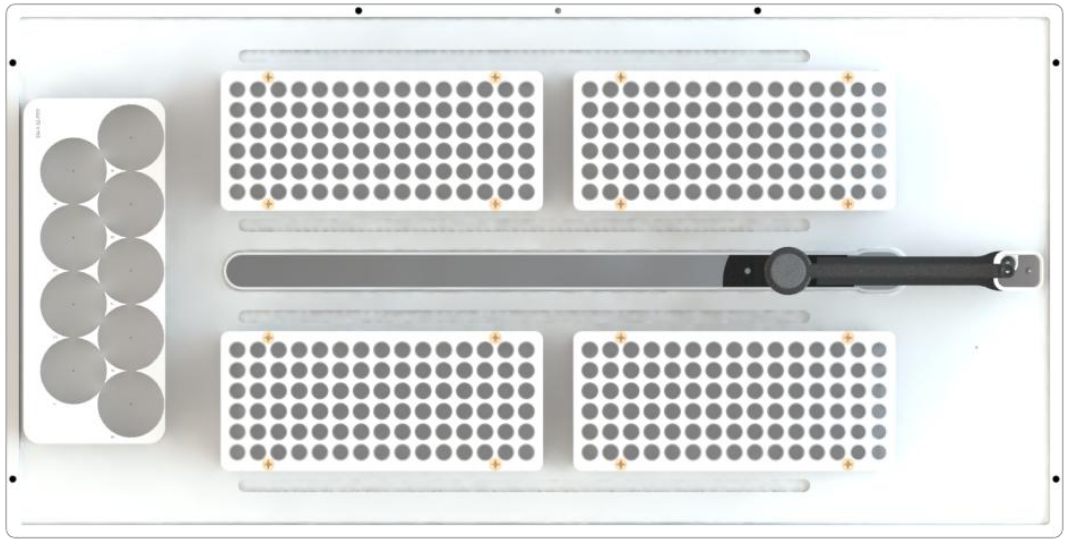
Error Notification
Detects and logs incomplete sample loading due to clogged filter/capped vial/empty vial etc.



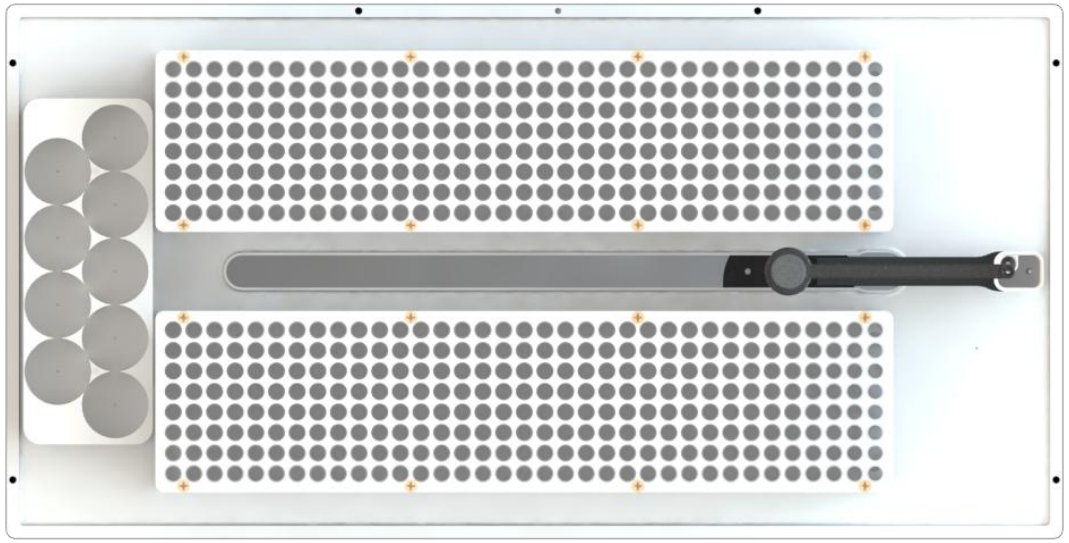
4DXW Autosampler

- Up to 55% more capacity than traditional 4-rack autosampler
- Similar footprint to conventional 4-rack autosampler

16”



360 samples



560 samples

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Mehlich-3-ICP Experiment
FASTFluidic FilterProbe Soil

Instrument Conditions & Sample Intro Parameters

Table 1. Instrument Conditions

Instrument	Avio 550 Max
Peri-Pump Rate	1.5 mL/min
Matrix	2% HNO_3
Radial Acquisition View	15 mm
Plasma Gas Flow	12 L/min
Auxiliary Gas Flow	0.5 L/min
Nebulizer Gas Flow	0.55 L/min
RF Power	1500 Watts
Read Time	**3 Seconds**

Table 2. Sample Introduction Parameters

***FAST* System**	*FAST*Fluidic FilterProbe Soil
Filter	FilterProbe CTFE Filter
Autosampler	ESI 4DXW with RidingRinse
Nebulizer	PFA ST3 Nebulizer
Spray Chamber	G3 Cyclonic
Injector/Torch	2.0 mm Quartz ZipTorch
Sample Tubing	Black-Black
ISTD Tubing	Orange-Green
Backflush Syringe	HPQ-24 mL

Instrument Read Time & Acquisition Time

Read Time

	F'n	Analyte	Integration Time (sec)	Read Time (sec)
1	A	S 180.668	0.100	3.000
2	A	Mg 279.077	0.100	3.000
3	A	Ca 317.933	0.010	0.050
4	A	K 766.490	0.100	3.000
5	A	Na 589.592	0.100	3.000
6	A	Fe 238.204	0.100	3.000
7	A	Mn 257.610	0.100	3.000
8	A	Cu 327.393	0.100	3.000
9	IS	Tm 313.126	0.100	3.000
10	A	P 214.914	0.100	3.000
11	A	Zn 213.857	0.100	3.000
12	A	B 249.677	0.100	3.000

Acquisition Time

☐ Show RSDs ☐ Show Replicates

	Sample Id	Acquisition Time	S (cps)	Mg 279.077 (cps)
1110	Bottom Soil Std	12/15/2025 10:49:19 AM	1337.3	37597.1
1111	Low Mid Soil Std	12/15/2025 10:49:29 AM	3272.6	91375.7
1112	Low Mid Soil Std	12/15/2025 10:49:38 AM	3300.7	92306.2
1113	Low Mid Soil Std	12/15/2025 10:49:48 AM	3336.6	93173.3
1114	High Mid Soil Std	12/15/2025 10:49:58 AM	6747.0	187370.2
1115	High Mid Soil Std	12/15/2025 10:50:08 AM	6645.8	183501.8
1116	High Mid Soil Std	12/15/2025 10:50:19 AM	6638.9	183373.4
1117	Top Soil Std	12/15/2025 10:50:28 AM	13467.8	370985.0
1118	Top Soil Std	12/15/2025 10:50:38 AM	13429.2	368930.1
1119	Top Soil Std	12/15/2025 10:50:48 AM	13288.1	364503.1
1120	Blank	12/15/2025 10:50:58 AM	29.3	561.7
1121	Blank	12/15/2025 10:51:08 AM	-26.3	-52.8
1122	Blank	12/15/2025 10:51:18 AM	-36.2	-6.3
1123	Bottom Soil Std	12/15/2025 10:51:28 AM	1417.4	40146.2

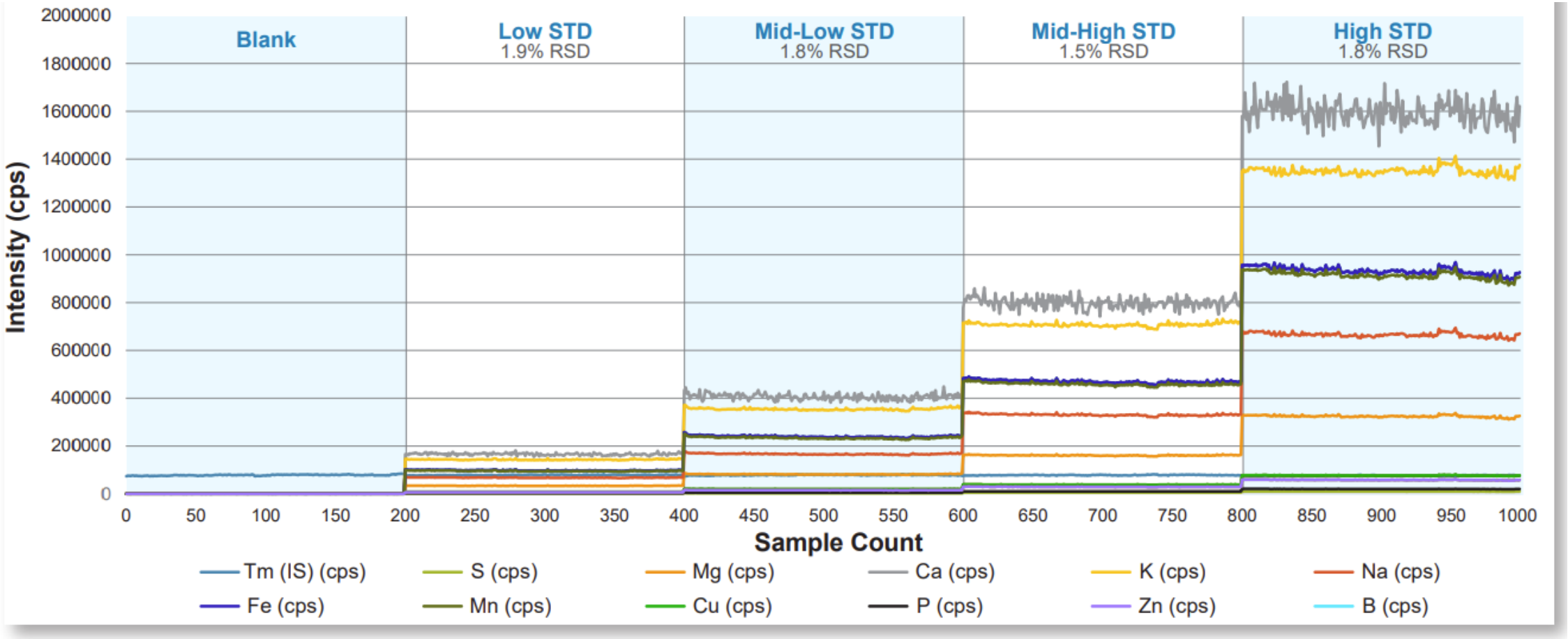
Rinse Out Factor

>500x for all elements (except B)

Element	Rinse Out Factor
S	799
Mg	664
Ca	1592
K	507
Na	701
Fe	645
Mn	642
Cu	566
P	514
Zn	659
B	325

Reproducibility Across Calibration Ranges

RSD <2% for all elements at each concentration level

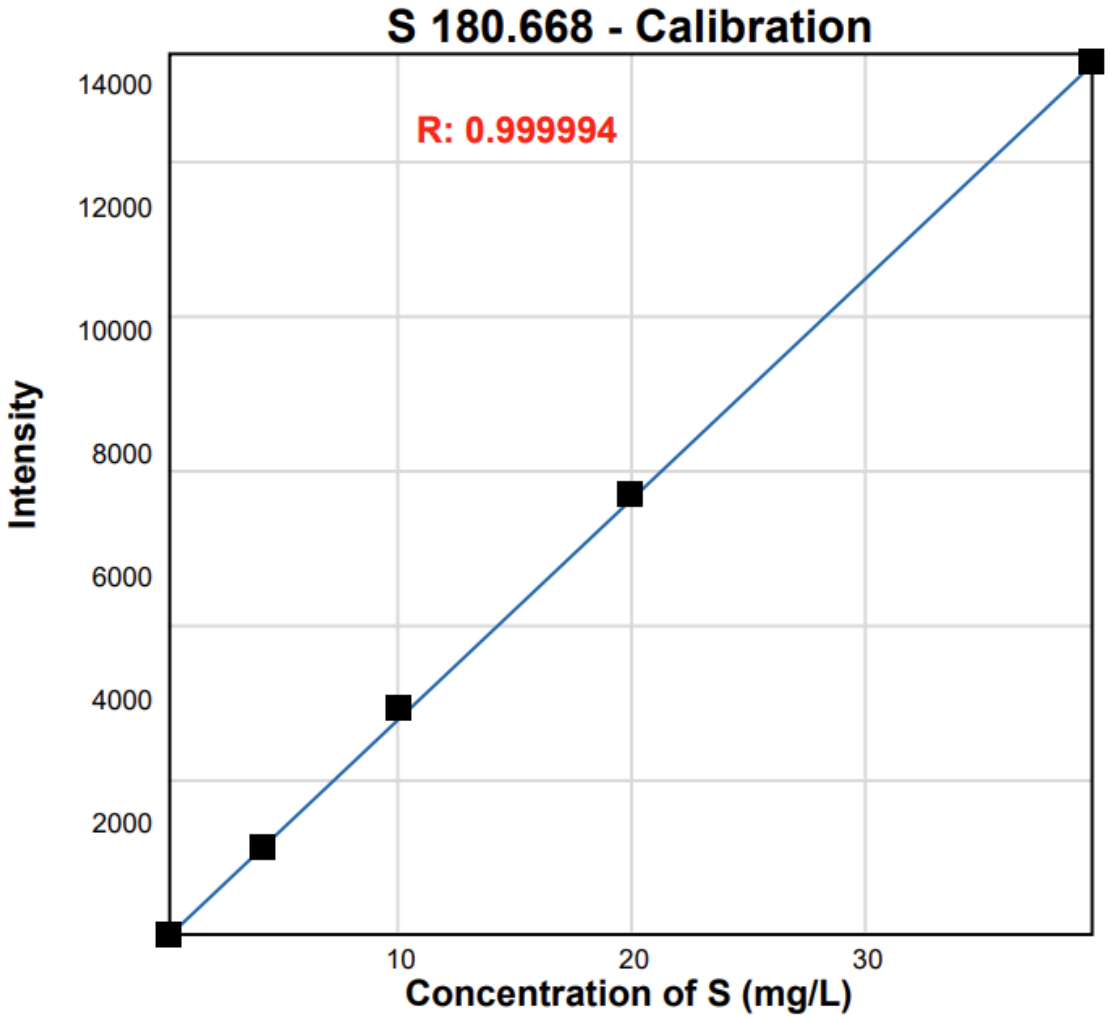


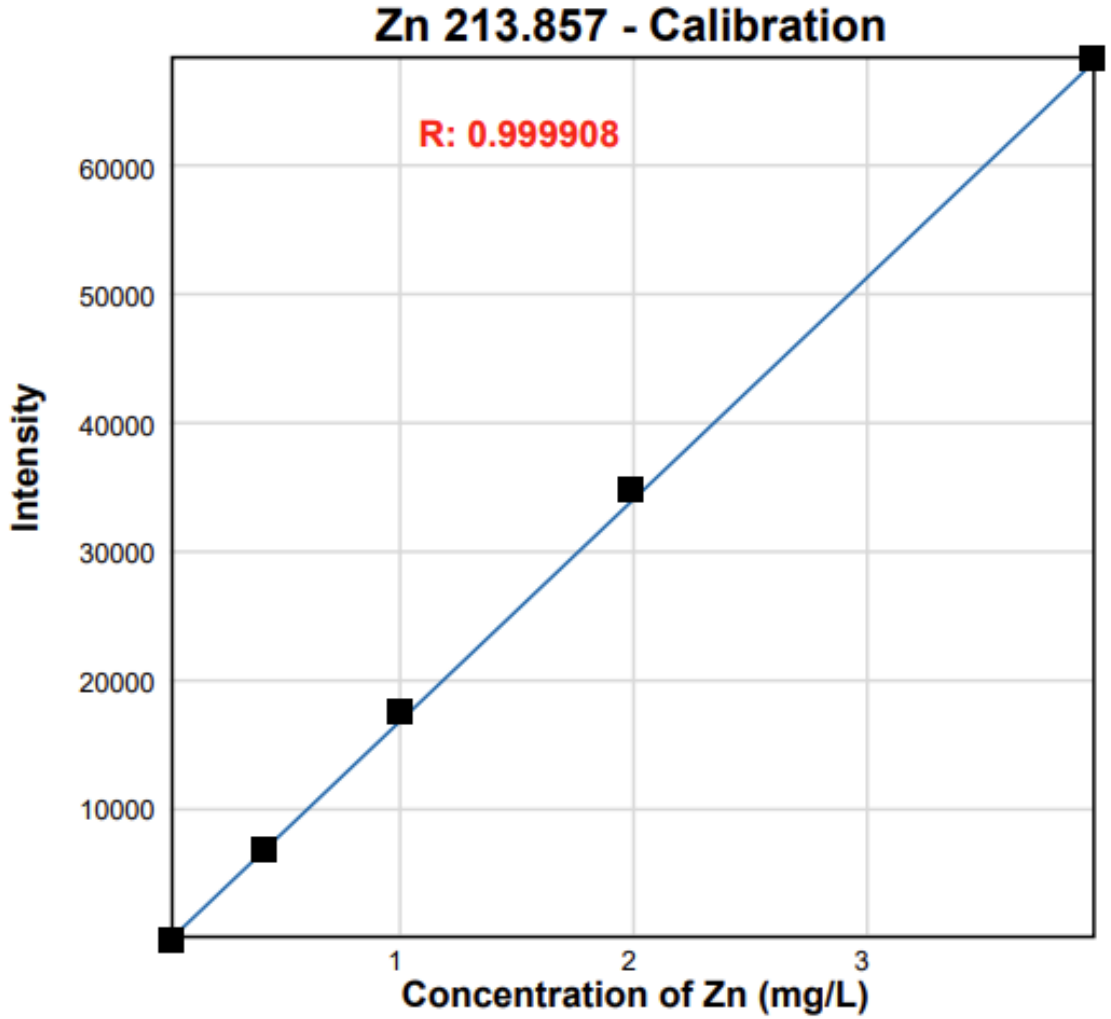
Calibration Linearity

Element (λ)	Low STD	Mid-Low STD	Mid-High STD	High STD
S 180.668	4	10	20	40
Zn 213.857	0.4	1	2	4
P 214.914	8	20	40	80
Fe 238.204	8	20	40	80
B 249.677	0.2	0.5	1	2
Mn 257.610	2	5	10	20
Mg 279.077	24	60	120	240
Ca 317.933	10	25	50	100
Cu 327.393	0.8	2	4	8
Na 589.592	6	15	30	60
K 766.490	40	100	200	400

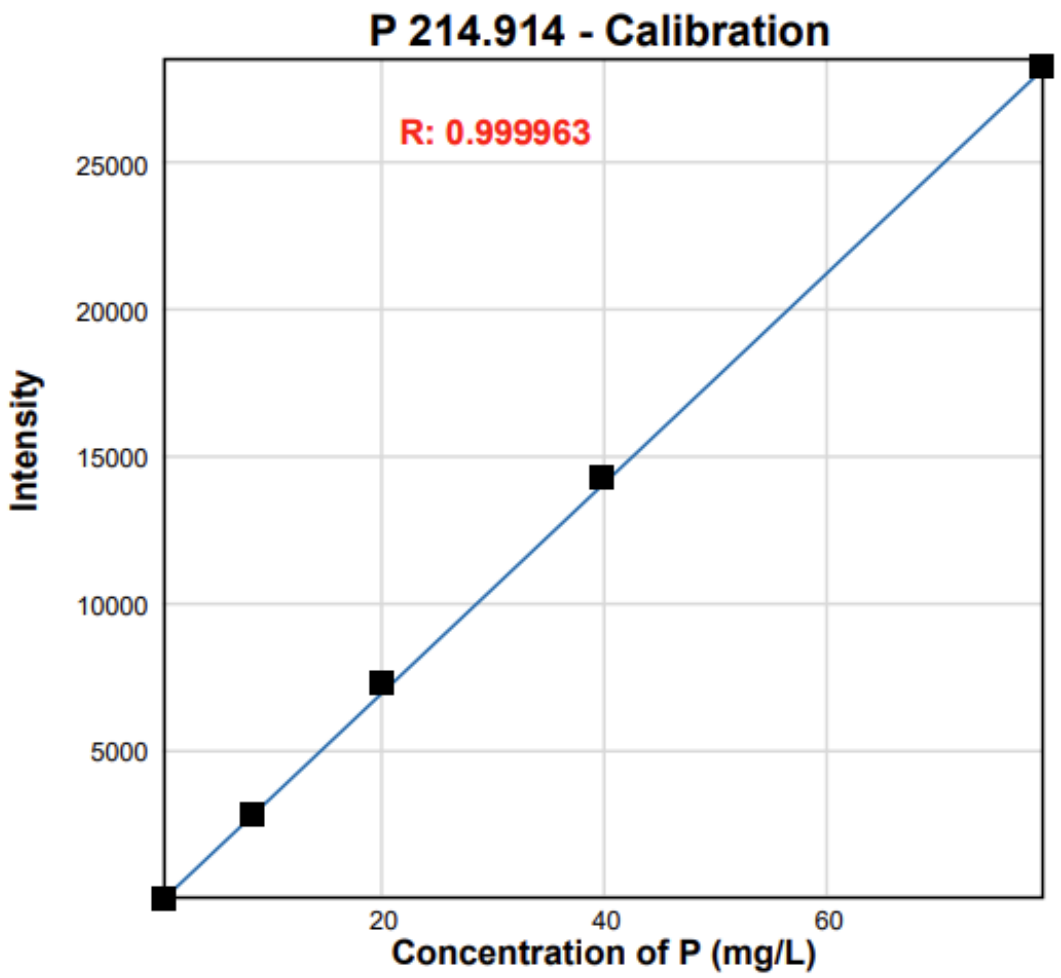
Figure 10. Representative 5-point calibration curves for the 11 Mehlich analytes (Ca, Cu, Fe, K, Mg, Mn, Na, P, S, Zn, B) with calibration levels show above. The entire calibration takes less than 50 seconds, with R>0.9995 for all elements.

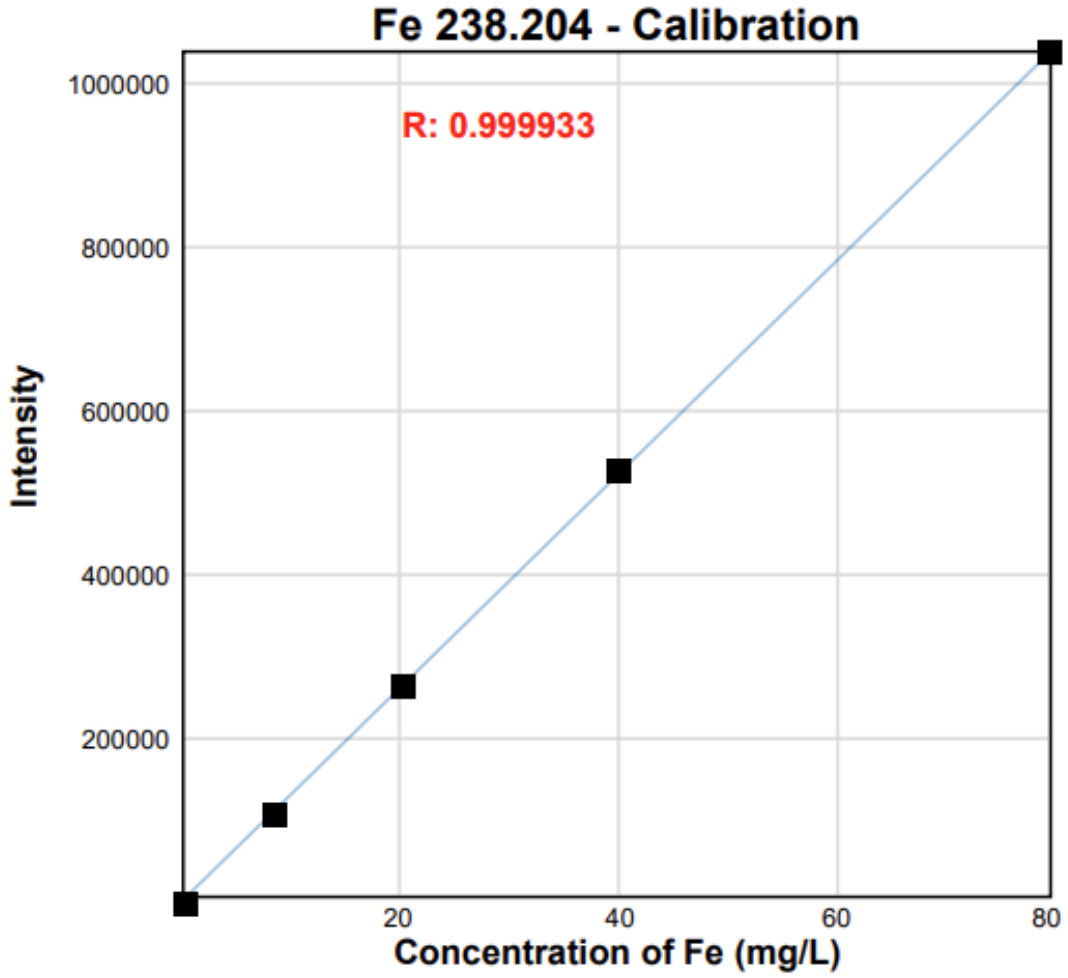
Calibration Linearity





Calibration Linearity





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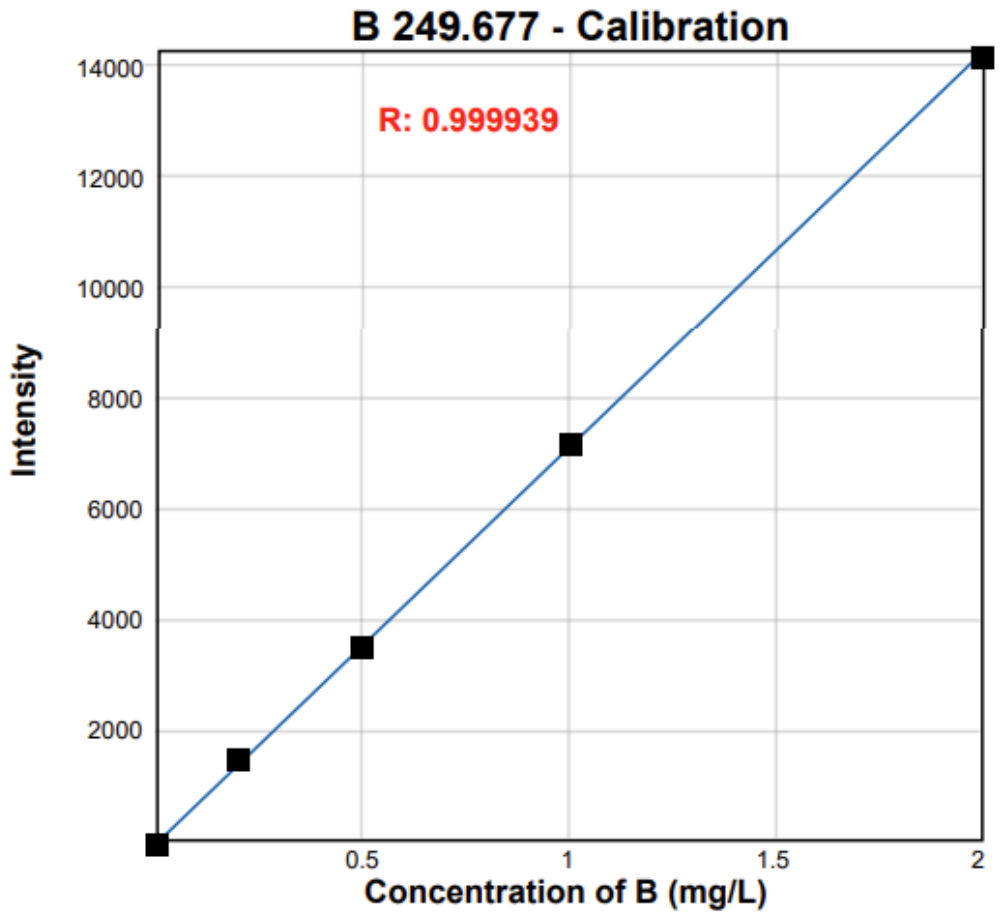
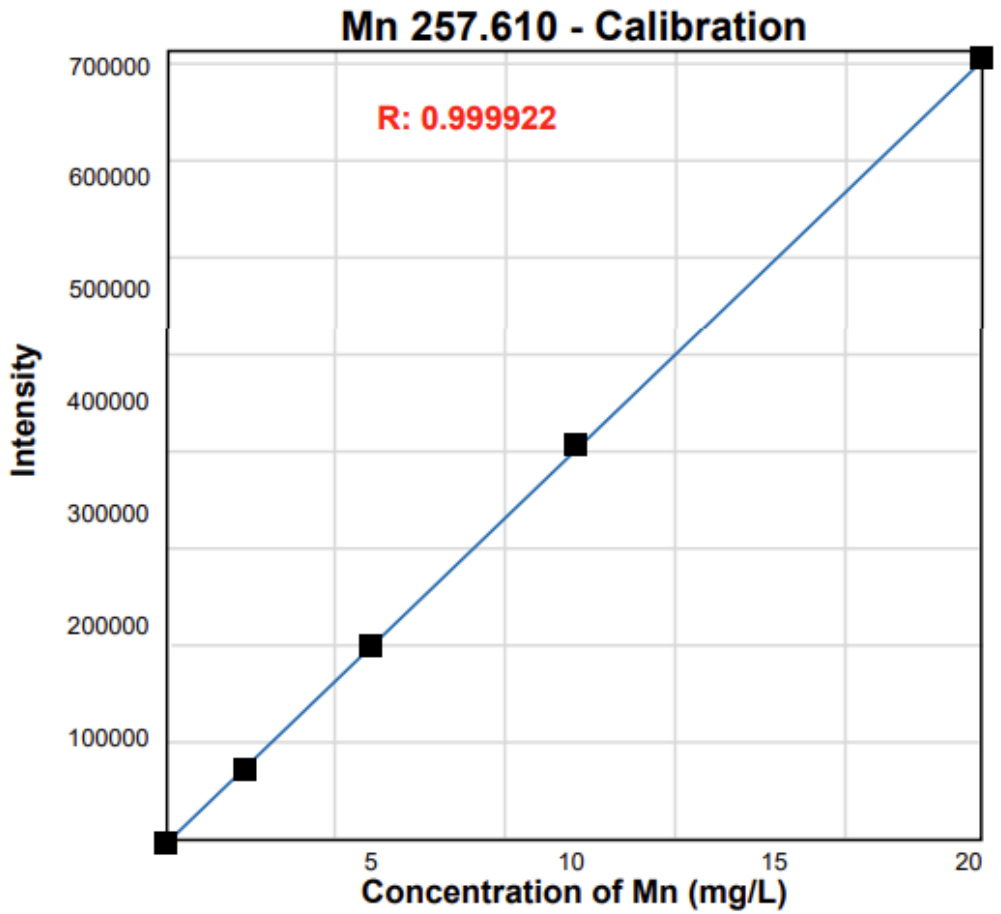
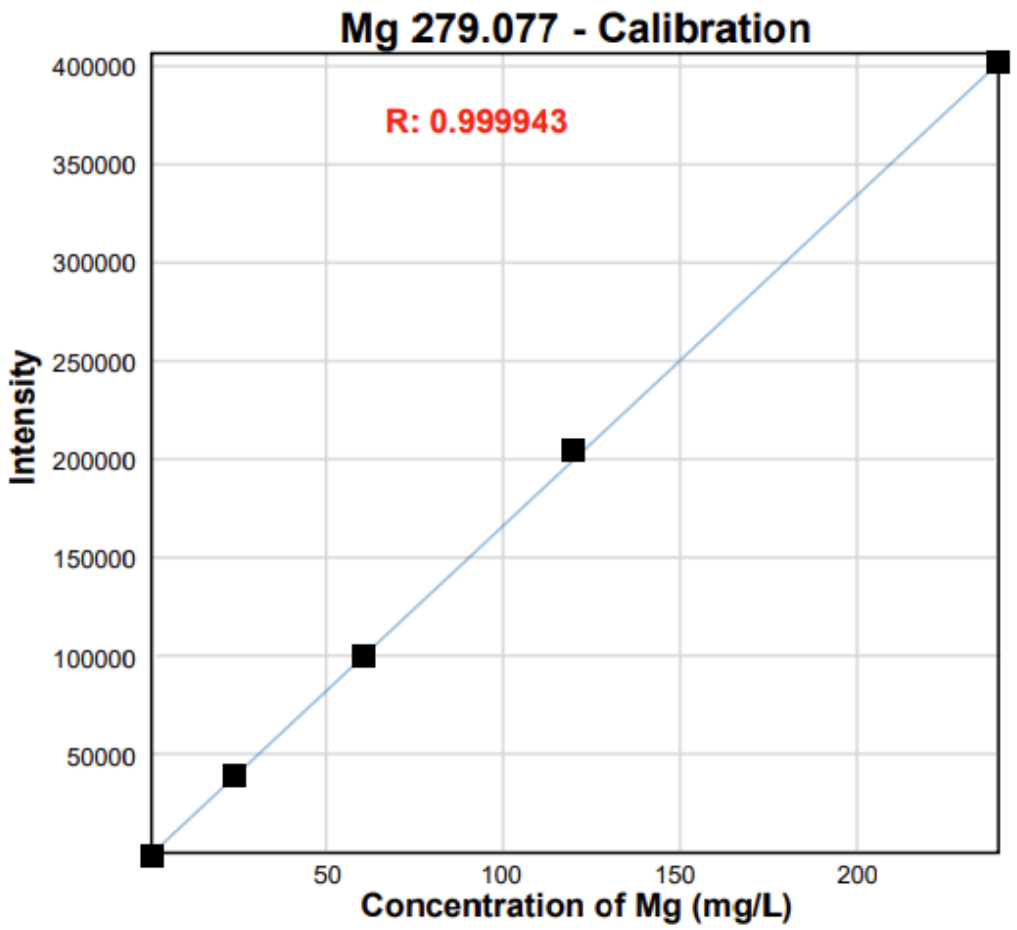
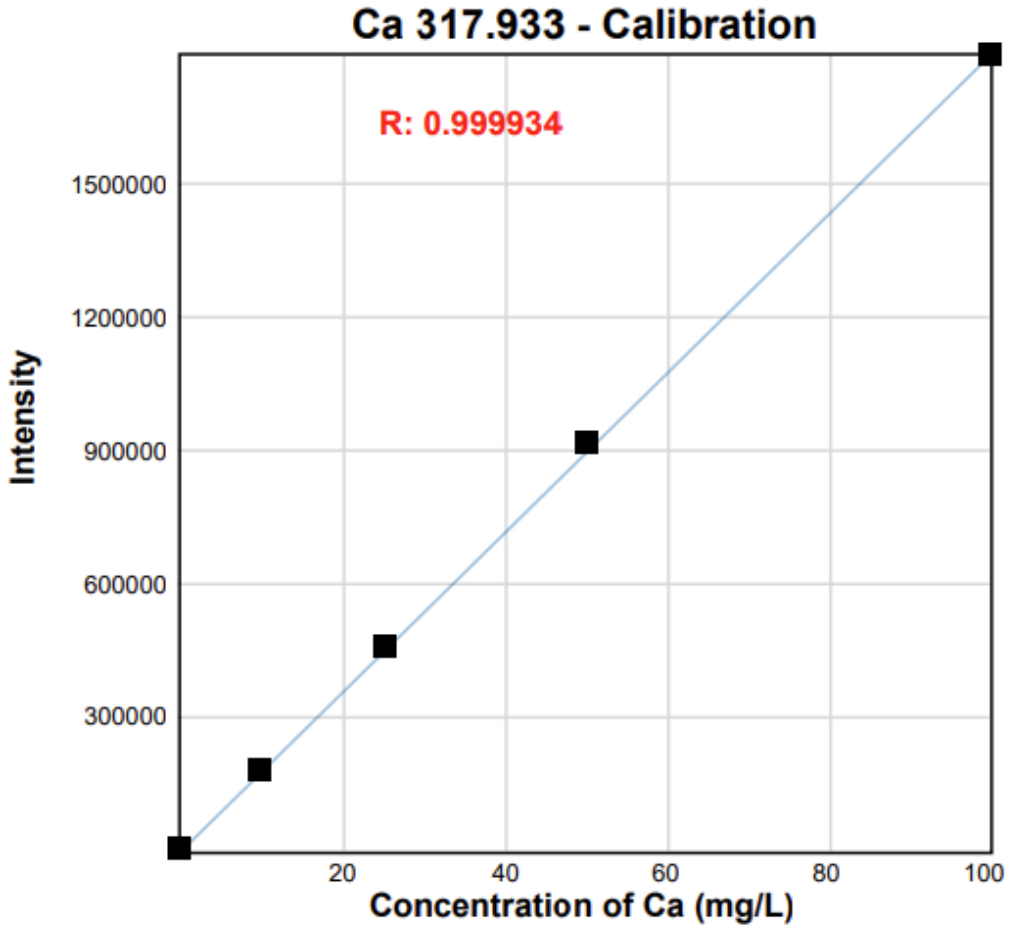
Calibration Linearity



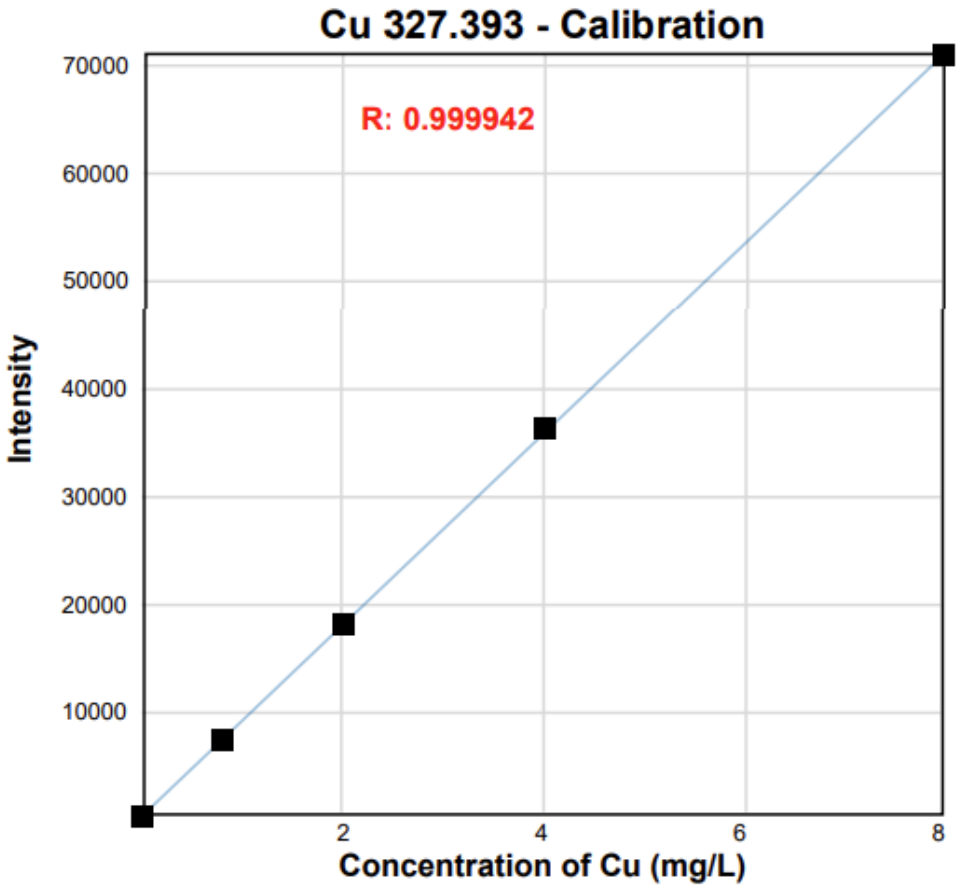


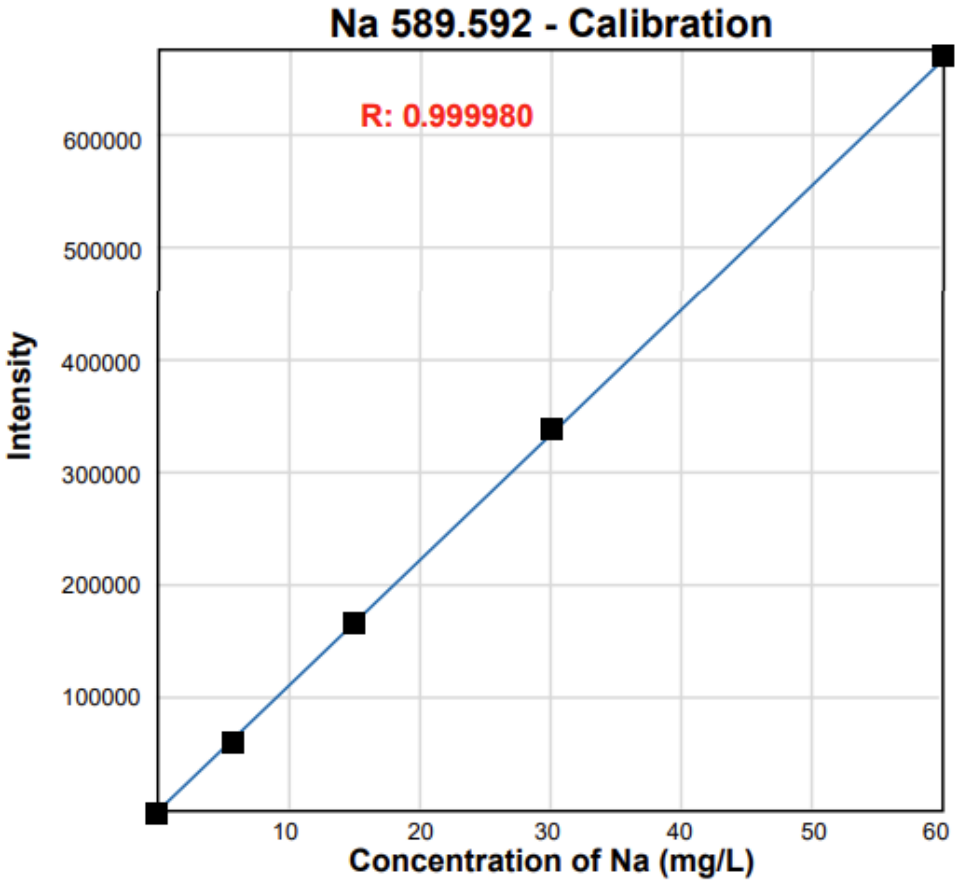
Calibration Linearity



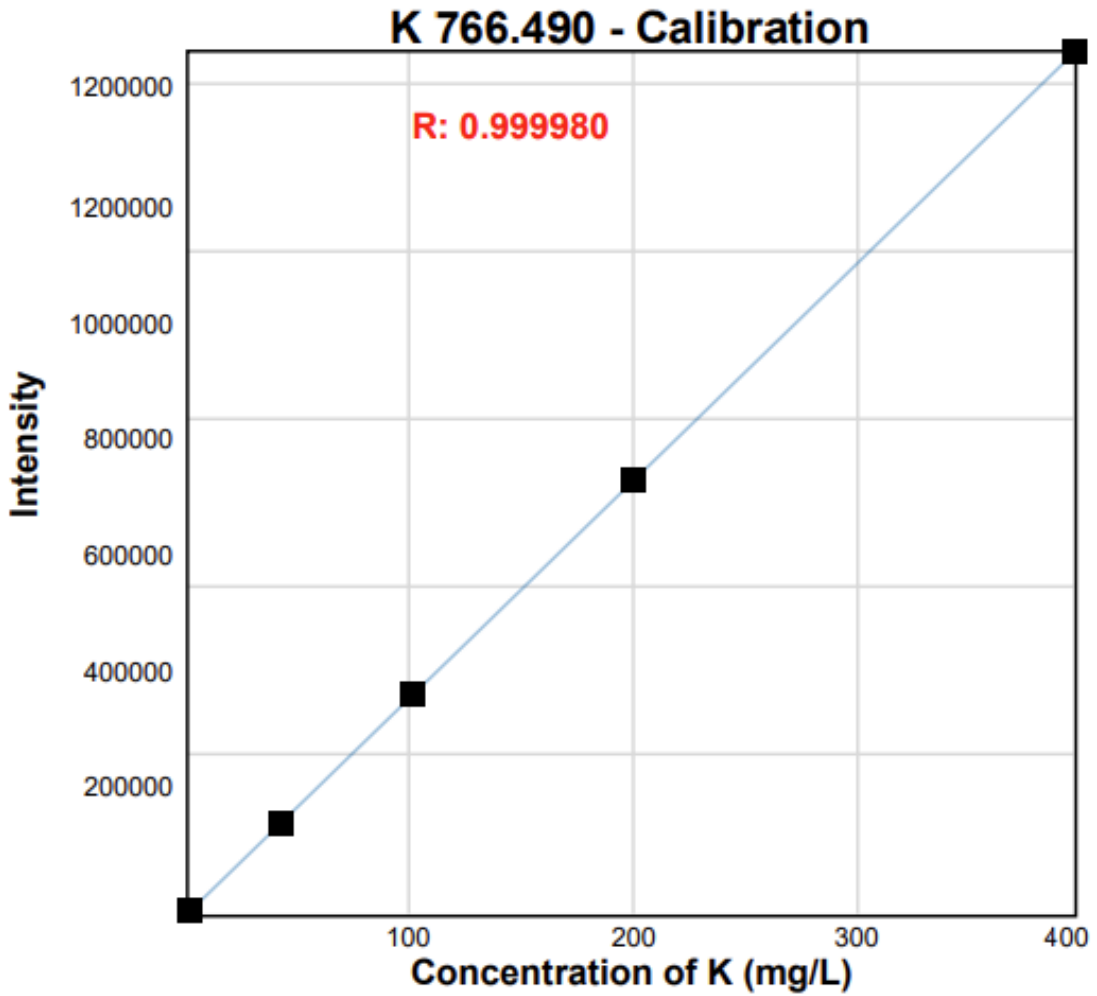


Calibration Linearity





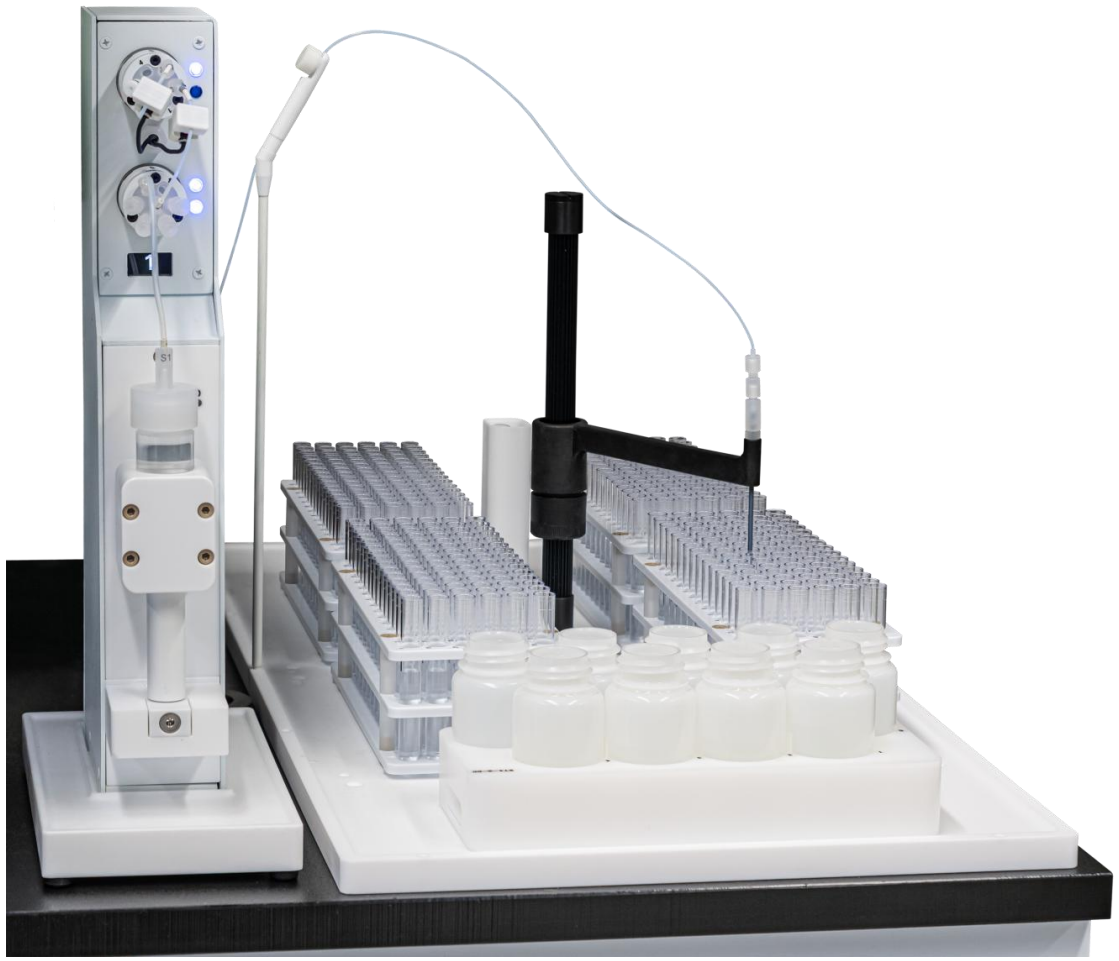
Calibration Linearirty



FASTFluidic FilterProbe Soil

4th Generation ICP Valve Injection with Backflush Rinsing

- **High throughput valve injection with rinsing**
  - 3 second ICP integration time with syringe-driven backflush rinsing
  - < 10 seconds per sample
- **Low Maintenance**
  - FilterProbe prevents clogs and eliminates daily valve maintenance
- **Low Carryover**
  - High-quartz syringe drives 1.5 mL rinse in 0.7 seconds
  - 500x rinse out between samples



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SolidSample ICPMS

Quantitative Multielement Analysis of Solid Samples by ICPMS

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How much time would you save if you didn't need to digest samples?

SolidSample ICPMS

Quantitative Multielement Analysis of Solid Samples by ICPMS

Minimal Sample Prep
Accelerate workflows and measurement from weeks to hours

Solution-Level Accuracy
Achieve linearity and quantitation on par or better than liquid ICPMS

Robotic Sample Handling
Fully automated workflow, from sample handling to data reporting

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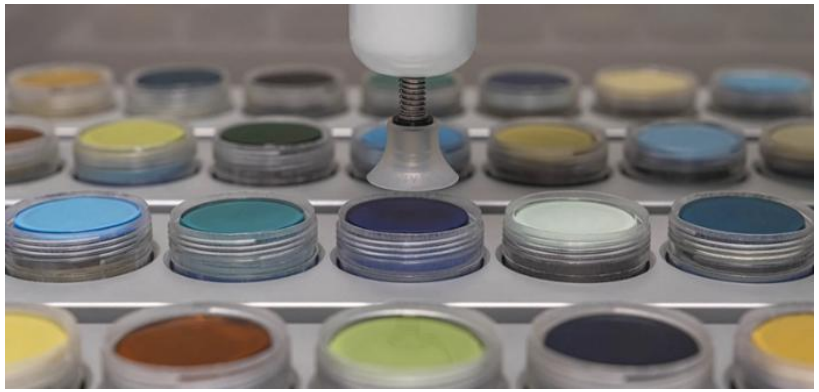
A Faster, Safer Solution to Solid Sample Analysis

* Reagent/Acid-free sample preparation saves time, lowers costs, and improves lab safety
* Automated 24/7 analysis of samples by ICP or ICPMS
* Integrated sample tracking enhances data reliability and integrity



ESI Custom Matrix-Matched Calibration Standards

Minor elements in Soil

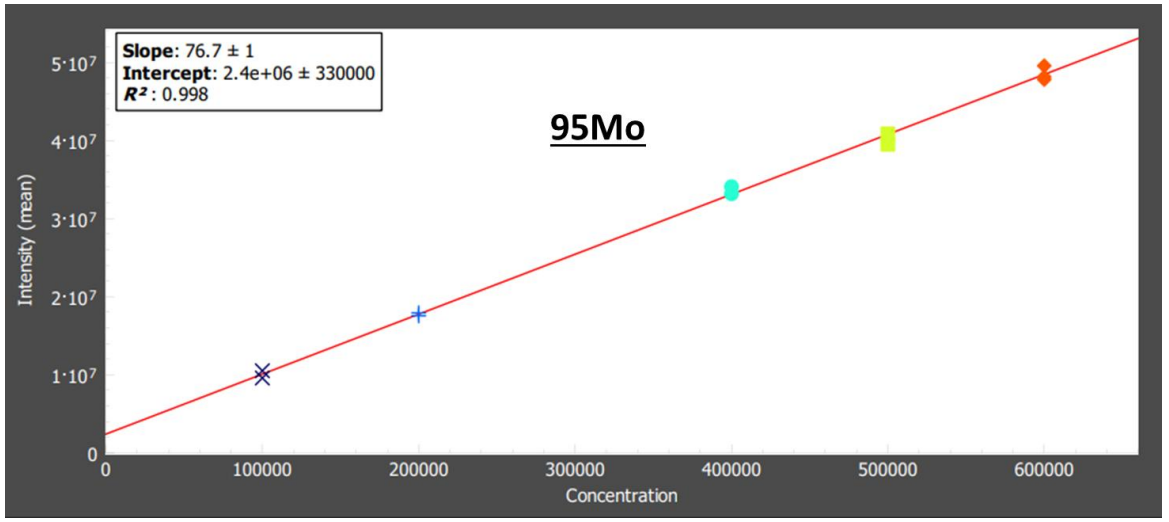
%Mo in Mo Concentrate

REE in Apatite

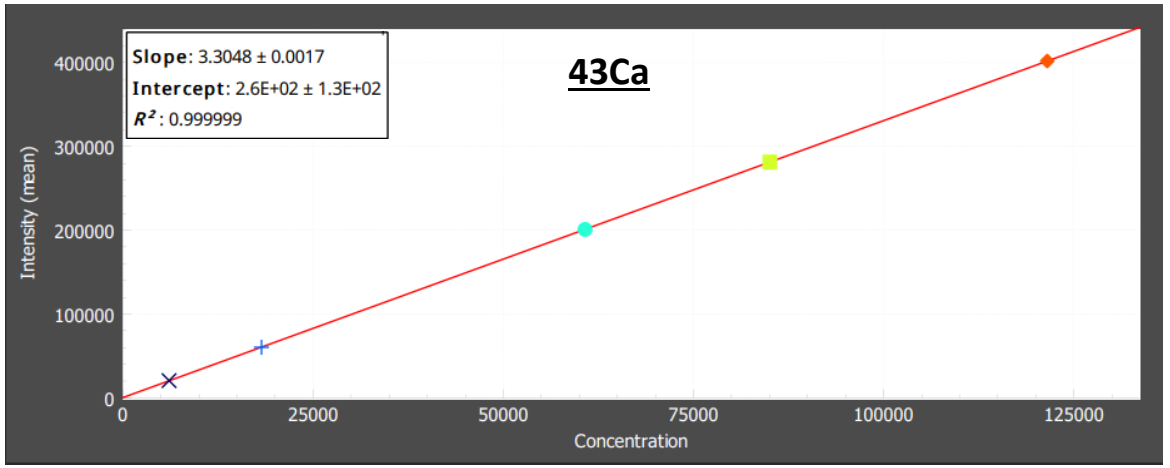
%Cu in Cu Concentrate

Minor elements in Cu Concentrate

Major Elements in Soil

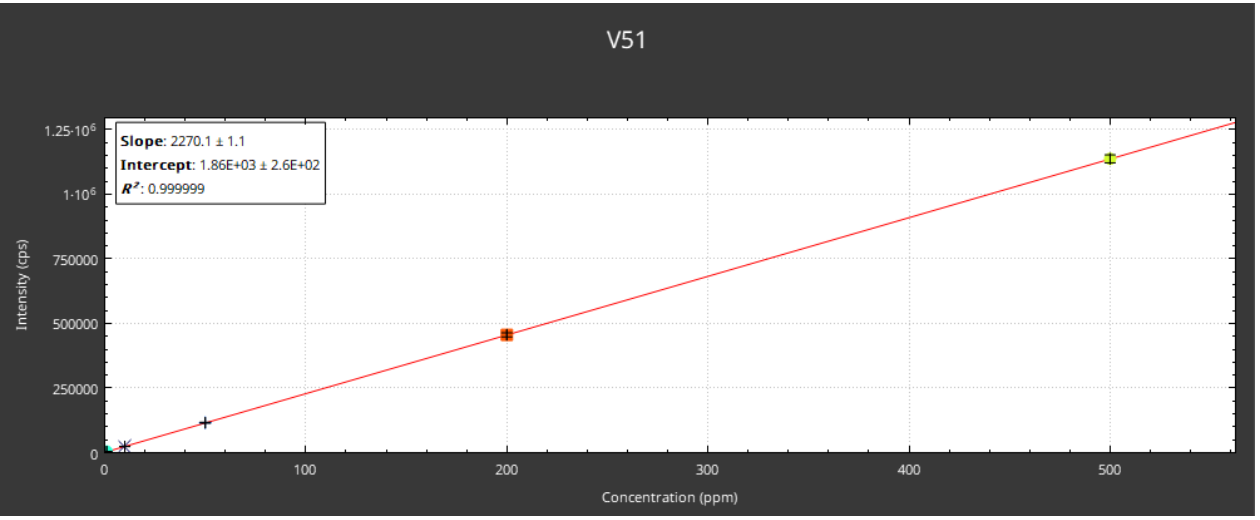


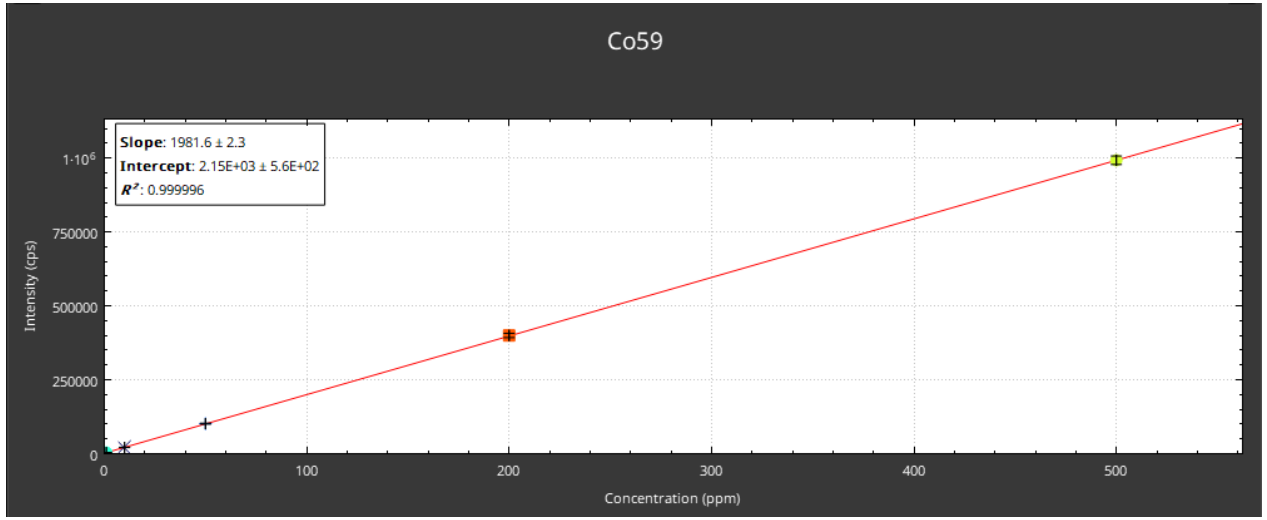
Linear calibration up to 60% Mo in Mo Concentrate

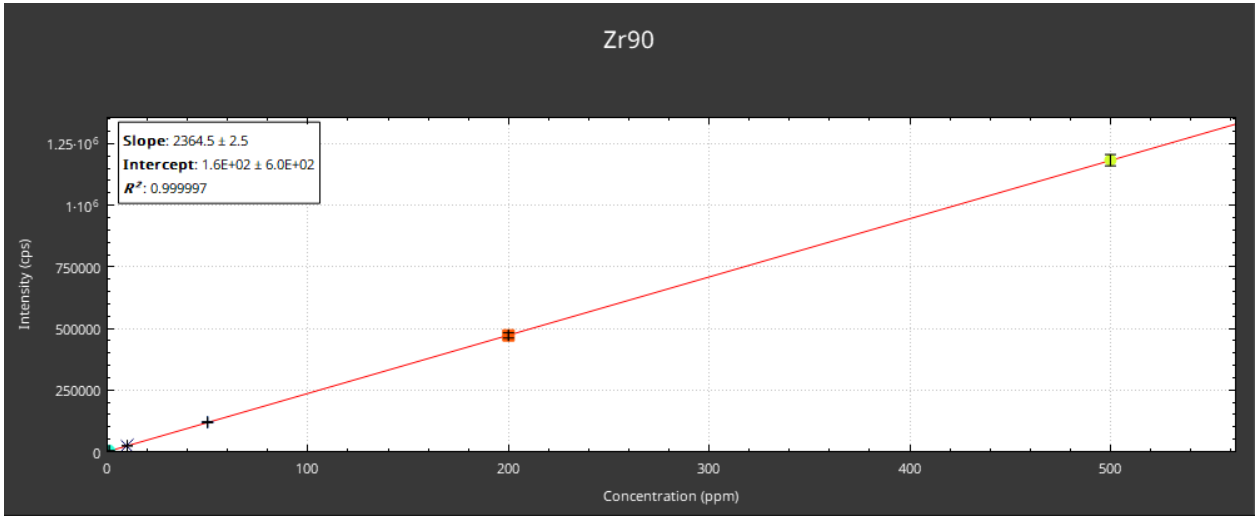


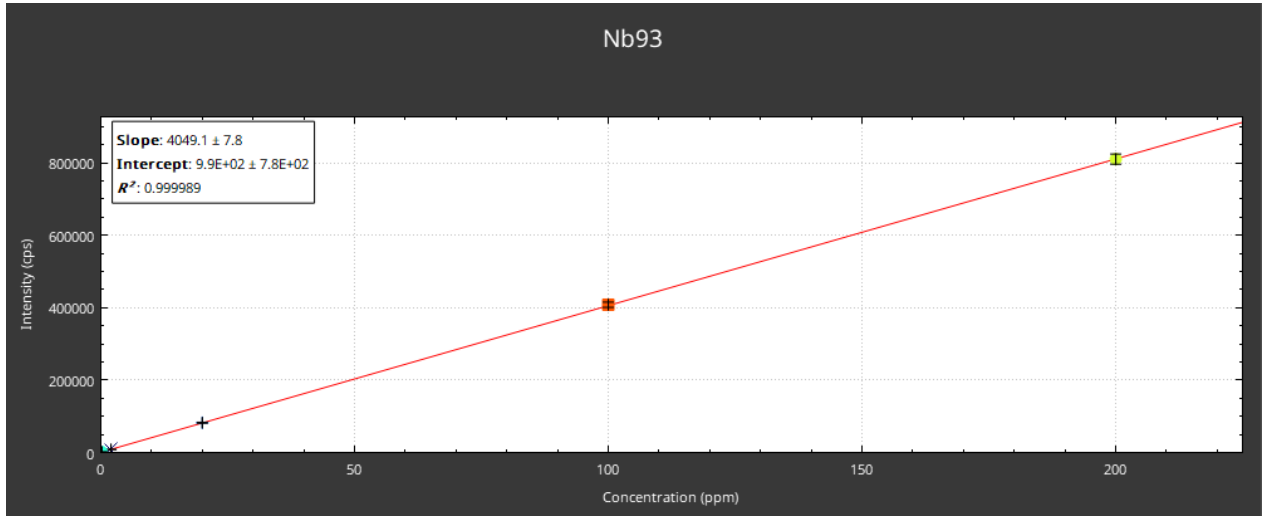
0.999999 linearity Ca up to 12% in Soil

Calibration Curves

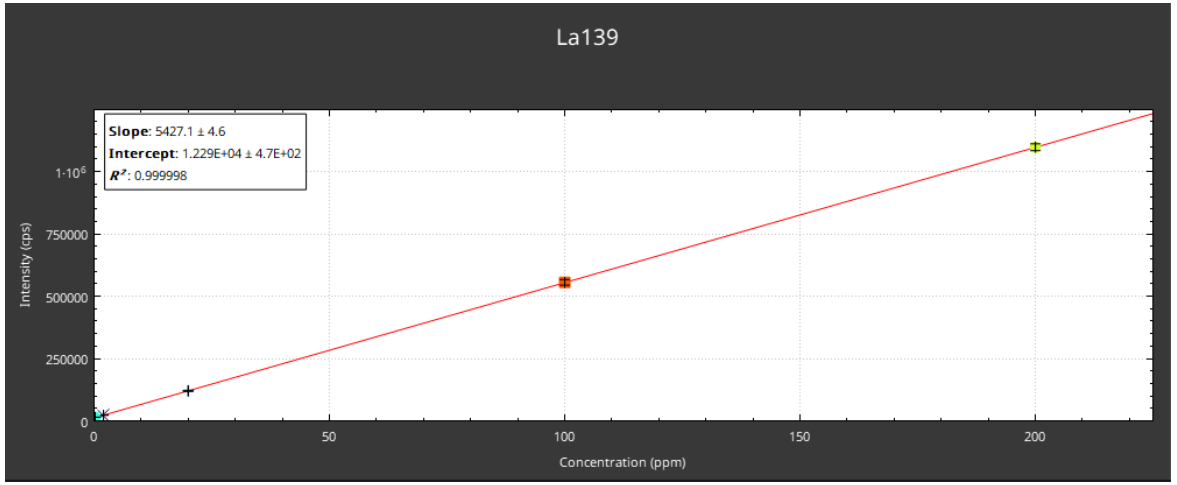


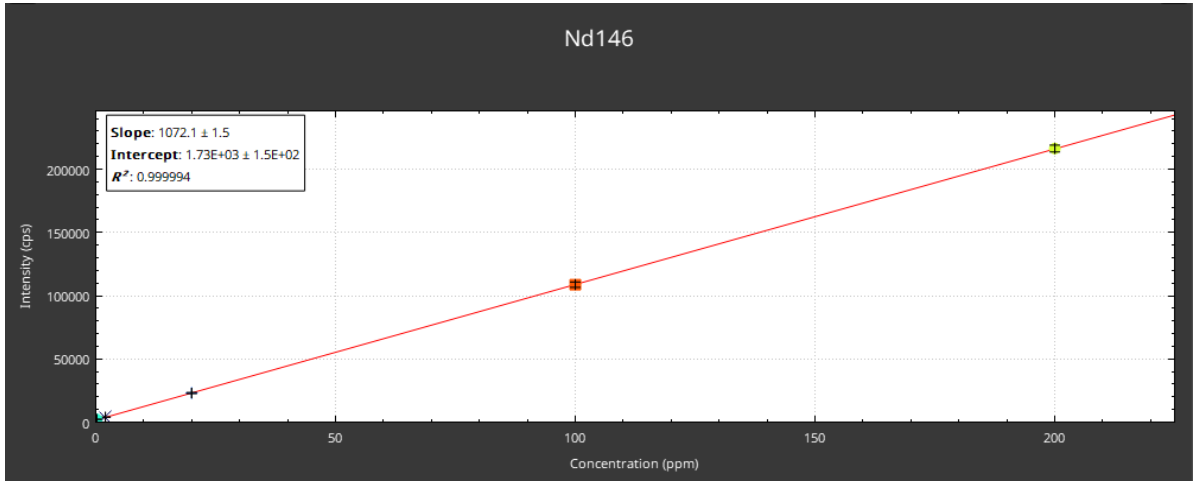


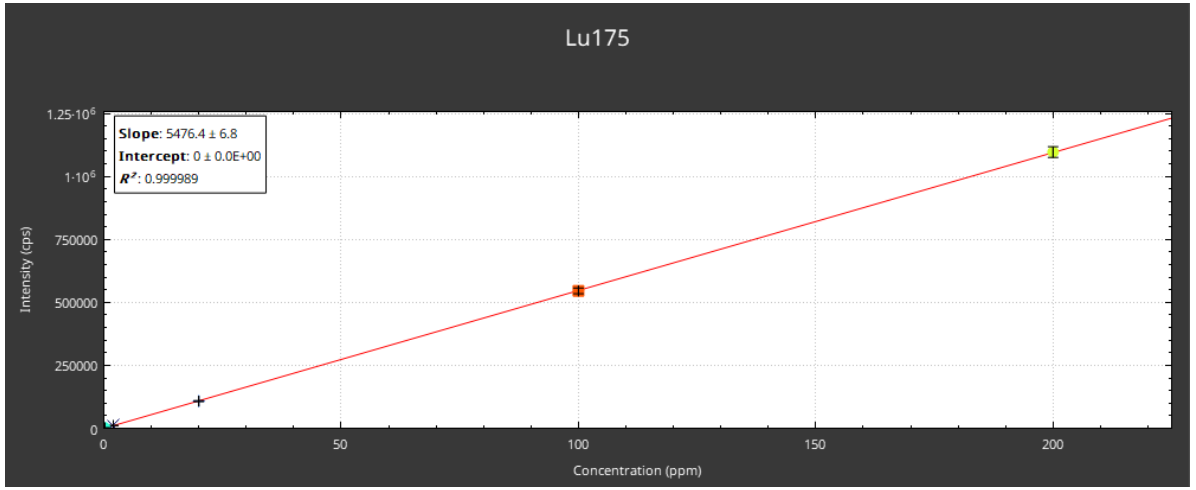


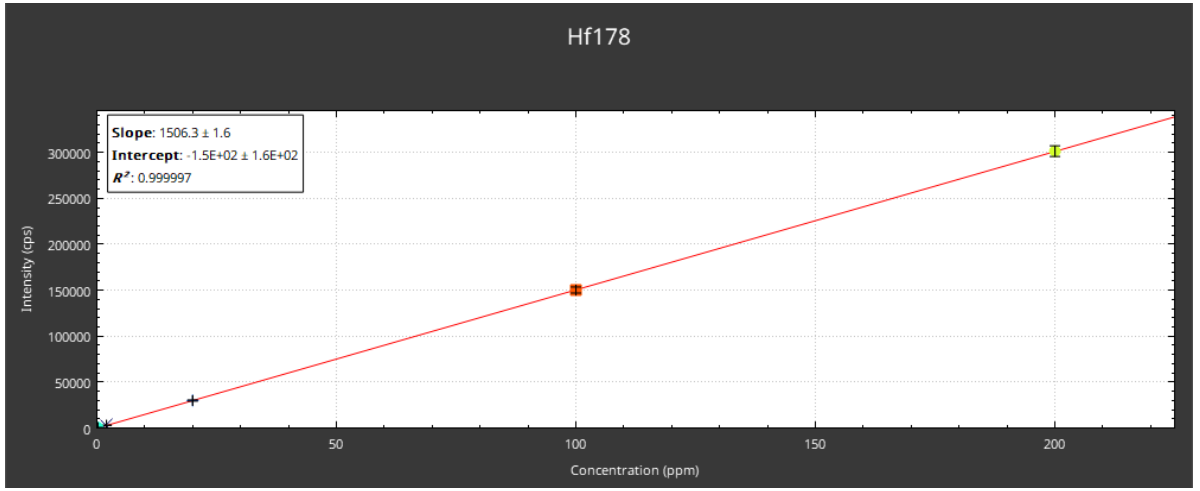


Calibration Curves









Recoveries on BCR2G Certified Reference Material

BCR2G Recoveries (ppm)			
Analyte	Measured	Accepted	% Diff
Na23	25720.7	23962.0	7.34
Mg24	20547.9	21467.0	-4.28
Al27	69252.5	70913.0	-2.34
K39	15717.1	14900.0	5.48
Ca43	48400.6	50429.0	-4.02
Sc45	34.3	33.0	3.96
Ti47	13010.5	14100.0	-7.73
V51	455.6	425.0	7.19
Cr52	18.8	17.0	10.71
Co59	38.8	38.0	2.2
Ni60	14.1	13.0	8.77
Cu63	22.5	21.0	7.08
Zn64	136.3	125.0	9.02
Rb85	48.4	47.0	3.08
Y89	33.7	35.0	-3.73
Zr90	187.0	184.0	1.66
Nb93	11.7	12.5	-6.66
Sn118	2.6	2.6	0.95
Cs133	1.1	1.2	-7.8
La139	24.0	24.7	-2.63
Ce140	55.6	53.3	4.37
Nd146	28.5	28.9	-1.45
Tb159	1.1	1.0	5.01
Yb172	3.5	3.4	2.19
Lu175	0.5	0.5	2.53
Hf178	4.6	4.8	-4.98
Ta181	0.7	0.8	-4.68
Th232	6.0	5.9	2.5
U238	1.8	1.7	6.7
Average			1.39

Linearity of ESI Solid Calibration Standards

Linearity	
Analyte	R2
Na23	0.999
Mg24	0.999
Al27	0.999
K39	0.998
Ca43	0.999
Sc45	1.000
Ti47	0.996
V51	1.000
Cr52	0.999
Co59	1.000
Ni60	0.998
Cu63	0.997
Zn64	1.000
Rb85	1.000
Y89	0.999
Zr90	1.000
Nb93	1.000
Sn118	1.000
Cs133	0.997
La139	1.000
Ce140	1.000
Nd146	1.000
Tb159	1.000
Yb172	1.000
Lu175	1.000
Hf178	1.000
Ta181	1.000
Th232	0.998
U238	1.000

Limits of Detection

Limits of Detection	
Analyte	LOD(ppm)
Na23	90.6295
Mg24	3.5426
Al27	22.9069
K39	8.8478
Ca43	53.8823
Sc45	0.0037
Ti47	3.2623
V51	0.0033
Cr52	0.0837
Co59	0.0011
Ni60	0.0334
Cu63	0.0040
Zn64	0.0439
Rb85	0.0025
Y89	0.0009
Zr90	0.0062
Nb93	0.0015
Sn118	0.0020
Cs133	0.0009
La139	0.0015
Ce140	0.0015
Nd146	0.0021
Tb159	0.0001
Yb172	0.0005
Lu175	0.0001
Hf178	0.0009
Ta181	0.0008
Th232	0.0012
U238	0.0006

Elemental Scientific

ICP | ICPMS | AA

LabStation

Automated Liquid Handling Systems

LabStation Product Line

Automatic Liquid Handling Stations

DilutionStation

FiltrationStation

TRAXStation

LabStation System Capabilities

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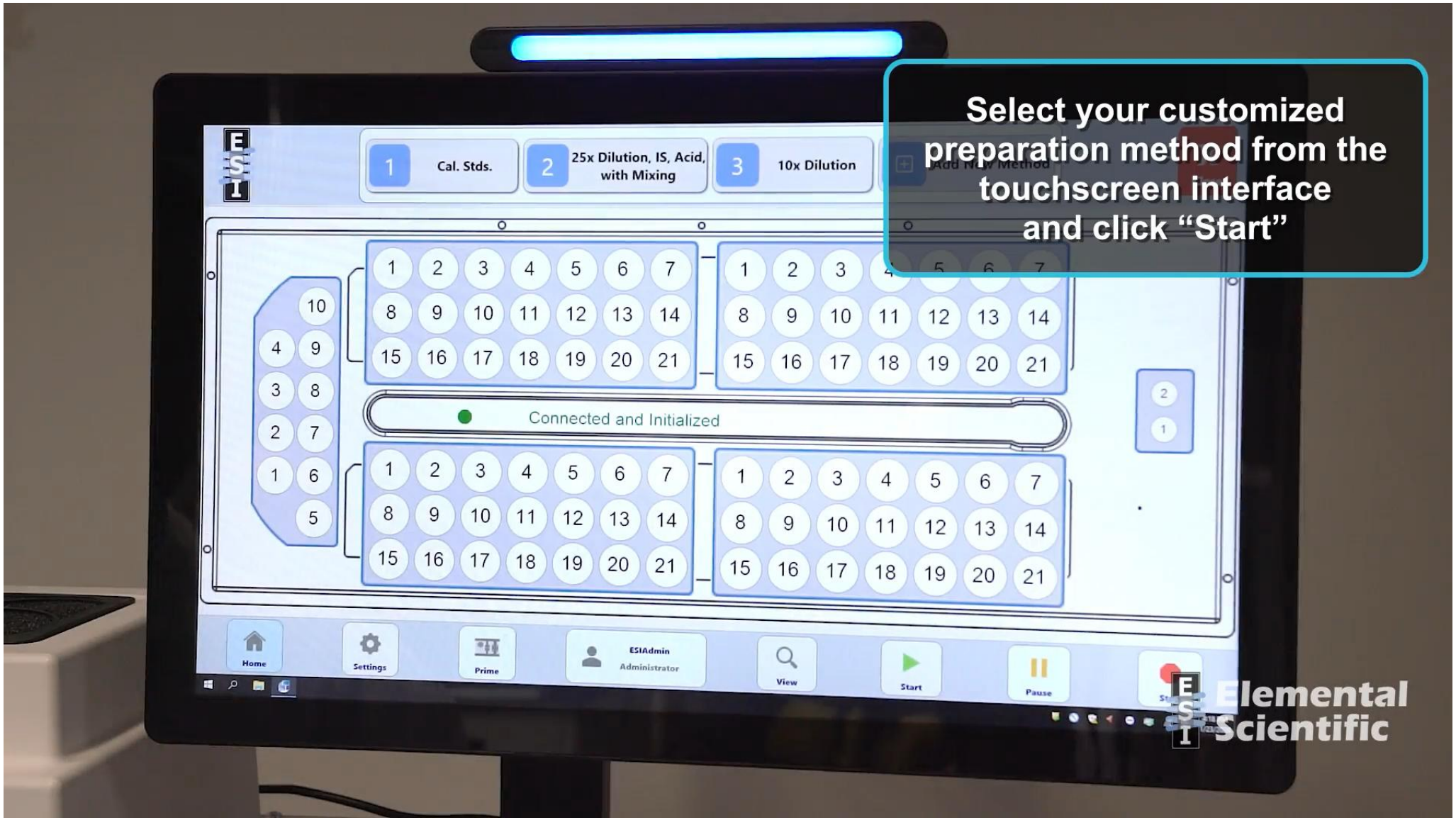
DilutionStation

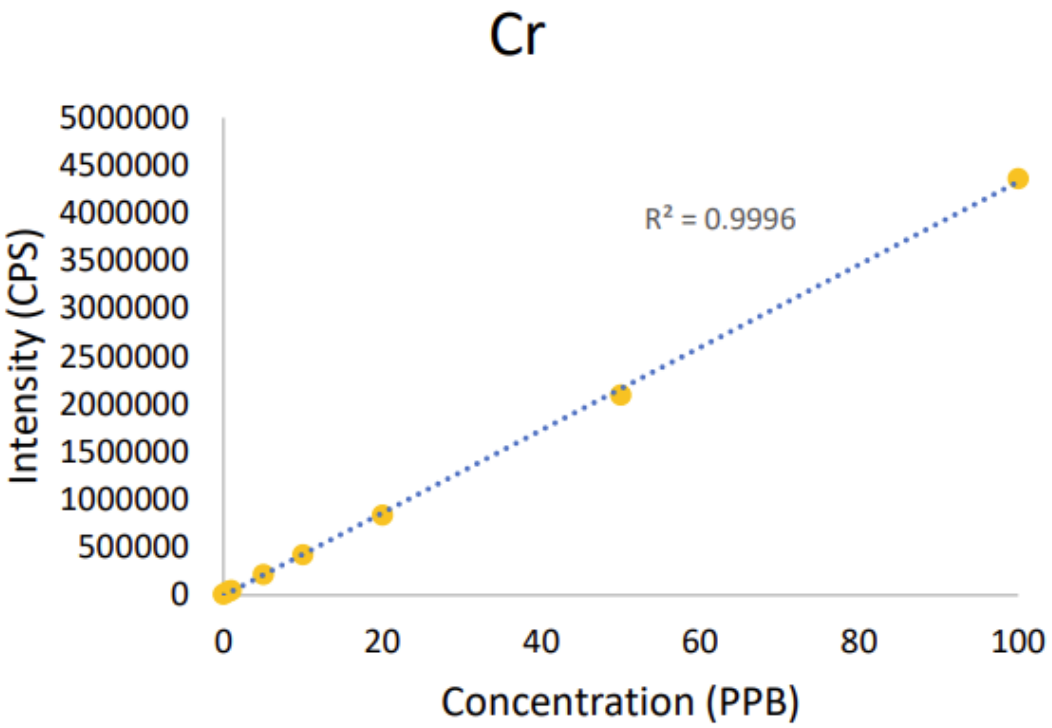
Flexible Sample Prep & Liquid Handling

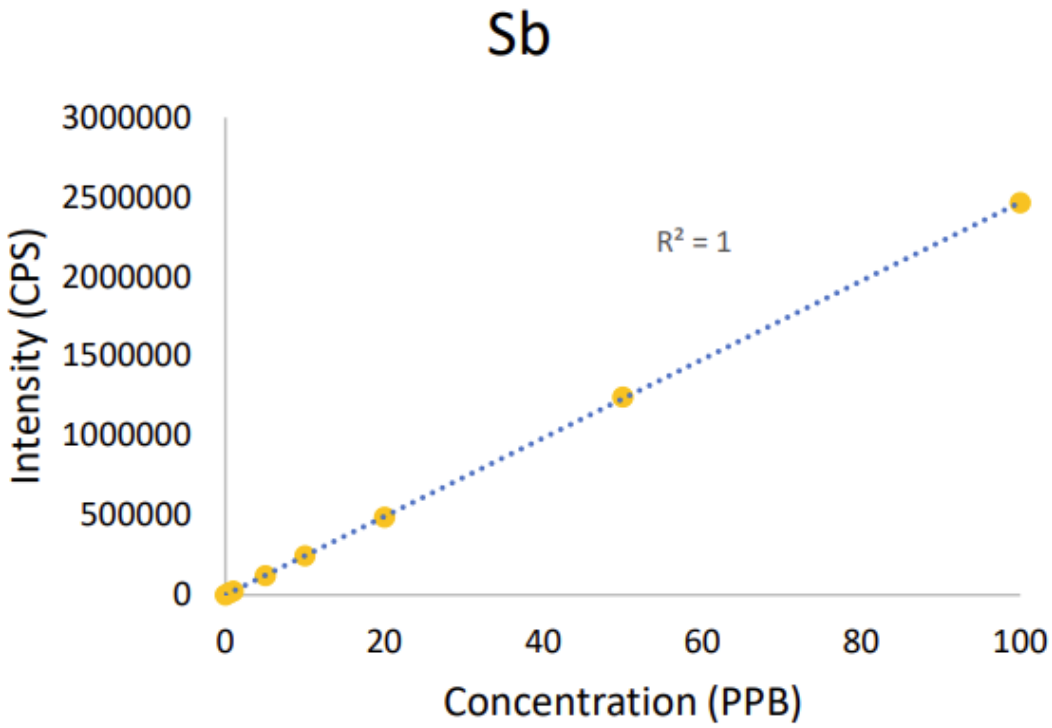
- Accurate & precise volumetric sample dilution
- Innovative syringe auto-dilution
- System Capabilities
  - Sample Dilution
  - Acidification
  - Internal Standard Addition
  - Sample Mixing
  - Standards Preparation
  - Serial Dilution

Automated Dilution, Acidification, IS Addition, and Mixing



Linearity of Cal Standards Prepared by DilutionStation





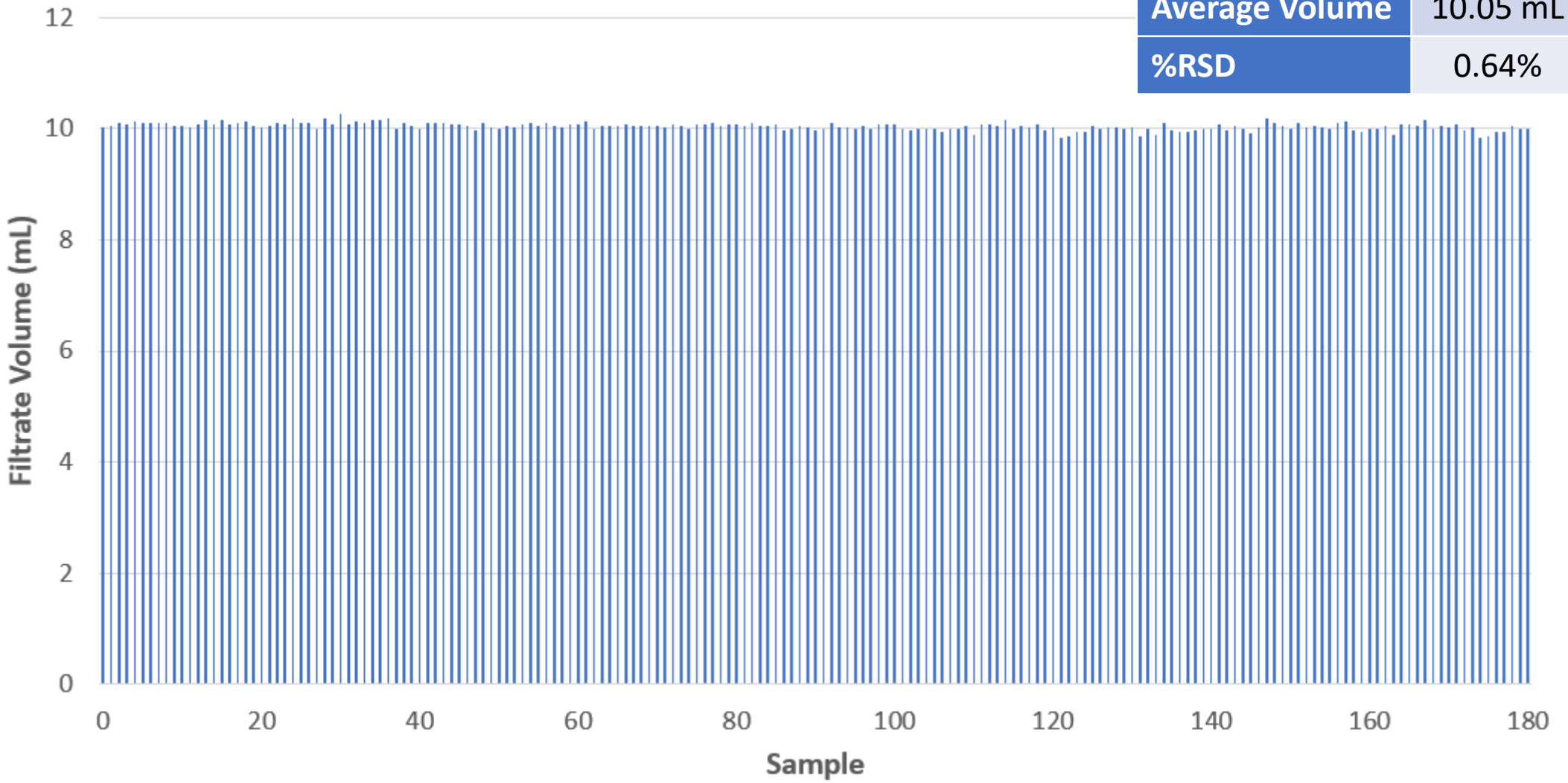
FiltrationStation

Automated Sample Filtration & Dilution

- Automated Luer-based filtering
- System Capabilities:
  - Filtration
  - Dilution
  - IS Addition
  - Acidification
  - Mixing
  - Standards Prep

Reproducibility of Final Filtrate Volume Following Autofiltration Using 13 mm 0.45 µm Filters

Average Volume	10.05 mL
%RSD	0.64%



TRAXPressure

Intelligent Pressure Control

Prevent Over-pressurization

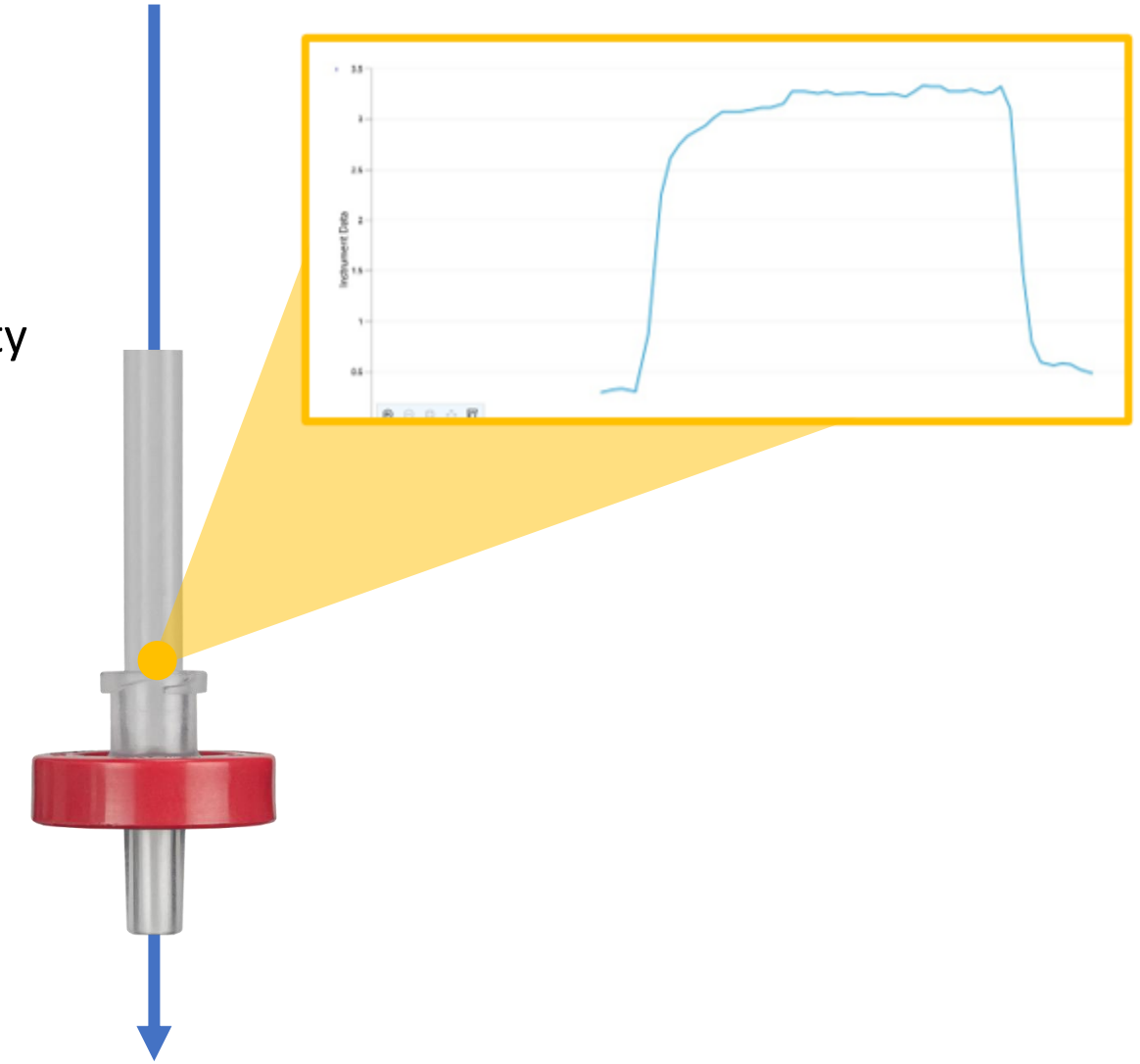
- Automatically slows syringe speed as pressure nears user-defined limits
- Reduces flow rate to protect filters and system integrity

Reduce Costs

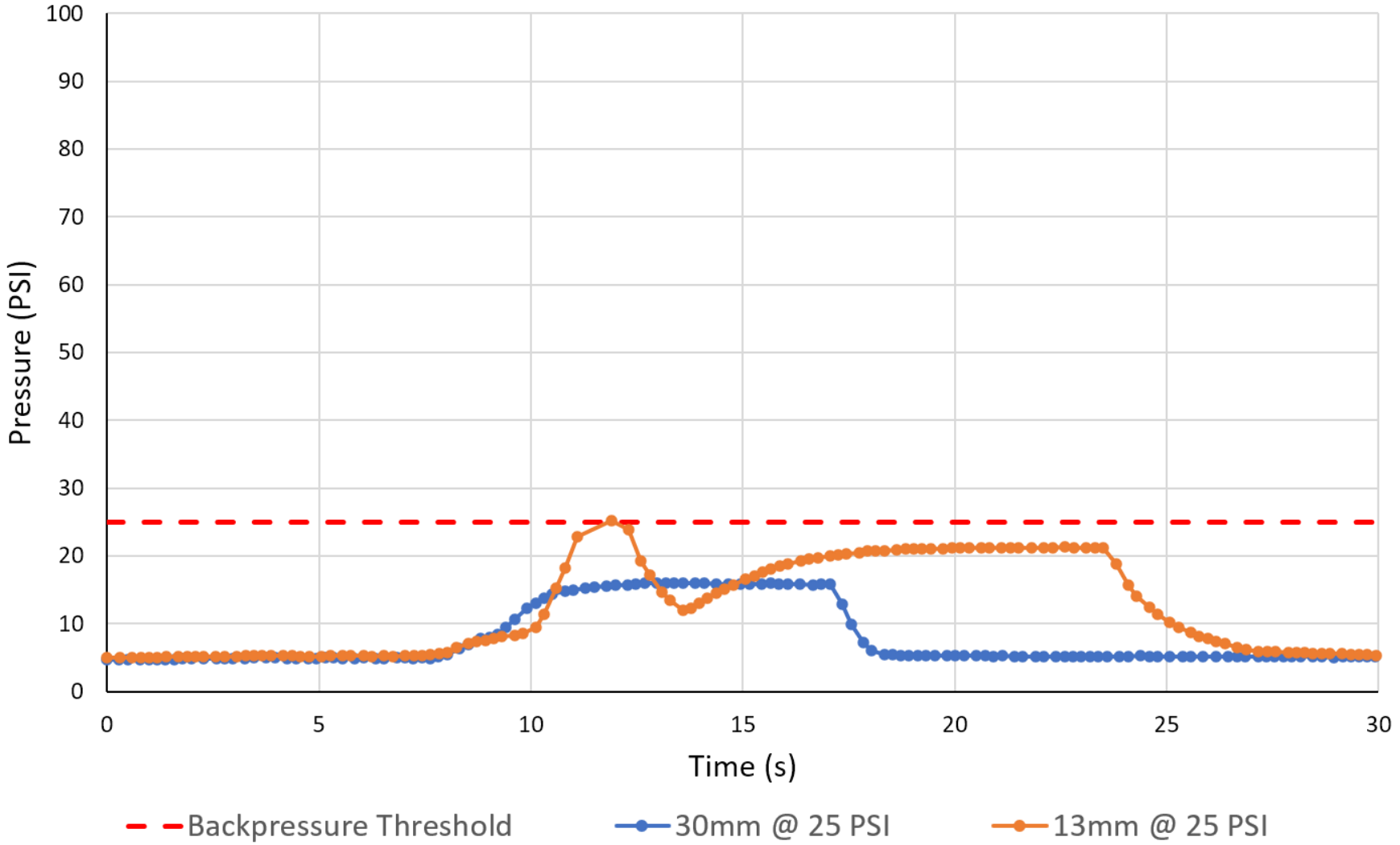
- Eliminates waste from ruptured filters
- Enables use of smaller, lower-cost filters

Software Tracked

- Records pressure profile for every sample
- View data easily within software per sample



Pressure Profiles vs. Time for 13 and 30mm While Producing 12mL of Filtrate



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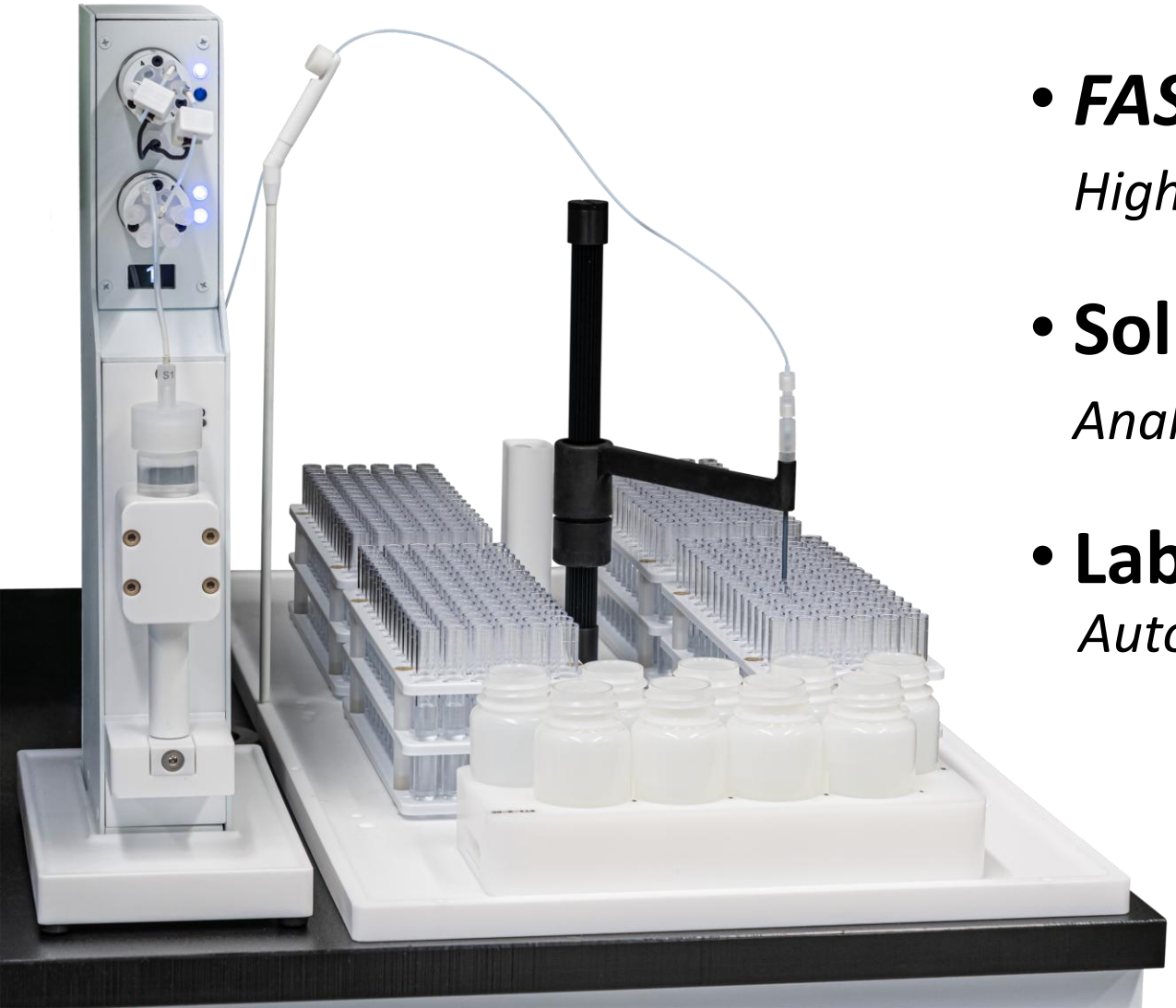
ESI's Product Portfolio for Soil Analyses



- ***FAST*Fluidic FilterProbe Soil**

  High-throughput Soil Analyses with High Rinseout

- **SolidSample ICPMS**

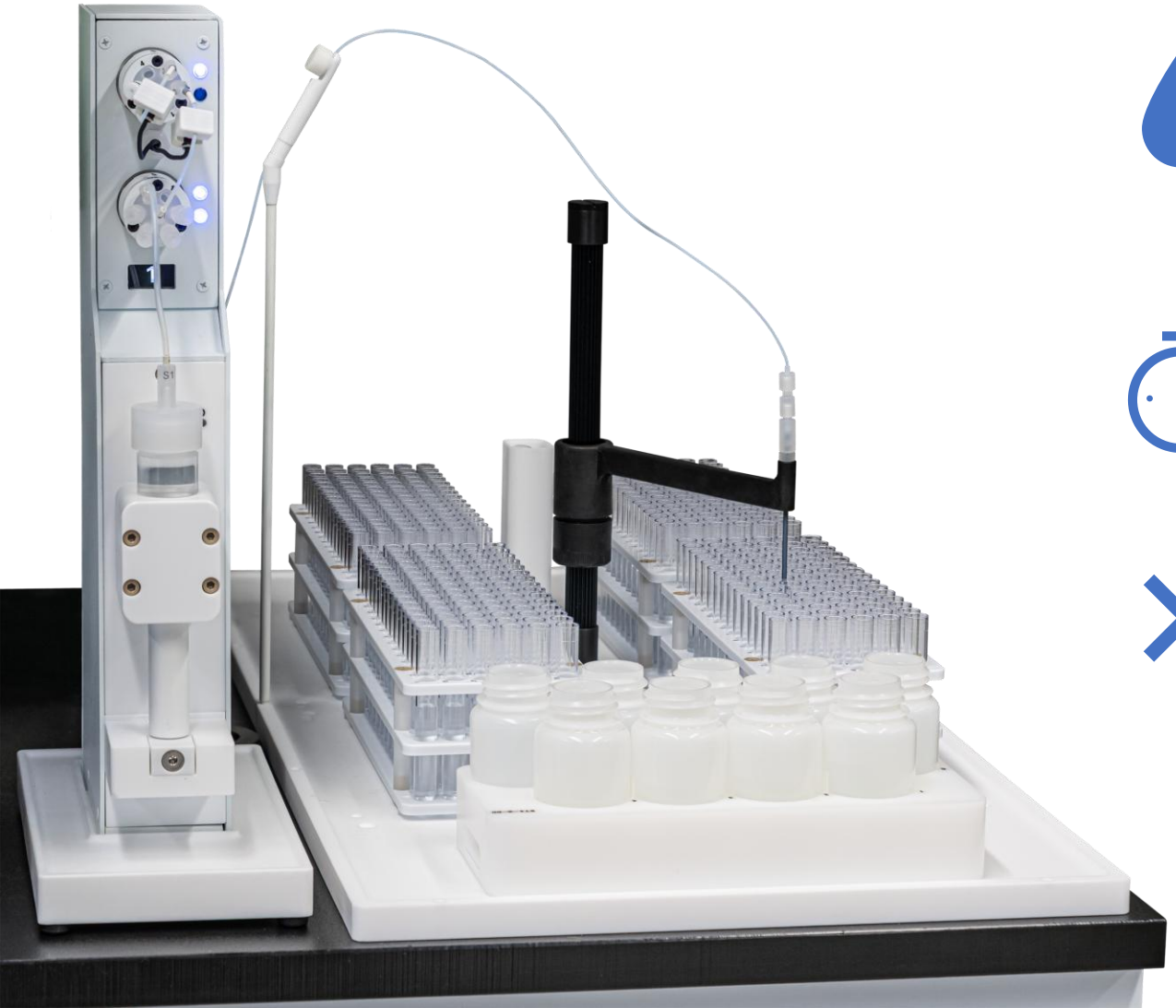
  Analysis of Elemental Grains in Soil by LA-ICPMS

- **LabStation**

  Automated Liquid Handling Systems

FASTFluidic FilterProbe Soil

4th Generation ICP Valve Injection with Backflush Rinsing



500X Washout

RidingRinse improves rinseout without sacrificing throughput

<10 seconds per sample

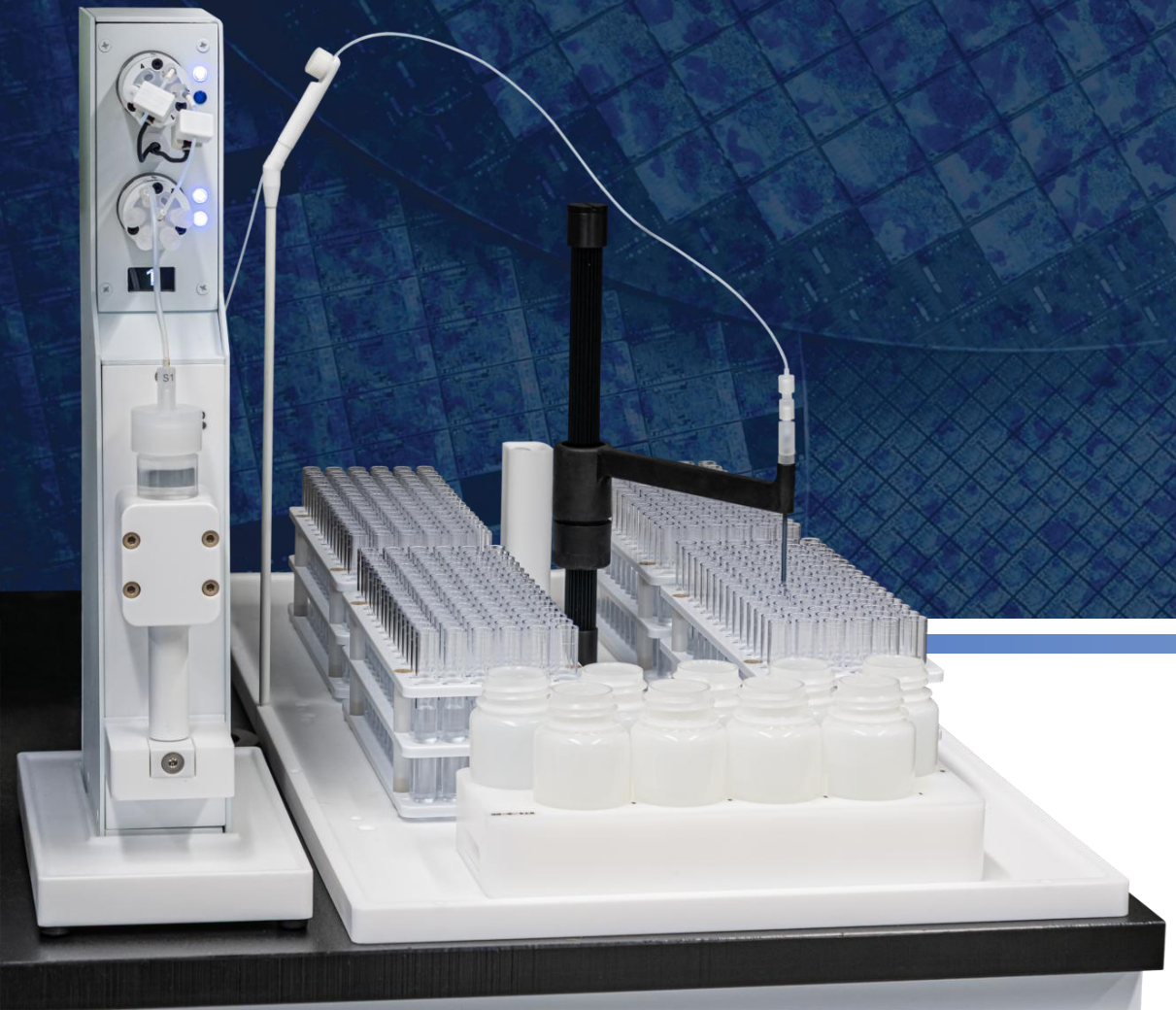
High-throughput soil analysis with Syringe-driven Backflushing

Clog-free analysis

FilterProbe prevents clogs and reduces daily maintenance

Elemental Scientific

ICP | ICPMS | AA



THANK YOU!