Flow Injection Analysis or Segmented Flow Analysis – which method to use for your application

William Lipps

Market Specialist – Water Analyzer Products

O·I·Analytical
A World of Solutions

Why do laboratories automate?

- **Automation increases productivity**
- **Automation decreases labor cost**
- **Automation increases day to day reproducibility**

O·I·Analytical

When laboratories should not automate

- **it takes more time and effort than it did before you automated**

Analytes that can be measured using automated chemistry

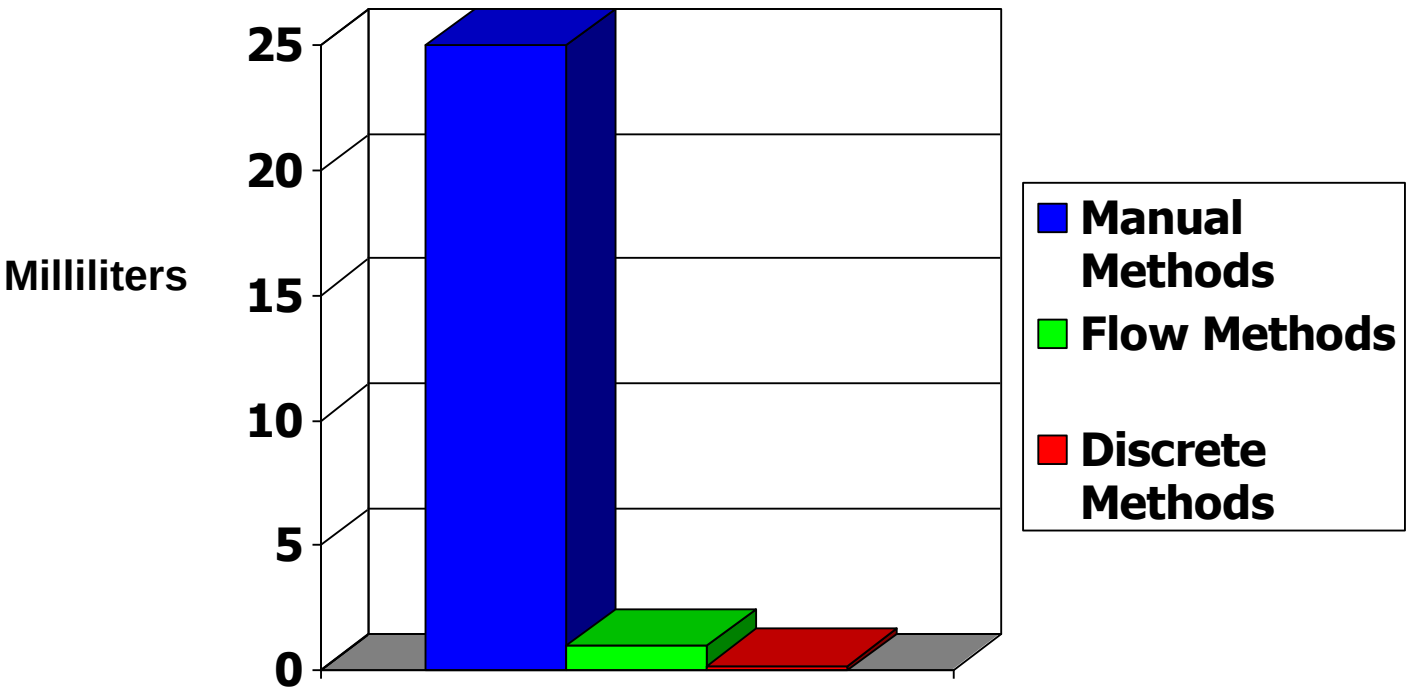
- Alkalinity
- Ammonia
- Chloride
- Nitrate
- Nitrite
- Nitrogen, Total Kjeldahl (TKN)
- Cyanide
- Phenolics
- ortho-Phosphate
- Total Phosphorus
- Silica
- Sulfide
- Sulfate

O·I·Analytical

Laboratory costs that can be reduced by automation

	Laboratory Cost
Direct labor	20 – 28 %
Indirect Labor	7 – 12 %
Operational Supplies	10 – 20 %

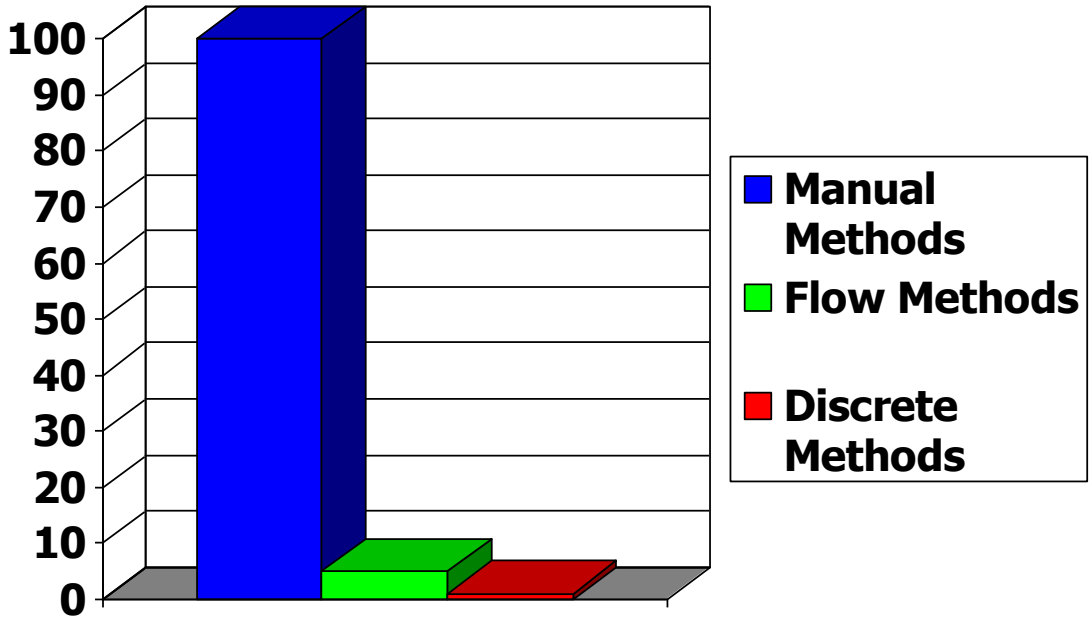
Reagent usage is decreased by automation



O·I·Analytical

Waste generation is decreased by automation

Milliliters



O·I·Analytical

The potential profit and cost savings is high using automated methods

	CATC	OIA 1677
Wage	$15	$15
Labor hours	4	1
Labor + OH	$150	$37.5
Capacity (day)	10	480
Per Test Price	$25	$25
Potential Profit	$100	$ 10, 360

O·I·Analytical

The grand daddy of automation is the continuous flow analyzer

- **Segmented Flow Analysis (SFA)**
  - **1954 by Leonard Skeggs**
  - **Technicon Autoanalyzer – introduced 1957**
- **Flow Injection Analysis (FIA)**
  - **About 1975 by Ruzika and others**
  - **Perstorp Tecator**

All continuous flow analyzers have common parts

- Autosampler
- Peristaltic Pump
- Chemistry Cartridge
- Flow through Detector
- Signal Processor

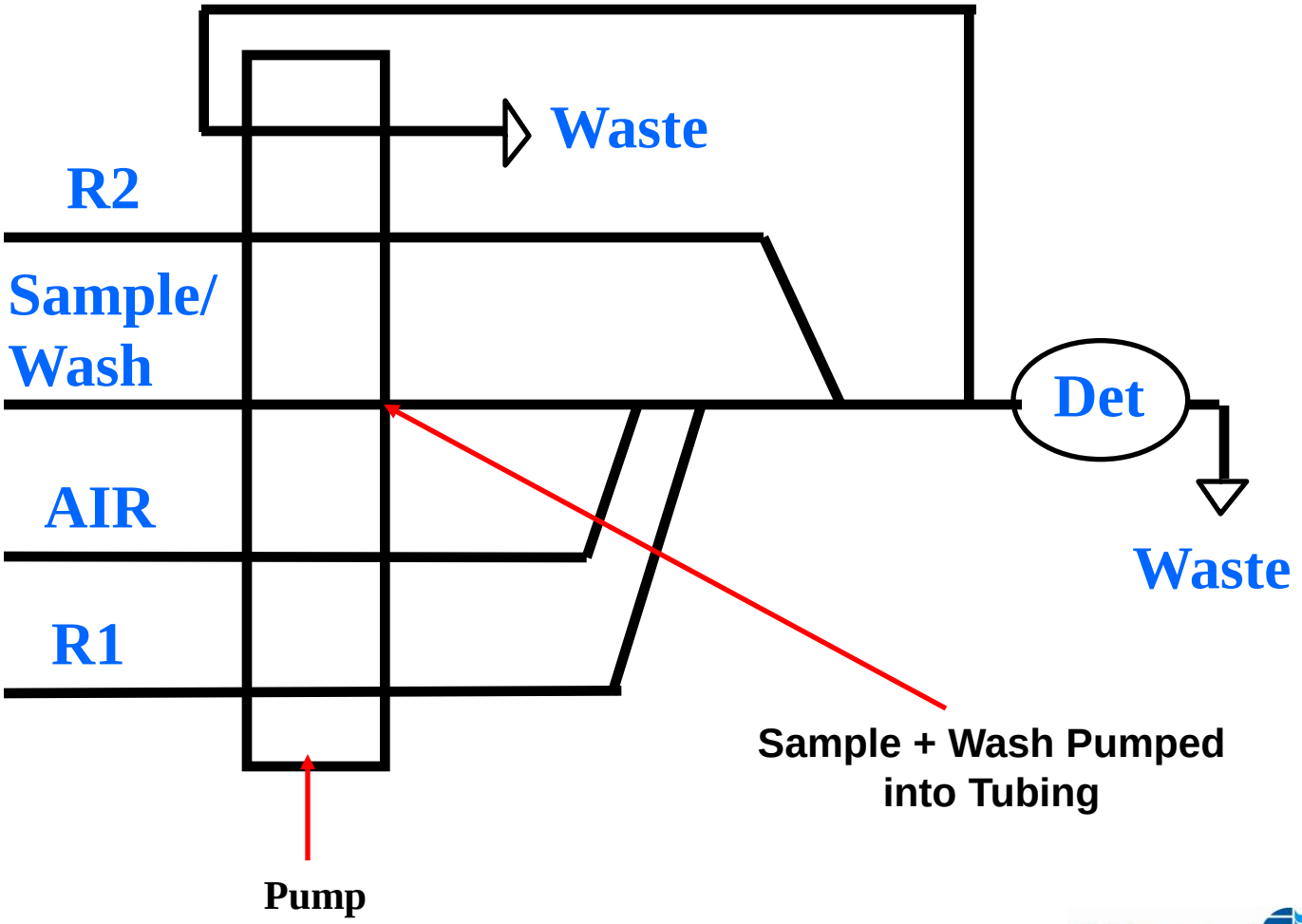
O·I·Analytical

Segmented Flow Analysis (SFA) - the first wet chemistry automation tool

- **Established, mature technique**
- **Multiple methods in literature and as approved regulatory test methods.**

O·I·Analytical

Sample is pumped into a segmented continuous stream of reagent



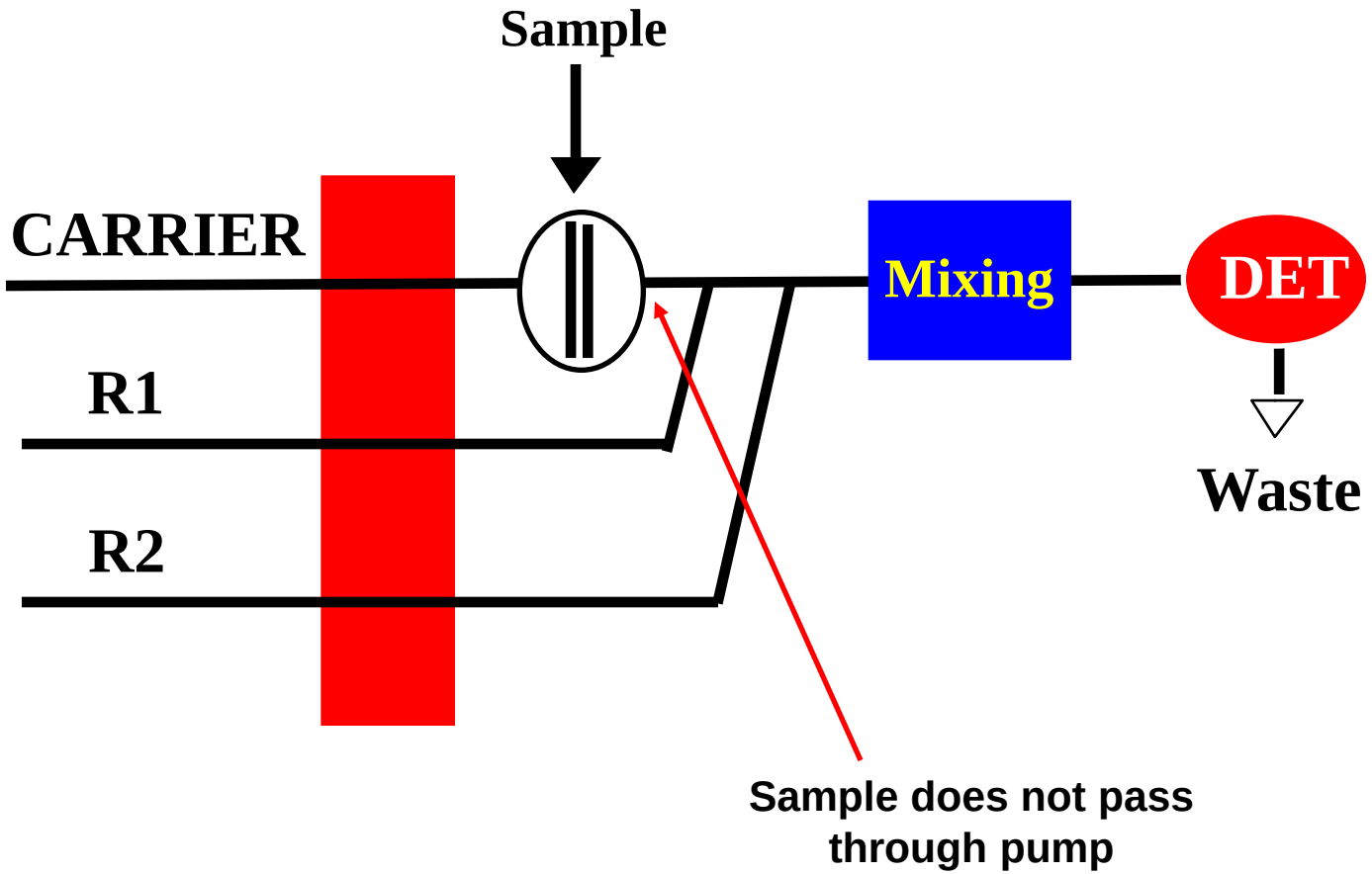
O·I·Analytical

Flow Injection Analysis was introduced as an alternative to SFA.

- **An acceptable alternative to SFA methods.**
- **Multiple literary references, ATP approvals.**

O·I·Analytical

Sample is injected into a continuous stream of reagent



SFA and FIA are both continuous flow methods

- narrow bore tubing, mixing coils, and finally a detector.
- reaction is determined by the configuration and placement of the tubing the sample and reagents pass through.

Comparison between SFA and FIA

	SFA	FIA
Startup time	15 minutes	15 minutes
Reagent System	Segmented	Non-Segmented
Conduits	0.034 – 0.050”	0.020 – 0.034”
Sample Introduction	Peristaltic pumping into flowing stream	Valve Injection into flowing stream

Comparison between SFA and FIA

	SFA	FIA
Sample Volumes	20 – 500 ul	20 – 2500 ul
Sample rate	30 - 120/hour	30 - 120/hour
Sample mixing	“end over end” (inversion)	Controlled Dispersion
Steady State	Almost always	rarely
Reproducibility	< 1%	< 1%

Comparison between SFA and FIA

	SFA	FIA
Incubation Times	Up to 20 minutes or more	< 2 minutes preferred
Dialysis/Gas diffusion	yes	yes
Shutdown	15 minutes	15 minutes

Reasons to use a continuous flow analyzer

- Method requires it
- Eliminate interferences
- Decrease manual labor
- Lower your MDL

Choosing between FIA and SFA is not personal preference

- use the best approach for the intended purpose

- methods must be adapted to suit the technique chosen
  - Redox reactions require long contact times
  - Exposure to air causes extraneous results

There are some methods best by FIA and some best by SFA

- Some flow methods cannot be done as well by FIA
  - Dialysis
  - Distillation
- Some flow methods cannot be done as well by SFA
  - Gas diffusion
  - Alkalinity

SFA has significant detection limit advantages with dialysis methods

Analyte	SFA MDL (mg/L)	FIA MDL (mg/L)
NH_3	0.01	0.2
NO_3/NO_2	0.004	0.05
PO_4	0.02	0.1

SFA has a significant throughput advantage in in-line distillation

Analyte	SFA Samples / hour	FIA Samples / hour
CN	30	17*
Phenol	33	17

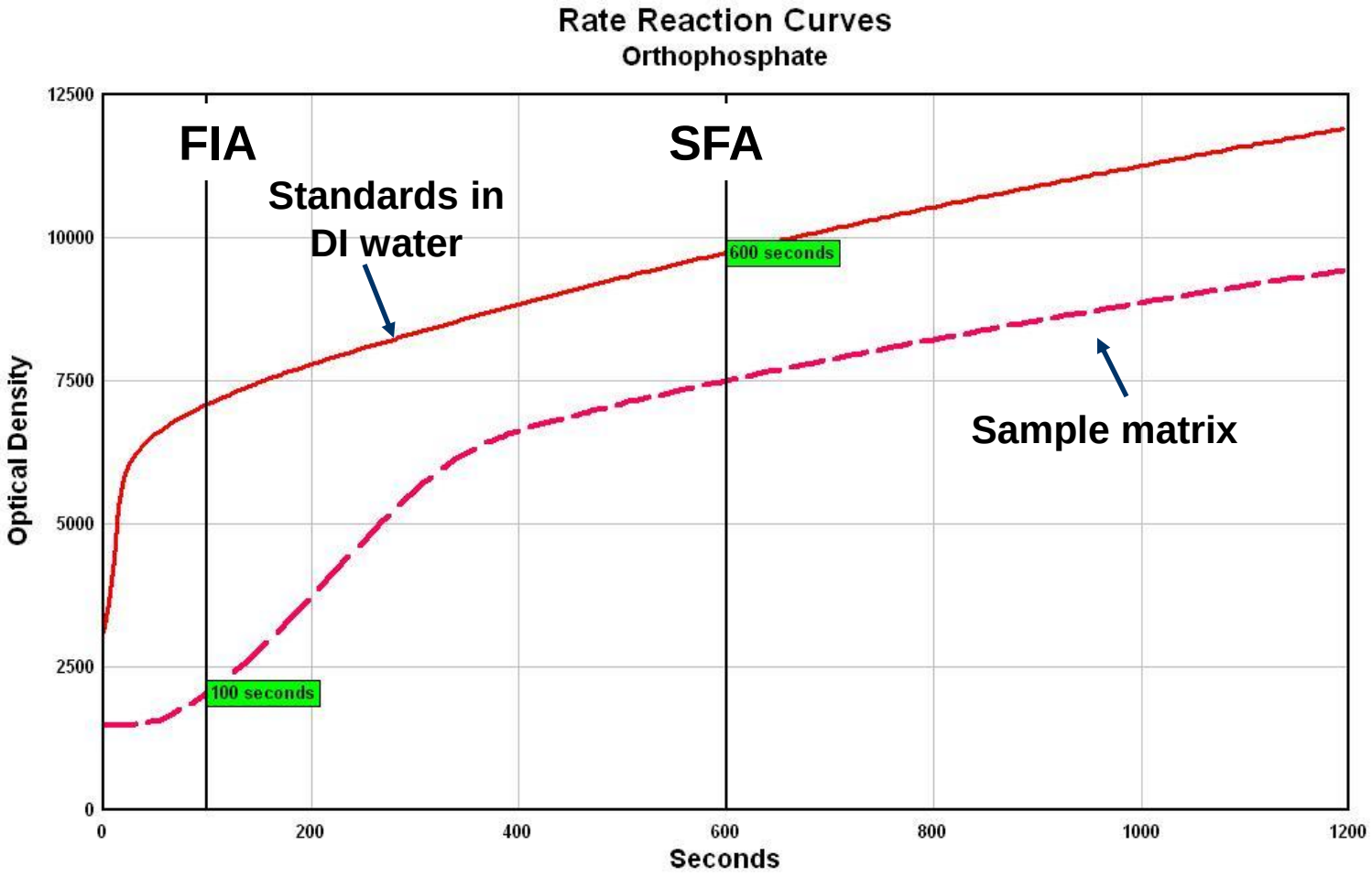
* Competitor data

O·I·Analytical

Reaction rates are independent of the technique used

- Reaction rates are determined by the temperature and concentration of the reagents.
- The rate of a color reaction is the same whether by FIA or SFA.

Matrix interferences could cause FIA results to be biased low.



CN

NH_3

PO_4

NO_3

O·I·Analytical

When to use SFA or FIA is based on optimum method performance

- **FIA**
  - **Full color in < 2 minutes**
  - **Simplicity**
  - **Ease of Use**
- **SFA**
  - **More than 2 minutes for reaction**
  - **Complex matrices**
  - **Dialysis**
  - **On-line distillations / digestions**

O·I·Analytical

We will help you choose the best auto-analyzer for you.

- Depends entirely upon your application.
- We will determine the optimum solution for you.
- We assume you desire to automate some aspect of your laboratory.

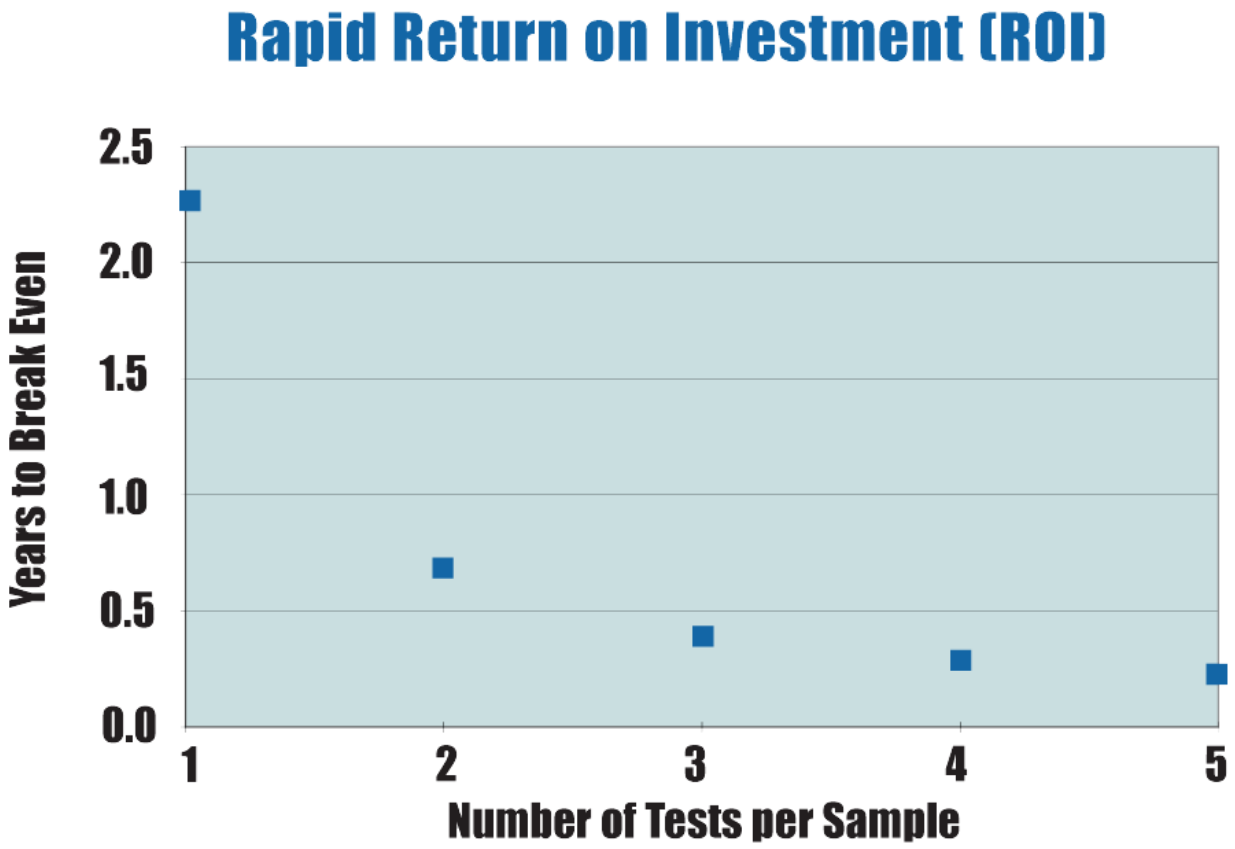
O·I·Analytical

OI flow analyzers are capable of SFA and FIA on the same instrument

- User flexibility
- Modular design
- Increased capability
- Low operating cost

O·I·Analytical

Multiple channel instruments should run every channel at the same time



O·I·Analytical

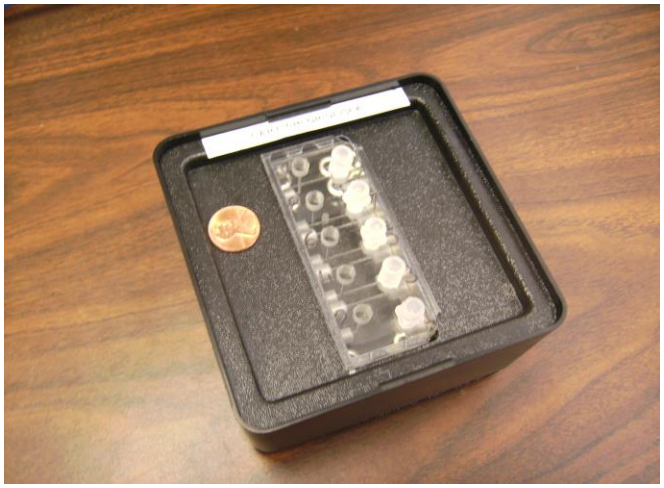
SFA cartridges traditionally use glass coils

A SFA cartridge

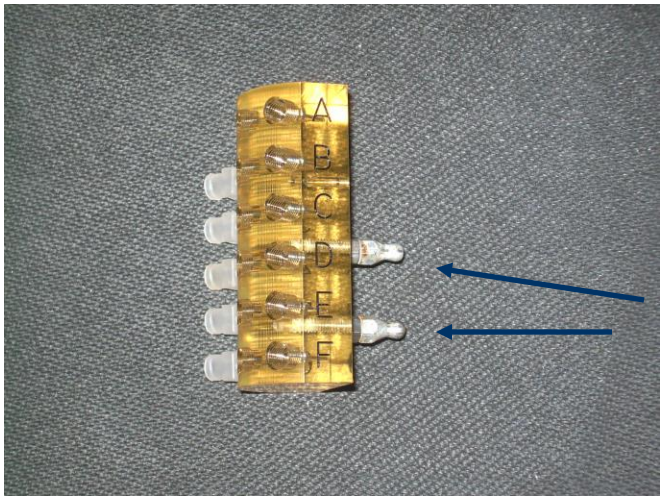
A broken glass coil

O·I·Analytical

Plastic cartridges that do not break; both SFA and FIA



- Flow IV cartridge

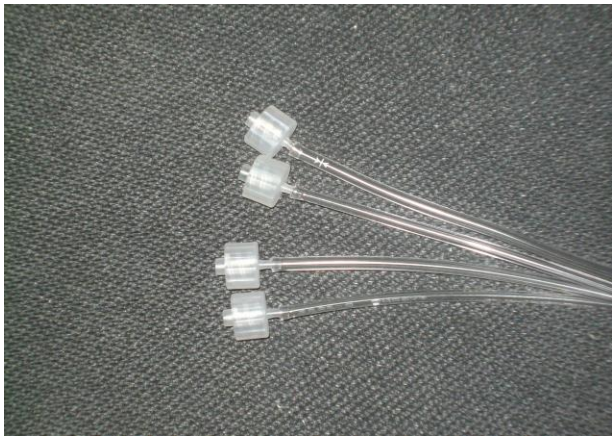


- FS3100 cartridge

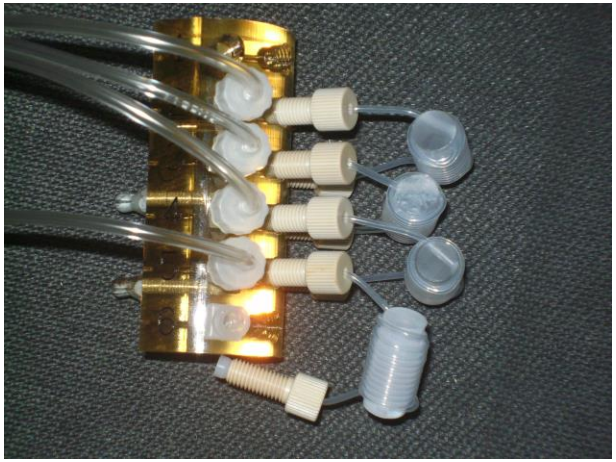
Pins

O·I·Analytical

Plastic cartridges are easier to interchange than glass



- Reagent connections – Luer lock



- Mixing coils
  - Nut and ferrule
  - Teflon or EVA

O·I·Analytical

Comparison of SFA and FIA on the OI FS3100

	SFA	FIA
Sample intro	time	loop
Volume	~200 µL	~200 µL
Max delay time	10 minutes	1 - 2 minutes
Sample/hour	40 - 90	30 - 120
RSD	< 2%	< 2%
Reagent (mL)	2 - 3	2 - 4

Method comparison of SFA and FIA on the FS3100

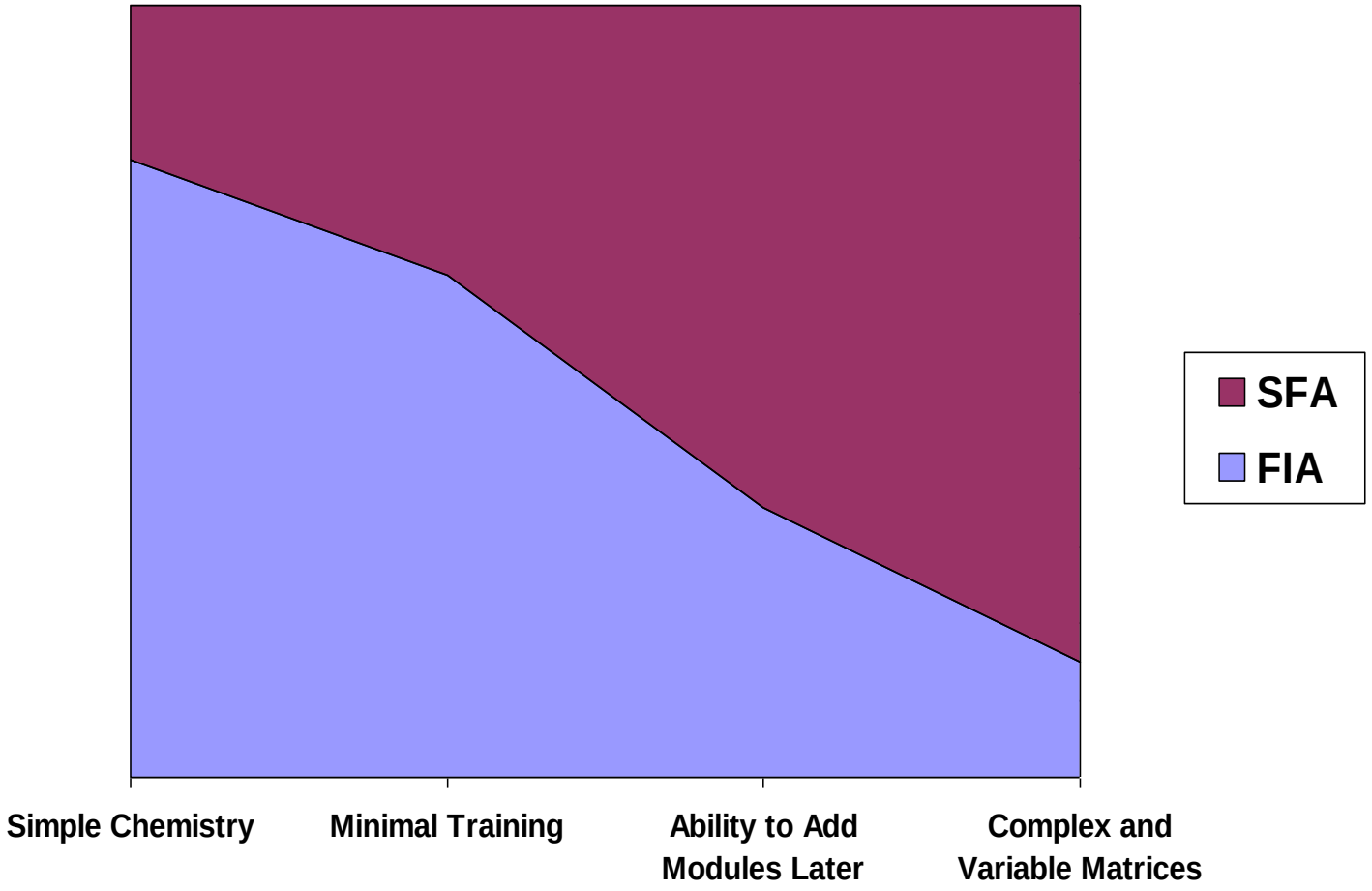
Analyte	SFA MDL	SFA through put	FIA MDL	FIA through put
NH_3	0.003	72	0.002	51
NO_3/NO_2	0.0005	55	0.002	60
PO_4	0.001	45	0.001	60

OI Flow methods enjoy a large calibration range

Analyte	SFA Calibration Range (mg/L)	FIA Calibration Range (mg/L)
NH_3	0.01 - 25	0.01 - 20
NO_3/NO_2	0.005 - 10	0.005 - 10
PO_4	0.01 – 2.0	0.01 – 5.0

O·I·Analytical

Choosing between SFA and FIA by laboratory requirement



O·I·Analytical