Fluorescence-solid phase Extraction (F-SPE) Microfluidic Platform – FluoroFind – for Rapid, Onsite Detection and Identification of PFAS with Machine Learning

**Accurate results when you need them –
it's all about time, cost, and performance**
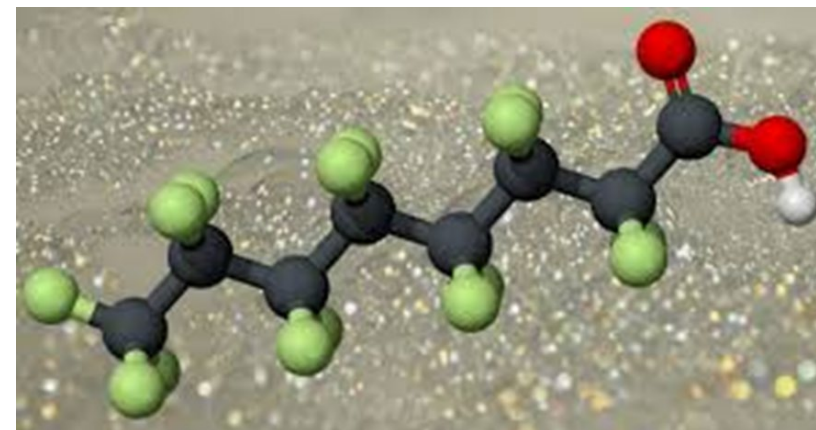
C. Hogue, C&E News, 2022, 199, 14.

Espira Inc.
Speaker: Jason Beck
Grant #: R44ES035349
Sept. 24th, 2025

Espira, Inc.

Email: jason.beck@espirainc.com; himanshu.sant@utah.edu
Website: espirainc.com

BW tek MEDICAL

The Problem: Forever Chemicals (PFAS)

Rising threat to health and the environment. How can we measure it?

⁉️ Problem

- Negative health effects Immune/reproductive/cancer

- PFAS accumulates in the body through water/food/environment

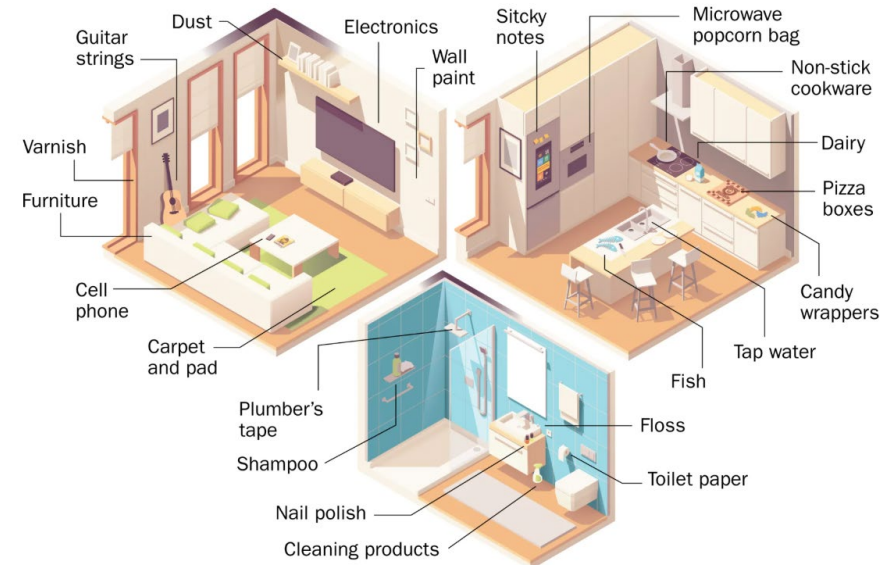- PFAS has been produced since 1940s

- PFAS is difficult to measure
*requires expensive and slow laboratory process

AQUEOUS FILM-FORMING FOAM (AFFF)

Something's Poisoning America's Land. Farmers Fear 'Forever' Chemicals.

New York Times, Aug. 2024

Time Magazine, May 2023

Six PFAS Target Analytes

National Primary Drinking Water Regulation (*MCL*) for Perfluorooctane sulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA): 4 ppt
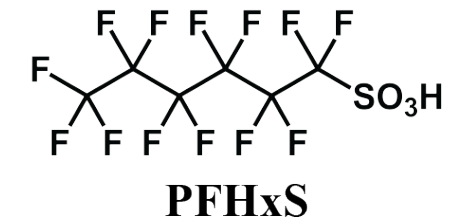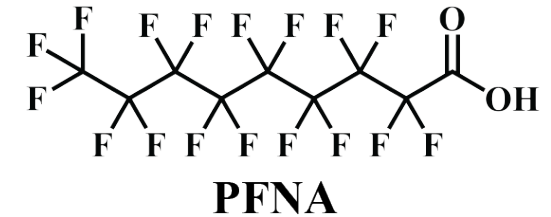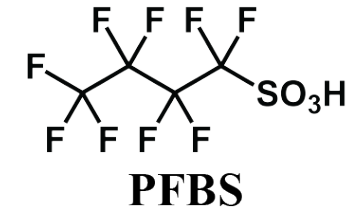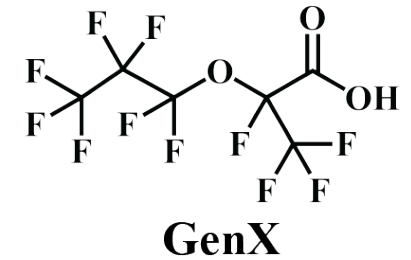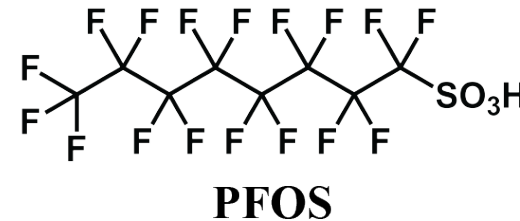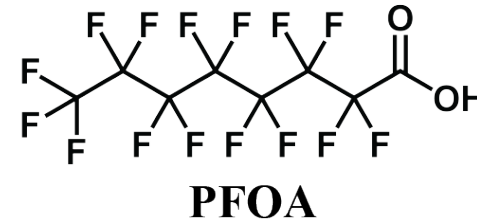
Hazard Index <1, *HBWC*
  Combines levels for Perfluorononanoic acid (PFNA), Hexafluoropropylene oxide dimer acid (HFPO-DA, aka GenX), Perfluorohexane sulfonic acid (PFHxS), and Perfluorobutane sulfonic acid (PFBS)

MCL: maximum contaminant level
HBWC: Health-Based Water Concentrations

4 ppt PFOA   4 ppt PFOS
EPA-mandated MCL

GenX

PFOA

PFBS

PFOS

PFNA

PFHxS

$$\text{Hazard Index} = \frac{[\text{GenX}_{\text{water}}]}{[10\ \text{ppt}]} + \frac{[\text{PFBS}_{\text{water}}]}{[2000\ \text{ppt}]} + \frac{[\text{PFNA}_{\text{water}}]}{[10\ \text{ppt}]} + \frac{[\text{PFHxS}_{\text{water}}]}{[9.0\ \text{ppt}]}$$

The Solution: Portable, Quick, and Accurate

How it Works

Our solution is to deliver accurate results on the spot.

Our technology combines state-of-the-art chemistry, mechanical engineering, and AI.

Espira offers cost-effective and time-saving (hours versus months) technology.

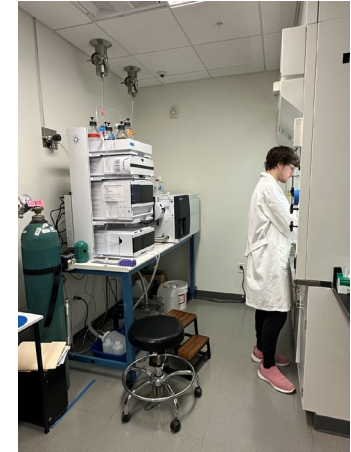We designed FluoroFind to have a simple user interface.

Our platform is adaptable and scalable for future demands.

Existing LC-MS/MS Lab versus Espira's FluoroFind

HPLC-MS/MS

A desktop platform for on-site analysis

Target Deliverables: FluoroFind vs. conventional HPLC-MS/MS
- 1-2 h per test (vs. several weeks, at least)
- Instrument cost ~$20,000; Test kit ~$100 (vs. >$300)

Custom Fluorophores for Selective and Sensitive Detection

Free fluorophore **fluorescent**
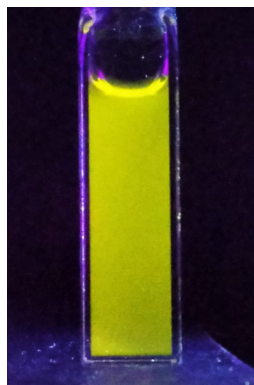
PFOS

quenching

Fluorophore\PFOS complex: **nonfluorescent**

[PFOS]

0 μM

6 μM

LOD: 7.0 nM (3.7 ppb)

All interferences: 6 μM
(1) PFOS, (2) PFOA, (3) GenX, (4) SDS, (5) EDTA, (6) Lauryl Sulfate, (7) Lauric Acid, (8) TFA, (9) n-octanoic acid, (10), Na^+, (11) K^+, (12) Ca^{2+} and (13) Mg^{2+}.
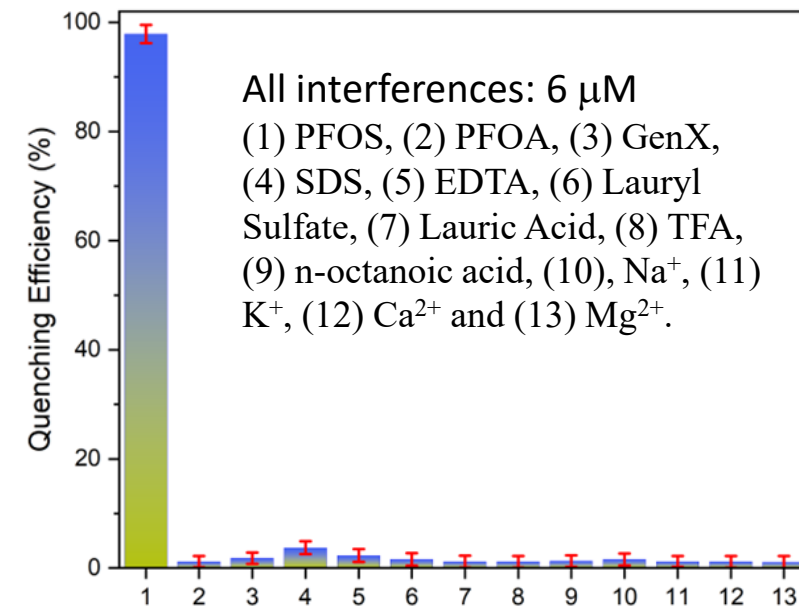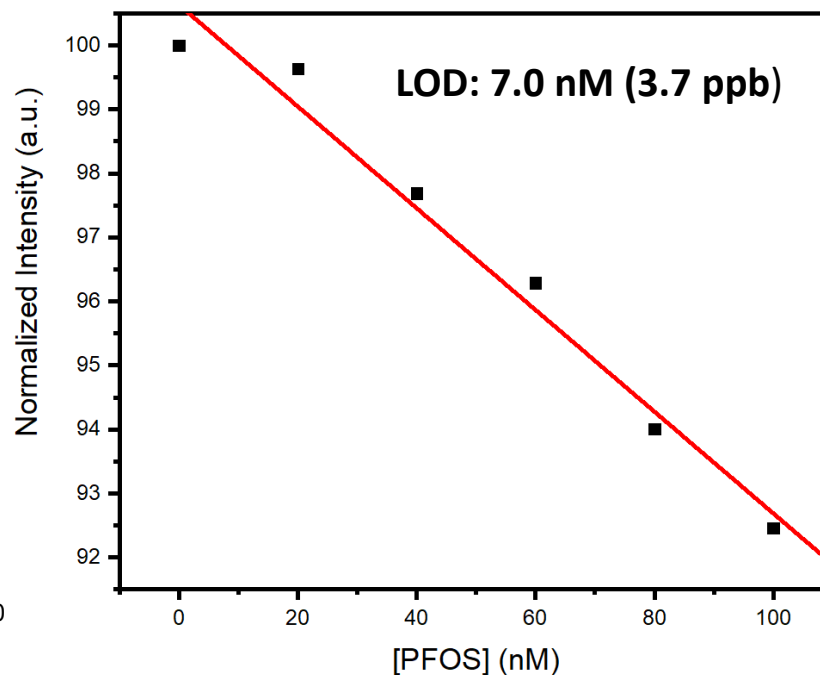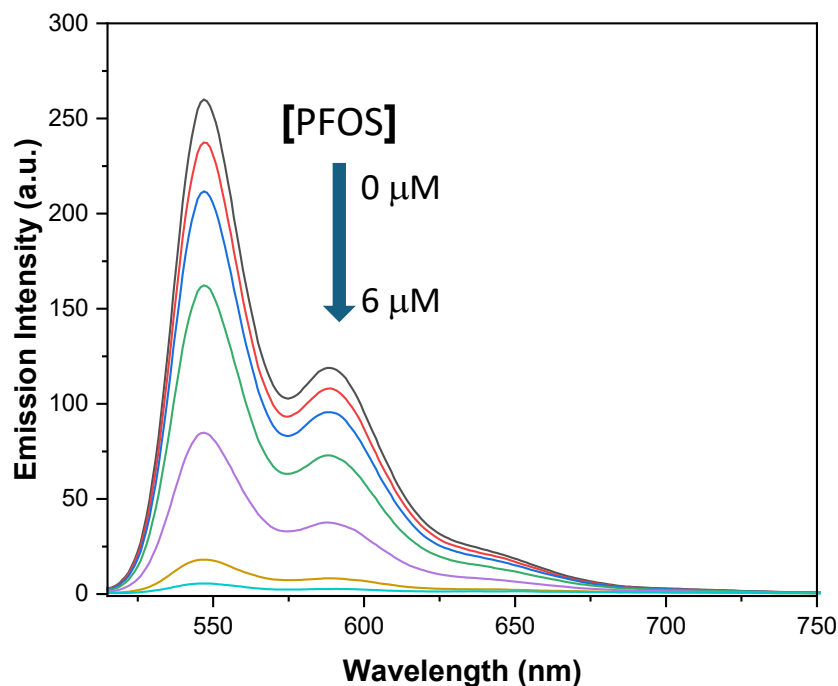
11 Custom Fluorophores, "Turn-on and Turn-off"
Fluorescence LODs : single-digit ppb for PFAS

Machine Learning Overview

- Led by Dr. Yu Xiang (UofU faculty)
- Identify optimal set of fluorophores
- Minimize samples needed for accurate quantification

Fluorescence Spectra Training Data:

- 11 fluorophores (so far)
- 6 target PFAS
- PFAS analogues
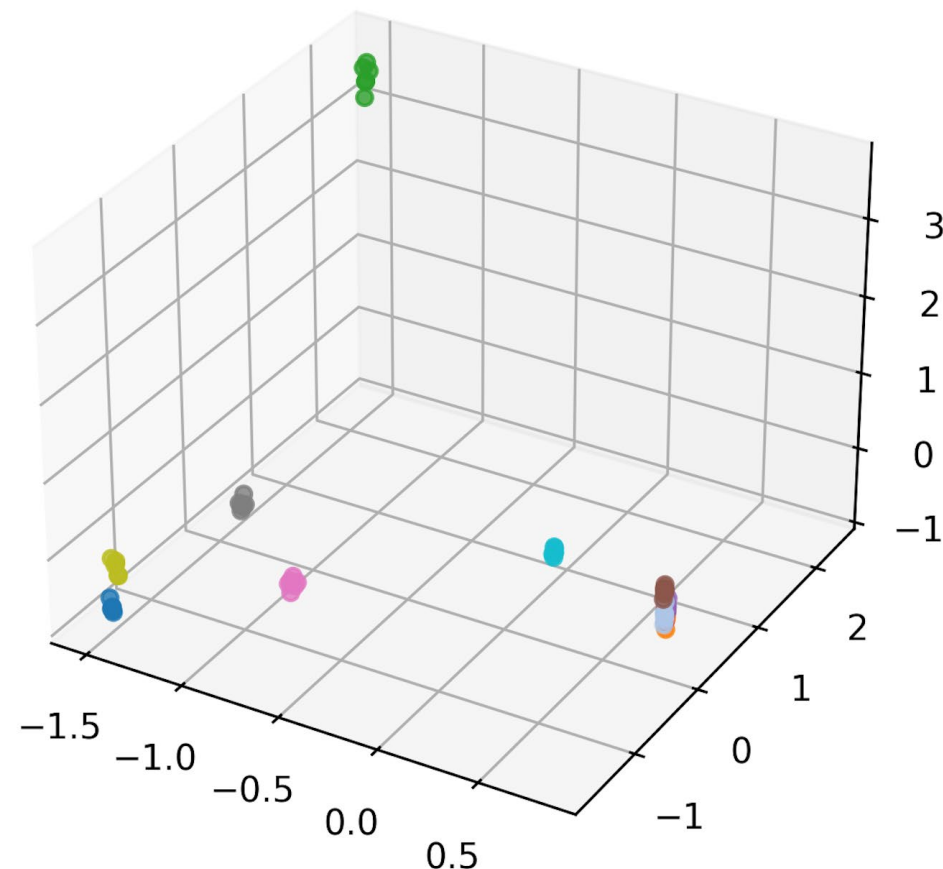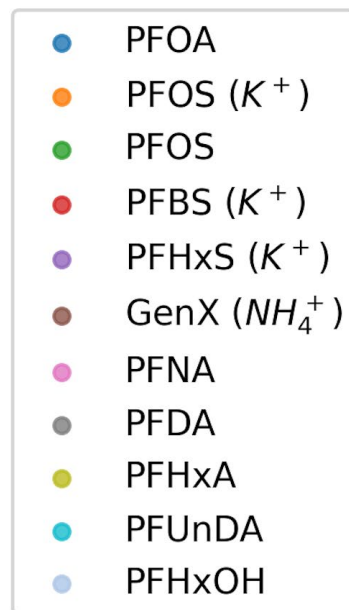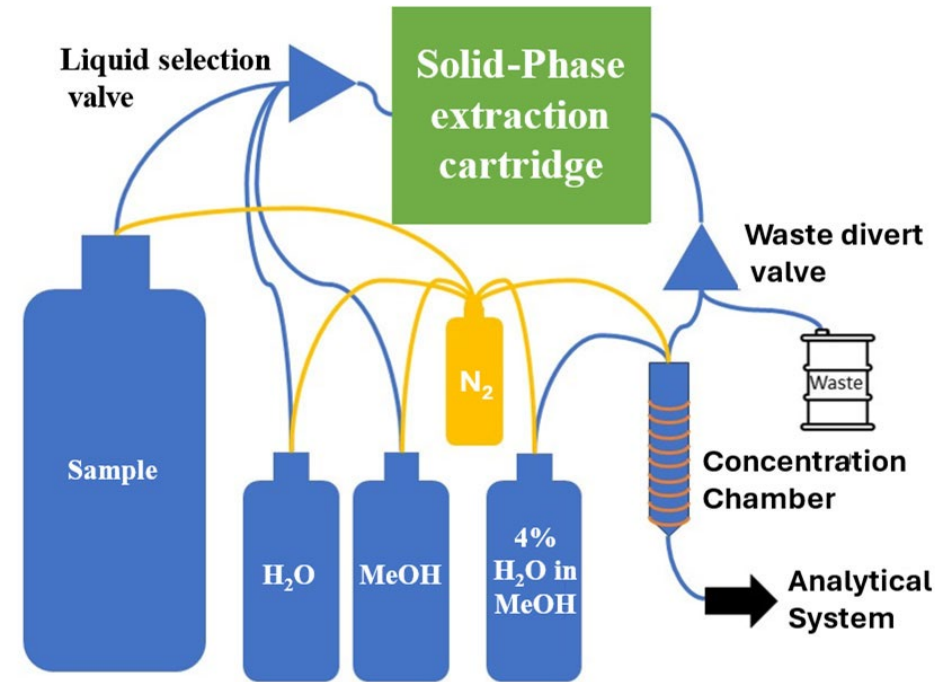- Common interferents
- Acids
- Salts

Illustration of the separation of 10 analytes including the six target ones in 3-D space using linear discriminant analysis. Classification accuracy = 97.7%

FluoroFind Instrument Overview

Module 1: Solid-phase extraction and sample concentration
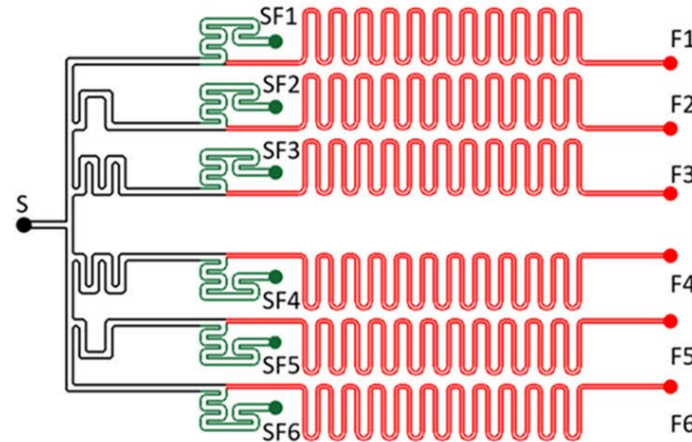
Module 2: Microfluidics for fluorophore/sample mixing and analyte preparation

Module 3: Multi-channel fiber optic fluorescence spectrometer

- Each module tested independently
- Validation using EPA Method 537.1 and HPLC-MS/MS

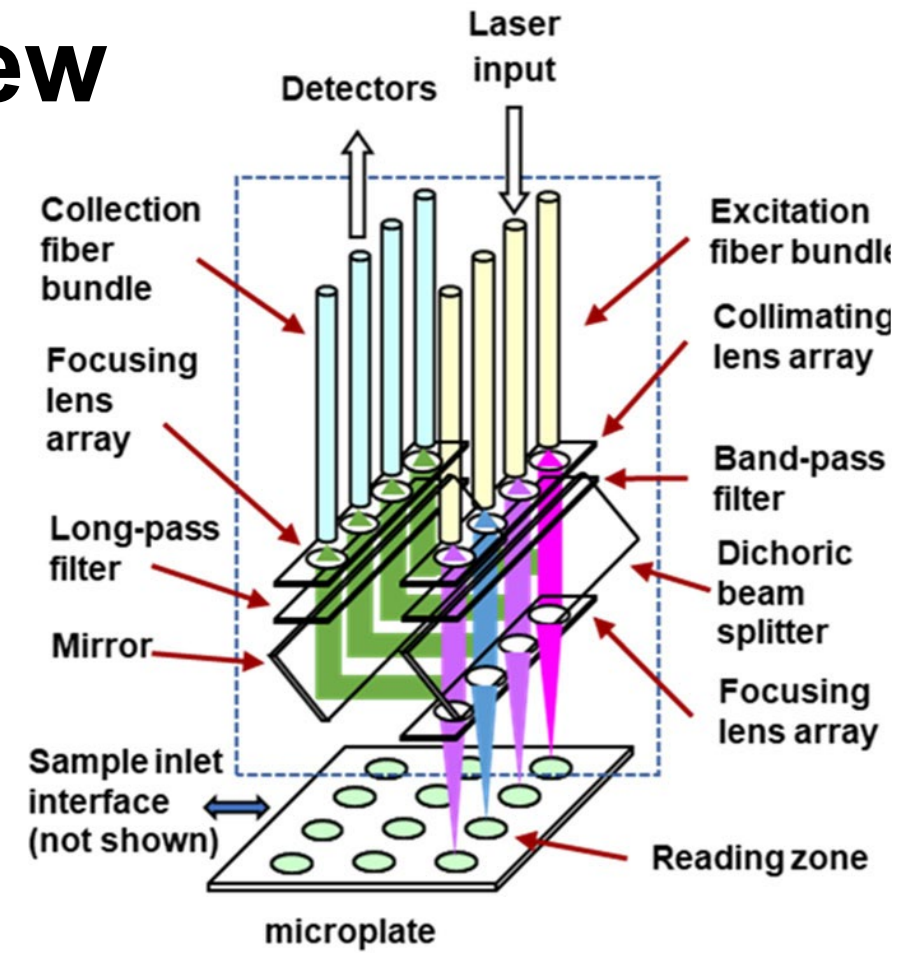# Fluidic Components
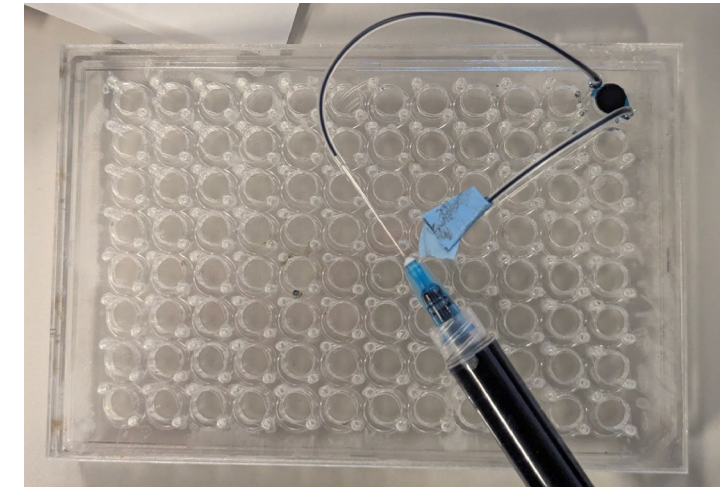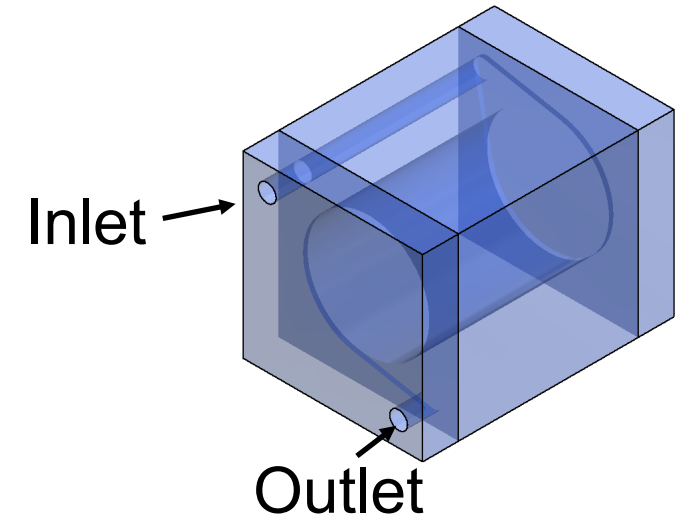
Fluorophore/Sample Mixing Chip:
S= sample, F = fluorophores, SF = sample + fluorophores

- Disposable fluidic chips
- Passive mixing based on varying fluidic resistance
- One sample split to mix with each fluorophore in separate channels
- PFAS standards for calibration

Top: Single Detection Cell
Bottom: Prototype Plate

Fluorometer Development

B&W Tek (development partners)

- Total solution provider in bio-photonics, analytical instruments, and medical devices
- Vertically integrated R&D teams with in-depth knowledge to turn concept into commercial product
- Global leader in the spectrometer marketplace with >75,000 units sold

The B&W Tek *i-Raman* instrument: 6-channels for rapid Raman measurements (96-well plate)
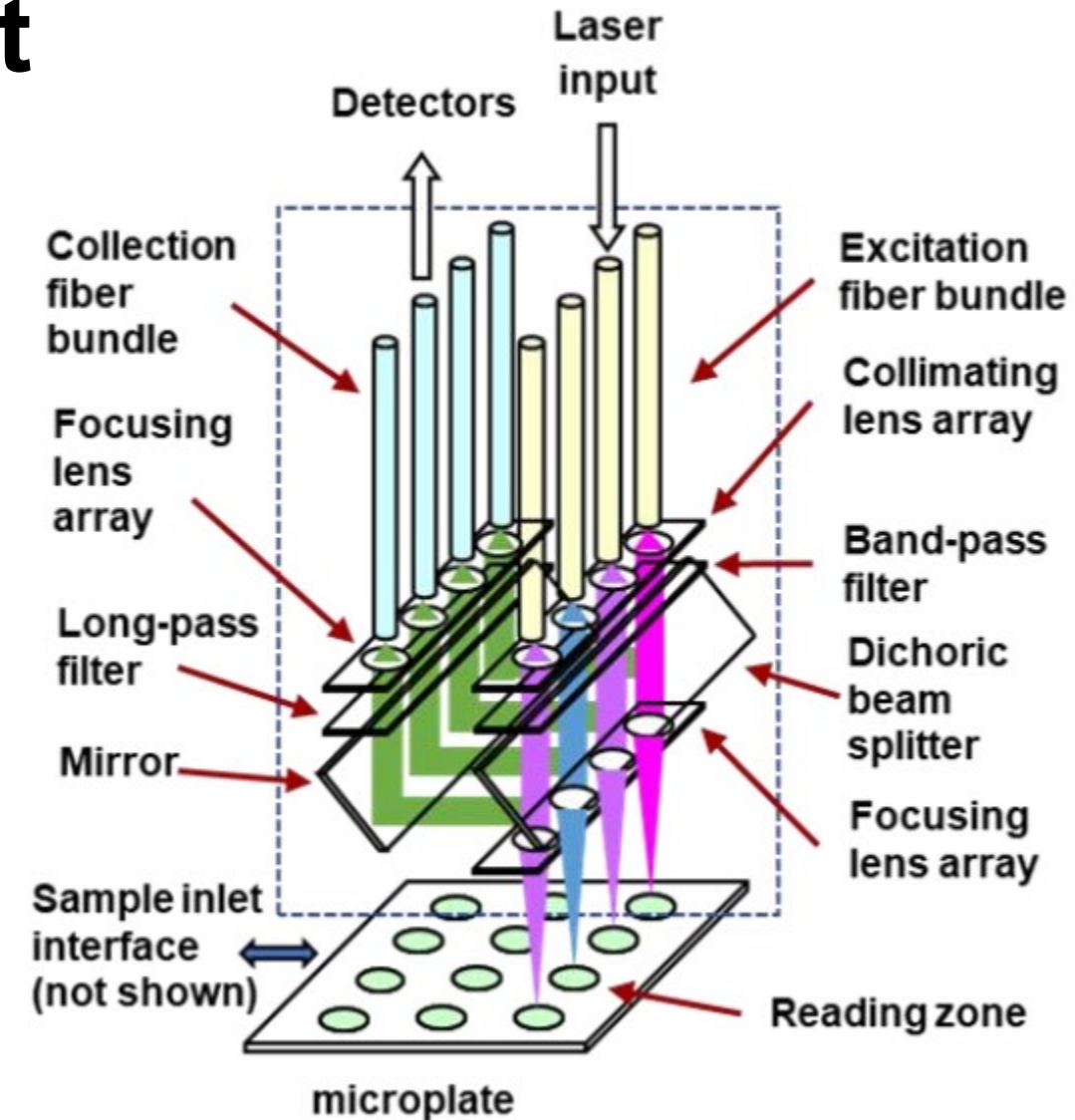
Multichannel fluorescence measurement for high-throughput sample analysis

Grant Information	Dr. Jason Beck, Fluorescence-Solid Phase Extraction (F-SPE) Microfluidic Platform for Rapid, Onsite Detection and Identification of PFAS With Machine Learning, Espira Inc., Grant Number: R44ES035349, Project Link: https://reporter.nih.gov/search/DEySY0RZR0S_rv1ryhRK7A/project-details/11186390#details
Presenter	Jason Beck, Fluorescence-Solid Phase Extraction (F-SPE) Microfluidic Platform for Rapid, Onsite Detection and Identification of PFAS With Machine Learning
Technology Name and Description	FluoroFind is a benchtop instrument that detects and quantifies several PFAS in sample solutions via the change in fluorescence signal that is observed upon interaction with a set of custom fluorescent molecules.
Innovation	FluoroFind will be field-deployable and deliver near real-time results for the measurement of 6 PFAS, which is not possible using current commercial instrumentation. Fluorofind will give results in 1-2 h and cost around $100 per test, which is much faster and less expensive than conventional HPLC-MS/MS testing for PFAS. Patent-pending technology: "Methods for detecting per- or poly-fluoroalkyl substances with fluorophores," App No.: 63/717,453 (Filed: 2024.11.07)
Contaminant and Media	**Contaminants/targets:** Six PFAS variants: PFOS, PFOA, PFHxS, PFBS, PFNA, and GenX **Media:** Aqueous PFAS samples (e.g., drinking/groundwater, AFFF tank rinsates, soil sample extracts) **Target contamination levels and Limits of Detection:** Our goal is the detection/quantification of PFAS at EPA-regulated levels. We have detected PFAS via fluorescence at low-PPB levels. LODs are further improved according to the concentration factors achieved via solid-phase extraction procedures.
Technology Readiness Level	3-4
Site Work	Testing in-house at our headquarters in Salt Lake City, UT
Main Point of Contact	Email: jason.beck@espirainc.com Website: https://espirainc.com/