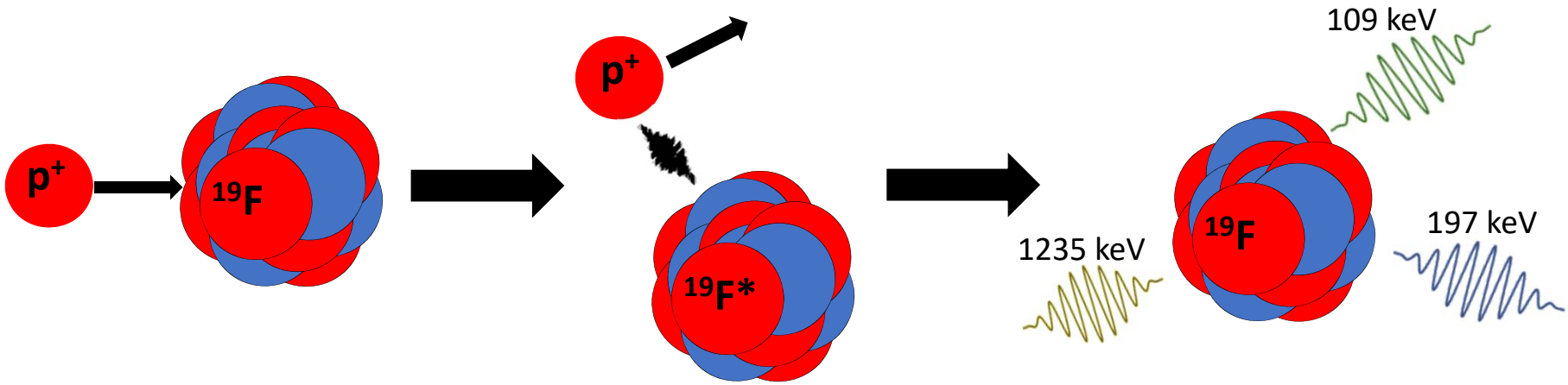
John Wilkinson

University of Notre Dame

Developing PIGE into a Rapid Field-Screening Test for PFAS

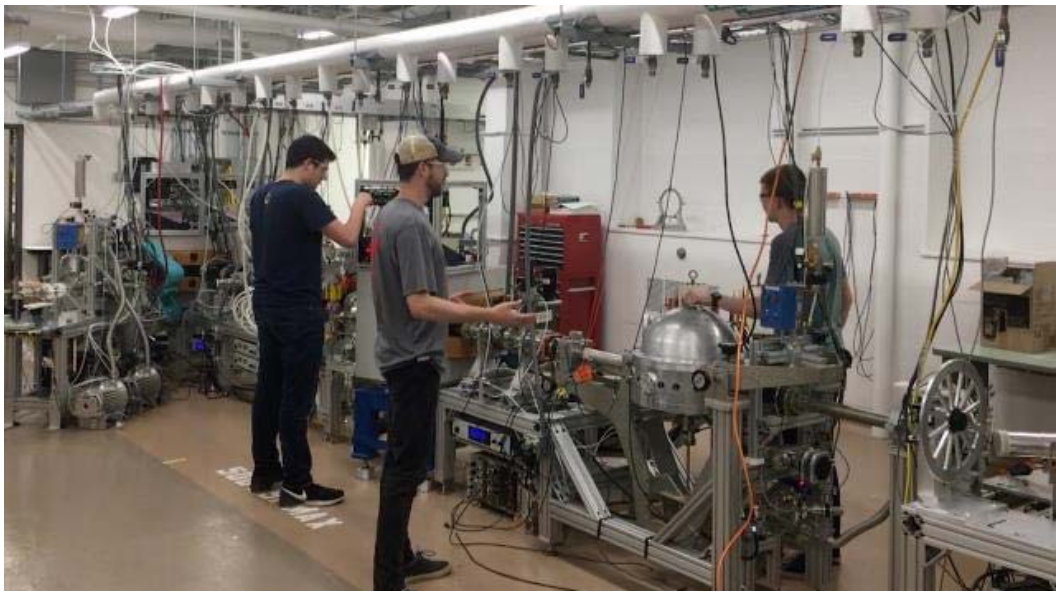
What is PIGE?

- Particle-Induced Gamma Ray Emission Spectroscopy
  - Nuclear de-excitation at discrete and characteristic energies



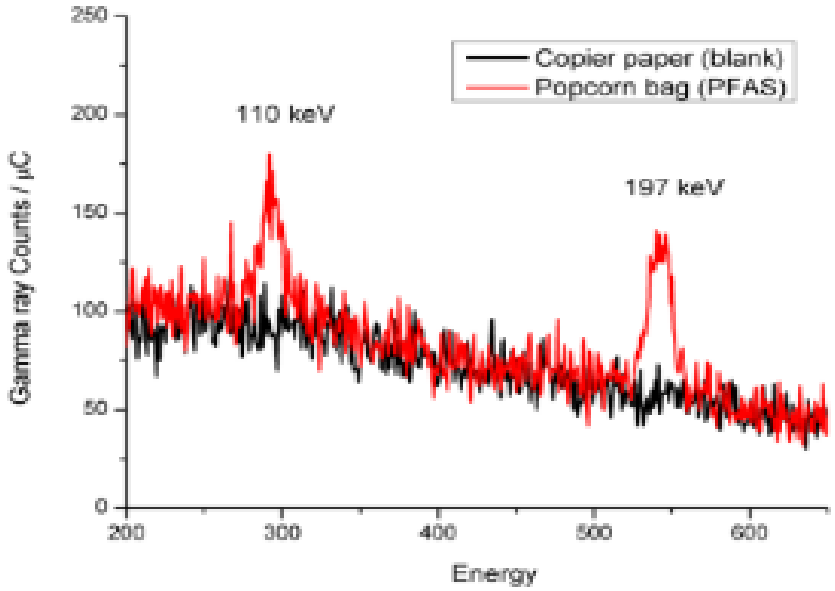
Notre Dame Nuclear Structure Laboratory

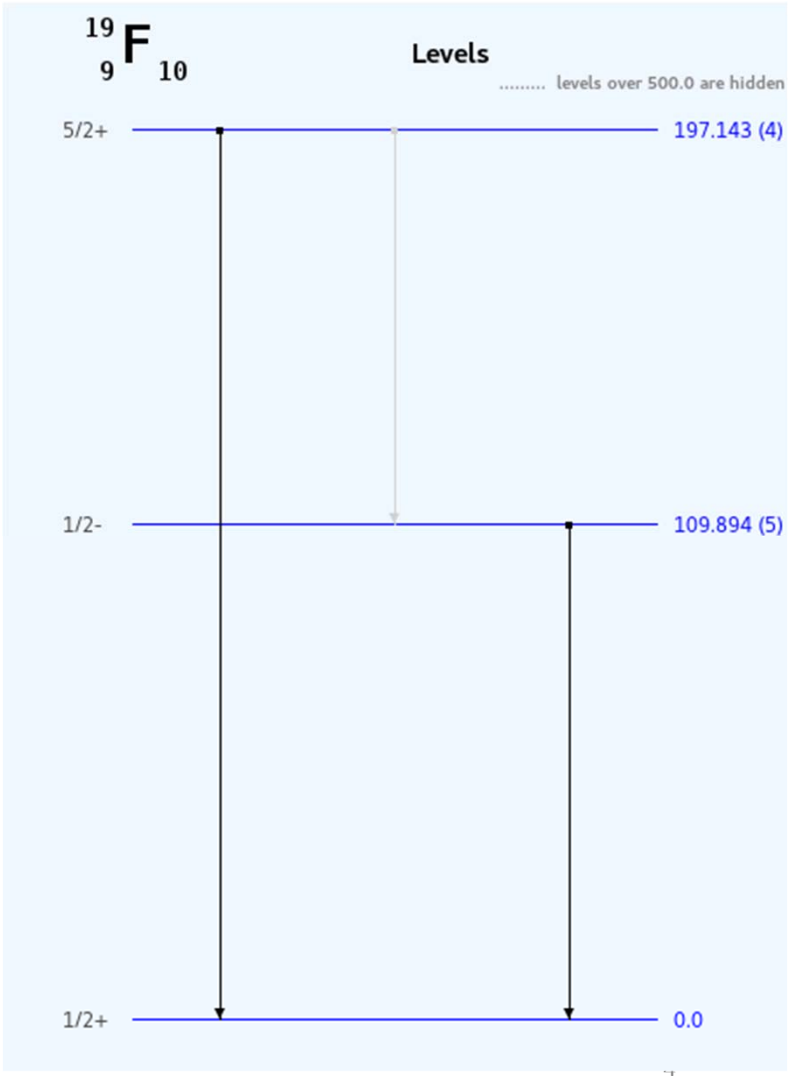
- Modified Alphatoss ion source
- 3 MV tandem accelerator
- ~4 MeV proton beam
- ~50nA beam current



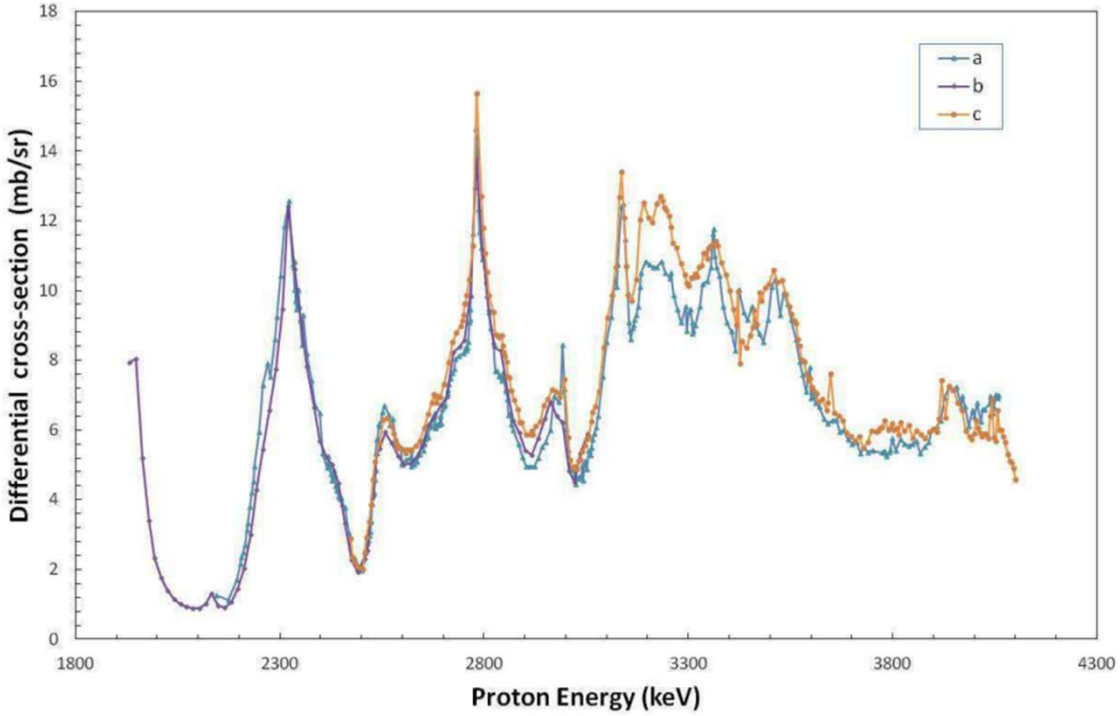
Ion Beam Analysis

- High Purity Germanium (HPGe) Detector
- Samples mounted *ex-vacuo*
- Argon normalization

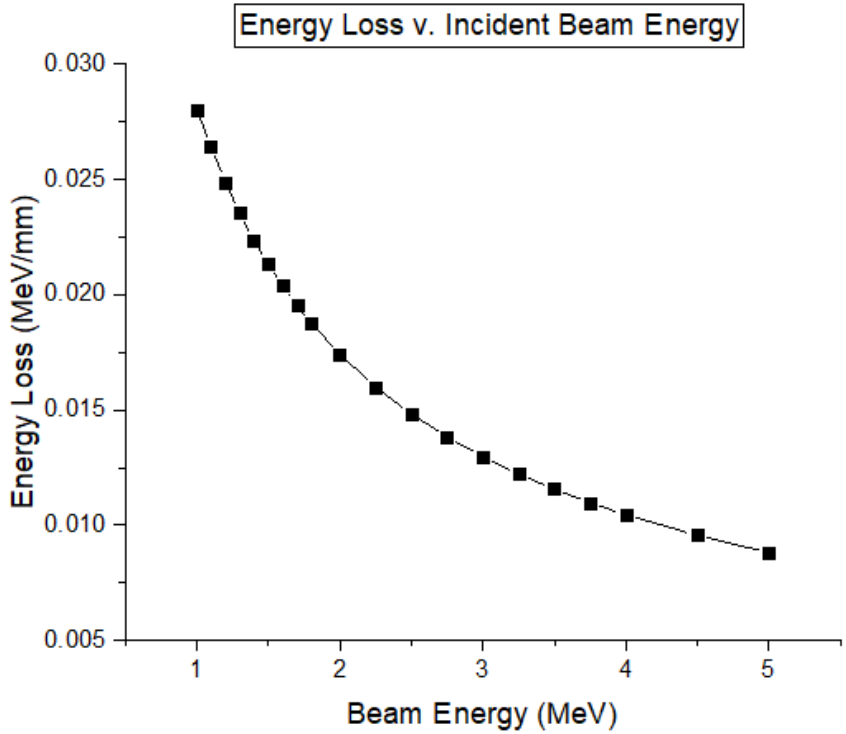




Beam Interactions with Matter



IAEA-TECDOC-1822



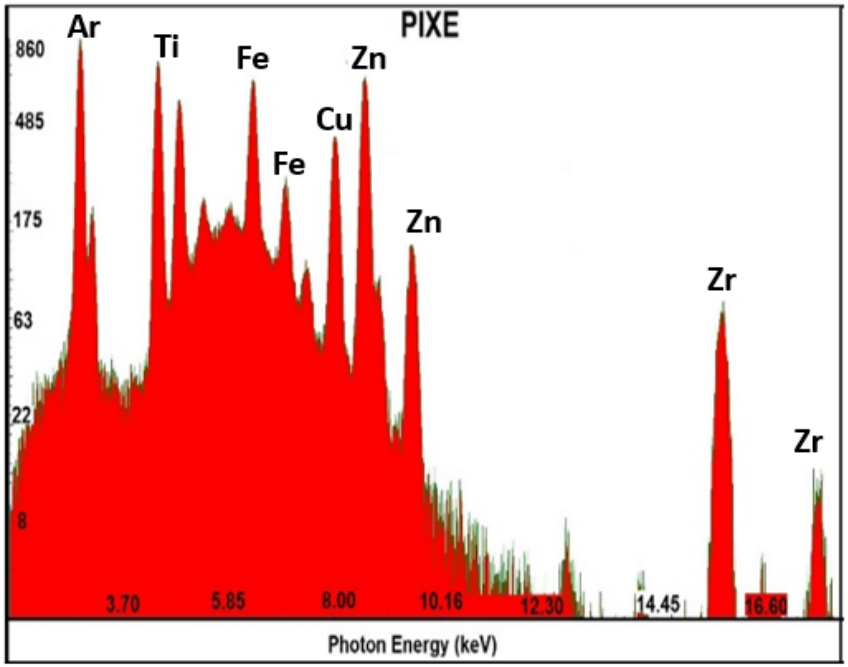
Prior Applications

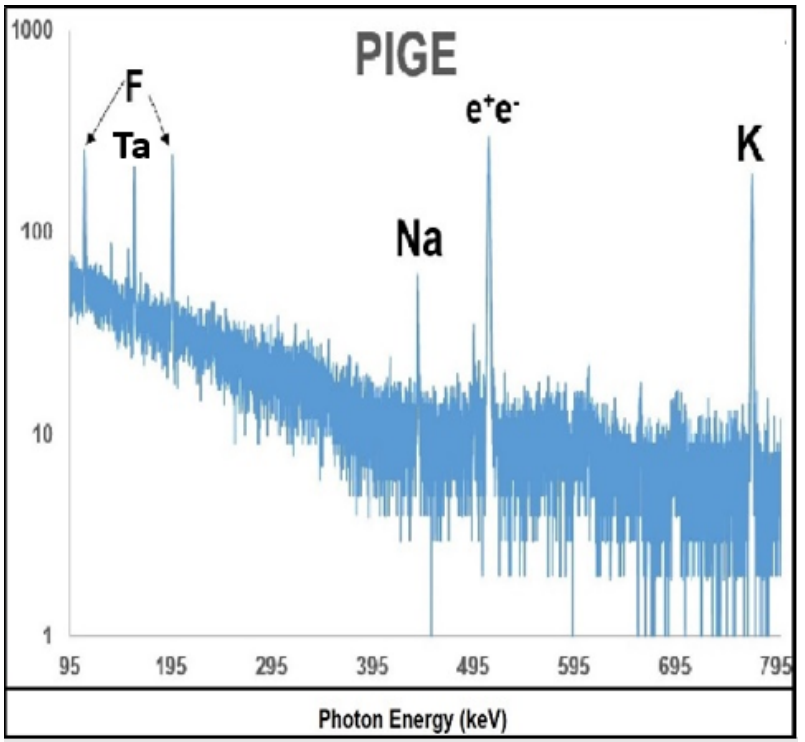
ENVIRONMENTAL Science & Technology LETTERS
pubs.acs.org/journal

Fluorinated Compounds in U.S. Fast Food Packaging

Laurel A. Schaider,*[†] Simona A. Balan,[‡] Arlene Blum,[§,∥] David Q. Andrews,[⊥] Mark J. Strynar,[#] Margaret E. Dickinson,[▽] David M. Lunderberg,[▽] Johnsie R. Lang,[○] and Graham F. Peaslee[@]

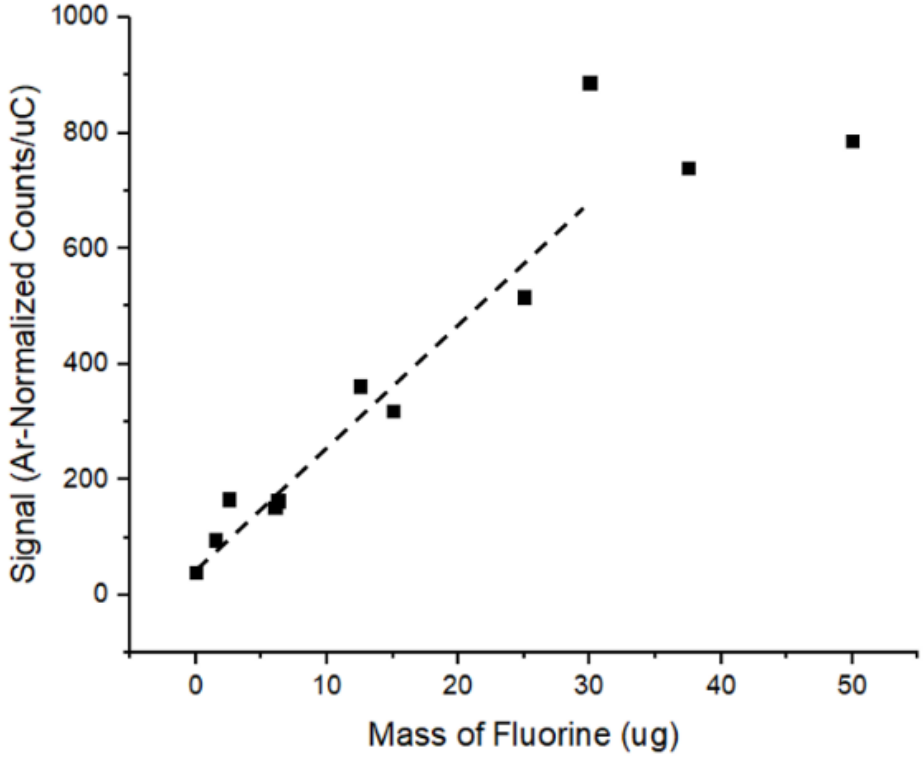
- Solid Target Analysis – Firefighting gear, carpets, food packaging, dust
- PIXE/PIGE co-contaminants





Solid Phase Extraction

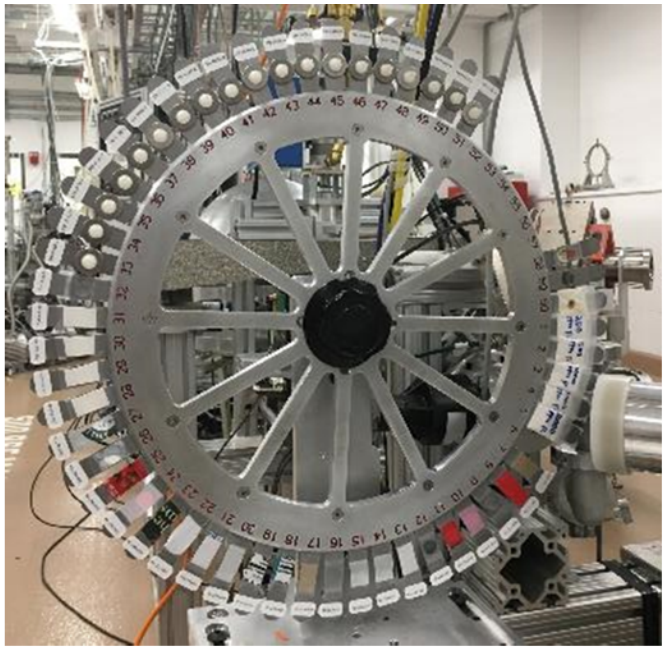
- Waters Oasis WAX cartridges
- 3mL activation washes
  - Ammonium Hydroxide in Methanol
  - Methanol
  - De-ionized Water
- Vacuum filtration and air dry
- Solidify target with Shellac
- LOD- 0.45 µg fluorine



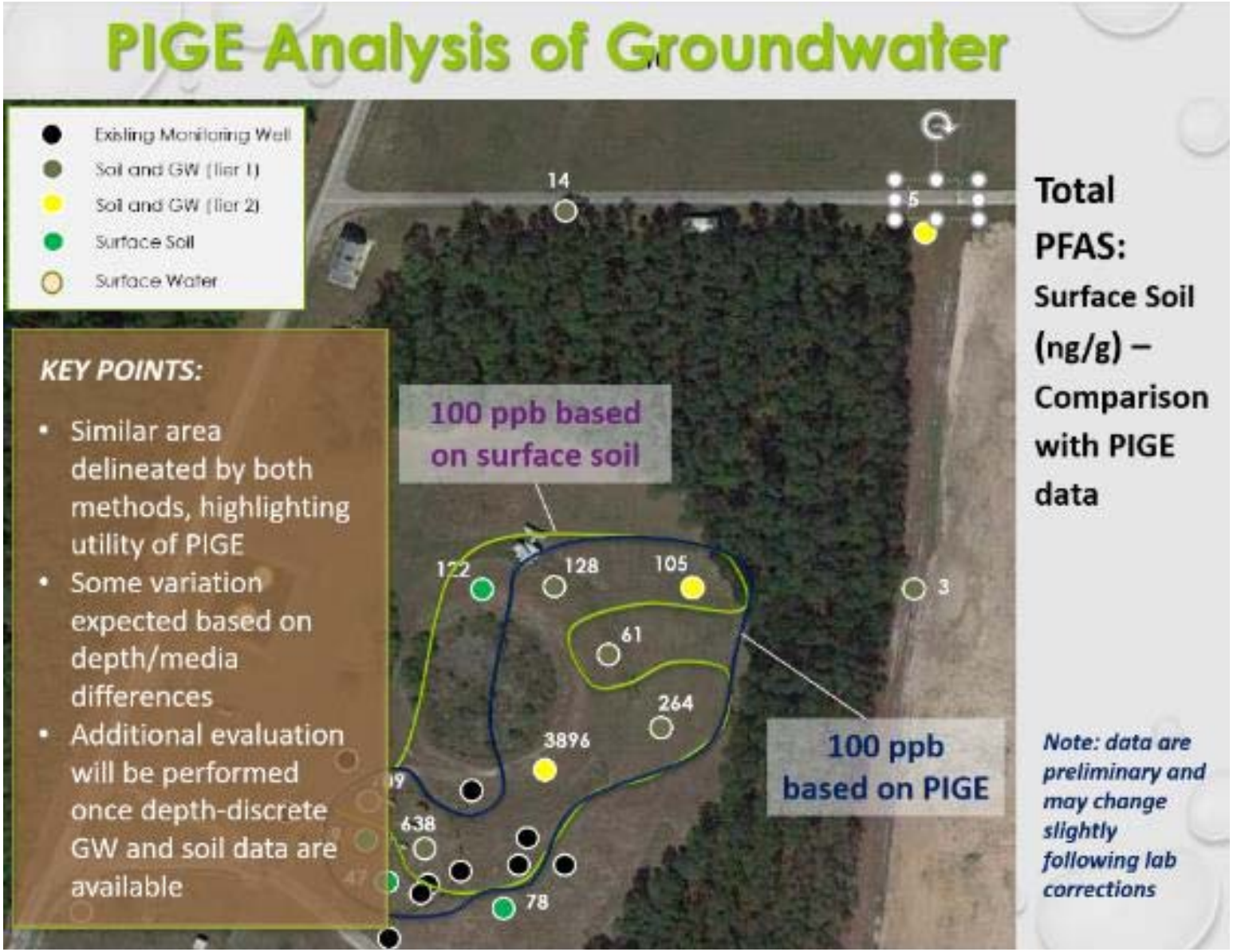
(Courtesy of E. McGill)

Aqueous Analysis

- Aqueous film forming foams (AFFF), groundwater, wash water



PIGE Analysis of Groundwater



KEY POINTS:

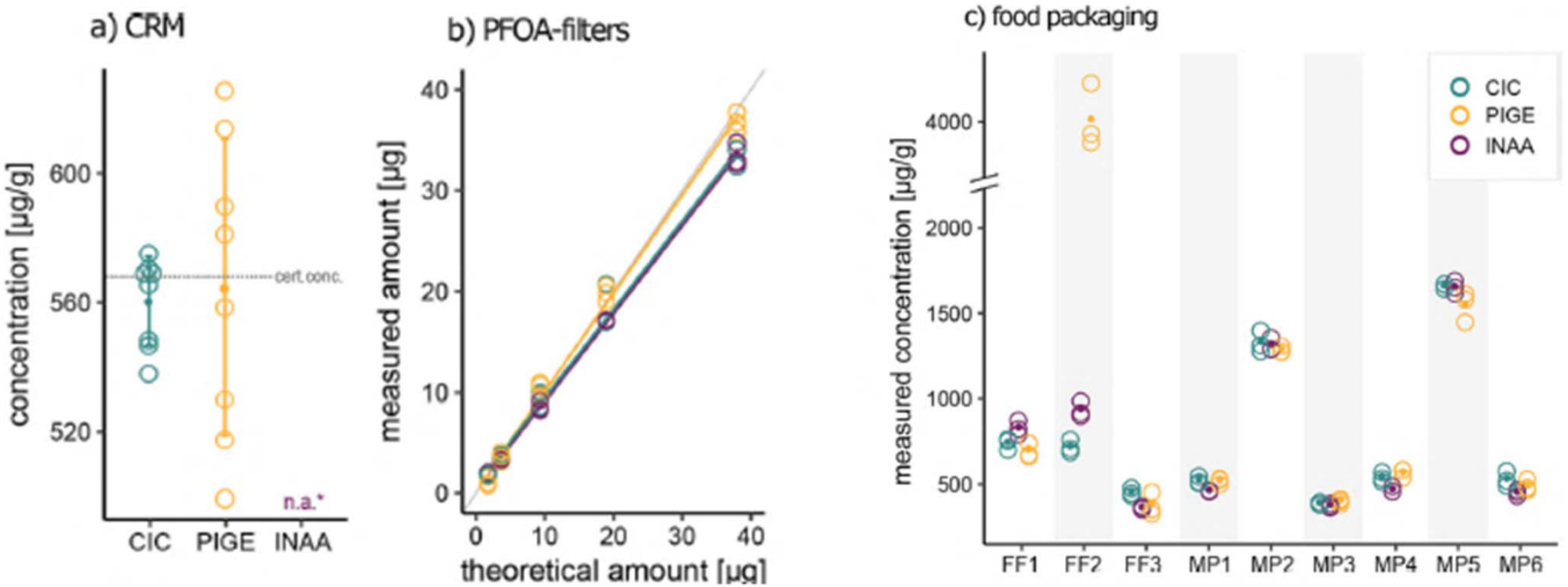
- Similar area delineated by both methods, highlighting utility of PIGE
- Some variation expected based on depth/media differences
- Additional evaluation will be performed once depth-discrete GW and soil data are available

Total PFAS: Surface Soil (ng/g) – Comparison with PIGE data

Note: data are preliminary and may change slightly following lab corrections

Total Fluorine Measurement

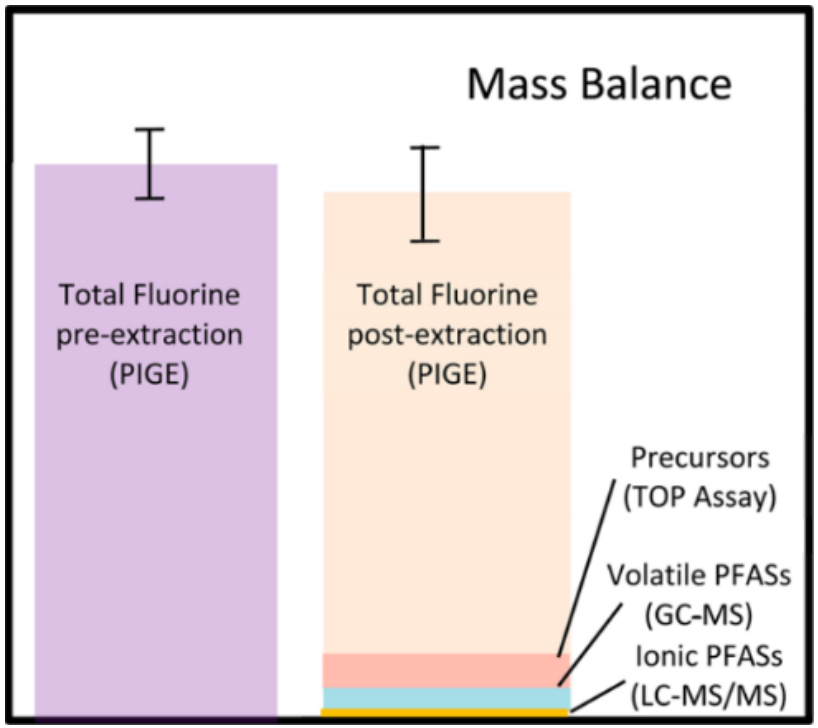
- Method Comparison
  - Combustion Ion Chromatography (CIC) & Instrumental Neutron Activation Analysis (INAA)



Schultes et al. ES&T, 2019

Method Takeaways

- Screening technique
- Rapid sample analysis
- Total fluorine analysis
- ~100x yield of fluorine contaminants



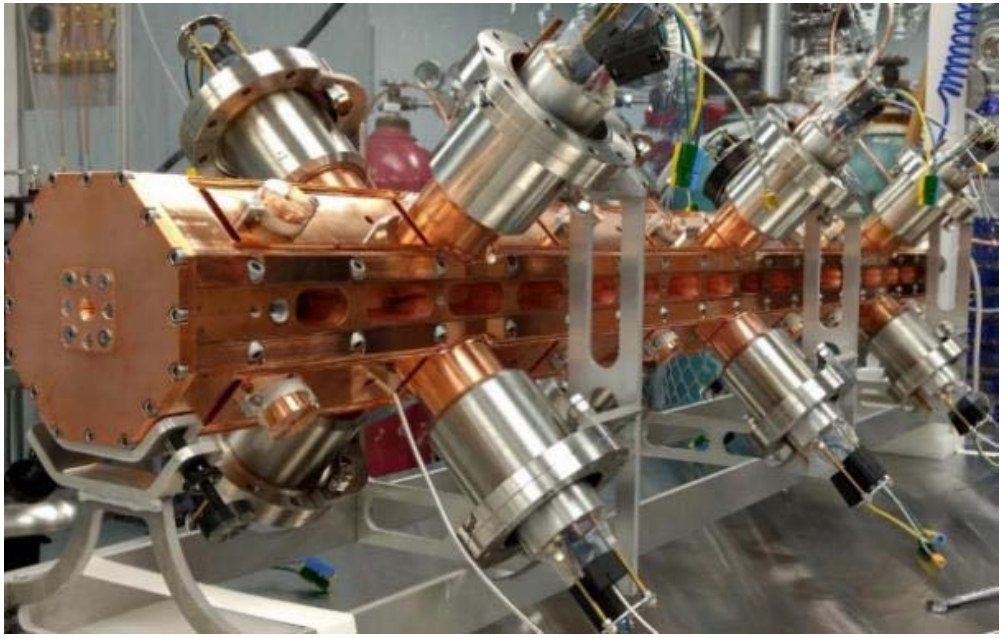
Robel et al. ES&T, 2017

Mobilization

The Centurion™ Technology

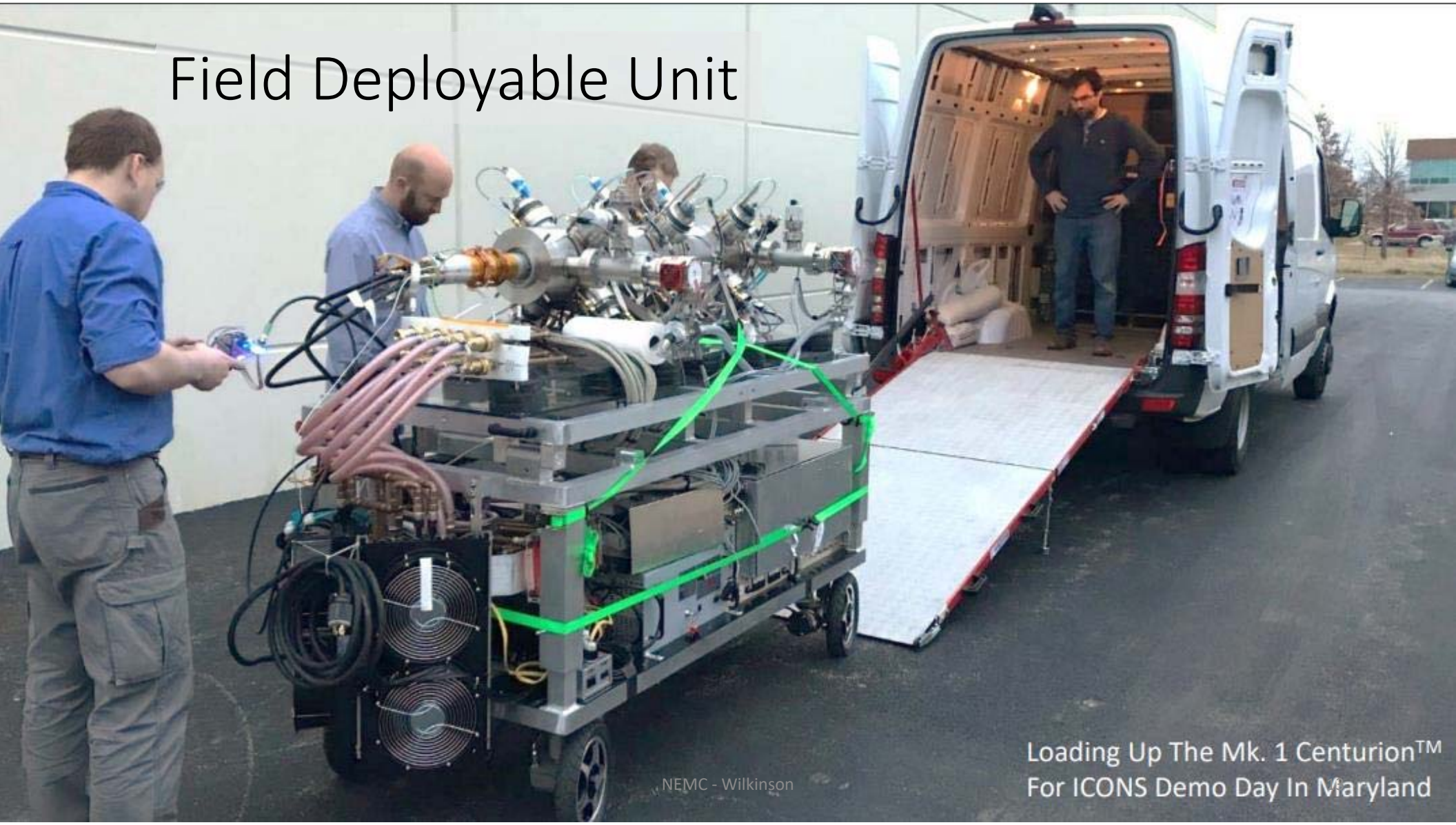
- **Distributed RF Power Injection Using RFQ Cavity As Power Combiner (patent pending)**
  - Hermetic Copper-Ceramic Sealing Technology
  - Air-Side CPT Coupling For Easy Installation
- **Pulsed ECR Plasma Ion Injector**
  - Very Low Beam Emittance
  - Based On nGen™-300 Pulsed System
- **High-Gradient Ion Acceleration (>4MV/m)**
  - Advanced Power Control & Arc Suppression
  - Proprietary Fabrication Methods
- **Small Beam Diameter @ 1-5 MeV**
  - Closely Couples With Moderator/Collimator
  - High-Flux Thermal Management
- **High Power Efficiency For Small Size**

starfire industries



DARPA funded project

Field Deployable Unit



Loading Up The Mk. 1 Centurion™
For ICONS Demo Day In Maryland

In-Development

- Higher volume throughput
- Lower limit of detection
- Membrane alternatives to solid phase extraction

Acknowledgments

- ER19-C2-1142

- Brian E. Jurczyk, Tom Houlahan

- Graham Peaslee, Sean McGuinness