An Applied Nuclear Physics Program at the University of Notre Dame

Graham Peaslee
Department of Physics

NSAC Meeting
April 8, 2019
Nuclear Science Laboratory at the University of Notre Dame

3 active accelerators
All operated by graduate students.
Basic vs. Applied Science

Nuclear Reactions for DHS
Ion Beam Analysis for Archeology
Ion Beam Analysis for Public Health:
  Environmental Lead
  Heavy Metals
  Halogenated Flame Retardants
  PFAS – Consumer Products
    – Environmental Fate
    – Occupational Health
Radioisotope Tracing
Isotope Harvesting
Impact & Education
High-contrast Material Identification by Energetic Multi-particle Spectroscopic Transmission Radiography

J. Nattress\textsuperscript{1},* T. Nolan\textsuperscript{1}, S. McGuinness\textsuperscript{2}, P. Rose\textsuperscript{3}, A. Erickson\textsuperscript{3}, G. Peaslee\textsuperscript{2}, and I. Jovanovic\textsuperscript{1}\textdagger

\textsuperscript{1}Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, MI 48109 USA
\textsuperscript{2}Department of Physics, University of Notre Dame, Notre Dame, IN 46556 USA and
\textsuperscript{3}G.W. Woodruff School of Mechanical Engineering, Nuclear and Radiological Engineering Program, Georgia Institute of Technology, Atlanta GA 30332, USA

Surface Manipulation Techniques of Roman Denarii

Khachatur Manukyan*, Cecilia Fasano, Ashabari Majumdar, Graham F. Peaslee, Mark Raddell, Edward Stech, Michael Wiescher

Nuclear Science Laboratory, Department of Physics, University of Notre Dame, Notre Dame, IN 46556

(Submitted: Appl. Surface Sci., 2019)
Risky Bismuth: Distinguishing Between Lead Contamination Sources in Soils

Meghanne Tighe*,1, Heidi Beidinger3,5, Christopher Knaub3, Matthew Sisk3,4, Graham F. Peaslee2, Marya Lieberman1

1. Department of Chemistry and Biochemistry, University of Notre Dame, Notre Dame IN 46556
2. Department of Physics, University of Notre Dame, Notre Dame IN 46556
3. Eck Institute for Global Health, University of Notre Dame, Notre Dame IN 46556
4. Navari Family Center for Digital Scholarship, University of Notre Dame, Notre Dame IN 46556
5. Department of Biological Sciences, University of Notre Dame, Notre Dame IN 46556

(Submitted: Chemosphere, 2019)
A Survey of Metals Found in Tattoo Inks

Meghanne E. Tighe¹,², D. Kai Libby³, Stanna K. Dorn¹, Jeffrey R. Hosmer³, Graham F. Peaslee²

![Bar Chart](chart.png)

**All Samples**

- **% of samples above EPA approved limit**
- **Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, Sr, Zr, Nb, Mo, Ba, W, Pb**

- Blue: % between LOQ-100ppm
- Yellow: % between 100-1000ppm
- Orange: % between 1000-10,000ppm
- Red: % > 10,000ppm

PIXE
Fire test performance for foam plastic insulation with and without flame retardants: ASTM E119 and ASTM E84

Donald Lucas, Sara M. Petty, Vytenis Babrauskas, David Rich, Avery Lindeman, Graham Peaslee, Arlene Blum

*(Submitted: Fire Technology, 2019)*

Table 2 Measured bromine content.

<table>
<thead>
<tr>
<th>Name of Insulation</th>
<th>Type</th>
<th>Origin</th>
<th>FR Content (BR ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XPS FOAMULAR 400</td>
<td>XPS</td>
<td>US</td>
<td>27800</td>
</tr>
<tr>
<td>XPS SL 300 Sundolitt</td>
<td>XPS</td>
<td>UK</td>
<td>ND</td>
</tr>
<tr>
<td>XES Ecoprim Paroc</td>
<td>XPS</td>
<td>Sweden</td>
<td>ND</td>
</tr>
<tr>
<td>EPS Type XIV Insulfoam</td>
<td>EPS</td>
<td>US</td>
<td>39500</td>
</tr>
<tr>
<td>EPS S300 Sundolitt</td>
<td>EPS</td>
<td>UK</td>
<td>ND</td>
</tr>
<tr>
<td>XPS FOAMULAR 250</td>
<td>XPS</td>
<td>US</td>
<td>41900</td>
</tr>
<tr>
<td>XES Ecoprim Paroc</td>
<td>XPS</td>
<td>Sweden</td>
<td>ND</td>
</tr>
<tr>
<td>EPS Insulfoam</td>
<td>EPS</td>
<td>US</td>
<td>6000</td>
</tr>
</tbody>
</table>
FOR IMMEDIATE RELEASE:
Monday, June 18, 2012

Governor Brown Directs State Agencies to Revise Flammability Standards

- Smolder standards for fabric
- Increased fire safety without flame retardants

Science & Policy
Toys, Décor, and More: Evidence of Hazardous Electronic Waste Recycled into New Consumer Products

Gillian Z. Miller¹, Meghanne E. Tighe², Graham F. Peaslee², Karla Peña³, Jeff Gearhart¹

Holiday and Mardi Gras beads found to contain lead and hazardous flame retardants
The “Forever” Chemicals: PFAS

PFOA

PFOS

STAIN-RESISTANT, NONSTICK, WATERPROOF, AND LETHAL
THE HIDDEN DANGERS OF C8
CALLIE LYONS

microwave popcorn
PIGE Analysis of Fluorine

Fig. 3: PFAS-coated paper sample compared with uncoated paper. Irradiation time of 180 second with 9 nA of 3.4 MeV protons.

Graph:
- Intercept: -2.801
- Slope: 31.398
- Std. Error: 12.597
- Std. Error: 0.876

Graph:
- 110 keV
- 197 keV

Gamma ray Counts / uC

Energy
The Madrid Statement on Poly- and Perfluoroalkyl Substances (PFASs)

http://dx.doi.org/10.1289/ehp.1509934

As scientists and other professionals from a variety of disciplines, we are concerned about the production and release into the environment of an increasing number of poly- and perfluoroalkyl substances (PFASs) for the following reasons:

1. PFASs are man-made and found everywhere. PFASs are highly persistent, as they contain perfluorinated chains that only degrade very slowly, if at all, under environmental conditions. It is documented that some polyfluorinated chemicals break down to form perfluorinated ones (D’Eon and Mabury 2007).

2. PFASs are found in the indoor and outdoor environments, wildlife, and human tissue and bodily fluids all over the globe. They are emitted via industrial processes, firefighting and firefighting operations (Darwin 2011; Firefighter Coalition 2014), and they migrate out of the ground into air (Shoeib et al. 2011), household products (Wilson et al. 2009), food (Begley et al. 2008; Tittlemier et al. 2011), soil (Sepulvedo et al. 2011), surface water and ground water, and make their way through the food chain, as well as into tap water (Eschauzier et al. 2012; Rahman 2014).

3. In animal studies, some long-chain PFASs have been shown to cause liver toxicity, disruption of the immune and endocrine systems, adverse developmental effects, neonatal toxicity and death, and affect multiple organ systems (Lau et al. 2007; Phipps et al. 2011). A growing body of epidemiological evidence shows adverse effects are supported by significant or suggestive associations between specific long-chain PFASs and health outcomes, including associations with testicular dysfunction (Liston et al. 2012) and increased incidence of prostate cancer (Liston et al. 2013).
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

Researchers found fluorinated compounds in a third of the fast food packaging, according to a report from CNN. Researchers find "another reason" to avoid fast food: Chemicals in the packaging. The nasty ingredient in fast-food wrappers from Mother Jones.
Total Fluorine Measurements in Food Packaging: How Do Current Methods Perform?

Lara Schultes,*†‡ Graham F. Peaslee,‡‒§ John D. Brockman,§ Ashabari Majumdar,‡
Sean R. McGuinness,‡ John T. Wilkinson,†‡ Oskar Sandblom,† Ruth A. Ngwenyama,§
and Jonathan P. Benskin†

†Department of Environmental Science and Analytical Chemistry (ACES), Stockholm University, Svante Arrhenius väg 8, SE-10691 Stockholm, Sweden
‡Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, United States
§Department of Chemistry, University of Missouri, Columbia, Missouri 65211, United States

PIGE & INAA & CIC
PFAS & Firefighters

Rate of cancers in firefighters compared to the general public

- Testicular cancer (2.02 times greater risk)
- Multiple myeloma (1.53 times greater risk)
- Non-Hodgkin’s lymphoma (1.51 times greater risk)
- Skin cancer (1.39 times greater risk)
- Prostate cancer (1.28 times greater risk)
- Malignant melanoma (1.31 times greater risk)
- Brain cancer (1.31 times greater risk)
- Colon cancer (1.21 times greater risk)
- Leukemia (1.14 times greater risk)
Field-Deployable PIGE Analysis

Figure S4: (Left) Centurion™ Mk1 system being loaded into a van for transport to an off-site demonstration >1000 miles away. (Right) The compact RFQ LINAC itself (shown assembled with Starfire’s patent-pending RF power injectors) is approximately 4’ long and can be modified for energies between 1—5 MeV.
Radiosynthesis and Biological Distribution of $^{18}$F-Labeled Perfluorinated Alkyl Substances

Jennifer L. Burkenper,†,## Tolulope A. Aweda,† Adam J. Rosenberg,‡,§ David M. Lunderberg,‖ Graham F. Peaslee,⊥ and Suzanne E. Lapi*,†

DOI: 10.1021/acs.estlett.7b00042

Isotope Harvesting on the Proton-Rich Side…

Production of $^{52}$Fe from Symmetric Complete Fusion-Evaporation Reactions

Sean R. McGuinness$^1$, John T. Wilkinson$^1$, Samuel J. Ferran$^2$, C. Shaun Loveless$^2$, Suzi E. Lapi$^2$, and Graham F. Peaslee$^1$

$^1$Department of Physics, University of Notre Dame, Notre Dame, IN 46556
$^2$Department of Radiology, University of Alabama at Birmingham-School of Medicine, Birmingham, Alabama 35294,

(In Preparation: 2019)

$^{52}\text{Fe}$

$t_{1/2} = 8.3$ h
The role of students...
The role of funding agencies...

Is to provide stable funding opportunities for basic research in nuclear science...

However, Federal budgets are rarely increasing and we are increasingly asked what is the purpose of basic research?

Including a small mix of applied nuclear science in the funding portfolio will increase visibility, attract students and can take advantage of current events to increase funding streams...

gpeaslee@nd.edu