



Letter from the Editor



Dear FIP Members,

In this FIP newsletter issue, you will find an overview of our recent efforts in serving the international physics community.

On behalf of the Executive Committee, I want to give a warm welcome to our new elected Executive Members 2019: the

Chair-Elect Luisa Cifarelli (University of Bologna), the *Vice-Chair* Alan Hurd (Los Alamos National Laboratory) the *Secretary/Treasurer* Carlos Bertulani (Texas A&M University, Commerce) and the two *Members-at-Large* Ilham Al-Qaradawi (Qatar University) and William Barletta (Massachusetts Institute of Technology).

Let me thank Noemi Mirkin, our previous Secretary/Treasurer who served the FIP in the past 19 years! Her contribution has always been precious for advancing in all our activi-

ties. She represented the history and the backbone of the FIP in all these years and a reference point for the new Executive members. Thank you again Noemi, for your kindness and all your efforts!

A special thank to the Past Chair Jerry Peterson for his enthusiasm and dedication to the international physics community in 2018 as Chair. For the 2019, I would like to send Elena Aprile all my best wishes for a successful and fruitful year, as current Chair of the FIP.

I hope to see you all at our next APS meetings!

My warmest best wishes to you all,

Maria

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Message from FIP Chair Jerry Peterson



Our Forum has three seats on the APS Committee on International Scientific Affairs (CISA). This Committee advises the APS Board of Directors and APS leadership on all international matters affecting physics. FIP membership on CISA includes the Past Chair, the Chair, and the Chair-Elect. The current Chair of CISA is Carlos Henrique de Brito Cruz ('Brito') from Brazil, and the most recent Past Chair of CISA was Alan Hurd, who was recently elected by

you to begin his FIP leadership as our Vice Chair starting in 2019.

CISA meets twice a year, seemingly always in Washington DC, with its most recent meeting held Saturday October 12, 2018, and this is a summary of matters considered that affect FIP.

The big news is that the APS has recommended that CISA work with the APS Office of International Affairs to create a draft of a new Five-Years Plan for International Engagement, with near- (one year), mid- (three years) and long- (five years) term goals. We must expect strong inputs from members of FIP in outlining, writing, and reviewing this draft. I invite you all to start thinking and discussing what should be in this deterministic Plan.

For instance—if foreign speakers are invited by the FIP for March or April, might we invite those noted physicists to attend and participate in our FIP Executive Committee meetings? How might we make better use of foreign national physicists working in the US? They surely have valuable insights and connections. Should the APS 'recognize' (in the diplomatic sense) groupings of foreign national physicists working in the US? And, OK, we will list some lofty goals. How might we measure our success in meeting these goals? Are current APS (and FIP) efforts to support global collaborations and young people effective? The proposal pressure for the Distinguished Student Program (DSP) and the International Research Travel Award Program (IRTAP) efforts are a very good indicator. How else might we document the successes of the programs in order to find resources to expand them? CISA will have a large responsibility and a large impact on the global implications of our science, and I, for one, would greatly appreciate a wide range of thoughts, ideas, and analyses from our FIP membership as CISA debates and creates the expected Five-Year Plan. Next year I will be the FIP Past Chair member of CISA.

In the meantime, you who are reading this Letter who are members of any diaspora (the APS term) group of physicists working in the US who have common overseas origin please tell me of your group, especially the contact information for the group's leadership, so I may start an informal FIP Directory of these groups.

The African School of Physics: Namibia 2018

Mario Campanelli (CERN and UCL) and Ketevi Assamagan (Brookhaven National Laboratory)

The African School of Fundamental Physics and Applications (africanschoolofphysics.org/) has been founded in 2010 with the aim of promoting fundamental science in Africa, where research in some of these topics is still in an early stage.

So far the school has been biennial, with a continuous mentorship of students even when there is no formal school. The 2018 edition, the fifth, took place in Windhoek, Namibia, after the previous venues of Stellenbosch (South Africa), Kumasi (Ghana), Dakar (Senegal) and Kigali (Rwanda). Students at master and PhD level from various African countries are selected from a vast number of potential candidates based on their academic records, and invited to spend three weeks with their peers and the teachers, following classes in theoretical physics, experimental physics and technological developments, given by world-class experts from universities and research institutes from all over the world (including Africa, and African scientists working outside the continent). Despite the differences in the academic level of the students and in their field of specialization, the lectures and practical demonstrations are always followed with great interest and participation, and are followed by discussions in dedicated sessions and in more informal settings.

The ASP has evolved to be much more than a school. It is a program of actions with directed ethos toward physics as an engine for development in Africa.

Apart from an dedicated public session with policymakers about the



2018 African School and Conference in Windhoek, Namibia

future of science in Africa, for the first time the school was coupled with the first African Conference on Physics and Applications (africanschoolofphysics.org/acp2018/), an international conference with speakers on topics like high-energy physics and astrophysics, nuclear physics, computing, medical physics, renewable energies, outreach and science communication, etc. The students from the school were encouraged to attend a few sessions from the conferences, and the speakers for the conference were participating to the same social program as the students and lecturers of the school, providing interesting opportunities for discussion and networking. In addition, a teachers' program has been developed, with several high-school

teachers from Namibia following a dedicated program of talks and demonstrations of didactic experiments they could perform in a school setting, even with limited means. Finally, a school program running in parallel has taken lecturers from the school giving day-long presentations and demonstrations in schools from various parts of the capital and its surroundings, attended by hundreds of school-children of different age ranges.

The sixth edition of the African School, and the second edition of the conference, will take place in summer 2020 in Marrakesh, Morocco. Even if there is still quite some time to go, the preparation for the venue, the contact with local organizers (some of whom have been regular lecturers in the previous editions of the school, others have visited the Namibia edition) are well under way. A closer interplay between the school and the conference is foreseen, and the program aimed at schools (teachers + students) is expected to be further expanded.

From the APS International Affairs Office

Amy Flatten (APS)



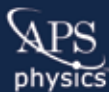
With 2018 having come to a close, I appreciate the chance to begin the new year by reflecting upon the international activities APS undertook over the past year, many of which were offered through a partnership of the Forum on International Physics (FIP), the APS Committee on International Scientific Affairs (CISA), and the APS International Office. As some of you may be aware, the FIP Chair, Past Chair and Chair-Elect, all serve on CISA, allowing for a great opportunity for coordination.

This past year, APS and the Sociedade Brasileira de Física (SBF) continued to offer an exchange program for physics Ph.D. students, postdocs, and professors in the United States and Brazil. Moreover, APS and SBF partnered to host the “SBF-APS São Paulo School of Advanced Science on Experimental Neutrino Physics”, held December 3-14, at the University of Campinas (Unicamp), in Campinas, São Paulo, Brazil. The idea for the school came from discussions by CISA, following a successful APS-SBF Young Physicists Forum that was held in Baltimore, in 2016. The School included approximately 100 Ph.D. students/early pos-docs representing diverse countries, including ~ 20 participants from the United States.

Likewise, APS continued to lead the SESAME Travel Award Program, a partnership of 11 scientific societies in Europe and the United States that support training opportunities for scientists in the Middle East. Likewise, APS also served developing country physicists through FIP’s International Research Travel Award Program and also through the Entrepreneurship Workshops cosponsored by APS, the UK Institute of Physics, International Centre for Theoretical Physics and other societies.

As we look ahead to 2019, we can feel energized about the growing opportunities for APS to serve the international physics community. In past issues of the FIP Newsletters, I have shared news of the Task Force on Expanding International Engagement, launched by APS CEO, Kate Kirby. The Task Force has spent 18 months reaching out to APS members and partners regarding how the Society can expand its offerings, strengthen its connections, and ensure its long-term value to the international physics community.

I am pleased to announce that the Task Force’s report and recommendations were presented to the APS Council of Representatives at its meeting in November 2018. Likewise, the Task Force report and recommendations will be highlighted as the *APS News* “Back Page” feature in the January 2019 issue, and will be available on the APS website in the new year. I look forward to working with FIP in 2019 to expand the Society’s international engagement. We can feel proud of our past efforts and can anticipate an exciting year ahead.



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APS FIP Fellows 2018

It is a pleasure to recognize and congratulate our five FIP members who have recently been elected to APS Fellowship upon nomination by the FIP. They have been awarded for their significant contributions to physics and the advancement of physics throughout the world.

Congratulations to all!



Ming-Chung Chu
The Chinese University of Hong Kong

Citation: For pioneering work in neutrino physics experiment in Daya Bay, and for his dedicated efforts in nurturing, promoting and internationalizing the STEM education in Hong Kong, as well as promoting international collaboration through the Daya Bay reactor neutrino experiment and ATLAS.



Amy K. Flatten
American Physical Society

Citation: In recognition of her program development serving physicists worldwide, especially in support of scientists in the Middle East through the SESAME Travel Award Program, and for fostering new opportunities for international collaboration among young physicists from diverse cultural backgrounds.



Jason S. Gardner
National Synchrotron Radiation Research Center

Citation: For leadership in the application of neutron scattering techniques in geometrically-frustrated magnets, for global outreach in neutron scattering and for the support of international students and scientists worldwide in their early careers.



Ernesto A. Medina
School of Physics and Nanotechnology, YachayTech, Ecuador

Citation: For many contributions to the physics of quantum transport in disordered and spin active media, and for his deep influence on physics in Venezuela, through teaching as well as through leadership in research.



Alexander Valishev
Fermilab

Citation: For outstanding contributions to the physics of particle beams at the international research facilities, such as the Tevatron and the Large Hadron Collider, for leadership in accelerator science, and for tireless mentorship and supervision of an international summer internship program at Fermilab.

Denver, CO
April 13 - 16

quarks 2019 cosmos

A banner for the APS April Meeting 2019. The background is orange with white and blue abstract lines and curves. On the left, it says "Denver, CO April 13 - 16". On the right, it says "APRIL MEETING 2019" in a dark blue box, and below that, "quarks 2019 cosmos" in a stylized font where the '2019' is large and the 'quarks' and 'cosmos' are smaller.

Applications of Accelerators in Nuclear Science from the Viewpoint of Photon Activation Analysis

Philip Cole, Physics Dept. Lamar University



I would first like to thank the organizers of the Forum on International Physics for the opportunity to give an invited talk on the **Applications of Accelerators in Nuclear Science from the Viewpoint of Photon Activation Analysis** in the section Opportunities in Global Science Industries for the 2018 APS April Meeting. Not only was it a joy to give the talk, but it serendipitously resulted in a book contract. A representative of Cambridge University Press was in the audience. The upcoming second edition¹ will be a thoroughly revised and updated edition of Photon Activation Analysis², which is currently out of print.

I will give a brief background on the physics of photon activation. Photon Activation Analysis (PAA) is based upon the photonuclear interaction. When a photon of energy 15 MeV, say, strikes a nucleus, a neutron can be liberated, and through these means, an excited, proton-rich nuclide is formed. These photons are produced, for example, when a 30-MeV electron beam is directed onto a rather thick slab of a high-Z radiator, usually of thickness of around two radiation lengths. Most of the post-bremsstrahlung electrons will be stopped in this thick radiator or converter. The bremsstrahlung photons have a characteristic $1/E_\gamma$ fall-off and will span the entire cross section of the giant dipole resonance curve. Thus, the yield of knockout neutrons is a convolution of the bremsstrahlung spectrum with the photonuclear cross section in the giant dipole resonance regime as can be seen in Fig. 1.

During photon activation analysis, nuclides of the analyte elements in the material samples are excited to radioactive nuclides. The high-energy photon interacts with the target nucleus and in the ensuing photonuclear reaction, a nucleon (proton or neutron) is ejected from the probed nucleus. Usually this nucleon is a neutron, as the Coulomb energy barrier will tend to inhibit protons from escaping. In fact, the most important contribution to the total photoneutron cross section in the giant dipole resonance region, by far, is single-neutron emission from the photo-excited nucleus. The resulting nuclide will be a proton-rich isotope of that interrogated element. In most cases, the isotope is unstable and this excited nuclide will cascade down to its ground state; usually through emitting several gamma rays, each having a characteristic energy ranging from ~ 100 keV to several MeV. Measuring these discrete gamma rays will “fingerprint” the nuclide; the resulting characteristic spectral lines can then be identified with an appropriate spectrometer, such as a high-purity Germanium (HPGe) detector as indicated in Fig. 2. And through the spectroscopy of identifying peaks within the complete gamma-energy spectrum, each chemical element – not the chemical species – can be detected qualitatively.

¹ C. Segebade, V. Starovoitova, and P.L. Cole, *Photon Activation Analysis: Theory, Procedures, and Applications*, Cambridge University Press (expected January, 2020).

² C. Segebade, H.-P. Weise, and G.J. Lutz, *Photon Activation Analysis*, W. de Gruyter & Co. (1988).

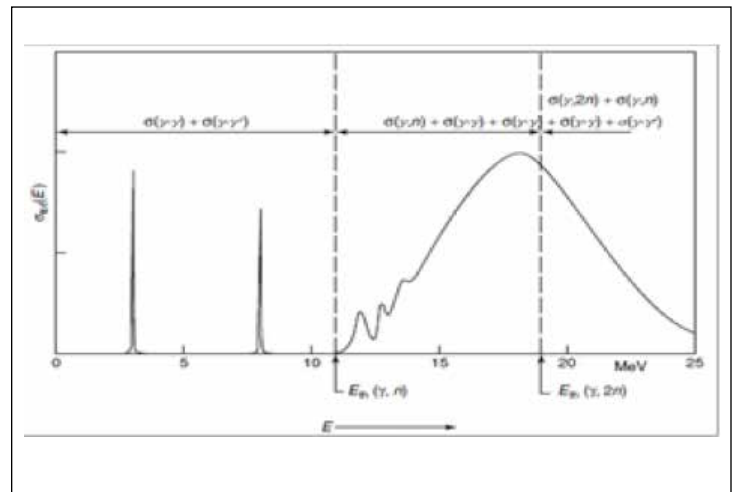
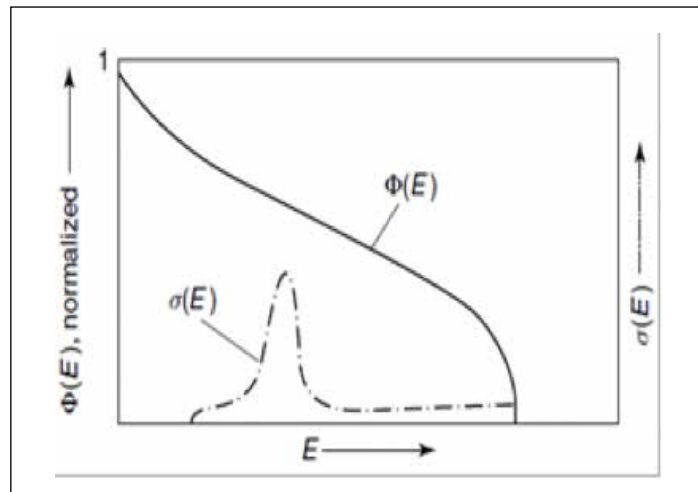


Figure 1. (Left) Bremsstrahlung continuum and photonuclear cross section; $\Phi(E)$, differential bremsstrahlung photon flux density; and $\sigma(E)$, differential cross section, both as functions of photon energy. (Right) Total (γ, γ) and (γ, xn) absorption cross section; σ_{tot} , total photon absorption cross section; E_{th} , threshold energy.

Photon activation analysis gives information on the type of element present within the sample. It cannot, however, determine the absolute number of nuclides activated. One cannot know *a priori* the exact mass of each of the separate elements within a random sample. Assuming uniform irradiation of the sample under interrogation, with all other beam parameters held fixed, the number of the proton-rich nuclides produced will scale with the absolute number of the interrogated isotopes of a specific element. Once the photon activation period is complete, the decay gamma rays from the excited nuclides will be measured. And similarly a greater number of the photoproduced nuclides will be reflected by the higher intensities of the characteristic spectral signals, which are emitted from the proton-rich nuclides as they decay to ground state. To determine the absolute masses of specific elements of the samples under scrutiny, a

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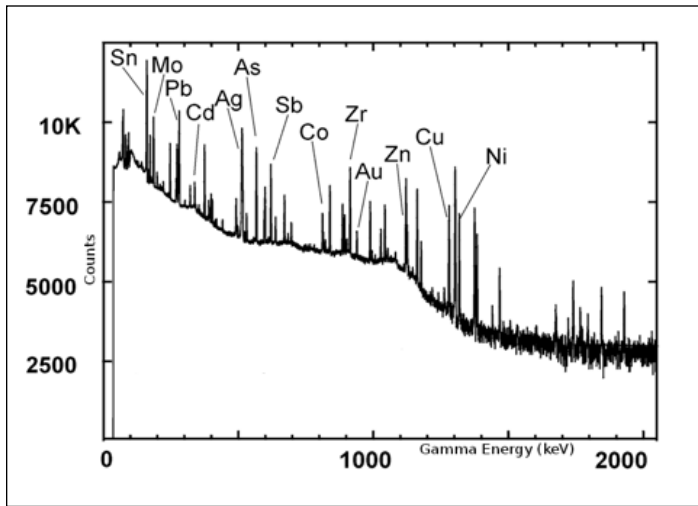


Fig 2. A typical gamma energy spectrum of multi-element sample, where the elements can be identified by the characteristic gamma energies.

calibration material will have to be irradiated along with the interrogated sample. One usually employs a standard calibration material, where the elemental components are well known. After making the necessary spectroscopic measurements, we compare the spectra of the sample with that of the calibration material. We then can exactly determine the elemental make-up and thereby can ascertain the absolute concentration of specific elements present within the sample.

The primary advantage of this *in situ* method of PAA (sample with a reference or calibrator) is that it can be carried out non-destructively. One does not need to specially prepare or machine the sample and hence there is a reduced danger of contamination from the debris of aggregated particles. And with this ease of handling, many more kinds of materials are open to investigation, especially materials, which are difficult to treat chemically, such as dust particles, fly ash, etc. Another advantage of PAA is its inherent high sensitivity. PAA has wide latitude of applications, ranging from the very small, i.e. minute mass, such as microgram dust particles, to the very big, i.e. massive multi-kilogram samples. In any case, should one wish to element analyze a large object – be it precious or inexpensive – large volume irradiation facilities can be engineered for employing PAA. This is easily achieved by using an electron accelerator with a suitably designed bremsstrahlung converter which will allow for large-aperture rastering to provide an appropriate photon beam flux for proper activation.

In the talk I touched upon several applications:

- environmental (dust particles, volcanic ash, electronic waste, etc.),
- agriculture (e.g. coffee plant provenance and the soil),
- biological (plant materials and tissues),
- forensic science,
- geological and extraterrestrial materials (ores, meteorites, lunar samples, etc.),
- art and archaeology,
- raw products, industrial, and high purity material,

waste material assay, and Harvey recovery assay. [this tropical storm dumped 1.2 m of rain in SE Texas over 4 days]

Tabulated in Table 1 below, we find the photonuclear reactions, where the second column expresses the primary one-neutron knock-out (see above) mechanism for photoproducing a nuclide or isomer. An excited nuclide will tend to beta decay and subsequently give off specific γ rays (photons) as it goes to ground state; these gamma-energy fingerprints are delineated in the fourth column. These spectral lines (γ rays) can be identified from a well-calibrated HPGe detector described above. In the third column one can see the half-life or the time for half the excited nuclides to decay. For the elements of interest, the decays can be mere seconds to days. This process follows an exponential-decay curve.

Element	Reaction	Half-life	Eg, [keV]*
Chlorine	$^{35}\text{Cl}(\gamma, n)^{34}\text{mCl}$	32 m	146 (36)
			2129 (48)
Calcium	$^{44}\text{Ca}(\gamma, p)^{43}\text{K}$	22.2 h	372 (100)
			616 (87)
	$^{48}\text{Ca}(\gamma, n)^{47}\text{Ca}$	4.54 d	1297 (75)
Chromium	$^{52}\text{Cr}(\gamma, n)^{51}\text{Cr}$	27.7 d	320 (10)
Iron	$^{57}\text{Fe}(\gamma, p)^{56}\text{Mn}$	2.58 h	847 (99)
			1811 (30)
Cobalt	$^{59}\text{Co}(\gamma, n)^{58}\text{Co}$	71.3 d	811 (99)
Nickel	$^{58}\text{Ni}(\gamma, n)^{57}\text{Ni}$	36 h	1378 (85)
			1920 (10)
Zinc	$^{68}\text{Zn}(\gamma, p)^{67}\text{Cu}$	62 h	93 (16) ^a
			185 (45) ^a
Arsenic	$^{75}\text{As}(\gamma, n)^{74}\text{As}$	17.8 d	596 (60)
Selenium	$^{76}\text{Se}(\gamma, n)^{75}\text{Se}$	120 d	136 (58) ^a
Bromine	$^{79}\text{Br}(\gamma, 2n)^{77}\text{Br}$	56 h	239 (26)
Cadmium	$^{116}\text{Cd}(\gamma, n)^{115}\text{Cd}$	53.4 h	527 (43)
			$^{115}\text{Cd} \rightarrow ^{115}\text{mIn}$
Tin	$^{112}\text{Sn}(\gamma, p)^{111}\text{In}$	2.83 d	171 (91) ^a
			245 (94)
Antimony	$^{123}\text{Sb}(\gamma, n)^{122}\text{Sb}$	2.7 d	564 (63)
Thallium	$^{203}\text{Tl}(\gamma, n)^{202}\text{Tl}$	12.2 d	439 (95)
Lead	$^{204}\text{Pb}(\gamma, n)^{203}\text{Pb}$	52.1 h	72.8 (47) ^a
			278 (81)
Uranium	$^{238}\text{U}(\gamma, n)^{237}\text{U}$	6.75 d	59.5 (35) ^a
			208 (23)

Table 1. Photonuclear reactions of the elements (*Value in parentheses is the emission probability [%], exclusively via a low-energy photon spectrometer).

For low-Z elements, from H to B, no analytically useful radionuclides are produced. From carbon, nitrogen, oxygen and fluorine pure β^+ -emitters are produced by (γ, n) -reactions. These radionuclides cannot be analyzed by means of nuclide specific gamma-rays, but only by detecting the unspecific 511-keV annihilation radiation, which originates from positrons emitted from radioactive nuclei

being absorbed in the surrounding material. In the annihilation process, a positron captures an electron from the material forming positronium, which then decays by conversion of the positron and electron rest mass (511 keV each) into two 511-keV photons. These two 511-keV photons are simultaneously emitted into opposite directions. Since only the 511-keV annihilation radiation is available for the analysis of the light elements up to fluorine, a chemical separation of these elements must be performed.

In the case of medium and heavy elements, however, the radionuclides produced by photonuclear reactions emit – with very few exceptions – characteristic gamma-radiation. Due to the specific gamma-radiation an instrumental multi-element analysis of medium and heavy elements using high resolution gamma-ray spectroscopy becomes possible. In general, photoneutron reactions – (γ, n), ($\gamma, 2n$), etc. – result in neutron-deficient nuclides. In the case of low-atomic-number nuclei, their predominant decay mode is β^+ -emission, which leads to excited states followed by decay to the ground state. Neutron deficient radionuclides with medium and high atomic number decay through two competing modes, namely β^+ -emission and electron capture. Electron capture usually leaves the decay product in an excited state, which will return to the ground state through gamma-ray emission. Instead of positron emission, the nucleus captures an orbital electron – predominantly a K-electron – thus leaving an electron hole in the K-shell. When this hole is subsequently filled by an electron from a higher shell, characteristic x-rays are produced, or an Auger electron is emitted. For heavy nuclei, x-ray emission is favored and the xray energy is proportional to the square of the atomic number.

Photonuclear cross sections are poorly known in the Giant Dipole Resonance region ($5 < E_\gamma < 30$ MeV) for the vast majority of elements and common isotopes. There have been no new cross-section data since the mid 1980s. Photo-induced reaction cross-section data are of importance for a variety of current or emerging applications. Among them are:

- Radiation shielding design and radiation transport analysis (of particular concern are photoneutrons produced by photons with energies above the neutron separation energy, typical above about 8 MeV),
- Photoproduction of rare isotopes, including radioisotopes for therapy.
- Calculations of absorbed dose in the human body during radiotherapy,
- Physics and technology of fission reaction (influence of photoreactions on neutron balance) and fission reactors (plasma diagnostics and shielding),
- Activation analyses, safeguards and inspection technologies (identification of materials through radiation induced by photonuclear reactions using portable bremsstrahlung devices),

- Nuclear waste transmutation, and
- Astrophysical nucleosynthesis.

A facility having a 30-MeV electron continuous-wave linear accelerator or a microtron, coupled with proper detectors for coincidence measurements, would enable the necessary photonuclear reactions for measuring the total cross section as a function of the photon energy and the cross sections for $1n$, $2n$, np , $1p$, etc. Such a unique facility would make a significant impact on the world knowledge of photo-induced reactions on nuclei and address the burning issues of radiation shielding design, rare-isotope and radioisotope production and the ensuing calculations of absorbed dose on the human body, physics and technology of fission reactors, nuclear waste transmutation, and conceivably the identification of proper C/N/O ratios for explosives detection. And with the upcoming advent of the TRIUMF's new electron linear accelerator³ in 2021, such absolutely necessary cross-section data can finally be accessed and realized.

Again, I wish to thank the organizers of the Forum for International Physics for giving me this wonderful opportunity to discuss the often-overlooked area of photon activation analysis. And I further wish to thank my colleagues Dr. Christian Segebade (retired, Bundesamt für Materialforschung und -prüfung in Berlin, Germany) and Dr. Valeriia Starovoitova (International Atomic Energy Agency, Vienna, Austria).

Philip Cole received his PhD from Purdue University in 1991 and was a postdoctoral researcher and then an Assistant Research Professor at George Washington University. Dr. Cole held a JLab-Bridged Assistant Professorship at the University of Texas at El Paso (1997-2004) and received the 1999 NSF CAREER Award in Nuclear Physics and was honored as the Society of Physics Students Advisor of the Year in 2002. While at Idaho State University (2004-2017), he was twice elected Chair of the Faculty Senate and he recently became Professor Emeritus from that institution. In 2014/2015 he was a Fulbright Scholar at the University of Bonn. Dr. Cole was twice elected Chair of the Accelerator Applications Division of the American Nuclear Society and has been the General Chair for three iterations of the International Topical Meeting on the Applications of Accelerators (AccApp'15, AccApp'17 & the upcoming AccApp'20). He holds one U.S. patent on a nuclear physics accelerator application. On Sept 1, 2017, he officially began his new position as Chair of the Physics Department at Lamar University, just two days after Tropical Storm Harvey dumped 66 cm of rain in one night in Beaumont, Texas (and 154 cm in total). Thus his abiding interest in using photon activation analysis for soil assay in Harvey recovery studies.

³ fiveyearplan.triumf.ca/teams-tools/e-linac-electron-linear-accelerator/

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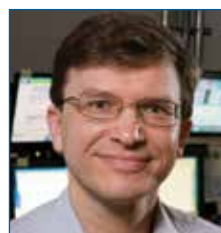
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