Accelerator Section

Q4 2023

HPS Accelerator Section Newsletter

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All articles are to be considered personal/professional in nature and do not reflect the opinions of the institutions described unless otherwise stated.

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President's Message: Adam Stavola

We are in an exciting time for the field of Health Physics. With a renewed focus on clean nuclear energy from the Department of Energy, exploratory agreements by the Nuclear Regulatory Commission, exciting prospects for new medical treatments using radiopharmaceuticals and direct irradiations, and various new industrial applications, the future for nuclear and radiological technology is looking bright. Our field is vibrant and is vital in ensuring the longevity of these endeavors. As members of the Accelerator Section of the Health Physics Society, we are intimately aware of the rapid pace of innovation, and the responsibilities placed on us. We hold a special privilege in helping to usher new technologies to the greater public while ensuring their uses are ethical and safe practices are upheld.

With that said, I implore you to reach out and engage our community. Nothing is done in isolation, and the ability to lean on your fellow colleagues is extremely beneficial, especially in the accelerator community. This is why we'll be instituting a "Question(s) of the Article" section in upcoming newsletters. We are incredibly grateful to our article contributors, but we hope soliciting questions will establish a less-formal, natural dialogue across the community. Further, we hope this will increase engagement across the section.

We are soliciting questions from the section on any topic related to (accelerator/general) health physics and will post these on our website and email the question to solicit responses. Responses will be provided in the subsequent article. We are a community of practitioners and professionals, I hope this communication channel will allow us to share our experience across the section. If you would like to submit a question, please send your question to hpsaccelerator@gmail.com and indicate if you would like to ask anonymously or have your contact information listed.

As a closing note, I would like to extend a special thanks

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to Andrew Rosenstrom for volunteering as a mentor for the first HPS Hackathon representing the Accelerator Section of the Health Physics Society. Andrew crafted a unique, real-world problem that will challenge students and career Health Physicists alike.

The Hackathon will be a grueling 24-hour challenge in which a team of students and early career Health Physicists must approach a research problem that is provided in the form of an abstract. The team must research the problem, understand the fundamental challenges, develop a proposed solution, and devise an experimental strategy. The culmination of the project will be a 5-minute talk on the results. The winning team will be announced at the HPS/IRPA 2024 meeting and awarded a cash prize!

The challenge is meant to be fun, engaging, and provide rewarding networking opportunities across our communities. If you are early in your career or a student member, stay tuned for the participation announcement!

100 Words From Board Member Daniel I. Menchaca, CHP

Dan Menchaca is a Senior Health Physicist at Texas A&M Cyclotron Institute. The Institute houses two cyclotrons, a K500 capable of 80 MeV per nucleon and a K150 capable of 50 MeV per nucleon.

Dan was RSO for Texas A&M University, College Station. Prior to coming to TAMU, he worked for General Electric Company constructing and maintaining nuclear power reactors. He also worked on startup test and monitoring systems for Clinton and Grand Gulf and worked in maintenance outages at various plants.

Dan has been involved in the ABHP Part II Panel, AIRRS, and now the Accelerator Section. Away from the job, Dan enjoys travel and family stuff.

From the Newsletter Editor

We have three articles for the Q4 newsletter, two sourced from the 2023 (68th) Health Physics Society (HPS) meeting in July and one from the 2023 American Chemical Society (ACS) fall meeting (August) Nuclear Chemistry and Technology (NUCL) Division Symposium.

Tom Hansen presented TAM-C.1 "Cyclotron Decommissioning" at the 2023 HPS Meeting; Tom has agreed to write a series of articles about accelerator decommissioning. Shaun Kelley presented PEP 2-E at the HPS Meeting about dose modelling in accelerators.

From the ACS NUCL Division Symposium, Dr. Annie Kersting moderated a panel about internships, postdocs and career jobs at National Labs. Her article provides an overview of career opportunities at National Labs, including contacts.

Accelerator Decommissioning: A Series by Tom Hansen

Ed: Tom has agreed to write a multi-part series on accelerator decommissioning with installments appearing in subsequent issues of this Newsletter.

Part I, Overview

To "decommission" means to remove a radiologically-impacted facility or site safely from service and to reduce residual radioactivity to a level that usually permits release of the property for unrestricted use. Accordingly, decommissioning projects are complex undertakings.

Unlike an organization's regular operation that involves the routine and repeated implementation of radiation control and waste management practices, decommissioning often involves non-routine tasks. Controls that are sufficient during operation are based on the presumption that large amounts of contamination are prevented or cleaned up immediately when they occur; whereas remediation often involves the purposeful breaking up of tightly bound contamination so that it can be removed. Regular operations occur within well-designed rooms with permanently installed engineering features; whereas decommissioning involves degraded structures and the disassembly and removal of contaminated equipment that once provided important engineering controls. Finally, the fact that a site is shut down so that its source term can decay or be removed provides an opportunity to perform certain surveys that were not possible during operations. As a result of these and other considerations, sites that are well equipped to implement the radiation protection, waste management, and safety programs that are needed for compliance during operation are not necessarily expected to be efficient decommissioners straight out of the gate.

As a subset of the decommissioning projects that are accomplished across the nuclear industry, particle accelerator projects present unique challenges, and in some cases, opportunities. The uniqueness of accelerator decommissioning projects is largely due to the space accelerators occupy within the nation's regulatory framework. The Energy Policy Act of 2005 (EPAct) expanded the Atomic Energy Act of 1954 definition of byproduct material to include, among other materials, any material made radioactive by use of a particle accelerator. That said, the resulting U.S. Nuclear Regulatory Commission regulations excuse accelerator produced radioactive material from some of the important rules that are otherwise broadly applicable to byproduct material. Chief among these exemptions is that while the material an accelerator facility discards (i.e., its waste) may be radioactive, it is not a "radioactive waste" *per se* as the definitions of waste throughout Title 10 of the Code of Federal Regulations specifically exclude accelerator-produced byproduct material.

Anyone who has visited an accelerator site understands that space is at a premium, with the accelerator, its ancillaries, and support equipment occupying much of the volume of the room in which the machine operates. This is particularly true in instances where the accelerator is not equipped with integrated shields and thus the room is constructed in a manner that provides the requisite bioshielding. Characterization data are needed to make decisions that are important for decommissioning planning, and the process of obtaining such data is often compli-

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Membership and Objectives

The members of the Accelerator Section include representatives from accelerator centers throughout North America, pharmaceutical companies, and government regulatory agencies.

The objectives of the section are threefold:

1. To improve communication between those involved in accelerator radiation protection activities;

2. To provide forums for discussion and resolution of scientific, technical, and administrative problems related to accelerator radiation protection; and

3. To provide coordination between the development of accelerator regulatory and administrative standards and relevant standards under development by private and professional organizations.

cated by the lack of space, high dose rates, and other interferences.

This article is intended to introduce an article series that examines accelerator decommissioning in terms of important regulatory aspects and the resulting characterization, remediation, and waste management considerations. The information these articles provide is expected to be applicable across a variety of sites including those that operate linear accelerators, small and large cyclotrons, and neutron generators or those involved in the emerging fusion system industry.

Bio: Tom Hansen

Tom Hansen, PhD, is a Certified Health Physicist and the owner of Ameriphysics, LLC, a US NRC licensed decommissioning and waste management firm that, in 2009, became the first organization to be specifically licensed to accomplish accelerator decommissioning projects. He has experience on more than 40 accelerator decommissioning projects in 19 states since 2002 and has made more than 20 presentations on accelerator decommissioning at national and international workshops and symposia.

Utility of Modeling in Operational Health Physics

Shaun W. Kelley, CHP
NorthStar Medical Radioisotopes

Health Physicists (HPs) are required to make extensive use of models in their work to predict/estimate doses from many possible sources. Probably the most common models used are for shielding requirements and dose rates. There are numerous models and software implementations of these models in use. While all of these models can be very useful, they all also have their limitations. These limitations can include incomplete or inaccurate input data, model simplifications, differences between model and real world, over-conservative assumptions and of course, human error.

Possibly the most effective way to improve the accuracy of any model is to compare its results to measured, "real world" results and adjust the model as needed for its output to more closely match those measured values. However, when modeling a novel design for the first time this kind of feedback is unavailable. This is the situation I found myself in as Lead HP at NorthStar Medical Radioisotopes, which inspired this article.

NorthStar uses a first-in-kind electron accelerator design to produce the medical radioisotopes copper-67 (Cu-67) and soon non-carrier-added (n.c.a.) actinium-225 (Ac-225) from radium-225 decay. This technology works via a photonuclear reaction that indirectly knocks out a nucleon (i.e., neutron or proton) from a target nucleus (the "γ,n" or "γ,p" interaction). The beam energy in these reactions are generated using Ion Beam Applications (IBA) Rhodotron® TT300-HE E-beam accelerator and associated beam lines (Figure 1). The first three of these enhanced Rhodotrons used to transmute certain stable isotopes optimally to medical- use radioisotopes have been installed at NorthStar's headquarters in Wisconsin. This unique combination of accelerator design, energy, power, and target configuration required extensive use of modeling in the design stages to ensure radiation safety and ALARA.

The greatest challenge of the design and licensing process was the dose rate modeling of the accelerator and target vaults. Modeling was conducted by three different modelers using MCNP/FLUKA with three significantly different sets of results. (Figure 2). To the extent that one model predicted

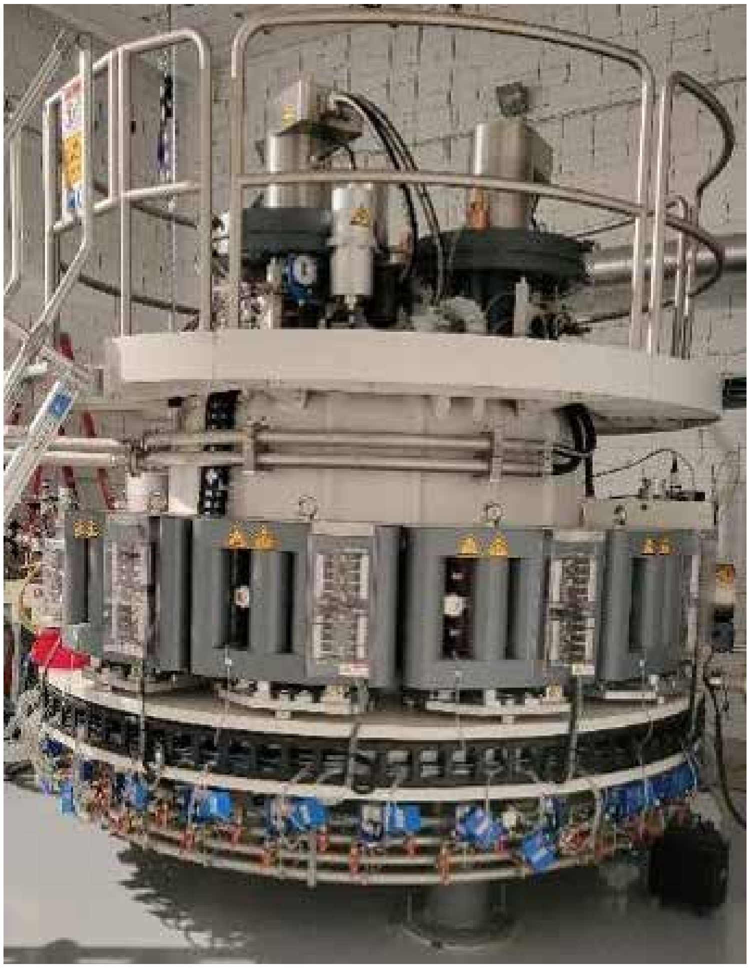

Figure 1. IBA's Rhodotron® TT300-HE electron accelerator, located at NorthStar's headquarters in Wisconsin.

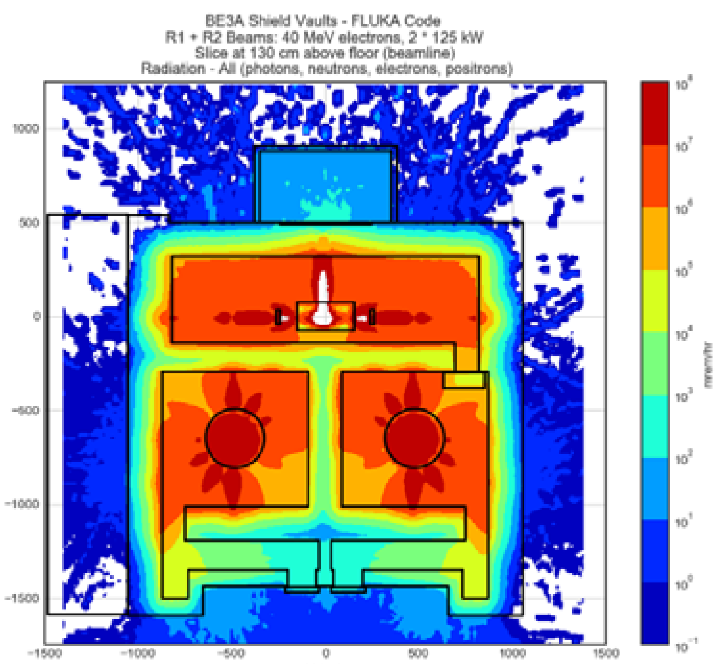

Figure 2. FLUKA-generated sample vault dose map.

dose rates roughly 10 times the other two models outside of the vault. We investigated this difference, including rerunning models, but could not positively identify the source of discrepancy prior to license amendment submittal. This required designing and modeling contingency shielding modifications if the higher dose rate model was found to be more accurate upon startup. This cost significant time and resources to complete and was found to have been unnecessary upon startup, as measured dose rates outside of the vault shielding were found to be significantly lower than any of the other models. A fourth modeler used MCNPX to estimate dose rates inside of the target vault following shutdown. The results of this model also greatly overestimated the measured dose rates by roughly a factor of 10.

Even comparatively simple models can have large inaccuracies. NorthStar regularly uses RayXpert, a commercially available dose calculation software using a Monte Carlo method for dose modeling of components such as hot cells and transfer casks. We used this program to estimate dose rates to design a cask used to transport irradiated targets for Cu-67 production. When compared to measured dose rates, the RayXpert results were 2-7 times higher. The higher levels of overestimation were seen specifically at two points. The first point was the junction between the cask shield plug and body. It is suspected that RayXpert overestimates the shine through the tight fit tolerance between these two components. The second point of high error was the "on contact" dose points. The cause was that the modeler chose 1

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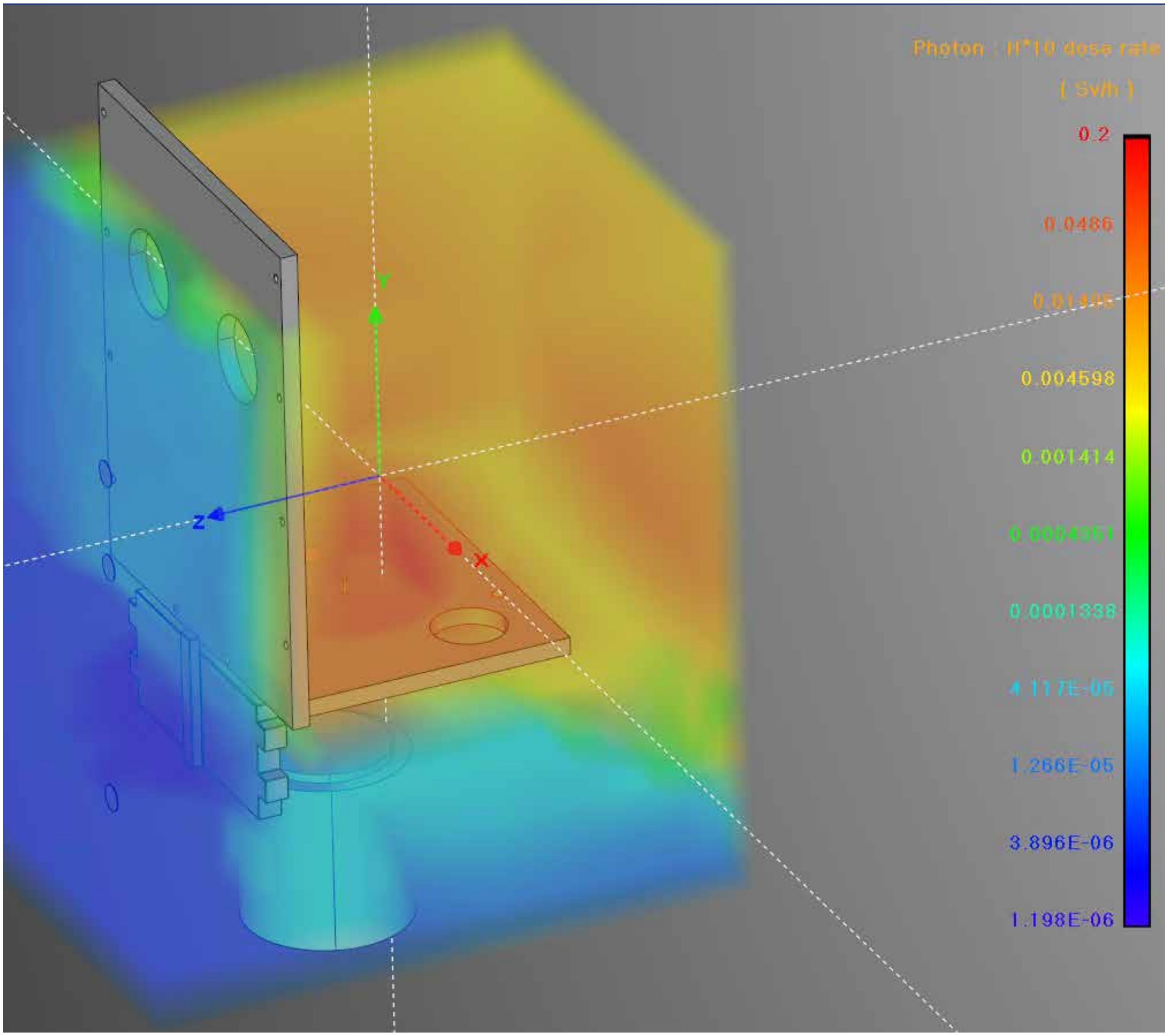

Figure 3. RayXpert-generated sample dose map results for a Cu-67 production hot cell.

mm as on contact, whereas most all available dose rate meters are incapable of measuring that close to the surface.

Both MCNP and RayXpert are capable of quite complex geometries and source terms and, due to the nature of the Monte Carlo method, modeling runs can take hours to days to complete. However, many modeling problems that operational HPs encounter are relatively simple, and answers are needed more quickly. For example, how much lead is needed to shield a known quantity of radioactive material to achieve the desired dose rates outside of the hot cell, cask, safe, etc. For these types of problems, we have used MicroShield, another commercially available dose modeling software. MicroShield uses reference data from ICRP and ANSI (i.e., attenuation coefficients, buildup factors, dose conversion factors) to determine photon and energy flux through the shielding and convert that to dose rate. MicroShield models generally take minutes to set up and seconds to run. Even though it is much simpler, we have found it to give comparable results to the more complex methods. For example, Figure 3 shows the dose map results from RayXpert for a hot cell used to process Cu-67, and Figure 4 shows the MicroShield model for that same hot cell. The reported results at

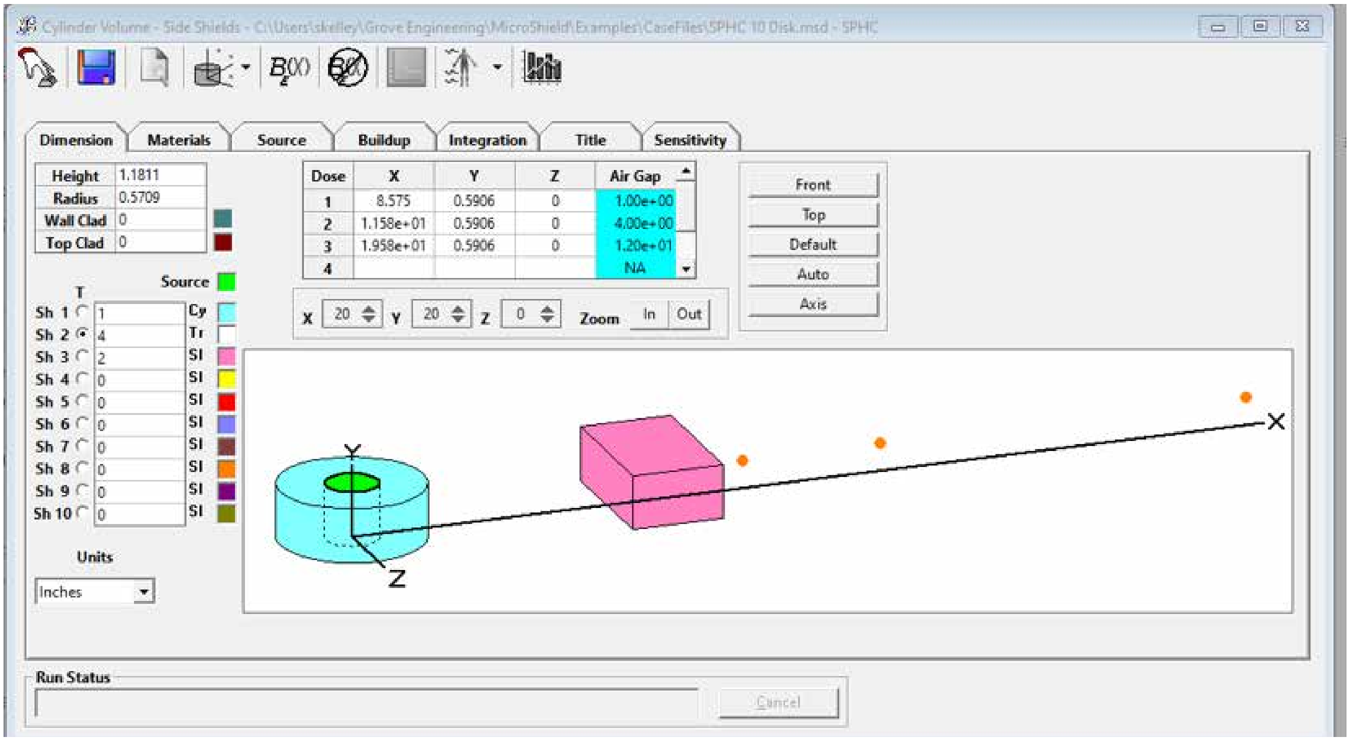

Figure 4. Microshield-generated results for the same Cu-67 production hot cell.

the point of interest (i.e., 30 cm from the hot cell wall) were 0.67 mrem/hr from RayXpert and 0.71 mrem/hr from MicroShield. From an operational standpoint, those results are equivalent (i.e., both 0.7 mrem/hr), and both compared favorably to the measured dose rate (0.4 mrem/hr), even though MicroShield took minutes and RayXpert took days.

I did not come into this project as a modeling expert and, four years later, I still am not one. However, I have learned several things that could help other HPs make better use of models in their work. First, understand as much as you can about the model that is being used: *What are the inputs and how do they affect results? What is the process/algorithm the model uses? What are the model outputs and what do they actually mean?* Second, get to know the person running the model if it is not you. *How well do they understand your problem and the model?* Plugging and chugging likely will not yield the most accurate results. Third, and perhaps the most useful, *How have their past models compared to measured results?* If they normally come in significantly different, then be cautious. Lastly, use modeling results with caution. As HPs, we always should be conservative, and it is better to have modeling results a bit higher than actual, rather than vice versa. However, devoting an excess of limited ALARA resources to a design due to significantly inaccurate dose models can take away those resources from other areas where they would have a greater impact.

By the way, we did eventually discover the source of the large discrepancy in the vault models. The significantly higher model had used the percent number of atoms of the constituent elements in the high-density concrete the shield was composed of instead of the percent weight of those elements. That one little mistake caused an order of magnitude increase in the reported dose rates and significantly slowed the licensing process for the facility.

Ever thought of a STEM internship or career at a National Laboratory?

Annie B. Kersting, PhD
Visiting Scientist, Lawrence Livermore National Laboratory

There are 17 national laboratories across the U.S. and they all hire talented students and postdocs for internships and career jobs. These Department of Energy laboratories comprise a preeminent federal research system providing the Nation with strategic scientific and technological capabilities. Their collective mission ensures America's national security by addressing its energy, environmental, and nuclear challenges through transformative science and technology.

At a recent American Chemical Society (ACS) meeting (San Francisco, August 2023) the Nuclear Chemistry and Technology Division (NUCL) hosted a panel discussion about job opportunities at five of the national laboratories. Each of these Labs (Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, Idaho National Laboratory, and Oak Ridge National Laboratory) includes a Seaborg Institute that plays an important role in national laboratory workforce development. The Seaborg Institutes/Centers provide critical training for undergraduates, graduates, postdocs, and early career scientists in a range of nuclear science disciplines, and have unique facilities to conduct state-of-the-art research. These disciplines include solid-state chemistry, radiochemistry, nuclear energy, coordination chemistry, nuclear forensics, and heavy element chemistry, among others.

If you are interested in finding out more about internships or career opportunities through the Seaborg Institutes, or jobs more broadly, please visit the national laboratory websites and search under job openings, and/or student internships. Now is the time to apply for the 2024 summer programs. If you are specifically interested in the opportunities through the Seaborg Institutes/Centers, you can access their websites below:

- LLNL: https://seaborg.llnl.gov, director: Dr. Mavrik Zavarin
- LANL: http://seaborg.lanl.gov, director Dr. Franz Freibert
- LBNL: http://gtsc.lbl.gov, director Dr. Rebecca Abergel
- INL: https://gtsi.inl/gov, director Dr. Rory Kennedy
- ORNL: https://gtsi.ornl.gov, director, Dr. Sam Schrell

Bio: Dr. Annie Kersting

Dr. Kersting was the moderator for the ACS-NUCL panel, and has recently retired from a 30- year career where she conducted research in environmental radiochemistry and was a former director of the Seaborg Institute at LLNL. During her tenure, she also served as the director of University Relations and Science Education where she developed and oversaw a broad range of initiatives and university research collaborations that helped develop the workforce pipeline and advanced the mission and vision of LLNL.

Afterword

The next newsletter **Q1 2024** will be scheduled for March. Tom Hansen will provide a second installment of his Decommissioning articles. We're seeking more articles like the three in this issue of HPS Accelerator Newsletter. What in particular are your special projects that can be made public? What new radiopharmaceuticals are being produced by accelerators? What new targets can be revealed? Have a great Winter Holiday!