Fall 2009 | Winter 2010 | Spring 2010 | Summer 2010 | Volume XXXVIII, Number 1

JNMM Journal of Nuclear Materials Management

Non-Profit Organization
U.S. POSTAGE
PAID
Permit No. 2066
Eau Claire, WI

INMM
INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT
Published by the Institute of Nuclear Materials Management

JNMM Journal of Nuclear Materials Management

JNMM (ISSN 0893-6188) is published four times a year by the Institute of Nuclear Materials Management Inc., a not-for-profit membership organization with the purpose of advancing and promoting efficient management of nuclear materials.

SUBSCRIPTION RATES: Annual (United States, Canada, and Mexico) $200.00; annual (other countries) $270 (shipped via air mail printed matter); single copy regular issues (United States and other countries) $55; single copy of the proceedings of the Annual Meeting (United States and other countries) $175. Mail subscription requests to *JNMM*, 111 Deer Lake Road, Suite 100, Deerfield, IL 60015 U.S.A. Make checks payable to INMM.

ADVERTISING, distribution, and delivery inquiries should be directed to *JNMM*, 111 Deer Lake Road, Suite 100, Deerfield, IL 60015 U.S.A., or contact Jill Hronek at +1-847-480-9573; fax, +1-847-480-9282; or E-mail, inmm@inmm.org. Allow eight weeks for a change of address to be implemented.

JNMM Journal of Nuclear Materials Management

Fall 2009, Volume XXXVIII, No. 1

Topical Papers

Institute News

Departments

INMM
INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

The Leadership of the IAEA

By Steve Oritz
INMM President

INMM Vice President Scott Vance and I had the opportunity to represent the Institute of Nuclear Materials Management as observers at the IAEA General Conference in late September. The General Conference is the most senior policymaking body of the International Atomic Energy Agency. It is composed of representatives of all member states of the agency. The General Conference began by recognizing Ambassador Yukiya Amano as the newly elected director general. Many of the speakers over the duration of the conference recognized that by unleashing the energy that binds the nuclei of atoms, we have created a source of energy that can play an important role in helping the world decrease its carbon emissions. But this same energy of nuclear reactions has also given us weapons of enormous destructive capability, so we must be vigilant in guarding against the threat of proliferation.

U.S. Department of Energy Secretary Steven Chu provided some comments from President Barack Obama to the General Conference. He said, "The United States stands with the IAEA and its member states in seeking to advance the nonproliferation, energy, and developmental goals embodied in this agency. These goals advance the common interests of our nations and the needs of our citizens. They also define the central challenge of the nuclear age—that of using nuclear energy in ways that prevent proliferation and pursuing the peace and security of a world without nuclear weapons.

"We know the road to elimination of nuclear weapons will be long and difficult, and can only be achieved if all nations live up to their responsibilities. But we must not defer tough problems to future generations—there are important steps that we must take to advance the common security of all people. The stakes involved are enormous. Now is the time to strengthen a durable, global regime that prevents the spread of nuclear weapons to additional states or terrorist groups; reduces the world's nuclear weapons; and pursues a world in which nuclear power is used for peaceful purposes. It is for this reason that in Prague last April, I laid out a comprehensive agenda for nuclear arms control and nonproliferation, which you will hear more about later today.

"The IAEA is central to that agenda and to the establishment of new, durable frameworks for cooperation. To that end, we must ensure that the IAEA has the resources and authority it needs to verify that nuclear programs are peaceful, to facilitate access to a clean source of energy, and to improve the lives of citizens the world over—all without incurring new nuclear dangers.

"Working together, with renewed commitment and the exercise of our shared obligations, we can succeed in making real, substantive progress towards a world that is safer, more secure, and more prosperous. I hope you will join me and my delegation in committing to this goal and to the IAEA and other institutions that support it."

Secretary Chu went on to discuss four areas in which the world needs the IAEA's continued leadership. These areas are:

- A New Framework for Peaceful Nuclear Cooperation
- Strengthening International Safeguards
- Moving Toward a World Without Nuclear Weapons
- Preventing Nuclear Terrorism

These topics encompassed the discussions from members of the General Conference. The scientific forum that runs in parallel with the General Conference also addressed these topics. Details from the 53rd General Conference and the scientific forum can be found at the IAEA Web site. The proliferation of nuclear energy for peaceful purposes strengthens the roles and need for nuclear materials management professionals.

INMM president Steve Ortiz may be reached via e-mail at sortiz@sandia.gov.

Our Annual Roundup of the INMM Annual Meeting

By Dennis Mangan
Technical Editor

As has been done in the past, this fall issue of our *Journal* is dedicated to our recent Annual Meeting held this past July in Tucson, Arizona, USA. Charles Pietri, Technical Program Committee chair, provides an excellent summary of that Annual Meeting. Interesting is that despite the economic situation we are experiencing, the attendance at the Annual Meeting was the largest yet. And as Charles notes, such a large crowd caused some inconveniences as well as some great benefits.

We had two opening plenary speakers, and thus there are two roundtable articles in this issue. The first article reflects the discussion that occurred with Olli Heinonen, Deputy Director General for safeguards at the International Atomic Energy Agency in Vienna, Austria. His presentation, *20/20 Vision: Future International Safeguards,* addressed the challenges foreseen by the IAEA in the future with growing nuclear energy involvement around the world. His presentation was based upon his paper published in the summer issue, which was a special issue dedicated to *The Next Steps in International Safeguards.* This issue was distributed at the past Annual Meeting (Volume XXXVII, Number 4). For completeness, however, we have reprinted his article in the issue.

The second roundtable discussion features an interview with Charles Curtis, president of the Nuclear Threat Initiative. The theme of Curtis' plenary speech, which is also included in this issue, was an up-to-date history of the World Institute for Nuclear Security (WINS), coupled with a plea for continued involvement of the INMM in WINS. (His speech can also be found on the NTI Web site at www.nti.org.)

The closing speaker, arranged by Amy Whitworth, chair of the Government-Industry Liaison Committee, was Hans Blix, former Director General of the IAEA, and presently director Weapons of Mass Destruction Commission. His interesting speech, along with an introduction by Whitworth, is also included in this issue.

In addition to Pietri's annual meeting summary and the three plenary speech articles and the two roundtable discussions, there are three technical papers, which are this years J. D. Williams Student Paper Award winners: the first and second place winners of the student oral presentations, and the winner of the student poster presentations.

Braden Goddard of Texas A&M University, College Station, Texas, USA, was the first place winner for oral presentations. His paper, *Real-Time Detection of UREX+3A Extraction Streams for Material Accountancy,* proposes a qualitative gamma ray and neutron measurements approach as an addition to existing safeguard strategies for reprocessing plants. Goddard's co-authors are William Charlton and Sean McDeavitt, also of Texas A&M University.

The second place winner for oral presentations was Jennifer Dolan of the University of Michigan, Ann Arbor, Michigan, USA. Her paper, Measurement and Characterization of *Nuclear Material at Idaho National Laboratory,* describes the efforts accomplished in preparing for proposed measurements of new MOX fuel pins at INL. Her co-authors are Marek Flaska and Sara Pozzi, also from the University of Michigan, and D. Chichester of Idaho National Laboratory, Idaho Falls, Idaho, USA.

The winner of the poster presentation was Scott Ambers, also of the University of Michigan. His paper, *Neutron/Gamma-Ray Pulse Shape Discrimination with Liquid Scintillation Detectors Based on Average Pulses,* presents a new method of pulse shape discrimination to distinguish neutron from gamma-ray pulses measured with liquid organic scintillation detectors. His co-authors are Flaska and Pozzi.

Finally, Jim Lovett, our INMM president in 1971 and 1972, an a Fellow Emeritus of INMM, provides some interenting tales regarding our Institute's first twenty years of existence.

If you have any questions or comments, please feel free to contact me.

JNMM *Technical Editor Dennis Mangan can be reached by e-mail at dennismangan@ comcast.net,*

Report of the INMM 50th Annual Meeting: The Price of Success

by Charles Pietri
Chair, Technical Program Committee

An outstanding meeting full of startling events beyond our expectations and some not so good—more later on!

Please be aware that this report is merely a snapshot summary of a few highlights at the Annual Meeting; it is not meant to be comprehensive, and does not include all individuals, groups, and events.

In 2005, Charles Curtis, president of Nuclear Threat Initiative (NTI), stood before us at the Annual Meeting in Phoenix, Arizona, and challenged the INMM to consider a potential institutional model for promulgating best practices for nuclear materials security. He suggested that INMM build an operational capacity in INMM to provide such best practices support globally on a full-time basis! He said "if not INMM, then who…" would do it? Curtis returned this year to open the 50th INMM Annual Meeting, July 12-16, 2009, at the Marriott Starr Pass Hotel and Resort in Tucson, Arizona, USA, where he reported on the progress of that best practices model, the World Institute of Nuclear Security (WINS). He told us that the "…greatest source of expertise in nuclear materials management [resides] …in INMM" and that "…INMM is an essential part of WINS…" With such an invigorating beginning to our 50th annual meeting anniversary we knew we were off to a great start.

Figure 1. Vibrant discussions (left to right) INMM President Steve Ortiz, Corey Hinderstein, and Charles Curtis, President, Nuclear Threat Initiative

But there was more: Olli Heinonen, deputy director general and head of the Department of Safeguards at the International Atomic Energy Agency (IAEA), spoke as our Opening Plenary speaker on *20/20 Vision: Future International Safeguards,* again pointing out to us that the IAEA can meet the expectations in the ever-changing environment through *innovation* and *adaptation*—it needs to move with the times when it comes to technical capabilities. Here's another role that INMM can continue to fill well with its annual gathering of the experts in the nuclear materials management field.

Figure 2. Dr. Olli Heinonen, IAEA deputy director general (for safeguards)

Each year INMM conducts a Roundtable to discuss issues with the Opening Plenary Speaker, hosted by Dennis Mangan, technical editor of the *Journal of Nuclear Materials Management (JNMM)*. We had a delightful time with our plenary speaker Olli Heinonen and his off-the-cuff comments that you can read in the *Journal* along with his transcribed remarks; these articles also will be found in the *Proceedings of the INMM 50th Annual Meeting*.

The closing plenary was another sparkler with Hans Blix, chair of the Weapons of Mass Destruction Commission (and former IAEA Director General), speaking on *Can We Now Move Toward Peace and Disarmament*?—a provocative and positive outlook on a world facing the current and anticipated nuclear issues. His paper also will be found in the *Proceedings* and in the *Journal*. INMM President Steve Ortiz presented Blix with an honorary INMM membership.

Figure 3. INMM President Stephen Ortiz presenting Dr. Hans Blix with an honorary INMM membership

Amy Whitworth, chair of the INMM Government Industry Liaison Committee, was instrumental in enticing Blix to attend and for arranging for his presence at our meeting.

Now for the startling events: we thought that INMM had hit its peak in 2006 at Nashville by breaking several records. Surprise! INMM, or rather our attendees, did it again:

Figure 4. Amy Whitworth, chair, Government Industry Liaison Committee

Total attendance was a record of 1,060 (compared to 949 for Nashville in 2006) including ninety-two students—another record. In early deliberations INMM believed that because of the economy and some uncertainty in some programs, there might be fewer participants at this year's meeting. We were wrong and had the greatest attendance ever! Sadly, there were not enough hotel rooms although we had booked nearly the entire hotel; some attendees had to stay at outlying hotels—a definite inconvenience for them. Further, many of the meeting rooms were crowded because of the record attendance. More about these matters later.

Figure 5. Standing room only in meeting rooms—but yet a few seats still available.

There were 433 papers presented including nineteen posters and twenty-nine student papers—a record breaker over the previous 320 high. We had sixty-two sessions including the plenary sessions (ordinarily, we have about forty-eight maximum); one day there were eleven concurrent sessions. Unfortunately, there were also five "no-shows." This problem continues to plague and amaze us—why anyone would not notify INMM of their intention not to present their paper? We also had forty-five paper withdrawals, which was about normal and twenty-one papers that were presented by other than the original author/speaker who for one reason or another could not personally attend the meeting. Our Meeting Report Card, which includes the meeting evaluation from the electronic surveys, session chair reports, and verbal comments at the meeting, was of the usual variety, many complimentary, a few critical, and, as occurs each year, several responses with positive suggestions for future meetings. One disappointment was the five final papers that, at this writing, have not been submitted for publication in the *Proceedings of the INMM Annual Meeting*. We'll deal with that issue later on along with a more detailed evaluation summary. Why a professional would present a paper and then not make the effort to have that paper included in the *Proceedings* for posterity really baffles us. (On the other hand, we have folks who could not attend the meeting but requested that their paper be published! Unfortunately, we can't: to be published the paper has to be presented.)

INMM continues to be indebted to all those who made this meeting such a success. About 93 percent of the respondents to the meeting survey indicated that the INMM Annual Meeting met their professional learning needs, 85 percent said they were satisfied overall with the meeting, and just 5 percent indicated that they were overall dissatisfied. So once again, the Annual Meeting has to be a success since it's "our" meeting and everybody works as a team. But we need to recognize the many speakers who, once again, played the critical role. Every day I say to the speakers at the Speakers Breakfast, *"You are the major contributors to success at the Annual Meeting—yes, it's our meeting but it's really your meeting if it's a success. Without your active participation and your quality papers, the meeting could not exist."* So that is an ongoing recognition to our speakers. And, we continue to be indebted to the Registration Committee that meets on early Sunday morning to start the meeting process. D. L.Whaley, chair, and his committee deal with attendees in a professional and exemplary manner at all times.

The session chairs, Technical Program Committee, and especially the technical division chairs, play a major role in developing and managing the Annual Meeting. Our student attendees were most helpful as projection managers for some sessions and as photographers for the meeting. We are further thankful for our INMM HQ staff lead by Leah McCrackin, our executive director, and our Queen of the Annual Meeting Jodi Metzgar, Administrator (also known as the "Queen Bee"); Lyn Maddox, our conference manager; Kim Santos, assistant conference manager; and Patricia Sullivan, the INMM communications manager and *JNMM* managing editor. I especially appreciate Metzgar's efforts in reviewing this report for factual accuracy—nothing gets by her!

Last year the Annual Meeting was the kickoff for the Institute's 50th Anniversary Celebration Year and this year we ended it by celebrating the 50th Annual Meeting.

We continued the Anniversary Celebration Lounge and its historical slide show along with souvenir mugs and umbrellas carefully guarded and dispensed by INMM Vice President Scott Vance. We also retained the Tuesday afternoon extended open period to allow more time to have lunch, visit exhibits, and view the poster session.

The INMM 50th Annual Meeting—a landmark achievement—officially opened on Sunday, July 12, but on the previous day two important planned events occurred: the INMM Executive Committee met to discuss issues of importance to the Institute and future directions to explore; and, the Annual Meeting of the New Brunswick Laboratory Measurement Evaluation Program took place to review progress in this evaluation of international

measurements to date. Both meetings were very well attended.

As is customary, on Sunday morning, Whitworth chaired a meeting of the NNSA MC&A Implementation Panel to address activities and interests in that area. Whitworth can provide additional details for those interested (amy.whitworth@nnsa.doe.gov).

Sunday at noon, the ANSI/INMM 5.1 Analytical Chemistry Laboratory Measurement Control Committee, an ANSI N15 writing group, met and discussed the following: *INMM ASC N15 Committee Update* has two active standards with three more under various stages of development, a paper addressing the history, current and future activities of N15 has been prepared; *Growing and Changing U.S. Nuclear Fuel Cycle; NRC Nuclear Fuel Cycle Developments; GUM Statement.* A GUM statement was prepared and circulated but INMM 5.1 requests additional input; *IAEA International Target Value (ITV) Update—ITV 2010.* The ITVs will be updated in 2010 and INMM 5.1 will participate in the process. Copies of the INMM 5.1 Committee Meeting Minutes can be obtained from cpietri@aol.com, and the ANSI N15 Meeting Minutes from carrie.matthews@pnl.gov.

Figure 6. Members of the INMM 5.1 Committee

Sunday afternoon is not only the start of meeting registration but it is also when the six Technical Divisions meet to discuss matters of importance to their technical functions. (The Waste Management technical division combined with the Packaging & Transportation Technical Division for this meeting.) These divisional meetings are generally well attended and progress toward initiatives for the coming year based on past experience and insight for the future are discussed. This year was no exception and the technical division chairs report a great deal of activity and resolutions for ongoing and upcoming efforts in their areas of expertise. Contact the technical division chairs directly for a summary of their meeting and further information. Their contact information is available on the INMM Web site at www.inmm.org/about/technical_divisions.cfm.

Figure 7. First day of meeting registration

Moving on to Sunday evening, the **President's Reception,** where we reacquaint ourselves with colleagues and friends, is always a good way relax and prepare for a long, intensive meeting the next day. Mark Leek, chair of the INMM Student Activities Committee, ended the day with a well-attended Student Orientation meeting, which generated a lot of enthusiasm from the ninety-two students registered for the meeting this year.

While we were all either going to meetings, registering, or carousing with buddies on Sunday, the exhibitors were busy setting up their exhibits in the spacious Exhibit Hall. The 50th INMM Anniversary Lounge was set up outside of the Exhibit Area, near the Registration Desk—a very useful spot for folks to gather. INMM Vice President Scott Vance managed the Lounge ably.

We continue to note that this opportunity for organizations to meet in conjunction with the Annual Meeting

Figure 8. Scott Vance and Leah McCrackin at the INMM Anniversary Lounge

provides a travel cost savings but more importantly it brings the right people together in a common forum. However, a word of caution: there has been some concern that excessive and lengthy side meetings later in the week have been diverting attendance from the Annual Meeting and those affected attendees who had planned to spend time hearing the papers being presented complained bitterly about this distraction. Although INMM provides meeting space for side meetings as an accommodation, these meetings are to be brief and not conflict with, or impede attendance at, the technical sessions. New requirements for ad hoc meeting rooms are being formulated for next year.

We had the usual daily addendum with changes in the program that were made after the Meeting Program went to press and those changes that occurred during the meeting: changes in speakers, withdrawals, and no-shows. Some of the meeting speaker changes were caused by surrogates stepping up to present papers because of changes in speaker's schedules and by several overseas speakers who could not get their visas in time to attend the meeting. We're fortunate that many speakers are prepared to have a backup available but it's still a perturbation of the program.

On Tuesday, July 14, the Business Meeting followed by the INMM Annual Awards Banquet took place. The Business Meeting this year was a sad one since Vincent DeVito, INMM secretary, who had presided over this function for so many years passed away this spring (http://www.inmm.org/about/vince_devito.cfm). Obie Amacker stepped in and did a commendable job as interim secretary.

Figure 9. INMM officers at the annual business meeting

At the Annual Awards Banquet we encountered another issue arising from a greater meeting attendance than expected—not enough tables initially for all the attendees. Although I am told that there was adequate seating but perhaps not enough separate tables for some people to sit together as a group. We apologize for any inconvenience and discomfort that may have been caused. Generally, everyone enjoyed the meal and presentations, remembering that the focus of the evening is recognizing those who have contributed much to INMM and to the nuclear safeguards community. We have some additional comments that are addressed later in the meeting Report Card. However, to liven up the atmosphere a bit, some post-banquet entertainment was provided by David Lambert, who excels at entertaining especially when he has such a responsive audience. The following awards were presented: for Distinguished Service—Jill Cooley, IAEA, Koji Ikawa, Japan; for INMM Thirty-Year Service—Central Chapter, Pacific Northwest Chapter, Vienna Chapter. And sadly the following Resolutions of Respect for our deceased members were read: Vince DeVito, Barbara Hammond, Jerry Hickman, Nikolay Isaev, Sheldon Kops, and Wilma Williams.

Each Annual Meeting we strive to make the presentations better—the most common criticism we get is that the content was good but the presentation was fair or even poor. But there has been noticeable improvement over the years and we can attribute that improvement (although not perfect yet) to Professor Paul Ebel, who returns each year with his

Figure 10. Chapter Thirty-Year Service Awards

tutorial on how to present an animated, clear, and coherent paper. Always innovative, Ebel convinced INMM Past President John Matter to produce a video based on *what not to do* with the eleven most important points in making successful presentations—the eleven commandments for speakers. Both younger and more experienced speakers could benefit from this presentation. Next year we are going to focus on the essentials of being a successful session chair. Beware!

Ebel also coordinates the LCD PowerPoint© projection systems for the speaker presentations. Based on his assessment of the process for the past few years, we feel comfortable that the technical division chairs, who have been the mainstay of this activity, can manage this effort with ease once we resolve some equipment issues. Ebel will still provide counseling and assistance as necessary.

Many attendees report that five to six intensive days at INMM Annual Meetings leave them exhausted. I want to encourage all of you to find some time to relax during the meeting. To set some examples, you might wish to follow the lead of several INMM regular attendees:

Other, more healthy, fun activities we engaged in were the golf outing and the early Tuesday morning 13th Annual 3K Charitable Fun Run, the proceeds of which were donated to the *Vincent John DeVito Memorial Fund.*

A lot of people, including those who were not at the meeting, anxiously await the posting of the "Report Card" that

Figure 11. David Lambert orchestrating the dance floor after the banquet

Figure 12. Nancy Jo Nicholas and daughters learning new dance steps

Figure 13. The Rhinestone Cowboy Gang doing karaoke at the Margarita Café

Figure 14. Denny Mangan, at the Fun Run: "What do you mean the men have longer legs!"

describes how those of you who provided feedback to INMM really rate the Annual Meeting. Several different ways were used in the evaluation: the post-meeting electronic survey and feedback onsite from attendees as well as a report from the session chairs. The Report Card this year continues to show improved ratings in many areas over previous years and the comments were mostly very positive with some exceptions. Each year you tell us that the Annual Meeting continues to improve—if so, it's because of the feedback we get from attendees and the actions INMM takes in response.

The responses we get from the electronic survey continue to be relatively small. For example, this year 29 percent of the attendees responded to the survey—up from last year. About 71 percent of the respondents were INMM members in several membership categories. (An interesting note: this annual meeting was the first one for 34 percent of respondents.) So, despite the fact that the response level has improved since we moved to electronic surveys, be aware that these findings may not be representative of the entire group of participants but only those who took enough time and interest to respond. It continues to be very significant to note that, 95 percent of the respondents indicated that the quality of the INMM Annual Meeting was judged as neutral-satisfactory and 93 percent said that the program met their professional needs! Although this year we changed the rating criteria from *satisfied/very satisfied* to *neither satisfied nor dissatisfied,* INMM Annual Meetings have consistently rated above 90 percent for many years. Furthermore, about 90 to 95 percent of the respondents thought that the quality of the papers was *as expected or better than expected.* A few responses to some of the topical areas were so small that we could not tally them meaningfully. About 80 percent of the respondents rated the Opening Plenary session as meeting their needs or interesting while 50 percent of the respondents similarly rated the Closing Plenary—both about the same percentage as last year.

Figure 15. Gathering at the exhibit hall for coffee and discussions

The Hotel Accommodations were not rated as high as in some previous years as we had problems due to the unexpected (and spectacular) increase attendance: not enough hotel rooms, not many hotels in the vicinity for the overflow, hotel staff were a bit overwhelmed, and some of the meeting rooms were overcrowded, As several of our attendees commented "the price of success." INMM, to assure hotel space and services for its Annual Meeting, contracts out for hotels several years in advance based on past meeting experience and other factors. Each year in late winter, the Technical Division Chairs provide a best estimate of the room size they will need for each session based again on previous experience and the topical material. This year, after all arrangements were made, we were overwhelmed by this unexpected attendance at the meeting! For this success, we apologize to all those who were inconvenienced in any way at the meeting.

About 94 percent of the respondents visited the **Exhibits.**

The poster session had its high points and yet some disappointments this year. Taner Uckan, the poster session chair, works hard to make this activity really shine. He did so again this year. INMM has always considered poster sessions as equivalent to oral presentations. One good example, among others, was Christina Moore of the U.S. Naval Academy, *"Autonomous Robotic Detection of Radioisotopes by High Purity Germanium Detector.* For next year, we plan to upgrade the poster session and provide more specific guidelines with examples of good posters.

Figure 16. Activity at the poster session

Figure 17. Christina Moore and Robotic Detection of Radioisotopes poster

Active and extensive promotion of **student participation** in the Annual Meeting and other related activities by INMM for the eighth year has contributed to major growth in this area. I am indebted to Leek, for his contributions to this summary. The number of students that attended the Annual Meeting is unprecedented and established a benchmark for us: ninety-two students registered and attended the meeting (compared to seventy-six in 2008). This is the first year that INMM was able to acquire outside funding to support student participation at the Annual Meeting. Dunbar Lockwood, safeguards team leader in the Office of International Regimes and Agreements in NNSA, DOE, funded Pacific Northwest National Laboratory to be used for direct support for student participation at the Annual Meeting. Subsequently, twelve students from universities across the country were able to attend; none of them would have attended without this support. Prior to his Closing Plenary speech, Hans Blix conducted a students only forum, which was significant for several reasons: most of the stu-

dents attended, appropriately signaling that students are special in the eyes of INMM and the questions asked by these students demonstrated their astuteness and understanding of nuclear technology and policy. Other items of note:

- An important step was taken toward institutionalizing the role of students within the organization when officers of the several student chapters met to discuss the possible formation of a student council as a vehicle for two-way communication between students and the organization. While students chose not to directly endorse a formally structured council, they did decide that a student forum was appropriate to serve the same function but on a less formal basis.
- By all accounts the **Student Career Fair** was a tremendous success: well attended with very direct and very full engagement between recruiters and students. Both students and recruiters seemed to get a lot out of the event.
- It seems that INMM is approaching or has reached a threshold where students feel that they are an integral part of the Institute. Whether it is attending the Executive Committee Meeting, presenting papers, participating in break-out sessions, or returning as alumni, students appear to have fully embraced their role as participating members of INMM.

Further information on the INMM student activities program may be obtained from Leek (leekk@battelle.org).

The competition for the **J. D. Williams Best Student Paper Award** resulted in: First Place—Braden Goddard, Texas A&M University, *Real-Time Detection of UREX+3a Extraction Streams for Materials Accountancy;* second place—Jennifer Dolan, University of Michigan, *Measurement and Characterization of Nuclear Material at Idaho National Laboratory;* and first place poster—Scott Ambers, University of Michigan. *Neutron/ Gamma-Ray Pulse Shape Discrimination with Liquid Scintillation Detectors Based on Average*

Figure 18. Mark Leek leading the student career fair

Pulses. All these articles are in this issue of *JNMM*.

The **New Member/Senior Member Reception** on Monday evening was, as usual, a well-attended, successful event. New regular members and senior members along with new student members had the usual opportunity to meet. Students, especially, were encouraged to become involved in both their technical divisions and local regional chapters.

The Annual Meeting was chosen by the Pacific Northwest National Laboratory (PNNL) as the site to continue its efforts to gather institutional knowledge in international safeguards and nuclear nonproliferation. International safeguards experts have been working to capture the collective institutional memory of this rich and dynamic field, by filming interviews with individuals who were involved in key events over the past forty years, since the negotiation of the Nuclear Nonproliferation Treaty in the late 1960s. The first film series, "Foundations of International Safeguards," was published in DVD and on webstreaming video in 2007. A new series, underway in 2009, is focusing on the evolution of the verification approaches used by the International Atomic Energy Agency to fulfill its safeguards mission, beginning with the traditional accountancy-based approaches of traditional safeguards, and ending with the advanced measures used in the special cases of Iraq, South Africa, and North Korea in the early to mid-`90s. The first filming included notables involved in implementation of international safeguards in Japan who discussed how safeguards objectives were met at large bulk facilities such as the Rokkasho reprocessing plant. Interview participants include Erwin Kuhn, Howard Menlove, Takashi Osabe (INMM Japan Chapter), Yusuke Kuno, Shirley Johnson (Consultant), and Tom Shea. Shea moderated and Carrie Mathews coordinated this effort at the filming.

To conclude this momentous week and a year of celebration we served a bountiful anniversary cake, and once again, I was not able to convince anybody that we needed ice cream and champagne to complement it. Oh, well, we can look forward to the 75th Anniversary, can't we?

Figure 19. Interview filming (l to r): Kuno, Kuhn, Johnson, Mathews, Shea, Menlove, and Takashi Osabe

Figure 20. 50th INMM Annual Meeting anniversary cake – well worth waiting for!

INMM reviews all comments from all sources and investigates those that warrant further action. We try to give a balanced perspective of what our attendees report at the Annual Meeting whether their perceptions are favorable or unfavorable. That's one of the most important ways we learn how to continually improve the Annual Meeting process. Some readers have criticized us for expressing other attendees' sentiments that are contrary to their beliefs—that is their right to do so, just as

is the other parties' right to do the same. So, remembering that we only have a snapshot in time with these responses, here are a few selected comments (some provocative, a few erroneous, others thoughtful) in a composited summary format—and as it can be readily seen there is a diversity of opinion and perspective and understanding of the 50th Annual Meeting:

More program topics on specific countries. There are very interesting cases like Japan, DPRK, Iran, and others …. [addressing] the role of policy and science in the course of national decision making on both sides (i.e. U.N. and Iran or U.S. and DPRK). … wanted to learn more about destructive analysis. […] more information within the Physical Protection area. Presentations were usually a lot more technical than expected. Many of the presentations were general, non-specific, or a rehash of previous presentations. Very lackluster when compared to last year's. The last three meetings were the best ever. There were plenty of opportunities to expand my knowledge in other fields. A great place to meet worldwide partners and collaborators. Somewhat chaotic student orientation meeting. As an exhibitor, exposure to industry leaders was satisfactory. Unavailability of rooms at host hotel and reduced staff for social events was evident. … the predominance of policy and paper studies as opposed to scientific works. Itinerary planner is a good help. Too few rooms available. Excellent range of different topic areas, generally professionally managed and good range of participants. Any issues … this year were clearly caused by the record attendance—it is better to have the problems of success than the alternative. [….] dissatisfied with the banquet meal. […] impressed with the organization of the meeting. The timing for the closing plenary was such that … it forced participants to stay until the next day in order to get a flight out—extend [the sessions] into the afternoon [prior to the closing plenary] to provide more time for papers [to reduce the] number of concurrent sessions. The biggest frustration, however, was limited space in some sessions. [...] no computers set up for checking e-mail. … the refreshments were very limited. Ran out of materials provided to registrants. Location was very nice, especially for companions, but there were not enough hotel rooms. Audio problems are inexcusable; speakers don't know how to use a microphone—won't listen to feedback from audience that they can't be heard—soft spoken presenters barely whispering. Overall, INMM is doing a great job.

We provide this report of the INMM Annual Meeting for your information and entertainment. Even though there appears to be a variety of perceptions about the meeting, its events, and its activities, including a few that are totally erroneous and frivolous, we consider all. Our past performance demonstrates that each year we take action to resolve issues of significance and are dedicated to continuous improvement to enhance your stay at the meeting. After all, it's *your* meeting!

This continuous improvement is reflected in the quality of the presentations, the efforts made by speakers to find surrogates to give their talks when they are unable to attend the meeting, and the participation of individuals who are not members of the Technical Program Committee who propose and orchestrate special sessions. However, we continue to see that the significant issues facing INMM in managing the Annual Meeting program are excessive paper withdrawals after the Final Program has gone to press and even during the meeting, frequent speaker changes, "no-show" speakers, and late and absent final paper submittals. INMM encourages you to keep these obstacles to a *perfect* meeting in mind when planning to participate in our Annual Meeting.

Many of you—most I hope—will attend the Annual Meeting next year based on your conversations with me and your evaluations. In fact, 96 percent said you would be back depending mostly on funding and schedule. Tell your management how important it is to be at our meeting where, in Charles Curtis' words, the "…greatest source of expertise in nuclear materials management is in INMM."

In 2010 we try a new venue for our 51st Annual Meeting: the Baltimore Marriott Waterfront in Baltimore, Maryland, USA, on July 11-15, 2010. So, as I say each year, start planning for it now by completing your research, getting your subject approved by management in a timely manner, writing your abstract, and submitting it by **February 1, 2010.** Then write your paper and submit it early—certainly no later than the **June 9, 2010,** deadline. Remember, for those of you who are planning to organize a special session, you need to contact me by **November 15** or sooner and be prepared to attend the Technical Program Committee review meeting in March 2010. There are no exceptions! If you wish to discuss any issues with me, contact me at cpietri@aol.com.

On behalf of INMM President Steven Ortiz and myself, we look forward with great pleasure to your presence at the 51st Annual Meeting next year—I'll be there—will you?

Opening Plenary Presentation
20/20 Vision: Future International Safeguards

This article originally appeared in the summer 2009 issue of JNMM. *It is reprinted here as a courtesy to readers to provide context for the Roundtable discussion with Olli Heinonen that follows.*

Olli Heinonen
International Atomic Energy Agency, Deputy Director General and Head of the Department of Safeguards, Vienna, Austria

Since 1957 the International Atomic Energy Agency (IAEA) has worked to bring the benefits of nuclear technology to humankind, while at the same time minimizing its risks. Over the last fifty years the world has seen a steady growth in the application of nuclear technology that now spans from the generation of electricity to applications in food security, resource conservation, environmental protection, human health, and more. We have also witnessed nuclear accidents, threats to the peaceful use of nuclear technology, and the emergence of clandestine nuclear procurement networks. Throughout this time the role of the IAEA has been, and remains, a fundamental component of the nuclear nonproliferation regime. The IAEA, and safeguards, have advanced tremendously and must continue to do so in order to address future changes and challenges. Although it might not be possible to predict them all with full certainty, there are some that can indeed be anticipated.

The 20/20 report of the Commission of Eminent Persons[1] on the future of the IAEA encapsulates the anticipated challenges and opportunities that the IAEA will face in maintaining global nuclear order. Trend projections for the coming decades indicate considerable growth in the use of nuclear energy and nuclear technology: the acquisition and utilization of nuclear technology is seen as a matter of economic, scientific, and technological advancement. While such benefits will bring greater prosperity to different parts of the world, it may also increase proliferation risks; without appropriate control measures, nuclear material and technology could be misused to build nuclear weapons.

Recently published IAEA studies show that nuclear electricity generation may grow by 17–45 percent by 2020 and by 27–100 percent by 2030.[2] To date nuclear power has been used mainly in industrialized countries. However, much of the future growth is expected to take place in the developing world: about half of the forty-four new reactors currently under construction are in developing countries, particularly in Asia. We also know that many of the new nuclear facilities to be established will be in states that have limited or sometimes no previous nuclear experience. Many of these states have also yet to establish or enhance their nuclear regulatory bodies and appropriate legislation and resources for effective state systems of accounting for and control of nuclear material.

Of the countries that already use nuclear technology for electricity generation, more have shown interest in mastering the nuclear fuel cycle to ensure a supply of reactor fuel for their nuclear power plants—a step that brings them closer to developing a nuclear weapons capability.

We have all witnessed the emergence of illicit nuclear technology trade in covert nuclear trade networks, whose activities span the globe. Such networks conceal their clandestine shipments within legitimate trade, often taking advantage of weaknesses of states' export control systems. The IAEA was disturbed to learn that sensitive information provided by the clandestine nuclear supply network existed in electronic form adding another dimension of challenge to nonproliferation.

How can the IAEA meet expectations in the changing environment? Through innovation and adaptation. New thinking is required to provide the IAEA's safeguards system with the *legal authority, technical capabilities, and financial and human resources* for it to be fit for tomorrow's environment.

With a changing landscape of increased nuclear proliferation challenges, and cases where the letter and spirit of the Nuclear Nonproliferation Treaty (NPT) has been threatened, a strengthened system of safeguards has been instituted that incorporates the additional protocol as well as state-level approaches to safeguards and a move towards information-driven safeguards. The IAEA can also be part of a solution to a multinational approach (MNA) to the nuclear fuel cycle that addresses the issue of proliferation of the sensitive aspects of the nuclear fuel cycle.

The IAEA's task of carrying out responsible safeguards verification to ensure the peaceful use of nuclear energy entails that timely and early detection in verifying states' compliance with their safeguards obligations is necessary. To carry out its verification activities effectively, the IAEA needs to have adequate inspection authority and access to all relevant information and locations. The IAEA's two main types of legal instruments are comprehensive safeguards agreements (CSAs) and additional protocols (APs). Together, the two instruments enable the IAEA to conclude that states are not diverting nuclear material to nuclear weapons.

Yet today, twenty-seven NPT state parties have not brought into force their required CSAs and some 100 states have

yet to conclude an AP. The CSA-AP combination should, in my view, be the universally accepted verification standard, if verification is to be credible. It will also be important for the IAEA to fully utilize all measures available under these legal instruments.

This new standard would not only increase transparency, but would also enable the IAEA to optimize its verification activities, resulting in a reduced inspector presence and workload in the states. Realizing such efficiencies will be increasingly important, especially in light of the projected expansion in the use of nuclear energy. The IAEA estimates an increase from the current 250 facilities to 350 facilities subject to actual safeguards by 2020, and eventually to 420 by 2030. However, despite the expected doubling of the number of facilities subject to safeguards, the estimated overall in-field efforts by 2030 is an increase of some 10 percent from the current level. If states give the IAEA the necessary legal authority—under both a CSA and an AP—efficiencies can be realised so that the IAEA can conclude and continuously reaffirm with a high level of confidence that they are not diverting nuclear material and have no undeclared nuclear material and activities.

In addition to the universalization of CSAs and APs the IAEA will need to move with the times when it comes to its technical capabilities. Having state-of-the-art verification technology will remain an important requirement, particularly for the detection of clandestine nuclear activities. The IAEA would benefit greatly from having the capacity to commission R&D in safeguards technology, be it in cooperation with member states or the commercial market. It will need to strengthen existing detection capabilities, especially with regard to environmental sampling, satellite imagery and information analysis. For example, the increasing number of environmental samples taken will require the IAEA to improve its own laboratory capabilities as well as to expand its network of analytical laboratories in member states. In addition, new types of nuclear reactors and associated nuclear fuel cycle technologies will emerge, requiring the IAEA to begin designing dedicated safeguards approaches and techniques well in advance. The IAEA will also work with states and facility providers and operators to design and operate "safeguards friendly" nuclear installations to facilitate efficient and effective verification.

The IAEA will continue to strive to finance its verification activities under the double challenge of increasing workload and member state pressure not to grow its budget but to seek efficiencies. Unpredictable, pressing verification responsibilities as well as the need to maintain verification infrastructure and equipment add to the IAEA's financial strain.

Regarding human resources, the IAEA will be facing the retirement of large numbers of experienced inspectors and senior staff in the coming years at a time when interest in nuclear energy, and therefore the needs for nuclear professionals, is growing. Yet, the global pool of experienced personnel with appropriate technical backgrounds has been shrinking in recent years. The IAEA will need to compete with industry and member states for experienced professionals. Its personnel policies will further compound that challenge. The retirement boom and personnel policies pose a challenge also to retaining and passing on critical knowledge to incoming staff.

In the future, the IAEA may also be called on to take on new roles, such as verification of nuclear materials released from military programs, thereby contributing not only to nonproliferation but also to disarmament.

New technology, sufficient financial and human resources, expanded legal authority and the demonstration of full commitment, cooperation and transparency from member states are not only crucial to the IAEA's verification role, but will also improve its effectiveness and efficiency. As we stand looking towards the future, now is the time for member states and the international community to make a difference. A resilient safeguards verification system that provides the necessary assurances is the ultimate stamp of confidence that promotes the peaceful uses of nuclear energy.

Notes

1. 2008. *Reinforcing the Global Nuclear Order for Peace and Prosperity: The Role of the IAEA to 2020 and Beyond,* Report prepared by an independent Commission at the request of the Director General of the IAEA.
2. 2009. *"Nuclear Technology Review 2009: Report by the Director General,* IAEA, GOV/2009/3.

JNMM Roundtable

Participants:

Olli Heinonen
Deputy Director General, International Atomic Energy Agency

Glenn Abramczyk
JNMM Associate Editor

Obie Amacker
Fellows Committee Chair, Interim INMM Secretary, INMM Past President

Cameron Coates
JNMM Associate Editor

Robert Curl
INMM Treasurer

Debbie Dickman
Bylaws Committee Chair, INMM Past President

Felicia Duran
JNMM Associate Editor

Jessica Feener
Vice President, Texas A&M University Student Chapter

Les Fishbone
JNMM Associate Editor

Roushan Ghanbari
(Student Guest with Cameron Coates)

Dennis Mangan
JNMM Technical Editor, INMM Past President

John Matter
Chapter Relations Committee Chair, INMM Past President

Steve Ortiz
INMM President

Charles Pietri
INMM Technical Program Committee Chair

Bernd Richter
JNMM Associate Editor

Gotthard Stein
JNMM Associate Editor

Patricia Sullivan
JNMM Managing Editor

Jim Tape
INMM Past President

Scott Vance
INMM Vice President, Interim
JNMM Associate Editor

David Vermillion
President, University of Tennessee Student Chapter

Dennis Mangan: It's my personal opinion that the United States' new administration is not high on nuclear energy. You very seldom see or hear anything they say about our technology and yet they make claims that they're going to support and continue to support and even increase support of the IAEA. Do you believe that that will happen or do you have any insights as to what will happen?

Olli Heinonen: Well, I think that there are indications the U.S. is supporting the increase in our budget for 2010-2011. You know our system is based on consensus of the member states, the members in all, we have 135 of them. They have to agree on the size of the budget and funding for various IAEA activities and since it's based on consensus and there are views that are differing. Some people think that verification is not so important. Some people think that nuclear energy is not important. Of course there are anti-nuclear states, so it's a complex process. When we talk about the budget increase I mentioned today, we have their approval of safeguards. We have only one big problem there and this is we have to reconstruct our chemicals analytical laboratory and that's fairly expensive, roughly 35 million EURO for the whole complex. One can compare this to the total 530 million EURO safeguards budget. So you see that this is a lot and it's difficult for member states to agree that so much money should go to safeguards in the next couple of years. I think the U.S. has taken a positive role. They try first to get attached to our regular budget, so we have all this money at our disposal. But more recently I remember we have received a donation-type extra-budgetary contribution from the U.S. so it seems to me that the U.S. government is supporting us.

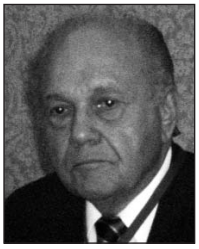
Mangan: I'm happy to hear that. When one see's the charts that you showed with regard to the growth of the nuclear business, particularly in Asia, it's going to be a burden on your whole activity and I would think the U.S. would be behind supporting that.

Heinonen: I think there are some gaps but in 2030 it goes away. We estimate if we get to this remote monitoring in safeguards properly, we could save the safeguards effort by 30 percent but there is also an R and D effort and we don't have resources for that. That part we have not estimated how much that will cost.

Gotthard Stein: I would like to congratulate you on your excellent speech, especially the change in safeguards to an information-driven system. This new direction offers also new perspectives for safeguards in nuclear weapon states. As a first step I would like to stress the importance to separate peaceful and military nuclear activities in nuclear weapon states. The implementation of the Additional Protocol in nuclear weapon states seems to be very helpful as a first step as also can be recognized from the Indian case. Finally the goal should be to have common safeguards standards in all peaceful activities in all states as we have it also for the other fields in triple S (Safeguards, Security and Safety). I hope that the new safeguards direction and especially the State-Level Approach can give sufficient support to reach this goal.

Heinonen: It's an important step in the way… There are pros and cons and

particularly in this country we used quite a bit of invariance, is it a good deal or not. We saw it happen, it's a step forward. Actually we need to think of the next step after this one. Most likely this might be also the way to get the India situation resolved. It might be that this last remaining bastion of North Korea, Pakistan, India, we need to treat them differently and not try to use the same mechanism as the NPT weapons states versus non-weapon states. Because it's not going to come. So it might be better to concentrate on this final goal, which is a nuclear free world and the same destination with the same objective.



Charles Pietri: You said some very nice things about INMM and you talked about the future of the IAEA. My question is, what suggestions would you have for a vision for INMM, a way that we can work with you in your proposed or contemplated approach to the future?

Heinonen: You know, I see INMM as a big resource. We see it as a resource, a very valuable resource because you can present papers here in different ways without policing them. It brings also people from various parts together and it collects non-proliferation people and other people in the political arena. I think this kind of institute should look to the future. For safeguards, it's a nuclear renaissance. In addition to safeguards, we have to make sure that nuclear safety and security are maintained. How to bring perhaps more to this? I know for example in the Next Generation Safeguards there is this, and how to establish uncertainties for qualitative information and this sort of thing.

Bernd Richter: Olli, do you imagine that remote monitoring is going to play a bigger role in the implementation of integrated safeguards? You even went so far as to say "remote inspections." You are having remote monitoring in Japan and Canada, where you have regional offices, but I think a large field would be the European Union with currently only one member state out of twenty-seven implementing remote monitoring in cooperation with the Euratom Safeguards Authority. Do you have an approach how to implement remote monitoring in the European Union?

Heinonen: Bernd asked why we had not to a greater extent remote monitoring in the European Union.

Richter: I asked whether you have a *strategy* to implement remote monitoring in the EU.

Heinonen: We always had a strategy. Now in the mid-1990s, the expectations were very high. Today it's in a good sector of 145 installations worldwide of nuclear monitoring. In the beginning this was more a data transfer problem because we transferred images and data files [that] were very large so there were applications where we created data faster than we were able to transfer it. But then with the modern transfer technologies we use the Internet or leased lines and digital telephone lines today so that hurdle has gone away. Then came a new hurdle in September 11, 2001. That caused changes in a few countries because security aspects came to this picture and additional provisions were required for us to make sure that the data we collect can't be compromised and in certain cases we were asked not to transfer it in real time. Actually we don't transfer it in real time anyway, because for safeguards purposes there is, most of the time, no need. so now that we have found a way to meet security requirements of the European Union; a month ago I think we had a solution on how to do it. There are still some older camera systems where the data is not in such form that we can transfer the data. We have instructions to come up with a plan how we are going to implement [remote monitoring in] the European Union. That will be quite a lot. Germany has a lot of light water reactors, as do the Netherlands, Sweden, and Finland. So it is a lot, and I hope it comes.

The cost benefits are not huge because there will still be maintenance although you can do some maintenance remotely, like software. We still need to have some inspections taking place, but it's coming now finally. Also we had an institutional problem because the vision in Europe is most different from the vision that we have in-house for data sharing. We have now agreed on how the data goes to Vienna.

Les Fishbone: I think that the director general said that he believes that Iran is trying to obtain nuclear weapons. I think he's quoted on that. Does that affect what the inspectors do?

Heinonen: I don't think that there is any dependency at all.

The verification is to make sure there is no diversion of the assets described to us and that those assets that have been declared are there. We have a very rigorous system particularly at Natanz for a number of reasons. The director general was referring to the military program. There we are stuck. We have been stuck now for a year and a half actually. Iran doesn't want to answer our questions and until they answer and provide access to those locations, we cannot make much headway. They have been able to do it in spite of the sanctions and other measures. I think today, even now, the situation in the country is, perhaps, not a very optimistic situa-

tion. At the same time, they do admit they are building uranium enrichment capabilities, they have now some 1.5 tonnes of low-enriched uranium there. This will make the IAEA's task more difficult. We have seen some value for breakdown scenarios but if they are to be implemented one has to work outside of Natanz; I don't think it will work there.

Scott Vance: I was interested in your observation that an emerging or increasingly important area is going to be spent fuel. What interested me about that is that as an organization, the Institute has been trying for several years to get those in the United States who generate spent fuel interested in safeguards issues and interested in our organization. So far, we have been unable to do so. Do you have any thoughts in terms of how we might be able to convince them that this is an area that they need to be involved in, that they need to have input in and that they are going to be affected in the future as we continue to produce spent fuel?

Heinonen: Especially in the United States as you know there is no reprocessing or final disposal now for spent fuel. Sweden and Finland have started experiments for the disposal process. However, a small amount of spent fuel will disappear in the next twenty years. Today even in Japan, they create even more than they reprocess, and that's the biggest producer of material for safeguards. For me spent fuel is not so much of a safeguards problem. When I travel out there in the world, I see it more as a safety problem in certain places. I think there's a need to pay more attention to safe storage. I personally think that's important for these multinational approaches for enrichment; they are also important for the back-end of the fuel cycle. And we are starting to work seriously with those countries who can take it. That's where we're focused.

Cameron Coates: As a systems engineer, I've done some academic work on effectiveness and looking at safeguards regime I think of it as a system of systems and in assessing any system of systems, there are things that we like to call measures of effectiveness. If you were to take a 10,000-foot fly-over of the international safeguards system, not on an individual countries' point of view, what do you think the key measures of effectiveness would be for the overall regime?

Heinonen: The safeguards system has evolved over time. There was a basic concept, something was added, something more was added, and some things were taken away. But I don't think we have analyzed the system in its totality. That was what I was talking about today. We need to think outside the box knowing our financial restrictions for the upcoming nuclear renaissance with tasks increasing so that we don't put our resources in the wrong place. Bernd knows and Gotthard knows that my home is Singapore. So I've been looking at this small continent, three million people, no natural resources, an island 40 km this way and 20 that way. So how do they survive? They have come to a similar transformation. One is that they reorganized their government. They rethought the whole thing, how they run their civil service and they say that one of the slogans they use is those governments survive who fear more and grow less. This is also true for safeguards. When we go to the next generation safeguards in Vienna, we should stop growing in Vienna and we should increase the role of facilities operators, SSACs (State Systems of Accounting and Control) and others, and then we are there, and I think this is the way at least from our perspective, we gain substance. At the same time, however, we should not throw away the few things, indifference, impartiality, verification, and such things. We should not do away with verification but we can do it perhaps in a much smarter way, for example take advantage of information technology. It is easy to have some tools and pull stuff from the computer and you find this and that but we need to think here again much of our information is nuclear material declarations and verification results, and there are answers, which we handle pretty well. We have a quality management system in place. This is good. But how you deal with this other problem of information which is qualitative in nature; it's more a consistency check than anything else and you combine those two—quantitative and qualitative—and then you come to the overall conclusion. It's easy to have that quantity out there because it's easy to handle but you deal with this other question and what kind of answer do you assign to this conclusion because after all this is for our member states risk assessment. The U.S. is worried about Iran's enrichment; it's a risk assessment and how we get to that is interesting and possibly we could use your help.

Felicia Duran: I'm also a proponent of taking the systems approach and have done some thinking along those lines with regard not only to MC&A safeguards types of systems but also physical security. Are there any initiatives that you could show with this that are currently ongoing at the agency that are taking this direction?

Heinonen: Actually we have our R&D program. You can get it from the Web site that I can send you. There are clear objectives for what we need. And we are going to produce a new one by end of this year, an updated version. You can look at the history of how safeguards developed. In the 1970s was the safeguards approach, that's when the basics principles were developed.

Then you can say that in the 1980s we set up our inspection criteria. What

exactly we needed to do and how we measure the effectiveness of it. In the 1990s we started to move to this information management and open source programs, we discovered the Iraqi nuclear program and clandestine acts, and then parallel to that we started to introduce our remote monitoring program. In the last decade, we started to bring this evaluation thing together. But now there is one more decade and I think we need to change the way we operate in order to survive.

Glenn Abramczyk: Do you have a staffing program or policy for meeting the needs that you are seeing for your 2020 vision?

Heinonen: Jill Cooley is doing a presentation on the department of safeguards staffing plan. We have never done this before. As I mentioned, this 2020 actually started from the department of safeguards and then it became agency wide. So we are not the first ones who now go and move this to strategy and the strategy has all aspects of what we think we need. It's a learning process because there is no benchmark for us. We never did it before. The target for that is October or November when we have finalized the basic plan we are looking into. Our budget cycle is two years. So medium-term strategy is six years and long-term is twelve. So it's two, six, and twelve years. We need very different education for the inspectors. We need lots of support also that is very different.

John Matter: There have been several references today to the change in administration in Washington and you have a change in administration in Vienna, so I wonder what your thoughts are about that. What impact do you think the new director general will have in terms of what you do or how you do it, will there be a change in emphasis?

Heinonen: Let's wait until he gets to the office. I don't think from safeguards there is any revolt. It is pretty much said that there is a lot of inertia in the system and we should also note that the DG has 2,400 people to guide. We are actually one small part. So we will see but I think the basic education scheme continues as it is.

David Vermillion: Back to the staffing, does the IAEA have any incentives for younger generation?

Heinonen: Yes, we have what is called the Junior Professional Officer Program. It's pretty much actually supported by the U.S. government so we have people to fill posts. We used to have interns but for safeguards it is dealing with confidential information and we can't have interns work with that according to our rules so then we ended up with the Junior Professional Program (JPO)and they are maybe more in the technical parts of the organization. I think if you contact Susan Pepper, she will give you all the information. (pepper@bnl.org) But as far as IAEA professional staff I would say three or four years of practical experience. We don't hire directly from the universities.

Mangan: If you go to the IAEA's Web site you can get a brochure on this program Olli is talking about.

Jessica Feener: Do you have any suggestions, the JPO program is a very competitive. Do you have any suggestions on how to better your chances?

Fishbone: Become a nuclear physicist who can speak a very unusual language. (laughter) I'm not joking.

Heinonen: You can start studying Farsi because I hope that the problem is solved (laughter).

Coates: My question is sort of in the personnel area. The practice, human assurance, trust interactions area, I wonder what role human assurances play in the IAEA in terms of looking at not only the inspectors but other employees. Is there any program along those lines?

Heinonen: Yes, there are some. IAEA is an international organization. We have 148 member states as of last week. In principle, we recruit our staff from all those member states but actually I think we have close to 100 nationalities represented today. Their understanding about this thing varies quite a lot. But first of all we have confidence in their ethics, we have special training. Two years ago we, the department of safeguards, for the first time recruited a security professional full time; before that it was always done kind of like an extra thing. Today when you visit the department of safeguards we are behind closed doors and there are exit and entrance protocols in and out so we have our own area hermetically sealed from the rest of the house. For information in general, it is very compartmentalized. It has its price because then information is available on a need-to-know basis. But then for staff itself we cannot do background checks as such. It doesn't work, we have to handle it through other means.

Jim Tape: I want to pick up on a couple of the things you've said already. Related to people, you discussed the need for people with different kinds of educational backgrounds and you talked generally about the importance of people in this

business. I wanted to ask a question about the environment, using the term safeguards culture. We've heard it said that "safeguards culture" is moving from one of bookkeepers to investigators and in fact I was sitting in the board room when the director general introduced you, announced you as the new [Deputy Director General] DDG of safeguards and, I won't get the quote exactly, but I think he introduced you as his detective. What can you say about the evolution of the safeguards culture among the inspectors? Is it indeed moving from bookkeeping to investigation?

Heinonen: Yes, it is because the conclusions are basically done per state at the end of each year. And you have seen the safeguards implementation progress. It is in our annual report on verification activities. We need various teams so it is not that our whole department is all the same. We don't need only investigators because nuclear material verification, some people like the measurements and the NDA. There are enough jobs for those people so let them do what is needed for those things. And then these guys who like other investigative things, they are assigned to such kind of duties and support for divisional operations. Before we had a structure that we had a division which was in charge of a geographical area and then there is a section which is in charge of a number of countries or a particular country. And then they have their duties which were light water reactors, for example, and although we went a little bit away from that we made two senior inspectors. All the people are talking about the same unit. Some have this investigative type of work and they report to the other senior inspector and then the other senior inspector takes care of day to day inspections. As a result of that, I think that the quality of the reports has improved radically.

We produce now about 80 full evaluations every year for various countries and they reorganize it so that you get more flat because they don't want a layered report. But then what will be the next thing? I wish I knew what kind of proliferation challenges we will have because then we would do the right things but what I see is we still need a group of specialists who are not part of this operations division but are kind of a departmental resource, and this is probably what we will try to do. Then we'll need to bring these two hemispheres together, the ones who will do the field inspections and all those who do the evaluations because now the problem is that it's not A type inspector and B type. They work as a team. I'm not sure that it's always that. We have special training for everyone.

Matter: I was very interested to hear your implied support today for remote inspections. I can recall, not too many years ago, when quite a few of us were working to help you introduce radio monitoring systems and one of the impediments, one of the concerns, was reduced inspector presence and fewer eyes on the ground so to speak. Has that issue gone away now or is that still a concern that you have with remote inspection?

Heinonen: Some people had it but you know I think that this is a misconception if we do the remote inspections properly. Because now you go [to the site] with a pass key, and they give you a computer read out. You take your pocket calculator and you check it. It doesn't make sense, you know, today. So by reviewing the situation at headquarters we prepare everything and go to the site and then when you're on a site, then you focus on those where your technical knowledge clearly is beneficial. As an engineer you see all the processes quite likely with this and this capacity, and it becomes a design information verification inspection rather than our standard auditing type of inspection. This has an impact on staffing and a need for a different staff.

Steve Ortiz: You mentioned there are a lot of new countries looking to nuclear as a source of energy technology as stated in the 2020 report. My question has to do with what the agency is doing. It's easier to establish a culture than change a culture so if you go into these countries where they don't have nuclear, what are you doing to establish a security culture versus going to a country who has had nuclear for a while and is trying to establish a security culture there.

Heinonen: We have a program. If you go to the IAEA Web site, we produce what is called milestones document. I think it was published a couple of months ago which actually has the milestones for any member state who embarks on a nuclear program, what they need to do in terms of safety, security, and safeguards legislation. The milestone, it's not hardwired, you know. For example, when you come to a certain milestone then you ask and say IAEA support for example, a safety analysis of a reactor core, or let's say some feasibility study. We assume that they have done certain things before on that milestone document before we render that service. I don't know if it will survive in the real life because there are some pressures. But it's a guideline and then we have for the newcomers a special mission so we can evaluate where they are. So there are various kinds of evaluations we offer then they can get the kind of auditing, independent audit, how good they are doing and what might they be missing. If they use it in a smart way, then they can go to their decision makers and say we need stable funding for this and that. One thing worth mentioning is that at the end in nuclear it's the responsibility of the country and you cannot render or give the responsibility, for example, to a private company. They get everything taken care of. Many countries think that it's a turnkey thing where they get legislation and regulatory

policy when they pay but we try to encourage them to climb to the tree on their own.

Coates: In any relationship, human, country to country, whatever there is assurance and trust. In a verification regime is the assumption trust or lack of trust?

Heinonen: It's trust but verify. (laughter) I think that's what it is you know. It's a very delicate thing but you get better results when you treat them cordially, nicely, in an equal way. It's socially important. So in that sense we are not really like some rule enforcement agency. We are a little bit softer but not always soft enough.

Vermillion: Is the IAEA supporting the advancement of spent fuel cycles. I heard you were talking about problems with that or are you considering that more like a problem child?

Heinonen: No, I don't think it's a problem child. It's a complex issue now because when you have a complete fuel cycle, it has lots of sensitive technologies. You have separated plutonium and enriched uranium and those who can do it can do it for other purposes. So therefore in general in the Secretariat we have promoted recently multinational initiatives where the ownership of these installations is distributed among several states. This builds confidence over time.

Duran: In your response to Cameron's last question, you mentioned enforcement. So you've got trust but verify and then you mentioned enforcement and you made some comments about issues with enforcement, examples of enforcement problems, North Korea, that sort of thing. What are your thoughts on what could be done better in that area?

Heinonen: I think it's leadership. If I could put it in one sentence. Nuclear enforcement needs leadership and I don't think in the last ten years, all after the cold war, actually there has been no such kind of leadership. Before that, it was clear. There were two camps and they took care of their own. But when that setup disappeared we ended up in a situation that when it came to the problem cases the international community was not unified, was unified in Iraq, and was unified in North Korea in the beginning. But I think this was simply because after the cold war, the Soviet Union was weak, China had the problem in Tiananmen Square, so that was a unique opportunity and then the leadership was provided by the United States alone. That's how we got our first talks with North Korea but then after that the situation changed. Next year's NPT Review Conference is in Poland and we have to make sure that this outlier case is handled in a fair and decisive way. It's not only sanctions particularly, sanctions or no sanctions. I think something very different is needed here and there are not so many countries who can take the leadership role.

Mangan: I can say from my perspective that our side of the table enjoyed this interview, and I hope you likewise enjoyed it.

Heinonen: Yes, thank you very much. It was a different day than I thought.

Mangan: Thank you, sir. It's an exciting time for IAEA and particularly in the safeguards area seeing the emergence of the state-level approach and initiatives like that that are interesting. Thank you very much for your time. (Applause)

Charles B. Curtis
President, Nuclear Threat Initiative (NTI)

INMM 50th Annual Meeting
July 13, 2009
Tucson, Arizona USA

Thank you. It is a special honor to have a place at the podium at the 50th Annual Meeting of the Institute of Nuclear Materials Management. Completing the celebration of your fiftieth year is a happy occasion. Of course, the real celebration is not that you've survived fifty years—but what you've accomplished in that time.

In the late 1950s, when a group of professionals came together to discuss the establishment of a new institute—the primary concern was preventing loss of material that was expensive to make and essential to the military policies of the United States.

The rise of terrorist groups with global reach was not on the minds of the people present. Nor was the prospect that such a terrorist group might one day acquire nuclear weapons or the means to make them.

But the measure of any great organization is whether it can apply its principles and its growing expertise to meet the evolving needs of the people it serves. You have met that test.

Four years ago, I came to this meeting to invoke your past to make an appeal for the future. I cited a 1970 INMM report that bluntly criticized Atomic Energy Commission safeguards in transporting nuclear materials. That kind of candor in 1970 was startling—and the report included this explanation: "As a professional society, the Institute of Nuclear Materials Management can do no less than follow objectively where professional responsibility and logic lead."

I then suggested to the professionals gathered in 2005 that the current nuclear material security situation required a comparable act of leadership—one in keeping with the heritage of the INMM.

The chair and the vice chair of the 9/11 Commission had both recently stated that the terrorist nuclear threat was the greatest threat facing the country.

Al Qaeda was reported to be seeking a nuclear weapon since the early 1990s. The nuclear materials they need is housed in hundred of sites around the globe. We all know our best defense against nuclear terrorism was to make the nuclear materials at these sites as secure as possible. And we all knew these materials were not "as secure as we could make them."

I did not tell this story to inform you of these facts; you already knew them.

I told this story because I had an agenda.

The government of the United States and governments around the world had launched a number of important initiatives to keep nuclear materials out of terrorist hands. But two pieces were missing: We had no formal plan to identify the world's best practices in nuclear materials security; and we had no plan to put these best practices in place in every facility with nuclear or radiological materials where ever located in the world.

These were not steps that regulatory bodies could accomplish with the efficiency the task required. But they were steps that the nuclear community could take—voluntarily—with the right leadership.

So I came to your annual conference to appeal to you to use your expertise and your leadership to help build a new international organization—with the goal of spreading best practices in materials security to every nuclear facility in the world. You immediately formed a committee of INMM Fellows to think about how INMM should engage this issue. A Coordinating Committee was formed that included representatives from INMM, the U.S. Department of Energy (DOE), and NTI. A series of workshops led to a business plan in line with the 2005 recommendations of the INMM fellows.

The final plan was supported by the DOE, by the governments of Norway and Canada, by an NTI grant, and also by the International Atomic Energy Agency (IAEA) whose own leadership saw very early that WINS could play a vital role in complementing the work of the IAEA.

So in Vienna this past September, with your immediate Past President Nancy Jo Nicholas representing all of you, the World Institute for Nuclear Security, or WINS, was established—designed to share best practices on physical protection of nuclear and radiological materials, with a focus on keeping nuclear weapons out of terrorist hands. It has been headquartered in Vienna to ensure close cooperation with the vital work of the IAEA.

As an article in the *Economist* described it: "WINS is a place where for the first time those with the practical responsibility for looking after nuclear materials—governments, power plant operators, laboratories, universities—can meet to swap ideas and develop best practices."

Dr. Roger Howsley has been appointed as the organization's first executive director. Dr. Howsley previously served as director for security, safeguards, and international affairs at British Nuclear Fuels, where he was responsible for security and safeguards covering 17,000 employees in sixteen countries. He also co-chaired the police force responsible for armed defense of civil nuclear sites in the UK. He is a consummate professional drawn from your ranks and is a great leader for this new organization.

WINS held its inaugural workshop this past May in the UK—in collaboration with the UK's Nuclear Decommissioning Authority and the U.S. National Nuclear Security Administration. Dr. Howsley noted that the workshop showed again what was

proved out in a pilot program in Norway and at workshops in Baden and Prague—that you can share best practices without divulging sensitive nuclear information.

In addition, WINS was invited to last month's meeting of the seventy-five nation Global Initiative to Combat Nuclear Terrorism, held in The Hague. The head of the U.S. delegation and co-chair of the meeting said this in his plenary remarks:

"My government strongly supports WINS as a complementary component of the Global Initiative to Combat Nuclear Terrorism and I encourage each of your delegations to carry back to your capitals the need to support and participate in WINS."

Clearly, our new organization is being welcomed by major governments and international organizations—they see WINS as a helpful and necessary part of the international architecture for bolstering nuclear security.

This is a terrific accomplishment in very short time. I want to pause just a moment and recognize some of the people who—out of a sense of professional responsibility and public duty—helped build the World Institute for Nuclear Security:

INMM past presidents Cathy Key and my fellow WINS Board member Nancy Jo Nicholas played material roles. Both encouraged the active participation of the INMM membership, Executive Committee, and Fellows to help develop the WINS concept from the beginning.

The INMM Fellows' Committee and the WINS Steering Committee: including, in particular John Matter, Paul Ebel, Dennis Mangan, and Ed Johnson provided invaluable guidance from day-one.

WINS Coordinating Committee participants: helped make it all happen. We should all thank Jim Tape—who worked tirelessly on a volunteer basis, and Joyce Connery—who worked within the U.S. Department of Energy, the National Security Council, and across the U.S. government.

I want also to acknowledge the contribution my NTI colleagues Joan Rohlfing and Laura Holgate, and especially our and Director of International Programs Corey Hinderstein, without whose efforts we would not have gotten WINS off the ground.

Many others here—and some who couldn't be here—played vital roles. We could not have established WINS without the collective expertise, guidance, and commitment of the INMM membership and the nuclear materials management community as a whole. I thank you all.

I'm now going to break an honored rule of courtesy, tactics, and politics—namely, the rule that says: "Never say thank you and make a new request in the same message. It's bad form."

I try to observe this rule in most circumstances. But I do believe there is a national security exception to this rule—which I would like to invoke here. In Prague this past spring, (U.S.) President Obama announced an international effort to secure all vulnerable nuclear material around the world in four years. Nothing can speed improvement of security faster than having the experts become the teachers —and spread best practices. That is the founding purpose of WINS. It will be crucial to the global effort to secure nuclear materials to the highest standards. That is why we have to move now to build WINS up quickly so its membership includes those who have the most to learn, and those who have the most to teach.

To bolster my point, I would like to draw on the words of Vince DeVito. His wisdom will keep guiding this organization for a long time to come. A while back, Vince was asked to write some reflections on INMM for the fiftieth anniversary year—he was the unofficial historian after all. In his account, he described the formation meeting fifty years ago when the first officers were named. And then he wrote: "It was recognized that to start achieving the objectives they set for INMM, the most urgent concern was increasing membership."

In short, to make an initiative work, you've got to get everyone involved. That was true for the INMM fifty years ago. It was true today for WINS.

WINS now has applications from more than thirty countries. The new members are being surveyed about their concerns—and they are now shaping the WINS agenda. The INMM is an ex officio member of the advisory council—as is the IAEA—but to make this organization effective and vital we are seeking the membership of your companies, your agencies, and organizations.

Membership can help you shape this new organization, improve your own practices, and give you the chance to dedicate your talents to the cause of global security. If you need a greater incentive than that, here's another one: it won't cost you anything for the next year and a half. But we need more than just your membership. We need your home organizations to send experts to WINS events, host events, and provide material support.

In plain words, I am asking you to dedicate your talent and expertise to making WINS a success. I hope you conclude that this commitment is—in the words of that 1970 report—"where professional responsibility and logic lead."

The clock is ticking. As my leader, former U.S. Senator Sam Nunn, points out, "We are in a race between cooperation and catastrophe."

Conclusion

At the start of my remarks, I noted that one test of a great organization is whether it can change with the times. As you conclude the fiftieth year celebrations, you can confidently say that you have met that test.

But there is a higher test of greatness—not just whether you can change with the times—but whether you yourself can *change* the times.

By playing an indispensable and expanding role in the global security of nuclear materials, you will be answering an urgent need to apply your expertise to the greatest cause you can—ensuring a safer future for the human family. I thank you for what you've done in the past—and I look forward to what we can do together in the future.

JNMM Roundtable

Participants:

Charles Curtis
President, Nuclear Threat Initiative

Obie Amacker
Fellows Committee Chair, Interim
INMM Secretary, INMM Past President

Cameron Coates
JNMM Associate Editor

Bob Curl
INMM Treasurer

Felicia Duran
JNMM Associate Editor

Jessica Feener
Vice President, Texas A&M University
Student Chapter

Leslie G. Fishbone
JNMM Associate Editor

Corey Hinderstein
Director of International Programs at
NTI, INMM Northeast Regional
Chapter President

Dennis Mangan
JNMM Technical Editor,
INMM Past President

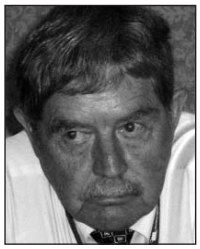
John Matter
Chapter Relations Committee Chair,
INMM Past President

Steve Ortiz
INMM President

Charles Pietri
INMM Technical Program
Committee Chair

Scott Vance
INMM Vice President, Interim
JNMM Associate Editor

Charles Curtis: I remember in 2005 we had a similar roundtable and I'll say it again: This organization has done such a good job in involving its past leadership in the continuing work of the INMM and it is something that the U.S. government does not do well. I really think you should be congratulated for how well you do that and how important it is to have the perspective, judgment, and experience of people who have been long engaged in this important work. It's a pleasure to be here.



Dennis Mangan: I thought your talk today was really interesting and fun because of the fact that, of course, all of us were here when you said you challenged us, if not you, who? If not now, when? I thought, well you challenged us and we responded, and so you challenged us again. You closed your speech with "I challenge you to do this."

Curtis: Well, it worked the first time. It got such a good response the first time.

Mangan: I'll start off the questioning. Several people who know that INMM was involved in the World Institute for Nuclear Security (WINS) have asked me what a WINS organization looks like and is there strategic plan, and so I hustled down to the WINS booth (in the Annual Meeting Exhibit Hall) and I asked about these topics. That's where I learned there are only four staff members currently. It would be interesting to know on what kind of a time scale, organizational chart, and a strategic plan might evolve. We'd love to publish that in the *Journal*.

Curtis: First of all we'd be delighted if you would do that. Let me give you a sense of the progression. It was clear that one of the more significant duties that we had was to make sure that the work of WINS was fully coordinated with the IAEA—and that we have the support of the leadership of the IAEA. We saw the work as complimentary but the IAEA needed to as well. So in order to optimize the chance that we would be entirely coordinated, we needed to place the organization in Vienna under Austrian law. We also had to engage accountants and lawyers and all of the machinery of establishing a new organization, which under Austrian law has a place for a board of directors and membership. That is the model that we are working on because that is the model that the law provides for us. Ideally WINS will evolve into an international organization, under Austrian law, but it will need a sponsorship and a record of work in order to do that because it must be legislated and it must be legislated because what we need to establish is an organization that is tax exempt so that it can receive funds without tax liability. That is important for the economy of resources but it's also going to be important to various contributors to the work of WINS as our organization develops. Our first duty was to find an executive director and with Roger Howsley we think, as I said this morning, he is a consummate professional drawn from the ranks of the folks in this room. Great experience, great credentials, and now we are building a staff around Roger. It has the complication of recruiting people who are willing

to relocate or locate in Vienna for what may be an indefinite period of time. The funding is uncertain in the future. We have established WINS with a little over $6.5 million worth of funding. NTI has put up $3 million. The U.S. Department of Energy is going to contribute $3 million, Canada $500,000, the government of Norway $100,000 but we expect those commitments from Canada and Norway to be repeated in future budget cycles. Of course those commitments can't be made at the present time. We are starting to fill out the staff. We are recruiting. We have, as everybody now in this world has, a Web site and on it is the information that also includes the type of staff positions we are recruiting. We are trying to put in the key staff positions. Next is head of operations and a security specialist. WINS is almost certainly not going to be able to build, nor should it build, a large indigenous staff to meet the various demands that may be placed on WINS. We will want to rely upon a number of relationships in which WINS can draw resources from other professional organizations and in appropriate circumstances, the private sector, industry, and the government sector directly. We're working on models that will allow WINS to meet requirements as they may present themselves.

So this is a story still being written. We are, at present, governed by a board of directors that was necessary to form in order to file the organizational documents. That board consists of myself as chair and Nancy Jo Nicholas as the other board member. Roger Howsley was originally a member of the board for organization purposes but has now resigned so that we could hire him as executive director. So that's the type of dance one has to dance through in these types of circumstances. We hope to populate the board with designees of the United States, France, Russia, Japan, probably Norway. Whether those designees are drawn from government or from the private sector will depend on how we flesh out the board. So that's what we're going to concentrate on, filling out the governance system as we fill out the staff and as we develop a programmatic agenda. We do have a strategic plan that we're working on. It is certainly a matter that WINS will share. We have a related operations plan. As you heard from Roger Howsley, we have applications for membership from I think thirty-one countries and we have developed membership criteria, a process for acceptance of membership and related exclusion, if you will. I want to emphasize the intention is to make WINS broadly available to any organization that has the custody responsibility for nuclear materials and radiological materials so that we will see people come up to the booth—I saw one today—whose first question was is anybody eligible to join and the answer to that is yes. We want as members and participants, as I tried to say in my remarks today, those who have the most to learn and those that have the most to teach. WINS is this broad community that will share information and develop best practices today to elevate the physical protection and security of nuclear materials.

Felicia Duran: So you're making quite a bit of progress and you've achieved quite a bit in the community that has supported this in a relatively short period of time. One of the things that you mentioned is that you're already taking on these activities of bringing together those who need to learn and those who need to teach in this area. You mentioned your inaugural workshop. Would you comment on the outcome of that, how you felt it went?

Curtis: Well, I think Roger would be the best source to comment on that. I was not a participant in the workshop so I'm not the best evidence, if you will, on it. The point I wanted to make this morning is the workshop referred to in my remarks was with the U.S. NNSA (National Nuclear Security Administration) and the UK's nuclear authority. I wanted to emphasize that they found that there was a great deal that they could talk about, share, and benefit from without trespassing the line of sensitive information. That is something that, of course with INMM's help, we developed through workshops in Prague and then Bonn, Austria. Then we ran a pilot program in Norway at a research reactor with highly enriched uranium. The truth about security information is that a very high percentage—about 90-95 percent is not classified. And we can share if we want to. This is true of weapons as well as materials.

Mangan: There are three of us here who were at the Prague workshop: Steve, myself, and John Matter, and we had no problem with that at all. I mean there was no concern about this sensitive issue thing. People were open in discussions with Roger, when he talked to the INMM Executive Committee, the key things now were noted security culture and backing of management. I told Roger that the exact same things came out of the Prague workshop.

Curtis: Right. At some level it's just good sense. So that's important but I'd encourage you to talk to Roger about it. I'm sure that he can share some detail.

Cameron Coates: As I understand, at Sandia there is still some work to be done regarding agreement on the precise term *nuclear security* and if you could share some of the thought processes for, or the actual process to get to that, could you also comment on where personnel assurance fits into that.

Curtis: I think of this as a process not as a point of destination. I don't think there is a satisfactory definition of a secure facility or an insecure security. I think it is a more nebulous concept than what I think you're

trying to do. The whole theory behind WINS is that on a volunteer basis, the professionals in charge of the custody of these materials sharing best practice can elevate the security of the materials through that practice sharing to a much higher degree so I don't think nuclear security is a destination. It's a matter of continuing improvement by a process of applying best practices. And it is that process that we need to strengthen globally.

Charles Pietri: Going back to your previous comment about security information—when soliciting papers for the annual program we've gotten some comments back from folks that said, "If we had given this paper, even sanitized, at our own site it would have been classified. Or, "If we had given it in another forum it would have been classified." But here, given at the INMM Annual Meeting, it proves the point that you can present this information without compromising any sort of perceived security or classification.

Curtis: You know it's an interesting point. A number of you around the table have been a participant in the MPC&A program and if you look back and think that in the aftermath of the break-up of the Soviet Union, we were able to develop in the former Soviet Union states and the Russian Federation in particular this program through cooperative threat reduction in which we have U.S. experts come in to some of the most sensitive Soviet sites, now Russian Federation sites, and make security assessments for upgrades for both the short and long term, and help them develop applications for technical means for the monitoring of inventory control systems when they had basically no classification system. Everything was secret. The site? You shouldn't be on the site.

Coates: What site? (laughter)

Curtis: What site exactly. The courage it took for those scientists, those professionals in working with us. The MPC&A program succeeded because we developed it as an extension of cooperation on science issues. So the Russians didn't have to give permission. They only had to step in and say no. And because we developed on a lab-to-lab basis, we had advocates, constituents, responsible scientists in the Russian program who wanted to do this because they knew the dangers that were inherent in their system. I think it's an act of great courage. They were tiptoeing through the risk of being accused of a treasonous act. Think of that.

Pietri: Scientists don't just want to do their work. They want everybody to know about it.

Curtis: That's another problem. (laughter)

Obie Amacker: Since the original challenge and the courtship, if you will, with INMM, we worked hand-in-hand to get to where we are today and have made tremendous progress. Nancy Jo is on the board as you mentioned, but as we go forward or as WINS continues to mature, what role or what is it that you see that we can really do and is there anything of a formal nature that INMM needs to work on with WINS as it matures?

Curtis: Yes, I think there are two things. First of all I should have emphasized, in addition to our board we have an advisory committee. That will be chaired by Roger Howsley. He's our executive director. There are two ex officio members of that advisory committee. One is the IAEA. The other is INMM. So as we go forward I hope that INMM will play an important authorship role in what that forward direction is. That's number one.

Second, we just had a WINS board meeting on the shoulders of your meeting here. And we have kind of this tension between an orderly development of our staff and what may be a very sudden demand for WINS that will emanate from the global initiative to combat nuclear terrorism. You heard me quote the co-chair's remarks in The Hague just last month. I did not mention the G8 meeting last week in which there were significant discussions on what the White House documents characterized as commitments to the development of best practices and you did see from the U.S.-Russian statement a bilateral commitment to spreading best practices globally, which the White House tells us is going to rely on WINS as an instrumentality.

Now let me jump back to what Denny started with. There are only four people. (laughter) So WINS is going to be dependent on its ability to marshal expertise and the greatest source of expertise in the world is in the membership of INMM. I see a very close cooperative relationship on a going-forward basis that will be mutually directed from INMM and WINS. There was once a statement about Madeleine Albright describing the United States as the essential government. I think INMM is the essential partner for WINS. We have to work with and make this thing real and vital and that's why I made part of my remarks today this second challenge or at least request, that you all have to make WINS successful because unless the professionals respond and continually validate the importance of this mission it will not work. But you are also going to be an important part of WINS' capacity for action. Because they're not going to develop a large staff capability. It's going to need professionals in their various organizations and associations and relationships because you can't yank those people out of their career paths. You've got to take advantage of the opportunities for willing associations and organizations where those professionals reside to lend their assistance to the mission of WINS. So that's how I see it.

Coates: What type of mechanisms do you see to enable that?

Curtis: We were talking about that today and I think a fair point is we don't know yet. The cooperative research and development arena that we have developed at the national laboratories to facilitate the laboratories cooperation in private industry ended up to be extraordinarily useful tools for bypassing what is otherwise a mind-numbing procurement process. I asked Nancy Jo Nicholas this morning if she might take a look at the CRADA (Cooperative Research and Development Agreement) mechanism, as we call it, to see if there is a comparable use that WINS might contemplate so that when WINS and you decide that there are things to do together in support that you have the means, a template, if you will, by which that support can be provided, that doesn't confound your budget, that doesn't require a "Mother, may I?" approach to the Department of Energy.

(INMM President) Steve Ortiz is going to read a letter from U. S. Department of Energy Secretary Chu at some appropriate time at these proceedings.

Steve Ortiz: At the banquet.

Curtis: That is not only appropriately congratulatory of your fiftieth anniversary but makes very crystal clear the U.S. Department of Energy's support for WINS. So as you know that's how you get these things written in to the Department of Energy's mind. That is one area where I have experience.

Pietri: That CRADA process, you know it started in 1989 and we've ages of experience with it and it works. I wish I had thought of it.

Curtis: Maybe it's something that looks like a CRADA you can show the Department of Energy that they recognize, that has survived congressional scrutiny and fits in their budget. That's what you need to find. Something that works with them.

Mangan: But CRADAs are one of the important aspects, for a lot of us in national laboratories. Of course are programs that come out of DOE that allow us to do things like support the IAEA, like to support the International Physical Protection Advisory Services and those funds are in the labs. It's just a matter of getting the right people to go. Do you envision a comparable organization in DOE that is WINS?

Curtis: I don't know the answer to that, I think it's something we have to riddle through. The Department of Energy, as I mentioned, has agreed to put up $3 million. They are in conversations right now with Roger Howsley and his team as to the form that will take and that is something that I hope is not the limit of their support but the beginning of their support. I think it would be a mistake if WINS got into the zero-sum game on the labs' budgets so that WINS became just another eligible candidate for this funding line. I think it needs to be incremental, but the IAEA would feel very concerned if they were suddenly in competition with WINS for this type of assistance. We would want to avoid that at all cost. But the principle is right. That we can build into the labs' budgets, we can build into DOE a prudent process, a recognition of appropriateness of resources essential to this work, and the labs can draw upon for specific things that they agree to do and contribute to. That is the way it has to work.

Les Fishbone: Is the focus exclusively on physical security?

Curtis: Well it's exclusively on physical protection and security. We like to say is it begins with nuclear materials. We will also have to embrace radiological materials and facilities nuclear, broadly writ, eventually. It's just a matter of priorities. I think WINS is going to be engaged in a parallel development path where it will be addressing the security issue more systematically, its culture, etc. broadly at the time it is in parallel addressing some of the known and more immediate dangers where we need to increase physical protection on more of an urgent basis. I would include in that highly enriched uranium research reactors on the agenda but it's going to be a parallel evolution of a program and activity and thought leadership. It's exciting to have this opportunity. We're giving him a little over $6.5 million and saying you have the opportunity, the birth of our organization that can really make a difference in the security of the world and we all know that $6.5 million dollars is far short of what is required to do this. To go to Obie's question, he's going to need a lot of helping hands and a lot of institutional support.

John Matter: You used the words "make WINS successful." Have you or the board or Roger defined what your metrics for success are?

Curtis: Roger has. Roger is a very well-trained professional in this field and every well-trained professional in this field develops metrics to measure success and so that's part of the operational planning. So he is developing metrics that are performed against time horizons that he is managing against. I would probably define metrics in terms of broader political terms with a small p, political terms. For example, if WINS in fact became the institutional means for sharing best practices among the seventy-five nation participants in the global initiative to combat nuclear terrorism that would be one of my metrics. If WINS in fact became in part an

institutional assistance to the U.S.-Russian bilateral commitment to spread best practices globally, I would measure that as one of the metrics that I would look at. Then I would say more broadly, I use the phrase that WINS is being recognized but I would say is uniformly recognized as a helpful and necessary part of the security architecture, then I would say WINS will have been successful. Those are the three I'd say. Roger's metrics are higher operations. (laughter)

Matter: You mentioned earlier the importance of the WINS relationship with the IAEA. Have you had an opportunity to meet with the new Director General to discuss WINS?

Curtis: I have not met with incoming IAEA Director General Yukiya Amano since he has been selected. But both Sam Nunn, Corey Hinderstein, and I have met with him several times in the course of the development of the WINS concept. I believe him to be supportive. About four years ago I chaired the special event on fuel assurances at the IAEA and Amano was the immediate past chair of the board of IAEA at that time. He was very, very helpful to me. I sought his advice and counsel in terms of where sensitivities lie, etc. I find him a very astute and able diplomat who on a one-to-one basis is very engaging and very engaged and I think he is going to end up being an excellent director general of the IAEA. I don't think he, nor do I think it appropriate for him to have, said anything officially yet. Japan's position is interesting. As I said before, Japan is a necessary participant, but Japan is very self-reliant on its own best practice and so I think they have great teaching opportunities, particularly as nuclear energy develops largely in that Asian orbit. Japan recognizes that the development of nuclear power and their own capacity to rely on it for their energy security is very vulnerable to accidents or problems of either safety or security in the world. The Japanese quite rightly promote this concept of the three S's, which is safeguards, security, and safety. I think they believe it and I think that's a basis on which the Japanese will come into WINS and be very helpful. Japanese society is largely consensus driven and they would much prefer to see WINS operational and have a fully developed confident understanding of what WINS is and is not. We need to convince them to come in and shape that answer.

Fishbone: The national laboratories for the last few years have had a tremendous emphasis on safety from the secretary's office on down and it gradually pervades the population of those working there. And it has been necessary and essential. It's hard to estimate how many accidents have been avoided, injuries avoided, but you know the message is reinforced, reinforced, and reinforced. I think it's necessary. Going to Russia as many times as I have, the need for the culture being slammed in and slammed in and repeated and repeated is vital.

Curtis: I've always thought that safety and security are integral parts of the mission and if they are imposed requirements that are taxed to the mission, namely that you have to pay for safety and security out of what you consider is your mission responsibility of doing great science, that is an inherently unsuccessful model. You've really got to persuade people that it's their mission and there is as much their responsibility as is producing great science and being great stewards. But it's hard to do because the Department of Energy has organized itself and its budgets in such a way that it looks like and feels like a tax. And certainly on the security side. It is a cultural thing. I think it's changing. I'd be very interested. I'm not as intimate with it as I once was, but I think it's changing. I think it's more appreciated that one's capacity for action requires high standards of safety and security. But we'll see.

You know it's one of the largest problems in Russia as you know. We don't know how sustaining will be their security environment and that's a big problem.

Ortiz: What's the criteria for membership?

Curtis: That there is a recognized interest in the issue, basically. The point is if you have a legitimate interest in the work, then we want you in.

Ortiz: The reason I asked the question is if you look realizing the headquarters are in Vienna but the funding profile makes it look like a U.S.-centric program. Will that cause problems for recruiting members?

Curtis: You know, sure it might but if you had asked me this question, Steve, two years ago, I would have said it would be more of a problem than it is today. I think almost anything that was being proposed internationally, if it had a U.S. flag on it, provoked an immediate adversarial response. I think that the atmospherics have changed. Where I think the concern is now, is that WINS ought not to evolve in such a way that it appears that best practices have a particular U.S. definition to them and that's why you emphasize the process. You know it's obviously more than a process but it is very important that we not appear that we're trying to evolve a U.S. template for security best practice. We hope to influence people by our learning process and where we can teach about what we have learned but we certainly don't want to have people believe that this is an extension of U.S. practice that they seem to have to adopt. That will not succeed.

One of the interesting things, we very much want private sector participation but the funding support for the organization on a going forward basis we've covered the first two years at least. It's still yet to be determined how we're going to fund the organization as we go forward. Right now, it's NTI. Those who have the custody responsibility are broadly distributed and very unlike the case of civilian nuclear power operators, which has a very defined universe and revenue streams that you can think of as contributing to the funding of an organization that contributes value. We don't have that in nuclear materials secu-

rity and radiological security. We don't have that type of homogeneity. We have isolated examples of it but it's a much more heterogeneous operation. I don't know how it's going to work out truly. I understand INMM has money so…. (laughter)

Coates: Recognizing your process issue, maybe what you ought to do is add a second I… the World Institute for Improving Nuclear Security. So there is no end state.

Curtis: Yeah, I think that actually best practice is not the right phrase. It's really a good practice. We hope to engage in constant improvement but we're set on best practice. We had a lot of discussion when we started up what is best practices.

I've always been uncomfortable with that, it has its antecedents in continuous improvement in the business world and etc. But that's why we want to involve the professionals because they know better.

Matter: You talked about the role of government and the role of private companies. You also then talked about the contribution of individuals such as INMM members. Have you considered or are you promoting a class of individual memberships in WINS?

Curtis: It's a good question, John. That can happen and you can slice and dice this by various membership classifications. That may be appropriate as we go on. It's something that I think you've put your finger on and we're looking at.

Corey Hinderstein: Currently the organizations who can designate an individual or an individual can join, that's the current standing.

Scott Vance: Has there been any opposition?

Curtis: That's a very good question. There are concerns, let's say. One is very understandable. In the IAEA among the professional staff. If you look at WINS competing for funds for a program, I'm talking the security program, that is materially short of funds, then there is a concern. We had to work with IAEA a lot to allay those concerns. They will never be fully allayed, so that's one. Second, why do we need another organization? Can we do this through other means? And a third is "I'm uncomfortable with separating safety and security and they really need to be two sides of the same coin, so tell me how this is going to work." So those are all legitimate questions. And they can only be answered over time. I mean ideally in the civil power world I would love to see WANa and NPO take security on, just because I think they are large areas of overlap. The difficulty is that the people who have the responsibility for safety and security come themselves from different cultures and they're not well integrated. So, as we go forward, those are the things that we are being sensitive to and trying to manage through successfully. I don't think there has been any real opposition. Roger has done a real good job of trying to address these things, trying to develop a relationship with WANO, for example, and various other elements. That's why I emphasize this has been a part of the architecture so the WNTI, for example, transportation, that's something, and they're very much concerned about the security of transportation. We want to make darn sure that we don't get in conflict with them. We're hopeful that they're going to come on the advisory committee as a way of guarding against that. We're going to try to institutionalize those concerns as a way to give people confidence.

Mangan: We thank you. I'd like to just make a personal comment. I think it probably applies to a lot of people at this table. I know Roger Howsley and when I heard that he was going to be your number one boy, I was happy. I thought you couldn't find a better person as far as I'm concerned. But now you've got Lisa Hilliard and for those of us who know Lisa you couldn't find a better person than Lisa. So two out of two ain't bad.

Curtis: Thanks for that and let me say what I said before. I think this organization should be very proud of its response and what it has done and all the help that went into bringing us to this day. So John in particular, and all of you, were there at the creation. You know it took a lot of hands. I hope you all feel that this is your success, because you should. So thanks.

Mangan: Thank you.

INMM 50th Annual Meeting Closing Plenary Session

Speaker: Hans Blix

By Amy Whitworth
Chair, Government Industry Liaison Committee

In planning this year's Closing Plenary program, the Government Industry Liaison Committee discussed speakers and potential topics that would be suitable for celebrating the 50th anniversary of the Institute of Nuclear Materials Management. It was clear to us as a committee that this was no ordinary meeting and the situation called for no ordinary speaker. At the top of our wish list was Dr. Hans Blix, an individual of amazing distinction in nuclear nonproliferation and the broader area of arms control and disarmament. The committee had tried for several years to obtain Dr. Blix as a speaker, but his continuing active work schedule did not permit his participation. This year, the committee was elated when Dr. Blix graciously accepted our invitation, especially considering it was taking time away from his much deserved family vacation.

Dr. Blix, accompanied by his wife, Ambassador Eva Kettis, arrived in Tucson, Arizona USA, close to midnight on Tuesday night of the Annual Meeting, having traveled from Stockholm, Sweden. Wednesday and Thursday were a blur trying to keep up with this very active couple. On Thursday morning, Dr. Blix visited some of the morning paper sessions to listen to the speakers and then held a closed door session with the students that attended the INMM Annual Meeting. More than 70 students attended this session where Dr. Blix discussed his career and most recent efforts in arms control and disarmament and answered some very thoughtful questions by the students. Following his discussions with the students, he stayed to pose for photographs and sign autographs (including custom t-shirts and "Team America" DVD jackets) with great enthusiasm and humor.

Attendance at this year's Closing Session was a record high with more than 500 attendees present. Dr. Blix held the attendees captive with his soft-spoken manner sharing personal anecdotes while delivering a strong message on arms control and disarmament.

From left to right: INMM Member-at-Large Martha Williams, INMM President Steve Ortiz, Hans Blix, INMM Immediate Past President Nancy Jo Nicholas, INMM Fellows Committee Chair Obie Amacker, INMM Treasurer Robert Curl, INMM Vice President Scott Vance, INMM Government-Industry Liaison Committee Chair Amy Whitworth.

Following his Closing Plenary speech, Dr. Blix was awarded a lifetime honorary membership from the INMM by President Steve Ortiz with the following citation:

Whereas, Dr. Hans Blix has

- Promoted throughout his career the safe and secure operation of nuclear facilities; the safeguarding of nuclear materials worldwide; and the safe, secure and peaceful use of nuclear technologies
- Made outstanding and statesmanlike contributions toward the peaceful uses of nuclear energy
- Generously supported the Institute of Nuclear Materials Management during his tenure as Director General of the International Atomic Energy Agency through active participation in symposia and meetings conducted by the INMM Vienna Chapter
- And in recognition of his long and distinguished career and many contributions to disarmament, the nonproliferation of nuclear weapons, and freeing the world of nuclear, biological, and chemical weapons

The Executive Committee is honored to declare Dr. Hans Blix an Honorary Member of the Institute of Nuclear Materials Management.

It is safe to say that the Closing Plenary Session was one of the main highlights of this year's Annual Meeting. The complete text of Dr. Blix's speech, including his wonderful stories and anecdotes, follow in this volume of the Journal of Nuclear Materials Management. *It remains the goal of the Government Industry Liaison Committee to provide a high level of quality for future Closing Plenary sessions.*

Can We Now Move Toward Peace and Disarmament?

It is a great honor for me to be invited to speak at the Institute of Nuclear Materials Management on its fiftieth anniversary. I see the invitation also as an honor to the IAEA—the intergovernmental institute of nuclear materials management and I am happy to see several participants who worked with me at the IAEA: Olli Heinonen, a central actor; Jill Cooley, a professional anchor; Tom Shea, a thinker and innovator; Kaoru Naito, cheerful and competent; and Michael Rosenthal, who reminded me that he and I joined the IAEA at the same time—in November 1981.

Normally it takes a lot to pull my wife and I away from our July paradise on an island in the Baltic Sea. When the summer sun gives us a scorching 72º F we can cool ourselves by a dip in the sea at 64º F. We also enjoy the privilege of having three nuclear power units in our vicinity—at Forsmark. Moreover, the final disposal site for all Swedish low- and medium-level waste is located under the sea bed not far from us and we look forward to the construction in the same area in a few years time of the facilities for the disposal all Swedish spent fuel and high-level nuclear waste. Two communities in Sweden competed offering sites and I am happy that it is landing in my backyard.

You are addressing and finding solutions to matters that can literally become explosive or poisonous or both: how to keep check and control over substances like plutonium, cobalt, and cesium.

As a former head of the International Atomic Energy Agency, I have a great appreciation and admiration for the professionalism you show in helping the global community. Let me warmly congratulate you on your fiftieth anniversary. I know that you will continue to be scientific, solid, and innovative. I also know that the control and management of nuclear materials will become even more important in the future, if—as I ardently hope—the world succeeds in moving toward disarmament.

I fear that in the public there is not yet an adequate understanding of the importance of nuclear management, accounting, and reporting. In the Team America video to which I owe most of my fame I just have time to say to the North Korean leader: "If you don't declare accurately we will report on you…" before I am released to the sharks in the aquarium below. Great fun—but it fails to tell the viewer that reports from nuclear watchdogs are not mere bureaucratic verbiage but may lead to action by other dogs that bite.

I propose to comment first on some matters dealing directly with the control of nuclear materials and thereafter to turn to the much wider issues of how the world could seek to prevent the threat or use of nuclear weapons and ensure peace.

The National and International Control of Dangerous Materials

All national communities seek to control items and activities that they think hold significant dangers to their members and they set up joint international measures—like IAEA safeguards—for such control where they can agree.

The effectiveness of control and the selection of items for control vary. WMD—weapons of mass destruction—is an agreed choice though there is less agreement on what is covered by the term weapons of mass destruction. Some will say that small caliber weapons are the real weapons of mass destruction today. True, but they are not included in the normal definition of WMD. Other will suggest that cluster munitions should be included—but they are also normally not.

Perhaps I may lighten up the sinister subject by telling you about something that happened to me. I once received a mail from a lady who said she wanted to name her cat after me. She wanted to call it Blix and asked if I had any objection. I mailed back that my wife and I love cats and would feel honored. We only wanted to know that the cat accepted the name. The reply came promptly and informed us that the cat seemed very content and now performed beautifully as a weapon of mice destruction.

Well, while cats are not WMD, nuclear, biological, and chemical weapons fall within the definition. I remember a press conference in Baghdad in 2002 when I tried to drive home the point that the Iraqi government should be able to tell us where all the mustard gas was or had gone. I said, "Mustard gas is not marmalade. You keep control of it."

Well, you should. Governments should know how much dangerous material is produced or acquired, what has been consumed and how, and what may remain and where. The material balance should tally. However, as we know there may be errors in measurements or counting—resulting in material unaccounted for—MUF. Small quantities of enriched uranium or plutonium might be stuck in pipes and add up. What is a reasonable loss? When should we suspect that something is hidden or diverted and not merely stuck or lost? You have the expertise to discuss and answer these questions.

One item on which we were very suspicious in Iraq in 2003 concerned anthrax. We did not get a satisfactory explanation for the absence of a fairly substantial quantity. Only after the war was it explained that it had been disposed of in an area rather close to one of Saddam's palaces. While the dictator was still around our counterparts did not dare to report that.

The Development and Tasks of Nuclear Safeguards

With the Nonproliferation Treaty non-nuclear weapons state parties became obliged to declare at all times all fissile nuclear material within their jurisdiction. Thus, completeness of declarations became a requirement. However, while the IAEA was able to verify the correctness of the declarations, regrettably it was neither given the authority nor the adequate tools to check the completeness. On the whole, inspectors were limited to declared sites. As the IAEA had no access to satellite surveillance or intelligence from member

states, inspectors would often have been short on ideas where to go beyond declared sites anyway.

More Effective Safeguards Became Acceptable After the Discoveries in Iraq

The restrictive attitude of states changed somewhat after the Gulf War in 1991 and the discoveries made through the inspections in Iraq. The mandate laid down by the UN Security Council went much further than standard safeguards agreements and gave the inspectors the right to interrogate anyone and to go anywhere and the more intrusive inspections revealed that Iraq had successfully hidden its program for the enrichment of uranium. Noting the failure of the IAEA to detect the program and the inadequate authority given to the IAEA to perform effective safeguards I said at the time that the IAEA needed:

- greater access to sites
- greater access to information
- greater access to Security Council assistance.

The Iraq debacle led state members to support the IAEA embarking on the so-called 93+2 program that resulted—not in 1995 but during my last year as director general of the IAEA—in 1997—in a Model Additional Protocol (AP) that considerably improves the IAEA's ability to verify the completeness of nuclear declarations. Slowly—too slowly—the AP is being accepted by states.

Are the new IAEA safeguards in which the Additional Protocol has been integrated sufficient? Rights to more data and more access, environmental sampling, access to commercial satellite imagery are powerful new tools. Remote transmission of data automatically recorded at key installations increases efficiency without foreign inspectors milling around. However, more can be done and will be done—with your assistance. For instance, there could perhaps be more unannounced inspections and why on earth should IAEA inspectors need visas?

Let me now focus on a few other important points that surfaced in connection with the Iraq inspections.

Intelligence and Safeguards—An Almost Exclusively One-Way Traffic

First: the link to national intelligence. In going to the 2003 war in Iraq, the United States and other governments trusted the reports of some national intelligence organizations and ignored the fact that during many hundred inspections on the ground international inspectors had found no evidence of weapons of mass destruction. It has been reported that many ambassadors at the UN, Mohamed ElBaradei, and I were bugged by intelligence. If true, I only wish they had listened a little more carefully to what I had to say.

A few governments, while showing a 100 percent conviction that WMD existed, had 0 percent knowledge of where they were. Six years of war, occupation, and chaos is a colossal tragedy that might have been avoided if the usefulness of further inspection had not been dismissed with the impeccable but simplistic phrase "the absence of evidence is not the evidence of absence…" Regrettably, the absence of evidence gives room for fabulation.

I am not negative to national intelligence. I see national intelligence and international verification not as alternative sources of information but as different sources supplementing each other. International verification operates with the consent of governments and calls for their cooperation. It allows legal access to sites and equipment, to people and records. It should be perceived by governments not as a punishment but as a service helping them to show with a measure of credibility something they cannot show by themselves—namely, the correctness of their declarations and the absence of undeclared nuclear material and equipment.

National intelligence acquires information regardless of consent through electronic eavesdropping, export controls, interrogation of defectors, satellite surveillance, and espionage. Governments receive the results of both international verification and intelligence. Where these tally—fine. Where they diverge, governments should be careful in their conclusions and actions. International safeguards can sometimes act as a quality control of national intelligence.

Conversely, intelligence has the potential of increasing the effectiveness of safeguards. Relevant information can be passed to safeguards by intelligence organizations when through their many channels they get wind of something that is suspicious and perhaps unknown to safeguards. As director general of the IAEA I recruited an intelligence professional to join our staff to be the recipient of information that national intelligence might be ready to provide.

Information obtained through intelligence has thus the potential to alert safeguards to put forth relevant questions and to demand inspection. This is the way the affair of the alleged Syrian research reactor could have been handled. Instead, Israel simply bombed it. In the case of Iraq, UN inspectors received around 100 tips from intelligence about suspected sites. We had time to perform surprise inspections on some three dozens of them—finding no WMD. The negative result should have warned intelligence about the quality of their sources.

Intelligence organizations sometimes speak about intelligence sharing. However, while this might be common and useful between such organizations the path to international verification authorities should be almost exclusively one way. Authorities set up by the international community cannot engage in barter trade or joint operations with national intelligence. Inspected countries would not be cooperative if they believed that by agreeing to international safeguards they open up for foreign intelligence. International inspection must be independent. A short rhyme by a Danish poet comes to my mind:

> *"Little cat, little cat, walking so alone,*
> *Whose are you, whose are you?*
> *I am … my own…"*

One reason for the Iraqi obstruction to UN inspections in the 1990s, I am convinced, was the presence within the UN teams at that time of intelligence agents who tried *inter alia* to locate Saddam by electronic eavesdropping—not exactly a task mandated by the governing UN resolutions. Iraqi awareness that intelligence agents might also have used their presence in UN inspection teams in the 1990s to identify suitable targets for bombing by the United States or the United Kingdom can also not have made the Iraqi side more cooperative.

You Cannot Prove There are Zero Nuclear Relevant Items

According to recently reported disclosures from the U.S. Federal Bureau of Investigation, Saddam Hussein explained that a reason for his reluctance to readmit UN inspectors in 2002 was a concern that they would reveal to Iran how weak and exhausted Iraq was. I somewhat doubt that Saddam could have been sincere in thinking that Iran—with so many Shia friends in Iraq—would be ignorant of Iraq's exhausted condition.

Nevertheless, one reason—among several—for Iraq's obstructions to UN inspectors in the 1990s and resistance to their return in 2002 could well have been that Saddam wanted to create an impression both in Iran and elsewhere that Iraq might possess some WMD and still be dangerous. He put up a sign and one side of it warned, "Beware of dog" though he did not have a dog. The other side of the sign said to the UN: "No WMD. Lift sanctions!" His misfortune was that the U.S. government believed—or made itself believe—that there was a dog. I am sure Iran was never misled.

The reason why it was at all possible for a country that was prostrate after over ten years of sanctions to appear—at least to some—as a continued threat to the peace is important in this discussion. It lies in the extreme difficulty of proving the negative.

International inspectors charged with the task of covering a large country with big cities, industries, and military installations will simply not report "there is nothing" because there will always remain a residue of uncertainty. Not every basement has been inspected. Whether the uncertainty is so small as to be negligible is a political judgment—a decision that is not entrusted to an international civil service but must be left to governments that might disagree.

In the case of Iraq both I (in 1997) and Mohamed ElBaradei (in 1998) noted in our reports about the nuclear sector that there was no infrastructure left for the making of nuclear weapons but it was not possible, we wrote, to certify that there were no nuclear-relevant minor items, like computer programs or even prototypes of centrifuges. Five years and many new IAEA inspections later the residue of uncertainty in the nuclear sector appeared even smaller to inspectors and to most countries. The United States, however, expressed the conviction that a nuclear program was under way and acted on that conviction.

Verifying Global Zero Nuclear is a Distant Problem; Start Reductions Now

Reducing the residue of uncertainty in inspections to a minimum permitting the conclusion that it is negligible is, of course, particularly important when the declared quantity of fissile material—or bombs—is small or zero. Whether a country has zero bombs or one bomb matters a great deal. Whether it has 1,000 or 1,001 bombs matters less. This circumstance is often invoked as a great problem in the discussion of how to get the world to a nuclear global zero. How—we are asked—can we develop a nuclear materials counting that reliably assures us that the Russians, Chinese, or North Koreans—or indeed, terrorists—do not hide a couple of bombs in some caves when others have loyally done away with theirs?

While the wake-up call for global zero offers an attractive vision, it invites such questions. In my view, the questions are not terribly relevant today and we do not know whether they will turn out to be significant at a time when nuclear arsenals are getting very low. Global zero is some time off.

The Next Steps in Arms Control and Disarmament and Their Verification

Today and for a number of years to come it is not the final but the next steps that matter most. If we think that it is now desirable to start reducing the role of nuclear weapons and the number of nuclear weapons and weapons states in the world, we should try to do so. If a centipede would not move until it knew where next to put is last legs it would never move its first legs.

Can We Verify Reductions with a Level of Credibility that We Find Acceptable?

Most will agree that the verification difficulties in the measures now discussed should not be insurmountable. No arms control agreement has stronger and more reliable verification mechanisms than that which is on the top of the agenda—the Comprehensive Test Ban Treaty: seismic, hydro-acoustic, infrasound, radionuclide monitoring and space tracking.

Ratification of the treaty by the United States and some other states and entry into force would be helpful to nonproliferation and to impede qualitative developments of nuclear weapons. It would also send a strong signal that arms control and disarmament is seriously on the world's agenda. Failure by the United States and others to make the treaty enter into force might send a signal that the option to test remains valuable.

Adequate verification of a Fissile Material Cut-Off Treaty raises greater difficulties but they can and—with the support of the new U.S. administration and with your support—will be tackled. Many fuel-cycle plants are, in fact, subject to IAEA inspection—as in Japan, Brazil, and China and to EURATOM inspection in France and the United Kingdom.

The current worry about new fuel cycle activities has some rational reasons. However, efforts to impede expansion of

them will be counterproductive if the aim is a system that would seek to pressure the majority of states to renounce them while "licensing" a small group of states to perform them. In practice, the economic realities will go a long way to limit the spread of fuel cycle activities. Just as most countries refrain from building oil refineries most countries will not build enrichment plants. Where they do, despite access to clearly cheaper reliable services, the world may have reason to be suspicious and alert.

I shall not go through the long catalog of measures urged by political groups, think tanks, and international commissions to reduce the number and roles of nuclear weapons and to move toward disarmament. You will find an extensive and reasoned list in the report *Weapons of Terror* (wmdcommission.org).

The report was adopted by an international Weapons of Mass Destruction Commission that I headed. If governments have the political will and energy there is a big agenda to tackle.

In this regard let me make two points. The first is that in my view the Obama administration has shown a strong will to tackle the agenda and embarked admirably on it. The joint London declaration with President Medvedev, the Prague speech, and the Cairo speech provide encouraging policy declarations. Positions taken in some specific matters also appear constructive:

- In a little noticed passage of the Cairo speech President Obama declared that no nation can "pick and choose" which nations can have nuclear weapons and he made it clear that in his view all states—including the United States—should move away from nuclear weapons. This is a more principled position than one that says "OK" for Israel and India, absolutely "No" for Iran and North Korea and "Well, well" for Pakistan. I do not suggest that it will convert North Korea and Iran but, in my reading, it offers the United States a more respectable negotiating position. Consistently with this posture the United States recently joined an appeal at a Prep Com meeting for the NPT review conference that Israel, India, and Pakistan should join the treaty as non-nuclear weapon states.
- By no longer refusing to discuss subjects that other states worry about the United States has recently helped to break the deadlock that for over ten years prevented the Conference of Disarmament in Geneva from even adopting a work program. The subject of weapons in space can now be taken up and the Cut-Off Treaty will again be on the negotiating table with no U.S. objection to discuss verification.
- With no delay the United States has got down to talks with Russia on a follow up to the START I treaty that is due to expire in December 2009. I note that this comprises the important question of continued verification in the United States and in Russia. I note also that a successful conclusion of a follow up agreement will depend on measures that can dispel the Russian fear that the United States will seek to put a new policy of containment in place. I note lastly, that the preliminary understanding reached recently in Moscow appears to introduce rather modest new restrictions on deployed warheads and delivery vehicles. An improved political climate, I hope, would bring discussions and set in motion sharper cuts and reductions by other nuclear weapon states.

My second point is that global measures to improve the safe management and reliable accounting of nuclear material—as well as verification—are vitally important parts of the long disarmament agenda. The Nunn-Lugar program has been a wise investment. Good control is needed not only for highly enriched uranium and plutonium but also for material like cobalt and cesium. The public needs protection from accidents—like the Goiania case a number of years ago and from anybody putting together a dirty bomb.

More Reliable Security Will Facilitate Disarmament. Is the Cold War Over?

I have already noted that we cannot sketch the pattern or system of collective security and verification in a world that has done away with the threat of nuclear weapons and—in tandem—has reduced its conventional armaments. This, however, is not a reason for abstaining from ardently striving for improvements in security and verification today. Indeed, such improvements are a precondition for the revival of arms control and disarmament that could be within reach.

What brings states security today—apart supposedly from military readiness, deterrence and mutual assured destruction?

The classical advice has been *Si vis pacem, para bellum* (If you want peace, prepare for war). Is it still valid? Or, if we want peace, perhaps we should prepare for peace? Perhaps we should listen as much to peace research institutes as to the institutes of strategic studies. The counting of warheads, delivery vehicles, and checking of ranges is attractively concrete and factual compared to the analysis of political threats—or absence of threats. Yet, the volume of arms should correspond to the threats we identify. If we do prepare for war, as we undoubtedly still do, we must answer the crucial questions: which war and at what level and types of armaments?

Armaments and arms races used to be prompted by political controversies and respond to identified potential threats. In recent years, strangely, arms developments have been driving political controversy. This is particularly true for Russia where recent increases in military spending may have been prompted by the coordinated military power of the NATO alliance moving closer to Russia and by the planned placement of parts of the U.S. missile shield near Russian borders.

Many of us have lived a good part of our lives during the extremely risky Cold War with mutually assured destruction (MAD) as the ultimate scare—and supposedly ultimate protection. It was a time when the Danish poet I quoted a moment ago wrote that

"the noble art of losing face, may one day,
save the human race."

The increasingly frosty East-West climate of the last ten years is worrisome. We missed the chance that arose right after the end of the Cold War to move the world to a more reliable security order. Instead, the U.S. unilateral moment was prolonged. We may now have a second chance. Improving the political climate and reducing armaments could now be within reach, if—a big if—we choose to recognize and confirm that the Cold War is over and decide to act on that conviction.

Well, do we recognize that? The remarkable four U.S. elder statesmen (George) Shultz, (Henry) Kissinger, (William) Perry, and (Sam) Nunn, a large part of the U.S. foreign affairs elite are convinced

- that the threats to peace in the world today come from other quarters than the big powers that declare that despite differences armed conflict is out of question between them;
- that continued development of and reliance on nuclear weapons by the big powers may well lead to further proliferation; and
- that we should begin the march out of the nuclear weapons era.

Several groups of senior statesmen in Europe have come out in support of this view and the response of the Russian civilian leadership has been cautiously positive. I suspect, however, that large numbers of the military and of the weapons producers everywhere are skeptical and I am sure we shall hear from them.

Do the Risks of the Post Cold War World Justify Current Armaments?

Of course, we cannot ignore that some dangerous flash points remain in the world—although none of them would be likely to trigger a larger conflagration, as the Cuban crisis could have done. Taiwan and Kashmir are the most obvious flashpoints but areas with unsettled borders and disputes about land in the Middle East and parts of Africa also pose risks of armed conflicts.

Proliferation of nuclear weapons and activities of non-state actors present other risks.

The cases of North Korea and Iran are acute and dangerous but will not lead to conflicts between the big powers. While the interests of the big powers are not identical they all wish to prevent the two states as well as non-state actors from becoming nuclear threats.

At this moment—July 2009—inability or unwillingness in the two countries to negotiate has led to a kind of intermission and pressure on them right now might well provoke undesired responses. At the same time there appears to be some convergence of positions between the big powers negotiating. The United States continues to voice the mantra that "all options are on the table" but it seems probable that the Obama administration's general preference for diplomacy and direct talk is leading it to join the other negotiating states in common positions that can be given legal force in the Security Council.

Diplomacy is not just "the bland talking to the bland" but the art of solving differences by other means than the threat or use of physical force. Iran may be threatened by sharpened non-violent economic sanctions for non-cooperation. For cooperation the country will be offered benefits, for instance in the areas of economic development, security, and diplomatic relations. In my view the parties have neither exhausted the non-violent pressures they can apply nor the positive incentives they can offer.

The threat of armed force or efforts of subversion are likely only to stimulate the two states to move further on the nuclear weapons route while a use of armed force may have unforeseeable and catastrophic consequences. Negotiated solutions will undoubtedly comprise important and difficult elements of verification. Be prepared to offer advice!

Do the risks that I have discussed justify some 25,000 nuclear warheads and modernizations that ensure that the nuclear arsenals are still in good shape even in 2050?

Some time ago during a Q and A period I was asked: Could we not at least agree to limit the nuclear arsenals to a level that would be enough to wipe us out once?

We are evidently still much more engaged in planning for war than for peace! Big powers are busy constructing new aircraft carriers, new supersonic fighter planes, new nuclear submarines, making costly preparations for space war etc…? is it to have a readiness against terrorists? Or is it to keep the military-industrial complexes in the world happy?

We had better ponder these questions. The military spending of the world is calculated currently to be about $1.4 trillion, half of the sum falling on the U.S. taxpayers. Is this not overdone? Could we not decisively reduce these costs if we revive disarmament instead of reviving the Cold War? We could use the savings for badly needed measures to protect our biosphere and to reduce poverty.

Over Time Peace Has Expanded and Many Causes of War Disappeared

Looking at the question of peace over a longer period of time gives some reasons for optimism. We find that the areas of peace in the world have grown immensely in the last fifty to100 years.

- There will be no wars between the United States and Mexico although there were such wars in the past;
- In South America there could perhaps be internal strife in some countries but hardly armed conflicts between states;
- The European Union was created as a peace project and today war between any members of the European Union is unthinkable and few think a war with Russia could be possible.

Looking at the question of what over time have been causes of war also gives some reason for optimism:

- Wars used to be fought about land but exception made for Kashmir and the Middle East and parts of Africa disputes about land are not a likely source of armed conflict. Perhaps Saddam Hussein was the last ruler bent on the conquest of land in a big way;
- Wars used to be fought about borders but—with the same exceptions—most borders in the world are settled; lastly
- Wars used to be fought about religion or ideology, but with the end of the Cold War this is surely a thing of the past. The market economy of various shapes and democracy of various kinds seem to be the universally acclaimed—if far from always practiced—models. There will be no wars of civilizations.

Could competition about commodities, notably oil and gas, lead to armed conflicts between the big powers? It is true that areas of tension coincide remarkably with areas of large oil and gas sources: the Middle East and Central Asia. However, is it not more likely that the competition about oil and gas and other commodities will play out in prices rather than in the control of land?

If, indeed, we would fear that a competition about oil and gas resources could cause serious conflict should we not—rather than further arming ourselves—strive urgently to reduce our need for imported oil and gas? Security reasons should be added to the compelling environmental reasons to reduce a continued excessive use of these fuels. An increased reliance on nuclear power may help to reduce the risk of potentially conflicting needs for oil and gas.

Institutional Aspects of Peace and Disarmament: The UN Security Council

Let me turn, lastly, to some institutional aspects of security. What arrangements for collective or other security can be developed in the future as big powers gradually reduce their stocks of nuclear weapons? How can possible nuclear break-outs be handled?

The first answer is that it will be a while before the United States and Russia go down to really low nuclear levels. Moreover, they and most states will retain a good deal of advanced conventional armed force.

What about Security Council action to avert threats? Will the big powers—permanent members—be able to cooperate?

The Security Council of the United Nations and its five veto-wielding permanent members were entrusted by the Charter with the task of maintaining international peace and from 1945 until the end of the Cold War the Council and the UN security system were largely paralyzed. I would certainly not claim that it is effectively policing the world now but I do submit it is no longer paralyzed!

In 1991 the Council agreed on armed action against Iraq to liberate Kuwait and there have been many important agreed decisions since then.

There is also something new developing in the world: the accelerating interdependence of states in areas like economy, finance, trade, and communication. It is giving rise to new non-military leverages that I believe will increasingly induce states to be more conciliatory and accommodating to each other and less inclined to flex military muscles.

It is not farfetched to expect that this will happen also between states in the Security Council, including the veto wielding permanent members. We can already see signs of this. Despite some differences in interests and in attitudes the permanent five members are evidently seeking to maintain united positions in the cases of North Korea, Iran, and many other instances.

The second answer is that while in all likelihood the Security Council of the United Nations will become the central mechanism it was meant to be for maintaining security in the world we cannot foresee how the Council will be modified in the next forty years—say between 2010 and 2050. All we know is that much will happen.

Between 1910 and 1950 there were two world wars; there was the establishment of the first world organization, the League of Nations that existed for the some twenty years between the wars. And after World War II we established the world's first really universal organization of states—the United Nations and a host of specialized agencies.

Can we help to bring about changes in the United Nations resulting in more reliable security and reliably less weapons? It is easy to see that the statutory presence of the five veto equipped permanent members reflects the world power structure of 1945—not that of 2009. It is also easy to see that powers like Japan, India, and Germany now consider themselves unfairly excluded. Their presence in the Council would add to its economic power. Yet, the Council must not simply become a big power cartel and to be effective the Council must not be too big.

Perhaps France and the United Kingdom could give up their separate seats and force the European Union to speak with one voice from one seat? Perhaps the permanent members could renounce the right of veto in all questions that do not pertain to the use of military sanctions? I do not know.

I shall end with Mr. Hammarskjöld's modest assessment that the UN may not take us to heaven but might help us avoid going to hell.

Real-Time Detection of UREX+3a Extraction Streams for Materials Accountancy

Braden Goddard, William S. Charlton, and Sean M. McDeavitt*
Texas A&M University, College Station, Texas USA
**Braden Goddard is the 2009 recipient of the J. D. Williams Student Paper Award – First Place*

Abstract

Due to increased construction of nuclear power plants, current stockpiles of used nuclear fuel, and a desire of the public to reduce the amount of this used nuclear fuel, reprocessing is gaining popularity. However, reprocessing facilities in non-weapon states must be safeguarded. To help create a safeguards strategy for non-weapons states, gamma ray measurements from samples of the UREX+3a reprocessing method were made with a variety of detector types and times. It was determined that the errors from quantitative measurements were too large for safeguards purposes; however, a safeguards strategy based on qualitative gamma ray and neutron measurements was created. Self-shielding and neutron damage to gamma detectors were also looked at. It was determined that there is no noticeable self-shielding for internal pipe diameters less than two inches and that HPGe N-type detectors would be suitable for a neutron radiation environment. Gamma ray spectra were simulated in Monte Carlo Neutron Particle Transport Code for UREX+3a reprocessed fuel that had a decay time of three years. A conclusion was reached that the safeguards approach proposed in this paper would best be suited as an addition to existing safeguard strategies.

Introduction

There is a renewed and increasing interest in building new nuclear power plants. This is evident in the recently proposed and current construction of twenty-six nuclear reactors in the United States and ninety-seven nuclear reactors throughout the world.[1] People throughout the world are concerned about disposal solutions for used nuclear fuel produced by future, current, and past nuclear reactors. Previously proposed and attempted solutions, such as permanent geological storage, have met resistance from the public. Reprocessing is a possible solution to the waste problem of used nuclear fuel that currently appears to be more accepted by the public than previous proposed solutions.

Isotopes of transuranic (TRU) actinide elements emit gamma rays with a unique spectrum of energies that are characteristic to each of the individual isotopes. These unique energy gamma rays can be observed and quantified by a variety of existing detectors. Quantitatively keeping track of $_{235}$U and Pu isotopes in a reprocessing facility is of significant concern from safeguards viewpoints.

Non-nuclear weapons states that wish to comply with the Nonproliferation Treaty must certify that they are not diverting nuclear material. This is done through the International Atomic Energy Agency (IAEA). Since all measurements have some error the IAEA allows for some material to be unaccounted for. This measurement error must be such that three times the one sigma uncertainty is less than one significant quantity (SQ). One SQ is the approximate amount of nuclear material that the IAEA considers sufficient for a state to manufacture its first nuclear explosive, taking into account process manufacturing losses.[2] Table 1 provides a list of how much material is needed for one SQ of different isotopes.[4] The IAEA currently does not have a method in place to safeguard Uranium Extraction (UREX+) reprocessing facilities. The safeguards in place at current commercial reprocessing facilities use costly and time-consuming destructive analysis of samples taken through the reprocessing process.[3] If a real time material accountancy measurement could be used it would save the IAEA money and man hours.

Background

UREX+3a is a specific separation scheme in the UREX+ family. All UREX+ methods extract U and Tc as the first step. What is separated after this first step is determined by the type of UREX+ process. A list of the PUREX, COEX, and different UREX+ separation methods can be seen in Table 2.

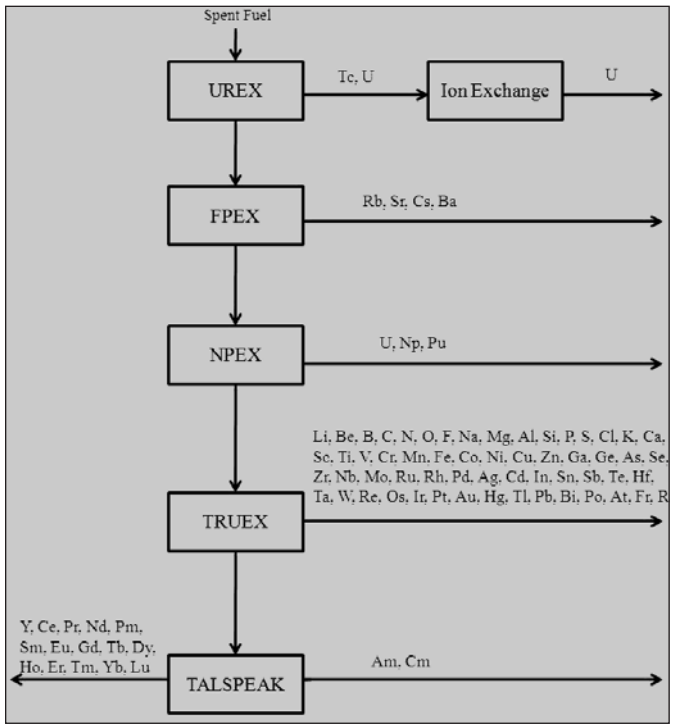
Table I. Values of one SQ for different isotopes [4]

Material	Mass quantity
Pu[a]	8 kg
$_{233}$U	8 kg
$_{235}$U, greater than 20% enriched	25 kg of $_{235}$U
$_{235}$U, less than 20% enriched	75 kg of $_{235}$U
Th	20000 kg

[a]Pu with an isotopic fraction of $_{238}$Pu greater than 80 percent is exempt.

The UREX+3a method was chosen for measurement because it is one of the more likely UREX+ methods to be used in a full-sized reprocessing facility.[5] Also, several national laboratories, including Argonne National Laboratories (ANL), have done laboratory scale experiments with the UREX+3a process and have samples available for each of the steps in the separation process.

Figure 1. High-level process flow diagram for the UREX+3a separation method



The physical mechanism that mixes chemicals into the dissolved used nuclear fuel is not UREX+ specific. Common methods include mixer settlers, pulse columns, and centrifugal contactors. For this research it was assumed that centrifugal contactors would be used in a full-sized reprocessing facility. Centrifugal contactors mix and separate chemicals and elements quickly, less than a minute, thus preventing most daughter products from building up before making a gamma measurement.

Theory

By accurately measuring gamma ray energies and determining ratios of peak heights, the isotopes that the gamma rays come from can be determined. Alpha and beta particles also have unique energies and maximum energies, respectively. Unfortunately, both alpha and beta particles can be attenuated by very thin materials. They are also both charged particles, which means that they continuously lose energy as they pass through a material, unlike gamma rays, which lose their energy discretely. This creates a problem when trying to measure dissolved used nuclear fuel in nitric acid that is flowing through a stainless steel pipe. Due to the limited scope of this research it was left for another research team to solve this problem.[6]

Neutrons can come from both fission and alpha-n reactions. Neutron energies from either of these reactions are not unique; however, a neutron coincidence counter can discriminate between spontaneous fission and alpha-n neutrons. Knowing that certain nuclides are not present in a material can be just as valuable as knowing what nuclides are in the material.

Table 2. A list of the PUREX, COEX, and different UREX+ separation methods

Process	Product	Product	Product	Product	Product	Product	Product
	#1	#2	#3	#4	#5	#6	#7
PUREX		TRU/Ln/FP	U		Pu		
COEX		TRU/Ln/FP	U		U/Pu		
UREX+1	U	Tc	Cs/Sr		TRU/Ln	FP	
UREX+1a	U	Tc	Cs/Sr		TRU	FP/Ln	
UREX+1b	U	Tc	Cs/Sr		U/TRU	FP/Ln	
UREX+2	U	Tc	Cs/Sr	Pu/Np	Am/Cm/Ln	FP	
UREX+2a	U	Tc	Cs/Sr	U/Pu/Np	Am/Cm/Ln	FP	
UREX+3	U	Tc	Cs/Sr	Pu/Np	Am/Cm	FP/Ln	
UREX+3a	U	Tc	Cs/Sr	U/Pu/Np	Am/Cm	FP/Ln	
UREX+4	U	Tc	Cs/Sr	Pu/Np	Am	Cm	FP/Ln
UREX+4a	U	Tc	Cs/Sr	U/Pu/Np	Am	Cm	FP/Ln

UREX+3a Samples

Nine different UREX+3a samples that were separated in summer 2007 were acquired from ANL and analyzed in December 2008 at Texas A&M University. These samples were taken from different locations in the UREX+3a process. No samples of the Am and Cm bearing TALSPEAK raffinate or Lanthanide (Ln) bearing product were acquired because these samples were unavailable.

The samples are composed of four different fuels, ATM-101, ATM-103, ATM-106, and high burn-up H.B. Robinson. Additional information on these fuels can be seen in Table 3.[7,8,9]

Table 3. Information on used nuclear fuels used to create the samples

Fuel	Mass used	Burn-up	Discharge date
ATM-101	415.95 grams	28.03 GWd/MTU	1974
ATM-103	58.97 grams	29.80 GWd/MTU	1980
ATM-106	59.12 grams	42.32 GWd/MTU	1980
High burn-up H.B. Robinson	7.89 grams	N/A	N/A

Gamma Measurements

In order to determine what type of gamma measurement would provide good results while remaining inexpensive and fast, a matrix of detector types and measurement times where created, as seen in Table 4. The detector types considered were, High Purity Germanium (HPGe) P-type, HPGe N-type, Lanthanum Bromide (LaBr), and Sodium Iodide (NaI). The measurement times ranged from 10 seconds to 21,600 seconds and were counted in life-time mode.

Table 4. Detector type and measurement time matrix

Detector types	Measurement times [seconds]					
HPGe N-type	10	600	3600a	3600ab	7200ab	21600ab
HPGe P-type	10	600	-	-	-	-
LaBr	10	600	-	-	-	-
NaI	10	600	-	-	-	-

Gamma Ray Data

Table 5 contains the isotopes that could be identified for a 3,600 second long count using an HPGe N-type detector. There are several isotopes identified, $_{208}$Tl, $_{212}$Pb, $_{214}$Pb, and $_{214}$Bi, in the measurements of the UREX product and NPEX product that belong to background radiation from nearby unshielded cinder blocks. These background isotopes, which also appear in background measurements, only appear in the measurements of the UREX product and NPEX product due to the low activity of the samples.

The peaks in the gamma ray spectra were identified using tabulated gamma ray tables and online gamma ray databases.[10,12] Of all the gamma ray measurements taken, there are only four well-defined peaks that could not be identified: 291 keV, 371 keV, 917 keV, and 1,319 keV in the FPEX raffinate, NPEX raffinate, and TRUEX raffinate. It is suspected that these gamma rays come from the lanthanides since they appear whenever Eu peaks are visible.

Figure 2. Geometry for an HPGe gamma ray measurement

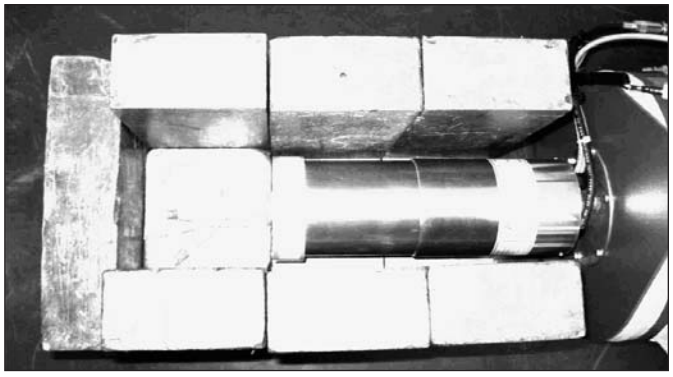
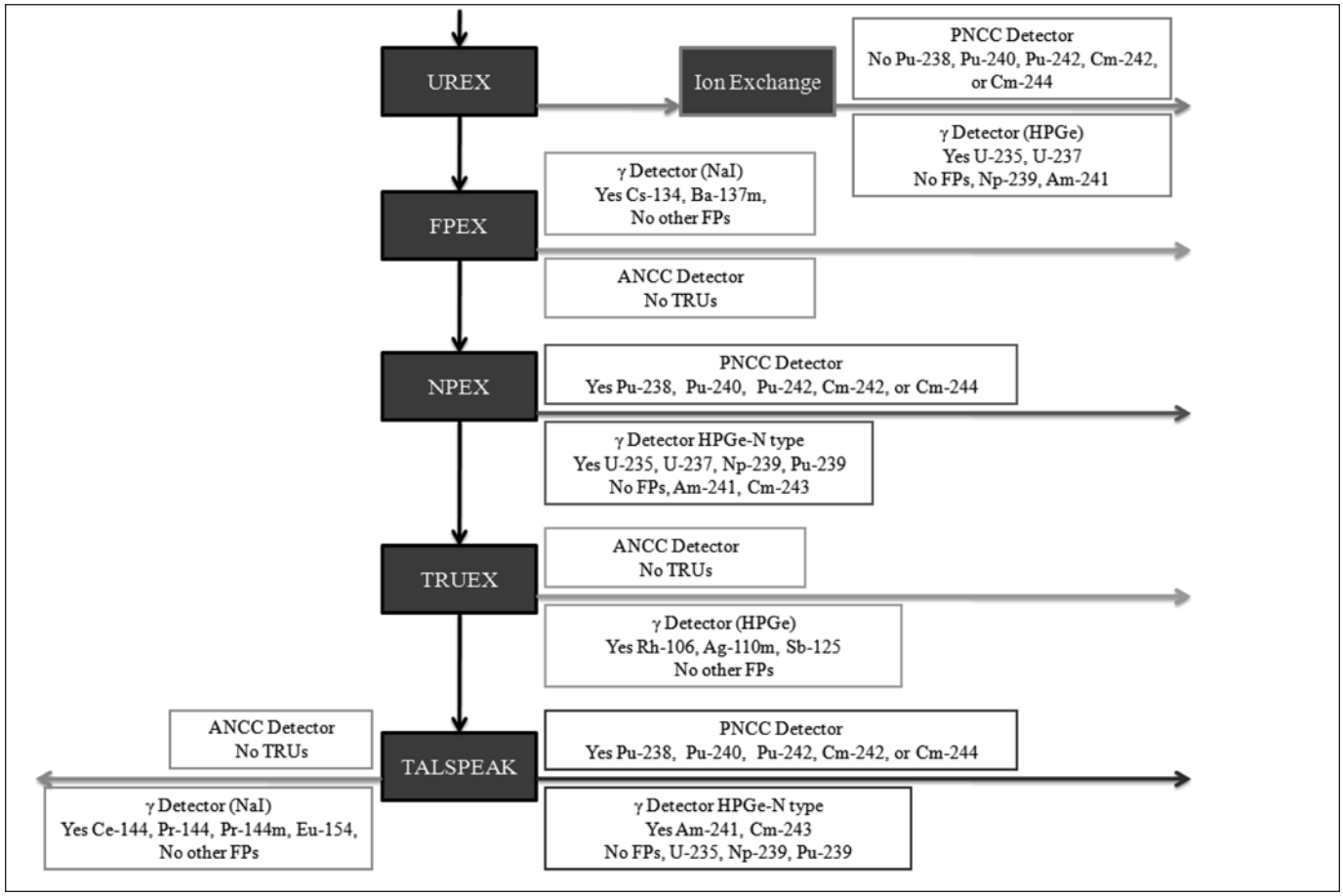


Table 5. Isotopes that could be identified in a 3600 second HPGe N-type gamma ray measurement

Extraction stream	Isotopes Identified
Dissolved fuel	$_{134}$Cs, $_{137}$Cs, $_{154}$Eu, $_{241}$Am
UREX raffinate	$_{134}$Cs, $_{137}$Cs, $_{154}$Eu, $_{241}$Am
UREX product	$_{137}$Cs, $_{208}$Tl, $_{212}$Pb, $_{214}$Pb, $_{214}$Bi, $_{234}$mPa, $_{234}$Th, $_{235}$U, $_{238}$U
FPEX raffinate	$_{137}$Cs, $_{154}$Eu, $_{239}$Np, $_{241}$Am, $_{243}$Cm
FPEX product	$_{134}$Cs, $_{137}$Cs
NPEX raffinate	$_{137}$Cs, $_{154}$Eu, $_{239}$Np, $_{241}$Am, $_{243}$Cm
NPEX product	$_{137}$Cs, $_{212}$Pb, $_{214}$Pb, $_{214}$Bi, $_{233}$Pa, $_{237}$U, $_{241}$Pu
TRUEX product	$_{60}$Co, $_{106}$Rh, $_{125}$Sb, $_{126}$Sb, $_{134}$Cs, $_{137}$Cs
TRUEX raffinate	$_{154}$Eu, $_{239}$Np, $_{241}$Am, $_{243}$Cm

Figure 3. A detection scheme for the UREX+3a process to prevent all but small amounts of Pu from leaving the system undetected through undesired paths



Neutron Damage to Detector

Neutron radiation can damage the crystal structure of HPGe detectors, thus reducing their energy resolution. If the material being measured has a complex gamma ray spectrum in a narrow energy range, such as Pu, a neutron damaged HPGe detector loses the ability to distinguish the individual gamma ray peaks. An estimate of the threshold damage for a 30 percent efficient HPGe N-type detector is 4x109 n/cm^2.[13] Any damage done to an HPGe N-type detector can be repaired by annealing for twenty-four hours at 100°C. This annealing process can be done as many times as is required without any loss of gamma ray resolution or damage to the crystal.[13] This is not true for an HPGe P-type detector, which requires 168 hours of annealing at 120°C and will lose significant gamma ray resolution after annealing. Because of this, it is suggested that HPGe P-type detectors should not be used for gamma ray detection in a reprocessing facility.

ORIGEN

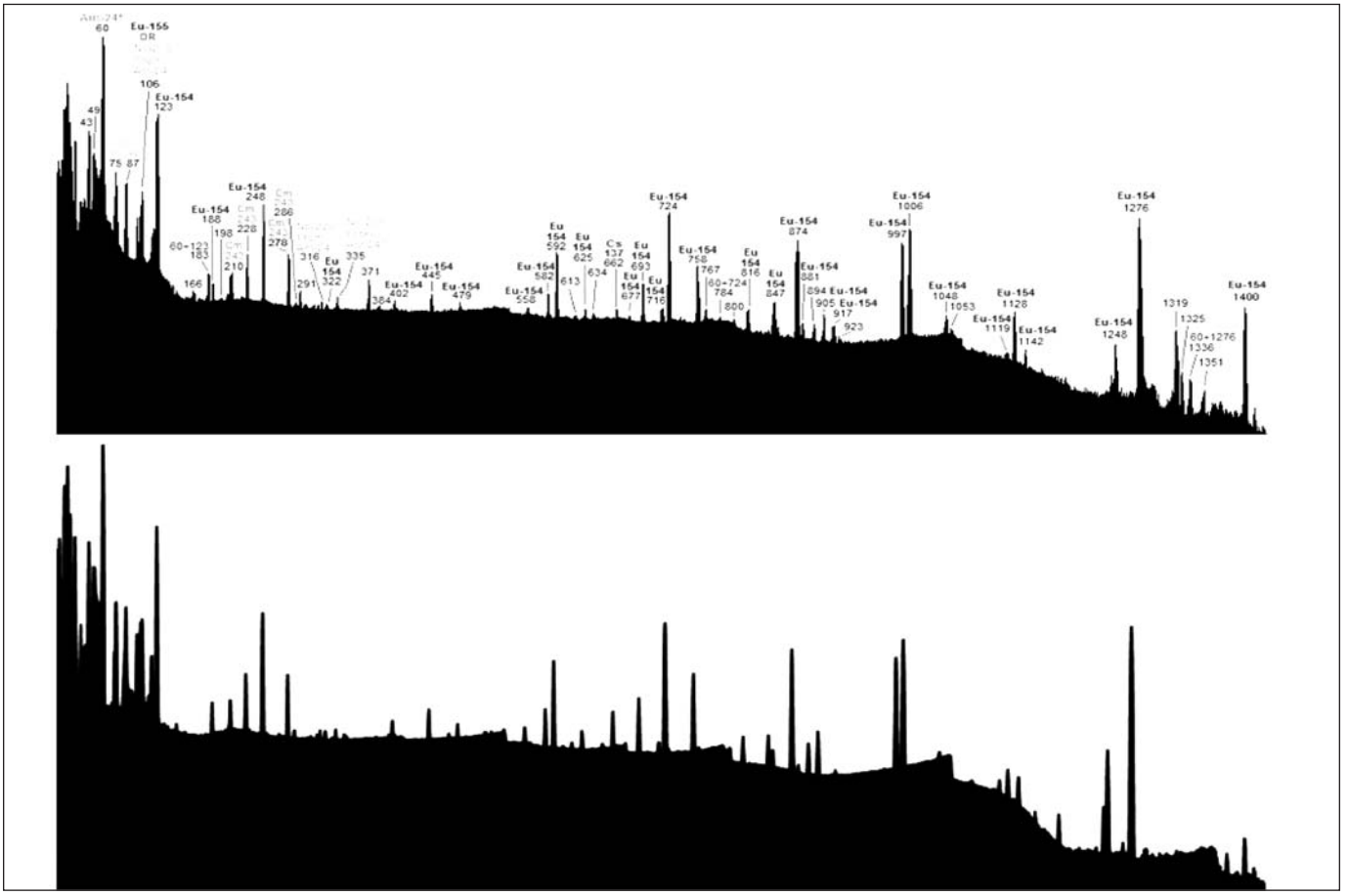
Because the fuels from which the UREX+3a samples are comprised of do not represent what would most likely be reprocessed in a real facility, the Oak Ridge Isotope Generation and Depletion Code (ORIGEN) was used to simulate the isotopics of fuel more likely to be reprocessed. The fuel simulated is a 17x17 PWR, 44 GWd/MTU fuel with an initial enrichment of 4 percent $_{235}$U. This fuel was burned at a specific power of 40 MW/MTU for 1100 days. After discharge it was allowed to decay for three years before being reprocessed. This fuel is representative of nuclear fuel currently being burned in commercial nuclear plants. Also, it is felt by some researchers that it would be more economical to reprocess the recently burned, higher Pu content, fuel.

MCNP

Because the fuels from which the UREX+3a samples used in this study were comprised do not represent what would most likely be reprocessed in an actual facility, MCNP simulations were run to give a more accurate representation of what the gamma spectra would look like from fuel that was reprocessed.

The first step in this process was to accurately simulate the gamma spectra of the UREX+3a samples. This was done by taking the measured isotopics after the UREX+3a chemical separa-

Figure 4. Comparison between a measured (top) and MCNP simulated (bottom) gamma spectrum for the UREX+3a FPEX raffinate



tions, in summer 2007, and decaying them until December 2008 using the software program ORIGEN. These isotopics were then converted into a MCNP source definition format and combined with the geometry and material types used in the actual measurements of the UREX+3a samples. The MCNP simulations compared well to the actual measurements. This can be seen in Figure 4, which shows both a measured and simulated gamma spectrum from the FPEX raffinate. The main differences between the actual measurements and the MCNP simulations are inconsistencies in $_{134}$Cs and $_{137}$Cs, a lack of $_{237}$U in the NPEX product simulation, and several isotopes in TRUEX raffinate.

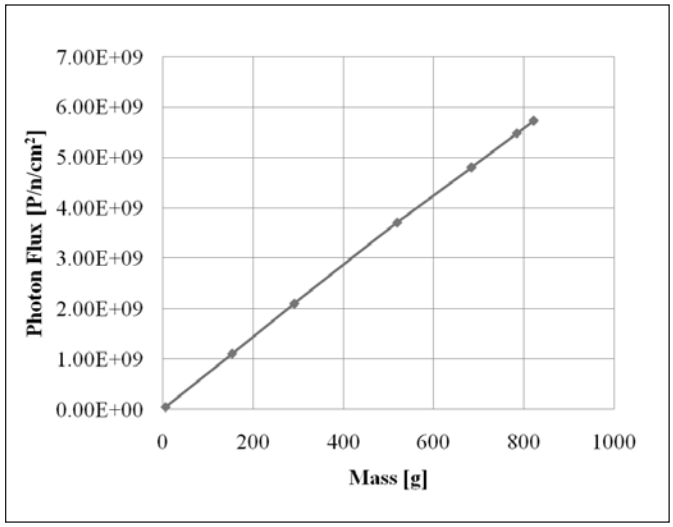
After confidence was gained that the gamma ray spectra from the UREX+3a process could be accurately created, gamma spectra for the simulated fuel were created using the same geometry, material types, and detector data used in the UREX+3a sample HPGe N-type simulations. The same elemental fractions were used for the simulated fuel as the UREX+3a samples for each extraction stream but the isotopics were different due to different fuel histories. The gamma spectra from the simulated fuel have more short lived isotopes which complicate the gamma spectrum, as would be expected.

Self-Shielding

A common problem that occurs when trying to measure gamma rays from bulk, dense, or high atomic number materials is that the radioactive material attenuates its own gamma rays. To address this problem for a reprocessing facility, MCNP simulations were run. A model of a two-inch inside diameter stainless steel 316 schedule 40 pipe was created in MCNP with an internal radioactive fluid composition based on proprietary information from ANL. A 2.6 cm diameter sphere of germanium was placed a distance of 40 cm away from the center of the pipe. The MCNP source definition was based on ORIGEN isotopic calculations of the simulated fuel that was then converted into a MCNP source definition format. The internal radioactive pipe fluid geometry was simulated as a hollow cylinder of varying thickness on the inside of the pipe. A curve relating the photon flux inside the germanium sphere to the total mass of the radioactive fluid inside the pipe can be seen in Figure 5 for the FPEX product.

If the radioactive fluid was significantly self-shielding, the gamma rays that was creating toward the center of the cylinder would have a smaller probability of reaching the sphere of germanium due to photon absorption in the radioactive fluid. This

Figure 5. MCNP simulation showing that the mass FPEX product inside a pipe is proportional to the flux inside a nearby detector



would create a curve that would level off and approach a limiting value. The curve in Figure 5 is linear, which indicates that no significant amount of self-shielding occurred. Photons of low energies, such as those of Pu, are more readily absorbed than higher energy photons, such as those from $_{137}$Cs. However, further MCNP simulations showed no self-shielding of Pu gamma rays.

Conclusion

Due to the limiting gamma ray resolution of HPGe detectors it is recommended that the safeguards approach proposed in this paper be combined with existing safeguards techniques. It is also recommended that HPGe N-type gamma ray detectors be used due to their good resolution, neutron resistance, and ability to quickly and fully anneal defects.

Further research that should be pursued is a sensitivity study of the amount of impurities, Pu in particular, that can be present in an extraction stream before they are detected by either gamma ray or neutron coincidence counter detectors. This should be done with both real samples and MCNP simulations.

Another area of further research is the measurement of recently separated bulk UREX+ extraction streams. This would allow for gamma ray spectra that do not contain daughter products. This would also allow for geometry configuration experiments and neutron coincidence counter measurements of real UREX+ facility activity extraction streams.

References

1. 2009. World List of Nuclear Power Plants, *Nuclear News,* 41-62.
2. Key Terms. Institute for Science and International Security. 6 June 2009. http://www.isis-online.org/publications/fmct/primer/keyterms.html.
3. Private communication William S. Charlton (September, 2008).
4. Reilly, D., N. Ensslin, H. Smith, and S. Kreiner. 1991. *Passive Nondestructive Assay of Nuclear Materials,* Washington, DC: U.S. Nuclear Regulatory Commission.
5. Private communication Candido Pereira (December 13, 2007).
6. Lapinskas, J. R., S. M. Zielinski, J. A. Webster, R. P. Taleyarkhan, S. M. McDeavitt, and Y. Xu. 2009. Tension Metastable Fluid Detection System for Special Nuclear Material Detection. *Proceedings of the 17th International Conference on Nuclear Engineering*, Belgium, Brussels.
7. Materials Characterization Center. 1985. *Characterization of LWR Spent Fuel MCC-Approved Testing Material-ATM-101,* Pacific Northwest Laboratory.
8. Materials Characterization Center. 1988. *Characterization of Spent Fuel Approved Testing Material-ATM-103,* Pacific Northwest Laboratory.
9. Materials Characterization Center, 1988. *Characterization of Spent Fuel Approved Testing Material-ATM-106,* Pacific Northwest Laboratory.
10. Frame, P., G. Gleason, and M. Worthington. 1988. *Nuclear Identification Catalog for Gamma Emitters and Alpha Emitters.* Oak Ridge, Tennessee: Oak Ridge Associated Universities, Professional Training.
11. Table of Nuclides. 2000. Korea Atomic Energy Research Institute. 4 June 2009 http://atom.kaeri.re.kr/.
12. Aigner, H., R. Binner, and E. Kuhn. 2000. *International Target Values 2000 for Measurement Uncertainties in Safeguarding Nuclear Materials, IAEA.*
13. ORTEC. 2007. *Neutron Radiation Damage in Germanium (HPGe) Detectors.* http://www.ortec-online.com/detectors/photon/a8.htm.

Measurement and Characterization of Nuclear Material at Idaho National Laboratory

Jennifer L. Dolan, M. Flaska, and S. A. Pozzi*
Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, Michigan USA

D. L. Chichester
Idaho National Laboratory, Idaho Falls, Idaho USA

**Jennifer L. Dolan is is the 2009 recipient of the J. D. Williams Student Paper Award – Second Place*

Abstract

A measurement plan and preliminary Monte Carlo simulations are presented for the investigation of well-defined mixed-oxide fuel pins. Measurement analysis including pulse-height distributions and time-dependent cross-correlation functions will be performed separately for neutrons and gamma rays. The utilization of Monte Carlo particle transport codes, specifically MCNP-PoliMi, is discussed in conjunction with the anticipated measurements. Four EJ-309 liquid scintillation detectors with an accurate pulse timing and digital, offline, optimized pulse-shape discrimination method will be used to prove the dependency of pulse-height distributions, cross-correlation functions, and material multiplicities upon fuel pin composition, fuel pin quantity, and detector geometry. The objective of the measurements and simulations is to identify novel methods for describing mixed-oxide fuel samples by relating measured quantities to fuel characteristics such as criticality, mass quantity, and material composition. This research has applications in nuclear safeguards and nonproliferation.

Introduction

The need for advanced safeguards techniques to accurately characterize nuclear fuels containing plutonium and other transuranic elements is increasing in demand as the desire to utilize nuclear power as a reliable energy source increases. In this context, fuel reprocessing and advanced fuel recycling are important topics in the nuclear power industry. Mixed-oxide (MOX) fuels utilize plutonium that persists after the use of reactor fuel. Re-use of both plutonium and uranium in the form of MOX fuels offers a significant increase in the amount of total energy produced from the fuel material.[1]

Organic scintillation detectors are being increasingly used in systems that are developed to measure both neutrons and gamma rays from fissile materials such as MOX. These detectors function at an appropriate range of energy for neutron detection within this application (typical neutron-measurement range is between 500 keV and 10 MeV), allowing high-energy neutron detection without moderation.[2] In addition to neutron detection, organic scintillators are sensitive to gamma rays. This dual mode of detection makes organic scintillators viable in applications requiring the detection and characterization of special nuclear material (SNM). Furthermore, liquid scintillators offer the capability to post-process measured data utilizing pulse-shape discrimination (PSD), thus providing an accurate method for distinguishing between neutrons and gamma rays.[3] The PSD method has been established in the past and is based on standard charge-integration method. Specifically, two integrals are calculated for each measured pulse: an integral of the pulse tail and an integral of the total pulse. The two range-optimized integrals allow the calculation of a ratio to distinguish the interacting particle type.[2]

Recently, a measurement system developed at the University of Michigan (UM) was used to measure plutonium-oxide samples at the Joint Research Center (JRC) in Ispra, Italy: pulse-height distributions (PHDs), cross-correlation functions, and multiplicities were acquired. The amplitude of the PSD-attributed neutron and gamma-ray pulses, which is a function of incident particle energy, is used as the basis for creating PHDs.[4] Cross-correlation functions are derived from differences between the arrival times of two correlated detections.[5] The Monte Carlo particle transport code, MCNP-PoliMi, has the capability to accurately model interactions necessary for these measurements.[6] This paper presents new simulation results of cross-correlations from fresh MOX fuel pins; these cross-correlations will be measured at the Idaho National Laboratory (INL) in June of 2009 and this novel measurement will result in a large amount of data that will be used to validate Monte Carlo results. The ultimate goal of this measurement is to provide new methods for the detection and characterization of MOX fuel elements that will be accurate, fast, and robust.

Measurement Description

Description of Measurement Setup

Figure 1 shows a single EJ-309 detector, secured to its height-

adjustable holder. The measurements will be performed using four EJ-309 liquid scintillation detectors. The detectors will be placed horizontally in 90° intervals around a MOX sample, with each detector equidistant from the sample (see MCNP-PoliMi model in Figure 3a). Lead bricks will surround a MOX fuel pin assembly as necessary to appropriately attenuate the fuel assembly's gamma-ray background. A CAEN V1720, 8-channel, 12-bit, 250-MHz digitizer with real-time sampling capability will be used to digitize and store measured pulses. Each of the four channels provides time-synchronized pulse information that is collected only when exceeding the applied 70 keVee (keV electron equivalent) light output threshold (corresponding to approximately 450 keV neutron deposited energy). This digital data acquisition system enables the implementation of pulse-height and time correlation algorithms enhanced by optimized offline PSD methods.[3]

The detectors were calibrated to the same gain using a 137Cs source. The data acquisition system was tested using a 12-μCi 252Cf neutron source as well as a 1-Ci Pu-Be neutron source.

Two MOX pin types will be measured at INL jointly by UM and INL personnel. The measurements will be performed with a measurement system developed at UM to measure PHDs, cross-correlation functions, and multiplicities. The dependence of these measured quantities on fuel pin composition, fuel pin quantity, and detector geometry will be determined. The material compositions of the pins are shown in Table 1 where a notable difference can be observed between the pins in the mass of 240Pu. This isotope is the strongest spontaneous-fission neutron source in the MOX pins. In addition to dependence upon fuel pin material composition, the ability to detect differences in fuel pin quantity will also be assessed. The measurements will be performed on a quantity of approximately 100 fuel pins (equivalent to approximately 1 kg of plutonium), for the two fuel types, and an additional configuration of approximately fifty fuel pins will be available for one of the fuel types. The final measurements will be performed with varying sample-detector distance.

Data Analysis and Expected Results

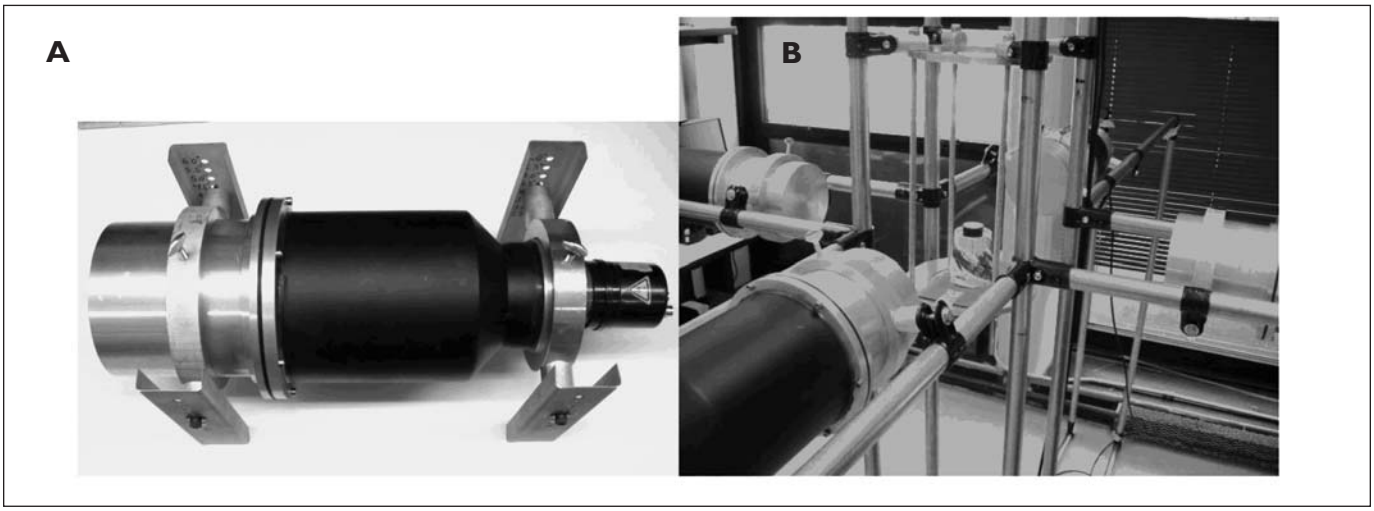
The measured data will be processed by optimized, offline, digital PSD techniques. The data acquired during each measurement configuration of the MOX fuel pin assemblies will be processed to obtain PHDs and cross-correlation functions.

The amplitude of the PSD-attributed neutron pulses is strongly related to the incident neutron energy. Despite this relationship, when using organic scintillation detectors, the resulting PHDs require the use of spectrum unfolding to obtain incident neutron energy spectra. Additionally, time of flight (TOF) measurements can be used to confirm neutron energy spectra obtained

Table 1. Isotopic compositions of two MOX fuel pin types at the INL [8].

Isotope	Pin #1 (wt. %)	Pin #2 (wt. %)
238Pu	0.01	0.01
239Pu	11.42	10.98
240Pu	***1.53***	***4.10***
241Pu	0.17	0.58
242Pu	0.02	0.02
241Am	0.06	0.16
235U	0.17	0.16
238U	74.78	72.13
O	11.85	11.86

Figure 1. a) EJ-309 liquid scintillation detector with height-adjustable stand, b) Detector geometry for cross-correlation measurements of 252Cf



through PHDs and Monte Carlo simulations. Measured energy distributions provide insight into the presence of oxide in a mixed-oxide fuel pin assembly. For this purpose, the presence of valleys in the unfolded energy spectra, significance of (α, n) contributions, and changes in the average detected neutron energy are employed as discussed below. The average detected energy provides information with regards to the quantity of fuel pins within the assembly.

Timing information will be used to calculate cross-correlation functions and material multiplicity. Separate contributions to Total cross-correlation functions (i.e. neutron-neutron, gamma-ray-neutron, etc.) are identified through PSD and provide information that is unique to the sample's material composition, constituent activity, and structural geometry. Relationships will be formulated, connecting correlation measurements and multiplicity analysis with quantities such as material criticality, mass quantification, and sample composition.

Monte Carlo Analysis

MCNP-PoliMi Description

Many Monte Carlo simulations of nuclear processes utilize interaction physics in conjunction with stochastic particle transport. Examples are the MCNP codes. However, MCNP does not incorporate the correlated particle detection required in several SNM-characterization applications. MCNP-PoliMi is a modified version of the MCNP4C code developed in order to obtain these time-correlated quantities—specifically the correlation between neutron interactions and their consequent gamma-ray production. MCNP-PoliMi utilizes a unique event-by-event modeling technique that does not stray from physical reality by using non-analog physics, unlike MCNPX. [7]

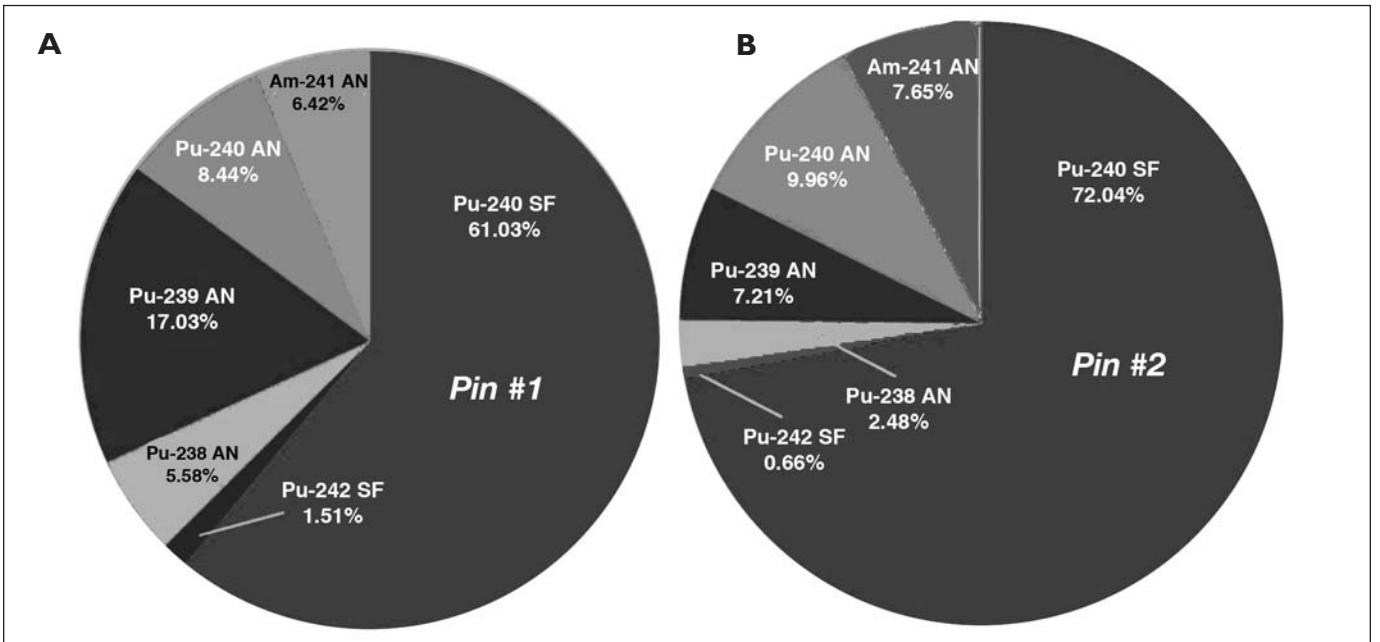
The latest version of MCNP-PoliMi, version 1.2.5, incorporates the ability of simulating all standard MCNP sources with additional custom sources. These novel sources, such as 240Pu and 242Pu spontaneous-fission sources include spontaneous-fission distributions with specific multiplicity distributions. Additionally, (α, n) distributions are source options for situations involving plutonium isotopes in oxides. All spontaneous-fission sources and (α, n) sources from the isotopes shown in Table 1 were modeled. Figure 2 shows the contributions of the sources to the neutron production rate.

The data outputs from MCNP-PoliMi simulations include details about each individual interaction that took place in the detector. The data are subsequently post-processed and tailored to anticipate a particular detector's response. These simulations of well-defined INL MOX fuel pins provide the information necessary to obtain PHDs, cross-correlation functions, and multiplicities. A light-output threshold of 70 keVee is used in post-processing to discard any neutron that creates a pulse that does not produce enough light to be detected in a practical situation. [5]

Description of Monte Carlo Models

The MCNP-PoliMi model of the proposed measurement set-up includes four EJ-309 liquid scintillation detectors that are placed around the axis of the MOX fuel pin set-up, with each detector equidistant from the source, as shown in Figure 3a. Parameters that are adjusted during the simulations include the composition of the fuel pins (two pin types), the distance between the detec-

Figure 2. Contributions of spontaneous fission and (α, n) neutron sources present in the INL MOX fuel pins to the total neutron



tors (30 cm and 60 cm), and the number of pins under investigation (50 and 100 pins).

All measurements scenarios were simulated with the MCNP-PoliMi code in order to determine dependence of PHDs, cross-correlation functions, and multiplicities upon sample type. The sources simulated in MCNP-PoliMi were two varieties of MOX fuel pins with different isotopic compositions, as outlined in Table 1 and Figure 2.[9] The neutrons and gamma rays emitted from each pin originate from the individual spontaneous fissions seen in plutonium or (α, n) reactions occurring in the presence of oxygen. All six source contributions in Figure 2 were modeled individually. The reported results are then the summation of the products of the six simulation results with their reaction probabilities. Exact fuel pin geometry and cladding material are specified in the literature and included into the model.[8]

Simulation Results

Initial simulation results included the neutron energy distributions for various numbers of pins and the detector response: PHDs and cross-correlation functions.

Figure 4a shows the energy distributions of the neutrons incident upon the detector from an individual MOX fuel pin for both pin types. Figure 4b shows the neutron energy distributions for 100-pin assemblies. Self-shielding and multiplication effects significantly alter the general shape of the neutron energy spectra in comparison to the single pin case. The valleys located in the lower energy region of the spectra, specifically near 0.05 MeV, 0.1 MeV, and 1.3 MeV, are due to energy resonances in the neutron elastic scattering cross-section for $^{16}0$, which is shown in Figure 5.[10] Simulations were also performed to determine that neutron energy distributions are a strong function of pin quantities with respect to both the shape of the spectra (Figure 6a) and average energy values (Figure 6b).

Time-dependent cross-correlation functions were generated from the simulation data output with a MCNP-PoliMi post-processor. Total cross-correlation functions for assemblies of both pin type #1 and #2 are shown in Figure 7. For correlations detected with time differences of -40 ns to 40 ns, it is anticipated that a 100-pin assembly of type #1 will produce approximately 18 cross-correlations per second (ccs/s); and a 100-pin assembly of type #2 will produce approximately 47 ccs/s. The shape of the curves are quite similar for the pin type comparison in Figure 7, although the relative amount of ccs/s varies significantly due to pin type #2's larger abundance of 240Pu.

Each total cross-correlation curve from Figure 7 can be broken down into individual contributions as shown in Figure 8. Specific correlation curves such as the neutron-neutron curve can be used to study concepts such as multiplicity and criticality. The total cross-correlation functions as a function of pin quantity are shown in Figure 9a. Integrating these total correlation curves provides valuable information on parameters such as mass quantification; Figure 9b shows the relationship between pin quantity and the number of cross-correlations per second.

The presented correlations result from a combination of six

Figure 3. a) Three-dimensional MCNP-PoliMi model including four EJ-309 cylindrical liquid scintillators 30 cm from the axis of the fuel pin array, b) Two-dimensional depiction of the MCNP-PoliMi model of the centrally located array of 100 MOX fuel pins where yellow represents fuel and green zirconium cladding

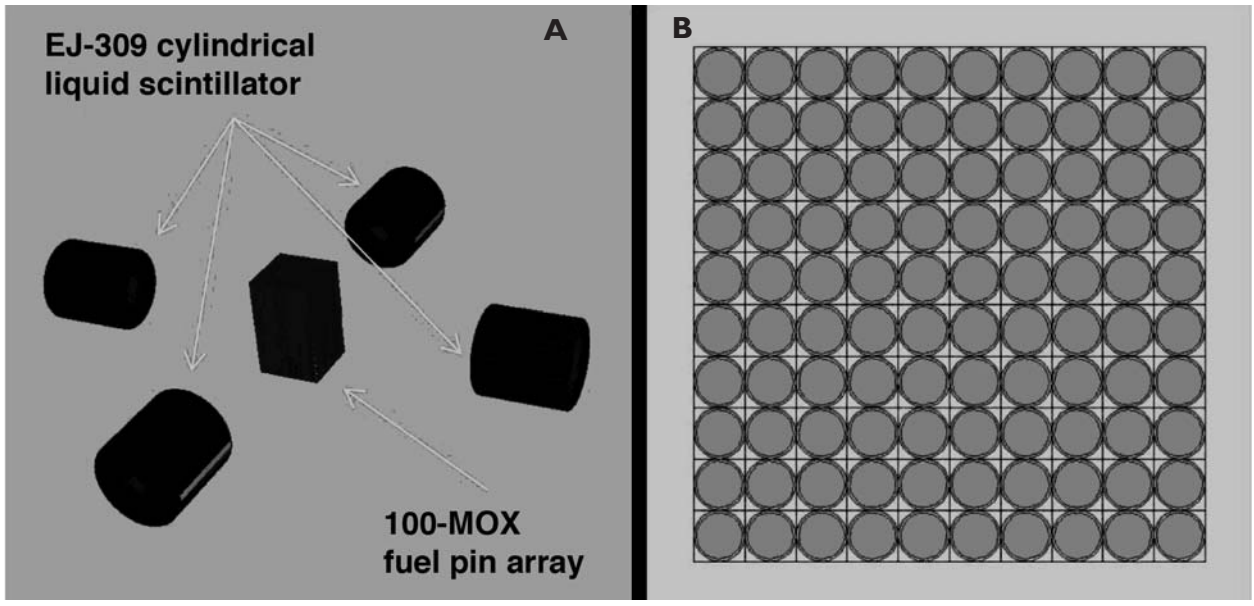


Figure 4. a) MCNP-PoliMi simulated neutron energy spectra incident on the face of the detector for a single MOX fuel pin, b) MCNP-PoliMi simulated neutron energy spectra incident on the face of the detector for a 100-pin MOX fuel assembly

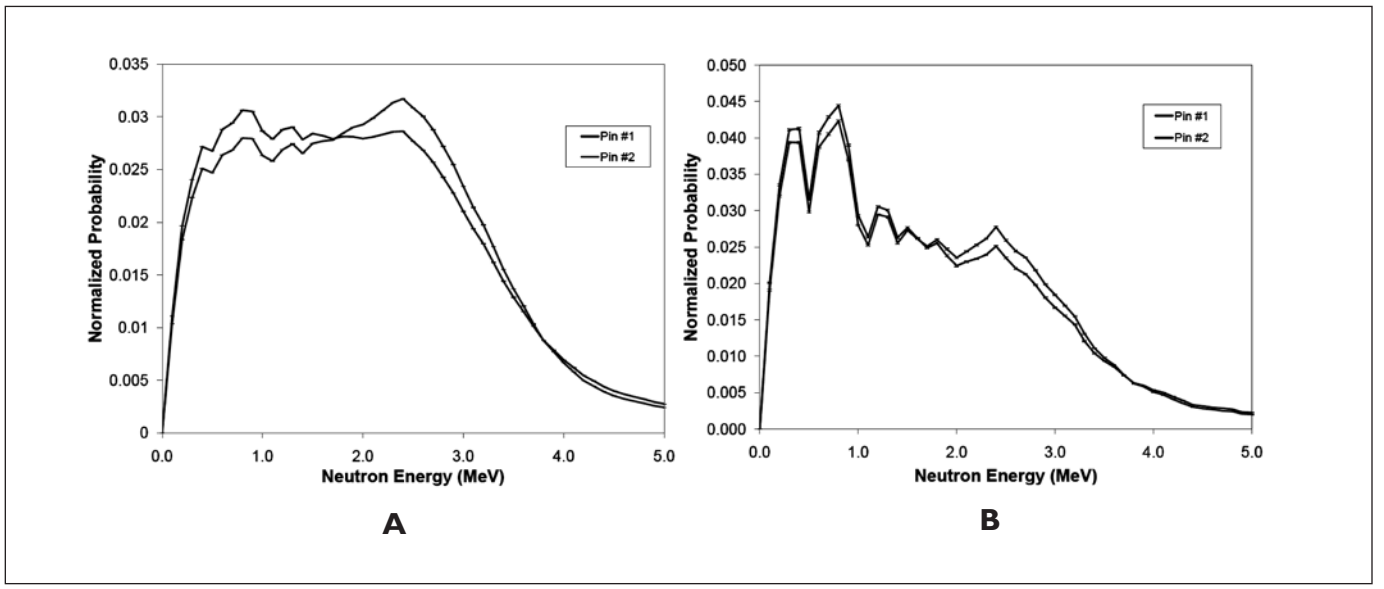


Figure 5. Comparison of the MCNP-PoliMi simulated neutron energy spectrum tallied on the face of the detector for a single MOX fuel pin type #1 and the elastic neutron scattering cross-section on 0-16

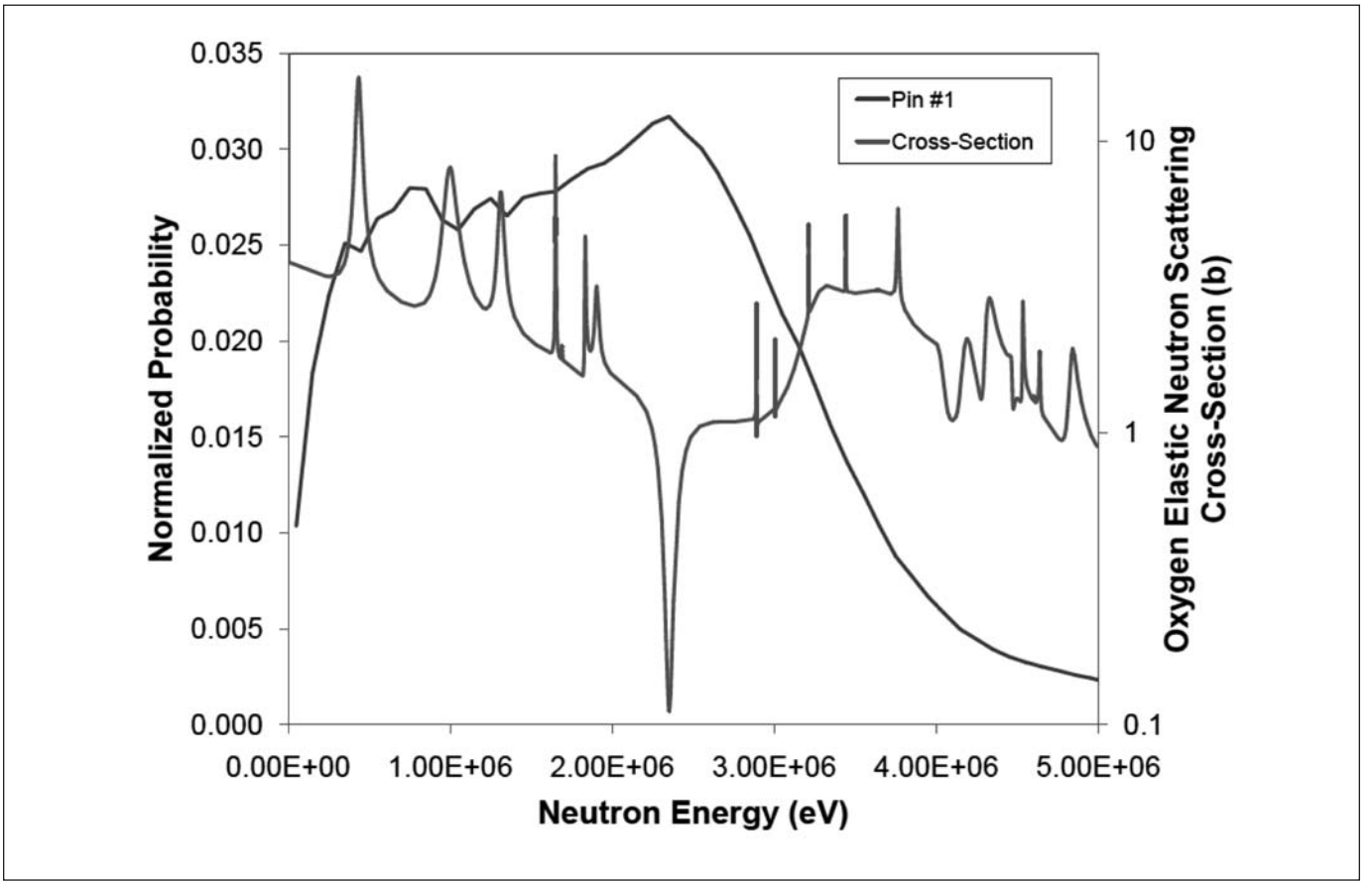


Figure 6. Neutron energy spectrum (a) and average detected neutron energy (b) as a function of the quantity of fuel pins (type #1) included in the assembly

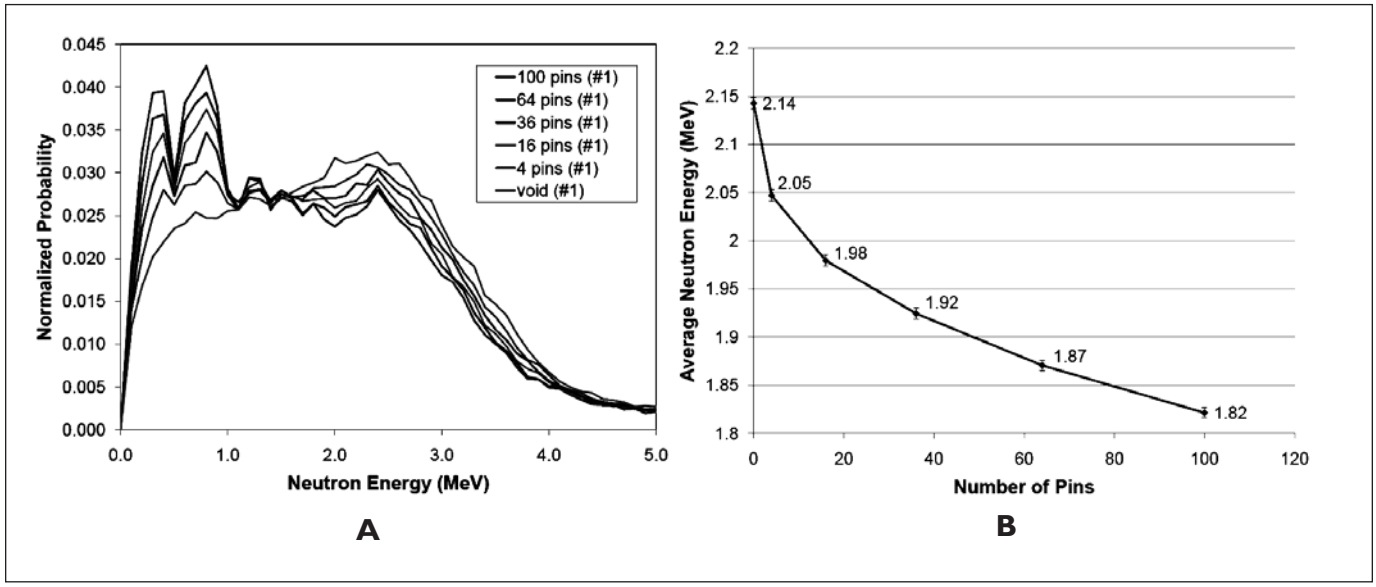
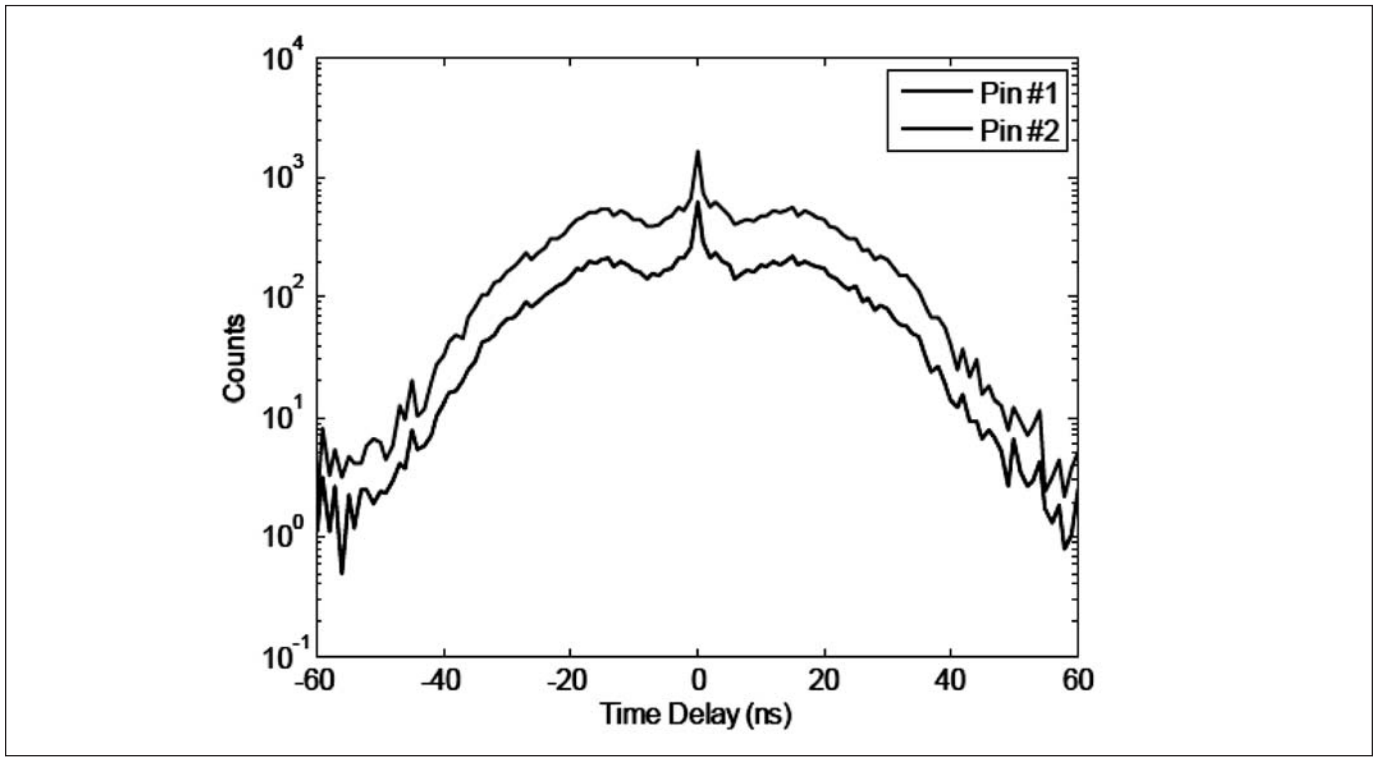


Figure 7. Comparison of the MCNP-PoliMi simulated total cross-correlation functions for pins #1 and #2 in a 10-minute acquisition time



simulations, originating from spontaneous fission and (α, n) reactions that are present in MOX fuel. Pin type #1 acquires approximately 90 percent of its correlations from the spontaneous fission sources and 10 percent as a result of the (α, n) sources. Pin type #2 acquires approximately 93 percent of its correlations from the spontaneous fission sources and 7 percent as a result of the (α, n) sources. This is expected because pin type #2 contains more 240Pu than pin type #1. The passive detection of oxygen in plu-

Figure 8. Breakdown view of cross-correlation functions showing the individual correlation contributions for pins #1(a) and #2 (b) the simulations were normalized to a 10-minute acquisition time

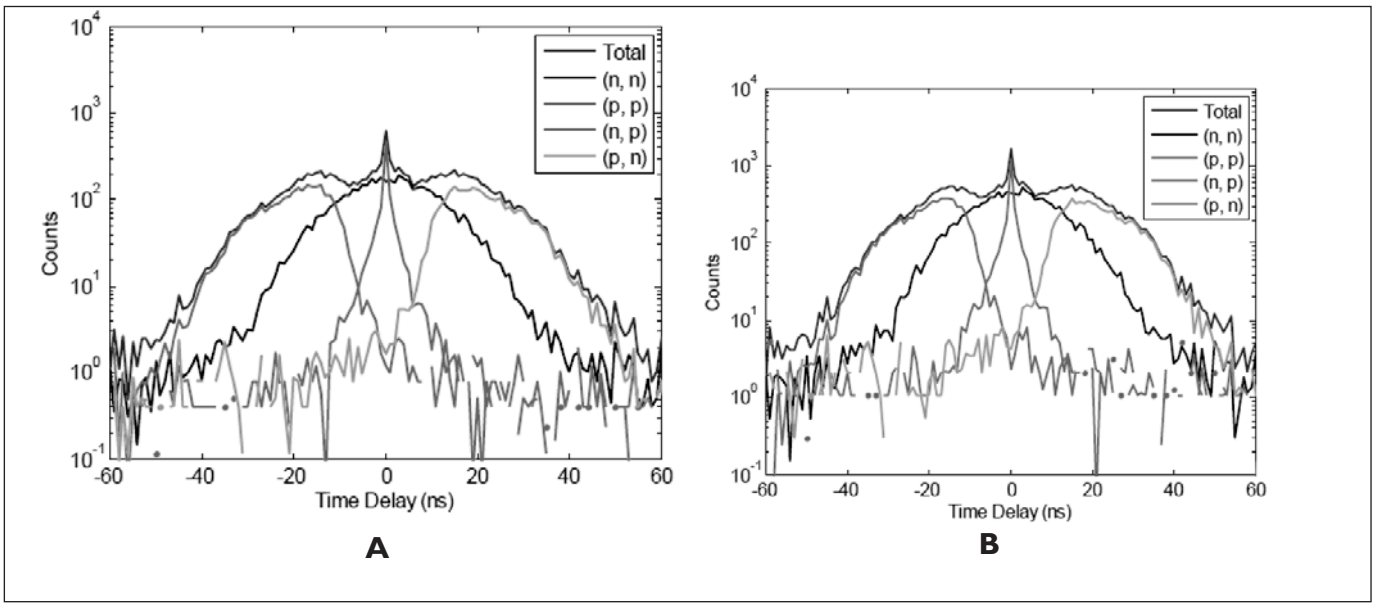
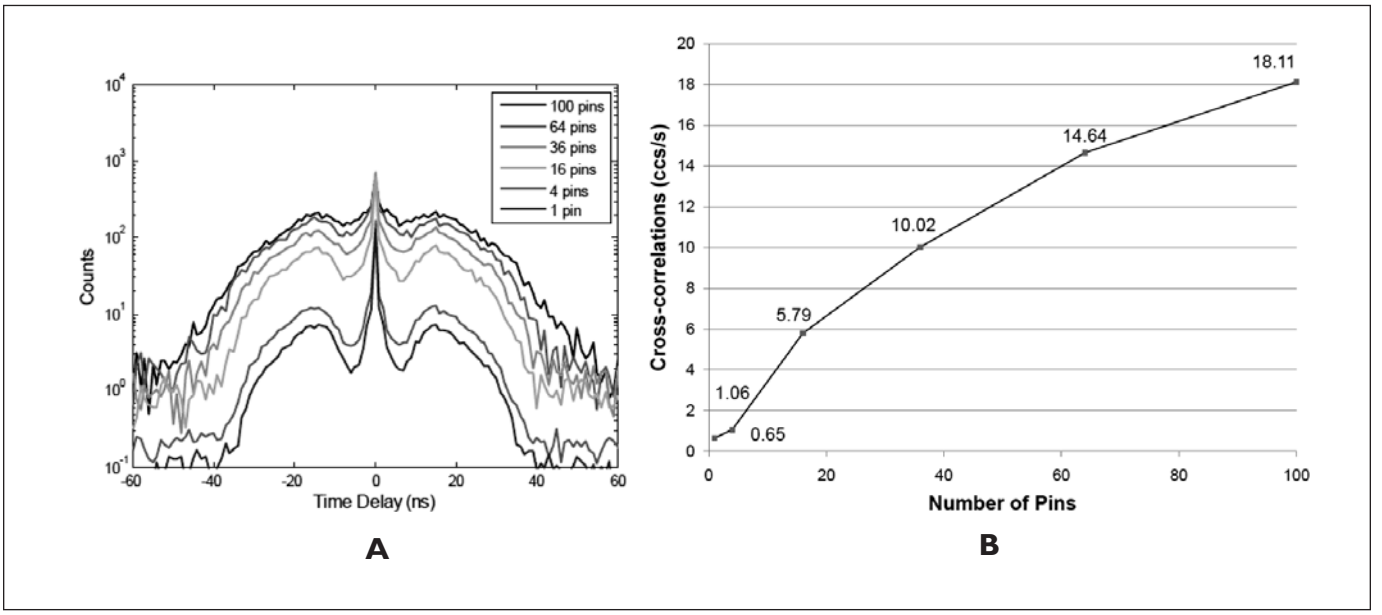


Figure 9. a) MCNP-PoliMi simulated total cross-correlation functions for different pin quantities for a 10-minute acquisition time, b) trend in total cross-correlations per second for different pin quantities



tonium is made possible by the (α, n) reactions which alter the shape of the cross-correlation functions, primarily the neutron-gamma and gamma-neutron components of the correlation curves.

Conclusions

This paper presented new simulation results for MOX fuel pin assemblies that will be measured at the Idaho National Laboratory in June 2009. The experimental setups were derived from detailed Monte Carlo modeling that incorporated accurate detector response functions. We presented a detailed model of the neutron source from the MOX fuel, which includes spontaneous

fission and (α, n) contributions. The neutron energy spectrum incident on the detectors for a varying number of fuel pins was determined. Neutron and gamma-ray cross-correlation functions were simulated for a varying number of pins. The separate contributions to these correlation functions were discussed and analyzed. The results show that this type of measurement can be used to distinguish the two pin types and to determine the mass (or number of pins) of the assembly. In addition to developing an experimental methodology, this study will be used as a basis for the future validation of the MCNP-PoliMi code for modeling MOX type fuel assemblies.

Future work will consider a more customized methodology in experimentally distinguishing MOX fuels. Relation between measured pulse-height distributions and cross-correlation functions, and quantities such as material criticality, mass quantification, and sample composition will be assessed in detail.

Acknowledgements

This work was supported by the U.S. Department of Energy Office of Nuclear Energy and the Advanced Fuel Cycle Initiative Safeguards Campaign. Idaho National Laboratory is operated for the U.S. Department of Energy by Battelle Energy Alliance under DOE contract DE-AC07-05-ID14517.

References

1. "MOX, Mixed Oxide Fuel: WNA." World Nuclear Association. http://www.world-nuclear.org/info/inf29.html. 2009.
2. Eljen Technologies. EJ-309 Liquid Scintillator Pulse-Shape Discrimination Properties.
3. Flaska, M., and S. A. Pozzi, *Nuclear Instruments and Methods A* 654-663, 2007.
4. Pozzi, S. A., S. D. Clarke, M. Flaska, and P. Peerani. 2009. Pulse-Height Distributions of Neutron and Gamma Rays from Plutonium-Oxide Samples. Submitted March 2009.
5. Clarke, S. D. 2009. *Nuclear Instruments and Methods A.* 2009.
6. Pozzi, S. A., E. Padovani, and M. Marseguerra. MCNP-PoliMi: A Monte Carlo Code for Correlation Measurements, *Nuclear Instruments and Methods A,* 513, 2006. 550-558. 2003.
7. X-5 Monte Carlo Team. *MCNP - A General Monte Carlo N-Particle Transport Code,* Version 5, vols. 1 - 3. Los Alamos National Laboratory. LA-UR-03-1987, LA-CP-03-0245, and LA-CP-03-0284.
8. Klann, R. T., B. D. Austin, S. E. Aumeier, and D. N. Olsen. 2006. *Inventory of Special Nuclear Materials from the Zero Power Physics Reactor,* Nuclear Technology Division at Argonne National Laboratory-West. ANL-NT-176. 2001.
9. Reily, D., N. Ensslin, and H. Smith Jr. 1991. Passive *Nondestructive Assay of Nuclear Materials.* Los Alamos National Laboratory. Los Alamos, 2006.
10. Evaluated Nuclear Data File. Brookhaven National Laboratory. ENDF/B-VII.0, USA. http://www.nndc.bnl.gov/sigma/.

Neutron/Gamma-Ray Pulse Shape Discrimination with Liquid Scintillation Detectors Based on Average Pulses

Scott D. Ambers, Marek Flaska, and Sara A. Pozzi*
Department of Nuclear Engineering & Radiological Sciences, University of Michigan, Ann Arbor, Michigan USA

**Scott D. Ambers is the 2009 recipient of the J. D. Williams Student Paper Award, Poster Category*

Abstract

In this paper, we present a new pulse shape discrimination (PSD) method that is based on detailed knowledge of the average detector response to radiation. Traditionally, PSD has been performed using standard methods such as charge integration. In this work, average pulses were obtained for several pulse height regions separately for neutrons and gamma rays. The average neutron and gamma-ray pulses were used in the new PSD algorithm for classification of a large number of measured pulses. This new PSD approach proves to be more accurate than the standard charge-integration PSD for neutron and gamma rays under 70 keVee (keV electron equivalent; 450 keV neutron energy). Specifically, the improvement is approximately 40 percent for neutrons in the smallest pulse height bin considered, which was between 23 and 30 keVee (corresponding to approximately 175 keV and 225 keV neutron energy, respectively). For this pulse height bin, approximately 66 percent of the neutrons were correctly classified. The average number of correctly classified neutrons is approximately 82 percent for the average-pulses PSD method between 23 and 100 keVee (corresponding to approximately 175 keV and 670 keV neutron energy, respectively).

Introduction

Pulse shape discrimination (PSD) techniques are widely used to distinguish neutron from gamma-ray pulses measured with liquid organic scintillation detectors. The liquid scintillators are sensitive to both neutron and gamma rays, thus they can be used to simultaneously measure both particle types. Unlike traditional He-3 tubes there is no need for the neutrons to be moderated as the liquid is able to detect neutrons of any energy in the keV-MeV range. These characteristics make liquid scintillators ideal for performing measurements in mixed neutron/gamma-ray fields. The ability of a detection system to accurately identify the interacting particle is vital to fields such as nuclear nonproliferation, international safeguards, nuclear material control and accountability, and national security. Optimized charge-integration algorithms significantly lose reliability when the neutron energy is below 490 keV (70 keVee).[1] The ability to accurately identify neutron pulses at low energies increases the number of neutron pulses available to perform real-time source identification. This improvement could allow for shorter counting times and more robust identification methods at borders due to the increase of useable pulses. The novel method presented in this paper utilizes detailed knowledge of the detector's response to a given radiation.[1] This approach is based on measuring an average detector response at several low energy intervals for both detected neutrons and gamma rays. These average pulses are then used as a reference to identify the particles detected. The focus of this work is to compare this average-pulses PSD method against a traditional charge-integration method.

Acquisition of Average Pulses

Gamma-ray pulses were measured using a single EJ-309 liquid scintillator and a 1-μCi Cs-137 source that was placed on the face of the detector. The EJ-309 liquid scintillator does not allow for full energy deposition of gamma rays. The gamma rays interact primarily through Compton scattering, resulting in a Compton continuum as shown in Figure 1.

Neutron pulses were measured using two EJ-309 liquid scintillators and collected using a CAEN V1720, 12-bit, 250-MHz waveform digitizer. A few million pulses were collected and stored, and subsequently they were cleaned to eliminate clipped and double pulses. The accepted pulses were then separated by

Figure 1. Pulse height distribution of measured Cs-137 gamma-ray pulses

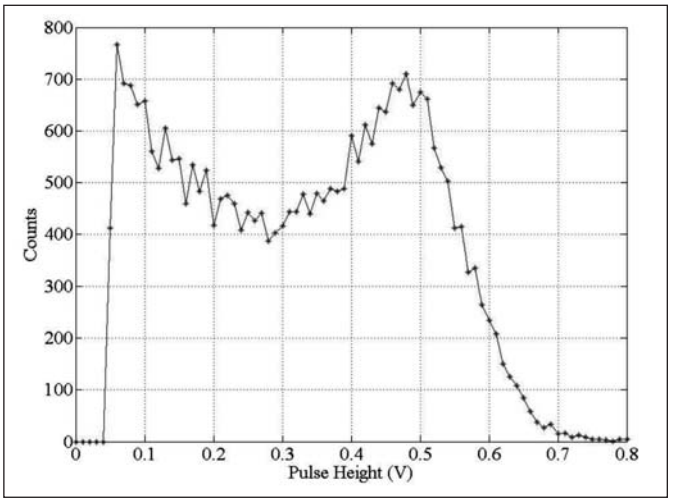
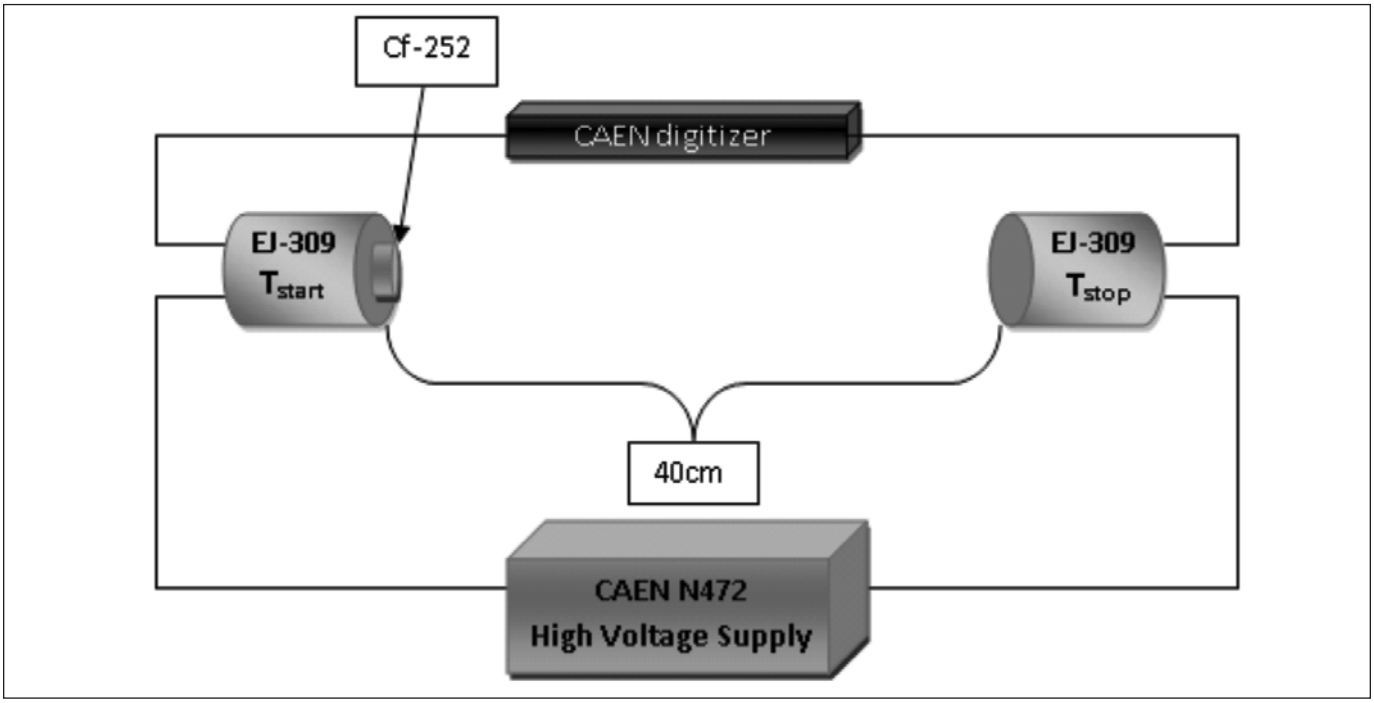


Figure 2. TOF measurement setup



pulse height into several bins. The pulses in each of the bins were averaged to create a reference pulse. In order to acquire known neutron pulses a time-of-flight (TOF) method was used using a 17 µCi (76,000 n/s) Cf-252 spontaneous fission source. The Cf-252 source was placed on the face of a detector and the pulse recorded from this detector was used as a start time (T_{start}) for a spontaneous fission event. A second detector was placed 40 cm away. When a pulse interacted in this detector a stop time (T_{stop}) was generated. The TOF setup is shown in Figure 2.

In the next step, the difference between the T_{start} and T_{stop} was calculated. Since these two pulses are likely from the same spontaneous fission, this difference corresponds to TOF of a particle traveling between the detectors. As the next step, the TOF for each measured pulse was calculated using a specialized MATLAB® post-processing algorithm. The algorithm calculates the TOFs using the time values at 50 percent of the pulses maxima. This TOF is shown in Figure 3.

The histogram bins are 1-ns wide, and the gamma-ray peak is centered at approximately 1 ns, as expected for 40-cm distance. The full width at half the maximum of the gamma-ray peak was calculated to be approximately 2.4 ns. Using these data and neutron energy to TOF conversion it was determined that particles with a time difference between 11 and 37 ns are likely neutrons. The ratio of accidental to real coincidences was calculated, based on the measured data, to be approximately 1.9 percent.

The pulses were binned by pulse height into eight bins below 100 keVee, as shown in Table 1. Figure 4 shows the TOF spectra in these bins in the neutron region from 11 to 37 ns.

Table 1. Description of light output bins

Bin Number	Light Output (keVee)	Particle Energy (keV)	TOF for 40 cm (ns)
1	23-30	175-225	65
2	30-40	225-295	57
3	40-50	295-362	50
4	50-60	362-427	46
5	60-70	427-490	43
6	70-80	490-552	40
7	80-90	552-611	38
8	90-100	611-670	36

In Figure 4, higher energy neutrons reach a maximum within the time range shown and begin to decline. This is expected from the TOF values shown in Table 1. Since partial neutron deposition is a possibility in the scintillator, all bins show counts throughout the spectrum. As described by the kinematics of neutrons scattering on hydrogen approximately 50 percent energy deposition per collision is most common in the liquid scintillator.

Figure 3. Neutron and gamma-ray TOF spectrum from Cf-252

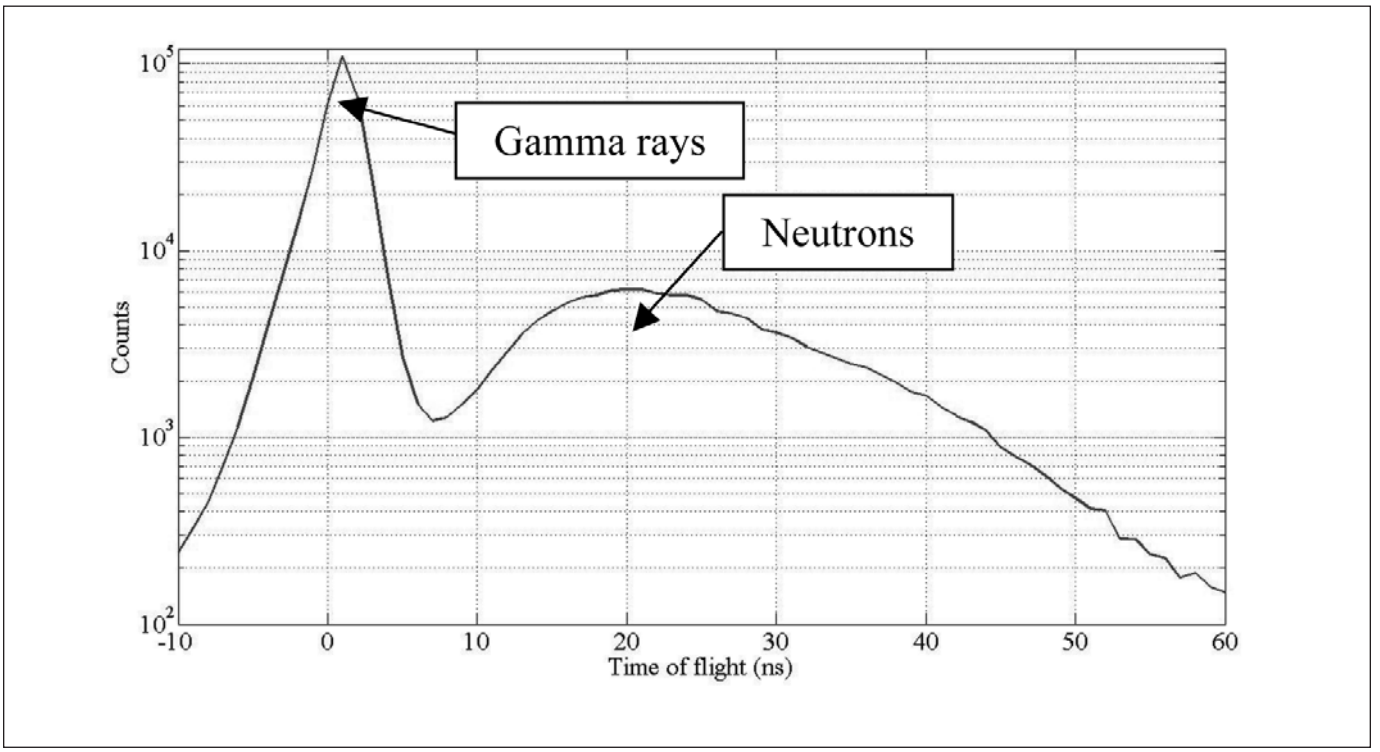


Figure 4. Measured TOF spectra for eight different pulse height bins

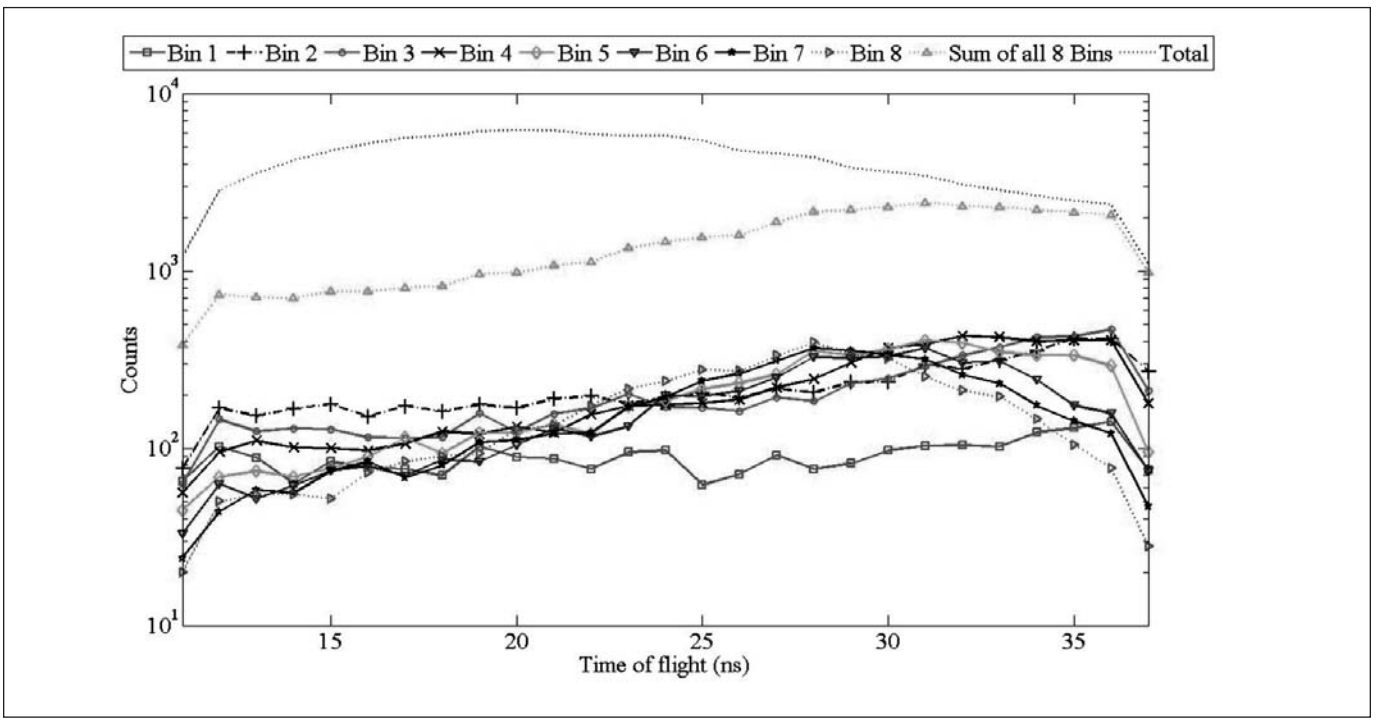
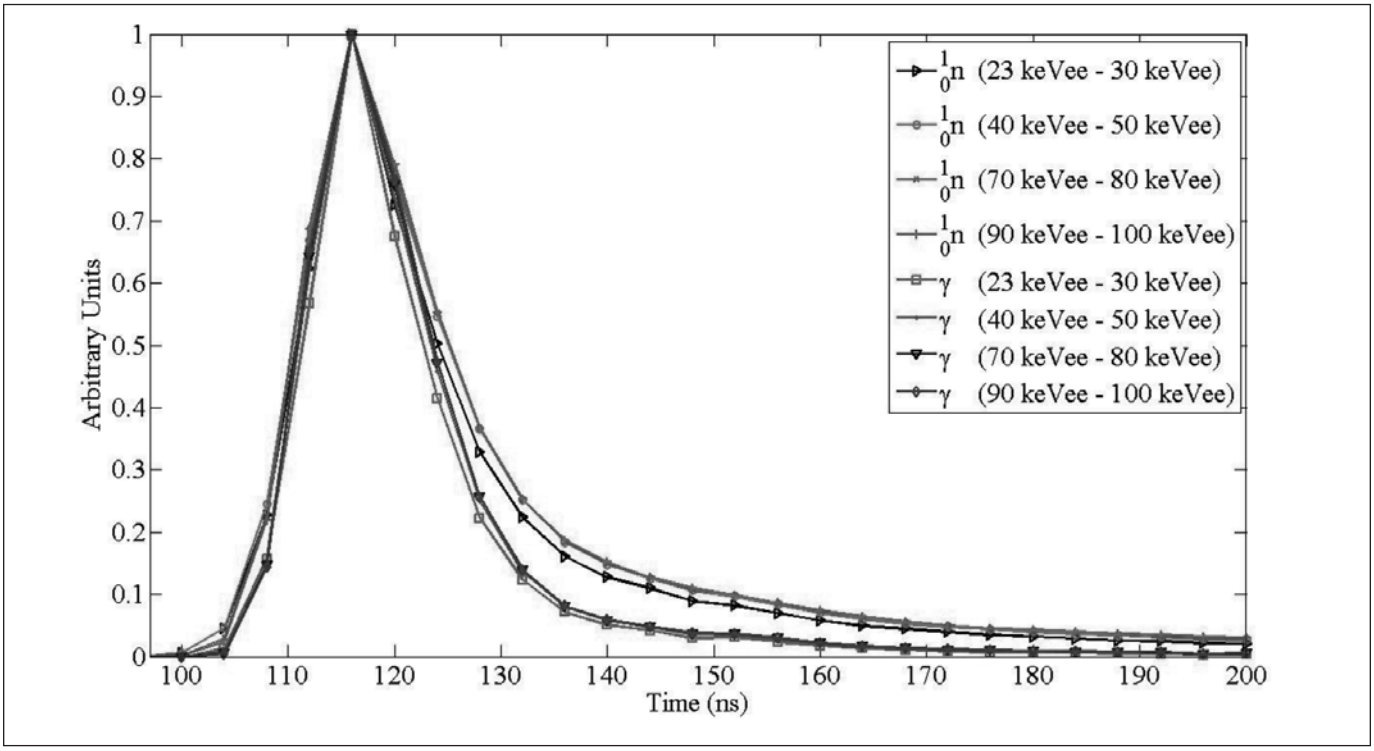


Figure 5. Normalized average neutron and gamma-ray pulses. Large differences are observed between neutron pulses themselves and neutron and gamma-ray pulses.



As the TOF increases (corresponding to lower neutron energies) nearly all of the TOF-attributed neutron pulses are classified in one of the eight pulse height bins.

For each pulse height bin, a single *reference* pulse was obtained by averaging all the pulses within the bin. This step was done separately for neutrons and gamma rays. Thus, sixteen average pulses were obtained in total. Four of the neutron and four of the gamma-ray average pulses are shown in Figure 5. The pulses were normalized to their maximum values to allow for tail shape comparison.

Figure 5 shows the well-known behavior of neutrons and gamma rays in liquid scintillators, which results in a difference in the fraction of light in the tail of the pulses. Generally, neutron pulses have larger tails than gamma-ray pulses. While the shape of the gamma-ray pulses does not significantly change with energy deposited (i.e., pulse height), the shape of the neutron pulses is highly dependent on the energy deposited.

Average Pulses PSD vs. Standard Charge Integration

The acquired average pulses were used as a reference for identifying and distinguishing neutrons from gamma rays measured with the EJ-309. Specifically, each measured pulse is compared point by point to the average neutron and gamma-ray pulses with the appropriate pulse height. The comparison is done from 20 ns after the pulse maximum to 220 ns after the pulse maximum, a region of the pulse where the difference is the most prevalent. This tail region was optimized to be in a region where the difference between the pulses is above a certain level. The average pulses and the 'unknown' measured pulses are normalized in order to compare the pulse shapes regardless of the bin width. Each pulse is then identified by determining the smallest sum of absolute differences between the two average pulses and the pulse to be discriminated.

The average-pulses PSD method was compared to the standard charge-integration method by post-processing the same set of measured TOF-attributed neutrons and Cs-137 gamma rays. An optimized offline digital PSD method was used in the comparison.[2] This method is based on a standard charge-integration method[3,4] and calculates the ratio of integrals of two different pulse intervals. Typically, the first interval covers the tail of a pulse, while the second interval covers the entire pulse. Generally, the heavier the particle is the larger fraction of light is in the tail of the pulse. This results in a larger ratio of tail-to-total-integrals for neutrons when compared to gamma rays[5, 6] The integration range was optimized for the best separation of neutron and gamma-ray pulses when the tail integral is plotted against the total integral. The neutrons have a larger tail integral because the scintillation light takes longer to be emitted through the de-excitation of the scintillation molecules after interacting with a

Figure 6. Tail integral versus total integral for (a) 70 keVee threshold, (b) 26 keVee threshold. Standard charge-integration PSD method was used

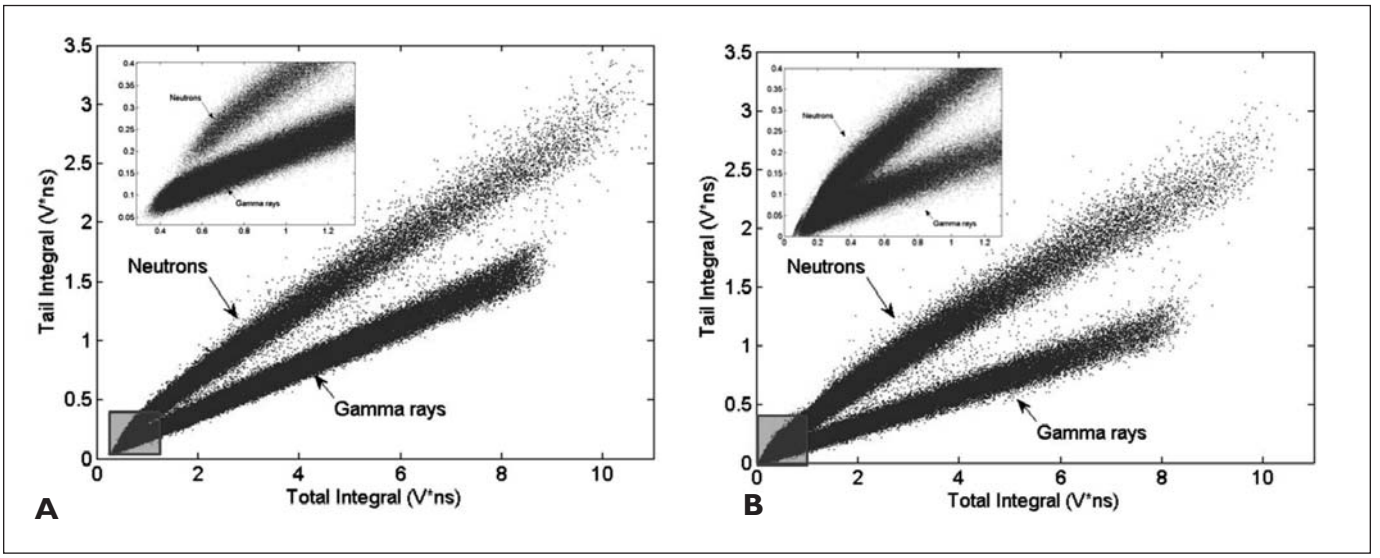
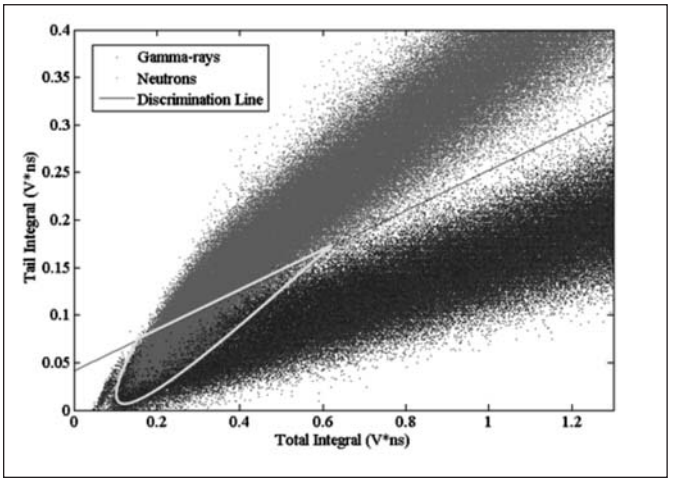


Figure 7. TOF-attributed neutron pulses and gamma-ray pulses overlap at low energies when the charge-integration method is used.



neutron than gamma rays. The charge-integration method is not accurate at discriminating neutrons and gamma rays at low energies. This is shown in Figure 6 for two different energy thresholds.

In the inset of Figure 6a very good separation can be seen between the neutrons and the gamma rays for a measurement threshold of 70 keVee (490 keV neutron energy deposited). In Figure 6b the separation between the neutron and gamma rays is poor for small total integral values, as the threshold is lowered to 26 keVee (200 keV neutron energy deposited). This lack of separation at lower energies makes it very difficult to discriminate between neutron and gamma-ray pulses. This is the region where the average-pulses PSD method could improve pulse identification.

The charge-integration method is unable to discriminate between neutrons and gamma-ray pulses at the low energies that are being investigated here. This effect occurs because when the tail integrals are plotted against the total integrals the pulses overlap, as shown in Figure 7.

The discrimination line shown in Figure 7 was optimized at 100 keVee where the separation between neutron and gamma-ray pulses is very good. This optimized line was then extended to a lower energy threshold. The overlap region shows where neutron pulses cross over this discrimination line and overlap the gamma-ray pulses.

Results

Approximately a hundred thousand TOF neutron pulses were processed by a MATLAB® algorithm that calculated the sum of absolute differences between the measured and average pulses. At low energies, the pulses are affected by noise. This noise makes comparing of the average pulses difficult. The average pulses appear smooth when plotted because the noise is random and disappears when averaged over a large number of pulses. Once the absolute differences were found between the average and measured pulses the sums of the differences were compared and the pulse was identified by the smaller of the two sums. Figure 8a shows a plot of a measured neutron pulse with both the neutron and gamma-ray average pulses and Figure 8b shows a measured gamma-ray pulse and both average pulses.

The measured neutron pulse shows smaller absolute difference when compared to the average neutron pulse and therefore the average-pulse PSD method identified it correctly as a neutron. The same is true for the measured gamma-ray pulse that closely follows the average gamma-ray pulse, thus it is correctly identified as a gamma ray.

The average-pulses PSD approach is able to discriminate par-

Figure 8. Illustration of the average-pulses PSD method for (a) measured neutron pulse (b) measured gamma-ray pulse from bin 8

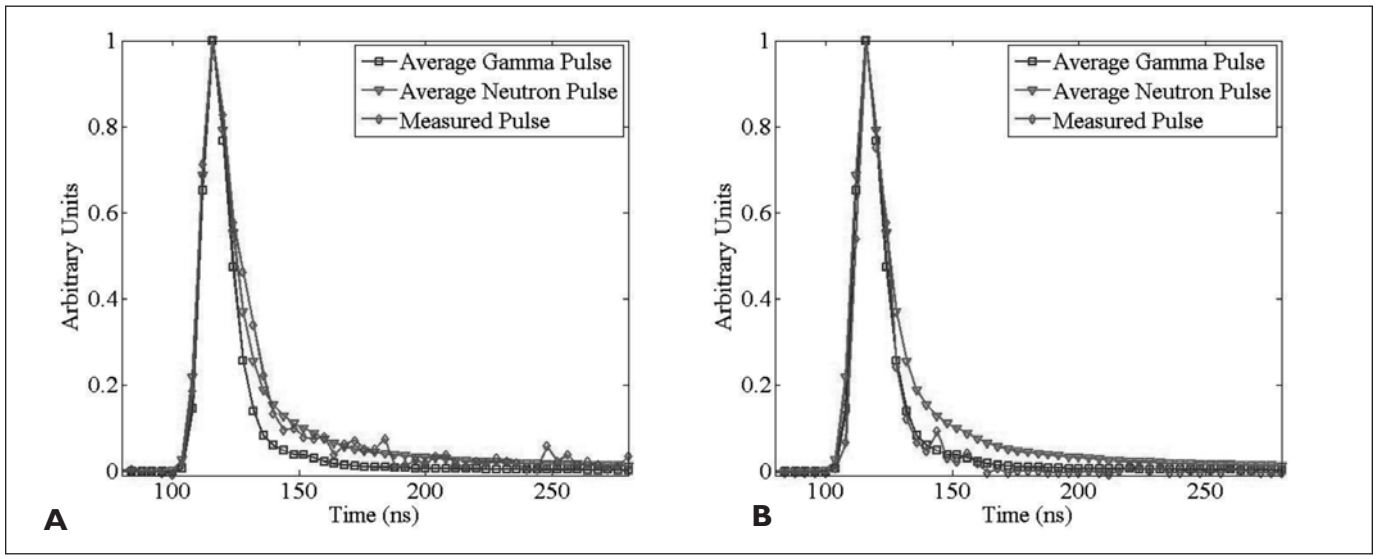


Figure 9. Comparison of PSD methods for TOF-attributed neutrons

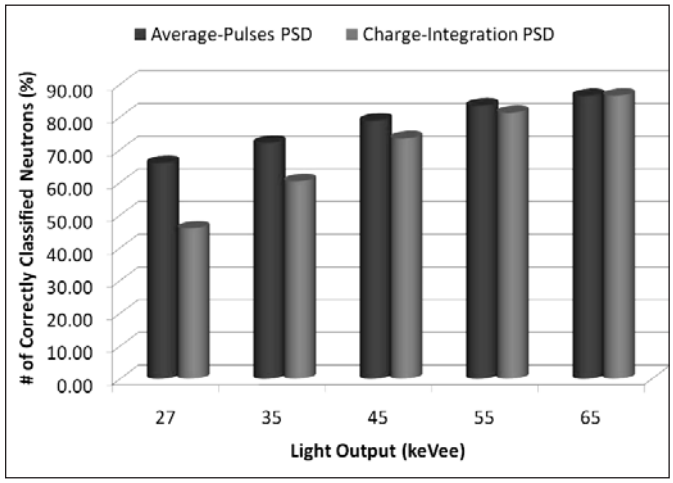
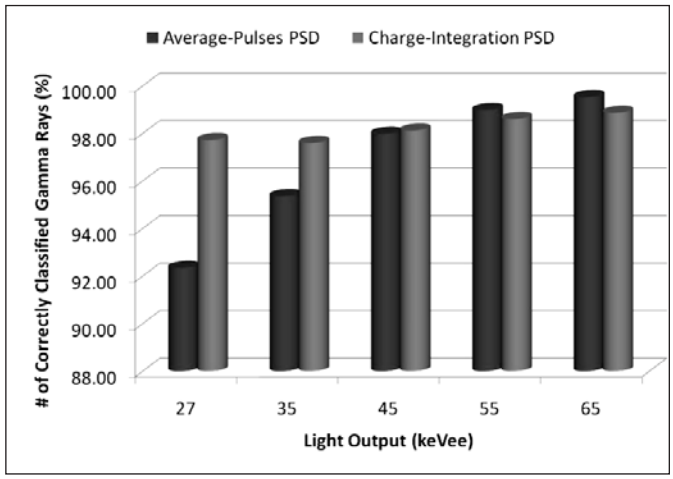


Figure 10. Comparison of PSD methods for gamma rays



ticles at low energies more accurately than the standard PSD method. This is because the difference between neutron and gamma-ray average pulses becomes larger with decreasing energy (see Figure 5). The average pulses were created by averaging 15,000 measured pulses in each bin. After that, 15,000 measured pulses were postprocessed with the algorithm and compared to the average pulses. The comparison of the PSD methods for low energy TOF-attributed neutrons is shown in Figure 9.

The average number of correctly classified neutrons is approximately 77 percent between 23 and 70 keVee. In this light output range, the average-pulses PSD method shows an improvement of approximately 11 percent over the standard charge-integration technique. At a detection threshold of 23 keVee the average-pulses PSD was approximately 66 percent successful. This corresponds to an improvement of approximately 40 percent over the standard charge-integration technique. The comparison of the PSD methods for low energy gamma rays is shown in Figure 10.

The average-pulses PSD performs slightly better at correctly classifying gamma-ray pulses than neutron pulses. The ability of the PSD approach is limited by the system noise that is present in the tail region. Although this noise is present in all pulses it is more relevant at low energies because the noise can be a considerable fraction of the measured signal. When this noise is larger than the difference between the two average pulses this significantly alters the calculated differences. This effect is minimized by choosing the region of the tail with the largest difference between average pulses as the region used for the comparison with measured pulses.

Conclusions

Liquid scintillators are frequently used in conjunction with optimized PSD methods to accurately distinguish neutrons from gamma rays. The standard PSD method based on charge integration has excellent properties for liquid scintillators such as EJ-309 for thresholds above approximately 70 keVee. The method can be used to accurately discriminate neutrons from gamma rays originating from a neutron source. The new PSD method that is proposed in this paper is based on average neutron and gamma-ray pulses that serve as references for identifying the measured particles. This new method shows improved particle identification for neutron energies between 200 keV (measurement threshold) and 450 keV. This improvement will allow more accurate neutron identification at these energies when using liquid organic scintillators, eliminating the need for the TOF approach. An increased sensitivity for particle identification is beneficial in many fields of nuclear measurements such as nuclear nonproliferation, international safeguards, nuclear material control and accountability, and national security.

References

1. Ambers, S. D., M. Flaska, and S. A. Pozzi. 2009. Analytical Description of Pulses Measured with an Organic Liquid Scintillator for Pulse Shape Discrimination, *International Conference on Advances in Mathematics, Computational Methods, and Reactor Physics*.
2. Flaska, M., and S. A. Pozzi. 2007. Identification of Shielded Neutron Sources with the Liquid Scintillator BC-501A Using a Digital Pulse Shape Discrimination Method, *Nuclear Instruments and Methods A,* 577, 654 – 663.
3. Wolski, D., M. Moszynski, T. Ludziejewski, A. Johnson, W. Klamra, and O. Skeppstedt. 1995. Comparison of n-Á Discrimination by Zero-Crossing and Digital Charge Comparison Methods, *Nuclear Instruments and Methods A,* 360, 584 – 592.
4. Klein, H., and S. Neumann. 2002. Neutron and Photon Spectrometry with Liquid Scintillation Detectors in Mixed Fields, *Nuclear Instruments and Methods A,* 476, 132 – 142.
5. Bollinger, L. M., and G. E. Thomas. 1961. Measurement of the Time Dependence of Scintillation Intensity by a Delayed-Coincidence Method, *Review of Scientific Instruments,* 32, 1044 – 1050.
6. Birks, J. B. 1964. *The Theory and Practice of Scintillation Counting,* Pergamon Press, Oxford, 219 – 227.

The First Twenty-Five Years of INMM

By James Lovett
Past President, 1971-1972
Fellow Emeritus

The spring issue of *JNMM* included an excellent piece by Yvonne Ferris covering the last twenty-five years of INMM. Since I joined INMM pretty much at the beginning and transferred to Vienna in 1972, when Yvonne's piece began, permit me to add my memories of the first twenty-five years.

In my retrospective piece last year, "Materials Accountancy—The Formative Years," I discussed how control of nuclear materials initially was seen as an issue of stewardship, how operators of Atomic Energy Commission-owned, government-owned, contractor-operated (GOCO) facilities were required to establish a system of measuring and accounting for nuclear materials, and how, after the rewritten Atomic Energy Act of 1955, fixed-price contractors were incorporated into the system.

As part of the AEC material control system, GOCO contractors were required to designate one person, termed the accountability representative, to be responsible for implementing material control requirements, signing transfer documents, etc. Once a year, the AEC convened an AEC-contractor material control meeting to discuss mutual material control problems. Initially these meetings were pretty much AEC controlled ("we need to discuss and agree on how to deal with ...."), but gradually technical papers were added, and the meetings, typically two days, became mini-technical meetings.

Fixed-price contractors also had accountability representatives who, after 1955, were invited to the AEC-contractor meetings, but the two groups had different types of problems. By 1958 a growing number of people were arguing that an independent professional society was needed. The result was the INMM, formed in 1958, and the first annual meeting, held in 1959.

The early years, I remember, were years in which the INMM struggled to find its identity. The first meeting lasted two days, and the program was filled with a mixture of technical papers and panel discussions. I was not there, but I believe the attendance was around fifty. The second meeting was better, but attendance was still less than 100. After three or four years, however, the INMM expanded to three-day meetings, usually with the AEC tacking its contractor meeting onto the fourth day. By 1972 both INMM membership and typical meeting attendance had grown to more than 200. (Not every member attended every meeting, of course, but the nonmember attendees more or less balanced the member non-attendees. Membership was a good predictor of meeting attendance.)

If an organization commits to a hotel that X number of people will attend a meeting and will stay in the hotel, the hotel will offer a certain number of free rooms, including a suite for the organization president. It became the practice of the INMM chairman to host a reception in that suite (at INMM expense) on the evening before the meeting. At first the affairs were small, the Executive Committee and committee chairs, plus a few selected personal friends. However, attendance was never restricted, and over the years it became common practice for most of the "regulars" to attend.

After the second or third year there was always a reception followed by a dinner on the second evening, but instead of awards the dinner featured a prominent speaker. More than once we were able to get a congressman. Other sought-after speakers were presidents of major companies in the nuclear industry. The 1960s were enthusiastic years for nuclear energy. The industry began to struggle in the late 1960s, but it wasn't until after 1976 that President Carter delivered the mortal blow from which the nuclear energy industry is only now beginning to recover. Really good speakers were looking for a forum to tout nuclear energy, and INMM was a good forum, even if the speaker was "preaching to the choir."

In those years the INMM was strictly a volunteer organization. Someone, occasionally several someones, proposed that the organization meet in their city and gave a pitch at the business meeting. Having your city selected meant that you were in charge of local arrangements. The vice chair (the change to president occurred later) was in charge of the technical program; the chairman was in charge of things like keynote and dinner speakers, as well as overall coordination. Then as now, the vice chair more or less automatically became chair two years later. The Executive Committee (EC) met quarterly, but in total as many as eighteen or twenty people attended. Discussions were open; the distinction between EC members and miscellaneous committee chairs was relevant only when a vote was called for.

By 1968, when I was vice chair, it was becoming difficult for people to take time from their day jobs to give INMM everything that was required. The American Nuclear Society repeatedly suggested that we should become a division of ANS, but we repeatedly agreed that would not help, and in many respects would be counterproductive.

The answer at the time was "more people." and I specifically remember telling various volunteers, "Don't try to do what I ask all by yourself, try to organize a committee." But even that had its

limits. I recall touching base with both Les Weber and Zal Shapiro, for whom I worked, before I agreed to be vice chair (knowing that in two years I would be chair), and I thank them for supporting me, especially when the local arrangements person for the Las Vegas meeting (tenth as I recall) stated that he was too insecure to do the job alone, and a couple of us made an unplanned trip to Vegas to plan the meeting with him.

A newsletter was added in one of the early years, but it was of varying quality depending on who was chair and who was selected to head the newsletter committee. I do not take credit for *JNMM*. That occurred after I left. I do take credit, however, for arguing that the newsletter as it then existed was insufficient. My argument was simple. Most companies would pay for meeting attendance whether or not you were a member. Ergo, why join? My answer was that there had to be a technical journal; there had to be something, other than a warm fuzzy feeling, that a person got by being a member.

I have lots of personal memories. When Roy Cardwell made a pitch for meeting in Gatlinburg, he reported that Tennessee had amended its local option liquor law to allow certain incorporated cities within an otherwise dry county to vote independently to allow alcohol. He stated, and I have no reason to doubt him, that Gatlinburg was the only city in Tennessee that qualified.

The convention manager for the Las Vegas meeting tried very hard to convince us not to start technical sessions before 10 a.m. He also tried to convince us not to schedule a dinner and dinner speaker in competition with the hotel's shows. After the meeting he confessed that we were one of a kind. Both the 8 a.m. technical sessions and the INMM dinner were well attended, and his staff reported that we also gambled and attended the hotel shows. He didn't know why we rented rooms, because obviously we didn't sleep.

In West Palm Beach, my wife and I had a non-functioning bedroom air conditioner. (The air conditioner in the hospitality portion of the suite worked fine.) After trying to fix it, the hotel moved us to a smaller suite. In the phone conversation in which the move was offered there was a lot of background "tittering." It was later explained to me that the manager had started the conversation with, "I have been told about your bedroom problem." I confess that I had not noticed the accidental double entendre.

It was a wild ride, and I enjoyed every minute of it.

Author Submission Guidelines

The *Journal of Nuclear Materials Management* is the official journal of the Institute of Nuclear Materials Management. It is a peer-reviewed, multidisciplinary journal that publishes articles on new developments, innovations, and trends in the management of nuclear materials. Specific areas of interest include physical protection, material control and accounting, waste management, transportation, nuclear nonproliferation/international safeguards, and arms control and verification. *JNMM* also publishes book reviews, letters to the editor, and editorials.

Submission of Manuscripts: *JNMM* reviews papers for publication with the understanding that the work was not previously published and is not being reviewed for publication elsewhere. Papers may be of any length. All papers must include an abstract.

The *Journal of Nuclear Materials Management* is an English-language publication. We encourage all authors to have their papers reviewed by editors or professional translators (if appropriate) for proper English usage prior to submission.

Papers should be submitted as Word or ASCII text files only. Graphic elements must be sent in TIFF, JPEG or GIF formats as separate electronic files.

Submissions may be made via e-mail to Managing Editor Patricia Sullivan at psullivan@inmm.org. Submissions may also be made via by regular mail. Include one hardcopy and a CD with all files. These submissions should be directed to:

Patricia Sullivan
Managing Editor
Journal of Nuclear Materials Management
111 Deer Lake Road, Suite 100
Deerfield, IL 60015 USA

Papers are acknowledged upon receipt and are submitted promptly for review and evaluation. Generally, the author(s) is notified within ninety days of submission of the original paper whether the paper is accepted, rejected, or subject to revision.

Format: All papers must include:

- Author(s)' complete name, telephone and fax numbers, and e-mail address
- Name and address of the organization where the work was performed
- Abstract
- Camera-ready tables, figures, and photographs in TIFF, JPEG, or GIF formats.
- Numbered references in the following format:
  1. Jones, F. T. and L. K. Chang. 1980. Article Title. *Journal* 47(No. 2): 112–118.
  2. Jones, F. T. 1976. *Title of Book*, New York: McMillan Publishing.
- Author(s) biography

Peer Review: Each paper is reviewed by at least one associate editor and by two or more reviewers. Papers are evaluated according to their relevance and significance to nuclear materials safeguards, degree to which they advance knowledge, quality of presentation, soundness of methodology, and appropriateness of conclusions.

Author Review: Accepted manuscripts become the permanent property of INMM and may not be published elsewhere without permission from the managing editor. Authors are responsible for all statements made in their work.

Reprints: Reprints may be ordered at the request and expense of the author. Contact Patricia Sullivan at psullivan@inmm.org or +1-847-480-9573 to request a reprint.

Contract Awarded for Construction of NNSA's Waste Solidification Building at SRS

The U.S. National Nuclear Security Administration (NNSA) announced in July that a team led by Baker Concrete Construction, Inc., of Monroe, Ohio, has been awarded a $91.5 million contract for the construction of NNSA's Waste Solidification Building (WSB) at the Savannah River Site (SRS), near Aiken, South Carolina USA. The WSB will process waste streams from the NNSA's plutonium disposition efforts at SRS—principally wastes from the Mixed Oxide Fuel Fabrication Facility and from weapons pit disassembly operations—by converting them to a cementitious material for offsite disposal.

NNSA's MOX program will take at least thirty-four metric tons of surplus weapon-grade plutonium—enough material for approximately 8,500 nuclear weapons—and use it to create mixed oxide (MOX) fuel for use in nuclear power plants to generate electricity and render the plutonium unusable for nuclear weapons.

In July in Moscow, U.S. President Barack Obama and Russian President Dmitry Medvedev signed a joint statement on nuclear cooperation that reaffirmed their commitment to each dispose of thirty-four metric tons of weapon-grade plutonium.

This contract marks the second phase of construction for the WSB project, which began in December 2008, and includes the structural construction of the facility and installation of the process systems. The contract was awarded by Savannah River Nuclear Solutions, LLC, the primary contractor on the WSB project. This phase of construction will provide approximately 120 labor positions. The WSB has a total project cost of $345 million.

The Baker team includes Intermech of Winston-Salem, N.C., and Besco of Knoxville, Tenn.

NNSA Announces Letter of Intent Signed by MOX Services and the TVA

The U.S. National Nuclear Security Administration (NNSA) in July announced that Shaw AREVA MOX Services, LLC (MOX Services) and the Tennessee Valley Authority (TVA) have signed a letter of intent to enter into contract negotiations for the irradiation of mixed oxide (MOX) fuel. MOX Services is NNSA's contractor to build and operate the Mixed Oxide Fuel Fabrication Facility, which currently is under construction at the Savannah River Site near Aiken, South Carolina USA. The MOX fuel will be fabricated from surplus weapon-grade plutonium at the facility.

The MOX program is a critical part of NNSA's nuclear nonproliferation efforts. The program will take at least thirty-four metric tons of surplus weapon-grade plutonium—enough material for approximately 8,500 nuclear weapons—and use it to create MOX fuel for use in nuclear power plants to generate electricity and render the plutonium unusable for nuclear weapons.

The nonbinding letter of intent signed by MOX Services and TVA came one week after U.S. President Barack Obama and Russian President Dmitry Medvedev signed a joint statement on nuclear cooperation that reaffirmed their commitment to disposing of thirty-four metric tons each of weapons-grade plutonium in the United States and Russia.

TVA is evaluating the use of MOX fuel in its Sequoyah Units 1 and 2, its Browns Ferry Units 1, 2, and 3, as well as future reactors. Following further evaluation, TVA and MOX Services intend to enter contract negotiations that could result in the execution of an agreement in the summer of 2010 for irradiation of MOX fuel in two or more reactors. According to current schedules, the MOX facility will begin producing fuel in 2016.

NNSA Announces Removal of Last HEU from Romania; Air Shipment of Russian-Origin Spent Fuel

In June, the U.S. National Nuclear Security Administration (NNSA) announced the final shipments of Russian-origin highly enriched uranium (HEU) nuclear fuel from Romania. The material was removed and returned to Russia by air for storage at two secure nuclear facilities, making Romania the first country to remove all HEU since U.S. President Barack Obama outlined his commitment to securing all vulnerable nuclear material around the world within four years. This was also the first time NNSA has shipped spent HEU by airplane, a development that will help accelerate efforts to meet the president's objective.

The shipments are part of NNSA's Global Threat Reduction Initiative (GTRI), which also removed all U.S.-origin HEU from Romania in 2008. NNSA worked in close cooperation with Romania, Russia, and the International Atomic Energy Agency to return the material.

In one shipment, 23.7 kilograms of spent HEU stored at a research reactor in Magurele, Romania, was packaged in Russian TUK-19 specialized transportation casks. The casks were then secured in shipping containers, transported in an armed convoy from the reactor site to a nearby airport, loaded onto an Antonov-124 cargo plane, and flown to a secure facility in Russia near Chelyabinsk.

In addition, 30 kilograms of fresh HEU from a reactor in Pitesti was shipped by air to a secure Russian facility near Dimitrovgrad.

With the completion of these shipments, Romania is the fourteenth country to have all of its HEU removed. Previous countries to have all HEU removed include Brazil, Bulgaria, Colombia, Denmark, Greece, Latvia, Philippines, Portugal, Slovenia, South Korea, Spain, Sweden, and Thailand. This results in permanent threat reduction because it

eliminates bomb material at civilian sites.

The shipments from Romania are in accordance with a prioritized, accelerated schedule developed from the February 2005 Bratislava Joint Statement on Nuclear Security Cooperation, which specifically called for international cooperation to return HEU fuel from U.S. and Russian-designed research reactors in other countries and to take other steps to reduce the threat of global nuclear terrorism.

GTRI's mission is to reduce and protect vulnerable nuclear and radiological materials located at civilian sites worldwide. With the successful completion of these shipments, a total of approximately 862 kilograms (1,896 lbs) of Russian-origin HEU fuel have been returned from Serbia, Romania, Bulgaria, Libya, Uzbekistan, Kazakhstan, Poland, Germany, the Czech Republic, Latvia, and Vietnam since the program began.

International Nuclear Safety Experts Conclude IAEA Peer Review of Canada's Regulatory System

In June 2009, an international team of nuclear safety experts completed a two-week International Atomic Energy Agency (IAEA) review of the regulatory framework and effectiveness of the Canadian Nuclear Safety Commission (CNSC). The team identified good practices within the system and gave advice on some areas for improvement. The IAEA has conveyed initial findings to Canadian authorities; the final report will be submitted by autumn.

The IAEA assembled a team of nuclear, radiation, and waste safety experts at the request of the government of Canada, to conduct an Integrated Regulatory Review Service (IRRS) mission.

The mission was a peer review based on IAEA Standards, not an inspection or an audit.

The scope of the mission included sources, facilities, and activities regulated by the CNSC: the operation of nuclear power plants (NPPs), research reactors and fuel cycle facilities; the refurbishment or licensing of new NPPs; uranium mining; radiation protection and environmental protection programs; and the implementation of IAEA Code of Conduct on Safety and Security of Radioactive Sources.

The twenty-one-member team from thirteen IAEA states and from the IAEA itself reviewed CNSC's work in all relevant areas: legislative and governmental responsibilities; responsibilities and functions; organization; activities of the regulatory body, including the authorization process, review and assessment, inspection and enforcement, the development of regulations, as well as guides and its management system of CNSC.

The basis for the review was a well-prepared self-assessment by the CNSC, including an evolution of its strengths and proposed actions to improve its regulatory effectiveness.

Among the particular strengths of CNSC, its policy, its regulatory framework, and its regulatory activities identified by the IRRS team were:

- The Canadian legislative and regulatory framework is very comprehensive, and the legal regime is effectively applied through an appropriate range of instruments.
- CNSC has done commendable work over the last years in establishing and implementing a strong management system that seeks continuous improvement within the organization.
- The consistent harmonized plan that considers the results of all recent audits and assessments brings together all improvement initiatives under one plan and optimizes the use of resources to deliver further improvements in key areas.
- The recommendations made by the Talisman International LLC report on the NRU and reviewed by the IRRS team have been adequately addressed by the CNSC.

The IRRS team also made recommendations and suggestions that may significantly enhance the overall performance of the regulatory system. Examples include:

- CNSC should initiate a periodic strategic planning program to define both short- and long-term research activities needed to support pending and potential regulatory decisions. Sufficient resources should be allocated to support the results of the program.
- CNSC should continue developing a methodology and implementing management system reviews to be conducted at planned intervals by internal and/or external resources and should develop the internal audit program.
- CNSC should ensure that its operational and technical support branches work together in a more harmonized manner to assure security measures do not compromise safety and vice versa.
- CNSC should refine existing plans and confirm its readiness to support the transition from the project planning phase to the technical review of new design applications, inspection of construction activities and oversight of the start-up and operations.
- CNSC should consider updating the 1998 Memorandum of Understanding with Health Canada to define the roles and responsibilities of the Federal Provincial Territorial Radiation Protection Committee and to ensure comprehensive and consistent safety regulation and oversight.

For the review, team members met key personnel at CNSC and other organizations, such as the Ministry of Natural Resources and Environment (NRCan); Chalk River Laboratories (CRL) and NRU research reactor; Fuel Cycle Facilities (Cameco-Zircatec, Port Hope and GE-Hitachi, Peterborough); McArthur River Uranium Mine and Key Lake Uranium Mill; OPG Western Waste Management Facility (Bruce Site); Darlington (OPG) and Bruce (Bruce Power) NPPs; Calgary (Radiation Devices); Laval Irradiation Facility (MDS Nordion) and the Ottawa Hospital.

UN Agencies Mark Chernobyl Anniversary with Launch of US$2.5-million Project

In April 2009, four United Nations agencies marked the twenty-third anniversary of the Chernobyl nuclear accident by launching a $2.5 million program designed to meet the priority information needs of affected communities in Belarus, the Russian Federation, and Ukraine. Funded by the UN Trust Fund for Human Security, this three-year initiative aims to translate the latest scientific information on the consequences of the accident into sound practical advice for residents of the affected territories. The project is a joint effort by the International Atomic Energy Agency (IAEA), the United Nations Development Program (UNDP), the United Nations Children´s Fund (UNICEF), and the World Health Organization (WHO).

Providing scientifically sound information for Chernobyl-affected communities is a shared priority for UN work on Chernobyl. Supported by a 2007 UN General Assembly resolution, the project, known as the International Chernobyl Research and Information Network (ICRIN), is part of a larger effort to help local communities "return to normal" in the course of the decade that ends in 2016. The project will draw on the work of the UN Chernobyl Forum, a joint undertaking by eight UN agencies and the governments of Belarus, Russia, and Ukraine that in 2005 issued authoritative scientific findings on the accident´s consequences for health and the environment. Dissemination of these findings in plain language accessible to non-specialists should help dispel widespread misconceptions and fight the stigma that still afflicts the region.

Activities planned under the ICRIN project include the dissemination of information, through education and training for teachers, medical professionals, community leaders, and the media; providing local residents with practical advice on health risks and healthy lifestyles; the creation of Internet-equipped information centers in rural areas; and small-scale community infrastructure projects aimed at improving living conditions and promoting self-reliance.

INMM Election Results

The following people have been elected to serve on the INMM Executive Committee for the coming year:

President: Steve Ortiz
Vice President: Scott Vance
Secretary: Chris Pickett
Treasurer: Robert Curl

Members at Large:
Corey Hinderstein
Larry Satkowiak
Grace Thompson
J. Michael Whitaker

INMM Sustaining Members

INMM thanks its sustaining members for their generous support of the Institute.

ABACC
Aquila Technologies
Australian Safeguards & Nonproliferation Ofc
Brookhaven Natl Lab
BWXT Pantex
Canadian Nuclear Safety Commission
Canberra Albuquerque
Canberra Industries Inc
Ctr for Intl Trade & Security/UGA
Exchange Monitor Publications
Gregg Protection Services Inc
Haselwood Enterprises Inc
IAEA
ICx Radiation
Idaho National Lab
Intl Fuel Containers Inc
Intl Services & Advisors Inc
JAI Corp
Joseph Oat Corp
Lawrence Livermore Natl Lab
Los Alamos Natl Lab
National Nuclear Security Administration
Natl Security Technologies
Nuclear Threat Initiative
Nucsafe LLC
Oak Ridge Natl Lab
ORTEC
Pacific Northwest Natl Lab
Pajarito Scientific Corp
Sandia Natl Labs
Savannah River Nuclear Solutions
Talisman Intl, LLC
TSA Systems Ltd
TSGI
Westerman Companies
World Inst for Nuclear Security
Wyant Data Systems Inc
Y-12 Natl Security Complex

Calendar

December 7–11, 2009
International Conference on Fast Reactors and Related Fuel Cycles: Challenges and Opportunities FR09
Kyoto, Japan
Organized by: the International Atomic Energy Agency
Hosted by: the Japan Atomic Energy Agency
Web Site: www.fr09.org/

December 14–18, 2009
International Conference on Effective Nuclear Regulatory Systems: Further Enhancing the Global Nuclear Safety and Security Regime
Cape Town, South Africa
Organizer: International Atomic Energy Agency
Host: the Government of South Africa through the National Nuclear Regulator of South Africa
Web Site: http://www.iaea.org

February 2–3, 2010
Fourth Annual Workshop on Reducing the Risk from Nuclear and Radioactive Materials
Nonproliferation and Arms Control Standing Committee on the International Security of Radioactive and Nuclear Materials
Chair: Ruth Duggan
E-Mail: rduggan@sandia.gov
Hosted by: the INMM Northeast Chapter

February 3–5, 2010
Decommissioning of Nuclear Facilities 2010
Overcoming Legal and Regulatory Challenges in Decommissioning
Pre-conference Workshop: Tuesday February 2, 2010
Radisson Blu Portman Hotel
London, United Kingdom
Web Site:
www.ibcenergy.com/ibce/events.htm

February 11, 2010
Helium-3: A Crisis in Supply
Washington, DC USA
Organized by: American Association for the Advancement of Science
Web Site: http://helium3.aaas.org

February 24–26, 2010
International Workshop for Users of Proliferation Assessment Tools
Workshop I: Users in Regulatory Roles
Texas A&M University, College Station, Texas USA
Sponsors/Organizers:
INMM Standing Committee on Proliferation Assessments and Methodologies, Texas A&M University INMM Student Chapter, and the INMM Southwest Chapter

March 21–24, 2010
INREC '10
1st International Nuclear & Renewable Energy Conference
Jordan University of Science and Technology
Amman, Jordan
Web Site: http://inrec10.inrec-conf.org/

April 11–16, 2010
Northwest International Conference on Global Nuclear Security: The Decade Ahead
Portland, Oregon USA
Sponsors: Pacific Northwest Chapter of INMM and Eastern Washington Section of ANS
Contact: Carrie Mathews
Pacific Northwest National Laboratory
+1-509-375-6783
E-mail: carrie.mathews@pnl.gov
Web Site: http://pnwcgs.pnl.gov/PNIC/PNIC.stm

July 11–15, 2010
51st INMM Annual Meeting
Marriott Waterfront Baltimore Hotel
Baltimore, Maryland USA
Sponsor: Institute of Nuclear Materials Management
Contact: INMM
+1-847-480-9573
Fax: +1-847-480-9282
E-mail: inmm@inmm.org
Web Site: www.inmm.org/meetings

October 3–8, 2010
PATRAM 2010
16th International Symposium on the Packaging and Transport of Radioactive Materials
IMO Headquarters
London, UK
Hosted by: Department for Transport of the United Kingdom, in cooperation with the International Atomic Energy Agency, the International Maritime Organization, and the World Nuclear Transport Institute
E-mail: admin@patram2010.org
Web Site: www.patram2010.org

INMM Membership Application

MEMBERSHIP

All information should be printed or typewritten.

Name _____ Date _____

Employer _____ Title _____

Address

Address _____

City _____ State/Province _____ Country _____ Zip _____

Telephone _____ Fax_____ E-mail _____

If you would like your INMM mail sent to an alternative address, please indicate preferred mailing address:

Address _____

City _____ State/Province _____ Country _____ Zip _____

Occupation

❑ Commercial Utility ❑ Government Contractor ❑ Nuclear Material Processing
❑ Equipment Manufacturer ❑ Government or International Agency ❑ Research or Consulting
❑ Other (describe): _____

Field(s)/Subject(s) of expertise _____

Total number of years work experience in nuclear materials management field(s) _____

Education (If you are applying for a student membership, indicate the year that you anticipate receiving your degree)

College/University Major/Degree Year Degree Obtained/Expected

1. _____

2. _____

3. _____

If you are applying for a student membership, provide contact information for a faculty advisor to verify your full-time status:

Name _____ Telephone _____ E-mail _____

Membership Type Desired

❑ Student $20
❑ Regular $50

Sustaining:
❑ 0 – 19 employees $250
❑ 20 – 49 employees $500
❑ 50 or more employees $750

From the categories listed below, please indicate your top 3 areas of interest within INMM (1 being the greatest interest):

___ International Safeguards
___ Materials Control and Accountability
___ Nonproliferation & Arms Control
___ Packaging & Transportation
___ Physical Protection
___ Waste Management

Membership in Other Scientific and Technical Societies (Attach additional sheet if necessary)

Society Names and Membership Grades _____

Signature _____
PAID BY: ❑ Check ❑ MasterCard ❑ VISA ❑ American Express ❑ Diners Club

Card No. _____ Exp. Date _____

Complete the application (keep a copy for your records) and mail or fax it with membership dues to:

INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT
111 Deer Lake Road, Suite 100 • Deerfield, Illinois 60015 USA
+1-847-480-9573, Fax: +1-847-480-9282
E-mail: inmm@inmm.org • Website: www.inmm.org

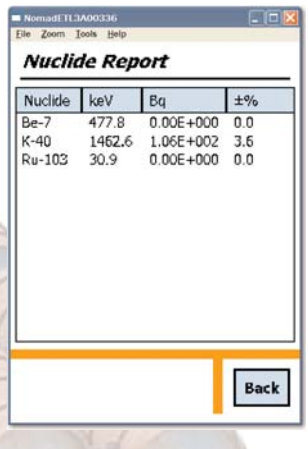
INMM
INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

The NEW ORTEC Micro-trans-SPEC: tailored to your application.

The Lightweight and Compact Solution for Heavyweight Spectroscopic Problems

- All-in-one ultra-light HPGe Spectrometer: No LN_2 required.
- High Sensitivity — 50 mm Ø x 30 mm HPGe detector.
- Tough — Enclosure, Display, and all connections sealed against moisture and dust. Water spray resistant.
- Amazingly light: 15 lb (6.8 kg).
- Digitally Stable electronics.
- High Visibility display.
- Removable data storage on SD card.
- Multiple choice of power sources.

Smart MCA Software — Onboard ROI-based Nuclide ID and activity calculation.

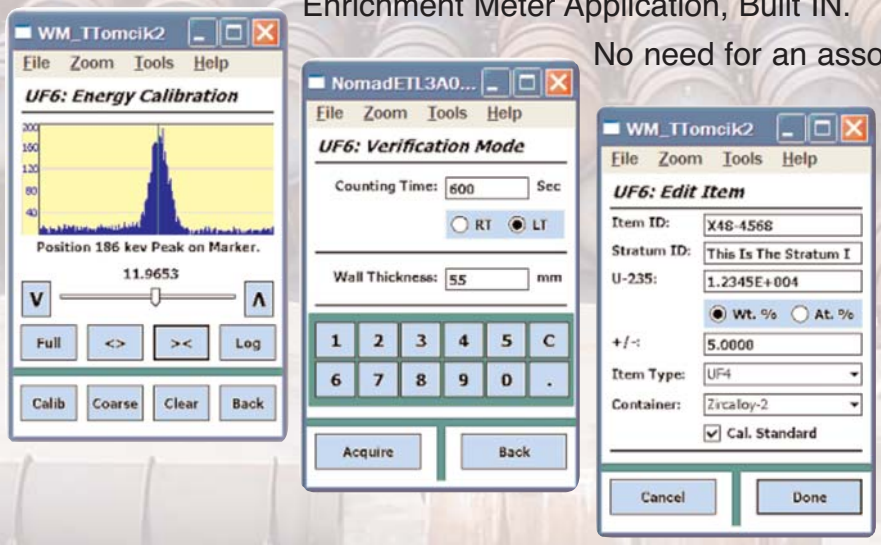


And NOW: available with Custom Software Applications

Application Example: Simpler UF6 Cylinder assays.

Enrichment Meter Application, Built IN.

No need for an associated computer.



The ORTEC Micro-trans-SPEC is a great NDA platform for HPGe applications. It is light, rugged, reliable, compact, and available now. Contact us with your application needs and we will work with you on implementation.

801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A. • (865) 482-4411 • Fax (865) 483-0396 • ortec.info@ametek.com
For International Office Locations, Visit Our Website

ORTEC® www.ortec-online.com AMETEK® ADVANCED MEASUREMENT TECHNOLOGY