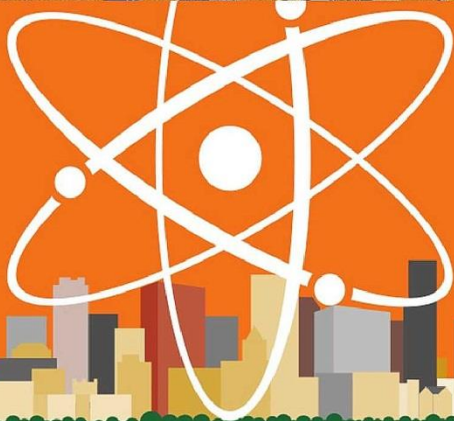
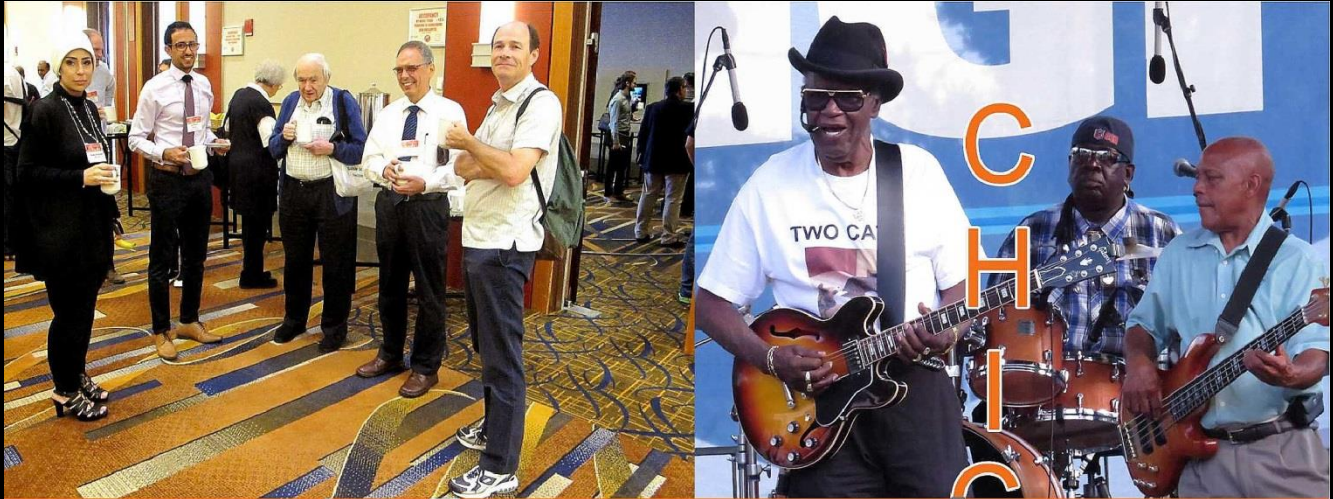


IRPS BULLETIN

Newsletter of the International Radiation Physics Society

Vol 31 Nos 1,2,3

September, 2017



IRRMAX

10th International Topical Meeting on
Industrial Radiation and Radioisotope
Measurement Applications

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From the Editors

Dear Reader,

Greetings on behalf of your IRPS Council ! The content in this issue of the Bulletin of the International Radiation Physics Society is brought to you by a group of generous volunteers. One is our current Society Secretary Jorge Fernandez who chaired (and herein reports upon) the first International Forum on Advances in Radiation Physics (FORUMBA-2017). This is the Society's first topical-format forum and was organized in Buenos Aires, 4-5 May 2017. The model is being pursued for upcoming IRPS-sponsored fora as well.

The big event within the IRPS family this summer was, of course, the tenth International Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications (IRRMA-X). Coverage begins on the front cover, and is ably summarized by program chair Professor John Mattingly, NCSU. We express again our warmest thanks to John, general chair Clair Sullivan, and all the organizers for their hospitality and preparations that made this IRRMA such a memorable success. For those who could not attend, the overview article beginning on page 11 will be your second chance, albeit attenuated by (x,t).

This issue also includes a Vice President's report submitted by V.P. of Western Europe, José Ródenas Diago, as well as a bit of radiation-physics history: the

beginnings of radio astronomy by Keith Martin of the NIST Research Library.

For the December issue of this Bulletin, we look forward to an article about our favourite exoplanet from an astronomer at the Adler Planetarium (located in Chicago, 3 miles from the IRRMA-X venue, by the way), a bit of IRPS history, and the launch of the election of a new slate of officers for IRPS. And speaking of transitions, one will note that this issue bears the designation Vol. 31 No. 1/2/3, rather than simply issue No. 3. This bespeaks louder than words that after over 13 years, the editor positions of this Bulletin also need to "transition" (think Auger) to a refreshed state. We ask for your assistance in identifying suitable candidates, including self-nominations, for editor or co-editor volunteers to take the reins of this publication. The opportunity is to gather interesting, timely, and sometimes even compelling content, as well as to keep the Society connected and informed on the many Society sponsorships, activities, and collaborative benefits. Good grammar is secondary to enthusiasm for the fellowship of international radiation physics and the bright potential that can flower from such.

Stay tuned!

For your kind consideration,

Larry Hudson and Ron Tosh, Editors

FROM THE PRESIDENT

Dear All

I write this from the Swissotel in Chicago at the end of the IRRMA-X meeting, and indeed following the Forum in Buenos Aires and the earlier ICDA-2, all of which are reported in the Bulletin of the Society. It is sometime impressive to see and realise how active and international our Society is, and how it can pull together excellent conferences on three very different but overlapping themes together with exciting Fora on important and relevant international and local topics. Many of us appreciated introductions and overviews to the funding and success of our members in non-proliferation and threat detection and verification, across the world but also as a strength and focus in the IRRMA meeting in Chicago; and indeed the dosimetry focus in Surrey. This diversity and topicality is a continuing strength and flexibility of our Society, and we hope it develops and continues.

A short message to any at these meetings who have not become members (and I hope somehow you see this Bulletin message!); remember you can sign up after a meeting on-line on our website and via pay pal, and it will help assist you in getting to our next few meetings in Moscow, Russia; Cordoba, Argentina; and Lisbon, Portugal. Each of these will bring us new insight, physics and opportunities. Plan early as the early rates are better and it is easier to lock the dates in when they are available.

In modern times it is always challenging to fund international travel, and occasionally

some might be tempted to pass a poster or talk to a friend for presentation. Of course this invalidates the chance for student prizes, and also for any proceedings submission being accepted. We do expect that, if you want citations and impact, you must make the impact. It also ensures that the community works and thinks together. Also in terms of making submissions, it is better to submit one great paper that produces lots of citations than ten which are marginal and receive none. I make this comment as the journal Radiation Physics and Chemistry rises in its Impact Factor this year but also rises to 62.4% rejection rates.

Again to emphasise that our recent meetings were huge successes and will further bring people and radiation science together. We have an advantage that our members are both theoretical and experimental; fundamental and applied; young and older. Some 30 % of the presentations at IRRMA were by students and some of the talks revealed new faces for the Society and for the Future. Well done all.

Chris Chantler



Report from Vice President Western Europe, Jose Rodenas Diago

for period September 2016 – June 2017

- I participated at the 13th International Conference on Radiation Shielding - Radiation Protection & Shielding Division Topical Meeting 2016 of American Nuclear Society. ICRS-13 & RPSD-2016 (<http://www.icrs13-rpsd2016.org>) on October 3-6. I was chairman of a session and presented one oral contribution "*Application of the Monte Carlo method to the analysis of doses and shielding around an X-ray fluorescence equipment*".
- The Erasmus + Strategic Partnership "Blended Learning in Radiation Protection and Radioecology", funded by the AEF Europe, started in September 2015, and continued during 2016 and 2017. There are 8 academic partners (from the CHERNE network) representing **7 countries**:

- Haute Ecole Paul-Henri Spaak - **BELGIUM**
- Universiteit Hasselt (UHasselt)- **BELGIUM**
- Fachhochschule Aachen (FH Aachen) - **GERMANY**
- Università di Bologna (UNIBO) - **ITALY**
- Universidade de Coimbra - **PORTUGAL**
- Czech Technical University in Prague (CTU) - **CZECH REPUBLIC**
- National Technical University of Athens (NTUA) - **GREECE**
- Universitat Politècnica de València (UPV)- **SPAIN**

And 2 non-academic partners to add value to the partnership:

- a research institute: National Radiation Protection Institute (SURO) - **CZECH REPUBLIC**
- a regulatory body: Greek Atomic Energy Commission - **GREECE**
- **Development of e-learning modules** in radiation protection and radioecology has been performed during the period till June 2017.
- During this period six training courses have been organised with participation of students and professors of partners of the project.
 - **MARC** - held in Jülich (Germany) from 12th to 16th September 2016, is the training course for **Radiochemistry**.
 - **MaraWas** - training course on **Management of Radioactive Waste**, held in Universiteit Hasselt, Diepenbeek, Belgium, on Nov 21-25, 2016.

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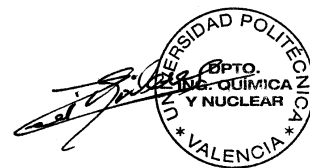
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- **SARA 2016 (Safe Application of Radiation and radionuclides)** training course held from November 5th to November 9th, 2016 at CTU in Prague, mainly focused on practical ionizing radiation utilization.
- **PRA** - training course on **Risk Assessment**, held in Universitat Politècnica de València (UPV) Spain, on Feb 13-17, 2017.
- **MANTRA** - training course on **Practical Radiation Protection in the Medical Field**, held in Università di Bologna (Italy), on March 13-17, 2017.
- **MERiBel** - training course on **Measurement of Environmental Radioactivity in Belgium**, held in Brussels (HE2B), Belgium, on April 19-26, 2017.

- Other courses organised during the period:
 - **RADAM** - held in Jülich (Germany) from 5th to 9th September 2016, a laboratory for nuclear measurements of alpha, beta, gamma, neutron and X-ray radiation in a great variety of experiments.
 - **GATE** - held in Jülich (Germany) from 19th to 23rd September 2016, a course on how to use GATE for simulations in medical imaging (PET, SPECT etc.).
 - **Soft Computing** - intensive course (in Spanish) (**Introducción a los métodos de Soft Computing en ingeniería: Algoritmos Genéticos, Redes Neuronales y Lógica Fuzzy**) in the frame work of the **MÁSTER UNIVERSITARIO EN SEGURIDAD INDUSTRIAL Y MEDIO AMBIENTE** of UPV (Universitat Politècnica de València), held in València from 30 January to 3 February 2017 and given by Prof. Enrico Zio from Politecnico di Milano (Italy).
 - **NATURAL RADIOACTIVITY** - intensive course given by Prof. Isabelle Gerardy from Haute Ecole Bruxelles-Brabante (HE2B), held in València (Universitat Politècnica de València), from 6 - 10 February 2017

- **CHERNE-2017** - 13th Workshop on European Collaboration for Higher Education and Research in Radiological and Nuclear Engineering, held at the Universidade Beira Interior, Covilhã (Portugal) from 22 to 25 May 2017. This meeting was already announced at the IRPS Council held on July 2016 in Guildford.

València, 3rd July 2017



Report on International Forum on Advances in Radiation Physics (FORUMBA-2017)

*Jorge E. Fernandez, University of Bologna, Italy
(Chair FORUMBA-2017)*



Logos of participating institutions and sponsors:

- ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
- Embajada de Italia Buenos Aires
- ISTITUTO italiano DI CULTURA
- FAdA
- UNC
- Ministerio de Ciencia, Tecnología e Innovación Productiva Presidencia de la Nación
- CONICET
- FAMAF
- Facultad de Matemática, Astronomía, Física y Computación
- Ministerio de CIENCIA Y TECNOLOGIA
- CEPROCOR
- IRPS

Topics

- Processes in radiation physics (atomic)
- Quantitative x-ray and particle analytical techniques
- Absorption and fluorescence spectroscopy (especially XAFS, XANES and Raman)
- Sources and detectors
- Simulation of radiation transport
- Materials science and applications to minerals, mining and processing
- Medical applications and biology
- Applications to space, earth and environmental sciences
- Cultural heritage and art and new technologies and industrial applications

 <http://forumba2017.ing.unibo.it/>

**INTERNATIONAL FORUM ON ADVANCES IN RADIATION PHYSICS
BUENOS AIRES, MAY 4-5 2017**

The International Forum on Advances in Radiation Physics (FORUMBA-2017) was the first one of its type and was organized in Buenos Aires, 4-5 May 2017. It was created to promote the encounter of Latin-American scientists with prestigious specialists active in radiation physics in other regions of the world. It was inspired by the International Radiation Physics Society (IRPS) primary objective of promoting the global exchange and integration of scientific information pertaining to the

interdisciplinary subject of radiation physics, including the promotion of theoretical and experimental research in radiation physics, investigation of physical aspects of interactions of radiations with living systems, education in radiation physics, and utilization of radiations for peaceful purposes.

The scientific program consisted of invited lectures and oral presentations given by the delegates in five topical areas:

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Fundamental Processes in Radiation Physics; Sources and Detectors; Applications in Medicine and Biology; Applications to Cultural Heritage and Environmental Sciences; and Applications to Space and Earth. The intense

program of invited lectures given by experts offered to the delegates an up-to-date view of the radiation physics status in other regions of the world:

- David Bradley, University of Surrey, UK. *Novel media and mechanisms applied to radiation dosimetry*
- Aldo Craievich, University of Sao Paulo, Brazil. *Modern photon sources: new applications and challenges*
- Sultan Dabagov, Istituto Nazionale di Fisica Nucleare, Italy. *On advanced channeling technologies*
- William Dunn, Kansas State University, USA. *A review of the activities of the consortium for nonproliferation enabling capabilities on replacement of dangerous radiological sources*
- Jorge E. Fernández, University of Bologna, Italy. *The x-ray characteristic line in the framework of the Boltzmann transport equation*
- Rafael Ferragut, Milan Polytechnic, Italy. *Detection methods for positron and positronium interferometry*
- Odair Goncalves, Universidade Federal de Rio de Janeiro, Brazil. *Medical physics research at the Laboratory of Radiation Physics at the Federal University of Rio de Janeiro*
- Isabel Lopes, University of Coimbra, Portugal. *Detectors for dark matter search: present status*
- Héctor Jorge Sánchez, University of Córdoba, Argentina. *Low resolution RIXS: a versatile spectroscopic tool for chemical state assessments.*
- José Paulo Santos, Universidade Nova de Lisboa, Portugal. *Fundamental parameters for interactions of x-rays with matter*
- Joaquim Teixeira de Assis, Rio de Janeiro State University, Brazil. *Study on Brazilian 18th century imperial carriage using x-ray nondestructive techniques*
- Marcelo Rubio, CEPROCOR, Argentina. *A review of advances in phytoremediation of soils contaminated by Pb and Sb in Argentina*

Another 17 reports from the delegates were communicated and discussed as oral presentations.

The venue of the Forum was the Italian Cultural Institute of Buenos Aires in the downtown district, close to the Argentinian

branch of the University of Bologna. The foreseen scientific programme was executed completely without missing lectures. The Forum was attended by 42 scientists from 8 countries, 66% from South America and in all exhibited a very good scientific level. The Book of Abstracts is available from the web site

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(<http://forumba2017.ing.unibo.it>) for download, as are many of the photos taken during the event. Radiation Physics and Chemistry has approved the publication of a special issue by invitation for the Forum with Jorge Fernandez, Marcelo Rubio and David Bradley acting as guest editors.

To taste the traditions of Argentina nightlife the organizers organized a social mixer consisting in a Dinner and Tango Show at a suggestive location in Buenos Aires.

The organizers acknowledge the support and assistance from several sponsoring institutions. They are indebted to the Italian Embassy in Buenos Aires for supporting the travel of one invited speaker. They deeply thank the Italian Cultural Institute of Buenos Aires for granting

the permission of using the Benedetto Croce auditorium and the Roma exhibition hall. Sincere acknowledgement is due to the whole staff of the Argentinian branch of the Alma Mater Studiorum Università di Bologna that supported the whole organization. The following organizations are deeply acknowledged for active support to this initiative: the International Society of Radiation Physics (ISRP), the Universidad Nacional de Córdoba and particularly its Faculty of Mathematics, Astronomy and Physics; the CEPROCOR; The Ministry of Science and Technology of the Córdoba Province; the CONICET; the National Ministry of Science; Technology and Productive Innovation and the Fábrica Argentina de Aviones "Brig. San Martín" (FaDEA). Many people of these institutions were involved, and the organizers are indebted to all of them.



IRPS Council Meeting, Chicago 2017 and IRRMA-X, 2017

Before IRRMA-X began, the IRPS Council met on Sunday, July 9, 2017 in the aptly named Matterhorn Room on the 42nd floor of the Swissotel in downtown Chicago.

Shown from left to right are

Clair Sullivan (IRRMA-X Chair), Jorge Fernandez (Secretary), Christopher Chantler (President), Ladislav Musilek, Tomas Trojek, William Dunn (Treasurer), John Mattingly, Sultan Dabagov, Richard Pratt, and Richard Hugtenburg. Not pictured: Larry Hudson (photographer).



SEE IRRMA-X REPORT ON THE FOLLOWING PAGES



IRRMA-X highlights

John Mattingly, NCSU

Overview

The tenth triennial international topical meeting on Industrial Radioisotope and Radiation Measurement Applications ([IRRMA-X](#)) was hosted July 9 – 13, 2017 in Chicago, Illinois by [University of Illinois at Urbana-Champaign's Department of Nuclear, Plasma, and Radiological Engineering](#). This was the 27th anniversary of IRRMA since its inaugural meeting organized by [Prof. Robin Gardner](#) of North Carolina State University's Department of Nuclear Engineering. This year, the organizing committee was:

- General Chair: [Prof. Clair Sullivan](#), University of Illinois at Urbana-Champaign (UIUC)
- Program Chair: [Prof. John Mattingly](#), North Carolina State University (NCSU)
- Technical Chair: [Prof. Bill Dunn](#), Kansas State University (KSU)
- Conference Coordinator: [Michelle Marquart](#), University of Illinois at Urbana-Champaign (UIUC)
- Communications Chair: [Stefani Buster, JD](#), North Carolina State University (NCSU)
- Companion Tour Chair: [Michael Sullivan](#), University of Illinois at Urbana-Champaign (UIUC)
- Excursion Chair: [Prof. David Ruzic](#), University of Illinois at Urbana-Champaign (UIUC)
- Exhibitor Chair: Steven Mell, [Mirion Technologies](#)

The conference organization was advised by the [International Radiation Physics Society](#) (IRPS) and financially sponsored by the exhibitors

- [Mirion Technologies](#)
- [ORTEC](#)
- [Transco Products](#)
- [XIA](#)

IRRMA-X received over 120 contributed and invited papers, resulting in nearly 50 oral presentations and over 70 poster presentations organized in 3 plenary sessions, 13 oral sessions, and 2 poster sessions covering 10 tracks:

- Industrial Applications of Radiation
- Radiation Sources and Measurements for Applications
- Detection of Threat Material and Contraband

...//Continued

- Radiation Data Science and Analytics
- Dosimetry and Detector Applications
- Monte Carlo Methods and Applications
- Biological and Medical Applications of Radiation
- Use of Radiation in Environmental Sciences
- Radiation Effects on Materials
- Radiation Shielding and Protection

The IRRMA-X attendees represented academic, government, and industrial research institutions from *every continent* (except, of course, Antarctica).

In particular, IRRMA-X featured a significant proportion of student-authored papers: over one-third of the contributed papers were authored by students.

IRRMA-X officially opened Sunday evening July 9, 2017 with a reception atop the award-winning, architecturally stunning, all-glass, triangular [Swissotel Chicago](#) with a spectacular view of the beautiful Chicago nighttime skyline, overlooking the mouth of the Chicago River where it spills into Lake Michigan. Traditional Chicago delicacies like deep-dish pizza and libations from the open bar were provided by University of Illinois at Urbana-Champaign (UIUC).

Technical program

Monday, July 10

The IRRMA-X [technical program](#) began Monday morning, July 10 with a plenary session where IRPS President [Prof. Chris Chantler](#) of University of Melbourne and IRRMA-X General Chair [Prof. Clair Sullivan](#) of UIUC welcomed the attendees to the conference.

In the second plenary session Monday morning, July 10, Prof. Bill Dunn of KSU introduced two invited speakers, the leaders of two academic consortia for nuclear security studies sponsored by the US National Nuclear Security Administration (NNSA), [Prof. Sara Pozzi](#) of University of Michigan, Director of the [Consortium for Verification Technology](#) (CVT), and [Prof. Yousry Azmy](#), Director of the [Consortium for Nonproliferation Enabling Capabilities](#) (CNEC). The presentations by Profs. Pozzi and Azmy were followed by the inaugural *Pratt Technical Lecture*, honoring [Prof. Richard Pratt](#) of University Pittsburgh for his lifelong scientific achievements and contributions to IRPS and IRRMA. The first invited *Pratt Lecture* on “Thermo- and Radioluminescence Dosimetry Using Doped Silica Forms” was delivered by [Prof. David Bradley](#) of University of Surrey, and Prof. Bradley presented Prof. Pratt a plaque recognizing his career-long achievements and contributions.

Monday afternoon, July 10, IRRMA-X conducted two parallel technical sessions on:

- Biological and Medical Applications of Radiation
- Radiation Sources and Measurements for Applications

Those technical sessions were respectively chaired by Prof. David Bradley and [Dr. Cyrus Larijani](#) of the UK National Physical Laboratory (NPL).

The technical program on Monday, July 10 concluded with a [poster session](#) summarizing diverse research in:

...//Continued

- Radiation Sources and Measurements for Applications
- Biological and Medical Applications of Radiation
- Use of Radiation in Environmental Sciences
- Radiation Effects on Materials
- Radiation Shielding and Protection

The poster session was chaired by [Prof. Shiva Abbaszadeh](#) of UIUC. The poster presenters represented institutions from across the world.

Tuesday, July 11

The IRRMA-X [technical program](#) continued Tuesday morning, July 11, beginning with a plenary session where IRRMA-X Program Chair Prof. John Mattingly of NCSU introduced two invited talks by [Prof. Paul Sellin](#) of University of Surrey, on “Organic materials for next-generation radiation detectors,” and [Dr. Andrey Elagin](#) of University of Chicago, on “Using Photon Drift Time to Reconstruct Nuclear Processes and PET Event Topologies.”

Following the plenary session, Tuesday morning, July 11 the conference conducted two parallel technical sessions on:

- Radiation Sources and Measurements for Applications
- Radiation Data Science and Analytics

Those technical sessions were respectively chaired by [Prof. Walter McNeil](#) of KSU and Prof. Chris Chantler of University of Melbourne, and the “Radiation Sources and Measurements for Applications” session featured an invited talk on “Production of ^{236}Pu of suitable purity as a chemical yield tracer by proton irradiation of uranium targets” by Dr. Cyrus Larijani of the UK NPL.

Tuesday afternoon, July 11, IRRMA-X conducted two more parallel technical sessions on:

- Dosimetry and Detector Applications
- Radiation Data Science and Analytics

Those technical sessions were respectively chaired by Prof. John Mattingly of NCSU and Prof. Clair Sullivan of UIUC. The “Dosimetry and Detector Applications” session featured an invited talk on “Double-Sided Microstructured Semiconductor Neutron Detectors” by [Prof. Douglas McGregor](#) of KSU, and the “Radiation Data Science and Analytics” session featured an invited talk on “X-ray and electron data science and analytics” by Prof. Chris Chantler of University of Melbourne.

The technical program on Tuesday, July 11 concluded with a second [poster session](#) summarizing diverse research in:

- Industrial Applications of Radiation
- Detection of Threat Material and Contraband
- Radiation Data Science and Analytics
- Dosimetry and Detector Applications
- Monte Carlo Methods and Applications

Again, the poster presenters represented institutions from across the world. The second poster session was again chaired by [Prof. Shiva Abbaszadeh](#) of UIUC.

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Wednesday, July 12

The IRRMA-X [technical program](#) continued Wednesday, July 12, beginning in the morning with two parallel technical sessions on:

- Detection of Threat Material and Contraband
- Dosimetry and Detector Applications

Those technical sessions were respectively chaired by [Prof. Jim Baciak](#) of University of Florida and [Prof. Amir Bahadori](#) of KSU.

Later that same morning, the conference conducted two parallel technical sessions on:

- Industrial Applications of Radiation
- Monte Carlo Methods and Applications

Those sessions were respectively chaired by Prof. Bill Dunn of KSU and [Prof. Richard Hugtenburg](#) of Swansea University. The “Monte Carlo Methods and Applications” session featured an invited talk by [Dr. Avneet Sood](#) of Los Alamos National Laboratory (LANL).

The conference’s technical program concluded on the afternoon of Wednesday, July 12 with three technical sessions on:

- Dosimetry and Detector Applications
- Monte Carlo Methods and Applications (2 sessions in series)

The “Dosimetry and Detector Applications” session was chaired by Prof. Douglas McGregor of KSU, and the two “Monte Carlo Methods and Applications” sessions were respectively chaired by Dr. Avneet Sood and [Dr. Madison Andrews](#), both of LANL.

Closing Ceremonies

IRRMA-X officially closed Wednesday evening, July 12 with an extravagant banquet hosted by UIUC at the [Chicago Museum of Science and Industry](#). General Chair Prof. Clair Sullivan, accompanied by her daughter Sophie, thanked IRPS, the organizing committee, the session chairs and invited speakers, and all the attendees for making IRRMA-X a success.

Prof. Sullivan also announced the winners of the best student paper competition. Awards were presented to:

- Mr. Jason Hite, an NCSU Nuclear Engineering PhD student, for the best student oral presentation on “Bayesian Metropolis Methods for Source Localization in an Urban Environment”
- Mr. Aaron Feinberg, an NCSU Nuclear Engineering PhD student, for the best student poster presentation on “Detector Resolution Effects on Spectral Uncertainty in Gamma-Ray Elemental Analysis”

IRPS sponsored the best student paper competition and presented Messrs. Hite and Feinberg each with a certificate recognizing their papers and a monetary award of \$250 each for their excellent contributions to the conference.

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At the conclusion of the closing ceremony, IRPS President Prof. Chris Chantler announced that IRRMA-XI will be held in Moscow in 2020. We all look forward to seeing you there!



Clair Sullivan presents to awardees Jason Hite (left) and Aaron Feinberg (right) certificates recognizing “best student oral presentation” and “best student poster presentation,” respectively .

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Internet Address : <http://www.canberra.edu.au/irps>

New Memberships, Membership Renewals

Membership form for new members, and details for payments by cheque for new and renewing members are on the last 2 pages of this journal and information for payment by credit card is on page

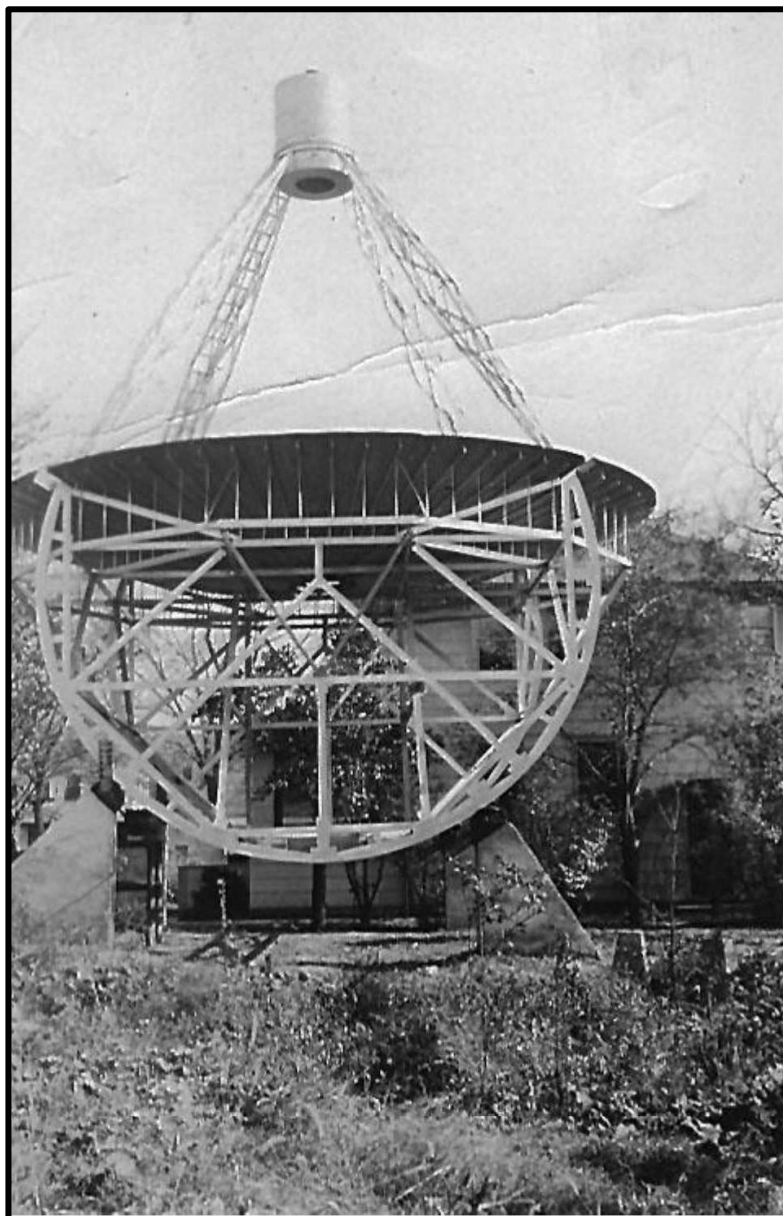
If you are unsure when your renewal is due, contact

Elaine Ryan : **email:** elaine.ryan@sydney.edu.au

Electrical Disturbances of Extraterrestrial Origin

By Keith Martin, NIST Research Library

Dulles International Airport, in the Northern Virginia suburbs of Washington, D.C., sits on land once owned by NIST. It was on this spot that NIST brought together an eclectic combination of people and projects that would help birth the field of radio astronomy. It would involve a backyard tinkerer, a former Nazi radar installation, a confidential Defense Department project, and the desire of people living west of the Mississippi River to watch television.



Reber's self-built telescope in the backyard of his home in Wheaton, Illinois, circa 1938. It is widely considered to be the world's first radio telescope.

Credit: National Radio Astronomy Observatory

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In 1932 Karl Jansky, a radio engineer at the Bell Laboratories campus in Holmdel, N.J., published a paper with the rather sedate title “Directional Studies of Atmospheric at High Frequencies.

The paper described his work identifying the sources of radio static experienced when testing Bell Laboratories’ new trans-Atlantic radio telephone service. Most of the static came from thunderstorms, but Jansky also identified errant radio signals from another source, seemingly coming from the direction of the sun. This was not terribly surprising. Physicists had already theorized that the sun could emit radio waves.

Jansky continued to study and refine his data, and the following year published two follow-up papers. This time around, the titles of his papers would be far more exciting: “Radio Waves from Outside the Solar System” and “Electrical Disturbances Apparently of Extraterrestrial Origin”! Jansky had determined that the radio signals were coming not from our sun, but from some distant point in the Milky Way.

His finding would eventually revolutionize the study of astronomy. No longer would astronomers be limited by what they could see through optical telescopes. Since large swaths of the cosmos are filled with dust that light cannot penetrate, studying the radio signals given off by distant invisible celestial bodies opened up a larger window on the universe.

Unfortunately for Jansky, his employer Bell Labs was not in the astronomy business. They moved him on to other projects.

The Backyard Telescope

Hoping to pick up where Jansky left off was a 22-year-old college senior named Grote Reber. He had read Jansky’s papers and excitedly applied to work at Bell Labs. Bell turned him down. Inquiries at several other institutions received the same response. Reber settled for a job as an engineer with a radio equipment manufacturer in Chicago, and decided to pursue radio astronomy as a hobby. He would spend his free nights and weekends in the backyard of his Wheaton, Illinois, home designing and building a 9-meter-wide, 2-metric-ton dish antenna on an adjustable tilting stand. Completed in 1937, it is considered to be the world’s first astronomical radio telescope. Reber used his backyard dish to map cosmic radio sources, and discovered new galaxies, supernovas and other celestial bodies.

Reber would spend a decade working out of his backyard, essentially the world’s only radio astronomer.

He published some of his findings in 1940 in the *Astronomical Journal*, but the article attracted little interest. Partly this was the fault of the Great Depression; there was no funding available to explore new avenues of science. Reber would also later

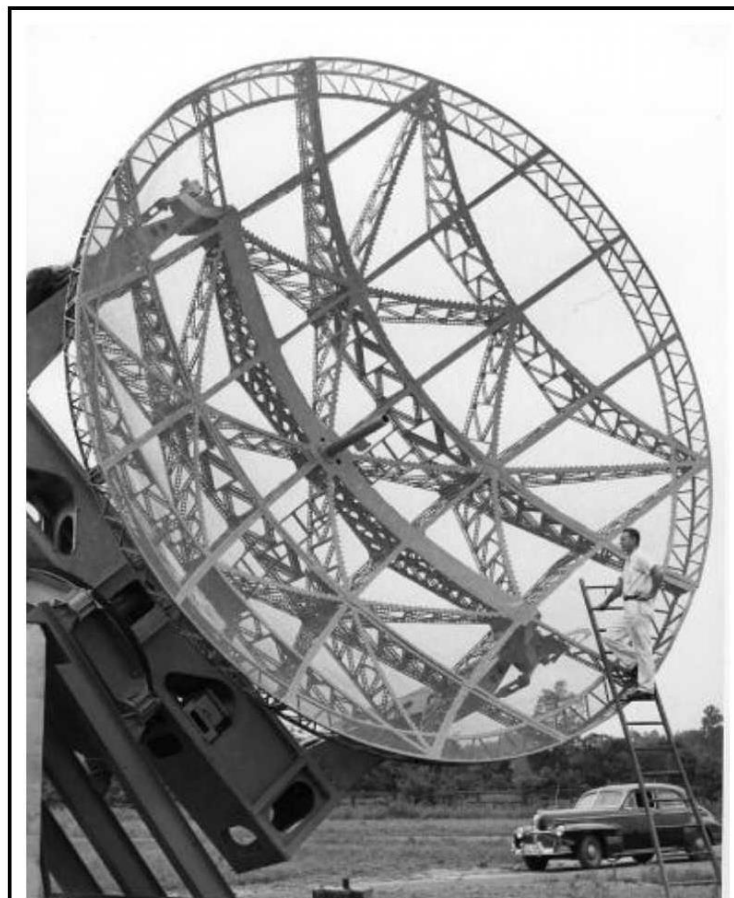
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claim that the lack of interest was because "the astronomers of the time didn't know anything about radio or electronics, and the radio engineers didn't know anything about astronomy."

Whatever the reason, Reber would spend a decade working out of his backyard, essentially the world's only radio astronomer.

NIST Offers a Job

Things would change after World War II. In 1947 Reber was in the audience at a radio engineers' conference listening to a talk given by Edward Condon, the director of NIST (at the time known as the National Bureau of Standards, or NBS). Condon described NBS' role "to undertake research that commercial companies couldn't do well or couldn't do at all." Reber quickly dashed off a letter to Condon explaining that this was the exact type of research he was doing. Intrigued, Condon sent two NBS physicists to meet with Reber and take a look at his backyard radio telescope.



Reber with the dish of the Giant Würzburg during its reassembly at NBS' Sterling, Virginia, field station, circa 1948. Although it was built by Nazi Germany as an anti-aircraft radar antenna, NBS repurposed the instrument for radio astronomy.

Credit: National Radio Astronomy Observatory

The meeting went well. Using funding provided by the Defense Department, Condon offered to hire Reber and purchase his backyard dish, with the proviso that Reber and his equipment move to NBS' radio-propagation research station near Sterling, Virginia. NBS had been involved in radio research for decades, using rural field stations far from urban sources of interference to study how the Earth's atmosphere affects radio transmissions. These studies helped the burgeoning radio broadcasting industry, and benefited military communications during the war.

Hiring Reber was a win-win for all concerned:

- Reber could now focus full-time on radio astronomy, backed by institutional-level funding.
- NBS, with its eye on helping grow the commercial TV industry—the first licensed TV station west of the Mississippi River would go on air that same year, and many more were expected—needed the cosmic radio data Reber would compile. That data could be used to help determine the best designs, locations and operating frequencies for TV transmitters in order to avoid sources of interference.
- The Defense Department's reasons for funding the project were left unstated. "Neither Reber nor anyone else at the Bureau even hints that this had anything to do with his being hired, [but] Reber's big mirror [his radio telescope] may have some bearing on future war," said a 1948 article in the magazine *Popular Science*. The magazine speculated about one possible reason for the military's interest: If cosmic radio interference could be accurately predicted and mapped, airplane attacks during future wars could be timed to occur when an enemy's radar would be temporarily disabled by the interference.

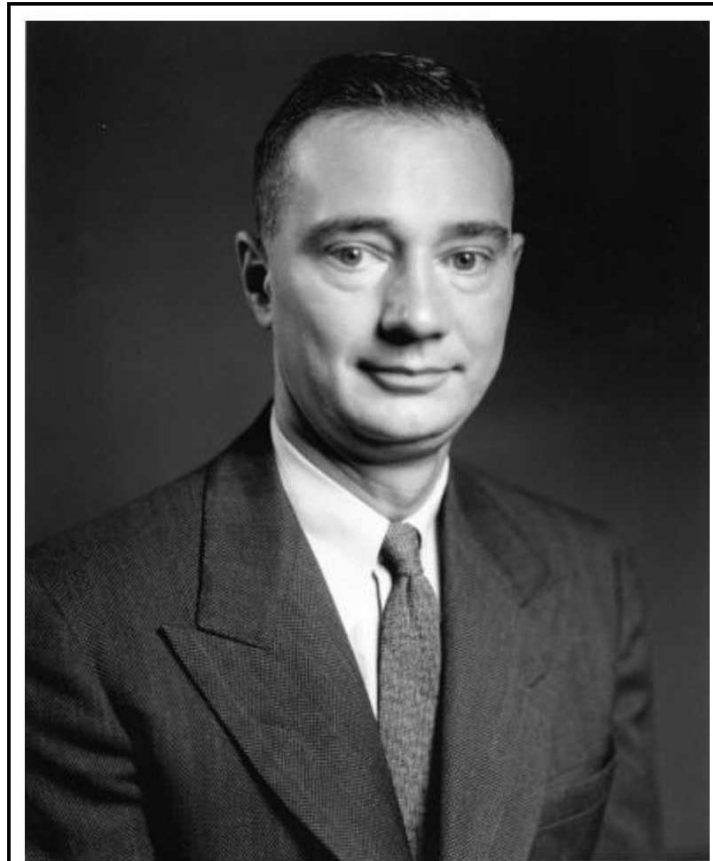
In addition to providing the funding for Reber's project, the military had one other gift for him: a Giant Würzburg. During the war the Germans deployed sophisticated anti-aircraft radar along the front lines. Named "Giant Würzburgs" after a German city and because of their large 7.4-meter diameter, these Nazi radar dishes were of intense interest to Allied forces, and were often targets of covert special-operations missions. When American forces captured a Giant Würzburg from the retreating Germans toward the end of the war, it was dismantled and shipped to the U.S. for study by the Army Signal Corps. Its technical secrets now known, the military donated the Würzburg to NBS to be repurposed for the radio-astronomy project, supplementing Reber's home-built telescope and allowing for the study of a wider range of radio frequencies.

Telescopes on the Move

By the early 1950s, with the influence of the research program at NBS and subsequent programs at other scientific institutions, radio astronomy had grown to become an accepted field of study. After five years working on the NBS project, Reber grew

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troubled by the rise of McCarthyism in Washington, D.C., and he decided to leave government work. Luckily for him, in 1951 he won a generous grant from the Research Corporation for Science Advancement, a private philanthropic organization. This funding allowed Reber to become an independent researcher. He left the NBS Sterling, Virginia, field station and moved to the then territory of Hawaii, before finally settling in Tasmania, the island state of the Commonwealth of Australia that is located to the south of the Australian mainland. Reber remained active in radio astronomy until his death in 2002.



Grote Reber spent a decade working out of his backyard using self-built equipment, essentially the world's only radio astronomer. He is pictured here in 1947, the year he joined NBS.

Credit: NIST Archives

Reber's equipment and the Giant Wurzburg were still owned by NBS. In the mid-1950's the government asked NBS for its land in Virginia to use as the site for the future Dulles Airport. NBS moved Reber's dish and the Giant Wurzburg to the Bureau's new Boulder, Colorado, campus. In 1959 NBS sent Reber's telescope to the National Radio Astronomy Observatory installation in Green Bank, West Virginia. It remains there to this day, on display for public viewing, next to a replica of the apparatus Karl Jansky used to make his original discovery.

Reber's telescope was declared a National Historic Landmark in 1989. The Giant Würzburg remained in Boulder until 2006, when it was acquired by the National Electronics Museum in Linthicum, Maryland. The giant dish is on display outside the museum, where it stands taller than the museum itself.

Radio Astronomy Today

Although the instruments Reber used during his NBS work are now museum pieces, the field of radio astronomy that he pioneered keeps growing in importance. In a "State of the Profession" report published in 2010, the director of the National Radio Astronomy Observatory notes that radio astronomy "plays a critical role in all areas of modern astrophysics." He further elaborates:

"Radio instruments carry out precision cosmological measurements, test fundamental physics, and probe astrophysics and chemistry in extreme environments. ...Radio astronomy probes deep into the earliest, most intense, and optically obscured, phases of planet, star, galaxy, and black hole formation. ...Radio astronomy provides the highest-resolution imaging and astrometry [measurement of the positions of stars] currently available, as well as providing essential tools for study of magnetic fields and energetic particles throughout the cosmos."

The National Research Council agrees on the importance of radio astronomy. In its 2010 Decadal Survey of Astronomy and Astrophysics, the Council stated that "radio astronomy stands poised to continue to offer considerable promise in the exploration of our universe."

NIST played a critical role in raising radio astronomy from a backyard hobby to what is now a major field of research. Reflecting on this legacy in an oral-history interview with the American Institute of Physics, physicist Alan Shapley, who worked with Reber at NBS, said, "Whenever you land at Dulles [airport], you can envision all the good scientific work on radio [astronomy] that was done on those grounds." No doubt I will.

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INTERNATIONAL RADIATION PHYSICS SOCIETY

The primary objective of the International Radiation Physics Society (IRPS) is to promote the global exchange and integration of scientific information pertaining to the interdisciplinary subject of radiation physics, including the promotion of (i) theoretical and **experimental research in radiation physics**, (ii) investigation of physical aspects of interactions of radiations with living systems, (iii) education in radiation physics, and (iv) utilization of radiations for peaceful purposes.

The Constitution of the IRPS defines Radiation Physics as "the branch of science which deals with the physical aspects of interactions of radiations (both electromagnetic and particulate) with matter." It thus differs in emphasis both from atomic and nuclear

physics and from radiation biology and medicine, instead focusing on the radiations.

The International Radiation Physics Society (IRPS) was founded in 1985 in Ferrara, Italy at the 3rd International Symposium on Radiation Physics (ISRP-3, 1985), following Symposia in Calcutta, India (ISRP-1, 1974) and in Penang, Malaysia (ISRP-2, 1982). Further Symposia have been held in Sao Paulo, Brazil (ISRP-4, 1988), Dubrovnik, Croatia (ISRP-5, 1991) Rabat, Morocco (ISRP-6, 1994), Jaipur, India (ISRP-7, 1997), Prague, Czech Republic (ISRP-8, 2000), Cape Town, South Africa (ISRP-9, 2003), Coimbra, Portugal (ISRP-10, 2006), Australia (ISRP-11, 2009), Rio de Janeiro, Brazil (ISRP-12, 2012) and Beijing, P.R.China (ISRP-13, 2015) The IRPS also sponsors regional Radiation Physics Symposia.

The **IRPS Bulletin** is published quarterly and sent to all IRPS members.

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