ARPS 2021 CONFERENCE

LEGACY AND INNOVATION IN RADIATION PROTECTION

AUSTRALASIAN RADIATION PROTECTION SOCIETY

CONFERENCE ORGANISING COMMITTEE

Ron Rubendra 2021 Conference Convenor	Australasian Radiation Protection Society
Bill Bartolo	Bartolo Safety Management Service
Tony Mills-Thom	Department of Defence
Neha Kodwani	Australian National University
Michael Went	Department of Defence
Asif Ahmed	Department of Defence
Brent Rogers	South Eastern Sydney Local Health District
Hefin Griffiths	ANSTO
Jim Hondros	Australasian Radiation Protection Society
Paula Veevers	Australasian Radiation Protection Society

CONFERENCE MANAGERS

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WELCOME

On behalf of the Organising Committee, it is my great pleasure to welcome you to the 43rd Annual Conference of the Australasian Radiation Protection Society (ARPS).

ARPS was founded in 1975 and has more than 200 members engaged in radiation protection activities. Members are engaged in a variety of activities designed to ensure the safe use of both ionising and non-ionising radiation for a wide variety of applications in medicine, pure and applied science, industry, and mining.

The theme of the 2022 conference is 'Legacy and Innovation in Radiation Protection'. We have an exciting scientific program lined up for you.

The aim of the conference is to enrich the understanding of non-ionising and ionising radiation safety, highlight the importance of effective communication and stakeholder involvement on radiation safety, highlight new technologies and generate discussion across a broad range of radiation protection aspects looking to the past as well at the future.

The Organising Committee is keen to welcome you to Canberra!

Ron Rubendra
ARPS 2021 Conference Convenor

GENERAL INFORMATION

REGISTRATION DESK

The Registration Desk is located at the Canberra Rex Hotel in the Grand Ballroom Foyer. Please direct any questions you may have regarding the conference to the team from Leishman Associates. The registration desk will be open at the following times:

Monday 7 March	**0800-1700**
Tuesday 8 March	**0730-1630**
Wednesday 9 March	**0830-1700**
Thursday 10 March	**0900-0930**

ACCOMMODATION

If you have any queries relating to your accommodation booking, please first see staff at your hotel. Your credit card details have been passed onto the hotel to secure your booking. If you have arrived 24 hours later than your indicated arrival day you may find that you have been charged one night's accommodation.

SPECIAL DIETS

All catering venues have been advised of any special diet preferences you have indicated on your registration form. Please identify yourself to venue staff as they come to serve you and they will be pleased to provide you with all pre-ordered food. For day catering, there may be a specific area where special food is brought out, please check with catering or conference staff.

FACEBOOK

Follow Australasian Radiation Protection Society-ARPS

WEBSITE

Updated conference information can be found at www.arpsconference.com.au

CONFERENCE NAME BADGES

All delegates and exhibitors will be provided with a name badge. Please wear your name badge at all times as it will be your entry into all sessions and all social functions.

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CONTINUTING PROFESSIONAL DEVELOPMENT

ACPSEM CPD Endorsed Activity

ACPSEM CPD Endorsement

The Australasian College of Physical Scientists & Engineers in Medicine have endorsed the ARPS 2021 Conference as a quality CPD activity. A total of 30 CPD points may be awarded for attendance to the full Conference.

The following CPD points will be awarded for each day of attendance:

10 points for full day attendance on Monday 7 March

10 points for full day attendance on Tuesday 8 March

3 points for Breakfast workshop on Tuesday 8 March

10 points for full day attendance on Wednesday 9 March

2 points for the Technical Tour on Thursday 10 March

ENTRY TO CONFERENCE SESSIONS

It is suggested that delegates arrive at preferred sessions promptly to ensure a seat. If sessions become full then delegates will not be allowed entry.

INFORMATION FOR PRESENTERS AND SESSION CHAIRS

All speakers will be asked to check into the Speakers Preparation Room, Boardroom to load their presentations onto the conference network. This must be done AT LEAST three hours before you are due to present.

An audio-visual technician will be available throughout the conference. Speakers are asked to introduce themselves to their session chair during the break if possible and arrive in the room on time.

The Speakers Preparation is located at the Boardroom. Please see the staff at the registration desk for further assistance or directions.

POSTER PRESENTATIONS

Posters will be displayed in the Grand Ballroom for the duration of the conference. There will be a poster session on Wednesday 9 March, 1215-1245. Posters will be available for viewing in the exhibition hall from Monday 7 March.

ENTRY TO SOCIAL EVENTS

Entry to social events will not require a ticket if you have purchased a full registration.

Attendees and additional guests will appear on a guest list and must wear a name badge. If you are unsure about whether you are registered, please refer to your registration confirmation email or see one of the team from Leishman Associates.

CONFERENCE WIFI

Delegates have access to complimentary WIFI for the duration of the conference. Please note that movies, music or illicit downloads are restricted.

Network Name: ARPS 2021

Password: sensaweb

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DRESS CODE

The dress code for the conference sessions and social functions is smart casual.

PHOTOGRAPHS, VIDEOS & RECORDING

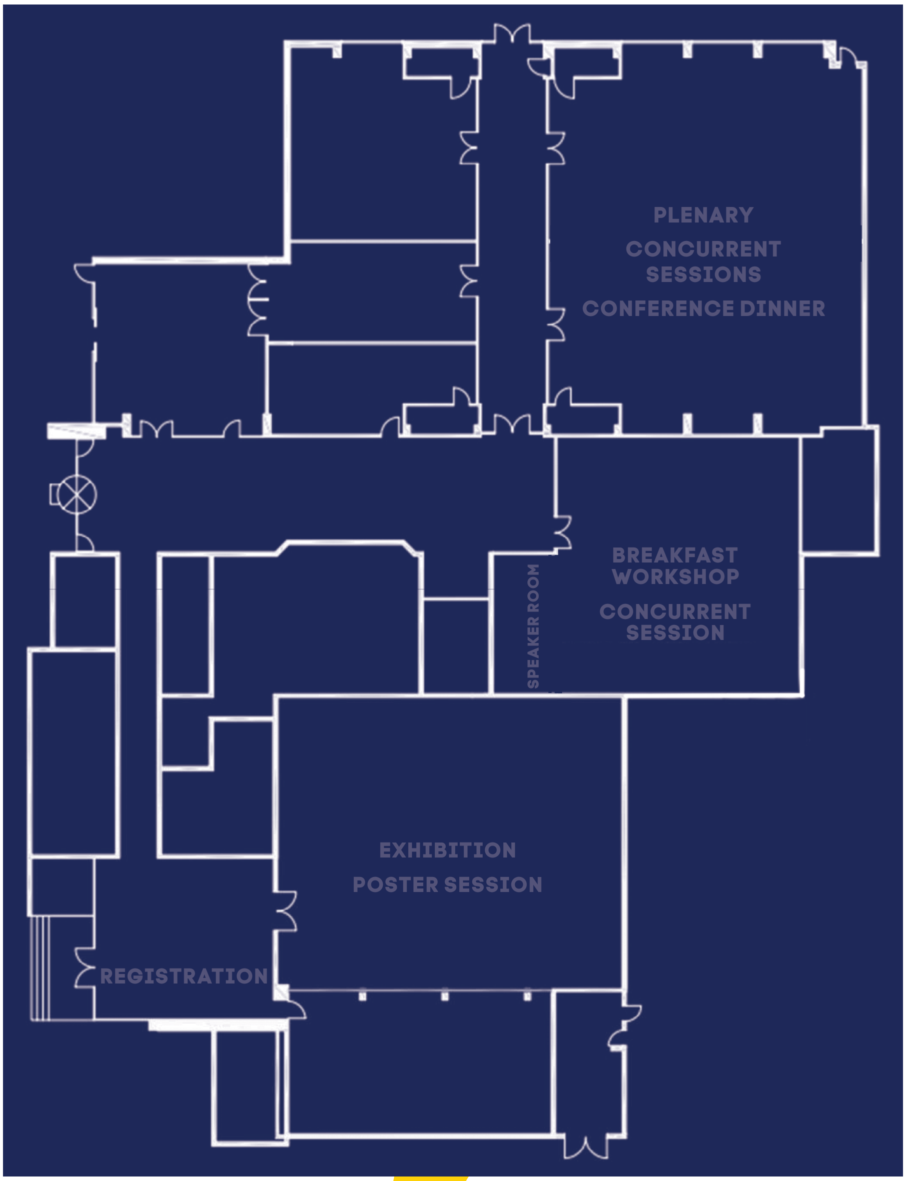
Delegates are not permitted to use any type of camera or recording device at any of the sessions unless written permission has been obtained from the relevant speaker.

MOBILE PHONES

As a courtesy to other delegates, please ensure that all mobile phones are turned off or in a silent mode during all sessions and social functions.

DISCLAIMER

The ARPS 2021 Conference reserves the right to amend or alter any advertised details relating to dates, program and speakers, if necessary, without notice, as a result of circumstances beyond their control. All attempts have been made to keep any changes to an absolute minimum.



PROGRAM

MONDAY 7 MARCH 2022

0800-1700	Registration Desk Opens		GRAND BALLROOM FOYER
0800-1545	Speaker Room Opens		BOARDROOM
0800-1540	Exhibition Opens Barista Cart Available. *Barista Cart Sponsored by* LANDAUER		
	PLENARY SESSION 1		ROOMS 1&2
0900-0915	**CONVENOR OPENING COMMENTS & WELCOME** **Ron Rubendra, Australasian Radiation Protection Society**		
0915-1015	**KEYNOTE ADDRESS** *"Safety is a Continually Emerging Property of a Dynamic System"-Implications for Nuclear Regulation and Practice?* **Dr Adi Paterson, Siyeva Consulting**		
1015-1050	Morning Refreshments & Trade Exhibition		GRAND BALLROOM

	CONCURRENT SESSION 1 ROOMS 1&2 *THEME: DEVELOPMENTS IN RADIATION PROTECTION, TECHNOLOGY AND METHODS* **Chair: Neha Kodwani**	**CONCURRENT SESSION 1.1** ROOM 6 *THEME: COMMUNICATION/ EDUCATION* **Chair: Bill Bartolo**
1055-1115	*Minimal Reportable Dose and what is an acceptable level of uncertainty in Personal Dosimetry* **Stephen Marks, ARPANSA**	*RP is 75% B...S...* **Hefin Griffiths, ANSTO**
1115-1135	*Old and New: Internal Dosimetry Calculations with the OpenDose Calculator* **Erin McKay, St. George Hospital**	*The ARPANSA "Talk to a Scientist" Program: Radiation risk perception trends identified via our public engagement* **Dr Christopher Brzozek, ARPANSA**
1135-1155	*Radon in Workplaces - A New IAEA Standard* **Jim Hondros, JRHC**	*Radiological Protection Assessment of Drinking Water based on News Media Reporting* **Cameron Jeffries, Department of Health and Wellbeing, SA**
1155-1215	*Australian National Radiation Dose Register: Current Status and Future Direction* **Ben Paritsky, ARPANSA**	*Optimisation of radiation protection in practice: an ANSTO perspective* **Andrew Popp, Radiation Protection Services, ANSTO**
1215-1235	*Investigating Immunological and Respiratory Effects in a Healthy, in Vivo, Radon Inhalation Exposure Model* **James McEvoy-May, University of Adelaide**	*JRPR: A Scientific Research Journal Supported by ARPS* **Dr Riaz Akber, Safe Radiation**
1235 –1345	Lunch & Trade Exhibition & Posters Viewing	GRAND BALLROOM

PROGRAM

	CONCURRENT SESSION 2 ROOMS 1&2 *THEME: COMMUNICATION/ EDUCATION* **Chair: Tony Mills-Thom**	CONCURRENT SESSION 2.1 ROOM 6 *THEME: MINING/ ENVIRONMENTAL* **Chair: Jim Hondros**
1350-1410	*Radiological and Nuclear Emergency Preparedness and Response Training* **John Bus, ANSTO**	*Thoron (Rn-220) and Radon (Rn-222) in Closed Space-Will Ventilation Help in Dose Reduction?* **Dr Riaz Akber, Safe Radiation**
1410-1430	*The Influence of Human Factors on Significant Radiological Events* **Hefin Griffiths, ANSTO**	*Challenges of Radionuclide Deportment in the Oil and Gas Industry* **Robert Blackley, ANSTO**
1430-1450	*There's Nothing NORMal about Training Course Development* **Samantha Sonter, ANSTO**	*The Design and Challenges of Developing a Community Based Environmental Radiation Study in Madagascar* **Frank Harris, Rio Tinto**
1450-1510	*Communicating Radiation & its Risks to the Public* **Tina Paneras, ANSTO**	

1510-1540	Afternoon Refreshments & Trade Exhibition	GRAND BALLROOM
	CONCURRENT SESSION 3 *THEME: SURVEY RESULTS AND ARPS GENERAL UPDATE MEETING* **Chair: Brent Rogers**	ROOMS 1&2
1540-1615	*Survey Result Discussion-2021 ARPS Members Survey - A Summary of Results* **Brent Rogers, ARPS & Jim Hondros, ARPS**	
1630-1745	**ARPS GENERAL UPDATE MEETING**	
1800-1930	**WELCOME RECEPTION**	HOWLING MOON & SWAN AND KING ROOM, CANBERRA REX HOTEL

PROGRAM

TUESDAY 8 MARCH 2022

0730-1700	Registration Desk Opens	GRAND BALLROOM FOYER
0845 - 1600	Speaker Room Opens	BOARDROOM
0915-1520	Exhibition Opens Barista Cart Available. *Barista Cart Sponsored by* LANDAUER	GRAND BALLROOM
0800-0930	**BREAKFAST WORKSHOP** *National Capacity Building in Radiation Protection* **Dr Marcus Grzechnik, ARPANSA** **Chennell Allan, ARPANSA** **Tony Hooker, CRRIEI**	ROOM 6
	PLENARY SESSION 2	ROOMS 1&2
0945-0950	**WELCOME TO DAY 2** **Ron Rubendra, Australasian Radiation Protection Society**	
0950-1050	**BOYCE WORTHLEY ORATION** *Optimisation-Risk Management in Theory and Practice* **Dr Carl-Magnus Larsson, ARPANSA**	edVirtus Professional Education; OPTICUM LASER SAFETY
1050-1120	Morning Refreshments & Trade Exhibition	GRAND BALLROOM

	CONCURRENT SESSION 4 ROOMS 1&2 *THEME: NON-IONISING RADIATION* **Chair: Asif Ahmed**	CONCURRENT SESSION 4.1 ROOM 6 *THEME: IONISING RADIATION* **Chair: Prashant Maharaj**
1125-1145	*5G WIRELESS: A Radiobiological Assessment* **Victor Leach, Oceania Radiofrequency Scientific Advisory Association**	*A Selection of Fluoroscopic Imaging Hazards* **Dr Kent Gregory, SA Radiation Pty Ltd**
1145-1205	*5G and Health - A Review of the Research into Low-level Millimetre Waves* **Asso Prof Ken Karipidis, ARPANSA**	*Handling High Activity Sources* **Robert Blackley, ANSTO**
1205-1225	*Reality Versus Perception in the Laser Lab* **Dr Trevor Wheatley, University of New South Wales**	*Radiation Protection at Low Doses - The Time for Change* **Cameron Jeffries, Department of Health and Wellbeing-SA**

1225-1325	Lunch, Trade Exhibition & Posters Viewing	GRAND BALLROOM

PROGRAM

	CONCURRENT SESSION 5 ROOMS 1&2 *THEME: IONISING RADIATION* Chair: Andrew Popp	CONCURRENT SESSION 5.1 ROOM 6 *THEME: DEVELOPMENTS IN RADIATION PROTECTION, TECHNOLOGY AND METHODS* Chair: Vic Leach
1330-1350	*Dose Conversion Factor Changes* **Dr Cameron Lawrence, ARPANSA**	*Use and Benefits of Gamma Imaging for Radiation Protection* **Nicholas Karantonis, ANSTO**
1350-1410	*UNSCEAR Work Programs and Reports* **Dr Cameron Lawrence, ARPANSA**	*Geant4 Simulations to Characterise Silicon Microdosimeters for the Radiation Protection of Astronauts in a Lunar Mission* **Matthew Large, University of Wollongong**
1410-1430	*SCM21: Practical Radiation Protection in A Large Industrial Shutdown Project* **Michael Stuckings, BHP**	*How Detector Geometry Effects Signal to Background Ratio in Aerial Gamma Radiation Surveys. A Study Using Geant4 and Analytical Tools* **Timothy Doughney, University of Adelaide**
1430-1450	*Radiation Protective Apparel: Is Testing Needed?* **Raihan Rasheed, Southeast Sydney Local Health District**	*Australia's Nuclear Forensic Science Capability* **Jack Goralewski, ANSTO**
1450-1520	Afternoon Refreshments & Trade Exhibition	GRAND BALLROOM
	CONCURRENT SESSION 6 ROOMS 1&2 *THEME: NON-IONISING RADIATION* Chair: Paula Veevers	CONCURRENT SESSION 6.1 ROOM 6 *THEME: PLANNED EXPOSURE SITUATIONS, EMERGENCY RESPONSES* Chair: Hefin Griffiths
1525-1545	*The New ARPANSA Radiofrequency Exposure Standard* **Assoc Prof Ken Karipidis, ARPANSA**	*Lucas Heights Radiological Hazard Assessment and Protection Strategy* **Andrew Popp, Radiation Protection Services, ANSTO**
1545-1605	*Genotoxic Potential of Radiofrequency Exposures* **Steven Weller, Oceania Radiofrequency Scientific Advisory Association**	*The Unintentional Radon Chamber: Ventilation of NORM Stores* **Alice Jagger, SA Radiation Pty Ltd**
1605-1625	*Non-Ionising Radiation Cosmetic Devices-Treatment Applications, Risks and Current Regulation in Australia* **Assoc Prof Ken Karipidis, ARPANSA**	*Mo-99 Contamination Incident Leading to Tissue Reactions to the Hands of a Radiopharmaceuticals Manufacturing Worker* **Andrew Popp, Radiation Protection Services, ANSTO**
1900-2230	**ARPS CONFERENCE DINNER** Australian Government | ANSTO Science. Ingenuity. Sustainability.	REX CANBERRA HOTEL, ROOMS 1&2

PROGRAM

WEDNESDAY 9 MARCH 2022

0830-1630	Registration Desk Opens	GRAND BALLROOM FOYER
0830-1600	Speaker Room Opens	BOARDROOM
0830-1505	Exhibition Opens Barista Cart Available. *Barista Cart Sponsored by* LANDAUER	GRAND BALLROOM
	PLENARY SESSION 3	ROOMS 1&2
0900-0905	**OPENING COMMENTS** **Ron Rubendra, Australasian Radiation Protection Society**	
0905-1005	**KEYNOTE ADDRESS** *Baking a cake, selling it twice, eating it once and keeping a little as inspiration for the next cake* **Professor Tim Senden, Australian National University**	
1005-1035	Morning Refreshments & Trade Exhibition	GRAND BALLROOM

	CONCURRENT SESSION 7 ROOM 1&2 *THEME: RESEARCH AND ENGINEERING* **Chair: Riaz Akber**	CONCURRENT SESSION 8 ROOM 6 *THEME: WASTE MANAGEMENT* **Chair: Tony Mills-Thom**
1035-1055	*Immunomodulating Acute Respiratory Inflammation using Low-Moderate Dose Ionising Radiation* **Dr James McEvoy-May, University of Adelaide**	*Challenges for Radiation Protection in the Design of the National Radioactive Waste Management Facility* **Ciara Collins, ANSTO**
1055-1115	*Computer Codes for Radiation Assessments* **Blake Orr, ARPANSA**	*Soil Sampling around Waste Storage Facility* **Asif Ahmed, Department of Defence**
1115-1135	*Introduction of ARPAB Expert Certification* **Brent Rogers, Southeast Sydney Local Health District**	*Australia's World-Class Solution to LLW Waste-Tellus' Sandy Ridge Near-Surface Geological Repository* **Annelize Van Rooyen, Tellus Holdings**

1135-1205 **POSTER SESSION** — GRAND BALLROOM

Chair: Bill Bartolo

1. *Flinders University Radon Facility-Purpose Built, Small Animal Radon Chamber for Environmentally Relevant Exposures*
   Dr James McEvoy-May, University of Adelaide
2. *Conceptualisation and Modelling of Human Exposure to Sources of Radiation in Arid and Semi-Arid Zones of Australia*
   Jarrah Mik, University of Adelaide
3. *Correction Factor for Calibration of SPA-3 Probe When Measuring I-131 Released from a Reactor Incident*
   Ajay Thomas, ANSTO
4. *Comparison Between High-Purity Germanium Detectors for Measurement of 210Pb in Sediments*
   Dr Christopher Kalnins, University of Adelaide

1205-1305 Lunch & Trade Exhibition — GRAND BALLROOM

PROGRAM

	PLENARY SESSION 4 SESSION AVAILABLE VIA ZOOM **Chair: Jim Hondros**	ROOMS 1&2
1310-1350	**KEYNOTE ADDRESS** *The Future of Radiation Protection – Where to from here?* **Dr Gillian Hirth, ARPANSA**	
1350-1435	**PANEL DISCUSSION 1: FUTURE DIRECTIONS IN MEDICAL RADIATION SAFETY** **Facilitator: Cameron Jeffries, Department of Health and Wellbeing** **Rapporteurs: Paula Veevers, Queensland Health + Alice Jagger, SA Radiation Pty Ltd** **Panellists + Q&A**	
1435-1505	Afternoon Refreshments & Trade Exhibition	GRAND BALLROOM
1510-1555	**PANEL DISCUSSION 2: FUTURE DIRECTIONS IN NON-MEDICAL RADIATION SAFETY** **Facilitator: Jim Hondros, JRHC Enterprises** **Rapporteurs: Paula Veevers, Queensland Health + Alice Jagger, SA Radiation Pty Ltd** **Panellists + Q&A**	
1555-1625	**AWARDS PRESENTATION** **CLOSING REMARKS AND CONFERENCE CLOSE** **Ron Rubendra, Australasian Radiation Protection Society**	

THURSDAY 10 MARCH 2022

0900-0930	Registration Desk Opens	GRAND BALLROOM FOYER
0900-1300	**TECHNICAL TOUR - HEAVY ION ACCELERATOR FACILITY** Meet at the hotel lobby at 8:45am	

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BREAKFAST WORKSHOP

NATIONAL CAPACITY BUILDING IN RADIATION PROTECTION

Date **Tuesday 8 March**

Time **0800-0930**

Venue **Room 6**

Cost **$100 per person inclusive of breakfast. Pre-registration required**

The aim of this workshop is to communicate plans and progress in understanding and building national capacity and capability in radiation protection, with an emphasis on emergency preparedness and response. The importance of this work has amplified with the nuclear submarine announcement of September 2021.

ARPANSA has been undertaking surveys of jurisdictional capacity and capability during 2021. The information obtained will be applied to the identification of gaps, justifying funding and a programme of nationally consistent training (undertaken by education partners).

This discussion workshop will be of interest to radiation protection professionals, leaders of first response agencies, and representatives of all Australian jurisdictions. As well as national plans, international linkages to the International Atomic Energy Agency's capacity building programmes will also be discussed.

AGENDA AND PRESENTERS

1. Building national capacity and capability- Marcus Grzechnik (ARPANSA)

An overview of the project, including reference to:

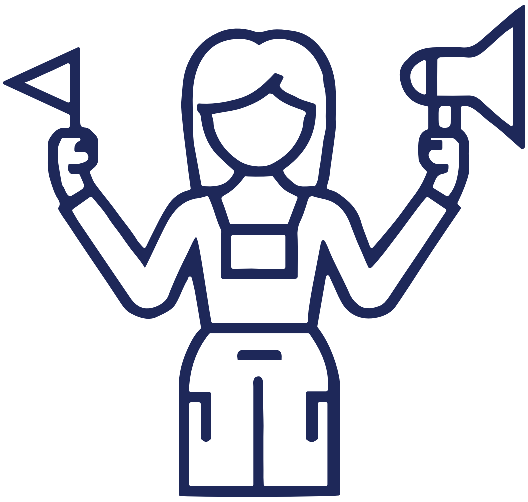
- Confirmation of roles and responsibilities
  - Revision of AGCMF
  - National coordination
  - Layers of response
  - Sustainable funding lines
- National capacity building in radiological and medical response
  - Partnerships (national and international)
  - Training
  - Exercising
- Future testing of national capacity and capability
  - Peer review

2. Understanding national capacity and capability Chennell Allan

- National Survey
  - Jurisdictions & Agencies consulted
  - Survey outcomes and analysis
  - National gaps

3. Training plans and programmes-Tony Hooker (CRREI)

- What is CRREI?
- Training for capacity building
- What will be required in the future?



TECHNICAL TOUR

Date Thursday 10 March

Time Starting at 0915 (approx. 45-60 minutes)

Cost $70 per person. Pre-registration required.

Dress Casual, long trousers and closed in shoes recommended

The Heavy Ion Accelerator Facility (HIAF) comprises the 14UD pelletron accelerator and a superconducting 'booster' linear accelerator (LINAC) housed and operated by the Department of Nuclear Physics in the Research School of Physics at the Australian National University.

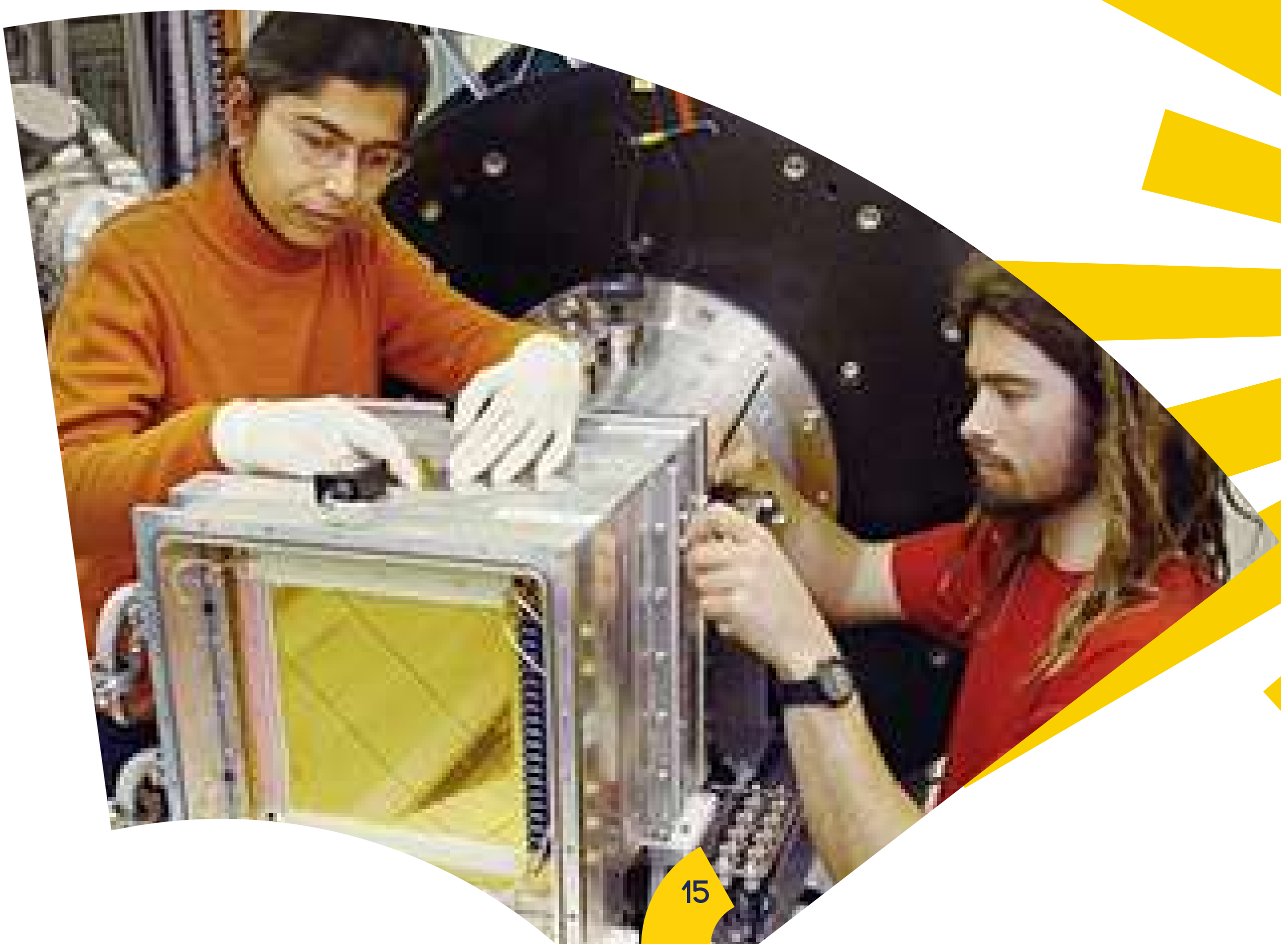
Meet at the hotel lobby at 8:45am. Delegates will be guided to walk from the hotel lobby through the car park to the back street to board the bus for the tour. The bus stop is behind the hotel on Henty Street.

Please ensure you have had breakfast before boarding the bus. Food is not allowed on the bus. Water and snacks will be provided to the delegates.

After the tour at HIAF, a coach will stop at the National Arboretum where you can go for a leisurely stroll before heading back to Canberra Rex Hotel. A coach transfer to and from Canberra Rex Hotel will be provided for those who have registered for the workshop.

ITINERARY

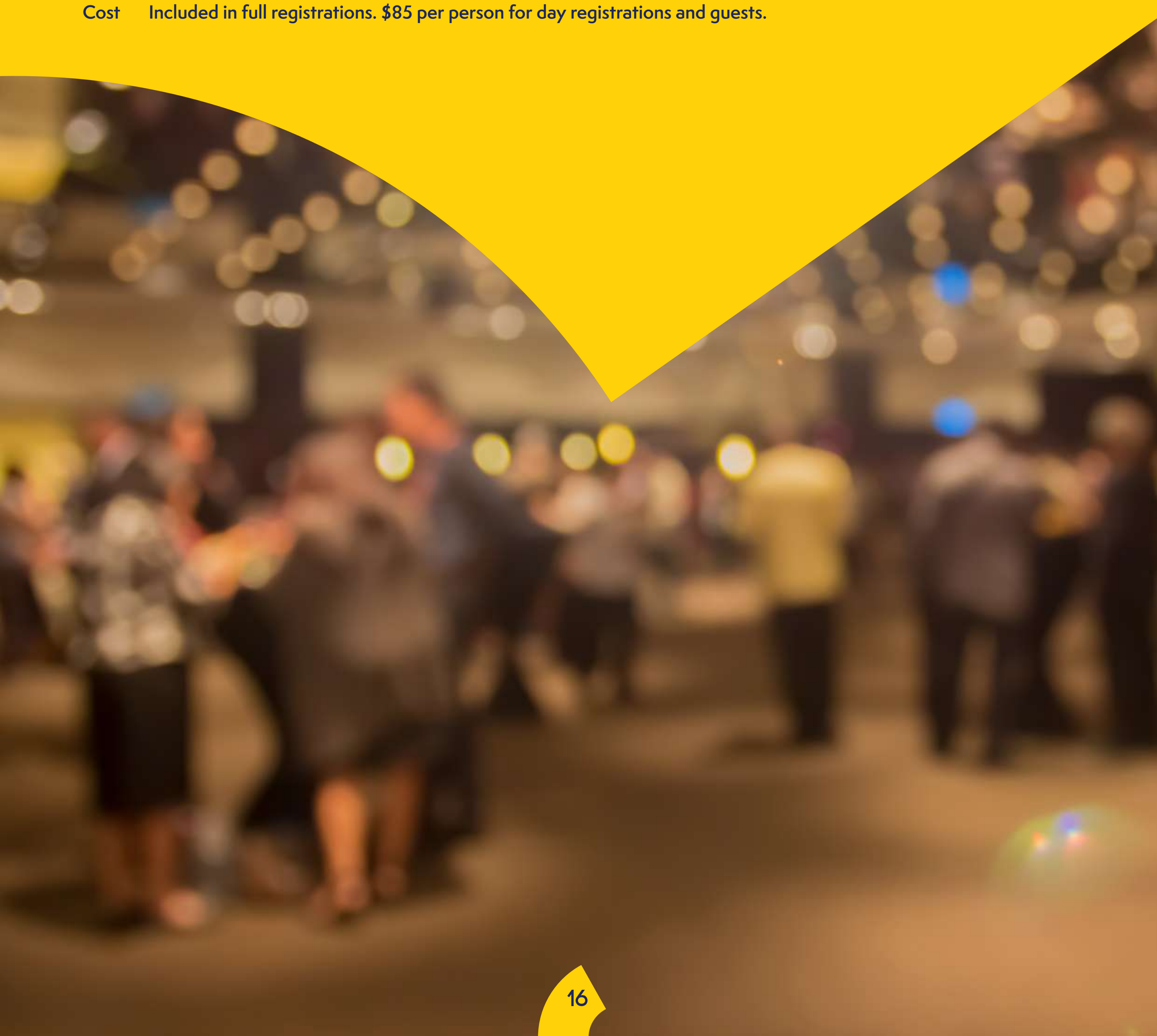
0900-0910	From Canberra Rex Hotel Lobby (gather at 0845) To Heavy Ion Accelerator Facility
1020-1040	From Heavy Ion Accelerator Facility To National Arboretum
1155-1230	From National Arboretum To Canberra Rex Hotel



SOCIAL PROGRAMS

WELCOME RECEPTION

Date	Monday 7 March
Time	1800-1930
Venue	Canberra Rex Hotel - Howling Moon & Swan and King Room
Cost	Included in full registrations. $85 per person for day registrations and guests.



CONFERENCE DINNER

Our social program highlight is once again the Conference Dinner. This is your opportunity to dress up, enjoy great food, network with peers, and celebrate yet another successful Conference with us!

If you will not be attending the dinner, please let the team from Leishman Associates know.

Date	**Tuesday 8 March**
Time	**1900-2230**
Venue	**Rooms 1&2**
Cost	**Included in full registrations. $160 per person for day registrations, exhibitors and guests**

Australian Government

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DR CARL-MAGNUS LARSSON

Chief Executive Officer, ARPANSA

Tuesday 8 March

0950-1050

Optimisation – Risk Management in Theory and Practice

Dr Larsson studied chemistry and biology and subsequently completed his PhD in Botany in 1980. He became Associate Professor in Physiological Botany at Stockholm University (Sweden) 1984.

Following a career in science he took up a position with the Swedish Radiation Protection Authority (SSI) in 1993 to work on environmental aspects of nuclear power. Apart from working for the National Chemicals Inspectorate for a year, Dr Larsson continued to work for SSI as Department Head, Deputy Director General and Director General until SSI and the Swedish Nuclear Power Inspectorate merged in 2008. In the new organisation, the Swedish Radiation Safety Authority, Dr Larsson held positions as Head of the Department of Radiation Protection and the Department of Radioactive Materials.

Dr Larsson coordinated the multinational European Commission-supported research projects FASSET and ERICA (both on environmental assessment and protection) between 2000 and 2007 and he has been a member of the Organisation for Economic Cooperation and Development-Nuclear Energy Agency's Radioactive Waste Management Committee (RWMC) and the chair of the RWMC-Regulators' Forum. He was the Australian Representative to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2010-2016 and was the Chair of the Committee 2012-2015. Dr Larsson was a member of the Commission on Safety Standards of the International Atomic Energy Agency (IAEA) from 2008 to 2019. He has been a member of the International Commission on Radiological Protection (ICRP) since 2005 and a member of ICRP's Main Commission from 2013 to 2021. In 2018, he was elected as the Vice-President of the Eighth Review Meeting of the Convention on Nuclear Safety.

BOYCE WORTHLEY ORATION

DR CARL-MAGNUS LARSSON

Optimisation-Risk Management in Theory and Practice

Boyce Wilson Worthley (1917-1987), medical physicist, was educated at Adelaide High School, Adelaide Teachers' College and the University of Adelaide. During his marvellous career he developed comprehensive medical physics roles in cancer treatment and the early application of reactor-produced radionuclides in diagnostic nuclear medicine. He published more than forty papers, and a book with J. Tooze and R. M. Fry, Dosage Estimation in Radiotherapy and the Wheatley Integrator (1955).

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KEYNOTE SPEAKERS

DR ADI PATERSON

Principal and Founder, Siyeva Consulting, Former CEO - Australian Nuclear Science and Technology Organisation

Monday 7 March

0915-1015

"Safety is a Continually Emerging Property of a Dynamic System" – Implications for Nuclear Regulation and Practice?

Dr Adi Paterson has a strong public science and senior management background, operational and strategic management expertise, nuclear programs and in the commercialisation of scientific research.

Dr Paterson was the General Manager for Business Development and Operations at the Pebble Bed Modular Reactor Company in South Africa.

From March 2009 to September 2020 Adi had strategic oversight and responsibility for ANSTO's multi-facetted portfolio of activities.

Dr Paterson has driven a program of positive change and growth. Putting people first, with a focus on diversity and inclusion, underpins the transformation process. This has leveraged outcomes based on the nexus of public science investment and practical innovation with positive impacts on health, industry and the environment.

Dr Paterson's focus on the importance of diversity and equity, particularly in STEM, led to his appointment in 2016 as a Male Champion of Change for STEM.

Dr Paterson has experience in key policy areas including science and innovation, energy and the nuclear fuel cycle. He is a Fellow of the Australian Academy of Technology and Engineering (ATSE), Engineers Australia (EA), and the Royal Society of New South Wales. The Sydney Division of Engineers Australia recognised him as the 2012 Professional Engineers of the Year.

Dr Paterson holds a BSc (Chemistry) and a PhD (Engineering), both from the University of Cape Town. He was awarded an Honorary Doctorate by the University of Wollongong in 2017.

KEYNOTE SPEAKERS

PROFESSOR TIM SENDEN

BSc (Hons) PhD (ANU), Director, Research School of Physics and Engineering Australian National University

Wednesday 9 March

0905-1005

Baking a cake, selling it twice, eating it once and keeping a little as inspiration for the next cake

Prof Senden, is a graduate of the ANU, completing his BSc (Hons) in Physical Chemistry in 1989 at the Research School of Chemistry, and subsequently his PhD in Atomic Force Microscopy in 1993 in the Research School of Physics and Engineering.

He held positions at the College de France (Paris), Institute Charles Sadron (Strasbourg), and UNSW (ADFA) before returning to ANU's Department of Applied Mathematics in Research School of Physics and Engineering in 1997. He served as Head of the Department and as Deputy Director (Technology Development). He is the current Director of the Research School of Physics and Engineering.

Tim uses his background in experimental surface science to teach undergraduate chemistry and to investigate surface phenomena at the nanometre scale covering topics including the stretching of single polymer chains, mechanical deformations in biological membranes, ceramics processing and measuring forces on nanoparticles.

Over the past decade he has branched into X-ray micro-Tomography studying porous and granular materials, oil recovery, wood composites, paper and one of his life passions, Palaeontology. He has also been involved in developing novel uses of radioactive nanoparticles to aid medical diagnosis. Over the past decade he has had the opportunity to commercially develop some of his research activities, including a spin-off Lithicon, a Global services company in digital rock analysis.

DR GILLIAN HIRTH

Deputy Chief Executive Officer ARPANSA

Wednesday 9 March

1350-1430

The Future of Radiation Protection – Where to from here?

Dr Gillian Hirth, Chief Radiation Health Scientist and Head, Radiation Health Services (RHS) Branch at ARPANSA was appointed as Deputy Chief Executive Officer of ARPANSA in March 2017.

Dr Hirth completed a PhD in environmental radiochemistry in 1999 and from 2000 to 2003 she was a Post-Doctoral Research Fellow at the Australian Nuclear Science and Technology Organisation. Her research focussed on the transport of uranium decay series in the environment and their transfer to biota.

Dr Hirth worked for the Australian Defence Organisation from 2003 to 2010 in the field of hazardous materials and environmental management, this work included the management of radiation sources and facilities, nuclear materials, occupational exposures and radioactive waste. She has been with ARPANSA since 2010. Initially working in codes and standards development, she then led a project examining radionuclide activity concentration ratios in wildlife inhabiting uranium mining environments and was Director of the Monitoring and Emergency Response Section in RHS Branch from March 2014 to August 2016. In August 2016 she was appointed Head of the RHS Branch.

Dr Hirth is the current Australian Representative to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) since the 64th session in 2017, and was appointed as Chair of UNSCEAR for the 66th and 67th sessions in 2019, a role extended for 68th session and one that she will hold until the commencement of the 69th session in 2022.

Dr Hirth was appointed as a member of the Commission on Safety Standards of the International Atomic Energy Agency (IAEA) for the 7th term, 2020 to 2023, and was the Australian representative on the IAEA's Emergency Preparedness and Response Safety Standards Committee for the term 2015-2017. Dr Hirth is member of the International Commission on Radiological Protection (ICRP) Main Commission for the term 2021-2025 having been a member of ICRP Committee 4 for the term 2017-2021. Dr Hirth is a member of the Board of Council of the International Union of Radioecology.

CONCURRENT SESSION 1: DEVELOPMENTS IN RADIATION PROTECTION, TECHNOLOGY AND METHODS

ROOMS 1&2

Minimal Reportable Dose and what is an acceptable level of uncertainty in Personal Dosimetry

Stephen Marks[1], Stephen Long[1]

1 Australian Radiation Protection and Nuclear Safety Agency

Nearly 55 years ago, Lloyd Currie published his seminal paper (Currie, L.A., Analytical Chemistry, volume 40, issue 3, pp 586-593, 1968), which now underpins international standards for reporting measurements. In that paper, he rigorously defined three characteristic limits for a measurement: the critical limit, the detection limit, and the quantification limit.

This last characteristic, the quantification limit, defined as the "*the smallest signal of interest which has an acceptable uncertainty*" generally dictates what is set as the minimum reportable value. In personal radiation monitoring the relative high background signal and what is an "acceptable" uncertainty are the two biggest factors when calculating the minimum reportable dose. As the background signal can not be changed the defining factor becomes what do we deem as acceptable.

Old and New: Internal Dosimetry Calculations with the OpenDose Calculator

Erin McKay[1]

1 St. George Hospital, Sydney

Introduction

The MIRD methodology for model-based internal dosimetry is both general and well established. However, there are a variety of implementations which differ in the range of phantom geometry and radiation spectra that they support, as well as in the methods they provide for the operator to specify input data.

The OpenDose Calculator (OCD) is an implementation of the MIRD methodology which allows operators to perform MIRD calculations for their own phantoms, using their own radionuclide spectra. Furthermore, it includes support for users who wish to create their own plug-in modules for specifying residence time.

This project uses OCD (beta version 0.48) to compare equivalent dose distributions and effective doses for several common radiopharmaceuticals using specific absorbed fractions (SAFs) and radiation spectra from the RADAR web-site and from ICRP publications 133 and 107.

Methods

Header files in JSON format were prepared for the RADAR and ICRP SAF and spectra data. These files reference the raw data files from each source and provided necessary contextual information such as source and target masses, containment relationships and name mapping for phantom regions and radiation types. When imported into OCD the referenced files were used to build a standardised internal representation of the phantom or spectrum that they described.

Biokinetic models representing the commonly used radiopharmaceuticals F-18 FDG, Tc-99m HDP and I-131 were defined using an OCD plug-in. These models were used to generate distributions of residence time in the source regions of the RADAR and ICRP phantoms. These were, in turn, converted into distributions of equivalent dose and an effective dose estimate, then compared.

Results

Closest results to the ICRP 128 reference data were obtained with the RADAR Adult phantom, perhaps unsurprisingly as this is the most similar in geometry to the Cristy & Eckerman Adult phantom used by the ICRP.

Radio-pharmaceutical	ICRP 128 (mSv/MBq)	OCD RADAR (mSv/MBq)		OCD ICRP 133 (mSv/MBq)	
	Adult	Adult	Female	AF	AM
Tc-99m HDP	4.90×10^{-3}	5.42×10^{-3}	7.23×10^{-3}	5.71×10^{-3}	3.65×10^{-3}
F-18 FDG	1.90×10^{-2}	1.86×10^{-2}	2.42×10^{-2}	2.11×10^{-2}	1.59×10^{-2}
I-131 Iodide	$2.20 \times 10^{+1}$	$2.17 \times 10^{+1}$	$2.63 \times 10^{+1}$	$2.24 \times 10^{+1}$	$1.87 \times 10^{+1}$

Table 1. Effective doses calculated for 5 different phantoms using tissue weighting factors from ICRP 60.

Conclusion

The OpenDose Calculator has been used to compare internal dosimetry for several common radiopharmaceuticals estimated using RADAR and ICRP phantoms and spectra. Effective dose estimates are similar but equivalent dose distributions are harder to compare due to differences in the target regions used by the two data sets.

Radon n Workplaces – A New IAEA Standard

Jim Hondros[1]

1 JRHC Enterprises

There has been an increasing concern by many international organisations, including as the WHO and ILO, of the impact of radon and its decay products in the workplace.

The IAEA through the Radiation Safety Standards Committee (RASSC) has taken the lead and is developing a new standard to address radon more broadly in the workplace. The standard aims to provide advice to regulators and industry in accordance the IAEA General Safety Requirements (GSR Part 3).

While the management of radon in 'planned exposure situations' should be relatively straightforward, there will be difficulty when addressing radon exposures in workplaces that are covered under 'existing exposure situations'. This is mainly because radon, in these workplaces, has not previously been considered a problem.

Work on the draft has been completed and the document is available to IAEA member states for comment.

This paper aims to provide an overview of the draft standard and to highlight some of its more contentious aspects.

Optimisation of radiation protection in practice: an ANSTO perspective

Andrew Popp[1], Jordan Saratsopoulos[1], Reddy Induri[1], Sarah Turek[1], Michael Polewski[1], Tina Paneras[2], Henry Lake[1], Bronte Sial[2], Rani Sharma[1], Prashant Maharaj[1], John Bus[1], Robin Foy[1], Hef Griffiths[3]

1. Radiation Protection Services, Australian Nuclear Science and Technology Organisation
2. Radiation Services, Australian Nuclear Science and Technology Organisation
3. Nuclear Office, Australian Nuclear Science and Technology Organisation

There is a potential for the principle of optimisation to be misunderstood, and taken as implying a need to minimise exposures regardless of cost. The level of protection should be the best under prevailing circumstances and should provide for adequate margin of benefit over harm. Think optimisation not minimisation.

Optimisation of protection is a process that is at the heart of a successful radiological protection program and is a frame of mind that encompasses the following:

- Forward-looking, but informed by learnings from past experience,
- Aimed at preventing unnecessary exposures before they occur,
- Ongoing and iterative, and
- Considers both technical and socio-economic developments.

Effective Implementation of Optimisation measures occurs when all stakeholders are involved, who know and agree with the principles of radiological protection, and adhere to an active safety culture.

The basic role of the concept of optimisation of protection is to foster a 'safety culture' and thereby to create a state of thinking in everyone responsible for control of radiation exposures, such that they are continuously asking themselves the question, 'Have I done all that I reasonably can to avoid or reduce these doses whilst still allowing the net benefit to be realised?'

ALARA (as low as reasonably achievable) is often used to express the principles underlying optimisation of radiation protection.

The responsibility of implementing optimisation lies with all parties involved including management, workers and radiation protection. It should be a collective effort to strive for doses that are ALARA.

Optimisation is applied in various types of exposure situations and these can be in Planned, Emergency or Existing situations. New designs and existing facilities can also benefit from applying the optimisation process to demonstrate that ALARA has been applied and implemented in the process.

ANSTO has three campuses across two states of Australia and is the centre of Australia's capabilities and expertise in nuclear science and technology. The variety of radiation sources at ANSTO encompasses the breadth of the health physics field. Our sources of ionizing radiation include but are not limited to: the OPAL multi-purpose research reactor; the Australian Centre for Neutron Scattering; the Australian Synchrotron; Particle Accelerators; Unsealed radioisotopes used in medical radioisotope production settings; as well as biomedical and chemical research applications; and naturally occurring radioactive materials.

This paper discusses optimisation of radiation protection in practice, and gives a couple of real world examples at ANSTO from the last few years.

Investigating immunological and respiratory effects in a healthy, *in vivo*, radon inhalation exposure model.

McEvoy-May JH[1,2], De Bellis D[1,2], Puukila S[1,3], Hooker AM[1,2], Boreham DR[3], Dixon DL[1,3]

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2. Centre for Radiation Research Education and Innovation, University of Adelaide, Adelaide, SA, Australia
3. Northern Ontario School of Medicine, Sudbury, ON, Canada

Introduction: Radon gas is believed to be the second leading cause of lung cancer after smoking. Although this statement has been accepted worldwide, there has recently been some debate over its validity. In Australia, to prevent radon induced lung cancer, regulatory authorities recommend that radon exposure does not exceed 200 Bq/m^3 at home and 1000 Bq/m^3 in the workplace. Although there have been numerous studies investigating exposure to high doses of radon, there are limited studies investigating the effects of low dose exposure and its effects on pulmonary inflammatory responses. Thus, the aim of this study was to investigate the effects of low single and chronic exposures to inhaled radon (200 Bq/m^3 and 1000 Bq/m^3) on the respiratory system.

Methods: For this experiment, our purpose built, small animal Flinders University Radon Facility was used. Male Sprague-Dawley rats were housed with or without radon for 1x 18-hour, 1x 90-hour or 2x 90-hour exposure. After exposure, rats were anaesthetised, euthanised and outcomes measured including respiratory function (lung mechanics), physiology (pulmonary oedema and epithelial layer damage), and immunology (cellular infiltrate into the lung and cytokine profile).

Results: Following both 1x 18-hour and 1x 90-hour exposures to 200 Bq/m^3 or 1000 Bq/m^3 radon gas, there was no evidence of change to any outcome measured. However, following 2x 90-hour exposures at 1000 Bq/m^3 radon gas, there was a significant increase in the number of white blood cells which had entered the lung.

Conclusion: Our results show that short-term exposure to either 200 Bq/m^3 or 1000 Bq/m^3 radon gas does not induce immediate pulmonary responses or alter respiratory function. However, significantly increased cellular infiltrates after 2x 90-hour exposures of 1000 Bq/m^3 radon suggests that long term exposure to high levels may trigger pulmonary inflammatory responses that potentially may lead to injury that requires further investigation.

CONCURRENT SESSION 1.1: COMMUNICATION/ EDUCATION

ROOM 6

Radiation Protection is 75% B…S… !

Hefin Griffiths[1], FARPS

1 Chief Nuclear Officer, ANSTO

A former colleague who worked for me in the UK told me that the best advice I had given him was that "RP is 75% B…S…". I struggled to remember the context in which I had made such an outrageous comment, but then concluded that it relates to the importance of soft skills in achieving a good outcome.

RP is a complex, technical subject, but unless we can understand the challenges of our clients and stakeholders, their motivations and fears we cannot provide advice in a way that will make sense to them. EQ is as important as IQ when achieving good RP outcomes.

So how do we as RP professionals communicate accurately, but in a way in which our stakeholders can understand? I will discuss the Linear No Threshold theory, which has been – unfairly in my opinion - blamed for holding back the application of nuclear science and technology and denying it's benefits to society, when the real fault lies with us as RP professionals in failing to explain radiation risks.

The ARPANSA "Talk to a Scientist" Program: Radiation risk perception trends identified via our public engagement

Christopher Brzozek[1], Blake Orr[1], Brendan Tate[1], David Urban[1], Ken Karipidis[1]

1 Australian Radiation Protection and Nuclear Safety Agency, Melbourne, Australia

The Talk to a Scientist (TTAS) Program is a key forum in which ARPANSA engages with the public, helping to deliver its mission for a safe radiation environment within Australia. This program provides the public with the unique opportunity to communicate directly with our scientists on issues about radiation exposure, health, and protection in Australia. Addressing community concerns, tackling misinformation, and informing risk perception are core to promoting the health and safety of the public, workers, and the environment. The TTAS program responded to 1129 enquiries in 2020 from which data is gathered including types of enquiries (call, email, social media) and topics and sub-topics addressed (e.g. Radiofrequency – Communication infrastructure. This data provides ARPANSA with valuable insight on community concerns and risk perception trends from the public. One of the main risk perception trends identified from the 2020 data was heightened community concern around the deployment of 5G telecommunications infrastructure. In 2018, there were only 17 enquiries regarding 5G (1.9% of all enquires for that year). However, this increased significantly in 2019 and 2020 as the 5G rollout gained more media attention with 327 (25.1%) and 441 (39.1%) 5G enquiries made respectively across those years. Interestingly, this heightened concern now appears to have subsided as the 5G rollout becomes more commonplace with only 17 (3.8%) 5G based enquiries received to June 2021.

The majority of the enquiries made to the TTAS program are on non-ionising radiation matters, with ionising radiation accounting for only 12.4% of the total enquiries since 2017. With the exception of 5G, ELF - Electrical Supply Infrastructure and RF – Communications Infrastructure have consistently been the top two topics. An effective risk communication method developed in response to ELF – Electrical Supply Infrastructure enquiries has been to offer a meter hire service which allows the public to hire an easy to use ELF meter. The meter is then sent to the person who can take measurements, record the data, and speak directly with a scientist to discuss and provide context to the measurements recorded. ARPANSA does not hire RF meters, however, the RFNSA website and EME reports provide similar reassurance when dealing with RF – Communications Infrastructure queries. ARPANSA aims to continue to identify radiation risk perception trends and further develop effective risk communication methods. The data collected within the TTAS program is an invaluable tool for achieving this outcome.

Radiological Protection Assessment of Drinking Water based on News Media Reporting

Cameron Jeffries[1]

1 South Australia Medical Imaging, Department of Health and Wellbeing

In early 2021, media reports of "dangerous" uranium in the drinking water of Dajarra in western Queensland appeared in the author's social media algorithm. The reporting coincided with the recent draft update to the Australian Drinking Water Guideline (ADWG). The initial media report was devoid of monitoring results making it impossible to assess if the uranium concentration in water was "dangerous" or if it was indeed dangerous because of radiation. Further investigation found the reporting was based on reported uranium concentrations ranging from 0.023 mg/L to 0.046 mg/L, which implies analysis using ICP-MS to assess chemical toxicity rather than radiological assessment. The quality of drinking water was found to have been an issue as far back as 2007, when the town supply "exceeded the ADWG for Chloride, Total Hardness, Sodium, and Total Dissolved Solids (as tested by Queensland Health)."

This presentation will assess the radiological conclusions that might be drawn from the reported uranium concentrations with reference to the ADWG. Typical annual drinking water consumption (730 L) is estimated to give an annual dose due to uranium of approximately 6 μSv. The maximum case for radiation dose occurs where secular equilibrium has been established in the uranium series has been established. Annual radiation dose due to ^{226}Ra, ^{210}Pb and ^{210}Po is estimated to be 12 μSv, 29 μSv and 50 μSv respectively, in the case that secular equilibrium has been established for the uranium series in the groundwater. The ADWG advice on chemical toxicity of uranium will be reviewed against the media position that it represents the boundary between safe and dangerous.

Australian National Radiation Dose Register: Current Status and Future Direction

Ben Paritsky[1], Cameron Lawrence[1], Rick Tinker[1]

1 Australian Radiation Protection and Nuclear Safety Agency

Since its inception in 2010, the ANRDR has moved beyond the uranium industry to allow employers from all industries with occupationally exposed workers to participate. To achieve its goals and maximise its potential, a national dose register must attain coverage of all radiation workers in the country in which it operates. However, due to the onus on employers to voluntarily sign up and commit to making regular submissions, with the exception of the uranium mining and milling industry and ARPANSA's licence holders for whom participation is mandatory, the ANRDR has seen a slow uptake. To address this issue, ARPANSA established an independent Advisory Board comprised of regulatory representatives from most jurisdictions with the aim of developing strategies and providing advice to ARPANSA on the advancement of the dose register. On the advice of the Advisory Board, ARPANSA has changed direction to pursue a model for collection of dose records directly from dosimetry service providers (DSPs). This model is in line with the approaches used in other countries with well-established national dose registers, such as Canada and the United Kingdom. The creation of a proposed accreditation program that would require DSPs to meet specific conditions to be permitted to operate in Australia will support this objective with the inclusion of a requirement for the submission of dose records to the ANRDR. Operating a centralised register for long-term maintenance of occupational dose records is considered best practice as set out by the International Atomic Energy Agency (IAEA) in their *General Safety Guidance no. GSG-7 for Occupational Radiation Protection* (2018). In Australia this is captured in the *Code for Radiation Protection in Planned Exposure Situations* (RPS C-1) (ARPANSA 2020). ARPANSA is now working towards closing this gap and enhancing radiation protection for all radiation workers. This paper will provide an overview of ARPANSA's activities in relation to and strategic direction of the ANRDR.

Journal of Radiation Protection and Research: A Scientific Research Journal Supported by ARPS

Riaz Akber[1]

1 Editor in Chief, Journal of Radiation Protection and Research

Journal of Radiation Protection and Research (JRPR) disseminates scientific and technical information on radiation protection and related issues covering both ionising and non-ionising radiation. The topics include both technologically developed and naturally occurring radioisotopes and radiation sources. The journal accepts submissions to comprehensively encompass the broad spectrum of fields related to radiation protection, such as production and use of radiation emitting sources and radioisotopes, nuclear power production, diagnosis and therapy, nuclear accelerators, space travel and extra-terrestrial radiation, waste management, mining and processing of ores, emergency response, remediation, regulation, and protection of non-human biota. Contributing expertise may also come from a diverse range of disciplines including radiation biology, radiation physics and radiation detection, nuclear engineering, occupational and public health, training and education, social risk communication, and environmental science.

JRPR originated in 1976 by the Korean Association of Radiation Protection, initially under the title of Radiation Protection – The Journal of the Korean Association of Radiation Protection (1976-1995), the title Journal of Radiation Protection and Research was adapted in 2015. During AOCRP5 (Melbourne, May 2018) Australasian Radiation Protection Society (ARPS), Japan Health Physics Society (JHS) and Korean Association of Radiation Protection (KARP) to make collaborative efforts to manage JRPR as a scientific research journal of radiation protection, to be run by the editorial board set up by the three societies. The first publication of JRPR under this arrangement appeared in September 2019.

JRPR is published on quarterly basis. The contributions are refereed, and published volumes are available for viewing as open access. The journal is indexed by Scopus, Google Scholar, and Korean Citation Index; the application for Science Citation Index (SCI) is under review. JRPR table of contents also appear in the ARPS and SPERA Newsletters. ARPS, JHS, KARP, and a grant from the Korean Federation of Science and Technology Societies financially support the JRPR publication. Consequently, there is no manuscript processing charge to the contributing authors and their organisations. Radiation protection professionals from the Australasian region are expected to benefit from publication in the JRPR.

CONCURRENT SESSION 2: COMMUNICATION/ EDUCATION

ROOMS 1&2

Radiological and Nuclear Emergency Preparedness and Response Training

John Bus[1], Prashant Maharaj[1], Andrew Popp[1]

1 Radiation Protection Services, Australian Nuclear Science and Technology Organisation

This paper describes ANSTO's recently developed 5-day training course in Radiological and Nuclear Emergency Preparedness and Response. The target audience for the training is personnel that have either direct or indirect response and/or decision-making responsibilities in radiological and/or nuclear emergency situations. This could be first responders to a radiological/nuclear emergency as part of a State or Commonwealth combat agency (for example Fire and Rescue, Police or Ambulance), organisations that provide support through field deployment and external base support (for example Nuclear forensics, Environment Protection Agencies, State and Commonwealth regulatory bodies), and State and Commonwealth government agencies (for example Defence and counter terrorism agencies).

The purpose of this training is to provide guidance on the effective use of radiation detection equipment, the appropriate decision-making criteria and response structure for an effective emergency response to incidents involving nuclear or radiological materials.

The training course is a mixture of classroom presentations, activities, tabletop and field exercises. The presentations and classroom activities provide both an overview of important EPR concepts and specific information on the appropriate use of equipment to enable an effective response.

A recognised strength of the training is the strong practical focus giving many opportunities for the participants to apply what they have learnt during 'live-agent' field exercises. Field exercises are designed to test these competencies using small, low radioactivity sealed sources and short-lived radioactive contamination, for the scenarios of: (a) radioactive source search and recovery; (b) airborne radioiodine release from a reactor incident; and (c) radiological dispersal device or "dirty bomb" incident. These exercises allow first responders and radiological field assistance teams to practice radiation measurement, assessment and decision-making skills and have clearly defined learning outcomes that describe what the participants should know or be able to do to successfully complete the exercise, thus demonstrating the associated competencies.

The Influence of Human Factors on Significant Radiological Events

Hefin Griffiths[1], Aaron Flett[1],

1 ANSTO

Whilst controls on radiological exposures, rightly focus on eliminating or controlling exposures through engineered means, the human factor cannot be ignored.

When analysing some significant events, both nuclear and non-nuclear, the actions of individuals or groups of individuals can, with hindsight, appear counter-intuitive. However, if correctly analysed from a human factors perspective, the actions of individuals can be understood and seen as logical. In these circumstances blaming the individuals is not only wrong, but short-sighted and leaves the organisation vulnerable for repetition.

The impact of human factors played a significant part in tragic events such as Chernobyl and the Teneriffe Air disaster.

Using an event that occurred at ANSTO, where 3 operators received a significant extremity exposure, with 2 operators receiving an extremity dose above the relevant statutory dose limit, as a case study, the human and organisational factors that may have contributed will be examined.

The focus will be on the way human perception, training, experience determine the way we perceive situations at a given time and the impact of known heuristics such as similarity matching and frequency gambling determine the way information is evaluated. The impact of dependency is also a key factor that will be discussed.

Only by understanding the way that humans perceive and evaluate situations and the performance shaping factors that influence decision making can exposure scenarios be effectively evaluated beforehand to try and minimise the potential for unwanted exposures.

No worker intends to make an error, but organisations sometimes increase the likelihood of errors occurring even with experienced, well-trained and committed operators. The actions ANSTO has taken in learning from this event will also be discussed.

There's Nothing NORMal about training course development

Tina Paneras[1], **Samantha Sonter[1]**, Robert Blackley[1]

1 ANSTO

The radiation safety training landscape in Australia is complicated. There are some sectors of our industry that are well catered for with regard to formal and practical training programs. Other parts of our industry have less straight forward or less complete programs available. There has long been a need to develop advanced level radiation safety training material specific to the mining industry. For personnel engaged as Radiation Safety Officers (RSO) in the mining of radioactive material, training is often a mixture of multiple training courses patched together, internal training program development, importing of knowledge and/or mentoring programs.

Over a number of years ANSTO has developed a comprehensive radiation safety training course specifically addressing the management of NORM, aimed at those with RSO level responsibilities. This course is designed to provide the knowledge and practical skills required within the mining industry, to compliment other training such as mentoring programs.

This paper discusses some of the difficulties in the development of such a training course and the methodologies utilised to address these. This includes understanding industry needs, preparing content against different regulatory requirements, balancing expectations from industry, regulators and what we think people need to know, and utilising the most appropriate teaching techniques to the course's delivery. Some are unique to this specific course whilst others are applicable to all in our industry who are developing radiation safety training material.

Communicating radiation & its risks to the public

Tina Paneras[1], Samantha Sonter[1]

1 ANSTO

Effectively communicating scientific concepts to the public is a challenge. Many obstacles stand in the way such as a wide range of basic scientific understanding, radiation misconceptions and fear. So how can we, as a community, communicate about radiation in a way that addresses these barriers and leads to a greater understanding? In this presentation I will submit my personal experiences of radiation communication as a member of the public and as a radiation safety educator. I will also discuss methods of communication that I have found can lead to an audience receptive to having their misconceptions challenged and their understanding broadened. Scientific communication is something we all need to do better, especially if we want to gain public support for the future applications of radiation and nuclear power in Australia.

CONCURRENT SESSION 2.1: MINING/ ENVIRONMENTAL

ROOM 6

Thoron (^{220}Rn) and Radon (^{222}Rn) in Closed Space – Will Ventilation Help in Dose Reduction?

Ismael Khan[1], **Riaz Akber[1]**

1 Safe Radiation, Unit 19, 8 St Jude Court, Browns Plains, QLD

After radon (^{222}Rn, $T_{1/2}$ 3.824 d, uranium series), thoron (^{220}Rn, $T_{1/2}$ 55.6s, thorium series) is the longest living naturally occurring radioisotope of inert gas element Rn. Both ^{222}Rn and ^{220}Rn are important from radiation protection perspective, although ^{220}Rn transport and behaviour in the environment is much less investigated. This presentation is based on the results of experiments that we conducted to investigate the effect of air movement on the response of radon and thoron in enclosed space. The experiments were conducted in a small size chamber, and in a closed room. Both systems had a fan that could be controlled from outside to circulate the air.

In the fully enclosed chamber, ^{222}Rn concentration continued to build up, and turning the fan on did not affect this trend. In the closed room, fan forced air movement decreased ^{222}Rn concentration, most likely due to some interaction with the outside air through the unsealed door panel and some other perforations.

In both cases, thoron behaviour has been much different from radon. Turning the fan on caused a substantial to dramatic increase ^{220}Rn concentration. Air movement perhaps assists in mixing the shorter-lived thoron already diffused out near the emanating surface, or it causes additional exhalation of the gas from the pores. These effects are not mutually exclusive.

These results are relevant in situations where radon and thoron mitigation is desired for radiation dose reduction. Australian guidelines propose increased ventilation for reducing radon concentration in buildings.[1] These results show that ventilation-based reduction in radon concentration would be achieved perhaps with a simultaneous increase in thoron concentration. Thoron progeny is about 10 times more toxic than radon progeny[2]. Hence thoron rise in the air has the potential to counter the effect of ventilation for radon dose reduction in the buildings and other enclosed spaces such as underground mines, caves, and tunnels.

References

1 ARPANSA, '... For those homes and workplaces that exceed this reference level, there are some simple measures that can be taken to bring radon levels down, such as increasing ventilation.' https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiation-sources/radon

2 Monitoring, Assessing, and Recording Occupational radiation Doses in Mining and Mineral Processing; ARPANSA (2011) Radiation Protection Series 9.1 Annex A, page 32 . ^{222}Rn 3.1 nSv/Bq.m^{-3}.h, ^{220}Rn 36 nS/Bq.m^{-3}.h

Challenges of Radionuclide Deportment in the Oil and Gas Industry

Robert Blackley[1]

1 ANSTO

Within the Oil and Gas industry, Naturally Occurring Radioactive Material (NORM) can be a radiation hazard during operations but can be more significant particularly during maintenance work and the management of wastes. Understanding the deportment of radionuclides within infrastructure during normal operations, during maintenance periods and during decommissioning can have an impact on radiation safety measures implemented.

This paper discusses the most commonly observed deportment of radionuclides in both offshore and terrestrial oil and gas facilities, monitoring techniques used and some of the common traps that can be encountered. Less common scenarios that impact radiation readings are also discussed. The paper also covers the problems with waste management and the characterisation of decommissioned components.

The design and challenges of developing a community based environmental radiation study in Madagascar

Frank Harris[1], Steve Green[2],

1 Rio Tinto

2 JBS&G

QMM is a major mineral sand operation situated in southern Madagascar. As part of its ongoing review of its monitoring system and to address community concerns, a major study was launched to investigate the radiological impacts on local communities. The study was driven by the location, lifestyle and diet of the local communities and was designed to cover the season aspects of the area. Local challenges and the impact of COVID19 had to be addressed whilst maintaining a high level of quality assurance in remote locations. The design also had to take into account the impacts of a variable natural background characterised by a geology with high spatial variance. The study remains ongoing but initial results highlight the importance of stringent scientific process to ensure high quality data.

Laser Safety Operator, Supervisor & Officer Courses

Face to Face & Virtual Delivery Across Australia in 2022

edVirtus and **Opticum combine to present a series of Laser Safety Courses for those operating, supervising or managing lasers in the workplace or laboratory. Delivered in face-to-face and hybrid mode, these professional education courses are specifically targeted towards those needing appropriate levels of understanding of the principles of laser safety practice to meet Australian and International standards for laser safety operators, supervisors, and officers.**

Your Presenter

Dr Trevor Wheatley, Director, Opticum Pty Ltd has extensive experience teaching and consulting in laser safety for defence, industry, and academia both in Australia and Internationally. Dr Wheatley holds a BE (hons) in electrical engineering and a PhD on quantum optics from the University of New South Wales. He is a Senior Member of the Institute for Electrical and Electronic Engineers (SMIEEE), a life member of the Laser Institute of America (LIA) and an LIA Board of Laser Safety Certified Laser Safety Officer (CLSO). In 2020, he was appointed by the Minister to the ARPANSA Radiation Health and Safety Advisory Council. From 2007 he has been the Head of the Australian delegation on International Electrotechnical Commission Technical Committee 76, where he is currently co-convener WG 7 (high power lasers) and secretary of WG 8 (development and maintenance of basic standards). He is the Chair of the Standards Australia SF-019 Committee and serves on the ANSI Accredited Standards Committee z136.

Which course is for you?

The Half-Day Laser Safety Operator Course provides a non-mathematical introduction to lasers and laser hazards for those using lasers in the workplace to meet the laser safety component for a laser operator or Defence level 3 laser operator or maintainer training. The course provides an introduction to laser safety practice, hazard control and regulation of the use of lasers. This course is aimed at personnel who work with or around hazardous lasers or are required to work in a laser hazard area.

The One-Day Laser Safety Supervisor Course provides a basic level of understanding of the principles of laser safety practice that meets the needs of Australian/International standards for a Laser Safety Supervisor (LSS) or Defence Level 2 Laser Safety Officer (LSO2). This course introduces the generation and the characteristics of electromagnetic radiation focusing on optical frequencies, emphasising the differences between conventional light sources and laser sources in relation to their hazard potential. The course looks at workplace safety legislation, and particularly how it relates to laser use in the various regulatory jurisdictions, identifying how laser safety standards apply. Additionally, the course focuses on the application of specific laser safety standards in the workplace and the requirements for appropriate policies and procedures. The course emphasises real world examples, introduces laser safety terminology, the roles of the laser safety personnel, an introduction to the new Australian Standards AS/NZS IEC 60825.1:2014; AS/NZS IEC 60825.14:2011; and laser safety practice in the workplace.

The Five-Day Laser Safety Officer Course builds on the One-Day *Laser Safety Supervisor* Course into a comprehensive delivery that provides an intermediate quantitative level of understanding of the principles of laser safety practice to meet the needs of Australian/International standards for a laser safety officer or a Defence Level 1 Laser Safety Officer (LSO1). From day two to five, knowledge is developed with more detailed coverage of the key properties, including mathematical descriptions of lasers and laser beams. Through a series of presentations and worked examples followed by tutorial problems, the five-day course offers a very comprehensive quantitative coverage of laser safety practice and the use of laser safety standards.

For further detail and to register, visit our web site at:
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CONCURRENT SESSION 3: SURVEY RESULTS

ROOM 1&2

2021 ARPS Members Survey – A Summary of Results

Jim Hondros[1]

1 On behalf of the ARPS Executive

After a number of years of high activity for ARPS, the ARPS Executive commenced a review of its strategic plan during 2021.

The review consisted of an assessment of the existing strategic plan and also a member survey.

The survey was based on a set of 22 questions and the response was excellent. As well as answers to the questions, the survey produced over 550 comments. It is true to say that the comments were 'varied' and largely insightful and useful.

This presentation provides a summary of the ARPS members survey and a proposed worksplan for the forthcoming years.

Key Words: ARPS, Strategy

CONCURRENT SESSION 4: NON-IONISING RADIATION

ROOMS 1&2

5G WIRELESS: A Radiobiological Assessment

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Professor Yuri G. Grigoriev (PhD, DMedSci), an independent Oceania Radiofrequency Scientific Advisory Association (ORSAA) advisor, has been a vocal critic of the ICNIRP approach in the setting of exposure limits for RF-EMF guidelines. ORSAA has also been highly critical of the ICNIRP philosophical approach to setting these limits and believes ICNIRP's approach represents a move away from the ICRP ethical approach. Professor Yuri Grigoriev was a giant in the science of Radiobiology in Russia and recently published a book (titled: 5G CELLULAR STANDARDS. Total Radiobiological Assessment of the Danger of Planetary Electromagnetic Radiation Exposure to the Population). Grigoriev's breadth and depth of understanding of the interactions between biology and physics should not be ignored by governments, telecommunications engineers, or social scientists charged with responsible decision-making in this matter.

Soviet radiobiological scientists and clinicians were amongst the first to realise the therapeutic and detrimental effects of millimetre Waves (mmWaves), which is documented in a significant body of scientific literature spanning many decades. The findings were very clear in the 1970s that pulsed modulated low frequency signals on mmWaves, although having shallow penetration in the skin, can lead to a variety of bioeffects that over the longer-term will result in health effects particularly amongst the most vulnerable, including children, the infirm and the aged.

It is necessary to assess the degree of radiosensitivity of various organs and their interaction with the biological systems of the body. These vital organs develop over the course of our lives and should be considered when setting safety standards. This is necessary to assess potential adverse reactions in important organs such as the brain, the visual and auditory systems, the vestibular system, the thyroid gland, the sclera of the eyes, the endocrine system, the reproductive system and the immune system. The study of the effects of long-term or chronic radiation exposure, such as benign and malignant tumors, is particularly important for assessing the risk of all forms of EMF. We urgently need specialized research to assess the degree of danger of cellular communication for children and those individuals who have other health issues. It is important to establish a scientific basis for developing ethical radiation protection standards that are optimised with appropriate "safety factors" to address unknown and emerging factors related to health impacts, as well as possible future technological developments.

5G and Health - A Review of the Research into Low-level Millimetre Waves

Ken Karipidis[1,3], Rohan Mate[2], David Urban[1], Rick Tinker[1], Andrew Wood[3]

1 Australian Radiation Protection and Nuclear Safety Agency

2 Monash University

2 Swinburne University of Technology

The introduction of the fifth generation (5G) wireless communications network has caused some public concern about any possible health effects from exposure to radiofrequency (RF) electromagnetic fields. The possibility of adverse effects from wireless communications, particularly mobile phone networks, has been a long standing issue but renewed public concern surrounds new technologies using RF fields above 6 GHz and into the 'millimetre wave' range (30–300 GHz).

In order to investigate whether low-level millimetre waves such as those produced by the 5G network are associated with any health effects we reviewed the state of the science into the effects of millimetre waves at levels below current international exposure guidelines. The review assessed 107 experimental studies that investigated various biological effects including genotoxicity, cell proliferation, gene expression, cell signalling, membrane function and other effects. The review of experimental studies showed a diverse range of results but provided no confirmed evidence that low-level MMWs are associated with biological effects relevant to human health. Many of the studies reporting effects came from the same research groups and the results have not been independently reproduced. The review also included 31 epidemiological studies that investigated exposure to radar, which uses RF fields above 6 GHz similar to 5G. The epidemiological studies showed little evidence of health effects including cancer at different sites, effects on reproduction and other diseases.

To follow up the diverse results of the experimental studies we also conducted a meta-analysis of these results. The meta-analysis showed that there was no dose-response relationship between the exposure level and the size of the effect. In fact, studies with a higher exposure tended to show a lower effect size. An investigation into the methods of the experimental studies showed that the majority of studies were lacking in a number of quality criteria including proper attention to dosimetry, incorporating positive controls, using blind evaluation or accurately measuring or controlling the temperature of the biological system being tested. The meta-analysis further showed that studies with a low quality score were more likely to show a greater effect.

In conclusion, a review of all the studies provided no substantiated evidence that low-level millimetre waves, like those used by the 5G network, are hazardous to human health. The findings remain consistent with national and international radiation health and safety guidelines, which have deemed low-level 5G millimetre waves safe for public exposure.

Reality versus perception in the laser lab

John MacLeod[1], **Trevor A Wheatley**[2]

1 UNSW Sydney

2 UNSW Canberra

The common approach in laser research laboratories and workplaces is to have a single central source of knowledge in relation to laser safety. This person is assigned the role of laser safety officer and is responsible for managing the safety of laser activities across multiple areas. This approach is flawed and results in the perception of safety rather than actual safety. We report on the process transitioning a workplace from centralized laser safety role to a distributed network of vertically integrated laser safety personnel. This approach is consistent with the future direction of workplace laser safety standards and puts in place a more robust structure of skills. The approach taken here requires a collegial approach whereby each laser facility have a laser safety supervisor, typically a senior operator, who is additionally responsible for day-to-day safety. They work with the more highly qualified and experienced laser safety officer to create and implement a robust, documented laser safety plan. We explore some real examples of the failings of users not taking ownership of the safety plan and discuss the approach taken to change the culture. We implemented a hazard-based policy of laser management based on an understanding of the existing laser hazard classification scheme documented in the current Australian Standard, consistent with the ARPANSA controlled apparatus definitions.

CONCURRENT SESSION 4.1: IONISING RADIATION

ROOM 6

A Selection of Fluoroscopic Imaging Hazards

K Gregory[1], M Cooper[1]

1 SA Radiation Pty Ltd

Fluoroscopic imaging is responsible for a significant portion of medical imaging dose to the population. As these X-ray units are used for both diagnostic and interventional applications, their use continues to grow. The need to have proper regulatory oversight of these devices, and for regular testing, is more important than ever.

This presentation seeks to highlight a number of radiation safety issues that may be of interest to regulators, hospital RSOs and compliance testers, including;

- Scatter dose rates near fluoroscopic imaging devices used for a range of orthopaedic imaging procedures
- An unexpected relationship between skin entrance dose rates and frame rates
- A radiographer's lack of understanding regarding fluoroscopic modes leading to high patient doses, and
- Scatter dose rates near O-arm systems.

Measured dose rates, images and scatter diagrams will form part of the presentation.

Handling High Activity Sources

Robert Blackley[1]

1 ANSTO

The management and handling of high activity sealed sources creates significant potential radiation safety hazards.

This paper explores the methodologies used recently by ANSTO in the safe handling of a number of different sealed sources, with activities in the terra becquerel range. The paper covers the assessment of the risks, the controls employed and the different techniques utilised to safely handle, transfer and transport these sources, prior to either long term storage or disposal.

Radiation Protection at Low Doses – The Time for Change

Cameron Jeffries[1], Jim Hondros[2]

1 South Australia Medical Imaging, SA Dept of Health and Wellbeing

2 JRHC Enterprises

The International Commission for Radiological Protection (ICRP) has commenced a review of the system of Radiological Protection. This review commenced with a discussion paper, *Keeping the ICRP Recommendations Fit for Purpose* (C Clement et al 2021 J. Radiol. Prot. **41** 1390), and workshop in October 2021. The review, planned to take ten years, is an opportune time to rethink the way we do radiation protection. ARPS members are at the cutting edge of implementation of ICRP recommendations. As practitioners we know there can be undue effort applied at low doses (< 5 to 10 mSv/y). This effort may, at times, divert resources from more significant radiation protection matters. This paper proposes practical approaches to the application of LNT for radiation protection at doses in the range of natural background levels. The proposals adopted the IRPA position of reasonableness and aim to be consistent with the IAEA graded approach to regulation of radiation.

CONCURRENT SESSION 5: IONISING RADIATION

ROOMS 1&2

Dose Conversion Factor Changes

Blake Orr[1], **Cameron Lawrence**[1]

1 Australian Radiation Protection and Nuclear Safety Agency

The International Commission for Radiation Protection (ICRP) is an independent, international organisation that develops and maintains the International System of Radiological Protection. The work produced by the ICRP is published in their reports and is commonly used as a basis for radiation protection standards, legislation, guidelines, programmes, and practice.

The ICRP are in the process of publishing a series of new reports on the Occupational Intake of Radionuclides (OIR) that update dose coefficients for occupational exposed workers. To date four parts of the five-part series has been published. This series will impact the dose assessment methodology for determining occupational exposures to workers from the intake (inhalation and ingestion) of radioactive materials.

Comprehensive updated data for the uranium and thorium decay series is now available. It has previously been recognised that the information provided for dose coefficients in Table 1 of the *Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (RPS9)* has not been consistently derived and the results have been calculated for different radon retention percentages. This has resulted in calculations demonstrated in the *Safety Guide Monitoring, Assessment and Recording Occupational Radiation Doses in Mining and Mineral Processing (RPS 9.1)* also being inconsistent. ARPANSA has previously provided advice to address the inconsistency with the dose coefficient values in RPS 9. Reference is made to the Western Australian document *Managing Naturally Occurring Radioactive Material (NORM) in Mining and Mineral Processing – Guideline NORM 5, Dose Assessment*, Department of Mines and Petroleum, (2010) which also relies on the older dose coefficients. The publication of OIR Part 4, completing the dose coefficients for the uranium and thorium decay series, now makes the dose coefficients provided in RPS 9, RPS 9.1 and the WA Guideline NORM 5 outdated.

Work has commenced to update RPS 9 and RPS 9.1. In the interim ARPANSA has revised Tables 1 and 2 from RPS 9 and Tables A1 and A2 from RPS 9.1. This revised information provides new dose coefficients for radon, mixtures of radionuclides, uranium and thorium decay series.

UNSCEAR Work Program and Reports

Cameron Lawrence[1]

1 Australian Radiation Protection and Nuclear Safety Agency

Established in 1955 the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have an ongoing mandate to review the sources, risks, and effect of ionizing radiation. Over the last several years they have worked on a range of scientific annexes of interest to ARPS, a number of these annexes will be published in the next few years.

With the 10-year anniversary of the Fukushima Daiichi accident UNSCEAR have published the annex *Levels and effects of radiation exposure due to the accident at the Fukushima Daiichi nuclear power station: implications of information published since the 2013 UNSCEAR Report*. This report provides the latest research and scientific data on the issues. Also approved for publication this year is the annex *An evaluation of medical exposure to ionizing radiation* that examines the most recent data on this exposure and identifies the emerging issues and trends in exposure to patients. The committee have also completed the annex *Biological mechanisms relevant for the inference of cancer risks from low-dose and low dose rate radiation*. This report comprehensively evaluates and synthesizes the current knowledge on biological mechanisms of radiation action, particularly at low exposure levels, considered to contribute to or modulate carcinogenesis following radiation exposure.

Still under development with UNSCEAR is the annex *An evaluation of occupational exposure to ionising radiation*, it is expected to be approved for publication at this year's committee meeting. This annex provides the results from a survey of member nations and relevant literature as well as worldwide estimates of occupational exposure.

The committee are also progressing with other work in the pipeline such as *Second primary cancer after radiotherapy*; *Epidemiological studies of radiation and cancer*; and *Public exposure due to ionizing radiation*.

This presentation reviews these UNSCEAR projects and published annexes, summarises the major findings, looks at the future program of work proposed for the committee and provides insight into the committee's operation.

SCM21: Practical Radiation Protection In A Large Industrial Shutdown Project.

Michael Stuckings[1], James Gardner[1]

1 BHP Olympic Dam

BHP Olympic Dam recently completed a large shutdown project known as the Smelter Campaign Maintenance 2021 project, or SCM21. This involved shutting down the main production of the site for 4 months to replace the flash furnace, electric furnace and associated infrastructure. During this time, up to 2500 people were working in the smelter complex with multiple simultaneous operations ongoing. During an undertaking of this scale, it can be easy to lose focus on radiation protection due to the sheer scale of simultaneous safety issues. BHP approached this by resourcing a project specific Radiation and Occupational Hygiene (ROH) team. As part of this a Radiation and Occupational Hygiene Management Plan (ROHMP) was submitted to the South Australian EPA in accordance with the requirements of the

Mining Code.

The first critical aspect of the project was to ensure workers are properly fit tested for personal protective equipment and informed of the risks present at the work site. This was managed in advance of site mobilisation, with additional training as part of site induction.

The second part of preparation is task assessment, which began long before site mobilisation but extended throughout the project. This included Construction Risk Assessment Workshops (CRAWs) during the planning phase followed by Task Hazard Assessment (THA) and Confined Space Hazard Assessment (CSHA) at execution. In these, radiation is an important consideration because time, distance, shielding and ventilation are challenging to manage in confined spaces. Next it is necessary to verify the controls identified are in place. This requires both formal verification during sign on, particularly for the first instance of an activity, but also informal walk arounds of the site to identify issues as they arise. Formal work management of tasks by the SCM team allows the ROH team to coordinate the daily activities for maximum effectiveness.

Radiation monitoring is a critical part of the plan with monitoring of Long Lived Radioactive Dust (LLRD), gamma surveys and radon decay product measurement undertaken on a planned basis during the project.

Logistically, the team also needs to manage isolation of gamma density gauges and Non-Destructive Testing (NDT) radiography issues. Managing radiation perimeters during radiography in the smelter complex is very challenging.

A dedicated waste processing area was set up as part of the project. This allowed identification and appropriate cleaning of surface contaminated objects. Following cleaning, the waste can then be directed to the appropriate area, either storage, landfill or recycling.

Finally, it is a requirement of the site that all outgoing equipment or other goods are cleared to prevent surface contaminated objects or radioactive substances leaving the site without authorisation. This presented a significant logistical challenge towards the end of the project due to the large number of workers and equipment leaving site on a tight timeframe.

Review of the project is expected to begin soon, with the aim to understand possible improvements for the next SCM.

Radiation Protective Apparel: Is Testing Needed?

Raihan Rasheed[1], William Rae[1], Katie Compagnoni[2], Erin McKay[2]

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2 Department of Nuclear Medicine, St George Hospital, Sydney, NSW.

Introduction

Radiation protection apparel, commonly referred to as "lead aprons", is widely used to minimise exposure from ionising radiation. Innovation has meant that such personal protective equipment (PPE) are often composed of composite materials containing no lead and provide better protection across diagnostic imaging modalities. They are also lighter and more durable. Lead equivalence testing determines the attenuation properties of materials used. Fluoroscopic screening of protective apparel is used to detect degenerative changes over time.

This poster summarises the findings from lead equivalence and screening tests performed during 2021 across **two** hospitals.

Method

Lead equivalence was determined for 201 pieces of apparel from national and international manufacturers. This was done in accordance with Australian Standards AS/NZS 4543.1:1999 [1], using a narrow beam geometry. Lead equivalence based on labels of garment was compared against measured lead equivalence at 100 kVp.

Garments were visually inspected during mandatory screening. Criteria for non-compliance were based on NSW EPA (2018) [2]. Panels with less than 0.3 mm Pb equivalence, surface cracks or tears, and labelling that was not in accordance with AS/NZS 4543.1:2000 [3], were considered non-compliant and were taken out of use.

Mandatory annual screening was done for 633 pieces of apparel. Testing criteria included structural defects such as cracks, tears or holes in panels, mislabelling or damaged labels, were considered to be non-compliant and removed from service.

Results

Lead equivalence testing revealed 11 out of 201 (5.5 %) articles to be non-compliant, with lead equivalence measured below 0.3 mm. Following fluoroscopic or CT x-ray screening, 53 out 633 (8.4 %) of articles were removed from service. Structural defects were seen in 22 articles, including cracks and tears due to degradation, improper storage, or degenerative changes. Indicated lead equivalence on the garment labels were nonspecific and unclear on 13 (6.5 %) occasions and mislabelled on 21 (10 %) garments where the measured Pb equivalence was higher or lower than indicated.

Conclusion

Our results show the importance of performing lead equivalence tests, as screening alone may not be sufficient in determining if adequate protection is provided. Newly acquired apparel fails were mostly due to insufficient lead equivalence, or visible defects observed during initial screening. Older apparel tended to fail due to structural defects such as cracks and tears. Lead equivalence testing has associated costs, but is necessary to properly assess the protective qualities of PPE.

References

AS/NZS 4543.1:1999 Protective devices against diagnostic medical X-radiation Determination of attenuation properties of materials.

NSW EPA (2018) Guideline 4 Compliance for x-ray protective clothing.

AS/NZS 4543.1:2000 *Protective Devices Against Diagnostic Medical X-Radiation. Part 3: Protective clothing and protective devices for gonads*

CONCURRENT SESSION 5.1 : DEVELOPMENTS IN RADIATION PROTECTION, TECHNOLOGY AND METHODS

ROOM 6

Use and Benefits of Gamma Imaging for Radiation Protection

N. Karantonis[1], J. Ilter[1], M. Guenette[1], L. Chartier[1], A. Flynn[1], G. Watt[1], J. Barnes[1], L. Petkovic[1] and D. Boardman[1]

1 ANSTO

CORIS360® is an advanced gamma imaging system that offers new insight into complex radiation environments. It has been used in many scenarios which have aided decision making for the benefit of personnel safety and dose optimisation. The wide 360° x 90° field of view makes this imager ideal for radiation protection applications, being able to image wide areas and effectively reducing worker exposure to radiation. In addition, CORIS360® can simultaneously image different radionuclides over a broad 40 keV - 3 MeV range.

CORIS360® incorporates interchangeable spectroscopic CLLBC ($Cs_2LiLa(Br,Cl)_6$:Ce) detector assemblies, which have different detector volumes and sensitivities. A 1.5 inch detector is ideal for imaging low to medium dose rate scenarios such as standoff imaging and background assurance imaging, whereas a smaller 0.5 inch detector is beneficial in higher dose rate environments, which could be used for hot cell contamination imaging or nuclear decommissioning projects. The lithium component in this scintillator detector allows for neutron detection, which is beneficial for nuclear security.

The CORIS360® technology is also being further developed to image thermal neutrons, higher energy prompt gammas as well as lower energy photons, making it an important tool in enclosed beamline environments, such as neutron scattering facilities and particle accelerators. This presentation will exhibit radiation imaging case studies, demonstrating the benefits to radiation protection and safety when working in radiation environments.

Geant4 Simulations to Characterise Silicon Microdosimeters for the Radiation Protection of Astronauts in a Lunar Mission

M. J. Large[1], S. Peracchi[1], D. Bolst[1, 2], L. T. Tran[1, 2], M. Povoli[3], A. Kok[3], H. Lambropoulos[4], A.B. Rosenfeld[1, 2] and S. Guatelli[1, 2]

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4 National & Kapodistrian University of Athens, Greece

In this project the authors describe the development of a Geant4 application to recreate the radiation environment on the surface of the Moon for astronaut radioprotection studies and to characterise silicon microdosimeters developed at the Centre for Medical Radiation Physics (CMRP), Wollongong. Galactic Cosmic Rays (GCRs) are a major component of the space radiation environment and consist of protons, alphas and heavy ions. The spectra for GCR particles incident on the Moon are calculated via the European Space Agency's Space Environment Information System (SPENVIS), taking the Moon's position in interplanetary space to be one astronomical unit from the sun. The spectra from SPENVIS are imported into Geant4 by means of the G4GeneralParticleSource. GCR particles are generated from a random position on a hemisphere of 5 km radius above the lunar surface. The momentum of incident particles follow a cosine distribution to mimic an isotropic radiation field typical of space, and traverse towards a large slab re-creating the lunar surface (200 x 200 m^2 surface area, 10m soil depth). The modelled lunar soil varies in composition with soil depth. The lunar soil consists primarily of oxygen, silicon and iron at percentage weight concentrations of approximately 42%, 19% and 13%

respectively. The resulting secondary particles created from incident GCR particles are recorded, detailing particle energy, type, and positioning from the point at which the primary particle hit the surface. First results show that of secondary particles emitted from the Moon's soil approximately 45% are photons, 25% are neutrinos and 22% are neutrons, with average kinetic energies of 5.11 MeV, 19.32 MeV and 21.46 MeV, respectively. The remaining 8% of secondaries consist mainly of pions, electrons, muons, protons and heavier ion fragments. The Geant4-simulated lunar secondary radiation environment will be further utilised to characterise the response of CMRP developed silicon microdosimeters. These simulations will provide vital insights into the feasibility of silicon microdosimeters for radioprotection applications in future crewed lunar missions. These results will be complimented with additional Geant4 simulations to estimate the absorbed and effective dose to the organs of astronauts in the lunar radiation environment. This will be achieved via the integration of adult computational reference phantoms, as described in publication 145 of the International Commission on Radiological Protection (ICRP), with the authors developed Geant4 lunar surface simulation. This study will be presented in full at the 2021 ARPS conference.

How detector geometry effects signal to background ratio in aerial gamma radiation surveys. A study using Geant4 and analytical tools

Tim Doughney[1], Nigel Spooner[2], Antony Hooker[3], Chris Kalnins[3], John Gillam[4]

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A UAV gamma radiation survey is an efficient way to obtain the radiological profile of a large area. Survey data can be used to ensure the safety of first responders operating in a contaminated environment, monitor the buildup of radiological contaminates in mining operations, or ensure compliance of waste repositories.

One of the most challenging aspects of conducting an aerial survey is distinguishing useful signal information from signal stemming from background radiation. This study investigates how detector geometry effects the ratio of useful signal to unwanted background radiation seen by a detector. Five common detector geometries, planar, cube, sphere, and cylinders in both vertical and horizontal orientations consisting of a set common volume of 1875 cm^3 were investigated. The geometries were modelled using both analytical tools developed in Python and Monte Carlo methods in Geant4. A footprint area estimation that encompasses 99% of the contribution of background radiation for each detector geometry was established. This footprint was used as a variance reduction limit for background contributions in extensive Geant4 simulations. The simulations modelled realistic background contributions and set distance limits of detectability for various source isotopes and activities that could be detected by a "perfect detector". This work contributed to further research in selecting and optimising a prototype detection system for aerial surveys.

Australia's Nuclear Forensic Science Capability

Tegan Bull[1], Katherine Adena[1], Ned Blagojevic[1], **Jack Goralewski**[1], Elizabeth Keegan[1], Nikki Keighran[1], Elaine Loi[1], Anny Toch[1], Kaitlyn Toole[1], Riley Van De Voorde[1], Emma Young[1], Jennifer Harrison[1]

1 ANSTO, Nuclear Stewardship, Nuclear Forensics

The International Atomic Energy Agency (IAEA) defines nuclear forensic science as 'the scientific analysis of nuclear or other radioactive material, or of other evidence that is contaminated with radionuclides, in the context of international or national law'. ANSTO has almost two decades of operational and research experience in the field of nuclear forensics. A dedicated team of scientific staff maintain and operate Australia's national nuclear forensic capability.

The capability draws upon the broad scientific expertise and landmark infrastructure across ANSTO campuses. This expertise includes radiation protection; the implementation of appropriate controls to safely handle radioactive materials which may not be fully characterised without impeding on the timely examination of these materials can be a significant challenge. Close collaboration between radiation protection professionals and nuclear forensic scientists is critical throughout the process of a dynamic risk assessment.

The Nuclear Forensics team directly support national and state response agencies, policing services, and emergency management authorities through on-site access to and familiarisation with laboratories that house specialised equipment, sample receipt processes, analysis, interpretation and reporting in a nuclear forensic science context. This complements the training offered by radiation protection professionals to enable safe operation in hazardous environments. ANSTO also collaborates regionally and internationally to exchange knowledge and strengthen nuclear forensics capabilities in partner nations.

This presentation will discuss the capabilities and activities of ANSTO's Nuclear Forensics team including their role to:

- Operate the national capability for the forensic examination of evidence contaminated with radionuclides in partnership with the Australian Federal Police
- Produce and deliver education and training materials on nuclear forensic science to Australian Government departments and partner nations on radiation awareness for investigators and scene-going personnel, radiological crime scene examination and laboratory-based nuclear forensic analysis
- Respond to requests for support from stakeholders for timely advice and analytical services
- Cooperate with the IAEA through expert representation in nuclear forensic science and nuclear security related activities and contributing to the development of guidance documentation
- Undertake knowledge sharing activities in nuclear forensics with partners in our region, underpinned by memoranda of understanding and collaborative agreements
- Participate in Global Initiative to Combat Nuclear Terrorism (GICNT) activities which may include the chairing of working groups and attending workshops
- Represent Australia at the International Technical Working Group (ITWG) on Nuclear Forensics

CONCURRENT SESSION 6: NON-IONISING RADIATION

ROOMS 1&2

The New ARPANSA Radiofrequency Exposure Standard

Ken Karipidis[1], Stuart Henderson[1], Sarah Loughran[1]

1 Australian Radiation Protection and Nuclear Safety Agency

In order to protect the Australian community from the harmful effects of exposure to radiofrequency (RF) fields, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) published a national RF exposure standard in 2002. The ARPANSA RF standard provides the basis for national regulation of exposure to members of the public from wireless communications and can be applied by work health and safety regulations for the protection of workers from occupational RF sources. The exposure limits in the 2002 ARPANSA RF standard were based on guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1998.

Since the publication of the 1998 ICNIRP guidelines there has been a considerable body of science further addressing the relation between RF and adverse health outcomes, as well as significant developments in the technologies that use RF, including the new 5G mobile network. Accordingly, in March 2020 ICNIRP published updated guidelines taking into account current knowledge of how RF affects the human body. The new ICNIRP guidelines triggered ARPANSA to develop a new RF exposure standard, titled "RPS S-1: Standard for Limiting Exposure to Radiofrequency Fields – 100 kHz to 300 GHz" which was published in February 2021. The new ARPANSA standard has adopted the exposure limits of the 2020 ICNIRP guidelines and Australia is one of the first countries in the world to harmonize with the updated ICNIRP guidance.

The new ARPANSA standard provides protection against all scientifically substantiated adverse health effects due to any RF exposure, including exposure of any time duration (from instantaneous to long-term) and the combined exposure from all sources in the everyday environment. The standard also includes additional restrictions for RF exposure at frequencies above 6 GHz, which is of importance to 5G and other future technologies using these higher frequencies. The exposure limits have been set substantially lower than the lowest RF exposure level that science has found to cause harm and aim to protect everyone, including people of any age and health status.

Apart from prescribing exposure limits the standard also includes requirements for protection of the general public and the management of risk to workers, together with additional information on verifying compliance with the limits of the standard. The new RF standard is a critical component of the Australian Government's Electromagnetic Energy Program, which aims to promote health and safety and address misinformation about RF exposure from current and future technologies like 5G.

Genotoxic Potential of Radiofrequency Exposures

Steven Weller[1], Victor Leach[2], Murray May[3]

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2. Radiation Protection Consultant App. Physics (RMIT) MSc (Melb.) MARPS. MORSAA.
3. Environmental Health researcher (previously Visiting Fellow, UNSW Canberra), BSc (Hons) PhD, MORSAA

In genetics, the term genotoxicity describes the action of physical agents, such as chemicals and ionising radiation, which results in damage to genetic material encoded in deoxyribonucleic acid (DNA), and can take many forms. Markers of genetic damage include single strand and double strand DNA breaks, DNA base damage, chromosome aberrations and micronuclei induction. It is well-recognised that genetic damage is a major pathway to carcinogenesis.

There has been much debate over the last 30 years as to whether man-made radiofrequency radiation is genotoxic. With a number of narrative reviews, Ruediger's review (2009) found 49 studies reporting a genotoxic effect while 42 did not, and more recently, a review by Lai (2021) found 237 or 66% of studies investigating genetic effects had a significant finding while 124 or 34% did not. Both papers provide a summary of the current state of science with a "balance of evidence" finding. Further, both suggest some possible reasons for the discrepancies. However, such reviews can only best be described as superficial, as neither of these papers investigated in depth (using meta-analysis techniques) about how experimental methodology and parameters used may affect outcomes.

A search of the ORSAA database has identified over 350 papers investigating RF exposures and genotoxicity. A comprehensive data set was then constructed by capturing important comparable parameters from the collection of identified studies. Example parameters include: experiment type (in vivo, in vitro, epidemiological); funding source; cell type (primary vs cell line); species; RF generation source; carrier wave frequency and signal modulation used; number of sequential exposures; duration of exposures; intensity of the signal; DNA damage assay type; sacrificial method (animal studies); time between exposure cessation and commencement of DNA damage assay. These parameters and their inter-relationships were methodically analysed.

The resulting comprehensive data set provides valuable insights into how some of these parameters can have significant influences on study results and identifies the main drivers contributing to the mixed findings. The data set also shines a light on methodological limitations and issues that will need to be addressed in future studies in order to further clarify the genotoxic potential of radiofrequency exposures. The preliminary findings to be presented are likely to have far-reaching implications for our understanding of radiofrequency exposure in relation to health and safety. The findings also bring into question the applicability of the current RF Standard (ARPANSA 2021) and RF Guidelines (ICNIRP 2020) for providing suitable protection to all species, not just humans.

Non-ionising radiation cosmetic devices – treatment applications, risks and current regulation in Australia.

David Urban[1], Trevor Wheatly[2], Rick Tinker[1], **Ken Karipidis[1]**

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The use of devices that emit non-ionising radiation (NIR) for the purposes of applying cosmetic treatments has been well established for many years. The most common devices expose patients to intense optical radiation through use of high powered lasers and intense pulsed light (IPL) sources. In recent years, the cosmetic industry has continued to expand and new devices that emit other NIR, including radiofrequency and ultrasound, have made their way into practical application. There is a wide range of treatments performed, which include epilation, tattoo removal, body sculpting and removal of pigmented lesions. Cosmetic NIR treatments are marketed as low-cost, low risk alternatives to invasive cosmetic surgical procedures. However, exposure to the intense NIR energies that are required for efficacy of treatment to the targeted tissue carries a risk of injury particularly from improperly performed treatments.

Although there have been a number of documented and anecdotal reports of injuries including burns, scarring and pigmentation changes from undergoing NIR cosmetic treatments, studies focussed on both qualifying and quantifying the potential adverse health effects is limited, particularly in regard to poor treatment practices or misuse of devices. There have been a number of attempts in Australia over the last two decades by regulators, health organisations and special interest groups to explore and implement a national regulatory framework for oversight of the use of these devices for cosmetic treatments. However, despite the presence of clear mechanisms for harm, the scale of the societal health impact is not well established.

Currently, certain cosmetic NIR practices are regulated in three Australian states; Queensland, Tasmania and Western Australia.

All three jurisdictions have a framework in place which covers the use of high powered lasers and Tasmania's regulations also extend to IPL devices. The Australian Radiation Protection and Nuclear Safety Agency published national safety advice for optical NIR devices directed to both cosmetic treatment providers and consumers in 2019. For treatment providers, the focus is on standards of service delivery, risk communication to clients, qualifications and training, and injury reporting. For consumers, the focus is on making informed decisions about undergoing NIR cosmetic treatments. ARPANSA's advice has the objective of promoting good practice across the cosmetic industry, however, best safety practice may be well served by consideration for implementing a nationally consistent model for oversight of the industry.

CONCURRENT SESSION 6.1: PLANNED EXPOSURE SITUATIONS, EMERGENCY RESPONSES

ROOM 6

Lucas Heights Radiological Hazard Assessment and Protection Strategy

Andrew Popp[1], Prashant Maharaj[1], Richard Barton[2], Chris Penny[2], Lili Wang[2], Robin Foy[1], Hef Griffiths[3]

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2 System Safety and Reliability, Australian Nuclear Science and Technology Organisation

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This paper discusses the potential combined off-site radiological impacts of the reference accidents for OPAL multipurpose research reactor, ANSTO radiopharmaceutical production and ANSTO Nuclear Medicine facilities', and the protection strategy that would be employed if such a scenario were to occur. For the Lucas Heights Radiological Hazard Assessment and Protection Strategy the ANSTO Lucas Heights campus fence line is prudently considered the boundary between on-site and off-site as described in IAEA GSR Part 7 (2015).

The Lucas Heights Radiological Hazard Assessment and Protection Strategy has been prepared as a technical document in support of the Lucas Heights subplan to the New South Wales State

Emergency Management Plan (EMPLAN). This details the hazard assessment and protection strategy for aspects of the preparation for, response to, and immediate recovery from a radiological or nuclear emergency occurring at Lucas Heights.

The off-site radiological impact of the combined reference accidents is assessed for adults, children and infants over an exposure period of 50 years using conservative assumptions, such as unfavourable meteorological conditions and lack of response actions, such as sheltering (no sheltering during the exposure period). This hazard assessment supports the preparation for, and the response to, a substantial radioactive release, including radiological monitoring, other response actions, and communication with relevant parties (response agencies, government agencies, members of the public, etc).

The protection strategy describes the outcomes required in response to a radiological emergency during all its phases, and how this will be achieved. The aim is to prevent severe deterministic effects, reasonably reduce the risk of stochastic effects, and to ensure the safety of emergency workers and helpers.

The Unintentional Radon Chamber: Ventilation Of NORM Stores

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1 SA Radiation Pty Ltd

During a routine audit of a store for unsealed radioactive material, elevated surface contamination levels (0.3 – 2.2 $Bq.cm^{-2}$) were detected on the clothing and bodies of the two consultants conducting the audit. All controls for safe handling of the material in the store had been adhered to, and by exclusion it was inferred that the contamination levels were due to elevated levels of radon and thoron decay products from a quantity of NORM material in the store. This was supported by the rapid decrease in contamination on all surfaces once the consultants left the store.

A potential source of contamination was identified (container of NORM). Wipe tests taken from inner surfaces of the container were assessed by gamma spectroscopy. Elevated levels of Pb210 and evidence of radon decay products were confirmed. Further investigation and monitoring were conducted over the following weeks showing radon at levels exceeding the ARPANSA reference levels for radon in workplaces. Grab samples indicated elevated radon decay products at levels that would result in exceedance of the member of public radiation dose limit within five standard working weeks.

While regulatory frameworks in Australia require that radioactive material is stored securely and provide high level guidance on measures to ensure safe storage that will maintain radiation doses to within constraint levels, the specific controls are left to the owner of the material to determine and implement. Where source inventories include NORM materials, the owners should be cognisant of the potential for significant build up of radon and decay products that can result from a relatively small quantity of material under conditions where air exchange is not adequate.

Mo-99 Contamination Incident Leading to Tissue Reactions to the Hands of a Radiopharmaceuticals Manufacturing Worker

Andrew Popp[1], Robin Foy[1], Hefin Griffiths,[1] Catherine Field[2]

1 Australian Nuclear Science and Technology Organisation

2 IMMEX

The Australian Nuclear Science and Technology Organisation (ANSTO) operates one of the world's most modern nuclear research reactors, OPAL; a comprehensive suite of neutron beam instruments; the Australian Synchrotron; the National Research Cyclotron; and the Centre for Accelerator Science. ANSTO also provides the Australian and international community with nuclear medicine including Tc-99m using Gentech® generators which contain the parent nuclide, Mo-99.

During August 2017 a radiopharmaceuticals manufacturing QC analyst became contaminated whilst carrying out standard operating processes with a QC sample of Mo-99. Despite the rapid reactions of the operator the radioactive contamination on the analyst's gloves and hands led to an estimated dose to the skin of the hands of approximately 20Gy. The accident was reported on the IAEA International Nuclear Event Scale (INES) as a level 3, serious accident. There were a number of improvements to equipment, process and protective equipment identified in the resulting investigation.

This presentation will describe the process which led to the accident, the immediate responses and causes of the accident, initial dose estimates and the error margins of the early dose estimates based on the information available at the time and lessons learned. Immediate changes to equipment were implemented and longer term modifications requiring significant design changes were identified to reduce the risk of a similar accident happening and these will be described. The tissue reactions due to the radiation exposure to the workers hands will be described along with the medical treatments administered. Finally, the emotional / psychological impacts will be briefly discussed.

CONCURRENT SESSION 7: RESEARCH AND ENGINEERING

ROOM 1&2

Immunomodulating Acute Respiratory Inflammation using Low-Moderate Dose Ionising Radiation

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Low-dose ionising radiation has been used in the past to treat respiratory inflammation, such as pneumonia. Currently, it is being used by a number of European nations to treat and reduce the severity of chronic inflammatory conditions and its application is currently being trialled as a treatment option for acute respiratory inflammation caused by SARS-CoV-2 worldwide. However, its use is currently under scrutiny with the balancing act between therapeutic reward and radiation risk always at the forefront of the public eye. This study utilises lipopolysaccharide stimulation to induce acute respiratory inflammation in a murine model of acute lung injury. This model generally results in the advanced infiltration of leukocytes to the site of inflammation, which can lead to the induction of pro-inflammatory pathways and damage to healthy tissue. Furthermore, pulmonary oedema, cellular apoptosis, and impaired lung function also result from this stimulus of acute lung injury. However, the literature suggests that low-moderate doses of X-irradiation can have immunomodulatory effects that stimulate anti-inflammatory pathways including, decreasing leukocyte mobility, reducing pro-inflammatory and promoting anti-inflammatory mediator release. This study then aims to clarify the immunomodulatory effects elicited by a single dose of low-moderate X-irradiation, to alleviate acute respiratory inflammation. Adult male Sprague-Dawley rats (200-300g) were X-irradiated in a cabinet irradiator with a single dose of 0 (Sham), 20, 200, or 750 mGy, at either 6 or 18-hours post instillation *of E. coli* derived LPS (3mg/kg). Animals were then euthanised and the following outcomes were measured: lung function, pulmonary oedema, cellular infiltrate and total protein, DNA damage and cellular damage, and apoptosis. Animals exposed to LPS show reduced lung function, greater cellular infiltration into the lung, and increased wet lung lobe weights to body weight ratios than models exposed to saline. Preliminary results suggest that X-irradiation is showing anti-inflammatory responses to LPS stimulated animals.

ARPANSA use of U.S. NRC RAMP computer codes for radiation assessments

Blake Orr[1]

1 Australian Radiation Protection and Nuclear Safety Agency

The United States Nuclear Regulatory Commission (NRC) maintains and develops a series of computer codes used for radiation assessments through their Radiation Computer Code Analysis and Maintenance program (RAMP). The codes range from Nuclear Power Plant licensing codes to Environment Assessment, Emergency response, Phantom Modelling, and other dose assessment codes. The U.S. NRC allows both domestic and international access to RAMP through a formal agreement, and hosts up to two technical meetings each year, one with an international partner and the other hosted at the NRC site in Washington.

In 2017 ARPANSA began engagement with computer codes associated with RAMP when undertaking an assessment related to public exposure from consumer products. In 2019 APRPANSA signed a formal agreement to join RAMP and has since expanded its use of the RAMP codes. Federal and State government agencies are also granted access to the RAMP codes under the ARPANSA agreement.

Examples of use of the RAMP codes within APRANSA include:

- VARSKIN: Primarily used for undertaking skin dose assessments, recent upgrades to the software now allow assessments of eye, wound and neutron doses to be estimated. ARPANSA has used this code to underpin advice warning consumers against the use of certain consumer products and to assess contamination events to the skin.
- RASCAL: Consequence assessment for radiological emergencies. ARPANSA has used this code to supplement other consequence assessment tools and to obtain source terms from potential nuclear emergencies.
- Visual Sample Plan: This tool supports development of defensible sampling plan for radiation assessments and has been used to support ARPANSA measurement campaigns.

ARPANSA and the U.S. NRC will be hosting the Virtual International RAMP meeting starting 5th April 2022 and would welcome attendance from the ARPS community.

For more information, please see the RAMP web-site - https://ramp.nrc-gateway.gov/

ANSTO's Health Physicist Development Framework

Andrew Popp[1], Robin Foy[1], Hef Griffiths[2]

1 Radiation Protection Services, Australian Nuclear Science and Technology Organisation

2 Nuclear Office, Australian Nuclear Science and Technology Organisation

The Australian nuclear industry is suffering heightened concerns of a skills gap. The following paper provides an overview of ANSTO's approach to developing a radiation protection competency-based framework. The aim is to provide a holistic view of the professional development requirements within ANSTO for current and aspirational Health Physicists, whilst also providing a technical skill profile across ANSTO (i.e. what knowledge, skills and experience Radiation Protection Services are required to show). This will allow the identification and implementation of the required professional development initiatives (learning and competency based activities) to support the development of personnel, their careers, and the radiation protection profession (i.e. how the individuals will show the required knowledge, skills and experience). This is used by ANSTO to create and recognise Qualified Experts in the absence of a formal recognition mechanism within Australia.

ANSTO recognises that locally developed measures are more relevant and sustainable than those imported substantially from outside. It is therefore important to support and facilitate indigenous methods and to factor in Australia's and ANSTO's culture – 'the way we do things here' – whilst still achieving radiation protection objectives that reflect international norms. This health physicist development framework has been developed by drawing on the requirements for recognition of example accreditation schemes / professional societies, including ARPAB, ARPS, RPA 2000, SRP (Membership and Chartership); the European Network on Education and Training in Radiation Protection (ENETRAP III); and the International Radiation Protection Association (IRPA) Guidance on Certification of a Radiation Protection Expert.

This Health Physicist development framework is not intended to be definitive, but rather something that grows and adapts as experience is gained using it as part of the professional development of individuals, Radiation Protection team, and ANSTO.

In order to support Health Physicists in showing that they possess the required radiation protection knowledge, skills and experience for their ANSTO role, and to support the development of personnel, their careers, and the radiation protection profession, a list of professional development initiatives (learning and competency based activities) has been identified. This includes on-the-job training, mentoring, and attendance at training courses for less experienced health physicists; whilst for more experienced individuals, development requirements are likely to be primarily met by supporting attendance at industry seminars, conferences and specialist training courses.

Introduction of ARPAB Expert Certification

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Professional Accreditation in radiation protection had its official origin in Australia at the 1990 Conference, which was held jointly between ARPS and ACPSEM. Over the next decade a working group was empanelled to develop an accreditation scheme consisting of various practical examinations and a bank of questions so that a theoretical exam could be completed and graded. In 1997, ARPS and ACPSEM completed the "Candidates Kit" for a Radiation Protection Advisor level of certification, and were joined by the Australian Institute of Occupational Hygienists as a sponsoring organisation. In 2000, the Australasian Radiation Protection Accreditation Board was incorporated and began certifying Radiation Protection Advisors (CRPA).

Since that 2000 establishment, very little has changed about ARPAB aside from the doubling from two to four representatives from each sponsoring society, however at the 2021 ARPS Conference, an advanced level of certification is being introduced. In 2018, under the Chairmanship of Kent Gregory, a new working group was empanelled to create an exam bank for an expert level of certification, along with designing the Candidates Kit for being a Certified Radiation Protection Expert (CRPE). This advanced level of certification is designed to comply with the 2016 IRPA Guidance on Certification of a Radiation Protection Expert. The Working Group with Kent as convenor further consisted of Riaz Akber, Cameron Jeffries and Brent Rogers, and as with the original certification, the expert certification has been internally authenticated. As such, the Working Group has now become the Panel of Examiners. The steps to achieving the Expert level of certification will be discussed in this presentation and both levels are discussed on the ARPAB website.

CONCURRENT SESSION 8: WASTE MANAGEMENT

ROOM 6

Challenges for Radiation Protection in the Design of the National Radioactive Waste Management Facility

Ciara Collins[1], Stanley Lee[1], Debbie Mackay[1]

1 Australian Nuclear Science and Technology Organisation

The National Radioactive Waste Management Facility (NRWMF) project is currently in the site-specific concept design phase. This facility will support the safe and secure long-term management of radioactive waste in Australia. The NRWMF will function as a disposal facility for Low Level Waste (LLW) and a temporary storage facility for Intermediate Level Waste (ILW) and Safeguarded Nuclear Material.

The Common National Inventory for Radioactive Waste (CNIRW) is intended to be a database of all radioactive waste in Australia. This includes current waste and waste predicted to be generated over the next 100 years. The information in the inventory will help identify the volume of waste requiring management at the NRWMF and will also allow the radiation protection and security requirements at the facility to be evaluated based on radiological properties and classification of the waste. The CNIRW along with the Waste Acceptance Criteria (WAC) provides critical input into the transport and storage requirements for the design of the NRWMF. Waste will be assigned to the NRWMF in accordance with the requirements within the WAC.

The ILW storage facility at the NRWMF has an expected operational life of 50 years. Optimisation of the design of the ILW storage facility will require careful input from waste holders, waste producers and subject matter experts to ensure that the design is safe for operators over the life of the facility, particularly in terms of radiation protection.

To facilitate the design and staging of the facility a live simulation model, which can be updated and refined to reflect the current status of fixed characteristics, and to test assumptions to optimise the design, will be developed.

Storage and transport of ILW presents unique challenges to ensure that waste can be managed in a safe, yet cost effective, way. The operational flow has been considered to allow for efficient conveyance of the waste from its entry on the site to its designated storage location. This has encouraged the development of a logical and modular layout which facilitates waste retrievability in order to meet International Atomic Energy Agency (IAEA) monitoring requirements and for transfer of ILW to a future disposal facility. In addition to radiation protection, competing considerations such as design life, environment, enabling services and engineering constraints play a role in the design of the facility.

The design of the NRWMF is being undertaken by ANSTO and Jacobs who are supporting the Australian Radioactive Waste Agency (ARWA). ARWA is leading the process to responsibly manage our nation's radioactive waste and will be the ARPANSA Licence Holder and ASNO Permit Holder for the NRWMF.

Soil Sampling around Waste Storage Facility

Asif Ahmed[1], Dr Michael Went[1], Dr Kapila Fernando[2], Roland Wong[2]

1 Department of Defence

2 Australian Nuclear Science and Technology Organisation (ANSTO)

In 1995, low level and intermediate level waste from a number of Commonwealth and State agencies was conditioned and packed by ANSTO and transferred to a site on Commonwealth Land at Woomera for interim storage at the direction of the Federal Cabinet. The material eventually came under Defence control when the land was transferred to the Department of Defence, with the ramp-up of activity at the Woomera Test Range. The waste consists of a variety of materials generated from industry, education and medical activity by universities, hospitals, medical practitioners and other Commonwealth and State agencies. Subsequently, the waste was combined with a separate consignment of Defence waste, moved to a repurposed munitions building which is now known as the Koolymilka Radioactive Waste Storage Facility (KRWSF). As part of the ARPANSA licence conditions to maintain the Facility Licence, periodical soil sampling must be conducted in the vicinity of the KRWSF. This paper describes procedure and results of the soil sampling at KRWSF conducted in June 2021.

The objective of soil sampling at the Koolymilka waste storage facility was to examine the soil around the facility for trace radioactive isotopes that may have been produced by activities in the facility. As such the sampling primarily looked at isotopes and products of materials stored in the facility. There are two potential paths for contamination of the facility surrounds: contamination entering the site from other sources and contamination from the facility itself. As such a random sampling approach is of limited benefit as this sampling methodology would not be able to distinguish between the two. It is reasonable to expect that contamination from the facility will be at its highest in the vicinity of the facility building and that external contamination will enter the site through water movement. Based on this assumption a judgemental sampling methodology had been chosen.

Soil samples were analysed using gamma spectroscopy for the presence of Ra-226 by measuring decay products (Pb-214, Bi-214, and Pb-210), Th-232 by its decay products (Ra-228, Tl-210, Bi-212, and Pb-212), U-235, Th-234, Am-241, Co-60 and Cs-137. Additional isotopes were also analysed on an opportunistic basis (Eu-152 and K-40) despite these isotopes not being held in the facility. A baseline study collected soil samples prior to the facility being commissioned. The baseline survey looked at the isotopes Ra-226, Ra-228, Pb-210, Co-60 and Cs-137. The analysis includes the total activity in Bq and the activity concentration in Bq/g.

Australia's World-Class Solution to LLW Waste – Tellus' Sandy Ridge Near-Surface Geological Repository

Matt Carroll[1], Georgia Mellor[1], **Annelize van Rooyen**[1]

1 Tellus Holdings Ltd

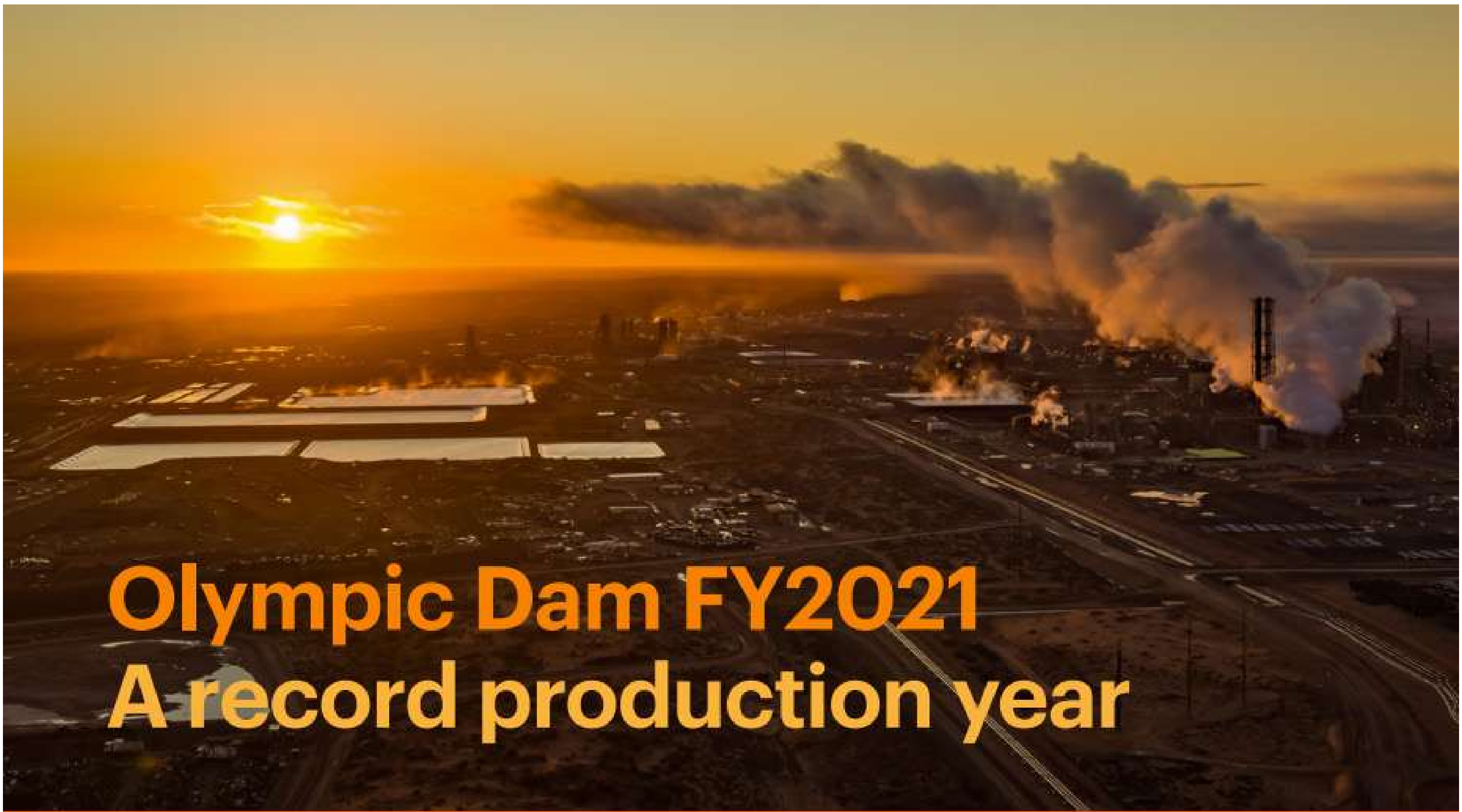
After nearly a decade of development and approvals work, Tellus Holdings Ltd (Tellus) is proud to announce the opening of Australia's first commercial near-surface geological repository at Sandy Ridge, which is capable of permanently isolating hazardous and intractable waste from all jurisdictions in Australia, including its Exclusive Economic Zone.

The opening of Sandy Ridge provides a potential solution to a decades old issue for the Radiation Safety Industry in Australia by providing an economically viable and environmentally sustainable domestic solution for dealing with redundant sources and other low-level radioactive material. This will better protect our communities and the environment.

Sandy Ridge has undergone years of approvals, community engagement and development work, including review by multiple independent international experts and scrutiny at all three levels of government. In October 2019, a Site Registration to store Naturally Occurring Radioactive Material (NORM) was granted by the WA Radiological Council. In April 2021, Tellus was granted approval to store disused sealed radioactive sources (DSRS). Construction on the Facility was completed in late 2020. Licensing and approvals for the disposal of hazardous and intractable chemical waste was obtained on 19 March 2021. We expect to obtain approval for disposal, containment and permanent isolation of LLW in cell by the WA Radiological Council in due course. However, Tellus can take risk and title to waste today, providing a unique offering to its clients.

Additionally, Tellus is working on strategic alliances to enable provision of the full scope of services to its clients. These include:

- Partnering with an expert consolidator to provide consolidation services for DSRS destined for permanent isolation at Sandy Ridge;
- Unique packaging solutions for transport of bulk materials with an internationally recognised packaging provider;
- Engaging with transport service providers and radiation safety consultants to take care of the identification, characterisation, handling, packaging and safe transport of radioactive material from the client to our repository;
- Actively engaging with regulatory authorities to facilitate the cross jurisdictional transport of radioactive material from anywhere in Australia to the facility; and
- The ability to handle and permanently isolate materials within Tellus' waste acceptance criteria.

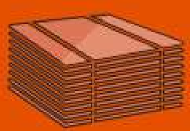


Olympic Dam FY2021
A record production year

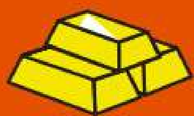
Located in South Australia, Olympic Dam (BHP ownership: 100 per cent) is one of the world's most significant deposits of copper, gold, silver and uranium. It comprises underground and surface operations, and is a fully integrated processing facility from ore to metal.

Ore mined underground is hauled by an automated train system to crushing, storage and ore hoisting facilities or trucked directly to the surface.

Olympic Dam has a fully integrated metallurgical complex with a grinding and concentrating circuit, a hydrometallurgical plant incorporating solvent extraction circuits for copper and uranium, a copper smelter, a copper refinery, including an electro-refinery and an electrowinning-refinery, and a recovery circuit for precious metals.



205kt
record copper production



146kOz
record gold production

Key developments in FY2021

Copper production **increased by 20 percent to 205 kilotonnes (kt)** (172 kt in FY2020), reflecting improved smelter performance and strong underground mine performance. This was the **highest annual copper production since Olympic Dam was acquired in 2005. Record gold production of 146 thousand troy ounces (koz)** was also achieved.

The short-term focus remains on completing the multi-year asset integrity program designed to improve the reliability of operations, which is on track heading into a planned major smelter maintenance campaign in FY2022. A new refinery crane commenced operation in FY2021 to improve stability and reliability at the electrorefinery.

At Oak Dam, next stage resource definition drilling commenced in May 2021 to inform resource characterisation and potential development pathways.

Flinders University Radon Facility – purpose built, small animal radon chamber for environmentally relevant exposures

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Radon is widely stated to be the second leading cause of lung cancer after cigarette smoking. Multivariate risk models, epidemiology studies and risk derived from uranium miner data have been used to predict lung cancer risk from residential or workplace radon exposure. However, some have contested this interpretation. We have designed and constructed a 3.1 m^3 radon chamber to examine radon exposure to small animals. The chamber is designed to operate as a sealed enclosure with a controlled atmosphere containing a known concentration of radon and its radioactive decay products. Sensors for air flow rate, temperature, humidity, HEPA filter and differential pressure ensure an optimal environment for exposure subjects. Radon gas is supplied to the chamber from a generator containing 320 kBq of radium in a dilute acid solution. Air containing radon is pumped continuously at 1 L per minute to maintain a steady state supply that can be fully or partially injected into the chamber to maintain a stable, required dose for experimentation (radon injection vs time curve, R^2 = 0.9897). Particles are injected into the re-circulating air stream via a particle generator to provide condensation nuclei (CN) for attachment of radon decay products as they form in the chamber atmosphere. A desired Equilibrium Factor can easily be achieved by varying the air circulation rate through the chamber and HEPA filter (equilibrium factor vs flow rate curve, R^2 = 0.9596). We found adult male Sprague Dawley rats generate potential CN particles of 0.3 µm, 0.5 µm and 5.0 µm, where the majority is 0.3 µm. Rat generated CN particles at 0.3 µm peak within the first hour inside the chamber (2 rats - $5.62 \times 10^6 \pm 1.92 \times 10^5/m^3$, 4 rats – $1.01 \times 10^7 \pm 3.16 \times 10^6/m^3$, 6 rats – $1.2 \times 10^7 \pm 2.17 \times 10^6/m^3$). Currently, we are not aware of any other radon chamber designed specifically to investigate environmentally relevant exposure time and doses of radon gas and decay products in small animal models.

Conceptualisation and Modelling of Human Exposure to Sources of Radiation in Arid and Semi-Arid Zones of Australia

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Some Indigenous communities in Australia are exposed to both anthropogenic and natural sources of radiation. Anthropogenic sources of radiation stem from mining activities and the fallout from nuclear trials conducted in the Montebello Islands (Western Australia) and Maralinga (South Australia) [1-3]. Natural sources of radiation stem from the naturally occurring radioisotopes present in the environment.

The presence of anthropogenic sources in the local environment leads to the increased radiation exposure of the local communities. The exposure routes include, consumption of food sources (bush tucker), consumption of water, proximity to exposed soil and the inhalation of airborne dust [1-3]. Human exposure modeling can be used to predict the annual dose received from various exposure routes, however, there is currently to model representing semi-arid and arid environments of South Australia. A qualitative model representing this environment and its people's unique relationship therein is required for an accurate prediction of the annual dose received by local Indigenous communities.

Past assessments [2,3] of the exposure to humans from the nuclear trials conducted at Maralinga have shown that there is no longer a radiation exposure concern (after remediation) to the local community outside the land-use restricted zones. However, due to the conservative nature (high screening levels for greater reassurance) of these assessments, the focus was on the exposure produced by plutonium as this was the most prevalent source of radiation in the area.

The other main anthropogenic radiation sources in the Maralinga area are Uranium-235/238 and their daughter products (used during the nuclear trials). The characterisation of these products is important since the soluble fraction of uranium varies with the presence of depleted uranium [4]. An increase in solubility leads to a higher bioavailability and, therefore, increased radiation exposure.

The origin of these sources (i.e. explosive dispersal) also differs to the origin of uranium from mining activities [2,3]. Therefore, the behaviour of these uranium sources and their daughter products may vary significantly, providing motivation for site-specific data. This data will help provide a more detailed understanding of the mechanisms and mobility of these contaminants and increase confidence about negligible radiation risks.

A generic model can be used to predict the exposure present in different scenarios, such as, extended occupation of land-use restricted zones or reverting back to traditional diets. This will help enable development in the community (e.g. tourism), assist in passing knowledge to future generations and maintain the traditional culture of the local community.

[1] TECHNICAL ASSESSMENT GROUP, "Rehabilitation of former nuclear test sites in Australia," Australian Government Publishing Service (1990).

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[3] O'Brien, R.S., Green, L., Long, S., Carpenter, J. and Grzechnick, M., 2012. Maralinga and Oak Valley dose assessment-2011. ARPANSA.

[4] Di Lella, L.A., Nannoni, F., Protano, G. and Riccobono, F., 2005. Uranium contents and 235U/238U atom ratios in soil and earthworms in western Kosovo after the 1999 war. Science of the total environment, 337(1-3), pp.109-118.

Correction factor for calibration of SPA-3 probe when measuring I-131 released from a reactor incident

Stephen Hughes[1], **Ajay Thomas**[1], Aithan Roufos[1], Emily Clark[1], John Bus[1], Stewart Gill[2], Prashant Maharaj[1], Andrew Popp[1]

1 ANSTO, Radiation Protection Services

2 ANSTO, Instrument Calibration Facility

A core meltdown from a nuclear reactor may involve the accidental release of a variety of fission products, including several radioactive isotopes of iodine (radioiodines). The ARPANSA document *RPS G-3 Part 2* (Guide for Radiation Protection in Emergency Exposure Situations – Planning, Preparedness, Response and Transition) defines Operational Intervention Levels (OILs) as measurable values that determine the need to implement certain protective actions in the aftermath of a nuclear emergency. The activity of Iodine-131 (I-131) in air (i.e. in-plume concentration) is collected using a charcoal air sampling cartridge, with the activity being measured using a contamination monitor. This result is one important OIL value used to decide if thyroid blocking with stable iodine is required, or if other protective measures are to be implemented. However, monitoring in-plume with a charcoal cartridge will collect all radioiodine present, not just I-131.

A sodium iodide scintillation probe (SPA-3) is used in the field to help quantify the activity level on the charcoal cartridge. The instrument requires a calibration factor to convert the measured reading in cps (counts per second) to an activity in kilobecquerels of mixed radioiodine. The calibration factor is determined from reference and experimental data, including the abundance ratio of each radioiodine to I-131 (given by the *2000 Reference Accident*), the probability of each gamma emission (from reference data) and the efficiency of the SPA-3 probe for I-131. The efficiency is obtained experimentally using a charcoal cartridge spiked with a known activity of I-131. A conversion factor should also be applied to account for the different radioiodines measured.

To conservatively calculate the conversion factor, several assumptions must be made. It is assumed that the ratio of radioiodines to I-131 is independent of reactor type and power; that the only nuclides trapped in the charcoal cartridge are radioiodines; and that the radioiodine will be near to the surface of the cartridge, given the short sampling time.

POSTERS

Comparison between high-purity germanium detectors for measurement of ^{210}Pb in sediments

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The measurement of ^{210}Pb has been inter-compared between multiple gamma-ray spectrometry detector models, using a set of samples of estuarine sediment from Singapore.

The 22.3-year half-life of ^{210}Pb and its pathway into sediments via meteoric precipitation make ^{210}Pb an extremely useful radionuclide for dating sedimentary processes over multi-decadal timescales up to about a century. Applications include quantifying build-up of young sedimentary deposits in streams, fluvial, marine and estuarine environments. Atmospheric ^{222}Rn decays over about 4 days via daughters ^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po to ^{210}Po. These daughters and ^{210}Pb will attach to atmospheric particulates, which are then caught by rainfall and accumulate on soil surfaces. The unsupported daughters decay rapidly to ^{210}Pb, and the total unsupported ^{210}Pb may accrue in the sediment upper layers or be transported into waterways. The ^{210}Pb will therefore exist in higher concentrations ("excess") than other ^{238}U daughters in these young sedimentary layers, and the ratio of unsupported ^{210}Pb to supported ^{210}Pb down the section provides a sedimentation rate dating technique.

Accurate quantification of both ^{210}Pb and the rest of the ^{238}U decay chain is required for an accurate estimation of the ^{210}Pb excess. Key considerations are that the ^{210}Pb gamma emission is low-energy (46.5 keV) and therefore strongly affected by matrix re-absorption in the sample, the sample containers, and the material housing the gamma detector.

The sample set was previously measured on a Canberra planar broad energy detector. The sample set is now re-prepared and measured on two newer Canberra detectors: a small anode germanium 16 mm well detector (SAGe Well), and a newer broad energy germanium detector (BEGe). The measurement efficiency for these newer detector types and the estimation of the ^{210}Pb excess over the ^{238}U decay chain is compared with the previous dataset acquired on the planar coax detector.

In this sample set ^{210}Po is in secular equilibrium with ^{210}Pb and can be used as a proxy measurement for ^{210}Pb. Alpha spectrometry of ^{210}Po was therefore used to compare with results for ^{210}Pb acquired by gamma spectrometry.

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EXHIBITION FLOOR PLAN

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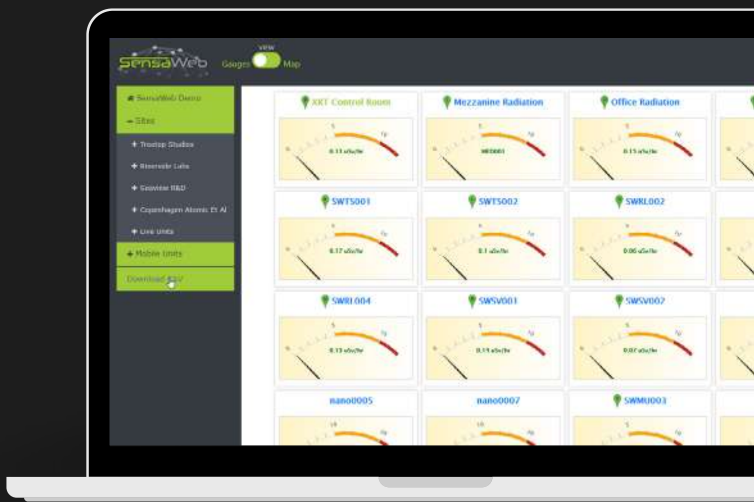

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