UOW Research Themes

Centre for Medical Radiation Physics (CMRP)

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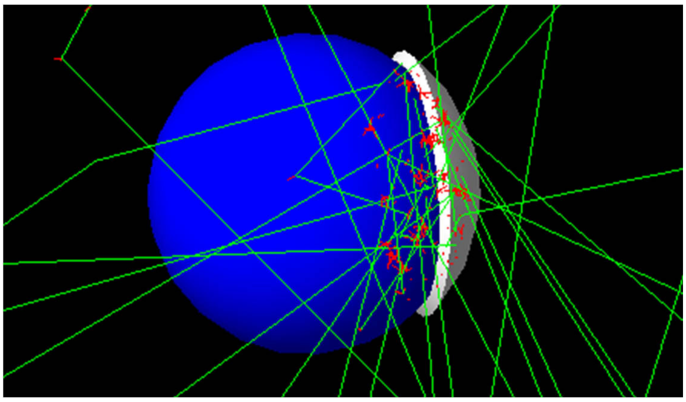

Overview

The Centre for Medical Radiation Physics (CMRP) has brought together academics, clinical medical physicists and physicians to create a unique environment for education and multidisciplinary research in Medical Radiation Physics to improve methods of cancer diagnosis and radiotherapy.

Our core objectives are:
• Excellence in research and development in the field of radiation detectors and radiation instrumentation for minidosimetry, microdosimetry and nanodosimetry for use in radiation therapy, nuclear medicine, radiology, space and high energy physics applications
• Excellence in education and training in medical physics through our comprehensive postgraduate research program and strong national and international collaboration
• Excellence in translational research from bench–to-the-bed and commercialisation of research and development for improvement of cancer treatment outcomes
• Development and application of new radiation oncology modalities including:
  • proton and heavy-ion therapy
  • synchrotron microbeam therapy
  • intensity modulated radiotherapy (IMRT)
  • volumetric modulated arc therapy (VMAT)
  • image guided radiotherapy (IGRT)
  for new methods of radiotherapy and cancer diagnosis

Key People

Professor Anatoly Rozenfeld is the director and founder of the CMRP and leads the research and educational program of centre. The CMRP has three dedicated research streams with designated leaders:
• Radiation Oncology Physics (Prof Peter Metcalfe)
• Radiation Instrumentation (Dr Michael Lerch)
• Micro-Nano Dosimetry and Hadron Therapy (Prof Anatoly Rozenfeld)
The CMRP currently has 6 academic staff members, 4 appointed staff scientists and 20 adjunct clinical medical physicists and physicians and 46 postgraduate students. A number of clinical radiation physicists and physicians are involved in lecturing and research at the CMRP.

Key Research Projects & Competencies

Radiation Oncology – Radiotherapy Physics stream

• Image Guided Radiotherapy / Adaptive Radiotherapy and advanced dosimetry
• Brachytherapy for prostate and eye cancer treatment and advanced dosimetry
• Synchrotron Microbeam Radiation Therapy and advanced dosimetry
• Radio-Magneto-Therapy and MRI guided-Linac radiotherapy and dosimetry for that
• Stereotactic Radio-Surgery advanced dosimetry

Radiation Detection and Instrumentation stream

• Semiconductor real time dosimetry for quality assurance (QA) in external beam radiotherapy and brachytherapy (MOSkin dosimetry, spectroscopy dosimetry, Medipix BrachyView, Dose Magnifying Glass, Magic Plate, neutron dosimetry).
• Neutron semiconductor detectors
• Radiation probes, Silicon photomultiplier (SiPM) PET detector modules
• PET gantry for small animal imaging
• Radiation detectors for synchrotron radiation therapy and imaging
• Radiation instrumentation for high energy physics and homeland security

Micro- and nano-dosimetry and hadron therapy modalities stream

• Silicon microdosimetry for radiotherapy, space, and avionics
• Proton therapy: proton computer tomography, proton dosimetry
• Radiobiology for hadron therapy and radio-magneto therapy
• Monte Carlo radiation transport simulations including on DNA level.

Research Partnerships

The CMRP is an active member of the Illawarra Health and Medical Research Institute (IHMRI) and has strong partnerships in education and translational research in medical radiation physics with:
• Illawarra Cancer Care Centre
• St George Cancer Care Centre
• Liverpool Hospital
• Ingham Institute
• Prince Of Wales Hospital
• Westmead Hospital

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Other collaborating institutions in Australia are:
• Peter MacCallum Cancer Centre
• Institute of Medical Physics, University of Sydney
• Imaging Physics Laboratory, Brain and Mind Research Institute
• University of New South Wales Semiconductor Nanofabrication Facility
• Australian Nuclear Science and Technology Organisation (ANSTO)
• Australian Synchrotron
• University of Melbourne

Collaborating overseas institutions include:
Advanced radiation therapy and dosimetry:
• Memorial Sloan Kettering Cancer Care Centre (USA)
• Department of Human Oncology and Medical Physics, University of Wisconsin (USA)

Proton therapy, proton computed tomography, microdosimetry and nanodosimetry:
• Francis H. Burr Proton Therapy Center, Massachusetts General Hospital (USA)
• James M. Slater Proton Therapy Treatment and Research Center, Loma Linda University Medical Center (USA)
• Weizman Institute of Science (Israel)
• Physikalisch-Technische Bundesanstalt (PTB) (Germany)

Space radiation medicine
• US Naval Academy
• National Space Biomedical Research Institute (USA)
• Brookhaven National Laboratory (USA)

High Energy Physics
• CERN, the European Organisation for Nuclear Research and MEDIPIX (Prague Technical University) collaboration

Synchrotron therapy and imaging
• European Synchrotron Radiation Facility (ESRF)

Semiconductor radiation detectors
• Polytecnico di Milano (Italy)
• University of Perugia (Italy)

Nuclear medicine
• Department of Medical Physics and Bioengineering, University College London (UK)

Industrial partners supporting and collaborating with CMRP include:
Radiation detectors and instruments
• ANSTO and CSIRO (Australia)
• Scintech (USA), Institute of Scintillating Materials (Ukraine),
• Institute for Microelectronics and SPA-BIT (Ukraine)

Radiation therapy
• Insight Oceania P/L
• Varian Medical systems
• Siemens
• Ingham Institute
• Australian Synchrotron
• Proton Therapy Australia

Research Outcomes
Surface Dosimetry
The MOSkin™, a novel MOSFET detector developed by the Centre for Medical Radiation Physics, University of Wollongong, has been engineered to provide real time surface dose measurements for radiotherapy. These surface doses include skin dose (scalp, breast) and cavity dose (rectal wall) for both external beam radiotherapy (IMRT, tomotherapy) and high dose rate (HDR) brachytherapy.
The MOSkin™ detector has a very small physical size, making the MOSkin™ detector ideal for surface dose measurements within high dose gradient radiation fields.

Proton Therapy
The rationale for using protons in radiotherapy treatments is due to the physical characteristics of proton energy deposition in tissue. Using proton therapy allows the same dose of radiation to be delivered to the tumour as with other radiotherapy techniques, but with less dose delivered to the surrounding healthy tissue.
The CMRP in conjunction with the Francis H Burr Proton Therapy Center at Massachusetts General Hospital, Boston and LLUMC, USA is working to characterise the doses delivered to the healthy tissue during proton therapy treatments using SOI silicon microdosimetry detectors developed at CMRP and novel detector developed in collaboration with Politecnico di Milano. This novel detector allow identification of the particle types incident upon the detector surface. This is of great importance for patients due to the different radiobiological characteristics of different particle types. Accurate characterisation of the doses and particle types delivered to the healthy tissue is imperative in quantifying the benefit of proton therapy compared to other radiotherapy modalities.

External Beam Radiotherapy Verification
Stereotactic Radiosurgery (SRS) is the use of small radiation beams to treat small tumours (less than 4cm diameter), usually delivered as one large dose. The target is often located close to critical organs which must be avoided using high precision beams. Helical tomotherapy is a complex radiation therapy delivery system where the patient is moved through a rotating treatment beam, resulting in a helical (spiral) beam around the patient. A multileaf collimator is used to vary the dose pattern during helical tomotherapy.

Both stereotactic radiosurgery and helical tomotherapy require new quality assurance tools to ensure accuracy of treatment delivery.

The Dose Magnifying Glass (DMG) introduced by CMRP is a 128-channel silicon detector, allowing the measurement of varying radiation fields in small steps of 0.2mm. The DMG was used in the quality assurance of the SRS and helical tomotherapy.

Intensity modulated radio therapy (IMRT)

IMRT uses a linear accelerator (linac) with a multileaf collimator on the exit of the beam to vary the shape of the beam, allowing a dose pattern which matches the tumour shape to be delivered at varying angles about the patient. As the beam shape is constantly changing during treatment, quality assurance tools are necessary to verify the beam shape and intensity. The magic plate, a thin flat panel containing an array of silicon radiation detectors, has been developed by the CMRP to provide this quality assurance for IMRT. A real time output display allows the direct and immediate comparison of the computer planned beam shape and intensity with the beam shape and intensity being delivered to the patient.

Microbeam Radiotherapy

Microbeam Radiation Therapy (MRT) is a novel method for the treatment of otherwise untreatable paediatric brain tumours. MRT uses a synchrotron generated X-ray beam shaped into several (~50-100) rectangular microbeams (~25-50 micrometres wide) to exploit an unexplained radiobiological phenomenon. The treatment dose delivered causes the death of tumourous tissue, but does no observable harm to the healthy brain tissue. CMRP has designed, and is developing and testing a unique ultra-high spatial resolution, real-time treatment dosimetry system for MRT. A microbeam intensity profile, the CMRP detector chip (inset 1) and detector mounted in a solid water phantom (inset 2) is shown in the figure above. This system will ensure that treatments are delivered effectively and safely and will help bring this treatment to the wider community, both nationally and internationally. Collaborators include the European Synchrotron Radiation Facility, France, and recently, the Australian Synchrotron.

Monte Carlo Computer Simulations

Named after the gambling city, Monte Carlo computer simulations are so named as they are calculations based on random numbers, similar to games of chance. The interactions of radiation within materials occur randomly, with each type of interaction occurring with known probabilities. By programming these probabilities into a computer simulation, individual radiation particles may be projected virtually through a model , with the overall effect of a large number of radiation events giving a prediction of the effects of radiation within the modelled system.

Monte Carlo computer simulations are used by the CMRP to both study the radiation dosimetry from new and existing cancer treatments, as well as to optimise the design of radiation detectors developed within the centre. Almost every research project within the CMRP is supported by Monte Carlo computer simulations, with our centre containing the largest medical physics dedicated supercomputer in Australia.

CONNECT:
UOW RESEARCH

UOW Research Themes

- Environmental Sustainability Past, Present and Future
- Innovative Materials, Engineering and Manufacturing
- Health and Medical Research
- Information and Mathematical Sciences
- Society, Policy and Culture

UOW Research Strengths

UOW Research Strengths	Environmental Sustainability Past, Present and Future	Innovative Materials, Engineering and Manufacturing	Health and Medical Research	Information and Mathematical Sciences	Society, Policy and Culture
Australian Health Services Research Institute			■	■	■
Centre for Archaeological Sciences	■				
Centre for Health Initiatives			■		■
Centre for Medical Bioscience			■		
Centre for Medical Radiation Physics			■		
Centre for Medicinal Chemistry			■		
Centre for Statistical & Survey Methodology	■			■	
Engineering Manufacturing	■	■			
Engineering Materials Institute	■	■			
GeoQuEST Research Centre	■				
Information & Communication Technology Research Institute				■	
Institute for Conservation Biology & Environmental Management	■				■
Institute for Innovation in Business & Social Research	■				■
Institute for Mathematics & its Applications	■			■	
Institute for Social Transformation Research					■
Institute for Superconducting & Electronic Materials	■	■	■		
Institute for Transnational & Maritime Security					■
Intelligent Polymer Research Institute / COE for Electromaterials Science	■	■	■		
Interdisciplinary Educational Research Institute			■	■	■

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