David C. Radford
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Department of Energy Project Director for LEGEND-1000
https://www.ornl.gov/staff-profile/david-c-radford

Major Scientific Accomplishments

Dr. Radford is the U.S. Department of Energy Project Director for LEGEND-1000, an ORNL-led international nuclear physics experiment that will use a ton-scale detector array, shielded from background radioactivity in an underground laboratory, to seek the hypothesized, extremely rare, neutrinoless double beta decay. If found, this decay would demonstrate that Lepton Number is not a conserved quantity, help explain why the cosmos contains more matter than anti-matter, and dramatically revise our understanding of the universe—especially neutrinos, electrically neutral particles that interact only weakly with matter. Radford oversees project management and funding of DOE Office of Science contributions, which include experiment design and planning for project execution. Prior, he was the Deputy Director of the Majorana Demonstrator (MJD), LEGEND-1000's predecessor experiment. Led by DOE's ORNL, the MJD showed that a sensitive, large-mass, enriched-germanium-76 (^{76}Ge) detector array could be scaled up to the ton-scale with very low background radioactivity. This experiment completed data collection in 2022 and produced the second-best lifetime limit and best energy resolution of any ^{76}Ge neutrinoless double beta decay experiment.

Pioneering background rejection algorithms and data analysis codes for MJD and LEGEND, Radford invented digital-signal processing algorithms to reject events from alpha-particles hitting passivated surfaces (the dominant source of background in the MJD) and beta- and gamma-ray events in the lithium n+ contact of the detectors.

Radford invented the Inverted-Coaxial Point Contact HPGe detector design. He prototyped, studied, and further developed the invention using DOE economic stimulus funds and ORNL LDRD funds. This invention was commercialized as the SAGe Well detector by Canberra/Mirion. The design was a critical innovation for LEGEND-200 and LEGEND-1000, reducing the number of detectors threefold and thereby reducing the background by a similar factor. The invention is also beginning to be used as a detector for radioactive decay studies and for neutrino–nucleus coherent elastic scattering detection.

Radford developed the signal-decomposition algorithms and software (and other digital signal processing software) for the gamma-ray tracking array GRETINA/GRETA. Both speed and accuracy are crucial to this application. Since the processing is done in real time, the speed of the code determines the rate of events that the detector array can produce. The accuracy determines the energy resolution, efficiency, and peak-to-background ratio of the array. Radford's original codes are still in use and are being adapted for GRETA, currently under construction for use in experiments at the Facility for Rare Isotope Beams at Michigan State University and the Argonne Tandem Linac Accelerator System stable-beam facility at Argonne National Laboratory. His innovations improve the reconstruction of energies and three-dimensional positions of gamma-ray interactions for unprecedented efficiency and resolution as well as good background rejection. GRETINA is in high demand for experiments at both accelerator facilities and has produced numerous high-profile published results using stable and radioactive beams.

Radford wrote the "RadWare" software (escl8r, levit8r, and others) for interactive analysis of in-beam gamma-ray spectroscopy data sets that is still in very active use worldwide. His software is used extensively in complex analyses of large, high-dimensional data sets studying superdeformation, rotational bands, shape transitions, and single-particle excitations in nuclei. Two sole-author publications from 1995 now have over 1200 and 170 citations, respectively. Example RadWare applications are in papers 9 and 10 cited below as well as *Svensson, C.E. et al, Superdeformation in the N = Z nucleus ^{36}Ar: Experimental, deformed mean field, and spherical shell model descriptions, Physical Review Letters 85, 2693 (2000).* (*166 citations)*

Radford developed ground-breaking tools and techniques for the study of unstable neutron-rich nuclei using in-beam gamma-ray spectroscopy with neutron-rich beams from the Holifield Radioactive Ion Beam Facility. This work produced measurements of Coulomb excitation, single-neutron transfer reactions, and nuclear magnetic moments. These techniques allowed for the highly productive use of the HRIBF neutron-rich beams that were too weak and short-lived for standard experiments (one example is in paper 7 cited below).

Professional Experience Summary

- Section Head, Fundamental Nuclear and Particle Physics, Oak Ridge National Laboratory, December 2020 – Present
- Interim Division Director, Physics Division, Oak Ridge National Laboratory, April 2018 – June 2019
- Group Leader, Nuclear Structure Group and Majorana and Advanced Detectors Group, Oak Ridge National Laboratory, January 2013 – April 2018

- UT-Battelle Corporate Fellow, Oak Ridge National Laboratory, June 2015 – Present
- Adjunct Professor, Department of Physics and Astronomy, University of North Carolina at Chapel Hill, 2012 – Present
- Research Staff / Senior Research Staff / Distinguished Research Staff, Oak Ridge National Laboratory, May 1997 – Present
- Research Scientist / Senior Research Scientist, Atomic Energy of Canada Limited, January 1985 – April 1997
- Research Associate, Physics Division, Argonne National Laboratory, February 1983 – December 1984
- Visiting Research Scientist, Centre de Recherches Nucléaires, Strasbourg, June 1981 – January 1983
- Research Staff Physicist, Wright Nuclear Structure Laboratory, Yale University, October 1978 – April 1981

Education

- B.Sc. Physics, University of Auckland, 1974
- Ph.D. Nuclear Physics, University of Auckland, 1978

Select Awards and Recognitions

- UT-Battelle Corporate Fellow (2015)
- Fellow of the American Physical Society (2006)
- Discovery Award of the Atomic Energy of Canada Limited (1995)
- University of Auckland Senior Physics Prize (1976)

Select Service

- Member, NSAC Long Range Plan Resolution Committee, 2023
- Member, FRIB Program Advisory Committee, 2023 – Present
- Member, LEGEND Collaboration Steering Committee and LEGEND Institutional Board, 2016 – Present
- Chair, GRETA Technical Advisory Committee, 2016 – Present
- Member, *Physical Review C* Editorial Board, 2016 – 2018
- Member, NSAC Long Range Plan Resolution Committee, 2015
- Member, DNP Program Committee, 2014 – 2016
- Chair, GRETINA Advisory Committee, 2004 – 2016
- Chair, GRETINA Electronics Working Group, 2003 – 2012
- Chair, Majorana Executive Committee, 2009 – 2010
- Chair, ATLAS Program Advisory Committee (ANL), 2003 – 2009
- Chair, GAMMASPHERE Users Executive Committee, 2005 – 2010
- Member, RIKEN RIB Factory Program Advisory Committee for Nuclear-Physics Experiments, 2006 – 2008
- Numerous DOE-NP and NSF reviews, including:
  - NSF Particle Astrophysics Review Panel, 2017
  - DOE Nuclear Structure / Nuclear Astrophysics Review Panel, 2014
  - NSCL (MSU) NSF Site Review Committee, 2014
  - CUORE CD-2 and Annual Reviews, 2009 – 2013
  - ATLAS (ANL) DOE Site Review Committee, 2006 – 2007
  - DOE SBIR proposals, NSF Merit Reviews
- Referee for *Physical Review Letters, Physical Review C, European Journal of Physics, Nuclear Instr. and Methods*, and *IEEE Transactions on Nuclear Science*
- As a mentor, Radford has directly supported and coached more than 10 postdoctoral fellows at ORNL, even while serving in leadership roles. Select examples of mentee successes include:
  - Dr. Ren Cooper, now a Senior Scientist at LBNL, where he is the Deputy Head of the Applied Nuclear Physics Program and the Deputy Director of the Nuclear Science Division.
  - Dr. Karin Lagergren, now working on AI-driven data analysis for the Whispr group in Sweden.
  - Dr. Mitch Allmond, now an R&D Staff scientist in the ORNL Physics Division, who has co-led the development of the FRIB Decay Station Initiator and produced exciting new results from the first FRIB experiments.
- In Dr. Radford's role as Adjunct Faculty at UNC, he has additionally mentored numerous graduate students. One, UNC graduate student Morgan Clark, was able to continue to be mentored by Radford at ORNL in 2022 under the Office of Science Graduate Student Research (SCGSR) program. (She received her PhD from UNC in 2023.)

Selected Publications

Complete publications include 313 articles in refereed journals and conference proceeding; over 10,000 citations; H-index: 49 (Web of Science), 51 (Scopus), 59 (Google Scholar); and Ref 8 below, a sole-author paper with over 1200 citations.

1. *N. Abgrall et al. (LEGEND Collaboration), LEGEND-1000 Preconceptual Design Report, arXiv:2107.11462 [Submitted on 23 Jul 2021].* (79 citations) – While not yet published, this preconceptual design report represents the culmination of years of work in developing the LEGEND-1000 ton-scale experiment to search for Neutrinoless Double-Beta Decay in ^{76}Ge. ORNL is the DOE lead laboratory, and Radford is the DOE Project Director. The 2021 Portfolio Review was extremely complimentary, and the team is supported to pursue CD-1 for the project.

2. *I. J. Arnquist et al. (Majorana Collaboration), Final Result of the Majorana Demonstrator's Search for Neutrinoless Double-β Decay in Ge-76, Physical Review Letters 130, 062501 (2023).10.1103/PhysRevLett.130.062501.* (18 citations) – Results from the MJD, the predecessor experiment to LEGEND, for which ORNL was the lead laboratory and Radford was the Deputy Project Director.

3. *C. E. Aalseth et al. (Majorana Collaboration), Search for Neutrinoless Double-Beta Decay in Ge-76 with the Majorana Demonstrator, Physical Review Letters 120, 132502 (2018). 10.1103/PhysRevLett.120.132502.* (163 citations) – Results from the MJD.

4. *S. Paschalis et al., The Performance of the Gamma-Ray Energy Tracking In-beam Nuclear Array GRETINA, Nuclear Instruments & Methods in Physics Research Section A - Accelerators Spectrometers Detectors and Associated Equipment 709, 44 (2013), 10.1016/j.nima.2013.01.009.* (198 citations) – Radford developed all the digital signal processing algorithms and code for extracting the number, positions, and energies of gamma-ray interactions in the GRETINA detectors (signal decomposition). The accuracy and speed of those algorithms are crucial for GRETINA's performance.

5. *R.J. Cooper et al., A Novel HPGe Detector for Gamma-ray Tracking and Imaging, Nuclear Instruments & Methods in Physics Research Section A - Accelerators Spectrometers Detectors and Associated Equipment 665, 25 (2012). 10.1016/j.nima.2011.10.008.* (41 citations) – Radford invented the ICPC detector that has now been commercialized and adopted as the detector of choice for LEGEND and that is in use for Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) experiments.

6. *C.E. Aalseth et al., Results from a Search for Light-Mass Dark Matter with a p-Type Point Contact Germanium Detector, Physical Review Letters 106, 131301 (2011).* (684 citations) – First use of a p-type point contact HPGe detector for fundamental physics.

7. *D.C. Radford et al., Coulomb Excitation of Radioactive Te-132,Te-134,Te-136 Beams and the Low B(E2) of Te-136, Physical Review Letters 88, 222501 (2002). 10.1103/PhysRevLett.88.222501.* (148 citations) – Radford pioneered both Coulomb-excitation and neutron-transfer experiments with heavy neutron-rich radioactive ion beams at HRIBF.

8. *D.C. Radford, ESCL8R and LEVIT8R - Software for Interactive Graphical Analysis of HPGe Coincidence Data Sets, Nuclear Instruments & Methods in Physics Research Section A - Accelerators Spectrometers Detectors and Associated Equipment 361, 297 (1995). 10.1016/0168-9002(95)00183-2.* (1223 citations) – Sole-author paper for Radford's software for analysis of gamma-ray data is still used extensively world-wide.

9. *S. Flibotte et al., Delta-I=4 Bifurcation in a Superdeformed Band - Evidence for a C(4) Symmetry, Physical Review Letters 71, 4299 (1993). 10.1103/PhysRevLett.71.4299.* (161 citations) – A major unresolved puzzle concerning an apparent C(4) symmetry exhibited by identical superdeformed high-spin bands around Gd-149.

10. *D.C. Radford et al., Multiple Band-Structure and Band Termination in Ho-157 - Towards Complete High-Spin Spectroscopy, Nuclear Physics A 545, 665 (1992). 10.1016/0375-9474(92)90298-X.* (75 citations) – The first application of ESCL8R (ref 8 above) to a detailed gamma-ray coincident data set; served as a model for many future analyses.