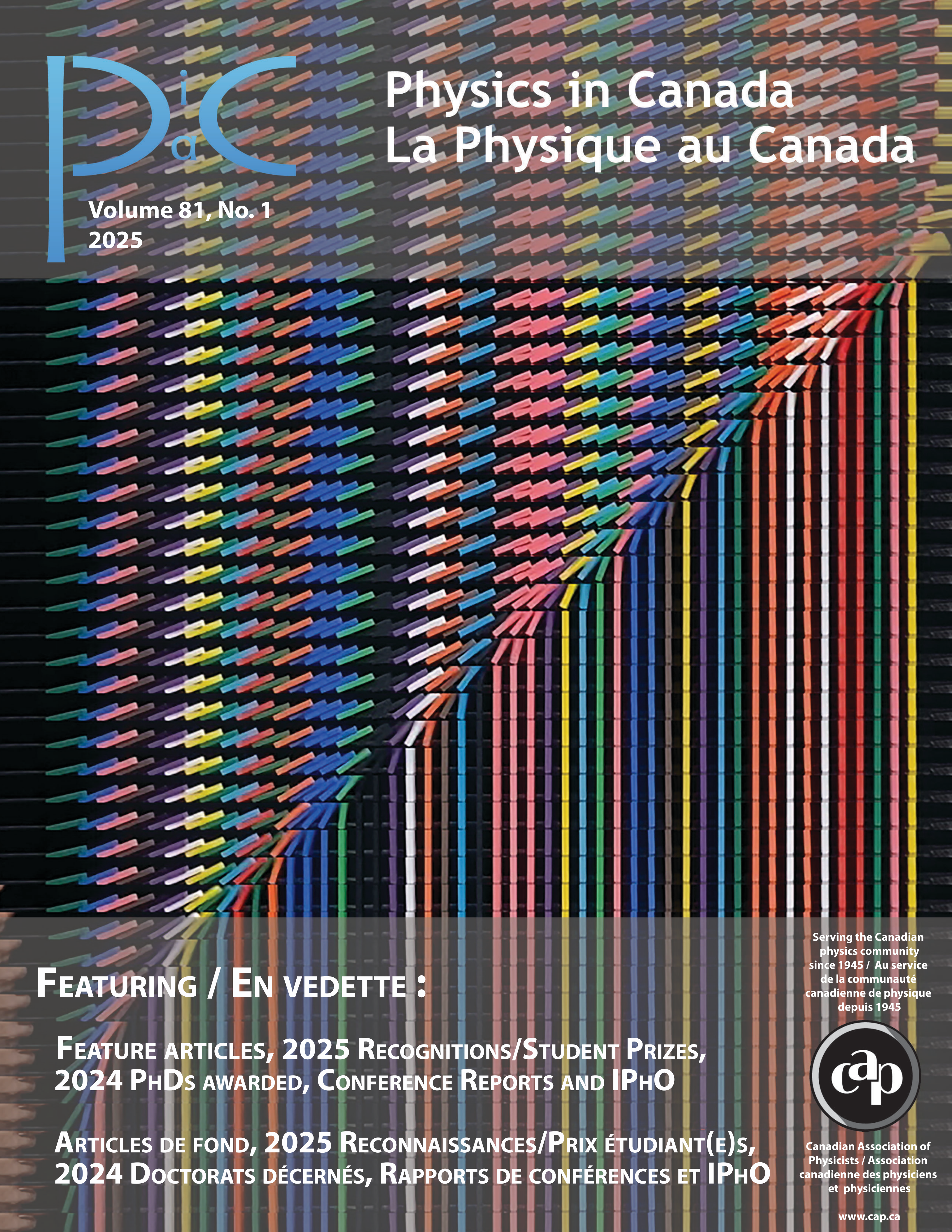

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Physics in Canada
La Physique au Canada

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Feature articles, 2025 Recognitions/Student Prizes, 2024 PhDs awarded, Conference Reports and IPhO

Articles de fond, 2025 Reconnaissances/Prix étudiant(e)s, 2024 Doctorats décernés, Rapports de conférences et IPhO

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Dominos falling in spacetime

The wave that travels along a chain of falling dominos has a speed which depends on the spacing of the dominos. Narrow spacings produce faster waves. The wave briefly converts the gravitational potential energy of the standing-up dominos into a pulse of kinetic energy as they fall. When the wave has passed, the dominos come to rest in a lower potential energy configuration. The difference in potential energy is dissipated by the inelastic collisions, and by the friction of each domino sliding down the back face of the one ahead. Because the motion is highly dissipative and involves a sequence of discontinuous collision events, the speed of the wave is difficult to calculate from basic physics. But measuring it makes an easy and fun experiment. We made videos of falling dominos and studied the speed of the wave as a function of the spacing. By extracting rows of pixels from video frames and stacking them, a spacetime image can be obtained. This image shows the spacetime view of a wave for a 2cm spacing, with time running upward. After a short transient, the wave achieves a speed of 98 cm/s. View an experimental video made by undergraduate student Theepiga Jeyasingham.

by **Stephen Morris**
Professor Emeritus, Department of Physics, University of Toronto

Dominos tombant dans l'espace-temps

La vitesse de la vague qui se propage le long d'une chaîne de dominos tombants dépend de l'espacement entre les dominos. Un espacement réduit produit des vagues plus rapides. La vague convertit brièvement l'énergie potentielle gravitationnelle des dominos debout en une impulsion d'énergie cinétique lorsqu'ils tombent. Une fois la vague passée, les dominos s'immobilisent dans une configuration d'énergie potentielle plus faible. La différence d'énergie potentielle est dissipée par les collisions inélastiques et par le frottement de chaque domino glissant sur la face arrière de celui qui le précède. Comme le mouvement est très dissipatif et implique une séquence de collisions discontinues, la vitesse de l'onde est difficile à calculer à partir des principes fondamentaux de la physique. Mais la mesurer constitue une expérience facile et amusante. Nous avons réalisé des vidéos de dominos tombant et étudié la vitesse de la vague en fonction de l'espacement. En extrayant des rangées de pixels des images vidéo et en les empilant, on peut obtenir une image spatio-temporelle. Cette image montre la vue spatio-temporelle d'une vague pour un espacement de 2 cm, le temps s'écoulant vers le haut. Après une brève transition, la vague atteint une vitesse de 98 cm/s. Visionnez une vidéo expérimentale réalisée par un étudiant de premier cycle Theepiga Jeyasingham.

par **Stephen Morris**
Professor Emeritus, Department of Physics, University of Toronto

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Canadian Association of Physicists (CAP)
Association canadienne des physiciens et physiciennes (ACP)

The Canadian Association of Physicists was founded in 1945 as a non-profit association representing the interests of Canadian physicists. The CAP is a broadly-based national network of physicists working in Canadian educational, industrial, and research settings. We are a strong and effective advocacy group for support of, and excellence in, physics research and education. We represent the voice of Canadian physicists to government, granting agencies, and many international scientific societies. We are an enthusiastic sponsor of events and activities promoting Canadian physics and physicists, including the CAP's annual congress and national physics journal. We are proud to offer and continually enhance our web site as a key resource for individuals pursuing careers in physics and physics education. Details of the many activities of the Association can be found at http://www.cap.ca. Membership application forms are also available in the membership section of that website.

L'Association canadienne des physiciens et physiciennes a été fondée en 1946 comme une association à but non-lucratif représentant les intérêts des physicien(ne)s canadien(ne)s. L'ACP est un vaste regroupement de physiciens et de physiciennes oeuvrant dans les milieux canadiens de l'éducation, de l'industrie et de la recherche. Nous constituons un groupe de pression solide et efficace, ayant pour objectif le soutien de la recherche et de l'éducation en physique, et leur excellence. Nous sommes le porte-parole des physicien(ne)s canadien(ne)s auprès du gouvernement, des organismes subventionnaires et auprès de plusieurs sociétés scientifiques internationales. Nous nous faisons le promoteur enthousiaste d'événements et d'activités mettant à l'avant-scène la physique et les physicien(ne)s canadien(ne)s, en particulier le congrès annuel et la revue de l'Association. Nous sommes fiers d'offrir et de développer continuellement notre site Web pour en faire une ressource clé pour ceux qui poursuivent leur carrière en physique et dans l'enseignement de la physique. Vous pouvez trouver les renseignements concernant les nombreuses activités de l'ACP à http://www.cap.ca. Les formulaires d'adhésion sont aussi disponibles dans la rubrique « Adhésion » sur ce site.

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The Editorial Board welcomes articles from readers suitable for, and understandable to, any practising or student physicist. Review papers and contributions of general interest of up to four journal pages in length are particularly welcome. Suggestions for theme topics and guest editors are also welcome and should be sent to the Editor-in-Chief, Béla Joós, at bjoos@uottawa.ca.

Le comité de rédaction invite les lecteurs à soumettre des articles qui intéresseraient et seraient compris par tout physicien, ou physicienne, et étudiant ou étudiante en physique. Les articles de synthèse d'une longueur d'au plus quatre pages de revue sont en particular bienvenus. Des suggestions de sujets pour des revues à thème sont aussi bienvenues et peuvent être envoyées à la Redacteur-en-chef, Béla Joós, à bjoos@uottawa.ca.

Artificial Intelligence in Physics

Béla Joós, Editor-in-Chief, *Physics in Canada*

There is a huge wave of interest in artificial intelligence (AI). So ubiquitous has the term become that the acronym is usually no longer defined. The 2024 Nobel Prize in Physics was awarded to two scientists who are credited with laying the foundations of the field of AI, John Hopfield, a physicist at John Hopkins University, and Geoffrey Hinton, a computer scientist at the University of Toronto [1]. The citation reads "for foundational discoveries and inventions that enable machine learning with artificial neural networks".

The subject of AI is vast, and the hype is tremendous. It has built up over the last decade to a feverish pitch [2-5]. The acronym is being used broadly, even in areas that simply reflect the increasing power of more or less traditional computational tools. In this time of rapid change, I would like to address a few points that are relevant to our physics community, in particular the impact of AI on education, research, and employment. In these few pages, I can only touch on them to promote further inquiry and emphasize the urgency of staying informed and preparing for the (near) future.

Universities and high schools are scrambling to adjust to the easy access of powerful AI tools [6-8]. They are invading student study space like a tsunami. Rejecting the tools is no longer an option. In high schools, students who have laptops and tablets enjoy an unfair advantage over those who do not as they can quickly collect information with AI tools. In universities, programs across the board are facing increased workloads to maintain integrity and fairness in their evaluation processes. Institutions are working on guidelines to make AI an effective educational tool, but guidelines are not yet in place in most institutions [8]. Guidelines that apply to all courses, all disciplines and all types of institutions will be difficult to provide. The field is moving very fast, courses are very different, and professors want to preserve their academic freedom. At the moment it is up to each professor to set their own rules, but for the sake of the students, the rules have to be transparent, and each academic unit should strive to set clear rules. Social science disciplines must rethink the whole purpose of essays and term papers [9]. Theses are included in this challenge. The impact of AI is notably significant in Computer Science where the breakthroughs in AI are seen in real time with exponential progress. They raise questions about the future of the field and how future computer scientists should be trained [10]. Controlling student online access has for years been a struggle in Computer Science. The exponential growth in the AI tools will force some professors to forego computer-based evaluations and to return to pencil and paper exams, as has done Jure Leskovec, a Stanford University professor [10].

However, whatever the threats and challenges (and they are many), AI is bringing excitement back into learning and ultimately teaching [8]. Students can be taught to harness AI tools and go deeper into a

The contents of this journal, including the views expressed above, do not necessarily represent the views or policies of the Canadian Association of Physicists.

Comments of readers on this Editorial are more than welcome.

subject. Information is collected in minutes but the hard work begins then. The material needs to be organized and analyzed, relevant content selected and structured, and references checked. This can only be done if the foundations of the field are understood. Critical thinking cannot be taught in a vacuum. It is worth noting that AI provides valuable help to students with difficulty writing or formulating sentences or working in a language which is not their native tongue. AI can easily generate content from a few keywords, and this raw material becomes the basis to build a coherent work. By providing a wealth of material with just a few keystrokes, AI makes critical thinking sexy again. But we must be mindful that large language models collecting information for AI tools are not yet able to distinguish between high quality science and poor quality or fraudulent science, and this task will only become more difficult as fake science and fraudulent scientific publications fill up the internet [11].

We hear almost every day of new applications of AI in research, engineering and industry, ranging from the simple to the very complex, some are simply applications of our computer tools with on-time data regulating processes, instead of historical data which takes time to collect and input [2-4]. That is not really AI, even if the press calls it so. For instance, a few judiciously placed cameras along a busy road can feed data into a computer to optimize the timing of traffic lights based on the actual flow of cars instead of average data collected over weeks by teenagers sitting at intersections. AI algorithms use AI's unique ability to learn from data and identify complex patterns. AI can automate tasks and eliminate tedious work. It can write computer code and analyze data [5]. It increases productivity and makes modeling fun again. Applications are not without challenges such as algorithm bias, and privacy issues, but it is a powerful tool that will not cease to amaze us, and we should embrace it.

AI's strengths in automating routine tasks and providing powerful tools will revolutionize the work force. It will eliminate entry level jobs [5,12-16]. This is a societal problem, as those were the jobs where young graduates learned core skills in their profession and grew into the organization [5,14]. Employers need new tools to build a committed and integrated work force. A fundamental change in the structure of the workforce may occur. AI will revolutionize the nature of work at a pace not experienced probably since the industrial revolution. It is hard to predict how long this new age will last. Some wonder whether it is a just transitional situation. As with the move to increased online work and education, a significant permanent change is taking place, which should be faced with purpose [5].

Unemployment among new graduates across the world is increasing [12,13]. Over the years, a university degree has become less of a guarantee of employment. There is still the conviction that higher education is the right choice for good employment prospects on the long run as it provides intellectual growth and skills difficult to learn on one's own or on the job. But ultimately what matters is skills and not degrees. The employment challenges will likely accelerate with AI taking a more important role in all sectors of the economy. One comes across intriguing headlines that illustrate the rapidly changing employment landscape: "META is hiring entry-level roles that pay up to $290,000 a year and require little prior experience" [5,17]. META is still looking for the very best talent, but they select their new hires after extensive interviews. In many technological fields job candidates are subjected to grilling interviews, often multiple interviews. In AI-relevant sectors, degrees can still get you an interview but not the job. Universities are aware that the skills acquired to complete degree requirements are not enough to prepare graduates for a successful career and they try to offer opportunities to broaden them.

The AI revolution is making it urgent to look critically at our curriculum [18,19]. It is still essential to teach the fundamentals, but the age of AI requires graduates "who are adaptable, forward thinking, ready to learn, and ready to embrace these (AI) tools in particular"[15]. We as physicists want to think that training in physics which combines problem solving skills, critical thinking, analytical tools, both experimental and computational, and an ability to quantify natural phenomena or systems of all types (including economic or financial) provides a training like none other to face the challenges of the new world. We need now to look critically at the delivery of our teaching and see how we can put the emphasis on developing skills that are important for a changing economy. And AI tools should be an integral part of this. We are better placed than most diciplines to produce graduates who can adapt to new circumstances. Our graduates, especially those with advanced degrees (MSc and PhD), do well. Many of our BSc graduates bring their skills to other disciplines, and we cannot emphasize enough the invaluable service our graduates provide if they become high school, college or CÉGEP teachers. Urgent work needs to be done in our teaching. We should not take a relaxed or complacent attitude to the situation. To finish on a revealing note which shows that there is a consensus on the issue, ChatGPT exhorts us to take on the challenge: "Universities should adapt, not resist. They should embrace AI, teach AI, govern AI, and prepare students for a world shaped by AI—while preserving the human-centered essence of higher education."

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Editor-in Chief, *Physics in Canada*

Béla Joós is Emeritus Professor of Physics at the University of Ottawa. He has been a member of the Editorial Board of *Physics in Canada* since January 1985 and took over as Editor in June 2006.

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L'INTELLIGENCE ARTIFICIELLE EN PHYSIQUE

Béla Joós, rédacteur en chef, *La Physique au Canada*

L'intelligence artificielle (IA) suscite un énorme engouement. Le terme est devenu si omniprésent que l'acronyme n'est généralement plus défini. Le prix Nobel de physique 2024 a été décerné à deux scientifiques reconnus pour avoir établi les bases du domaine de l'IA, John Hopfield, physicien à l'Université John Hopkins, et Geoffrey Hinton, informaticien à l'Université de Toronto [1]. La citation précise « pour leurs découvertes et inventions fondamentales qui permettent l'apprentissage automatique à l'aide de réseaux neuronaux artificiels ».

Le sujet de l'IA est vaste et l'engouement qu'il suscite est énorme. Il s'est amplifié au cours de la dernière décennie pour atteindre un niveau de fébrilité sans pareil [2-5]. L'acronyme est largement utilisé, même dans des domaines qui reflètent simplement la puissance croissante d' outils informatiques plus ou moins traditionnels. En cette période de changements rapides, je voudrais aborder quelques points qui concernent notre communauté de physiciens, notamment l'impact de l'IA sur l'éducation, la recherche et l'emploi. Dans ces quelques pages, je ne peux que les effleurer afin d'encourager la discussion et souligner l'urgence de se tenir informé et de se préparer pour un avenir plus proche qu'on ne le pense.

Les universités et les écoles secondaires s'efforcent de s'adapter à l'accès facile à de puissants outils d'IA [6-8]. Ceux-ci envahissent l'espace d'étude des élèves comme un tsunami. Il n'est plus possible de rejeter ces outils. Dans les écoles secondaires, les élèves qui possèdent des ordinateurs portables et des tablettes bénéficient d'un avantage injuste par rapport à ceux qui n'en ont pas, car ils peuvent rapidement recueillir des informations à l'aide d'outils d'IA. Dans les universités, tous les programmes sont confrontés à une charge de travail accrue pour maintenir l'intégrité et l'équité de leurs processus d'évaluation. Les établissements travaillent à l'élaboration de lignes directrices visant à faire de l'IA un outil pédagogique efficace, mais celles-ci ne sont pas encore en place dans la plupart d'entre eux [8]. Il sera difficile de fournir des lignes directrices applicables à tous les cours. Le domaine évolue très rapidement, les cours sont très différents les uns des autres et les professeurs veulent préserver leur liberté académique. En ce moment chaque professeur doit établir ses propres règles, mais pour le bien des étudiants les règles doivent être transparentes. Il incombe aux unités académiques d'établir des règles claires. Les disciplines des sciences sociales doivent repenser l'objectif même des dissertations et des travaux de fin de semestre [9]. Ceci inclut les thèses. L'impact de l'IA est particulièrement significatif en informatique où les avancées sont visibles en temps réel et le progrès est exponentiel.

Elles soulèvent des questions sur l'avenir du domaine et sur la manière dont les futurs informaticiens devraient être formés [9]. Le contrôle de l'accès en ligne des étudiants est depuis des années un sujet de préoccupation en informatique. La croissance démesurée des outils d'IA va contraindre certains professeurs à renoncer aux évaluations sur ordinateur et à revenir aux examens sur papier, comme l’a fait Jure Leskovec, professeur à l'Université de Stanford [10].

Cependant, quelles que soient les menaces et les défis (et ils sont nombreux), l'IA rend à nouveau l'apprentissage excitant et, par conséquent l'enseignement aussi [8]. On peut apprendre aux élèves à exploiter les outils d'IA et à approfondir un sujet. Les informations sont collectées en quelques minutes, mais le travail difficile commence ensuite. Il faut organiser et analyser les données, puis sélectionner et structurer les contenus pertinents, et vérifier les références. Cela n'est possible que si l'on comprend les fondements du domaine. La pensée critique ne s'enseigne pas dans le vide. Il convient de noter que l'IA apporte une aide précieuse aux élèves qui ont des difficultés à écrire ou à formuler des phrases, ou qui étudient dans une langue autre que leur langue maternelle. Elle peut facilement générer du contenu à partir de quelques mots-clés, et cette matière première devient la base pour construire un travail cohérent. En fournissant une multitude de documents en quelques clics, l'IA rend la pensée critique à nouveau attrayante. Mais nous devons garder à l'esprit que les grands modèles linguistiques qui récoltent des informations pour les outils d'IA ne sont pas encore capables de faire la distinction entre une science de haute qualité, une science de mauvaise qualité ou une science frauduleuse, et cette tâche ne fera que devenir plus difficile à mesure que les fausses sciences et les publications scientifiques frauduleuses envahissent l'internet [11].

Nous entendons presque tous les jours parler de nouvelles applications de l'IA dans la recherche, l'ingénierie et l'industrie, allant des plus simples aux plus complexes. Certaines ne sont que des applications de nos outils informatiques avec des processus de régulation en temps réel, au lieu de données historiques qui prennent du temps à collecter et à saisir [2,3,4]. Il ne s'agit pas vraiment d'IA, même si la presse l'appelle ainsi. Par exemple, quelques caméras judicieusement placées le long d'une route très fréquentée peuvent transmettre des données à un ordinateur afin d'optimiser la synchronisation des feux de circulation en fonction du flux réel de voitures, plutôt que des données moyennes collectées pendant des semaines par des adolescents assis aux intersections. Les algorithmes d'IA utilisent leur unique capacité à apprendre à partir des données et à identifier des modèles complexes. L'IA peut automatiser des tâches et éliminer les travaux fastidieux. Elle peut écrire du code informatique et analyser des données [5]. Elle augmente la productivité et rend la modélisation à nouveau amusante. Les applications ne sont pas sans défis, tels que les biais algorithmiques et les questions de confidentialité, mais il s'agit d'un outil puissant qui ne cessera de nous étonner, et nous devrions l'adopter.

Les atouts de l'IA dans l'automatisation des tâches routinières et la production d'outils puissants vont révolutionner le monde du travail. L’IA va éliminer les emplois de premier échelon [5,12-16]. Il s'agit là d'un problème sociétal, car ces emplois permettaient aux jeunes diplômés d'acquérir les compétences fondamentales de leur profession et d'évoluer au sein de l'organisation [5,14]. Les employeurs ont besoin de nouveaux outils pour constituer une main-d'œuvre engagée et intégrée. Un changement fondamental dans la structure de la main-d'œuvre pourrait se produire. L'IA va révolutionner la nature du travail à un rythme sans précédent, qui n'a d'équivalent que ce qui s'est passé durant la révolution industrielle. Il est difficile de prédire combien de temps durera cette nouvelle ère. Certains se demandent s'il s'agit simplement d'une situation transitoire. Comme pour le passage au travail et à l'éducation en ligne, un changement permanent important est en train de se produire, auquel il convient de faire face avec détermination [5].

Le chômage chez les nouveaux diplômés augmente partout dans le monde [12,13]. Au fil des ans, un diplôme universitaire n'est plus autant une garantie d'emploi. On continue de croire que les études supérieures sont le bon choix pour avoir de bonnes perspectives d'emploi à long terme, car elles permettent un développement intellectuel et l'acquisition de compétences difficiles à acquérir par soi-même ou sur le terrain. Mais en fin de compte, ce sont les compétences qui comptent, et non les diplômes. Les difficultés en matière d'emploi vont probablement s'accélérer avec le rôle de plus en plus important de l'IA dans tous les secteurs de l'économie. On trouve des titres intrigants qui illustrent l'évolution rapide du paysage de l'emploi : « META recrute des débutants pour des postes rémunérés jusqu'à 290 000 dollars par an et ne nécessitant que peu d'expérience préalable » [5,17]. META recherche toujours les meilleurs talents, mais sélectionne ses nouvelles recrues après des entretiens approfondis. Dans de nombreux domaines technologiques, les candidats sont soumis à des entrevues rigoureuses, souvent multiples. Dans les secteurs où l'IA est pertinent, les candidats peuvent avoir une entrevue grace à leurs diplômes, mais cela ne garantit aucunement une offre d'emploi. Les universités sont conscientes que les compétences acquises pour obtenir un diplôme ne suffisent plus à préparer les diplômés à une carrière réussie et elles s'efforcent de leur offrir des possibilités d'élargir leurs horizons.

La révolution de l'IA rend urgent un examen critique de nos programmes d'études [18,19]. Il est essentiel d'enseigner les fondements, mais l'ère de l'IA exige des diplômés « qui soient adaptables, tournés vers l'avenir, prêts à apprendre et prêts à adopter ces outils (IA) en particulier » [15]. En tant que physiciens, nous voulons croire qu'une formation en physique qui combine des compétences en résolution de problèmes, une pensée critique, des outils analytiques, tant expérimentaux que computationnels, et une capacité à quantifier les phénomènes naturels et les systèmes de tous types (y compris économiques ou financiers) offre une base unique pour relever les défis du nouveau monde. Nous devons maintenant examiner d'un œil critique la manière dont nous dispensons notre enseignement et voir comment nous pouvons mettre l'accent sur le développement des compétences importantes pour une économie en mutation. Et les outils d'IA devraient en faire partie intégrante. Nous sommes mieux placés que la plupart des disciplines pour former des diplômés capables de s'adapter à de telles circonstances. Nos diplômés, en particulier ceux qui ont obtenu des diplômes supérieurs (maîtrise et doctorat), réussissent bien. Et bon nombre de nos diplômés de BSc mettent leurs compétences au service d'autres disciplines, et nous ne saurions trop insister sur le service inestimable que rendent nos diplômés lorsqu'ils deviennent enseignants au secondaire, dans les CÉGEPs et les collèges. Il y a un travail urgent à faire dans notre enseignement. Nous ne devons pas adopter une attitude détendue ou complaisante face à la situation. Pour conclure sur une note révélatrice qui montre qu'il y a un consensus sur la question, ChatGPT nous exhorte à embrasser le défi : «Les universités doivent s'adapter, et non résister. Elles doivent adopter l'IA, enseigner l'IA, réguler l'IA et préparer les étudiants à un monde façonné par l'IA, tout en préservant l'essence même de l'enseignement supérieur, centrée sur l'humain. »

Béla Joós, Université d'Ottawa
Rédacteur en chef, *La Physique au Canada*

Béla Joós est professeur émérite de physique à l'Université d'Ottawa. Il est membre du comité de rédaction de La Physique au Canada depuis janvier 1985 et en est le rédacteur en chef depuis juin 2006.

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Kathryn McWilliams (1972-2025)

Kathryn McWilliams (PhD, PEng, FRAS), Professor of Space Physics at the University of Saskatchewan and Director of the Super Dual Auroral Radar Network (SuperDARN) Canada National Research Facility, passed away at her home in Saskatoon on January 3, 2025, after a short illness.

After Kathryn finished her Master's at the University of Saskatchewan, she went on to complete a PhD at the University of Leicester in the UK on a prestigious Commonwealth Scholarship. She then came back to USask as a postdoc in 2002, before quickly becoming a professor in 2004. At USask, Kathryn became the first ever female tenured faculty member in Physics. In 2022, she became the first Canadian ever to be recognised as a Fellow of the Royal Astronomical Society of the United Kingdom.

Kathryn McWilliams was SuperDARN, and SuperDARN was her. She was there from the very beginning – building the Saskatoon antenna array in 1993 when she was a summer student and leaving her handprint in one of the cement bases. Her memory will echo there, and at her four other radars, for years to come.

Her enthusiasm for this field, her radars, her colleagues, her students, her engineers, was boundless and inspirational. The way she spoke with those not in our field was passionate and loving. And to those in our field, she would lift high above herself. There are many examples, but one shining achievement is the CaNoRock Canada-Norway rocket launch program, which she led, and resulted in the funding of over 250 Canadian students in graduate programmes.

Kathryn was a true leader and an incredible human being. Many of us will remember her for the sincere generosity she gave in every aspect of her life. We should all strive to be more like her. She built countless people up to love her field, and her absence now at the University of Saskatchewan, within the international SuperDARN community, CAP/DASP, CEDAR, GEM, and MIST communities, has been, and will continue to be, extremely painful for all of us. The world has lost an astounding scientist and person, and the international space science community mourns this loss together with Kathryn's family.

Rest in peace, Kathryn.

Daniel Billett, Physics and Engineering Physics, University of Saskatchewan

DAVID MARK HARRISON (1943-2025)

David Mark Harrison, Senior Lecturer Emeritus in Physics at the University of Toronto St. George Campus, died at home on July 22, 2025, with his family at his side.

David was born in New London, Connecticut, one of two children of Mark Harrison and Mary Davis Hughes. David's father, also a physicist, worked at the Naval Submarine Medical Research Laboratory during World War II. After the war, the family moved to Washington, D.C., where David completed high school. He attended Antioch College in Ohio for several years and eventually obtained his B.Sc. in physics from American University in 1967. In the 1960s David became active in the U.S. civil rights movement, protesting segregation and participating in Freedom Summer in Mississippi in 1964. He later came to Canada as a Vietnam War resister and completed his Ph.D. in experimental high-energy physics at the University of Toronto in 1972 under James Prentice.

After his doctorate, David became a teaching-stream faculty member at the University of Toronto, and thus began his life's work in physics education. He won many teaching awards throughout his career, including the Canadian Association of Physicists Gold Medal for Excellence in Teaching Undergraduate Physics in 2012.

In the 1970's, David was a pioneer in computational physics education, advocating for the devotion of a mainframe computer to undergraduates to use for data analysis in the labs. He started a popular breadth course called "The Zen of Physics", in which he explored the nature of reality and the parallels of the concepts with modern physics and Eastern mysticism.

David developed a vast collection of teaching resources that can still be found on the U of T physics website, ranging from explanations of Bell's inequality to the use of animations in teaching and uncertainties in physical measurements (https://faraday.physics.utoronto.ca/~harrison/). In the 2000's David spearheaded a massive transformation of the laboratory and tutorial components of all of the first-year physics courses at the University of Toronto. He designed and implemented the Physics Practicals, which applied new, evidence-based teaching methodologies from Physics Education Research. This project included a $2 million interior renovation and laboratory equipment purchase, as well as more than 200 pages of student guides, along with instructor resources and detailed set-up notes. The Practicals launched in 2009 and we continue to use David's materials today.

All who knew David appreciated his warmth, as well as his irreverent humour. David loved bluegrass and country music and played the piano. He was an avid motorcyclist, and was a passionate student of the martial arts, especially karate and tai chi. He was also a devoted fan of baseball and of the Toronto Blue Jays. He is survived by Wendy, his wife of 45 years, and their son Christopher.

I will remember David not only as a colleague but as a great friend and supporter of my career. I know he played this role for many others who were fortunate to count him as a friend.

Jason J.B. Harlow, University of Toronto

KOSTADINKA BIZHEVA (1970-2025)

It is with great sadness that we acknowledge the passing of Kostadinka Bizheva, Professor in the Department of Physics and Astronomy at the University of Waterloo, affectionately known as Dida to her colleagues and friends.

Dida was passionate about her research into biomedical optics and designing optical imaging technology. She initiated the field of optoretinography, a non-invasive method of measuring physiological and metabolic changes in the photoreceptors of the retina. She joined the Department of Physics and Astronomy in July 2004 and established her Biomedical Optics Research Group, which is world-renowned for its development of novel imaging technology for use in clinics. Dida was cross-appointed to the School of Optometry and Vision Science and to the Electrical and Computer Engineering Department in the Faculty of Engineering. She was also the Graduate Officer for her home department of Physics and Astronomy. In addition, she had just joined the CAP-NSERC Liaison Committee representing Biomedical and Biological Physics.

Recently, Dida was named a 2025 Optica Fellow, acknowledging her lifetime of achievement in optics and imaging. Teaching and mentoring were important to Dida, and she looked forward to how this appointment would help her shape the trajectory of students entering the field of biomedical optics.

Dida is remembered for her passionate approach to her research and her warmth in connecting with collaborators and students alike.

Sourced mainly from the Faculty of Science Website, University of Waterloo

Melanie Campbell, University of Waterloo

"OKAY LET'S GO": 80 YEARS AGO CANADA BECAME THE SECOND NATION TO HARNESS THE ATOM

SUMMARY: For Canada, nuclear fission was a scientific coming-of-age story half a century in the making. Take a journey from Rutherford to CANDU, which peaked in 1945 when Canada astounded all by leaping into the big leagues of nuclear science and engineering.

By **DR. JEREMY WHITLOCK** < jeremyjwhitlock@gmail.com>

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At the end of WWII Canada didn't know what it couldn't do.

For six harrowing years the young nation had punched above its weight on numerous fronts – military, industry, aerospace, agriculture, science – to help bring the world's greatest conflict to a close.

And on September 5, 1945 – a month after the world learned of nuclear fission when two atomic bombs destroyed Hiroshima and Nagasaki – Canada again stunned the world by firing up its ZEEP reactor ("Zero Energy Experimental Pile", Fig. 1) in remote Chalk River, Ontario, becoming the second country to harness the atom.

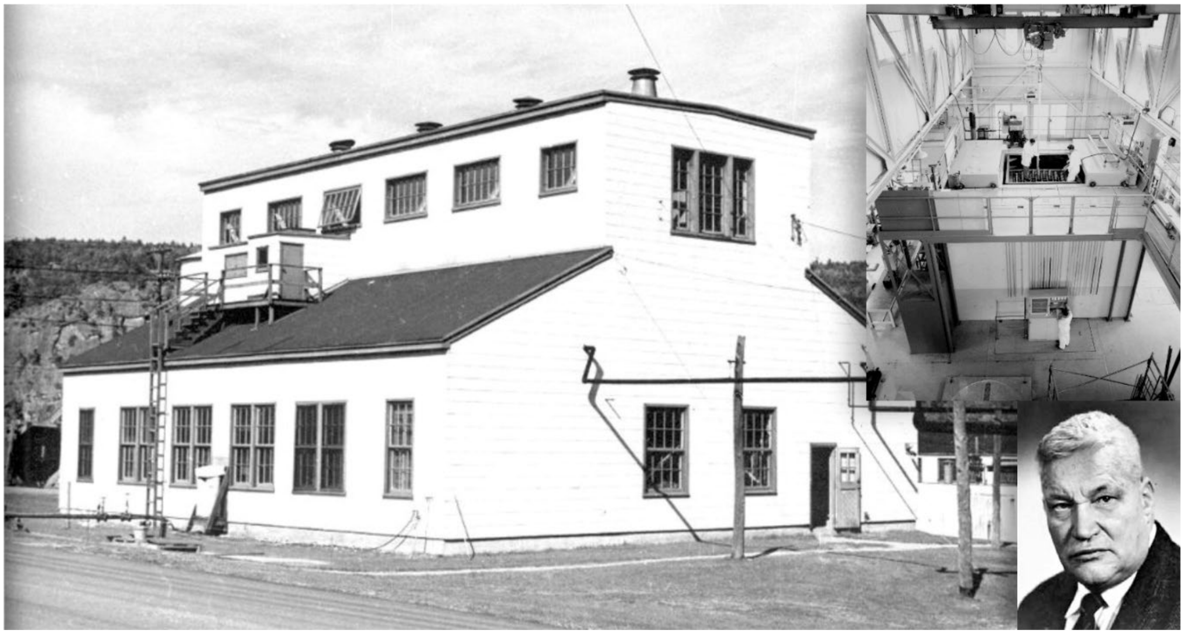

Figure 1. The ZEEP reactor at Chalk River Laboratories: first criticality Sept 5, 1945. Inset top: interior of ZEEP. Inset bottom: Dr. Lew Kowarski, one of the first to experiment with heavy water and fission in Paris, and later head of ZEEP design in Canada. *(Photo source: AECL)*

At the time neither the lab at Chalk River, nor the nearby townsite of Deep River housing its scientists and their families, was on the map – both created in secrecy during the darkest days of the war: effectively a satellite operation of the Great U.S. Secret the world came to know as the Manhattan Project.

The Allies' goal was ostensibly a nuclear weapon to end the war, but the new wonder of nuclear science was unmistakably the long-term prize – and Canada had been all-in since 1942 with a pronouncement as understated as it was bold:

"Okay, let's go!"

Those words were famously uttered on August 17, 1942 by the honourable Clarence Decatur (C.D.) Howe as he created the Canadian nuclear program with the stroke of a pen.

Howe, known as the "Minister of Everything" in Prime Minister Mackenzie King's wartime cabinet, had been considering a request from Britain to transfer a significant piece of its wartime nuclear project (under the code name "Tube Alloys") to Canada – the mission: to investigate the possibility of a heavy water reactor.

Figure 2. The Montreal Group of the National Research Council *(Photo source: AECL)*. Inset: The Hon. C.D. Howe. *(Photo source: Legion Magazine)*

It was a hefty commitment, and nobody could say for sure what would come of it, but the allure was undeniable: first-floor access to a new science (discovered scarcely three years earlier) that promised to revolutionize industry, medicine and energy production.

With its hearty "*Okay, let's go*", Canada invited a team of top French and British scientists to join a Canadian contingent setting up shop at the University of Montreal. It would be known as "The Montreal Lab" (Fig. 2) under the auspices of the National Research Council (NRC).

Remarkably, this was not Montreal's first brush with cutting edge nuclear science: that happened half a century earlier when the redoubtable Ernest Rutherford earned his 1908 Nobel Prize conjuring up concepts like half-life, alpha, beta and gamma radiation at McGill University (Fig. 3).

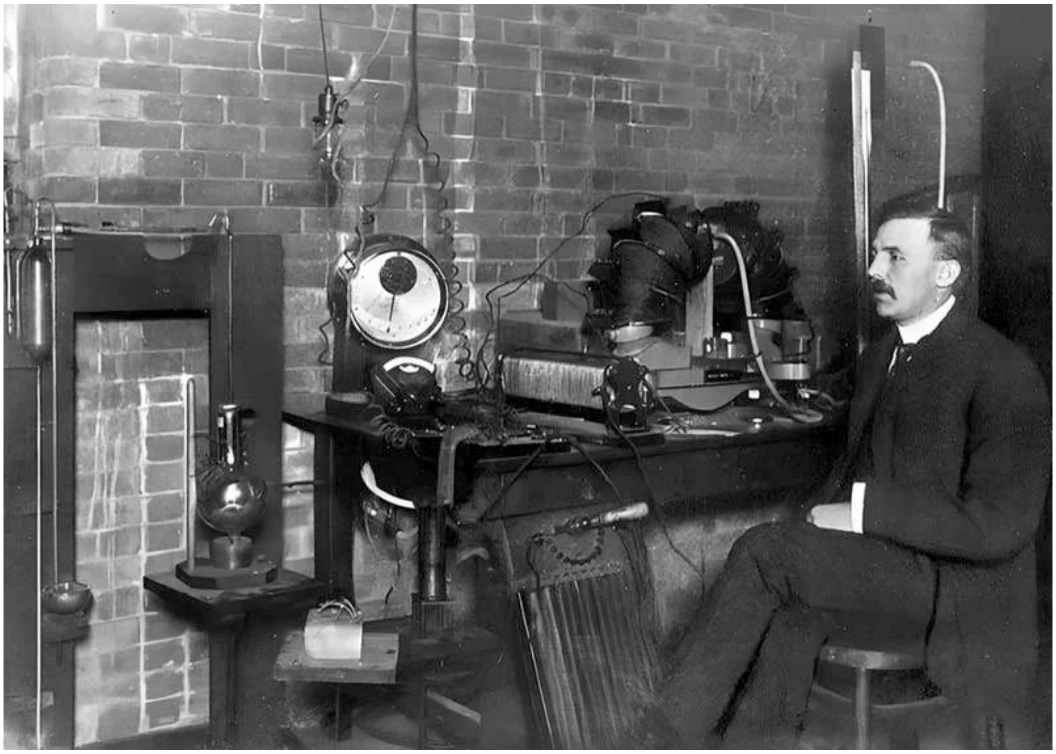

Figure 3. Ernest Rutherford in his lab at McGill University, Montreal, 1905. *(Photo source: Wikimedia)*

Around that time, a thousand kilometres to the east in Charlottetown, PEI, a lad named George Laurence was born. Two decades later young Laurence would find himself studying under Rutherford in Britain, and by the outbreak of WWII was a respected researcher at the NRC laboratories back in Ottawa.

That's when an earthquake broke science.

Nuclear fission – the splitting of the uranium atom, considered impossible by contemporary knowledge – was announced to the world in January 1939. Germans Otto Hahn and Fritz Strassman did the experiments, Austrians Lise Meitner and her nephew Otto Frisch pieced the unconventional physics together, and an entire half-century of nuclear theory converged overnight.

Canada's George Laurence, working in secrecy in downtown Ottawa with the help of B.W. Sargent of Queen's University (a fellow Rutherford protégé), was the first to assemble a large graphite reactor to test the theory (Fig. 4). Later, in 1942, Enrico Fermi would attain physics superstardom with the first fully functional version under the football stands at the University of Chicago, but Laurence put Canada on the map by being one of the first to test the process.

Figure 4. The National Research Council (NRC) laboratories on Sussex Drive in Ottawa. *(Photo source: NRC)* Inset top: Dr. George Laurence. Inset bottom: depiction of Laurence's graphite pile. *(Photo source: Nuclearfaq.ca)*

This earned Canada an unlikely seat at the Manhattan Project table, confirmed in August 1943 by Mackenzie King, Churchill, and Roosevelt at their Quebec Conference to discuss how the war would end (Fig. 5).

Canada was tasked with building a large prototype reactor based on heavy water.

Figure 5. Canadian Prime Minister Mackenzie King, US President Franklin D. Roosevelt, and British Prime Minister Winston Churchill at the Quebec Conference in August 1943, where Canada's role in the then-top-secret Manhattan Project was agreed. *(Photo source: Imperial War Museums)*

A natural variant of water but 10% denser, heavy water was first discovered only a decade earlier – and until the discovery of fission had almost no practical use. Then overnight its status soared as one of the rarest and most sought-after materials of the Second World War.

The reason: it was immediately recognized as a key ingredient for a nuclear reactor running on unenriched uranium (the kind found in nature).

Unfortunately, although it is found wherever you find water (approximately one water molecule in 3200 contains deuterium, a heavy isotope of hydrogen), separating heavy water from regular water is not trivial. In time Canada would master the process but in that period it was in short supply.

In fact, early in the war the French had ended up with almost all the world's inventory of heavy water (185 kg), spirited out of Norway on the eve of Nazi occupation (Fig. 6), and again spirited out of France on the eve of its Nazi occupation – eventually ending up, along with its French scientist caretakers, at the Montreal Laboratory.

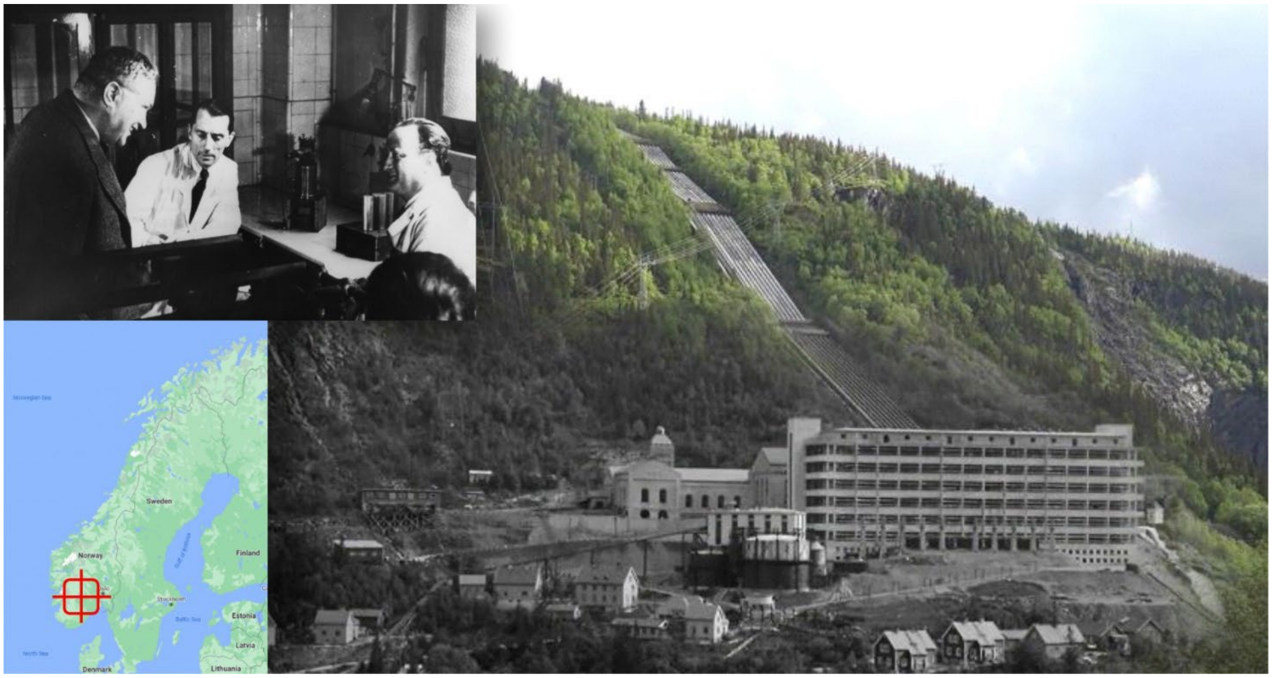

Figure 6. The Vemork hydroelectric plant (Norway) produced most of the world's heavy water pre-WWII. *(Photo source: National Library of Norway)* Inset top: Scientists Lew Kowarski, Frederic Joliot-Curie, and Hans von Halban experimented with heavy water in Paris. *(Photo source: public domain)* Inset bottom: location of Vemork plant.

Additional heavy water in the massive quantities demanded by a reactor (many tonnes) eventually arrived via the Manhattan Project – interestingly, its first production site technically on Canadian soil at Trail, BC.

Uranium, of course, was the other essential ingredient, and here Canada was blessed.

Since 1930 uranium had been mined in the Northwest Territories for its lucrative radium content – a wonder element since the days of Madame Curie, especially useful during the war making aircraft instruments glow in the dark.

In fact radium's singular commercial value is evident in the fact that it made economic sense at the time to mine it in Great Bear Lake, NWT, then ship it 5000 km southeast to Port Hope, Ontario for extraction – at that point basically casting its host uranium rock aside as waste.

Then in 1939 the discovery of nuclear fission flipped Port Hope's objective: uranium itself became the main attraction.

Meanwhile, the decision to build a large research reactor unleashed Canadian science and industry into uncharted territory (a metaphor extending to the living conditions of scientists and their families as they moved to the new company townsite of Deep River, Ontario, on the banks of the Ottawa River about 200 km upstream from Ottawa).

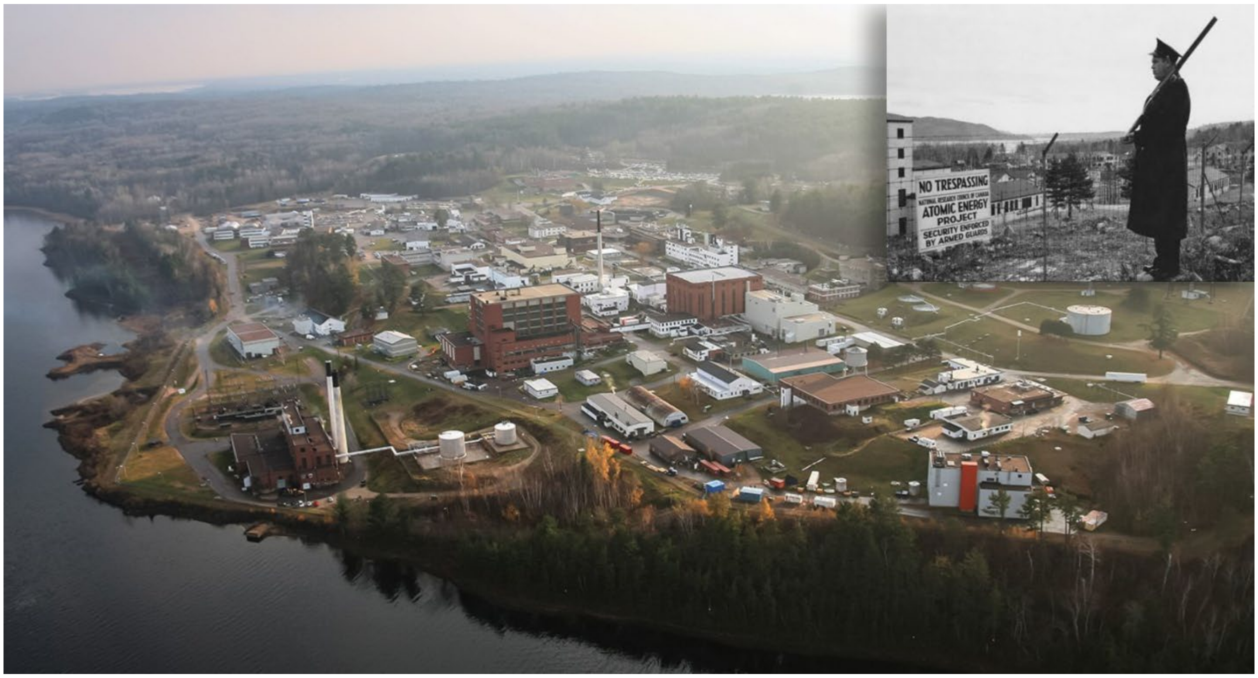

Figure 7. Chalk River Laboratories today, operated by Canadian Nuclear Laboratories (CNL). *(Photo source: CNL)* Inset: armed guard in the early days. *(Photo source: AECL)*

Nearby the massive nuclear campus at Chalk River was under construction, with all the infrastructure of self-contained, cutting-edge science: at its heart, an innovative nuclear reactor that would change the course of medicine, industry, and electricity generation (Fig. 7).

That reactor would be known as the National Research eXperimental, or NRX – the most powerful research reactor on the planet in its day, and a scientific watershed for Canada.

But that day was still three years away: for now, with the war still raging and Canadians preparing to storm the shores of Normandy, Canadians back home prepared to storm the shores of nuclear science.

First on their list was a small test reactor, also based on heavy water – something to get their feet wet (so to speak) before tackling the full might of NRX.

This would become known as ZEEP: Zero Energy Experimental Pile – built over the following year in the looming shadow of NRX next door (Fig. 8). True to its name, ZEEP generated almost no measurable energy, but provided the physics platform for fine tuning the NRX design. It continued to host important experiments at Chalk River until 1970.

Figure 8. The ZEEP reactor in 1945, with the NRX reactor under construction next door. *(Photo source: AECL)*

More than this however, ZEEP was the first reactor to start up outside the U.S., heralding the entry of Canada into the nuclear big leagues.

The date was Sept 5, 1945. The war had just ended and a new world was emerging from its ashes – a world where nuclear energy held an early promise of prosperity and peace.

Canada would help define this new world. With its flagship research reactor NRX starting up in 1947, joined by the even more powerful NRU (National Research Universal) a decade later, Canada would soon gift to humanity the medical revolution of cobalt-60 cancer therapy (saving lives already by 1951), and a host of other medical and industrial radioisotopes (Fig. 9).

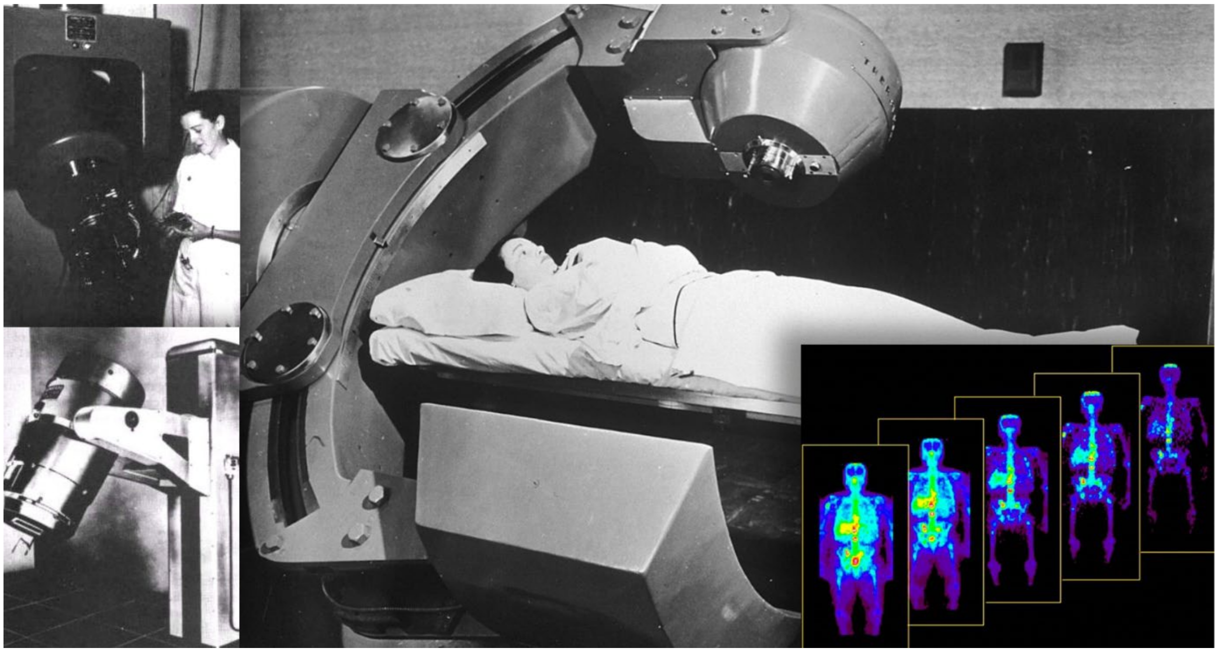

Figure 9. The earliest use of nuclear energy for peaceful purposes was the production of radioisotopes to diagnose and fight disease. Left insets: the first cobalt-60 cancer therapy units in Saskatchewan and Ontario (1951) *(Photo source: AECL)*; right inset: nuclear imaging. *(Photo source: Riga Technical University)*

This new world demanded oversight since nuclear reactors would soon be operating in dozens of countries, and in 1957 Canada helped establish the International Atomic Energy Agency (IAEA) to ensure that this evolved safely and securely. (At home this mission had been upheld since 1946 by one of the first national nuclear regulators, later rebranded the Canadian Nuclear Safety Commission, CNSC).

Chalk River Laboratories itself became a mecca for nuclear science – the best and the brightest attracted by the unmatched capabilities of its two research reactors (Fig. 10), soon accompanied by other new tools for probing the universe. One significant legacy of this era is the technique of neutron scattering – using neutron beams from a research reactor to probe the structure and behaviour of materials. In 1994 Chalk River's Bertram Brockhouse (later of McMaster University) shared the Nobel Prize in Physics with Clifford Schull of the USA (Oak Ridge Laboratories, and later MIT) for this game-changing contribution to science.

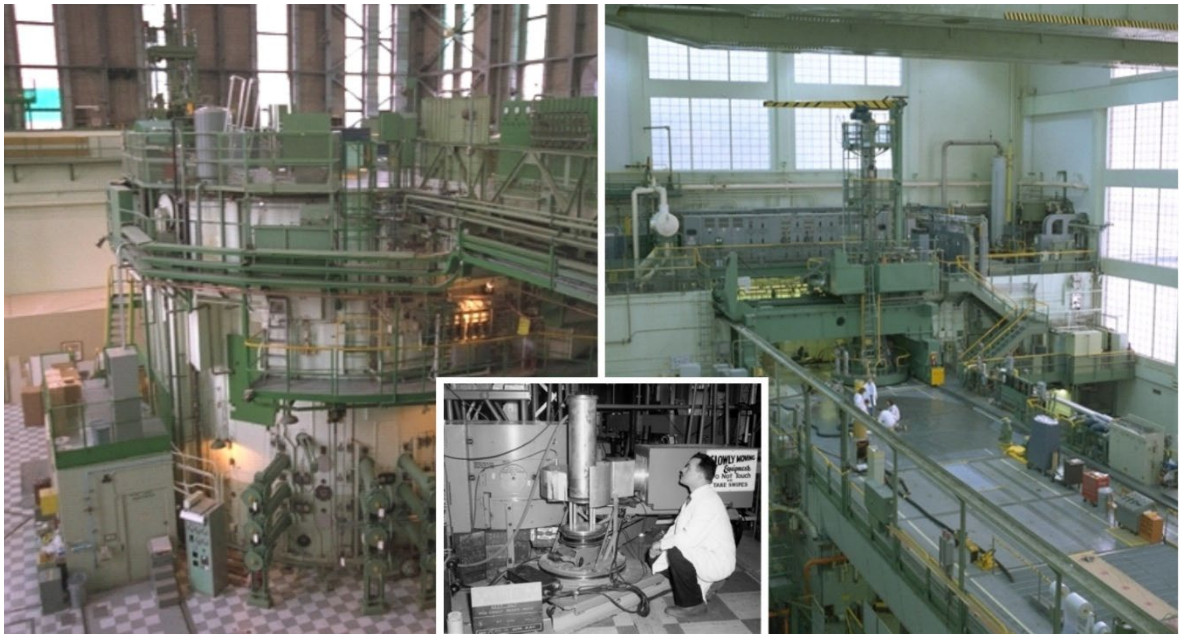

Figure 10. Giants of early nuclear science: the NRX reactor (left, 40 MW, 1947-1993) and NRU reactor (right, 120 MW, 1957-2018). Inset bottom: Dr. Bertram Brockhouse in the NRX - 1994 Nobel laureate in Physics for neutron scattering. *(Photo source: AECL)*

By the 1960s Canada, through its new crown corporation Atomic Energy of Canada Ltd. (AECL), had developed one of only two power reactor concepts to reach full commercialization: the CANDU reactor.

CANDU was almost a contradiction: arguably the most efficient power reactor on the planet, running on natural (unenriched) uranium that – under most circumstances – can't be made to support its own fission chain reaction.

The Canadians not only made it work; they made it one of the safest reactors in operation. Today these machines power half of Ontario, and enable that most industrialized of Canadian provinces to have an almost 100% clean electricity grid (Fig. 11).

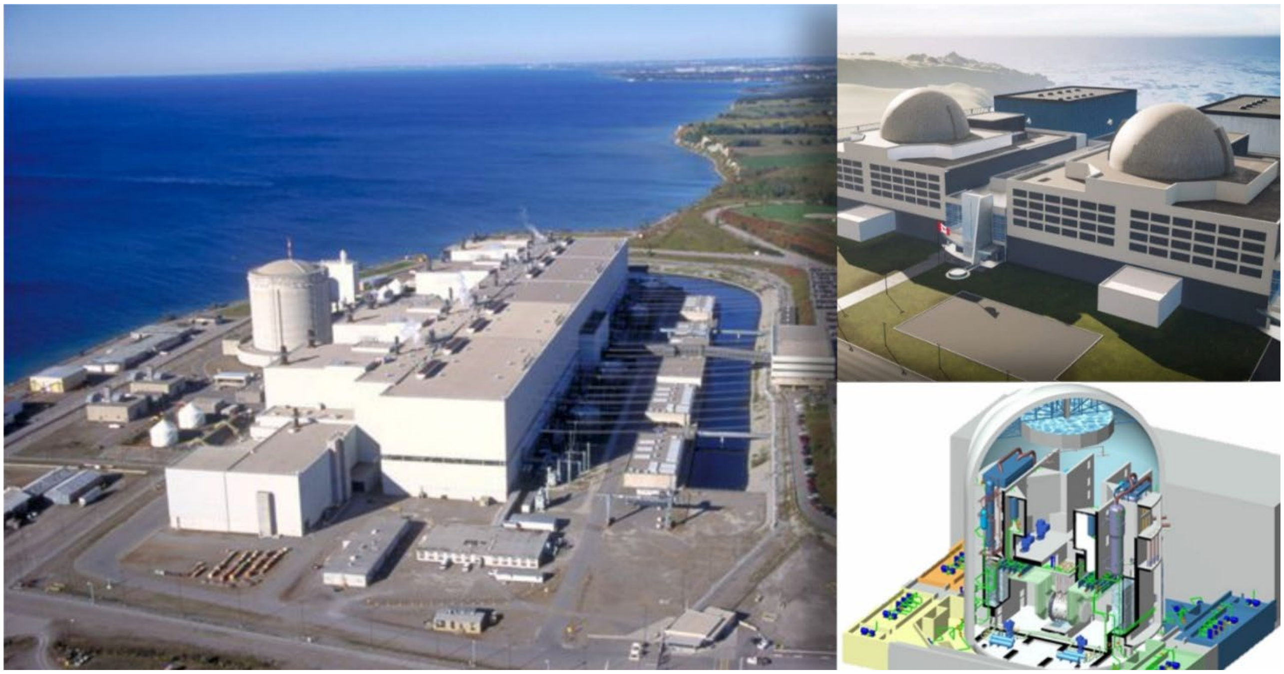

Figure 11. Darlington NPP near Toronto (3600 MW from four CANDU units). *(Photo source: OPG)* Inset right: CANDU MONARK (1000 MW, developed by AtkinsRéalis - Candu Energy) takes the CANDU product forward, building on over 60 years of fleet experience. *(Photo source: AtkinsRéalis - Candu Energy)*

And increasingly, while doing so, they are producing medical isotopes on the side – fighting cancer and heart disease (both diagnosis and treatment), and generally carrying forth the torch of nuclear energy's first philanthropic role in Canada.

Today CANDU reactors quietly tout Canadian ingenuity on four continents, their very name a respectful nod to the spirit of their genesis: 80 years ago when 20th century physics reached an apex in two countries, and equally today as the world searches for sustainable solutions to energy supply and climate deterioration.

Okay, let's go.

Figure 12. ZEEP's legacy: sustainable energy supply, environmental protection, and isotopes for water, agriculture and medicine.

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STUDENT COMPETITIONS 2025 COMPÉTITIONS ÉTUDIANTS

The CAP would like to thank and congratulate everyone who participated in this year's Best Student Presentation Competition, including 102 student competitors competing for a total of 46 prizes and the 53-member judging team, and to thank everyone who attended the talks and visited the posters. Your support and participation was vital to the success of the event.

As always, this year was met with a series of fantastic poster and oral presentations and all presenters should be proud of their hard-work and accomplishments!

L'ACP tient à remercier et à féliciter tous ceux qui ont participé au concours du meilleur presentation d'étudiant de cette année, notamment les 102 étudiant(e)s en compétition pour un total de 46 prix et les 53 membres de l'équipe de juges, et à remercier tous ceux qui ont assisté aux conférences et visité les affiches. Votre soutien et votre participation ont été essentiels à la réussite de l'événement.

Comme toujours, cette année a été marquée par une série de présentations orales et d'affiches fantastiques et tous les présentateurs peuvent être fiers de leur travail et de leurs réalisations !

CAP OVERALL STUDENT POSTER AWARDS

PLACEMENT	NAME/AFFILIATION
First	Laura Gonzalez Escudero, McGill University
Second	Samin Majidi, McGill University
Third	Caleb Guthrie, University of Alberta
Honourable Mention	(in alphabetical order) Jessica de Kort (University of Winnipeg), Saloni Saloni (University of Saskatchewan)

CAP OVERALL STUDENT ORAL PRESENTATION AWARDS

PLACEMENT	NAME/AFFILIATION
First	Coral Hillel, York University
Second	Cameron Burns, McMaster University
Third	Joshua Yu, Simon Fraser University
Honourable Mention	(in alphabetical order) Alex D'Ippolito (Toronto Metropolitan University), Gabby Gelinas (University of British Columbia/TRIUMF), Christopher Kallio (Simon Fraser University), Remington Rohel (University of Saskatchewan), Justin Suys (SNOLAB)

CAP DIVISION STUDENT POSTER AWARDS

DIVISION OF APPLIED PHYSICS AND INSTRUMENTATION (DAPI)	
PLACEMENT	**NAME/AFFILIATION**
First	Samin Majidi, McGill University

DIVISION OF CONDENSED MATTER AND MATERIALS PHYSICS (DCMMP)	
PLACEMENT	**NAME/AFFILIATION**
First	Saloni Saloni, University of Saskatchewan
Second	Meemansha Bahuguna, University of Saskatchewan
Third	Sakshi Sakshi, University of Saskatchewn

DIVISION OF GENDER EQUITY FOR PHYSICS (DGEP)	
PLACEMENT	**NAME/AFFILIATION**
First	Maryam Bibi, Memorial University of Newfoundland

DIVISION OF NUCLEAR PHYSICS (DNP)	
PLACEMENT	**NAME/AFFILIATION**
First	Lukas Opitz, University of Regina

DIVISION OF PARTICLE PHYSICS (PPD)	
PLACEMENT	**NAME/AFFILIATION**
First	Laura Gonzalez Escudero, McGill University

DIVISION OF PHYSICS IN MEDICINE AND BIOLOGY (DPMB)	
PLACEMENT	**NAME/AFFILIATION**
First	Michael Hogue, University of Saskatchewan
Honourable Mention	Jessica de Kort, University of Winnipeg

DIVISION OF PLASMA PHYSICS (DPP)	
PLACEMENT	**NAME/AFFILIATION**
First	Caleb Guthrie, University of Alberta

CAP DIVISION STUDENT ORAL PRESENTATION AWARDS

DIVISIONS OF APPLIED PHYSICS AND INSTRUMENTATION (DAPI), PHYSICS EDUCATION (DPE), AND PLASMA PHYSICS (DPP)	
PLACEMENT	**NAME/AFFILIATION**
First	Justin Suys, SNOLAB

DIVISION OF ATMOSPHERIC AND SPACE PHYSICS (DASP)	
PLACEMENT	**NAME/AFFILIATION**
First	Remington Rohel, University of Saskatchewan
Second	Jennifer Peterson, University of Alberta
Third	Giacomo Radaelli, University of New Brunswick

DIVISION OF ATOMIC, MOLECULAR AND OPTICAL PHYSICS, CANADA (DASP)	
PLACEMENT	**NAME/AFFILIATION**
First	Alex D'Ippolito, Toronto Metropolitan University
Second	Christian Ramirez Rodriguez, University of New Brunswick
Third	Kate Dingle, Toronto Metropolitan University

DIVISION OF CONDENSED MATTER AND MATERIALS PHYSICS (DCMMP)	
PLACEMENT	**NAME/AFFILIATION**
First	Cameron Burns, McMaster University
Second	Marzuk Gazi, McMaster University
Third (tie)	Saba Karimi, University of Waterloo
Third (tie)	Ghazaleh Gholizadeh, University of Calgary

DIVISION OF NUCLEAR PHYSICS (DNP)	
PLACEMENT	**NAME/AFFILIATION**
First	Joshua Yu, Simon Fraser University
Second	Alicia Postuma, University of Regina
Third	Thomas Hepworth, University of Winnipeg

DIVISION OF PHYSICS IN MEDICINE AND BIOLOGY (DPMB)	
PLACEMENT	**NAME/AFFILIATION**
First	Coral Hillel, York University
Second	Simaya Rosenbloom, McMaster University

DIVISION OF PLASMA PHYSICS (DPP)	
PLACEMENT	**NAME/AFFILIATION**
First	Mina Papahn Zadeh, University of Saskatchewan
Second	Nishka Sheth, University of Saskatchewan
Third	Brad Dempsie, University of Saskatchewan

DIVISION OF QUANTUM INFORMATION (DQI)	
PLACEMENT	**NAME/AFFILIATION**
First	Christopher Kallio, Simon Fraser University

DIVISION OF THEORETICAL PHYSICS (DTP)	
PLACEMENT	**NAME/AFFILIATION**
First	Angel Neira, Memorial University of Newfoundland
Second	Sijia Wang, University of Waterloo
Third	Rashaad Reid, University of Waterloo

DIVISION OF PARTICLE PHYSICS (PPD)	
PLACEMENT	**NAME/AFFILIATION**
First	Gabby Gelinas, University of British Columbia / TRIUMF
Second	Jon Clarke, Queen's University
Third	Nicholas Swidinsky, Queen's University

A CASE STUDY OF A STUDENT-LED RESEARCH GROUP

SUMMARY: We present a case study of a multidisciplinary undergraduate-led research group that provided research experience to undergraduate students at Queen's University. By reflecting on the case study we identify guidelines to help reproduce and improve the undergraduate research experience.

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ASHLEY MICUDA WAS A FINALIST IN THE 2022 CAP BEST OVERALL STUDENT ORAL PRESENTATION AND RECEIVED 1ST PRIZE IN THE DIVISION OF PHYSICS EDUCATION

Despite efforts to integrate research into curricula, many STEM programs lack accessible research opportunities [1]. Yet, providing research experience to undergraduates enriches their academic experience [2]. Undergraduate physics education often fails to expose students to current research [3] despite approximately 48% of physics undergraduates continuing to graduate school [4]. Traditional research opportunities, such as final year thesis and capstone projects, or summer research opportunities may be limited to students already excelling [5], thus restricting the pool of potential researchers according to pre-existing biases. Expanding research experience through alternative pathways could aid in making research more inclusive and accessible to a broader range of students.

A STUDENT-LED RESEARCH GROUP

This case study reflects on our work to build an undergraduate-led research group that developed an epidemiological model for the spread of COVID-19. This project started in summer 2020, primarily as a way to occupy undergraduate physics students hired as summer researchers at Queen's University just before the pandemic closed most physics research labs. In order to learn about the pandemic while developing skills that would transfer to physics, we proposed that the undergraduate students develop a Monte Carlo simulation to model the spread of COVID-19. The graduate students, postdoc, and faculty in the research lab provided support. As the summer progressed, more undergraduates from several departments joined the group which continued for four years. The students obtained grants to fund stipends, traveled to conferences, and published an article [6].

In this article we describe how we built this group and reflect on how it benefited the undergraduate students in order to extract guiding principles to replicate and improve this experience. Through reflection and through a survey administered to members of the group, we identified eight student learning outcomes (SLO) from this project, shown in Table 1, which will be highlighted throughout this article.

TABLE 1

Skills and learning outcomes determined by surveying the students to find out the benefits that they found from participating in the research group.

	Student Learning Outcomes (SLO)
1	Conduct a literature review
2	Learn and/or improve programming skills in Python
3	Work as a group
4	Mentor and educate peers
5	Collaborate on a complex software project with version control
6	Disseminate research findings
7	Apply for research funding

FORMATION AND EVOLUTION OF THE RESEARCH GROUP

The students first conducted a literature review to assess existing COVID-19 modeling approaches (SLO1), which revealed that Monte Carlo agent-based models were not used often. Instead, less computationally intensive models, based on differential equations, were more common due to their simplicity. It was thus suggested that, as a first "assignment", students should try to develop a simple Susceptible-Infected-Recovered (SIR) differential equation-based model to gain a basic understanding of epidemics [7]. The students were encouraged to develop code collaboratively, teach each other, and review each other's work using GitHub (SLO2, SLO3, SLO4, SLO5). The version-controlled code is now publicly available on GitHub [8]. Simultaneously, the undergraduate students contributed code to the Monte Carlo simulation following a framework that the graduate students designed.

After four months, the model was advanced enough to extract meaningful results and the students decided to continue working on the project throughout the school year. Additionally, the group expanded due to interest from undergraduates in several departments from word of mouth (SLO8). Each student pursued a sub-project of their choice, usually by adding a feature to the simulation, such as vaccinations, and then researching its effects to gain publishable insights. One student assessed how to optimize capacity restrictions leading to the group's published paper. Each project was student-driven, with individualized goals, supported by peers, and could be completed at a pace adapted to the student.

The undergraduates organized weekly meetings where everyone was encouraged to discuss their work from the week, ask questions, and schedule additional meetings for individualized help. This provided an opportunity to practice presenting research in a low-stakes environment and receive feedback.

The undergraduate students also applied to the Queen's Arts & Science Undergraduate Research Fund and received over $10,000 over three terms to cover the cost of conferences (SLO6), publications, and stipends. The students learned how to develop a research proposal with a budget and manage the research funds (SLO7). The group's work was presented three times at various conferences, including CAP 2022 (SLO6), by three different undergraduate students and a paper was published with all students involved in the group [6].

Graduate students provided oversight on the programming and sub-projects, asking questions during group meetings, and suggesting ideas to keep students on track (SLO4). Graduate students also acted as a review board for presentations, grant applications, and formal scientific publications. While the group was focused on the undergraduates, a strong emphasis was also placed on providing graduate students with the opportunity to gain leadership and mentoring experience. In total, 12 undergraduates and six graduate students participated in the group.

Figure 1 shows a diagram of the process that we envisioned to develop sub-projects as new undergraduate students joined the existing research group. While the goal for most of the students was not to ultimately write a paper, thinking of the sub-projects as having the potential to lead to a publication made them more meaningful and allowed us to think of a structured approach for the SLOs that may be useful for replicating the experience.

A survey was conducted to allow the group members to reflect on the positive outcomes from their involvement with the group. Responses included:

- Improved oral communication skills
- Large contributor in finding a research position
- Improved programming skills and software development
- Connecting and learning from people in other disciplines
- Valuable mentoring experience
- Learned about modeling

Five of the seven original undergraduate students from the group have continued to graduate school.

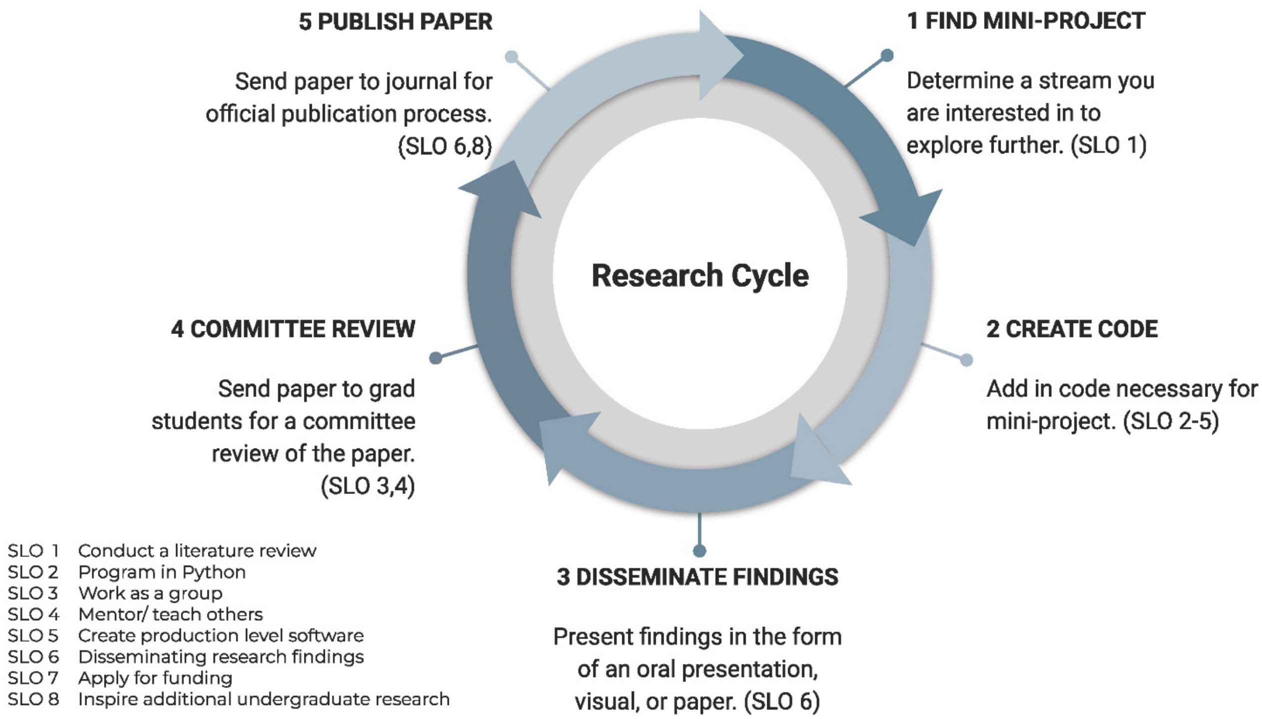

Figure 1. The research life cycle of the group, highlighting the major stages of general research and where each student learning outcome (SLO) fits to highlight the skills learned during the research process.

CONSIDERATIONS IN DEVELOPING AN UNDERGRADUATE-LED RESEARCH GROUP

Reflecting on our experience, we introduce here some guidelines that we think are helpful in building an undergraduate-led research group.

DEVELOPING A SUPPORTIVE STRUCTURE FOR RESEARCH ALONG A BROAD TOPIC

By far the most challenging aspect is to develop the project to the point where students can join the group to take on a sub-task. In our case, this required a dedicated faculty member motivated to provide the experience, graduate students willing to volunteer their time, and motivated undergraduate students. The topic of developing a COVID-19 simulation code worked well in our case for several reasons. It required developing skills (programming, research, funding) that transferred well to the students' own fields of study (STEM). It naturally allowed for many sub-projects to be developed by using the code to examine various aspects of the pandemic. Finally, it also provided a way for students to gain a tangible grasp on the rapidly changing world around them.

USING KOLB'S LEARNING CYCLE TO IDENTIFY SLOS AND REPLICATE EXPERIENTIAL LEARNING [9]

- **Concrete Experience:** New members express interest and observe ongoing work.

- **Reflective Observation:** They determine how they can contribute and what they want to learn.
- **Abstract Conceptualization:** Members propose a sub-project they are passionate about and their ideas on how to implement it.
- **Active Experimentation:** They complete the work for their sub-project that aligns with their goals (ex. wanting to learn how to code so they choose a coding heavy project).

Identifying sources of funding and opportunities for dissemination

Students were prompted to seek funding to support the group with the idea of presenting at a conference or publishing in a journal. This provided students with meaningful opportunities to communicate their work as well as get hands-on experience with the realities of research funding. As noted earlier, students were quite successful and even obtained funding for stipends to work five hours per week.

Fostering independent research in a collaborative environment

We found that empowering students to lead sub-projects was important and allowed them to have a natural place in the group. Students were invited to present their work at weekly group meetings, and as it matured, they were then encouraged to present at undergraduate conferences. While providing research experience, this also provided ownership of a project and something that could be reflected in a reference letter.

Encouraging leadership, mentorship, and inter-disciplinarity

An important aspect of the group was the mentorship between students at different levels. Graduate students helped undergraduates, and upper year undergraduates acted as mentors to their lower-year counterparts. Students in life-sciences educated all of us on biology while learning to code in Python. The upper year undergraduates were encouraged to show leadership and seized the opportunity to organize weekly meetings, setting agendas, and milestones for publishing a paper.

Conclusion

Opportunities for undergraduate experiential learning in research are limited but can have significant positive impacts on student's careers. To address this gap, we presented a case study from an undergraduate-led research group at Queen's University in hopes that others may replicate and improve upon our experience.

Acknowledgements

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QUANTUM CATASTROPHES, BLACK HOLES, & RAINBOWS

SUMMARY: Caustics are a well-known phenomena in optics where light is focused due to naturally occurring lensing effects. Some examples include rainbows, the wavy lines at the bottom of swimming pools, and the cusp-shaped focusing of light that can be seen inside a coffee mug. By studying a flowing, ultracold quantum gas, we were able to show that the universal mathematics of caustics also locally describes the thermal radiation predicted to be emitted by black holes [1].

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LIAM WAS A FINALIST IN THE 2022 CAP BEST OVERALL STUDENT POSTER PRESENTATION AND RECEIVED 1ST PRIZE IN THE DIVISION OF THEORETICAL PHYSICS

Gravitational black holes (BHs) are at the forefront of where our current understanding of physics fails; our best theories of gravity and quantum mechanics do not play nicely near such cosmic entities. Despite the lack of a complete and successful theory of quantum gravity, it has been shown that BHs are expected to emit thermal Hawking radiation (HR) as if they were black bodies (like the glowing hot heating elements on a stove) [2]. However, at BH event horizons the HR appears to possess infinite energy, heralding a breakdown of the predicted physics [3]. To overcome the experimental difficulty in studying BHs and to help address this HR breakdown, laboratory analogues of BHs have been created in flowing ultracold gases [4]: if the flow speed of the gas exceeds the speed of sound, then soundwaves are unable to propagate against the flow and an analogue of an event horizon occurs. Remarkably, HR is produced near this sonic horizon in the form of oppositely travelling pairs of soundwaves. A sonic black hole is depicted in Figure 1.

The non-physical energy divergence of HR at the horizon is in fact an example of a quantum catastrophe [5]: a generalization of a well-known effect in optics, namely caustics [6]. Caustics are regions where light focuses due to naturally occurring lensing effects. Some examples are displayed in Figure 2, which include rainbows, the wavy lines at the bottom of swimming pools, and the cusp-shaped focusing of light that can be seen inside a coffee mug. In the geometrical ray approximation of optics, caustics are where a finite number of rays are focused into an infinitely small region, leading to an infinite ray density and thus a non-physical prediction of infinite intensity. This heralds a breakdown

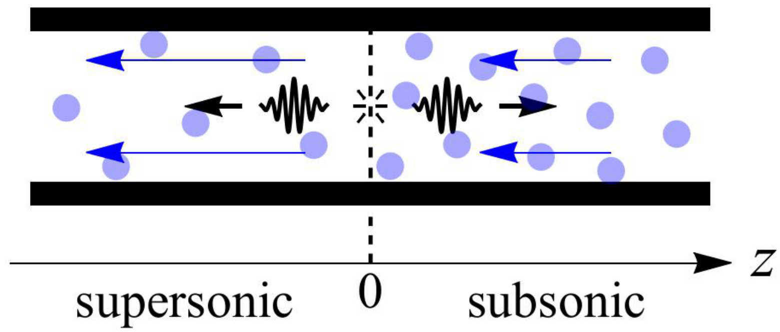

Figure 1. Schematic representation of a sonic BH formed by flowing an ultracold gas in-between two trapping walls (thick black lines), where z denotes the axial distance from the BH horizon. The blue circles are the constituent particles, and the blue arrows indicate their direction and magnitude of flow. The vertical dashed line at $z = 0$ indicates the position of a sonic event horizon so that the flow is supersonic when $z < 0$ (inside the BH), and subsonic when $z > 0$ (outside). The localized oscillations represent the spontaneously produced sonic HR which forms near and propagates away from the horizon: one particle escapes the BH and moves rightwards, while the other gets swept leftwards into the BH.

of the ray picture and motivates the need for a wave-based description, which the field of mathematics known as catastrophe theory [7] precisely provides. Catastrophe theory tells us how to cure the ray singularities of caustics and that each one falls into a hierarchy of families with certain universal shapes and properties. The two simplest cases are known as fold and cusp caustics and are respectively described by the following two integrals: the Airy (left) and the Pearcey (right) functions [8], where (x, y) are control parameters (e.g., position coordinates) characterizing the geometry of the caustics.

$$\mathrm{Ai}(x) = \int_{-\infty}^{\infty} \mathrm{e}^{\mathrm{i}(\mathrm{k}^3/3+\mathrm{kx})}\, \mathrm{dk} \qquad\qquad \mathrm{Pe}(x,y) = \int_{-\infty}^{\infty} \mathrm{e}^{\mathrm{i}(\mathrm{k}^4/4+\mathrm{xk}^2/2+\mathrm{ky})}\, \mathrm{dk}$$

The frequency of the HR (ω) in our ultracold gas is approximated by the equation below [9], where u describes the sub- to super-sonic flow speed of the gas, k is the HR momentum (wavenumber), c the average speed of sound within the gas, and Λ a quantum length scale related to the interatomic distance between constituent particles (analogous to the existence of a Planck scale that might discretize spacetime in quantum gravity).

$$\omega - uk \approx ck + \Lambda k^3$$

The term proportional to Λ is relatively small and thus often ignored, resulting in the analogous relativistic form: $\omega - uk \approx ck$. However, the HR breakdown at the sonic horizon can in fact be resolved by retaining the quantum length scale term, and by doing so one finds that the HR is

Figure 2. Examples of caustics due to the refraction and reflection of sunlight. **Left:** Each band of colour in a rainbow is formed due to two waves focusing together and is mathematically described by an Airy function. **Middle:** The wavy lines at the bottom of swimming pools are due to the focusing of waves by the noisy surface of the water. **Right:** The cusp shaped focusing in the bottom of a coffee mug is mathematically described by a Pearcey function, where 3 waves focus together thanks to the cylindrical shape of the mug.

approximately described by the integral below [9]. We denote this the 'log-Airy' integral because it appears similar to the Airy function, but is modified by a logarithmic term within the integrand's phase.

$$\mathrm{LAi}(z, \omega) = \int_{-\infty}^{\infty} \frac{1}{k} \mathrm{e}^{\mathrm{i}\left(\mathrm{k}^3/3+\mathrm{kx}+\omega \ln(\mathrm{k})\right)}\, \mathrm{dk}$$

To understand how the HR forms and behaves near the horizon, we applied a modified version of the method of steepest descents [10] — a technique used to approximate integrals. For the log-Airy this involves deforming the 1D integration path from the real k-axis to new 3D contours that traverse complex k-space. The contours must pass through saddlepoints of the phase whilst simultaneously starting and ending in specific regions. Doing so ensures that each relevant contour-saddle pair physically represents a Hawking particle during a particular segment of its evolution. Combining every contour-saddle contribution thus yields a complete description of the HR dynamics near the horizon. It turns out that for the log-Airy integral the physical choice of contours is non-trivial. Previous approaches introduced additional approximations [9] which, although simplified the choice of steepest descent contours, led to a breakdown of the near-horizon physics, defeating the original purpose of keeping the quantum length scale term.

To overcome the challenge of non-trivial contour selection and the need for further approximation, we applied a simple exponential coordinate transformation, $k \to e^w$. This unfolds the infinitely spiraling structure of the 3D complex k-space into a flat, infinitely extended 2D complex w-plane [11], providing a more intuitive framework for identifying which contour-saddle contributions are relevant for describing the HR, as shown in Figure 3. Through our unfolded steepest descent analysis, we discovered that the log-Airy exhibits properties of the Airy function while also displaying steepest descent behavior locally equivalent to that of the Pearcey function [1]. As a result, the universal

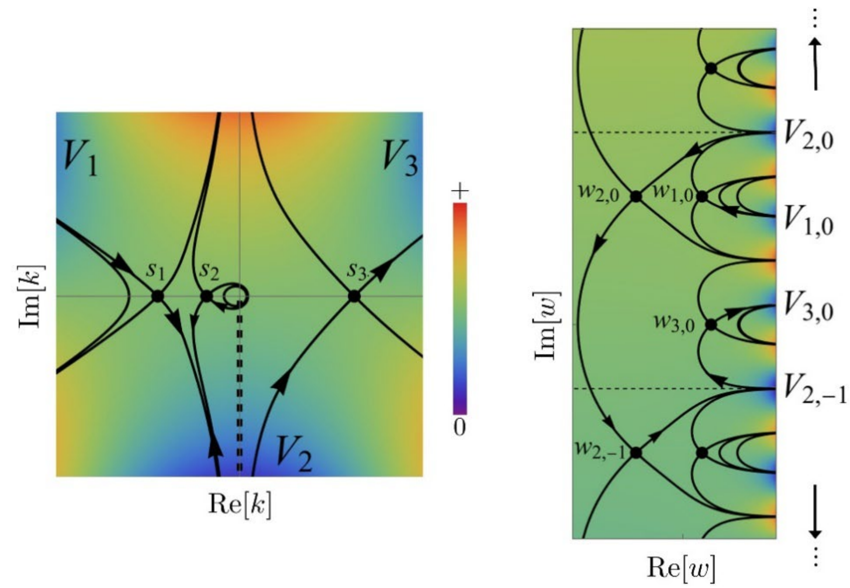

Figure 3. **Left:** 2D steepest descent diagram before unfolding, obtained by projecting the spiraling complex 3D contours (black solid lines) into 2D from $\theta = 0 \rightarrow 2\pi$ (starting at the black dashed line: a branch cut) for a particular choice of parameters (z, ω). To physically describe the HR, the contours must start and terminate in the various $V_{1,2,3}$ regions and simultaneously pass through saddlepoints (black dots)**.** Due to the presence of the branch cut the physical contributions are non-trivial in k-space. **Right:** Unfolded steepest descent diagram. In this w-space the correct contour-saddle pairs, and therefore the correct physical interpretation of the HR, becomes much more apparent.

mathematics of caustics — catastrophe theory — also applies to the log-Airy integral. This caustic-motivated approach uses the same universal physics that describes rainbows, offering a more accurate description of sonic HR by retaining the near-horizon behavior! It also bridges the concept of quantum catastrophes to the rigorous mathematics of catastrophe theory, reinforcing the idea that analogue models of gravity are valuable tools for investigating quantum-gravitational phenomena due to their universality.

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DEVELOPMENT OF A DIFFUSER BALL TO MONITOR THE WATER-CHERENKOV MUON VETO SYSTEM IN nEXO

SUMMARY: nEXO is a neutrinoless double beta decay search using a single phase liquid xenon time projection chamber shielded by a water-Cherenkov muon veto system (Outer Detector). A laser-driven system with diffuser balls is being developed to calibrate and monitor the performance of this Outer Detector. The status of the monitoring system is presented in this article.

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SAMIN MAJIDI RECEIVED 2ND PLACE IN THE
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Neutrinoless double beta ($0\nu\beta\beta$) decay is a weak interaction that is ideally suited for studying fundamental properties of neutrinos and the limits of the Standard Model. In $0\nu\beta\beta$ decay, two neutrons in a nucleus simultaneously transform into two protons and two electrons without emitting the corresponding electron antineutrinos $(\mathrm{A}, \mathrm{Z}) \rightarrow (\mathrm{A}, \mathrm{Z}+2) + 2\mathrm{e}^-$. This decay has not been observed yet [1, 2].

Neutrinoless double beta decay is forbidden in the Standard Model as it violates lepton number conservation in weak interactions. A positive observation of $0\nu\beta\beta$ would imply that neutrinos are Majorana particles—that is, they are their own antiparticles [3]. The observation of this decay would further support scenarios in which lepton number violating processes contribute to the generation of the baryon asymmetry of the Universe through leptogenesis [4].

Although the relationship is model-dependent, a measurement of the $0\nu\beta\beta$ decay half-life can provide information on the absolute scale of neutrino masses. The KamLAND-Zen experiment currently sets the limit for double beta decaying isotope, ^{136}Xe, reporting a half-life of $T^{0\nu}_{1/2} > 2.3 \times 10^{26}$ years at 90% confidence level [5]. This corresponds to an upper limit on the effective Majorana neutrino mass in the range of 36–156 meV, based on commonly used nuclear matrix element calculations [5]. The LEGEND experiment has reported a limit of $T^{0\nu}_{1/2} > 1.9 \times 10^{26}$ using ^{76}Ge, translating to an effective Majorana mass of <75–200 meV at 90% confidence level [6].

One of the next-generation experiments searching for $0\nu\beta\beta$ decay with a half-life sensitivity of beyond 10^{28} years is the nEXO experiment [2, 7]. It is being designed using 5 tonnes of liquid xenon enriched to 90% in the isotope ^{136}Xe. Its single-phase liquid xenon (LXe) time projection chamber (TPC), housed inside a vacuum-insulated cryostat which contains a hydrofluoroether cryogenic fluid. The entire assembly is placed at the center of a water-Cherenkov muon veto system, referred to as the Outer Detector [8]. Figure 1 (left) presents an engineering rendering of the nEXO experiment.

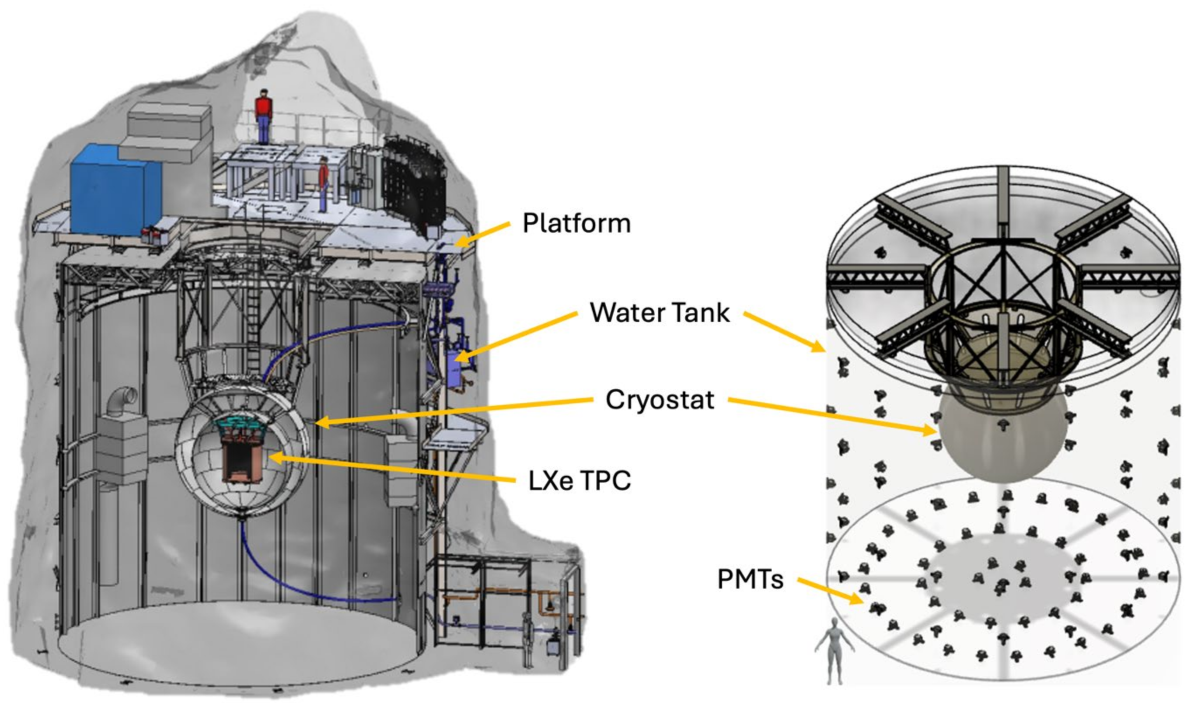

Figure 1. Left: Schematic of the nEXO experiment. The LXe TPC, vacuum-insulated cryostat, and the Outer Detector water tank are shown. Right: Layout of the PMTs in the Outer Detector. PMTs are positioned to optimize the detection of Cherenkov light from charged particles traversing the Outer Detector volume.

THE OUTER DETECTOR

The anticipated location for nEXO is the SNOLAB Cryopit, a cavern in Canada's deep underground laboratory, 2 kilometers below the surface, close to Sudbury, Ontario. This depth provides an effective overburden equivalent to 6000 meters of water, which reduces the flux of cosmic muons, shielding experiments against these muons. At SNOLAB, muons generated by cosmic rays in the upper atmosphere reach the laboratory with a flux of 0.27 μ/m^2/day [9]. Despite this reduction, muons that do penetrate to this depth can produce neutrons through various processes, which may subsequently interact with detector materials and generate background signals.

As muons pass through the Outer Detector, they emit Cherenkov light in a forward-facing cone, with a broad wavelength spectrum that peaks in the ultraviolet and extends into the visible range. In addition to this light, muons interacting with the water produce hundreds of neutrons. These neutrons can capture on ^{136}Xe inside the TPC, producing ^{137}Xe via the reaction: $\mathrm{n} + {}^{136}\mathrm{Xe} \rightarrow {}^{137}\mathrm{Xe}^*$. ^{137}Xe has a half-life of 3.82 minutes and decays via beta decay with a Q-value of 4173 keV through the reaction: $^{137}\mathrm{Xe} \rightarrow\ ^{137}\mathrm{Cs} +\ e^{-} +\ \bar{\nu}_{e}$. This decay mimics the topology of the signal of interest [8].

The Outer Detector of nEXO [10, 11] is being designed to enable the tagging of these cosmic-ray muons for later analysis and vetoing of muon-induced backgrounds. The Outer Detector will be a cylindrical water tank measuring 12.3 meters in diameter and 12.8 meters in height, filled with 1.5 kilotonnes of ultra-pure water. The water acts as a shield against gamma rays and moderates neutrons originating from the surrounding cavern rock. The Outer Detector will also be instrumented with an array of 125 Hamamatsu R5912 photomultiplier tubes (PMTs) mounted inward facing on the outer walls of the tank [8]. Figure 1 (right) shows the layout of the PMTs in the Outer Detector.

The veto system will tag muons via their Cherenkov light emission, which will be detected by the PMTs. In offline analysis, we will examine correlations between muon events and signals in the inner detector. Once a muon is tagged, a window of approximately 10 ms of data from the TPC will be selected and the system will search for prompt gamma signals from neutron capture de-excitation. If an increase in gamma activity is observed, the corresponding data will be associated with the muon event. The data will subsequently be vetoed for an extended period, corresponding to several half-lives of ^{137}Xe. Approximately 99% of ^{137}Xe decays will occur within a 25-minute veto window.

THE OUTER DETECTOR MONITORING AND CALIBRATION SYSTEM

A system is being developed to calibrate the muon veto and to monitor its performance throughout the lifetime of the experiment. The optical properties of the water and the performance of the PMTs must be monitored and the timing properties of the PMTs readout system need to be calibrated. This system consists of a fiber and a diffuser ball. Laser light pulses are injected into the fiber connected to the diffuser ball which emits isotropically and enables continuous monitoring of the PMTs responses. Laser sources with wavelengths between 360 and 390 nm are optimal for our system, as this range corresponds to the peak quantum efficiency of the PMTs [12]. In a current test setup, a 450 nm laser is being used due to availability in the lab.

The diffuser ball consists of a Teflon plug and a Teflon sphere. The Teflon plug is slightly more transmissive than the sphere, causing initial light diffusion at the plug, followed by a second diffusion stage in the sphere. The Teflon plug and sphere are housed inside a pressure housing made of a titanium flange and borosilicate hemispherical glass window. A photosensor will be placed inside the pressure housing, next to the Teflon sphere, to monitor the light output of the diffuser ball. All of the internal surfaces will be coated with a low-reflective coating material to prevent introducing reflective elements into the emission profile. Figure 2 shows the first prototype of the diffuser ball without the anti-reflective coating and without photosensor. The concept of the diffuser ball and its design is based on the design developed for the P-ONE and IceCube experiments [13, 14].

Simulations with varying numbers and configurations of diffuser balls inside the water tank indicate that the optimal number for monitoring the Outer Detector is five. The results also show that the placement of the diffuser balls does not affect the system’s performance, provided they are distributed

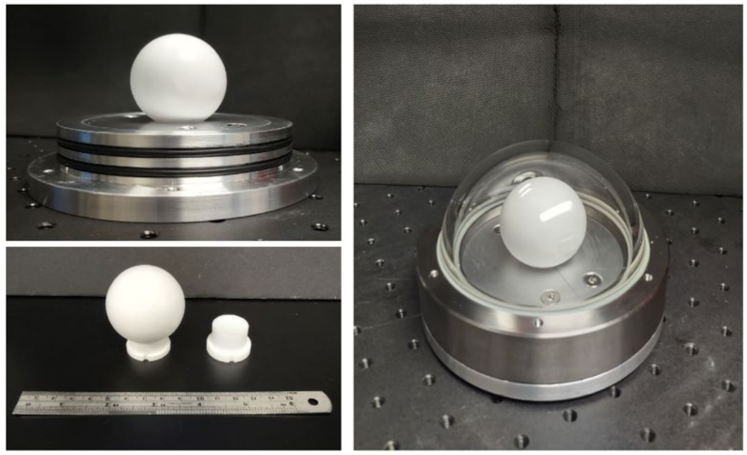

Figure 2. First prototype of the diffuser ball for the Outer Detector monitoring system. Bottom left: the Teflon plug and the Teflon sphere. Top left: the latter mounted in the flange. Right: the entire assembly.

homogeneously throughout the tank. In this case, all PMTs receive the required light intensity for proper calibration. A requirement of at least 10 photons reaching each PMT has been chosen as the design requirement for the calibration system [12].

We are developing a setup to test and characterize the diffuser ball, in particular to verify the isotropy of the emission profile. The diffuser ball assembly with glass window and flange is mounted on a two-axis rotary stage that can rotate the diffuser ball in 4π. A picture of the diffuser ball assembly mounted on the rotary stage is shown on the left in Figure 3. A PMT will measure the light intensity at each angle. The characterization setup will be housed inside a dark box. Laser light will be injected into the ball via a fiber optic patch cable connected to a fiber port at the back of the ball.

The development of a diffuser ball for calibrating and monitoring the Outer Detector of nEXO has been the focus of my work. The project began with proposing the idea of using laser-driven diffuser balls, followed by simulations to evaluate the concept for our detector and to determine optimal system parameters—such as laser wavelength, the number of diffuser balls, and their placement. The next stage involved designing the mechanical structure of the diffuser ball and building the first prototypes. Currently, the focus is on developing a setup to test and characterize the light emission profile of the diffuser ball. In the future, we plan to make necessary improvements to the prototype, including the integration of a photosensor to monitor the light intensity of the diffuser ball *in situ*.

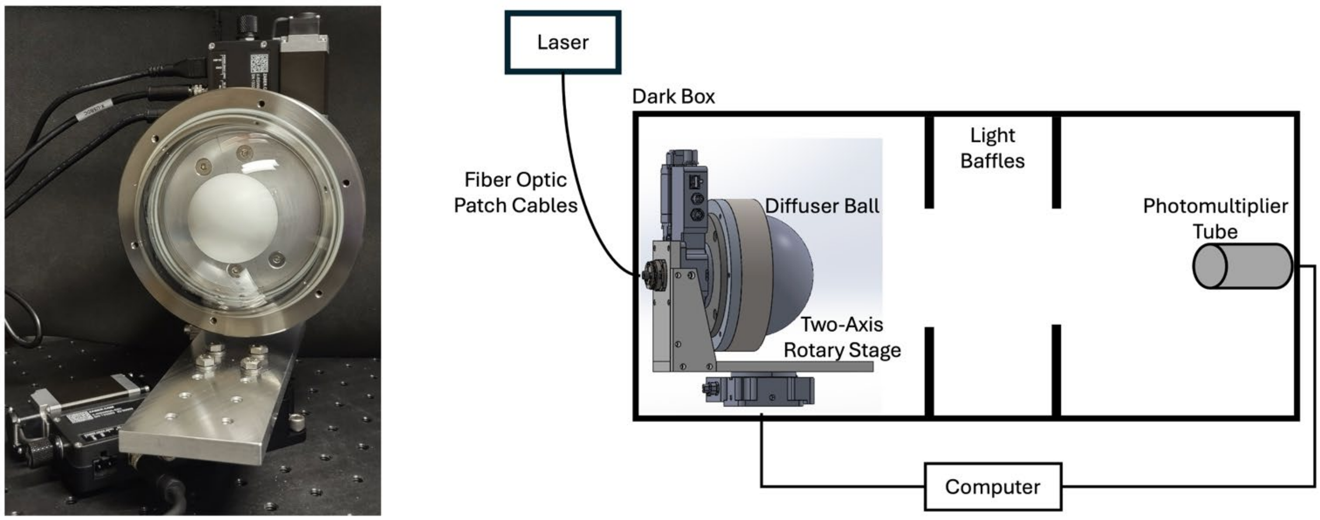

Figure 3. Test setup for measuring the emission profile of the diffuser ball. Left: Photograph of the Teflon sphere inside its pressure housing with optical hemisphere mounted on two-axis rotary stage. Right: Sketch of the characterization setup consisting of a dark box, housing the stage and the PMT. A laser beam is delivered to the diffuser ball via a fiber optic patch cable connected to a fiber port at the back of the stage. The computer controls the motors and records the PMT output.

ACKNOWLEDGMENTS

The author gratefully acknowledges the valuable feedback provided by project supervisors Thomas Brunner and Erica Caden, as well as the nEXO Outer Detector group. Appreciation is also extended to Irina Nitu, Iskender Isikbay, and Peter Liimatainen for their important contributions. Special thanks to the engineering team at SNOLAB for their support and technical assistance.

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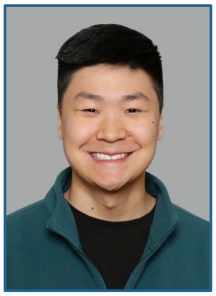
THE 8PI BGO BALL ARRAY AND ITS APPLICATION TO 3-GAMMA PET

SUMMARY: Three-gamma positron annihilations, measured with the 8pi BGO ball array, were used to generate a PET image with a 4 cm FWHM spatial resolution.



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JOSHUA YU RECEIVED 3RD PLACE IN THE
2025 CAP BEST OVERALL STUDENT ORAL PRESENTATION

Cancer is the leading cause of death in Canada, taking the lives of one in four Canadians [1]. Accurate diagnosis is an essential step in fighting this disease. Medical imaging techniques, such as Positron Emission Tomography (PET) scans, help doctors non-invasively detect and monitor cancer, guiding decisions about surgery, radiation therapy, and other treatments.

In a PET scan, the patient is injected with a drug containing a small amount of a positron-emitting radioactive isotope, known as a radiopharmaceutical. As it circulates through the body, it accumulates in areas of interest such as cancerous tissue. When the radioactive isotopes decay, they emit positrons which interact and annihilate with nearby electrons. This annihilation typically produces two gamma rays, each with an energy of 511 keV, that travel 180° apart (Fig. 1). By detecting these gamma rays, the surrounding PET scanner pinpoints where the annihilation occurred, revealing the location of cancerous tissue with millimeter precision.

In tissue, about 0.5% of positrons annihilate into three gamma rays instead of two [2]. These rare annihilations are ignored by traditional PET scans, but could provide valuable information about the local annihilation environment. For example, the rate of three-gamma annihilations is influenced by oxygen levels and tissue porosity, making it a potential early biomarker of hypoxia and other cancer-related changes [3]. However, to take advantage of this information, the locations of the three-gamma annihilations must be determined. Mapping these annihilations requires three-gamma PET imaging, which could be done alongside traditional two-gamma PET to provide complementary diagnostic information about the patient. The goal is not to replace traditional PET imaging, but to enhance it by offering additional insight into tissue properties.

Three-gamma PET image reconstruction requires locating the annihilation point from the detected gamma rays. One method uses the detection times and positions of the gamma rays to calculate the annihilation location. However, this relies on the system's timing resolution. A recent study using a PET scanner with 250 ps timing resolution achieved a spatial resolution of 8 cm [4].

In this work, an alternative energy-based approach is demonstrated using conservation of momentum. By measuring the energies and locations of the three gamma rays, the annihilation point can be reconstructed. Unlike the timing-based approach, the spatial resolution relies here on the energy resolution of the detectors. This approach is implemented using the 8pi gamma-ray spectrometer (Fig. 1), located at the Simon Fraser University Nuclear Science Laboratory (SFU NSL).

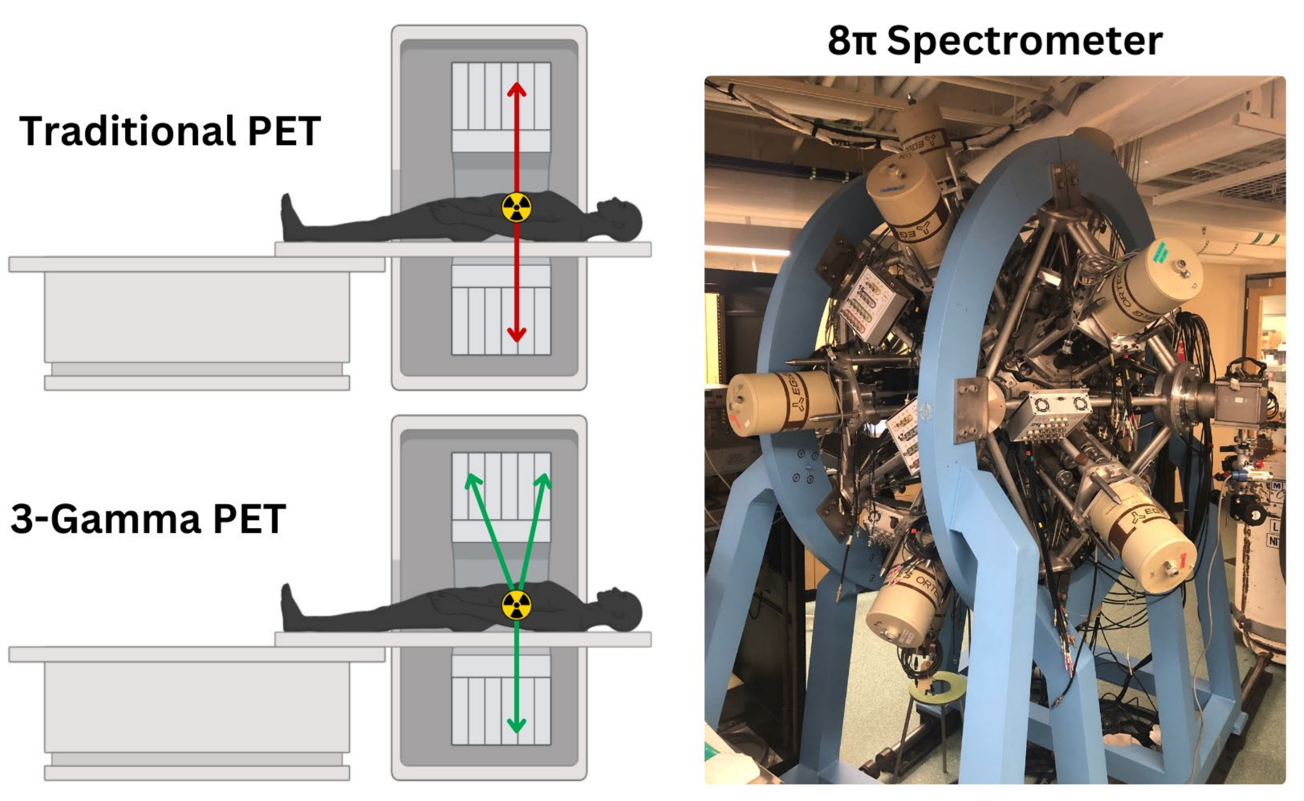

Figure 1. Illustration of a traditional PET scan and a three-gamma PET scan (left). The 8pi gamma-ray spectrometer (right).

THE 8PI GAMMA-RAY SPECTROMETER

The 8pi gamma-ray spectrometer [5] consists of 72 Bismuth Germanium Oxide (BGO) pentagon and hexagon detectors arranged in an icosahedron geometry around a central sample chamber (Fig. 2). It measures gamma-ray energies and their times of detection with high efficiency, owing to the intrinsically high gamma ray stopping power of BGO and the array's 95% solid angle coverage. Energy resolution at 661 keV is 11.7% for pentagons and 21.1% for hexagons.

The system's digital Data Acquisition System (DAQ) provides online multiplicity filtering to select events with a specific number of coincident gamma rays. When a gamma ray interacts with a BGO detector, the BGO produces a flash of light that is converted into a current pulse. This current pulse is transformed into a voltage signal whose area is related to the energy of the gamma ray, enabling energy measurements. If at least two gamma rays are detected in coincidence, the DAQ takes a snapshot of the voltage signals from all active detector channels and packages them into a single event for data analysis. This triggering requirement ensures that positron annihilations are recorded while background detections are suppressed.

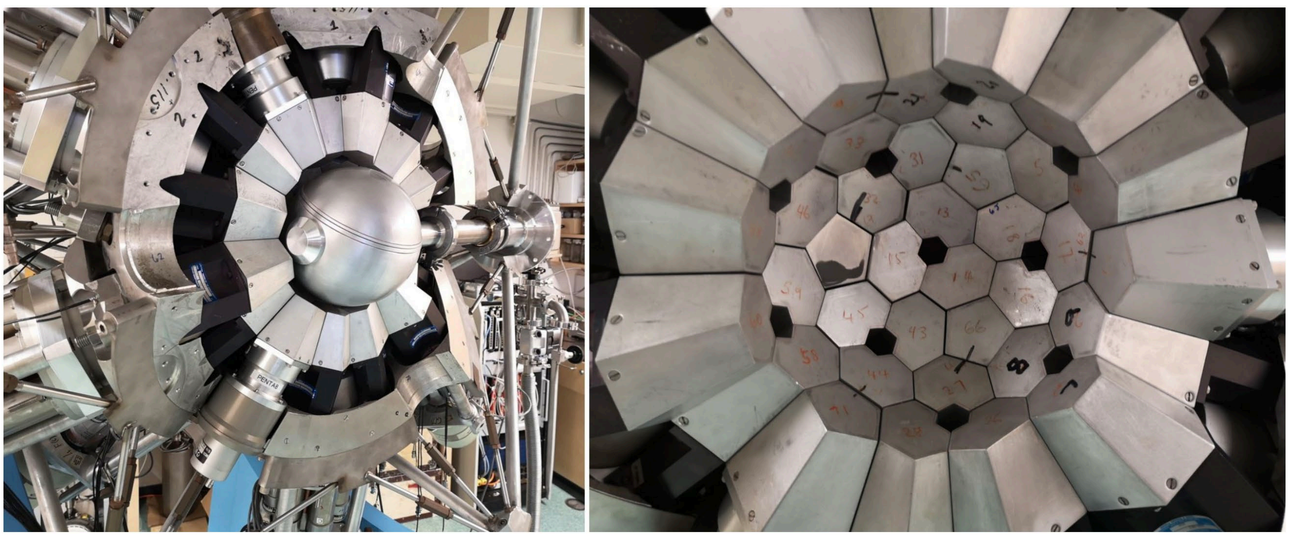

Figure 2. The 8pi gamma-ray spectrometer's BGO ball array.

THREE-GAMMA PET

In this experiment, the radioactive isotope fluorine-18 (^{18}F) is used as the source of positrons. It emits positrons with an energy of 250 keV and decays with a half-life of 110 min. ^{18}F is the most widely used PET isotope, commonly found in ^{18}F-fluorodeoxyglucose (^{18}F-FDG), a radiopharmaceutical that mimics glucose and accumulates in tissues with high metabolic activity, a characteristic of many cancers.

While ^{18}F is typically produced in hospitals using medical cyclotrons, this experiment uses a novel production method with a neutron generator [6]. A disk of polytetrafluoroethylene (Teflon) is irradiated with 14.2 MeV neutrons (n) from the generator (Fig. 3), causing the fluorine atoms naturally present in Teflon to undergo the nuclear reaction

$$^{19}F + n \rightarrow 2n + {}^{18}F,$$

which transforms stable fluorine-19 (^{19}F) into positron-emitting ^{18}F with a chosen activity of 450 Bq.

After irradiation, the Teflon disk is secured to the 8pi sample holder and encased in a copper sheath. The copper ensures that the emitted positrons annihilate within the sample holder, improving localization (Fig. 3). The sample is then mounted at the center of the 8pi spectrometer and measured over a period of three ^{18}F half-lives.

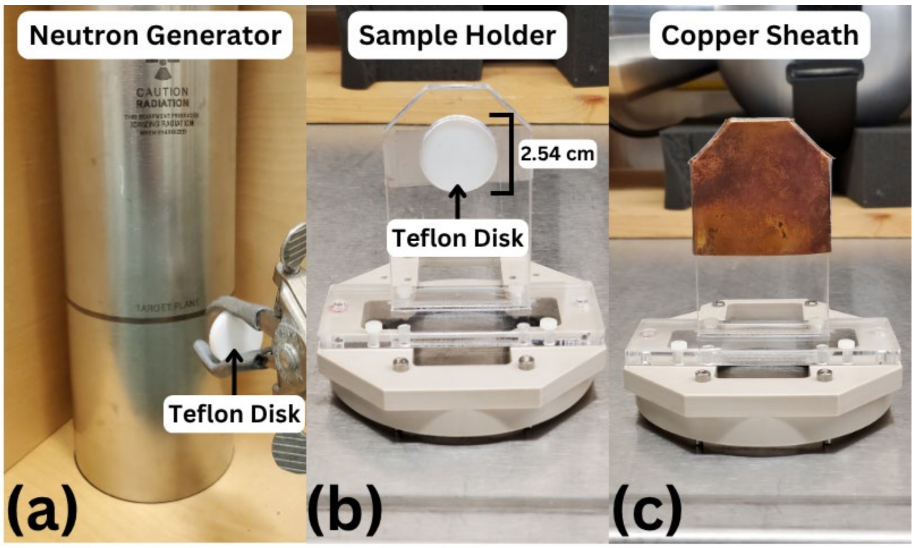

Figure 3. (a) Teflon disk secured in front of a neutron generator; (b) Irradiated Teflon disk secured in the 8pi sample holder; and (c) Irradiated Teflon disk sheathed with copper.

The collected data must be processed to isolate genuine three-gamma annihilation events. The analysis begins by identifying events in which three gamma rays are detected in coincidence. From these, only events with a total energy close to 1022 keV, the characteristic energy released in positron annihilation, are kept.

These candidate events are plotted on a ternary energy histogram (Fig. 4), which shows how the total energy is shared among the three gamma rays. Events where one gamma ray carries more than 511 keV (γ_i>0.5) are unphysical for three-gamma annihilation, as they violate conservation of linear momentum, and are excluded. Events where one gamma ray carries approximately 511 keV (γ_i≈0.5) likely correspond to two-gamma annihilation and are also excluded. Only events within the central region of the histogram, consistent with three-gamma annihilations, are kept.

A similar approach is applied on a ternary angle histogram (Fig. 4) to further isolate the final subset of events. Events where two gamma rays are emitted approximately 180° apart (θ_{ij}≈0.5) are excluded. Again, only events near the center of the histogram, consistent with three-gamma annihilation, are kept.

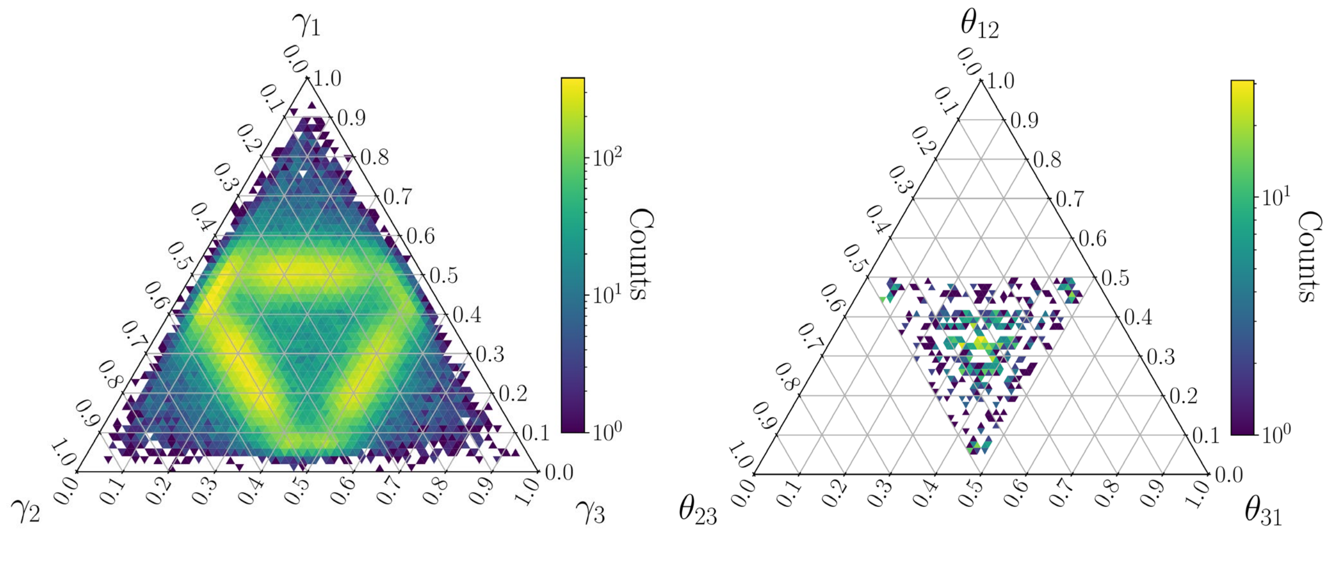

Figure 4. Ternary energy histogram (left) and ternary angle histogram (right). In the energy histogram, each axis represents a gamma ray's fraction of the total energy. In the ternary angle histogram, the interior angles between each pair of hit detector position vectors (defined from origin) are calculated. Each axis represents that interior angle's fraction of the sum of interior angles.

For each event in the final subset of data, the location of a three-gamma positron annihilation, $\vec{r} = (x, y, z)$, can be determined from solving the set of conservation of momentum equations

$$p_x = \frac{E_1}{c}\frac{x - x_1}{|(\vec{r} - \vec{r_1})|} + \frac{E_2}{c}\frac{x - x_2}{|(\vec{r} - \vec{r_2})|} + \frac{E_3}{c}\frac{x - x_3}{|(\vec{r} - \vec{r_3})|} = 0$$
$$p_y = \frac{E_1}{c}\frac{y - y_1}{|(\vec{r} - \vec{r_1})|} + \frac{E_2}{c}\frac{y - y_2}{|(\vec{r} - \vec{r_2})|} + \frac{E_3}{c}\frac{y - y_3}{|(\vec{r} - \vec{r_3})|} = 0$$
$$p_z = \frac{E_1}{c}\frac{z - z_1}{|(\vec{r} - \vec{r_1})|} + \frac{E_2}{c}\frac{z - z_2}{|(\vec{r} - \vec{r_2})|} + \frac{E_3}{c}\frac{z - z_3}{|(\vec{r} - \vec{r_3})|} = 0,$$

where E_i and $\vec{r_i} = (x_i, y_i, z_i)$ is the energy and detected location of the three gamma rays $(i = 1,2,3)$, and c is the speed of light in vacuum (Fig. 5) [7].

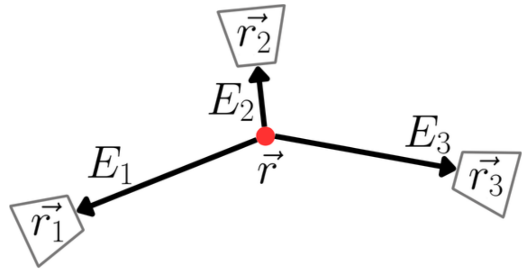

Figure 5. Schematic of three-gamma positron annihilation.

The solved locations, corresponding to 709 selected events, are plotted in Fig. 6, giving the reconstructed three-gamma PET image. The experiment was then repeated with the irradiated Teflon disk offset by -7.5 cm along the Y-axis. Following a similar analysis procedure, the reconstructed offset three-gamma PET image is plotted in Fig. 7, corresponding to 1425 selected events. The experimentally measured offset was found to be -7.4 cm ± 3.5 cm, in good agreement with the actual offset.

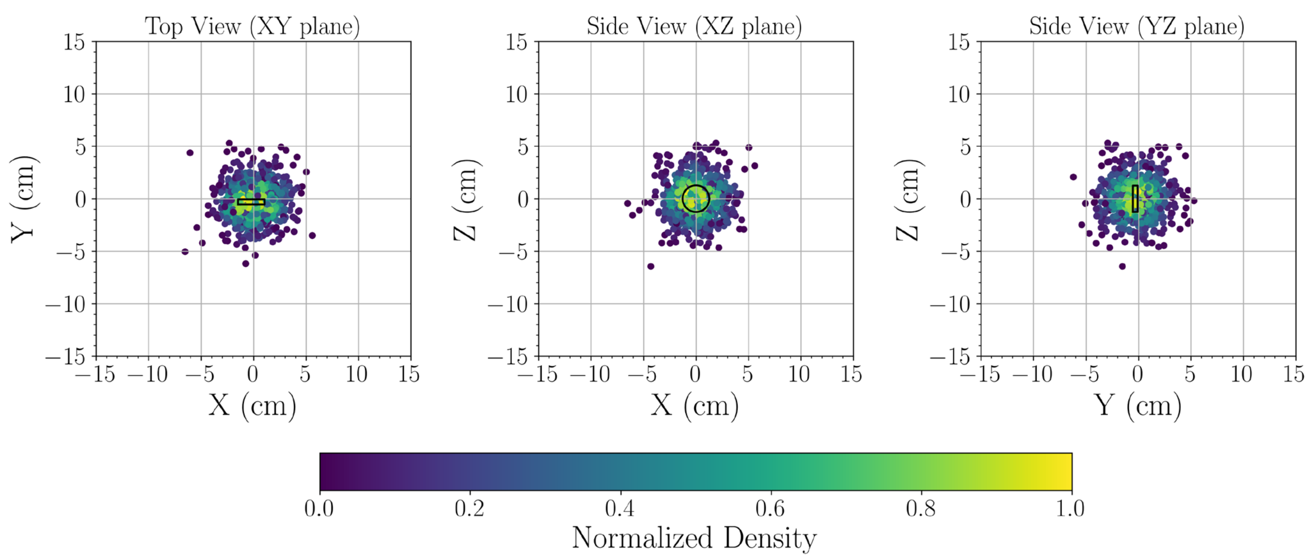

Figure 6. Three-gamma PET image of a Teflon disk measured in the center of the 8pi spectrometer. The black outline indicates the true physical size and calculated position of the irradiated Teflon disk.

The energy-based three-gamma PET image reconstruction method demonstrated here achieves a spatial resolution of 4 cm FWHM, outperforming the 8 cm resolution achieved with the timing-based approach [4]. This experiment is the first demonstration of three-dimensional image reconstruction using this energy-based approach. Owing to the high efficiency of the 8pi spectrometer, comparable statistics were obtained using much lower source activities and shorter measurement times than in previous two-dimensional energy-based three-gamma annihilation imaging experiments [7, 8]. This resulted in a four-order-of-magnitude improvement in reconstruction efficiency, defined as the number of reconstructed events divided by the total number of three-gamma annihilations.

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The authors would like to thank Greg Hackman from TRIUMF, Ken van Wieren from the SFU Science Technical Centre, and Jan Tõke from JTec Instruments for their invaluable contributions with the 8pi spectrometer. This research was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) Subatomic Physics Discovery Grant Program.

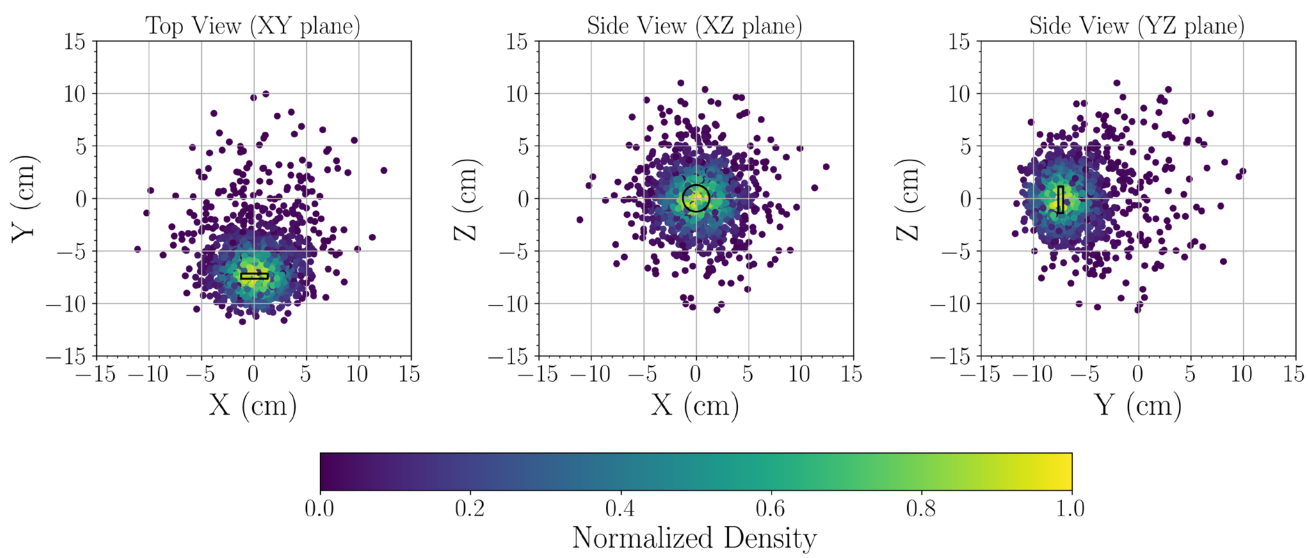

Figure 7. Three-gamma PET image of a Teflon disk offset by -7.5 cm along the Y-axis, measured in the 8pi spectrometer. The black outline indicates the true physical size and calculated position of the irradiated Teflon disk.

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2025 CANADIAN CONFERENCE FOR UNDERGRADUATE WOMEN AND GENDER MINORITIES IN PHYSICS

SUMMARY: The Canadian Conference for Undergraduate Women and Gender Minorities in Physics (CCUW*iP) is a three-day series conference for undergraduate physics, astronomy, and engineering students from across Canada. This edition of the event was the first to include 'Gender Minorities' in the official title, showcasing the Canadian Association of Physicists' (CAP) commitment to inclusivity. This report serves to outline key aspects and results of CCUW*iP, encouraging future editions and similar events of its kind.

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The 12th edition of the Canadian Conference for Undergraduate Women and Gender Minorities in Physics (CCUW*iP) was held at the University of Calgary, Calgary, Alberta, from January 31st to February 2nd, 2025 [1]. Over 3 days, 92 students from 20 universities across Canada came together, attending social and academic events to build connections for their academic and professional development. These student-run events demonstrate the tenets of leadership and the importance of fostering welcoming environments in Science Technology Engineering and Mathematics (STEM) disciplines, where women and gender minorities are often underrepresented.

The CCUW*iP aims to support women and LGBTQIA+ students in physics by creating networking platforms, highlighting diverse research, and addressing challenges specific to underrepresented groups in STEM [2]. This event is sister to the American Physical Society's (APS) Conferences for Undergraduate Women and Gender Minorities in Physics (CU*iP) concurrently hosted at universities across the United States [3].

As a rotating event hosted by a different institution across Canada each year, the CCUW*iP enables undergraduate students to visit institutions across the country and provides an opportunity for them to host the event themselves. This annual congress offers an occasion for these students to:

- Present their research in poster and oral presentation competitions
- Attend plenary lectures and panel discussions
- Participate in workshops
- Visit laboratory and observatory facilities
- Network at a graduate and career fair
- Participate in social networking events
- Access mentorship from established scientists in their fields

This event provides important peer and professional support systems that are often difficult to access as a minority in traditional academic settings, creating visibility and substantial resources for undergraduate students' academic and professional advancements. The 12th edition of CCUW*iP featured a variety of events, including plenary lectures, roundtable panel discussions, workshops, tours to local laboratories and the Rothney Astrophysical Observatory (RAO), a graduate and career fair, and networking/social events. For specific information, please refer to the event programme [1].

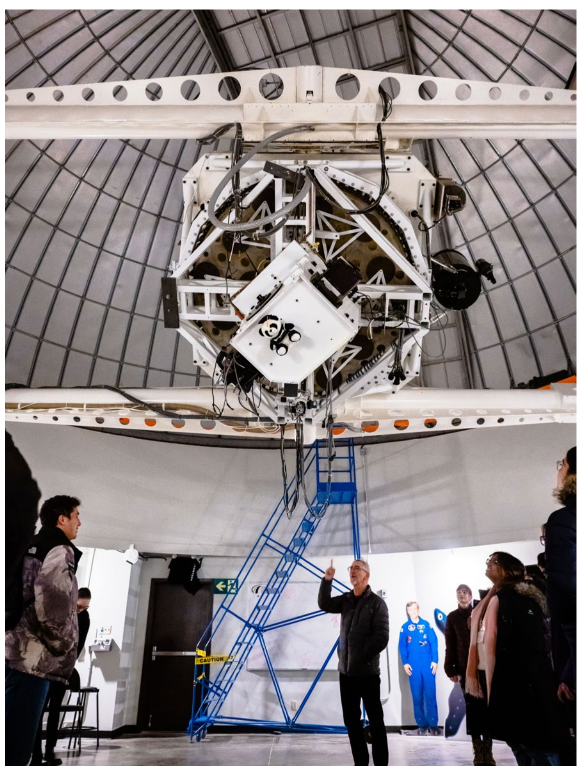

Figure 1. Dr. Phil Langill speaking to delegates at the tour of the Rothney Astrophysical Observatory.

Figure 2. Delegates Michaela Hishon (left) and Emma Greenall (right).

2025 CCUW*iP at the University of Calgary

With over 215 participants (consisting of attendees, committee members, volunteers, tour guides, speakers, panellists, judges, and representatives from visiting institutions), CCUW*iP 2025 provided a transformative environment for networking, mentorship, and professional academic development. This scale was made possible by the remarkable capacity for community support beyond the institutional level. Local businesses offered significant discounts and product donations, and graduate students, postdocs, staff and faculty members contributed in ways beyond their commitments out of support for the cause.

The 92 student delegates paid a registration fee of $60, which (with contributions from generous sponsors) covered hotel accommodation, meals, snacks, and refreshments throughout the event, removing common barriers for event attendance. Attendees also received a customized tote bag filled with an assembly of items such as notebooks, pens, merchandise, and local transportation passes. Visiting participants were asked to return any unused transit tickets at the end of the event, which were subsequently donated to the local Women’s Emergency Shelter, extending the event’s values beyond immediate participants.

When registering for the CCUW*iP, students were encouraged to submit an abstract to compete in oral and poster presentation competitions at an undergraduate level. These presentations were made

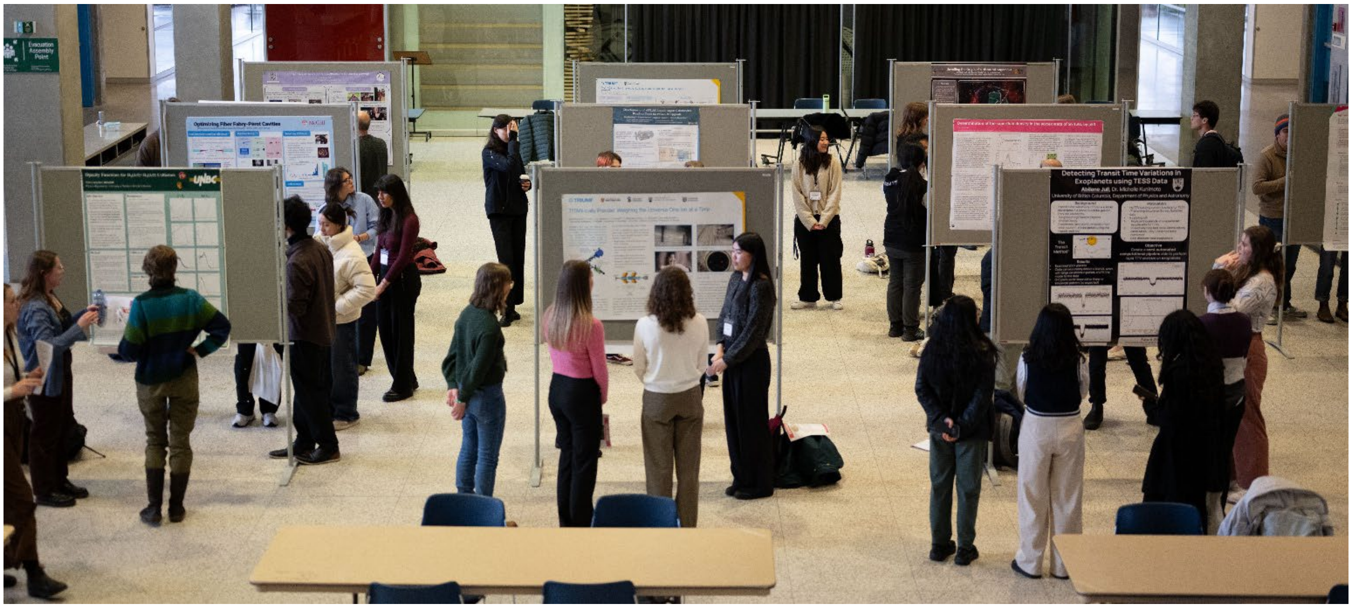

Figure 3: A snapshot from the student poster presentation competition hosted on Saturday, February 1st, 2025.

to an audience of undergraduate students and a panel of judges on the second day of the event. Award recipients were announced and celebrated at the banquet dinner. A total of 42 students presented at the event. Also, upon registration, students were prompted to note their preferences for workshop, lab tour, and parallel panel sessions. Beyond academic structured events, the graduate and career fair was a huge success with 22 institutions, industry, and organizations hosting tables at the event—allowing for substantial networking and inquiries about careers and future studies.

The organizing committee implemented comprehensive accessibility accommodations throughout the duration of the event. This included quiet rooms for sensory needs and study spaces, volunteer escorts on and off campus for participant safety, and access to emergency campus contact information. The organizing committee also worked to offer a well-rounded and accessible food experience for everyone. To achieve this, lunches were, by default, halal and gluten-free, with selections between chicken and vegan options. These efforts received incredible positive feedback from participants, demonstrating the significance and impact that food accessibility can have for conference experiences.

For the organizers, the most meaningful impact came from witnessing participant testimonies. After both the banquet and closing ceremony, delegates expressed their gratitude and favourite components of the event, sharing how different talks and panels resonated with them, as well as the opportunities and insights they took away from the experience. This feedback made months of planning worthwhile, highlighting the genuine connections and learning opportunities that were facilitated for everyone involved. A selected number of pictures from the 2025 CCUW*iP are depicted in Figures 1, 2, 3, and 4.

Conference Leadership

A team of 9 organizing committee members from three universities (the University of Calgary, the University of Alberta, and the University of Lethbridge) orchestrated CCUW*iP 2025. Together, the team secured 45 sponsorships, organized a comprehensive programme for social and academic events, and coordinated 20+ volunteers who dedicated their time during the three-day event.

The CCUW*iP enables considerable administrative and leadership development opportunities for organizers. Managing these logistics fostered skills in coordinating well-structured events/schedules, time management, communication, and overseeing a large team to accomplish collective goals. This experience highlighted the importance of catering to complex stakeholder relationships and attendee needs while navigating a schedule with significant moving parts. Involved leadership experiences like CCUW*iP are valuable experiences at the undergraduate level, allowing students to develop professional skills in the contexts of organization, community building, and scientific events management.

Future Directions

Conferences like the CCUW*iP are critical for highlighting the accomplishments of gender minorities in traditionally male-dominated fields and promoting equity, diversity, and inclusion (EDI) values in STEM settings. These events function as platforms for marginalized groups, offering environments where participants feel welcome and supported, surrounded by like-minded individuals and allies, celebrating diverse experiences and contributions to STEM.

The 13th edition of CCUW*iP will be held in Vancouver at the University of British Columbia in January 2026. Expressions of interest in hosting the 2027 edition should be submitted to CAP by January 15, 2026, with full bid applications due on February 15, 2026. Links and further information about the application process can be found at [2].

Figure 4: All delegates and organizing committee members present at the closing ceremony on Sunday, February 2nd, 2025.

Acknowledgements

All photos in this document are credited to Nick Kuzmin.

We would like to extend our sincere gratitude to all attendees, speakers, visiting institutions, sponsors, donors, and volunteers who contributed to CCUW*iP 2025. Their dedication and support made this event possible. In particular, we thank the Department of Physics and Astronomy and the Faculty of Science at the University of Calgary for all their support. We would also like to thank CAP for this incredible event-hosting opportunity.

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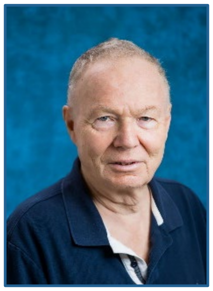
2. https://cap.ca/congress-conference/ccuwip
3. https://www.aps.org/initiatives/inclusion/gender-inclusive/undergraduate-women-minorities

SUCCESSFUL PARTICIPATION OF CANADIAN STUDENTS IN THE 55TH INTERNATIONAL PHYSICS OLYMPIAD IN PARIS



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Our students did quite well in Paris, winning 5 medals while competing with the best physics students from 89 countries from all continents except Antarctica! It was great to participate in the International Physics Olympiad (IPhO) again after deciding against participating in the 2024 IPhO in Iran due to Canadian government travel restrictions. Fortunately, we were kindly invited to participate in the 2024 European Physics Olympics (EPhO) instead [1].

Our team was selected from among 1028 students from 146 schools participating in the 2025 CAP High School/CEGEP Prize Exam. This was almost twice as many students that participated in 2024 but still 50% below pre-COVID levels. The top 15 students were invited to the 8-day Canadian Physics Olympiad camp at the University of British Columbia. Only 14 participated as one student declined, at the last moment, due to health reasons.

This year the preparation of our students for the International Physics Olympiad was greatly improved by the amazing help of a group of our alumni led by Tristan Yan-Klassen. They organized an online camp with lectures and problem-solving sessions in April, before the in-person camp in May.

During the in-person Canadian Physics Olympiad camp we always introduce a large number of new subjects not covered in Canadian high schools, but that are part of the IPhO curriculum. Also, many schools are not equipped for teaching experimental work. Introducing these new subjects and experimental techniques before the in-person camp helped the students to master these new subjects and techniques.

Following an idea proposed by Prof. Silberman, the group also started training students not graduating from high school this year who participated in the 2025 CAP exam but were not selected for the final camp. The inaugural online Junior Physics Olympiad with lectures, theoretical and experimental examinations was held from August 3-9. Our alumni volunteers intend to continue supporting the Olympiad program by supporting the training of prospective team members and giving mentorship to talented young students.

At the end of the camp, five students with the highest scores in 2 experimental and 2 theoretical exams were chosen to represent Canada in the 55th IPhO in Paris. They were:

- He (Harry) Gong from St. George's School (BC), student of Nathan Moens
- Hongyi (Alex) Huang from Upper Canada College (ON), student of James Weekes
- Zander Li from Laurel Heights Secondary (ON), student of David Vrolyk
- Robert Yang from Walter Murray Collegiate (SK), student of Murray Guest
- Wuhua (Steven) Zhu from London International Academy (ON), student of Jeff Shen

The French IPhO organizers did a great job creating, presenting and marking Olympiad problems. The Academic Committee was composed of distinguished professors from top French universities, including the famous military École Polytechnique (founded in 1794), alma mater of many famous French scientists, politicians and military leaders. Like in Japan, the problems were very well designed not only to challenge the best high school physics students in the world but also to interest them in subjects of physics usually not taught in schools and to teach them some new skills. The International board discussion resulted in very few significant changes to the problems.

There were six Nobel Prize winners on the IPhO honorary committee, two of which gave short, fascinating lectures, one during the opening and one during closing ceremonies.

All the International board meetings were hosted by École Polytechnique. One could even spot some French students in full dress uniform.

Apart from hard work during the experimental and theoretical exams the students had a chance to socialize with other participants and in many cases form new and lasting friendships. They were treated to a number of cultural events including a visit to Versailles, the Musée d'Orsay, the Science museum (Cité des sciences et de l'industrie) and a boat tour on the Seine.

EXPERIMENTAL AND THEORETICAL PROBLEMS

In the first experimental problem students were expected to measure the horizontal component of the Earth's magnetic field using a torque pendulum. The magnets, a hall sensor with an Arduino processor-based supply, amplifier and display, and a pair of coils in the anti-Helmholtz configurations were provided. Students were tasked to figure out the calibration and measurement method which would achieve the maximum accuracy of the measurement. It was interesting that, in order to ensure fair marking, the organizers had to measure the Earth's magnetic field at each of the student's booths. The magnetic field inside the building varied a lot due to the iron structures around the rooms.

The second experiment tested the students' ability to measure very accurately some surprisingly simple relations: the dependence of the size of an impact crater on the energy of the impacting ball and the dependence of the drag force acting on a ball rolling in sand on the ball's velocity.

Determining experimentally both of these dependencies required good experiment planning and execution to cover, in the first case, 5 orders of magnitude of energy by using various ball sizes and initial ball heights, and in the second case many repetitions for different ball energies. Statistical and graphic analysis of the results was essential.

The first theoretical problem reflected the methods used in analysing astronomical observations. First, students had to develop the model of hyperfine interactions in hydrogen atoms to obtain the hydrogen emission spectra. Next, they were given the original data describing the rotation curves for typical spiral galaxies and had to show that they indicated the existence of some hidden mass. Finally, students were introduced to some elements of the MOdified Newtonian Dynamics (MOND) theory and were then expected to use the given data to determine the Tully-Fischer exponent. All the calculations needed to solve this problem are available in textbooks, but not in the ones the IPhO contestants were likely to read.

The second theoretical problem was based on the design of a unique clock wound by atmospheric pressure changes. It was built in 1765 and nobody knows if and for how long it worked. The students had to analyse a simplified model of this contraption and calculate how much usable work it could provide.

The third problem was related to the famous French product, champagne. Students had to analyse the nucleation, growth and rise of the champagne bubbles, the sound of their bursting and the mechanics of extracting the champagne cork. To solve the problem, they needed knowledge of thermodynamics and acoustics as well as some mechanics. Personal experience of drinking champagne or opening the bottle was not needed. Some leaders who were strongly opposed to the idea of drinking alcohol were welcome to refer to any bubbly drink rather than champagne in their translation of the problem.

RESULTS

The problems were difficult. Figure 1 shows the distribution of points with the limits for gold, silver and

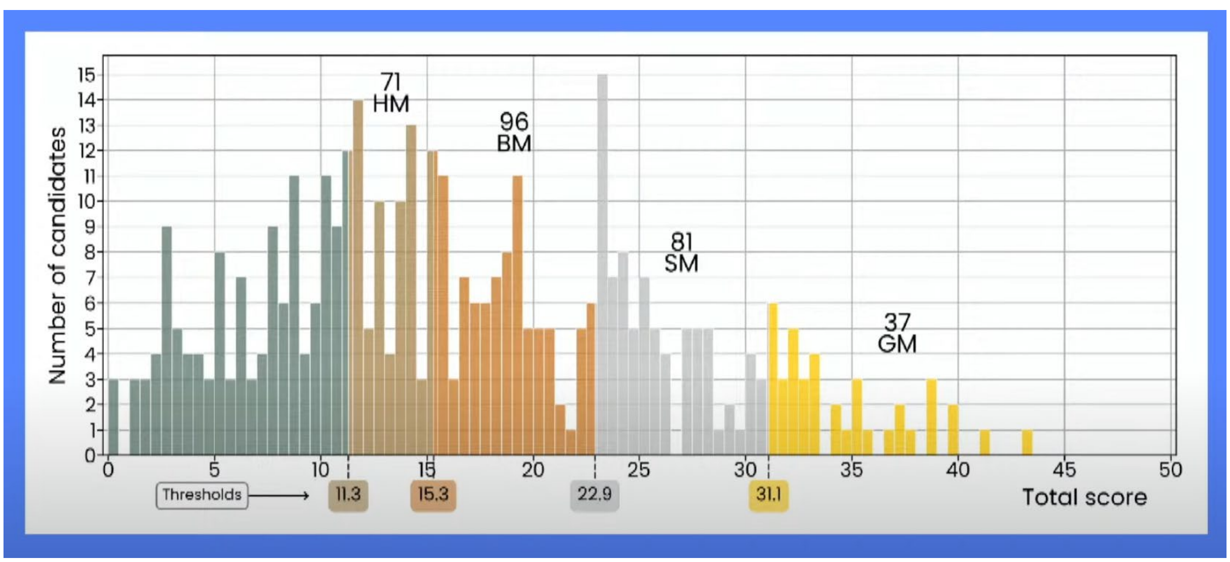


Figure 1. The distribution of the final scores showing thresholds for the different awards. Each problem was worth 10 points; 50 corresponds to 100%.

bronze medals and honorary mentions. Notice that only 2 students scored more than 80% (40 on the graph), and a large number of students scored less than 20% and some students scored 0 points. It seems that the theory clock problem was most difficult - see the points distribution for this problem in Fig. 2. Notice that almost 100 students did not receive any points for this problem!

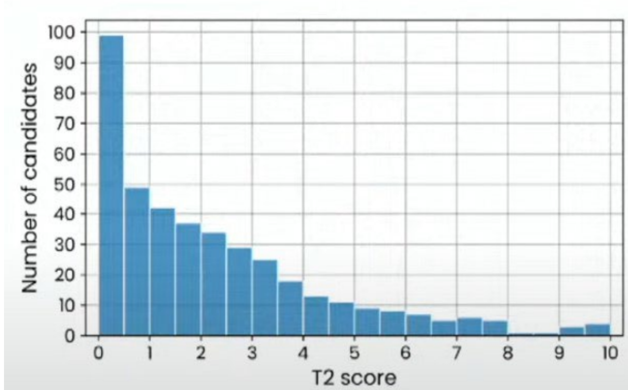


Figure 2. Grade distribution for theory problem 2.

Our students did very well, with the best results we've seen in the last few years: Zander Li, Robert Yang and Hongyi Huang received silver medals; He Gong and Wuhua Zhu earned bronze medals. Zander was very close to winning a gold medal; he received the top score amongst the silver medalists.

At the end of the closing ceremony the IPhO flag was formally transferred from France to Colombia. Colombian leader, Professor Elena Losada-Falk, invited all participating countries to participate in the 56th International Physics Olympiad in Bucaramanga, Colombia in 2026.

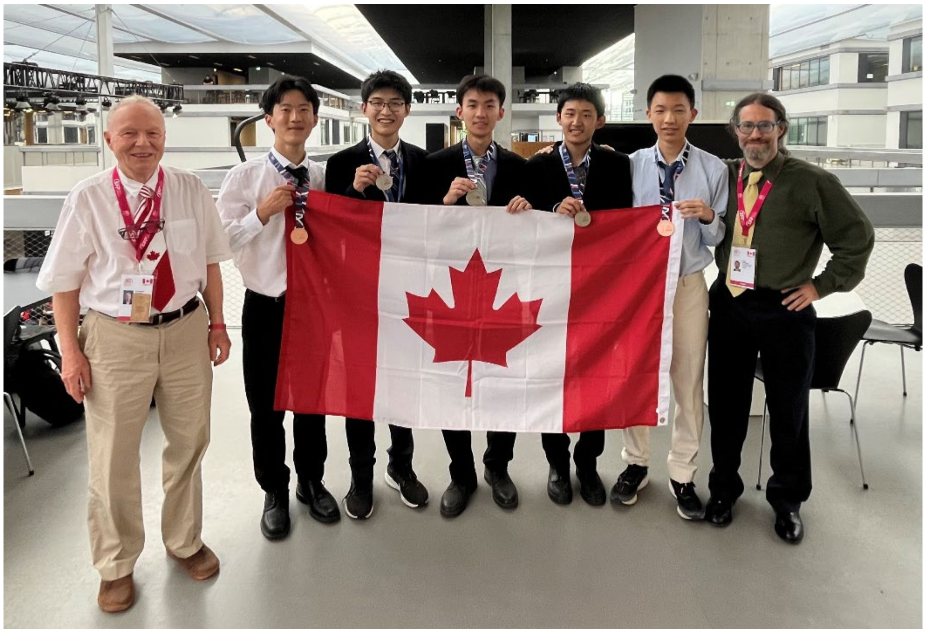


Figure 3. The members of the Canadian team with medals after the closing ceremony. From left to right: Team leader Dr. Andrzej Kotlicki (UBC), Director for the Canadian Physics Olympiad Program, He Gong, Hongyi Huang, Zander Li, Robert Yang, Wuhua Zhu, and Team leader Dr. Lior Silberman, Professor of Mathematics at UBC and past IPhO contestant (on the 1994 Israeli team).

ACKNOWLEDGEMENTS

Many thanks to our sponsors, whose support made Canadian student participation in this prestigious competition possible:

- The Department of Physics and Astronomy, UBC
- The Trottier Family Foundation
- Sonny Chan, IPhO alumnus (1998,1999) and medalist
- TRIUMF, Canada's Particle Accelerator

REFERENCES

1. L. Silberman, Report on Canada's Participation in the 8th European Physics Olympiad in Kutaisi, Georgia, Physics in Canada **80**, 77-78 (2024). https://pic-pac.cap.ca/index.php/Issues/showpdf/article/v80n1.0-a4218.pdf

2025 INTERNATIONAL TEACHER WEEKS PROGRAMME AT CERN

SUMMARY: Participation in the CERN International Teachers Workshop was a once-in-a-lifetime experience to join an international community of educators focused on better understanding not just particle physics, but how its inclusion in the curriculum can engage and motivate future physicists, engineers and technicians. Thank you CAP, Perimeter Institute, and the Institute of Particle Physics for your generous support!

By **TASHA RICHARDSON** (tasha.richardson@tdsb.on.ca)
Albert Campbell Collegiate Institute, Toronto, Ontario[1]

In August 2025, with the generous support of the Canadian Association of Physicists (CAP), the Perimeter Institute (PI), and the Institute of Particle Physics (IPP), I had the privilege of attending the two-week International Teachers Programme at CERN in Geneva, Switzerland. I joined 39 other educators from 31 countries to dive into the world of particle physics to deepen our understanding of and explore strategies for bringing this advanced content into high school classrooms.

The programme offered a full and varied schedule of lectures, workshops, and site visits. Hosted by Jeff Wiener (CERN) and Milena Vujanovic (University of Leeds), we began with warm welcomes from Charlotte Lindberg Warakaulle (CERN) and Sascha Schmeling (CERN), followed by an overview of particle physics from Jonathan R. Ellis (King's College London). Throughout the two weeks, we heard from leading experts in the field: Simon Albright (CERN) spoke on the design and operation of particle accelerators, Veronika Kraus (Vienna University of Technology) explained the function and architecture of particle detectors, and Luis Roberto Flores Castillo (Chinese University of Hong Kong) walked us through the intricacies of the Higgs boson, Feynman diagrams, and antimatter. We also heard from Raymond Veness (CERN) on the engineering challenges at CERN, Bettina Mikulec (CERN) on the realities of running a particle accelerator, and Piotr Traczyk (CERN) on the Compact Muon Solenoid (CMS) detector. One particularly memorable talk came from Manjit Dosanjh (University of Oxford), who spoke about the medical applications of particle physics, particularly in cancer treatment. Her

[1] Formerly with the Ontario Science Centre Science School, Toronto District School Board

lecture highlighted the need for cross-curricular collaboration and served as a powerful reminder of how fundamental physics can have profound real-world impact.

In our second week, Markus Joos (CERN) presented on the computing infrastructure required to process and analyze the vast amounts of data generated by the LHC, while Flavia de Almeida Dias (Nikhef National Institute for Subatomic Physics) focused on the statistical methods and data analysis tools used in modern particle physics. Patrick Koppenburg (Nikhef National Institute for Subatomic Physics) introduced us to “beauty” physics and the study of B-quarks, Panagiota Chatzidaki (Uppsala University) shared insights on heavy ion physics from the ALICE experiment. Maurizio Pierini (CERN) explored the use of machine learning in high-energy physics research, Claudia Ahdida (CERN) addressed radiation protection measures at CERN, and Michael Benedikt (CERN) gave an overview of the Future Circular Collider (FCC) project and the process for selecting its potential location. This final lecture emphasized the importance of large-scale scientific projects engaging with all stakeholders affected by their outcomes, and underscored the necessity of incorporating equity and justice into discussions surrounding international scientific infrastructure.

Direct teaching strategy discussions were led by Jeff Wiener, who shared research on best practices for introducing particle physics into the classroom. His work included practical resources like the “Mystery Boxes” activity, which encourages students to hypothesize and infer based on limited evidence—mirroring the methods used by physicists themselves. Additionally, Milena Vujanovic’s research on the use of Concept Maps was revisited throughout the programme, and she shared important considerations of their use in the classroom.

Alongside the lectures, we participated in several site visits. We toured ATLAS, CMS, ALICE, LHCb, the antimatter factory, and LEIR, and visited the CERN Control and Data Centres, as well as the Cryogenic Test Facility. Although the LHC was running during our stay and we couldn’t enter the tunnels, we still went underground at CMS (90 plus metres) to experience the magnetic fields—still perceptible through thick concrete walls. At CERN’s Science Gateway (an educational and outreach science centre), we built cloud chambers and observed particle decay tracks of electrons, protons, and muons.

Figure 1. Inside the Cryogenic Test Facility at CERN.

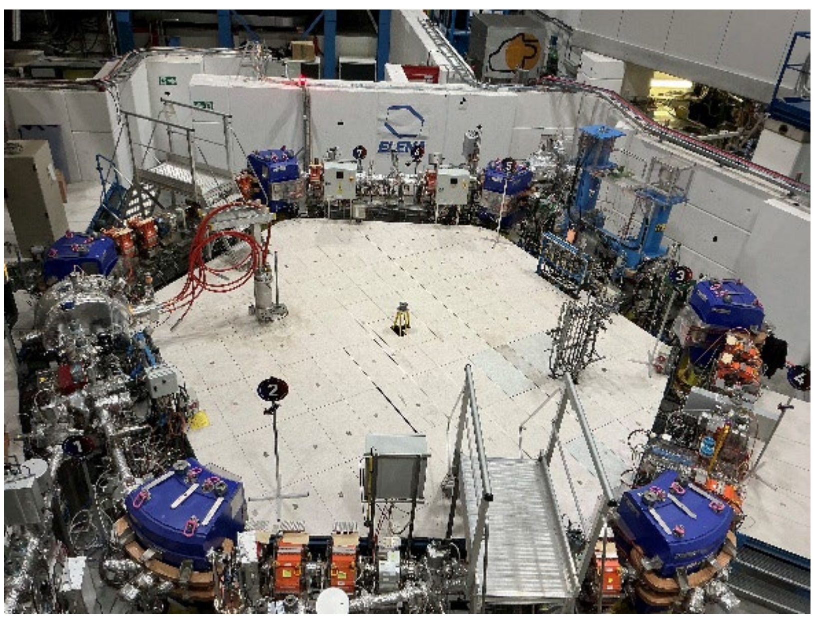


Figure 2. Extra Low Energy Antiproton ring (ELENA) in the Antimatter Factory at CERN. ELENA slows antiprotons to make them easier to trap.

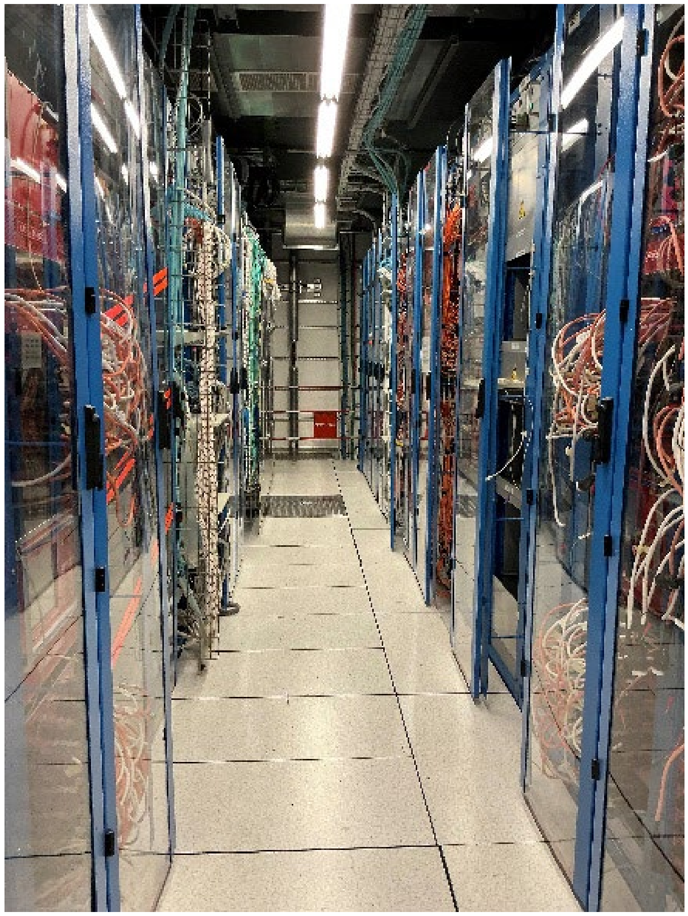


Figure 3. The Counting Room, 87.9 m underground at the Compact Muon Solenoid (CMS) at CERN.

Throughout the programme, I was repeatedly struck by how well the Ontario science and physics curricula align with the foundational concepts explored at CERN. Topics such as law of conservation of energy and momentum, nuclear energy, the motion of charged particles in electric and magnetic fields, and the Standard Model are all critical for understanding particle physics. For my final group presentation on the specific experiments run at CERN, I reflected on how these curricular components join together to form a strong base for students to begin engaging with this exciting field.

One of the most profound takeaways from the programme was the sense that particle physics is not a finished story, but an evolving pursuit. As Jonathan Ellis remarked in his opening lecture, “I hope there is a difference between theory and experiments.” The field of particle physics thrives not on confirming what we already know, but on seeking what we don’t. This mindset – that the unknown is not a limitation but an invitation – is something I am eager to bring back to my students. Physics becomes far more meaningful when presented not as a set of answers, but as a field driven by open questions.

There is space for everyone in this pursuit, and that in itself is a powerful message to carry into the classroom.

Acknowledgements

I am deeply grateful to the CAP, the Perimeter Institute, and the Institute of Particle Physics for making this experience possible. Opportunities like these help keep Canadian science education globally connected and forward-thinking, and I'm excited to maintain the international connections I built at CERN to better support and inspire my students moving forward.

2025 CAP MEDAL RECIPIENTS / LAURÉATS DES MÉDAILLES DE L'ACP DE 2025

The CAP is very pleased to recognize its 2025 medal recipients. Please visit the CAP website for the list of medal recipients with a link to the detailed citations and any remarks submitted by the recipient following the receipt of the award.

L'ACP est très heureuse de reconnaître ses récipiendaires de médailles 2025. Veuillez consulter le site web de l'ACP pour obtenir la liste des récipiendaires de médailles, ainsi qu'un lien vers les citations détaillées et les remarques à la suite de la réception de la récompense.

CAP Medal for Lifetime Achievement in Physics / Médaille de l'ACP pour contributions exceptionnelles à la physique

Hong Guo, McGill University, in recognition of pioneering work and world leadership in quantum transport theory and applications to nanoelectronic devices.

CAP Herzberg Medal / Médaille Herzberg de l'ACP

Jo Bovy, University of Toronto, in recognition of profound and original contributions to our understanding of the formation, evolution, and current dynamical structure of the Milky Way.

CAP-COMP Peter Kirkby Memorial Medal for Outstanding Service to Canadian Physics / La Médaille commémorative Peter Kirkby de l'ACP-OCPM pour services significatifs à la physique au Canada

Stephen Pistorius, in recognition of his service to both COMP and the CAP in service and leadership roles, and in the words of one of his colleagues for being instrumental in bringing physics into the forefront of the work of COMP.

CAP-CRM Prize in Theoretical and Mathematical Physics / Le Prix ACP-CRM de physique théorique et mathématique

Alexander Maloney, McGill University, in recognition of his pioneering contributions to the fields of conformal field theory and three-dimensional quantum gravity.

CAP-DCMMP Brockhouse Medal / Médaille Brockhouse de l'ACP-DPMCM

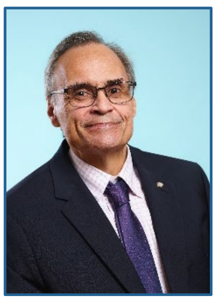
Peter Grutter, McGill University, in recognition of his impactful contributions to experimental research in several areas of condensed matter and materials physics, surface science, biophysics, and nanotechnology and, in particular, for his pioneering work on force microscopy detection methods.

CAP-TRIUMF Vogt Medal for Contributions to Subatomic Physics / Médaille Vogt de l'ACP-TRIUMF pour contributions en physique subatomique

Mark Boulay, Carleton University, in recognition of important contributions to the direct search for dark matter using liquid argon detectors. Highlights include the development of pulse shape discrimination to reduce backgrounds in dark matter searches and leadership on the DEAP and Darkside-20k experimental programs.

CAP Medal for Excellence in Teaching Undergraduate Physics / Médaille de l'ACP pour l'excellence en enseignement de la physique au premier cycle

Nancy Forde, Simon Fraser University, in recognition of her contributions to enhancing the learning experience of her students through innovative teaching methods, involvement in curriculum development, and an impressive record of undergraduate research mentorship.



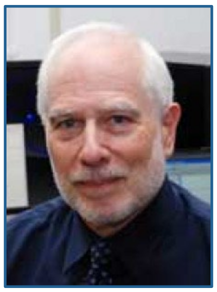
CAP Medal for Outstanding Achievement in Industrial and Applied Physics / La Médaille de l'ACP pour des réalisations exceptionnelles en physique industrielle et appliquée

Richard Boudreault, in recognition of contributions to medical imaging, photonics, space technology, and sustainable materials. His leadership in translating physics research into real-world applications has driven innovation across multiple industries, advancing technologies that benefit society.

2025 CAP FELLOWS / LES FELLOWS DE L'ACP DE 2025

The CAP is pleased to announce the 2025 CAP Fellows (FCAP). The CAP Fellowship Program recognizes CAP members who have made important contributions in physics research, in physics teaching, in the advancement of technology, or in service to physics in Canada.

L'ACP est heureuse d'annoncer les Fellows de l'ACP (FCAP) de 2025. Le programme de bourses de l'ACP reconnaît les membres de l'ACP qui ont apporté une contribution importante à la recherche en physique, à l'enseignement de la physique, à l'avancement de la technologie ou au service de la physique au Canada.



Douglas Bryman, University of British Columbia, for outstanding research contributions to the study of rare decays of light mesons and muons; and in recognition of extensive leadership, mentorship, and service to the physics community.

Sarah Gallagher, Western University, for outstanding research contributions in astrophysics and leadership in major projects that will benefit scientists in Canada and around the world; and for championing equity, diversity, inclusion and decolonization.

Bruce Gaulin, McMaster University, in recognition of outstanding research accomplishments using scattering techniques in the study of quantum materials; and for contributions to the development of new neutron scattering facilities and leadership in the Canadian and international physics community.

Shohini Ghose, Wilfrid Laurier University, for outstanding service to the Canadian Association of Physicists, tireless advocacy for equity, diversity and inclusion in STEM fields; and in recognition of contributions to the fields of quantum chaos and quantum information, as well as efforts to raise the profile of Canadian physics nationally and internationally.

D**arren Grant, Simon Fraser University,** for establishing Canada's first very-high-energy neutrino research effort, thereby advancing our knowledge of neutrinos and their role in the extreme Universe and leadership in the foundational studies to realize Canada's first high-energy astrophysical neutrino telescope; and for contributions to training a diverse generation of high-energy physicists.

Béla Joós, University of Ottawa, for dedication to promoting physics in Canada through service, including leadership in the Canadian Association of Physicists and as editor of Physics in Canada; and for research contributions to condensed matter physics and biophysics.

Norman Murray, University of Toronto, for outstanding research in theoretical astrophysics, with major contributions in extrasolar and solar planets, helioseismology, energetics of galaxies, and black hole AGN feedback; and for an outstanding record of mentorship and training.

Pekko Sinervo,University of Toronto, for advancing our understanding of the basic building blocks of the universe, for contributions to the discovery of the top quark and the Higgs boson, and for leadership that has strengthened the physics community and the broader academic enterprise in Canada.

Louis Taillefer, Université de Sherbrooke, for innovative experimental research on quantum materials, including superconductors, spin liquids, and strange metals; and in recognition of extensive service and leadership in the quantum materials field in Canada.

André-Marie Tremblay, Université de Sherbrooke, for extensive contributions to the theory of quantum materials and the development of numerical methods applied to strongly correlated systems, including the Hubbard model; and in recognition of leadership, mentorship, and training, especially in the field of quantum materials.

CONGRATULATIONS / FÉLICITATIONS!

2025 STUDENT PRIZE WINNERS / GAGNANTS DES PRIX POUR LES ÉTUDIANT(E)S 2025

2025 CAP HIGH SCHOOL-CÉGEP PRIZE EXAM NATIONAL WINNERS / L'EXAMEN DU SECONDAIRE OU COLLÉGIAL DE L'ACP – GAGNANTS À L'ÉCHELLE NATIONALE 2025

First prize / Premier prix	**William Ma**	**Strathcona Composite High School, AB**
Second prize / Deuxième prix	**Wuhua Zhu**	**London International Academy, ON**
Third prize / Troisième prix	**Robert Yang**	**Walter Murray Collegiate, SK**

2025 CANADA-WIDE SCIENCE FAIR PRIZES / PRIX DE L'EXPO-SCIENCES PANCANADIENNE 2025

The 2025 Canada-Wide Science Fair was held in Fredericton, NB from May 31 to June 7. This year the CAP sponsored one prize in the Senior category.

SENIOR CAP PHYSICS PRIZE – JERONE ARRISTAN AND ALAN GABRIEL, TORONTO, ON

Project: Utilizing Electromagnetic Systems for Hybrid Space Launches

Abstract: Our project is geared towards hybrid electromagnetic launches for energy efficiency and long term usage. Through electronically timed electromagnets, speed is attained without chemical propellants. The launch track involves coil windings and accurate distancing between solenoids with controlled sensory data and input voltage for accurate power cycling. To reduce atmospheric drag and friction, the launch track is placed within a vacuum tube with a graphene coating on the guided rail to reduce friction on the payload. Alongside internal tests, additional research and proportionality calculations allowed for scalability and efficiency rate comparisons of initial phases with traditional launch systems.

Meet Your 2025-2026 Executive

President / Président

Pierre Bénard's educational background includes a Ph.D. and undergraduate studies completed at the Université de Sherbrooke, as well as a Master's degree from the University of Toronto. He has focused his research and scholarly endeavors primarily on condensed matter theory, particularly in the area of high-temperature superconductivity. However, Pierre's interests have expanded to encompass applied physics, specifically working on materials and technologies relevant to the energy transition. From 2017 to 2023, Pierre served as the Director of the Hydrogen Research Institute at the Université du Québec à Trois-Rivières, where he has made significant contributions to the field. During his tenure, he successfully established a collaborative research unit with colleagues at INRS EMT in Varennes, concentrating on materials for the new energy transition. Furthermore, he played a key role in the creation of an innovation zone focused on technologies essential to the energy transition. Pierre's dedication extends beyond his research and academic pursuits. He aims to address the future and role of physics in Canadian society while considering the regional context and the challenges faced by smaller universities. With his comprehensive understanding of the discipline, Pierre seeks to bring valuable perspectives to the development of the Canadian Association of Physicists and advocate for the interests of physics within the broader scientific community.

Vice-President / Vice-présidente

Wendy Taylor is a Professor of Physics at York University. After she completed her PhD in physics at the University of Toronto in 1999, she was a Stony Brook University (NY) postdoctoral fellow based at Fermilab (IL). She then joined the faculty at York University in 2004, where she held a Tier 2 Canada Research Chair in Experimental Particle Physics for 10 years. Her research is currently focused on the search for the hypothetical magnetic monopole using the ATLAS detector at the CERN Large Hadron Collider in Geneva, Switzerland. Wendy's past leadership roles include President of the Board of Trustees of the Institute of Particle Physics (2023-24), executive membership of the TRIUMF Board of Management (2018-21), Chair of the CAP Particle Physics Division (2007-08), and Chair of the CAP Committee to Encourage Women in Physics (1997-99). She has also served on international, federal, and provincial review panels and award selection committees. Wendy engages with the media and with the public on particle physics topics. Throughout her career, Wendy has advocated for equity, diversity, and inclusion in physics.

Vice-President / Vice-présidente élue

Cornelia Hoehr serves as Interim Director of TRIUMF's Life Sciences Division, where she guides the division's scientific programs and the Institute for Advanced Medical Isotopes (IAMI) initiative. She leads a diverse team operating at the crossroads of nuclear physics, radiochemistry, medical physics, and accelerator science, driving both fundamental discoveries and applied research aimed at improving health outcomes.

Dr. Hoehr earned her Ph.D. in experimental physics from the University of Heidelberg and carried out postdoctoral work at the Max Planck Institute for Nuclear Physics, Argonne National Laboratory, and TRIUMF. She holds adjunct faculty positions in medical physics at the University of British Columbia – Okanagan and the University of Victoria. Her research focuses on developing medical radioisotopes, advancing innovative radiotherapy techniques, and creating cutting-edge detector systems for clinical applications. She has contributed her expertise to numerous national and international boards, committees, and expert panels, including those of the IAEA, PTCOG, and CMIE. She currently serves as Vice President Elect of the Canadian Association of Physicists (CAP).

Past President / Président sortant

Martin Williams is a tenured faculty member in the department of physics at the University of Guelph and serves as the university's Director of Teaching and Learning. Martin's teaching has been recognized through several awards including the CAP Medal for Excellence in Teaching Undergraduate Physics and the University of Guelph's Distinguished Professor Award for Excellence in Teaching. Martin obtained his Ph.D. degree in Experimental Condensed Matter Physics from Imperial College, University of London, UK. Martin has an active research programme with current interests in the Scholarship of Teaching and Learning. Before arriving at Guelph, he worked as a postdoctoral fellow at Imperial College and University College London. He is a chartered Physicist and member of the Institute of Physics UK and a past Chair of the Division of Physics Education of the Canadian Association of Physicists.

Secretary-Treasurer / Sécretaire-Trésorier

Christine Kraus is a SNOLAB research scientist, with adjunct positions at Laurentian University and Queen's University. Her research field is particle astrophysics. In 2004 she received her Ph.D. from the Johannes Gutenberg University in Mainz, Germany for the final analysis of the Mainz Neutrino Mass experiment. From there she moved to Canada to pursue a postdoctoral fellowship on the famous SNO experiment at Queen's University. Since 2010, when she moved to Sudbury as a Canada Research Chair, her main focus has been the SNO+ experiment, which is now taking data. Prof. Kraus is a past advisory council member as well as a past PPD chair.

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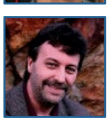

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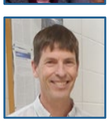

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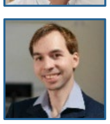

Director – Student Affairs / Directeur – Affaires étudiantes
MATTHEW ROBBINS, University of Toronto

PhD Physics Degrees Awarded in Canadian Universities

Doctorats en physique décernés par les universités canadiennes

January 1 2024 to December 31 2024 / 1 Janvier 2024 à 31 Décembre 2024

This list documents recipients of Ph.D. degrees as reported by Canadian Physics departments. Each entry lists the recipient, thesis title, advisor(s), semester of graduation, and current position (if known).

Cette liste répertorie les titulaires d'un doctorat tels que déclarés par les départements de physique canadiens. Chaque entrée indique le nom du titulaire, le titre de la thèse, le ou les directeurs de thèse, le semestre d'obtention du diplôme et le poste actuel (si connu).

CARLETON UNIVERSITY

ALLEN, C., "Development and Application of a Multimodal Coherent Raman Scattering Microscope", (S. Murugkar), Winter 2024, Pursuing a Research Associate position at Oak Ridge National Laboratory, Oak Ridge, TN, USA.

ELBELTAGI, M., "Study of High Voltage Breakdown in Liquid Xenon Time Projection Chambers and Statistical Interpretation of Machine Learning Assisted Event Discrimination in Rare Event Searches", (R. Gornea), Fall 2024, Now a Data Scientist at Larus, Ottawa, ON, Canada.

ERLANDSON, A., "First observation of solar neutrino absorption on 40Ar using the DEAP-3600 detector", (M. Boulay), Fall 2024, Physicist at Canadian Nuclear Laboratories, Chalk River, ON, Canada.

FLETCHER, E., "Advances in Monte Carlo modelling for characterization of specific energy and absorbed dose distributions from cell to patient length scales", (R. Thomson), Fall 2024.

DALHOUSIE UNIVERSITY

BORSAVAGE, J., "The theranostic benefits of a novel 2.5 MV sintered diamond target beam on a modern radiation therapy linear acceleartor", (J. Robar, A. Cherpak), Oct 2024, Medical Physics Resident, Warren Alpert Medical School, Providence, RI, USA.

GUO, H., "Portable Ambient Light-compatible Spectroscopic Approach Applied to Non-invasive Real-time Quantification of Global and Macrovesicular Steatosis in Donor Liver: Proof of Concept, Development, and Early Commercialization Attempts", (K. Hewitt), May 2024, Clinical Medical Physics Resident, Icahn School of Medicine, New York, NY, USA.

KALLIECHARAN, D., "Measurements of the force exerted by a forced pulsed water jet, and its affect on the mechanical properties of titanium alloys", (T. Monchesky), May 2024.

LYNCH, N., "A 3D Printed Patient-Specific *in vivo* Dosimetry System", (J. Robar, T. Monajemi), Oct 2024, Oncology Physics Resident, Dept of Human Oncology, Madison, WI, USA.

MARRIOTT, A., "3D Simultaneous Quantification of SPIO and Gadolinium contrast agents *in vivo* using MR Fingerprinting", (K. Brewer, J. Rioux), Oct 2024, Research Scientist, Synex Medical, Toronto, ON, Canada.

PRIDHAM, G., "Modelling Causal Mechanisms in Organismal Aging", (A. Rutenburg), Oct 2024, Postdoctoral Fellow, Weizmann Institute, Rehovot, Israel.

RATHORE, D., "Understanding and modifying active material structures for improved Li-ion batteries", (J. Dahn), May 2025, Research Scientist, BMW, Munich, Germany.

MCMASTER UNIVERSITY

BANGASH, S.U.K., "Designing and Evaluating a 109 Cd based XRF System For Skin Iron Measurements: A Validation Study in Normal and Iron Overload Conditions", (M. Farquharson, F. McNeill), Winter 2024, pursuing a CAMPEP diploma at McGill University, Montreal, QC, Canada.

BESHARAT, A., "Effective Field Theory of Dissipative Dynamics On Lie Group", (S. Sibiryakov), Fall 2024, Postdoctoral Fellow at the University of Alberta, Edmonton, AB, Canada.

BICKLEY, L., "Studies to improve the *in vivo* measurement of strontium by X-ray fluorescence", (F. McNeill), Spring/Summer 2024.

BOGOJEVIC, S., "Magnetic Monopoles and Dyons: The Low-Energy Perspective", (C. Burgess), Fall 2024.

BORISSOV, A., "Low-Energy Effective Field Theories for the Antiferromagnetic Quantum Critical Metal with Z2, O(2) and O(3) Spin Symmetries", (S. Lee), Spring/Summer 2024, Quantum Computing Researcher at SoftwareQ, Waterloo, ON, Canada.

HE, H., "Molecular Gas and Star Formation in Nearby Starburst Galaxy Mergers", (C. Wilson), Summer 2024, Postdoctoral Fellow at the University of Bonn, Bonn, Germany.

HESHMATZADEH, Y., "Bulk Properties of Cohesive Frictionless Granular Aggregates", (K. Dalnoki-Veress), Fall 2024.

HOGGARTH, J., "Cohesive Oil Droplets As An Idealized Model Granular System", (K. Dalnoki-Veress), Fall 2024, Postdoctoral Fellow at Yale University, New Haven, CT, USA.

KHATTAK, H., "Driven Motion in Droplets", (K. Dalnoki-Veress), Spring/Summer 2024, Research Associate at McMaster University, Hamilton, ON, Canada.

LEDGER, B., "Using the Cyanide Radical to Trace Dense Molecular Gas in Nearby Star-Forming Galaxies", (C. Wilson), Fall 2024, Postdoctoral Fellow at the University of Victoria, Victoria, BC, Canada.

SUNDARAM, S., "Effective field theory based on the quantum inverted harmonic oscillator and the inverse square potential with applicatios to Schwinger pair creation", (D. O'Dell), Fall 2024.

WANG, J., "Local Physics of Disordered Quantum Spin Liquid Systems Individuated by NMR and Inverse Laplace Transform 1=T1 Analysis", (T. Imai), Spring/Summer 2024, Postdoctoral Fellow at the University of Toronto, Toronto, ON, Canada.

QUEEN'S UNIVERSITY

ANDERSON, M., “Studies of machine learning for event reconstruction in the SNO+ detector and electronic noise removal in p-type point contact high purity germanium detectors”, (R. Martin), Summer 2024, Data Scientist at Larus, Ottawa, ON, Canada.

BISARIA, D., “Hunting for anomalous gas: kinematic models of spiral galaxies in 2D and 3D”, (K. Spekkens), Spring 2024.

BULENGA, T., “Advancing An Open-Source Radiation Treatment Planning for Orthovoltage X-ray and Cobalt-60 Teletherapy”, (J. Schreiner), Spring 2024, Medical Physics Resident at Thunder Bay Regional Health Sciences Centre, Thunder Bay ON, Canada.

DARLING, K., “Linear Operator Theory of Phase Mixing in Collisionless Systems”, (L. Widrow), Spring 2024.

GODFREY, J., “Innovation Through Optical Manipulation: From Parahydrogen Macrocoherence to Enhanced 2D Semiconductors”, (J. Fraser), Fall 2024.

HAWLEY HERRERA, H., “Light collection as a veto for PICO and SBC dark matter searches”, (K. Clark), Summer 2024, Research Scientist at Canadian Nuclear Laboratories, Chalk River, ON, Canada.

LI, H., “Weighing the Milky Way While Exploring Disequilibrium”, (L. Widrow), Spring 2024, Research Scientist at the School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai, China.

TYSON, K., “Manipulation and Enhancement of Excitonic Optical Spectroscopy in Two-Dimensional Semiconductors”, (R. Knobel), Spring 2024, Staff Scientist at Light Machinery, Ottawa, ON, Canada.

SIMON FRASER UNIVERSITY

DEABREAU, A., "Towards Integration of Optically Active Defects in Silicon Photonics", (S. Simmons), Spring 2024, Quantum Networking Engineer at Photonic, Burnaby, BC, Canada.

LEIGHTON, M., "Stochastic Thermodynamics of Multicomponent Molecular Machines", (D. Sivak), Fall 2024, Mossmann Independent Postdoctoral Fellow at Yale University, New Haven, CT, USA.

MARTIN, M., "Electromagnetic Transition Rate Measurements in 28Mg and Identification of Exotic Molecular Symmetries in Actinide Nuclei", (K. Starosta), Spring 2024, Postdoctoral Researcher at Argonne National Laboratory, Lemont, IL, USA.

MOKHTARI-JAZI, A., "Correlations in the Clean and Disordered Bose Hubbard Model", (M. Kennett), Spring 2024, Researcher at the BC Centre for Excellence in HIV/AIDS, Vancouver, BC, Canada.

WANG, X., "Cosmological Tests of Gravity with MGCAMB", (L. Pogosian), Summer 2024, Postdoctoral Researcher at Peking University, Beijing, China.

TORONTO METROPOLITAN UNIVERSITY

DAY, J., "Assessment of Cadmium Telluride Photon-Counting Detectors for Breast Imaging Applications", (J. Tanguay), Spring 2024, Postdoctoral Researcher at University of Victoria, Victoria, BC, Canada.

LALEGANI DEZAKI, F., "Insights from Random Language Model", (E. De Giuli), Spring 2024.

SAFAKISH, A., "Predicting Head and Neck Cancer Treatment Outcomes with QUS, CT and MRI Radiomics Enhanced with Deep Texture Analysis, a Machine Learning Approach", (G. Czarnota, A. Pejovic-Milic), Fall 2024, Medical Physics Resident at Thomas Jefferson University, Philadelphia, PA, USA.

VIRDEE, S., "Development and Evaluation of the Computed Tomography Imaging Normalized Join Count for Quantifying Emphysema", (M. Kirby), Fall 2024, Medical Physics Resident at Sunnybrook Health Sciences Centre, Toronto, ON, Canada.

UNIVERSITÉ DE MONTRÉAL

CHOUTEAU, S., « Compréhension des mécanismes réactionnels dans un procédé hybride de dépôt de couches minces nanocomposites couplant plasma et injection de solution colloïdale », (L. Stafford, A. Granier), Fall 2024, Postdoctoral Fellow at JSPS (Japan Society for the Promotion of Science), Osaka University, Osaka, Japan.

HERRMANN, A., « Étude expérimentale et modélisation de la dynamique spatiotemporelle de décharges nanosecondes impulsionnelles en contact avec l'eau », (A. Hamdan, J. Margot), Postdoctoral Fellow at CNRS (École Polytechnique), Palaiseau, France.

JAHANDAR, F., « Étude de la composition chimique des naines M du voisinage solaire grâce à la spectroscopie infrarouge à haute résolution », (R. Doyon), Fall 2024, Data Scientist at Roc360, New York City, NY, USA.

KHOSRAVI, A., « Modélisation de la cinétique des interactions entre l'hydrogène et les défauts dans le Fer à l'aide de la technique d'activation et de relaxation cinétique (ARTc) », (N. Mousseau), Fall 2024, Postdoctoral Fellow at the University of British Columbia (UBC), Vancouver, BC, Canada.

MANN, C., "TESS Exoplanet Candidate Follow-Up with Ground- and Space-Based Instruments", (D. Lafrenière), Winter 2024, Postdoctoral Fellow (Research Officer) at the National Research Council Canada, Herzberg Astronomy and Astrophysics Research Centre, Victoria, BC, Canada.

PASCUAL DIAS, B., "Improving the Search for New Physics and the Identification of Electrons using Machine Learning at the ATLAS Experiment", (J.-F. Arguin), Fall 2024, Postdoctoral Fellow at Université Clermont Auvergne, Clermont-Ferrand, France.

PELLETIER, S., "Probing the Elemental Composition of Gas Giant Exoplanets in the Context of their Formation and Evolution", (B. Benneke), Fall 2024, Postdoctoral Fellow at University of Geneva, Geneva, Switzerland.

PIAULET, C., « Caractérisation des atmosphères d'exoplanètes dans le contexte de leur formation et évolution », (B. Benneke), Fall 2024, Postdoctoral Fellow at University of Chicago in Chicago, IL, USA.

RADICA, M., "Insights into the Diversity of Exoplanet Atmospheres in the Era of JWST", (D. Lafrenière), Fall 2024, Postdoctoral Fellow at University of Chicago, Chicago, IL, USA.

RHEA, C., « Avancées récentes dans l'observation et l'application des techniques d'apprentissage automatique aux études des galaxies et des amas de galaxies », (J. Hlavacek-Larrondo), Fall 2024, Software Algorithm Developer (développeur de logiciel algorithmique) at Dragonfly Focused Research Organization, Santa Fe, NM, USA.

ROBERT, R., « Étude de décharges Ar-NH3 en simple et double fréquence à la pression atmosphérique », (L. Stafford, F. Massines), Fall 2024, Postdoctoral Fellow at Université de Montréal, Montréal, QC, Canada.

ZAIMI, M., « Algèbre d'Askey–Wilson, centralisateurs et fonctions spéciales (bi)orthogonales », (L. Vinet), Fall 2024, Postdoctoral Fellow at Perimeter Institute for Theoretical Physics, Waterloo, ON, Canada.

UNIVERSITÉ LAVAL

AOUJI, S., « Développement et caractérisation de verres et fibres optiques à base de système BaO - Ga2O3 - GeO2 pour les lasers à fibre dans l'infrarouge moyen », (Y. Messaddeq, T. Cardinal), Summer 2024, Posdoctoral Fellow, ICMCB, Bordeaux-France.

BERUMEN MURILLO, F., "Deep learning-based advanced dose calculations in low-dose rate prostate brachytherapy", (L. Beaulieu, S. Enger), Summer 2024, Postdoctoral Fellow, Université de Montréal et IVADO, Montreal, QC, Canada.

BUQUET, J., « Intégration et applicabilité des méthodes d'apprentissage supervisé pour la conception de systèmes optiques grand-angle », (S. Thibault, J-F. Lalonde), Summer 2024, AI Developer, Immervision Inc., Montréal, QC, Canada.

CORRER, W., "Development of chalcogenide-based resistive switches", (Y. Messaddeq), Winter 2024, Chercheur, INO, QC, Canada.

LORD, M-P., « Développement de lasers à fibre optique opérant dans la région visible du spectre électromagnétique », (R. Vallée, M. Bernier), Winter 2024, Chercheure, Teraxion, QC, CANADA.

ROCHON, J., « Développement et application d'un analyseur de mobilité ionique différentielle (FAIMS) à électrodes multiples en LDTD-MS/MS », (S. Rainville, R. Paquin), Winter 2024, Global Technological Support Coordinator at Phytronix, QC, Canada.

SAFARI, M., "Using MRI Physics and AI for Multi-Parametric MRI-Guided Radiotherapy", (L. Archambault, A. Fatemi-Ardekani), Winter 2024, Postdoctoral Fellow, Emory University, Atlanta, GA, USA.

TABOURIN, L., « Développement d'outils miniatures à base de cristaux liquides permettant d'améliorer la résolution spatiale de mini-endoscopes », (T. Galstian, F. Bretzner), Winter 2024, Professeur au CEGEP St-Lawrence, QC, Canada.

ZEMSKA, Z., "Development of a new generation of tunable liquid crystal lenses", (T. Galstian), Fall 2024, chercheur(se) au PATQER Photonique Inc., Québec, QC, Canada.

UNIVERSITY OF ALBERTA

BUI, H., "Integrated analysis of anomalous microseismic behavior in a Montney treatment: Engineering parameters, locations, moment tensors, and geomechanics", (M. van der Baan), Winter 2024, Alberta Geological Survey, Edmonton, AB, Canada.

CHASE, B., "Tectonic studies of the lithosphere of Laurentia using magnetotelluric data and the implications for diamond resources", (M. Unsworth), Fall 2024.

DEAN, C., "Dynamics and Composition of Collapsar Disk Outflows", (R. Munoz), Summer 2024.

GAERTNER, A., "The Pacific Ocean Neutrino Experiment: Site characterization, background studies and tau neutrino sensitivity", (C. Krauss), Summer 2024, Postdoctoral Fellow at Simon Fraser University, Burnaby, BC, Canada.

GANESH, S., "Instantons in Parton Gauge Theories of Condensed Matter", (J. Maciejko), Summer 2024, Postdoctoral Fellow at Yale University, New Haven, CT, USA.

GUO, Y., "Optimal seismic acquisition design, reconstruction and denoising", (M. Sacchi), Winter 2024.

HATFULL, R., "When Stars Collide: Simulating a Stellar Contact Binary Merger", (N. Ivanova), Fall 2024, Independent Developer.

HUGHES, A., "Enabling the full capacity of meekat for studying X-ray binaries", (G. Sivakoff), Fall 2024.

JENSEN, C., "Time-Resolved Terahertz Spectroscopy of Semiconductor Nanomaterials", (F. Hegmann), Winter 2024, Research Associate at the University of Alberta, Edmonton, AB, Canada.

NGUYEN, P., "Terahertz near-field coupling in scanning tunneling microscopy", (F. Hegmann), Winter 2024.

RASTOGI, A., "Broadband, on-demand optical memories based on alkali-atom-ensemble for photonic quantum technologies", (L. LeBlanc), Fall 2024, Postdoctoral Fellow at Imperial College London, London UK.

SENARATH YAPA ARACHCHIGE, P., "Unconventional Cooper pairing and confinement: Studies of lattice superconductivity and superfluid helium-3 enclosed by surfaces", (J. Maciejko, F. Marsiglio), Spring 2024, Postdoctoral Fellow at Universität Innsbruck, Fakultät für Mathematik, Informatik und Physik, Institut für Experimentalphysik, 6020 Innsbruck, Austria.

SMITH, B., "Nonlinear interactions using neutral atomic gases", (L. LeBlanc), Winter 2024, Postdoctoral Fellow at Sandia National Laboratories, Albuquerque, NM, USA.

TORRES BAUTISTA, K., “Seismic reflectivity inversion using deep learning and model-based methods”, (M. Sacchi), Spring 2024.

UNIVERSITY OF BRITISH COLUMBIA

BELLEY, A., "Probing beyond standard model physics through *ab initio* calculations of exotic weak processes in atomic nuclei", (R. Kruecken, J. Holt), Fall 2024.

CAN, O., "Topological superconductivity in twisted cuprates and device applications inspired by their Josephson physics", (M. Franz), Spring 2024, Research Scientist at Model 6, Vancouver, BC, Canada.

CARPENTIER, E., "Four dimensional dose calculations and planning strategies for dynamic tumour tracking treatments", (A. Mestrovic, S. Reinsberg), Spring 2024, Medical Physics Resident at BC Cancer, Vancouver, BC, Canada.

CHILD, T., "Direct entropy measurements in mesoscopic systems : from proof of concept to the Kondo regime", (J. Folk), Spring 2024, Founder and Developer at AthenaInstruments, Vancouver, BC, Canada.

FRIELING, E., "Explorations of universality in ultra-cold and room-temperature collisions", (K. Madison), Spring 2024, Postdoctoral Fellow at TRIUMF, Vancouver, BC, Canada.

HSUEH, C., "A journey into computational protein design : simulation methods, physical origins of disease, and therapeutic design for neurodegenerative diseases and COVID19", (S. Plotkin), Spring 2024.

KONIAR, H., "Dosimetry and biodistribution of actinium radiopharmaceuticals for targeted alpha therapy", (P. Schaffer, C. Uribe), Spring 2024, Medical Physics Resident at Princess Margaret Cancer Centre, Toronto, ON, Canada.

KORCHINSKI, D., "Scaling theories and simulation of ductile yielding in amorphous solids", (J. Rottler), Fall 2024, NSERC Postdoctoral Fellow at École Polytechnique Fédérale de Lausanne, Lausanne, VD, Switzerland.

KRAFT, A., "Inconclusive results, confirmation bias, and model breakdowns: exploring and improving student experiences in a first year physics lab", (D. Bonn, J. Ives), Fall 2024.

LYKIARDOPOULOU, E. "Resurrecting the N = 20 shell closure and upgrades to the TITAN measurement Penning trap", (J. Dilling), Spring 2024.

MILLER, C., "An analysis of imaging and biological effects impacting theranostic dosimetry using radiopharmaceutical pairs", (A. Rahmim, C. Uribe), Fall 2024.

POON, J., "Cardiac radiosurgery motion management – investigation of regional myocardial motion and cardiac gating", (S. Thomas, S. Reinsberg), Spring 2024.

PRADEEP, A., "Novel reconstruction techniques for detecting low mass dark matter in the SuperCDMS experiment and characterization of SuperCDMS SNOLAB detectors", (S. Oser), Fall 2024, Research Associate at SLAC National Accelerator Laboratory, Menlo Park, CA, USA.

REEVES, W., "Quantum chaos in conformal field theories", (M. Rozali), Spring 2024.

REID, G., "Topics in numerical relativity", (M. Choptuik), Spring 2024.

ROSTAMZADEH, M., "Markerless dynamic tumor tracking using diaphragm as a soft-tissue anatomical surrogate for liver tumors", (A. Bergman, S. Reinsberg), Spring 2024, Medical Physics Resident at BC Cancer, Abbotsford, BC, Canada.

SAMPLE, C., "Towards improving radiotherapeutic treatment of the parotid glands : a cross-modality investigation", (H. Clark, S. Reinsberg), Spring 2024, Medical Physics Resident at BC Cancer, Abbotsford, BC, Canada.

TULLY, A., "From growth to TR-ARPES of C_{60} : a prototypical OPV system", (S. Burke, D. Jones), Spring 2024, Director at New Leaf, Vancouver, BC, Canada.

YANG, D., "Emergent optical and electronic properties in atomically thin rhombohedral-stacked transition metal dichalcogenides", (Z. Ye), Fall 2024.

ZUREL, M., "Classical descriptions of quantum computations : foundations of quantum computation via hidden variable models, quasiprobability representations, and classical simulation algorithms", (R. Raussendorf, W. Unruh), Fall 2024, NSERC Postdoctoral fellow at Simon Fraser University, Burnaby, BC, Canada.

UNIVERSITY OF GUELPH

CORRIGAN, E., "Balancing the Equation: Examining Gender Gaps in Physics and STEM Across Canadian Classrooms", (M. Williams, M. Wells), February 2024.

UNIVERSITY OF MANITOBA

ALKADOUR, B.A.R., "Magnetic properties of nanoparticle arrays", (B.W. Southern, G. Gwinner), October 2024.

DUGGAL, C., "Galactic scale radio-mode feedback in compact radio galaxies", (C. O'Dea, S. Baum), October 2024, Research Associate at the University of Manitoba, Winnipeg, MB Canada

HUCKO, T., "Measurement of the 7s − 8s M1 transition in laser-trapped francium", (G. Gwinner), February 2024, Scientific Employee at PlanQ, Ulm, Germany.

MONKMAN, K., "Entanglement in Symmetry - Protected Topological Phases", (J.M.R. Sirker), February 2024, Postdoctoral Researcher at UBC Blusson Quantum Matter Institute, British Columbia, Canada.

NICKEL, R., "Understanding the Role of Fe-O Hybridization in the Characteristic Transitions of Iron Oxide Nanoparticles", (J. van Lierop), February 2024, European Synchrotron Research Facility Grenoble.

REIMER, T.A., "Robust Approaches to Image Reconstruction and Image Quality Analysis in Breast Microwave Sensing", (S. Pistorius), October 2024, Radiotherapy Physics Resident at CancerCare Manitoba.

UNIVERSITY OF NEW BRUNSWICK

MORIN, D., "A New Low Field Magnet for Overhauser Dynamic Nuclear Polarization Magnetic Resonance Studies", (B. Balcom), Fall 2024.

REID, B., "The Assimilative Canadian High Arctic Ionospheric Model (A-CHAIM)", (P. T. Jayachandran, D. Themens), Summer 2024.

UNIVERSITY OF OTTAWA / UNIVERSITÉ D'OTTAWA

BÉGIN, J.-L., "Strong-Field Chiral Light-Matter Interaction", (R. Bhardwaj), August 2024, Postdoctoral Fellow at University of Ottawa, Ottawa, ON, Canada.

CHARRON, M., "Nanopore Resistive Sensing: Bridging Theory and Experiments", (V. Tabard-Cossa), December 2024, Postdoctoral Fellow at University of Ottawa, Ottawa, ON, Canada.

CUI, W., "Tunable broadband and high-field THz time-domain spectroscopy system", (R. Bhardwaj, J.- M. Ménard), Research Associate, SLAC National Accelerator Laboratory, Menlo Park, CA, USA.

FORCADE, G., "High-Efficiency III-V Semiconductor Device and System Optimization for Photovoltaic Applications", (K. Hinzer), December 2024, Optical Engineer, Ciena, Ottawa, ON, Canada.

FRANCISCO FERRER GARCIA, M., "Structuring Light: From knots to geometrical phases", (E. Karimi), May 2024, Postdoctoral Fellow at University of Ottawa, Ottawa, ON, Canada.

HUFNAGEL, F., "Spatially Structured Light for High-Dimensional Quantum Information", (E. Karimi), September 2024, Postdoctoral Fellow at Simon Fraser University, Burnaby, BC, Canada.

JAIN, A., "Helical phase-based spectroscopy in matter", (R. Bhardwaj), September 2024, Senior Optical Scientist, Irradiant Technologies, Cambridge, MA, USA.

KILLAIRE, G.J.R., "Applications of Ultrafast Laser Ablation to Material Colouring and Physical Unclonable Functions", (A. Weck, P. Berini), October 2024, Postdoctoral Fellow at Carleton University, Ottawa, ON, Canada.

KRARUP, O., "Enhancement of Fiber Optical Environmental Sensor Performance Via All-Optical Signal Processing", (X. Bao), February 2024, Optical Engineer, Ciena, Ottawa, ON, Canada.

LAURENT MOLINO, L., "Scanning tunneling microscopy investigations of interlayer interaction induced superstructures in transition metal dichalcogenides", (A. Luican-Mayer), October 2024, Application Scientist, Onnes Technologies, Leiden, Netherlands.

MARTINEZ BECERRIL, A.C., "Unitary transformations of optical beam arrays", (J. Lundeen), March 2024, pursuing a Postdoctoral Fellowship at University of Toronto, Toronto, ON, Canada.

PLUMADORE, R., "Investigating Band Structure Modifications in 2D Materials and Heterostructures via Scanning Tunneling Microscopy and Spectroscopy", (A. Luican-Mayer), March 2024, Senior Technician, MOCVD, at University of Ottawa, Ottawa, ON, Canada.

SCHAEFER, S., "Design and operation on monolithic InAs/InP quantum dash ridge laser diodes operating in the C-band", (K. Hinzer), February 2024, PIC Design Engineer, Ciena, Ottawa, ON.

WANG, T., "Following a Photochemical Reaction of Br_2 using Photoion and Photoelectron Momentum Spectroscopy", (A. Staudte), March 2024, Postdoctoral Researcher, Wuhan Institute of Physics and Mathematics, Chinese Academy of Science, Wuhan, China.

UNIVERSITY OF REGINA

KOERICH, L., "Development of scintillator-based components for the photosensor system for the Intermediate Water Cherenkov Detector of the Hyper-K experiment and for the time of flight system of the Water Cherenkov Test Experiment", (M. Barbi, N. Kolev), Fall 2024, Postdoctoral Fellow at University of Regina, Regina, SK, Canada.

KUMAR, V., "Measurement of the pion exclusive electro-production cross-section in the E12-19-006 experiment in Hall-C at Jefferson Lab", (G. Huber), Fall 2024, Postdoctoral Fellow at University of Regina, Regina, SK, Canada.

NEELAMANA, V., "Beam asymmetry in the reaction channel $\gamma p \rightarrow \eta \Delta^+$ at Glue X", (Z. Papandreou), Fall 2024, Postdoctoral Fellow at University of Regina, Regina, SK, Canada.

SURESH, K., "Partial wave analysis of Neutral b1 Meson at GlueX", (Z. Papandreou), Spring 2024, Postdoctoral Fellow in the Data Science Department, College of William & Mary, Williamsburg, VA.

UNIVERSITY OF SASKATCHEWAN

BSHARAT, H., "Experimental Studies of Fluctuations and Turbulences in the STOR-M Tokamak and TJ-II Stellarator", (C. Xiao), Fall 2024, Assistant Professor at An-Najah National University and at Palestinian Technical University, Nablus city, West Bank, Palestine.

BUTLER, M., "Solution Methodology in Higher Dimensional Extended Einstein Theory", (M. Ghezelbash), Spring 2024.

POLISCHUK, T., "Measurement of the Neutron Spin-Polarization in Deuterium Photodisintegration", (R. Pywell), Spring 2025, Postdoctoral Researcher at University of Hawaii at Manoa, Honolulu, HI, USA.

RUNGE, E., "Development, Analysis and Evaluation of the LIFE Prototype Instrument", (A. Bourassa, D. Degenstein), Fall 2024, Research Scientist at Dias Geophysical, Saskatoon, SK, Canada.

YOUSAF, T., "Plasma Immersion Ion Implantation Studies of Tungsten and Tungsten Alloys as Plasma-Facing Components for Fusion Devices", (M. Bradley, J. Szpunar), Spring 2024

UNIVERSITY OF TORONTO

ANTO-SZTRIKACS, N., "Open quantum system techniques beyond the Lindblad equation", (D. Segal).

CHOU, C.-C., "Using ESA's Aeolus Mission to Study the Impact of Wind Observations on Numerical Weather Prediction", (P.J. Kushner).

CLEPKENS, J., "Unconventional Multiband Superconductivity in Correlated Metals", (H.-Y. Kee).

JOW, D.L., "Theory and applications of wave optics in the gravitational and plasma lensing of coherent sources", (U.-L. Pen).

KLYSHKO, Y., "Not Just Proteins: Unraveling the Role of Water in Protein Dynamics and Allostery", (S. Rauscher).

LAU, B., "Anomalous electronic transport in the hexagonal ternary arsenides FeCrAs, CrNiAs, and CrPdAs", (S.R. Julian).

LUPU-GLADSTEIN, N., "Quantum Measurements are Disturbing: Experiments studying the role of disturbance in postselected metrology, quantum pigeonholes, and entangled sheep", (A.M. Steinberg).

MA, T., "An (Ultimate) Guide to Surviving on the Bacterial Battleground: The Role of Mechanics on Microbial Ecology within Confined Spaces", (J. Milstein).

MIU, O., "Boosted top quark measurements in hadronic final states with the ATLAS detector", (P.K. Sinervo).

MORRIS, M.O., "Dynamics of Extreme Wind Speeds in Canada and Their Response to Climate Change", (P.J. Kushner).

SCHEE, M., "Thermohaline staircases in the Arctic Ocean: Detection, evolution, and interaction", (N. Grisouard).

SCHULTZ, D.J., "Quantum Phase Transitions in the Multipolar Kondo Lattice", (Y.-B. Kim).

SMYTH, S., "Characterization of Disordered Protein States and Complexes using Single-molecule Fluorescence Spectroscopy", (C. Gradinaru).

UNCU, J., "The Scattering of Internal Tides by Balanced Flows", (N. Grisouard).

WANDLER, F.D., "Nonperturbative physics of center-stabilized compactifications of Yang-Mills theory & A new perturbative method for extracting effective spin models out of condensed matter systems", (E. Poppitz).

ZHANG, E.Z., "Dynamical Signatures of Exotic Phases in Frustrated Honeycomb Magnets", (Y.-B. Kim)

UNIVERSITY OF VICTORIA

ALHUSSAN, A., “A Novel Synergetic Combined Modality of Nanotechnology, Chemotherapy, and Radiotherapy for the Treatment of Pancreatic Cancer", (D, Chithrani), Spring 2024, Entrepreneur.

CARLSON, E., “Searching for Long-Lived Supersymmetric Particles Using Displaced Vertices and Missing Transverse Energy with the ATLAS Detector", (I. Trigger, R. Kowalewski), Fall 2024, Process Engineer at nLIGHT, Vancouver, WA, USA.

CHEN, B., “Differential cross-section measurements of WbWb production in the lepton+jets channel at $\sqrt{13}$ TeV with the ATLAS detector", (R. Kowalewski), Summer 2024, Graduate Seismic Analyst for Viridien in Calgary, AB, Canada.

CROTTS, K., "Expedition Unknown: Characterizing and Modelling Perturbed Debris Disks in Search for Elusive Planets", (B. Matthews, R. Dong), Summer 2024, Postdoctoral Fellow at the Space Telescope Science Institute, Baltimore, MD, USA.

HART, A., "Dosimetry and Radiobiology of ultrahigh dose-rate radiotherapy delivered with low-energy X-rays and very high-energy electrons", (M. Bazalova-Carter), Summer 2024, Postdoctoral Fellowship at BC Cancer, Victoria, BC, Canada.

HUBER, A., "Optical, mechanical, and detector developments for the Prime-Cam 850 GHz module", (S. Chapman, J. Albert), Fall 2024, Postdoctoral Fellow at the Dominion Astrophysical Observatory, NRC Canada, Victoria, BC, Canada.

MAO, S., "Accelerating Fluid Dynamics Problems in Planet Formation with Machine Learning", (R. Dong), Summer 2024, Postdoctoral Fellow at Los Alamos National Laboratory, Los Alamos, NM, USA.

RICHTSMEIER, D., "Exploration of applications of photon-counting detector computed tomography (CT) using a table-top CT system", (M. Moffitt, M. Bazalova-Carter), Spring 2024, Medical Physics Resident at BC Cancer, Victoria, BC, Canada.

SAEEDZADEH, V., "Dynamics of Galaxy Evolution: Insights from Circumgalactic Medium and Supermassive Black Hole Mergers", (A. Babul), Spring 2024, Postdoctoral Fellow at Johns Hopkins University, Baltimore, MD, USA.

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BONDY, A., "The Broad Utility of Pseudospectral Methods in Atomic Physics", (G. Drake), October 2024, Postdoctoral Fellow at Drake University, Des Moines, IA, USA.

WESTERN UNIVERSITY

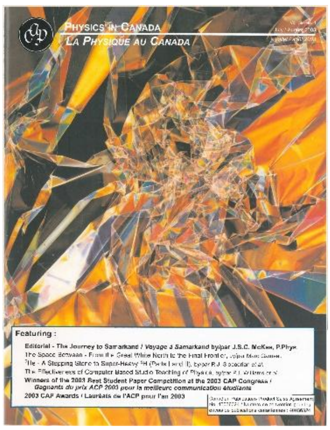
ADAM, M., "Luminescence and Structural Properties of Silicon-Germanium Quantum Structures Fabricated by Ion Implantation", (L. Goncharova, P. Simpson), Winter 2024, Photonics Engineer, Xanadu, Toronto, ON, Canada.

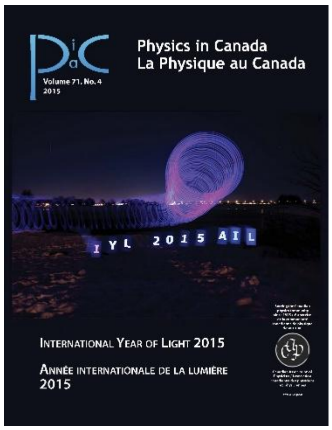
AFRASIABIAN, N., "Predictive Models of Polymer Composites", (C. Denniston), Summer 2024, Research Assistant, Western University, London, ON, Canada.

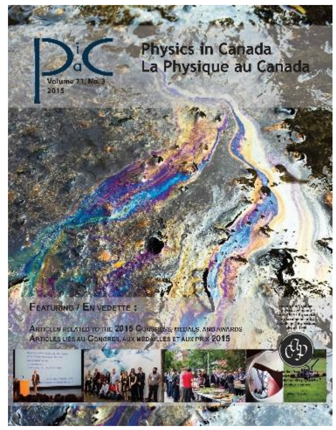
SOLTANI, F. "Black-to-White Hole Transition", (F. Vidotto, D. Christensen) Winter 2024.

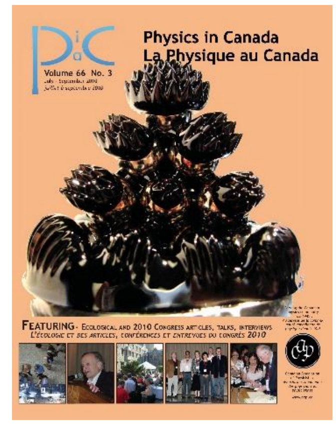
CALL FOR COVER ART FOR PHYSICS IN CANADA

You are invited to submit photographs of beautiful or unusual physics phenomena that may be selected to appear on the cover of Physics in Canada. Please send an electronic copy of the photograph, with a short (200 words or less) description explaining the phenomena in terms suitable for, and understandable to, any practising or student physicist, to the Editor of Physics in Canada at pic-pac@cap.ca. Please note that all entries must be original artwork produced by the participant.









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Vous êtes invités à soumettre des photographies de phénomènes physiques magnifiques ou inhabituels qui pourraient être sélectionnées pour figurer sur la couverture de La Physique au Canada. Veuillez envoyer une copie électronique de la photographie, accompagnée d'une brève description (200 mots ou moins) expliquant le phénomène en des termes adaptés et compréhensibles pour tout physicien(ne) en exercice ou étudiant(e), au rédacteur en chef de La Physique au Canada à l'adresse suivante : pic-pac@cap.ca. Veuillez noter que toutes les contributions doivent être des œuvres d'art originales produites par le participant.

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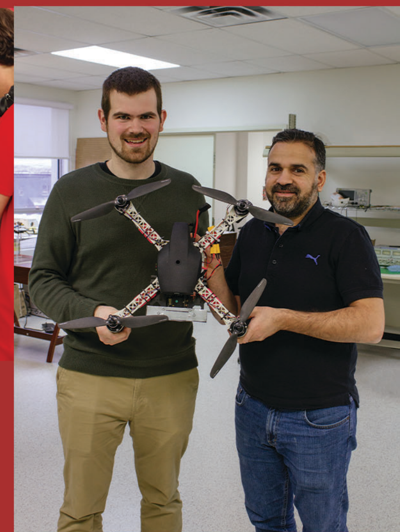
l'Association canadienne des physiciens et physiciennes : **La Physique, une communauté**



How are we a community?

Focus on Equity, Diversity & Inclusion in Physics
Annual Congress - Community Partnerships
Lecture Tours - Professional certification
Networking - Conferences - Scholarships
Awards and Medals - Science Policy and Advocacy
Resources - Read & Publish in *Physics in Canada*
Employment Board Postings - Advertising
Recognitions Program - Art of Physics
Reciprocal Agreements - Group Insurance

Comment sommes-nous une communauté ?

Priorité à l'équité, à la diversité et à l 'inclusion en physique
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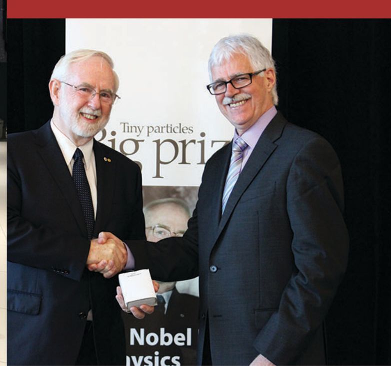

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