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Hailee Morgan seat testing upcoming valve in liquid nitrogen. Credit: Cryolab

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Cold Facts

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From the Executive Director

As the cryogenics community continues to evolve, so too does *Cold Facts*. This issue highlights the next generation of talent in our field – our Young Professionals – alongside timely features on fluid storage and transfer systems, quantum technology and cryogenic treatment processes. These areas are critical to advancing innovation and ensuring the future vitality of cryogenic science and applications. We hope you enjoy reading!

In CSA news, we recently hosted a series of Short Courses in collaboration with CEC/ICMC in Reno, Nevada, on May 18. Though the courses will have been concluded by the time this issue reaches you, we extend a heartfelt thank you to our exceptional instructors: Dr. Ray Radebaugh, Dr. Jacob Leachman, Dr. Konstantin Matveev, Dr. Steven Van Sciver, Dr. John Weisend II and Dr. Scott Courts. Your dedication to education and mentorship strengthens our community.

We're also proud to reflect on the Space Cryogenics Workshop, held May 13–15 at the Hyatt Regency, Lake Tahoe. The SCW began in 1980 as a one-day event at the ICEC Conference. An instant success, the workshop now stands on its own and brings together scientists and engineers from around the world who are actively involved in the field of cryogenics as it relates to space applications. Many thanks to our generous sponsors – OPW Clean Energy Solutions, OmegaFlex, AVCO, Spaceline Technologies, and Quest Thermal Group – for helping make it all possible. I also want to extend my sincere thanks to the co-chairs of the event, Wesley Johnson and Daniel Hauser of NASA Glenn Research Center. Their leadership was invaluable to the workshop's success.

Looking ahead, we're focused on enhancing how we deliver content and connect with our audience. *Cold Facts* is undergoing a digital refresh, starting with an updated online article format that improves readability and accessibility. Each issue, selected articles will be posted to our new *Cold Facts* Digital archive, accompanied by industry updates from our CryoChronicle eNewsletter. We're also developing new digital advertising opportunities – stay tuned for details. We invite you to explore the updated webpage at **www.cold-facts.org**.

Thank you for being part of the CSA community. Whether you're just beginning your career or have spent decades advancing cryogenics, your contributions matter – and we're proud to support you.

Megan L Galeher


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YOUNG PROFESSIONALS 2025

The Next Generation in Cryogenics and Superconductivity

This feature introduces outstanding young professionals (under 40 years of age) who are doing interesting things in cryogenics and superconductivity and who show promise of making a difference in their fields. Debuted in the 2006 issue, the feature has presented many young persons whom we are proud to see have indeed lived up to that promise.

Qian Bao, 37

What is your educational and professional background?
I completed my undergraduate studies in Mechanical Engineering at Shanghai Jiaotong University, China. Following that, I earned my Master's degree from Tohoku University in Japan, where my research focused on computational fluid dynamics simulations involving two-phase flow. Specifically, I worked on modeling microchannel nitrogen heat sinks using the Volume-of-Fluid (VOF) method. I joined SHI (Sumitomo Heavy Industries) in 2013 as a research and development engineer, where I worked primarily on cryocooler development.

How did you get into cryogenics?
My interest in cryogenics began during my university studies, inspired by supervisors with extensive research experience in low-temperature heat transfer. After graduation, I joined SHI cryogenics group—one of the world's leading cryocooler manufacturers.

Do you or did you have a mentor? Tell us about your experience with him/her.
My first professional mentor was Dr. Mingyao Xu at SHI Cryogenics Group. Dr. Xu, a renowned expert in GM and pulse tube cryocoolers, guided me through the successful development of the world's smallest 2 K GM cryocooler between 2014 and 2017. Beyond his profound technical knowledge, Dr. Xu greatly influenced my approach to research and development by demonstrating the importance of grit, perseverance and meticulous attention to details.

What is your present company/position?
Sumitomo Cryogenics of America, Inc, R&D Engineer.

What are some of your contributions to the cryogenic field?
As mentioned above, I worked with Dr. Mingyao Xu to develop the world's smallest 2 K GM cryocooler between 2014 and 2017. Achieving a remarkable cooling capacity of 20 mW at 2.1–2.2 K, this compact cooler played a crucial role in advanced research at Japan's National Institute of Information and Communications (NICT), where it cooled superconducting single-photon detectors (SSPD). Additionally, we designed a groundbreaking 630W single-stage GM cryocooler during 2017-2020 —the largest of its kind at the time—to enable on-site liquid nitrogen production, significantly benefiting customers in regions like Africa with limited access to conventional supply chains.

What do you believe the most important developments in cryogenics are? Have you tailored your work to try to address them?
I believe quantum computing represents one of the most significant developments shaping our future, and cryogenics plays a foundational role in enabling this transformative technology. Recognizing this potential, I've tailored my recent work toward developing high-efficiency pulse tube cryocoolers—one of the critical cooling solutions integrated into dilution refrigerators.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
I believe one of the biggest challenges in cryogenics today is the industry's heavy reliance on experiments, which are often time-consuming, costly and resource-intensive. Recognizing this, I've dedicated much of my professional focus to bridging the gap between numerical simulations and mechanical design. I think within five to ten years, the computation power and technology will allow us to move towards a more model-based design approach.

Where can readers find out more about your projects?
You can find more information about my work on LinkedIn at **www.linkedin.com/in/qian-bao**, my company's website at **www.shicryogenics.com**, my publications on Google Scholar at **https://scholar.google.com/citations?user=QianBao**, and my occasional CFD side projects on GitHub at **https://github.com/houkensjtu**.

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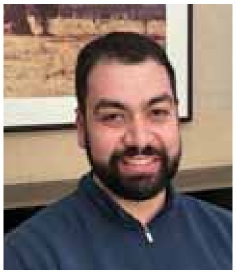

Anthony Damigella, 30

What is your educational and professional background?
I received my BS in mechanical engineering with a concentration in manufacturing engineering from Boston University in 2017. I've been employed as a mechanical engineer in the cryogenic industry since 2017.

How did you get into cryogenics?
My first full-time job out of college was with Vacuum Barrier Corporation, an industry leader with nearly 70 years of experience in cryogenic technology.

Do you or did you have a mentor? Tell us about your experience with him/her.
Erik Showers, Product Development Manager at Vacuum Barrier Corporation, has been one of my biggest influences in cryogenics. Despite learning all the engineering concepts needed in college to be successful as a mechanical engineer, putting them into practice in the cryogenic industry required a lot of on-the-go training and Erik was instrumental in guiding me through this process early in my career. Erik has been invaluable in advancing our company's line of standard and aseptic dosing equipment over the past 20+ years and has been an incredible resource and mentor throughout all my projects.

What is your present company/position?
I've been employed at Vacuum Barrier Corporation since 2017, initially as a mechanical engineer. My work has focused mainly on research and development for cryogenic piping and LN_2 dosing equipment. I was promoted in January 2025 to Engineering Production Supervisor, which expanded my responsibilities to oversee CAD documentation for production jobs as well as existing and future products. This new role also requires designing and performing analysis on new piping systems and has a greater focus on interactions with VBC sales staff, sales representatives and end customers.

What awards/honors have you received?
I've attained my EIT designation from NCEES and received certifications for Cryogenic Safety and ISO 9001:2015 QMS Internal Auditing.

What are some of your contributions to the cryogenic field?
Vacuum Barrier Corporation constantly aims to provide high-quality products and continually improve our offerings of liquid nitrogen piping and dosing equipment. Much of my work the last few years has focused on designing our next generation of liquid nitrogen dosing equipment, the Nitrodose® G3, which features enhanced controls and dosing capabilities. On the piping side, I have done a lot of design and testing for our upcoming ES Semiflex family of vacuum-insulated liquid nitrogen transfer lines.

What do you believe the most important developments in cryogenics are? Have you tailored your work to try to address them?
The applications in which cryogenics can be used are ever-expanding. It is critical to stay up to date with the different industries so that our equipment meets the unique needs of our various customer bases. We are constantly trying to improve our offerings to make them better, faster and more reliable, all while keeping safety in mind to ensure that our customers and their consumers all get the best products and experiences possible.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
OEMs are constantly driving us to innovate dosing equipment that can run at faster speeds while improving both accuracy and precision. The smallest time reduction per bottle dosed with LN_2 can result in massive cost savings for companies, and a more consistent dose weight can result in better quality products for end consumers. We strive to meet our most demanding customer applications with our advanced non-aseptic liquid nitrogen dosing system, the Nitrodose® G3 Servodoser®.

Where can readers find out more about your projects?
You can find out more about us at **www.vacuumbarrier.com** or follow Vacuum Barrier Corporation on LinkedIn for regular updates on our company.

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Daniel Hollibaugh, 26

What is your educational and professional background?
I have a bachelor's degree in mechanical engineering from the University of Central Florida and am currently enrolled in the mechanical engineering master's program there, focusing on thermofluids. I have been with Eta Space for almost four years, working in a variety of roles centered on heat transfer and cryogenics.

How did you get into cryogenics?
My introduction to cryogenics came through an internship at Eta Space in the summer of 2021. As an intern, I was tasked with creating CAD models of existing cryogenic systems, which sparked my interest in cryogenic hardware and component testing. Since joining Eta Space, I have enjoyed becoming more involved in the cryogenic community and connecting with the people driving innovation in the field.

Do you or did you have a mentor? Tell us about your experience with him/her.
Bill Notardonato has been my mentor throughout my career in cryogenics, providing me with invaluable knowledge and guidance. As the CEO and founder of Eta Space, Bill possesses a wealth of both practical and conceptual expertise. I am grateful for the many opportunities he has given me to learn and grow, as well as for his patience in answering my endless questions. I would also like to acknowledge Tom Tomsik, chief engineer of Eta Space, who has set a high standard of excellence and continues to be an invaluable resource to me and our team.

What is your present company/position?
I am currently a thermofluid analyst and LOXSAT co-investigator at Eta Space.

What awards/honors have you received?
I have not received any awards specific to the field of cryogenics.

What are some of your contributions to the cryogenic field?
During my time at Eta Space, I have had the opportunity to work on multiple innovative

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projects, including serving as the lead test engineer for our Electrochemical Hydrogen Refrigerator (ECHR) testing. ECHR was a collaboration between Eta Space and NASA Kennedy Space Center's Cryogenic Test Lab, where we successfully demonstrated the ability to reach temperatures in the 20 K range using a cryocooler driven by an electrochemical compressor.

However, my most significant contributions have come from my involvement in the LOXSAT mission, which aims to demonstrate the long-term storage of liquid oxygen in low Earth orbit. Since the project's inception, I have played a key role in the system's design, analysis and testing, helping to advance cryogenic storage capabilities for future space applications.

What do you believe are the most important developments in cryogenics? Have you tailored your work to try to address them?
The evolution of cryogenic system integration with space vehicles is of particular interest to me. Cryogenics have been an essential part of the space industry since the launch of Sputnik 1 in 1957, and their role continues to expand. Beyond propulsion, cryogenic systems are crucial for cooling sensors and detectors, such as those found on the James Webb Space Telescope. Looking ahead, cryogenic technologies will enable in-space propellant production, storage and transfer, allowing spacecraft to travel farther and operate longer. Much of my work at Eta Space is focused on advancing space cryogenic systems to support these objectives.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
I believe hydrogen is a vastly underutilized resource with significant potential for safe and efficient applications. The ECHR system demonstrated hydrogen's viability as a refrigerant, yet its use has been limited due to concerns over flammability. Fortunately, hydrogen is gaining traction as a fuel beyond rockets, and I hope to see a future where large trucks, trains, boats and aircraft widely adopt hydrogen powertrains.

Where can readers find out more about your projects?
I actively post about my professional and volunteer work on LinkedIn: **www.linkedin.com/in/daniel-hollibaugh**.

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Uday Kumar, 39

What is your educational and professional background?
I completed my bachelor's degree in mechanical engineering from the Institute of Technology and Management, Gurgaon, India. I began my career at the Institute for Plasma Research, Gandhinagar, and have been working with ITER-India on the ITER project since 2010. I am also pursuing my post-graduation in the Department of Metallurgical and Materials Engineering at IIT Madras.

How did you get into cryogenics?
During my undergraduate studies, I developed a strong interest in thermal science and worked on a project for ISHRAE. I became particularly curious about the technology used to achieve low temperatures and its applications in superconductivity. After completing my bachelor's degree, I joined the Cryogenics Division at ITER-India, Institute for Plasma Research, where I began working on the design and development of cryolines for the ITER cryogenics system.

Do you or did you have a mentor? Tell us about your experience with him/her.
I've been incredibly fortunate to be surrounded by several great mentors throughout my academic and professional journey. I attribute my professional growth and scientific contributions to these advisors.

I had the great honor of working under the guidance of Prof. Yogesh C. Saxena on various deliverables related to the ITER cryogenic system. He possesses extensive practical and conceptual knowledge and is generous in sharing it, especially with early-career scientists. His mentorship played a significant role in my development, introducing me to technical challenges in cryogenics and encouraging me to explore further.

Through his guidance, I have gained invaluable insights into the design and material aspects of efficient cryogenic systems. I am deeply grateful to all my mentors for their support.

What is your present company/position?
Since starting my career, I have been working at ITER-India (Institute for Plasma Research, Gandhinagar) for the ITER cryogenics system.

What are some of your contributions to the cryogenic field?
A few of my early contributions to the cryogenic field include developing a methodology for the characterization of multilayer insulation to ensure its quality and performance. I have had the opportunity to work on various technological aspects to improve the efficiency and reliability of cryoline systems, particularly in controlling heat-in-leak at cryogenic temperatures.

What do you believe are the most important developments in cryogenics? Have you tailored your work to try to address them?
I believe it's crucial to have a cryogenic system that can reliably and efficiently cool superconductors used in particle accelerators and nuclear fusion-grade Tokamak machines. Helium is a precious resource that is often lost after use. The increasing demand for low-temperature applications, coupled with the global scarcity of helium, presents a formidable challenge to the cryogenics community.

Active and passive cooling techniques are being developed to eliminate boiloff losses, significantly improving the efficiency of cryogenic systems. Zero-boiloff storage, achieved through these techniques, has the potential to transform the economic viability of liquid helium and liquid hydrogen storage infrastructure.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
I aspire to see advancements in cryogenics and superconductors that enable the production of carbon-free, cost-effective and reliable power through nuclear fusion-based systems. Innovations in cryogenics for MRI technology could open new possibilities for accessible medical treatments, life extension and improved healthcare, ultimately enhancing human longevity and quality of life.

Where can readers find out more about your projects?
Readers can learn more about the ITER project at **https://www.iter.org/**, **https://www.iterindia.in/**, and **https://ipr.res.in/**.

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Hailee Morgan, 36

What is your educational and professional background?
I earned a Bachelor's of Engineering in Mechatronics from Middle Tennessee State University. I spent six years as a design engineer in new product development for hydraulic valves at Sun Hydraulics. After that, I transitioned into cryogenics, spending the past two years as a design engineer for cryogenic valves and accessories at CPC-Cryolab, part of OPWCES, a Dover Company.

How did you get into cryogenics?
Like some, I fell into it. Out of school I was looking for Mechatronic-specific roles, and Sun Hydraulics was specifically hiring mechatronics engineers to integrate electronics into valves. After I left Sun Hydraulics, I sought alternate opportunities in valve design and discovered that CPC-Cryolab was looking for a design engineer with a background in valve design.

Do you or did you have a mentor? Tell us about your experience with him/her.
I have three mentors who have shaped who I am and whom I look up to with great respect. First is Stan Levandowski, who I mentioned in a published article in 2024. Stan, a true pioneer in cryogenics with over 50 years of experience, was pivotal in my understanding of what it takes to succeed in the ultracold cryogenics world (LH_2, LHe) by helping me appreciate the past. Second is Dan Cole, a close mentor I work with daily. He is incredibly kind, thoughtful, and generous. He has helped me become a better engineer by teaching me to take a moment to look, listen and understand before making any preconceived notions, keeping me grounded in the present.

Lastly, is Ryan Felsenthal, who has been a huge proponent of my career growth. He helps give me a voice when others may not and constantly pushes the limits, something I love to do. He keeps me excited about the future and what's to come.

What is your present company/position?
CPC-Cryolab, part of OPWCES, a Dover company / Design Engineer.

What awards/honors have you received?
None in the cryogenics world yet, but I received several at my previous company. I was awarded a patent for an energy-harvesting valve (ENERGEN), which was also a runner-up in the 2023 IDEA Awards for Electronic Components. It was an honor to be selected as the lead design engineer on this project and to work with a team that pushed the limits of technology in that space.

What are some of your contributions to the cryogenic field?
While my contributions differ from most, since I focus more on design and sustaining engineering than research projects, I have several unique designs in the works. These include liquid hydrogen safety relief valves and custom customer-requested extended stem liquid helium valves for ultralow heat leak applications. My recent contributions focus on ensuring the highest quality in engineered cryogenic valves and accessories while making sure they are robust and designed to the highest safety standards.

What do you believe the most important developments in cryogenics are? Have you tailored your work to try to address them?
Safety is critical in cryogenics. As hydrogen gains global attention as a viable alternative energy source, getting the infrastructure right from the beginning is crucial to its adoption and public perception. I contribute by designing and building the latest generation of products based on historic designs and to the highest level of code. Engaging with customers and listening to their feedback helps me consider future design iterations that improve performance while maintaining safety and usability.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
Cryogenics plays a major role in the next evolution of the energy sector. We are in a pivotal position to reshape the future over the next 10, 20 and 50 years. Different regions of the world will transition, adapt, and adopt at different rates, making it difficult to predict exact timelines. Political and economic factors will also play a significant role in shaping progress.

Where can readers find out more about your projects?
You can find more about OPWCES and CPC-Cryolab at **www.linkedin.com/company/opwces/** or **www.linkedin.com/company/cpc-cryolab**. If you are interested in my background, follow me at **www.linkedin.com/in/haileedmorgan33/**. You can also learn more about me in the March 2024 issue of Cold Facts.

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Maggie O'Donnell, 23

What is your educational and professional background?
I graduated from the University of Wisconsin-Madison with a BS in Mechanical Engineering in the spring of 2023. During my last year, I researched topology-optimized heat exchangers manufactured with DMLS 3D printing. I interned at Lake Shore Cryotronics in the summer of 2022 between my junior and senior years. After graduating in June 2023, I began working full-time at Lake Shore in Woburn, MA, focusing on the Environment by Janis product line.

How did you get into cryogenics?
I decided to pursue engineering as a career in middle school, but it wasn't until my junior year of college, when I took thermodynamics, that I found my niche. The concepts I learned in that class helped me understand the world and modern inventions. After completing the course, I sought out companies with thermodynamic-based applications and found Lake Shore. During my internship, I gained hands-on experience with complex system designs, fabrication, testing, and driving a product to market. Returning to campus in the fall, I started my heat transfer class with Professor Franklin Miller, who provided me with complex cryogenic heat transfer problems and additional

▶ *continues on page 12*

education on cryogenic topics. This experience solidified my desire to focus my career on cryogenics.

Do you or did you have a mentor? Tell us about your experience with him/her.
I have had the privilege of multiple mentors who have advanced my knowledge of cryogenics. Professor John Pfotenhauer at UW-Madison agreed to teach me in a one-on-one independent study course in cryogenics during my last semester as a student and his last semester as a full-time professor. We discussed topics ranging from the history of cryogenics, detailed explanations of cryogens, different liquefaction cycles, how cryocoolers operated, and how cryogenics is advancing in the modern world.

His willingness to teach me gave me a significant head start in my career. Another mentor, Scot Snyder, the director of engineering for cryostat and probe stations at Lake Shore, has helped me grow my skills and knowledge by assigning increasingly difficult projects and providing the resources and support I need to excel.

What is your present company/position?
I am currently a Development Engineer Mechanical II at Lake Shore Cryotronics.

What awards/honors have you received?
I received the "Next Big Thing" award at Lake Shore as the young employee most likely to develop the next big product.

What are some of your contributions to the cryogenic field?
I have worked on simplifying and improving designs and manufacturing processes for cryostats as part of a standardization effort, resulting in shorter lead times and lower costs, making scientific discoveries more feasible. I also lead designs on custom dewars, cryostats, probe stations, and superconducting magnet systems, providing tailored solutions to meet researchers' specific needs. The fast-paced work allows me to influence many industries that rely on cryogenics to succeed such as materials science research, aerospace, and energy.

What do you believe the most important developments in cryogenics are? Have you tailored your work to try to address them?
With liquid helium becoming increasingly difficult to source, cryocooler-based systems are essential for the industry's progress. I have focused on developing systems traditionally cooled with liquid helium to be cooled with a cryocooler, enabling measurements in vacuum, exchange gas, and liquid down to 1.5 K without liquid helium. Additionally, I am working on new systems for material testing at liquid hydrogen temperatures, driven by increased research in aerospace and energy industries.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
Cryogenics can be dangerous and complex. Automation in cryogenic systems makes the field more accessible and safer, allowing for remote control in environments where human presence is not possible. I believe that automated systems controlled remotely will become the new standard in cryogenic research within the next five years, requiring less training and incorporating safeguards to reduce risk.

Where can readers find out more about your projects? Are there websites or social media handles that actively promote your field, company, research, etc? Do you actively post yourself, and if so, where should people follow you?
Readers can find out more about my projects on Lake Shore's website at www.lakeshore.com, specifically on the Environment by Janis page. You can also follow new technology and advancements that I make on Lake Shore's, Janis's, and my LinkedIn pages:

Lake Shore Cryotronics: **www.linkedin.com/company/lake-shore-cryotronics**

Janis Research: **www.linkedin.com/company/janis-research**

Margaret O'Donnell - Development Engineer Mechanical II: **www.linkedin.com/in/margaret-odonnell-5678**

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Michael Sedaille, 31

What is your educational and professional background?
For the past three years, I've held the role of Principal Cryogenic Engineer at Hypres, where I design, assemble and test cryo-vacuum systems for digital superconducting and other cryo-electronics. Prior to Hypres, I worked at Advanced Research Systems (ARS) as the lead engineer, supporting the design and manufacture of open- and closed-cycle cryocoolers and cryostats. I obtained an M.S. in Mechanical Engineering from Lehigh University, where I focused on tribology under the direction of Dr. Brandon Krick. I also received a bachelor's degree in mathematics and physics from Drew University.

How did you get into cryogenics?
While working in the Tribology Lab at Lehigh, a visiting ARS engineer suggested I apply for a local position with them. Learning the ins and outs of ARS cryocoolers and the laboratory cryostats that use them was a fun and gratifying experience—akin to discovering a new and unfamiliar area of science. My interest in the field continued to grow, and my efforts were rewarded when I spent nearly three years as lead engineer.

Do you or did you have a mentor? Tell us about your experience with him/her.
As Principal Cryogenic Engineer at Hypres, I have had the privilege of being mentored by our CTO, Elie Track, an industry veteran and IEEE Fellow. Elie's vast experience with cryogenic systems and strategic vision as a technical leader at Hypres have been invaluable to my professional development. Through regular guidance, Elie has helped me navigate complex challenges and refine my problem-solving skills. His mentorship has broadened my technical knowledge and shaped my leadership approach, showing me the importance of fostering collaboration within the team.

I would be remiss not to also mention those at ARS who guided me in my early career, including Shenghong Yao, Tim Schilling, Len Wagner, Lou Santodonato and others. Their influence helped lay the foundation for my expertise in cryogenic engineering.

What is your present company/position?
Principal Cryogenic Engineer at Hypres Inc.

What awards/honors have you received?
No major awards in cryogenics.

What are some of your contributions to the cryogenic field?
I feel that my greatest contributions have come from combining my varied backgrounds in fundamental physics, practical engineering and tangible manufacturing to ensure that every project is approached from a broad field of view. I've been lucky enough to apply this experience to various "cool" projects over the years, including the Hypres ADR, superconducting magnet probe stations and low-drift, low-vibration cryostats for quantum computing.

What do you believe are the most important developments in cryogenics? Have you tailored your work to try to address them?
To grow the field of cryogenics and the technologies that rely on it, the most important developments involve usability and the reduction of SWaP (size, weight and power). Historically, cryogenic systems have been rather unwieldy, requiring significant training to use and install. Widespread adoption requires that cryogenic systems become more human-scaled and plug-and-play. Users prefer systems that resemble the computers, devices, or equipment they encounter in everyday life.

Closed-cycle cryocoolers have made major leaps in creating cryogenic systems that fulfill this need, and further improvements are on the horizon. All of the work I've done in my professional life has been toward the goal of creating user-friendly cryogenic systems, and I look forward to continuing to do so.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
I am biased, but I believe the world of superconducting digital logic is ripe with potential for creating truly life-changing advancements in technology. The current investment in semiconductor computing has been experiencing diminishing returns for years. Redirecting just a small fraction of that investment toward superconducting computing could lead to huge leaps forward in areas where semiconductors will struggle. It's my hope that the next decade will bring more investment in and prioritization of this technology.

Where can readers find out more about your projects?
Be sure to check out my LinkedIn (**linkedin.com/in/michael-sedaille**) and **Hypres.com**.

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Chintan M. Sheth, 36

What is your educational and professional background?
My journey to becoming a mechanical engineer began at Nassau Community College, where I completed foundational courses before transferring to Hofstra University to earn my Bachelor's degree. Afterward, I worked as a research and design engineer at an elevator firm for several years while simultaneously completing my Master's in Engineering Management from Ohio University. Approximately four years ago, I joined Brookhaven National Laboratory as a cryogenic mechanical engineer, where I have had the opportunity to further develop my expertise and contribute to innovative projects in the field.

How did you get into cryogenics?
In my previous role as a sales application engineer, I gained valuable experience in designing cooling and freezing systems that utilized refrigerants such as freon and nitrogen. These systems operated at higher temperatures and did not extend into the cryogenic range. Upon joining Brookhaven, I took the initiative to enroll in a cryogenics course offered by the U.S. Particle Accelerator School (USPAS). This foundational course equipped me with the essential knowledge to design cryogenic piping and components effectively, bridging the gap between my prior experience and the advanced requirements of the cryogenic field.

Do you or did you have a mentor? Tell us about your experience with him/her.
Over the past four years at BNL, I have had the privilege of working closely with Roberto Than, whom I consider to be a mentor. As a senior cryogenics engineer and a recognized expert across the DOE national labs, Roberto plays a vital role within the Cryogenics Department in C-AD and is a key cryogenics engineer and project manager for the upcoming EIC project. Despite his demanding schedule, he has always taken the time to explain cryogenic design principles, offering valuable guidance to me and fellow engineers whenever we had questions. Additionally, Roberto conducts weekly lessons to teach us the functionality of the Central Plant, ensuring that future engineers and technicians are well-prepared to operate the plant successfully.

What is your present company/position?
I have been recently promoted to serve as the Level 3 Control Account Manager (CAM), a project management role for a large portion of the EIC project cryogenic scope. I am also a mechanical design engineer in the Collider Accelerator Division Cryo Group, servicing the RHIC central helium plant and connected systems.

What awards/honors have you received?
Last year, under significant time pressure, I led the effort to reroute cooling lines for the sPHENIX detector, ensuring continuity of operations. Through careful planning and coordination, and applying the knowledge of cryosystem design, I've accumulated over the past three years, my team completed the work. In recognition of my efforts, I was honored with a BNL "Spotlight Award."

What are some of your contributions to the cryogenic field?
I have made several contributions to the liquid helium cooling operations at the RHIC collider facility and attached experiments. For the sPHENIX project, I conducted stress and relief analysis for piping, valve box design and various engineering calculations to support the PDR and FRD of critical components.

EIC SRF cryomodules will undergo full power capacity testing at BNL before installation in the EIC tunnel, making the upgrade of the

▶ *continues on page 14*

cryogenic infrastructure at the SRF test facility a key priority. I have played a pivotal role in the procurement process for a new helium dewar and subcooler, including the development of the SOW and specifications. Additionally, I led the efforts to compile the overall P&ID for the entire SRF test facility building, encompassing both existing and new cryogenic components.

For the Electron-Ion Collider (EIC) project, I am actively involved in developing the scope, schedule and cost estimates for the overall 4 K helium distribution system. I am also leading the efforts to develop the master P&ID, which will integrate 2 K and 4 K helium distribution systems.

What do you believe are the most important developments in cryogenics? Have you tailored your work to try to address them?
Advances in cryogenic sealing materials and technologies – such as pure indium wire seals and reusable low-profile cryogenic wire seals – have made it easier to contain cryogenic fluids with greater safety and minimal leakage. We are also trying to reduce warm helium leakage throughout the distribution system by minimizing Swagelok-type connections and replacing them with welded or phastite connections.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
I am excited to see the next generation of MRI machines utilizing cuprates, a type of high-temperature superconductor. Traditional MRI scanners rely on superconducting magnets made from materials like niobium-titanium (NbTi), which require the use of liquid helium for cooling. In contrast, high-temperature cuprate superconductors, such as Yttrium Barium Copper Oxide (YBCO), can achieve superconductivity at higher temperatures, potentially allowing for the use of liquid nitrogen or even simpler, more cost-effective cooling methods.

Where can readers find out more about your projects?
For updates on the Electron-Ion Collider (EIC) project and related cryogenics developments, visit Brookhaven National Laboratory's website or follow updates on the EIC project at **eic.bnl.gov**.

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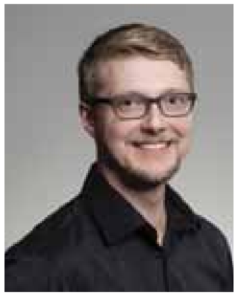


Zachary A. Zgardzinski, 29

What is your educational and professional background?
I graduated from Alfred University's Inamori School of Engineering in 2017 with a bachelor's degree in mechanical engineering. I worked as an M.E. for an Architectural/HVAC company right out of college, designing clean rooms and large heating and cooling systems. In 2021 I wanted to explore other more technical opportunities and that is when I applied for a position at Cryomech (now Bluefors).

How did you get into cryogenics?
In 2021, a colleague and friend, Jacob Tatlock, who was working at Cryomech at the time, encouraged me to apply for an open position and kindly recommended me to the head of engineering.

Do you or did you have a mentor? Tell us about your experience with him/her.
I consider many of my coworkers and supervisors to be mentors in different ways. I am fortunate to work with a team of highly skilled and experienced individuals, and I've learned a great deal from collaborating with them on various projects. In particular, Tim Hanrahan, Brent Zerkle and Kayleigh Byrns have each played meaningful roles in my growth and development during my time at Bluefors.

What is your present company/position?
I am a Mechanical Engineer in the Specialty Applications Group at Bluefors Cryocooler Technologies' Syracuse, NY facility (formerly known as Cryomech).

What awards/honors have you received?
I have not received any awards or honors yet in the cryogenic field, but I hope to one day make a large enough impact on the industry to be recognized for my innovation.

What are some of your contributions to the cryogenic field?
As part of the Specialty Applications team at Bluefors, my contributions to the cryogenic field involve designing and building custom products tailored to customers' unique requirements. A large amount of my work focuses on the development of 1 K cryocooler and cryostat systems used for low-temperature physics, superconducting magnets and quantum circuits. I have also worked on a large argon reliquefying and filtering recirculation system for neutrino detection experiments.

What do you believe the most important developments in cryogenics are? Have you tailored your work to try to address them?
One of the most important developments in cryogenics is helium recovery and helium reliquefiers. Helium is critical for low-temperature cryogenic systems, but it is expensive, limited and easily lost, making efficient use essential. Advancing technologies that minimize helium loss is key to reducing costs and supporting the sustainability of the field.

The rapid growth of quantum computing in recent years has significantly influenced the cryogenic industry. As the race to build a reliable, fault-tolerant quantum computer accelerates, researchers are striving to scale up qubit counts, which demands greater heat lift and larger, more capable cryogenic systems. Bluefors is currently a leading producer of high-capacity cryogenic systems, and I have been fortunate to play an ongoing role in that development.

What advances do you hope to see in the future? How long do you think it will take to achieve these advances?
In the future, I hope to see significant advances in cryocooler system efficiency, including higher heat lift with lower power consumption and more compact designs. These improvements would support the growing demands of industries like quantum computing and reduce operational costs. While incremental gains are already being made, I'm hopeful that with continued innovation and investment in cryogenic technology, we'll start to see major improvements in system efficiency within the next 5–10 years.

Where can readers find out more about your projects?
You can find our product information at Bluefors.com or you can also follow Bluefors on LinkedIn for more regular updates about recent projects.

HyPStore project team at the University of Southern Queensland. Credit: HyPStore

HyPStore's Cryogenics-at-the-Core Vision for Liquid Hydrogen Storage

by Dr. Sadik Omairey and Dr. Vasiliki Loukodimou, Brunel Composites Centre, Brunel University London

As global industries push toward decarbonization, hydrogen has re-emerged as a promising energy carrier. From aviation to long-haul trucking, hydrogen offers a zero-carbon fuel alternative that could reshape mobility. But unlocking its full potential depends on solving one of its biggest hurdles: storage. Hydrogen is challenging to contain, particularly in its most energy-dense form – liquid hydrogen, which exists only at cryogenic temperatures below -253 °C. That's where HyPStore enters the picture, bringing cryogenics, nanomaterials, and international collaboration into focus.

HyPStore is a project funded under the UK-Australia Renewable Hydrogen Innovation Partnership Program, with additional support from Innovate UK. It brings together partners from both countries in a concentrated effort to develop safer, lighter, and more efficient cryogenic tanks for hydrogen storage. The United Kingdom's contribution includes Graphene Innovations Manchester Ltd. (GIM), Marshall Slingsby Advanced Composites, Stratospheric Platforms Ltd, First Graphene (UK) Ltd, Queen Mary University of London and Brunel Composites Centre. From Australia, the team includes the University of Southern Queensland, University of Melbourne, and the Australia Sunlight Group, which is known for its work converting plastic waste into hydrogen.

At the heart of the project is the pursuit of an advanced storage solution capable of handling liquid hydrogen in real-world conditions. HyPStore's consortium is focused on developing liner-less, fully composite tanks made from graphene-enhanced materials that are both structurally resilient and impermeable to hydrogen molecules. These tanks aim to outperform current systems by resisting mechanical stress, reducing hydrogen loss, and increasing durability under cryogenic conditions.

Storing hydrogen at -253 °C poses extreme challenges. Traditional polymer systems can embrittle and crack under rapid thermal cycling. Hydrogen's low molecular weight and high diffusivity increase the risk of leakage, and any failure in containment poses serious safety risks. The HyPStore team is addressing these issues using graphene-reinforced nanocomposites that offer superior cryo-mechanical stability and barrier performance.

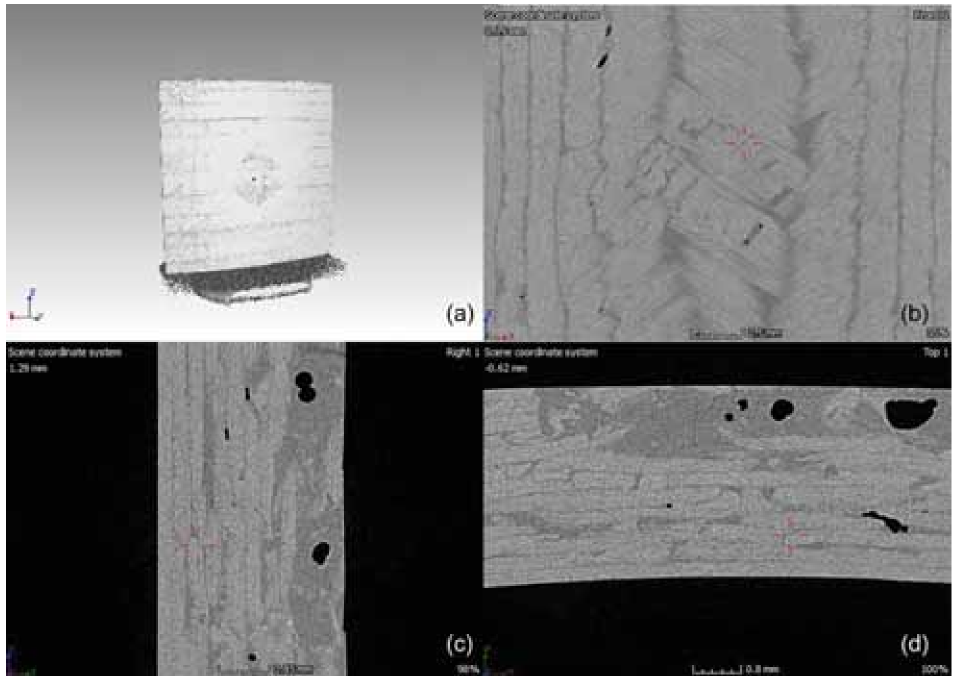
"These nanomaterials, produced through scalable processes, serve not only as a barrier to hydrogen migration but also enhance fracture resistance under extreme conditions," said Dr. Sadik Omairey.

The nanocomposite tanks are being designed to integrate structural and safety innovations from the ground up. Brunel Composites Centre is leading the structural engineering effort, which includes incorporating leak-before-break features. Instead of catastrophic rupture, these tanks are engineered to vent under pressure, improving safety. Meanwhile, Queen Mary University is contributing self-healing polymer systems that allow microcracks to seal autonomously – adding resilience over time.

Graphene plays a central role in both structural and containment performance. Embedded within thermoplastic matrices, graphene nanoplatelets act as reinforcements that increase stiffness and create tortuous diffusion paths, dramatically reducing hydrogen permeability. Their two-dimensional structure bridges microcracks and distributes stress more evenly across the matrix. This dual function – mechanical strengthening and barrier enhancement – allows HyPStore to engineer tanks that are both lightweight and highly resistant to embrittlement.

"We're seeing graphene act not just as a filler, but as a game-changing design element," said Dr. Vasiliki Loukodimou. "It allows us to mitigate hydrogen embrittlement while reducing overall tank weight – an essential factor in aviation and aerospace applications."

Leak Before Break (LBB) test sample. Credit: https://2csa.org/jzu



X-CT of a piece of test pressure vessel with Leak Before Break (LBB) feature. Credit: https://2csa.org/jzu

The project's material validation process is rigorous. Samples undergo thermal cycling to simulate real-world conditions like launch and re-entry. Cryogenic mechanical testing includes tensile, compressive and interlaminar shear evaluations. High-resolution imaging, including X-ray computed tomography and scanning electron microscopy, helps track microcrack propagation. Raman spectroscopy confirms the dispersion of graphene throughout the composite, while embedded sensors allow real-time data collection during mechanical strain, feeding back into modeling and certification efforts.

Thermal insulation is another priority. Hydrogen boiloff – the gradual loss of fuel due to heat ingress – can be a critical flaw in cryogenic storage, especially for mobile applications. Traditional insulation methods add weight or complexity. HyPStore's solution is to embed insulation into the composite itself using graphene aerogels and other nano-structured fillers. These materials combine ultralow thermal conductivity with structural reinforcement, creating hybrid laminates that retain stiffness and reduce boiloff without additional bulk.

"This approach is powerful because it allows us to control both heat transfer and mechanical performance with a single material system," said Dr. Loukodimou.

To meet the mechanical demands of pressure cycling and thermal contraction, the tanks are being engineered with multilayer composite structures optimized for load distribution. Finite element models guide the architecture, ensuring resilience under the repeated strain of refueling and deployment. Each layer contributes a unique function, from impact resistance to permeability control.

While HyPStore is laser-focused on hydrogen, the technologies it develops could impact the broader cryogenics industry. Applications in spaceflight, liquefied natural gas, and medical cryogenics could all benefit from lighter, safer tanks with embedded insulation and self-healing properties. Lessons from this project may also support cryogenic systems used in quantum computing and superconducting infrastructure.

The implications for the hydrogen economy are significant. To make hydrogen viable as a mainstream fuel, storage must become more efficient, scalable, and cost-effective. HyPStore's tanks promise reduced system mass, extended service life, and improved safety margins – critical factors for sectors where every kilogram matters. In aviation, these tanks could help bridge the gap between hydrogen's potential and its practical application.

More broadly, HyPStore illustrates the importance of international cooperation in clean energy innovation. UK-based breakthroughs in nanomaterials and composite design are being paired with Australian advancements in hydrogen production and lifecycle sustainability. Together, the team is building a system that stretches from waste-to-hydrogen conversion through to cutting-edge cryogenic containment.

"We're not just developing a product, we're creating a platform that can be scaled globally," said Dr. Omairey. "This project is about establishing the missing link between green hydrogen production and its real-world use."

Set to deliver prototypes and scalable manufacturing data within its 21-month timeline, HyPStore is positioned to influence both near-term deployment and long-term strategy in the hydrogen sector. And as the need for high-density, zero-emission fuels continues to grow, cryogenics will remain a cornerstone of this transition.

In the end, the future of hydrogen depends not just on how we generate it, but on how we keep it cool, stable, and safe. With cryogenics at the core, HyPStore is bringing that future closer—layer by engineered layer.

Techno-Economics of Liquid Hydrogen Supply for Australian Antarctic Operations

by Dhashan Nagesh, Dhanvin Nagesh, Joshua Ooi, Hashini Udugoda, and Zoe Choo

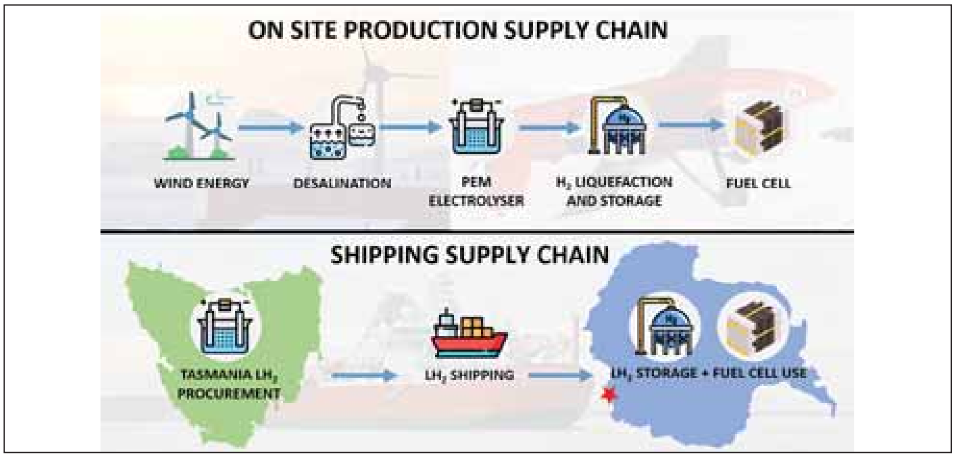


Figure 1: Supply chain steps for onsite hydrogen production and import scenarios. Credit: Nagash, Ooi, Udugoda, and Choo

Antarctic research productivity relies on consistent access to energy. Increased availability of cheaper and cleaner energy could enhance the research capacity at Antarctic stations and expand the frequency of research flights using aircraft such as the Basler BT-67 (a modified DC3) to map climate change impacts on glaciers. The Australian Antarctic Division (AAD) resupplies its three Antarctic stations biannually with special Antarctic blend diesel using the icebreaker RSV Nuyina from Hobart, Tasmania. The ambition of achieving net-zero Antarctic station emissions by 2040 presents an opportunity to harness the abundant wind energy, particularly at Mawson Station, for onsite green hydrogen production, enabling greater energy independence. Renewable liquid hydrogen (LH_2) could provide clean, dispatchable fuel suitable for aerial-based research and station operations, addressing both the reliance on diesel and the intermittency of renewable resources such as wind and solar. Investigating the potential use of LH_2 in a resource constrained environment like Antarctica could provide valuable insights for developing LH_2 supply chains in other remote and extreme locations worldwide.

Hydrogen produced by electrolysis has already been used in Antarctic research activities, including filling weather balloons at Australian research stations and demonstrating fuel cell power at Argentina's Esperanza Antarctic station.[1] However, the techno-economics of Antarctic hydrogen energy remain poorly understood due to the region's uncertain location cost factors, logistical challenges and the need for redundancy in equipment and personnel. To assess the feasibility of scaling up green hydrogen energy use in Antarctica, the levelized cost of supplying green LH_2 to Australia's Mawson Station was estimated for both a low and high demand scenario. This was conducted through the comparison of the costs of importing versus producing green LH_2 onsite using a techno-economic model developed in MATLAB. Understanding the economic viability of green hydrogen in Antarctica is a vital step towards decarbonizing human activity in the region.

Hydrogen Demand Scenarios

The low demand scenario was based on the hydrogen needed to match the distance covered by the Basler research plane using lightweight LH_2 drones. This corresponded to a hydrogen demand of 13.6 kg/month using small-scale fixed-wing drones akin to the LH_2-powered ScanEagle demonstrated by Insitu and Washington State University.[2] The high demand scenario was based on providing 25% of the electricity and heat of Australia's Mawson Station and corresponded to a hydrogen demand of 1914 kg H_2/month.

Supply Chain Analysis

Onsite production and shipping LH_2 supply chains were modelled based on the processes in Figure 1 to determine the levelized cost of energy (LCOE) breakdown for a 20-year project lifetime. The onsite production supply chain required additional processes for wind energy generation, seawater desalination, electrolysis and modular cryocooler based liquefaction. Comparatively, the shipping scenario involved procuring LH_2 offsite in Tasmania, at $6.50 AUD/kg and transporting it to Mawson biannually, where it was stored in 40-ft ISO-containers.

Economic Analysis

The LCOE for both LH_2 demand scenarios and supply chains is shown in Figure 2. At low hydrogen demands, labor was found to account for the highest proportion of the LCOE for both shipping and production, whilst factors such as storage and electrolysis were less significant. Additional plant operators were required to ensure sufficient skills for maintenance and operation of LH_2 equipment new to Antarctica. At higher demands, the cost of LH_2 storage dominated the LCOE for both supply chains. Oversizing the storage capacity to account for boiloff losses and parallelizing expensive LH_2 ISO-containers both contributed to levelized hydrogen costs over $57 AUD/kg. This emphasizes the R&D needs to lower the cost of hydrogen storage and distribution to meet use case price points. Potential paths to reducing the supply cost of LH_2 to remote areas could include minimizing boiloff losses arising from passive heat leak and tank transfers such as through reliquefication or utilization of boiloff gas and increasing the manufacturing scale of LH_2 storage ISO containers.

Further analysis indicated that onsite production became more cost-effective compared to offsite production and shipping as the demand for hydrogen increased, with a crossover point at a demand of

▶ *continues on page 20*

Techno-Economics of Liquid Hydrogen... Continued from page 18

68 kg H_2/month. It cannot be definitively concluded that onsite production is the best pathway as there are practicalities that must be considered given the sensitivity of the location, such as the logistics of shipping equipment, weatherization of systems, labor requirements and safety considerations. Redundancy, location factors and the small scale of use all contributed to levelized costs of LH_2 of approximately $500 AUD/kg at 100 kg/month decreasing down to approximately $50 AUD/kg above a scale of 2000 kg/month.

Figure 2: Breakdown of LCOE with scale and supply chain. Credit: Nagash, Ooi, Udugoda, and Choo

While LH_2 may have a significantly higher cost than conventional energy sources, the potential value of Antarctic LH_2 cannot be assessed through a simple cost comparison to diesel alone. Lightweight LH_2 fueled drones could extend the range of research flights without producing emissions in one of our most fragile natural environments and is a use case that has no direct comparison to diesel. Beyond cost considerations, demonstrating hydrogen's viability in Antarctica could establish the region as a model of energy sustainability in remote and extreme environments, while also helping to preserve its priceless ecosystems.

The authors would like to acknowledge the support of Dr. Thomas Hughes, Liam Turner and James Wang from the Civil Engineering Department at Monash University, David Waterhouse at the Australian Antarctic Division, Dr. Felicity McCormack from the School of Earth, Atmosphere and Environment at Monash University and the Securing Antarctic's Environmental Future (SAEF) ARC special research initiative in completing this work.

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GARDNER CRYOGENICS
FLEXI-VAN

Cool Fuel

by Dr. Jacob Leachman, Professor, Washington State University, jacob.leachman@wsu.edu

Getting Real with Zero Boiloff LH_2 Storage

Low-cost zero-boiloff liquid hydrogen (LH_2) storage is one of the greatest opportunities in cryogenics. This opportunity has not gone unnoticed – many publications over the last decade have conducted carefully controlled experiments and modeling efforts toward zero-boiloff storage.[1] Curiously absent from this list are studies of real-world liquid hydrogen tank performance through routine operations at logistics centers, which are currently the largest use of liquid hydrogen in North America. To address this need, Plug Power commissioned a study in the Hydrogen Properties for Energy Research (HYPER) Center between myself and Professor Konstantin Matveev to analyze the problem. Kyle Appel, a HYPER graduate student, recently published a Master's Thesis on the work.[2] What we quickly realized during the course of the research is that real-world LH_2 tank operations are far removed from the idealized studies often found in the literature.

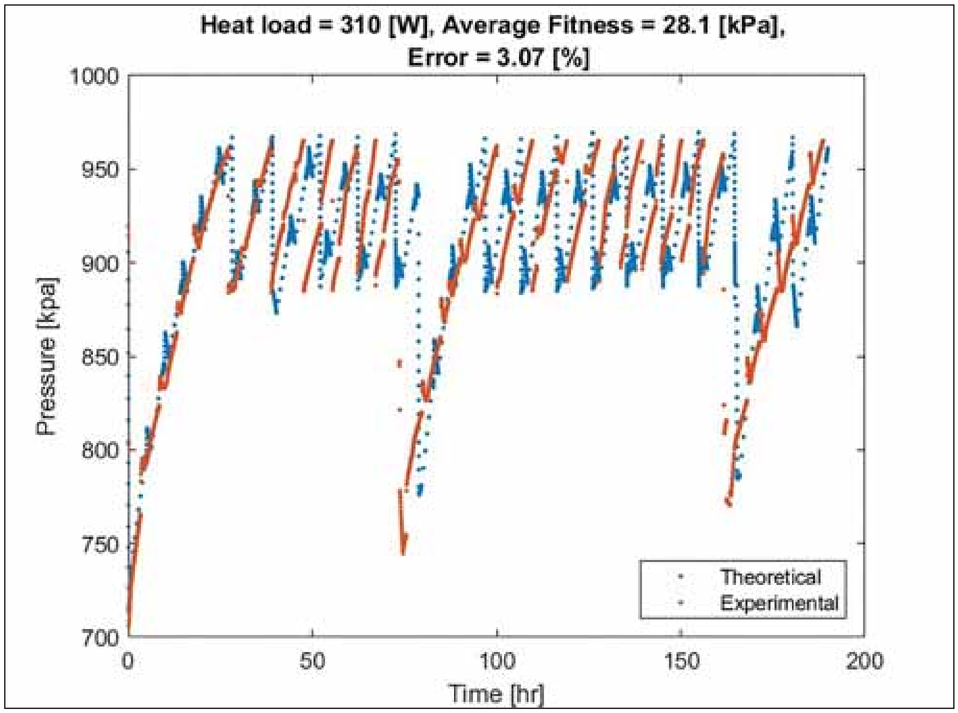

Figure 1: Comparison of experimental versus theoretical tank pressures during liquid extraction, venting and fill events over a 200-hour period. *Credit: J. Leachman*

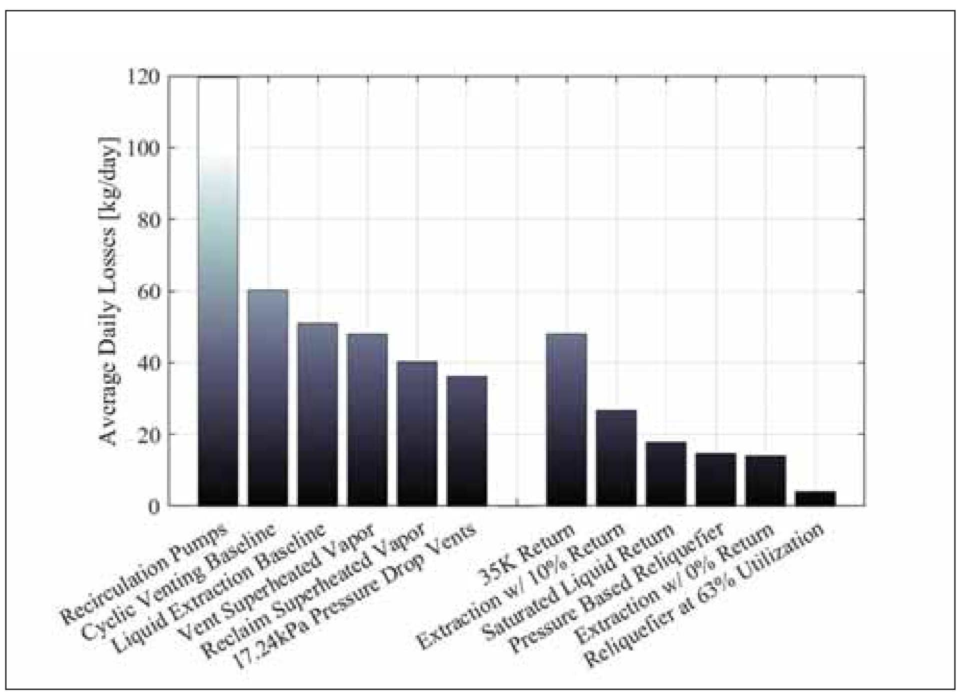

Figure 2: Average daily venting losses versus various operational changes for a hypothetical liquid hydrogen tank. *Credit: J. Leachman*

Kyle's thesis developed what is known as a nonthermal equilibrium model for liquid hydrogen tanks. Nonthermal equilibrium models partition the vapor (in what is known as the ullage space) from the liquid in the bottom of the tank into two control volumes that exchange both mass and heat but are ultimately at different temperatures.

While only two nodes may seem like an oversimplification, we're only aware of a single in-service tank with enough diodes to resolve the temperature stratification in the ullage space. Tanks typically have only a single temperature sensor in the ullage, which makes it difficult to justify more expensive Computational Fluid Dynamics studies, which tend to indicate that the ullage temperature is relatively uniform anyway. Kyle validated and then verified his model using the exquisite NASA IRAS and MHTB studies before turning to the real-world tanks. [2]

Real-world tank operations include several scenarios typically absent from conventional research-environment tanks: periodic actuation of pressure relief valves, pressurizing circuits to maintain tank pressure during long liquid extraction events, vapor extraction to a boiloff-gas compressor, recirculation of two-phase fluid from extraction pumps and manual vent/fill cycles. This list doesn't even include thermoacoustic and other fluid-flow instabilities that could have transient heat load effects. Regardless, these processes create complex combinations that are difficult to simultaneously analyze for verification.

Through extensive data analysis of the real-world tanks, Kyle was able to parse enough different operating conditions that he could combine operational scenarios with his model to reproduce tank pressure data within ±10% and typically within ±5%, over all operational scenarios. Figure 1 shows a comparison of his model simulation versus experimental pressure measurements over a 200-hour tank operation period. Kyle showed that with small adjustments to a liquid-surface calibration coefficient, his model could be adapted to other tank configurations within the Plug Power fleet.

With a verified model, the opportunity is to predict what changes to real-world LH_2 tank operations can most expeditiously reduce venting losses, potentially all the way to zero. We were surprised to discover that some relatively simple changes to operations could make a significant difference and that a path exists, with some investment, to zero-boiloff operations. Figure 2 shows a range of expected venting losses for various operational changes and associated reductions if a baseline 60 kg/day venting loss is assumed. Thank you to Plug Power for providing real-world data and collaborating with us on this study!

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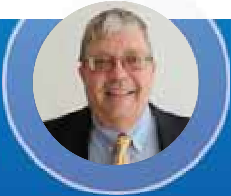
[2] In a 2024 master's thesis at Washington State University, K. Appel focused on numerical modeling of liquid hydrogen storage tanks to reduce boil-off losses. https://rex.libraries.wsu.edu/esploro/outputs/graduate/Numerical-Modeling-of-Liquid-Hydrogen-Storage/99901195439501842

[3] W. Notardonato and colleagues explored zero boil-off methods for large-scale hydrogen tanks using integrated refrigeration and storage in Advances in Cryogenics, published during the 2017 Cryogenic Engineering Conference. https://ntrs.nasa.gov/api/citations/20170006481/downloads/20170006481.pdf

[4] O. Kartuzova presented simulations on spray cooling and self-pressurization for NASA's Multipurpose Hydrogen Test Bed in a 2015 AIAA propulsion conference paper. https://ntrs.nasa.gov/citations/20150000249



Cryo Bios

by Dr. John Weisend II, European Spallation Source ERIC, CSA Chairman, john.weisend@esss.se, with Anne DiPaola, *Cold Facts* Editor

Angela Krenn

Angela Krenn and OpenStar founder/CEO, Ratu Mataira, with OpenStar's fusion reactor, taken shortly after the reactor achieved first plasma. Credit: Angela Krenn

Angela Krenn's journey into cryogenics began with a fortuitous opportunity during her college years. She secured a co-op position with Lockheed Martin at the Michoud Assembly Facility, where the Space Shuttle's External Tanks were manufactured. Though her role focused on structural design, the experience provided her with a deep familiarity with the cryogenic propulsion tanks used in spaceflight. This foundational knowledge positioned her well for her next role in cryogenics. After graduating, Krenn joined United Space Alliance at NASA's Kennedy Space Center as an operations engineer in the Liquid Hydrogen group. She was part of a small team responsible for testing, maintaining, repairing and operating the liquid hydrogen storage tanks and transfer systems at the Space Shuttle launch pads and on the mobile launch platforms. This hands-on experience provided invaluable lessons in the safe handling of cryogenics and the operational intricacies of space-bound cryogenic systems.

Her career in space cryogenics has been marked by adaptability and a relentless pursuit of learning. Just six months after joining the Space Shuttle's liquid hydrogen team, the Columbia accident occurred, leading to an indefinite stand-down. Rather than waiting for the program to resume, Krenn took the initiative to pursue an MBA while continuing rigorous training in propellant loading simulations. After earning certification as a primary console operator for Space Shuttle propellant loading and launch, she expanded her expertise by cross-training in the liquid oxygen system. However, with the announced end of the Shuttle program, Krenn shifted gears once again, moving into the ground support system design group to support the Constellation program. During this time, she contributed to the design, building and testing of a cold gas helium heat exchanger using liquid hydrogen as the working fluid. Recognizing the importance of accurate analytical models in design, she transitioned to an analysis role, where she sized relief valves and learned to model in Thermal Desktop. However, she missed the hands-on aspect of her work, leading her to the Cryogenics Test Lab. There, she tested insulation in cryostats, built cryogenic test setups and analyzed data.

Krenn's pursuit of knowledge took her to Kennedy Space Center's Applied Physics Lab, where she expanded her expertise beyond cryogenics. She tested ultrasonic detectors for detecting air leaks in vacuum spaces and developed a Thermal Desktop model of a large vacuum jacketed liquid hydrogen storage tank. Her dedication to continuous learning led to a Kennedy Graduate Fellowship, through which she earned a master's degree in physics.

One of her most significant projects was leading the Kennedy Space Center team supporting Goddard Space Flight Center's Robotic Refueling Mission 3. This mission, which transported liquid methane to the International Space Station to test in-space cryogenic transfer, presented Krenn with new challenges, from handling liquid methane for the first time to navigating the complexities of flight experiments.

Her expertise in cryogenics also made her a sought-after contributor to the Mars Architecture Team (MAT), where she provided input on cryogenic propellant surface transfer concepts for future human missions to Mars. After leading multiple studies with MAT, she was appointed Principal Technologist for Thermal Management Systems within NASA's Space Technology Mission Directorate. Though her background was primarily in cryogenics, she was tasked with overseeing technical expertise across a broader range of thermal systems, including moderate and high-temperature applications. The shift exposed her to new engineering challenges and deepened her technical acumen. Today, she serves as the Deputy Chief Architect, developing strategies for technology development and integration across NASA, industry, government agencies, academia and international partners.

International Space Exploration Coordination Group's Technology Working Group at a recent face to face meeting. Credit: Angela Krenn

Touring CERN with Marta Bajko, the lead of the cryogenic integrated test stand. Credit: Angela Krenn

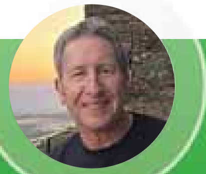
Among Krenn's many technical contributions, one of the most groundbreaking was her role in the development of the Solar White thermal control coating. This technology, designed for in-space cryogenic systems, progressed from an early-stage concept under the NASA Innovative Advanced Concepts program to a fully developed solution licensed to multiple companies. A significant challenge arose when standard testing methods produced seemingly impossible results, suggesting the coating reflected more light than it received. To resolve this, Krenn and her team devised a novel space irradiance simulator. This innovative test apparatus allowed them to expose the coating to deep-space conditions and measure its actual performance. The findings demonstrated that Solar White significantly reduced heat loads on cryogenic tanks in space, ultimately enabling more efficient spacecraft designs with smaller propellant tanks and lower power requirements for cryogenic refrigeration systems.

Krenn also played a pivotal role in the design and testing of an integrated refrigeration and storage (IRAS) system. This technology, which incorporates a heat exchange coil within a cryogenic storage tank, actively controls the fluid's state to eliminate boiloff losses. IRAS was implemented in the construction of a large-scale liquid hydrogen tank at Kennedy Space Center's launch pad, but its applications extend beyond spaceflight. The technology has the potential to revolutionize liquid hydrogen storage for terrestrial transportation, reducing costs and enhancing the viability of hydrogen as a clean energy source. Additionally, as NASA plans for lunar infrastructure, IRAS could play a critical role in preserving essential cryogenic resources on the Moon. Recognizing its broad impact, Krenn has collaborated with the Department of Energy to advance data collection and promote further adoption of IRAS technology.

Over the course of her career, Krenn has witnessed significant shifts in the field of cryogenics. One notable trend is the renewed emphasis on developing cryogenic propulsion technologies to support future human missions to Mars. NASA has heavily invested in these technologies to ensure mission feasibility. At the same time, commercial spaceflight companies are increasingly favoring liquid natural gas over hydrogen as a rocket propellant. While liquid natural gas is easier to handle, it sacrifices some performance efficiency, highlighting the ongoing trade-offs in aerospace engineering.

Beyond her technical contributions, Krenn remains an active member of the professional cryogenics community. She serves on the American Institute of Aeronautics and Astronautics (AIAA) Hydrogen Committee on Standards, contributing to revisions of the AIAA/ANSI Guide to Safety of Hydrogen and Hydrogen Systems. She is also a regular participant and technical reviewer for conferences such as the Cryogenic Engineering Conference, the Space Cryo Workshop and the Thermal and Fluid Analysis Workshop. Additionally, she has spoken at numerous industry events, including workshops on hydrogen use in aviation, Department of Energy collaborations and NASA's Moon to Mars Workshops.

Angela Krenn's career reflects a commitment to innovation and learning that has advanced cryogenic systems, thermal management, and spaceflight technologies in support of NASA and future space exploration.



Cryotreatment

by Jack Cahn, Chief Technologist, Deep Cryogenics International, jack@deepcryogenics.com

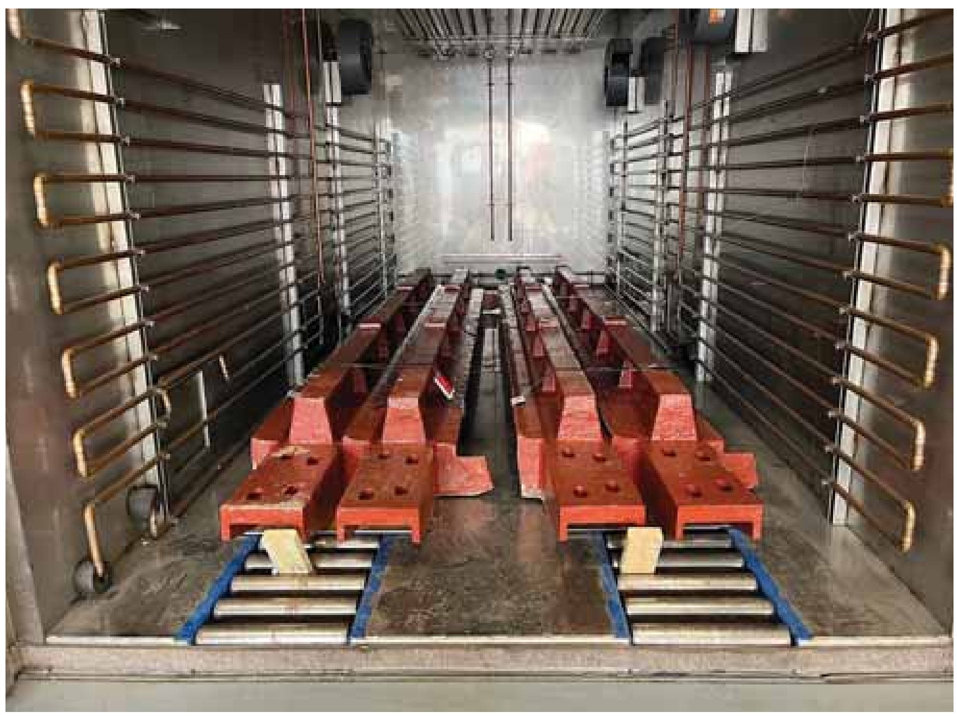
The Cold Cure

Hello, cryogenics community! This is my first column in *Cold Facts*, and I'm excited to dive in. As co-founder of a deep cryogenic treatment (DCT) company (www.deepcryogenics.com), I'll explore the science, applications, limitations and challenges of cryogenic treatment, including technology adoption, equipment, test methods, service providers and end users. Heck, there's two years' worth of columns in just that one run-on sentence!

So, what is DCT and how does it differ from shallow cryogenics (-60° F to -176° F)? DCT uses a 36-hour process at -230° F to -320° F, which refines atomic-level grain structure, precipitates carbides in alloys, triggers the TRIP/TWP effect and increases dislocation density in metals. This results in 20-40% greater wear life, 10-20% higher yield strength and 10-20% less corrosion. Unlike heat treatment or coatings, DCT is non-toxic, chemical-free and generates no environmental waste. It is low-cost, works on both ferrous and non-ferrous materials, supports mixed alloys during treatment and allows economy-of-scale batch processing. However, despite academic backing, cost-effectiveness and acceptance by the heat treat community, DCT has remained in the undeveloped backwater of material improvement processes. Why is this?

DCT doesn't work on all metals all the time. Despite early studies and claims of 200% benefit, DCT improvement depends on the alloy chemistry, the method of manufacture, prior heat treatment and the item's failure mode. While lab results show significant improvements, field results often fall short, requiring further research to match materials to specific benefits. Some materials don't improve from DCT, while others show benefit only in a single metallurgical characteristic. Extensive applied research is needed to link each material alloy to specific end-use and actual benefits.

The DCT process. Credit: Jack Cahn



9,200 pounds of manganese steel feeder pans undergoing DCT. Credit: Jack Cahn

Limited industrial equipment and scale-up. Most DCT chambers are small, modified deep freezers with high LN_2 consumption due to latent heat loss. Very few can handle large industrial volumes at the required low temperatures. Until recently, DCT has bottlenecked at early Technology Readiness Levels), which has slowed adoption, especially in sectors like energy, aerospace and automotive.

No certification, acceptance or test standards. While heat treatments are ISO, NADCAP and ASTM certified, DCT lacks similar standards, hindering widespread industry acceptance. Although sectors like

DCI President Linda Williams loading a 3,500-pound pump cyclone for DCT. Credit: Jack Cahn

DCT of O&G slurry pump bushings. Credit: Jack Cahn

motorsports and knife-making are advocates, they don't require testing, limiting DCT's scalability.

Lack of collaboration among DCT service providers. The DCT industry is fragmented. We are generally independent service providers who offer localized DCT; some of us also build DCT chambers. Fewer than 50 companies globally offer DCT as a stand-alone service, and another 750-1,000 companies (mostly existing heat treaters) provide cryogenic treatment as an ancillary service. Unlike the dozens of heat treat organizations, industry trade groups and trade journals that share technical advice, innovation news or a community forum… deep cryogenics has nothing like that. Just our individual company websites, occasional articles and reliance on DCT "chatter."

After discussing the industry's challenges with Applied Cryogenics Inc. President Dr. Jeff Levine and DCI President Linda Williams, I reached out to 100 DCT providers, scientists and industry professionals. About 25% responded — scientists curious about DCT, engineers interested in certification standards, heat treaters seeking greater opportunity and service providers keen to work together — who supported the formation of a trade organization to:

- Promote DCT technology awareness and adoption
- Create a working group to develop DCT standards and certifications
- Showcase companies, services and products
- Increase professionalism and quality in cryogenic treatment
- Foster collaboration and knowledge-sharing

Both Megan Galeher and Anne DiPaola have offered to promote an emerging cryogenic treatment group under the CSA mantle, lending its scientific and professional credibility. Doug Glenn, publisher of *Heat Treat Today*, has offered similar support. Heat treaters have thrived globally by navigating the scale-up process and adhering to certification standards required by commercial and industrial users. They have also focused collaboratively on quality, innovation and knowledge-sharing within their industry.

I believe a cryogenic treatment organization could launch under the combined CSA/heat treat umbrella. What do you think? Email your thoughts to me at jack@deepcryogenics.com, and I'll share them in my next column. Thanks for welcoming DCT into the community!


by Quan-Sheng Shu, cryospc.com, and Jonathan Demko, Le Torneau University

Superconducting Wiggler/Undulator for Modern Synchrotron Radiation and X-Ray FEL Explained

Synchrotrons and linear accelerators propel electrons to near-light speeds and guide them through circular tracks using superconducting (SC) wigglers or undulators, inducing the emission of ultrabright synchrotron radiation source (SRS), including X-rays from free-electron lasers. This radiation, a billion times brighter than the Sun and 10,000 times more powerful than traditional microscopes, is directed into beamlines for applications in imaging materials and biological structures at atomic to nanometer scales and capturing chemical reactions within nanoseconds [1-3].

In addition to SC magnets' applications in accelerators [4-5], the wigglers/undulators—periodic magnetic structures—force electrons into a slalom motion, causing them to emit X-ray radiation. This radiation interacts with electrons, aligning them into thin disks and amplifying emission through self-amplified spontaneous emission (SASE). X-ray Free-electron lasers require long undulators, such as those exceeding 100 meters at the 1.7 km European XFEL.

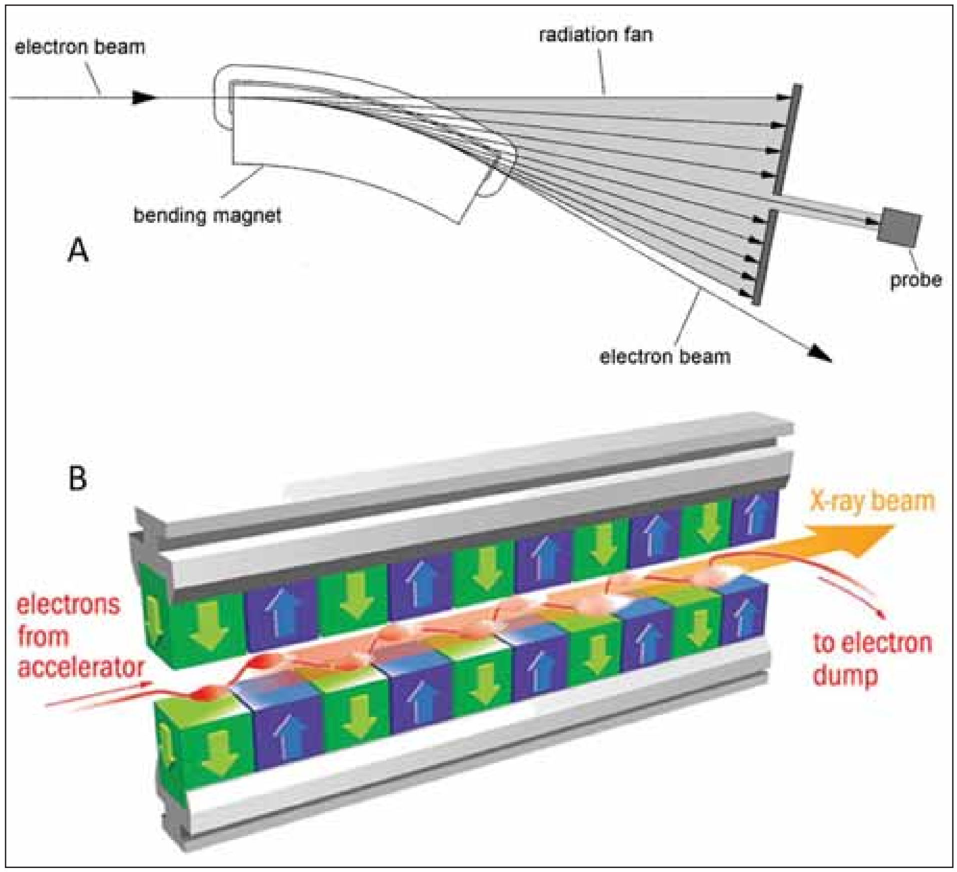


Figure 1. A. Synchrotron radiation emitted by a bending magnet.[1] Credit: Wille, and B. Synchrotron radiation emitted from the W/U magnet array. Credit: European XFEL

Functions of SC Bending Magnet, Wiggler and Undulator

At the very beginning, the synchrotron radiation emitted by an electron beam passing through a bending magnet as Figure 1A.[1] The probes are only a small fraction of the radiation, and the horizontal resolution is not very high. Much better beam quality and significantly higher brilliance is provided by wiggler and undulator (W/U) magnets' so-called insertion devices as Figure 1B,[2] which are installed in electron storage or linear accelerator.[1-3, 6-7] It consists of a sequence of short bending magnets of constant length with a gap of G. Along the beam axis, the resulting field is about a sine curve with the period length λu. The design principle of wiggler magnets is basically the same as of undulator magnets and both utilize SC magnets to reach higher magnetic fields, 1.5 to above 5T to obtain the high radiation. The W/U strength parameter K is presented,

$$K = \frac{eB\lambda u}{2\pi m_e C} \text{ or } K = 0.934\ \lambda_0 B_0\ [\mathrm{mT}]$$

where e is the electron charge, B is the magnetic field, λ_μ is the spatial period of the undulator magnets, me is the electron rest mass, and c is the speed of light. And,

$$\lambda_n = \frac{\lambda u}{2n\gamma^2}\left(1+\frac{K^2}{2}\right) \approx \frac{\lambda u}{n\gamma^2}$$

$$\varepsilon_n\ (\mathrm{eV}) = 9.496\,\frac{nE\,[GeV]^2}{\lambda u[m]\left(1+\frac{K^2}{2}\right)}$$

Wigglers have a large K value (K>>1) and a smaller number of periods. The magnets in a wiggler are often arranged in a Halbach array. Undulators have a low K value (K~1) and a larger number of periods. Undulators are designed to produce a highly coherent, narrowband beam of light due to the smaller amplitude of electron oscillations, making them ideal for detailed studies, while wigglers produce a broader spectrum of radiation with higher intensity.

Design of SC Wiggler Magnet

The performance of a wiggler is strongly dependent on its magnetic field strength, making superconducting (SC) magnets the preferred choice. Based on this criterion, SC wigglers can be categorized into three types: [3,6-7]

High-field SC Wigglers (7–10 Tesla). These multipole wigglers have a period of approximately 148–200 mm, with high stored energy ranging from 400 to 900 kJ and internal coil pressures exceeding 400 bars. They feature a wide vacuum chamber to accommodate the large fan angle of radiation and generate high radiated power. However, they also exert a significant influence on beam dynamics. Examples include installations at BESSY II, LSU and DELTA.

Medium-field SC Wigglers (2.5–4.5 Tesla). These wigglers typically employ two-section coils and have a period of 48–60 mm, with approximately 50–70 poles. They are used in facilities such as JEEP, ANKA and DLS.

Short-period SC Wigglers (λ ≈ 3–3.3 cm, B ≈ 2–2.2 Tesla). A notable example is the 2 Tesla superconducting wiggler with a 33 mm period length and 63 poles, designed and fabricated as an X-ray source for the HXMA beamline at the Canadian Light Source Inc.

Most of the operational SC wigglers utilize NbTi superconducting wires, while Nb_3Sn and high temperature superconductors (HTS) have been explored for prototype development. Figure 2 shows the open 72 poles-magnet for vacuum chamber installing, and Figure 2B is the cross-section of a wiggler cryostat.

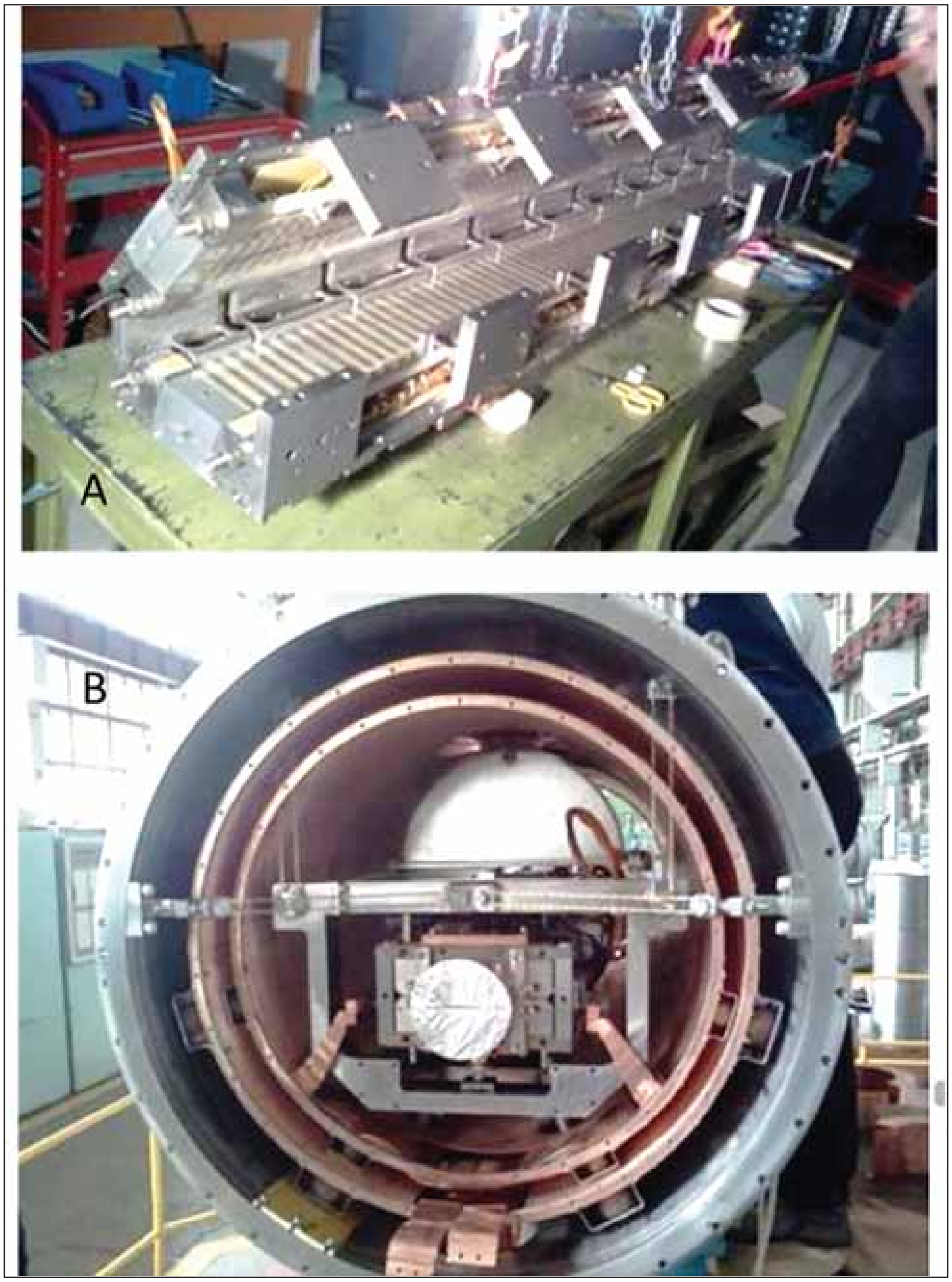


Figure 2. A: 3-T superconducting 72-pole wiggler for ANKA-CLIC. B: SC magnets inside cryostat.[3] *Credit: Mezentsev and ANKA-CLIC*

Design of SC Undulator Magnet

As electrons traverse the undulator, they initially emit spontaneous synchrotron radiation. Interactions with this radiation and the periodic magnetic field induce microbunching, where electrons group at the emitted wavelength, leading to constructive interference and exponential radiation amplification. Unlike conventional lasers that require optical cavities and external seeding, self-amplified spontaneous emission (SASE) is a self-driven process, enabling ultrashort, high-brightness X-ray pulses in FELs like the European XFEL and LCLS.

Superconducting (SC) undulator magnets generate their main magnetic field through horizontal crosscurrents. In an idealized infinite winding scenario, current closure does not impact the fields. Some designs with finite windings close currents either in the vertical plane using vertical racetrack coils or in the horizontal plane with neutral poles as shown in Figure 2. Vertical racetrack coil undulators require a period length of 15–20 mm, over 100 poles, a K-value above 1 and a vertical aperture of 4.5–10 mm. A specific approach using horizontal racetrack coils with neutral poles was developed at BINP, Argonne, ASTeC and JBNL, optimizing field characteristics through horizontal current closure. A BINP-designed SC undulator prototype with a 15.6 mm period, 8 mm pole gap, and 15 periods achieved a 1.2 T maximum field, validating the feasibility of this design for advanced SC undulator applications. Magnetic field measurements as a function of the longitudinal coordinate are shown in Figure 3D.

▶ *continues on page 30*

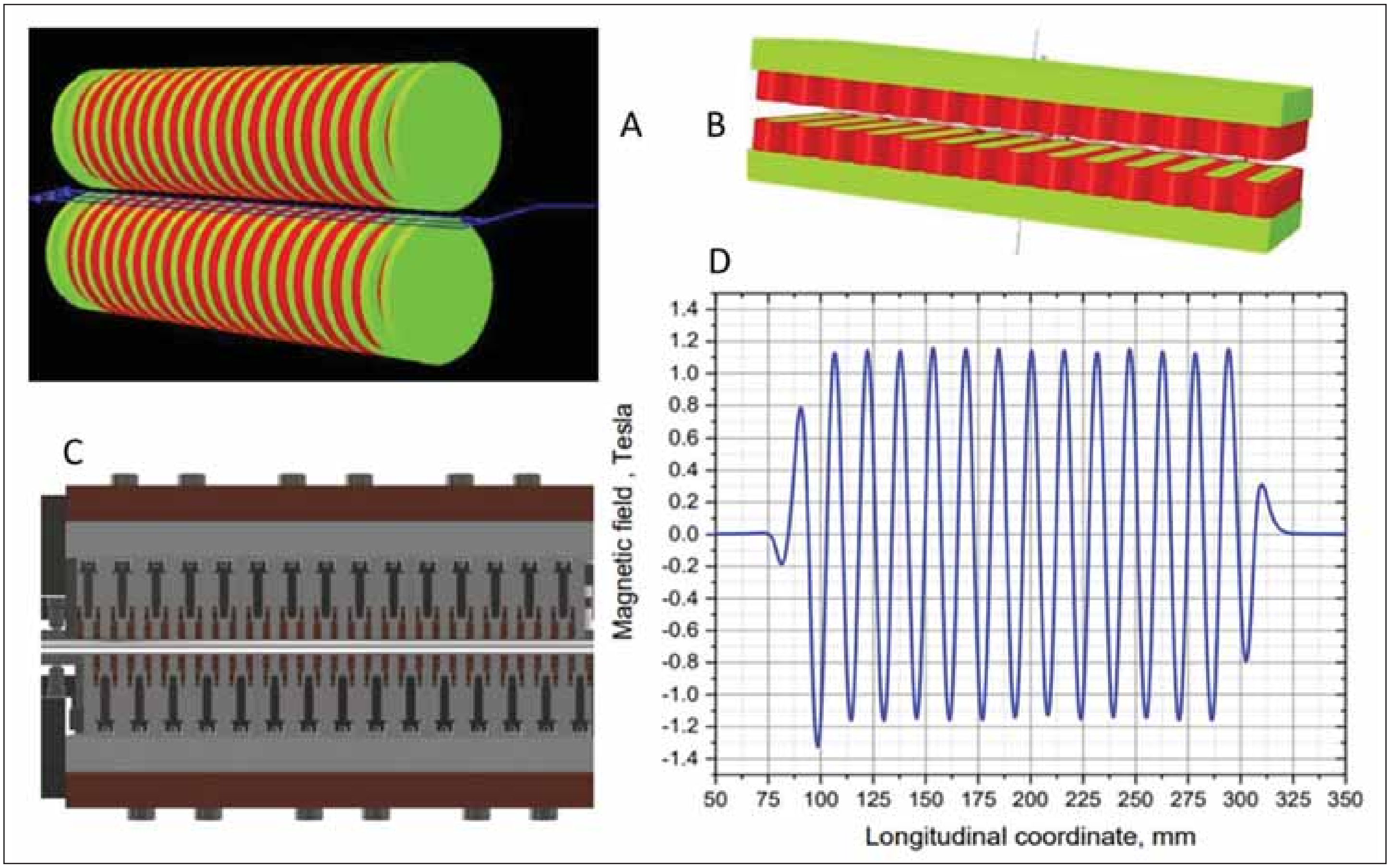


Figure 3. A. Vertical racetrack SC undulator coil. B. Horizontal racetrack SCU coil. C. Horizontal racetrack coil with neutral poles. D. Measured magnetic fields as functions of the longitudinal coordinate, λ-15.6mm, gap=8mm, I=512A. [3] *Credit: Mezentsev, Gluskin and BINP*

Cryogenic System for SC Wiggler and Undulator

Superconducting (SC) wigglers and undulators have employed three distinct cooling methods, each chosen based on technological suitability and cost efficiency. The first approach uses a liquid helium (LHe) bath cryostat to cool SC magnets and associated components, including the current leads and beam vacuum chamber, ensuring stable low temperature operation. The second method integrates a cryocooler with the LHe bath cryostat to achieve zero helium boiloff, reducing helium consumption and operational costs. The third approach relies solely on a cryocoolers to cool all components, eliminating the need for liquid helium and offering a more compact and maintenance-friendly solution. The optimal choice among these methods depends on specific system requirements, balancing performance, operational complexity and economic considerations.

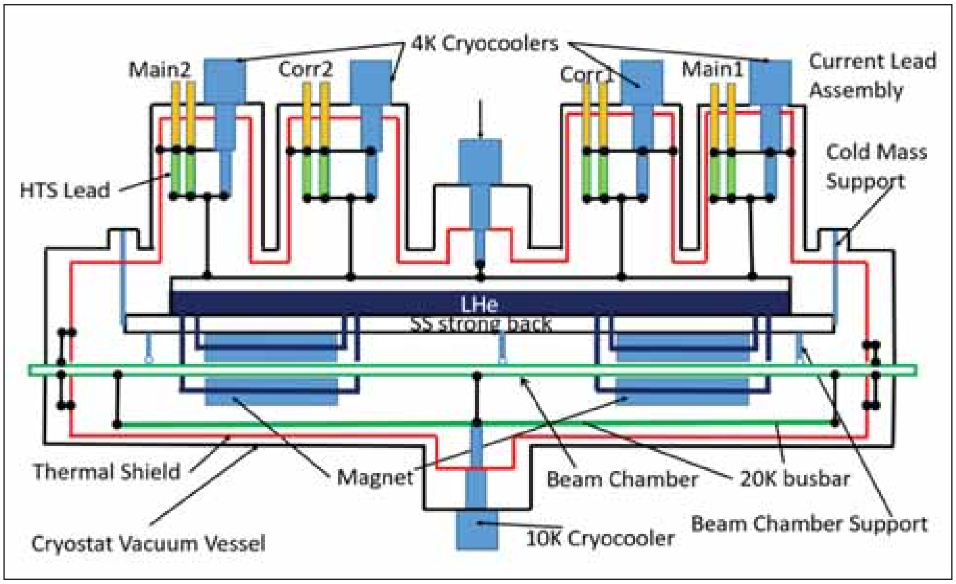


Figure 4. Cooling schematic of the APSU-SCU cryostat. [8] *Credit: Shiroyanagi*

Anliker and Shiroyanagi reported that the Advanced Photon Source Upgrade (APSU) includes four superconducting undulator (SCU) cryostats, each housing two planar NbTi undulator magnets up to 1.9 m in length.[6,8] The cryogenic system consists of six cryocoolers arranged in three thermal circuits to maintain the necessary low temperatures. The cooling system layout of the APSU-SCU cryostat is illustrated in Figure 4, highlighting the placement and function of each cryocooler. Two pairs of 4 K cryocoolers positioned on the left and right turret assemblies, connected via copper flexible links to the LHe tank ends. A fifth 4 K cryocooler, located at the top center, cools the LHe tank through a central copper link, while a 10 K cryocooler at the bottom center cools the vacuum beam chamber via a copper busbar and thermal links. The sophisticatedly cooled vacuum beam tube in the W/U magnet gap will be introduced in a separate article.

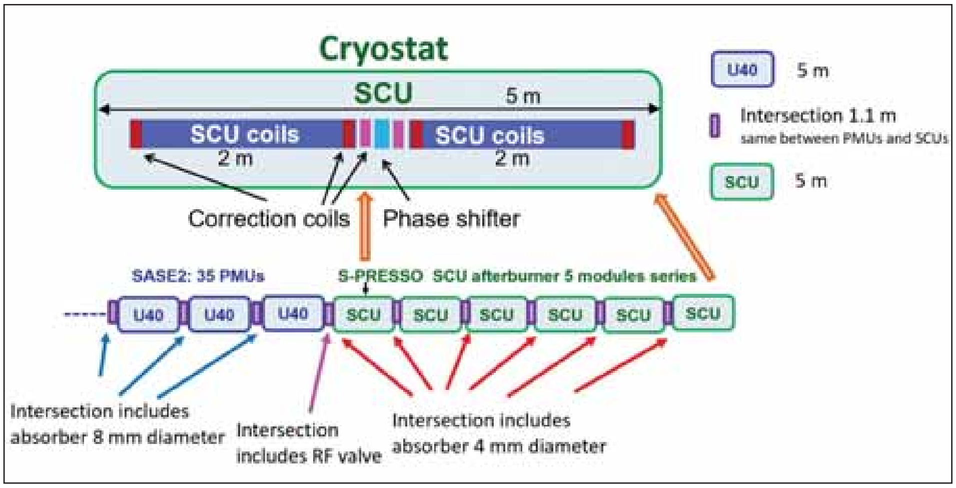


Figure 5. Sketch after SASE2 (Bottom) and one SCU module (top).[2] Credit: Casalbuoni and European XFEL

Development of Future SC Wiggler and Undulators for Modern SRS and XFFL

Assuming the relative peak brilliance by the first X-ray tube emitted is one, then first generation synchrotron (GS) – 10^9, the 2nd GS – 10^{11}, the 3rd GS – 10^{18}, and the fourth GS or XFEL is about 10^{27} stronger than the first X-ray tube. When a relativistic electron beam of small emittance passes through a very long magnetic array known as an undulator, a series of alternating magnetic fields force the electrons to follow a sinusoidal path. Hence, the intensity is proportional to N_p^2, where Np is the number of undulator periods (typically ~100). This is the regular undulator radiation generated at 3rd GS sources such as the ESRF in France and APS in the US.[9-11] If the undulator is very long, the interactions between the electrons and the radiation field that builds up will eventually lead to micro-bunching of the electron beam into coherent packages that radiate in phase. This results in a huge amplification (lasing) of emitted intensity as it becomes proportional to N_e^2, where N_e is the number of electrons emitting in phase within the co-operation length (typically 106, or more). The hard-X-ray undulators of the European XFEL have magnetic lengths of 175-m to ensure that SASE works over a wide range of photon energies and electron beam parameters.[2] The SC undulators have been designed and partially tested, and will be installed in the world's longest EU XFEL as shown in Figure 5.

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Clean Energy Future

by James E. Fesmire, President, Energy Evolution LLC, james@321energy.us

Remembering Dr. Stan Augustynowicz, a Cryogenics Pioneer

Stanisław ("Stan") was my mentor, business partner, and dear friend. He was a distinguished colleague, a visionary trailblazer, and a true leader in cryogenics. Stan played a pivotal role in the Cryogenic Society of America as Director of International Affairs and Board Member, and he served as VP-USA for the International Institute of Refrigeration, Commission A1/2, Cryophysics and Cryoengineering. He opened up a whole new world—and mindset—for me. Stan always advocated for using cryogenics in ways that were productive and beneficial for the *human being*.

Together, we founded the Cryogenics Test Laboratory (CTL) at NASA's Kennedy Space Center in 1997, with an official ribbon-cutting in 2000 by then-Center Director Roy D. Bridges [see *Cold Facts*, N36, N_2]. Stan's decade of cryostat invention and thermal insulation systems testing at CTL laid the groundwork for new technical standards under ASTM International. He also contributed to problem-solving efforts during the Space Shuttle Return-to-Flight mission, following the tragic loss of *Columbia* in 2003 due to a piece of cryogenic foam insulation breaking off the External Tank.

A superconducting, magnetically levitated cryostat under test in the NASA CTL in 2005. Credit: Fesmire

The patented Cryostat-the-First (CS1) insulation test apparatus, of the original NASA CTL, in 1998. Credit: Fesmire

Stan and James receiving a Gold Dollar Award from NASA Kennedy Space Center Director Jim Kennedy in 2006. Credit: Fesmire

The patented Cryogenic Pipeline Tester behind the original NASA CTL in 2001. Credit: Fesmire

The ribbon-breaking ceremony for the opening of the new NASA CTL facility in 2000. Credit: Fesmire

Stan authored more than 230 publications, articles, and patents.

Stanisław Dyonizy Augustynowicz was born in Warsaw, Poland, on May 8, 1932, the only child of Ludwik and Stanisława (Zygmuntowicz) Augustynowicz. The family owned a furrier shop and lived a comfortable life until the Nazi occupation. In 1942, Ludwik was arrested for harboring a Soviet paratrooper and was ultimately executed. Stanisław and his mother remained in Warsaw, surviving its near-total destruction in 1944 as punishment for the Warsaw Uprising. They were rounded up for transport to the Dulag 121 transit camp but managed to escape from the train into the surrounding woods after his mother bribed a guard with her gold jewelry.

After the war, Stanisław's mother reopened her fur shop in Łódź, and they later returned to Warsaw. Stanisław graduated in 1951 from the Prince Józef Poniatowski State Secondary School and went on to study at the Warsaw University of Technology, eventually earning a Ph.D. in cryogenic engineering from Wrocław University of Technology. He married Barbara Wielgomas in Warsaw in 1958, and their daughter, Karolina, was born in 1976.

In 1981, the family came to the U.S. for a short cultural exchange program, with Stanisław working at Frigitronics in Connecticut. Soon after they arrived, martial law was declared in Poland, and the family decided to stay. Stan's career took the family across the U.S.: Ansonia, CT (Frigitronics – cryosurgical probes); Charleston, SC; Nashua, NH; Bethlehem, PA (Union Carbide – deployment of Polarstream refrigerated trucks); Mountainside, NJ (Cryodynamics – R&D Manager, medical refrigeration, 1986–88); Chicago, IL (Fermilab and Liquid Carbonic – Senior Testing Project Engineer, 1989); Waxahachie, TX (Superconducting Super Collider – Senior Mechanical Engineer, 1990–94); and New Prague, MN (MVE Inc. – Senior Engineer and leader in thermal insulation systems and vacuum, 1994–98).

At NASA/KSC on Florida's Atlantic coast—where he capped off his remarkable career—is where I had the privilege of knowing and learning from Stan for ten years. A joint industry development program with MVE (now Chart Industries) under a Space Act Agreement was instrumental in launching the CTL. Together, we built it under the theme of *Energy Efficient Cryogenics – on Earth and in Space*, designing and testing cryostats and thermal insulation systems of all kinds, producing extensive data libraries, standard designs, patents, and publications. Upon being awarded five patents, Stan received the Gold Dollar ACE Award from Roy Bridges. He also represented the U.S. State Department in monitoring cryogenic projects supported by Russia.

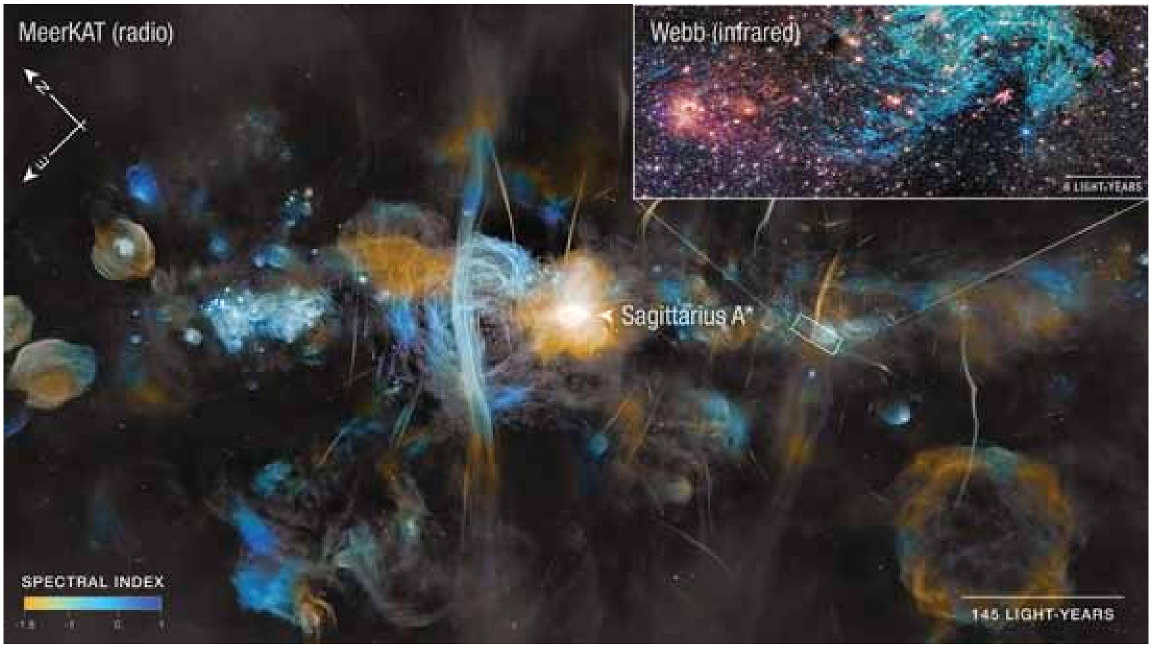
Stan's wife Barbara passed away in 2000, shortly after attending the CTL ribbon-cutting ceremony. In retirement, Stan settled in Mississauga, Canada, among the Polish community, and took up building PCs as a hobby. He passed away on October 23, 2024. He is survived by his daughter Karolina (Ben) King and grandchildren Baxter and Beatrice, as well as his second wife, Zofia Sochacka—the mutual friend who had introduced him to Barbara decades earlier.

Stan's scientific grounding was matched by his practical insight and ability to inspire action. He had a gift for turning vision into real-world problem-solving. His hands-on approach is evident in the selected photos included here. Among his many sayings—both in Polish and their English equivalents—one stood out: *"Don't just talk about it but do something with your two hands connected to one brain."* It was a call to action: have vision and start with yourself and your environment as your first resource. One of our lab mottos grew from that: *"Don't just talk about it—do something. Don't just do something—think about it."*

And my personal favorite, especially for adapting to change: *"Only a cow doesn't change its mind."*

NASA Webb Explores Effect of Strong Magnetic Fields on Star Formation

by Laura Betz, NASA Goddard Space Flight Center, Greenbelt, Md., Leah Ramsay, and Christine Pulliam, Space Telescope Science Institute, Baltimore, Md. *Originally published on science.nasa.gov*



Milky Way Center (MeerKAT and Webb). An image of the Milky Way captured by the MeerKAT (formerly the Karoo Array Telescope) radio telescope array puts the James Webb Space Telescope's image of the Sagittarius C region in context. Like a super-long exposure photograph, MeerKAT shows the bubble-like remnants of supernovas that exploded over millennia, capturing the dynamic nature of the Milky Way's chaotic core. At the center of the MeerKAT image the region surrounding the Milky Way's supermassive black hole blazes bright. Huge vertical filamentary structures echo those captured on a smaller scale by Webb in Sagittarius C's blue-green hydrogen cloud. Credit: NASA, ESA, CSA, STScI, SARAO, Samuel Crowe (UVA), John Bally (CU), Ruben Fedriani (IAA-CSIC), Ian Heywood (Oxford)

Follow-up research on a 2023 image of the Sagittarius C stellar nursery in the heart of our Milky Way galaxy, captured by NASA's James Webb Space Telescope, has revealed ejections from still-forming protostars and insights into the impact of strong magnetic fields on interstellar gas and the life cycle of stars.

"A big question in the Central Molecular Zone of our galaxy has been, if there is so much dense gas and cosmic dust here, and we know that stars form in such clouds, why are so few stars born here?" said astrophysicist John Bally of the University of Colorado Boulder, one of the principal investigators. "Now, for the first time, we are seeing directly that strong magnetic fields may play an important role in suppressing star formation, even at small scales."

Detailed study of stars in this crowded, dusty region has been limited, but Webb's advanced near-infrared instruments have allowed astronomers to see through the clouds to study young stars like never before.

"The extreme environment of the galactic center is a fascinating place to put star formation theories to the test, and the infrared capabilities of NASA's James Webb Space Telescope provide the opportunity to build on past important observations from ground-based telescopes like ALMA and MeerKAT," said Samuel Crowe, another principal investigator on the research, a senior undergraduate at the University of Virginia and a 2025 Rhodes Scholar.

Bally and Crowe each led a paper published in *The Astrophysical Journal*.

Using Infrared to Reveal Forming Stars

In Sagittarius C's brightest cluster, the researchers confirmed the tentative finding from the Atacama Large Millimeter Array (ALMA) that two massive stars are forming there. Along with infrared data from NASA's retired Spitzer Space Telescope and SOFIA (Stratospheric Observatory for Infrared Astronomy) mission, as well as the Herschel Space Observatory, they used Webb to determine that each of the massive protostars is already more than 20 times the mass of the Sun. Webb also revealed the bright outflows powered by each protostar.

Even more challenging is finding low-mass protostars, still shrouded in cocoons of cosmic dust. Researchers compared Webb's data with ALMA's past observations to identify five likely low-mass protostar candidates.

The team also identified 88 features that appear to be shocked hydrogen gas, where material being blasted out in jets from young stars impacts the surrounding gas cloud. Analysis of these features led to the discovery of a new star-forming cloud, distinct from the main Sagittarius C cloud, hosting at least two protostars powering their own jets.

"Outflows from forming stars in Sagittarius C have been hinted at in past observations, but this is the first time we've been able to confirm them in infrared light. It's very exciting to see, because there is still a lot we don't know about star formation, especially in the Central Molecular Zone, and it's so important to how the universe works," said Crowe.

Magnetic Fields and Star Formation

Webb's 2023 image of Sagittarius C showed dozens of distinctive filaments in a region of hot hydrogen plasma surrounding the main star-forming cloud. New analysis by Bally and his team has led them to hypothesize that the filaments are shaped by magnetic fields, which have also been observed in the past by the ground-based observatories ALMA and MeerKAT (formerly the Karoo Array Telescope).

"The motion of gas swirling in the extreme tidal forces of the Milky Way's supermassive black hole, Sagittarius A*, can stretch and amplify the surrounding magnetic fields. Those fields, in turn, are shaping the plasma in Sagittarius C," said Bally.

The researchers think that the magnetic forces in the galactic center may be strong enough to keep the plasma from spreading, instead confining it into the concentrated filaments seen in the Webb image. These strong magnetic fields may also resist the gravity that would typically cause dense clouds of gas and dust to collapse and forge stars, explaining Sagittarius C's lower-than-expected star formation rate.

"This is an exciting area for future research, as the influence of strong magnetic fields, in the center of our galaxy or other galaxies, on stellar ecology has not been fully considered," said Crowe.

The James Webb Space Telescope is the world's premier space science observatory. Webb is solving mysteries in our solar system, looking beyond to distant worlds around other stars and probing the mysterious structures and origins of our universe and our place in it. Webb is an international program led by NASA with its partners, ESA (European Space Agency) and CSA (Canadian Space Agency.)

Who's New in the Cold Facts Buyer's Guide?

Pelican Wire

Pelican Wire manufactures custom-engineered wire solutions with numerous product-specific applications for the cryogenics industry. The company continues to provide engineer-based product development to meet or exceed all technical requirements.

Cryoperl

Perlite and wool blanket installation for the large bulk storage tanks at air separation plants, LNG import/export sites and other large "cryogenic" chemical tanks. The company also offers removal of damaged perlite and refill/top-off.

MiTeGen

Innovative technologies and services for the cryogenics community, with offerings that span from essential tools for sample preparation, such as crystal mounts and cryo-EM pucks, to advanced equipment like cryocoolers and workstations.

***CSA CSM**

Fermilab's Lederman Fellows Drive Quantum Research to Discover Dark Matter

by Marcia Teckenbrock, Fermilab

A trio of Lederman fellows at Fermilab are developing ways to use quantum technology to probe the universe for dark matter and other physics phenomena. While doing so, they are sharing their enthusiasm for their work to inspire the next generation of scientists.

Fermi National Accelerator Laboratory is a leader in physics research, offering world-class facilities and expertise, along with a talented group of emerging researchers. Among them are Sara Sussman, Dylan Temples and Christina Wang, who are conducting groundbreaking quantum research as Lederman fellows. Their work aims to confirm the existence of dark matter, potentially uncovering insights into new physics beyond the Standard Model. Named after the late Nobel Prize-winning physicist and Fermilab Director Emeritus Leon Lederman, the Lederman Fellowship has helped to launch the careers of many distinguished scientists, including current Fermilab Chief Research Officer and Assistant Laboratory Director Bonnie Fleming. This prestigious program was designed for exceptional postdoctoral researchers who not only excel in scientific research but also share a passion for education and outreach — areas that were deeply valued by Lederman.

"The importance of effectively communicating Fermilab's science to audiences of all ages and academic backgrounds is essential to motivating and inspiring others to be even more inquisitive about science in general," said Natalie Johnson, head of the Office of Education and Public Engagement at Fermilab. "We hope that every educational engagement will propel individuals on a trajectory toward STEM careers and lifelong enthusiasm for science."

Quantum technology and the search for dark matter are fascinating topics that can inspire young people to think about careers in physics and science in general. At the same time, it is crucial to be able to explain to funding agencies and the public what is

Dylan Temples. Credit: Dan Svoboda, Fermilab

being done with their money and why it is important. But doing so can be challenging — even for physicists. "Lederman understood that education and outreach go together," said physicist Joe Lykken, head of Fermilab's Quantum Division. "If you want to be able to educate and inspire the next generation, you need to be able to explain what you do in an interesting way. That's an important thing for scientists to learn and value. Getting our junior scientists excited and giving them the skills they need to reach out to other people will be super valuable, and it will be valuable to them in their careers as well."

Fermilab's most recent Lederman fellows are each studying ways to use quantum technology to search for dark matter — the mysterious substance scientists believe makes up most of the universe — along with other applications of quantum science.

Dylan Temples joined Fermilab as a Lederman fellow in 2021 and has just renewed his fellowship for another two years. At Fermilab, he continues research he began while working on similar projects at Northwestern University while earning his doctorate in physics. Temples splits his time between projects for the Quantum Science Center, a Department of Energy National Quantum Initiative research center headquartered at Oak Ridge National Laboratory and the Matter-wave Atomic Gradiometer Interferometric Sensor, or MAGIS-100.

For the Quantum Science Center, Temples is part of the Cosmic Quantum group. This interdisciplinary group is testing superconducting quantum bits for use as quantum sensors. Scientists can manipulate qubits to place them in delicate quantum states that are sensitive to changes in the local environment, such as variations in temperature or electric fields. A change induced through a particle impact, for instance, can disrupt the quantum state, leading to decoherence. A high decoherence rate could signal particle interaction, possibly making qubits useful for dark matter detectors.

In addition, Temples is working on special devices called phonon-mediated kinetic inductance detectors. These detectors will search for dark matter in previously unexplored areas. Specifically, he is seeking ways to reduce radiofrequency noise, which degrades the performance of these highly sensitive devices. Dark matter produces very faint signals that are easily hidden by these factors.

Temples' second area of focus, MAGIS-100, features a different type of detector. This one aims to detect dark matter but in a very different mass range. "Because we have never observed dark matter in a particle detector, the majority of the evidence we have for its existence is from the dynamics of astrophysical objects — galaxies, galaxy clusters and so on," said Temples. "All that tells us is how much of it there is, not what the properties are or whether it's a new fundamental particle. If so, there are about 50 orders of magnitude in mass in which a potential particle could live."

While testing and optimizing quantum equipment to search for ephemeral particles from space, Temples also enthusiastically shares his work with students of all ages through the Fermilab Office of Education and

Public Engagement. Once his fellowship concludes, Temples hopes to obtain a faculty position at a university or national laboratory. As a former software engineer prior to graduate school, Temples enjoyed his work but found that he wanted more academic freedom. "I wasn't flexing all the creative parts of my brain that you need to do science, and it wasn't sating my curiosity," he said.

Sara Sussman, a Lederman fellow since 2023, designs and fabricates multi-qubit devices and contributes to the open-source Quantum Instrumentation Control Kit, which was developed at Fermilab. QICK is a system used by more than 350 researchers worldwide that helps scientists to control and read out the information from superconducting qubits. Sussman earned her doctorate in physics from Princeton University, where she focused on designing, fabricating and measuring superconducting qubits. During the second year of her doctoral research, she got the chance to work on QICK with Fermilab engineer Gustavo Cancelo. This earlier experience influenced her to come back to Fermilab as a Lederman fellow.

In addition to her work on QICK, Sussman enjoys working in the Cosmic Quantum group with Temples as part of what Sussman said is "an amazing group of scientists." Using superconducting qubits to search for dark matter, she explained, is an ideal application for qubits. "Currently, qubits are noisy and not error corrected, Sussman added. "They're very sensitive. They can set some of the most stringent limits on searches for dark matter, so it's great to use them."

Working on these two projects is interesting because she is addressing very different aspects of qubits. For the Cosmic Quantum group, she designs and fabricates qubits, while for QICK, she helps enable scientists to control and measure the quantum states of qubits to read out information from them. "Being a Lederman fellow is great because I get to spend time doing outreach," said Sussman, who helps create educational materials and teaches new and established researchers to use QICK. Last summer, she and colleague Sho Uemura taught at the U.S. Quantum Information Summer School in Knoxville, Tennessee, and she regularly gives tutorials covering the latest QICK features.

Sara Sussman. *Credit: Dan Svoboda, Fermilab*

Christina Wang. *Credit: Dan Svoboda, Fermilab*

In doing so, she hopes newcomers can use qubit control to advance their research. "It's kind of like when someone buys a really nice camera and learns how to do photography," said Sussman. "I help students learn how to do qubit control and how to see, read out and measure the qubits in ways that that are useful for their particular environment and lab setup."

Christina Wang, Fermilab's newest Lederman fellow, began her fellowship in September 2024. While earning her doctorate in physics at California Institute of Technology, Wang received a DOE Office of Science Graduate Student Research Award in 2022 to work at Fermilab, exploring dark matter at the Large Hadron Collider and use quantum-sensing technology for dark matter searches. Her advisor for that project, Cristián Peña, a former Lederman fellow, now oversees part of Wang's research in Fermilab's Quantum Division. Once Wang completed her doctoral degree, she decided to continue her career at Fermilab as a postdoctoral research associate. "The Lederman fellowship allows me to have flexibility to choose what I want to do within the core program," Wang said. "This flexibility will allow me to continue to work both on quantum sensing and on the CMS experiment at the Large Hadron Collider. I like that the Lederman Fellowship allows me to do both."

On the quantum side, Wang works primarily on using superconducting nanowire single-photon detectors to search for the existence of axions, hypothetical particles that may comprise dark matter. SNSPDs are incredibly fast light sensors that operate at cryogenic temperatures and are made of superconducting wire to detect single photons. In theory, these photons are produced when an axion encounters a strong magnetic field. According to Wang, they are still at the early stage of the experiment, conducting R&D for the detector. "I'm hoping in the next few years, we'll be able to build the experiment, integrate the SNSPD and optical reflector into a cryostat and have a meaningful physics result," she said.

Wang has engaged in several outreach activities, including planning and hosting events related to the annual Dark Matter Days celebration and a science trivia event for the local public. Most recently, she helped organize and present for an American Physical Society conference hosted at Fermilab. Wang said she is looking forward to helping launch a future public quantum network between two Fermilab sites.

Next Generation Leaders

While it will take many years to develop full-scale quantum computers, sensors, and other quantum technology, Fermilab researchers are working towards becoming leaders in these areas. "This technology is really going to mature 20, 30 years from now," said Lykken. "We're going to need that next generation. They're going to be doing the stuff that we're dreaming about today."

Lykken added, "It's important strategically for our nation and for U.S. industry to be leaders in quantum, so having these young people get people's attention is good." "When these fellows become leaders in the field, it will come as a reflex for them to explain their scientific work and why it's important to the future of the nation."

www.fnal.gov

▶ ***continues on page 38***

Hear from the Lederman Fellows

For projects like MAGIS-100 and phonon-mediated kinetic inductance detectors, how does cryogenic technology contribute to reducing noise and improving measurement precision?

"MAGIS-100 isn't truly a cryogenic experiment, even though we get our atoms to the 100s of nanokelvin level. This is accomplished with lasers rather than cryogenic systems. However, for KIPMDs (and qubits), cryogenic operation is necessary for both transitioning metals into their superconducting state, as well as mitigating thermal excitations. For phonon-mediated sensors, one aims to operate at as low a temperature as reasonably achievable, as this suppresses the phonon population (by descending below the Debye temperature) and the thermal excitation of quasiparticles in the superconductor (by descending well below the critical temperature of the superconductor, e.g., for Aluminum, Tc ~ 1 K and we operate at 10 mK). Both sources of noise are mitigated by going to colder and colder temperatures." - *Dylan Temples*

Are there emerging cryogenic materials or techniques that you believe could further enhance quantum sensing capabilities for fundamental physics experiments?

"One area of active research is investigating novel, low-Tc superconductors like AlMn or Hf for fabricating KIPMDs. In principle, a low Tc corresponds to a low Cooper-pair binding energy, which is desirable for sensing low energy signals. The challenge here is that by moving to superconductors with Tcs at the 100s of mK level, you need a cryostat capable of maintaining very low temperatures (10 mK) reliably. This is achieved by the helium dilution refrigerator technology of today, but to push the envelope of low-Tc superconductors for sensing, one benefits by going to even colder temperatures. How that is accomplished on a macroscopic scale is not a simple question." - *Dylan Temples*

With the increasing demand for quantum sensing in dark matter detection, how do you see the role of cryogenics evolving at Fermilab in the coming years?

"Cryogenics has always been a big part of Fermilab's scientific mission, from cooling the hardware needed to maintain accelerator operations, to keeping large tanks of liquid argon cold, and more recently, in the endeavor into operating quantum bits (qubits) for quantum computing and sensing. With the recent inauguration of the "Quantum Garage" at the Superconducting Quantum Materials and Systems Center and the cryogenic facilities established through the Quantum Science Center at Fermilab, the demand for cryogenic engineers and technicians is at an all-time high. In the search for low energy, rare events, such as in a dark matter direct detection experiment, the biggest challenges are noise suppression and background radiation mitigation. As we seek to look for lighter and lighter dark matter, we really need to pull all the energy we can out of these systems to suppress noise, and the best way to do that (broadly speaking) is by going colder." – *Dylan Temples*

With the increasing demand for quantum sensing in dark matter detection, how do you see the role of cryogenics evolving at Fermilab in the coming years?

"We are continuously upgrading and optimizing our dilution refrigerator setup to reduce thermal population in our qubits, which improves their coherence and signal to noise ratio. We do careful A-B comparison tests of each configuration to see which changes made the biggest difference and why. New cryogenic parts such as IR filters, attenuators and circulators come out every year that we try to test out in our fridges. As Fermilab's capability in quantum sensing grows I am sure we will see far more sophisticated cryostat setups on site in the coming years." – *Sara Sussman*

What are the primary cryogenic challenges in maintaining superconducting nanowire single-photon detectors (SNSPDs) for axion detection, and how is Fermilab addressing them?

"The temperature that is needed to operate single-photon detectors (SNSPDs) is about sub-Kelvin level, so they are usually operated in cryostats. Given the limited space and difficulty to access the coldest stage of the cryostat, it's very challenging to wire large number of channels, enable light injection to measure the calibrated efficiency while maintaining a low dark count rate. To address these issues, we collaborated with JPL to develop custom filters and cold enclosures designed to limit background thermal photons from reaching the cryostat." – *Christina Wang*

Oxford Instruments NanoScience's Low Temp System

by Oxford Instruments Communications Team

Oxford Instruments NanoScience has unveiled its latest advancement in low-temperature, superconducting magnet measurement technology: the TeslatronPT Plus. Designed for fundamental materials physics research, this system streamlines the measurement process, allowing users to focus on their experiments rather than complex setup procedures. By combining flexibility, scalability, and an open architecture, TeslatronPT Plus represents a significant leap forward in cryogenic measurement systems.

One of the system's most notable features is its open design, distinguishing it from traditional "black-box" solutions that lock users into proprietary software and hardware. TeslatronPT Plus provides an intuitive browser-based interface for remote, OS-independent control, offering unparalleled accessibility. This adaptability ensures that as experimental needs evolve, the system can scale accordingly, making it an investment not just for the present, but for the future of scientific discovery. Additionally, the system's modular approach reduces obsolescence concerns, allowing researchers to update components rather than replace entire setups.

Oxford Instruments has seamlessly integrated Lake Shore's (CSA CSM) flagship measurement instrumentation into an upgraded TeslatronPT cryomagnetic system, now enhanced with automated operation and environmental control. These advancements enable precise characterization of materials' fundamental properties, including low and high resistance measurements, Hall effect studies in both Hall bar and van der Pauw geometries and I-V characterization. The expanded system capabilities ensure that researchers working on next-generation electronic materials, such as topological insulators and superconductors, can access high quality data with minimal setup time.

By leveraging open source software, TeslatronPT Plus provides researchers with the flexibility to customize and extend their measurement capabilities. A Python programming environment using Jupyter Notebook comes pre-loaded with scripts to facilitate immediate experimentation, while real-time visualization dashboards powered by Grafana offer an intuitive way to monitor results. The system also supports third-party instrument integration via the QCoDeS driver framework, which benefits from an active development community, ensuring compatibility with a broad range of research tools. This level of interoperability makes it easier for multidisciplinary teams to collaborate and share data across different experimental setups.

Oxford Instruments NanoScience introduces open-architecture low temperature measurement system. Credit: Oxford Instruments

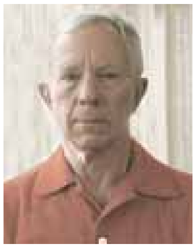
Cryogenic environment parameters—temperature and magnetic field—are seamlessly managed through oi.DECS, Oxford Instruments' cross-platform control software. This integration reduces setup time, ensures reproducibility and provides remote access via a network-based browser interface. Additionally, oi.DECS timestamps all environmental and measurement data, enabling fully correlated analysis for a comprehensive understanding of experimental results. Researchers can fine-tune their experimental conditions with precise control over temperature sweeps and magnetic field adjustments, enabling complex multivariable studies with ease.

The TeslatronPT Plus comes with ready-to-use software bundles, including Lake Shore's M81 Synchronous Source Measure System and M91 FastHall™ Measurement Controller. The M81 system is designed for high precision electrical transport measurements, handling both DC and AC lock-in detection with scientific grade sensitivity. Meanwhile, the M91 FastHall™ Controller revolutionizes Hall analysis by minimizing thermal drift and delivering results up to 100 times faster for low mobility materials. Users can further refine their setups with Oxford Instruments' range of breakout boxes and low-noise measurement probes, ensuring optimal signal integrity. The enhanced low-noise electronics allow for precise detection of small signals, crucial for studying emerging quantum materials.

Researchers got their first look at the TeslatronPT Plus in action at the APS Global Physics Summit 2025, March 17-21 in Anaheim, Cal. As research demands continue to evolve, the TeslatronPT Plus is positioned to redefine expectations in cryogenic measurement, blending precision, flexibility and ease of use in one powerful system. By prioritizing adaptability and ease of integration, this system aims to accelerate discovery in fields ranging from condensed matter physics to next-generation quantum technologies. **www.oxinst.com**

A Salute to an Old Friend, Glen McIntosh

by Charlie Danaher, Danaher Cryogenics (CSM)



Glen McIntosh
1925-2025

As they say, oftentimes in life we don't know what we've got until it's gone. And only later, upon reflection, do we come to realize and appreciate what we had. Such is the case with my old friend Glen McIntosh.

Glen and longtime friend and coworker Gerry Mordhorst, in front of Gerry's house in Boulder, Colorado. Loaded in the truck is the 750 gal helium dewar for Earthwinds, which attempted an around-the-world balloon flight. Picture was taken in ~1990, just after having driven home from NASA GSFC in Greenbelt, MD. Gerry Mordhorst is holding a copy of the October 1990 issue of Popular Science Magazine, whose cover featured the Earthwinds balloon. Credit: McIntosh Family Collection

I first met Glen in about 1995, when applying for a mechanical engineering position at Cryogenic Technical Services (CTS), eventually being hired on in 1998. Thence began a series of exciting cryogenics projects, including: a cryostat for General Atomics, that was destined for the Ignition Facility at Lawrence Livermore National Lab, for fusion research, meant to hold a sample of deuterium or tritium at 7 K; a LOX subcooler for Boeing, supporting the fueling of the Space Shuttle; and a 19" warm bore cryostat for detecting Anti Matter for Harvard University, destined for CERN.

Working alongside Glen was like drinking from a fire hose. He was a hard fellow to keep up with.

When it came to cryogenic projects, anyone who knew Glen would agree with me that there was no job too unusual or intimidating for him to take on. One such project was a liquid helium storage dewar for an around-the-world balloon mission. Earthwinds hired CTS to design the 750-gallon dewar that would supply helium gas to the balloon for this audacious mission. After the dewar was fabricated at CDM in Denver, Glen and his son Ross drove the dewar out to NASA Goddard Space Flight Center in Greenbelt, MD for testing that would simulate flight at 35,000 feet. The balloon made the cover of the October 1990 issue of Popular Science Magazine. Unfortunately, the multiple attempts to circle the earth were not successful due to weather conditions.

But in addition to cryogenics, for me, the more rewarding part of knowing Glen (not to diminish one bit what was to be learned from him about cryogenics), was the stories he shared about times gone by. Being 37 years my senior, and having lost my dad at age nine, Glen became somewhat of a father figure to me. And I very much relished hearing him recount the "old days." Heck, I didn't even mind hearing them repeated. Perhaps doing so would help them sink in. And, in some cosmic sense, prepare me for this honored exercise.

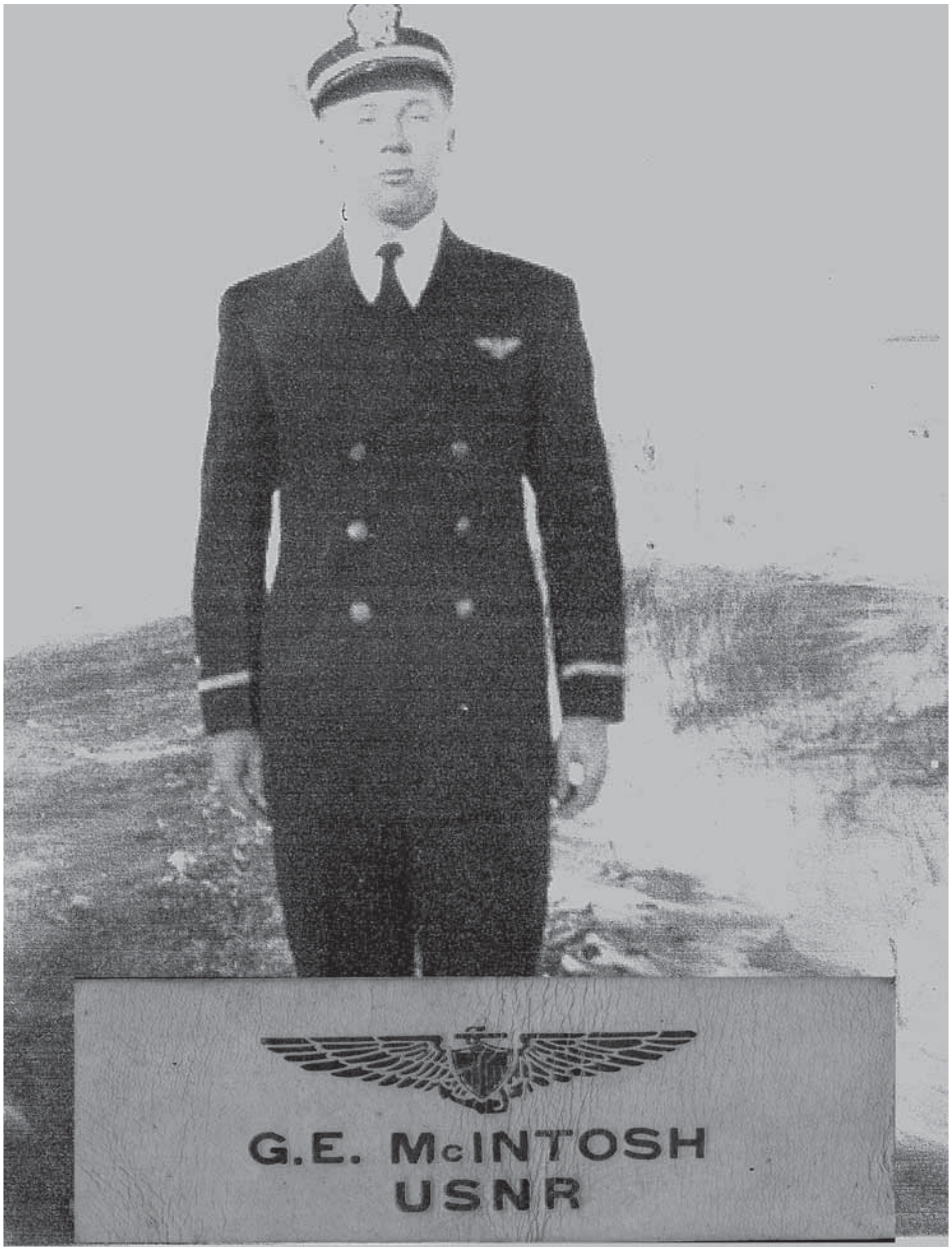
It was a somewhat dangerous habit to stop by his office at the end of the workday and say goodnight. For he was known to lure you into the telling of one of his marvelous recountings. And I'm thoroughly blessed to have benefitted from many.

Please be patient as I reminisce on a few such vivid tales.

If I go in chronological order, the first episode would have to be when, in about 1929, Glen was about three years old, he was visiting his Granddad Thol Wolfe at the Wolfe farm just north of Conway Spring, KS. As the story goes, Granddad and Glen were riding in Thol's blue Whippet when they heard a rolling thunder. (Whippets were only manufactured from 1927 until 1931.) They pulled over and watched as a 1,000 (that's correct, one thousand) airplanes flew overhead in formation.

It was the Army Air Corps, putting on their show-of-force flight across the country.

Perhaps it was those airplanes passing overhead that gave Glen the flying bug. For following high school he was selected for the Navy Aviation program. During his



Glen in his Navy uniform, late 1945. Credit: McIntosh Family Collection

Navy time, Glen was stationed in both Iowa City and Ottumwa, Iowa, and Corpus Christi, Texas. Glen tells how he and his buddies would swoop down and touch their tires on the Mississippi River. I bet you couldn't get away with doing that today.

Not long ago, I was telling Glen about a windmill that I recently put up on our property and that spurred him to tell yet another flying story. This one was set near King Ranch in Southern Texas, while he was stationed in Corpus Christi. Glen tells of him and his buddy flying just 50 or 60 feet off the ground, weaving through the trees chasing each other. Upon rounding a particular grove, he found himself flying directly at a man atop a drilling rig. He and the worker were at the same elevation, looking straight at each other, with Glen quickly closing in. Glen (and his buddy right behind) made a quick maneuver to avoid the rig, and proceeded on their way. I think Glen wondered long after the incident what that oil worker made of that experience.

From hearing the stories, it was obvious that Glen had a love for flying. Accordingly, I think he had a sense of disappointment that his instruction program had to come to an end. He tells the story about one of his last

▶ *continues on page 42*

Remembering *Glen McIntosh*

by Steven Van Sciver

I first met Glen McIntosh in 1976 at the University of Wisconsin-Madison where I was a new postdoc in Roger Boom's superconducting magnetic energy storage project. At that time Glen was a visiting professor providing cryogenics advice to Roger and his team. As a newcomer to applied superconductivity with a background in low temperature physics, I was looking for an opportunity to apply my skills to the UW project.

I soon realized that Glen, with his extensive experience, was a resource that I should tap. At that time Roger and Glen had decided that it would be best to cool the energy storage magnets with He II mainly to save on superconducting material. However, there was limited experience with He II cooling of superconducting magnets. Further, UW-Madison didn't have a He II R&D program to support the design effort.

One day Glen and Roger suggested that I might want to establish such a program during my postdoc. I thought the task would offer me an opportunity to learn about helium cryogenics for a couple of years. I did not fully appreciate the significance of that advice and feel very fortunate to have accepted the challenge.

For over 40 years, Glen and I had many fruitful discussions at UW, during conferences and my occasional visits to Colorado. I will always be thankful that I knew Glen McIntosh as a mentor, colleague and friend.

flights. Before he gave up flying, he wanted to fly 200 knots. His Douglas SBD dive bomber wouldn't cruise at that speed, but it could go that fast if you pointed it downward. So, he proceeded to do just that, and upon reaching the desired speed, he slowly pulled out of the dive and flew back to the airport. And as he was walking away from his airplane, his mechanic mentioned to him that he was dragging his antenna. As I recall, he played a little dumb, and shrugged at that report, as though he had no idea why that might be.

Even though Glen's completion of the Navy Pilot program was in November 1945, he would tell you this story like it was yesterday. He finished in Chicago and, before he boarded the train to head back to Martin, SD, he went in to Chicago and bought his dad a box of cigars.

Glen made no secret of his being adopted. He would even recall how, when he was just a small boy, at the Wolfe farm in Kansas, his granddad would tell Glen that "your parents wanted you."

My last fond memory took place on February 12, 2025, just six days before his passing. Glen's son Ross informed me that Glen seemed to be slowing down and invited me over to visit. I took him up on the offer right quick like, and, as I entered his home, he ordered Ross to get the red wine out of the fridge, so that he and I could together have a drink. And sure enough, we did. I offered up a toast to "99 years."

And, as per usual, he then proceeded to tell stories.

Sincerely,

Charlie Danaher
Danaher Cryogenics, Ltd.

Glen and colleague at NASA, Cape Canaveral. Credit: McIntosh Family Collection

Glen's wife, Alice McIntosh, Glen, & Glen's mother, Nellie Aura Wolfe (left to right), at Glen's PhD graduation from Purdue University. Credit: McIntosh Family Collection

Product Showcase

This Product Showcase is open to all companies and related manufacturers offering new or improved products for cryogenic applications. We invite companies to send us short releases (150 words or fewer) with high-resolution JPEGs of their products to editor@cryogenicsociety.org.

TURBOVAC MAG iS 2807 and 3207 iS Maglev Turbomolecular Pumps

Leybold

Leybold has launched the TURBOVAC MAG 2807 iS and 3207 iS, compact, magnetically levitated turbomolecular pumps with pumping speeds of up to 3,200 l/s. Designed for hydrocarbon-free, high vacuum environments, these low-vibration pumps are ideal for research and industrial applications, including coating, electron beam processes, space simulation chambers and beamline applications. With a lightweight design of under 60 kg, the TURBOVAC MAG iS can be installed in nearly any position, making it a flexible solution for space-limited environments. These pumps offer extended maintenance intervals of up to 80,000 hours or 10,000 cycles, ensuring long-term reliability. TURBOVAC MAG iS series delivers clean, vibration-free operation for precision industries and research. **www.leybold.com**

LD400sl Cryogenic Measurement System

Bluefors

Bluefors introduces the LD400sl Cryogenic Measurement System, featuring two side-loading ports for easy installation of measurement infrastructure modules. Maintaining the performance of standard LD400 systems, the LD400sl simplifies complex experiments by allowing wiring to be assembled on a workbench while the system is running. It is fully compatible with XLD systems, enabling seamless scalability from LD to XLD configurations. With the ability to support the High Density Flex Wiring platform—offering up to 240 channels per port—the LD400sl enhances flexibility and efficiency in cryogenic research. The system is also available for Bluefors' Ultra-Compact LD platform, making it a versatile solution for a wide range of experimental setups. **www.bluefors.com**

Cryostation 200 PT

Montana Instruments

Montana Instruments has launched the Cryostation 200 PT, a high-power optical cryostat delivering over 250mW of cooling at 4.2 K. Engineered for quantum technologies, this system integrates a pulse tube cryocooler with Montana Instruments' low-vibration technology to provide a highly stable, cryogen-free environment. Its versatile sample chamber offers extensive optical access and vacuum feedthroughs for RF, DC, fiber optic and gas connections. With a push-button cooldown function, users can effortlessly reach target temperatures for demanding cryogenic applications. The Cryostation 200 PT is designed to meet the needs of researchers working in cutting-edge quantum experiments. **www.montanainstruments.com**

Integrated MLI (IMLI)

Quest Thermal Group LLC

Quest Thermal Group has successfully developed new technology for NASA since 2006, supplying beyond cutting-edge insulation systems. IMLI is a high performance insulation using proprietary Discrete Spacer Technology® with low thermal conductivity polymer spacers to reduce heat leak, control layer spacing and density, and provide unique structural capabilities. IMLI offers 2.5X lower heat leak per layer as netting MLI, robust structure, predictable performance, fewer layers/lower mass, can span large spaces and support various loads such as Broad Area Cooled shields, MMOD ballistic layers and lightweight vacuum shells. IMLI is on Roman and NEOS space telescopes, and new lunar landers and rovers.Quest Thermal works with you to develop optimal solutions for insulating spacecraft, cryogenic fluid management, vapor cooling, load bearing insulation, cryofeed line insulation, lunar landers, rovers and science payloads, LH_2 storage, and cold supply chain. Quest provides expertise, novel technology and the highest performance thermal solutions for our clients. **https://questthermal.com**

People & Companies in Cryogenics

On International Day of Women and Girls in Science, **CPC-Cryolab**, part of OPWCES, proudly celebrated **Widy Linn**, a manufacturing engineer whose dedication to continuous improvement and innovation has shaped their processes for nearly two decades. Her problem-solving skills and unwavering commitment make her an invaluable team player, always ready to tackle challenges and support her colleagues. Widy's expertise and leadership drive excellence in their operations, reinforcing the critical role of women in STEM.

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Danfoss Climate Solutions has appointed **Dennis Appel** as Divisional President of its new Controls and Thermal Management division, which integrates heat exchangers with refrigeration, cooling and air conditioning technologies to drive innovation and efficiency. Since 2020, Appel has been instrumental in expanding Danfoss' heat exchangers business, bringing 20 years of leadership experience in international heat transfer and thermal management. Appel holds an MBA from Purdue University and a Bachelor's in Mechanical Engineering from Vanderbilt University, with previous executive roles at Modine Manufacturing and Luvata.

Dennis Appel. *Credit: Danfoss Climate Solutions*

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A team from **Harvard's School of Engineering and Applied Sciences** has developed a groundbreaking photon-routing device that could help scale modular quantum computing by bridging superconducting microwave qubits and optical networks. The new microwave-optical quantum transducer, built with lithium niobate and shaped like a tiny paper clip, allows quantum systems to communicate via existing fiber-optic infrastructure. This innovation eliminates bulky microwave control lines and enables quantum control using light, marking the first successful light-based control of a superconducting qubit.

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The National Quantum Computing Centre (NQCC) has released its first Insights Paper, "The convergence of healthcare and pharmaceuticals with quantum computing: A new frontier in medicine," highlighting the transformative potential of quantum computing in revolutionizing healthcare and pharmaceuticals. The paper explores how quantum technologies could help overcome computational limits faced by conventional systems, particularly in areas like drug discovery, diagnostics, personalized medicine and healthcare system optimization. Drawing from stakeholder engagement and technical analysis, it outlines both near-term opportunities and longer-term challenges, such as the need for scalable quantum hardware, hybrid integration and workforce development. It also emphasizes the importance of collaboration, ethical considerations and coordinated global initiatives to accelerate real-world impact. Aligned with the UK's National Quantum Strategy and NHS goals, the paper positions quantum computing as a key driver in future medical innovation.

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Researchers at the **University of Texas at Dallas**, led by physicist **Dr. Fan Zhang**, are exploring the unique properties of rhombohedral (ABC-stacked) graphene—a chiral, multi-layered form of graphene that exhibits tunable semiconducting, magnetic and superconducting behaviors. Unlike more stable hexagonal stacking, rhombohedral graphene enables remarkable quantum phenomena such as the quantum anomalous Hall effect, all within a single device. Zhang's team has shown that these properties can be manipulated using electric gates, avoiding the need to alter chemical composition. Despite challenges in isolating pure rhombohedral samples, collaborations with cutting-edge experimentalists have advanced their progress. Zhang, who recently received a Humboldt Research Award, will present this work with his students at the American Physical Society's Global Physics Summit.

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Meetings & Events

31st Space Cryogenics Workshop
May 13-15, 2025
Incline Village, Nevada
https://spacecryogenicsworkshop.org

CSA Short Courses at CEC/ICMC'25
May 18, 2025
Reno, Nevada
www.cryogenicsociety.org/2025-short-courses

CEC/ICMC 2025
May 18-22, 2025
Reno, Nevada
www.cec-icmc.org/2025

CRYOCO Cryogenic Engineering and Safety Course
July 14-18, 2025
Golden, Colorado
www.cryocourses.com

30th International Conference on Low Temperature Physics
August 7-13, 2025
Bilbao, Spain
www.lt30.es

European Conference on Applied Superconductivity (EUCAS)
September 21, 2025
Porto, Portugal
https://eucas2025.esas.org

24th International Cryocooler Conference
June 2026
Syracuse, NY
https://cryocooler.org

A discovery at the **National University of Singapore** has revealed a groundbreaking copper-free superconducting oxide, (Sm-Eu-Ca)NiO_2, capable of zero electrical resistance at approximately 40 K (−233 °C) under ambient pressure. This marks the first such oxide discovery since the Nobel-winning identification of copper oxide superconductors nearly 40 years ago. The new material not only challenges the long-held belief that high-temperature superconductivity is exclusive to copper oxides but also offers practical advantages such as stability and ease of synthesis. The research, published in *Nature*, opens new possibilities for energy-efficient technologies and next-generation electronics.

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