UNVEILING THE MARVELS OF PARTICLE PHYSICS: OUR JOURNEY TO CERN




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SUMMARY: This article chronicles the extraordinary journey of four Canadian high school physics teachers to CERN, the European Organization for Nuclear Research, in Geneva, Switzerland. Sponsored by the Canadian Association of Physicists, The Perimeter Institute for Theoretical Physics, and the Institute for Particle Physics, our expedition was a testament to the unity of global scientific pursuit. Through this immersive experience, we delved into the heart of particle physics, witnessed groundbreaking research, exchanged pedagogical practices, and forged international connections. This article serves to illuminate the transformative power of CERN and its impact on science education.

A SHINING BEACON OF UNITY

CERN, the European Organization for Nuclear Research, is a symbol of human achievement that transcends borders, politics, and conflicts. Nestled on the Franco-Swiss border near Geneva, Switzerland, CERN is a sprawling scientific campus that has become synonymous with groundbreaking research in particle physics. Established in 1954, it has since evolved into one of the world's most iconic and influential scientific institutions.

At its core, CERN is driven by a singular mission: to unravel the mysteries of the universe by studying the fundamental particles that make up everything around us. This mission is realized through colossal scientific experiments conducted with a spirit of cooperation that knows no boundaries. CERN's scientists, researchers, and engineers come from diverse cultural backgrounds and corners of the globe, even scientists from nations currently engaged in armed conflict can unite at this international hub of scientific inquiry.

CERN operates on a truly global scale, with 23 member states and countless partner institutions from around the world. Its collaborative nature is encapsulated in the organization's motto: "Science for Peace." This ethos reflects the belief that scientific knowledge is a common heritage of humanity, and that by pooling resources and knowledge, we can achieve profound discoveries that benefit all.

One of CERN's most iconic achievements is the Large Hadron Collider (LHC), a colossal scientific instrument that spans a circumference of 17 miles (27 kilometers) beneath the Earth's surface (Figure 1). The physicists who operate the LHC are conducting the world's largest ever scientific experiment. It propels subatomic particles to nearly the speed of light before smashing them into one another, allowing scientists to observe the resulting subatomic debris and gain insights into the fundamental building blocks of matter.

Figure 1. April Butler is posing beside a poster of the tunnel housing the collider. The poster shows one of the Large Hadron Collider's 1,232 dipole magnets, which are designed to bend the particles' paths as they travel around the beamline.

CERN's impact extends far beyond the boundaries of particle physics. It is a beacon of unity, bringing together scientists, educators, and students from all walks of life to engage in collaborative research and exchange of knowledge. It inspires awe and curiosity not only among those within its gates but also among people worldwide, igniting a passion for science and exploration.

CERN's commitment to education and outreach is exemplified through programs like their two International High School Teacher programmes, which bring together educators from across the globe, including the four of us from Canada. CERN's Science Gateway, an outreach project currently under development, further underscores its dedication to making science accessible to the public and fostering the next generation of scientists.

During our time at CERN, we had the privilege of witnessing the incredible scientific instruments and experiments used in particle physics research. One of the most striking moments came when we learned about the humble beginnings of particle detectors. In the early days of research, scientists used simple objects like pots – yes, ordinary cooking pots – as makeshift particle detectors when they couldn't find more suitable equipment. This revelation was a poignant reminder of the resourcefulness of scientists and the determination to explore the unknown, even with limited means. The sight of a simple pot transformed into a scientific tool spoke volumes about human curiosity and the relentless pursuit of deeper knowledge.

GLOBAL GATHERING OF EDUCATORS AT CERN

The High School Teacher Programme at CERN is a profound immersion in the power of international collaboration. For the last 25 years CERN has been bringing together educators from around the world. In the summer of 2023, 78 physics teachers from 32 different countries were united in two groups stewarded by Educational Outreach leader, Jeff Wiener. Our shared passion for science education had united us in a unique global gathering of educators, each bringing a distinctive background, perspective, and teaching style to the table.

The diversity within our group emphasized the universal language of science. Whether from North America, South America, Asia, Europe, or Africa, we had convened at CERN driven by a common objective: to deepen our grasp of particle physics and ignite inspiration in our students. Conversations in the cafeteria ranged from particle detectors' intricacies to innovative methods for conveying complex scientific concepts to young learners. We were engaged in a truly global exchange of ideas and knowledge.

This diverse convergence underscored the critical role of international collaboration in scientific research. Science recognizes no borders, a principle epitomized by CERN. The institution's existence hinges on contributions from member states and partner institutions worldwide. For instance, the Large Hadron Collider is the largest scientific experiment ever conducted by humankind and its creation was a monumental cooperative endeavor, with scientists and engineers from diverse countries working seamlessly to push the boundaries of human knowledge.

Our interactions with educators from various nations enriched our insights into diverse approaches to science education. We swapped teaching techniques, discussed educational system challenges in our respective countries, and explored innovative ways to engage students in scientific exploration. This dynamic exchange broadened our horizons as educators and fostered enduring friendships.

Our time at CERN extended beyond classrooms and lecture halls, allowing us to forge strong bonds. Shared experiences, such as bowling and pizza nights, movie screenings, international gift exchanges,

and even impromptu ceilidh dancing lessons, created connections that will endure long after our Geneva visit. These cultural exchanges were as profound as our scientific discoveries, emphasizing the significance of nurturing connections between individuals from various corners of the globe.

LEARNING FROM THE FOREFRONT AT CERN

Our CERN experience was a rare opportunity to glean insights from some of the world's brightest minds in the field of particle physics. During our visit, we had the privilege of engaging in discussions and lectures with these luminaries. Interactions with leading physicists and researchers at CERN granted us firsthand exposure to groundbreaking work and profound understandings of their achievements. Each encounter was an immeasurable educational experience, expanding our comprehension of the universe and the enigmas of particle physics.

Numerous tours of active experiments were expertly intertwined with our lectures and discussions. There is something about taking an elevator down 100 meters underground to visit the LHC's Compact Muon Solenoid (CMS) that brings a sense of awe and wonder (Figure 2). The CMS is one of four giant particle detectors that acts like a camera, taking snapshots of the aftermath of high-speed proton collisions. The magnetism of this device is so strong that a string of paper clips defies gravity and strikingly turns sideways toward the detector.

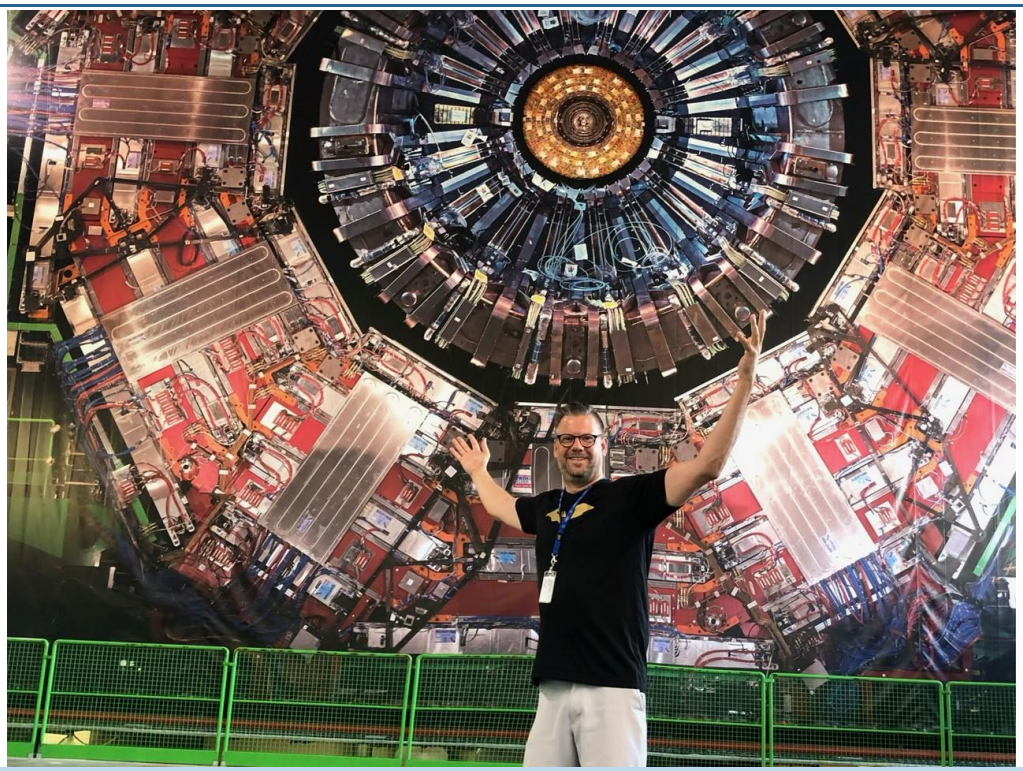

Figure 2. Edward Csuka standing in front of a life-size poster showing CERN's 15 meter tall Compact Muon Solenoid (CMS) particle detector.

Another remarkable experience was delving into antimatter research alongside Dr. Sameed, who provided insights into the Alpha G experiment. Antimatter, the enigmatic counterpart to the matter composing the visible universe, remains one of the most puzzling aspects of particle physics. Dr. Sameed's passion for his work was palpable, and his explanations offered glimpses into the intricacies of antimatter research.

Our journey also led us into the realm of Higgs boson exploration, a particle discovery that sent seismic ripples through the physics community. We had the privilege of engaging with physicists like Luis Roberto Flores Castillo, who stand at the vanguard of this groundbreaking research. Their explanations illuminated the significance of the Higgs boson and its role in shaping our comprehension of the fundamental forces governing the cosmos.

Beyond particle physics, we ventured into medical research at CERN, where scientists like Manjit Dosanjh are pioneering innovative techniques and technologies. These applications of particle physics in the medical field broadened our horizons and underscored the far-reaching impacts of fundamental research. Our encounters with these luminaries left enduring imprints on our grasp of physics and the potential that lies ahead.

IGNITING TOMORROW'S SCIENTISTS

The High School Teacher Programme allowed us to amass a treasury of ideas and strategies to kindle the flames of curiosity and passion for science among our students. CERN's dedication to education and outreach inspired us, equipping us with the inspiration needed to shape the future of budding scientists.

One of the most profound lessons from our time at CERN was the realization and confirmation that science education transcends textbooks and classrooms. The real world of science is dynamic, engaging, and filled with opportunities for hands-on exploration. We discovered that students thrive when they can connect their learning to the real world, and CERN furnished us with tangible examples to bring into our classrooms.

For instance, we were introduced to educational programs that employ LEGO, the beloved building blocks, to impart complex particle physics concepts in an accessible way. This innovative approach illustrates how abstract ideas can be made tangible and relatable to young minds, motivating us to incorporate similar hands-on methods to make scientific principles come alive for our students.

The Cloud Chamber demonstration was another eye-opening experience. It allowed us to visualize subatomic particle paths as they interacted with matter, offering the opportunity to "see" the invisible world of particle physics. This hands-on experiment proved a powerful tool for demystifying complex concepts and igniting curiosity among students, inspiring us to provide similar experiences in our own classrooms.

Furthermore, our comprehensive tour of the Large Hadron Collider (LHC) and its operational insights were invaluable resources to bring back to our students. These insights allowed us to explain the intricate science behind the LHC in an accessible and relatable manner. We realized that sharing the

immense scale of the LHC and the global collaboration it embodies could inspire students to appreciate the beauty of teamwork and the grandeur of scientific exploration.

Our time at CERN underscored the importance of nurturing curiosity and critical thinking in our students. The concept maps shared by Milena Vujanovic, a CERN expert in education outreach, provided practical tools to encourage students to connect ideas and visualize the interplay of scientific concepts. These strategies are essential for cultivating a deep and enduring passion for science.

Strategies to ignite curiosity and passion for science:

1. Inquiry-Based Learning: We embraced the idea that curiosity is the driving force behind scientific discovery. Encouraging students to ask questions, investigate, and find answers fosters a love for learning. We adopted inquiry-based learning methods to empower students to take ownership of their scientific explorations.
2. Storytelling: We realized the power of storytelling in making science relatable and engaging. Sharing the stories of scientific discoveries, struggles, and the human element behind research can captivate students' imaginations and inspire them to pursue scientific careers.
3. Interdisciplinary Connections: CERN's multidisciplinary approach highlighted how science transcends traditional boundaries. We encouraged students to explore connections between physics, mathematics, engineering, and other disciplines, emphasizing the holistic nature of scientific inquiry.

BROADER PERSPECTIVE GAINED FROM CERN'S RESEARCH

CERN's research extends far beyond the confines of particle physics. It delves into the very essence of our universe, seeking answers to questions that have puzzled humanity for centuries. By studying the fundamental building blocks of matter and the forces that govern them, CERN's scientists are unraveling the secrets of the cosmos.

Our visit allowed us to grasp the interconnectedness of all things. We saw how the tiniest particles, invisible to the naked eye, play a crucial role in the grand tapestry of the universe. CERN's research reminds us that even the smallest components of our world are intertwined with the most significant cosmic phenomena, creating a holistic understanding of reality.

CERN's pursuit of knowledge is, at its core, a quest to explore the origins of the universe. It seeks to answer questions about the Big Bang, the formation of galaxies, and the nature of dark matter and dark energy. This endeavor reminds us of humanity's insatiable desire to understand its place in the cosmos and to trace its origins back to the very beginning.

The research at CERN ignites our imagination and reminds us that we are the descendants of stardust, born from the fusion of atoms in the hearts of ancient stars. It invites us to contemplate the surprisingly deep connections between the smallest particles and the vast expanses of the universe, fostering a sense of wonder and humility.

In conclusion, our journey to CERN provided us with a new perspective on everyday objects and the broader implications of scientific research. It revealed the resourcefulness of scientists, the

interconnectedness of all things, and the potential of humanity to explore its origins. It reinforced our belief that science is not confined to the laboratory but is a journey of discovery that unites us all in the quest to unlock the mysteries of the cosmos. As Ralph Waldo Emerson once wrote: "The mind, once stretched by a new idea, never returns to its original dimensions." Our minds have been stretched, and we are forever changed by the awe-inspiring journey through the world of particle physics at CERN.

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