## An Interview with George Miley

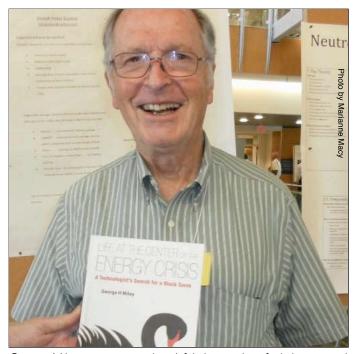
## Christy L. Frazier

E arlier this year, Dr. George Miley (Emeritus Professor, University of Illinois-Urbana) released a retrospective book, Life at the Center of the Energy Crisis: A Technologist's Search for a Black Swan (World Scientific), about his long career primarily in energy and fusion research. After over 50 years at the University, Miley reflects back on research conducted there and elsewhere, including important work in fuel cells and cold fusion.

In Issue 113, we will publish a full review of the book, by Miley's former student Dr. Mark Prelas (University of Missouri). Here we present a conversation we had with Miley about not only the release of his book but his stellar career in research.

You credit Tom Valone, of the Integrity Research Institute, with encouraging you to put your career and research down in book form. Do you recall when he first suggested this to you (i.e., how long did it take you to write the book), and can you speak to the evolution of the book project?

Tom approached me at an AIAA meeting about four years ago with a suggestion to write a book. The idea was soaking in, when, about four years ago some students attending my retirement celebration suggested I write something to hand out about why I had supervised Ph.Ds in so many different areas. In my view, the areas were related since they were a



George Miley was surprised and felt honored to find that several attendees at the ICCF18 meeting at the University of Missouri brought copies of the book for him to sign. The photo shows one instance when he was walking through the posters at the meeting.

search for improved or new energy systems. About the same time I went to the meeting where, as described in the book, John Nuckolls said the NIF would achieve breakeven and a burn within the year unless they hit a "Black Swan" ( which they did!). This introduced me to Nassim Taleb's book, *The Black Swan*. All of this converged in my mind so I produced a CD with an early version of the book for my retirement celebration—attended by many former students and colleagues. After I sent a copy to Tom Valone, he suggested I add "Life at the Center of the Energy Crisis" and eliminate Black Swan. Later I worked with the publisher to keep both. The conversion of the early version to the published book took about two years working on it off and on. My assistant Robyn Bacher was a tremendous help with that.

Your book title is thought-provoking. Can you make some comments that generalize your experience and career at the "center of the energy crisis" (i.e., what projects had the most potential impact on the energy crisis, etc.)?

My best answer is to look at the "Sighting Score Card" on p 195. But, I would like to emphasize that the search is the important and enjoyable part of this. [In Miley's book, the areas listed as closest to reaching the black swan status are diode electron beam pumped lasers, advanced lasers and teaching/education; LENR is one of the "closer to black swan" areas.]

Your search for a "black swan" in energy has led you down many paths. What projects have come the closest to being a black swan and what current projects seem to have the most promise?

See my answer above. However, I would add that now as Emeritus Professor I have cut back to two projects—gas loaded nanoparticles for LENR power units and a Helicon injected IEC thruster for satellite positioning.

The black swan is defined as something that lies outside the norm, occur when least expected and can have a profound effect. You note that the black swan could have good or bad consequences, or a mixture of the two. Specific to your LENR research, what would be the impact (good and/or bad) of this black swan if realized?

Good question. LENR power units are possibly a revolutionary new nuclear power source which would have a tremendous positive impact on our future energy needs. In my opinion, this new field of condensed matter nuclear physics is very rich in possibilities. Some workers, for example, have found ways to produce tritium, neutrons, X-rays etc. The down side is that some of this new technology might lead to military uses. That is not clear at present, and I hope not.

On page 109, you infer that you coined the term low-ener-

gy nuclear reaction (LENR) early on. Can you talk about the progression you made from the term cold fusion to LENR? It seems you understand why many still use the term "cold fusion" even though it doesn't adequately describe the process.

That is a continuing controversy in the community. Condensed matter nuclear physics is, in my opinion, the best general term. I believe that Steve Jones first coined the term "cold fusion" and many who were working on D-D reactions adopted this terminology. When I first detected transmutations which clearly were not cold fusion but nuclear type reactions involving the lattice as well as the deuterium (or hydrogen), I decided to change the term. John Bockris held several meeting in College Station, Texas where he also used the term LENR. The problem is that many do not know what LENR means. My meaning was that the reactants have such small energy that the compound nucleus formed has little excitation energy so decays with differ pathways vs. normal high energy reactions.

You are a distinguished fusion scientist and professor, and one of very few in the "mainstream" fusion community who investigated cold fusion. Do you think the interdisciplinary academic model at the University of Illinois influenced you in such a way that you were more open-minded to controversial research? Or, perhaps you were born with this trait?

Maybe I was born that way! Anyway, even before coming to Illinois I thought scientists were to keep an open mind and not discard areas due to "public opinion." I came to Illinois so I could do research on topics I thought were interesting and important. Unfortunately, no matter that one has freedom for research in the University, money (grants and contracts) still comes into play. I have been fortunate in that I have been very successful with proposals over the years, allowing me to support students and equipment for research that I felt was interesting and important.

You write (p. 1) that you "have tried to achieve a career characterized not only by innovation, but also by a willingness to consider new ideas and to employ patience and optimism in all endeavors." Can you give a few examples of how innovation, patience and optimism helped you have success (success defined as anything: "mute swans," ability to get funding, etc.)?

Most of my research has long term goals—*e.g.* hot fusion, LENR, fuel cells, etc. To stick to any of these takes innovation, patience and optimism.

Would you say that innovation, patience and optimism were especially useful when it came to LENR research? If so, why?

Right, several things. There is little government funding out there for this area (it still has a bad name in many government circles) and while some private funding has gone in, the persons doing that must take a long range point of view vs. a few year payback.

In the book, you discuss an amazing breadth of collaboration between you and researchers in various fields, many of them very well-known. Yet, it comes across that you are most proud of the impact you have made on students, some

of whom have gone on to do amazing things. To that role of mentor and professor: on p. 111 you write that in March 1989 when you returned from a trip to Japan, you were met with students who sought the heavy water you possessed in your lab. You could have passed on your materials, but instead you worked with the students on electrolysis experiments and then pursued more experiments, continuing to this day. Aside from general scientific curiosity, what made you take on what was controversial from day one?

See above. I had a scientific curiosity about cold fusion. It was obviously very important. I did not feel I could compete with Pons-Fleischmann and other electrochemists, so rather than trying to duplicate their work, I tried to think of new approaches. One of my first used a dense plasma focus (DPF) to drive ions into a metal target. I reported that at an early ICCF meeting along with some reaction theory. But diagnostics (particularly calorimetry with the DPF) was complicated. Thus I switched to multiple layers of thin films (electrolytically loaded) based on the swimming electron layer (SEL) theory Prof. Hora and I proposed. This required selection of the thin film materials with a large Fermi energy level difference. About that time I became involved with Jim Patterson and his thin films on plastic beads. Much of the rest is described in the book.

You write (p. 193) that "Like many educators, I feel my duty is to lead young students into the pond where Black Swans are thought to live, and instill in them the joy of the search." Do you think your students' search for their own black swans has been as invigorating as your own?

I cannot speak for them—but I would assume and certainly hope so. Indeed several former students at my retirement celebration told me they are.

Did you ever feel pressure from your university (or outside funding sources) to discontinue your experiments on cold fusion?

As a tenured full professor I felt less pressure. But several colleagues did not like for me to work on this in fear of giving the Department a bad name. Some in administration were also sensitive to this. Most recently I was to be, along with the University of Illinois, co-supporter of ICCF18 at the University of Missouri (support did not involve money, just the name). However, when the website went up listing that, the office of Vice President for Research asked that I have this "support" line removed immediately. I was not able to find out who complained, but they sure did.

Regarding funding sources, most just return the proposal on this topic saying it is out of their area of interest. Some years back I had a proposal submitted to DOE's NE program go through peer review resulting in a grant. However, so many critics complained to DOE officials, including the Secretary of Energy, they recalled the grant before I could start work. I think this was illegal, but I decided not to try legal recourse, but put this behind me and move ahead with my research. Attempts by me to fight the decision would have drawn much of my energy away and probably leave me extremely frustrated and down. It was better, I thought, to view their decision as "water over the dam."

Throughout the book, you encourage readers to continue to pursue their black swan events. You write (p. 197): "Even if

that wonderful event never happens, the search has been (and is still) an invigorating journey." Looking back over your decades of research and teaching, what areas have you found most invigorating (even if they are not the closest to the black swan event)?

I cannot pick one project over another. I have thrown myself into any of these research projects I started on, so all were invigorating in one way or other.

In what year did you form NPL Associates? Now you have also formed LENUCO. Is LENUCO the LENR branch of NPL, or has/will NPL do LENR work? Have you yet been successful in raising money to do more LENR work at LENUCO?

NPL Associates was founded about 20 years ago. It has had a series of SBIR and STTR grants and also several small commercial projects. The topics have been varied, as noted in the book—usually employing talented researchers from the university, including some of my research students as part time employees. The goal has been to support research and develop IP which could later become valuable. Thus, compared to many start-up companies, making a big profit was not a goal. In my view, the goal of research and IP has been very successful. IP ranges from patents on neutron sources to fuel cells. More recently, NPL funded our LENR patents (two now issued with two more in progress). Since some of the LENR used university facilities, they have a royalty agreement with NPL, but NPL owns and has full license rights to these patents. LENUCO was founded to separate LENR work from the other varied work in NPL. They have exclusive license rights to the LENR patents from NPL. LENUCO received some money from the state of Illinois through the University Research Park to support the start-up of LENUCO (called I-Start funds). However, I have held back on pushing too hard for investments into LENUCO—instead asking for money to go into the university via a gift fund account to support basic research in my university lab on extending the run time of our gas loaded nanoparticles. Once that problem is solved, we can move ahead in LENUCO with a demonstration reactor. I believe we are getting close to that now.

You credit some work in cold fusion leading you to fuel cell research. Did you often find that one endeavor would lead to some new, exciting endeavor? Has the area of cold fusion led you to other areas of research as well?

Yes. With LENR we found that the dislocation sites we create in thin films where the dense cluster of deuterium or hydrogen are formed (and where the reactions occur) are of use for developing MeV deuterium beams. This is done by focusing an intense Petawatt laser beam on the back side of the thin film. This interaction first drives electrons out of the front face of the film and these, in turn, create a virtual electrode at high negative potential in front of the film. This then draws the deuterons out from the clusters. This method of forming such a beam (but of protons from a hydrogenous coating on films) has been studied a lot at several labs having Petawatt lasers. We have done experiments to demonstrate our approach at the TRIDENT Petawatt laser at LANL. There are two important potential uses of such deuteron beams—one is so-called fast ignition of inertial confinement fusion targets (laser fusion such as done at NIF); the second is to focus the deuteron beam on a tritium loaded target to

create an intense pulse of D-T fusion neutrons. Indeed, we have filed a patent on that approach and it was recently issued. Such an intense neutron source can have a number of research uses, including studies of neutron damage to materials, to electronics, or NAA for homeland security.

You are well-known as the founding editor of Fusion Technology, for a time the only mainstream journal that would publish cold fusion papers. You wrote in 2000 (Accountability in Research) that at that time the rejection rate for cold fusion papers was "noticeably higher" than that for hot fusion papers. Do you recall what that ratio was, and had it been lower in the earlier days? And, presumably, after your retirement in early 2001, cold fusion papers have become non-existent in FT?

I don't recall the exact numbers off hand, but if needed badly could probably find the records to answer that. The problem was that my editorial board insisted on several reviewers from the hot fusion area, and they were often negative from the start. On the other hand, for hot fusion papers, no one asked me to find reviewers from out of the field. It was assumed that the experts came from the hot fusion area and they were best qualified to do the reviews. To counter this I tried to find hot fusion people who had an open mind to review the cold fusion papers. Then often the hardest questions came from the cold fusion experts—people working in the area.

Yes, few papers, if any, have been accepted in the journal (now called *Fusion Science and Engineering*). The editorial board never liked my willingness to have cold fusion papers reviewed and published. They sought an editor who was in tune with that view when I retired as editor. (I might note that I did not retire due to the pressure—but this was very time consuming and I wanted more time for research after many years as editor. I felt I had done my due service to the fusion community and to the American Nuclear Society, which published the journal.)

Life at the Center of the Energy Crisis is available on Amazon in hardcover and Kindle editions.



Dr. Mark Prelas' review of
Life at the Center of the Energy Crisis
is included here. It will appear in
Issue 113 of the magazine.

## **Book Review**

## Life at the Center of the Energy Crisis: A Technologist's Search for a Black Swan

George H. Miley World Scientific, 2013 ISBN 978-981-4436-48-9

Review by Mark A. Prelas

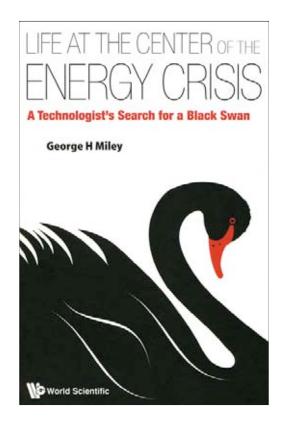
n. George H. Miley has written a book about his professional career in energy research from the perspective of his very personal journey. The subtitle "A Technologist's Search for a Black Swan" sheds light on his methodology. The book becomes both memoir and tutorial on the long journey of searching for elusive energy technologies to lead mankind into the future.

As explained in his book *The Black Swan*, Nassim Taleb defines a Black Swan as an unexpected event which has immense direction-changing implications. Miley seizes this concept to describe his own creative scientific endeavors as a continuing exploration of "outlier" phenomena—a "thinking outside the box," if you will—to advance knowledge without prejudice. His journey focuses on such big issues as energy transport, storage, conversions, conservation, limited resources and conflict, while describing his unique approaches to examining the solutions embedded in the problems.

Dr. Miley's story begins in his childhood home as the son of a scientist and educator, raised in Pennsylvania and educated at Carnegie Tech (now Carnegie Mellon University) and the University of Michigan studying physics and chemical engineering.

Encouragement initially came from his biological family. His private life intersects with his professional life; his many colleagues are by turns collaborators from whom he learns and eventually mentors.

The list of discovery and work are remarkable. While Miley worked at Knolls Atomic Power Laboratory he solved the problem of using burnable poisons for control of submarine reactors, a remarkable achievement for the young scientist at the start of his career. He joined the University of Illinois and quickly took advantage of the pulsing capability of TRIGA reactor studying nuclear pulse propagation. This work was an important driver for his future research in nuclear-pumped lasers (NPL) and direct fission energy conversion. His group was engaged in a race to discover the first NPL. Although his group was not first, it did pioneer impurity type nuclear pumped lasers, developed nuclear-driven flashlamp pumped lasers, and discovered the first visible NPL. His work on the direct conversion of fission reactions to energy culminated in his classic book Direct Conversion of Nuclear Radiation Energy, published by the American Nuclear Society (ANS) in 1971.



Miley's next innovation began when he saw the ions being produced in fusion as being valuable for self-heating (leading to his studies of alpha effects in thermonuclear plasmas) and direct energy conversion. For fusion energy conversion, he envisioned technology progressing to the point where high temperature ion producing fuels like D-He3 and p-B11 would eventually be incorporated into fusion devices of the future. He then produced his second classic book, *Fusion Energy Conversion*, published by the ANS in 1976. He was one of the first proponents of advanced fusion fuels. His work with the electron beam driven Krypton Fluoride laser at the Naval Research Lab in 1969 and his interests in NPLs were a natural driver for his interests in laser fusion research.

Miley engaged in advanced Inertial Confinement Fusion (ICF) target designs and while working in this area, he began a life-long collaboration with Heinrich Hora, a world-renowned theoretical physicist. Together they pioneered new target designs and new compression physics.

Miley and his group pioneered alternate fusion concepts. He reinvigorated research in Inertial Electrostatic Confinement (IEC) fusion, a concept invented by Philo Farnsworth (the inventor of modern television). Miley quickly recognized the commercial potential of the IEC for a portable neutron source and pursued commercialization with Daimler Benz.

Miley's group pursued research in Low Energy Nuclear Reactions (LENR, originally called cold fusion) soon after the announcement made by Stanley Pons and Martin Fleischmann on March 23, 1989. Even though he was skeptical of Pons and Fleischmann's results at first, he was a proponent of allowing this controversial research to be published. When other scientific journals refused to publish LENR work, the journal that Miley started for the ANS, Fusion Technology, was one of the few publications that would publish original research in LENR. His collaborations were many, but the most influential was that with Jim

Patterson (inventor of the Patterson cell). The Patterson cell appeared to have better excess heat output and reproducibility than other experiments of the day. The cell used millimeter-sized plastic beads coated with layers of metals such as copper, nickel and palladium. The cell's success was based on layered metals and this concept has formed the basis for Miley's current innovative designs. His cells have managed to produce perhaps the most excess heat of any U.S.-based LENR experiments.

Miley's list of collaborators is extensive and distinguished. He has worked with the world's leading energy experts from virtually every continent. He has the ability to transcend personalities and communicate in a common language.

My own personal and professional relationship with Dr. Miley began in graduate school in Nuclear Engineering at the University of Illinois Urbana-Champaign (UIUC). My reason for joining the program at UIUC was to work with Professor Miley. The UIUC campus becomes Dr. Miley's base of operations for much of his story and for many of the lives which he significantly influenced amongst the faculty and student body where he served as mentor and collaborator.

Searching for a Black Swan when seen in a scientific context metaphorically describes experimental and theoretical work as positive, negative, productive, inconclusive, benign, dangerous...but the work is always an advancing of knowledge and understanding. Dr. Miley's Black Swan in this light is a thing of beauty. It is also elusive. It is why George Miley continues his public and private explorations to shed insight into the world's energy crisis. It is an inspiration for future generations to continue the search for the Black Swan.