# On the Quest for a Commercial LENR Reactor with Robert Godes and Brillouin Energy

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Robert Godes had a rough arrival to ICCF19 in Padua, Italy. Many people had looked forward to the presentation of the founder and chief technology officer of Berkeley-based Brillouin Energy, which seems to be a contender for being one of the first to produce a working LENR reactor. A month before, a 55-minute run of their reactor at SRI appeared to show that they had a functioning engineering system, although a simple mistake with the wrong connector resulted in it burning out and setting them back weeks. Godes shook his head about what he deemed "a bunt to first base," saying that it was still important in closing in on and demonstrating that they were making engineering systems. "We are an engineering company. We are making equipment that companies should be able to go out and produce things themselves. We don't want to produce things; it's not what Brillouin is about. The company is about licensing intellectual property so other companies can build devices themselves. This is an enormous market. There's no way that one company can supply everything. How many oil companies, how many miners are there? It will require more companies than that to fill the need. This makes energy very inexpensive. The demand for energy is going to expand tremendously once this technology makes its way to the market. Brillouin will be licensing the technology."

Where is Brillouin Energy Corporation now in their development? Godes describes that Brillouin has put together "a plan that will allow us to build ten more reactors to test cores that we are developing. We have many cores in CAD (computer-aided drafting) in our computer system. Within 18 to 24 months the current target product is a boiler capable of producing 104 kilowatts (kW) of thermal energy."

Why would he do that? "That 104 kW will come out in the form of 400°C oil and we are doing that because it keeps the system at atmospheric pressure," he explains. "This simplifies things because you don't need a pressure vessel to produce it. The oil will flow through a Stirling engine that will produce around 20 kW of electricity. A portion of that electricity will be used to run the pumps in the drive system for the unit as well as to drive an absorption chiller. So the customer will wind up with about 10 kW of electricity and close to two tons of cooling."

Who is Brillouin's projected customer? Companies that have energy intensive processes, Godes says, such as manufacturing, metals refining, waste remediation and water desalination, to name a few. Many of these companies are paying in excess of $1 billion per year for the energy they need to run their processes. Viewed in that light, what are the comparative costs of what his system offers?

Robert Godes' vision is an encouraging one. He responds, "Modern Stirling engines have come a long way and some of my engineers are working on other technologies that will further enhance Stirling energy technologies. Assuming a 20 year life cycle for the Stirling engine, producing the electricity with this system comes out to about six cents per kilowatt hour. The fuel costs are next to nil. As the technology is scaled to large plants the cost will drop significantly." He smiles.

## Signing Up the Experts

As inventor, company founder and chief technology officer Godes had looked around and found the gold standard for research partners in Drs. Michael McKubre and Fran Tanzella, electrochemists who'd been working in the cold fusion field since the beginning. "We've established a formal research relationship with their highly regarded technology lab, SRI International in Menlo Park, California," Godes declares. "We've hired SRI and its leading cold fusion scientists at its Energy Research Center to assist our entire engineering process." SRI, Godes reminds us, has invented many world-class technologies, including the Siri voice recognition software that all Apple iPhones use today.

In an interview in Padua, Robert Godes spoke of the tremendous experience in metallurgy that McKubre and Tanzella had helped Brillouin with. "We have meetings every week and they tell us, 'You can do this, don't do that! We've tried that and it doesn't work!' SRI has and continues to help us in innumerable ways, and we are the only LENR technology start-up in the world that has this kind of relationship with them. We are continuing to work with SRI and looking at a variety of different experiments to run, coming up with something that could be done either with other universities or research entities."

Brillouin Energy has now been incorporated since early 2009, and has come a very long way. Godes says it took the first three years to really coalesce, but they have since built a strong engineering and executive team with a staff of 12 to 15 engineering consultants and executives helping at various levels at any one time.

"We have invested a tremendous amount of engineering work around our goals," Godes continues. "We are developing real commercial prototype LENR test systems that are increasingly proving in a carefully engineered fashion that a new kind of controllable, pollution-free heat energy source is actually possible. Our systems continue to grow their test results and are pointing to a near-term future of becoming industrially useful and to becoming a real alternative to fossil fuels...We have filed a number of patents with more on the way."

To date, besides Godes' own founding cash and some family and friend support, Brillouin has now raised approximately $8.5 million through stock sales to angel investors. He reports they have sold one early adopter commercial technology license to a middle market Asian industrial company.

So it was that Robert Godes headed to Padua for ICCF19 feeling optimistic.

Godes had received an email from the conference's technical committee saying he was going to give an oral presentation. The email said, "Your abstract was selected for oral presentation at ICCF19." He bought his tickets, paid for a hotel room and everything associated with the conference. Then he received another email saying he was no longer on the schedule and would need to upload his poster. He asked his SRI colleagues Fran Tanzella and Michael McKubre, who were on the conference's technical committee, if they'd take care of the poster for him. Because he'd received the official conference email saying, "Dear Dr. Godes, you will be giving an oral presentation," McKubre told him, "No, you're giving an oral talk." So Robert Godes went to Padua only to find he was *not* on the schedule. He was dismayed—as were many conference attendees. But at the end of the week, sitting for an interview and pasta on the way to the airport, he declared, "I have enjoyed being here. It's great to talk to all the people in this field."

Robert Godes at ICCF19 in Padua, Italy. *(Photo by David Nagel.)*

## Background of a Future Energy Technology Inventor

A positive outlook has served Robert Godes in his life. Certainly one of the youngest and seemingly most energetic inventor/LENR company founders, Godes can outline the engineering and theoretical basis for his thinking in quickly enunciated, thoroughly considered creative leaps. Often wearing jeans, a fast and somewhat bouncy walker, he could pass for a post-doc but is the father of a teenager. Who is this founder of Brillouin Energy? Where did this energy entrepreneur come from?

Robert Godes was born and raised in Ohio with the exception of two eye-opening years. When he was eight his family moved to Ethiopia. The Godes family spent three weeks in France, Italy and Greece on the way there and three weeks in India, Nepal, Thailand and Japan on the way home.

"Those two years had a dramatic effect on my outlook on life and view of the world," he says. "In 1972-74 much of Ethiopia was barely beyond the stone age. We saw farmers digging their fields with sharpened sticks with rocks on top and throwing wooden vessels of water up human ladders for water for themselves and their livestock. Many did their cooking using animal dung for lack of firewood. Most people in the USA don't have a clue about the quality of life they have or what real hardship really is."

Godes went to a public high school and then to Ohio Northern University (ONU) for college. Had he been one of those kids who started life by taking his playpen apart? Was he born gifted? "My grandfathers were both very mechanical and my dad was always building stuff in our garage. I loved working with him in the garage and started my first business fixing everything from bicycles and lawn mowers to electronics in elementary school. I was always way more interested in designing and building stuff than my schooling."

"They had a huge 'scrap' yard at the university in Ethiopia where my dad was supervising the construction of dormitories and classroom buildings. That was one of the first things I found after we moved there. I went to a one-room school for the kids of professors on campus and made friends with a kid named Duncan McGee. He introduced me to Meccano, now Meccano-Erector [a manufacturer and distributor of "Multimodels"—construction sets that create functional models of race cars, airplanes, trucks, robots and whatever "endless possibilities" creative kids of all ages can make of them). Duncan would come with me to the scrap yard to look at and analyze machines and how they were designed. The amount of equipment and the condition of it in that yard was appalling. The USA sending this stuff over there and not training them how to maintain or fix it, that is what made me start to doubt how our government works... and that was 1972."

Robert Godes' academic background included a few hurdles. He notes, "I was diagnosed with a few learning disabilities in $11^{th}$ grade. They (my high school) had tried to get me to go into a work-study program to be a mechanic. I already knew I wanted to go into electrical engineering. I looked at several universities and ONU said, 'Based on your GPA you will flunk out of our engineering school in the first quarter. However, you got a 670 on your English SAT, and a 780 on your Math SAT [very close to a perfect score for math] and have designed some interesting electronic products, so if you can get your GPA up to a 2.0 by the time you graduate high school we will let you into the college of electrical engineering." I took and aced my AP Physics and Chemistry tests, which put my GPA up at 2.05. As a result, I attended ONU and graduated. My only official degree is a BSEE from Ohio Northern University."

Did Godes remember hearing about cold fusion when it first showed up in 1989? Did he follow it? Did he say, "Man, I'm going to work on that someday?"

"Actually," Godes replies, "I was disillusioned with the gomedia [the government and media] by 1974 and completely missed the entire cold fusion news debacle in 1989. I did not even hear about it until 1992 when I was talking with some other engineers at Versatec in Silicon Valley, where I was working. When I heard about the Pons and Fleischmann news conference, I said, 'Palladium—there is something about palladium and hydrogen.' I spoke with fellow electrical engineer Steve Salkow and he said, 'They use that to filter hydrogen and it was the PEM for the original fuel cells.' I asked, 'Helium will not pass through it?' He said, 'No, only hydrogen.' Well, I knew helium was about half the size of hydrogen and to act as a proton permeable membrane, the hydrogen was entering as just a proton, deuteron or triton. In an instant, I put that knowledge together with the constructive interference of phonons, the Lennard-Jones effect, the Heisenberg uncertainty/Bose-Einstein effect and said, 'I know what is going on!' Steve said, 'No, the whole thing was debunked by MIT and Caltech and there is nothing there.' I said to Steve, 'No, they were on to something and if no one builds a reactor in ten years, then I will. This is just too obvious to me what is going on. Surely someone else is already building something already!'"

"I had access to the early internet at work back then, even though the worldwide web had not started yet. I looked around and found no one going in the right direction. I later took a job in 1996 with a company that had a great lab. They could not afford to pay me much but they were willing to let me modify their NDA and allow me to develop my own IP as long as I let them have anything that was directly related to their business. I solved lots of problems for them while developing technology that I could apply to driving the underlying physics of the Pons-Fleischmann reaction (ultimately known today as low energy nuclear reactions or LENR)."

How did Robert Godes' early work career influence his eventual work in LENR?

"The name of the company that I joined in 1996 was called Energy Line. When they later started to get serious about selling out to a larger, stodgy manufacturing company that would potentially restrict my freedom to experiment, I went into the lab over several weekends and cobbled together sub-systems to build and test the fore-runner of what is now Brillouin Energy technology. I completed those tests in early 2002, almost exactly ten years after I had said I would build a reactor in ten years if no one else had."

So how did the work progress? "Because I figured out the physics in 1992, and then started developing the components of the hardware and system design in 1996, I was able to build the first functional prototype LENR test system in 2002. With the acquisition of Energy Line looming (and my freedom to experiment in their lab soon to be curtailed), I quit my day job and began running experiments out of my house, using my daughter's original nursery room as homespun lab space. After a couple years of such work, I later approached a highly regarded Intellectual Property (IP) law firm in the San Francisco Bay area now called Kilpatrick Townsend Stockton (KTS). Specifically KTS (then Townsend & Townsend & Crew) had a highly respected IP lawyer on its staff named David Slone, who has both his JD Law and his Ph.D. in high-energy physics from Stanford University. A known authority in his field, I began a dialog with Dr. Slone about my hypothesis that I had developed as the theoretical basis to produce LENR, and after much review, technical analysis and scrutiny, eventually convinced him and a couple of his fellow physics and engineering colleagues that my hypothesis could in fact eventually lead to a commercial breakthrough. The process wasn't easy, but after many months of review and dialog, Slone was actually persuaded that what later became the Brillouin Energy hypothesis was significant enough, that he got his law firm to agree to perform all of my early patent work on my behalf and to become my IP law firm in exchange for a then 5% equity stake in the founders stock of my venture in 2005."

## Birthing Brillouin

How did Godes decide to form a company and really pursue LENR?

"As my earliest experiments at home began to take shape, by 2004, I became very confident that this work was well worth pursuing and would lead to a breakthrough technology in clean renewable energy generation, and that I would commit myself to forming a company, which later became the forerunner of Brillouin Energy Corp."

"We now have much larger joint venture type project development proposals pending. We anticipate that, pending a significant development contract/cash infusion, we are within 18 to 24 months from the integration of our technology into actual products. Products that we are confident will create breakthrough, ultra-clean, renewable energy. Anyone that wants to know more should simply look at our website at www.brillouinenergy.com."

## Experiments and Data

Where is Brillouin Energy now in terms of experimental evidence and data? Brillouin has been incorporated since 2009, with an engineering and executive team, consultants, engineering work invented and patent protection filed for, commercial prototypes and test systems on the way. Now the next questions are: How is it working? Does it work?

If Robert Godes had been granted his speaking slot at ICCF19 in Padua, he would have discussed his hypothesis, described the experimental apparatus and the results from the experimental apparatus including radiation effects like exposure of X-ray film and also about excess heat results and production of tritium results.

The evidence of tritium in the Brillouin system was confirmed by a condensed matter physicist who has spent many years at Los Alamos National Laboratory (LANL), Tom Claytor. If the Italian inventor Andrea Rossi has his Hot Cat, cold fusion's coolest cool cats would include Tom Claytor and radiochemist Ed Storms, another Los Alamos scientist. Storms and Claytor talked about tritium work at LANL in a 2008 oral history interview with me. What they said sheds light on why the tritium Claytor confirmed in the Brillouin system is significant.

## Tom Claytor and Tritium

"I have done a lot of nuclear work in the past on reactors at Argonne National Lab, and other things at LANL," Claytor said. "LANL has an excellent nuclear chemistry department and state of the art neutron detection equipment so instead of excess heat, we initially decided to try and detect tritium and neutrons. What we did and were thinking about initially was not electrolysis but gas phase work. In particular, some way of stimulating the deuterium in solids. Initially, we were thinking of this whole process, and at that time no one was doing gas phase experiments. So what we started out with was a gas phase experiment and the unique feature was a semiconductor metal interface designed to get hot electron injection into the palladium."

Ed Storms added, "You had the idea of a super heavy electron, I remember."

"That's right," Claytor agreed. "Those experiments worked to some degree but were difficult to fabricate and control. In addition, the experiments used about 12 g of expensive palladium powder. That is a lot of 200 nm powder. After the analysis, we did some physical disassembly of the cells and we found that it looked like there was arcing in the material. So then we jumped immediately to plasma loading of palladium foils. That uses only 250 mg of palladium per experiment. And it produced similar quantities of tritium. So this was a much more effective way to explore the conditions needed to produce small amounts of tritium."

The Department of Energy gave funding as a package to the lab, which got the work started. While Claytor's group got some of the funding, they later wrote a LDRD, which was a laboratory sponsored directed research program. "We got $300,000 to do that," Claytor recalled. "That's when we did most of the work. We had several graduate students and we were doing plasma experiments using Pd and Pd alloys as well as other materials. Another experiment that was fruitful in terms of tritium production was the hydriding-dehydriding of wire. What we were trying to do was hydride a Pd wire in deuterium, and then immediately pulse a current through the wire that would quickly promote diffusion of the deuterium out. As the wire cooled it would reabsorb the deuterium; the process would then be repeated. We found the results varied with the wire samples and current density. This is similar to what we are seeing now with the plasma, the results are very current- and materials-dependent. The wire is much more difficult to make as an alloy because you have to draw it into a wire, whereas with the plasma you just have to have a little plate or little tiny sliver of material and you can get that made into any sort of alloy you want. So we had a number of alloys that we had custom fabricated for this."

"We never looked for heat," Tom Claytor said. "We always just looked for the tritium."

Why did they start with tritium? What were they hoping to accomplish?

"The reason we started looking for tritium was that Ed Storms had already looked at tritium and (electrochemist John) Bockris had looked at tritium in the electrochemical cells," Claytor explained. "If you look at all the products that can be made, the tritium is the easiest to detect. It doesn't go away. It's not like the neutrons where you just get a signal, but it accumulates."

"And it is a nuclear product," Ed Storms pointed out.

"Yes," Claytor nodded, "And it is a nuclear product. You are more sensitive to it than you can be to helium. So you can see parts per trillion there, whereas with helium you see parts per billion. So you are a thousand times more sensitive to tritium than you are to anything else."

"And the background is low," Storms added.

"Yes, the background is low. It's not like there's a lot of tritium in the atmosphere right now," said Claytor.

Asked to explain the significance of background in terms a mainstream audience would understand, Claytor and Storms were good teachers.

"The significance of background is that the bigger the signal over background, the more confident you are you have an effect," said Claytor. "In these experiments, we saw variations in the tritium output of maybe four or five orders of magnitude. Most of the palladium that we used in these experiments would give very small signals. Occasionally we would see a large signal from a particular alloy. Well, the larger signals were unfortunately from rather complicated alloys that were not homogenous. But if you have a batch of consistent material, and it gives you a small signal, now you can learn something because you can rerun it with different parameters. So having a very sensitive system or very sensitive methodology to look at tritium is important in this field. Once you have tweaked up getting the tritium to a particular gas pressure or a particular current pulsing regime, then you are more confident that you can try another material under the same conditions. You're not just starting from ground zero. You're going to a higher level of understanding."

Ed Storms added, "See, if you are making heat, before you can detect the heat you have to make about $10^{20}$ fusions per second. With tritium you can make $10^{10}$ fusions per second and see it accumulate over a period of time."

"It accumulates," emphasized Claytor.

"That's right," said Ed Storms, "It accumulates, which the heat doesn't. And so you can see a situation that's very inefficient and has only a very small amount of the nuclear active environment, using tritium, whereas you have to be really pretty good at making the stuff to see heat. So it is much harder to see heat than it is to see something like tritium."

## Claytor Looks at Godes' System

In 2014, Robert Godes provided Tom Claytor samples for tritium analysis. Claytor's interest in Godes' system and results dated back to similar, early work that Claytor had done, albeit in a gas system. Claytor says. "It was a long time ago (1993) and I wanted to go back and repeat the experiments with higher currents in wires and/or foils. We ran unidirectional current pulses through the wires as we hydrided and dehydrided them in gas. Robert is doing it in liquid but it is essentially the same thing with the twist that he is reversing the current on each subsequent pulse. In our initial experiments we had long thin wires (50 to 100 microns in diameter by 1 meter long) and we ran high current through them, up to $1 \times 10^6$ A/cm$^2$. At these current densities, the wires didn't last very long before breaking and I thought perhaps what we should do, in light of the fact that Robert is apparently getting heat out of short wires, is that we should just go ahead and put huge currents into very short length of wire or foil. So about a year ago we tried shorter wires with higher currents in our gas system. The big advantage to using these short foils (25 microns thick by 3 cm long by 2 mm wide) is that we can run different alloys and other materials that might be difficult to fabricate into thin wires. From our early experiment we know that hydriding and dehydriding the wire like we were doing...We were hydriding because it is cool and it's palladium and then when you run a current through it you dehydride (as it rapidly heats) to some degree, then you let it hydride again as it cools. You are breathing the hydrogen in and out: these cycles can take a few seconds and you do it for up to 40 hours."

Claytor continues, "This procedure does a couple of things. It anneals the wire at low temperatures so the crystal grains grow. They are initially in a very filamentary structure in the wire. If you do a cross-section you see that the grains are very tiny. After 20 or 30 hours of current pulsing you have grown the grains and pretty much annealed wire so you just have one or two grains across a 50 micron wire. At that point the wire seems to be inactive in terms of producing tritium. It is only active when you are rearranging the microstructure in the wire. Also I think the fact that you are repeatedly expelling the deuterium, reabsorbed, expelling it across the surface has always seemed to be necessary for tritium generation. So when I talked to Robert about his experiment it seemed reasonable that he should be generating some tritium. He is running really large current pulses through these short wires and he is simultaneously loading the wires by electrolysis. So we switched from small diameter wires, 1 meter long, and started using short thin foils with much larger currents than we used in 1993 in a gas loading system. The results were positive, but not really much larger than when we were using the long wires. Based on the samples that Robert sent me, he is getting larger results from his electrolysis system than I did with our gas loading system. He is doing at least two things differently than I do: he is using electrolysis as a means of loading the sample, and he reverses the current on each subsequent pulse. I am just running it one way, stopping and then letting it hydride and hitting it again. Because I know that just hydriding it and dehydriding it repetitively will generate small amounts of tritium just by moving the deuterium across the surface."

Naturally, when Robert Godes and Tom Claytor met up again at the Missouri ICCF18 conference, Claytor was intrigued with what Godes was doing and told Godes he should look for tritium. Claytor relates, "So he agreed to send me a few samples of electrolyte from some of his cells and I prepared them and counted them in our scintillation counter. He sent me eight samples in all. He was able to tell me which ones he thought would have tritium and which ones would have much less activity or be null. He was pretty accurate. They varied in levels but the last couple of samples which he said probably shouldn't have anything in them were null."

Claytor notes, "In order to count these samples you have to take the electrolyte water and you have to distill until the conductivity of the resultant water indicates that the lithium hydroxide has been removed. This process results in clear, clean water that can be mixed with the scintillation fluid. Prior to counting the active samples the scintillation fluid and vials have been counted for 600 minutes over a period of several days to establish a background for each vial. Then after the water is added to the scintillation fluid and vial the samples are counted for another 600 minutes over several days. A couple of Robert's samples were above background by 3 sigma, probably 4 or 5 sigma. Some of the other samples were marginal or zero."

When did Tom Claytor get Robert Godes' samples? "He sent them some time after August 18, 2014," Claytor responds. "The samples I have here are labeled 8/18 and 9/02. I ran them late in 2014. I wrote up a few PowerPoint slides describing the results and process for him, and I sent them off. This was completely free. I was just curious as to what he had. I was running the wire samples and gas at the same time but they were not as prolific in terms of tritium production as Robert's best samples. We measured the amount of tritium in a 1 g sample but he has multiple tens of grams of water or heavy water in his system so there is more tritium in the whole system than I reported."

What is the level? "The biggest sample had 31 dpm. The next biggest one had 22 dpm and then one other was 14 dpm and the rest were at the 1 sigma level but they were positives above zero but not to the 2 sigma level. There were a couple that were null that he sent later. So I can't say he wasn't seeing something in his electrolytic system or wasn't doing anything. I'm not interested in writing up a paper with him because I don't know what the preparation was, what the metal is, how long he ran them. I don't know anything about the system he used, so in my viewpoint it is not possible for someone to replicate what he did without all those other details. I basically was doing a blind analysis of unknown samples."

Tom Claytor explains that the analysis he did was the job an analytic chemistry lab would do. Due to IP reasons, Godes could not share all the details of his system with Claytor, as is standard in new technology work. Not knowing the details of the Brillouin system, Claytor supplied the data of his tritium analysis to Godes so that Godes could incorporate it into a report on his system. Claytor's work was a big contribution. He notes, "This is not exactly easy to do. If you had to pay someone to do this the cost could be significant. I am just saying the effort was not trivial. You have to distill these things. You have to measure conductivity. You have to count the backgrounds for a long time. You have to count the samples for a long time to reduce the variance. We were using very low background Ultima Gold scintillation fluid. It took six weeks to do it."

To avoid contamination of the samples, Robert Godes details that all samples were handled the same way. "Mixed. Poured directly into the blank bottle or into the reactor. The reactor was operated and then the electrolyte was poured from the reactor into the bottle for Tom to analyze."

When were the experiments run? Tom Claytor answers, "This is a 2014 effort we are talking about here. I don't remember talking to him about gas loading in 2009. Maybe I did. If I did it was in passing. I was mostly doing plasma loading in 2009. But I may have run a few wires between those plasma runs but they were the long wire experiments rather than the short high current foils we ran in 2014. There were no big pulses of tritium. These experiments produce picocuries of tritium. It's above background but it's hard to detect. There's nothing big about this. This is really low level counting. The only way you can tell if you've got something is if someone sends you background and you can compare it to an active sample and it is over several sigma. It's not like nanocuries or microcuries or something like that. If you look at the picocuries and say there are so many reactions per second...Say you have thousands of reactions per second. But that's not going to get you watts of energy or anything like that. Detecting tritium in your sample is like seeing wisps of smoke from a fire, it says something is going on but it's not the main event."

Tom Claytor and Robert Godes focused on different things in their earlier conversations, and accordingly, remembered them differently. Godes recalls conversations with Claytor as to why his wires were loading in a particular way and why he was seeing tritium, what he would have to do to see helium. Claytor says, "I probably didn't believe it at the time!" Did their work together change his mind?

"No," says Claytor, "because this is partly in sync with what we know generates tritium. Robert is putting it in terms of this particular kind of theory. I am agnostic about theories. What you need to do to get some specific result (such as tritium) is fine with me and then we can let theoreticians battle it out. So I am more of an experimentalist. If someone comes up with a really good theory that explains all sorts of things, I am all for it. But it would have to be endorsed by more than one or two theorists."

Does Claytor remember a specific conversation with Robert about the difference in the way he could operate his experiment doing a different pulse width or amplitude of the pulses?

Claytor ponders and answers, "You know, I can't remember if he gave me any details on that at that point. Later when we had a conversation in Missouri, then I realized he was running a lot of current to really short wires. I think before that he didn't give me any details of exactly how he was doing it. If he had, I probably would've remembered the conversation a bit more. So after he said, 'what we have is a short sample and high currents alternating back and forth,' I was probably more attentive. I said, 'I've done uni-directional pulses maybe not with as high current density as what you've got. But it is pretty much the same system so I can do that.' So that's what we did; instead of 20 amps we went to 150, 200A pulses. It is very interesting because the palladium really does move during those pulses. It actually physically moves due to the Lorentian forces and it morphs into a very different type of surface structure. It's a very interesting system. I don't know if he is seeing that kind of thing but he might be seeing something like that. He doesn't say that much about what's going on there, except in terms of his theory. I would like to see more experimental stuff. If he wants me to write up the wire results that I did, where I probably did a dozen runs of the wires, I would say it's pretty complicated, I'm not ready to go there. It was strictly kind of an exploratory experiment phase and while I did get some tritium it wasn't as good as what he got. His results are positives, they are just not huge. If I saw nanocuries or microcuries I would be more excited."

Did Godes talk to Claytor about his pulses compared to what Claytor was doing? Robert Godes talks about pulses on the order of tens to a few hundred nanoseconds. But Claytor's pulse was reportedly in microsecond range. "The leading edges of our pulses are 5 to 10 ns, ~35KV/us," Godes reports.

"Even the millisecond regime," Claytor affirms, "there is a difference there that differentiates these two experiments. What I am doing is dehydriding, rehydriding and dehydriding wire. He is using fast pulsing that doesn't seem to affect what I think needs be done. It doesn't seem to affect whatever we are doing. The rise time on the pulse doesn't seem to be the key feature for me. The key feature for me seems to be the energy dump into the sample, the total power dissipated. But we do have fairly fast rise times (500 ns) in the pulses we are using."

What other rise times did Claytor see? "Whew," said Claytor, "I don't have that right in front of me. I have to look at the lab book, but probably 300-500 ns. Not as fast as what he's got."

Robert Godes discusses these results. "Our faster edges and shorter pulses is part of the reason we are able to produce more tritium than Tom," he says. "It is also why we can produce heat. His rise times are longer than our entire pulse 0 to 100+ amps and back to 0."

Michael Melich, a professor of physics at the Naval Postgraduate School, notes that there is a whole literature on the effects of ultra-short very high-powered laser pulses on materials. He thought that what Robert Godes is talking about seems to be a "potentially profitable area."

"Just to tell you my thinking also," Claytor responds, "We have a Nd Yag laser that goes 50 kHz and with nanosecond pulses. I have that ready to go but because I am working on other projects I don't have time to set it up and do the things you need to do to get an experiment going."

What is the power expected out of the Nidinium Yag? Claytor says, "That laser is about 0.5 mj per pulse. If you focus it down you get pretty intense power density, it will ablate a sample in a small area. I would just load up a palladium sample with $D_2O$, and then irradiate with the focused laser beam and look for tritium in either a gas or liquid system. A European group did this some time ago. They were just looking for heat, so it was not quite as sensitive as if they were detecting tritium. I think we could do that. If there was anything going, we would see it."

Robert Godes mused on this discussion and comments, "Loading Pd with D and doing that is likely to not produce that much tritium. The physics explanation of why that is, is quite involved but my prediction is not much tritium production if loaded with deuterium."

See the Brillouin tritium report in the sidebar beginning on page 14.

## Analysis

Some questions that remain have to do with the analysis Tom Claytor did with the production of tritium. How much material was there?

Claytor notes, "What Robert sent was basically 30 grams each of the electrolyte. I asked him for enough so that I could distill it. So after distillation I got 25 to 20 g each time for each of the samples and that was plenty because I just need a gram or two to do the analysis. He also sent some background sample of electrolyte. Those background samples were zero. That was nice. Sometimes people will send you something you don't know what the background is. He was forthcoming with his background samples as well. The electrolyte that was mixed up but not run etc."

The distillation will remove all the dissolved solids in the water but it will also remove any particulates. "If you have transmutation," Claytor adds, "that's not what I would've done but with tritium this is what we do."

# Test Results Showing Tritium Produced in Brillouin's Reactor

**Brillouin Energy Corp. — February 2015**

**Summary**

To verify that Brillouin's reactor produces energy through nuclear reactions, Brillouin had samples of the electrolyte from its low temperature reactor tested by an independent scientist for the presence of tritium. Tritium can only be produced in nuclear reactions. Tritium is found on earth in extremely low concentrations; if tritium concentration is confirmed above this low background level, it is a clear indicator that nuclear reactions are taking place.

The samples selected for testing were from test runs conducted in August and September of 2014 using three different reactor designs of Brillouin low temperature (or "wet boiler") reactor. The tests were conducted by Dr. Thomas Claytor, a research scientist who worked at Los Alamos National Laboratory ("LANL") for many years, specializing in designing instrumentation, until his retirement. The equipment and procedures employed for testing the Brillouin samples (described in detail below) are generally accepted in the scientific community as suitable for measuring tritium.

The table below summarizes the results of Dr. Claytor's tritium testing. The test results show that all of the samples taken from the reactor after it was operated contain levels of tritium that are greater than background levels. For the samples denoted with the dates 8/20/14 and 8/23/14, the measured counts exceeded the significance level by 5-8 sigma which means that, with a very high level of statistical confidence, one can say these results are extremely unlikely to be statistical anomalies. For the samples denoted 8/25/14 and 9/2/14, the results exceed the significance level by 1-3 sigma which means that evidence that tritium was detected was positive but with a marginal level of statistical confidence.

The control sample (not exposed to reactor operation)—denoted 8/18/14—showed a small excess of counts over background; the excess was less than 1 sigma meaning that, statistically, the results for the control sample are not significantly different from background. This supports the conclusion that the higher number of excess counts measured for the other electrolyte samples were due to those samples having been in the reactor while it was operating.

The energy in the radiation that was emitted by the samples was consistent with what would be expected from tritium decay.

These tritium test results demonstrate with a very high level of confidence that nuclear reactions are taking place in Brillouin's reactors.

**Why test for tritium?**

Tritium is a form of hydrogen. The nucleus of the most common form of naturally occurring hydrogen—the isotope called "protium"—contains one proton and no neutrons. Tritium is another isotope of hydrogen that has one proton and two neutrons. Tritium is not a stable isotope of hydrogen: it has a half life of 12.3 years, which means that after 12.3 years, only half of the original amount is left. Over a long period, its concentration will continuously diminish unless there are nuclear reactions taking place which produce tritium. On earth, small amounts of tritium are constantly being produced by cosmic rays interacting with the nuclei of nitrogen and deuterium ($^2H$) in the atmosphere. Because the tritium so produced decays, there is a relatively constant, but very low, level of naturally occurring tritium on earth.

Since tritium can only be created through nuclear reactions, if it is found in excess of the natural background level that is created by cosmic rays, it is clear evidence that some other nuclear reactions are occurring.

The nuclear reactions that take place in Brillouin's reactors convert protium into helium. This transformation does not occur in a single reaction step; rather, it occurs through a sequence of nuclear reactions. Tritium is an intermediate product in this sequence; *i.e.*, it is produced in one reaction and consumed in another. This means that if the nuclear reactions are stopped at any point, there will be some level of tritium within the reactor that has been produced but not yet consumed.

If tritium is detected within Brillouin's reactors at levels above its normal background concentration, it demonstrates clearly that nuclear reactions are taking place in the reactors.

**How is tritium detected?**

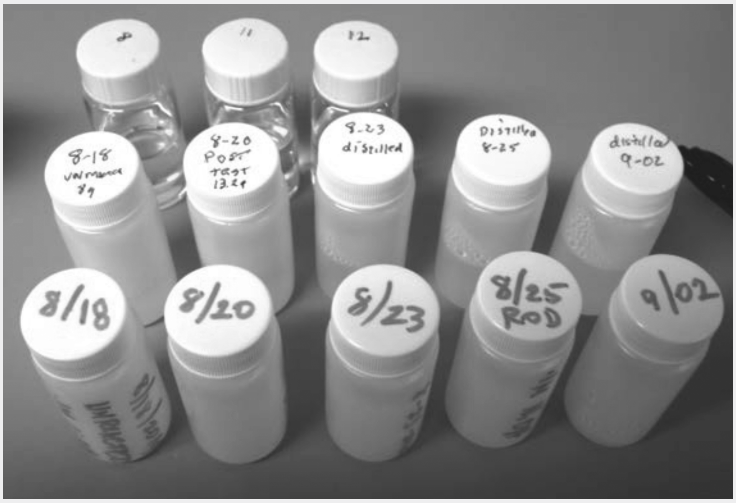
Tritium can be detected through a process known as a liquid scintillation counting. The material being tested for tritium is mixed with a solvent and placed in a vial. The solvent used for tritium has the property that it will emit light when a $\beta^-$ passes through it. When tritium decays, the $\beta^-$ radiation emitted excites the molecules in the solvent, which then emit a pulse of light. The vials are placed in a device called a liquid scintil-

**Tritium test results**

*Background radiation level: 20 counts/min*
*Test results adjusted for background radiation level*
*Significance level: 1 sigma = 4 dpm*

| Test Date | Electrolyte sample description *[exposed to reactor operation except for 8/18/14]* | Test result *[dpm]** |
|---|---|---|
| 8/18/14 | Not exposed to reactor operation (control) | 3.75 |
| 8/20/14 | Operating parameters "optimal"** for nuclear reactions | 22.4 |
| 8/23/14 | Operating parameters "optimal"** for nuclear reactions | 31.5 |
| 8/25/14 | Rapid loading and unloading of hydrogen onto core | 6.6 |
| 9/2/14 | Palladium wire substituted for nickel rod in core | 14.5 |

**Notes:** * dpm = disintegrations per minute
** "optimal" as best Brillouin understood them at the time




lation counter which contains light detectors that count the number light pulses emanating from the solvent.

**What was tested?**
Tritium is generated in the nuclear core of Brillouin's in the nickel rod. In the low temperature reactor, some of the tritium generated in the rod migrates into the electrolyte where it displaces protium in water molecules. If tritium is being produced in the reactor core, it follows that some of it should be found in the water molecules in the electrolyte.

For the purpose of the tritium tests, samples of the electrolyte from Brillouin's low temperature reactors were provided to Dr. Claytor.

**Testing Procedure Employed by Dr. Claytor —**
**Equipment**
The liquid scintillation analyzer employed by Dr. Claytor is a Packard 1900TR.

**Samples Tested**
A variety of samples from Brillouin's low temperature reactors were tested. All of the samples were of the electrolyte—0.01 moles per liter of lithium hydroxide in deionized water— that Brillouin uses in its low temperature reactor. To demonstrate that any tritium measured was due solely to the operation of the reactor, one sample of electrolyte (denoted as test date 8/18/14 in the table) that was not subject to reactor operation was also tested as a control.

The electrolyte samples denoted by the test dates 8/20/14 and 8/23/14 were taken after operation of the low temperature reactor with operating parameters considered to be optimal for nuclear reactions as best Brillouin understood them to be at the time. The sample with the date 8/25/14 was taken after a test where the electrolyzer was repeatedly turned on and off to test the effects of cycling hydrogen loading of the core on a short time scale. The sample with the date 9/2/14 was taken after a test where a palladium wire was substituted for the nickel rod in the core.

**Preparation and Testing of Samples**
All of the electrolyte samples provided by Brillouin were distilled to remove the lithium hydroxide and leave only the water component of the electrolyte (which is where the tritium, if it were present, would be found).

The solvent employed by Dr. Claytor is a commercially available product—Ultima Gold scintillation cocktail—designed specifically for use in scintillation counters. The water distilled from each of the Brillouin samples was mixed in a vial into the cocktail in a ratio 1 cubic centimeter of water to 10 cubic centimeters of cocktail.

The picture shows the vials containing the samples provided to Dr. Clayton as well as the vials containing the cocktail/water mixture.

Each vial was "rested" for at least one day prior to testing. Each vial was placed in the scintillation counter for testing for a sixty-minute period. Ten such 60-minute runs were conducted for each vial over 10 separate days. This process was repeated for all of the test samples provided by Brillouin.

Environmental conditions in the laboratory were monitored as follows:

- Ambient room temperature was monitored and controlled to remain in the range 68-71 F
- Radon levels were monitored. If readings were high, test runs made during such periods were discarded.

**Adjustment for Background Radiation**
There is a natural background level of radiation that the equipment will measure even when there is no irradiated sample within the test chamber. This needs to be determined so that it can be subtracted from the results obtained using samples containing radioactive materials.

To determine the background level of radiation, a vial containing only scintillation cocktail (*i.e.*, without adding the water distilled from any of Brillouin's electrolyte samples) was placed in the scintillation counter for ten 60-minute runs as well.

The background level so measured was 20 counts/minute. This background level was subtracted from the test results; the values shown in the table have been so adjusted.

**Additional Observations on Results —**
**Results Are Consistent with Tritium as Source of Radiation**
The characteristics of the light detected by scintillation counters reveal, within certain broad bands, the energy level deposited in the solvent when a radiation event is detected. When a tritium nucleus decays, a total of 18.6 keV of energy are released, only a portion of which will be deposited in the solvent. Radiation events detected by the scintillation counter showing energy levels below 18 keV are consistent with tritium being the source of the radiation; events with levels above 18 keV are not.

The Packard 1900TR can distinguish between radiation events depositing 0-18 keV of energy into the solvent from those depositing 18-150 keV. The tests results show that for each of the test samples, counts detected in excess of background levels are below 18 keV and no counts in excess of background in the higher 18-150 keV window. In other words, the results are consistent with tritium being the source of the excess radiation.

**Change in Activity Level**
A slight increase in activity was noticed after three days.

❑ ❑ ❑

## Other Effects

What instrumentation does Brillouin have and what other nuclear effects have they seen? Godes says he has a palmRad 907 radiation detector. "It's a Geiger Mueller. Measures all kinds of stuff. I generally don't see anything that I could classify above background. I've had guys from Google come by with gamma ray detectors. We're not seeing gamma rays with sufficient energy to make it out of the reactor."

Does he have safety badges around his device? "No, I don't, but I did take dental X-ray film and mounted it a couple of milliliters in a protective bag near one of my wet systems. What I got was images of the cathode. As alpha particles come off they generate and it is actually an X-ray spectrum. I don't have that offhand. Someone gave me that number but I don't have firsthand information on the 21 kV X-ray. Whatever it is, it is great for exposing dental film. It's not going through a stainless steel vessel." Recently Robert Godes went to get his teeth checked and made the most of his time there. "I went to my dentist and said, 'hey, have you got some X-ray film I could use and stick in my reactor?'"

## Brillouin Now

Robert Godes and his company are hard at work, as are many of the research groups and companies pursuing LENR technology. In just a short time, Godes created Brillouin and surrounded himself with top level people to pursue his ideas and make a working technology out of them. Fran Tanzella from SRI declares that SRI has interacted with Robert and the Brillouin team over the past three years and have come to believe that the early high-pressure "Wet Boiler" results were reproducible, controllable and significant. "I personally presented that work at ICCF17 because I believe it is real and important," Tanzella says. "Although there have been instances of intriguing results in the 'Hydrogen Hot Tube' reactor at SRI, they have not yet shown to be controllable or reproducible. The correlation between Robert's controlled electron capture (CEC) hypothesis and the Brillouin results is quite encouraging. It has not yet been proven. However, that's probably true for all existing LENR hypotheses. At this point, to my mind, Brillouin is still the only effort that has shown control over some of its excess power production."

The complexities of trying to do what Robert Godes and Brillouin are doing are shown in the successful data they've got in their lab, and the work they are doing with other partners. Numerous successful backers, bet-placers on outside new technologies, have felt confident enough to put their money down.

At Padua, Robert Godes mused on working on LENR and what it was like, what the selling points are as he has gets feedback.

"Funny," said Godes, "I think the reason that we have 500 people at this conference is due to a guy who's not even here. Rossi. You can say what you want about the guy. You can say he is a showman. People say he's a fraud. I think he actually has something. Maybe not commercially useful but I think he really does have something. Other very competent people working with the system think he has. As far as I can tell, several of them have sporadically seen excess heat production. Parkhomov has seen several times more energy out than he's put in. The Martin Fleischmann Memorial Project has seen several times more thermal energy out than they are putting electrical energy in. But until we get a product to market, anyone who goes and asks a physics professor at a university other than Missouri or Texas Tech, they will tell them, 'Are you crazy? That's impossible and loony. It can't be.'"

"You have asked me essentially who are you talking to? A spokesperson for Brillouin Energy? The head of the company? I'm not exactly the owner. I'm the chief technology officer. I'm still the largest stockholder of Brillouin Energy. I own less than half the company. But one of the biggest problems of this field, particularly with some of the individual inventors, is you are much better off owning 10% of a watermelon than 99% of a grape. Business 101. People invest in individuals but what they really invest in is individuals with a team around them. If you want someone investing in you, you have to get a team around you. I can do it all but there's only 24 hours of the day and I'm working 12 of them. There is no way one person can get it done and it takes a diversity of people to launch a company. You have to build a team if you want to get somewhere."

Robert Godes has a lot to do with all that on his plate. What's next? It takes a lot of energy (so to speak) to create a new energy technology company. People will be paying close attention to Robert Godes, his team, and Brillouin.

## Acknowledgement

I would like to thank Michael Melich for his technical assistance.

*Marianne Macy has been doing oral histories relating to cold fusion since 2007. She is writing a book on the start of the field to the present day.