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ANNIE KRITCHER INTERVIEW

Hi and welcome to GridTalk. Today we have with us a really special guest, Annie Kritcher, who is the physicist at the Lawrence Livermore National Lab (LLNL) in Livermore, California. She is the principal designer for the experiment that you've been reading about in the news since December and she's the Team Lead of the Inertial Confinement Fusion Program.

Q: Hi, Annie. How are you today?

A: Great. How are you?

Q: Good. So, when I think of somebody at the center of the universe when it comes to energy, I think that you're going to occupy that space for me because fusion is tremendously exciting and I want to start you to take us back to where you were on December 5, 1:03 a.m.

A. Yes, happy to talk about this!

Q: What you were doing and how you reacted to it?

A: The shot was actually supposed to go off the day before and so the entire day before I was watching the shot clock looking at the online dashboard trying to see if the shot went off, also checking for updates from my co-lead on the experimental side. Since I'm the designer I set all of the details for the requested inputs to the experiment well ahead of the experiment and I'm on call during the shot time but I don't have to be there physically at the facility and ever since COVID, it's been the same thing for the Lead Experimentalist that I work with so neither one of us were actually there in the building. I tried to stay up for the experiment but fell asleep. When I saw the results in the early morning I was literally in shock. I had been dreaming (literally dreaming) of a range of outcomes from utter failure to utter success. When I woke up I thought "now time to see which one it was".

Q: So, let me help you set the stage for a second. We're talking about 192 giant lasers and I'm going to ask you when you start responding to this question to tell me what a giant laser is and what it looks like, pointed at a cylinder the size of a pencil eraser in which we have deuterium and tritium compressed inside a diamond, is that right?

A: That's right so if you want, I can go ahead and jump into the details of the experiment. What we're doing here is essentially creating a miniature star in a lab about the size of a human hair to half the size of the human hair. We have 192 giant lasers and when we say giant, that means that the whole system that is used to create this laser energy and all the details associated with it, it’s the size of three football fields when you put all of the 192 laser beams together. We shine the 192-laser beams with two megajoules of energy into the center of a 10-meter diameter target chamber and then inside of that target chamber; it's a spherical target chamber, the lasers all come in and they’re focused onto the inside of a small cylinder which is about a centimeter long.

Q: Now, this is something that’s so small, you’re tracking this all on computer screens and via diagnostics, right? It’s not anything that you can visually witness or see?

A: Exactly. We have very, very high precision, special diagnostics that can see things smaller than a human hair.

Q: So, I’m going to stop you right there and it’s very hard to come at this but I’m going to try a variety of ways to make this alive for people. You’re a 39-year-old scientist, grew up and was born and raised in Traverse City, Michigan.

A: Um hum.

Q: For the women out there and for the fathers of young girls, tell me how do you get to be the principal designer of an experiment like this that’s so critical to the future of humanity?

A: I grew up in Northern Michigan and there this wasn’t a typical career path. I wasn’t sure what I wanted to do, and then you start to realize, well, hey, I’m really good at this math thing and what cool things can you do with it? I did have a lot of encouragement from my father and my family, my entire family. That meant a lot to me. They encouraged me do nuclear engineering at the University of Michigan, and then at the University of California at Berkeley later on. All throughout my career I’ve had a lot of support, also from mentors that support women in science and that has made a difference, both male and female role models.

Q: Would you have called yourself a nerd when you were in middle school or high school?

A: Yeah, sure. Yes, that’s a good way to put it I guess and yes, introverted-type personality and liking to see how things work and figure things out. Physicists come in all different personality types and obviously shapes, sizes, genders, etc. It can be hard when you feel like you don’t fit in but I guess that’s the whole point is that there’s no fitting in; there’s no right or wrong.

Q: I mean, we could probably spend 15 hours talking about you and how you got to where you were to do what you did but basically you went to the University of Michigan. You found your way to the University of California at Berkeley where you ultimately had a Masters and a Doctorate. Did you know you wanted to get into the building blocks of energy early on or is this something that kind of came to you as your career progressed?

A: When I was at the University of Michigan, kind of in my last year there, I wasn't quite sure what I wanted to focus on; there was a variety of different things in the Nuclear Engineering Department. I took a summer internship at Lawrence Livermore National Laboratory in the nuclear physics area and when I was out here, I got to see what was going on at NIF (National Ignition Facility) and I just thought it was a really awesome grand challenge science problem that there was so many really smart people working on it and it just seemed like something that would be fun for a long period of time to tackle.

Q: Now, let's take a timeout because we're going to try to navigate a lot of landscape here.

A: Um hum.

Q: There's a project in the South of France that I'm sure you're familiar called ITER in Cadarache, France outside Marseilles that was launched by an initiative with to take us back, Gorbachev and Ronald Reagan in 1985 and ultimately all the principal countries in the world including the E.U., the United States, Russia, Japan, and others, have been trying to work at fusion since several decades and have thrown billions of dollars at this. Have you been to Cadarache? Are you fully conversant with what they're doing? And then immediately segue into how what you've done in Berkeley in California is different.

A: Sure, so there's a lot of different approaches to achieving fusion energy. Both their approach and our approach are trying to get energy gain, which is more fusion out than the energy required to drive the plasma. Their approach is the magnetic confinement approach and what they do is they use magnetic fields to confine a much lower density, a much hotter plasma for a longer duration of time . What we're doing at NIF is we're creating miniature stars in the lab and confining the plasma with its own inertia, so we have an implosion and then an explosion. It lasts for a much shorter duration of time but you get a much more intense burst of power

Q: So, what they're trying to do is achieve 10 times the amount of energy output as input into the process and who knows how long it will take. You've already achieved 1½ times, is that correct?

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A: That's correct.

Q: So, what; do you have a timetable of when you think you'll get to 10X?

A: There’s a few things to note here, NIF is an basic research facility, a demonstration facility, and doesn’t use the most efficient laser driver. We produced 1.5 times fusion energy as the laser energy on target but the amount of energy that’s required to operate the laser is higher than that. A power generating facility would require a different laser infrastructure, higher gain scaled-up designs, and other engineering developments. In terms of a timeframe, it’s hard to put a timeframe on research and science although I will say we are making rapid progress and once the thing ignites and starts going,the progress becomes accelerated.

Q: So, the fusion as you know and a lot of the folks that are listening now include folks like…you may know who Ralph Izzo is, who is the head of PSEG, is a physicist. And over the years he’s kind of always arched his eyebrows when I’ve asked him about when will fusion be ready for primetime. So, there’s a lot of skepticism about the utility industry and among energy policymakers.

A: Yes.

Q: Why do you think this may be different? Why this may be a game changer?

A: Um hum.

Q: And some of the articles that have been in *The New York Times* and elsewhere think it may be a decade or two off which is always what is being said about fusion. Why do you think this is more optimistic this time around?

A: A decade or two is not unrealistic because a number of engineering developments need to happen to actually be able to harness this type of energy, both for this approach and also for the other approaches that are being looked at. The thing that's different this time is that for the first time we've actually demonstrated in the laboratory that we can achieve fusion energy gain in a controlled way. Before that, we've never actually generated fusion energy output that was controlled in a laboratory setting. This result motivates and is a proof of principal for all the different approaches out there. There's also a huge resurgence in the number of people working in this area and the different approaches that are being looked at and when you have that many people looking at a problem, the progress is highly accelerated.

Q: Just to throw in here just for a second, it uses a Tokamak Reactor, which is a design by the Russians back in the 1950s. There are 200 of them around the world now. Do you think that approach is moot or is it, as a scientist, do you want to see all these efforts continue on parallel tracks?

A: Oh, yes, definitely. Fusion as a scientific and engineering grand challenge. The more approaches and the more people looking at developing diagnostics, engineering developments, the more people we have looking at this, the better and the more different ways to look at fusion energy. There are synergies between what we're doing and what they're doing at ITER in the magnetic confinement area as we can share diagnostics, etc. I don't think it makes it moot at all, I think it just invigorates the whole field. We're not in a place at this point where we're all trying to compete. We're all trying to help each other learn to make this a reality.

Q: So just to complicate it a little further, we have small commercial players, too.

A: Um hum.

Q: You may be familiar with General Fusion up in Vancouver, British Columbia…

A: Uh huh.

Q: Which started around 2002 and they claim they're pursuing something called magnetized target infusion with steam-power drivers. Tell us a little about that and what you think about that approach.

A: Yeah, so I and there's a lot of different approaches out there. Some look like what we're doing, some look closer to

ITER's. Some look in between there being type plasmas. This particular one in Canada with the steam and magnetized target, I don't feel comfortable commenting on that one specifically because I haven't looked at all of the details.

Q: Suffice it to say, there's a lot of different efforts out there and do you think that makes you optimistic that somebody's really going to hit the breakthrough that makes this viable in our lifetime?

A: I think it's good to diversify definitely and also in that diversification even if something isn't successful in becoming the fusion plan prototype, we can still learn a lot along the way and so I definitely think that the multi-pronged approach is what we should be doing.

Q: Okay. Take a second; tell us what you think the promise of fusion is? It's be heralded as the future energy source that solves climate change. That means we don't have to burn coal. That means we don't have to burn natural gas anymore and possibly don't need the kind of conventional nuclear power that generates a significant long-lasting waste problem. Do you think that's hype or do you think this is the solution for mankind going forward?

A: I think this is—it will take a longtime to get everything working at the precision that we need it to be and at the cost that we need it to be, but the reward is that you have clean, limitless energy which is carbon-free, fueled by isotopes of hydrogen and doesn't create long-lasting reactive waste. Right now the biggest challenges are to keep the plasma hot and confined. The fusion plasm wants to cool itself very rapidly and we're trying to confine it and keep it heated for long enough periods of time to harness the energy output in a cost-effective way. This is something that is largely an engineering challenge at this point, an applied physics challenge .

Q: Let's play a little bit with the idea of scale here. Not as much fuel is going to be needed to generate the vast quantities of energy as people think; a lot less fuel in a nuclear reactor. Can you talk a little bit about that?

A: Sure so the target that we used shot micrograms of fuel so they're very, very tiny amounts of fusion fuel can give high amounts of output energy. Approximately 1/10 of a gram of fusion fuel could sustain a person's energy needs for an entire year.

Q: And we're talking about deuterium and tritium; there's a lot of that around, correct?

A: These are isotopes of hydrogen (hydrogen with an extra neutron and two extra neutrons) and hydrogen is abundant on earth. Plans to breed tritium which is not readily abundant needs to be a part of any fusion reactor scheme.

Q: And talk about the scale of the problem here. You mentioned the lasers that you're using here being multiple football fields in size, aim at essentially something the size of a pencil eraser.

A: Um hum.

Q: How do you solve that problem? How do you get that scale into manageable proportions?

A: In terms of the laser being able to hit the target and at the precision that we need, we're quite good at doing that now and it is one of the things that humanity is really good at high precision engineering, and we've done amazing things in many other areas. This isn't something that we have trouble with although to create fusion energy plants we have to look at more compact laser designs.

Q: As a scientist you're probably going to wince at this question, but tell us a little bit about Annie Kritcher, the person. You're a 39-year-old woman. I assume if you're in Berkeley, you'd go to the Berkeley Bowl to do you shopping. How do you go about your life and how excited and energized are you by this project? I mean, do you wake up in the morning and can't wait to get back at it and do you stay at it until midnight? Talk about your life and how you are integrating into it?

A: I did live in Berkeley for many years when I was going to graduate school there and working out here. The experiments themselves are in Livermore, California, and I've been living out here for 7 or 8 years now. It's about 50 minutes from Berkeley. I did used to shop at the Berkeley Bowl, so that's true.

Q: Okay.

A: I have three young children: a three-year-old, a six-year-old, and an eight-year-old and my daily life looks like trying to balance work/life together and then in the evenings, I do work until midnight. The cracks in my time are usually filled up with this work and have been for many, many years. This result definitely has energized me. The previous success was about a year ago and that was very, very motivating for a lot of people. And then getting back into it and make the next technical step has been the most fulfilling time of my career and it does make me extremely happy.

Q: Well, since this news broke in mid-December about this breakthrough, tell me what kind of response you've gotten from; I mean, did the president call you? Did the Secretary of Energy call you? Have you heard from colleagues in kindergarten classmates? What's been your life? What's your life been like?

A: I actually presented the results in a panel discussion in D.C. with the Secretary of Energy herself and my teammates. We didn't get a call directly from the president but I got to speak to her directly and she presented the results along with our panel to the entire world; it was televised, so I have received calls from people from my childhood, my past teachers from kindergarten, friends from childhood, friends from grad school, mentors. Some people I know and hadn't heard from in a long time, they sent their congratulations. A lot of requests to do media, interactions, colloquia, giving to Colloquia Berkeley in the next couple of months, so I've had quite a bit of contact from people throughout my entire life over this result.

Q: What do you do to relax? Do you read science fiction? Do you go for a hike? How do you unwind?

A: *Chuckling…*I like to run. I also like to paint and playing with my kids which is , surprisingly, calming at times and makes me happy. I like to do woodworking so I like to play around with that sort of thing, kind of like the hands-on building type of stuff I like to do.

Q: So, you're relatively young as a scientist. You could have three or four decades ahead of you working on this project. How do you see your life unfolding and is this it? Are you going to be solving this problem the rest of your life and how does that make you feel?

A: Yeah, I mean, it is a grand challenge problem. I’m in no way…

Q: Why don’t you define what that means? What is a grand challenge problem?

A: A multi-decadal, really high impact, long-term payout requires many people to work together from different areas to make it happen. So, in a sense when you work on a problem like this, you feel obligation to the community, to the world, on these grand science challenge problems. So, I think that is a definitely a possible career path for me to just continue working on this for the remainder of my career and it is something that I want to do. I can do that at the lab in collaboration with the universities and also starting up more collaborations between the laboratory and the private industries.

Q: I’m going to ask you another personal question and I hope I’m not overstepping my bounds here but do you consider yourself a religious person? And what does it feel like to be creating something like a star in the space of a human hair?

A: *Laughing*…yeah, so I do consider myself to be a religious person and I think there are many unsolved mysteries in the universe and just to be able to harness that a little bit in the laboratory and study it different ways and sort of see the wonders of our universe, I think it’s an awesome thing to be able to do and to go to work and say that’s what you do.

Q: I’m now going to as you a very practical question. For the utility executives and managers and energy policy writers and state legislators and Congress and their staff that may be listening, they make decisions every day…

A: Um hum.

Q: On capital expenditures of billions of dollars of deploying energy assets that will last upwards of 50 years. How should they monitor what you’re doing and the potential transformation and revolution that might be coming?

A: That’s a great question so as we talked about earlier, we’re not expecting major progress on the day/type timescale, weeks/ type timescale. We’re talking about steady progress over the next few decades. We have milestones that we’ve set in place with the policymakers so that they can, in the intermediate sense, track these improvements, and we have some finite goals for the next couple of years. It’s important to note that we are making more rapid progress than in the past, and the more people involved, the faster the progress will be, and so, getting that extra support is impactful. And as I mentioned earlier, the payoff is huge and it’s just the beginning so getting that buy-in from our policymakers for to be in it for the long-term is going to be really important.

Q: Thank you, Annie. What a pleasure to meet you and hear about what you're up to.

A: Yeah, thank you for having me.

And thanks for listening to GridTalk. We've been talking to Annie Kritcher, a physicist at the Lawrence Livermore National Lab, more appropriately titled the Principal Designer for the Experimental Fusion Team you've been reading about their headlines. Thank you for sharing your insights, Annie and we look forward to visiting with you again really soon to talk about more and more developments.

Thank you, Marty.

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END OF TAPE