The Joy of Discovery

Sau Wan Lu '63

According to the Standard Model of particle physics, 17 types of subatomic particles explain everything we know about matter, but only 16 had been scientifically observed until Sau Lan Wu '63 and a team of fellow physicists found proof of what appears to be the elusive Higgs boson particle (dubbed the "God Particle"). Many say this is the most significant observation in the field of physics in more than 30 years.

Wu is the Enrico Fermi Distinguished Professor of Physics at the University of Wisconsin, Madison, and a key member of the ATLAS team of physicists at CERN in Geneva, Switzerland, whose ongoing research led last summer to the discovery of the new subatomic particle. The physicists' key research tool is the Large Hadron Collider (LHC), a 17-mile-long particle accelerator built 300 feet underground.

CERN announced the monumental findings in July 2012, and Wu visited the campus last fall to share the discovery and her experiences with the Vassar community. Before her lecture, she sat down with Zosia Krusberg, visiting assistant professor of physics and astronomy, for a conversation spanning the joy of discovery and teaching, women in physics, and Wu's memories of kind Vassar alumnae who helped her adjust when she first arrived in the U.S. from Hong Kong.

Interview by Zosia Krusberg

Zosia Krusberg: I thought we'd begin by talking about the hot physics topic of the year—the possible discovery of the Higgs boson. Many of us associate scientific discovery with the archetypal image of Archimedes running naked down the street screaming "Eureka!" In reality, today, scientific projects tend to extend over years and even sometimes decades. How does it feel to finally arrive at statistically significant data that seems to be telling us, "Here's something new?"

Sau Lan Wu: All these 20-something years that we *didn't* see it, I sometimes wondered if I ever would. I get a lot of funding from my university in addition to the Department of Energy. And every year I had to write a justification to my university and I would say, "Well, we're going to find the Higgs next year." And then I'd say, "We're going to find the Higgs *next* year." I just kept going. And sometimes people would ask me, "Are you really serious?" But the Higgs boson is so important in the Standard Model. It's the only missing piece that allows for the elementary particle to have mass. The universe would be very different without this particle: There would be no atoms, no human beings. Everything would be massless. So this really is a discovery of the century.

One of my students combined the different channels and saw the five-sigma and when he told me—actually, he screamed—all my students surrounded him and yelled and laughed with joy. So this was something extremely exciting. It was really a great pleasure, and I am especially happy that my young students and postdocs had this moment in their lives.

ZK: On a project that has lasted for over 20 years, how do you stay motivated?

SLW: I didn't ask myself how. If I had asked myself, I don't know what would have happened. The fact is, you

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think next year you're going to find it, so you're motivated to move on. But I have two missions in my life. One is discovery. I was extremely fortunate to have experienced two discoveries. So even if I hadn't found a third one, I'd still feel that I'd have lived a rich life. The other mission is the education of graduate students. I have now graduated close to 50 PhDs and placed them very well. [I've placed] students in the University of Chicago, Harvard, Princeton, and CalTech. So I feel that, in addition to the physics, I also have a strong function in educating young people.

ZK: As the experiments at the LHC [Large Hadron Collider] have made clear, you now have thousands of researchers from all over the world and hundreds of institutions collaborating together on these missions. What are the advantages and disadvantages to working in these very, very large groups versus the traditional picture of the advisor and the student in a smaller group?

SLW: If you have one student, one post-doc, and one professor it's harder because no one person can really do enough to make a big impact. So I have about 10 graduate students and another 7 or 8 post-docs and other personnel. The important thing in this collaboration is that there are many working groups. We have a meeting every Sunday afternoon at 2:30, and I encourage everybody to report on what they are doing. So not only do you work on what you are good at, but you also get to know about other people's work. That way, they get feedback and advice from each other and not just from me.

I think if I didn't have a large enough group, the whole atmosphere, the motivation would have changed. When I first became a professor, I had only one student and some post-docs and the student was extremely lonely, so then I said, "This is not going to work." I begin to expand the number of students, so they sort of become a family and support each other.

Also, the question of motivation doesn't come up so much for students. It's the opposite problem; we never seem to have *enough* time to do things. At every major conference we have to present new results. The conferences are always pushing physics to move quickly.

ZK: Scientific research has really changed dramatically in the last 100 years. We've gone from very small table-top experiments with just a few group members to these enormous collaborations, exemplified by those at the LHC. What skills does the new generation of physicists need to develop in order to successfully do science in this environment?

SLW: In high-energy physics, the nature of our work has changed a bit. The experiments last so long and there are so many areas of expertise. If a student came to me and said, "I don't want to build electronics. I just want to do analysis of data," this student still would have a future

Professor Wu meets with Vassar physics students during a fall visit to campus.

because you will always find yourself an area in which you can excel. My students have a chance to witness discovery and they have the capacity to solve problems under tremendous time pressure, and that is extremely good training for them. So even if they leave the field and they go into industry, they will carry all those abilities with them. These are especially important in the international, global arena. So I don't think there's a *particular* skill that they have to have; they should do what they are interested in.

The other part of the training they get is competitiveness. You cannot be slow. For example, tomorrow there will be a meeting. The French and Italian groups are going to present on the same thing my students will, so they'd better be good. They'll stay up all night to do their best. Speed matters. If you have different groups from different countries competing with you, you know you'd better be the first.

ZK: What was it like for you to enter the field of physics as a woman in the early '60s?

SLW: When I was at MIT, I stayed for quite a long time—first as a post-doc and then as a research scientist. When I got the position at the University of Wisconsin as assistant professor, I was one of the first women in the physics department—that year, I think, they hired two women. That was 1977. And it's sort of a strange feeling, how my colleagues viewed us. I had the feeling some of them didn't take us too seriously. But I went to the leader of the high-energy physics group at that time, David Cline, and said, "Well, Dave, what do you want me to work on?" He said, "You are your own boss. Do whatever you like." Then I decided to work at DESY [a German research center]. That's where the gluon was found in 1979. (See Wu's bio for more.)

At that time, I was at the age where I had to decide whether I should have children or not. My husband and I talked about it and realized that if I did so when I was an assistant professor, I probably would not get tenure and I would lose all my funding. Now, today, you would never think about that. But in those days it was a reality. So that was the decision I had to make.

ZK: Today, there are more role models for women who are entering the field of physics. But of course, the field is still very much dominated, demographically speaking, by men. Do you have any reflections about what it's like to work in an environment where almost everybody around you is a man?

SLW: You have to accept the fact that people think you are less competent. I remember reading in *Life* magazine that if you are a man, people assume you are competent until you prove you are not. If you are a woman, they assume you are not competent until you prove you are. I encountered that mentality a lot early on. If you're a woman, and there's something not quite fair and you speak up, people get upset. When I became successful, people would point to me and say that I am an aggressive person. People have called me Dragon Lady. I'm not like that, but people make a picture of you. In the end, you have to be immune to this kind of criticism.

What they don't see is that I'm successful because I try very hard. I work for it, totally devote myself, my life, to my job.

ZK: So, you're back at Vassar. I wonder, as you think back on your time here, what was the most valuable part of your Vassar education? Is there something that you've carried

with you throughout your career from your experience here at Vassar that you'd like to tell us about?

SLW: Number one: I will say that I was rejected by the whole United States except Vassar. So if Vassar had not admitted me, I would not be where I am. I applied to 50 places, but I asked for a full scholarship. There were only four places that said they would consider me, and I was rejected by three.

And number two: I came to Vassar with no money. My father gave me $40 and Vassar basically covered all of my costs. I had a full scholarship, room and board, and the American girls donated clothes for the foreign students, so I didn't have to go shopping. Vassar even sent me to a summer school the first summer I was here because my English was so poor that I couldn't pass my requirement. Vassar really made sure I would succeed and graduate. They trained me to have perseverance, persistence, and if you have that, you basically will not fail.

Vassar really made my career. I dedicate my share of the Higgs discovery to Vassar.

ZK: So tell me about coming to the U.S. You were born and grew up in Hong Kong. I understand that you came to the U.S. by boat and some Vassar alumnae came to pick you up in California.

SLW: That's right. The boat landed in San Francisco, and some alumnae met me. They were very kind. I had to take two trains from San Francisco to New York. Alumnae also picked me up in New York and were really very nice, but the first thing they did was take me right away to the Metropolitan Museum. That was really wonderful, but I was *dead tired* after the trip!

ZK: What a transition!

SLW: But I have to tell another story about coming to the U.S. My father was against me going to college because he had a number of concubines—my mother was number six. He was relatively rich and well known, but I was living in a slum. We were the youngest children and I have a dozen brothers and half-brothers. So my father said, "You should now earn your living, and support your mother." I secretly applied to college and when Vassar accepted me, I didn't dare to tell him. But my father got a letter saying I had been admitted and he happened to be in New York at that time, staying at the home of a friend whose daughter was about to graduate from at Vassar.

So he attended her graduation and was so pleased to realize that Vassar was not just *any* old place. The only thing he complained about was that they only served peanuts at the reception.

ZK: So after seeing the college, he was supportive of you?

SLW: Yes!

ZK: Well, thank you, Professor Wu. You've had such an amazing career and an incredible life. It's been wonderful to hear these stories.

SLW: Well, you live long enough and you have a lot of stories.

Sau Lan Wu *is based at the renowned CERN research center for fundamental physics in Geneva, Switzerland, where she leads a large Wisconsin team of physicists, graduate students, and technical personnel. After earning her PhD from Harvard, she worked as a research associate at MIT, where she assisted in the 1974 discovery of the charm quark.*

Soon after, Wu joined the Wisconsin faculty, where she immediately began work to unearth the gluon, so named for its ability to hold quarks together to form composite particles such as protons and neutrons. For this discovery, she and her three of her collaborators received the 1995 High Energy and Particle Physics Prize of the European Physical Society. In 1996, Wu was named a fellow of the American Academy of Arts and Sciences.

Zosia Krusberg *is a visiting assistant professor of physics and astronomy at Vassar. She received her PhD in theoretical particle physics and cosmology from the University of Chicago, where she studied dark matter and theoretical extensions of the Standard Model of particle physics.*

Watch a video of Sau Lan Wu's on-campus lecture at vq.vassar.edu.

Sau Wan Wu with interviewer Zosia Krusberg