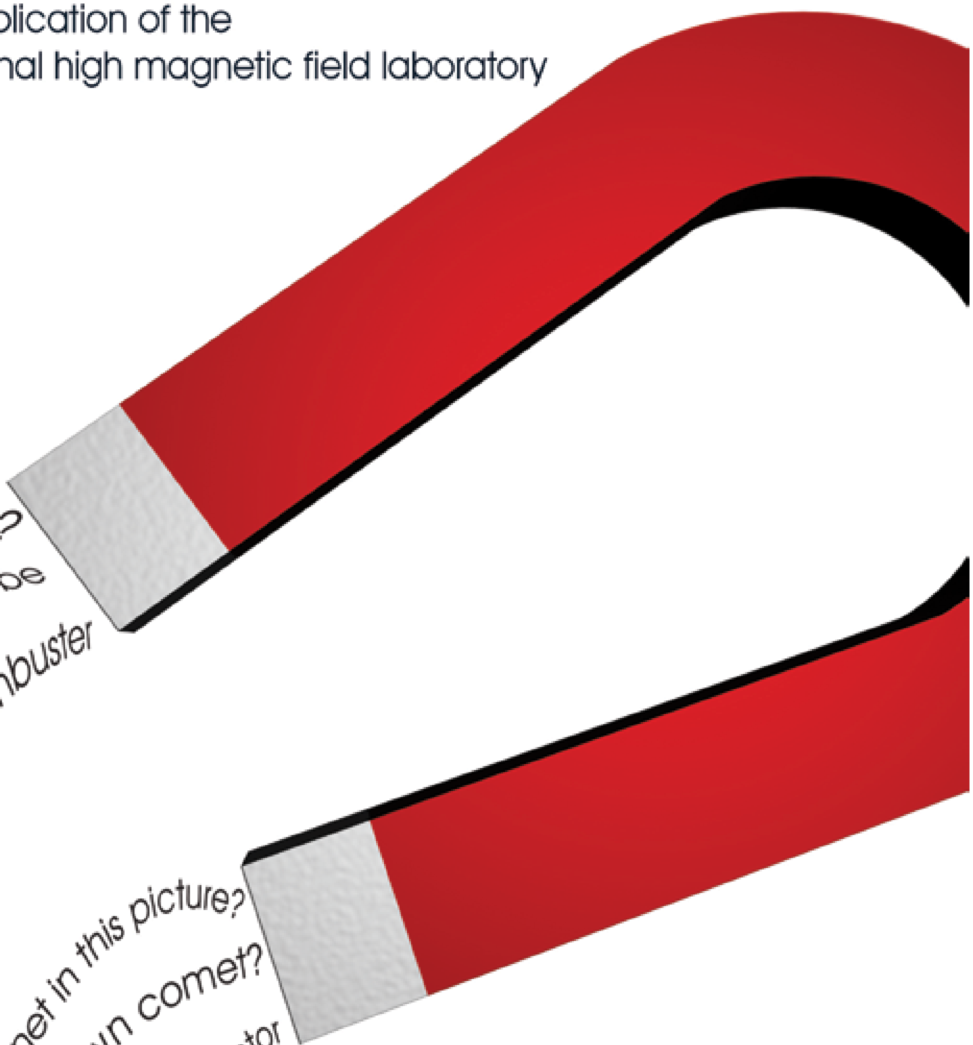
flux

a publication of the
national high magnetic field laboratory



How can I make a magnet of my own?

Go inside a magnet probe

Meet a real-life Mythbuster

Do magnets at the lab look like the magnet in this picture?

Can a high school girl make her own comet?

Nikola Tesla, forgotten inventor

Table of Contents

Magnet Lab Director .... Greg Boebinger
Director of Public Affairs .... Susan Ray
Flux Editor .... Amy Mast
Graphic Designer .... Savoy Brown

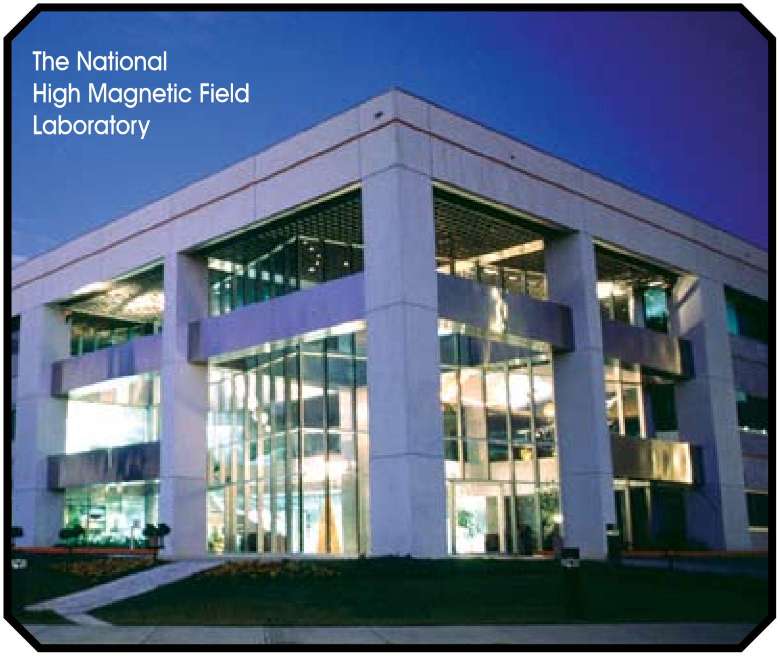
The National High Magnetic Field Laboratory, or Magnet Lab, is a national user laboratory that provides state-of-the-art facilities for magnet-related research in all areas of science and engineering, including biology, medicine, chemistry, geochemistry, bio-engineering, materials science, and physics. It is one of the nine laboratories of its kind in the world. The Magnet Lab is supported by the National Science Foundation and the State of Florida. It is operated by Florida State University, the University of Florida, and Los Alamos National Laboratory, with unique facilities at all three campuses. Users come from universities, private industry, and government laboratories worldwide.

This document is available in alternate formats upon request. Contact Amy Mast for assistance. If you would like to be added to our mailing list, please write us at the address shown below, or call 850-644-1933, or email winters@magnet.fsu.edu.

National High Magnetic Field Laboratory
1800 East Paul Dirac Drive
Tallahassee, FL 32310-3706

What is Flux?

An introduction to our new publication



The Magnet Lab is an institution unlike any other, capable of producing the world's strongest and most powerful magnetic fields and attracting researchers from all over the world. These researchers use the high magnetic fields created at the lab to study many aspects of physics, chemistry and biology – everything from the mechanics of cancer to the behavior of particles that make up matter in its most fundamental forms.

As exciting as a lot of this research is, it can be difficult for many researchers to find the time or words to fully explain how the magnets work or why they're important for answering questions about our world. That's where *Flux* comes in. Inside the pages of each issue, you'll find:

- News about research conducted at the lab;
- Profiles of scientists working with the magnets or building new ones;
- Explanations of the tools, machines and concepts that keep the lab running; and
- Answers to questions we hear most often at the Magnet Lab.

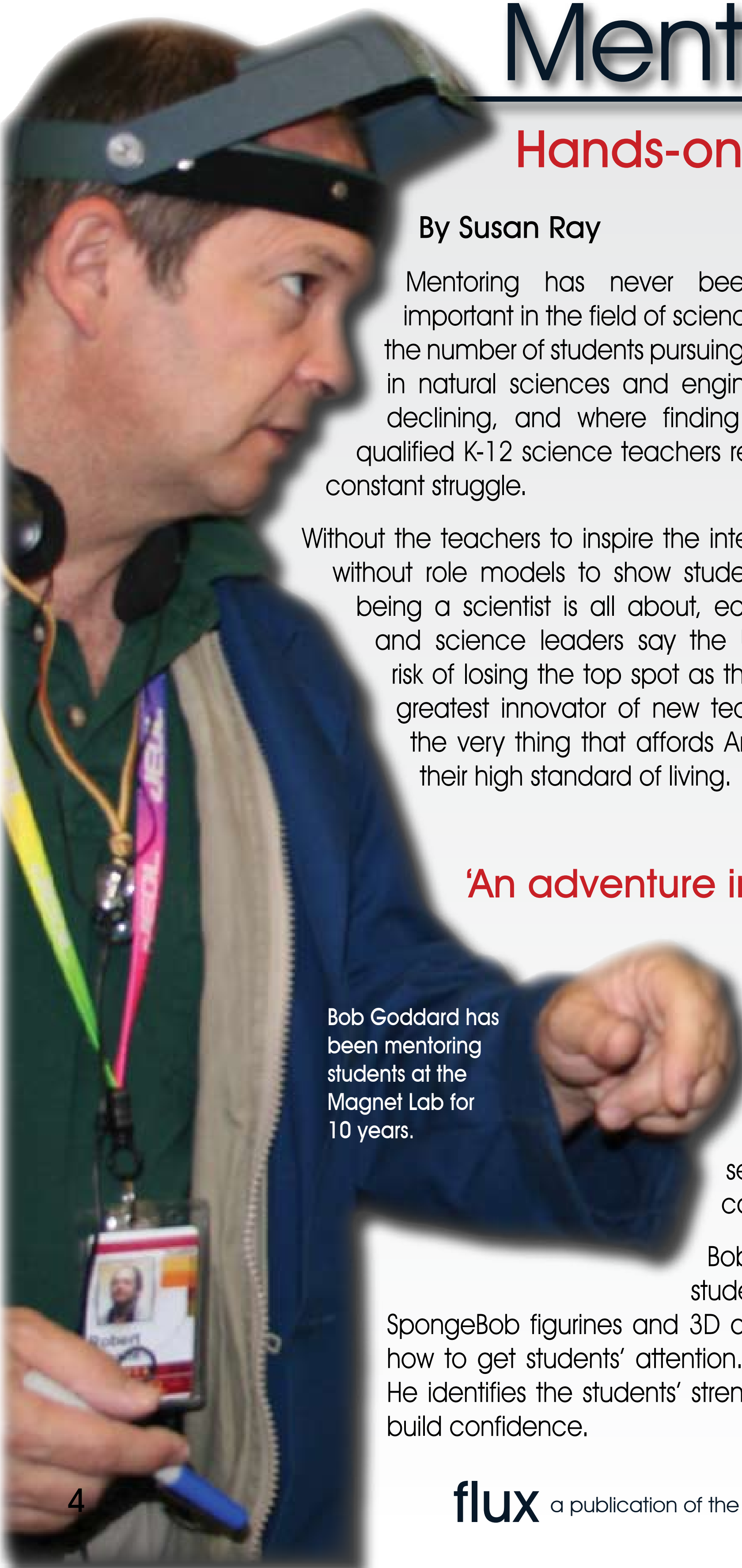
As committed as the lab is to pushing toward new scientific discoveries, it's equally committed to creating new scientists. Undergraduates, grad students, and grade school students as young as elementary age work and learn at the Magnet Lab. Inside *Flux*, you'll find educational resources, including projects you can do with your children or students, profiles of young people who use the lab's resources to build a relationship with science and stories about researchers committed to building and mentoring the next generation of scientists.

At the heart of the Magnet Lab's mission is curiosity-based research – a drive to understand how and why the world works on its most basic level. This kind of work requires precision, focus and creativity. Like the lab, *Flux* is curiosity-based. Find a story or a page that interests you and settle in. Try one of our at-home experiments, learn about a new person or write us a letter and ask a question. We'll be happy to explore the answer with you.

Mentoring Matters

Hands-on instruction pays off

By Susan Ray



Bob Goddard has been mentoring students at the Magnet Lab for 10 years.

Mentoring has never been more important in the field of science, where the number of students pursuing degrees in natural sciences and engineering is declining, and where finding enough qualified K-12 science teachers remains a constant struggle.

Without the teachers to inspire the interest and without role models to show students what being a scientist is all about, economists and science leaders say the U.S. is at risk of losing the top spot as the world's greatest innovator of new technology, the very thing that affords Americans their high standard of living.

The Magnet Lab takes very seriously its responsibility to help groom the next generation of scientists and has developed an extensive educational outreach program that capitalizes on lab resources.

The key to the success of the lab's educational outreach programs are the scientist mentors who volunteer their time – and lots of it – to ensure students and teachers leave the lab with lasting lessons.

"We are completely dependent on the mentors, and I am grateful to them every day," said Patricia Dixon, who directs the lab's Center for Integrating Research & Learning. "There's often a lot of talk about how successful our programs are, but what underlies that success, what makes it possible, is the incredible commitment the scientists make to these students and teachers. We really could not do it without them."

'An adventure in science'

The lab reaches out to the community in myriad ways, but the middle school mentorship and research experiences for teachers and undergraduates are its signature programs.

For the middle school mentorship, between 12 and 17 students from Tallahassee's School of Arts and Sciences conduct a semester-long research project at the Mag Lab. Working with lab scientists, they see firsthand how real-world science is conducted and what kinds of careers they could pursue in the field.

Bob Goddard, who runs the lab's Microanalysis Laboratory, has mentored students, primarily middle schoolers, for 10 of his 11 years at the lab. From SpongeBob figurines and 3D displays to pictures of insects magnified many times over, he knows how to get students' attention. And while he has it, he's going to get them interested in science. He identifies the students' strengths and works from there, giving them daily doses of science that build confidence.

"They don't always realize when they come in that this is an adventure in actual science," Goddard said. "I show them how to use the tools, but they choose the adventure."

His middle school students have looked at rust, stainless steel – and even french fries – under high-powered microscopes, and the lessons they learn can be applied to more than science.

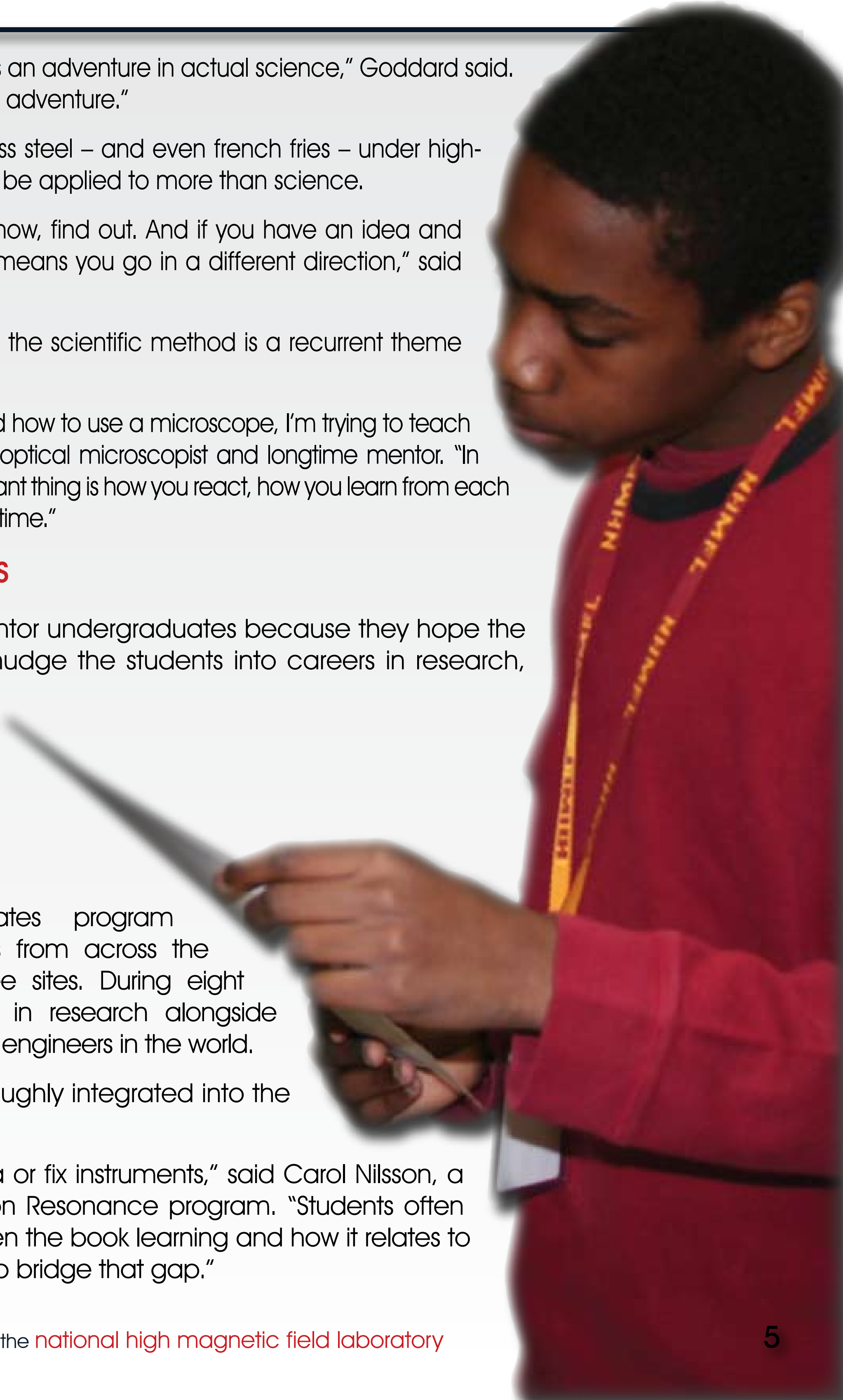
"I try to tell these kids, if there's something you don't know, find out. And if you have an idea and the data doesn't support it, that's not failure. That just means you go in a different direction," said Goddard. "That's the adventure."

Teaching kids how to learn and familiarizing them with the scientific method is a recurrent theme among the lab's mentors.

"Beyond what I teach kids about how to work in a lab and how to use a microscope, I'm trying to teach them how to learn in general," said Mike Davidson, an optical microscopist and longtime mentor. "In science, things screw up on a daily basis. The most important thing is how you react, how you learn from each screw-up how to anticipate what might happen the next time."

Active participation key to success

While it's true that many of the lab's scientists mentor undergraduates because they hope the experience will leave a lasting impression and nudge the students into careers in research, it's also true that the undergraduates do real work and contribute to the scientists' research in meaningful ways.



"I have seen firsthand how productive and valuable they are," said Davidson. "They learn fast and stay focused."

The Research Experiences for Undergraduates program matches high-achieving undergraduate students from across the country with scientists at the Magnet Lab's three sites. During eight weeks in the summer, the students participate in research alongside some of the finest scientists, magnet designers and engineers in the world.

The students aren't just shadowing; they are thoroughly integrated into the research and development activities.

"They might do hands-on work, help analyze data or fix instruments," said Carol Nilsson, a scientist in the lab's Fourier Transform-Ion Cyclotron Resonance program. "Students often have a hard time bridging the connection between the book learning and how it relates to what's happening now. Research experiences help bridge that gap."

That was the case for Nathaniel Falconer, who is now a laboratory assistant and probe developer in the lab's Nuclear Magnetic Resonance division. He participated in the 2003 REU program.

"My experience as an REU was excellent. I was exposed to many facets of the Magnet Lab," said Falconer, who was mentored by William Brey, an engineer. "Through mentorship, I was able to see the manifestation of what I learned in the classroom. It was definitely because of this experience that I chose my career path."

Manuel Ramos had a similar experience. He was an undergraduate at the University of Texas-El Paso when he participated in the 2003 REU program, and when the eight weeks were up, he knew graduate school and a career in research were in his future.

"My mentors taught me how to design an experiment, the relevance of it, how to interpret the data and the most important thing — the purpose of such experiments," said Ramos, who was mentored by Justin Schwartz, Sastry Pamidi and Ulf Trociewitz. "I remember going back home and talking with my relatives about (my research experience). To me, it was like a real performance for a musician or a real art exhibition for an artist."

Now enrolled in the Ph.D. materials science program at UTEP, Ramos said the guidance and friendship offered by his mentors was just as valuable as the learning experience.

"I've decided to become a professor just like my mentors, because to mentor someone and to learn about things that are hidden in nature are experiences that last forever."

Teaching the teacher

The program with perhaps the greatest potential for enhancing science education and students' classroom learning is the Research Experiences for Teachers program. This six-week, summer residential program for teachers is modeled after the REU program and is one of the few programs of its kind in the country that accepts elementary school teachers. In addition to working directly with a scientist, teachers attend weekly seminars focusing on elements of science education, experimental design, the nature of science, process skills, communication in science and inquiry based teaching and learning.

"The teachers take it seriously because they understand the scientist is taking the time and making the effort to translate the work they are doing to the teachers to help them bring real-world science into the classroom," said Dixon. "Through this process, the teachers learn about inquiry, about the nature of working as a scientist and about the process of doing science. Teachers – and especially students – don't get that from a book."

Goddard, who also works with teachers, said that when teachers come in to his lab, he shows them the microscopes and tells them what he does. They learn by assisting him with images or other data he's working with. But the teachers, he said, come up with the ideas for how to relate what they've learned back to their students.

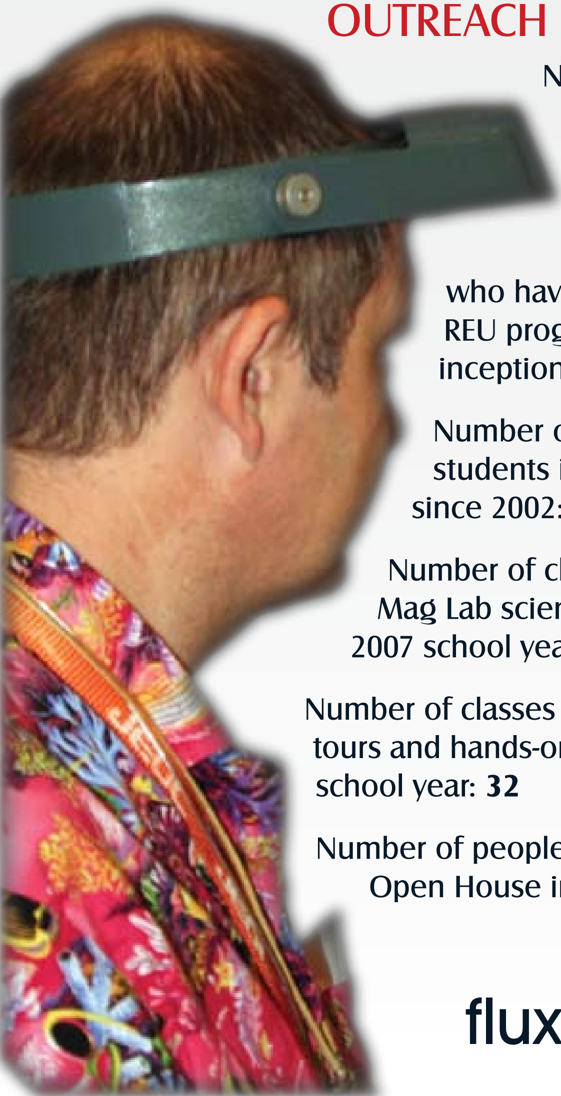
"I want teachers to have fun and to get a renewed appreciation for science," said Goddard. "A lot of teachers feel their knowledge of science is not adequate, but they leave here more confident because they have contributed to actual research."

Apart from sharing what they know with teachers, lab scientists help the teachers reconnect with their natural curiosity and remind them what it's like to be a student.

"I don't think the mentors have any idea how lasting this experience is, particularly for the teachers," said Dixon. "Think about all the teachers who have come through the Research Experiences for Teachers program, and how many students these teachers have touched since. It's enormous the impact lab mentors have on science education."

STAY INFORMED

For more information about the lab's educational outreach efforts, visit www.magnet.fsu.edu/education, contact Pat Dixon at 644-4707, or e-mail pdixon@magnet.fsu.edu.



OUTREACH BY THE NUMBERS

Number of teachers who have participated in the RET program since its inception in 1999: **128**

Number of undergraduates who have participated in the REU program between since its inception in 1999: **160**

Number of middle school students in the mentorship program since 2002: **72**

Number of classrooms visited by the Mag Lab science educators in the 2006-2007 school year: **329**

Number of classes served at the lab through tours and hands-on activities in the 2006-2007 school year: **32**

Number of people who visited the Magnet Lab's Open House in 2007: **3,500**

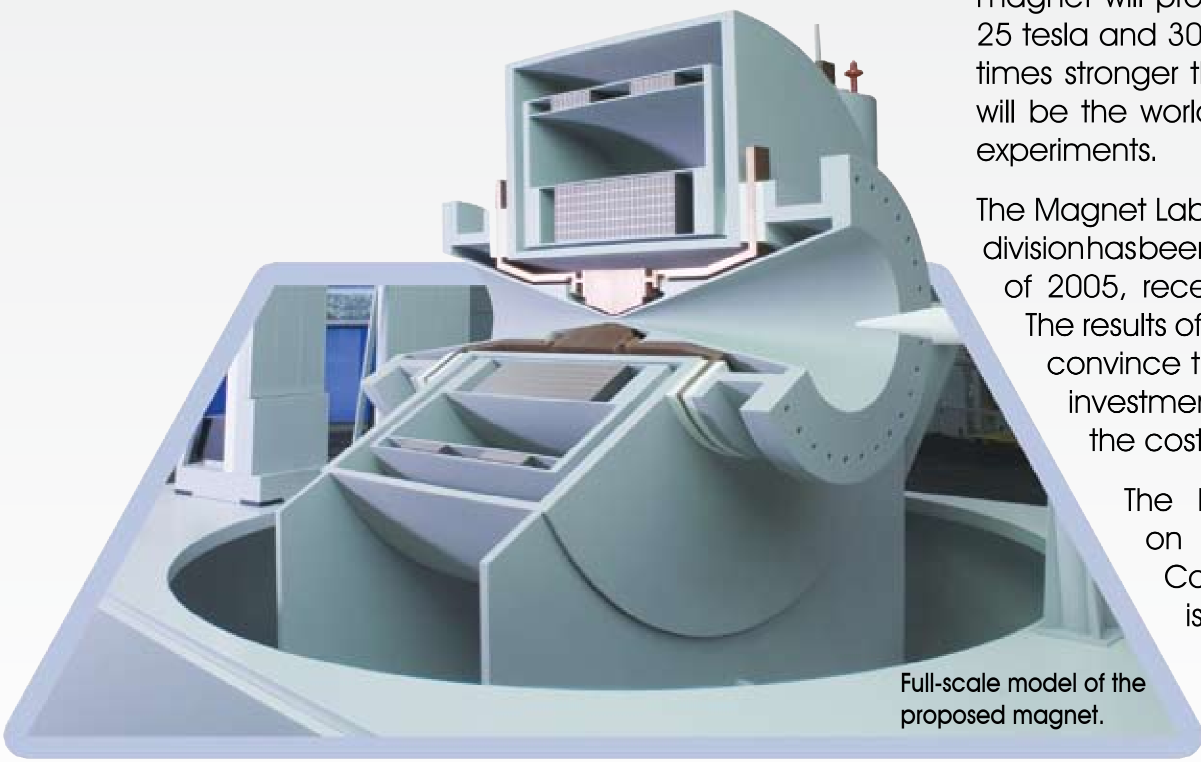
International Partnership

Magnet development pairing a major win for Magnet Lab

By Susan Ray

A world-class research institute in Germany has contracted with the Magnet Lab and Florida State University to build a multi-million-dollar, one-of-a-kind magnet for experiments scientists hope will shed new light on unsolved mysteries of the subatomic world.

The Magnet Lab's engineering team is building the $8.7 million hybrid magnet for the Berlin Neutron Scattering Center, which is part of the Hahn-Meitner Institute (HMI). Like the Magnet Lab, HMI is an international user facility that hosts scientists from around the world who conduct experiments at its facilities.



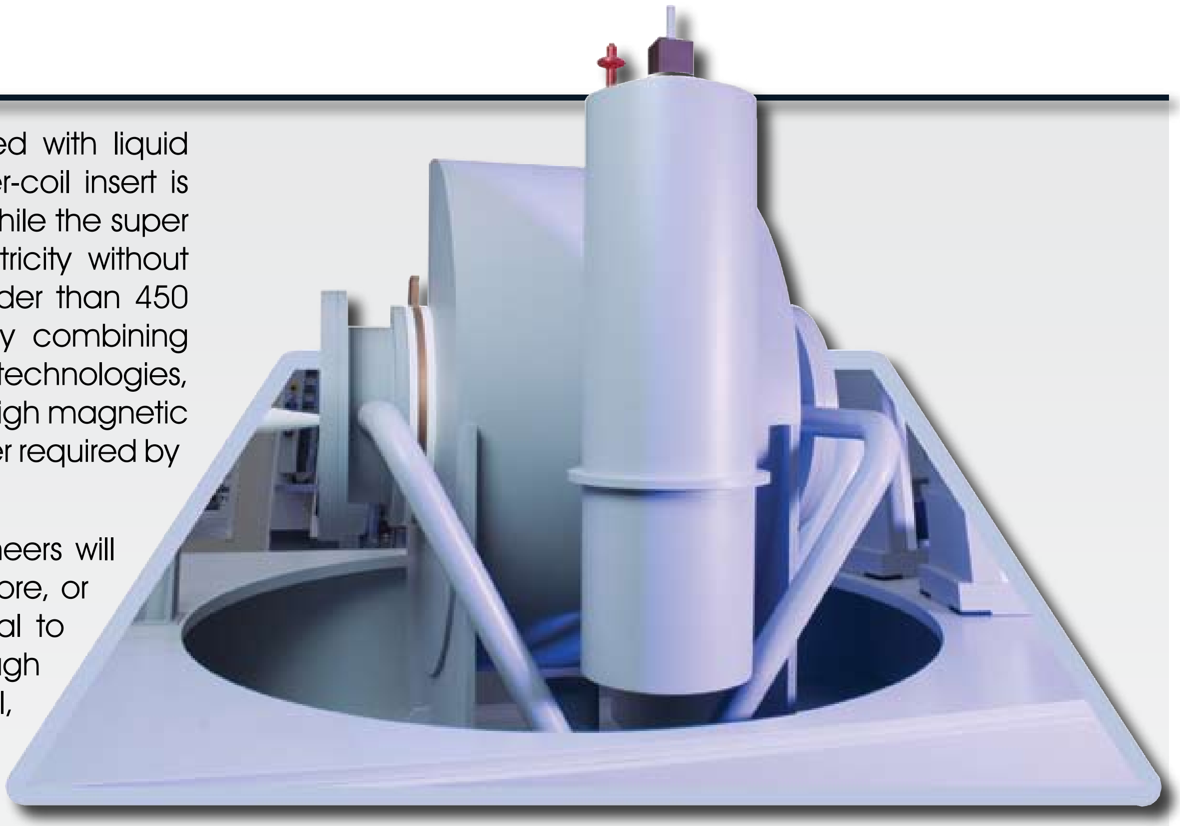
Full-scale model of the proposed magnet.

"Part of the challenge in science is figuring out how to maximize resources," said Mark Bird, director of the lab's Magnet Science & Technology division. "We can't always afford to bring the tools and techniques to our own magnets; sometimes we have to send the magnets to the tools to advance the science."

Developing partnerships with other universities, national and international labs and industry are part of the laboratory's mission to advance magnet technology to provide the highest magnetic fields possible for scientific research. When finished in 2011, the new, high-field magnet will produce a magnetic field between 25 tesla and 30 tesla — more than half a million times stronger than the Earth's magnetic field. It will be the world's strongest magnet for neutron experiments.

The Magnet Lab's Magnet Science & Technology division has been working with HMI since the summer of 2005, recently completing a design study. The results of that study were strong enough to convince the German government that the investment in the new technology was worth the cost.

The Berlin-bound magnet is based on the Magnet Lab's Series Connected Hybrid concept, which is currently under development. The lab's Series Connected Hybrid combines copper-coil "resistive" magnet technology in the magnet's interior with a superconducting magnet, cooled with liquid helium, on the exterior. The copper-coil insert is powered by an electrical current, while the super conducting outsert conducts electricity without resistance as long as it is kept colder than 450 degrees below zero Fahrenheit. By combining the power supplies of these two technologies, engineers can produce extremely high magnetic fields using just one-third of the power required by traditional magnets.



The version that Magnet Lab engineers will build for HMI is different in that its bore, or experimental space, will be conical to allow neutrons to be scattered through large angles. It also will be horizontal, as opposed to the traditional vertical bore of most high-field magnets. These modifications make the magnet ideal for neutron scattering experiments, which are among the best methods for probing atoms to better understand the structure of materials.

"With this major piece of equipment, Hahn-Meitner Institute itself becomes a magnet, pulling in researchers from around the world to Berlin," said Thomas Rachel, parliamentary state secretary of Germany's Federal Ministry of Education and Research.

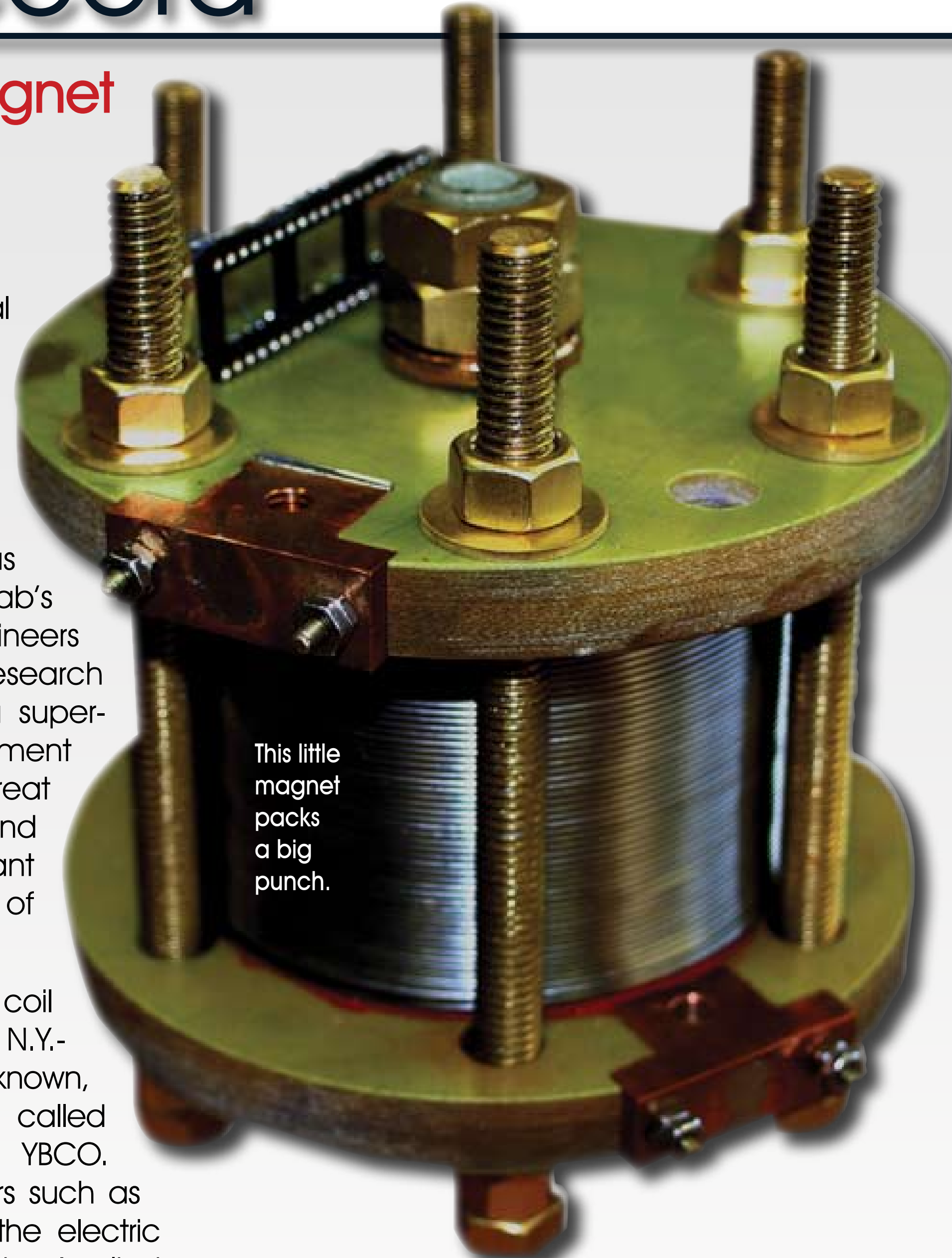
Neutrons are remarkable probes of phenomena within solids. With this new magnet, scientists from around the world will be able to carry out experiments that aren't currently possible. One of the greatest challenges in physics is to develop a comprehensive theory describing high-temperature superconductors. The study of superconductors could lead to revolutionary and cost-saving applications for the electric power industry.

In addition to the HMI work, the lab also is conducting a National Science Foundation-funded engineering design of a split-gap Series Connected Hybrid for the Spallation Neutron Source, a neutron facility in Oak Ridge, Tenn.

New World Record

Superconducting magnet hits 26.8 tesla

By Susan Ray



This little magnet packs a big punch.

A collaboration between the National High Magnetic Field Laboratory and industry partner SuperPower Inc. has led to a new world record for a magnetic field created by a superconducting magnet.

The new record — 26.8 tesla — was reached this summer at the Magnet Lab's High Field Test Facility and brings engineers closer to realizing the National Research Council goal of creating a 30-tesla superconducting magnet. The development of such a magnet could lead to great advances in physics, biology and chemistry research, as well as significant reductions in the operating costs of many high-field magnets.

The world-record magnet's test coil was wound by Schenectady, N.Y.-based SuperPower with a well-known, high-temperature superconductor called yttrium barium copper oxide, or YBCO. SuperPower develops superconductors such as YBCO and related technologies for the electric power industry. The Magnet Lab's Applied Superconductivity Center has worked with the company to determine the superconducting and mechanical properties of YBCO, as well as other materials.

"This test demonstrates what we had long hoped — that YBCO high-temperature superconductors being made now for electric utility applications also have great potential for high-magnetic-field technology," said David Larbalestier, director of the Applied Superconductivity Center and chief materials scientist at the Magnet Lab. "It seems likely that this conductor technology can be used to make all-superconducting magnets with fields that will soon exceed 30 tesla. This far with fields that will soon exceed 30 tesla. This far exceeds the 22- to 23-tesla limit of all previous niobium-based superconducting magnets." (Niobium is the material used to build most superconducting magnets.)

Venkat Selvamanickam, vice president and chief technology officer at SuperPower, said the YBCO wire's potential for application outside the electric power industry has long been in the company's sights.

"We are encouraged by the results of these tests at the Magnet Lab and look forward to continuing our collaboration to more completely explore the additional possibilities in high-field applications," Selvamanickam said. Scientists have been aware of the amazing properties of YBCO and its potential for magnet technology for 20 years, but only in the past two years has the material become commercially available in the long lengths needed for magnets. Scientists at the Magnet Lab are interested in the material because at very low temperatures, the conductor is capable of generating very high magnetic fields.

"In principle, YBCO is capable of producing the highest-field superconducting magnets ever possible," said Denis Markiewicz, a scientist in the lab's Magnet Science & Technology division. Based on the potential of the material, he said, it's even possible that it could one day produce magnetic fields as high as 50 tesla.

"What we learned from this test really opens the door to imagining that one day, we could use superconducting magnets in place of our resistive magnets," he said. Resistive magnets, primarily used for physics research, are more costly to operate because they are powered by tremendous amounts of electricity, while superconducting magnets require little or no electrical power to run once they are brought up to full field. The Magnet Lab's annual utility costs to run the magnets are close to $4 million, and the lab consumes 10 percent of the city of Tallahassee's generating capacity.

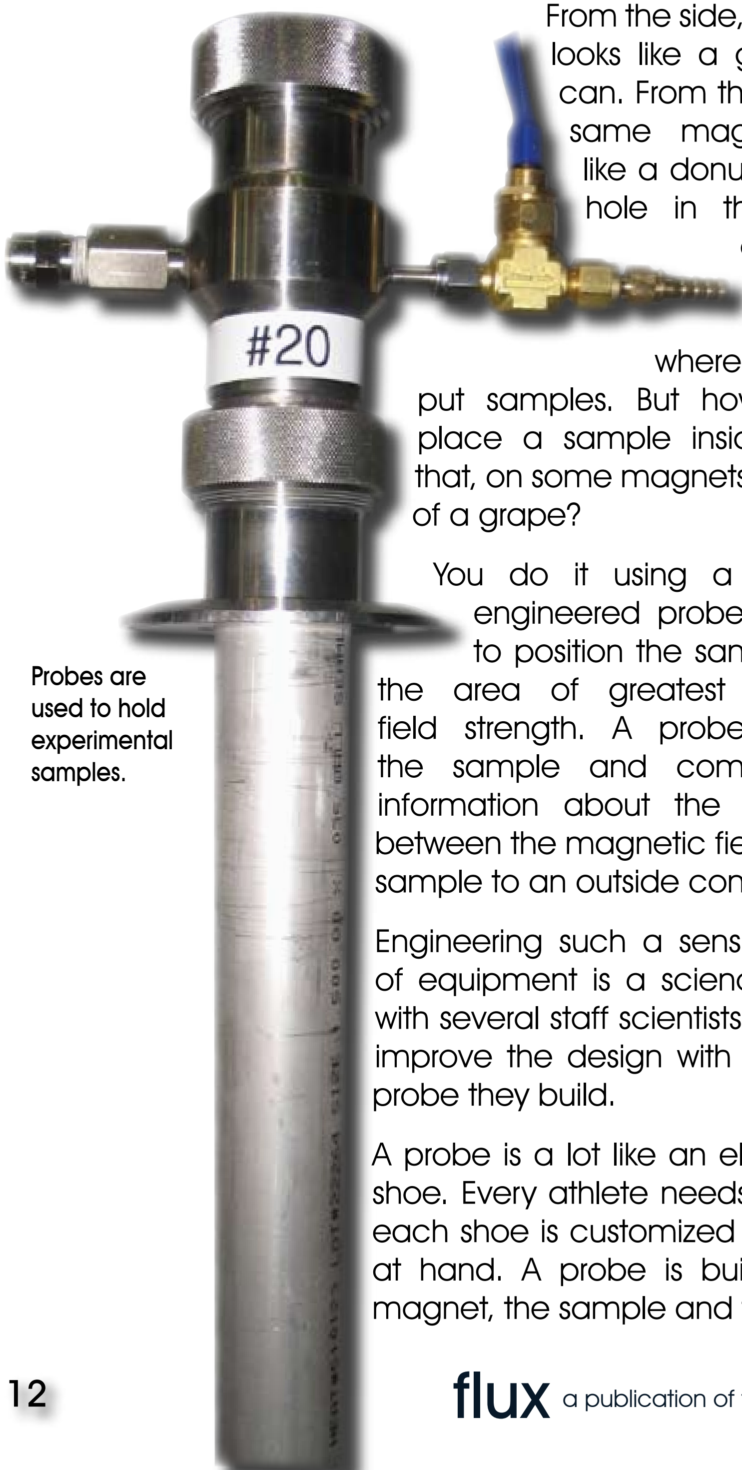
STAY INFORMED

To learn more about superconductivity and superconducting magnets, visit the Magnet Academy in the Education section at http://www.magnet.fsu.edu/education/tutorials/magnetacademy/

What is This?

A look inside magnet probes

By Amy Mast



Probes are used to hold experimental samples.

From the side, a magnet looks like a giant soda can. From the top, that same magnet looks like a donut hole. The hole in the middle of the cylinder is the place where scientists put samples. But how do you place a sample inside a hole that, on some magnets, is the size of a grape?

You do it using a precision-engineered probe designed to position the sample inside the area of greatest magnetic field strength. A probe stabilizes the sample and communicates information about the interaction between the magnetic field and the sample to an outside computer.

Engineering such a sensitive piece of equipment is a science in itself, with several staff scientists working to improve the design with each new probe they build.

A probe is a lot like an elite athletic shoe. Every athlete needs one, and each shoe is customized for the job at hand. A probe is built with the magnet, the sample and the type of data scientists need in mind. Building a probe is such detailed, research-intensive work that, when creating new kinds of probes, the lab completes only four to six per year.

"The fewer we build, the harder we're working – it means we're putting together something we haven't done before," said Bill Brey, an engineer in the lab's Nuclear Magnetic Resonance group.

The probes must be built wholly out of non-magnetic parts, some of which are machined from scratch in the lab's machine shop, some of which are purchased from companies that sell parts for MRI equipment.

As complex as the construction of a probe can be, once they are complete, they're easy enough for visiting scientists from many different fields of study to use.

In addition to the probes built by Magnet Lab engineers, visiting scientists often bring their own probes. But whether it's a state-of-the art Mag Lab probe or a commercially produced products you can't do research in high magnetic fields without one!

Magnet Fact or Fiction?

By Amy Mast

Aren't magnets pretty much shaped like horseshoes? Are the ones at the Magnet Lab larger versions of the ones on our refrigerators?

The magnetic field created at the Magnet Lab is the same kind of field created by refrigerator and horseshoe-shaped magnets. The field is just created differently. The magnets on your fridge are permanent magnets, while electromagnets at the lab are temporary – created by a current.

How do scientists create these super strong fields?

All magnetism comes down to electrons. In electromagnets, magnetic fields result from electron flow through a conductor. In the case of permanent magnets, it's the spinning of the electrons that creates magnetism, not their movement through a conducting material.

Engineers make the temporary magnetic fields used at the Magnet Lab in three ways, explained below.

1. Many of the magnets at the lab are built by placing hundreds of metal plates with a hole in the middle on top of one another. These plates are called Bitter plates after their inventor, Francis Bitter. An electrical current is run though these plates, creating a temporary magnetic field that will stay in place as long as the magnet is supplied with electricity. The big hole in the middle creates a space where the magnetic field is concentrated, and researchers put their samples inside this space. The smaller holes are for water to run through; the water helps keeps the magnets cool and running efficiently.

2. A superconducting magnet is also capable of creating very strong fields, but with a different method. For nearly a century, scientists have known that many metals become superconductors – meaning they lose all electrical resistance and can conduct electric current endlessly – when exposed to very low temperatures. The application of this knowledge has led to such technological innovations as magnetic-levitation trains and magnetic resonance imaging, or MRI. So what's the catch? In order to create a magnetic field, superconducting magnets must be kept extremely cold with liquid helium.

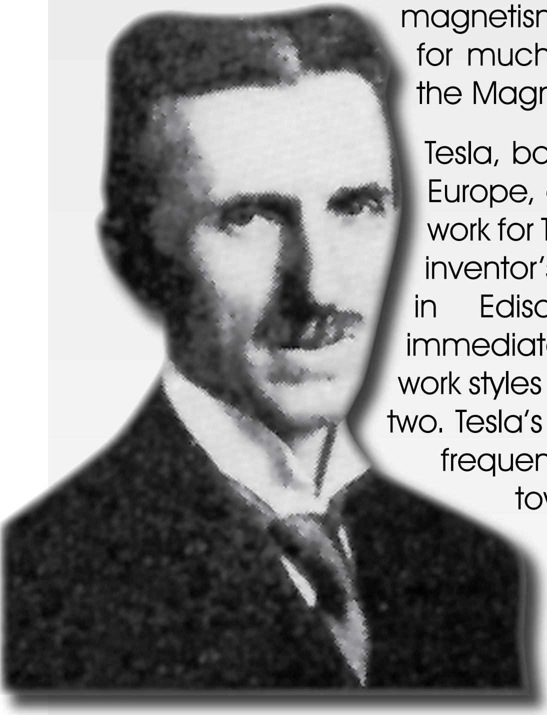
3. A combination of the first two, called a hybrid magnet. A hybrid magnet combines elements of both types of magnets. Like the lab's other magnets, a hybrid is a giant cylinder. There's a resistive magnet- the first type- at the inner core, surrounded by a superconducting outsert.

Mark Bird works on a resistive magnet.

America's forgotten innovator, Nikola Tesla

By Amy Mast

Nikola Tesla may not be the best-known man in American science and invention, but he's one of the most important. His discoveries – aimed at harnessing the power of electricity and magnetism – formed the groundwork for much of the technology used at the Magnet Lab today.



Nikola Tesla (1856-1943)

Tesla, born in Serbia and schooled in Europe, came to America in 1884 to work for Thomas Edison at the famous inventor's Menlo Park laboratory in Edison, New Jersey. Almost immediately, their different ideas and work styles caused tension between the two. Tesla's focus on scientific discovery frequently clashed with Edison's bent toward turning a profit. Inside of two years, Tesla left Edison's employ, and he worked for a year as a ditch digger to raise funds for his own New York City laboratory.

In the late 1800s, his most productive years as a scientist, Tesla was a prolific inventor. He is credited with the invention of the radio and with the development of technology to harness alternating current (AC) into the reliable power source we all use today. AC power and Tesla's AC polyphase motor, along with the incandescent light bulb (invented by Tesla's rival, Edison) ushered in the second Industrial Revolution. This revolution in mechanization helped to establish America as a world power that was here to stay.

In New York City, Tesla built various laboratories, making discovery after discovery and also at times making his neighbors uneasy, earning for himself the reputation of a "mad scientist." He built vacuum tubes that lit up wirelessly and he developed the Tesla coil in the 1890s, using it for many of his electrical experiments. Tesla, fascinated by the coil's erratic bursts of miniature lightning, experimented with them all his life, building the world's largest coil in Colorado Springs, Colorado, in 1899. Unlike his former mentor Edison, Tesla was

A TRUE ECCENTRIC

- Tesla spoke seven languages fluently: English, French, Czech, Serbo-Croatian, Latin, Hungarian and Italian.
- Nikola Tesla's many innovations and accomplishments were not accompanied by sustained riches; his profits were poured back into each new scientific endeavor and he died in debt. He once famously tore up a contract with Westinghouse that would have made him a billionaire.
- Tesla was a close friend of legendary American author Mark Twain.
- Today, Tesla probably would have been diagnosed with obsessive compulsive disorder (OCD). In later life, the scientist was hamstrung by many of his obsessions, including a hatred of jewelry and round objects and a fixation on the number three. He never owned a house or an apartment, preferring to live in hotel rooms whose room numbers were divisible by three.

never an astute businessman. When a project or line of experimentation was finished, he'd sell off his supplies, pay off some of his debts and start over from scratch.

Nikola Tesla holding in his hands balls of electrical energy.

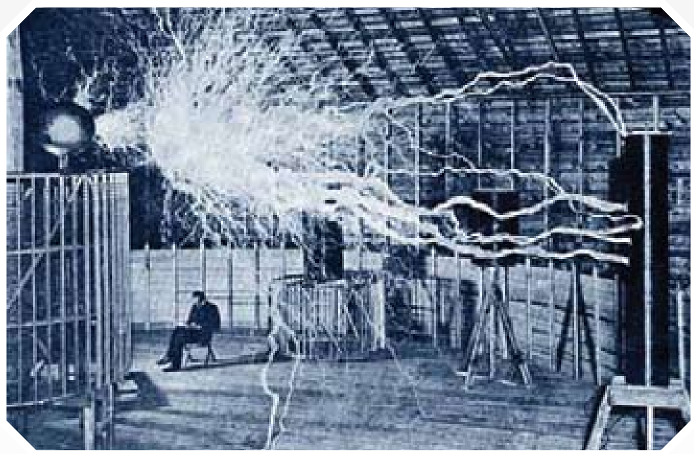
Though Tesla continued working as furiously as ever, after 1900 his reputation began to fall into disrepute. While he continued to produce important results, such as outlining in 1917 the technology that would eventually become radar, his interests began to dovetail into ideas as diverse as harnessing energy from the air and contacting life on other planets. Ideas like these made investors nervous, and several of Tesla's large projects either failed or remained unfunded.

The most crushing blow to Tesla's later career was the 1904 decision to rescind the radio patent Tesla had been awarded and instead give it to Italian inventor Guglielmo Marconi, who then shared the Nobel Prize in Physics for the invention. Tesla filed a lawsuit to reclaim the patent, but it wasn't restored to him until after his death in 1943, when the U.S. Supreme Court reversed the decision.

Though Tesla died in obscurity, his work earned him a place in history as America's greatest electrical engineer. Computer science, theoretical physics, ballistics, nuclear physics, robotics and radar all benefited from his theories and experiments. Though his accomplishments were at times overshadowed by his eccentricities and carelessness with money, he earned for himself an important place in world scientific history.

FACTOID

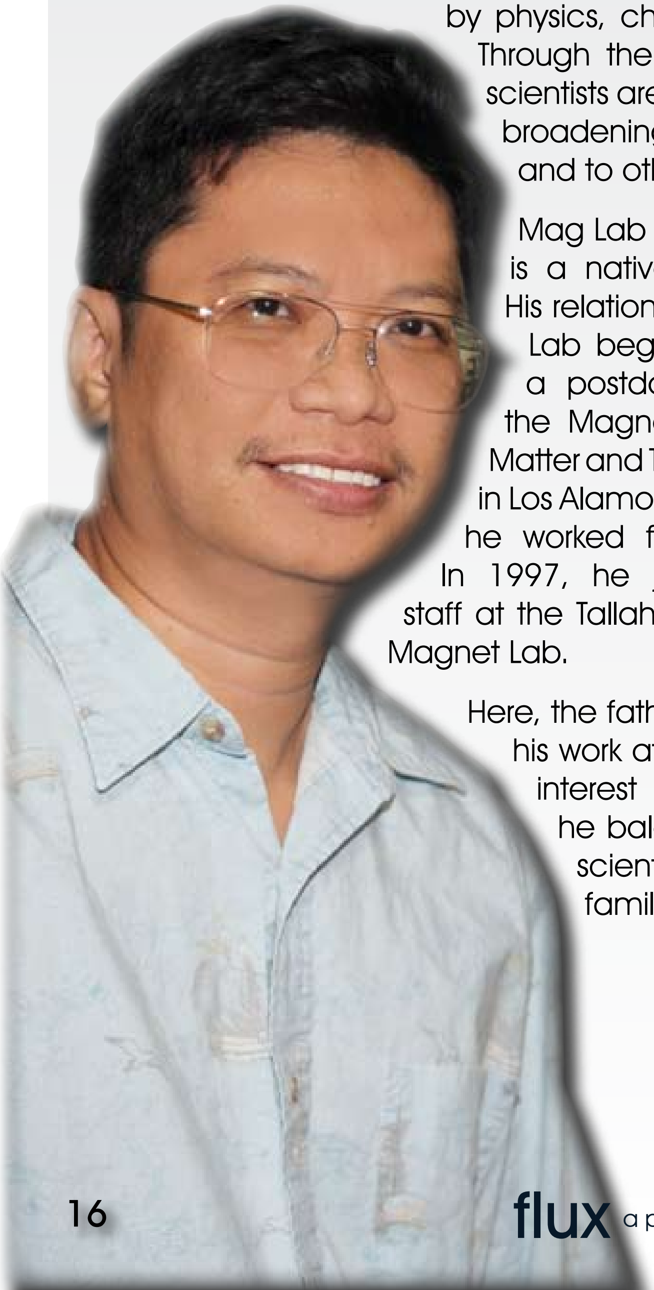
Every day at the Magnet Lab, someone says Tesla's name. Why? The unit of measurement "tesla," which describes the strength of a magnetic field, was named in Nikola Tesla's honor in 1960. The Magnet Lab's largest continuous field magnet is measured at 45 tesla.



Tesla's Colorado labaratory.

Condensed matter scientist Arneil Reyes talks about his career as a real-life mythbuster

By Amy Mast



Magnet Lab staff scientists come from all over the world, building lives in Tallahassee and exploring some of the most intriguing questions posed by physics, chemistry and biology. Through the lab's user program, scientists are exposed to an ever-broadening exchange of ideas and to other cultures.

Mag Lab physicist **Arneil Reyes** is a native of the Philippines. His relationship with the Magnet Lab began when he landed a postdoctoral fellowship at the Magnet Lab's Condensed Matter and Thermal Physics group in Los Alamos, New Mexico, where he worked from 1990 to 1994. In 1997, he joined the scientific staff at the Tallahassee branch of the Magnet Lab.

Here, the father of four talks about his work at the Magnet Lab, his interest in science and how he balances a demanding scientific career with his family life.

How would you describe your job to a layperson?

I'm a mythbuster. I get a chance to be creative, to make something original out of the resources at the lab; it allows me to test whether a myth is possible or busted. It's really exciting. I am an experimental physicist, which means I do a lot of testing of scientific theories. Where it departs from the mythbusters comparison is where we have the chance to discover something new.

How did you come to know you wanted to pursue physics as a career?

I was always fascinated by watching my uncles. None of them graduated college but they were so skillful with their hands. I have an uncle who's a painter. I have an uncle who can do a lot of electrical stuff; one who repairs radios. One has a junk shop and he can repair a lot of stuff. I was impressed with the things they could do. Physics was my favorite subject when I was in high school, and that combined with how I grew up and what I saw around me helped me to decide.

How did your career in physics begin?

I started at a junior school and got a scholarship, an opportunity to do physics. After college I was teaching at a high school and a college at the same time. I would start at 7:30 a.m. and go until 9:30 p.m., from one school to another. In my country teaching is not a financially rewarding career, so I thought this would not be something I want to stay with if I had a family. Coming here to this country is very different and the experience has been very satisfying.

You have a degree in physics education. How is science education in the United States different from the Philippines?

A lot of things have changed since I left. I have spent half of my life here. The U.S. government gives a lot of support toward understanding how science works in this country and it's a very positive thing. There are a lot of resources for researchers and educators. I see my kids growing up here and they knew the Pythagorean theorem in middle school. I didn't learn that until college.

In the Philippines, in order to graduate, I had to go out to a village and teach the teachers how to teach physics. I had to do a lot of improvisation. What we do in the U.S., for example, when we measure a specific heat capacity of matter, we use dewars and a thermometer. There, we were using Styrofoam cups. Without instrumentation, you have to be resourceful.

You frequently mentor students here at the Magnet Lab. Why do you think it's important to keep working with students?

I still love to teach, primarily because I feel more useful to people in the community that way. It's not just the picture of scientists we have in our mind of someone shut up in the lab all of a sudden having this big discovery… I think a scientist has a responsibility to the society he gets his funding from; he owes it because of his training, and most importantly, the society pays his salary. It's a privilege at this lab to do experiments without having to teach. Still, teaching is one way of sharing your knowledge.

Do you find it difficult to balance the demands of a scientific career with your family?

I have four children. I try to set an example – even if I am always busy I will always have time for my children, that's important. A career in science is very susceptible to getting ... addicted to. Once you get stimulated, you want to continue and finish it. When I have a problem, I want to go until I solve it. You have to kind of discipline yourself.

Somebody told me at the beginning of my career that there is more to life than physics, and I keep on remembering that, because the ultimate happiness is not only your career but also the people you love and understand.

When you retire and you leave the science, what's going to happen is people are not going to ask you, what did you do? They are going to ask you, how are your kids? How did your kids turn out? They are not going to say, did you do experiments with superconductors when you were a scientist? No one is going to ask me that at a party.

You can make an electromagnet!

Mag Lab Staff Report

What do you get when you mix a battery, a bit of copper wire and a nail? You get an electromagnet – one of the most important forces in science. Electromagnets are not like the permanent magnets you're used to (the ones holding up calendars on your refrigerator); they are basically a wire conducting electric current, which in turn generates a magnetic field. (Magnetism and electricity are very closely related phenomena.) With an electromagnet, you can turn it off and on.

Electromagnets have a wide range of uses and can be found in many devices, including Magnetic Resonance Imaging Machines used in hospitals, remote-control toy cars and many appliances in your home. They vary in strength from very weak magnets used to detect electric currents to the huge research instruments used at the Magnet Lab. Are you ready to make one?

What you'll need

- One D-cell battery
- Insulated copper wire (available at most hardware stores)
- A nail from a hardware store
- Paper clips
- Compass

What you'll do

1. Before you begin to build your electromagnet, let's check to see if the nails are magnets. Do they attract the paper clips? Now, place the wire against the compass. Do you see any reaction?
2. Connect the insulated wire to the battery. Make sure you complete the circuit by attaching the ends of the wire to opposite ends of battery. Place the compass under the wire. Is there any reaction?
3. Disconnect one end of the wire. Wrap it around a nail 15 times before connecting it back to the battery. What do you see when you bring the compass near? Is this reaction different from what you saw when you placed the compass under the straight wire? Can you pick up paper clips with the wire? Can you pick up paper clips with the nail?
4. Remove the nail from the wire without unwinding it. Will the wire pick up any paper clips? Will the nail alone pick up any paper clips?
5. Place your compass under the wound wire. Do you get the same reaction as you did when you observed the compass in Step 4? How can you explain this?

What happened (and why)?

In step 1, when you tested the nail to see if it was a magnet, you realized it was not because it didn't attract the metal in the paper clip. However, nails can be magnetized. Your compass did not react to the wire because the wire by itself emitted no magnetic field.

In step 2, when you placed the compass under the wire, the needle deflected because the wire was now carrying an electric current generated by the battery, and current-carrying wires have a magnetic field around them.

In step 3, after you added the nail and coiled the wire around it, the compass picked up a much stronger magnetic field. That's because a coiled wire creates a stronger magnetic field than a simple length of wire (the more coils, the stronger the field), and adding a nail in the middle boosts that field even more. The wire itself did not pick up the paper clip (its magnetic field was too weak), but the nail and coiled wire did.

In step 4, the nail picked up the paper clip this time because you had magnetized it by exposing it to the magnetic field of the current running in the wire. But without the nail inside it, the wound wire still didn't produce enough of a magnetic field to pick up the paper clips.

In step 5, the compass measured a magnetic field in the wound wire (minus the nail) that was stronger than the field in the uncoiled wire, but weaker than the field in the coiled wire with the nail inside.

DID YOU KNOW?

- The magnetic field of a refrigerator magnet is more than 10 times stronger than the Earth's magnetic field.
- There are two units of measure for magnetic fields: gauss and tesla. One tesla equals 10,000 gauss. The Earth's magnetic pull is about 0.5 gauss. A 1 tesla magnet is strong enough to pick up a car. Our strongest magnet at the Mag Lab is a whopping 45 tesla – the strongest sustained magnetic field on the planet.

THINK QUICK

Which of the following household items does not use an electromagnet?

- An automobile
- A computer
- A washing machine
- A stereo system

Answer: None of the above! The fact is it's hard to find an appliance that doesn't have an electromagnet in it!

TRY THIS AT HOME...

...highlights easy, fun and low-cost ways to explore science outside the classroom. Explore this and similar activities online at magnet.fsu.edu/education.

Science Starts Here

Garage comets propel teen to science success

By Amy Mast

Most kids come home from summer camp with bug bites, dirty laundry and a nascent crush. Tallahassee resident Annie Bist came home with a winning idea – but then, she didn't visit an ordinary camp.

Bist had participated in SciGirls 2006, a multi-stage, hands-on science day camp for middle- and high-school girls. There, the girls met students, educators and science professionals who shared their interest in science. In addition to the science itself, the girls learned investigative and problem-solving techniques with more general applications.

SciGirls is a partnership between WFSU, the Magnet Lab, the FSU Saturday at the Sea Program and the Tallahassee Museum that's made possible through funding from Dragonfly TV and the National Science Foundation. Each site develops activities designed to inspire girls to consider careers in science. It was one of these demonstrations at the Magnet Lab that inspired what would become Bist's award-winning science fair project the following year.

Pat Dixon, director of the lab's Center for Integrating Research & Learning, showed the girls how to use common household materials to create a facsimile of a comet.

"I was just enthralled. It was so cool to see," said Bist. When the time rolled around for her freshman year science fair project, she said, she remembered the demonstration and contacted the Magnet Lab.

Bist connected with Mabry Gaboardi, a graduate research assistant in the lab's Geochemistry Program, who helped her develop a project. Together, they decided to focus on what makes comets most distinctive – the formation of a tail.

"Mabry had been telling me that they had been finding comets in the asteroid belt where technically, they're not supposed to be. One of

KEY TERM: SUBLIMATION

Sublimation is when a solid, frozen material changes to gaseous form. It's like ice melting directly into steam without the middle, watery stage. A common material that sublimates is dry ice, which Annie used in her experiments.

the hypotheses that had been made as to why they were finding them there was that there had always been comets there, but something was making the comets suddenly sublime so they were showing the tail," Bist explained.

"She said even if there was just a really thin outer layer around those volatiles inside the comet then there would be no tail because that outer layer would be protecting the volatiles from heat."

Bist decided to test whether an impact would take off that outer layer and make the volatiles show, in turn creating a tail. The Magnet Lab lent her a "comet kit" containing basic ingredients and instructions – and Bist set up shop in her garage, cooking up comets in three different sizes for comparison.

After two hours in the family freezer, Bist's comets were ready. She dropped them on the concrete floor of her garage from a height of 6 feet. Her results weren't consistent with the size of the comets as she had expected.

"I wanted to see whether they sublimed," she explained. "I found out that most of them didn't and there was really no definite conclusion that I could make, because one of the smallest comets sublimed, and two of the largest comets sublimed, so it didn't really make sense."

When Bist took her results to Gaboardi back at the Magnet Lab, she was reassured to learn that some of her research dovetailed with the Magnet Lab's more sophisticated research and methods.

Bist works with SciGirls team.

Bist's project was presented at her school's science fair, where it was selected for regional competition and then for state. Her experience at SciGirls, she said, motivated her to investigate her project on her own.

"I think SciGirls really opens up your horizon," she said. "At school, maybe you have yourself, and you might be interested in science. And then you have twenty-something other kids, who may be interested, or who may not be. When you come to SciGirls, you have all these people who all love science, and so you have the people who are going to be interested. And the teachers working here can really get in-depth and specific, really open our eyes to what's out there."

This summer, as a high-schooler, Bist returned to SciGirls with SciGirls II, where she taught the same comet lesson that inspired her project last year to a new, younger group of girls.

You can watch a video presentation of SciGirls 2006 online at http://www.wfsu.org/kids/sci_girls.html

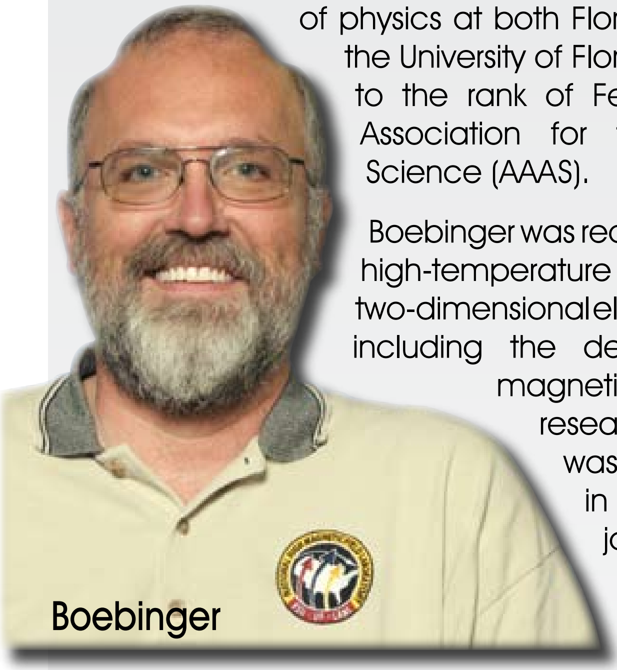
WHAT IS A COMET KIT?

To make her comet, Annie used:

- dry ice
- beach sand
- coca-cola
- soil
- water
- window cleaner

Because dry ice can be dangerous to use, Annie's parents supervised her project.

Mag Lab director named AAAS Fellow



Boebinger

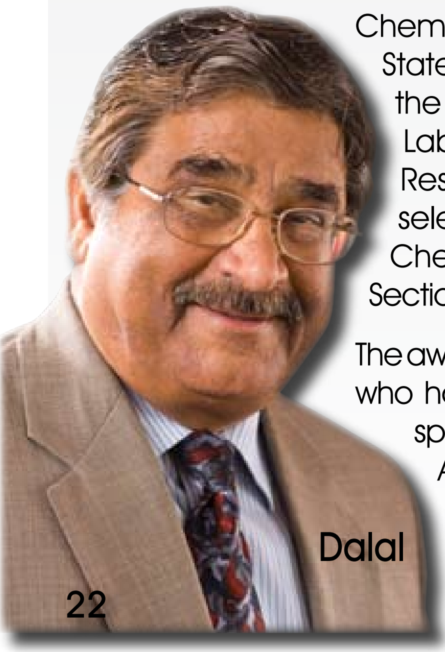
Gregory Boebinger, director of the National High Magnetic Field Laboratory and professor of physics at both Florida State University and the University of Florida, has been elevated to the rank of Fellow by the American Association for the Advancement of Science (AAAS).

Boebinger was recognized "for research in high-temperature superconductivity and two-dimensional electron and hole systems, including the development of pulsed magnetic fields as a prominent research tool." The honor was formally announced in the Oct. 26 issue of the journal *Science*.

Boebinger, a leading researcher in high-temperature superconductivity, also has a strong commitment to interpreting science for students and the general public. In addition to his many scientific publications, he has written articles designed for mainstream audiences in both *Physics Today* and *Scientific American* and has given public lectures all over the country. He also has been interviewed and demonstrated magnetic levitation on the History and Discovery channels.

"I am particularly honored to be named a Fellow in the AAAS because it is a wonderfully cross-disciplinary organization focused on advancing science broadly – much like high-magnetic-field research itself," Boebinger said. "This mission is critically important because there is an increasingly urgent need to educate and train greater numbers of the next generation to become scientists and science-aware citizens."

Dalal receives 2007 Southern Chemist award



Dalal

Naresh S. Dalal, the Dirac Professor of Chemistry and Biochemistry at Florida State University and a researcher with the National High Magnetic Field Laboratory's Electron Magnetic Resonance Program, has been selected to receive the 2007 Southern Chemist Award from the Memphis Section of the American Chemical Society.

The award honors "an outstanding researcher who has brought recognition to the South," specifically the states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Virginia.

Dalal has made notable contributions to spectroscopic techniques spanning frequencies from a few hertz to several terahertz over more than three decades of pioneering research in magnetic resonance spectroscopy, mainly electron magnetic resonance. Such research has novel applications to a wide range of problems, ranging from free radicals in toxicology and carcinogenesis to ferroelectric and magnetic phase transitions in quantum solids, quantum dots, quantum computing and high-temperature superconductivity. Over the course of his career, Dalal has been a prodigious writer and researcher, publishing scholarly articles in more than 350 publications.

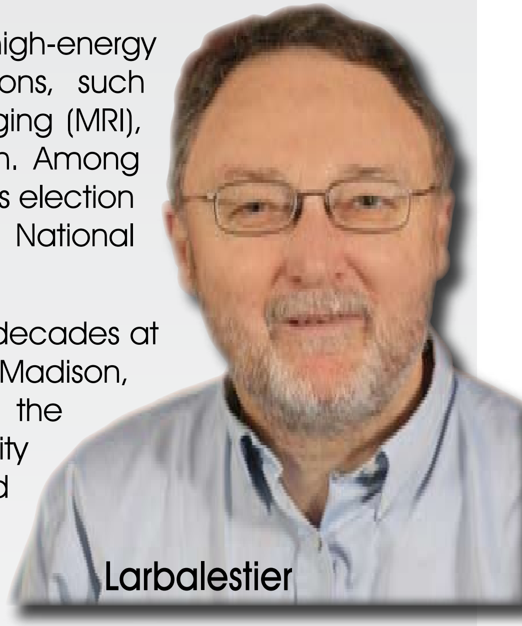
Materials scientist honored with lifetime achievement award

A Florida State University researcher already recognized as one of the world's foremost authorities in the field of materials science is adding another top honor to his collection.

David Larbalestier, the director of Magnet Lab's Applied Superconductivity Center, received the Cryogenic Materials Award for Lifetime Achievements 2007 from the International Cryogenic Materials Conference (ICMC).

Larbalestier is viewed by many of his peers as the leading researcher in the United States, and possibly the world, in the basic research of practical superconducting materials for magnets and power applications. Over a 35-year career, he has profoundly influenced the development of high-field magnets for high-energy physics and other applications, such as magnetic resonance imaging (MRI), that have evolved from them. Among the highlights of his career is his election in 2003 to the prestigious National Academy of Engineering.

In 2006, after more than two decades at the University of Wisconsin in Madison, Larbalestier agreed to move the Applied Superconductivity Center to FSU, where it would work as a new division of the Magnet Lab.

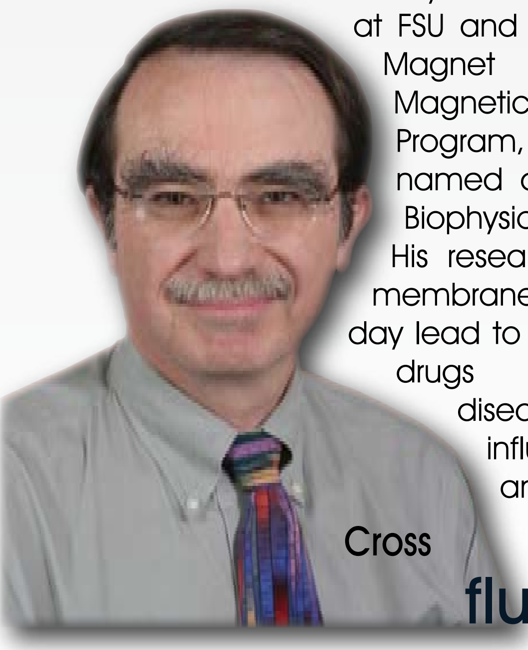


Larbalestier

Two distinguished scientists designated as fellows

Two Magnet Lab scientists have been named fellows of prestigious scientific societies.

Timothy A. Cross, the Earl Frieden Professor of Chemistry and Biochemistry at FSU and director of the Magnet Lab's Nuclear Magnetic Resonance Program, has been named a fellow of the Biophysical Society. His research on protein membranes could one day lead to more effective drugs for treating diseases such as influenza type A and tuberculosis.

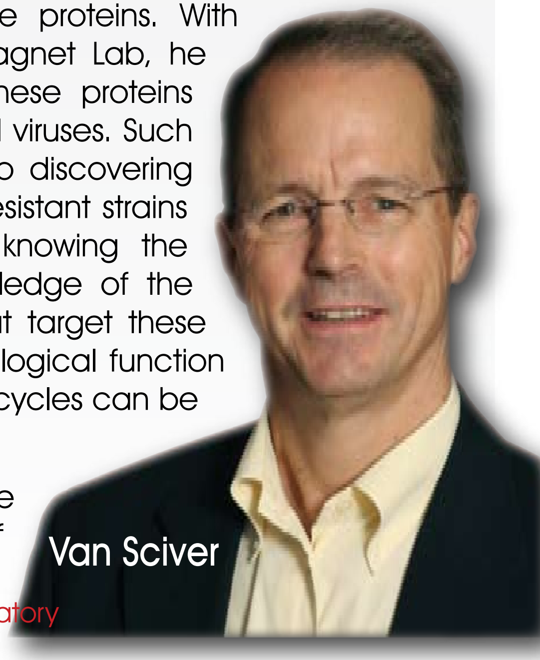


Cross

Cross is one of only five scientists recognized this year by the Biophysical Society out of its membership of 8,000. His research focuses on understanding the chemistry, structure and function of membrane proteins. With unique resources at the Magnet Lab, he is developing images of these proteins that coat bacterial cells and viruses. Such images could be the key to discovering novel drugs to battle drug-resistant strains of infectious diseases. By knowing the shape and having a knowledge of the protein chemistry, drugs that target these proteins and hinder their biological function in the bacterial and viral life cycles can be more easily designed.

Steven Van Sciver, the John Gorrie Professor of

(see page 24)



Van Sciver

Mechanical Engineering at the Florida A&M University-FSU College of Engineering and a founding member of the Mag Lab, is just the fifth member of the Cryogenics Society of America to be named a fellow of that organization since its founding in 1964.

The fellow honor is bestowed on a society member of distinction in cryogenics who has made notable valuable contributions to the field of cryogenics. Van Sciver is the author of more than 150 publications on low-temperature physics, liquid helium technology, cryogenic engineering and magnet technology, and also is author of the highly regarded textbook, "Helium Cryogenics." In addition, he is a fellow of the American Society of Mechanical Engineers and the American editor for the journal *Cryogenics*.

'Absolute Zero' premiers in January

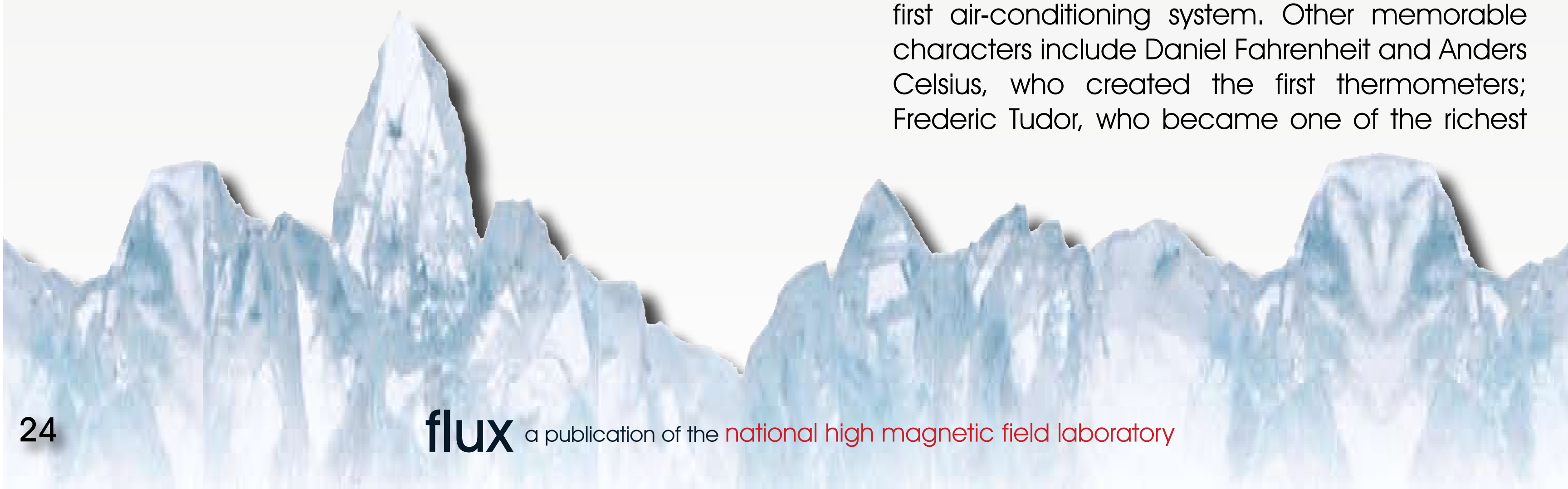
Ever wonder how low-temperature physics affects your daily life? Probably not, but the things we now know about the nature of "cold" were once a mystery to philosophers, scientists and engineers.

The Magnet Lab – a place where very low temperatures are an integral part of our magnets and related research – is a national partner in the Absolute Zero campaign to raise awareness about low-temperature physics. The campaign culminates in January of 2008 with a two-part NOVA special demonstrating how civilization has been profoundly affected by the mastery of cold.

Based on the book, *Absolute Zero and the Conquest of Cold*, the NOVA special will be presented as two hour-long programs scheduled to air Jan. 8 and Jan. 15 at 8 p.m. on Public Broadcasting Service stations (check local listings).

Absolute Zero features the struggle over four centuries to understand the nature of cold, from dark beginnings to an ultra-cold end point. Along the way, scientists created cold technologies that have transformed the way we live, and gained insights into the nature of matter itself. NOVA brings this subject to life using a combination of colorful historic recreations and insightful interviews with science historians and Nobel Prize winners.

Part 1, "Absolute Zero: The Conquest of Cold," begins with 17th century court magician Cornelius Drebbel, who successfully created the world's first air-conditioning system. Other memorable characters include Daniel Fahrenheit and Anders Celsius, who created the first thermometers; Frederic Tudor, who became one of the richest



men in America simply deciding to sell ice; and Clarence Birdseye, who made his name with frozen food.

ABSOLUTE ZERO

Part 2, "Absolute Zero: The Race for Absolute Zero," tells the gripping story of the decades-long scientific race between Scottish physicist James Dewar and Dutch physicist Heike Kamerlingh Onnes, as the two men fought to reach the coldest temperature. Their discoveries opened the door to the modern era of refrigeration and air conditioning. Absolute Zero's final chapter climaxes in the Nobel-winning breakthrough, the production of a new form of matter that Albert Einstein predicted would exist within a few billionths of a degree above absolute zero. This is a temperature so cold that the physical world as we know it transforms completely, electricity and fluids flow without resistance, and the speed of light can be reduced to 38 miles per hour. Three men, in two different labs, were awarded the Nobel Prize in Physics for being the first to see the peculiar state of matter that occurs near absolute zero.

In addition to the TV special, the Absolute Zero campaign includes an educator's guide and a Web site.

STAY INFORMED

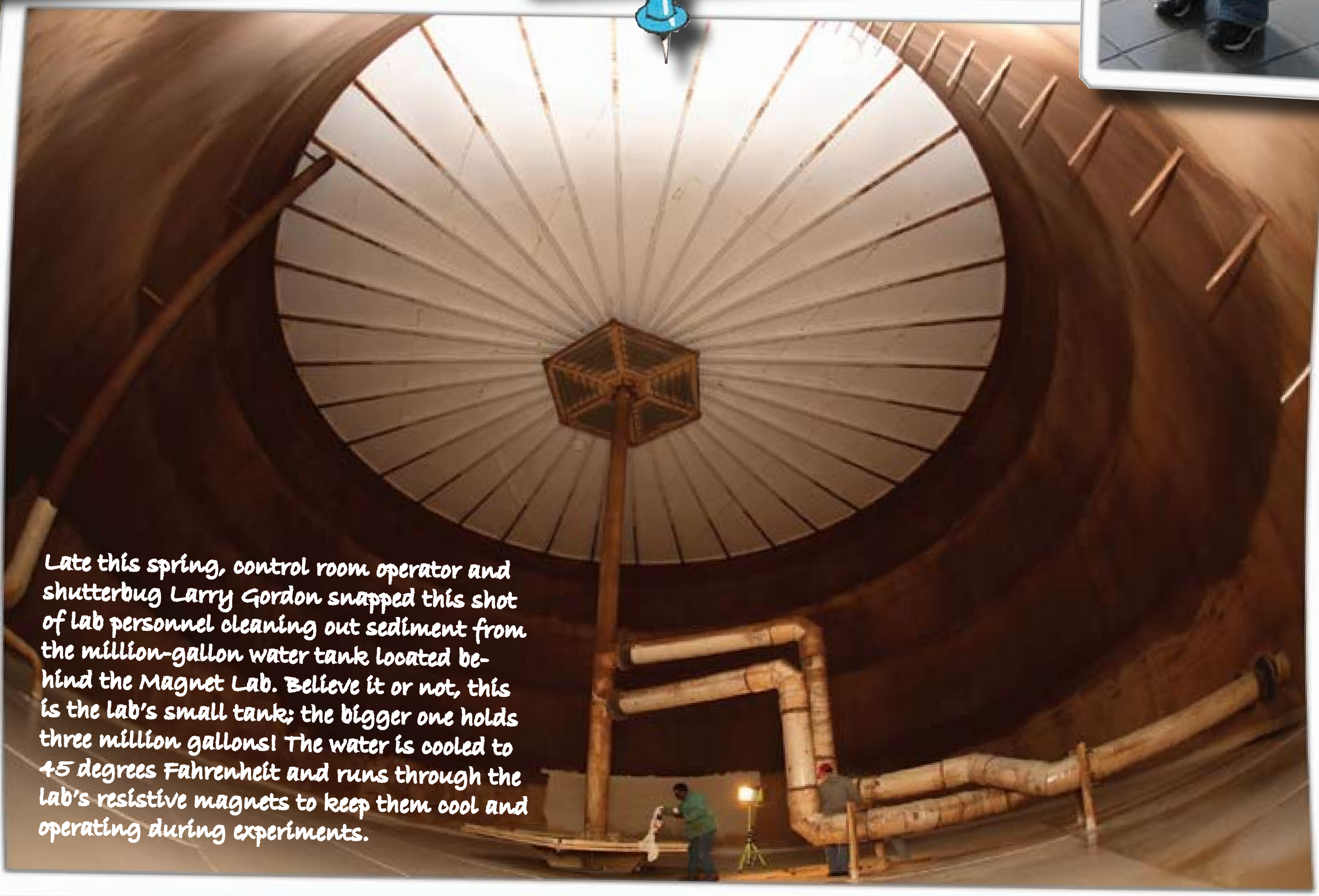
For more informtion visit
http://www.absolutezerocampaign.org/

Mag Lab Photo Board

Lab health and safety manager Angela Sutton gets a surprise visit from Jimmy Hosey during the water tank cleaning.

Geochemistry at the Annual Mag Lab open house.

Mag Lab open house.

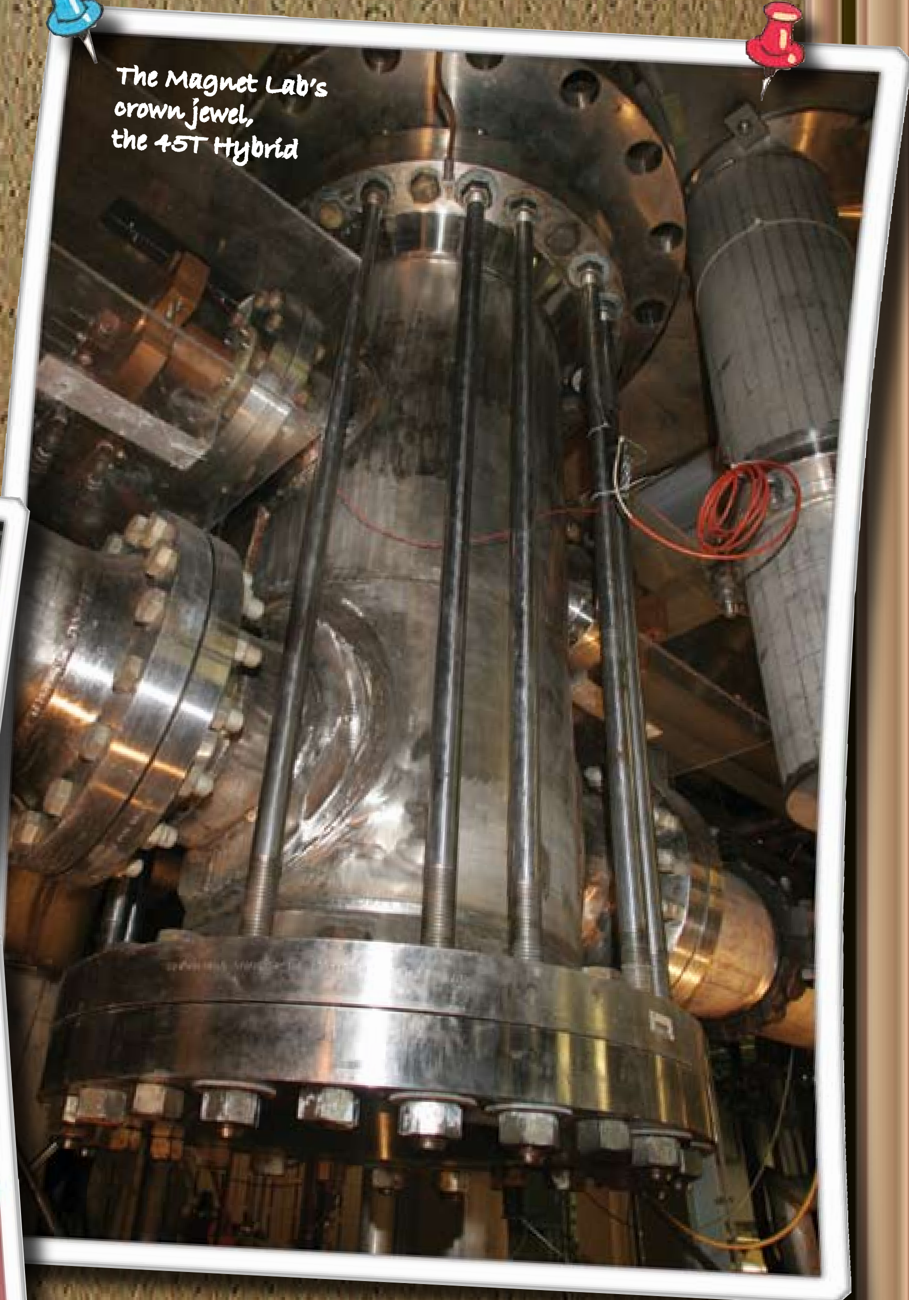


Late this spring, control room operator and shutterbug Larry Gordon snapped this shot of lab personnel cleaning out sediment from the million-gallon water tank located behind the Magnet Lab. Believe it or not, this is the lab's small tank; the bigger one holds three million gallons! The water is cooled to 45 degrees Fahrenheit and runs through the lab's resistive magnets to keep them cool and operating during experiments.

Cryogenics at open house

Electricity demonstration at open house.

The Magnet Lab's control room.



The Magnet Lab's crown jewel, the 45T Hybrid

Volume 1: Issue 1

Flux is supported by:
The National Science Foundation
The State of Florida