others. Not all learning-impaired children had the problem, however.

To find the source of the difficulty, the team then compared the brain waves of children who had trouble with "da-ga" to those of normal children. With electrodes taped to their heads, the children sat watching and listening to a video on TV, while trains of sounds—either "da-da-da-da" or "da-da-da-ga"—were piped softly into their ears. The children weren't asked to distinguish between the sounds, and the soundtrack of the video probably kept them from noticing them at all. But their unconscious brains were tuned in, and in the normal children the brain waves of the auditory system, including the auditory thalamus and cortex, changed shape abruptly when "ga" followed a train of "da"s. There was no such change in the children who had trouble telling "da" from "ga." That, says Kraus, means that at this early step in sound processing, even before the child becomes consciously aware of the sounds, the brain has already failed.

That result, Tallal and Merzenich argue, strengthens their case against a competing idea: that the defect in learning-impaired children is in the language centers of the brain, rather than the auditory system. But pediatrician Sally Shaywitz of Yale University, an advocate of the language-center hypothesis, disagrees. "Learning disability is a broad term," she says, arguing that the children with the auditory defect may be different from the dyslexic children she studies. Kraus agrees that "some children may very well have learning problems that are more linguistic in nature." But her team's work, she maintains, shows that "there is a subset of kids with learning problems who really have difficulty perceiving speech sounds at a basic acoustic elemental level."

Among the unanswered questions is whether children with the auditory defects can benefit from training aimed at helping them to hear the phoneme distinctions. One reason for optimism is the Northwestern team's finding that the abnormal brain response isn't hardwired. In studies with normal adults they showed that the response of the auditory system changes when the subjects are trained to make finer distinctions between sounds. "This is an area of the brain that changes with learning," says Kraus's co-author, Therese McGee. Kraus and her colleagues are planning studies to see if the same is true for learning-impaired children, and if an improved auditory-system response correlates with better learning ability.

If it does, Tallal says, someday it may be possible to use the neurophysiologic testing to identify kids at risk for learning problems who would benefit from auditory training very early, even before their learning problems set in. That approach, she says, may be able to "keep the kids from ever getting impaired."

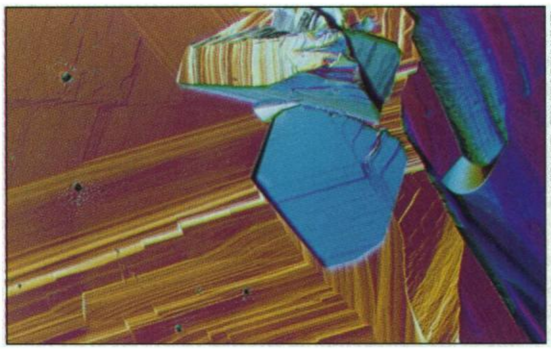
–**Marcia Barinaga**

INSTITUTIONAL PROFILE

Florida State's Magnet Lab: Attracting Funds and Hopes

TALLAHASSEE—Mention this Florida Panhandle city to most people, and condensed-matter physics isn't likely to be the first association they come up with. But to magnet scientists it's fast becoming the Mecca of their discipline. Physicists have been making pilgrimages here since 1993, when a new national laboratory opened its doors on the campus of Florida State University (FSU).

In a move that stunned many scientists at the time, FSU wrested a grant to establish the facility—the National High Magnetic Field Laboratory (NHMFL)—away from the Massachusetts Institute of Technology (MIT) in 1990. Vice President Albert Gore showed up to dedicate the lab in 1994, and earlier this year the National Science Foundation (NSF) awarded it a new 5-year contract worth $87.5 million. The award will raise the lab's funding level by about 45%—enough to keep its programs running smoothly into the next century.



MICHAEL DAVIDSON/NHMFL

Practical art. Organic superconductor with a 10.4 K transition temperature made by NHMFL.

That's an impressive coup for a rookie research center, particularly because the lab has won these funds from the federal government at a time when many academic departments are struggling just to stay afloat. But scientists are now wondering whether the lab's fund-raising feats will be equaled in coming years by similarly spectacular science. It's still too early to predict what NHMFL will achieve, but its staff recruitments, world-class magnets, and agenda suggest that it is already becoming an important player in areas ranging from high-temperature superconductivity to biology.

NSF decided in the late 1980s to bet heavily on magnet science because its leaders—including former NSF Director Erich Bloch—argued that the investment would lead to important breakthroughs in such critical technologies as semiconductors, magnetically levitated trains, and magnetic resonance imaging (MRI) machines. With higher magnetic fields, the rationale went, physicists would be able to understand and improve these devices to a degree never before possible. What's more, U.S. officials viewed magnet technology as vital to the competitiveness of high-tech American industries, especially in the face of increasing competition from Japanese and European magnet labs.

When NSF announced that it would award a grant to establish a national magnet lab, many assumed that MIT would win the competition hands down. MIT's Francis Bitter National Magnet Laboratory had for 30 years held a tight grip on U.S. magnet science and was an acknowledged world leader in the field. But FSU's Jack Crow, who had recently transferred from Temple University, decided he'd take a shot at the title.

After enlisting the University of Florida (UF) and Los Alamos as research partners, he secured $58 million in backing from Florida's legislature. Then he scrambled in 4 months to write an ambitious proposal that promised a world-class facility within 5 years. At the time, many independent scientists felt it would take the Florida lab that long just to catch up to the Bitter lab in magnet technology. But NSF was impressed. After it awarded the lab to FSU, the NSF's governing science board, in a letter signed by Chair Mary Good, responded to MIT's protests by arguing that the Florida team's enthusiasm and the state's matching offer demonstrated a commitment to magnet science not evident in MIT's proposal.

The state of Florida followed through by providing more than $80 million in capital funds—about $22 million more than it initially pledged. With such generous support, the lab had little trouble getting off the ground. This strong financial support was essential, but it was Crow, the lab's director, who made things happen. After muscling aside MIT, Crow began building a state-of-the-art facility from scratch. One of his first hires was chief scientist Robert Schrieffer, a Nobel laureate physicist who had recently retired from the University of California, Santa Barbara. Together, Crow, Schrieffer, and UF's physics Chair Neil Sullivan began recruiting with the zeal of college football coaches. "It's like starting from the beginning and hiring the

Dream Team," Schrieffer says.

But getting scientists to move to Tallahassee—where intellectual ferment is far more likely to focus on state politics than physics—wasn't all that easy. One drawback: Colleagues were few and far between. The Boston area, home of MIT, has about 60 institutions of higher education; Tallahassee has two. Another sticking point, says Sullivan, was pay. Florida ranks 47th in the nation for scientists' salaries. To compensate, the recruiters stressed the unique opportunities the new facility would offer for working in condensed-matter physics and emphasized Florida's robust economy, dense with high-tech industries.

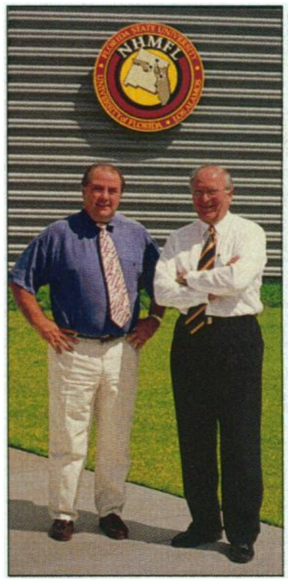
When Crow called to recruit Schrieffer, for example, the Californian had just finished building a house on a cliff overlooking the Pacific. But Schrieffer was attracted by Tallahassee's low cost of living and its proximity to the beach; he made the move, and now says he has learned to enjoy the "urban area on a wonderfully small scale." Similarly, theorist Lev Gor'kov had long considered Moscow, where he was working at the Landau Institute for Theoretical Physics, to be a "very lovely cultural and scientific atmosphere." But funding there was growing scarce, and NHMFL offered superior working conditions. "Tallahassee is not Moscow," he says, "but for me working as a professional in a scientific climate, it's very comfortable." Others, like Bruce Brandt, who left MIT to become head of NHMFL's user services, concede that the move was difficult. "The kids grew up" in Boston, Brandt says, noting that the family left "a lot of friends" behind.

Yet despite Tallahassee's limited cultural appeal, FSU's recruiting campaign has gone well. Before winning the grant, the university had a scant presence in magnet science, but since 1990, it has scrambled to fill 13 new faculty slots. FSU has snared such leaders as James Brooks from Boston University, Zachary Fisk from the University of California, San Diego, and Alan Marshall from Ohio State University. Now that FSU has invested heavily in a handful of top faculty, one external user says FSU needs to beef up its junior-level ranks because "that's who ends up doing most of the work." Without junior staff, research projects will suffer. But it may take some time before FSU builds the reputation and credibility that automatically attract topnotch graduate assistants. Schrieffer says he has to spend a lot of time promoting the university: "What you have to do is spend time on the phone and personally invite people down."

Scientists who have already joined the magnet lab's intramural staff have received their marching orders—in broad terms—from a report issued by NSF in September 1995, based on an external review. The report sums up the message by saying that NHMFL must provide "intellectual leadership for research in magnetic materials and magnetic phenomena." Under this heading, NHMFL is supporting staff experiments in a variety of areas. Brooks, for example, is studying the strange magnetic phase transformations of low-dimensional organic metals—thin films of metal atoms that behave like a flat surface under high magnetic fields. Fisk is developing metals with heavy fermions—electrons that act like heavy particles—where magnetism actually enhances superconductivity. And UF chemist Russell Bowers is using a laser pumping system to allow the detection of nuclear magnetic resonance (NMR) in quantum wells—an experiment that may shed new light on a little-understood phenomenon called the quantum Hall effect. The science in each case, Schrieffer says, is fundamental.

The external users seem to be pleased with the new lab's high technical quality and supportive environment. Under the direction of Hans Schneider-Muntau, who was lured from a competing magnet lab in Grenoble, France, magnet designers have built the Florida-poly-Bitter magnet—a modified version of MIT's technology—that in February reached a world record 33.1 tesla for continuous field by a resistive magnet. The lab supports several other unique systems, including a 600-megahertz, wide-bore NMR magnet for studying the structure of molecules in living cells. It is also developing the world's highest resolution MRI system: a 12-tesla, 40-cm device for studies involving small animals. Perhaps the lab's most impressive technical feature is its 40-megawatt dc power supply—consisting of four mammoth bus bars the length of a tennis court—that may be the most stable of its size anywhere. The Tallahassee lab also earns praise for eliminating the cooling-system noise and vibration that plagued experiments at the Bitter lab.

User support, many visitors to NHMFL say, is refreshing. "At the Bitter lab, you often had to go get people" to help with an experiment, says Sergei Ivanov of Clark University in Worcester, Massachusetts. "Here, they just sort of appear" when needed. Athos Petrou of the State University of New York, Buffalo, adds that the lab has helped with funding for such essentials as liquid helium and travel. And Users' Committee Chair Horst Stormer of Lucent Technologies, who in 1982 helped discover the fractional quantum Hall effect at MIT's magnet lab, said he has encountered people who say, "I have used five labs around the world, and this one is the best."



NHMFL

Magnetic duo. Lab chief Crow (*left*) and chief scientist Schrieffer.

For all this goodwill, however, the lab has yet to reach one highly visible goal: the development of a 45-tesla "hybrid" magnet that will couple the 33-tesla resistive coil with a 12-tesla superconducting outer coil. The hybrid magnet's power-consuming resistive coil allows researchers to increase magnetic field strength rapidly, while its slow- ramping superconducting coil provides extra field without the disadvantages of high power. Originally promised for late 1995, that magnet now is scheduled to begin operating in early 1997. When finished, it will become the world's highest strength continuous field magnet. Until then, that title will continue to rest with a 35-tesla hybrid magnet at MIT, idle since NSF cut off the Bitter lab's funding earlier this year.

Although the new lab has a bright future, says Woowon Kang of the University of Chicago, in some ways, it is just now catching up to the level of the Francis Bitter lab. What's more, as the lab comes of age, it may face new problems associated with its popularity—such as a long wait for magnet time, which, at 3 months, is already causing complaints.

The true test of NSF's decision to invest in the Tallahassee lab will be gradual. The results will become evident during the next 5 years. The process will not be as dramatic as the hunt for a new subatomic particle because—in contrast to high-energy physics—condensed-matter physics is not pursuing a Holy Grail. No single experiment or set of experiments will make or break the lab's reputation. Rather, says Crow, scientists at NHMFL will be investigating many diverse topics, any one of which could open a door on some new and exotic physical phenomenon. But meanwhile, all eyes will be watching to see when and if that will happen.

MIT isn't yet ready to concede that the award was justified. "It's going to be interesting to look back in 10 years and see … if it was worth this very large investment that the NSF has decided to make," says David Litster, former director of the Bitter lab and now MIT's vice president for research. "I think we just don't know yet." Crow, meanwhile, is optimistic. He has been around a lot of powerful magnets during his career. But these magnets, he says, pull him closer to a Nobel Prize than he has ever been before.

–Bradley Keoun

Bradley Keoun is a science writer based in Gainesville, Florida.