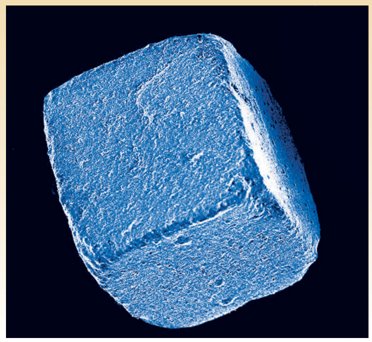
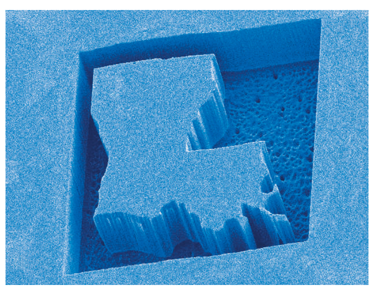
SHARPER FOCUS

CENTER FINDS NICHE AS WORLD LEADER

BY KATHLEEN THAMES

FOR SOMEONE WHO SPECIALIZES IN manipulating atomic particles, Dr. Gary Glass thinks big. • The UL Lafayette physics professor has spent most of his career tinkering under the hood, so to speak, of a 45-foot-long machine that produces a beam of ions traveling at speeds of about 7,500 miles per second.





This outline of Louisiana, carved by an ion beam, is the size of a grain of table salt [top]. Opposite page: An optical microscope image of a stained section of rat brain. The dark blue spots are individual neurons; the dark outline is a copper grid used to locate the neurons with the focused ion beam. The large circular hole is a section of a capillary blood vessel.

Glass has parlayed his knowledge and experience into making the Louisiana Accelerator Center on UL Lafayette's campus one of the premier research facilities of its kind in the world. Scientists there can use its high energy focused ion beam system, HEFIB for short, in ways other HEFIB owners haven't figured out yet. They can analyze brain tissue and fabricate computer chips, for instance, on an incredibly small scale. How small? They can neatly carve the outline of Louisiana on a speck of material the size of a grain of table salt.

Better yet, they believe they can shrink the HEFIB, while giving it more capabilities. If they succeed, it could be as revolutionary in the field of research as the development of personal desktop computers, which made early, mammoth computers extinct. One of the LAC's goals is to design a HEFIB so small and easy to use that it will become an indispensable tool for academic and industrial research labs.

That project has already caught the attention of some heavy hitters, such as the National Science Foundation and the National Institutes of Health, agencies with a reputation for funding only the most innovative, but plausible, projects that researchers can dream up. Also interested: the world famous Los Alamos National Laboratory.

It will take a while to produce a prototype of a smaller HEFIB, even working with some of the most brilliant researchers in the business.

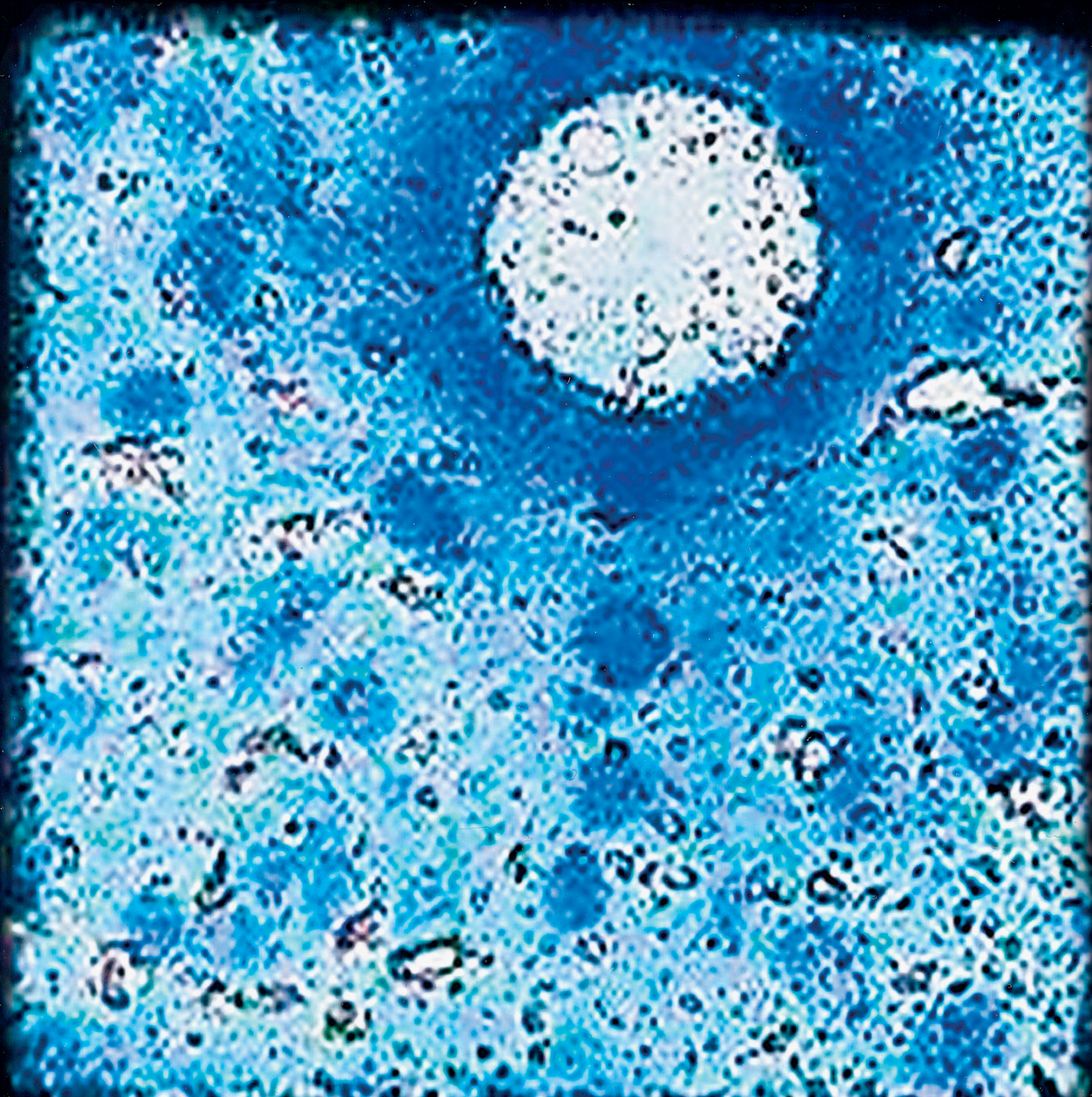
But that's okay. Dr. Gary Glass is a patient man.

THE STORY OF HOW THE top HEFIB expert in the world joined the LAC staff provides insight into why the center is on the cusp of something so big.

About four years ago, Glass placed an ad in an academic journal about a vacant postdoctoral position at the LAC. Soon after it was published, he received a phone call from a man with a heavy, foreign accent who wanted to apply for the job. "He told me, 'I'm over here at Columbia (University) and I'd like to go down to Louisiana. You're working on microprobes and that's what I do,' " Glass recalled recently. He asked the caller to submit a resumé for consideration.

A week or so later, Glass was going through his mail and noticed an envelope with a Columbia University return address. Inside was a resumé from Dr. Alexander Dymnikov.

Glass was flabbergasted. "He's the person who, in the 1960s, developed the theory for the first ion microprobe that everyone is now using. There are a lot of systems



DOUG DUGAS

Dr. Gary Glass, director of the Louisiana Accelerator Center, confers with Dr. Karen P. Briski, a professor of pharmacology and neuroanatomy, at UL Monroe. They are using the center's HEFIB to gather information about the distribution of elements, such as sulfur and potassium, in nerve cells in glucose-sensitive areas of a lab rat's brain.

called 'Russian microprobe systems.' Well, he's the Russian.

"I phoned him and said, 'Do you understand it's only a research associate position?' He said, 'Yes, I understand that, but I want to apply for it.' "

UL Lafayette hired Dymnikov to work at the LAC, not as a research associate, but as a senior scientist. As soon as he was settled in, Dymnikov began to design a high energy ion nanoprobe system that can be used for biological and materials research. No comparable system exists anywhere in the world.

"He did the theory. I did the mechanical design for it and wrote a grant proposal for $450,000," Glass said. "Six months later, the proposal was approved and we got the funds to construct it. It was that quick, that productive."

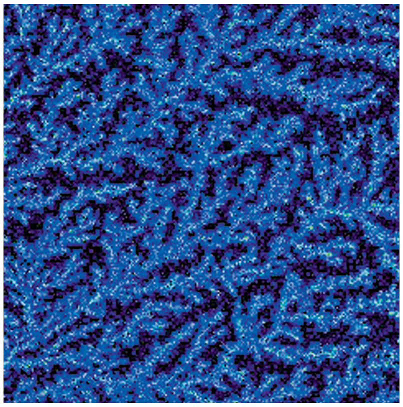
The LAC's draw for Dymnikov was the freedom to pursue HEFIB-related projects that interest him.

THE LAC HAS EARNED PROMINENCE IN RECENT YEARS, IN PART, because of Glass' persistence almost two decades ago.

He was hired by the university in 1985 to work at its Acadiana Research Lab, later renamed the Louisiana Accelerator Center. Scientists there set a goal of establishing a complete ion beam research facility. But times were tough in the 80s, due to a downturn in the oil industry that crippled the state's economy.

The Louisiana Education Quality Support Fund was a godsend.

"Microprobe" refers to the ion beam. Its "spot size," the area that the beam covers, is critical. The smaller, the better. There are only five laboratories in the world with HEFIBs that have beam sizes smaller than 500 nanometers by 500 nanometers. The LAC is one of them.



An x-ray image produced by the HEFIB shows how a chemical fixative has spread throughout the capillary blood vessel system in a section of rat brain.

Created a year after Glass was hired by the university, it is supported by royalties from a settlement related to offshore oil leases and managed by the Louisiana Board of Regents. It offers research monies through a competitive process.

"By 1989, I had written about 40 proposals," Glass said. Not one was funded. But he hit the bull's-eye in 1990, when the Board of Regents approved two proposals totaling $800,000. The money was used to buy a high energy ion accelerator and to build an analysis chamber. Since then, the LAC has generated an additional $6 million in grants and equipment from non-university sources.

But those 40 failed proposals taught Glass a lesson that continues to pay off.

"When you're trying to get funding for research, you have to find a niche. That's exactly how we got into the microprobe business. That was something that nobody in this country had done," he explained.

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Glass believes the Center's scientists will soon reduce that beam size even further, to about 300 nanometers by 300 nanometers. With new equipment, the size will decrease even further, to about 30 nanometers by 30 nanometers. To put this in perspective, the width of a human hair is about 80,000 nanometers. A red blood cell is about 7,500 nanometers in diameter.

IN A SOCIETY THAT PRIZES THE LATEST TECHNOLOGY, THE CENter's HEFIB might seem like a dinosaur, since some of its parts were acquired more than a decade ago. But its age isn't a problem. "Although the accelerator is roughly 15 years old, it's really pretty much state of the art, and the HEFIB itself has been upgraded tremendously since its first installation 10 years ago," Glass explained.

Many HEFIBs are comparable to a software program that has vast capabilities that go unused because the user doesn't take the time to learn all about it. The trick, Glass said, is to determine what the system can do and then use it in new ways.

A collaborative project with the University of Louisiana at Monroe is an example of how the LAC is doing that. It's a unique marriage of physics and neuroscience that's funded by the National Science Foundation and the National Institutes of Health.

First, a little bit of background:

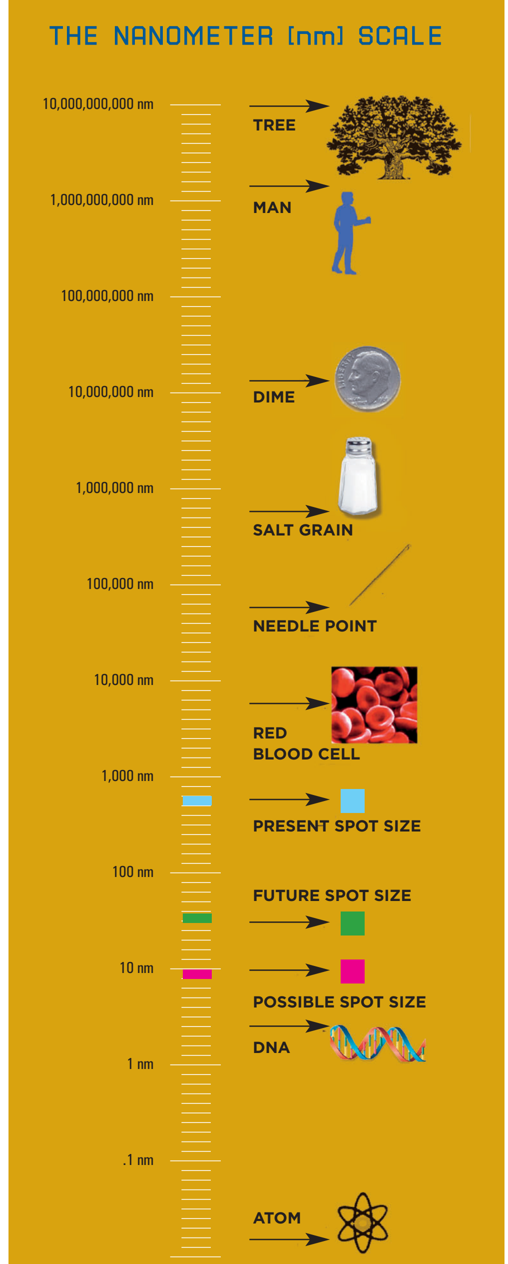
Glucose molecules act as fuel for brain cells. They are the primary energy source for nerve cells and generate energy that supports vital cell functions. So, the body must be able to detect any shortfall in glucose. That's particularly critical because the body doesn't store a lot of glucose in its central nervous system.

Neurons in the brain help keep the brain posted about glucose levels. If they sense the glucose supply is getting low, they activate neural pathways that can prompt the body to make more.

A big question for scientists: How do "sensor" neurons detect glucose deficits?

Glass and Dr. Karen P. Briski are using the center's HEFIB to try to find some answers. She is a professor of pharmacology and neuroanatomy at UL Monroe and head of its Department of Basic Pharmaceutical Sciences of the College of Pharmacy.

The plan is to direct the microprobe at a sample of brain tissue taken from a lab rat. When high energy ions collide with atoms in a cell, the ensuing interactions can provide scientists



The Louisiana Accelerator Center is one of only five laboratories in the world that has demonstrated the capability to focus a high energy ion beam to a spot size smaller than 500 nanometers by 500 nanometers.

with information about the materials they're examining. Glass and Briski hope to measure how elements such as sulfur, potassium and calcium are distributed in nerve cells in glucose-sensitive sites in the brain.

The targeted brain tissue sample is one tenth the size of a single red blood cell. A red blood cell is about 3/10,000 of an inch in size.

According to Glass, the HEFIB is the only system sensitive enough to accurately detect low concentrations of elements in samples that are so small. Until now, researchers have had to settle for using microneedles to measure positive and negative voltage and then making some inferences.

THE HEFIB HAS POTENTIAL APPLICATIONS in many fields but there are two that are particularly noteworthy. One is the semiconductor industry, which makes com-

WHAT OTHERS ARE SAYING ABOUT THE LOUISIANA ACCELERATOR CENTER

"I would rank the research work done at Louisiana Accelerator Center among the top tiers in the world and the only ones demonstrating the ability to fabricate high aspects ratio 3D micro-structures using high energy focused ion beams."

Dr. K. Sekar, Senior Scientist
Varian Semiconductor Equipment Associates, Inc.

"...In summary, it is clear that the UL Lafayette team (members) are the world leaders, bar none, in focused ion beam microprobe technology."

Dr. David J. Brenner, Director
Radiological Research Accelerator Facility
Columbia University

"The P-Beam writing capability at UL Lafayette is unique in the USA . . . This capability may result in a variety of inventions that eventually will result in patent filings and returns on investment for UL Lafayette."

Dr. Daryush Ila, Executive Director
Alabama A&M University Research Institute

"....the Louisiana Accelerator Center is the only laboratory in the U.S. that has demonstrated the use of a high energy proton microprobe for microlithography. This unique technique has a significant potential for future applications, particularly with respect to semiconductor photomasks and MEMS. The program at the Louisiana Accelerator Center to develop high energy focused ion beam systems has resulted in one of the most advanced focusing systems now in existence worldwide – the Russian magnetic sextuplet....when this new system is completely operational, the Louisiana Accelerator Center will have increased its substantial technological lead within the U.S. and will provide a truly unique capability. . ."

Dr. Floyd Del McDaniel, Director
Ion Beam Modification and Analysis Laboratory ,
University of North Texas

DOUG DUGAS

Dr. Bibhudutta Rout, left, and Dr. Gary Glass examine the sample placement in the target chamber of the 45-foot-long high energy focused ion beam system.

ponents for electronic equipment, such as chips for computers and flat panel displays. The other, logically enough, is the nonsemiconductor industry, which includes microelectromechanical systems or MEMS. With MEMS, Glass said, "You build components and then you take those components and you put them together to make microelectromechanical systems. . .You can actually make power generators and motors, optical switches, microsized laboratories, sensors and all kinds of neat little devices."

The two industries have something in common – microlithography, a process in which microscopic geometric patterns are transferred to the surface of a material, such as a silicone wafer. Those patterns make up the parts of the circuit or components of a device.

To get an idea of how it all works, here's how most computer chips are manufactured:

A silicone wafer is covered with a material, called a resist, which resembles a thin layer of Plexiglas®. A mask, which is like a stencil, is placed on top. The wafer is then flooded with a special light, such as ultraviolet light. The mask is removed and the wafer is put through a chemical developing process, similar to the way photos are printed in a darkroom. So, there are differences between the areas that have been exposed to light and those protected by the mask. To increase the chip's complexity, manufacturers repeat the steps, using different masks, to create layers.

At the Louisiana Accelerator Center, researchers are testing two ways to use the HEFIB to make computer chips. In one, a mask is placed on the silicone wafer. Then researchers flood the wafer with a "wide" ion beam to produce the pattern underneath. Those steps can also be repeated to produce layers.

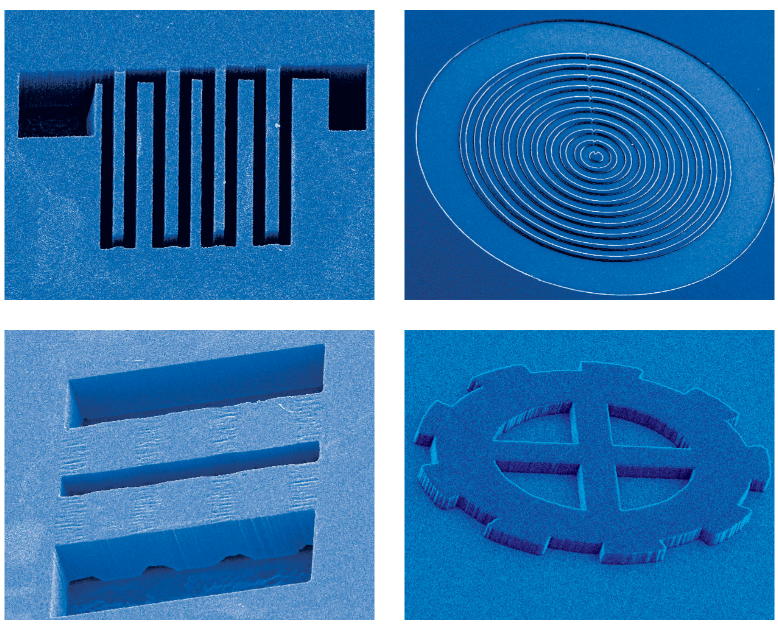
The other technique they're exploring is rapid prototyping, which means focusing the ion beam to a very small size and "writing" directly onto a silicone wafer, like using a pen to write on paper.

"We can create a pattern that we can then use to create a structure," Glass said.

Most recently, he was able to make seamless "tunnels" with the HEFIB, a feat no one else has managed to accomplish.

LAC staff member Dr. Bibhudutta Rout, another talented international expert, has helped to establish LAC on the world stage in this area of development. He previously worked at the Microanalytical Research Center at the University of Melbourne in Australia.

The LAC is working with scientists at UL



Unique microstructures can be formed using the special abilities of the HEFIB system. The tunnels, shown bottom left, were fabricated in a one-step process that's not possible by any other method.

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Lafayette's Center for Advanced Computer Studies to use the HEFIB to develop improved switches that direct fiber optic signals.

If there's already a way to make computer chips, why would the HEFIB's technique be better? Scale and speed are two reasons. The HEFIB can operate in a smaller environment, which means it can create smaller features. The LAC can also produce prototypes of computer chips with its HEFIB quicker than other researchers.

"There are a number of barriers that have to be overcome for that to actually happen on a mass production scale, but that's one of those things we're developing right now," Glass said.

PROJECTS SUCH AS ANALYZING BRAIN tissue and making computer chip components illustrate the HEFIB's versatility and applications.

But the most promising project of all, from a commercial perspective, is the Louisiana Accelerator Center's plan to make the HEFIB so small, compact and easy to use that it becomes as commonplace in research labs as electron microscopes.

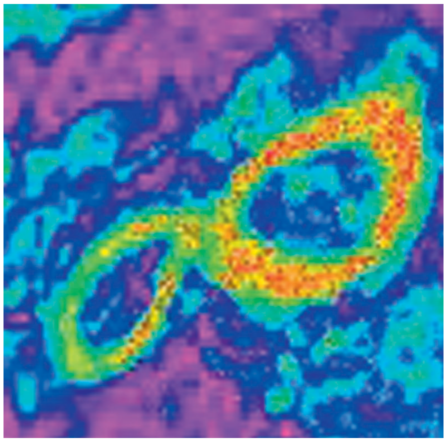
The LAC has a couple of electron microscopes that it uses for particular types of work. But the high energy focused ion beam can do some tasks that the electron microscope cannot. Could an electron microscope be attached to the smaller HEFIB? "Absolutely . . . The electron microscope would complement the high energy focused ion beam system," Glass replied.

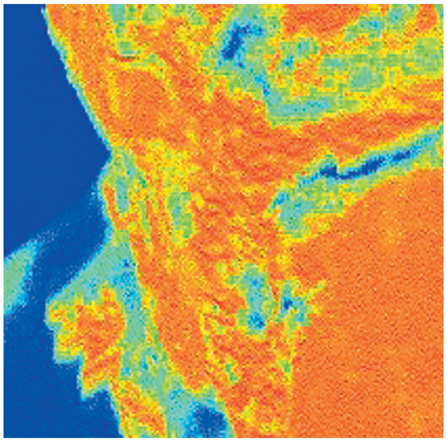
One aspect of the proposed HEFIB makes it much different than current HEFIBs: its focusing lens system. Existing HEFIBs rely on magnetism; the proposed system will rely on electricity.

"Magnetic lenses focus ions based on the ions' velocity, while the electrical lenses focus on the ions' energy," Glass explained.

Magnetic lenses also depend on the electrical charge and the mass of the ion. "It turns out that those factors really limit the magnetic lenses," he continued.

An ion is an atom with one electron removed. Although "an ion is an ion is an ion," Glass said, elements have differmasses.





Top: This cross-sectional image of two blood vessels in a section of rat brain was produced by transmission ion microscopy. Lighter colors represent thicker portions of the section. Red dots indicate the presence of sulphur as identified using x-rays emitted as a proton microbeam passed through the section. Bottom: A secondary electron image of a tungsten-carbide coating produced by electrons emitted as a result of the passage of a proton microbeam. Lighter colors indicate areas of higher electrical conductance.

The magnetic lenses work best to focus protons because protons are the lightest ions available.

But the electrical lens system "doesn't care about the mass. It cares only about the energy." That means the proposed HEFIB can easily focus any ion beam, even with the heavy ions, such as gold.

Last year, the LAC asked the National Science Foundation for $2 million to build a prototype of a scaled down version of the HEFIB. The proposal got rave reviews from an NSF committee that studied its merit. Committee members strongly recommended that the NSF fund the project.

". . . collaboration with industry is expected to lead to the development of a commercially viable design that will be applicable for materials studies in a wide range of fields. Successful development of the instrument could fundamentally alter developments in these fields," the NSF review panel's report stated.

But the NSF did not follow the committee's recommendation.

In retrospect, even Glass admits that $2 million was probably too much to ask for at once. So he has regrouped and will take another approach. He will first seek funding to build the focusing system. Once that's nearing completion, he'll submit a proposal for money for a new ion accelerator.

Along the way, LAC researchers will collaborate with some out-of-state universities who offer expertise in certain areas. The center is already collaborating with the Los Alamos National Lab on the project. And, it's working closely with National Electrostatics Corporation, based in Wisconsin, one of only two companies in the world that manufacture commercial high energy ion accelerator systems.

Glass is content to wait as the prototype is developed. In addition to being patient, he is pragmatic.

"There's a danger in research and technology development of creating what we call a self-licking ice cream cone. Whoever made the ice cream and put it in the cone is the same one that's eating it up. It never goes anywhere," he said. "We don't want to be in that situation."