NATIONAL HIGH MAGNETIC FIELD LABORATORY

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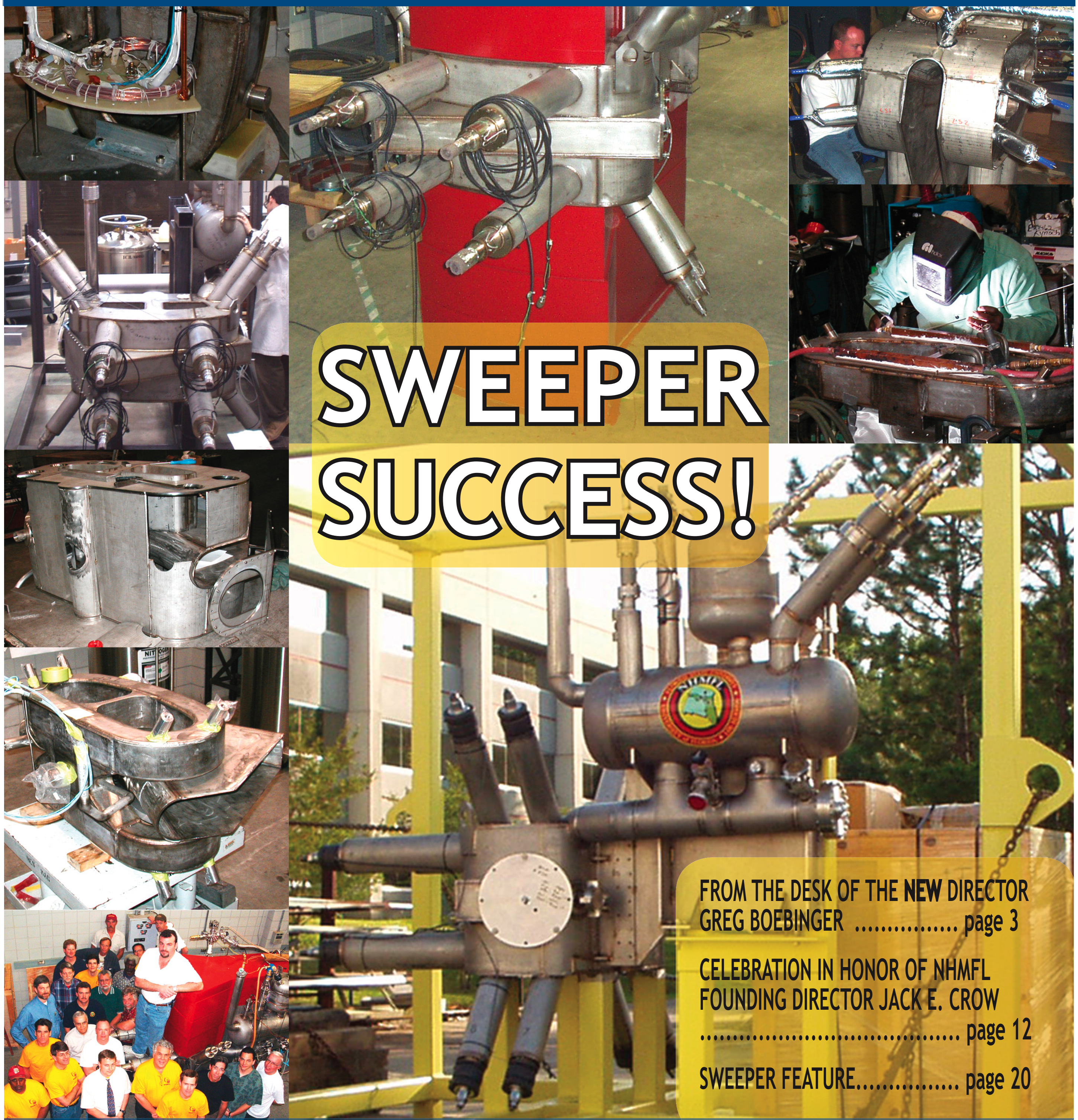

SWEEPER SUCCESS!

FROM THE DESK OF THE **NEW** DIRECTOR GREG BOEBINGER .... page 3

CELEBRATION IN HONOR OF NHMFL FOUNDING DIRECTOR JACK E. CROW .... page 12

SWEEPER FEATURE............... page 20

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NHMFL REPORTS

CONTENTS

3 **From the Director's Desk**

4 **From the Chief Scientist's Desk:** Optical Microscopy at the National High Magnetic Field Laboratory

7 **PULSED FIELD PROGRAM: ATTENTION USERS** 3-ω Thermal Conductivity Studies in Pulsed Fields

8 **EDUCATION OUTREACH ACTIVITIES:** At the Laboratory and On the Road

10 **NEWS FROM AMRIS** Mapping Emotions Using 3 T MRI

12 **NHMFL Founding Director Jack Crow Honored**

14 **NMR PROGRAM: ATTENTION USERS** Membrane Proteins: A Scientific Frontier for NMR Spectroscopy—A National Effort Led by the NHMFL

16 **Center for Advanced Power Systems Update**

18 **PEOPLE IN THE NEWS**

19 **"Crow's Feet" Relay For Life Team Top Fundraiser**

20 **News from Magnet Science and Technology** SWEEPER SUCCESS!!

23 **Meeting News** Looking Back... Looking Ahead...

24 **Conferences and Workshops 2004-2005**

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FROM THE DIRECTOR'S DESK

Greg Boebinger

I am greatly honored to have been selected as the new director of the National High Magnetic Field Laboratory. As a scientist who has been involved with the laboratory since being named to its first Users' Committee, I continue to be amazed by how far we have come in ten short years—from essentially a field of green grass to a world-class magnet laboratory, recognized as the world leader in magnet science, engineering, and experimental infrastructure. The exceptional faculty and staff at FSU, UF, and LANL, the involvement and counsel of the NHMFL's advisory committees, and the vision and leadership of Jack Crow have all collaborated to make this happen. We stand today on a very solid foundation, and we face exciting challenges as we expand our research portfolio that will remain focused on the unique capabilities offered by the NHMFL, and will span interdisciplinary research ranging from physics and chemistry to geology, biology, and medicine.

We are in this position of strength because of the laboratory's founding director and my good friend, Jack Crow. In accepting the leadership of the NHMFL, I recall that Thomas Jefferson, when accepting his appointment as the second United States ambassador to France, acknowledged the ground-breaking and visionary achievement of his predecessor, Benjamin Franklin, by simply stating, "I might succeed him, but no one can replace him." As I assume the duties and responsibilities of this "House That Jack Built," I would like to publicly thank Jack for his extraordinary accomplishments and dedication. His outstanding contributions to science and education in our Nation and around the world have made a lasting impact.

In early March, I had the pleasure of participating in the 10th Anniversary Open House of the NHMFL. This once-a-year event for the community and for the magnet lab is fantastic, and *big*! The level of participation and enthusiasm in the 2004 event—both by community groups and members of the NHMFL family—was truly remarkable. It was *too much fun...* (a "quality metric" by which I'd like to measure many of our NHMFL activities, by the way). Pat Dixon's article on page 8 of this issue gives all the details and photographs that tell the story.

No scientific institution can ever rest on its laurels. As we approach our NSF renewal proposal, an agenda of focused workshops and meetings is already underway to help sharpen our vision for the next 5 to 10 years and prepare us for the scientific and engineering opportunities of future high magnetic field research. This began with the NHMFL Users' Committee workshops in Los Alamos and Santa Fe in November 2003. An NHMFL renewal retreat in January 2004 in Tallahassee has resulted in numerous white papers that outline exciting research frontiers we could attack in the renewal proposal. In March, we hosted *Solid State NMR and Material Applications at High Magnetic Fields*, and the *International Workshop on Materials Analysis and Processing High Magnetic Fields*. In May, we are very excited to be holding a *"Big Light" Workshop: Exploring the Combination of High Magnetic Fields and Bright Light Sources*. A major goal of the NHMFL over the next decade will likely be to bring together bright photon sources and high magnetic fields in a configuration that is scientifically optimized and fiscally efficient for the Nation. This workshop will bring together experts from around the world to discuss the scientific and technological opportunities associated with this vision....and, if all goes according to plan....should be *too much fun.*

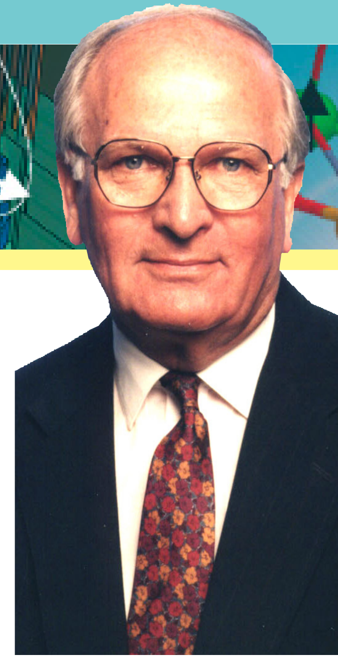
These are a few of the efforts underway that will broaden this laboratory's capacity to serve academic and industrial users, build cutting-edge engineering partnerships (such as the one that led to the Sweeper Magnet, this issue's cover story), and drive our future innovation in research and technology in high magnetic fields.

Rock and roll.

Greg Boebinger

FROM THE CHIEF SCIENTIST'S DESK

J. Robert Schrieffer



In the past tradition of this section I have chosen outstanding scientific highlights in such areas as Biology, Physics, Chemistry, and Engineering. This issue I would like to focus attention to Optical Microscopy, which has led to advances in many of these fields.

Optical Microscopy at the National High Magnetic Field Laboratory

M. Davidson, NHMFL

Over the past ten years, advances in laser technology, fluorescent probes, CCD camera systems, and digital image processing have led to a virtual renaissance of new developments in the field of fluorescence microscopy. Widefield, spinning disk, and laser scanning confocal microscope systems are now several of the most important investigational tools in cell biology, neurology, embryology, and many related disciplines. Along with the expansive growth in these technologies has come an ever-increasing need to train students at all levels in the basic concepts of optics, the physics of light and color, image processing, and the various often-complex requirements for successful microscopy. In particular, the relatively new techniques in fluorescence, including resonance energy transfer, total internal reflection, lifetime imaging, photobleaching intensity loss, photoactivation, and multiphoton imaging, have generated steep learning curves that must be overcome in order to achieve productive research efforts.

Scientists and educational specialists at the NHMFL have banded together with researchers and industrial organizations from around the world to build collaborations having a targeted goal of producing a world-class Web-based educational system dealing with topics related to optical microscopy. This effort has resulted in the construction of several Web sites that are now used on a daily basis by thousands of educational institutions from around the world, ranging in scope from K-12 to post-graduate. Among the industrial partners are notable names such as Nikon and Olympus, as well as many lesser-known specialty companies, including Bioptechs, Chroma, Omega, Molecular Probes, QImaging, Foveon, Linkham, and Media Cybernetics. The larger companies produce complete microscope systems, while the smaller partners provide essential aftermarket products. In addition to the industrial collaborations, which provide the core funding for the facility, a host of scientists from some of the nation's most prestigious educational institutions assist in development of the educational materials. Several of the over 100 contributing scientists are based at the universities of Michigan, Indiana, Illinois, Tennessee, North Carolina, Texas, Albany (New York), Maryland, Hawaii, Mississippi, Wisconsin, Virginia, Pennsylvania, and Massachusetts. Private institutions also provide participation with collaborators from Harvard, Johns Hopkins, Brown, Oxford (UK), Temple, and Vanderbilt, as well as governmental laboratories, including the NIH, Marine Biological Laboratory (Wood's Hole), Medical Research Council (UK), Rutherford Appleton (UK), and Scripps (La Jolla). Together, these collaborations have helped build the foundation for what may ultimately become the most important and widely utilized source of educational information on microscopy ever assembled.

Aside from the educational efforts, the program is also developing a research initiative that may result in the establishment of a "user facility" for investigations in cell biology and related disciplines at the NHMFL. At the heart of this facility are the tissue culture laboratory, a live-cell imaging laboratory, and several laser scanning confocal microscopes. Coupled with a significant level of imaging equipment and computer processing capability, the facility should enable outside visiting investigators to observe the effects of high magnetic fields on living systems. It is becoming increasingly clear that a deeper knowledge about magnetic field effects on living tissue is ever more important, especially in light of the continually increasing exposure of humans to magnetic and electrical fields of varying frequency in day-to-day life. Many studies have concentrated on magnetic effects in tissues, organ systems, and basic biological functions *in vitro*, but effects at the cellular and molecular levels are still not understood to a significant degree. Initial investigations of cell cultures placed in

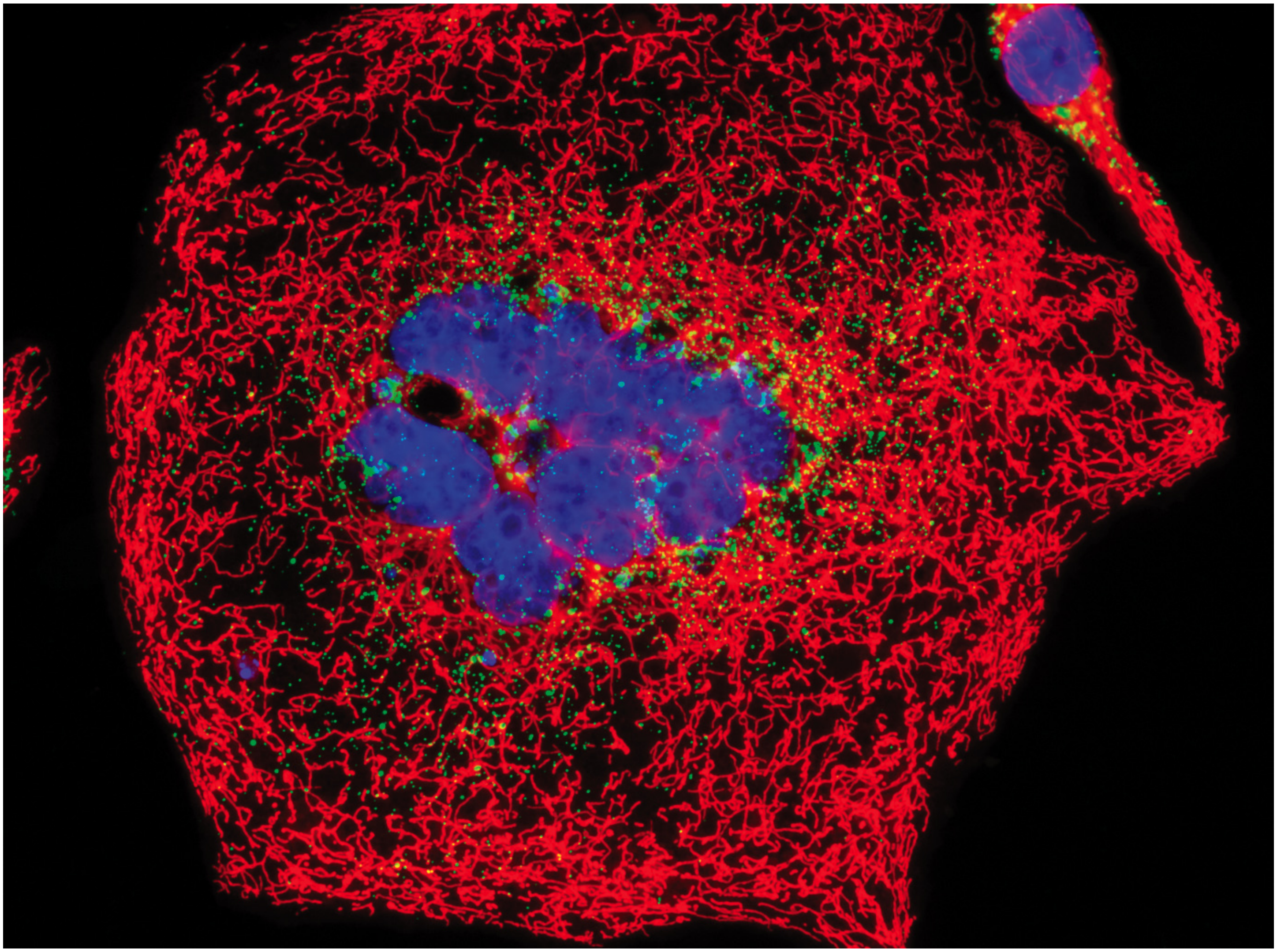


Figure 1. Fluorescence digital image of a multi-nucleated HeLa cell that was transfected with a plasmid chimera containing coding regions for enhanced yellow fluorescent protein fused to the peroximal targeting signal 1 (PTS1). Live cell transfectants were treated with a mitochondrial-specific fluorescent probe (MitoTracker Red CMXRos), and then fixed and counterstained with the nuclear targeting agent Hoechst 33258. Creating images from these specimen types is the culmination of substantial efforts in molecular and cellular biology, as well as biochemistry, immunology, fluorescence microscopy, digital imaging, and post-acquisition image processing.

high magnetic fields over long periods, by a number of scientists, have demonstrated a wide variety of effects not seen in the absence of these intense electromagnetic fields. For example, hundreds of studies have indicated that many cellular components (those with a net magnetic moment) become highly oriented in magnetic fields, and reports of both enzyme enhancement and inhibition have surfaced, as have observations on increased and/or decreased cell proliferation (of normal and transformed cells) at a multitude of field strengths. Perhaps the most important discovery, however, is the magnetic field effects on mitotic spindle orientation in developing embryos, which has broad implications on the potential impact of magnetic fields in human development and medicine. These studies provide an excellent foundation for further investigations into the nature of magnetic field effects on biological systems, which would be an excellent target for scientific collaboration at the NHMFL.

Regardless of whether the optical microscopy laboratory ultimately develops into a broad based user facility, it will continue to be available to assist in-house researchers in observing and recording images of specimens ranging from semiconductors to new materials. An ongoing collaboration with the Justin Schwartz program has led to the development of a magneto-optical imaging center to observe flux patterns in superconducting ceramics using the Faraday effect with reflected polarized light microscopy. This effort, which has already generated meeting presentations and several publications, is being expanded to include a second Nikon microscope that should be operational within a few months. Other industrial and synthetic materials under investigation by the optical microscopy laboratory through collaborations include liquid crystals, integrated circuits (in collaboration with Intel, Texas Instruments, Hewlett-Packard, and Advanced

Micro Devices), medical devices, gemstones, pharmaceuticals, archeological artifacts, electronic components, petrographic thin sections, pathology specimens, forensics (hairs and fibers), and thin films. The facility is continuing to expand collaborations, an effort that is dramatically assisted by the huge number of visitors to the Web sites.

Statistical analysis results of the main optical microscopy Web site (Molecular Expressions; http://microscopy.fsu.edu) are impressive. Since its inception, this site has distributed over 110 million pages to an estimated 49 million visitors. On an ordinary weekday, the site hosts an average of 40,000 individual visitors who download between 170,000 and 200,000 pages. Traffic monitoring by the FSU ACNS (Academic Computing and Network Services group) indicates that the combined Web sites consume between 20 and 30 percent of FSU's daily Internet bandwidth usage. Most of this activity derives from traffic through the Internet search engines (Yahoo, Google, etc.), which collectively place the sites relatively high in the returned results priority rankings.

The six Web sites currently hosted by the program include:

Molecular Expressions
(*http://micro.magnet.fsu.edu;* 10,200 html pages)

Nikon's MicroscopyU
(*http://www.microscopyu.com;* 3,400 html pages)

The Olympus Microscopy Resource Center
(*http://www.olympusmicro.com*; 3,000 html pages)

The Olympus Fluoview Resource Center
(*http://www.olympusconfocal.com*; 225 html pages)

The Office of Research
(*http://www.research.fsu.edu*; 1,800 html pages)

The NHMFL Budget Management Server
(*http://budget.magnet.fsu.edu*; 350 mixed pages)

On the publicity front, the Powers of Ten tutorial, which starts 10 million miles from the Milky Way galaxy and winds up in exponential steps at a proton in an Oak leaf behind the NHMFL, provides not only an education in scientific exponential concepts, but clearly demonstrates the exact location of the laboratory to visitors from around the globe. This tutorial has experienced over 12.5 million downloads, and averages 25,000 page views a day. In addition, the "Optical Microscopy Primer," which is widely employed as a teaching tool, hosts several thousand visitors per day. The numerous photo galleries have a large audience and are well-represented by the Internet search engines, a factor that is important in providing visitors.

Visitors to the Molecular Expressions Web site are invited to send comments, criticism, and questions directly to the laboratory through email links on every page. As a result, thousands of messages are sent and received annually. These range from flattering comments about the Web site content to constructive criticism of tutorials and technical information, along with many pleas for assistance in one form or another. Negative comments are rare, but they do occur. An important effect of these messages from the visitors is that the Web site is proving to be self-correcting, because many of our visitors are helpful in assisting us to find and alleviate mistakes. The most rewarding aspect of the numerous emails, however, are the stories relating to the impact that the Web site has on the education of our children. One of the most moving notes was sent to us by an anonymous father in Kansas:

> ***"Last night I showed your Web site with the images moving from beyond the Milky way through to protons to my 5-year old son. I am writing to thank you for putting it on the Web, because the first thing he asked me when we woke up this morning was to look at it again. It has really excited his imagination and we'll try to build on that."***

Even though the primary educational effort of this program focuses on optical microscopy, many of the supporting technologies necessary for a full understanding of the field are also of paramount importance to many areas in engineering, physics, biology, chemistry, and geology. For example, the Web site sections on basic optics are useful to students in a wide variety of disciplines, as are the discussions and interactive tutorials on electricity and magnetism, cell biology, digital image processing, laser technology, image and point sensors (CCDs, photodiodes, and photomultipliers), fluorescence phenomena, prisms, light emitting diodes, and interference filters. Blanketed under the umbrella of "optical microscopy" for the purposes of the Web site organization, these sections are available to anyone who wishes to visit.

ATTENTION USERS

C.H. Mielke, Head of the NHMFL/Los Alamos Users Program

Don Kim, Al Migliori, and co-workers have successfully taken a novel instrumentation design concept and created a new sensor for use in high magnetic fields. Funded by the NHMFL In-House Research Program, this success story marks a significant step forward in thermo-physical sensor development. The method known as the "Three-ω" technique is a powerful way in which researchers can determine the thermal conductivity (or thermal diffusivity) of a sample with great accuracy in a very short period of time (sub milli-second). Such a technique is ideal for users of pulsed magnetic fields in which the field often sweeps at rates of 2000 to 20,000 T per second. Below is an example of the power of this new tool available to users of the NHMFL.

3-ω Thermal Conductivity Studies in Pulsed Fields

D. Kim, LANL
K.H. Kim, LANL
F. Balakirev, LANL
J. Betts, LANL
J.Y. Sohn, LANL
A. Migliori, LANL
J.-S. Lee, LANL
Q. Jia, LANL
Y, Moritomo, CIRSE, Nagoya Univ., Applied Physics, Japan
R. Manginell, Sandia National Laboratory

Why measure thermal conductivity? Resistivity below T_c tells us nothing about the superconducting gap, the physics, or the critical exponents. But heat capacity does! And so does thermal conductivity for similar reasons. That is, superconductivity does not reduce heat capacity or thermal conductivity to zero. Thermal measurements, however, are difficult in the short-pulse magnets that can suppress superconductivity completely in some high temperature superconductors, thus the development of new techniques for these measurement in pulsed magnetic fields is of major importance to the mission of the NHMFL. The results described here as part of an In-House Research Program award are a major accomplishment. What we show in Figs. 1 and 2 are the data taken in a short-pulse magnet that match the results of Fig. 1 in a static magnetic field. Although this demonstration experiment itself is perhaps not of major scientific significance, the fact that one can now, for the first time, look at the thermal conductivity of high temperature superconductors both in the superconducting and normal state (critical field values are ordinarily too large for easily accessible DC magnets) will make possible the extraction of the temperature dependence of the electronic contribution to the thermal conductivity. Such measurements are fundamental since they will yield answers to longstanding questions regarding the electronic density of states and, therefore, order parameter in these complex systems. It is to be noted that these experiments would not be possible if it were not for the pulsed high magnetic fields available at the NHMFL and the newly developed measurement techniques.

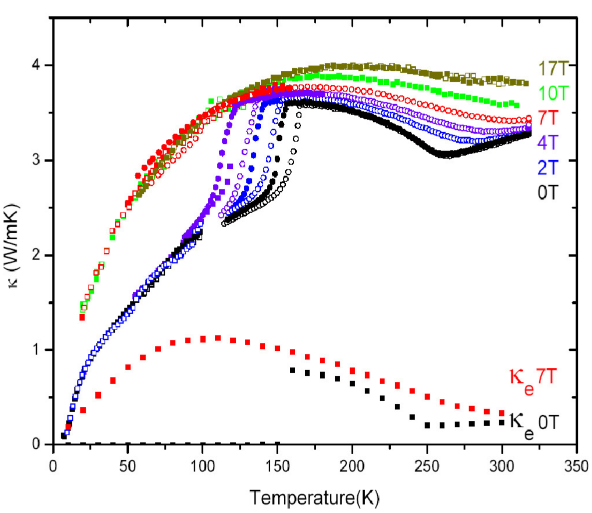


Figure 1. 3-ω measurement of a colossal magnetoresistance material through the field-dependent antiferromagnetic transition.

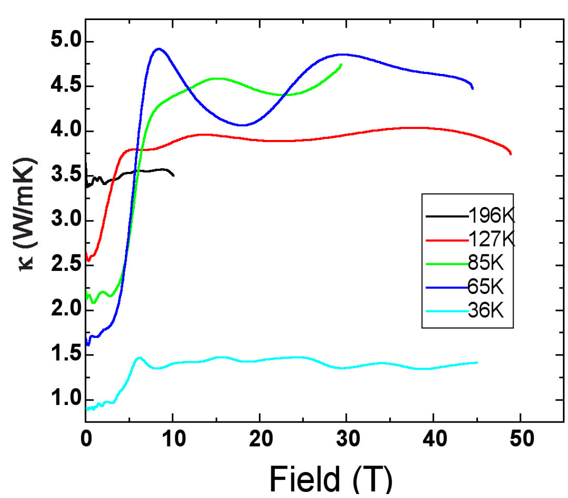
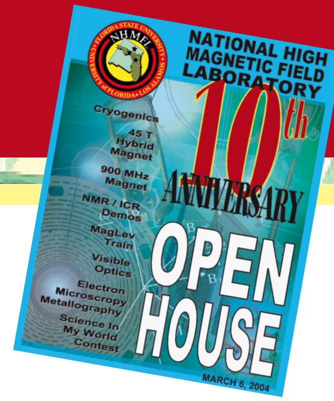


Figure 2. The identical set-up as for Fig. 1 except in a pulsed field. The measurement is a landmark because data were taken with 500 microsecond resolution in a short-pulse magnet. The results clearly show the field-induced antiferromagnetic phase transition. High T_c is next!

EDUCATION at the NHMFL

OUTREACH ACTIVITIES: At the Laboratory and On the Road

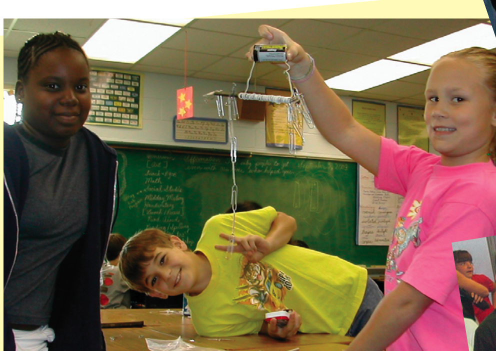


On March 6, 2004, the NHMFL opened its doors to 2,500 members of the general public. The 10th Anniversary Open House featured exhibits, demonstrations, activities, and displays to translate research conducted at the laboratory for the surrounding community. High school and community college students came from as far away as Bay County and busloads of students working with the Boys and Girls Clubs of America arrived to receive awards for entries to the Science in My World Contest. Interested seniors from the Westminster Oaks Retirement Community were treated to a special tour of the facility before they participated in the many hands-on activities developed by faculty and staff at the lab.

To further the mission of educational programs at the laboratory, the Center for Integrating Research and Learning expanded its educational outreach program, mentoring a local middle school in their efforts to compete in the Science Olympiad, assisting several schools in conducting "science days," and in 2003, providing outreach for over 7,000 K12 students. Carlos Villa, Outreach Coordinator, continues to find new ways to get students motivated.

CIRL will again host 40 local K12 teachers in two 4-day summer institutes designed to provide content-rich hands-on activities and strategies for making science exciting while accommodating the State's requirements for high-stakes testing. Pat Dixon recently conducted a "Literature in Science" workshop at Troy State University in Dothan, Alabama, as part of a partnership with the Wiregrass Math and Science Consortium. It is partnerships like these that enable CIRL to expand its outreach beyond the laboratory's immediate community.

Pat Dixon attended the 2004 National Science Foundation Research Center Educators Network Conference hosted by The Particle Science & Technology Engineering Research Center at the University of Florida in Gainesville. The conference brought together a diverse group of people conducting educational outreach at centers from the United States and Ireland. In addition to this network, an offshoot of the Research Experiences for Teachers (RET) Network Conference last fall met in San Francisco in April to discuss evaluation of RET programs. Networking with both of these groups has provided a unique opportunity to interact with program directors, program managers, outreach coordinators, and educators. This interaction helps CIRL develop new programs and enhance and expand existing programs.



Gina LaFrazza and Pat Dixon represented CIRL at the National Science Teachers Association national convention in Atlanta in April furthering the national outreach of CIRL and the NHMFL. Meeting with teachers regarding RET, workshops, and curriculum materials keeps us current as to issues of concern to teachers and administrators, as well as to needs of schools and students. Ysonde Jensen, Administrative Coordinator, and Justin Schwartz, Magnet Science and Technology, attended and featured the interactive traveling museum exhibit created to help translate complex concepts of superconductivity for the general public. The 4-foot version of a larger 12-foot exhibit will be on display at the Exhibit Hall at NSTA and teachers will be recruited for a teacher-student workshop at the Applied Superconductivity Conference in Jacksonville, FL, October 2004. This is a unique opportunity for educators to take part in an international scientific conference and to learn firsthand about the excitement of real-world science.

The Superconductivity interactive museum exhibit will debut at the Mary Brogan Museum of Art and Science, Tallahassee. The 12-foot exhibit takes viewers on a journey to learn how superconductors will be used in the City of the Future. Viewers can choose from five areas: What is a Superconductor?; How are Superconductors Made?; History of Superconductivity; Practical Applications of Superconductors; and Types of Superconductors. Special teacher and student activities will accompany the debut.

The newly-designed Web site for educational programs, http://education.magnet.fsu.edu has already received over 5,000 visitors. The Web site has been accessed to apply for REU and RET, to register on the REU Network, to fill out RET surveys, and to download pre- and post- visit and pre- and post- outreach materials. In addition, new features such as the Book of the Month, designed to help teachers use literature in their science classes and a Calendar of Events have received many positive comments from educators and from the general public.

Summer plans are already underway for adding new features to REU and RET as well as for expanding summer workshops to meet the needs of the large number of teachers requesting science professional development. A total of 20 REU students will be placed with NHMFL researchers in Tallahassee, Gainesville, and Los Alamos, and 14 teachers will work in Tallahassee. A record number of applications were received for both programs as the applicant pools grow in size, scope, and geographical diversity.

For more information, contact Pat Dixon, who contributed this article. She can be reached at 644-4707 or pdixon@magnet.fsu.edu.

Mapping Emotions Using 3 T MRI

P. Wright, UF, Psychiatry and Neuroscience and McKnight Brain Institute
Y. Liu, UF, Psychiatry and Neuroscience and McKnight Brain Institute

In recent years, functional magnetic resonance imaging (fMRI) has opened a new window onto the neural pathways underlying emotion and psychiatric disorders. This allows us to test our models of healthy and unhealthy brain function. Our lab recently applied this approach to obsessive-compulsive disorder (OCD). Our model supposes that OCD with obsessions about cleanliness and washing is not an anxiety disorder, but more accurately a disgust disorder. Our fMRI experiments suggest that the insula, a brain region implicated in disgust, is overactive in these patients.

Since functional imaging has only recently been used to study emotion, several useful but competing schemas exist for describing emotion. These models seem to mature in symbiosis with our understanding of their neural basis: they suggest new experiments and are in turn informed by the results. The biphasic theory of emotion is a simple but strong model that says emotional feelings and in particular the physical effects of emotion are produced by an approach system and an avoidance system. Thus our emotions can be described using two dimensions: valence (or pleasure), which means whether we feel nice or nasty, and arousal, which refers to the strength of our feelings.[1] But while this model describes the reliable, physiological features of emotion well, it seems inadequate to describe the shifting panoply of emotional feelings. When asked to identify emotions in facial expressions, people can reliably identify six "basic" emotions regardless of culture: happiness, sadness, fear, anger, disgust and surprise.[2] While these labels are closer to social concepts than physiological states, there is evidence from lesion studies that disgust may be distinct from the other negative emotions. Patients with Huntingdon's disease and certain, specific strokes have been shown to be impaired both at identifying expressions of disgust and even at experiencing the feeling of disgust.[3] It has been suggested that the somatosensory cortex allow conscious identification of emotions, and that since the insular cortex, which receives somatosensory input from the viscera, is specialized in recognizing disgust.

The first fMRI experiments to show distinct responses to disgust used pictures of facial expressions.[4] Expressions of disgust evoked greater brain activation at the insula than expressions of other emotions, such as fear. But subsequent experiments using pictures of disgusting scenes, such as rotten food, yielded conflicting results. The first study of patients with OCD found an increased response in the insula to disgusting scenes in patients with the washing variety of OCD, but this study used no other emotion as a control.[5] Two subsequent studies found that pictures inducing disgust and fear both caused equal activation of the insula, contrary to claims that the insula is an emotional specialist.[6,7] Our lab combined these approaches and found a greater insula response in OCD patients to disgust-inducing pictures but not for fear-inducing pictures.[8]

While puzzling over these conflicting results, we noticed that the previous study comparing fear and disgust included gory pictures (such as injuries and corpses) in its disgust-inducing pictures, whereas ours did not. We therefore designed a study to compare disgust evoked by pictures of contamination with disgust evoked by pictures of mutilation. The first set contained pictures such as an overflowing toilet, cockroaches exploring a pizza, and piles of garbage. In the second set were pictures of traffic accidents, murder victims, tumors, and birth defects. We also included a fear-inducing set of pictures of attacking dogs, snakes, gunmen, etc. and a neutral set of landscapes and household objects. In order to understand our subjects' responses better, we asked them to rate the pictures after their scan according to the six basic emotions (happiness, sadness, fear anger, disgust, and surprise). The pictures in this and the previous study were taken from the International Affective Pictures System (IAPS) and were already rated for the emotional dimensions of pleasure, arousal, and dominance.[9]

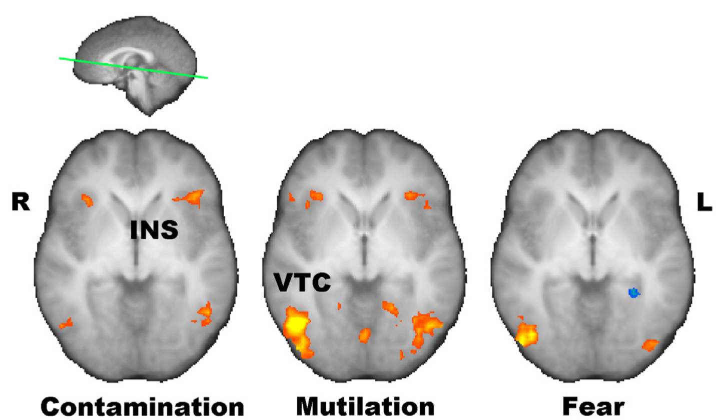


Figure 1. Statistical activation maps showing contrasts between each emotional condition and neutral. Contamination and mutilation caused activation of the anterior insula. The ventral visual cortex responded to all three emotional conditions, but only weakly to contamination. INS = insula, VTC = ventral temporal cortex. Green line in inset shows slice angle.

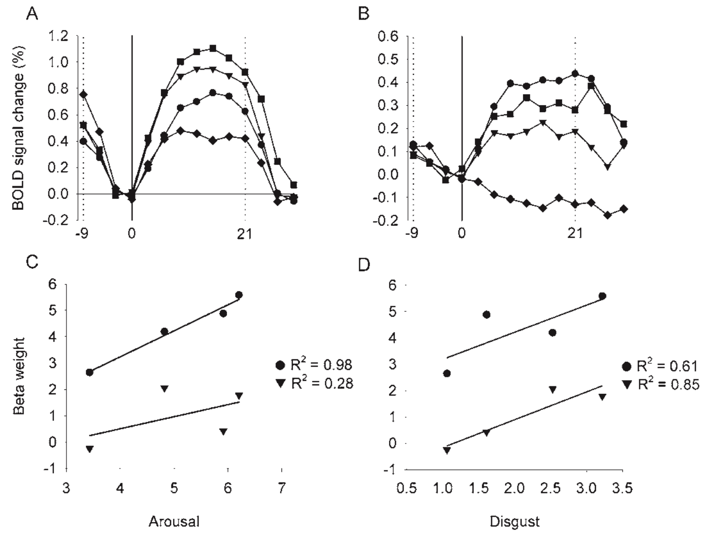


Figure 2. A & B: Averaged BOLD signal change (%) at the ventral visual area (A) and insula (B). Note the different relative responses between emotions at each region. ● = contamination, ■ = mutilation, ▼ = fear, ◆ = neutral. C & D: Emotion ratings plotted against modeled signal peak (Beta weight). Arousal predicted secondary visual activity (C), whereas disgust predicted activity in the anterior insula (D). ● = secondary visual cortex, ■ = anterior insula.

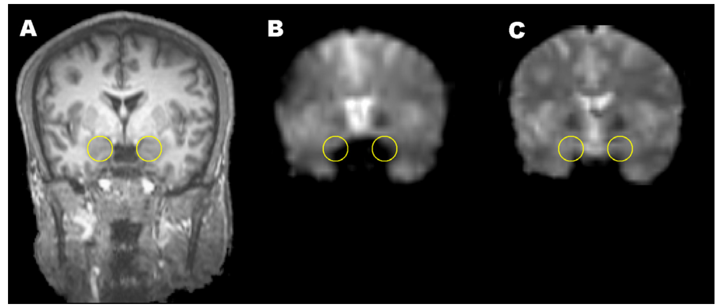


Figure 3. The effect of voxel size when imaging the amygdala. A: Structural image showing the left and right amygdala (circled) in the coronal plane. B: Identically positioned functional image from the disgust study showing susceptibility at the amygdala. Voxel resolution = 3.8 x 3.8 x 5 mm. C: EPI image showing reduced susceptibility at the amygdala. Voxel resolution = 3.0 x 3.0 x 3.0 mm.

Surprisingly, we were able to recruit eight volunteers willing to endure these gruesome pictures. They were scanned using the 3 T Siemens Allegra scanner at the University of Florida's McKnight Brain Institute. We found again that the disgust picture sets evoked activity in the insula, but that fear pictures did not. We also saw increased activity in the secondary visual cortex for all emotion conditions. This has previously been noted as an effect of emotional arousal.[10] When we took a closer look at the blood oxygen level-dependant (BOLD) responses in the insula and secondary visual cortex, we noticed that the response to the contamination pictures was greatest at the insula, but least at the secondary visual cortex (compared to the other emotional pictures). This suggested the two regions were processing different information. We confirmed this by correlating the peak activity at each region with our emotional ratings. Activity at the secondary visual cortex was predicted by pleasure and arousal ratings, whereas activity at the insula was predicted by the disgust rating. The reverse correlations were not significant.

Although these results strongly support the theory that the insula selectively processes disgust distinctly from emotional arousal, it is still not clear why some previous studies failed to find a specific insula response. The mutilation pictures induced comparable insula activity to the contamination pictures, and differed mostly in arousal of the secondary visual cortex. It is unlikely that they "diluted" the insula response to contamination pictures.

It is possible that the different findings were due to different scanner parameters. Perhaps the relatively small signal changes at the insula are only detectable at 3 T (the other studies used a 1.5 T scanner). But the most likely explanation comes, ironically, from a failed emotional experiment at our lab. The disgust study failed to show activity at the amygdala in response to emotional pictures because our scans failed to detect any signal in this region (this is due to the increased susceptibility artifact at 3 T). In order to study the amygdala, we reduced the voxel size in our functional scans from 3.8 mm in-plane resolution to 3.0 mm. This produced excellent images of the amygdala, but obliterated any contrast between the BOLD response to emotional and non-emotional conditions—even the reliable visual arousal effect. We confirmed this in a subsequent experiment comparing the response to fear-inducing pictures using both voxel-sizes: the larger 3.8 mm^3 voxel scans were more sensitive to differences in the BOLD response to fear-inducing and neutral pictures. Both of the previous studies that found equal insula activity to fear and disgust used 3.0 mm voxels.

We plan to continue expanding our emotional studies, beginning with a series of validation studies to test the reliability of the BOLD response to emotion in various brain regions. The study presented here demonstrates the ability of high-field fMRI to detect subtle changes in brain activity between emotional conditions, and confirms that the insula is still a valid target for studies of disgust and OCD.

1 Lang, P.J., *et al.*, *Psychol. Rev.,* **97**, 377-395 (1990).
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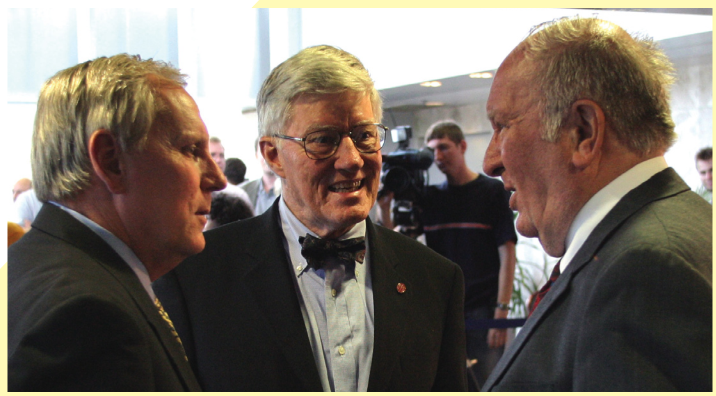
NHMFL Founding Director Jack Crow Honored

On Friday, March 26, 2004, Dr. Jack Crow was honored for his vision for a new national research facility, for his success in getting the NHMFL established at FSU, UF, and LANL, and for his extraordinary leadership of the laboratory since its inception. Over 100 of his family, friends, colleagues, and students gathered at the lab for the unveiling of a bust in his honor. Dr. Crow's bust is the first of many in FSU's "Legacy Walk," a walking history of FSU's major figures and events that will be strategically placed throughout campus and Innovation Park, where the NHMFL is located.

FSU President T.K. Wetherell presided over the ceremony and said that Dr. Crow is "just a treasure and we want to make sure he understands how much he's loved and how successful this program has become because of his efforts."



FSU President T.K. Wetherell, former FSU President Sandy D'Alemberte, and Bob Schrieffer

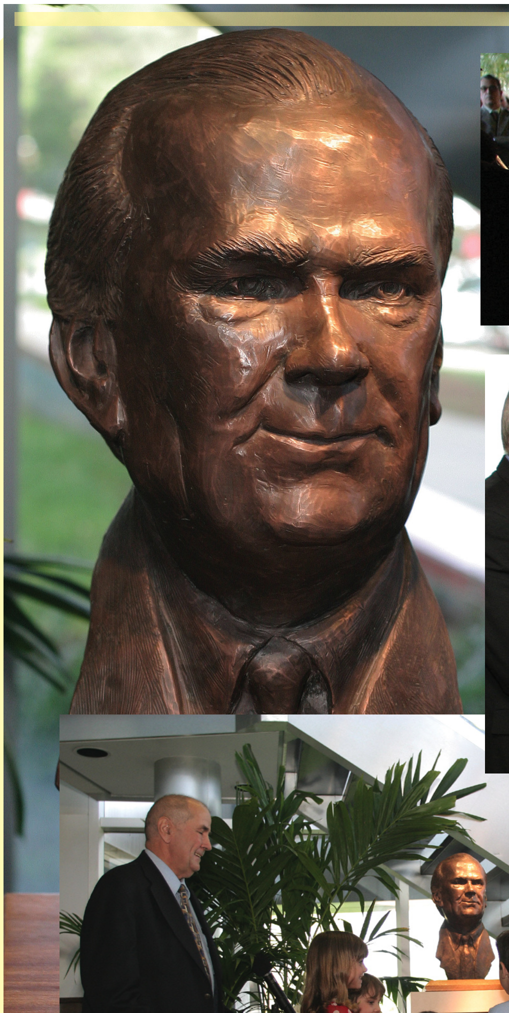
Special guests who spoke at the ceremony included Hugh Van Horn, Director of the National Science Foundation's National Facilities, Division of Materials Research; Bob Schrieffer, NHMFL Chief Scientist and Nobel Laureate; and California State University Chancellor Charles Reed. Chancellor Reed was the State of Florida's higher education Chancellor when the lab was being proposed as a model federal-state partnership and his staunch support was essential to NSF's decision to locate the laboratory in Tallahassee.

Hugh Van Horn

T.K. Wetherell (left) and Crow

Chancellor Reed (left) and Jack Crow

Chancellor Reed



Don Parkin (former NHMFL Co-principal investigator for LANL) presented flowers to Joan, Dr. Crow's wife of 44 years. Dr. Crow's granddaughter Alexa (see picture, left) read a poem on behalf of the grandchildren that recognized their grandfather for being "an inspiration and hard worker who never gives up."

Dr. Crow will remain at the laboratory in the Condensed Matter/Theory group and continue his research in transition metal oxides. These systems have been the source of considerable new physics, namely high temperature superconductors, colossal magnetoresistance, etc. He is excited about having the opportunity to do what he loves—working with his graduate students and expanding collaborations.

Don Parkin and Joan Crow

Membrane Proteins: A Scientific Frontier for NMR Spectroscopy—A National Effort Led by the NHMFL

T. Cross, NHMFL and FSU
F. Sönnichsen, Case Western Reserve University
C. Sanders, Vanderbilt University
S.J. Opella, University of California, San Diego
R. Nakamoto, University of Virginia
F.P. Gao, NHMFL and FSU
A. Korepanova, NHMFL and FSU

A program project grant that targets the expression, purification, and sample preparation for the structural characterization of membrane proteins is being coordinated from the NHMFL. Membrane proteins represent one of the most significant frontiers in the fields of structural biology and structural genomics. While 20 to 30% of all proteins are membrane proteins, less than 0.5% of the protein structures that have been characterized are membrane proteins. This and other factors contribute to the fact that the Protein Data Bank, where structural coordinates are deposited, is a very biased representation of protein structures. These proteins carry out many important cellular functions and represent more than 50% of all present and future drug targets.

There are many reasons why the success rate for the structural characterization of membrane proteins to-date has been so poor. As a class, these proteins are very different—largely due to the very heterogeneous environment in which they are found. This protein environment includes the bulk aqueous environment outside of the membrane, the hydrocarbon core of the membrane and the thick interfacial regions between hydrocarbon and water domains. The lipids that make up these membranes also induce certain global properties, such as a tendency to be non-planar, known as curvature frustration. There is also a lateral pressure gradient across the bilayer structure that can be as great as 300 atm. Consequently, in samples for structural characterization it is necessary to mimic this complex environment with a simpler model environment. This latter environment may or may not be adequate to support the native conformational and functional state of the protein.

Two protein production facilities have been established, one in the Department of Chemistry and Biochemistry at FSU under the direction of F. Philip Gao and Alla Korepanova and one in the Department of Molecular Physiology and Biological Physics at the University of Virginia under Bob Nakamoto's direction. The membrane proteins that have been targeted for this project are from the *M. tuberculosis* genome. The success of *Mycobacterium*

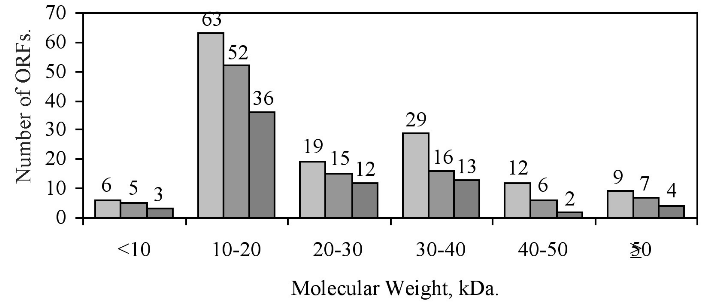


Figure 1. An analysis of 138 targeted ORF (light grey) out of approximately 328 that our consortium has attempted to clone. 73% of these targets have been successfully cloned (medium grey) using pET vectors with either an N-terminal or C-terminal hex-His tag. Expression (dark grey) of these cloned membrane proteins has been achieved using *E. coli* host strains.

tuberculosis, as a human pathogen is unchallenged. Nearly three million people die annually from this bacillus infection. Half of all those who die of AIDS die from tuberculosis. As much as a third of the world's population is infected, with ten million cases in the U.S. alone. Increasingly, there is concern that drug resistance will leave many more susceptible to this disease. Tuberculosis is currently treated with a cocktail of four front-line drugs, but in 80% of patients today the bacterium is resistant to at least one of these drugs. *The World Health Organization predicts that by 2020 there will be 1 billion additional cases of TB and 70 million additional deaths.*

Over the past two years from 328 open reading frames (ORFs), 228 have been cloned and 150 membrane proteins have been expressed in *E. coli* (Fig. 1). This success clearly shows that many membrane proteins can be produced in sufficient quantities to initiate structural characterizations. Membrane proteins are expressed in the cells in a variety of different ways. The most natural way is for the proteins to be expressed directly in the cellular membranes, sometimes tubular structures of lipid and protein are produced in the cells, which presumably have the protein in a native or native-like state. Alternatively, these proteins may end up in inclusion bodies, a precipitated and aggregated state of the protein that is non-native like or the protein may actually be expressed as a soluble protein in the cellular cytoplasm in a conformation that is certainly not the same as the conformation in the membrane environment. These different expression forms necessitate different solubilization, purification, and sample preparation protocols. All forms of expression have been observed in the efforts from both of our protein production facilities. While one might think that protein production in the membranes is optimal, often the expression yield in the membrane environment is low. A variety of tricks can be tried to increase to some extent the over-production in the membrane environment, but then there are

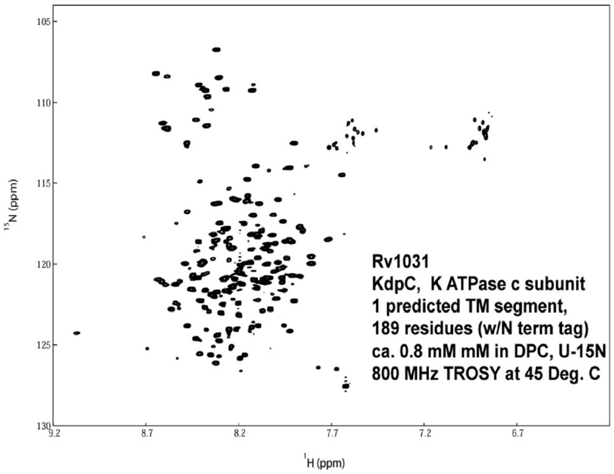


Figure 2. TROSY spectrum obtained by C. Sanders *et al*. at Vanderbilt University, for Rv1031 KdpC. Many such spectra have been obtained by several members of the consortium on a number of different membrane proteins both at the NHMFL and their home institutions. The choice of purification protocol and detergent are critical for obtaining a high quality spectrum. Even here there are a number of resonances that are not observed, probably reflecting dynamic regions of the protein.

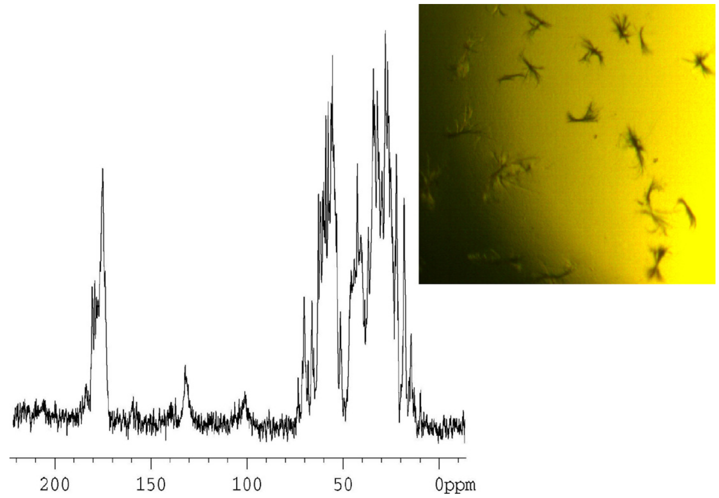


Figure 3. It has been noted in a number of labs recently that spectra of microcrystalline samples of proteins leads to much improved spectral resolution compared to what can be obtained from lyophilized samples. Here, Zhehong Gan at the NHMFL has recorded spectra of Ubiquitin at natural abundance using a 4 mm Magic Angle Spinner in our 830 MHz spectrometer. The insert shows microcrystals of a

a lot of different proteins in this environment The incorporation of special amino acid sequences at either end of the protein (tags) that specifically bind to an affinity column greatly enhances the efficiency with which these proteins can be purified.

While there are challenges at the expression and purification level there are also great challenges at the sample preparation stage. This effort includes a very broad range of technologies including X-ray crystallography, cryo electron microscopy, as well as solution and solid state NMR spectroscopy. The preparation of samples for each of these technologies is very challenging: X-ray diffraction even with synchrotrons needs large crystals with excellent long range order; cryo EM needs very homogeneous preparations with two dimensional order; solution NMR needs homogeneous samples at high concentration even with cryoprobe technologies; solid state NMR needs large samples as well as very homogeneous preparations in lipid or detergent preparations. Interestingly, many of these problems are closely related. For crystal growing efforts the first step is to find the right detergents to obtain very high solubility of the protein—a virtually identical problem to that of the solution NMR folks. By bringing these two groups together there is a hope that both more crystals for crystallography and more acceptable solutions for solution NMR can be achieved. Cryo EM needs can be facilitated with the collection of protein enriched tubular structures as described above—it may be that these preparations will be a major stepping stone toward the preparation of uniformly aligned bilayer preparations for solid state NMR. In addition it has been noted by many crystallographers that microcrystals of membrane proteins can be readily achieved while large crystals are very challenging, yet these small crystals are very homogeneous preparations for Magic Angle Spinning NMR spectroscopy.

The difficulties in preparing homogeneous preparations of membrane proteins are closely tied to the inherent properties of these proteins and consequently this is a new challenge in the structural biology and structural genomics community. The old methodologies used for water soluble proteins represent a starting point, but because the whole balance of molecular interactions that stabilizes these protein structures is different from water soluble proteins many of the old tricks have very limited applicability. Therefore, there is good reason to take a fresh look at each of the methodologies in an effort to see what can be learned through such an interdisciplinary effort. What we have learned so far is very promising—the groups of Sanders, Sönnichsen, and Cross have generated many initial two dimensional spectra such as the one shown in Fig. 2 that are promising for a structural characterization by solution NMR. Aligned sample methodologies developing in the labs of Opella and Cross have submitted several structures to the Protein Data Bank, but so far none of them are from the TB genome as aligned sample preparation is in an early stage of development. Zhehong Gan and F. Philip Gao have recently obtained high quality MAS solid state NMR spectra of microcrystalline ubiquitin, as have a number of other solid state NMR laboratories pursuing this rapidly developing approach for structural characterization.

There is another challenge—for solid state NMR probe technology has not been refined by the NMR spectrometer manufacturers and recently Bill Brey and Peter Gor'kov wrote in the *NHMFL Reports* (Volume 10, Issue 4, 2003) about the development of a high performance NMR probe for aligned samples at 600 MHz. These technological developments are continuing both for aligned samples and for MAS samples with Stan Opella, Robert Griffin, and Ago Samosan as collaborators. The search for improved sensitivity and spectral resolution is of immense importance to the success of NMR spectroscopy. Higher fields complemented by superior NMR probes will go a long way toward advancing the science in this structural genomics frontier.

Center for Advanced Power Systems Update

The Center for Advanced Power Systems (CAPS) at Florida State University is developing a unique research and test environment by combining real time simulation with power component testing in a hardware-in-the-loop facility. The facility, which will have power test capability of 5 MW will allow interactive dynamic load testing of equipment by controlling the source and load conditions applied to the test apparatus to emulate the actual system conditions in which the test apparatus will subsequently be applied, such as a propulsion motor and drive unit on a ship at sea. The power distribution system has been designed to allow easy reconfiguration of the test setup, and has the ability to create system configurations that can model new system designs and a variety of applications, including that of an isolated ship system.

CAPS was established in July 2000 and was built on the expertise of the NHMFL and resources and faculty at FSU and the FAMU-FSU College of Engineering, and broad interactions among the groups continue. It is a collaborative effort between the U.S. Navy, Office of Naval Research, and the Florida State University to provide insight and options for the Navy of the future's all-electric ship power system. The facility will have the capability to simulate and test full size components up to 5 MW, such as ship propulsion motors, power distribution systems and Zonal DC distribution concepts, and prototype conventional and superconducting components. It is expected that the equipment and systems developed at CAPS will have broad applications in aerospace, defense, and electric utilities.

CAPS Capability

The capability at CAPS consists of two parts: a real-time digital simulator and a physical test facility that can handle equipment testing of up to 5 MW steady state. The real-time digital simulator can control a 5 MW dynamometer and a 5 MW AC-DC-AC converter to provide test objects with real load conditions (e.g., voltage, current, frequency, and torque).

Real-Time Digital Simulator. The real-time digital simulator can perform digital simulations of complex electrical power networks in real time. Large numbers of input and output channels permit this simulator to be interfaced with and control external hardware. The simulator is modular and may be easily expanded by adding new racks. The present capability of the RTDS simulator is 128 parallel processors with a typical time step of 50 microseconds. The simulator allows the development of fast and accurate simulations for large and complex power systems, such as the closely coupled power system in an all-electric ship, or the electric power grid of a state or region. The simulator can be set up to operate as a hardware-in-the-loop simulation for testing power system components and control and protection systems in real-time in a simulated service environment. The simulator also allows development and validation of accurate models for hardware components and control of hardware/software systems. These simulation and testing capabilities will be crucial as simulation becomes an increasingly important tool for designing and maintaining power systems, both to improve performance under normal conditions and to improve resistance to and recovery from natural and man-made catastrophes.

5 MW Advanced Prototype Test Facility. The test facility offers a unique capability of testing large scale prototype and commercial equipment under dynamic loading conditions. Two 2.5 MW dynamometers connected on the same shaft will allow testing and evaluation of prototype and commercial motors under simulated ship propulsion and power system conditions up to 5 MW. Short-term overloads up to 10 MW will be available. Various control strategies can be analyzed in real-time under simulated loads, including firing pulse command levels. The test bed digital distributed control system runs tests with pre-programmed load profiles for extended periods of time (e.g., 24 hours). The real-time digital simulator can provide the object under test with dynamic load characteristics through the control of the dynamometers.

A unique capability will be a 5 MW variable voltage and frequency converter to study the impact of voltage sags, harmonics and system dynamics on the equipment under test such as motors, transformers, and power converters. This converter, under control of the real-time simulator, will be able to reproduce interactively the conditions at the busbar where the element under test would be connected in the real environment, such as a ship power system or utility grid. The value of current drawn by the element under test will be fed into the simulator and becomes part of the simulation to decide

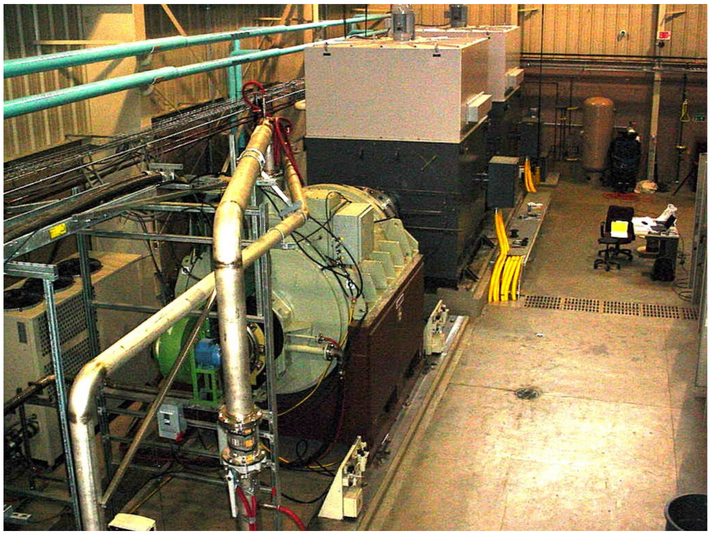


Figure 1. 5 MW dynamometer motors and 5 MW HTS motor.

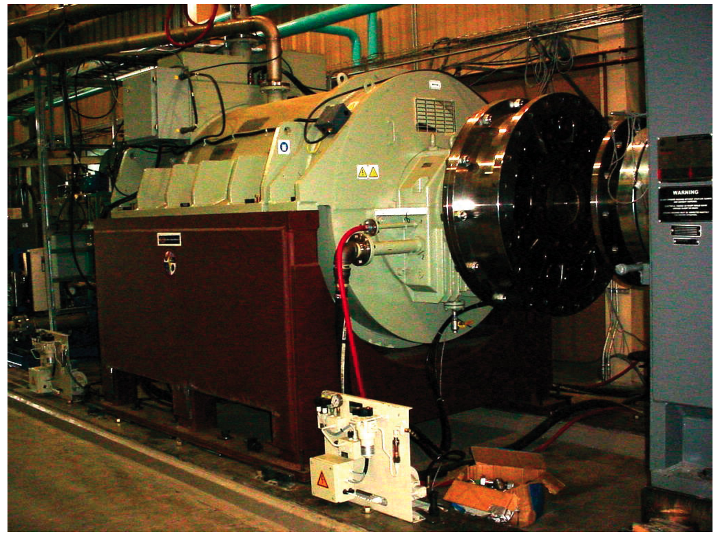


Figure 2. ONR's 5 MW AMSC-ALSTOM HTS motor in the test stand.

how the busbar voltage varies. Two separate AC and DC buses will provide the capability to simulate power systems with AC and/or DC distribution, investigate controls strategies, identify stability criteria for power systems, and test and evaluate large scale prototype models under varying power system and load conditions.

The test bed facility is supplied from an adjacent City of Tallahassee substation at 12.47 kV. The power is distributed via a 7.5 MVA transformer to a 4.16 kV experimental bus with 8 independent switch positions.

Energy Storage Test Facility. The original plan is also for the installation of a 100 MJ superconducting energy storage system, with a current rating of 4 kA and voltage rating of 24 kV DC on the DC bus. The SMES magnet is designed to provide up to 98 MW of pulse power for 0.5s, and a capability of providing up to 5 MW for up to 20 seconds.

Testing of the World's Largest HTS Motor. As the first major test in the facilities, the Office of Naval Research (ONR) has tasked CAPS to test and evaluate a 5 MW high temperature superconducting propulsion motor, which was designed and manufactured by American Superconductor-Super Machines in conjunction with ALSTOM Electrical Machines Ltd. The motor, which has a maximum rotational speed of 230 rpm, has a superconducting rotor cooled to 35 K using gaseous helium.

Based on the unique possibilities of the CAPS Test Facility, ONR decided to ship the 5 MW motor for full load dynamic testing at CAPS in Tallahassee, Florida. In July 2003, CAPS received the 5 MW HTS motor, and all of the associated equipment (consisting of circuit breaker, transformer, motor drive, and cryogenic system) has been installed in the high bay. The testing of the 5 MW HTS motor will start in early June, 2004, and take four months to complete following a rigorous test plan. The motor will be coupled to the 5 MW dynamometer that will act as load. The first test will be to verify that the motor has a rated power of 5 MW at 230 rpm. In the dynamic test phase of the motor, the 5 MW dynamometer will be controlled by the real-time digital simulator to emulate the propeller action on a ship at sea.

The Center for Advanced Power Systems is a member of the ONR university consortium for the Electric Ship Research and Development (ESRDC). The consortium members are: Florida State University, University of Texas at Austin, University of South Carolina, Mississippi State University, and the Advanced Technology Institute. The Center for Advanced Power Systems is staffed with a combination of 12-month appointed scientists, engineers, specialists, and faculty from the FAMU/FSU College of Engineering. CAPS provides opportunities for graduate students and postdocs to engage in cutting edge research in electric power systems testing, modeling and simulation, controls systems, and advanced power equipment research including high temperature superconducting transformer and advanced power electronic conversion.

For more information, contact Steinar Dale, Florida Advanced Power Laboratory Director, CAPS, who contributed this article. He can be reached at 645-1183 or dale@caps.fsu.edu.

PEOPLE IN THE NEWS

Gonzalo Alvarez, an FSU graduate research assistant working with Elbio Dagotto in the Condensed Matter/Theory group, has received an Outstanding Dissertation Award in Magnetism from the APS topical group on magnetism. His work is titled "Computational Studies of Diluted Magnetic Semiconductors and Other Materials."

Lev P. Gor'kov, Condensed Matter/Theory Program Director, and Spartak T. Belyaev jointly were awarded the 2004 Eugene Feenberg Medal for their pioneering work on superfluidity and superconductivity. They independently introduced the revolutionary concept of anomalous propagators, thereby changing our understanding of the physics of quantum systems. The applications span all facets of the many body problem: Belyaev explored dilute Bose liquids and pairing in nuclear matter, and Gor'kov laid down a powerful formulation of superconductivity that goes far beyond the original BCS work. Through the years, that formulation has become the standard language, as productive today as it was forty-five years ago. Gor'kov and Belyaev will be honored at the 12th International Conference on Recent Progress in Many-Body Theories in August 2004.

Gor'kov studied engineering at the Moscow State University and was one of the first graduates of the "Moscow Mechanical Institute" that had just been created for outstanding students. In the late fifties, Russian theorists were among the first to use field theoretical methods borrowed from quantum electrodynamics in the field of Statistical Physics. A series of landmark papers applied them to a wide variety of problems. Some of them were also conceptual breakthroughs. The papers of Spartak Belyaev and Lev Gor'kov belong to that very special class.

Gor'kov left Moscow in 1992 and is one of the founding scientists at the NHMFL. He is a full member of the Russian Academy of Sciences and has received the Lenin award, the Landau award, and the Bardeen award.

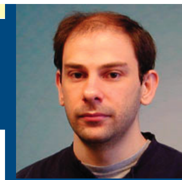
Nancy Greenbaum, FSU assistant professor of chemistry and biochemistry and one of the pillars of our in-house science program in NMR spectroscopy, is the recipient of a 2003-2004 University Teaching Award. This student-driven award recognizes her efforts in teaching undergraduate general chemistry and biochemistry courses. Dr. Greenbaum's NIH- and NSF-funded research focuses on the structural biology of RNA splicing. Her primary experimental approach includes solution NMR studies of RNA and RNA-protein interactions and she is a new member of the NHMFL In-House Research Program Committee.

In addition, Dr. Greenbaum has recently been awarded tenure, received promotion to Associate Professor, and a $1.1 million, five-year grant from the National Institutes of Health for structural and functional studies of the spliceosome. A four-year, $500,000 National Science Foundation grant was also awarded to study the basic functions of RNA splicing, as well as a two-year, $120,000 grant from the American Heart Association. This basic research could provide better understanding of the cause of cardiovascular diseases and certain cancers, and aid in the design of new approaches to treatment. She uses NMR facilities at FSU and the NHMFL.

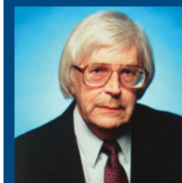
Kristina Håkansson, a former ICR Program postdoctoral fellow and now Assistant Professor of Chemistry at the University of Michigan, has been named a Searle Scholar for 2004. The Searle Scholars Program supports "the independent research of outstanding individuals who are in the first or second year of their first appointment at the assistant professor level, based on the potential of the applicant to make innovative and high-impact contributions to research over an extended period of time, in the areas of biochemistry, genetics, immunology, neuroscience, pharmacology, and related areas in chemistry, medicine, and the biological sciences."

John Miller, a scholar/scientist in the Magnet Science and Technology program at the NHMFL, has been named Director of MS&T. Previously, he was the leader of the Large High-Field Systems Group (part of MS&T), which is focused on the design of large superconducting magnets, the development of superconducting and cryogenic technologies that are essential to their reliable and efficient operation, and to their production. In particular, he had primary responsibility for the design, development, and fabrication of the NHMFL's 45 T Hybrid Magnet System, a $12+ million system that provides researchers with the highest steady magnetic field available anywhere in the world.

Miller will provide expanded and experienced leadership in both enabling R&D programs and in the development of magnet projects for the NSF, other National Labs, and additional "Work for Others."



GONZALO ALVAREZ



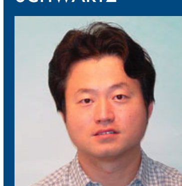
LEV P. GOR'KOV

NANCY GREENBAUM

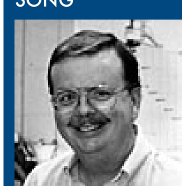
KRISTINA HÅKANSSON

JOHN MILLER

JUSTIN SCHWARTZ



LIKAI SONG



GREG STEWART

Justin Schwartz, professor of mechanical engineering, was named a 2004 Institute of Electrical and Electronics Engineers (IEEE) Fellow for contributions to high temperature superconductors and magnet systems. Schwartz received his B.S. in nuclear engineering from the University of Illinois at Urbana and his Ph.D. from MIT. He heads the High Temperature Superconductor Magnets and Materials Group at the NHMFL, where he conducts research on high temperature superconductors, including high field magnet applications, materials processing, magnetic properties, and engineering issues such as magnetothermal stability and mechanical behavior. He is the president, chairman of the board, and 2004 conference chair for Applied Superconductivity Conference, Inc. (see page 23 for conference information).

Likai Song, CIMAR/EMR graduate research assistant, received the Student Achievement Award of the Biophysical Society at the annual meeting in Baltimore, Maryland in February. The award honored a dozen students (from about 2,000) for the best poster presentations. He presented two posters and coauthored one platform talk. Song won in the motility subgroup.

Greg Stewart, UF professor of physics, was awarded a CLAS Term Professorship. The UF College of Liberal Arts and Sciences honors outstanding faculty who excel in both scholarship and teaching with this designation. Stewart received his Ph.D. from Stanford University in 1975 and has taught at UF since 1985. His research advances the understanding of the unusual magnetic and superconducting properties of highly correlated f-electron metallic compounds. He has numerous outside collaborations and is a user of high magnetic fields since 1982. Stewart is an American Physical Society Fellow.

FAREWELL TO BILL LUTTGE, FOUNDING DIRECTOR OF MCKNIGHT BRAIN INSTITUTE

WILLIAM G. LUTTGE

DOUGLAS K. ANDERSON

William G. Luttge, Ph.D., founding Executive Director of the Evelyn F. and William L. McKnight Brain Institute of the University of Florida (MBI-UF) retired on January 16, 2004 after 32 years of dedicated service to UF. The MBI-UF is the host site of the NHMFL's magnetic resonance imaging (MRI) and much of the biological NMR efforts. As the Executive Director, Dr. Luttge's vision stressed the integration of all fields involved in brain and/or neuroscience investigations and he was the driving force behind the development of the world-class Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) facility at the MBI-UF. Dr. Luttge has entered into quiet retirement by hiking the 2200 mile Appalachian Trail.

Douglas K. Anderson, Ph.D., an Eminent Scholar, Chair of the Department of Neuroscience, and a Senior Career Research Scientist with the Department of Veterans Affairs, has been named the Interim Executive Director of the MBI-UF. He previously served as Director of Research and Development for the MBI-UF. For the past 30 years, Dr. Anderson's research program has focused on spinal cord injury (SCI) and repair. The emphasis of his research has been on understanding the mechanisms responsible for post-traumatic tissue damage and employing repair strategies such as pharmacological agents, cellular replacement, and task specific training.

"CROW'S FEET" RELAY FOR LIFE TEAM TOP FUNDRAISER

Congratulations to the NHMFL's American Cancer Society Relay For Life Team, "Crow's Feet," for being recognized as the Top Online Fundraiser in Florida State University's first-ever Relay For Life event. The university's fundraising goal was $50,000—a figure that was far surpassed by generous contributions from 56 FSU teams. The total collected by the university was $78,600, and the NHMFL team is proud to have raised $10,901.02—or 13% of the total.

Members of the lab contributed in various ways: donations, T-shirt purchases, behind the scenes, and/or willingness to walk from 30 minutes to 3 hours or more. Relay For Life is the American Cancer Society's signature activity. It unites millions of people in thousands of communities nationwide each year to raise money to help prevent cancer, save lives, and diminish suffering from the disease.

SWEEPER SUCCESS!!

M.D. Bird, NHMFL
J.R. Miller, NHMFL

Introduction

The National High Magnetic Field Laboratory at Florida State University has completed the design, fabrication, and testing of a large-gap, super-ferric dipole magnet for use in radioactive beam experiments at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (see Fig. 1). The magnet was successfully tested at the NHMFL reaching the design current on March 19, 2004, with only a single training quench. The magnet should arrive at the NSCL in April and be installed and in-service performing experiments along the nuclear drip-lines using the coupled-cyclotron sometime this summer (see Ref. 1 for more information on the cyclotron lab and the physics opportunities). The National Science Foundation is the primary funding source for both laboratories as well as this project.

Magnet Design

Electromagnetically, the sweeper magnet consists of two "D"-shaped NbTi superconducting coils, a twenty-ton "C"-shaped iron yoke, and two square resistive trim coils as shown in Fig. 2.

From an assembly perspective, the magnet consists of four major sub-assemblies shown in Fig. 2: the iron yoke, the magnet cryostat, the satellite cryostat, and the resistive coils.

The two most sophisticated sub-assemblies are the magnet cryostat and the satellite cryostat. The magnet cryostat, in turn, consists of the two NbTi coils, a stainless steel bobbin that serves as the main structural support and provides helium containment around the windings, structural links from 300 K to 4 K, a nitrogen shield, and a vacuum vessel. The satellite cryostat consists of the helium reservoir, the nitrogen reservoir, nitrogen shields, warm-to-cold links, vapor-cooled leads, bus work and a joint, and a vacuum vessel (see Ref. 1-5 for more information on magnet design).

Frequently, superconducting magnets of this class fail to reach the performance goal on the first attempt. Instead they will transition from the superconducting to the resistive state in a process known as "quench." After a series of "training quenches," the magnet may reach the performance target. Large-gap dipole magnets developed at other labs have required over 100 training quenches to reach their design points. Occasionally, magnets fail to reach their design currents at all and are either re-built or operated at less than design expectations. The NHMFL/NSCL Sweeper magnet reached its design current after only a single training quench. The exceptionally good performance of this magnet may be attributed to the extreme attention to detail that was provided by the magnet design and fabrication staff of the NHMFL. Numerous innovations were developed that contribute to a more robust design.[1-5] Table I compares large-gap superferric magnets built at various facilities in recent years and presents some performance comparison.

Table I. Comparison of Recent Large-Gap Dipole Projects

Design Parameters	Sweeper	Superbend	Septum
Gap Height (mm)	140	53	250
Peak Field (T)	6.3	6.8	5.3
Current Density (A/mm2)	143	154	250
Stored Energy (kJ)	926	150	226
Field Integral (T*m)	3.0	1.1	2.8
Current (A)	365	291	665
Performance	**Sweeper**	**Superbend**	**Septum**
Years	5.5	4-7	5
Attempts	1	4	1
Actual/Design Current	1.0	1.0	0.5
Quenches	1	~110	~10

Figure. 1. NHMFL/NSCL Sweeper magnet and many members of the project team after successful testing at the NHMFL in March 2004.

SWEEPER MAGNET PROJECT TEAM

Analysis	Mechanical Design	Technology Advisors	Materials Testing
Yehia Eyssa Andy Gavrilin Soren Prestmon Gabor Tanacs Jack Toth	Scott Bole Danny Crook Scott Gundlach Steve Kenney	Denis Markiewicz John Miller Al Zeller	Ke Han Mike Haslow Vince Toplosky Bob Walsh

Winding & Assembly	NHMFL Machining	Welding	FSU Physics Machining
Jerry Kenney Benny Lesch Ed Miller	Mark Collins John Farrell Andy Harper Danny McIntosh Vaughn Williams	Raymond Lewis Willie Nixon Robert Stanton	Dan Baxter Ryan Newsome Randall Smith Terry Volsh Ian Winger

System Testing	Leak Checking	Purchasing
Iain Dixon George Miller Andy Powell Bianca Trociewicz Huub Weijers	Scott Maier Ken Pickard John Quinn	Keith Bookholdt Jim Payne Lee Windham

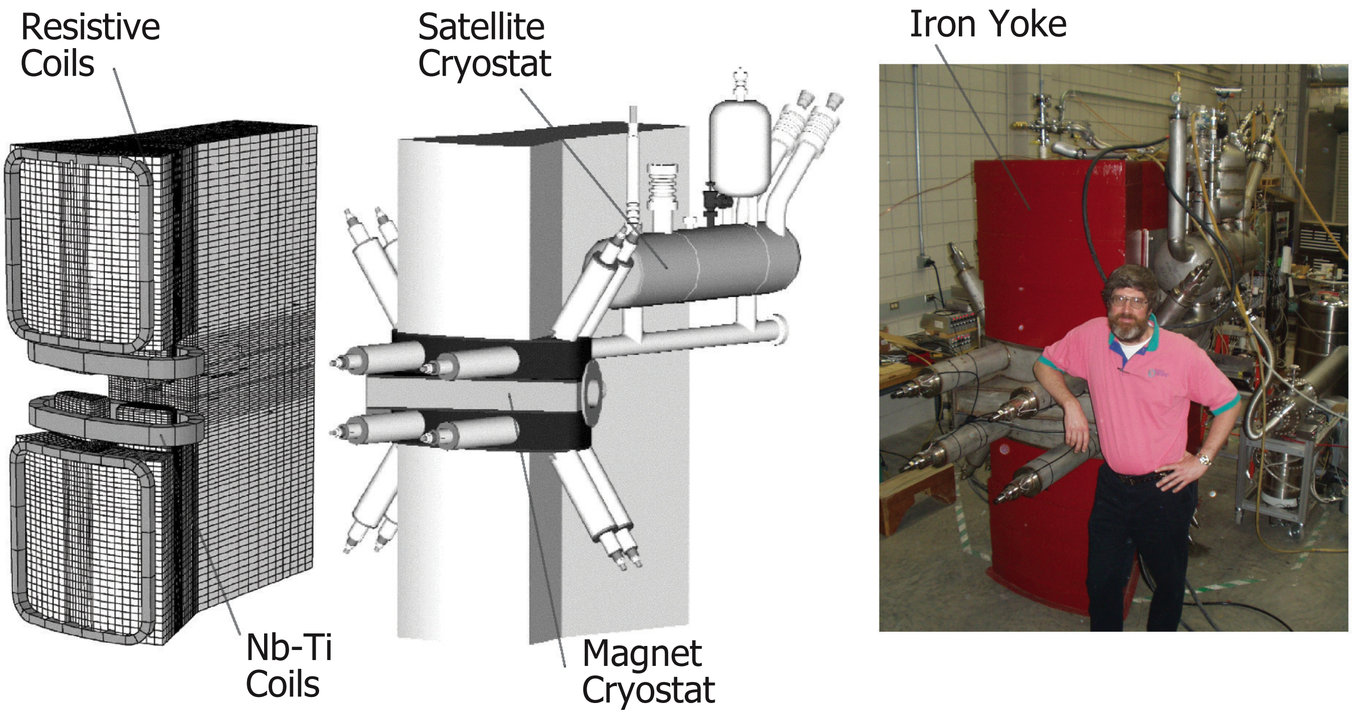


Figure 2. Evolution of the Sweeper from electromagnetic model (left) to Computer-Aided-Design (CAD) model (middle) to working system (right). Mark Bird is pictured.

The Superbend magnet was built by Wang NMR, Inc. for Lawrence Berkeley National Laboratory[7] while the Septum magnet was built by BWXT for Jefferson Lab.[8] Of the three magnets presented, the Sweeper had by far the largest stored energy and field integral. The Superbend had slightly higher field, the Septum had a larger gap. The three projects required similar amounts of time to complete. Successful completion of the Sweeper magnet adds to the growing list of mutually beneficial external collaborations to produce unique magnet systems, whether superconducting, resistive, or pulsed for a variety of institutions (national and international—public and private).

Acknowledgements

This project has been made possible through the combined efforts and cooperation of numerous persons here at FSU as well as at the NSCL and various commercial suppliers. The success of the project is a testament to their skill, dedication, and teamwork. The persons listed on the previous page have made major contributions to this project and their efforts are sincerely appreciated. Any omissions are purely accidental. Many individuals served in multiple capacities but only their primary role is listed on previous page.

1 *NHMFL Reports*, **9**, 4, 15-18 (2002).
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Looking Back . . .

Membranes: A Challenge for Protein Magnetic Resonance

On January 23-25, 2004, 120 people met for a workshop entitled "Membranes: A Challenge for Protein Magnetic Resonance" hosted by the FSU Institute of Molecular Biophysics with generous additional support from the Department of Chemistry and Biochemistry and the NHMFL. Attendees came from Australia, Europe, and Canada, as well as the United States.

The scientific program marked the significant progress that is being made in the structural, dynamic, and functional characterization of membrane proteins by electron spin resonance, solution-state NMR, and solid state NMR spectroscopy. In addition, we heard about the excellent progress being made in developing robust protocols for the expression and purification of membrane proteins, long considered one of the major bottlenecks in this research arena.

For more information, contact Timothy Cross, NMR Program Director, at 850-644-0917 or cross@magnet.fsu.edu.

Solid State NMR Workshop

The NHMFL hosted a workshop "Solid State NMR and Materials Applications at High Magnetic Fields" on March 12-13, 2004. This meeting gathered researchers from Australia, Canada, England, France, Korea, The Netherlands, Russia, and the United States who apply solid state NMR spectroscopy of quadrupolar nuclei for study of materials ranging from glass, zeolite, catalyst, and biological macromolecules. High magnetic fields reduce the second-order quadrupolar shift, the major source of line broadening, and are essential for better spectral resolution and sensitivity for quadrupolar nuclei NMR. In addition to scientific presentations, the participants gave many good suggestions and comments for the future development of solid state NMR capabilities and the unique utilization of high magnetic fields at the NHMFL.

For more information, contact Zhehong Gan at 850-644-4662 or gan@magnet.fsu.edu.

International Workshop on Materials Analysis and Processing in Magnetic Fields

The NHMFL hosted the "International Workshop on Materials Analysis and Processing in Magnetic Fields" on March 17-19, 2004. In spite of the very short notice, 55 researchers attended the meeting (9 from Europe, 19 from Japan, and 27 from the United States; 6 participants represented various industry companies). Forty-one really outstanding presentations covered many areas of magnetic field effects in physics, chemistry, and biology.

Over the last decade, new science opportunities and research activities have arisen due to the impressive progress made in the generation of high magnetic fields, spearheaded by the NHMFL. *Materials analysis and processing in magnetic fields* is a rapidly expanding research area with a wide range of promising applications in materials development and design. In response, industry now offers a variety of superconducting magnets, many specifically designed for this purpose and equipped with cryocoolers that dispense the need for cryogenic fluids. Numerous research centers dedicated to materials research and processing in magnetic fields have been created around the world, their magnets covering a wide range of experimental space and field strength. This workshop was organized to review the most recent activities in this field.

Magnetic fields are at the origin of many effects in materials, of which the following are a few examples.

The high fields available now allow us to levitate diamagnetic matter with the advantage of containerless processing of materials, or control gravity on earth from – g to + g. Magnetic anisotropy can be used for aligning fibers, polymers, and carbon nanotubes, resulting in matrix systems with superior quality. The magnetic field has an impact on texturing of materials during a phase transition, both liquid-to-solid and solid-to-solid state transitions. Grain boundary migration and change of their mobility have been demonstrated in Bi and Zn crystals, giving us the perspective for texture development in metals. The damping effect of magnetic fields on conductive liquids is exploited for improved crystal growth quality. Magnetic fields can help manipulate cells and cellular processes, such as cell divisions. Nanomagnetic particles can be mixed with biological blood components for treatment, through magnetic blood cell separation or as a marker. Magnetic fields are also used to reduce defects in crystalline and carbon fibers.

For more information, contact Hans J. Schneider-Muntau, Chief Technology Officer, at 644-0863 or smuntau@magnet.fsu.edu

Looking Ahead . . .

Applied Superconductivity Conference

Over 1,400 abstracts have been received. It will be hosted by the NHMFL in Jacksonville, Florida, October 3-8, 2004. Special sessions are planned in cryo-packaging and integration of superconducting electronics, cryo-power electronics for large scale superconducting devices, and integration of superconducting devices to the utility grid. In addition, a special memorial session honoring the late John Hulm, a key figure in the discovery of superconducting materials and their applications, and marking the 50th anniversary of the discovery of A15 superconductors is planned.

Conference registration will open May 17, 2004. For additional information, please check the ASC Web site at www.ascinc.org or contact the Local Conference Chair, Ysonde Jensen, NHMFL (ASC04LocalChair@magnet.fsu.edu, 850-644-0807).

See back cover for full list of upcoming conferences and workshops.

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CONFERENCES & WORKSHOPS

2004

"Big Light" Workshop: Exploring the Combination of High Magnetic Fields and Bright Light Sources
http://www.magnet.fsu.edu/news/events/conferences.html
May 6-7, 2004
Tallahassee, Florida
Contact: L.C. Brunel (*brunel@magnet.fsu.edu*, 850-644-1647)

Fluctuations and Noise in Materials
http://spie.org/Conferences/Programs/04/fn/conferences/index.cfm?fuseaction=5469
May 25-28, 2004
Maspalomas, Gran Canaria, Spain
Contact: Dragana Popovic (*dragana@magnet.fsu.edu*, 850-644-3913)

16th International Conference on High Magnetic Fields in Semiconductor Physics (SemiMag16)
http://SemiMag16.magnet.fsu.edu
August 2-6, 2004
Early Registration Deadline: June 25, 2004
Tallahassee, Florida
Contact: Yong-Jie Wang (*SemiMag16@magnet.fsu.edu*, 850-644-1496)

Applied Superconductivity Conference (ASC04)
http://www.ASCinc.org
October 3-8, 2004
Jacksonville, Florida
Contact: Justin Schwartz (*ASC04ConfChair@magnet.fsu.edu* 850-644-0874)

15th Conference of the International Society of Magnetic Resonance (ISMAR 2004)
http://www.ismar2004.org/
October 24-29, 2004
Ponte Vedra Beach, Florida (near Jacksonville)
Contact: Tim Cross (*mail@ismar.org*, 850-644-0917)

2005

Physical Phenomena at High Magnetic Fields – V (PPHMF-V)
August 5-9, 2005
Tallahassee, Florida
Contact: Coordinator Alice Hobbs (*aclark@magnet.fsu.edu*, 850-644-3203)

24th Low Temperature Physics Conference (LT-24)
http://www.phys.ufl.edu/~lt24
August 10-17, 2005
Orlando, Florida
Contact: Gary Ihas (*ihas@phys.ufl.edu*, 352-392-9244)

Sixth International Symposium on Crystalline Organic Metals, Superconductors, and Ferromagnets (ISCOM 2005)
September 11-16, 2005
Key West, Florida
Contact: Jim Brooks (*ISCOM2005@magnet.fsu.edu*, 850-644-9186)