ken strongly in support of the excellence of the science at the laboratories and ensuring that the secrets that need to be protected, are protected. So the issue is improving security, but doing it in such a way that does not hurt the quality of the science. I believe that [Richardson] tried very hard to do that, but this is still a tough challenge and we're not there yet.

PT *Given the high costs and increasingly international nature of big science projects, what does the US government, and Congress in particular, do to be a credible, reliable partner in such projects?*

LANE We've seen very positive developments in the last 8 years on that. Let me pick out the LHC [Large Hadron Collider at CERN] as an example. I think we really did cross a threshold with the LHC. I mean DOE and NSF . . . committed quite substantial amounts of money in support of the accelerator, the detector, and the experiments at CERN. I think that's a sign of maturity on the part of our US political process. We have to be a real partner [in international projects]. We have to be a credible partner and honor our commitments. I just point to the LHC as a recent example of us moving in the right direction. But we'll continue to be challenged to figure out how to do that.

PT *During your tenure at OSTP you urged scientists to leave their labs occasionally and interact with the media or give talks about science to school and community groups. In other words, put a more human face on science. How has that message been received in the science community?*

LANE I think for the most part, all of our colleagues understand that it is important. Everybody isn't equally good at doing some of these sorts of things, but for God's sake, even if you don't want to do it, support those people who are good at it. Support those who want to give a little of their time communicating through the media, or giving talks in the schools and communities. It's a long-term issue that we all have to focus on.

PT *Is Bill Clinton personally interested in science?*

LANE Science and technology are the areas in which I've spent most of my time talking with him, and he loves the stuff. Sometimes he sends me an article he's read in a magazine and he marks it up and makes some comment on it when we're together. He's a very intellectually curious and enormously intelligent person.

JIM DAWSON

Electron Holography Lab Pushes Resolution Limit

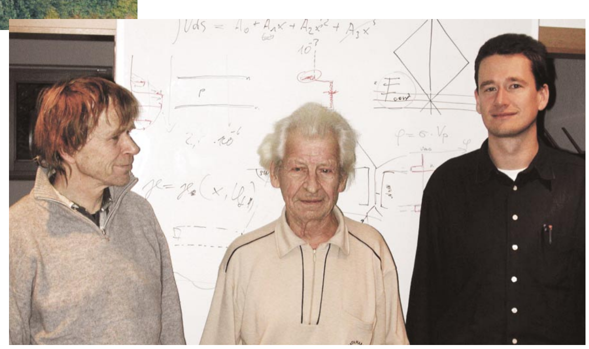
By minimizing electromagnetic, mechanical, and other disturbances, physicists in Dresden, Germany, aim to perfect electron holography and popularize its use in semiconductor, superconductor, and other materials studies.

Driving through the bucolic countryside just east of Dresden in the former East German state of Saxony, you wouldn't expect to see one of the world's top labs for advancing electron microscopy. And you don't, because it's off the road, concealed by trees the Soviets planted when they used the same patch of land for a radar spy station before German reunification.

The isolation of the spot, atop a hill called Triebenberg, plus a specialized building design, will improve resolution in transmission electron holography, says Hannes Lichte, the new lab's director. Over the past 70 years, he adds, "electron microscopes have been developed to achieve brilliant performance down to atomic dimensions. But often they cannot be exploited because the disturbance level of the lab is too high."

It was no different at the Technical University of Dresden, Lichte discovered soon after moving there a few years ago from Tübingen in western Germany. "There were vibrations from streetcars and noise from the building." So Lichte and retired physicist Dietrich Schulze tested some 30 sites on the outskirts of town. At the former radar station, says Lichte, "we found an AC stray field of about 1–2 nanotesla. This is a factor of a hundred better than is usually found in such labs. The site of Triebenberg is simply fantastic."

GUENTER SCHOELER



THE TRIEBENBERG electron holography lab (above), 13 km east of Dresden, Germany, is designed to minimize disturbances to microscopes, which are housed in the rightmost part of the building. Offices and utilities are on the left, with a separate foundation. Triebenberg lab founders (right) Hannes Lichte (left) and Dietrich Schulze (center), with the lab's technical director, Michael Lehmann.

The ultimate site

Scientists always strive to reduce vibrations and other disturbances to their electron microscopes. But the Triebenberg lab, which was completed just over a year ago, is the first to have been designed from the outset to minimize electromagnetic, mechanical, acoustic, and thermal interference. Power supplies, air conditioning, heating and cooling units, and other utilities are structurally isolated from the electron microscopes. "Lichte has recognized that the building is an integral part of the whole instrument," says Abbas Ourmazd, director of the Institute for Semiconductor Physics in Frankfurt on the Oder, Germany. "The time is ripe. Instruments and algorithms only recently got to the point that they are limited by buildings. Now he is truly limited by the aberrations of the instruments."

Lichte aims to take electron holography to the limits of resolution, to define those limits, and to refine the method so that it becomes attractive for widespread use. Analogous to optical holography, electron holography involves combining a beam—in this case, of electrons—that has passed through the sample with one that has not. The resulting interference fringes yield phase as well as amplitude information, and so offer more scope than traditional electron microscopy for correcting aberrations. Just moving the electron microscopes into the Triebenberg lab more than doubled the fringe contrast, says Lichte. "The results are overwhelming. To judge the progress, you should know that formerly we had to struggle for every percent in improvement."

"We have 0.9 Å resolution. We want to get to 0.8 Å—that could take another five years," Lichte adds. It's a matter of optimizing spherical aberration, axial coma, astigmatism, and a half dozen other parameters.

Improving resolution, says Uli Dahmen, who heads the National Center for Electron Microscopy at Lawrence Berkeley National Laboratory, "is extremely important in terms of materials science—to help us understand how materials behave on the atomic scale." At 0.85 Å, Dahmen's newest microscope is among the highest resolution machines in the world but, he says, reconstructing images takes a few hours, whereas "electron holography has the potential to do nearly real-time images."

That's not electron holography's only advantage: "The phase lets you extract the electric and magnetic fields present inside a sample. No other technique does it with anywhere near the same spatial resolution," says David Smith, director of Arizona State University's Center for High Resolution Electron Microscopy. Visualizing these fields is expected to become increasingly important for applications involving microelectronics, superconductors, and other materials. "Electron holography is a wide open field, one of the frontiers. There is a great deal to be done, and great opportunities," says Dahmen. "As far as sites for electron microscopy, [the Triebenberg lab] is the ultimate—it's the site that all microscopists would want. I'm eager to see what it does."

Lichte and his colleagues are still outfitting the Triebenberg lab. So far, they have three electron microscopes, with space for three more. The microscopes have electron energies of 100 keV, 200 keV, and 300 keV. A few other labs, in particular Akira Tonomura's at Hitachi's Advanced Research Lab in Hatoyama, Japan—the other leader in electron holography—use energies around 1.0 MeV (see PHYSICS TODAY, June 2000, page 9), which give inherently better resolution, but can also do more damage to samples.

Land resolution

Making the lab happen took the persistence of Lichte and the connections of Schulze, a longtime Dresden resident who knows the ropes in the former East Germany. They got support from Triebenberg's local authority, who, Schulze says, was interested in a swap: If the university promised to remove a telescope from a 100-year-old tower, the region would officially support the electron microscopy lab's coming to Triebenberg. The other key to landing the former Soviet radar station was a conversation with the head of the Real Estate Bank of the State of Saxony. "After an hour, we agreed," says Schulze. "He said, 'I'll save the land for you.' We owe him thanks." Lichte won't say how much the new building cost, except that it came to roughly the same as two of his electron microscopes.

And, although the lab is up and running, it's not quite in the clear: The little road leading to the lab crosses private land, and wrangling over the form and amount of compensation to the farmer who owns it is holding up a long-term permit for using the Triebenberg site and delaying the lab's opening celebration. In the meantime, a small telescope to look for asteroids is planned for the site, and the rest of the 5.5 acres is growing wild and will be studied by botanists from the Technical University of Dresden.

"It was extraordinarily difficult getting the lab together," says Smith. "Hannes now needs people with cutting-edge problems to reward his extraordinary efforts." **TONI FEDER**

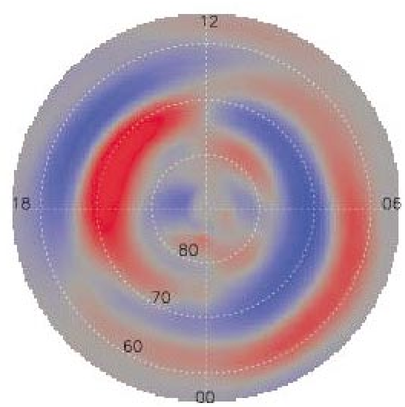
Iridium Satellites Kept Aloft, Piggyback Magnetic Measurements Continue

For most of the past year, the future of Brian Anderson's experiments was up in the air—which is where the experiments will stay, thanks to the December bankruptcy bailout of Iridium LLC's global satellite system. The fleet of 66 telecommunications satellites averted being deorbited when a new company, Iridium Satellite LLC, armed with a hefty contract from the Department of Defense (DOD), bought the $5 billion system for the token sum of $25 million.

With Iridium still aloft, Anderson, a space physicist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, can continue using onboard magnetometers—whose actual purpose is to keep tabs on satellite orientation—to watch how the solar wind drives Earth's space weather.

From an hour's worth of Iridium data, Anderson and colleague Colin Waters of the University of Newcastle in New South Wales, Australia, create snapshots of current flow in the northern polar region. Their data matches earlier maps pieced together from measurements taken over 18 months, and they have further shown that the currents change with the solar wind's magnetic field, says Anderson. (They presented some of their early results at the American Geophysical Union meeting in San Francisco this past December.) Now they're hoping to get more frequent data samples: "Solar wind activity varies on a scale of 20 minutes, so for storm monitoring we'd like to get down to a nine-minute refresh time." Nine minutes is the time between two Iridium satellites on the same orbit passing a given spot.

"What users of space weather [data] really need is to fully characterize ionospheric current systems," says John Kappenman, a division manager at Metatech Corp, which provides space weather forecasting to power companies. "How large are [the currents]? Where are they at any spe-



CURRENT FLOW in Earth's northern hemisphere (as seen from above) derived from data from the magnetometers onboard the Iridium satellites. The currents flow up (red) and down (blue), parallel to Earth's magnetic field. Upward flowing currents correspond to regions of auroral displays. (Courtesy of Brian Anderson and Colin Waters.)