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Physicists Play A Hands-On Role In Super Facilities Construction

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Well-rounded scientists who directly oversee the building of accelerators and reactors swap glory for grander achievements

High on a ridge in Berkeley, Calif., construction workers swarm over a $100 million scientific instrument, called the Advanced Light Source, that will allow scientists to peer into living cells and photograph lightning-fast chemical reactions. A continent away, at Brookhaven National Laboratory in Upton, N.Y., bulldozers have begun chewing up the dirt for the Relativistic Heavy Ion Collider, a $400 million accelerator that will give physicists a window into nuclear processes that have not occurred in the natural universe since microseconds after the Big Bang.

Similar activity is going on in Norfolk, Va., home of the $430 million Continuous Electron Beam Accelerator Facility (CEBAF); Argonne, Ill., future home of the $450 million Advanced Photon Source (APS); and Oak Ridge, Tenn., site of the $900 million Advanced Neutron Source (ANS).

Scientists expect that these massive instruments, now in various stages of development, will give them the tools to make fresh and startling discoveries (see stories, pages 6, 7, and 19).

To a handful of physicists, however, the cranes, girders, concrete, and cable represent more than the distant promise of experimental results. These men and women, who are responsible for seeing that these instruments are built right, on time, and within budget, say that their science is the machine itself.

"When you're a young scientist, the joy [of discovery] means so much to you that you want to do your own work and put your own name on things," says Colin West, project director for the ANS, a research nuclear reactor, now in the design stage at Oak Ridge National Laboratory. "But if you're doing good science, creative science, eventually you find you have more ideas than you can ever carry out yourself.

"Then you find a job like this, and the even greater joy of having many, many collaborators--not just those who are building it, but also those who will use it down the years. And lo and behold, you're contributing more, and doing far more science, than you had ever dreamed."

West was perfect for the job, says Alex Zucker, an associate director at Oak Ridge and the man who hired West, because of his willingness to forgo the urge to attach his own name to a piece of work. He was also capable of cutting all ties to his previous research, and focusing his energies on the ANS.

"The job is so demanding that the person has to devote all his time to it," says Zucker. "He can't be looking down the road to what he'll do next if this falls through. And he can't be keeping one eye on his favorite research project."

That characteristic is only one of many attributes of a scientific project manager, say those who fill that role. Other important qualities include an ability to set and hold to long-range goals, the talent to be a jack-of-all-trades, the vision to know what the machine is ultimately capable of doing, and the steel will to keep the science uppermost in everyone's mind.

"The fact is, in the long run this is a scientific instrument," says Jay Marx, project manager for the Advanced Light Source (ALS) at Lawrence Berkeley Laboratory, which is scheduled to begin operation in 1993. Squeezing in more apparatus that will make more scientific experiments possible makes for a better project, "even if it makes the job more challenging," Marx says.

Before being named ANS director, Colin West divided his time between research in neutron detection and power-source design and work with a lab planning group at Oak Ridge. And though West agrees that serving as director puts an end to the kind of research a scientist can publish and take personal credit for, he says it can also mean the beginning of a new kind of creativity.

"A great project comes out with more in it than you anticipated," says West. And achieving that bonus, he says, is the job of the project manager, who must keep an eye on the biggest scientific picture possible.

"What the specialist thinks is a boundary is nearly always just a rule that we can change," West says. "What I'm able to do with my perspective is point out that maybe we're asking the wrong question. That opens another door, so the scientists can go out and play. It sounds childish, but I think that's how new ideas come about."

As an example, West cites his contribution to the design of the reactor's fuel core. Two groups--one from Oak Ridge and another from the Idaho National Engineering Laboratory in Idaho Falls--submitted proposals. And debate centered initially on which of the two very different designs to choose.

But West saw the issue in broader terms. "I kept pressing people for new ideas," West says. "At last, we came to a wholly different design." The result, he says, is a reactor that will use fuel more efficiently, operate at a cooler temperature, and have room for additional experimental apparatus.

The key for West is to get people to move away from their narrow interests and focus on long-term goals. It's not always easy, he says. "When you talk about scientists' view of engineers," West says, "the words `predator' and `prey' come to mind. It's a fear that the engineers will come and eat up all the money, that they don't care about science.

"But if the project director leads by example, you won't be able to tell who's who from listening to the arguments. Oh, yes, the beards are probably scientists, and the ties are engineers, but everybody will be arguing about how to make a better end product."

Even looking at the big picture isn't enough, however. A good project director also worries about the daily, often mundane, details, says Satoshi Ozaki, who oversaw construction of Brookhaven Lab's multiparticle spectrometer and Japan's TRISTAN electron-positron collider before taking on the Relativistic Heavy Ion Collider.

"You have to be a mechanical engineer, a materials specialist, an electrical engineer, an electronics engineer, a computer programmer," says Ozaki. "You have to be the manager, you have to be an accountant, you have to sweep the floor."

Such breadth of knowledge, says Ozaki, enables a manager to inject a healthy dose of pragmatism into the project. "Every expert's trying to build something `perfect,' according to his point of view," Ozaki says. But such discussions, he says, could go on forever. "At a certain point, somebody has to say, `That's good enough. Go in that direction.' Because it's the entire system that's got to work, not just the little pieces."

Officials at the Department of Energy, which funds all five instruments, sometimes show a preference for professional project managers rather than scientists, says David Moncton, director of Argonne's APS. That puts an extra burden on the scientist turned administrator to prove his or her worth. Says Moncton, "They ask, `Where's the project management experience?' What they mean is, `Who the hell are you to manage this?'"

Moncton is a former AT&T Bell Laboratories researcher who describes himself as "one of the first traveling condensed matter physicists." As a young experimental physicist, he conducted experimental work at labs around the country. And he believes that those experiences, far from being irrelevant to the task of project management, taught him the value of long-term planning. "Conducting an experiment at a distant location requires thinking everything through in advance, and that's the essence of project management," says Moncton.

The willingness to put scientific goals ahead of other considerations, including institutional loyalties, is another important trait that scientists can bring to project management, Moncton says. Most large experimental facilities are initiated by the national laboratories that house them. And Moncton says that decisions are often made for institutional reasons.

"In those cases, they're liable to go for what's politically saleable, like global warming or whatever's hot at the moment," he says. "That can compromise their long-term support for [the project], if the political winds change."

Such thinking was not present at the birth of the APS, Moncton asserts. Rather, its origins lie within the instrument's user community of materials scientists. "We built in a bidding framework that would prevent a cost war and test the labs' real commitment to the project," Moncton says. "Anybody who said it would cost less [than the user community's estimate] was suspect.... Finally, only Argonne's proposal was substantive." Beverly Hartline wasn't there at the creation of CEBAF. As a geophysicist who did scientific program planning for Lawrence Berkeley Lab, she assumed control over CEBAF late in its construction phase. But she agrees with her colleagues that scientists can bring an element to project management what no one outside the field possesses--total commitment to creating the best possible research instrument.

"Management types cut the world up differently," says Hartline. "They have categories like `environmental quality assurance'--things aimed not so much at getting the job done as at keeping everybody out of trouble. To finish a job this big, you need somebody with a come-hell-or-high-water attitude. And the people most strongly motivated in that way are those most interested in the science that will come out of it."

ALS director Marx, agrees that commitment to what the instrument will contribute to science is what keeps a project director focused amid the million details of the job. And he literally goes out of his way to make sure that he doesn't forget that fact.

"Every day, when the daily frustrations get to me, I go out and touch [the ALS building]," Marx says. "Once it was just an idea on paper, and now it's real, a new window on nature. That's why it's important to have people at my level that don't see their participation ending when the machine is built.

"The end of the building is just the beginning of the science. And that's where your loyalties have to be."

Jay Marx, Advanced Light Source

Ask Jay Marx what he'll be doing 10 years from now, and he answers immediately. "I'll be in a management position at the Advanced Light Source, and I'll be doing Light Source research part-time." But that answer, says Marx, who holds a physics Ph.D. from Columbia University, hides a bit of scientific irony.

The ALS, Marx's $100-million baby, will produce soft synchrotron radiation, the ultraviolet and low-energy X-ray radiation that electrons emit when they change direction or speed. Accelerators create such radiation when they send charged particles around a storage ring.

Particle physicists like Marx have long considered such radiation to be an annoying waste of energy. But that was before other scientists discovered that the unwanted beams could function as laser-like probes into living matter. Now, scientists hope, synchrotron radiation from the ALS will open up a host of new worlds, including a new generation of computer chips with features smaller than 0.00001 of an inch.

Now Marx, who undertook his first accelerator-related construction project--a particle detector--out of "a deep and abiding love for particle physics," finds himself creating an accelerator that will be devoted to this new community of users. And he's been sold on a whole new branch of science. "I took the project because I know accelerators," he says. "But I'm falling in love with new possibilities."

--M.C. .

David Moncton has fond memories of Brookhaven National Laboratory. As a doctoral candidate at the Massachusetts Institute of Technology, he conducted dissertation research at the National Synchrotron Light Source there. "It was wonderful," he says. "The NSLS came up like clockwork, cycle after cycle, year after year. It was everything a researcher needed it to be."

In the early 1980s, when Moncton dreamed of creating a high-energy synchrotron radiation source dedicated to materials science, he hoped it could be located at Brookhaven. But as much as he loved the Upton, N.Y., lab, he says, something mattered even more. Throughout most of Moncton's career, he says, solid-state physicists were treated a bit like stepchildren at the accelerator facilities they used for experiments. High-energy physicists had priority at the experimental table, while others were left with the crumbs. Moncton was determined that wouldn't be the case at the Advanced Photon Source. To make sure, the APS, primarily dedicated to the study of materials, had to be its home lab's first priority.

"Brookhaven had commitments that prevented that," he says. "Argonne [National Laboratory in Illinois, the APS's home] didn't." But, Moncton still plans to make good use of his Brookhaven memories. "I hope to manage the APS," he says, "so that it will work as well for its users--especially young researchers--as the Brookhaven Light Source worked for me."

--M.C.

Satoshi Ozaki's machine at Brookhaven National Laboratory, called the Relativistic Heavy Ion Collider, will create high-energy collisions of nuclei of elements as heavy as gold. Scientists expect that such colliding nuclei will break into their fundamental parts and then reunite, as they did when the universe began. But no one knows if the recombined particles will create the physical order we know or different pattern.

That kind of large question intrigues Ozaki, a native of Japan. Ozaki, who received his Ph.D. in physics from the Massachusetts Institute of Technology, has been building scientific instruments since the early 1960s, but he says that's not really his first love.

"What I'm interested in are the exciting phenomena to be found, out on the far edge of physics," Ozaki says. "Building instruments to observe them is my way of advancing the cause of physics."

Ozaki, a Brookhaven physicist since 1959, credits his early experiences at the lab for his expertise as a builder. "From early in my career, I was encouraged to be involved in many aspects of projects," he says, "to know them from the ground up." But Ozaki worries that the well-rounded scientists required for such projects are becoming fewer in number. "Somehow we have to find a way to educate them," he says, referring to senior officials as well as the next generation of physicists. "As a manager, I try to help by not pigeonholing people, by letting them move around to see more and more of the picture."

--M.C.

Beverly Hartline, Continuous Electron Beam Accelerating Facility As a visiting professor at Hampshire College in Amherst, Mass., Beverly Hartline says her fondest memory is of a course that encouraged nonscience majors to conduct scientific experiments. "It was designed to demonstrate that everyday life is full of questions it takes scientific experiments to answer," Hartline says. "What happens, for instance, if you're making bread and you reverse the order of ingredients? Or, what do fish do when the pond freezes? Helping people become scientific experimenters has always been one of my biggest interests," Hartline says.

As project manager of the Continuous Electron Beam Accelerating Facility, Hartline, who holds a Ph.D. from the University of Washington, is doing just that. Scheduled to begin operation late in 1993, CEBAF will create focused beams of charged particles to act as precise probes into the electromagnetic structure of atomic nuclei. The biggest satisfaction of her job, Hartline says, is knowing that the work will open new experimental doors for the nuclear physics community.

During CEBAF's construction phase, Hartline says she has tried "to open doors for the technical team. For that you need communications skills." During an early stint as a science reporter, Hartline says, she learned to boil down technical details to an easily digestible essence. That skill comes in handy, she says, "when the scientists talk to me for five months, and I get to talk to DOE for one hour!"

--M.C.

Colin West is building the Advanced Neutron Source in the most beautiful place he ever saw. A neutron-detection physicist, West grew up in England and received a Ph.D. from the University of Liverpool. But it was during a trip to the New World, as a visiting scientist at Oak Ridge National Laboratory, that he was "stunned by the beauty of the [Tennessee] hills."

The lab's intellectual climate was equally pleasing to him. So a few years later, at the lab's invitation, he returned for good. Now he's helping construct the ANS, a research nuclear reactor whose slow-moving beam of neutrons will reveal the detailed structure of materials like plastics, new metal alloys, and environmental pollutants.

Unlike synchrotron radiation sources, the ANS's uncharged particles reveal nuclear structures and magnetic moments, West says. "They're complementary techniques," he says, "and vital to advance our study of new materials. Japan and Europe are ahead of us in this now by a factor of 10 to 100. But the ANS will put us that far ahead of them."

On weekends, West still luxuriates in the beauty of Tennessee, now in the company of his sheep dog, Tess. The pair are taking herding lessons with a farmer neighbor and, once again, West prefers to stay in the background. "Tess is such a bright girl," West says. "Our teacher says I'm beginning to hold her back."