IDEAS

Summer science study

DOE offers high school students two weeks of front-line research

By Simson L. Garfinkel
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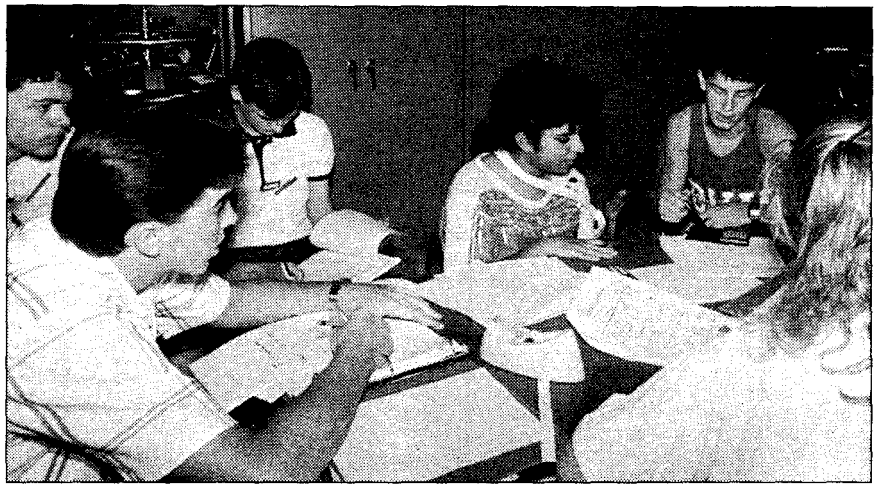

Participants at the Brookhaven National Laboratory check an experiment they did on the synchrotron

Brookhaven, N.Y.

FOR three days this month, one of the most expensive machines in the United States was at the service of 58 high school students from all over the country and around the world.

The students are part of the Department of Energy's High School Science Honors Program. Now in its fourth year, the program enables six similar groups to spend two weeks at a national laboratory learning about scientific research.

Here at Brookhaven National Laboratory, the students' experiments centered on the laboratory's showpiece: the National Synchrotron Light Source.

"Synchrotron light is the most powerful source of light," says Laura E. Grego, an honors program student from Michigan. The NSLS is one of the most intense sources of X-rays and ultraviolet light in the country (see story below).

Dozens of experiments cluster around the synchrotron's two main rings. Some are aimed at learning how to use X-rays "to make really small microchips for computers," Laura explains. Others are using the energy to study chemical catalysts, chemical and biological reactions, and the structure of proteins.

"X-ray diffraction has been around for years," says Peter Williams from Louisiana. "But a lot of samples that chemists and biologists are coming up with now are too small to use those techniques. Since this [the NSLS] has such a large flux – a large number of photons per area per second – you can analyze samples that you couldn't previously."

Nearly every minute of the students' two-week stay at Brookhaven's 5,265-acre campus was scheduled and accounted for. They started at the end of July with a series of lectures on topics ranging from safety and the workings of the synchrotron to arms control. Then, after a one-day tour of New York City, they began three days of intensive use of the NSLS.

"They do several experiments at the Light Source," says Donald J. Metz, who heads the laboratory's office of educational programs. "A couple of them will be part of ongoing research. However, their contribution will be as very intimate observers. They will get a set of data – they may get to turn a few knobs – but to say they are actually doing research would be misleading.

"With that data, they have to write up a report. It's a team effort," he adds. The three reports each student writes will be published for the group, and a copy will be given to the governor of each student's state.

EDUCATION

The students' enthusiasm is contagious, straight up to the highest levels of the Department of Energy: "The High School Honors Program is one of the ways that the DOE is sharing the resources of our national laboratories with the scientists of the future – the youth," says John Herrington, secretary of the Department of Energy.

The program started in 1985 at the Lawrence Livermore Laboratory in Berkeley, Calif. "I have expanded the program from one laboratory to six laboratories because it is so successful," Mr. Herrington says. "I am most impressed by the caliber of the youth I have met. Our nation's future depends on the initiative and hard work of these and similar students."

Other laboratories in the program include the Argonne National Laboratory and the Fermi National Accelerator, both in Illinois, the Lawrence Berkeley Laboratory and the Lawrence Livermore Laboratory, both in California, and the Oak Ridge National Laboratory in Tennessee.

The program at each laboratory had a different emphasis. At Livermore, for example, students learned how supercomputers can be used to solve extremely complex problems.

"During high school, I derived a theorem on integral Pythagorean triples," says Sharon Kineke from Rhode Island, who returned from Livermore in July.

Sharon wrote a program, using her theorem, on her own computer to find such triples. Then she ran it on Livermore's supercomputer. "It was generating numbers starting with 1 million and faster than a PC could do 100. It was quite amazing," she says.

Although students were officially selected by their state's governors, various techniques were actually used. Some students had to fill out applications that were reviewed by committees. Others received their scholarships as prizes for science fairs or mathematics competitions. "My school

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High-energy light for high-intensity research

Brookhaven, N.Y.

"When you accelerate an electron by changing its velocity or direction, it gives off light," says Katrina Smith, a high school senior participating in Brookhaven's summer program. The electrons in the National Synchrotron Light Source (NSLS) are moving so fast that they give off light of extremely high energy. Their vast numbers contribute to the light's high intensity.

The electrons are first fired from an "electron gun" into a booster ring that accelerates them to near the speed of light. Then they are vented into either the ultraviolet (UV) storage ring or the larger X-ray storage ring, where they cycle for hours, giving off tremendous amounts of light at every turn.

"It's not really a circle – it's actually a straight section, a bend, a straight section, a bend," says Nick Brookes, who operates an experiment at the NSLS.

Each time an electron goes around the ring, it goes through an area called the "RF cavity" that "keeps pumping life back into it," or replacing energy that was lost in the form of synchrotron light, says Mike de Temple, a student from West Virginia.

At one point along the UV ring is a special device called an "undulator," which guides the beam past rows of magnets with alternating polarity. As the beam moves past, the electrons wiggle in the magnetic field and give off even more ultraviolet light – up to a hundred times as much light, Dr. Brookes says.

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The Light Source can accelerate electrons to very high speeds

One experiment the high school students performed involved calculating the distance between the undulator's magnets and the electron beam by measuring the color of the light given off. Brookes himself is using the high-intensity light to look at the arrangements of electrons in thin films of metals such as iron, nickel, and cobalt.

X-rays from the synchrotron "can be used to find crystal structures," says Sunita Bhatia of Delaware. "You hit [the atoms] with the rays and they start vibrating. Of course, the next atom over starts vibrating, too." By examining the interference pattern created by the two waves, Sunita says, "you can tell how the crystal is structured."

"Synchrotron light has revolutionized the field of protein crystallography," says Gregory Petsko, a professor of chemistry at the Massachusetts Institute of Technology. "It has made it possible to look at much larger structures with much smaller crystals."

"It has also opened up the possibility of [observing the structure of] biological molecules as they function," Dr. Petsko says. "The intensity of the beam is such that you can collect data in a very short time." – S. L. G.