The hometown newspaper for Atherton, Portola Valley, Woodside and Menlo Park.

The Almanac

WWW.CALMANAC.COM

NOVEMBER 17, 1999 ■ VOL. XXXV, NO. 11 ■ 50c

Heart of Matter

SLAC probes nature's mysteries – from the beginning of the universe to new treatments for AIDS

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News This Week

LOTS WORTHLESS?

Landowners sue Woodside over sewer rules they say make lots worthless. **Page 6**

RECREATION PLAN

Massive recreation plan for Menlo Park will be reviewed by City Council this week. **Page 5**

FOOD & DRINK

Local women open boutique and grocery in West Menlo Park. Cover, Section 2

Heart of MATTER

Under a new director, SLAC probes nature's mysteries from the beginning of the universe to treatments for AIDS

By MARION SOFTKY

SLAC is the kind of place that stretches the mind. Under the sere brown hills south of Sand Hill Road, electrons and positrons are zipping at nearly the speed of light toward collisions that may shed light on why there is more matter than anti-matter in the universe.

"We are trying to understand something very important to all of us," says Jonathan Dorfan, new director of SLAC, the Stanford Linear Accelerator Center in Menlo Park. "Why are we here? Why is there a universe?"

The original Big Bang that created the universe made equal amounts of matter and anti-matter, he points out. "Those should have annihilated each other in a puff of energy."

Dr. Dorfan, a quiet man who can make the farthest reaches of physics understandable — if only briefly — recently succeeded Nobel Prize-winning physicist Burt Richter as director of one of the world's top research centers in high-energy physics. Stanford University operates SLAC for the U.S. Department of Energy.

Dr. Dorfan was in charge of planning, designing, building and operating SLAC's latest machine to probe ultimate questions about matter. The Asymmetric B-Factory, or PEP II, started operation last spring; by next summer it may produce enough data to begin providing answers.

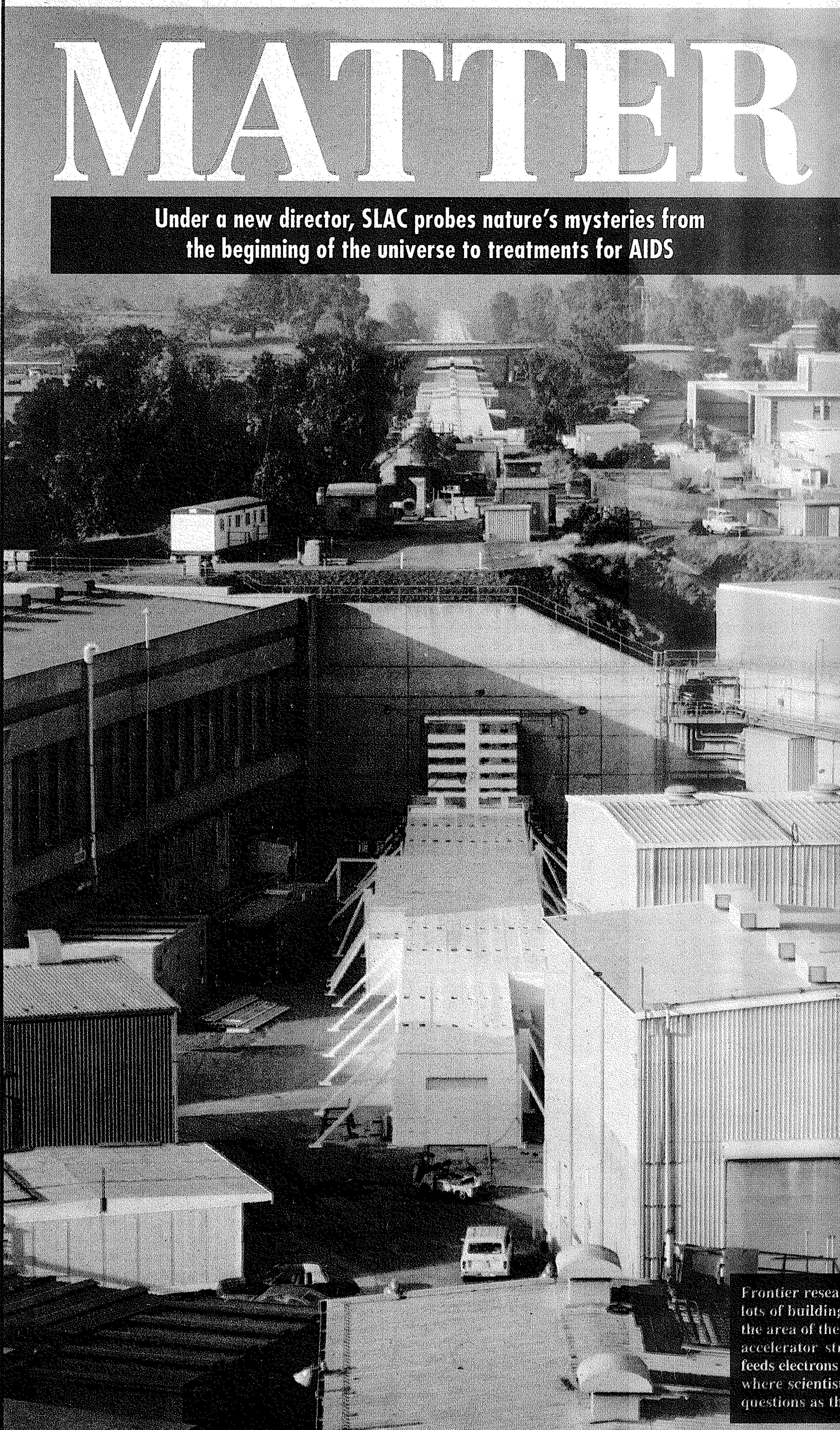
The B-Factory was designed to produce sub-atomic particles called B-mesons, which are similar to quarks that appeared by the gazillions in the moments after the Big Bang. SLAC aims to recreate these particles, collision by collision, in search of mechanisms to explain why more matter survived than anti-matter.

"The fact that we are here is due to this small anomaly, and that's what we hope to recreate in the B-Factory," explains Dr. Dorfan. "We go back to the very, very early time, just after the Big Bang, and recreate that soup of matter and anti-matter. Then we watch to see if we start to develop that small asymmetry."

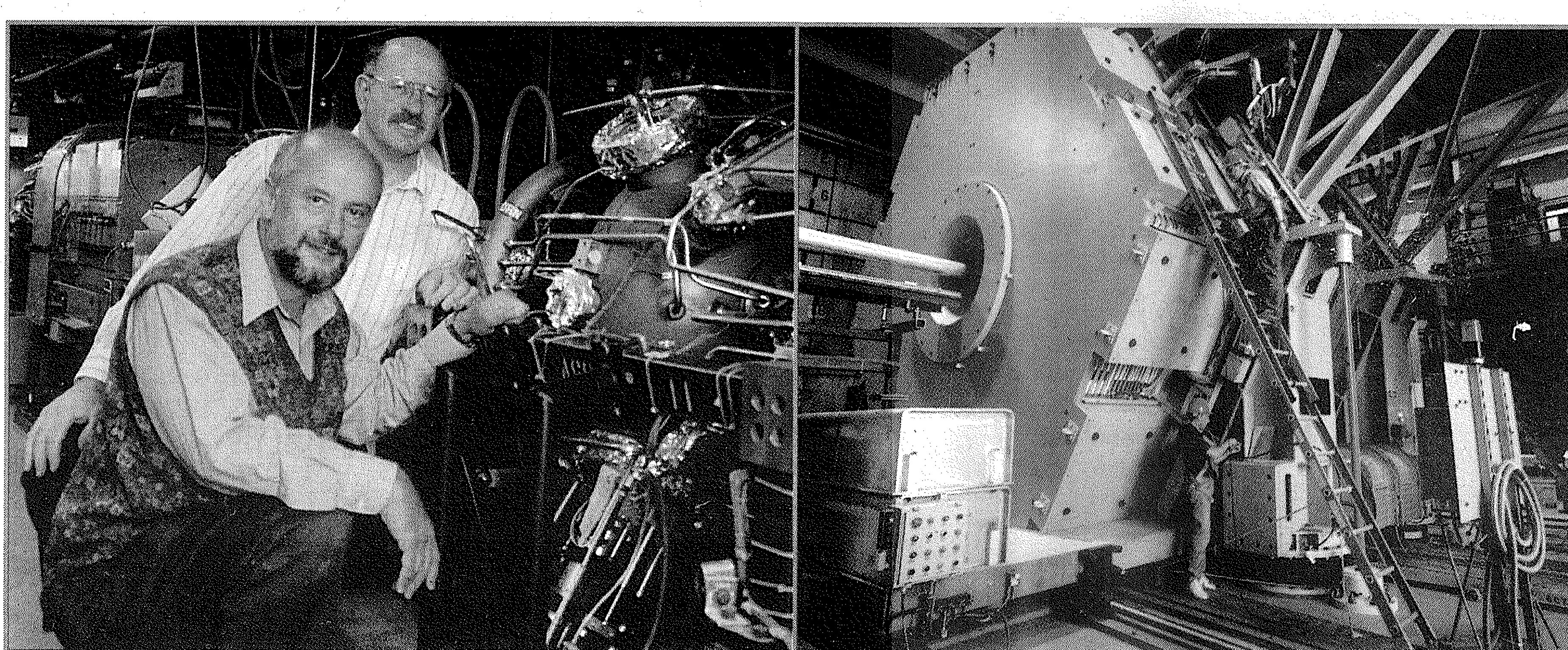
But SLAC is much more than the high-profile B-Factory, or even the original linear accelerator, which extends under a two-mile shed, constructed on SLAC's 426 foothill acres, almost to the intersection of Whiskey Hill and Sand Hill roads.

For example, the Stanford Synchrotron Radiation Laboratory (SSRL) uses high-intensity X-rays, which spin off from curving electron beams, for experiments with tangible benefits. Hundreds of scientists do practical experiments, ranging from developing drugs to treat AIDS, to analyzing impurities in silicon wafers, and cleaning up pollution in lakes.

"The research and development support of our basic science gets back into the



Frontier research into the beginnings of matter requires lots of building and equipment. This picture, taken from the area of the B-Factory, shows the two-mile-long linear accelerator stretching toward the Peninsula hills. This feeds electrons and positrons into hundreds of experiments where scientists from around the world investigate such questions as the origins of matter to pollution in lakes.



Jonathan Dorfan, SLAC's new director, right, kneels with Pier Oddone of Berkeley, who had the idea for the Asymmetric B-Factory, in the tunnel where electrons and positrons spin in opposite directions before colliding in a flash of energy and particles. These collisions are detected and analyzed by the 1,200-ton BaBar detector, right, which was designed and built with help from 73 scientific institutions in 10 countries, including France, Germany, Russia, China and Taiwan.

marketplace and benefits humankind," Dr. Dorfan says.

Local residents may not realize that SLAC is not only a major international research center, but also a living institution on the Midpeninsula. Beyond some 1,300 people employed there, about 3,000 people do research, says Dr. Dorfan. At least 2,500 of these come from research institutions around the world. "It's a fully international laboratory which is servicing the world scientific community," says Dr. Dorfan.

It's not all work. Just last week, more than 100 employees joined a four-mile race around the accelerator. In the 28th year of the race, Knut Skarpaas VIII of Woodside skated to victory in the in-line skating competition. And at 72, SLAC retiree Robert Gex of Palo Alto ran the race for the 21st time, said SLAC spokeswoman P.A. Moore.

SLAC's new director has spent his whole professional life at SLAC. A native of South Africa — with a touch of English to his accent — Dr. Dorfan graduated from the University of Capetown before coming to the United States for graduate studies. He came to SLAC in 1972 to do his thesis in experimental particle physics — and never left. He and his wife, Renee, live in Palo Alto. They have two grown daughters — one a junior at Stanford.

Dr. Richter, a towering figure in physics who directed SLAC for 15 years, may have stepped down as director, but "he's not retiring by any means," says Dr. Dorfan.

Dr. Richter is now chairman of the International Union of Pure and Applied Physics. But he's also looking for ways he can still contribute to SLAC, Dr. Dorfan notes. "Knowing him, he'll find something important."

Reinventing SLAC

"This place lives by reinventing itself," says Dr. Dorfan.

Ever since the groundbreaking in 1962, scientists at SLAC have dreamed up and built a series of new atom smashers to wrest inner secrets of the forces and matter that make up the universe. "Roughly every 10 years it has reinvented itself," he says.

The importance of the work is widely recognized. It has earned SLAC scientists three Nobel prizes.

The original linear accelerator, called a linac, was an enlargement of a machine developed at Stanford to accelerate electrons down a tube in high vacuum to bombard a target, where scientists could study what happened.

SLAC's research into the physics of elementary particles uses a beam of electrons, rather than the proton beams studied in more famous accelerators such as Fermilab in Chicago, and CERN in Switzerland.

In 1972 SLAC began measurements with a new kind of accelerator called SPEAR, a ring 80 meters in diameter in which electrons and positrons rotated in opposite directions. Scientists measuring the energies and trajectories of particles resulting from collisions of electrons and positrons learned much about what makes up matter and energy.

Discoveries of two new particles in SPEAR, in 1974 and 1976, won Nobel prizes for Burton Richter and later Martin Perl.

SPEAR was so successful, it was followed by PEP, the Positron-Electron Project, a much larger ring where positrons and electrons could rotate and annihilate each other at higher energies. PEP, 800 meters in diameter, started operation about 1980.

In 1989, the still larger Stanford Linear Collider (SLC) — also tunneled under oak-dotted foothills — began producing Z-zero particles to investigate the nature of forces that bind nuclei together.

For the next reinvention, SLAC is recycling its old PEP tunnel into the Asymmetric B-Factory, which is — quite logically — being called PEP II.

Meanwhile, the old SPEAR ring has remained in use as the SSRL. The radiation given off when electrons are forced to spin around a circle provides a versatile source of X-rays for use in applied research. Twenty-six experimental stations around the ring provide high-quality X-rays for some 1,500 researchers.

Barring more flip-flops in Washington, SLAC's federal budget for this year is expected to be $177 million, according to Ms. Moore. Of that, $148 million is dedicated to programs in high-energy physics, and $29 million for the SSRL.

Apurva Mehta, a post-doctoral fellow at Stanford who lives in Woodside, is studying crystal structure in high-temperature superconductors using X-ray beams from the Stanford Synchrotron Radiation Laboratory (SSRL) at SLAC.

Dr. Dorfan admits that a lot of this frontier research is "a little esoteric. It confronts the deepest mysteries of the most fundamental kind in nature," he says.

'Dance without a partner'

Dr. Dorfan treats the B-Factory as his baby. And no wonder. The original idea came from Pier Oddone of the Lawrence Berkeley National Laboratory, but Dr. Dorfan has been with it ever since. He was in charge of the team that designed the original machine; he was project manager for building the machine and technical director for the 1,200-ton detector, known as BaBar.

"I was involved from the first teething until finishing college," he sighs. "It was 11 years of my life."

A key feature of the B-Factory is its asymmetry. The electrons spin at three times the energy of the positrons, and collide in the center of a 1,200-ton detector called BaBar. Thus the particles resulting from the collisions fly preferentially in one direction, giving additional information to researchers.

The B-Factory, which made its first B-meson May 26 — just days ahead of a competing Japanese machine — is performing superbly, Dr. Dorfan says proudly. "It makes B-mesons in profusion. That's why it's called a factory."

The B-mesons stand in for B quarks, fundamental particles that were made in huge numbers right after the Big Bang. This created a huge burst of energy which quickly transformed into a stew of quarks and anti-quarks.

The B-quarks, which are heavy and can't be observed directly, combine with a light quark to form a B-meson — which is appearing in abundance in the B-Factory. "In the original Big Bang there were millions and billions of quarks," says Dr. Dorfan.

Poring over computer analyses and instricate equations, SLAC scientists are looking for the B-mesons that don't immediately annihilate with their anti-matter partner. Those left over are key to the paradigm they are testing.

In the mathematical arcana of high energy physics, this is referred to as a "CP violation," meaning a violation of laws of symmetry that are supposed to apply to transformations among elementary particles according to the Standard Model. Developed in the 1970s, this model has so far been remarkably successful in describing burgeoning numbers of elementary particles and their interactions.

"We put together the billions of occurrences one at a time," explains Dr. Dorfan. "There's a quark and an anti-quark each time. If we ever find two quarks, we'll have an anomaly. If that happens, even rarely, we have shown there was a

(See **SLAC**, next page)