INTERACTION POINT

June 18, 2004

GLAST Test Bed Complete

By Davide Castelvecchi

Peeking through the glass doors of a room in Bldg. 84, the occasional passer-by puzzles at a giant, revolving electronics contraption skewered on what looks like a cow-sized spit. The imposing apparatus, completed last month, is the Large Area Telescope (LAT) Test Bed, a hardware simulator part of the Gamma-Ray Large Area Space Telescope (GLAST) development.

See whole story...

All are Invited to Kavli Ground Breaking

By Jennifer Formichelli

The ground breaking ceremony for The Fred Kavli Building at SLAC, the new home of the Kavli Institute for Particle Astrophysics and Cosmology (KIPAC), will be held on Monday, June 28, at 4 p.m. on the Kavli Building site in front of the Research Office

Director's Corner

By Jonathan Dorfan

Without exception, SLAC's great accomplishments have been due to the collective efforts of the staff—everyone cooperating together as a 'team' to conquer mountains both big and small.

We now need the participation of the full SLAC team to reduce our accident rates and to help bring injured employees back to health and back to work. While we can be very proud of SLAC's historical safety record, we had significantly more accidents last year than the year before.

See whole story...

Richard Helm, Early Beam Dynamicist, and a Bit of SLAC History

By Gregory Loew

When Richard Helm died in Palo Alto on May 2, SLAC lost the first member of its staff who made beam dynamics his full time occupation. Helm studied at Stanford

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Research Building (ROB).

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University and earned his Ph.D. in 1956 as part of Robert Hofstadter's team engaged in the famous electron scattering experiments which measured the cross-sections of many nuclei.

See whole story...

Luda Fieguth: EPA Champion of Green Government

By Wayne Heiser

Luda Fieguth (SEM) received an award for energy efficiency from Region 9 of the U.S. Environmental Protection Agency (EPA) on June 2. The Champion of Green Government award is given annually to federally funded facilities for efforts to prevent pollution and to exercise environmental stewardship.

See whole story...

Old Equations Tell New Stories

By Davide Castelvecchi

Future experiments at the Large Hadron Collider (LHC), at the Tevatron and at the Linear Collider will hunt for the elusive particles that could exist beyond the Standard Model. Finding new particles amidst the barrage of old ones produced by any collision may require calculating Standard Model predictions with unprecedented precision.

See whole story...

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Director's Corner

By Jonathan Dorfan

Without exception, SLAC's great accomplishments have been due to the collective efforts of the staff—everyone cooperating together as a 'team' to conquer mountains both big and small.

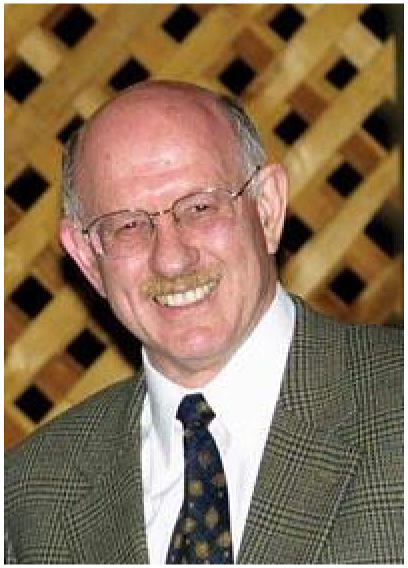

Photo by Diana Rogers

We now need the participation of the full SLAC team to reduce our accident rates and to help bring injured employees back to health and back to work. While we can be very proud of SLAC's historical safety record, we had significantly more accidents last year than the year before. In addition, the number of accidents last year exceeded the goal set for the Laboratory complex by our funding agency, the Department of Energy, Office of Science. Whereas two years ago we had the lowest accident rate in the Office of Science complex, we now fall in the quartile of the least good performers.

We need to take action now, both to protect our employees' health and to meet the DOE's goals. I am optimistic that, as with our other many challenges, we can reduce accident rates through our coordinated efforts, our intellect and our dedication to the health and safety of our fellow employees. Toward that end, I will be leading a Task Force to implement a program to involve all elements of the laboratory in reducing employee occupational injury and illness. In addition, the Task Force will seek better strategies to help those injured or sick get the treatment they need to get healthy sooner and to come back to work as rapidly as is medically appropriate.

I will keep you informed as the program elements are developed and are ready for your engagement. I look forward to your full and enthusiastic cooperation. Have a safe and healthy month and please remember that placing operational expediency above health and safety is never appropriate.

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All are Invited to Kavli Ground Breaking

By Jennifer Formichelli

The ground breaking ceremony for The Fred Kavli Building at SLAC, the new home of the Kavli Institute for Particle Astrophysics and Cosmology (KIPAC), will be held on Monday, June 28, at 4 p.m. on the Kavli Building site in front of the Research Office Research Building (ROB).

The ceremony, which will include short talks by Fred Kavli (The Kavli Foundation), Stanford Provost John Etchemendy and SLAC Director Jonathan Dorfan, will be followed by a reception on the ROB patio. Drinks and appetizers will be served.

The SLAC community is invited and encouraged to attend this important milestone in the history of the Laboratory. The building will eventually house around 90 members of KIPAC. It represents an important commitment on the part of SLAC to a new generation of science—bridging the worlds of experimental and theoretical particle astrophysics—in the hope of making new and exciting discoveries in these crucial fields.

KIPAC Director Roger Blandford and Deputy Director Steven Kahn hope that all SLAC staff will join them to celebrate this happy occasion.

For further information, and to RSVP, please see our website: www-conf.slac.stanford.edu/kipac_gb

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Graphic by Jennifer Formichelli

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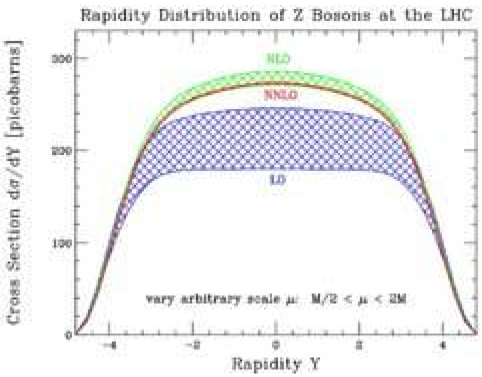
Old Equations Tell New Stories

By Davide Castelvecchi

Future experiments at the Large Hadron Collider (LHC), at the Tevatron and at the Linear Collider will hunt for the elusive particles that could exist beyond the Standard Model. Finding new particles amidst the barrage of old ones produced by any collision may require calculating Standard Model predictions with unprecedented precision. A recent paper by Charalampos 'Babis' Anastasiou and Lance Dixon (both of THP) and their colleagues introduces a method to make such predictions with a previously inaccessible level of accuracy.



Production of Z bosons at the LHC, at three different orders of approximation. The bands represent the chance that a particle shoots out at a given angle. (Graphic by Lance Dixon)

In the paper, soon to appear in Physical Review D, the researchers also applied their method to a special case, the copious W and Z particles that will come out of strong-force interactions at the LHC, plotting curves that predict how such particles will disperse inside the detector.

"You can't make experiments that only produce new physics," Dixon points out.

"The data you are looking for," he says, "could be masked or mimicked by Standard Model particles. In many cases, to pin down the new physics you have to figure out what the Standard Model background is going to be." That's not easy.

If nature were a chess game, Richard Feynman used to say, the fundamental laws of physics would be the rules for how pieces are allowed to move.

And just as knowing the rules doesn't make you a grandmaster chess player, knowing the basic equations of physics—as encoded in the Standard Model—is not enough by itself to know what those equations actually predict.

Making predictions on the strongforce is notoriously hard, and gets increasingly harder if one tries to improve the level of accuracy. Known as order of approximation, these predictions quickly lead to impossibly complex calculations. Until now, the complete curves for any particles produced by hadron colliders were known only ‘in first approximation,’ known as leading order, and at the ‘first step up’, or next-to-leading order. Dixon’s team carried out the first calculation at the next level, known as next-to-next-to-leading order, or NNLO.

The NNLO involves enormous numbers of challenging mathematical formulas, which correspond to the many possible strong-force interactions, or Feynman diagrams. Brute-force calculations would be too complex even for advanced computing farms such as SLAC’s, so physicists have had come up with clever shortcuts.

The method employed in the new paper was first introduced by Laporta in 2000, building on earlier work by Chetyrkin and Tkachov and others. Laporta’s technique uses algebra to reduce the calculation to a manageable number of formulas.

Calculating the NNLO still required solving between 10,000 and a million interdependent equations. Dixon’s team devised several methods to reduce the amount of calculations by a factor of 1,000. The results were better than expected.

To estimate the reliability of their curves, the physicists repeated the calculation wiggling certain parameters, and they plotted bands that represented how the curves changed in the process. The bands came out surprisingly thin, meaning that the results were quite reliable, with less than one percent error. “We were pretty shocked when the bands came out so thin,” Dixon says.

“Calculations at the NNLO level are truly daunting,” comments Michael Peskin (THP). “This is a major piece of work.”

Dixon and his team are making their software publicly available, and hope that other researchers will find it a valuable tool. Dixon himself plans to use it in future projects. “The need to do this basic, not very flashy theoretical work is not always recognized. But there are many more types of NNLO calculations that can be done over the next few years,” he says.

NNLO predictions are precise enough for practical purposes – but how about going to the NNNLO? “That would be almost total insanity,” Dixon says. “But maybe it can be done.”

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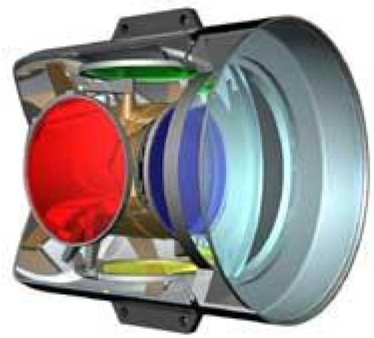
The KIPAC Guide to Exploring the Universe

By Heather Rock Woods

Scientific forecast: heavy dark matter and gusty dark energy with a chance of exciting discoveries.



KIPAC is leading the effort to design and build the LSST camera which will be the world's biggest digital camera. (Courtesy of Steve Kahn)

The young Kavli Institute for Particle Astrophysics and Cosmology (KIPAC) has already kicked off its science program, looking to unravel fundamental mysteries that connect the tiniest particles and universeshaping forces.

"Our programs range from physics that happens in the very early universe to the physical processes of current sources like black holes, both from a theoretical and experimental standpoint," said Steve Kahn, deputy director of KIPAC.

The institute's inaugural experiments (see TIP, January 23, 2004) seek to find and explain dark matter and dark energy, the shadowy constituents of 96 percent of our universe. The answers lie in better observations of the universe and in higher-energy accelerators on Earth.

"Very exciting discoveries in the last 10 years have changed our understanding of the universe and shown deep connections to high energy physics," Kahn said.

Land-Based Telescope with Powerful Sight

One project is a ground-based telescope that will survey the entire visible sky every few nights to observe even faint objects. Called the Large Synoptic Survey Telescope (LSST), it works more rapidly, is 20 times more powerful than existing survey telescopes and will "produce a great map of all the dark matter in the universe," Kahn said.

To capture and record images every 10 seconds, the telescope will use the biggest digital camera ever built at six feet tall and a few thousand pounds. KIPAC is taking the lead in designing and building the camera, that will have 2.8 billion pixels (500 times more than in a typical consumer digital camera).

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LSST is envisioned to be a joint NSF and DOE project.

To map dark matter, scientists look for the effects it creates, somewhat like studying animal tracks to learn about elusive animals. The gravitational pull of dark ma� er bends light streaming from distant galaxies toward Earth. LSST will observe these distortions, called weak gravitational lensing, to map the location of dark matter and, more importantly, how it's clustered together.

"This may be one of the best ways of analyzing the evolution of the universe. It gives us useful information about the size and shape, growth and structure of the universe," said Roger Blandford, KIPAC director.

Detailed measurements of the distribution of dark matter will shine intellectual light on dark energy—the perplexing 'anti-gravity' force that is driving the universe to expand at an accelerating rate.

"So the telescope will help us understand dark energy, using dark matter as a probe," said Kahn. The telescope comes online in 2012, several years after the start of a new accelerator at CERN that may find evidence for supersymmetry— particle physics' current theory to explain dark matter and to unify the fundamental forces.

Using Supernovae to Illuminate Dark Energy

The second main project is also aimed at measuring dark energy but by a different technique. KIPAC will develop and build the electronics for a space-based telescope called the Joint Dark Energy Mission (JDEM).

This joint NASA and DOE project will more precisely gauge the age and acceleration of the universe.

The JDEM telescope will record supernovae that always create the same intrinsic brightness when they explode. Dimmer supernovae are farther away than brighter ones. Linking their distance with their redshift—a measure of velocity based on how red, or stretched out, the light waves appear—allows calculations on how quickly they have moved away from Earth, and how fast the universe is expanding.

This experiment is similar to the one that discovered dark energy six years ago, but will go deeper into space to see more supernovae farther out and to measure them more precisely.

"It can tell us exactly how dark energy is behaving. Does it have constant energy or does its force evolve with time? There are no reliable theoretical predictions, it's such a mystery. But we need to quantify what's happening to have a hope of understanding," Kahn said.

Adding to the Universe's Photo Album

A more challenging space experiment is NASA's provisionally accepted NuSTAR to measure energetic hard x-rays emitted near black holes and by other astronomical processes.

"It's the best way to get a survey of the black holes in the universe," said Kahn. "We'll make the first real x-ray pictures of the sky," filling in a blank spot in the photo album of the universe at various wavelengths: visible light, microwave, infrared and ultraviolet. The GLAST project at SLAC is already working on taking pictures at gamma ray wavelengths.

Working in the hard x-ray wavelength band requires novel telescope mirrors to focus the x-rays. The mirrors were invented by a team from Columbia University and LLNL and are now being developed by project scientist Bill Craig (KIPAC), an expert in x-ray optics. In addition KIPAC is doing theoretical work for NuSTAR.

The Institute's Other Half

The other half of KIPAC involves theoretical and observational work. KIPAC professors, scientists, postdocs and students are evaluating and working on theories about the nature of dark matter and dark energy, relativistic astrophysics for black holes, high-energy cosmic rays and neutron stars, and the source of gamma ray bursts.

"We have very good projects," Blandford said. "We're not sure where the future will take us because it's a rapidly moving field. We're hopeful we can develop strong and productive research here."

The Stanford Linear Accelerator Center is managed by Stanford University for the US Department of Energy

Last update Wednesday June 16, 2004 by Emily Ball

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Richard Helm, Early Beam Dynamicist, and a Bit of SLAC History

By Gregory Loew

When Richard Helm died in Palo Alto on May 2, SLAC lost the first member of its staff who made beam dynamics his full time occupation. Helm studied at Stanford University and earned his Ph.D. in 1956 as part of Robert Hofstadter's team engaged
in the famous electron scattering experiments which measured the cross-sections of many nuclei. In 1958 he returned to HEPL after two years at Los Alamos and soon became an expert in the behavior of electron beams, a field of work which he pursued for the rest of his career.

Dick Helm, a SLAC pioneer, was noted for his beam dynamics work.
(Courtesy of Teresa Mize)

Today, beam dynamics is a recognized specialty but in the early days of Project M and SLAC, such work was carried out only as a sideline by many of us until Helm entered the field. I had the privilege of working with him quite often. He was incredibly smart and also incredibly modest, a master of understatement, and a man of few words. One of Helm's characteristics was that he wrote most of his beam dynamics equations by making all constants equal to 1, which meant that a common mortal like me had to painfully fill in the gaps. But Helm never lost track of these gaps when the time came to give numerical estimates! When I would tell him he leftout the velocity of light, he would just give me a little smile, and say "Oh well."

My first technical contact with Helm took place when he wrote a mimeographed (!) note warning us that the couplers that feed the microwave power to the accelerator sections would, in their uncompensated design, create field asymmetries that detrimentally kick the beam sideways. At first, he discovered that there was an amplitude asymmetry (which we fixed as a result of his warning), but then, when Sector 1 was built, additional asymmetry was discovered, which Helm identified as a phase asymmetry. That effect was then fixed by alternating the

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waveguide feeds of the remaining 29 sectors of the linac in a pattern designated as BABA-ABAB. Meanwhile, Helm had singlehandedly designed the entire quadrupole and steering dipole array for the machine.

When the linac was turned on in 1966, beam breakup (which we affectionately called BBU) was discovered and caused a lot of excitement and anxiety. The basic cause of BBU was soon recognized as cumulative growth of transverse electromagnetic wakefield forces which limited the linac current to 15 mA (one third of the original spec). To remove this limit, Helm calculated how to redeploy the quadrupole array and to dimple the accelerator sections in situ (which others then accomplished with a manual dimpling tool). Computers in those days had limited power, but in 1969 Helm figured out, almost by hand, what sections had to be dimpled by how much and where. Eventually the linac current rose to 80mA.

It is worthwhile mentioning that these coupler and beam breakup problems, which Helm successfully addressed, still play a major role in the design of the NLC.

Many of you, who in subsequent years worked with Helm on all the other SLAC machines, must have appreciated him as a scientist and as a human being. I am sure we will all miss him.

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Last update Wednesday June 16, 2004 by Emily Ball

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GLAST Test Bed Complete

By Davide Castelvecchi

Peeking through the glass doors of a room in Bldg. 84, the occasional passer-by puzzles at a giant, revolving electronics contraption skewered on what looks like a cow-sized spit. The imposing apparatus, completed last month, is the Large Area Telescope (LAT) Test Bed, a hardware simulator part of the Gamma-Ray Large Area Space Telescope (GLAST) development.

Sergio Maldonado (REG) at the LAT's test bed front-end electronics simulator (FES). (Photo by Diana Rogers)

Scheduled to launch in 2007, GLAST will scan the sky in our galaxy and elsewhere in the universe for such gamma-ray sources as black holes and supernova explosions. With its unprecedented energy range (20 MeV-300 GeV) and resolution, the four-ton probe may also discover new and unexpected sources of gamma rays.

The LAT is GLAST's instrument, an array of 16 tower modules. Each tower module, assembled in collaboration with Italy's INFN, will consist of a silicon strip tracker (designed by UC Santa Cruz and Japanese physicists) and a cesium iodide calorimeter (provided by the Naval Research Laboratory in Washington, D.C., in collaboration with Swedish and French physicists).

Gamma rays hitting the LAT will cause showers of electrons. Based on which silicon strips pick up the shower and on the energy absorbed by the calorimeter, the read-out electronics will reconstruct the gamma ray's trajectory and energy.

The LAT will also include an Anti-Coincidence Detector to pick up the ricocheting particles, which indicate if an event is caused by a background particle rather than a genuine gamma ray. "The read-out electronics will have to decide whether all this data corresponds to an actual cosmic gamma-ray event, and say: 'I think I see a gamma ray. We should store this data, and send it to Earth,'" Jana Thayer (REG) explains.

Designed to check if the on-board electronics work the way they are supposed to, the test bed has two

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main parts. On the front end is a four-by-four array of stacks of electronics boards, which simulate the signals produced by the LAT tower modules. Each board is the same size as the base of an actual tower module, so the whole simulator gives an idea of the dimensions of the whole probe.

On the rear end—the side hidden from the gawker's eye—is a full prototype of the LAT's read-out electronics. Gunther Haller (REG) headed the design team. "Soon we will put fake data in—about 100 megabytes per second—and read it from the other side, to see if what we get out matches what we put in," says Jana Thayer.

The simulator will also be useful once the real GLAST is in orbit, assisting with the LAT's calibration and helping diagnose any problems that may come up.

The first, preliminary version of the entire system was powered up on May 10.

"I just put the last chip in," says Gregg Thayer (REG) as, tethered to his bench by an anti-static wrist strap, he finishes assembling a Data Acquisition Board, a crucial component of the simulator. The rear end of the simulator is functionally identical to the electronics of the actual LAT, boasting over 200 custom made ASIC and programmable-logic (FPGA) chips—though not the $8,000 apiece, flight-certified versions. Radically different from your usual Pentium chip, an FPGA can be programmed, allowing for extreme flexibility during the design and development of the instrument.

Some of the boards fabricated at SLAC will be shipped to other GLAST labs around the world, but this will be the only lab with a 'fully populated' simulator, according to Thayer.

Both the tracker and the calorimeter are close relatives of instruments found in BaBar, which explains the , which explains the crucial role of high-energy physicists in the project. "The LAT is a nice, little particle physics detector—only it is going into space," said Jana Thayer, whose previous experience includes working at Cornell's CLEO detector.

The amount of data GLAST will handle is not comparable to BaBar's terabytes, but is still impressive for a space probe. And GLAST's circuits will embed extra redundancies, since humans will not be on hand to replace failed parts. "This is an unprecedented amount of electronics going into space," Thayer says.

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Last update Monday June 28, 2004 by Emily Ball

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Luda Fieguth: EPA Champion of Green Government

By Wayne Heiser

Luda Fieguth (SEM) received an award for energy efficiency from Region 9 of the U.S. Environmental Protection Agency (EPA) on June 2. The Champion of Green Government award is given annually to federally funded facilities for efforts to prevent pollution and to exercise environmental stewardship.

Director Jonathan Dorfan presents Luda Fieguth with her Champion of Green Government award. (Photo by Diana Rogers)

Fieguth is being recognized for a two-year project she recently completed, upgrading the Klystron Gallery with energy efficient lighting (see TIP, May 7, 2004). This project will reduce SLAC energy usage by an estimated 4.4 gigawatt-hours per year, enough energy for nearly 600 homes, with an estimated project payback period of less than three years. As Energy Conservation program manager, Fieguth initiated and implemented this energysaving project, which is helping reduce SLAC energy expenses and greenhouse gas emissions. In addition, the recycling of lighting materials as part of project implementation reduced waste disposal costs. Fieguth is thankful to the team—Alonzo Baker (AD), Hieu Dao (SEM), Thomas Graul (AD), Ardie Jacob (EP), Yolanda Pilastro (EP), Harry Shin (SEM) and the SEM electricians—for contributing to the success of the project.

If you have any questions about waste reduction or pollution prevention opportunities, please contact Richard Cellamare, Environmental Protection (Ext. 3401, rcellamare@slac.stanford.edu).

For more details on the U.S. EPA Region 9 award program, see:
www.epa.gov/Region9/cross_pr/fedfac/cga.html

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Klystron Milestone Achieved

By Davide Castelvecchi

On June 4, the Klystron Department celebrated the full-spec operational success of the XP-3 Klystron, a milestone in the warm-technology development for the Next Linear Collider. Project leader Daryl Sprehn was at the picnic with his main collaborators Erik Jongewaard and Andy Haase.

Shown left to right: Erik Jongewaard, Daryl Sprehn and Andy Haase (all KLY). (Photo by Davide Castelvecchi)

"The development of the XP-3 tube has been an ongoing, 5-year effort, involving virtually everyone in the department," Sprehn said. "The department is very busy building tubes for the Main Linac and the B Factory as well as rf components, accelerating structures and other special projects. It is amazing that time is still found to produce the world's most powerful klystrons at the cutting edge of technology."

Running at four times the frequency of SLAC's linac, the XP-3 is the world's first stable 75-megawatt periodic permanent magnet klystron.

Its predecessor, the XP-1, was constructed and completed testing back in 1999 and was limited to low levels of average power not suitable for the NLC parameters.

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Welcome New Employees

Photo by Diana Rogers

Ten new SLAC employees attended the latest New Employee Orientation on June 10. From leftto right: Mark Bostic (MFD), Dan Blankenship (MD), Devon McDonald (ESD), Luis Enrique Perez (ESD), Alonzo Avelar (ESD), Dan Ela (PUR), Noriaki Nakao (RPG), Dennis Hoff man (ESD) and Ryan Herbst (REG). Not pictured: Lester Miller (REG).

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Appointment
Weisend, John (EFD), to the Board of Technical Directors of the Cryogenic Society of America, announced in May, 2004.

Awards
Fieguth, Luda (SEM), EPA Champion of Green Government Award, presented on June 2, 2004 Service Awards

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Sandoval, George (SEM), 6/16

10 Years
Candelario, Rene (SEM), 6/20
Deanda, Armando (SEM), 6/20
Krebs, H. James (REG), 6/20
Maxson, Herbert (MFD), 6/20
Oden, Sharon (KM), 6/24
Pilastro, Yolanda (EP), 6/16
Santana, Rose Marie (MFD), 6/21

15 Years
Johnson, Leif (ASD), 6/19

20 Years
Nguyen, Minh (ESD), 6/18
Williams, Mark (MFD), 6/18

25 Years
Reif, Robert (EB), 6/18

30 Years
Ebel, Clark (MFD), 6/17

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35 Years
Burgueno, George (SHA), 6/16

Retirement
Bejsovec, Robert (ESD), 4/19

Deceased
Spicer, William (Bill) E. (SSRL), cofounder of SSRL and pioneer in photoemission spectroscopy, age 74, on June 6, 2004

To submit a Milestone, see:
http://www2.slac.stanford.edu/tip/milestonesubmissionguidelines.htm

See Awards and Honors at http://www.slac.stanford.edu/slac/award

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Changes to Voluntary Disability Insurance Plan

Effective July 1, all California employees who participate in the Stanford Voluntary Disability Insurance plan (VDI) or the State Disability Insurance plan (SDI) will be eligible to participate in the new California Family Temporary Disability (FTD) insurance benefit program. The program, which is funded by employee contributions to VDI/SDI plans, extends disability benefits to provide partial wage replacement to employees on approved leaves of absence to care for a seriously ill family member or to bond with a new child.

For a complete description, see:
news-service.stanford.edu/news/2004/june9/familyleave-69.html

For further information, see:
benefitsu.stanford.edu

Contact: Anita Piercey, Benefits, Ext. 2357, anita@slac.stanford.edu

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UK Minister Visits SLAC

Photo by Diana Rogers

Lord David Sainsbury, UK Minister for Science and Innovation, picks up the finer points of Linear Collider design from Dave Burke (NLC) during his tour of the Lab on June 8.

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WIS Group Tours MCC

By Joni White

On June 2, over 30 people turned out for a special behind-the-scenes tour of the SLAC Main Control Center (MCC). The event was arranged by the Women's Interchange at SLAC (WIS) and was presented by Kristina Kubler and Zoe Van Hoover (both AD), two of the Engineering Operators in Charge at MCC.

The tour group first enjoyed an illustrated description of what the people in MCC do and then walked around MCC and learned about particular monitors and procedures that keep our accelerator beamlines functioning.

Many thanks go to Van Hoover and Kubler, who gave us a clear and simple explanation of the MCC and its importance at SLAC.

Photo by Diana Rogers

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SLAC Public Lecture Series!
"Our Lopsided Universe: The Matter with Anti-Matter"

presented by
Steve Sekula (MIT/BABAR)

Tuesday, June 29, 7:30 p.m.
Panofsky Auditorium

INTERACTION POINT

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On-line Edition

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