

NERSC, LBNL Staff Share Expertise at Cyber Security Summit

When cyber security experts from some of the nation's top research institutions gathered Sept. 27-28 for a summit meeting to better prepare for future cyber attacks, NERSC and LBNL were there to share their experience and expertise.

Cyber Security Summit 2004, an invitation-only workshop held in Arlington, Va., was organized by the National Center for Atmospheric Research, with support from the National Science Foundation. A major driver for the meeting was the series of debilitating attacks launched against some of the nation's leading supercomputing centers last March and April. While a number of centers were shut down as a result, NERSC was able to remain up and running.

Representing NERSC and LBNL at the workshop were Howard Walter and Scott Campbell of NERSC's Networking, Security, Servers and Workstations (NSSW) Group, Nick Cardo of NERSC's Computational Systems Group, Jim Mellander of LBNL's Computer Protection Program, and LBNL Computer Protection Program Manager Dwayne Ramsey, who was an invited speaker. Walter co-chaired one of the breakout discussions, and Campbell was an invited member of a panel discussion.

"The biggest benefit to holding a meeting like this is building the trust relationships that are critical when it comes to developing an effective response to cyber attacks," said Walter, a member of the summit program committee and leader of the NSSW Group at NERSC. "When you are under attack, knowing who to talk to — and who to trust — can make all the difference."

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NERSC News

Welcome to the October 2004 issue of NERSC News, highlighting achievements by staff and users of DOE's National Energy Research Scientific Computing Center Division. NERSC News is distributed every other month via email and may be freely distributed. NERSC News is edited by Jon Bashor, JBashor@lbl.gov or 510-486-5849.

Laser Acceleration Simulations at NERSC Grace Cover of Nature Magazine

BERKELEY, CA — Researchers at the U.S. Department of Energy's Lawrence Berkeley National Laboratory have taken a giant step toward realizing the promise of laser wakefield acceleration, by guiding and controlling extremely intense laser beams over greater distances than ever before to produce high-quality, energetic electron beams.

The experimental results were then analyzed by running the VORPAL plasma simulation code on supercomputers at DOE's National Energy Research Scientific Computing Center (NERSC) at Berkeley Lab. The results were published in the Sept. 30 issue of Nature magazine, which chose an image from the NERSC simulations for the magazine's cover.

For a quarter of a century physicists have been trying to push charged particles to high energies with devices called laser wakefield accelerators. In theory, particles accelerated by the electric fields of laser-driven waves of plasma could reach, in just a few score meters, the high energies attained by mile-long machines using conventional radio-frequency acceleration. Stanford's linear accelerator, for example, is two miles long and can accelerate electrons to 50 GeV (50 billion electron volts). Laser wakefield technology offers the possibility of a compact, high-energy accelerator for probing the subatomic world, for studying new materials and new

technologies, and for medical applications.

In plasmas, researchers have generated electric fields a thousand to ten thousand times greater than in conventional accelerators — but these large fields exist only over the short distance that a laser pulse remains intense; for tightly focused beams, that distance is typically only a few hundred micrometers (millionths of a meter). The resulting beams are of relatively poor quality, with particle energies so widespread that fewer than one percent have enough punch for scientific applications.

The Berkeley Lab researchers achieve high-quality beams by first shaping a channel

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INCITE PIs to Present Results at SC2004

The principal investigators of the three computational science projects enabled by the first year of allocations under the U.S. Department of Energy's INCITE program will discuss their work in a series of presentations in the Berkeley Lab booth (#139) at the SC2004 conference in Pittsburgh.

INCITE, the Innovative and Novel Computational Impact on Theory and Experiment program, sought out computationally intensive large-scale research projects that could make high-impact scientific advances through the use of a substantial allocation of computer time and data storage at the NERSC Center. A total of 4.9 million hours were allocated to three projects.

The 45-minute presentations will begin at 1 p.m. Tuesday, Nov. 9, in the following order:

William A. Lester Jr. of Lawrence Berkeley National Laboratory and the University of California at Berkeley will discuss "Quantum Monte Carlo Study of Photoprotection via Carotenoids in Photosynthetic Centers."

Tomasz Plewa of the Center for Astrophysical Thermonuclear Flashes at the University of Chicago describe his research in "Thermonuclear Supernovae: Stellar Explosions in Three Dimensions" and

Professor P. K. Yeung of the Georgia Institute of Technology will summarize his work in "Fluid Turbulence and Mixing at High Reynolds Number."

NERSC's David Skinner will conclude the session with a talk on "Comprehensive Scientific Support of Large Scale Parallel Computation."

Laser Wakefield Acceleration (continued from p.1)

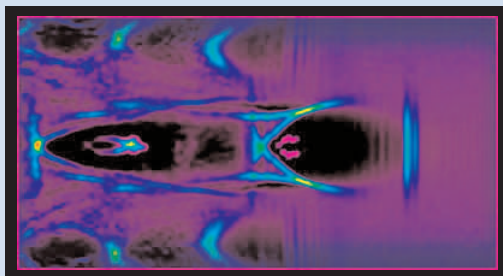
through hydrogen gas with powerful, precisely timed laser pulses, then accelerating bunches of electrons through the plasma inside the channel. Because of the controlled accelerator length and the characteristics of the channel, there are several billion electrons in each bunch within a few percent of the same high energy, more than 80 MeV (80 million electron volts).

The work was done by the L'OASIS group (L'OASIS stands for Laser Optics and Accelerator Systems Integrated Studies), led by Wim Leemans of the Center for Beam Physics in Berkeley Lab's Accelerator and Fusion Research Division. To analyze their successful experiment, the group collaborated with David Bruhwiler, John R. Cary and Chet Nieter of the Tech-X Corporation of Boulder, Colorado, using the VORPAL plasma simulation code to model their results on supercomputers at NERSC. This modeling allowed the scientists to see the details of the evolution of the experiment.

"With VORPAL, one can see the laser pulse breakup and the injection of particles into the laser-plasma accelerator," said Cary, CEO of Tech-X Corp. and a professor of physics at the University of Colorado. "This allows one to understand how the injection and acceleration occur in detail so that the experiment's designers can figure out how to optimize the process."

VORPAL, jointly developed by Tech-X Corporation and the University of Colorado, is an object-oriented C++ framework for 1D, 2D and 3D parallel electromagnetic simulation of charged fluids and particles on a structured grid. VORPAL is a relativistic, arbitrary dimensional, hybrid plasma and beam simulation code that contains utilities for data analysis and scripts for data visualization.

"Laser wakefield acceleration works on the principle that by sending a laser pulse



A plasma channel, denser toward the edges, guides the laser and allows it to form high-quality electron beams. As the laser pulse travels from left to right it excites a wake in the plasma, trapping and accelerating bunches of electrons to high energies (visualization by Cameron Geddes).

through a gas to create a plasma — separating negatively charged electrons from positively charged ions in the gas — some of the free electrons will be carried along in the wake of the plasma wave created by the laser," Leemans explains. "Imagine that the plasma is the ocean, and the laser pulse is a ship moving through it. The electrons are surfers riding the wave created by the ship's wake."

Unfortunately, simply punching a laser pulse through a plume of gas makes for a very short trip. "The acceleration distance is limited to what's called the Rayleigh length — the length over which the laser remains focused — which is determined by the wavelength of light and the size of the spot to which the beam is focused," says Leemans. "For optimum acceleration, you have to keep the wake going for many Rayleigh lengths, until just before the electrons start to get ahead of the wave and lose energy" — a distance otherwise known as the dephasing length.

To achieve this extended acceleration length, Leemans, working with his graduate student Cameron Geddes and other colleagues, implemented what he refers to as "the plasma

analogue of an optical fiber." The basic principle of this technique was developed a decade ago, using less powerful lasers, by Howard Milchberg from the University of Maryland, then improved upon by Leemans and his former student Pavel Volfbeyn in 1998. But it took nearly another six years before the L'OASIS lasers and instrumentation were sufficiently advanced to try guiding extremely intense laser pulses with the same method.

By tailoring the plasma channel conditions and laser parameters, the researchers are first able to achieve clean guiding of laser beams of unprecedented high intensity, while suppressing electron capture. This paves the way for using laser-powered plasma channels as ultra-high-gradient accelerating structures.

Next, by using even higher peak powers, plasma waves are excited that are capable of picking up background plasma electrons, rapidly accelerating them in the wake's electric field, then finally subsiding just as the surfing electrons reach the dephasing length, when they are on the verge of outrunning the wake.

How is it that the electrons in the bunch are accelerated to nearly the same energy? Following the experiments, Geddes and the other Berkeley Lab researchers, with the help of their Tech-X collaborators, modeled the evolution of the high-quality electron bunches on supercomputers at NERSC. They found that the formation of large bunches of electrons with nearly the same high energy is due to several factors. Most critical is matching the long acceleration path to the dephasing length. Other factors include plasma density and laser power, and how the laser pulse evolved during its propagation in the plasma channel.

"The plasma-channel technique is an essential step toward developing compact laser wakefield accelerators with multiple stages, which can produce focused, ultrafast, high-energy bunches of electrons to compete with state-of-the-art machines using conventional radio-frequency acceleration," says Leemans.

"High-quality electron beams from a laser wakefield accelerator using plasma-channel guiding," by Cameron Geddes, Csaba Toth, Jeroen van Tilborg, Eric Esarey, Carl Schroeder, David Bruhwiler, Chet Nieter, John Cary, and Wim Leemans, appeared in the 30 September 2004 issue of *Nature*.

Cybersecurity (continued from p.1)

The meeting provided a forum for computer security administrators, system administrators and center management to share information about the security intrusions last spring at numerous high performance computing and/or university sites, to review and discuss security best practices, and to develop a trust network among sites in order to

improve communication and real-time defensive responses between sites when future intrusions occur.

The agenda included a keynote presentation from nationally recognized security expert and author Bill Cheswick of the Lumeta Corporation, and a presentation from the FBI Cyber Intrusion Laboratory.

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