CASE STUDY

Berkeley Lab Particle Accelerator Sets World Record with Help from NERSC's Cray® XC™ Series 'Edison' Supercomputer

Organization

National Energy Research Scientific Computing Center
Oakland, CA
www.nersc.gov

About NERSC

The National Energy Research Scientific Computing Center (NERSC), located at Lawrence Berkeley National Laboratory, is the primary scientific computing facility for the Office of Science in the U.S. Department of Energy. One of the world's largest facilities devoted to providing computational resources and expertise to the scientific research community, NERSC serves nearly 6,000 researchers annually running over 800 different codes on more than 700 projects in varied disciplines from climate modeling to nuclear and high-energy physics, along with scientific visualization of massive datasets.

NERSC & Cray

Cray and NERSC share a long history, starting with a Cray-1 in 1978. Its current Cray systems are the Cray® XE6™ "Hopper" system and Cray® XC30™ "Edison" supercomputer. In 2016, Cray will deliver "Cori" — a next-generation Cray® XC™ system that is expected to deliver 10 times the sustained computing capability of the Hopper supercomputer.

Cray XC30 'Edison' Overview

- Cabinets: 30
- Peak Performance: 2.57 PF
- System Memory: 357 TB
- Compute Nodes: 5,576 12-core Intel® Xeon® "Ivy Bridge" processors (24 cores per node)
- Compute Cores:133,824
- Interconnect: Aries
- Storage: 7.56 PB
- I/O Bandwidth: 163 GB

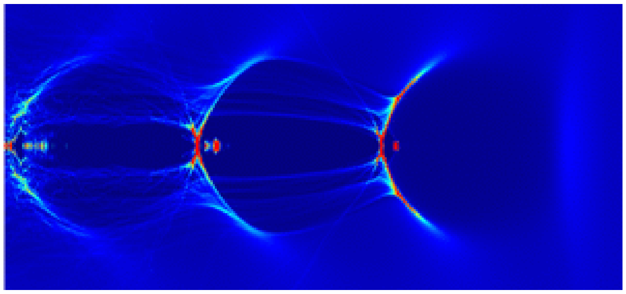
Simulations at NERSC Help Validate Experimental Laser-Plasma Design

Using one of the most powerful lasers in the world, researchers have accelerated subatomic particles to the highest energies ever recorded from a compact accelerator.

The team, from the U.S. Department of Energy's Lawrence Berkeley National Lab (Berkeley Lab), used a specialized petawatt laser and charged-particle plasma to get the particles up to speed. The setup is known as a laser-plasma accelerator, an emerging class of particle accelerators that physicists believe can shrink traditional, miles-long accelerators to machines that can fit on a table.

The researchers sped up the particles — electrons in this case — inside a nine-centimeter long tube of plasma. The speed corresponded to an energy of 4.25 giga-electron volts. The acceleration over such a short distance corresponds to an energy gradient 1,000 times greater than traditional particle accelerators and marks a world record energy for laser-plasma accelerators.

"This result requires exquisite control over the laser and the plasma," said Wim Leemans, director of the Accelerator Technology and Applied Physics Division at Berkeley Lab and lead author on the paper. The results were published December 8, 2014 in *Physical Review Letters.*



An image captured from the computer simulation of the plasma wakefield as it evolves over the length of the nine-centimeter channel.

Traditional particle accelerators, like the Large Hadron Collider at CERN, speed up particles by modulating electric fields inside a metal cavity. It's a technique that has a limit of about 100 mega-electron volts per meter before the metal breaks down. Laser-plasma accelerators take a completely different approach. In the case of this experiment, a pulse of laser light is injected into a short and thin straw-like tube that contains plasma. The laser creates a channel through the plasma as well as waves that trap free electrons and accelerate them to high energies.

The record-breaking energies were achieved with the help of BELLA (Berkeley Lab Laser Accelerator), one of the most powerful lasers in the world, and Edison, the National Energy Research Scientific Computing Center's (NERSC) Cray XC30 supercomputer.

At such high energies, the researchers needed to see how various parameters would affect the outcome. So they used computer simulations to test the setup before ever turning on a laser. The fully self-consistent, multi-dimensional particle-in-cell (PIC) simulations they ran on Edison have been fundamentally important to modeling the propagation of an high-intensity laser in the plasma, characterizing the nonlinear wakefield excitation and studying the details of particle self-trapping.

"PIC simulations of the laser-plasma interactions are usually very computationally demanding," Leemans said. "The computational power of Edison allowed us to perform extensive parameter scans, facilitating our understanding of the physics."

For more details see:
"Berkeley Lab Particle Accelerator Sets World Record." www.nersc.gov/news-publications/nersc-news/science-news/2014/berkeley-lab-particle-accelerator-sets-world-record

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