A Wondrous Machine to Unlock the Secrets of the Universe

UCLA scientists are playing pivotal roles in the international consortium of researchers seeking fundamental insights about the Big Bang.

By Stuart Wolpert

It weighs more than 13,000 tons and contains 75 million sensors. It has a detector like a digital camera that can take 40 million photographs per second. And through the work of more than 2,500 scientists and engineers from 38 countries—with UCLA physicists playing a lead role—the Compact Muon Solenoid Experiment (CMS) will lead to extraordinary discoveries about the nature of the universe.

CMS *(see photo)* is designed to measure the momentum, direction, and energy of the particles that remain when new particles decay. The experiments conducted with CMS will re-create conditions that existed less than a billionth of a second after the Big Bang, recording collisions of protons at energies as high as existed just after the Big Bang. Eventually, the experiments will include nearly one billion collisions per second.

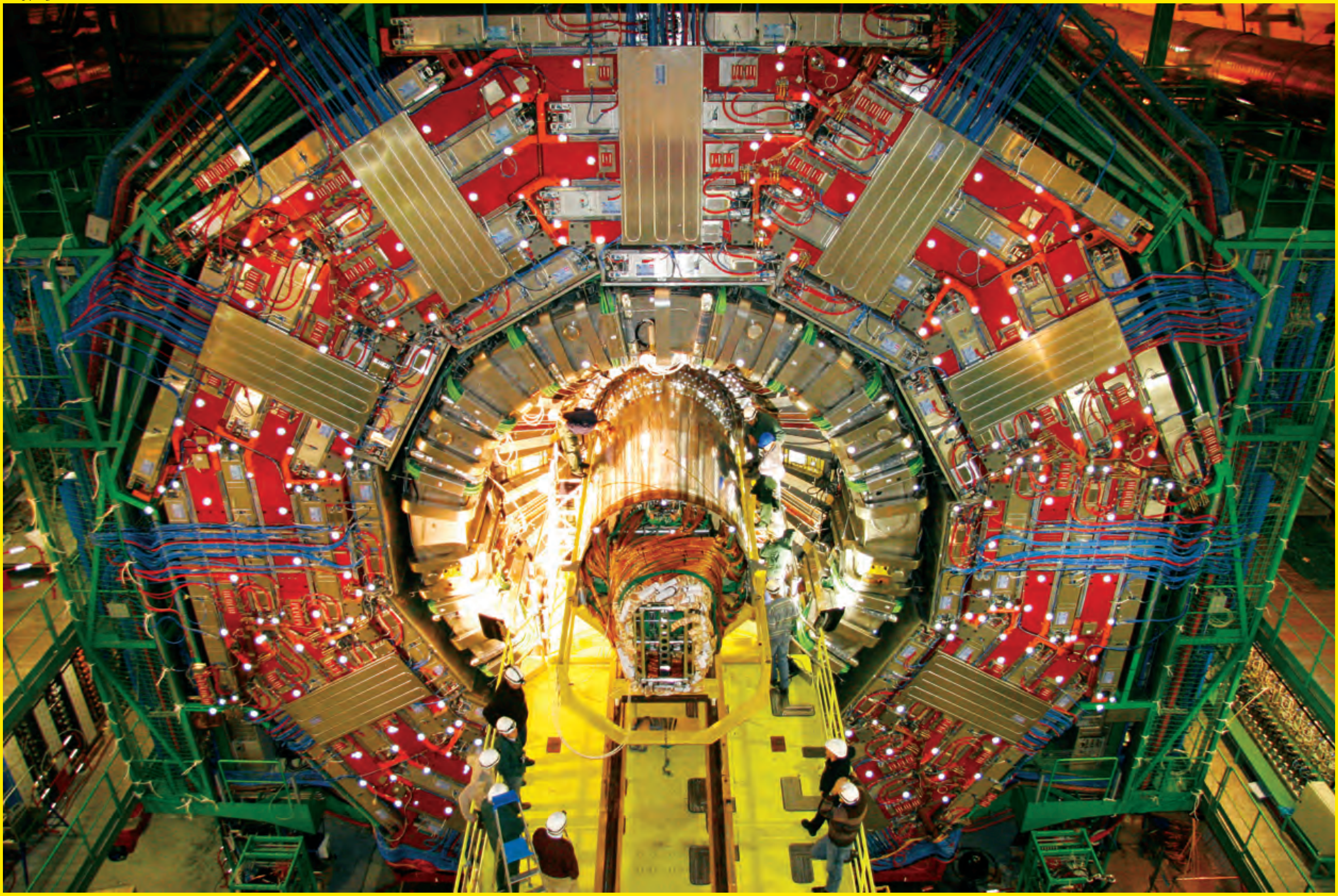
These repeated, controlled collisions are likely to yield new insights into the Big Bang, the building blocks of the universe, the mysterious properties of dark matter, and perhaps even extra dimensions in the universe, as they usher in a new era of particle physics research.

Located at the CERN Laboratory outside of Geneva, CMS is one of the main experiments of the Large Hadron Collider (LHC), the world's largest and highest energy particle accelerator, and one of the most complex scientific instruments ever built. Ten thousand people from 60 countries helped to design and build the LHC and its experiments, including scientists, engineers, technicians, and students from more than 90 U.S. universities and laboratories supported by the Department of Energy (DOE) and the National Science Foundation (NSF).

UCLA physicists and engineers have featured prominently in the collider's work. Seven UCLA physics professors and their research groups have contributed to CMS. Many UCLA professors, researchers, postdoctoral scholars, and graduate students have made major contributions to the research over many years, and UCLA scientists have built major portions of CMS. Indeed, when *Newsweek International* published a cover story in 2008, titled "The Biggest Experiment Ever," almost all the equipment in the cover photo came from UCLA.

UCLA's involvement started with physics professor David Cline, who two decades ago was one of the founders of the CMS Experiment—one of the collider's two large general-purpose experiments. Cline continues to be an active researcher on the project.

"It has been immensely gratifying to see the UCLA-built parts of CMS performing so well," said Jay Hauser, UCLA professor of physics who is a member of the management board for CMS. "I've spent a good part of my professional career on this experiment, starting in 1995, and am now eager to see the discoveries that will be made by this device. The UCLA scientists, including researchers Mikhael Ignatenko, Greg Rakness, and Viatcheslav Valuev, have done magnificent work in



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making a very complicated detector work considerably better than even we originally hoped."

Robert Cousins, UCLA professor ofphysics who started working on CMS in 2000 and has served as a leader of the CMS Experiment, is hopeful the LHC will unlock extraordinary discoveries about the nature of the universe.

"We're going to study the Big Bang as far back as we can take it," said Cousins, whose research group is supported by the DOE, and who is principal investigator of a CMS grant funded by the NSF.

"The fundamental questions," Cousins said, "were asked by the ancient Greeks: Where did we come from? What are we made of? How did the universe evolve and what are the forces of the universe?

"Nature likely contains undiscovered forces," he added. "The history of physics is one of unification of ideas. Any successful attempt to unify the known forces of nature will almost certainly unify some unknown forces of nature at the same time. The job of experimental physicists is to go find those forces."

Historically, high energy particle physics has addressed the smallest pieces of matter and the forces between those objects.

"In the last few decades, an enormous amount of progress has been made in cosmology, which addresses very large questions such as how the universe evolved from the Big Bang," Hauser said. "If you run the equations of general relativity for cosmology back to the Big Bang, you also need to know what the smallest objects in nature are and what the forces are between them in order to get close to the Big Bang.

"The cosmology measurements of UCLA professor of physics and astronomy Edward Wright constrain the speculation of what the forces are between particles, what the smallest particles are, and what dark matter can be," Hauser said. "There is much speculation about what dark matter might be since it is not ordinary matter."

With a few exceptions, the particles that the scientists make will decay into lighter particles—some common matter like electrons; others are particles that are well understood, such as muons, a heavy version of an electron that decays after one-millionth of a second.

"My thesis experiment 30 years ago had seven channels to detect photons and electrons," Cousins said. "The experiment I did after my thesis had a couple hundred. CMS has more than 75,000. We're going to find out what nature has in store for us."

www.uslhc.us http://cms.web.cern.ch http://ucla.in/d0S3v0